Muon Performance of the ATLAS Detector

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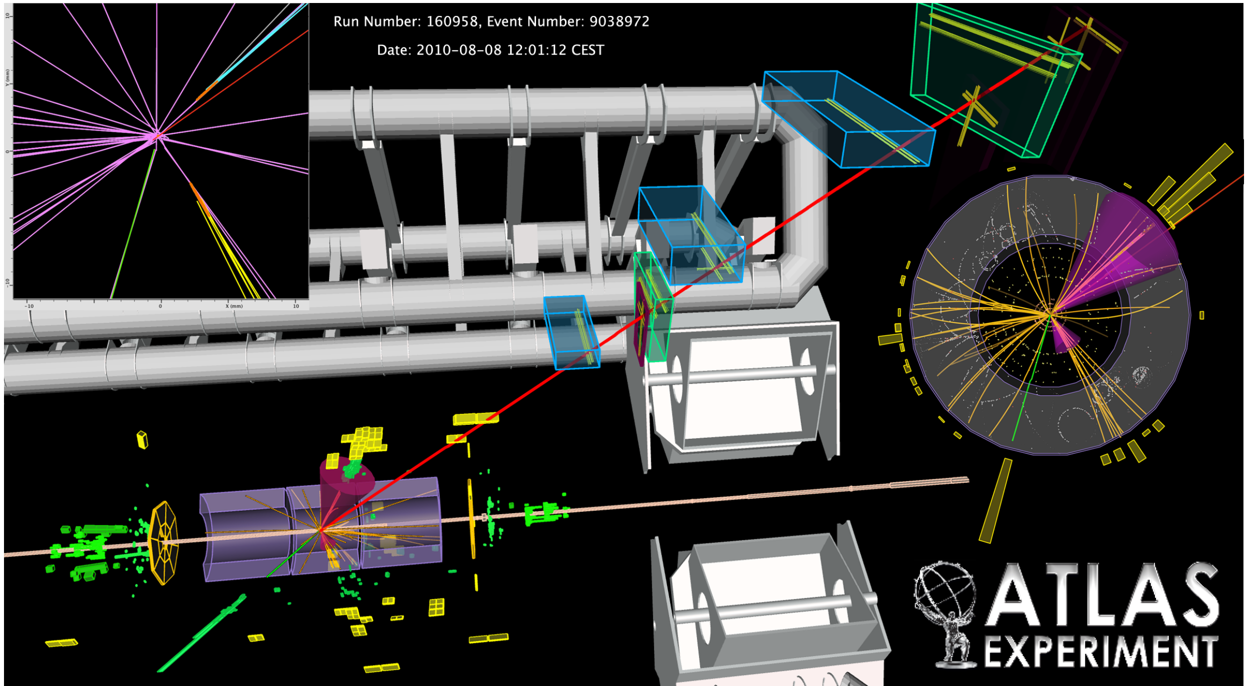
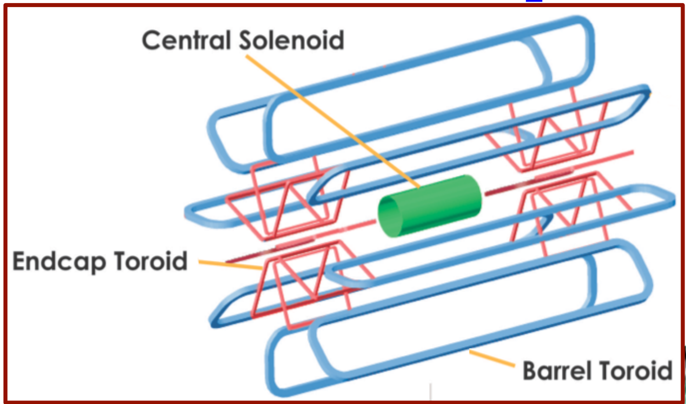
- Muon Identification in ATLAS
- Efficiencies and muon types
- Momentum resolution
- Pile-up

Muon Spectrometer

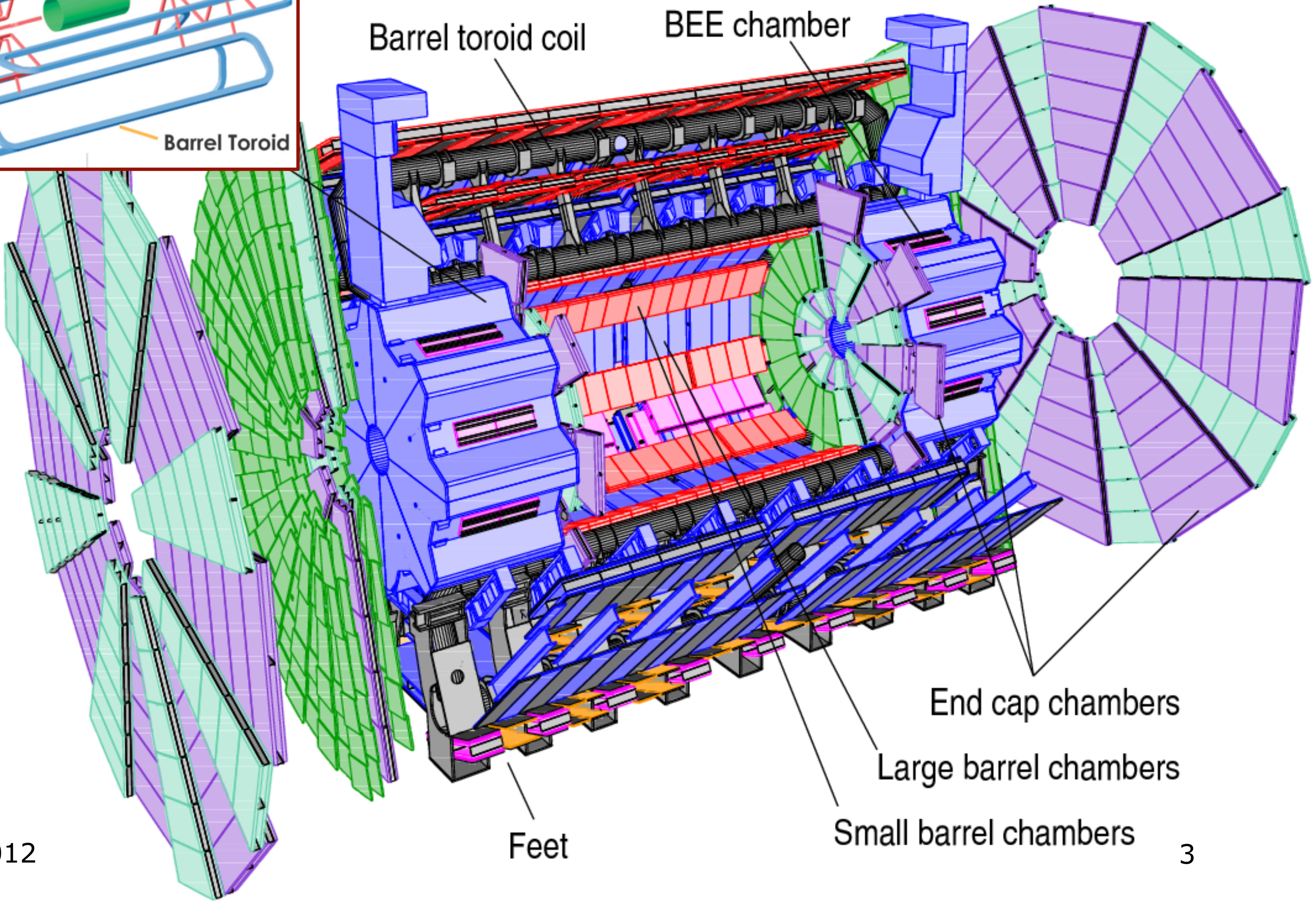
- Muon detection: charged particle emerging from calorimeters
- ATLAS has dedicated muon spectrometer (MS)
  - magnet system of its own: toroid field bends tracks over long distances
  - three layers of precision stations: monitored drift tubes (MDT)
  - fitted with fast trigger chambers: resistive-plate and thin-gap chambers
- Special Consequences
  - independent reconstruction of muon in MS
  - clean seed for muon identification and high muon quality after combination with ID
  - sharp momentum thresholds available for lowest level muon triggers
  - extend momentum resolution up to TeV scale



Muon Spectrometer

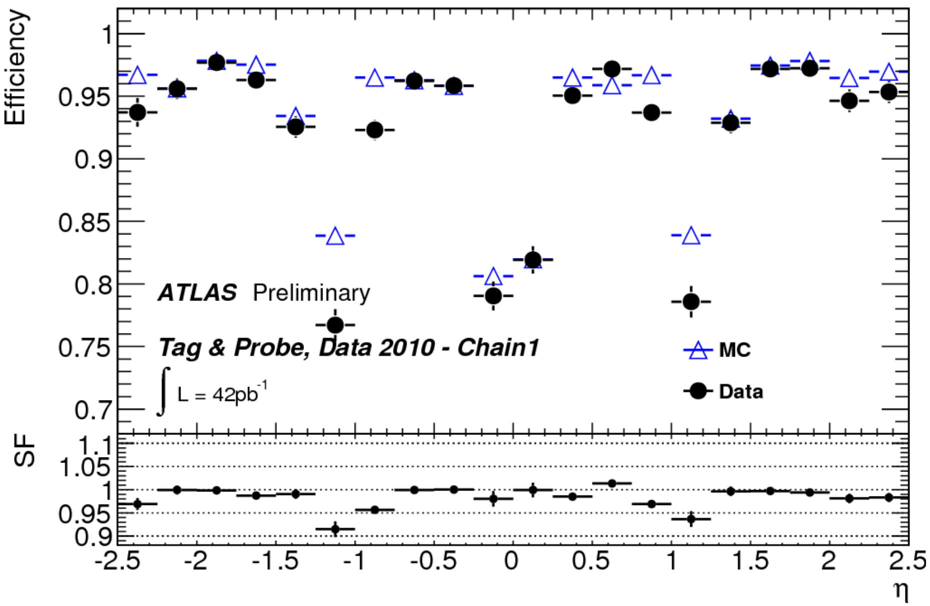


Magnet system

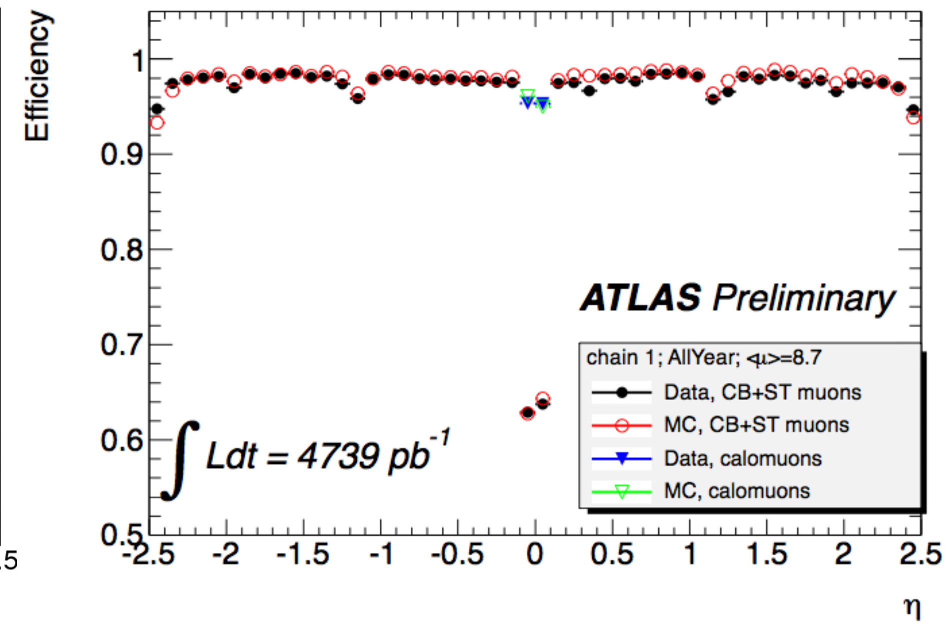


Muon Identification Types

Combined muons only



All muon types

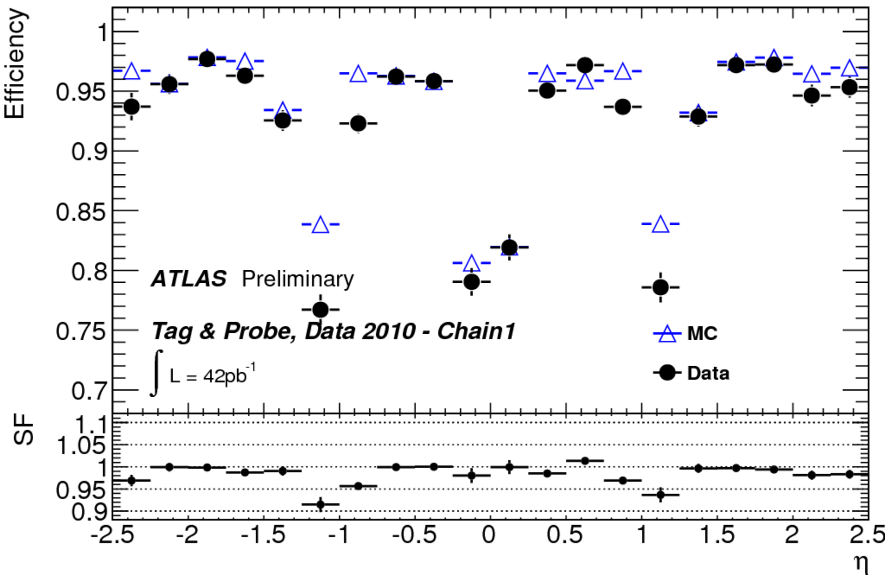


- Combined muons from ID and MS track
  - best momentum resolution and background rejection
  - efficiency loss in regions with <3 MS stations

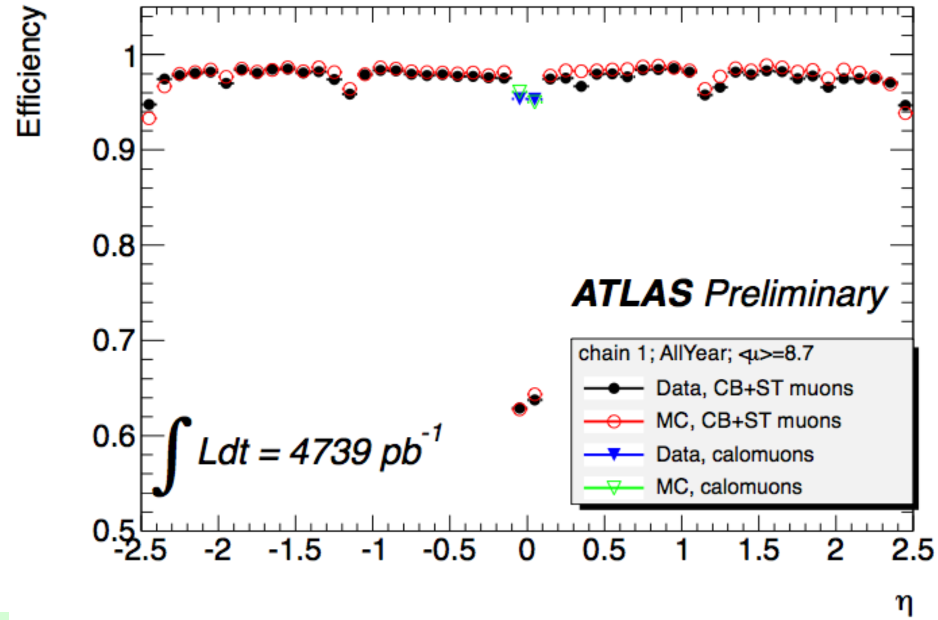
- Segment-tagged muons
  - ID seeded identification where only 1-2 MS stations
- Calorimeter-tagged muons
  - isolated ionization trajectory in had. Cal.
  - identification at η~0 (no MS stations)
- Standalone muons (|η|>2.5)

Muon Identification Efficiency

2010 (first-pass reconstruction)



2011 (reprocessed)

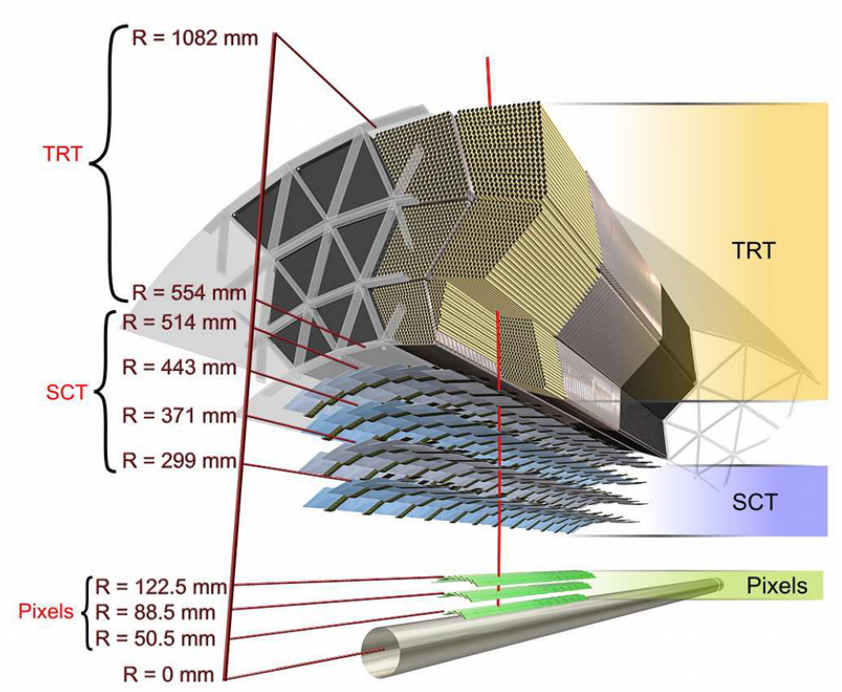


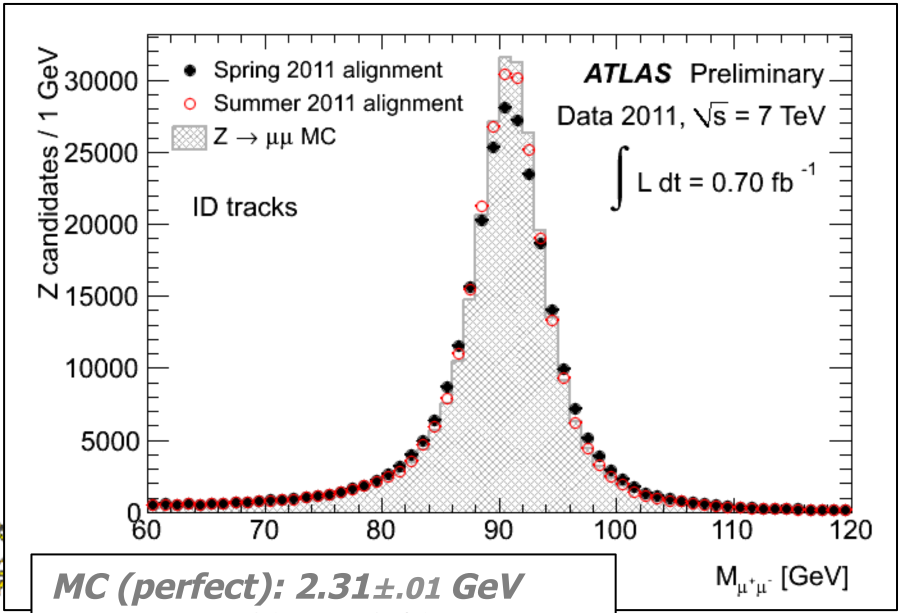
- efficiency from Z tag & probe
  - muon + 2^{nd} ID track at M_{inv}~M_Z
- Performance in first data
  - high efficiency from the start
  - regions of (un)expected inefficency
- Detector effects
  - track based drift tube calibration
  - alignment precision for some chambers

- Performance after 1 year of detector understanding
  - including improvements in software
- Addition of more muon types provides uniform efficiency

Momentum Resolution

- Series of alignment updates in inner detector
  - started with cosmic ray data 2008
  - main probe in collisions is Z–>μμ mass resolution
  - continuously improved, e.g. during 2011
  - affects resolution of tagged and combined muons

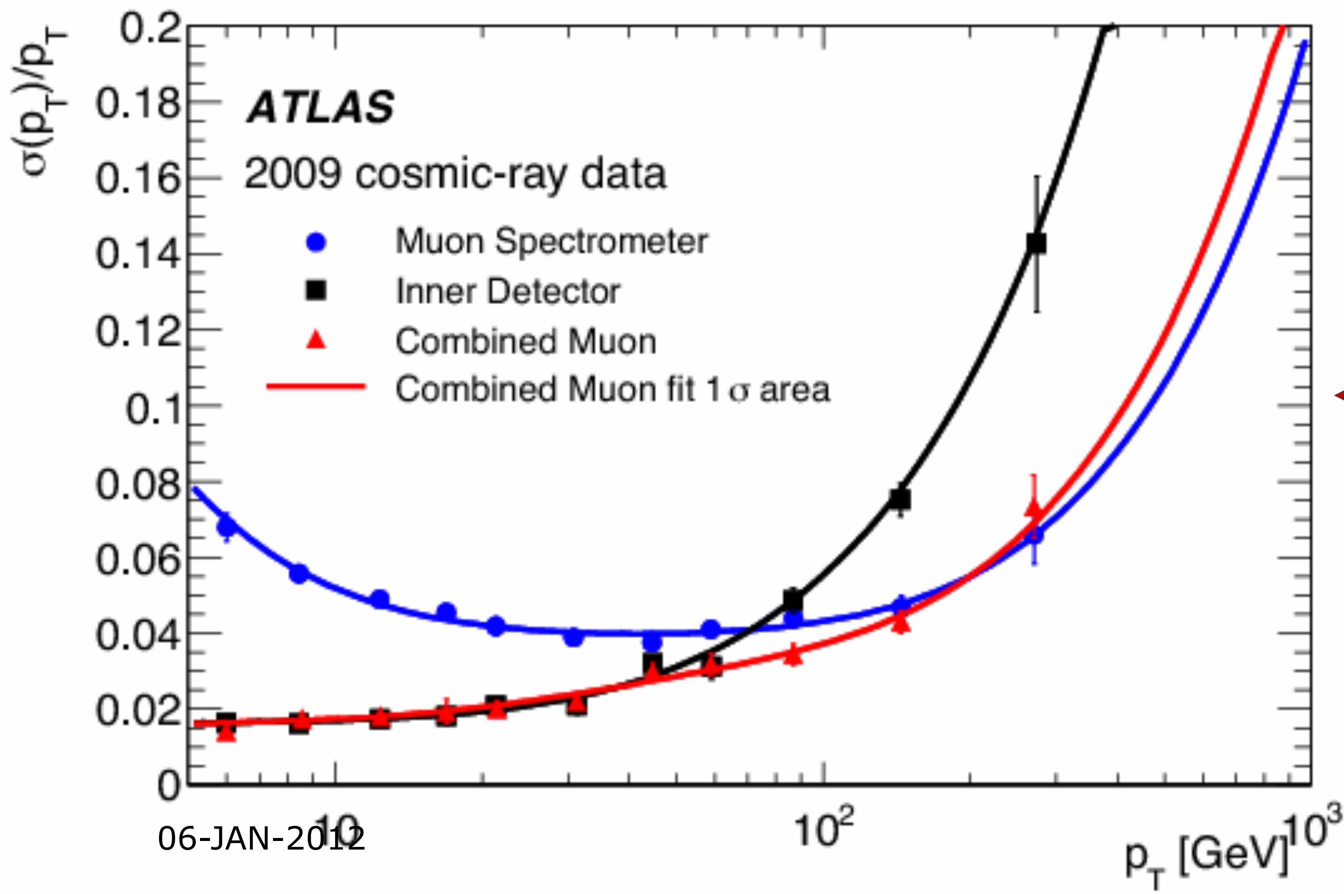




MC (perfect): 2.31±.01 GeV
Data Spring 2011 : 2.89±.01 GeV
Data Summer 2011: 2.45±.01 GeV

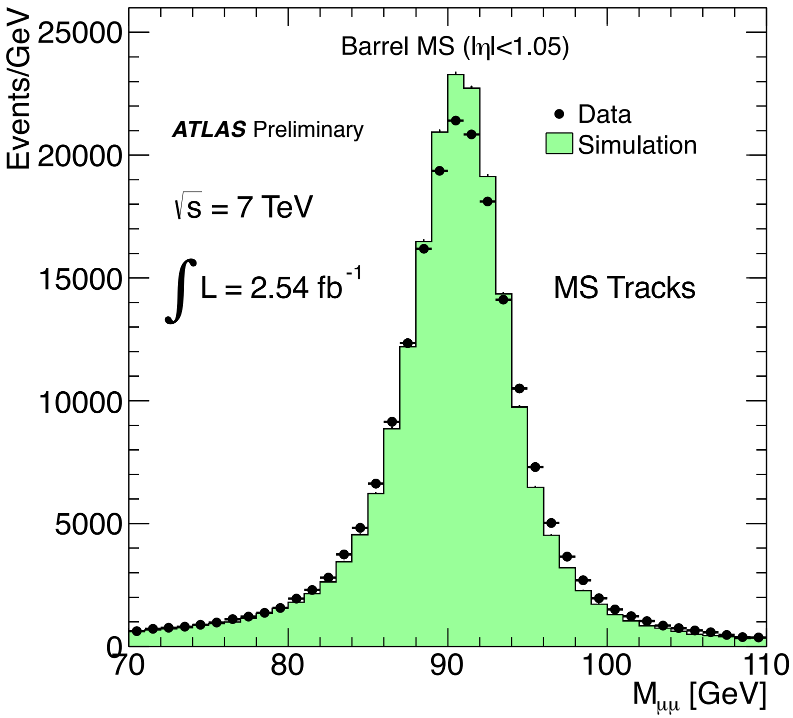
Resolution at High Momenta

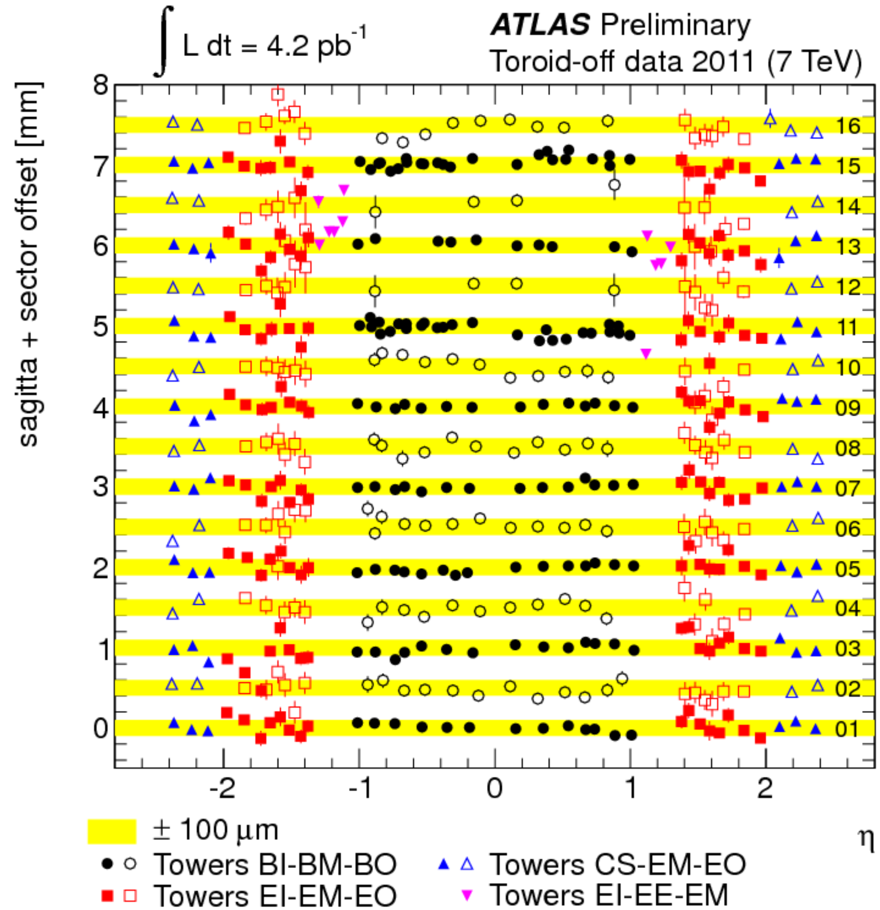
- Muon momenta at p ~ 1 TeV estimated mainly by MS
  - high field integral, lever arm, hit precision in Muon Spectrometer (MS)
  - low momenta determined by ID (material effects in calo+MS strong)
  - TeV scale momentum precision depends on MS alignment
- Precisions alignment of huge MS is a challenge
  - track-based alignment needed to complement and probe quality of optical alignment



Design performance is 10% at 1 TeV

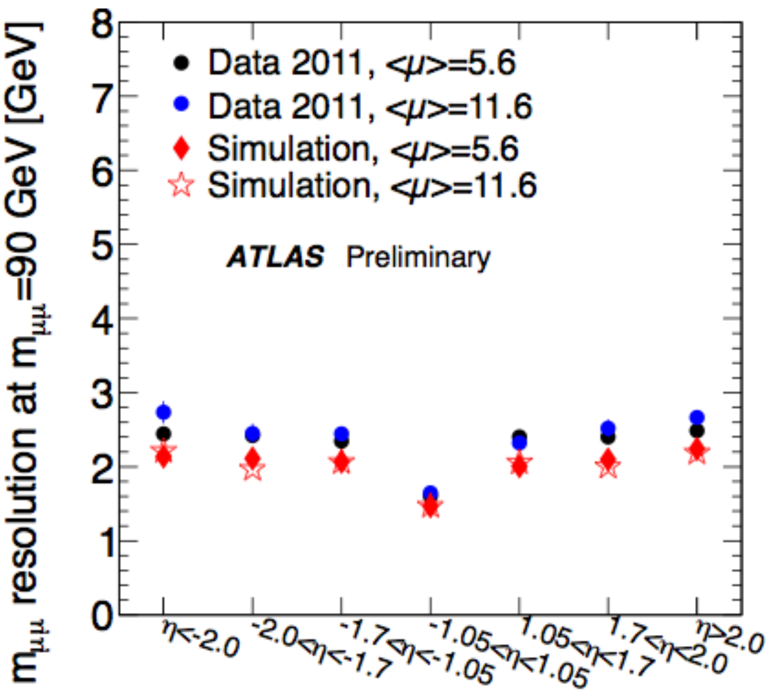
Resolution in Spectrometer

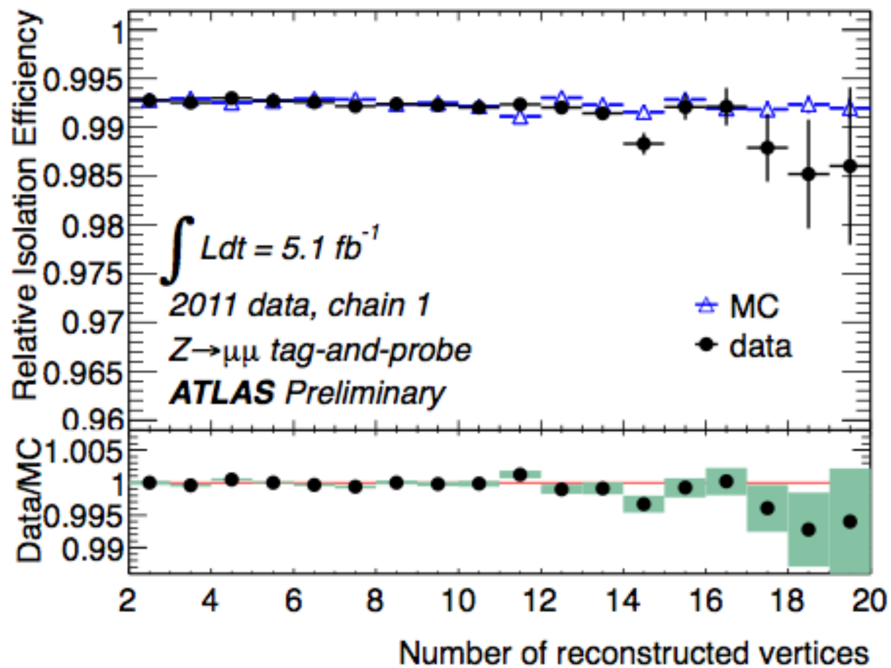




- $M_{\mu\mu}$ resolution probes also MS
  - remaining difference incorporated in analyses by momentum smearing
  - for intermediate momentum values
- High pT resolution consolidated by improving MS alignment
  - special data: solenoid on, **toroid off** –> study residuals from straight lines in MS
  - study tracks crossing overlaps in station sectors in
  - typical alignment precision now < ~100μm

Muon Performance with Pile-up





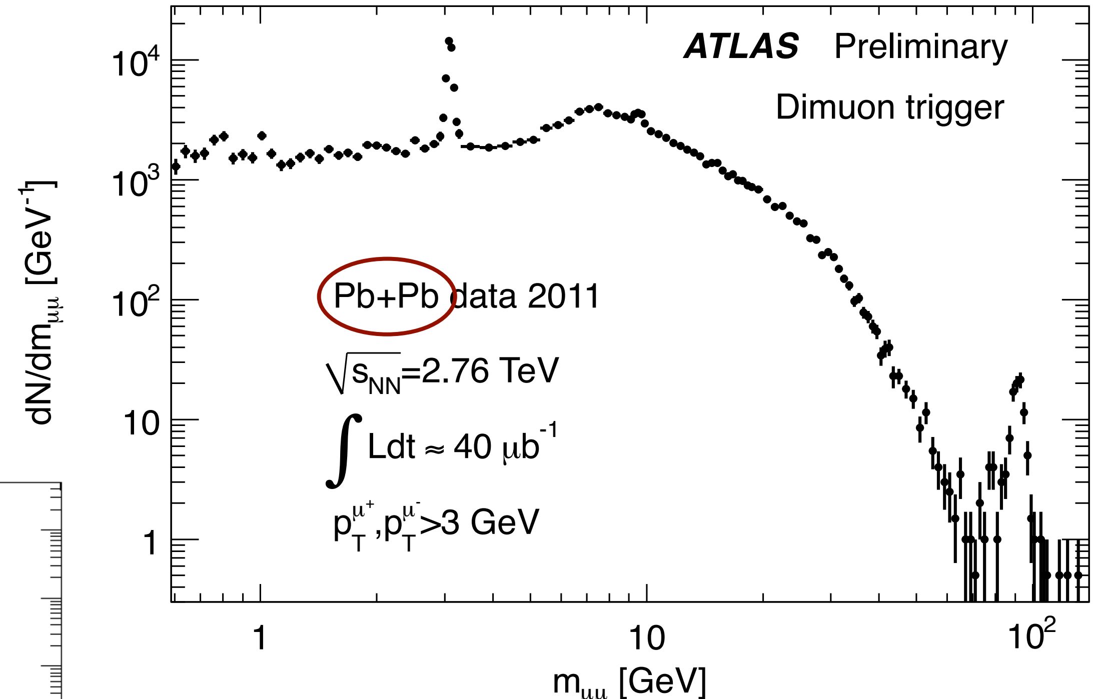
- $M_{\mu\mu}$ resolution again
  - now separated into periods of different machine conditions
  - discrepancies only between data and MC (from alignment)

- Muon efficiency with additional isolation cut
  - track isolation: $p_T$cone30/p_T < 0.15
  - calorimeter isolation is corrected for pile-up, leading to similar agreement

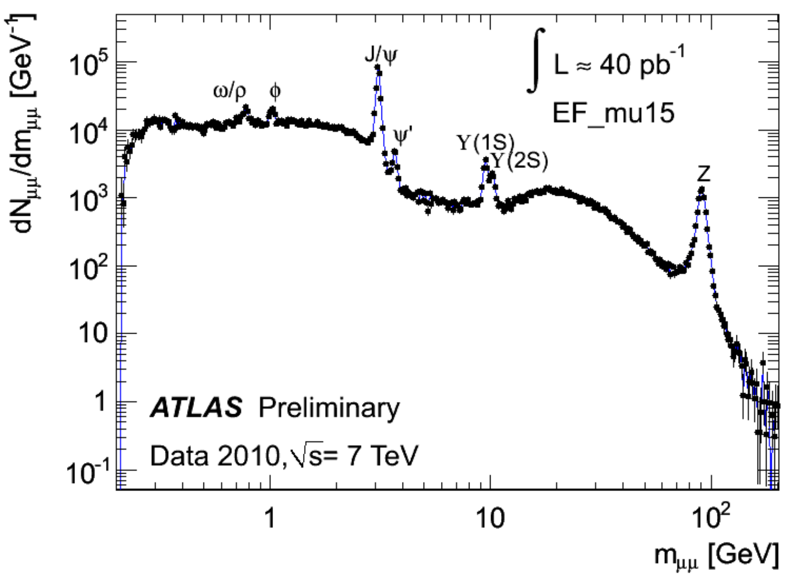
Di-muon pairs

(in addition to new chain deployment)

- muon pairs in muon triggered events
- clean spectrum also in heavy ion collisions



p–p data 2010



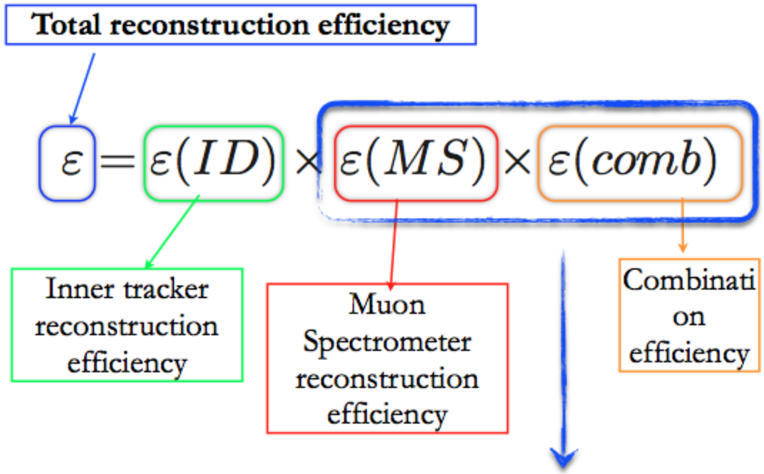
Concluding Remarks

- Good ATLAS muon performance right from beginning of p–p collisions
- Muon identification performance studied in increasing levels of detail, profiting from the rapidly growing data-set of 7 TeV collisions
  – feed-back to detectors and algorithms to make subsequent processing better
- substantial improvements from detector calibration and alignment particularly for the momentum resolution
- By using muon from all identification techniques physics analyses profit from highest and most uniform efficiency
- Performance stable when environment becomes more challenging (Pile-up, heavy ions)

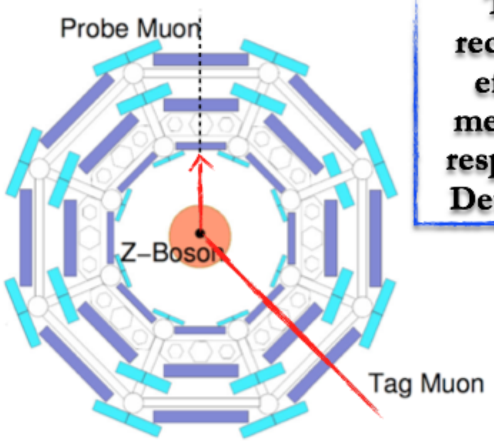
Thank you !

➔ Backup:

Tag and probe, low pT efficiency



The muon reconstruction efficiency is measured with respect to Inner Detector tracks



- Tag and probe method
  - exploit detector redundancy and uniform ID efficiency >99% for muons
- Muon identification turn-on curve
  - governed by muon mean energy loss in calorimeters (~3GeV)
  - and minimal remaining momentum to traverse spectrometer