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

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Summary. — The top quark mass has been measured with several methods. In this paper a method based on the Soft Muon Tagging is discussed; which relies on the identification of a muon in the semileptonic decays of hadrons originating from the hadronisation of the b (anti-b) quark coming from the top (anti-top) decay ($t \rightarrow Wb$). By reconstructing the invariant mass of the soft muon and the prompt lepton coming from the leptonic W decay, it is possible to extract the top quark mass. This measurement is being developed for Run-2 data collected with the ATLAS detector at the LHC.

1. – Top mass measurement exploiting the Soft Muon Tagging

The Soft Muon Tagging (SMT) is based on the identification of heavy flavor jets through semileptonic decay. This is a b-tagging technique complementary to other methods and used for $t\bar{t}$ and $W + c$ measurements. The SMT-based top mass method is used to relate the top quark mass to the invariant mass $m(\ell\mu)$ constructed using the SMT μ and the lepton ($\ell = e/\mu$) from the W decay [1]. This is the first top mass measurement using the SMT technique in ATLAS and is largely independent of standard techniques used to measure the top mass. Futhermore, the SMT method does not (necessarily) require precision secondary vertexing.

2. – SMT definition and implementation

The SMT is a set of requirements to identify muons originated from heavy-flavor decay in jets. Jets, reconstructed with an anti-k_T ($R = 0.4$) algorithm, are pre-selected if they are spatially matched with a muon within $\Delta R(\text{jet}, \mu) < 0.5$. The muon is reconstructed from a combination of an Inner Detector (ID) and a Muon Station (MS) track, and $|d_0| < 3\,\text{mm}$; $|z_0 \sin\theta| < 3\,\text{mm}$, where d_0 is the trasverse impact parameter of the muon with respect to the beamline, z_0 is the longitudinal impact parameter of the muon with respect to the primary vertex, θ is the polar angle. A cut in momentum imbalance

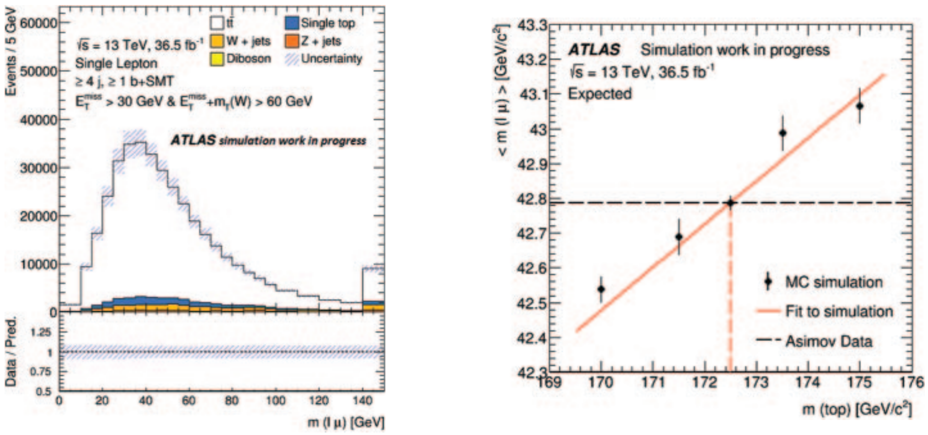

Fig. 1. – Left: the distribution of the invariant mass $m(\ell\mu)$ of the lepton from the W decay and the SMT μ from simulation with selections as described in sect. 2.1. The uncertainty band (dashed blue area) includes both the statistical and the systematic uncertainties on the prediction. The $t\bar{t}$ signal (white) and single top (blue), $W+$jets (ocher), $Z+$jets (orange) and diboson (yellow) backgrounds are also shown. Right: the calibration curve correlating the mean value of the distibution $m(\ell\mu)$ 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).

$MI = (p_{ID} - p_{MS})/p_{MS} < 0.1$ (where p_{ID} is the momentum in the ID of the muon and p_{MS} in the MS) is applied to reduce the mistag rate due π/K decays in flight. The SMT efficiency ϵ and rejection for the muons are, respectively, about 90% and of the order of 10^{-3} [2].

2˙1. *Event selection*. – The following cuts are applied to select the signal events: one isolated e/μ (27/28 GeV) and at least 4 jets (25 GeV); at least 1 b-tagged jet (vertex tagger with $\epsilon = 77\%$); $E_T^{miss} > 30$ GeV and $E_T^{miss} + m_T(W) > 60$ GeV; at least one SMT and vertex tagged jet (double tag).

Moreover, we use the ATLAS 13 TeV 2015 + 2016 dataset. The invariant mass $m(\ell\mu)$ is built using the highest p_T SMT-μ in the event and the top mass is extracted from the mean of the $m(\ell\mu)$ histogram through a calibration curve (fig. 1). The main systematic uncertainties expected are the top modelling, the b-quark fragmentation and hadronisation and the b-tagging.

3. – Conclusion

The SMT method and its definition and selection have been presented using a simulation of the ATLAS 13 TeV data. This method is currently under study and is expected to improve top quark mass measurements.

REFERENCES

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