Alignment of muon chambers with tracks

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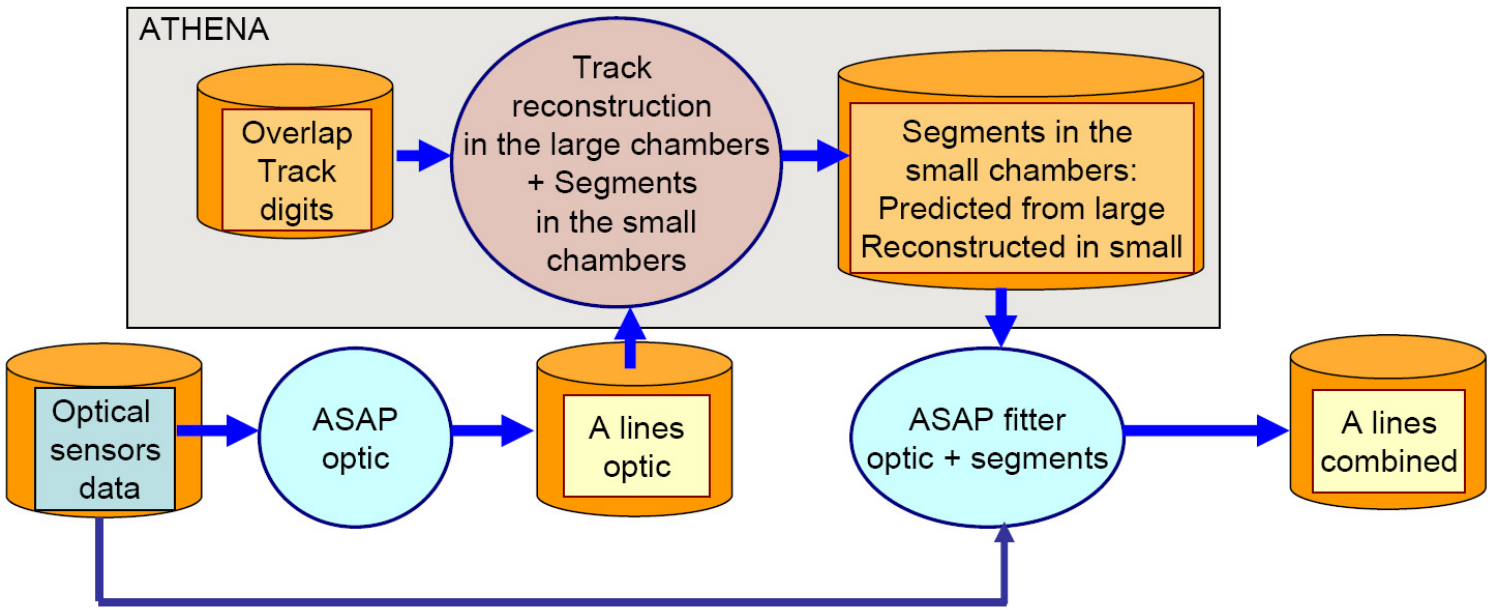
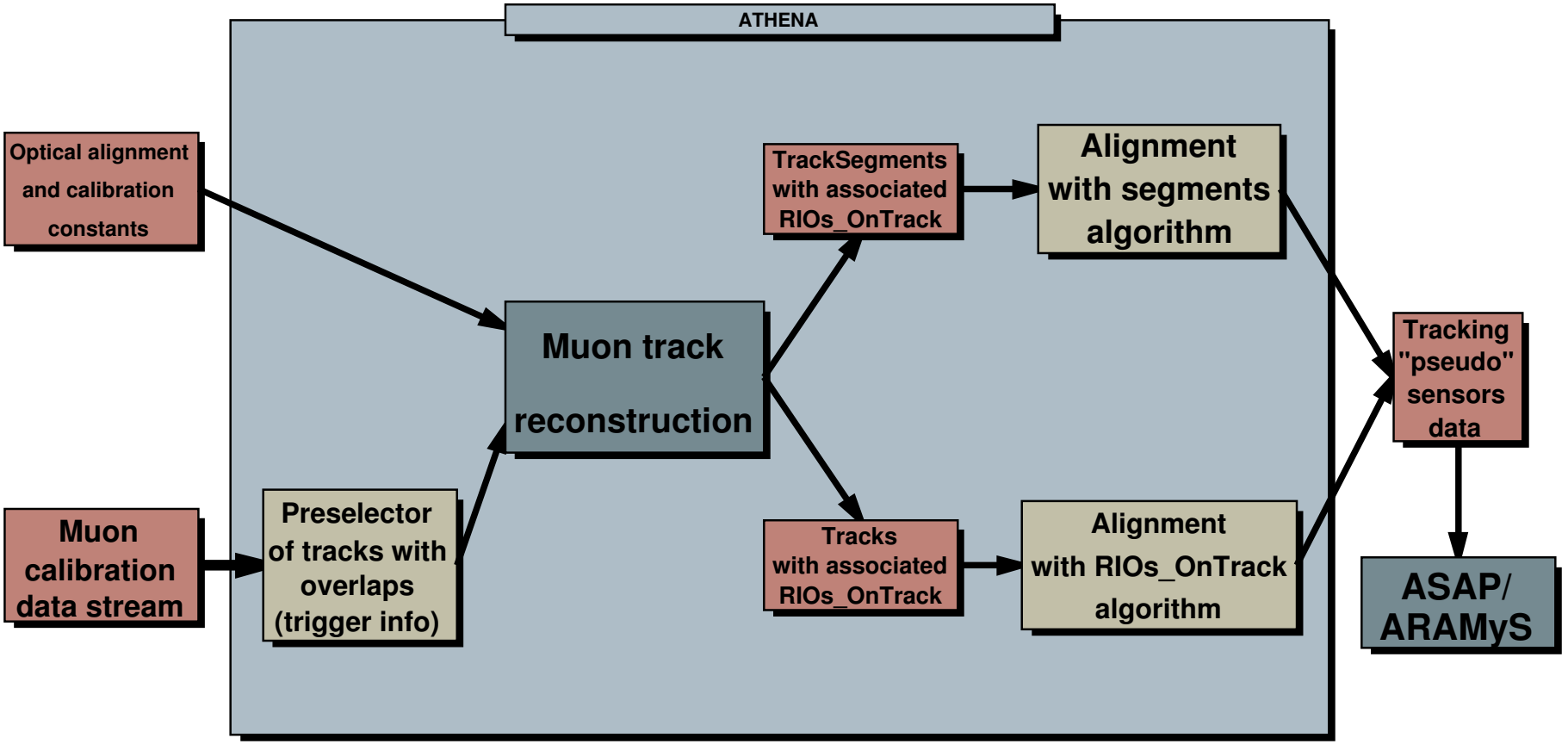
Tasks for track based alignment

- Alignment of the ATLAS muon spectrometer relies on an optical alignment system with several subsystems. Specifically, in barrel, sagitta corrections are calculated from readings of the projective alignment sensors
- Many muon chambers don't have projective optical alignment sensors – no correction to sagitta measurement
  - small barrel chambers
  - BEE chambers
  - BIS8 chambers
  - barrel-to-endcap connection
- Tracks passing through overlaps between these chambers and optically aligned chambers must be used to obtain their relative positions



Data flow in track based alignment



Basic features of the track based alignment algorithm

- It should be an algorithm within ATHENA framework
- This algorithm should make full use of new tracking EDM (be able to run on both Mounboy and MOORe output)
  - operate with tracking EDM data objects: Track, TrackSegment, RIO_OnTrack
  - use TrackFitters, TrackExtrapolators and other common tracking tools
- a skeleton of such an algorithm has been written at MPI (MuonTrkAlign package)

Structure of MuonTrkAlign algorithm

Steps of the MuonTrkAlign algorithm

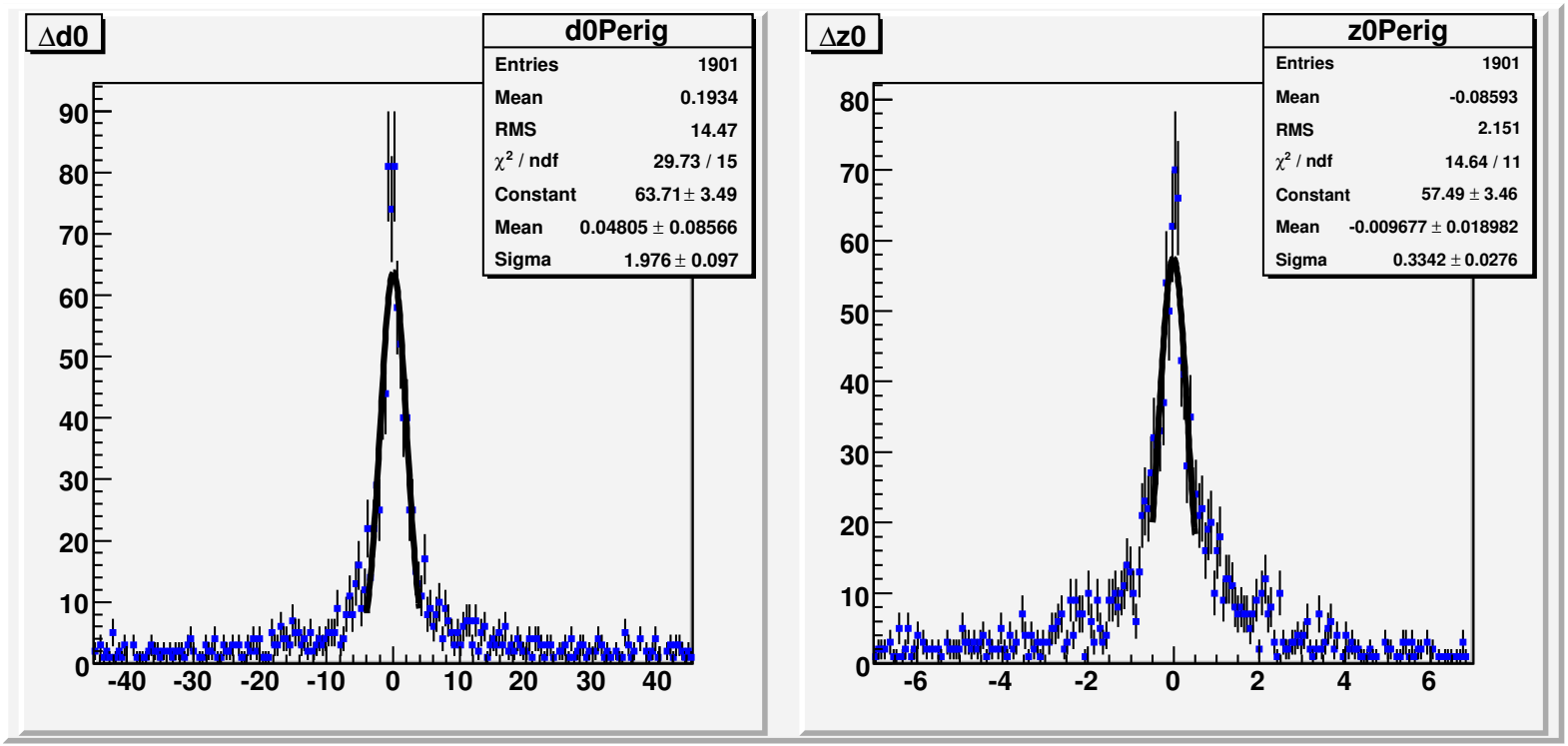
- select an overlap region Track with associated RIOs_OnTrack collection from standard muon reconstruction
- devide this collection into four parts: RIOs_OnTrack coming from large chambers and RIOs_OnTrack coming from small inner/middle/outer chambers
- refit the “large chambers” RIOs_OnTrack collection with TrackFitter from common tracking tools, using original track as a seed
- extrapolate this “large chambers” track into small chambers with TrackExtrapolator and get track’s extrapolated parameters
- refit inner/middle/outer small chamber RIOs_OnTrack collections with TrackFitter, using extrapolated “large chambers” track parameters as seed
- differences between the refitted inner/middle/outer small chamber tracks and the extrapolated “large chambers” track are the tracking “pseudo” sensors input for ASAP

Configuration of common tracking tools for MuonTrkAlign

- release 12.0.0, sample of 20 GeV muons (simulated with 11.0.4)
- input track container “ConvertedMooreTracks” or “ConvertedMuonboyTracks”
- setup of TrackFitter and TrackExtrapolator

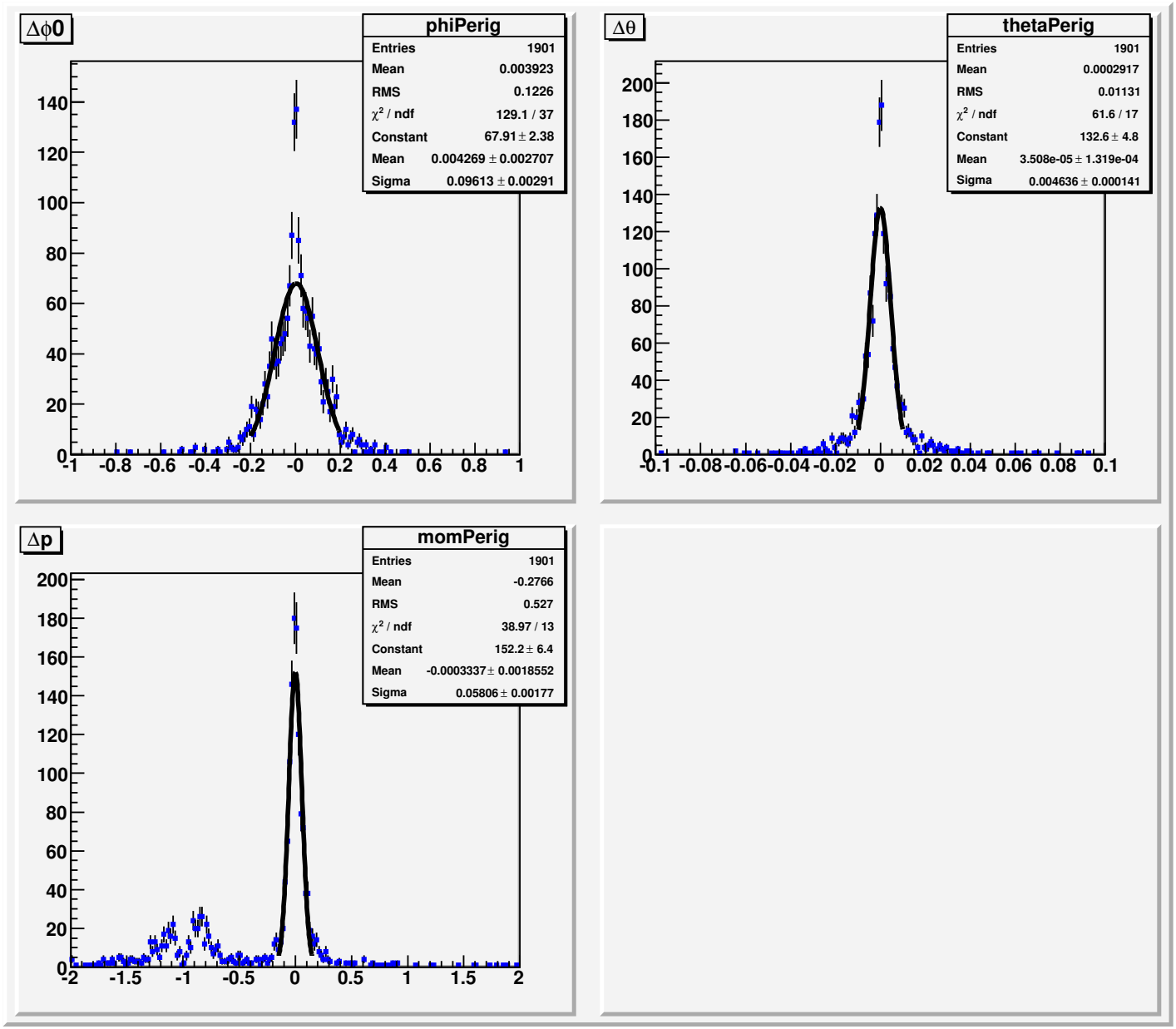
```
***** ConfiguredExtrapolator ****************************************************
* - ToolName:            ToolSvc.ConfiguredExtrapolatorATLAS
*-------------------------------------------------------------------------------
* - Propagator  0 :  Trk::StraightLinePropagator (Instance:  StraightLinePropagator )
* - Propagator  1 :  Trk::HelixPropagator (Instance:  HelixPropagator )
* - Propagator  2 :  Trk::RungeKuttaPropagator (Instance:  RungeKuttaPropagator )
* - Navigator     :  Trk::Navigator (Instance:  NavigatorWithEmptyGeometry )
* - Updator       :  Trk::MaterialEffectsUpdator (Instance:  MaterialEffectsUpdator )
*********************************************************************************
***** ConfiguredKalmanFitter ****************************************************
* - Tool:   Trk::KalmanFitter  under instance:  TrkKalmanFitter
* -------------------------------------------------------------------------------
* - Kalman ForwardFilter    TrkFwKalmanFitter
* - Kalman Smoother         TrkKalmanSmoother
* - Kalman OutlierLogic     TrkKalmanOutLogic
* - RIO_OnTrackCreator:     none
* - Extrapolator:           ConfiguredExtrapolatorATLAS
* - KalmanMeasUpdator:      Trk::KalmanUpdator/TrkKalmanUpdator
*********************************************************************************
MuonTrkAlignment                    INFO Tracking tool Trk::KalmanFitter booked as instance TrkKalmanFitter
MuonTrkAlignment                    INFO extrapolatorType=Trk::Extrapolator
extrapolatorName=ConfiguredExtrapolatorATLAS
MuonTrkAlignment                    INFO Tracking tool ConfiguredExtrapolatorATLAS booked as instance
ConfiguredExtrapolatorATLAS
MuonTrkAlignment                    INFO propagatorType=Trk::RungeKuttaPropagator
propagatorName=RungeKuttaPropagator
MuonTrkAlignment                    INFO Tracking tool Trk::RungeKuttaPropagator booked as instance
RungeKuttaPropagator
```

Comparison of original Moore track with refitted large chambers track



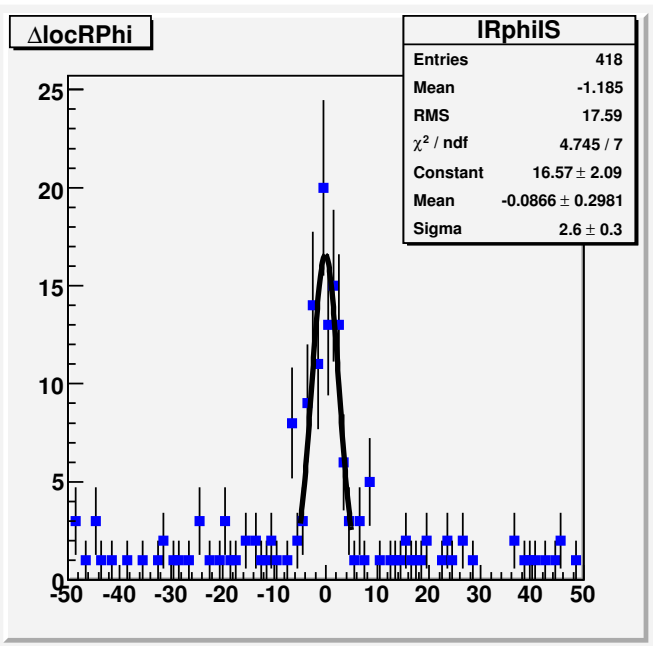
- impact parameters at original track perigee

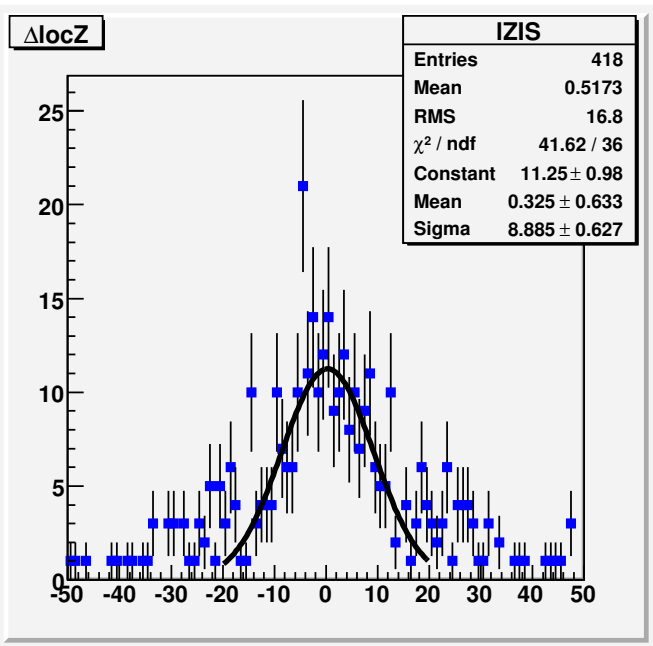
Comparison of original Moore track with refitted large chambers track

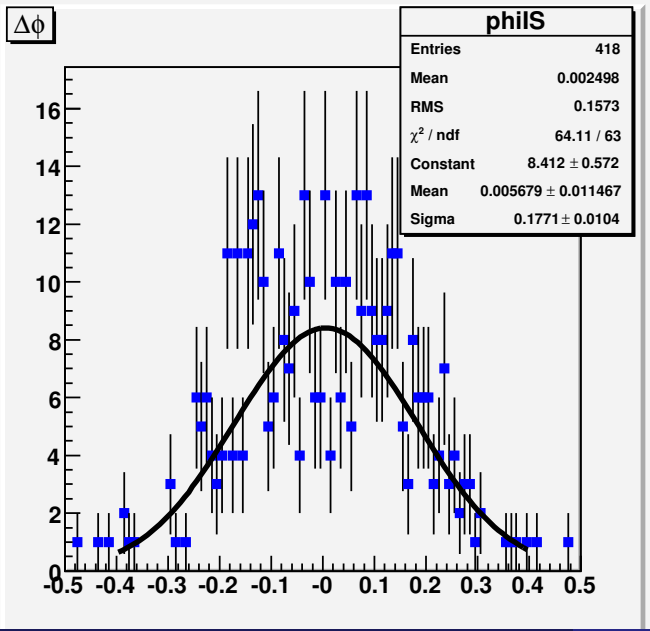


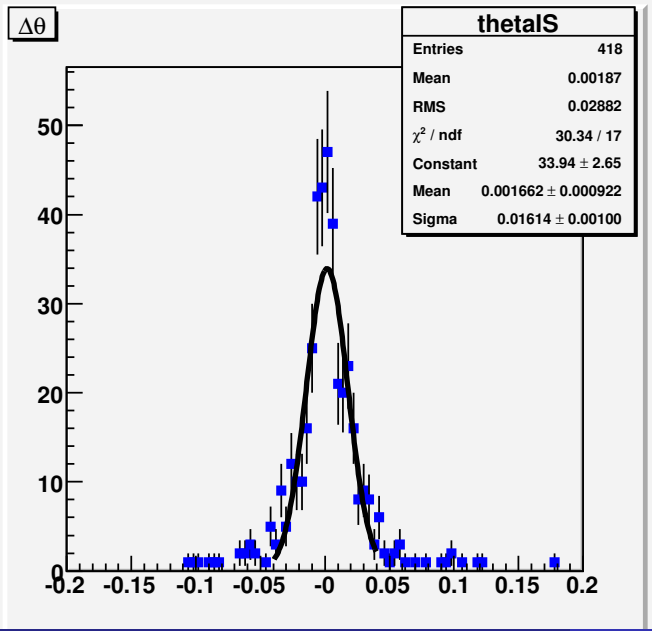
- momentum parameters at original track perigee

Extrapolated large chambers track vs inner small chamber track



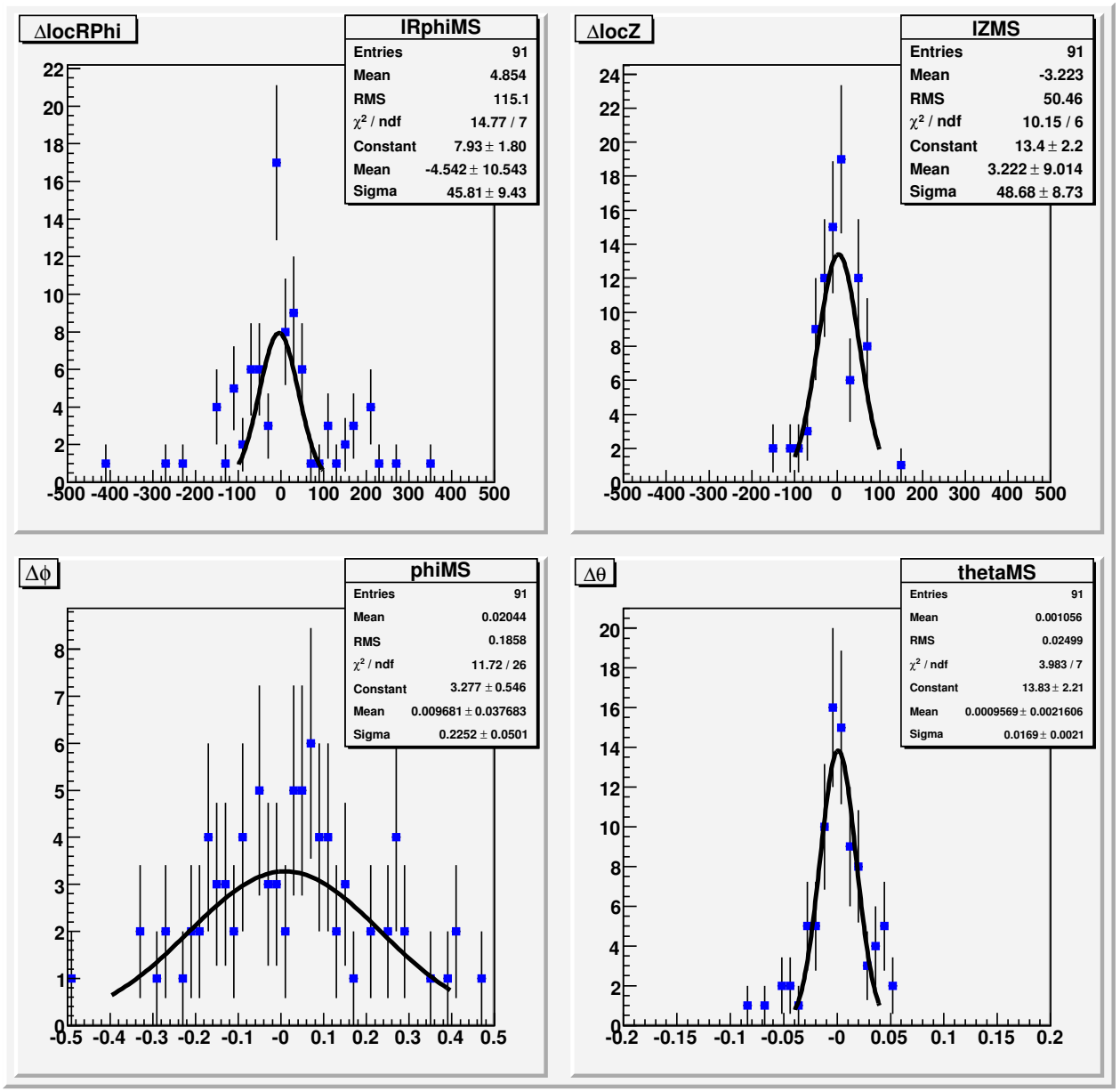




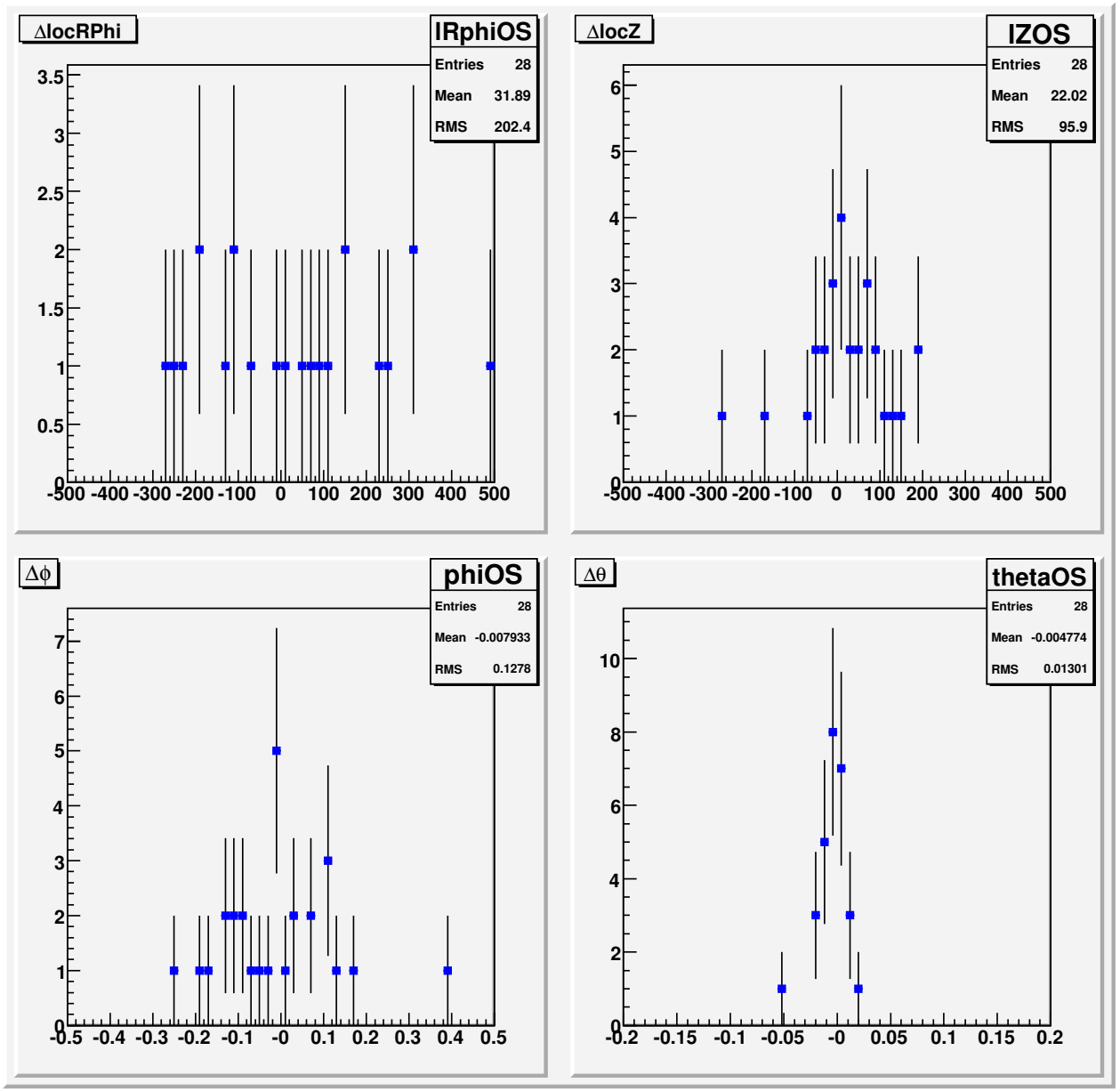


major bug just found - wrong orientation of the extrapolation surface, the correct pulls should be much smaller

Extrapolated large chambers track vs middle small chamber track



Extrapolated large chambers track vs outer small chamber track



Problems and Plans

Problems

- MuonClulsterOnTrack objects (RPCs, TGCs and CSCs) returned by MooreToTrack and MuonboyToTrack tools have 2D measurement but 1D covariance matrix
- couldn't find a way to constrain a track parameter (curvature) during the track refit in common tracking tools
- frequent crashes during refitting due to scatterers in original tracks
- the current code is just a skeleton of algorithm, so it might have some major bugs

Plans

- fix covariance matrix issue for converted tracks
- get rid of crashes to be able to run on larger samples
- tune common tracking tools parameters for use in muon spectrometer code
- run on a sample of muons with p_t=100 GeV