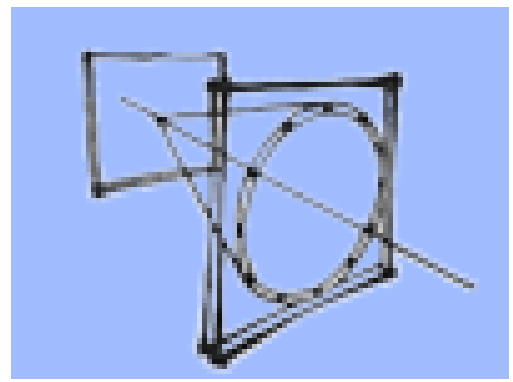
eRD6: PID detector R&D towards an EIC detector

S. Dalla Torre

(on behalf of the Trieste-EIC group)



R&D MOTIVATION: h-PID @ HIGH p 1/2

What is needed at high p at EIC:

- Gaseous radiator
- Focusing system (mirrors)
- Wide phase space acceptance

Poor worldwide panorama

- Presently only 2 running high-p & wide acceptance RICHes:
  - COMPASS
  - LHCb (2-counter system)
- Further future projects:
  - EIC
  - Empowering the physics reach at CpeC (not presently in the project baseline)

The challenges at EIC (and, in general, at colliders with hermetic experimental setup):

- Short radiator (No more than 1 m-long radiator at EIC)
  - *More detected photons per radiator unit length, increased space resolution*
- Presence of magnetic field
  - *A wide family of PDs excluded*

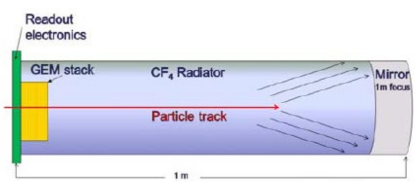
R&D MOTIVATION: h-PID @ HIGH p 2/2

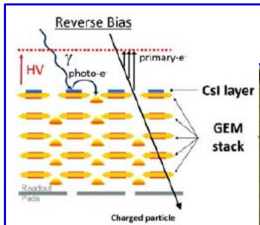
Options to match the quest:

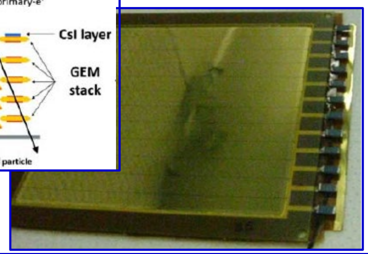
1. Windowless RICH

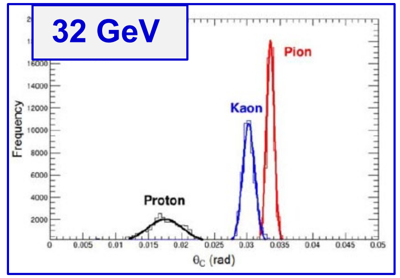
CF_4 windowless RICH concept, test-beam results

M. Blatnik et al., IEEE NS 62 (2015) 3256

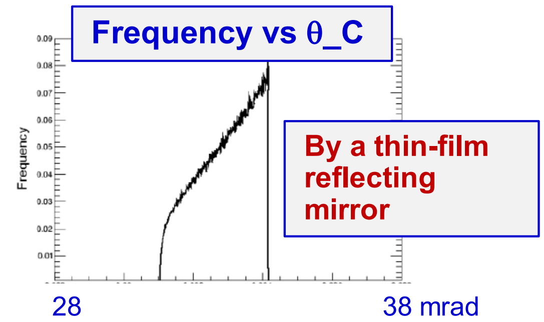








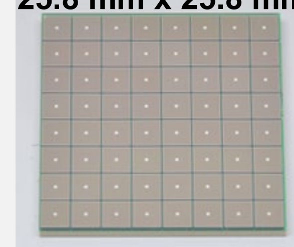
Pad-size ~ 5 mm, n_det_ph.s : 10



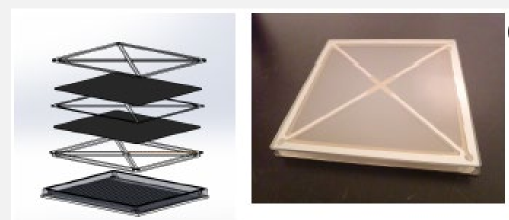
"Cheap" photon detectors, delicate FE, expensive mirrors, challenging radiator gas transparency

2. Photon detectors in the visible light (wide range) B-tolerant

25.8 mm x 25.8 mm



- **2 realistic possibilities**
  - **Hamamatsu MCCP arrays**
    - **But noise rate : 1.8 M counts/ m^2 in a time window of 10 ns**
  - **LAPPDs**
    - **But are they reasonable mature ?**
    - **In particular the second version, where pads can be used (pads is a MUST)?**



Costs: 0.5-0.8 M$ / m^2

OUR STRATEGY

1. Windowless RICH

- **Make use of our experience with COMPASS RICH to advance with MPGD-based PDs adequate for the Windowless RICH approach**

- ***This is our activity within eRD6 (discussed in this talk)***

2. Visible light photon detectors

- **Start getting some experience with the mentioned photon detectors**

- ***A proposal for AIDA++ (European project) in preparation together with partners: INFN-Trieste, INFN-Bari, Charles University, USTC, INCOM (mentioned for complete information)***

Expression of Interest for participating in the

H2020 Innovation Pilot on detector technologies at accelerators

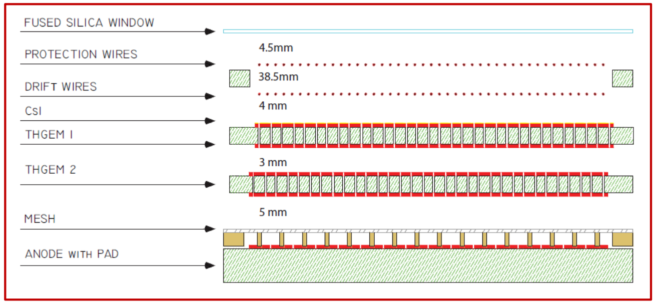
Title: ***Photon detectors for hadron particle identification at high momenta with compact RICHes***

Keywords: *PID, gaseous RICH, single photon detectors*

THE MINIPAD PROTOTYPE

The starting point

COMPASS MPGD PDs



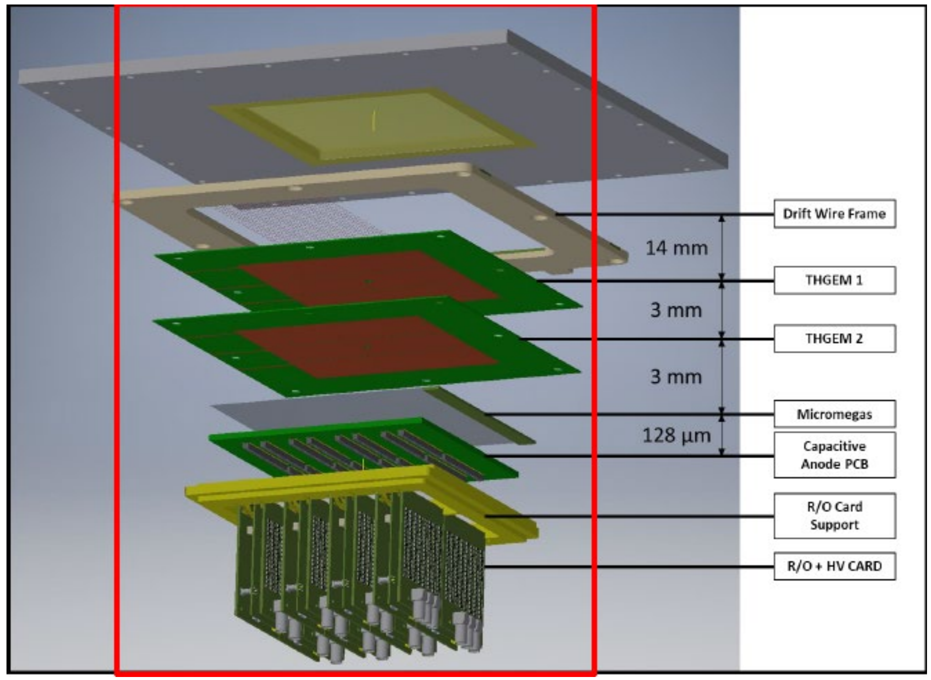
Some key parameters

- **Pad size 8 mm x 8 mm**
- **Current spark rate: ~1 h / 1.5 m^2**
- **Recovery time after a spark ~ 10 s**
- **Noise level < 900 e- equivalent**
  APV25 with extremely accurate FE boards
- **Gain ~ 14 k**
- **10 detected ph.s per ring at saturation**
- **Time resolution ~ 14 ns**

GOAL of the prototype:

increased space resolution

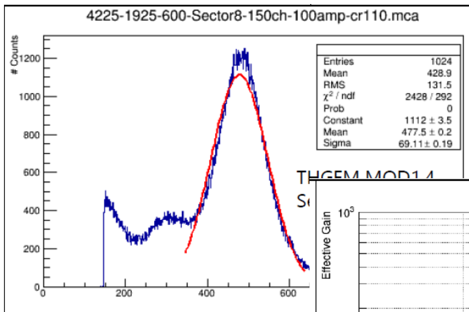
- **Pad size 8 mm x 8 mm → 3 mm x 3 mm (pitch 3.5 mm)**
- **To preserve the expandability of the detector size**
  → all services in the same area of the active pads (very dense connectors)

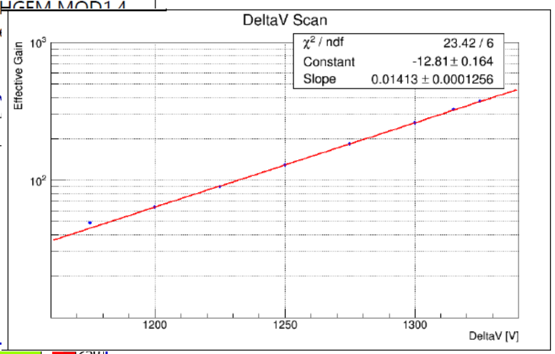


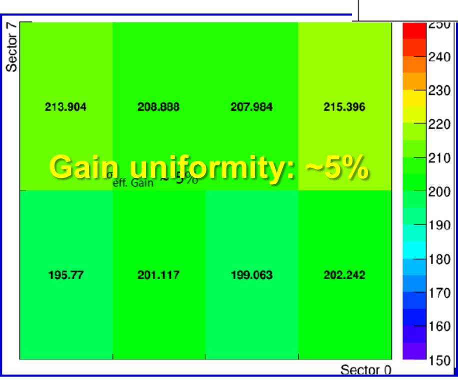
CAREFUL PREPARATION

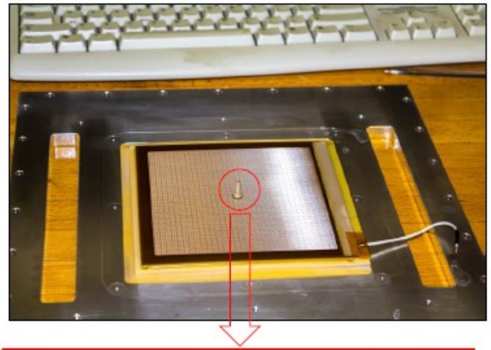
THGEM post-production treatment

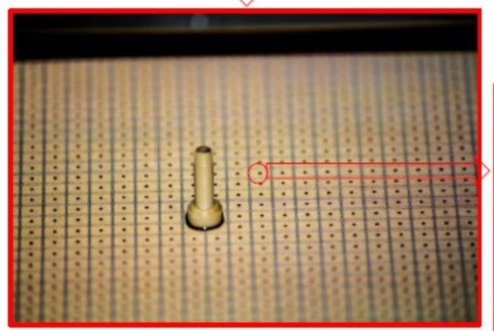
THGEM tested, Stand alone

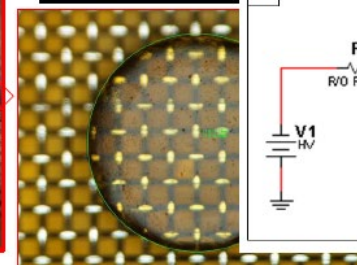




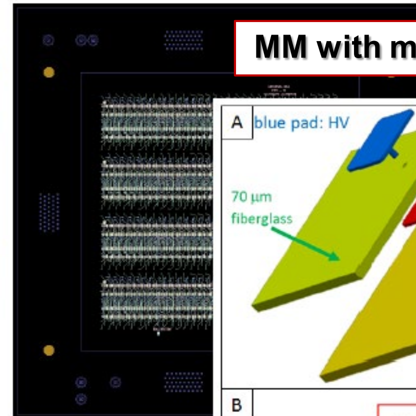


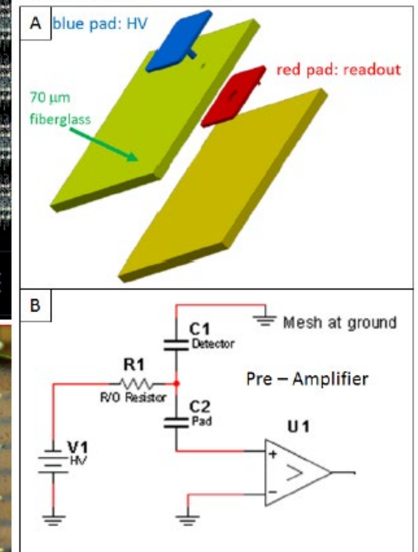


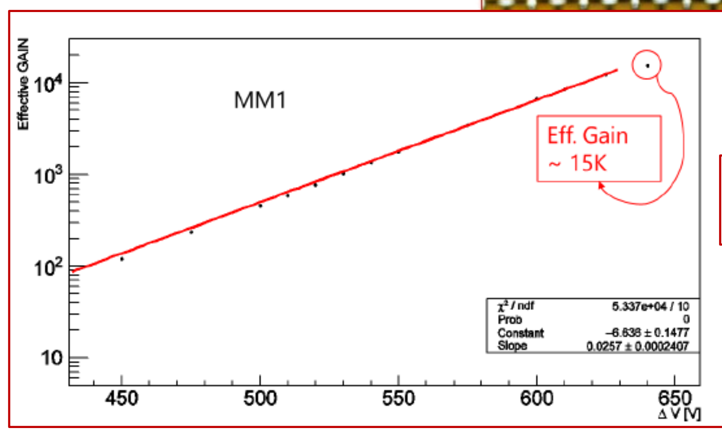




MM with miniPADs

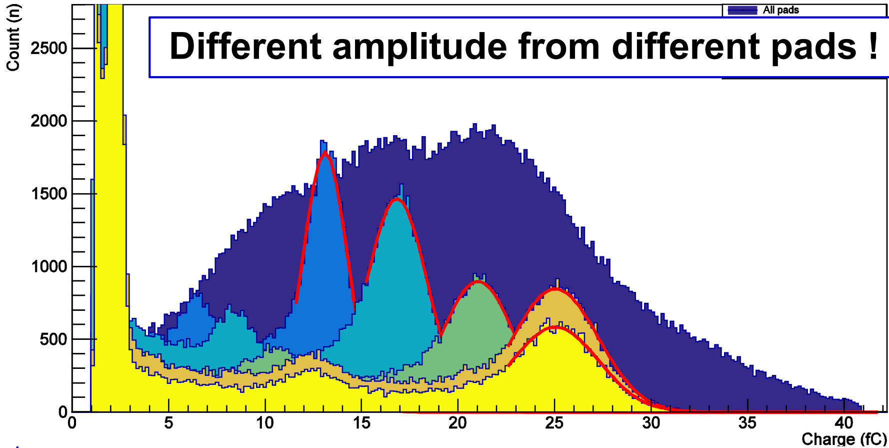






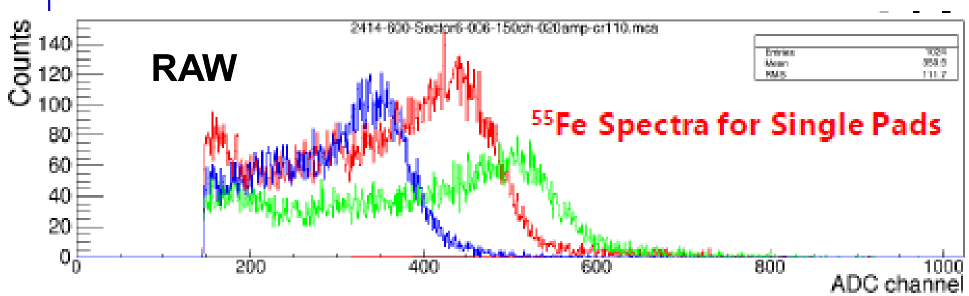
MM tested, Stand alone

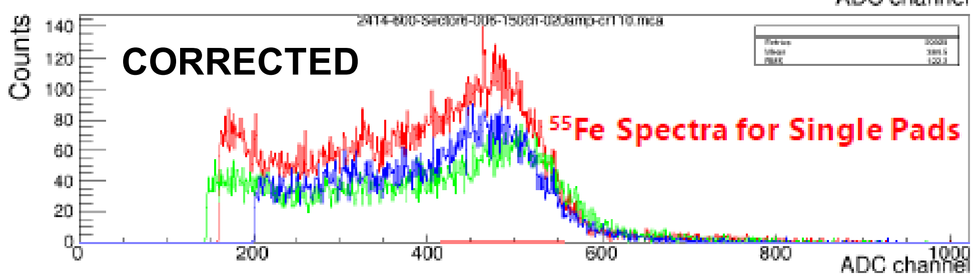
NON-OPTIMIZED ANODE PCB LAYOUT



Different amplitude from different pads !

Different capacity affecting the signal line:
Amplitude uniformity recovered correcting for C

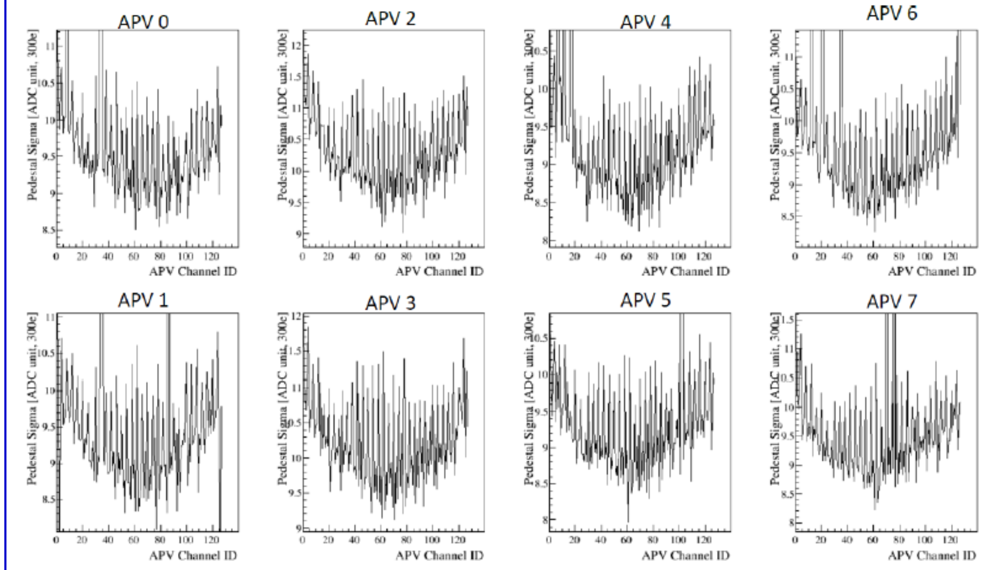




The PCB layout is the same for each group of 128 pads:

The noise pattern reproduced for the various groups is a further confirmation

noise pattern for the eight 128-channel groups

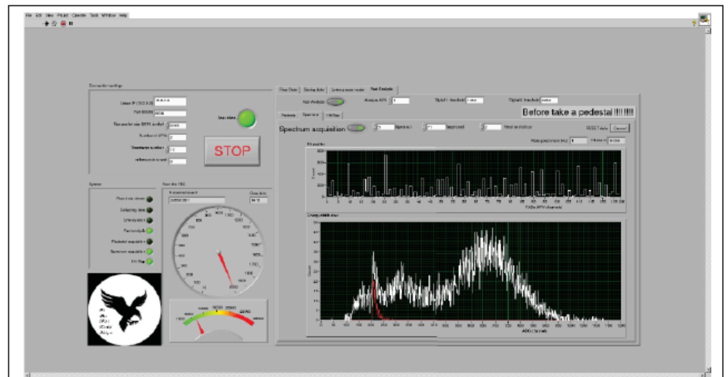


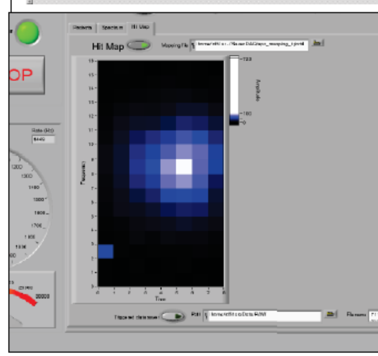
Typical noise level : σ~3300 e-
(COMPASS RICH: σ~900 e-)

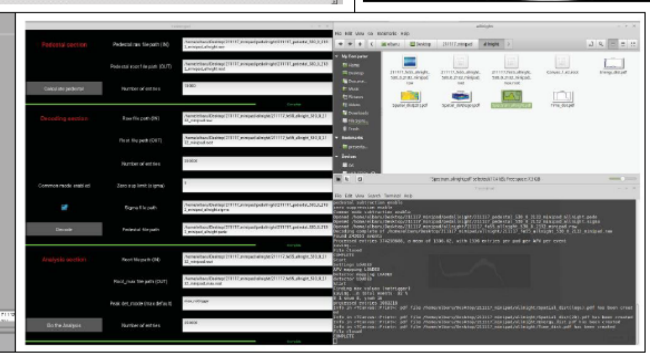
READ-OUT & DAQ

- **Read-out system : SRS (from RD51)**
- **FE chip: APV25**

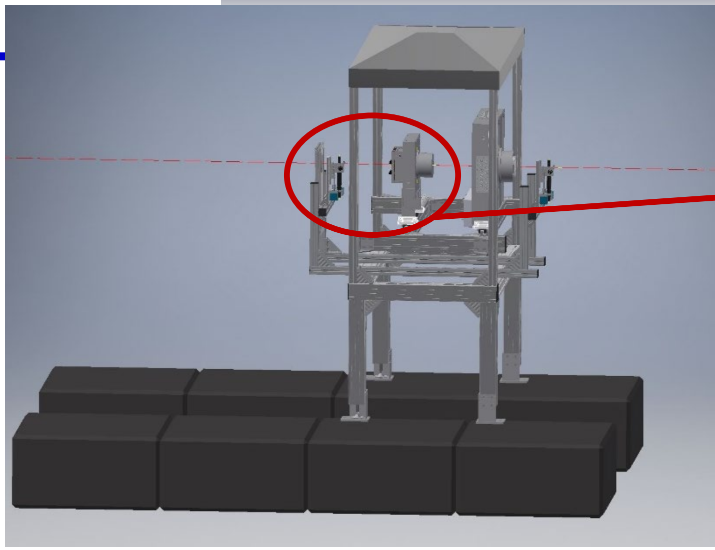
- **DAQ: RAVEN, an original system developed for these studies**
  - LabVIEW-based
  - Includes Decoder and on-line analysis tools (pedestal, subtraction, hit maps, spectra)
  - User-friendly via GUIs
  - Used for 1 k ch.s, extendable
  - Good rate capability: For single APV can handle up to 10 kHz

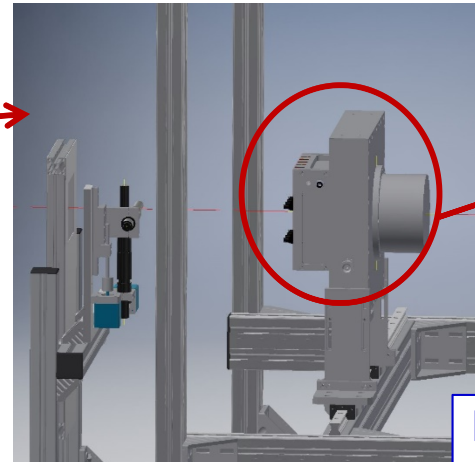


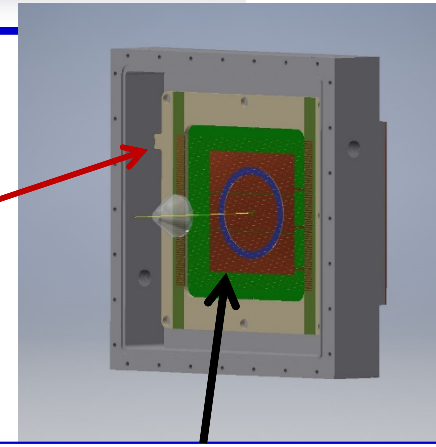




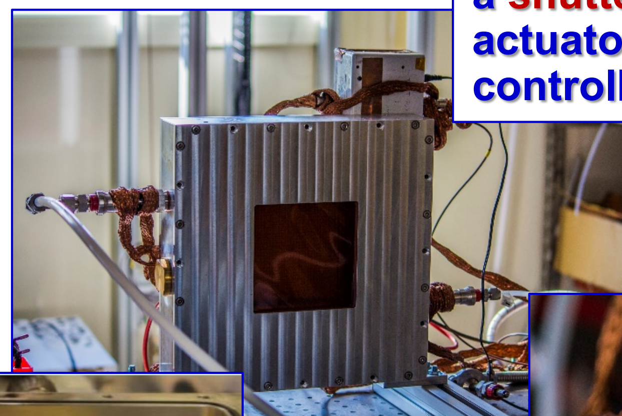
TEST BEAM: OCT-NOV 2018

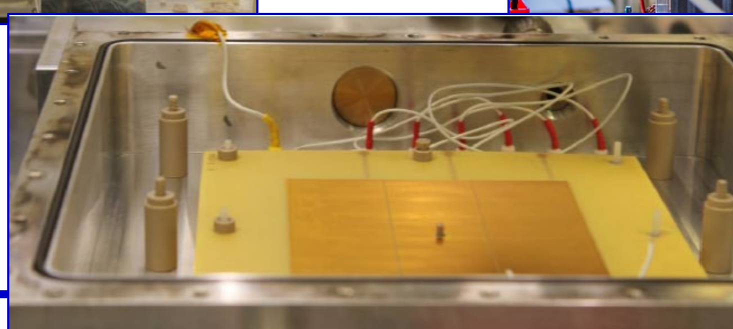


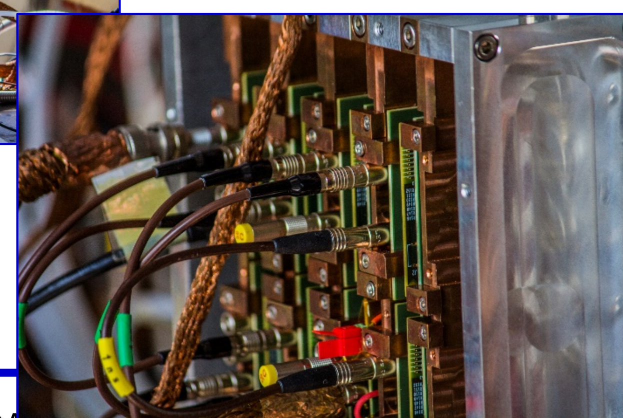




Between radiator and detector, a **shutter (iris)** with piezoelectric actuator, controlled from remote



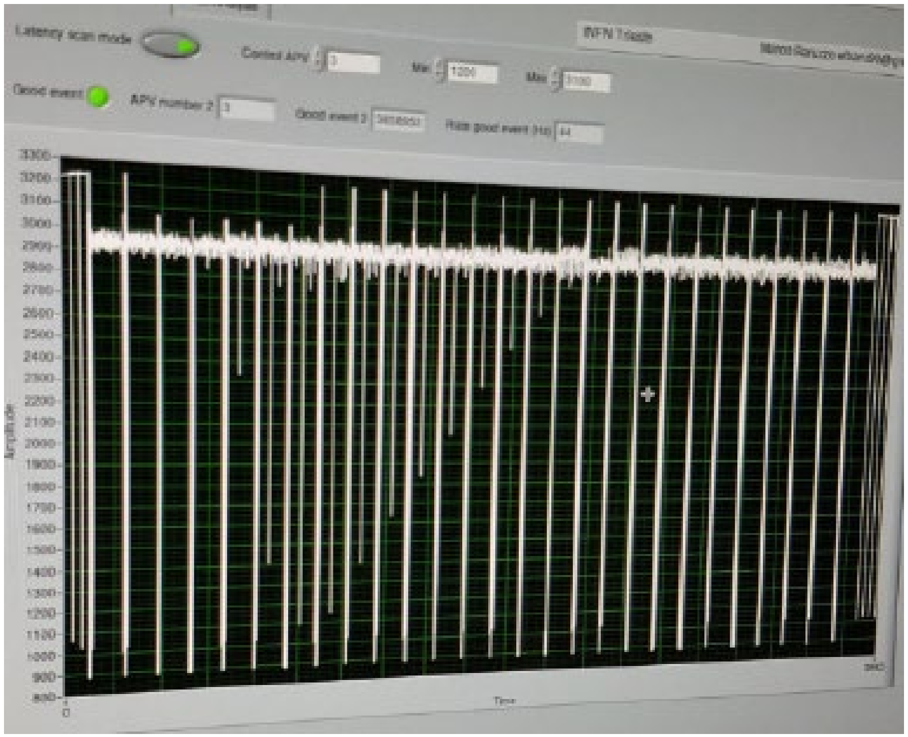


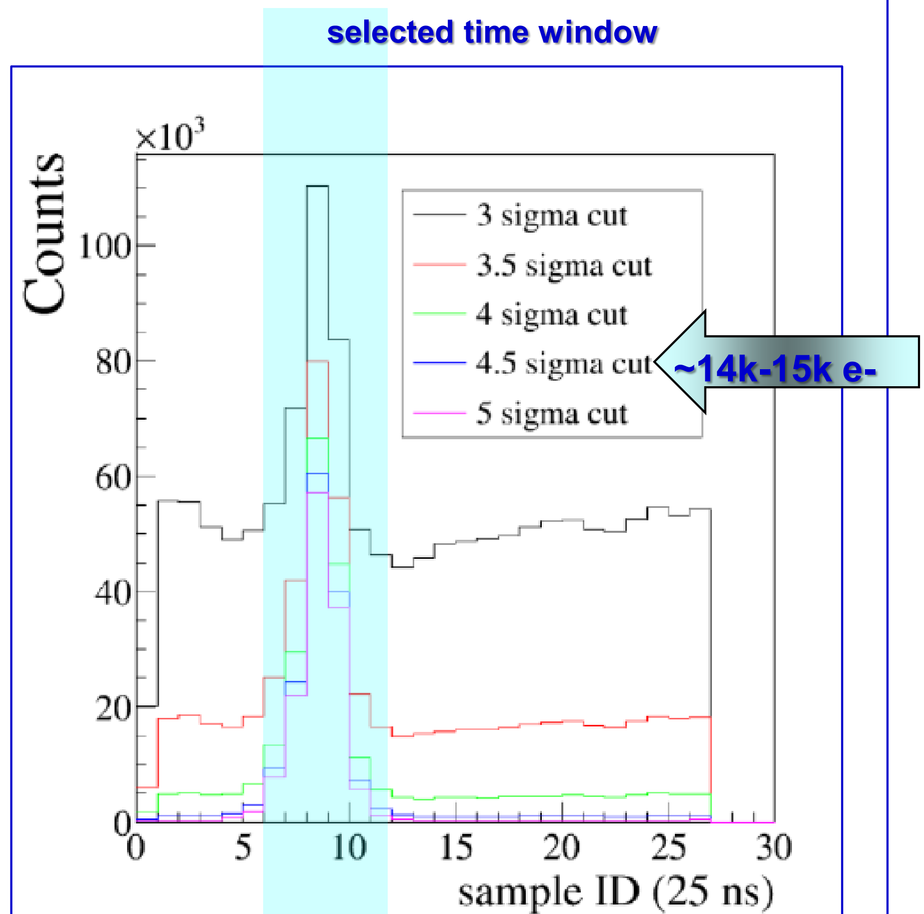


TEST BEAM DATA ANALYSIS

Ar : CH_4 = 50 : 50

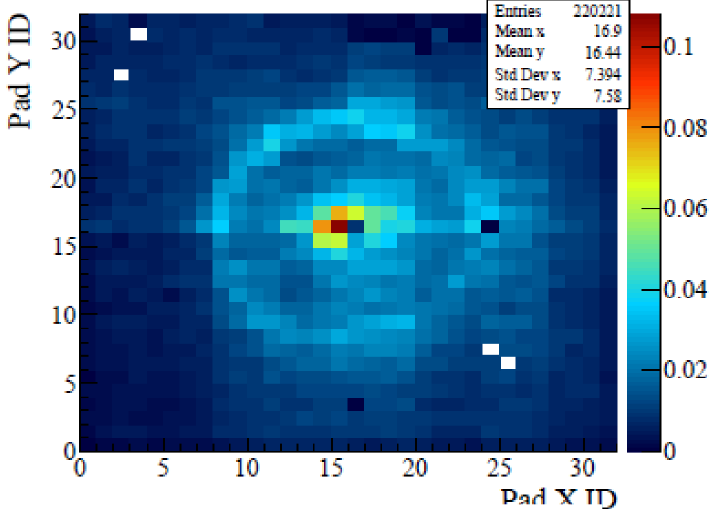
(analysis of pure CH_4 data ongoing)



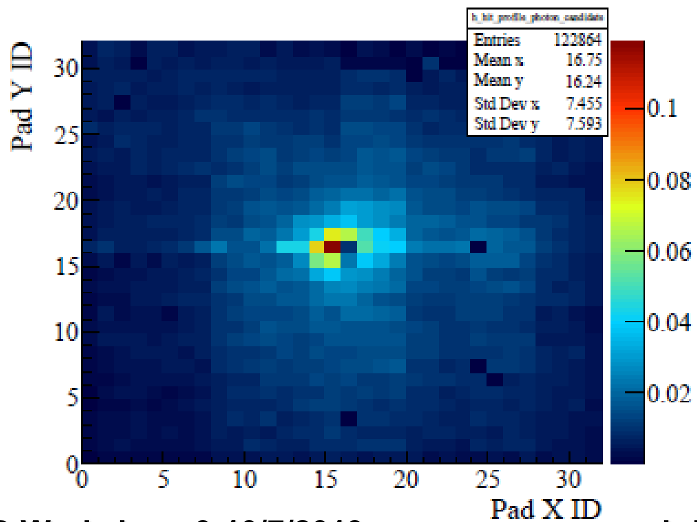


TEST BEAM DATA ANALYSIS, cont.

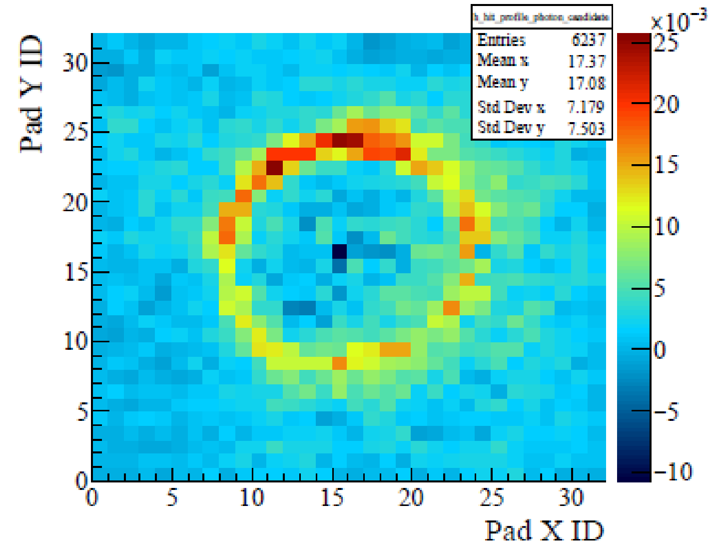
Iris open



Iris closed



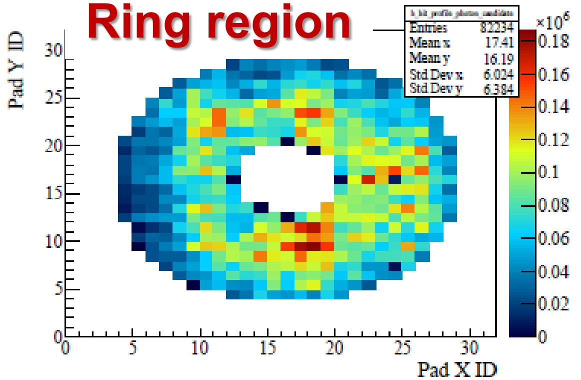
Open – close
(same number of events)



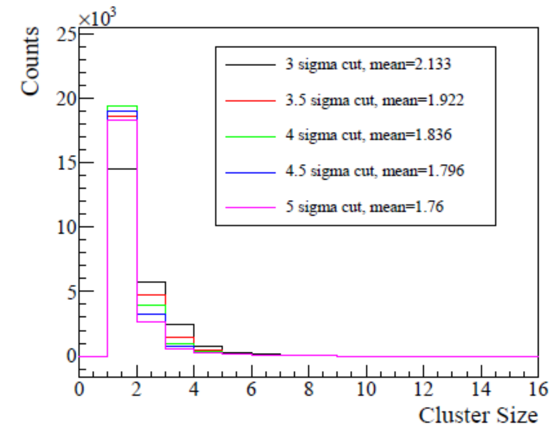
TEST BEAM DATA ANALYSIS, cont.

One more geographical cut:

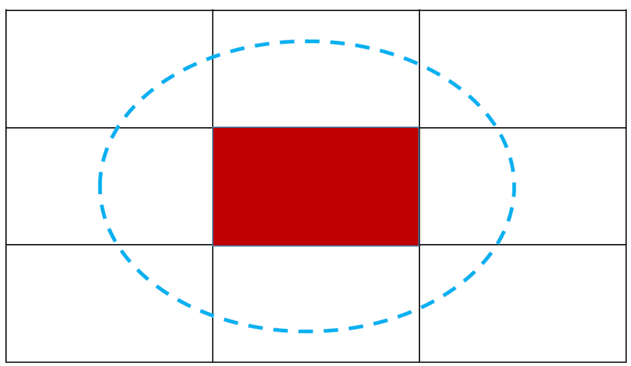
Ring region



Open – close
Cluster size

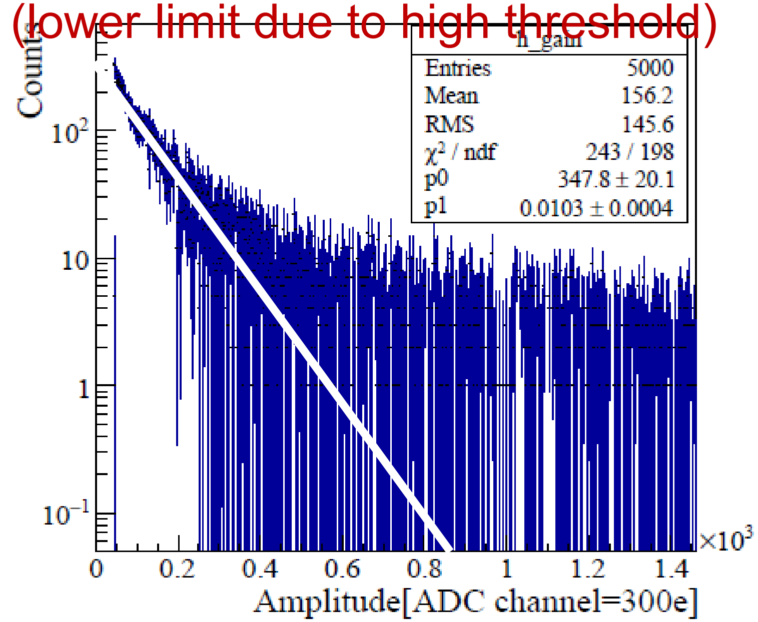


Clustering



Including all surrounding pads with signal above threshold

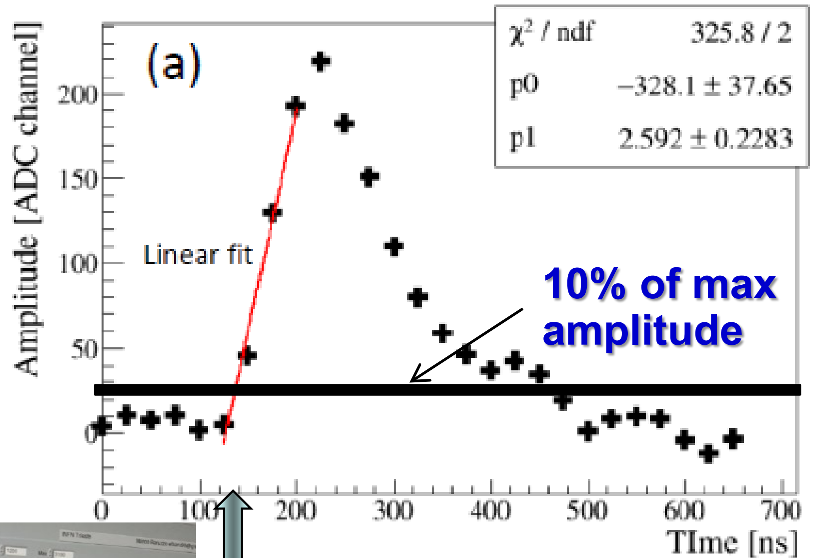
Gain from cluster amplitude : 30 K
(lower limit due to high threshold)



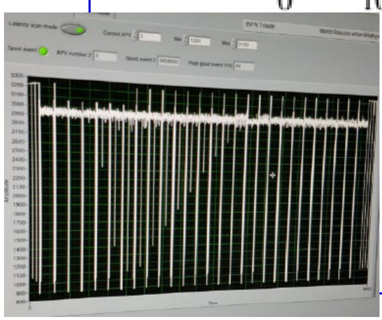
TEST BEAM DATA ANALYSIS, cont.

TIME PERFORMACE

Illustration of the algorithm

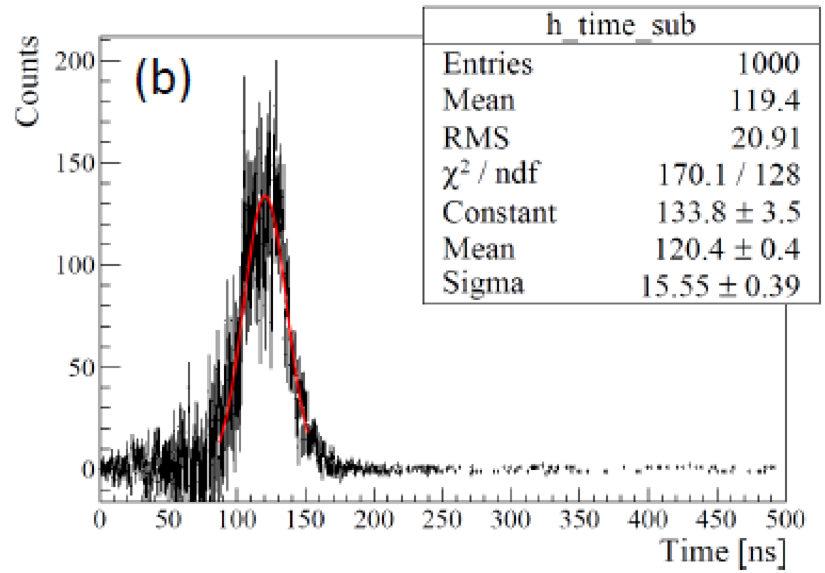


10% of max amplitude



“Photon” t

Time plot



subtracting the trigger time contribution (random in the 25 ns window):

$$\sigma_t = 14 \text{ ns}$$

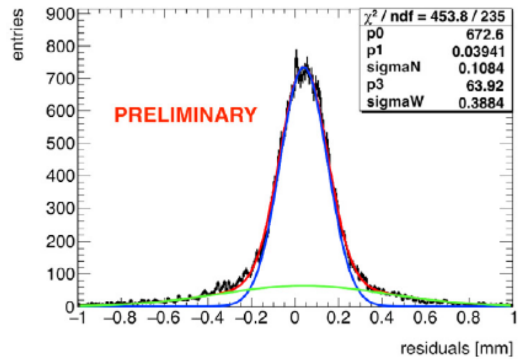
SUMMARIZING

- **First prototype with increased space resolution**
  - **2 critical aspects, both clearly traced and understood :**
    - **Signal lines in the anode PCB layout, C to be equalized**
    - **Non-ideal noise performance with SRS and read-out boards parallel to resistor board**
  - **positive outcomes:**
    - **Single photons clearly detected**
    - **Good gain**
    - **Good time resolution**
    - **Cluster relevance**

NEXT STEPS

- **PROSPECTS**
  - **This pad size is the limit with the present approach**
  - **Try increasing space resolution by resistivity:**
    - Spread the signal over several pads by the resistive layer

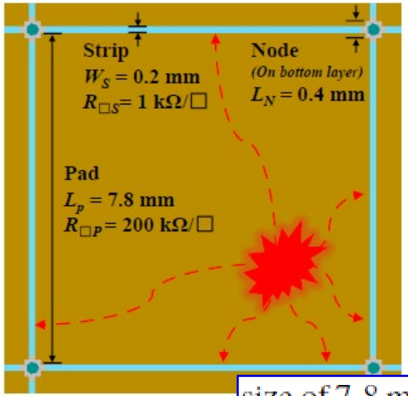
Pad-size: 1 mm
→ resolution ~ 200 μm



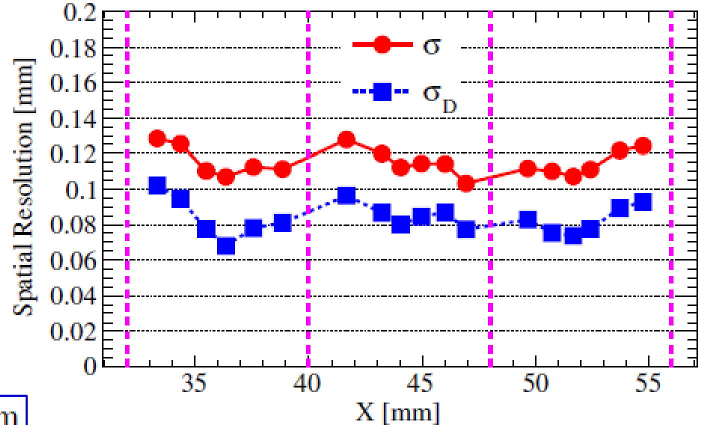
M. Alviggi et al., NIMA 936 (2019) 408.

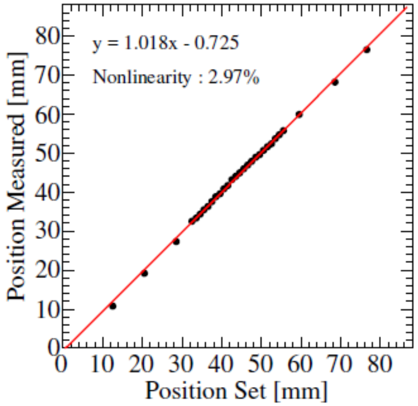
- 4-corner read-out scheme

X. D. Ju et al., JINST 12 (2017) P10008



size of 7.8 mm × 7.8 mm





THANK YOU !