Progress of GEM R&D in Lanzhou Univerity

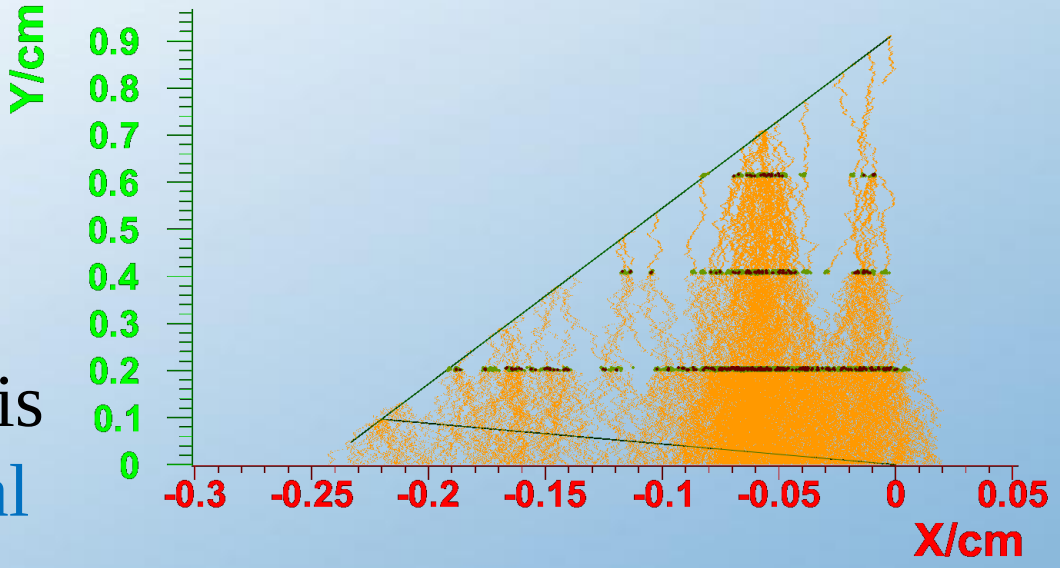
Yi Zhang

Contents

- **Time properties of GEM-detector signal**
- **R&D of GEM detector**
- **R&D of GEM-Daq**
- **Future plan**

Time properties of MPGD signals

- Fast raising time
- Signal duration depends on the way of energy deposition
  - Particle identification by cut on time
- The maximum duration is independent of incidental energy
  - Correct the initial position

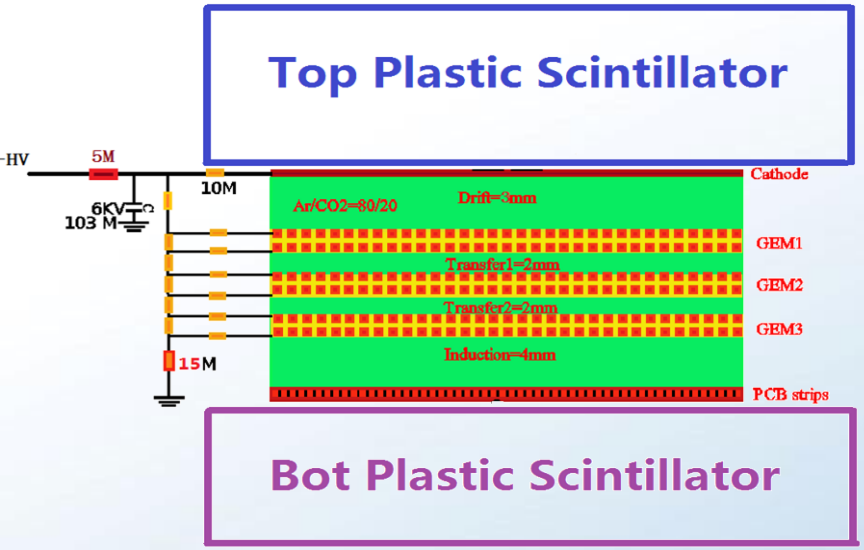


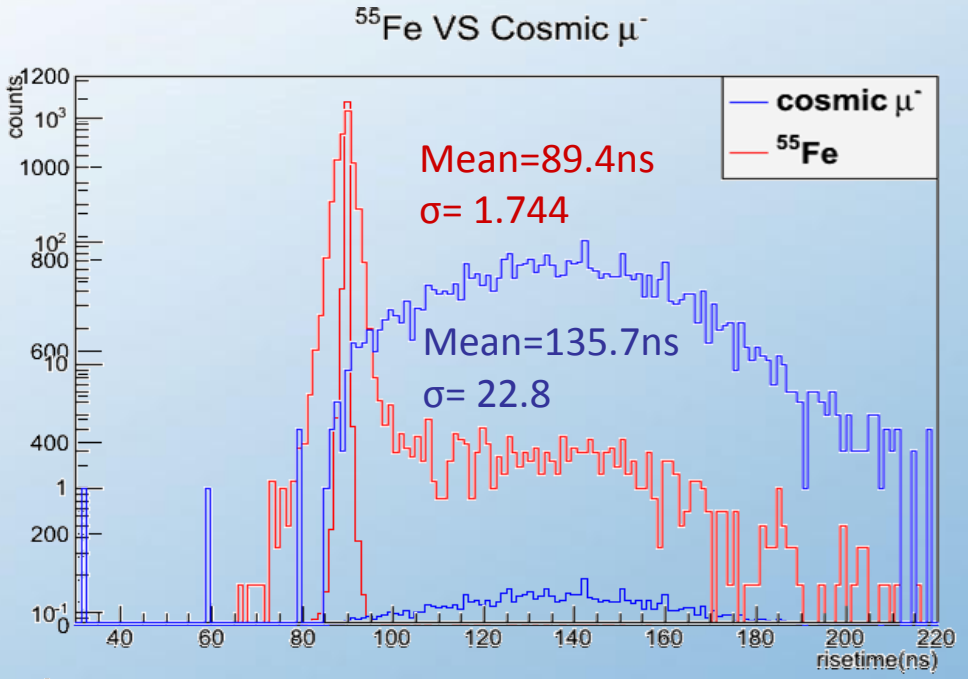
Goal

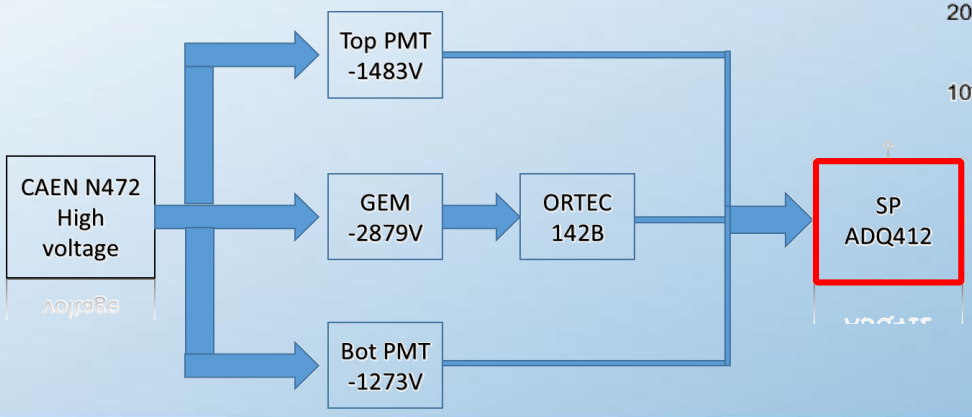
- reduce the local rates by rejecting γ signals according to the time information

- try to reduce the load of DAQ by clustering on hardware level (FPGA)

To demonstrate the conclusions, a test was done

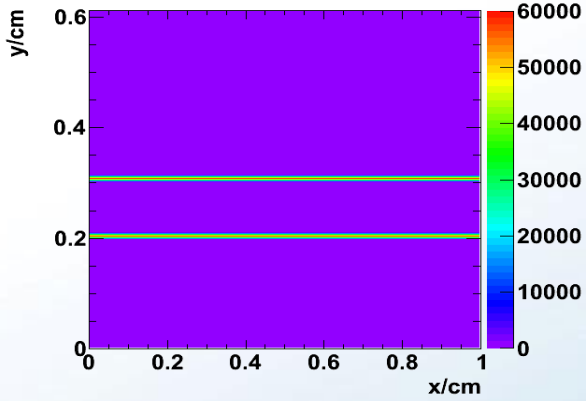


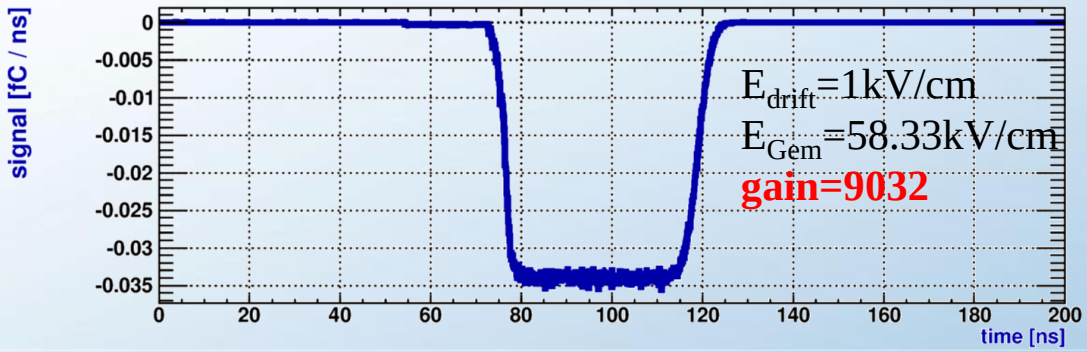




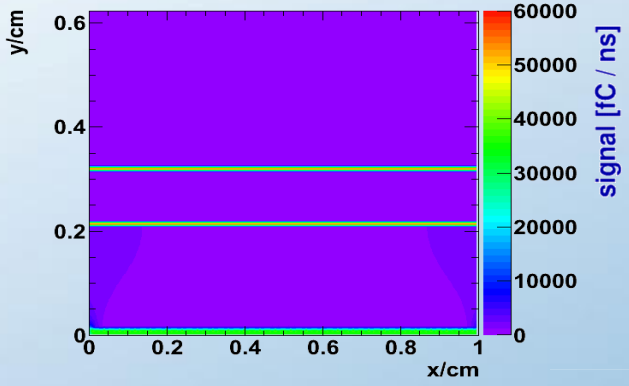
SP-ADQ412: 1.8GHz

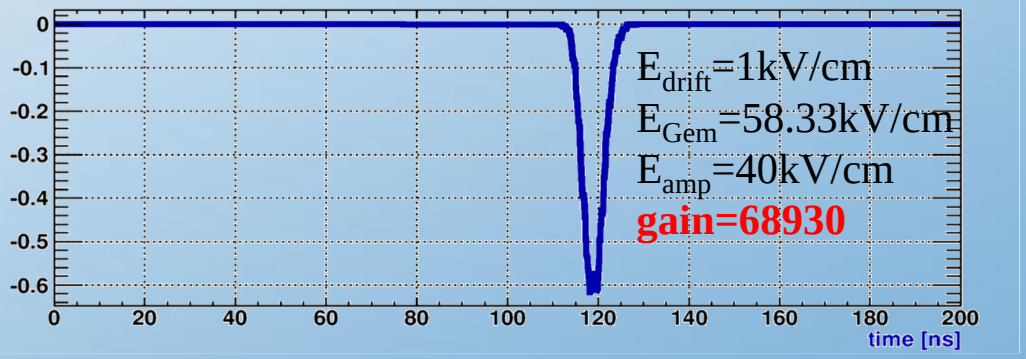
Garfield++ simulation of the double GEM (reference)





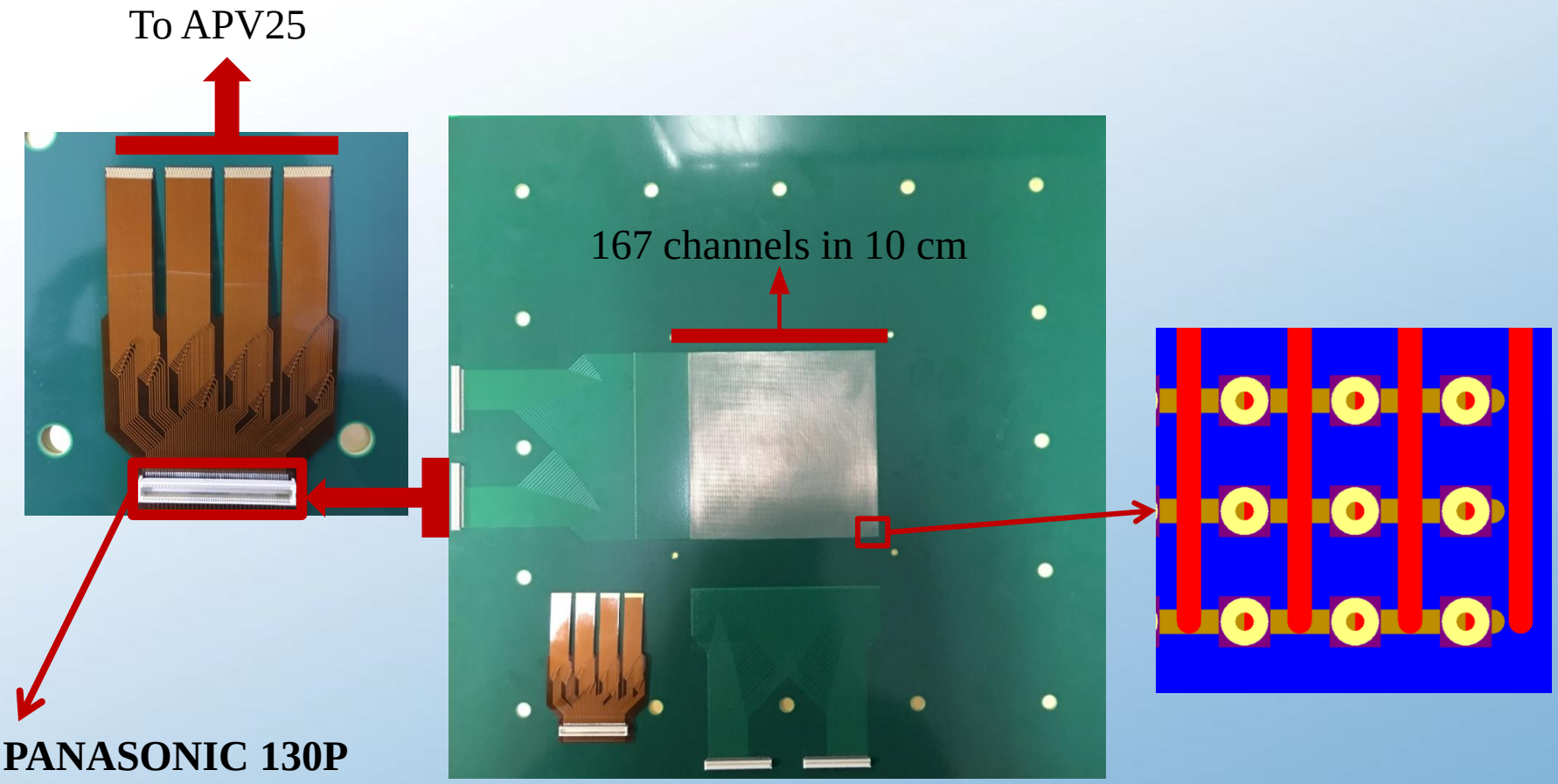
Garfield++ simulation of the double GEM + Mesh



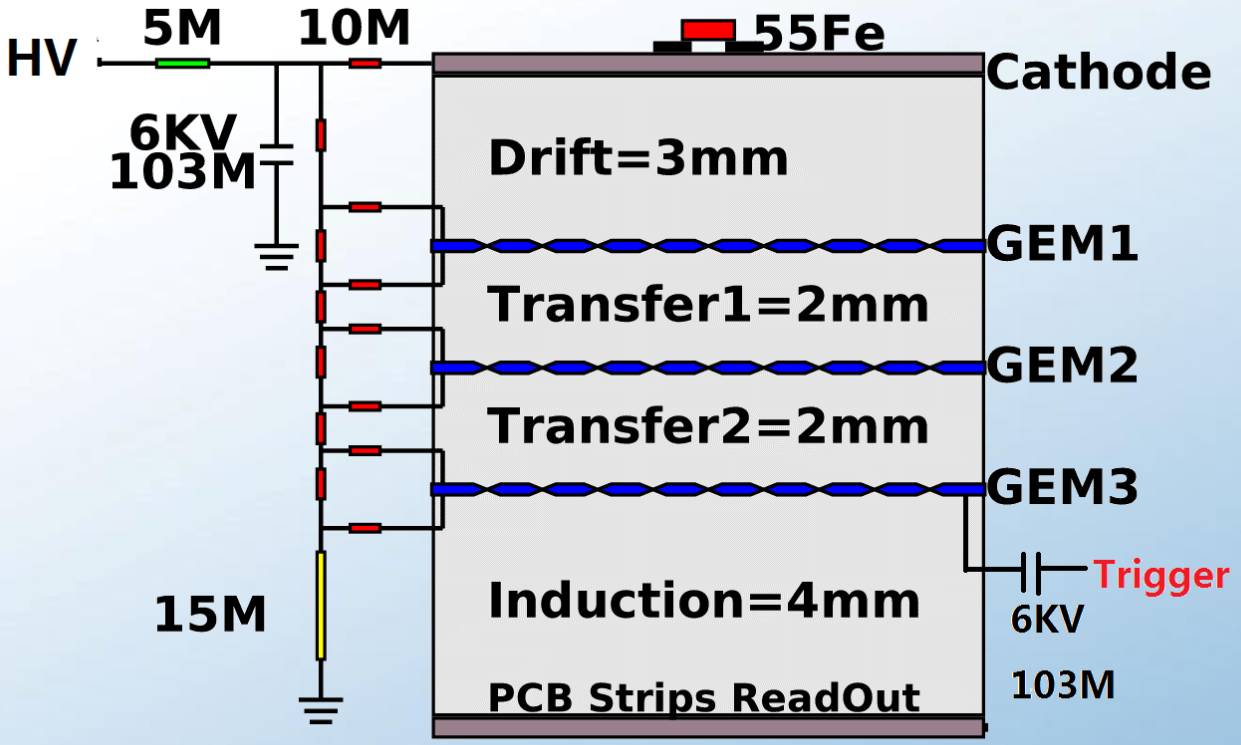


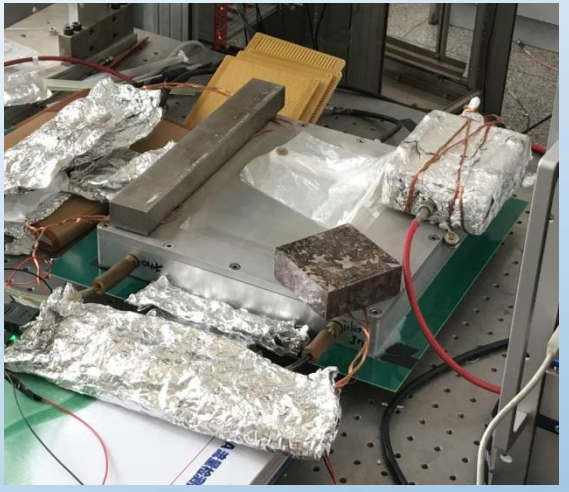
R&D of GEM detector

New readout panel

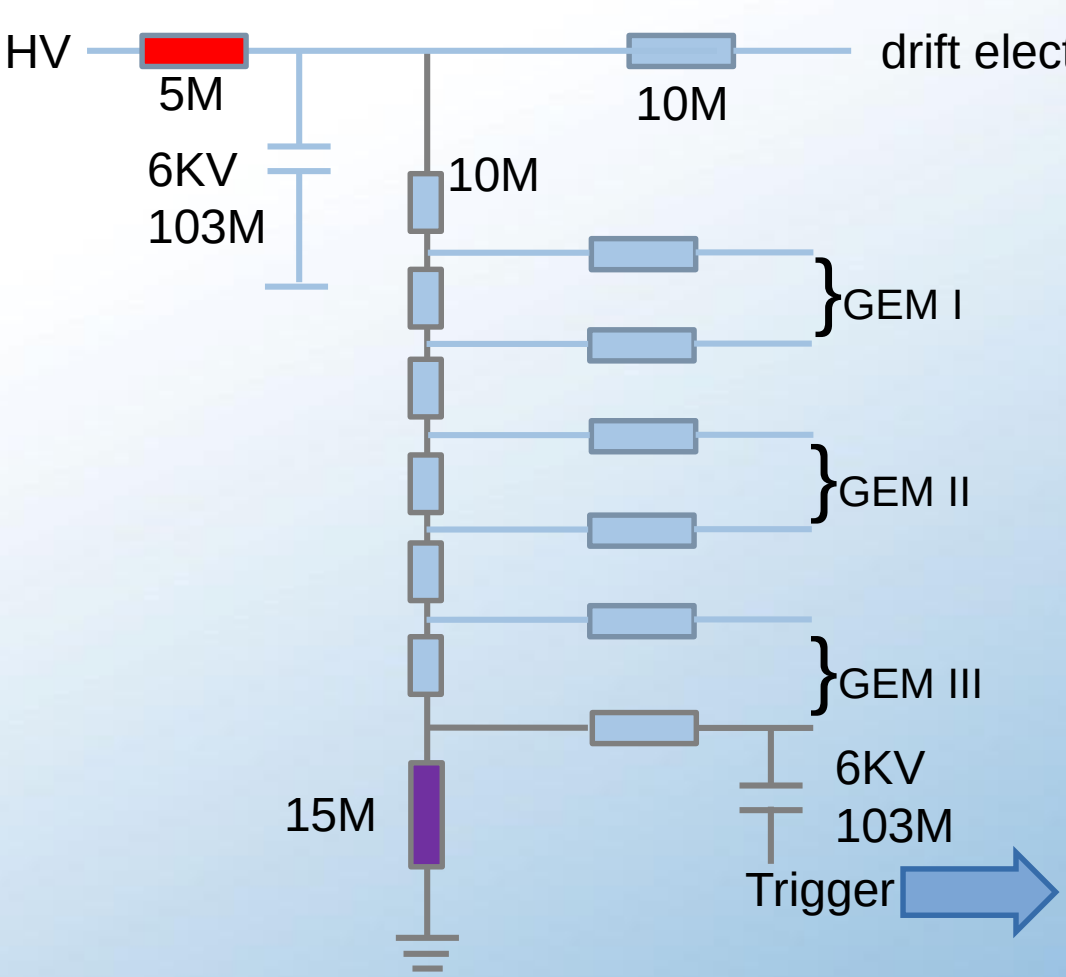


New version of triple-layer GEM detector



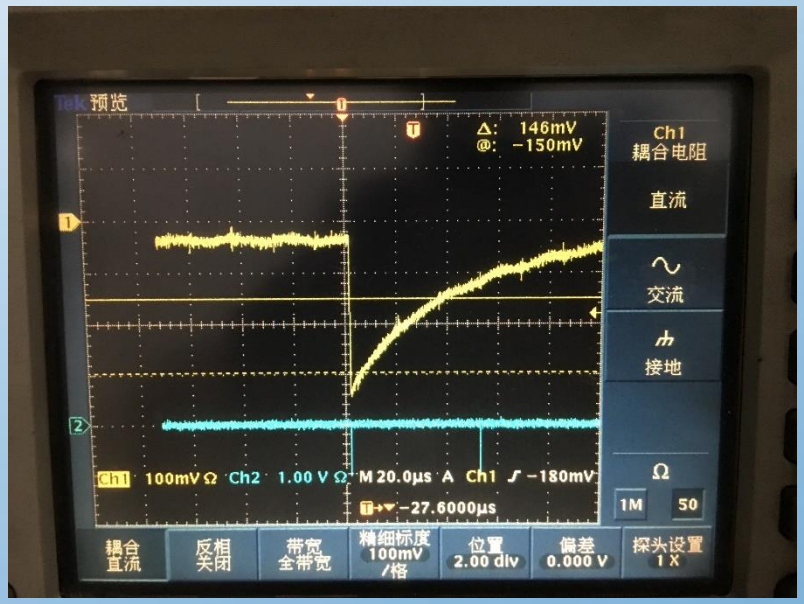


High voltage and trigger

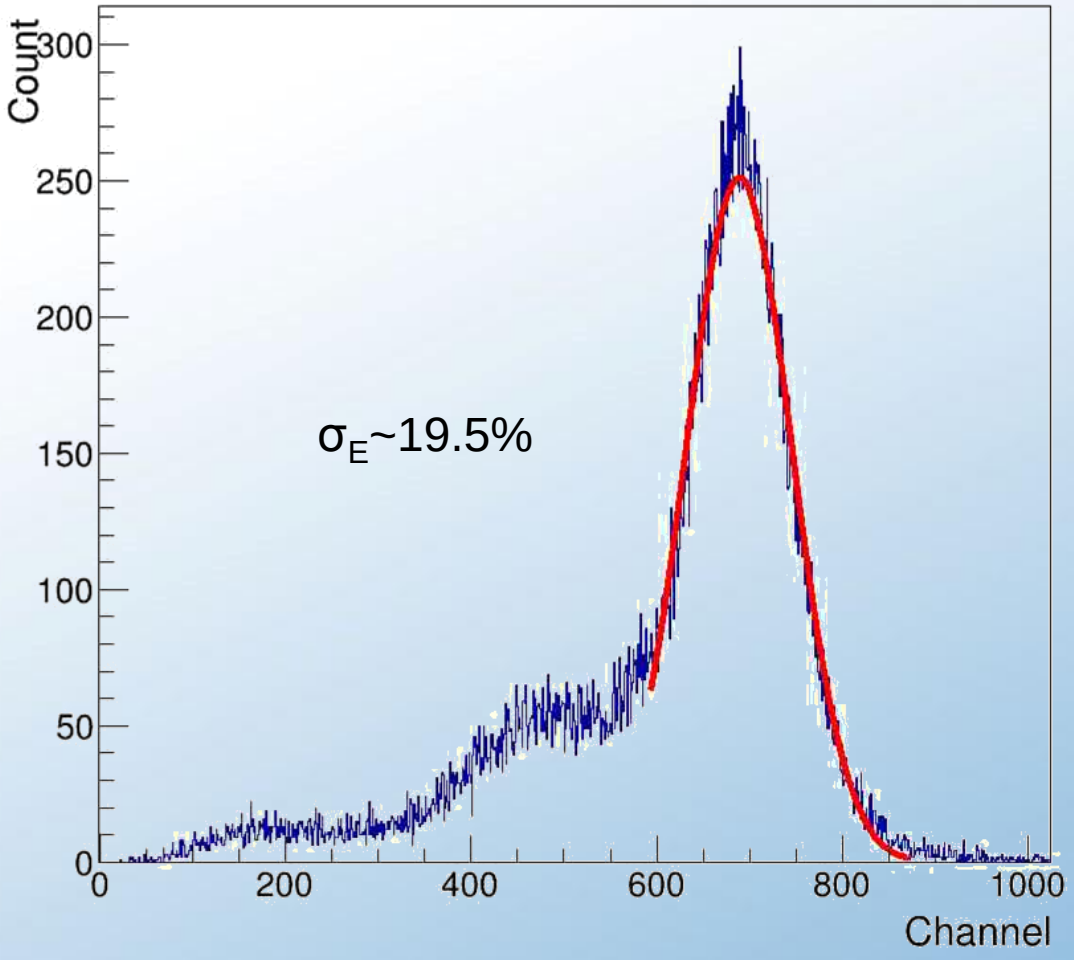


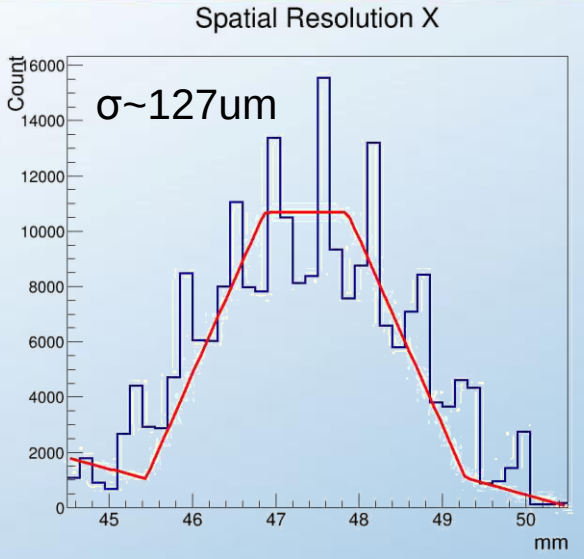
MPD+V1218

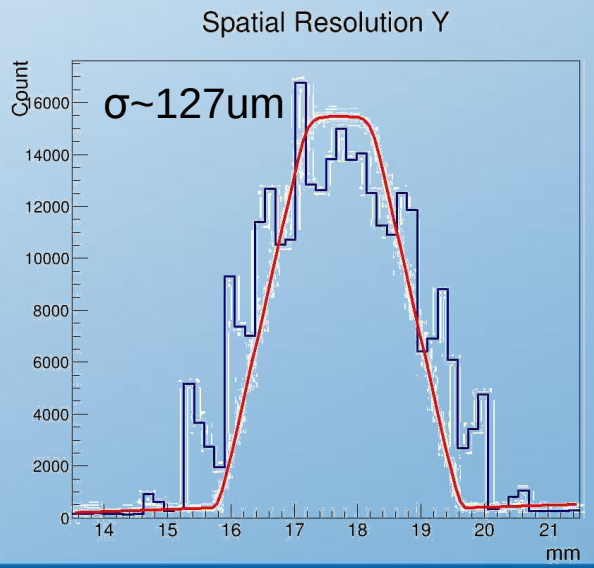
CF8000 discriminator



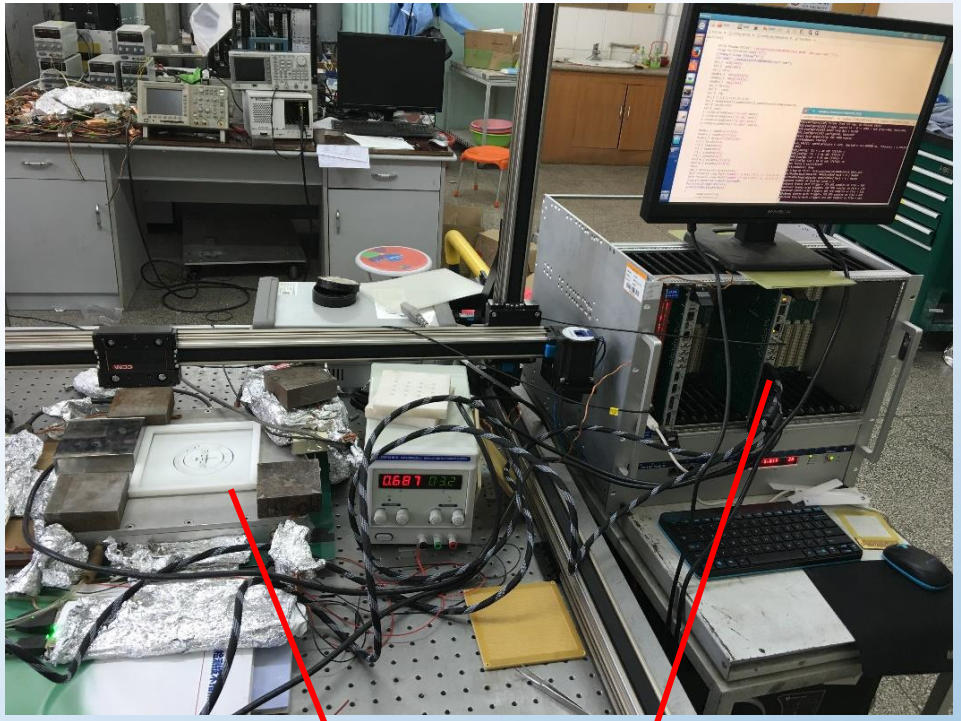
Test result of new detector (^{55}Fe)



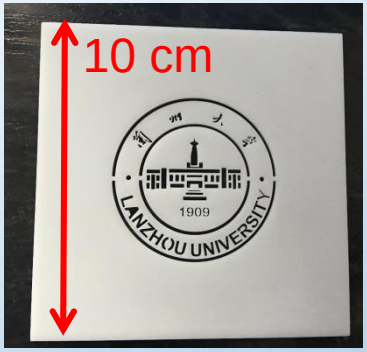


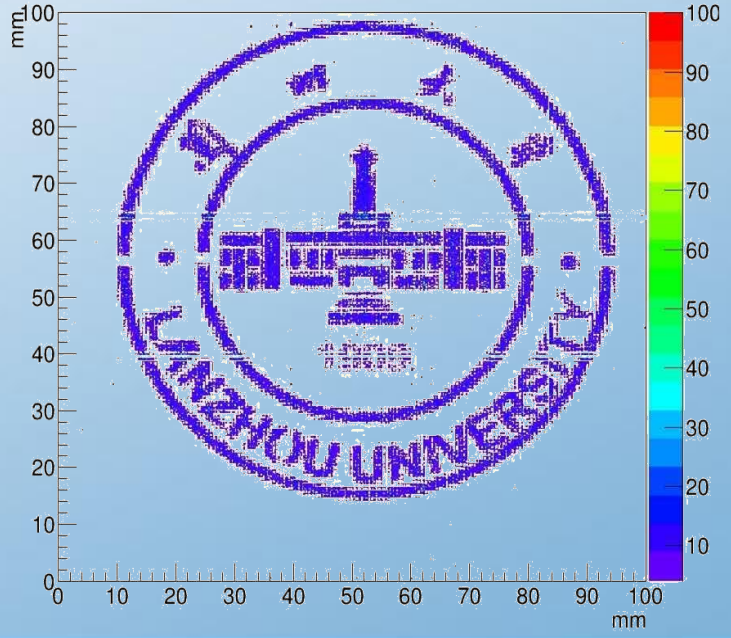


x-ray imaging by new detector and Daq



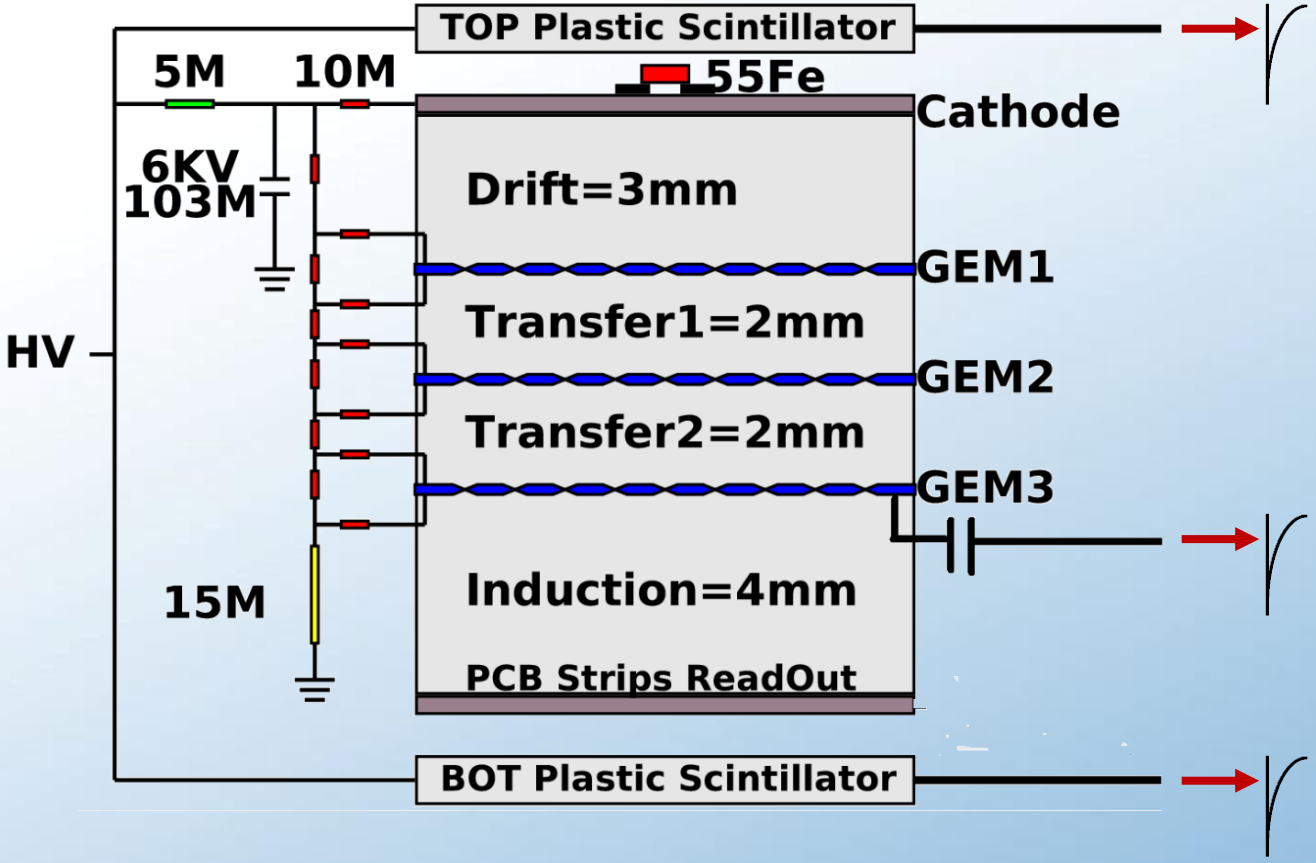
detector & daq system

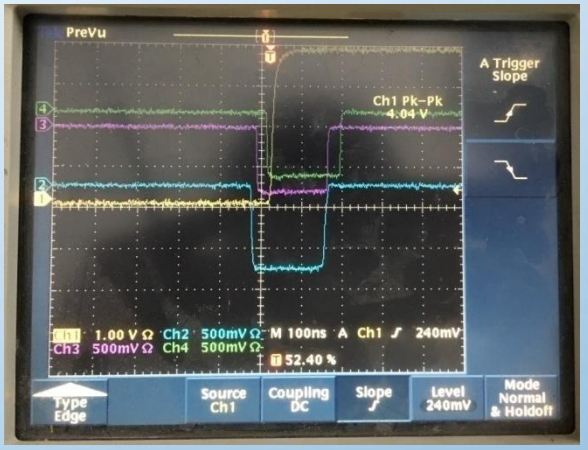




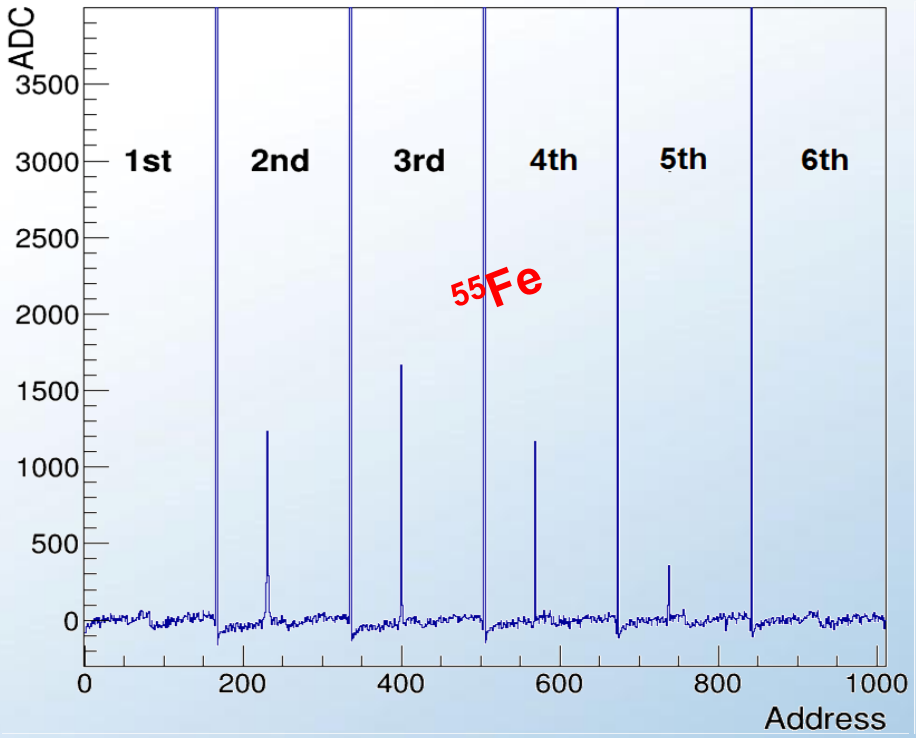
R&D of GEM-Daq

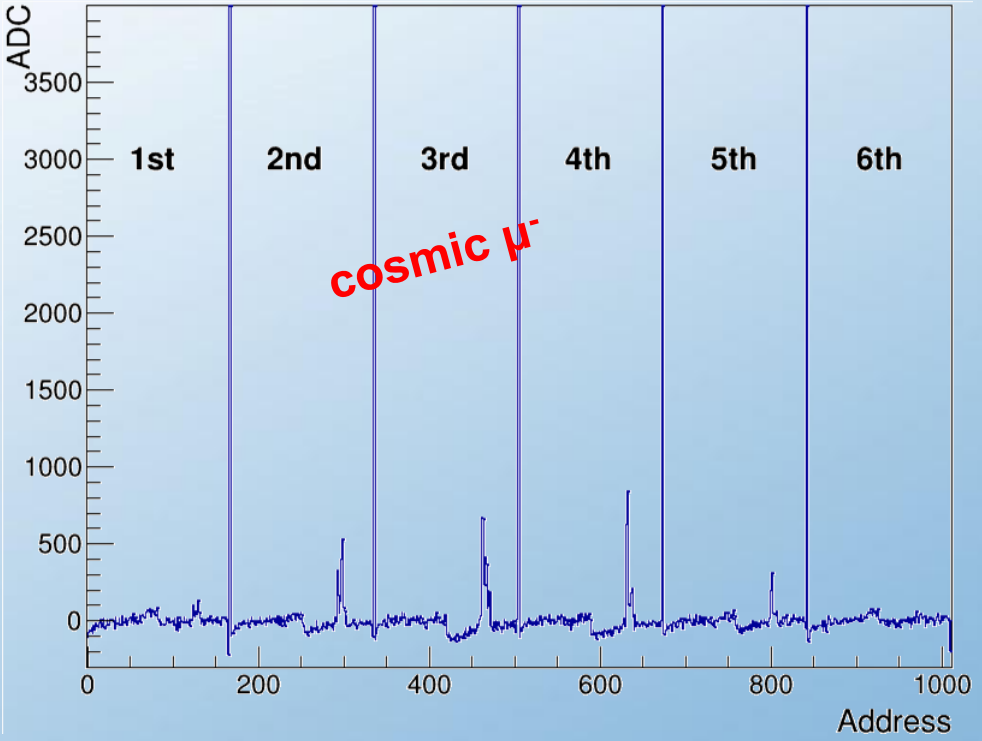
coincidence trigger to identify muon and photon



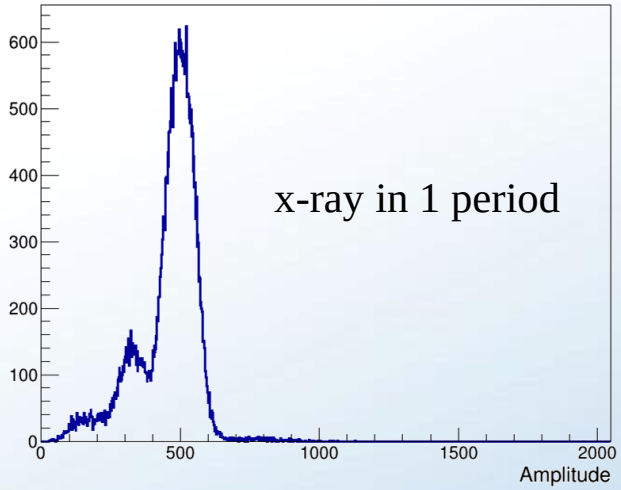


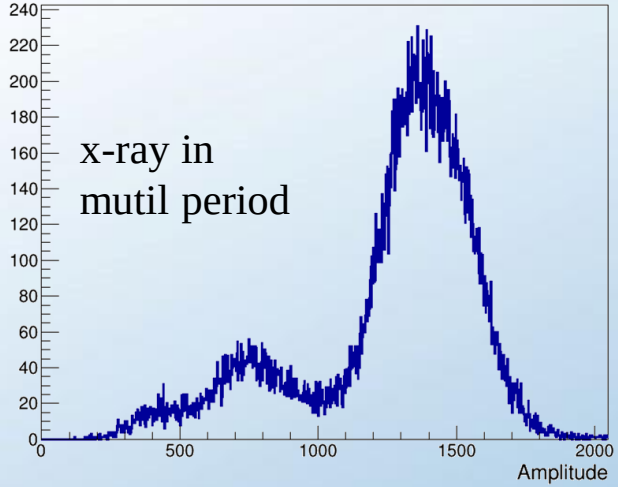
Real signals recorded in Daq

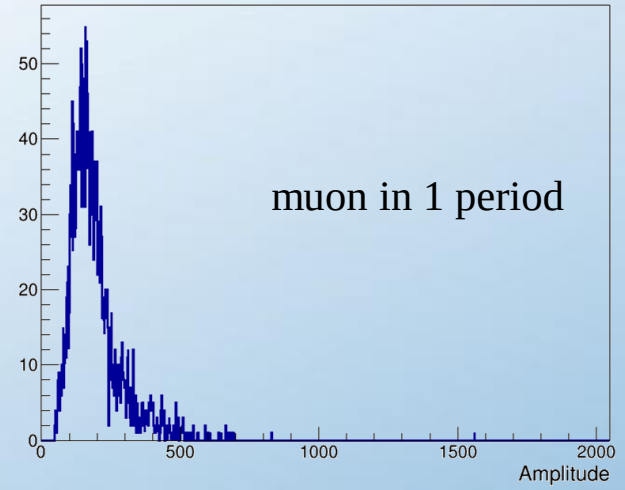


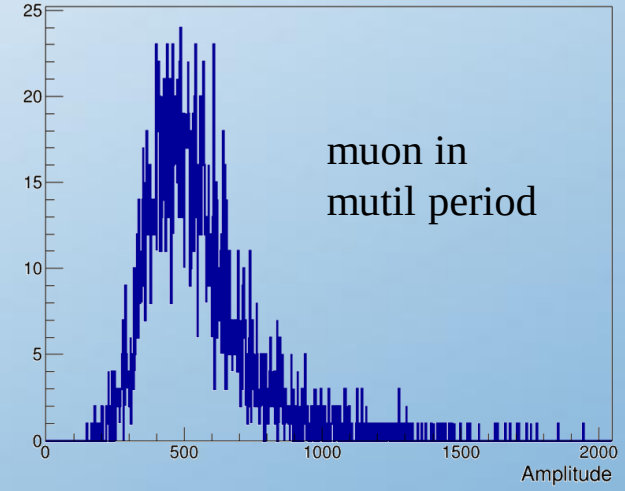


comparing signal amplitudes of different particle

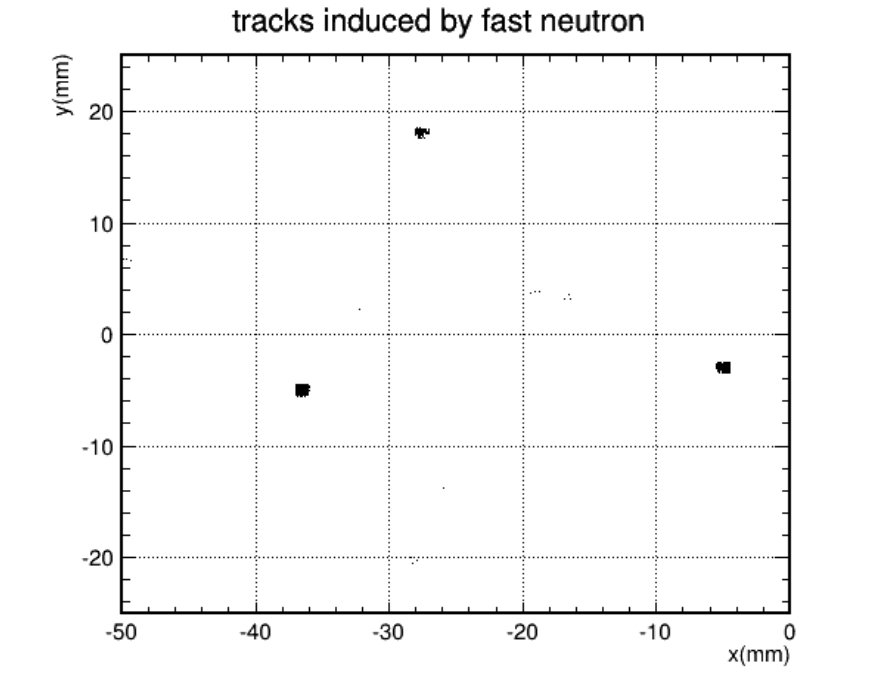


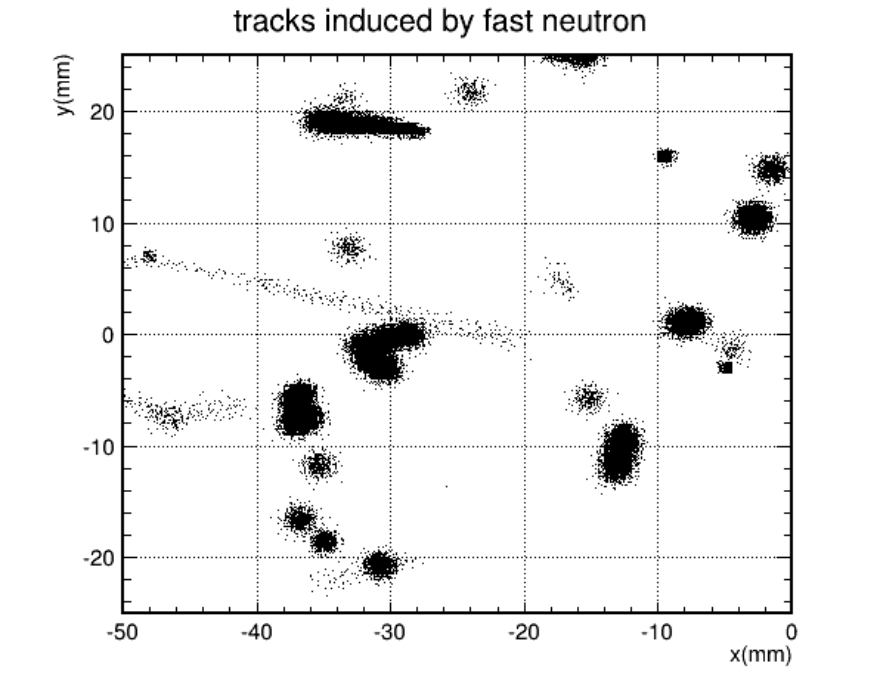






Avalanche electrons collected on by detector (simulation)

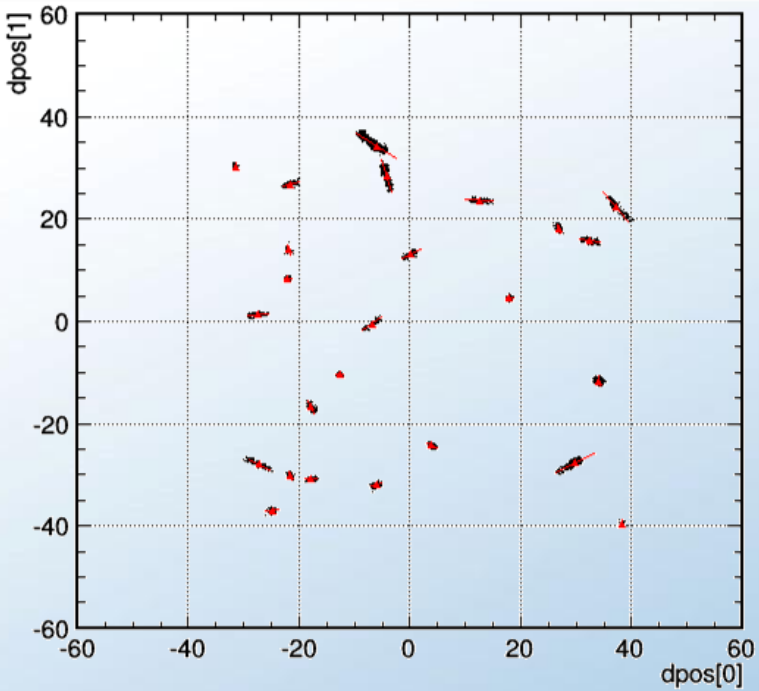


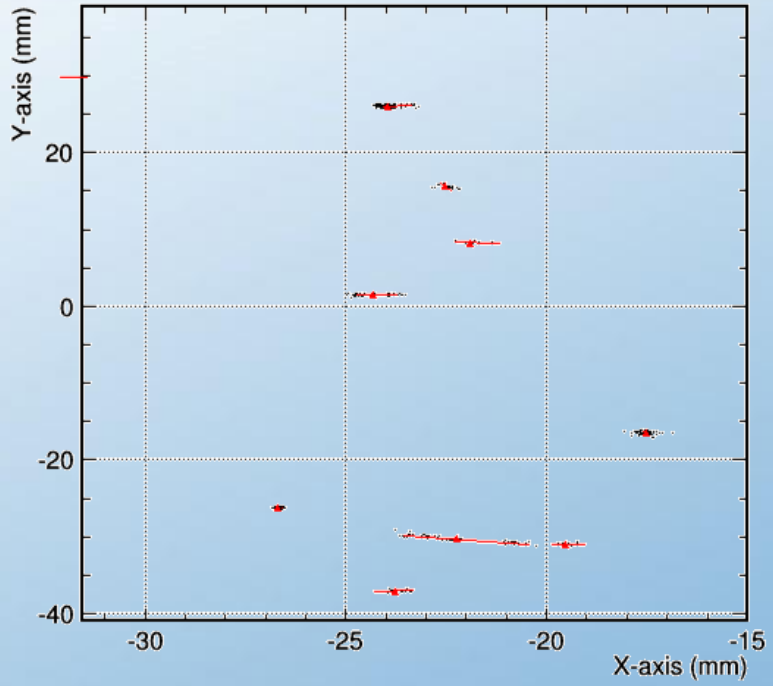


Steps of online track reconstruction

- **Divide signals into time slices (1 period for each)**
  - Segmentation in readout plane —— cut on signal amplitude
  - Combine adjacent segment —— identify clusters of hits
- **Process multi time slices**
  - Combine adjacent time slices —— distinguish if signal continues
  - Integrate multi time slices —— identify the start and end of a signal

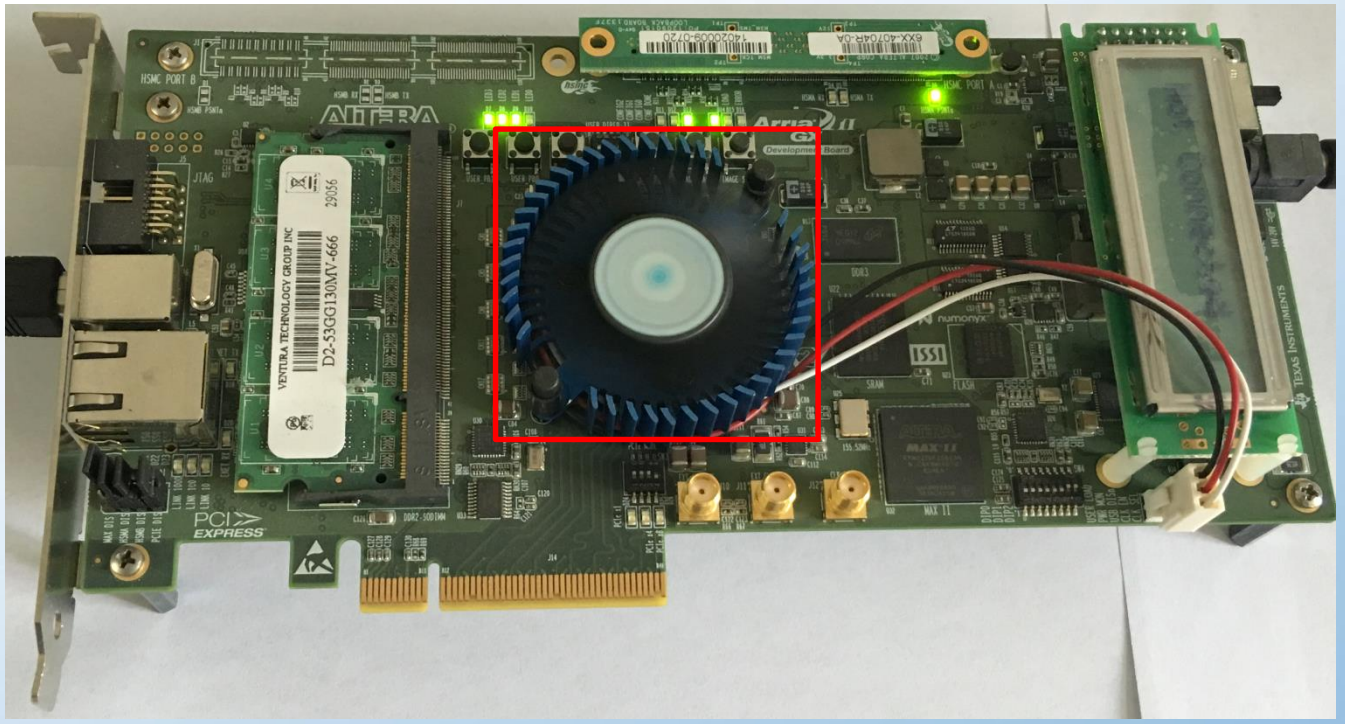
Forming hit clusters in one time slice (simulation)

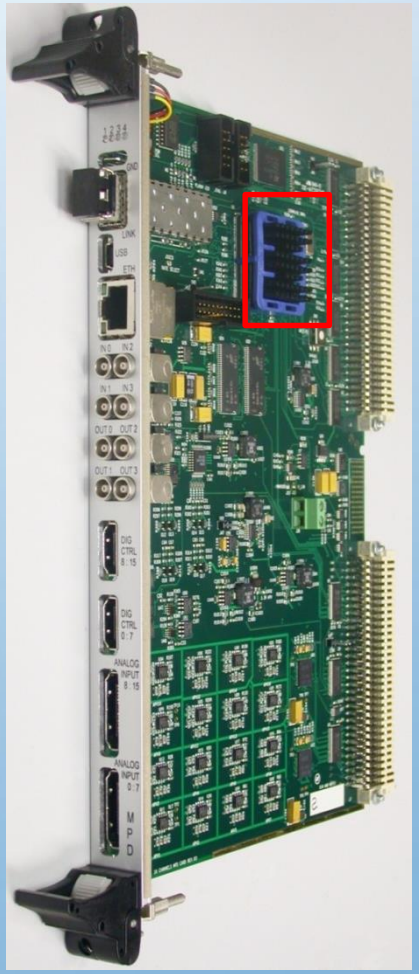




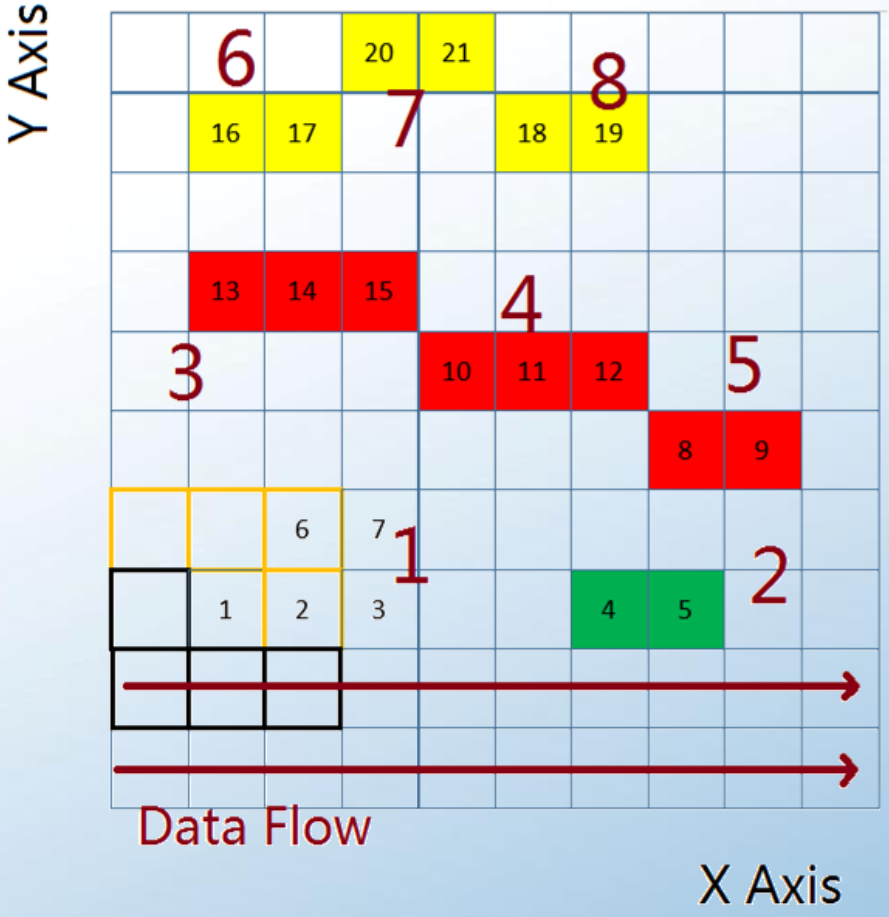
Development board: ARRIA GX FPGA toolkit

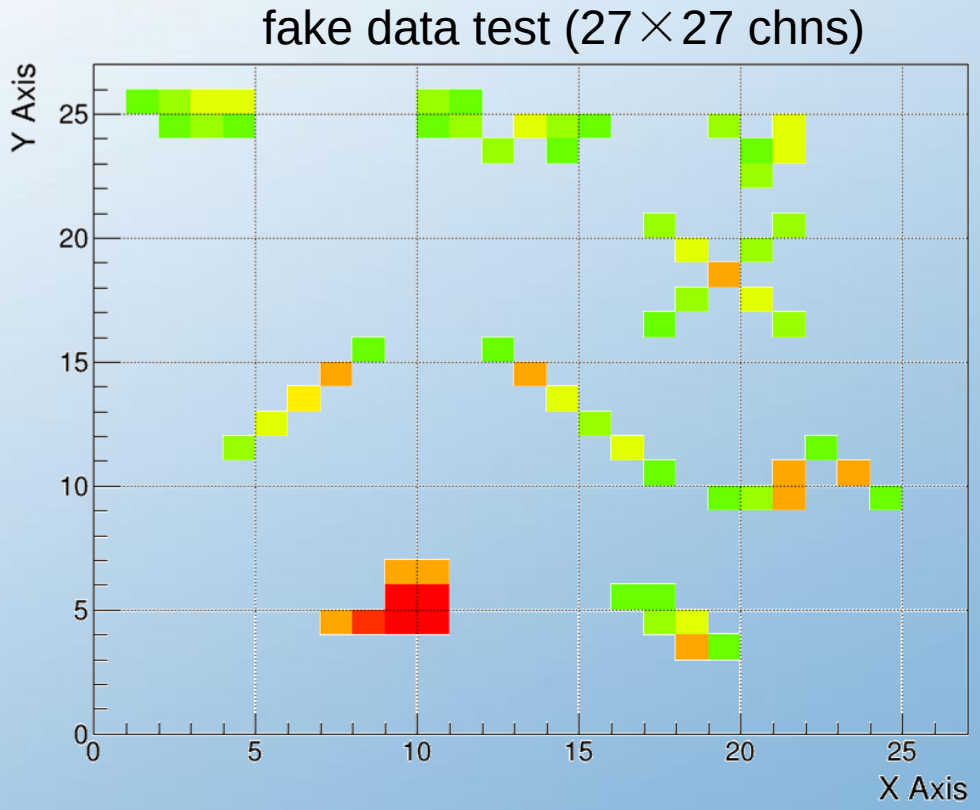
EP1AGX60DF780C6N



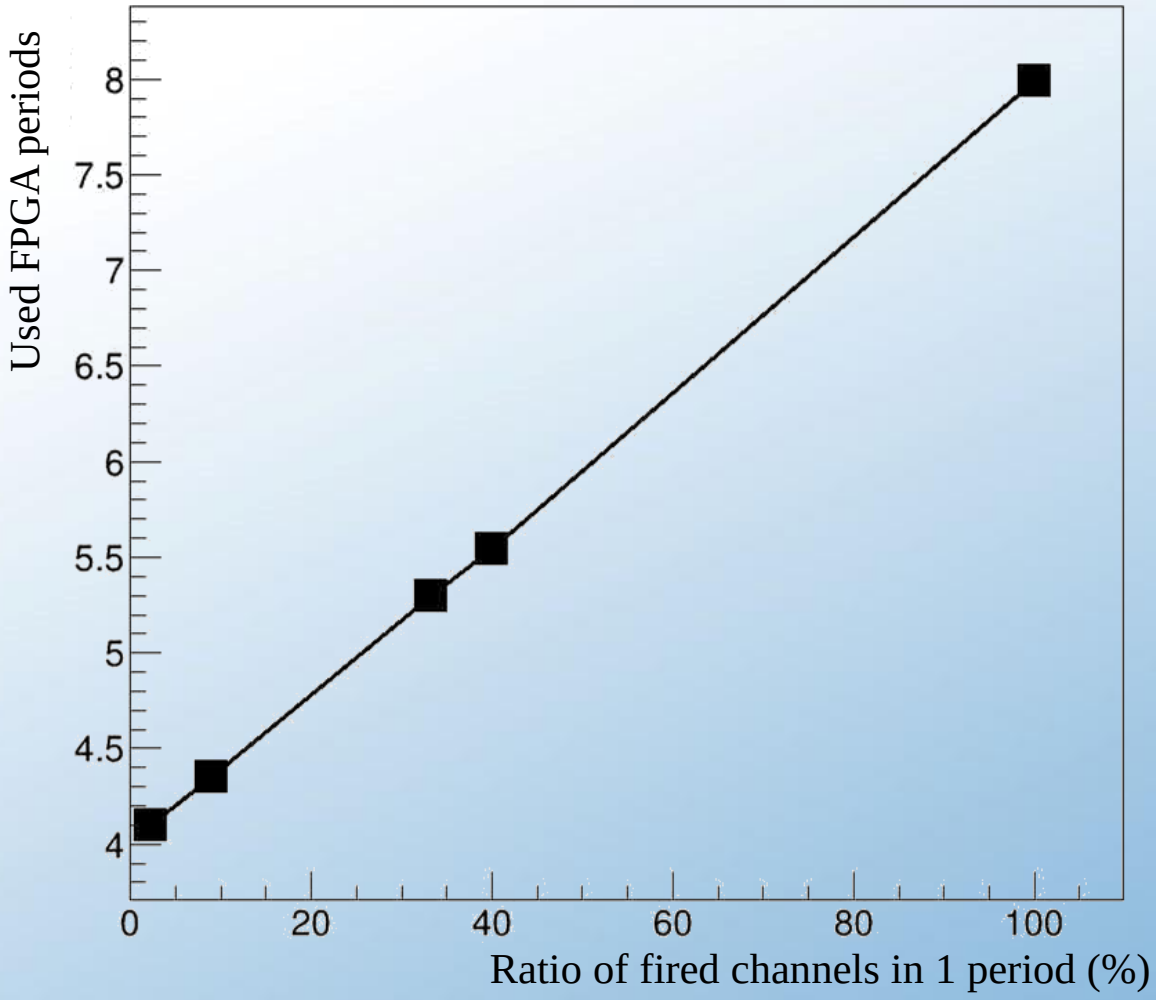


Forming hit clusters in 1 time slice





Processing speed VS signal coverage ratio



Resources consumption budget (2048 chs)

reports of our code:

SPM.v

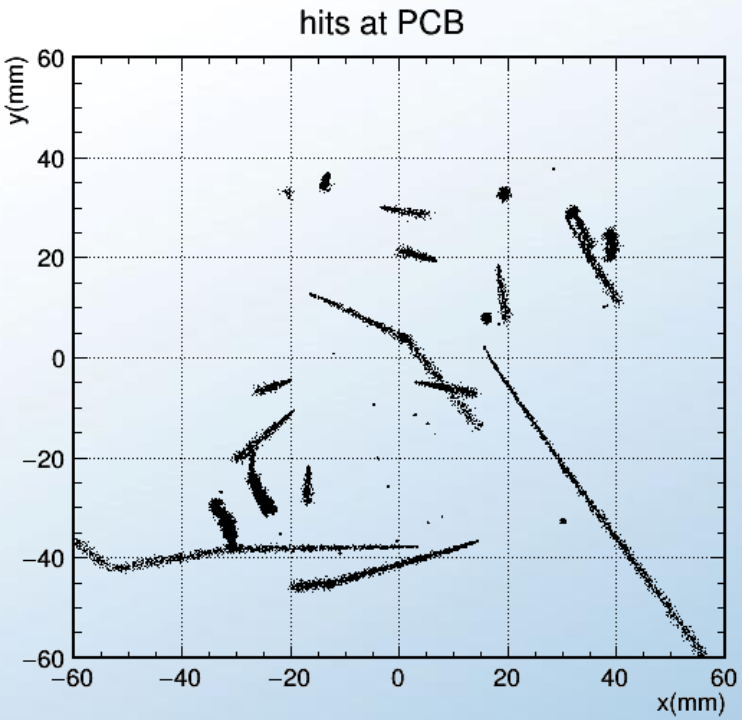
Flow Summary	
Flow Status	Successful - Wed Aug 03 15:06:08 2016
Quartus II 64-Bit Version	14.1.0 Build 186 12/03/2014 SJ Full Version
Revision Name	retrack
Top-level Entity Name	retrack
Family	Arria II GX
Device	EP2AGX125EF35C4
Timing Models	Final
Logic utilization	38 %
Combinational ALUTs	14,092 / 99,280 (14 %)
Memory ALUTs	0 / 49,640 (0 %)
Dedicated logic registers	32,224 / 99,280 (32 %)
Total registers	32224
Total pins	144 / 512 (28 %)
Total virtual pins	0
Total block memory bits	73,216 / 6,727,680 (1 %)
DSP block 18-bit elements	3 / 576 (< 1 %)
Total GXB Receiver Channel PCS	0 / 12 (0 %)
Total GXB Receiver Channel PMA	0 / 12 (0 %)
Total GXB Transmitter Channel PCS	0 / 12 (0 %)
Total GXB Transmitter Channel PMA	0 / 12 (0 %)
Total PLLs	0 / 6 (0 %)
Total DLLs	0 / 2 (0 %)

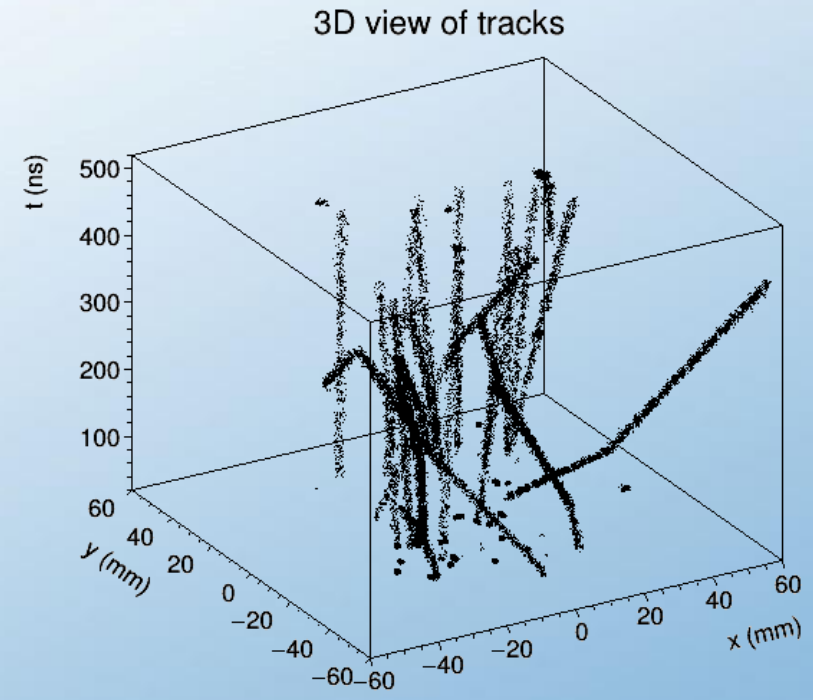
from INFN :

```
The fitting results without filters (actual version) are:
; Logic utilization                  ; 56 %
;     Combinational ALUTs            ; 21,247 / 48,080 ( 44 % )
;     Dedicated logic registers      ; 13,382 / 48,080 ( 28 % )
; Total registers                    ; 13661
; Total pins                         ; 312 / 395 ( 79 % )
; Total block memory bits            ; 1,808,252 / 2,528,640 ( 72 % )
; DSP block 9-bit elements           ; 0 / 256 ( 0 % )
; Total GXB Receiver Channels        ; 1 / 8 ( 13 % )
; Total GXB Transmitter Channels     ; 1 / 8 ( 13 % )
; Total PLLs                         ; 3 / 4 ( 75 % )
; Total DLLs                         ; 1 / 2 ( 50 % )
```

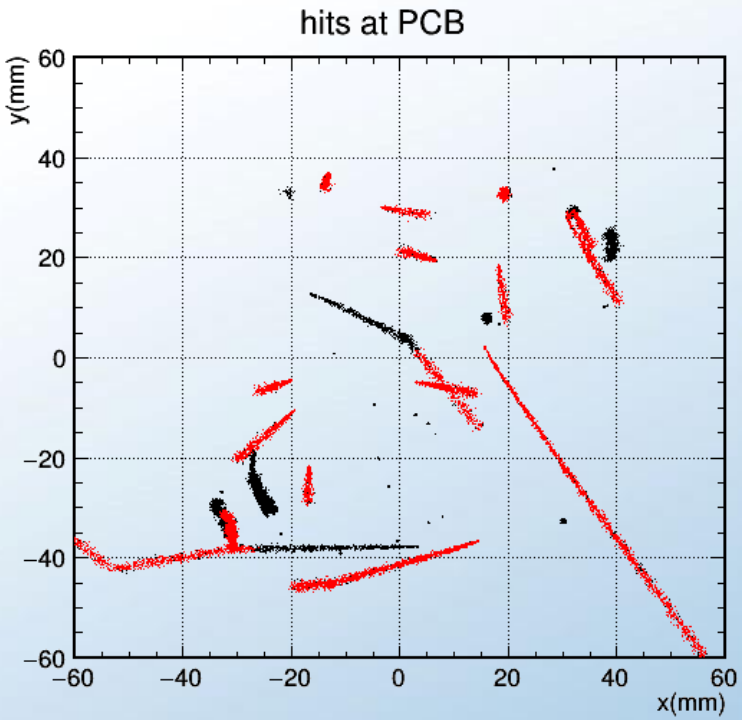
Iterms of resources	Total	Usage of current daq	Usage of out code
Combinational ALUTs	48,080	21,247 (44%)	14,092 (29%)
Dedicated registers	48,080	13,382 (28%)	32,224 (67%)
DSP	256	0	3(1%)
Block Memory Bits	2,528,640	1,808,252 (72%)	73,216 (3%)

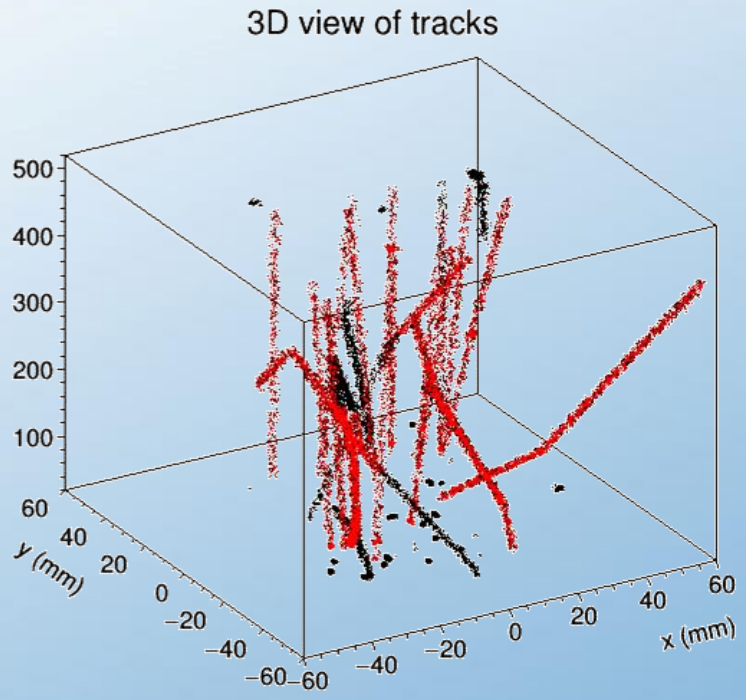
Combine few time slices, get the complete tracks (simulation)





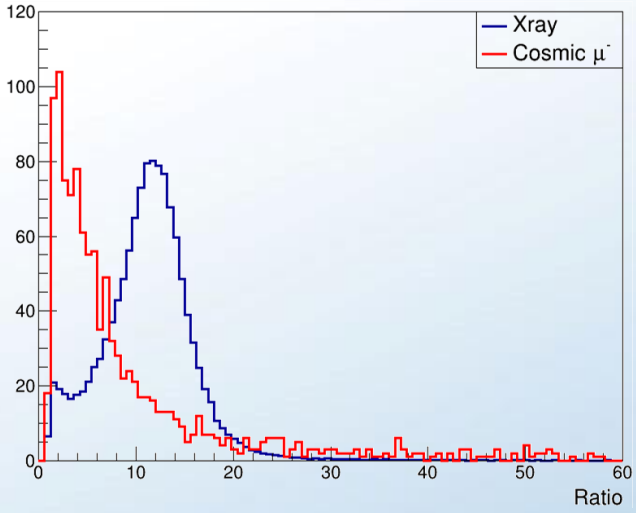
Identify the tracks (simulation)



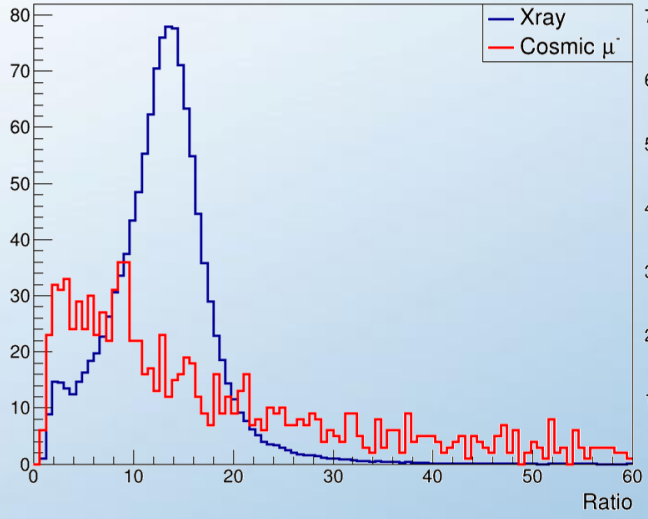


Try to identify signals of different particle (data)

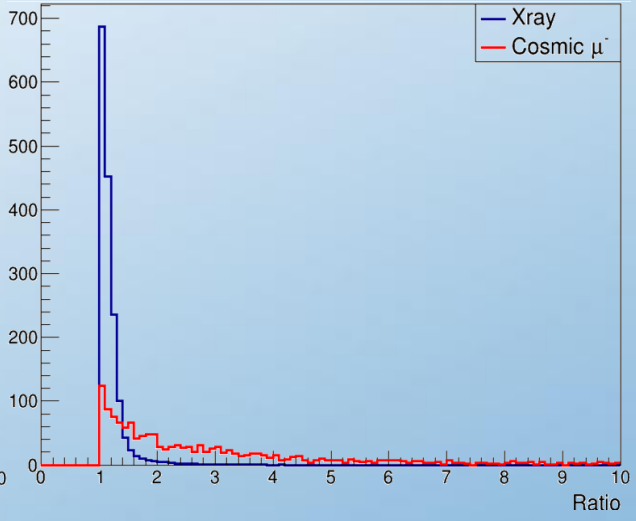
period2/period1



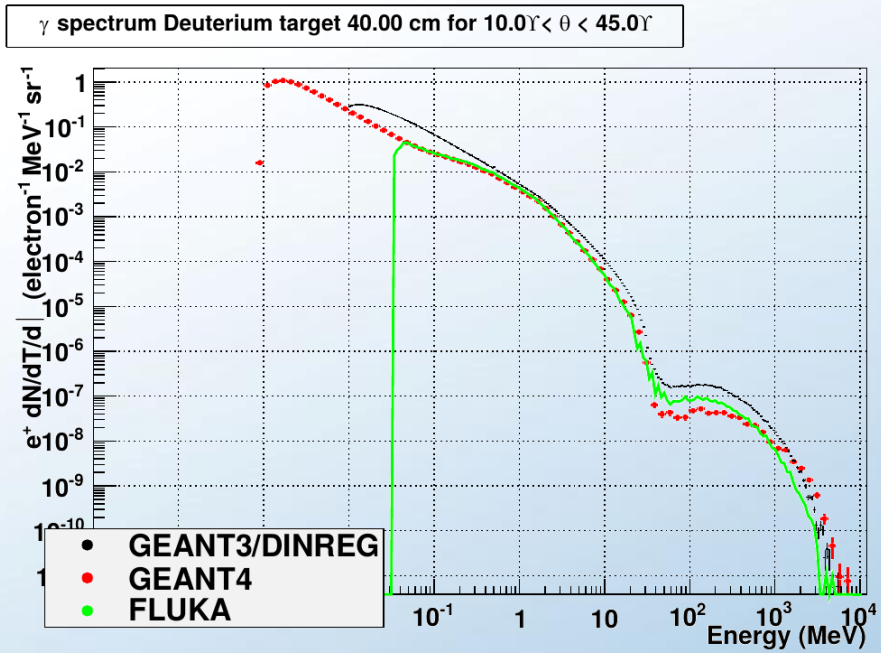
period3/period1

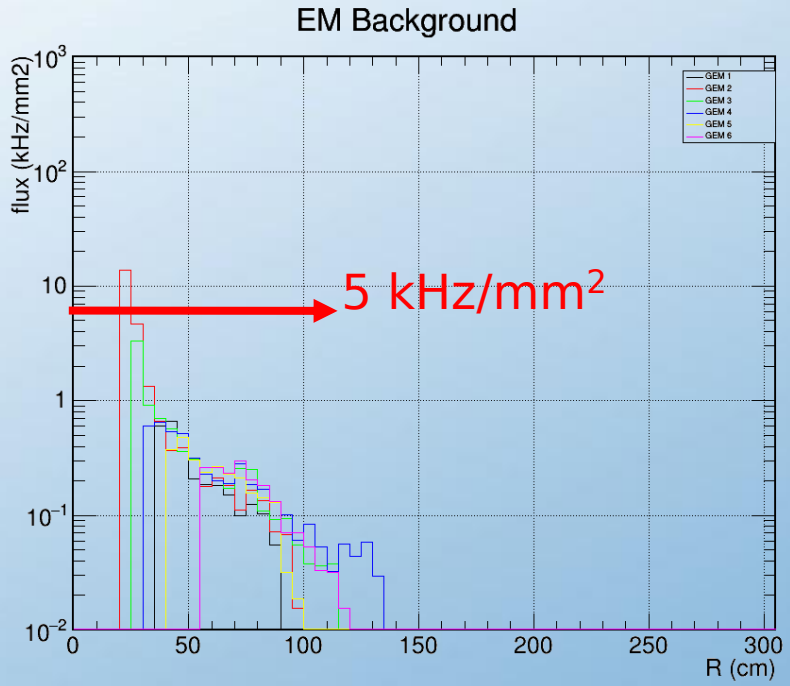


period3/period2



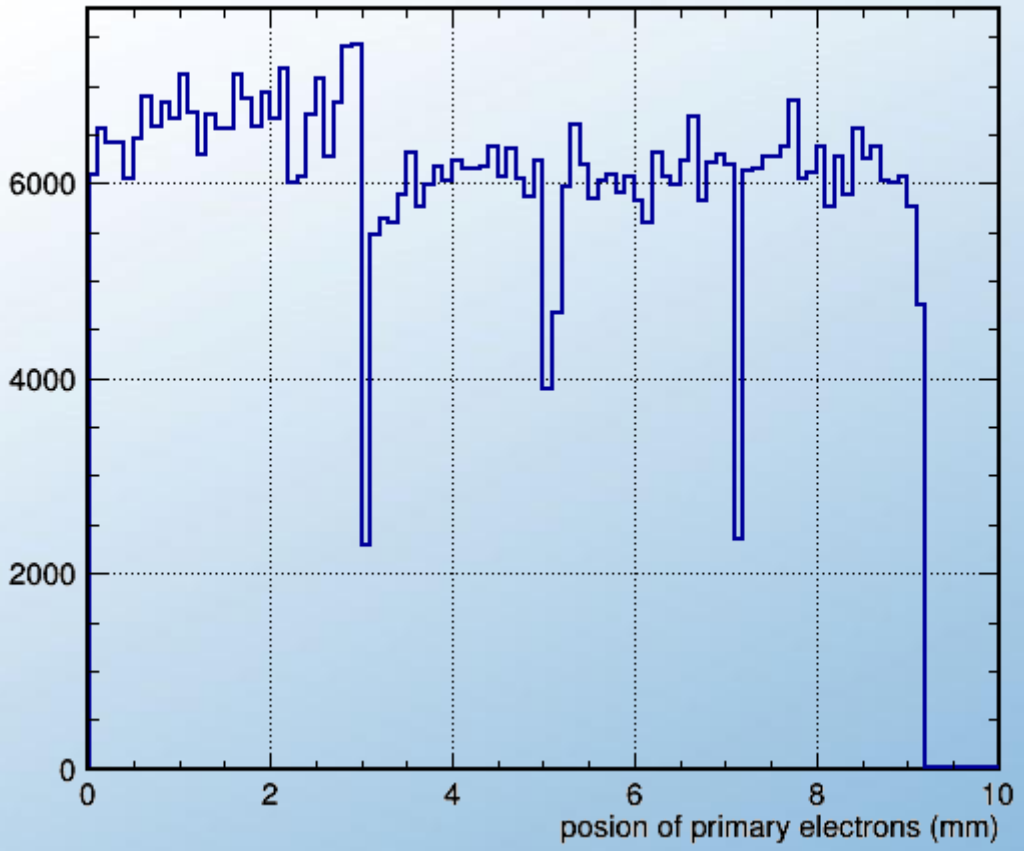
γ background in SoLID GEM



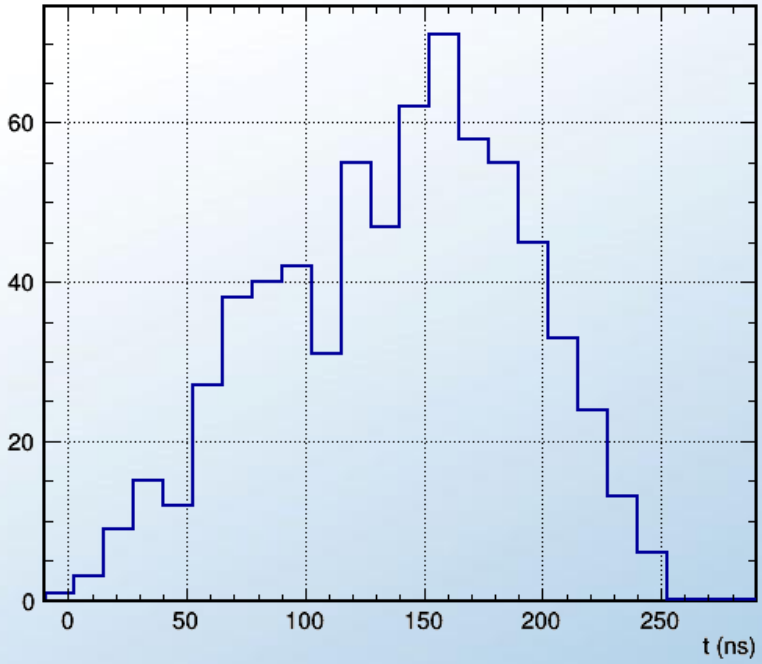


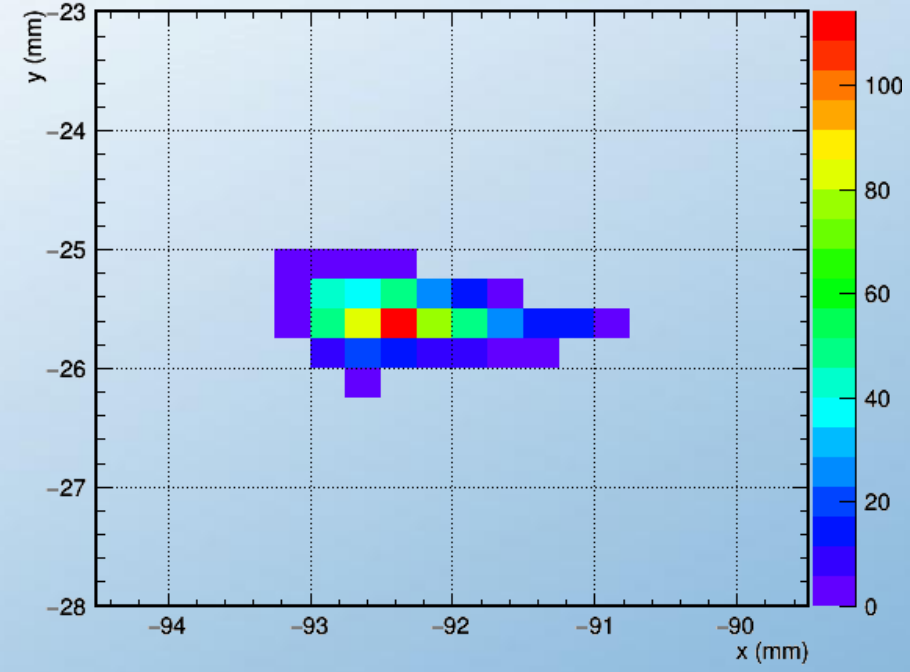
from SoLID PreCDR

primary electron-ion couples in triple GEM



Signals induced by 1 track





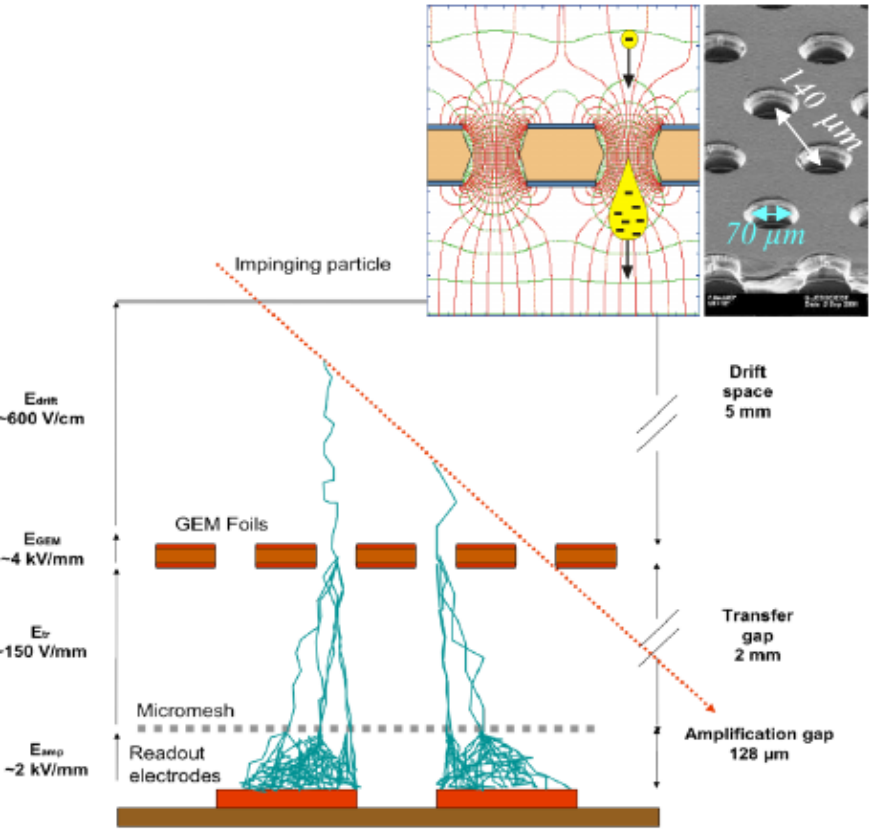
FEE rising time (22ns) included

Future plan

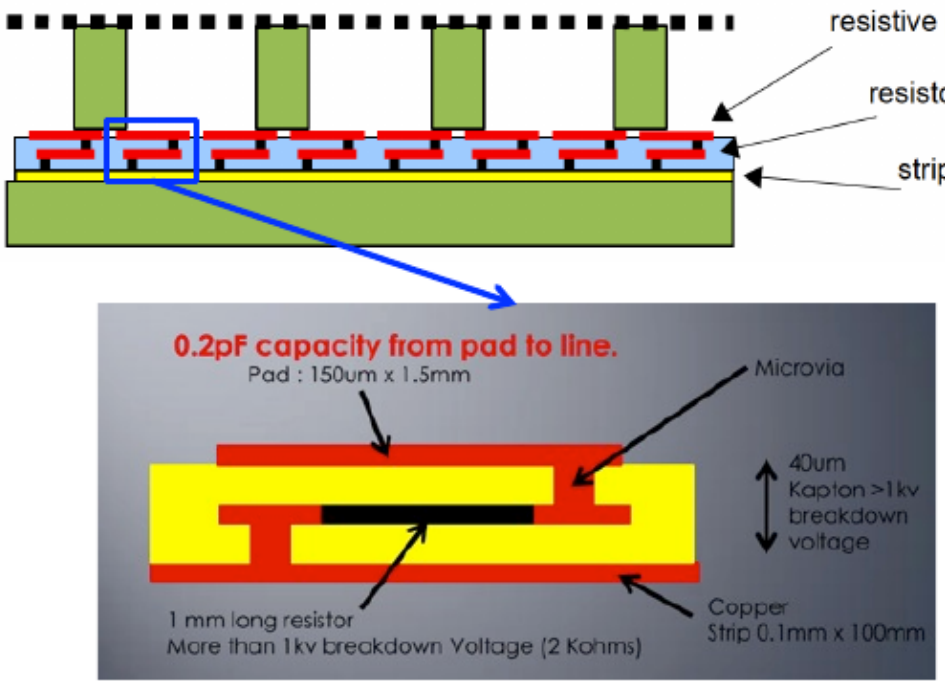
- **process multi time slices on FPGA**
- **test with real beam data?**
- **communicate with INFN experts**
  - try to merge our code into current firmware

Thank you !

- *Hybrid Micromegas + GEM detector :*
  - Gain shared between amplification gap and GEM foil
  - Diffusion of the primary electron cloud



- *Resistive Micromegas with buried resistors*
  - Quick rise of the resistive pads' potential
  - Limitation of the discharge amplitude
  - Compatible with a pixelized readout



Design by Rui de Oliveira et al.