Large GEM detector

August TB results

E. Graverini

on behalf of

University of Siena / INFN Pisa – CERN GDD Group

Outline

Test of a **large GEM prototype** (S. D. Pinto) realized with **single mask etching** and GEM foils **splicing** technology at CERN.

Readout electronics: **VFAT2** digital front-end chip.

Main objectives of our tests:

- Detector prototype performance.
- Single mask foils behaviour.
- Foils splicing effects.
- VFAT2 (digital front end) readout coupling with large capacitance pads ($\approx$ 40-80 pF).

Large GEM Detector

"A large area gem detector", Serge Duarte Pinto et al., 2008 IEEE Nuclear Science Symposium Conference

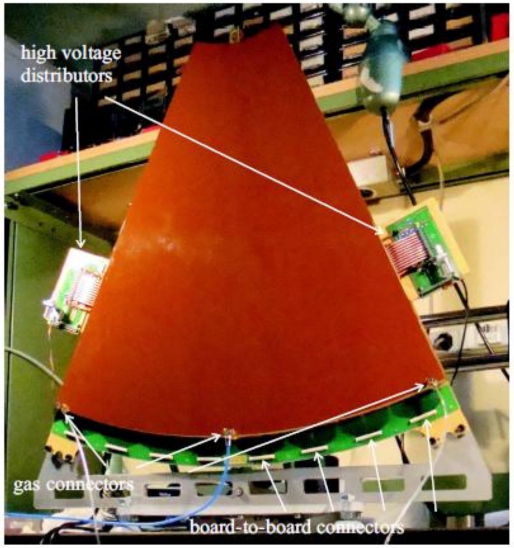
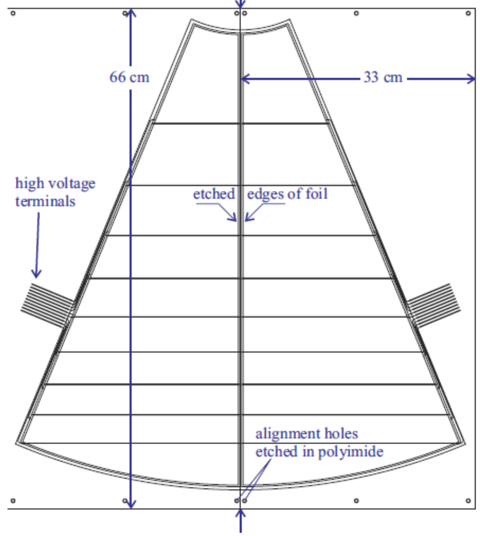
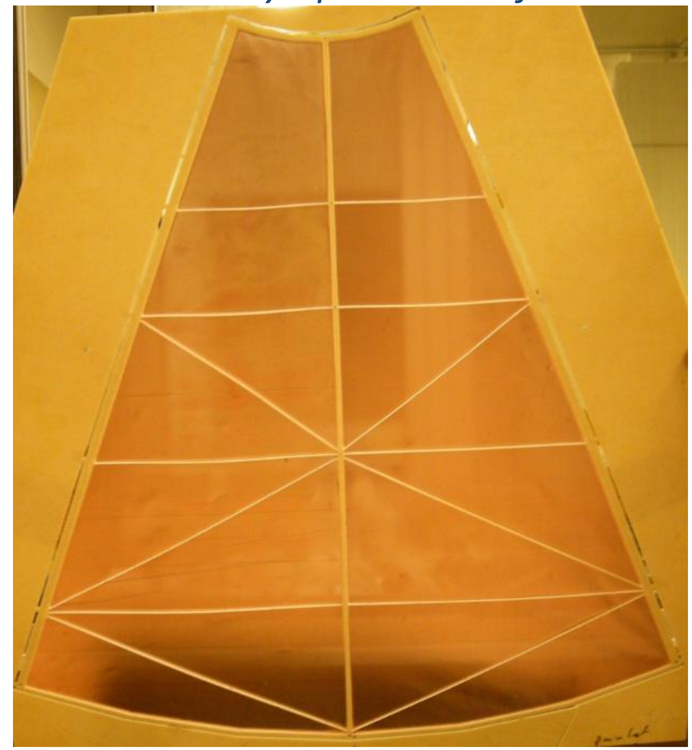


Figure 12. The prototype large area triple GEM detector, mounted on its support.

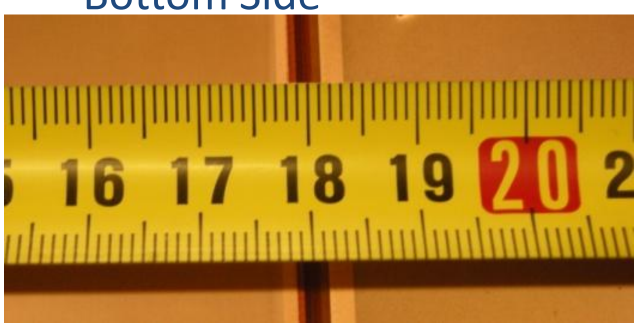


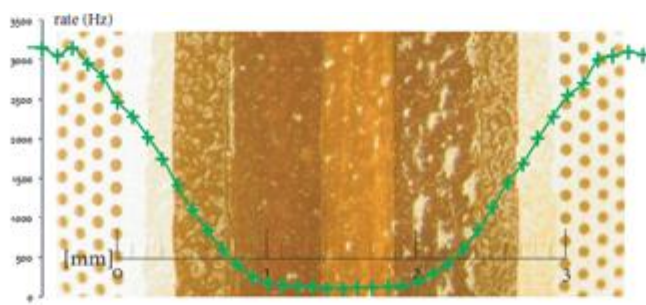
ure 14. Layout of the GEM foils used for the prototype. The top electrodes divided in sectors of $\leq$ 100 cm^2 to keep the capacitance per sector below F.



GEM foils splicing

Bottom Side





Top Side

A measure of the counting rate over the seam of two spliced GEM foils

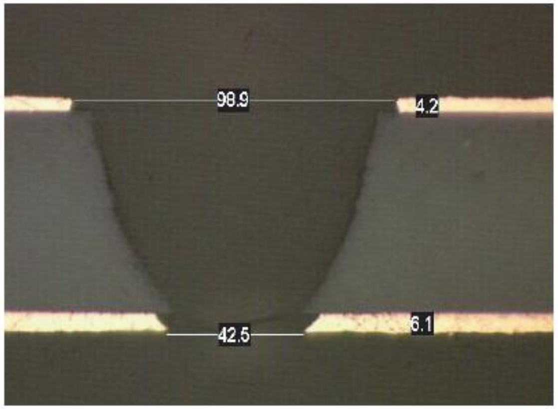
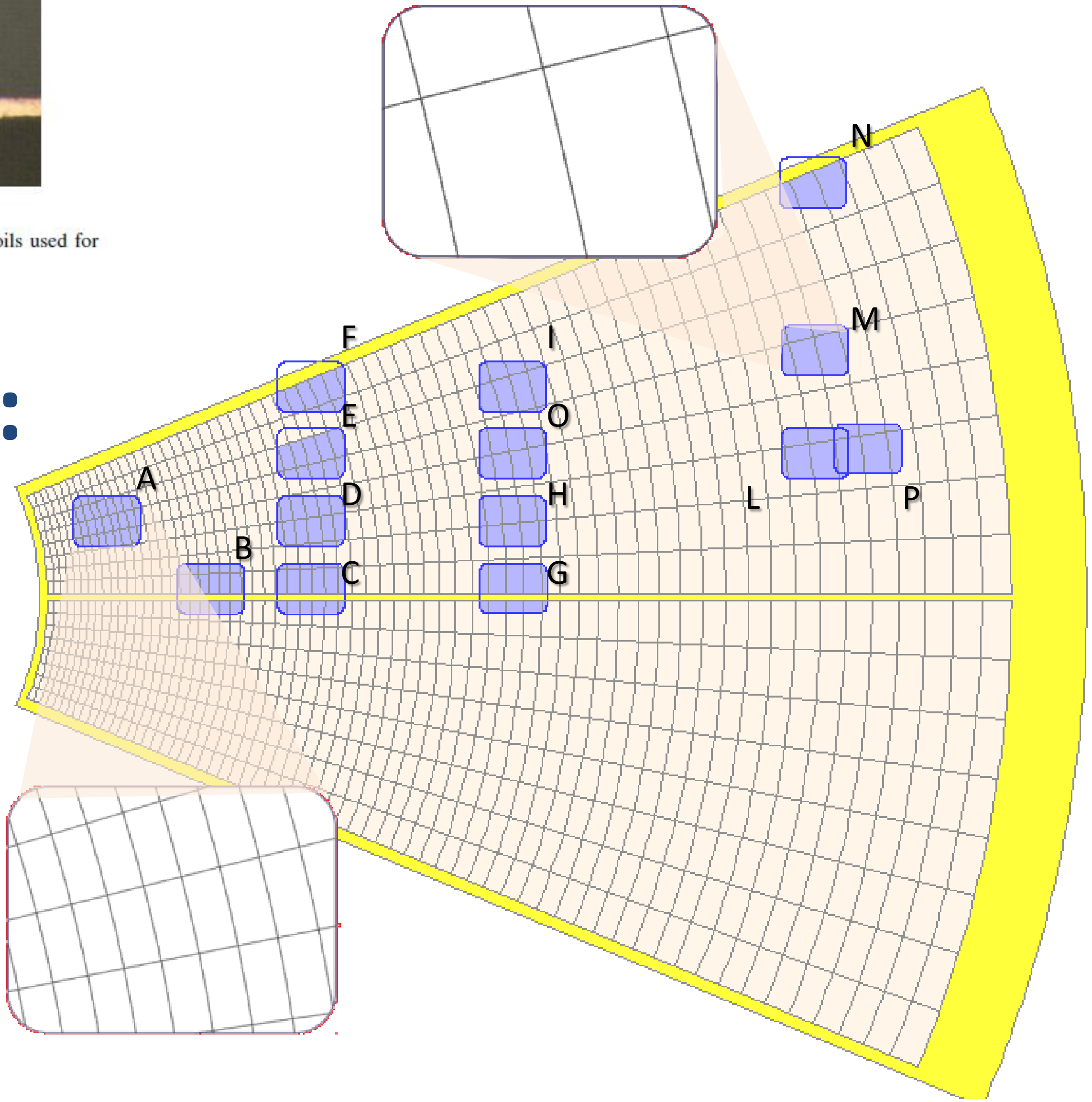


Figure 7. Cross section view of a hole, representative of the foils used for making the prototype. Indicated dimensions are in microns.

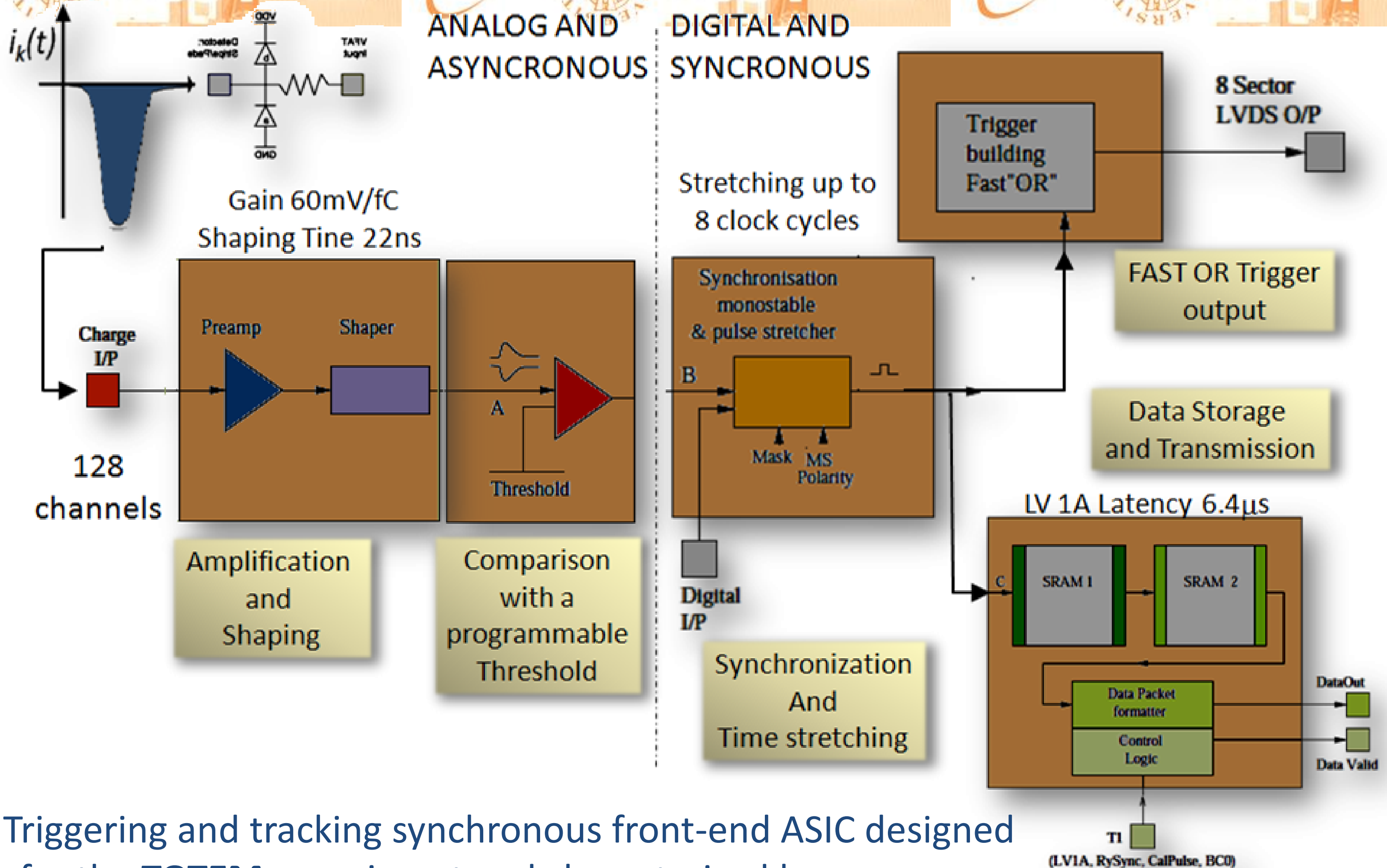
The foils used for the LG prototype are single-mask etched.

Readout Plane: pads



During the TB we tested the chamber over the regions A – P.

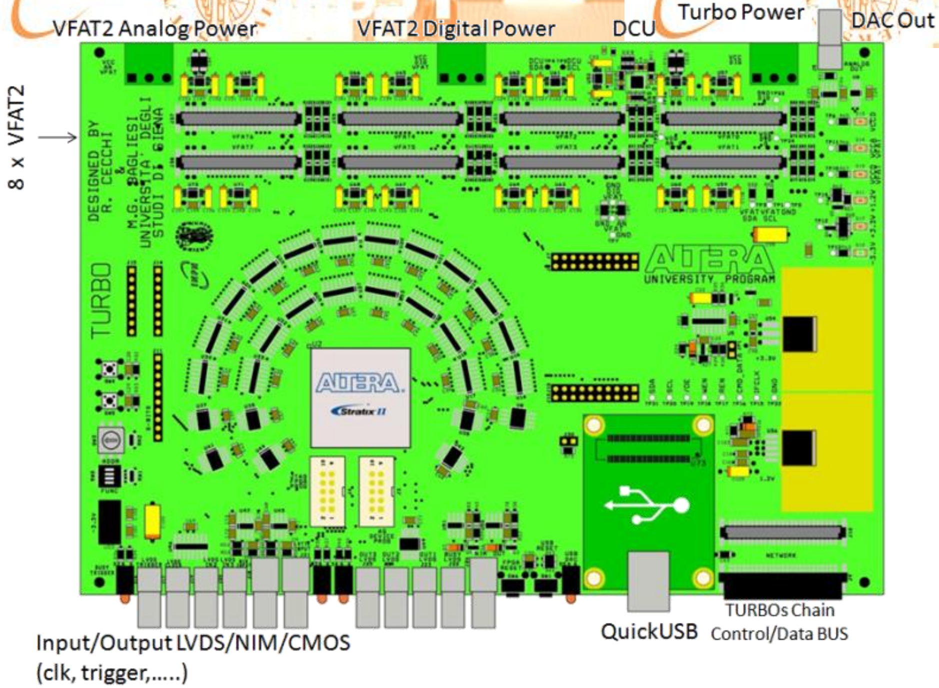
Readout: VFAT2 chip

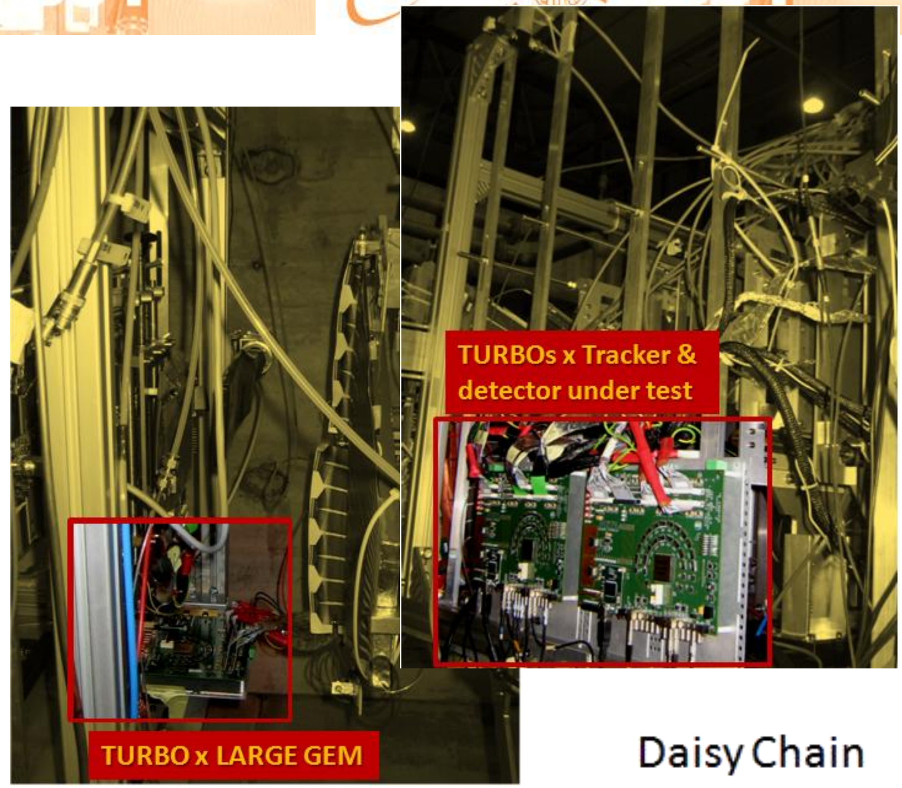


VFAT2: Triggering and tracking synchronous front-end ASIC designed primary for the **TOTEM** experiment and characterized by:

- **Preamplifier-shaper-comparator** readout chains (128) to detect signals above a programmable **threshold**.
- **Fast-OR** lines (up to 8) that merge channels of programmable sectors to provide a **trigger** signal.

Readout Electronics and DAQ: VFAT2 & TURBO

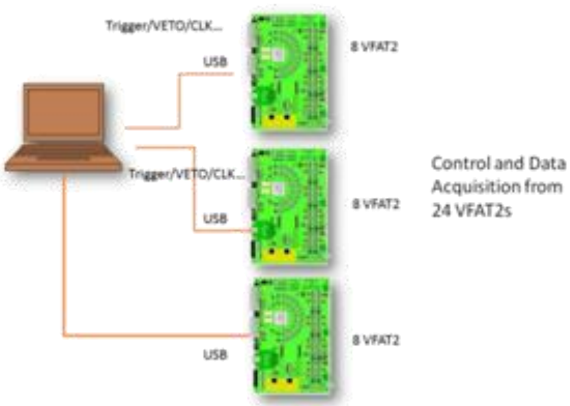




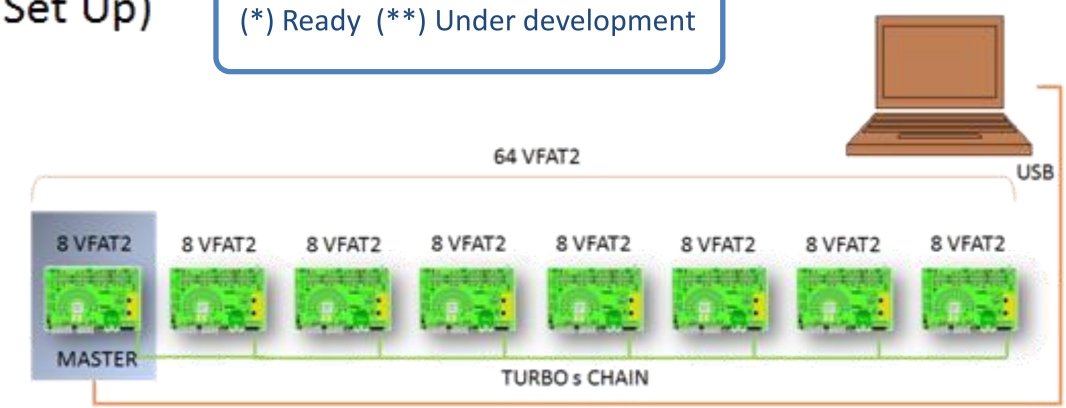
TURBO: SLOW Control and DAQ Interface
Parallel (*) and **Daisy Chain** (**) Operation

(*) Ready (**) Under development

Parallel Operation(RD51 Test Beam Set Up)

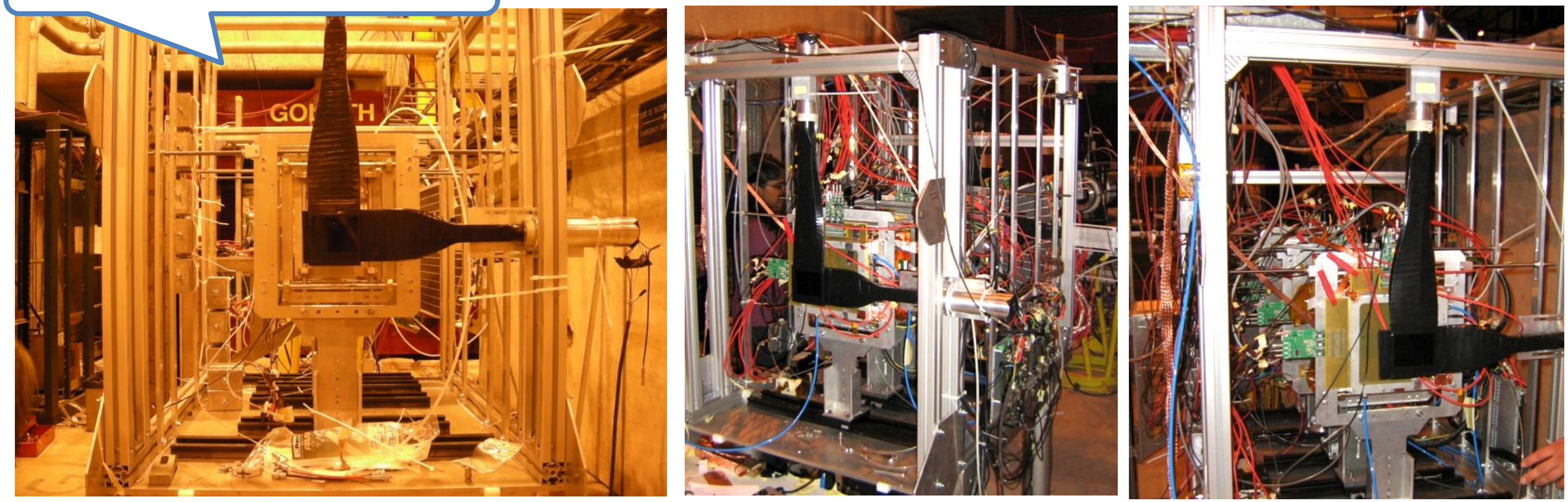


Daisy Chain
Operation

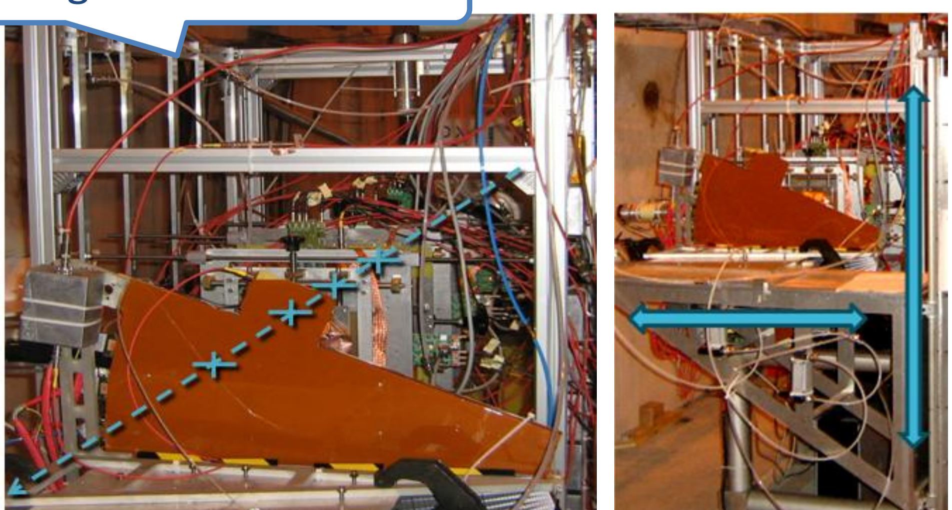


RD51 2010 Test Beams: SPS-H4

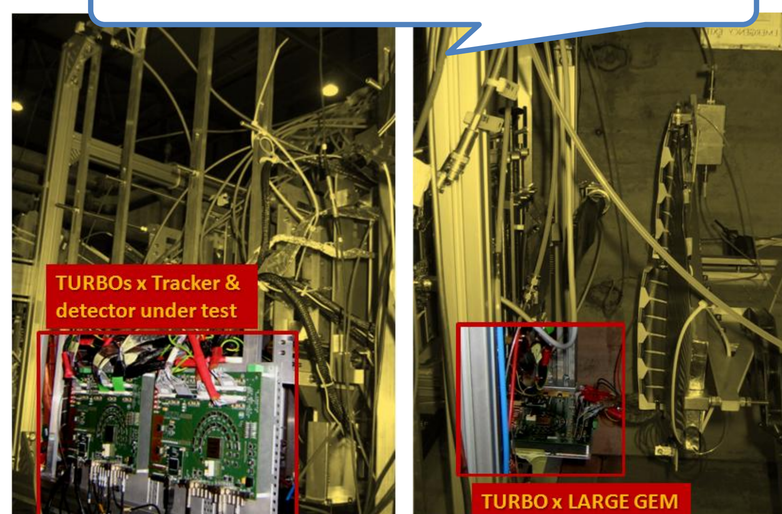
RD51-GDD Tracker setup



Large GEM installation



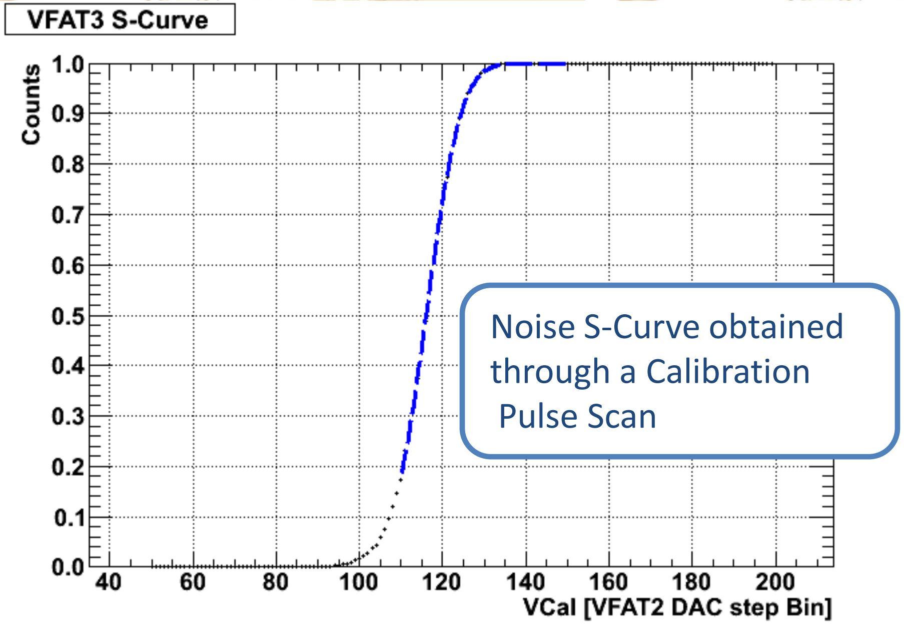
TURBO Slow Control & Readout

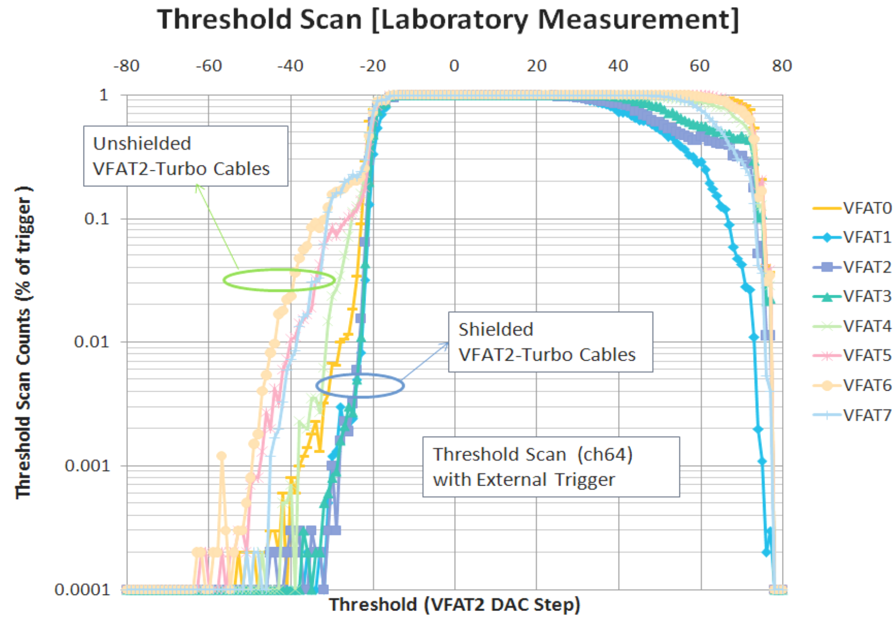


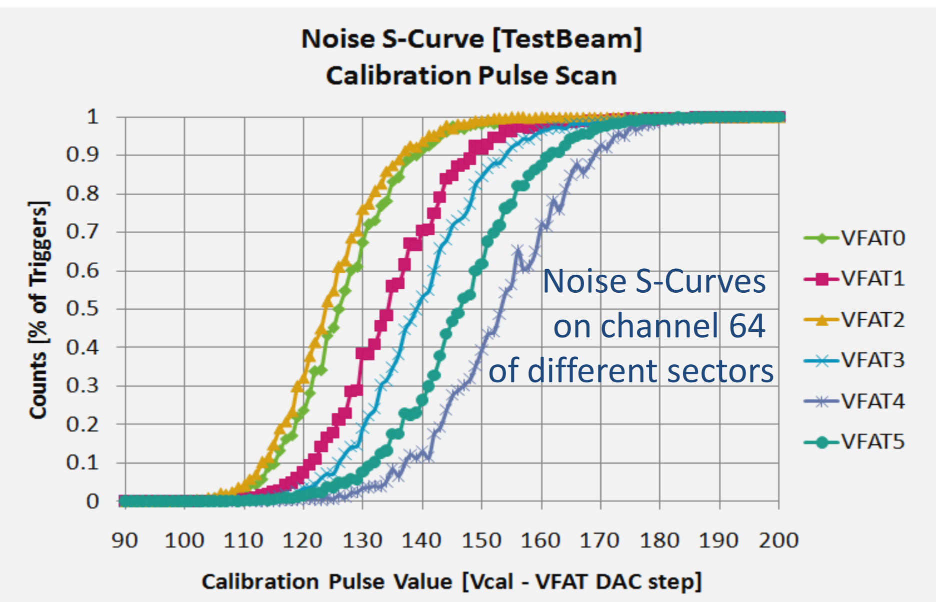
RD51 August Test Beam Data Analysis

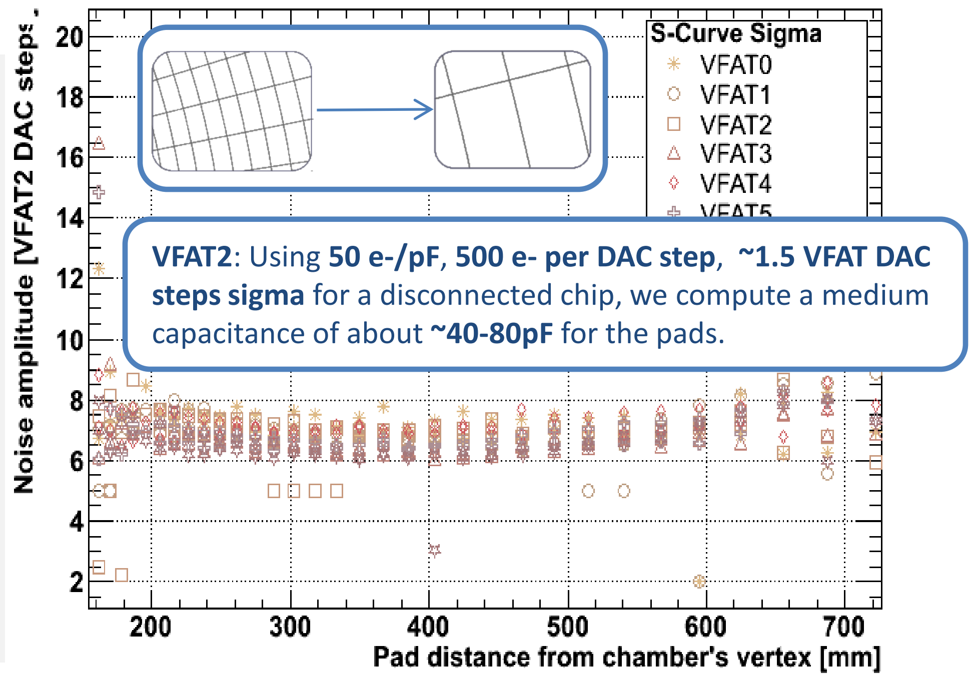
Preliminary results from the **ongoing** analysis of the data collected in the **August 2010 RD51 test beam** (and some ideas…)

Noise Characterization

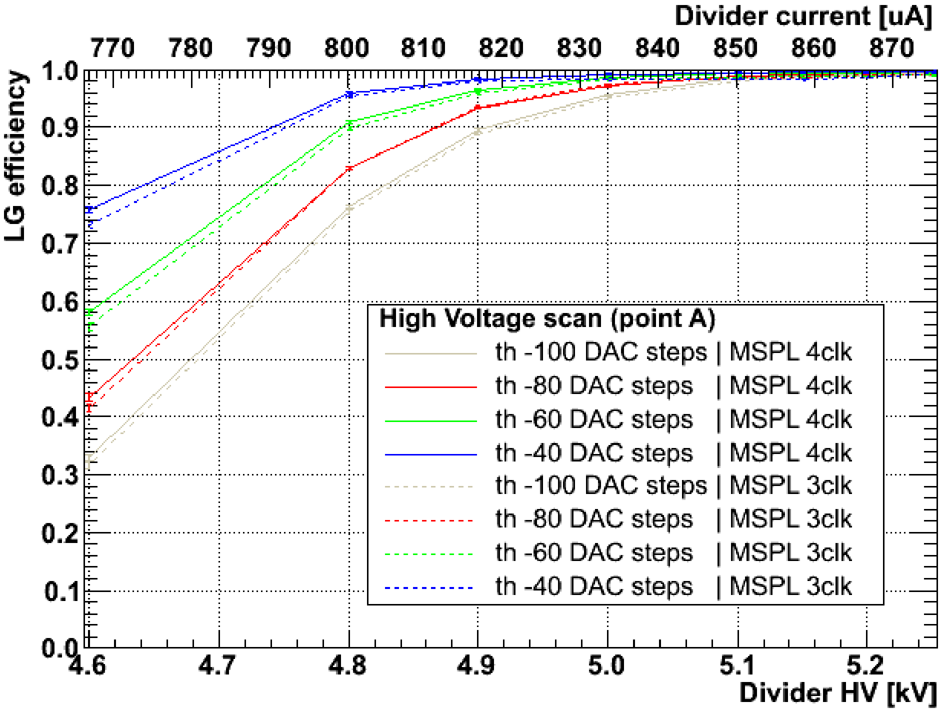




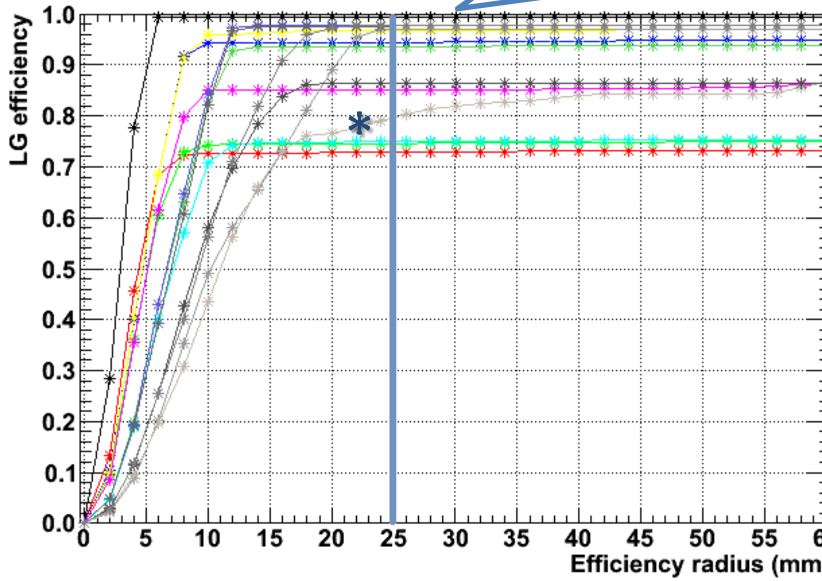


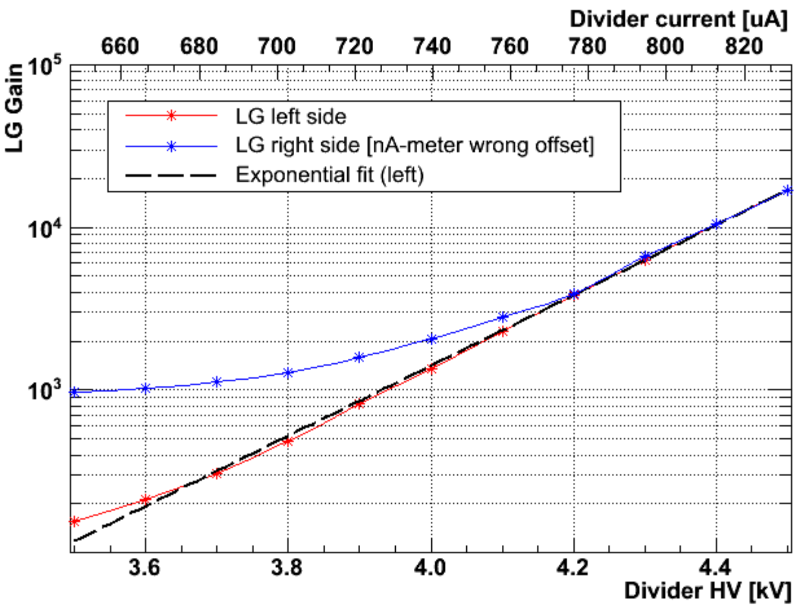


High Voltage scan



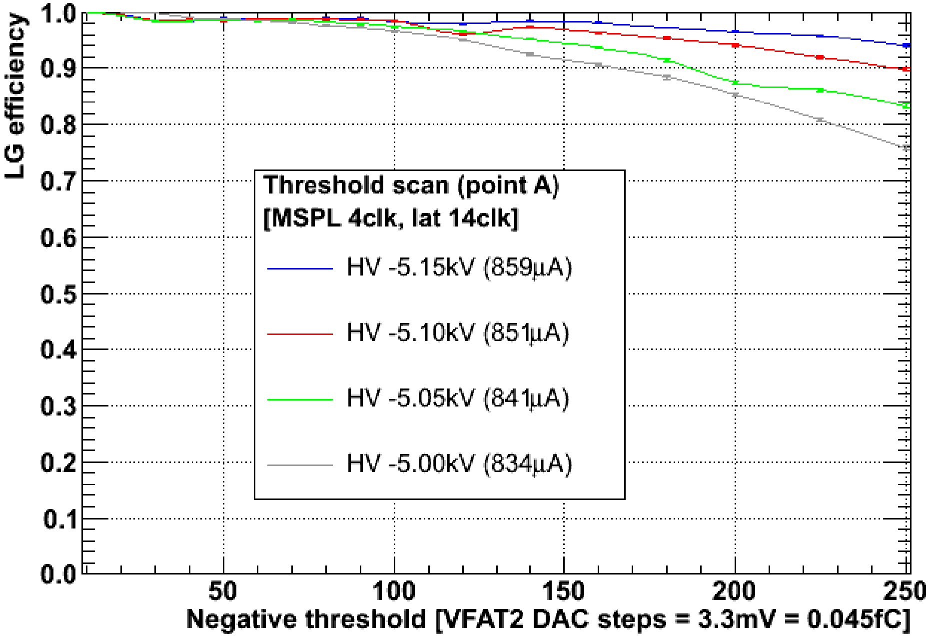
Efficiency computing algorithm check: an acceptance **radius** (distance between the **track projection** and the hit on the LG) of **25mm** was used in the computation. Here is an "acceptance radius scan" for the different LG regions.





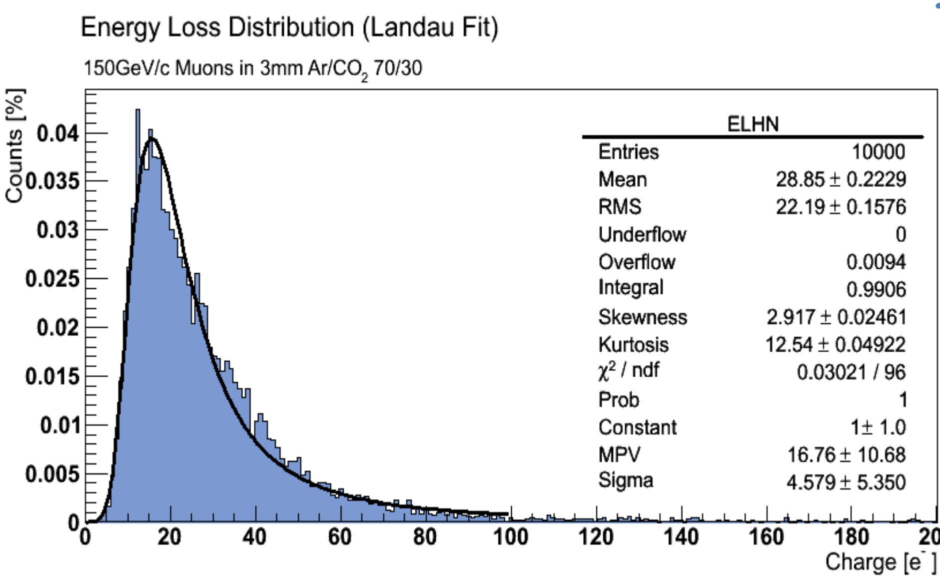
High Voltage Calibration Scan:
X-Ray Absolute Gain Measurement
(**S. D. Pinto**)

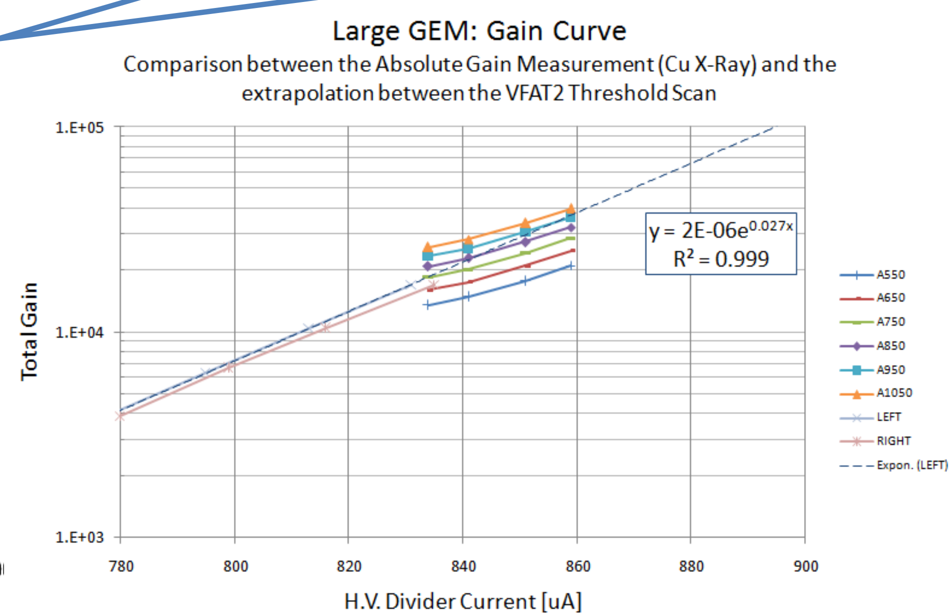
Efficiency vs VFAT2 Threshold



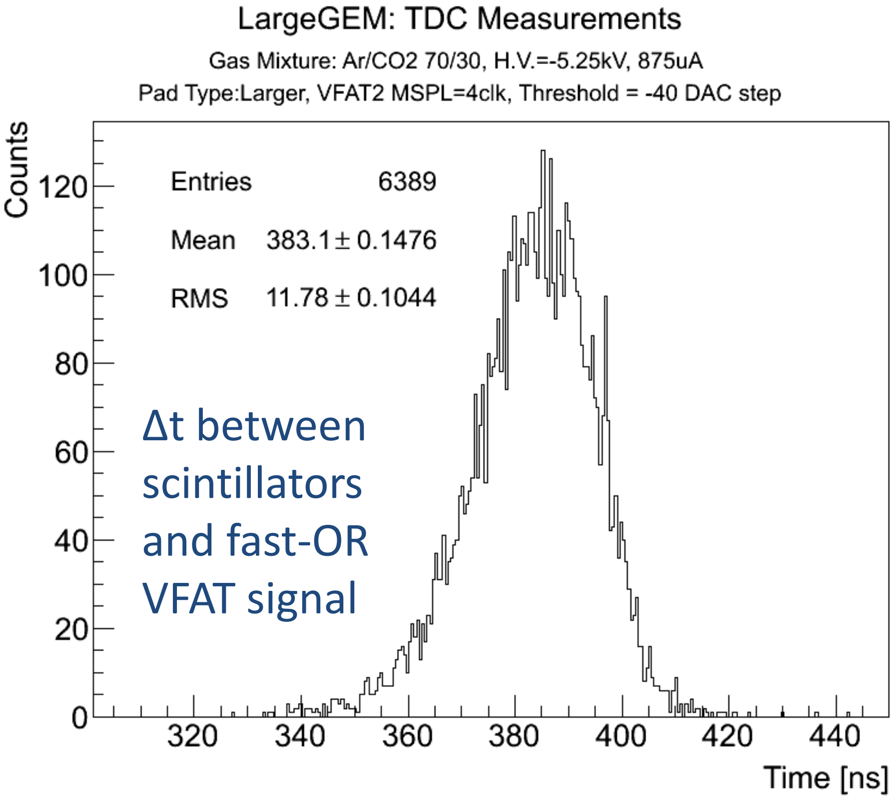
The prototype is still efficient at high threshold. It may be developed for use in noisy environments

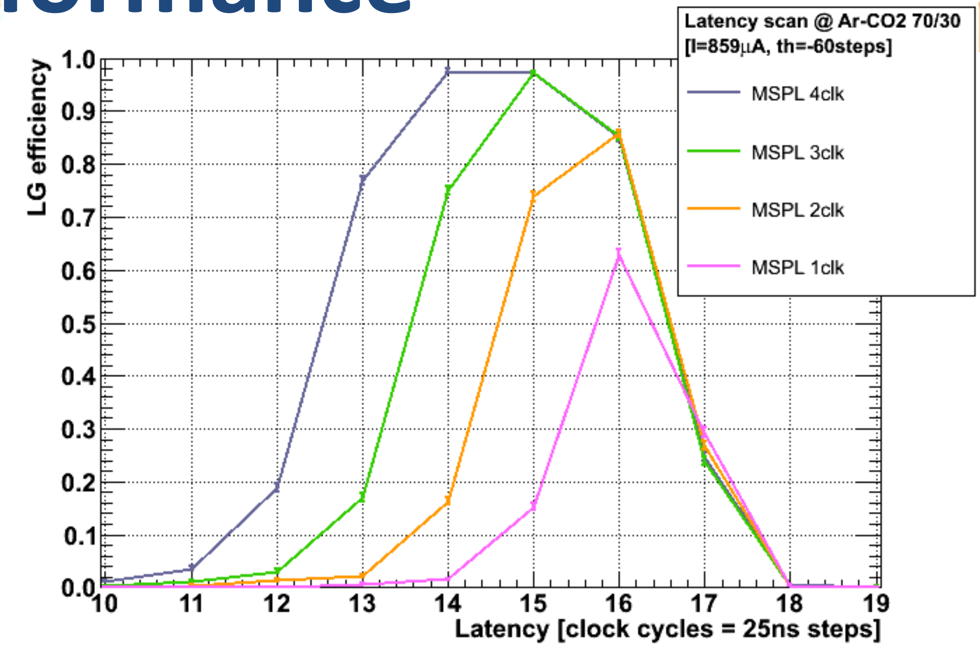
Data fitted according to the **Energy Loss Distribution** (Garfield simulation), the detector **gain** and the **number of electrons** per VFAT2 DAC step used as fit parameters (**E. Oliveri**).



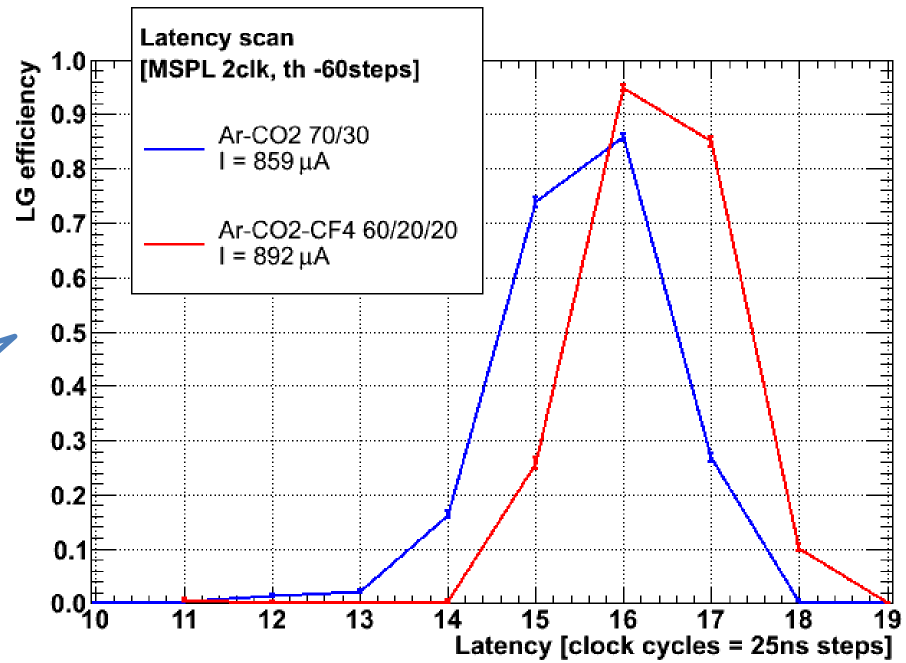


Time Performance



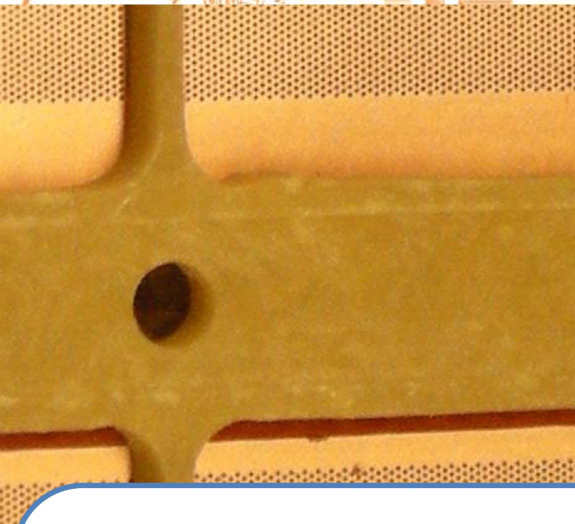


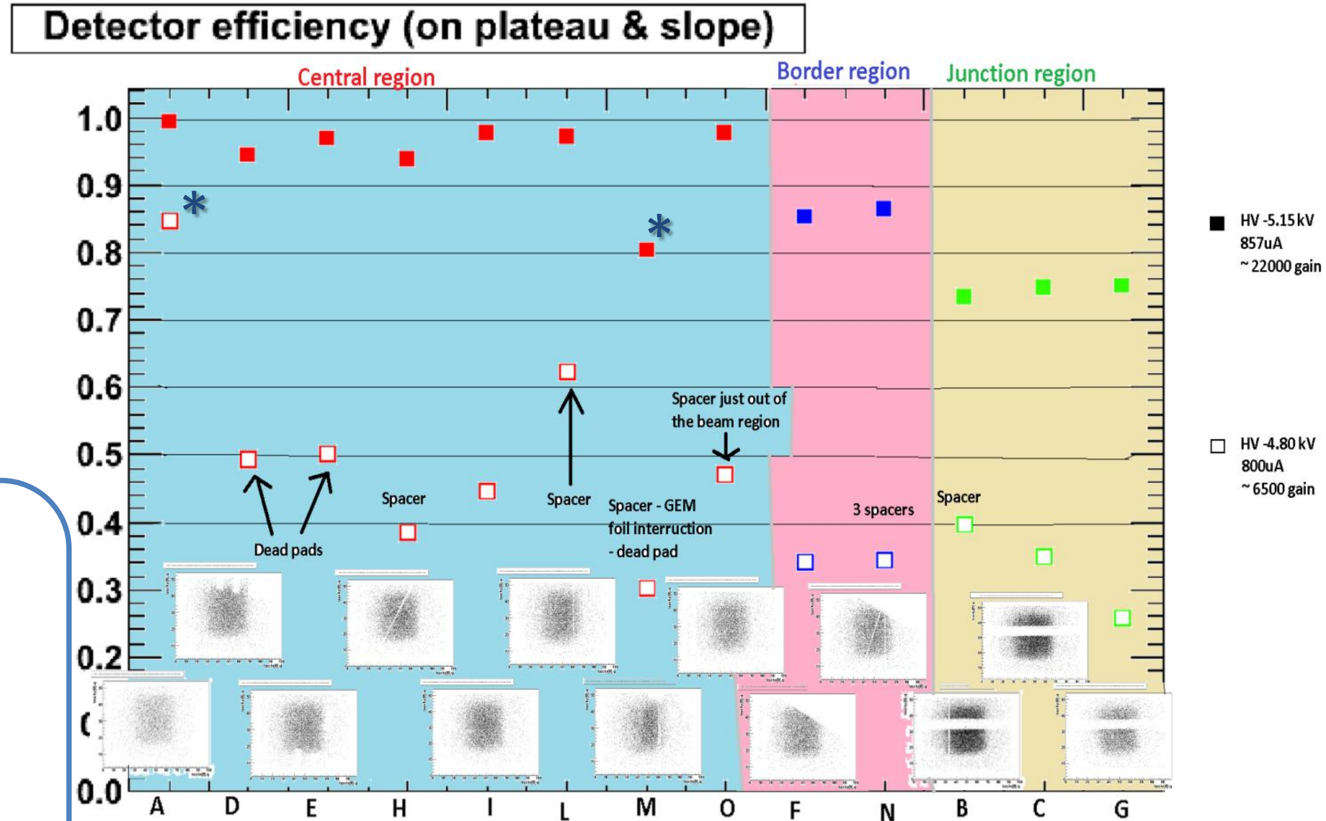
Fully efficient with at least **MSPL=3clk** (75ns)



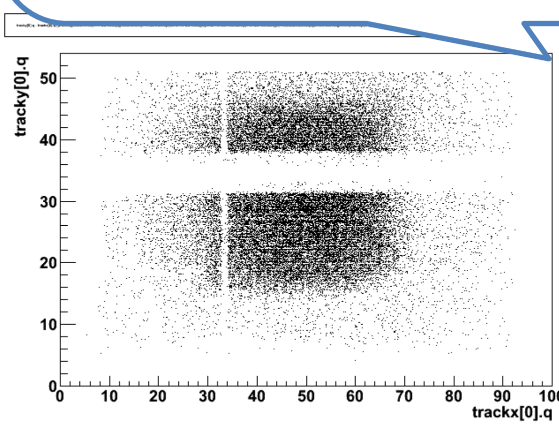
Data taken adding **CF4** to the standard Ar/CO2 70/30 gas mixture (**same internal voltages** and fields as for Ar/CO2, detector **not optimized** and **asyncronous** beam).

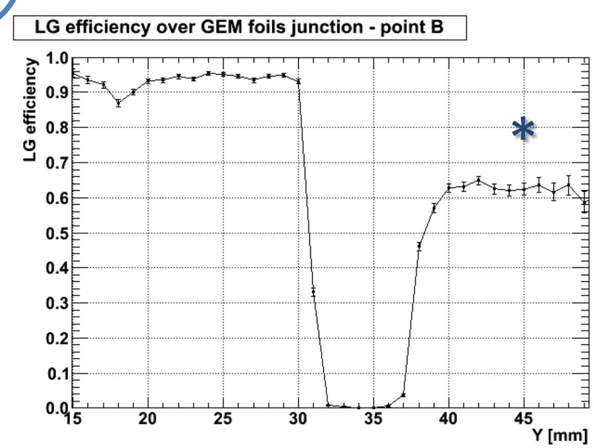
Efficiency vs detector alignment

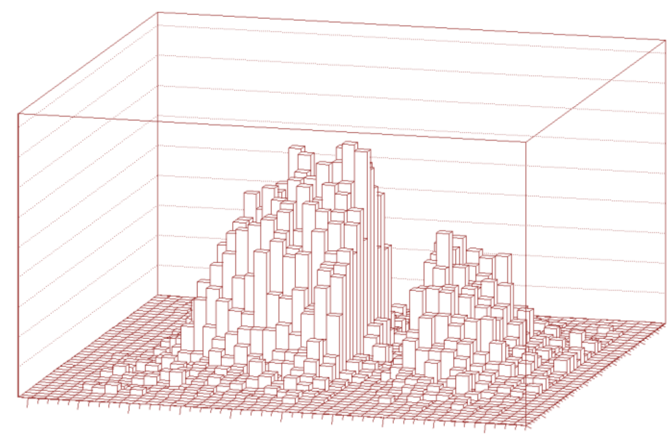




Different regions of the chamber were tested, and the variation of the efficiency over the spacer covering the GEM foils junction was measured.

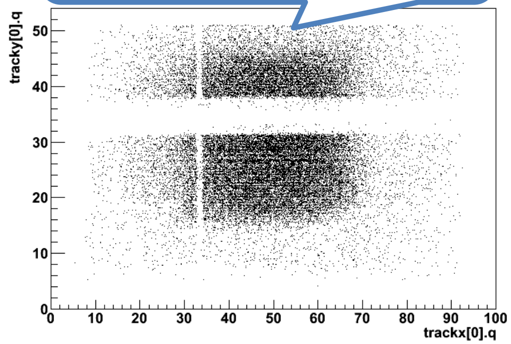




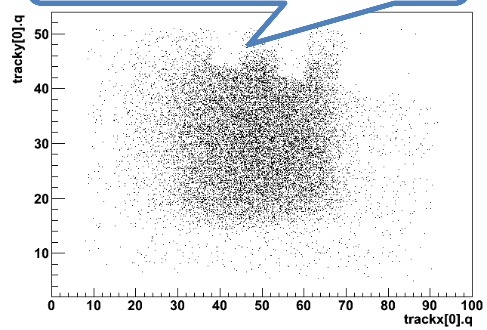


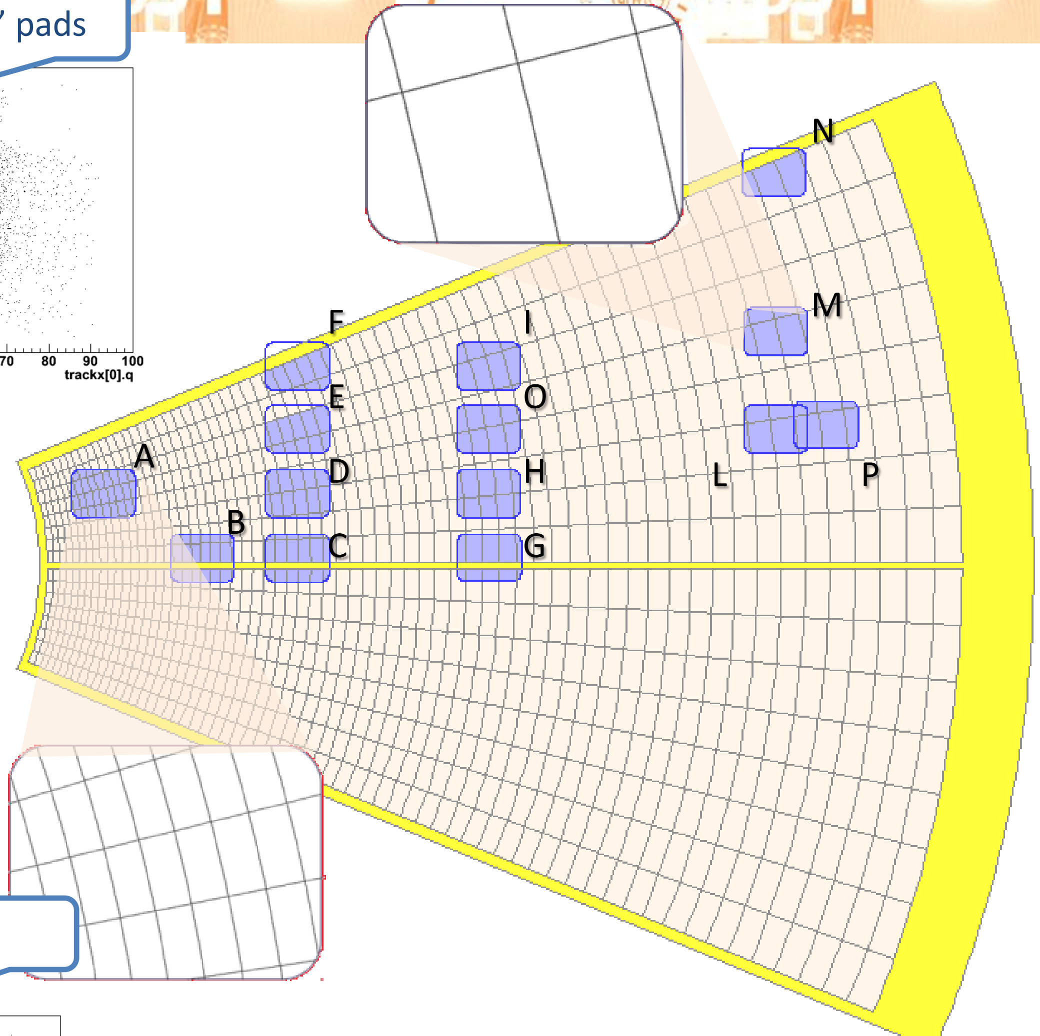
Large GEM prototype imaging!

Region B → GEM foils junction & spacer

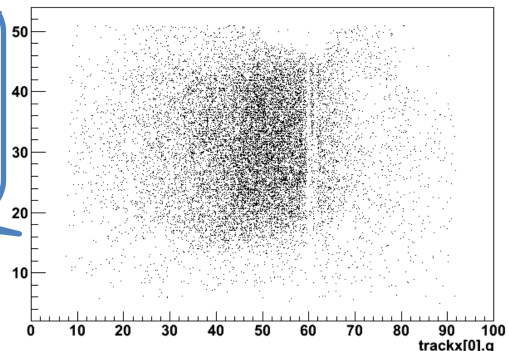


Region D → "dead" pads

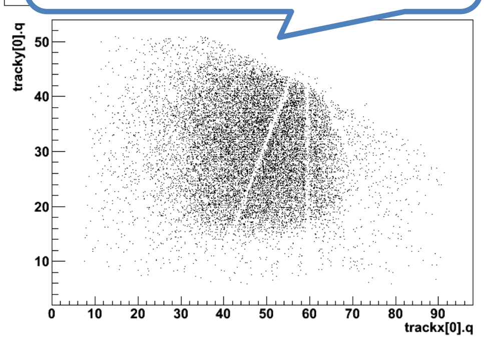




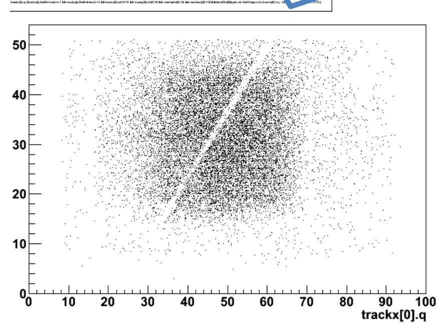
Region M → GEM sectors gap, dead pad & spacer



Region N → detector border & spacers

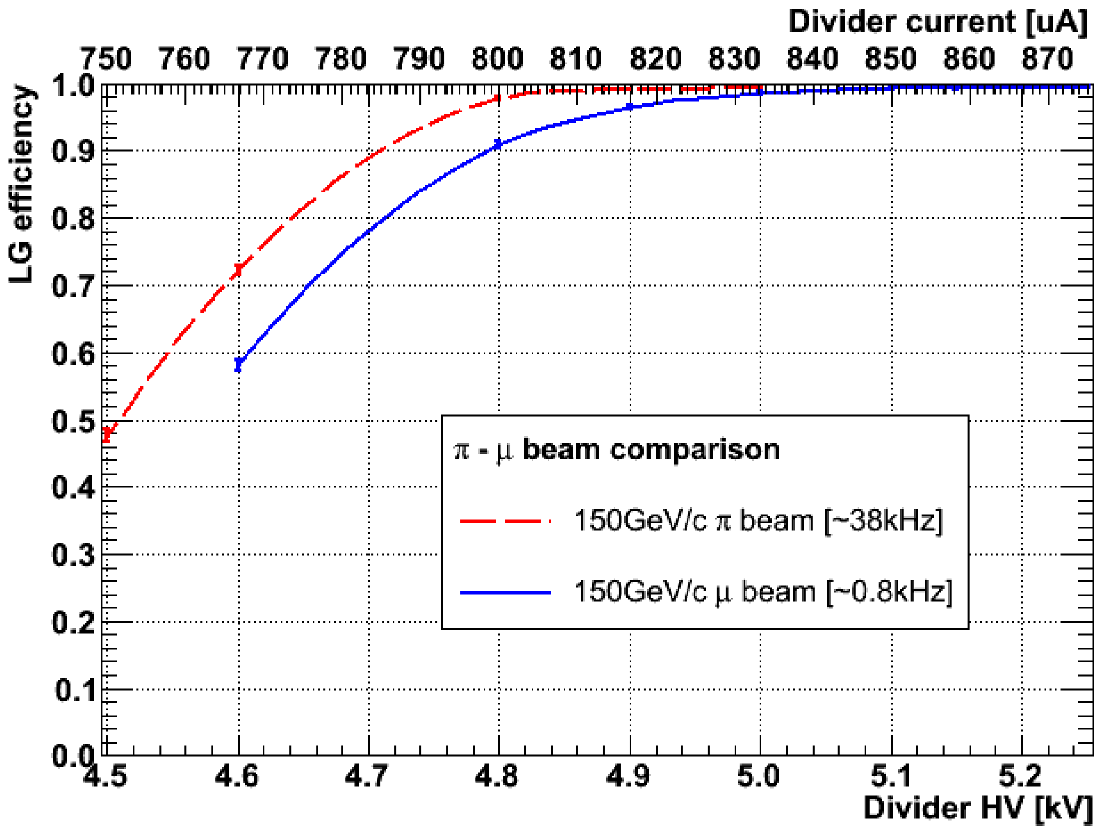


Region H → spacer

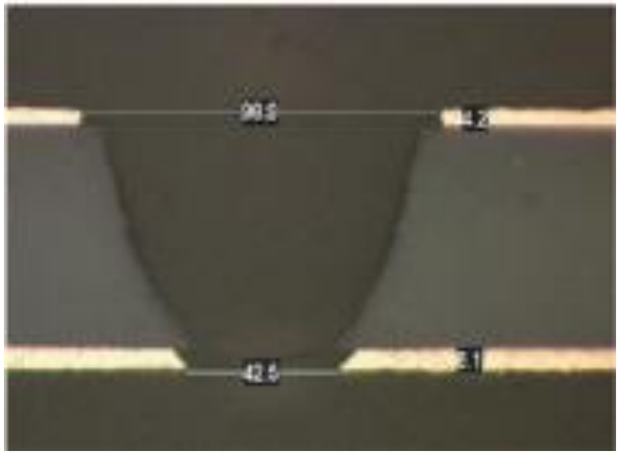


Open question: fall of the gain/efficiency on the bottom side of the LG prototype!

Hadrons beam



Charging up effects for high intensity beam (to be checked!)



If the difference can come from the two **different beam rates** (**charging up** effects), it should have affected the **absolute gain curves** obtained with Cu X-Rays (~300 e- per photon, @ 6KHz interaction rate ≈ **60kHz** equivalent MIP).

Conclusions & …

- **Large GEM with Single Mask Foils:** the performances of the detector are within the expectations. No problems encountered during the beam runs (high/low intensity muons / hadrons beams).

- **GEM foils splicing**: even if the prototype works well, the difficulties encountered on the assembly (**stretching**) do not justify the advantage of splicing GEM foils together in order to cover larger areas and thus to reduce the number of needed detectors (S. D. Pinto).

- **VFAT2 on Large Capacitance Readout Electrode (60-100pF)**: initial problems were solved improving the chip **grounding** on the readout plane.

- **Timing Measurements**: as expected, the use of **CF4** improves the time response of the detector, even if the **fields** and **internal structure** (gaps) of the detector are left **unchanged**. A redesigning (gaps and divider) will be done to optimize the performance (following LHCb and the recent studies of the group of **A. Sharma**).

- The **availability** of the **RD51-GDD Tracker** largely improves the analysis and comprehension of the data collected (e.g.: spacial resolution).

...Outlook

- **Gain extrapolation from VFAT2 measurements: a**nalysis is ongoing in order to test the accuracy of the **gain** extrapolation obtained from a threshold scan.

- **Charging up effect**: further laboratory tests are needed and will be done as soon as possible.

- **Left - Right sides prototype asymmetry**: laboratory measurements will be done to confirm and explain the results found via the TB experience.

thanks

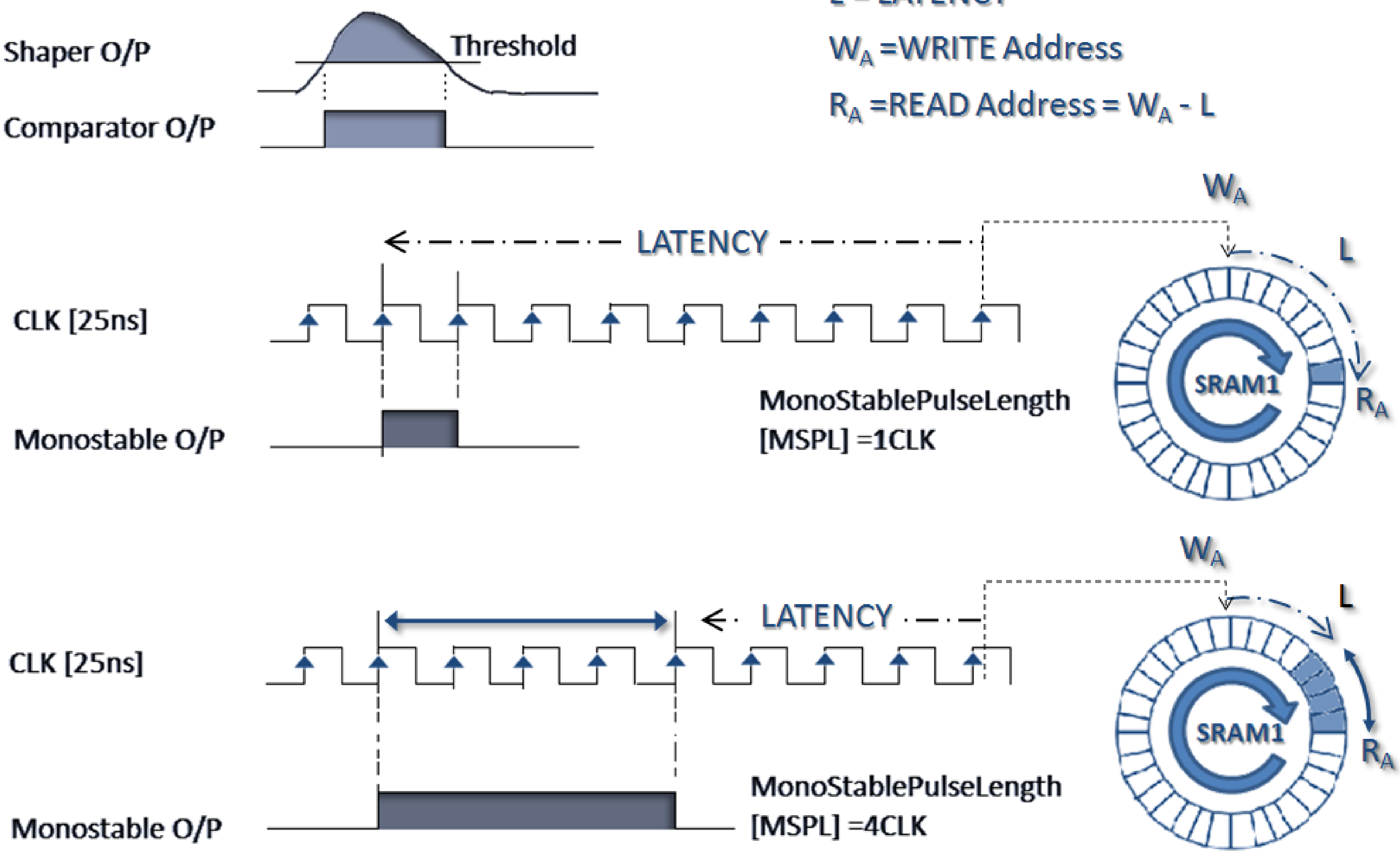
Backup slides

Monostable Pulse Lenght (MSPL)

L = LATENCY

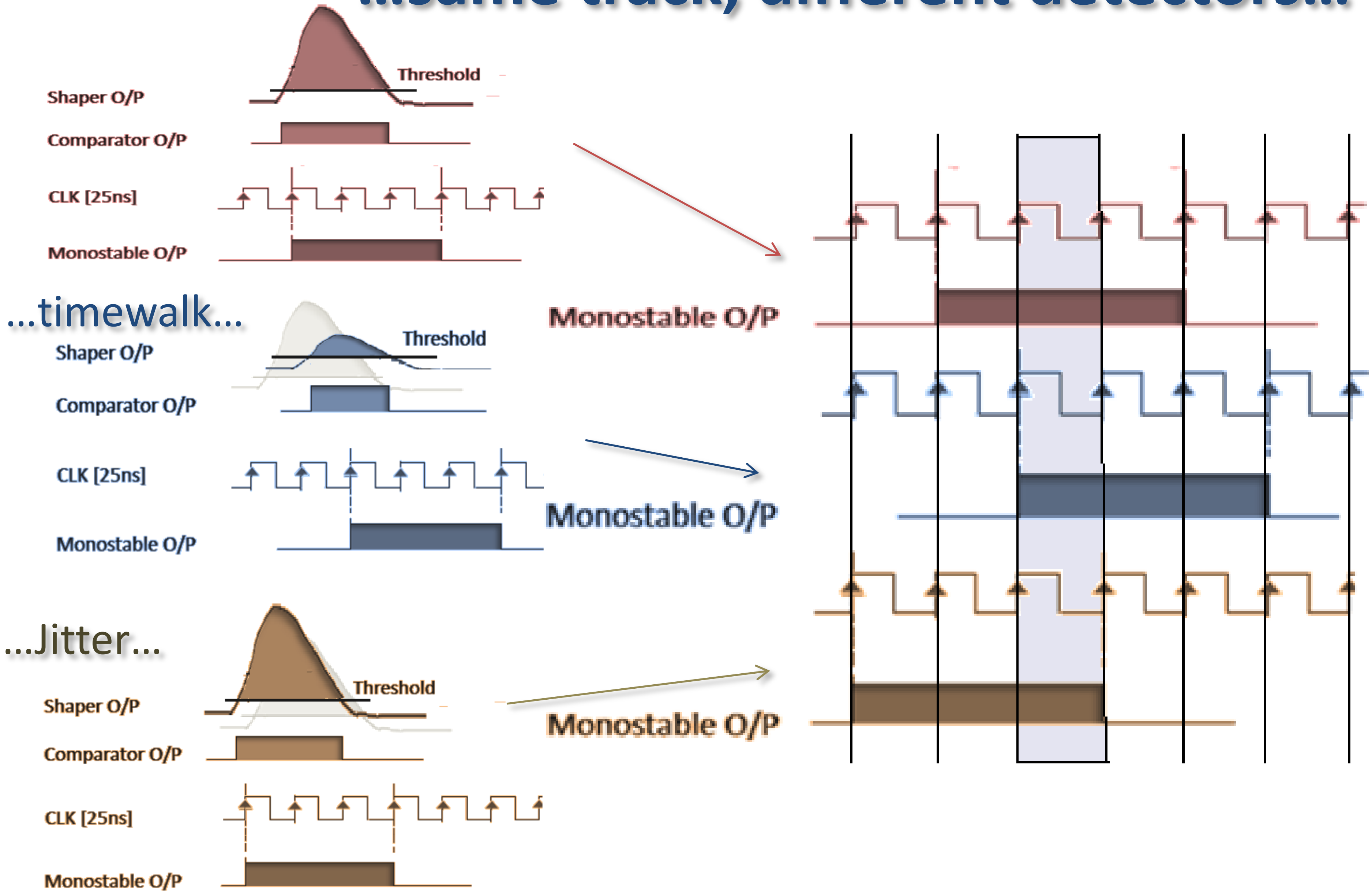
W_A =WRITE Address

R_A =READ Address = W_A - L

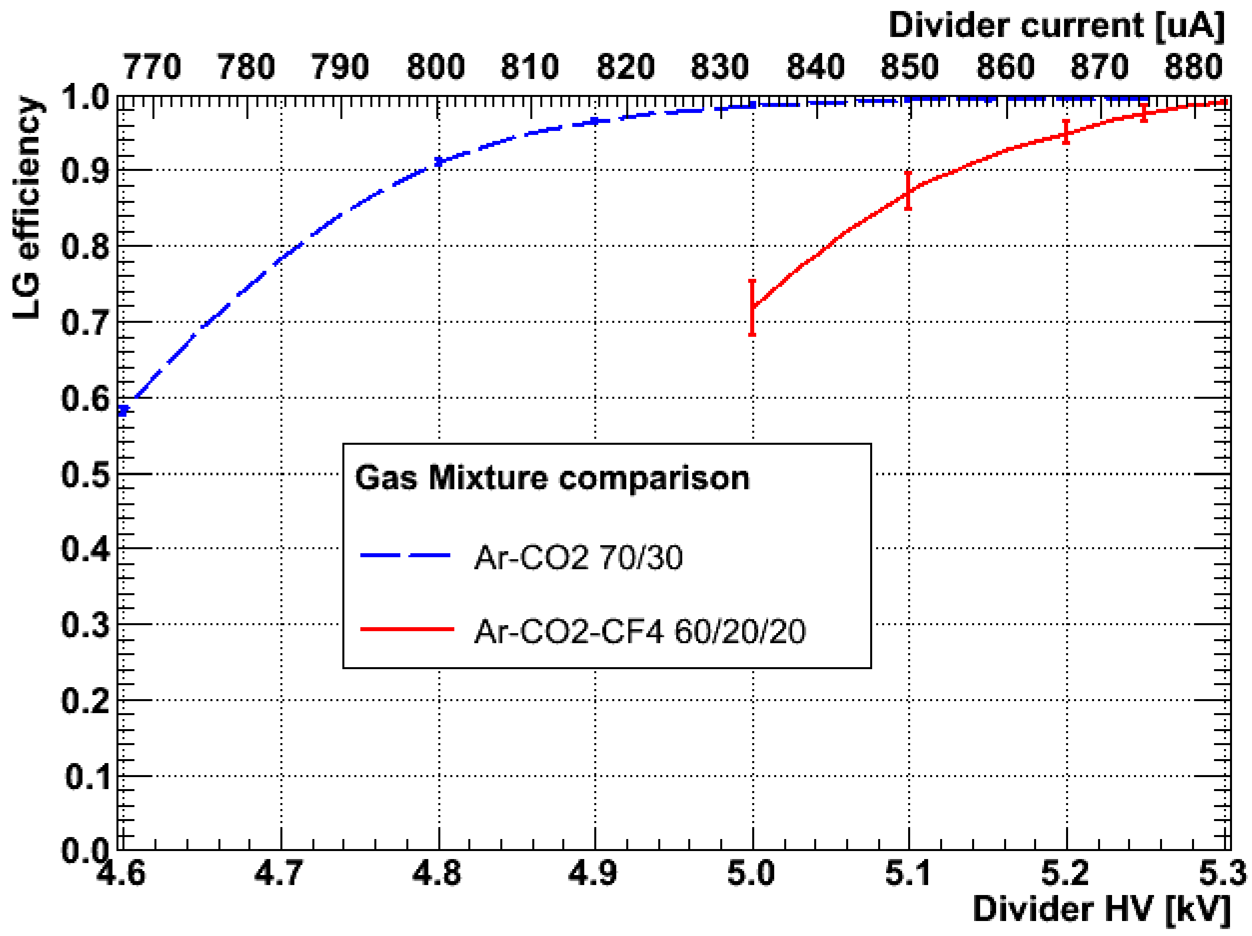


Stretching of the Monostable pulse

Same detector, different track or…
…same track, different detectors…

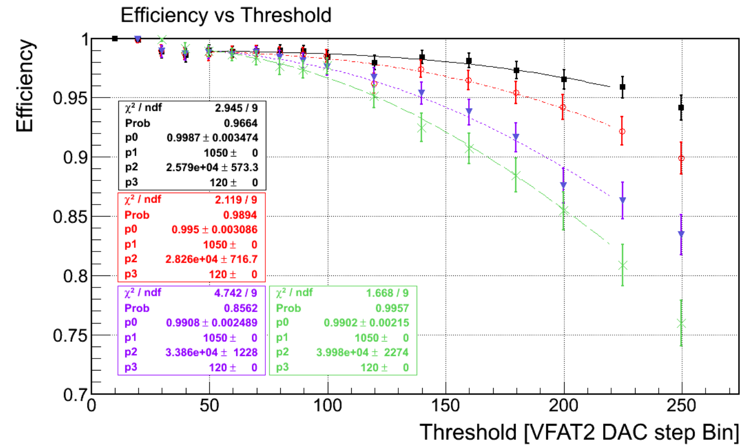


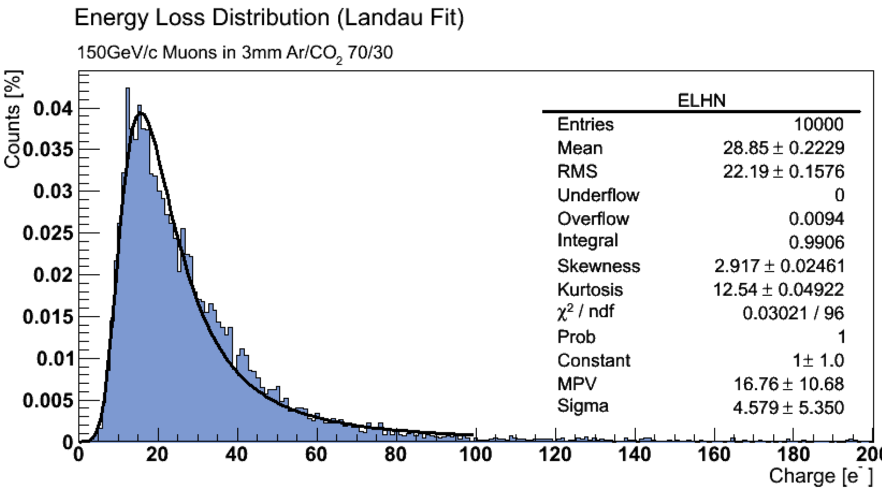
Ar-CO2-CF4 – High Voltage scan



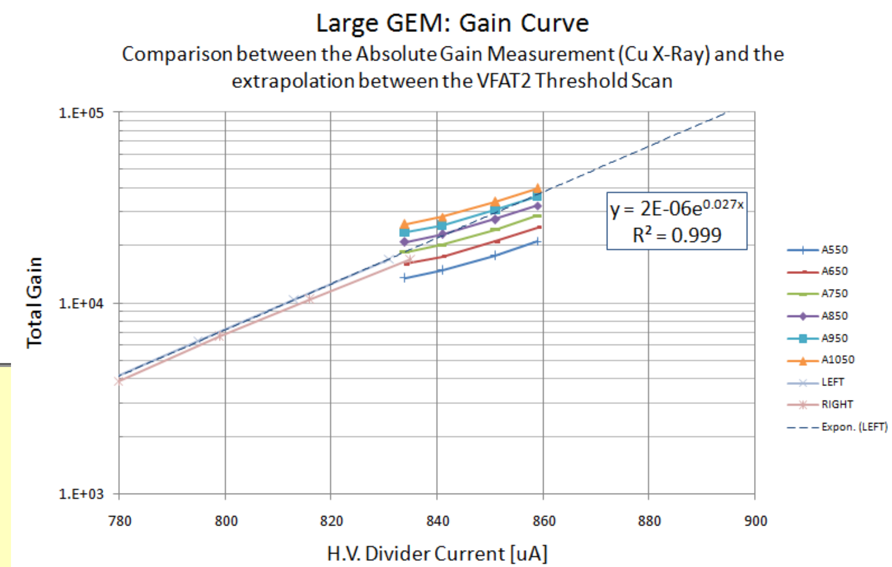
In order to get a better detector in time resolution, the divider needs to be optimized for a different gas mixture.

VFAT2 Threshold Scan & Gain extrapolation





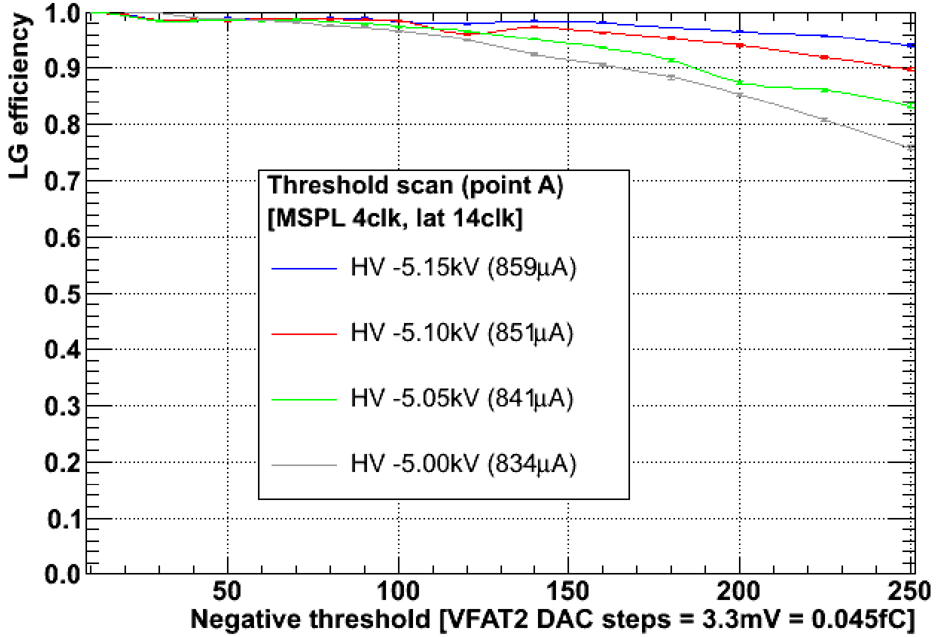
Energy Loss Distribution By Garfield




```
Double_t myIntOfLandau(Double_t *a, Double_t *par)
{

   TF1 *myLandau = new TF1("myLandau","landaun",0,2000);
   myLandau->FixParameter(0,1);
   myLandau->FixParameter(1,16.76);
   myLandau->FixParameter(2,4.579);
   Double_t IntOfLandau = par[0]*(1/myLandau->Integral(0,2000))*myLandau->Integral(par[1]/par[2]*(a[0]+par[3]),2000);
   return IntOfLandau;
}
```

Efficiency vs VFAT2 Threshold

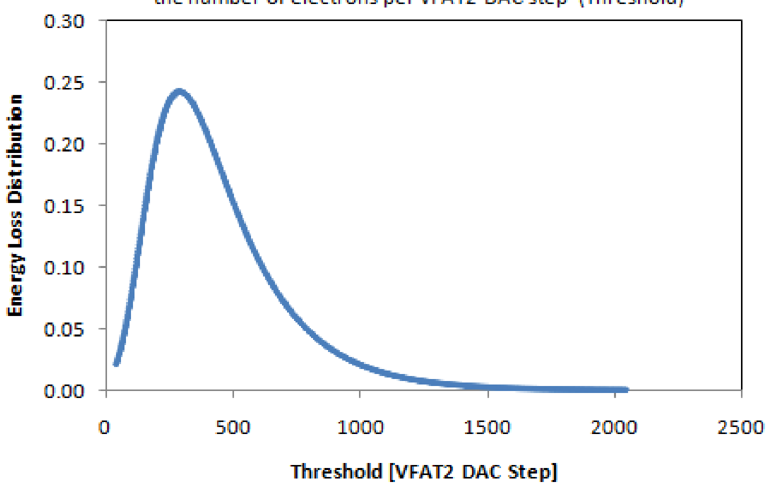


The prototype is still efficient at high threshold. It may be developed for use in noisy environments

Data fitted according to the **Energy Loss Distribution**, the detector **gain** and the **number of electrons** per VFAT2 DAC step

Energy Loss Distribution

Expressed as: Energy Loss times the GEMs Total Gain and divided by the number of electrons per VFAT2 DAC step (Threshold)



Efficiency: Threshold Scan