HadronColliderPhysics Symposium 2011 - Paris, November 14-17 2011
Poster Session

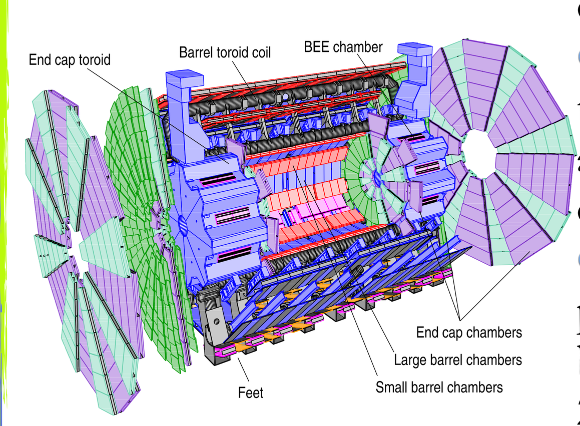
Measurement of the muon reconstruction efficiency in ATLAS

Muon definition

- Two types of muons are used for physics analysis in ATLAS
- **Combined muons (CB)**: reconstructed track in the Muon Spectrometer that matches a reconstructed track in the inner tracker;
- **Segment Tagged muons (ST)**: straight segment in the Muon Spectrometer that matches a reconstructed track in the inner tracker;
- Two families of reconstruction chains:
- **STACO chain (chain 1)**,
- **MUID chain (chain 2)**.

Muon reconstruction with the ATLAS detector

Muon Spectrometer

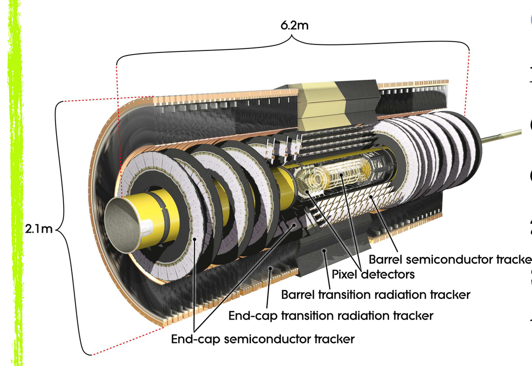


Four technologies of gas detectors are arranged in a air core toroidal magnetic field:

- RPC and TGC provide LVL1 trigger up to $|\eta|=2.4$ in addition to second coordinate coarse measurement;
- MDT and CSC allow precision tracking in the bending plane up to $|\eta|<2.7$;
- goal performance $\sigma(pt)/pt=10\%$ for p_T up to 1TeV.

Inner Detector

- A silicon detector (strips and pixels) provides high granularity track reconstruction up to $|\eta|=2.5$ near the interaction point.
- Tracking redundancy and electron/hadron discrimination power are achieved with a straw tube based transition radiation system for $|\eta|<2.1$.



Physics reach

Muons have a clean signature that allows an easy identification of interesting phenomena embedded in the typical dense event topology at LHC.

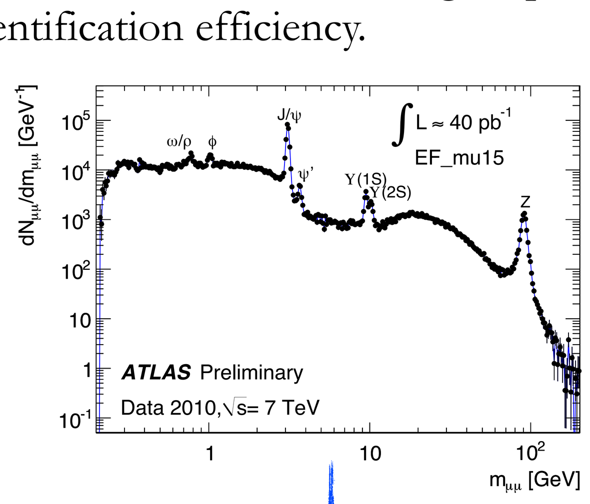
The ATLAS muon identification system is designed to provides a wide p_T acceptance for muons at $|\eta|<2.7$ in order to cover a large physics program:

- at low p_T, a rich precision B-physics program requires high efficiency and accurate estimation of the identification efficiency;
- at intermediate/high p_T (Higgs search) and very high p_T physics (extra gauge bosons search) excellent p_T resolution is requested, in addition to high identification efficiency.

"Tag-and-probe" method

In-situ measurement of the muon reconstruction efficiency with the so-called "**tag-and-probe**" method exploiting well known di-muon resonances

- A combined muon, the "**tag**", is required in the event.
- The tag is paired with a track reconstructed in the Inner Detector, the "**probe**", giving an invariant mass close to the considered resonance mass.
- The fraction of reconstructed signal probes measures the muon identification efficiency.

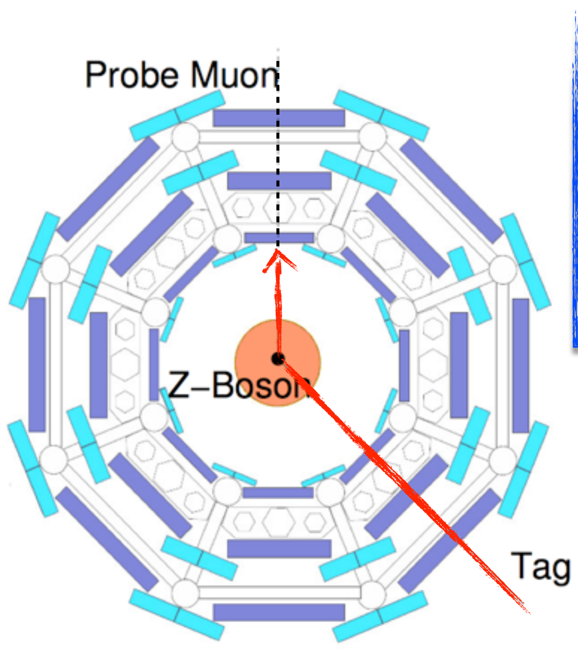


The $J/\psi\rightarrow\mu^+\mu^-$ decay is used to obtain a sample of low-p_T probes, while the $Z\rightarrow\mu^+\mu^-$ decay provides high p_T probes

Total reconstruction efficiency

$$\varepsilon = \varepsilon(ID) \times \varepsilon(MS) \times \varepsilon(comb)$$

- $\varepsilon(ID)$: Inner tracker reconstruction efficiency
- $\varepsilon(MS)$: Muon Spectrometer reconstruction efficiency
- $\varepsilon(comb)$: Combination efficiency



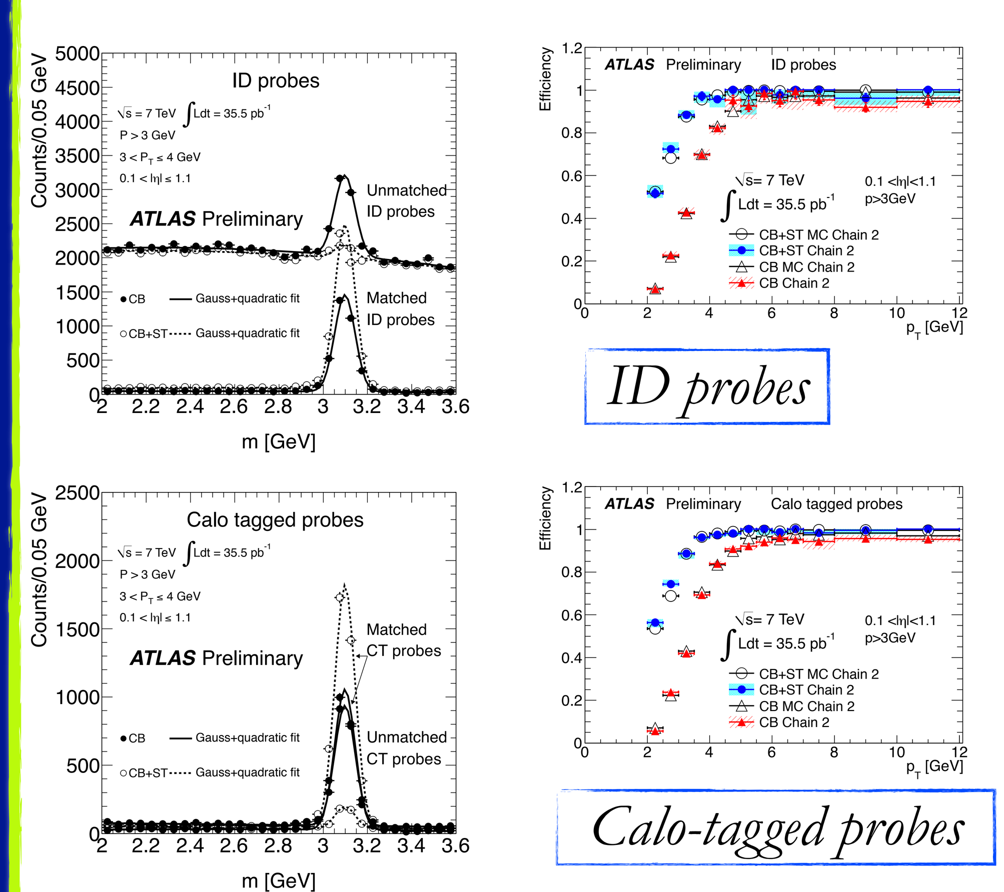
The muon reconstruction efficiency is measured with respect to Inner Detector tracks

Muon reconstruction efficiency at low p_T

Tag and probe selection with J/ψ

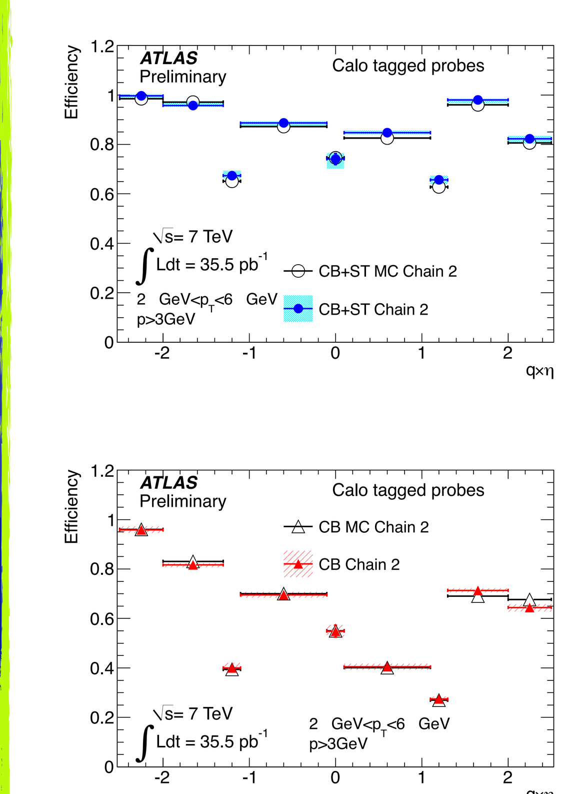
- Tag selection:
  - high quality combined muon with p_T>4GeV and $|\eta|<2.5$, with low impact parameter with respect to the interaction point;
  - η-φ based geometrical matching of the tag with one of the muon triggering the event;
- Probe selection: high quality track with p>3GeV and $|\eta|<2.5$ (named Inner Detector probes or, briefly, **ID probes**).
- Tag-and-probe selection criteria:
  - good tracks vertex fit;
  - η-φ cuts to avoid near-by tag and probe tracks to avoid residual trigger bias;
  - opposite charge tracks and invariant mass between 2 GeV and 4GeV.
- Additionally, to improve the background rejection, a track-calorimeter based isolation algorithm is used to identify the probes (Calo-tagged probes, or briefly **CT probes**).

Efficiency Determination



- Simultaneous fit of the invariant mass distributions of the disjoint samples with and without probes reconstructed as muons (**matched** and **un-matched** respectively).
- Gaussian model for the signal and quadratic model for the background.
- Systematic uncertainties estimated by varying background modeling and signal shape constraints.

Charge dependence



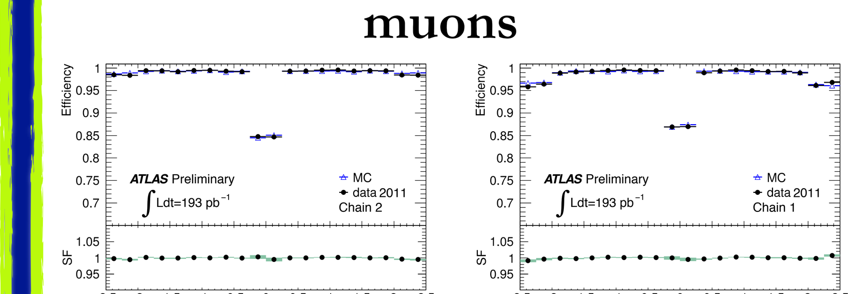
Due to the toroidal magnetic field of the ATLAS MS, muons with positive (negative) charge are bent towards larger (smaller) η. At a given η, a muon of low p_T has a different chance to be tracked in all three muon measurement stations depending on its charge. This effect introduces a **charge dependence** of the muon reconstruction efficiencies. As far as the ATLAS detector is symmetric around the beam line, the muon reconstruction efficiency only depends on $q\times\eta$ where q is the muon charge.

Muon reconstruction efficiency at high p_T

Tag and probe selection with Z

- Tag selection:
  - high quality combined muon with p_T>20GeV and $|\eta|<2.4$;
  - η-φ based geometrical matching of the tag with one of the muon triggering the event.
- Probe selection: high quality track with p_T>20GeV and $|\eta|<2.5$
- Tag-and-probe selection:
  - required to come from a common primary, azimuthal separation $\Delta\varphi$ (tag,probe)>2.0, opposite charge tracks, invariant mass falling in a window of 10GeV around the Z boson mass
  - both tag and probe are required to be isolated according to a track based algorithm

Reconstruction efficiency for combined or segmented-tagged muons



- Bin-by-bin background subtraction under the Z peak using MC background predictions.
- Muon efficiency measured in $\eta\times\varphi\times p_T$ slices to better match the detector layout geometry.

Further reading

For a description of the measurement strategies:
- The ATLAS Collaboration, ATLAS-CONF-2011-063,
- The ATLAS Collaboration, ATLAS-CONF-2011-021.

For the most recent efficiency determinations, see:
- https://twiki.cern.ch/twiki/bin/view/AtlasPublic/MuonPerformancePublicPlots#AnchorConfNotes.

Nicola Orlando on behalf of the ATLAS Collaboration
INFN Sezione di Lecce and Dipartimento di Fisica Universita` del Salento