CERN 08 Test Beam Results on RPC sDHCAL

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Synoptic

- GRPC detectors
- TB & Data taking
  - CERN 08
- Mip efficiency & multiplicity analysis
  - vs HT, Threshold, position, gas, angle particle flux
- Start of hadronic shower

Robert & Imad

- Noise study
  - RPC, MGRPC
- *Hints of* Uniformity
- Time reconstruction

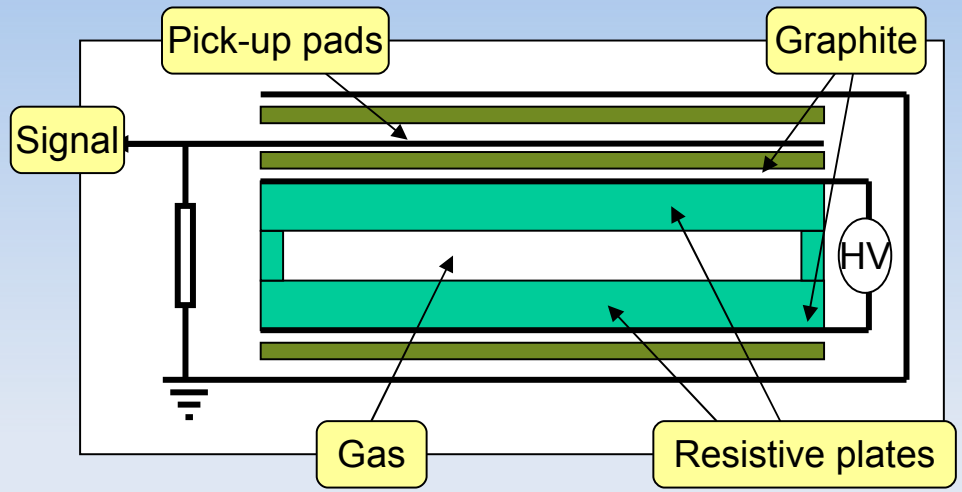
Khaled & Vincent

- Future plans

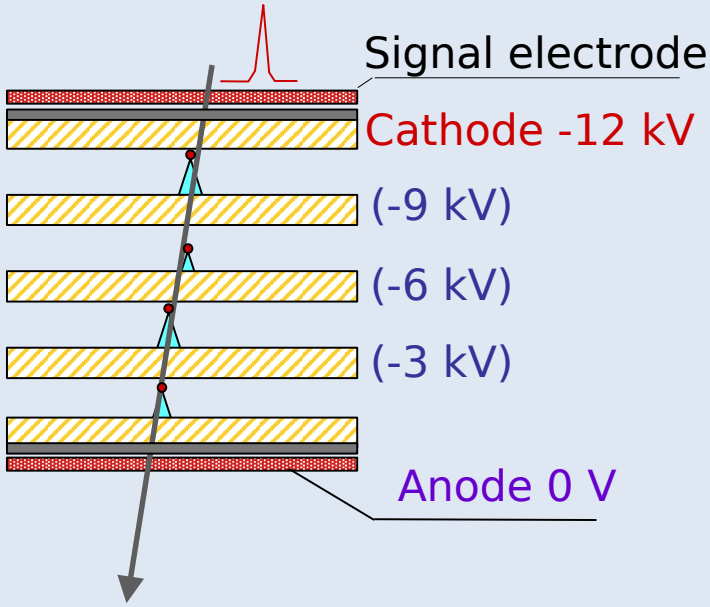
RPC Gaseous detector prototypes

TFE	93%
Isobutane	5%
SF_6	2%

- GRPC *(IHEP, IPNL)*
  - simple, robust, rate ≤ a few 100 Hz/cm²
    - 1.2 mm gas gap
    - 400 µm glass plate
    - Graphite/Licron/Statguard resistive cover
    - ~ 7.4 kV → Avalanche mode

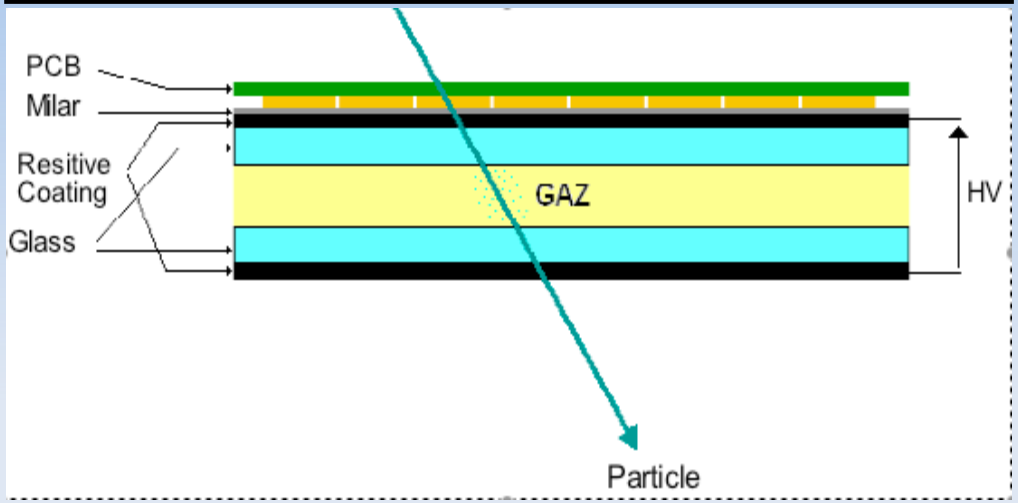


- Multi-gap RPC *(INFN Bologna-CERN)*
  - Higher rates & efficiency
  - Idem Alice ToF system
    - 4 x 250µm gas gaps
    - 400 µm inner glass plates
    - 550 µm ext. glass plates
    - ~ 10—12 kV

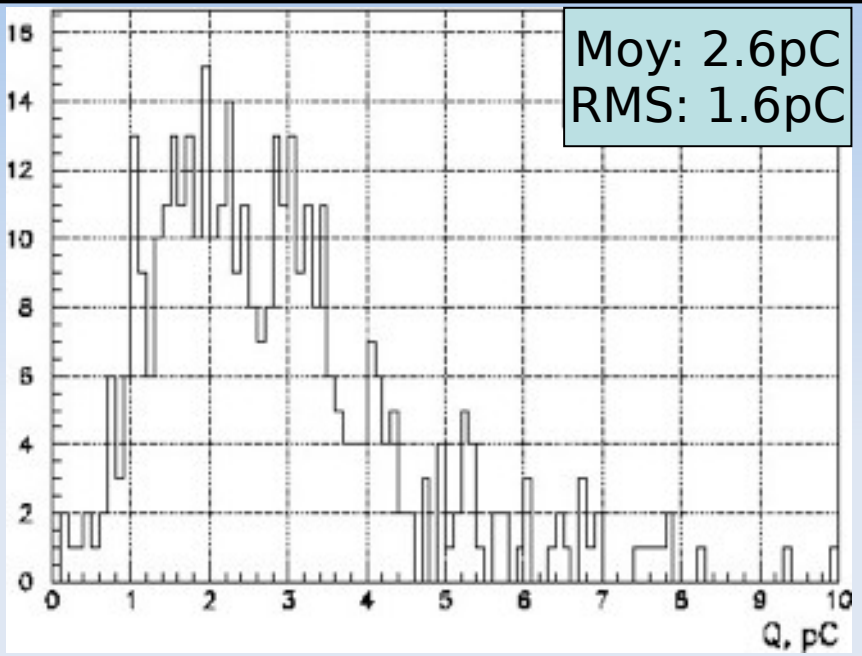


GRPC response

Schematical view of the GRPC

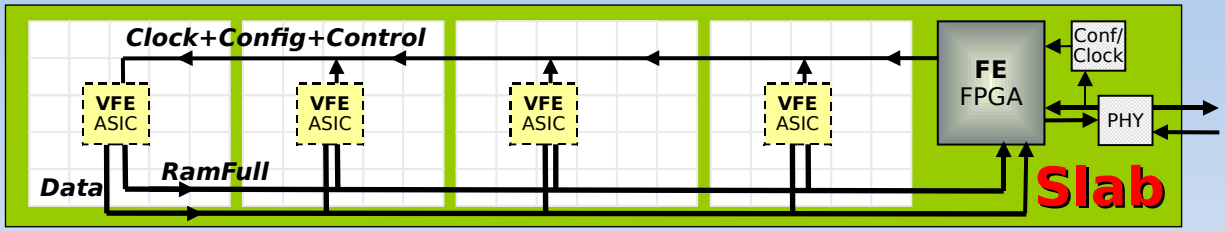


GRPC spectra (From Protvino laboratory)



- mip → 8-10 ionisations per mm
- exponential gain G ~ 10^{6-7}
  - Sensitive only to the 1-2 first (from cathode) ionisations
  - Q ~ 3 pC
- Inductive readout

GRPC readout (Used for the lasts TestBeams)



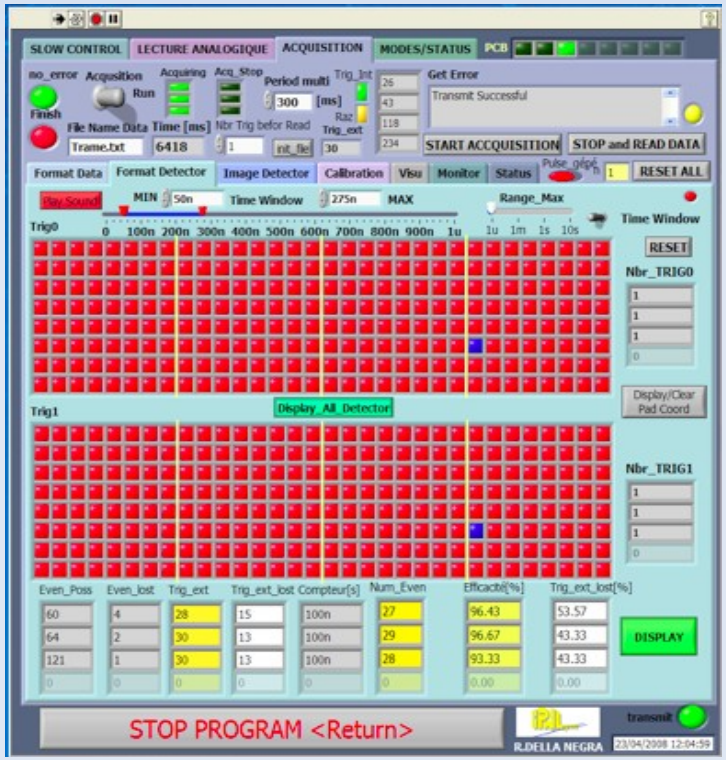
Readout circuit boards “DHCAL1” developed by IPNL, LLR and LAL:

→ 8 layers PCB, total thickness 800µm

→ ASICs: HARDROC1 (64 semi-digital channels)

→ 4 daisy chained ASICs on board

→ 256 [(4×8)×8] sensitive pads (1×1 cm²)



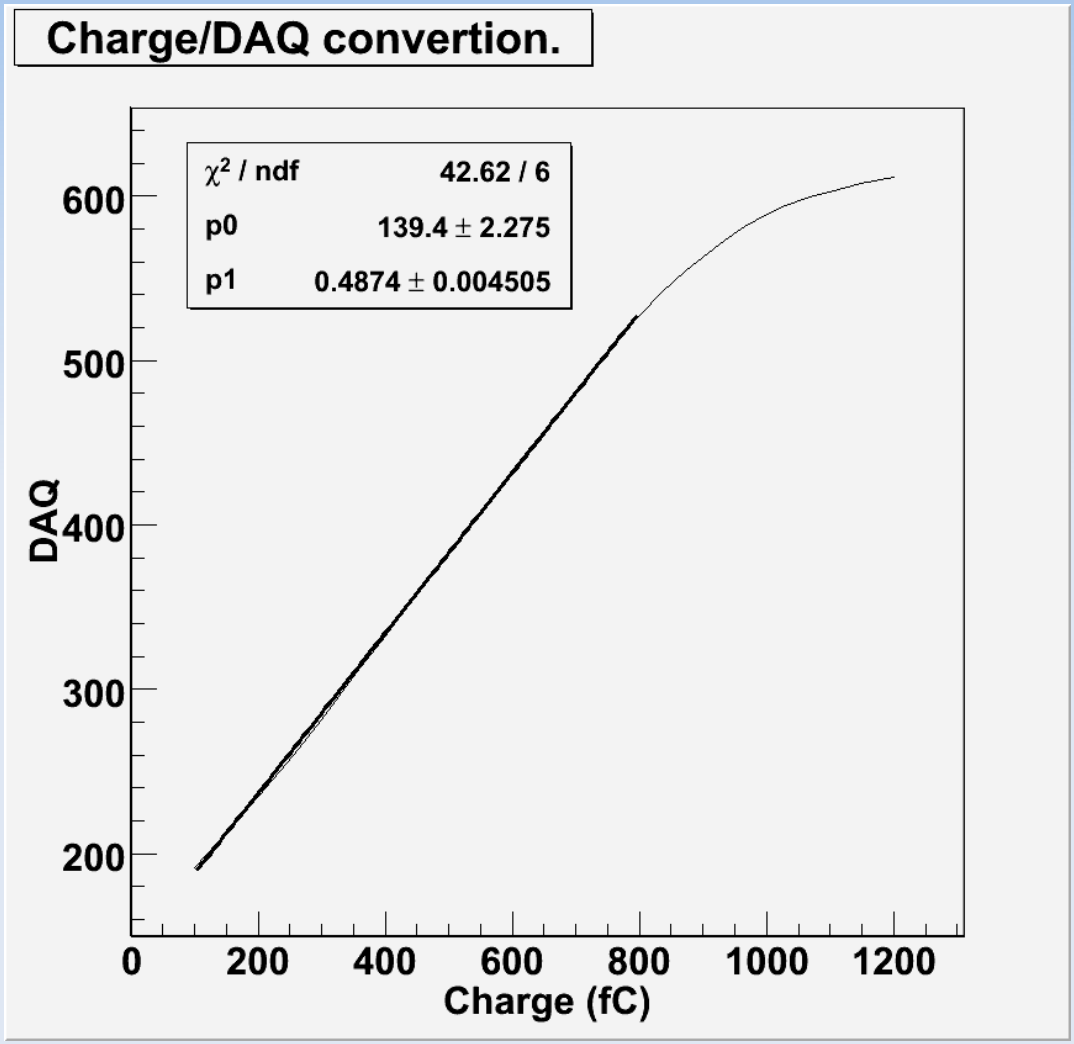
HARDROC’s config parameters:

- Adjustable gain for each channel to calibrate
- Two thresholds (independent, per ASIC)

Data:

- LabView + USB based DAQ (~20 Hz for 4 boards)
- For each triggered ASIC: Timing Flag + Thresholds maps

Equivalence between digital threshold and charge

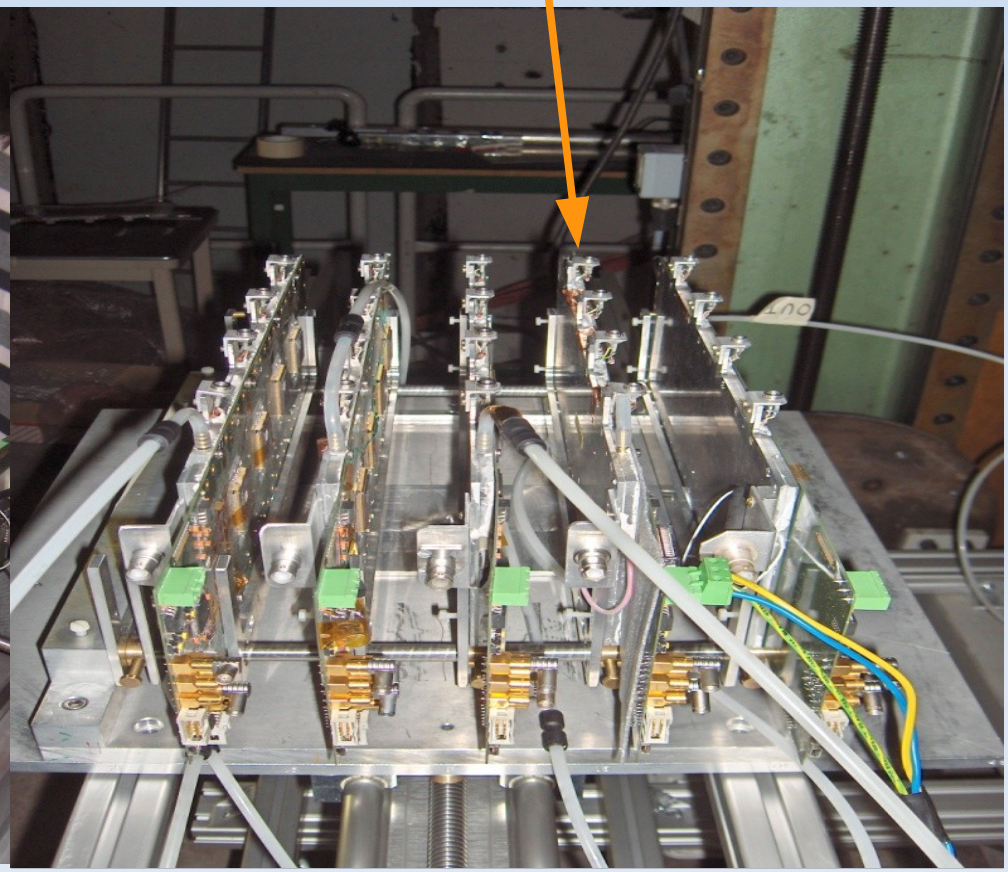


Mean value: 1 DAC u = 2±0,1 fC

Linear dynamic range: 800fC

Detectors in test beam

- **July-August 2008: 4 RPC 32×8 cm2**
- **November 2008: 5 RPC 32×8 cm2 (with one multi-gap RPC)**



Beam test periods

PS: Mostly π (3-12 GeV) + few μ, very few e-

PS T10 17—24 july with the EUDET telescope: ~260k trig evts

- With EUDET Pixel Telescope: 7×7 mm² active sensors
- **Angle & position** scans
- Other data: trigger large scintillators (10×40 cm²)

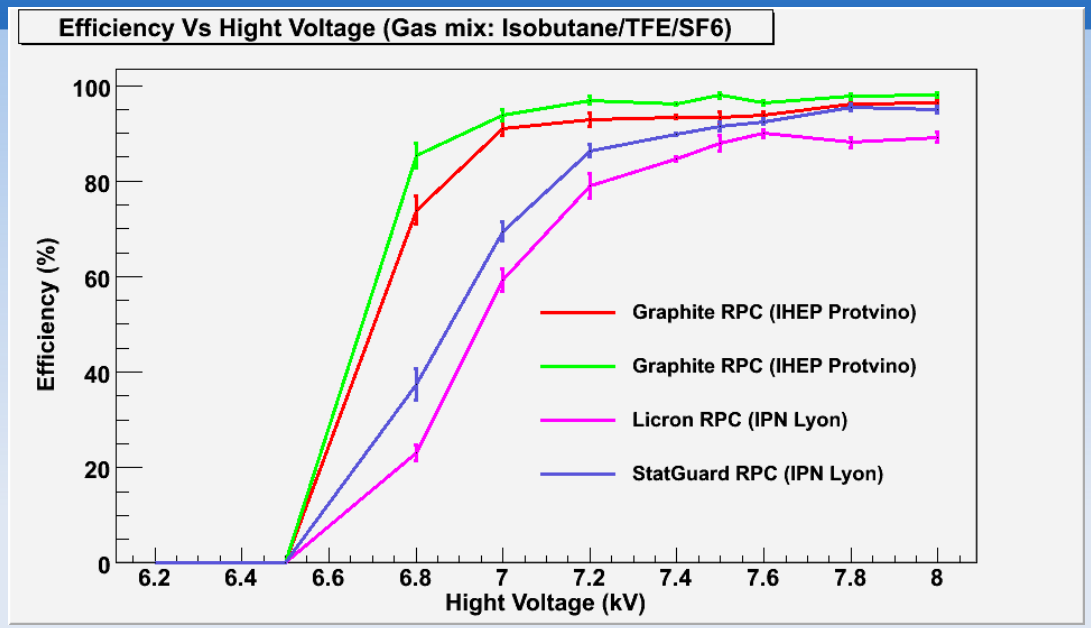
PS T9: 28/07 — 04/08 ~80k trig evts

- Complement Pion data with 2 λ of W, **angular** scan
- Analogue readout of 1 chamber
- Test of a wide RPC: 100×35cm² (readout with 4 PCB ⇒ ~32×32cm²)

PS T9: 07/11 — 12/08 ~65k trig evts

- Shared test with µMegas (≠set-up); Multi-Gap RPC
- Complement test: **HV** scan, **thr.** Scan, **CO_2** (as repl. of Isobutane), **Beam intensity** scan
- ***Tentative***: m² + 24 HR1 PCB + new DAQ elec & soft (DIF)

HV scan

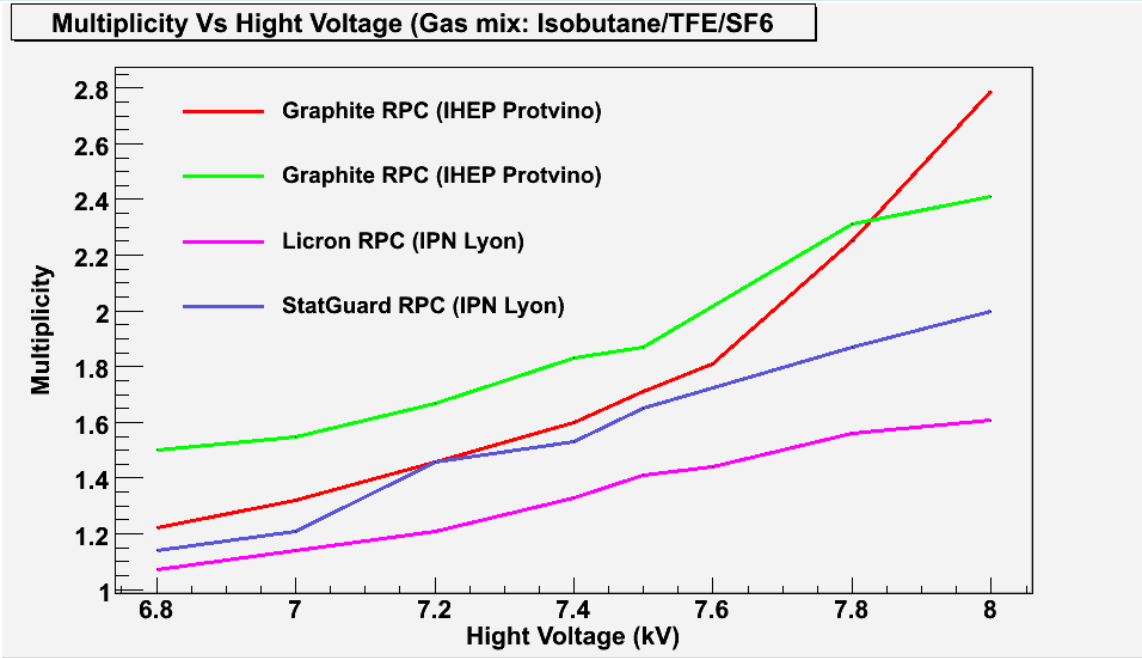


Threshold: 120 fC
Plateau: 7.2 — 8 kV
Efficiency between 80 and 98%
Best ratio Multiplicity/Efficiency:
@ 7.4 kV

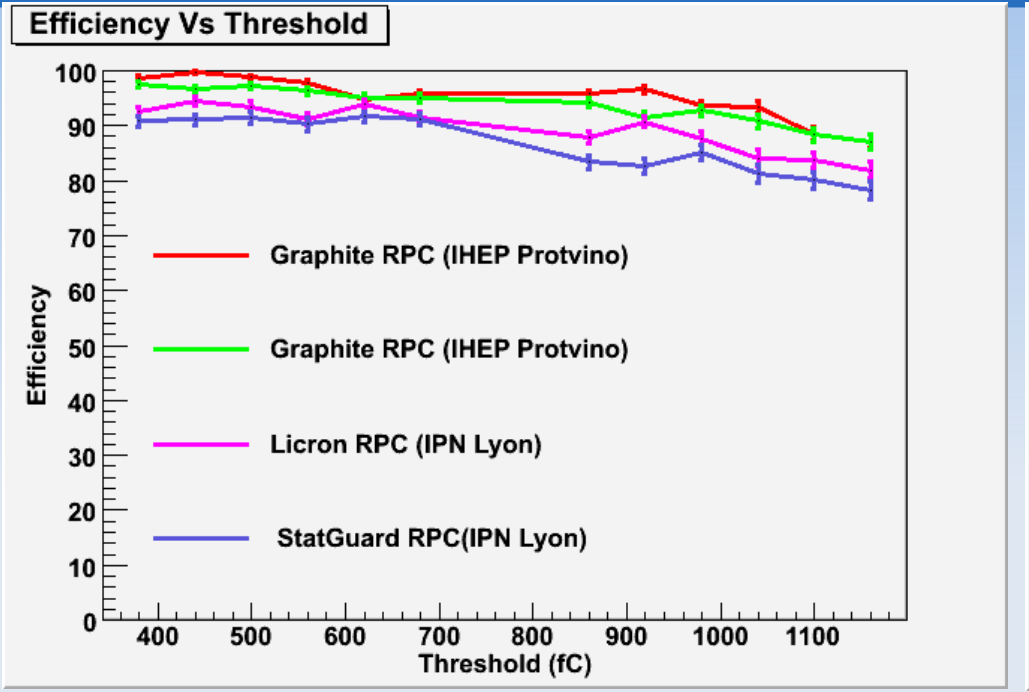
Variations for Graphite

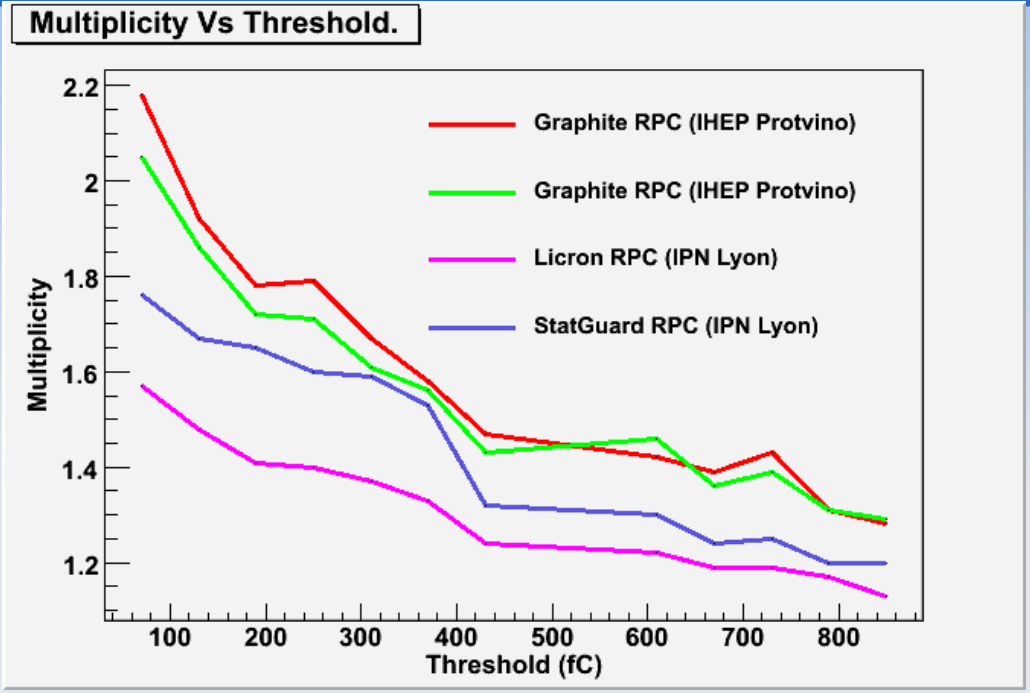
All solution ~ OK with a.h. HV

Slight advantage for Licron®:
lower multiplicity on plateau



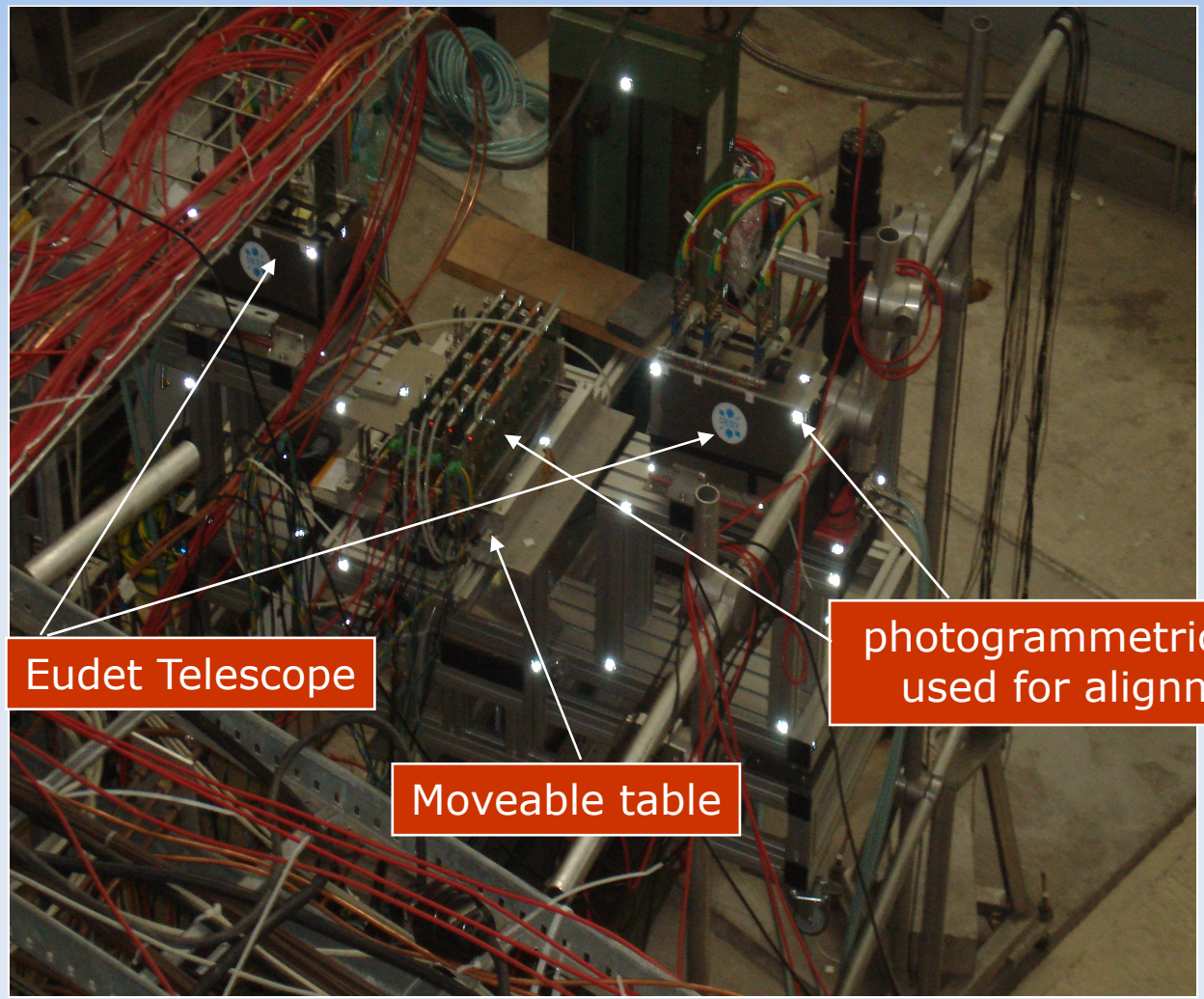
Threshold scan





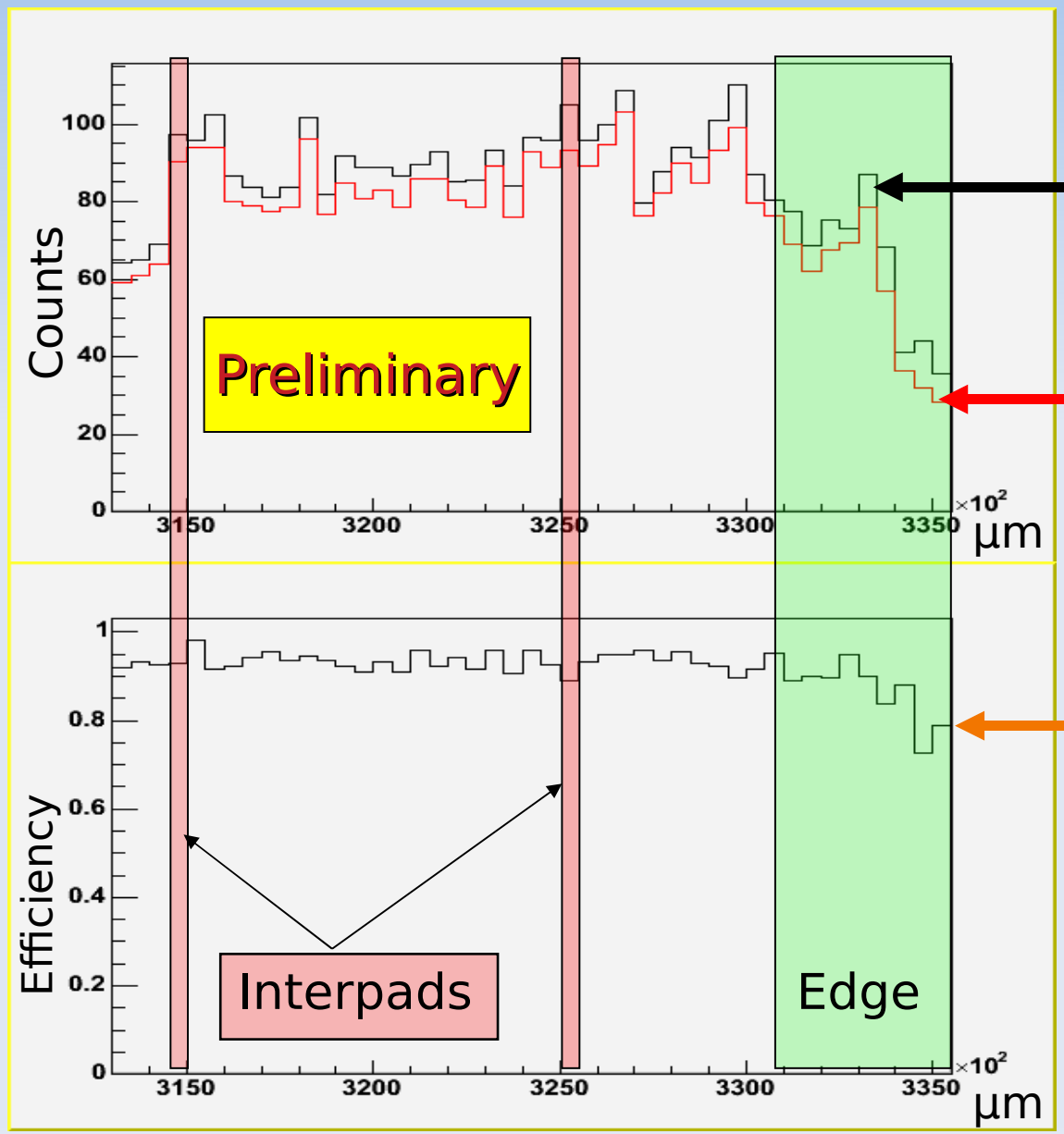
- Moving ASIC's threshold → Charge Spectra
- But the ASIC's dynamic range was too small,
  - possible with HaRDROC2 → to be repeated
- Multiplicity: the effect of threshold is as expected.

Use of Eudet Pixel telescope @ CERN



- small surface: ~7×7mm²
- 2 independent DAQ's
  - → Shift of 1 evt
- Track precision: ≤5 µm

Spatial efficiency using EuTel track reconstruction



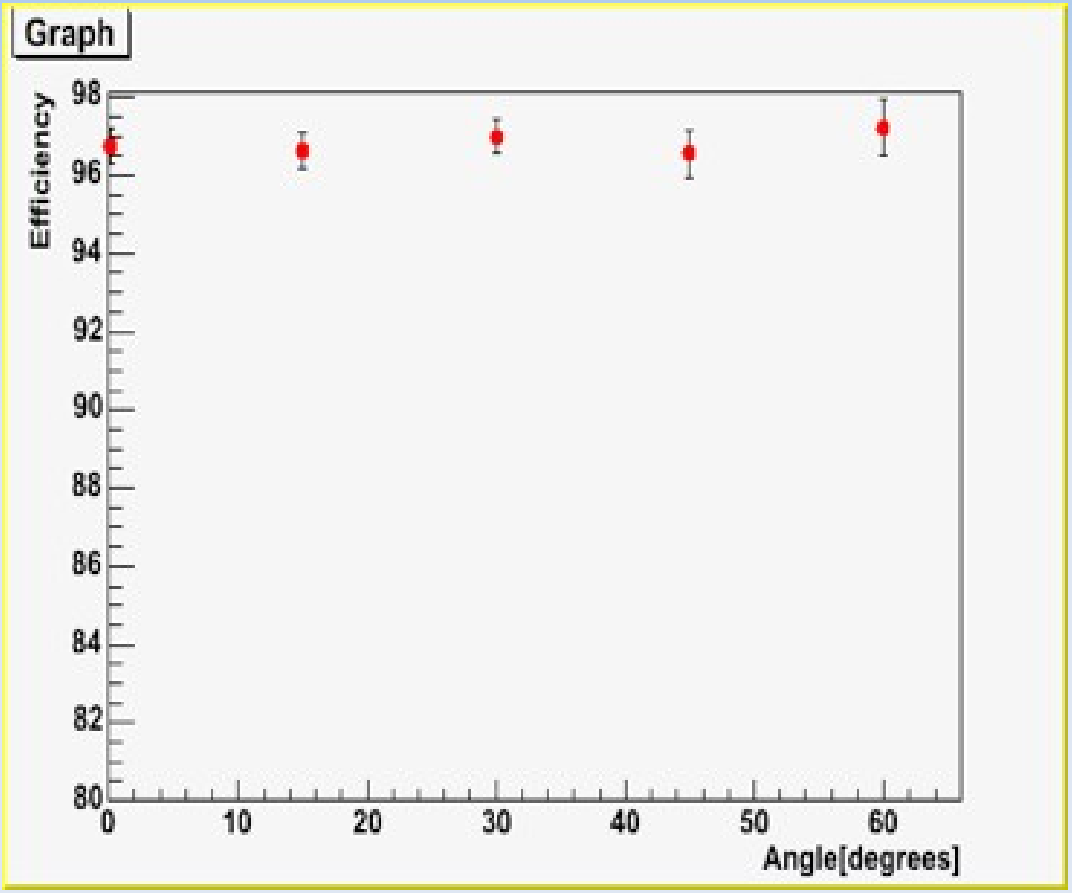
Black (Trigger): spatial prediction of hits in GRPC, from EuTel.

Red : matched digital hits (EuTel + GRPC)

Efficiency: Red/Black

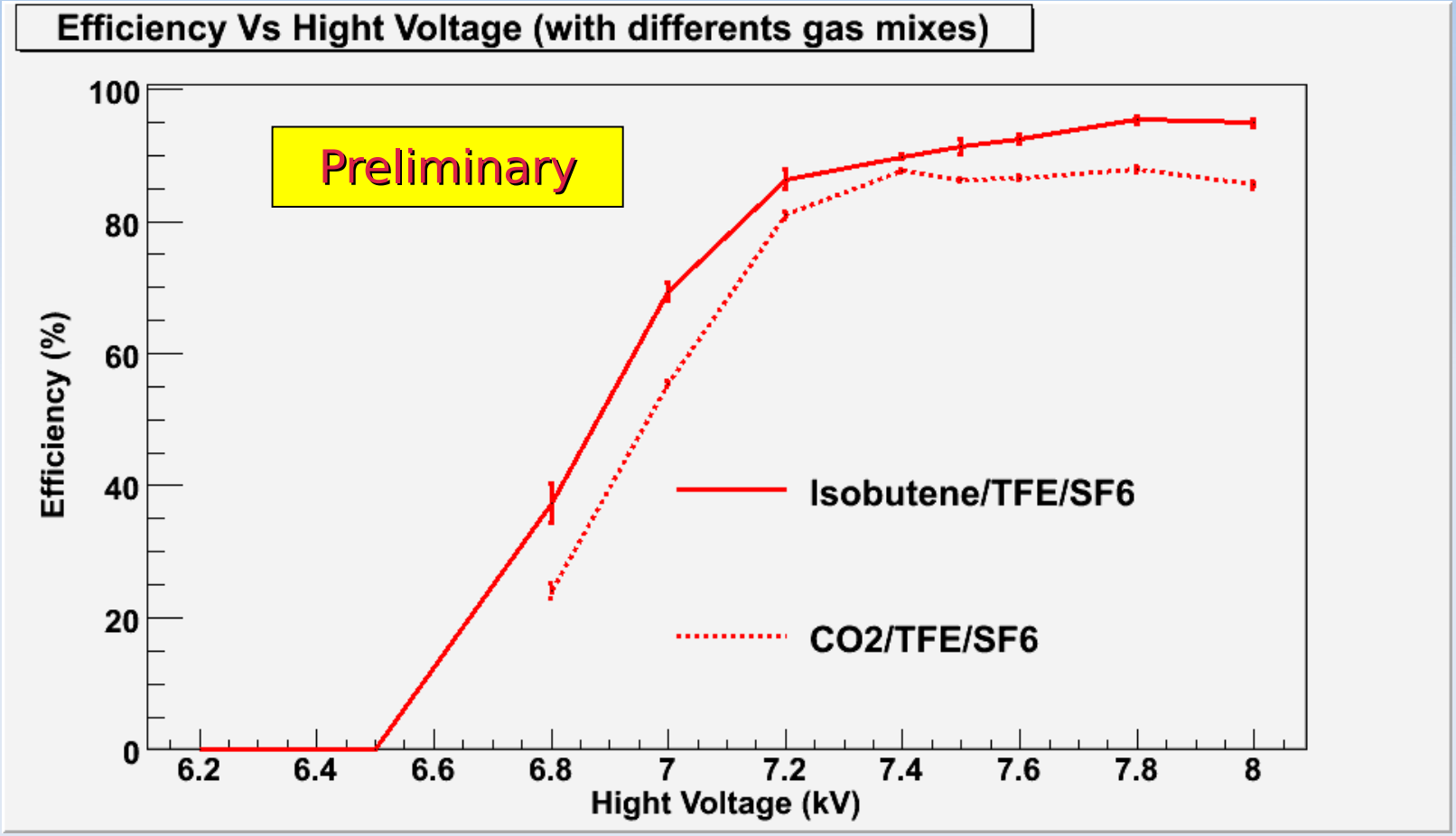
- No inter-pad drop
  - 0.5 mm
- Edge effect & avalanche size: ~ 30mm

Efficiency vs Impact Angle



Efficiency is quite constant, even for large angles.
→ ideal for PFA: uniform particle response (ε, μ) in shower
& at all angle in a large detector of the future experiment.

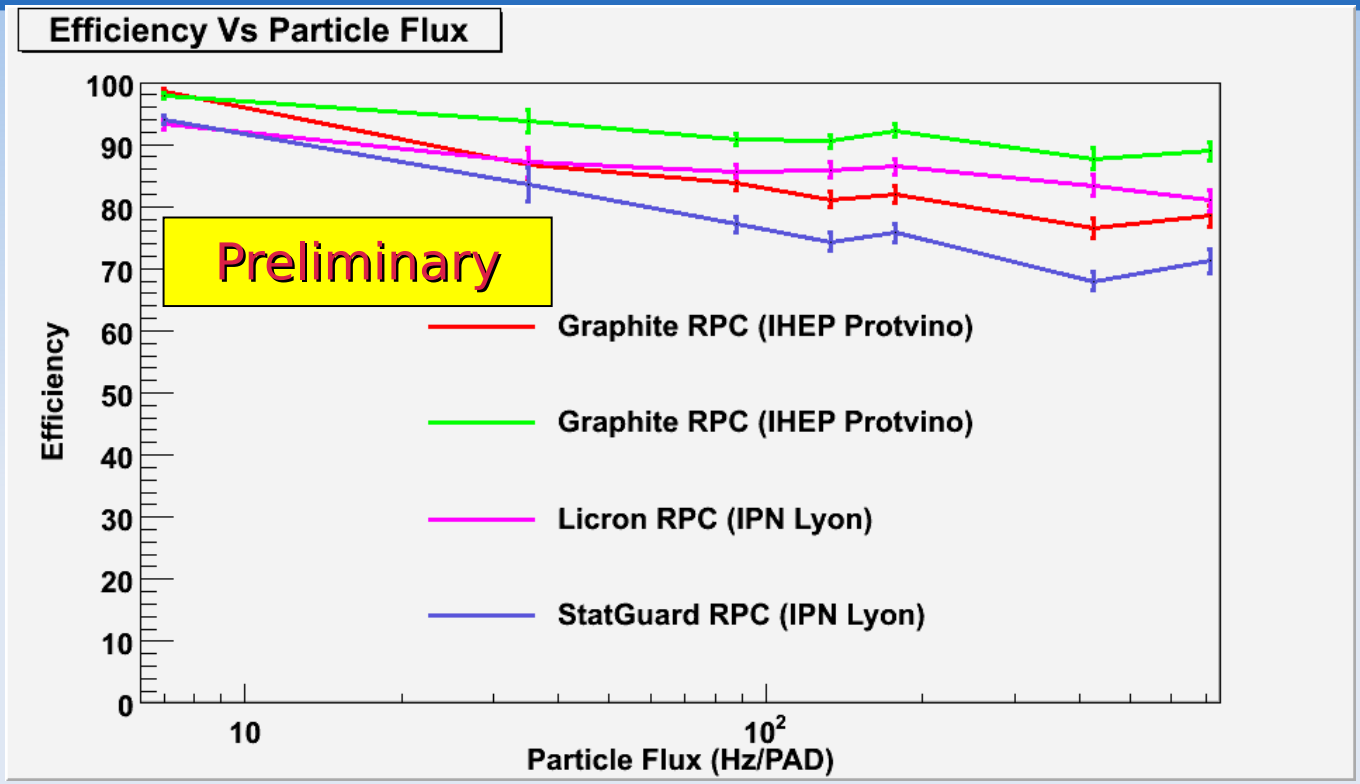
Gas : CO_2 vs Isobutane



These firsts tests using CO_2 , are quite promising.

Note: Complementary measurements have to be done to comfirm these results.

Evolution of performances with particle flux

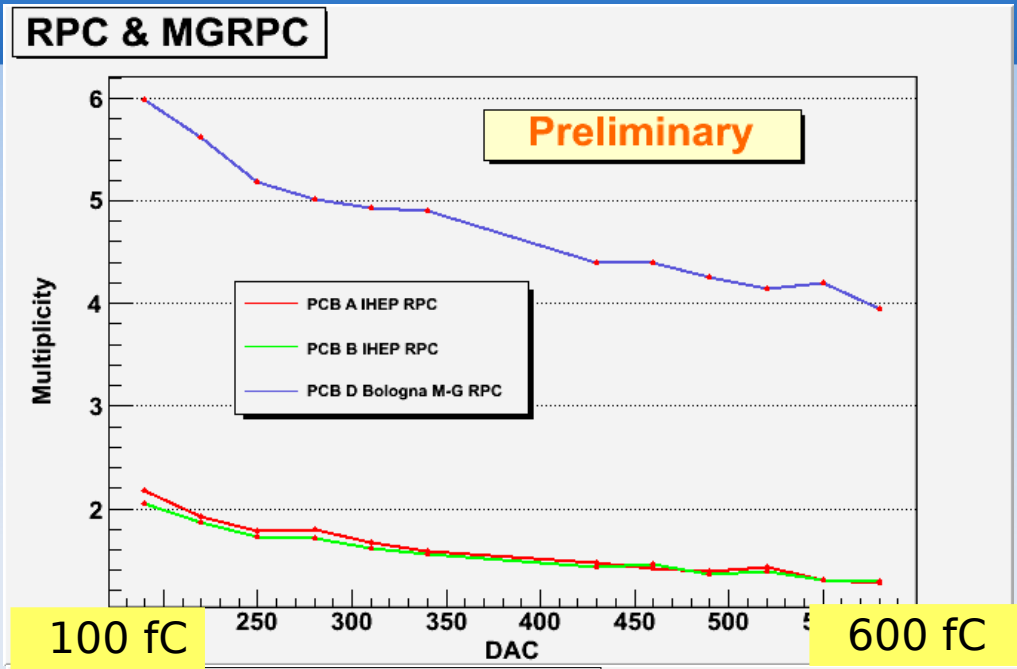


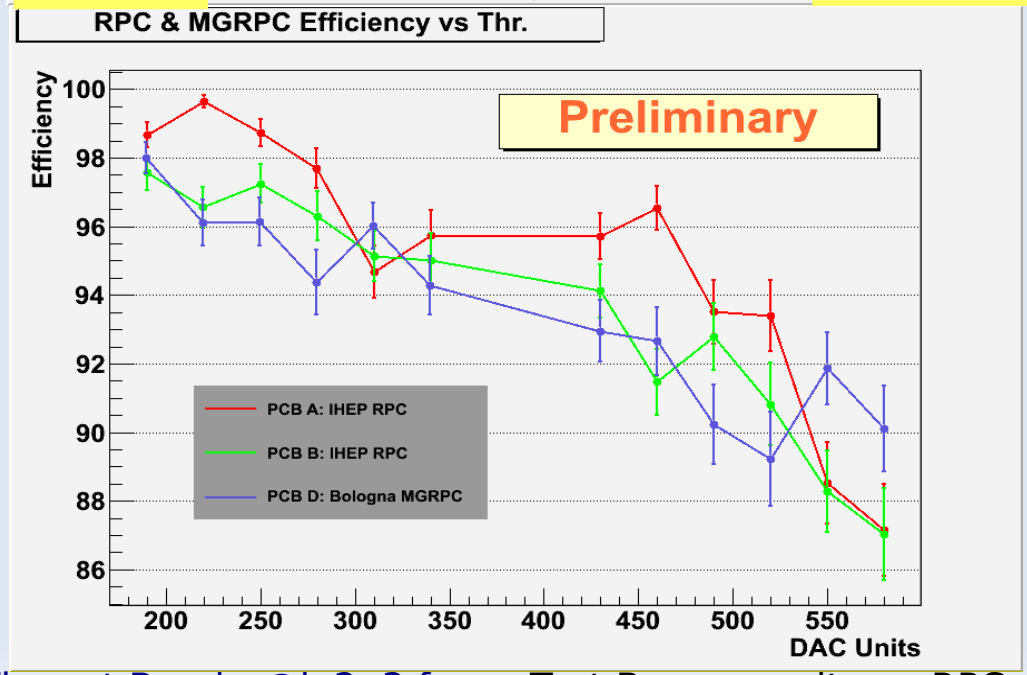
We made some correlations between flux measurement done with scintillators, and efficiency of the chambers.

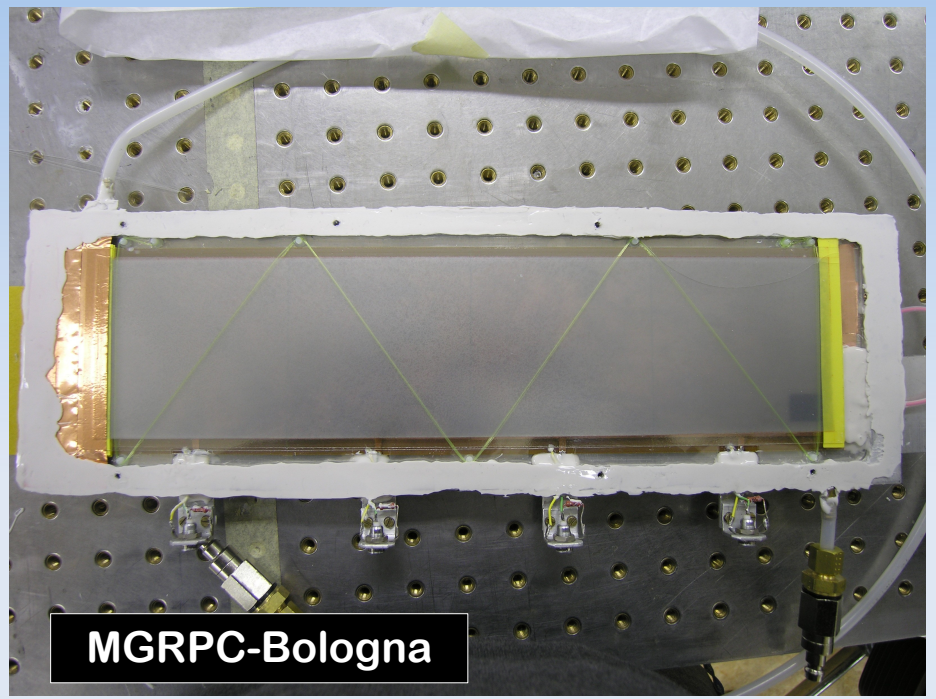
It gives us some preliminary results about GRPC running in real beam conditions.

Note: The flux measurement was not very precise, we have to make some complementary measurements to confirm these results.

RPC vs. Multi-Gap RPCs





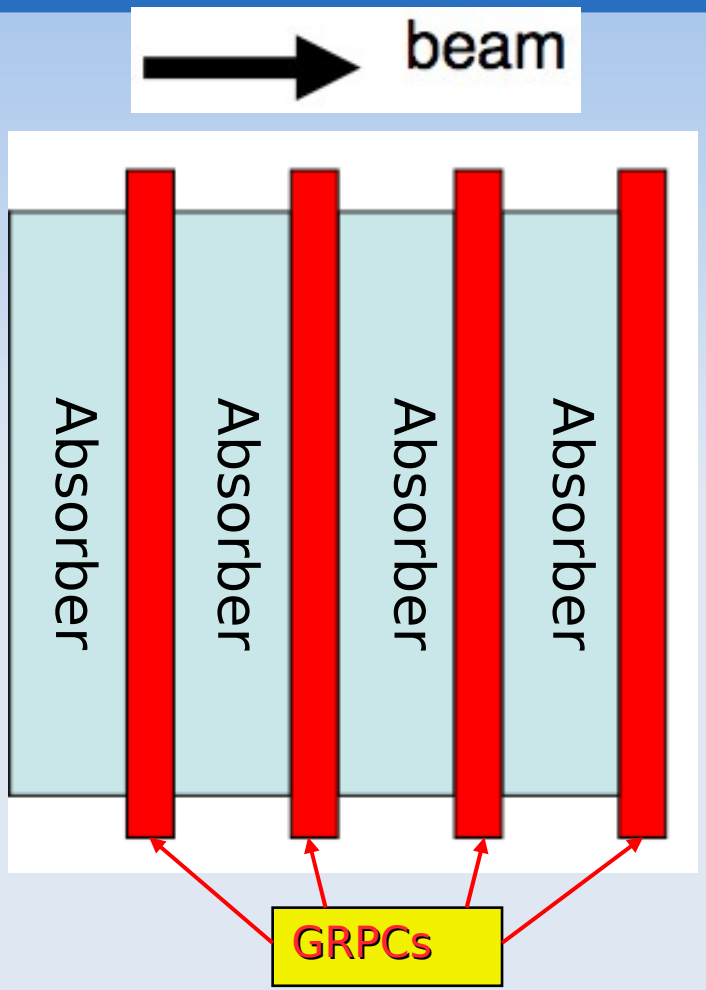


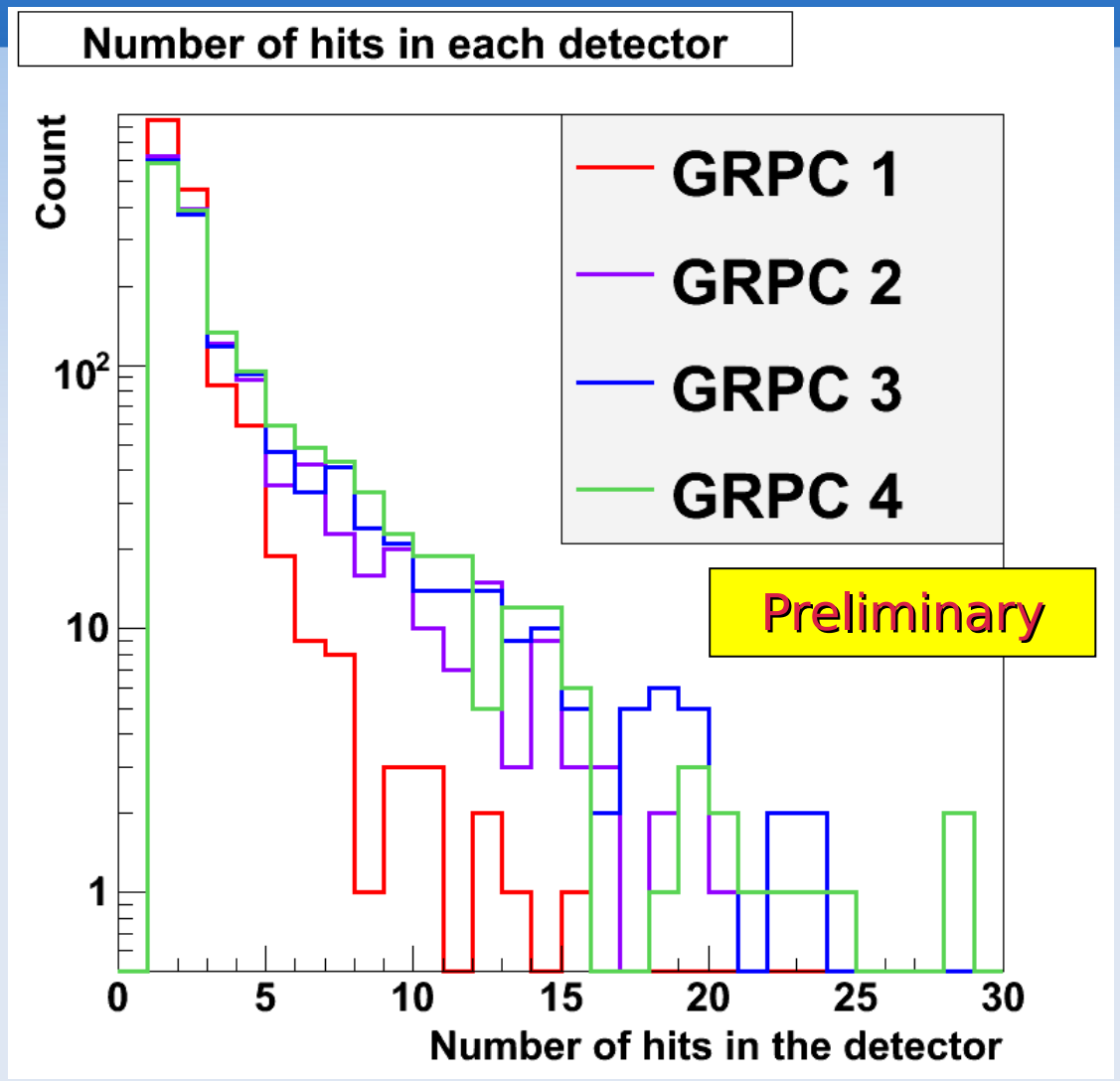
Preliminary results:

- Somewhat higher efficiency
- Very high multiplicity

⇒ useful for sDHCAL ?

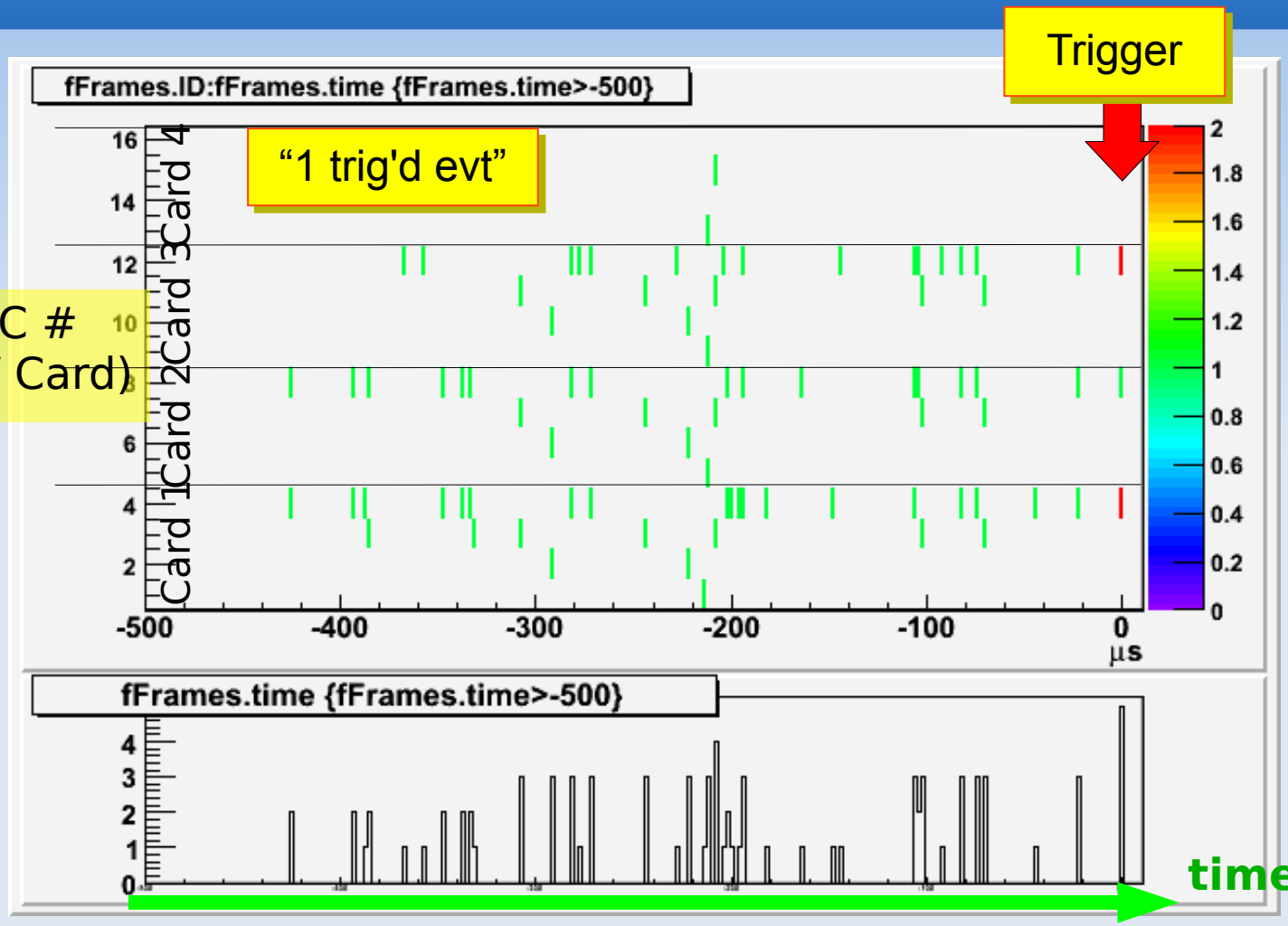
Hadronic showers





Hadronic shower are mostly not contained in Mini-DHCAL (~ ½ λ_I)
⇒ first idea of shower development and energy deposition.

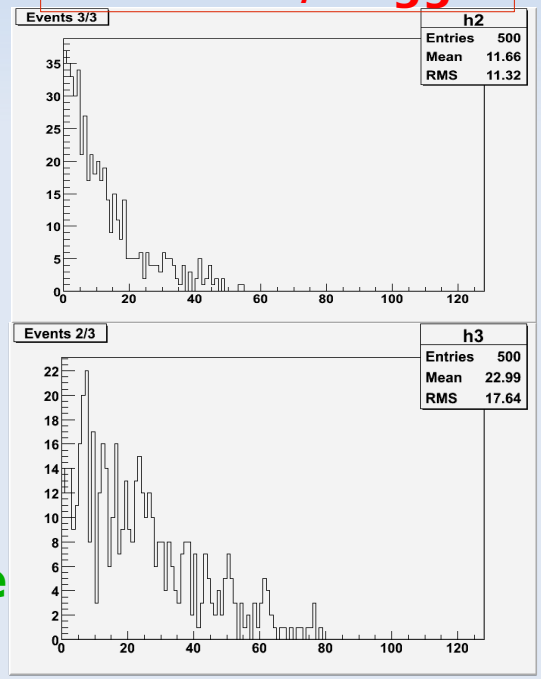
Timing: single event + auto-trig



Many More stat Available "in train" with proper time reconstruction

Expectation: ¥30

 # entrées / Trigger



- CERN PS: **400 ms** spills every 48 or 33s (day/night cycles).
- Running mode: **single event with auto trig**
  + BUSY logic & automatic RAMFULL recovery (⊃ BUSY signal)

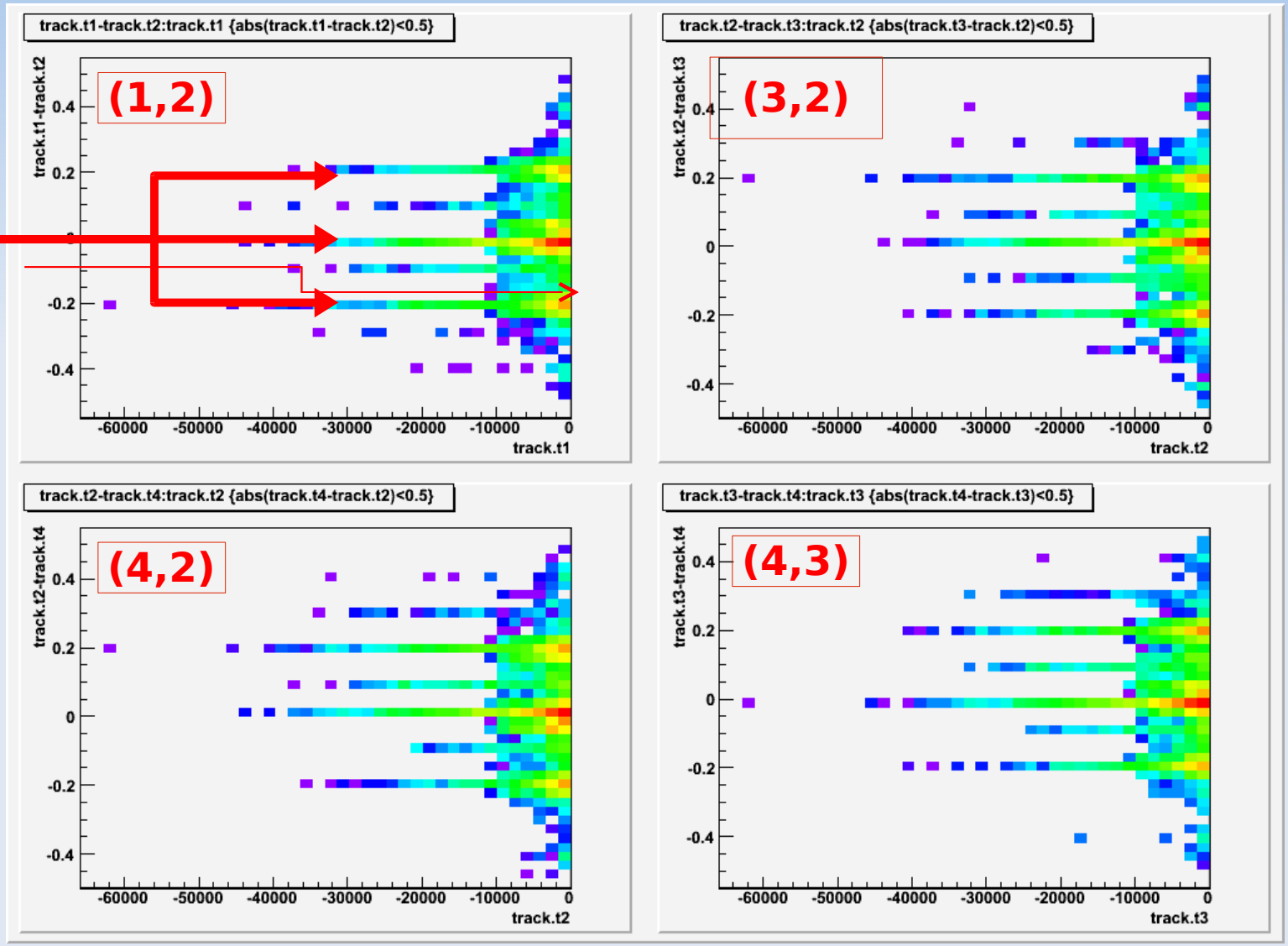
Time difference between hits in Asics

Time correlation between ASICs

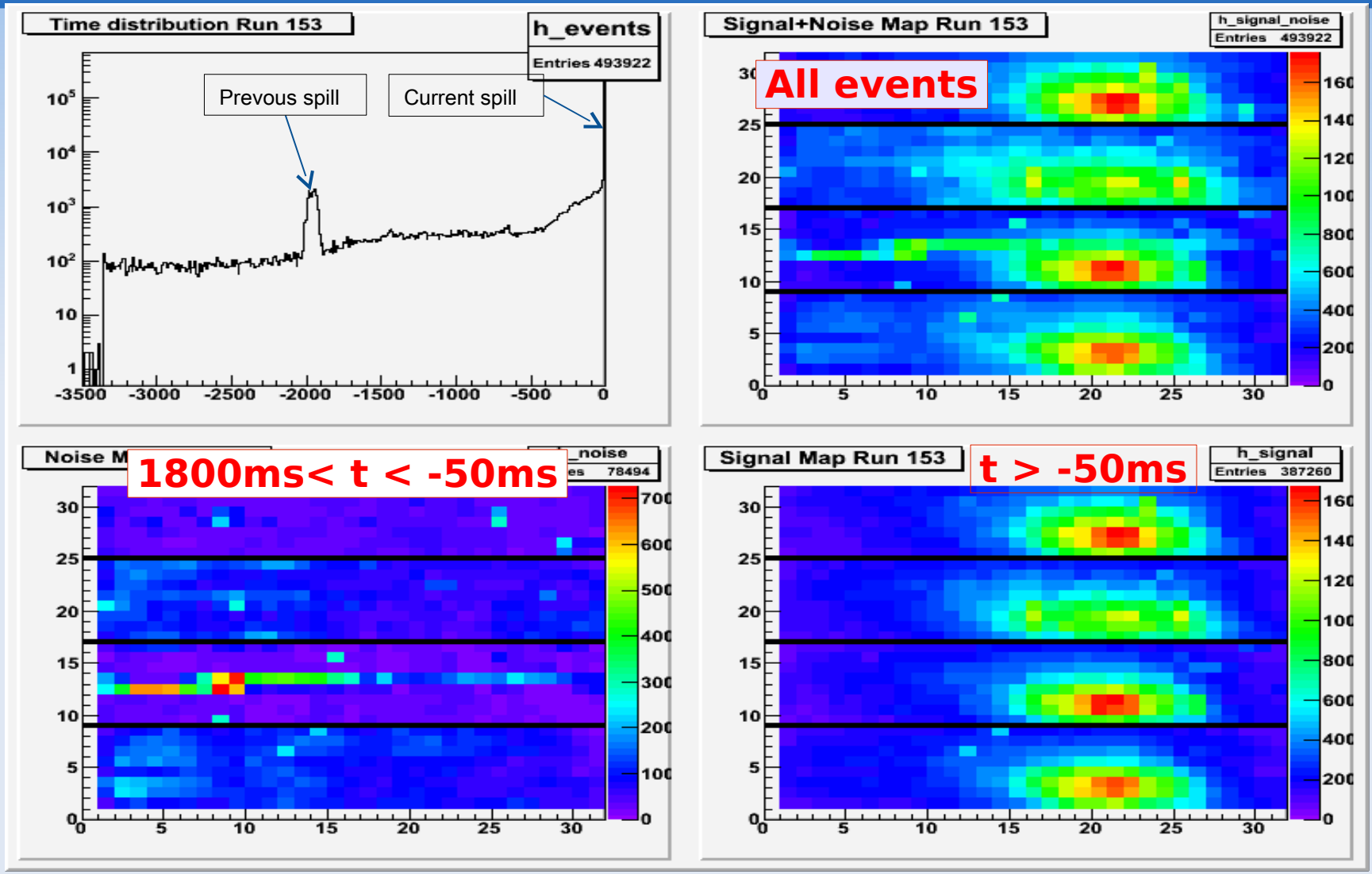
Pics @ ±200ns (and ±100ns)

Intercalibration

$\delta f/f \leq 0.5$ ppm

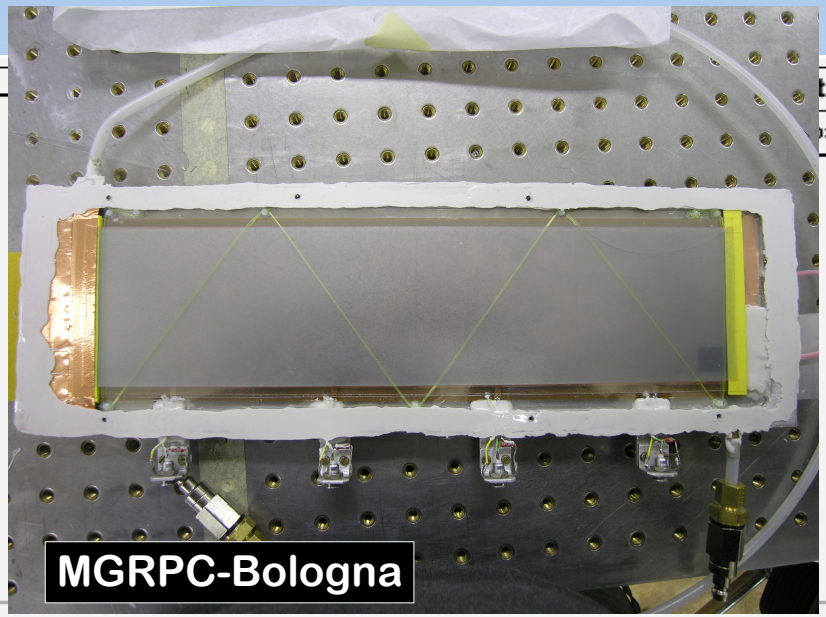


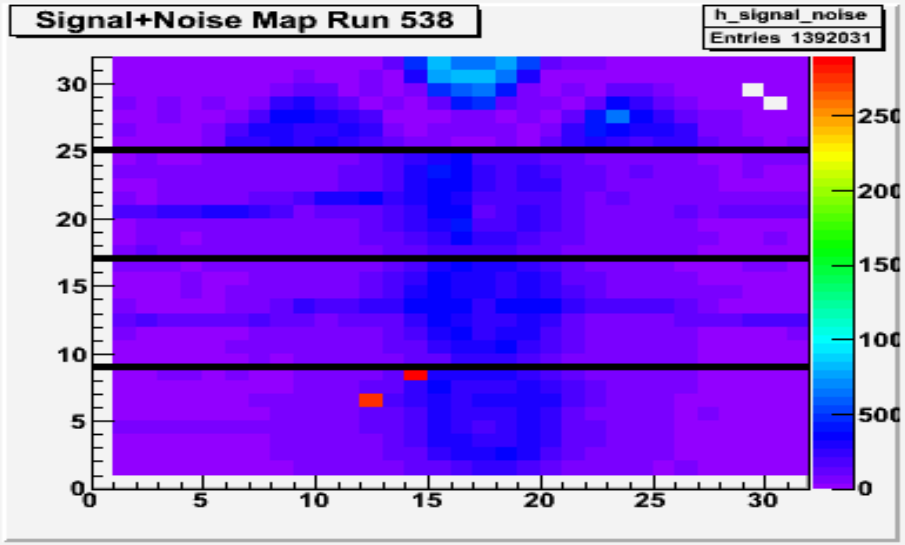
Noise & signal

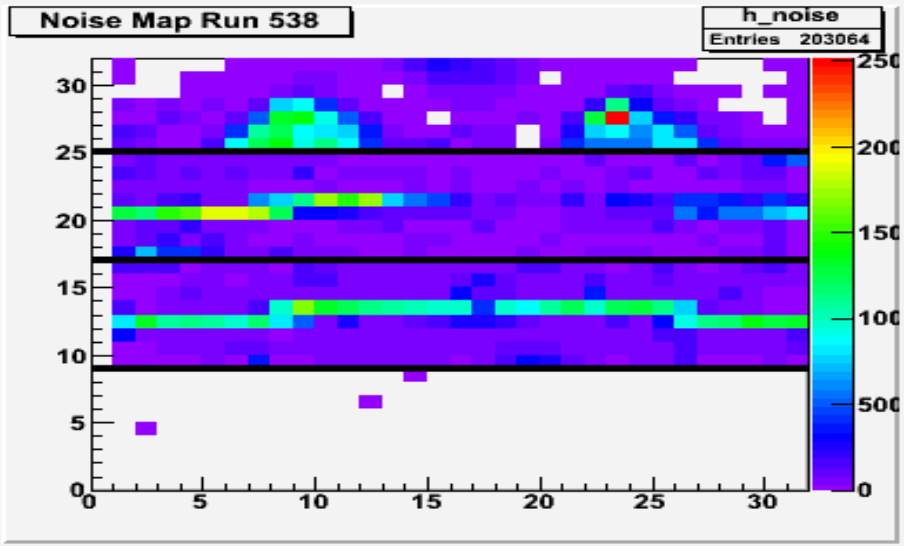


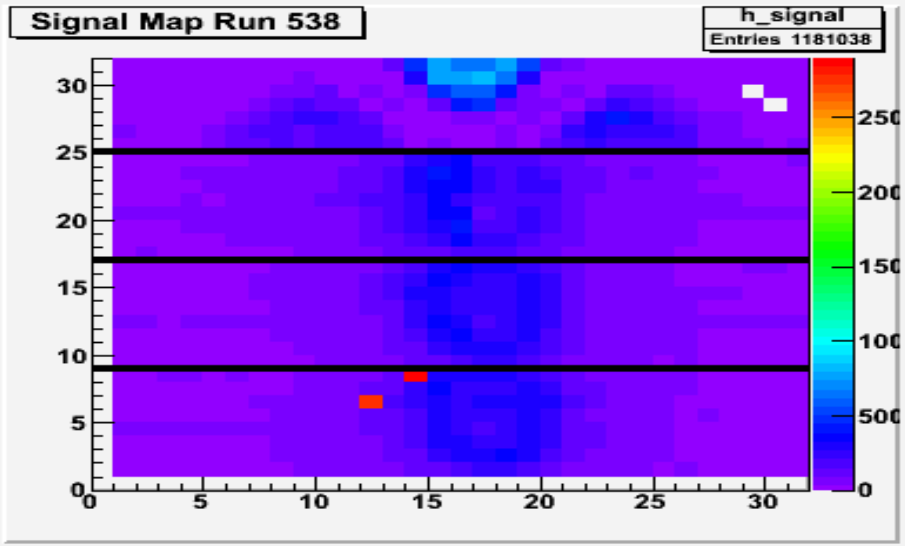
- All: ~ 493000 hits
- Noise (between the two spills) ~ 78000
- Signal >-50ms ~ 387000 → 78%

The multi-gap RPC Chamber

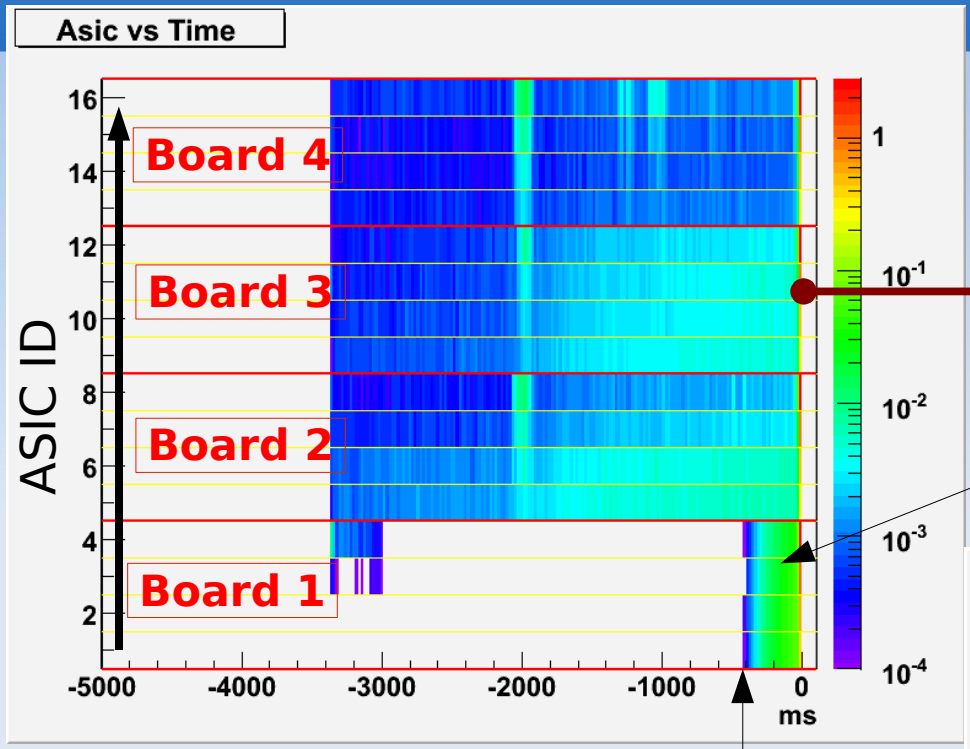








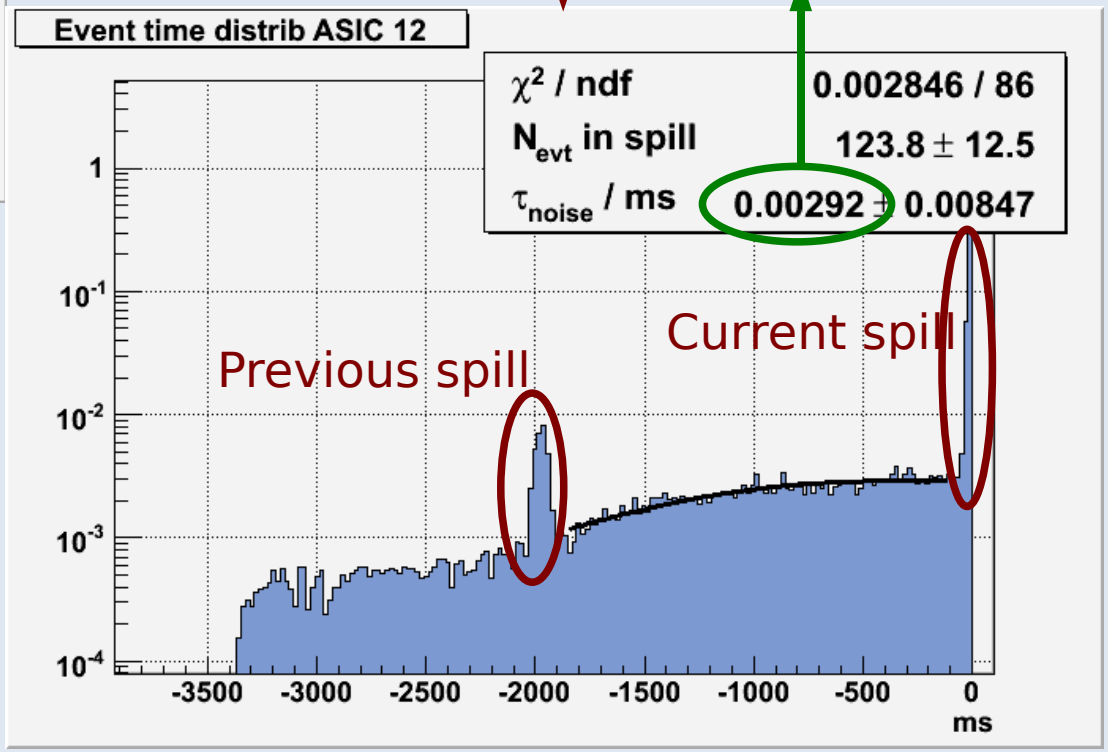
Noise & efficiency study



Run00101
Hit rates for each triggered event

2.9 Hz / 64 cm²
= 0.045Hz/cell
=~1 hit/BC for
50M chan

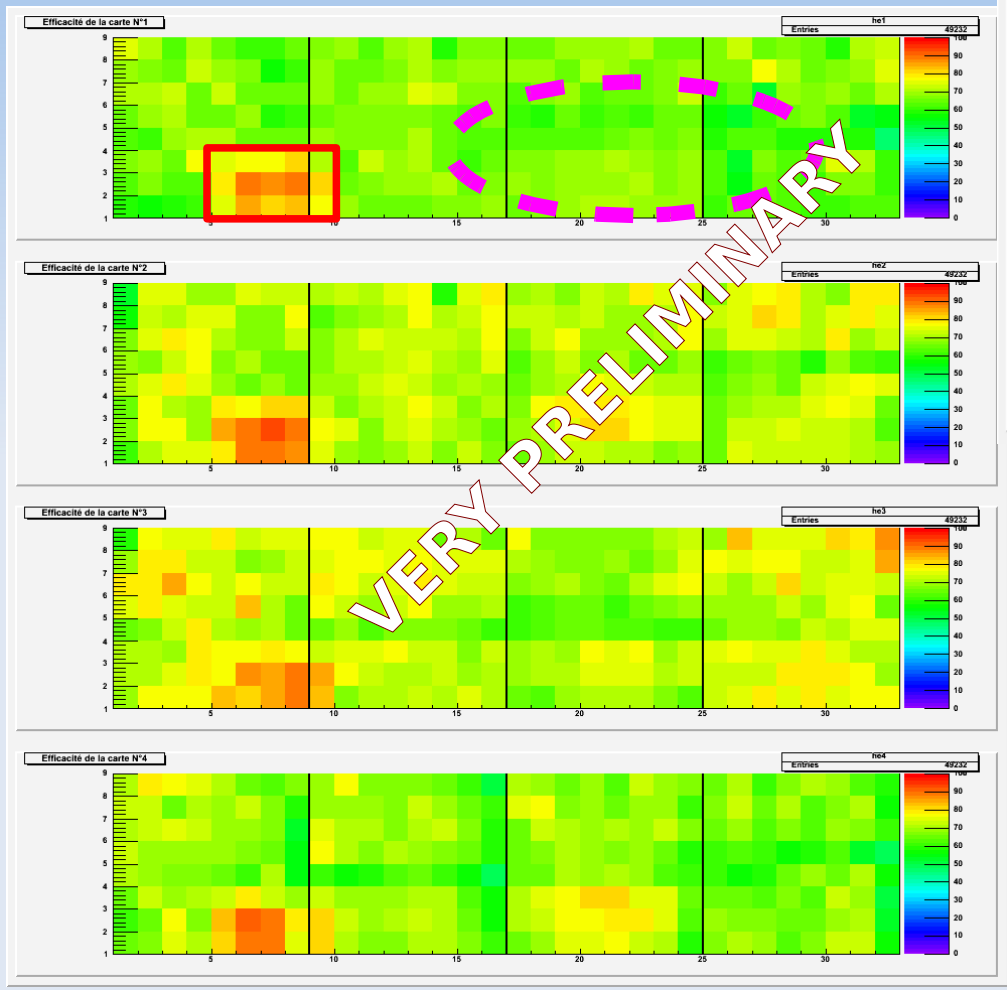
×15 or this one

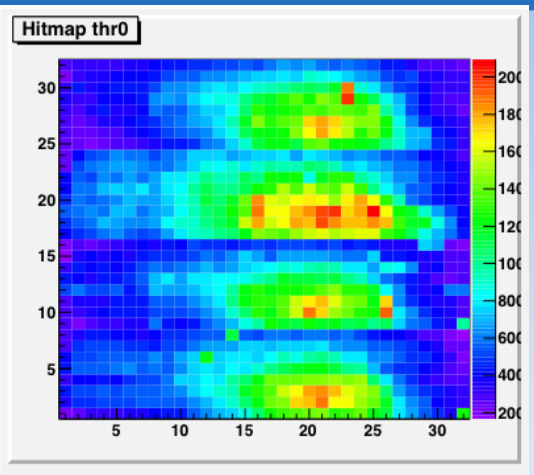


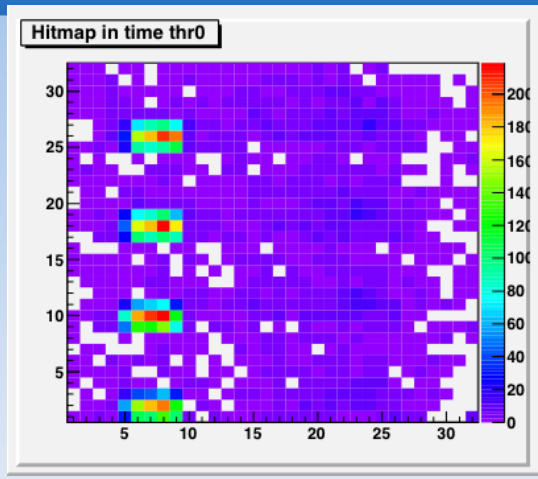
History of full detector
limited by noisiest board
(due to RAMfull reset of triggered DAQ mode)

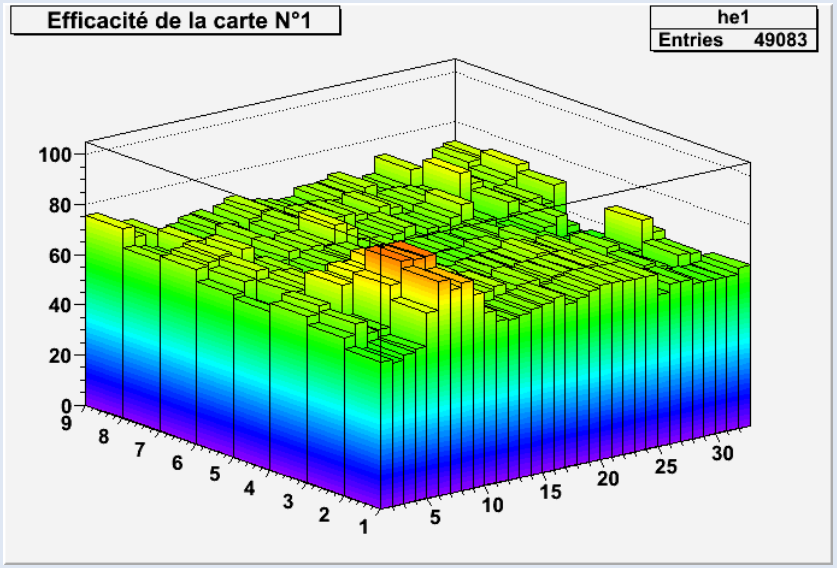
To be taken into account in all train mode analysis
→ Info to keep in reconstruction

1 gap GRPC Uniformity (⚠ prelim ⚠)







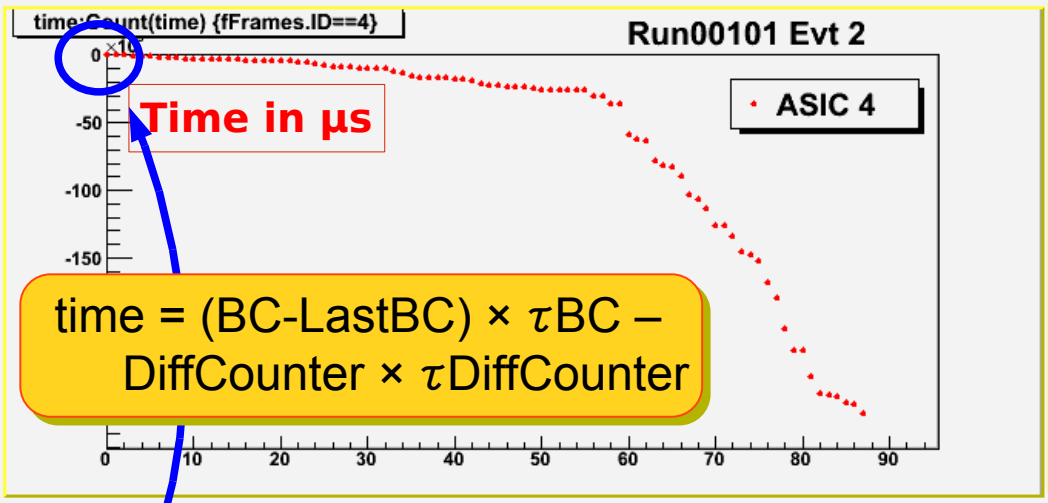


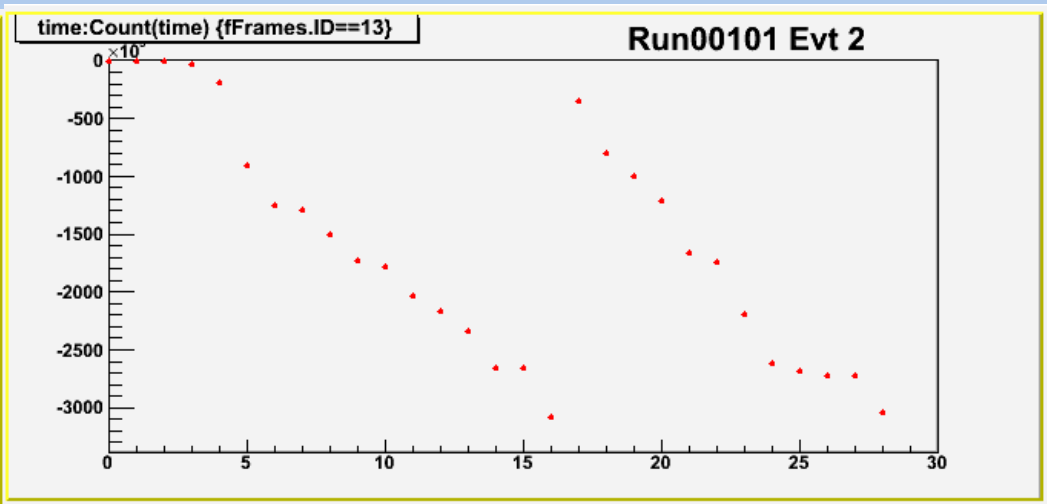
Very preliminary (global selection on noise)

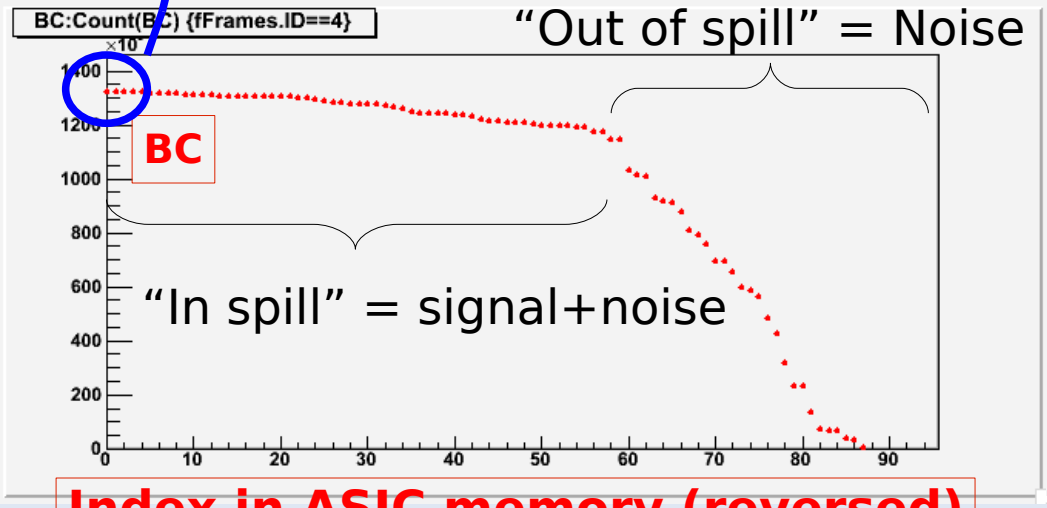
⇒ *Proof of principle*

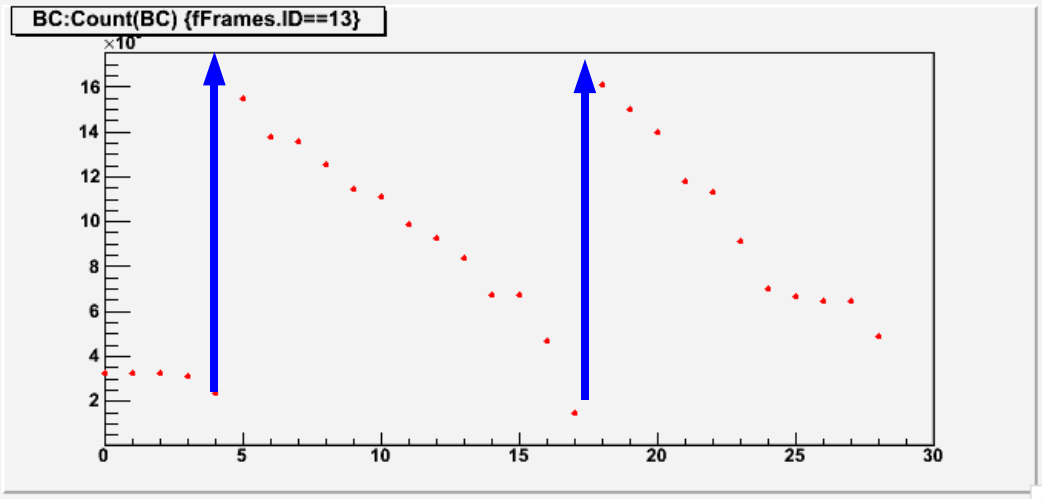
⇒ *Hints of flatness of efficiency*

1 ASIC History reconstruction



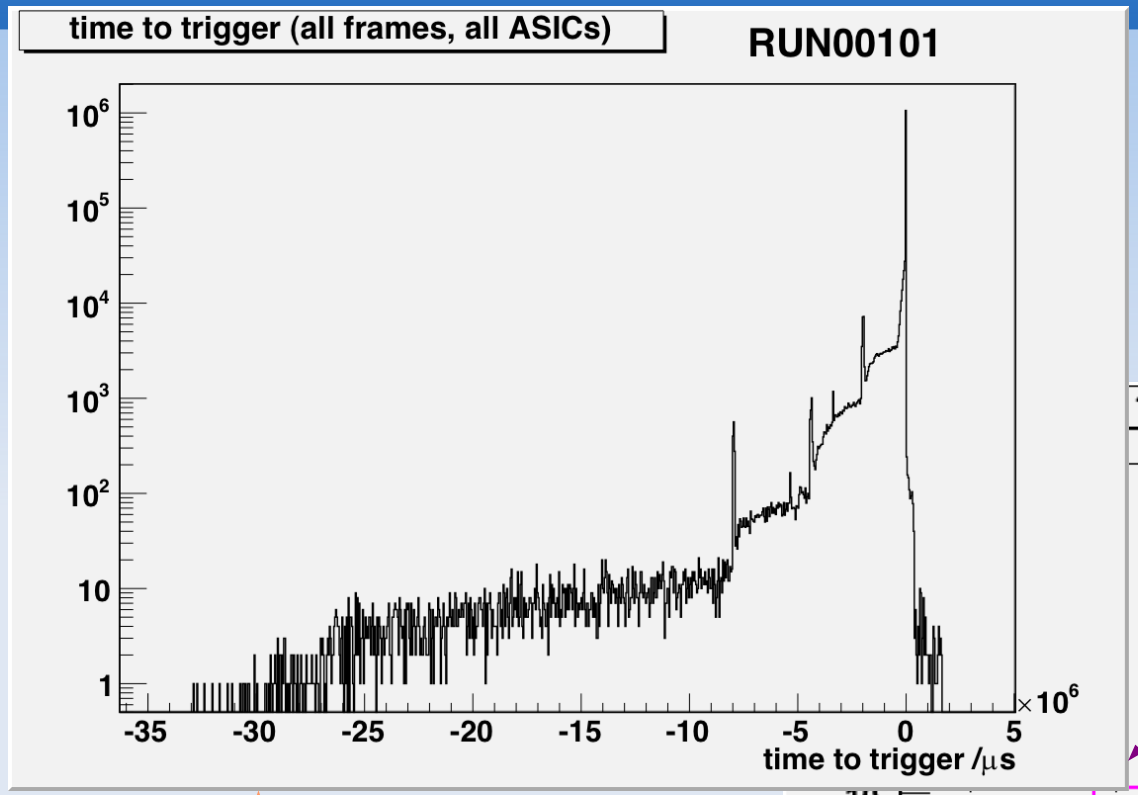






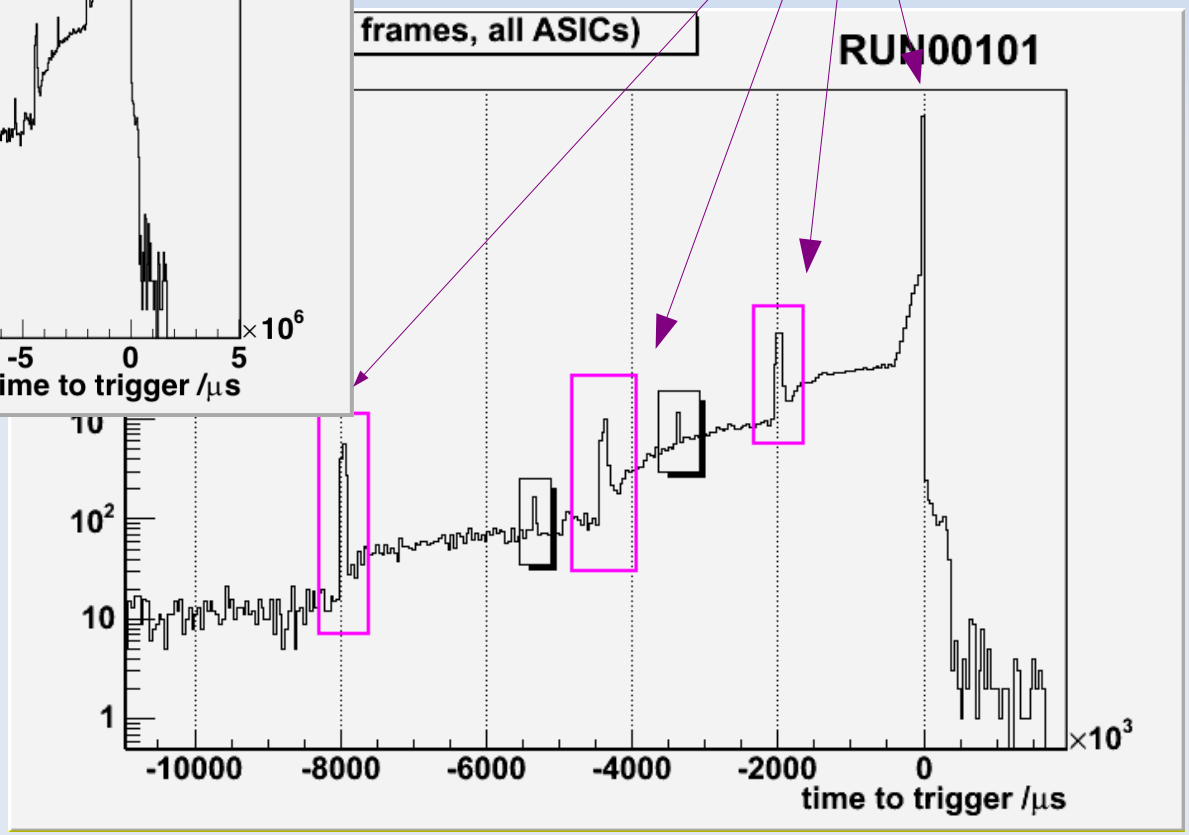
Counter overflow ~ 3s
(2^{24} × 200ns)

Full rec. spectrum



-30 s

Beam structure (spills)



Future plans

- Finish external triggered data analysis
  - vs environmental data (t°, P_{atm})
  - Shower development
    - clustering
  - Validate simulation & digitisation on data
- Finalise train reconstruction
  - → High stat of Hit (ijk, xyz, t, t_{prev}) {see Manqi's talk}
    - validation of data format completeness
  - Redo all analysis for checking +
    - Mapping
    - Time to previous ⇒ HV recovery behaviour
    - Check needed info for train analysis
- Publish...

Merci à...

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- Mary-Cruz Fouz
- Enrique Alamillo
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