TOP Physics at ATLAS

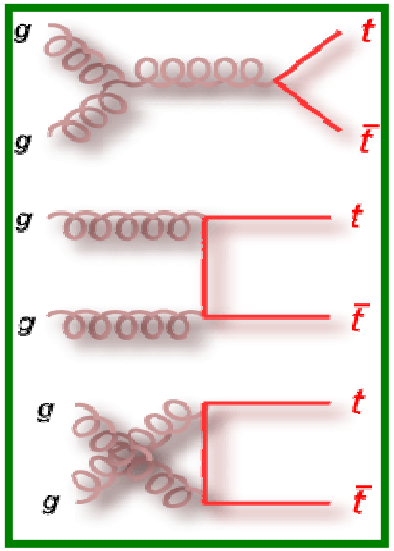
- Production of Top Quarks
  - Top-Pair
  - Single top
- Decay of Top Quarks
  - Decay products: b-jets
  - Tagging of b-jets
- Measurements
  - Top cross section
  - Top mass

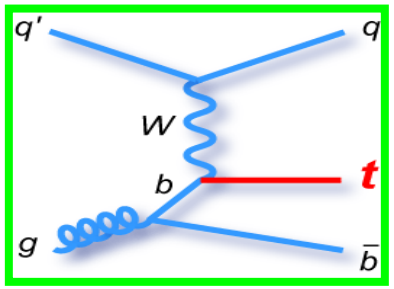
Physics: Top-Quarks

production:

strong interaction: top-pairs

weak interaction: single top





decay:

weak interaction

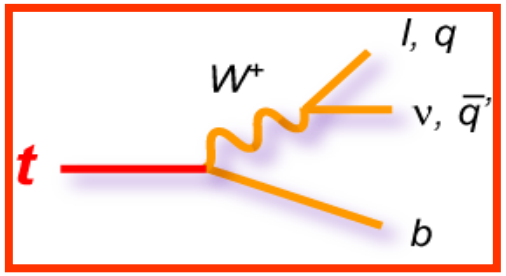
hadronic decay:

2 light quark jets

leptonic decay:

lepton + neutrino (E_T^{miss})

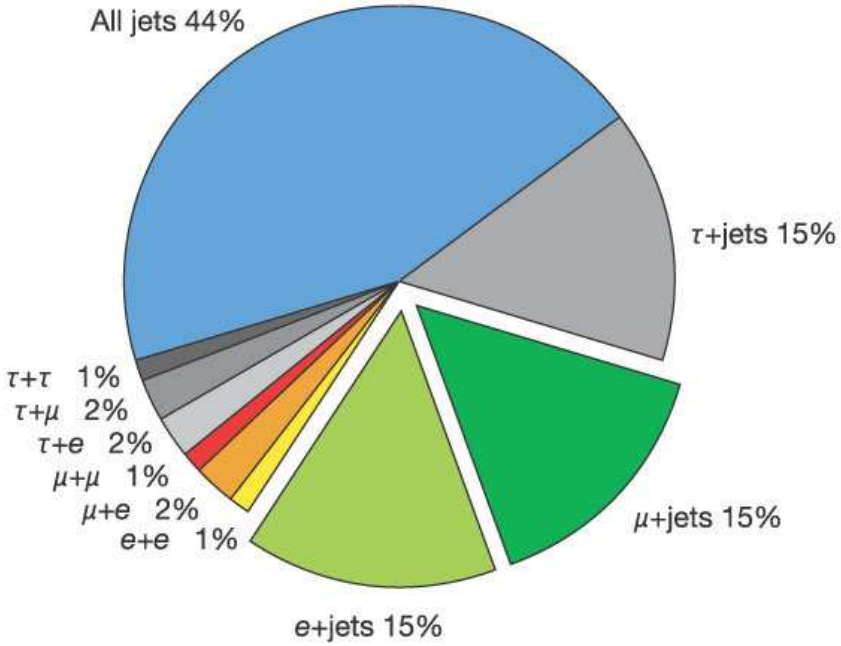
always: **one b-quark**



- **fundamental tests of the standard model**
  - well-known process
- **potential window for new physics in precision measurements**
  - high production rate at LHC
- **dominant background for many searches for physics beyond the Standard Model**

Top Quark Decay Channels

Top pair branching fractions

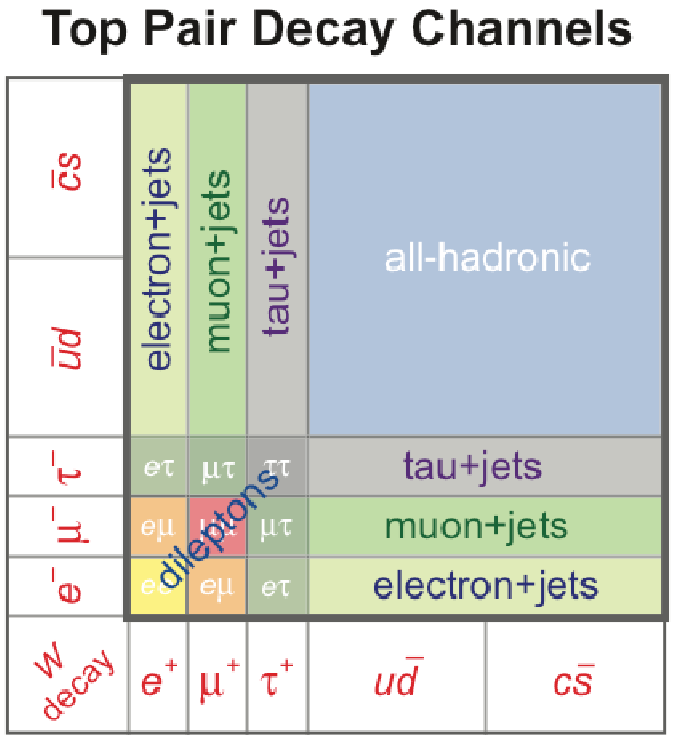


Top Pair Decay Channels

W decay	e^+	μ^+	τ^+	$u\bar{d}$	$c\bar{s}$
e^-	ee	$e\mu$	$e\tau$	electron+jets	
μ^-	$e\mu$	$\mu\mu$	$\mu\tau$	muon+jets	
τ^-	$e\tau$	$\mu\tau$	$\tau\tau$	tau+jets	
$\bar{u}d$	electron+jets	muon+jets	tau+jets	all-hadronic	
$\bar{c}s$					

dileptons

Phenomenology at the Detector



tt → (only) 6 quarks

largest fraction, very high background

tt → 4 quarks, charged lepton, neutrino

Some 30% ‚usable', low background

FAVOURED channel

tt → 2 quarks, 2 charged l, 2 neutrinos

Only 5% ‚usable', very low background, difficult to reconstruct

Decay fractions largely determined by fractions of W - decay

Top-Decay channels

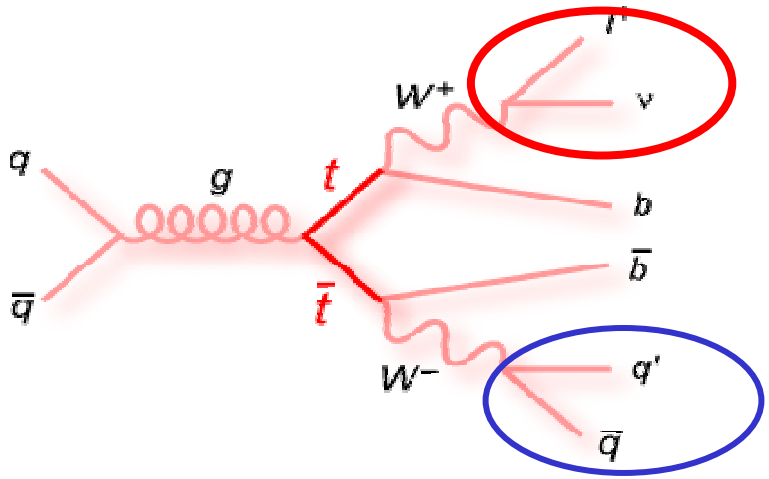
$$t \rightarrow W^{\pm} b$$

$$W^{\pm} \rightarrow q\bar{q} (\rightarrow \text{Jet} + \text{Jet})$$

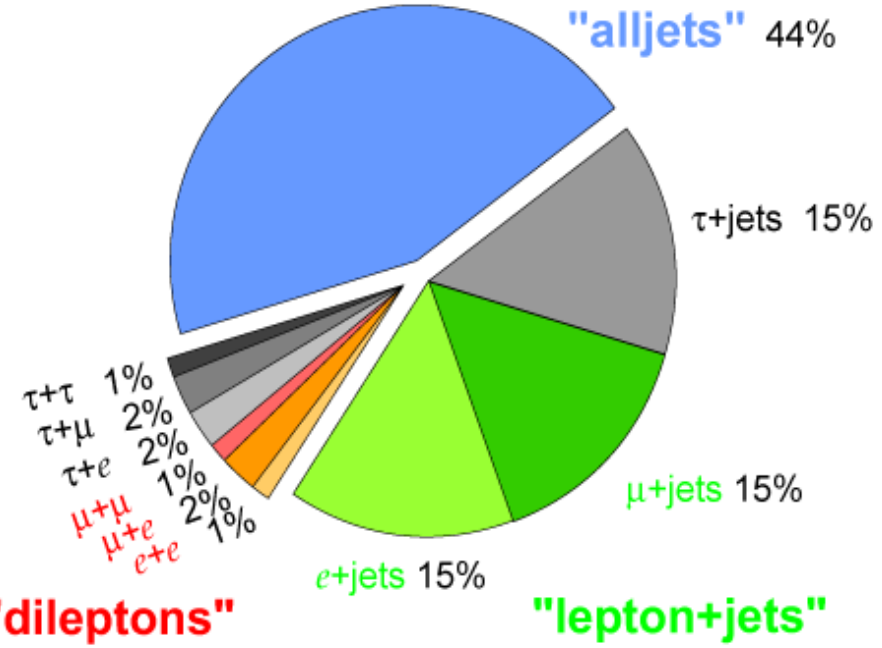
$$W^{\pm} \rightarrow l\nu_l (\rightarrow \text{Lepton} + E_{\perp}^{\text{miss}})$$

charakteristic Signal:
Lepton + missing energy

only Jets in final state:
dominant BG from QCD-multijet-events



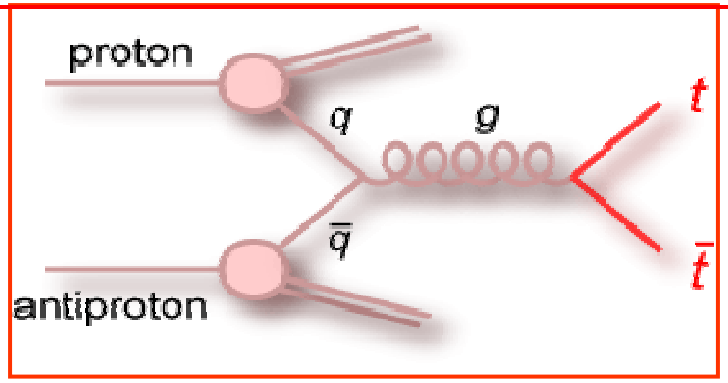
Top Pair Branching Fractions

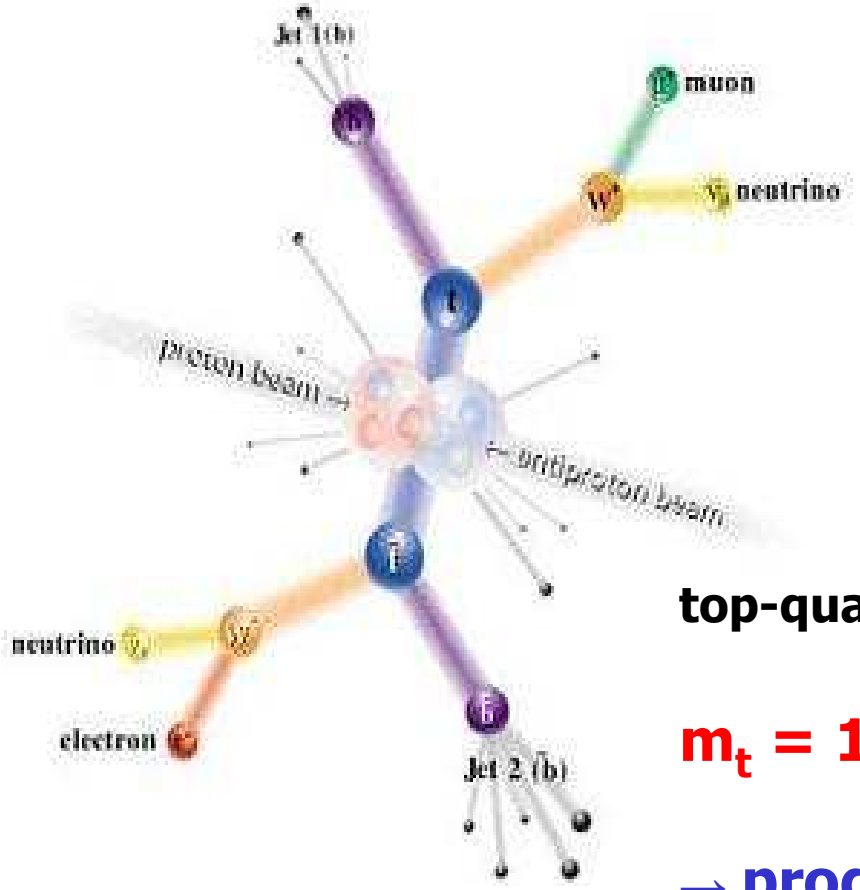


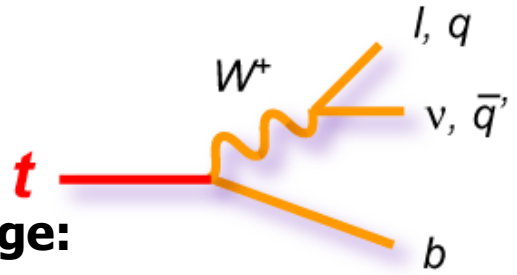
Discovery of the Top-Quark

Production in proton/antiporton collisions:

1995 at the TEVATRON





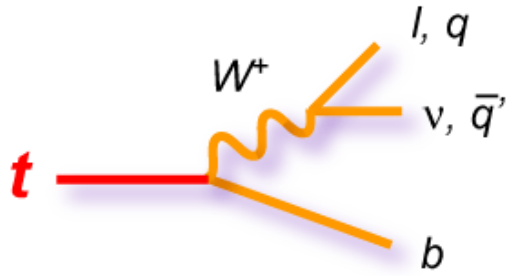


top-quark mass very large:

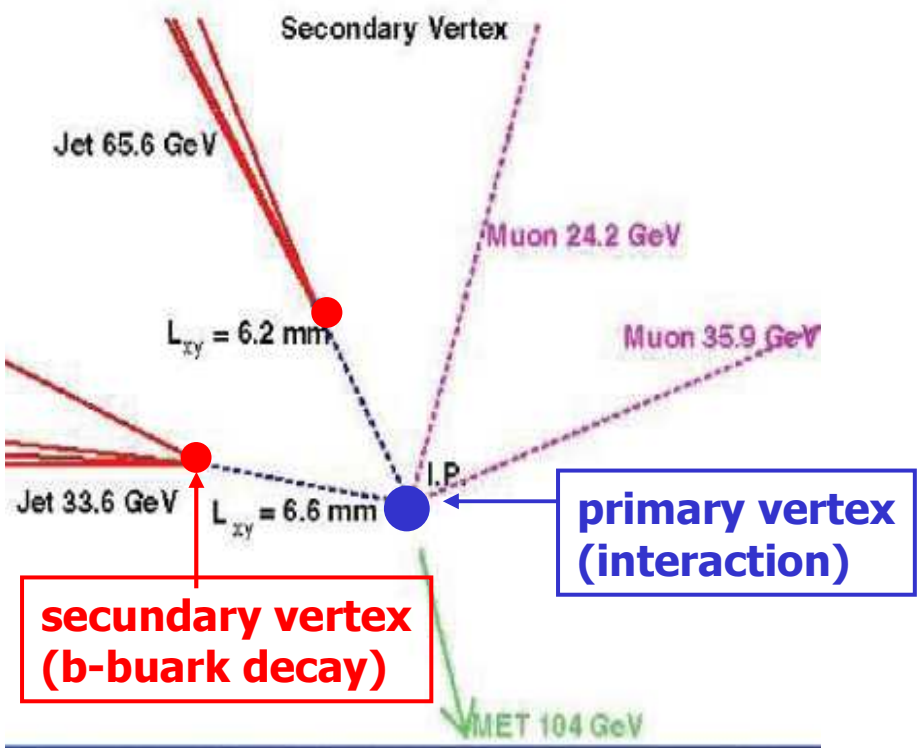
m_t = 173 GeV > m_W

→ production of real w-bosons

Signatur of a top-quark

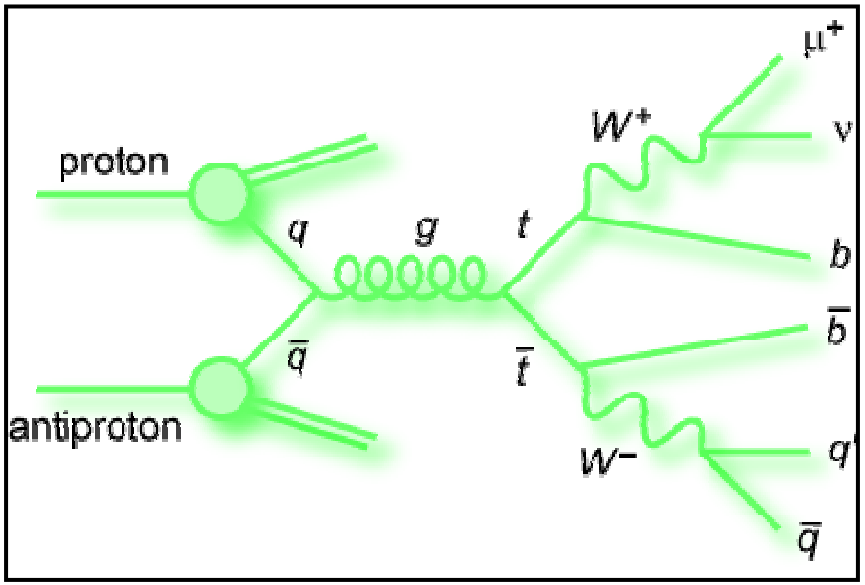


Measurement in the detector:
μ(l): clear signature, **ν: missing energy**
b-quark jet: secundary vertex (b-quark decay)

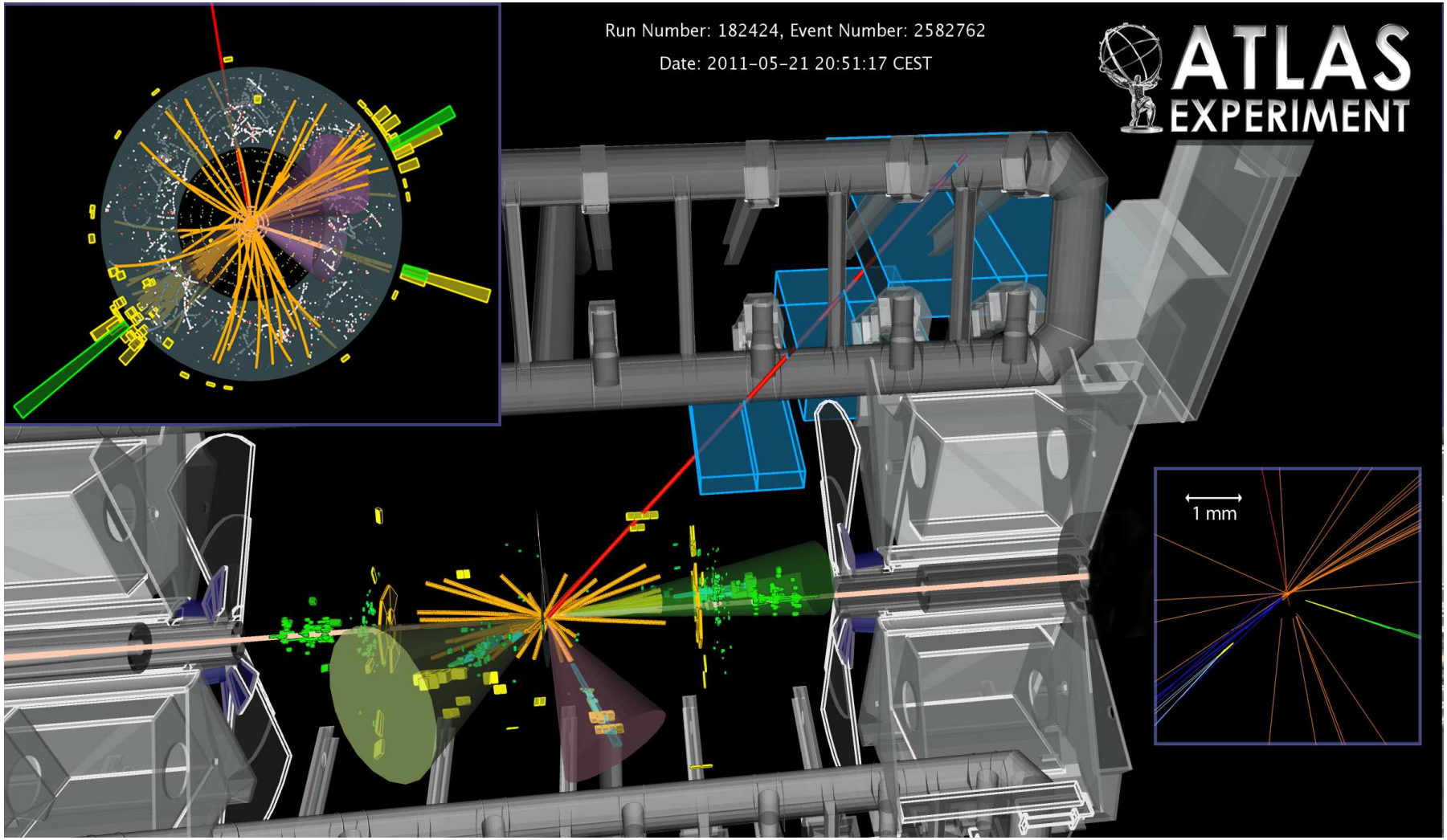


primary vertex (interaction)

secundary vertex (b-buark decay)

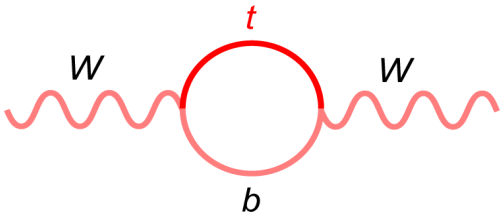


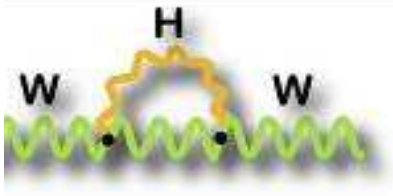
Top Event at LHC



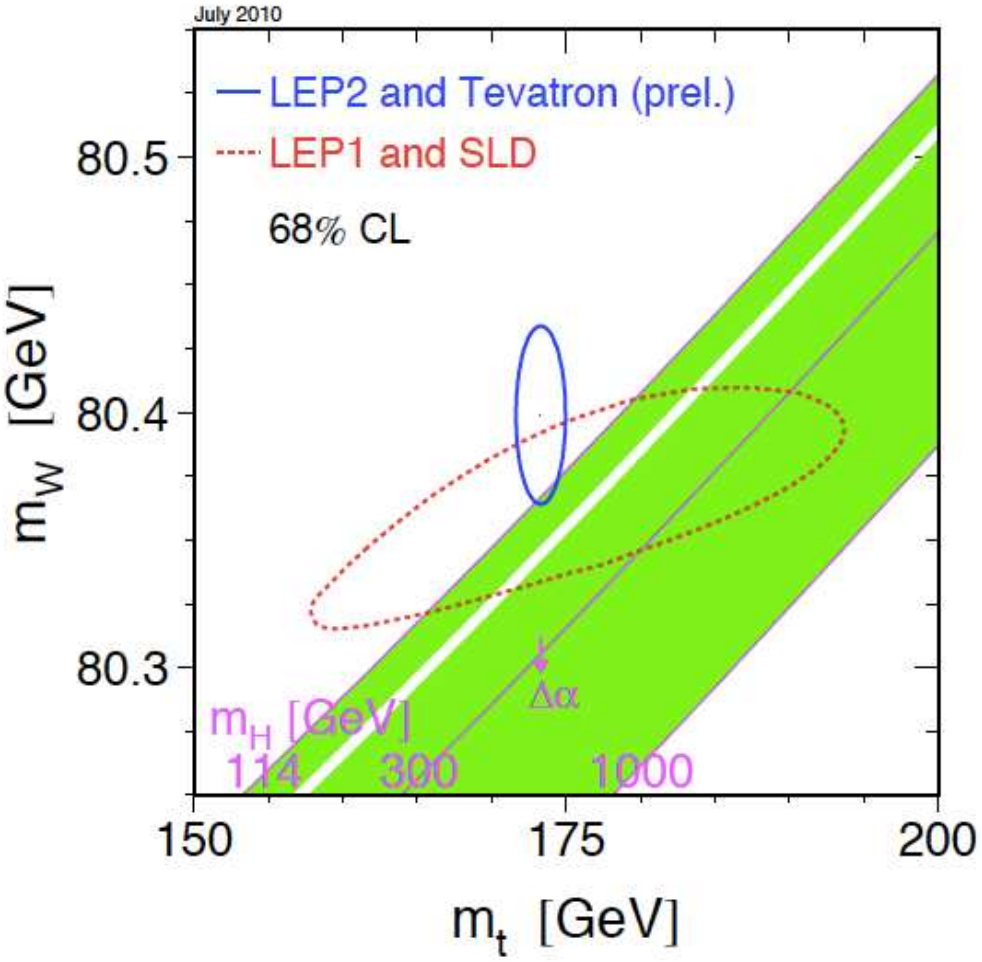
Correlation of W- and top-massen

fluctuation of the vacuum:
sensitive to the masses of W, t und Higgs





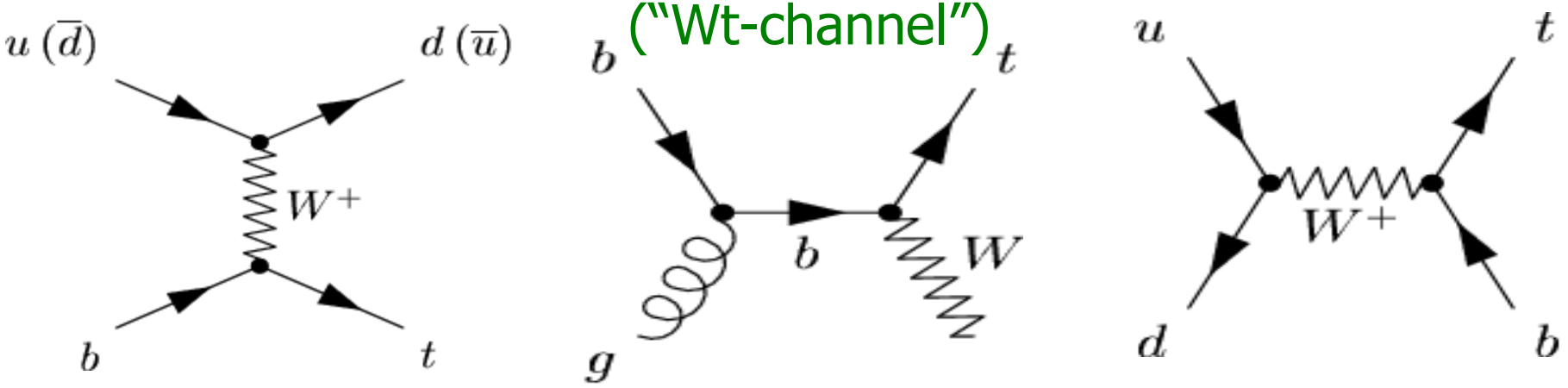
Correlation of **masses** of **top-quarks** and of **W-bosons**: theoretical prediction for the **masse region of the Higgs-boson**



Single Top Production

EW production of top-quarks, three production channels:

t-channel **Wt associated production** ("Wt-channel") **s-channel**



predicted cross sections for $\sqrt{s}$ = 7 TeV and m_t = 172.5 GeV

t-channel: 64.2 ± 2.6 pb

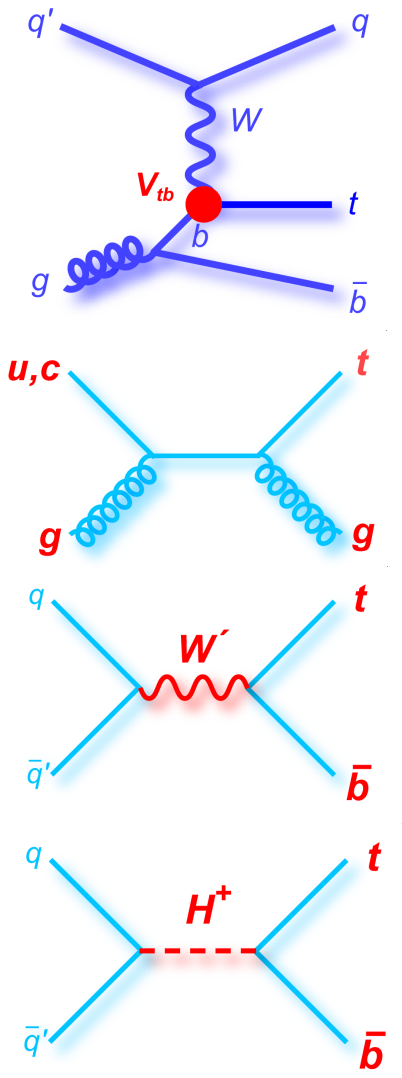
Wt-channel: 15.6 ± 1.3 pb

s-channel: 4.6 ± 0.2 pb

calculations by N. Kinodakis at NLO+NNLL resummation
arXiv 1103.2792, 1005.4451, 1001.5034

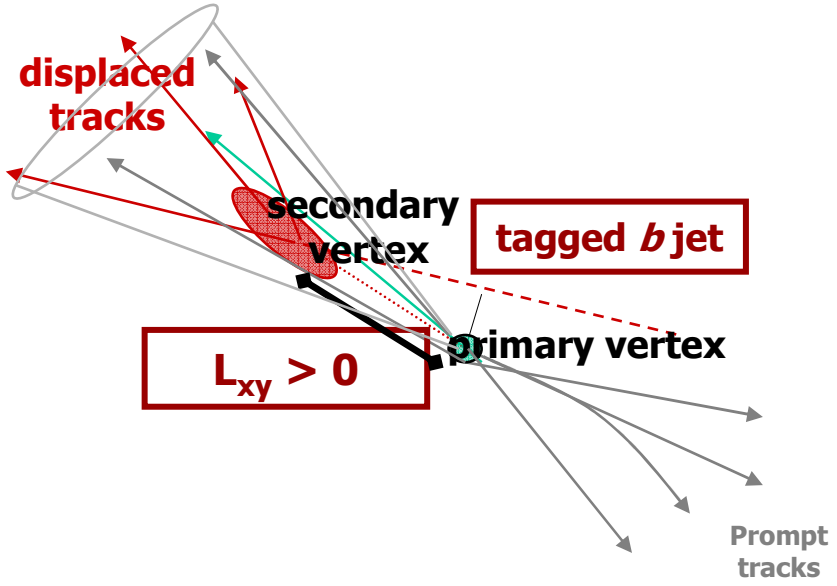
Interest in Single Top Production

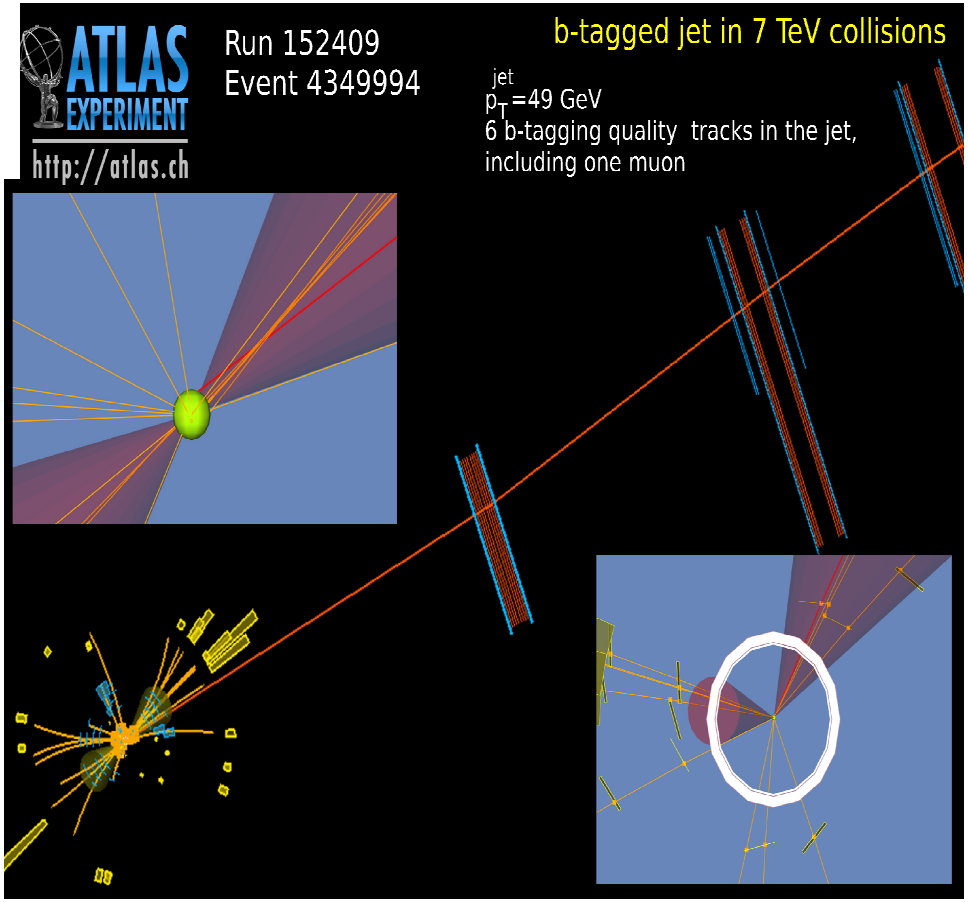
- **Test of SM prediction**
  - measurement of the different channels separately
  - compare measured cross section with SM predictic
  - test of unitarity of CKM matrix
    - Measurement of $\mathbf{V_{tb}}$, $\mathbf{V^2_{ub}+V^2_{cb}+V^2_{tb} = 1}$
    - hints for a 4th generation?
- **Search for phenomena beyond the SM**
  - search for FCNC, e.g. ug → t
  - search for W', charged MSSM Higgs $H^{\pm}$
- **Experimental benchmark for searches**
  - object identification
    - lepton fake rates
    - QCD Background estimates
    - b-quark jet identification / b-quark PDF



Combined Performance: b-quark Jets

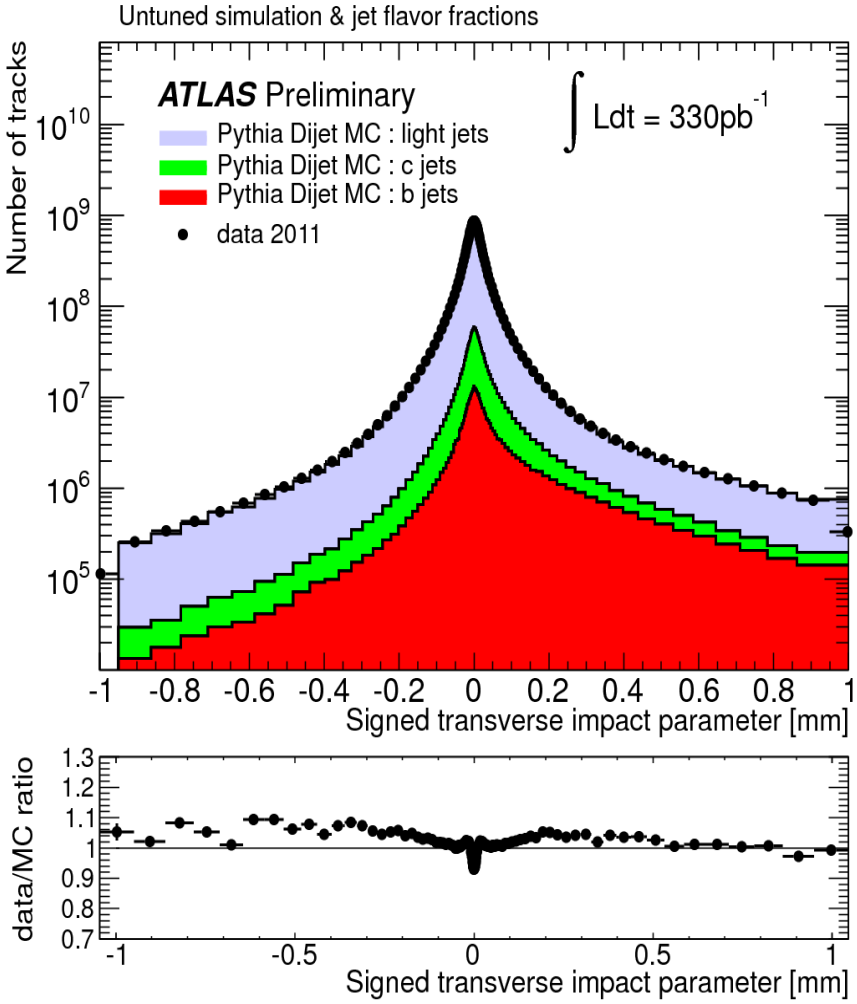
impact parameters and **secondary vertices** used to define **tag weights** for **b-jet** selection

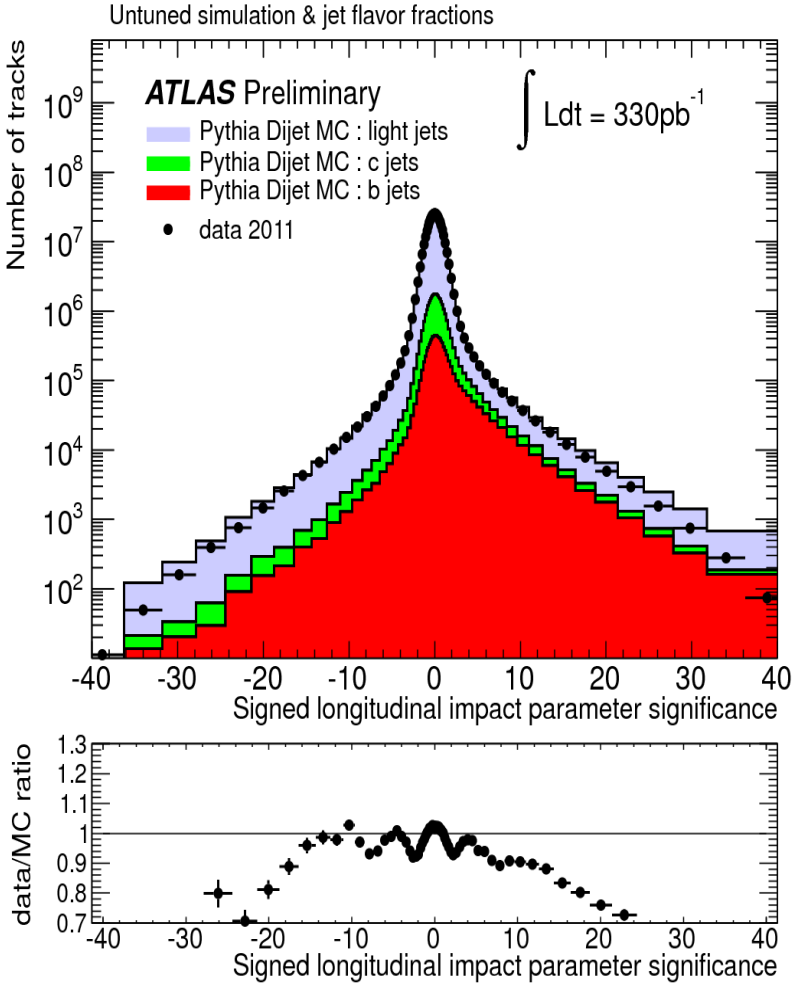




Light quark jet rejection as a function of b-tagging efficiency for various taggers

B-tagging Variables: Impactparameters





B-tagging: Performance Benchmarks

efficiency:

$$\varepsilon = \frac{\#\ jets\,(b-truth\,,tagged\ )}{\#\ jets\,(b-truth\,)}$$

rejection factor

$$RF \quad = \frac{1}{1\ -\ r}$$

purity:

$$p = \frac{\#\ jets\,(b-truth\,,tagged\ )}{\#\ jets\,(tagged\ )}$$

rejection:

$$r = \frac{\#\ jets(not-tagged\,,uds-truth)}{\#\ jets(uds-truth)}$$

misstag:

$$r = \frac{\#\ jets(tagged\,,udsc\,\tau-truth)}{\#\ jets(udsc\,\tau-truth)}$$

BaseLine Tagger (IP3D+SV1)

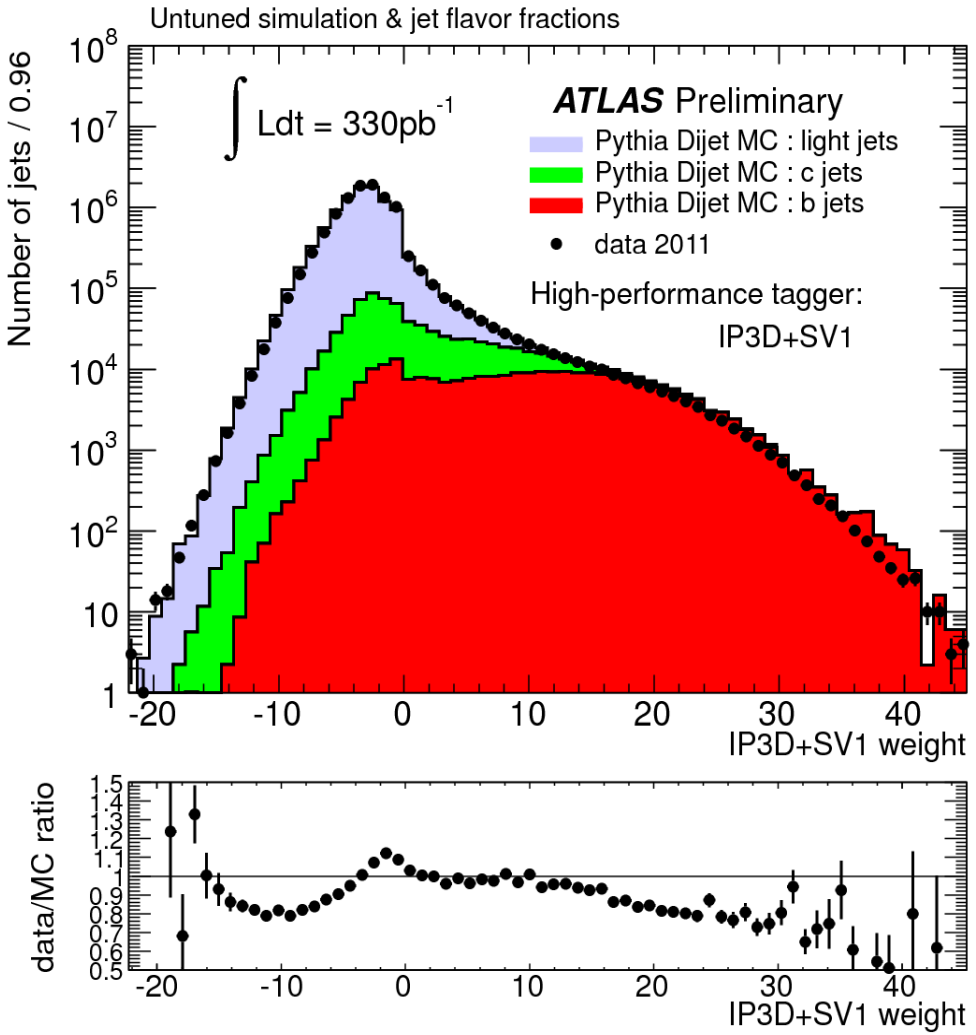
Likelihood ratio method:

measured discrimination variable S_i (impact parameter or secondary vertex) compared to predefined probability func for the **b-jet ($b(S_i)$)** and the **light jet ($u(S_i)$)** hypothesis

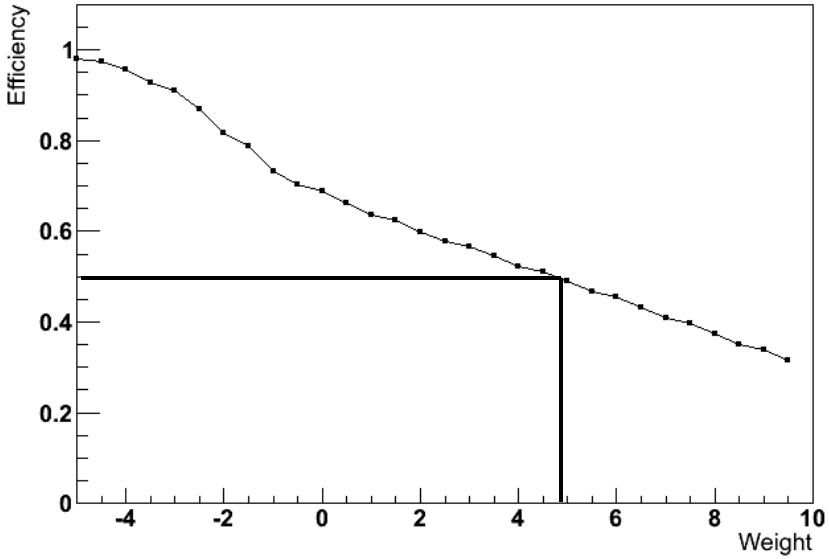
ratio of probabilities defines the jet weig w_{jet} for a jet with N tracks

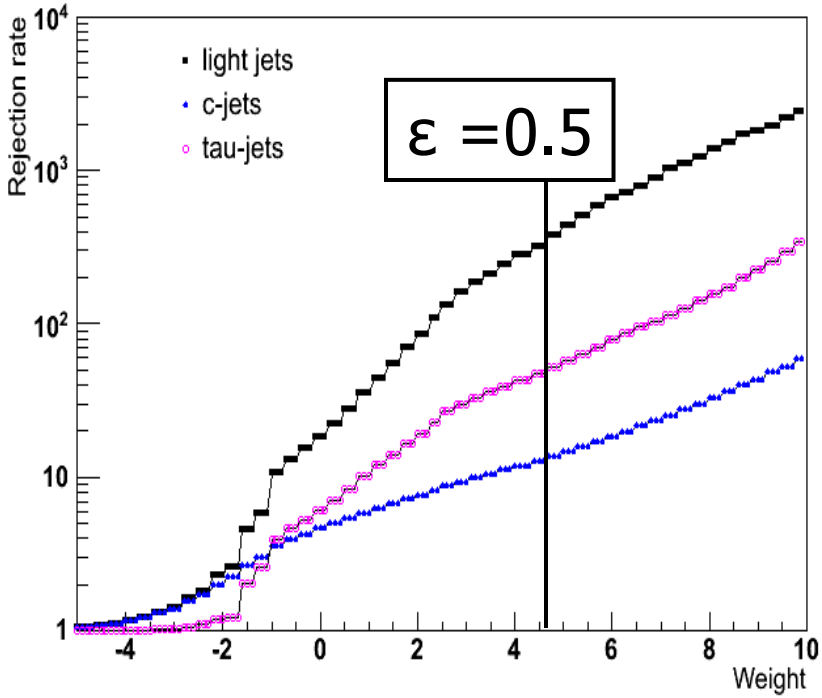
$$w_{jet} = \sum_{i=1}^{N} \ln w_i = \sum_{i=i}^{N} \ln \frac{b(S_i)}{u(S_i)}$$

weight of BaseLine Tagger: sum of SV1 and IP3D weights



BaseLine b-tagger Performance





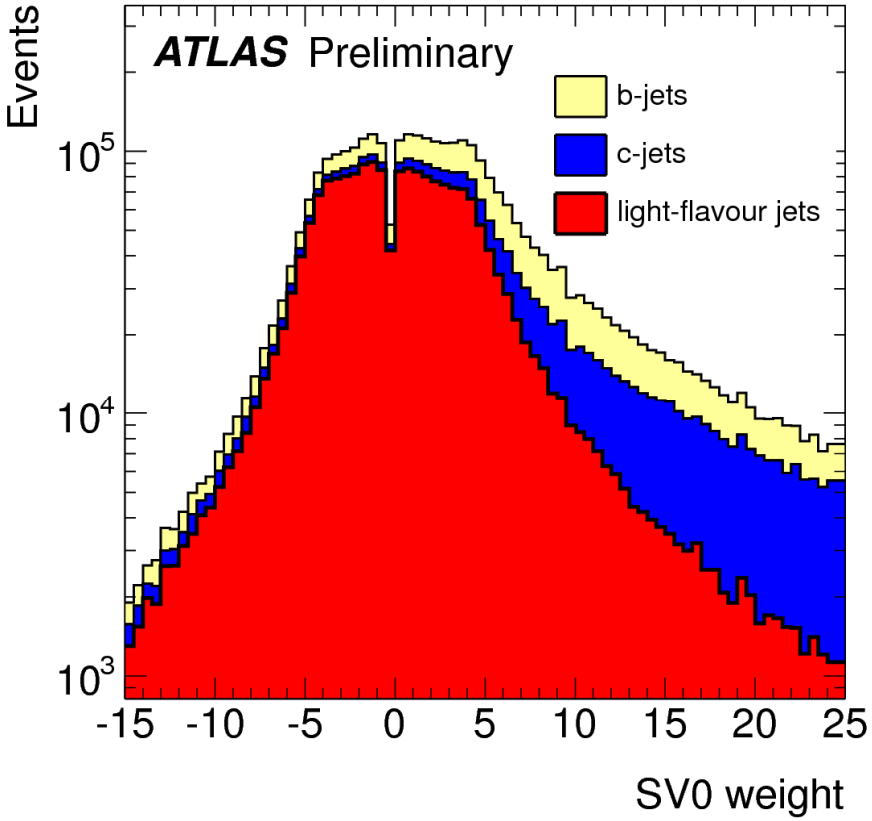
correlations of efficiency
and rejection factor with
the track weight,
based on a top-pair 7TeV MC sample

SV0 Tagger

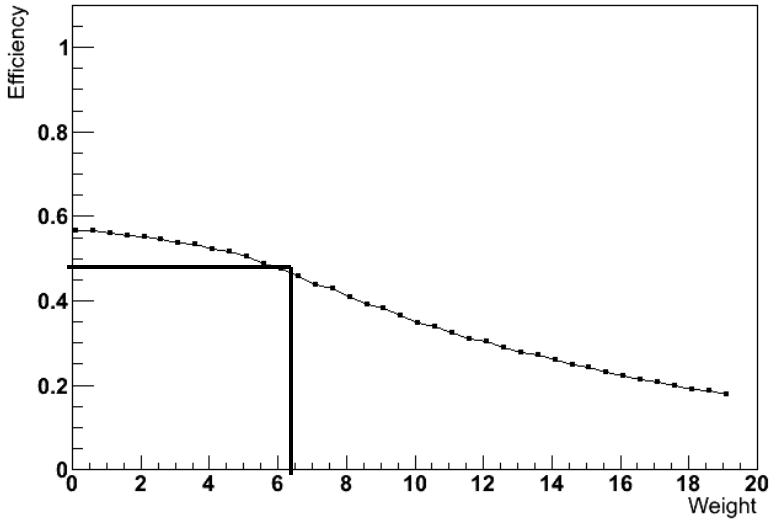
Lifetime based tagger:
reconstructs secondary vertices from track associated to a jet
cut on the signed decay length significance of secondary vertex

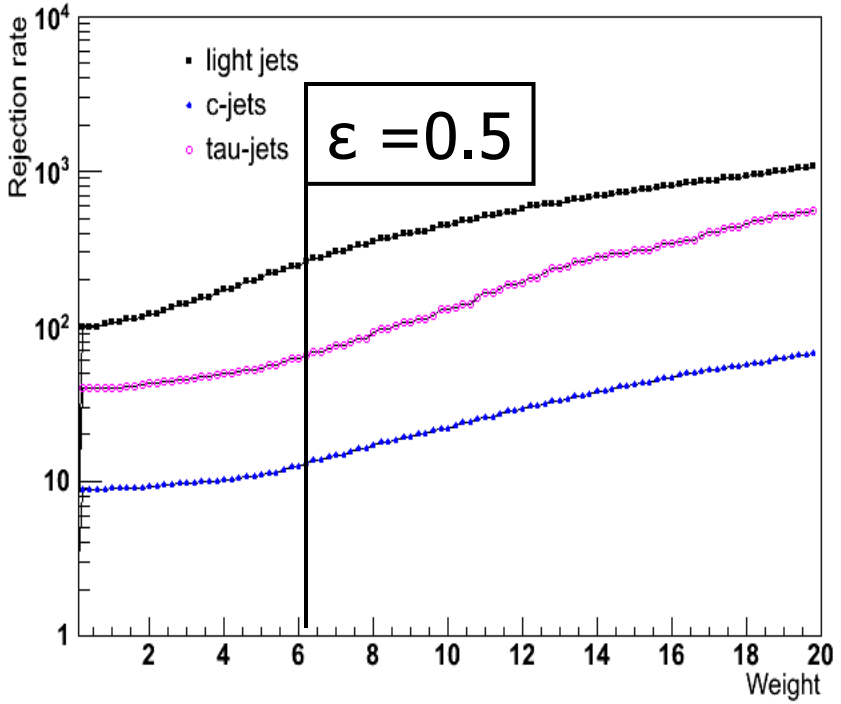
Basic track selection within the jet;
track with dca/σ(dca) > 2.3 considered
For two track vertices with:
- $\chi^2 < 4.5$
- incompatible with primary

Weight:
signed distance (computed in 3D) between the found inclusive secondary vertex and the primary vertex, divided by its error



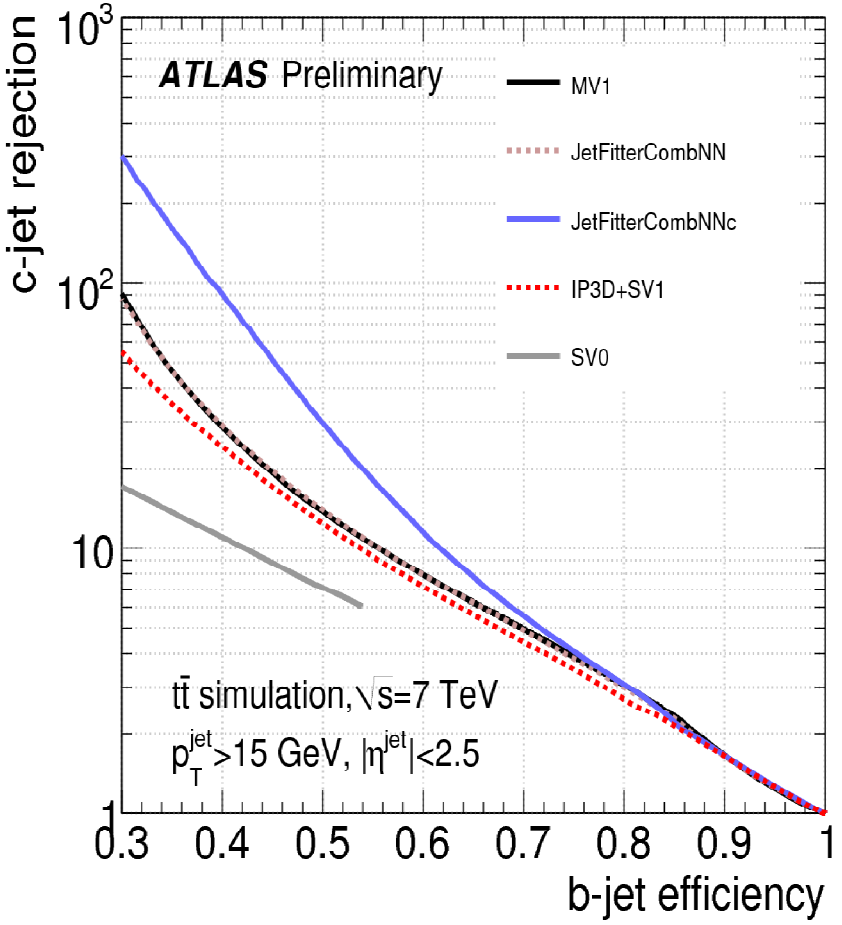
SV0 Performance

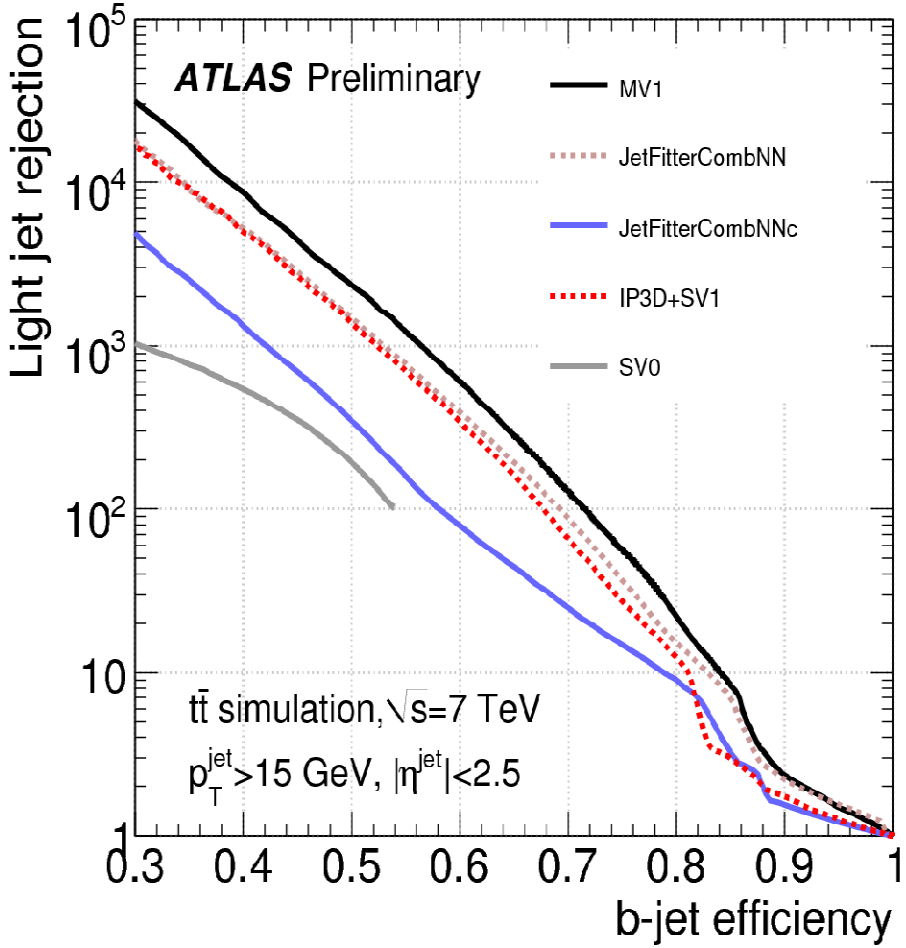




correlations of efficiency and rejection factor with the track weight,
based on a top-pair 7TeV MC sample

Performance Measurement





Calibration

- Measurements of b-tagging efficiencies and miss-tag rates in Data
- Application of scaling factors to Monte Carlo