Muon reconstruction performance in 2016 data-taking

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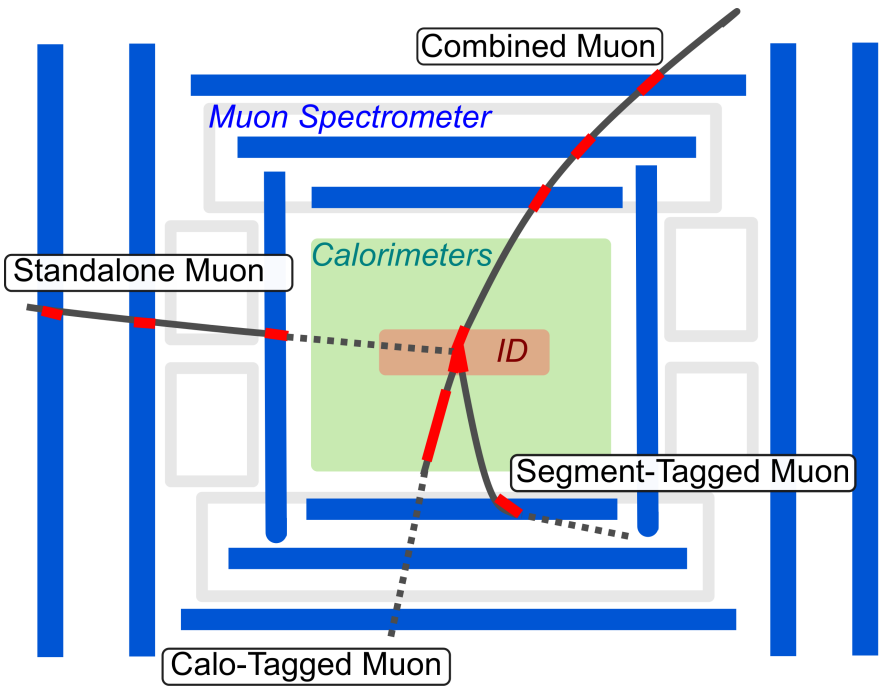
FSP 103
ATLAS

MAX-PLANCK-GESELLSCHAFT

Muon reconstruction at the ATLAS detector



- Combined muons (combine Inner Detector (ID) and Muon Spectrometer (MS) measurements)

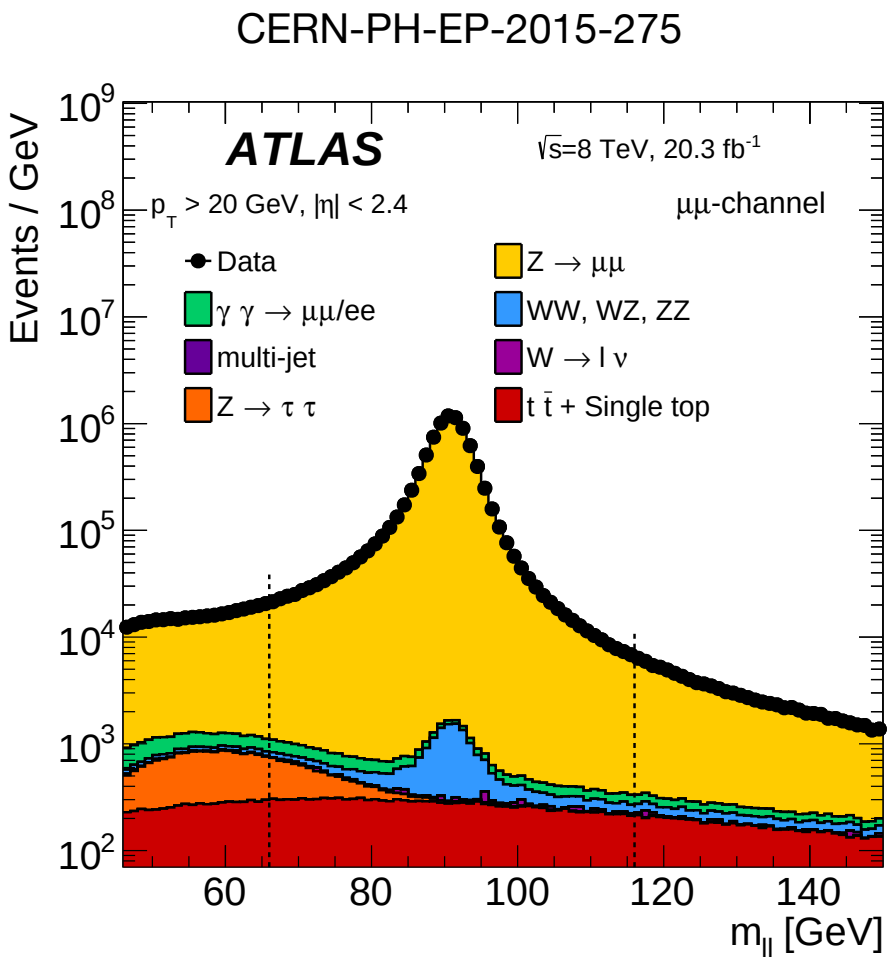
$\rightarrow$ Standard method used in ATLAS

- Standalone muons: MS only (at high η, near to the beam axis)
- Calo-Tagged muons: ID tracks with additional small energy deposits in the calorimeter (at $\eta \approx 0$)
- Segment-Tagged muons: ID tracks combined with single segments of the MS (at low energies)

Motivation: How well does the reconstruction work?

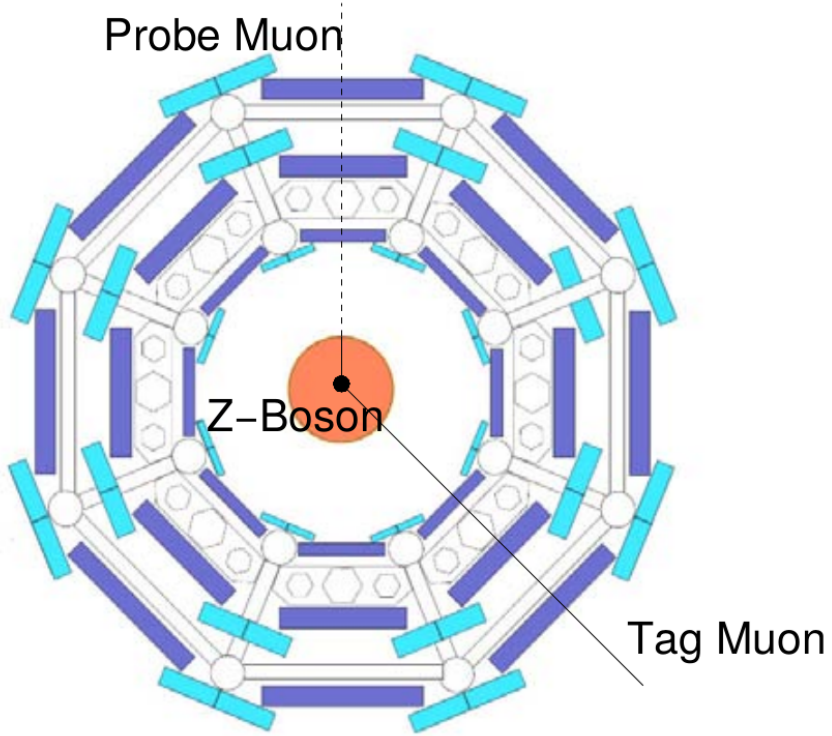
- All precision measurements of processes with muons in the final state require the knowledge of the muon reconstruction efficiency
- Tune agreement between measured data and MC simulation by applying corrections to the MC

$\rightarrow$ Muon efficiency ϵ especially important for multi-lepton final states (e.g. integrated Z-boson cross section measurement, where $N_{\mathrm{events}} \sim \epsilon^2$)



How to measure the muon reconstruction efficiency?

Example - Reconstruction efficiency for muons in the MS:



CERN-OPEN-2008-020

Select Z-decay by requiring
$81 < m_{\ell\ell} < 101$ GeV and $\Delta\phi_{\ell\ell} > 2$

- Use dimuon resonances where one muon is called *Tag*, the other one *Probe*
- MS efficiency is the probability that a *Probe* track measured in the ID is also reconstructed as a muon by the MS

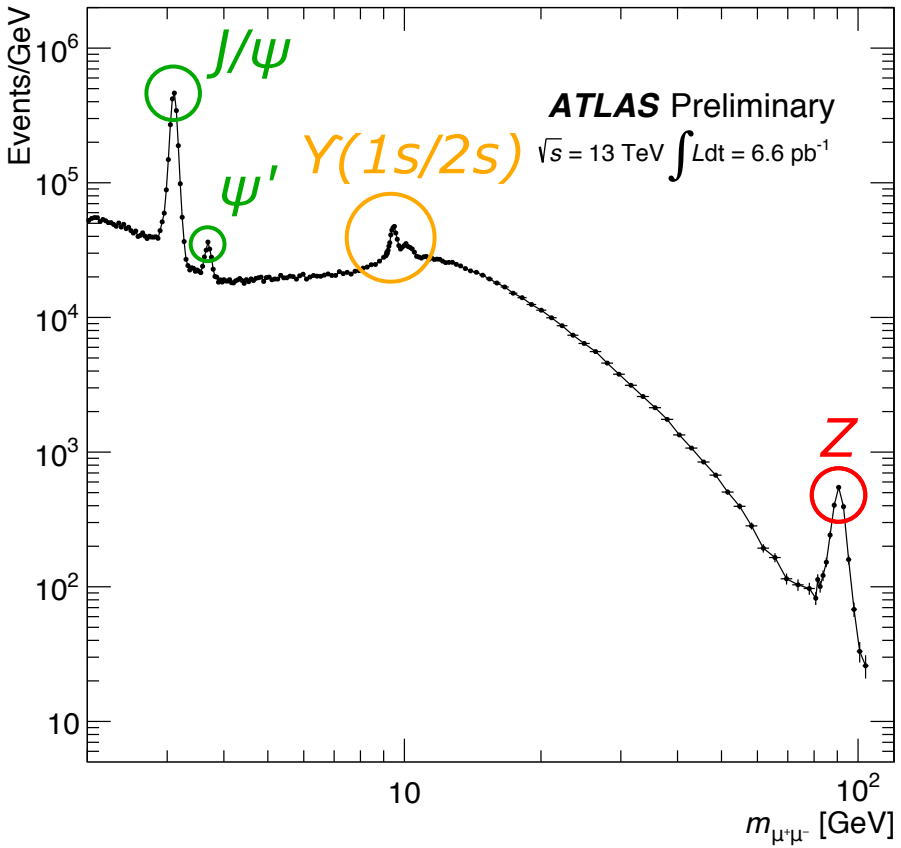
$\rightarrow$ Count number of ID tracks as *Probes*

$\rightarrow$ Try to match reconstructed MS muons to all the ID *Probes*

$\rightarrow$ Efficiency $\epsilon = \frac{N_{\text{matched Probes}}}{N_{\text{Probes}}}$

Invariant $\mu\mu$-mass spectrum

$\mu\mu$ mass resonances are the standard candle for Tag&Probe measurements



I.e. $Z \to \mu\mu$ and $J/\psi \to \mu\mu$ events profit from clear signature and good background suppression

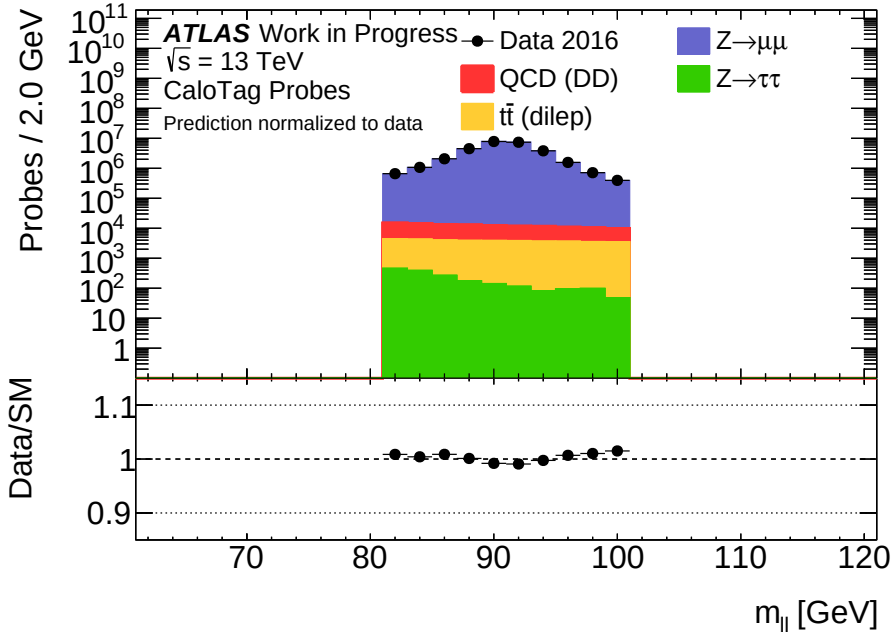
This talk: Efficiency measurement in $Z \to \mu\mu$

$J/\psi \to \mu\mu$ covered by Michael Holzbock [T63.4]

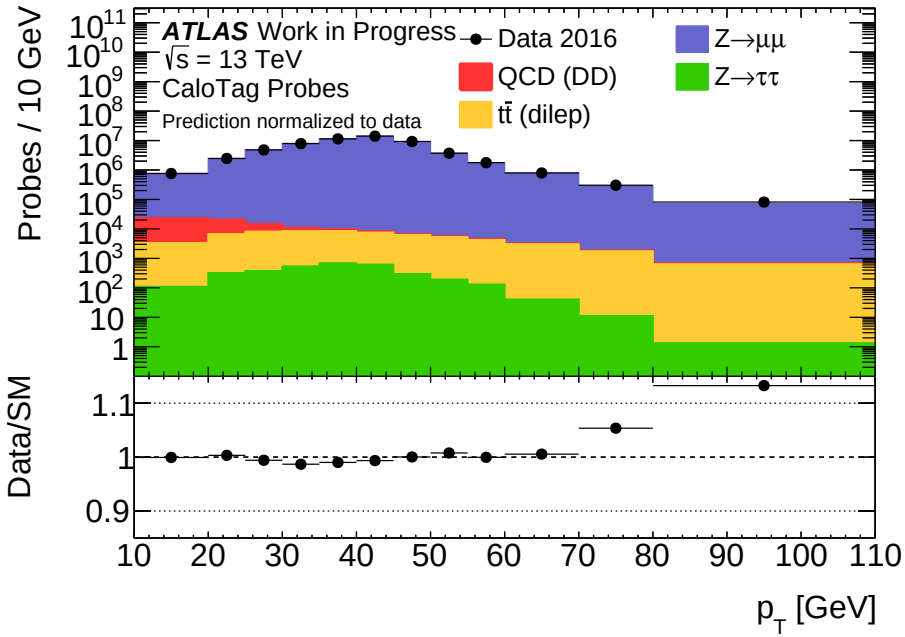
PublicPlots [MUON-2015-001]

Tag&Probe pairs after $Z \rightarrow \mu\mu$ selection

Invariant mass



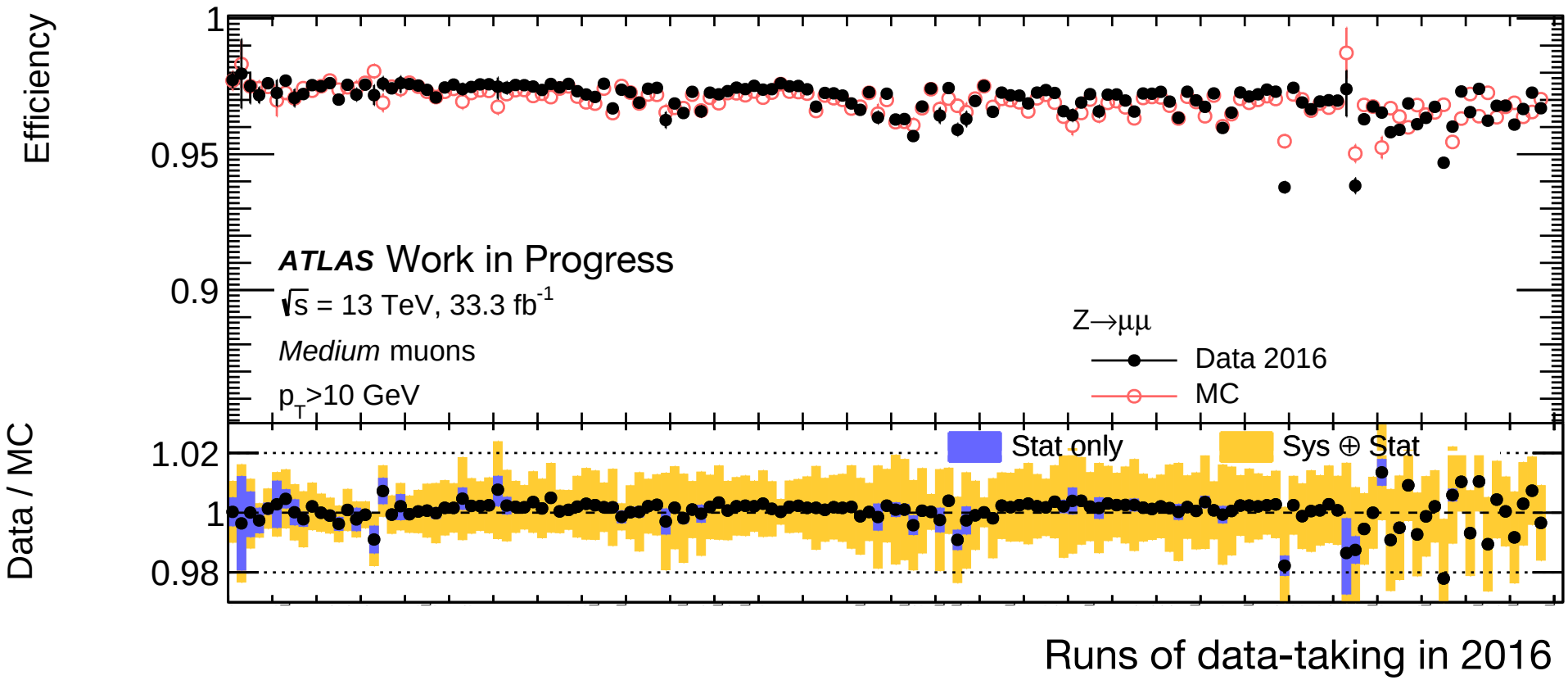
Transverse momentum of *probe* muon



$\sim 3.1 \times 10^7$ Tag&Probe pairs selected in 2016 $\rightarrow$ Large signal to background ratio

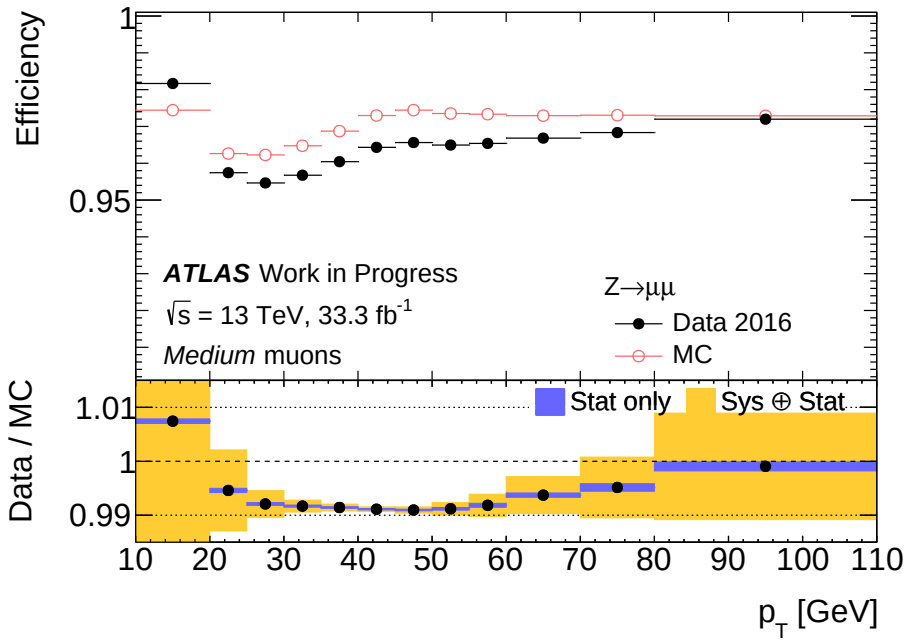
Data-driven (DD) QCD background estimate with same-charge muon events, irreducible backgrounds ($t\bar{t}$, $Z \rightarrow \tau\tau$) are taken from MC simulation

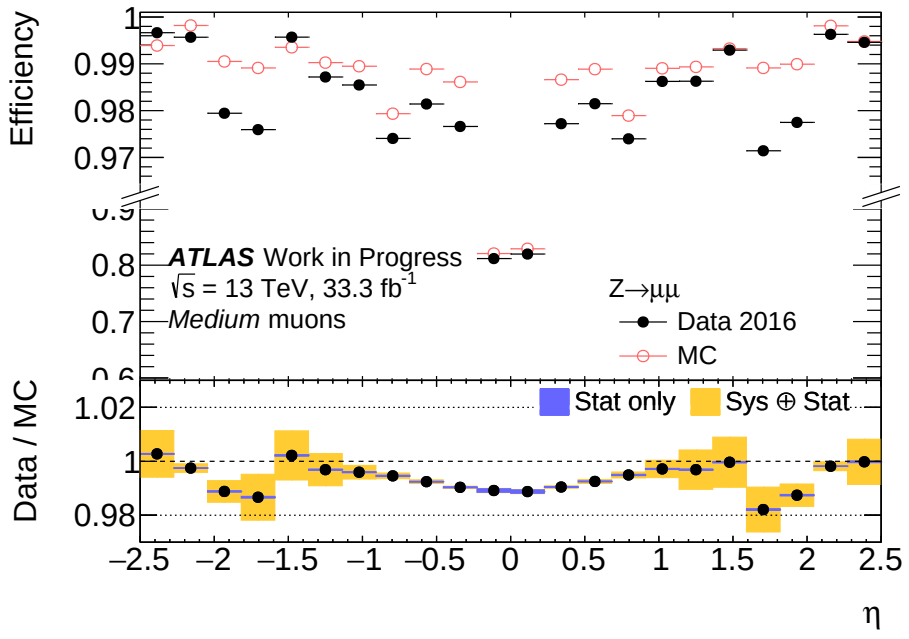
Monitoring μ reconstruction efficiency in 2016



- Operation of the muon system with 95% efficiency during 2016 data taking
- Time-dependent inefficiencies modeled within $\sim 1\%$ uncertainty

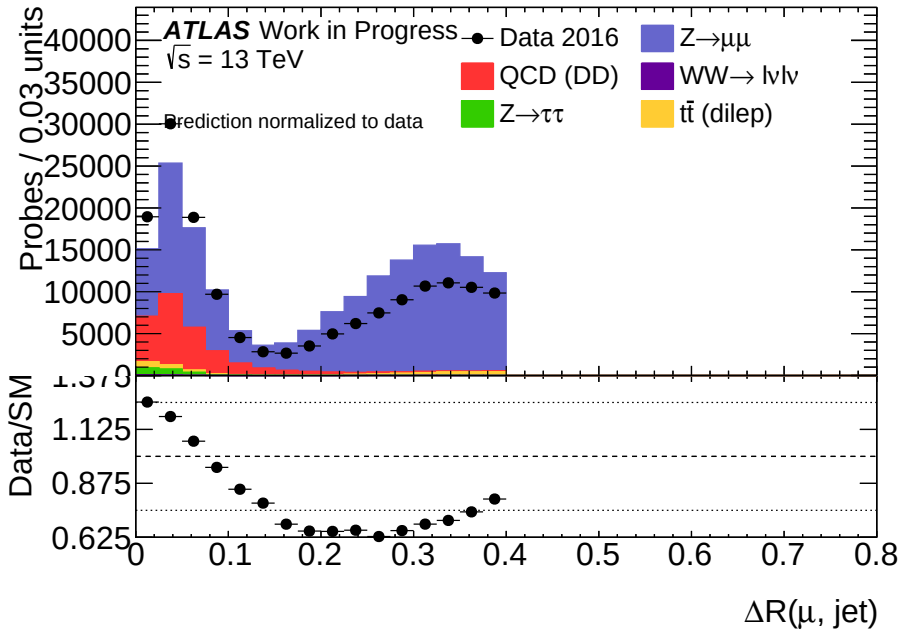
$Z \to \mu^+\mu^-$ reconstruction efficiencies vs. η & p_T

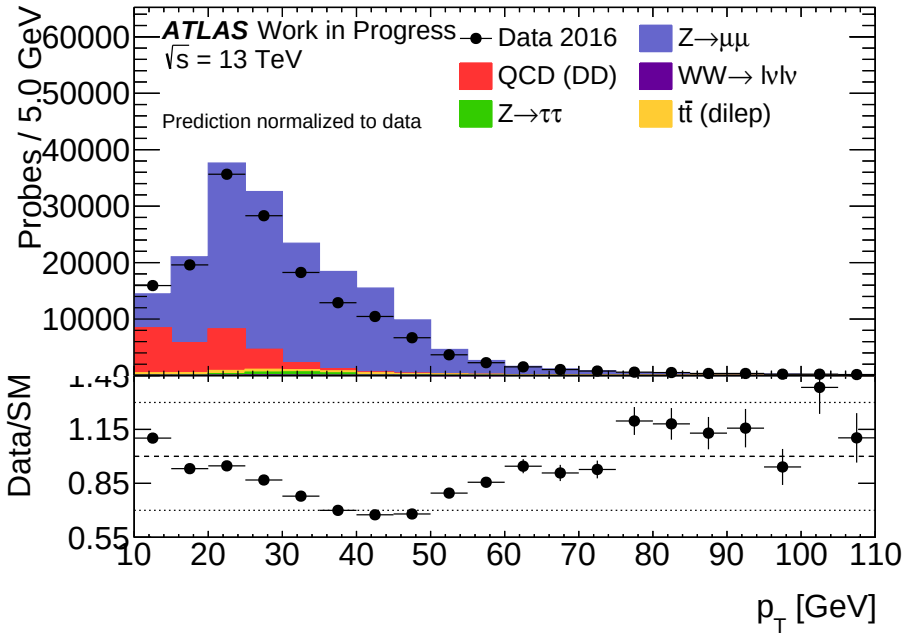




- Systematics at 1% level for high and low p_T muons
- Good modeling of the muons within 2% uncertainty

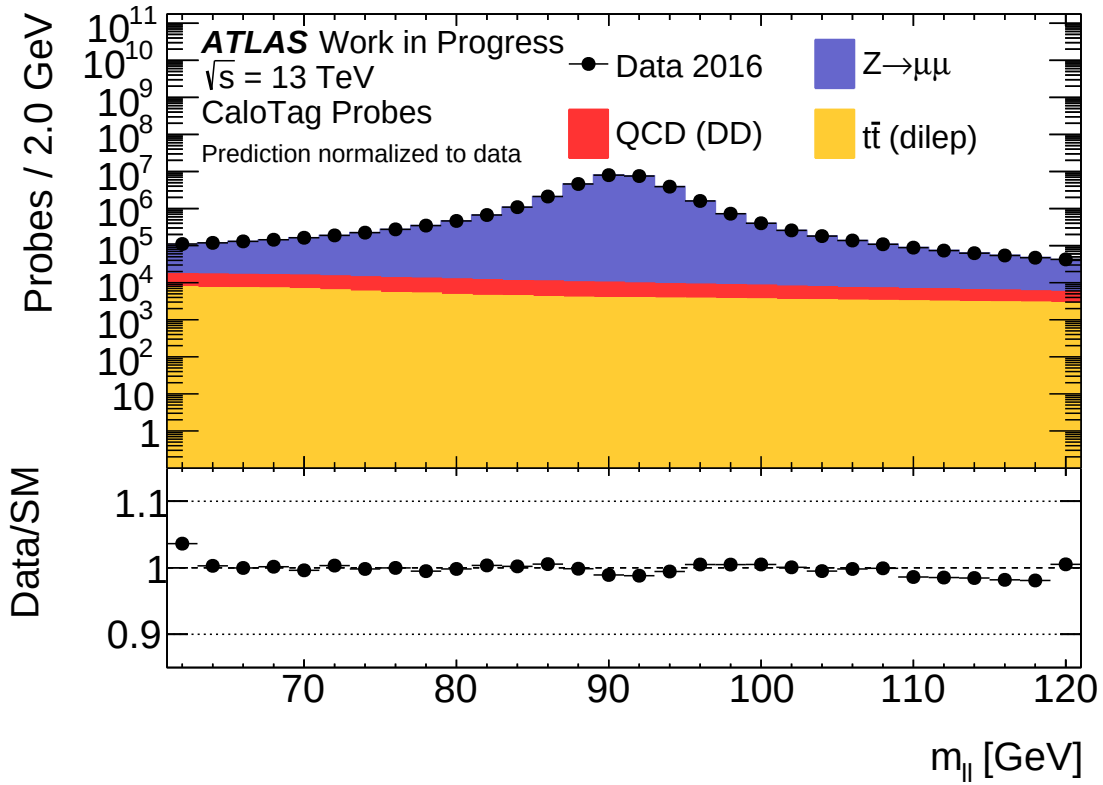
Muons close to jets





- Goal: Examine if μ reconstruction is affected by close-by jet
  - $\Rightarrow$ Select T&P pairs with $\Delta R(\text{probe, jet}) < 0.4$
- Much lower statistic with $\sim 160k$ pairs
- Breakdown of the current QCD estimation method

Template fit in $m_{\mu\mu}$



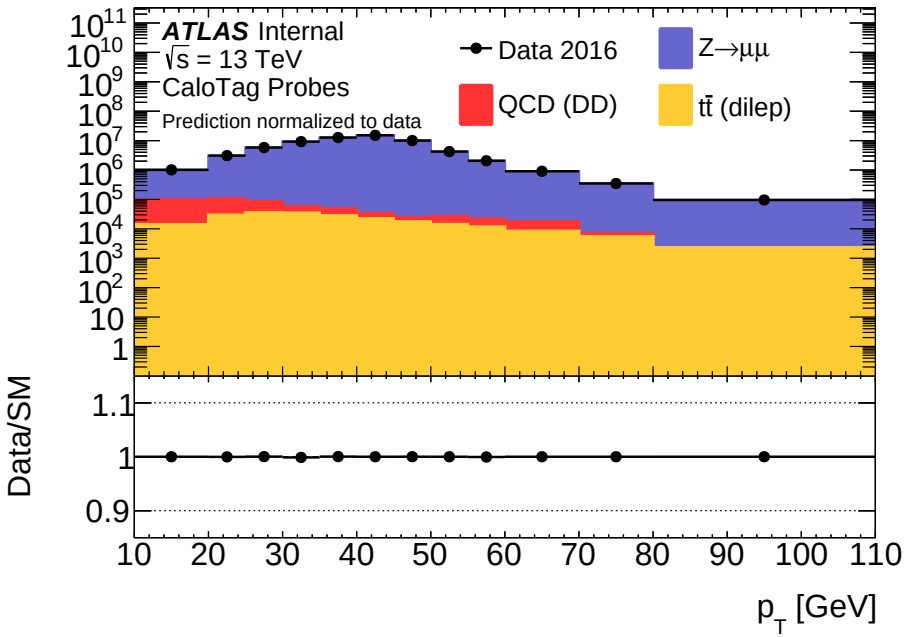
- Trial to fit the $m_{\mu\mu}$ spectrum in each bin of p_T, η, etc.

$\rightarrow$ Extract fractions of QCD, $Z \rightarrow \mu\mu$ & irreducible

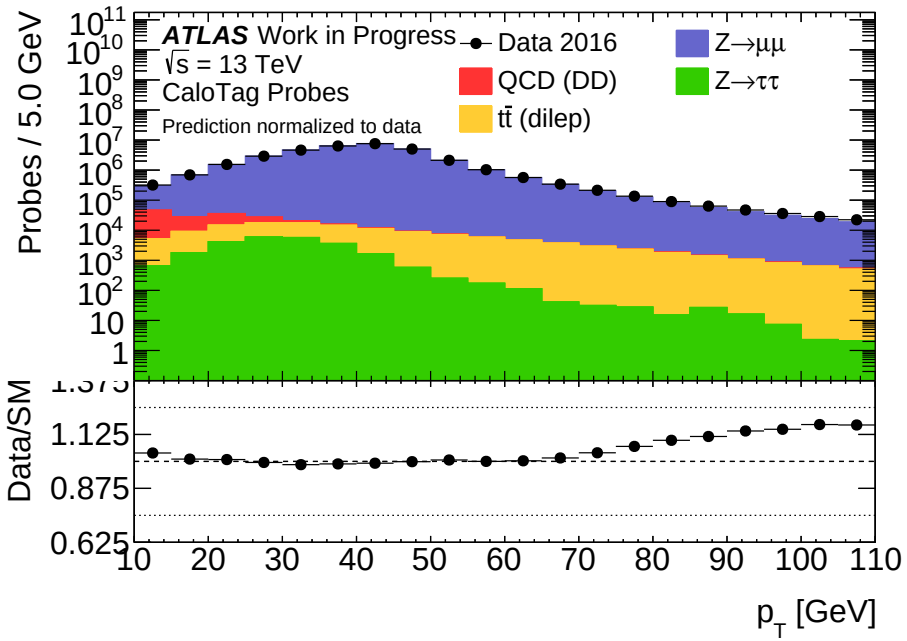
- First test in the $Z \rightarrow \mu\mu$ analysis

Validation in the usual $Z\mu\mu$ Reco analysis

Fitted:

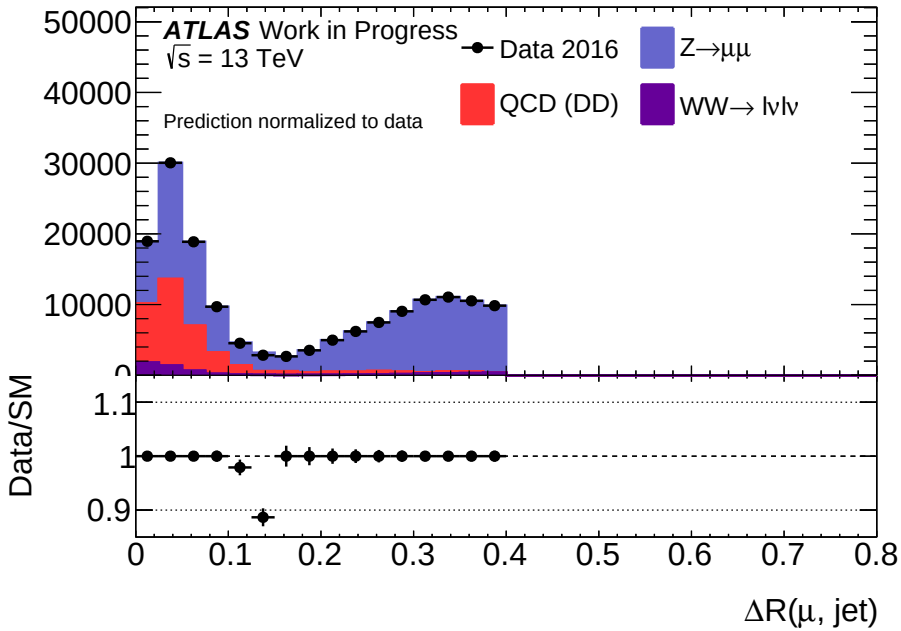


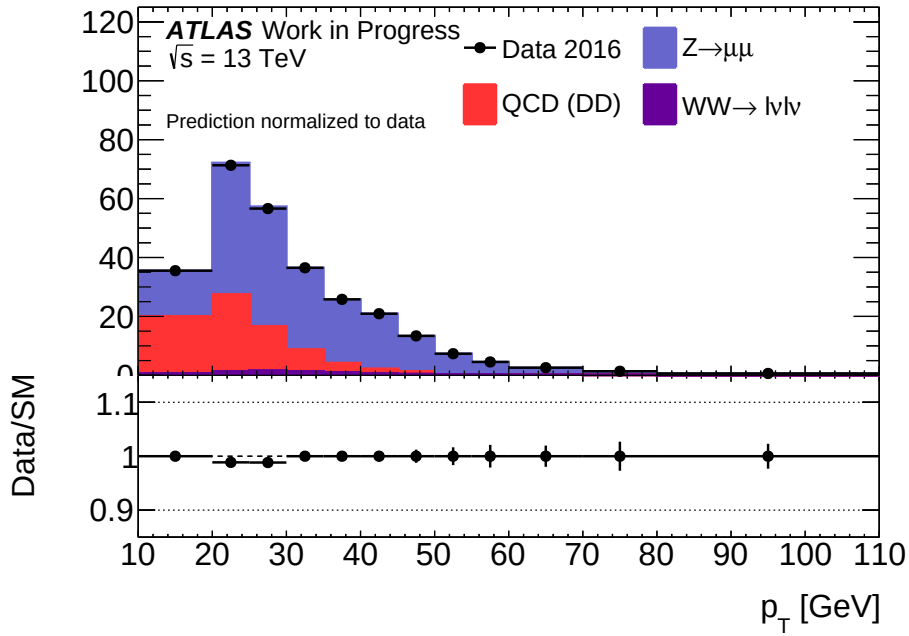
ABCD:



- Smoother QCD shape through the fit in the probe distribution

Background distribution for μ in jets





- Large QCD contribution for $\Delta R(\text{probe, jet}) < 0.1$ and low p_T
- Systematics of the extracted efficiencies still in validation

$\rightarrow$ Will be sown another time

Summary & Plans

Tag&Probe measurement of muon reconstruction efficiencies in ATLAS

- Muon reconstruction efficiencies around 98% in 2016
- Tiny systematic uncertainties ($\sim 1\%$)
- Very good agreement of $Z \rightarrow \mu\mu$ results

- Change of QCD estimation method started

$\rightarrow$ Allows to cover efficiency measurement of μ in jets

- Final results under validation

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Greetings from the uni cave

BACKUP