RD51 GEM Telescope:

results from June 2010 test beam and work in progress

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on behalf of CERN GDD group
and Siena/PISA INFN group

Outline

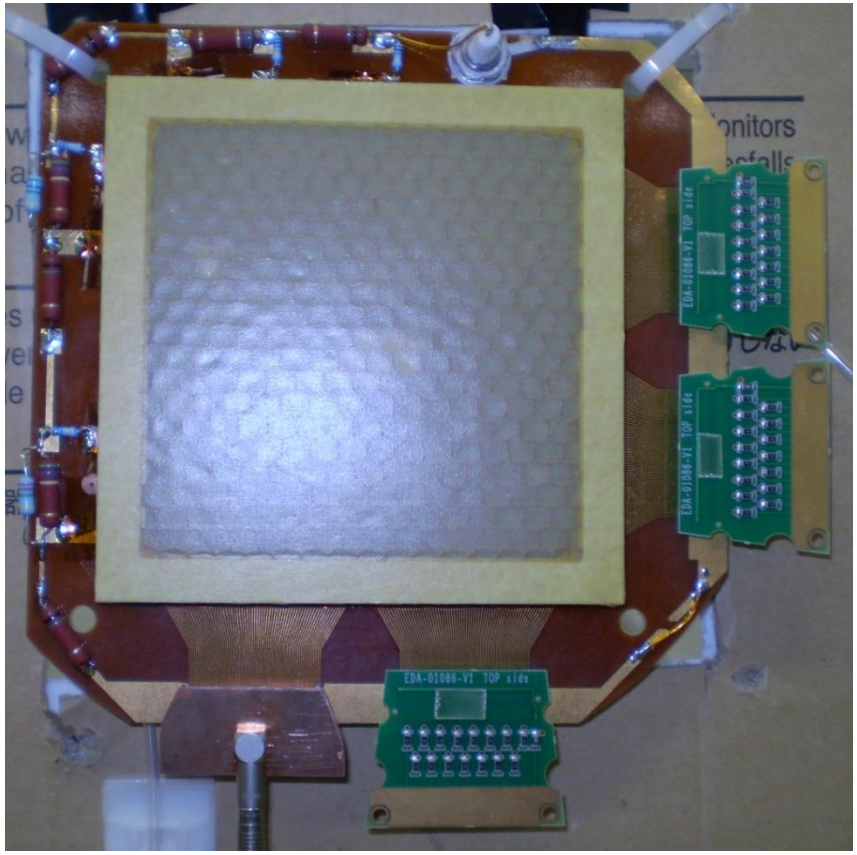
- Overview
- GEM tracking chambers details
- Electronics and DAQ
- Results from June 2010 test beam
- Synchronizing two different DAQs and other ongoing improvements
- Conclusions and future plans

CERN experimental table

- Mechanics with 5 movable supports mounted over rails.
- GEM telescope and MICROMEGAS telescope (both with 3 X-Y stations)
- Trigger scintillators (triple coincidence)
- Table with wheels and possibility to rotate in the "cosmic ray stand" position

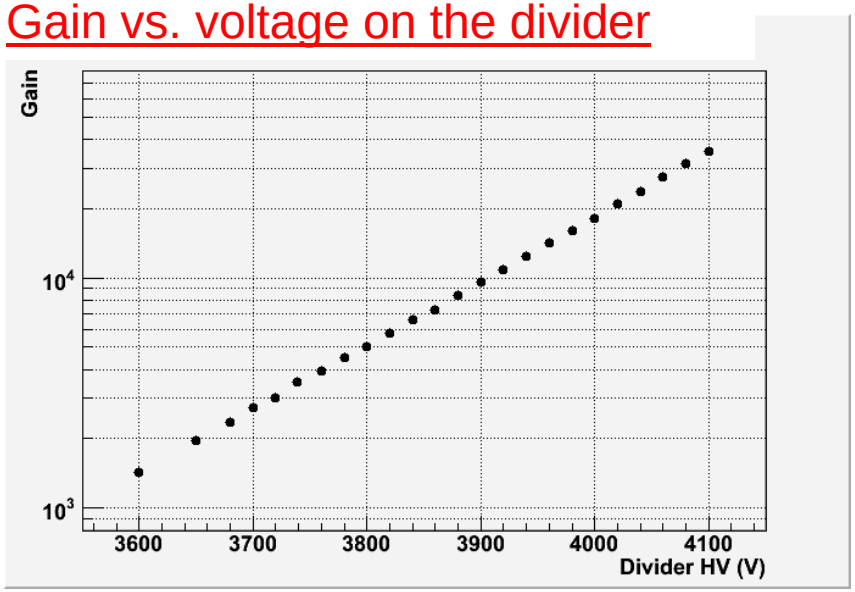
Triple GEM tracking chamber

- Active area: 10 x 10 cm^2
- "COMPASS" X-Y strip readout, with ~ 0.4 mm pitch
- Sealed Triple GEM detector with a compact design:
  - HV divider: only 1 HV channel
  - Ar/CO_2 70%/30% cheap premix

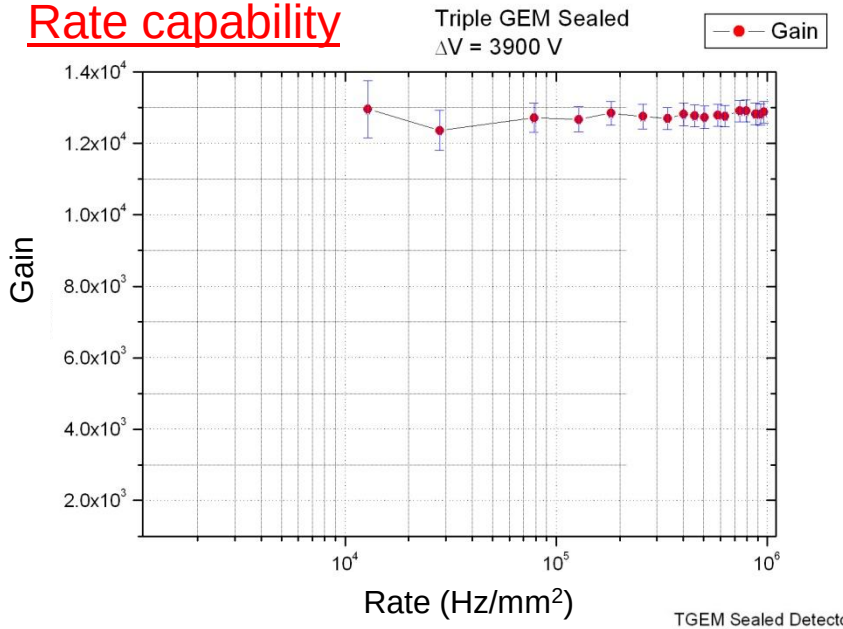


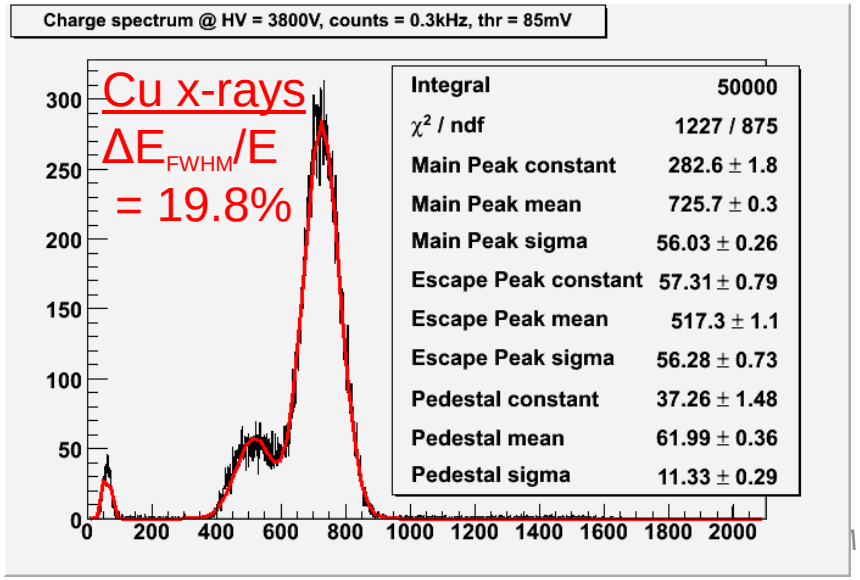
GEM Tracker characterization

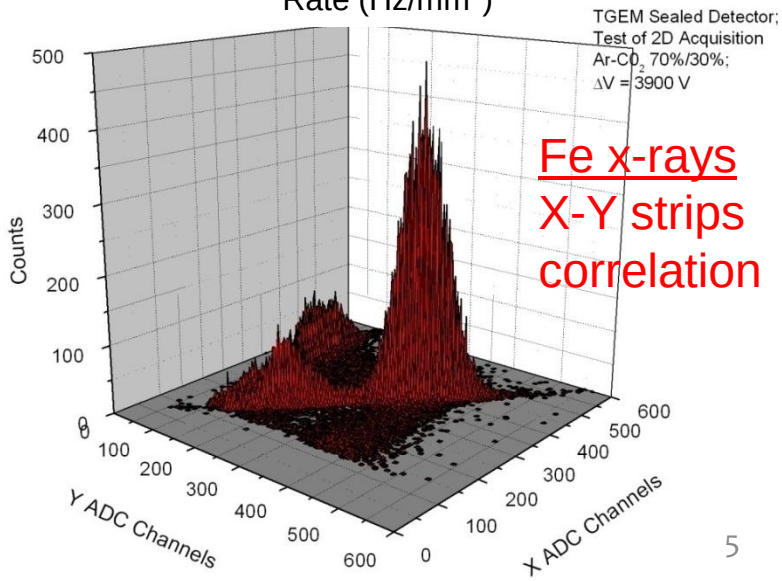
Gain vs. voltage on the divider



Rate capability



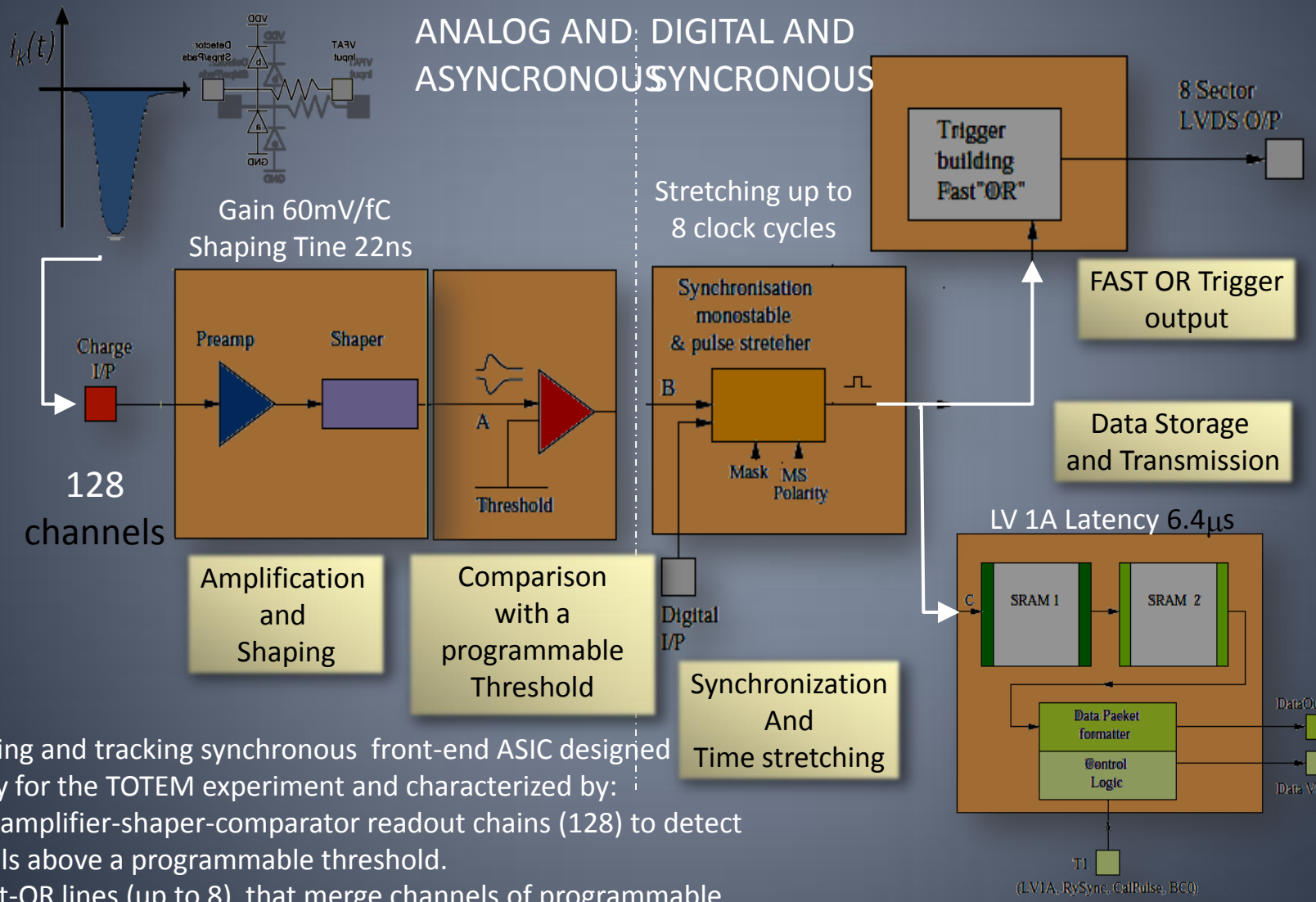




Electronics and DAQ

- VFAT2 front-end electronics
- Readout board "TURBO" developed by Siena and PISA INFN
- Some slides from E. Oliveri.. (and a special thank to him for the support in the beam!!)

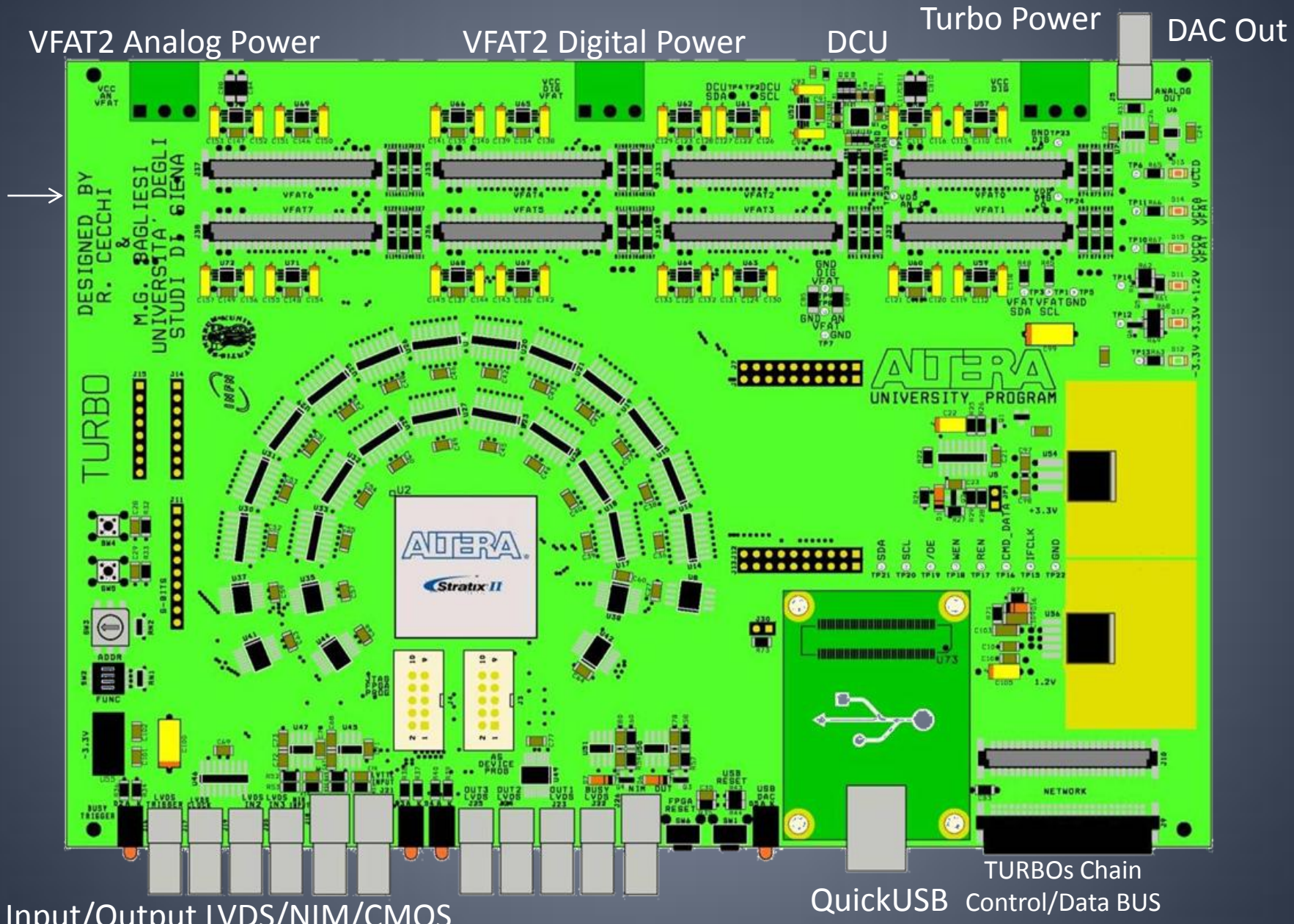
The readout chip: VFAT2



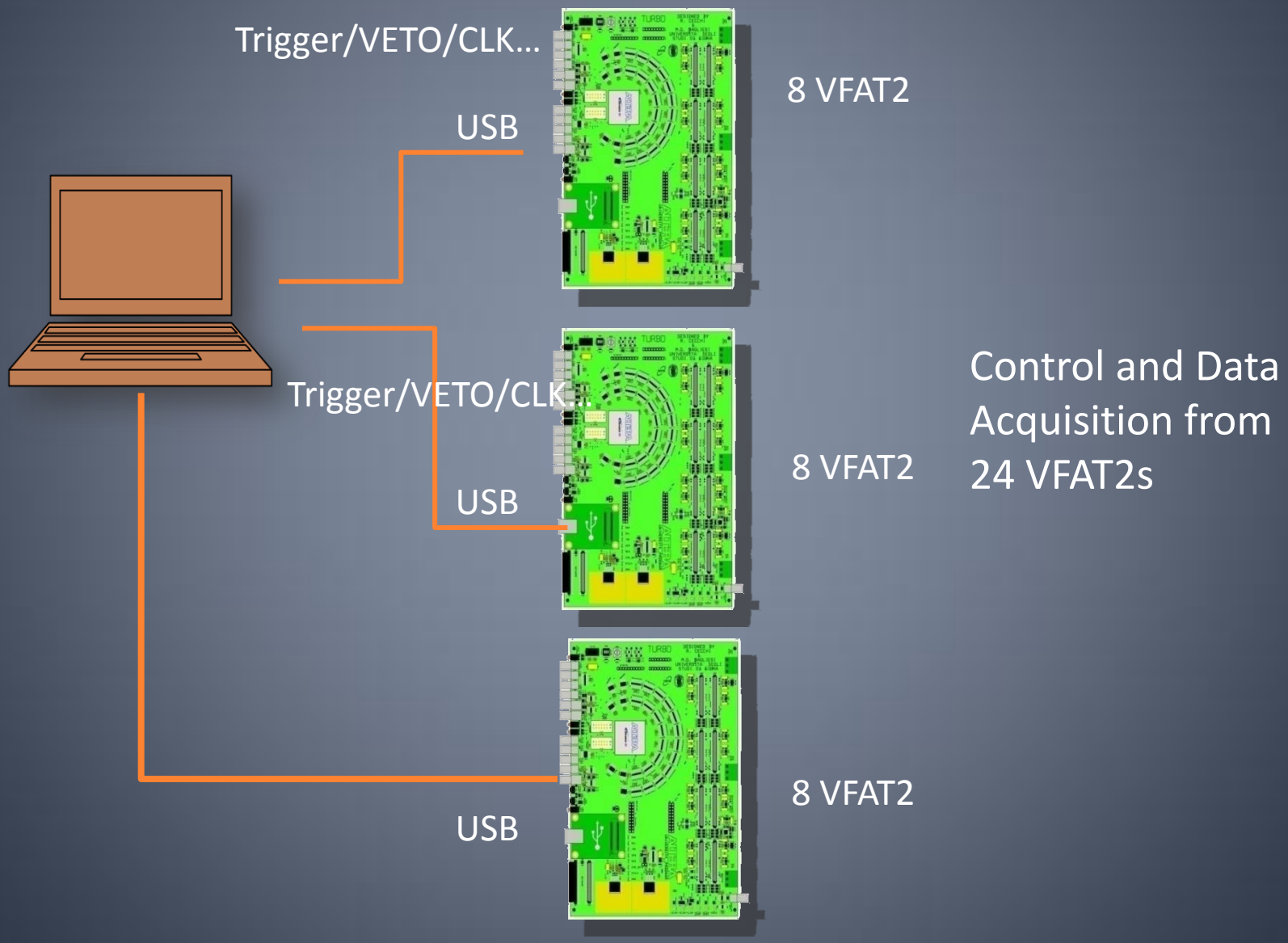
Triggering and tracking synchronous front-end ASIC designed primary for the TOTEM experiment and characterized by:

- 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.

TURBO


VFAT2 Analog Power
VFAT2 Digital Power
DCU
Turbo Power
DAC Out
8 x VFAT2
Input/Output LVDS/NIM/CMOS
(clk, trigger,…..)
QuickUSB
TURBOs Chain
Control/Data BUS

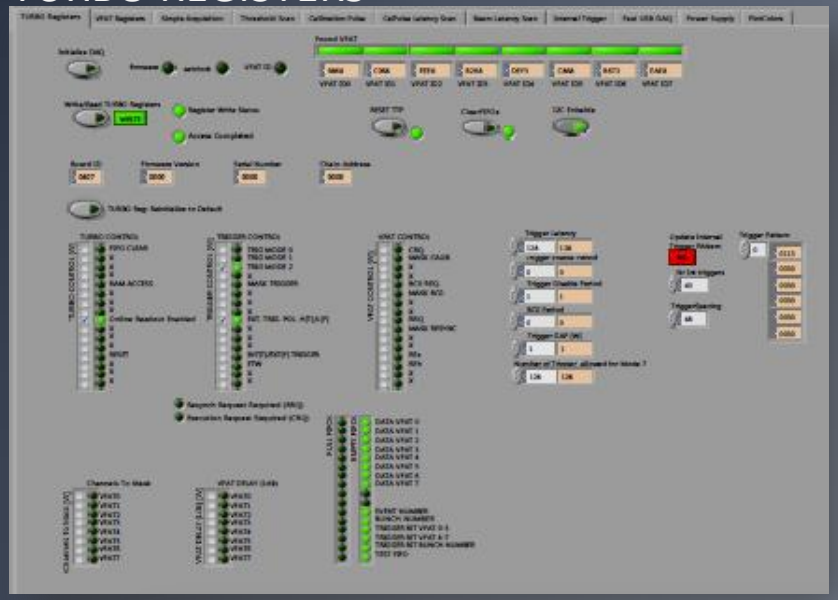
RD51 June TB Set Up



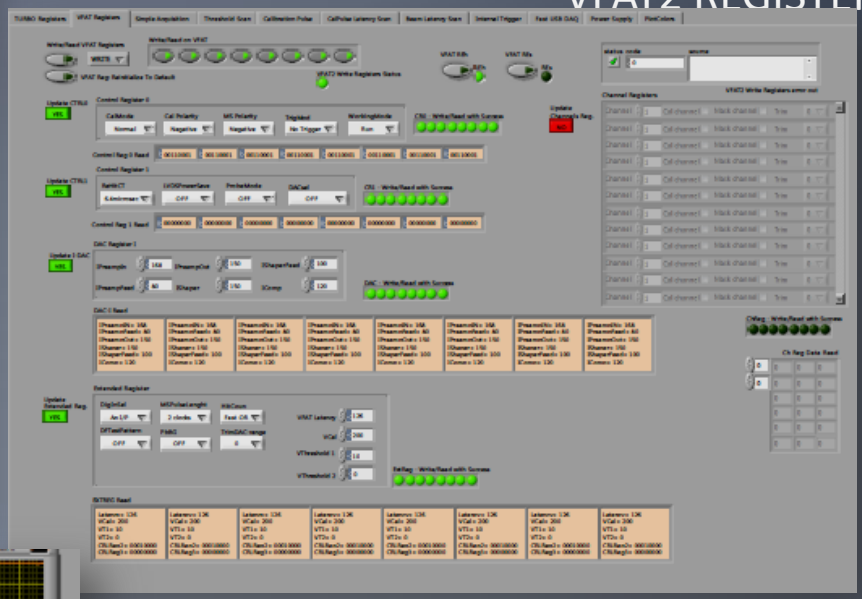
Control and Data Acquisition from 24 VFAT2s

TURBO/VFAT2 CONTROL and DAQ with LabVIEW

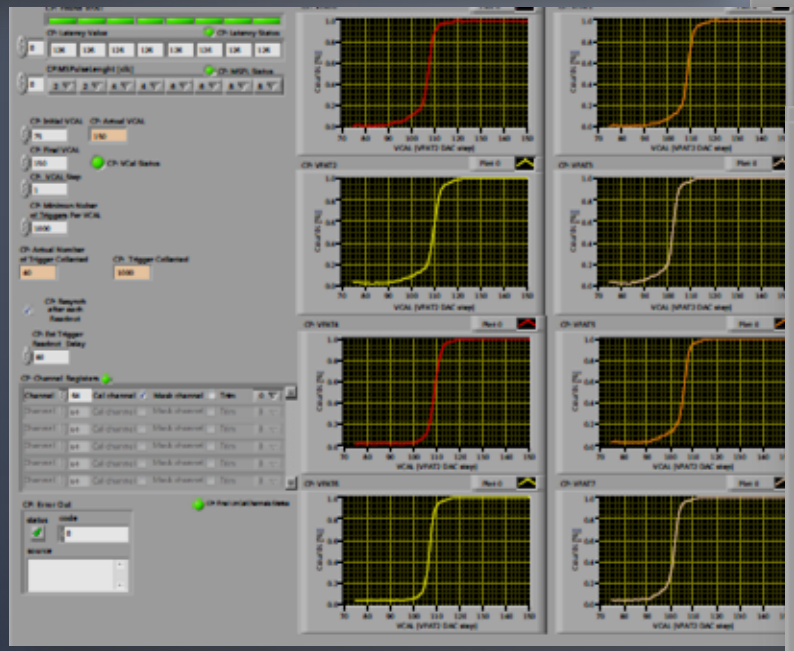
TURBO REGISTERS



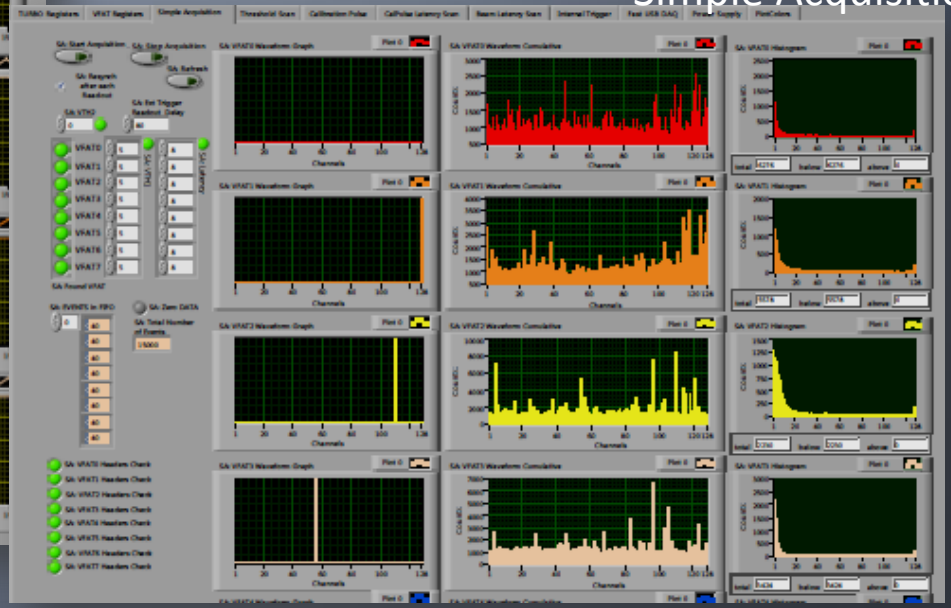
VFAT2 REGISTERS



Calibration Pulse Scan



Simple Acquisition

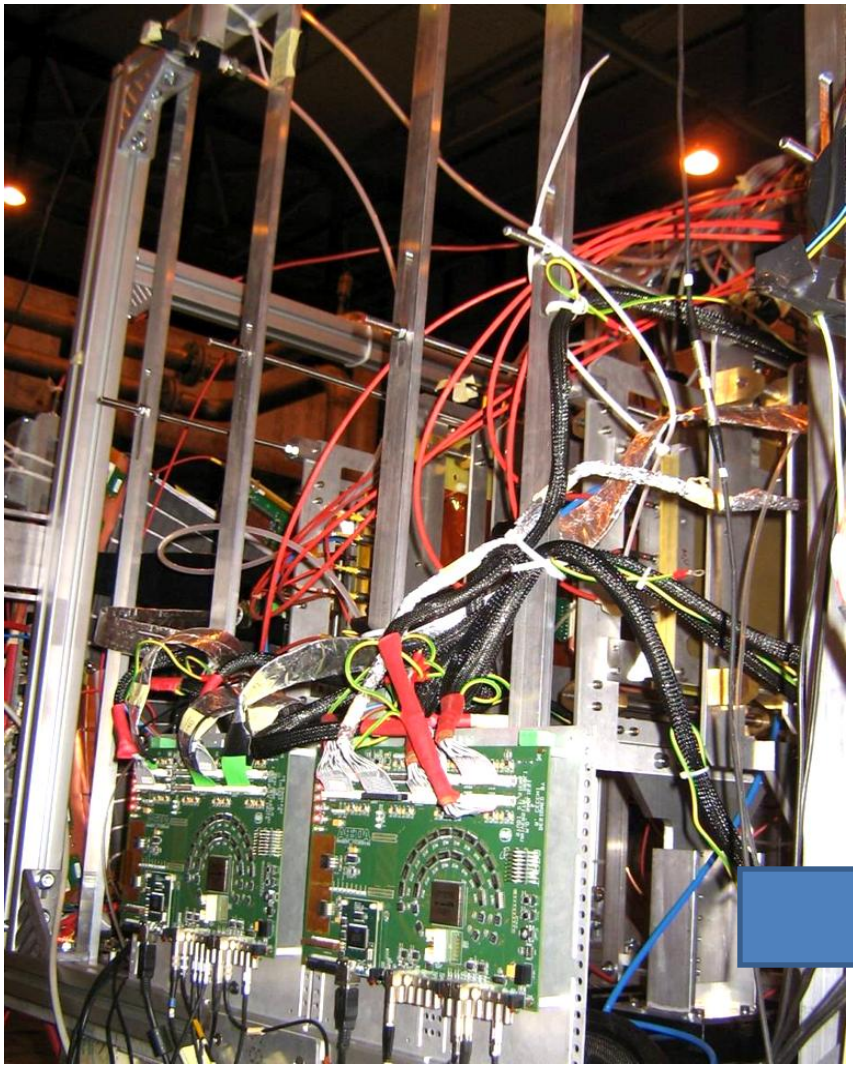


etc. etc. etc……

Results from the test beam

Test beam performed together with CMS MPGD group, which used tracks information for their devices under test.

Test beam setup in June 2010

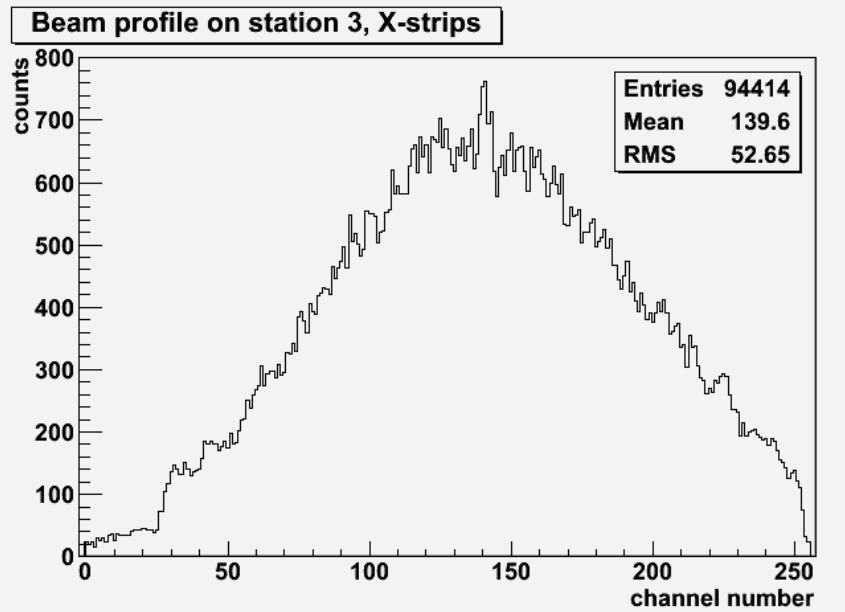


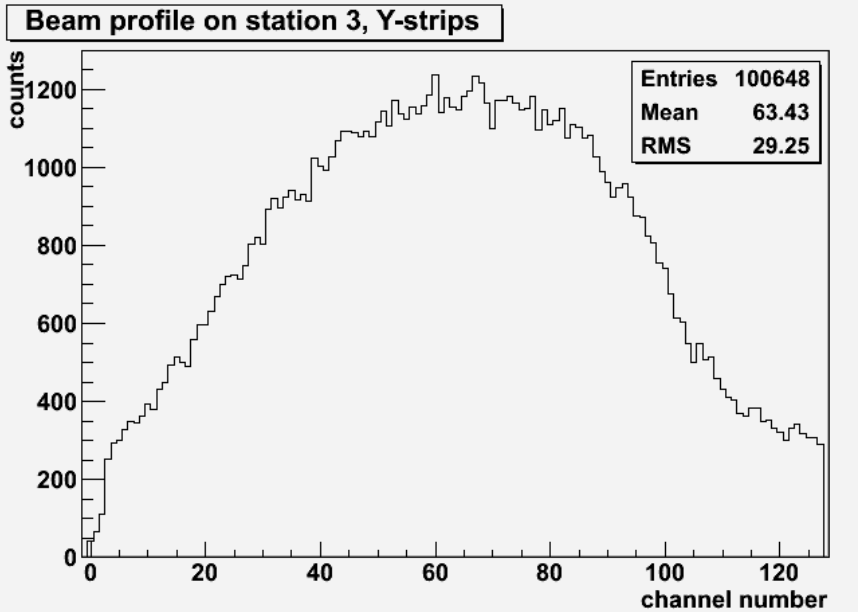
ROOT reconstructed data ("clusters" and "tracks")

ROOT raw data ("hits")

Binary raw data file

Raw data “hits”





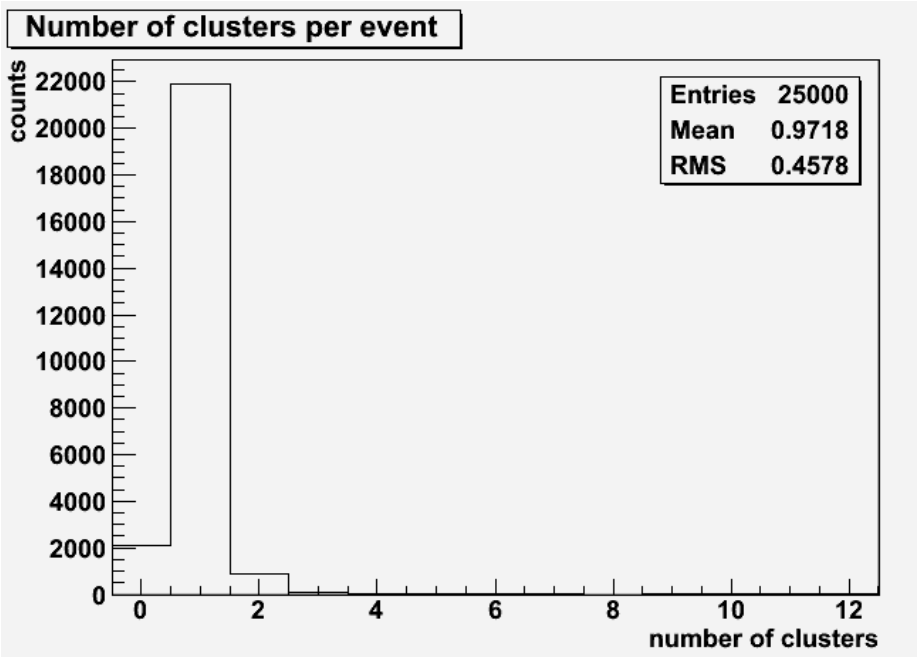
In June tracking chambers were 75% equipped, with:

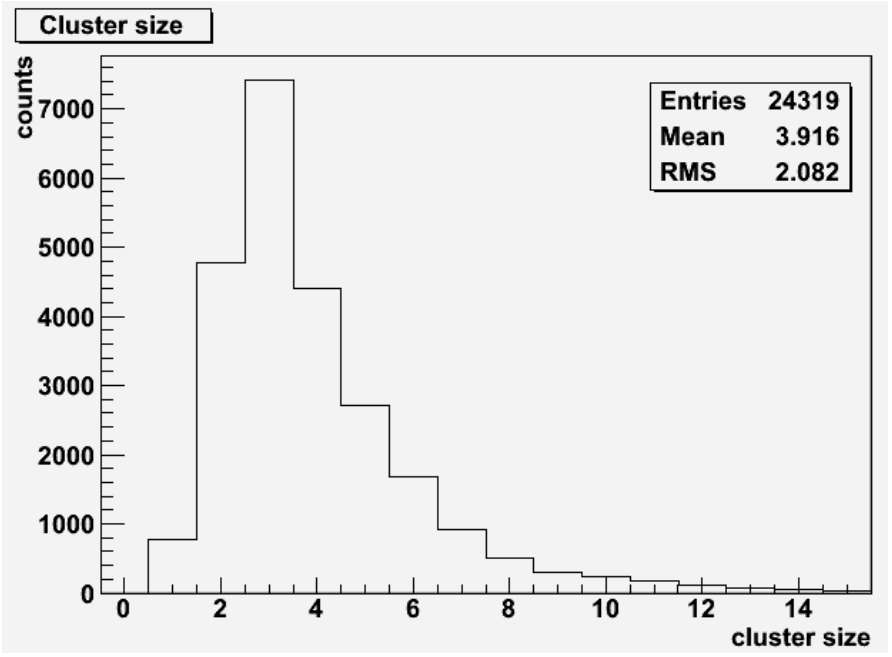
- 2 VFATs on the (vertical) X-strips, i.e. 256 channels over 10 cm
- only 1 on the (horizontal) Y-strips, i.e. 128 channels over 5cm.

The noise level with fully equipped detectors was in fact higher and, taking into account the beam size, decision was taken to postpone the investigation of the proper grounding and shielding.

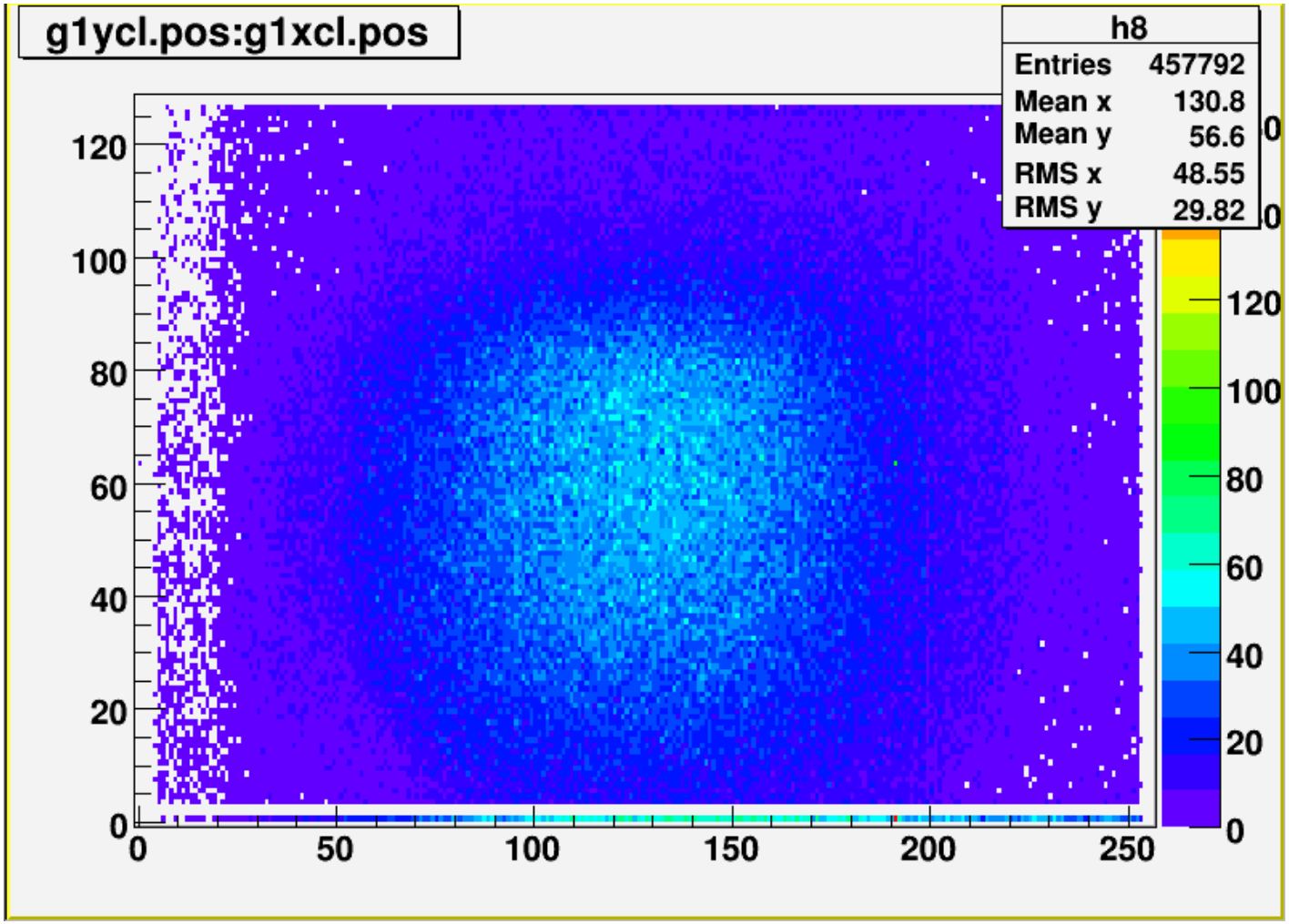
Clustering algorithm

- Neighbouring (with one channel gap maximum) channels belong to the same cluster.
- Cluster position is the centre of gravity of the included hits



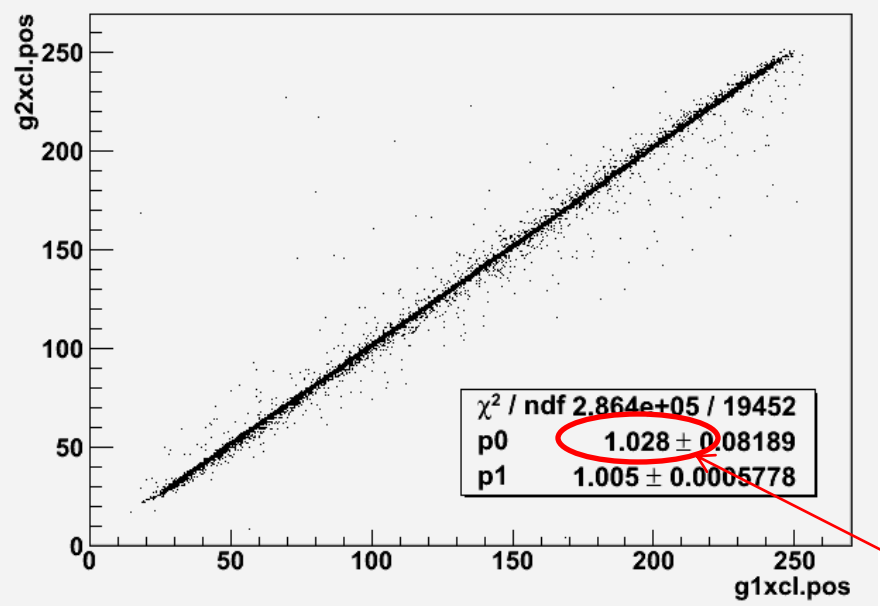


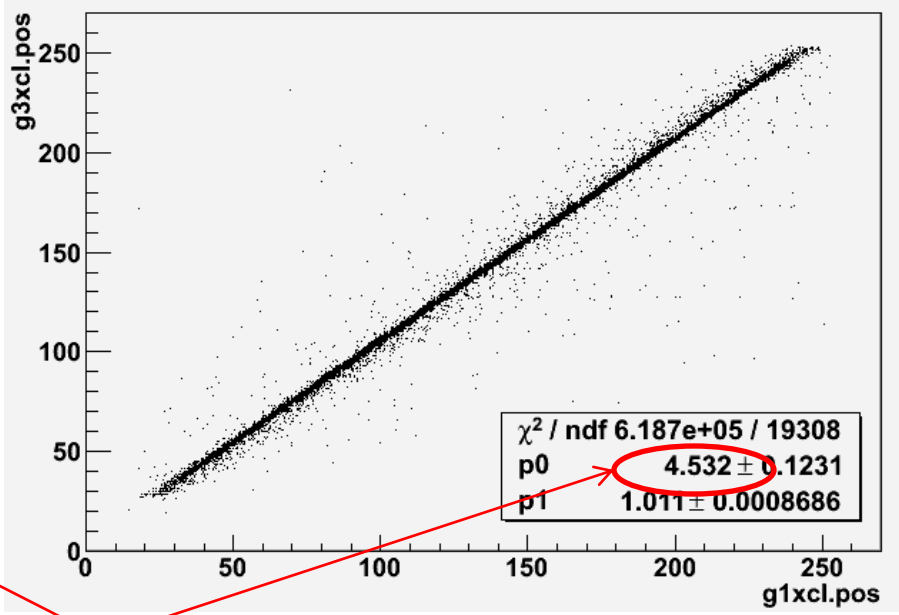
Beam profile



Alignment correction

- Before tracks reconstruction, alignment is corrected with the correlation plots





Misalignment (in strip units) between chambers

Track reconstruction

- Few limitations at the moment:
  - Combinatorial to be implemented (tracks are reconstructed only in the events with one cluster per station)
  - Tracks are reconstructed separately in the "X" projection and the "Y" projection

→ Tracks information available around 80% of the events

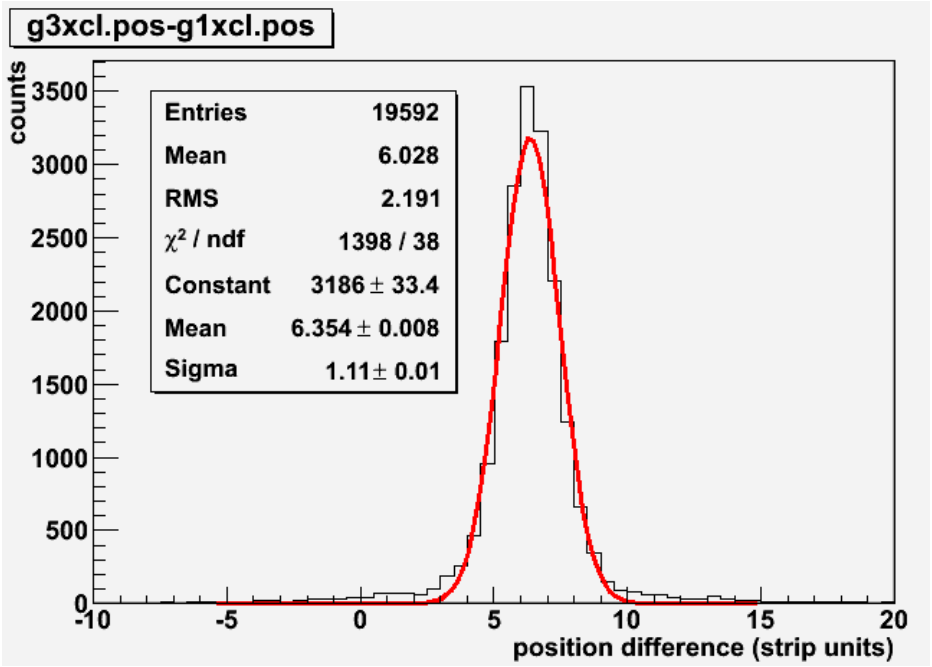
Spatial resolution

- Only 3 stations → a preliminary information can obtained from the broadening of the cluster position difference between two stations

- Assuming two identical devices:

$\sqrt{(2\sigma^2)} = 1.11$ 0.4 mm

→ σ ~ 300μm
(preliminary result!)



Future plans

- Synchronizing two different DAQs
- Other ongoing work

More DAQs synchronization

Very hard to find an universal solution, so we propose a reasonable strategy that could work over a large number of cases:

- Each DAQ must be able to VETO the trigger (on the common NIM coincidence unit!!!), for example when it busy or not running
- Each DAQ must implement a reliable trigger counter, which can be reset at the beginning of the run
- Separate datafiles can be merged again by a proper event builder

Other ongoing work

- Event builder: new raw data "hits" ROOT file with a "zero suppressed" format (to reduce file size)
- Generalization of the algorithm for any readout shape (useful for the TOTEM wedge-shaped chamber in August)
- Clustering algorithm for analog readout (in case of APV chip in October)
- Track reconstruction improvements
- All algorithms in a small "software framework"

Conclusion

- The GEM telescope is a good instrument for RD51 groups that need track information
- DAQ with digital VFAT2 readout is ready and improvement are ongoing
- Minimal analysis software is ready and further developments are ongoing
- A priority for the next test beam is the integration with different DAQs

Backup