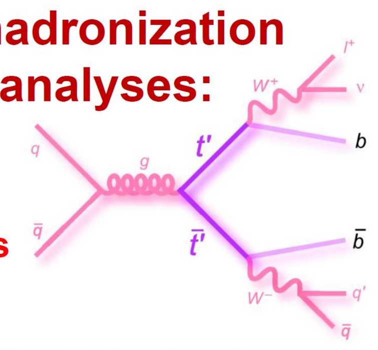
EPS HEP – Grenoble, July 21-27th 2011

ATLAS high-performance *b*-tagging algorithms

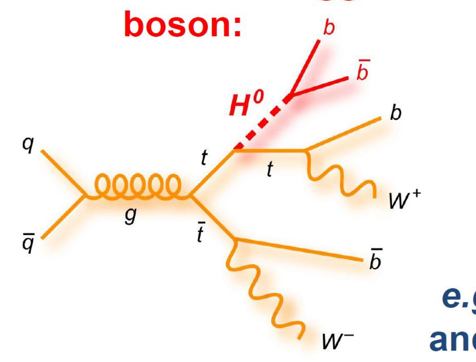
Physics motivations

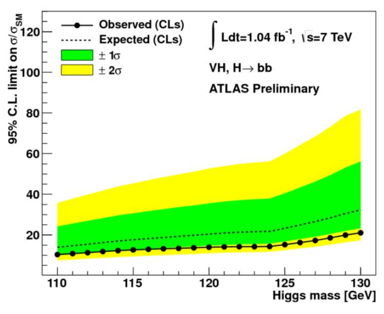
The ability to detect jets stemming from the hadronization of b-quarks is important for many physics analyses:

Standard Model measurements: σ(bbar), top physics…



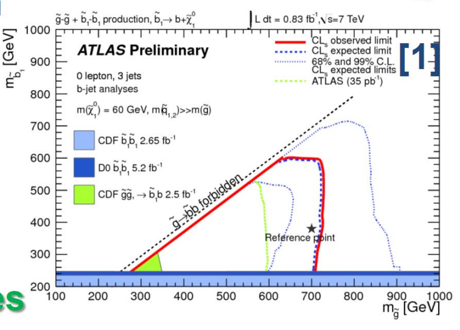
Searches for the Higgs boson:





Searches for Physics beyond the SM:

- 4th generation
- SUSY
- GUT models

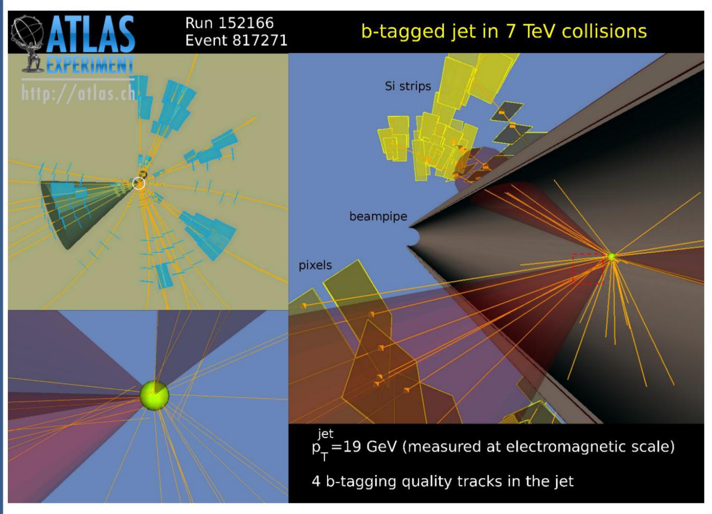


e.g.: exclusion limits of the ZH→ llbb and WH→ lνbb channels combined [2]

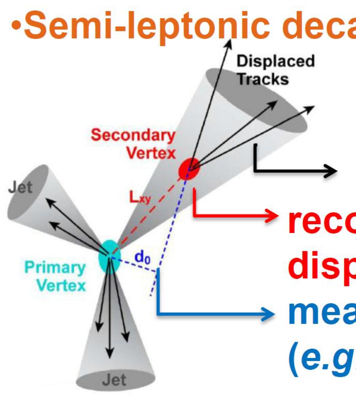
Simple b-tagging algorithms were already used in several 2010 analyses [1]

b-tagging overview

Identification of b-jets exploits the properties of *b*-hadrons:



- High mass (~5GeV) → many particles in decay
- Long lifetime (~1.5ps, cτ~450μm): a *b*-hadron in a jet (p_T~50GeV) flies on average ~3mm before decaying!
- Semi-leptonic decay: *BR(b→lνX)+BR(b→c→lνX)~21% (l=e, μ)*

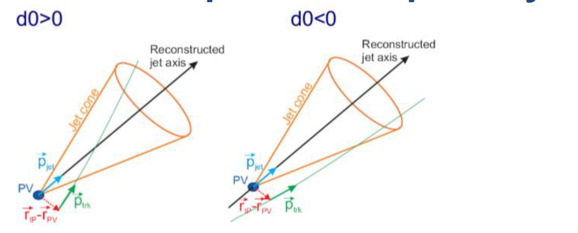


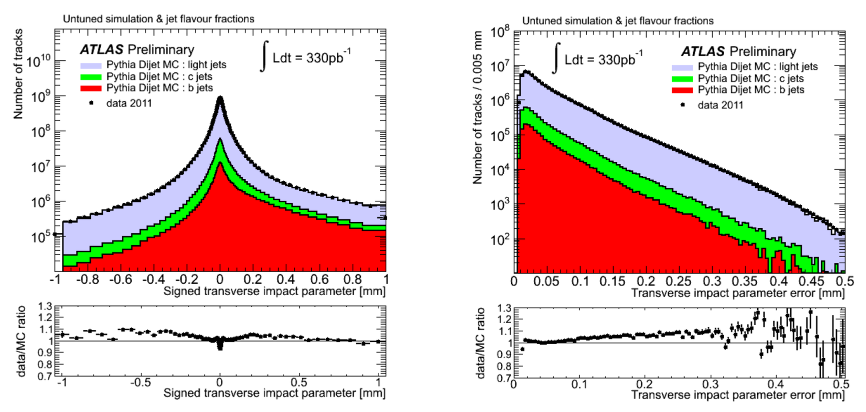
Experimentally, relies on:

- detecting soft leptons in jets
- reconstructing Secondary Vertices (SV) displaced from the primary vertex
- measuring large Impact Parameter (IP) (*e.g.* d_0) of tracks in jets

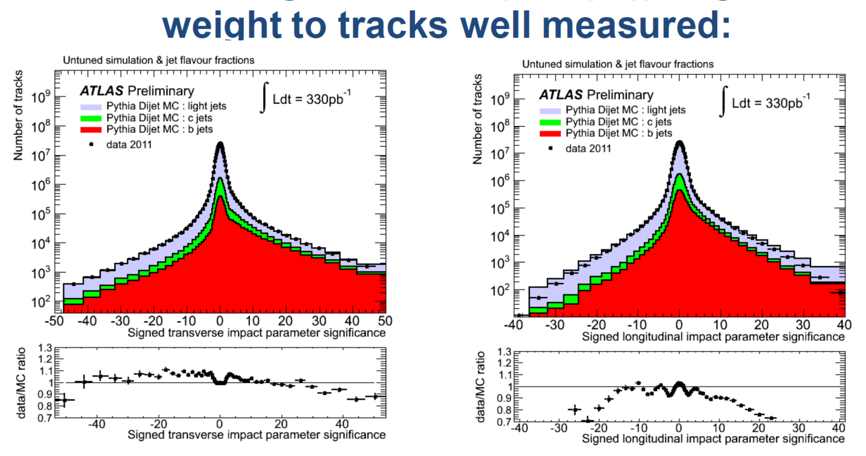
High-performance *b*-tagging algorithms

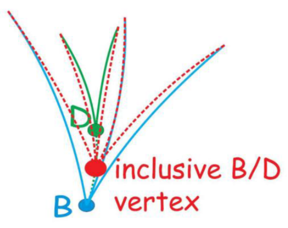
	IP-based algorithm: *IP3D*	SV-based algorithm: *SV1*	Multi-vertex fit algorithm: *JetFitter*
Principle:	It signs the transverse and longitudinal impact parameters of tracks with respect to the primary vertex:	It reconstructs the inclusive vertex formed by the decay products of the *b*-hadron, including products of the eventual subsequent *c*-hadron decay.	This algorithm tries to reconstruct the full *b*-hadron decay chain (*b*→*c*→…) including vertex topologies with single tracks (under hypothesis that *b*- and *c*-hadron decays lie on the same line)
Input variables:		It takes advantage of different properties of the SV:	It also takes advantage of the different properties of these vertices:
Combination of variables:	Likelihood ratio of 2D (d0/σ vs z0/σ) predicates from simulation for b-jet and light-jet hypotheses.	Likelihood ratio of variables related to SV properties. 2D and 1D predicates from simulation for b-jet and light-jet hypotheses.	Neural Network using several variables from simulation for *b*-jet, *c*-jet and light-jet hypotheses

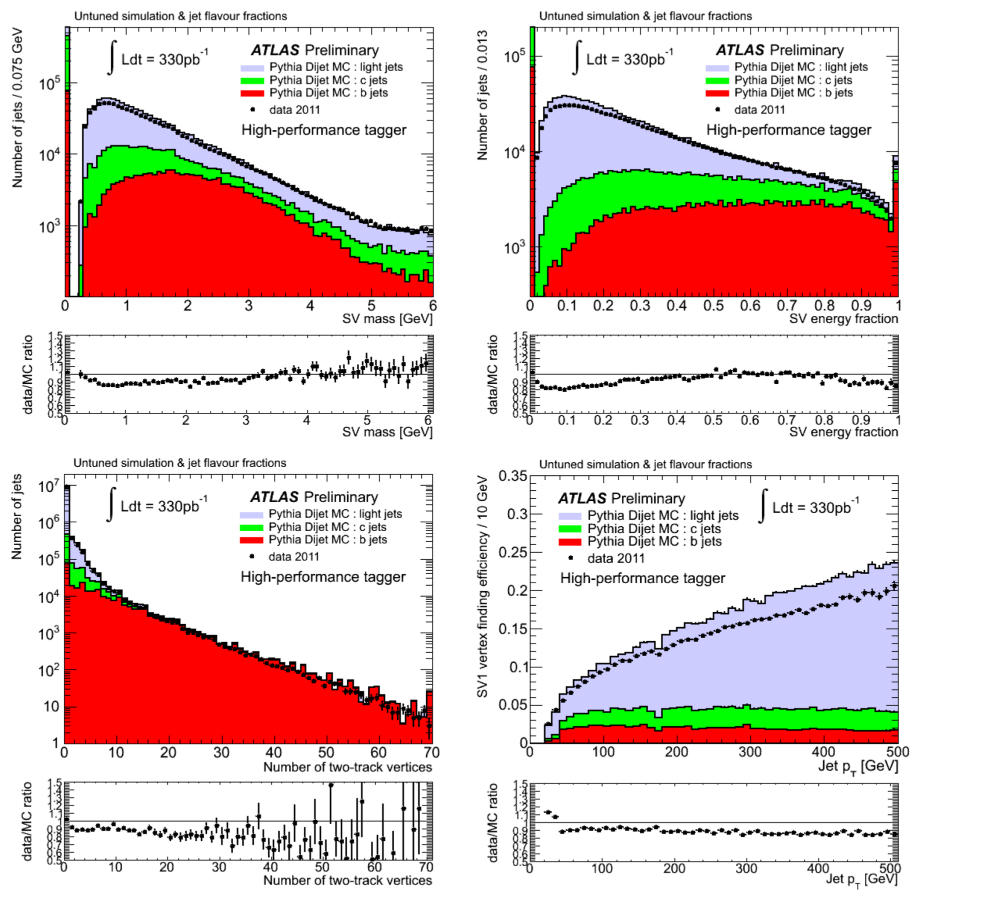




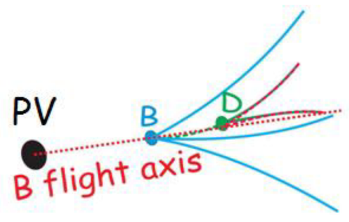
It uses the IP significances (IP/σ(IP)) to give more weight to tracks well measured:

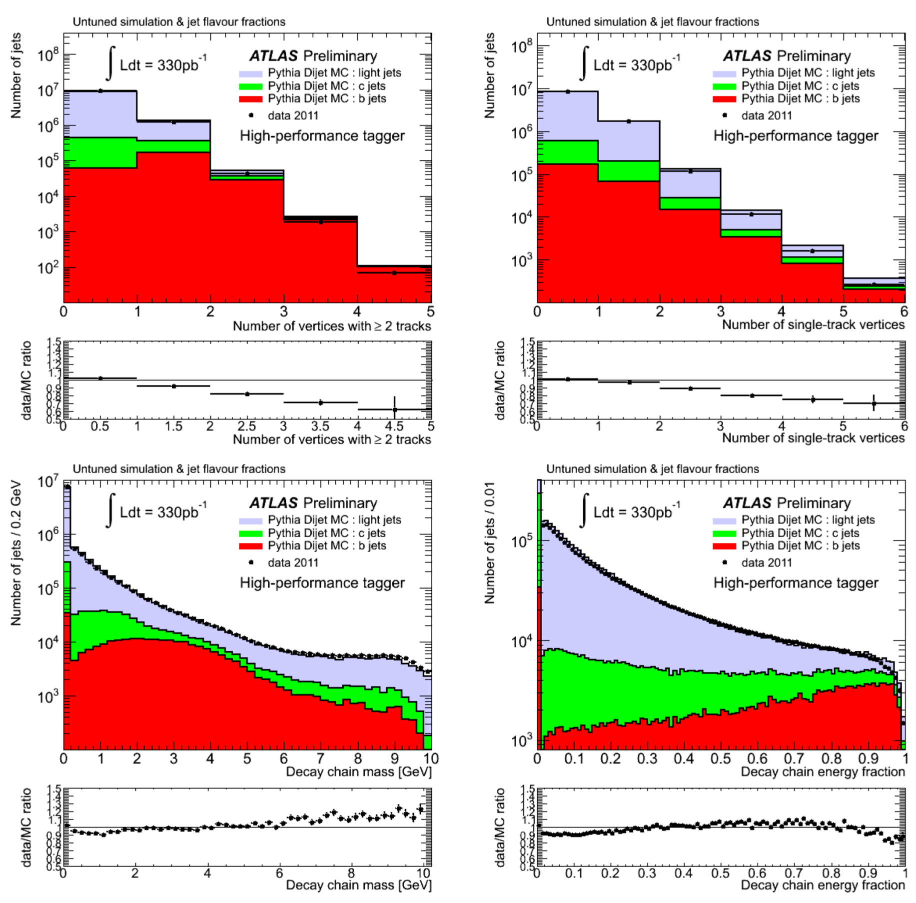






N.B.: This variable is not directly used in the L.R. below mentioned

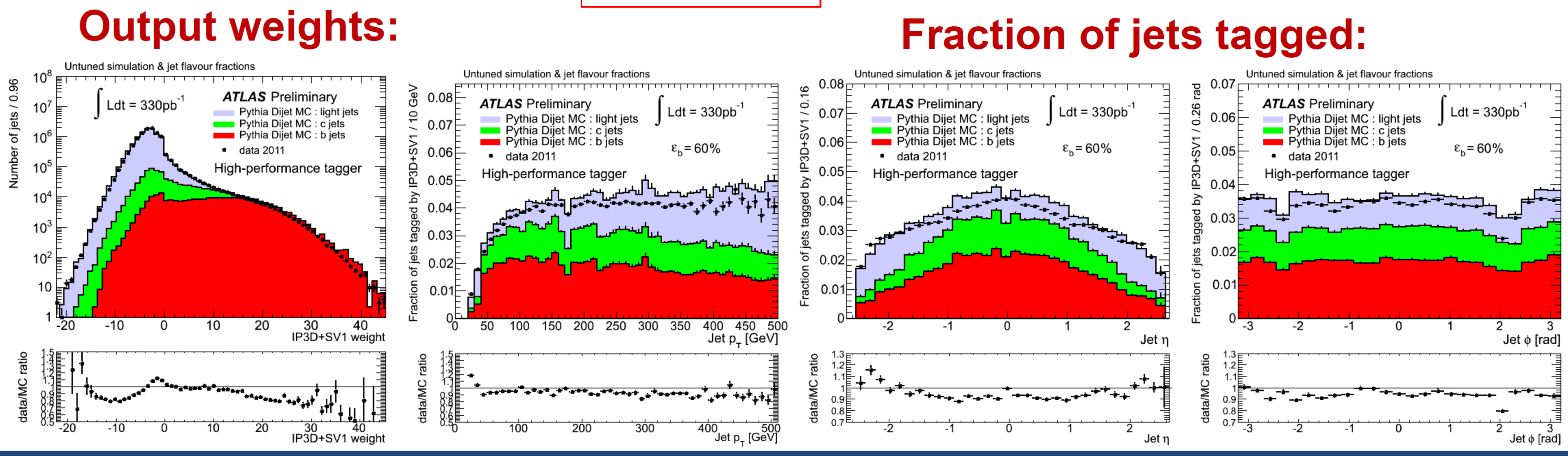




Combined taggers

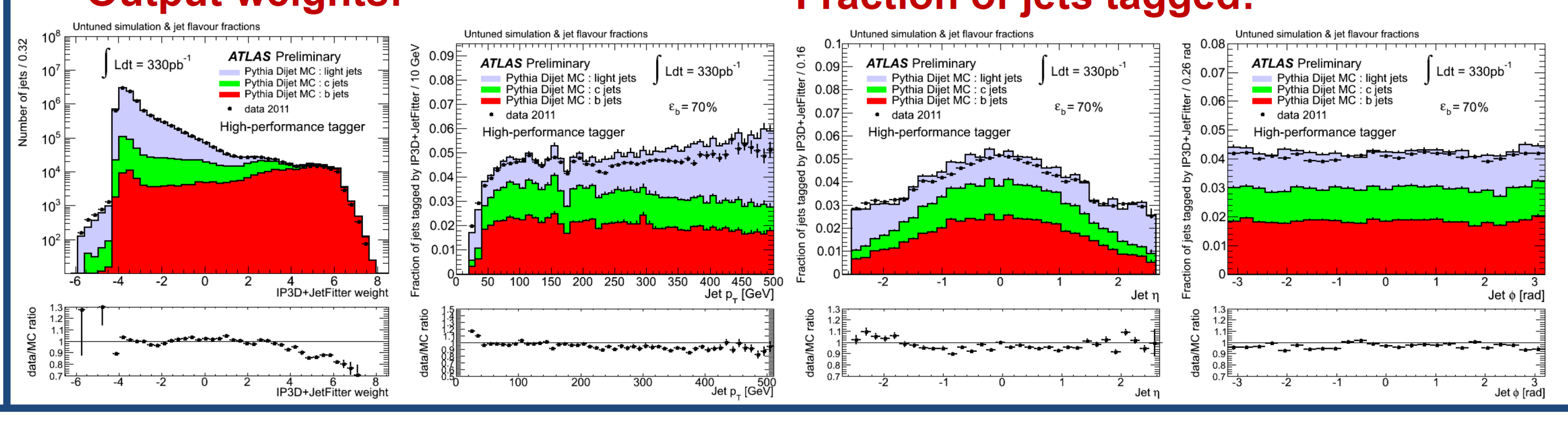
IP3D+SV1 *(sum of L.R.)*

Output weights: Fraction of jets tagged:



IP3D+JetFitter *(NN combination)*

Output weights: Fraction of jets tagged:



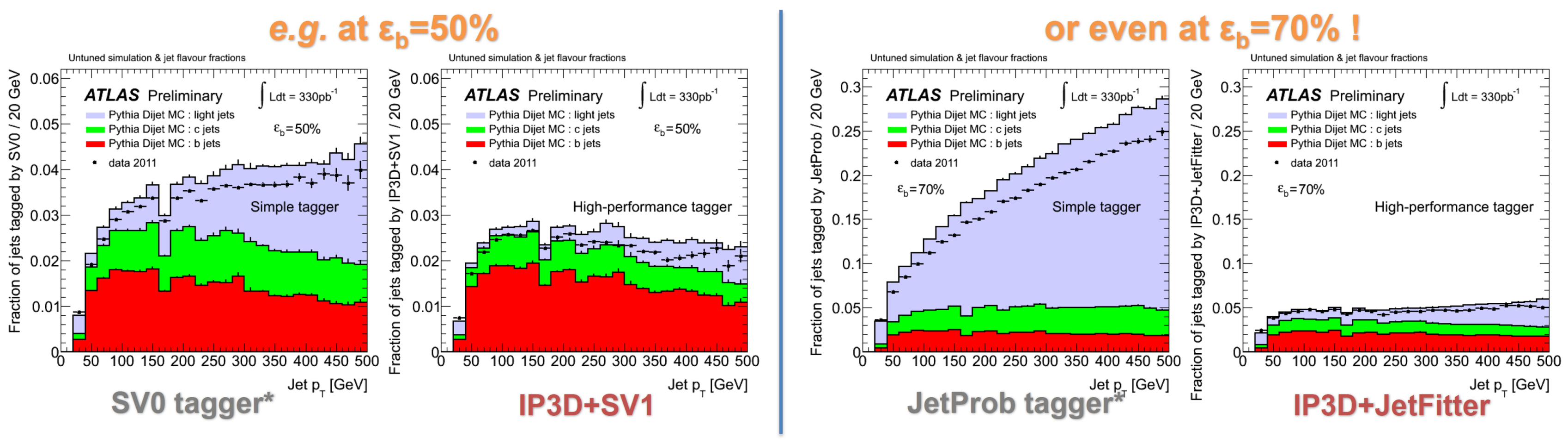
- Most distributions of these complex taggers are well reproduced by simulation (<20-10% or better). Residual discrepancies mostly due to slightly better impact parameter resolution in simulation, which will be addressed by a proper smearing procedure and other improvements.
- The current data/simulation agreement is good enough to allow their calibration in data !

Why using these taggers compared to the 'early' ones used in 2010 ?

→ Clearly visible…

For similar *b*-tagging efficiency : …in QCD jet events: Data and simulation:

e.g. at ε_b=50% or even at ε_b=70% !

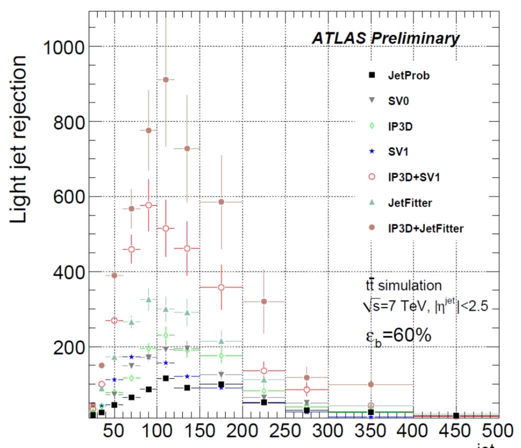


the fraction of light jets incorrectly tagged as *b*-jets is substantially reduced with the new taggers !

*: these so-called 'early' taggers, much simpler, were commissioned in 2010 and used for physics analysis

… and on ttbar simulation:

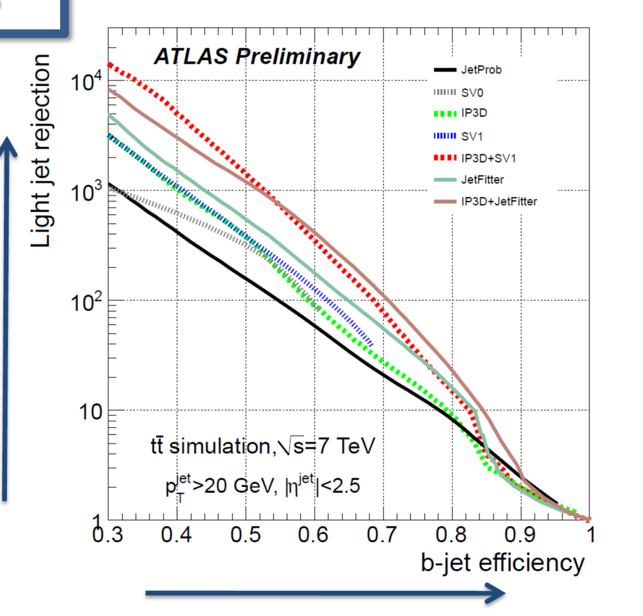
Light jet rejection at ε_b=60%:



New taggers will greatly improve tagging of high-pt jets

At same b-jet efficiency, mistagging rate (1/rejection) can decrease by a factor of 2 to 5 with new taggers

Allows better background rejection



For same rejection, can work at higher efficiency

Promising for searches with low production cross section!

ATLAS high-performance b-tagging algorithms have been commissioned [3] and their use is expected to increase greatly the rejection of *light*-jets (for fixed *b*-tagging efficiency), improving ATLAS physics reach !

Nicolas Bousson (CPPM – Marseille), for the ATLAS Collaboration

Ref.: [1] ATLAS Collaboration - ATLAS-CONF-2011-098
[2] ATLAS Collaboration - ATLAS-CONF-2011-103
[3] ATLAS Collaboration - ATLAS-CONF-2011-102