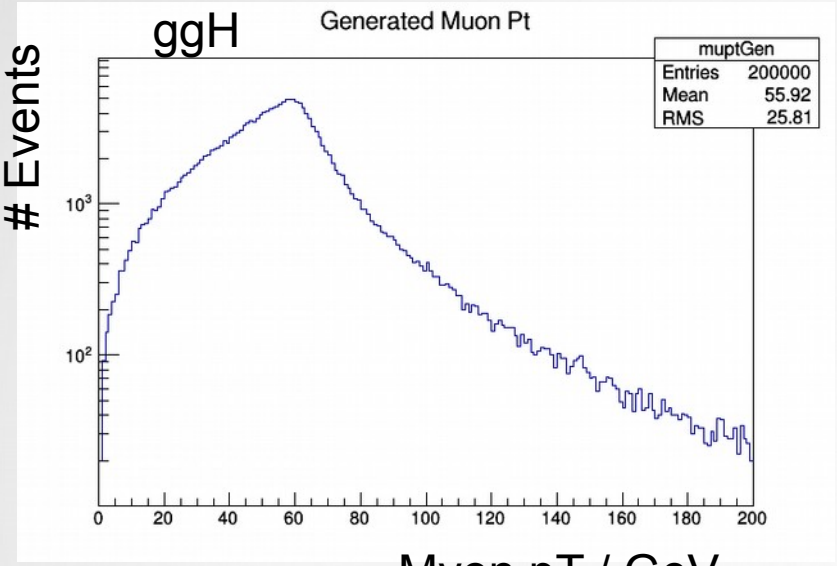
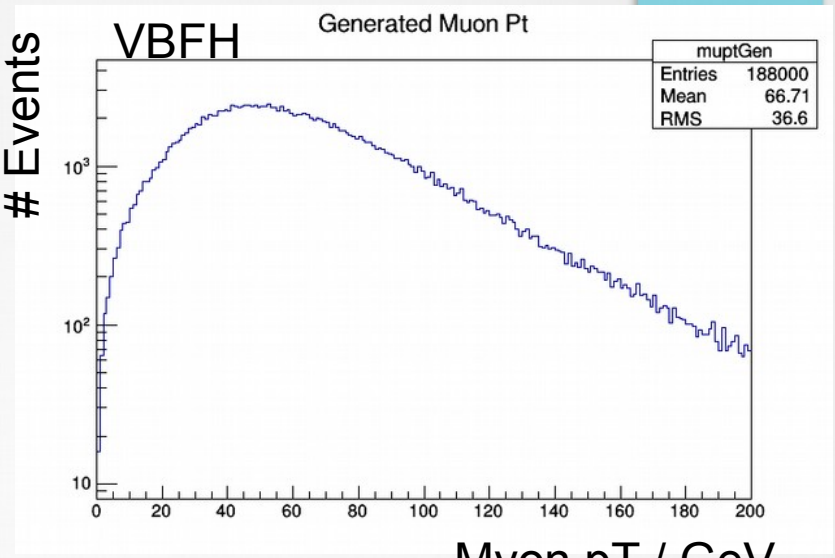
Detector design tune for final states with high-pT muons

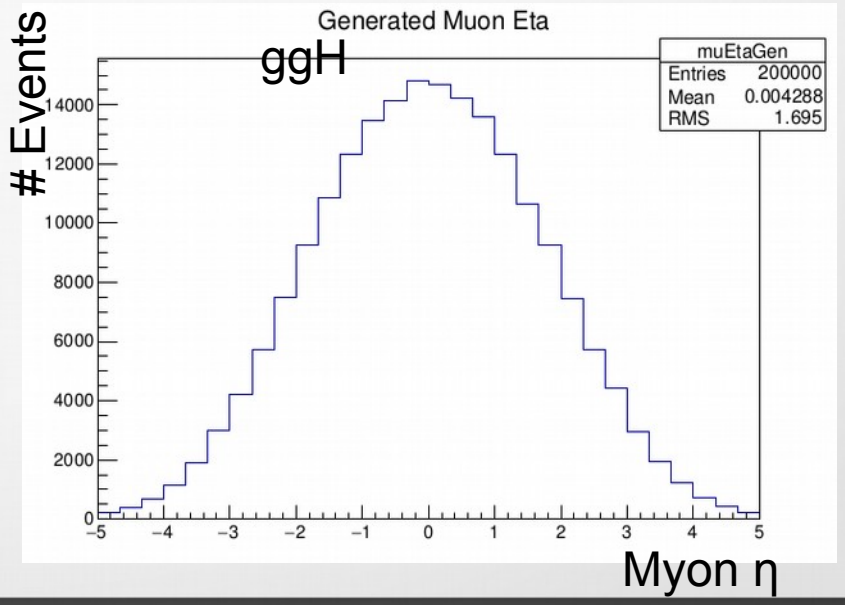
Team 4: Ennio, Marius, Martin, Mohsen, Olena, Suvankar

“Raw” generator level information





- Optimize for:
  - PT ~ 10 – 100 GeV
  - η ~ 0-3.5



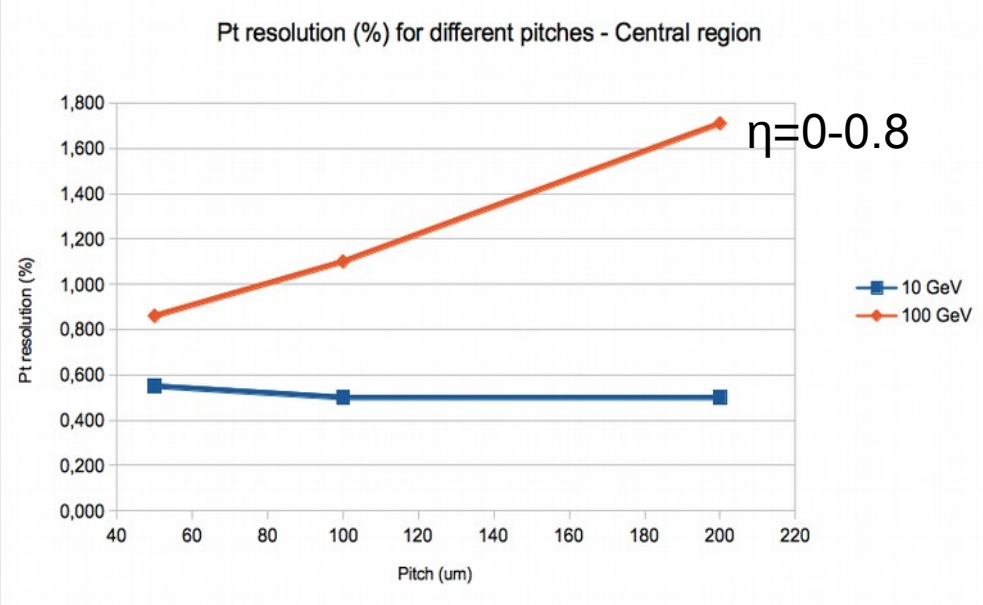
Detector Design Choices

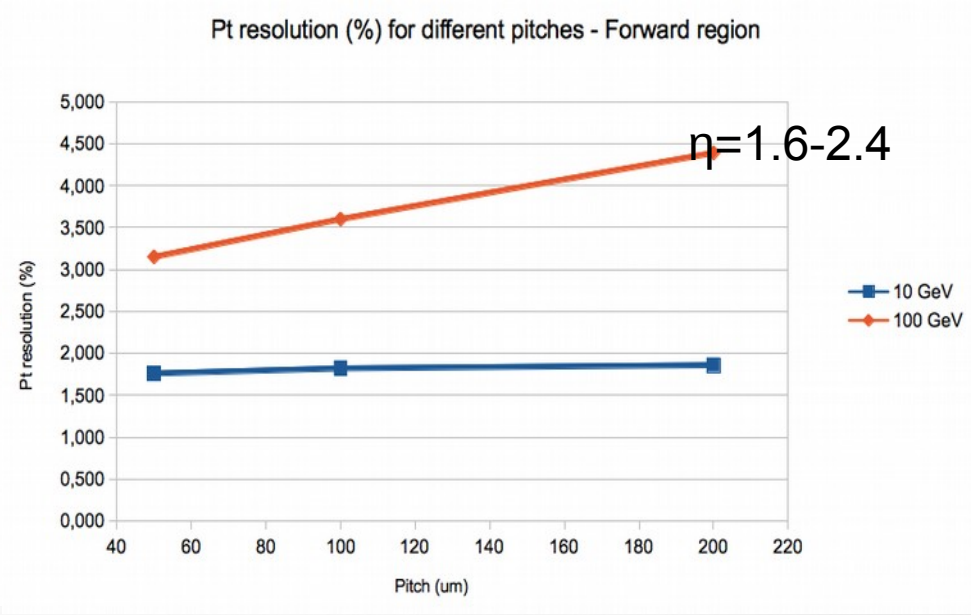
- We keep the CMS magnet → physically limits the Tracker size
- Keep the pixel as proposed for Phase II (Vertexing)

- Optimized for the pT and η distribution of the signal
  - We need a very good p_T resolution on muons
  - Also in the forward regions
  - Rough estimation:

$$\frac{\sigma(p_T)}{p_T} = \frac{\sigma_x p_T}{q\left|\vec{B}\right| L^2}\sqrt{\frac{720}{N+4}}$$

Variation of the pitch

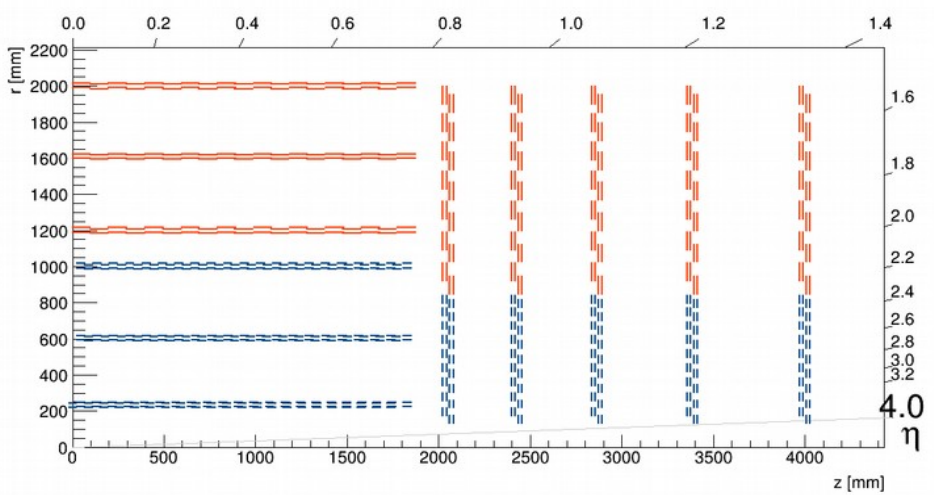


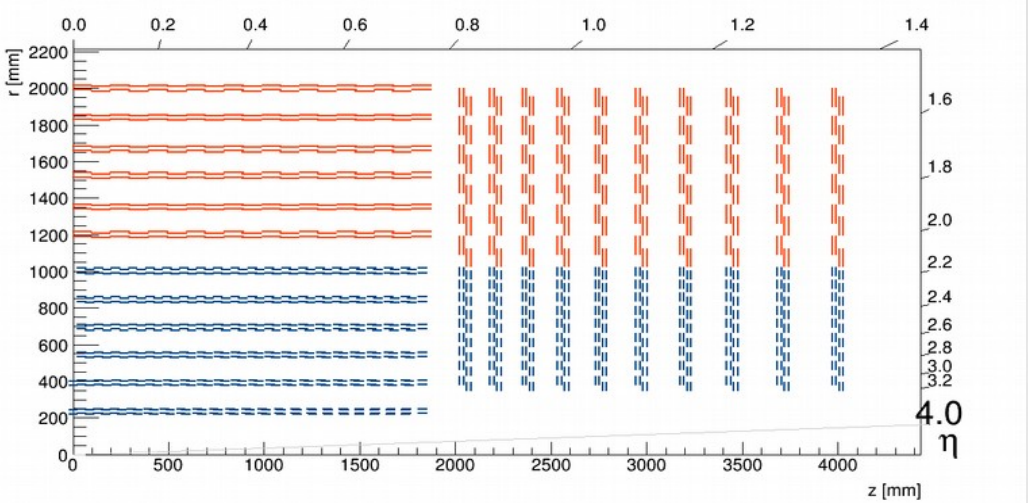


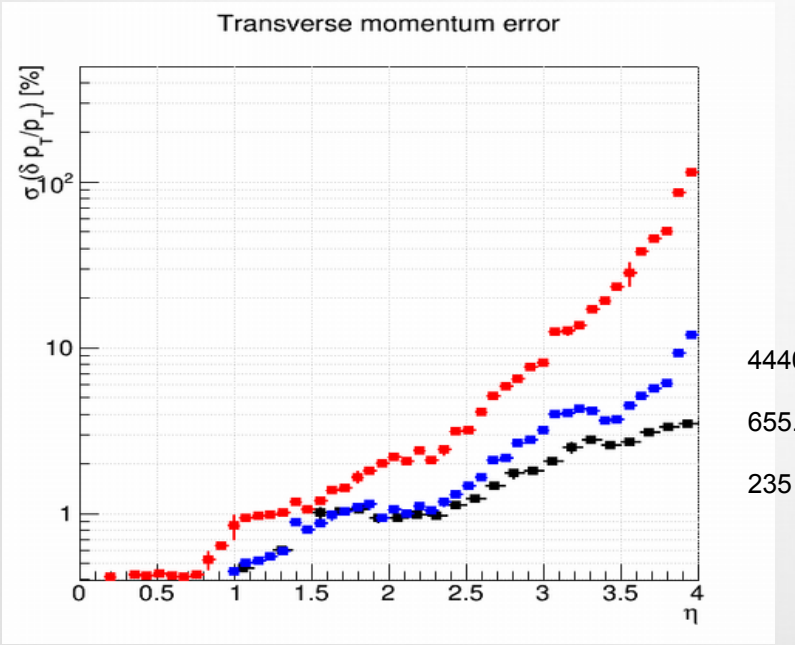
TP2014 geometry

- Change in the single point resolution
- Halfen the pitch → double amount of dead material

Tracker Leverarm



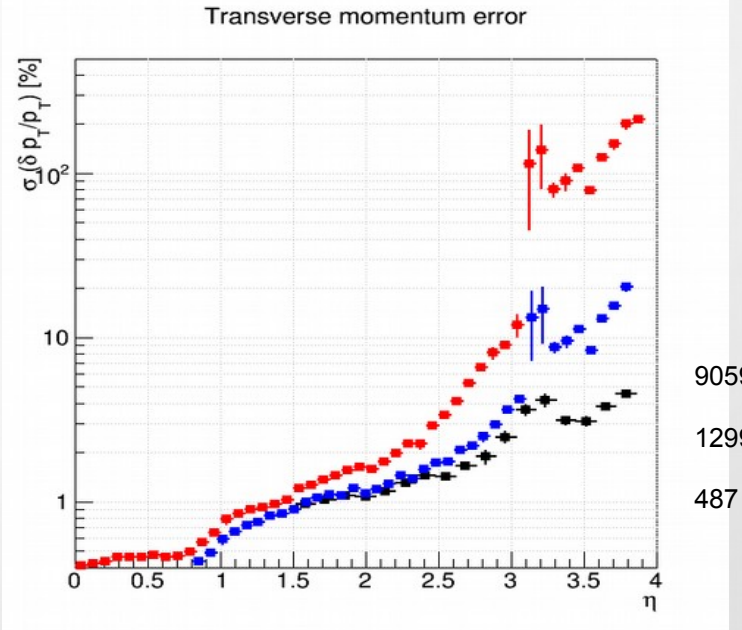




44404 Modules

655.8 m² Si

235 kw

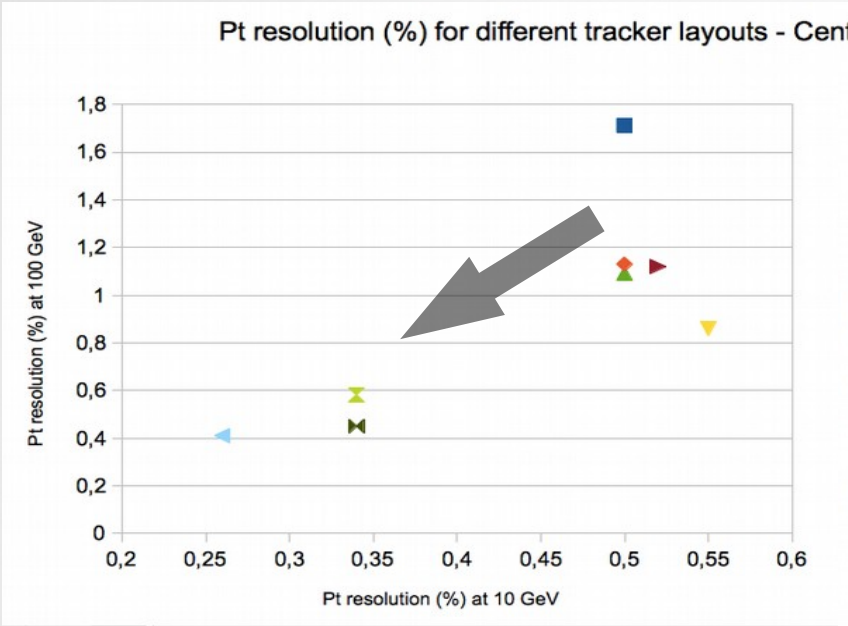


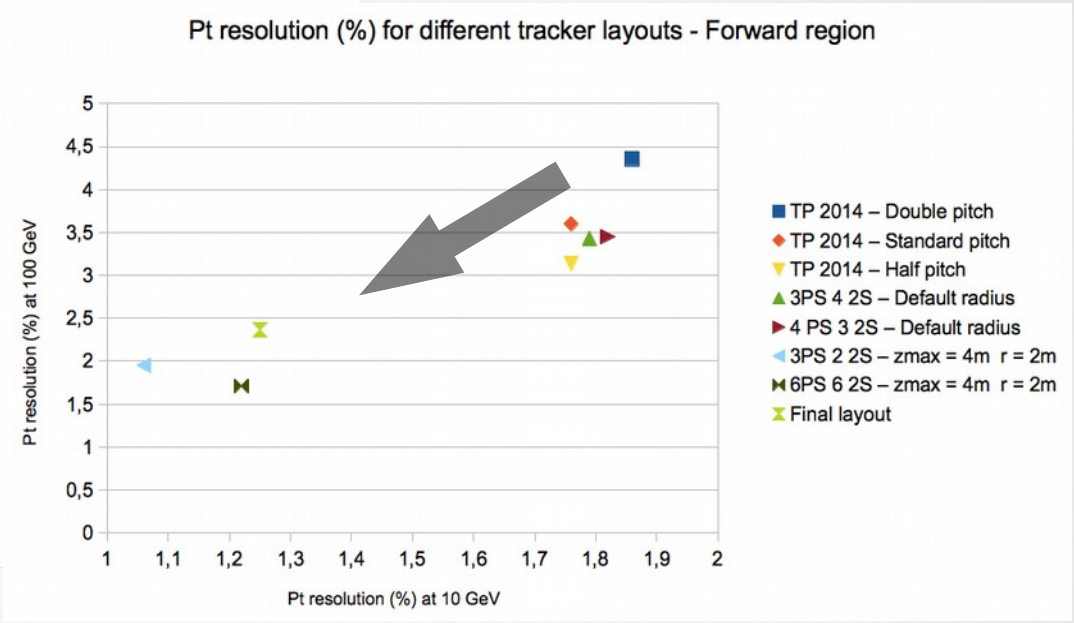
90592 Modules

1299.5 m² Si

487 kw

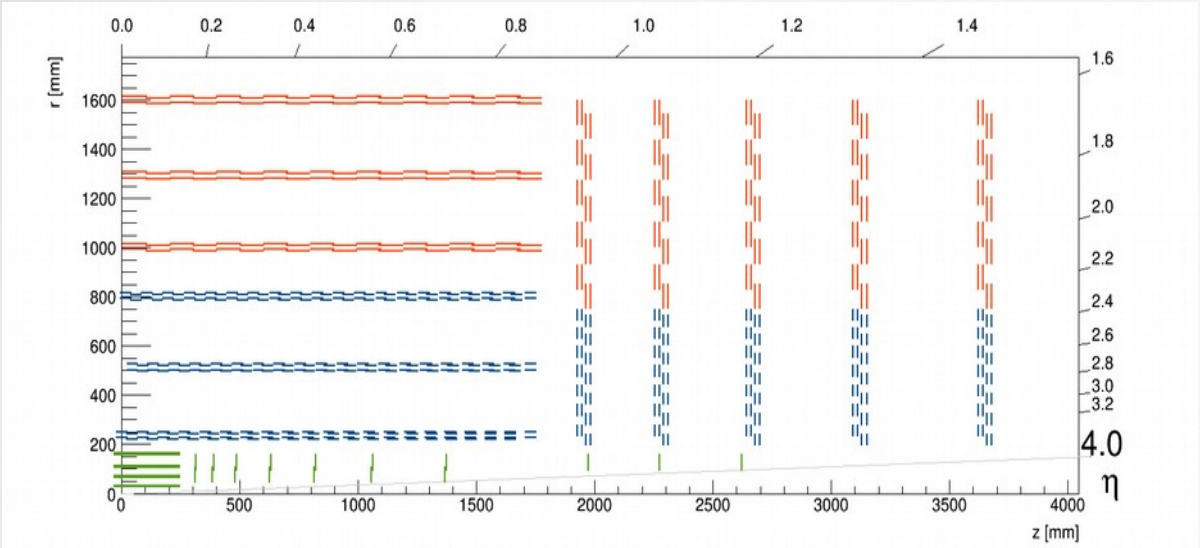
Comparison of all Tracker Layouts

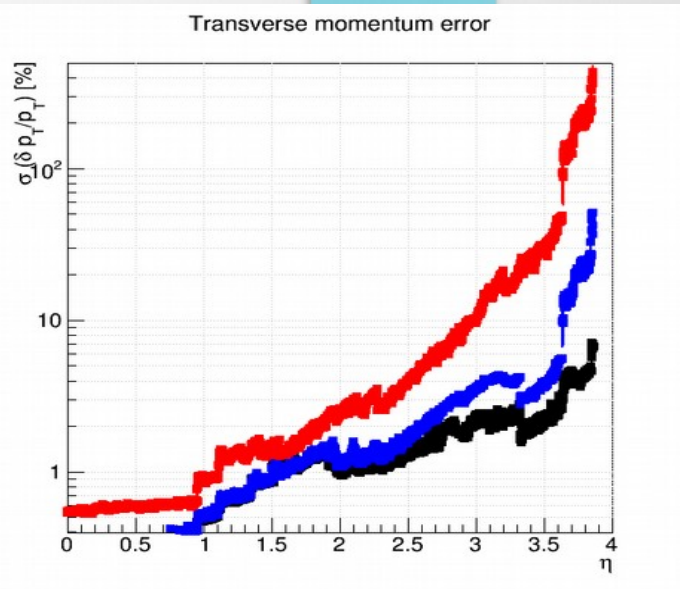


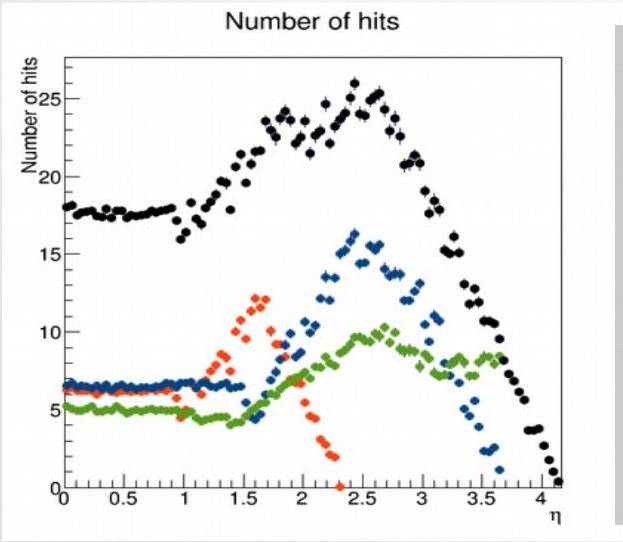


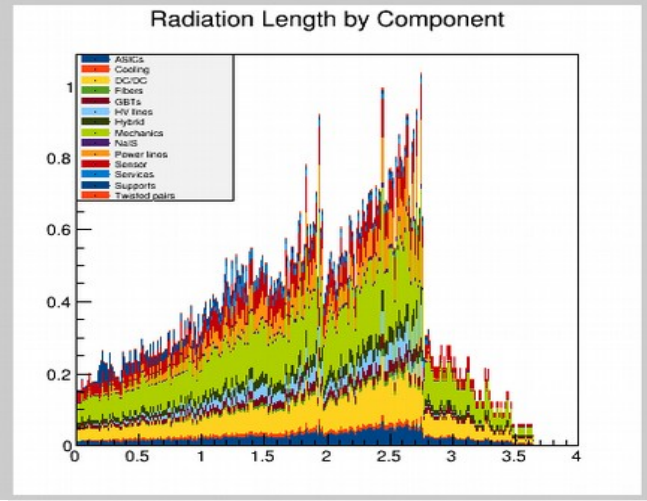
- Extension of the leverarm is more important than other parameters
- We concentrate on muons → C**M**S
  - Remove the ECAL, keep the HCAL, for basic jet/non muon measurement

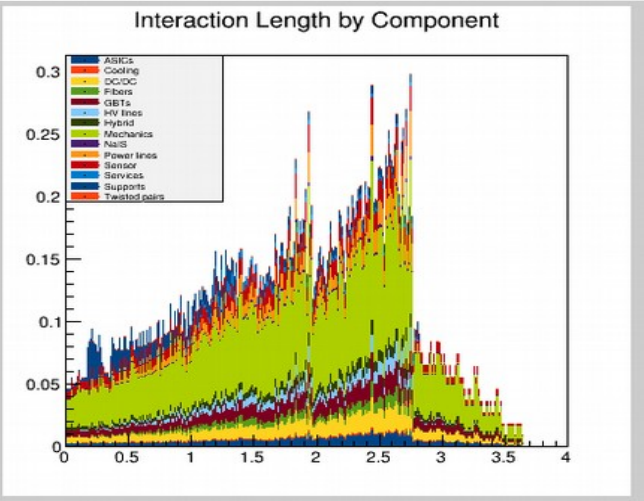
Final Tracker Layout











31586 (50% PS / 50% 2S), 456.4 m² Silicon, 500 mio. channels

Muon Design Considerations

Muon System:

- Used as trigger
- Provide good pT resolution for very forward muons

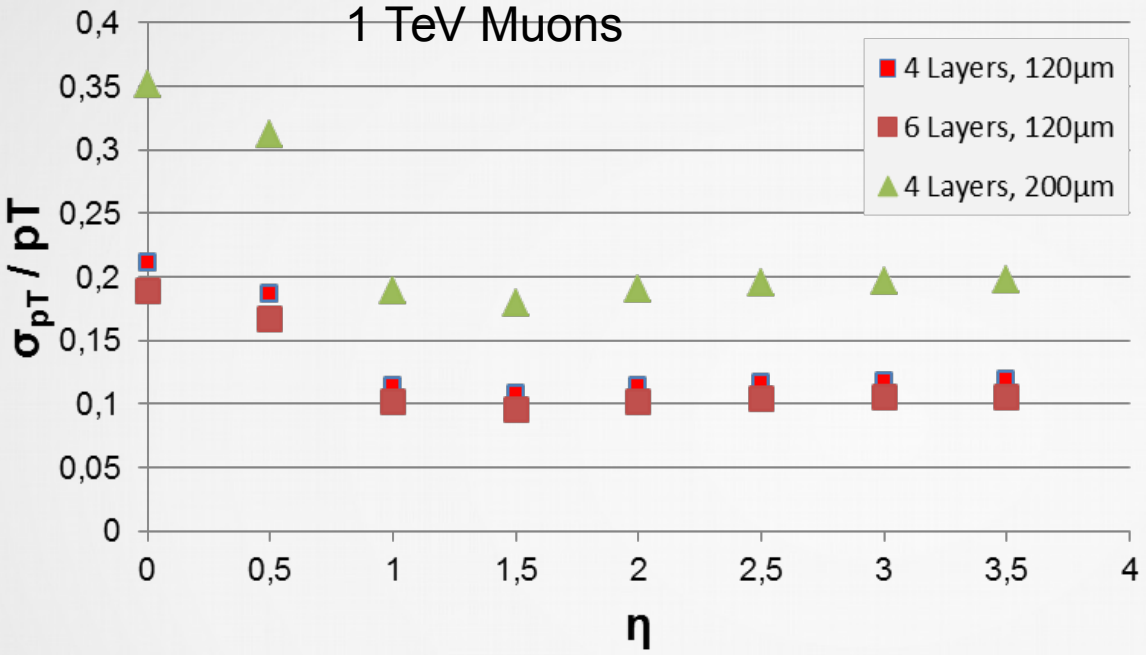
Improvement Options:

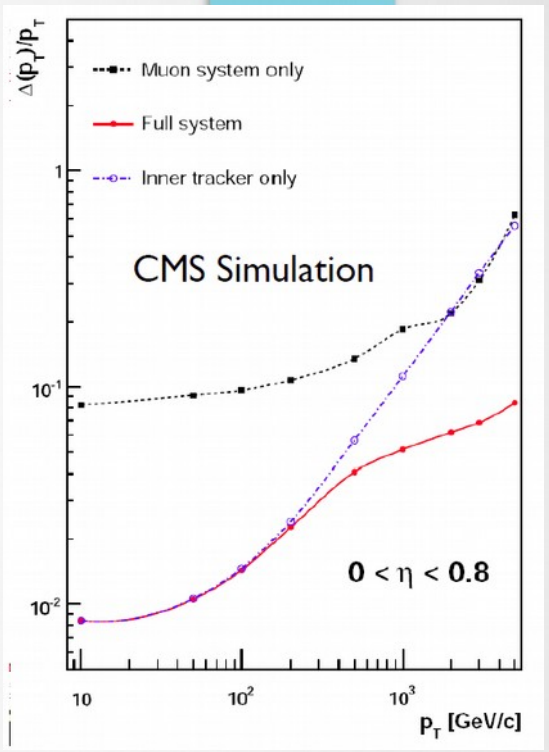
- Higher magnetic field strength
- Larger magnetic field & muon system
- Higher spatial resolution
- More layers in the forward region

Final Muon System:

- 2 double layers of GEMs, 2 layers of CSCs
- Single hit resolution 120µm
- Dimensions: 3m in Y, 4m in Z-Direction
- Limited by cavern size and the magnet we chose to keep

Muon System Resolution

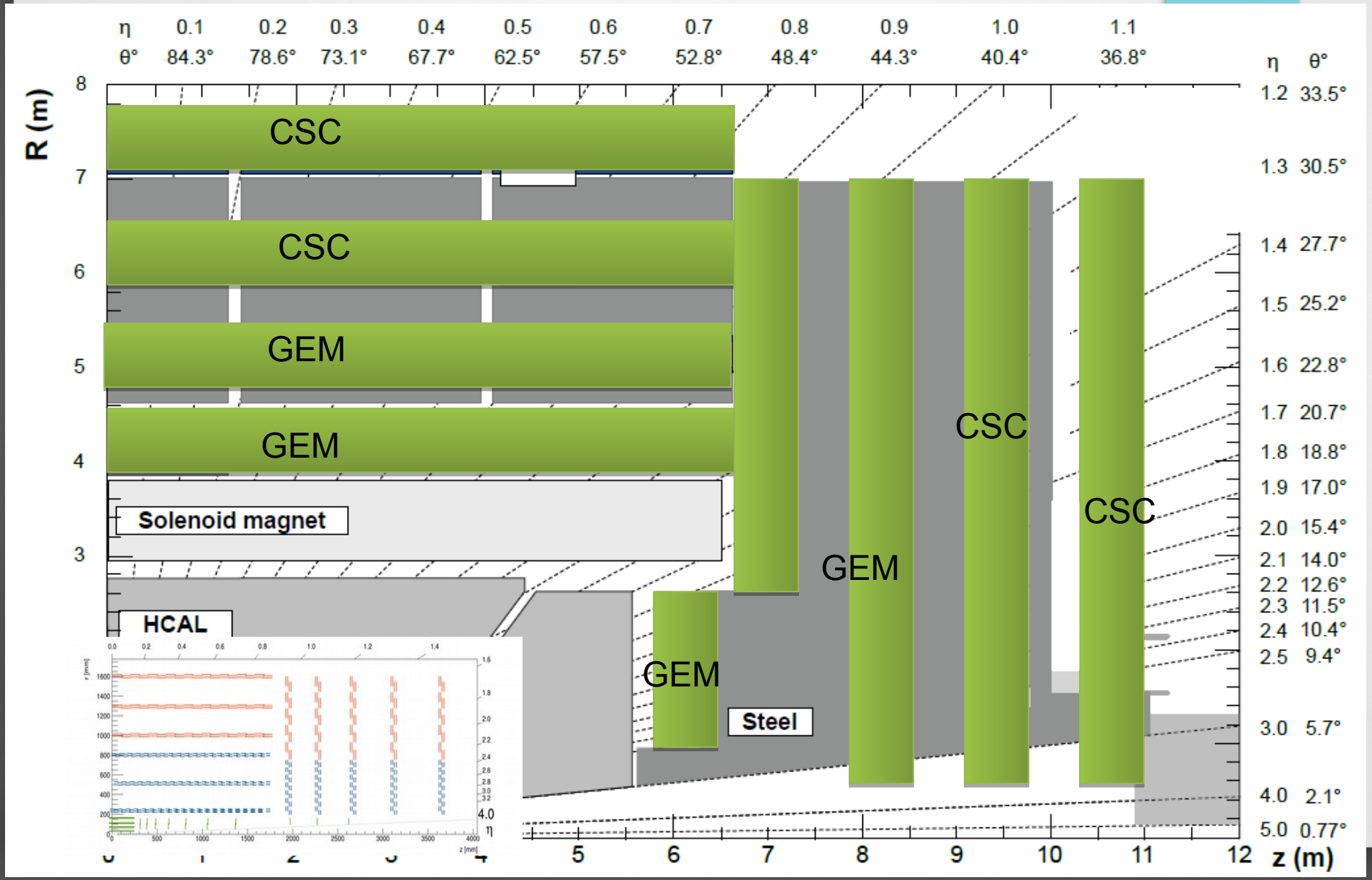




- For low eta muon system has worse pT resolution than tracker
- 1TeV muons in the foreward region performance of both systems is comparable

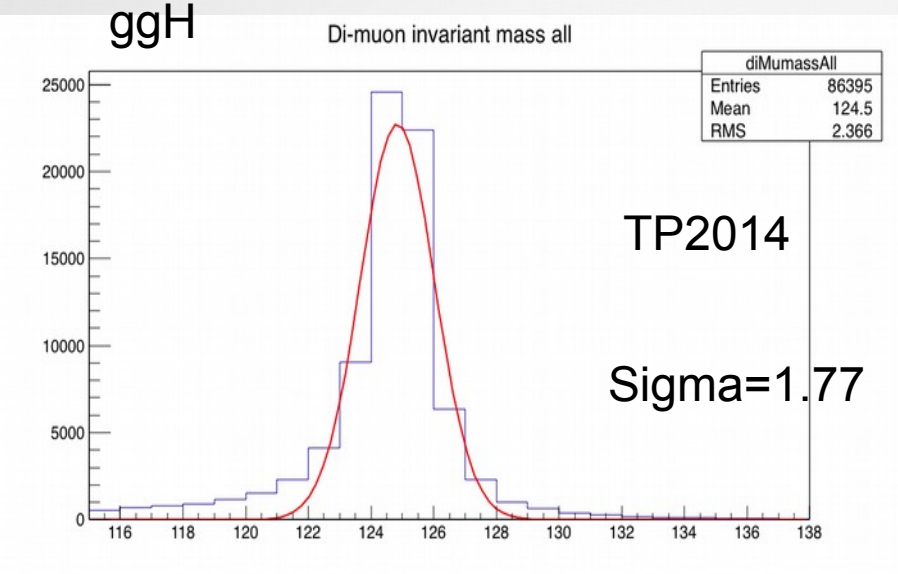
- Better resolution when combining both measurements
- we assume 50% of tracker σ_{pT} / pT (for T' analysis only)

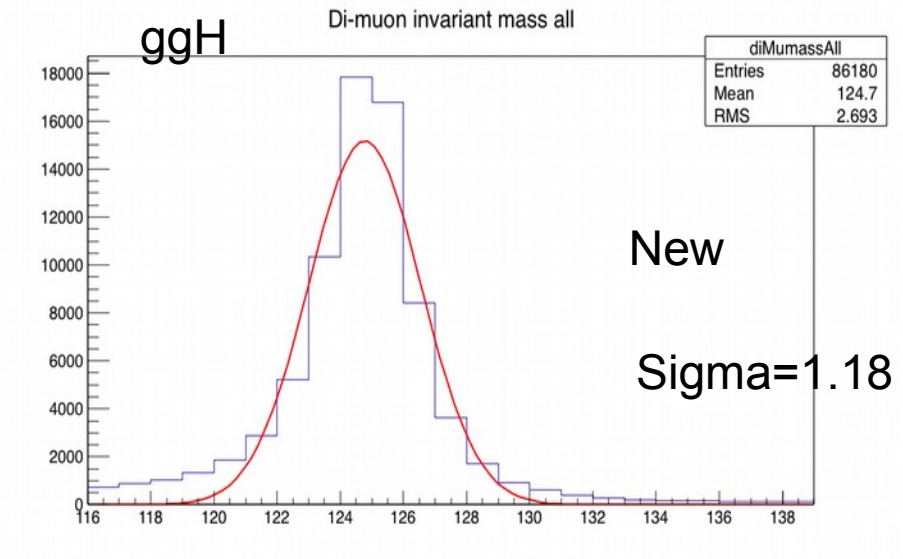
Overall CMS configuration



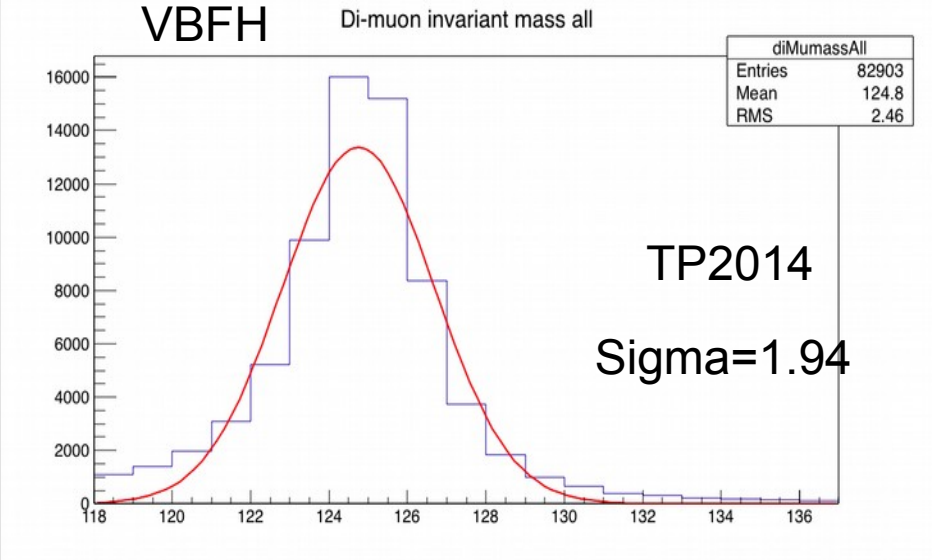
Signal Resolution

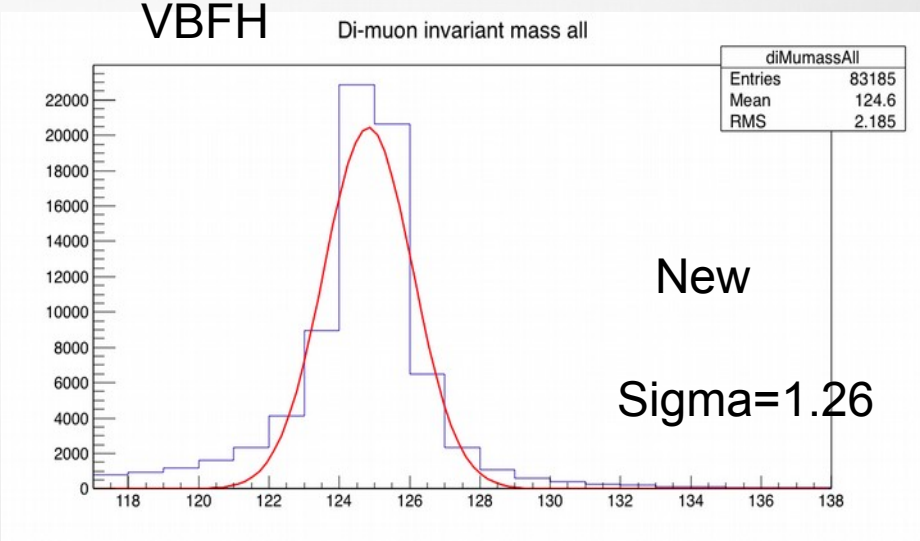
ggH



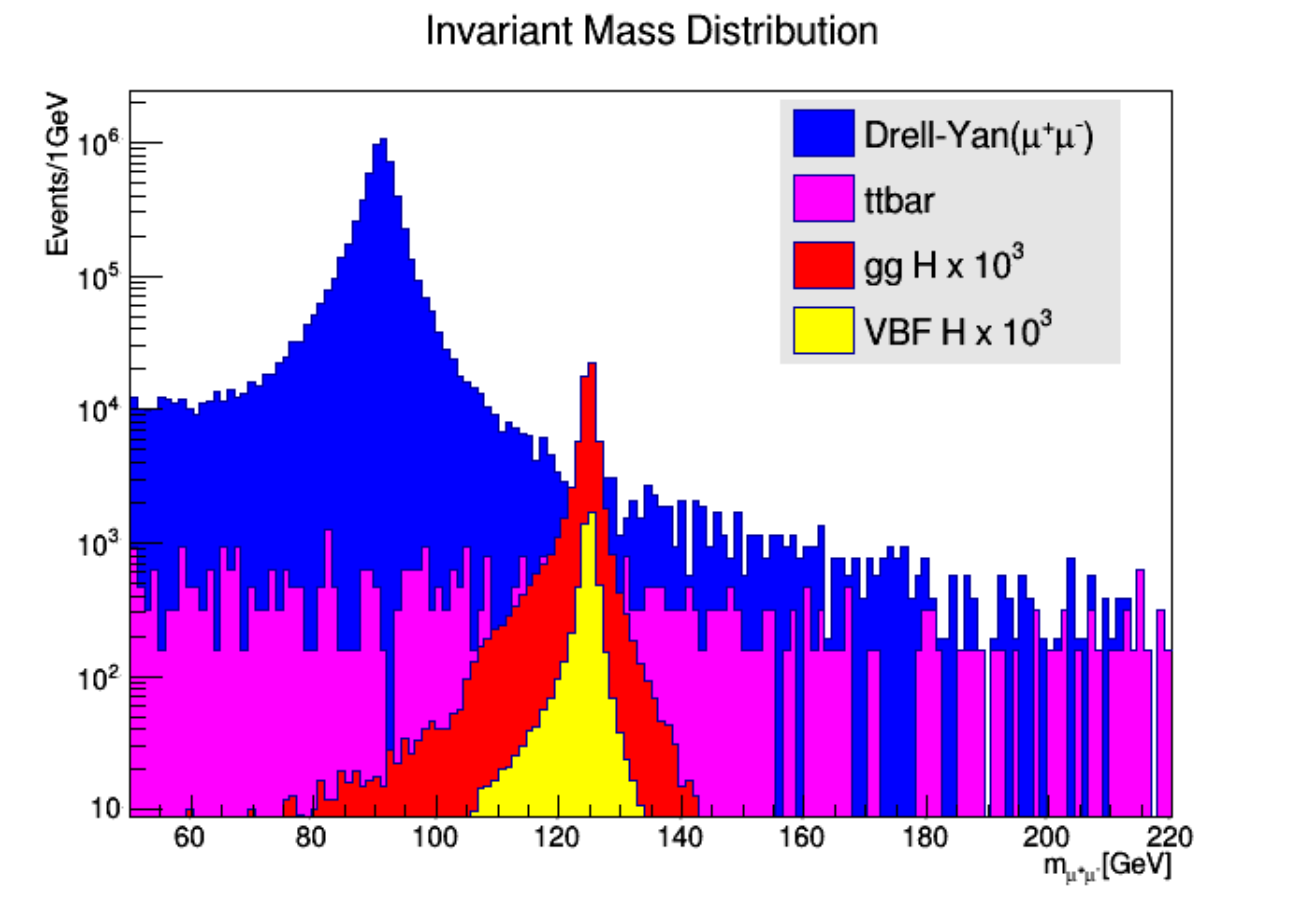


VBFH



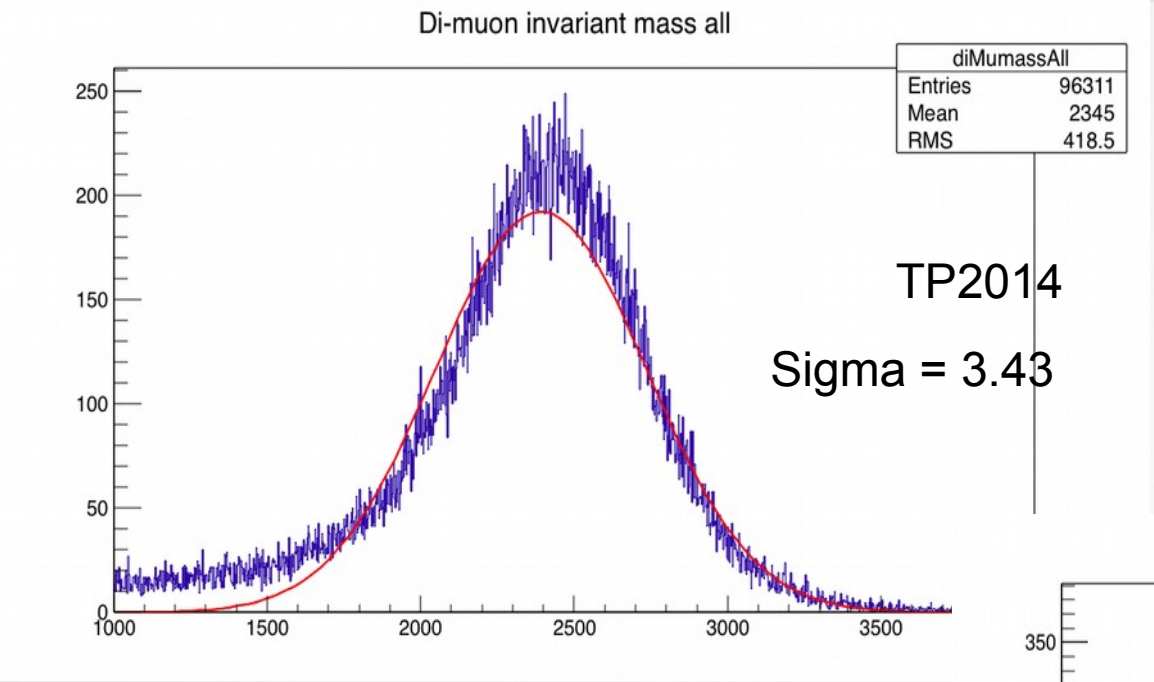


ggH and VBFH “Analysis”



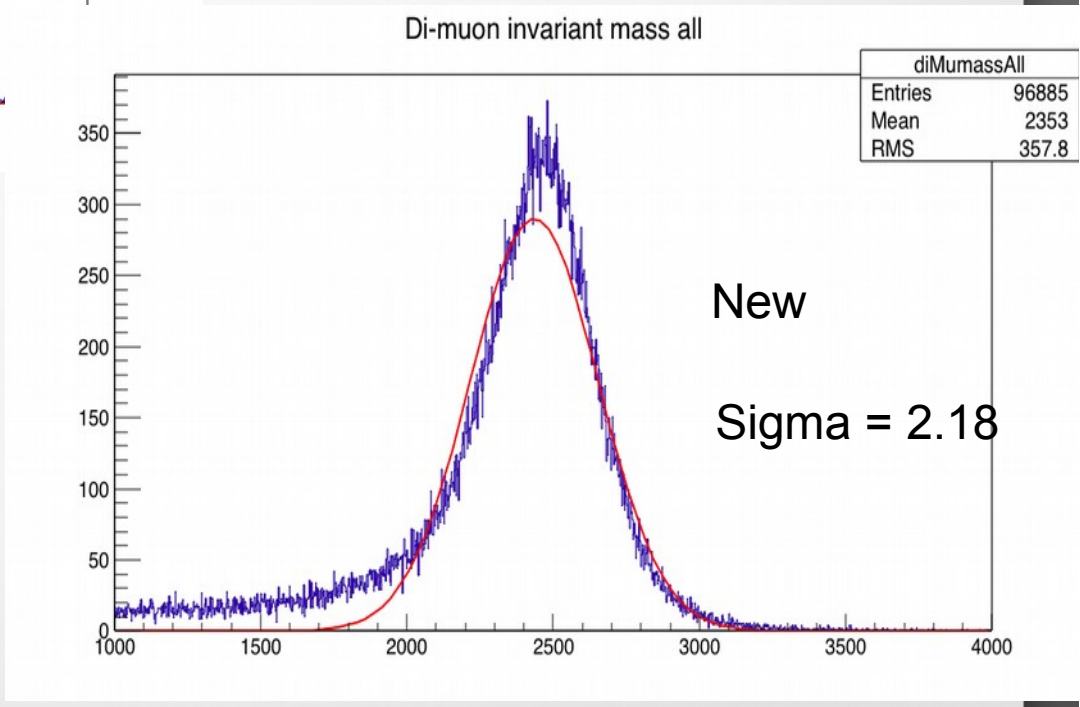
- Event processed:
  - DY=340000
  - ttbar=XX
  - ggH=100000
  - vbfH=94000
- Basic cuts on muon pT and eta
- Significance:
  - 2.78 in [120, 130]GeV

Signal resolution Z'



TP2014

Sigma = 3.43



New

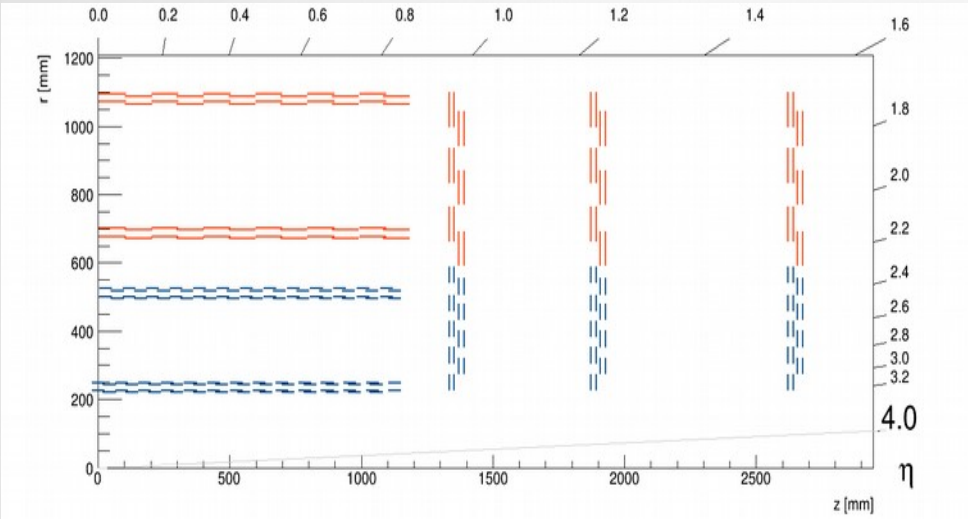
Sigma = 2.18

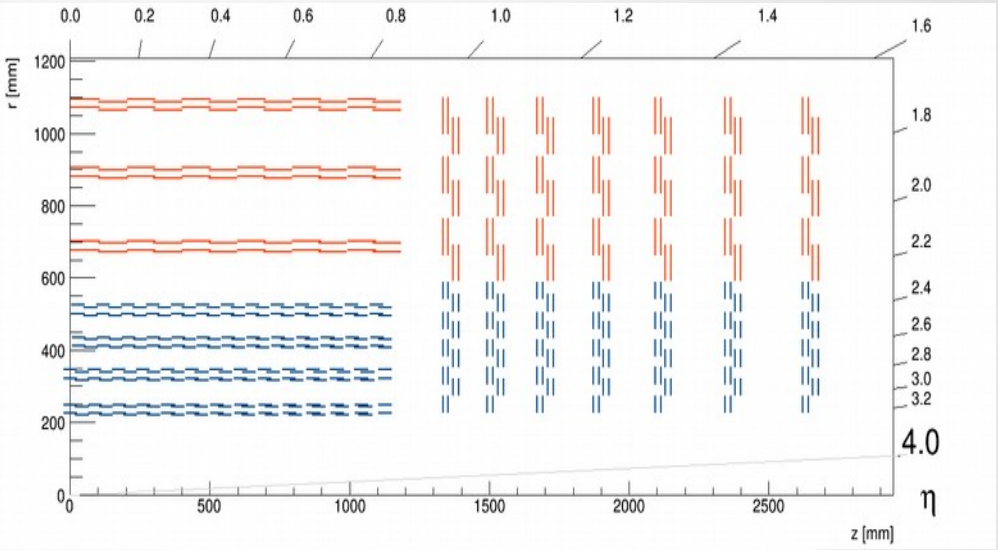
Summary

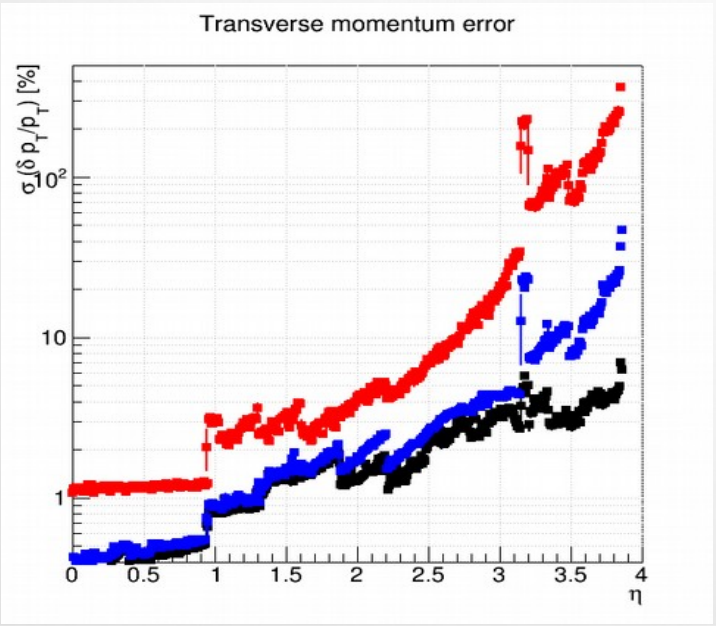
- Optimized the CMS Tracking Detectors for muon only experiment (removal of ECAL)
- Obtain a better pT-resolution and therefore dimuon mass resolution for our new geometry (w.r.t TP2014)
  ~ 30-50 %
- Significance in the Higgs analysis ~2.78 @ 3000/fb

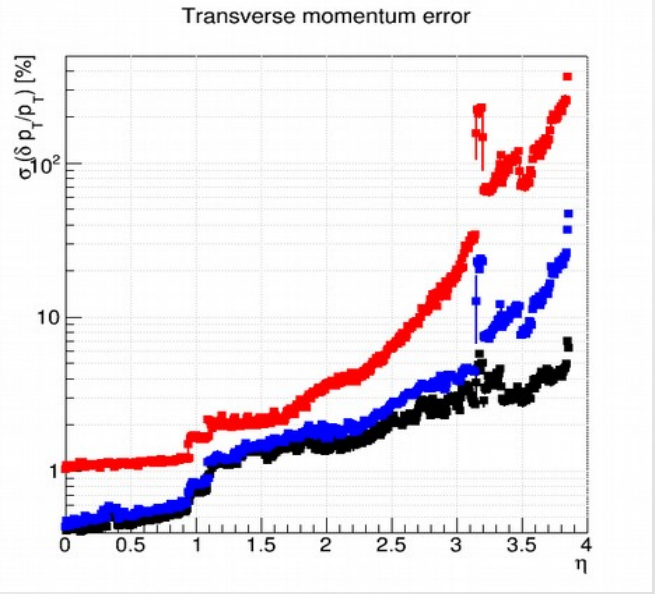
Backup

No layers


r [mm]
z [mm]
η

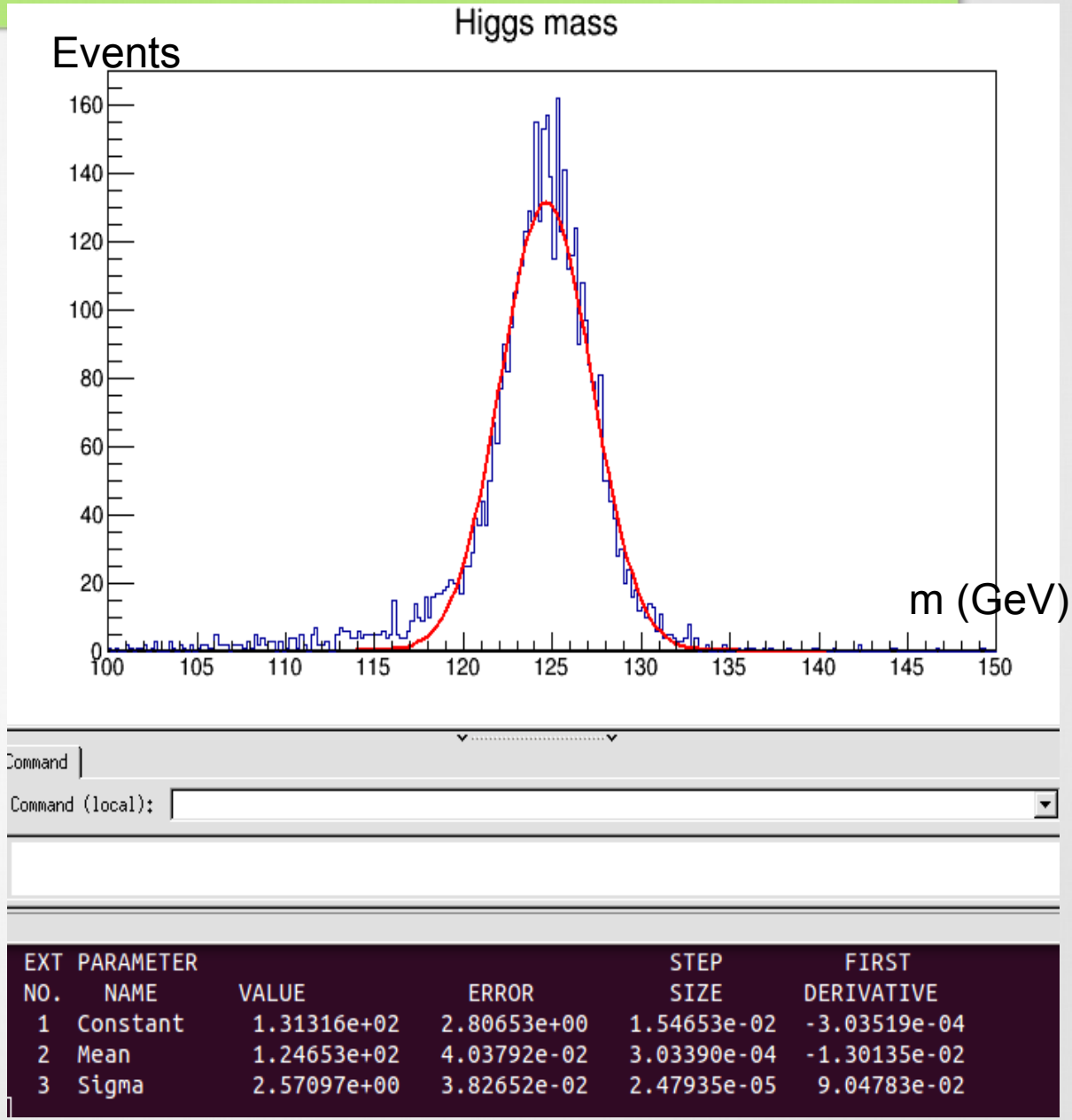

r [mm]
z [mm]
η


Transverse momentum error
σ(δ p_T/p_T) [%]
η


Transverse momentum error
σ(δ p_T/p_T) [%]
η

First steps

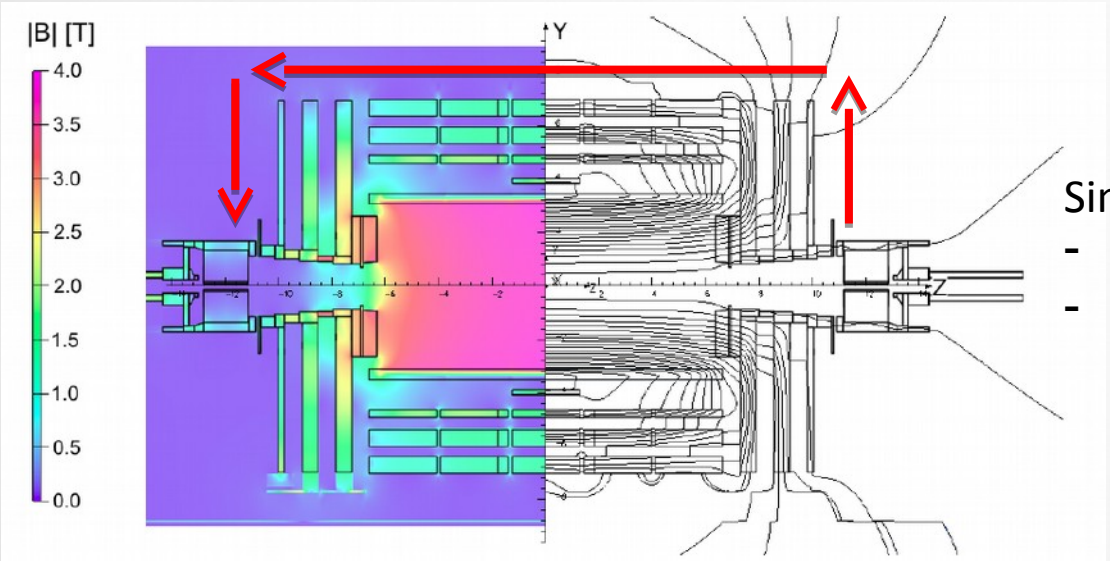
- Analyze the signals to have information about the pt and η distributions
-
- Example:
  Invariant mass combination for 3 merged VBF events



EXT NO.	PARAMETER NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	Constant	1.31316e+02	2.80653e+00	1.54653e-02	-3.03519e-04
2	Mean	1.24653e+02	4.03792e-02	3.03390e-04	-1.30135e-02
3	Sigma	2.57097e+00	3.82652e-02	2.47935e-05	9.04783e-02

CMS Magnetic fiel

Simulation of the CMS magnetic field [1]:



Simplified model used:

- Straight field lines
- Constant field (2T) in the whole yoke

[1] CMS Collaboration, “Precise Mapping of the Magnetic Field in the CMS Barrel Yoke using Cosmic Rays”
http://arxiv.org/pdf/0910.5530v2.pdf