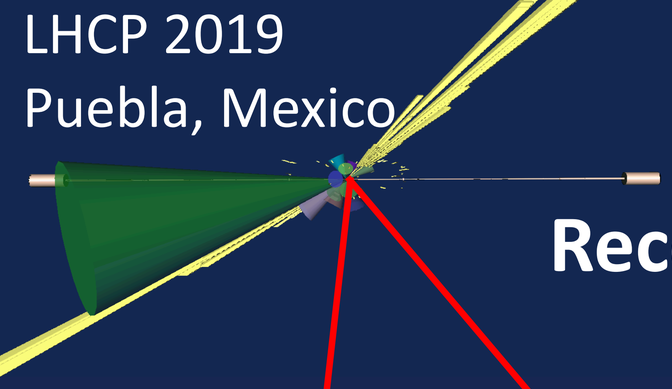
LHCP 2019
Puebla, Mexico

Story of a Muon in ATLAS

Reconstruction and identification of high- p_T muons in $\sqrt{s}$ = 13 TeV p-p collisions with the ATLAS detector



High-p_T muons (~TeV) are:
- typical signature of high- mass resonances ($Z' \to \mu\mu$, $W' \to \mu\nu$)
- very hard experimental challenge (almost-straight tracks)

With three points in a magnetic field we can measure the p_T from the sagitta:

$$p_T \approx \frac{l^2 \cdot B}{8 \cdot s}$$

$\bar{B}_{Barrel} \sim 2.5Tm$; $\bar{l}_{Barrel} \sim 5m$

$\bar{B}_{Endcap} \sim 6Tm$; $\bar{l}_{Endcap} \sim 15m$

@1TeV $\to$ $s \approx 500\ \mu m$

Alignment knowledge is crucial for p_T measurements!

1. Muon Spectrometer

Barrel : $|\eta| < 1.05$; End-cap: $1.05 < |\eta| < 2.7$

Precision chambers

Monitored Drift Tubes (MDT)
- 2 stations : $2.0 < |\eta| < 2.7$
- 3 stations : $|\eta| < 2.0$

spatial resolution $\sigma_x \sim 80\ \mu m$

Cathode Strip Chambers (CSC)
- 1 station : $2.0 < |\eta| < 2.7$

Trigger chambers

Thin Gap Chambers (TGC)
- 3 stations : $1.05 < |\eta| < 2.7$

Resistive Plate Chambers (RPC)
- 3 stations : $|\eta| < 1.05$

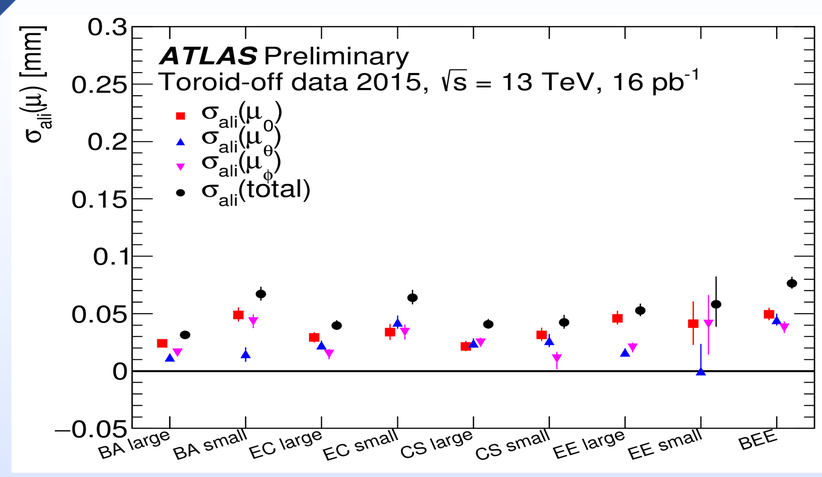
2. Muon Reconstruction

All sub-detectors are used:
inner detector (ID), calorimeters (Calo), spectrometer (MS)

Four muon types: combined (CB); segment-tagged (ST); calorimeter-tagged (CT); extrapolated (ME);

type	$\lvert\eta\rvert$	ID	Calo	MS
CB	< 2.5	✓	✗	✓
ME	< 2.7	✗	✗	✓
ST	< 2.5	✓	✗	✓
CT	< 0.1	✓	✓	✗

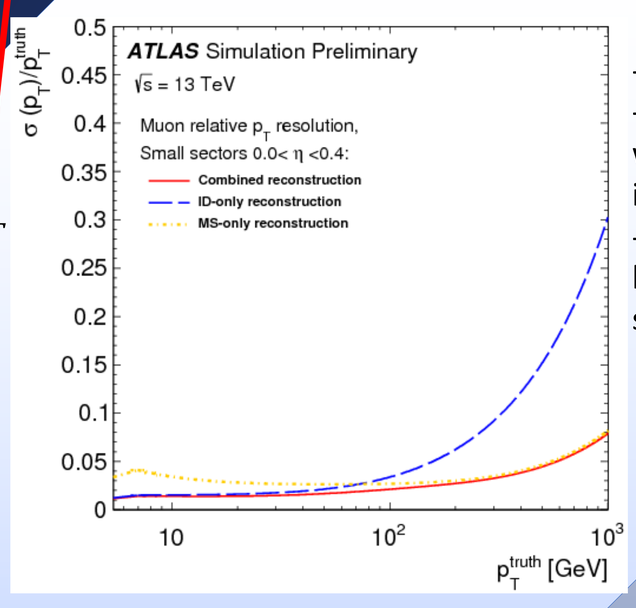
3. Alignment System



Knowledge of precision chambers alignment in all spectrometer with an average total uncertainty of **only** $\sigma_{ali}(total) \sim 50\ \mu m$!

Different techniques are used to measure the alignment of the chambers:
- optical system;
- toroid-off LHC dedicated runs
- toroid-off cosmic rays events;

4. High-p_T Working point



Relative p_T resolution as a function of p_T, in simulation assuming a perfect detector alignment

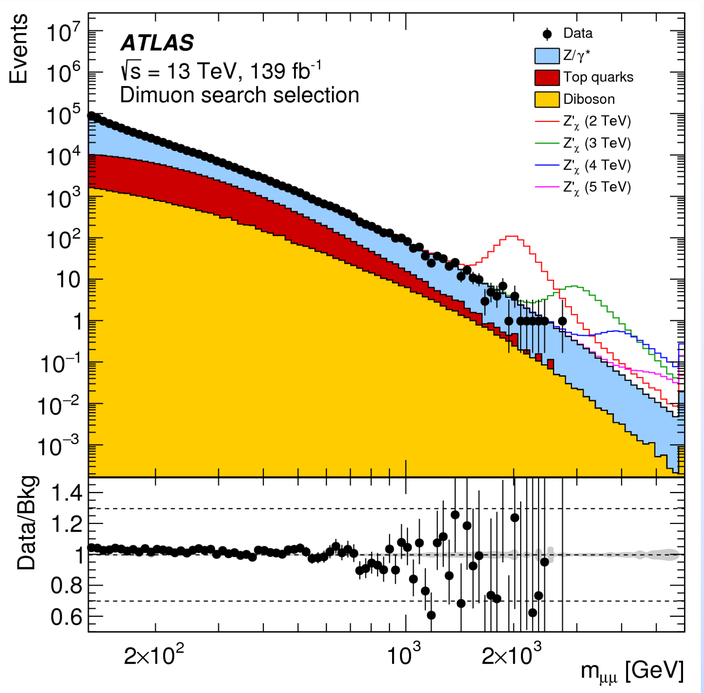
High- p_T muon selection criteria:
- CB only
- muon detection in region with a sub-optimal alignment is excluded
- having at least three hits in three MS stations

The High- p_T selection aims to maximize the momentum resolution for tracks with a transverse momentum above 100 GeV

5. Impact on Z' analysis

This analysis tests models with new resonances, such as an hypothetical Z' Dark Matter mediator

A new physics signal is sought as a narrow dimuon invariant mass peak on top of a smoothly-falling background continuum

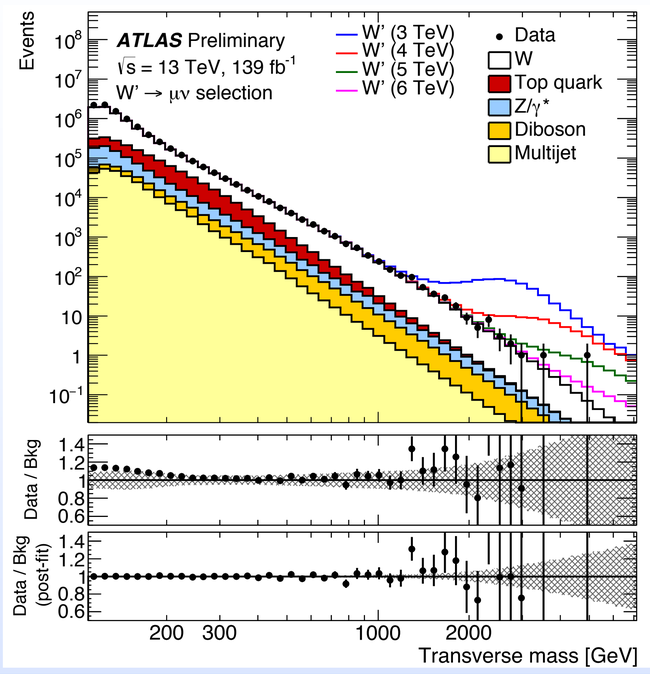


results using full Run 2 statistics!

Muon transverse momentum resolution is crucial for new physics searches

results using full Run 2 statistics!

6. Impact on W' analysis



7. Reference

[1] ATLAS Collaboration, Search for high-mass dilepton resonances using 139 fb^{-1} of pp collision data collected at $\sqrt{s}$ = 13 TeV with the ATLAS detector, (2019), arXiv:1903.06248v1

[2] Search for a heavy charged boson in events with a charged lepton and missing transverse momentum from pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector (2019), arXiv:1905.xxxxx available soon…

[3] ATLAS Collaboration, Muon reconstruction performance of the ATLAS detector in proton proton collision data at $\sqrt{s}$ = 13 TeV, Eur. Phys. J. C76 (2016) 292. MUON-2016-002 MUON-2018-003

Damiano Vannicola, on behalf of the ATLAS Collaboration
Sapienza University of Rome & INFN Section of Rome