SBS Front Tracker GEM

E. Cisbani

SBS Collaboration Meeting
2017 July 13

- GEM chamber mechanics
- Cosmic/Xray tests
- Recovering inefficient sectors
- Signal Analysis
- Status and plan

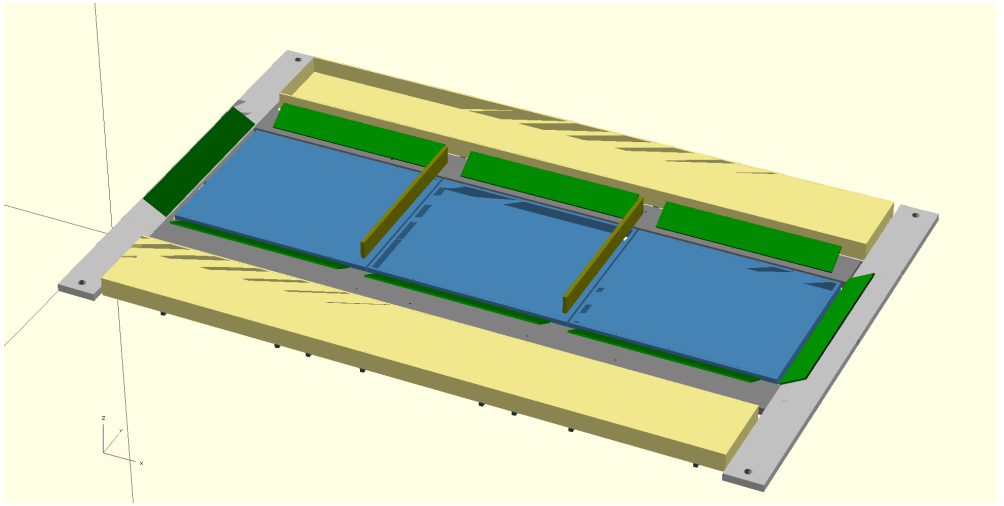
E. Bellini / CT / R
S. Colilli / RM / T
A. Del Dotto / RM /D
F. Giuliani / RM / T
A. Grimaldi / CT / T
F. Librizzi / CT / R+T
M. Lucentini / RM / T
P. Musico / GE / E
F. Noto / CT / E
R. Perrino / BA+LE / R
L. Re / CT / PhD-S
V. Rio / CT / S
M. Russo / CT / R
F. Santavenere / RM / T
G. Sava / CT / T
D. Sciliberto / CT / T
C. Sutera / CT / R

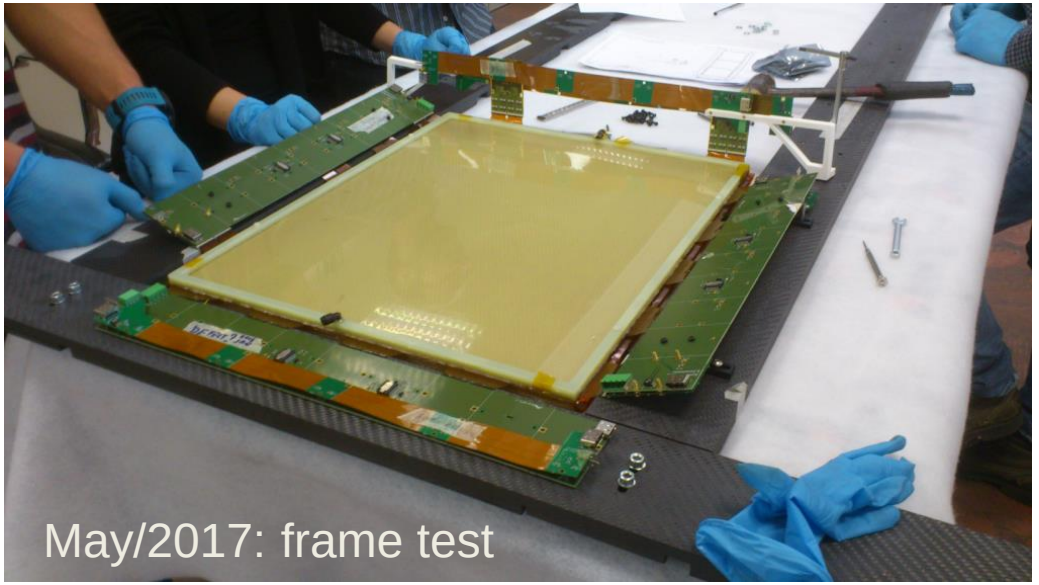
D=PostDoc
E=Engineer
P=PhD Student
R=Researcher
S=Student
T=Technician

BA+LE : Gas system / GEM Test
CT : GEM QA, Assembly, Test and Analysis
GE : Readout Electronics
RM : GEM Test and Integration, Reconstruction

GEM Chambers carbon fiber frames

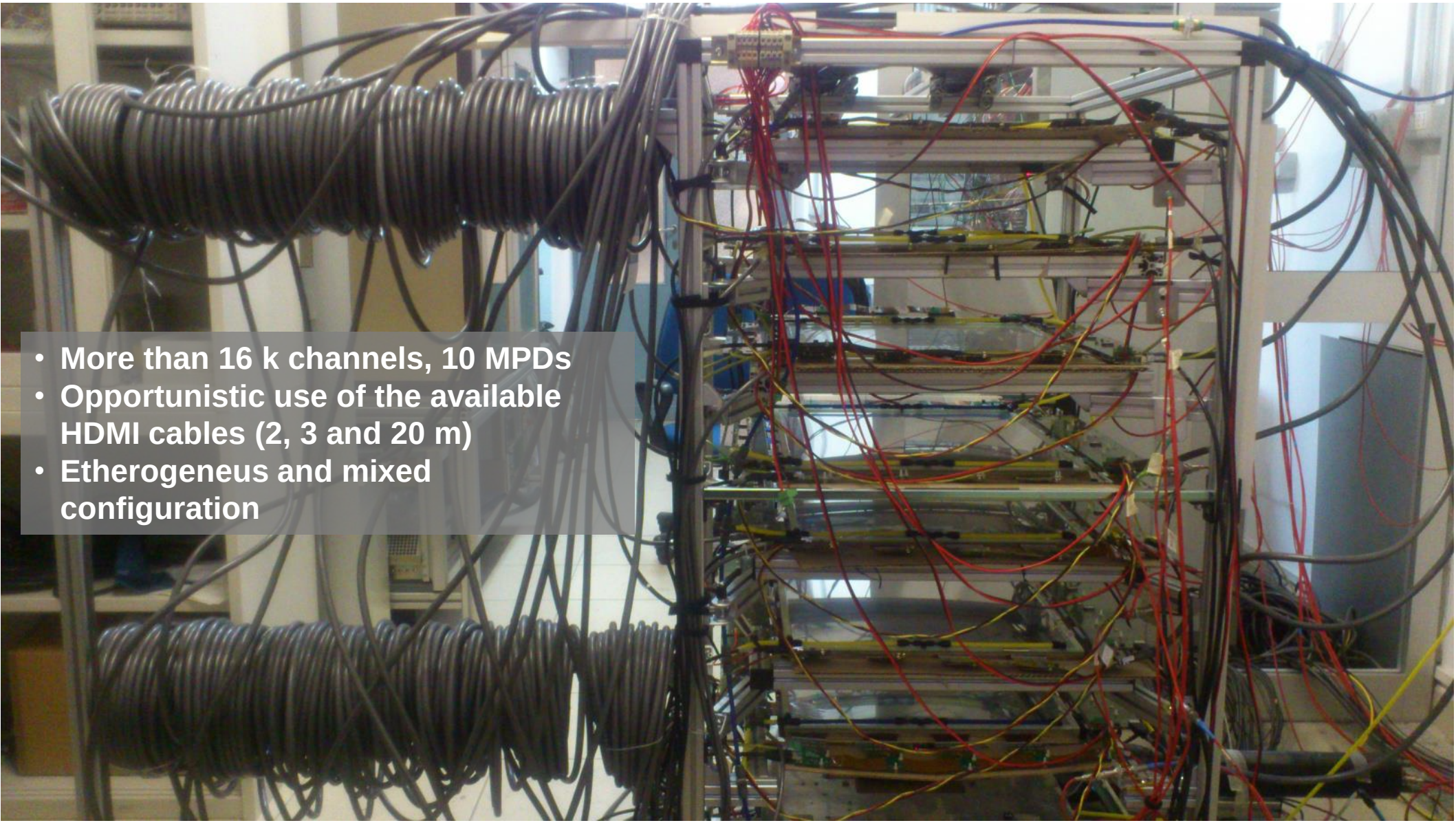
- Design completed last year (identical to chamber 1 except longer transverse bars)
- First frame tested at Riba Composites in May/2017
- Production completed end of June/2017
- Company quality checks completed first week of July/2017 then all frame sent to JLab
- Expected delivery of all frames by 17th of July





May/2017: frame test

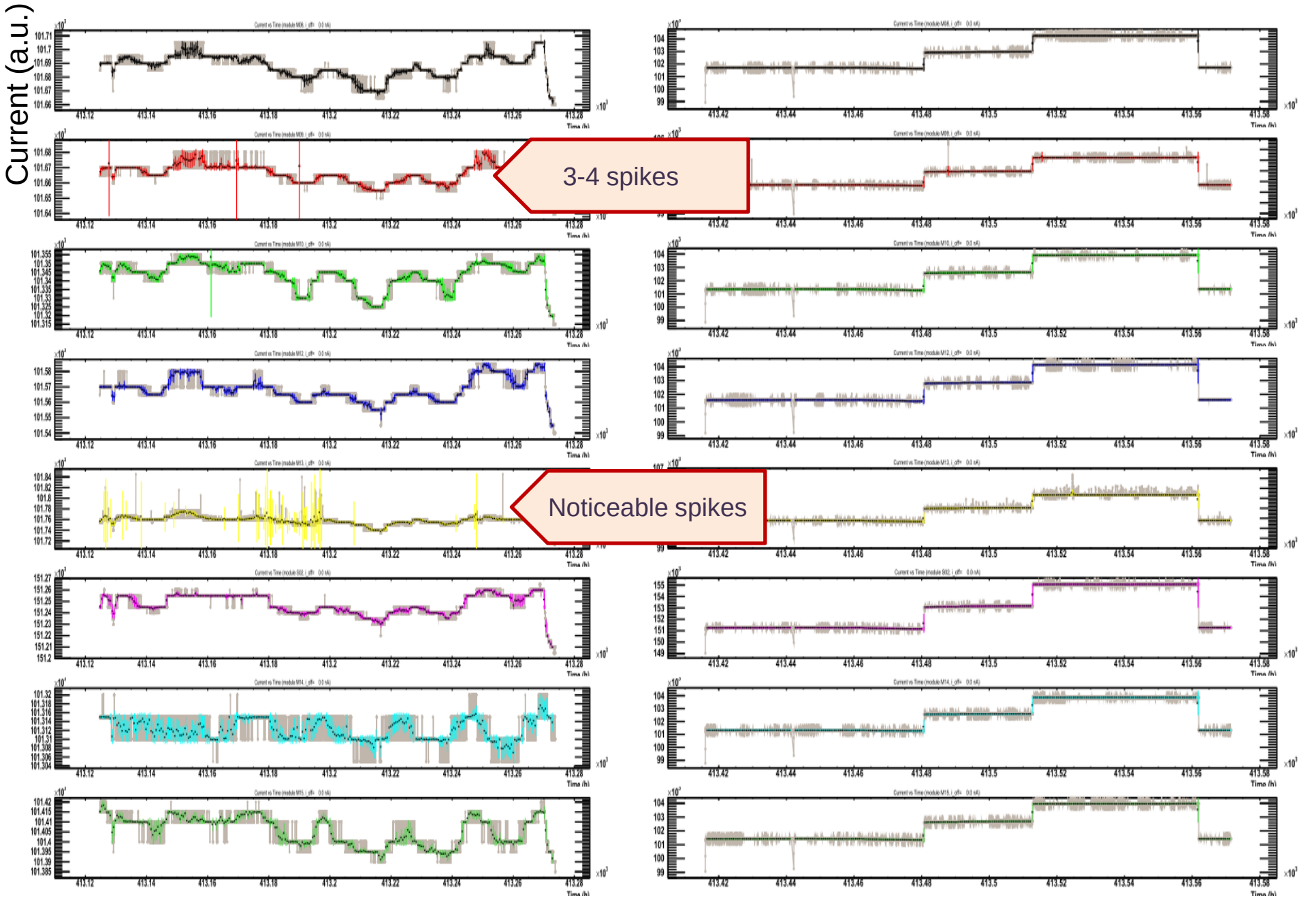
GEM Cosmic Setup in Rome (Mar/2016 – Mar/2017)



7 FT GEM modules and 1 Small Reference GEM
4 Scintillators (50x25 cm2 each): 2 TOP & 2 BOT
1 Small Scintillator near the small GEM

Too many modules at the same time, rather difficult troubleshooting

HV divider currents (≈3 week span)



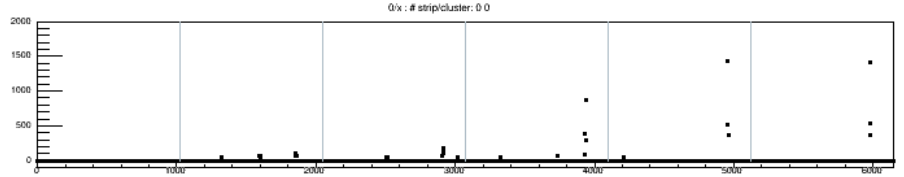
(new) Event Display

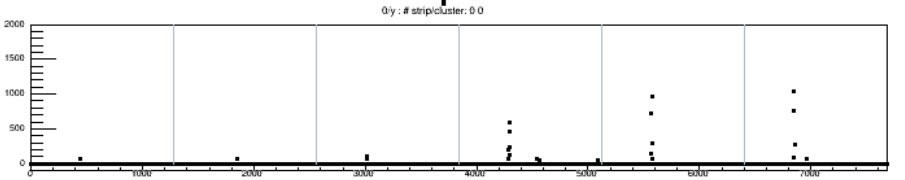
L. Lagamba is now looking at the trackign data

6 samples – X

6 samples – Y

M08





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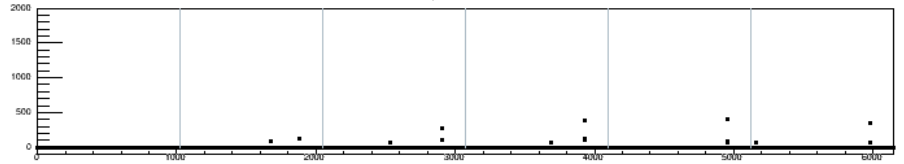

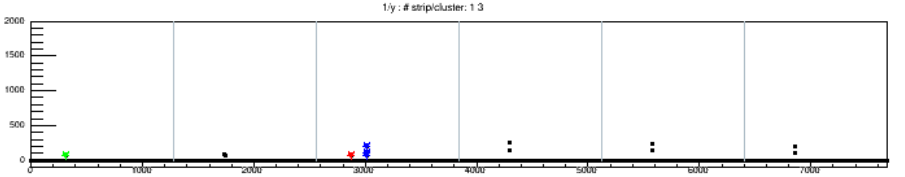

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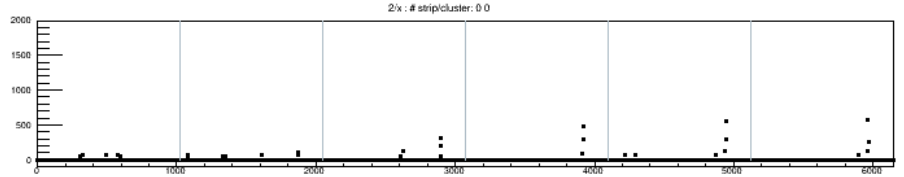

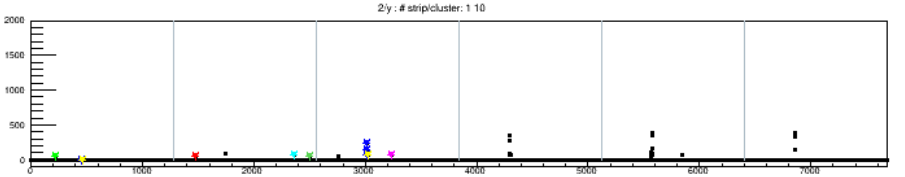

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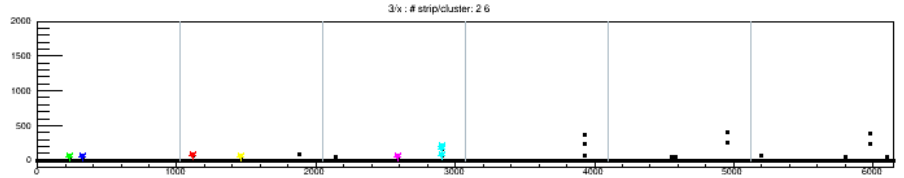

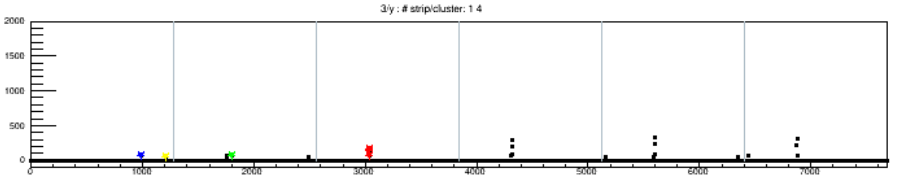

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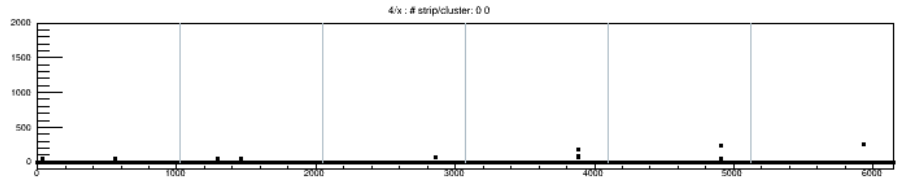

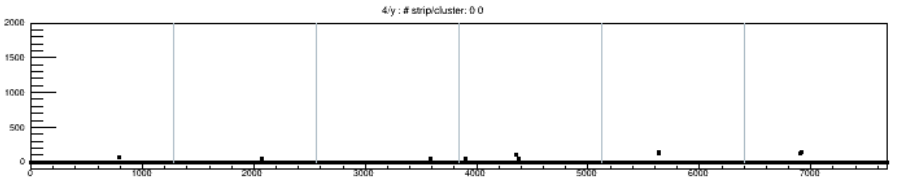

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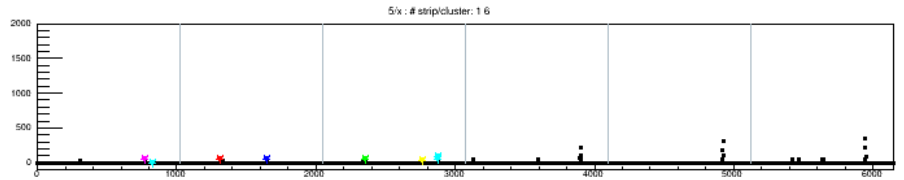

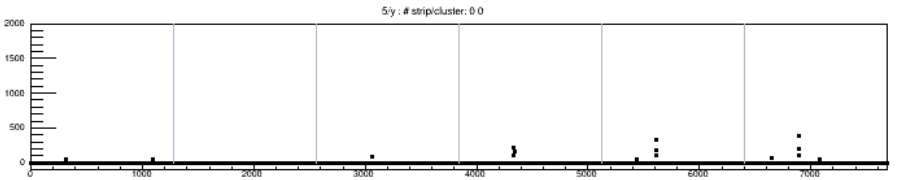

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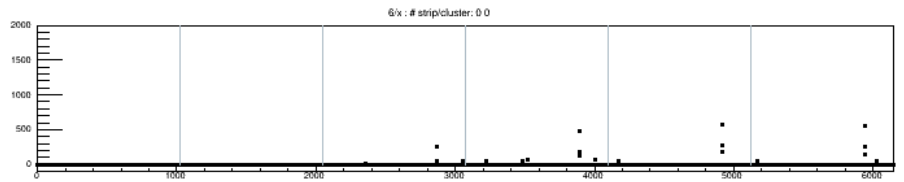
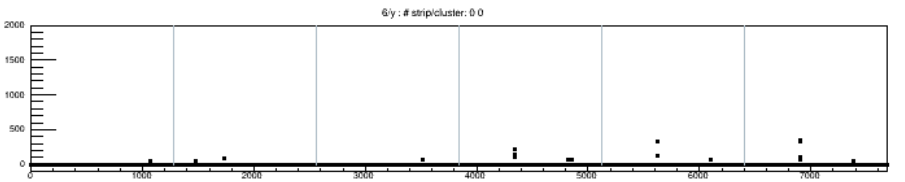
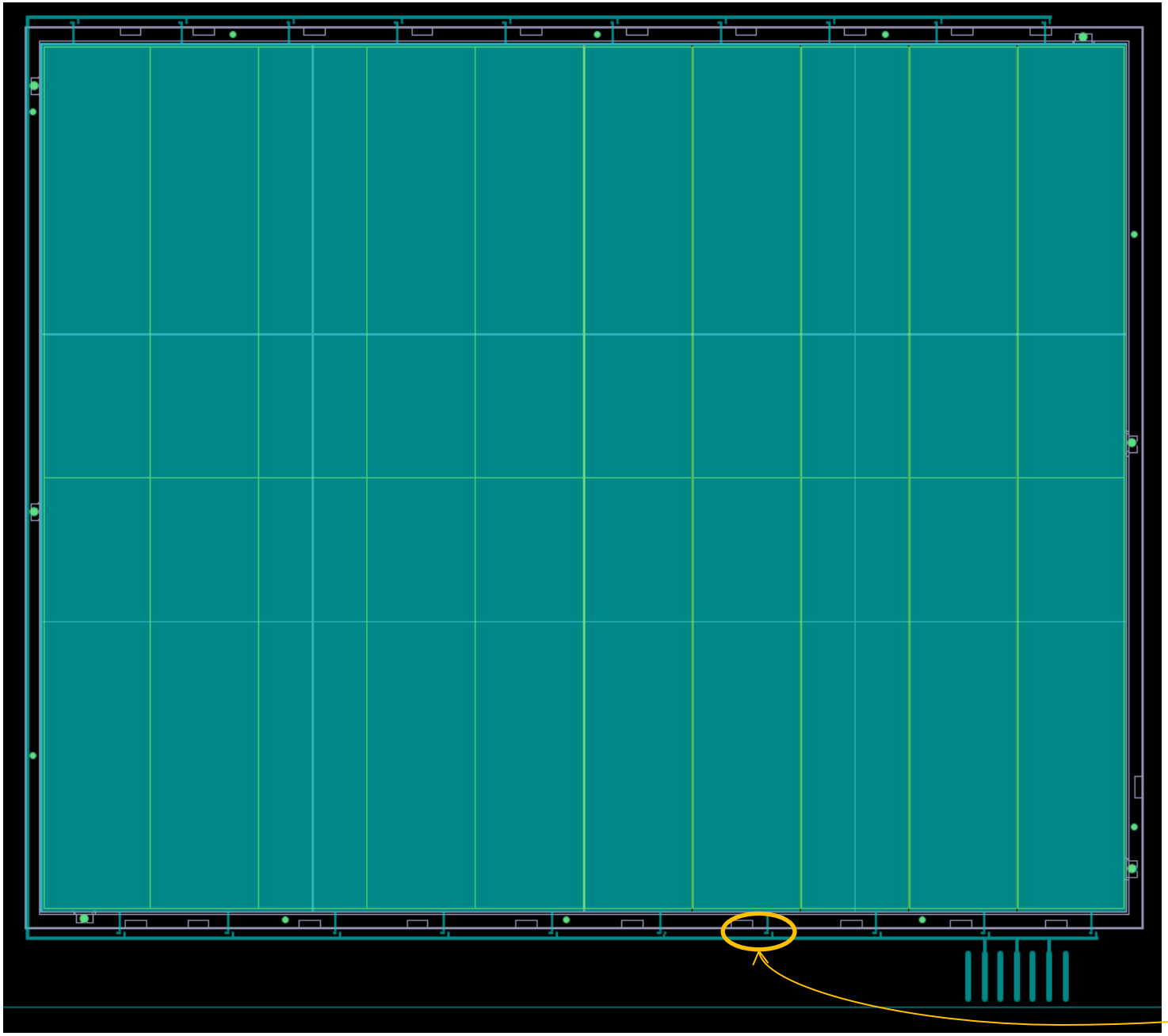




Front Tracker GEM



PERMAGLAS frame

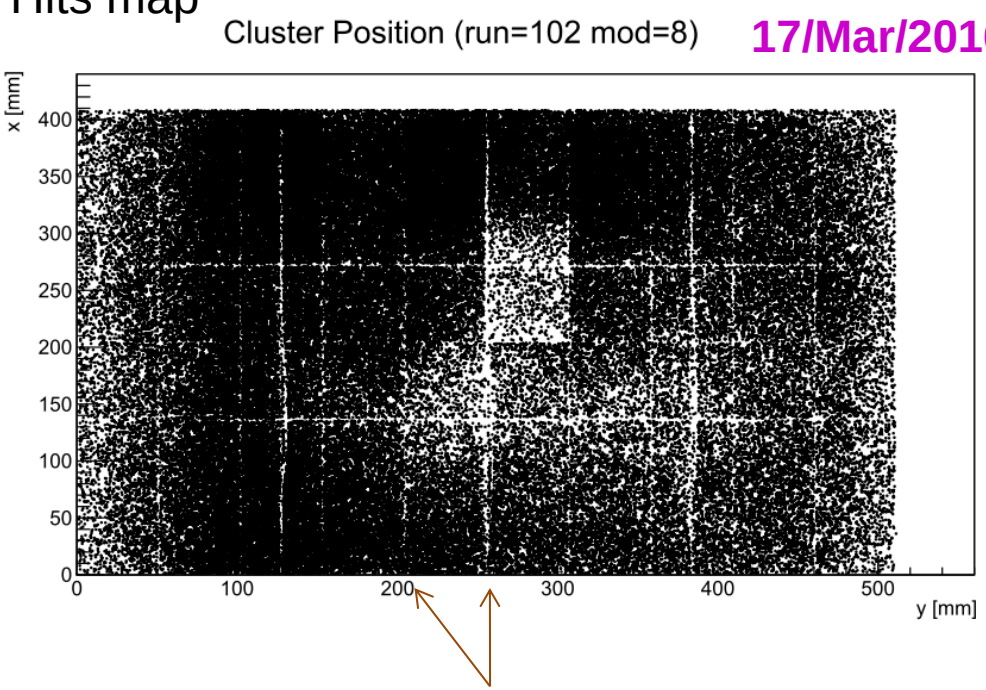
Spacers (cyan)

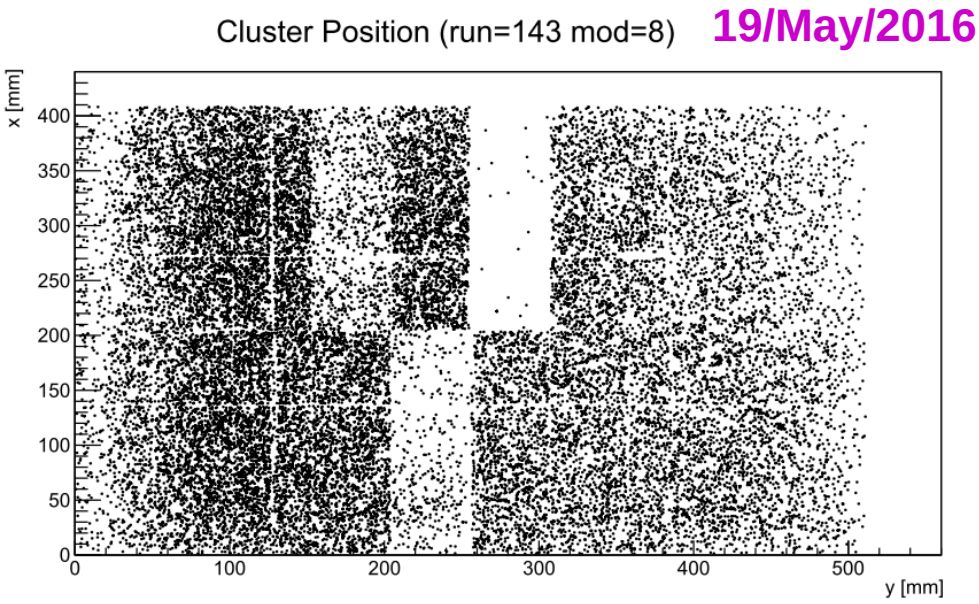
GEM sector borders (green

Protective resistors
(outside the frame)

Long Cosmic Test, GEM **Mod 8 – one year tests**

Hits map



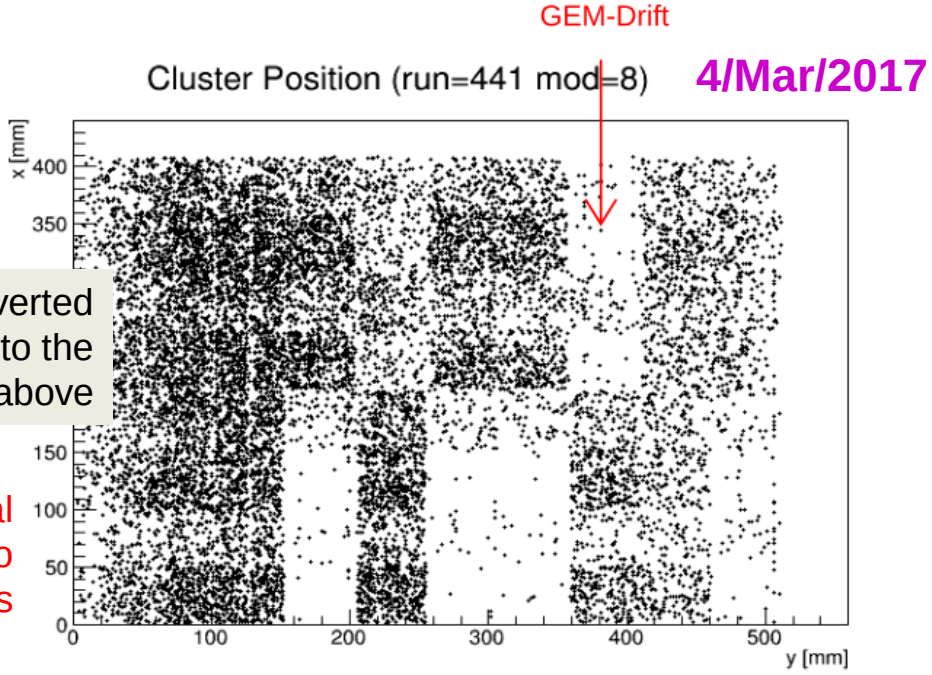


Nice «cosmo-graphy» of the spacers and dead area between GEM sectors

However something getting wrong starting from the center of the chamber …

… getting worse over time!

This is the **only one module** showing time degradation (with no apparent reasons)



x is inverted respect to the above

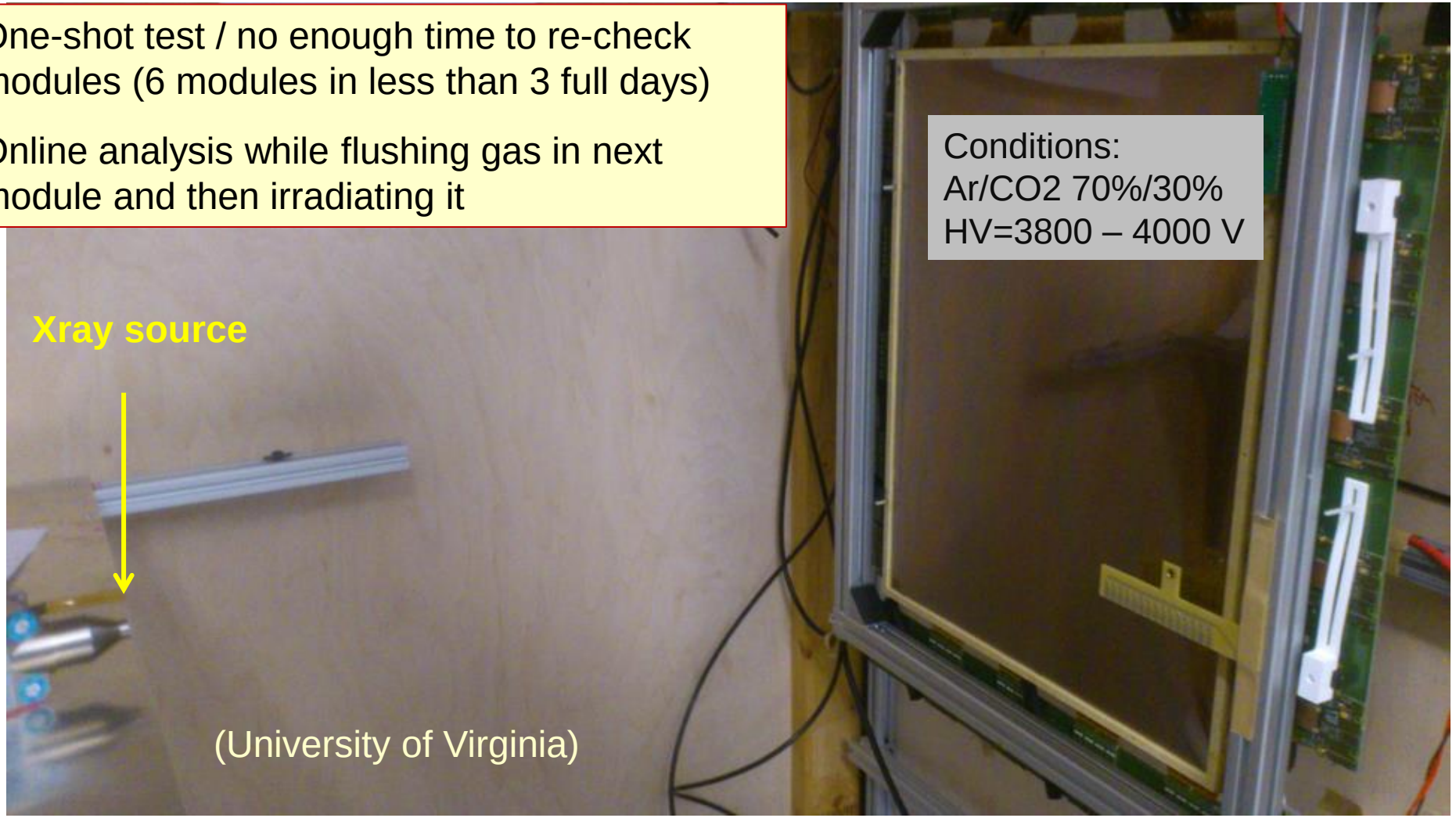
Horizontal stripes due to electronics

UVa Xray Test (13th-15th Dec/2016)

Thanks to UVa collaborators we irradiated the first 6 FT-GEM modules using the UVa Xray setup

- Test conditions of modules after overseas transportation and >1 year storage in «harsh» environment

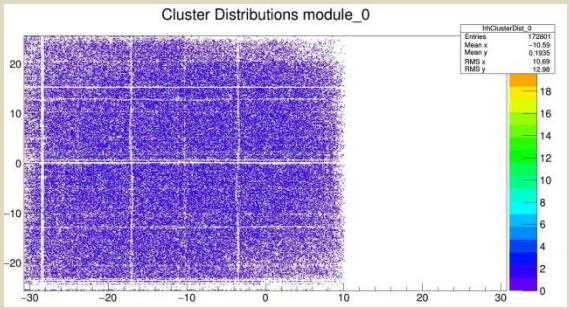
- One-shot test / no enough time to re-check modules (6 modules in less than 3 full days)
- Online analysis while flushing gas in next module and then irradiating it

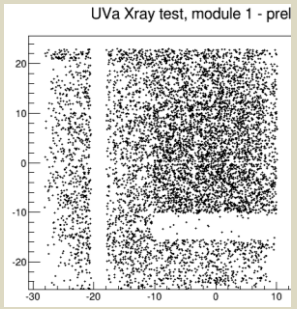


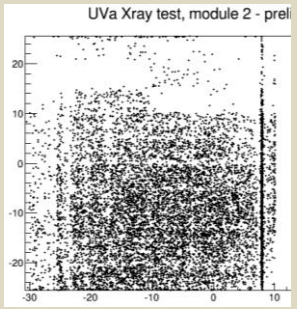
Status of GEM modules in March/2017

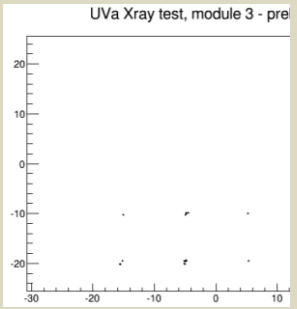
Hits maps

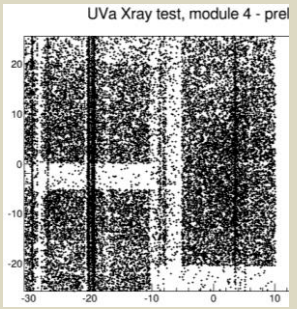
Latest test by X-ray at UVa, Dec/2016

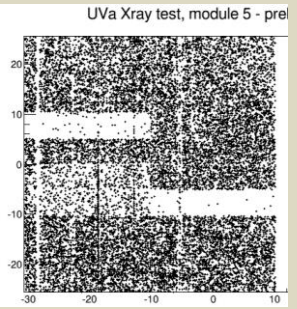






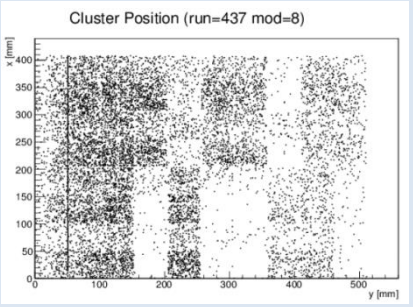


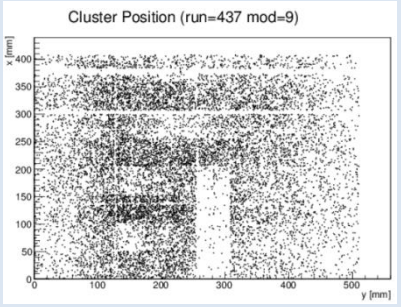


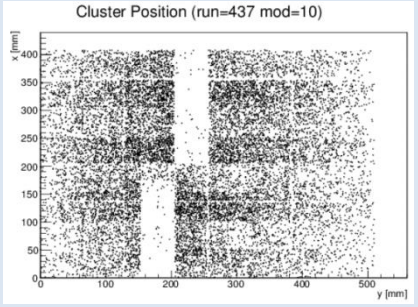


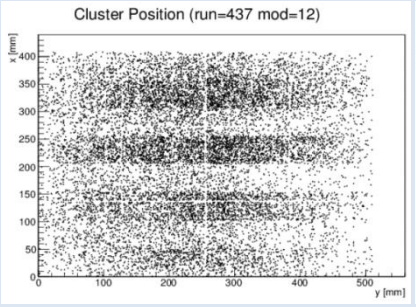
⇨ 4 inefficient sectors respect to previous test (cosmic in Rome, ~1 year earlier), mod 3 apparently dead

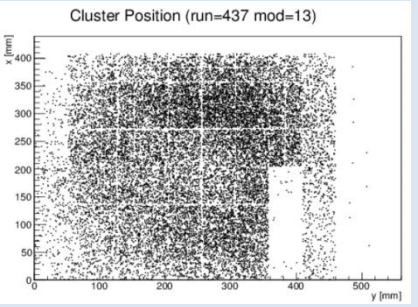
Latest test by cosmics in Rome, Mar/2017

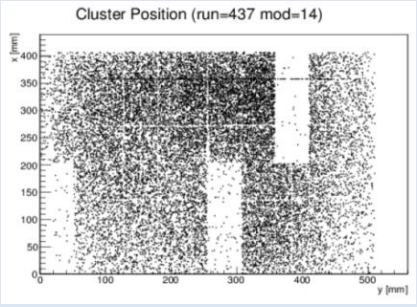


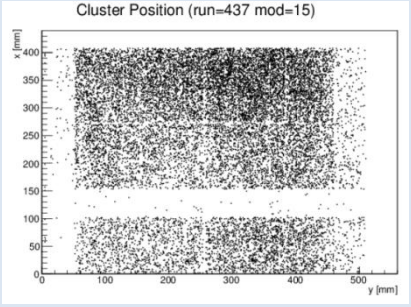












⇨ after approx. 1 years of cosmic tests: 3 shorted sectors and 8 inefficient sectors – stable behaviour except Mod 8 (see prev.)

Note: horizontal stripes-pattern are electronics/reconstruction artefact (no real concern)

+ 2 modules rejected (due to visual/evident construction problems)
+ 2 modules in Rome ready for testing
+ 2 modules in Catania waiting FR4 frames for readout window
+ 1 module ready for assembling (excpet FR4 frames)

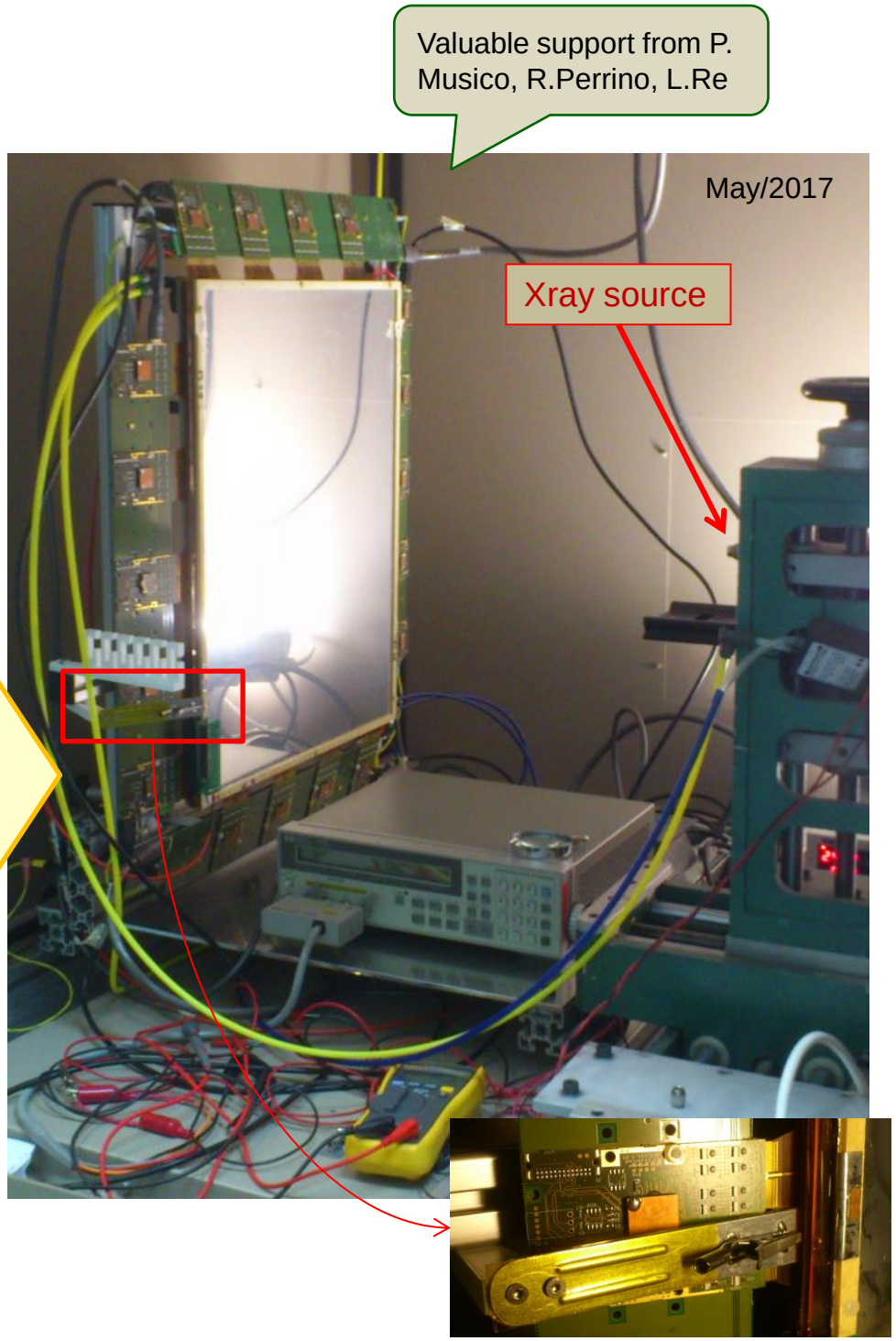
Total modules:17 produced so far, 3 to come soon

Two major issues:

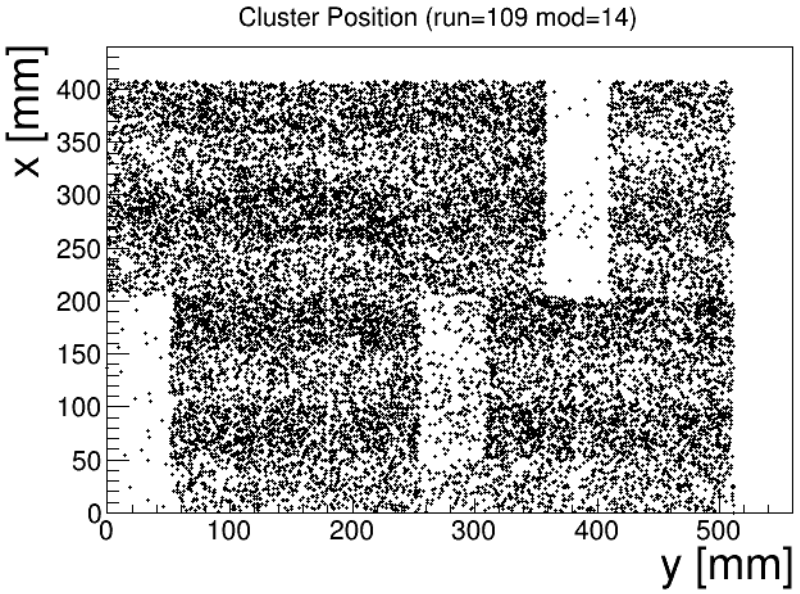
- **Inefficient sectors (see next)**
- **Shorted sectors (due to GEM foil ? -> L. Re talk)**

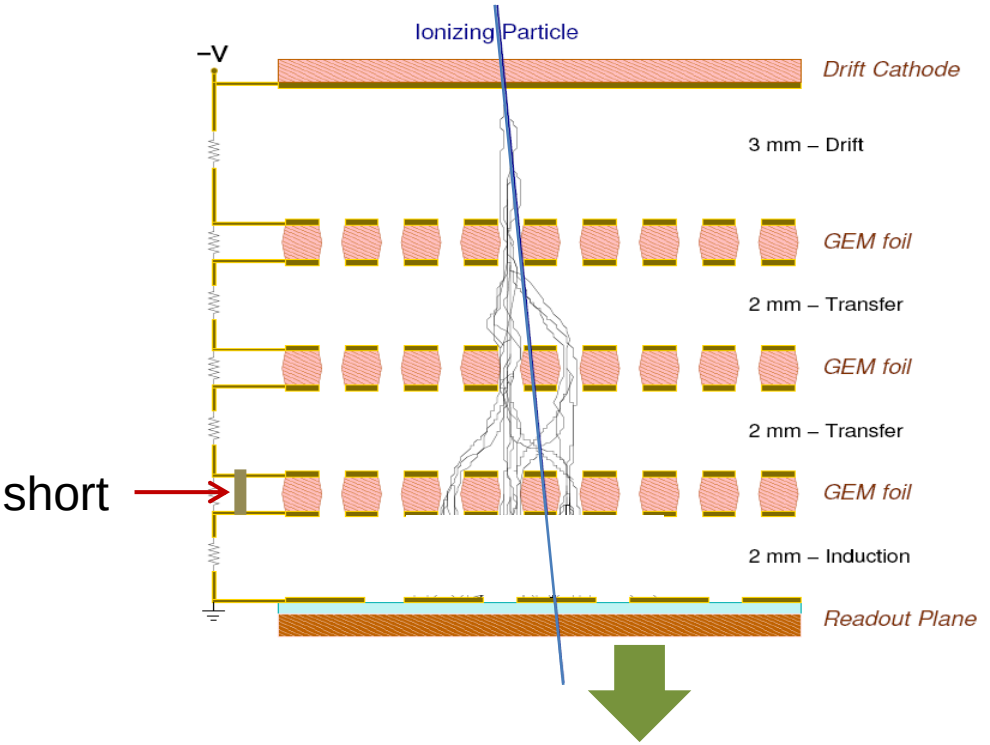
X-ray test facility in Rome

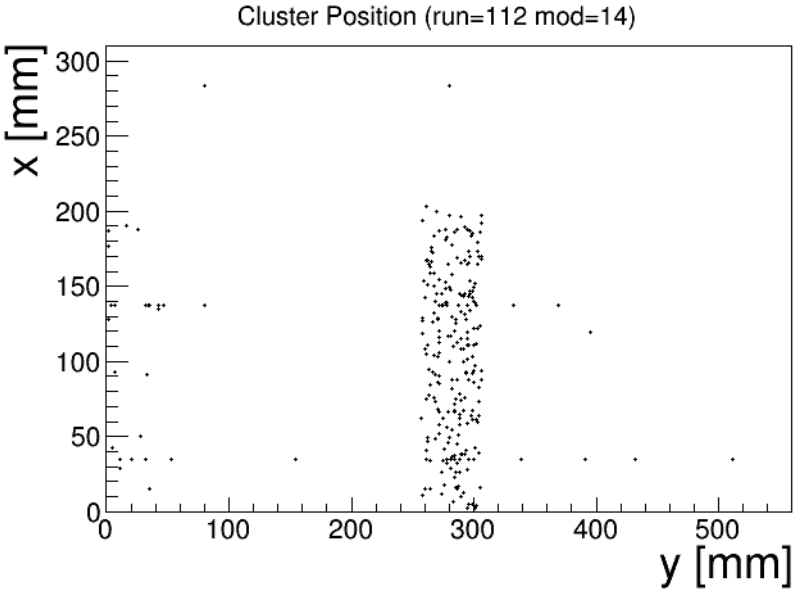
- Cosmic test: too many modules acquired and tested at the same time makes troubleshooting difficult, expecially with «slow» cosmics and etherogeneous cabling/connection
- Experiencing GEM sectors with low efficiency
- Move to single module test by Xray (and then cosmic)
- Spent quite few weeks to setup the Xray facility in Rome
  - Reused existing shielded box
  - Replaced radiation source
- Prepared suitable tools to access small parts of the GEM (e.g. protective resistors, HV terminals …) in restricted space, modified test frame to improve access
- Test each module by Xray, with the same electronics, if possible fix it!



Apparence of signal from inefficient sectors







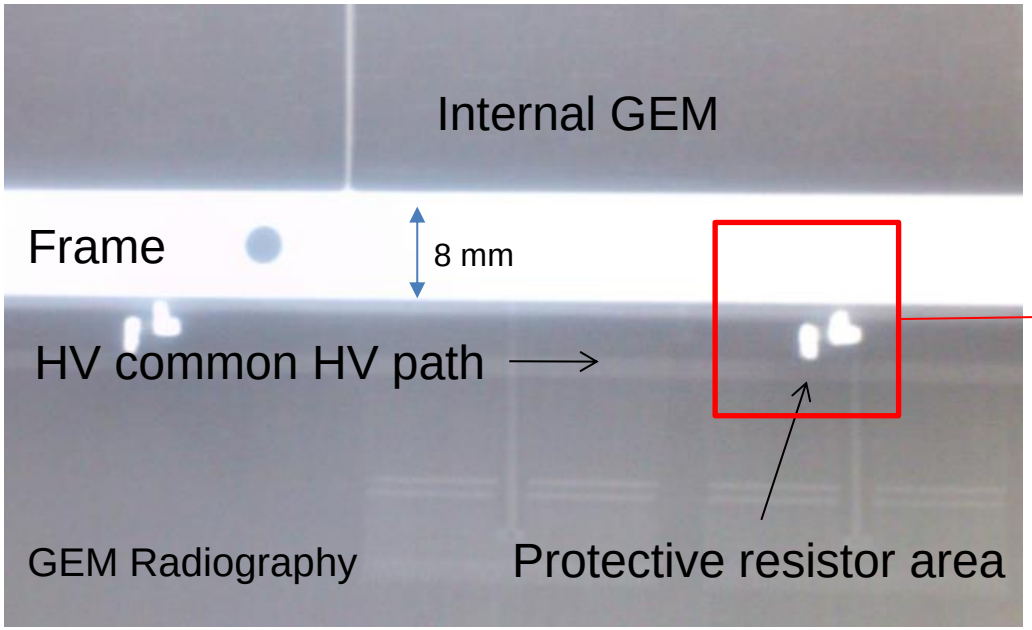
When the two sides of the GEM foil is Shorted, the avalache cannot reach the readout.

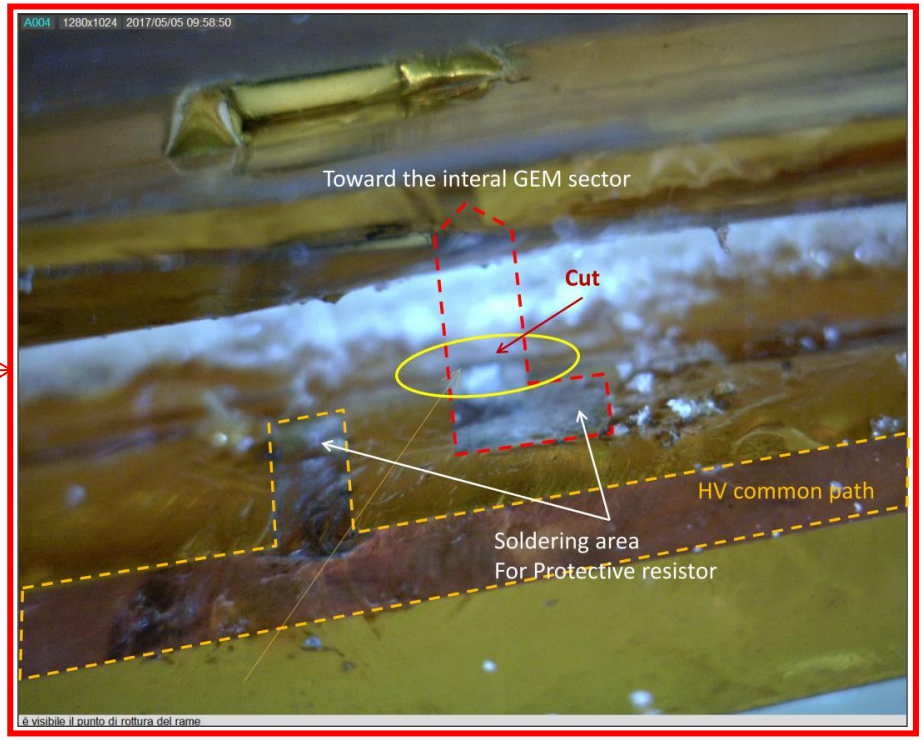
The inefficient sector remain transparent which mean it is not shorted

Revealed the origin of inefficient sectors

The HV distribution line is interrupted between the protective resistor and the border of the GEM frame – the sector does not get HV.

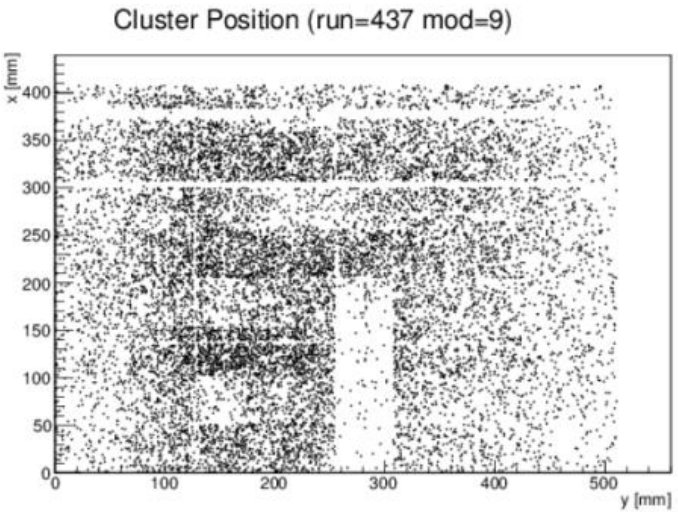
Cut is likely due to eccessive soldering of the protective resistor which extends beyond the expected pads (see GEM radiography) combined to bending of the kapton foil due to module handling (and/or transportation):
the extra soldered border acts as blade for the HV line

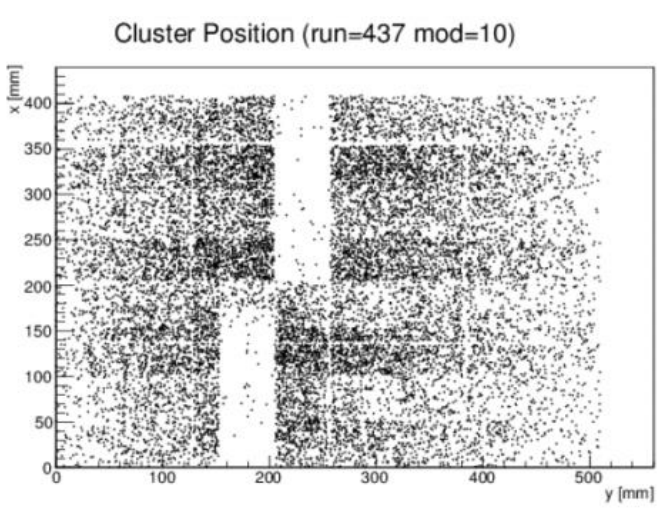


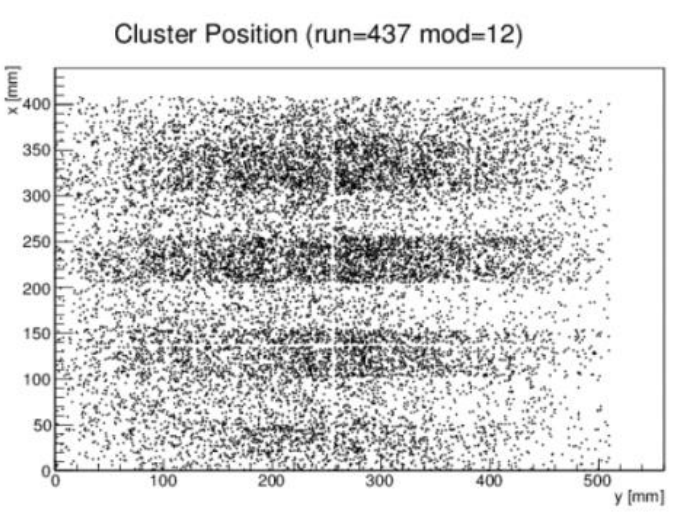


Recovering inefficient sectors – mod 9, 10, 12

Before

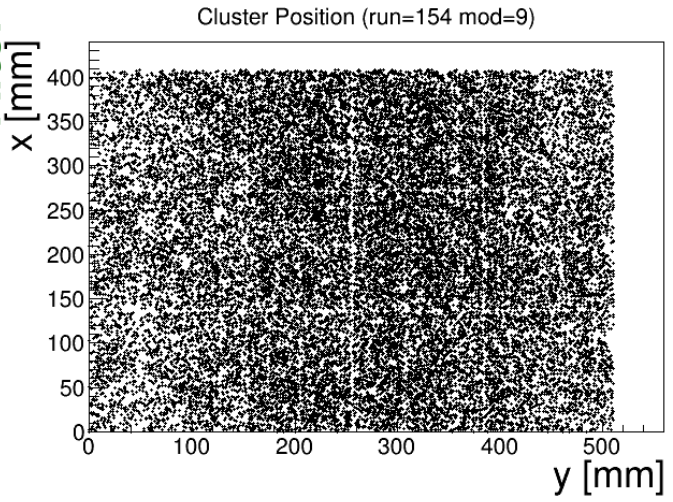


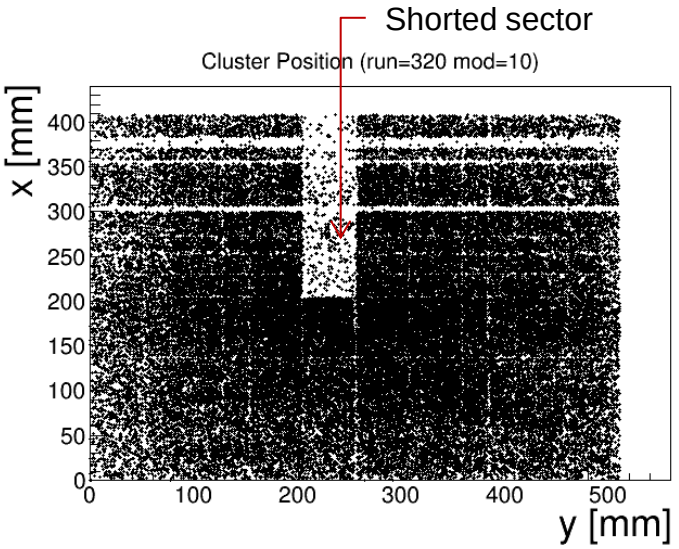


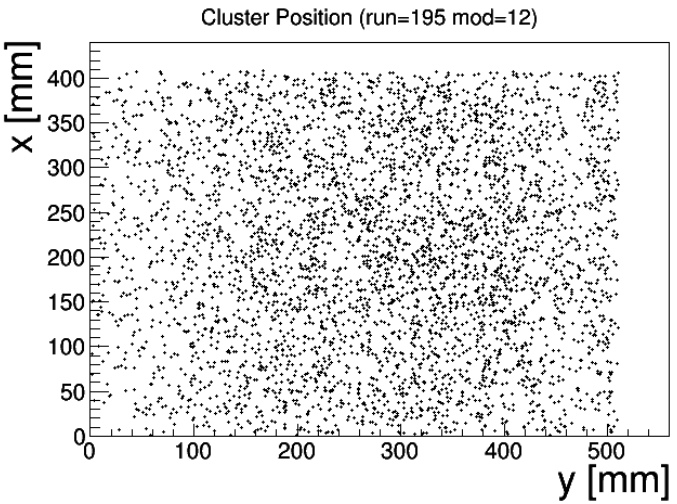


Above: cosmic tests / Below: Xray test (after fixing where applicable)

After



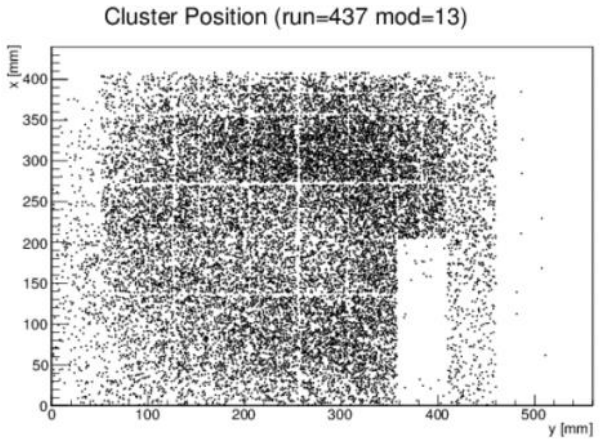


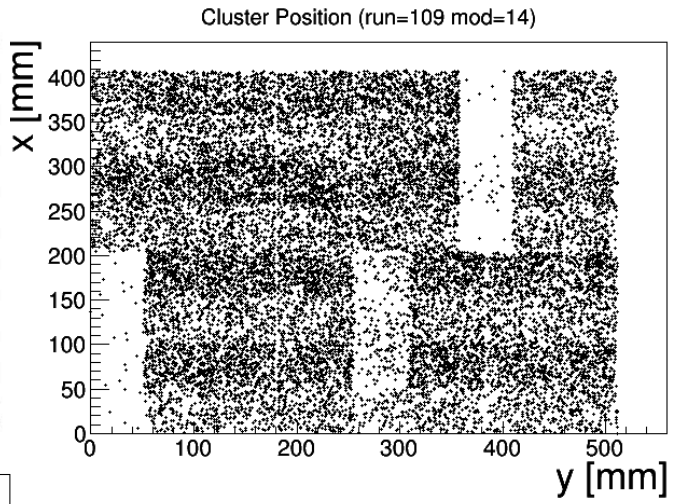


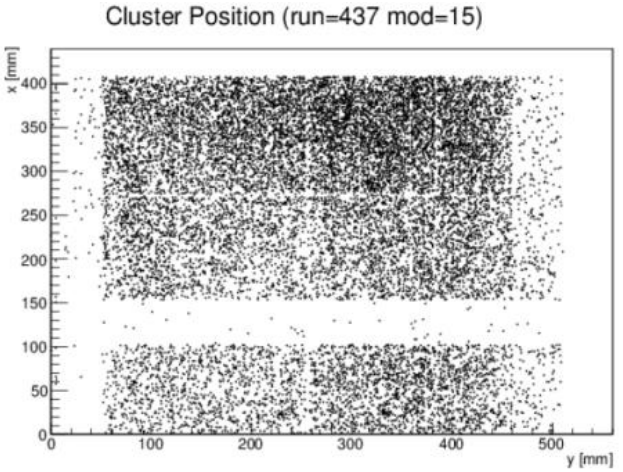
All sectors recovered except one shorted!

Recovering inefficient sectors – mod 13, 14, 15

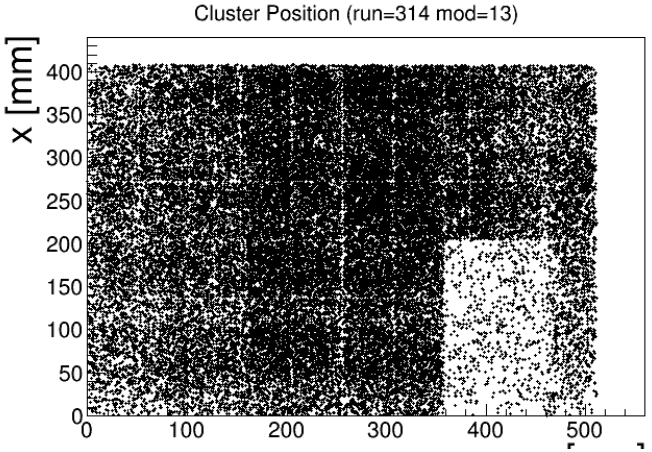
Before

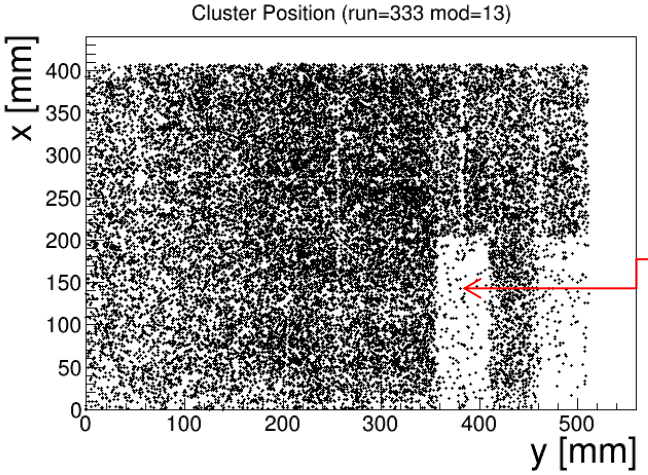




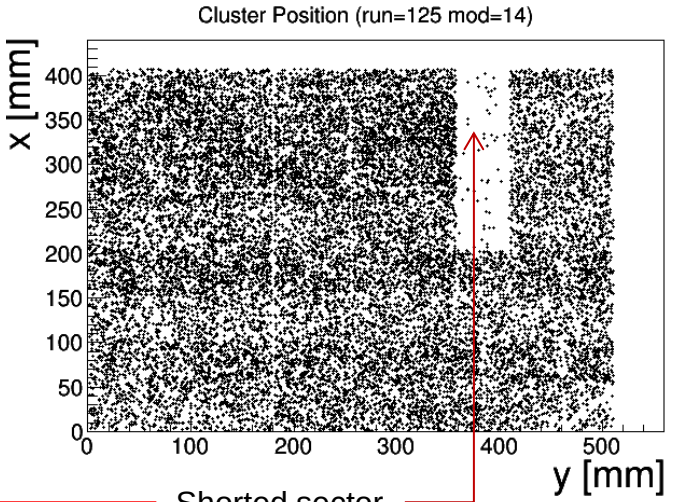


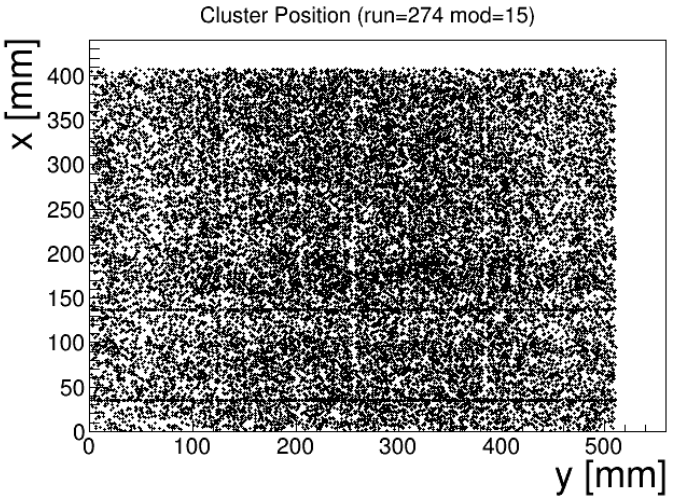
After





Above: cosmic tests / Below: Xray test (after fixing where applicable)

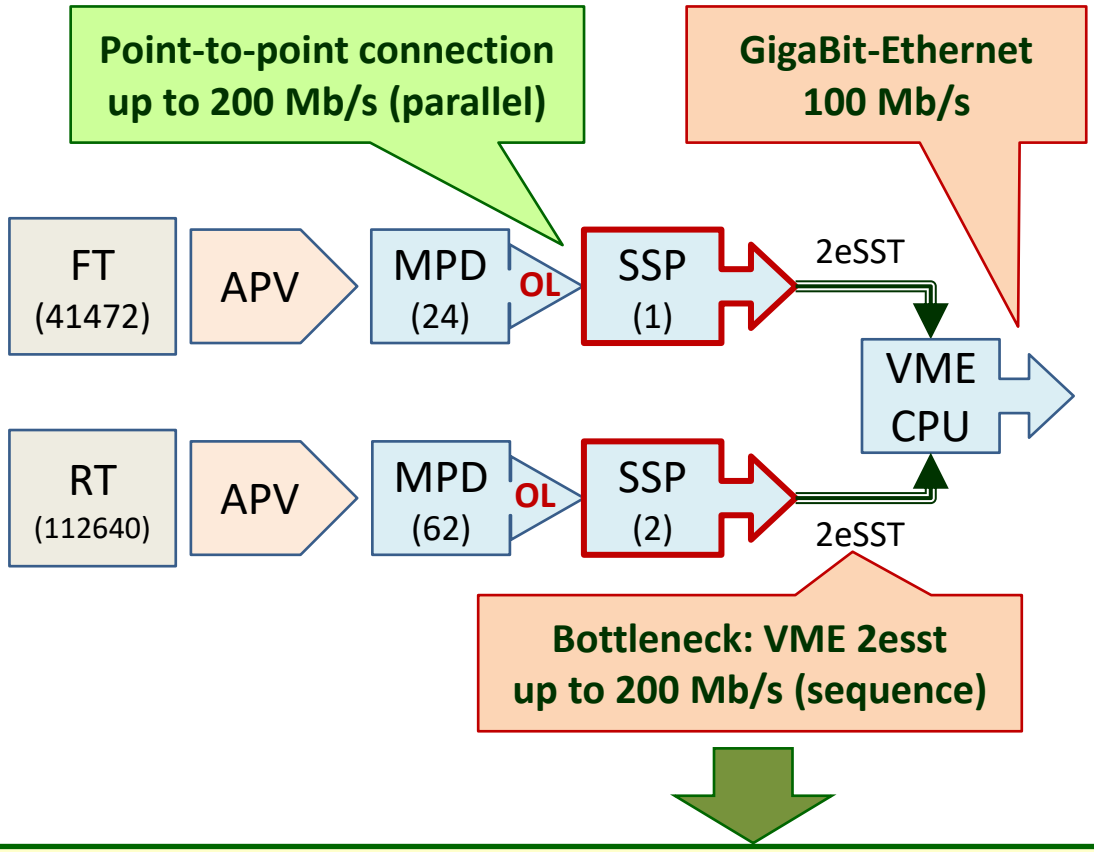




Shorted sector

All sectors recovered except two shorted!
One need fixed need extra care diring handling

GEp: GEM data rate



Front Tracker expected rate: 500 kHz/cm2
⇨ Estimated Strip Occupancy: 60%

Samples/events: 3 (or 6)
Sparsification
Trigger Rate: 5 kHz

⇨ **MPD-SSP: up to 100 Mb/s parallel transfer rate - SUSTAINABLE!**

⇨ **SSP-VME: up to 200 Mb/s non parallel transfer rate – NEED DATA REDUCTION**

(Rear Tracker expected rate: 200 kHz/cm2 but 2.7 times the channels → similar occupancy and transfer rate)

Need data processing on SSP (and MPD) to reduce data by factor >10:

- Trigger Time Correlation: 80ns / signal width ≈250 ns → factor 3;

  offline time resolution ≈5 ns

- e-p geometrical constraints: ECAL – HCAL alignment → factor >4.5

- x/y clustering with charge/time correlation … to be investigated

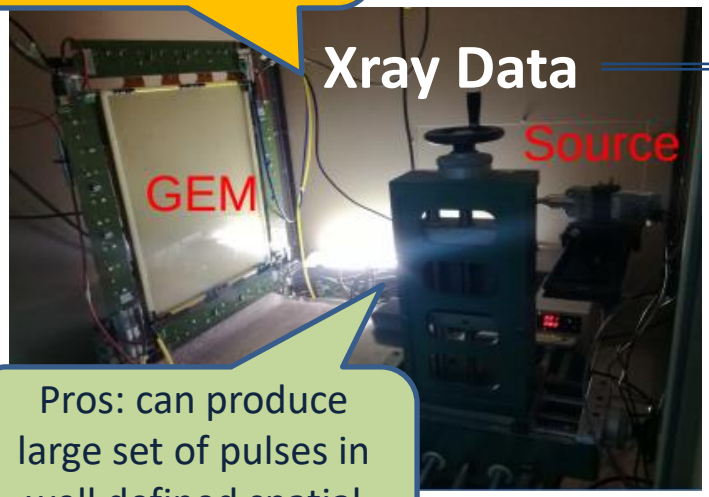
Part of the PhD activity of Leonard Re

APV Pulse Analysis for Data Reduction

- Find a **robust but simple function** that can be implemented in firmware to discriminate signal from background (noise and uncorrelated pulses)
- Use a Genetic Programming tool (**Brain Project** by M. Russo) based on A.I. that produces analytical expression from:
  - List of functions/operations with weigthing factors (interplay between complexity of firmware and speed of execution)
  - Desired final «error»
  - Learning and Testing data
- Critical aspects on learning/testing data:
  - Signal and background must be properly assessed
  - comprehensive set of signals and background

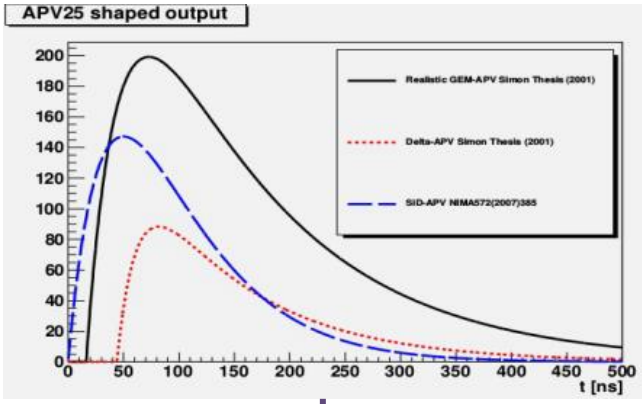
Generate Data: Signal and Bacground

Cons: signals not synch-ed to trigger
Xray signals ≠ MIPs signals



Pros: can produce large set of pulses in well defined spatial spot and short time

Common Noise suppression & Pedestal subtraction

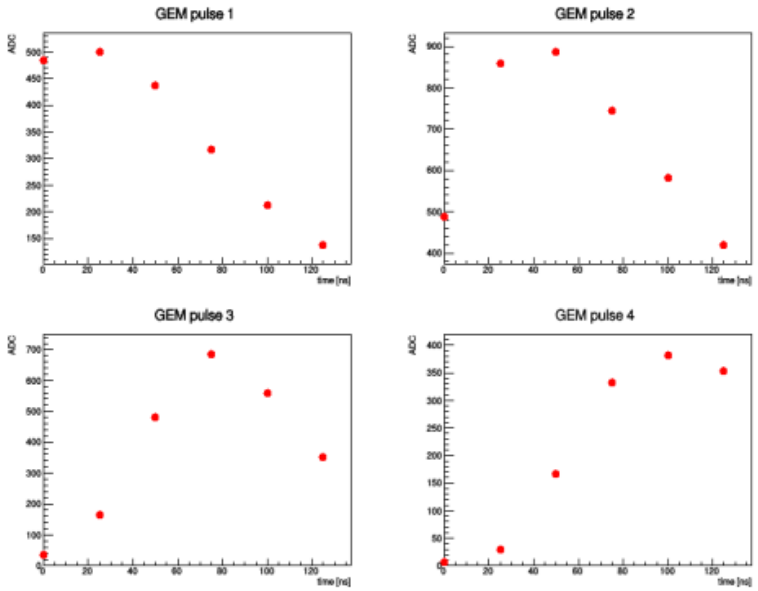


Apply «human» criteria to all pulses coming from each strip

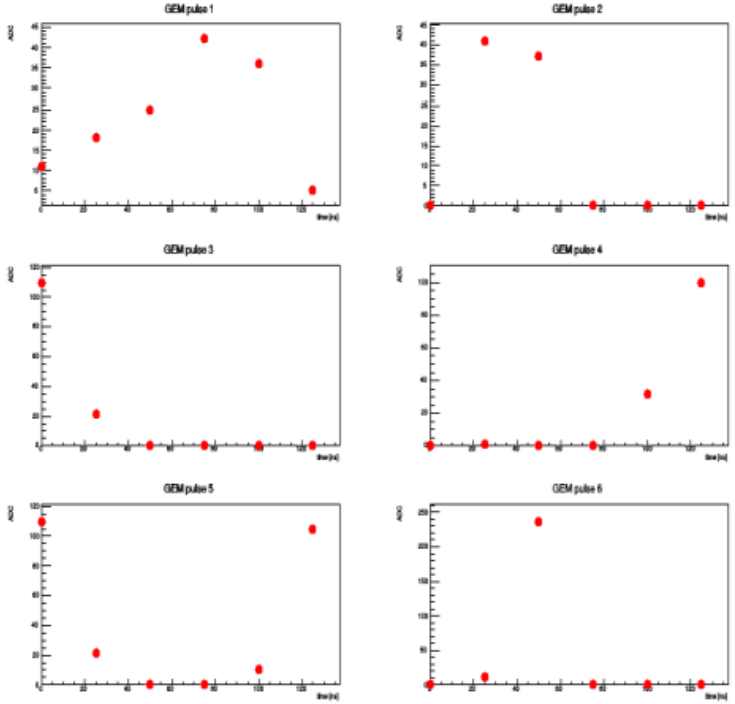
Pass criteria ?

yes

no



Signals



Background (noise, uncorrelated)

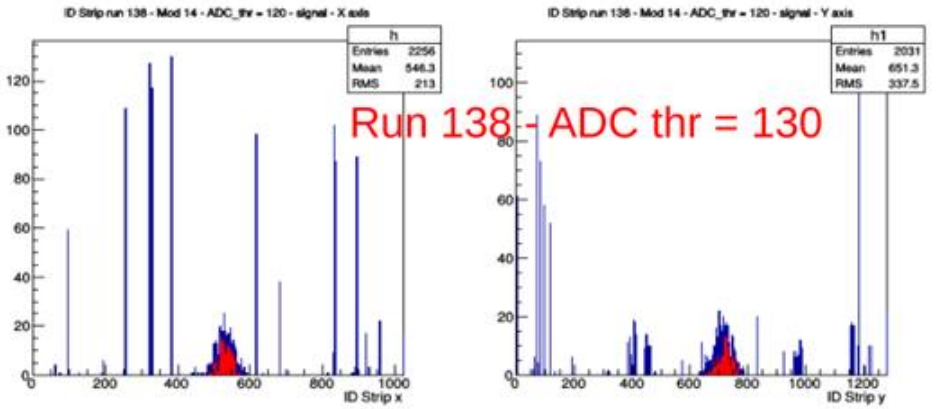
Data selection

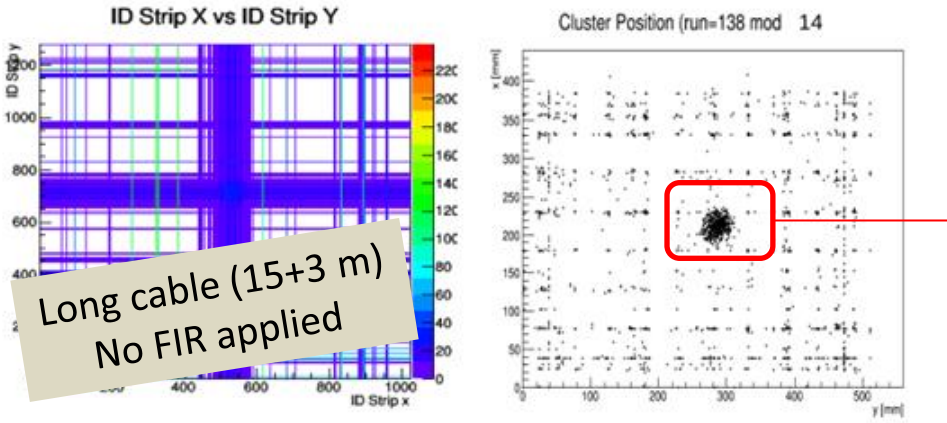
Signal

- Threshold (on sum of ADC samples)
- shape of the pulse
- position of the max amplitude
- signals must be in x-ray spot region

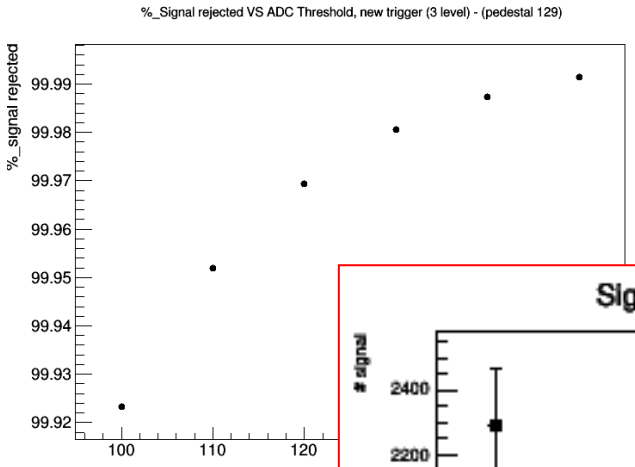
Noise

- pedestal runs and out-of-spot regions

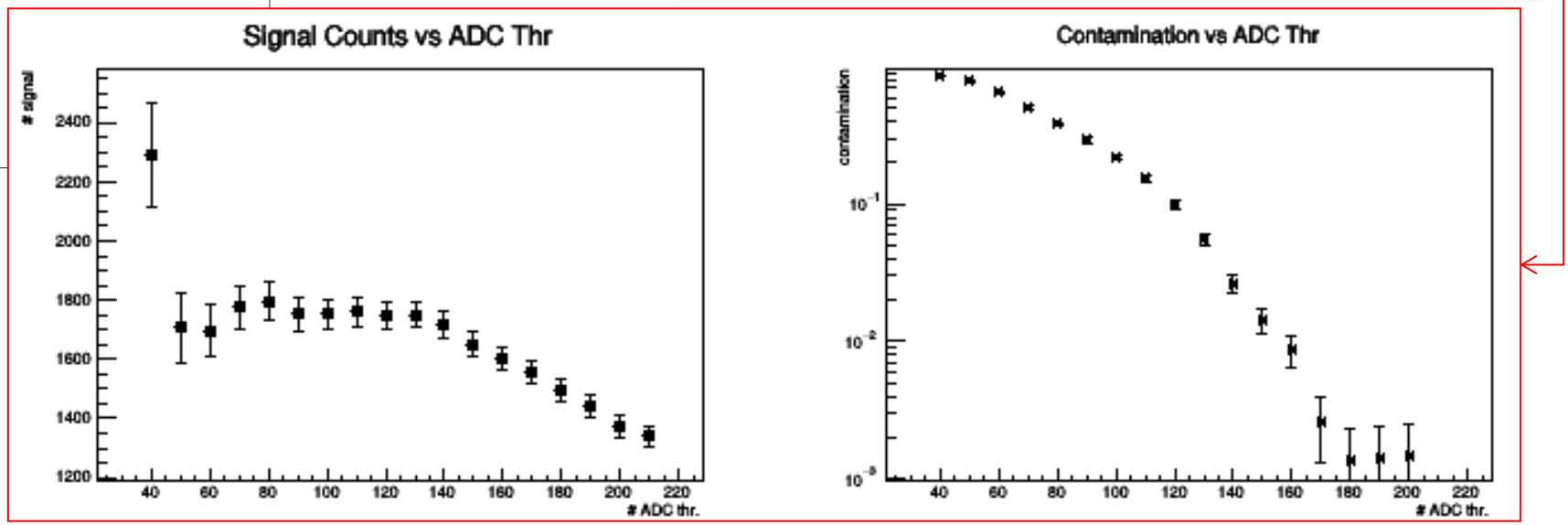




Long cable (15+3 m)
No FIR applied



Mod = 14
Events = 5000
All strips (NO clustering)
Energy X ray = 10 KeV
$I_{x\ ray}$ = 20 μA
Collimator = 2 mm
Source - GEM = 16 cm



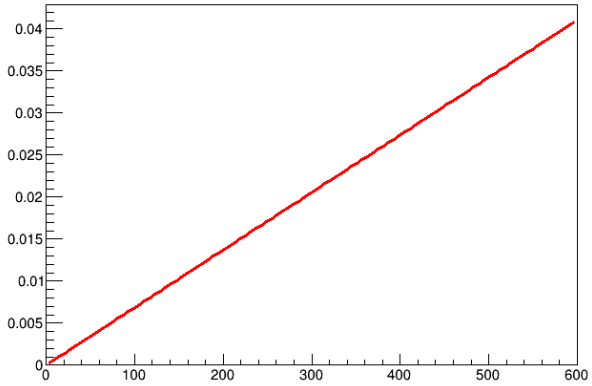
Brain Project result on xray

Simplest function

Current output from Brain Project, data from GEM 14:

Erf((6.07053e-05)***(y[2])*((y[4])+(y[0]))**)

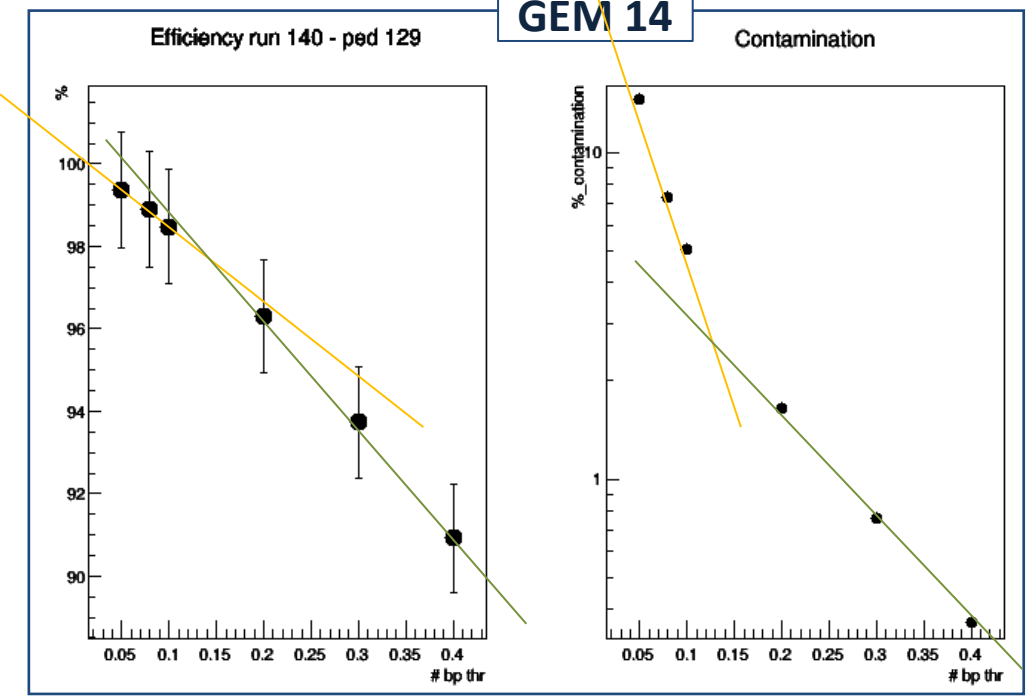
(0 = noise, 1 = signal)



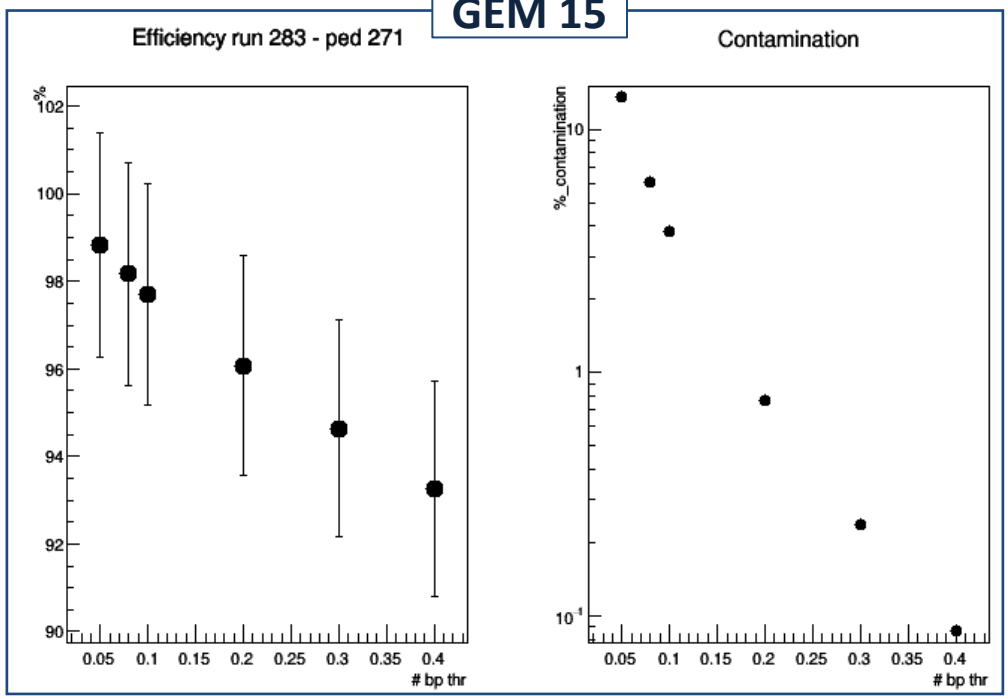
Performance evaluated on:

- GEM 14 (different xray spot)
- GEM 15

GEM 14



GEM 15



Sort of «natural» threshold at ~0.15

Noise suppression >95% / Signal Efficiency >96%

Data reduction from Brain Project

- Confindent to have a rather robust procedure to exploit the Brain Project potentialities
- Improvement on data characterization and comprehensiveness still possible

Next:

- Find the «theoretical» upper limit of efficiency / noise suppression, allowing use of complex functions
- Use pulses without common noise subtraction (or/and pedestal subtraction)
- Move on MIPs data

FT Status Summary

GEM modules

- 6 «old» modules at JLab: 3 of them need inefficient sector fixing, 1 looks completely dead – rework in progress.
- 6 «new» modules delivered to JLab last week: all tested by cosmic and xray. Three with no issues; 3 have 1 sector shorted.
- 3 modules in Rome: testing/fixing in the coming weeks.
- 3 modules in Catania waiting completion: 2 almost completed (missing readout window FR4 frames → ordered), 1 in the queue for assembling
- 3 additional modules planned (material ordered at CERN, ready in June (?)
- (2 modules rejected so far, due to problems during assembling)

Chamber Carbon Frame

- Expected delivery of all frames (6 chambers) to JLab from company (RIBA Composites) by 17th of July

Electronics/DAQ

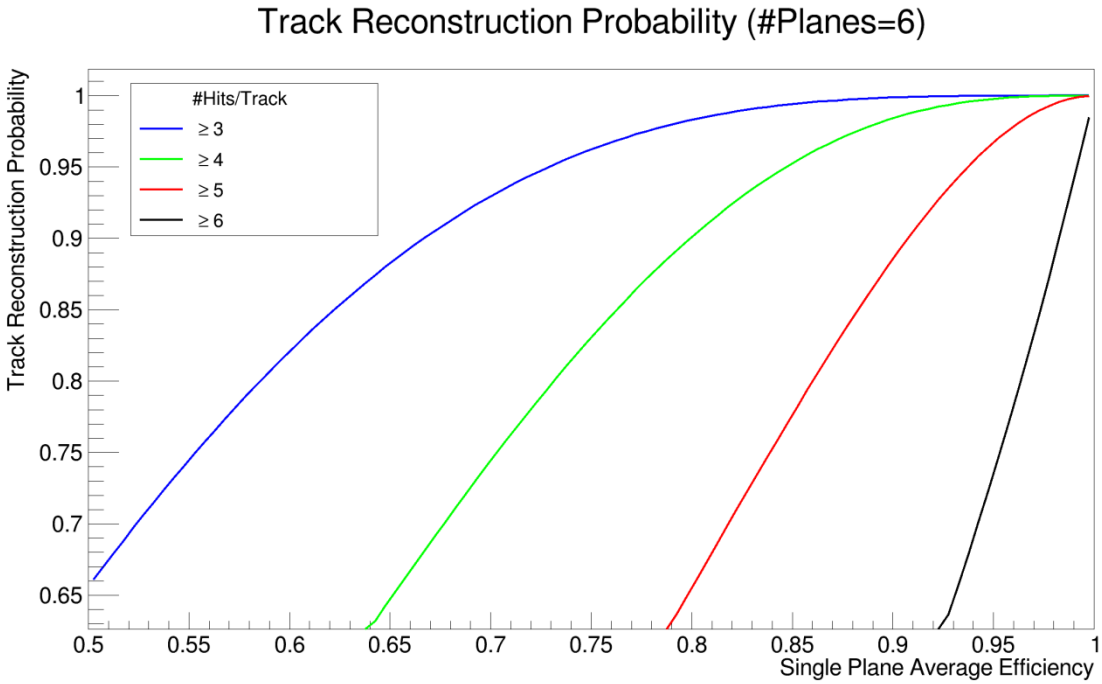
- Hardware: most of the staff procured: exception
  - Optical fiber transcievers
  - HDMI cable of proper length (10 m?)
  - Approx. 30 cards APV25 cards (did not passed the test, need rework or new to be produced)
  - Maybe some other minor parts

06/2017→12/2018 Plan

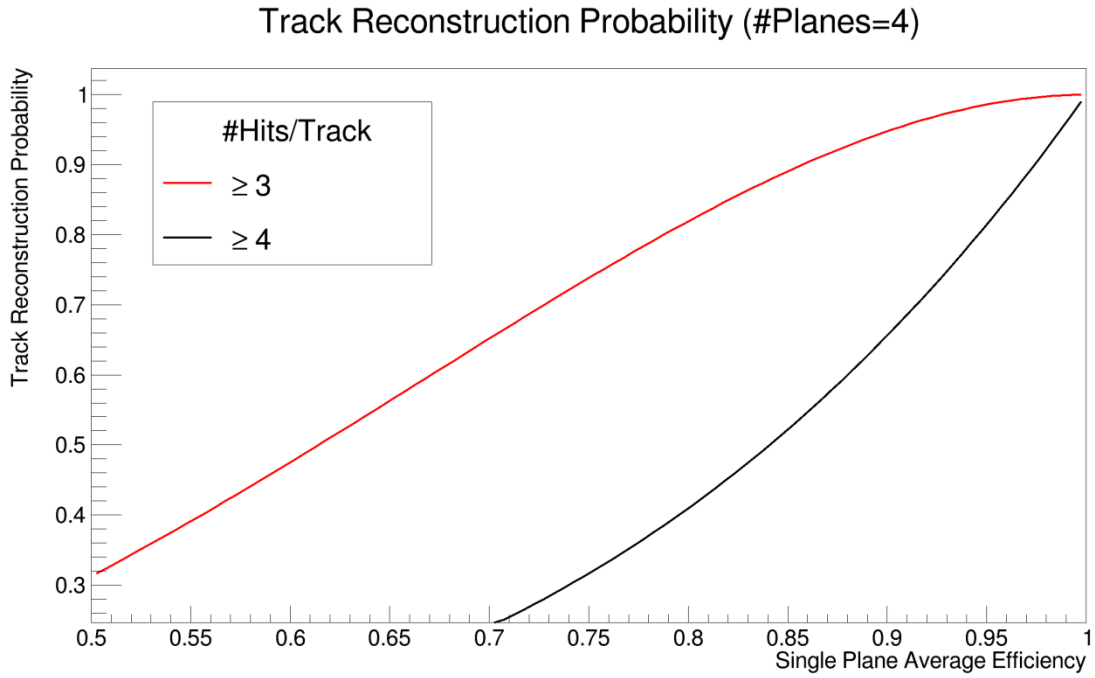
- Mid July/2017: 6 tested modules at JLab (and chamber carbon frames)
- Second half July 2017: fix GEM sectors and start installation GEM chambers for cosmic test at JLab (and possibly start testing)
- Second semester 2017: running cosmic test at JLab on 4 chambers
- By end of 2017: 6 additional modules assembled (3 extra for spare, pending material from CERN)
- By first trimester 2018: send all tested modules to JLab
- Second trimester 2018: install new chambers in cosmic test bed and run tests
- Second semester 2018: hopefully ready for installation

Support Slides

Tracking Efficiency



Goal is ~0.95 single GEM efficiency



GEM test - extended summary