



SAPIENZA
UNIVERSITÀ DI ROMA



CENTRO RICERCHE
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Beam monitor at low intensities for the CNAO XPR

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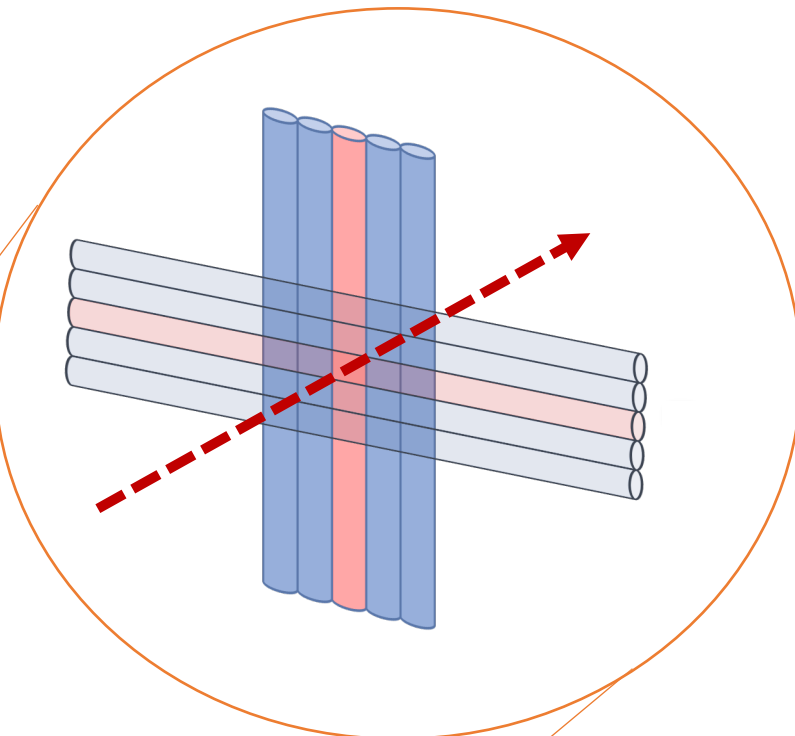
Detector goals

- Beam intensity online monitoring in the XPR in the range from 1Hz up to $\sim 10^5$ Hz)
- Beam position and shape online monitoring in the x-y plane
- Integrated in the slot of the Dose Delivery System and capable to provide particle counters to build “treatment plans” @ low intensity

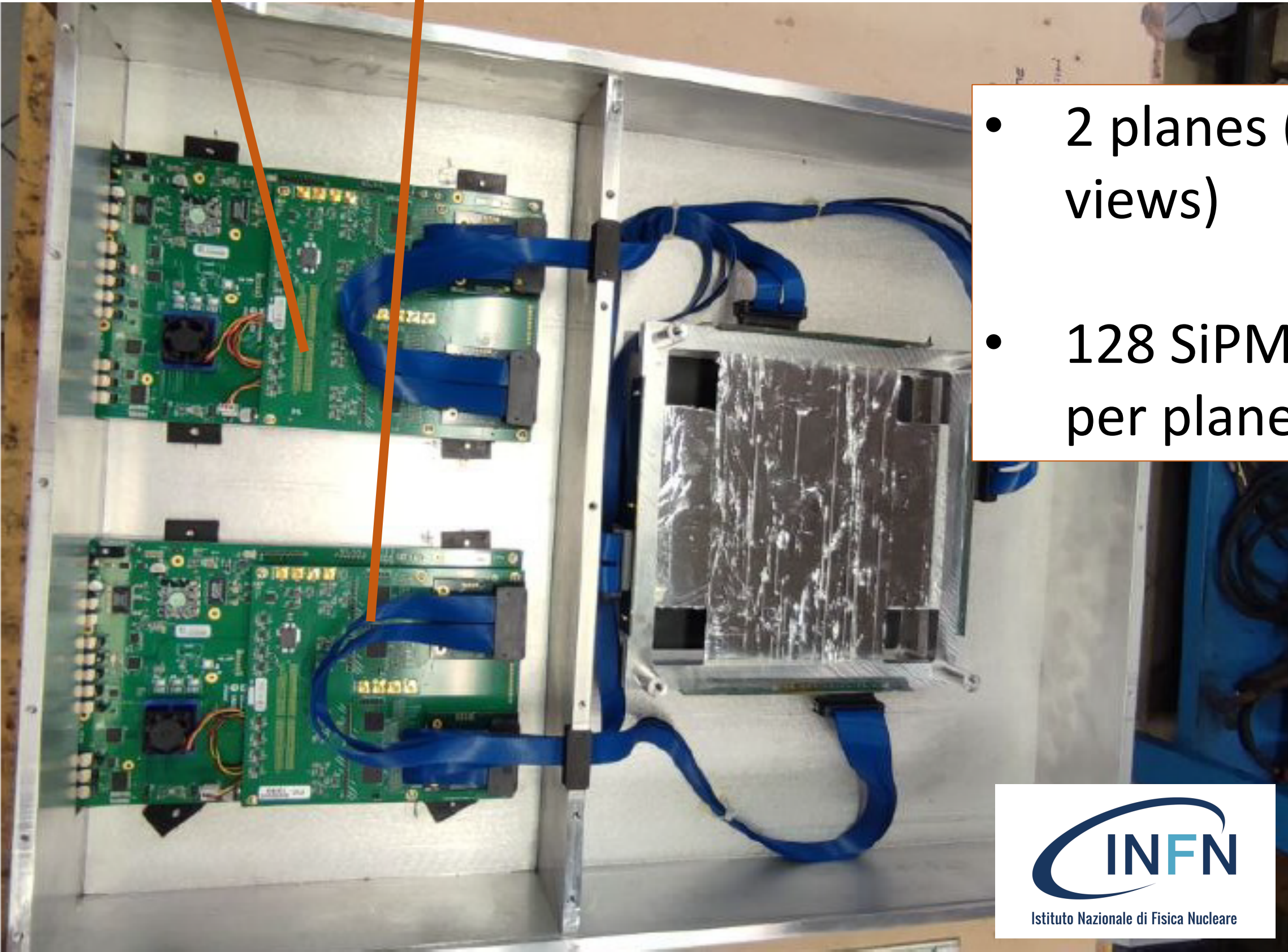


Detector design

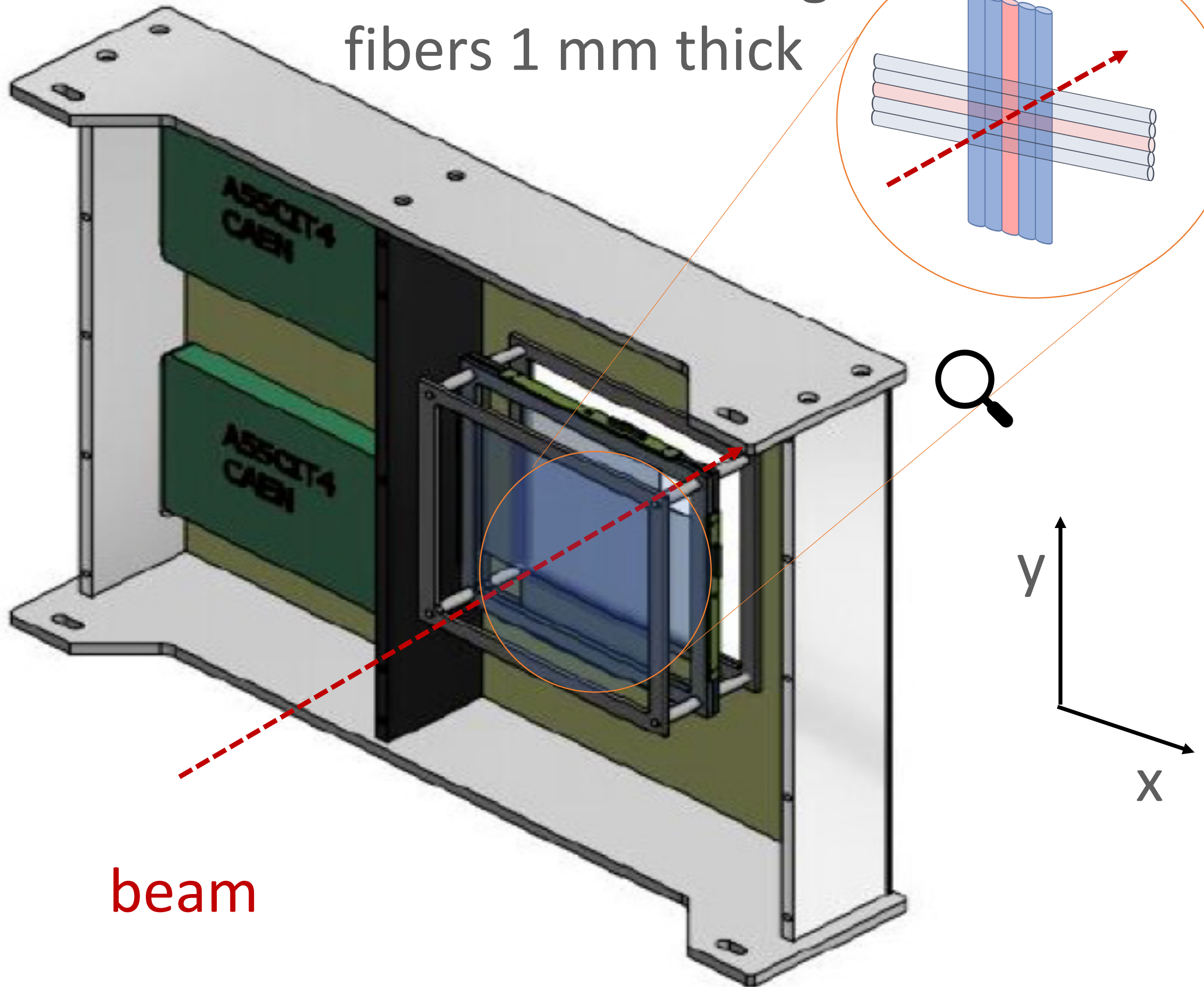
Plastic scintillating fibers 1 mm thick



CAEN DT5550W (CITIROC ASICs for SiPM readout + customizable FPGA)



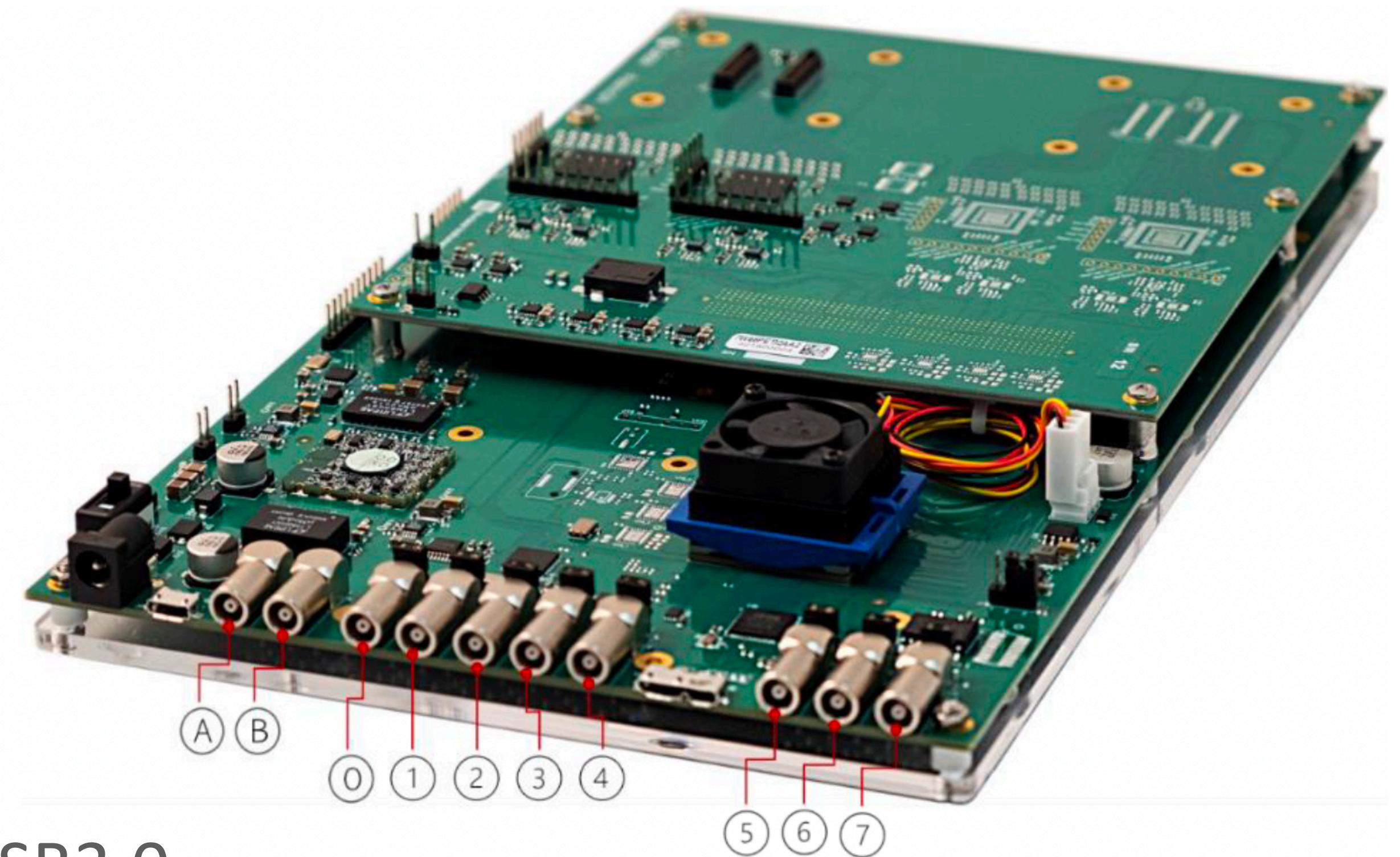
- 2 planes (x-y views)
- 128 SiPM per plane



beam

Read-out system

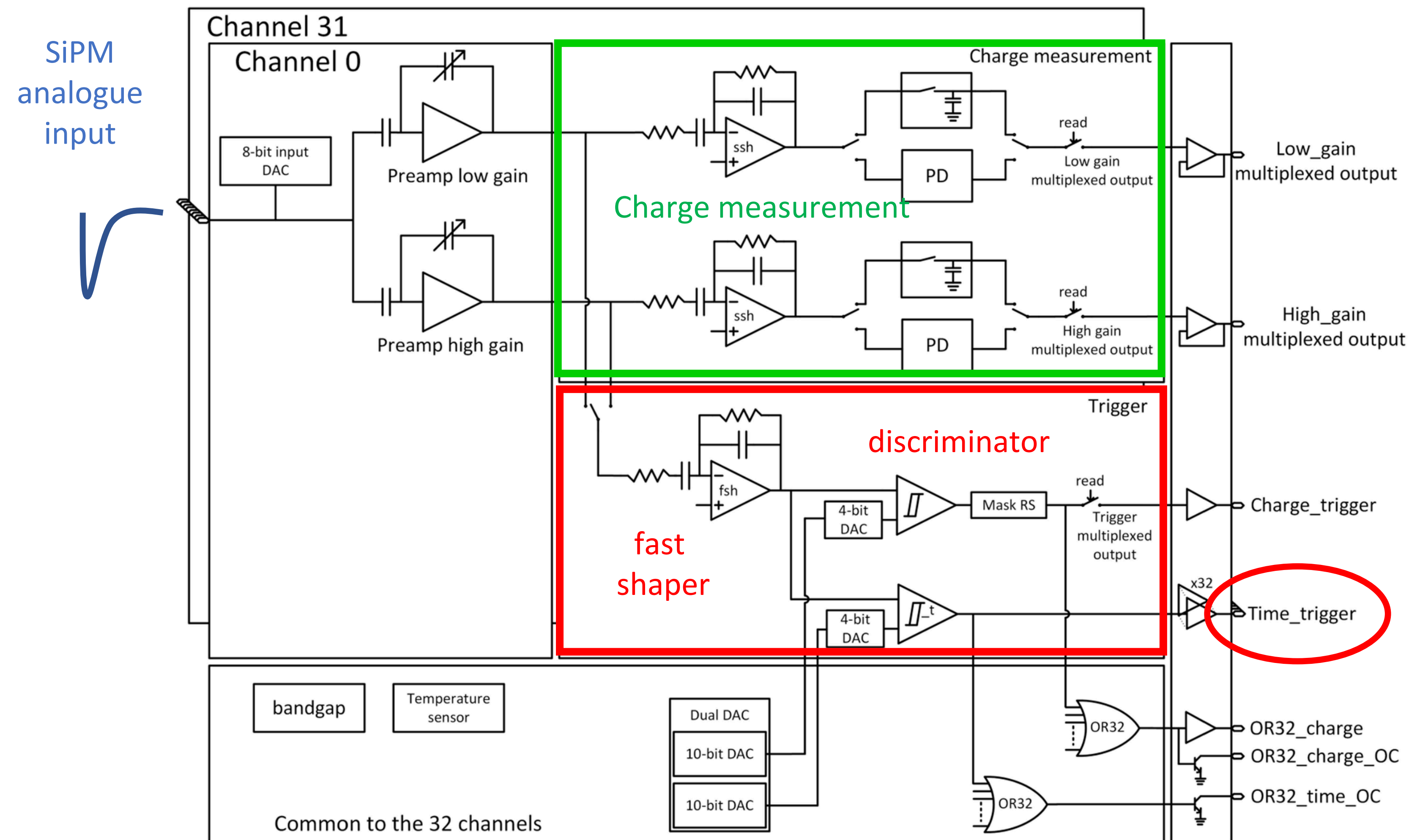
- Highly customizable thanks to the possibility of using a user firmware for the internal FPGA
- DAQ can be operated in two modes:
 - Analogue: event-by-event acquisition, store and transmit the charge of each channel and a timestamp (**used only for detector characterisation**)
 - Counting: periodic acquisition, transfer just the information of internal scalers (**used in standard operation**)



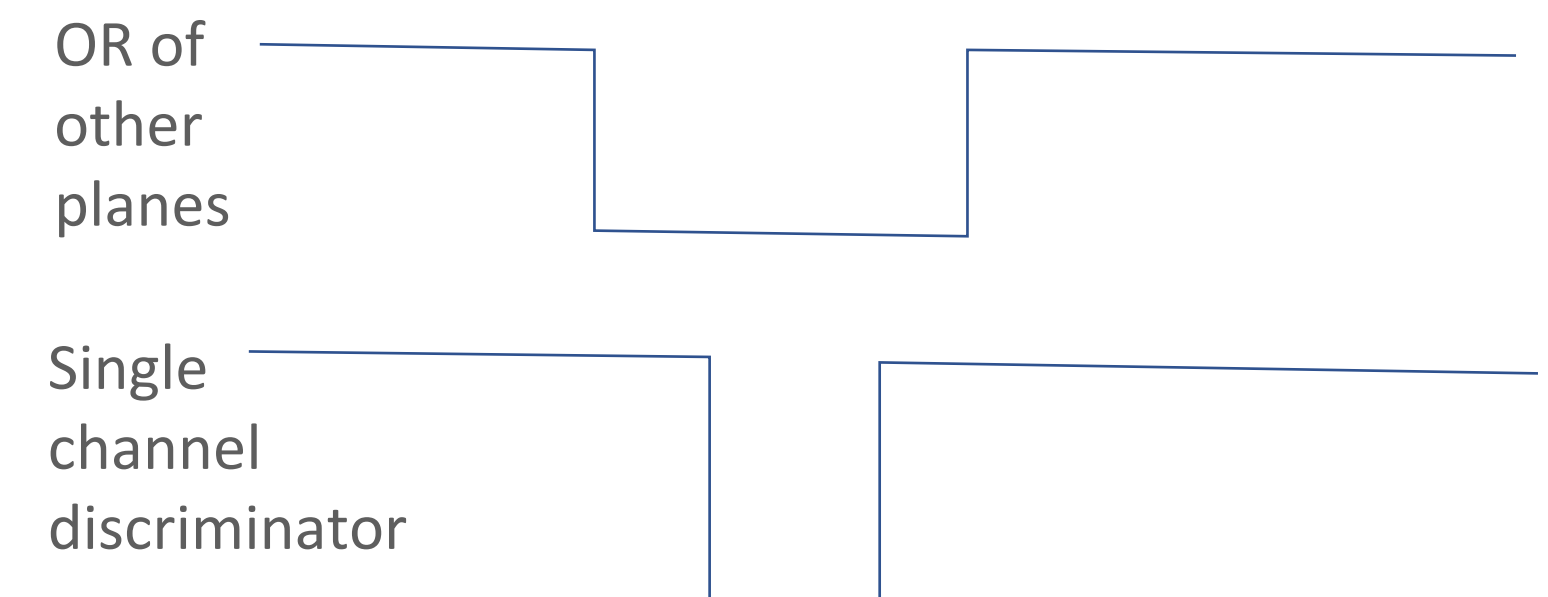
USB3.0
connection to
PC

8 LEMO
I/O

Measurements of beam intensity and position

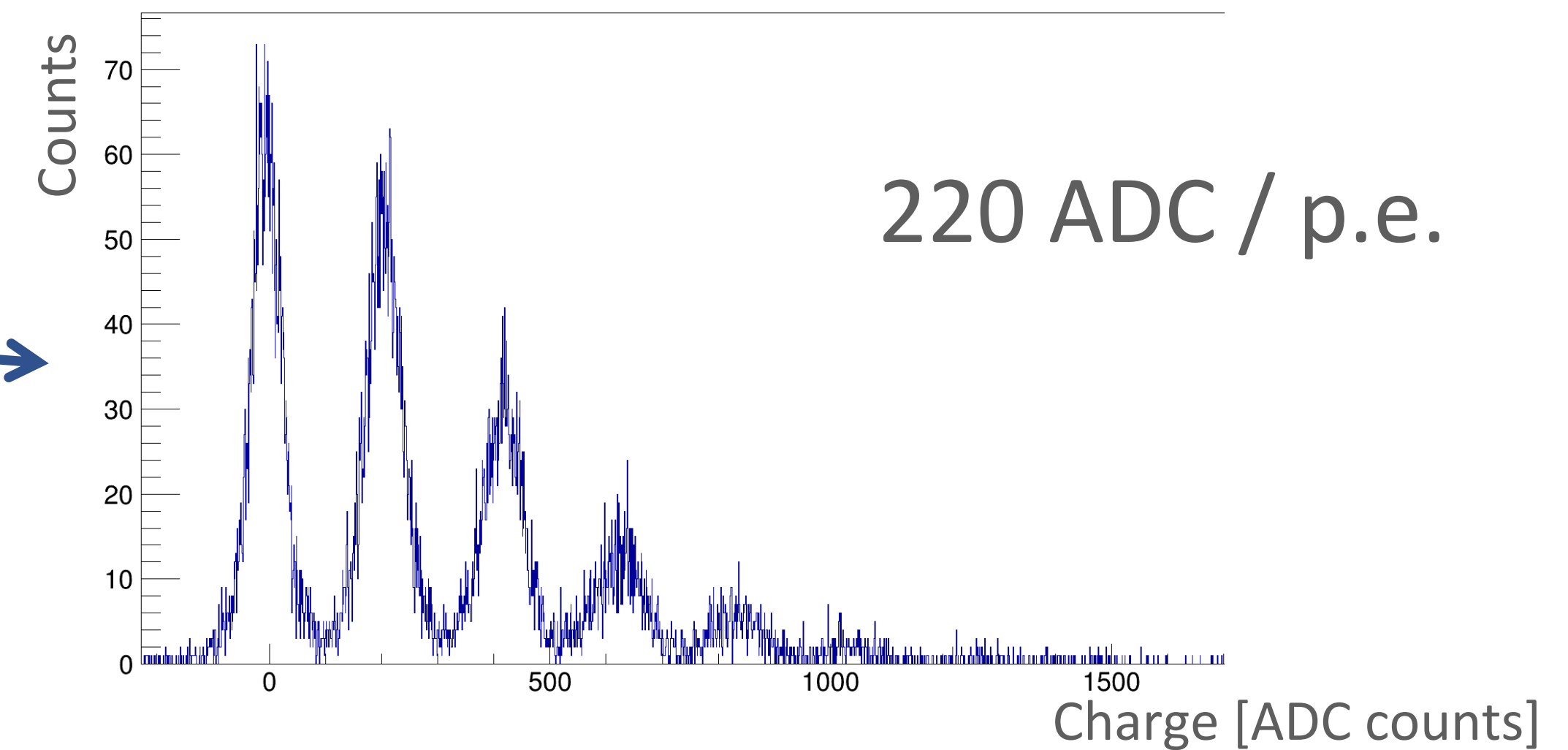


- The CAEN board provides counters of single channels discriminators with a quoted rate capability of 10 Mhz
- To reject the SiPM noise the factory firmware has been upgraded to support **coincidences** between different planes



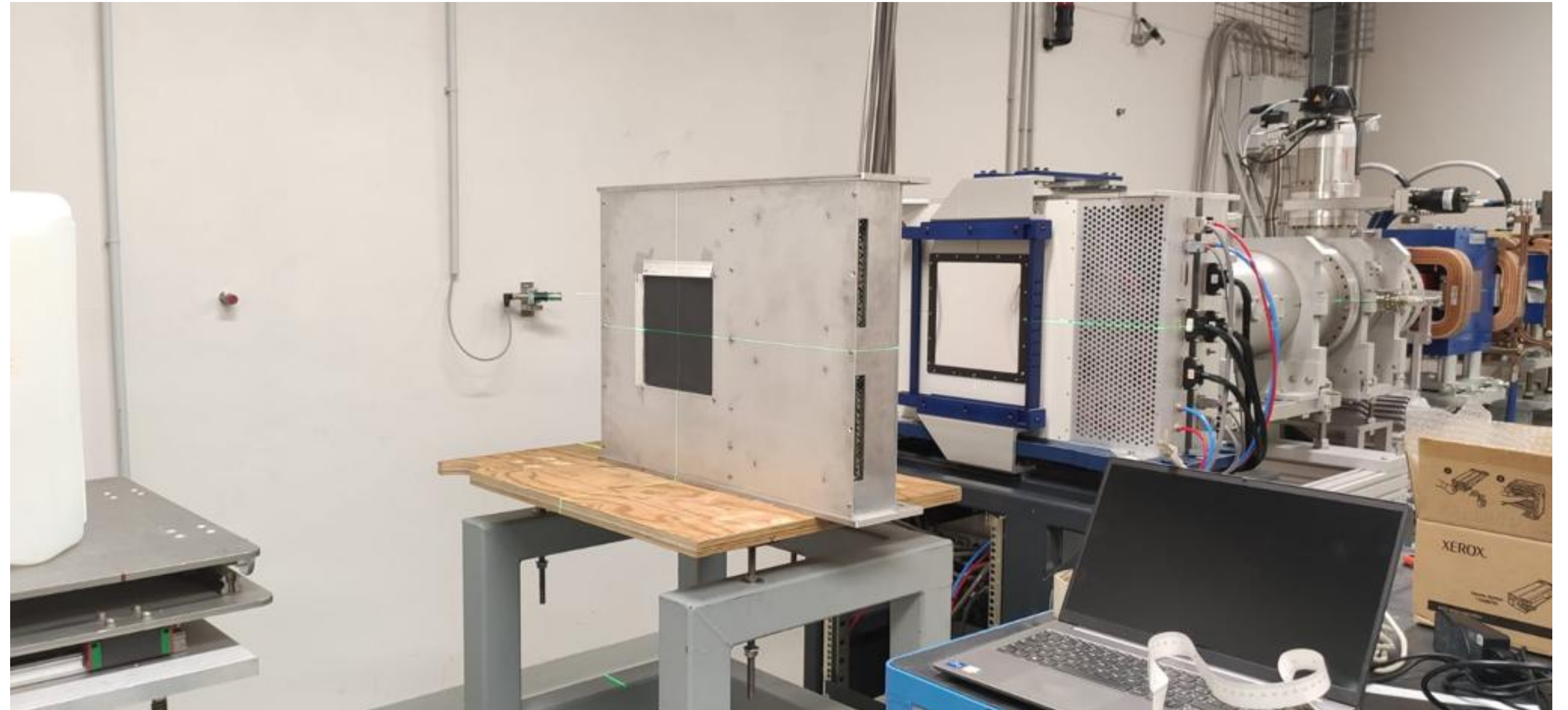
Put in operation of the detector @ SBAI labs

- Channel equalisation with an external **LED**
- Evaluation of the operation conditions (thresholds, gain, SiPM bias voltage) with cosmic rays and ^{90}Sr source
- Development of a GUI for XPR users capable of showing beam intensity and shape as a function of time



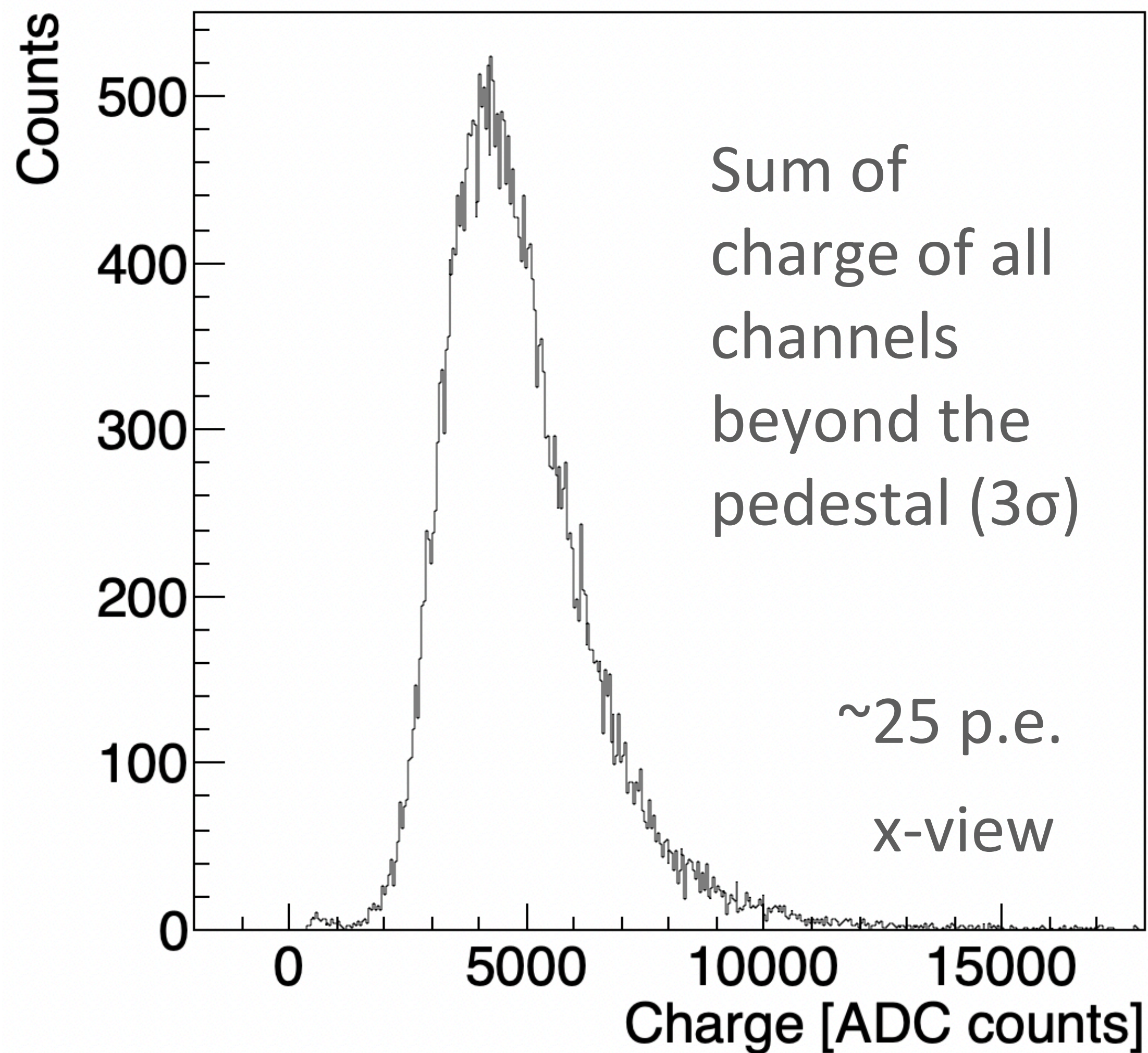
Test @ CNAO

- We performed several test @ XPR with proton and C ion beams at different energies
- Long story concerning the DAQ stability... issues have been solved just in the last test in April

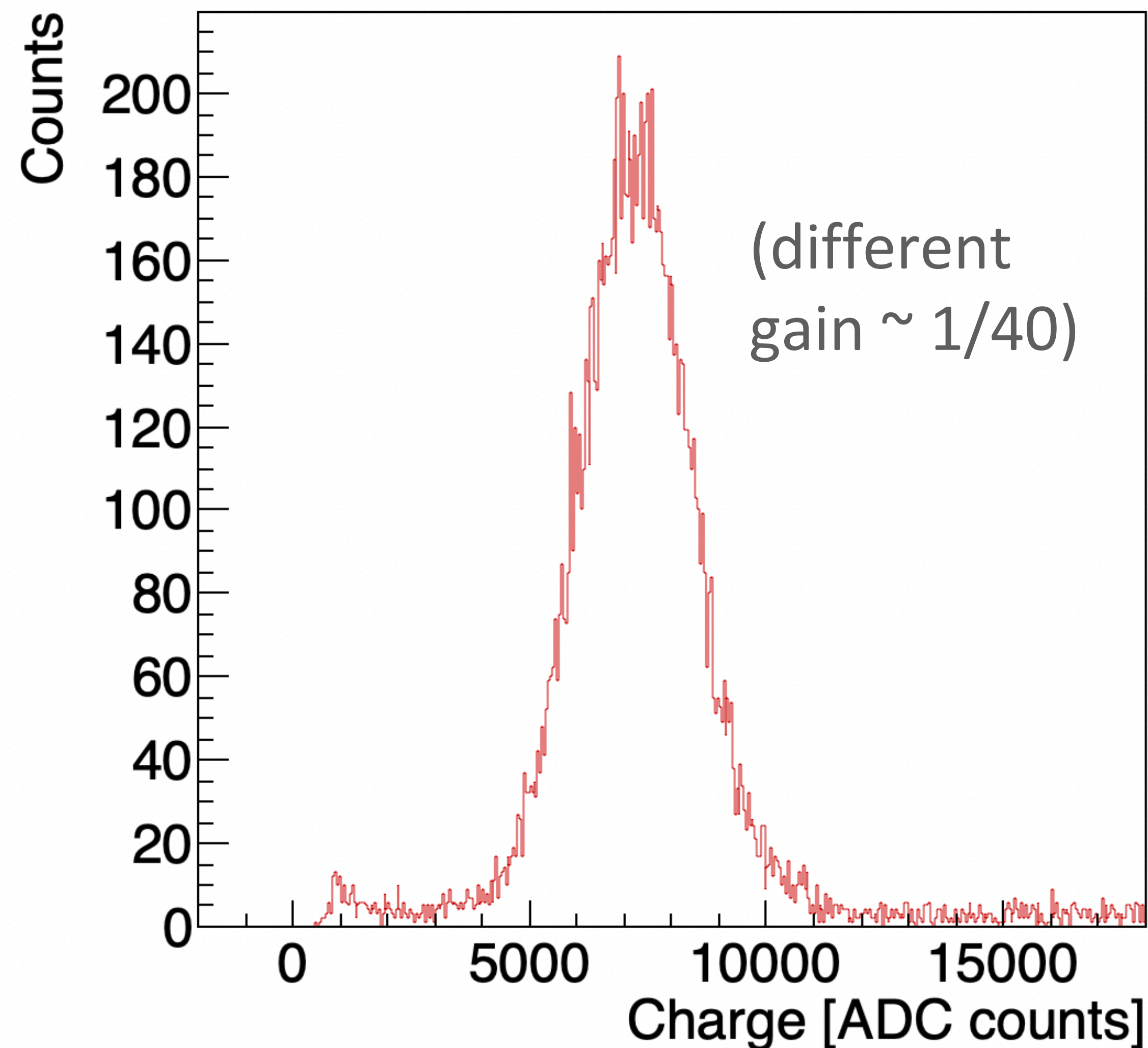


Detector response

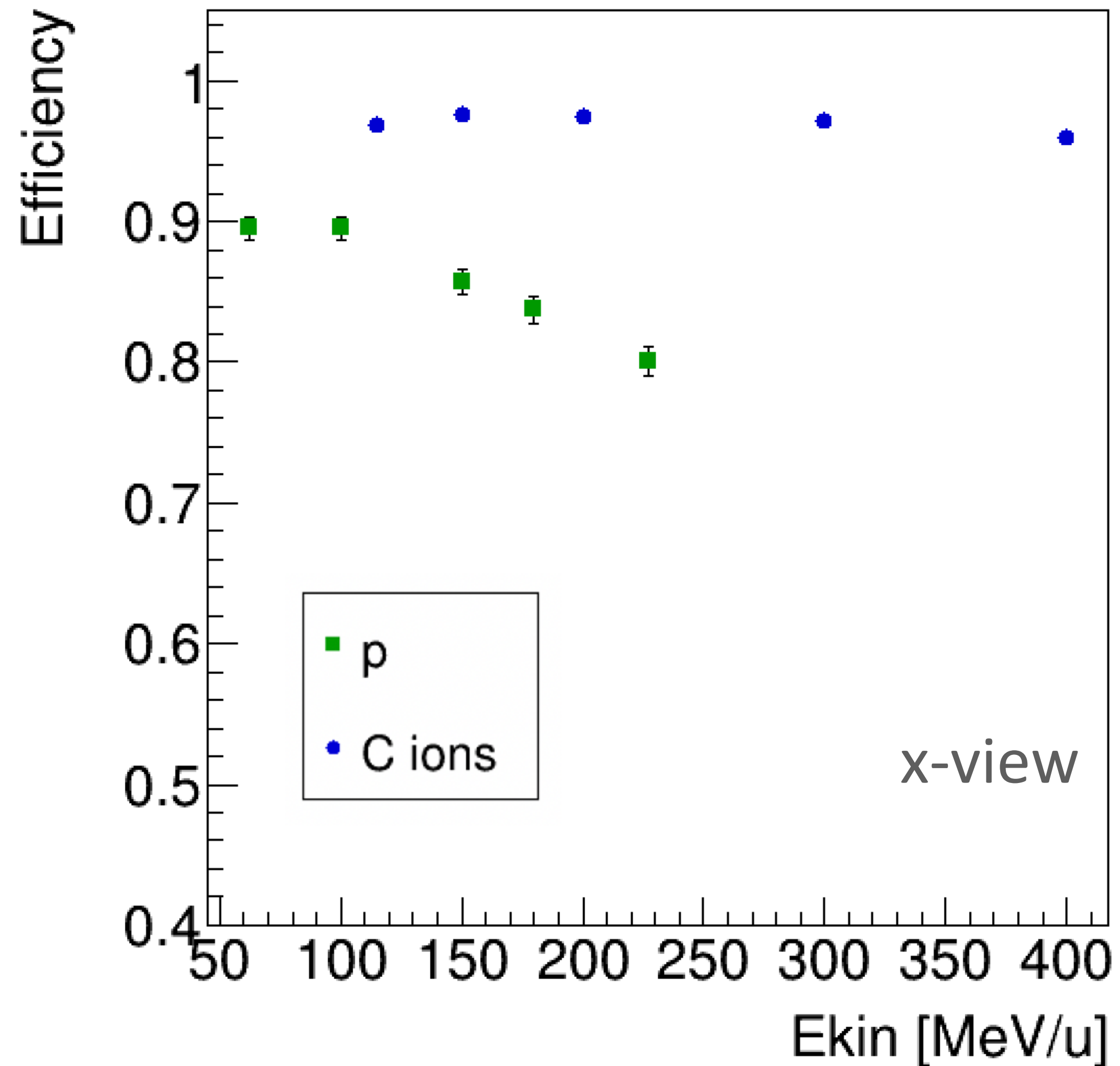
Protons @ 227 MeV



C ions @ 200 MeV/u



Detection efficiency



- Negligible inter-planes differences
- The efficiency is evaluated using an independent couple of plastic scintillators -> it covers just the center of the detector

beam monitor
fiber planes

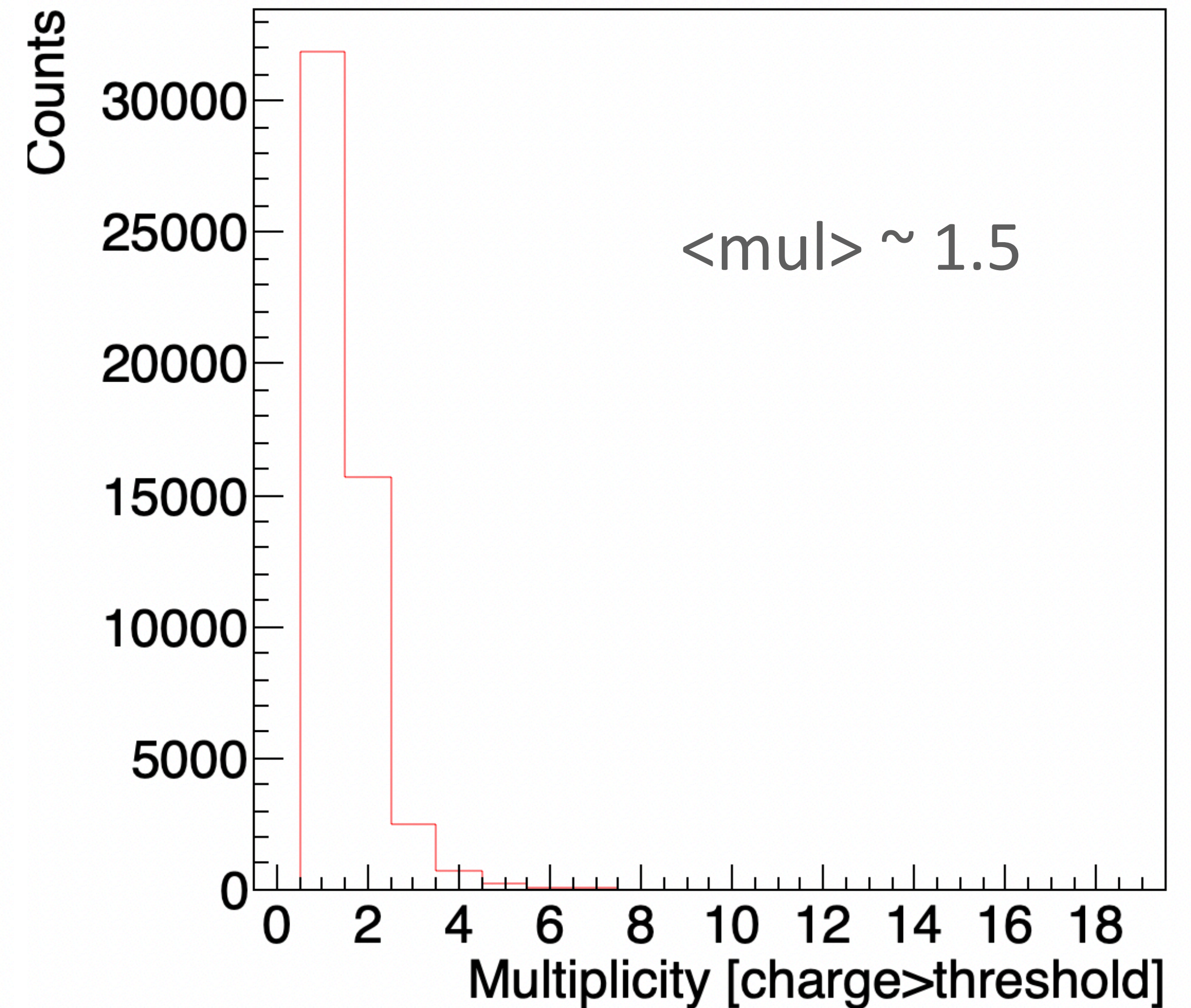
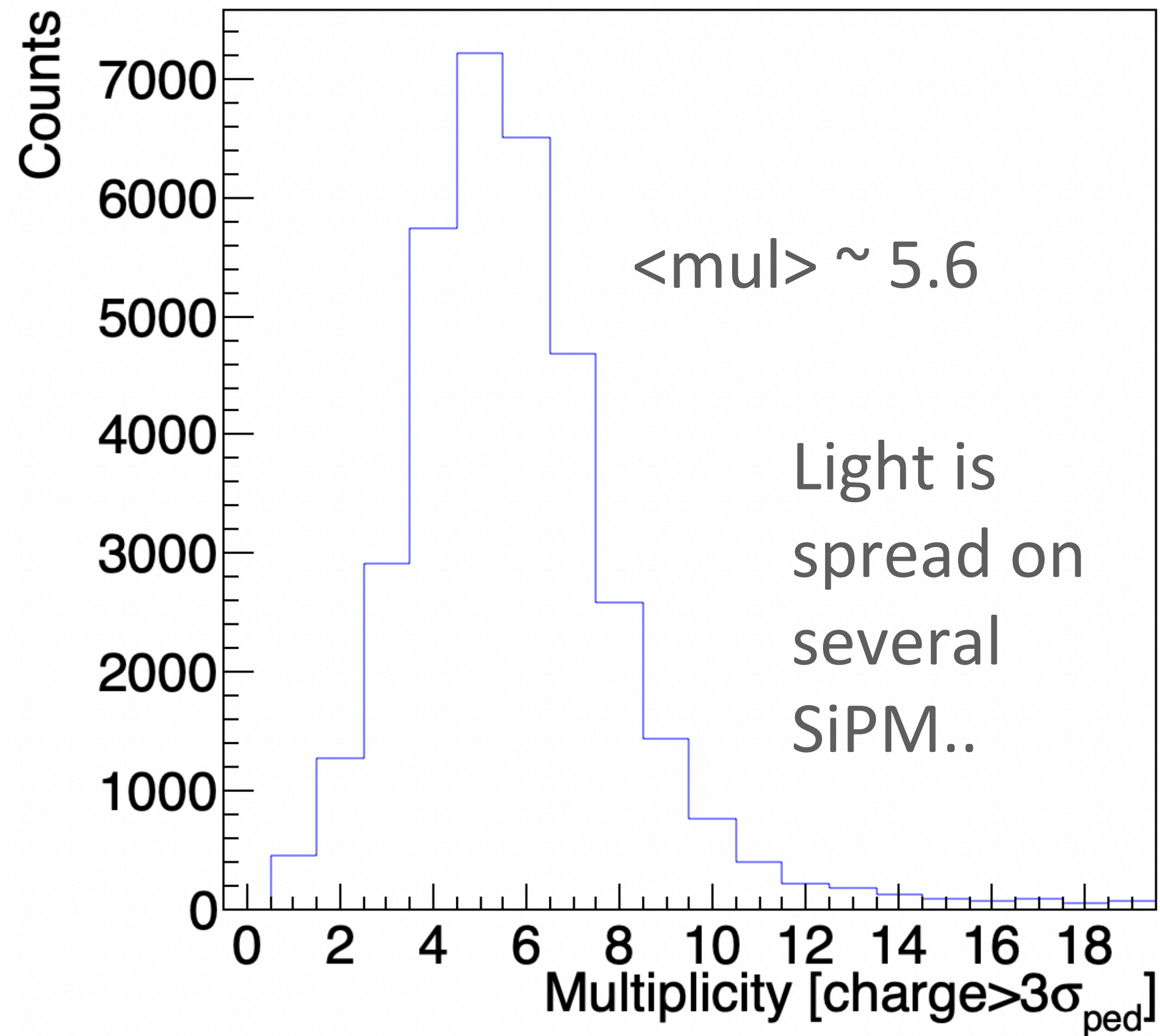
beam

External
Scintillators

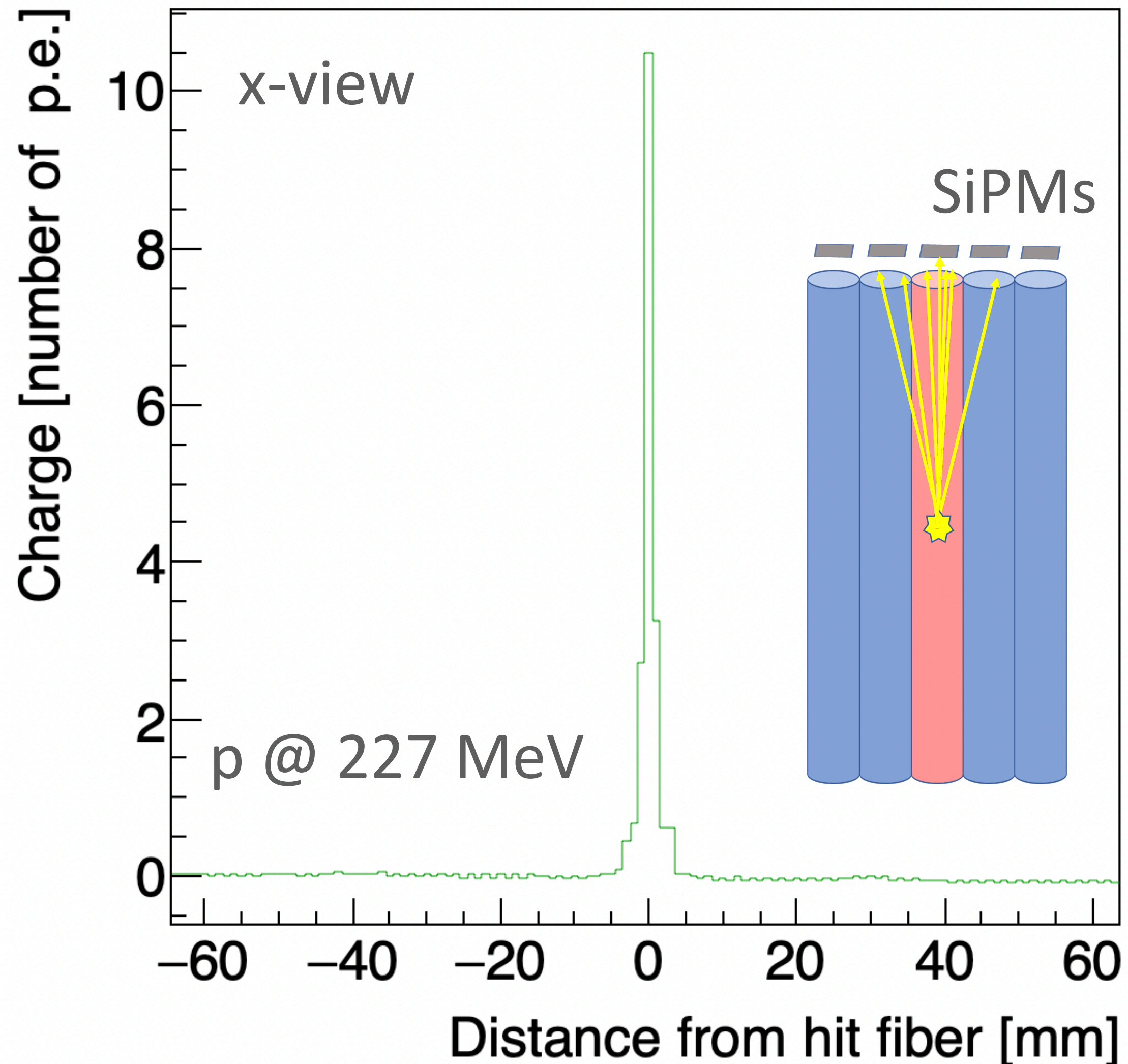
$$\epsilon = \frac{N_{OR}^{Fib}}{N_{ExtSC}}$$

Cross talk (I)

Protons @ 227 MeV

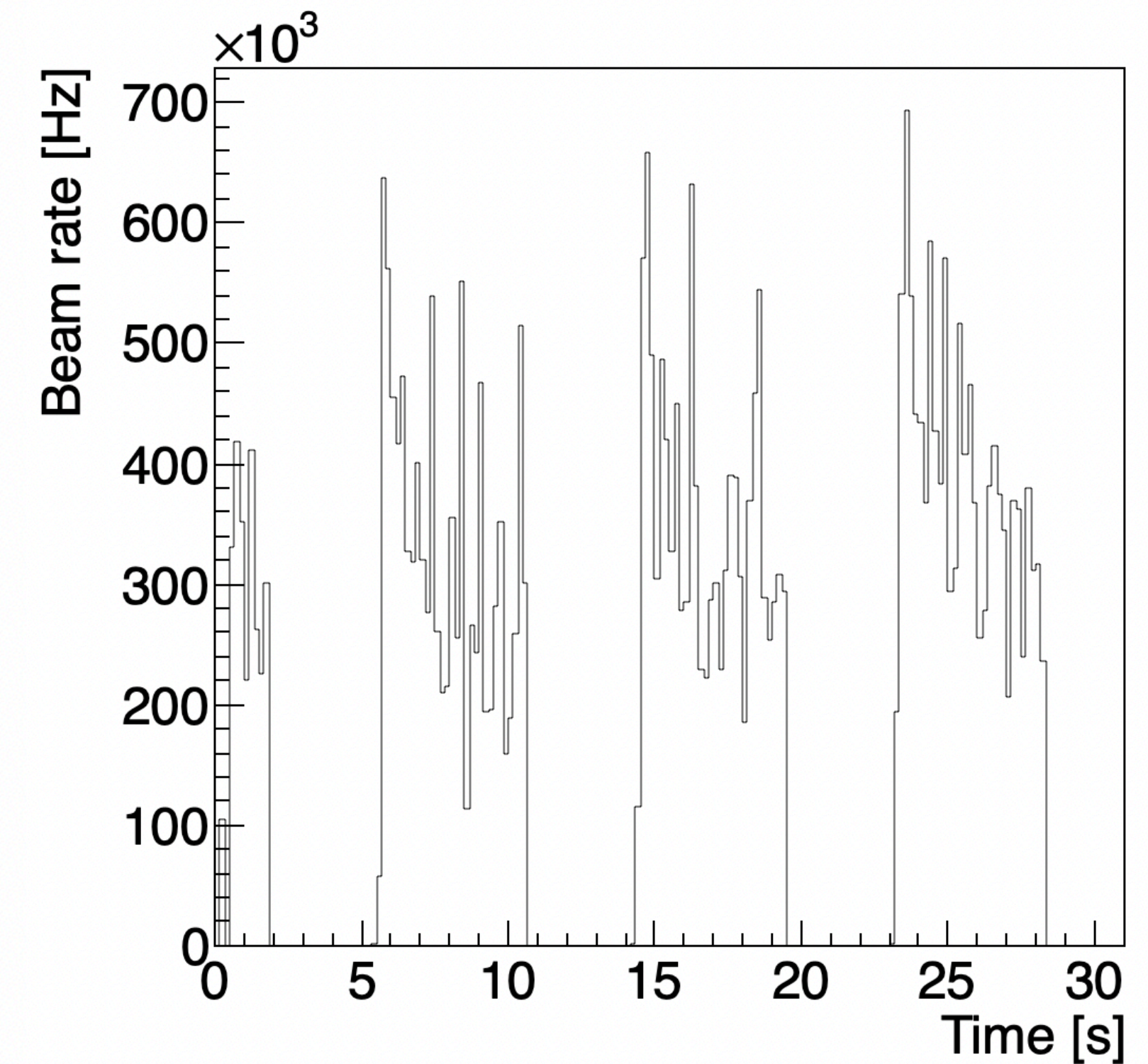
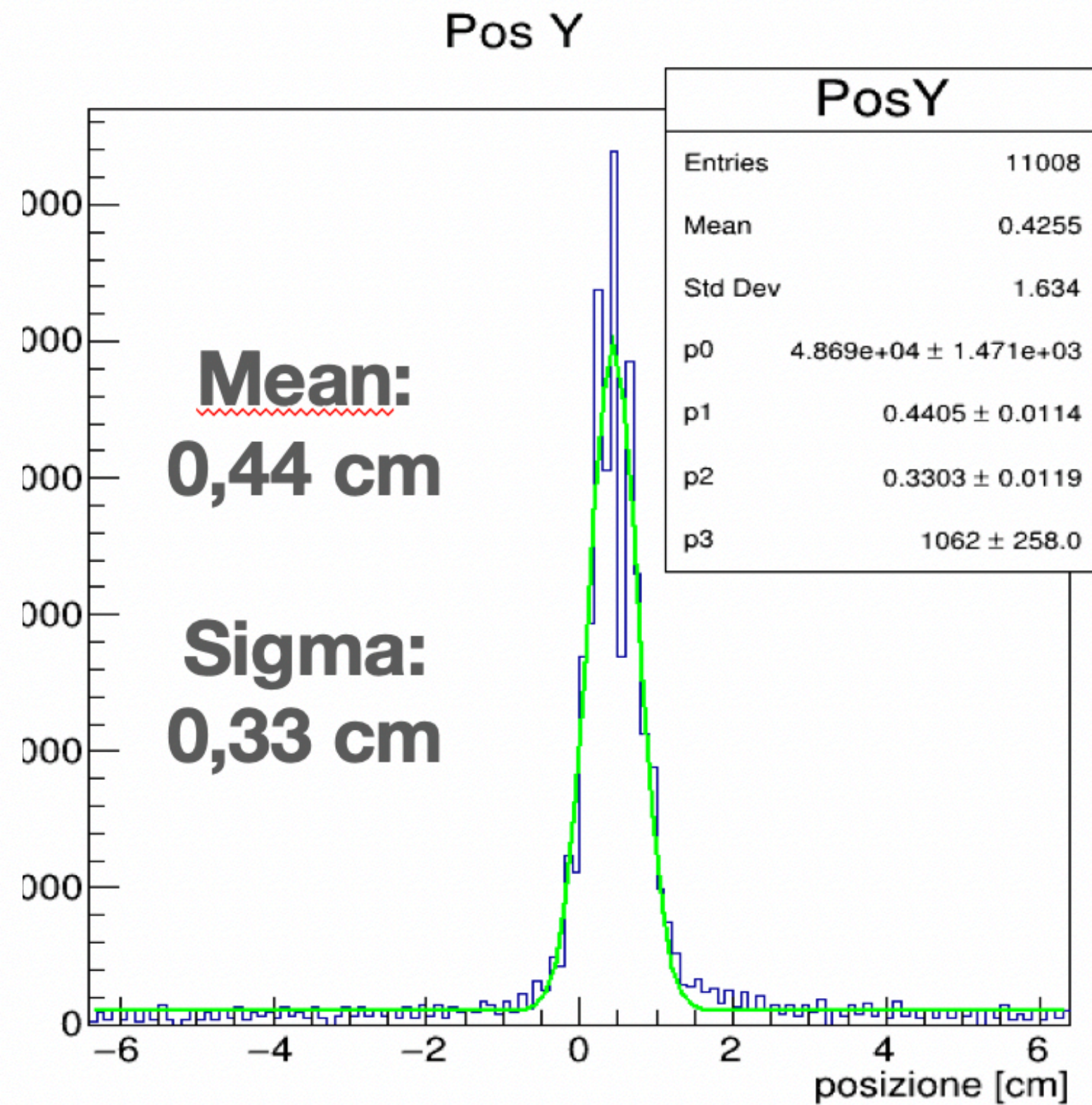
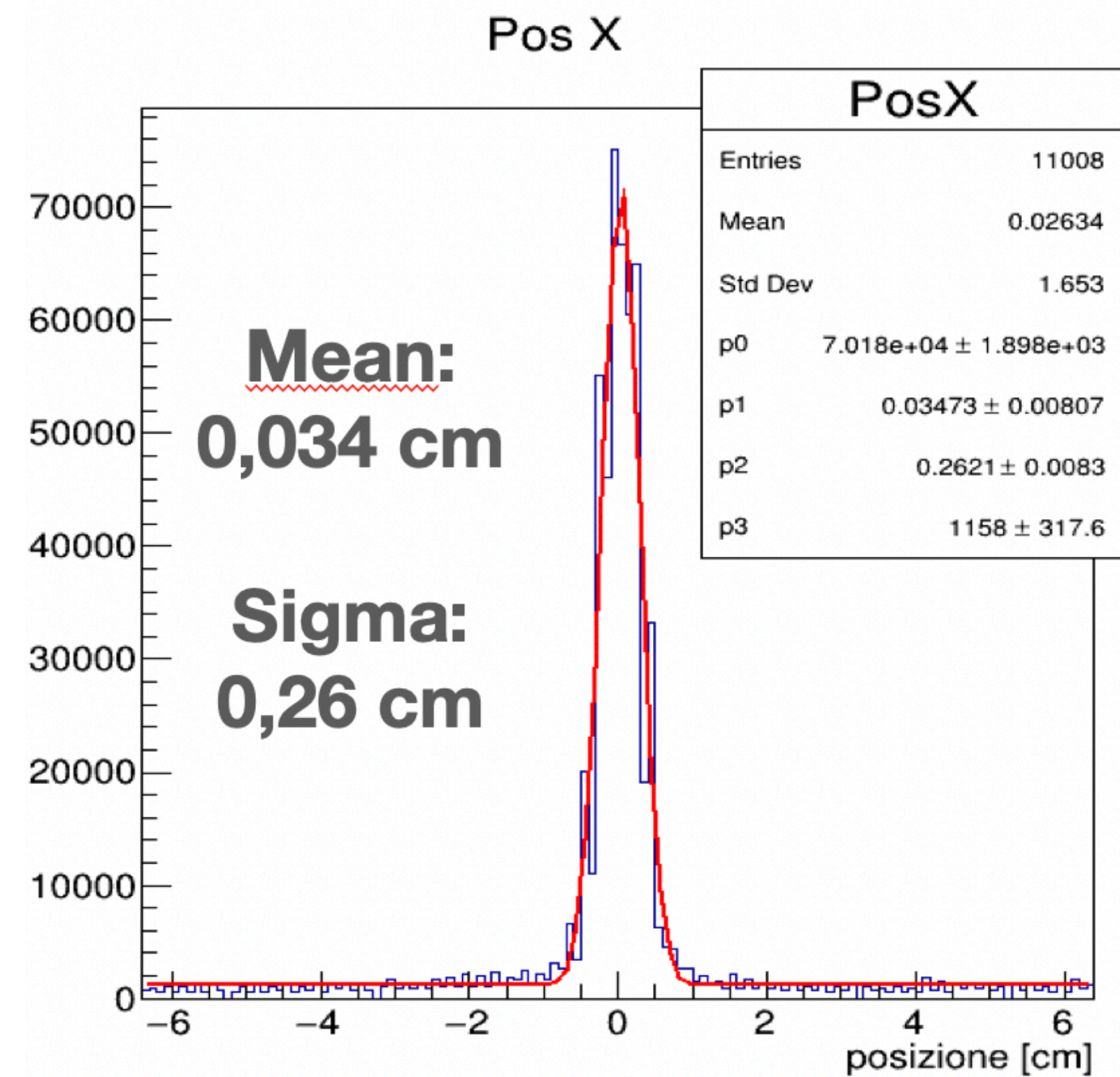


Cross-talk (II)



- According our tests the minimum threshold allowing for rejecting the SiPM intrinsic noise is $\sim 5-6$ p.e.
- This explains the “low” efficiency on proton beams despite the total amount of light produced is well beyond the set threshold
- Possible cure: lowering threshold using majority?

Beam monitoring



Conclusions

- Detector needs some minor mechanical modifications but it works properly and can be used for FOOT beam adjustment
- We need dedicated time before the data taking. It can not be used “online” to avoid undesired fragmentation (2 mm of plastic...)
- Possible future upgrade: time distribution (time scale of 100 us)

