Commissioning the ATLAS Muon Trigger with 900 GeV Collision Data

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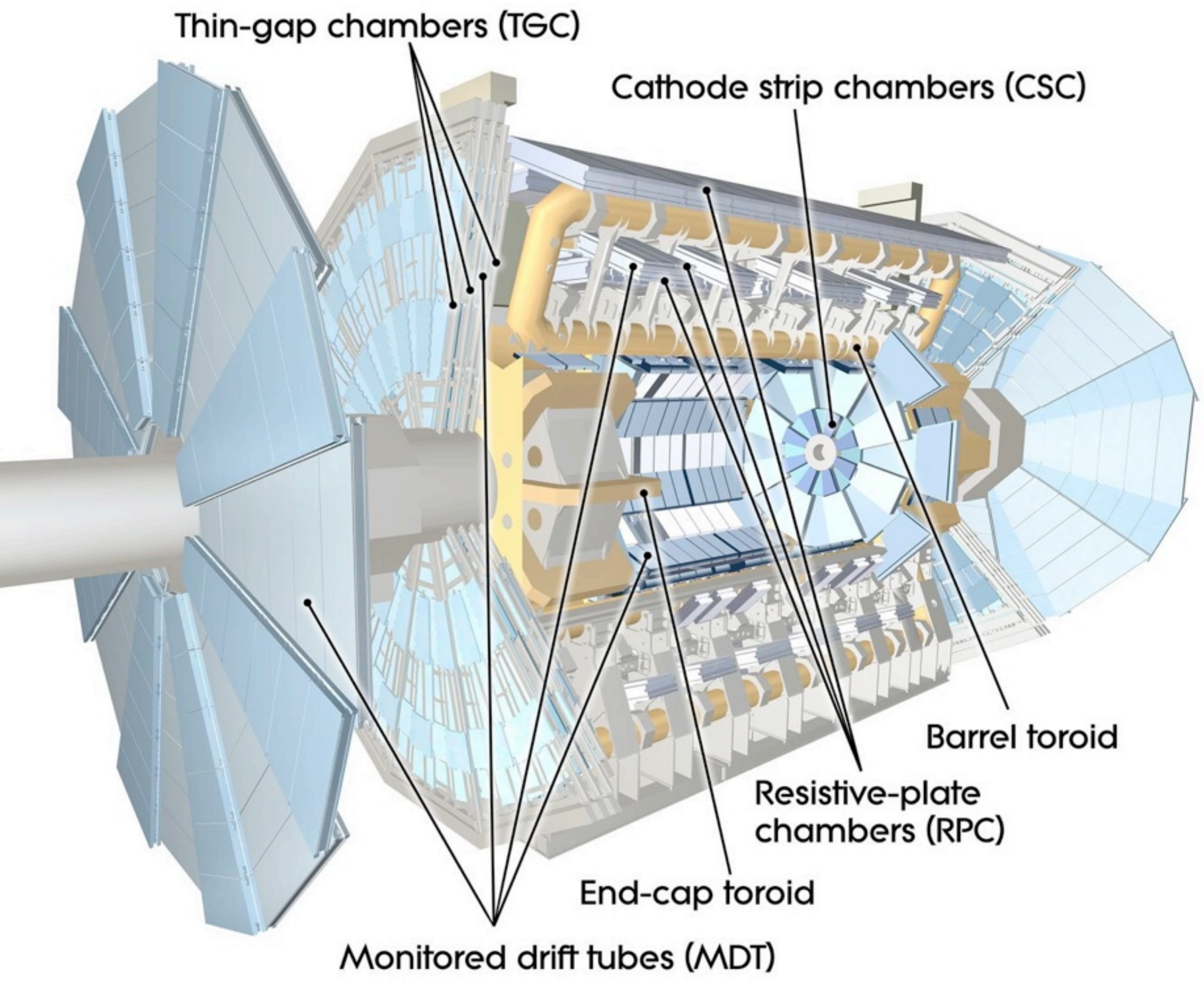
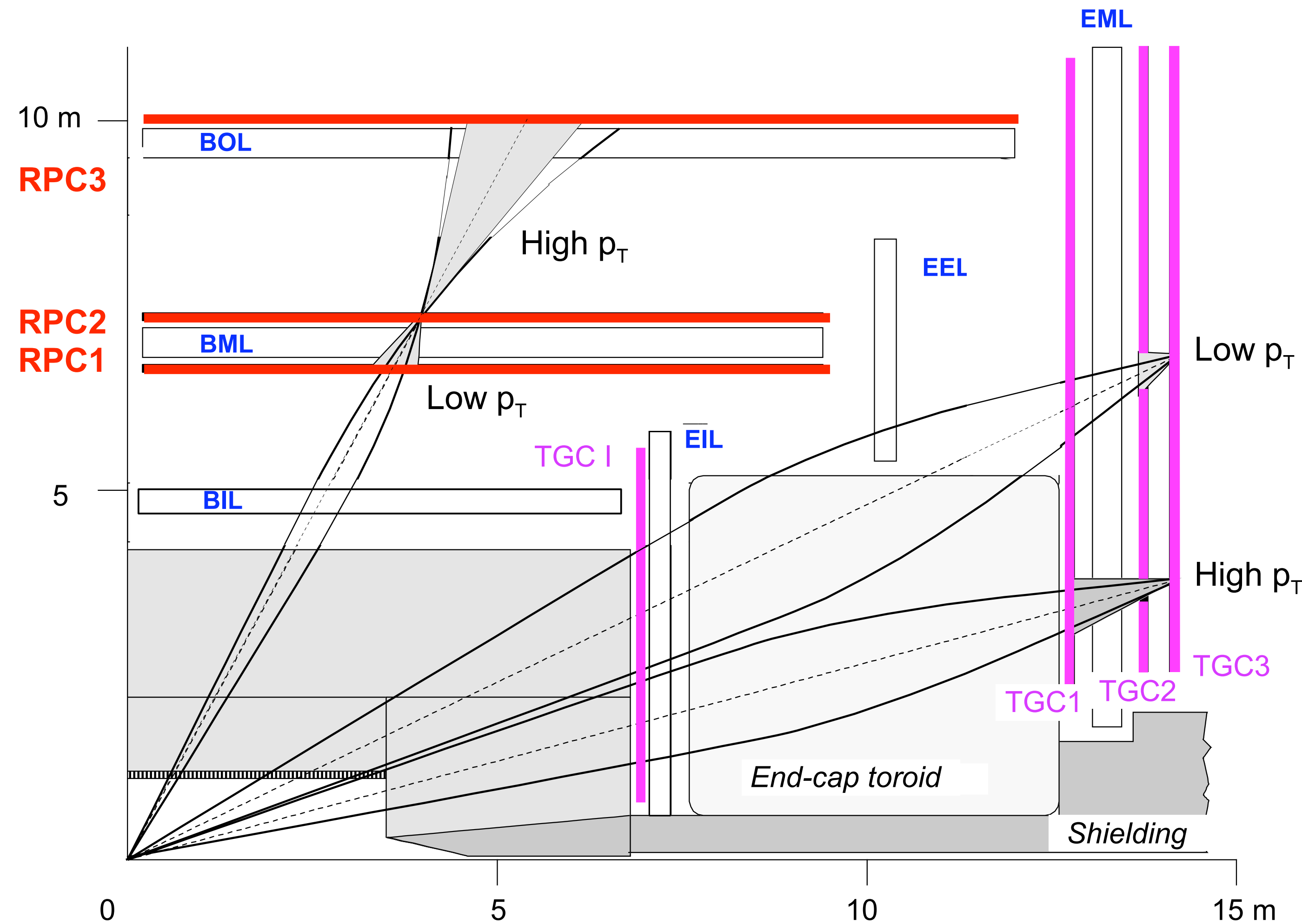
Introduction

- LHC delivered first collision data at $\sqrt{s}$ = 900 GeV in December 2009.
- First chance to examine muon & muon trigger performance in collision events.
- Luminosity much smaller than design ($L_{inst} \sim 10^{26}cm^{-2}s^{-1}$):
  - In this sample muons are expected to come from pion & kaon decays - low p_{T}.
  - Quite different momentum range than usually considered for ATLAS physics (W, Z, top, Higgs).

ATLAS Muon System

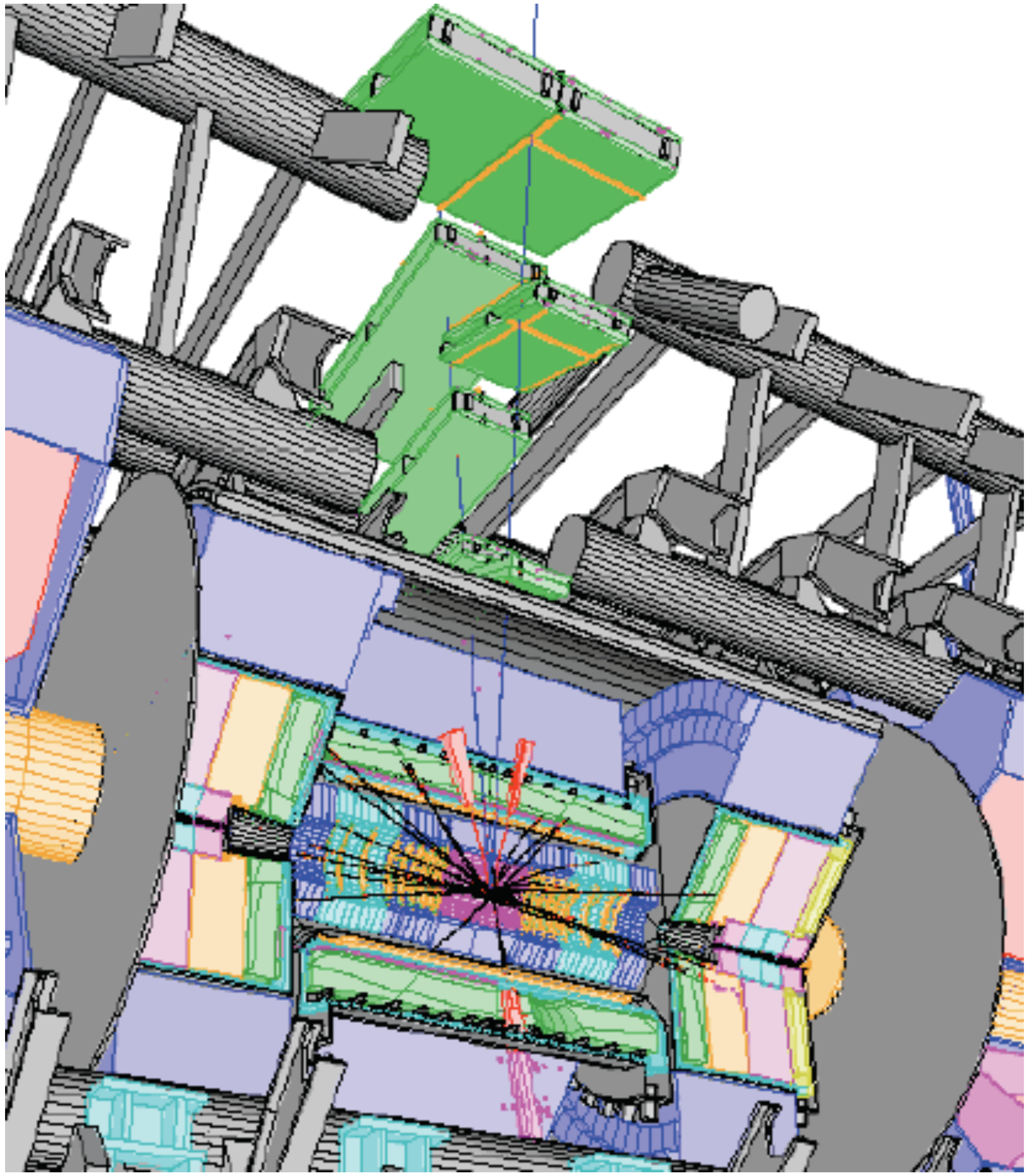
- Four detector sub-systems & magnet system:





ATLAS Trigger System

- ATLAS uses a three level trigger system (L1, L2 & EF).
  - L2 & EF refine the objects found at L1 by looking in a region-of-interest (RoI).
  - L1 muon trigger from RPC & TGC systems, L2 & EF have access to MDT data.
  - L2 & EF can make use of tracks in the inner detector (ID).



Data Selection

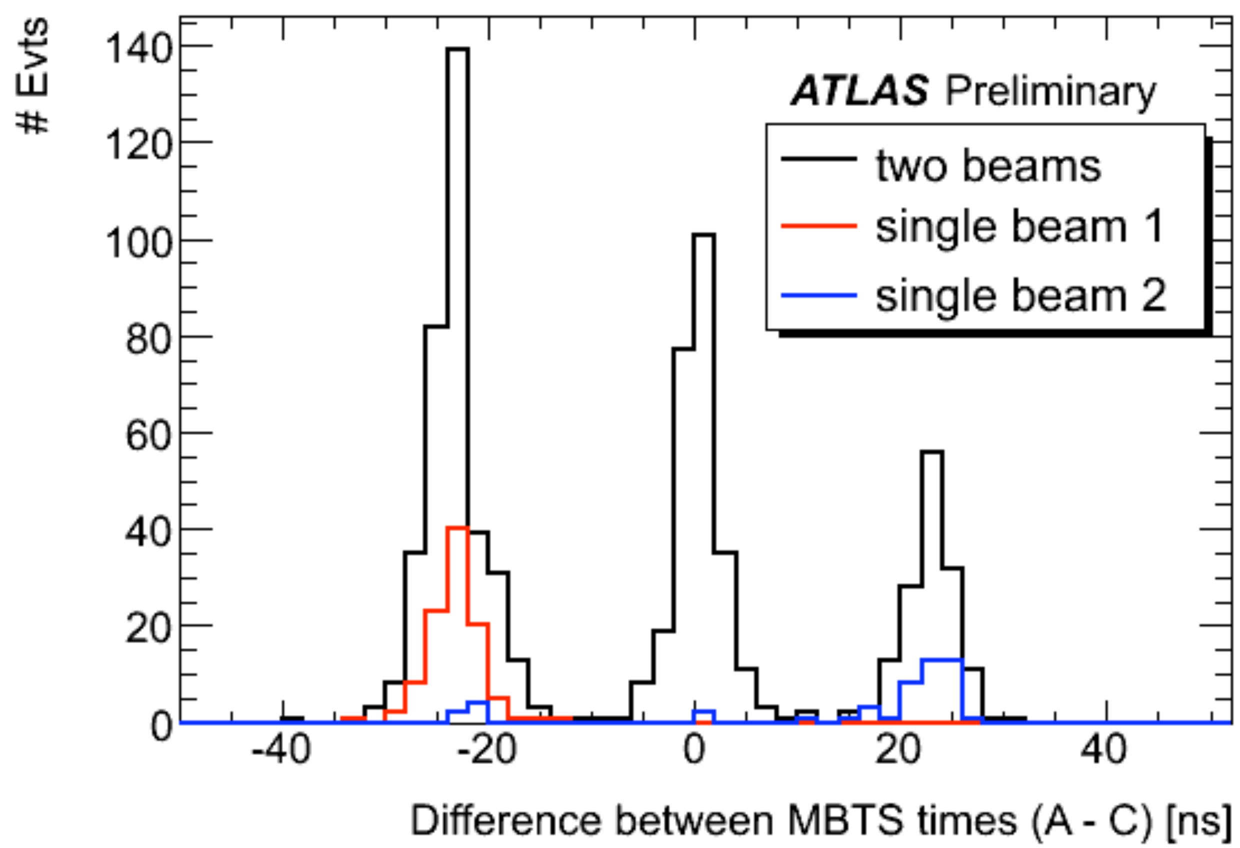
- Events are selected from the 900 GeV collision runs, requiring the ID & muon detectors to be fully operational and both magnets at nominal field strength.

- Selections are required to suppress the cosmic background:

  - Selected by the minimum bias trigger (MBTS).

  - At least 3 tracks in the ID & at least one with p > 4 GeV.

  - Timing consistent with collisions in the MBTS or Liquid Argon calorimeter.



Muon Identification

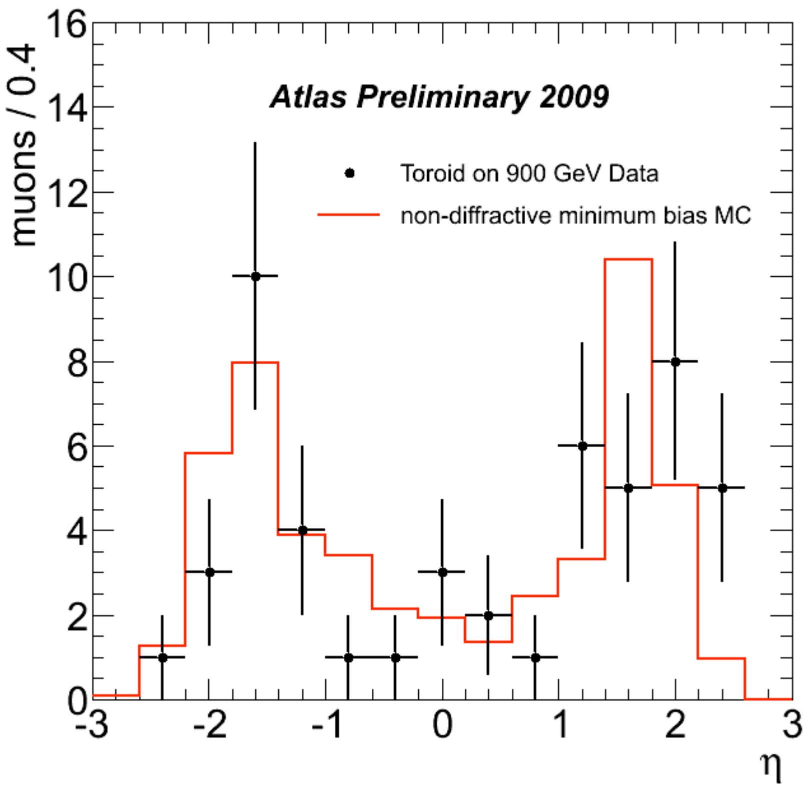
- Three strategies for muon selection:
  - Standalone - reconstruct the muon based on the muon spectrometer only.
  - Combined - associate a track in the muon spectrometer with a track in the ID.
  - Tagged - associate a track in the ID to segments in the muon system.
- Independent algorithm chains implement these strategies
- Provides robustness & maximises acceptance.

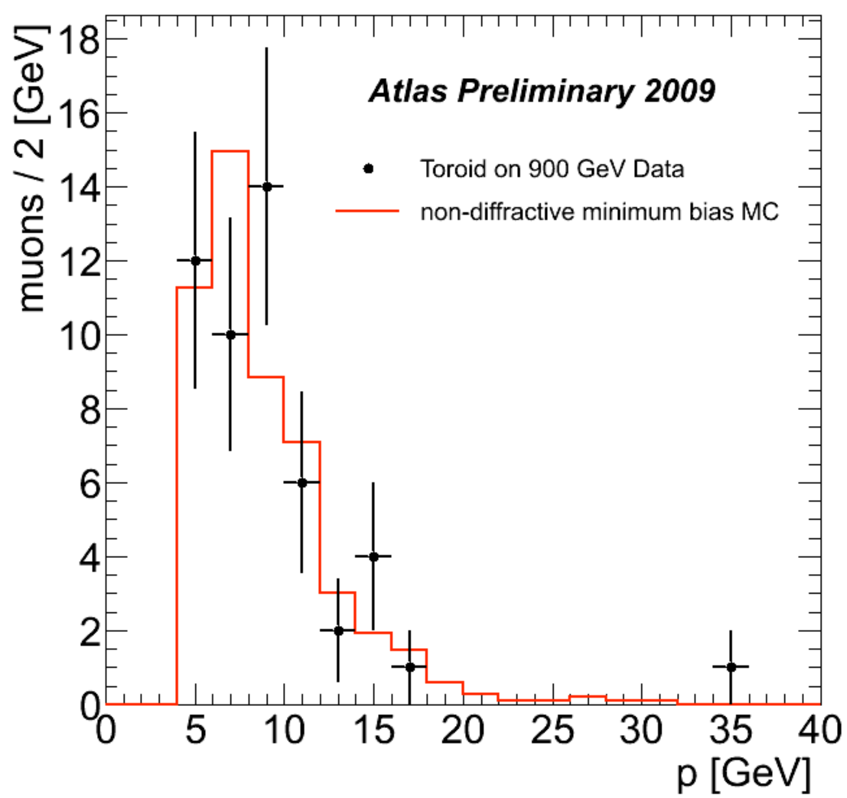
Muon Selection

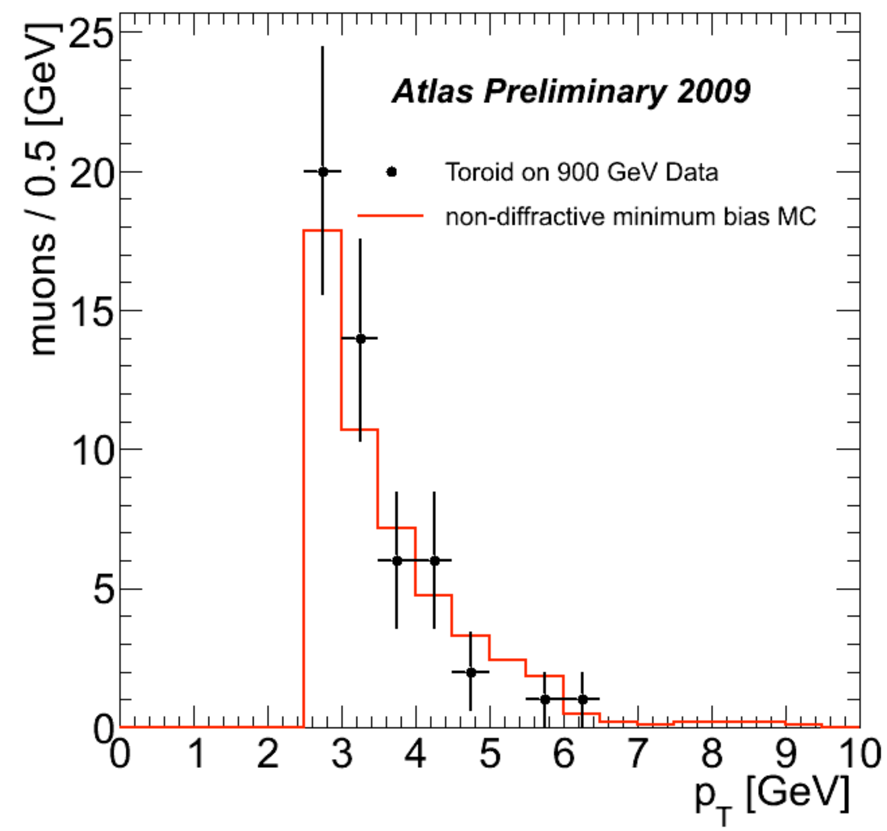
- To ensure good quality muons a number of quality requirements are applied, e.g. requiring silicon hits on ID tracks & trigger hits on the muon tracks.
- Kinematic requirements:
    - $p > 4$ GeV
    - $p_T > 2.5$ GeV
    - $|\eta| < 2.5$
- Reconstructed offline muons can then be compared to expectations from minimum bias MC events.

Offline Muons

- Comparison with PYTHIA minimum bias MC:







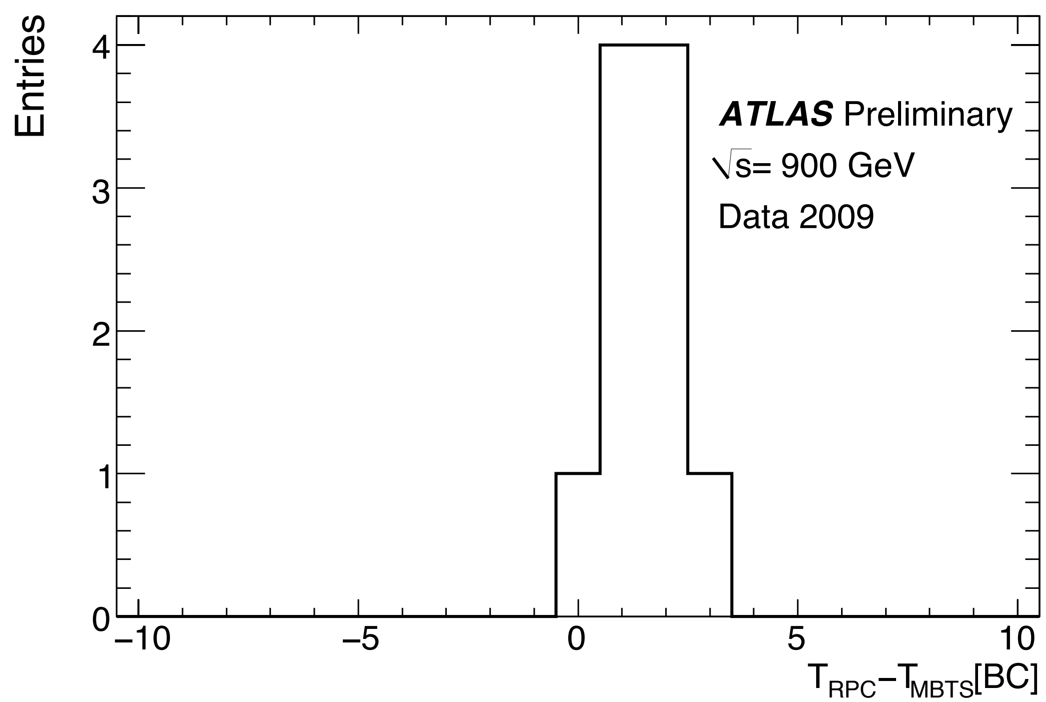
- Muons mainly in the forward region.
- Limited statistics, but good agreement with MC.

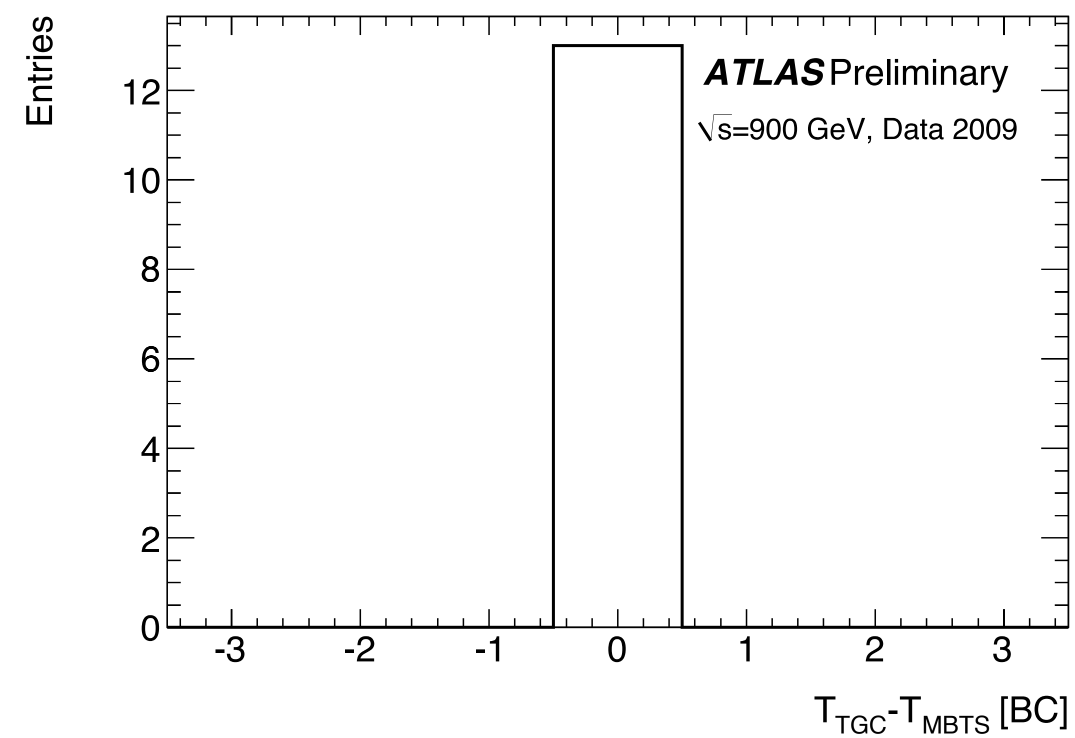
Triggers for 900 GeV Data

- Luminosity low enough so that only L1 trigger system needed to be used to control the rate.
  - Collision events collected on MBTS trigger - use as a reference for L1 muon trigger.
- The High Level Trigger (HLT) was in ‘transparent’ mode
  - All standard algorithms running, but not used for active rejection & selection of events.
  - Performance of algorithms can be studied in an unbiased way using the offline selected events.
- Lowest threshold is designed for $p_T \sim 4$ GeV - most muons below this value.

L1 Muon Trigger

- In order to have L1 muon triggers, the trigger must be in time with MBTS.
- TGC triggers well timed in, RPC triggers need some adjustments:

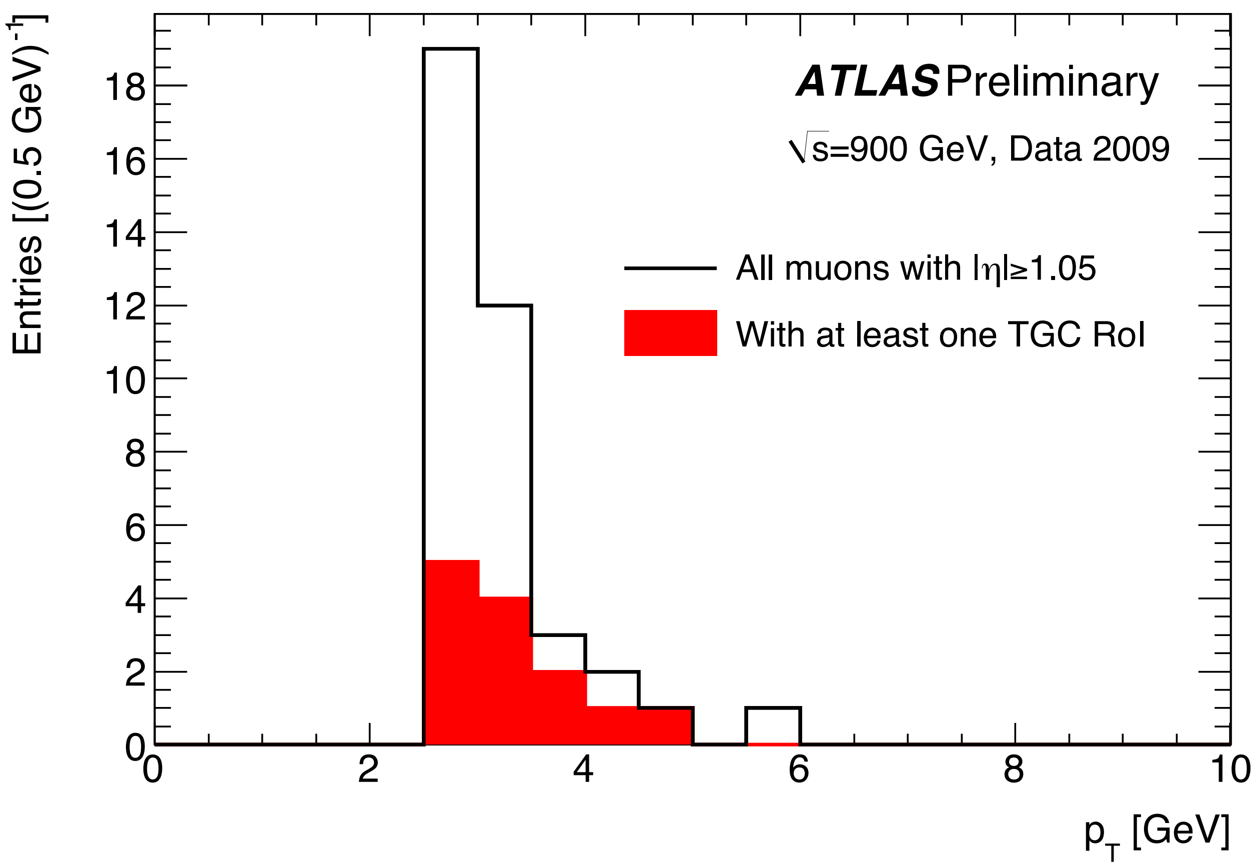


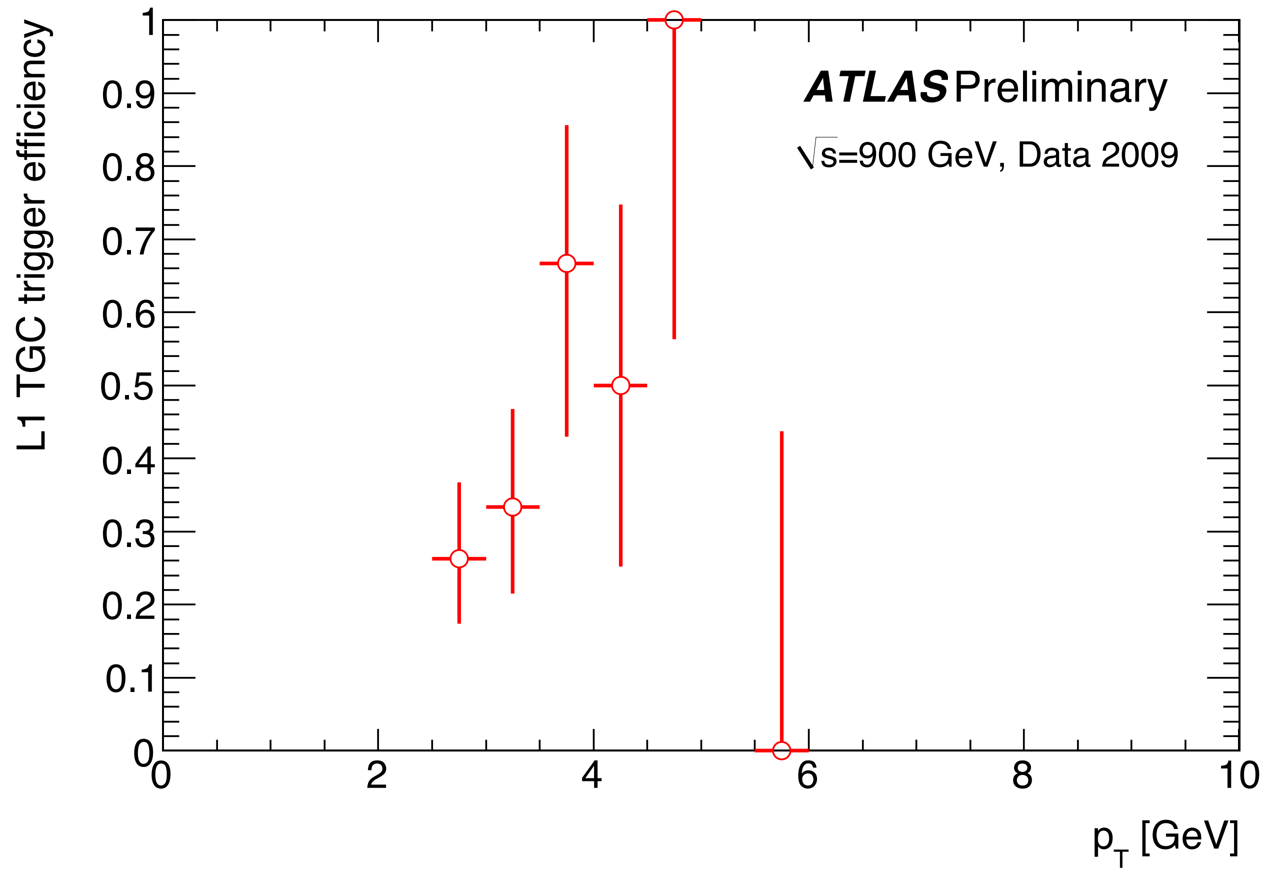


- RPC timing adjusted for 2010, detailed adjustments require more collision muons.

L1 Muon Trigger

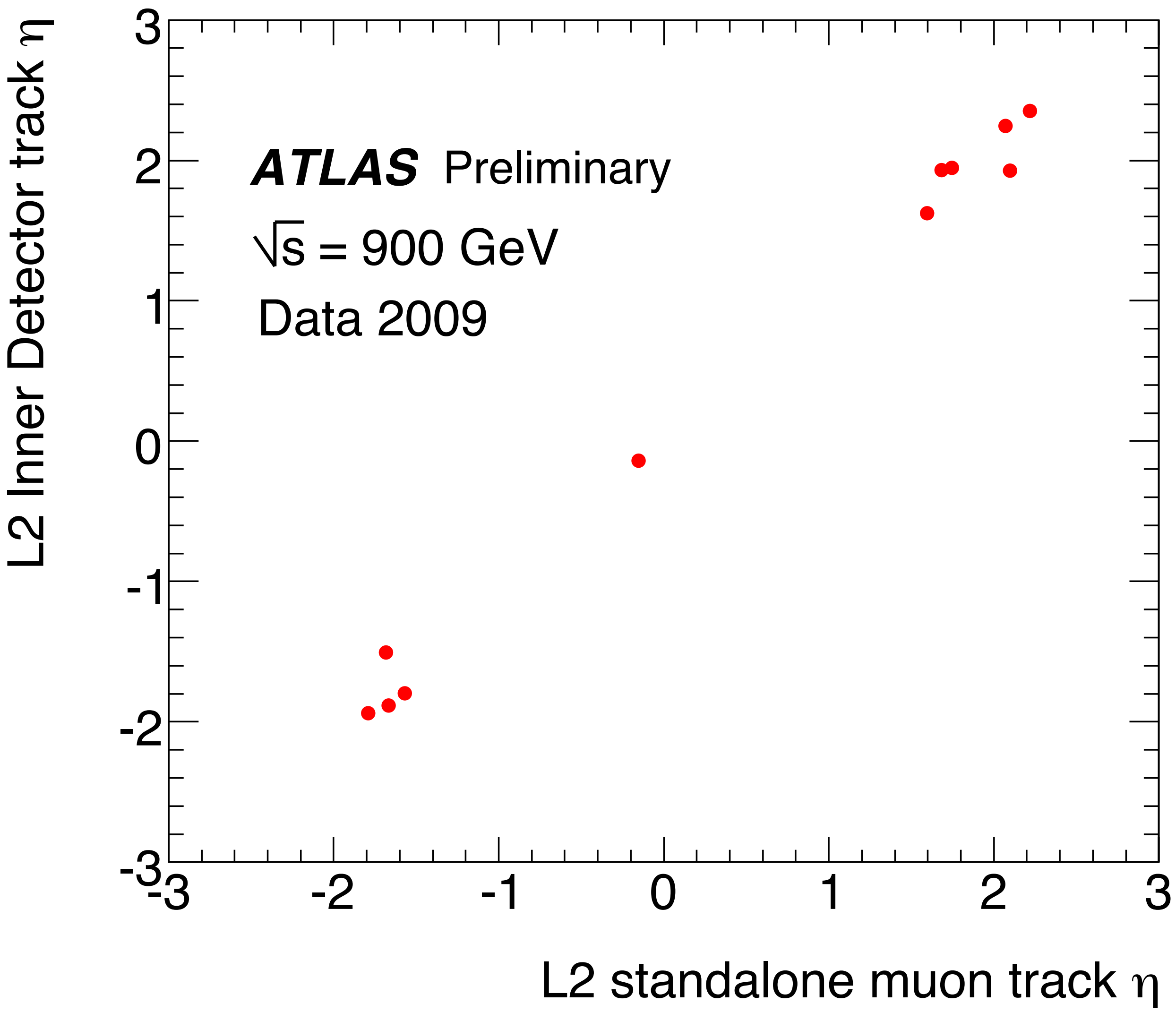
- As expected, lowest threshold has some acceptance for these low p_T muons:

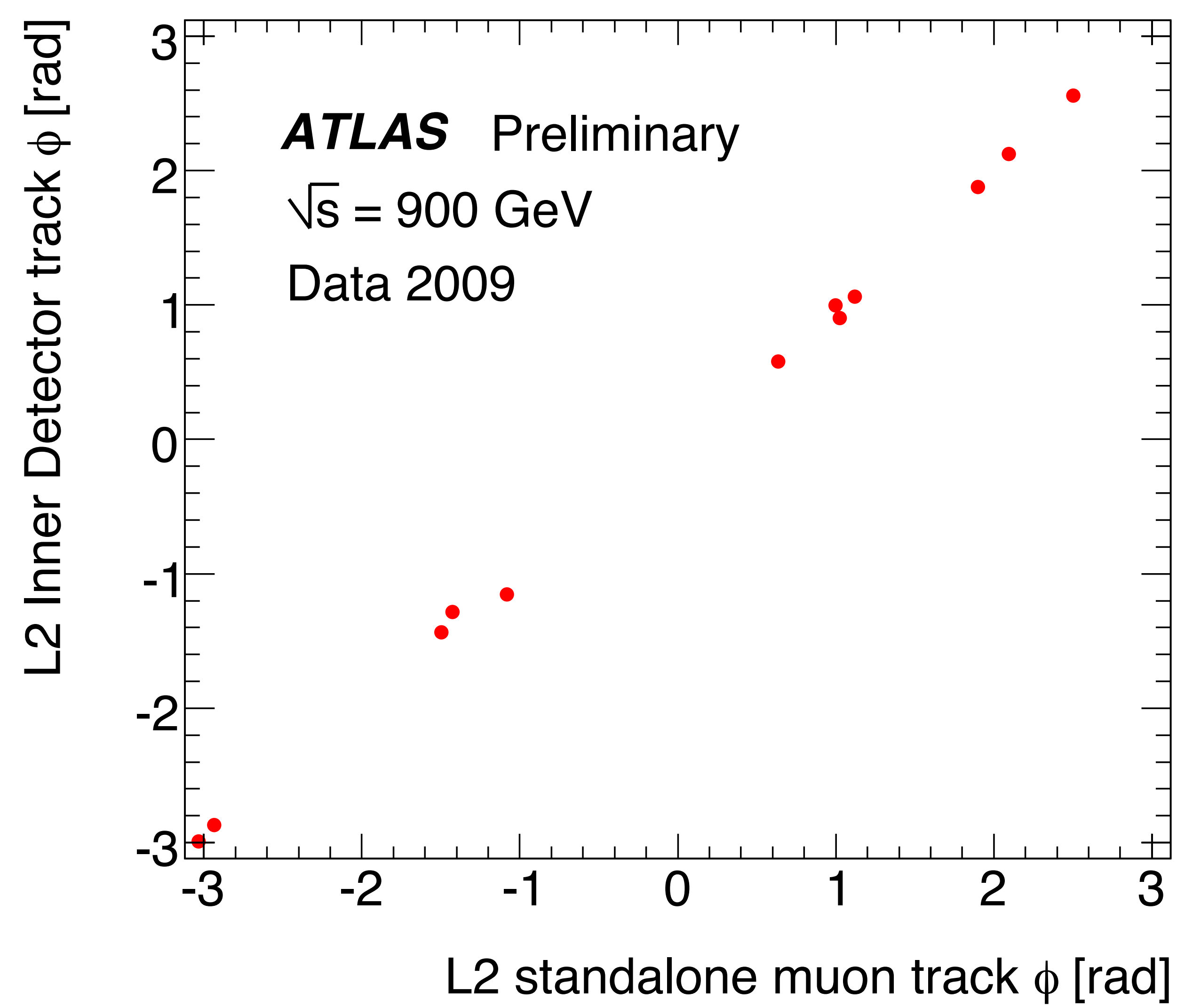




L2 Muon Trigger

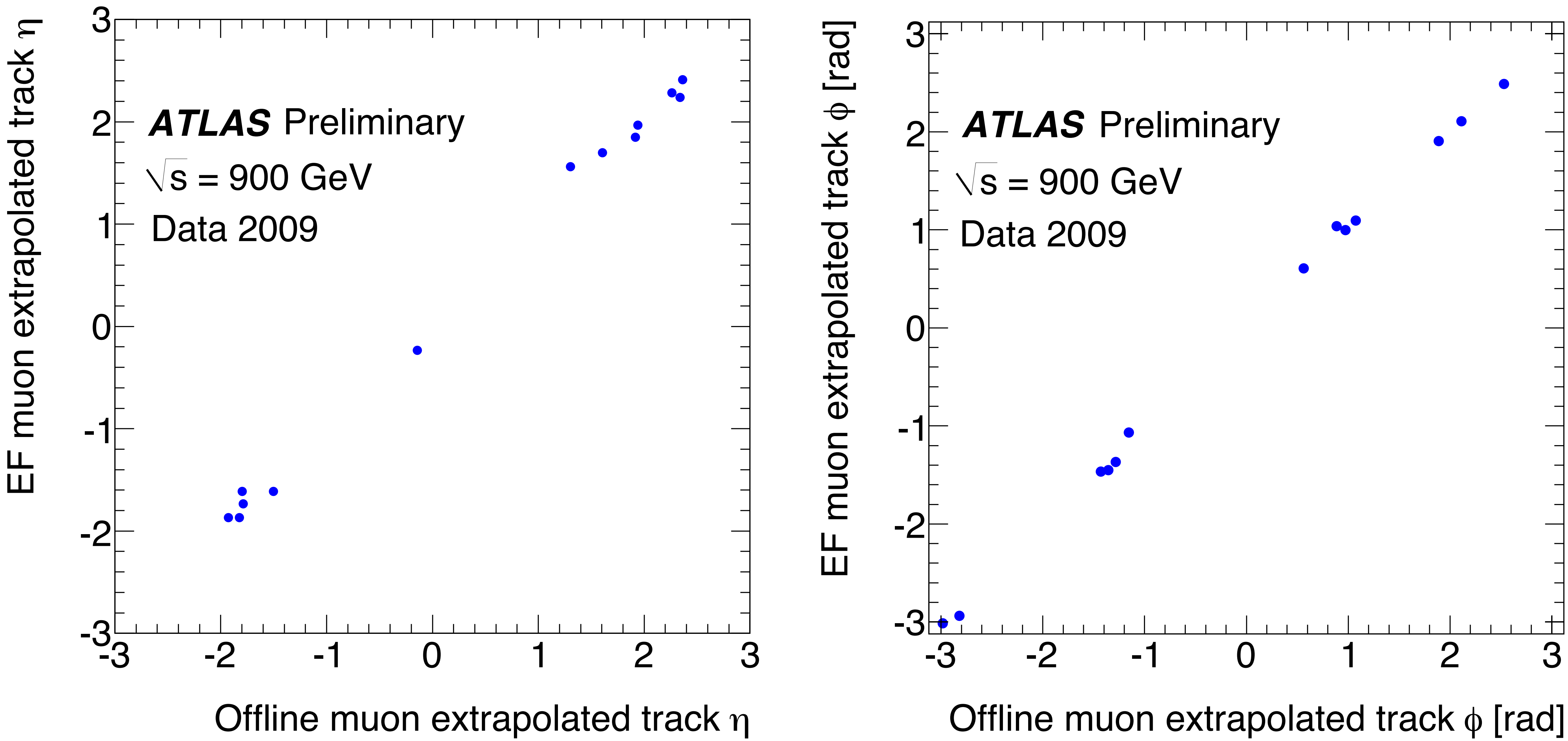
- L2 algorithm makes use of both ID & muon tracks, can compare the track parameters:





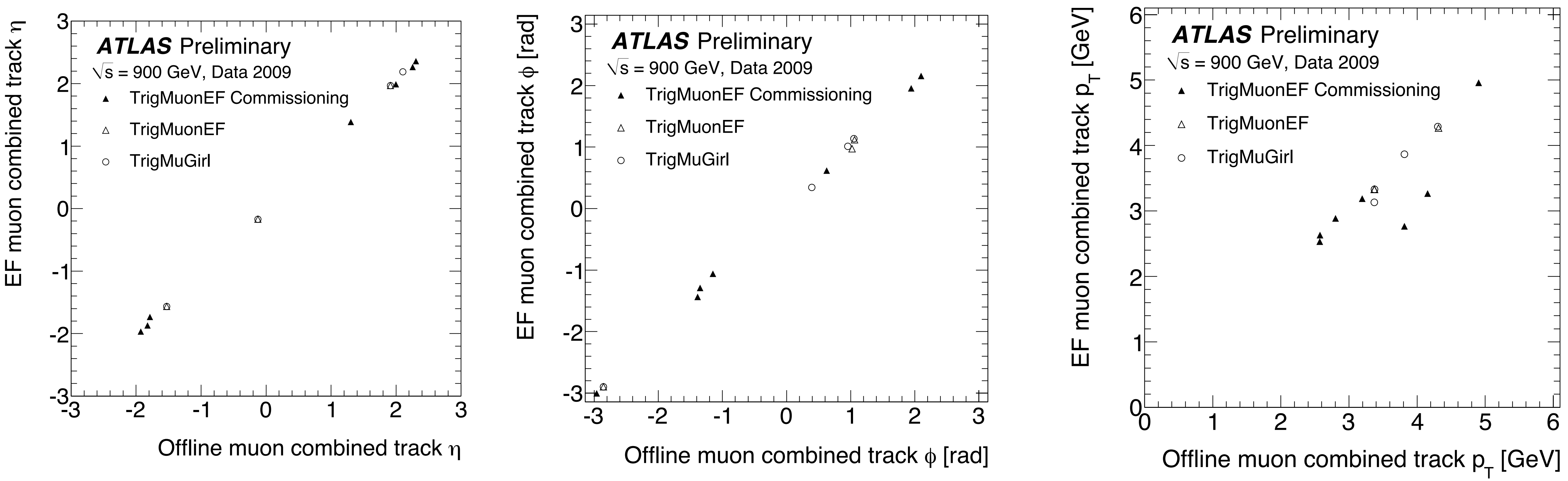
EF Muon Trigger

- Comparison between parameters for standalone muon tracks between EF & offline:



EF Muon Trigger

- Comparison to offline for EF combined & tagged muons (starting from muon tracks or starting from ID tracks):



Summary

- ATLAS successfully collected it's first muons from collision events in the 2009 run.
- In the limited statistics & difficult kinematic regime good agreement is observed between data & MC expectation for reconstructed muons.
- The trigger was exercised in the run & reasonable performance is observed.
- Looking forward to more muons in 2010.

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Backups

EF ID Track Resolution

- Difference in $1/p_T$ for offline & EF ID tracks: