Poster Review – Calorimetry

M. Aleksa (CERN)

Introduction

- 25 very interesting posters!
- 5 posters on ATLAS (LUCID-2 and TileCal) – Operation, calibration and upgrade
- 4 posters on CMS (ECAL, HGCal) – Operation, calibration and upgrade
- 2 posters on smaller experiments – Operation and calibration
- 8 posters on future experiments/upgrades – Results from prototypes
- 6 posters on calorimeter R&D

ATLAS

LUCID-2 (1)

- LUCID-2 (**LU**minosity **C**herenkov **I**ntegrating **D**etector) is the upgrade of the main detector dedicated to luminosity measurements in ATLAS. Most changes were motivated by the number of interactions per bunch-crossing and the 25 ns bunch-spacing in LHC RUN II (2015-2018).
- **LUCID-2 has provided luminosity to ATLAS since 2015**. By comparing measurements with different algorithms and detectors, **systematics are assessed and the robustness of results is reinforced**.

Carla Sbarra
(presenter)

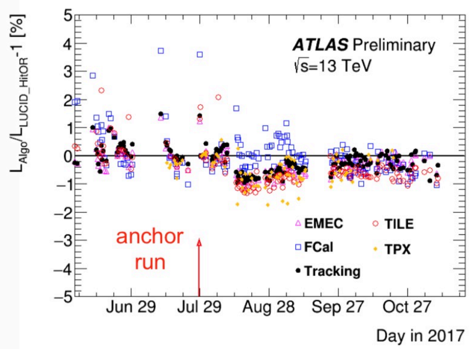


Fig 8: comparison between Lucid and other detectors

* preliminary

Year	Precision (%)
2015	2.1
2016	2.2
2017	2.4*

Table 1: systematic uncertainties on pp integrated luminosity

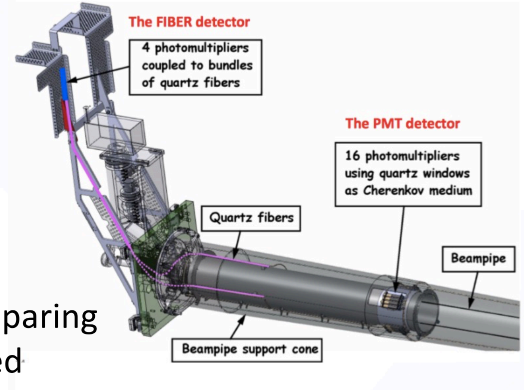
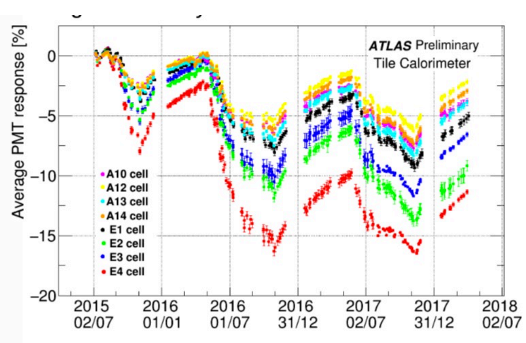


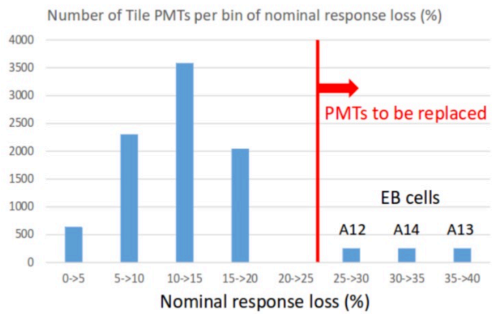
Fig.1: View of the LUCID detector

Two identical modules (Fig.1) are placed around the LHC beam-pipe at 17 m from the ATLAS interaction point. Each module hosts four groups of four photomultipliers (PMTs), and four quartz fibre-bundles coupled to PMTs located at about 1.5 m. All PMTs are model R760 by Hamamatsu. Both the quartz fibre-bundles and the ∅=10 (or 7) mm quartz window of the PMTs are used as Cherenkov radiators to detect charged particles. This peculiar use of PMTs is one of the novelties of LUCID-2.

Response stability over wide pileup range and time by comparing different algorithms and detectors → precision of integrated luminosity measurement better than 2.5%

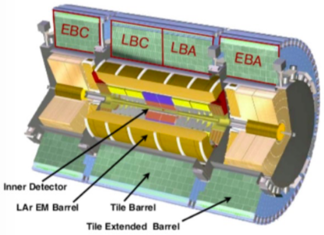
Robustness Studies of TileCal PMTs (4)



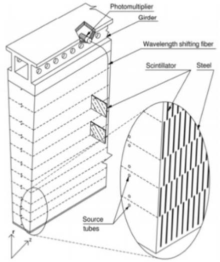


Robustness studies of the photomultipliers reading out TileCal, the central hadron calorimeter of the ATLAS experiment

Giulia Di Gregorio (University & INFN of Pisa)

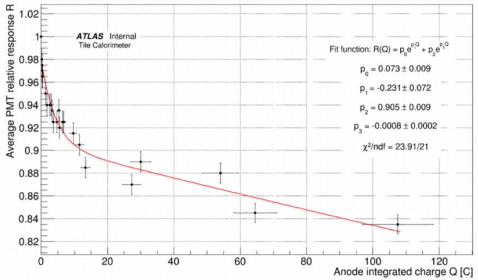


- TileCal is the central section of the hadronic calorimeter in the ATLAS detector.
- It is a sampling calorimeter (steel and scintillating tiles).
- Light produced by the passage of charged particle is transmitted to PMTs by WLS fibers.



- TileCal is readout by 10k PMTs.
- The PMTs response is monitored every 2-3 days with the TileCal laser calibration system.
- Time stability of the PMT response was studied since LHC Run 1.

Average TileCal PMT relative response as a function of the integrated anode charge

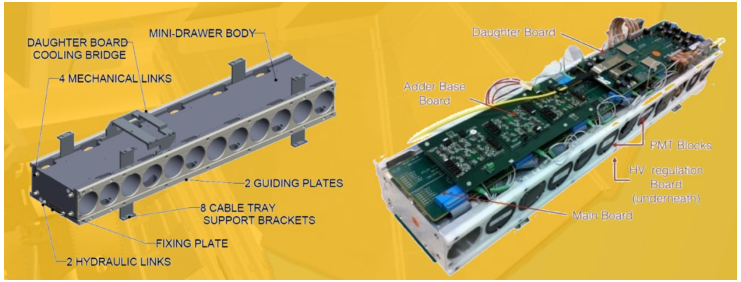


- PMT response loss is dominated by the amount of integrated anode charge.
- A double exponential function is used to describe the PMT response evolution and to estimate the response loss until the end of HL-LHC period (up to 600 C integrated charge).
- Larger amounts of anode charge were integrated from a small PMT sample on a test bench. Same model is applied and results are in agreement with those from on-detector PMTs.

Giulia Di Gregorio (presenter)

ATLAS Tile Calorimeter Upgrades for HL-LHC (5)

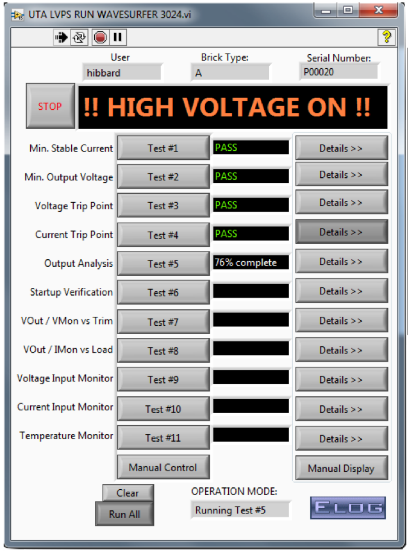
Stylianos Angelidakis
(presenter)



- In order to cope with the high trigger rates and intense radiation environment, expected at the High Luminosity (HL) LHC, the ATLAS Tile Calorimeter (TileCal) will be upgraded with re-designed electronic systems that will ensure optimal performance in its future operation.
- The TileCal upgrade program includes:
  - Redesign of all the readout electronics components (front- and back- end) to adopt the new ATLAS readout Trigger and DAQ architecture;
  - Improved reliability with a full redundant system with no single-point failure;
  - Revised calibration systems (charge injection, Cesium system, laser system);
  - New mechanical structure, including new tools for easier installation and maintenance of the electronics.

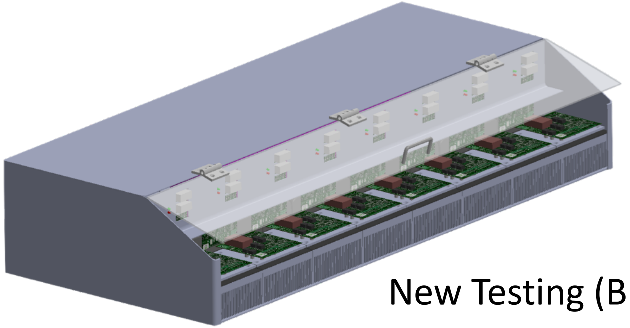
ATLAS TileCal LVPS Upgrade Hardware and Testing (6)

- UTA: **designing and producing new testing stations** to ensure the reliability and quality of new **TileLVPS** (Low Voltage Power Supplies), also produced at UTA, which will power the next generation of upgraded hardware in the TileCal (Tile Calorimeter) system of ATLAS at CERN.

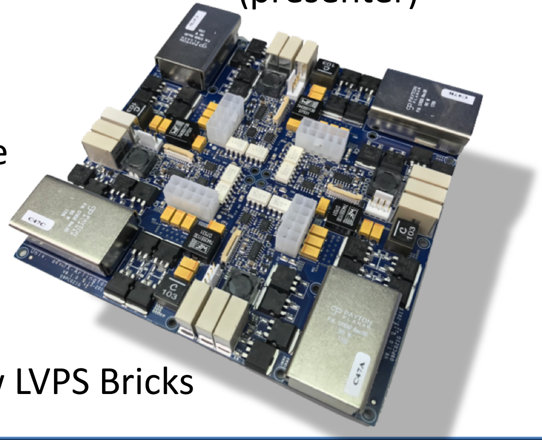


Developed Testing Software

Michael Hibbard (presenter)



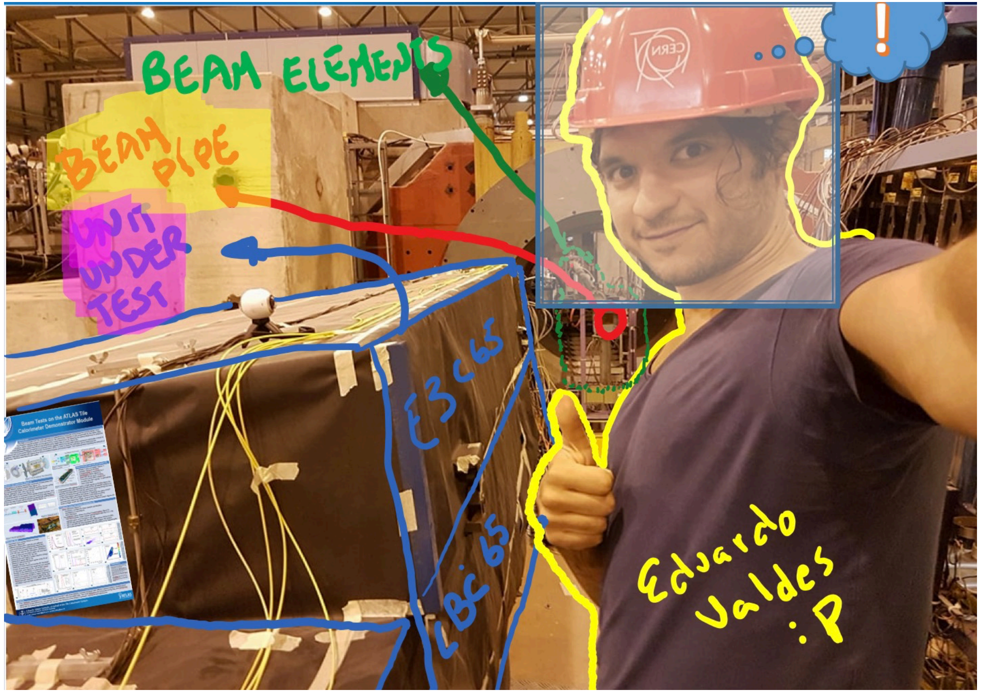
New Testing (Burn-In) Stations

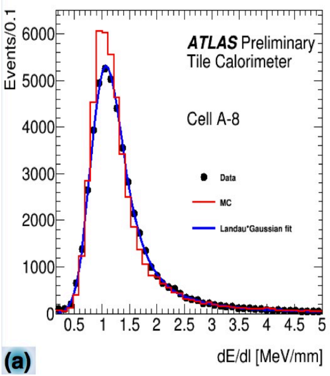


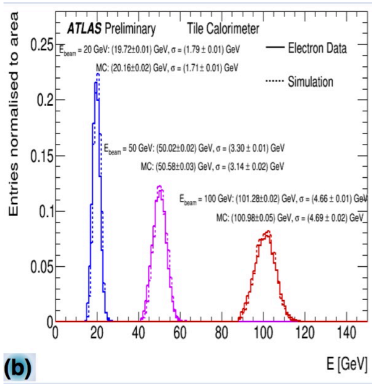
New LVPS Bricks

Beam Tests on Tile Demonstrator Module (7)

- A brief description of **TileCal Phase-II upgrade read out system** within the Demonstrator project framework.
- A description of the testbeam setup and module distribution for testing the new electronics.
- The **current status and results** where the new electronics were situated in calorimeter modules and exposed to beams of **muons, electrons and hadrons** with different energies and impact angles.







CMS

Performance of the CMS ECAL in LHC Run II (14)

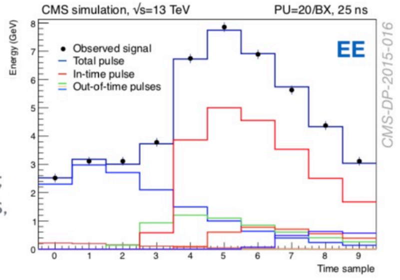
- **Electromagnetic Calorimeter is a crucial component of the CMS detector**
  - measures energy of electrons and photons with **resolution up to 1.5%;**
  - excellent position reconstruction thanks to fine detector granularity provides high photon-resonance mass resolution
- Ever increasing levels of absorbed irradiation dose and higher number of pile-up interactions make it **challenging to maintain the high level of ECAL performance**.
- Nevertheless, it is achieved thanks to a number of parallel efforts:
  - Continuous monitoring and servicing
  - Regular calibrations
  - Improvement of reconstruction algorithms

Nazar Bartosik
(presenter)

Signal amplitude affected by large pile-up (40+)
↳ **10 consecutive samples used in reconstruction**
Multi-fit performed to estimate 1 in-time and $\leq$9 out-of-time signal amplitudes (A_j)

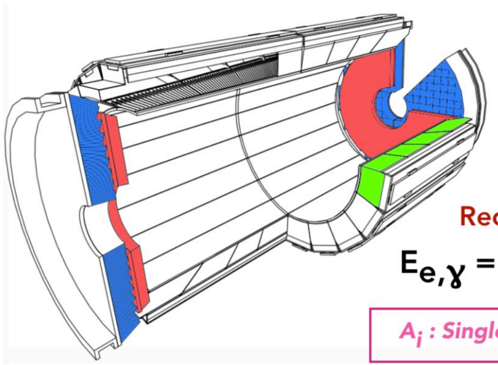
$$\chi^2 = \sum_{i=1}^{N} \frac{(\sum_{j=1}^{M} A_j p_{ij} - S_i)^2}{\sigma_{S_i}^2}$$

- p_{ij} - pulse height;
- S_i – electronic noise;
- sum over N samples,
  M bunch crossings.



CMS ECAL Calibration and Alignment (15)

- **Precise calibration and alignment** of the CMS electromagnetic calorimeter (ECAL) is crucial for achieving the excellent ECAL performance required by many physics analyses employing electrons and photons.
- This poster describes the methods used to **inter-calibrate the ECAL energy response**, using physics channels such as W/Z boson decays to electrons and pi0/eta decays to photon pairs, and also exploiting the azimuthal symmetry of the minimum bias events.
- In addition, the poster details the alignment procedure used to calibrate the position measurements in ECAL relative to the CMS Tracker.
- **Results of the calibration and alignment obtained with Run 2 data are presented.**

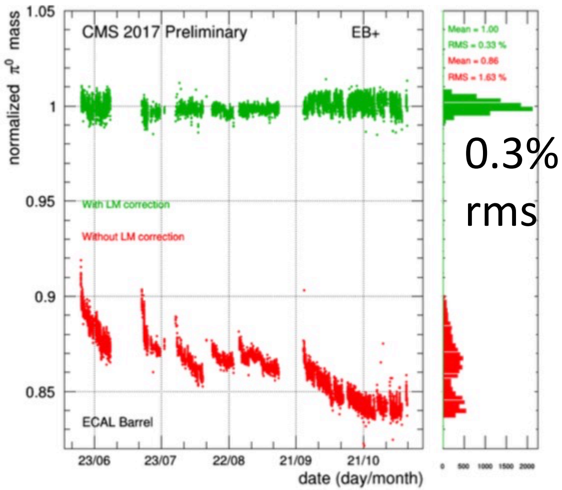


ECAL Barrel 61200 crystals
ECAL Endcap 14648 crystals
Preshower 137200 Pb/Si strips

Reconstructing energy with ECAL

$$E_{e,\gamma} = \sum_i [S_i(t) \times c_i \times A_i] \times G(\eta) \times F_{e,\gamma}$$

A_i : Single channel amplitude (Multifit reconstruction)

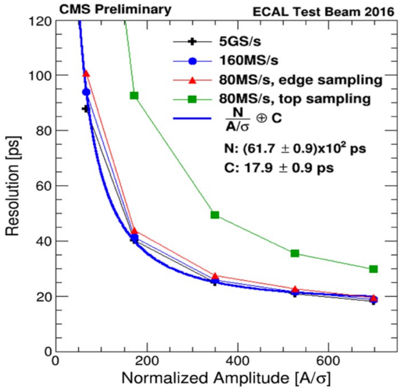


Tanvi Wamorkar
(presenter)

The upgrade of the CMS $PbWO_4$ crystal ECAL (13)

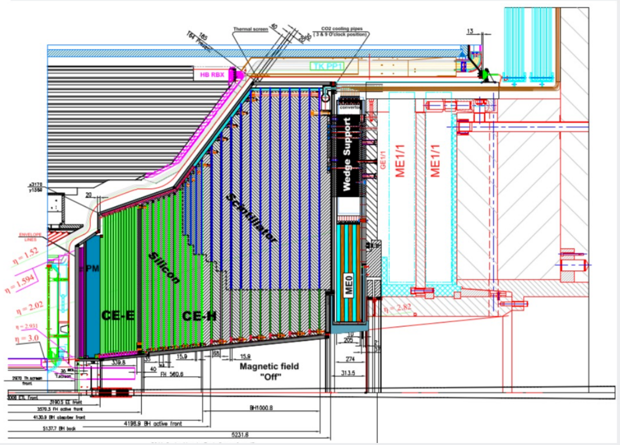
- In view of the high luminosity upgrade, a **refurbishment of the ECAL-EB read-out electronics** is foreseen to cope with the **higher bandwidth and latency requirements**. The upgraded front-end electronics, featuring a fast Trans-Impedance-Amplifier (TIA) and **sampling 160 MHz ADC**, will allow the individual readout of all crystals in streaming mode to the off-detector electronics. The TIA will exploit the fast response of the scintillating crystals coupled to the photodetectors **to reach a timing resolution of ~30 ps for high energy photons and electrons**.
- We discuss the present **ECAL-EB timing resolution**, the benefits of improved precision timing on ECAL event reconstruction, simulation studies on the timing properties of the crystals, as well as the impact of the photosensors and the read-out electronics on the timing performance. **Test beam studies of the timing performance of PbWO_4 crystals with prototypes of the new electronics are presented.**

Ghillardi Giorgio (presenter)



Detector perf. studies for the CMS HGCal (22)

HGCal Longitudinal cross section

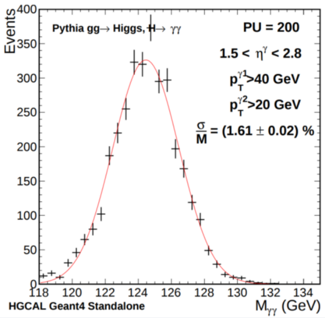


HGCal parameters

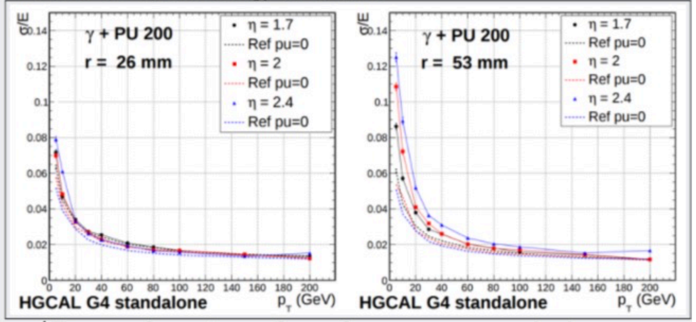
	CE-E	CE-H	
	Si	Si	Scintillator
Area (m^2)	368	215	487
Channels (k)	3916	1939	389
Si modules (Tileboards)	16 008	8868	(3960)
Partial modules	1008	1452	–
Weight (t)	23	205	
Si-only planes	28	8	
Mixed (Si+Scint) planes		16	

Proposed design uses silicon sensors as active material in the front section and plastic scintillator tiles with SiPM read out towards the rear, which enables:

- radiation tolerance
- dense calorimeter
- fine lateral and longitudinal granularity
- precision measurement of the time of high energy showers ability to contribute to the level-1 trigger decision



Electron fractional energy resolution



σ/E as a function of p_T for unconverted photons at (left) using a region of radius **2.6 cm** and (right) **5.3 cm** to sum the enrgy

M. Valentan (presenter)

OTHER RUNNING EXPERIMENTS

Calibration of the calorimeter signal waveform in the SND detector (8)

SND ECAL:

The main part of the SND is a three-layer electromagnetic calorimeter (EMC, Fig 2, 3), which consists of 1640 NaI(Tl) counters. Each counter includes NaI(Tl) crystal, vacuum phototriode, and charge-sensitive preamplifier.

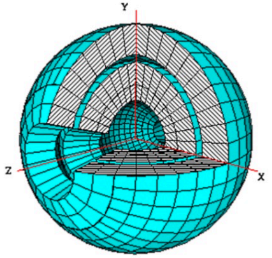


Figure 2. The EMC layout. SND calorimeter general parameters: total weight of NaI - 3.5 tons, 1632 crystals, VPT readout, 13.4 X_0NaI=(2.9+4.8+5.7)X_0 (34.7 cm), 0.9·4π solid angle, angular size of the counter Δφ=Δθ=9°

Energy resolution $4.2\%/\sqrt[4]{E(GeV)}$

Angular resolution $0.82°/\sqrt{E(GeV)} \oplus 0.63°$

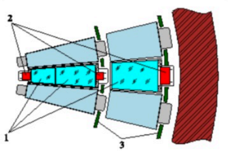


Figure 3. The segment of the EMC:NaI(Tl) crystals (1), vacuum phototriodes (VPT) (2), aluminum supporting spheres (3).

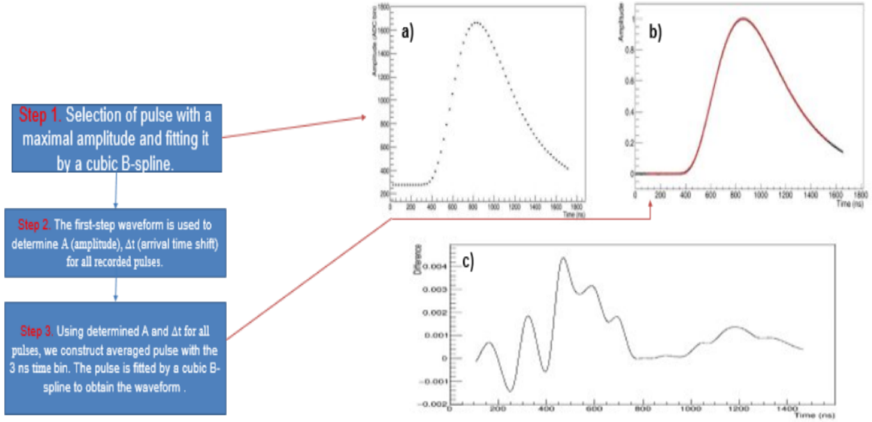


Figure 1. Waveform calibration procedure. a) The typical pulse with a digitization step of 27.12 ns. b) The averaged normalized pulse with the 3 ns bin. The pulse is fitted by a cubic B-spline c) The difference between the waveforms obtained on Bhabha and cosmic events.

The algorithm of pulse-parameters determination (time, amplitude) is based on invariability of the signal waveform. It is planned to use two procedures for waveform calibration. The first is to construct averaged pulse for cosmic muons and fit it. The procedure is described in Fig.1. All collected pulses have amplitude more then 25 MeV. This energy deposition provides optimal signal/noise ratio for obtaining waveform. The procedure converges after several iterations over steps 2 and 3. The pulse is fitted by cubic B-spline. The second procedure constructs the averaged pulse for Bhabha scattering events, which is then fitted to obtain a waveform. Comparison of the waveform obtained on Bhabha events with the waveform obtained on cosmic muons is shown in Fig.1.

Ilya Surin (presenter)

Introduction

The Spherical Neutral Detector (SND, Fig. 1) is one of the two detectors operating at VEPP-2000 e+e- collider, which is located at Novosibirsk, Russia

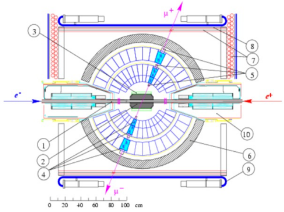
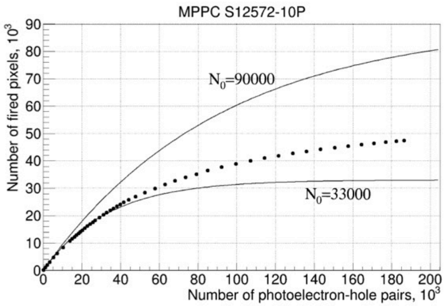


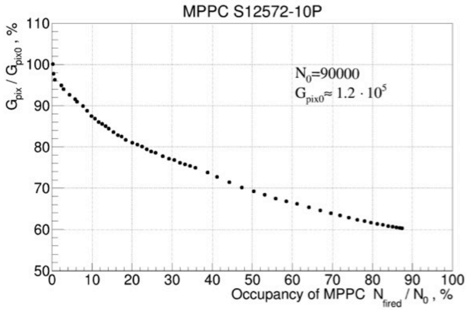
Figure 1 The Spherical Neutral Detector layout.. *1 – VEPP-2000 beam pipe, 2 – tracking system, 3 – aerogel Cherenkov counter, 4 – NaI(Tl) counters, 5 – vacuum phototriodes, 6 – absorber, 7-9 – muon system, 10 – VEPP-2000 superconducting focusing solenoids*

The matrix of 3×3 modules of the EM calorimeter ECAL0 (COMPASS II) read out by MPPC S12572-10P SiPM with the pixel density of 10^4 mm^{-2} and an area of 3×3 mm is studied in the range of electron energies 1-30 GeV. It is observed that the MPPC has additional response nonlinearity and a significantly smaller dynamic range of output signals than expected. The mechanism of the effect based on the influence of parasitic capacitance between pixels on the pixel gain is proposed. The energy resolution of the calorimeter is measured to be $\sigma_E/E = 7.1\%/\sqrt{E}(1+0.06/E) \oplus 1.4\%\ E^{0.25}$.

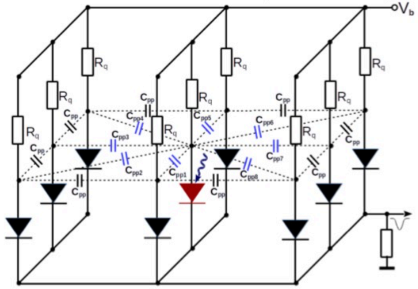
Igor Chirikov-Zorin (presenter)



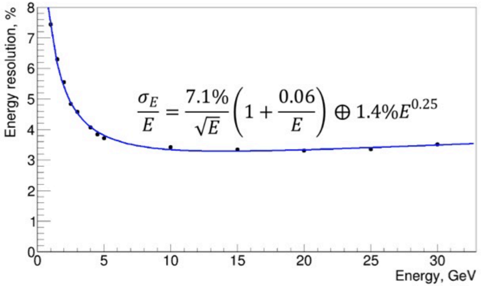
The response of the MPPC S12572-10P with a total number of pixels N_0 = 90000 exposed to light from a laser with a pulse width of 40 ps. For comparison, theoretical functions with N_0 = 90000 and N_0 = 33000 are shown.



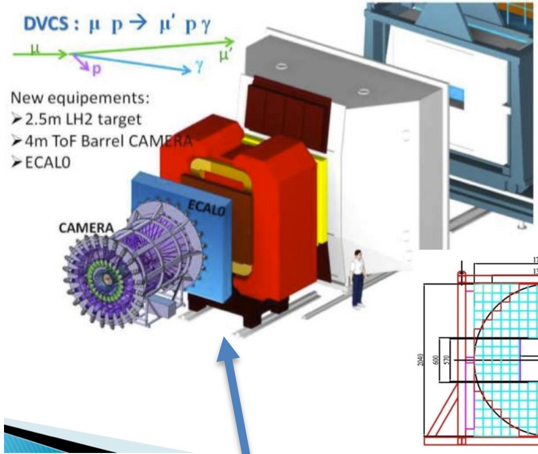
The dependence of the average MPPC S12572-10P gain on the occupancy of pixels.

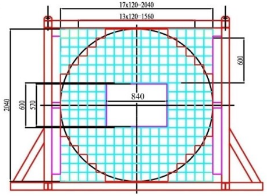


A simplified equivalent circuit of the MPPC S12572-010 and S12572-015 with high pixel density.



The dependence of the energy resolution of the ECAL0 3×3 module matrix read out by the MPPC S12572-10P on the electron beam energy.





ECAL0 of COMPASS II

FUTURE EXPERIMENTS / UPGRADES

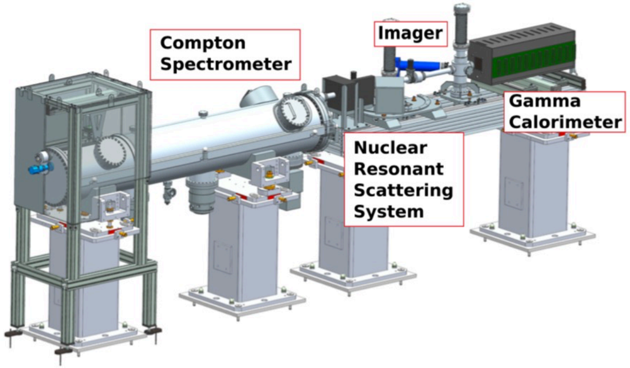
A Compton Spectrometer to monitor the ELI-NP beam energy (10)

ELI-NP Project

The **ELI-NP facility** (Extreme Light Infrastructure - Nuclear Physics), currently under construction near Bucharest, is the pillar of the European project ELI dedicated to the generation of high intensity gamma beams for frontier research in nuclear physics [1]. The ELI-NP gamma beam will be obtained by collimating the radiation emerging from incoherent inverse Compton scattering of a laser light off a relativistic electron beam.

Gamma beam characteristic [2]:

Quantity	Specification
Minimum photon energy	200 keV
Maximum photon energy	19.5 MeV
Photon energy tunability	steplessly
Bandwith	$\leq 0.5\%$
Linear polarization	≥ 95 %
Photons per pulse	$\leq 2.6 \cdot 10^5$

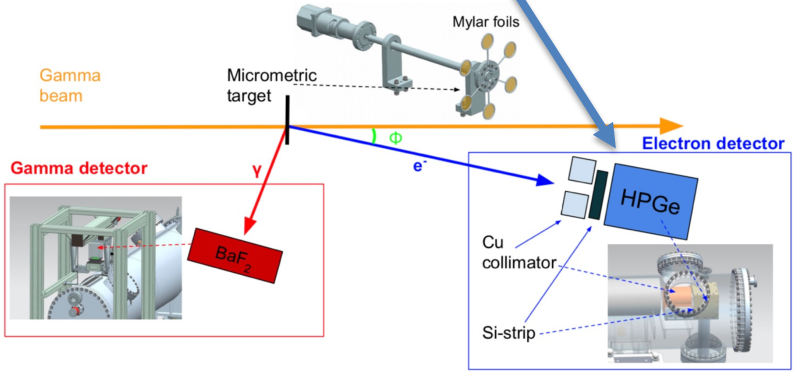


Rita Borgheresi (presenter)

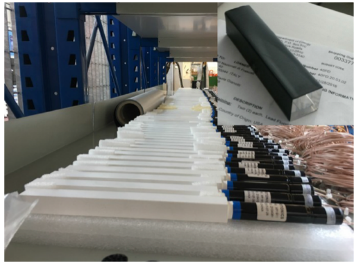
The **energy** of the Compton scattered **electron** (Te) is precisely measured with an **high purity germanium detector (HPGe)** and the scattering angle (ϕ) is determined by a double sided silicon strip detector.

Compton Spectrometer

The aim of the Compton spectrometer is to reconstruct the ELI-NP γ **energy spectrum** with a non-destructive method. The basic idea is to measure *the energy* and *the scattering angle* of electrons recoiling at small angles from Compton interactions of the beam on a micrometric target (1-100 μm). The scattered gamma is also acquired for trigger purpose.



The calorimeters of the PADME experiment (20)



Summary

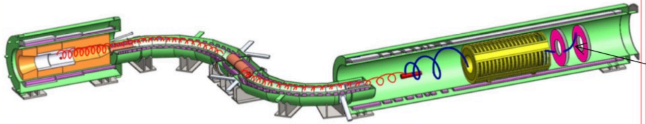
- The **PADME experiment** will be held at **Laboratori Nazionali di Frascati** (LNF) of INFN to **explore the coupling between ordinary and dark matter** (DM).
- This will be done by detecting the **Standard Model (SM) photons** produced in the reaction $e^+e^- \rightarrow \gamma A'$ [2]. The measurement of the 4-momentum of the SM photon allows to reconstruct the missing mass spectrum of the process, where the **dark photon A'** could appear as a peak.
- Positrons accelerated by the **LNF's LINAC at 550 MeV collide with a diamond target, possibly producing γ and A', with $M_{A'} \leq 23.7$ MeV**.
- The **Electromagnetic Calorimeter (ECAL)**, made of 616 21×21×230 mm^3 **BGO crystals,** is devoted to the γ detection and measurement. The scintillating units composing ECAL are arranged in a cylindrical structure with a central hole. This allows the passage of **Bremsstrahlung photons**, that otherwise would over-trigger the calorimeter. These photons are then detected by a faster calorimeter (time resolution ~ 90 ps), the **Small Angle Calorimeter (SAC), made of 25 30×30×140 mm^3 PbF_2 crystals**. The two calorimeters are presently under construction.
- In this work are presented the **results obtained with prototypes tested during test beams** performed at the Beam Test Facility (BTF) of LNF to evaluate the performance of the calorimeter's units.

Paola Gianotti
(presenter)

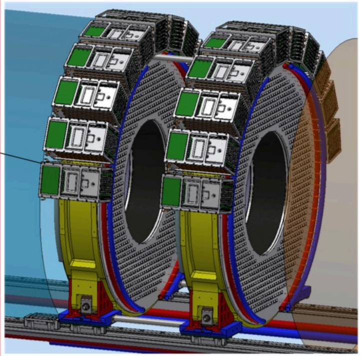
The Mu2e calorimeter: QA of production crystals and SiPMs and results from Module-0 test beam (26)

The **Mu2e Experiment at Fermilab** will search for **charged lepton flavor violation** looking for a coherent, neutrinoless conversion of muons into electrons in the field of an Al nucleus.

The Mu2e experiment will search for CLFV



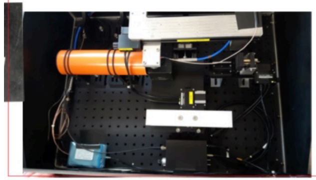
Expected sensitivity improvement 10^4



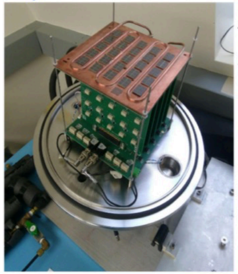
Mu2e calorimeter consists of 2 disks of CsI crystals read by SiPM arrays

Production and qualification of 1348 CsI crystals and 2696 SiPM arrays started

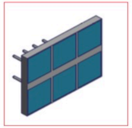
CsI crystal with wrapping



Crystal light output test station

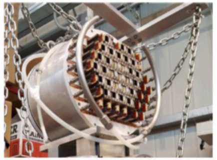


SiPM gain test station



SiPM array

Module-0 beam test



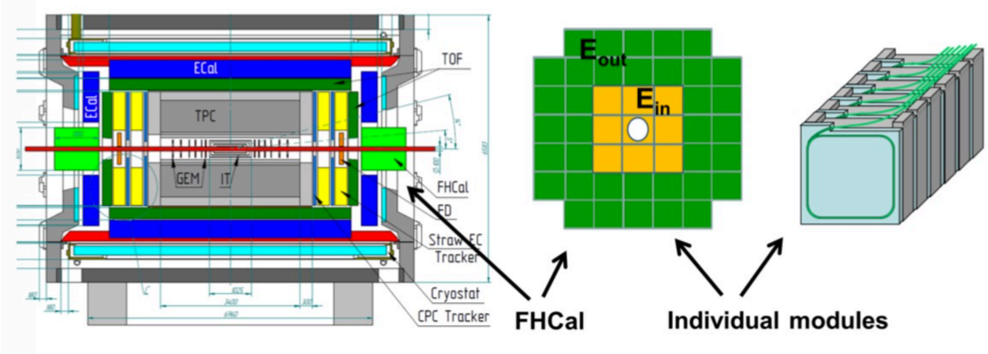
$\sigma(E)$~7%
$\sigma(t)$~240ps(1 SiPM)
@100MeV 50°@center

Stefano Di Falco (presenter)

Forward hadron calorimeter at MPD/NICA (9)

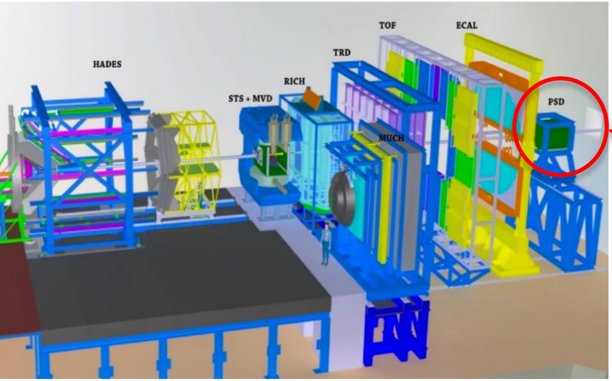
- A new **heavy ions facility NICA** is now under construction in Dubna, Russia. Multi-Purpose Detector, **MPD/NICA** is intended for the study of the dense baryonic matter. **Forward hadron calorimeter (FHCAL) is crucial element of MPD**. Its main purpose is to provide an experimental measurement of a heavy-ion collision centrality and orientation of its reaction plane.
- FHCal is intended for the determination of the **collision geometry at MPD/NICA**. It has fine segmentation in both **transverse and longitudinal directions**. The FHCal modules have 4 interaction lengths that is sufficient for the detection of the spectators with energies up to 6 GeV. The longitudinal segmentation in 7 sections ensures the uniformity of the light collection along the module and the measurement of the profile of hadron shower.
- According to simulation, the sampling fluctuations provide the energy resolution of calorimeter as: $\boldsymbol{\sigma_E/E}$~$(\mathbf{55}\%)/\sqrt{(\boldsymbol{E(GeV)})}$.
- The procedure of the **energy calibration of the modules with cosmic muons** is now being elaborated. The light yield of each longitudinal section is about 50 photoelectrons per minimum ionizing particle crossed the module. It allows the energy calibration of the FHCal modules with the cosmic muons during the calorimeter operation in MPD setup.

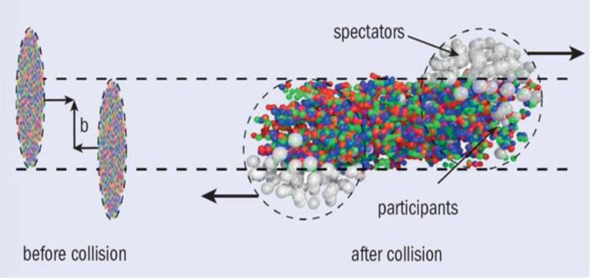
Anastasia Timoshenko (presenter)



The Projectile Spectator Detector for measurement of geometry of heavy ion collisions at the CBM experiment at FAIR (12)

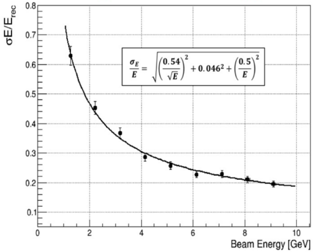
CBM@FAIR



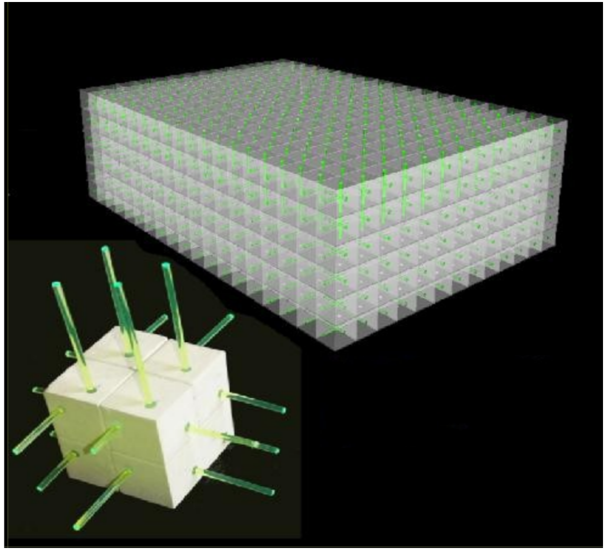


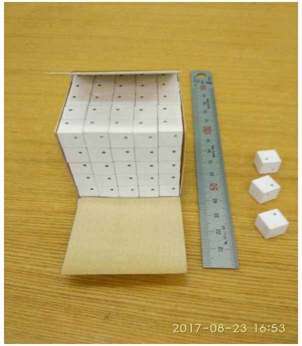
- The **Compressed Baryonic Matter (CBM) experiment** at the future Facility for Antiproton and Ion Research (FAIR) is aimed to explore the QCD phase diagram in the region of high baryon densities.
- The **Projectile Spectator Detector (PSD)** is the forward hadron compensating **lead/scintillator calorimeter** with sampling ratio 4:1. The PSD will measure the **event centrality** and the reaction plane orientation in heavy-ion collisions and will operate in the range of 2-10 AGeV and beam interaction rates up to 10 MHz.
- The **PSD supermodule is an array of 3x3 modules** and is assembled from 9 modules with transverse dimensions of 20x20 cm^2 and longitudinal dimension of 5.6 interaction lengths. **A study of the PSD supermodule response at proton momentum range 2 – 10 GeV has been done at the CERN T9 and T10 beam lines.**
- The construction of the PSD and the simulations of PSD operation under radiation conditions are discussed. **We present the results on the PSD supermodule resolution and the linearity of response**, as well as the PSD supermodule operation with irradiated photodetectors

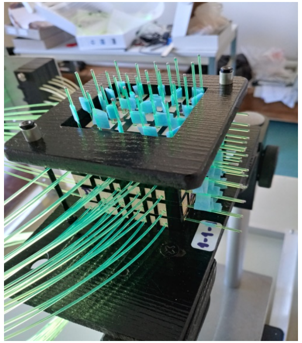
N. Karpushkin
(presenter)



Test results of 3D fine-grained scintillator detector prototype for a T2K ND280 neutrino active target (3)







Highlights:

- A small superFGD detector prototype was **tested in charged particle beam** and at test bench with cosmic rays. **125 scintillator cubes of 1x1x1 cm3 were assembled in 5x5x5 array**. 3D fiber readout was implemented by 1.3 m long Kuraray Y11 WLS fibers and Hamamatsu MPPCs.
- Average light yield in a single cube was over **40 p.e./MIP** per a readout fiber.
- **Time resolution** for a single cube with two readout fibers was σ_t = 640 ps. Four cubes with 8 readout fibers produced σ_t = 330 ps.
- Optical crosstalk between the cubes was measured to be ~ 3.4% through a single cube side.

Oleg Mineev (presenter)

Conception of superFGD (fine-grained detector) for T2K ND280

Detector size: 0.6 x 1.8 x 2.0 m^3 **Granularity:** 1x1x1 cm^3 sci. cubes
Number of cubes: 2,160,000 **Number of readout channels:** 58,800
3D Readout : Y11 Kuraray WLS fibers of 1 mm diameter + Hamamatsu MPPC

Shashlik calorimeters for the ENUBET tagged neutrino beam (18)

ENUBET (Enhanced NeUtrino BEams from kaon Tagging)

- New-concept ν_e source based on tagging of large angle e^+ from $\boxed{K^+ \to e^+ \pi^0 \nu_e}$ decays in an **instrumented decay tunnel**
- Reduction of the systematic uncertainties on the knowledge of the initial neutrino flux to O(1%) level

Physics implications

- Unprecedented high precision measurement ν_e of and $\bar{\nu}_e$ cross sections (short baseline neutrino experiments)
- Highly beneficial for tackling the main open neutrino-related problems: mass hierarchy, θ_{23} octant, leptonic CP violation
- First step towards a time tagged neutrino beam: direct ν production/detection correlation

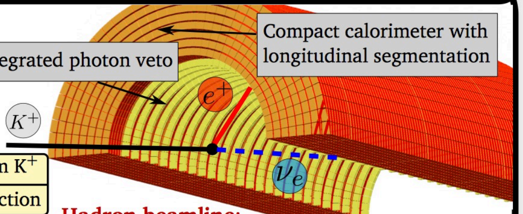
Experiment design

- **Monitored neutrino beam**: hadron beamline followed by an instrumented decay tunnel
- **Positron tagger requirements:**

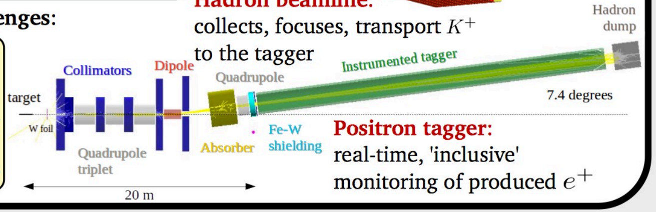
rates > 200 kHz/cm^2	main bkg: pions from K$^+$
source length $\sim$ 50 m	spread in initial direction

- **Implementation challenges:**

Radiation hard components
Recovery time O(10 ns)
Granularity $\simeq$ 10 cm^2:
scalable/cheap technology
(up to 10^5 channels)
Readout triggerless $\geq$ 10 ms

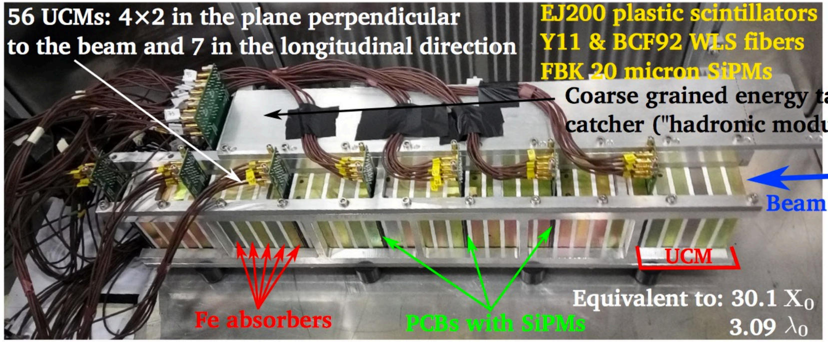


Hadron beamline:
collects, focuses, transport K^+ to the tagger



Positron tagger:
real-time, 'inclusive' monitoring of produced e^+

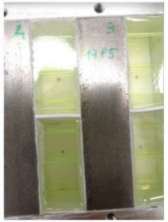
Tagger prototype tested at CERN (PS-T9)

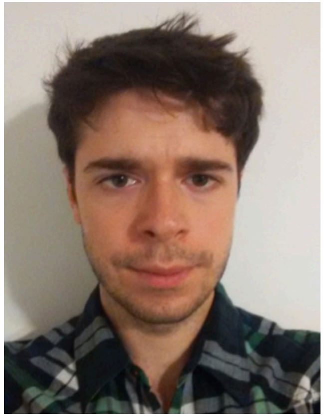


Polysiloxane shashlik calorimeters

First use in HEP. Elastometric material with interesting properties:

- Superior radiation hardness
- Easier fabrication process: initial liquid form. No drilling of the scintillator.
- Optimal optical contact with fibers
- Test beam of the prototypes at CERN PS-T9





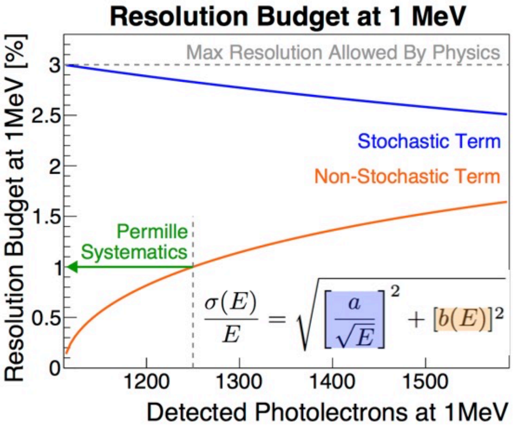
Michelangelo Pari
(presenter)

JUNO Stereo-Calorimetry System JUNO (23)

JUNO
Largest (20 kton) and more precise liquid scintillator detector currently under construction

Achieve 3% energy resolution to determine neutrino mass ordering

Detect $\bar{\nu}_e$ from Nuclear Reactor Goal: Determine Neutrino Mass Ordering by performing a precision measurement of the oscillated antineutrino energy spectrum at 53 km baseline



Marco Grassi
(presenter)

17000 20" PMTs

Large photocoverage yields 1200 PE/MeV

Many photoelectrons pile up at the PMT anode

Challenging charge linearity might compromise resolution

25000 3" PMTs

Low light level: 40 PE/MeV

N(PE) = N(active PMTs) "photon counting" regime

Negligible linearity issues

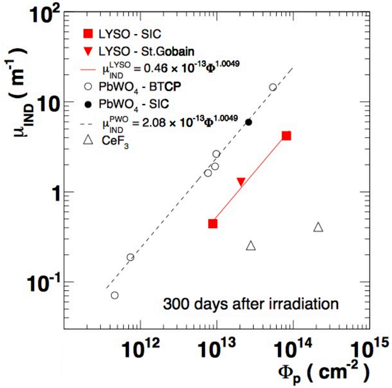
Control & Minimize non-stochastic resolution term

CALORIMETER R&D

Predicting hadron-specific damage from fast hadrons in crystals for calorimetry (2)

- Fast hadrons have been observed to cause a **cumulative damage** in **Lead Tungstate** and **LYSO** calorimeter crystals.
- The underlying mechanism has been proven to be the creation of **fission tracks**, which act as **scattering centers**, thus reducing the light collection efficiency.
- For calorimetry applications in an environment where large, fast **hadron fluences** are anticipated, **predictions about damage in crystals** are of great importance for making an informed choice of technology.
- In the study presented here, **simulations** using the **FLUKA** package have been performed in Lead Tungstate, LYSO and Cerium Fluoride, and their results have been **compared with measurements**.
- The **agreement** that is found between simulation results and experimental measurements allows to conclude that **the damage amplitude in a given material can be predicted** with a precision that is sufficient to anticipate the damage expected during detector operation.

C. Martín Pérez
(presenter)



Compact Calorimeters with Oriented Crystals (17)

- Experiment at CERN SPS H4 beamline with 120 GeV/c electrons
- Good agreement between simulations and measurements

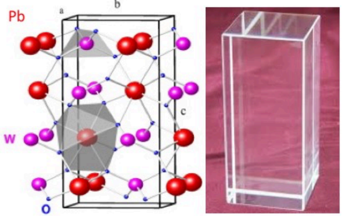
Laura Bandiera (presenter)

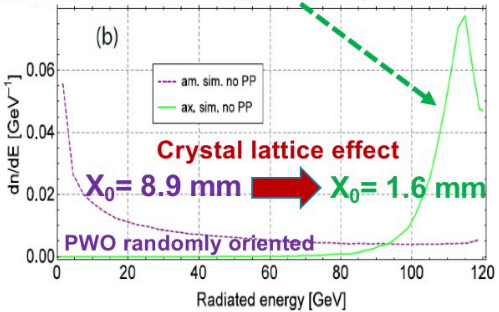
Motivation

The radiation length in an oriented crystal is strongly reduced !!

PWO X_0 reduction for electrons aligned to crystal axes

$PbWO_4$ scintillator crystal
X_0 standard = 8.9 mm





Possible Application Potentialities

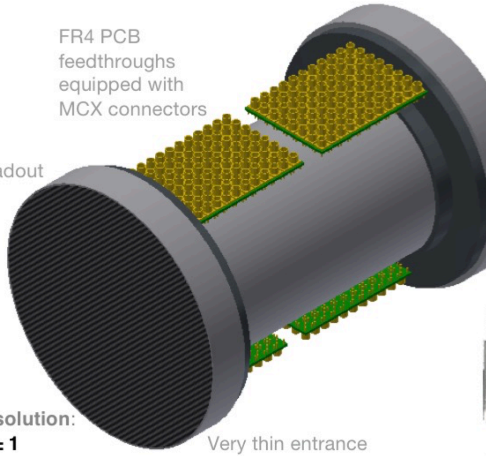
- **FIXED-TARGET EXPERIMENT**: forward e.m. calorimeters/preshower with reduced volume.
- **BEAM DUMP**: compact active beam dump with an **increase of sensitivity to dark photons**.
- **SATELLITE BORNE GAMMA-RAY TELESCOPE**: Containing e.m. showers for energies > 10 GeV in a smaller volume. **Cost reduction, increase of sensitivity and energy resolution!**

A first large calo. prototype based on Lanthanum Bromide coupled to SiPMs (21)

The detector

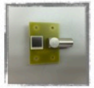
The first large crystal assembly for high energy gamma detection **O(50) MeV** with a MPPC double readout scheme for:

- Maximal photosensor coverage area
- Optimal geometrical acceptance
- Very high photosensor granularity
- High rate sustainability
- Optimum energy, timing and position resolutions
- Insensitive to magnetic field

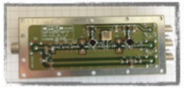


Very thin entrance window: ~ 0.03 X_0 (All materials before reaching the active detector)

Hamamatsu MPPC S13360-6050CS



PSI standalone MPPC pre-amplifier

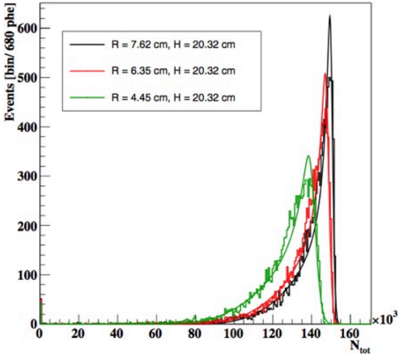


P. Schwendimann (presenter)

The Results (MC simulation predictions)

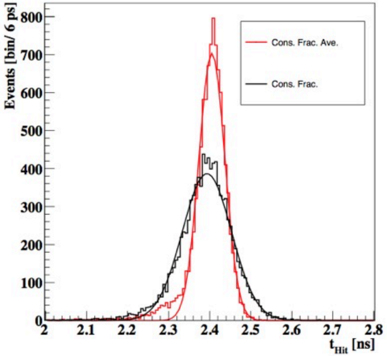
Excellent energy resolution:

σ_E/E [%]: **2.25(7)%**, **1.2(3)%**, **0.9(0)%**

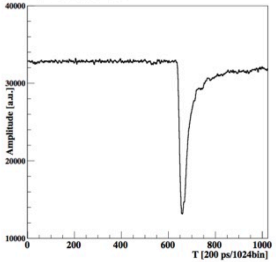


Excellent timing resolution:

σ_t [ps]: **32 ± 1**, **60 ± 1**



MPPC S13360-6050CS Waveform acquired with the DRS evaluation board



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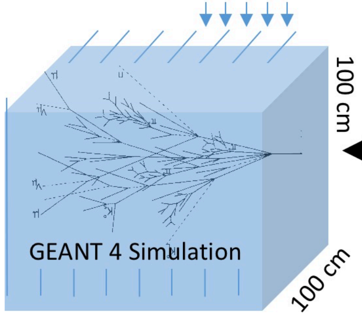
patrick.schwendimann@psi.ch

CALPRO, an unconventional calorimetry approach (24)

Abstract

We propose a calorimetry approach unconventional and innovative. The method is based on the measurement of the lateral distribution of charged particles around the shower axis. It has some peculiar characteristics which can be summarized in the following three points: 1) measurement of the shower energy by means of a single sampling; 2) calorimetry which renounces the classic concept of containment of the shower; 3) possibility to separate primary masses.

Simulations



Procedure

Sample a shower at a fixed depth, and build the lateral distribution of particles. Calculate **the truncated size P_{100},** which is the number of particles within a **100 mm** distance from the axis, and the **lateral age s' parameter** by fitting the lateral distribution of particles with a Nishimura-Kamata-Greisen (NKG) like function:

$$f(r,s') = K \cdot \left(\frac{r}{r_M}\right)^{s'-2}\left(1-\frac{r}{r_M}\right)^{s'-4.5}$$

Calculate Y(s',Pxx), as

$$Y(s', P_{100}) = s' + 0.8\, Log(P_{100})$$

Y has a linear relation with the logaritm of the shower energy

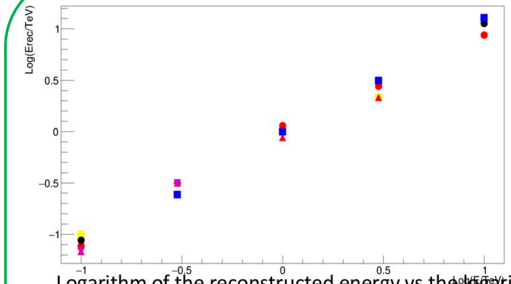
$$Y(s', P_{100}) = A + B\, Log(E),$$

Therefore the shower energy can be calculated by

$$\boxed{Log(E_{rec}) = (Y(s', P_{100}) - A)/B}$$

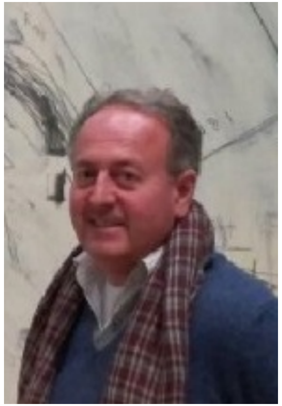
A and B are from MC simulations.

Results



Logarithm of the reconstructed energy vs the logarithm of the true energy - depth is 570 mm - Protons (red circles); Pions + (yellow squares); Pioni- (pink triangles); Elio4 (purple inverted triangles); Carbon12 (black circles); Iron (blue squares)

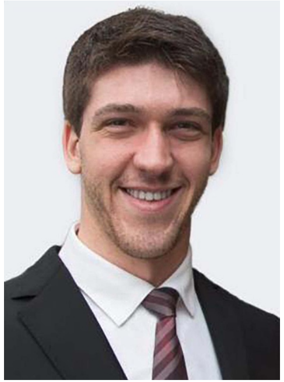
The percentage error on reconstructed energy, for protons, goes from 60 % at 300 GeV, to 45% at 10 TeV.



Michele Iacovacci (presenter)

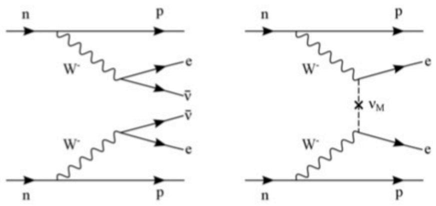
Test beam results of a SiPM based Dual-Readout Calorimeter module (19)

- Detectors for future collider experiments in high energy physics have to provide extreme precision in reconstructing trajectories and energies of both isolated particles and jets springing off the colliding beams.
- The **energy measurement performed for hadronic showers** is typically worse than the ones for electromagnetic showers mainly due to **the event-by-event electromagnetic fraction (fem) fluctuations**, unless measured.
- Following the Dual-Readout calorimetric technique, which reconstructs fem through the **simultaneous measurement of the scintillation and the Cherenkov light** produced by hadronic showers, a first Silicon PhotoMultiplier (SiPM) Dual-Readout calorimeter module was designed, constructed and tested on beam.
- An overview of the **latest beam test results** is reported together with the R&D program required to move towards a prototype conceived as a building block for a calorimeter that could be used in detectors at future accelerators.
- **The next steps are**:
  - Reduce the optical crosstalk between fibres improving the fibre insulation
  - Prevent the saturation of the scintillating channel applying a filter and improving the dynamic range of the sensors
  - Increase the Cherenkov light yield using an aluminized glass mirror
  - Find an optimal readout electronics solution (ASIC, FPGA, etc)



Massimiliano Antonello
(presenter)

Identification of Double-Beta Decay Events in a Liquid Scintillator Detector (25)



$2\nu\beta\beta$- and $0\nu\beta\beta$-decay diagrams

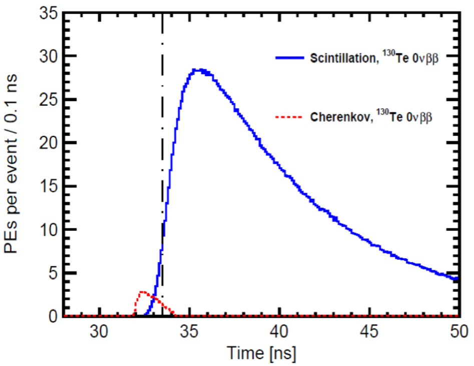
$0\nu\beta\beta$-decay

- Very large detector mass is required to search for $0\nu\beta\beta$-decay
- Liquid scintillator detectors offer good scalability
- Efficient background suppression is critical
- Event topology: two electrons

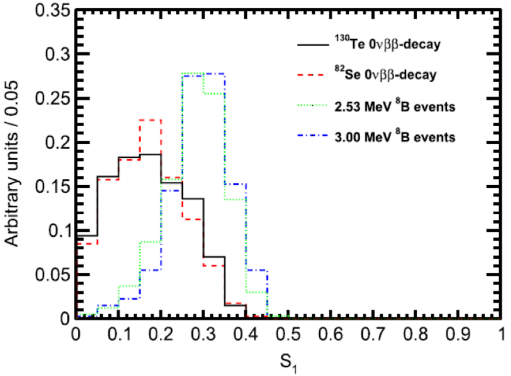
Backgrounds:

^{8}B, ^{10}C solar neutrino interactions

PE arrival times R = 6.5 m TTS=100 ps



Spherical harmonics analysis $0\nu\beta\beta$-decay vs ^{8}B



Andrey Elagin (presenter)

- Use fast photo-detectors to separate Cherenkov and scintillation light
- Use directionality of the Cherenkov light to identify event topology
- Suppress the “irreducible” ^{8}B background

Conclusions

- **Thank you for your Attention!**
- **Very interesting posters in this poster session!**
- **Please have a look and talk to the presenters!**