Alternative Layouts

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@ AUW, Plenary Tracker Phase-II
22/11/2012

For Alternative Layouts Task-Force:
***SB**, A.Clark, B.Heinemann, A.Salzburger,*
***T.Todorov**, P.Wells*

Outline

- Scope of the task-force

- Main parameters of alternative layouts

- Comparison to the LOI layout

- Plans

Scope

- Design of layouts alternative to the baseline LOI layout
  - So far the main focus was on the pixel detector
  - The layouts covered in this presentation
    - Alpine
    - Conical
    - 5-layer pixel
    - Very forward pixel extension (first thoughts)
- The main goals are
  - Improve the performance of the Inner Tracker
  - Make it cheaper if possible
  - Simplify the construction
- The approach
  - Extending classical designs
    - 5-layer
    - Very forward pixel extension
  - Using new engineering solutions
    - Bent stave → Conical
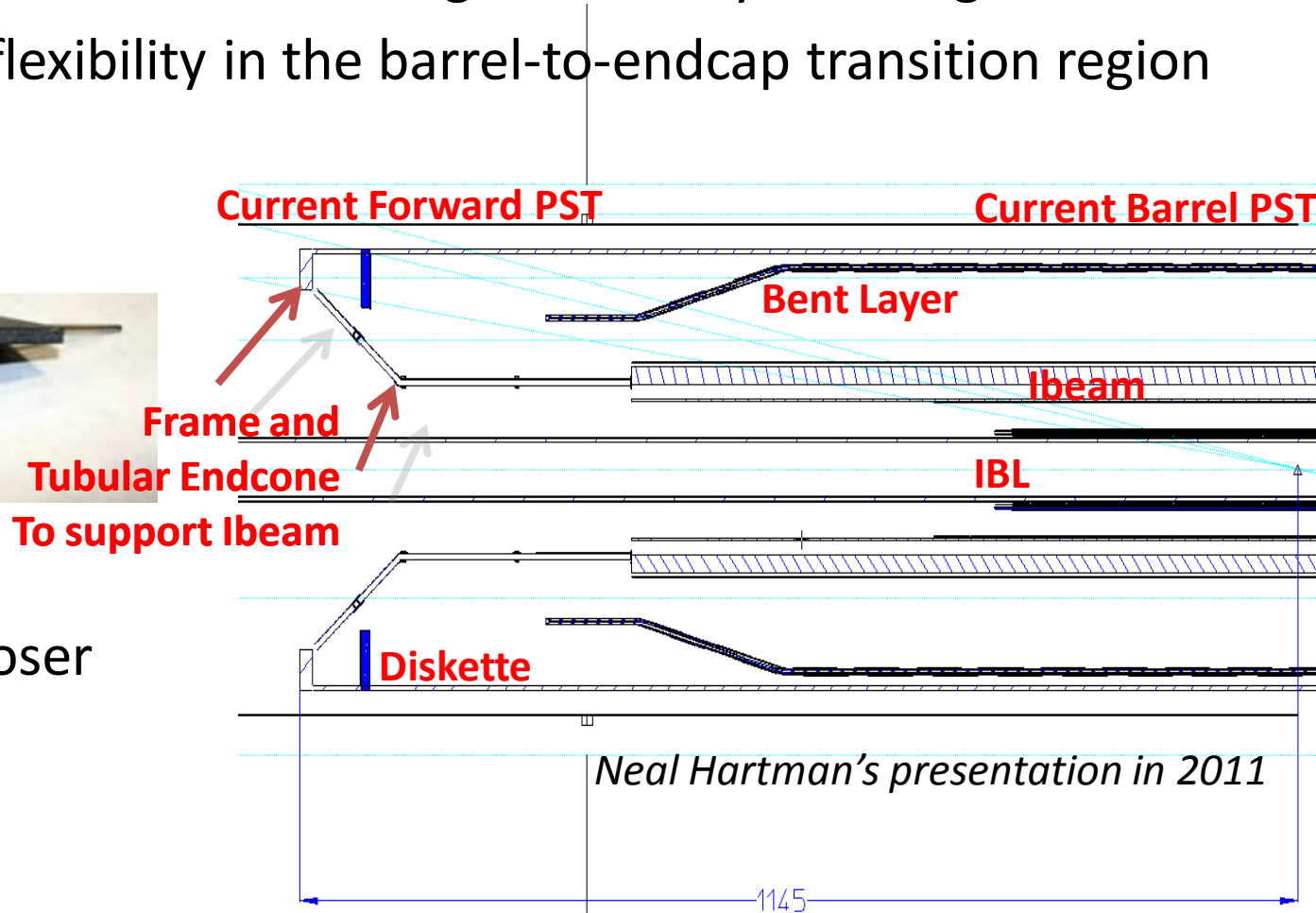   - Alpine stave
  - Combination

5-Layer Pixel Layout

ID geometry from baseline.geom 16:18:25 18/11/12

LOI
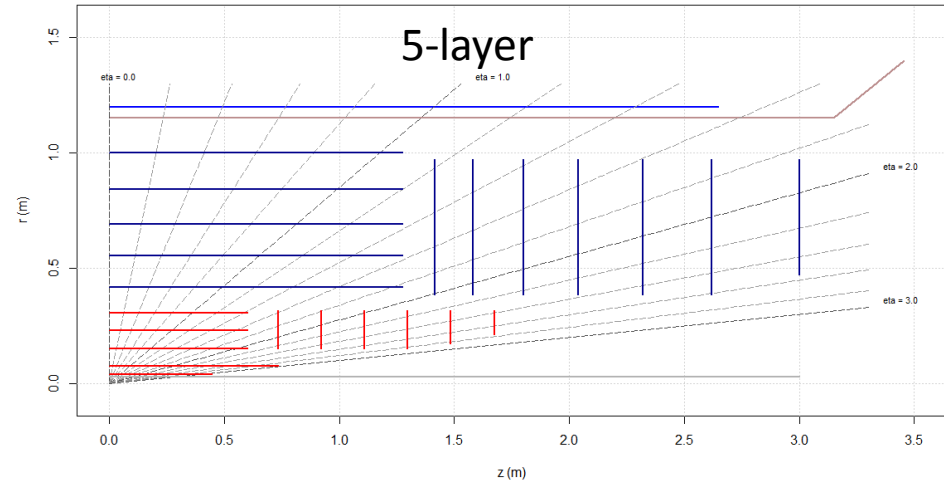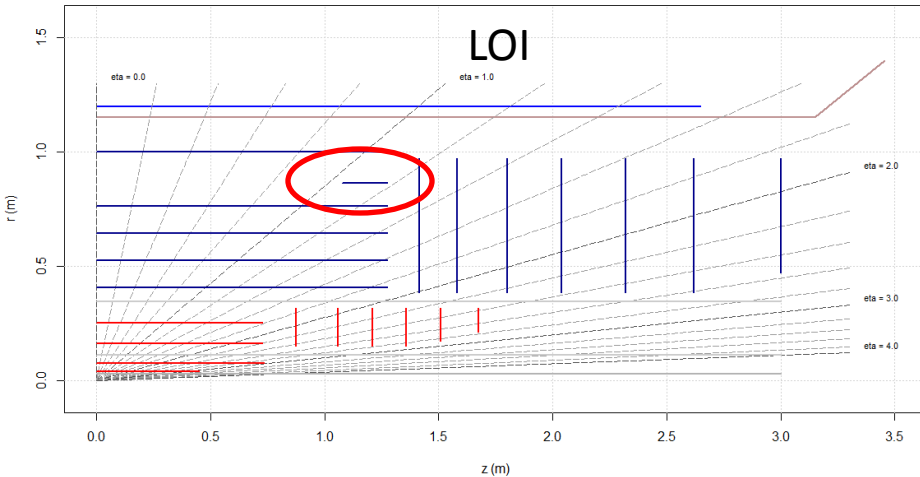
5-layer

- Part of the motivation is to remove the strip stubs but keep the same or larger number of space points
- Barrel strip layers repositioned
- Pixel barrel made shorter and end-cap disks repositioned to have the same coverage
- 5 pixel layers should improve the pattern recognition
  - Possibly special tracking is required to see full advantage
  - Could this help further simplifying the strip detector?
- Details: B. Heinemann, et al.
  https://indico.cern.ch/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=201771
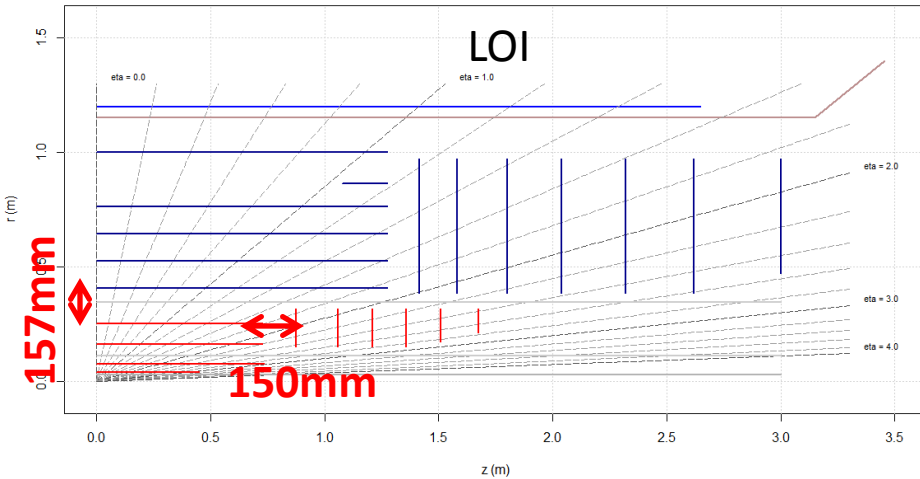
Bent Staves

- Suggested by Maurice Garcia-Sciveres and Neal Hartman
- The conical layout evolved following the LOI layout design
- Bent staves add flexibility in the barrel-to-endcap transition region
 - Shorter staves
  - Larger radius

Current Forward PST

Current Barrel PST

Bent Layer

Ibeam

Frame and
Tubular Endcone
To support Ibeam

IBL

Diskette

Neal Hartman's presentation in 2011

1145

- Incident angle closer
to normal at high η

Current Conical Layouts

ID geometry from baseline.geom 16:18:25 18/11/12

LOI

157mm
150mm

ID geometry from layout_LOI_050612conAtuned.geom 17:43:35 15/11/12

Conical A

127mm
162mm
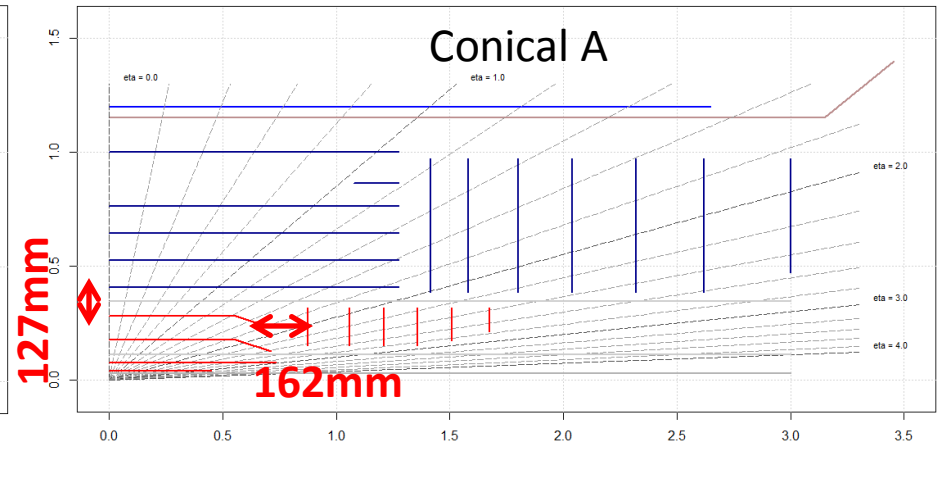
ID geometry from layout_LOI_050612conCtuned.geom 14:37:47 14/11/12

Conical C

157mm
256mm
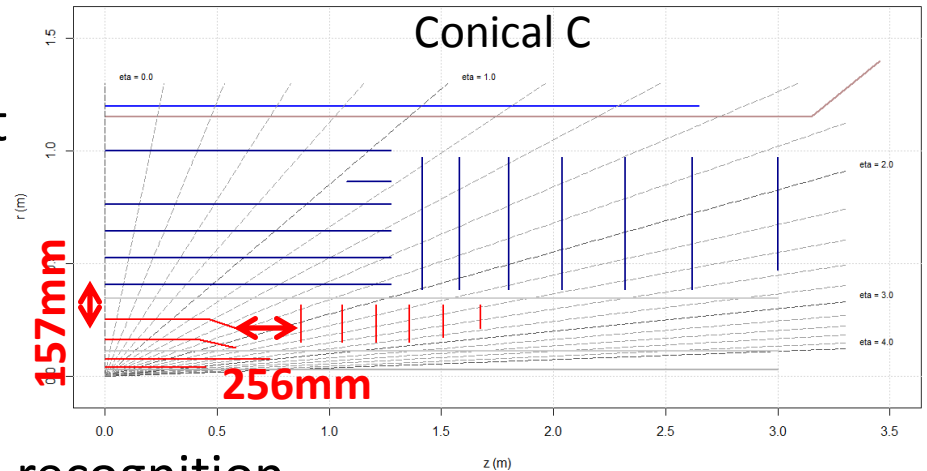
- Using the bent staves the LOI layout could be modified to have larger gaps between the barrel and endcaps and smaller gap between the pixels and strips
- The later could improve the pattern recognition
- Details: S.Burdin, et al.
  https://indico.cern.ch/getFile.py/access?contribId=0&resId=0&materialId=slides&confId=201771

Parameters in Geo Model

- Pixels

	LOI	Con A	Con C	5-layer
2nd layer R (mm)	160.0	175.0	160.0	150.0
2nd layer Nstaves	32	34	32	30
2nd layer Nmodules/stave	35	35	29	29
3rd layer R(mm)	250.0	280.0	250.0	227.5
3rd layer Nstaves	52	58	52	48
3rd layer Nmodules/stave	35	35	31	29
4th layer R(mm)	--	--	--	305.0
4th layer Nstaves	--	--	--	64
4th layer Nmodules/stave	--	--	--	29
Total N of outer modules	**2940**	**3220 (+10%)**	**2540 (-14%)**	**4118 (+40%)**

	LOI	5-lay
$N_{intermediate}$	11232	11960
N_{outer}	7168	6968
Sum	18400	18928

- Strips

IDRES comparisons
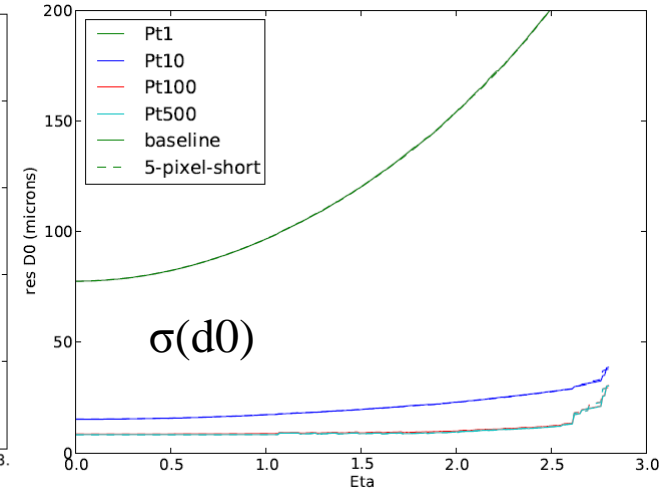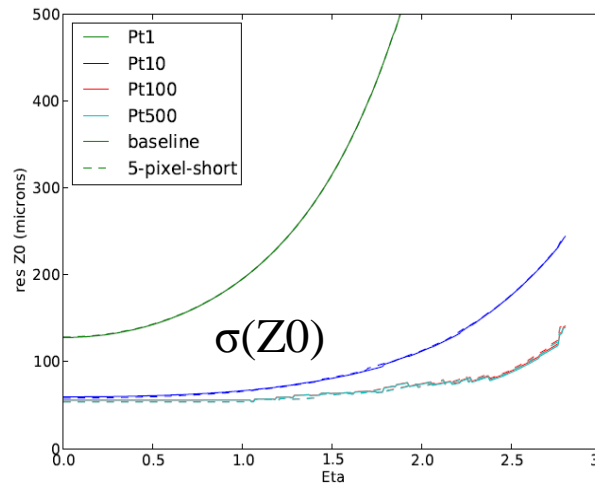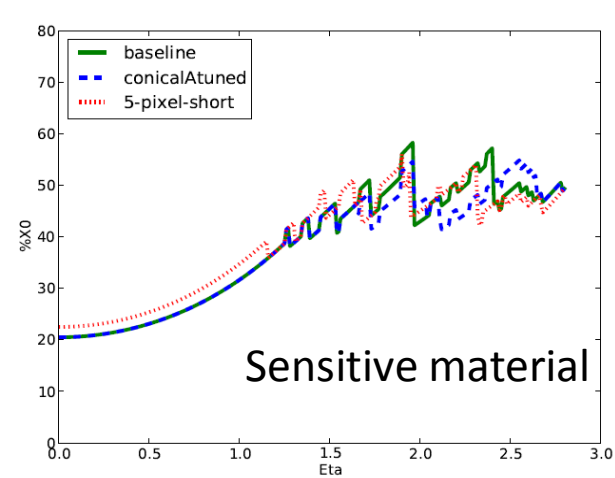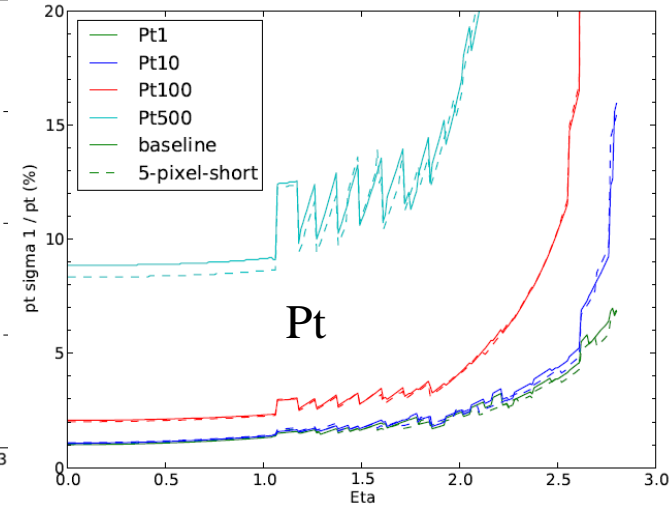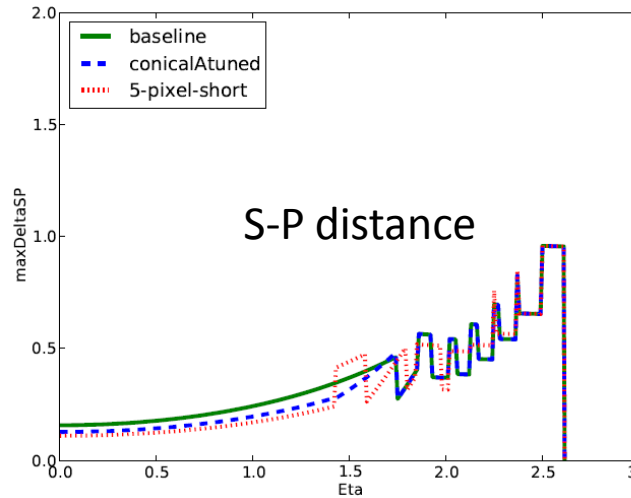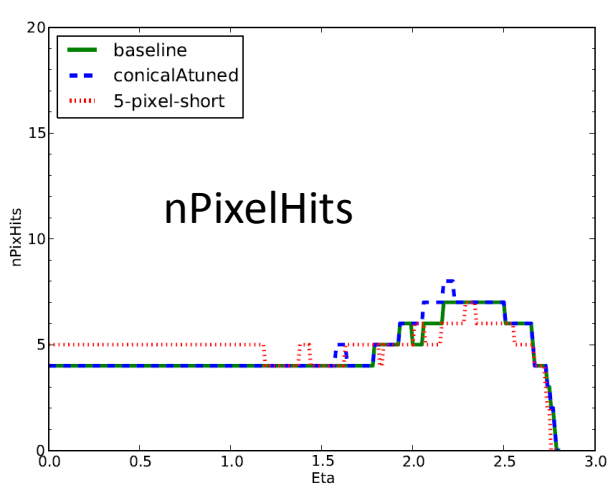
- Expecting no differences in resolutions up to very high Pt

Towards Full Simulation

- **5-Layer Pixel and conical layouts implemented in the GeoModel**
  - Need to tune placement of services for the conical geometries
- **First FATRAS single-particle simulations confirm that the resolutions and efficiencies are similar for all layouts**
  - Some differences could be for the low energy electrons and pions due to the material
- **More tests will be done with the FATRAS after the material tuning**
  - Multiparticle events
- **Full simulation requires manpower and expert help**
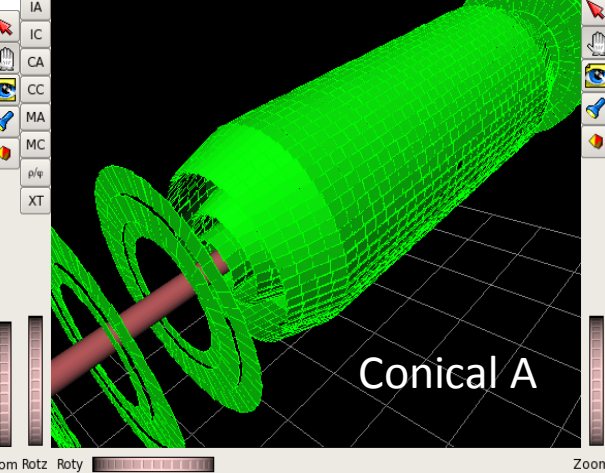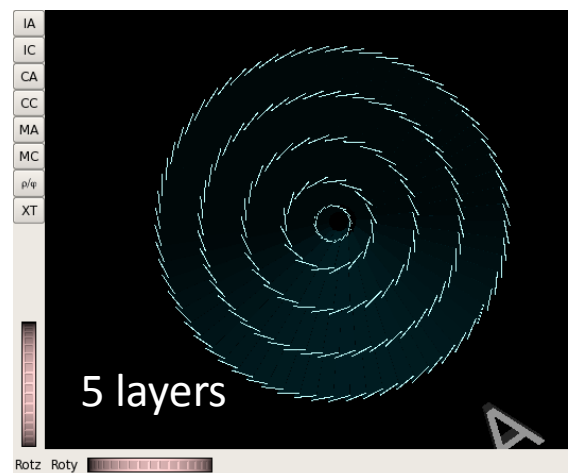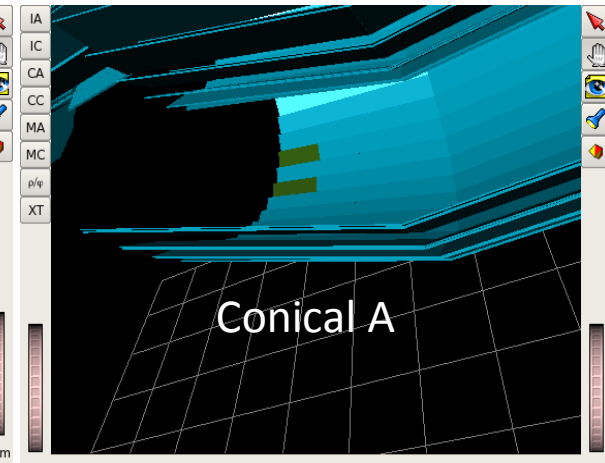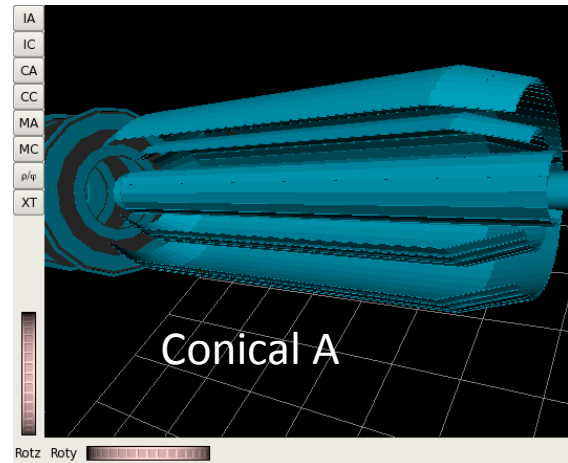
Alpine Staves

Ideally: constant track density (pixel occupancy) in all sensors

The track density is constant in eta at LHC

• Achieved on a cylindrical surface -> barrel-only layout?
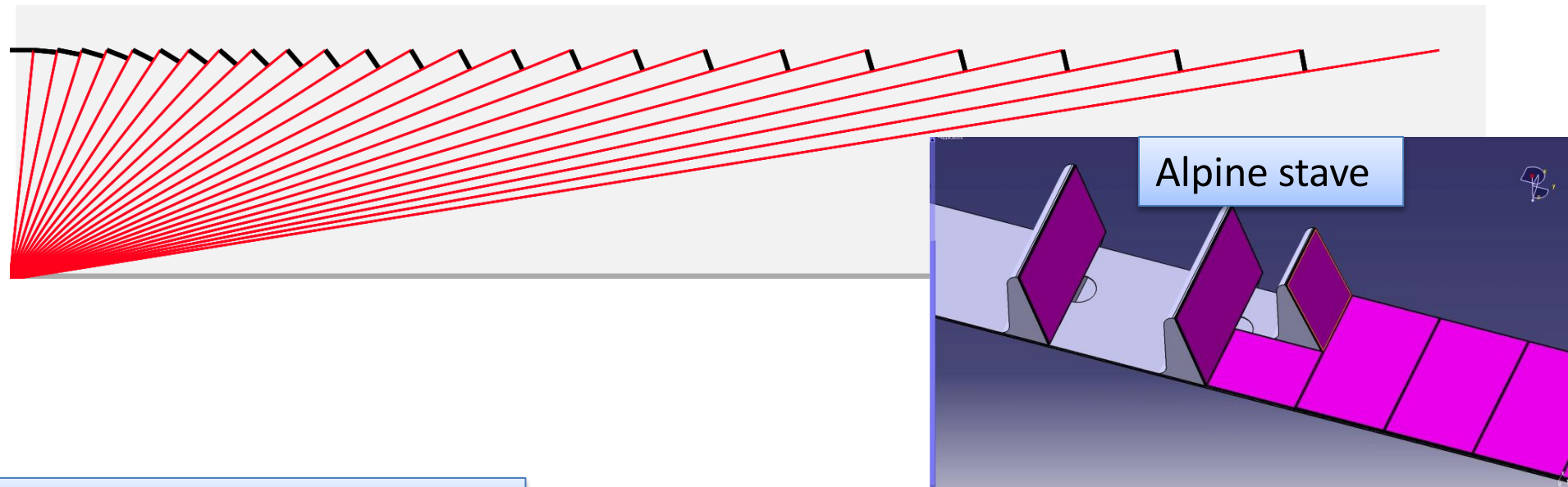
Alpine stave

Stave placement with phi overlaps

Hermetic layer of Alpine staves seen from the interaction point
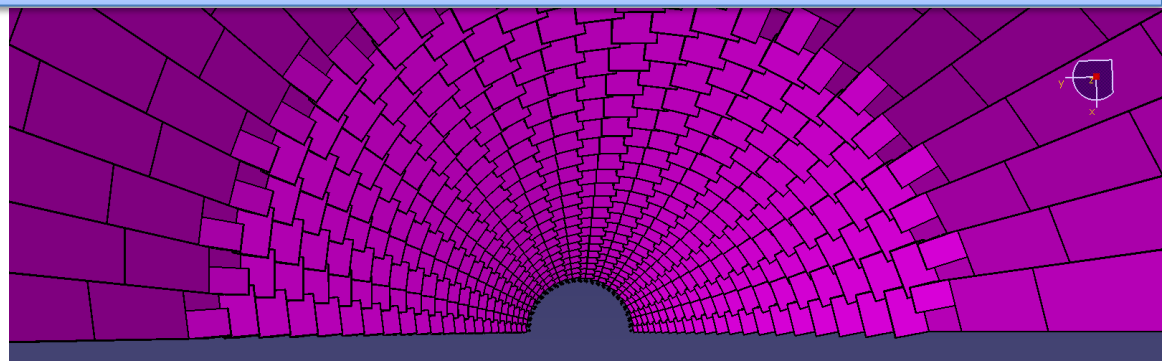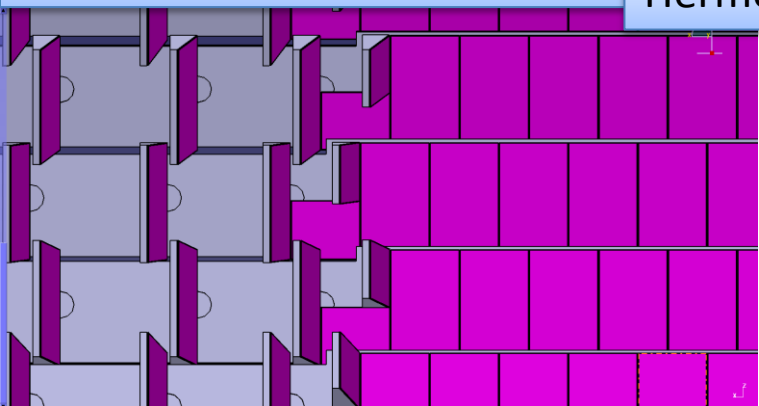
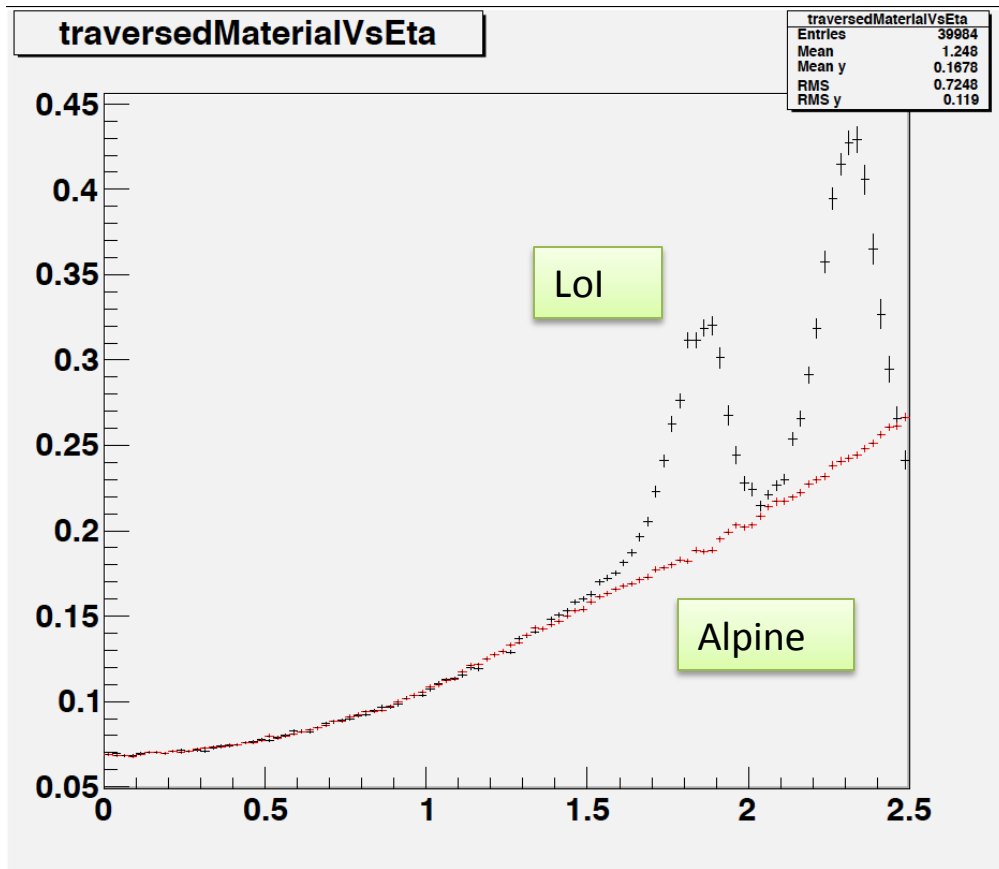# Alpine Layout VS LOI Layout

Alpine pixel layout
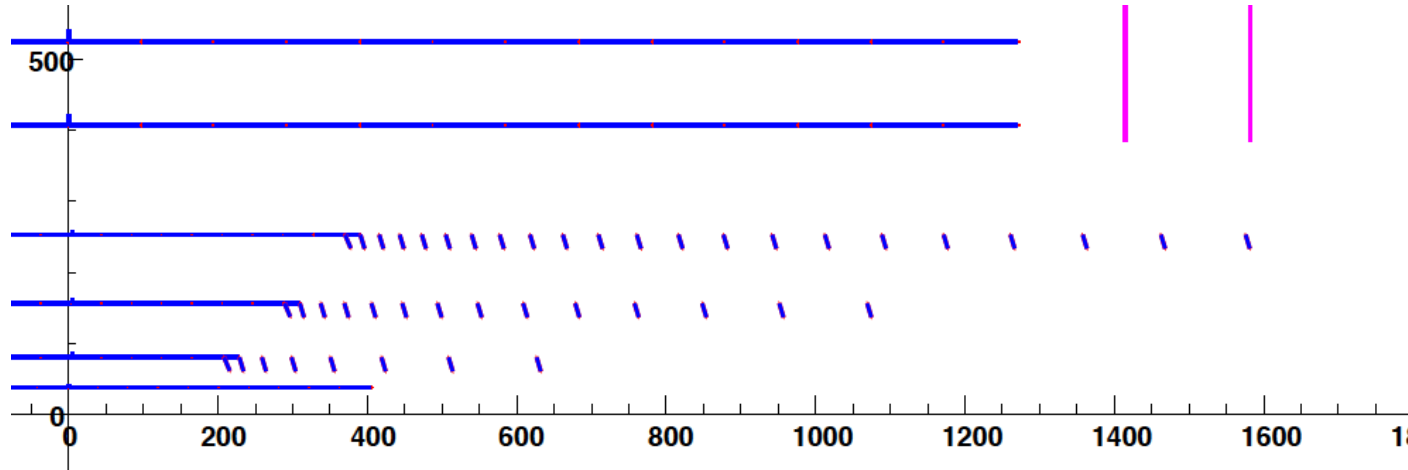
4.6 m² pixel area

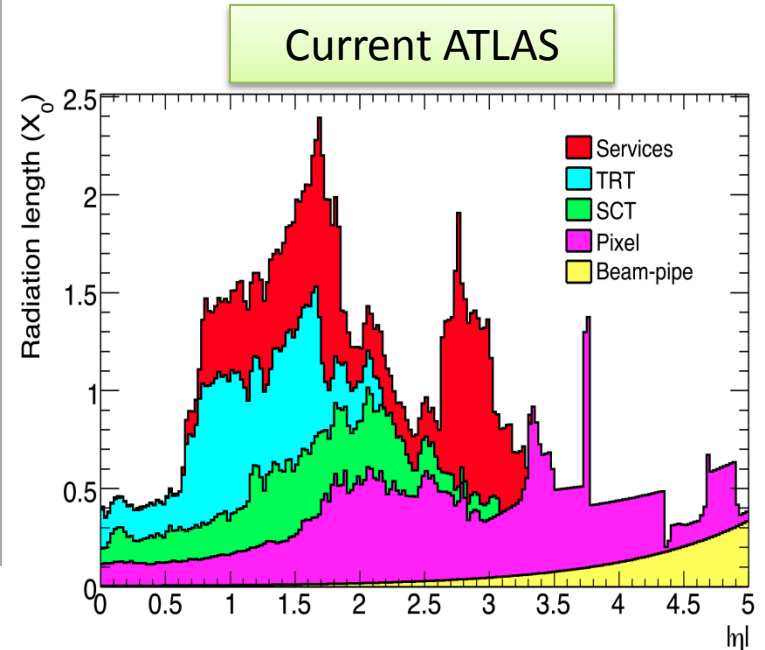*Details in T.Todorov's presentations*

Letter of Intent baseline pixel layout
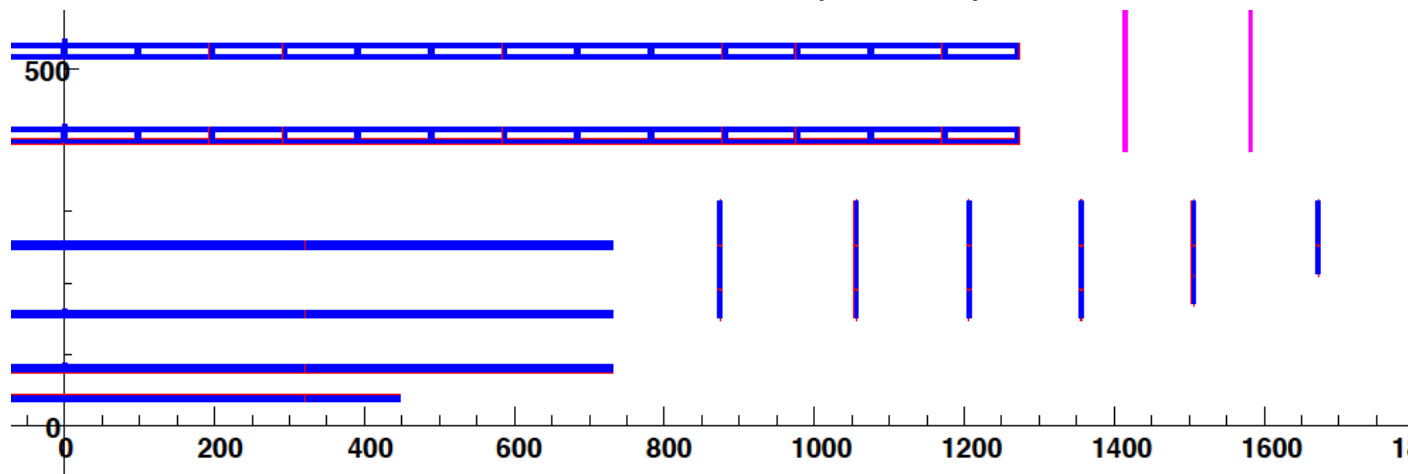
8.2 m² pixel area

Alpine Material Comparison

traversedMaterialVsEta

traversedMaterialVsEta	
Entries	39984
Mean	1.248
Mean y	0.1678
RMS	0.7248
RMS y	0.119

LoI

Alpine

LoI: EOS cards only, no cables, no pipes

- In the Alpine layout all material is on the stave
- In the LoI layout the services material is playing a big role

Current ATLAS

Radiation length (X_0)

- Services
- TRT
- SCT
- Pixel
- Beam-pipe

|η|

Service Material in Alpine Layout

All services out of tracking acceptance
(lines correspond to eta=2.5 from z=-15cm)

η=2.5
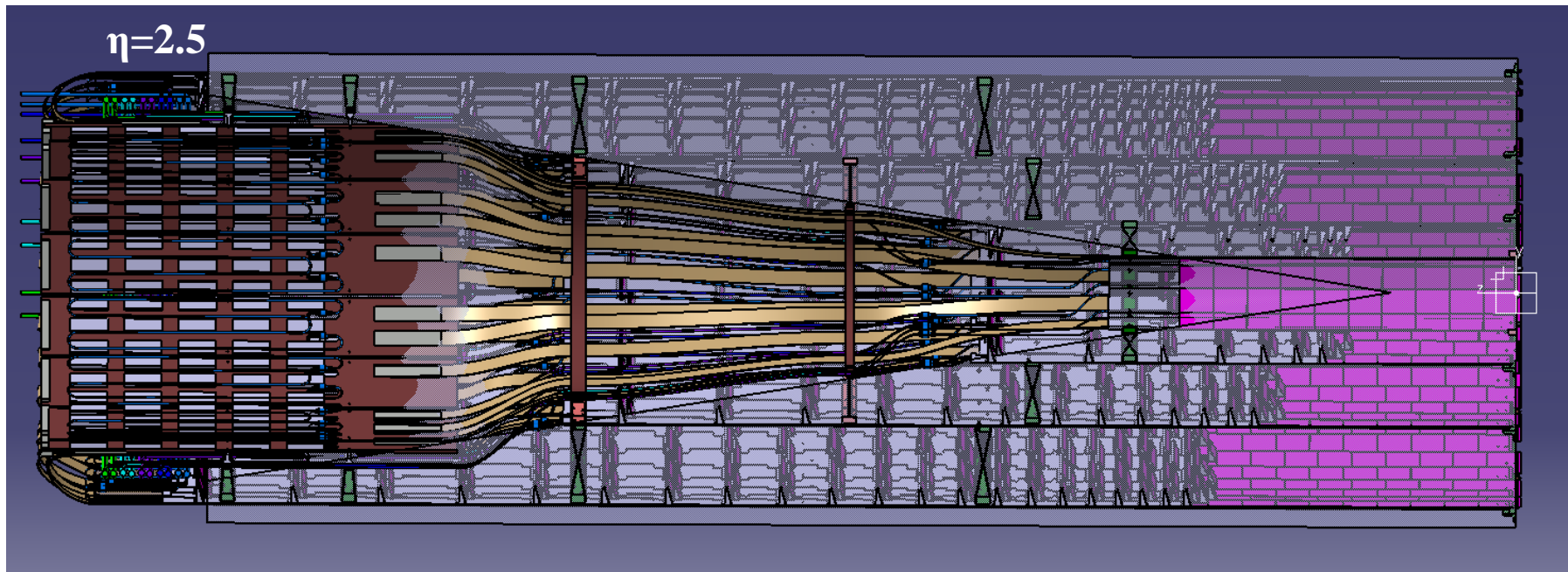
Very Forward Pixel Extension

ID geometry from baselinePlus6disks.geom 18:08:41 18/11/12

VBF

ATLAS
Simulation
14TeV

— VBF H(120)→τ⁺τ⁻→ μμ
··· Z(→μμ) +jets
··· t$\bar{t}$(→μμ) +jets

J.Schaarschmidt@OrsayHH2010

IDRES framework

Alpine framework
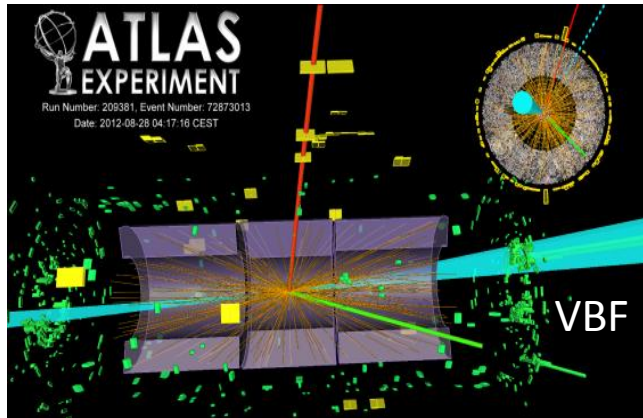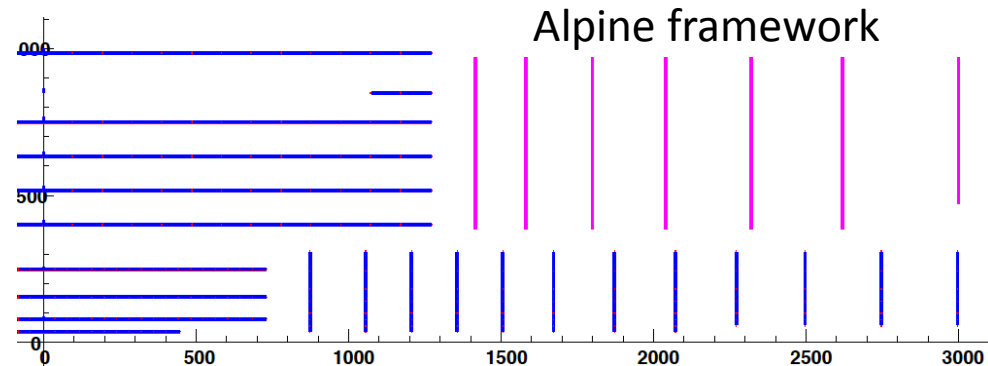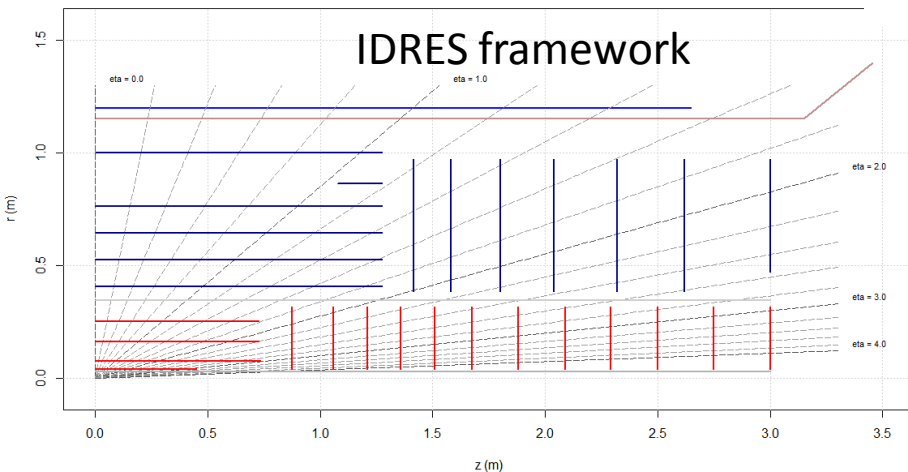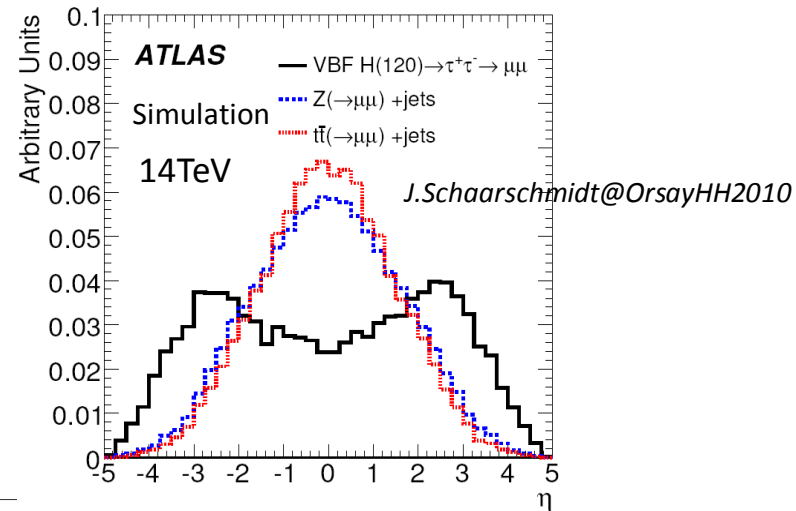
- Very Forward Pixel Extension with tracking capabilities up to η=4 could be useful for VBF processes in particular

- Very preliminary studies show that 1-2mm Z-resolution could be achieved at η=4

Very Preliminary Results
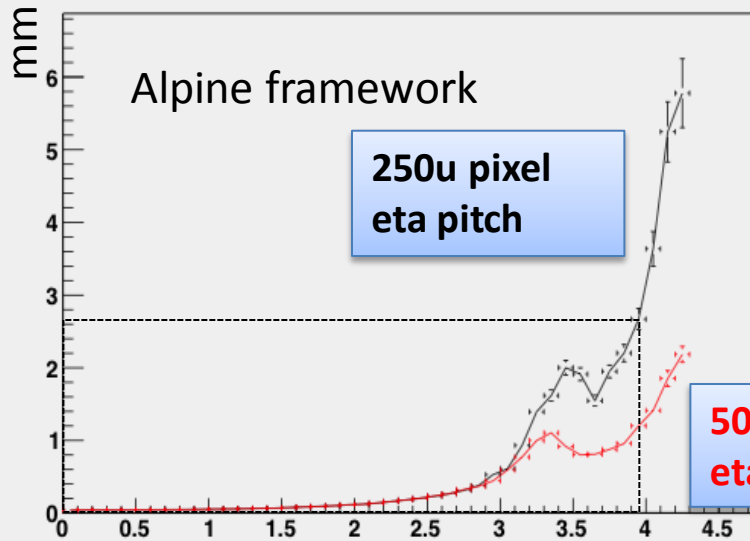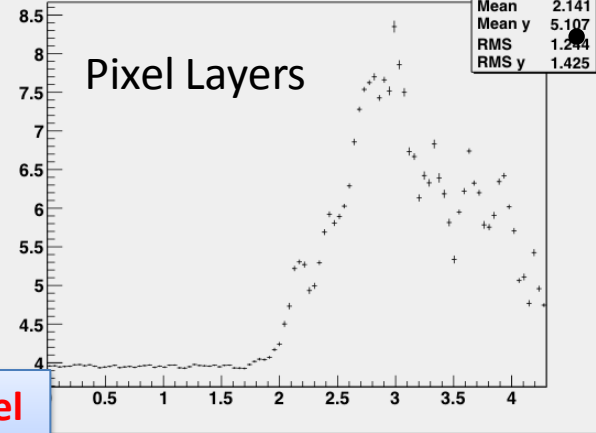
IDRES and Alpine frameworks give similar results for the very forward tracking
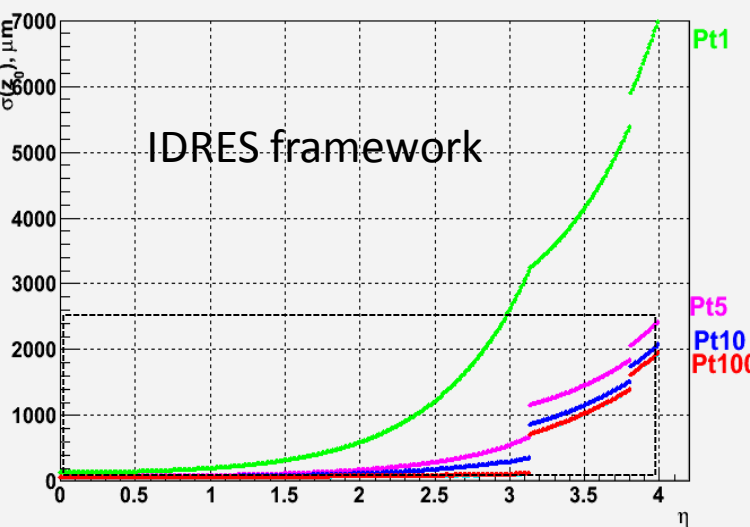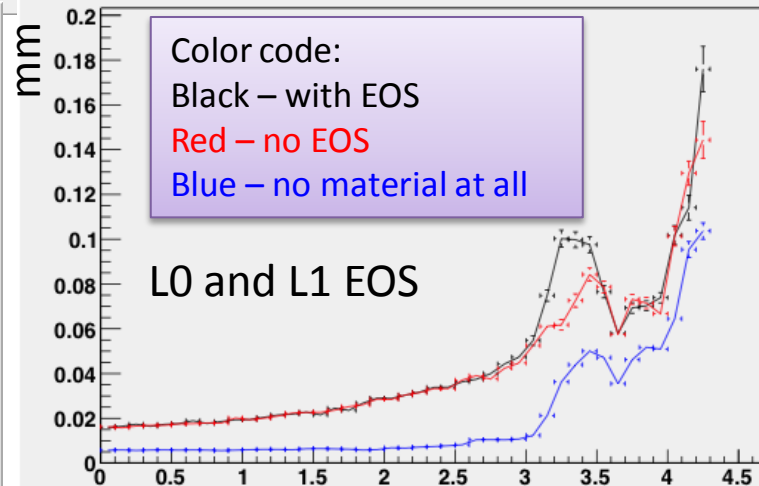
Summary

- There is opportunity to review the Inner Tracker layout during the transition from LOI to TDR
- Quite few layouts are under consideration already but new ideas are very welcome
- So far there is no clear winner
- More detailed studies are required to estimate pattern recognition, two-particle separation, material effects, etc.
  - Final studies should be done in Athena but the IDRES and Alpine frameworks show that simple preliminary studies are very useful as well
- Special ITk-SC session on Dec 12 devoted to the alternative layouts
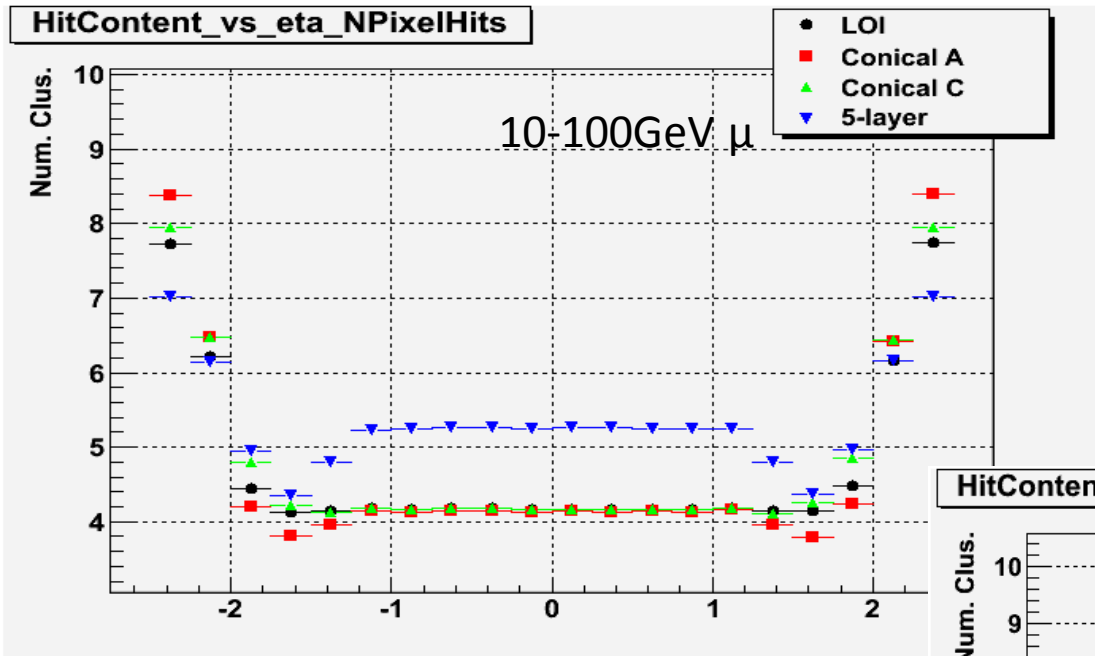 - YOUR contribution is very welcome!

Backup

Hit Maps
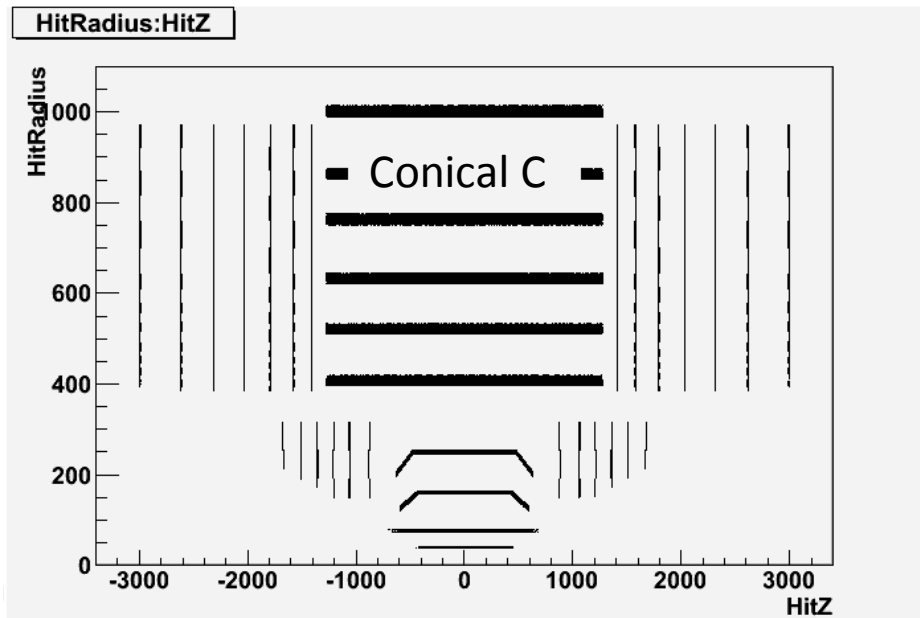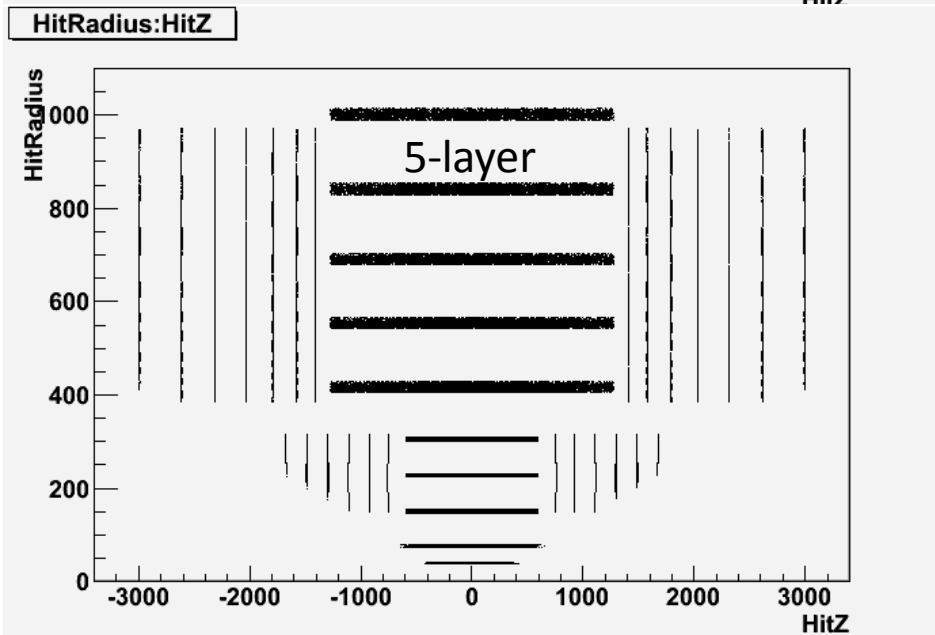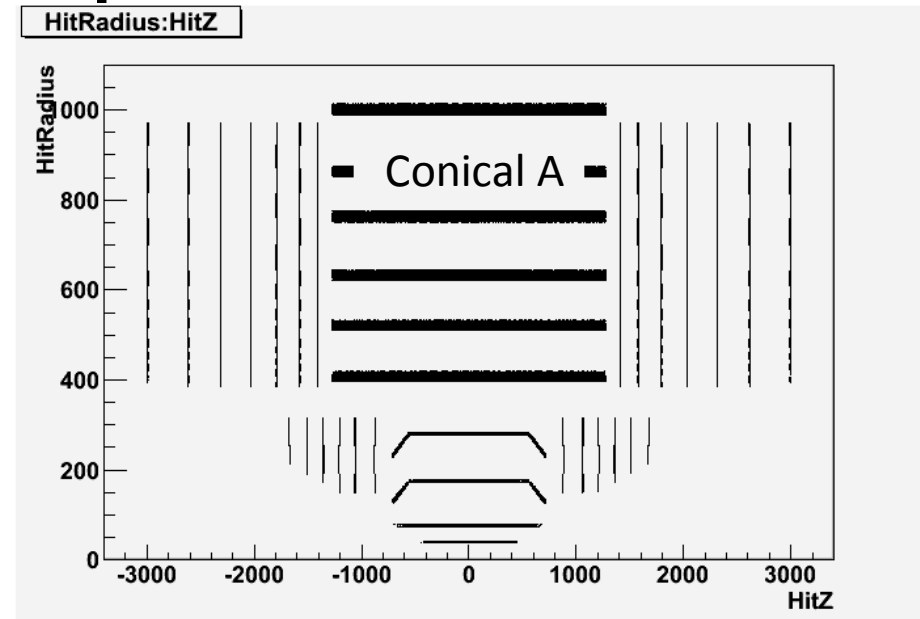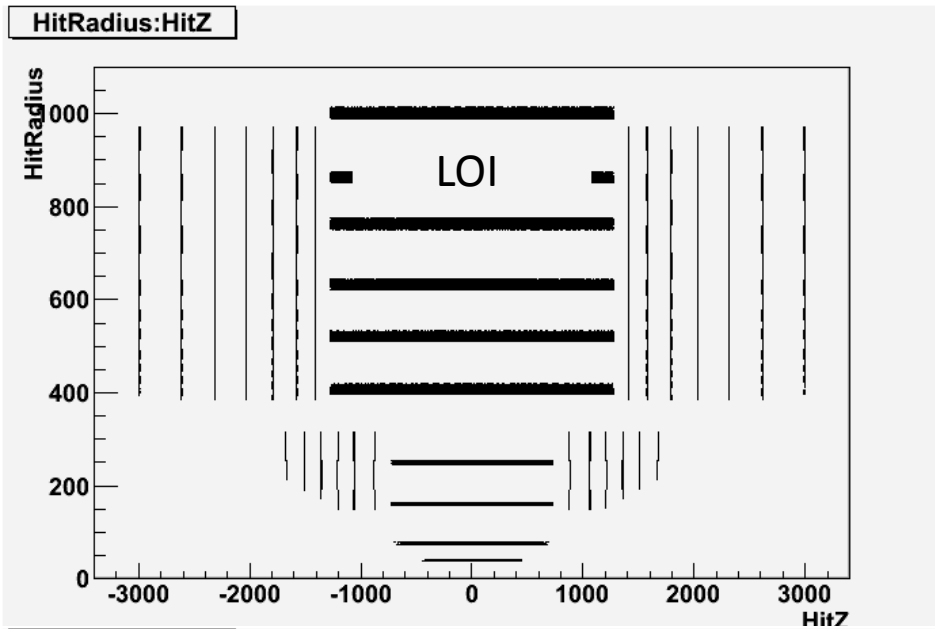
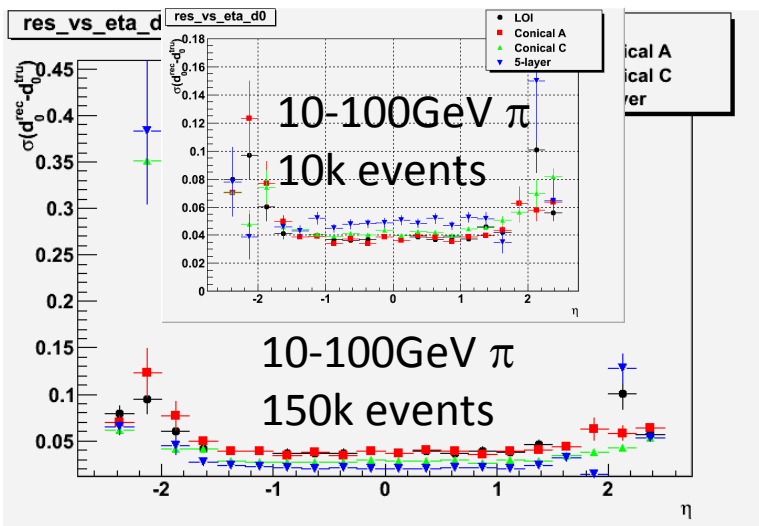# FATRAS comparison (Material)

Barrel Material

All Pixel material
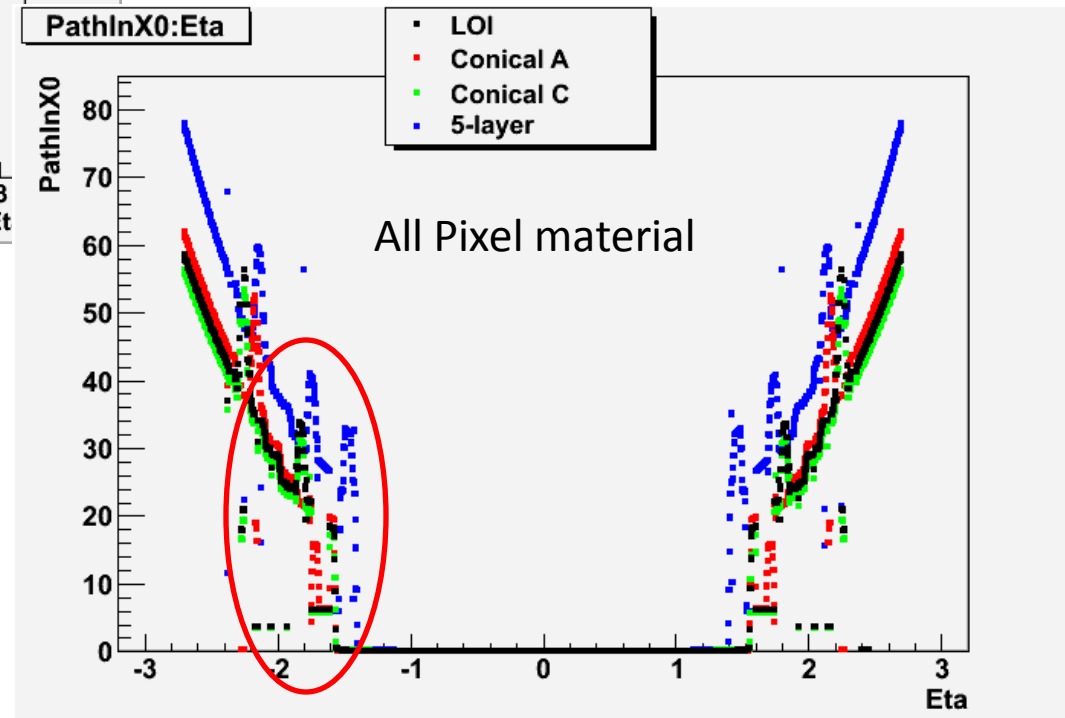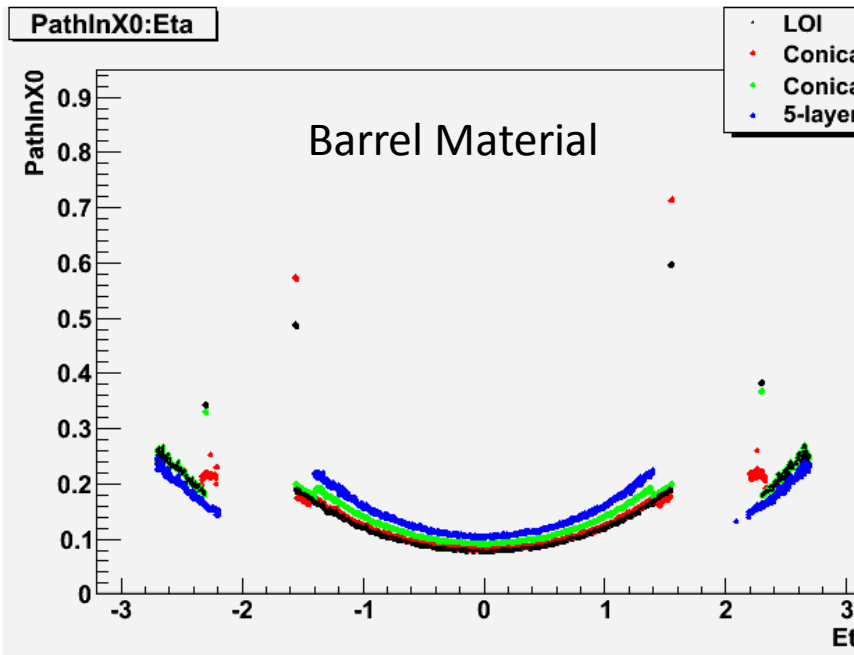
FATRAS comparison (NpixelHits)
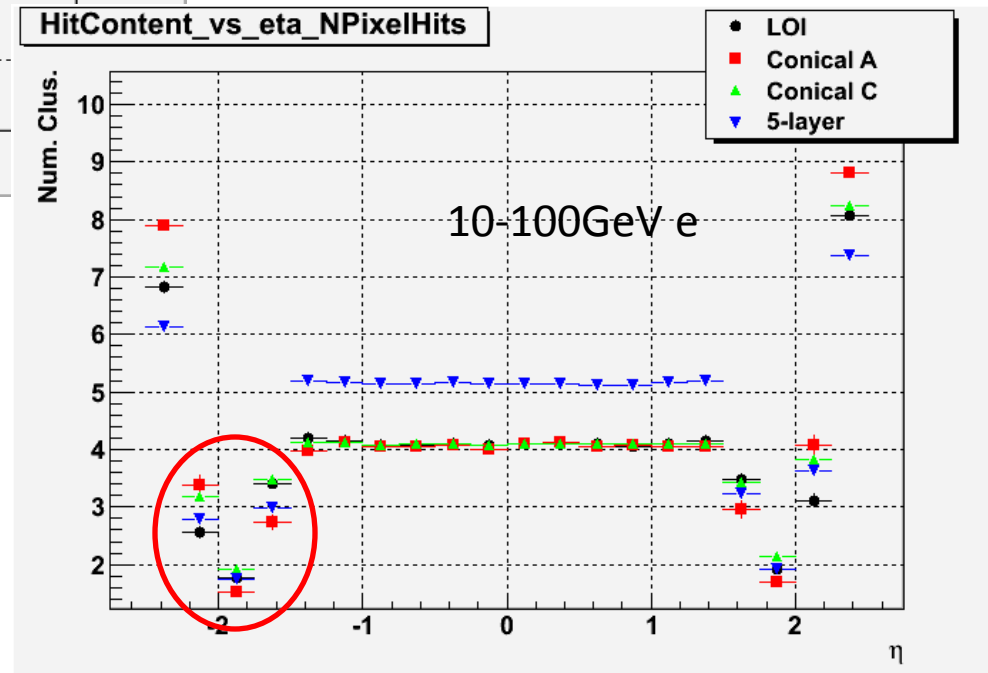
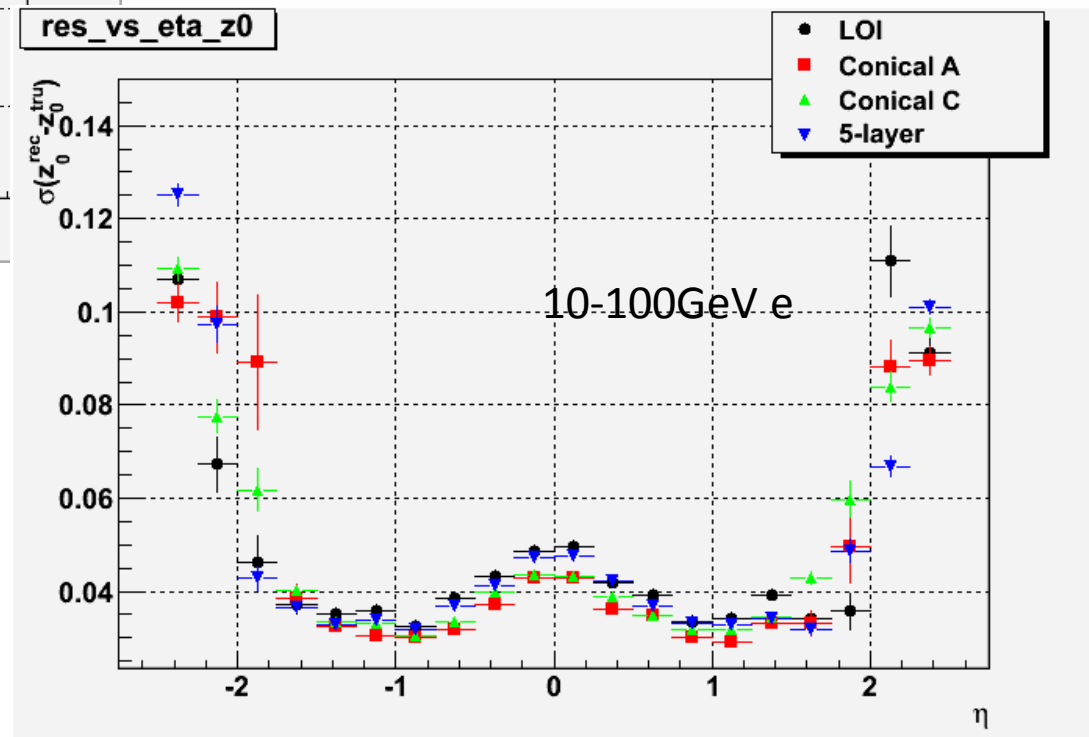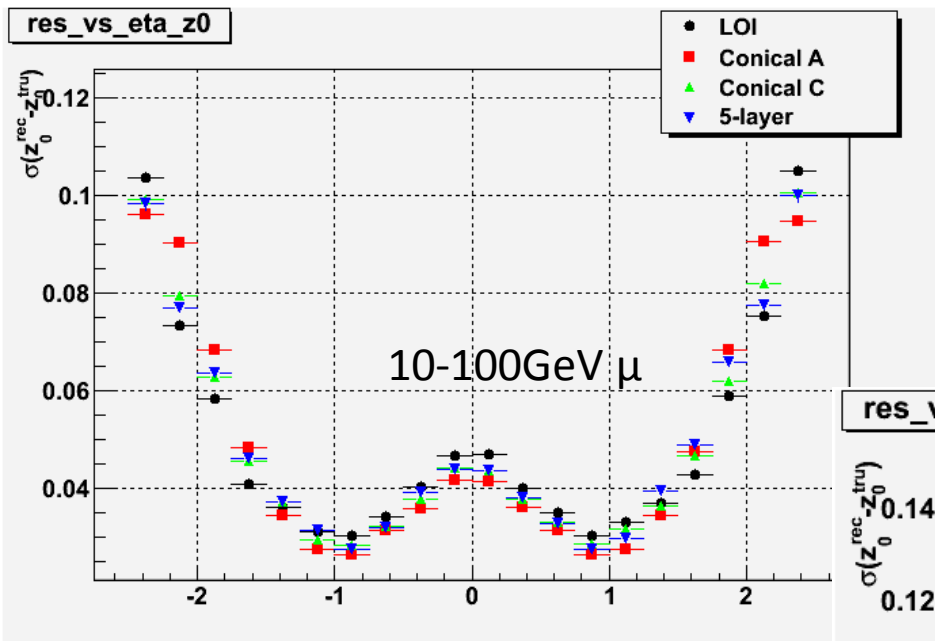# FATRAS comparison (Efficiency)

10-100GeV μ

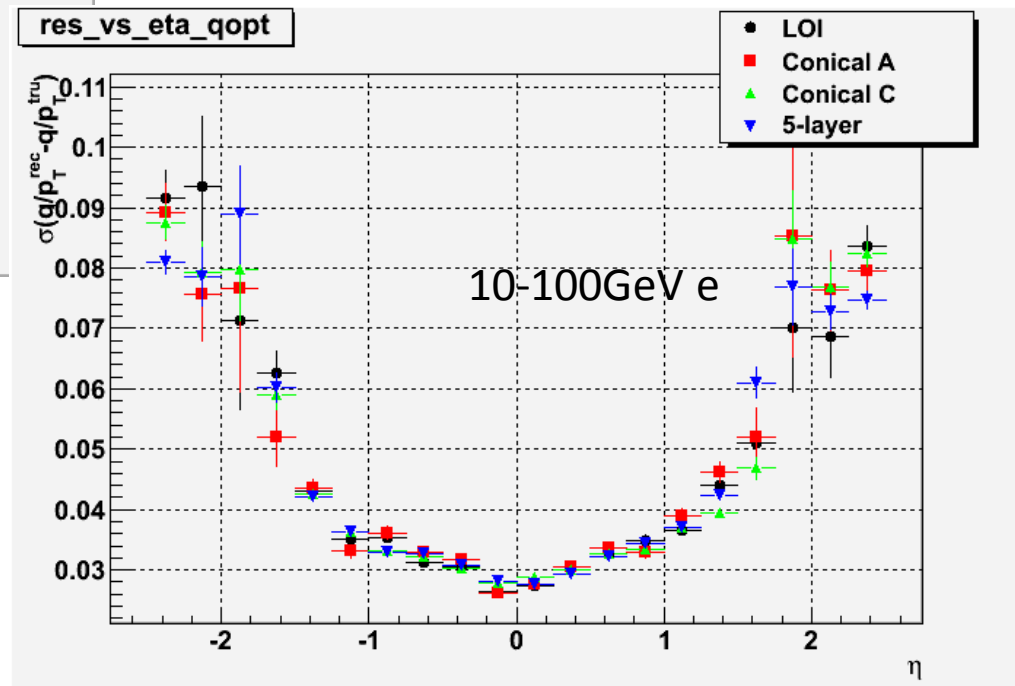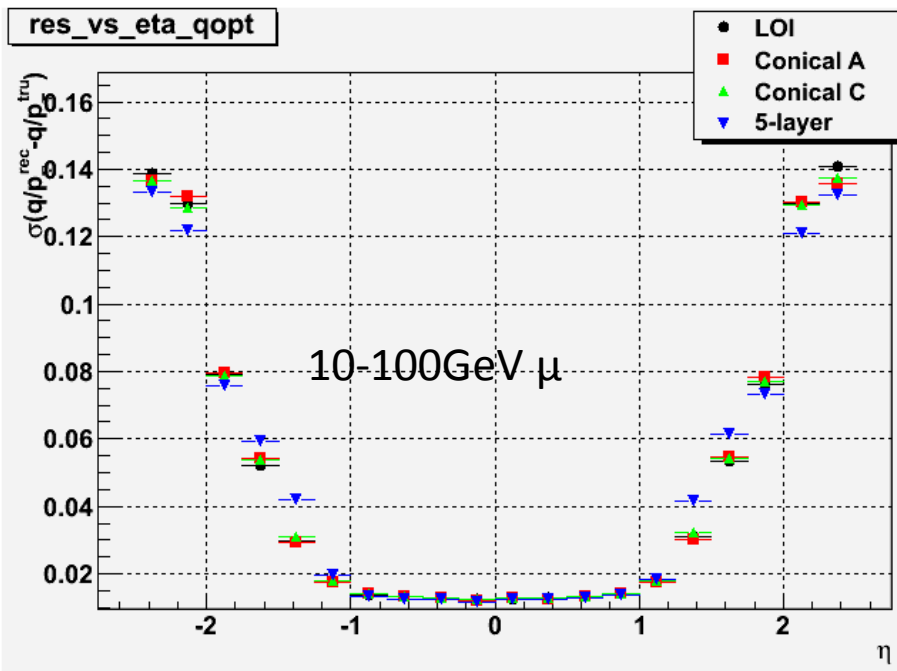10-100GeV e
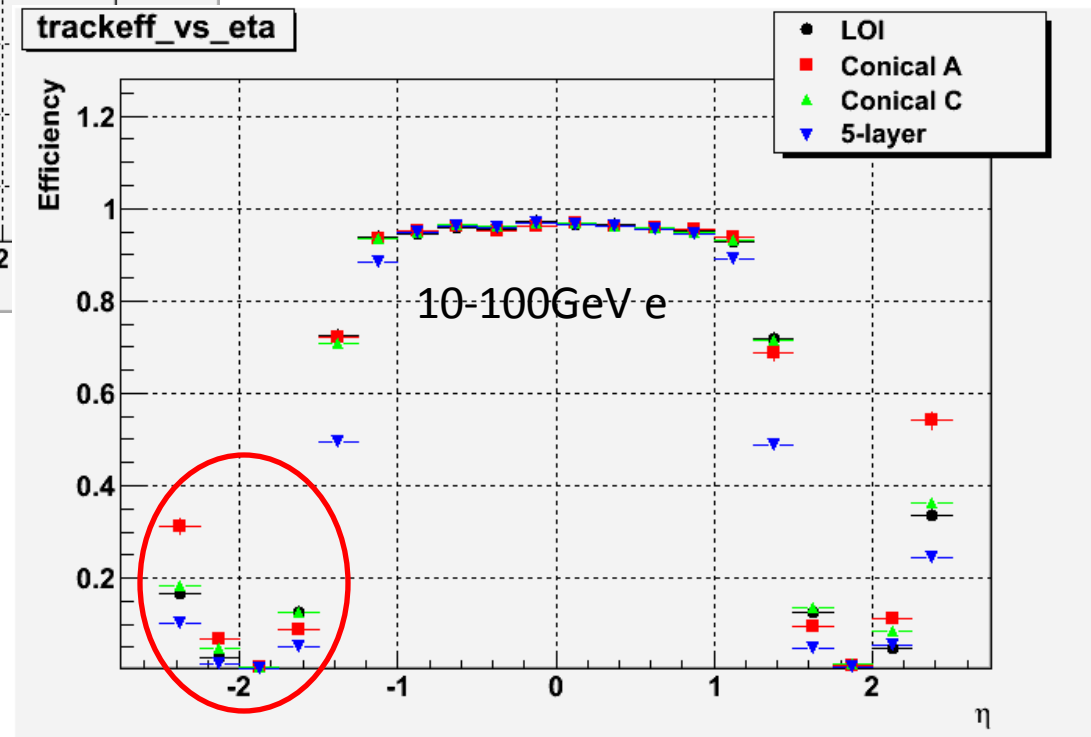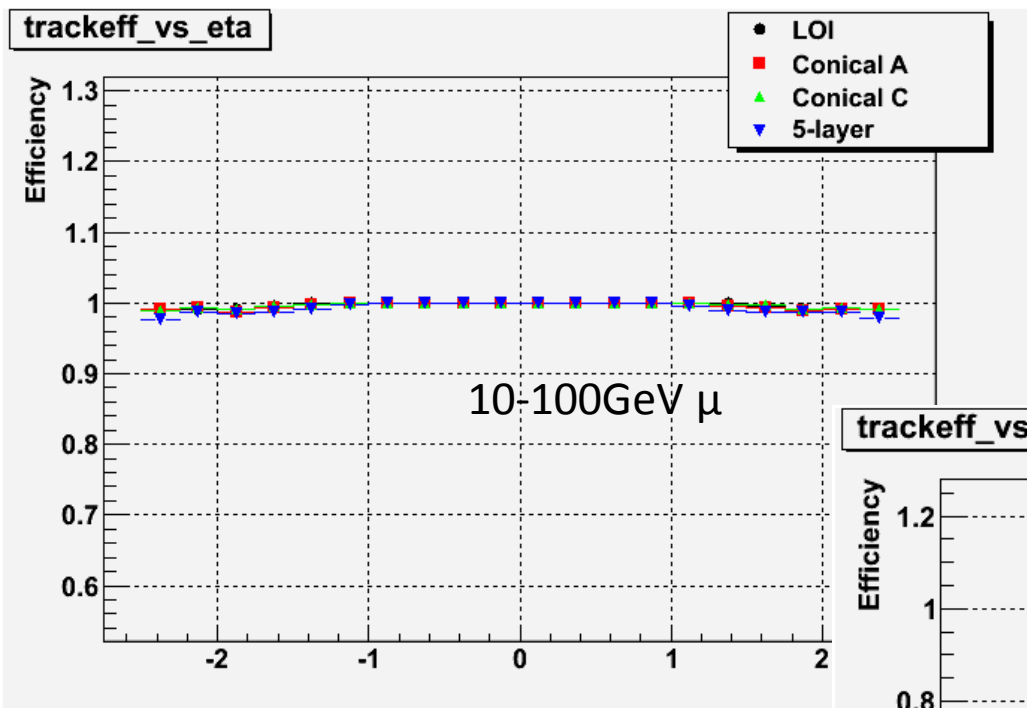
FATRAS comparison (D0 resolution)

- Disclaimer: the resolutions have rather strong dependence on the number of simulated events and some jobs crashed leading to different numbers of events for different geometries.

10-100GeV μ

10-100GeV π
10k events

10-100GeV π
150k events

10-100GeV e
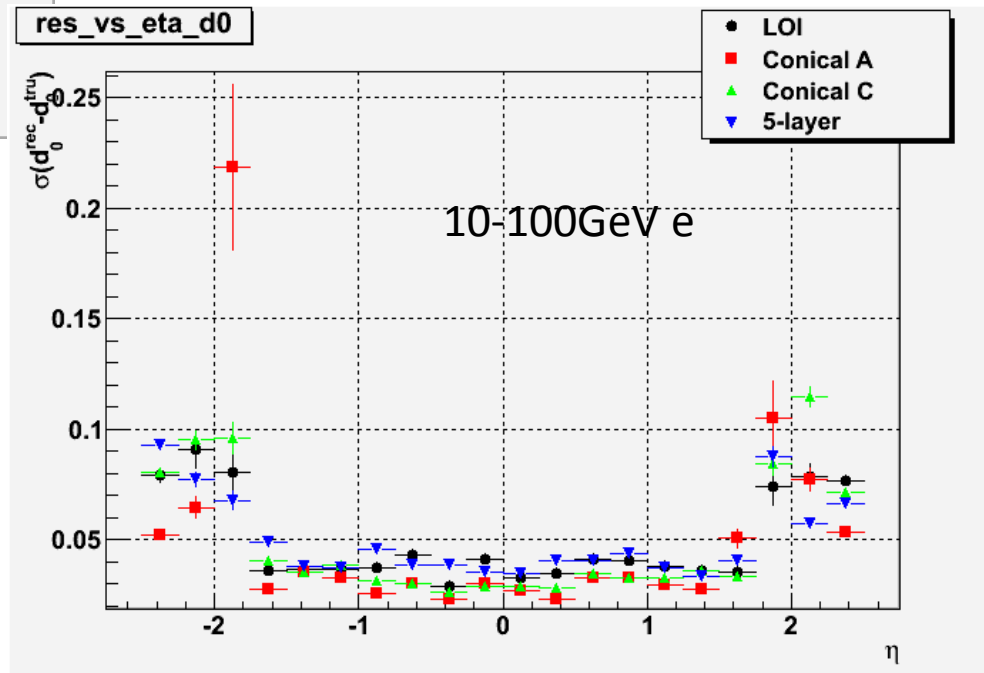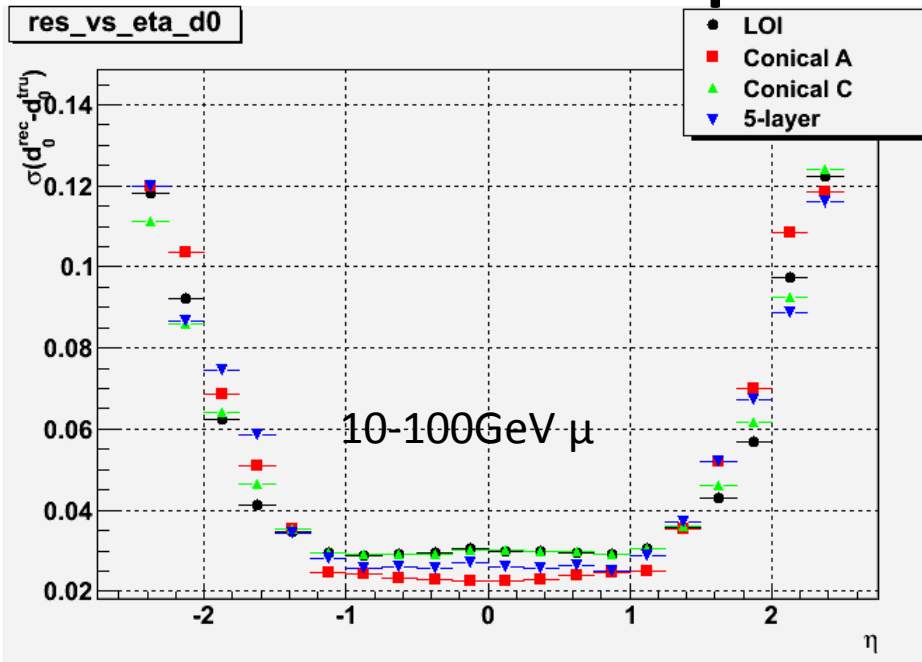
FATRAS comparison (Z0 resolution)

10-100GeV μ

10-100GeV e

FATRAS comparison (Pt resolution)

10-100GeV μ

10-100GeV e

Very forward tracking?

Good resolution in Z₀ reco down to η=4

- Resolution < 1mm for p_T>10 GeV/c down to η=4

$\sigma(\delta Z_0)$1 mm

Muon p_T
100 GeV/c
10 GeV/c
1 GeV/c

Courtesy of S. Mersi

Beneficial to VBF tagging as it provides coverage for Barrel/Endcap service cracks

CMS

ID geometry from baselinePlus6disks.geom 18:08:41 18/11/12

X0:Eta

6 October 2012   LHC days in Split 2012, T. Camporesi   27
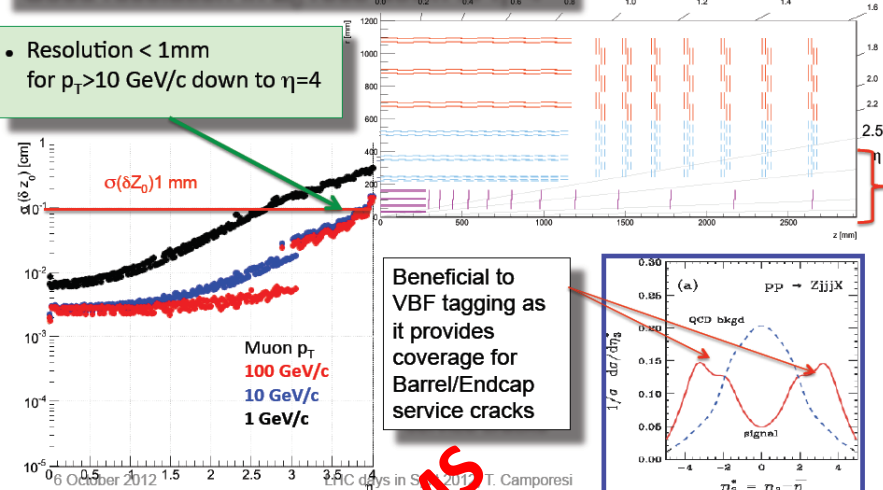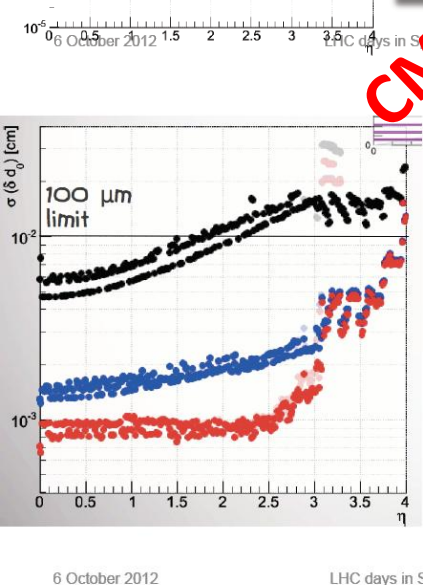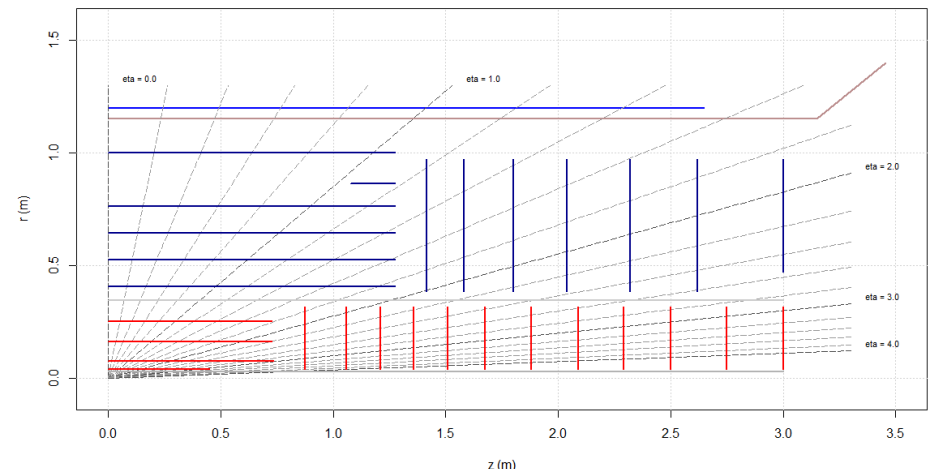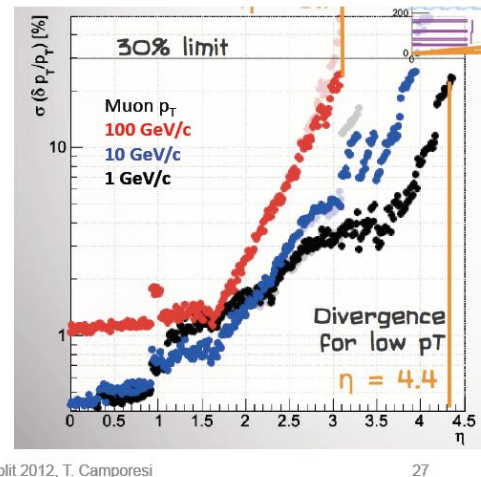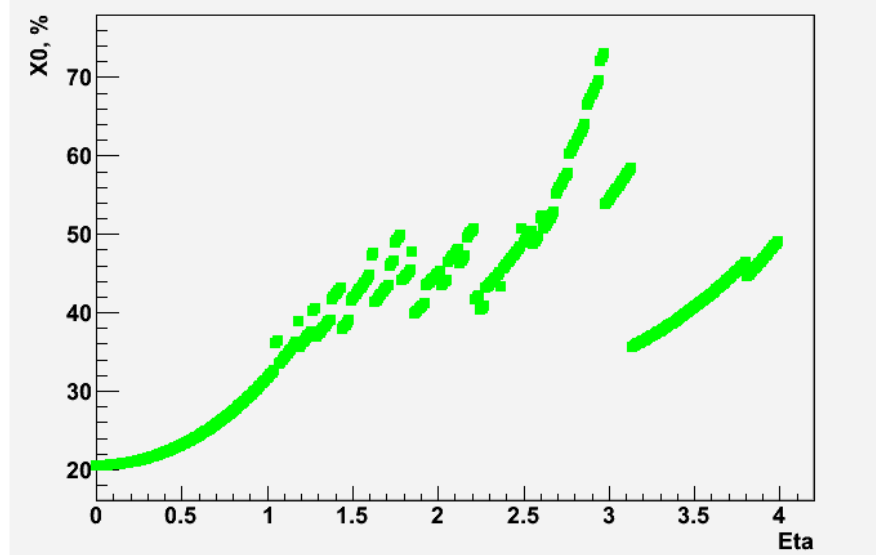
Resolutions with IDRES up to $\eta = 4$

- # B=const=2T