# Summary of activities

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21/12/2023

Muon Combined Performance (MCP)

- ended my 2 and ½ years as convener last October
- the group had a very significant growth during this time
- I'm still very active in the group, in particular on:
  - WP definitions and efficiency measurements
  - MC samples
  - Derivation framework
  - Publication editing
  - ML-based isolation
- the group is in the critical step of deriving precision recommendations for run-3 and reprocessed run-2, a huge ongoing effort
 - moving to the new release required a major restructuring of the MCP software tools

WPs

Current Run3 definition

| Tight	
Combined	nprecisionLayers > 1 **AND** combined fit chi2/Ndof < 8 **AND** η/pT dependent cuts on qOverP significance and ID/ME/CB momentum imbalance
Medium	
Combined	qOverP significance < 7 **AND** (nprecisionLayers > 1 **OR** (nprecisionLayers == 1 **AND** nprecisionHoleLayers < 2 **AND** abs(η)<0.1))
Loose	
Combined	As for Medium **OR** (pT < 7 GeV **AND** abs(η) < 1.3 **AND** nprecisionLayers > 0 **AND** isAuthor(MuGirl) **AND** isAuthor(MuTagIMO))
CaloTagged	abs(η) < 0.1 **AND** (passes CaloScore WP4)
SegmentTagged	abs(η) < 0.1
HighPt	
Combined	2/3/4 nprecisionLayers requested depending on detector region **AND** veto on specific MS regions **AND** qOverP significance < 7
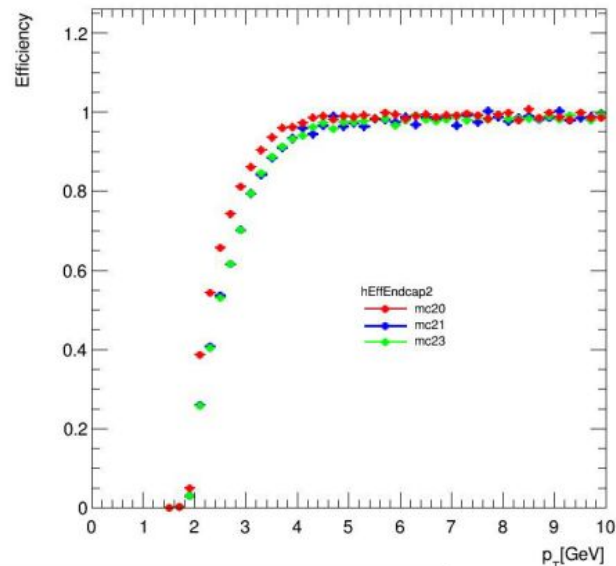
- requalified WPs for release 22 and 23 and for run-3
- lower efficiency at very low pt wrt run-2
- improved bad muon veto for high pt muons
- work ongoing on calo muons
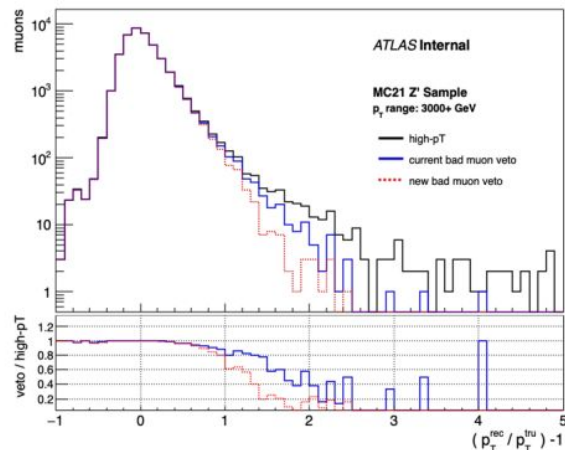
Efficiency

Work ongoing for precision r22/23 recommendations. A lot of technical work on derivations + software
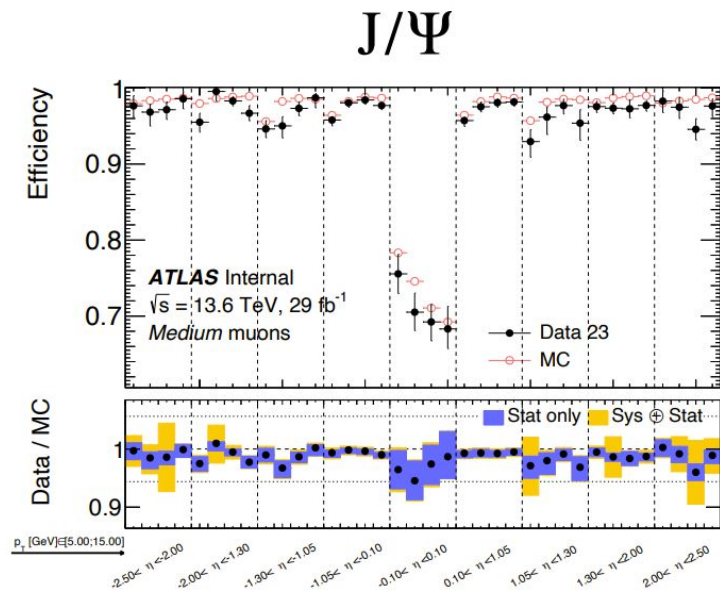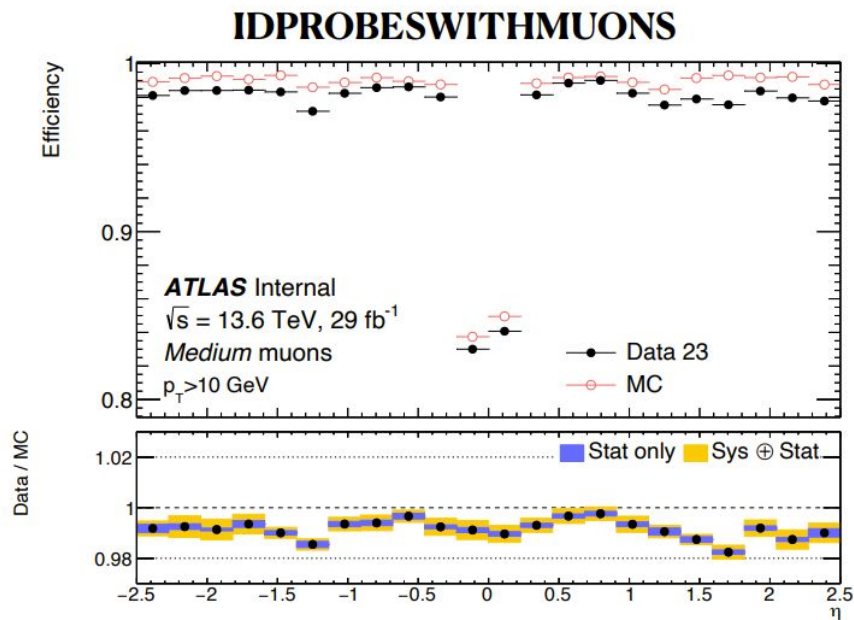
No worrying trend observed

Efficiency (2)

New method in development for efficiency measurement:

$$\varepsilon(X) = \varepsilon(X|ID) \times \varepsilon(ID) \approx \boxed{\varepsilon(X|CT)} \times \varepsilon(ID|MS)$$

bias!

With both the *bias correction* and the *approximation correction* terms, we arrive at a **final bias-free T&P efficiency** formula:

$$\varepsilon_{NEW}(X) = \left[\left(\varepsilon(X|ID\cap MS) \times \varepsilon(MS|CT) + \varepsilon(X\cap \overline{MS}|CT)\right) \times \varepsilon(CT|ID) + a + b\right] \times \varepsilon(ID|MS)$$
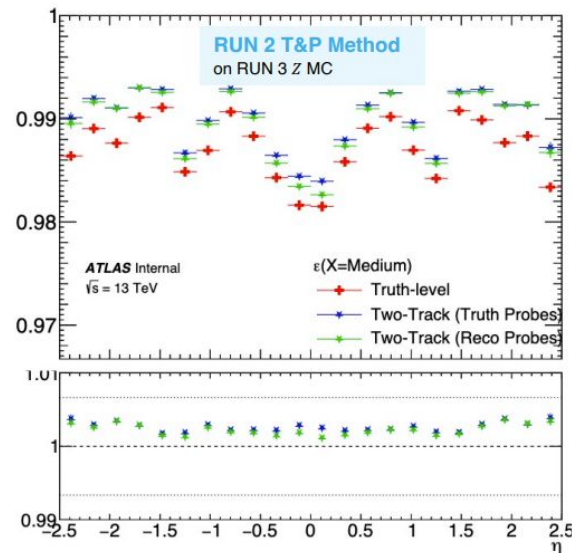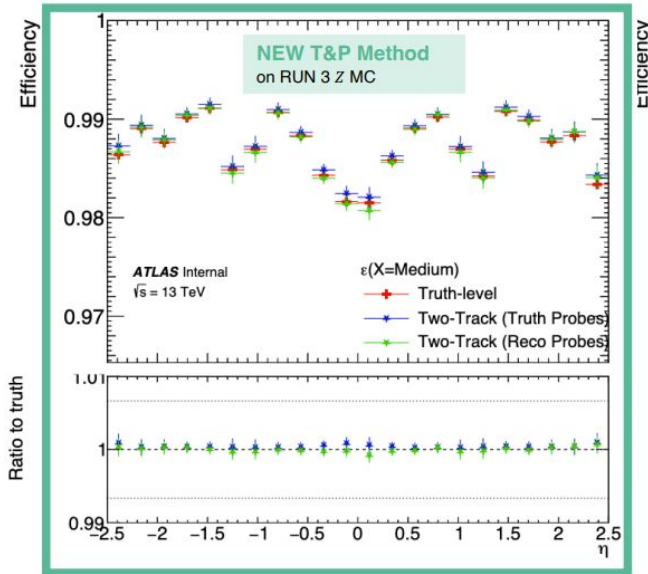
Where the new terms are shown in colour and the *correction terms a* and *b* are defined as:

$$a = \varepsilon(X|ID\cap MS) \times \varepsilon(MS\cap \overline{CT}|ID)$$
$$b = \varepsilon(X\cap \overline{MS}|ID\cap \overline{CT}) \times \varepsilon(\overline{CT}|ID)$$
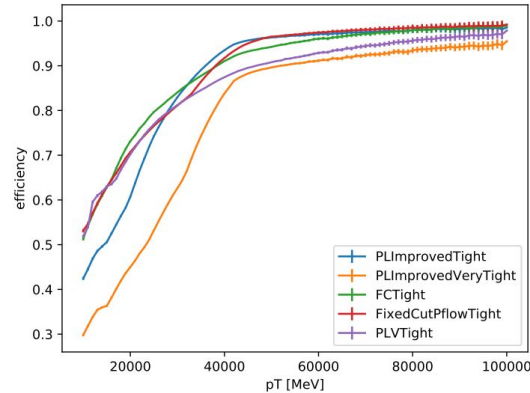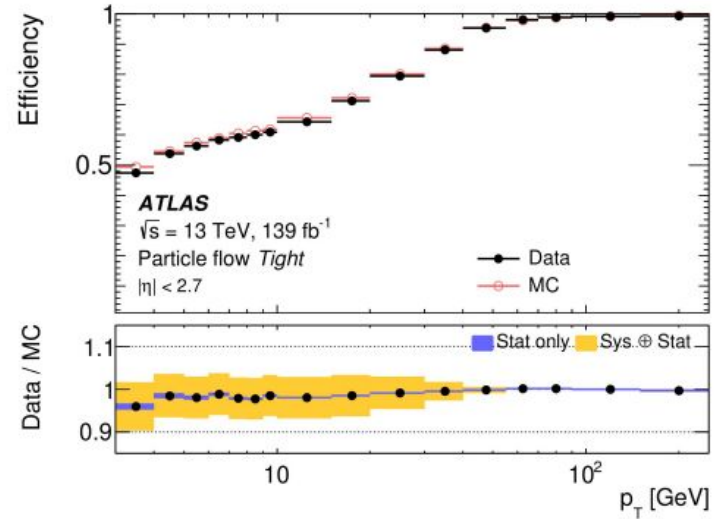
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Technical work + publication plans

- reintroduced two derivation formats in new release
- developed new JPsi samples, next year plan to develop:
  - Drell-Yan samples
  - Upsilon samples
  - Powheg+Herwig Zmumu (currently we have Powheg+Pythia8 and Sherpa)
- preparing publication on run3 (+ reprocessed run2) results as main contact editor
  - I would have shown you some of the plots, but I had them on the RM2 farm…
- I'm planning to significantly improve the quantity of publications on CP results. Next year I want to start working also on a Machine Learning-based publication (see next slides)
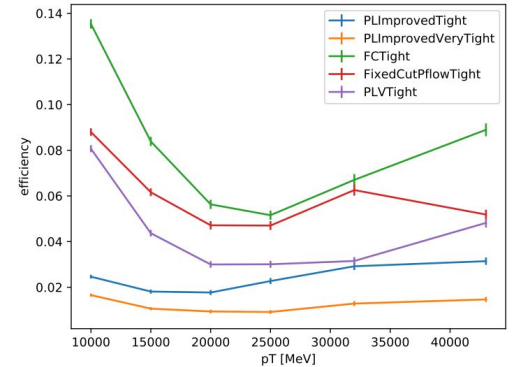
Work on isolation + machine learning

Recently started working on isolation. Two main aspects:

- uncertainty model (dominated by modelling uncertainties)
- PLIV → PLIT (isolation based on Machine Learning)
  - a LOT of technical work ongoing
  - very preliminary results in new release are promising

(a) Prompt muon efficiency vs. p_T

(d) Non-prompt muon efficiency vs. $p_{T'}$

ML-based identification of soft muons

- Soft Muon Tagging can be used to identify HF-jets
- For Top Mass we used a cut-based algorithm
- Working on the development of a ML-based discriminant as part of the PRIN project MIDDLE (next slide)

The MIDDLE project

- INFN (Marco, PI) + RM2 (Umberto) + Bologna (M. Franchini), 220 k€
- Each unit will (hopefully) hire a postdoc for 2 years.

4 WPs:

   a. WP1: development of MIDDLE, an innovative tool based on Deep Learning (DL) techniques for identifying muons produced by HF-hadrons inside jets.
   b. WP2: development of MIDDLETOP, an extension of the tool with advanced features tailored for top physics, allowing for high performance identification of the HF-hadron decay chain inside the event.
   c. WP3: first measurement of the fragmentation properties of the b-quark in ttbar events using observables based on the muons from b-hadron decays, exploiting the MIDDLETOP tool.
   d. WP4: measurement of the top mass exploiting muons produced by b-hadron decays using the MIDDLETOP tool. The goal is to achieve a precision of 500 MeV or better, resulting in the world's most precise single direct measurement.

WP4 builds on the previous round of top mass measurement (next slide)

Top mass published! JHEP06(2023)019

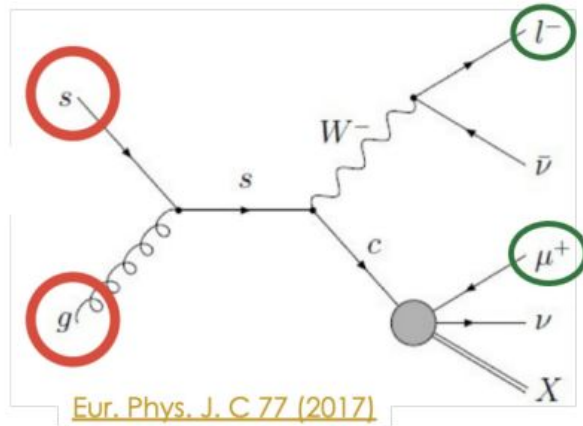$$m_t = 174.41 \pm 0.39 \,(\text{stat.}) \pm 0.66 \,(\text{syst.}) \pm 0.25 \,(\text{recoil})\ \text{GeV}$$

Time for new adventures: ATLAS Italia Top in january 2024!
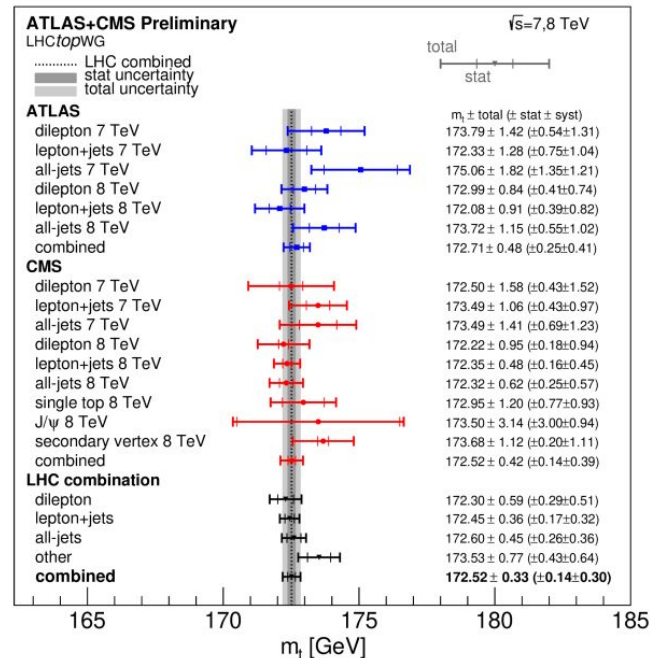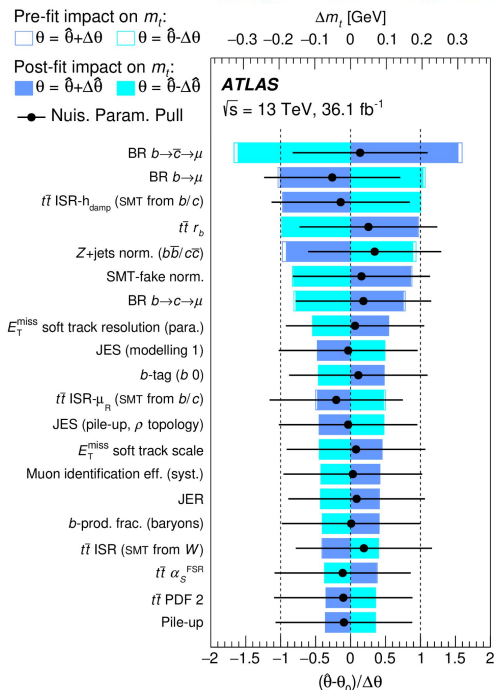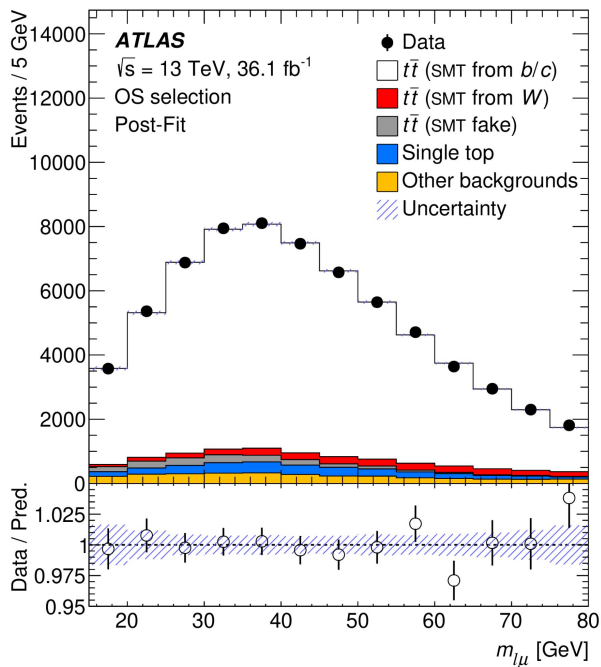
2.2σ from world average
(based on run-1 measurements,
very different uncertainty model)

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Wc measurement

Eur. Phys. J. C 77 (2017)

- Main W+c production process sensitive to the s-quark PDF (confirm or not unsuppressed s-quark content at low-x from W,Z 7TeV data)

- Charge correlation between the lepton from W decay and the muon from c-jet exploited

- Soft Muon Tagging(SMT)-algorithm to tag the c-jet, using a muon inside the c-jet

- analysis (slowly) progressing
- unfolding strategy defined
- the bottleneck is the data-driven background estimation, currently performed with a (very complicated) fit for which we're defining an optimal strategy

Wc measurement (2)
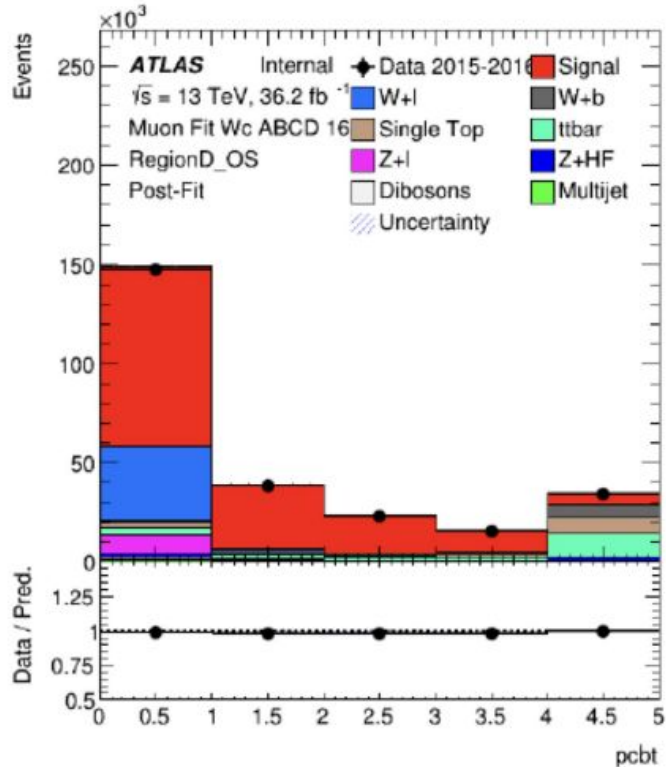
Fit: ABCD method used simultaneously in 4 different regions to estimate QCD multijet + W-light
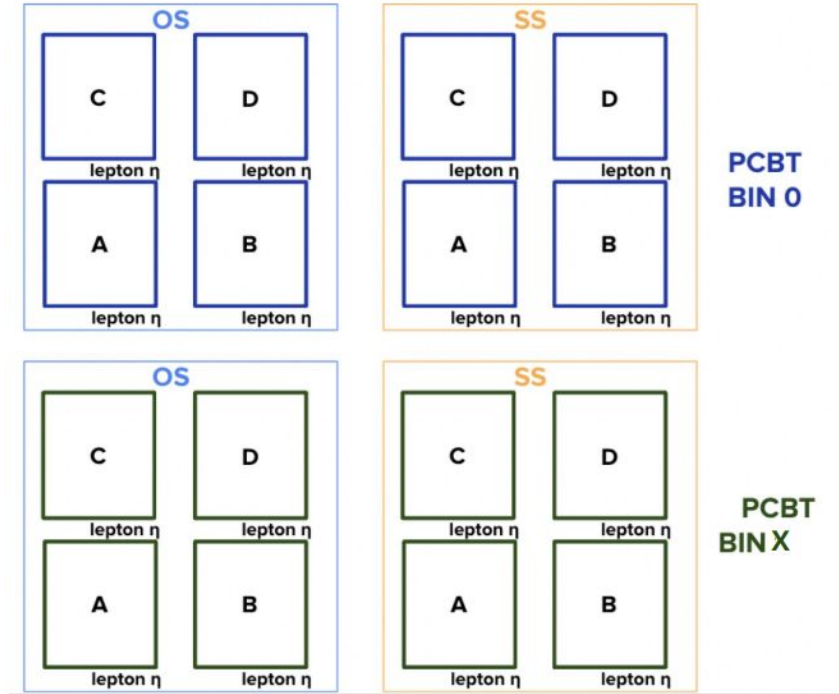
Currency working on stability issues + reduction of c-tagging systematics