Muon Barrel Workshop

Torino, Wednesday 17 November 2004

Muon reconstruction: status and perspective

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Outline

- Muon reconstruction packages in ORCA,
- Local reconstruction,
- Muon in DST: reconstruction and isolation,
- Results,
- Future,

Muon reconstruction in ORCA

- Different sub-packages

  Muon Geometry, digitization, local reconstruction, standalone reconstruction

  MuonLocalReco Will born soon from splitting of Muon: local reconstruction and standalone reconstruction

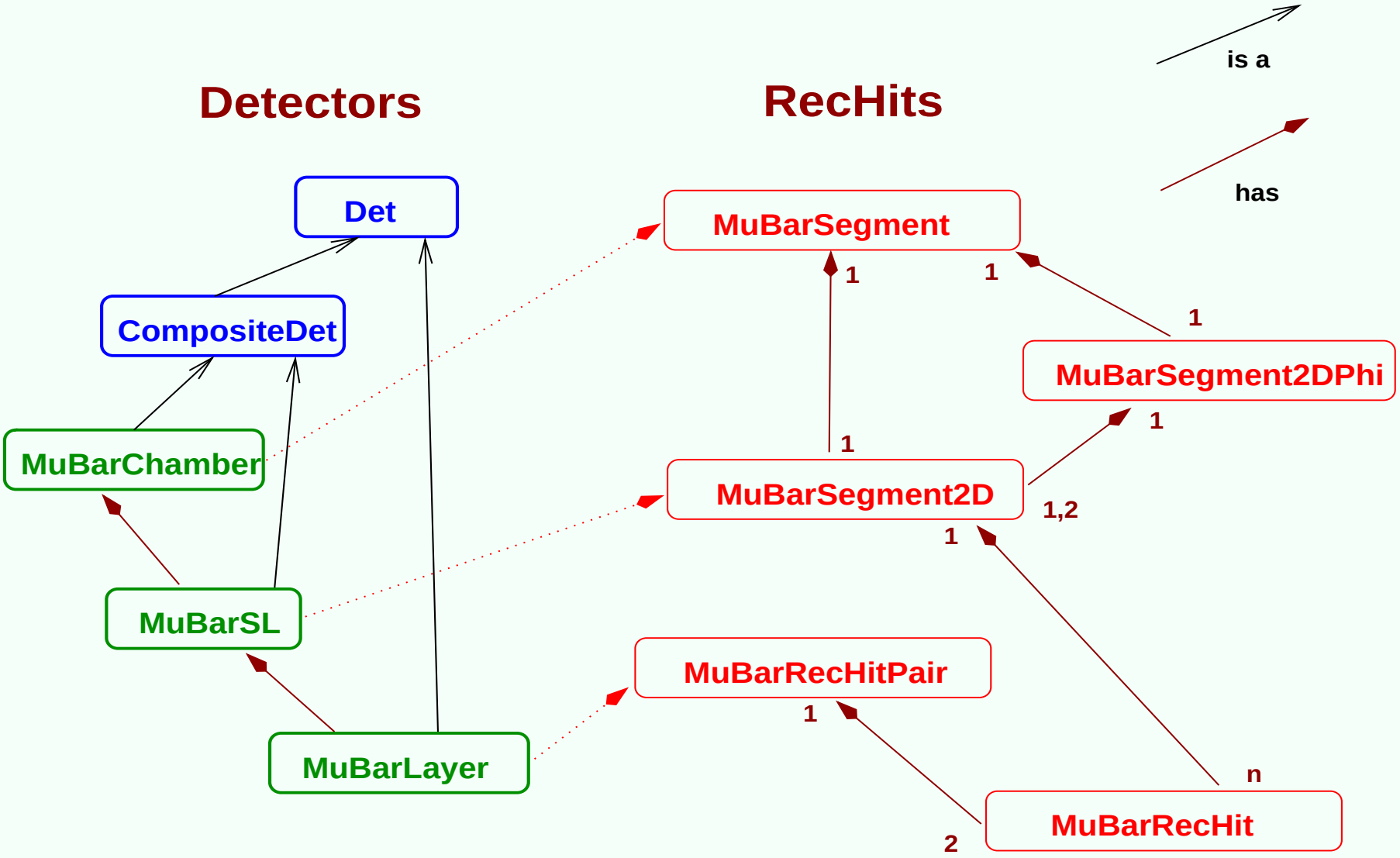
  MuonReco Global reconstruction, HLT reconstruction, isolation

  MuonAnalysis Package for PRS analysis (almost empty now)

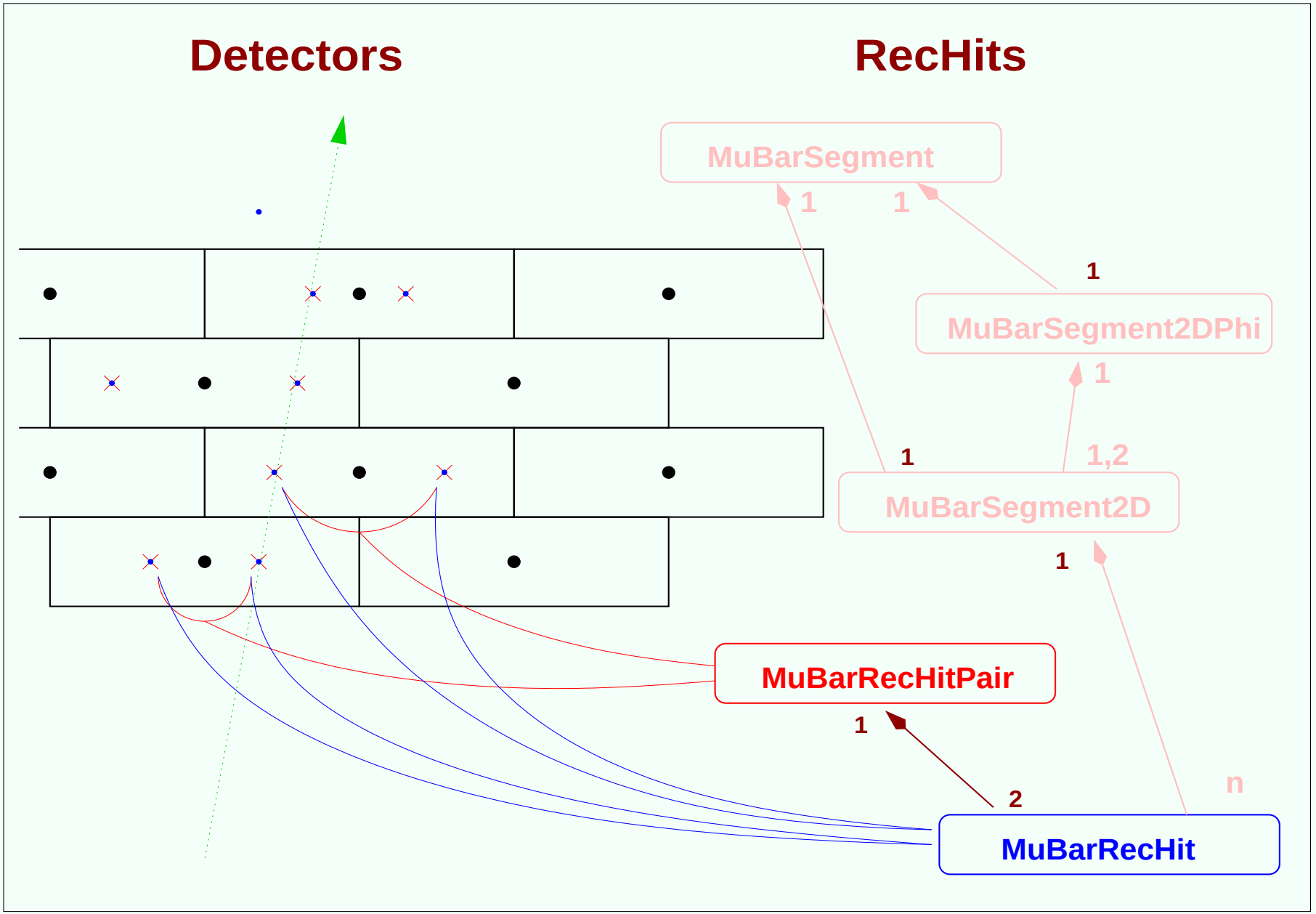
- Actual ORCA version 8_6_0
- Will stay stable as baseline for next months
- Massive DST production of DC04 data ($\sim 80\ Mev$) expected to start soon

DT segment reconstruction

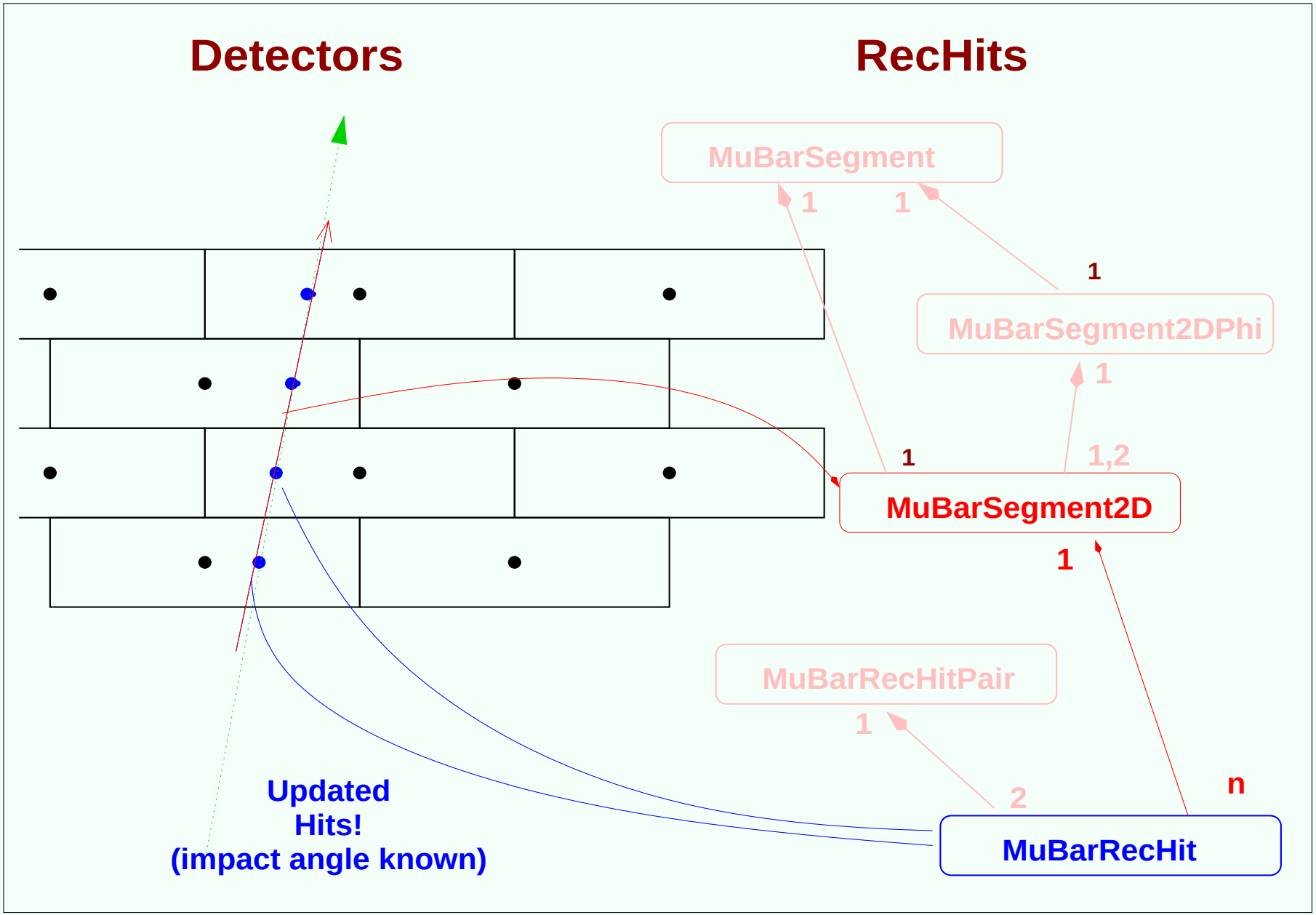
See my talk at PRSμ meeting on October, 14^{th}, 2003



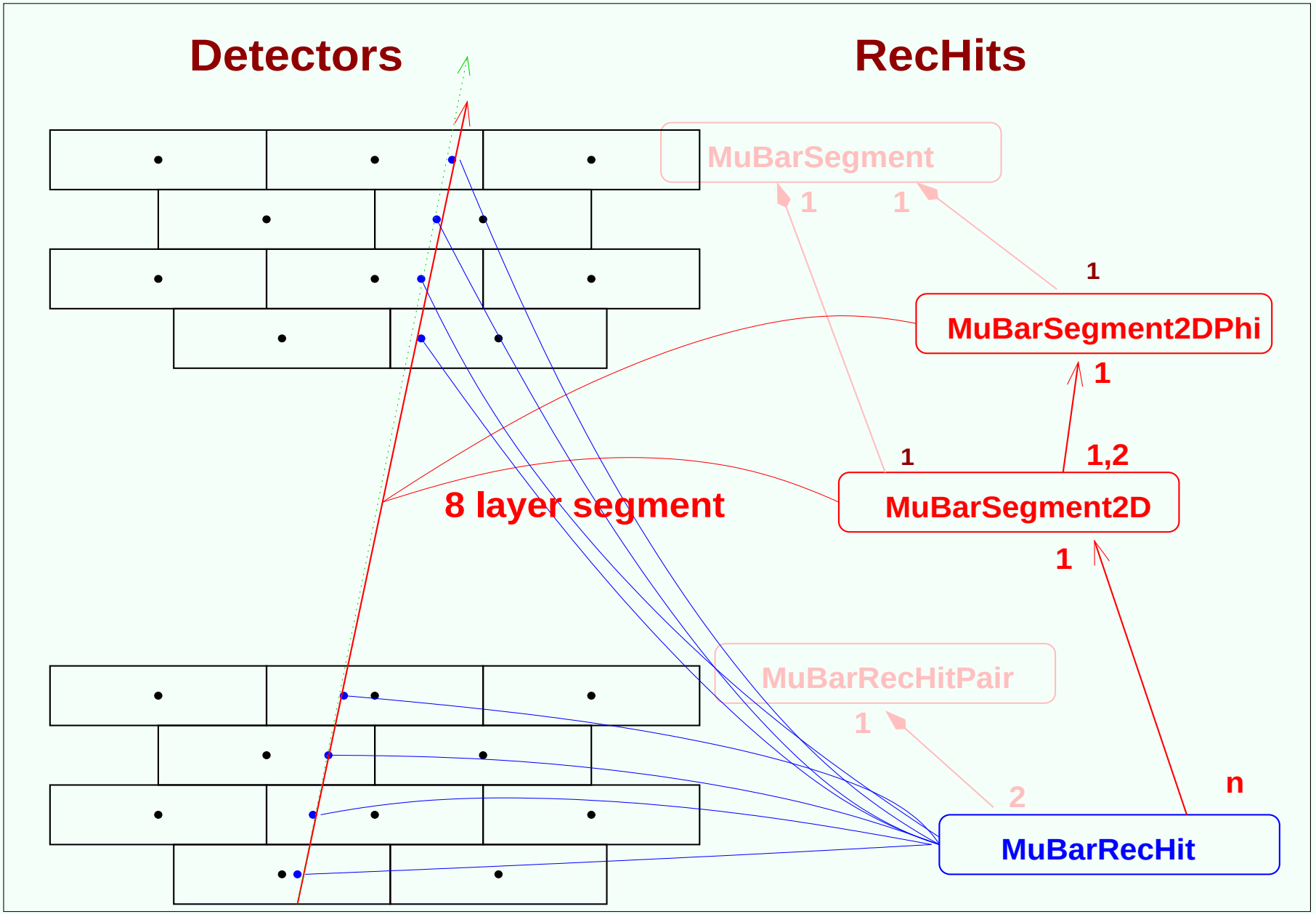
Layer hits and pairs



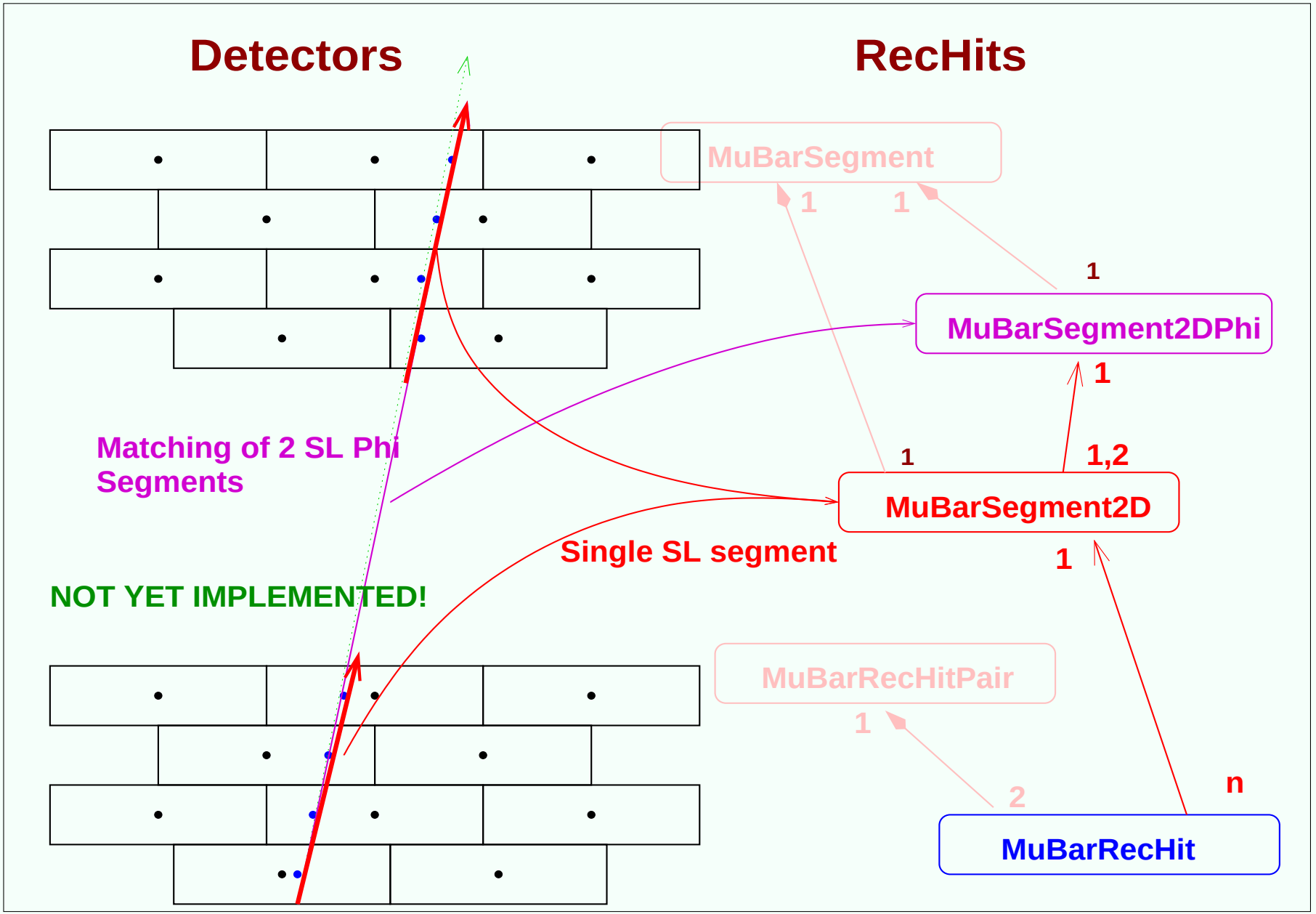
SL segments


Detectors
RecHits
MuBarSegment
1
1
1
MuBarSegment2DPhi
1
1
1,2
MuBarSegment2D
1
MuBarRecHitPair
1
2
n
MuBarRecHit
Updated
Hits!
(impact angle known)

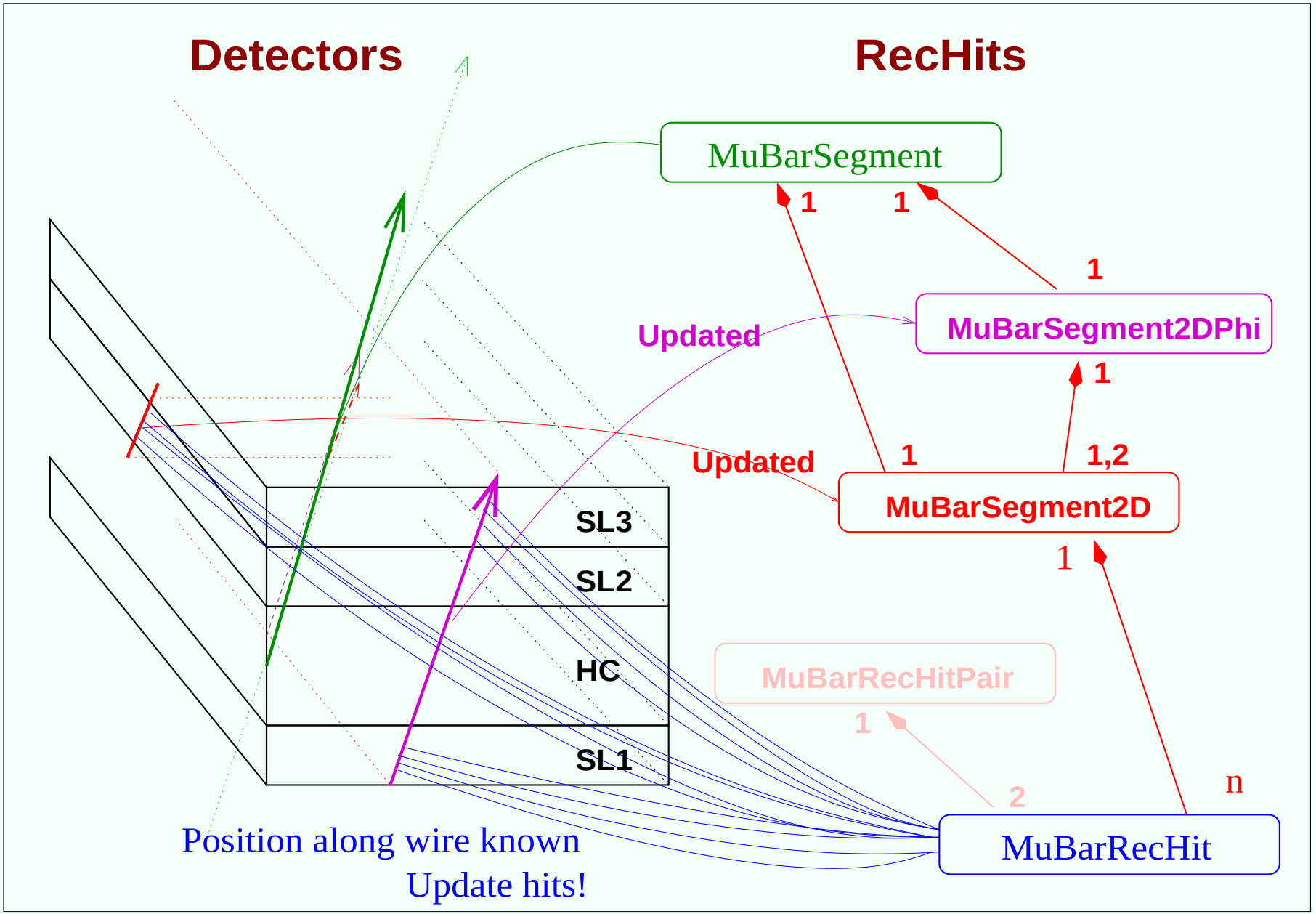
SL segments superϕ



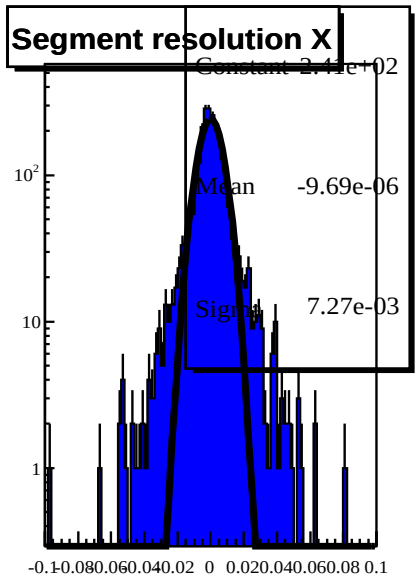
SL segments twin ϕ

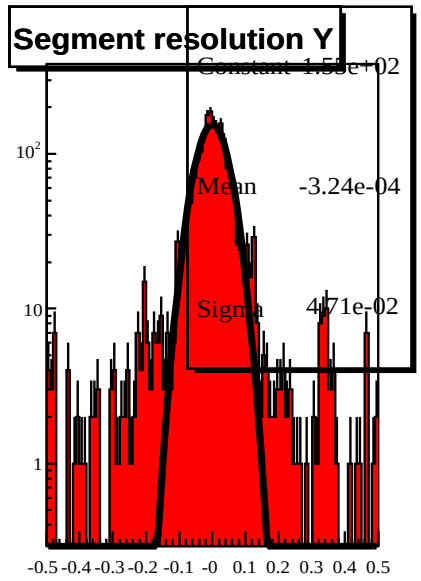


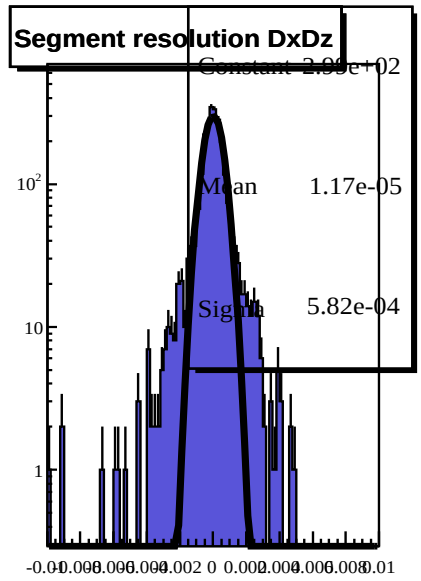
Chamber segments

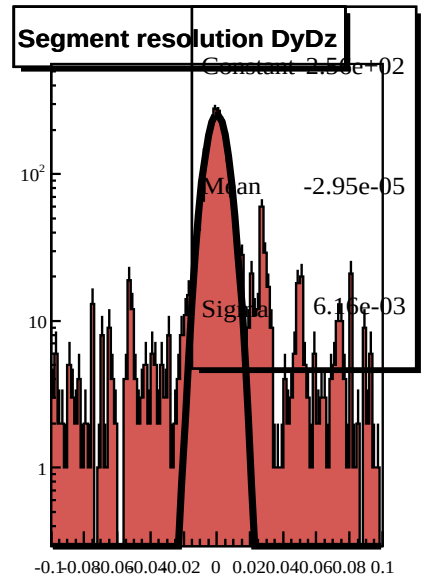


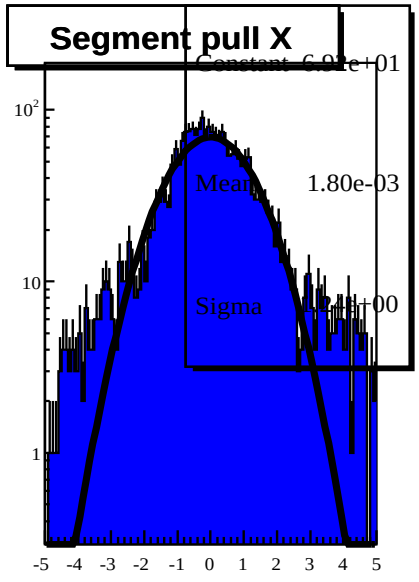
Chamber segment reso and pulls

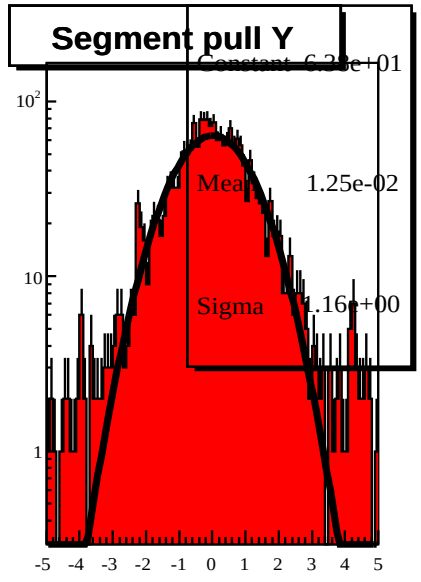


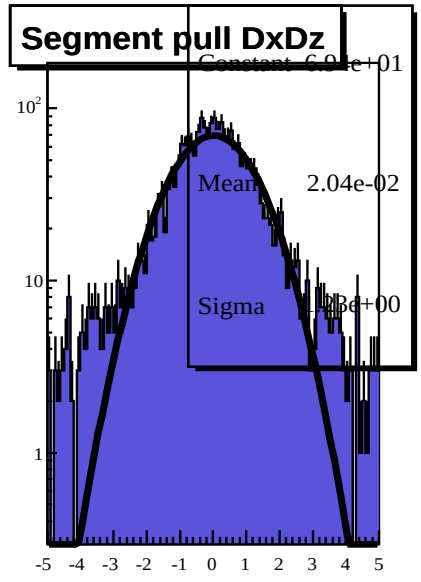


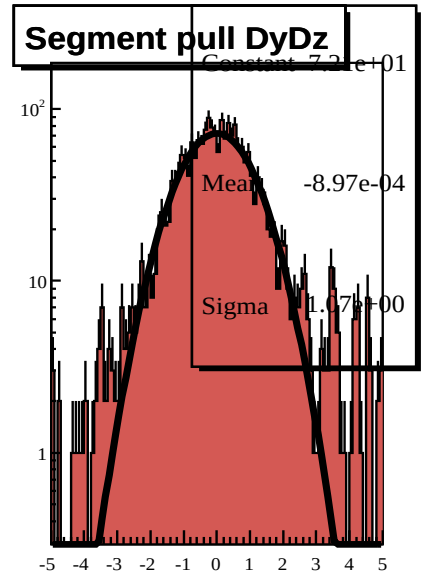




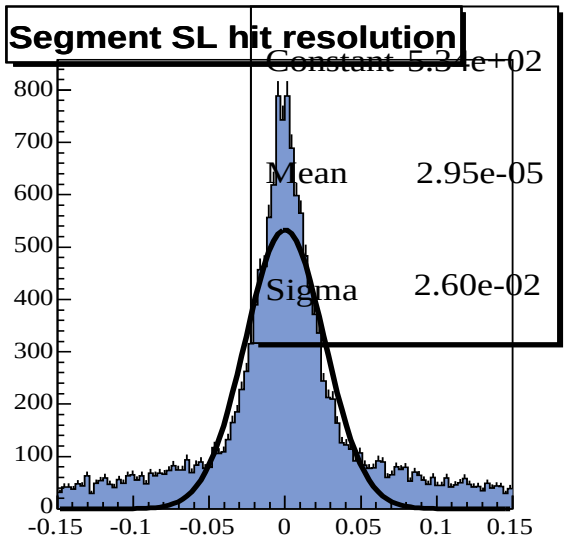


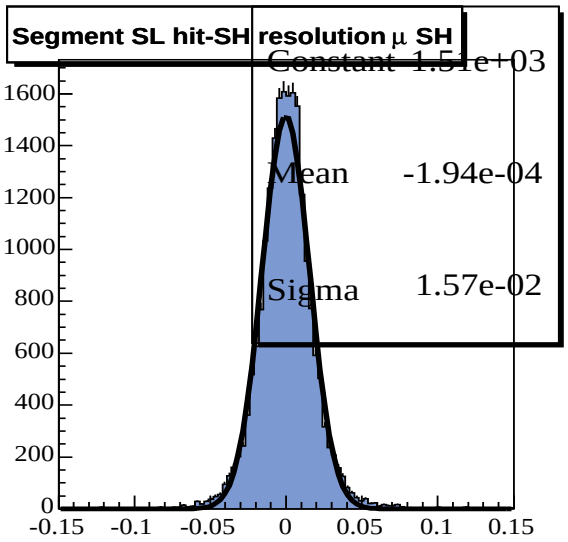


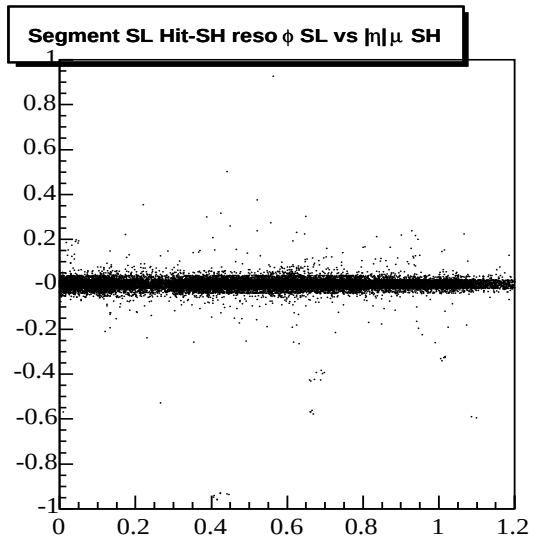


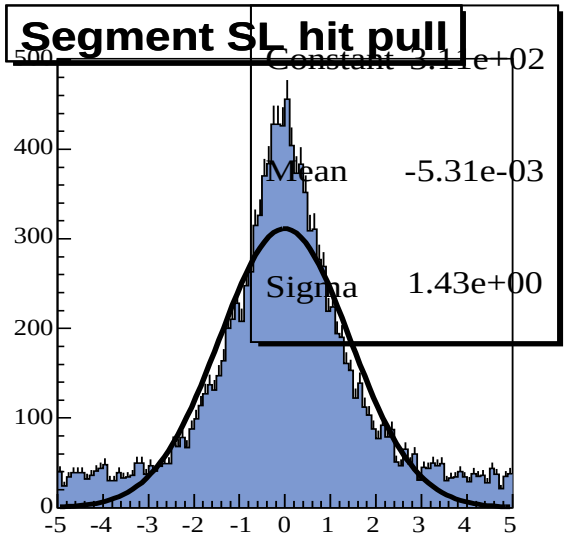


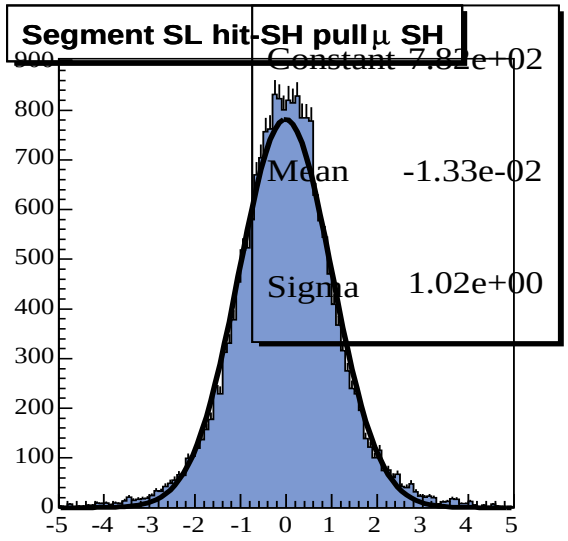
Chamber hits reso and pulls

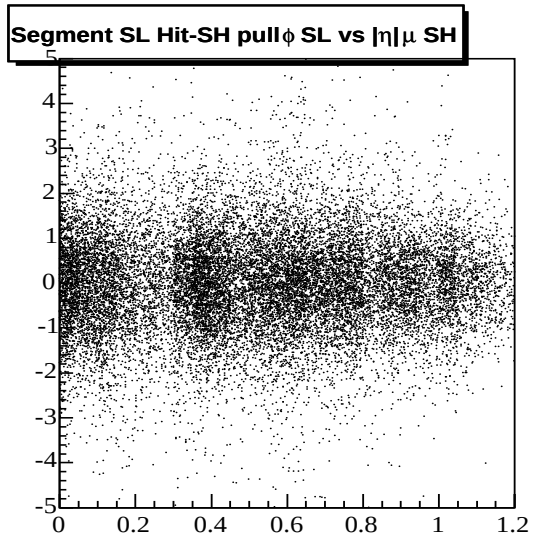






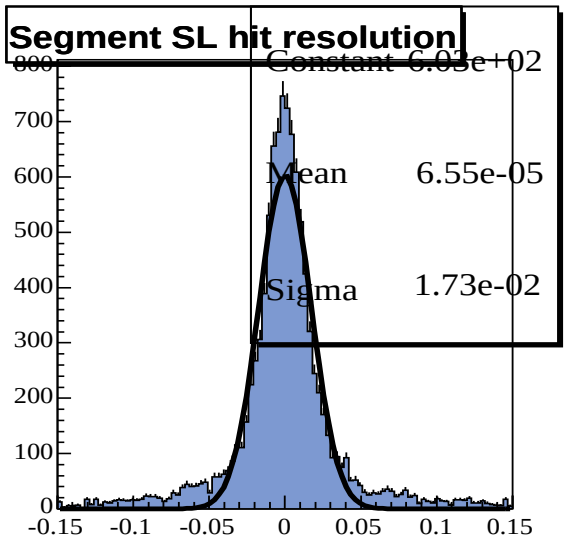


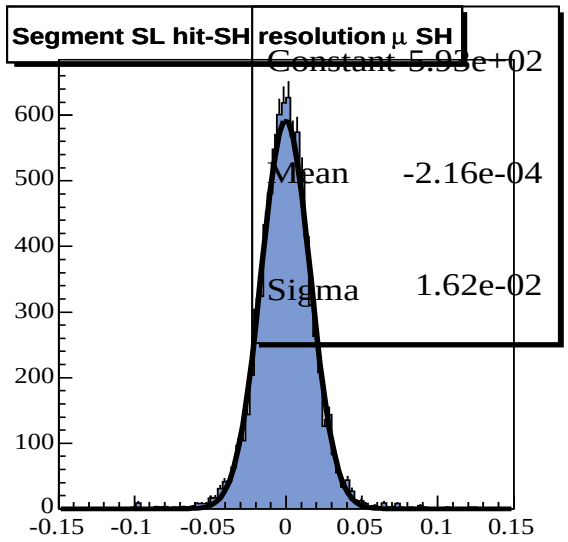


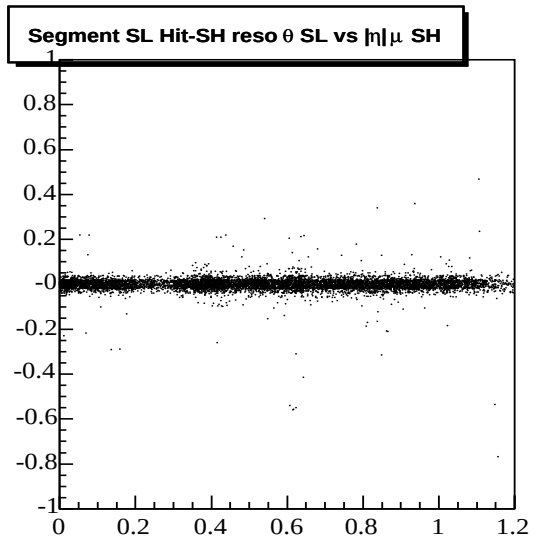


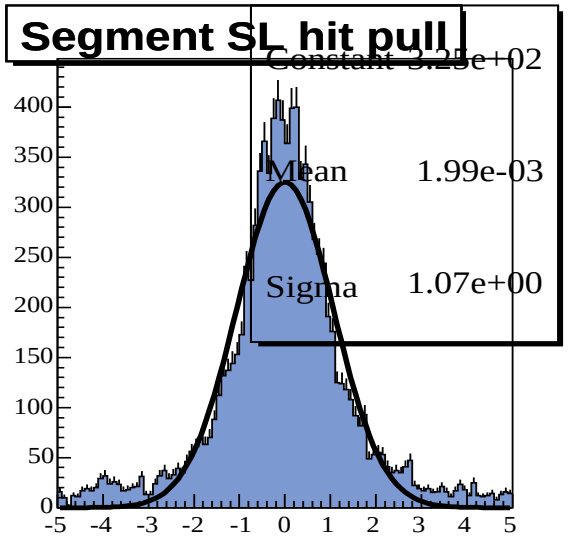
Hits from 4D segments: all corrections. ϕ-SL

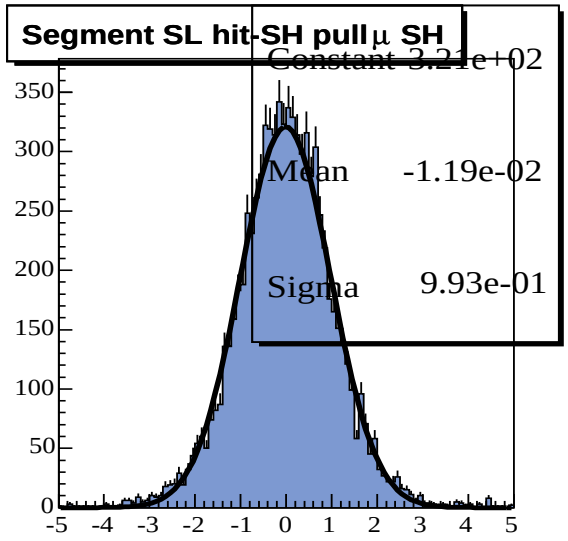
Chamber hits reso and pulls

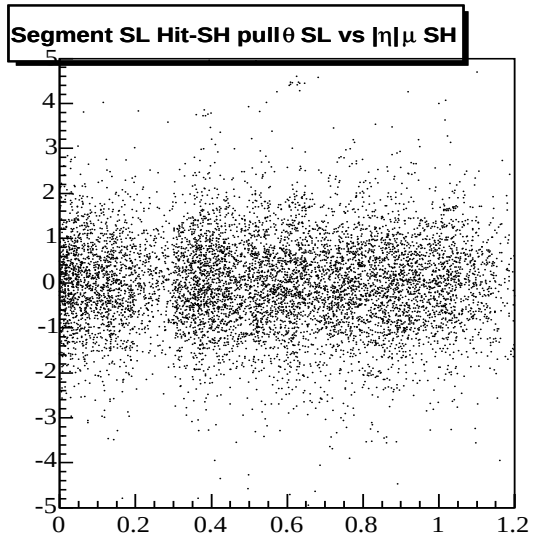












Hits from 4D segments: all corrections. θ-SL

Muon in DST

- Since beginning of this year (from DC04) DST available
- DST: Data Summary Table
  - Common framework for reconstruction algorithms
  - Store persistently (and retrieve quickly) reconstructed objects
  - Provide common interface to access (persistent and transient) all kind of reconstructed objects: muons, electrons, jets, tracks, ...
- Not **AOD**: Analysis Object Data
- *i.e.* not "just" 4-momentum, but reconstructed objects, with (almost) full information
- Underlying structure changed over past months
  - a lot of work for developers to adapt the existing algorithms to the new structure
  - not stable interface for user
  - Not much time left for developers to improve algos
  - Hard time for everybody!

Muon in DST

- With latest ORCA (860) DST frozen to allow big production of DC04 data
- Available RecAlgorithms for Muon reconstruction

  L2MuonReconstructor For HLT: start from L1 output using only Muon info + IP constraint

  L3MuonReconstructor For HLT: add tracker hits

  StandAloneMuonReconstructor For off-line: internal seed (from DT and CSC segments), uses only Muon info (+ IP)

  GlobalMuonReconstructor For off-line: start from SA plus tracker/pixel hits. Full reconstruction
- All provide RecMuon: the reconstructed muon
- It's more than just a track!

Muon in DST: code example

```
RecCollection<RecMuon> theCollection(RecQuery("GlobalMuonReconstructor"));

for (RecCollection<RecMuon>::const_iterator it=theCollection.begin();
  it!=theCollection.end(); it++) {
  cout << "innerState: " << (*it).innermostState() << endl;
  cout << "outerState: " << (*it).outermostState() << endl;
  cout << "chi2: " << (*it).chiSquared() << endl;
  cout << "mom@vtx " << (*it).momentumAtVertex() << endl;
  cout << "charge " << (*it).charge() << endl;
  ...

}
```

- Same code for all Reconstructor
- See ORCA tutorial for more information (from ORCA web page)

RecMuon in DST

- What is `RecMuon`
- Full interface documentation available via doxygen class documentation from ORCA web page
  - State at innermost/outermost station
  - State at closest approach to vertex in the transverse plane
  - State constrained to the vertex
  - SA muon constrained to IP, GMR not constrained (not using, yet, reconstructed vertex). Can be done by user.
  - all states (updated and predicted) along the path
  - all RecHits used along the path
  - χ^2 of track fit and vertex constraint
  - The Muon stand-alone track (only for GMR and L3): it's a RecMuon as well!
  - The Tracker stand-alone track (only for GMR and L3): it's a RecMuon as well!
  - ...
- Isolation information (next slide)

Isolation in DST

- Single RecAlgorithm IsolatedGlobalMuonReconstructor
- Improved user ability to play with isolation from DST: request from several PRS
- Do not store results of isolation algorithm, but components from which isolation can be computed
- `MuIsoDeposit`
- Store separately for **ecal**, **hcal**, **tracker** and **pixel**
- Class representing the energy profile of deposits around a muon, i.e. the differential and integral deposits around the muon as a function of ΔR.
- Get total deposit in a cone of ΔR=coneSize.

```
float within (float coneSize) const
```

- User can add E_t or p_t up to user defined ΔR and play with isolation
- Allow great flexibility
- Helper classes provided to apply “standard” isolation

Isolation example

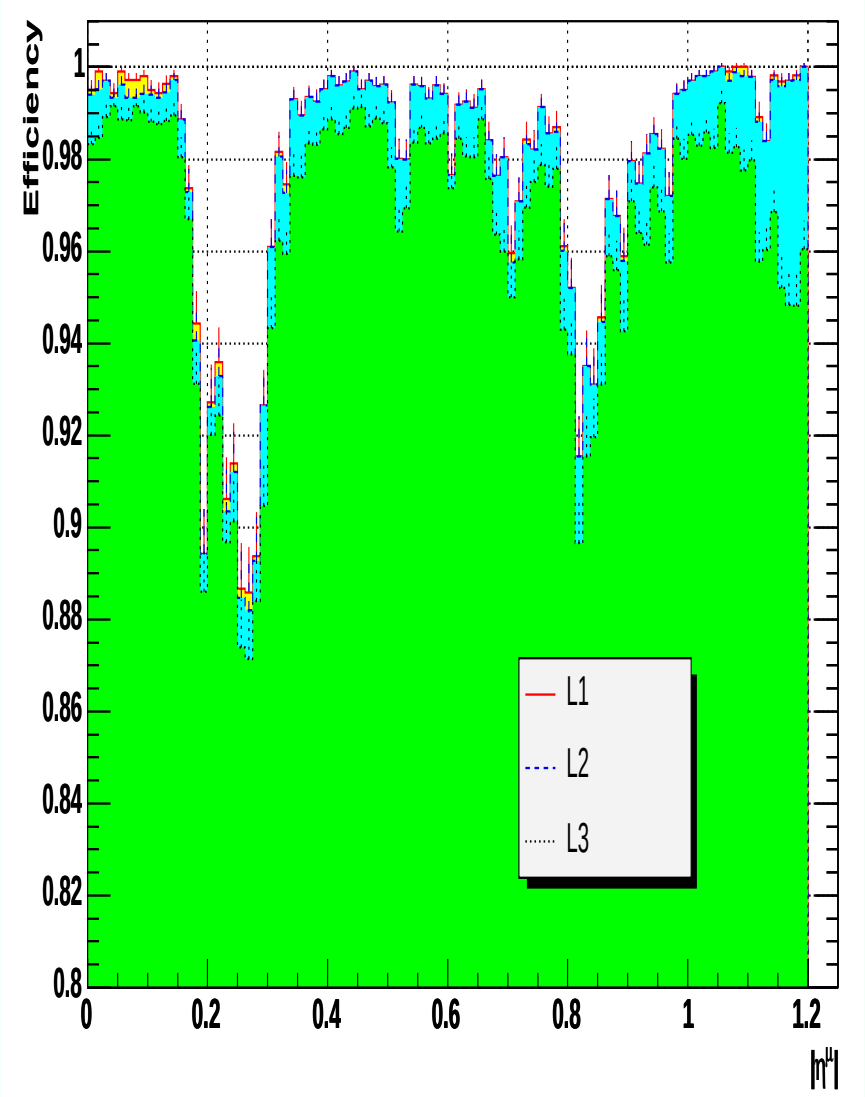
MuonReco/MuonIsolation/test/

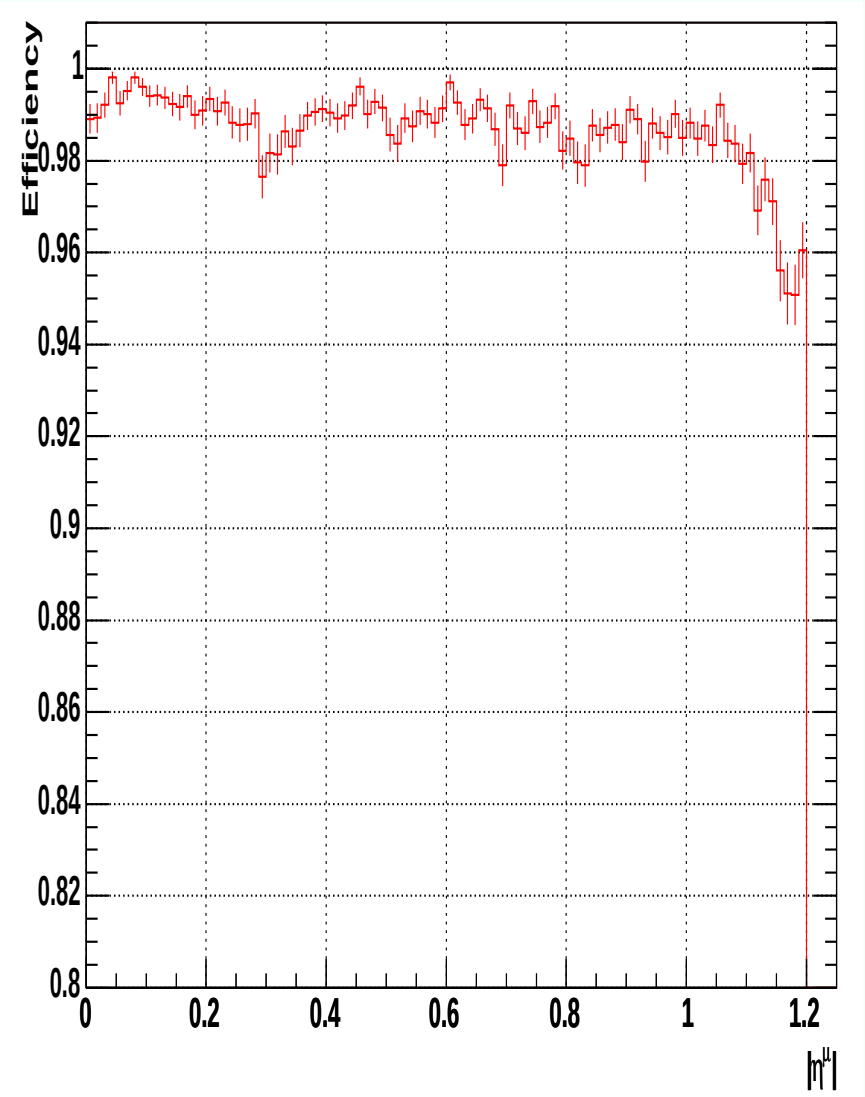
```
#include "MuonReco/MuonIsolation/interface/MuIsoByCaloEt.h"
#include "MuonReco/MuonIsolation/interface/MuIsoByTrackerPt.h"
#include "MuonReco/MuonIsolation/interface/MuIsoByPixelPt.h"
  ...
isolGlobalMu = new RecCollection<RecMuon>(
    RecQuery("IsolatedGlobalMuonReconstructor"));
isoCaloEt = new MuIsoByCaloEt();
isoTkPt = new MuIsoByTrackerPt();
isoPxPt = new MuIsoByPixelPt();
...
for (RecCollection<RecMuon>::const_iterator muon =
 isolGlobalMu->begin(); muon != isolGlobalMu->end(); muon++) {

 cout << "Calo Et isolation:    " << isoCaloEt->isolation(*muon) <<endl;
 cout << "Tracker Pt isolation: " << isoTkPt->isolation(*muon) <<endl;
 cout << "Pixel Pt isolation:   " << isoPxPt->isolation(*muon) <<endl;
}
```

Same interface works also for GMT muons, accessing Digis!

(used for HLT)

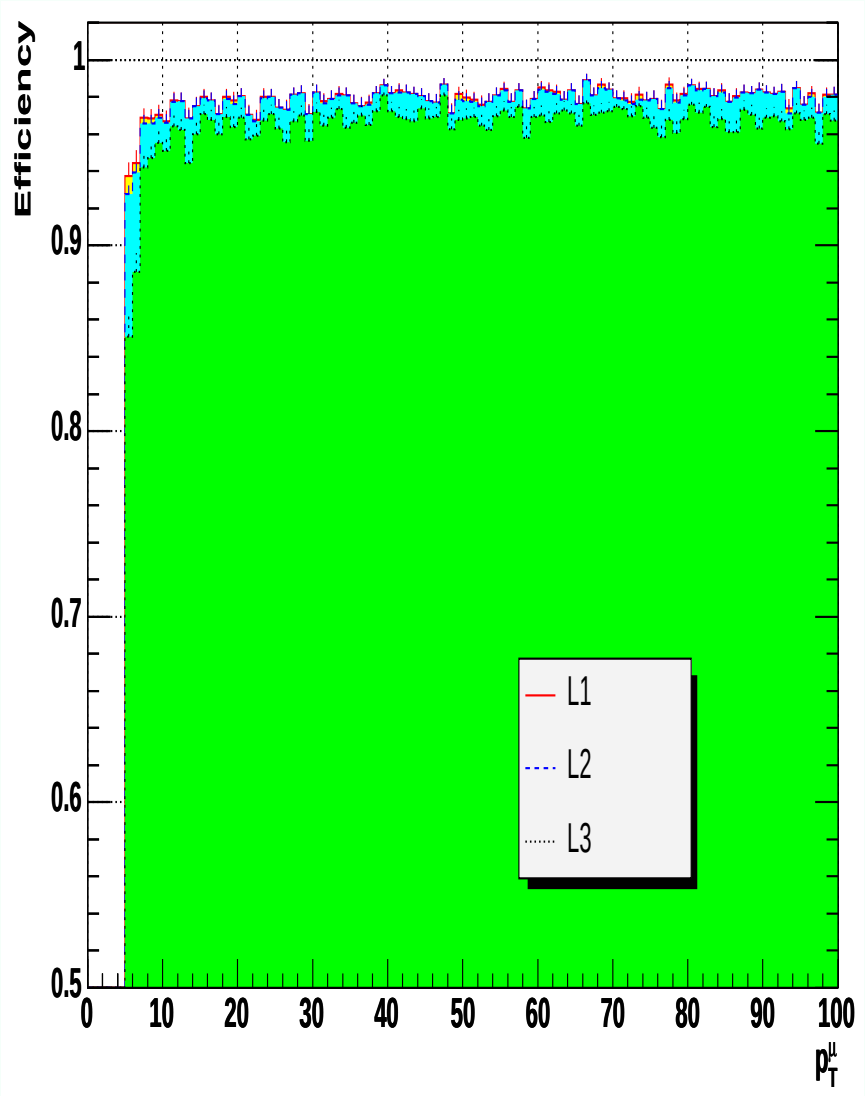
Results: L1, L2, L3 eff vs η

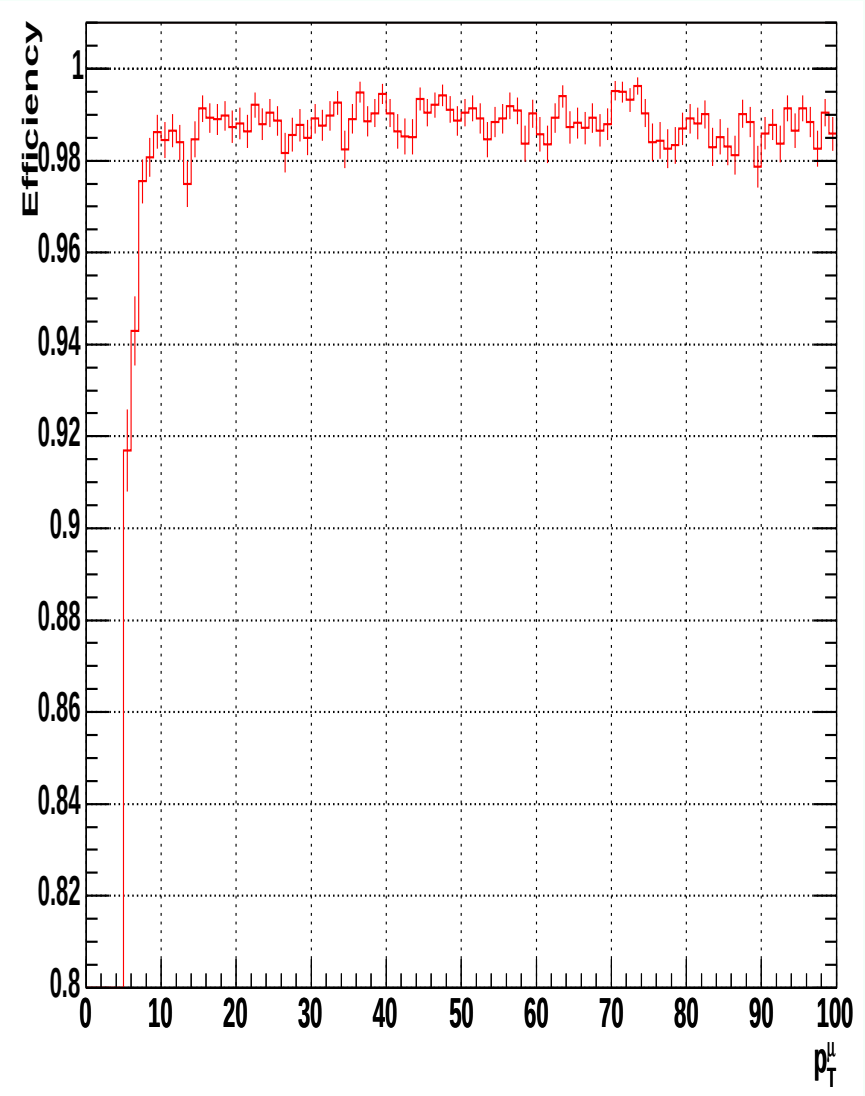




Single Muon, $5 \div 100$ GeV$/c^2$, $|\eta| < 1.2$ Eff $L3/L2$

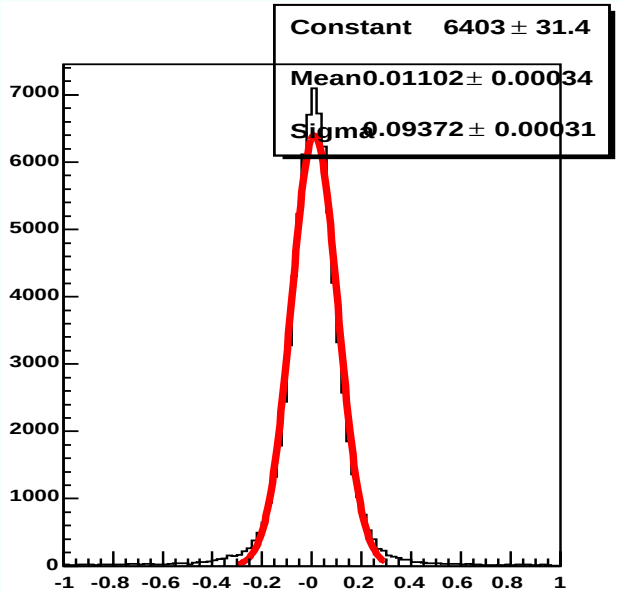
Results: L1, L2, L3 eff vs p_t

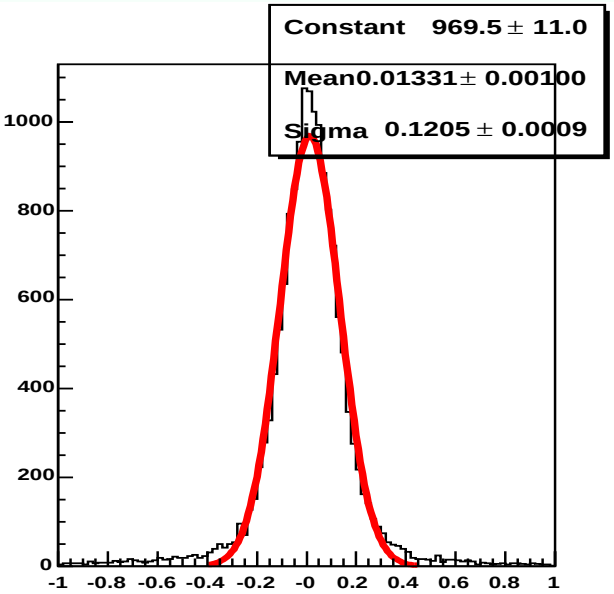


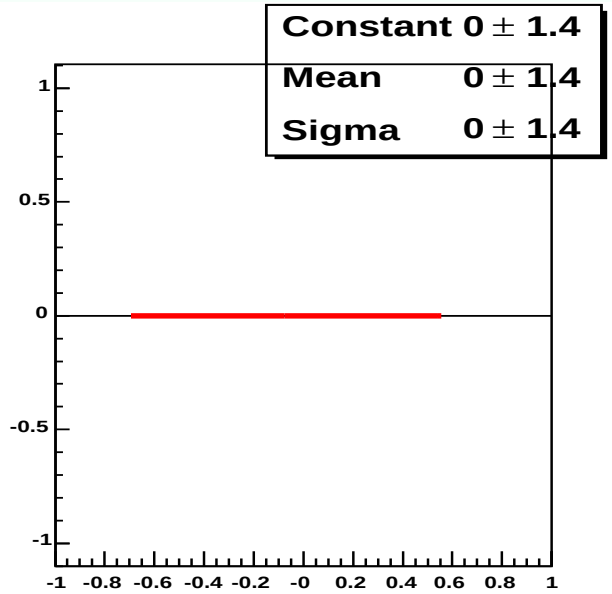


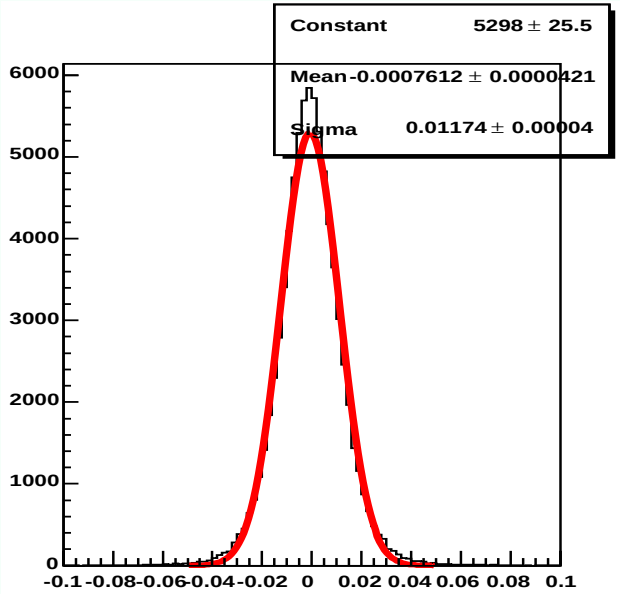
Single Muon, $p_t = 5 \div 100$ GeV$/c^2$, $|\eta| < 1.2$ Eff $L3/L2$

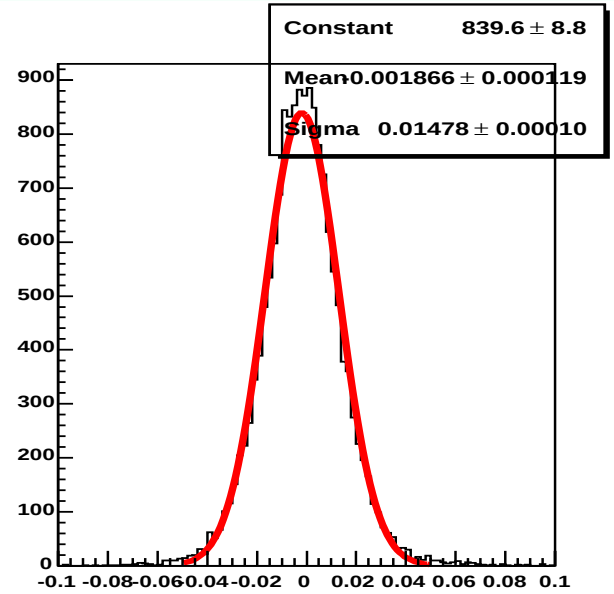
Results: $1/p_t$ Resolution L2, L3

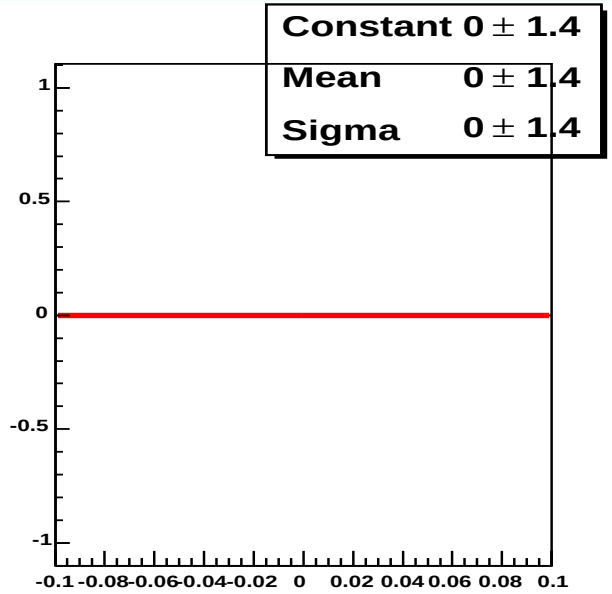




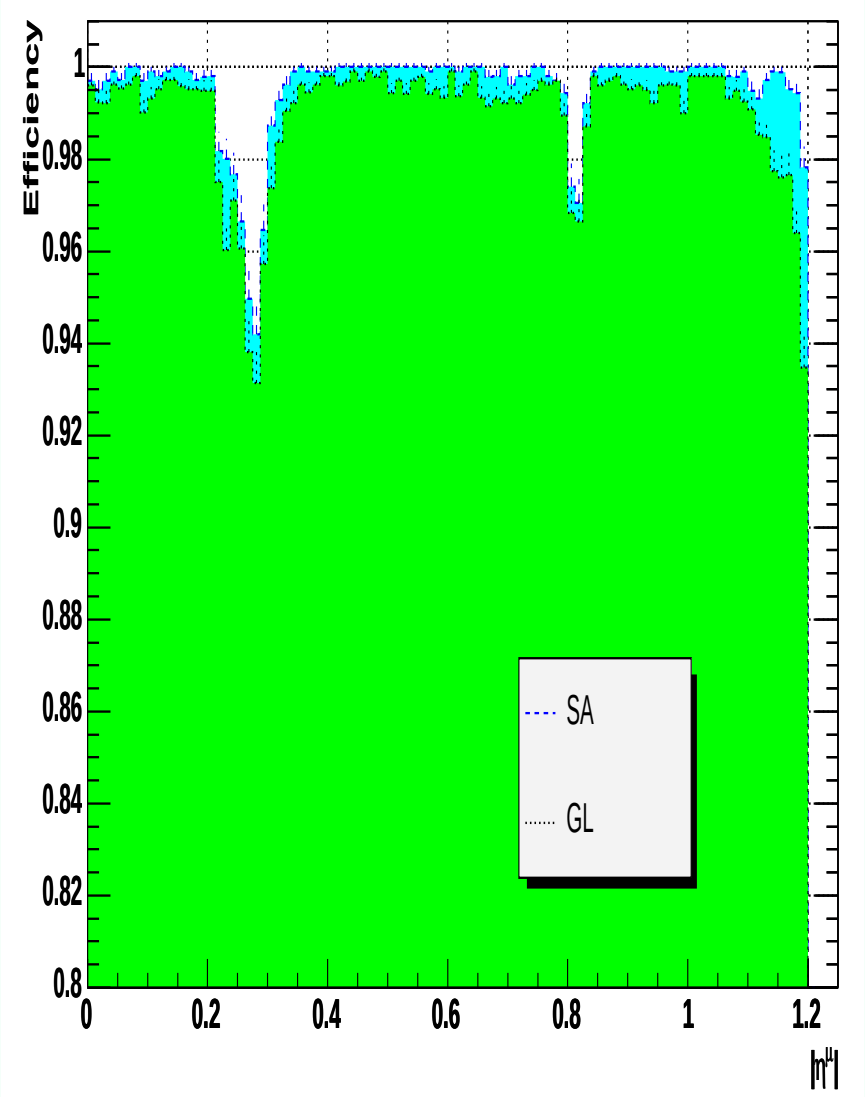


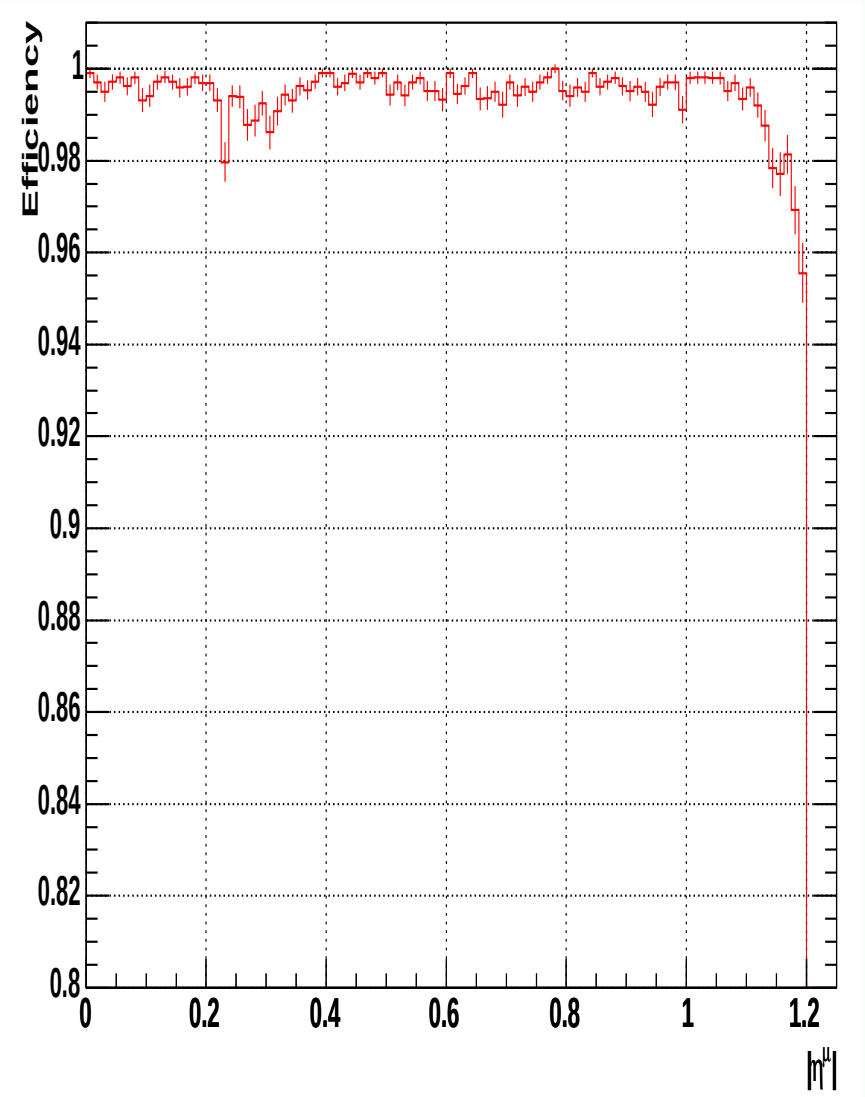






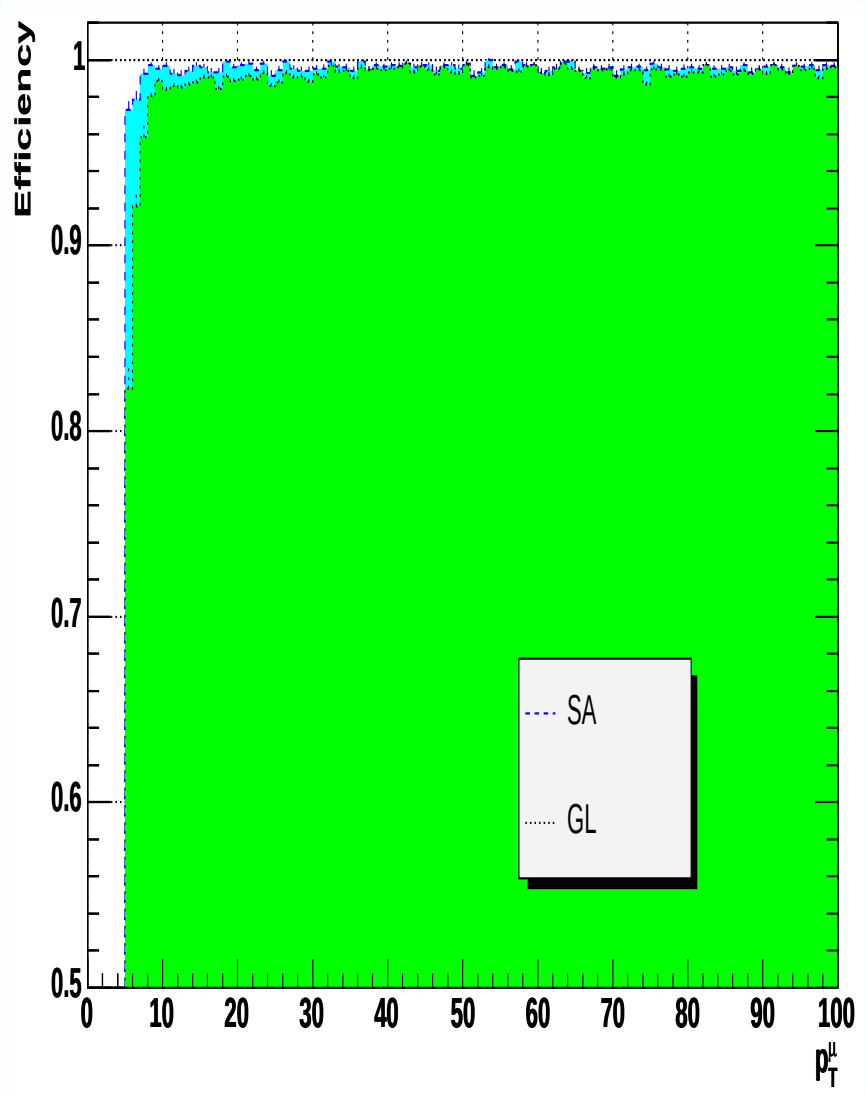
Results: SA, GMR eff vs η

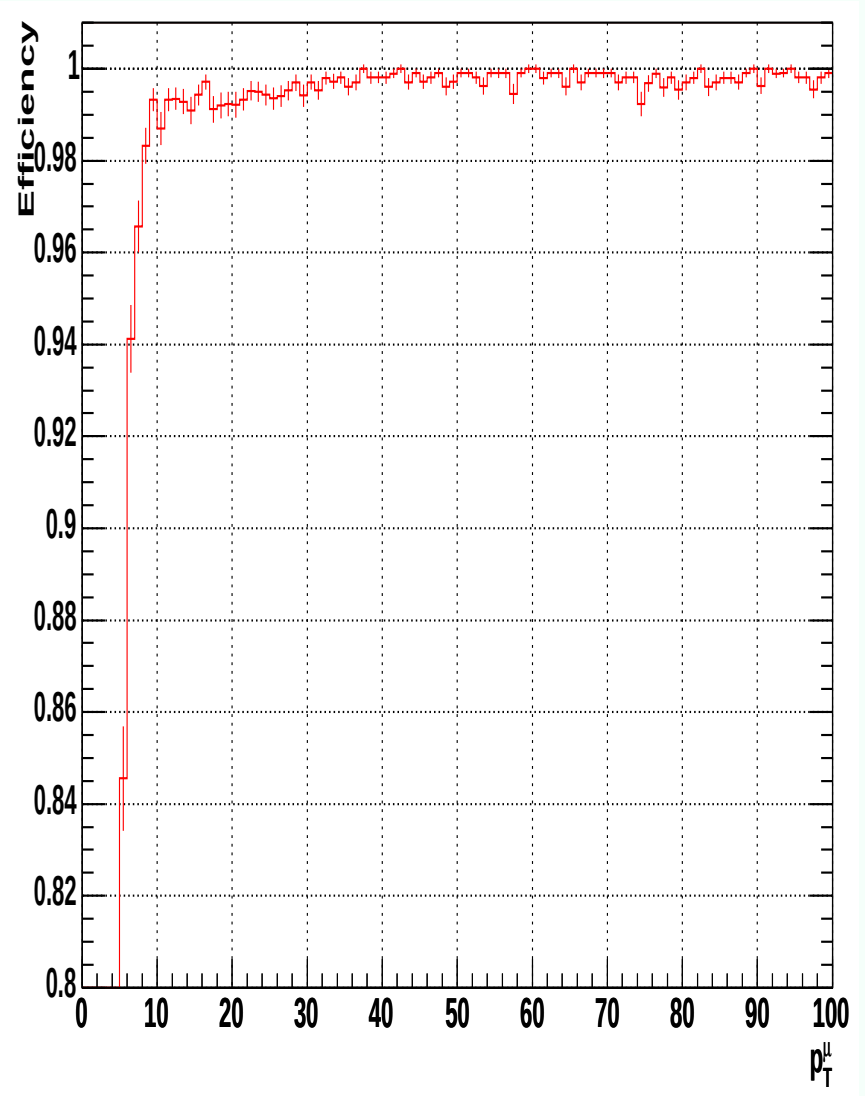




Single Muon, $p_t = 5 \div 100$ GeV$/c^2$, $|\eta| < 1.2$ Eff GMR/SA

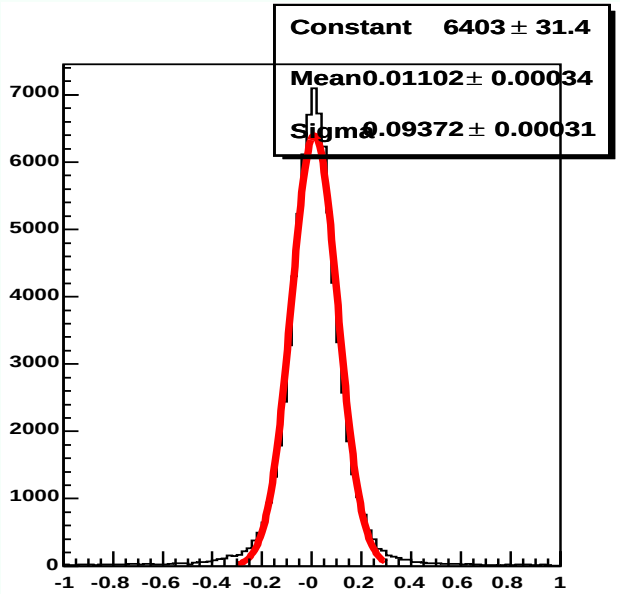
Results: SA, GMR eff vs p_t

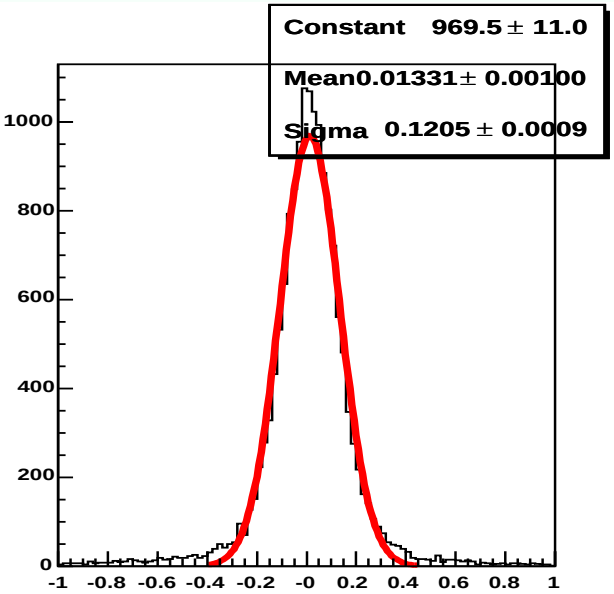


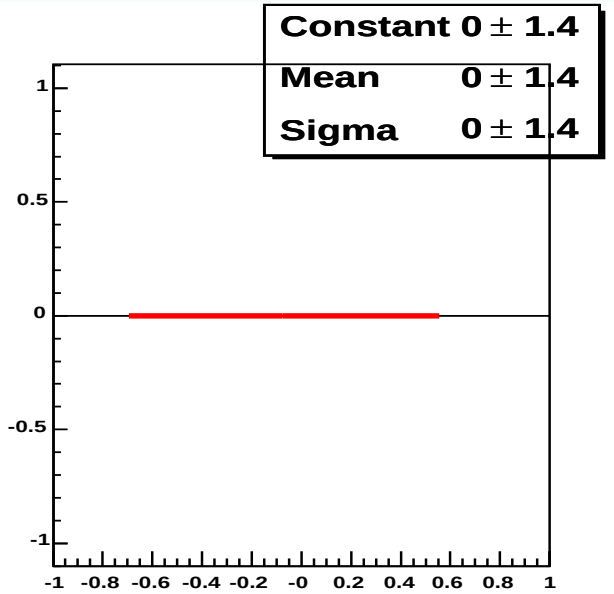


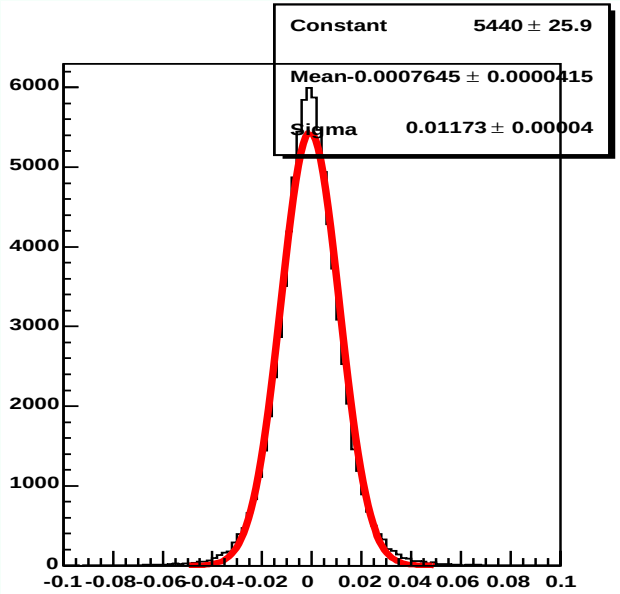
Single Muon, $p_t = 5 \div 100$ GeV$/c^2$, $|\eta| < 1.2$ Eff GMR/SA

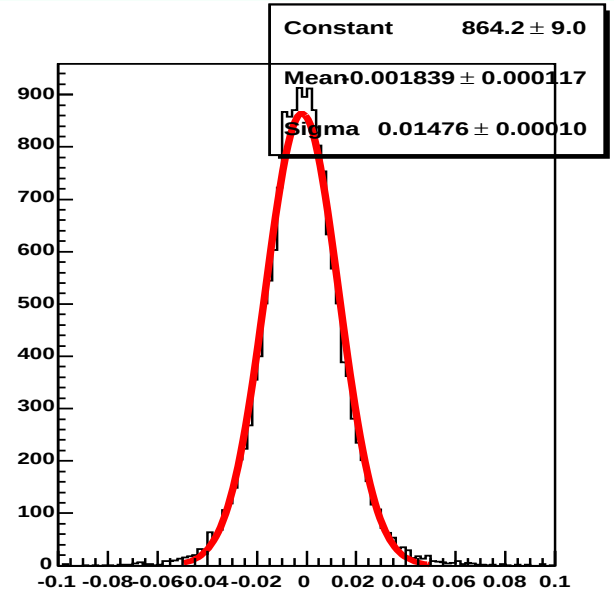
Results: $1/p_t$ Resolution SA, GMR

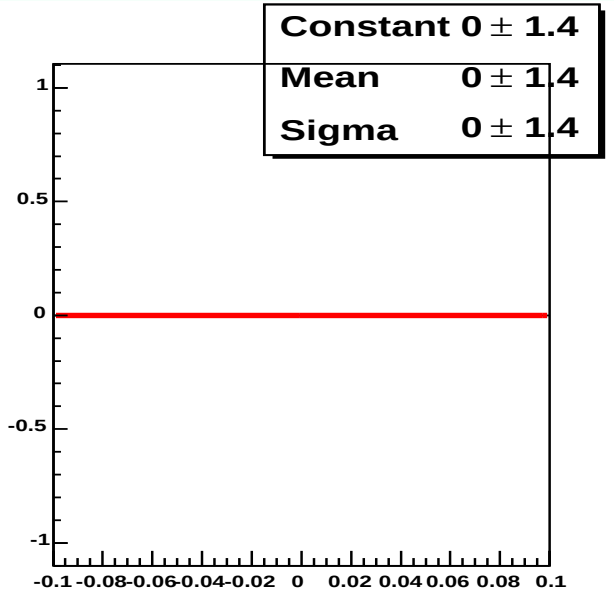




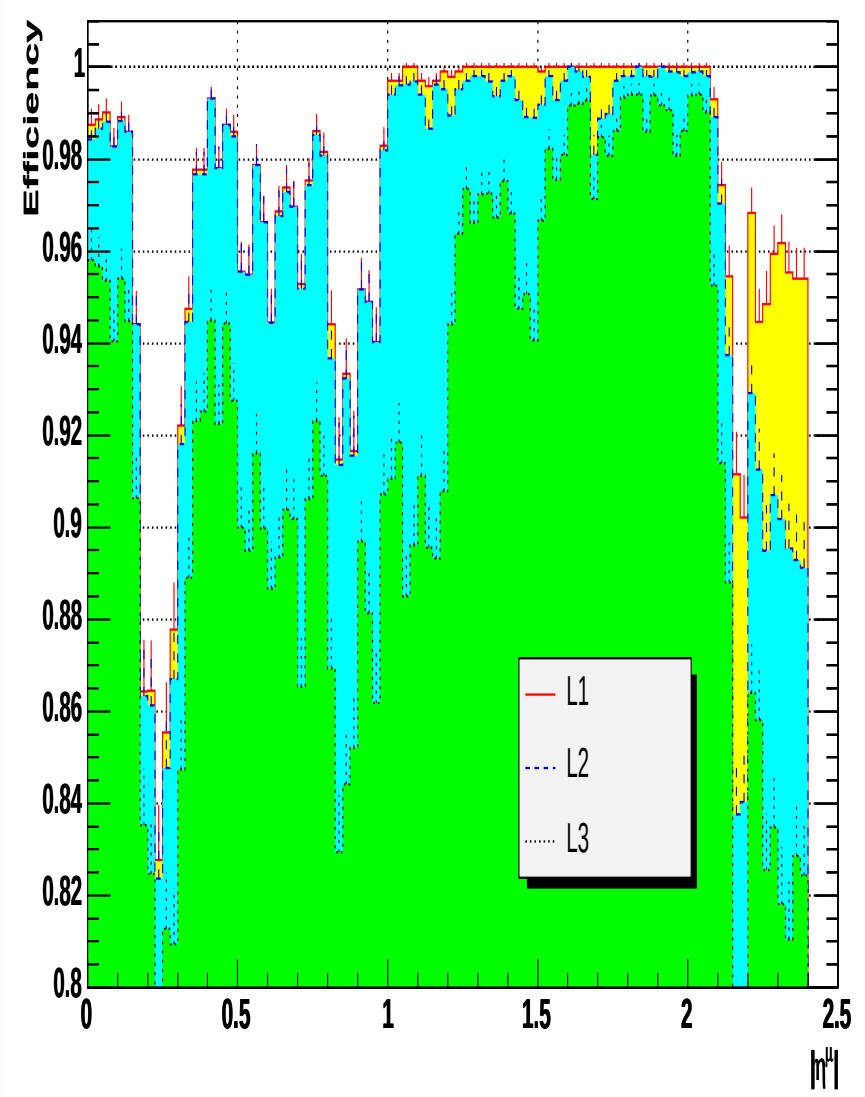


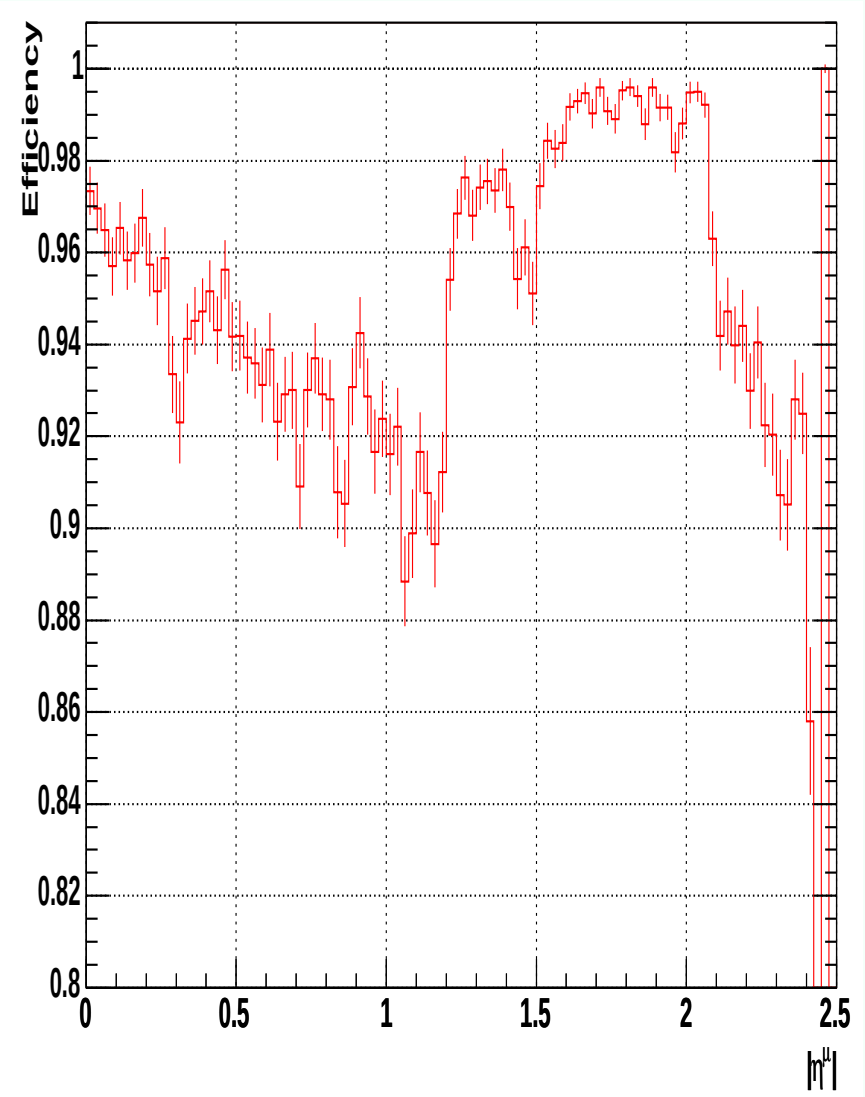






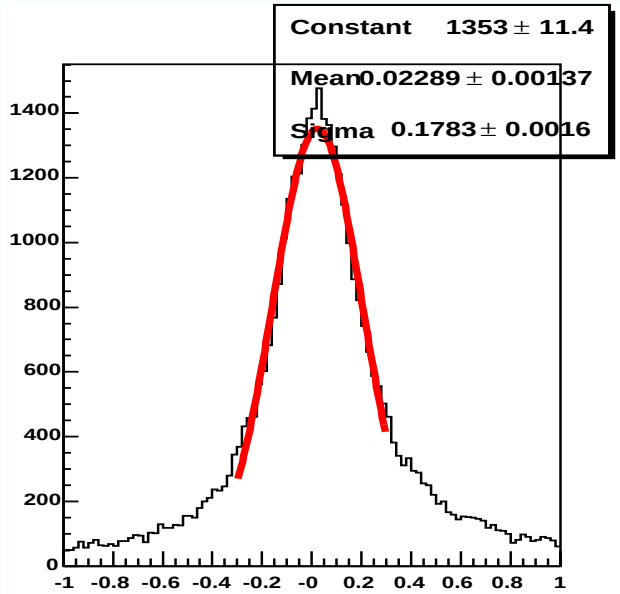
Results: L1, L2, L3 eff vs η

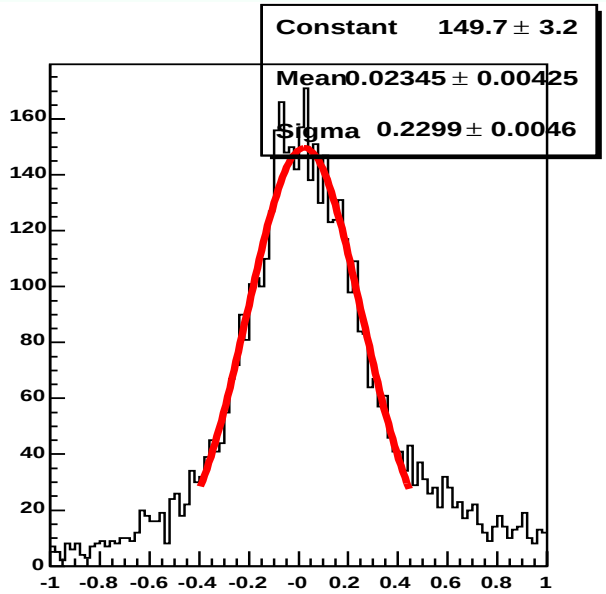


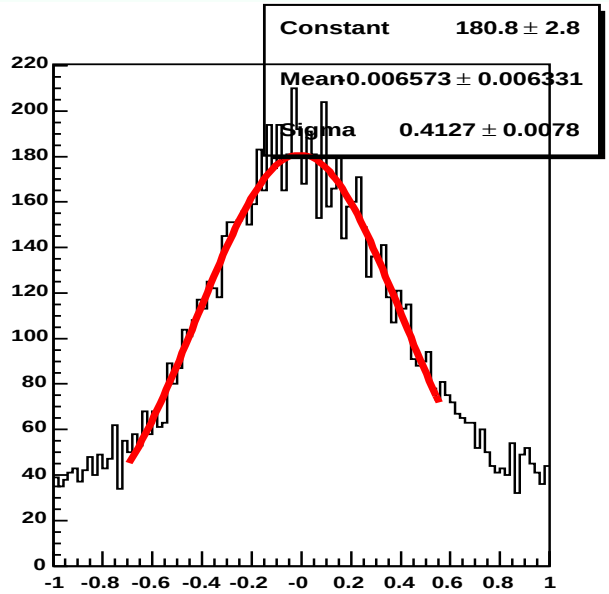


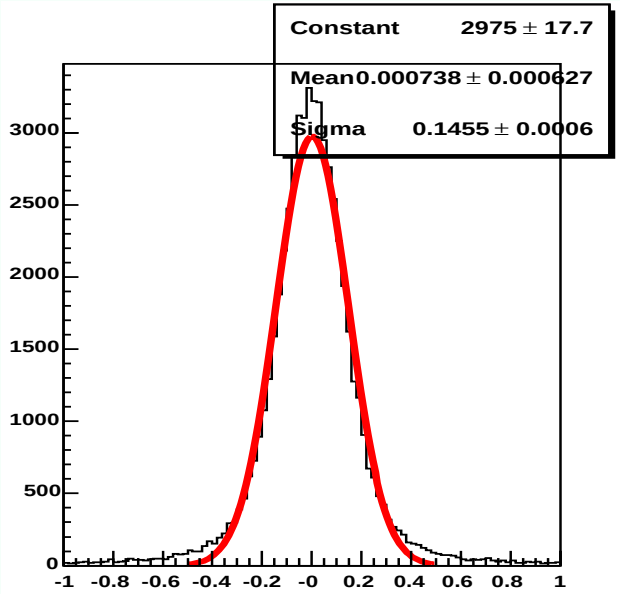
Single Muon, $p_T = 1$ TeV$/c^2$, $|\eta| < 2.4$ Eff $L3/L2$

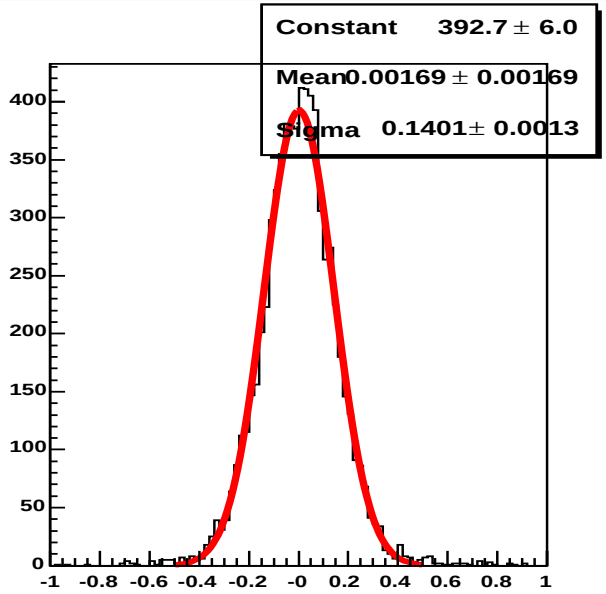
Results: $1/p_t$ Resolution L2, L3

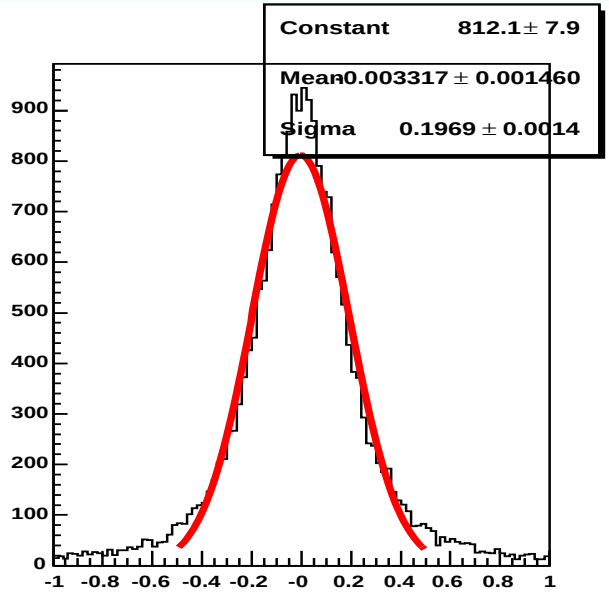




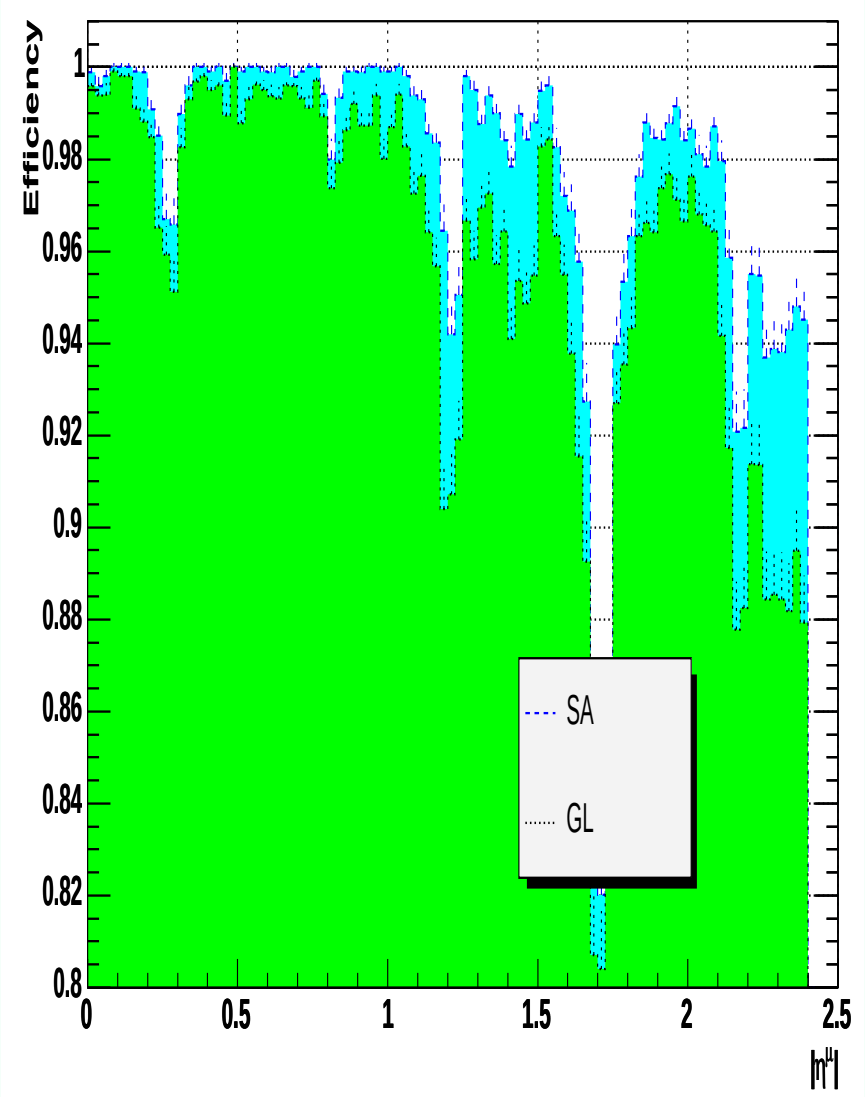


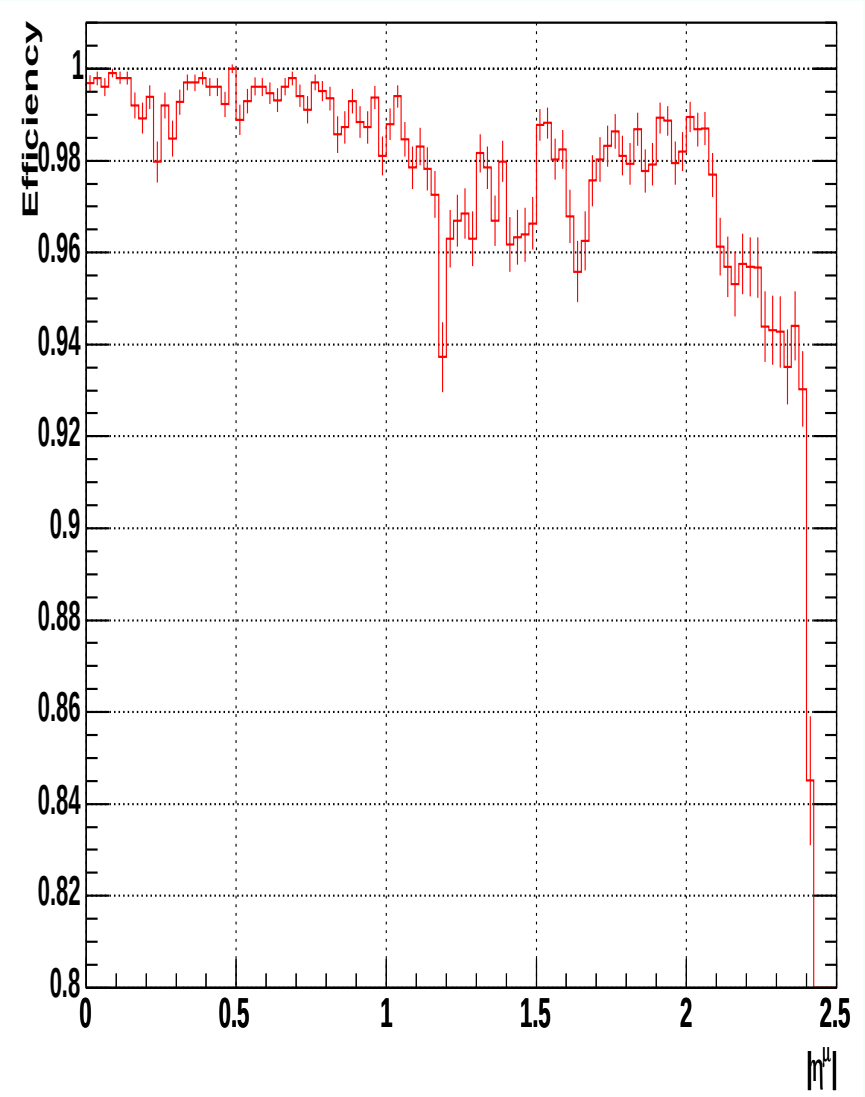






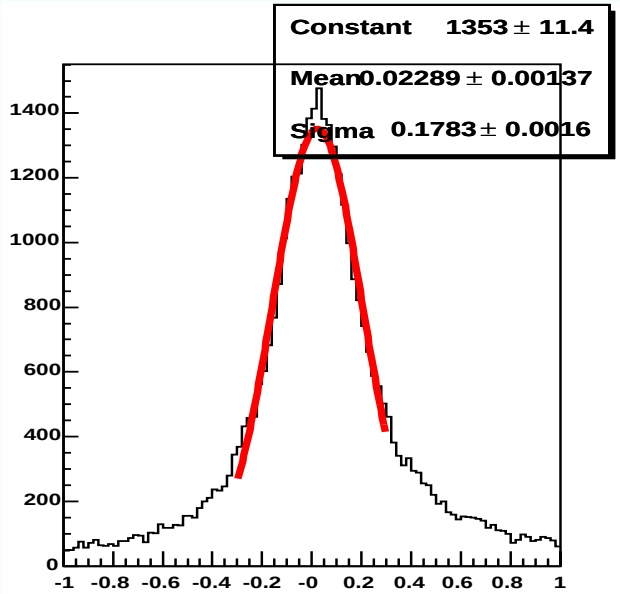
Results: SA, GMR eff vs η

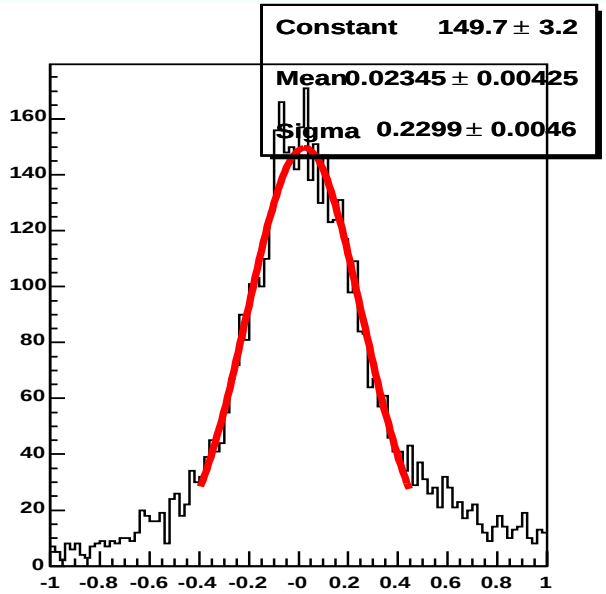


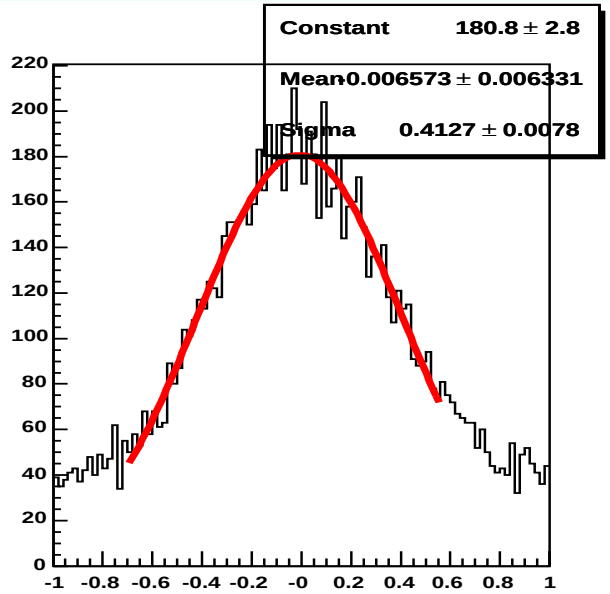


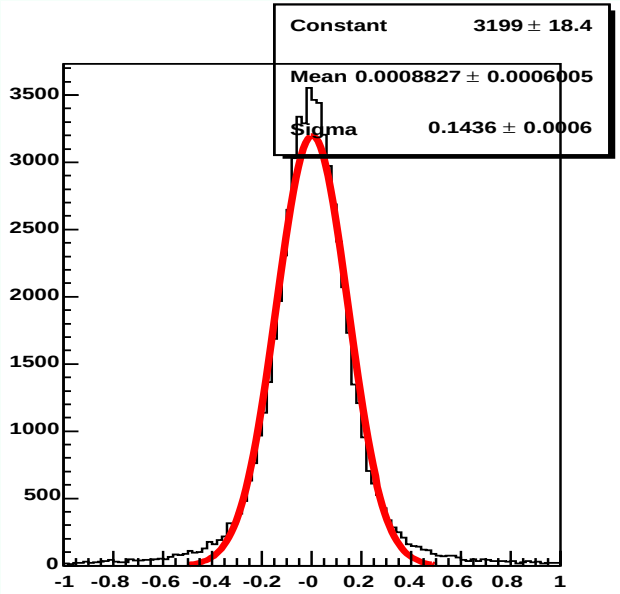
Single Muon, $p_T = 1$ TeV$/c^2$, $|\eta| < 2.4$ Eff GMR/SA

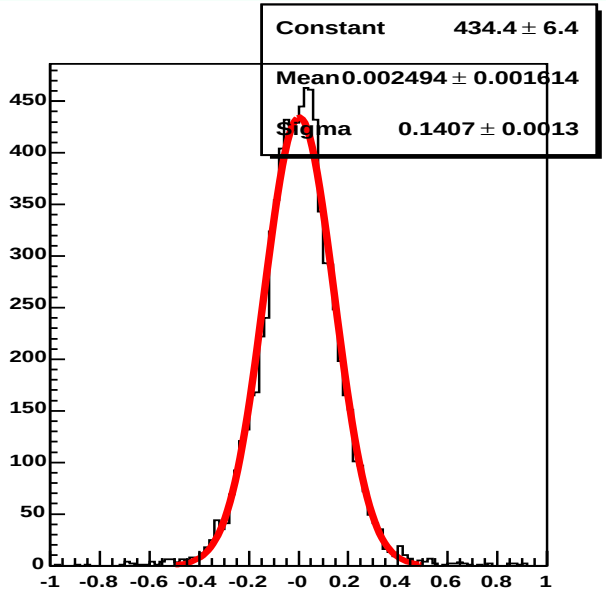
Results: $1/p_t$ Resolution SA, GMR

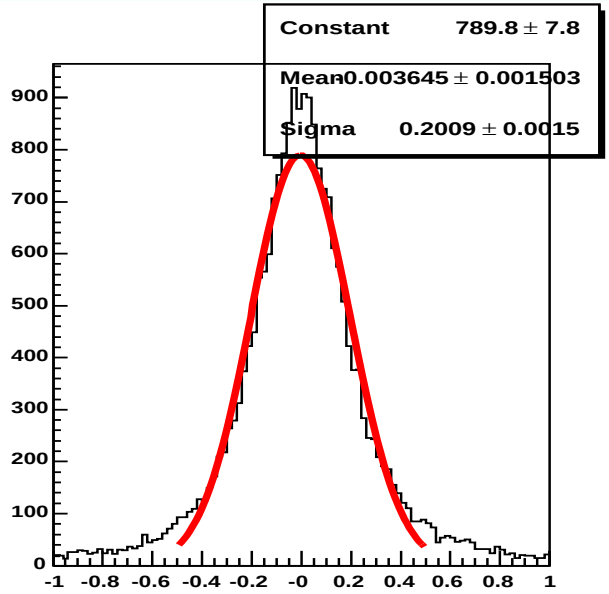












Conclusion and future

- ORCA framework and reconstruction fully used in last DT TB
- Point of contact between sw and hw people!!
- Already proved very important! Same strange behavior/bug found. *More expected in the future...*
- Active discussion about cosmic muon reconstruction: not coming from IP, not bunched, timing from trigger, . . .
- Quality of these results can be deceiving!
- Experience shows that for “real” dataset situation not so bright, even if improving over time/ORCA versions...
- Changes in ORCA/COBRA framework force key developer to spend **too** much time in following modifications
- Normal and foreseen for a starting project (DST), but not welcome!
- Hopefully now almost finished: more time to be spent on algo improvement . . .
- Complexity of framework and data access does not encourage new people to use ORCA software
- Learning curve is still very steep: prevent new ideas from new/experienced people
- Need more ideas/work/improvement: everybody is welcome!