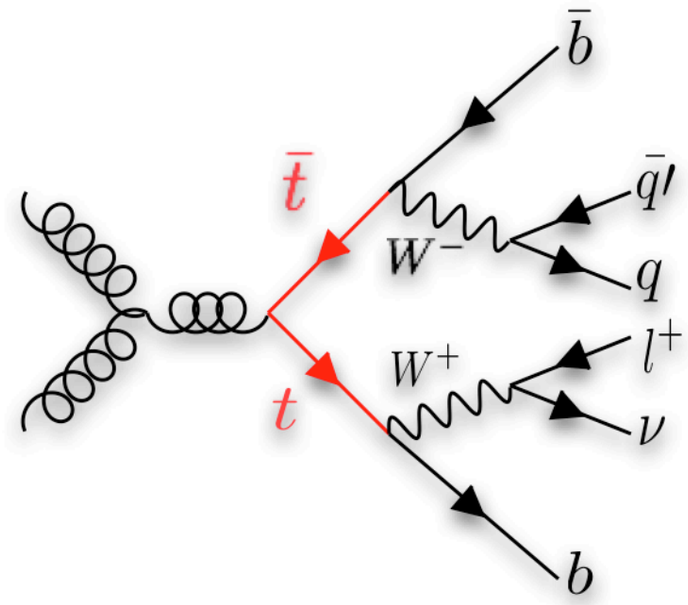
PHYSIKALISCHES INSTITUT

universitätbonn
Rheinische Friedrich-Wilhelms-Universität Bonn

Understanding backgrounds towards a first measurement of the top quark pair cross-section at ATLAS

B. Radics on behalf of the ATLAS collaboration

University of Bonn



FSP 101 ATLAS

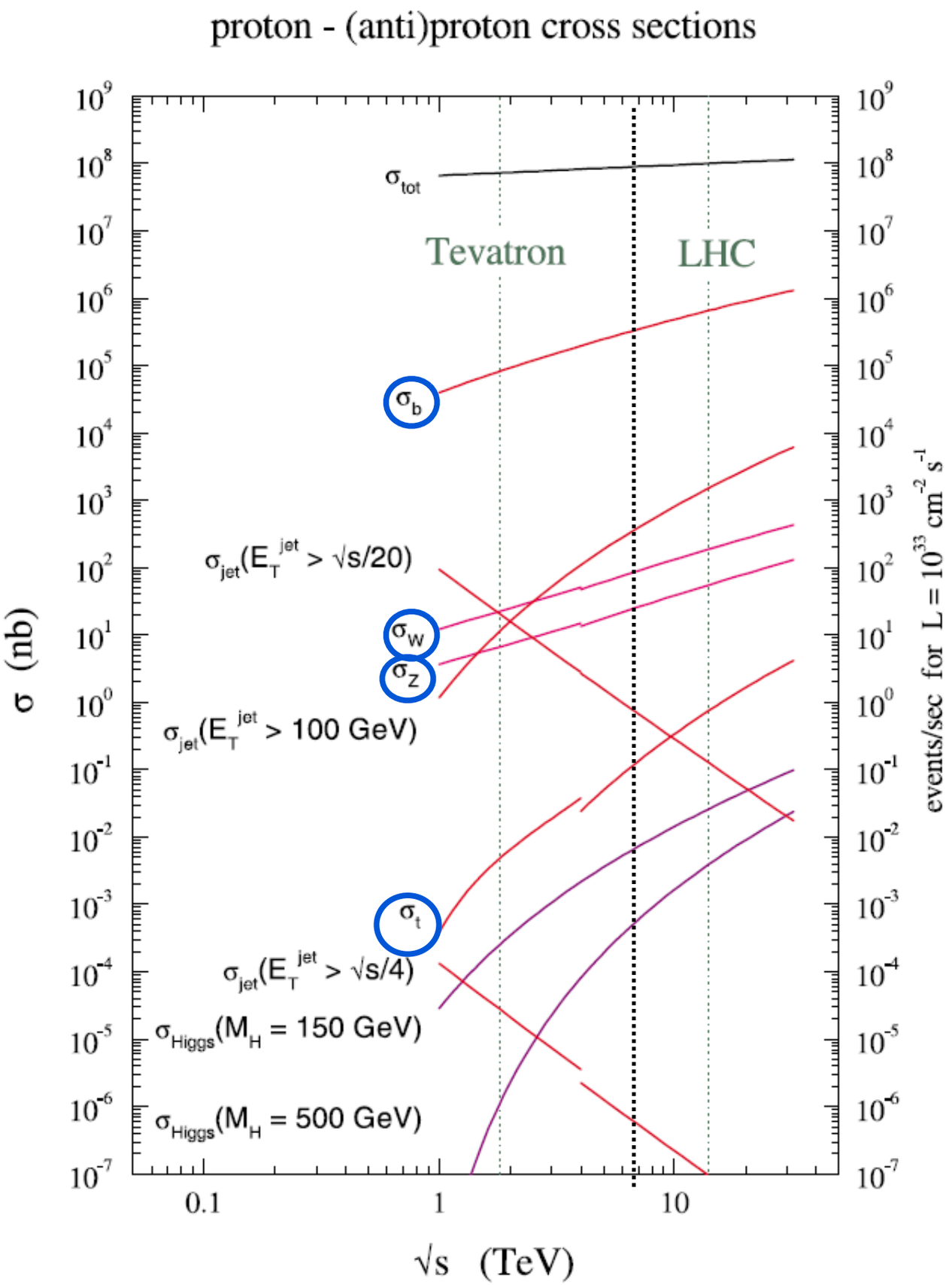
ATLAS

HQL Frascati, 14.10.2010

Outline

- Introduction: top pair signal and backgrounds
- The ATLAS detector
- Strategy for top quark search
- Performance of physics objects reconstructions
- Top quark candidate search using $\int L dt = 295\ nb^{-1}$
- Summary

Top pair signal and backgrounds



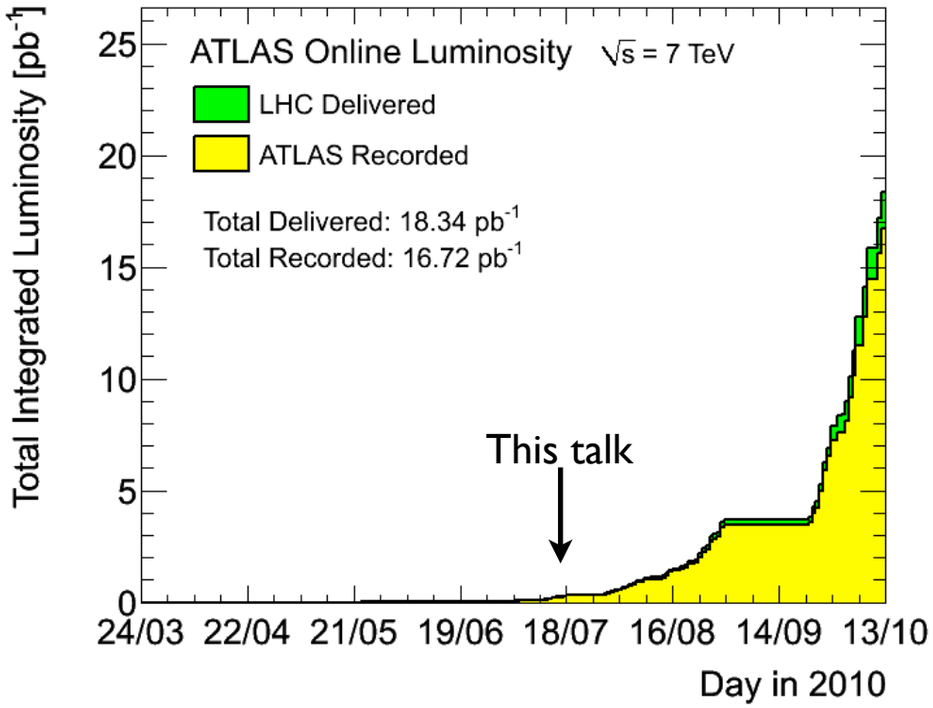
At ∫Ldt = 295 nb^{-1} we expect:

- ~15 events in l+jets, l=e,μ
- ~2 events in (ee, μμ, eμ)

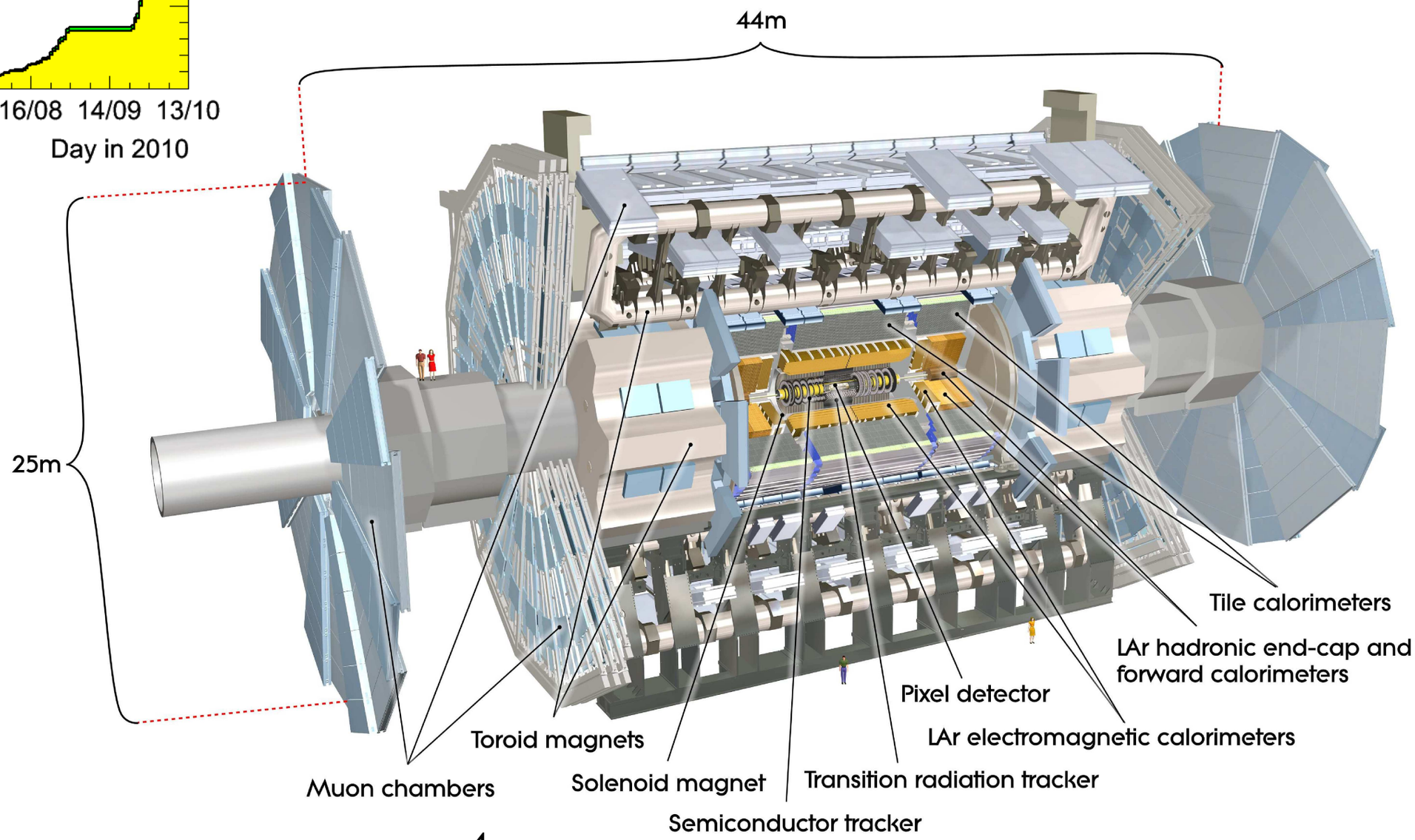
Tasks:

- Validate object reconstruction (quality, trigger, reconstruction, calibration, validate Monte Carlo predictions)
- Estimate QCD and W/Z backgrounds (HF/LF, data-driven methods vs. simulations)

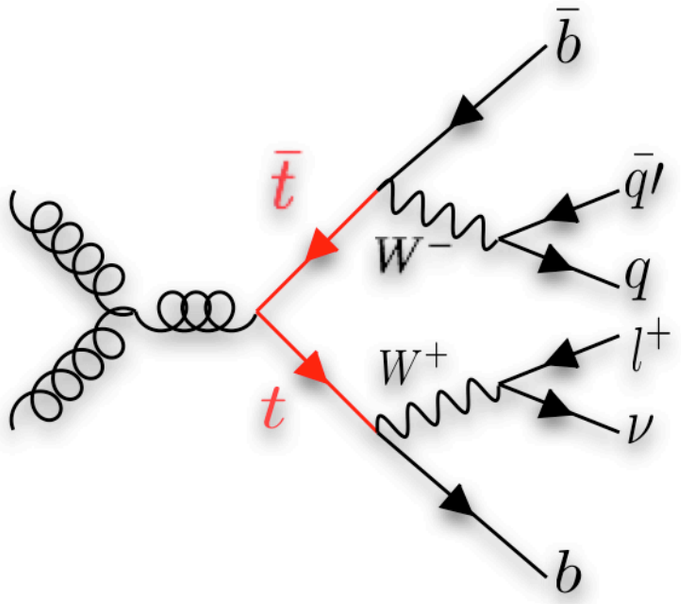
The ATLAS detector

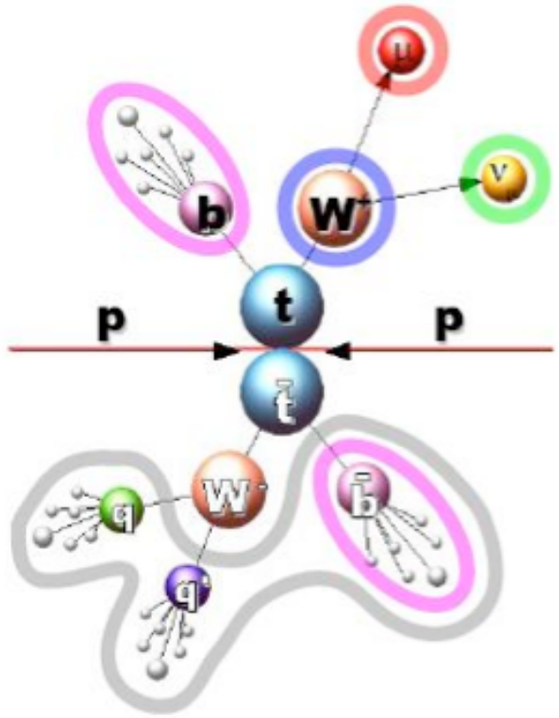


- Operational detector fraction >97%
- $\int L\,dt > 16\ pb^{-1}$ recorded



Strategy for top quark search





- Channels for early discovery: single lepton + jets (this talk), dilepton channel
- Trigger single lepton (electron or muon)
- Reconstruct single offline, isolated lepton
- Missing transverse energy
- Jet selection

Electron selection

Medium electrons:

- EMCal strips against pions (shower size, fraction of energy)
- Hits in Pixel, SCT, track impact parameter
- E_T^{HCal1}/E_T^{EMCal}

Tight electrons

- > 1 hit in vertexing layer (n_{BL})
- Fraction of high threshold hits in TRT (TRfrac)

Sources for electrons:

- W and Z boson decays
- Heavy flavor decays
- Photon conversions
- Fakes from charged hadrons

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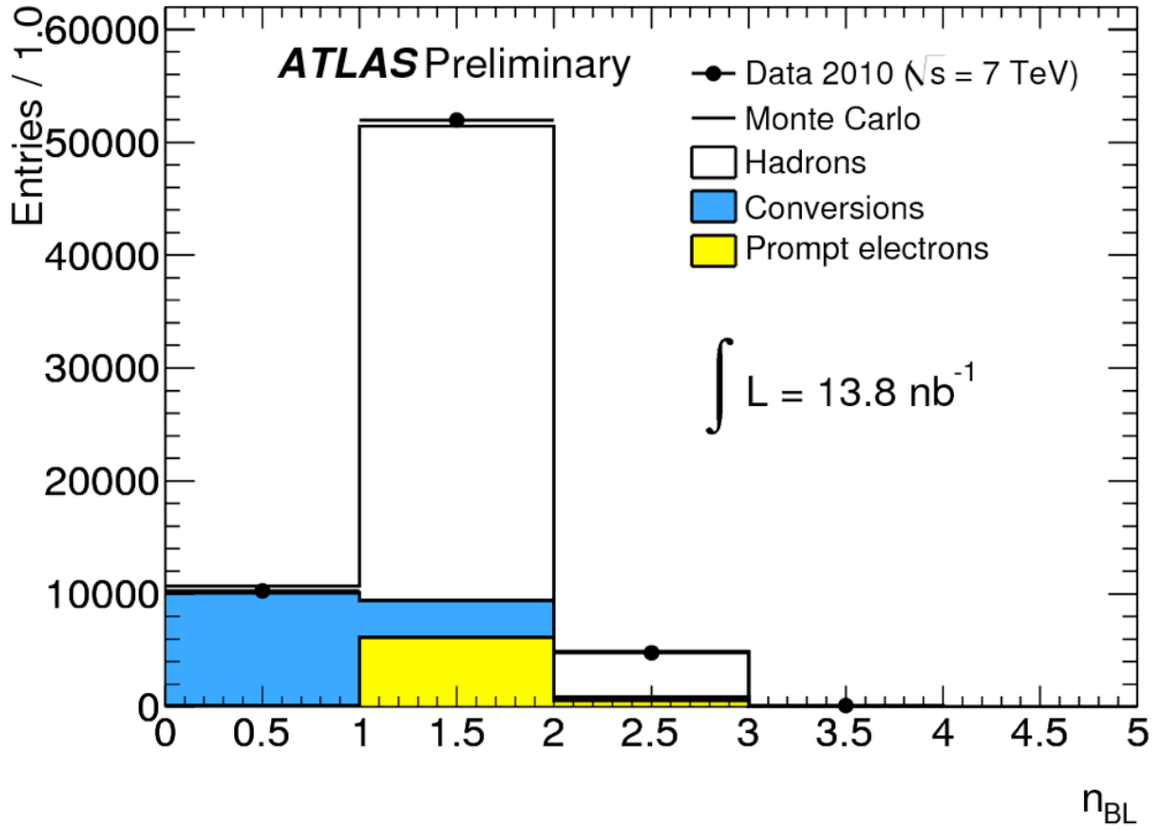
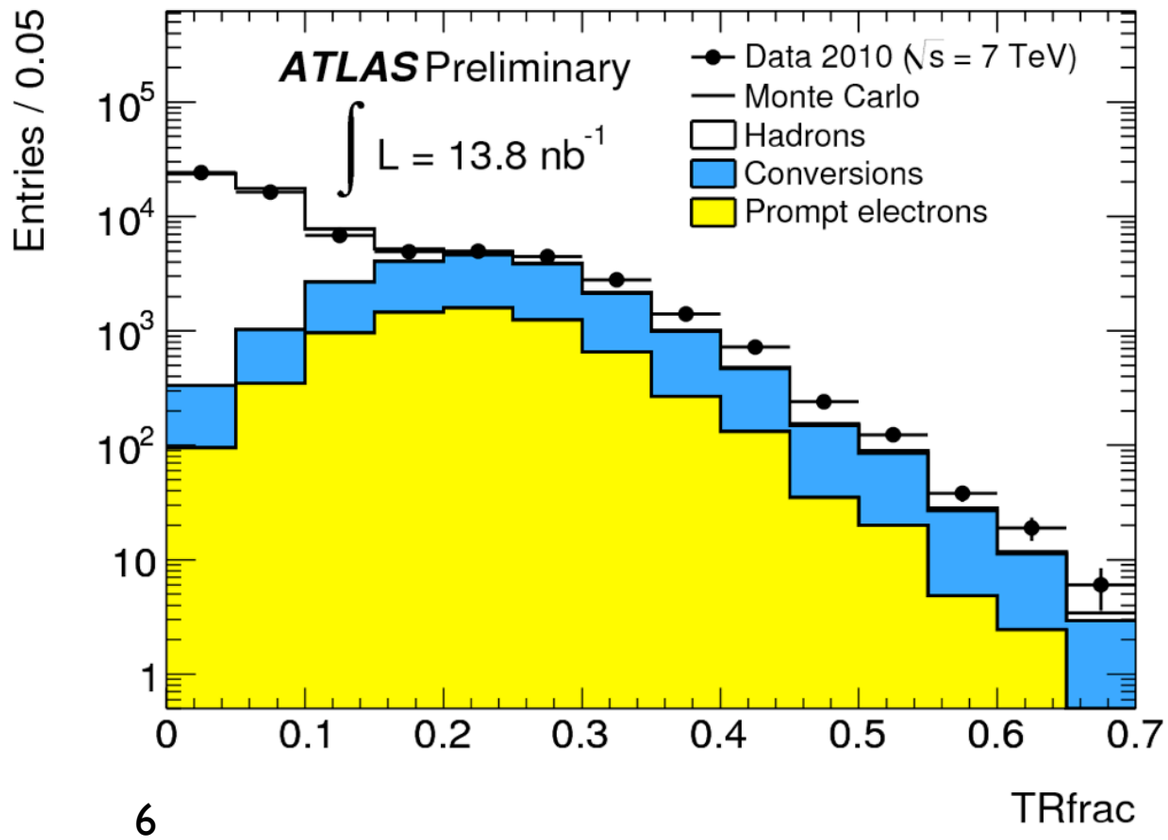




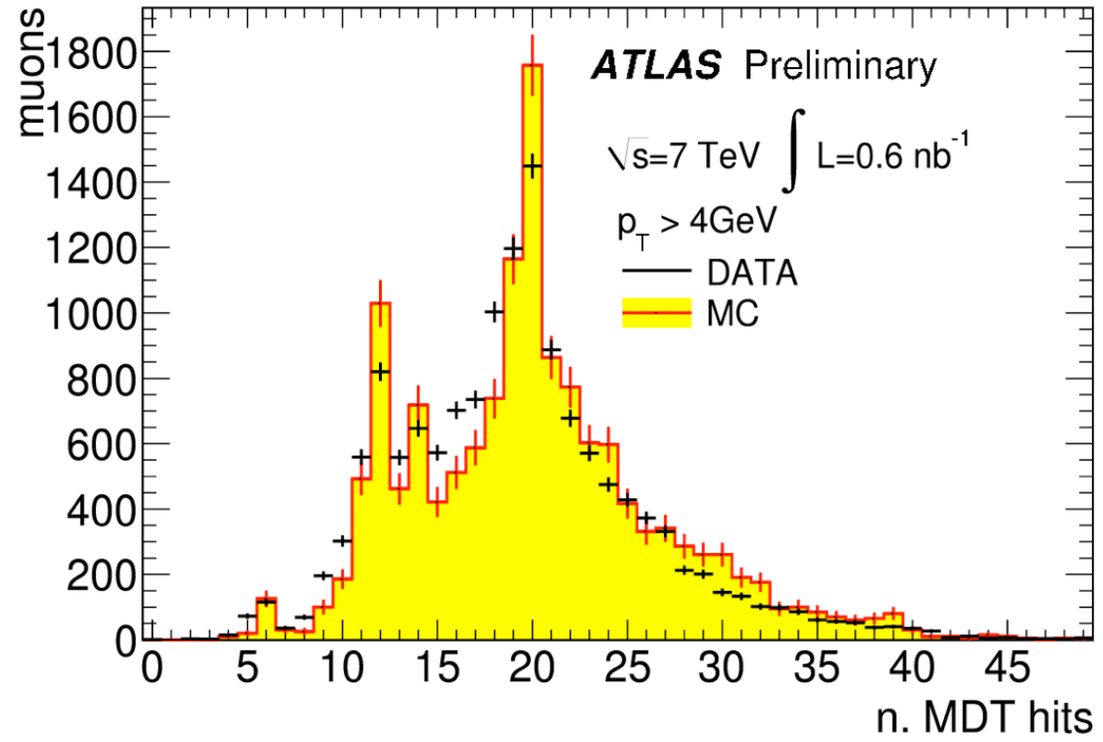
Muon selection

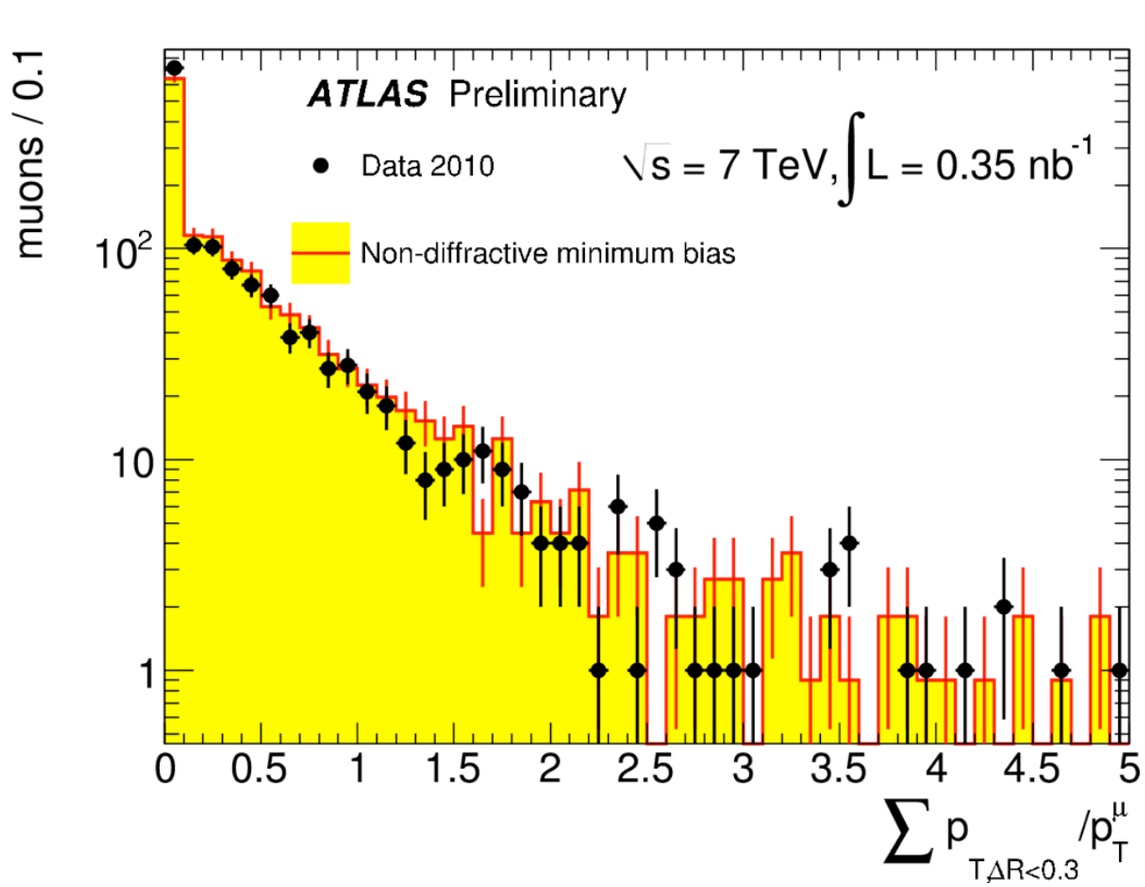
Identification

- Muon Spectrometer (MS)
- Inner Detector (ID)
- Use “combined ID+MS muons” by χ^2 match
- Combination:
  - statistical combination of ID, MS tracks
  - refit of ID+MS track

Muon isolation

- Sum of energy deposited around a combined muon
- Sum of transverse momenta of tracks around a combined muon
- Tool to suppress fake muon background





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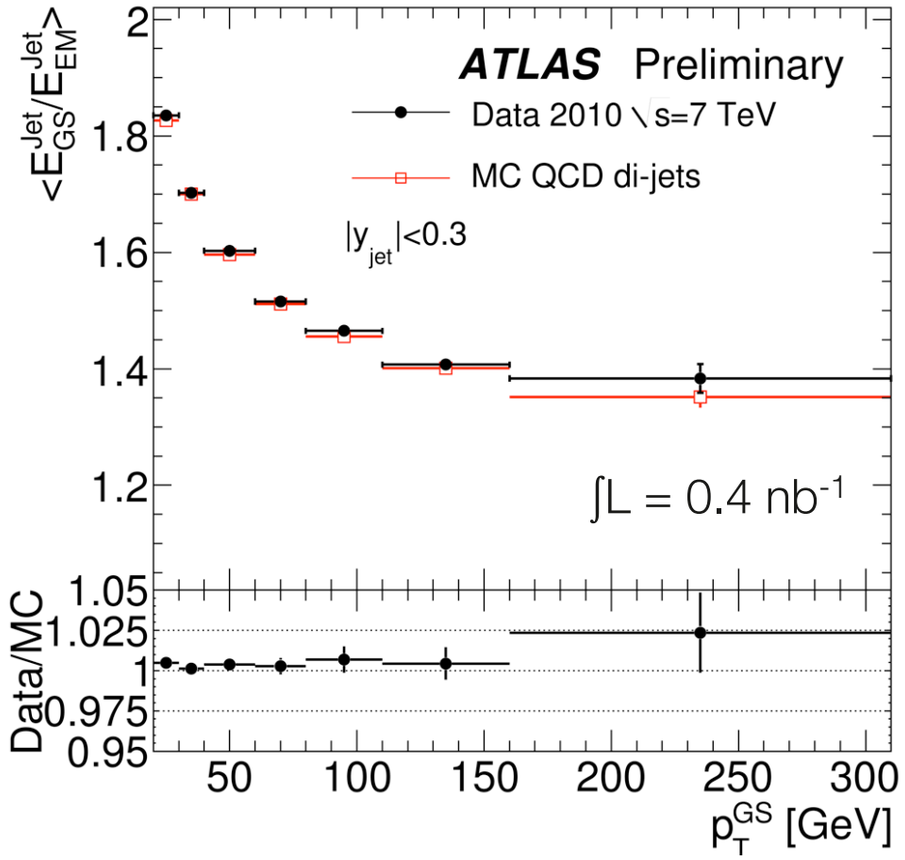
Jet reconstruction and calibration

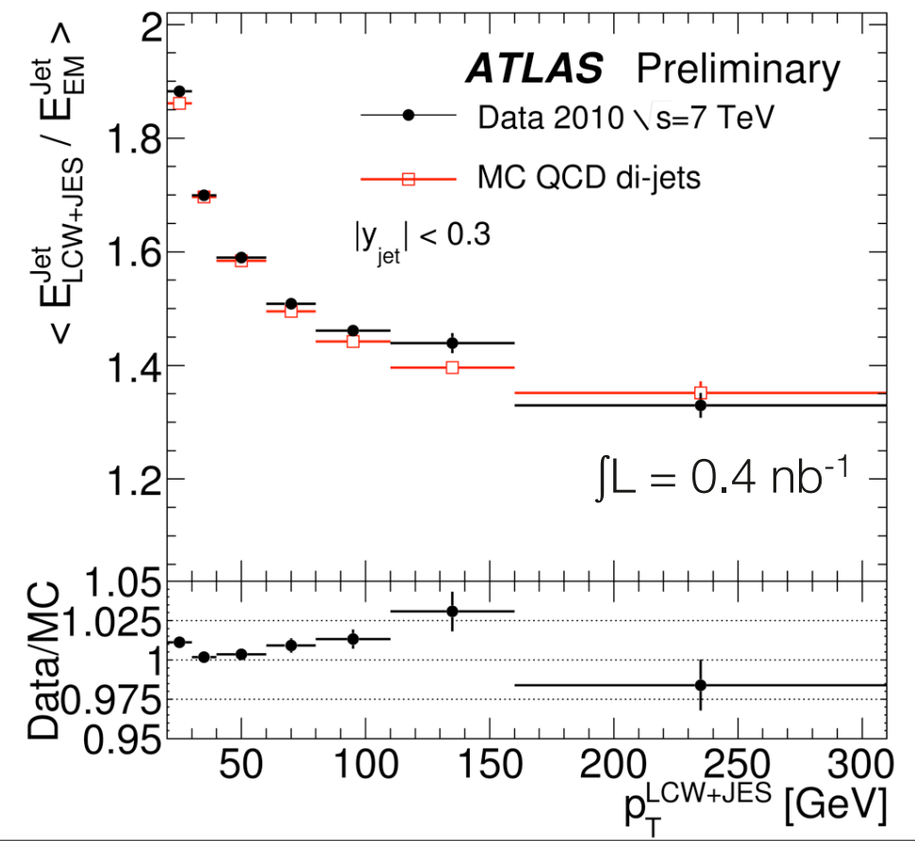
Jet reconstruction

- Anti-Kt algorithm with R=0.4-0.6
- Start with cells regrouped in clusters

Jet calibration schemes

- EM+JES scale: corrections from MC to bring from EM to hadronic scale
- Global Sequential: EM+JES+ add jet-by-jet information (shower shape)
- Global Cell energy-density Weighting: use cell weights to compensate for response of hadronic and em signals
- Local Cluster Weighting: use cluster properties for individual calibration derived from MC simulation of pions





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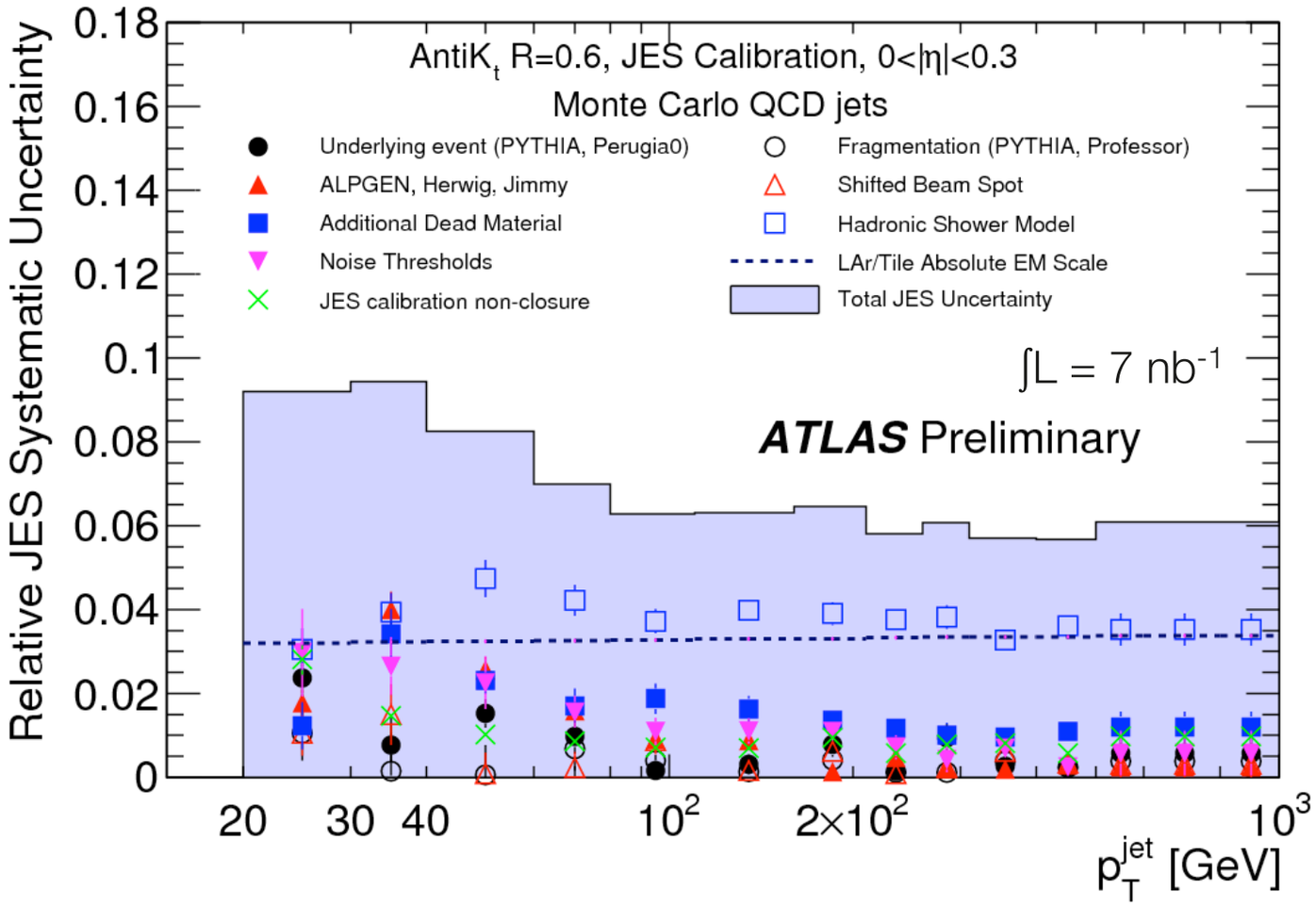
Jet energy scale and resolution

Jet energy scale uncertainty

- Dominant sources of systematics:
- Hadronic shower model (5%)
- Dead material (4%)
- Electronic noise (3%)
- LAr/Tile absolute EM scale (3%)



Jet resolution

- Select back-to-back jet events
- Measure A = (p_T^{probe} - p_T^{ref})/ $p_T^{average}$
- Compare MC and data
- Agreement within ~14%

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Missing Transverse Energy

Missing E_T definition

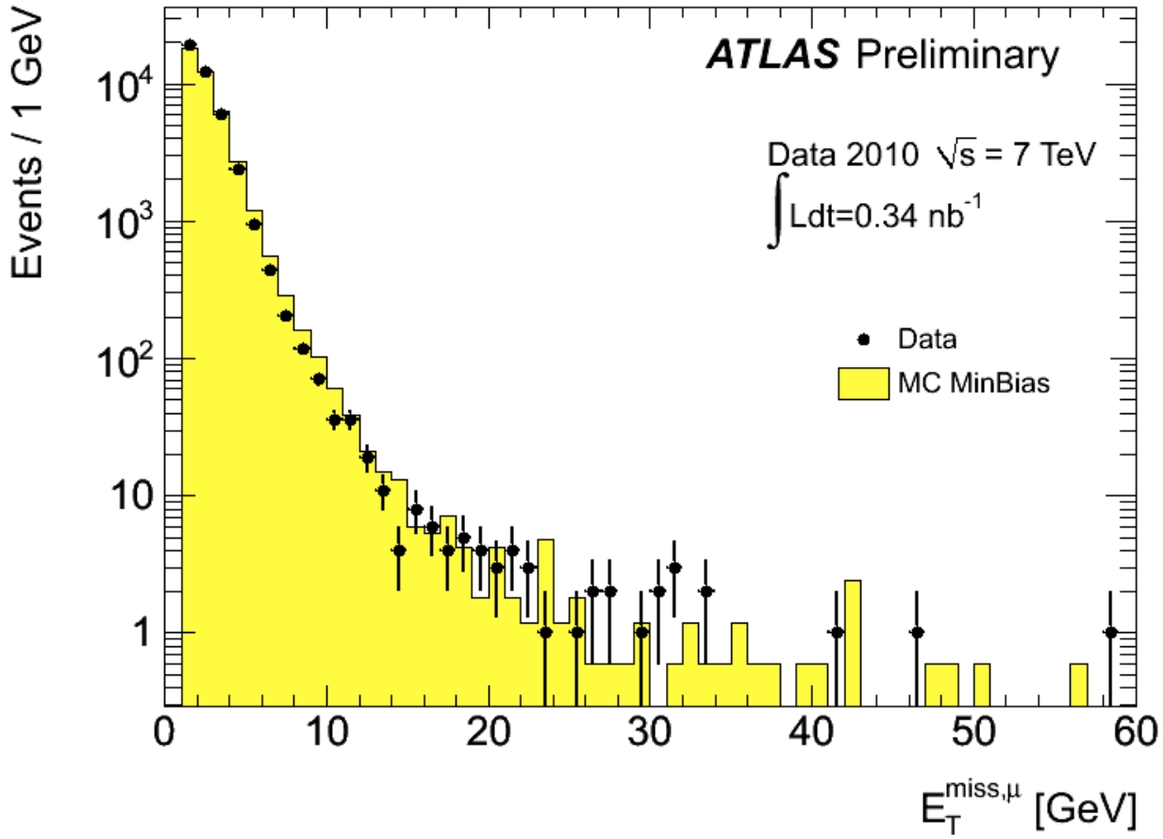
- Calculated from cells in clusters above noise and muon contribution

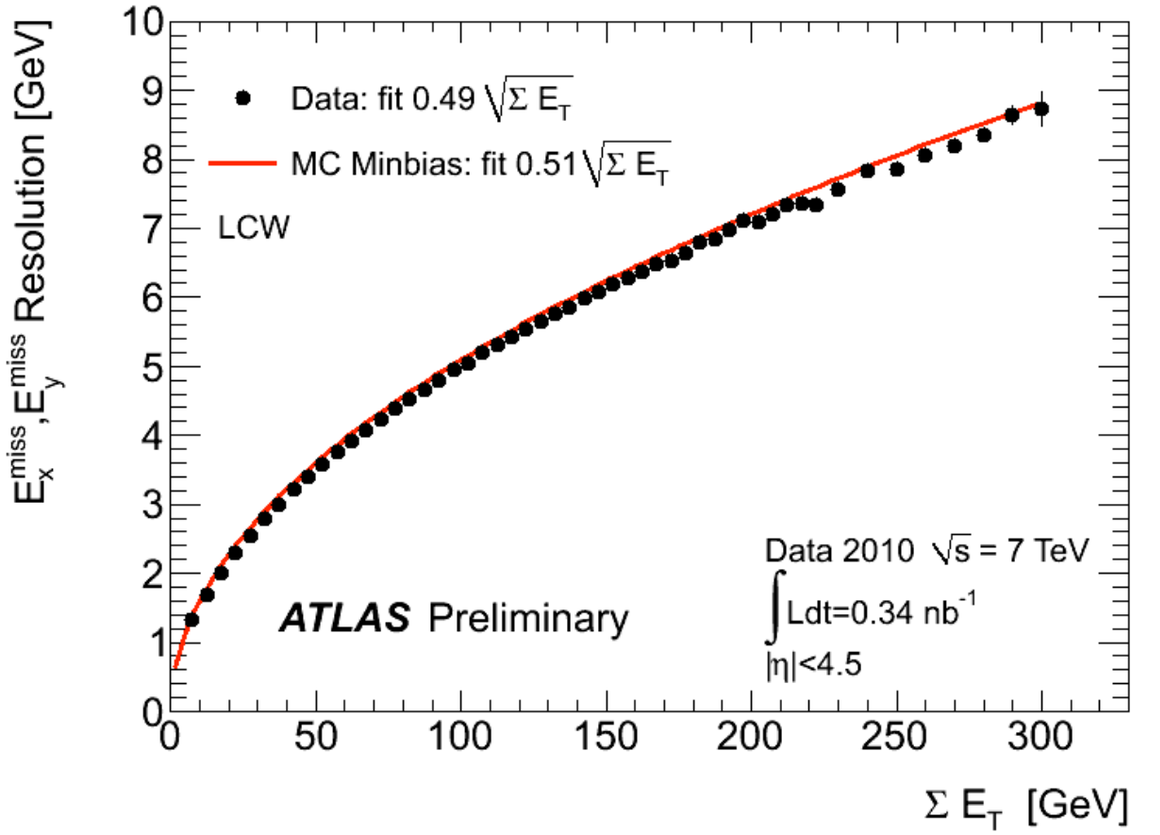
Missing E_T calibration

- Global cell weighting or Local cluster calibration
- Add corrections from reconstructed physics objects:
- $E_T^{miss,corr} = E^{e}_T + E_T^{\gamma} + E_T^{\tau} + E_T^{jets} + E_T^{calo,\mu} + E_T^{cellOut}$

Missing E_T resolution

- Reasonable agreement between data and MC





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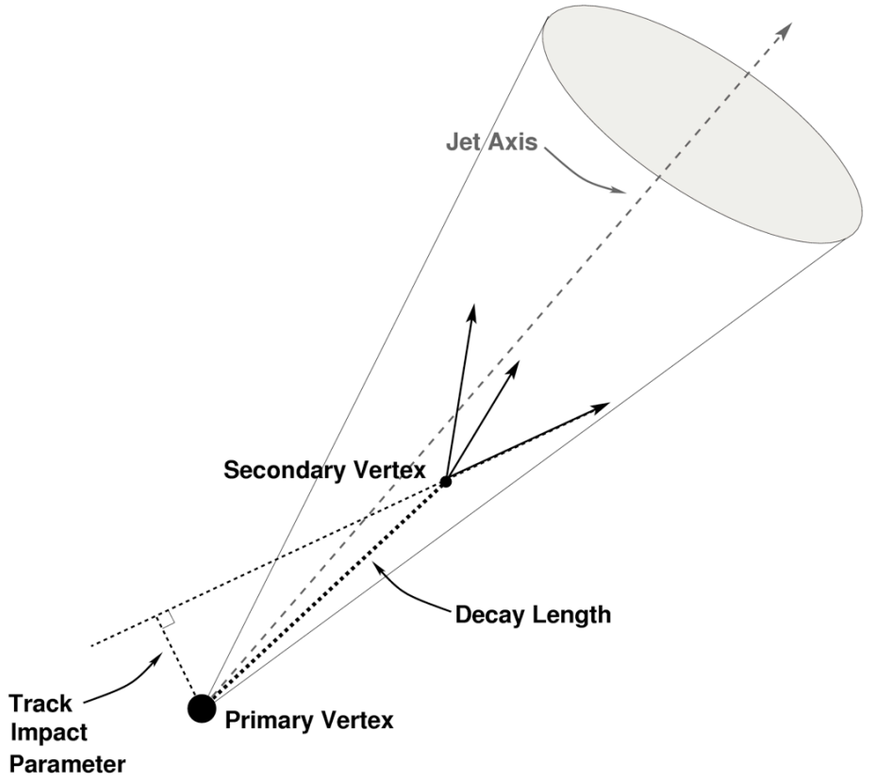
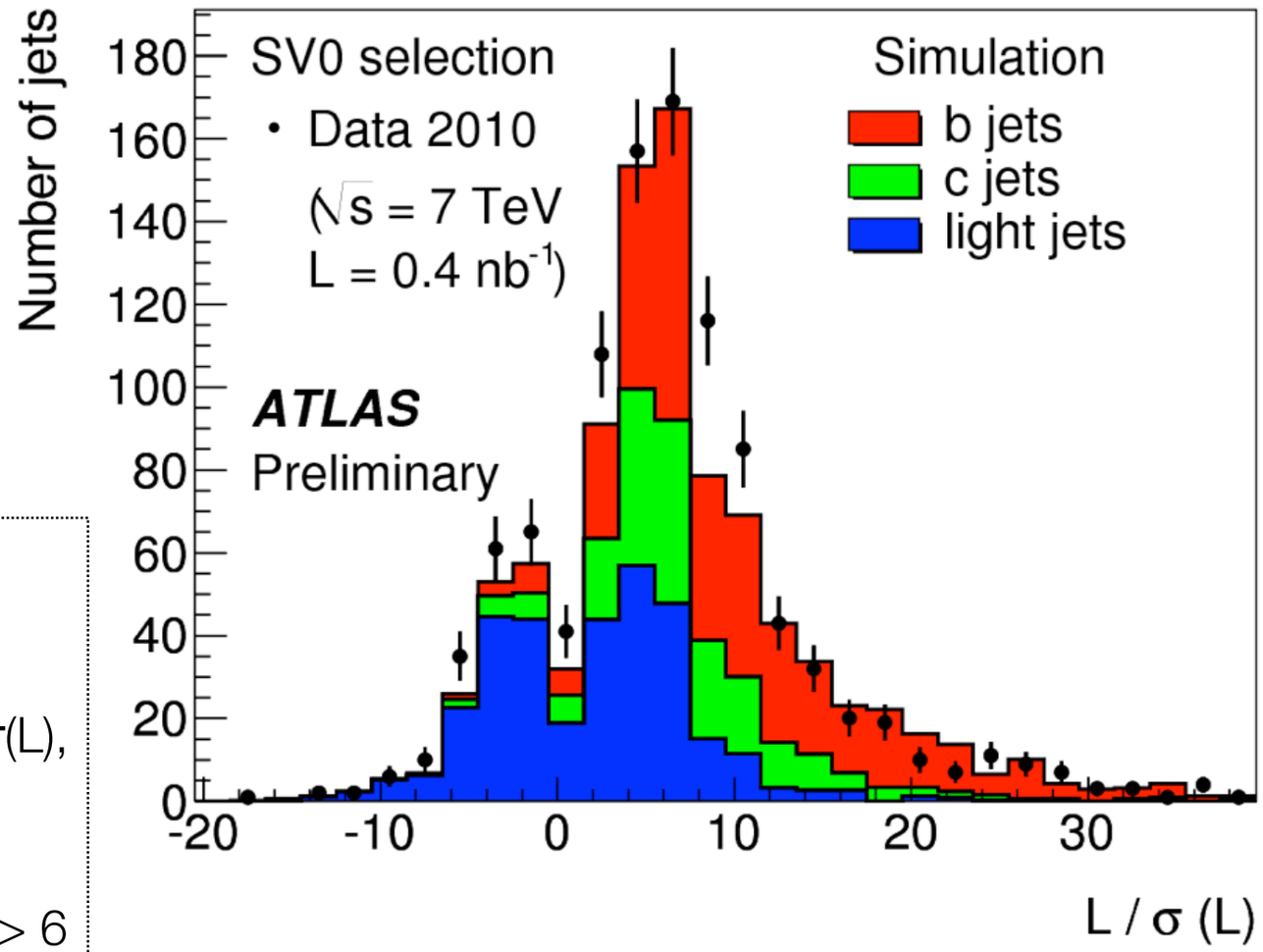
Secondary vertex tagging





SV0 algorithm

- Lifetime-based b-tagger
- Uses signed decay length significance, $L/\sigma(L)$, of the reconstructed secondary vertex
- Displaced vertex, impose tracks to have 2-track 3-dim impact parameter significance > 6
- Removal of two-tracks resonances, or photon conversion, vertices in vertex layer (interactions)

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Estimate of QCD multi-jet background

Sources of leptons

- Real leptons (W, Z, top)
- Non-prompt leptons (HF decays in jets)
- Fake leptons (misidentified hadrons)

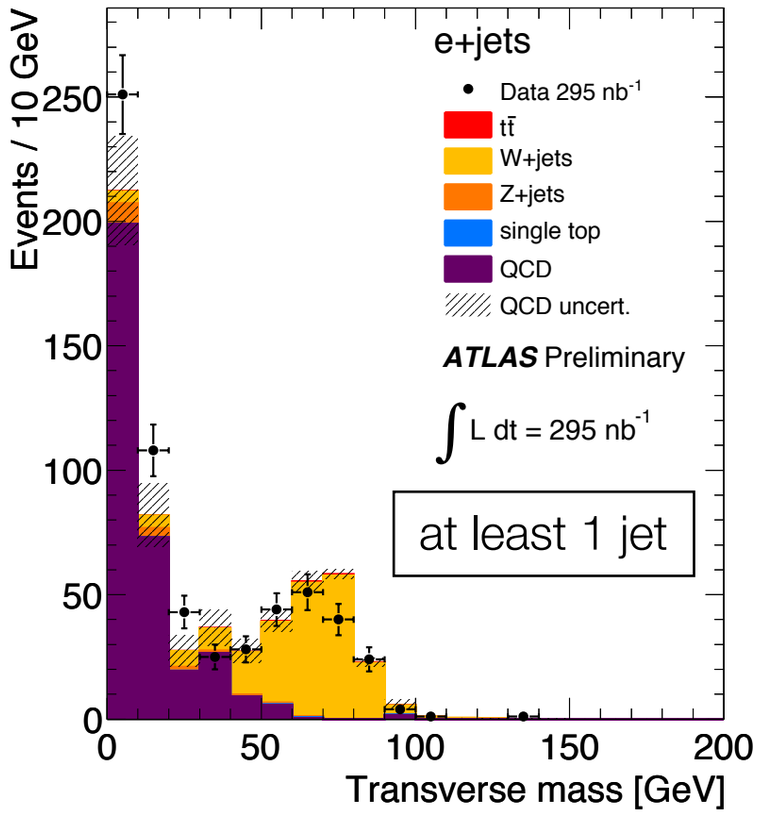
$$N^{\text{loose}} = N^{\text{loose}}_{\text{real}} + N^{\text{loose}}_{\text{fake}}$$
$$N^{\text{tight}} = \epsilon_{\text{real}} N^{\text{loose}}_{\text{real}} + \epsilon_{\text{fake}} N^{\text{loose}}_{\text{fake}}$$

$$\epsilon_{\text{fake}} = N^{\text{tight}}_{\text{fake}} / N^{\text{loose}}_{\text{fake}}$$

$$\epsilon_{\text{real}} = N^{\text{tight}}_{\text{real}} / N^{\text{loose}}_{\text{real}}$$

Matrix method

- Determine QCD from data
- Define ‘tight’ and ‘loose’ samples
  - ‘tight’: lepton quality tight
  - ‘loose’: lepton quality relaxed
- Determine $\varepsilon_{\text{fake}}$ from QCD enriched control data sample
- Determine $\varepsilon_{\text{real}}$ from Z→ll MC

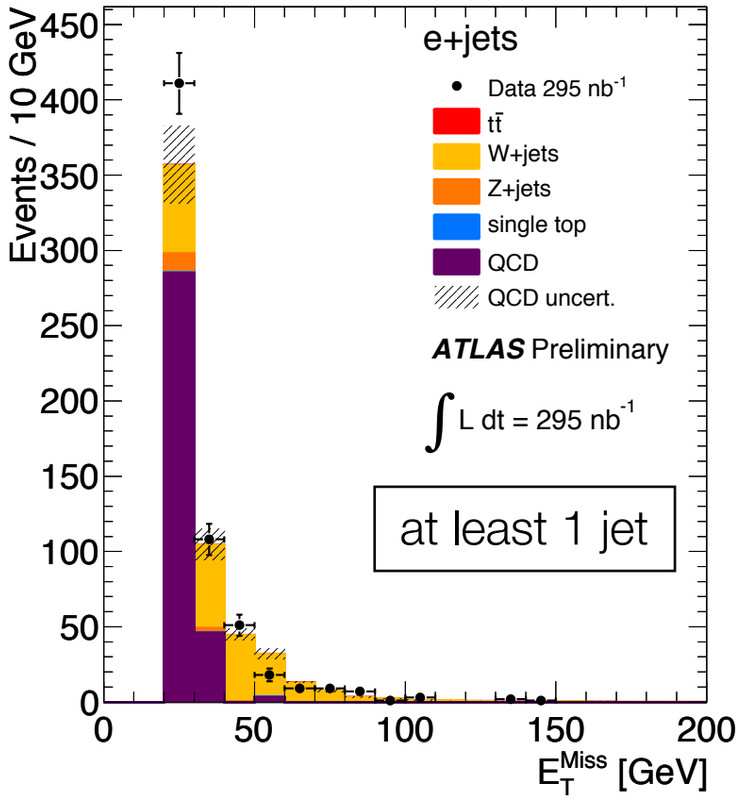


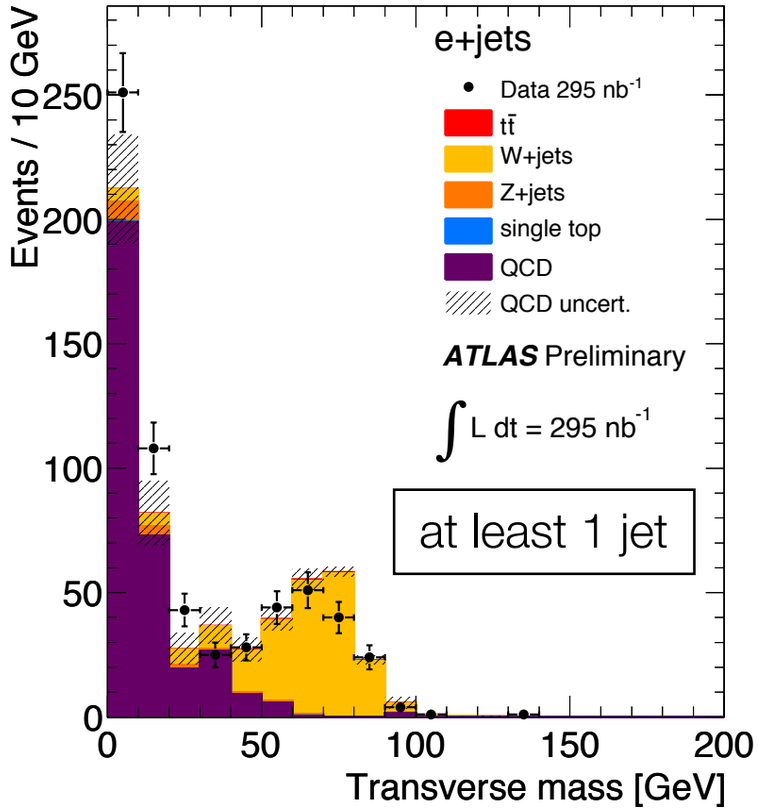
ATLAS-CONF-2010-087

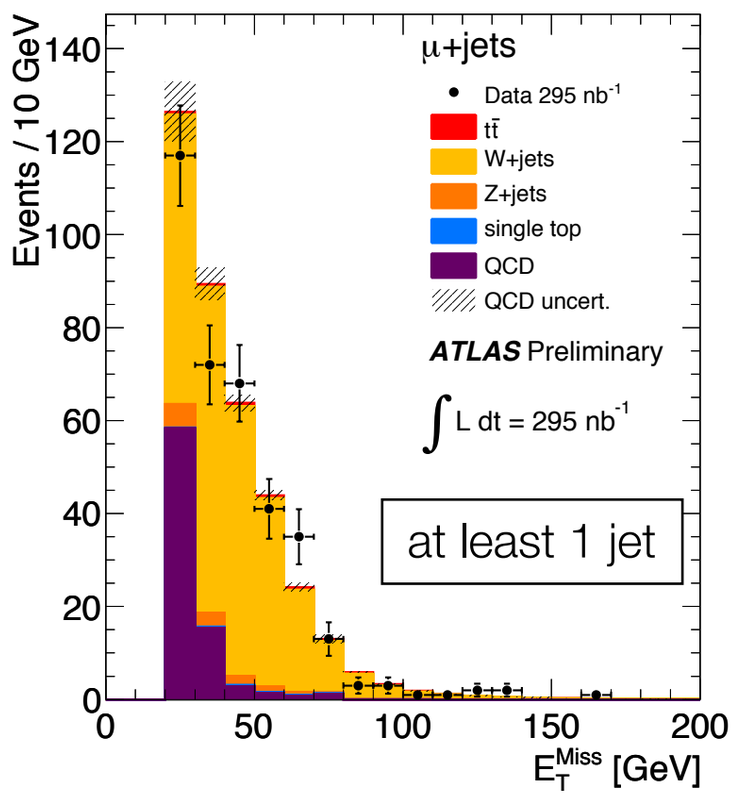
Top quark search with 0.3 pb-1

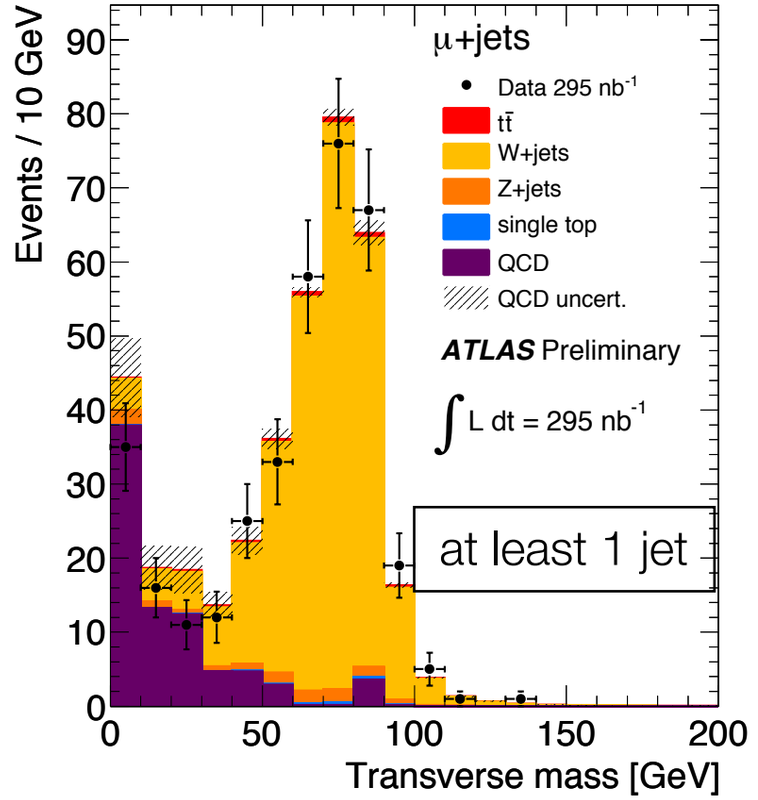
Event selection

- Primary Vertex with ≥ 5 tracks
- Trigger: single electron/ muon, 10 GeV
- One electron/muon with p_T > 20 GeV
- E_T^{miss} > 20 GeV
- Jet p_T > 20 GeV
- At least one b-tagged jet









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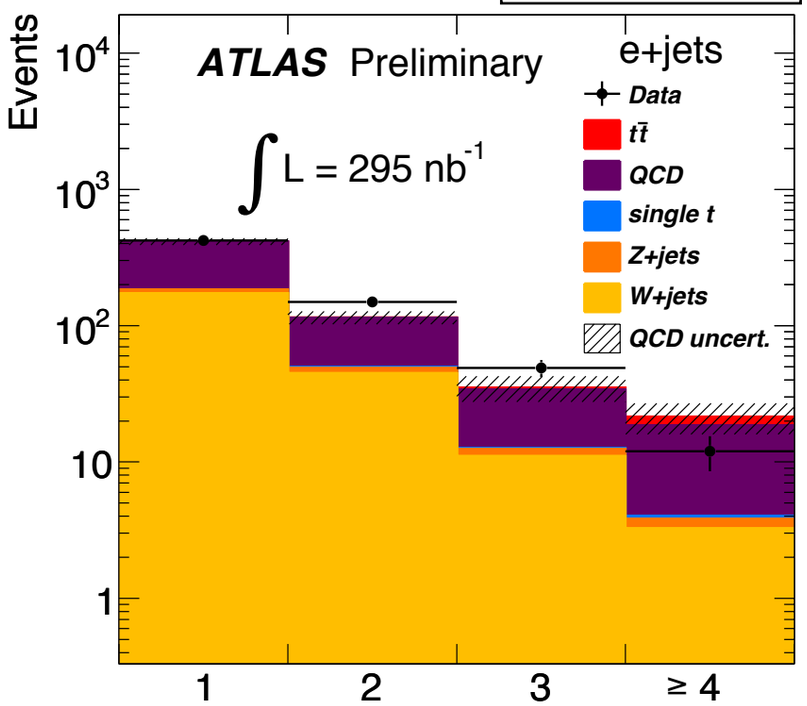
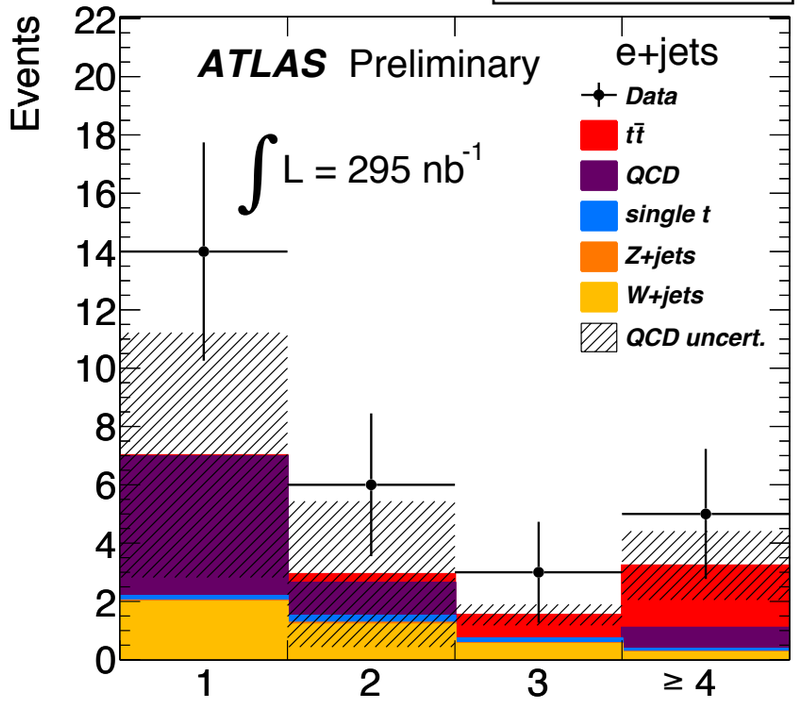
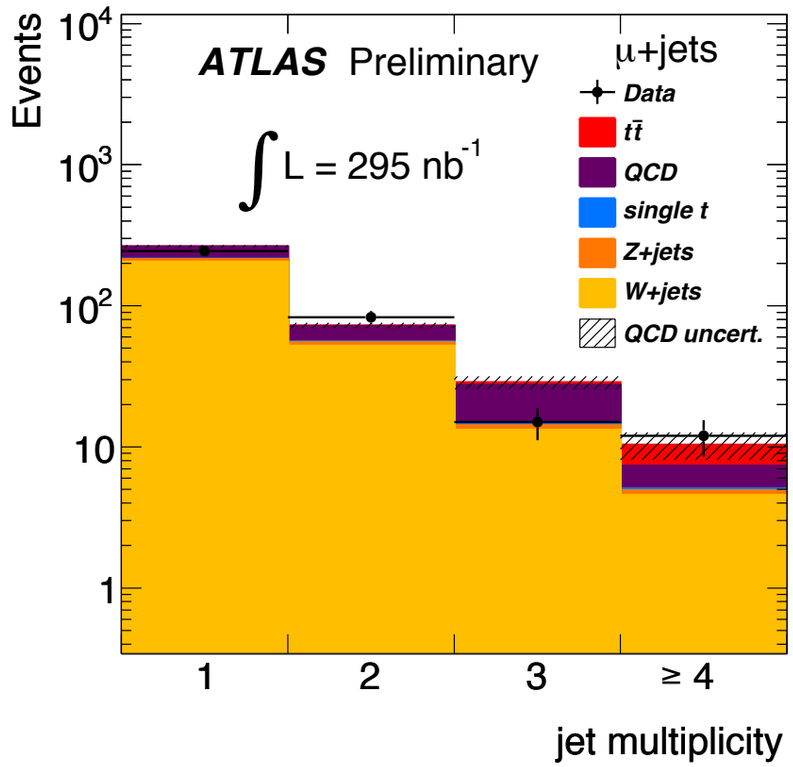
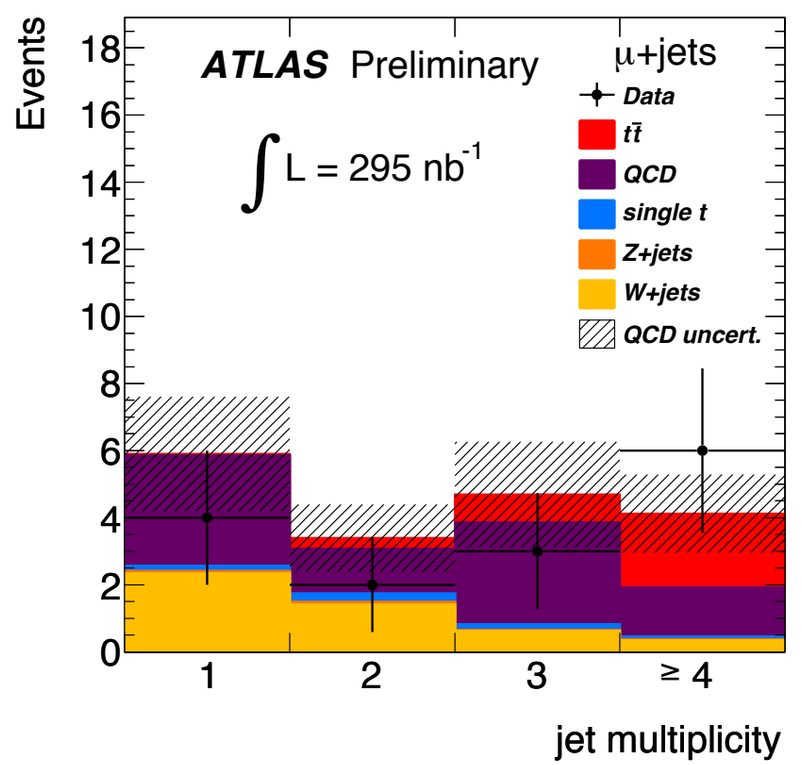
w/o b-tag



w/ b-tag







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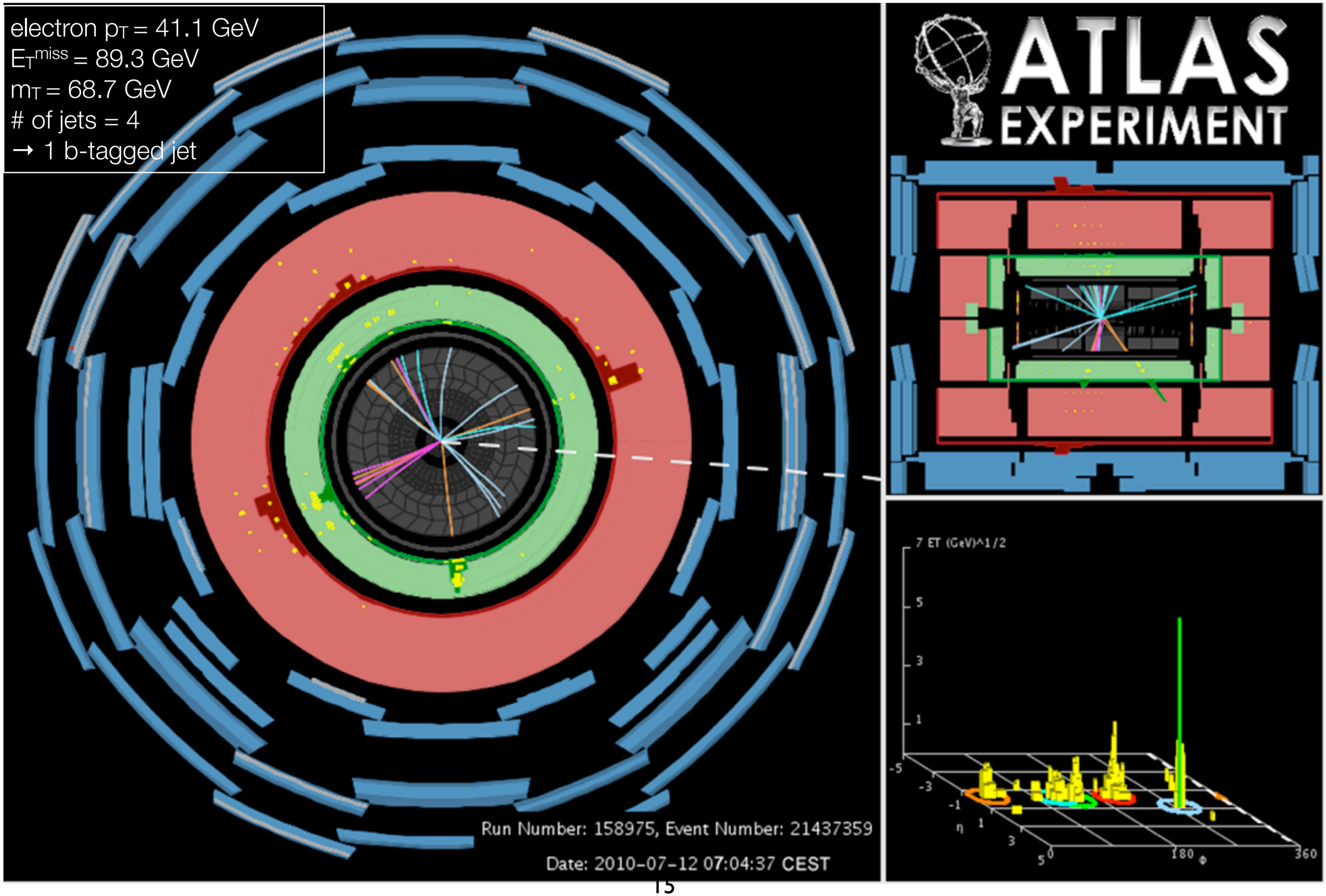
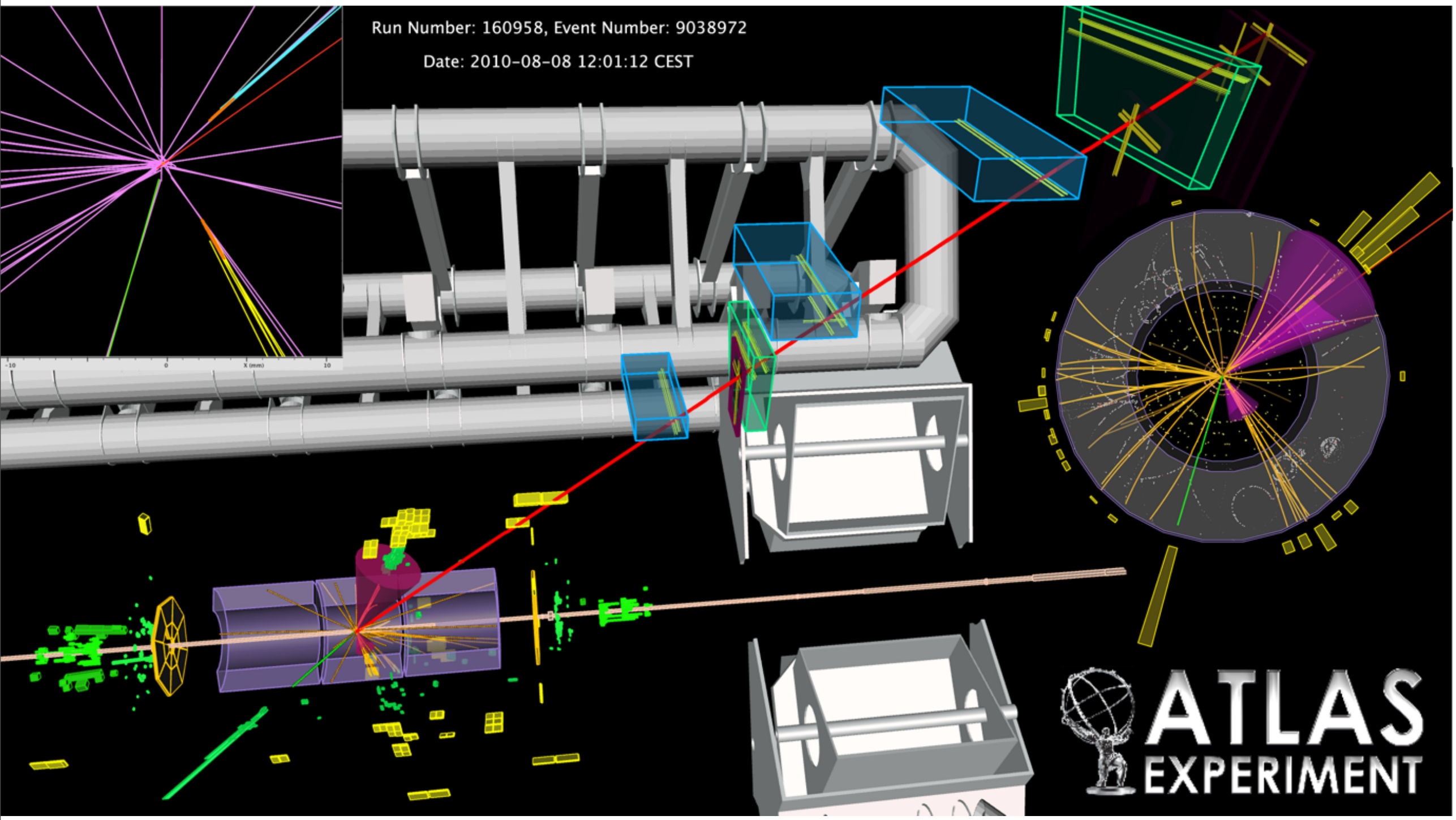
Top pair candidate in e+jets channel



Top pair candidate in e+mu channel



Summary

- ATLAS detector fully operational
- Reconstruction shows reasonable agreement between MC and data
- Top search in lepton+jets channel based on lepton, jet, E_T^{miss}, b-tagging
- MC expectations after event selections agree with data
- Analysis of larger data samples than shown here is underway
- Next step is a cross section measurement