Università di Roma Tor Vergata

ATLAS EXPERIMENT

New Phenomena at the TeV Scale With Top Quarks

NPTEV-TQP2020

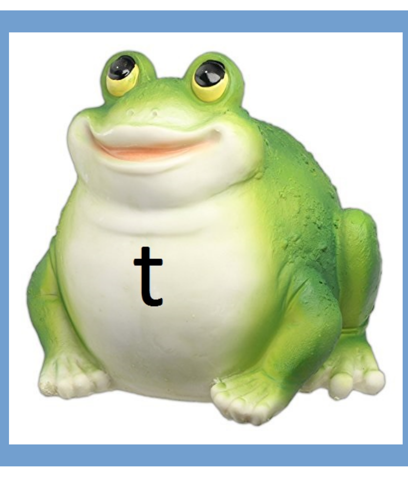
European Research Council

INFN

Maurizio De Santis & NPTEV-TQP2020 group
University of Rome Tor Vergata

XVI Incontri di Fisica delle Alte Energie, Trieste 2017

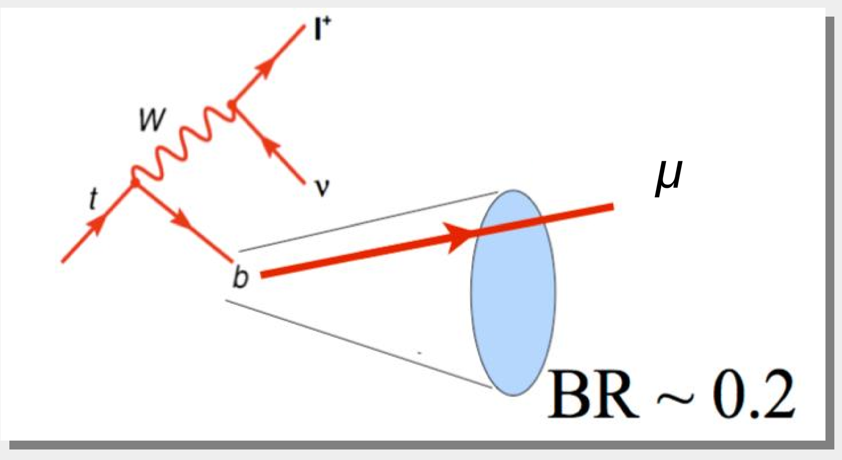
Top quark mass measurement with soft muons from b-hadron decay



Why Top quark?

The top quark is the heaviest particle known in the Standard Model (SM) of particle physics. Due to its large mass, the top quark decays before hadronising, providing the unique possibility to study the phenomenology of a bare quark. A precision measurement of the top quark mass is crucial to test the SM structure and to constrain any possible dynamics beyond the SM.

1. Top mass with Soft Muon Tagging (SMT) Method



- Relate the top quark mass to the invariant mass m(lμ) constructed using the Soft Muon Tagged (SMT) μ and the lepton (l=e/μ) from the W decay.
- b-tagging technique complementary to standard methods and used for $t\bar{t}$ and W + c measurements.

2. Method advantages and challenges

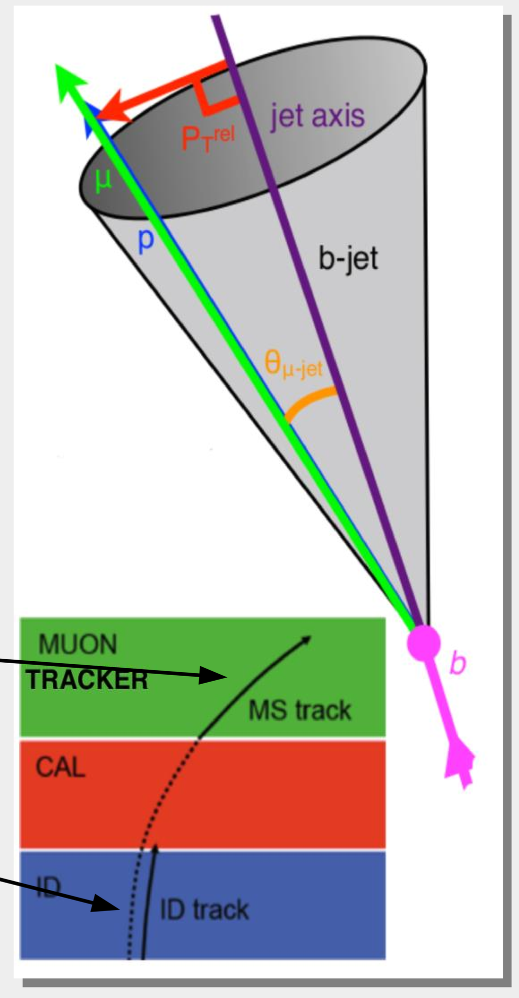
- First top mass measurement using SMT technique in ATLAS
- Largely independent from standard techniques used to measure top mass → good for combination
- Marginally dependent on Jet Energy Scale (JES)
- As it uses a partial invariant mass reconstruction, it is more boost invariant than secondary vertex decay length and lepton-p_T methods
- Leptonic end-points minimise color-reconnection effects wrt hadronic variables
- Does not (necessarily) require precision secondary vertexing
- Development of b-tagging based on SMT will allow for several other interesting measurements
- Main challenge are b-fragmentation function dependence and modelling of top kinematics

3. SMT Definition

- Require a muon within a jet cone: ΔR(jet,μ) < 0.5
- SMT selection: Momentum imbalance MI < 0.1; $|d_0| < 3$mm; $|z_0 \sin\theta| < 3$mm

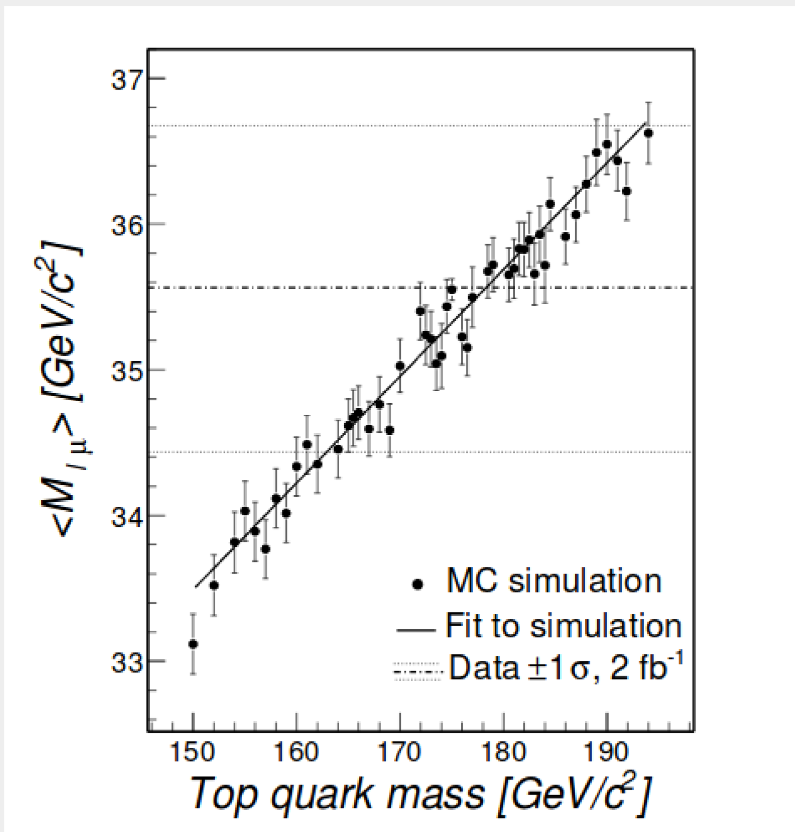
Where d_0 is the trasverse impact parameter with respect to the beamline, z_0 is the longitudinal impact parameter of the track with respect to the primary vertex, θ is the polar angle and p is the momentum of the muon

$$MI = \frac{p_{ID} - p_{MS}}{p_{ID}}$$

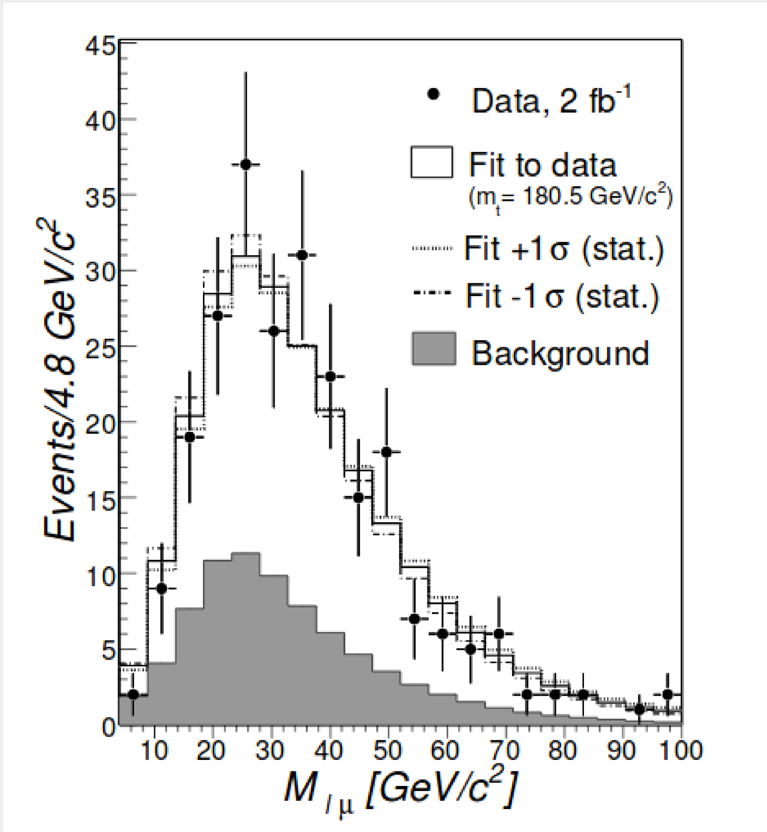


4. Analysis strategy

Proof of principle at CDF (2009)



Calibration curve correlating the mean value of the $M_{l\mu}$ histograms from simulated $t\bar{t}$ and background samples, and the input m_t. The continuous line shows a linear fit to the points



The distribution of invariant mass $M_{l\mu}$ of the lepton from the W decay and the SMT μ, from a sample of 248 candidate events $t\bar{t}$ with 79.5 backgrounds

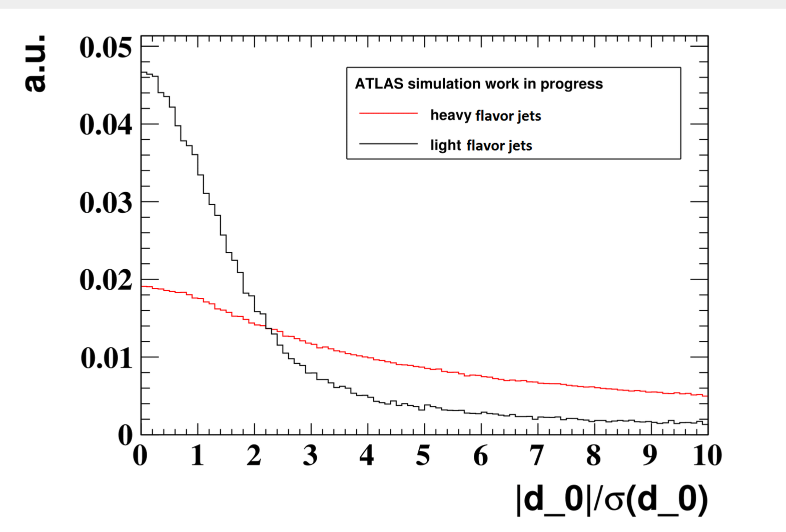
CDF: Phys. Rev. D80 051104 (2009), https://arxiv.org/pdf/0906.5371.pdf

Our implementation...

- Standard single lepton $t\bar{t}$ selection:
  - 1 isolated e/μ (27/28 GeV) + ≥ 4 jets (25 GeV)
  - ≥ 1 b-tagged jet (vertex tagger with ε = 77%)
  - E_T^{miss} > 30 GeV & E_T^{miss}+m_T(W) > 60 GeV
  - ≥ 1 SMT and vertex tagged jet ("double tag")
- Full ATLAS 13 TeV 2015 + 2016 dataset
- m(lμ) built using highest-P_T SMT-μ in the event (no attempt yet to distinguish pairs from same-tops / different tops)
- m(top) extracted from the mean of the m(lμ) histogram through a calibration curve

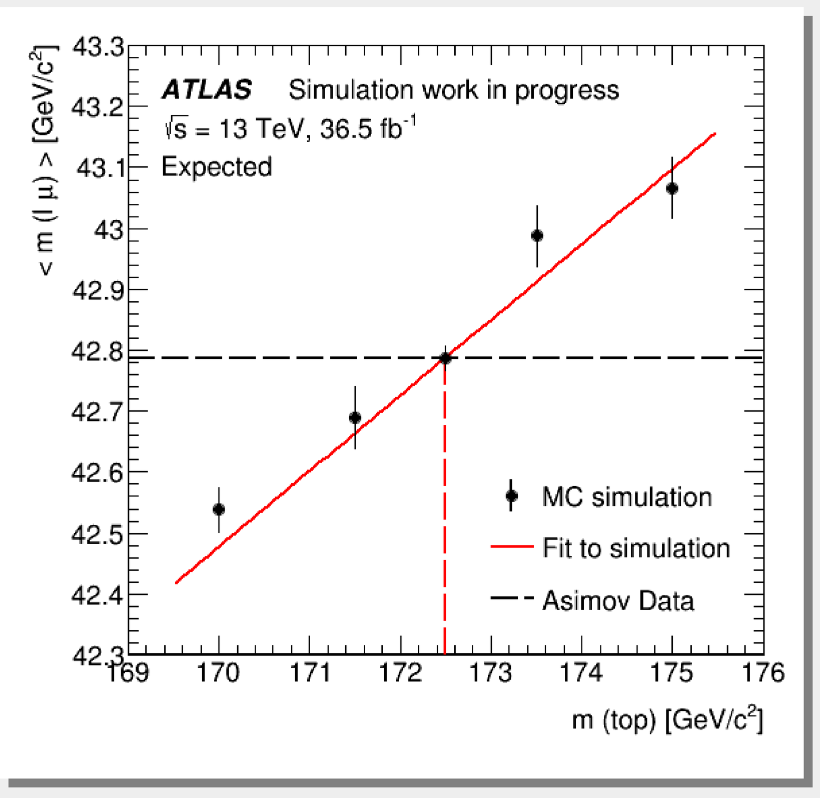
5. ... and results (work in progress)

- Currently study SMT jet selection
  Example: $d_0$ignificance (defined as $d_0/\sigma(d_0)$)

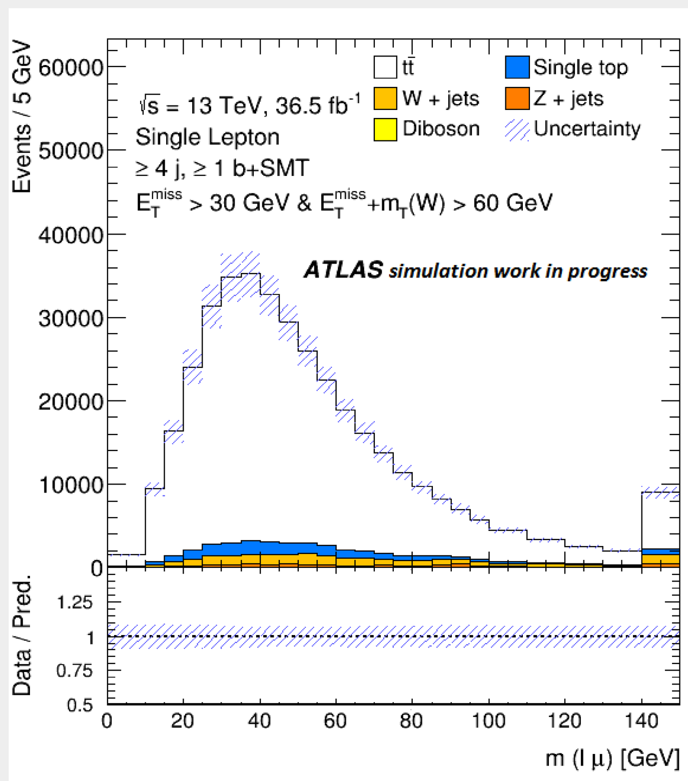


d_0 significance for muons from light jets (black) and heavy-flavor jets (red) in simulated $t\bar{t}$ events.

- Main systematics expected:
  - Top modelling
  - b-quark fragmentation and hadronisation
  - b-tagging



The calibration curve correlating the mean value of the $m_{l\mu}$ from simulated $t\bar{t}$ events, and the input top mass m_t. The continuous red line shows a linear fit to the points (black dots).



The distribution of invariant mass $m_{l\mu}$ of the lepton from the W decay and the SMT μ from simulation with selections described in box 4. The uncertainty is only systematic (dashed blue area). $t\bar{t}$ signal (white) and single top (blue), W+jets (ocher), Z+jets (orange) and diboson (yellow) backgrounds are also shown.

This project has received funding from the *European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme* under grant agreement No 648723