MPGD 2015 & RD51 Collaboration meeting

Monday 12 October 2015 - Saturday 17 October 2015

Trieste - Italy

Book of abstracts

INVITED TALKS

MPGD contributions in recent and running experiments

Invited talk - Board: 1 - Monday 12 October 2015 14:30

Presenter: Dr. TITOV, Maxim (CEA Saclay)

Frontier and trends in particle flow calorimetry

Invited talk - Board: 2 - Tuesday 13 October 2015 11:15

Presenter: Dr. SEFKOW, Felix (DESY)

Status and perspectives of large-size MCPs

Invited talk - Board: 3 - Tuesday 13 October 2015 17:15

Presenter: Dr. WAGNER, Robert (Argonne National Laboratory)

Trigger vs triggerles approaches in large-size experiments

Invited talk - Board: 4 - Wednesday 14 October 2015 11:15

Presenter: Dr. MARCONI, Umberto (BO)

Novel trends in solid state detectors

Invited talk - Board: 5 - Thursday 15 October 2015 12:30

Presenter: Prof. LIPTON, Ron (Fermilab)

Conference Summary

Invited talk - Board: 6 - Thursday 15 October 2015 17:30

Presenter: Prof. BRESKIN, Amos (Weizmann Institute of Science)

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ORAL

CONTRIBUTIONS

A Prototype Combination TPC Cherenkov Detector with GEM Readout for Tracking and Particle Identification and its Potential Use at an Electron Ion Collider

Contributed talks - Board: 1 - Monday 12 October 2015 15:10

Presenter: WOODY, Craig (Brookhaven National Lab)

A prototype detector is being developed which combines the functions of a Time Projection Chamber for charged particle tracking and a Cherenkov detector for particle identification. The TPC consists of a 10x10x10 cm3 drift volume where the charge is drifted to a 10x10 cm2 triple GEM detector. The charge is measured on a readout plane consisting of 2x10 mm2 chevron pads which provide a spatial resolution ~ 100 microns per point in the chevron direction along with dE/dx information. The Cherenkov portion of the detector consists of a second 10x10 cm2 triple GEM with a photosensitive CsI photocathode on the top layer. This detector measures Cherenkov light produced in the drift gas of the TPC by high velocity particles which are above threshold. CF4 is used as the drift gas which is highly transparent to UV light and provides excellent efficiency for detecting Cherenkov photons. The drift gas is also used as the operating gas for both GEM detectors. The prototype detector has been fully constructed and is currently being tested in the lab with sources and cosmic rays, and additional tests are planned in the future to study the detector in a test beam. This contribution will describe the current status of the prototype and results from these tests.
This work is part of the Detector R Program for a future Electron Ion Collider that is being planned to be built at either Brookhaven National Lab or Thomas Jefferson National Lab. EIC would collide beams of electrons with protons and heavy ions at high energies in order to study nucleon structure and QCD over a broad range of x and Q2. A large multipurpose spectrometer would be used to measure deep inelastic electron scattering over a wide range of rapidity and solid angle, and the tracking system for the central detector would consist of a TPC and a precision vertex detector. The combined TPC-Cherenkov detector described here could be used to provide both tracking and particle id information for measuring the scattered electron and hadrons produced in the central region. A description of the envisioned EIC spectrometer and how this type of detector could be used to improve its physics capabilities will also be discussed in this talk.

Study of the dE/dx resolution of a GEM Readout Chamber prototype for the upgrade of the ALICE TPC

Contributed talks - Board: 2 - Monday 12 October 2015 15:35

Presenter: Mr. MATHIS, Andreas (Physik Department, Technische Universität München, 85748 Garching, Germany; Excellence Cluster 'Origin and Structure of the Universe', 85748 Garching, Germany)

The ALICE Collaboration is planning a major upgrade of its central barrel detectors to be able to cope with the increased LHC luminosity beyond 2018. In order to record an increased interaction rate of 50 kHz for Pb–Pb collisions, the TPC will be operated in an ungated mode with continuous readout. This demands for a replacement of the currently used gated MWPC (Multi-Wire Proportional Chamber) by GEM based readout chambers, while retaining the present tracking and particle identification capabilities of the TPC via measurement of the specific energy loss (dE/dx).
The present baseline solution for the TPC upgrade consists of a stack of four large size GEM foils as amplification stage, containing both Standard (S, 140 µm) and Large Pitch (LP, 280 µm) GEM foils arranged in the order S-LP-LP-S. This arrangement, under a specific voltage configuration, has been proven to fully meet the design specifications in terms of ion backflow, energy resolution and stable operation under LHC conditions.
A prototype of the ALICE IROC (Inner Readout Chamber) has been equipped with such a quadruple GEM stack, installed within a field cage and exposed to a beam of electrons and pions delivered by the CERN PS.
An evaluation of the performance of the detector in terms of dE/dx resolution has been carried out using the AliRoot software – the framework for reconstruction, analysis and simulation in the ALICE experiment [1]. The presented analysis demonstrates a dE/dx resolution that meets the requirements of the ALICE upgrade physics programme. In order to understand the performance quantitatively, a Monte Carlo simulation has been carried out with the AliRoot framework aiming at reproducing the dE/dx results obtained during the test beam campaign.
It has further been demonstrated, that the dE/dx resolution of the detector prototype is comparable to the current readout chambers.
The outcome of this work represents a milestone for the project, proving the feasibility of replacing the currently used MWPC based readout. The project now proceeds to the phase of mass production. In the following years, 72 new readout chambers will be equipped with a quadruple GEM stack, for which a total of about 200 m^2 of GEM foils, including spares, will be produced.
This work has been supported by BMBF 05P12WOGHH and DFG Cluster of Excellence Origin and Structure of the Universe.

Construction and Test of First Full-Size MicroMegas Modules for the ATLAS New Small Wheel Upgrade.

Contributed talks - Board: 3 - Monday 12 October 2015 16:25

Presenter: Dr. BORTFELDT, Jonathan (LMU University Munich)

In 2015 the first full size resistive-strip MicroMegas operational modules for the ATLAS New Small Wheel upgrade will be realized. The goal is to provide precision muon tracking with spatial resolution below 100 µm on trapezoidal detector areas between 2 and 3 m2. The overall thickness of each detector modules is about 70 mm and the total number of read-out channels is of the order of 10^4.
Each module consists of a quadruplet of four MicroMegas with 5mm drift gaps intervaled with 2 read-out panels with anodes on both sides and 3 drift panels. The panels are realized as 11 mm thick stiffening sandwiches made of 10 mm thick honeycomb, 0.5 mm thick FR4 pcb material sheets as surfaces and aluminium frames.
The active part of the read-out anodes consists of horizontal strips with 0.45 mm pitch. Two out of the four anode planes are built with stereo strips of identical pitch and stereo angles of ±1.5 degrees. A sequence of 128 µm height insulating pillars on the read-out planes allows the pretensioned micromeshes to be kept at exact distance from the read-out strip planes.
The drift panels have the cathodes on one or on both sides and the pretensioned micromeshes are glued on very precise frames mounted on the drift panels. During assembly the grounded meshes will finally touch the pillars. An assembly procedure has been developed to build the single panels with the required mechanical precision and to assemble them in a unique module including the four meshes. The mechanical precision of each plane of the assembled module must be as good as 30 µm along the precision coordinate and 80 µm perpendicular to the chamber, a clear challenge for the construction of large size MicroMegas.
The procedure includes the tools to check the overall alignment of the strip positions together with the mechanical quality of the single parts of the modules during construction.
The first constructed modules, the so called module 0s, will be presented and the construction procedure will be reviewed. The results of the quality control checks done during the construction and on the full modules will be presented together with the first tests on cosmic ray tracks.

Upgrade of the CMS muon system with triple-GEM detectors

Contributed talks - Board: 4 - Monday 12 October 2015 16:50

Presenter: Dr. DORNEY, Brian (European Organization for Nuclear Research (CERN))

After 5 year of R on Gas Electron Multiplier (GEM) technology, the CMS GEM Collaboration proposed to instrument the vacant high eta region of the CMS muon system with large triple-GEM detectors, a technology able to sustain the harsh environment at the High-Luminosity LHC while operating for 20 years. New large size (990 x 440-220 mm2) triple-foil GEM detectors were developed, equipped with a new readout system. Combining triggering and tracking functions, the new GEM chambers will improve the performance of the CMS muon trigger and will also improve the muon identification and track reconstruction. With the addition of new detectors in the forward region (1.5<|eta|<2.2) the CMS muon spectrometer will recover its originally planned redundancy. Developing and testing several small and full size prototypes with different geometries yielded progressive improvement in assembly technique. These prototypes have been tested using radiation sources, cosmic rays, and test beams at CERN and Fermilab. The results show that these triple-GEM detectors fully satisfy the requirements for use in the forward region of the CMS muon system at HL-LHC. An additional station proposed in conjunction of the CMS forward calorimeter upgrade will extend the muon acceptance up to |eta|<3.0. We report on the status of the CMS GEM upgrade, including its expected impact on the performance of the CMS experiment, and the architecture of the GEM detectors and readout. We also present results of test beam measurements made in 2014 using the latest generation of chambers, including some with new readout electronics using the VFAT2 front-end chip and optical readout based on the micro-TCA standard.

Status of COMPASS RICH-1 upgrade with MPGD-based Photon Detectors

Contributed talks - Board: 5 - Monday 12 October 2015 17:15

Presenter: TESSAROTTO, Fulvio (TS)

The RICH-1 Detector of the COMPASS Experiment at CERN SPS is undergoing an important upgrade for the physics run 2016: four new Photon Detectors, based on MPGD technology and covering a total active area larger than 1.2 square meters will replace the actual MWPC-based photon detectors in order to cope with the challenging efficiency and stability requirements of the new COMPASS measurements.

The new detector architecture consists in a hybrid MPGD combination: two layers of THGEMs, the first of which also acts as a reflective photocathode (a CsI layer is deposited on its top face) are coupled to a bulk Micromegas on a pad segmented anode; the signals are read-out via capacitive coupling by analog F/E based on the APV25 chip.
The related R is reported at this Conference within a separate contribution.

All aspects of the COMPASS RICH-1 Photon Detectors upgrade are presented and large emphasis is dedicated to the engineering aspects, the mass production and the quality assessment of the MPGD componets.
In particular, the design and production of the detector components, the assembling and the validation tests of THGEMs and Micromegas and the engineering challenges of the detector installation are presented together with the expected performance of the upgraded COMPASS RICH-1.

Development of resistive Micromegas for sampling Calorimetry

Contributed talks - Board: 6 - Monday 12 October 2015 17:40

Presenter: Dr. GERALIS, Theodoros (NCSR Demokritos)

Micromegas, a micro pattern gaseous detector, is proposed as an active medium for sampling calorimetry. Future linear collider experiments or the High Luminosity LHC experiments can profit from those developments for Particle Flow Calorimetry. Micromegas possesses remarkable properties concerning gain stability, reduced ion feedback, response linearity, adaptable sensitive element granularity, fast response and high rate capability. Recent developments on Micromegas with a protective resistive layer present excellent results, resolving the problem of discharges caused by local high charge deposition, thanks to its RC slowed charge evacuation. Higher resistivity though, causes loss of the response linearity. We have scanned a wide range of resistivities and performed laboratory tests with X-rays that demonstrate excellent response linearity up to rates of 10s of MHz/cm2, with simultaneous mitigation of discharges. Beam test studies at SPS/CERN with hadrons have also shown a remarkable stability of the resistive Micromegas and low currents for rates up to 5 MHz/cm2. We will be presenting results from the aforementioned studies confronted with MC simulation as well as the potential in using Micromegas for sampling Calorimetry.

Caliste-MM, a new soft X-ray spectro-polarimeter based on gas detector with outer and contactless electronics

Contributed talks - Board: 7 - Tuesday 13 October 2015 08:45

Presenter: Mr. SERRANO, Paul (CEA)

Performing X-ray polarimetry of astrophysical sources is a topic of growing interest, with only a few flying experiments dedicated to it so far. For soft X-rays sources detection from 1 keV to few tens of keV, the best technique certainly consists in using the photoelectric effect, which is the dominant phenomenon at those energies in gaseous detectors. One of the main issues of such detectors is their reliability in space as gaseous detectors and their associated front-end electronics are sensitive to sparks caused by cosmic rays. To overcome this limitation, we investigate the opportunity of building a new spectro-polarimeter with outer and contactless radiation hard readout electronics, placed outside the gas chamber. To perform this, we used a Micromegas detector with a resistive anode deposited on a ceramic plate, the so-called Piggyback Micromegas. The signal is then transmitted by capacitive effect to the outer electronics. The readout electronics in question inherits from Caliste-HD, a fine pitch 3D detector module initially designed for semi-conductor applications.
In this talk, we present the different parts of our experimental set-up as well as recent results obtained by illuminating our prototype with a 55-Fe source. In addition to the optimization of the detector's parameters, we also present the first spectrum of a soft X-ray gaseous detector with outer and contactless electronics, and the first evidence of polarimetric possibility with such detector, making a step forward in the field of soft X-rays spectro-polarimeter.

A Cylindrical GEM Detector with Analog Readout for the BESIII Experiment

Contributed talks - Board: 8 - Tuesday 13 October 2015 09:10

Presenter: CIBINETTO, Gianluigi (FE)

Inner Trackers are key detectors in Particle Physics experiments; excellent spatial resolution, radiation transparency and hardness, and operability under high occupancies are main requirements. While planar Gas Electron Multiplier detectors are common in modern spectrometers, only one Cylindrical-GEMs detector has been produced up to now by the KLOE2 Collaboration and is being commissioned.

We are developing a cylindrical GEM detector with analog readout to upgrade the inner tracker of the BESIII experiment at the BEPC-II e+e- collider.
The new detector is expected to match the momentum resolution (σpt/Pt~0.5% at 1 GeV) and radial resolution (σxy~120µm) of the drift chamber and will improve significantly the spatial resolution along the beam direction (σz ~200µm) with very small material budget (about 1% of X0).

The inner tracker will be composed by three layers of triple cylindrical GEM with an angular coverage of 93% of the solid angle. Each layer will be assembled with five cylindrical structures: the cathode, three GEMs and the anode readout. A new Rohacell based technique will be used to manufacture the structure in order to minimize the material budget with respect to the state of the art.
The anode configuration will be also innovative; a jagged strips layout has been developed to minimize the capacitance couplings. The anode design has been studied by means of Maxwell and Garfield simulations and with a small-scale planar prototype.

The relatively strong BESIII magnetic field requires a new analogue readout; full custom front-end electronics, including a dedicated ASIC, will be designed and produced for optimal data collection.

To improve the spatial resolution in the magnetic field a µTPC readout feasibility study has been performed. The performance of analogue readout up to 1 T magnetic filed and of the new anode has been evaluated by means of a beam test performed at CERN within the RD51 collaboration.
Preliminary results of the test will be presented together with the mechanical design of the detector and the preliminary design of the frontend electronics.

The project has been recognised as a Significant Research Project within the Executive Programme for Scientific and Technological Cooperation between Italy and P.R.C. for the years 2013-2015, and more recently has been selected as one of the project funded by the European Commission within the call H2020-MSCA-RISE-2014.

Construction and Performance Studies of Large Resistive MicroMegas Quadruplets

Contributed talks - Board: 9 - Tuesday 13 October 2015 09:35

Presenter: FARINA, Edoardo Maria (PV)

In view of the use of MicroMegas detectors for the upgrade of the ATLAS muon system, two detector quadruplets with an area of 0.5 m2 per plane serving as prototypes for future ATLAS chambers have been constructed. They are based on the resistive-strip technology and thus spark tolerant. The detectors were built in a modular way. The quadruplets consist of two double-sided readout panels and three support (or drift) panels equipped with the micromesh and the drift electrode. The panels are bolted together such that the detector can be opened and cleaned, if required. Two of the readout planes are equipped with readout strips inclined by 1.5 degree. In this talk, we present the results of detailed performance studies based on X-Ray measurements, cosmic ray- and test-beam measurements at the MAMI accelerator that have been conducted in the past months. In particular, results on reconstruction efficiencies, track resolution and gain homogeneity will be presented.

Resistive Strip Micromegas Tracker for CLAS12 Experiment

Contributed talks - Board: 10 - Tuesday 13 October 2015 10:00

Presenter: Dr. ATTIÉ, David (CEA Saclay)

The Micromegas vertex tracker (MVT) of the future Cebaf Large Acceptance Spectrometer for the 12 GeV (CLAS12) accelerator upgrade in Hall B at Jefferson Lab will be installed at the end of this year.
The MVT consists of 2 cylindrical layers, 6 in the final phase, for the barrel part and 6 identical disks for the forward part. Micromegas bulk technology associated with resistive strips has been used. For the barrel detectors, the low material budget (0.33% of X0) offers a competitive alternative for central trackers with high-rate capabilities of the order 60kHz/strip.

The MVT final design has been validated and its construction is in progress after R on light material mechanics, long coaxial cables and large input capacitance electronics.

We will report on performance studies of both barrel and forward detectors using data taken from a cosmic ray test bench read out by the nominal electronics based on a new ASIC - Dream (Dead-timeless Readout Electronics ASIC for Micromegas). 2D efficiencies, time and spatial resolutions and operating parameters will be shown.

Large Area Coverage of a TPC Endcap with GridPix Detectors

Contributed talks - Board: 11 - Tuesday 13 October 2015 10:25

Presenter: KAMINSKI, Jochen (University of Bonn)

The Linear Collider is a future accelerator colliding electrons and positrons at center of mass energies of 250-500 GeV. One of the detector concepts under study foresees a large volume TPC as a main tracking device. The LCTPC collaboration studies several different MPGD technologies which could fulfill the requirements of the ILC physics program. To test and compare the readout technologies, a test setup with a fully operational TPC prototype (called Large Prototype, LP) in a B = 1 T magnetic field and an E = 6 GeV electron test beam was set up at DESY, Hamburg, by the collaboration. The LP can be equipped with up to 7 readout modules of about 400 cm^2 each.

One of the technology options is the GridPix detector, which consists of a Micromegas gas amplification stage on top of the highly pixelized Timepix readout ASIC. The pillars and grid of the Micromegas can be fabricated in photolithographic processes ensuring a very good alignment of each grid hole with a pixel of the ASIC. Therefore, single primary electrons entering in a grid hole are amplified in the gap and the charge is collected completely on one pixel. This has significant advantages in energy determination, since counting the number of pixels gives a direct measure of the energy deposited along the track without gas amplification fluctuations. Also, the track reconstruction profits from the detailed information on each electron, since for example effects of delta electrons, multiple-scattering kinks can be corrected. In addition, the track reconstruction is also free from the angular pad effect.

Covering a large area of about 10 m^2 per endcap with GridPix detectors of 2 cm^2 is, however, challenging and the feasibility has to be demonstrated. For this reason we have built 3 modules for the Large Prototype setup with a total of 160 GridPix detectors corresponding to 10.5 million pixels. A central module with 96 GridPix detectors and two outer modules with 32 GridPixes each give a lever arm of about 60 cm for each track. The construction of the modules including the production of the GridPixes, the specifically developed readout system based on the Scalable Readout System of RD51, the LV and cooling system
will be described in this presentation. Also, experience of operating a 160 GridPix detectors and analyses concerning the data quality and TPC performance will be shown.

The COMPASS experiment gets its new hybrid GEM-Micromegas pixelized detectors to track high particle flux

Contributed talks - Board: 12 - Tuesday 13 October 2015 11:55

Presenter: Dr. NEYRET, Damien (CEA Saclay IRFU/SPhN)

New large size Micromegas gaseous detectors (40x40 cm^2 active area) were developed since 2009 in view of the forthcoming COMPASS new physics programs starting this year, which uses the CERN high intensity muon and hadron beams of a few hundred GeV scattered on thick fixed targets. Compared to previous Micromegas installed in 2001-2002, the new detectors feature a huge reduction of the discharge rate, a major issue for Micromegas at high hadron flux, by a factor of above 100 using the hybrid solution where a pre-amplifying GEM foil is placed 2 mm above the micro-mesh electrode. COMPASS is indeed the first high energy physics experiment using high flux hadron beam to be fully equipped with Micromegas detectors not impacted by discharges. A pixelized read-out was also added in the center of the detector, where the beam is going through and where old detectors were blind, in order to track particles scattered at very low angles. The combination of the hybrid structure, the pixelized central anodes, and an APV-based read-out electronics allows to detect particle flux above 10 MHz/cm^2 with very good detection efficiencies and spatial resolution.

After several years of R, 12 detectors and additional spares were built, based on large bulk boards (80x60 cm^2) produced by the ELVIA company in France. The Micromegas-based tracking system was fully equipped with the new hybrid detectors for the Drell-Yan run started in May 2015. During this run the detectors were impacted by an important flux of very low energy hadron particles and neutrons leaked from the hadron absorber placed just after the target. The impact on detector performance is however limited.

A short summary on important results of the R will be presented, including the optimization of the printed circuit board design in order to connect a large number of pixels through a limited space. The aspects of the industrialization of the fabrication process of the PCB at ELVIA will also be shown. An overview of the performance of the tracking based on these new hybrid Micromegas detectors in high hadron flux environment will be presented, in particular in term of detection efficiencies, and spatial and time resolutions of the reconstructed particles. The impact of low energy hadron and neutron flux will also be discussed.

Status of GEM trackers for Super Bigbite Spectrometer in Hall A for 12 GeV CEBAF Upgrade at JLab

Contributed talks - Board: 13 - Tuesday 13 October 2015 12:20

Presenter: Dr. GNANVO, Kondo (University of Virginia, Charlottesville, VA 22903, USA)

The Continuous Electron Beam Accelerator Facility (CEBAF) of the Thomas Jefferson National Laboratory (JLab) has been upgraded to deliver 12 GeV high intensity beams. The upgrade will allow outstanding study of nucleon structure and structure functions in the valence quark region with an unprecedented accuracy. The Super Bigbite Spectrometer (SBS) combines a large acceptance detector package with a dipole magnet located close to the target, to provide a large solid angle for high luminosity experiments in Hall A. The SBS, however, requires very high counting rate detectors with excellent spatial resolution to cope with the large background rate and excellent momentum resolution of the detected recoil protons. With high counting rate and excellent spatial resolution capabilities, of around 70 microns over large area, the GEM technology has been adopted for the for the three tracker station of the SBS.
We will give an overview of the status of the SBS GEM trackers, highlighting the achievements over the past years in term of the overall performances of the prototypes and spatial resolution studies from test beam. We will discuss the lessons learned from the challenges imposed by requirement of large area and low mass GEM detectors for the operation in high background environment and will report on the ongoing production of large area SBS GEM modules. Finally, we will present the latest developments on the APV25-based Multi-Purposed Digitizer (MPD) readout electronics for the SBS GEM trackers.

Status of the R activities for the upgrade of the ALICE TPC

Contributed talks - Board: 14 - Tuesday 13 October 2015 12:45

Presenter: Mr. DEISTING, Alexander (GSI Helmholtzzentrum für Schwerionenforschung)

After the Long Shutdown 2 (LS2) the LHC will provide lead-lead collisions at interaction rates as high as 50kHz. In order to cope with such conditions the ALICE Time Projection Chamber (TPC) needs to be upgraded.

After the upgrade the TPC will have to run in a continuous mode, but without any degradation of the momentum and dE/dx resolution compared to the performance of the present TPC. Since readout by MWPCs is no longer feasible with these requirements, new technologies have to be employed. In the new readout the electron amplification is provided by a stack of four Gas Electron Multiplier (GEM) foils. Here foils with a standard hole pitch of 140um as well as large pitch foils (280um) are used. Their high voltage settings and orientation have been optimised to provide an energy resolution of $\sigma(E)/E$=12% at the photopeak of 55Fe. At the same settings the ion backflow (IBF) into the drift volume has to be less than 1% of the effective number of ions produced during gas amplification and the primary ionisations. This is necessary to prevent the accumulation of space charge, which eventually will distort the field in the drift volume. To ensure stable operation during the high loads during LHC run 3 the chambers have to be robust against discharges, too. Therefore a setting with a discharge probability in the order of 10^(-12) per stack was aimed for.

An overview of the ALICE TPC upgrade activities will be given in this talk. We will present the optimised settings foreseen for the GEM stacks of the future readout chambers. Furthermore we will report on the outcome of two beam time campaigns at SPS and PS (at CERN) in the end of 2014. There the stability against discharges and the dE/dx performance of a prototype - with the dimensions of an inner readout chamber of the TPC - was tested.

In addition we give an outlook on the challenges of the upcoming mass production of chambers for the upgrade during LS2.

OPERATION OF HYBRID MICROPATTERN GASEOUS DETECTOR IN LOW-PRESSURE HYDROGEN, DEUTERIUM AND HELIUM, FOR ACTIVE-TARGET TIME PROJECTION CHAMBER APPLICATIONS

Contributed talks - Board: 15 - Tuesday 13 October 2015 14:10

Presenter: Dr. CORTESI, Marco (National Superconducting Cyclotron Laboratory (Michigan State University))

In view of a possible application as a charge-particle track readout for an Active-Target Time Projection Chamber (AT-TPC), the properties of a hybrid Micro-Pattern Gaseous Detector (MPGD) were investigated in pure low-pressure Hydrogen (H2), Deuterium (D2) and Helium (He).
The detector consists of a MICROMesh GAseous Structure (MICROMEGAS) coupled to a single-, or double-cascade Thick Gaseous Electron Multiplier (THGEM) as a pre-amplification stage. The advantages of combined THGEM and Micromegas structures lies on one hand on the extended thickness of the multiplication region within the THGEM holes, several times larger than the mean free path of the avalanche electrons even at low pressure, which allows stable operation conditions and relative high effective gain. On the other hand, a position-sensitive charge-readout based on Micromegas provides excellent spatial resolution (crucial for a precise and wide-range kinematics reconstruction), and it is extremely versatile: for instance, different gas gains for different pad positions may be achieved by increasing or decreasing the anode pad potential individually, providing a large dynamic range over a large active area.
We will present and discuss the study of the effective gain dependence of the hybrid-MPGD on pressure (in the range of 100-760 torr) for different detector arrangements, long-term gain stability, ion-back flow, and energy resolution from tracks of 5.5 MeV alpha particles. In pure Helium (He), stable operational conditions and maximum achievable gains of 10^4-10^7 have been demonstrated at pressure ranging from 100 torr up to 760 torr. An energy resolution of 2.4% for 5.5 MeV alpha tracks was obtained at a pressure of 350 torr. In hydrogen (H2) and Deuterium (D2), maximum achievable gains above 10^4, from single photoelectrons avalanche, were achieve for a pressure of 200 torr and above; for lower pressure the maximum gain was limited to a value of around 10^3.
The results of this work are relevant in the field of avalanche mechanism in low-pressure, low-mass noble gases, in particularly for applications of MPGD end-cap readout for active-target Time Projection Chambers (TPC) in the field of nuclear physics and nuclear astrophysics.

The BAND-GEM detector: An improved efficiency GEM-based solution for thermal neutrons detection at spallation sources

Contributed talks - Board: 16 - Tuesday 13 October 2015 14:35

Presenter: CROCI, Gabriele (MIB - Università di Milano-Bicocca)

New high count rate and large area detectors are needed for future spallation neutron sources. Indeed, the 3He-shortage limits the use of 3He tubes in present and future applications where large areas (several m2) and high efficiency (>50%) detectors are envisaged. In this framework, GEM (Gas Electron Multiplier) is one of the explored detector technologies. GEMs feature good spatial resolution (< 0.5 cm) and timing properties. Moreover they have an excellent rate capability (MHz/mm2) and can cover large areas (about 1 m2) at low cost. The GEM technique is well established for charged particle measurements in high energy physics applications at CERN and elsewhere. The new development concerns the neutron conversion to charged particles. In the BAND-GEM (Boron Array Neutron Detector) approach a 3D geometry for the neutron converter was developed that is expected to provide an average efficiency >50% in the wavelength of interest for SANS (Small Angle Neutron Scattering) measurements at spallation sources, while meeting the spatial resolution requirements for these specific instruments. A system of thin lamellas (250 µm) of dielectric material coated with 1 µm layer of boron carbide (on both sides) has been built and positioned in the first detector gap, orthogonal to the cathode. By properly tilting the lamellas system with respect to the beam, there is a significant increase of effective thickness of the borated material crossed by the neutrons. As a consequence, the interaction probability, as well as the detection efficiency, is increased while keeping the beam perturbation small due to the reduced volume of non-active material. A first experiment with this new detector, performed at the JEEP 2 reactor (Norway), measured a detector efficiency of about 20% for 7° tilting to the incoming 1.54 Å neutron beam . The results of this experiment in terms of efficiency (as a function of tilting angle), gamma-ray insensitivity, stability and uniformity will be presented. Based on these results, which are in agreement with the simulations, a new detector with improved parameters is being designed at the moment and will be tested in the near future.

X-ray generator: an application of micro pattern gas detector

Contributed talks - Board: 17 - Tuesday 13 October 2015 15:00

Presenter: Dr. TAMAGAWA, Toru (RIKEN)

We invented an X-ray generator by using gas electron multiplier (GEM) foils combining with the coniferous carbon nano structure (CCNS), and demonstrated that the generator worked properly as we expected. Of course, this is not an usual application of MPGD but one of possibility to expand our field of the MPGD devices.

There is no doubt about the importance of X-ray generators in recent world, e.g. in commercial, industrial, and scientific applications. To fabricate an X-ray generator, an electron source (or an electron gun) is must in place. The X-ray generators usually employ thermally
heated cathode as the electron source. Recently, carbon nano tube (CNT), from which we can extract electrons by the field emission, is recognized as one of candidates of the electron sources.

We have employed the coniferous carbon nano structure (CCNS) as the field emission device, in which CNT roots to a substrate through some bulky structures of carbon nano wall and nano diamond, forming tight connection between CNT and substrate. We just put our GEM foil onto the CCNS substrate in vacuum and applied the gate voltage to the GEM electrodes. Thanks to the thinness of the GEM foil, the CCNS+GEM device becomes an efficient electron emitter working with a low (< 100V) gate voltage. The emitted electrons are guided to and bombarded on a target metal, and then characteristic and bremsstrahlung X-rays are emitted.

We can turn on and off the generator quickly (<1 us) by switching the gate voltage; it is not necessary to switch the high voltage applied to the target metal. The X-ray generator can issue trigger timing signals, i.e. the generator can emit X-rays with synchronous to the data aquisition timing of a detector system. This character implies that the generator becomes a good calibration device which we can operate during any experiments.

We will present the design and performance of the X-ray generator at the conference, and show some industrial applications, for example, the flat X-ray source for CT scan devices.

GET – A generic approach towards an acquisition system for TPCs in Nuclear Physics.

Contributed talks - Board: 18 - Tuesday 13 October 2015 15:25

Presenter: Dr. POLLACCO, Emanuel (IRFU/SPhN)

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GET (Generic Electronics for TPCs) is today being deployed in a number (>20) experiments including, TPCs, trackers and solid-state devices at RIKEN, J-PARC, GANIL, IBS, NSCL, IRFU, INFN(Catania), ELI-NP, CERN, IMP, … The system development covered the very front-end to data storage including basic software developments. It has been specifically tailored to respond to the needs in Nuclear Physics where i) a versatile multi-level numeric trigger is required, ii) the number of channels can are relatively small (256-32k), iii) having a wide dynamic range, iv) relatively high rates(<5kHz) and in particular v) generic via slow control to cater for different instruments in the domain.

Propose to present an overview of the GET system as coupled to ACTAR-TPC, AT-TPC (active targets) and SπIRIT(TPC). The performance of the recent (2015) integrated system will be given for recent experiments. Future extensions of the system leading to a high dynamic range will be described.

Recent progress with the RPWELL detector

Contributed talks - Board: 19 - Wednesday 14 October 2015 08:45

Presenter: Dr. BRESSLER, Shikma (Weizmann Institute of Science)

The RPWELL detector is a single-sided THGEM (copper clad on one side only) coupled to the readout electrode through a sheet of large bulk resistivity. Former laboratory and accelerator studies, performed in Ne/CH4(5%), have demonstrated its large dynamic range (from single electrons to thousand times MIPS), high gains (> 106), and high detection efficiency over a broad particle-flux range. The RPWELL operation under these conditions was stable, with no observable discharges.
In this work we will present the results of recent studies of these robust single-stage RPWELL detectors. We will compare their performance with Ar-based gas mixtures to that with Ne/CH4(5%) - making the RPWELL an attractive imaging detector for large-area applications in particle physics, astro-particle physics and homeland security. We will discuss the preliminary performance of RPWELL-based UV-photon detectors, with CsI-coated electrodes; among potential benefits for this application are the high sensitivity to single photoelectrons and large dynamic range (discharge-free operation under highly ionizing background).

R on a novel fast timing micro pattern gaseous detector (FTM)

Contributed talks - Board: 20 - Wednesday 14 October 2015 09:10

Presenter: Dr. SHARMA, Archana (CERN)

We would like to describe a novel class of Micro Pattern Gas Detectors, dedicated to fast time applications: the Fast Timing MPGD (FTM).

Time resolution in gas detectors is dominated by fluctuations in the drift region of the nearest distance of the primary ionisation to amplification region. In order to improve their time resolution, we propose a new configuration, in which we split the conventional drift region in several ones, each of them coupled to its multiplication stage.
The timing of the ionisation processes in the respective drift volumes will then compete leading to a decrease of the arrival time to any multiplication volume and consequently, a decrease of the fluctuations and an improvement of the time resolution.
The reduction of the time resolution is proportional to the number of drift layers employed.

The architecture of the proposed new device is then based on a stack of several layers where drift and multiplication stages alternate in the structure.
The signal from each amplification region can be read out through the capacitive couplings at both sides of the stack; in order to do that, the entire structure is realized by fully resistive materials. This
allows also a spark protection for the device.

We have built the first working prototype and we are on the way of building the second one. The two detectors are based on two different MPGD structures. The first one is made by two layers of resistive micro-well, while the second one will be formed by four amplification stages of resistive Micromegas.
In both cases each of the drift regions is kept at 250 um thickness and the readout electrodes are placed at both ends of the stacks and are made of copper.
Both detectors were designed and built at the CERN Micro Pattern Technology workshop; all the polarized layers were manufactured using resistive kapton or resistive coatings, taking advantage from the expertize acquired by the workshop in the recent years in the use of resistive material to build compact spark-protected MPGD.

We have demonstrated the construction feasibility with small prototypes, but we believe that those detectors can be fabricated also in large area and that this technique can be exploited for applications in high energy physics experiments and also in medicine and astronomy.

We will present preliminary results of both prototypes, under test at CERN, together with the detailed description of the applied production techniques.

Development of the micro pixel chamber based on MEMS technology

Contributed talks - Board: 21 - Wednesday 14 October 2015 09:35

Presenter: Mr. TAKEMURA, Taito (Kyoto Univ.)

(1) The u-PIC (micro pixel chamber) is our original gaseous two-dimensional imaging detector made by PCB (Printed Circuit Board) technology. The pixel Cu electrodes of u-PIC with a pitch of 400 um are placed on a polyimide substrate. At present u-PICs are used as the TPC of the Electron Tracking Compton Camera (ETCC) which is being developed for MeV gamma-ray astronomy. In order to improve the accuracy of electron tracking, a position resolution of electron less than 100 um and the uniformity of the gain less than one percent are requested. However, for the present u-PIC, the accuracy of the pixel structure and its pitch are strongly limited from the limitation of the PCB technology. For that reason, we require new technology that can manufacture a fine pixel structure with an um accuracy. And we fond MEMS (Micro Electro Mechanical System) technology that may be satisfied with it. To study this MEMS u-PIC, a small (5 mm x 10mm) MEMS u-PIC has been developed, and the fundamental feature of it as a MPGD has been measured.
(2) MEMS u-PIC consists of Cu electrodes and Si substrate, SiO2 wafer, polyimide wafer with a columnar cavity. For improvement of insulation, there are SiO2 and polyimide wafer between the cathode electrode and substrate. We made 4 types of prototype MEMS u-PIC in order to study the behaviors of MEMS u-PIC. Parameters for them are thickness of SiO2 wafer, diameter of polyimide cavity and manufacturing process. We investigated characteristics of them with X-ray source (Fe-55, 5.9 keV) and gas of 1 atm, Ar/C2H6 (90%/10%).
(3) In this work, all of 4 types MEMS u-PIC sent out signal from both anode and cathode. By the experiment, we obtained the gain of 700–1800 with MEMS u-PICs when anode voltage is 500 V. In comparison with PCB u-PIC, the gain of MEMS u-PIC is smaller than that of present u-PIC. However, our simulation gas avalanche using Garfield++ suggests that a gain of MEMS u-PIC is twice higher than the gain of present u-PIC. In addition, MEMS u-PIC with SiO2 1 um has a lower gain and a bigger leak current than MEMS u-PIC with SiO2 10 um.
(4) Most of MPGDs are made by PCB technology. But the processing accuracy of PCB technology is about 10 um while that of MEMS technology is about 1 um. Because processing accuracy make energy resolution higher, we expect MPGDs based on MEMS to open the new way. This work research MPGD based on MEMS and shows the characteristics.
(5) We think deterioration of MEMS u-PIC gain against simulation data is caused by Si working as semiconductor near anode. Thus we guess that the thicker SiO2 wafer become, the higher u-PIC gain become. Additionally MEMS u-PIC have more robustness against the discharge and higher gain than that with thin SiO2 wafer. MEMS enable us to make SiO2 wafer thicker than current prototype, therefore we make the next MEMS u-PIC with 20 um or thicker SiO2 wafer. Considering this work, we develop the next MEMS u-PIC and study characteristics of MEMS u-PIC in more detail.

Fast Timing for High-Rate Environments with Micromegas

Contributed talks - Board: 22 - Wednesday 14 October 2015 10:00

Presenter: Dr. PAPAEVANGELOU, Thomas (IRFU - CEA Saclay)

The current state of the art in fast timing for existing experiments is of the order of 100 picosec[1-2] on the time of arrival of both charged particles and electromagnetic showers. Current R on charged particle timing is approaching the level of 10 picosec [1] but is not primarily directed at sustained performance at high rates and under high radiation (as would be needed for HL-LHC pileup mitigation).
We propose a Micromegas based solution to reach this level of performance. The Micromegas acts as a photomultiplier coupled to a Cerenkov-radiator front window, which produces sufficient UV photons to convert the 100-picosec single-photoelectron jitter into an incident particle timing response of order 10 picosec.
A prototype has been built in order to demonstrate this performance. The first laboratory tests with a pico-second laser have shown time resolution of the order of 40 ps for ~50 primary photoelectrons, using a Microbulk readout. Other mesh types in combination with the optimization of the gas mixture are expected to give the desired results. First beam tests are planned for October-November 2015. The status and the latest results of the project are going to be presented here.

Charge Transfer Properties Through Graphene for Applications in Gaseous Detectors

Contributed talks - Board: 23 - Wednesday 14 October 2015 10:25

Presenter: Mr. RESNATI, Filippo (ETHZ / CERN)

Graphene is a single layer of carbon atoms arranged in a honeycomb lattice with remarkable mechanical, electrical and optical properties. It can be regarded as the thinnest and narrowest conductive mesh with a strong asymmetry for the transmission of low energetic electrons and ions.
Graphene layers with an area of the order of a few cm^2 were transferred onto metal support structures with holes of diameters from 30 um to 70 um and pitches of the order of twice the hole diameter, so that the graphene layers were freely suspended in the holes.
The samples were installed into a gaseous detector equipped with a triple Gas Electron Multiplier (GEM), and the transparency of the graphene to electrons and ions was studied in gas as a function of the electric fields applied.
We describe the transfer techniques of the graphene layers from the substrate to the experimental setup as well as the procedures to measure the charge transfer properties. Results will be presented with special attention to the challenges arising from defects in the graphene layers. We furthermore describe solutions to study the intrinsic transmission properties of this material and discuss applications where these techniques can be used to improve the state of the art of gaseous detectors.

Development and application of scintillating Glass-GEM detector

Contributed talks - Board: 24 - Wednesday 14 October 2015 11:55

Presenter: Dr. FUJIWARA, Takeshi (National Institute of Advanced Industrial Science and Technology)

A novel radiation imaging gaseous detector has been successfully developed and 3D computed tomography (CT) is successfully demonstrated. The imaging system consists of a chamber filled with Ar/CF4 scintillating gas mixture, inside of which Glass GEM (G-GEM) is mounted for gas multiplication. In this system electrons are generated by the reaction between X-rays and the gas, and visible photons by excited Ar/CF4 gas molecules during the gas electron multiplication process in the G-GEM holes. These photons are detected by a mirror-lens-CCD-camera system and a radiograph is formed. Here, we report on the scintillation properties of G-GEM and the results of using it as a digital X-ray imager with a large sensitive area. Since the imaging system is based on a gaseous detector, it shows high sensitivity to low-energy X-rays, which results in a high contrast radiograph for elements with low atomic numbers. In addition, the combination of G-GEM (280 µm pitch precise holes) and a 300,000 pixel CCD sensor enables high spatial resolution. Moreover, a high gas gain of G-GEM enables rapid imaging. Successful operation of G-GEM with a scintillating gas and a mirror-lens-CCD-camera system has enabled us to realize a novel radiation imaging device for digital X-ray imaging and we successfully demonstrated 3D X-ray CT.
In the presentation, we would introduce the development of the detector. In addition we will focus on new applications such as soft X-ray imaging, medical applications and 3D CT.

New substrate, high spacial resolution and big area THGEMs development and applications

Contributed talks - Board: 25 - Wednesday 14 October 2015 12:20

Presenter: Dr. XIE, Yuguang (Institute of High Energy Physics, CAS)

The THGEMs development and application activities at IHEP, Beijing, China in recent years will be summarized and reported. We have made great progresses in new substrate, high spacial resolution and big area THGEMs. A serials of new types of substrates, Ceramic, PTFE, Kapton and FR-4 were developed for low neutron scattering and low radioactivity applications. By using laser technology, the intrinsic spacial resolution of THGEM was improved to 87um (300um pitch)■And this technology has the capability to make 1.0*0.5m^2 THGEM with very high production efficiency. The THGEMs with high spacial resolution can be a candidate for tracking detectors. By mechanical drilling technology, the THGEMs with big area of 1.0*0.5m^2 had been produced. The big area THGEMs were proposed to apply for the digital hadron calorimeter (DHCAL). The simulation and performance test results will be presented.

Development of a transparent Single-grid-type MSGC based on LCD technology

Contributed talks - Board: 26 - Wednesday 14 October 2015 12:45

Presenter: Prof. TAKAHASHI, Hiroyuki (The University of Tokyo)

We have developed a multi-grid-type MSGC (M-MSGC) for neutron applications and proved 0.6 mm neutron spatial resolution for our test detector with a He-3 gas mixture. Then we try to enlarge the size of our M-MSGC for practical use. Also, we tried to fabricate a transparent MSGC and successfully operated the test device as shown in Fig. 1. It was operated in Ar/CF4 gas mixture and both charge and light (because CF4 emits visible light during avalanche process) signals are obtained for Fe-55 photopeaks. However, the manufacturing quality of small companies was a bit problem and we were not successful to fabricate devices over 10cm x 10cm. Recently, we were successfully working with SHARP, the leading LCD (Liquid Cristal Display) company in the world. We could utilize the state of the art LCD technology in this collaboration. Now we consider X-ray applications and reconsider the use of transparent multi-grid-type MSGC principle. IZO electrodes are transparent. We have fabricated a single-grid-type MSGC (S-MSGC) using IZO. The anode width was 5 um and the anode pitch was 150um. We placed an intermediate electrode between the anode and the cathode to stabilize the electric field and separate the anode edge and the cathode edge. This time we just focused on a single grid which plays an important role to the gas gain and the stability. Substrate is normal LCD glass but the surface space between the anode and cathode surface is covered by the grid electrode, therefore we could use high resistivity non-alkaline glass without significant charge-up problem. The test device was fabricated. The effective area of the test device was 15mm x 23 mm. The device was operated in Ar/CH4 and Kr(90%)/CO2(10%) gas mixture. We successfully obtained a gas gain up to 3000. We plan to get signals through optical readout and operated our S-MSGC with an Ar/CF4 gas mixture. The test detector was successfully operated and encouraged by these initial results, we are now fabricating a large area test device in the next run. The use of LCD technology allows us to integrate some simple circuit using TFT. Such an integrated device is our next target but the successful operation of S-MSGC is the very important first step for us.

Microbulk Micromegas as x-ray detectors for axion searches: CAST and developments for IAXO.

Contributed talks - Board: 27 - Thursday 15 October 2015 08:45

Presenter: GRACIA GARZA, Javier (Universidad de Zaragoza)

The basic layout of an axion helioscope requires a powerful magnet coupled to x-ray optics and a detector in its focal plane. When the magnet is aligned with the Sun, an excess of x-rays at the exit of the magnet is expected, over the background measured at non-alignment periods. Therefore, low background x-ray detectors are a fundamental tool for these searches, partially determining their sensitivity. One of the four detection lines of CAST (CERN Axion Solar Telescope) has been recently upgraded. It integrates for the first time an x-ray optic specifically designed for an axion application and a shielded Micromegas-based TPC, made from radiopure materials in the microbulk technique, in its focal point. In this work we present the commissioning and operation of this system, conceived as a technological pathfinder for IAXO (International Axion Observatory). Based in our understanding of the background nature of the Micromegas detectors, we also report in our current background reduction activities, aiming at levels below 10^{-7} c/keV/cm2/s. Finally, we present the R strategies for reducing the energy threshold to sub-keV energies, which could enlarge the physics case of axion helioscopes. These strategies are based on technological (thinner x-ray windows), electronic instrumentation (self-triggered electronics) and analysis (cluster shape versus energy) developments.

Microbulk Micromegas for the search of DBD of 136Xe in the PandaX-III experiment

Contributed talks - Board: 28 - Thursday 15 October 2015 09:10

Presenter: Dr. GALÁN, Javier (U. Zaragoza)

The search for the neutrinoless double beta decay (DBD) is one of the most important quests nowadays in neutrino physics. Among the different techniques used, high pressure xenon (HPXe) gas time projection chambers (TPC) stand out because they allow to image the topology of the DBD event (one straggling track ending in two blobs), and use it to discriminate signal from background events. Recent results with microbulk Micromegas in Xe + trimethylamine (TMA) mixtures show high promise in terms of gain, stability of operation, and energy resolution at high pressures (up to 10 bar). The addition of TMA at levels of ~1% reduces electron diffusion in up to a factor of 10 with respect pure Xe, improving the quality of the topological pattern, and therefore the discrimination capability. Moreover microbulk Micromegas have very low levels of intrinsic radioactivity. All these results show that a Micromegas-read HPXe TPC can be a competitive technique in the search for DBD. The recently proposed PandaX-III experiment, based on these results, aims at building a large TPC of 200 kg of enriched Xe, to be located at Jinpin Underground laboratory. In this talk the main features of the experiment will be presented, with an emphasis on the design and tests of the microbulk readout, as well as the status of the project and first results of the prototyping phase.

Two-phase Cryogenic Avalanche Detector with electroluminescence gap and THGEM/GAPD-matrix multiplier

Contributed talks - Board: 29 - Thursday 15 October 2015 09:35

Presenter: Dr. SOKOLOV, Andrey (Novosibirsk State University, Budker Institute of Nuclear Physics)

Two-phase Cryogenic Avalanche Detectors (CRADs) with THGEM multipliers have become an emerging potential technique for rare-event experiments. In this work the current status of the two-phase CRAD prototype in Ar, with electroluminescence (EL) gap and combined THGEM/GAPD-matrix multiplier, is described. The low threshold and high energy resolution of the detector is provided by the EL gap, optically read out in the VUV using compact cryogenic PMTs. The high spatial resolution of the detector is provided by the double-THGEM charge multiplier combined with a 5x5 matrix of Geiger-mode APDs (GAPDs), optically recording THGEM-hole avalanches in the Near Infrared (NIR). The proportional electroluminescence in gaseous Ar has for the first time been systematically studied at cryogenic temperatures in the two-phase mode. We also present the first results on nuclear recoil detection in liquid Ar, using the two-phase CRAD and DD neutron generator, relevant in the field of calibration of rare-event detectors for dark matter search and coherent neutrino-nucleus scattering experiments.

Recent R results on the double phase LAr LEM TPC

Contributed talks - Board: 30 - Thursday 15 October 2015 10:00

Presenter: Mr. WU, Shuoxing (ETH Zurich)

The Liquid Argon (LAr) Time Projection Chamber (TPC) is the state-of-the-art technology for neutrino detection thanks to its superb 3 dimensional (3D) charge imaging and calorimetry performance. Based on this technology, a giant (10-40 kt) LAr TPC has been proposed as the detector for an underground observatory for the study of neutrino oscillations, neutrino astrophysics and proton decay.

Unlike the single phase LAr TPC which collects the electrons by means of wire planes inside the liquid argon, the double phase LAr TPC takes the advantage of charge multiplication in the gas phase. Electrons produced in the liquid argon are efficiently extracted into the gas phase where they're multiplied by the Large Electron Multiplier (LEM) before being collected on the 2 dimensional (2D) anode. This novel technology offers various benefits in terms of signal-to-noise ratio, signal waveform, sensitivity to low energy interactions, long drift path and mm-scale channel pitch, etc.

In order to cope with the large strip capacitance with the increased detector size, a novel design of a low capacitance 2D anode has been proven meeting all the requirements on energy resolution, charge sharing symmetry and uniformity. This anode offers a capacitance per unit length as low as 150 pF/m, and thus keeps the electronic noise within 1000 e– for a readout length of 2 m. The design parameters of the LEM have been optimised in real double phase operations of a smaller setup with a readout area of 10 × 10 cm2. The optimised LEM could be operated with a stable gain over 20 in absence of discharge for weeks. This notable gain offers a large signal-to-noise ratio of over 100 for minimal ionising particles (MIPs). Based on these R outcomes, 50×50 cm2 anode and LEM panels have been successfully manufactured for the double phase LAr LEM TPC demonstrator – the LBNO-DEMO (WA105) experiment. Results of validation and performance tests of the large area anode and LEM will be presented.

As a demonstrator of the large double phase LAr LEM TPC, LBNO-DEMO (WA105) has a 6 × 6 × 6 m3 (appr. 300 t) active volume. Its construction and operation aim to test scalable solutions for the crucial aspects of this detector: ultra high argon purity in non-evacuable tank, long electron drift path, very high voltage generation and feedthrough, large area Micro Pattern Gas Detectors (MPGD), and cold front-end electronics. WA105 will implement a total area of 6 × 6 m2 LEM consisting of 144 independent 50 × 50 cm2 LEM panels. Operation of these LEMs will provide a vital feedback for the future design of the long baseline neutrino experiment following the double phase LAr LEM TPC concept.

Study of Negative-Ion TPC using μ-PIC for Directional Dark Matter search

Contributed talks - Board: 31 - Thursday 15 October 2015 10:25

Presenter: Mr. TOMONORI, Ikeda (Kobe University)

Negative-ion TPCs have been studied for low-rate and high-resolution applications. Lately, the discovery of "minority carriers" in CS2 gas, broadened its potential and the measurement of absolute Z-position in a self-triggering TPC became possible (J.B.R. Battat et al., (2014) arXiv:1410.7821). The minority carriers appeared after adding a few percent O2 to the original gas. They each drift with slightly different velocities. Recently, a GEM-TPC with SF6 negative ion drift gas was reported (Nguyen Phan, Eric Lee in: Cygnus 2015 Conference in Los Angeles). They also observed minority carriers without any additional gas. SF6 is non-toxic, it can be handled easily while keeping the same advantages as CS2 gas.
NEWAGE has been using a μ-PIC-based TPC for direction-sensitive dark matter search using CF4 gas (Nakamura et.al, PTEP(2015)043F01s). In order to increase the angular resolution and decrease the radioactive background, we started a new study using a uPIC-based TPC with negative ion gas. A test performed at Occidental College showed that a uPIC system with pure CS2 gas can have a gain as high as with pure CF4 gas. This was the first test of negative ion gas with a μ-PIC. We plan to test a μ-PIC-based TPC with SF6 gas. We will optimize the SF6 gas mixture and pressure for dark matter detection. Minority peaks in SF6 will be used to achieve full volume fiducialization without an external start pulse and should be a valuable tool for rare-event detection such as in Dark Matter Experiments.

VMM - An ASIC for Micropattern Detectors

Contributed talks - Board: 32 - Thursday 15 October 2015 12:05

Presenter: Dr. IAKOVIDIS, Georgios (Brookhaven National Laboratory)

The VMM is an ASIC that can be used in a variety of tracking detectors. It is designed to be used with resistive Micromegas and sTGC detectors in the New Small Wheel upgrade of the ATLAS Muon spectrometer. The ASIC is fabricated in the 130nm 1.2V 8■metal CMOS technology from IBM. The ASIC integrates 64 channels, each providing charge amplification, discrimination, neighbour logic, amplitude and timing measurements, analog-to-digital conversions, and either direct output for trigger or multiplexed readout. The front-end amplifier can operate with a wide range of input capacitances, has adjustable polarity, gain and peaking time. The VMM2 is the second version of the VMM ASIC family fabricated in 2014. It was tested with resistive Micromegas prototypes in the 2015 test beam campaigns at CERN. The specification and performance of the VMM2 will be presented as well as the Micromegas detector performance with the VMM2.

Diffusion of ions in gas medium

Contributed talks - Board: 33 - Thursday 15 October 2015 14:10

Presenter: Mr. KALKAN, YALÇIN (RD51)

Knowledge of the ion transport properties is not only required for the calculation of induced currents, the mobility and diffusion also enter the calculation of e.g. space charge evacuation. This is particularly important for TPCs with GEM readout operating in a high-rate environment, as envisioned by the Alice collaboration, where ions in the drift volume distort the tracks. Earlier, we investigated ion clustering and its impact on the mobility. In this talk, we report on the diffusion of ions in gas mixtures. This will enable us to produce a microscopic tracking model for ions.

Numerical Investigation on Electron and Ion Transmission of GEM-based Detectors

Contributed talks - Board: 34 - Thursday 15 October 2015 14:35

Presenter: Ms. BHATTACHARYA, Purba (School of Physical Sciences, NISER, India)

A Time Projection Chamber (TPC) is an ideal device for three-dimensional tracking, momentum measurement and identification of charged particles. They are used in many running experiments, including ALICE. Owing to the enormous particle multiplicity per event, very specific requirements are made on the performance of the detectors in harsh radiation environments. Different R activities are currently concentrated on the adoption of the Gas Electron Multiplier (GEM) as the gas amplification stage of the ALICE-TPC upgrade version. Despite the promise, several issues related to the operation of the GEM have to be resolved before it can be finally considered as an option. For example, to keep distortions due to space-charge at a manageable level a lower ion feedback in the drift volume is required. Again, for a substantial detector gain, it is important that a large fraction of primary electrons partcipate in the avalanche process and contribute to the signal generation. Thus, a proper optimization of the detector geometry, field configuration and gas mixtures are required to have a higher electron transparency and lower ion backflow.

In the present work, Garfield simulation framework has been adopted to numerically estimate the electron transparency and ion backflow fractions of GEM-based detectors. Extensive simulations have been carried out to enrich our understanding of the complex physical processes occurring within single, triple GEM detectors. A detailed study has been performed to observe the effects of detector geometry, field configuration, magnetic field and gas mixtures on the above mentioned characteristics.

The description of the single GEM and triple GEM detector have made it easier for us to understand the operation of a quadruple GEM detector which is one of the viable solutions for the ALICE TPC. Ion backflow and electron transparency of quadruple GEMs containing foils with different hole pitch and different field configuration in presence of magnetic field have been studied to get an optimum configuration. Some preliminary results on single and triple GEM detectors are given in the attached document. The simulation results shown in the document and the experimental and simulation results presented in available literature are found to be in close agreement. In this presentation, we plan to demonstrate and discuss our detailed numerical results and will try to make an attempt to relate the above studies in the context of the high luminosity experiments.

The number of parameters for a device such as the quadrupole GEM is large. In future we will try to optimize the other parameters keeping in mind the specific requirement for the ALICE TPC. In parallel, experimental efforts will be given to measure the aforesaid characteristics under different configuration. Besides that, space charge and charging up effects will be included in the future computations in order to achieve an even better understanding of these devices.

Bubble-assisted Liquid Hole-Multipliers: bubble stability and electroluminescence in varying electrode configurations

Contributed talks - Board: 35 - Thursday 15 October 2015 15:00

Presenter: Mr. ERDAL, Eran (Weizmann Institute of Science)

Liquid hole-multipliers (LHMs) have been suggested as a possible method for generating charge-induced proportional scintillation signals in single-phase noble-liquid time projection chambers (TPCs). Preliminary experiments have shown large scintillation yields in the holes of a Thick Gas Electron Multiplier (THGEM) immersed in liquid xenon. Further detailed studies have uncovered that the underlying mechanism is electroluminescence in xenon bubbles trapped below the THGEM electrode. In this talk we will present the results of additional investigations on the mechanism of bubble formation and sustainment in the noble liquid, as well as its correlation with the achievable energy resolution and stability. We will further discuss the electroluminescence process in different hole-multipliers and grid configurations.

Effects of High Charge Densities in Multi-GEM Detectors

Contributed talks - Board: 36 - Thursday 15 October 2015 15:25

Presenter: THUINER, Patrik (CERN, Vienna University of Technology)

Gaseous Electron Multipliers (GEM) are well known for stable operation at high particle fluxes. For the first time we present a study of the intrinsic limits of GEM detectors when exposed to very high particle fluxes of the order of MHz/mm^2.
We give an interpretation to the variations of the effective gain, which, as a function of the particle flux, first increases and then decreases. We also discuss the reduction of the ion back-flow with increasing flux, which was first observed during studies for the ALICE Time Projection Chamber upgrade.
We present measurements with a triple GEM detector, describing its behaviour in terms of accumulation of positive ions that results in changes of the transfer fields and the amplification fields.
The behaviour is expected to be common to all multi-stage amplification devices where the efficiency of transferring the electrons from one stage to the next one is not 100%. Simulations, and measurements on double-stage and single-stage devices complete the discussion.

Development of gating foils to inhibit ion feedback using FPC production techniques

Contributed talks - Board: 37 - Thursday 15 October 2015 16:15

Presenter: ARAI, Daisuke (Fujikura Ltd.)

Time Projection Chamber (TPC) with MPGD readout is proposed to be the central tracker of ILD detector for the International Linear Collider (ILC). Positive-ion feedback from the gas-amplification region to the drift region can deteriorate the position resolution of TPC. In order to prevent this from happening, ILC beam-train time structure allow us to use a gate to stop the ion feedback, mounting near MPGD, providing good electron transmission. A GEM foil with many holes, narrow rim and very thin thickness could satisfy these requirements which were learned in previous studies. Our prototype has an insulator thickness of 12.5µm, a hole diameter of 300µm and a hole pitch of 335µm over the TPC-module (170mm x 220mm).
In this study, we have produced this gating foil using the production technology of the Flexible Printed Circuits (FPC) commonly applied to cables inside electrical appliances such as personal computers and cell phones. The miniaturization of these products have forced the development of technologies which allow the production of finer and thinner FPC, along with the progress of the photolithography technology. The standard FPC technology can handle a minimum electrode width of 35µm, depending on the circuit space, and would be applicable to a production of this gating foil.
However, the size of major FPC products is no larger than a few tens of mm, an application to the required size of the gating foil is a significant challenge. In addition, the present conditions of the FPC manufacturing environment, including cleanliness and process-control, are based on the assumption of processing small-sized FPC, much smaller than the module size. Severe adjustment of machining accuracy and quality control is inevitable to produce this gating foil having a enormous density of through-holes with 35µm-width electrodes on the entire surface of the gating foil.
A single-mask process is applied to form a narrow-electrode pattern of the gating foil on one surface of a copper clad laminate. Laser etching of the polyimide insulator is performed using the copper-electrode as the mask, copper on the backside is etched by the standard chemical process. In order to achieve highly uniformed insulator etching over a large area, we use a UV-YAG laser which has high machining accuracy and use it also for making the high taper-angle holes, though its productivity is very low.
We have established a stable process to build the gating foil with optical aperture over 80% for a 100mm x 100mm size. Furthermore, we could also produce finer and higher density electrodes where the hole diameter is 205µm with 225µm pitch for a foil area of 30mm x 30mm. While the production yield of the module size (170mm x 220mm) is limited and unstable mainly due to some contaminations in the present environment.
The precision of pattern and size of area for achievable MPGD using the standard FPC process are also discussed from manufacturer point of view.

Aging and outgassing studies for GEM detectors in the LHC high-rate environment

Contributed talks - Board: 38 - Thursday 15 October 2015 16:40

Presenter: Mr. MERLIN, Jeremie (CERN)

Gaseous detectors potentially show degradation of their performances with time, mostly due to the deposition of polymers created in the plasmas surrounding the amplification region. This “classical aging” depends on many and various parameters such as the flux of particles, charge density in the amplification structure, gas composition with possible pollutants, gas flow rate as well as the physical and chemical properties of the plasma and the geometry of the detector itself. For these reasons it is not possible to produce reliable models simulating the aging process. The accelerated aging under laboratory conditions, i.e. realistic conditions of operation and assuming large safety factors, is thus the most appropriate way to measure the longevity of gaseous detectors. To test the latest generation of GEM prototypes, using the final materials, the final geometry and a gas mixture of Ar/CO2/CF4 (45:15:40%), was kept under heavy radiation for 12 months at CERN’s Gamma Irradiation Facility (GIF) to accumulate a total charge of 11 mC/cm2. This dose corresponds to the duration of a Slice Test, in which GEM detectors installed in the CMS experiment will be operational. No aging effects were observed and the chamber is now under test at the new irradiation facility GIF++ to extend the total accumulated dose and reproduce 20 years of real operation in CMS including a second CF4-free gas mixture of Ar/CO2 (70:30%). To complement the classical aging tests each type of detector material is tested for its outgassing behaviour to identify the materials that can possibly release pollutants in the gas mixture and trigger polymerization processes in the GEM layers. Each material was separately flushed with a gas mixture of Ar/CO2/CF4 (45:15:40%) sent to Single Wire Proportional Counters (SWPCs). The SWPCs are preferred to identify outgassing since the full detection process is based on the integrity of microscopic wire that establishes the amplification electric field and collects the readout signal. Even a small amount of polluting species may affect the gas properties or produce polymer deposits on the anode wire and cause fast and significant damages to the chambers. Many different materials were tested, some identified as not useable and thus replaced with an alternative. Once all the materials are tested and approved, the CMS GEM Collaboration will propose a set of recommendations to assemble and operate MPGDs for high rate experiments.

Development of μ-PIC with resistive electrodes using sputtered carbon

Contributed talks - Board: 39 - Thursday 15 October 2015 17:05

Presenter: Mr. YAMANE, Fumiya (Kobe Univ.)

Micro-Pixel chamber (μ-PIC) with resistive electrodes has been developed for particle tracking detector in the environment of high rate HIP (Highly Ionizing Particles). One of the target of this development is ATLAS Muon Tagger that is considered to be disposed at phase-2 upgrade. The amplification region of μ-PIC is separated by isolated pixels, so it is expected to separate multi incident tracks with high position resolution. In our previous research resistive μ-PIC has succeeded to get enough gain for observing minimum ionizing particles and to suppress the sparks. As new developments, sputtered carbon is used as resistive cathode strips which are arranged by 400μm pitch with 250μm diameter hole. Very fine pattern can be formed with lift off process and resistivity is well controlled by varying its thickness (50-500nm) and nitrogen doping. Physical and chemical toughness of the resistive electrodes are realized by its diamond-like carbon structure. The gain measurement and spark tolerant test by fast neutron irradiation will be reported.

MPGD 2015 & RD51 Collaboration meeting

Monday 12 October 2015 - Saturday 17 October 2015

Trieste - Italy

Book of abstracts

POSTERS

A Minidrift GEM Tracking Detector and its Potential Use for Large Angle Tracking at an Electron Ion Collider

Board: 1

Presenter: Dr. WOODY, Craig (Brookhaven National Lab)

At large angles (typically greater than ~ 20 degrees), the resolution of conventional GEM tracking detectors deteriorates rapidly due to the increased charge spread along the track direction in the collection gap. In order to circumvent this problem, a minidrift GEM tracking detector has been developed that measures both the position and arrival time of the charge deposited in the drift gap, which allows the reconstruction of a vector for the track traversing the chamber. The resulting position and angle information from the vector is then used to improve the position resolution for larger angle tracks.
The detector consists of a triple GEM stack with a 1.6 cm drift gap that is operated in a mini TPC mode. Charge is collected on a readout plane which is used to determine the position information, and the arrival time of the charge is measured by sampling the analog pulse in 25 ns bins using the CERN SRS readout system. Two types of readout planes were studied. One was a COMPASS style readout plane with 400 micron pitch XY strips and the other consisted of 2x10 mm2 chevron pads with a 0.5 micron zigzag pitch. The detector was studied in a test beam at Fermilab, along with additional measurements in the lab, in order to determine its position and angular resolution for incident track angles up to 45 degrees. Several algorithms were studied for reconstructing the vector using the position and timing information in order to optimize the position and angular resolution of the detector for the different readout planes. A position resolution of ~ 125 microns and an angular resolution less than 20 mrad was obtained for angles up to 45 degrees for the measurements obtained in these tests. However, we believe this resolution was limited by the time resolution of the readout system and could be improved significantly (well below 100 microns, even at large angles) with more precise timing information and the use of more sophisticated tracking algorithms.
This study was part of the Detector R Program for a future Electron Ion Collider that is being planned to be built at either Brookhaven National Lab or Thomas Jefferson National Lab. EIC would collide beams of electrons with protons and heavy ions at high energies in order to study nucleon structure and QCD over a broad range of x and Q2. A large multipurpose spectrometer would be used to measure deep inelastic electron scattering over a wide range of rapidity and solid angle and would include a large aperture forward spectrometer in the hadron going direction. This spectrometer would use large area GEM detectors for particle tracking and would benefit from the improved resolution that could be achieved with the minidrift detector developed here. A description of the envisioned EIC spectrometer and how this type of detector could be used to improve its physics capabilities will also be described in this presentation.

Gas measurements in a sealed TPC for the HARPO experiment

Board: 2

Presenter: Dr. FROTIN, Mickaël (LLR)

The HARPO detector is a demonstrator of gamma-ray detector and polarimeter, for a potential space telescope. It is a (30cm) 3 cubic TPC filled with high pressure (up to 4bar) Ar:isobutane mixture. It has been tested with cosmic rays and in a high intensity gamma-ray beam.
The TPC data, in particular from cosmic rays, can be used to monitor the
gas properties (gain, drift velocity and electron attachment). The TPC was sealed for several months with the same gas to study its long term stability. A lightweight system for recirculation and purification of the gas was installed and tested.
We will show the results and experience with this system, in particular on the gas evolution over several month.

Studies on Gas Electron Multiplier (GEM) modules of a Large Prototype TPC for the ILC

Board: 3

Presenter: VAUTH, Annika (DESY)

The International Large Detector (ILD) is one of two detector concepts at the ILC. It relies on highly granular calorimetry and a high precision tracking system. The tracking system consists of a Silicon vertex detector, forward tracking disks and a large volume Time Projection Chamber (TPC), which will be read out with micro-pattern gas detectors (MPGD).
Within the framework of the LCTPC collaboration, a Large Prototype (LP) TPC has been built as a demonstrator. Its endplate is able to contain up to seven identical modules of Micro-Pattern Gas Detectors (MPGD).
Recently, the LP has been equipped with MPGD modules and studied with electron beams (1-6 GeV) in a 1 Tesla magnetic field.
The interest of this talk lies in the studies of Gas Electron Multiplier (GEM) modules.
In particular, after introducing the LP, recent results (drift velocity, field distortions, spatial resolution, alignment measurements) as well as the current status and future plans of the LCTPC R will be presented.

Development of large area resistive electrodes for ATLAS NSW MicroMegas

Board: 4

Presenter: Dr. OCHI, Atsuhiko (Kobe University)

MicroMegas with resistive anode will be used for the NSW upgrade of the ATLAS experiment at LHC. The resistive electrode is one of key technology for MPGDs to prevent sparks. Large area resistive electrodes for the MM have been developed using two different technology; screen printing and carbon sputtering. Maximum size of each resistive foil is 45cm x 220cm with printed pattern of 425 micron pitch strips. Those technologies are also suitable to mass production. The prototypes of series production model have been produced successfully. We will report the development and production status and test results of the resistive MicroMegas.

Design, construction, quality checks and test results of first resistive-MicroMegas anode boards for the ATLAS experiment.

Board: 5

Presenter: Dr. IENGO, Paolo (CERN)

The development work carried out at CERN to push the MicroMegas technology to a new frontier is now coming to an end. The construction of the first anode (or read-out) boards for the upgrade of the ATLAS muon system will demonstrate in full-scale the feasibility of this ambitious project.
The read-out boards, representing the heart of the detector, are manufactured in industries, making the MicroMegas for ATLAS the first MPGD for a large experiment with a relevant part industrially produced. The boards are 50 cm wide and up to 220 cm long, carrying copper strips 315 µm wide with 415 µm pitch. Interconnected resistive strips, having the same pattern as the copper strips, provide spark protection. The boards are completed by the creation of cylindrical pillars 128 µm high, 280 µm in diameter and arranged in a triangular array 7 mm aside. The total number of boards to be produced for ATLAS is 2048 of 32 different types.
We will review the main design parameters of the anode boards for the ATLAS MicroMegas, following the physics requirements of the experiment, and the most relevant construction issues including technology transfer aspects. Particular emphasis will be on the industrial construction and subsequent quality control tests of the boards as well as on preliminary performance results.

Aging studies on the first resistive-MicroMegas quadruplet at GIF++: preliminary results

Board: 6

Presenter: Dr. ALVAREZ GONZALEZ, Barbara (CERN)

A resistive-MicroMegas quadruplet built at CERN, serving as prototype of the micromegas for the upgrade of the ATLAS muon system, has been installed at the new CERN Gamma Irradiation Facility (GIF++) with the aim of carrying out a long-term aging study.
The detector has four active layers about 0.5 m2 each equipped with 1024 read-out strip and sputtered resistive layer for spark protection. It is exposed to an intense gamma irradiation (~50 MHz/cm2 provided by the 16.65 TBq 137Cs source of GIF++), corresponding to ~10 times more than the expected irradiation at High-Luminosity LHC.
Two small resistive bulk-MicroMegas produced at the CERN PCB workshop have also been installed at GIF++ in order to provide a comparison of the aging properties of the MicroMegas quadruplet.
We will give an overview of the aging properties of the resistive MicroMegas in terms of dark and amplification currents, efficiency and noise stability.

Performance studies of resistive MicroMegas detectors for the upgrade of the ATLAS Muon Spectrometer

Board: 7

Presenter: Mr. NTEKAS, Konstantinos (National Technical University of Athens)

Resistive Micromegas (Micro MEsh Gaseous Structure) detectors have proven along the years to be a reliable high rate capable detector technology characterised by an excellent spatial resolution. The ATLAS collaboration at LHC has chosen the resistive Micromegas technology, along with the small-strip Thin Gap Chambers (sTGC), for the high luminosity upgrade of the inner muon station in the high-rapidity region, the so called New Small Wheel (NSW) upgrade project. The NSW requires fully efficient Micromegas chambers with spatial resolution better than 100 μm independent of the track incidence angle and the magnetic field (B < 0.3T), with a rate capability up to ~10 kHz/cm2. Moreover, together with the precise tracking capability the Micromegas chambers should be able to provide a trigger signal, complementary to the sTGC, thus a decent timing resolution is required.
Several tests have been performed on small (10x10 cm2) resistive Micromegas chambers using medium (10 GeV/c, PS) and high (150 GeV/c, SPS) momentum hadron beams at CERN. Results on the efficiency, position and timing resolution measured during these tests will be presented demonstrating the excellent characteristics of the detectors that fulfil the NSW requirements. Exploiting the ability of the Micromegas detectors to work as TPC chambers a novel method, called the μTPC, has been developed for the case of inclined tracks, allowing for a precise segment reconstruction using a single detection plane. A detailed description of the method along with thorough studies towards the refinement the method’s performance will be presented. Moreover, during 2014 the first Micromegas quadruplet following the NSW design scheme, comprising four detection planes, two of them with stereo strips to allow for the reconstruction of a second coordinate, has been realised (MMSW). Test-beam results of this medium size (1x0.5 m2) prototype will also be presented and compared to theoretical expectations.

Simulation of the CMS GEM System

Board: 8

Presenter: Dr. ARCHANA, Sharma (University of Wisconsin)

The new GE1/1 system of Gas Electron Multipliers (GEM) is going to be installed in the CMS detector in the forward region of $1.6 < |\eta| < 2.2$ after the second long LHC shutdown. 36 super-chambers are planned to be installed in order to ensure the redundancy and robustness of the muon system in high-luminosity conditions at the LHC. A further extension of the GEM system is also considered. Every super-chamber consists of two chambers segmented over certain number of readout sectors in a (η, ϕ) plane, where η is the pseudo-rapidity and ϕ is the azimuthal angle. The simulation of the entire GEM system integrated in the common CMS reconstruction chain is a necessary part of the performed Monte Carlo studies. A dedicated parametric model based on the exhaustive standalone MC studies and experimental test beam results has been developed in order to simulate the response of the GEM system. The simulated digital readout signals are used to build the reconstructed hits in the detector planes. They have been included in the common CMS muon reconstruction algorithms. This contribution will present the developed simulation model and the importance of the GEM system for the improvement of the muon reconstruction efficiency and muon identification.

Charge particle detection performance of large area triple-GEM detectors for the forward muon upgrade of the CMS detector

Board: 9

Presenter: Dr. GRUCHALA, Marek Michael (CERN)

Gas electron multiplier (GEM) technology is being proposed for the forward muon upgrade of the CMS detector for the Phase 2 of the CERN LHC. The proposed prototypes for CMS upgrade, referred to as GE1/1 detectors, are large-area trapezoidal shaped detectors using three GEM-foils arranged in the 3/1/2/1mm gap configuration with 3072 radial readout strips segmented over 24 readout sectors in the (η,ϕ)-plane. Here η is taken as the pseudorapidity defined as $\eta = -\ln(\tan(\theta/2))$; with θ being the polar angle and ϕ is taken as the azimuthal angle. The GE1/1 system will be located on the CMS endcap; it will add redundancy and improved trigger momentum resolution, in the $1.6 < |\eta| < 2.2$ range, to the CMS forward muon system. The charged particle, muons and mixed hadron beams, detection performance of GE1/1 detectors is studied at beam lines supplied by the CERN Super Proton Synchrotron. The experimental setup consists of multiple small triple-GEM detectors, featuring two-dimensional Cartesian readout strips for track reconstruction, and between three and five, depending on the run period, large GE1/1 detector prototypes. Detection efficiencies and time response measurements are made as a function of the gain of the GE1/1 detectors with both Ar:CO2 (70:30) and Ar:CO2:CF4 (45:15:40) gas mixtures. For the latter the measurements are also repeated as a function of the Cartesian strip pitch. The measured detector performance properties are found to be suitable for the CMS forward muon upgrade.

Quality control for the first large areas of triple GEM chambers for the CMS endcaps

Board: 10

Presenter: Dr. TYTGAT, Michael (UGent)

The CMS GEM collaboration plans to equip the very forward muon system with triple GEM detectors that can withstand the environment of the high-luminosity LHC. This project is at the final stages of R and moving to production. An unprecedented large area of several 100 qm are to be instrumented with GEM detectors which will be produced in six different sites around the world. A common construction and quality control procedure is required to ensure the performance of each detector. The quality control steps will include optical inspection, cleaning and baking of all materials and parts used to build the detector, leakage current tests of the GEM foils, high voltage tests, gas leak tests of the chambers and monitoring pressure drop vs. time, gain calibration to know the optimal operation region of the detector, gain uniformity tests, and studying the efficiency, noise and tracking performance of the detectors in a cosmic stand using scintillators.

Development of a TPC detector module equipped with a positive-ion gating device using high electron transmission GEM-type foils for the ILD detector at the ILC

Board: 11

Presenter: Dr. LUX, Thorsten (IFAE)

The International Large Detector (ILD) concept for the International Linear Collider (ILC) features a GEM- or Micromegas-based Time Projection Chamber (TPC) as a central tracking detector.
Considering the background environment of a high density of charged tracks at the ILC, a gating system located between the drift volume and the gas amplification device of the TPC to prevent positive ions from entering the drift region is required. This gating device will enable the excellent momentum resolution needed for the ILC to be met. This is in spite of the fact that the amount of backdrift ions is much smaller for MPGD amplification than in earlier MWPC amplification.
Due to the low mobility of the ions, they will be concentrated in discs of about 1 cm thickness near the TPC readout in the case of the ILC beam time-structure, and then drift back into the drift volume. Therefore, a positive-ion gating device should be placed about 1 cm in front of the first stage of the gas amplification device. We have been developing a TPC detector with a modular end-plate readout system integrated with amplification GEMs and a gating system.
A wire gating grid has been the traditional solution for gating. However, its implementation above the amplification GEMs or Micromegas would not be simple. Hence, we decided to employ an idea to use GEM-type foil as a gating device, whose GEM is operated in low voltage mode without the function of gas amplification. This kind of Gate-GEM acts as an electron transmission film and can easily be used as a closed gate against both positive ions and drift electrons by reversing the electric field in GEM holes.
The main requirement for Gate-GEMs of the ILC-TPC is 80% electron transmission, which corresponds to the deterioration of the azimuthal spatial resolution by about 10%. The TPC will be operated in a 3.5 T axial magnetic field. The gas will have a long mean-free-time between collisions of drifting electrons with gas molecules in order to have small transverse diffusion for 2.3 m long drift of the ILD-TPC. Consequently, the motion of the electrons is strongly restricted to the direction of the magnetic field. A high optical transparency of the gate is required to ensure its high transmission rate of the electrons in the open state. In order to achieve high electron transmission, a large-aperture GEM-type foil (17 x 22 cm^2) with hexagonal holes is now under development by Fujikura Ltd; it has 30 μm rim width and 335 μm pitch (corresponds to 82% optical transparency) with grid thickness of 12.5 μm.
We will present the electron transmission rate of the new Gate-GEM to be measured by comparing the signal charge passing through the gating device to that observed without it, while being irradiated with an 55Fe source. Also presented are the results of a simulation using an ANSYS-Garfield++ framework, including evaluation of the observed transmission rate and its extrapolation to the case of 3.5 T.

Characterization of a hybrid GEM-Micromegas detector with respect to its application in a continuously read out TPC

Board: 12

Presenter: Mr. RATZA, Viktor (Helmholtz-Institut für Strahlen- und Kernphysik, Germany)

In the context of the upgrade of the LHC during the second long shutdown the interaction rate of the ALICE experiment will be increased up to
50 kHz for Pb-Pb collisions. As a consequence, a continuous operation and read-out of the Time Projection Chamber (TPC) will be required.
To handle the expected increase of space-charge distortions without a gating grid, the ion backflow of the charge amplification system has to be significantly reduced, maintaining at the same time an excellent detector performance and stability. Although a solution with four Gaseous Electron Multipliers (GEMs) has been adopted for the upgraded chambers,
an alternative approach using one Micromegas (MM) and two GEMs has also been investigated. Due to the geometric and electrostatic structure of the MM the ion backflow suppression capability is superior to a single GEM. The two GEM stages in front of the MM are installed to further reduce the ion backflow and to keep the discharge probability of the device at a reasonable level. The recent results of this study will be presented and compared to measurements with four GEM foils.

Supported by BMBF and EU.

LBNO-DEMO (WA105): a large demonstrator of the Liquid Argon double phase TPC

Board: 13

Presenter: Dr. LUX, Thorsten (ETH, Zurich)

A giant (10-50 kt) Liquid Argon Time Projection Chamber (LAr-
TPC) has been proposed as the detector for an underground observa-
tory for the study of neutrino oscillations, neutrino astrophysics and proton decay. This detector has excellent tracking and calorimetric capabilities, much superior to currently operating neutrino detectors.

LBNO-DEMO (WA105) is a large demonstrator of the double phase LAr-TPC based on the GLACIER design, with a 6x6x6 m3
(appr. 300t) active volume. Its construction and operation test scal-
able solutions for the crucial aspects of this detector: ultra-high argon purity in non-evacuable tanks, long drifts, very high drift voltages,large area Micro Pattern Gas Detectors (MPGD), and cold preamplifiers.

The TPC will be built inside a tank based on industrial technology
developed for liquefied natural gas transportation. Electrons produced in the liquid argon are extracted in the gas phase. Here, a readout plane based on Large Electron Multiplier (LEM) detectors provides amplfication before the charge collection onto an anode plane with strip readout. Photomultiplier tubes located on the bottom of the tank containing the liquid argon provide the readout of the scintillation light.

This demonstrator is an industrial prototype of the design pro-
posed for a large underground detector. WA105 is under construction
at CERN and will be exposed to a charged particle beam (0.5-20
GeV/c), consisting of p; e+-; pi+- and K+-, in the North Area in 2018. The data will provide necessary means for analysing and developing shower reconstruction, energy response and calibration, MC event generator tuning, particle identification, and tracking, as well as related eficiencies, and for development of analysis tools. This project is a crucial milestone providing feedback for future long baseline experiments considering LAr-TPCs.

Micromegas calibration for ACTAR TPC

Board: 14

Presenter: Mr. MAUSS, Benoit (GANIL)

Active targets are gas-filled detection systems where the gas used as the detection medium serves also as a target for nuclear reactions. They have been used for a wide variety of nuclear physics experiments since the eighties. Improvements in MPGD (Micro Pattern Gaseous Detectors) and in micro electronics achieved in the last decade have lead to the development of a new generation of active targets with higher granularity pad planes that allow spatial and time information to be determined with unprecedented accuracy. A novel active target and time projection chamber (ACTAR TPC with 16k channels), that will be used to study reactions and decays of exotic nuclei, is presently under development and will be based on Micromegas technology. A demonstrator version of the ACTAR TPC detection system with 2048 channels has already been constructed and is presently being tested using the GET (General Electronics for TPCs) system.
The energy resolution is of primary importance for these experiments to identify the reaction products and reconstruct precisely the level scheme of the nuclei. Energy measurements are based on the charge collected in the pixels of the pad plane. One major contribution to the energy dispersion is the non homogeneity of the Micromegas gap. A gap variation of only 1% can result in more than 2% variation in signal amplitude, which is of the same order as the resolution obtained with an energy deposition of 5 MeV. One method to calibrate the pad plane homogeneity is the use of a 2D translational scanning table equipped a radioactive source. The system we are developing will be used to quantify the gain variation for moderate size detectors up to 25x50 cm2 using different types of gas and pressure adapted to the performed experiments.
In this poster, the ACTAR TPC detector will be presented. The calibration method will be explained and recent results obtained with the scanning table will be presented. Results will be compared to simulations and to other methods of calibration such as cosmic rays or pulser measurements.

Operation of an InGrid based X-ray detector at the CAST experiment

Board: 15

Presenter: Mr. KRIEGER, Christoph (University of Bonn)

The CERN Axion Solar Telescope (CAST) is searching for axions and other particles which could be candidates for Dark Matter and even Dark Energy. These particles could be produced in the Sun and detected by a conversion into soft X-ray photons inside a strong magnetic field. This field is provided by a decommissioned LHC prototype dipole magnet accurately pointed towards the Sun. In order to increase the sensitivity for physics beyond the Standard Model it is unavoidable to deal with low energies and weak couplings resulting in very low detection rates, therefore requiring efficient background rejection methods as well as a detection threshold below 1 keV.

Those criteria are fulfilled by an InGrid based X-ray detector. The InGrid (Integrated Grid) combines the high spatial resolution of a pixelized readout with a highly granular Micromegas gas amplification stage. Application of photolithographic postprocessing techniques allows for fabricating the amplification grid directly on top of the pixelized readout, e.g. on a Timepix ASIC. This results in a close to perfect match of grid and pixels facilitating the detection of single electrons on the active chip surface. The energy of an X-ray photon can be determined by simple electron (or pixel) counting and the good spatial resolution allows for using an event-shape analysis for background rejection. The detection threshold of such an InGrid based X-ray detector was explored at an X-ray generator and found to be well below the carbon K-alpha line at 277 eV. In an optimized setup an energy resolution of down to 3.85 % at 5.9 keV could be achieved.

After the successful demonstration of the detectors key features like e.g. the low detection threshold, the detector was mounted at one of CAST's four detector stations behind an X-ray telescope in 2014. After several months of successful operation without any detector related interruptions the InGrid based X-ray detector continues data taking at CAST in 2015.

As a result of the successful operation background rates in the order of 10E-5 /keV/cm^2/s will be presented along with the likelihood based method used to discriminate the non-photon background originating mostly from cosmic rays. As well future detector upgrades like integrated veto scintillators, sampling of the analog signal induced on the grid and ultra-thin detector windows will be shown as an outlook.

HARPO, TPC as a gamma telescope and polarimeter: Measurements in a polarised photon beam between 1.7 MeV and 74 MeV

Board: 16

Presenter: Dr. GROS, Philippe (LLR, Ecole Polytechnique)

Gamma-ray astronomy has become an important branch of astroparticle
physics. It now suffers from a sensitivity gap in the 1-100MeV range. Compton telescopes lose sensitivity above 1MeV, and pair production telescopes, due to multiple scattering, have low resolution and high background below a few 100MeV. HARPO proposes a gaseous detector, a TPC, to fill this gap and improve angular resolution by observing electron-positron pairs produced in gas up to 1GeV. It can also provide polarisation measurements above 1MeV, which has never been done in space.
A 30cm cubic demonstrator TPC has been built, equipped with a combina-
tion of Micromegas and GEM for amplification in a high pressure Argon based gas mixture. The TPC has been used to measure photons from 1.7MeV to 74MeV at the NewSUBARU accelerator in Japan. We will show the results
from this beam campaign, and prospectives on the continuation of the project.

Measurement of the GEM gain uniformity for the PRAXyS mission

Board: 17

Presenter: Ms. KUBOTA, Megu (RIKEN/Tokyo University of Science)

We have developed a gas electron multiplier (GEM) for the NASA small satellite mission, PRAXyS (Polarization from Relativistic Astrophysical X-ray Sources), which carries a photoelectron tracking type gas X-ray polarimeter using a time projection chamber technique. The GEM foil has a hole diameter of 70 um, hole pitch of 140 um, and insulator thickness of 100 um. We adopted a liquid crystal polymer sheet as the GEM insulator.
To achieve good energy resolution and high sensitivity for X-ray polarimetry, we should select GEM foils that have an uniform gain across the whole effective area. We scanned the whole active area, 30x78 mm2, of the semi-flight GEM in 1-atm Ar/CO2 (70%/30%) mixture gas and obtained two-dimensional maps of gain and energy resolution. The scan was performed at 2 mm intervals by perpendicularly irradiating the GEM plane with collimated 6.4 keV X-rays from an X-ray generator. In addition, we measured insulator thicknesses across the whole GEM active area.
The measured maps show a negative correlation between the GEM gains and insulator thickness. The correlation is thought to be due to the electric field strength variation in GEM holes. The strong electric field produced by a thin insulator is expected to make a high gain. Therefore, it is necessary to select the GEM that has a uniform insulator thickness. Currently, we are trying to establish a method to increase the production yield of the GEM with a uniform gain distribution by screening the flexible substrate before the GEM fabrication. In this presentation we report the result of the mapping of GEM gain and the insulator thickness, then propose the method to increase the production yield.

Polarimeter Detector development using GEM technology for Proton EDM Measurement

Board: 18

Presenter: Dr. PARK, Seongtae (CAPP/IBS)

Finding nonzero EDM (electric dipole moment) in a fundamental particle would signal strong CP violation and consequently it could explain matter and antimatter asymmetry in our universe. The storage ring proton Electric Dipole Moment (pEDM) experiment is one of the EDM searches using storage ring aiming sensitivity level of 10-29 e·cm per year. In the experiment, the stored polarized protons are slowly extracted and scattered on a carbon target. Through the interactions between the polarized protons and unpolarized carbon nuclei, one can measure the integrated spin precession angles which is caused by the constant electric field in the storage ring. GEM detectors are considered as the polarimeter detectors for asymmetry measurement of the elastically scattered proton signals. In this study, we report MC simulation results of proton scattering on carbon target. The design concept of the GEM-based polarimeter detector is also discussed.

Investigations of Kr-Xe mixtures in gas avalanche detectors

Board: 19

Presenter: Prof. VELOSO, João (University of Aveiro)

Recent investigations with a gaseous avalanche micropatterned detector operating in Kr-Xe mixtures will be presented. The use of such mixtures allows to keep a minimal position resolution over a wide X-ray energy range [1].
Measurements and simulations of the gain, energy and position resolution variation according to the Xenon mixture concentration will be presented. Our first results using a THCOBRA [2], measured and calculated, indicate a gain increase with the increase of Xe concentration. Calculation of the number of primary electrons and W value for such mixtures will be also presented.
The performance of the THCOBRA detector using different mixtures will be compared to the calculated results with a discussion of the possible deviations. Also, details on the gas purification system will be present.
The experimental results were obtained by using a 55Fe providing 5.96 keV photons while the calculations were performed by using Degrad software [3].
The detector, irradiated with an X-ray tube to produce image acquisition and its application on Computed Tomography applications will be discussed [4].
A discussion and results comparison with Kr and Xe pure will be presented.

[1] C. D. R. Azevedo et al., Phys. Lett. B, vol. 741, no. 0, pp. 272–275, 2015.
[2] A. L. M. Silva et al., NSS/MIC,IEEE, 2012, pp. 1160–1164
[3] S. Biagi, "Degrad." [Online]. Available: http://consult.cern.ch/writeup/magboltz/.
[4] L. F. N. D. Carramate et al., NSS/MIC, IEEE, 2012, pp. 3664–3666.

Progress of the Capillary Plate-based Gaseous Detector for high energy photon imaging.

Board: 20

Presenter: Mr. SUGIYAMA, Hiroyuki (Hamamatsu Photonics K.K.)

A Micro-patterned gaseous detector (MPGD) is one of the most attractive and useful detector in various field. A Hole-type MPGD with glass capillary plate (CP) is the most promising detector to provide two-dimensional imaging capability with a good position resolution and highly reliable to discharge. CP gaseous detectors have been intensively studied for the purposes of X-ray radiography, cosmic X-ray polarimetry, cold neutron imaging and photosensor sensitive to light ranging from vacuum ultraviolet to visible wavelength. The CP gas detectors can be expected ideal two-dimensional imaging system combined with amplified charges and scintillation light emitted from each hole upon gas excitation. For the realization of the imaging capability, we describe the operation properties and some of the characteristics of the CP with diameter less than 50μm .

The plate consists of a bundle of fine capillaries with diameter 25um and a uniform length of 0.2mm. The electrodes on the surface of both ends of CP were coated with metals. Because CP is made of glass material with proven vacuum tubes components such as PMT and Image Intensifier and possible to fabricate a large size substrate beyond 100mm square, it is also suitable for the fabrication of the sealed gaseous detectors.

A basic performance test of the CP gaseous detector was carried out with a gas mixture of Ne (90%) + CF4 (10%). We successfully obtained a gas gain of over 1000, and we have been studying the energy resolution and imaging capability using X-rays.

This result indicates that CP is possible to improve both the detection efficiency and imaging quality. By designing the shape of the CP, we are considering the improvement of the charge collection efficiency and charge extraction efficiency of the amplification region.

Hyperfast Sensor Development for the HL-LHC Era

Board: 21

Presenter: Dr. WHITE, Sebastian (Princeton University)

There is a growing interest in applying timing measurement of physics objects (leptons, jets, photons) in the high pileup environment planned for the next decade at the LHC. Time of occurrence of events within the same bunch (“in-time pileup”) can be used analogously to the more commonly used “event vertex position” tagging to resolve events of interest in this busy environment. Extending to this 2-D tool (time and space discrimination) is likely key to enabling the challenging measurements of the next decade by suppressing pileup background.
Currently both ATLAS and CMS are exploring the potential of this tool for improving physics capability.
In parallel our group has been developing timing technologies specific to the high rate environments and high radiation doses appropriate for the LHC for the past 5 years- mostly as a generic detector R Our current activities are within the framework of RD51(where Ioannis Giomataris and I are co-PIs) and RD50 where our High Gain hyperfast Silicon APD work is partly done. Our current HG-APD with mesh readout is achieving <10 picosecond time jitter at 1 MIP equivalent and is therefore approximately an order of magnitude faster than any other available solid state option.
I will also discuss briefly our work on the necessary infrastructure for such measurements at the LHC (timing readout architecture, FEE, clock distribution, etc).

Progress in Thick-Groove detector developments

Board: 22

Presenter: IENGO, Paolo (CERN)

Thick-Groove is a recently developed device belonging to the Micro Pattern Gaseous Detector (MPGD) family. It has been specifically designed for cosmic ray tomography, having the potential to be easily produced on industrial scale.
The Thick-Groove detector (TGD) has a large conversion region (few mm up to few cm) and an amplification region less than 1 mm wide. Anode and cathode strips are produced on two single-side PCB boards. The cathode board is then glued on top of the anode one and grooves are obtained by milling of the uppermost (cathode) board. The resulting board has anode and cathode strips alternated at different heights, thus integrating the amplification (grooves) and read-out (anode strips) systems in the same structure. The pitch of both anode and cathode strips is of the order of 1 mm.
The simplicity of the construction process and the potential for mass production makes TGD a good candidate for large-area applications like homeland security market.
Other possible fields of application of the TGD are HEP experiments with limited particle rates and where single plane space resolution of few hundreds microns is sufficient. Typical examples are neutrino and cosmics-ray experiments.
A first prototype of TGD has been realized at CERN and tested with 55Fe radioactive source and with cosmic rays.
We will review the construction procedure of the detector and the first test results obtained on gain stability, efficiency, spark probability and space resolution. Comparisons of experimental results with expected performance from simulations will be shown. Future plans for design and construction optimization and detector characterization will be also described.

The development of MPGD-based detectors of single photons

Board: 23

Presenter: LEVORATO, Stefano (TS)

A novel MPGD based architecture for single photon detection has been developed to overcome the limitations of the present generation of gaseous single photon detectors when large area coverage is needed (~ m2). It couples two different MicroPatternGasDetector structures, the THickGasElectronMultiplier and the Micromegas, resulting in a hybrid scheme able to exploit the properties and the performance of both architectures.
The main goal is to provide an upgraded approach for the detection of single photons by gaseous counters, as required in particular in Cherenkov imaging counters.
The constructions for a specific application, namely the upgrade of COMPASS RICH-1, is discussed at this Conference in a separate contribution.

The hybrid detector is the result of 8 years-long R program started with an extensive study of THGEM electron multiplier properties and followed by detailed studies of the aspects of single photon detection, ion back flow reduction as well as of the problematics related to the large area detectors instrumentation. The final large size hybrid scheme consisting of two THGEMs, the first coated with CsI, and one Micromegas is illustrated in detail.
The most important aspects related to the detector optimisation and the technological choices are discussed and the detector performance are presented making use of the laboratory test results and of the detector response measured at the several test beams.

In particular, the ion backflow aspects, the photoelectron extraction from CsI deposited on a THGEM substrate, the electrical stability of a multilayer and multi-technology MPGD and the response uniformity will be reported in detail.

Development of a new generation GEM using a fine ceramic

Board: 24

Presenter: Mr. KOMIYA, Kazuki (Tokyo Metropolitan Industrial Technology Reserach Institute)

In general, the GEM electrode is based on an organic material such as Polyimide or Liquid Crystal Polymer. However, they cause making short circuit between electrodes by discharge, emitting a lot of gas in high temperature envelopment, and more expensive by a lot of manufacturing process. Therefore the electrode has not higher reliability and the GEM in a sealed chamber is still not appearing in the market.

In order to increase the reliability and archive the sealed type GEM, we have developed a low cost electrode for GEM employing a fine ceramic and improving manufacturing method in successful.

The developed electrode has thickness of 100 micron, the hole diameter of 100 micron, the pitch of 200 micron, and the effective area of 225 square millimeter. The pressure of emitting out gas is less than 1.0 × 10^-3 Pa at 100 degrees Celsius. The gain is approximately 500 in Ar/CO2 gas mixture ratio of 70%:30% at applied voltage of 570 V.

We would like to report the development of the new generation GEM and result of evaluation of discharge and gain characteristics.

Innovative Micromegas Manufacturing with micro fabrication techniques and use of graphene

Board: 25

Presenter: Ms. VASSOU, CHRYSOULA (NCSR Demokritos)

Micromegas is a well-known micro-pattern gaseous detector with excellent properties in operation stability, position resolution, fast response, low ion feedback (about 10%) and good energy resolution. It can be adapted to detect the full range of particle radiation like photons, x-rays, neutrons, charged particles, alphas, nuclei etc. Micromegas implementation is based on PCB manufacturing technology. In this work, we propose an innovative fabrication process for micromegas structures using MEMS (Microelectromechanical systems) technology with potential improvements in micromegas properties, resulting from state-of-the-art microfabrication methods and novel materials. Graphene is a revolutionary material, a monoatomic carbon layer membrane with great properties, such as mechanical stability, high electrical conductivity and low ion transparency. Taking advantage of the excellent graphene properties, we aim at fully suppressing the ion feedback, when graphene is placed on top of the mesh electrode. A full exploration of potential benefits of the proposed layout will be attempted.
Our goal is to create a membrane mostly transparent to electrons and mostly opaque to ions. In order to fulfill these requirements, a novel membrane structure is under development. We have already succeeded in creating a mechanically stable support membrane on which a graphene monolayer is deposited. More specifically, consisting of 30 um-thick PDMS (Polydimethylsiloxane) membrane with through holes, acting as insulator layer, is bonded with a 5 um-thick Cu mesh. The fabrication process entails the steps that are described below: 1) construction of a Si/SU8 master so as to create by means of soft lithography a 30 um-thick PDMS membrane, bearing holes 50 um in diameter at a distance of 100 um, 2) transfer of the PDMS membrane to a modified glass carrier, 3) bonding of the PDMS membrane with a 5 um-thick Cu mesh, 4) creation of through holes in the copper layer, 50 um in diameter, via wet etching of copper through the PDMS membrane and 5) transfer of a graphene monolayer on top of the PDMS membrane. Ramman spectroscopy was used to confirm the graphene transfer uniformly on the PDMS membrane. We will present in detail the micro fabrication process and preliminary results concerning the electron transparency.

Low-energy electron source to characterise Micromegas/InGrid and study of dE/dx for low energy electrons

Board: 26

Presenter: Mr. KRYLOV, Vladyslav (LAL - Orsay, T. Shevchenko National University - Kyiv)

Large area single-electron sensitive gaseous detector consisting of Micromegas/InGrid as gas multiplication device and integrated CMOS ASIC as a replacement of the conventional pad/strip readout, is a promising candidate for comprehensive tracking systems serving also the trigger for future HEP projects.

Challenges for the InGrid concept for TPC detector systems are the large number of pixels, the readout speed, and the robust and safe integration of the silicon CMOS chips with the Micromegas amplification system. The MPGDs integrated with the pixel technology may also play a prominent role in significantly improving the dE/dx resolution. Direct cluster counting of the primary ionization would also eliminate fluctuations in charge measurements because of the gas gain instabilities (assuming single electron efficiency close to 100%). Moreover, it could provide an unprecedented potential for pattern-track recognition and track fitting in the high-rate environments, improved double hit/track resolution and a possibility to minimize γ-rays contributions. More studies are needed to prove the capability of the InGrid concept to perform cluster counting and to attain an ultimate resolution of about 2%.

LEETECH facility at the PHIL photoinjector at LAL has been developed, which will provide low multiplicity samples of quasi monochromatic electrons with the energy adjustable in the range from almost non-relativistic values of several hundred keV to 3-5 MeV.

PHIL photoinjector provide short (a few picoseconds) bunches of monoenergetic electrons with energy 3-5 MeV and intensity 108 electrons per bunch. Beam electrons pass through thin aluminum target, thus acquiring continuous energy and angular distribution. The set of collimators at the entrance to the LEETECH spectrometer selects unique direction of the electrons entering the uniform magnetic field area provided by the dipole magnet. Electrons make a half-turn in the magnetic field, inside the vacuum chamber. The set of collimators at the exit of the spectrometer adjusts the number of delivered electrons and their energy spread.

Before construction detailed GEANT4 simulation was performed to define the LEETECH design. First data from LEETECH are compared to the simulation results. Control and performance of the dipole magnet, automated collimator systems using compact piezo motors, vacuum chamber with integrated complementary collimating inserts are addressed. Main characteristics of LEETECH, commissioning and first delivered data are discussed.

Proposal of using the technique of single cluster counting using Micromegas/InGrid to measure dE/dx for low-energy electrons in the energy range, where limited precision has been achieved so far, is finally presented.

The micro-Resistive WELL

Board: 27

Presenter: BENCIVENNI, Giovanni (LNF)

In this work we present the micro-Resistive WELL (micro-RWELL): a compact spark-protected single amplification stage MPGD. The micro-RWELL is realized by merging a suitable etched GEM foil with the readout PCB plane coated with a resistive deposition. The copper on the bottom side of the foil has been patterned in order to create small metallic dots in correspondence of each WELL structure. The resistive coating is performed by screen printing technique. The WELL matrix geometry is realized on a 50 micron thick polyimide foil, with conical channels 70 micron (50 micron) top (bottom) diameter and 140 micron pitch (of course different geometries can be considered in order to optimize the detector performance, especially in terms of gain amplitude). A cathode electrode, defining the gas conversion/drift gap, completes the detector.
The micro-RWELL has features in common either with GEMs or MMs
- from GEM it takes the peculiarity of a "well defined amplifying gap", thus ensuring very high gain uniformity.
- from MMs it takes the resistive readout scheme that allows a strong suppression of the amplitude of the discharges.
Even though the amplifying element of the micro-RWELL is practically the same of the GEM, its signal formation mechanism is completely different. The signal in a GEM detector is mainly due to the electron motion, while in a micro-RWELL besides the very fast collection of the whole electron charge produced into the amplification channel also the ionic component contributes to the formation of the signal. In this sense the signal of a resistive-WELL is more similar to the one of a MMs. The assembly aspect of the micro-RWELL technology is a strong point in favor of this architecture. It does not require gluing or stretching of foils or meshes: a critical and time-consuming construction step of both GEM and MM technologies. With respect to the GEM and MM the proposed technology is extremely compact, does not require very stiff (and large) support structures, allowing large area covering based on PCB splicing with a very reduced dead space (< 1mm). The detector gain, about 10^4 has been measured with X-rays in current mode. The use of thicker kapton for the realization of the amplifying component of the detector should allow to achieve gas gain larger than those obtained with the 50 micron thick amplification gap. The detector rate capability, from 100 kHz/cm2 to 600 kHz/cm2 (measured with X-rays, for a surface resistivity of about 100 MOhm/square) can be tuned with a suitable segmentation of the resistive layer. The typical discharge amplitude for the micro-RWELL is of the order of few tens of nA. Results from a test at the H4-SPS beam line with a micro-RWELL prototype, equipped with a 400micron strip pitch, show a space resolution of 60 micron with a detection efficiency of the order of 98% (with 4 mm gas gap). The performance of the detector operated in magnetic field with different incident angles is under study.

The development of a new nTHGEM based neutron detector in CSNS

Board: 28

Presenter: Mr. ZHOU, Jianrong (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS))

Abstract: With the international development of the new generation neutron source, the traditional neutron detector can't satisfy the demand of the application of the high flux especially. And facing the global crisis of 3He supply, the research on the new style of the neutron detector becomes extremely urgent. Considered with the development demand of the domestic neutron scattering facility CSNS (China Spallation Neutron Source), this research proposes to develop the new style of neutron detector based on the boron convertor and a new nTHGEM with high flux capacity and two-dimensional position sensitivity. The nTHGEM, which use ceramics as the insulator with the gold coated on the two sides, is customized and designed specially for the neutron detection with the less scattering than the kapton GEM.
A prototype has been constructed and tested on the reactor beamline. A thin boron coating on the cathode is used as the neuron convertor and a single ceramic nTHGEM (active area:50mm*50mm, thickness: 200μm, pin: 200μm, pitch:600μm) is employed for the gas multiplication. 64 channels x-y crossed strips (x:32 channels, y:32 channels, strip period 1.56mm) are arranged for 2-D signal readout. The electronics integrates a 64 channel ASIC based readout with FPGA by using x-y coincidence. The latest test results using the radiation source, the monoenergetic beam and the pulsed beam are present, including the spectrum(~25%@5.9keV X ray), efficiency(4.9%@1.59 Å), counting rate(>1MHz), spatial resolution(<3mm/FWHM), TOF(<1μs) and the 2-D imaging(Fig.1). The detector can be used for the beam monitor or the diagnostor to measure the beam specifications such as the profile, the size, the intensity distribution and the wavelength spectrum. This would be helpful to study the nTHGEM based neutron detector with the larger area and the higher efficiency in the future.

Design and assembling of GEM detector sensitive volume for plasma radiation application.

Board: 29

Presenter: Dr. KOWALSKA-STRZ■CIWILK, Ewa (IPPLM)

This abstract is devoted to design and assembling of GEM detectors for plasma radiation application. In this work we will report the results of mounting of two triple-GEM detectors with different dimensions 100x100mm2 and 200x20mm2. A description of the assembling procedures including the gluing/stretching techniques and selection of materials is given in this work. Particular attention was paid to the selection of materials that will work under special conditions, such as magnetic field, high temperature, neutron flux, electromagnetic and any type interference. Moreover, those materials can not disrupt detector's operation, so to build it only certified materials should be used: checked under outgassing and ageing tests, radiation hardened, having appropriate electrical properties. The choice of materials was carried out so to have first of all the possibility of testing different materials (Ertacetal C and two types of fiberglass) for detector frames. There has also been the selection of assembly glue (Araldite) and the detector window material (thin aluminized Mylar foil).

Novel High-Resolution Neutron Detectors for the NMX Instrument at ESS

Board: 30

Presenter: Ms. PFEIFFER, Dorothea (European Spallation Source/CERN)

ESS instruments like the macromolecular crystallography instrument NMX require an excellent neutron detection efficiency, high-rate capabilities, time resolution, and an unprecedented spatial resolution in the order of a few hundred micrometers over a wide angular range of the incoming neutrons. For these instruments solid converters in combination with Micro Pattern Gas Detectors (MPGDs) are a promising option. A GEM detector with Gadolinium converter was tested on a thermal neutron beam at the IFE research reactor in Norway. The uTPC analysis, proven to improve the spatial resolution in the case of 10B converters, is here extended to Gadolinium based detectors. For the first time, a Gadolinium-GEM was successfully operated to detect neutrons with an estimated efficiency larger than 10 % at a wavelength of 2 ■ and a position resolution better than 500 µm.

Despite the very large neutron capture cross section of 155 Gd and 157 Gd, the material is not a popular converter due to the nature and the energy of the secondary particles. In fact, after the neutron capture, Gadolinium releases prompt gammas with an energy of up to 6 MeV and conversion electrons with energies ranging from 20 keV to 200 keV, considerably smaller compared to the energy of the secondaries from 3He, 6Li, and 10B converters. For this reason, and being a high Z material, Gadolinium based detectors are more sensitive to gamma background, when only the signal amplitude is used for the signal discrimination. Further, the range of the conversion electrons of at least 1 cm seems to be in contrast with the spatial resolution requirements.

Graph 1 shows a typical track that is created by the conversion electrons in the drift volume of the detector. The conversion electrons from the neutron capture ionize a macroscopic portion of the active volume, and an offline analysis takes care of the reconstruction of the neutron interaction point from the three dimensional topology of the event. With the help of an algorithm based on Principal Component Analysis (PCA), the position of the impinging neutron can be reconstructed. Graph2 shows the obtained position resolution.

GEM based detecting system for tungsten radiation focused tomography at WEST tokamak

Board: 31

Presenter: Dr. CHERNYSHOVA, Maryna (Institute of Plasma Physics and Laser Microfusion)

Tungsten, being a main candidate for the plasma facing material in ITER and future fusion reactor for some time [1], has recently started to be used as such on many machines, including on the WEST project, where an actively cooled tungsten divertor is being implemented. Inevitably, this forced a creation of the ITER-oriented research programs aiming to effectively monitor the impurity level of tungsten in plasma. Yet, the situation is even more complicated as, due to interaction between particle transport and MHD activity, such impurities might accumulate which could lead to disruption, especially, in case of long pulse tokamaks. Therefore, an appropriate diagnostic tool has to be developed which will not just monitor the level of impurity but will also reconstruct its distribution. Combining the spectral information on plasma radiation with good spatial resolution of its detection should allow recovering fundamental information in order to estimate the level of the plasma contamination and consider its effects on plasma scenarios. For this purpose, an SXR tomographic diagnostics with energy discrimination has been extensively considered for a while [2]. Detection system based on Gas Electron Multiplier (GEM) technology [3] has been recently proposed to be used as SXR tomographic system for ITER-oriented tokamaks and is under development by our group [4], [5]. Detectors built on this technology will satisfy the main constraints on dimension, spatial position and required energy sensitiveness imposed on any X-ray detector for tokamak plasma in ITER and/or DEMO.

Our research is devoted to design a new diagnostics for poloidal tomography focused on the metal impurities radiation monitoring, especially tungsten emission. This work reports on the current status of the design of such detecting system to be installed at WEST project tokamak. Two detectors constituting this system are to be installed in a poloidal section of WEST project tokamak – one of planar and other of cylindrical geometry to be put inside of the vertical and outside of the horizontal ports, respectively. For the internal structure of the detectors simulations selecting the optimal gas mixtures and window material were performed with Ar:CO2 and Ar:CO2:CF4 chosen as candidates for the initial tests and with one-side aluminized Mylar window chosen for a window material. Influence of magnetic field on detectors estimated by Garfield++ code is discussed. First concept of the detecting module electronics is presented with the elaborated data acquisition method allowing 1 ms of time resolution in online mode and up to 100 µs in offline mode for satisfactory data statistics. Ultimately, when implemented, the detecting system will add to the safe operation of tokamak bringing creation of sustainable nuclear fusion reactors a step closer.

Low consumption micromegas for muon tomography

Board: 32

Presenter: Mr. BOUTEILLE, Simon (CEA-Saclay)

The recent development concerning MPGDs, in particular with the work done by the R collaboration, makes us able to build large and robust detectors. These characteristics suit well the needs of a lot of applications which use the cosmic rays muons to make the tomography of large objects. However, these applications need the muon telescope to be run outside and with a low energy consumption. After multiplexing the readout of micromegas and miniaturizing the high voltage power supply, we made the very first micromegas-based muon telescope which was operated outside. All the system needed to operate this telescope, including a credit card format computer, worked smoothly during more than a month of data taking with an overall consumption 25W. With these data we successfully made a density map of the water tower by measuring its muon shadow. Moreover, the analysis in progress aims to see the water level time fluctuations inside the tank. This work make MPGDs able to be used in many new fields like volcanology, archeology or mining exploration.

Investigation of THGEM technology for nuclear security applications

Board: 33

Presenter: Ms. LEY, Katie (AWE)

Thick gaseous electron multiplier detectors are cheap, robust and scalable to large areas. Here we consider the application of THGEM technology to cosmic-ray muon scattering tomography in support of nuclear security. Muon tomography applications include the passive scanning of cargo containers for regions of abnormally high density, indicative of concealed special nuclear material. THGEMs are suited to this application as they are inexpensive and can be produced with large areas. THGEMs also have potential in response applications which require lightweight, high resolution, portable cosmic-ray tracking systems.

In support of these advantages, a preliminary experimental study was conducted. This work focussed on the design and characterisation of a 100×100 mm double THGEM detector with boards of 0.8 mm thickness, 1 mm hole diameter, 1.5 mm pitch and a rim width of 0.1 mm. The boards were operated in a Ar:CH4(95:5) gas mixture at a pressure of 1 atm. The detector readout was processed using a DRS4 evaluation board operated at a sampling rate between 0.7 GSPS to 5 GSPS. Each THGEM board was operated up to 2 kV, with transfer fields up to
1.1 kVcm-1.

A study of the pulse structure revealed a typical rise time of 3 to 4 ns, with a pulse height significantly above noise levels. The results also show good agreement between the operating point and breakdown voltage of the THGEM and Garfield ++ simulations. Through the comparison of THGEM detector to the coincidence of two scintillator detectors (using a DRS4 evaluation board), allows assessment of the THGEM efficiency.

Whilst this paper presents research focused on cosmic ray muon particle tracking, we discuss the applicability of THGEM detectors to other security
applications. These include, but are not limited to, the development of equipment for arms control and treaty verification, alongside the possibility for radiological detection using electron tracking within Compton Camera or Compton Tomography arrangements.

The M-Cube project: Large area Micromegas for homeland security

Board: 34

Presenter: Dr. PROCUREUR, Sebastien (CEA-Saclay)

The development of large and robust MPGDs has opened the door to a vast new field of applications. Among them, the detection of Special Nuclear Material (SNM) in goods transportation has the highest potential in terms of emerging market and mass production. Most of the current detection methods are based on artificial radiations (X-rays, gammas or neutrons), which all suffer from several drawbacks: high cost, risks associated to artificial radiations (outside and inside containers), possibility to hide SNM with shielding and limited spatial extension of the source. Several projects have therefore emerged in the last years to overcome these drawbacks by making use of cosmic radiation as a probe. Natural, free, without any radiation risk, penetrating heavy shielding, this radiation has however a relatively modest flux of the order of 150 particles/m²/s. This technique thus requires i) very precise and performant detectors to extract the maximum of information from each cosmic ray, ii) industrialized fabrication process for large scale production, and iii) at a reasonable price. Among the different technologies currently investigated, the multiplexed Micromegas seems to be the most promising detector, offering excellent spatial resolutions with very limited electronics. The M-Cube project started at CEA-Saclay plans to build and operate a container scanner prototype with about 20 detectors representing a surface of 5m². The detectors have a 2D readout with a resistive strip film, and reach 2D efficiencies above 97%. The Dream electronics developed for Clas12 further allows for self-triggering capabilities, and its performance has been successfully tested. The scanner prototype will be assembled in the next months, and detection time of Lead or Uranium bricks will soon be measured with a smaller scanner. Simulation has confirmed that this device has the best intrinsic performance of the devices currently developed in the world, and can in particular fulfill the criteria defined by the American DNDO (Domestic Nuclear Detection Office). Last but not least the development of such a project enhances the interest of industrials to master the fabrication process, which can in turn largely benefit to fundamental research and future experiments.

A BEAM MONITOR BASED ON MPGD DETECTOR FOR HADRON THERAPY

Board: 35

Presenter: Mrs. ALTIERI, Palma Rita (Università degli Studi di Bari & INFN)

In recent years, a remarkable scientific and technological progress led to the construction of accelerators based facilities dedicated to hadrontherapy was done. This kind of technology requires precise and continuous control of position, intensity and shape of the ions or protons used to irradiate cancers. Patient safety, accelerator operation and dose delivery should be optimized by a real time monitoring of beam intensity and profile during the treatment, by using detectors featuring not disruptive, high spatial resolution (beam current resolution less then few % and rate of the order of 10 kHz). In the framework of AMIDERHA (Enhanced Radiotherapy with HAdron) project funded by the Ministero dell'Istruzione, dell'universita' e della Ricerca (Italian Ministry of Education and Research) the authors are studying and developing an innovative beam monitor based on Micro Pattern Gaseous detectors characterized by a high spatial resolution and rate capability. The Monte Carlo simulation of the beam monitor prototype was carried on to optimize the geometrical set-up and to predict the behavior of the detector. A first prototype has been constructed and successfully tested using 55Fe and 90Sr and X-ray source. Preliminary results will be presented.

GEM based fast neutron detector for fusion and spallation sources experiments

Board: 36

Presenter: Dr. MURARO, Andrea (IFP-CNR)

The fast neutron GEM detectors (nGEM), i.e. GEM detectors equipped with a cathode that also serves as neutron-proton converter foil, represent a new frontier of beam monitor devices in the new fast neutron beam lines in the spallation sources experiments, such as ChipIR at ISIS, or in the future fusion experiments such as the ITER neutral beam injector. The GEM detectors are particularly suited to these applications due to their good spatial resolution and timing proprieties, excellent rate capability, radiation hardness and possibility to cover large areas. A series of nGEM detectors is foreseen in the framework of the ITER neutral beam test facility under construction in Padova (PRIMA) that will host two experimental devices: SPIDER, a 100 kV negative H/D RF source, and MITICA, a full scale, 1MeV deuterium beam injector.

One nGEM detector will be mounted in a detection system called Close-contact Neutron Emission Surface Mapping (CNESM) with the aim to resolve one of the eight beamlet groups in SPIDER. This is achieved by the evaluation of the map of the neutron emission due to interaction of the deuterium beam with the deuterons implanted in the beam dump surface. Due to the physics of the process (deuterium implantation on the beam dump and fusion neutron transport up to the CNESM system) the minimum required space resolution in order to resolve the single beamlet is equal to 15(x) x 25(y) mm2. The nGEM detector of the CNESM system has an active area of 35.2 x 20 cm2 and the readout anode is composed by 256 PAD, each with dimensions equal to 13(x) x 22(y) mm2. This PAD dimension allows measuring the intensity of each single beamlet. Future improvement of the spatial resolution, that can allow a better beamlets reconstruction precision in SPIDER or a better reconstruction of the beam profile in the fast neutron beam lines, could be obtained by fine moving the detector in small steps in each direction. This paper describes the test of a fine scanning technique implemented during a measurements campaign held at the ROTAX fast neutron beam-line at the ISIS spallation source. The nominal FWHM of the ROTAX beam is about 40 (x) x 35 (y) mm. The aim of the measurement was the precise reconstruction of the beam profile by scanning it in steps of 2 mm in each direction: a total of 750 x-y positions were recorded. This allows improving the resolution of about 60% in the x direction and of about 80% in the y direction. The fine results obtained with the nGEM detector are than compared with those obtained with a series of diamond detectors mounted on the same beam-line. This work was set up in collaboration and financial support of Fusion for Energy.

Design and parameterisation of a pinhole camera and selection of the X-ray source energy for the GEM based X-ray fluorescence imaging system

Board: 37

Presenter: Dr. MINDUR, Bartosz (AGH University of Science and Technology)

The basic principle of an X-ray imaging system based on a large area 10cm x 10cm GEM (Gas Electron Multiplier) detector equipped with 2-dimensional readout and its application to mapping of pigment distributions in historical paintings using X-ray fluorescence technique has been already demonstrated in our previous works. The key components of the developed system are: X-ray tube, adjustable pinhole camera to project the fluorescence radiation on the GEM detector, custom-designed front-end integrated circuits, FPGA based data acquisition system, and software. The system is fully functional and recently new features have been added to make in more versatile. In this paper we report on further studies and optimisation of the system performance with particular focus on the pinhole camera design and the X-ray energy used for excitation of fluorescence radiation.

For selecting the geometry of the pinhole camera one has to consider a fundamental trade-off between the spatial resolution and the yield of radiation projected on the detector, which translates directly into the measurement time required to obtain images of satisfactory quality. A new pinhole design with adjustable height and exchangeable pinhole plates (with different hole diameters) has been implemented. The experimental results on the spatial resolution for different pinhole camera configurations will be presented and compared with analytical predictions. Furthermore, possible improvements of the X-ray projection set-up by implementation of a multi-hole camera will be discussed and the measurement results obtained for such a set-up will be presented.

The effects of the energy of exciting radiation on the imaging performance will be discussed and comparison of images obtained with different X-ray tubes, with molybdenum and copper anodes, will be presented. Further possible improvements of sensitivity of the imaging system by combining images obtained for different energies of exciting X-ray primary beam and different energy windows optimised for detecting specific elements will be presented.

Essential data processing for soft X-ray diagnostics based on GEM detector measurements for fusion plasma imaging

Board: 38

Presenter: Dr. CZARSKI, Tomasz (Institute of Plasma Physics and Laser Microfusion)

The measurement system based on GEM - Gas Electron Multiplier detector is developed for X ray diagnostics of magnetic confinement tokamak plasmas. The fast and accurate mode of the serial data acquisition is applied for the dynamic plasma diagnostics. The ADC samples triggered by the detector current are acquired independently for the measurement channels. The charges are calculated within the defined time window for the activated channels. Coinciding signals for high flux radiation cause the problem for cluster charge identification. The amplifier with shaper determines time characteristics and limits the pulses frequency. Separation of overlapped signals was introduced and verified for simulation experiments. Data are synchronized with the specified ADC frequency and discrete intervals of charge acquisition are the multiples of the sampling time. Resulting data samples form the table of chronological triplets: [charge value, channel number, triggered time]. Data packages are loaded sequentially to the DDR memory and finally are conveyed to the PC. The charge cluster is identified as a set of adjacent pixel charges in the area of the detector. Regular clusters are counted in the four dimensional space determined by 2-D position, energy (charge value) and time intervals. Final data processing is presented in any 2-D cross-section for selected range of position, energy (charge) and time interval. Several detector structures with single-pixel channels and multi-pixel (directional) channels are considered for two-dimensional X-ray imaging. Radiation source properties are measured by the basic cumulative characteristics: the cluster position distribution and cluster charge value distribution related to the energy spectra.

A new transparent XY-MicroMegas neutron beam profiler

Board: 39

Presenter: Dr. BERTHOUMIEUX, Éric

A new transparent XY-MicroMegas neutron beam profiler

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A MicroMegas detector based on microbulk technology with an embedded XY strip structure was developed, obtained by segmenting both the mesh and the anode. This results in a very low-mass device with good energy resolution capabilities. Such a detector is practically “transparent” to neutrons, being ideal for in-beam neutron measurements. It will be used as a quasi-online neutron beam monitor and profiler at neutron Time-Of-Flight facilities, as the n_TOF facility (CERN, Geneva), GELINA (IRMM, Geel) and NFS (GANIL, Caen). The development of such a low mass and high radiopurity detector offers new possibilities for the measurement of neutron induced charged particle reaction cross sections, as well as the angular distributions of the emitted particles.
The amplification area of 60x60 mm2 is separated in 58+59 strips. The detector data acquisition system is based on the AGET - reduced CoBo technology [1]. Appropriate front-end cards have been developed for the protection of the AGET chips, the voltage distribution and the readout of the strips. The whole setup showed good energy resolution and the potential for good spatial resolution and was installed at the n_TOF facility at CERN [2, 3]. The beam profiles from both experimental areas of the facility will be presented.

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Use of Micro Pattern Gas Detectors In some Nuclear Physics Experiments

Board: 40

Presenter: Dr. POLLACCO, Emanuel (IRFU/SPhN)

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With cutting-edge progress in MPGD, yielding combined charge, time and position good resolution we are attempting to supersede conventional detectors (ion chambers or solid state devices) in nuclear physics. Basically the difficulties we are surmounting are (i) specific gases required for active targets (e.g. H2, D2 and He), (ii) at low and high pressures, (iii) the extraction of vertices from binary final states requiring wide dynamic ranges (iv) background subtraction from beta decay and (v) reaching optimum/reliable MPGD structures to reach competitive charge resolution total charge measurements.
In the presentation we will give an outline of new MPGD based instruments being deployed in experiments for RIKEN (ZiTiX – unitary charge, time and position tracker for fission fragments at high counting rates; MINOS – an 'active' LH2 target) and Texas A (AstroBox-2 low energy proton decay spectra <300keV), MDM (Multi sampling focal plane detector for heavy ions above 8 MeV.A), TexAT (Active target for astro-physics)). New recent experimental results will be given. Future developments being undertaken will be given.

"Ab initio" development of a gaseous Compton Camera

Board: 41

Presenter: Prof. VELOSO, João (University of Aveiro)

Compton Cameras are being pointed as the instrument for far X and gamma-ray detection where the traditional Anger Cameras are inefficient. Moreover, these devices avoid the use of a heavy mechanical collimator responsible for a huge decrease of the photons that reach the Anger Camera crystal [1], [2].
Traditionally a Compton Camera is composed of solid state detectors (Si detector + Ge or NaI detector)[3]. Our proposal is to use a single High Pressure Scintillation Counter for the Compton and scattered photon interactions, based on Bolozdynya setup [4], by changing the high cost and low position resolution PMT array by a low cost gaseous photomultiplier with energy resolution and position discrimination capability: THCOBRA [5].
In this work we present the initial characterization of the high pressure gas scintillation proportional counter (HpGSPC) for pure Xenon pressures ranging from 1- to 5 atm. The optical gain and energy resolution as function of the drift and scintillation fields where studied by using a PMT achieving energy resolutions below 4% for 59.6 keV photons. Calculation of the number of primary electrons and intrinsic position resolution will be presented as function of the gas pressure.
A detailed discussion of the experimental measurements and a comparison with simulation results is performed. Results and details on the coupling of a gaseous photomultiplier based on a THCOBRA and operating in Ne/CH4 will be presented.

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PI Surface Conductivity Measurements

Board: 42

Presenter: Mr. KALKAN, YALÇIN (RD51)

The gain in nearly all MPGDs can be calculated with a precision around $20~\%$ - with the notable exception of GEMs.
We know from systematic studies that the discrepancy (a factor of 2 in a standard GEM) can not be due solely to the modelling of the holes, to the accuracy of the ionisation cross section and to Penning effects.
Surface charge increases the gain by $20~\%$ in a dry standard GEM and therefore does not explain the difference between calculation and measurement.
However, this gain increase has repercussions on the accuracy of $\mathrm{d}E/\mathrm{d}x$ particle identification.
Surface charge evacuation depends on the surface conductivity which in turn depends on the humidity of the polyimide.
Few systematic measurements of the surface conductivity have been published and
here we report on a dedicated set-up for such measurements in the recently established physics laboratory in Bursa.

Influence of water on the surface of graphene

Board: 43

Presenter: Mr. KAYA, Yunus (Uludag University)

How does water modify the surface conductivity of graphene?

The hope is that the GEM lets electrons through but not ions. As a result, there would be no space charge due to ions drifting from their production point to the drift volume. Therefore, graphene can be use in GEM detectors.

Graphene is an allotrope of carbon in the form of a two-dimensional, atomic-scale, hexagonal lattice in which one atom forms each vertex. It can be considered as an indefinitely large aromatic molecule, the limiting case of the family of flat polycyclic aromatic hydrocarbons. It is also shows hydrophobic properties. Although these properties, the graphene interacts with water molecules, and then the water may condense on the graphene changing its properties. In this study, we will examine how does water modify the surface conductivity of graphene.

Noble gas cluster ions

Board: 44

Presenter: Mr. KAYA, Yunus (Uludag University)

In recent decades, quantum chemistry calculations have been used for various chemical fields such as reaction pathway analysis and spectroscopic assignments due to the theoretical developments, especially accuracy improvement of functionals in density functional theory (DFT), and high-speed parallel computers.

The kinetic studies of formation Xe+Xe cluster in Xe, Ar+Ar cluster in Ar, and Ne+Ne cluster in Ne have not been found as experimentally or theoretically in literature. Therefore, in this study, we report the DFT-based mechanistic studies and spectroscopic analyses on formations of these clusters. In addition, we will calculate the rate constants all cluster formations.

Study of the performance of Micromegas detectors in magnetic field.

Board: 45

Presenter: Dr. SAMPSONIDIS, Dimos Sampsonidis (Aristotle University ofThessaloniki)

Resistive Micromegas (Micro MEsh Gaseous Structure) detectors have been chosen by the ATLAS collaboration at LHC for the high luminosity upgrade due to their capability to maintain full efficiency and high spatial resolution at high rates. Operation in the Inner Muon Station of the high-rapidity region, the so called New Small Wheel (NSW) requires also these performances to be maintened in magnetic fields up to about 0.3 T.
The response of Micromegas chambers is affected by the magnetic field where the deflection of the drift electrons is described by the Lorentz angle, resulting in a bias in the reconstructed position.
Several test-beam campaigns have been performed to test the behaviour of small size resistive micromegas prototypes (10x10cm2) in magnetic fields up to 1 T using high momentum muon and hadron beams at CERN. These studies are performed in order to validate the capability to operate these chambers to get unbiased tracks in the NSW conditions.
Measurements of the Lorentz angle and drift velocity as a function of the magnetic field are presented and both are compared to expectations based on Garfield-Magboltz simulations. Several methods to correct the position bias are applied, based on the chamber configuration (the so called super-point method) or based on the knowledge of the local value of the magnetic field. The results of these studies are presented together with an overall discussion of the Micromegas tracking capability in magnetic field.

Electron losses during drift and mesh transit in an ATLAS-like MicroMegas

Board: 46

Presenter: Mr. KUGER, Fabian (CERN / University of Würzburg (Germay))

In the MicroMegas detectors currently under construction for the ATLAS New Small Wheel (NSW) upgrade, the conversion region is limited to 5mm thickness. The number of primary ionization-clusters induced by a passing muon is about 10-15, with a few electrons each. The accuracy of the µTPC reconstruction method relies on the single cluster positions. Consequentially high electron losses during the drift and mesh transit might effect the space resolution.
The Exchangable Mesh MicroMegas (ExMe) is a 40x50cm2 active-area prototype with identical geometrical microscopic-parameters to the NSW chambers. In addition it allows an easy exchange of the micromesh and comprises four sectors with different pillar spacing. Two chambers of this type were built using sputtered or screen-printed resistive layers.
A systematic test on the influence of these design parameters (mesh geometry, pillar spacing and resistive layer structure) on electron losses and chamber performance was carried out. Comparison between experimental data and detailed microscopic simulations carried out in Garfield++ disentangled the electron losses during drift and mesh transit. The study resulted in a proposal on parameters for the NSW MicroMegas.

Measurements and calculations of electron avalanche growth in ternary mixtures of Ne + CO2 + N2

Board: 47

Presenter: Dr. KOWALSKI, Tadeusz (AGH, University of Science and Technology, Krakow, Poland)

The ternary gas mixtures of Ne + CO2 + N2 is used in TPC, in the main tracking detector of ALICE at LHC accelerator. This mixture has a small diffusion constants, small thickness, reasonable value of electron drift velocity, small multiple scattering. A small addition of N2 increases the electron drift velocity and reduces the micro-sparking.
In this mixtures, besides the direct ionization, gas multiplication is enhanced by Penning transfer both with CO2 and N2. Up to now, the range of measured gas gain is limited by 2*10^3 – 5*10^4.
In this work, we want to present the gas gain curves in a wide range beginning from the ionization regime to the breakdown limit (few * 10^5), for mixtures pressures from 400 hPa to 1800 hPa, gas composition of Ne + CO2 (10%) + N2 (2.5 ; 5 and 7.5%, respectively) and for Ne + N2 (2.5; 5 and 7.5%, respectively). The measured data have been fitted using Magboltz simulation program to determine the Penning transfer rates.

Numerical Studies on Time Resolution of Micro-Pattern Gaseous Detectors

Board: 48

Presenter: Prof. MAJUMDAR, Nayana (Saha Institute of Nuclear Physics)

Owing to the use of typical manufacturing techniques for microelectronics, the new genre of Micro-Pattern Gaseous Detectors (MPGDs) with high granularity and very small distances between the electrodes can offer high spatial and time resolutions and good counting rate capability. The requirement of fast collection of data in various applications of the MPGDs has necessitated a thorough optimization of their time resolution through the modification of their design parameters and choice of gas mixture. In this context, the study of the time resolution of these detectors and their dependence on various parameters turns out to be an interesting aspect of MPGD development for many of the current and future applications. For this purpose, an attempt has been made to establish an algorithm for estimating the time resolution of an MPGD. In the present work, a numerical simulation of the time resolution of a few MPGDs, computed following the said algorithm, is reported.

The time resolution of a detector can be defined as the precision with which the detector can distinguish between two overlapping events in terms of time. The time resolution depends on the transit of the electrons from their generation point to the collecting electrode. The spread on the duration of transit leads to a finite time resolution of the detector. The two factors that contribute to the spread are the statistics and distribution of the primary electrons and their diffusion in the gas medium. The resolution has been estimated numerically on the basis of these two aspects while ignoring the electron multiplication. A threshold limit of detecting the signal has been considered which is related to the gain variance of a detector. The cosmic muons at different inclination angles have been used as the event generator. In this work, a comprehensive study on the dependence of time resolution on detector design parameters and field configuration, has been made for a few MPGDs. In addition, the effect of variation in the relative proportions of gas components in the gas mixture has been investigated. Two examples of these results are presented in figures 1 and 2 as calculated for a bulk Micromegas and a triple-GEM, respectively.

Several measurements on the time resolution of triple-GEM based prototype for muon endcap upgrade of CMS are available from the CMS GEM collaboration [1]. The simulated results have been compared with these references and the agreement with the experiment is very encouraging.

The present work aims to accomplish a comprehensive characterization of the time resolution of the MPGDs on the basis of numerical as well as experimental measurements. In addition to further improvement in the numerical work, development of a test bench for studying the MPGDs individually for their characteristic time resolution and its dependence on the design parameters and gas compositions has been planned.

[1] CMS Technical Design Report For The Muon Endcap GEM Upgrade

Numerical study of electrostatic field distortion on LPTPC end-plates based on bulk Micromegas modules

Board: 49

Presenter: Prof. MUKHOPADHYAY, Supratik (Saha Institute of Nuclear Physics)

A time projection chamber (TPC) is envisaged just beyond the vertex detector of the proposed linear collider. Because of the high flux environment, micro-pattern gaseous detectors (MPGD) have been proposed to build the end-plates of the TPC. Because of the large area coverage and their geometry, the end-plates are expected to be made of a number of MPGD modules. During experiments using the large prototype TPC (LPTPC), reduced signal sensitivity have been observed at the boundary of these modules. Electrostatic field distortion near the module boundaries has been considered to be the major reason behind these observations. In the present work, we will explore this hypothesis for endplates based on bulk Micromegas modules.

3D electrostatic field calculations have been carried out for two geometries representing the end-plates and distortion of the electrostatic field near the module boundaries has been analyzed. The simpler geometry has only two modules, while the more representative geometry has three staggered modules as in a real end-plate. The effect of application of 1T magnetic field has been simulated, in addition to the cases where there is no magnetic field. The drift and diffusion of electrons originating from tracks at different locations in the drift volume have been followed. Estimates of the residuals have been made by computing the difference among the starting and ending points of the electrons. Intrinsic position resolution of the device has been estimated without taking into account a pad structure and anode resistivity.

Significant electrostatic field distortion has been observed at the boundaries which is consistent with the module geometry. The resulting drift lines clearly show that areas close to the edge of the modules will have less number of electrons than those away from the edges. Residuals estimated close to the boundary are found to increase substantially and follow the “S” pattern observed in the experiments. Significant reduction in residuals is observed in general, when magnetic field is applied. The E×B effect is found to play an important role close to the boundaries since the directions of these two fields are no longer parallel due to the distortion in the electric field.

The simulated estimates follow trends very similar to the experimental results obtained using bulk Micromegas modules. Similar estimates for GEM-based TPC end-plates were made earlier. Although overall features of the electrostatic field, electron drift and diffusion are the same, no direct comparison can be made since the geometries of the modules and the approximations involved are of a different nature.

In future, the simulations will be made more realistic by making the end-plate geometry closer to the real one and making the anode resistive. In addition, possible suitable design modifications will be investigated, use of which may lead to less edge effects than that in the present scheme of things.

Simulations of electron avalanches in the GEM detector

Board: 50

Presenter: Dr. MALINOWSKI, Karol (Institute of Plasma Physics and Laser Microfusion)

Studies of Gas Electron Multiplier (GEM) detector are conducted at the IPPLM institute for several years. They aim to develop GEM detector to register the soft X-ray in tokamak experimental conditions. This paper presents the results of simulations of electron avalanches produced within the tested detector due to absorption of X-ray photon. In first step simulations involved the construction of spatial model of fragment (cell) of the GEM detector, and then computing the electric field distribution maps from the applied voltage. Comparative simulations were performed in a commercial ANSYS Maxwell and free software packages Gmsh/Elmer. These programs can compute approximate electric fields in nearly arbitrary three-dimensional configurations with dielectrics and conductors. In second step calculations were continued in Garfield ++ program. It aims at simulations of the electron signal (avalanche) in GEM detector. The results obtained in the program Gmsh/Elmer are input to Garfield ++. The paper presents comparative results obtained for different values of high voltages applied to the electrodes and different values of primary electron energy.

Speeding Up and Parallelizing the Garfield++

Board: 51

Presenter: Mr. SHEHARYAR, Ali (Texas A University at Qatar)

Garfield++ is a toolkit for the simulation of the particle detectors that use semi-conductors as sensitive medium. It takes enormous amount of time in the simulations of the complex scenarios such as those involving high detector voltages, gases with larger gains or electric field meshes with large number of elements. We observed that most of the simulation time is being consumed in finding the correct element in the electric field mesh. We optimized the element search operation and achieved significant boost in the speed up. In addition, we added the parallel computing support in the toolkit to simulate multiple events simultaneously over multiple machines. In this paper, we present our approach of speeding up the computations and benchmark results.

Statistical fluctuations of photoelectron emission from CsI photocathodes in Noble gases

Board: 52

Presenter: Prof. VELOSO, João (University of Aveiro)

CsI photocathodes coupled to Gaseous Photomultipliers have long been used in experiments and applications due to their high gains, fast response and coverage of large areas of detection at reasonable costs [1, 2]. In the future, experiments based on rare event detection, namely Dark Matter [3, 4] and Double Beta Decay [5] research, are faced with the problem of the prohibitive costs of the use of PMTs [6]. High mass pressurized GPMs with noble gases and CsI photocathodes are a promising solution; a note-worthy example is the research on single and double-phase Xenon-based detectors [7].

The drop in extraction efficiency caused by the photoelectron backscattering in gases is a well-known aspect of CsI photocathodes [8], but the way this affects the uncertainty over the number of electrons extracted is still not known. In this work we present the first results of our experimental investigations on the statistical aspects of the photo-electron extraction efficiency of CsI photocathodes. For that purpose, a detection chamber was assembled consisting of a photo converting plane and a thin aluminum layer above so a drift electric field can be applied. The CsI photocathode is irradiated with pulsed UV light and the photo-electrons are collected and measured without electron multiplication in the gas, thus allowing the study of the statistical fluctuations of the photon conversion process itself. Results are presented for different noble gas media at various pressures.

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Status of the electronics & DAQ for the Triple-GEM project for the upgrade of the CMS forward muon spectrometer

Board: 53

Presenter: Dr. AHMED, Waqar (National Centre for Physics, Quaid-I-Azam Univ.)

The CMS Collaboration is planning to use triple GEM detectors as part of its muon system upgrade in order to enhance the muon tracking and triggering capabilities in the region of 1.5 < | eta |< 2.2. Triple-GEM detectors have been identified as a suitable technology to sustain the specific high radiation environment in that region. In CMS the triple-GEM detectors will be equipped with the VFAT3 chip currently under design. All the tests and the development of the electronics and DAQ system are performed up to now with the existing TOTEM VFAT2 chip which is read-out by a new microTCA-based electronics system. In this contribution we will report on the status of the development of the CMS GEMVFAT microTCA-based readout system. We will report on first tests performed with a full size CMS triple GEM detectors in the laboratory as well as in a test beam.

Development of the GEM-TPC X-ray Polarimeter with the Scalable Readout System

Board: 54

Presenter: KITAGUCHI, Takao (Hiroshima University)

We have developed a gaseous Time Projection Chamber (TPC) containing a single-layered foil of a Gas Electron Multiplier (GEM) to open up a new window on cosmic X-ray polarimetery. The GEM-TPC polarimeter works as a highly sensitive tracker for photoelectrons whose initial direction is sensitive to linear polarization of incident X-rays. The GEM foil is used to increase signal-to-noise ratio of photoelectron track images by a few thousand-fold.

A prototype of the flight polarimeter has been built and evaluated in USA/NASA, while a spare for ground tests has been developed in Japan/RIKEN. The main difference between the two polarimeters is a signal readout system: the prototype uses the APV25 ASIC controlled by a NASA-programmed FPGA to read out signals from 128 one-dimensional strips, while the spare utilizes the Scalable Readout System (SRS) developed by CERN/RD51. In the conference, we will present the design and fabrication of the spare with the APV25-SRS electronics and its polarization performance.

In order to test the spare polarimeter, it was irradiated with monoenergetic and linearly-polarized X-rays from the BL32B2 beamline at the SPring-8 synchrotron radiation facility in December 2014. The polarized X-ray data were acquired by scanning with 5 mono energies from 4.5 to 7.5 keV. In addition, at each energy, the polarimeter was scanned with well-collimated beams in 6 different detector positions along the applied electric field.

The derived analyzing power (or modulation factor) for linear-polarized X-rays on the optical axis is approximately 40% at 4.5 keV and increases up to 50% with the beam energy. Moreover, the analyzing power increases by approximately 10% per cm with decrease in the electron drift length because of less image blurring caused by electron diffusion. These results show that the spare polarimeter has a comparable sensitivity to the flight prototype.

MOSAIC board: a modular system for readout and testing of particle physics detectors and their related electronics.

Board: 55

Presenter: DE ROBERTIS, Giuseppe (BA)

In this work the MOSAIC (“MOdular System for Acquisition, Interface and Control”) board, designed for the readout and testing of the new pixel tracker modules of the ALICE experiment, is described. It is based on a large Artix7 Field Programmable Gate Array device by Xilinx and is compliant with the six unit “Versa Modular Eurocard” standard (6U-VME) for easy housing in a standard VMEbus crate from which it takes only power supplies and cooling.
The board can read data through 10 high-speed serial receivers at rate up to 6.6 Gbps or using up to 132 slow LVDS lines and it is equipped with 1GB-DDR3 memory for temporary data storage. Two FMC-LPC mezzanine slots are provided for connectivity expansion to many other devices, such as ancillary modules, additional interfaces or devices to be tested. Furthermore, four programmable LEMO Input/Outputs, complying with Nuclear Instrument Module standard, are provided for addition flexibility in different test setups.
The FPGA houses an 8-bit microprocessor for system supervision, network management, data sending and diagnostics. Communications with external PC are done through Gigabit-Ethernet interface using TCP/IP and UDP/IP protocols. Thanks to Direct Memory Access technology, hardware IP fragmentation and TCP offload, the interface is able to send data at full Gigabit speed.
Moreover, the system is provided with an internal data generator for network testing and a pulser to automate the injection of test patterns into the device under test.
The board is currently used to perform the functional test of the modules of the new pixel tracker for the upgrade of the ALICE experiment and will be also part of the first readout and control system prototype.
The firmware architecture provides the possibility to easily add new custom interfaces to other front-end modules.
Thanks to its flexibility and configurability, MOSAIC board is suitable for many applications in the readout and testing of particle physics detectors and their related electronics.

The TOTEM DAQ based on Scalable Readout System (SRS)

Board: 56

Presenter: Dr. QUINTO, Michele (INFN, Sezione di Bari)

The TOTEM (TOTal cross section, Elastic scattering and diffraction dissociation Measurement at the LHC) experiment at LHC, has been designed to measure the total proton-proton cross-section with a luminosity independent method, based on the optical theorem, and study the elastic and diffractive scattering at the LHC energy.

To cope with the increased intensity of the LHC run 2 phase, and the increase on statistics required by the extension of the TOTEM physics program, approved for the 2016 run campaign, the previous VME based DAQ has been substituted by a new one based on the Scalable Readout System (SRS).

The system is composed of 16 SRS-FECs, and one SRS-SRU; it features a throughput of ~120MB/s, saturating the SRS-FEC 1Gb/s link, for an overall 2GB/s data transfer rate into the online PC farm. This guarantee a baseline maximum trigger rate of ~24kHz, to be compared with the 1KHz of the previous VME based system. This trigger rate will be further improved,up to 100kHz trigger rate, implementing second level trigger algorithm in the SRS-SRU.

The new system design fulfills the requirements for an increased efficiency, providing higher bandwidth, and increasing the purity of the data recorded supporting both a zero suppression algorithm and a second-level trigger based on pattern recognition algorithms implemented in hardware. Moreover a full compatibility with the legacy front-end hardware has been guaranteed, as well as the interface with the CMS experiment DAQ and the LHC Timing Trigger and Control (TTC) system.

A complete re-design of the firmware, leveraging the usage of industrial strength firmware technologies, has been undertook to provide a set of common interfaces and services between the standard system modules to the specific one of the user's application. This to allow an efficient development and easier insertion of different zero suppression and second-level trigger algorithms and a share of firmware blocks between different SRS components. Furthermore, to avoid packed losses and improve reliability of the UDP data transmission, a solution has been adopted that uses the Ethernet Flow control and New API (NAPI) mode driver, featuring a ticketing algorithms at the application layer.

In this contribution we will describe in details the full system and performances during the commissioning phase at the LHC Interaction Point 5 (IP5).

Tests of a new anode resistive coating for a Micromegas TPC

Board: 57

Presenter: COLAS, Paul (CEA/Irfu Saclay)

There are more and more applications of resistive coatings for MPGD anodes. They are used for spark suppression and damping in Large Area detectors and for charge spreading to improve the resolution in a TPC (with the suitable RC constant per unit area). Recently a new material, Diamond-Like Carbon has been tested as coating for Micromegas TPC modules. Performances of modules with this new coating are compared with results obtained in the same conditions with Carbon-Loaded Kapton. Advantages of this new material will be discussed.

Some advances of thinner-THGEM

Board: 58

Presenter: Dr. LIU, Qian (UCAS, China)

Thinner-THGEM, which has 0.2mm thickness, 0.1mm~0.15mm hole diameter, 0.3mm pitch and 5~20um rim has been manufactured successfully. Two methods have been investigated for the manufacture: drilling and laser. The performance has been studied and it shows that 1.0X10^4 gain for one layer and 16% energy resolution for 55Fe source can be achieved. The spatial resolution of thinner-THGEM with 0.3 mm pitch strip-anode has been measured with centroid and center of gravity method, respectively. The influence of anode strip pitch on the extremity of hole-pitch has been researched in detail. A resistive-WELL type thinner-THGEM has been tested at Beijing Electron Positron Collider (BEPC) test beam with 0.1~1GeV proton and pion beam. Abhout 99% and 94% efficiency for proton and pion, has been obtained respectively. The ion feedback effect is studied for a TPC prototype requirement. In respect of application, for one dimensional readout, a curved parllax free with large open angle of 48°,diffraction meter has being tested for TiO2 and SnO2 with good angular resolution of 0.14°, and a linear diffraction meter with 512 channel digital readout for outside mineral sample test is in using. For two dimensional readout a 20×20 cm2 and smaller one with 128 channels strip and a pexel readout have been used for α/β pollution and dosage measurement.

New results on hole-size dependence of GEM-foil performance

Board: 59

Presenter: Dr. HILDÉN, Timo (Helsinki Institute of Physics)

An optical Quality Assurance (QA) system has been developed at the Detector Laboratory of the Helsinki Institute of Physics. The size and shape of the holes in a Gas Electron Multiplier (GEM) -foil can be measured with the system. The system is used e.g. for the QA of the GEM foils of the TPC detectors being developed for the beam diagnostics system of the SuperFRS at future FAIR facility and in the QA of the GEM-foils for the upgrade of the TPC readout chambers of the ALICE experiment at CERN.

The correlation between the GEM hole size variation and the corresponding gain variation has been studied with several different gas compositions and operating voltages. It has been found that a quantitative estimation of the variation in gain across the GEM foil can be made based on precise
measurement of the geometry of the holes. This study has been made in collaboration between Helsinki Institute of Physics and Wigner Research Centre in Budapest as part of the R effort of the ALICE TPC upgrade project. The current status of the study is presented.

Study of spatial resolution of low-material GEM tracking detectors

Board: 60

Presenter: Mr. SHEKHTMAN, Lev (Budker INP)

Spatial resolution of GEM based tracking detectors is simulated and measured. The simulation includes GEANT4 based transport of high energy electrons with careful accounting of atomic relaxation processes including emission of phluorescent photons and Auger electrons and custom post-processing, including accounting of diffusion, gas amplification fluctuations, distribution of signals on readout electrodes, electronics noise and particular algorithm of final coordinate calculation (center of gravity). The simulation demonstrates that the minimum of spatial resolution of about 10 um can be achieved at a strips pitch of 250 um to 300 um. At a larger pitch the resolution is quickly degrading reaching 80-100 um at a pitch of 500 um.

Spatial resolution of low-material triple-GEM detectors for the DEUTRON facility at VEPP-3 storage ring is measured at the extracted beam facility of VEPP-4M collider. The amount of material in these detectors is reduced by etching of copper at GEMs electrodes and using the readout structure on thin kapton foil rather than on glass fiber plate. The exact amount of material in one DEUTRON detector is measured by studying multiple scattering of 100 MeV electrons in it and the result of these measurements is X/X0 = 2.4x10^-3 that corresponds to the thickness of copper layer on GEMs of 3 um. Spatial resolution of one DEUTRON detector is measured with 500 MeV electrons and the measured value is equal to 35 um for orthogonal tracks.

A new technique for assembling large-size GEM detectors and its experimental results

Board: 61

Presenter: Dr. ZHOU, Yi (China)

GEM detectors have been successfully used in modern nuclear and high-energy physics experiments which demonstrates the maturity of the GEM detector technology in applications for high-rate experiments. The key to the GEM application at large-scale experiments is cost-effective realization of large-size detectors, in which development of GEM detector assembly techniques plays a key role. The detector group at the University of Science and Technology of China (USTC) has been conducting intensive R of large-size GEM detectors, particularly on assembly techniques, since 2013, with one of the aims being to build up technology for the tracking detector at the SoLID experiment proposed for the 12-GeV upgrade program at JLab.
The large-size GEM R at USTC started with implementing the "No Stretching, No Spacer (NS2)" GEM assembly technique developed in the context of the CMS Muon GEM upgrade project at CERN. Two large-size GEM prototypes were built using the NS2 technique, with an active area of 30cm×30cm at USTC. A great deal of experience with the NS2 technique was gained through the prototyping. The performance of both prototypes including the response uniformity, effective gain and spatial resolution was tested.
From the implementation and practice of the NS2 technique, it was found that there is a major disadvantage in application for the GEM detectors size close to or larger than 1m. When GEM foil size reaches ~1m, the overall foil strain of a triple-GEM stack as used in the NS2 technique from a normal tension of ~ 5N/cm can be as large as ~2.5mm. This was precisely measured by a dedicated GEM stretching platform as shown in Figure 1. The screws will then be pulled by the inner frames and tilted towards the GEM stretching direction, and finally exceed the tolerance of the screw hole size and get blocked. This causes the stretching force can't be applied to the foil correctly and gas leakage. In view of these problems inherited from the original NS2 technique, a new GEM stretching technique called "Sliding NS2" (Figure2) has been developed based upon the NS2 technique. In this new technique,the nuts are fixed by the main frame which forces the stretching screws to keep vertical to the side-plane of the mainframe, and the GEM foils can move freely up to 5mm inside the main frame. With this "Sliding" NS2 technique, GEM foils as large as ~1m can still be stretched very uniformly and gas tightness is ensured. A large-size GEM prototype (1m*0.5m) has been successfully built with the Sliding NS2 technique, demonstrating the advantage of the Sliding NS2 technique over the original one in large-size GEM assembly. The GEM prototype was thoroughly tested in terms of uniformity, effective gain.
This report presents the details of the Sliding NS2 technique for large-size GEM assembly and the test results of the large-size GEM prototypes built for the GEM R The performance of the GEM prototypes is also compared.

The Recent Results of Glass Gas Electron Multiplier

Board: 62

Presenter: Mr. MITSUYA, Yuki (The University of Tokyo)

The glass gas electron multiplier, glass gem (G-GEM), is a GEM based detector which is composed of a photoetchable glass substrate (PEG3, HOYA Corporation, Japan). Its improved spark tolerance and mechanical stability provides better handling and simple detector setup. No outgassing from the substrate enables the long-term sealed operation of detectors.
In this research we report on the recent results of a new G-GEM composed of crystalized photoetchable glass (PEG3C). PEG3C is a crystalized type of PEG3 glass. The crystalization process is done by heat treatment. Its improved mechanical robustness (higher young's modulus and bending stress) enables arbitrary design of a detector such as a G-GEM with thinner substrate. The less deflection of the detector across its sensitive area is also achievable.
We designed a crystalized G-GEM with the geometry of 680 micro-meter thickness, 280 micro-meter hole pitch, and 170 micro-meter hole diameter. We investigated the basic characteristics of this crystalized G-GEM. The maximum effective gas gain of 25000 was achieved with a single stage G-GEM in Ar/CO2 90/10 gas mixture. The maximum gain was the similar value of that of non-crystalized G-GEM. The gain stability was also investigated. The gain decreased 20 % in the timescale of 30~60 minutes after applying high delta-V across the G-GEM, then it reached the plateau. The energy resolution of 24 % (Fe-55, 5.9 keV) at the gain of 6300 was obtained. We demonstrated an X-ray radiography of a small mammal with the analogue readout system. The spatial resolution of 110~130 micro-meter in sigma was obtained.

Characterization of multilayer Thick-GEM geometries as 10B converters aiming thermal neutron detection

Board: 63

Presenter: NATAL DA LUZ, Hugo (Instituto de Fìsica, Universidade de São Paulo, Brasil)

One of the most relevant issues in neutron detection is the search for alternatives to Helium-3 as neutron converter. Its high absorption cross section for thermal neutrons used to make it the preferred absorber to build large area thermal neutron detectors. Its current unavailability triggered an intense research to find for alternatives, turning the attention of gaseous detectors developers back to Boron-10. Boron is in the solid state at NPT conditions presenting an additional challenge in its deposition on surfaces, with reasonable thickness. This creates some limitations such as the loss of at least half of the solid angle and the problem of self-absorption of the products of the nuclear reaction when the films are too thick. All these limitations are reducing the detection efficiency of the final detector.

The use of many layers is an interesting solution to overcome these issues. This has been tried in several geometries, such as Multi-grid [1], Inclined detector [2], Jalousie[3] and Cascade [4]. In this work, a solution based in the Cascade concept for the use of many thin boron layers is exploited, using cost effective Thick-GEMs as neutron converters and electron transporters, together with a standard GEM-based charge amplification stage.

Some preliminary results of the characterization of the Thick-GEMs and of boron film depositions through Ion Beam Assisted Deposition using Nuclear Reaction Analysis and Rutherford and Elastic Backscattering Spectroscopy will be presented. Some ideas for the fabrication of simple elements of a scalable detector system will also be discussed.

References:
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[4] M. Klein and C. J. Schmidt, “CASCADE, neutron detectors for highest count rates in combination with ASIC/FPGA based readout electronics,” Nucl. Instr. Meth. A, vol. 628, no. 1, pp. 9 – 18, 2011.

Thick-GEM production in Brazil - characterization of the first prototype

Board: 64

Presenter: NEGRÃO, Renato (Instituto de Física, Universidade de São Paulo, Brasil)

Thick Gas Electron Multipliers (THGEMs) are based on the GEM microstructure, with thickness, pitch and hole diameter enlarged by a factor 10.The substrate is a common copper clad 0.5 mm thick FR4 or G10 board for printed circuits, with 0.5mm diameter holes mechanically drilled at a pitch of 1mm. Although it relies on a much simpler technological process to be fabricated, a precision of few micrometers in the position and shape of the holes is required to achieve gains and stability similar or close to the standard GEM. THGEMs are more robust to electrical discharges when compared to the standard GEMs giving an advantage in cases where the detector must operate at a higher gain.

The availability of MPGD detectors for R in laboratories without production infrastructure is a real problem and poses a great challenge when developing new ideas. In this work, the development of independent production of THGEMs is described and the characterization of the first working prototypes is shown. Maximum gain curves for single and double stages, energy resolution, collection and extraction efficiencies as a function of the hole pitch and performance as a function of time will be presented, introducing a new solution for supplying THGEMs to the MPGD community.

A novel application of Fiber Bragg Grating (FBG) sensors in MPGD

Board: 65

Presenter: BENUSSI, Luigi (LNF)

We present a novel application of Fiber Bragg Grating (FBG) sensors in the construction and characterisation of MPGD, with particular attention to the realisation of the largest triple GEM chambers so far operated, the GE1/1 chambers of the CMS experiment at LHC. The GE1/1 CMS project consists of 144 GEM chambers of about 0.5 qm active area each, employing three GEM foils per chamber, to be installed in the forward region of the CMS endcap during the long shutdown of LHC in 2108-2019. The large active area of each GE1/1 chamber consists of GEM foils that are mechanically stretched in order to secure their flatness and the consequent uniform performance of the GE1/1 chamber across its whole active surface. So far FBGs have been used in high energy physics mainly as high precision positioning and re-positioning sensors and as low cost, easy to mount, low space consuming temperature sensors. FBGs are also commonly used for very precise strain measurements in material studies. In this work we present a novel use of FBGs as flatness and mechanical tensioning sensors applied to the wide GEM foils of the GE1/1 chambers. A network of FBG sensors have been used to determine the optimal mechanical tension applied and to characterise the mechanical tension that should be applied to the foils. We discuss the results of the test done on a full-sized GE1/1 final prototype, the studies done to fully characterise the GEM material, how this information was used to define a standard assembly procedure and possible future developments.

Characterization of GEM foils and materials: simulation, measurements and interferometric monitoring tools

Board: 66

Presenter: RAFFONE, Guido (LNF)

The GE1/1 CMS project consists of 144 GEM chambers of about 0.5 qm active area each, based on the triple GEMs technology, to be installed in the very forward region of the CMS endcap during the long shutdown of LHC in 2108-2019. GE1/1 chambers will be operated for decades in harsh environment, and are expected to perform consistently providing good space and time resolution and excellent rate capabilities. An extensive material science simulation and measurement campaign is in progress to characterize GEM materials, with main focus on the GEM foils. Results are presented on full Finite Element Analysis simulations, measurement of tensile properties and humidity absorption coefficients, both for unused and irradiated samples. Preliminary results are shown on interferometric methods based on Moirè fringes for the monitoring of GEM foils' mechanical properties during chamber construction.

Candidate eco-friendly gas mixtures for MPGDs

Board: 67

Presenter: SAVIANO, Giovanna (LNF)

Modern gas detectors for the detection of elementary particles, and MPGDs in particular, require F-based gases for optimal performance. Recent regulations demand the use of environmentally unfriendly F-based gases to be limited or banned. This work investigates the properties of potential eco-friendly gas candidate replacements. The aim is to discuss some of the important properties of gases for MPGDs, to list and summarize basic properties of eco-friendly refrigerants from the literature available, to discuss their properties for materials compatibility and safe use, and to make a prediction on selected parameters (i.e., ionization potentials, ionization pairs, etc) crucial for the performance of gas detectors considered by making use of both known parametrizations and quantum chemistry simulation codes.

Quality Assurance of the QEM foils for the upgrade of the readout chambers of the ALICE TPC.

Board: 68

Presenter: Dr. BRÜCKEN, Erik (Helsinki Institute of Physics)

The ALICE (A Large Ion Collider Experiment) experiment at the Large Hadron Collider (LHC) at CERN is dedicated to heavy ion physics to explore the structure of strongly interacting matter.

The Time Projection Chamber (TPC) of ALICE is a tracking detector located in the central region of the experiment. It offers excellent tracking of charged particles and identification of those via dE/dx. After the second long shutdown (LS2) the LHC will run at substantially higher luminosities. To cope with the higher data acquisition rate of approximately a factor of 100, the ALICE experiment will upgrade the Multi-Wire Proportional Chamber -based readout chambers (ROC) of the TPC. The new ROC design is based on Gas Electron Multiplier (GEM) technology.

The production of the ALICE TPC ROCs is distributed over several institutes in two continents. This, combined with strict requirements on the performance of the ROCs, necessitates thorough Quality Assurance (QA) measures. The QA protocol, developed by the ALICE collaboration, will be presented in detail.

Report on mass production of large size bulk Micromegas boards at ELVIA company

Board: 69

Presenter: Dr. NEYRET, Damien (CEA Saclay IRFU/SPhN)

The CEA Saclay/IRFU COMPASS group built a dozen of new Micromegas pixelized detectors in 2014-2015 for the new hybrid detector based tracking system (see the corresponding abstract). These Micromegas detectors were based on bulk boards produced by the ELVIA company at Coutances (France). The boards are large, 80x60 cm^2 with an active area of 40x40 cm^2, and require a very precise etching of the PCB, with 60µm thick strips and 60µm insulation, due to the pixelized area at the center of the detector. The 200µm thin PCB is stiffened by being glued on a Rohacell sandwich, then a stainless steel micromesh is bulked on the board.

A collaboration between the CEA Saclay/IRFU and the CIREA company, PCB producer member of the ELVIA group, was initiated in 2010-2011 in order to transfer the bulk Micromegas technology to this company. After a learning phase which lasts several months, this company is able to produce large size bulk boards. Several prototypes of different types were produced by CIREA and ELVIA for the COMPASS experiment. Part of them were installed and tested in real condition in the COMPASS spectrometer in 2012 and 2014. The prototypes were also tested in laboratory with source and cosmic rays in order to determine their performances (in particular gain, efficiency, spatial and time resolution). Finally the mass production started in Fall 2014 and was completed in June 2015. The new hybrid pixelized detectors are presently routinely used for COMPASS data taking.

After a short introduction on the new pixelized Micromegas detectors for COMPASS, and the main difficulties of the board production, the proposed poster will show the progresses ELVIA made on the quality of the production, from the first prototypes to the last built boards.

Investigation of the microstructure of Thick-GEMs with single photo-electrons

Board: 70

Presenter: Mr. HAMAR, Gergo (Wigner RCP, Budapest)

Novel Cherenkov detector upgrades favour GEM and Thick-GEM based
MPGD systems. These detectors have reduced ion backflow, fast signal formation, high gain, and could suppress the MIP signals as well. Their common drawbacks are the inefficiencies of photo-electron collection from the top of the TGEM and the local variation of multiplication due to the special geometry.

The developed high resolution scanner[1] using a focused UV light gave the possibility to study single photo-electron response of MPGDs in the submilimeter scale. Revealing the microstructure of photo-efficiency and local gain provides a new tool to quantitatively compare different TGEM geomertries and field-configurations, and thus optimize the detector parameters.

The presentaion will focus on the key elemets of the scanning system; and on the microstructure evolution of different Thick-GEM configuraions.

[1]: Nucl.Instr.Meth.A 694 (2012) 16