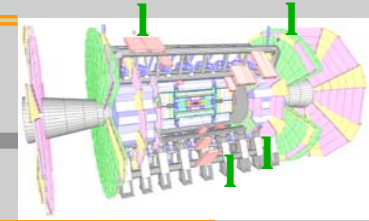




Update on $H \rightarrow 4l$ (e, μ) analysis with CSC samples



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OUTLINE

This talk is focused on specific aspects that will be addressed in the CSC note

- Improvement on analysis from 11.0.41 to 12.0.0
 1. Background rejection based on primary vertex finder algorithms
- ATLAS detector performance
 2. Calorimeter performance issues
 - Check of calibration, electron uniformity, efficiency in 12.0.0
 3. Muon Spectrometer performance
 - Misalignment effects of the MS system

Samples and Definitions

- ◆ **Samples for the vertexing, calorimeter studies:**
 - **H(120, 150, 180 GeV) to 4leptons for the vertexing / calorimeter studies**
 - CSC 4lepton samples 5300, 5301, 5302
 - Sim+Dig 11.0.41, Recon 12.0.0
- ◆ **Samples for the muon performance studies:**
 - **H(180)→ZZ*→4m test signal sample of 2,000 events**
 - **Sim+dig with release 12.0.1 and the R_light layout Muon detector description (nominal geometry)**
 - **Reconstructed with release 12.0.1 with two layouts**
 - "Nominal"
 - "Misaligned" by 1mm displacement and 1mrad rotation of muon chambers on average
- ◆ **Analysis for the H→4e studies:**
 - **HiggsToFourLepton package in CVS**
 - **Using EventView in 12.0.0 + necessary latest tags**
- ◆ **Analysis for the H→4μ studies:**
 - **CBNT based**
- ◆ **Electron / muon definitions**
 - **Electron efficiency definition:**
 - e passed (matching generated e from Z)/Gen electrons from ZZ
 - **Electron Definition (AOD):**
 - Egamma and/or softE object
 - Has track associated to the cluster with E/p>0.7
 - **Muon definition**
 - Reconstructed by the Muonboy package and combined with the Inner detector track using STACO package

Vertexing studies

Vertex fit under 11.0.41 vs 12.0.0

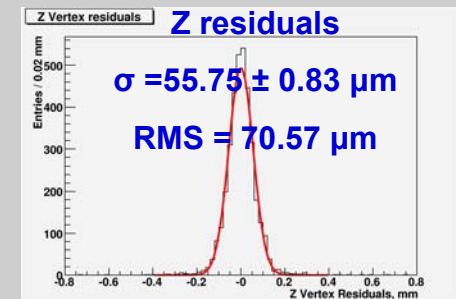
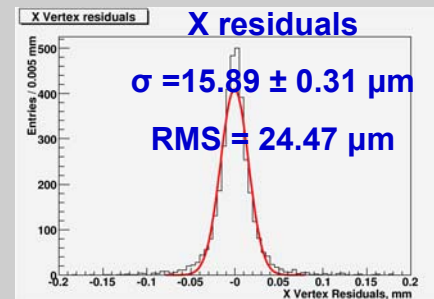
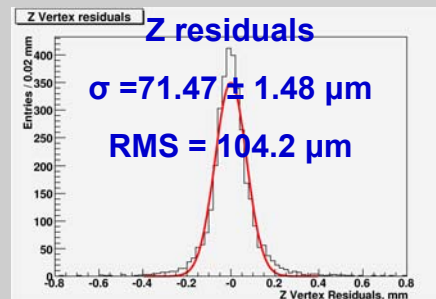
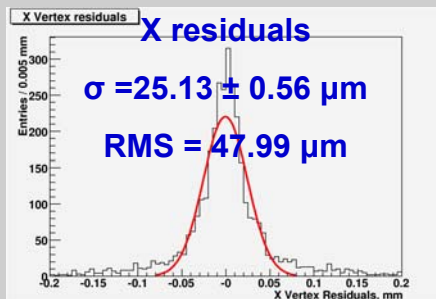
- ◆ The *NewTracking* becomes the default strategy of track reconstruction starting from release 12.0.0.
 - All numbers shown hereafter are obtained using *NewTracking* with default cuts. Results for other tracking strategies can also be produced.
 - Data sample used to test both releases: H(130)→4l, csc11 sampleA, geometry DC3-02.
- ◆ Exclusive H(130)→4l vertex fit: typical pictures and numbers (Kalman filter).

x,z residuals: Comparison between the reconstructed 4l vertex with the truth

rel. 11.0.41



rel. 12.0.0



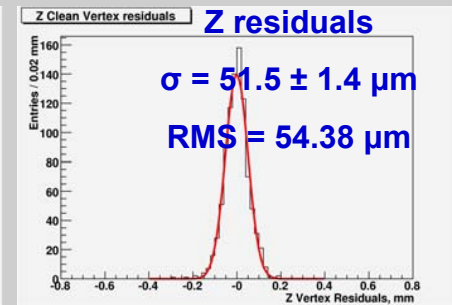
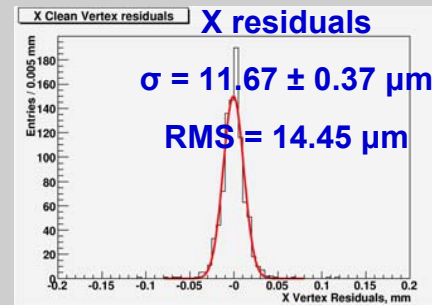
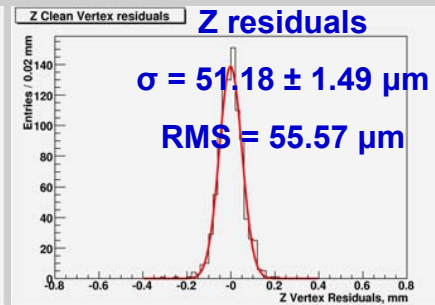
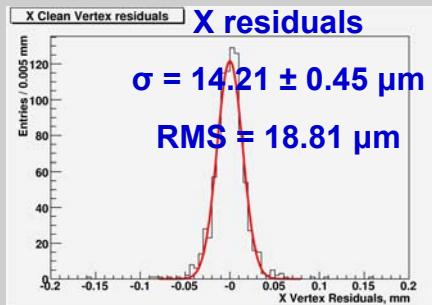
Vertex fit under 11.0.41 vs 12.0.0 (contd)

- ◆ Exclusive $H(130) \rightarrow 4\mu$ vertex fit: typical pictures and numbers (Kalman filter).

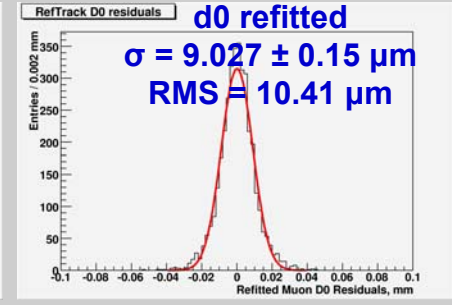
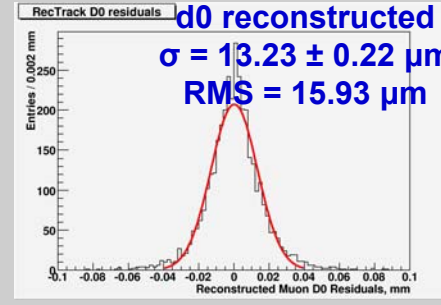
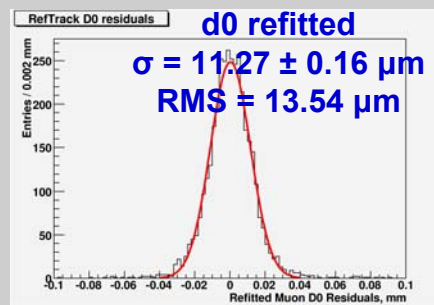
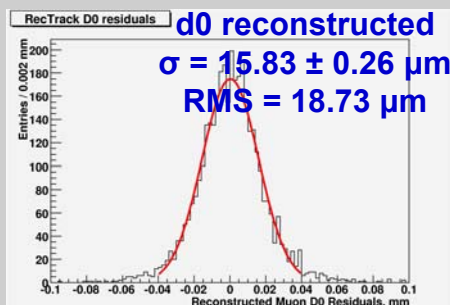
rel. 11.0.41



rel. 12.0.0



- ◆ Vertex smoothing: transverse (d_0) impact parameter of reconstructed muons w.r.t generated $H \rightarrow 4\mu$ decay vertex position.



d0 refitted: the fit is constrained (forced) to go through the reconstructed 4-muon (in this case) vertex. This is useful when we want to improve the 4-lepton resolution (i.e. when we know that this 4-l is from signal).

Primary Vertex Finding under rel. 12.0.0

- ◆ Up to rel. 11.0.41, the standard (and only) tool for primary vertex finding was *InDetPriVxFinderTool*:
 - Preselects tracks according to their p_t , d_0 , z_0 and reconstruction quality.
 - Creates track clusters in z_0 (pileUp case).
 - Fits candidate vertices with provided vertex fitter (Billoir *FastVertexFitter*).
 - Rejects least compatible tracks; refits the vertices.

- ◆ In rel. 12.0.0 more functionality added:
 - *InDetPriVxFinderTool* can now be used with any of four available vertex fitters.
 - Options configurable through *InDetFlags*.

- ◆ *InDetAdaptivePriVxFinderTool* added:
 - Preselects tracks according to their p_t , d_0 , z_0 and reconstruction quality.
 - Fits the vertex candidate using Adaptive Vertex Fitter.
 - Option configurable through *InDetFlags*.

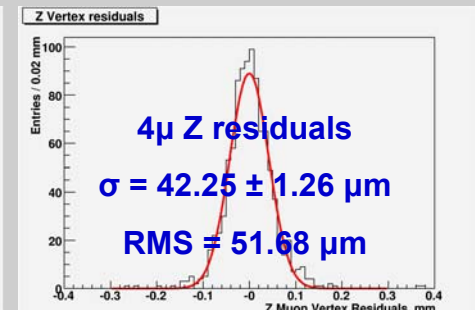
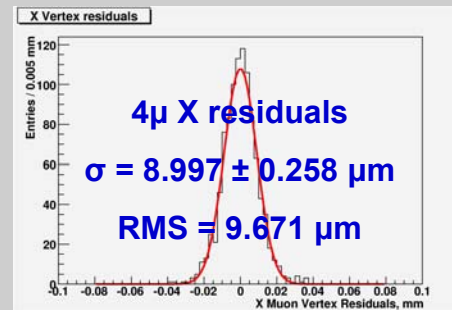
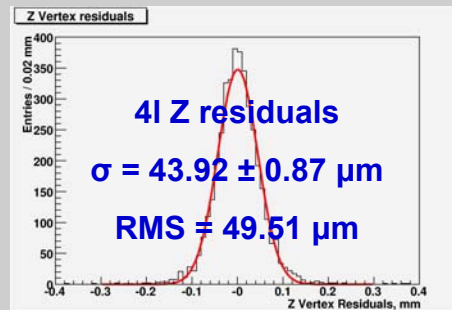
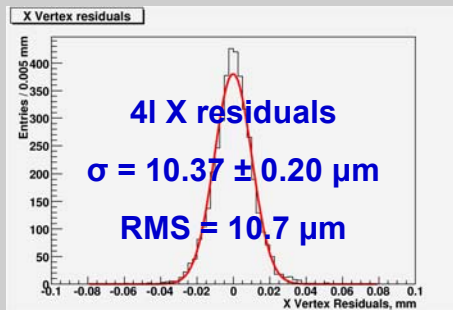
General results for release 11.0.41

Vertexing	4l X resolution	4l Z resolution	4 μ X resolution	4 μ Z resolution
Fast Billoir Fitter	$\sigma = 25.14 \pm 0.56 \mu\text{m}$ RMS = 48.07 μm	$\sigma = 71.13 \pm 1.48 \mu\text{m}$ RMS = 103.0 μm	$\sigma = 14.21 \pm 0.45 \mu\text{m}$ RMS = 19.92 μm	$\sigma = 51.34 \pm 1.49 \mu\text{m}$ RMS = 55.53 μm
Full Billoir Fitter	$\sigma = 25.17 \pm 0.56 \mu\text{m}$ RMS = 48.13 μm	$\sigma = 71.14 \pm 1.48 \mu\text{m}$ RMS = 102.2 μm	$\sigma = 14.21 \pm 0.45 \mu\text{m}$ RMS = 19.93 μm	$\sigma = 51.31 \pm 1.49 \mu\text{m}$ RMS = 55.53 μm
Kalman filter	$\sigma = 25.13 \pm 0.56 \mu\text{m}$ RMS = 47.99 μm	$\sigma = 71.47 \pm 1.48 \mu\text{m}$ RMS = 104.2 μm	$\sigma = 14.21 \pm 0.45 \mu\text{m}$ RMS = 18.81 μm	$\sigma = 51.18 \pm 1.49 \mu\text{m}$ RMS = 55.57 μm
Adaptive fit	$\sigma = 20.03 \pm 0.40 \mu\text{m}$ RMS = 35.11 μm	$\sigma = 61.38 \pm 0.99 \mu\text{m}$ RMS = 83.92 μm	$\sigma = 14.23 \pm 0.45 \mu\text{m}$ RMS = 16.47 μm	$\sigma = 49.79 \pm 1.38 \mu\text{m}$ RMS = 54.22 μm

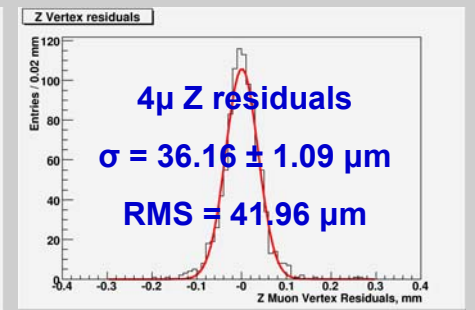
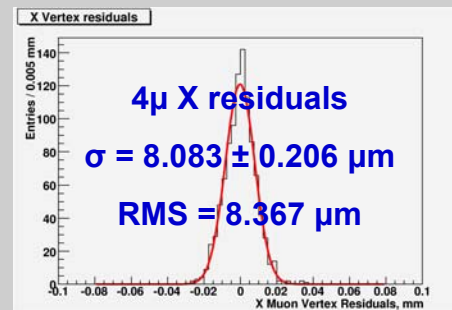
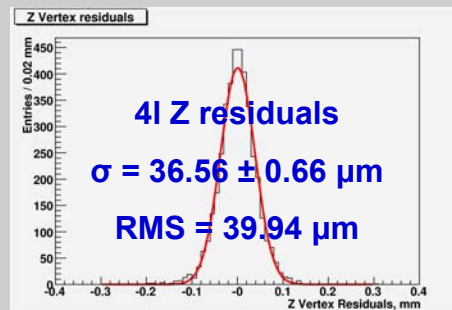
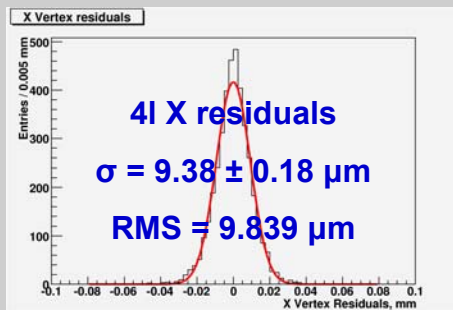
Track refit	Muon d0 reco.	Muon z0 reco.	Muon d0 refit.	Muon z0 refit.
Full Billoir Fitter	$\sigma = 15.83 \pm 0.26 \mu\text{m}$ RMS = 18.73 μm	$\sigma = 104.3 \pm 1.6 \mu\text{m}$ RMS = 118.0 μm	$\sigma = 11.38 \pm 0.16 \mu\text{m}$ RMS = 13.54 μm	$\sigma = 55.41 \pm 0.83 \mu\text{m}$ RMS = 65.57 μm
Kalman filter			$\sigma = 11.27 \pm 0.16 \mu\text{m}$ RMS = 13.54 μm	$\sigma = 55.35 \pm 0.83 \mu\text{m}$ RMS = 65.57 μm
Adaptive fit			$\sigma = 11.23 \pm 0.16 \mu\text{m}$ RMS = 12.65 μm	$\sigma = 54.73 \pm 0.8 \mu\text{m}$ RMS = 61.83 μm

Preliminary Primary Vertex Finding results under rel. 12.0.0

- ◆ Data sample used: H(130)→4l, csc11 sampleA, geometry DC3-02
- ◆ *InDetPriVxFinderTool* used with the Kalman Vertex Fitter



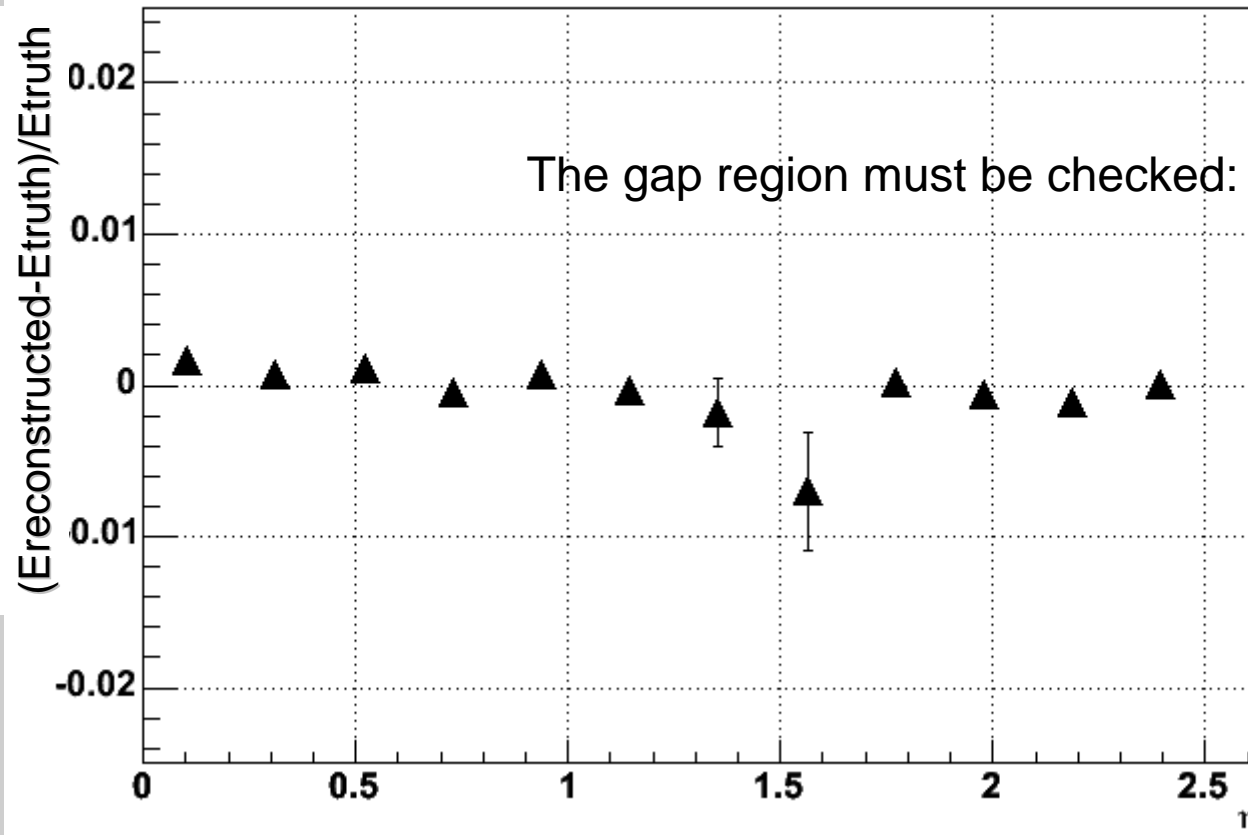
- ◆ *InDetPriVxAdaptiveFinderTool*



Electron studies in 12.0.0

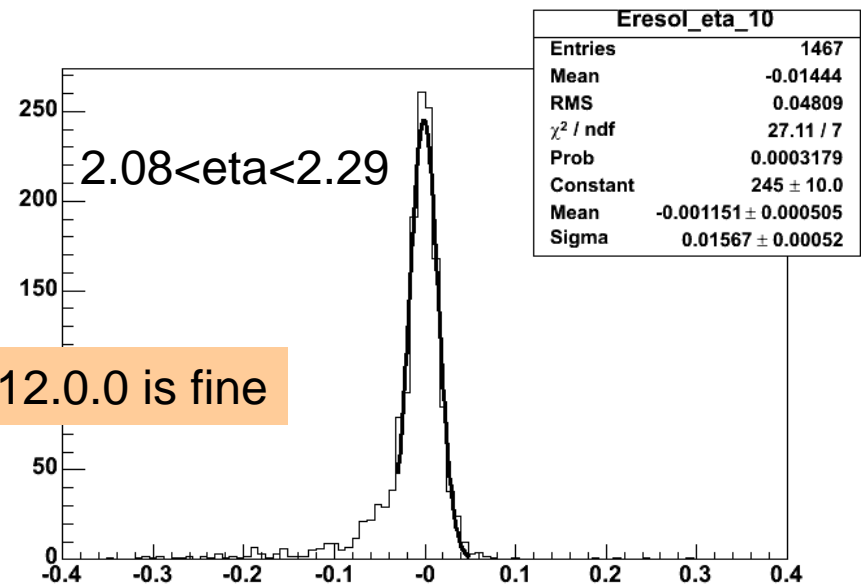
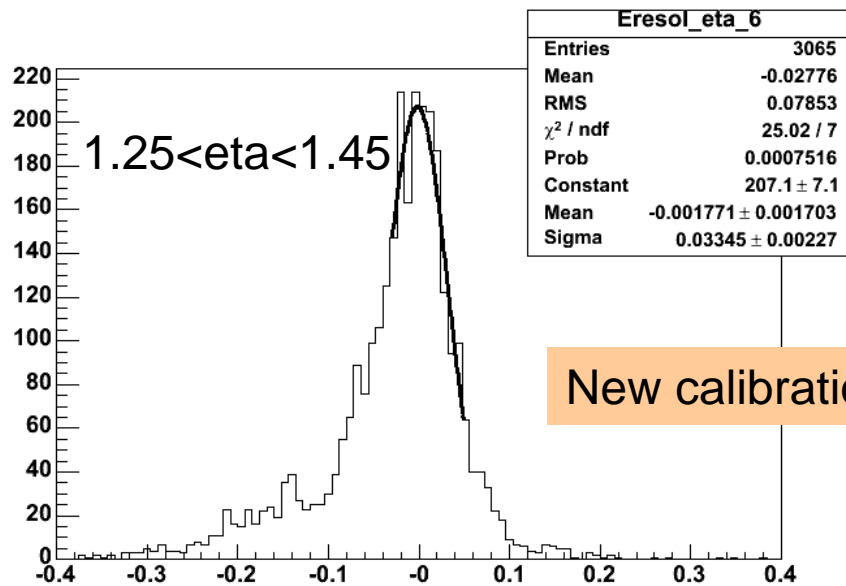
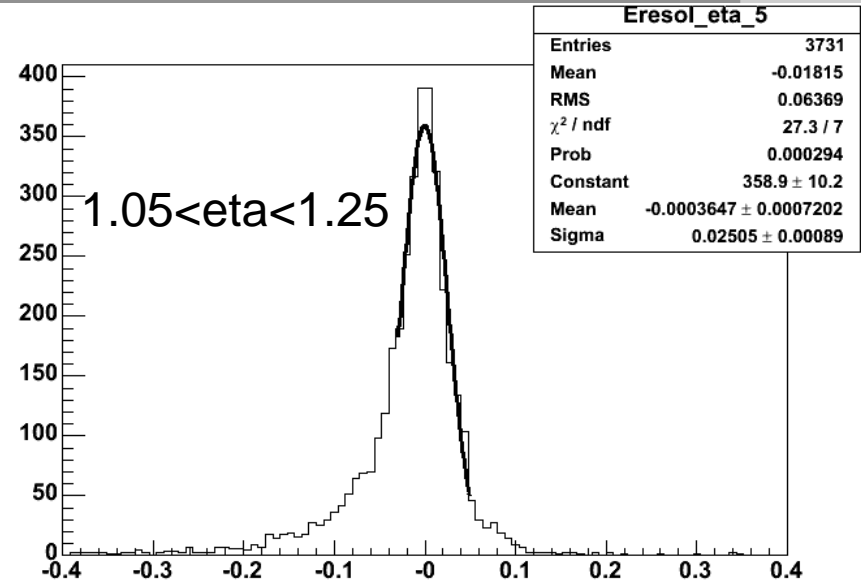
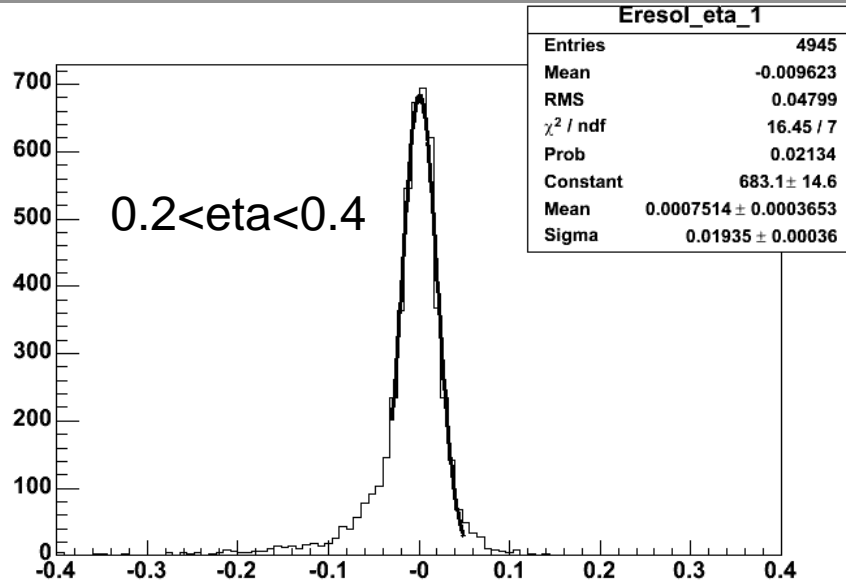
Electron Uniformity/Scale with $pt > 7\text{GeV}$

Higgs electrons with $pt > 7\text{GeV}$, 5x5 clusters



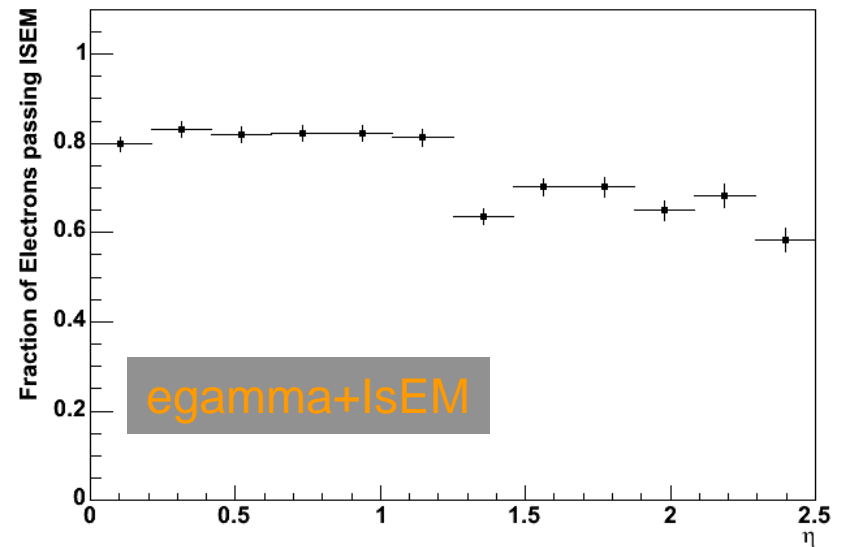
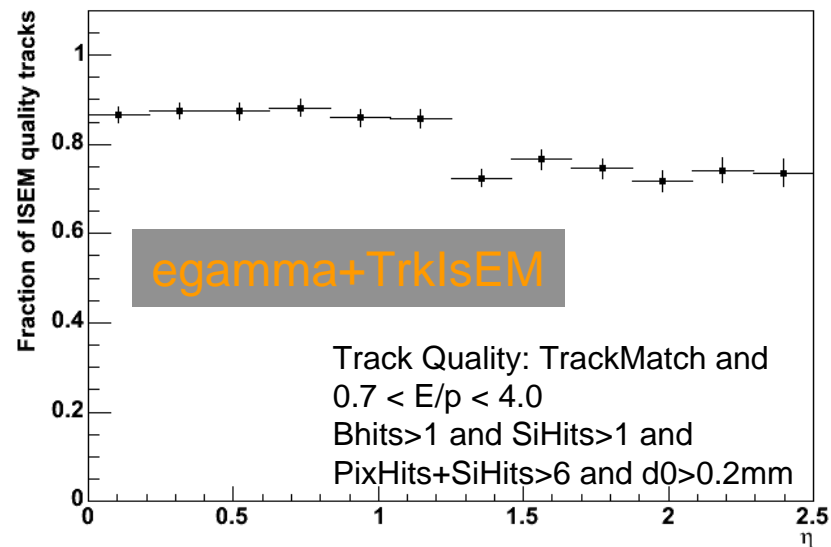
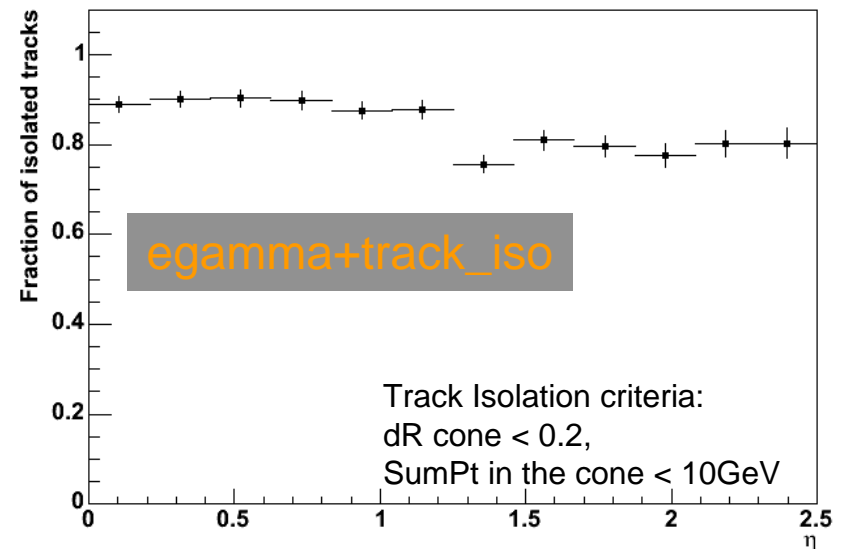
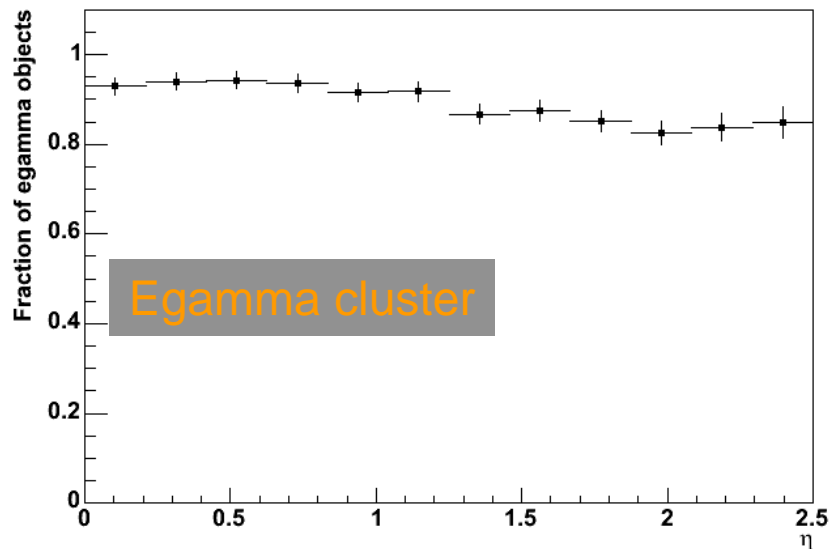
New calibration in 12.0.0 is fine

Sample resolution/Escale eta bins (pt>7GeV)

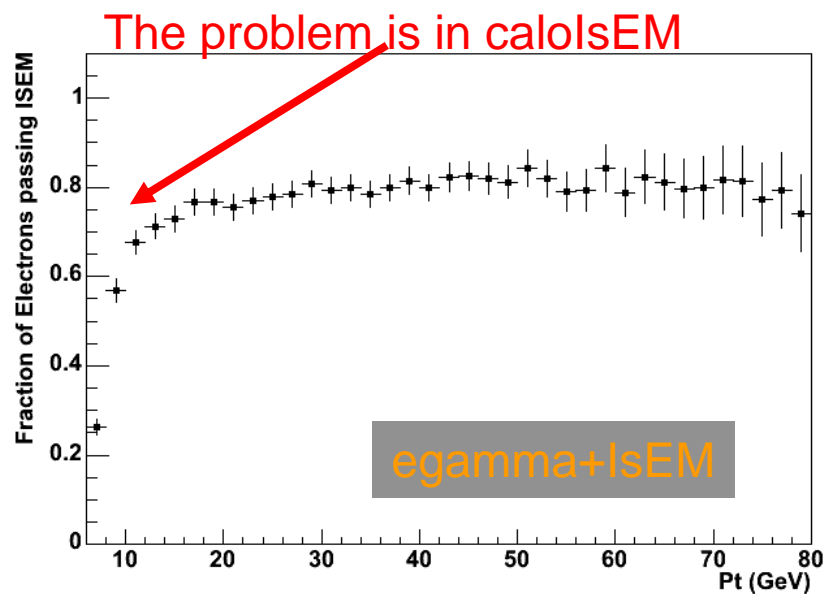
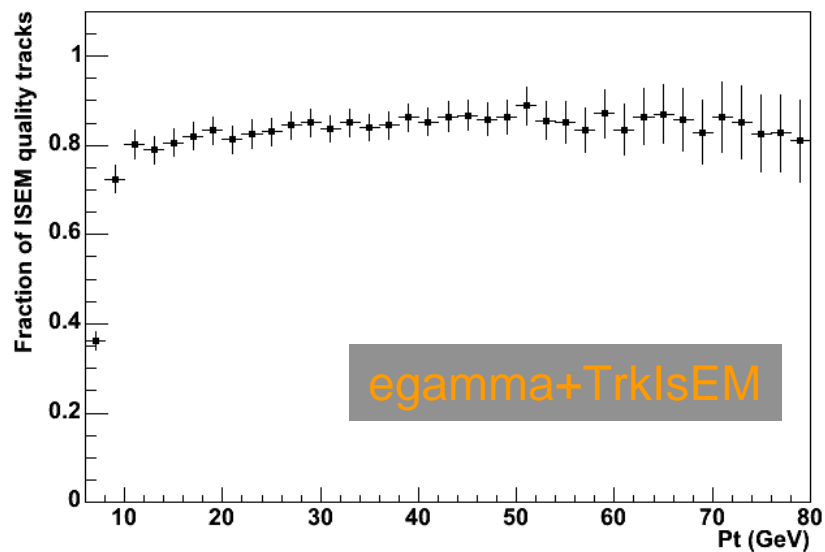
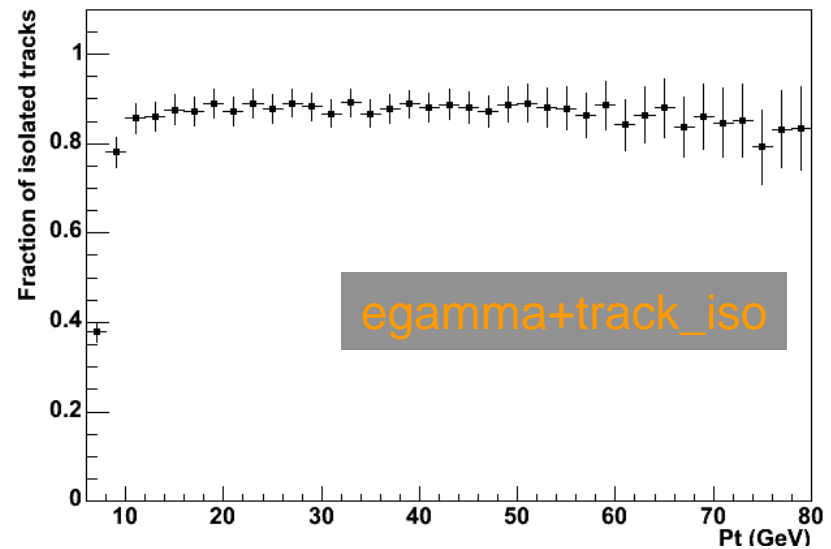
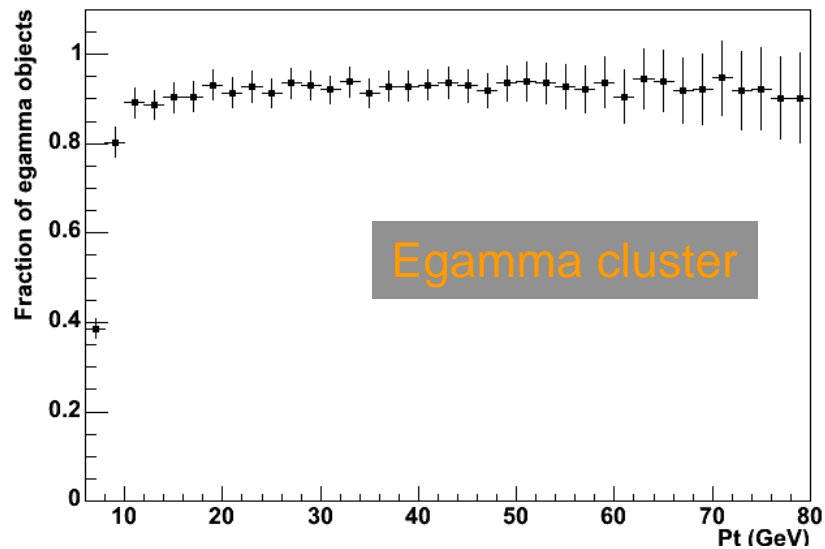


New calibration in 12.0.0 is fine

Higgs events: electron efficiencies vs eta



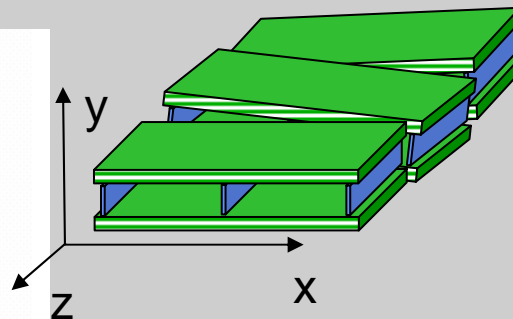
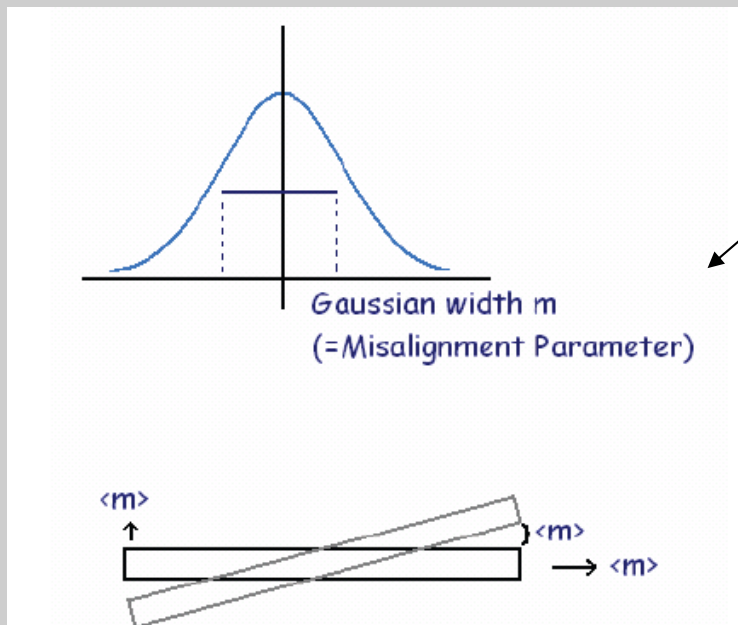
Higgs events: electron efficiencies vs pt



Misalignment studies in the Muon Spectrometer

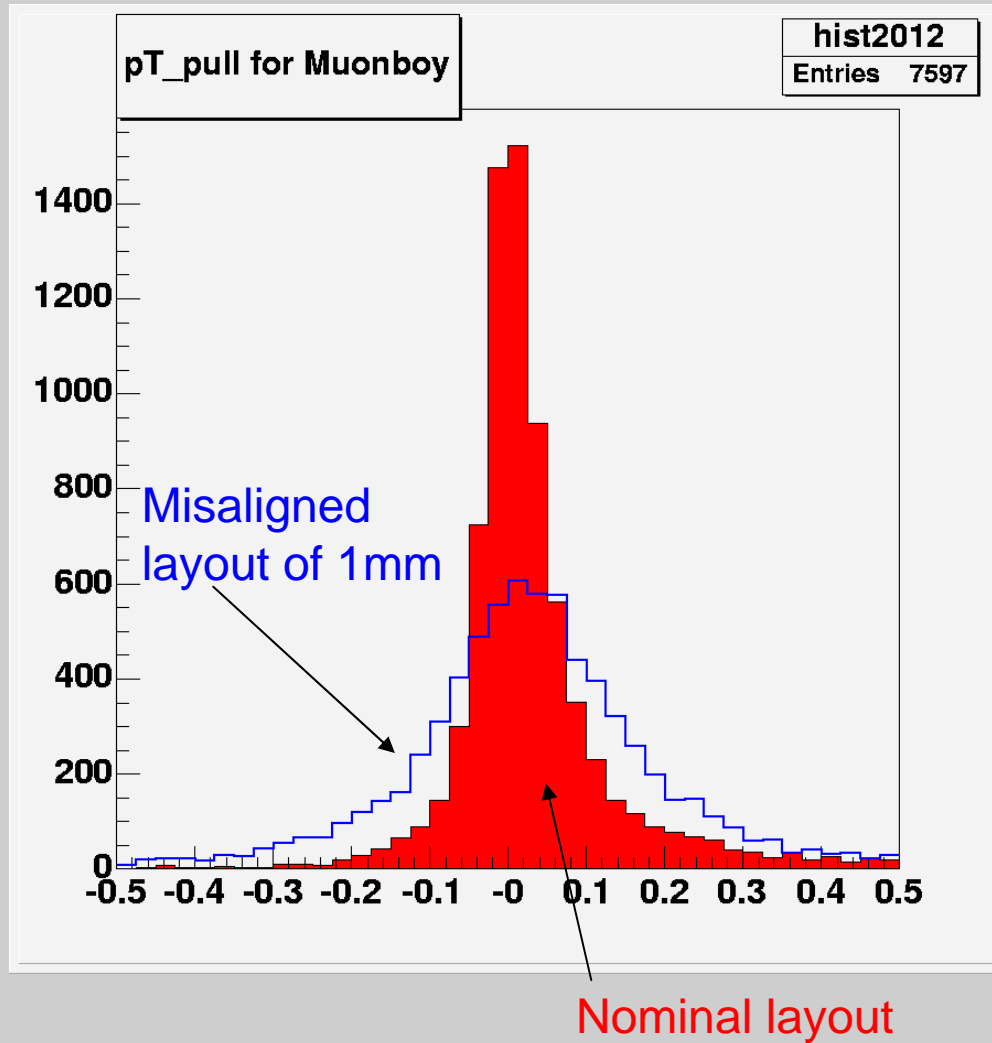
Impact of Muon Spectrometer Misalignment

- For this study each chamber was displaced and rotated randomly within the *G4* Simulation.
- We introduced a so called misalignment parameter m to describe the overall misalignment
- The value of m corresponds to a mean shift of a chamber wrt its nominal value,
 - e.g. in the case of $m=1\text{mm}$, each chamber was shifted in 3 dimensions 1mm in average
 - simultaneously the chambers were rotated by 1mrad in average.



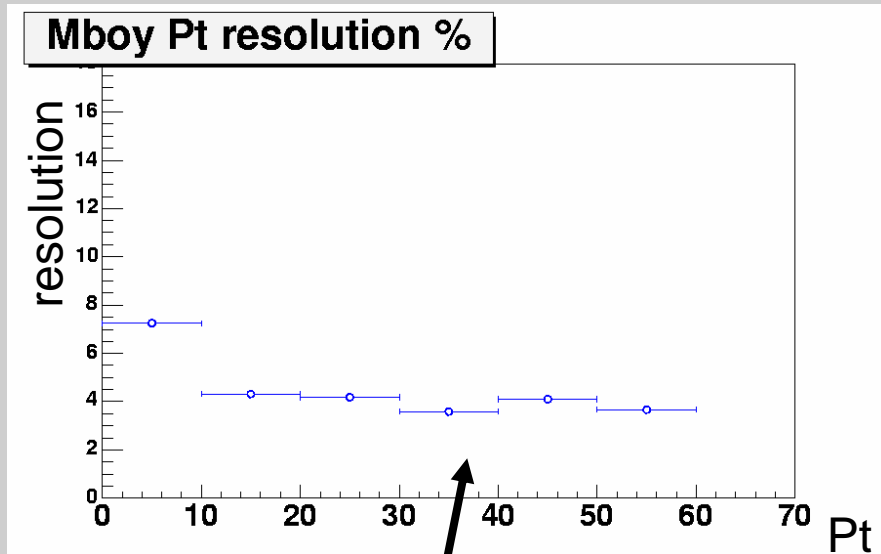
- **Simulation & Digitization:** This was done with the most recent MS Layout (R_light) of ATLAS
 - **Reconstruction** in release 12.0.1 :
 - with the misaligned layout
 - with nominal layout
- Comparison plots between the two are shown

Pt resolution effects with two MS geometries

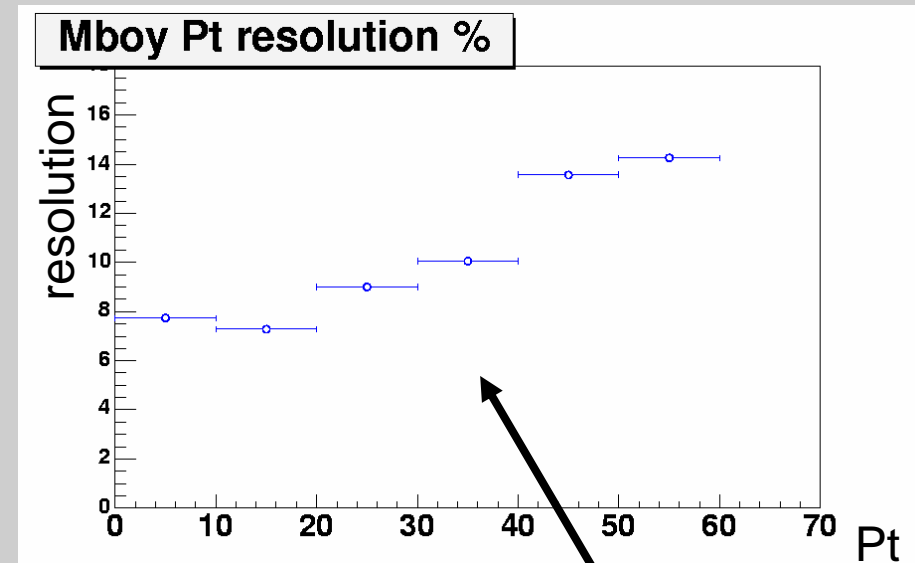


Clear effect of misalignment geometry is observed in the Pt distribution

Impact of misalignment on Pt resolution



Nominal layout
Constant behavior in the interesting region of Pt (for the Higgs analysis)

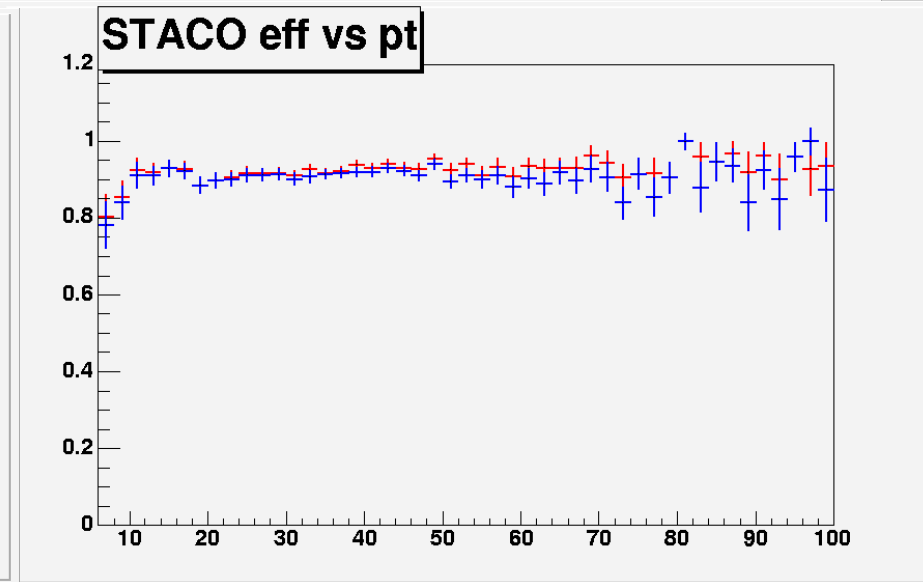
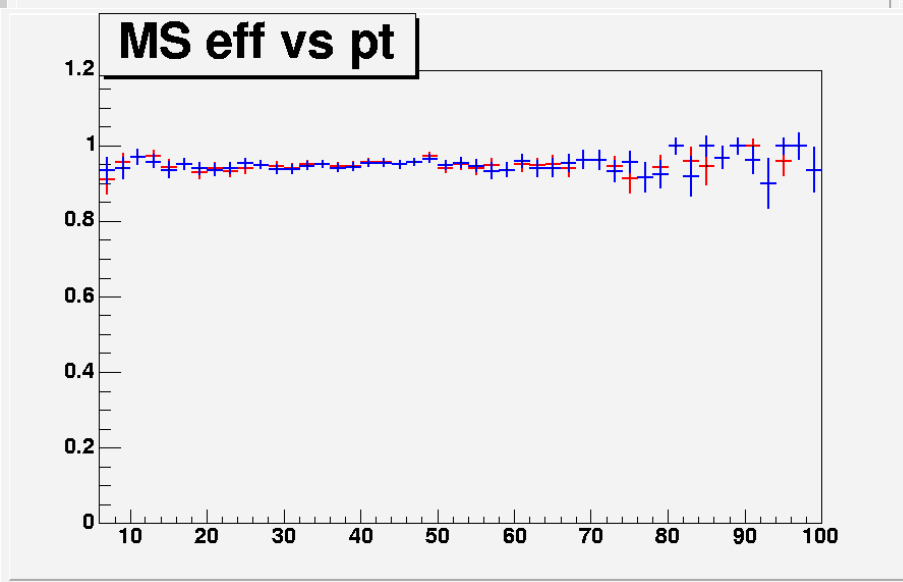
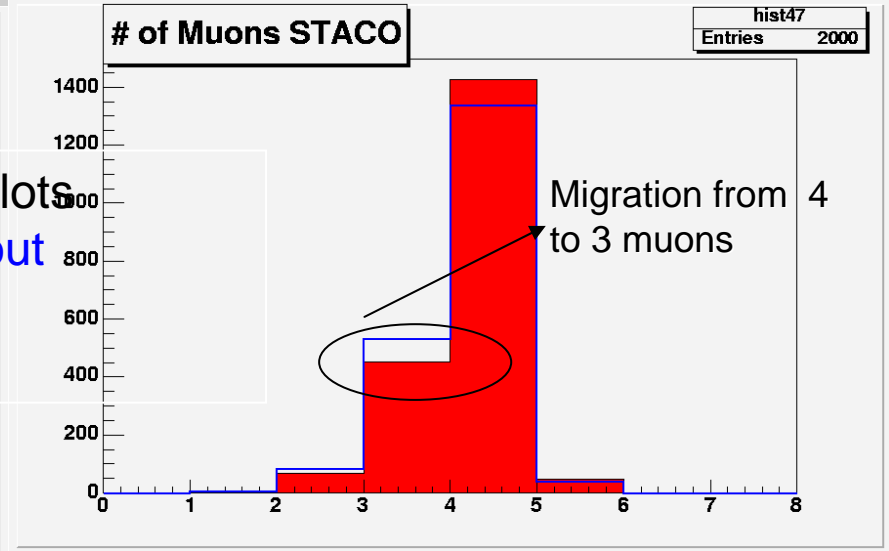
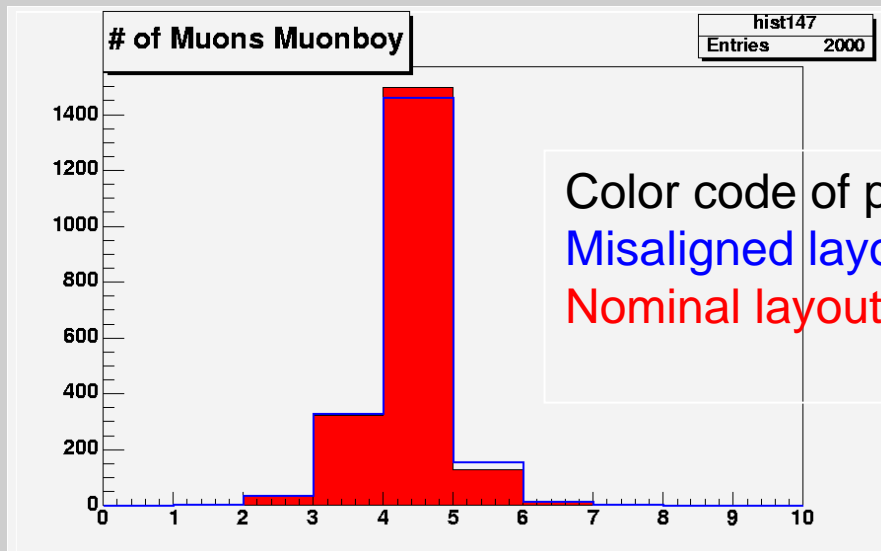


Misaligned layout of 1mm
Pt resolution decreases linearly with Pt

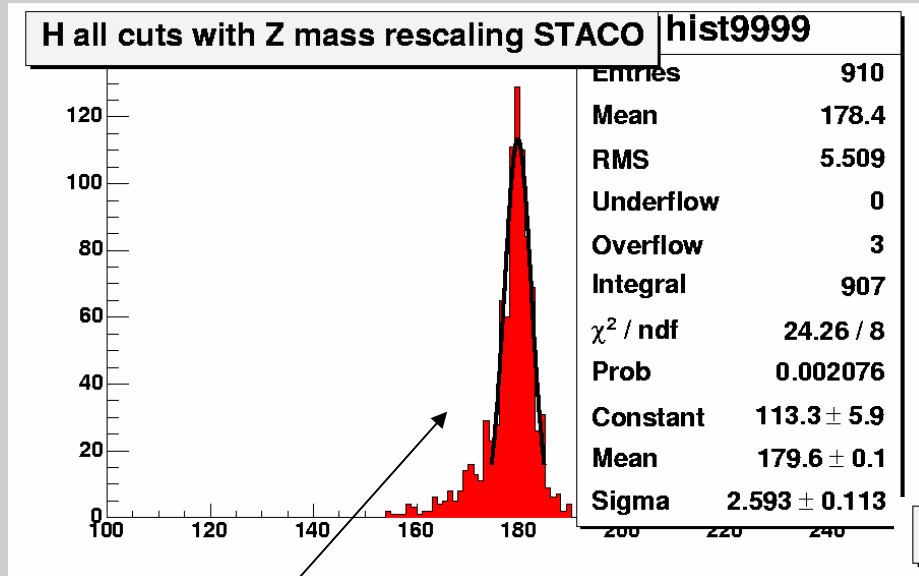
Results compatible with M. Schott analysis on $Z \rightarrow 2\mu$

<http://indico.cern.ch/getFile.py/access?contribId=s8t4&sessionId=s8&resId=0&materialId=0&confId=a061491>

Muon multiplicity / efficiency

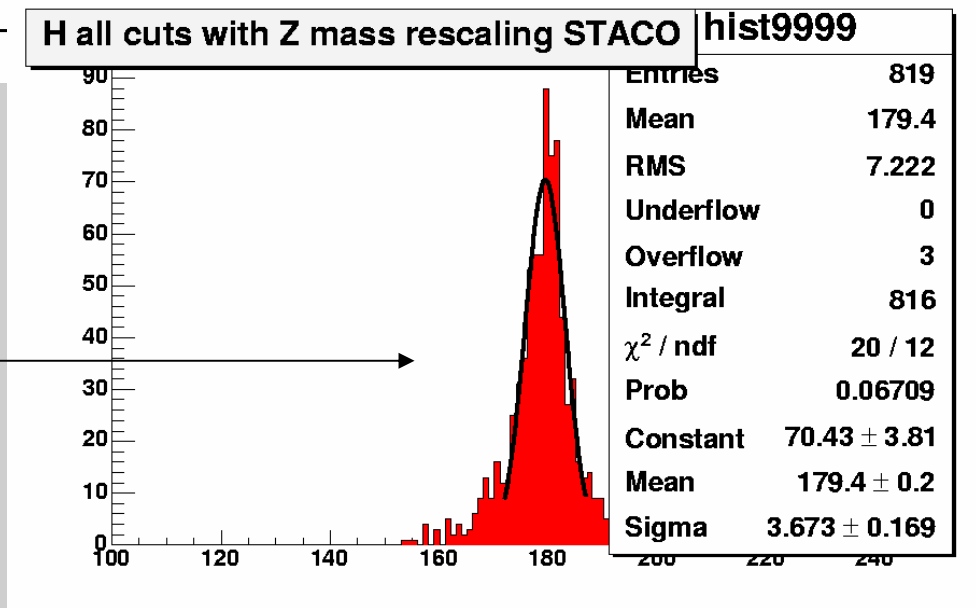


Higgs mass resolution with the two MS geometries



Nominal Layout

Misaligned layout



Summary

Vertexing studies:

- ◆ The PrimaryVertexFinding has changed since 11.0.41.
 - InDetPriVxFinder can be used with any existing vertex fitter.
 - Adaptive PV finder added.
- ◆ First results from the release 12.0.0 with default new tracking look impressive.
 - Improvements in resolutions on both vertex position and parameters of refitted tracks.
- ◆ First Primary Vertex finding results with New Tracking are very promising.

Electron performance studies:

- ◆ Calibration in 12.0.0 looks fine
 - the drop of efficiency in the gap region under investigation

Muon performance studies:

- ◆ Effects from muon geometry are studied for the first time in the context of a Higgs analysis
 - A detailed study of these effects should be done on event by event basis
- ◆ The studies must be completed including full ATLAS misalignment effects