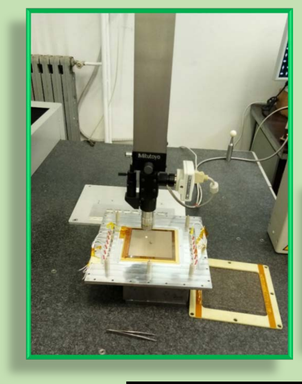


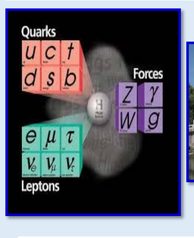
Optimized MPGD-based photon detectors for high momentum particle identification at the Electron-Ion Collider

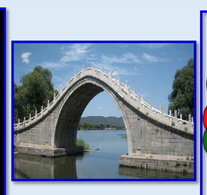
Jinky Agarwala
INFN, Trieste and ICTP
(On behalf of an AVEIRO-LIBEREC-TRIESTE COLLABORATION)

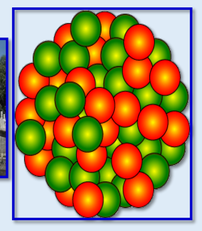
EIC

Why an Electron Ion Collider?

To explore the QCD frontier to understand the glue that binds us all
EIC is recommended by the US Nuclear Science Advisory Committee Long Range Plan in 2015



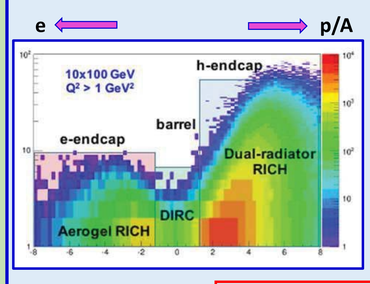




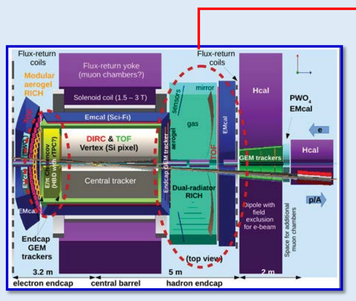
New accelerator, new detectors

- Collider requirements: A new accelerator complex is needed with high luminosity, high energy, with the possibility of varying the energy and varying the nuclear species, with polarization for both the electrons and light ions
- Detector requirements: Hermetic detector, low mass inner tracking, **good PID (electron/pion/kaon/proton) in wide range**, calorimetry, forward & backwards tracking

EIC PID



- Particle (covering the full momentum range) identification is essential in EIC
- Hadron identification relies on RICH technique
- High momenta hadron identification requires low density gaseous radiator to guarantee resolution in the Cherenkov angle at high momenta



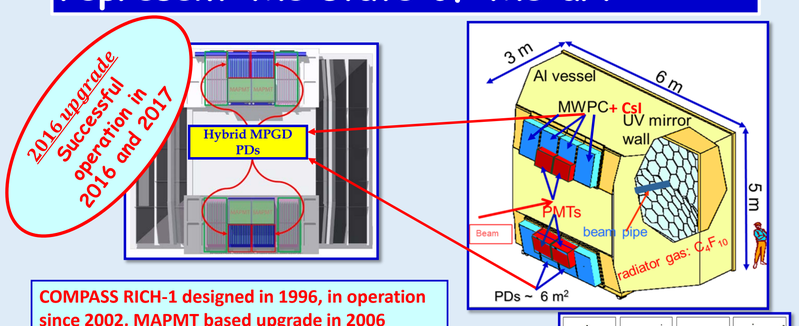
Overcoming the challenge

Limited length of the radiator region is a challenge

- To increase the number of detectable photons, selected photon wavelength range is in far UV domain (around 120 nm) where the Cherenkov photon rate is higher. Gaseous PDs with CsI photocathode are ideal
- The space resolution is needed to be increased as the focal length is reduced due to the shorter radiator

EIC high-momentum hadron PID needs photon detectors with unprecedented performance figures

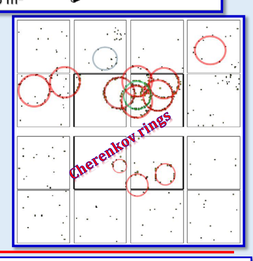
COMPASS RICH MPGD-based PDs represent the state of the art



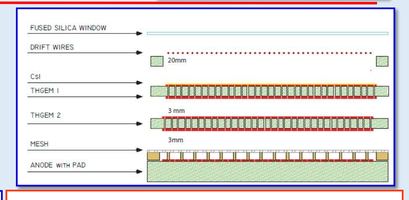
COMPASS RICH-1 designed in 1996, in operation since 2002, MAPMT based upgrade in 2006

RICH-1 recently upgraded by installation of $>1.2\ m^2$ MPGD-based photon detectors with sensitivity in the UV range, specifically developed for this application

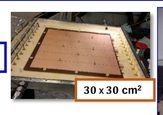
Hadron PID from 3 to 60 GeV/c
Acceptance: H: 500 mrad V: 400 mrad
Trigger rates: upto ~50KHz, beam rates upto ~10^8 Hz

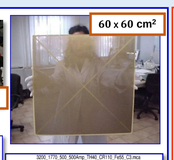


MPGD (THGEM + Micromegas)
⬇
Hybrid detectors of single photons

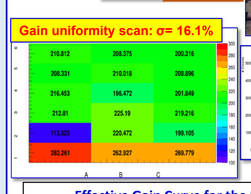


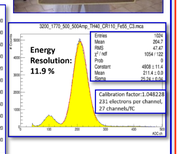
THGEM

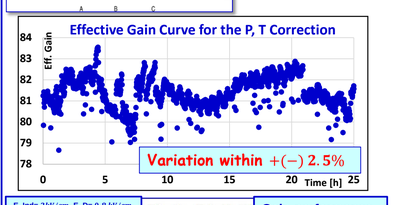


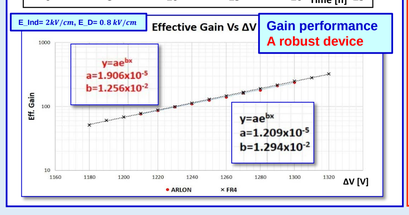


Gain uniformity scan: σ= 16.1%

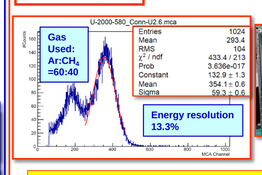


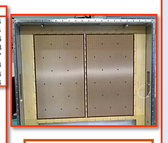






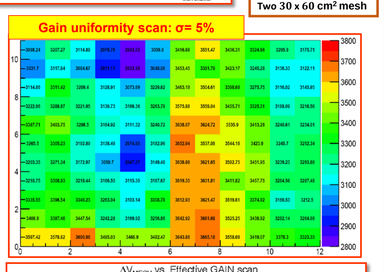
Micromegas

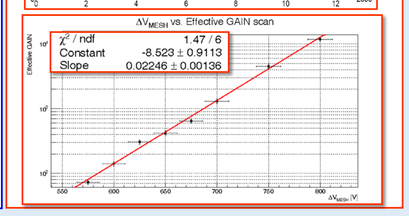




Two 30 x 60 cm² mesh

Gain uniformity scan: σ= 5%

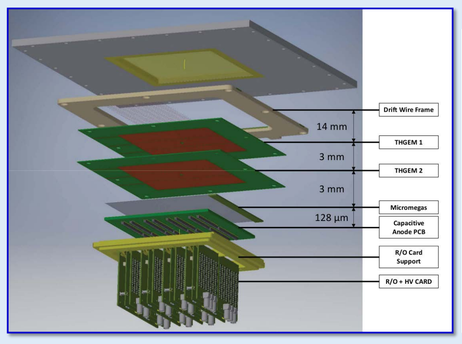




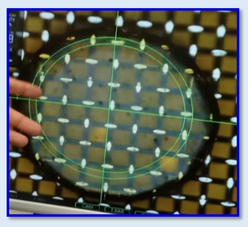
MPGD in LAB/MiniPAD

New Prototype Detector With 3x3 mm² Pads

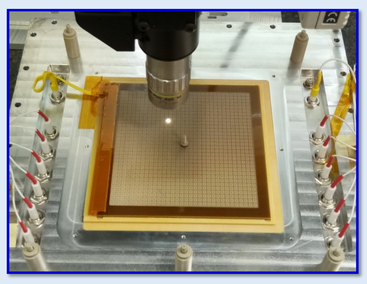
An evolution of COMPASS hybrid PDs with small pads has been designed and a prototype has been built

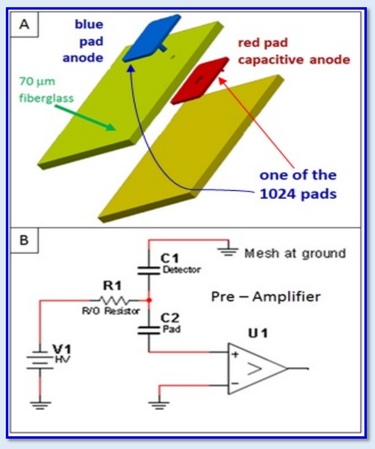


- Active area: **10x10 cm²**
- The anode is segmented in 1024 (64 × 64) pads each having area **(3 × 3) mm²** with **3.5 mm pitch**
- The anode is powered by 8 HV cards in a group of 128 pads (32 × 4) through 128 resistances in series
- Source: ^{55}Fe, AMPTEK MINI-X



Pillars Height: ~128μm Diameter: 350 – 400μm





CAPACITIVE ANODE

- **HV is provided to the blue pad via ~0.5 GΩ resistor and signal is induced in the red pad via RC coupling**

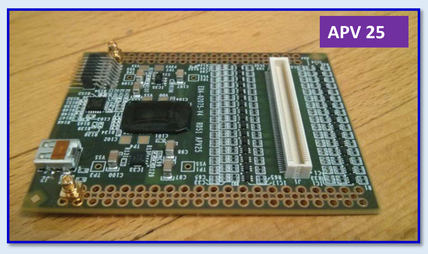
PURPOSE

- **To avoid the effect of inevitable discharges on the delicate front end electronics**
- **To avoid dead times after an occasional discharge**

Read out system and DAQ to study the prototype

Hardware: collecting and processing the signals by RD51-SRS

- Front End based on APV 25 analog chip
- An APV card host one APV25 chip with double diode protection against discharges
- Each chip reads 128 channels at a 40 MHz frequency (25ns)
- 8 APV cards are used for the prototype studies, for a total of 1024 channels
- Analog data is sent via HDMI cables to the ADC card managed by the FPGA.
- Data is sent using the UDP protocol via the Ethernet port to the PC for the data collection and storage

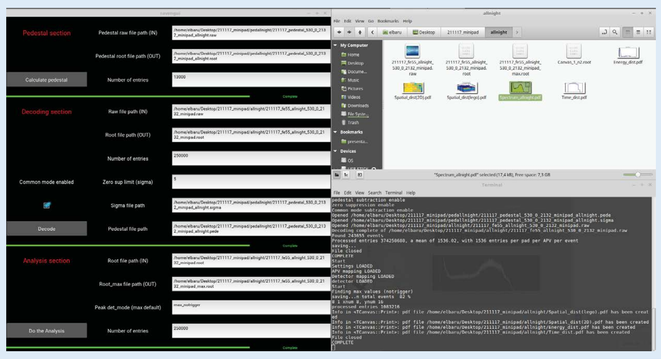


Software: RAVEN DAQ

Raven DAQ: An original DAQ system developed in Trieste for SRS

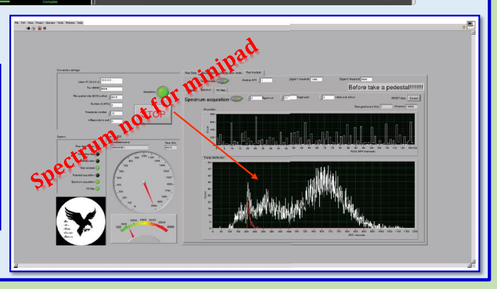
- **LabView based** novel DAQ Raven system has been developed to control the data acquisition and to increase the acquisition trigger rate
- The settings of the APV25 chips and their configuration is performed via Raven
- **Fast data processing** (nearly online collected data)
- RavenDAQ takes care of **Pedestal Subtraction** (noise filtering) and **Zero Suppression** (separating physics data and meaningless data)
- **RAVEN is enriched with extremely user friendly graphical interface**

Software: RAVEN Code



The data are handled offline by RavenCode (C++ and ROOT interface) in 3 steps

1. **RavenPedestal**
2. **RavenDecoder**
3. **RavenAnalyzer**



Experimental data and observations

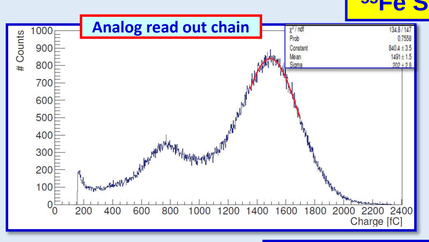
Good Spectra

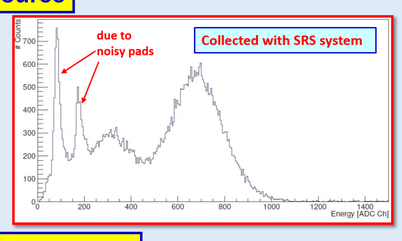
- **Gas used: Ar:CO_2=70:30**

Analog read out chain
HVPS: CAEN N1471H
Software for HVPS: GECO 2020
PreAmplifier: CREMAT CR110
Amplifier: ORTEC 672
MCA: AMPTEK 8000A

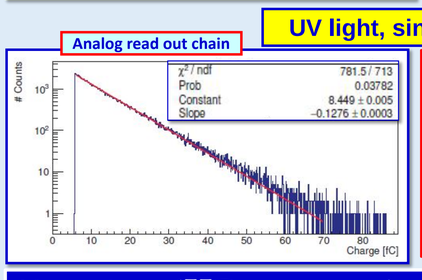
Drift-top1-bot1-top2-bot2-mesh-anode: −3200, −2600, −1700, −1300, −300, 0, +400 V

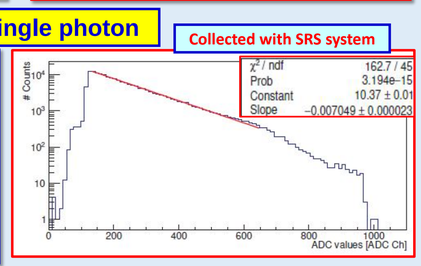
^{55}Fe Source





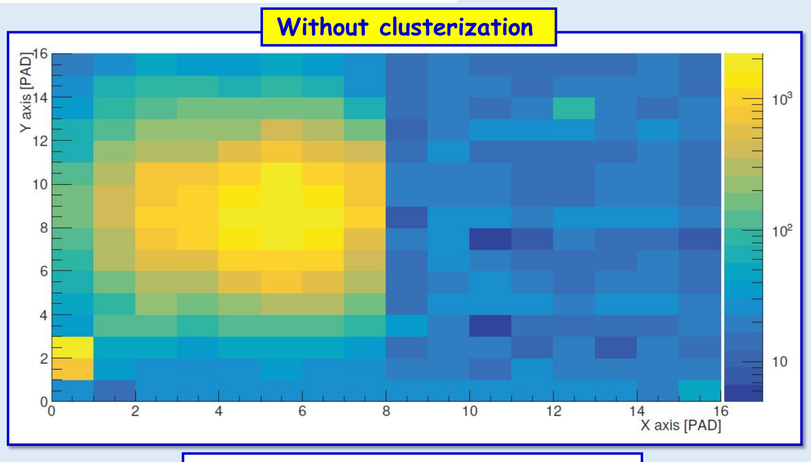
UV light, single photon





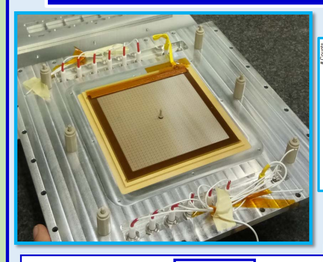
Mapping (^{55}Fe source)

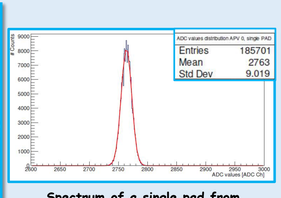
Without clusterization



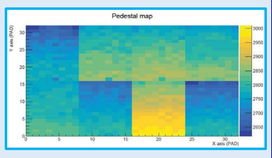
- ✓ Acquisition is from **two APVs**, the trigger is set only on the right APV

Characterization of the minipad hybrid PD





Spectrum of a single pad from a single APV pedestal data



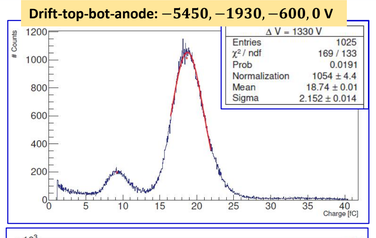
Hitmap of the pedestal using 8 APV (total working area)

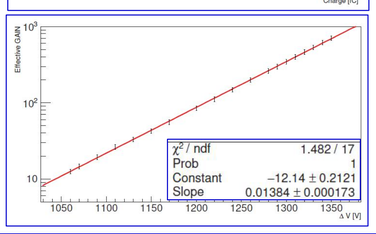
Analog read out chain

THGEM

- ✓ Area: (100 x 100) sq. mm
- ✓ ^{55}Fe source
- ✓ Thickness: 0.4 mm, pitch: 0.8 mm, hole diameter: 0.4 mm, No Rim
- ✓ All pads

Drift-top-bot-anode: −5450, −1930, −600, 0 V

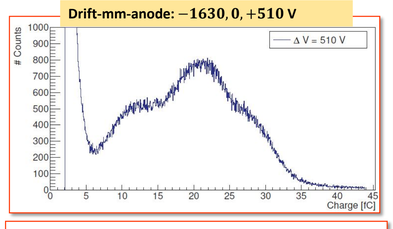


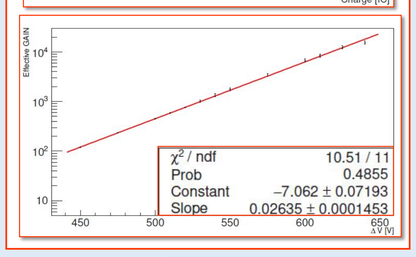


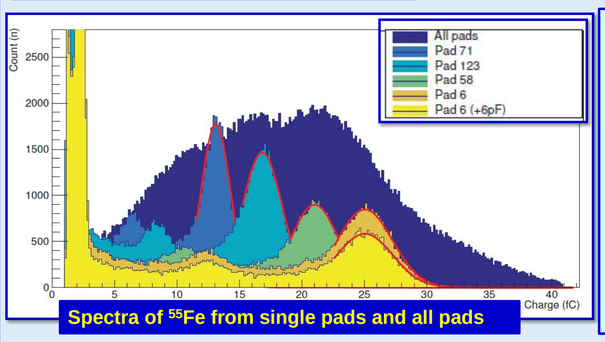
Micromegas

- ✓ Area: (100 x 100) sq. mm
- ✓ ^{55}Fe source
- ✓ 18 μm wires, 63 mm pitch
- ✓ All pads

Drift-mm-anode: −1630, 0, +510 V







Spectra of ^{55}Fe from single pads and all pads

- **The non-uniformity in observed amplitude is due to parasitic capacitance in the first version of the anode PCB. A new version is being produced**

Conclusions

1. In order to meet the challenging PID requirements from EIC detectors, a new MPGD-based photon detector is being developed
2. It consists of two THGEM layers and one Micromegas with **highly segmented anode** (square pads each of size 3x3 mm²)
3. A **first prototype** has been built and tested in laboratory: good stability and bad uniformity because of the parasitic capacitance in the read out PCB
4. An original DAQ system (**RAVEN DAQ**) has been developed for the SRS acquisition: **it has an extremely user friendly GUI** and allows for **fast and efficient data collection and reconstruction**

THE COLLABORATION

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PM2018 - 14th Pisa Meeting on Advanced Detectors at La Biodola, Isola d'Elba (Italy)