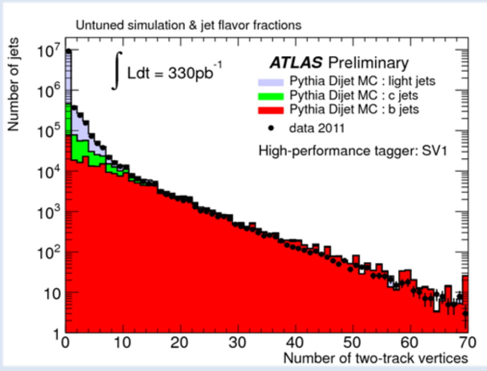
LHCC Poster Session - CERN, 21 March 2012

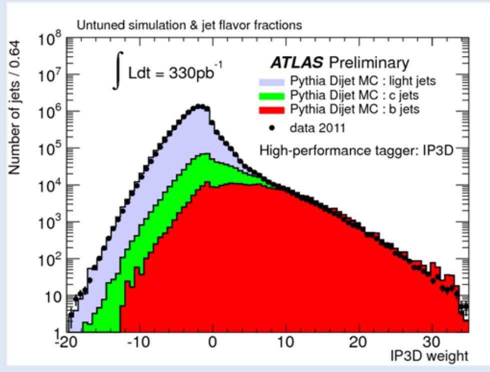
b-Tagging Performance in ATLAS

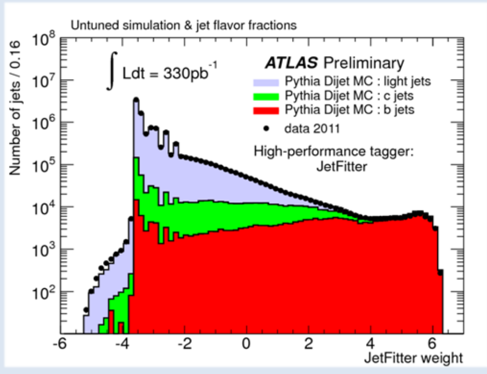
Tagging Algorithms: The Basic, The Enhanced, and The Combined

A wide range of *b*-tagging algorithms:
- SV0: *b*-decay vertex
- IP3D: *b*-decay track impact parameters
- JetFitter : reconstructed *b*- and *c*-decay vertices

Combinations:
- IP3D+SV1
- JetFitter+IP3D (neural net)
- MV1: JetFitter+SV1+IP3D (neural net)

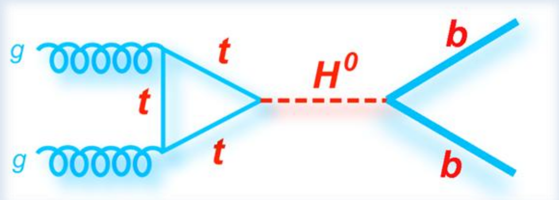


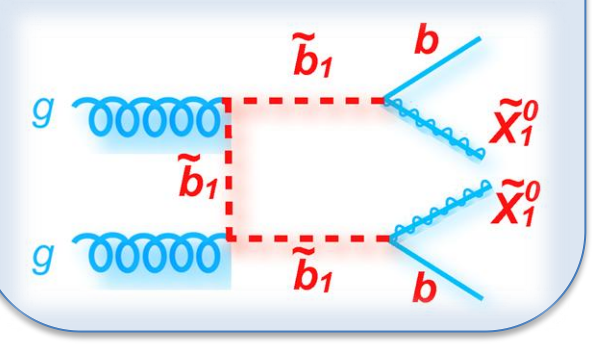




Why is *b*-Tagging Performance Important?

The *b*-quark is a common final-state component in many high-mass physics decays:
- Low-mass Higgs: preferentially decays to $b\bar{b}$
- SUSY: $\tilde{t}, \tilde{b}$ are the lightest squarks in many models; they produce final-state *b*-quarks
- Top: decays almost universally by $t \to Wb$
- and many more!



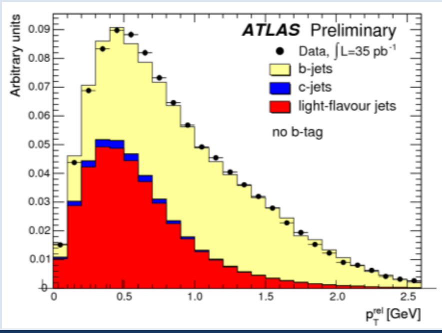


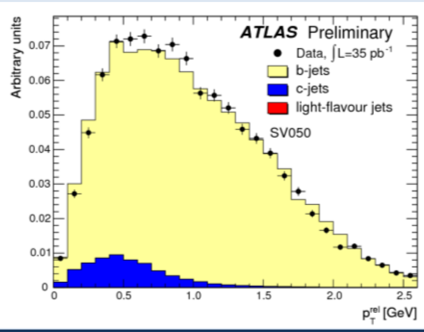
How Do We Measure b-Tag Efficiency? p_T^{rel} and *system8*

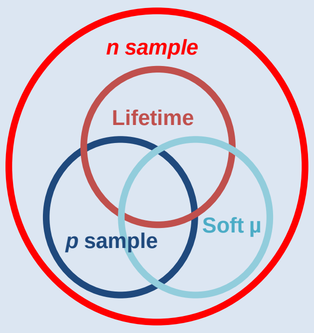
$p_T^{rel} = p_\mu \sin\theta_{\mu,jet}$ has a harder spectrum for *b*-jets than for *c*- or light-flavor jets. This calibration technique is based on fitting templates of each jet flavor from a high *b* content sample to the data distribution before and after tagging.

system8 uses 3 uncorrelated selection criteria, one of which is the tagger under study, to define 8 disjoint subsamples; a system of equations relates the samples to efficiencies and flavor composition.

b-Tagging Efficiency, $\varepsilon_b^{\mu\text{-jet}}$



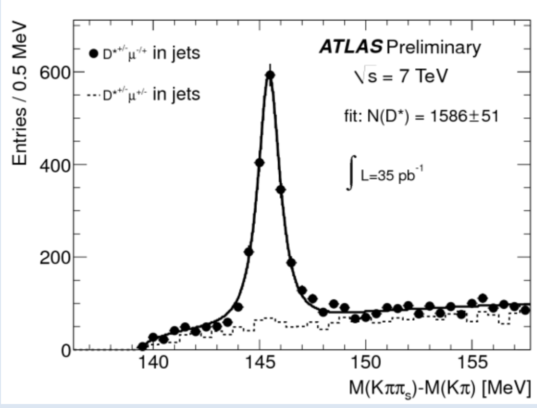




How Do We Measure *b*-Tag Efficiency in Reconstructed *B* Hadrons? $D^*\mu$

The *b*-tagging efficiency in can be measured in a very pure sample of *b* jets by reconstructing specific decays; here, we use $b \to X\mu D^{*+} \to X\mu D^0(\to K^- \pi^+)\, \pi^+$. The total distribution $\Delta M = m_{D^*} - m_{D0}$ is fit, and the *b*-tagging efficiency is extracted from this sample by comparing the signal yield before and after tagging and correcting for tagging rates for background contributions.

b-tag Efficiency, $\varepsilon_b^{D^*\mu}$

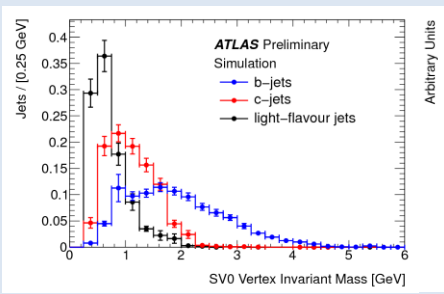


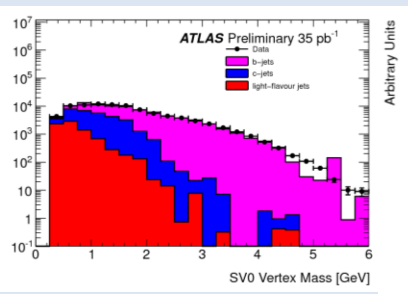
How Do We Measure the Light-Jet Tag Rate? *sv0mass, negative tag*

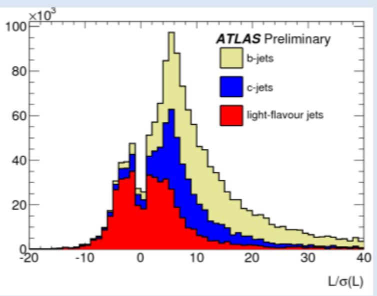
sv0mass builds templates of the secondary vertex mass for *b*-, *c*-, and light-flavor jets, then fits them to data in tagged and pretagged samples. The *mistag rate* is then defined as the ratio of tagged to pretagged light-flavor jets.

A *negative tag* is defined as a jet tagged by an algorithm where all lifetime selections are inverted. The negative tagging rate, corrected for heavy-flavor resolution effects and other long-lifetime particles, is a measure of the mistag rate.

Mistag Rate, ε_l



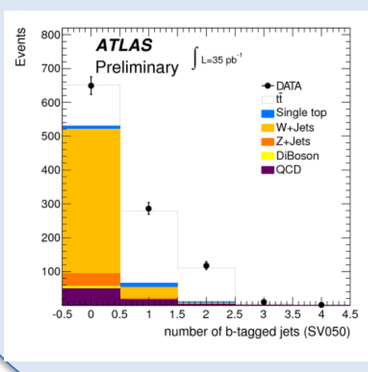


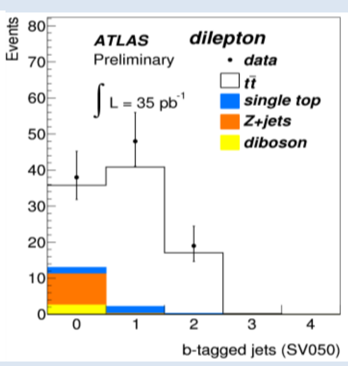


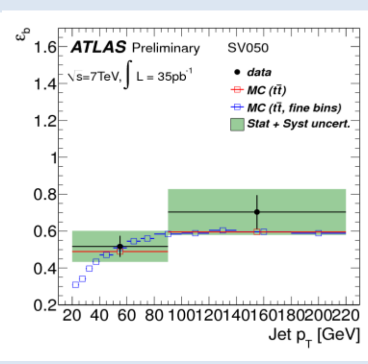
How Do We Measure *b*-Tag Efficiency in $t\bar{t}$ Events?

A top quark will decay to a *b* quark and a *W* boson almost 100% of the time, but not all resulting *b*-jets will be tagged.
- The *tag counting* methods use the number of *b*-tagged jets per event, and the expected flavor composition of those jets, to extract the *b*-tag efficiency.
- The *kinematic selection* method extracts the *b*-tag efficiency from the fraction of tagged jets in data, the expected flavor composition of the sample, and non-*b* tagging efficiencies obtained by other methods.

b-Tagging Efficiency, $\varepsilon_b^{t\bar{t}}$



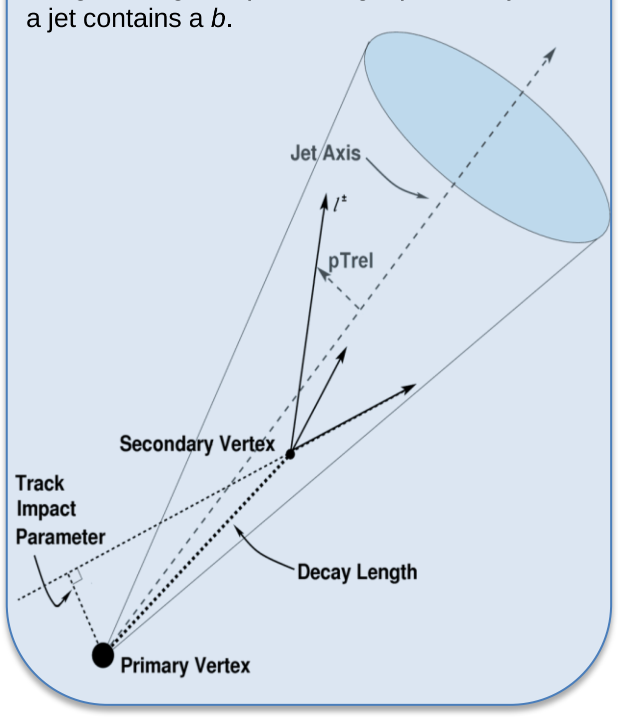




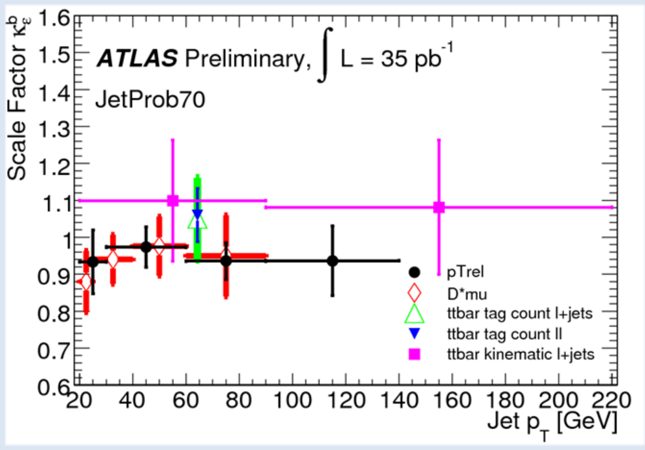
How Do We Find *b*-jets?

The *b*-quark is unique in the Particle Zoo for being heavy and forming long-lived mesons and baryons. Jets containing a *b*-quark can be distinguished from other jets by:
- Impact Parameters w.r.t the primary vertex
- Secondary Vertex decay length
- Leptons from *b*-decay (large angles relative to the axis of the containing jet, soft p_T spectrum)

These are incorporated into algorithms which assign a weight, representing a probability that a jet contains a *b*.



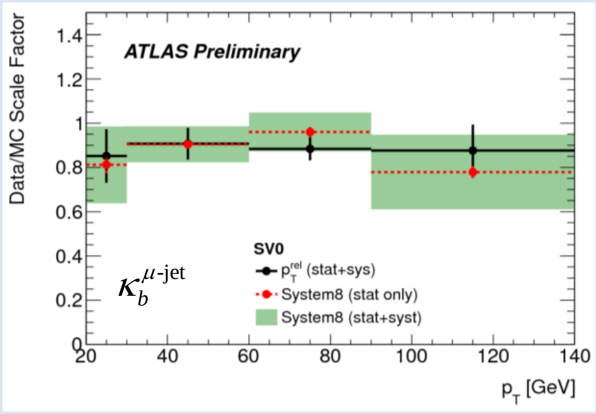
First Performance Measurements: 2010 Data

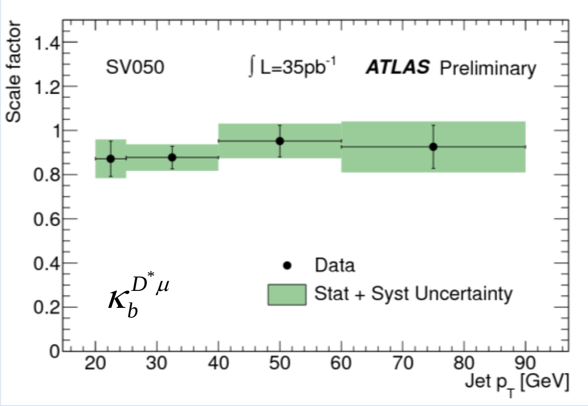


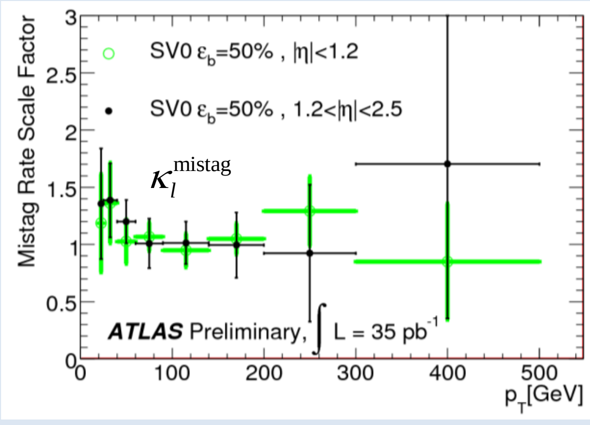
Consistent results between complementary measurements, with much lower statistics than in 2011 data

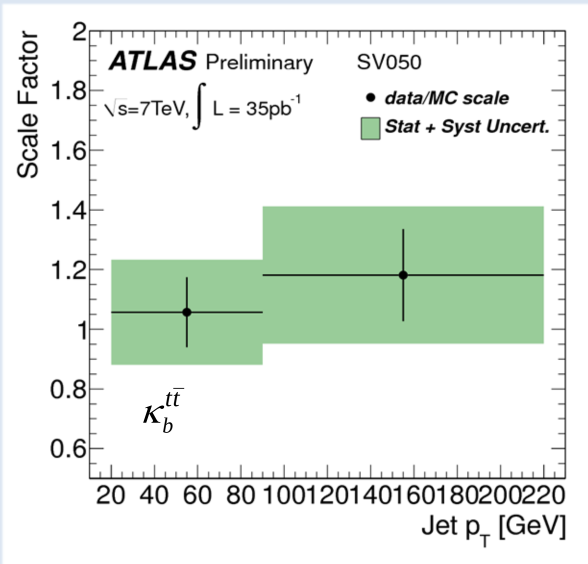
Compare to Simulation

Several methods to measure b-tagging performance in data are used to derive data-to-simulation *scale factors*, $\kappa = \varepsilon_{Data} / \varepsilon_{Sim}$:









These scale factors allow us to make use of well-calibrated, high-performance *b*-tagging algorithms

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