



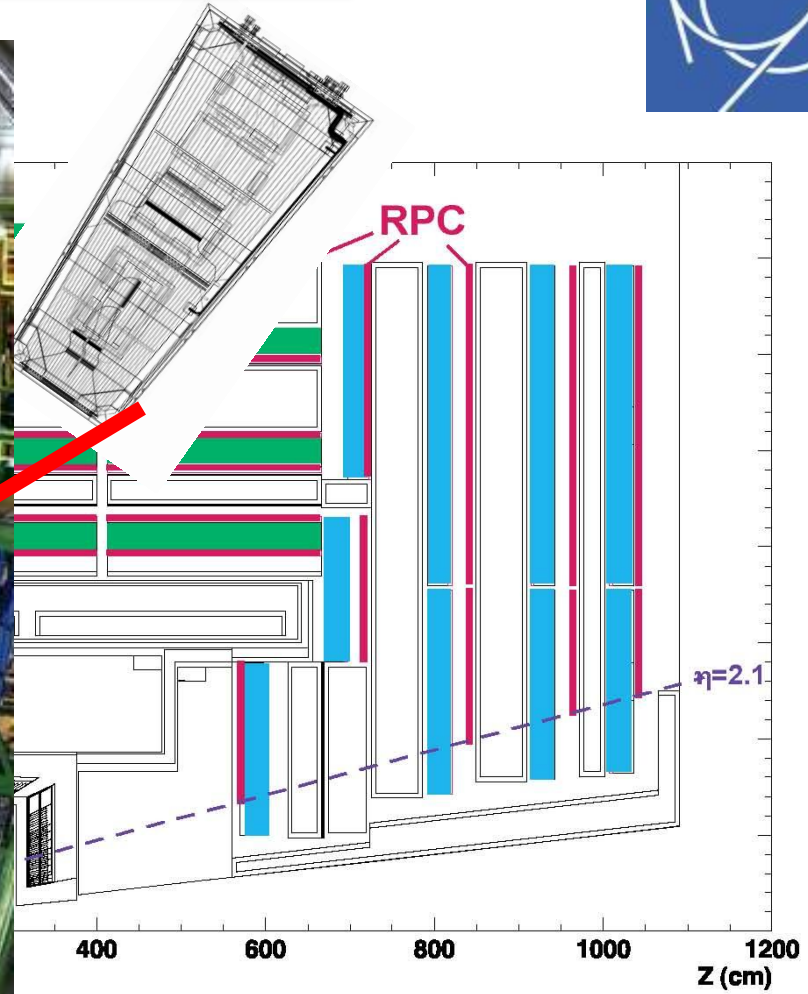
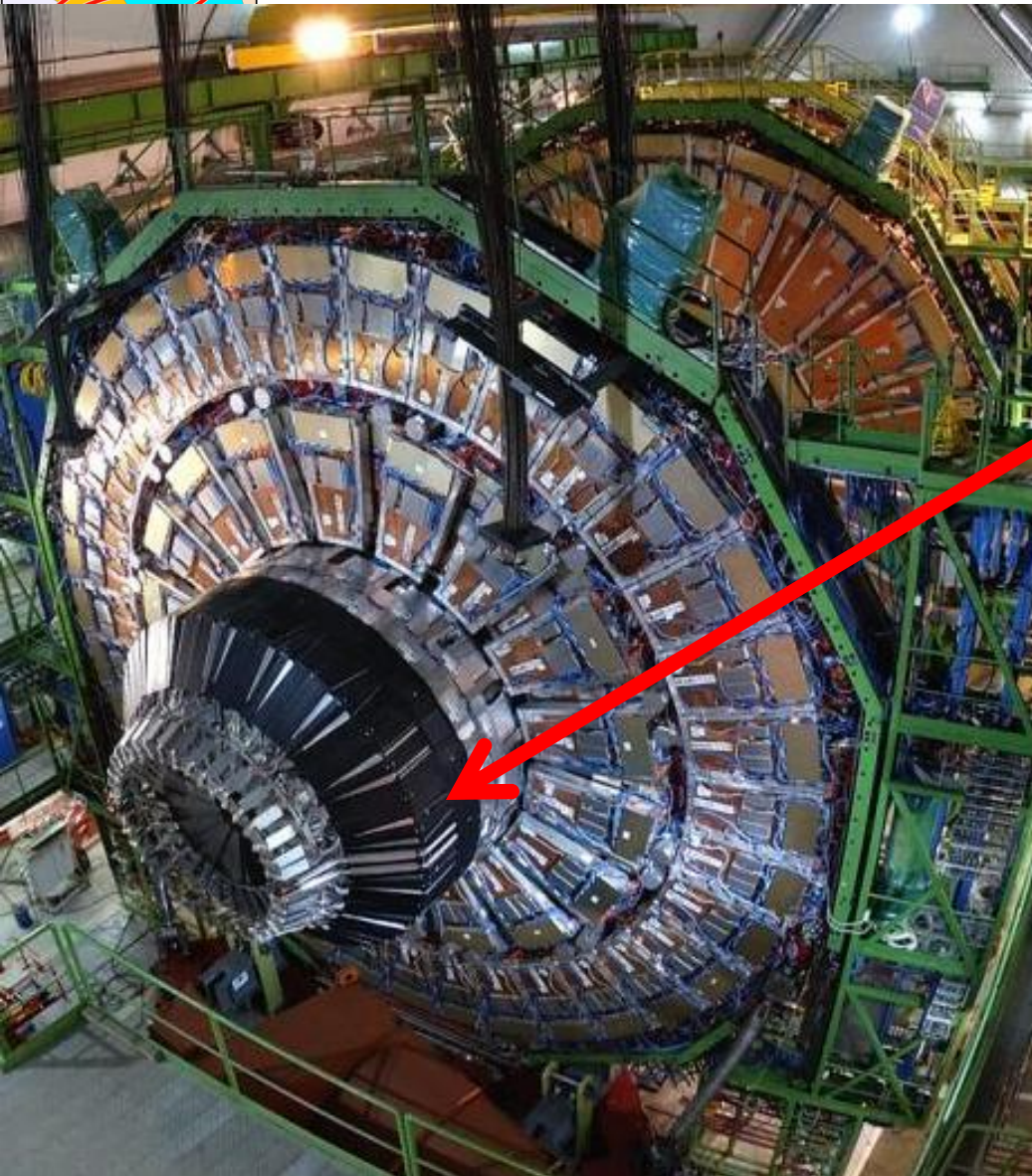
UPDATE AT RD51 COLLABORATION MEETING BARI
Beam Test Facilities Working Group - WG7

A High Eta Forward Muon Trigger & Tracking detector for CMS

Archana Sharma
For CMS High Eta Upgrade Team
(CMS, GDD and RD51)

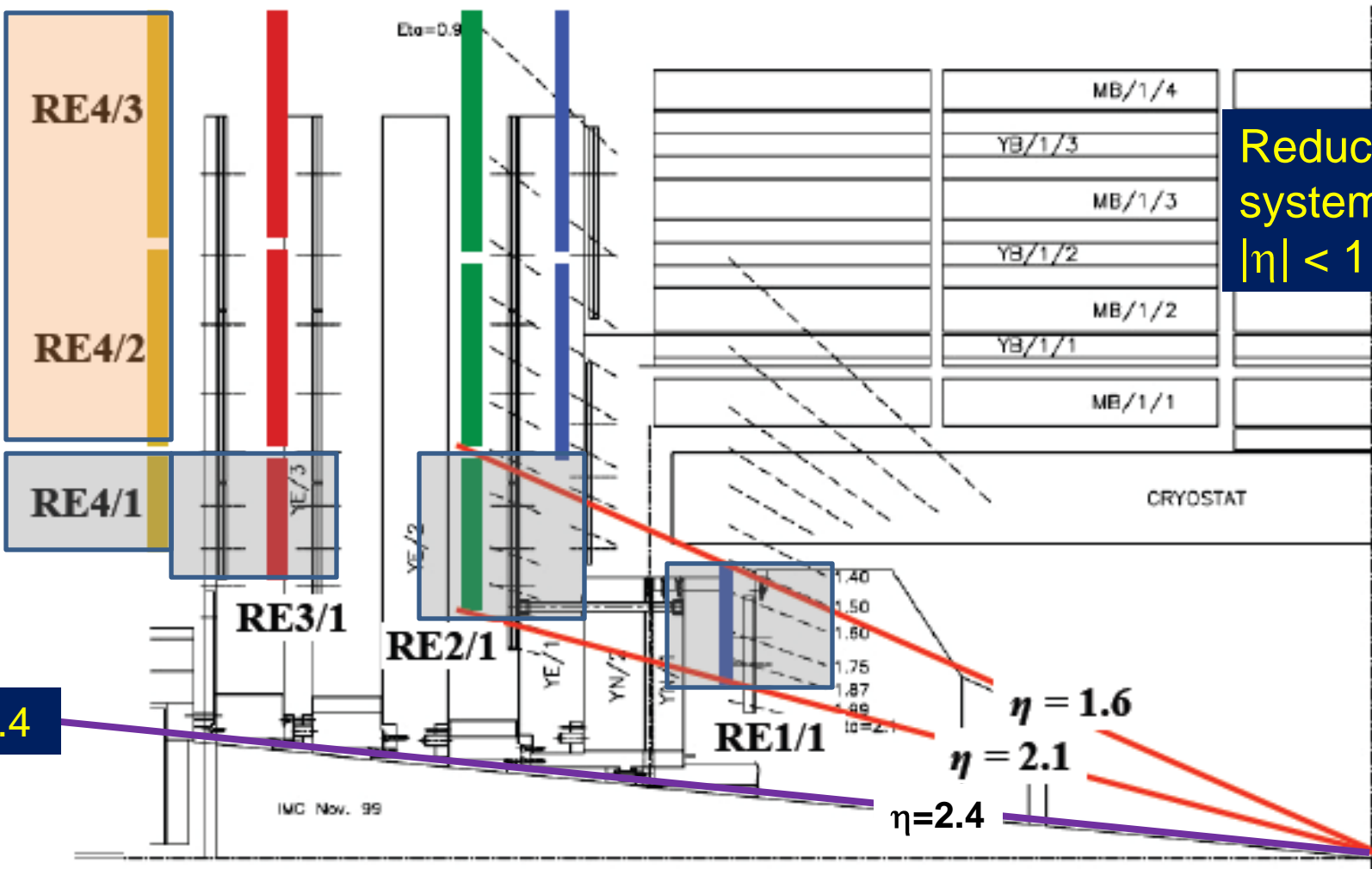
Oct 8-11, 2010

CMS - Redundant Muon System



- Endcap RPC:
- RE 1,2,3,4 = 1 layers
 - 540 trapezoidal chambers
 - 80 000 radial strips

Initial RE system –tailored to budget



Reduced RE system
 $|\eta| < 1.6$

$\eta = 2.4$

$\eta = 1.6$

$\eta = 2.1$

$\eta = 2.4$

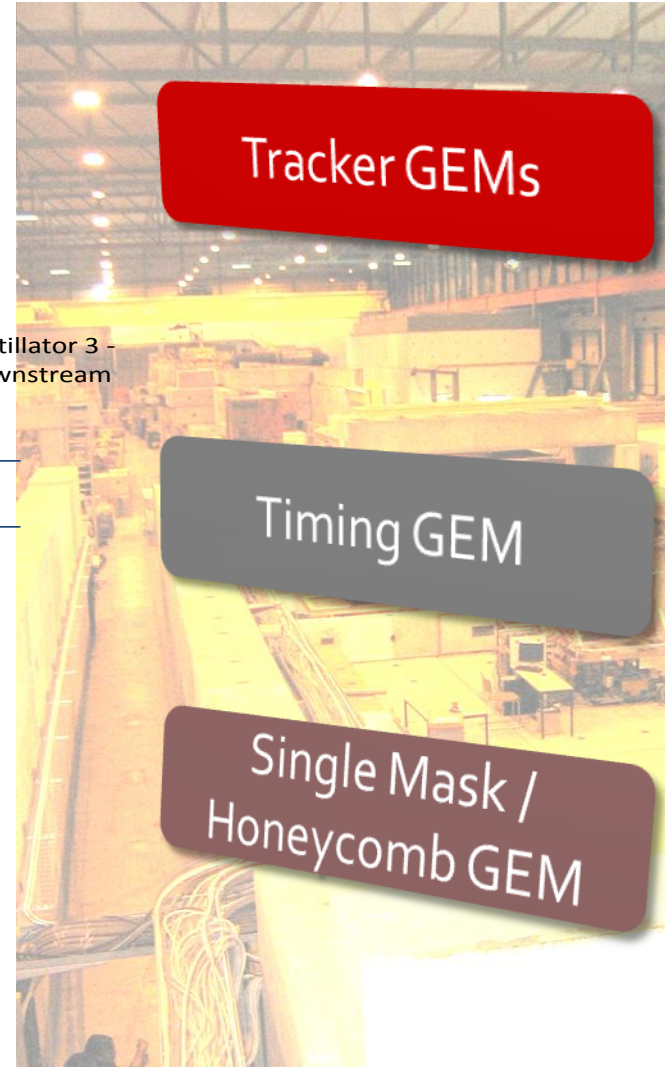
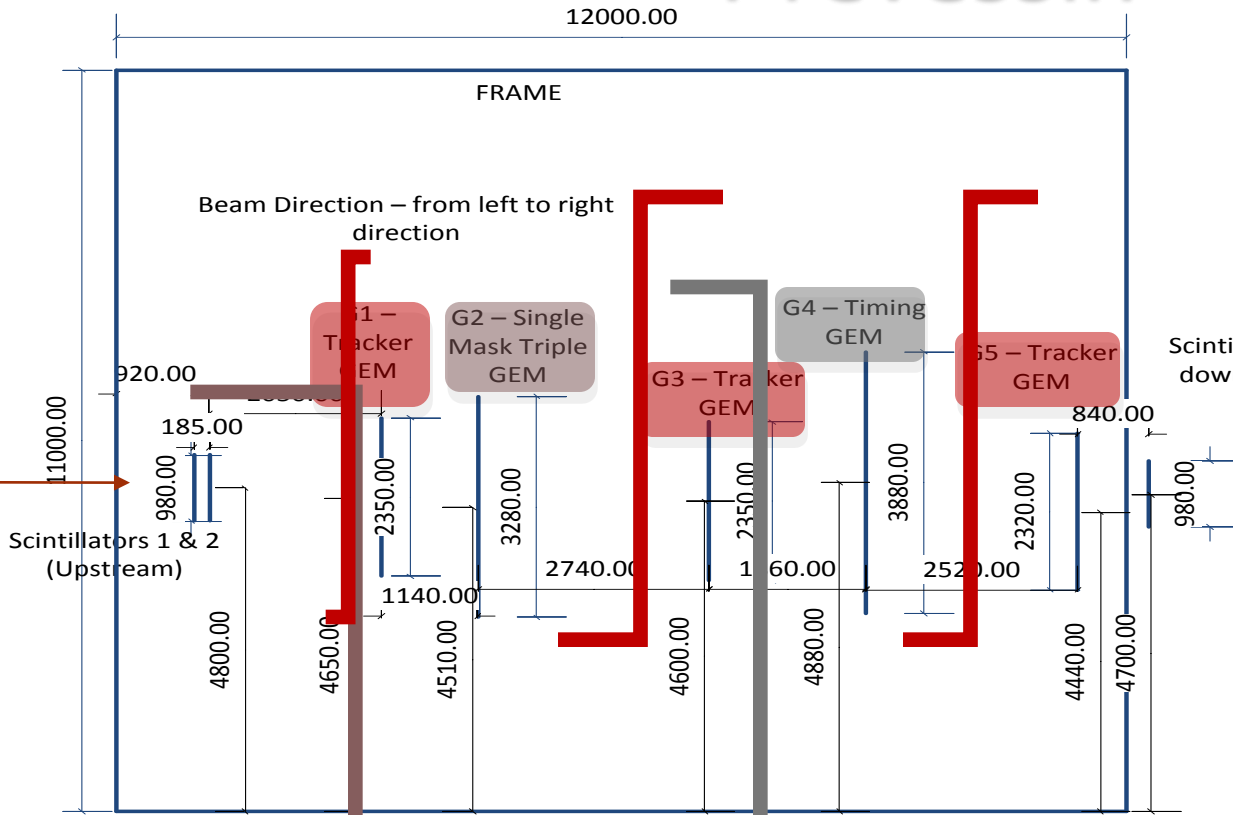
STAGED

| | RE 1/1 | RE 1/2 | RE 1/3 | RE 2/1 | RE 2/2 | RE 2/3 | RE 3/1 | RE 3/2 | RE 3/3 | RE 4/1 | RE 4/2 | RE 4/3 |
|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| No. of chambers | 36*2 | 36*2 | 36*2 | 18*2 | 36*2 | 36*2 | 18*2 | 36*2 | 36*2 | 18*2 | 36*2 | 36* |

Estimated Particle rates in Forward CMS

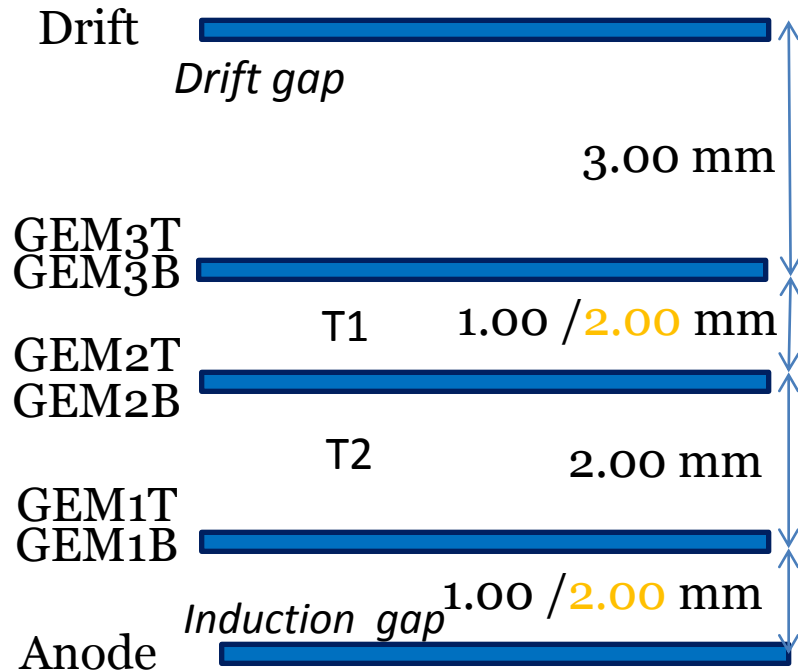
| RPC Region | Rates Hz/cm ² LHC (10 ³⁴ cm ² /s) | High Luminosity LHC 2.3 x LHC | (10 ³⁵ cm ² /s) Phase II SLHC ?? |
|--|---|----------------------------------|--|
| RB | 30 | Few 100 | 500 Hz - kHz (tbc) |
| RE 1, 2, 3,4 $\eta < 1.6$ | 30 | Few 100 | kHz (tbc) |
| Expected Charge in 10 years | 0.05 C/cm ² | 0.15 C/cm ² | ~ C/cm ² |
| RE 1,2,3,4 $\eta > 1.6$ | 500Hz ~ kHz | Few kHz | Few 10s kHz |
| Total Expected Charge in 10 years | (0.05- 1) C/cm ² | few C/cm ² | Few 10s C/cm ² |

Test Beam setup @ RD51 H4 Preveessin

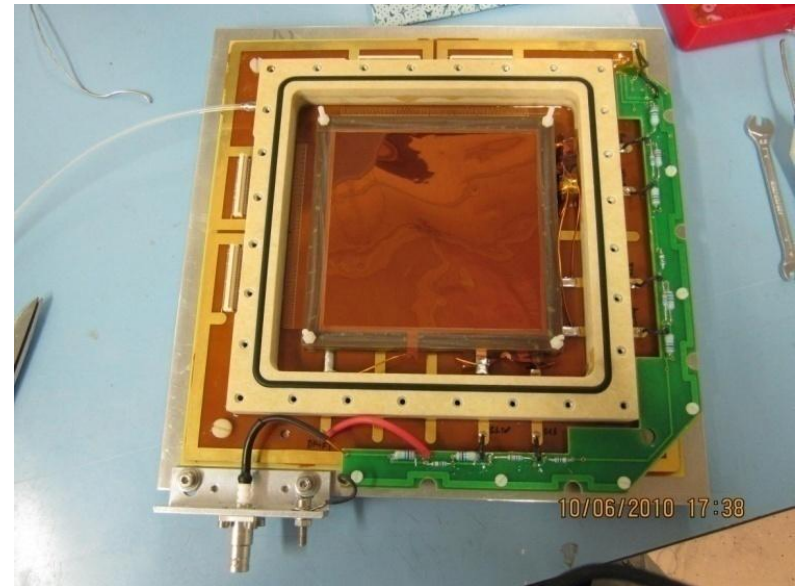


I TB: from 28 June to 8 July 2010
II TB: from 14 August to 20 August 2010

Triple GEM (standard)



- GEMs active area: 10 x 10 cm²
- Double mask standard GEM
- 1D readout
- Gas mixture:
 - Ar/CO₂ (70/30, 90/10)
 - Ar/CO₂/CF₄ (45/15/40, 60/20/20)
- Gas flow: ~ 5 l/h



Prototype Description 2/3

Triple GEM (honeycomb)

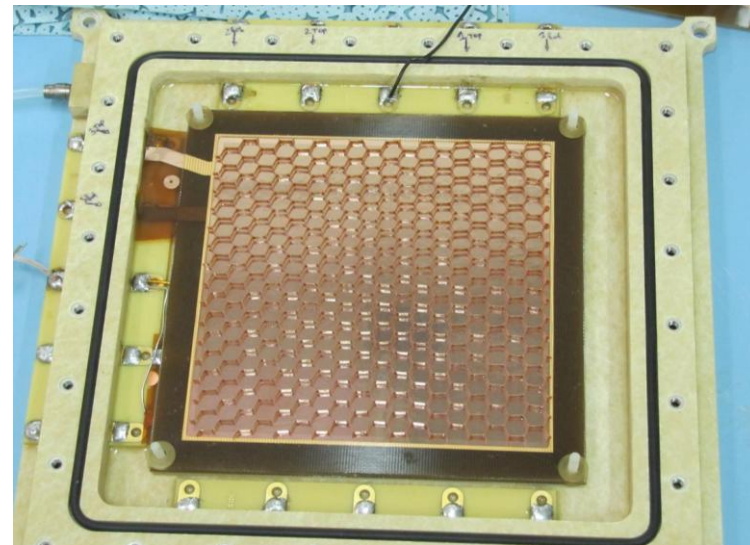
The GEM containing honeycomb worked without any problem during the data taking.

HONEYCOMB STRUCTURES

CONFIG. 1:
 12mm(Drift) /
 12mm(T1) /
 12mm(T2) /
 12mm(Induction)

CONFIG. 2:
 6mm(Drift) /
 12mm(T1) /
 12mm(T2) /
 12mm(Induction)

CONFIG. 3:
 6mm(Drift) /
 0mm(T1) /
 0mm(T2) /
 0mm(Induction)

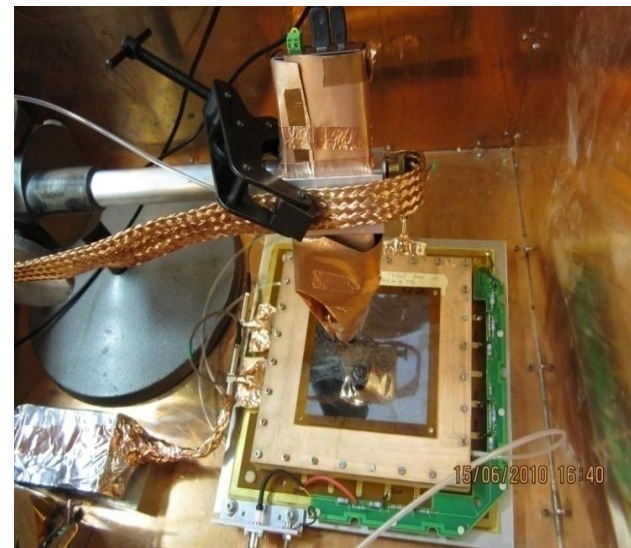
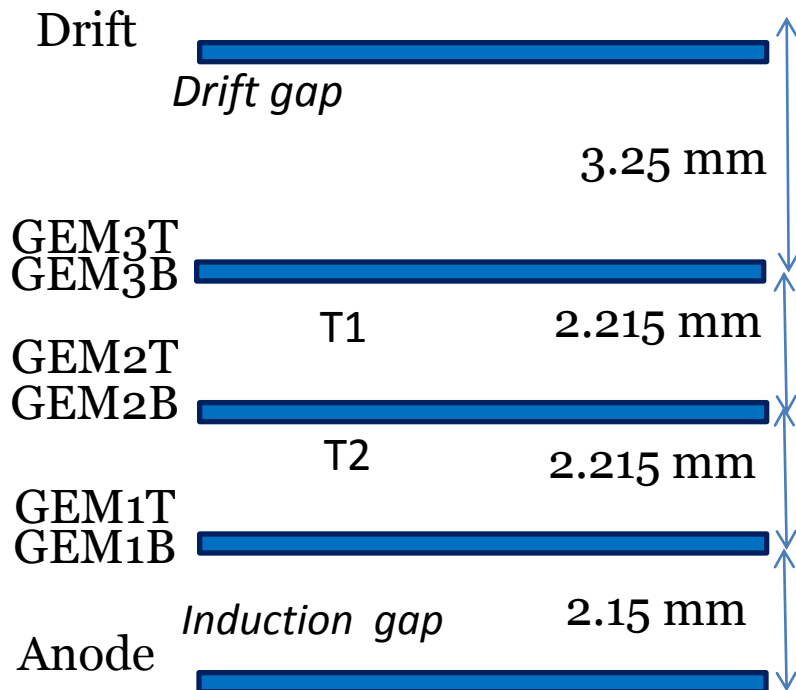


Honeycomb will allow to avoid GEM foil stretching!

Prototype Description 3/3

Triple GEM (single mask)

- GEMs active area: 10 x 10 cm²
- Single mask GEM
- 2D readout
- Gas mixture:
 - Ar/CO₂ (70/30, 90/10)
 - Ar/CO₂/CF₄ (45/15/40, 60/20/20)
- Gas flow: ~ 5 l/h



This technology has been used for large size detector and mass production!

Data Analysis

COSTANT Parameters for timing studies

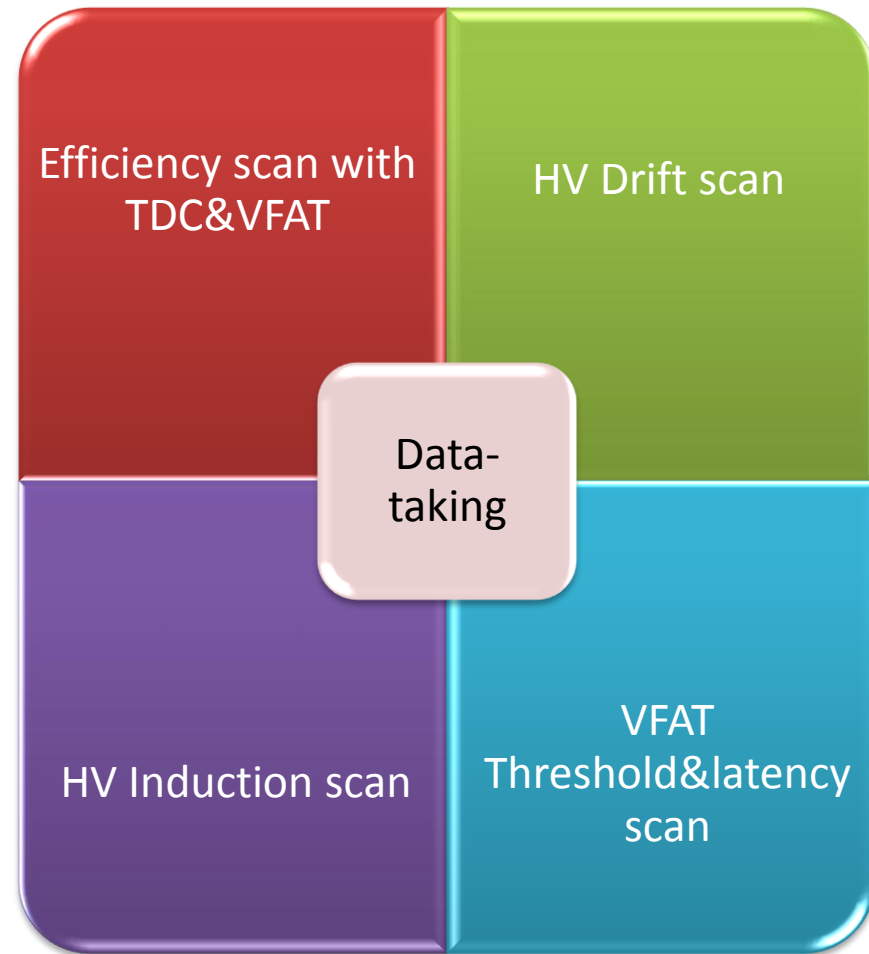
1d readout, strips 0.8mm pitch
(vertical to the beam)

$E_d=2.0$ KV/cm,
 $E_{t1}=E_{t2}=3.0$ KV/cm, $E_i=3$ KV/cm

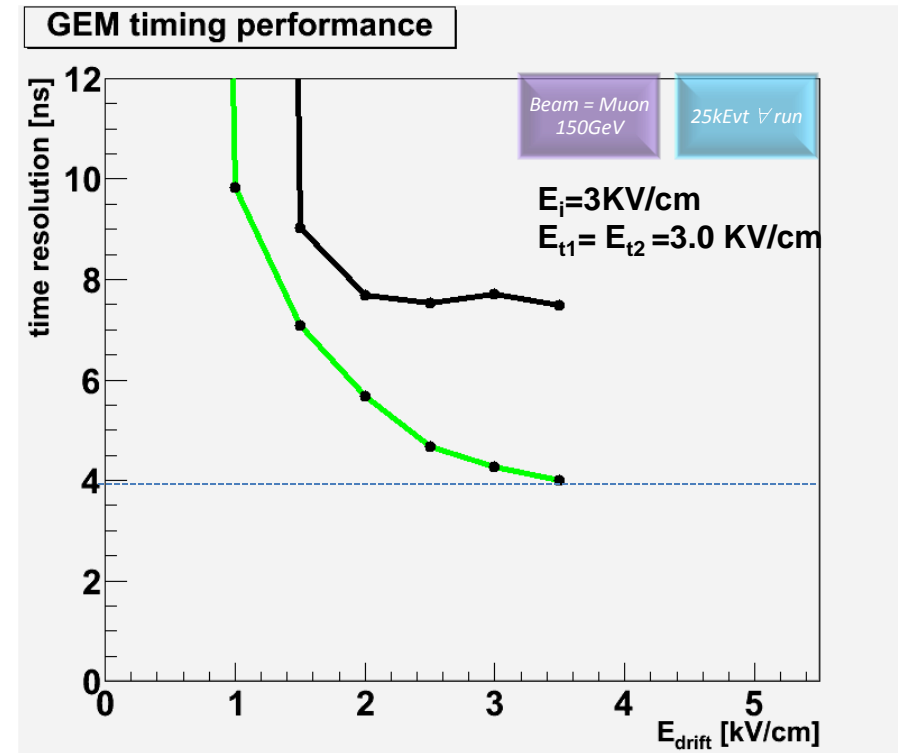
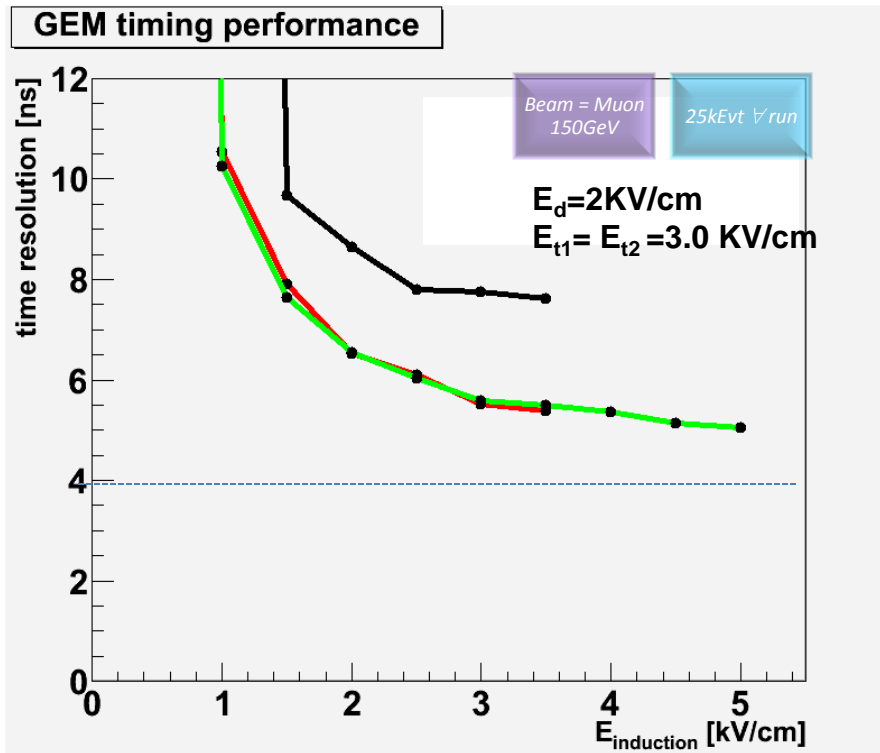
Detector gap configurations

3mm(Drift)
2mm(T1) , 2mm(T2)
2mm(Induction)

3mm(Drift)
1mm(T1) / 2mm(T2)
1mm(Induction)



Reached time resolution of 4ns (σ)



Standard GEM

- Ar(70):CO₂(30)
- [gaps 3/2/2/2]

Standard GEM

- Ar(45):CO₂(15):CF₄(40)
- [gaps 3/2/2/2]

Standard GEM

- Ar(45):CO₂(15):CF₄(40)
- [gaps 3/1/2/1]

Data Analysis: Efficiency Studies

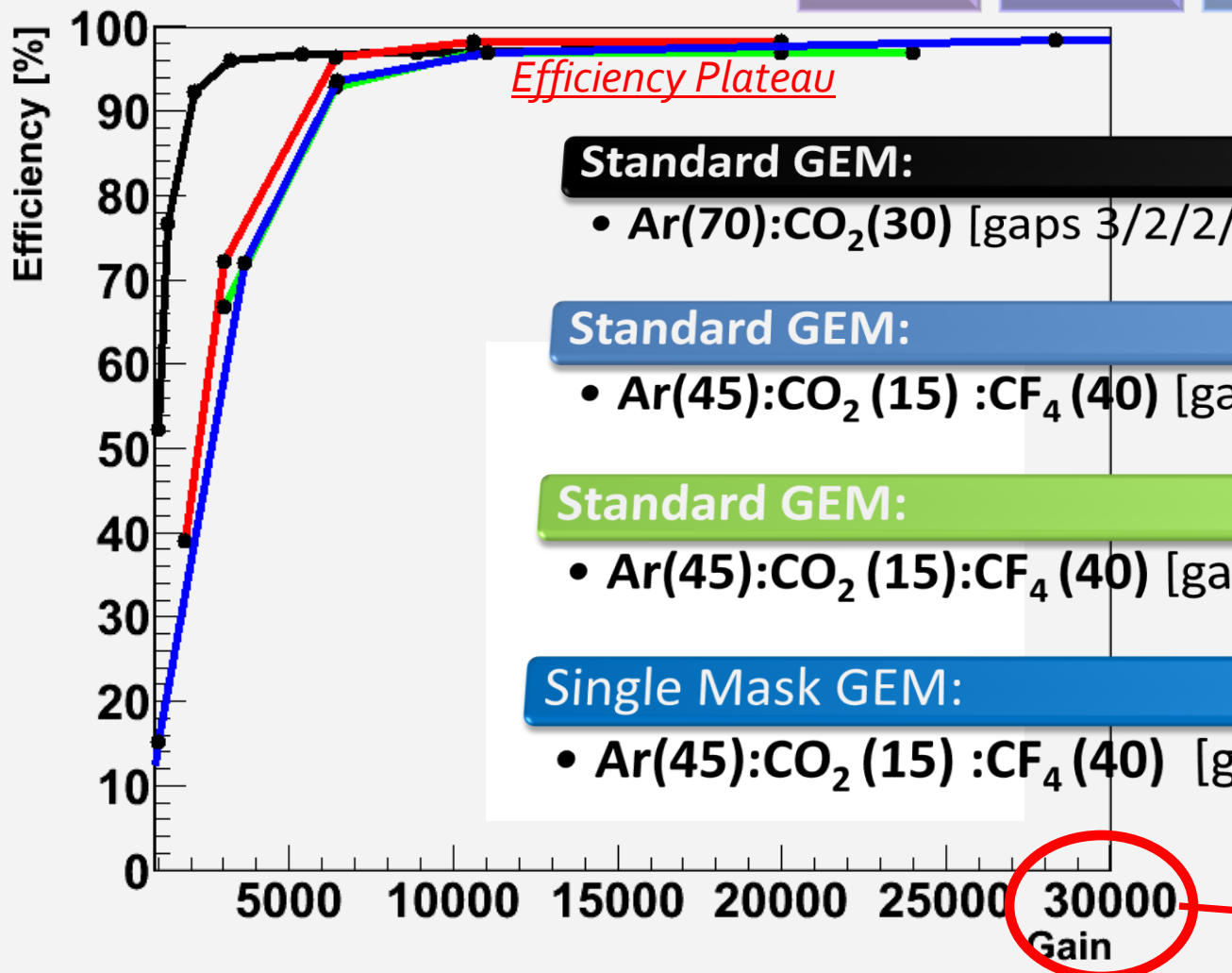
GEM efficiency performance

MSPL=4
(100ns)

VFAT thr = 25

Beam = Muon
150GeV

25kEvt ∇ run



Standard GEM:

- Ar(70):CO₂(30) [gaps 3/2/2/2]

Standard GEM:

- Ar(45):CO₂(15):CF₄(40) [gaps 3/2/2/2]

Standard GEM:

- Ar(45):CO₂(15):CF₄(40) [gaps 3/1/2/1]

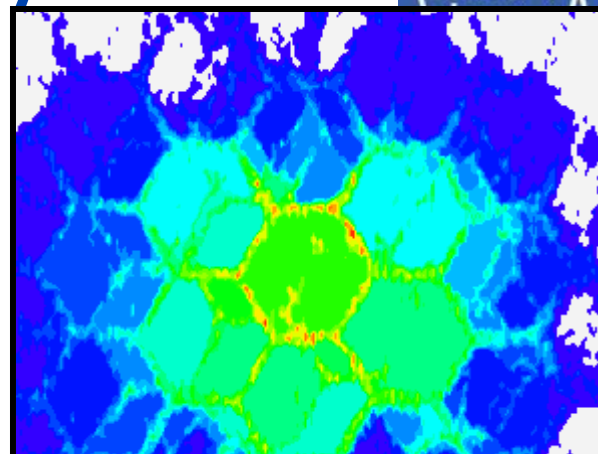
Single Mask GEM:

- Ar(45):CO₂(15):CF₄(40) [gaps 3/2/2/2]

30000
Gain

High achievable gain!

*Honeycomb will allow to avoid
GEM foil stretching!*



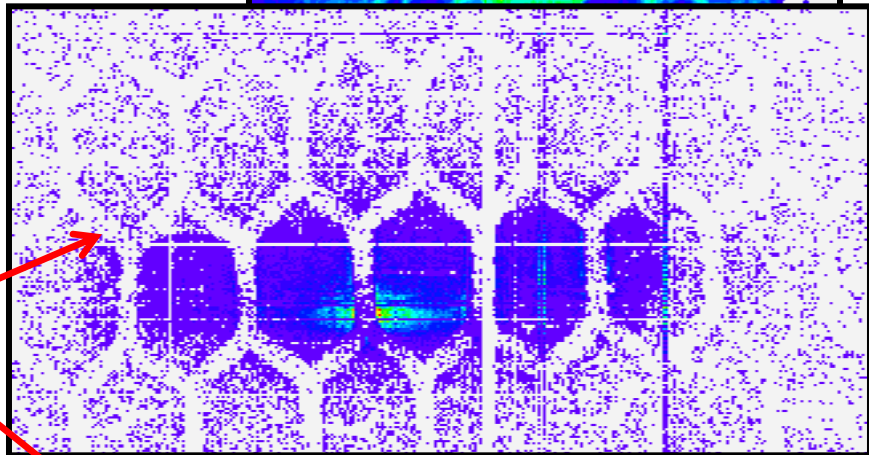
Honeycomb size

CONFIG. 1:
12mm(Drift)
12mm(T1), 12mm(T2)
12mm(Induction)

Efficiency=50%
(data taking affected
by grounding problem)

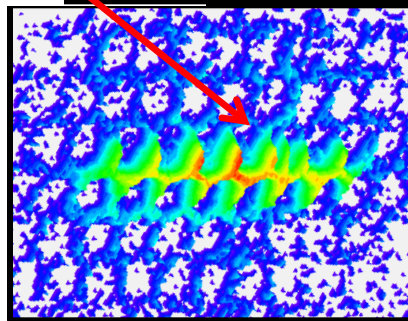
CONFIG. 2:
6mm(Drift)
12mm(T1), 12mm(T2)
12mm(Induction)

Efficiency=70%
**GEOMETRIAL
FACTOR**
rough est. 65%



CONFIG. 3: 6mm(Drift)
 \emptyset mm(T1), \emptyset mm(T2)
 \emptyset mm(Induction)

Efficiency=70%



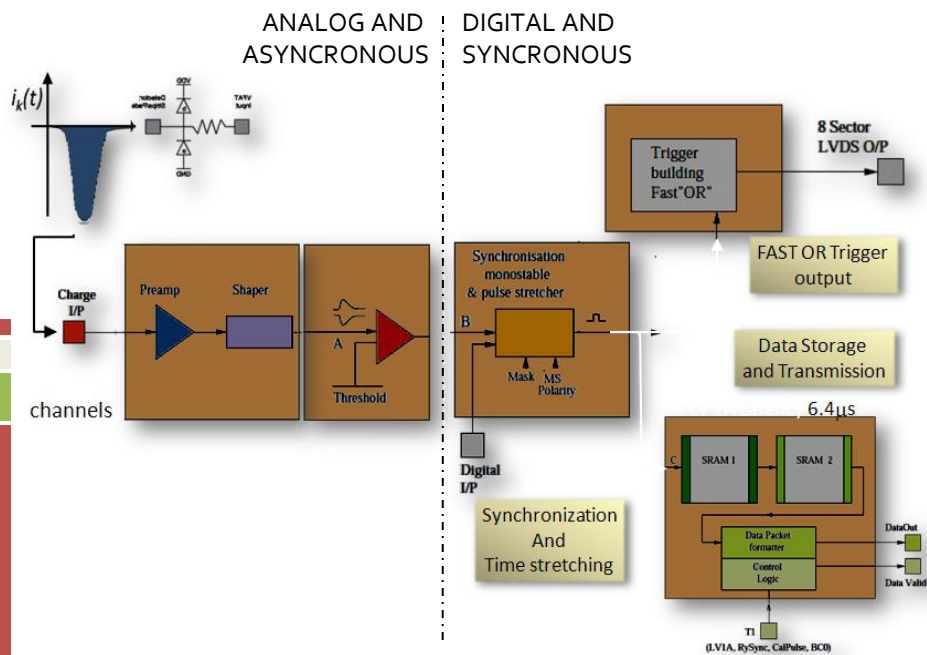
*For RPC spacers take
up more than 5% area
(1cm circular spacer
every 10cm)*

Efficiency loss will reduce with bigger cell size

VFAT chip: Introduction

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 0.25 μ m CMOS technology and its trigger function provides programmable “fast OR” information based on the region of the sensor hit.

- *Turbo board layout*



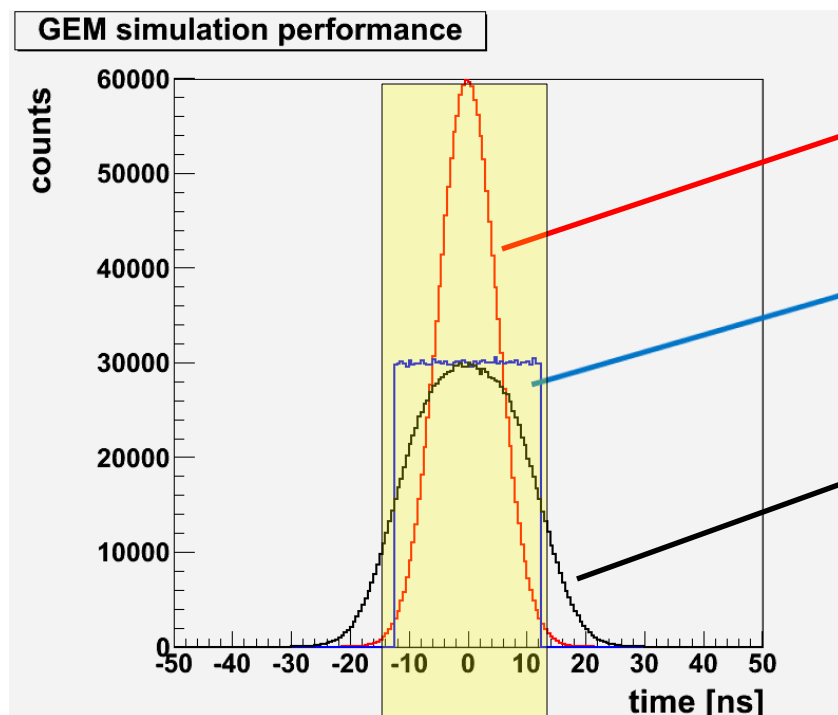
For prototype testing we used electronics developed by INFN (Siena and Pisa), based on the TOTEM VFAT chip.

Without synchronous signal the VFAT introduces a jitter in the digital output

..for more details see Paul slides..

VFAT chip: clock issue

VFAT output digital signals are synchronous to VFAT clock (40Mhz, 25ns), therefore the chip is introducing a jitter to the detector signal. This is especially critical when MSPL=1.



Time distribution from GEM (time res=5ns σ)

VFAT jitter

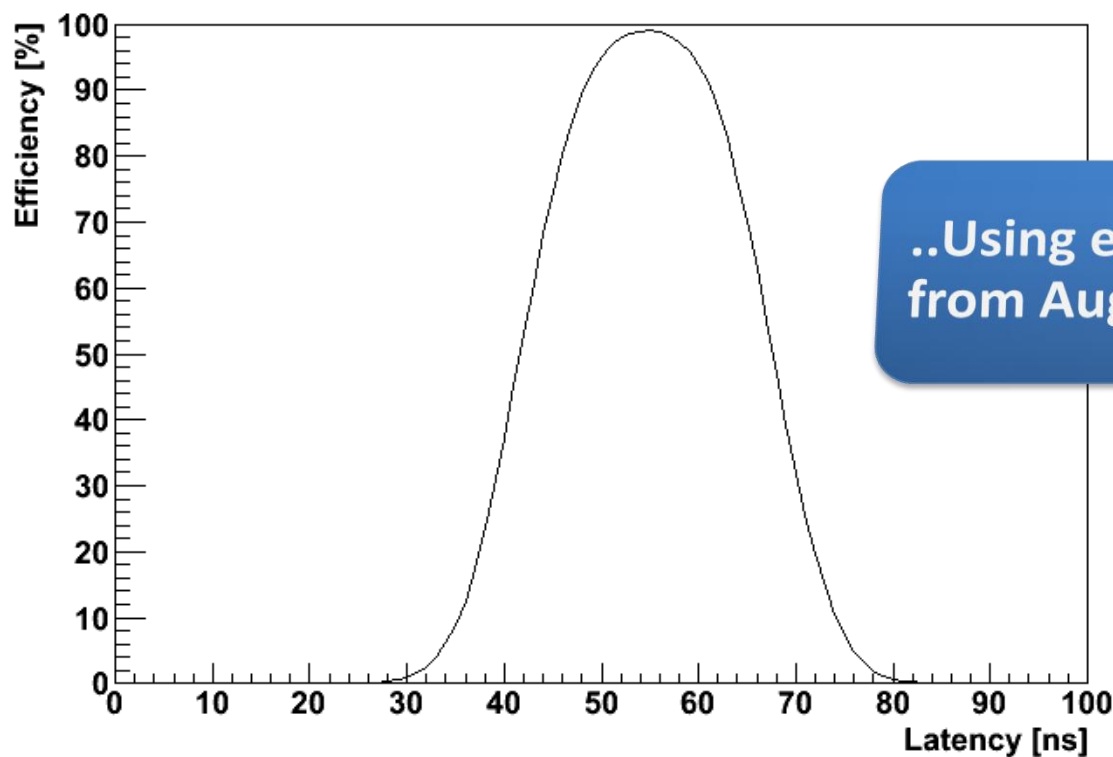
Jitter & Time distribution convolution

Considering MSPL=1 (25ns) a gaussian time resolution with rms=5ns will work at full efficiency, the convoluted distribution no!

Simulating LHC conditions

In order to remove the VFAT jitter the clock of the chip and LHC should be synchronized to achieve fully efficiency.

GEM timing performance - Maximum theoretical efficiency with LHC bx 25ns

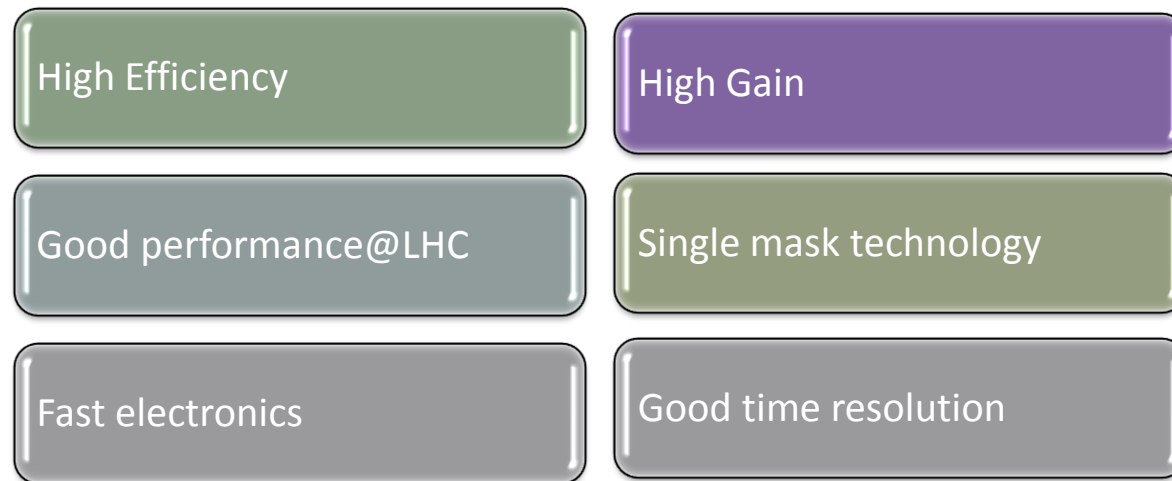


..Using experimental data from August Test Beam..

Considering MSPL=1 (25ns) a Gaussian time resolution with rms=5ns will work at full efficiency, the convoluted distribution no!

Final Considerations

- The TestBeams (June and August) demonstrated that prototype detectors fulfill all requirements:

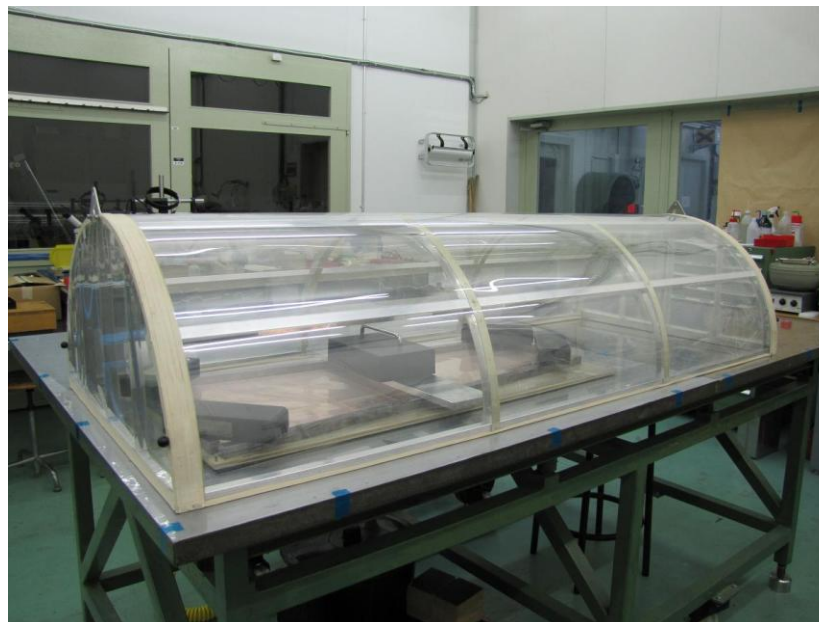


- The single mask GEM has been characterized with good performances.
- The honeycomb detector demonstrated to work without problem, good candidate once reached better efficiency performances .
- The detector+electronics works without issues.

OUTLOOK FOR OCTOBER BEAM TEST

Test the large area CMS prototype for:
Gain uniformity, efficiency, noise, electronics ...

Test small prototype in magnetic field





GE1/1 Status and Plans

| Item | Present Status |
|--------------------------------------|----------------|
| GEM foils production | Done |
| GEMs HV test | 90% finished |
| Stretching and Framing procedure | 90% finished |
| Drift Electrode | Done |
| HV divider production | In progress |
| HV divider test | Pending |
| Readout PCB production | Done |
| Readout PCB testing | In progress |
| Ready with prototype for 18.Oct.2010 | OK |