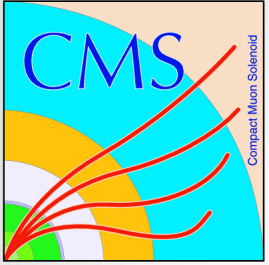




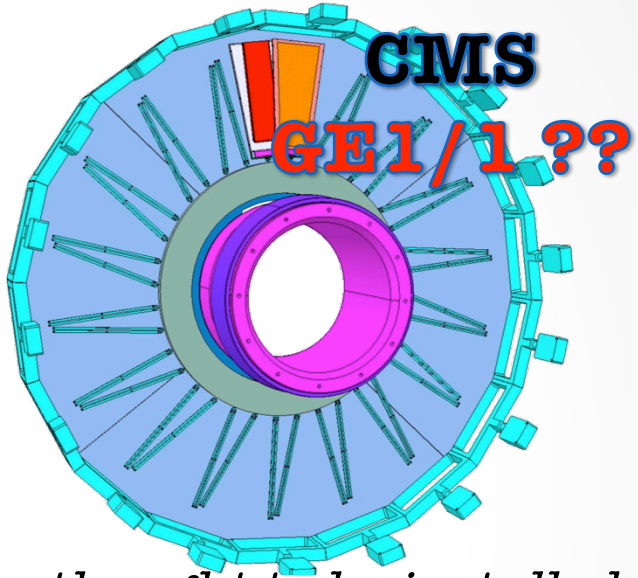
# Status and plans CMS-GEM group

Stefano Colafranceschi
for the GEM Collaboration (GEMs for CMS)

*RD51 mini-week 21-23 Nov 2011*
*CERN*

# Introduction

The Forward Muon RPC trigger system is equipped with detectors at $\eta < 1.6$, then high-$\eta$ region of CMS is presently vacant and presents an opportunity to instrument it with a detector technology that could sustain the environment and be suitable for operation at the LHC and its future upgrades.




*CMS_GE1/1 is a Triple-GEM based detector thought to be installed in the CMS Endcap high-eta area.*

**Combine triggering and tracking functions**

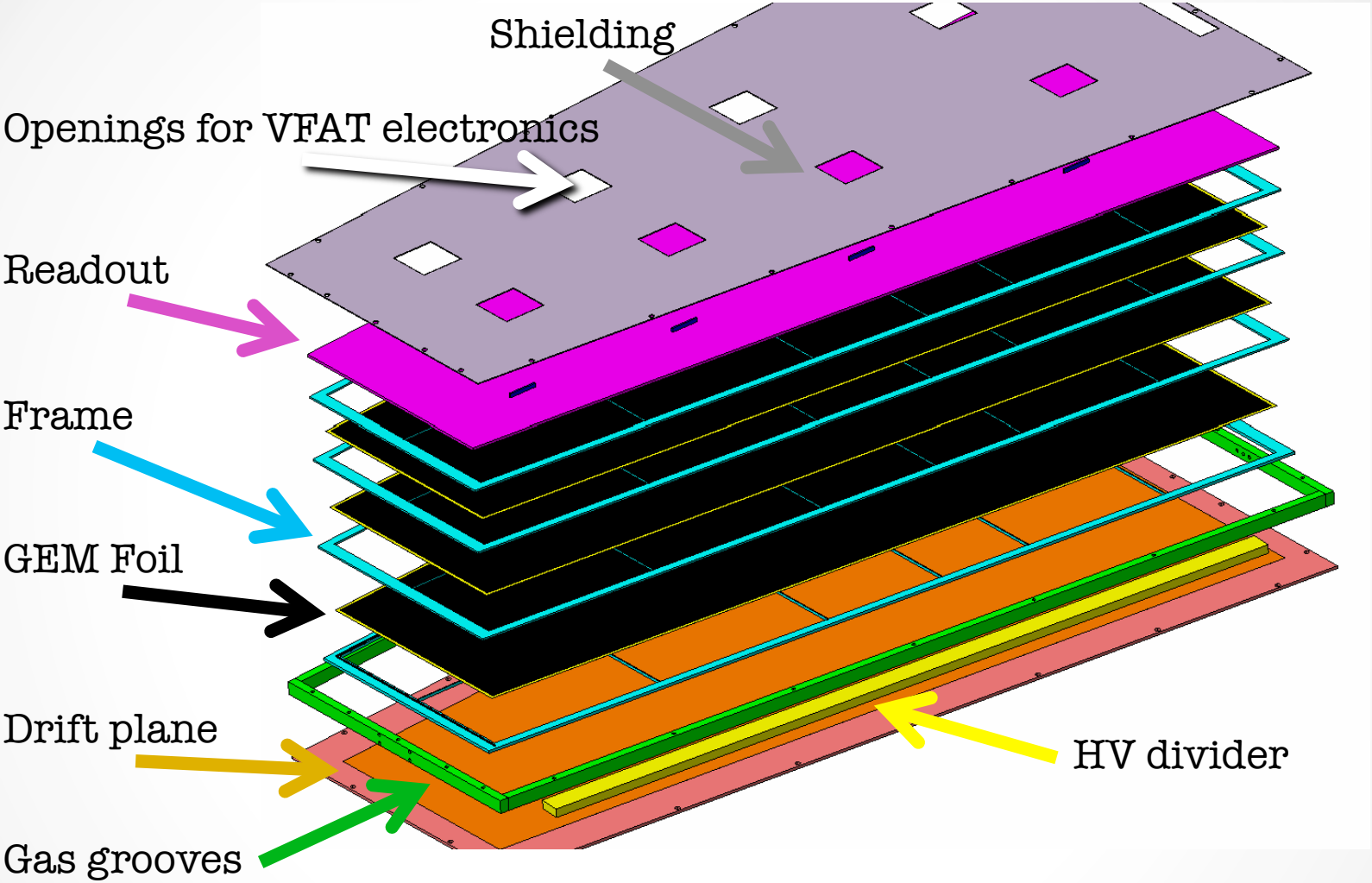
**Enhance and optimize the readout ($\eta$-$\phi$) granularity by improved rate capability $10^5/mm^2$**

**Spatial/Time resolution: ~ 100 μm / ~ 4-5 ns**
**Efficiency > 98%**

**Gas Mixture: Ar/$CO_2$ (non flammable)**
**Potential for going to large areas ~ 1m x 2 with**
**Industrial processes (cost effective)**

**Long term (10 years) operation experience in Compass and LHCb at CERN**
**Large margins of operation at full efficiency**

# The proposed CMS_GE1/1 detector




So far, in 2010 and 2011 we have successfully built and tested this prototype!

# Test beam 2011 motivations

- Evaluate performance of small and full-scale GEM based prototypes in muon and pion beams.
  - Comparison between single mask and standard double mask foils
  - Performance in intense magnetic field (3T)
  - Gas Studies (time and space resolution..)
  - Noise studies
  - New readout system (RD51 SRS)

# Building/testing prototypes…

## Small-prototypes

**CMS_timing_GEM: Standard double mask 10x10cm² 1D readout (3/1-2/2/1-2); 256 channels**

**SingleMaskGEM: Single Mask 10x10cm² 2D readout (3/2/2/2) 512 channels**

**CMS_Proto_III Single Mask 10x10cm² [N2] (3/1/2/1); 256 channels** 2011

**Korean_I Double Mask 7x7cm² (3/2/2/2); 256 channels** 2011

**CMS_Proto_IV Single Mask 30x30cm² [N2] (3/1/2/1); 256 channels** 2011

## Full-scale prototypes

**GE1/1_I: Single mask 990 x (440-220)cm² 1D readout (3/2/2/2); 1024 channels**

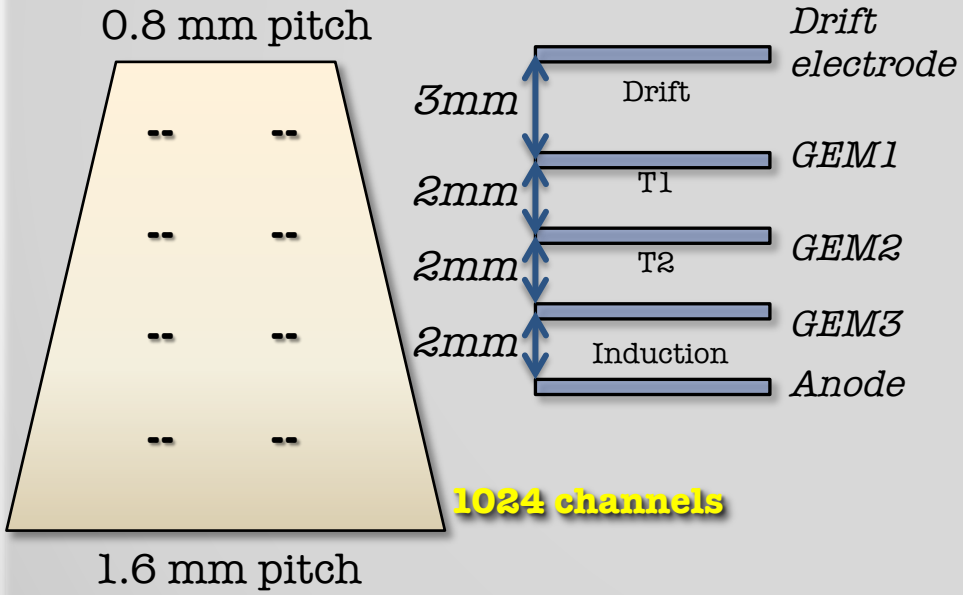
**GE1/1_II: Single mask 990 x (440-220)cm² 1D readout (3/1/2/1); 3072 channels** 2011

# Our full-scale prototype **GE1/1_I** & **GE1/1_II**

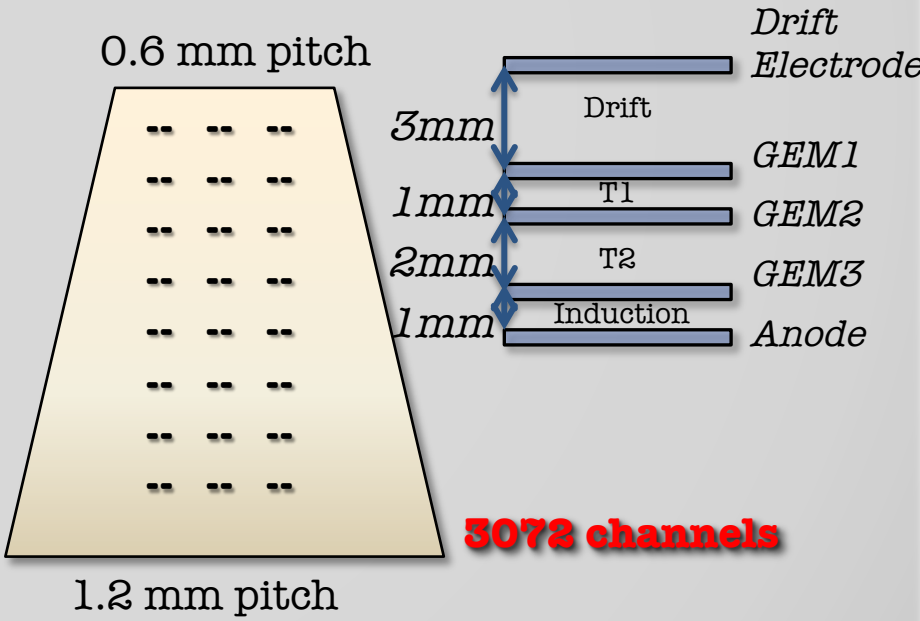
Ge1/1_I and Ge1/1_II

Single mask technique
1D read-out
GEMs active areas: 990 mm x (220-445) mm
Gas mixtures: $Ar/CO_2$ (70:30, 90:10) or $Ar/CO_2/CF_4$ (45:15:40, 60:20:20)
Gas flow: 5 l/h

## Ge1/1_I (2010)




## Ge1/1_II (2011)



# 2011 Test Beam campaigns summary

- June – July 2011

*CMS_timing_GEM, GE1/1_I, GE1/1_II*

- Efficiency, time resolution, space resolution with and without magnetic field

- August 2011

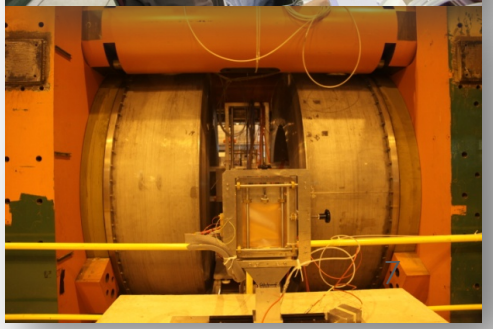
*CMS_timing_GEM, GE1/1_II*

- Testing new electronics (RD51 SRS, APV25)
- Electronics studies with the VFAT2

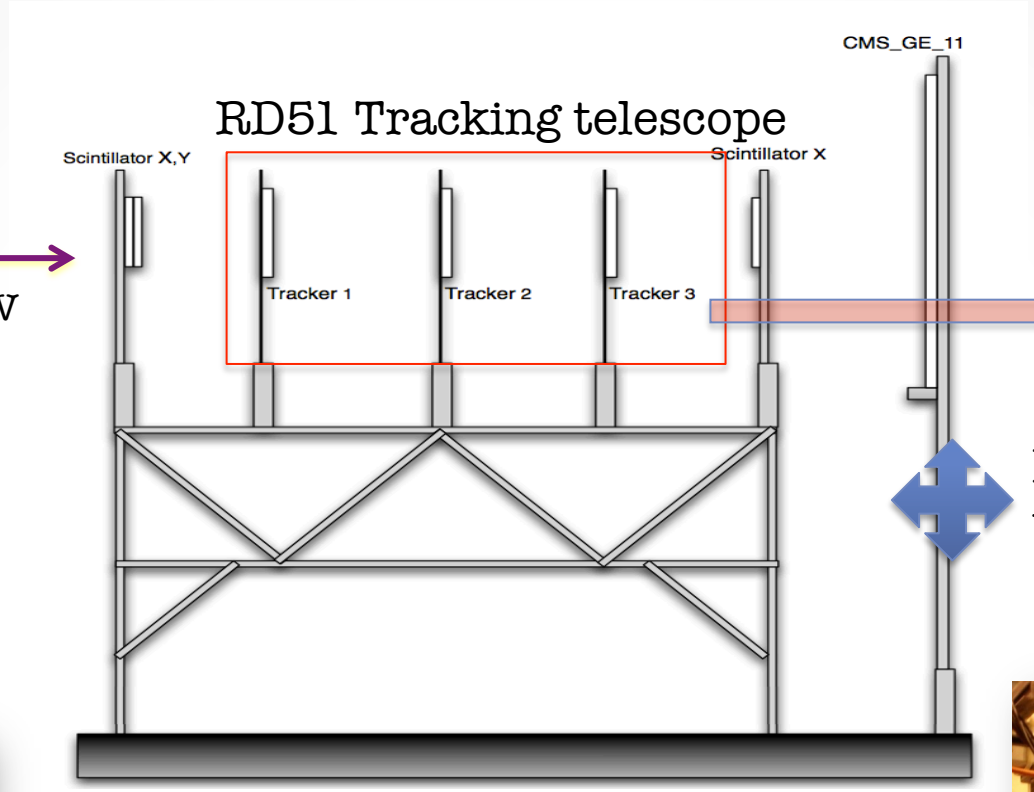
- Septemebr 2011

*CMS_timing_GEM, GE1/1_II*

- Time resolution studies
- Gas studies
- Electronics studies with the VFAT2



# The experimental setup@H4

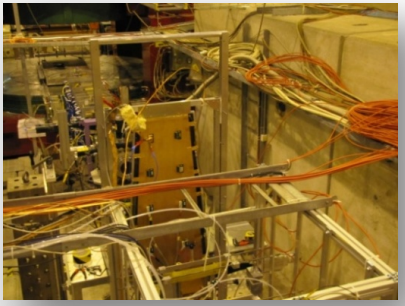


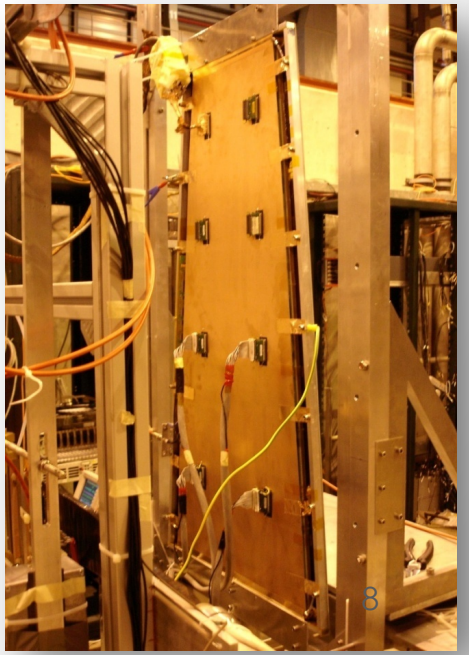

Beam line

Muon/pion 150GeV

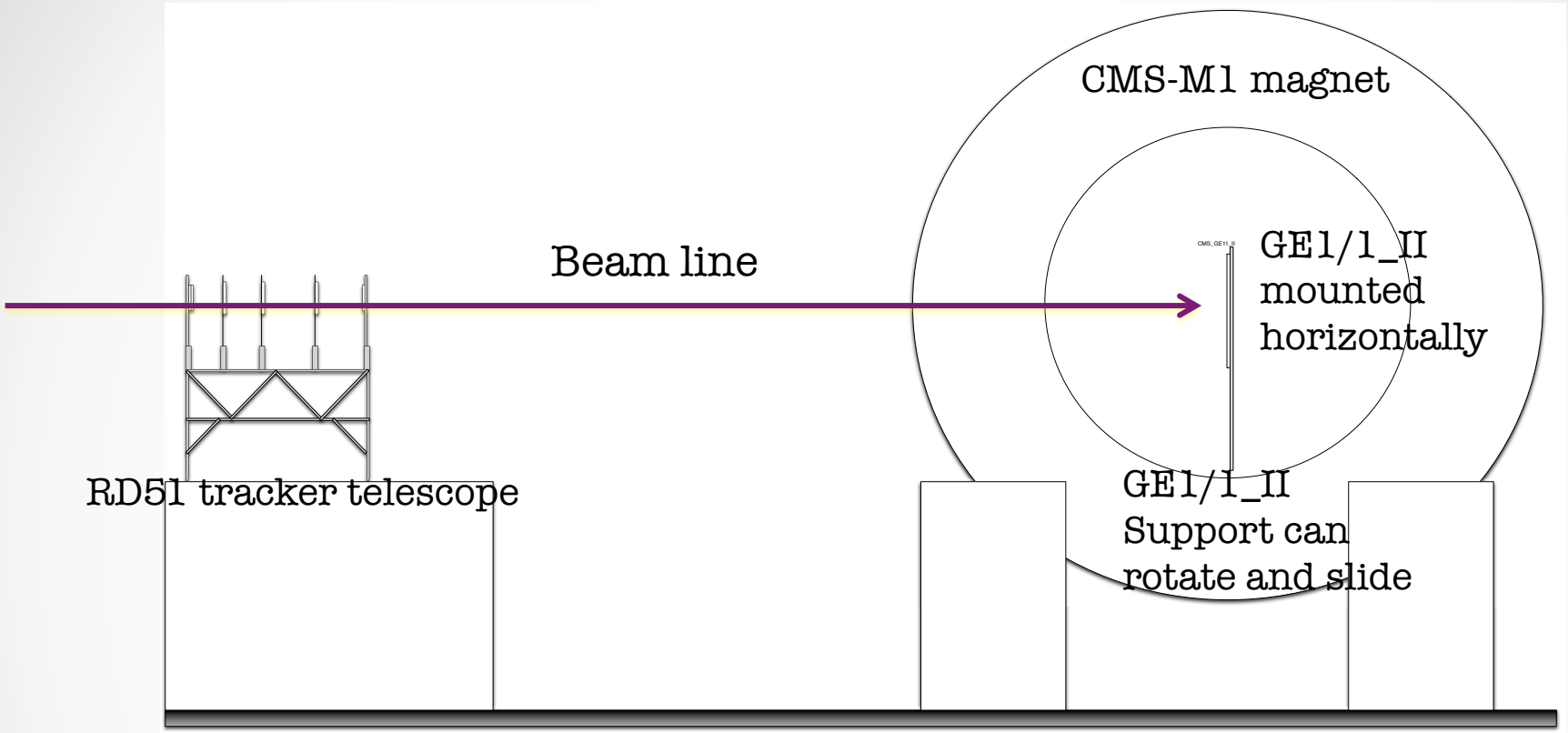
*3 * 10x10cm$^2$*
*standard GEMs*
*2D readout*
*256 channel x,y*
*Strip pitch 0.4mm*

Movable table





# The experimental setup@H2




Full scale prototypes and timing GEM were positioned in Y-Z plane inside the solenoid.

The tracker (3 10x10cms$^2$ standard Triple-GEM detectors and 3 scintilators) were located on the z axis – 5 m before the magnet.

Beam direction along the (-) X axis.

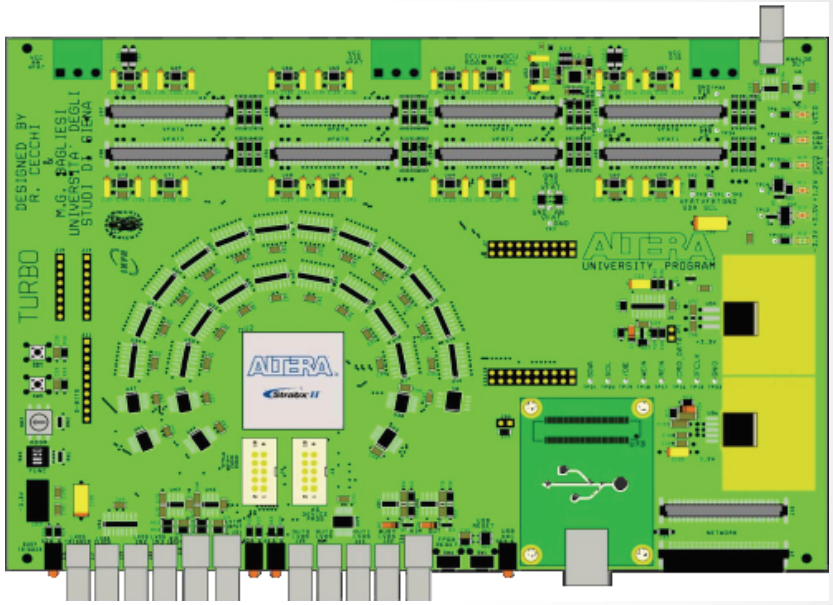
Magnetic field at 800 A = 0.68 T
Magnetic field at 1200 A = 1.0 T
Magnetic field at 2000 A = 1.68 T

Magnetic field higher than 1.68T affects PMTs.

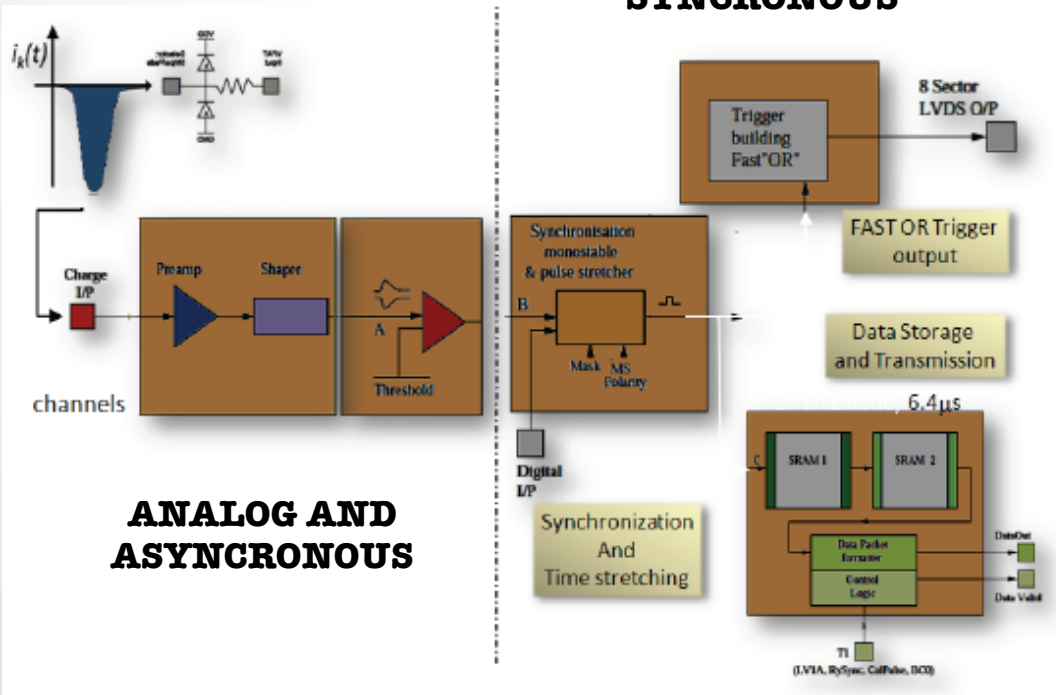
# TURBO and the VFAT2 chip

The VFAT(TOTEM) is a digital on/off chip for tracking and triggering with an adjustable threshold for each of the 128 channels; it uses 0.25μm CMOS technology and its trigger function provides programmable "fast OR" information based on the region of the sensor hit.

**Turbo board layout**




**DIGITAL AND SYNCRONOUS**

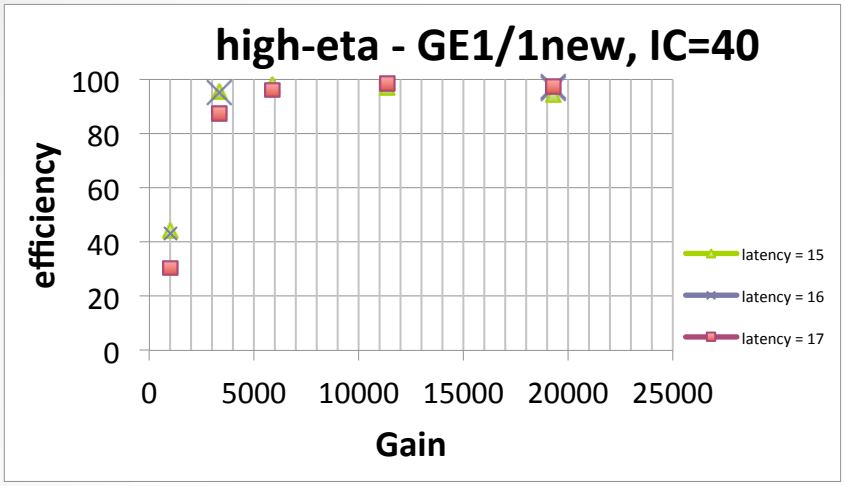


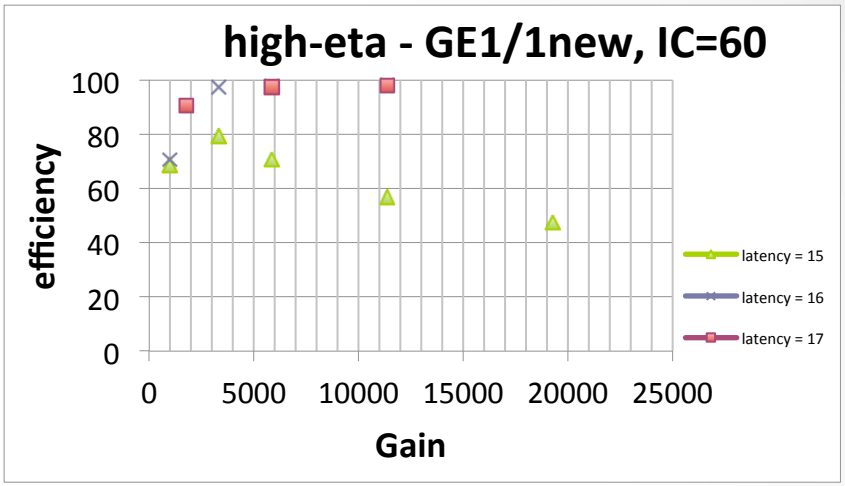

**ANALOG AND ASYNCRONOUS**

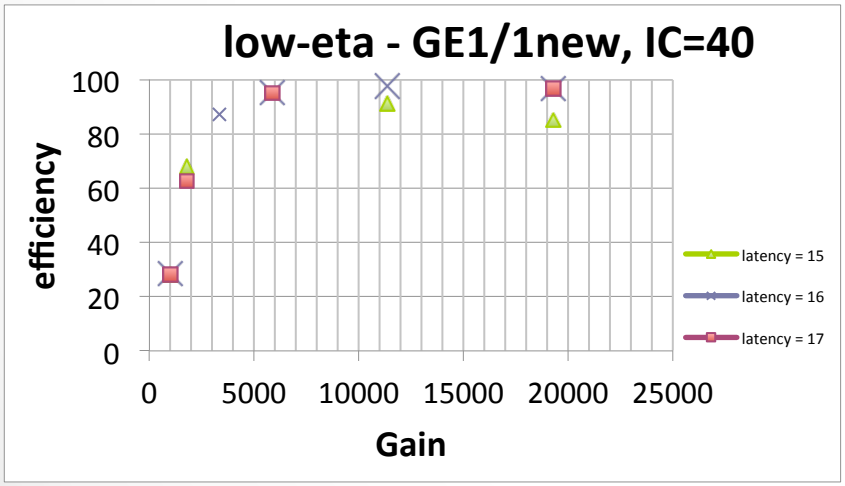
For prototype testing we used electronics developed by INFN (Siena and Pisa), based on the TOTEM VFAT chip.

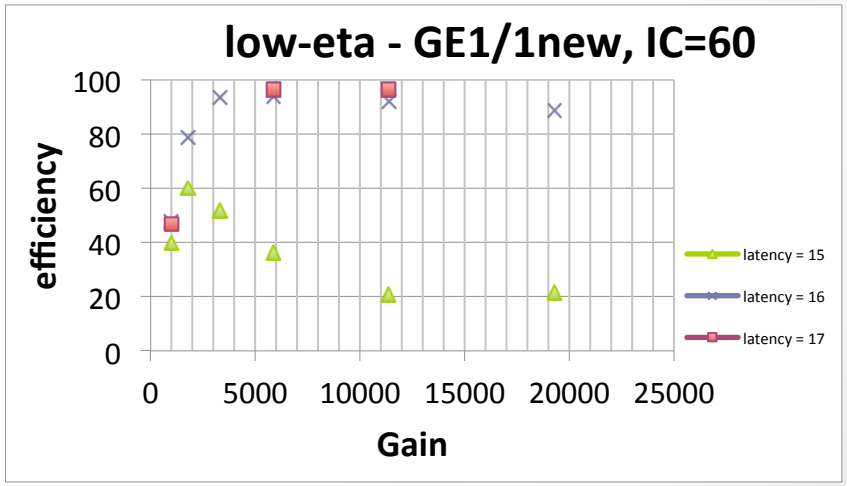
# Efficiency studies along with VFAT2 $I_{comp}$

Fully efficiency is reached at gain ~7000 and VFAT2 threshold=12 for $Ar/CO_2/CF_4$ 45/15/40.

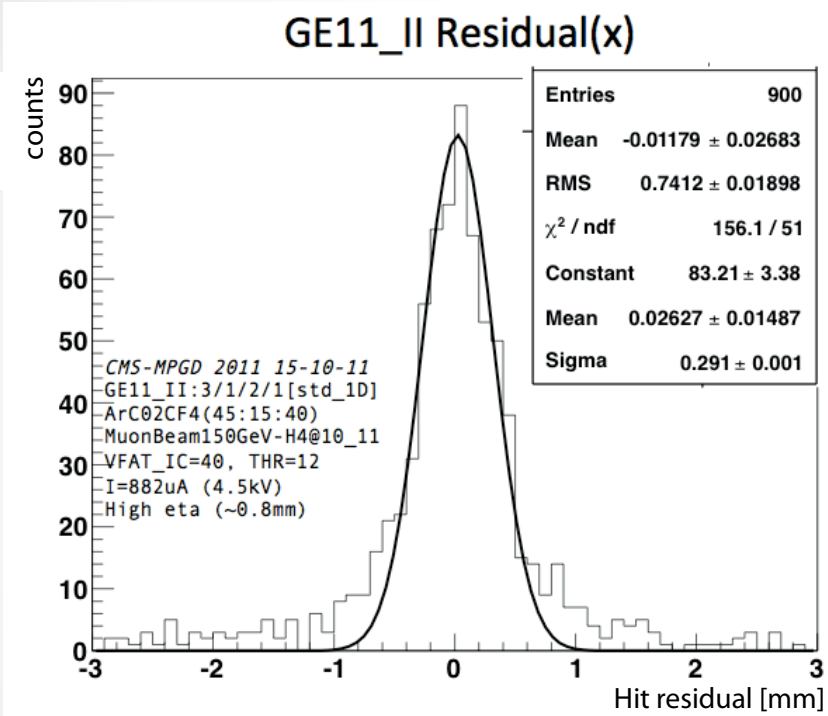


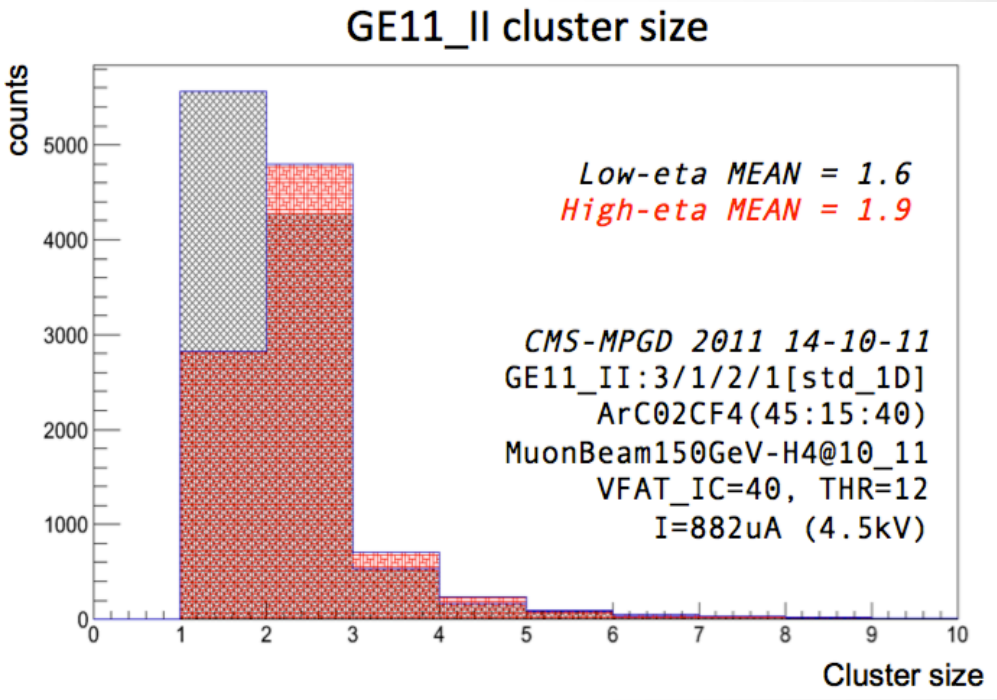



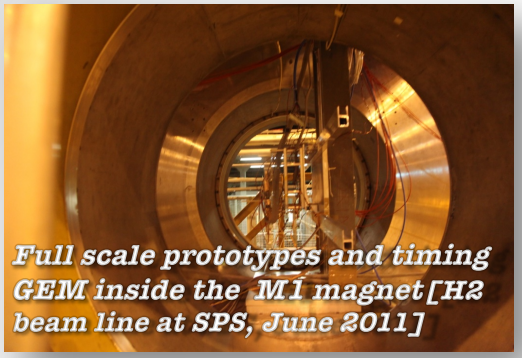
# Space resolution and cluster size

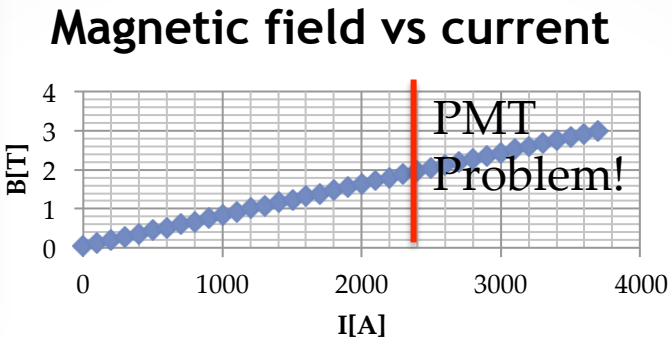


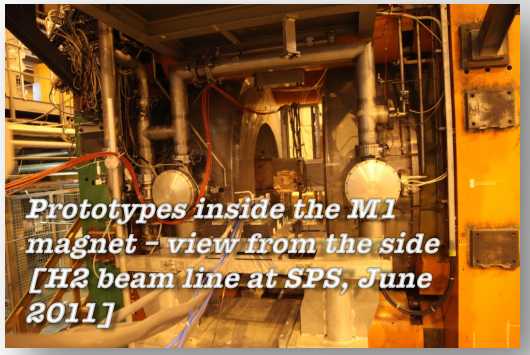



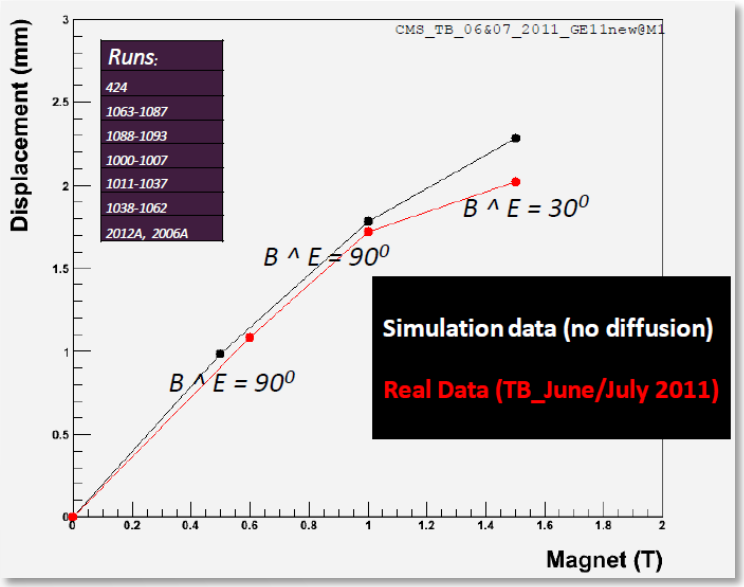

Ge1/1_II behaves excellently with stable, safe and reliable operation!

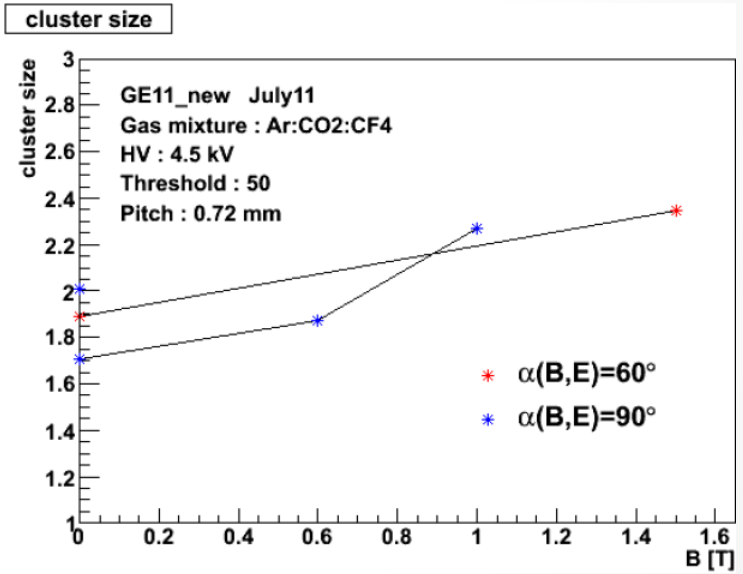
# GE1/1_II in the magnetic field



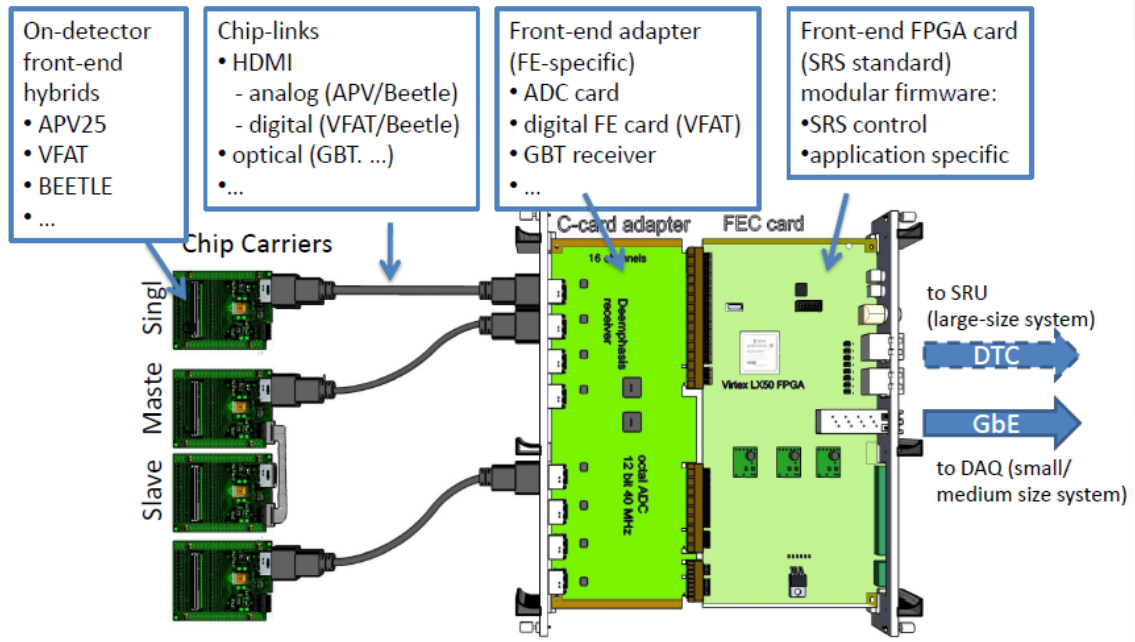



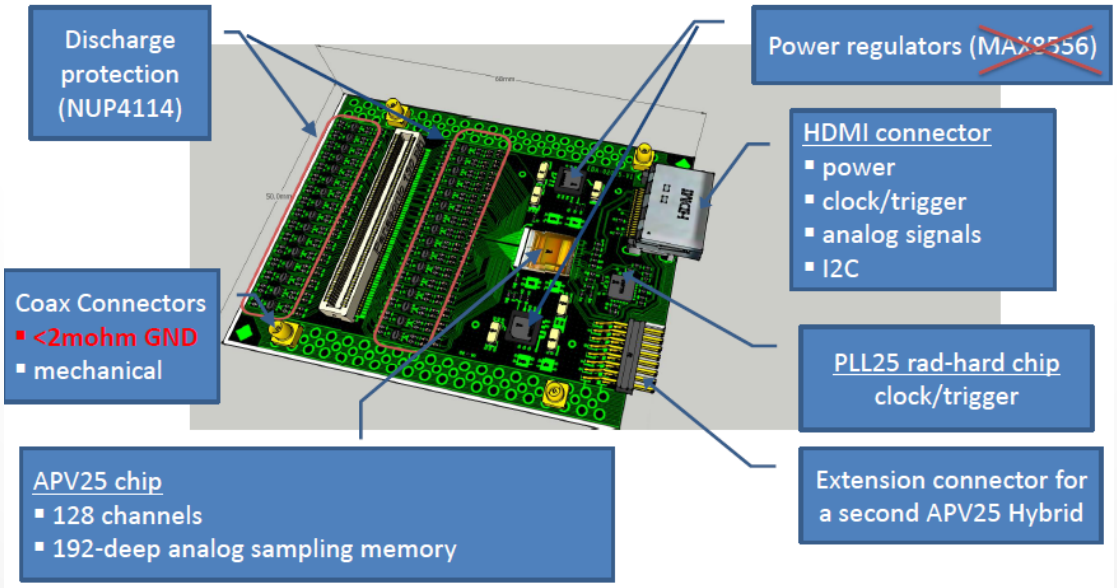



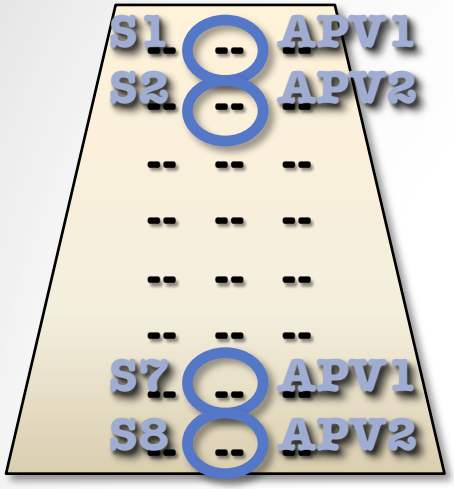

- Displacement due to magnetic field measured at the beam matches with GARFIELD simulations.
- Increasing the magnetic field no clear effect is visible in the cluster size.

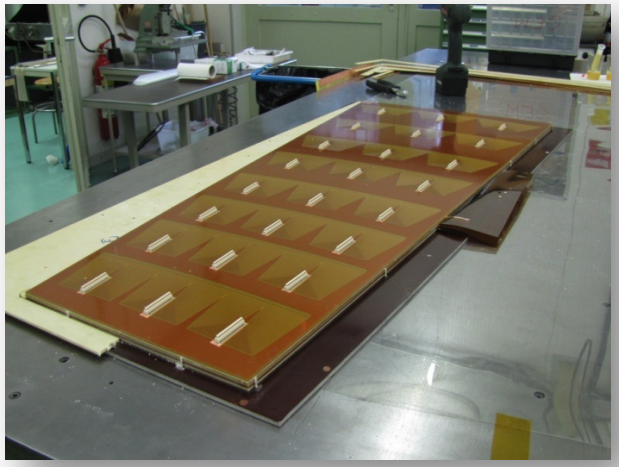
# Scalable Readout System (SRS) and APV25 chip



# Taking data with the APV25



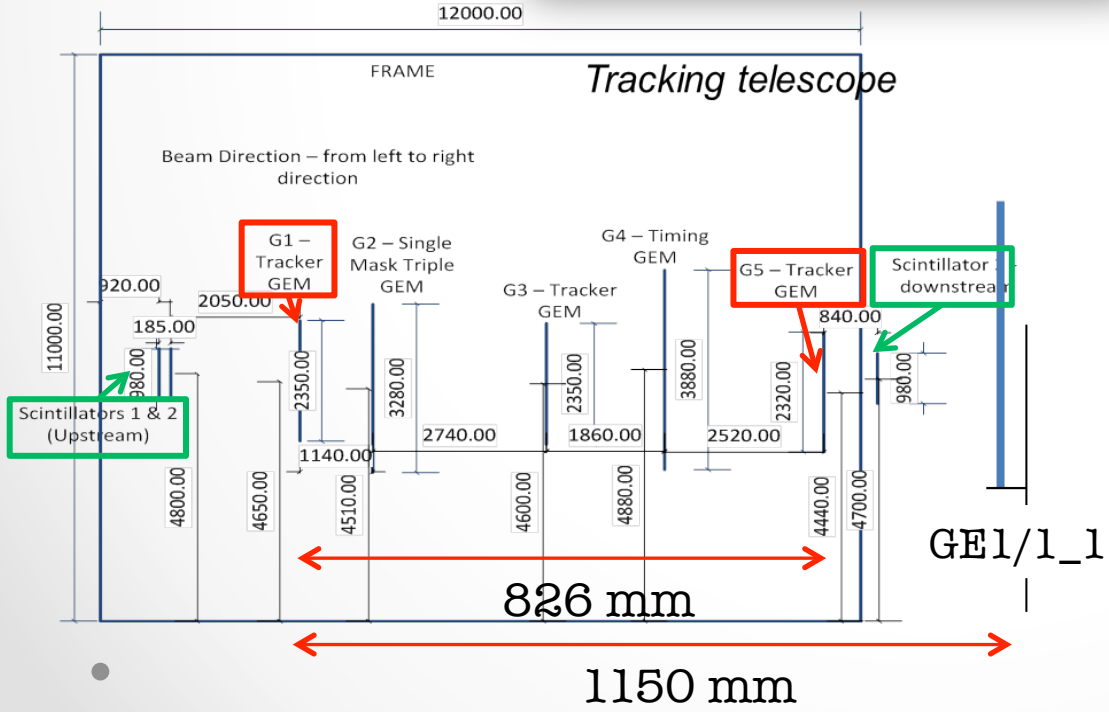
GEM active area: 990 x (220-445) mm

Single mask triple GEM

Gas mixture: $Ar/CO_2/CF4$ (45:15:40)

Gas flow: ~ 5 l/h

$Ar/CO_2$ (70:30) for the trackers 1 & 2




**APV1 – APV2 to S1 & S2**

Muons, 150 GeV, 100K events

Pions, 150 GeV, 250K events

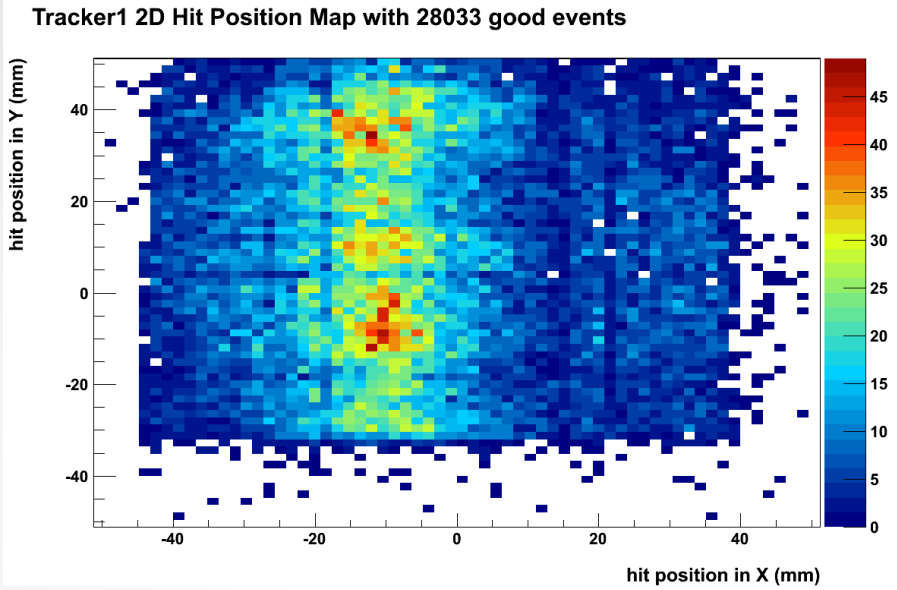
Pedestal run, 10K events

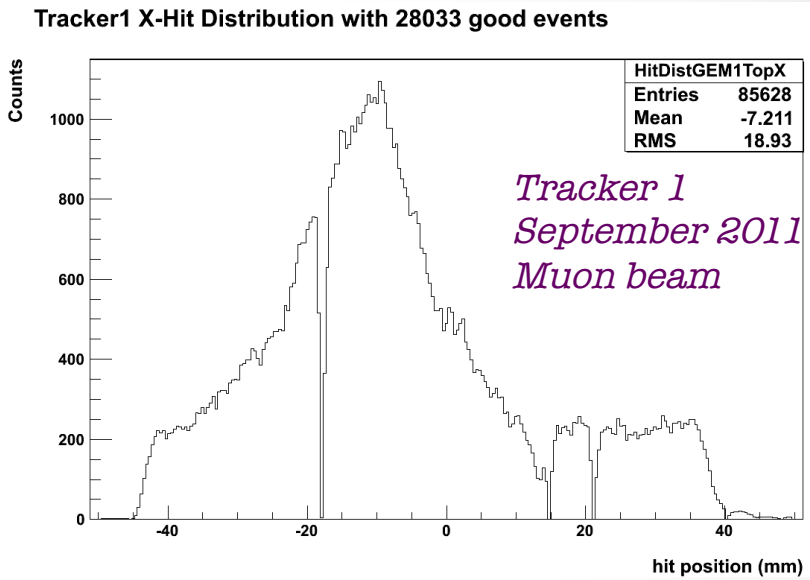
**APV1 – APV2 to S7 & S8**

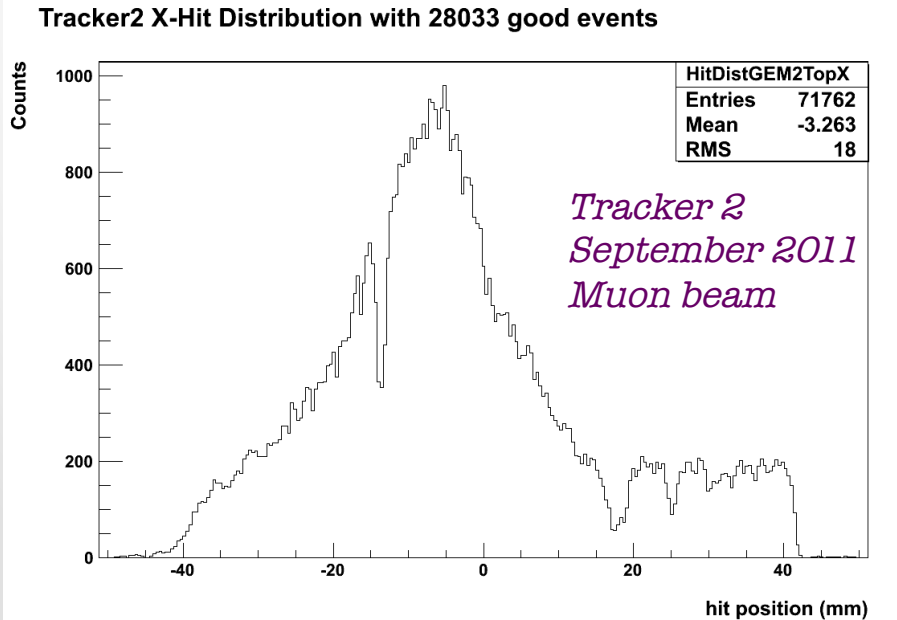
Muons, 150 GeV, 250K events

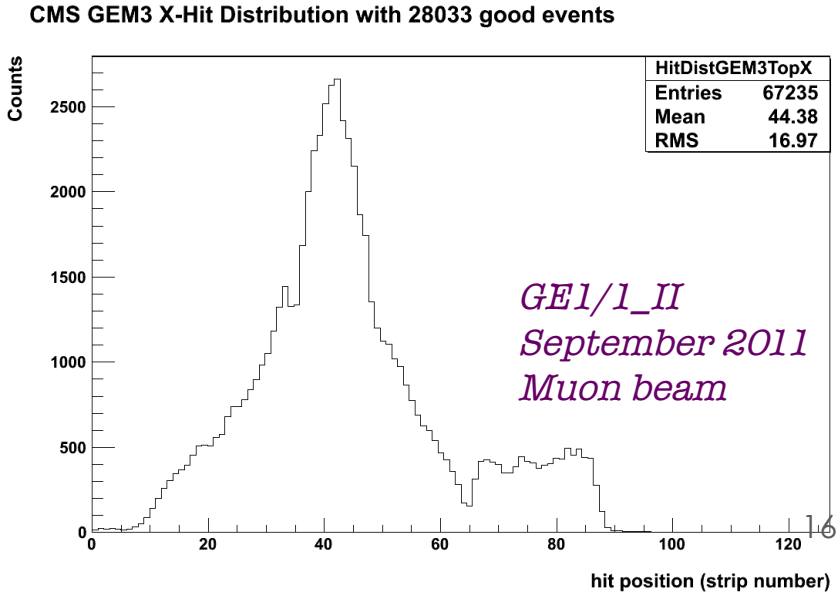
pedestal run, 10K events

# Taking data with the APV25

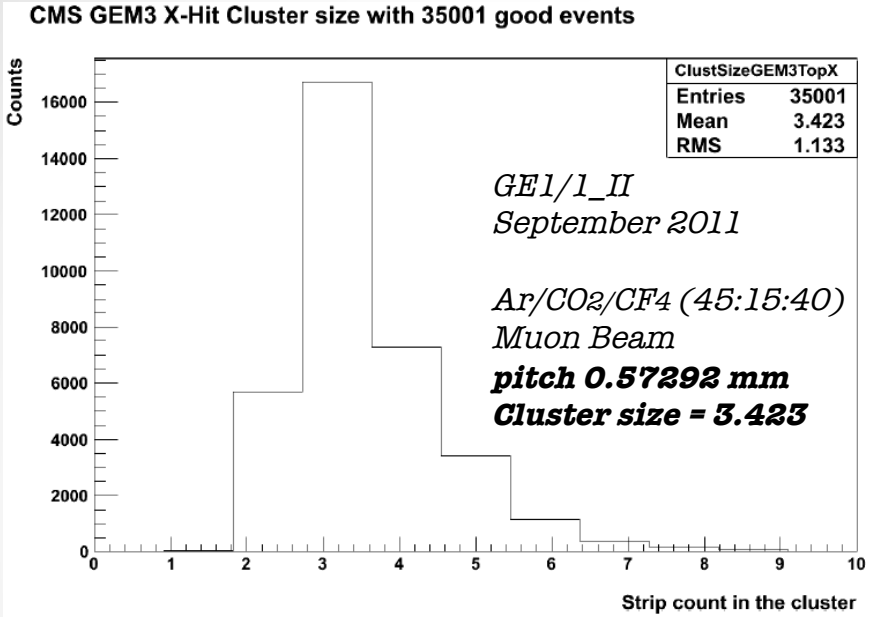


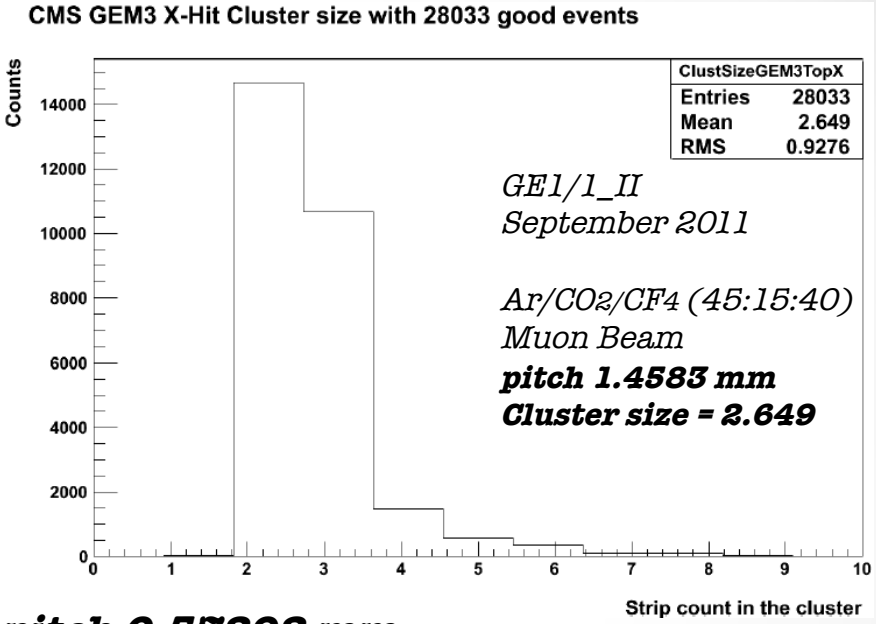



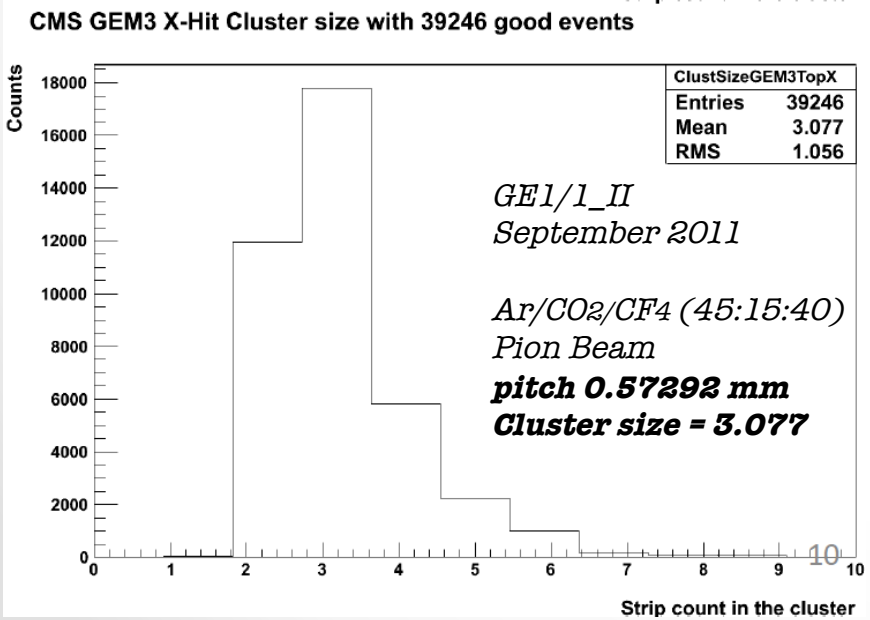



# Taking data with the APV25

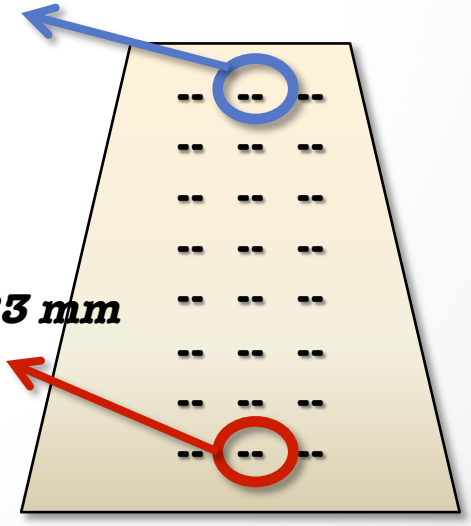



***pitch 0.57292 mm***

***pitch 1.4583 mm***



# Conclusions & Plans

Production and tests of small and full scale prototypes:

- Characterization of new prototypes in the lab (Gain calibration & stability, uniformity)
- Beam test preparation & data taking/analysis
- Simulations in the lab

Fully operational GEM detectors 990 x (445 – 220) mm have been designed and produced after long intense work on small size prototypes.

By the test-beams at RD51 and CMS setup with small size and full-size prototypes we demonstrated that the candidate prototype is addressing all the requested requirements in terms of high efficiency and gain, stable safe and reliable operation at CMS-LHC environment.

At SPS-H2 and H4 we have tested the performance of full-size prototypes in 1,5T along with small detectors.

Next year we are going to join RD51 test beams + we have submitted a request of 2 weeks@H2.

We acknowledge the RD51 for the strong support and the team who helped in the construction, testing and data-taking at the beams.