Muon Reconstruction

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Muon Reconstruction with Moore and MuonIdentification

Virtually all slides today are from the Moore talk at Athens, May, 2003

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The Moore/MUID group

Atlas Physics Workshop
Athens, May 2003

Outline

- Reconstruction method and architecture
- Muon spectrometer dead material treatment
- Performances on single μ
- $H \rightarrow 4\mu$
- $Z \rightarrow 2\mu$
- How-to guide for users and developers

Tasks

- Moore (Muon Object Oriented REconstruction)
  - reconstruction in the MuonSpectrometer
- MuonIdentification
  - Muon reconstruction and identification
  - Divided in two parts :
    - MuidStandAlone:
      - Back tracking of the MOORE tracks to the interaction point
    - Muid Comb:
      - Combination of the muon and the inner detector tracks
- Both work in ATHENA (= the ATLAS reconstruction framework)

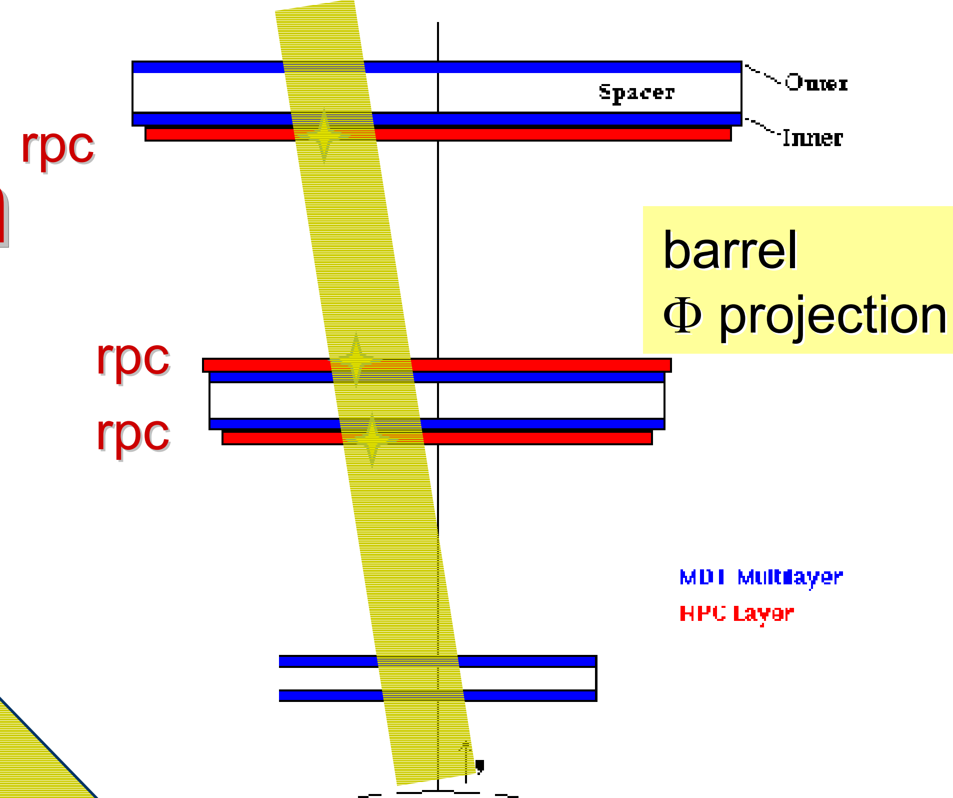
MOORE Reconstruction Strategy (I)

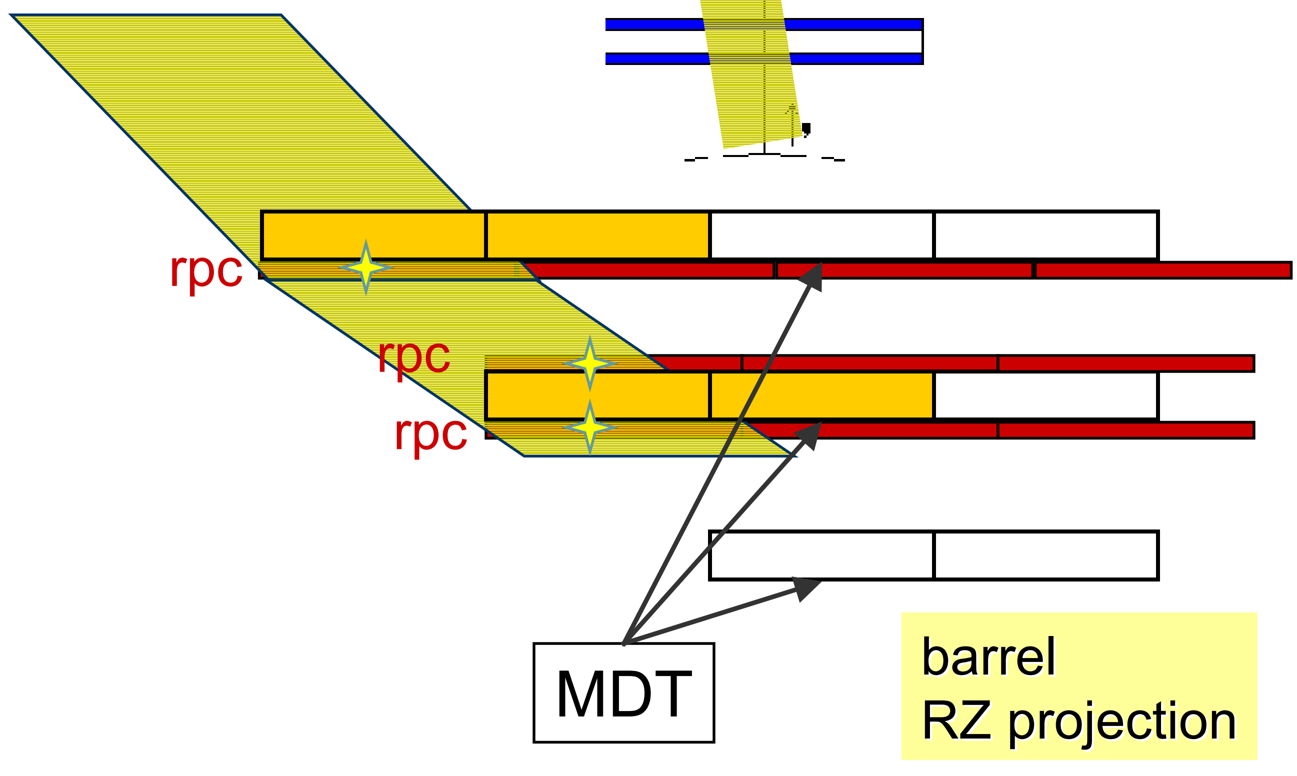
Search for region of activity in the

ϕ projection

and

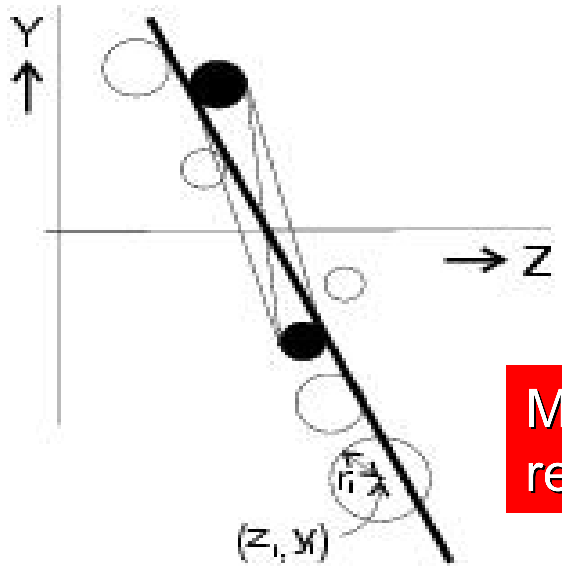
RZ projection



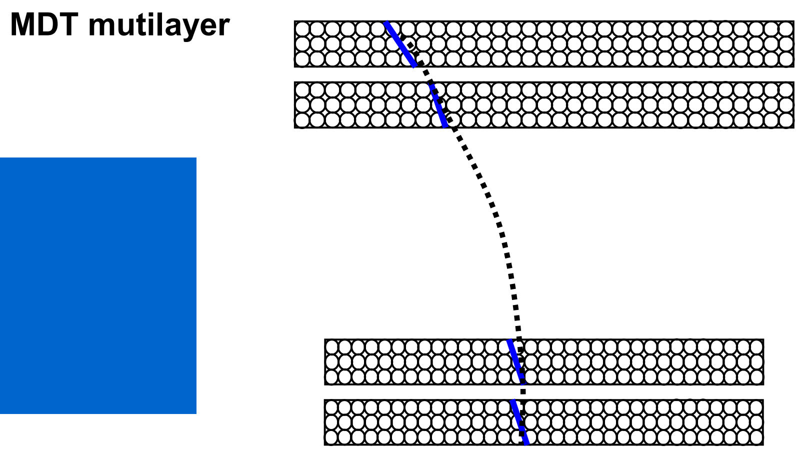


MOORE Reconstruction Strategy(II)

- Pattern recognition in the MDTs
  - the drift distance is calculated from the drift time, by applying various corrections on it (TOF, second coordinate, propagation along the wire, Lorenz effect). Among the 4 tangential lines the best one is found.
- Track segment combination.



MDT pattern recognition

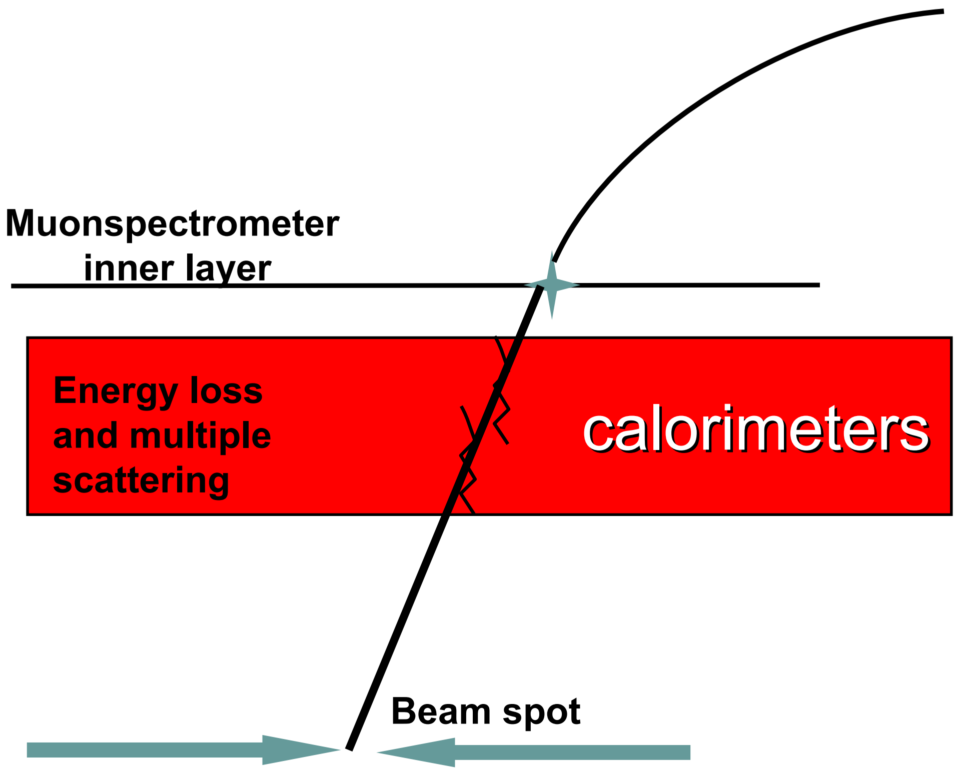


- Track fit

  track parameters (a0, z0, ϕ, cotθ, 1./pt) are expressed at the first measured point

MuonIdentification Method

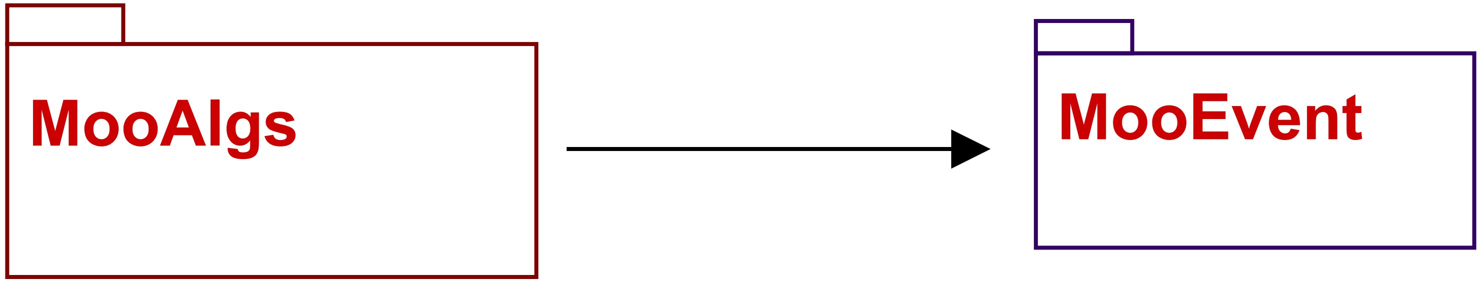
- Moore track parameters are propagated to the beam-axis
  - **multiple scattering parameterised as scattering planes in calorimeters**
  - **energy loss from truth, or from Calo Reconstruction, or from parametrization as function of (η,p)**
- Refit
  - **muon track parameters expressed at vertex**
- Muon/ID tracks matching with a χ^2 cut-off
  - **χ^2 based on track covariance matrices and on the difference in track parameters**
- Combined track fit



Architecture (I)

- C++ and OO technology
- High modularity and flexibility
  - Easier to develop alternative recostruction approaches
  - Successfully adapted for the test beam data reconstruction
  - Successfully integration in the HLT framework
  - Definition of base objects sharable with calibration packages (e.g. Calib for MDT calibration)
- Track class and Fitter class in common with the inner detector reconstruction (iPat)

• Separation of the algorithmic classes from data objects

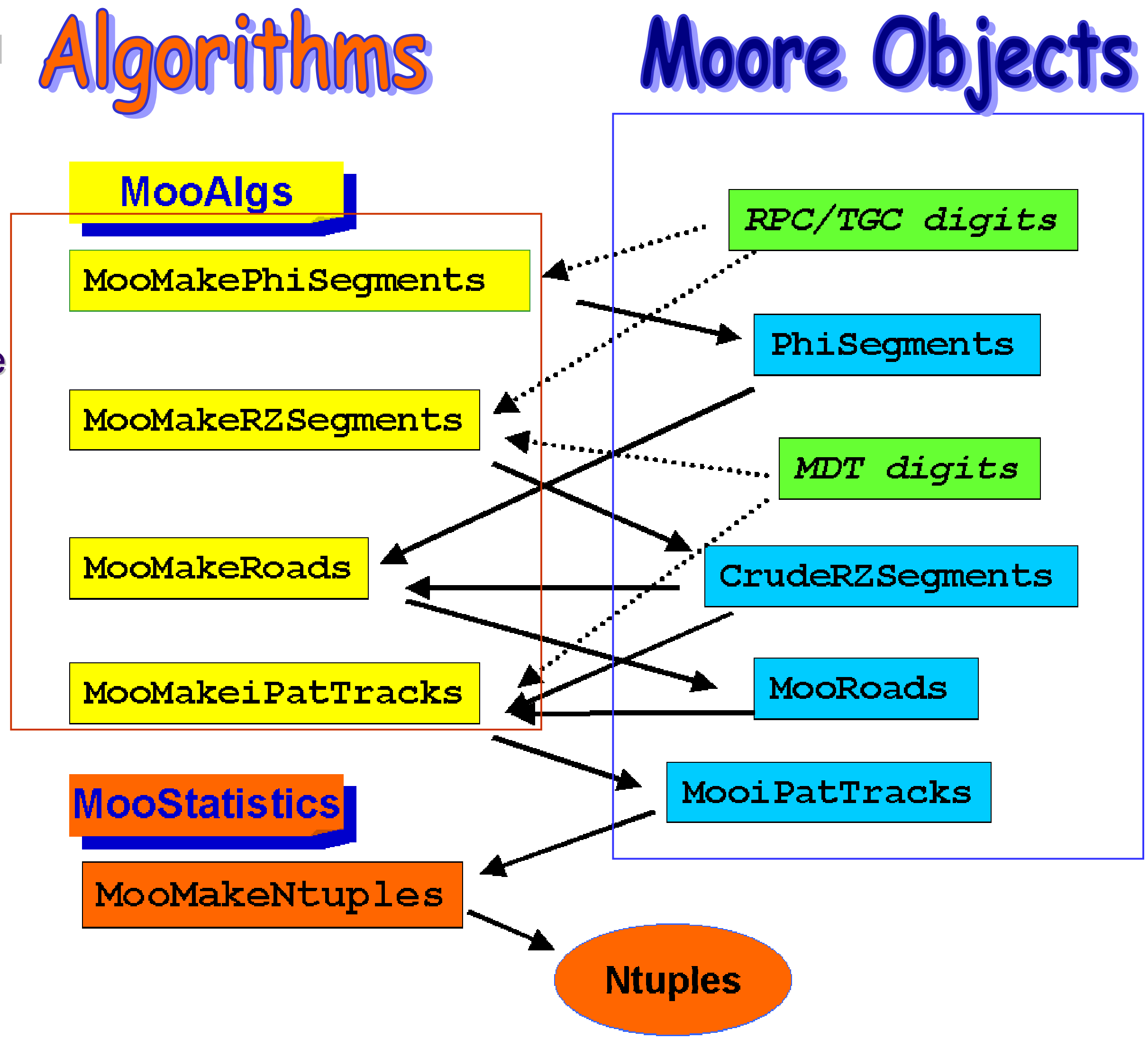


Architecture (II)

- Pattern recognition is divided in several steps.
- Each step is driven by an Athena top-algorithm
- Algorithms independent, imply less dependencies, code more maintainable, modular, easier to develop new reconstruction approaches

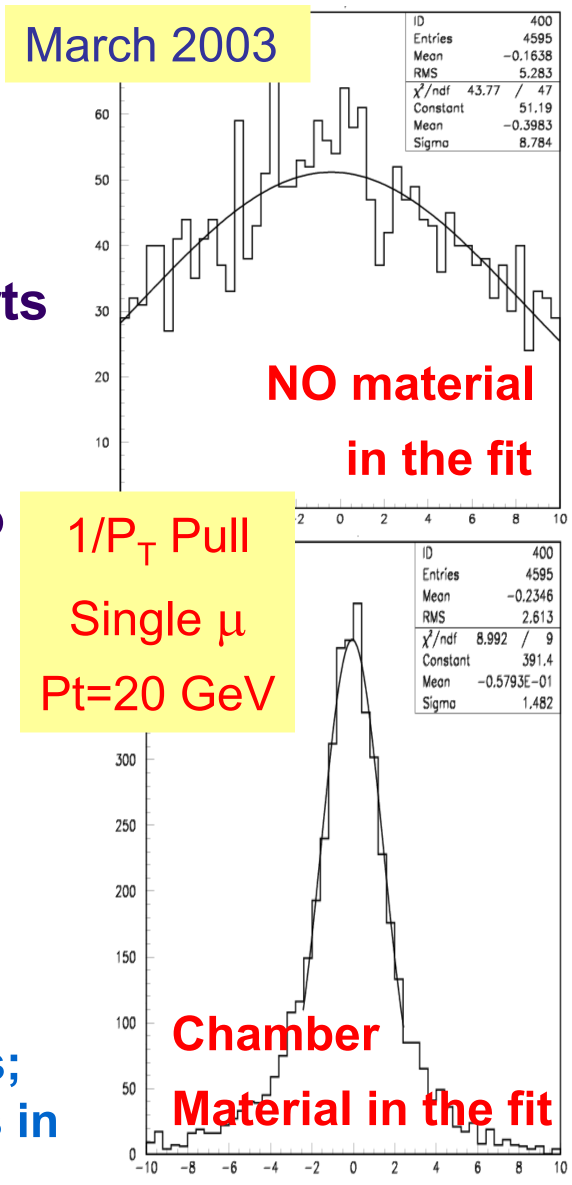
Basic idea:
Separation of the algorithmic classes from data objects

Same philosophy used for MuId



Parameterization of the dead Material (I)

- **No general services available in Athena for the description of the dead materials (toroids, supports etc.)**
- **The ATHENA geometry service allows to take into account in the fit multiple scattering and energy loss in the material of the chambers.**
- **In order to take into account the dead material effects:**
  - **Data driven approach: define a map of materials; tune materials with the pull distributions (available)**
  - **Geant4 based approach: describe all inert materials; propagate geantinos; define a fine map of materials in the Spectrometer (in progress)**



Parameterization of the dead Material (II)

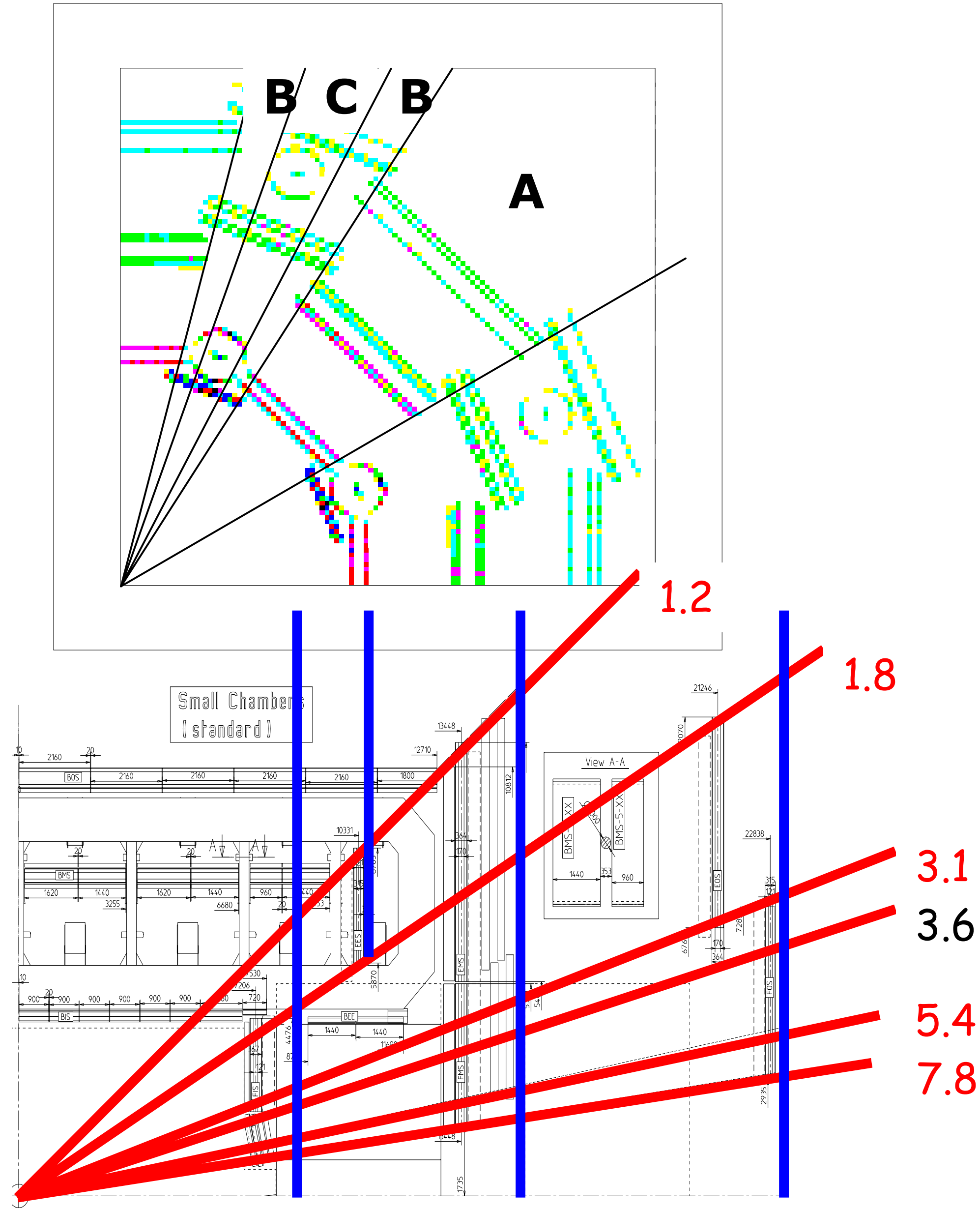
Main steps

- Define a segmentation of the Muon Spectrometer: Binning in $\eta/\phi/L$
  (L = trajectory path length)

- Estimate X0 and Energy Loss in each $\eta/\phi/L$ bin

- Refit the track with 2 scattering centers per station

- Tune X0 and energy loss of the “scatterers” against the pull distributions



Overall performances 1st iteration

1/pt pull distributions
with Parameterization of dead Material and with Detector Material only

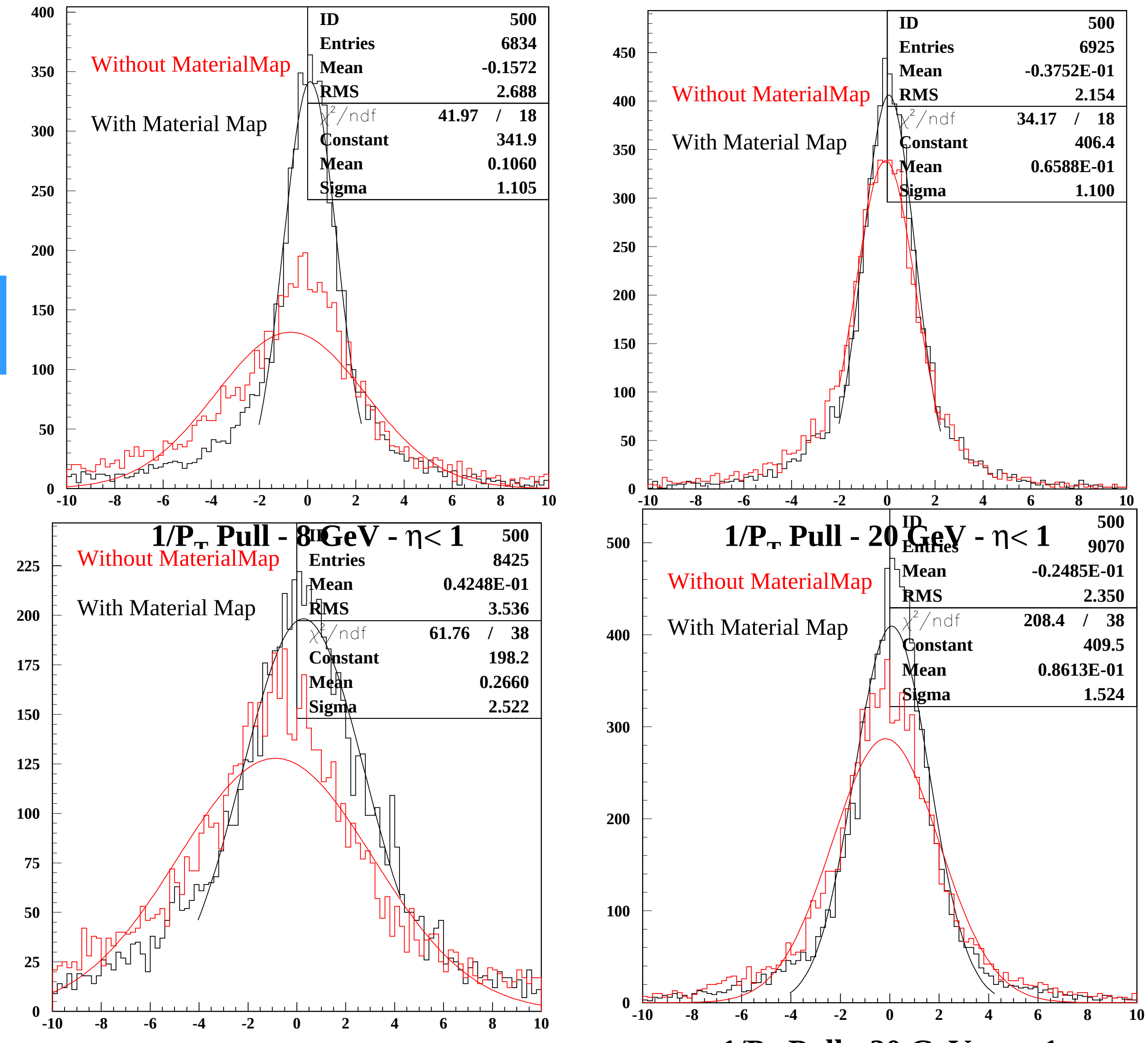
Pt = 6 GeV

Pt = 20 GeV

$|\eta| < 1$

$|\eta| > 1$

For fixed transverse momentum single muon samples

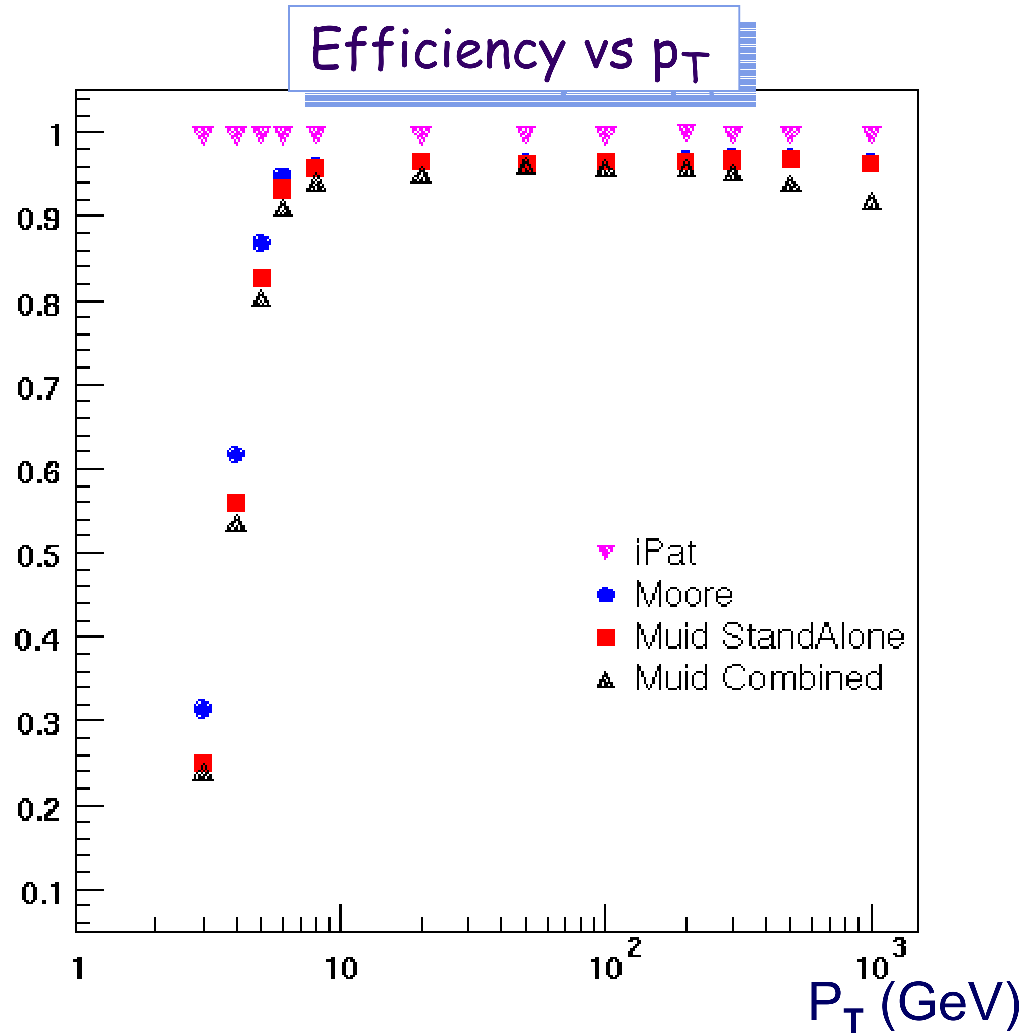


Single μ performances

- Single muons (DC1 data)

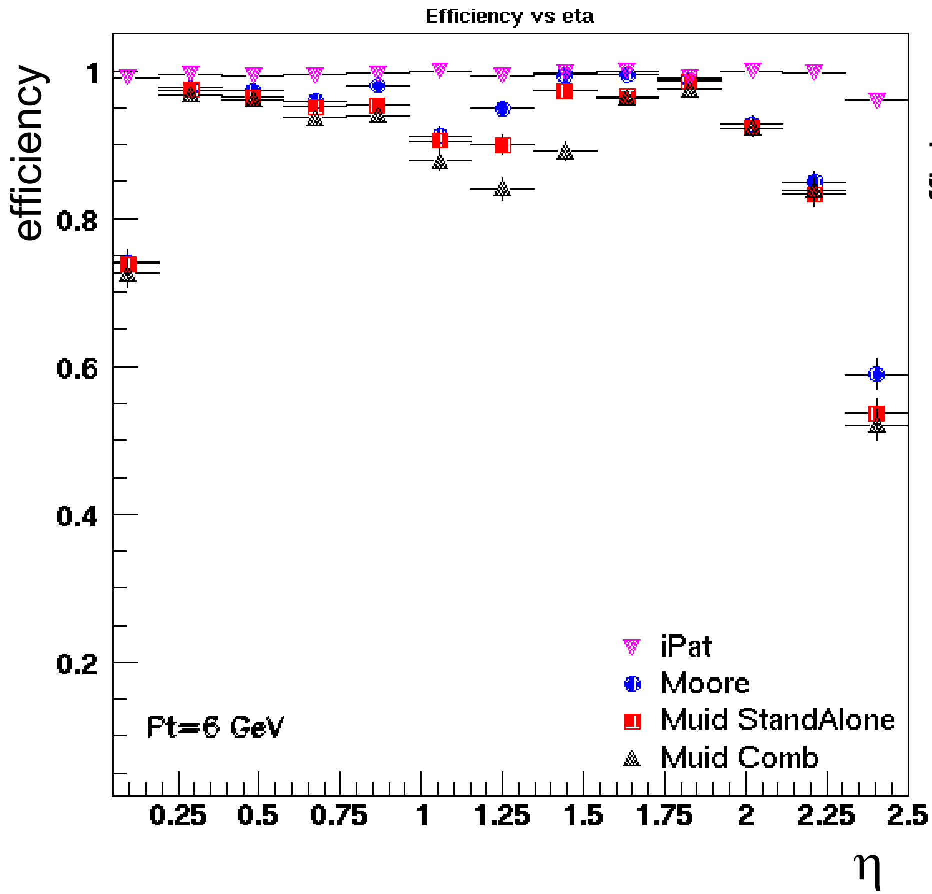
Moore/MuonID performances shown here are obtained with

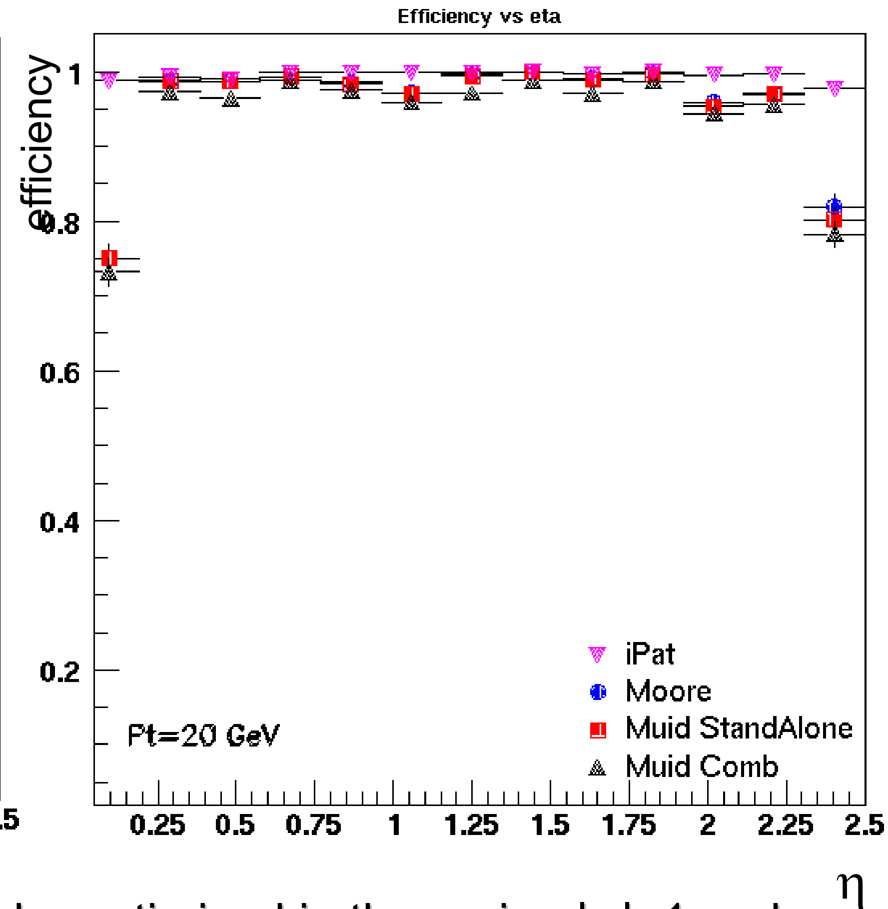
- Release 6.0.3
- A private improved version of MuonIdentification
  - Tracking in the magnetic fields, bug fixes
- Moore with the full material description
  MooAlgs-00-00-41
  MooEvent-00-00-42



Rather good agreement with Physics TDR results

Efficiency vs η

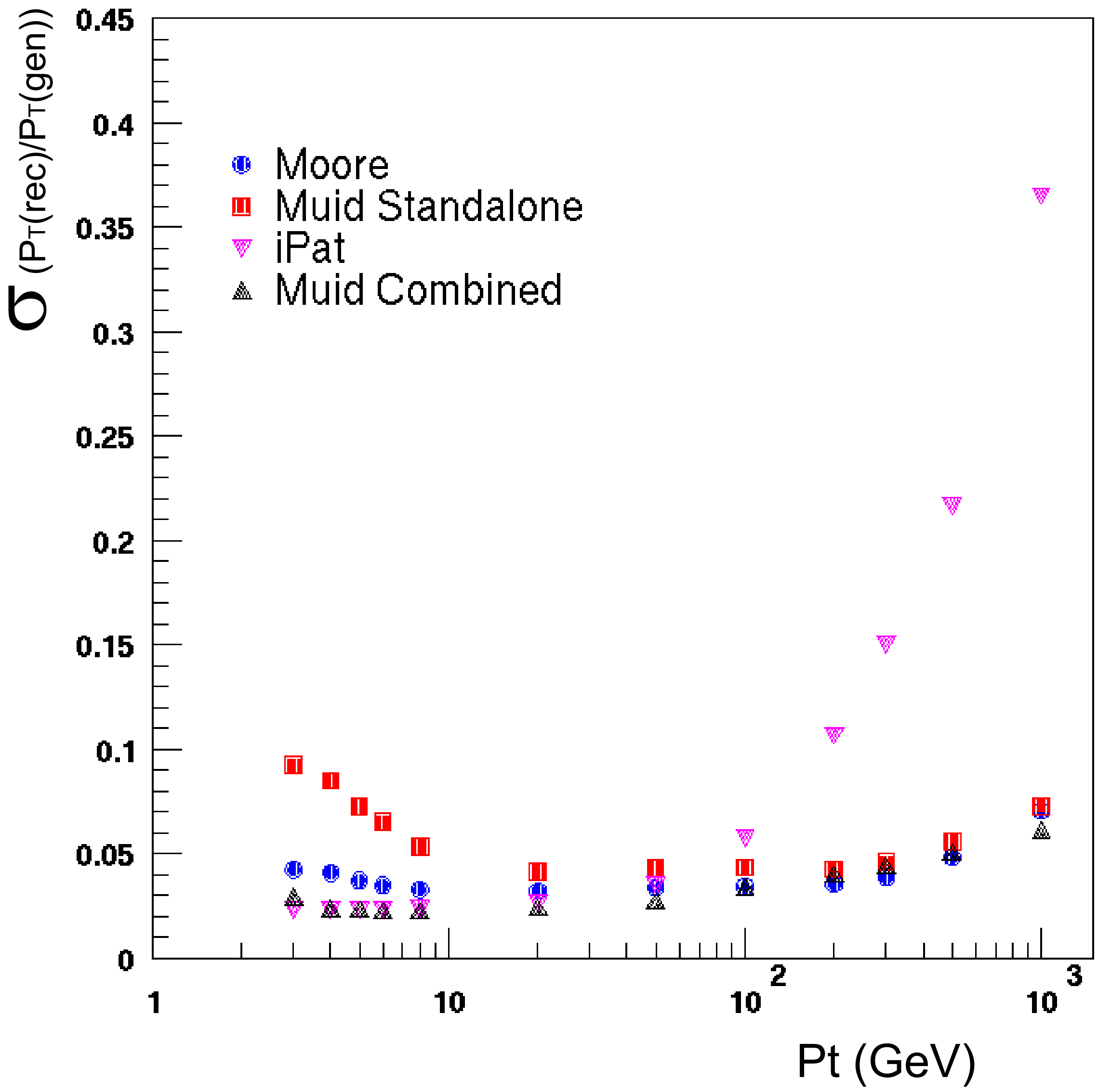




Stepping in the fit procedure needs to be optimized in the region |η|>1 and for low energy muons

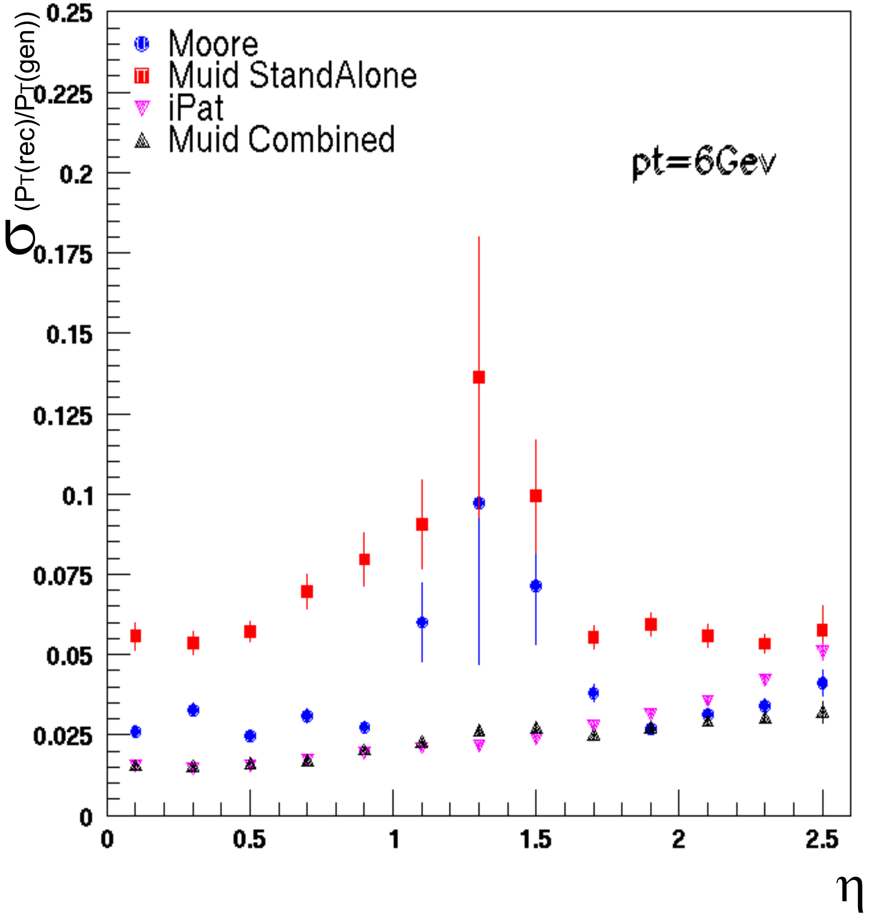
Uniform efficiency vs phi

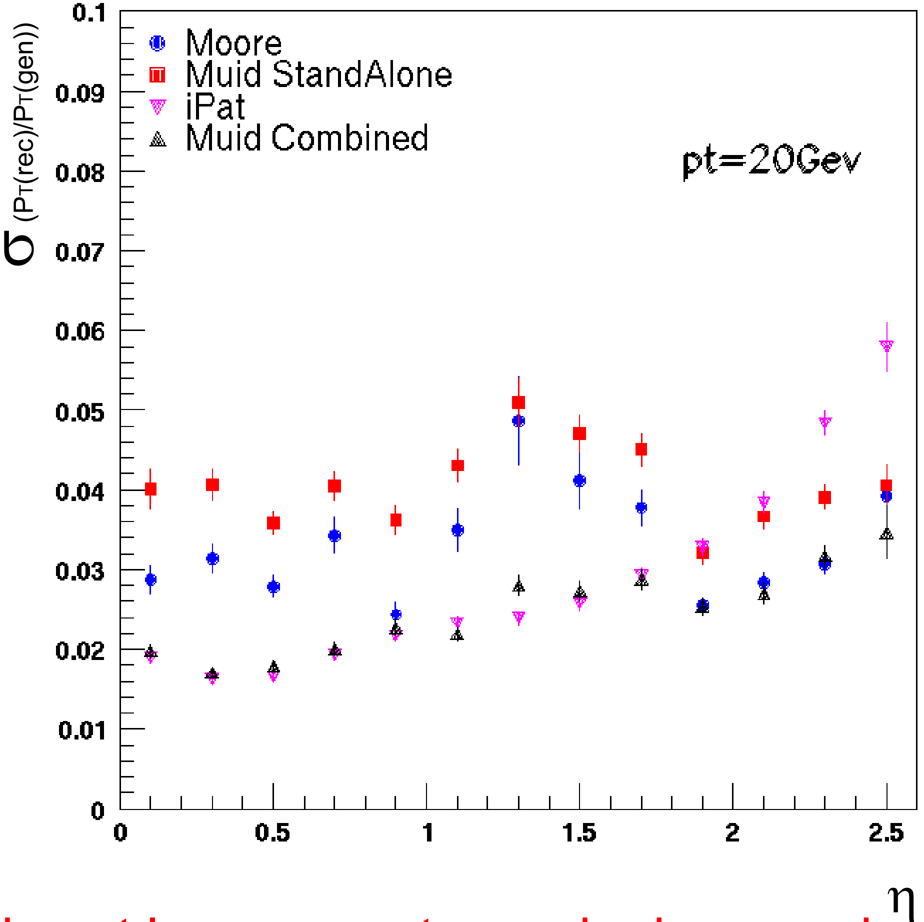
1/Pt Resolution vs Pt



Rather good agreement with Physics TDR results

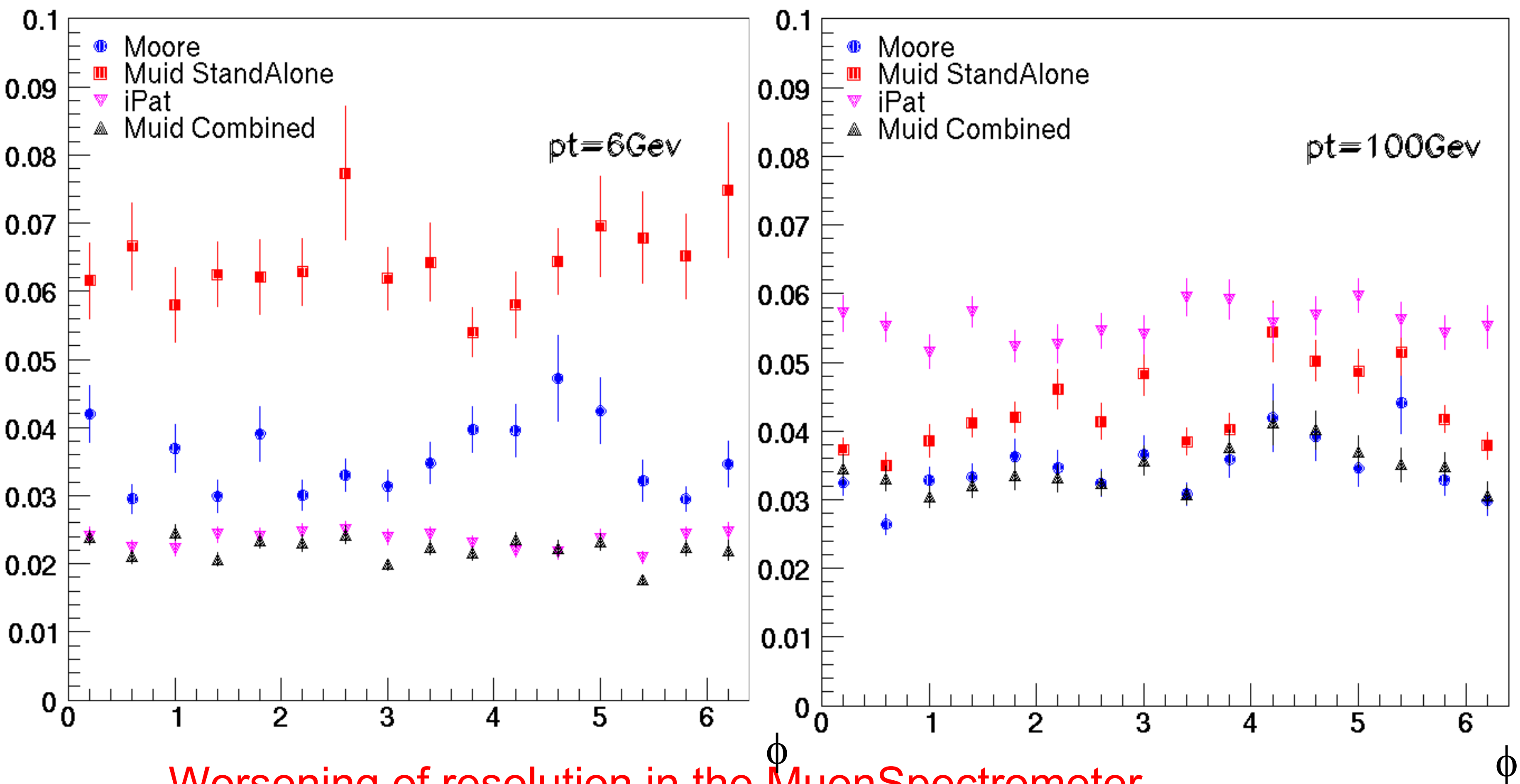
1/Pt resolution vs η





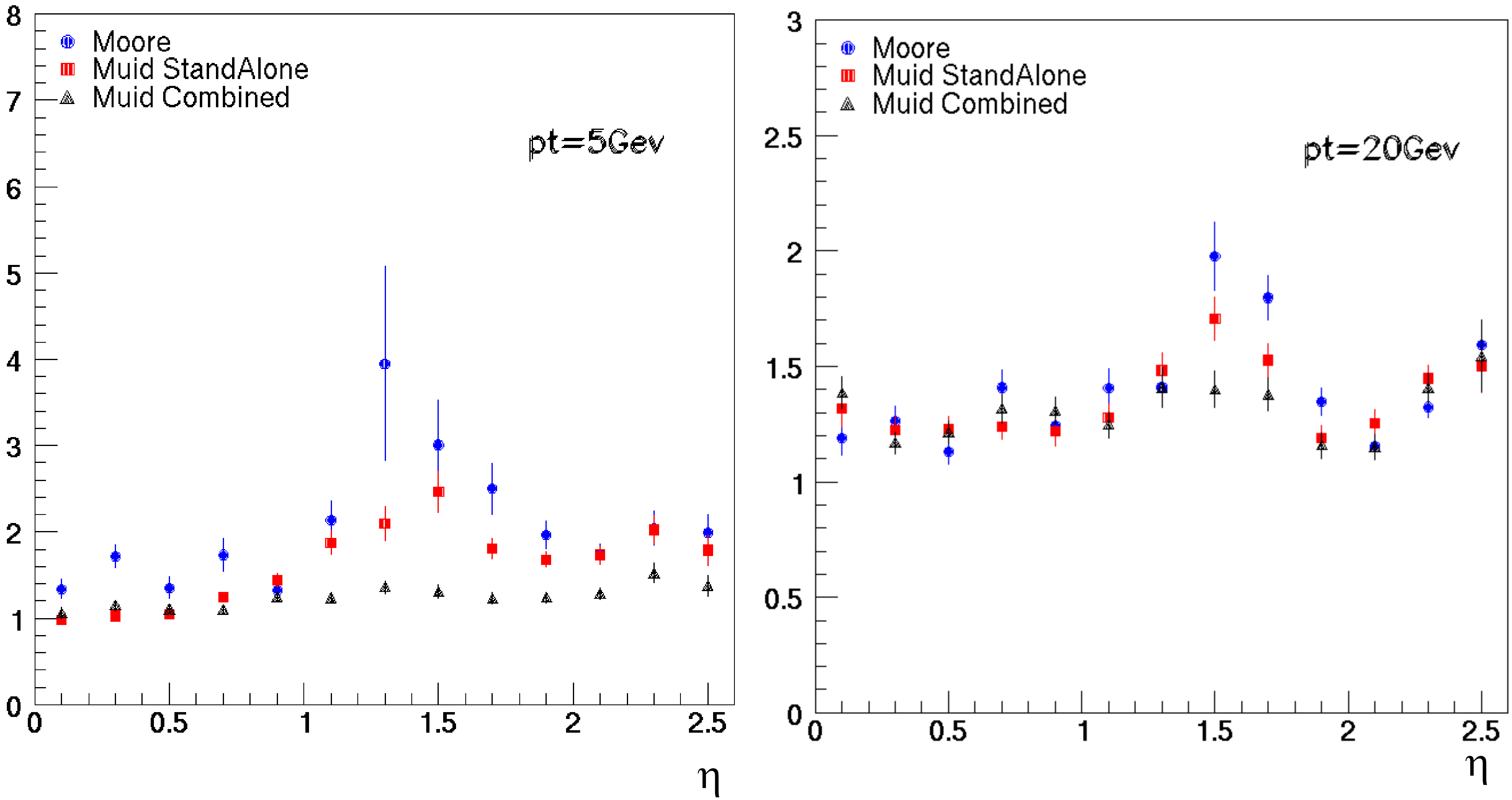
Reconstruction in the transition region at low momenta can be improved

1/Pt resolution vs ϕ



Worsening of resolution in the MuonSpectrometer
in the feet region at low momenta

σ(1/pt pulls) vs η

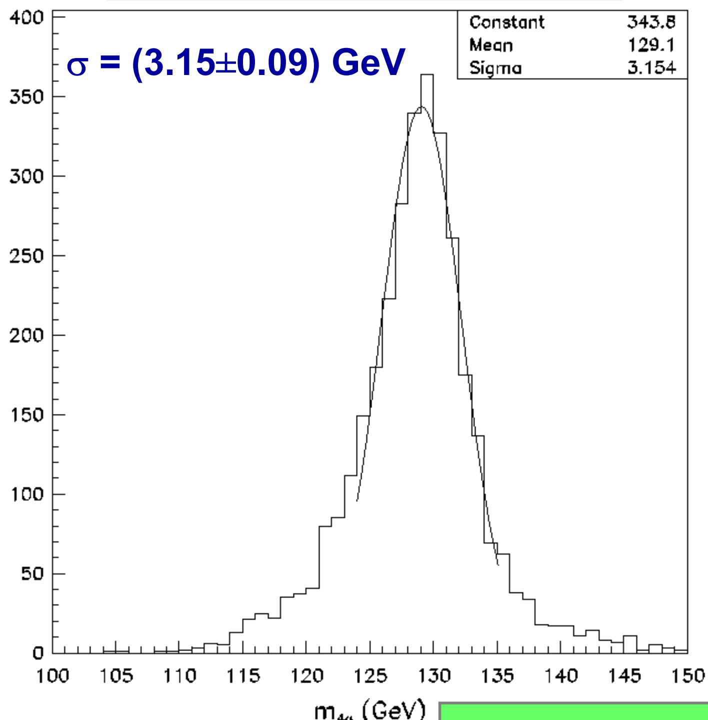


H→4μ (I) (from Evelin Meoni)

- DC1 sample (prod. in July 2002): H→4μ (with mH=130 GeV) ~ 10 K evt.
- ATHENA 6.0.3 (Moore-00-00-42)

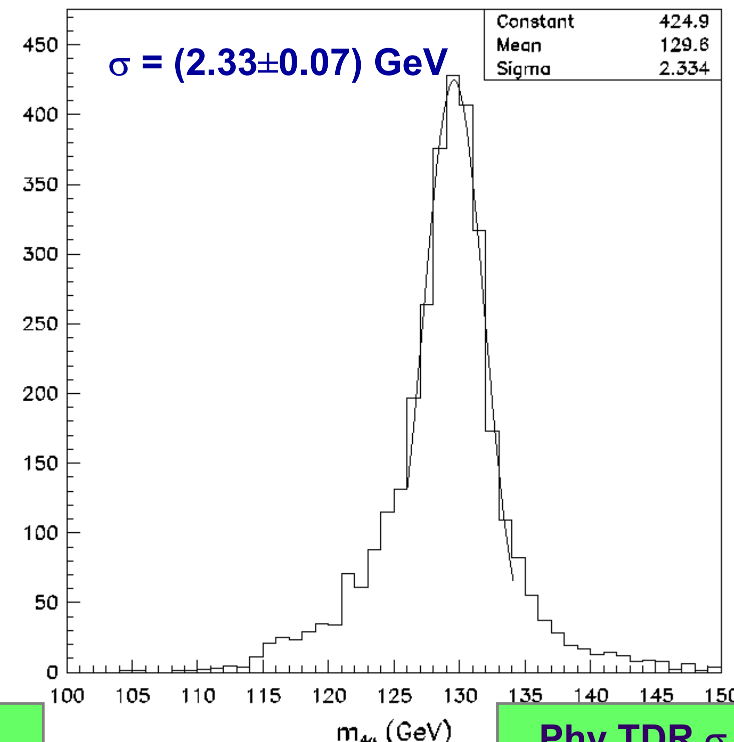
Reconstruction with Muon Spectrometer Standalone (Moore + MUID Standalone)

Without Z constraint



Phy TDR σ = 2.7 GeV

With Z constraint

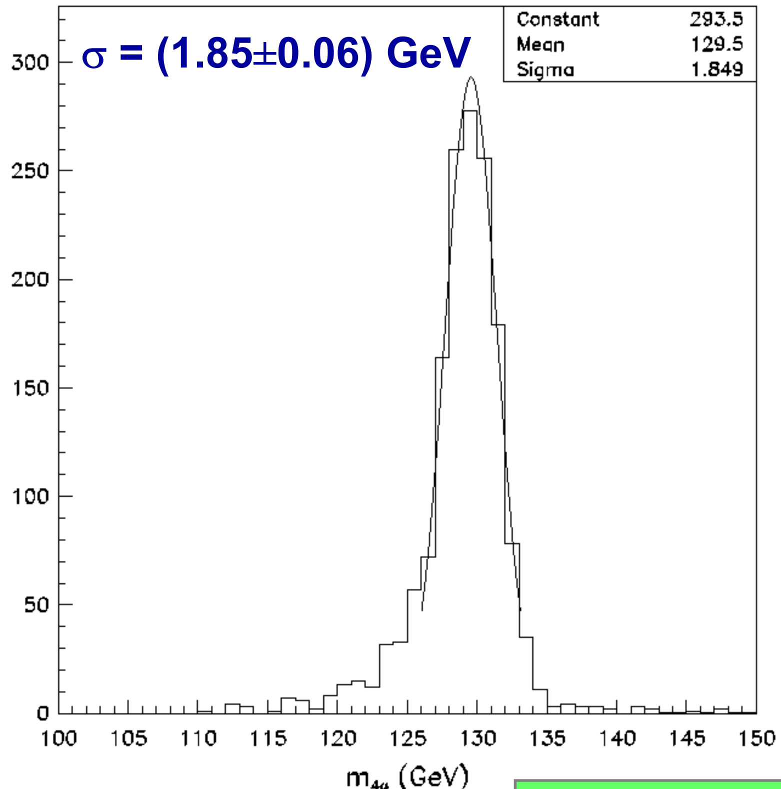


Phy TDR σ = 2.1 GeV

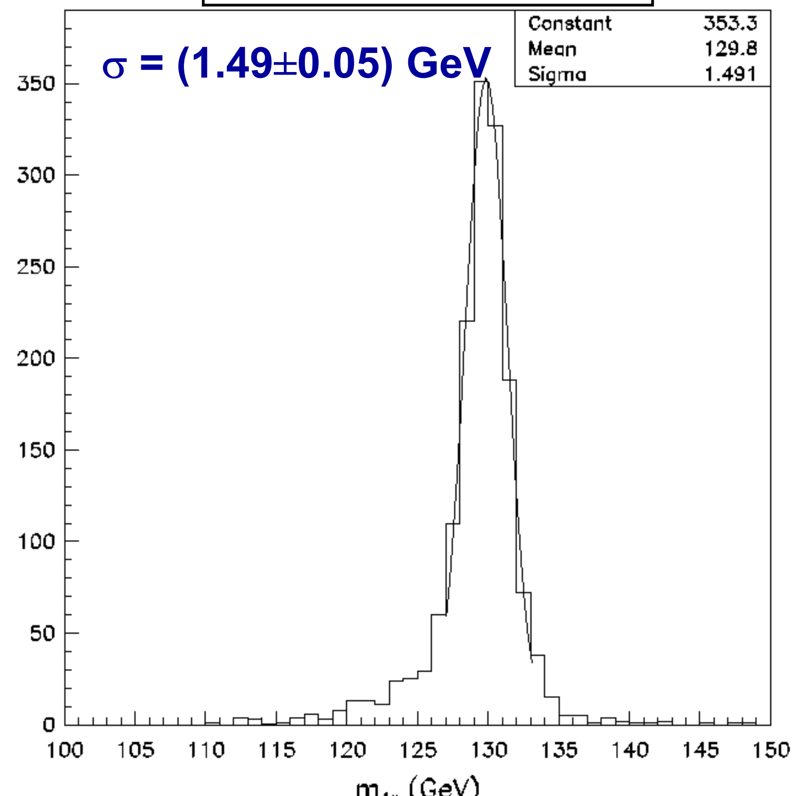
H→4μ (II) (from Evelin Meoni)

Combined Reconstruction (Moore + MUID + iPat)

Without Z constraint



With Z constraint



Phy TDR σ = 1.6 GeV

Phy TDR σ = (1.42 ±0.06) GeV

Moore/Muld – Preliminary time-performance test

PT	20GeV TDR	20GeV DC1	300GeV TDR	200GeV DC1	H $\longrightarrow$ 4 μ DC1
(time)	142 msec	155 msec	368 msec	279 msec	572 msec

Moore

•Average execution time per event calculated for the 500 events sample.

Muld standalone

Pt (GeV)	Time (ms)
20	5.1
100	6.3
300	4.9
H->4mu m_H= 130 GeV	25.2

Time tests in seeded version (considering also the Region Selector access) to be done.

How to run Moore

cd ~/cmthome

source setup.csh

cd $CMTTEST

cmt co TestRelease

cd TestRelease/TestRelease*/cmt

#<edit requirements file> or <copy from Moore/share/TestRelease_requirements>

cmt config

source setup.csh

gmake

cd $CMTTEST/TestRelease/TestRelease*/run/

magda_getfile dc1.001103.simul.0001.test.mu_minus_20.zebra

ln –sf /afs/usatlas.bnl.gov/offline/data/BmagAtlas02.data fieldmap.dat

or run the RecExample file RecExCommon_links.sh

ln -sf dc1.001103.simul.0001.test.mu_minus_20.zebra ZEBRA.P

athena Moore_jobOptions.txt

How to develop Moore

- Read the README file in cvs:
  - http://atlas-sw.cern.ch/cgi-bin/viewcvs.cgi/offline/MuonSpectrometer/Moore/README
- All commands are the same as the previous slide, but you add:
  - cmt co MuonSpectrometer/Moore
  - cmt co MuonSpectrometer/Moore/MooAlgs
  - cmt co MuonSpectrometer/Moore/MooEvent
  - cmt co MuonSpectrometer/Moore/MooStatistics
- …and the build commands must be broadcast:
  - cmt broadcast cmt config
  - source setup.csh
  - cmt broadcast gmake

Issues

- Large samples from dc1 did not have the correct digitization for muons
  - Symptoms: Athena assert fails (on certain TGC digits)➔core dumps.
  - Key samples were re-digitized, more are on the way.
  - Up to date list of files is in the Moore README file

Conclusions

- A lot of improvements have been made to MOORE/MUID in the last two months: it can now be used for Physics Studies
- The code has proved to be robust on high statistics DC1 samples ($\sim 10^6$ events processed – No Crash)
- A big (and successful!!) effort has been done for having MOORE/MUID as Event Filter in the HLT framework: results will appear in the HLT TDR
- Alternative tracking methods to be inserted in MOORE (e.g. Kalman Filter) are under developments
- We are aiming at keep going with the developments but always having a reference version to be used for Physics Studies