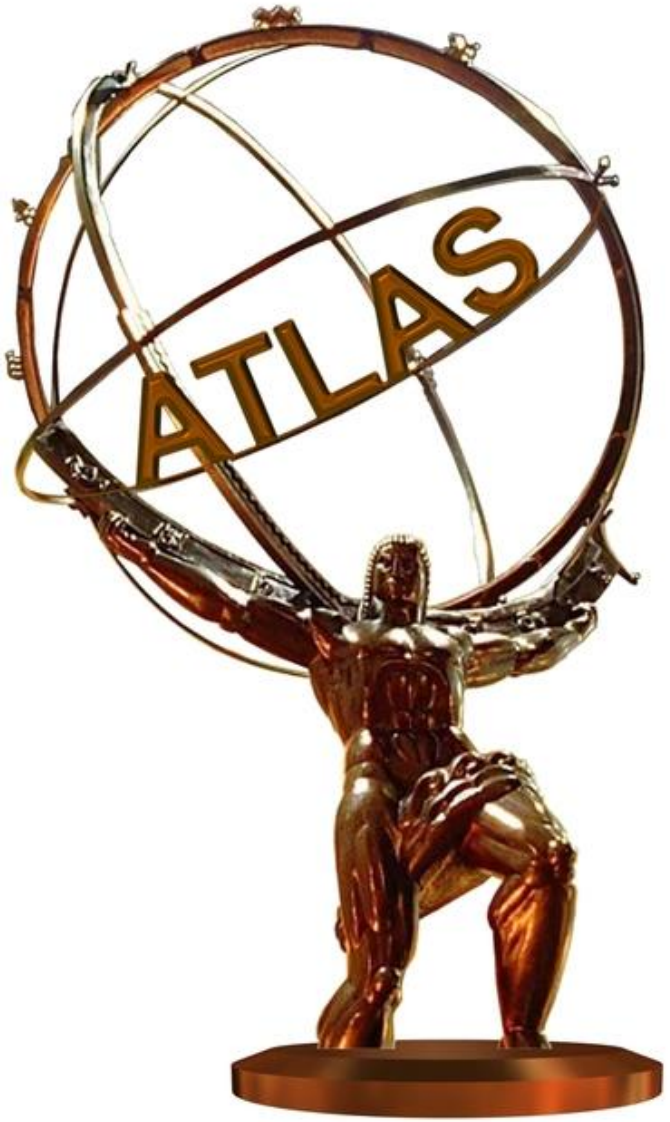


Status of b-tagging in ATLAS

Cécile Lapoire (CPPM)
On behalf of the ATLAS b-tagging group

12/08/2010
Implications of first LHC data workshop @ MIT

b-tagging overview

b hadron properties :

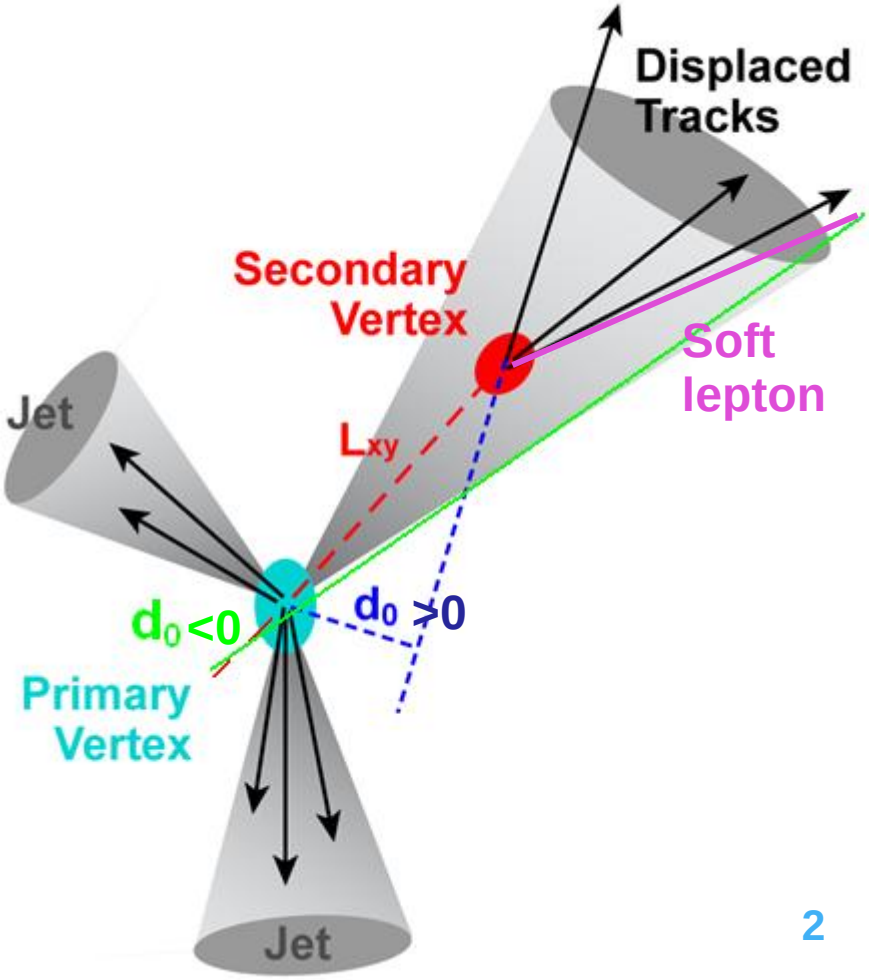
- Long lifetime (~1.5 ps, cτ=450 μm)
  - a b hadron in a jet (p_T=50GeV) flies ~ 5mm in the transverse plane before decaying
- Hard fragmentation
  - Keep 70% of the momentum of the initial b quark
- High mass (5GeV)
  - Decay products with large p_T
- Semi-leptonic decay (in ~40% of b-jets)
  - Br(b→l→X) + Br(b→c→l→X) = 11% + 10% (l=e, μ)

Experimentally :

- **Secondary vertex (SV)** displaced from **primary vertex**
- **Larger transverse impact parameter d_0 of tracks in jets from SV**
  - Signed w.r.t. jet axis
  - Significance S_{d0}

$$S_{d_0} = \frac{d_0}{\sigma_{d_0}}$$

- **Soft leptons**

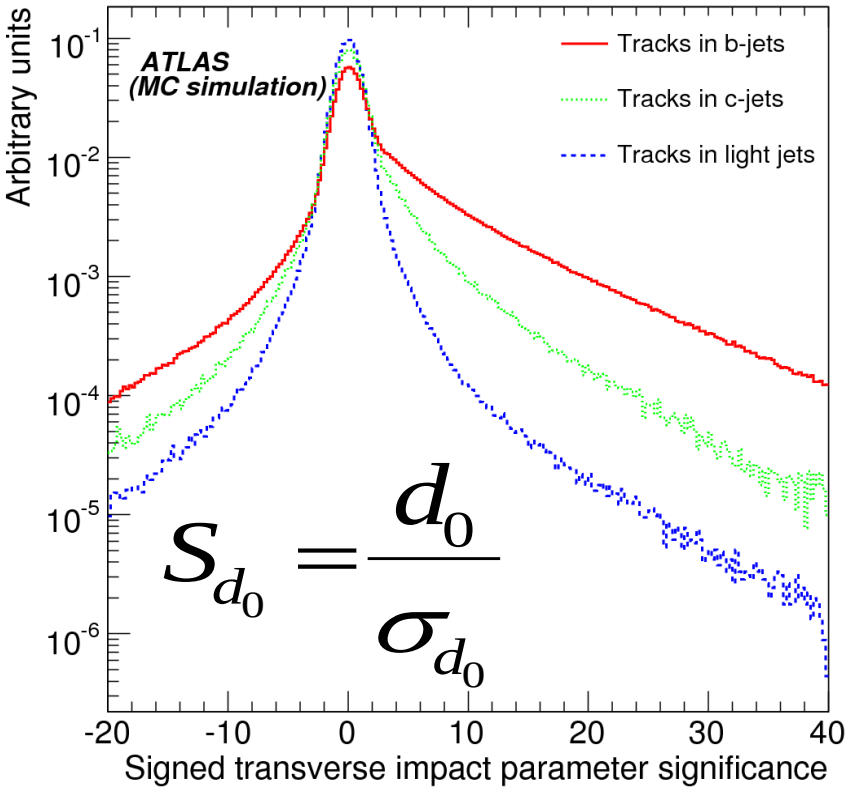


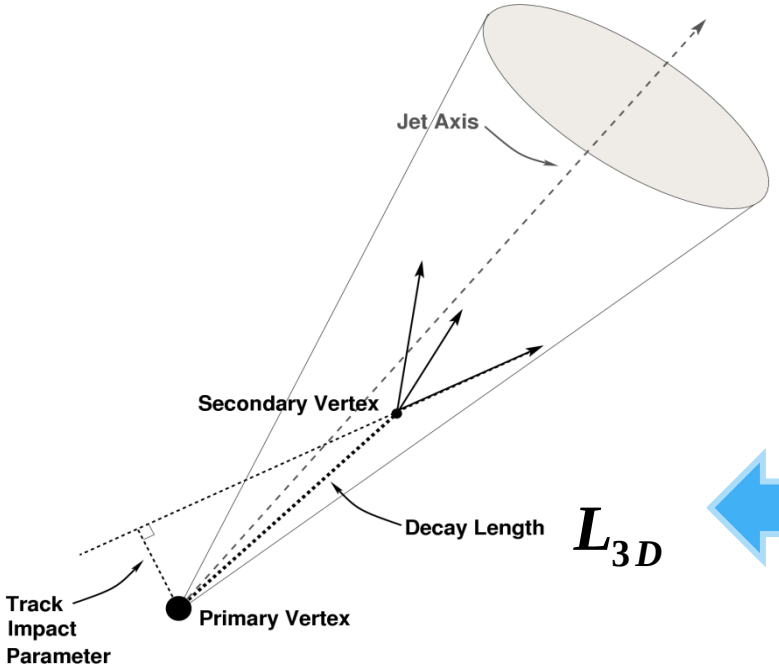
ATLAS b-tagging algorithms for first data

MC@14 TeV, taken from the ATLAS performance book (see ref. on last slide)

Based on track impact parameters :

- TrackCounting and JetProb
  - Discriminating variable : signed transverse impact parameter significance S_{d0}





Based on displaced secondary vertices :

- SV0
  - Discriminating variable : signed decay length significance S_{L3D}

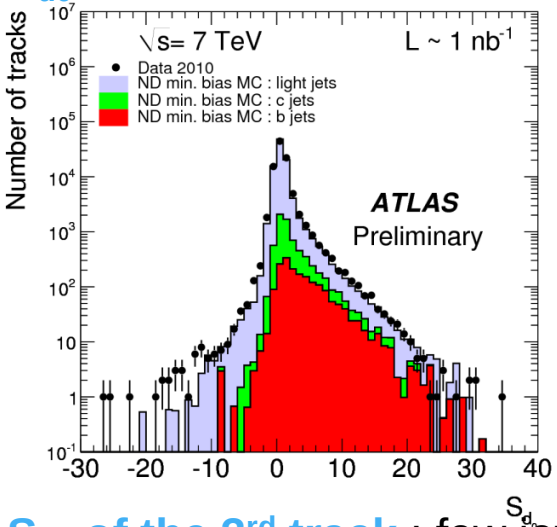
$$S_{L_{3D}} = \frac{L_{3D}}{\sigma_{L_{3D}}}$$

Plots shown in the following slides :
7 TeV data, 1nb^{-1}, minimum bias trigger

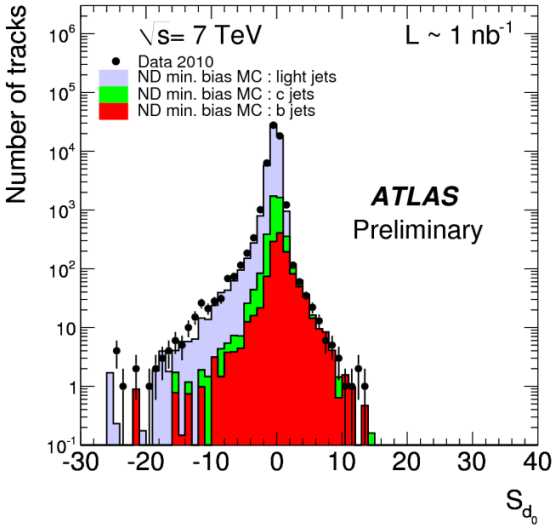
TrackCounting

- **TrackCounting**
  - Requires only a minimum number of good quality tracks with S_{d0} exceeding a given threshold
  - Discriminating variable : **S_{d0} of the 2nd track**, tracks being ordered in decreasing S_{d0}

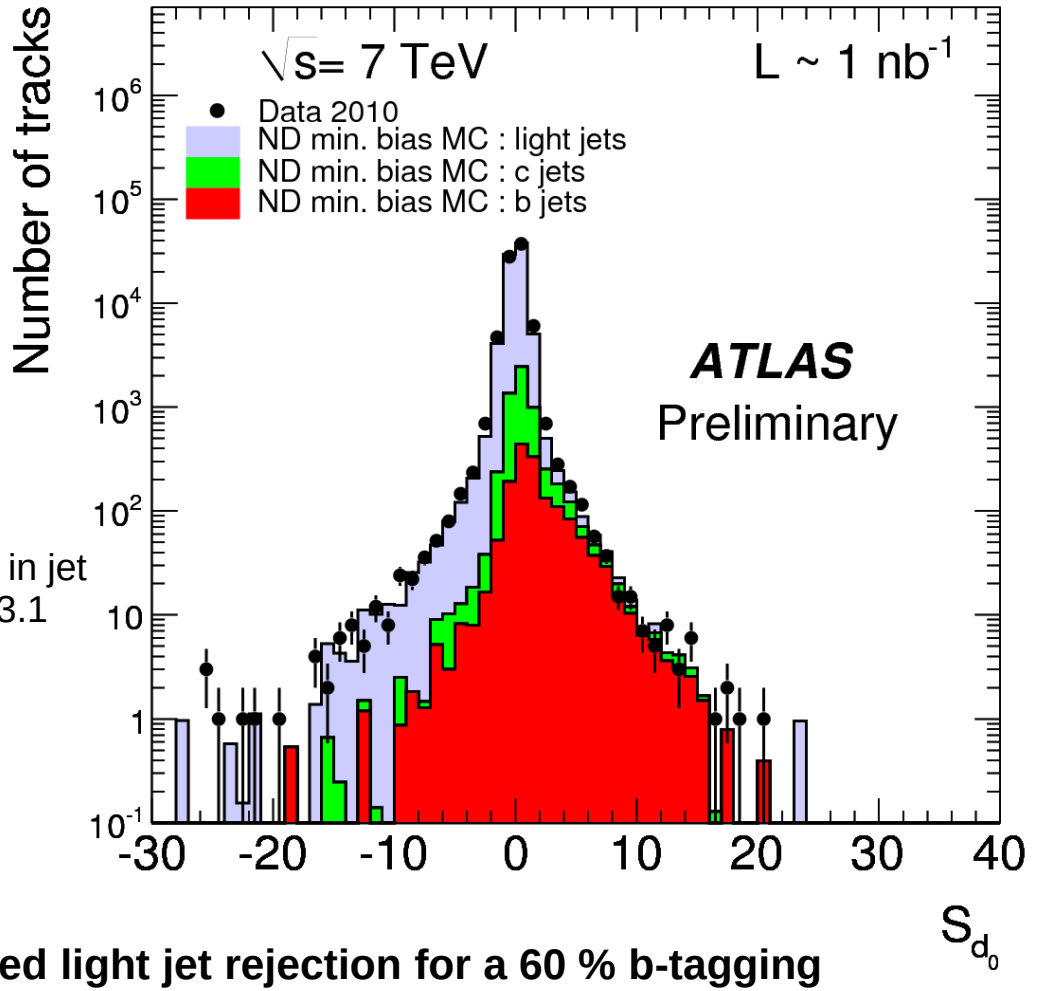
S_{d0} of the 1st track : not well discriminating



S_{d0} of the 3rd track : few jets*



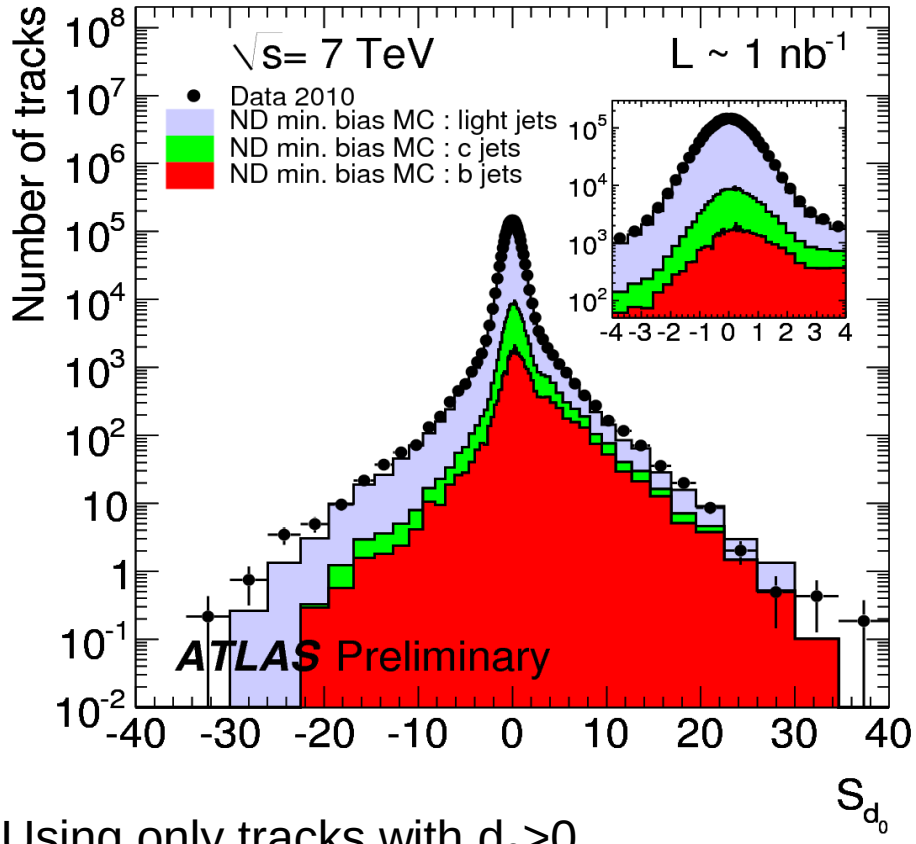
*Average track in jet multiplicity : 3.1



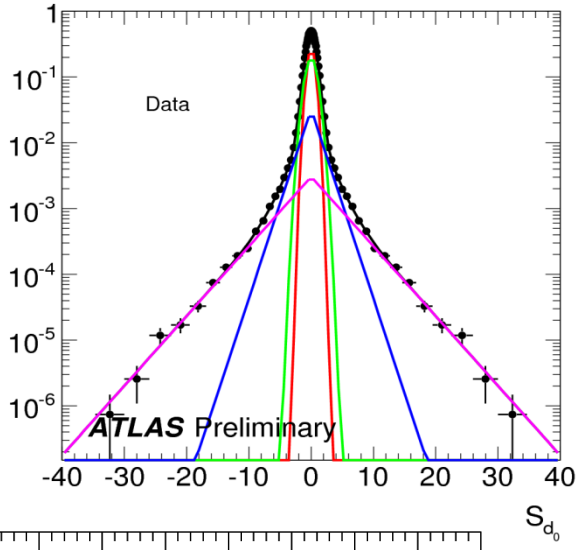
- **Expected light jet rejection for a 60 % b-tagging efficiency from MC @ 7 TeV (ttbar) : ~30**

JetProb : Track Probability

Computes the **probability for tracks in jet to be prompt**
Using a calibration function describing prompt tracks extracted from data

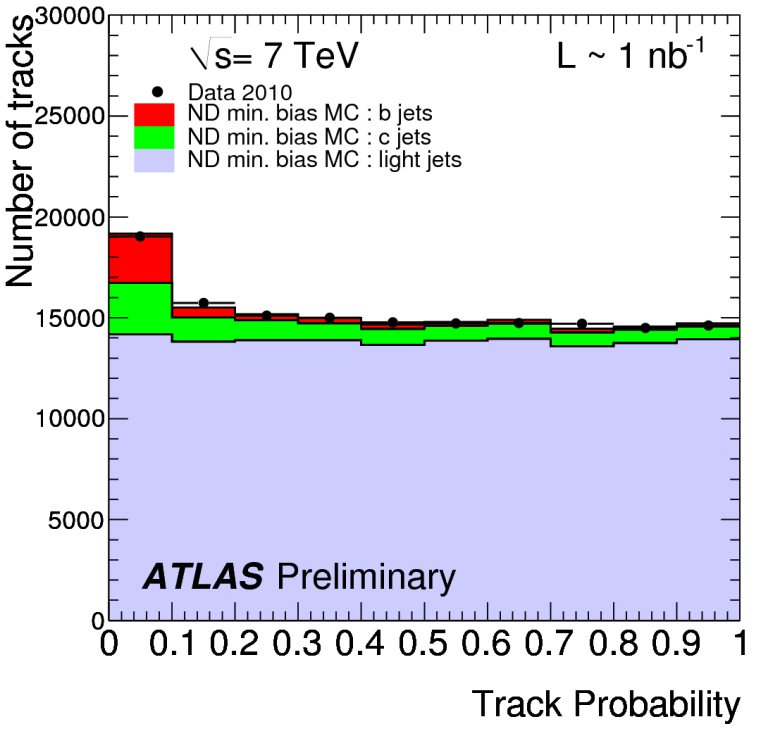


d_0<0 symmetrized



- Using only tracks with d_0>0
- Removing tracks reconstructed as coming from long-lived particles and material interactions

$$P_i = \int_{-\infty}^{-|d_0^i / \sigma_{d_0}^i|} \Re(x)dx$$

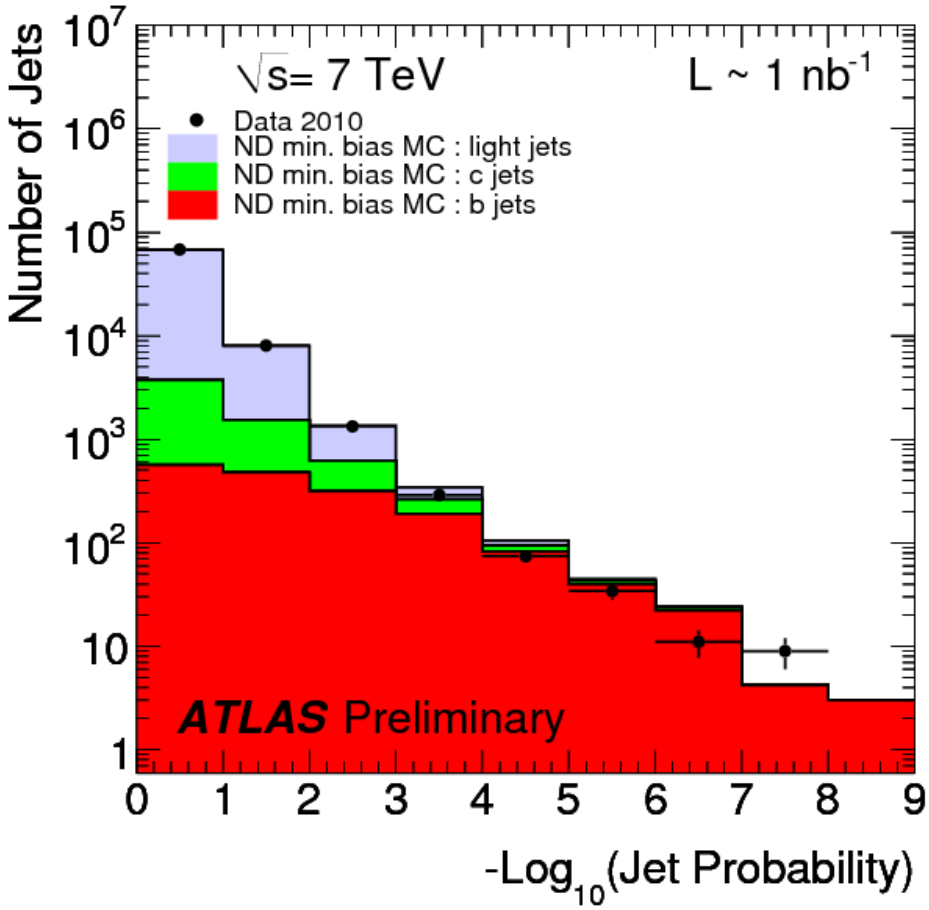


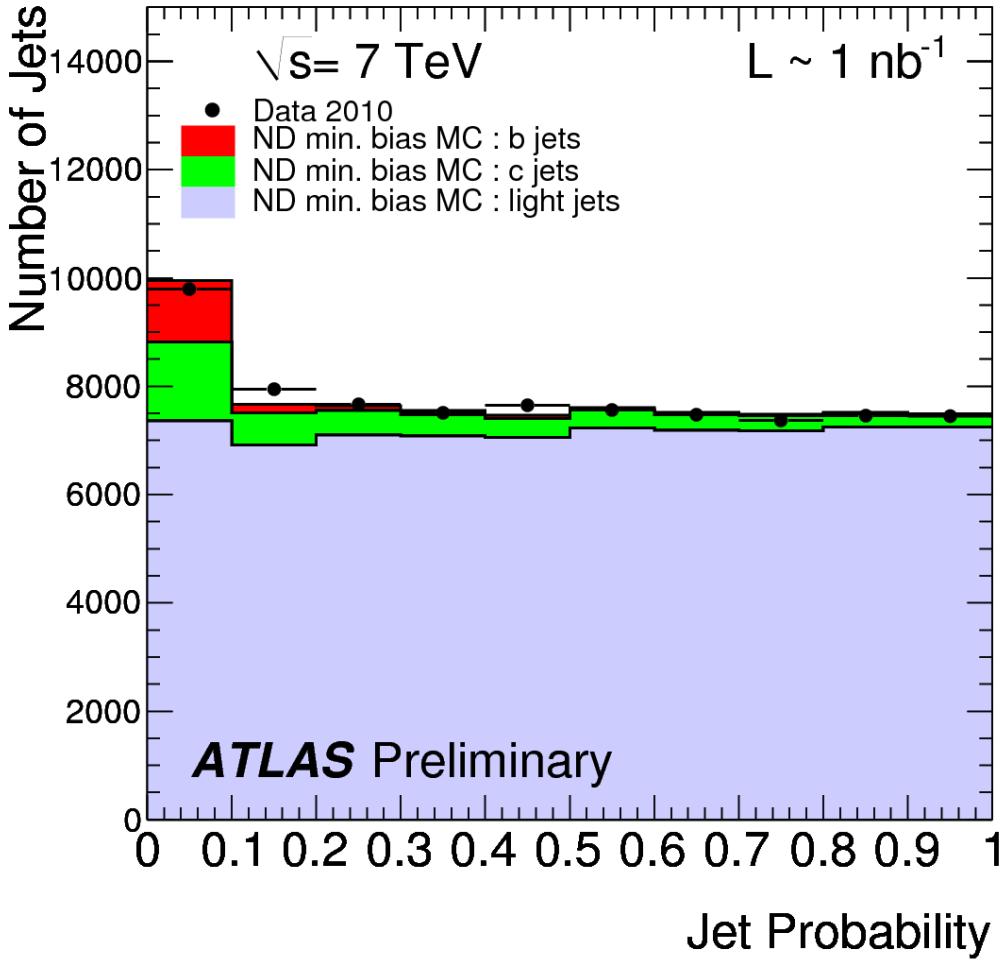
JetProb : Jet Probability

Computes the **probability for a jet to stem from light quark fragmentation**

$$P_{jet} = P_0 \sum_{j=0}^{N_{trk}-1} \frac{(-\ln P_0)^j}{j!}$$

$$where \ : P_0 = \prod_{i=1}^{N_{trk}} P_i$$

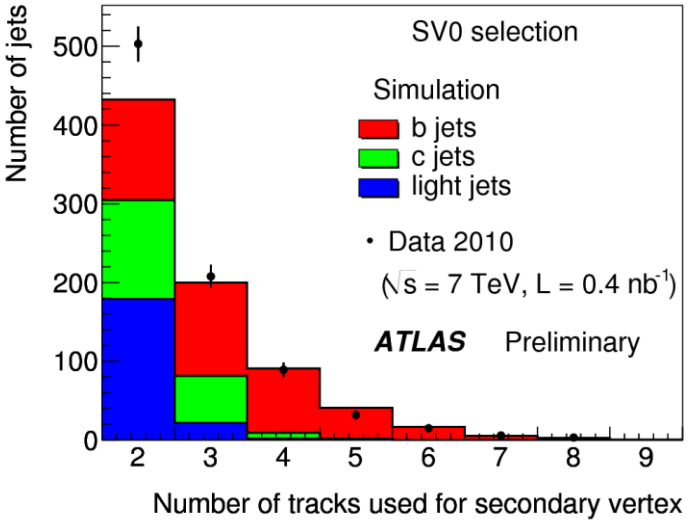


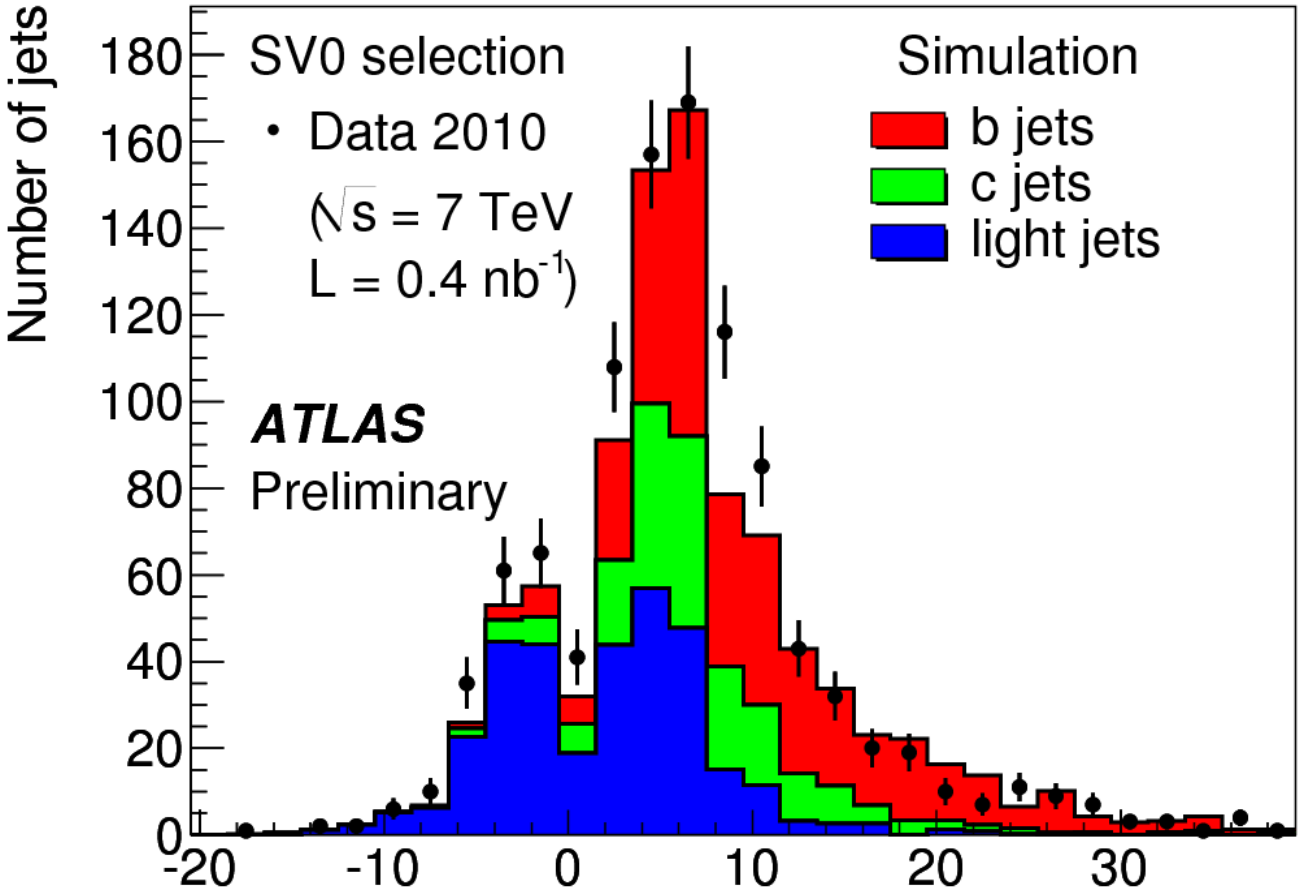


- **Expected light jet rejection for a 60 % b-tagging efficiency from MC @ 7 TeV (ttbar) : ~30**

SV0 (1)

- Secondary vertex reconstructed in ~60% of b-jets
- Plots are normalized to the total number of jets in data
- Discrepancies between data and MC can be explained by :
  - Different flavour composition
  - Different SV reconstruction efficiencies



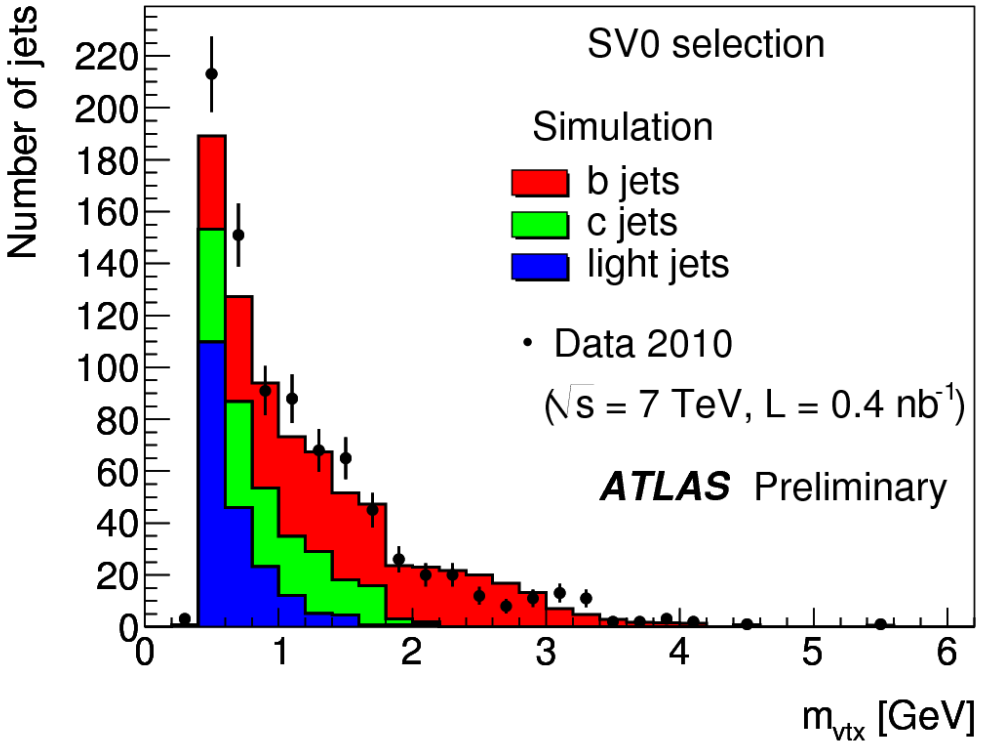


- **Expected light jet rejection for a 60 % b-tagging efficiency from MC @ 7 TeV (ttbar) : ~90**

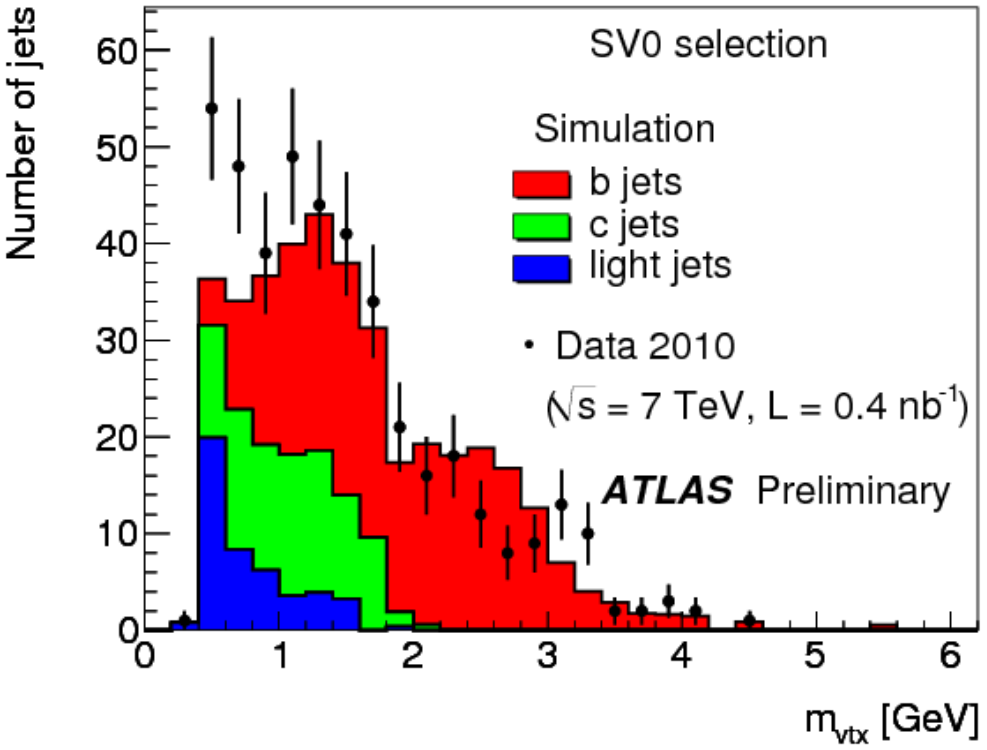
SV0 (2)

- Vertex mass → cutting on S_{L3D}

  - Using all jets with $S_{L3D}>0$



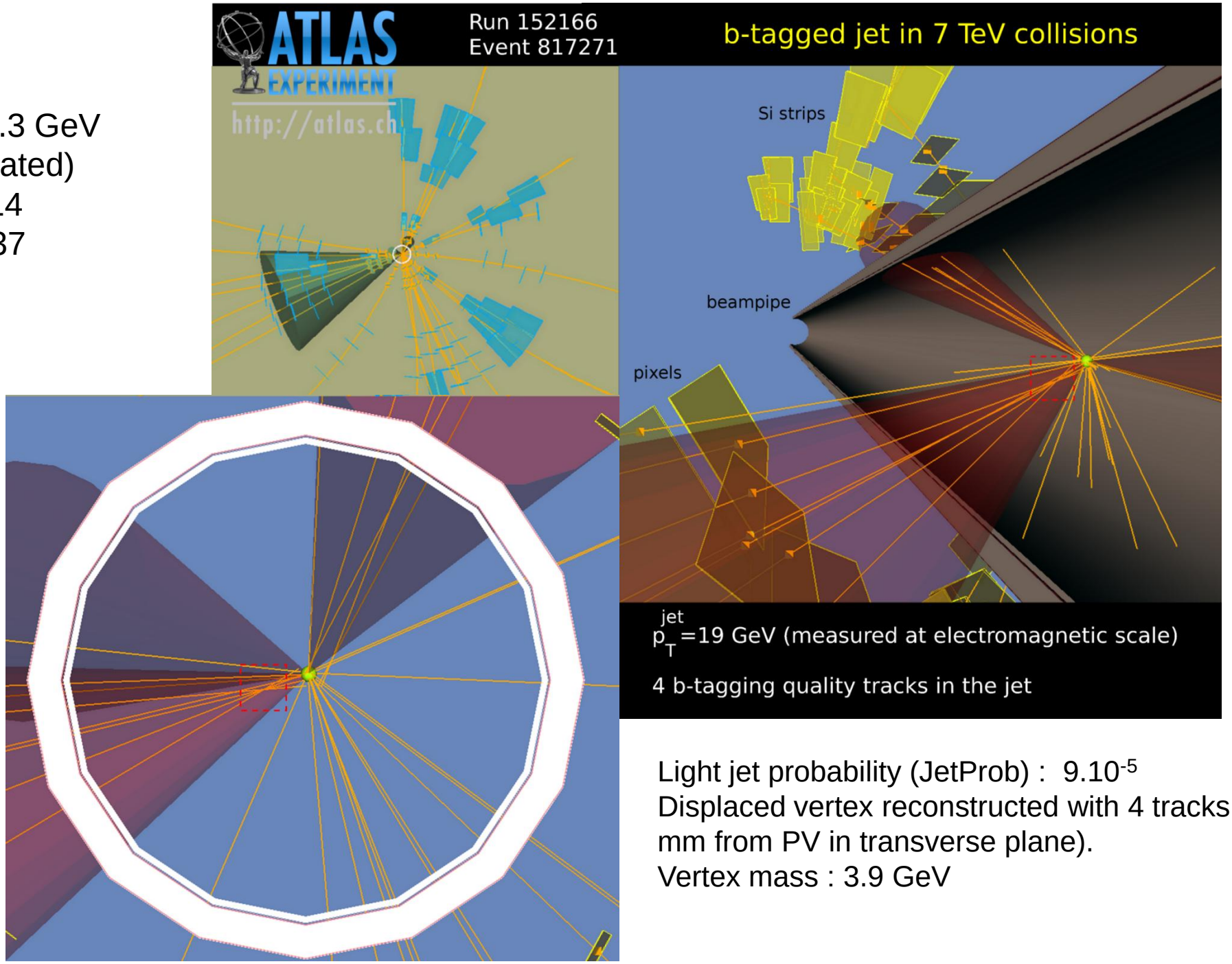
  - Using all jets with $S_{L3D}>7$



- **Large enhancement of b fraction when cutting on S_{L3D} demonstrates the power of the algorithm**

b-jet candidate in data @ 7TeV

Jet :
p_T=31.3 GeV (calibrated)
η=-0.14
φ=-0.37

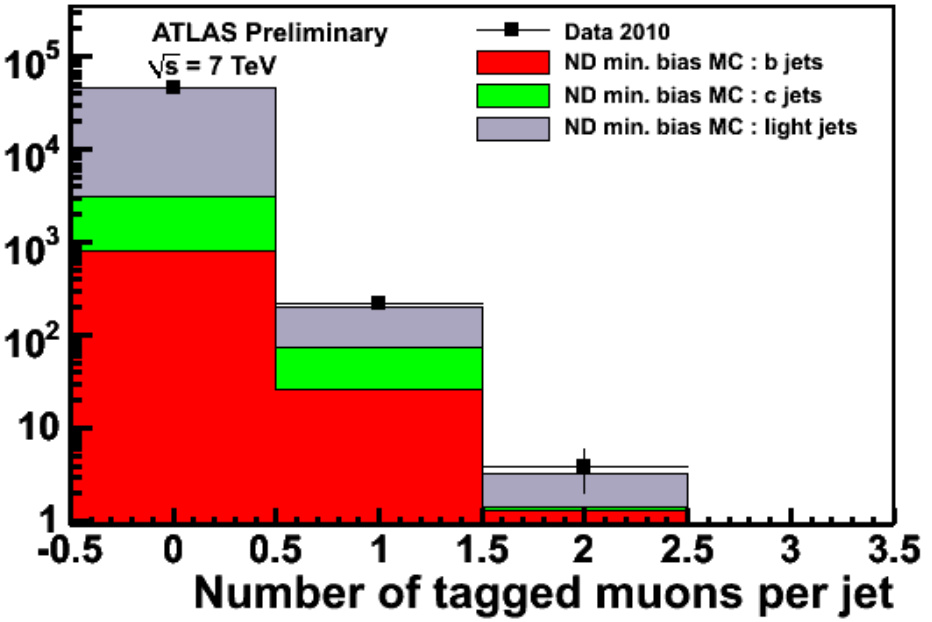


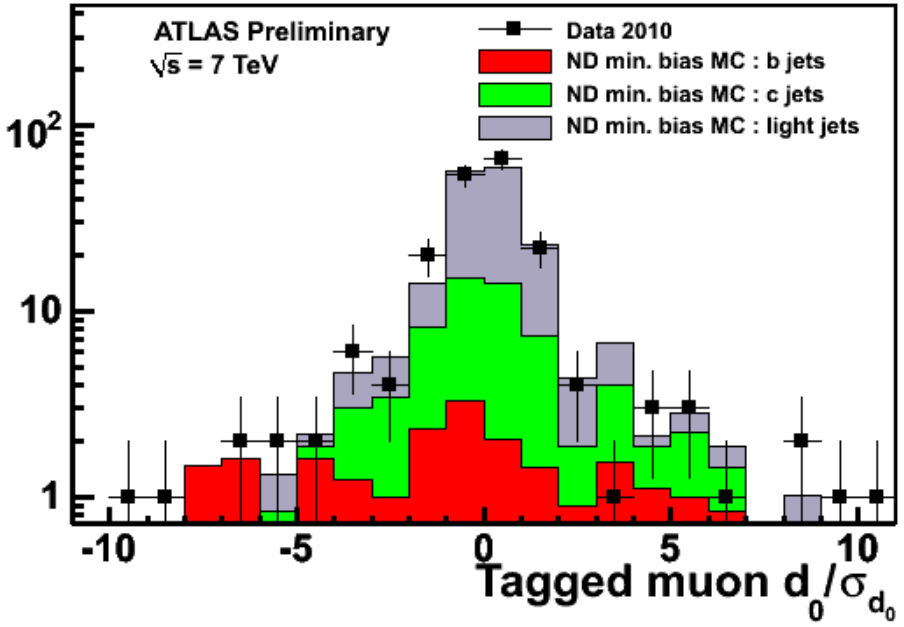
Light jet probability (JetProb) : 9.10^{-5}
Displaced vertex reconstructed with 4 tracks (5.8 mm from PV in transverse plane).
Vertex mass : 3.9 GeV

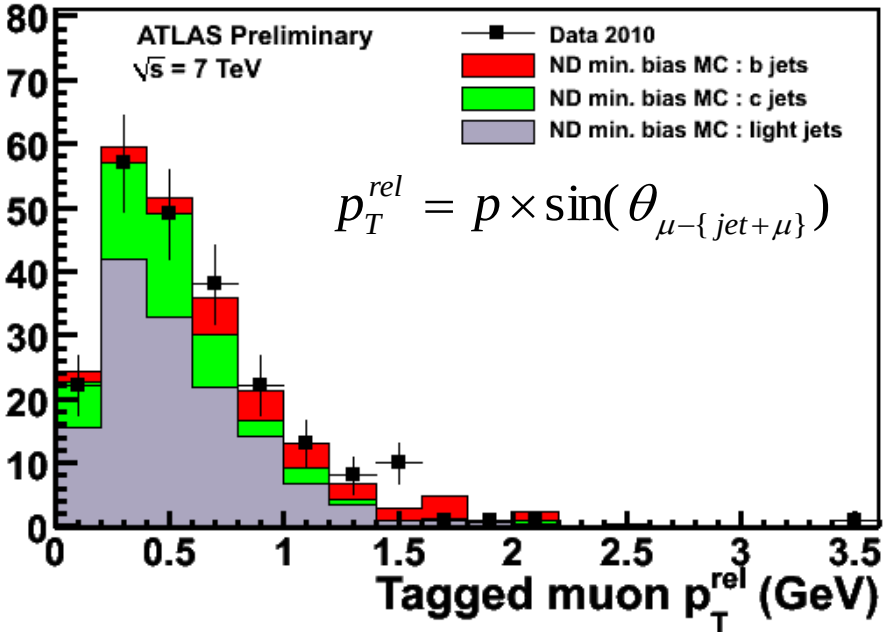
Muons

- Muon tagging :
  - Tagged muon :
    - p_T > 4 GeV
    - $|d_0|$ < 4mm
    - ΔR(Muon-Jet) < 0.4

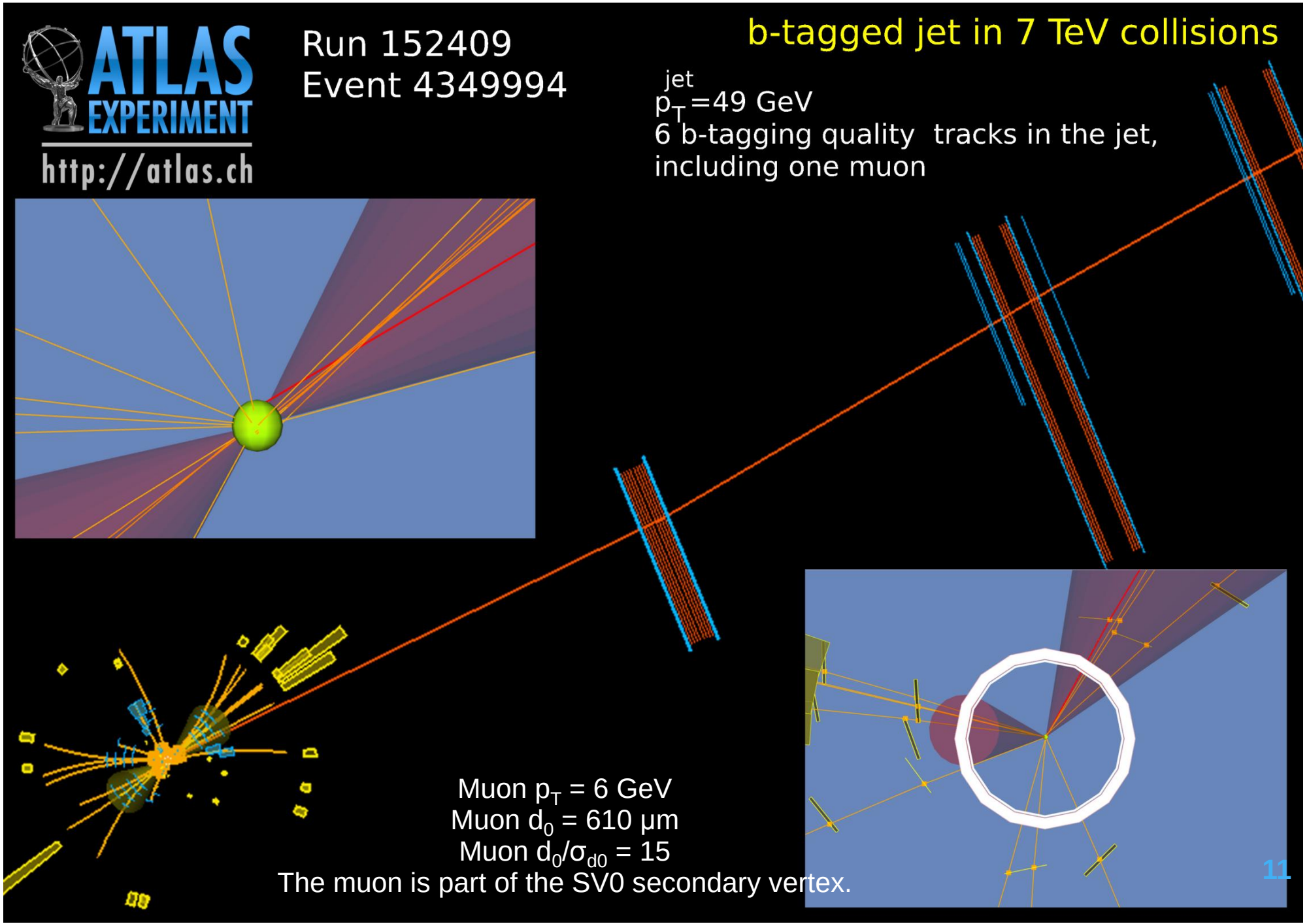
- Muons in jets play a key-role in the b-tagging calibration in early data (see next slides)





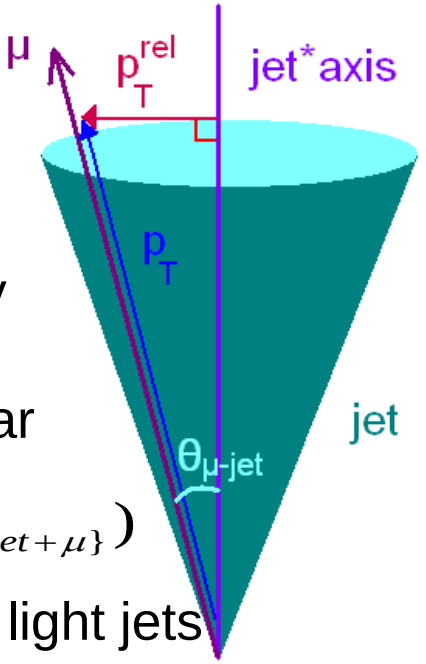


b-tagged jet with muon



Perspectives : b-tagging calibration in data

- Efficiency of the algorithms have to be measured in data : **Started this Summer**

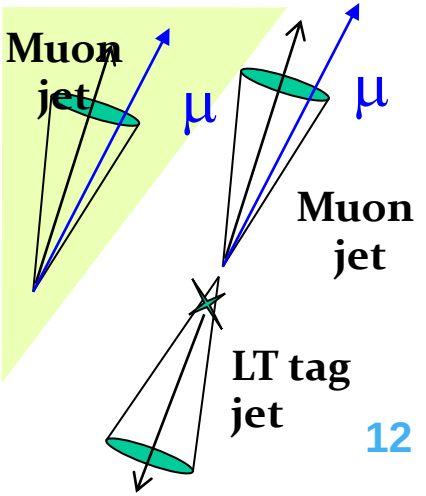


- Two methods for early data : p_T^{rel} and System8
  - Based on jets with muons
    - Measurement of the semileptonic jets b-tagging efficiency
    - Use a scale factor extracted from MC to obtain the efficiency for all jets
    - Works for jets with p_T up to ~80 GeV (above need to use ttbar samples, more stat. needed)

$$p_T^{rel} = p \times \sin(\theta_{\mu-\{jet+\mu\}})$$

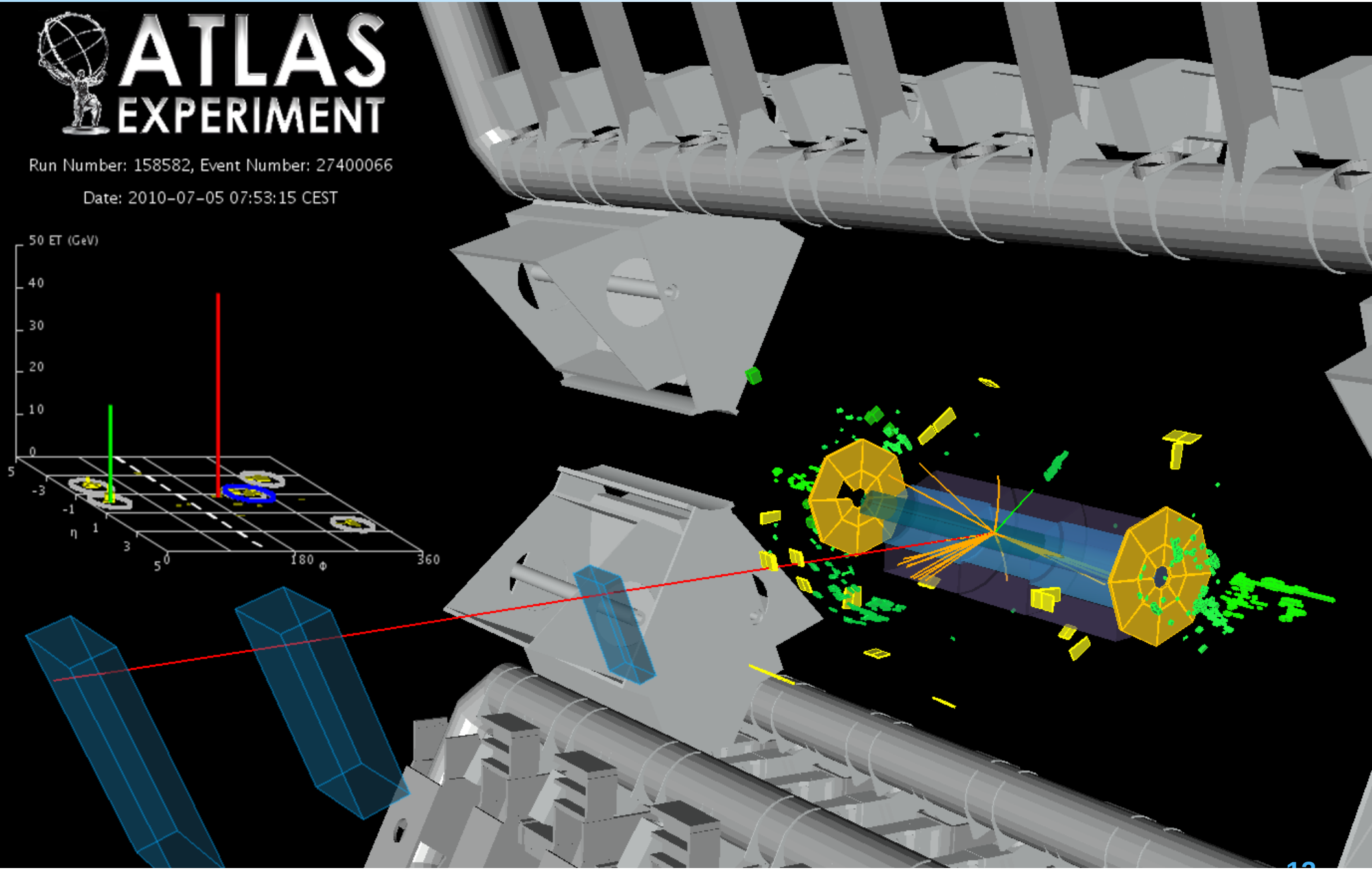
- p_T^{rel} :
  - Uses templates of the p_T^{rel} of the muon distributions in b, c and light jets
  - Fits them to the shape extracted from data before and after tagging
  - Extracts the fraction of b jets before and after tagging

- System8 :
  - Uses 2 samples with different b fractions and 2 taggers (soft muon tagger and a lifetime tagger to be calibrated)
  - Builds a system of 8 equations
  - b-tagging efficiency of the lifetime tagger is an unknown that is obtained by solving the system



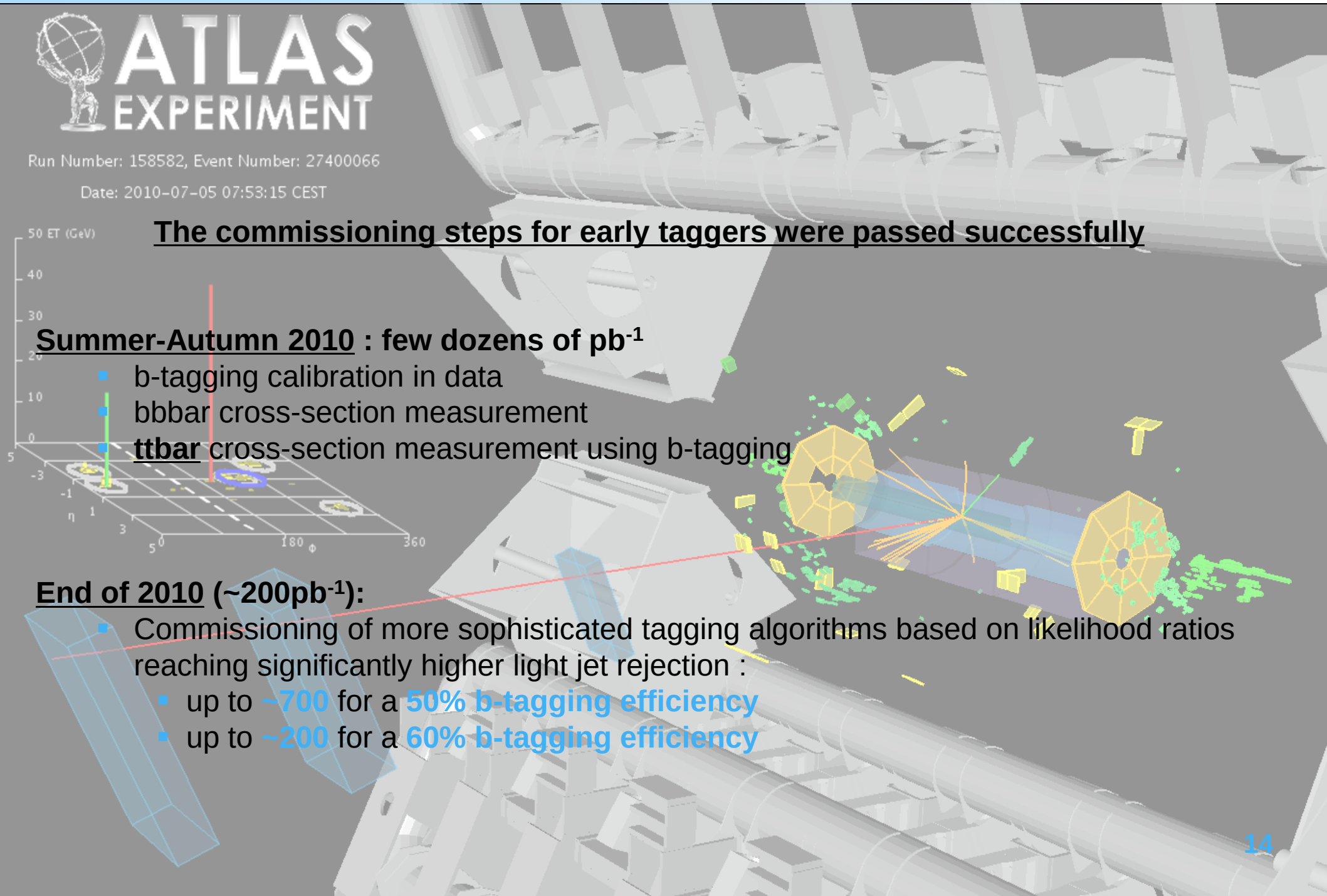
Results expected soon

Perspectives



Dileptonic (e-μ) ttbar event observed in 7 TeV data + Missing Transverse Energy + b-tagged jet (SV0 15.4, JP : 10^{-3})

Perspectives



The commissioning steps for early taggers were passed successfully

Summer-Autumn 2010 : few dozens of pb^{-1}

- b-tagging calibration in data
- bbbar cross-section measurement
- **ttbar** cross-section measurement using b-tagging

End of 2010 (~200pb^{-1}):

- Commissioning of more sophisticated tagging algorithms based on likelihood ratios reaching significantly higher light jet rejection :
  - up to **~700** for a **50% b-tagging efficiency**
  - up to **~200** for a **60% b-tagging efficiency**

Reference material

- **List of CONF Notes for 7 TeV Data :**

Tracking Studies for b-tagging with 7 TeV Collision Data with the ATLAS Detector (ATLAS-CONF-2010-070)

Impact parameter-based b-tagging algorithms in the 7 TeV collision data with the ATLAS detector: the TrackCounting and JetProb algorithms (ATLAS-CONF-2010-041)

Performance of the ATLAS Secondary Vertex b-tagging Algorithm in 7 TeV Collision Data (ATLAS-CONF-2010-042)

- **List of CONF Notes for 900 GeV Data :**

Tracking studies for b-tagging with 900 GeV collision data with the ATLAS detector (ATLAS-CONF-2010-003)

Performance of the ATLAS Secondary Vertex b-tagging Algorithm in 900 GeV Collision Data (ATLAS-CONF-2010-004)

First look at the JetProb b-tagging algorithm in the 900 GeV collision data with the ATLAS detector (ATLAS-CONF-2010-010)

- **ATLAS Performance book :**

ATLAS, G. Aad et al., Expected Performance of the ATLAS Experiment -Detector, Trigger and Physics, (2009), 0901.0512