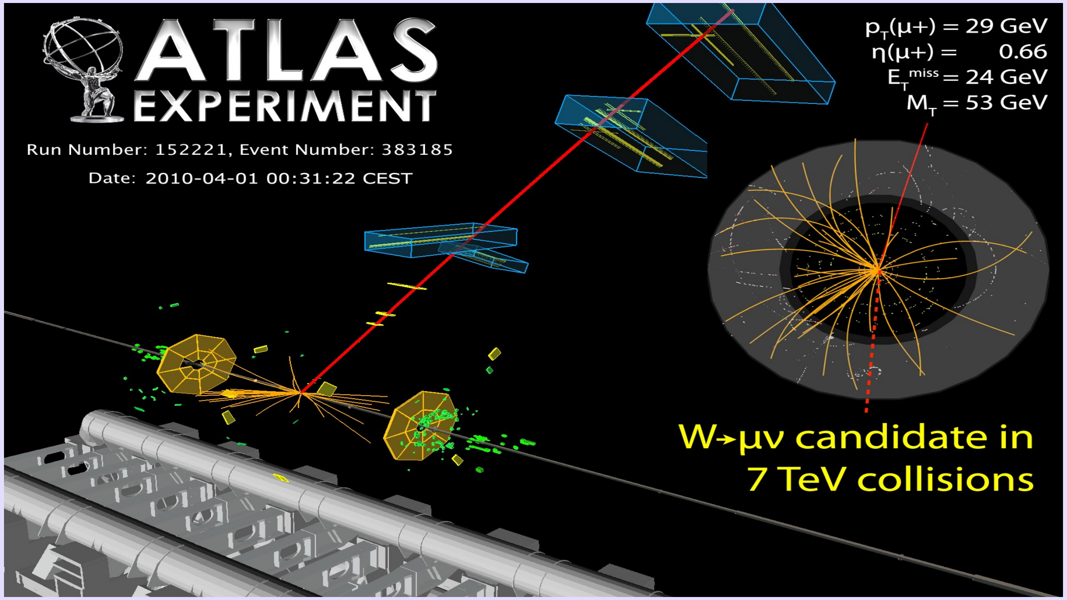
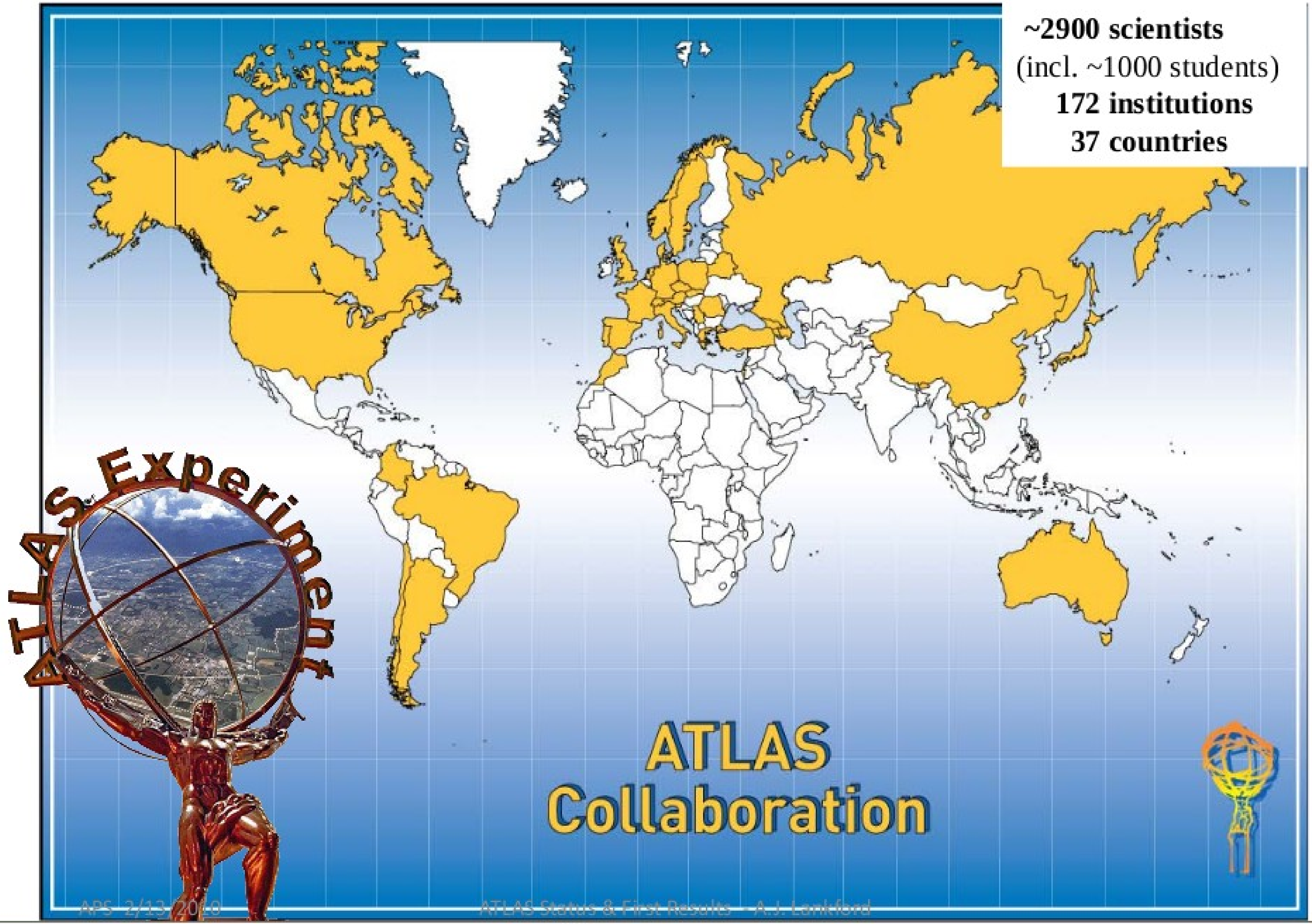
ATLAS Status and First Results

P. Conde Muíño (LIP-Lisboa)
on behalf of the ATLAS Collaboration
QCD@Work
Martina Franca (20th June 10)





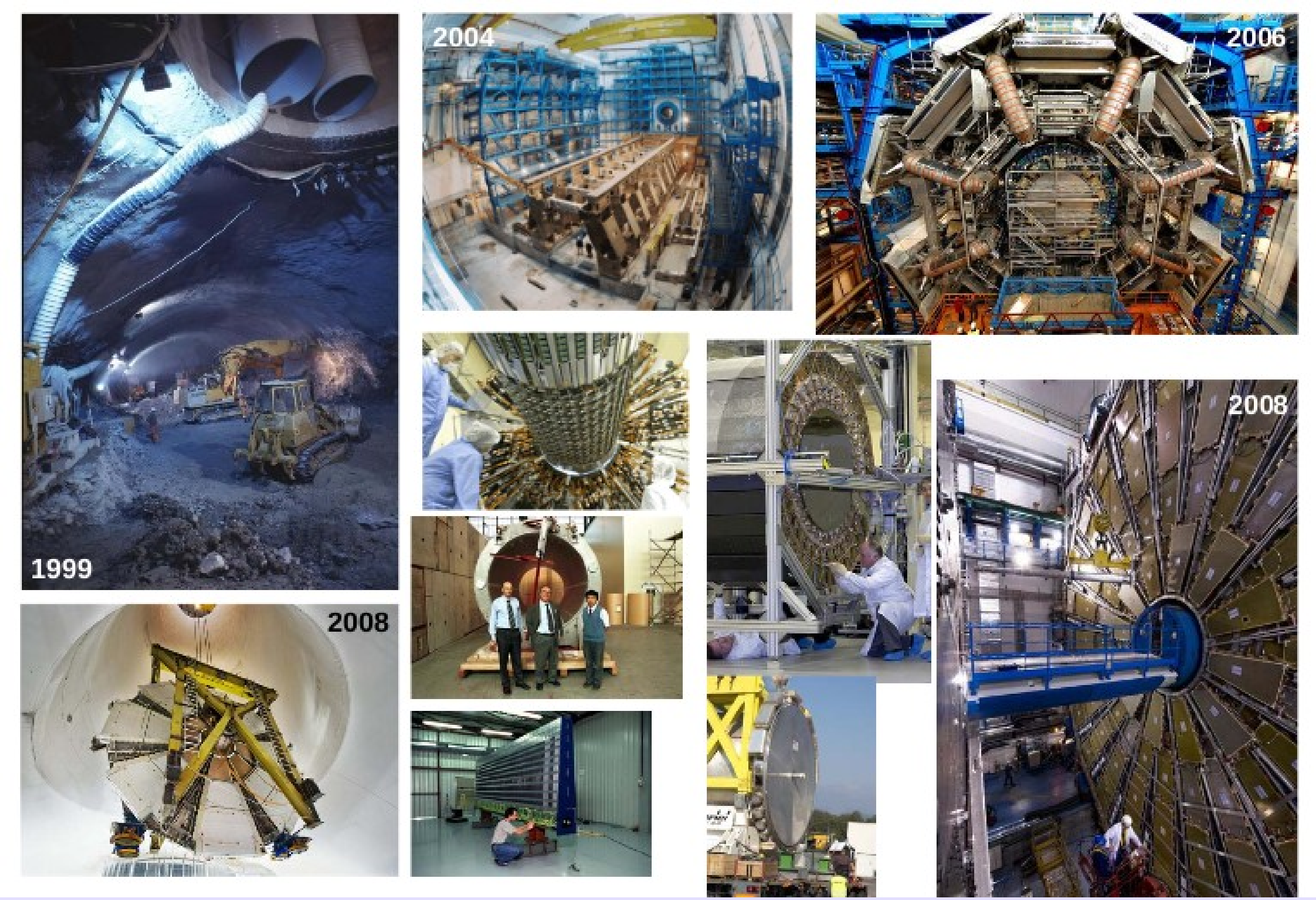
~2900 scientists
(incl. ~1000 students)
172 institutions
37 countries

ATLAS Collaboration

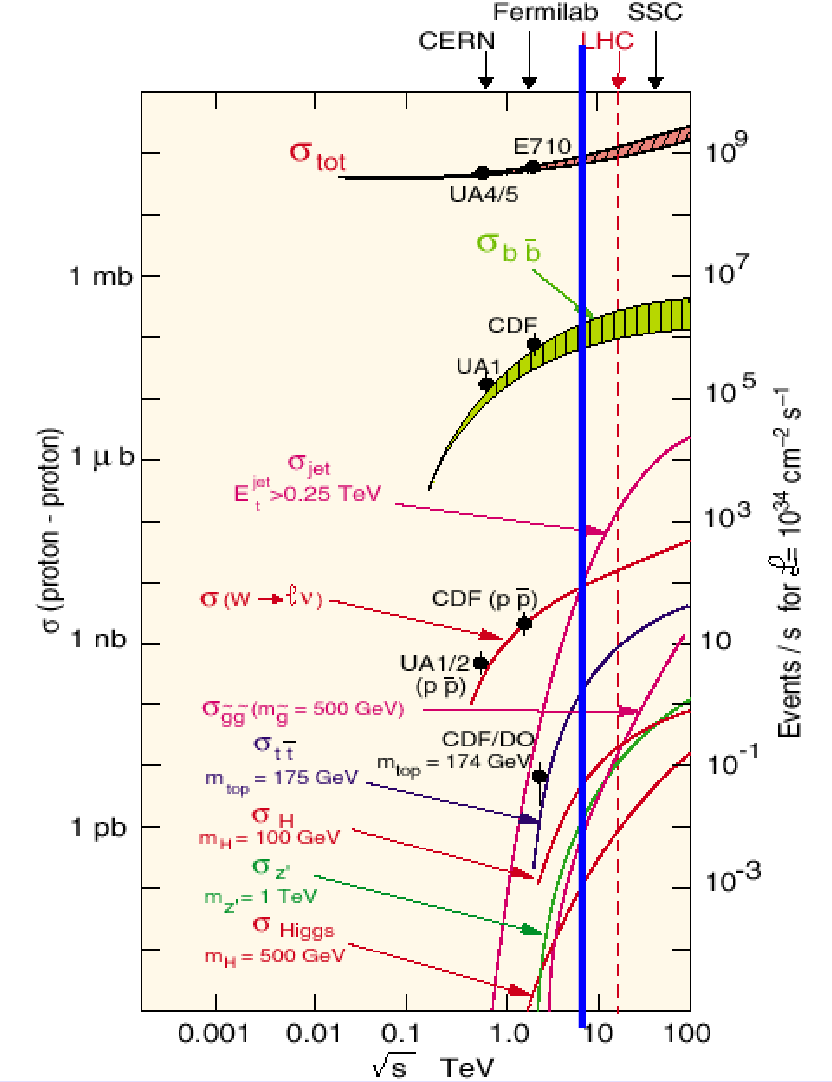
APS 2/13/2010 ATLAS Status & First Results - A.J. Lankford

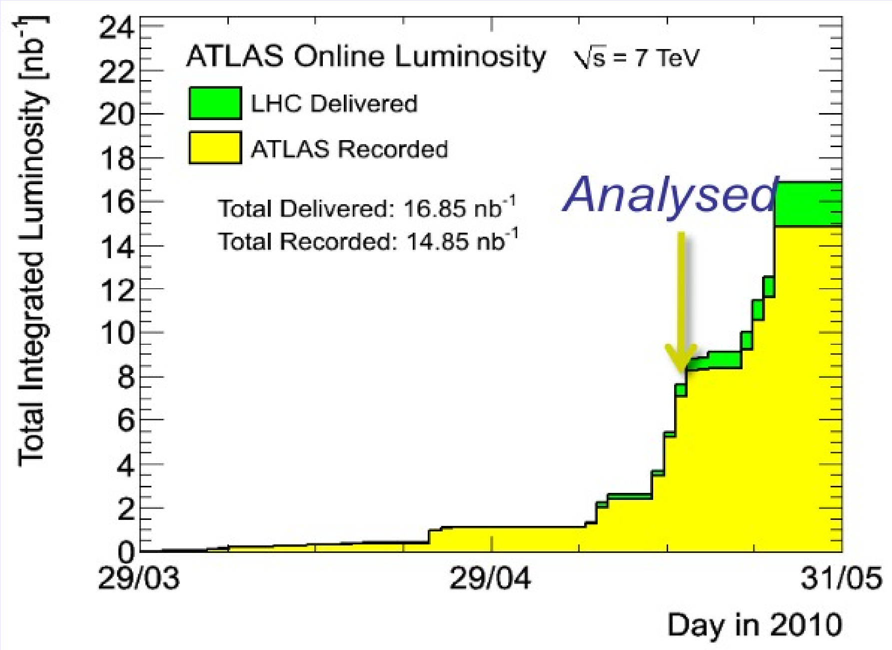
ATLAS in images

- More than 20 years of continuous work



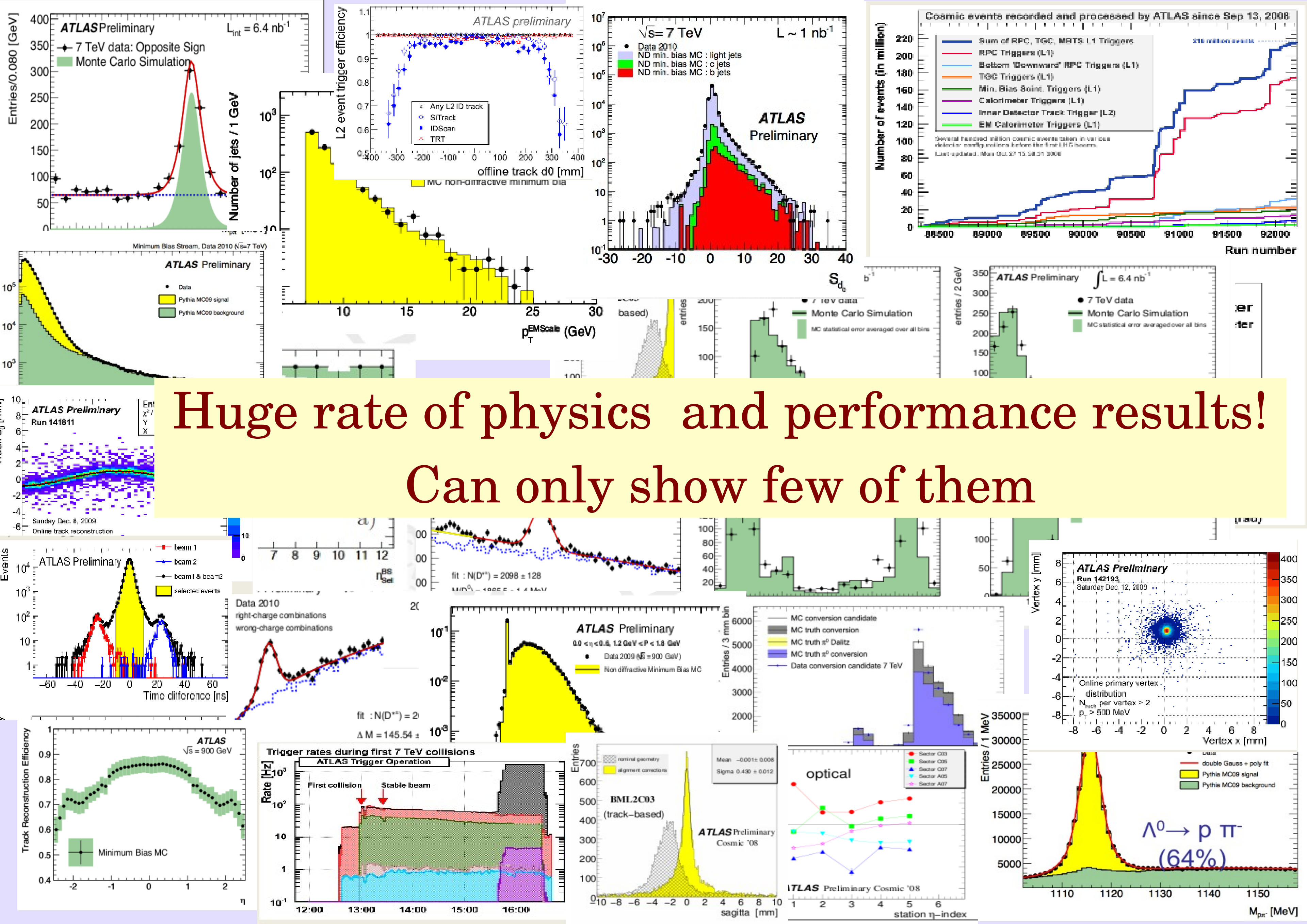
First 7 TeV data





- Record instantaneous luminosity:

  2.2 10^{29} Hz/cm^{-2} = 0.8 nb^{-1} ~ 8 W→lν per hour!
- Study detector and reconstruction performace
- First physics results

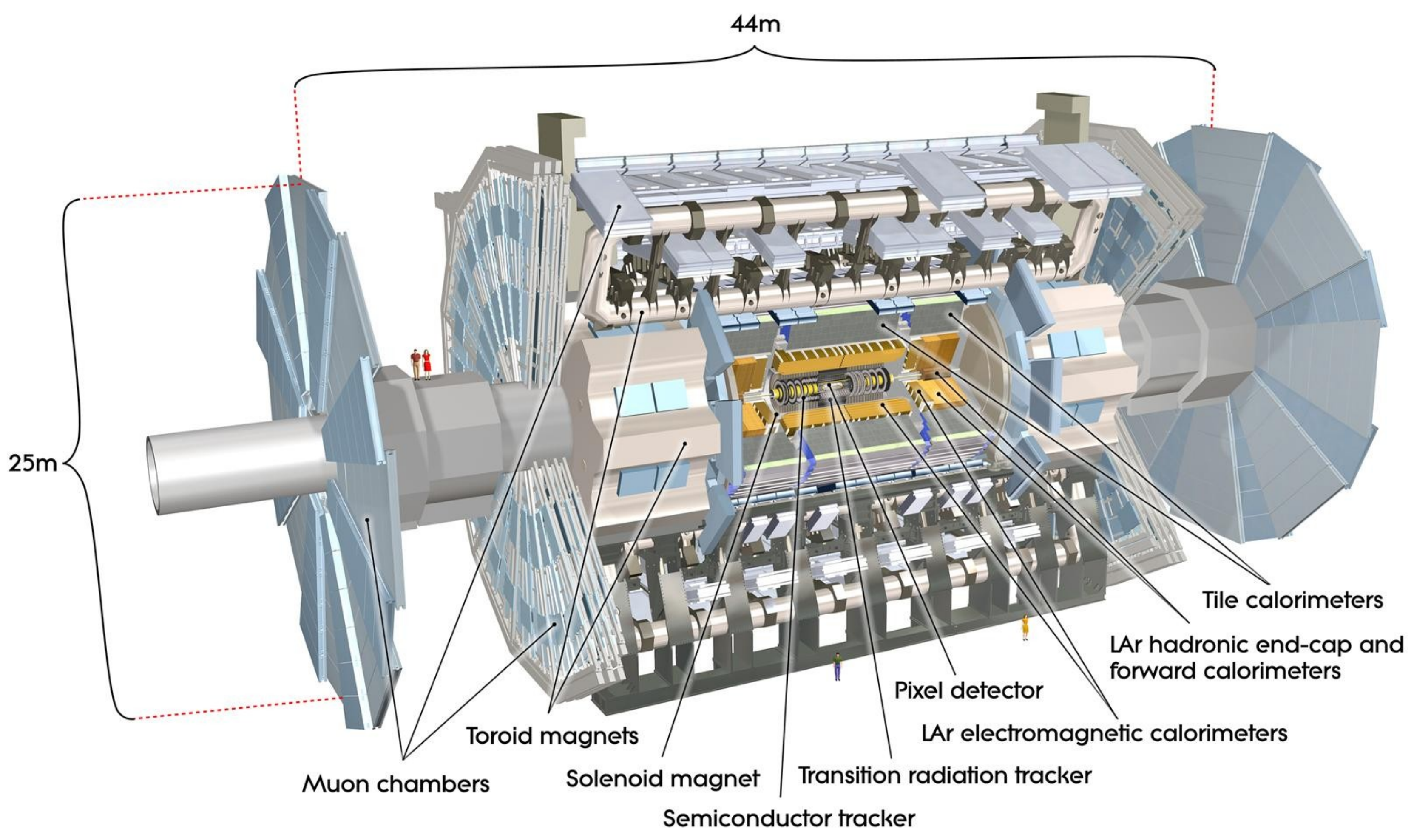


Huge rate of physics and performance results!

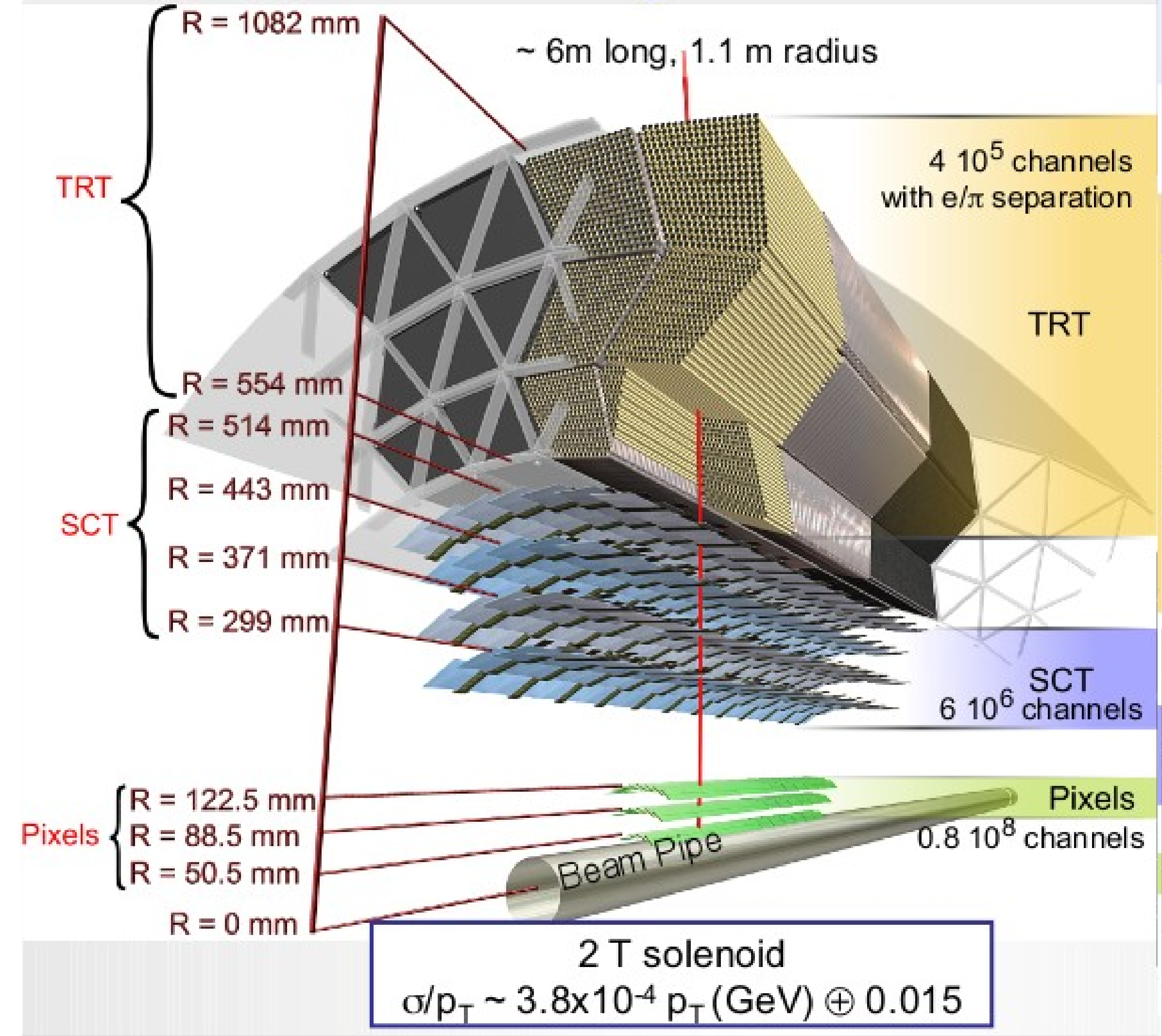
Can only show few of them

- Other topics that will be presented in more detail in this workshop and I will not cover:
  - Observation of high-pT jet production in pp at sqrt(s) = 7 TeV
    S. Majewski
  - ATLAS measurements of minimum bias and soft QCD
    M. Limper

The ATLAS Detector

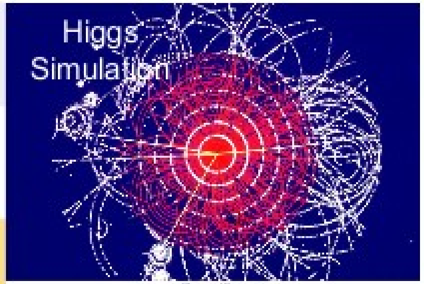


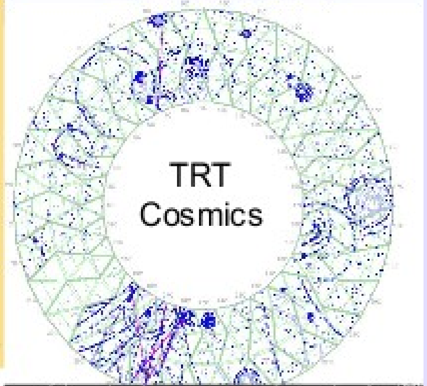
ATLAS Tracking Detectors

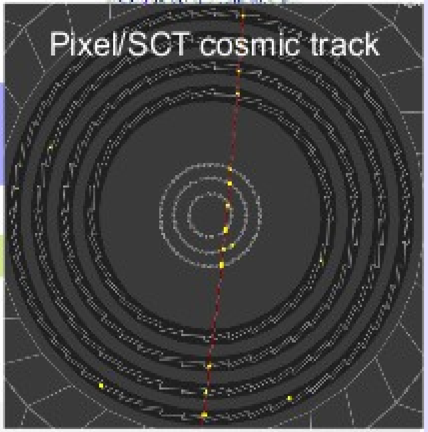


2 T solenoid

$\sigma/p_T \sim 3.8\times10^{-4}\, p_T\,(\mathrm{GeV}) \oplus 0.015$

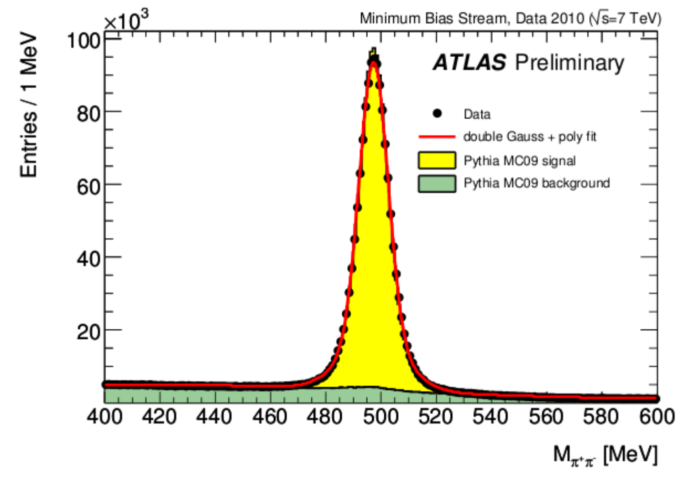




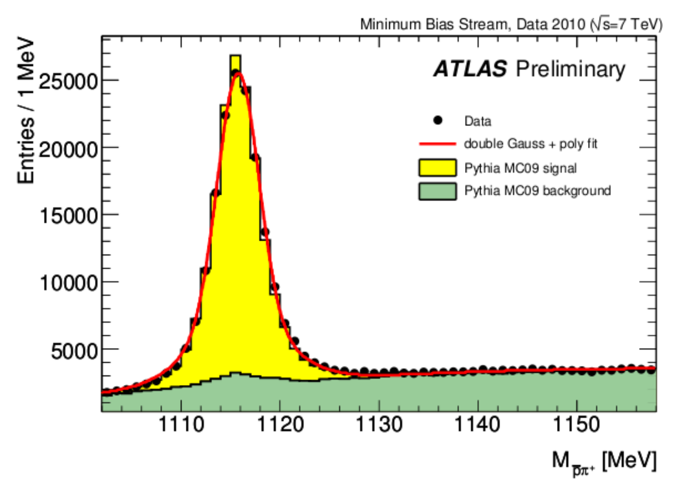


K_S^0, Λ^0 reconstruction

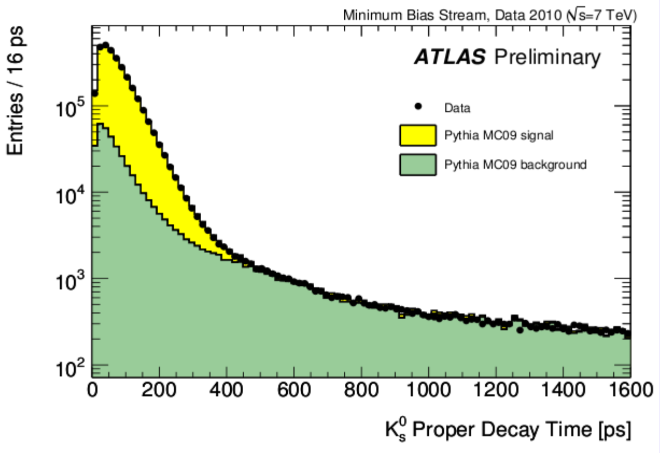
$K_S^0 \to \pi^- \pi^+$



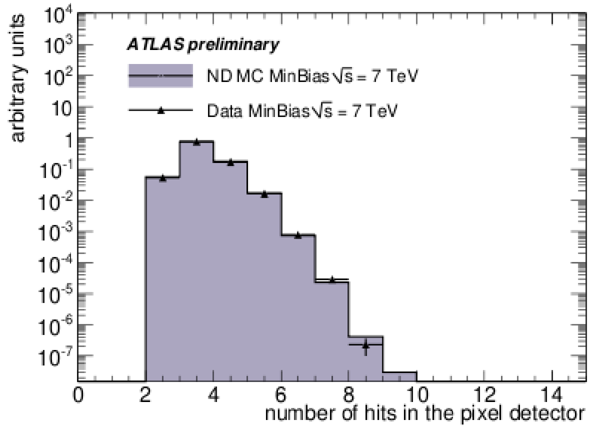
$\Lambda^0 \to \overline{p}\pi^+$



- Decays K_S^0 and Λ^0
  - study fragmentation of strange quarks
    - important for underlying event modelling!
  - Background to high p_T processes
- Mass resolution well simulated
  - Good momentum scale and magnetic field modeling
- Proper decay time: good agreement MC-data
  - Good tracking efficiency and momentum resolution modeling



Tracking studies for b-tagging

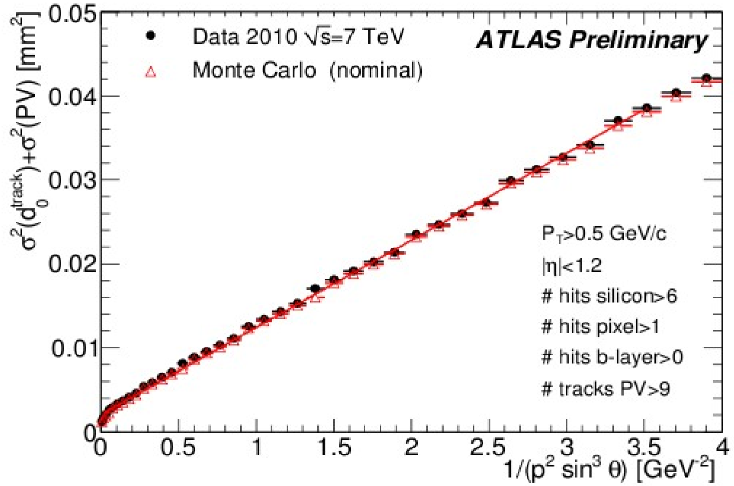


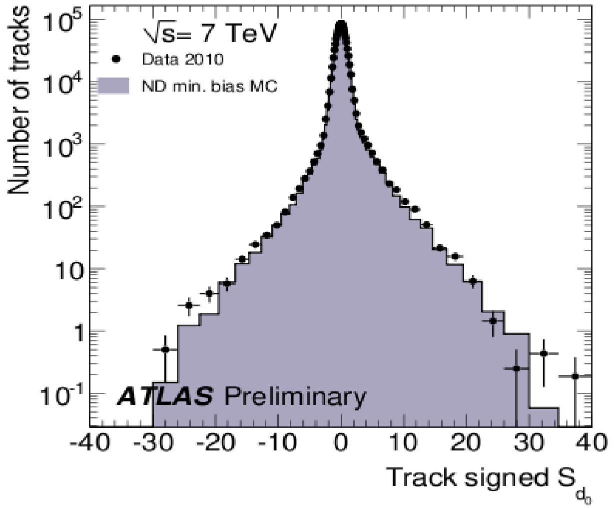
(a) Number of pixel hits on track.

- b-tag essential to select pure top quark samples
  - At 7 TeV worse tt signal to background ratio!
- Track resolution fit

$$\sigma^2(d_0^{\text{track}}) = \sigma^2_{\text{intrinsic}} + \frac{b^2}{p^2 \sin^3\theta}$$

  - Good agreement data-MC
  - Material well simulated
- Impact parameter significance: slightly narrower in MC
  - Residual misalignments

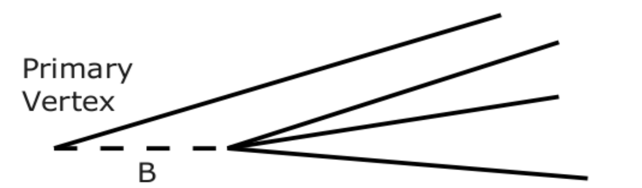


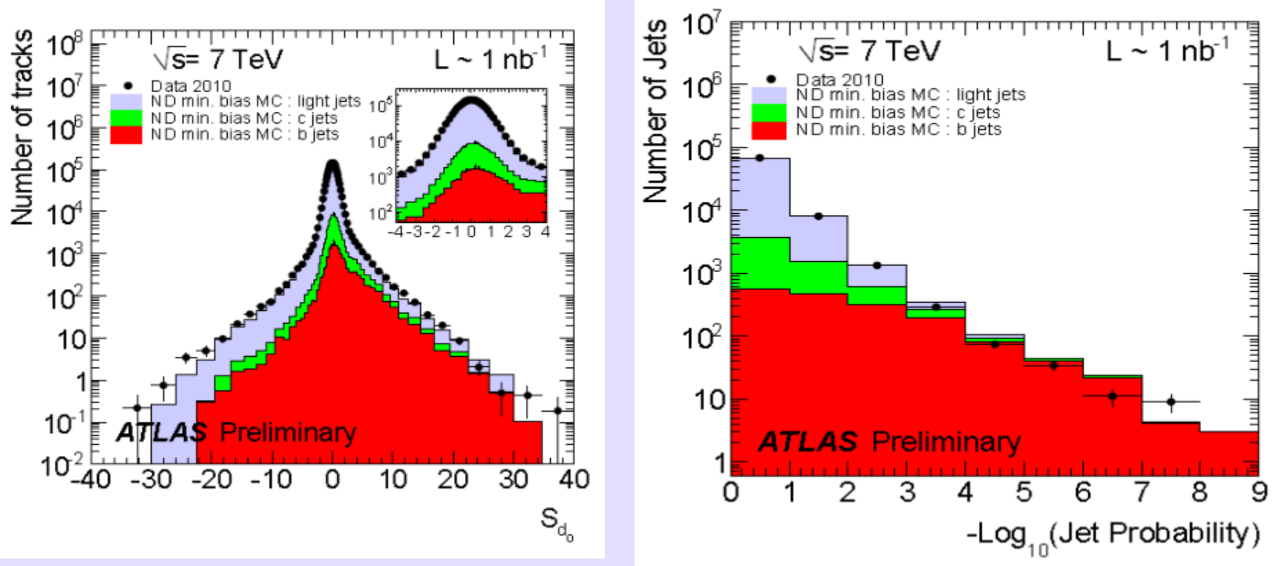


B-tagging performance

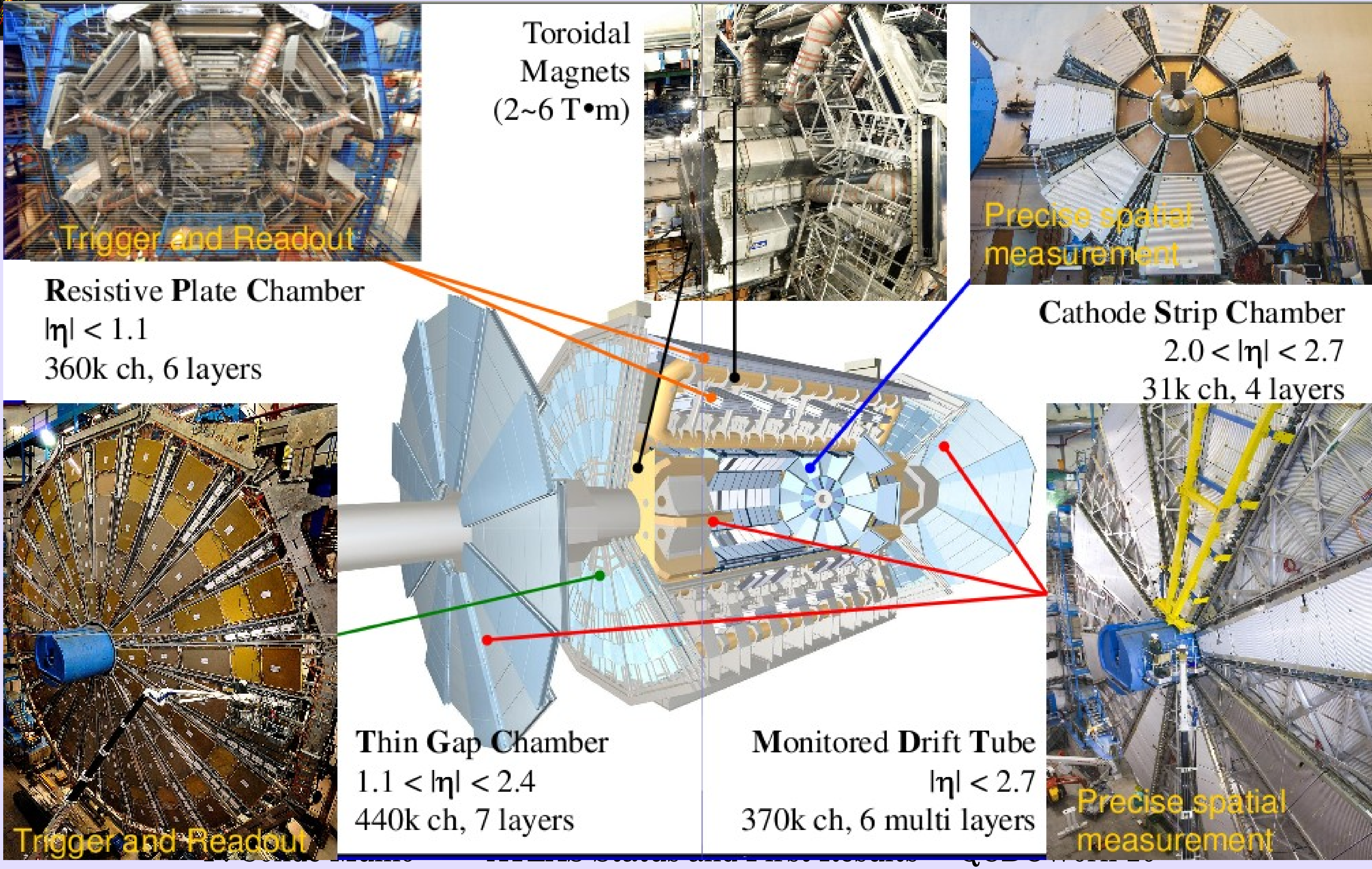
Example of one of the algorithms:

- Jet probability
  - Define signed impact parameter significance
  - Use negative side to parametrize primary vertex tracks
  - Combine track probabilities in a jet
- Distribution consistent with MC predictions





Muon spectrometer



Toroidal
Magnets
(2~6 T•m)

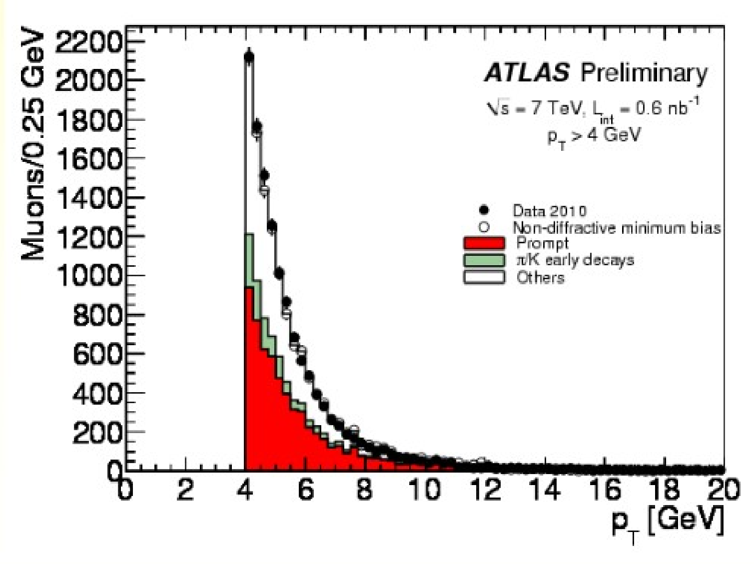
Resistive **P**late **C**hamber
$|\eta| < 1.1$
360k ch, 6 layers

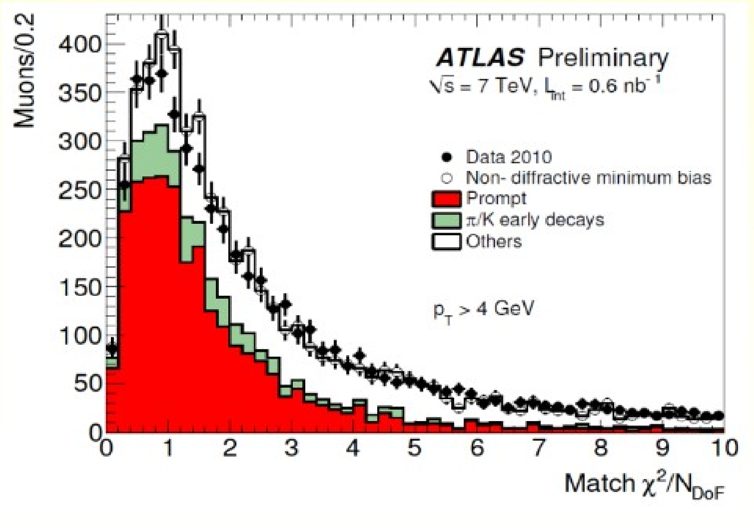
Cathode **S**trip **C**hamber
$2.0 < |\eta| < 2.7$
31k ch, 4 layers

Thin **G**ap **C**hamber
$1.1 < |\eta| < 2.4$
440k ch, 7 layers

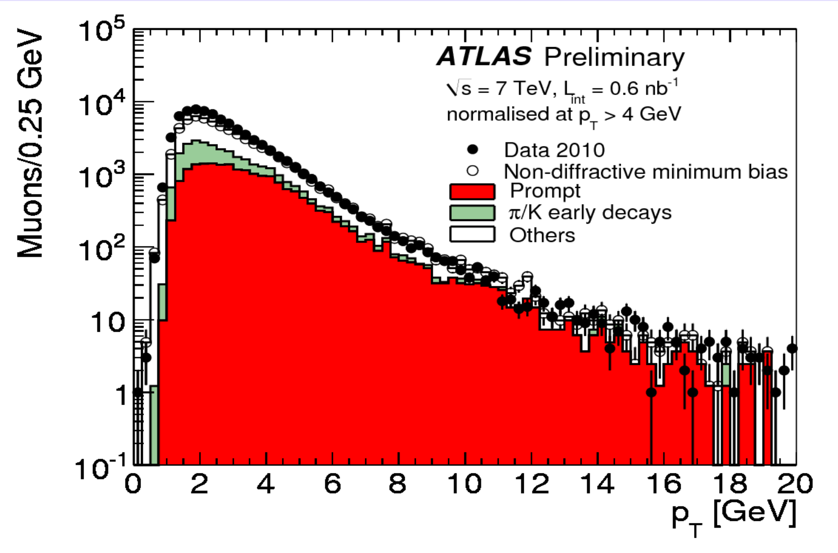
Monitored **D**rift **T**ube
$|\eta| < 2.7$
370k ch, 6 multi layers

Muon reconstruction performance

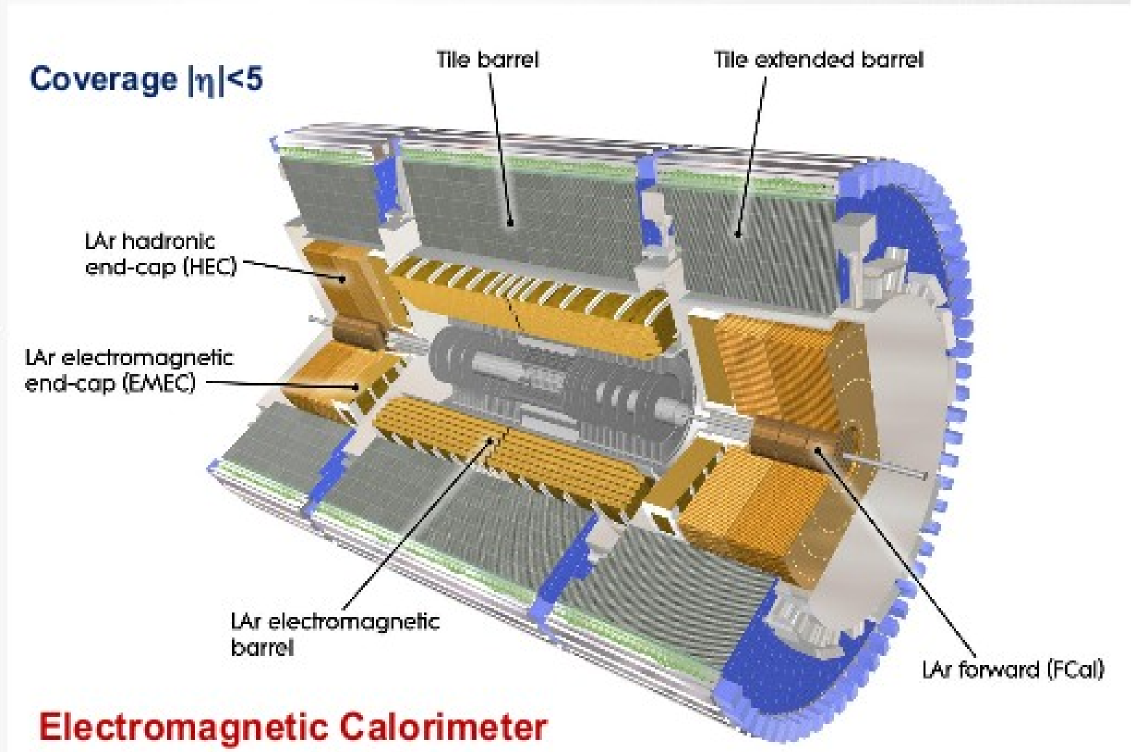




- Muons tracks reconstructed using muon spectrometer+inner detector
  - Two alternative algorithms
  - Similar performance
- Good agreement data-MC for many parameter distributions and $p_T > 4$ GeV
- Prompt muon spectrum consistent with MC

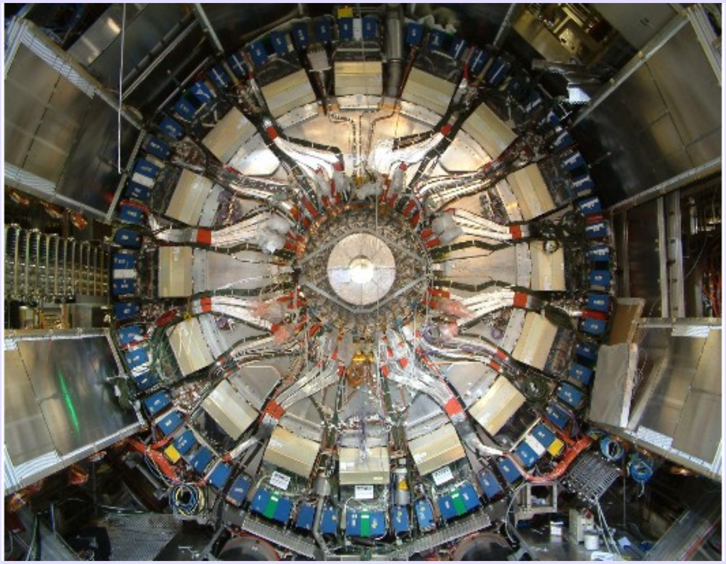


Calorimeter

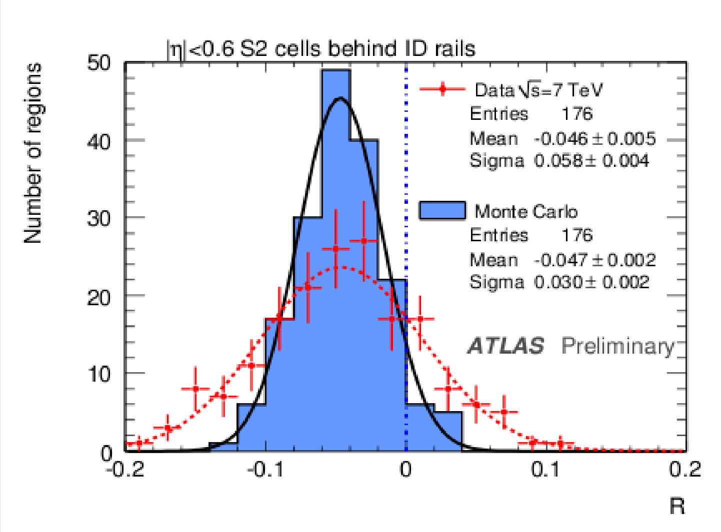


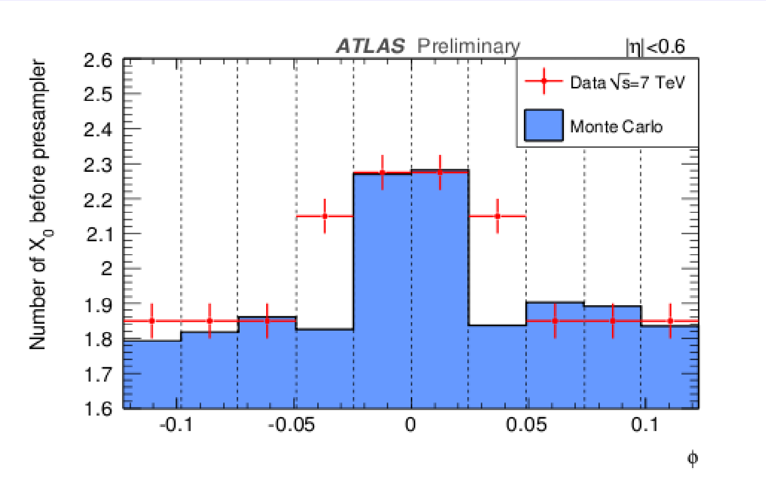
Electromagnetic Calorimeter
barrel, end-cap: Pb-LAr
~10%/√E energy resolution e/γ
170'000 channels: longitudinal segmentation

Hadron Calorimeter
barrel Iron-Tile, EC/Fwd Cu/W-LAr (~20000 channels)
σ/E ~ 50%/√E ⊕ 0.03 pion (10 λ)



Calorimeter performance studies



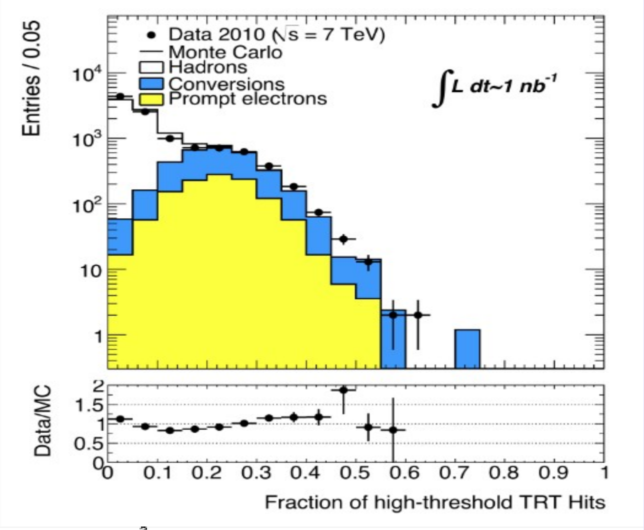


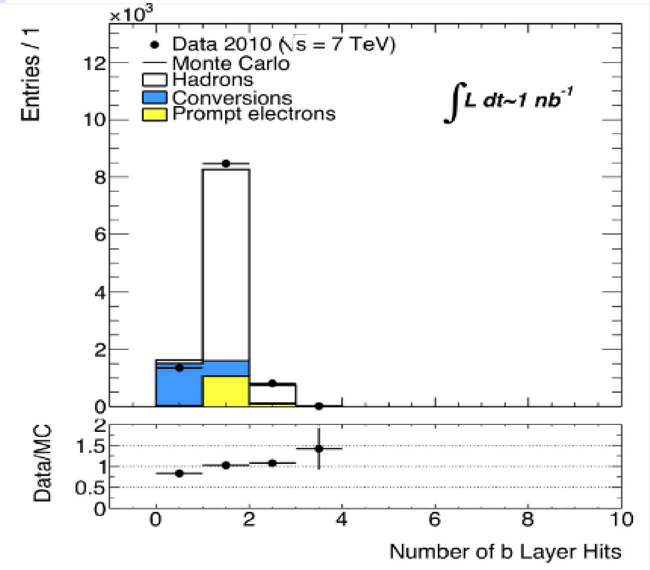
- Measure occupancy in minimum bias events
  - Study channel by channel response
  - Cross check material simulation in front of the calorimeter
- Symmetry in $\phi \Rightarrow$ measure R for different η slices:

$$R = \frac{Occ_{\phi,\eta-slice} - < Occ_{\eta-slice} >}{< Occ_{\eta-slice} >}$$

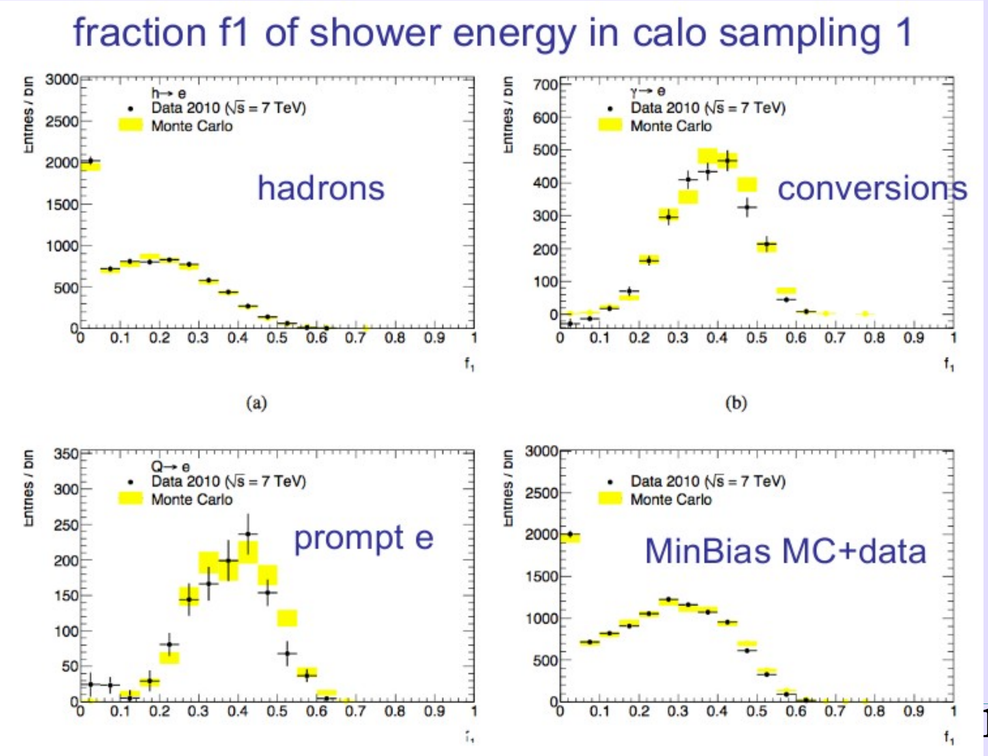
  - Larger width in MC: imperfect cell-to-cell response uniformity
  - Good agreement data-MC in most cases
    - Material missing in simulation in localized regions

Study of prompt electrons





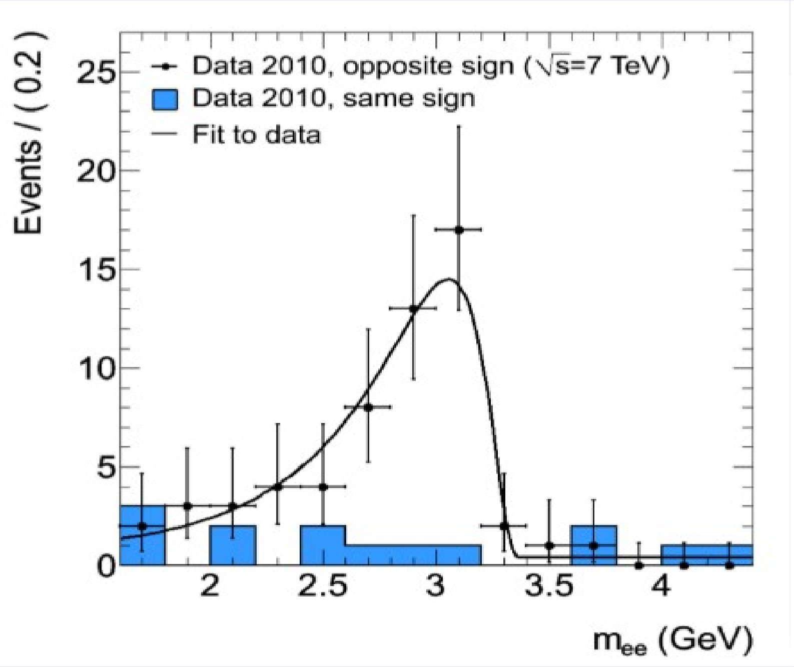
- Identify electrons using shower shape variables
- Use matrix method to separate components
  - TRT high threshold hits to separate hadrons
  - Hits in 1st pixel layer → conversions
- Study of electron identification variables



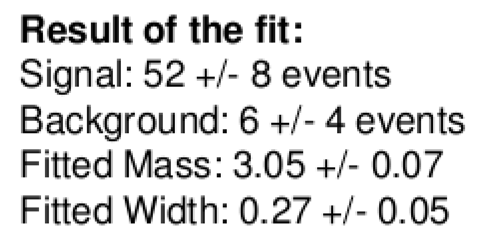
J/ψ reconstruction

- J/ψ and Υ production provide sensitive tests of QCD predictions
- Important to
  - understand detector performance: trigger, tacking, p scale
  - B-physics studies

J/ψ→ee



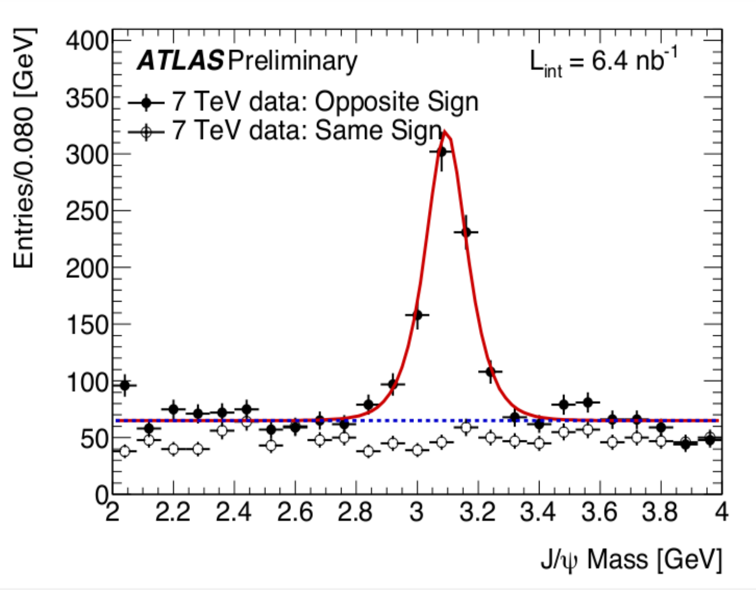
- Challenging due to large amount of material in front of the calorimeter
- Used very tight electron identification
- Mass based on track properties (not corrected for Bremstrahlung)



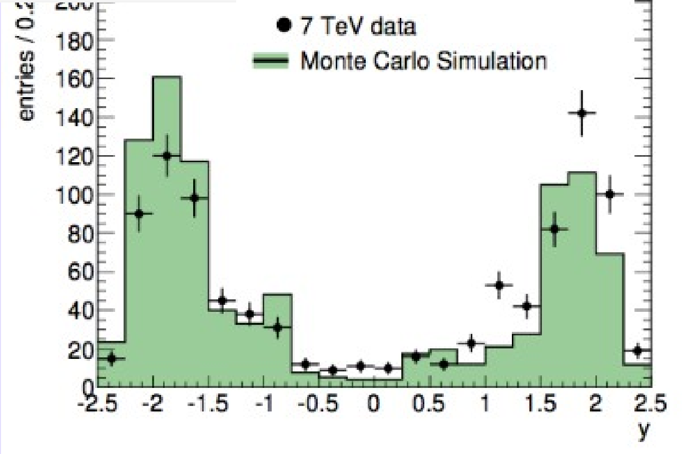
Result of the fit:
Signal: 52 +/- 8 events
Background: 6 +/- 4 events
Fitted Mass: 3.05 +/- 0.07
Fitted Width: 0.27 +/- 0.05

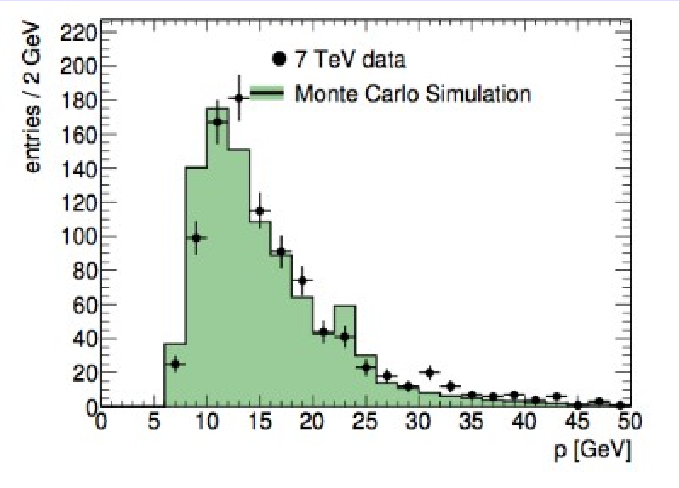
J/ψ reconstruction (μ channel)

J/ψ→μμ

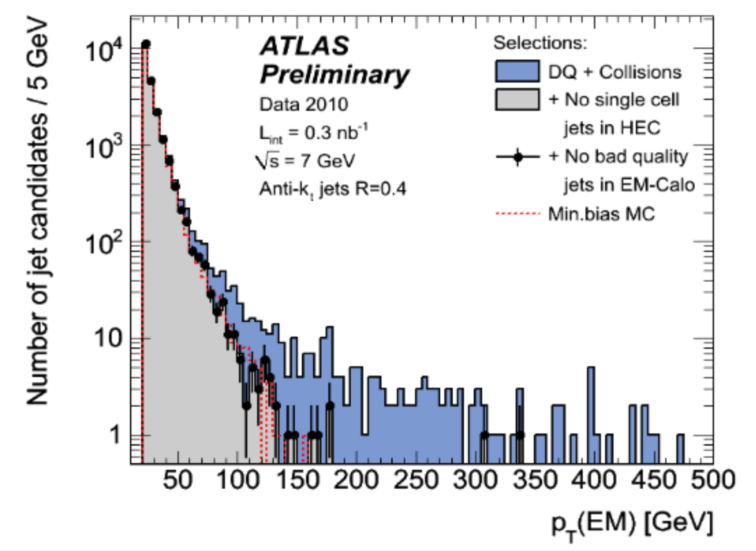


- At least one muon reconstructed in the tracking+muon spectrometer
  - Second muon: tracking+hits in muon spectrometer
- Measured mass consistent with PDG
- Study kinematic properties of candidates

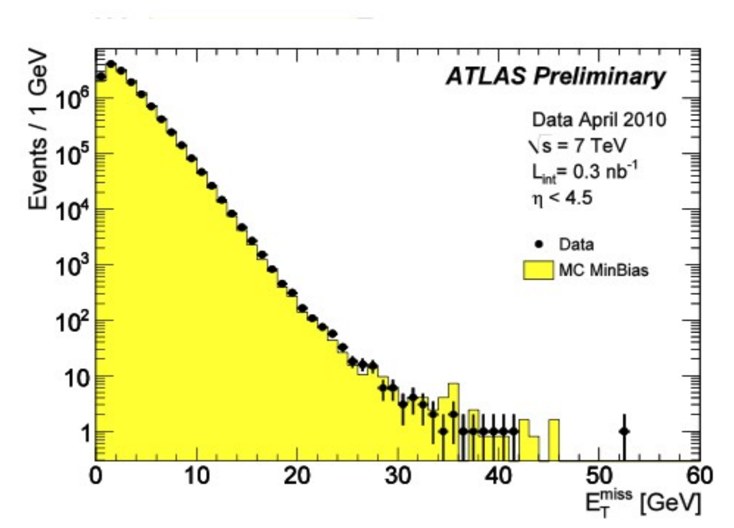


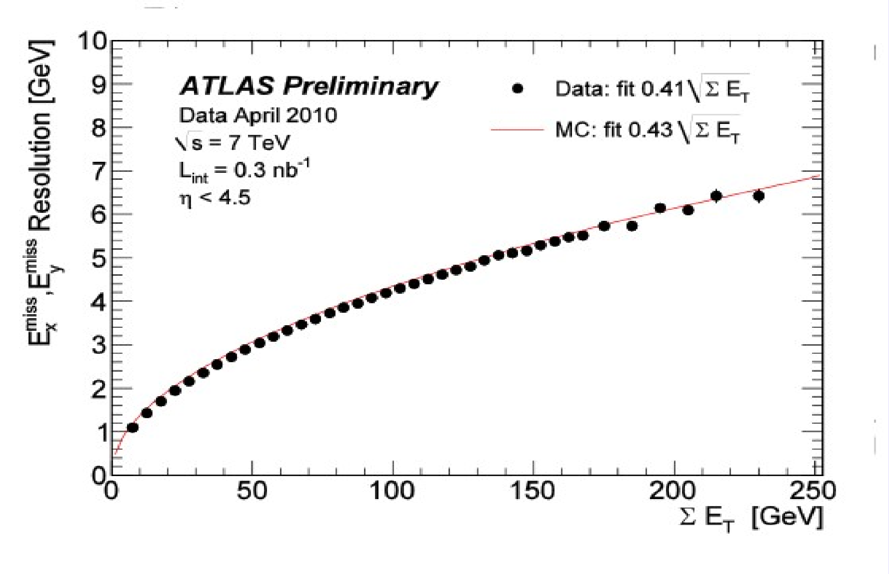


Jet and missing E_T performance



- Jet and $\not{E}_T$ performance studied in minimum bias events
- Apply jet cleaning cuts to remove noisy jets
- After cleaning cuts
  - Jet p_T spectrum consistent with MC
  - $\not{E}_T$ resolution in agreement with MC

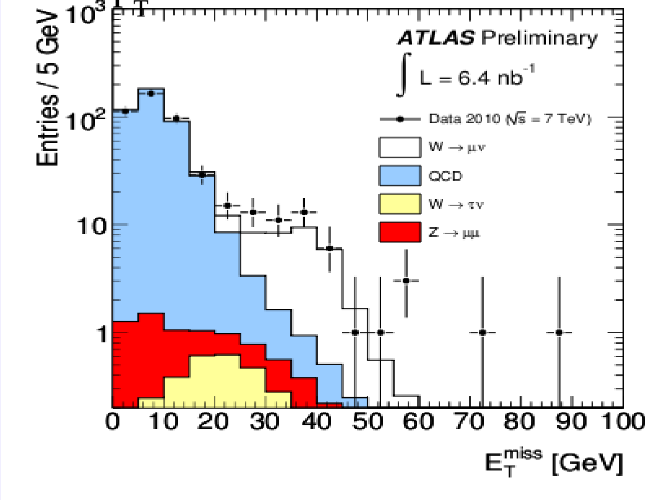




W→$\mu\nu$ observation in 7 TeV pp collisions

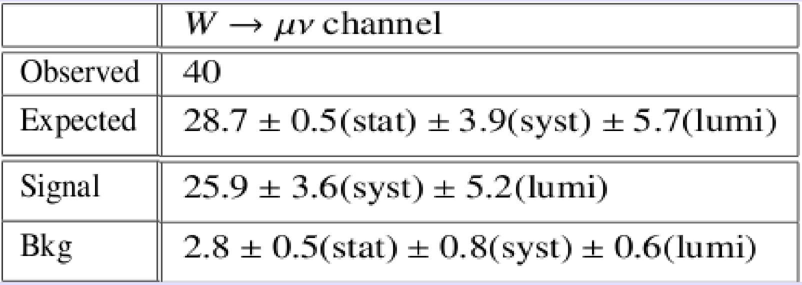
- Produced by 1st time in pp collisions! Unexplored energy scale!
- Measure W properties to reduce current uncertainties
- Stringent test non-perturbative QCD effects and PDFs

MC normalized to data, no isolation, softer p_T^l cut

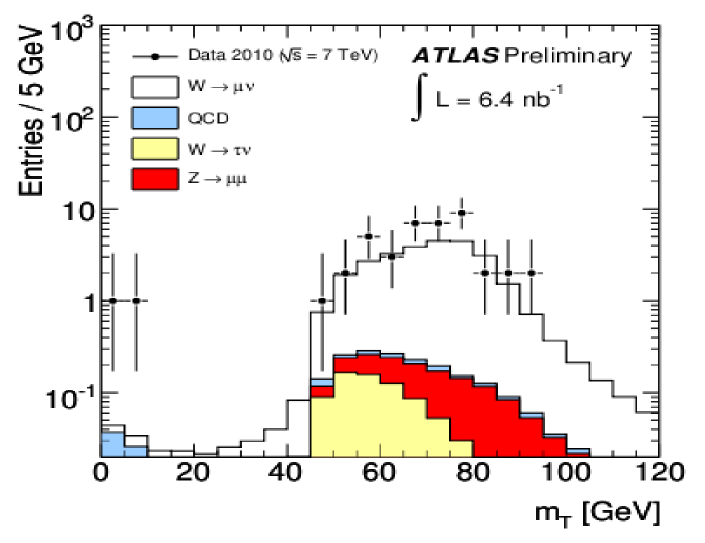


- Muon rec. in MS+tracker
- Muon trigger (no p_T cut)
- Primary vertex, > 3 tracks, consistent with beam spot

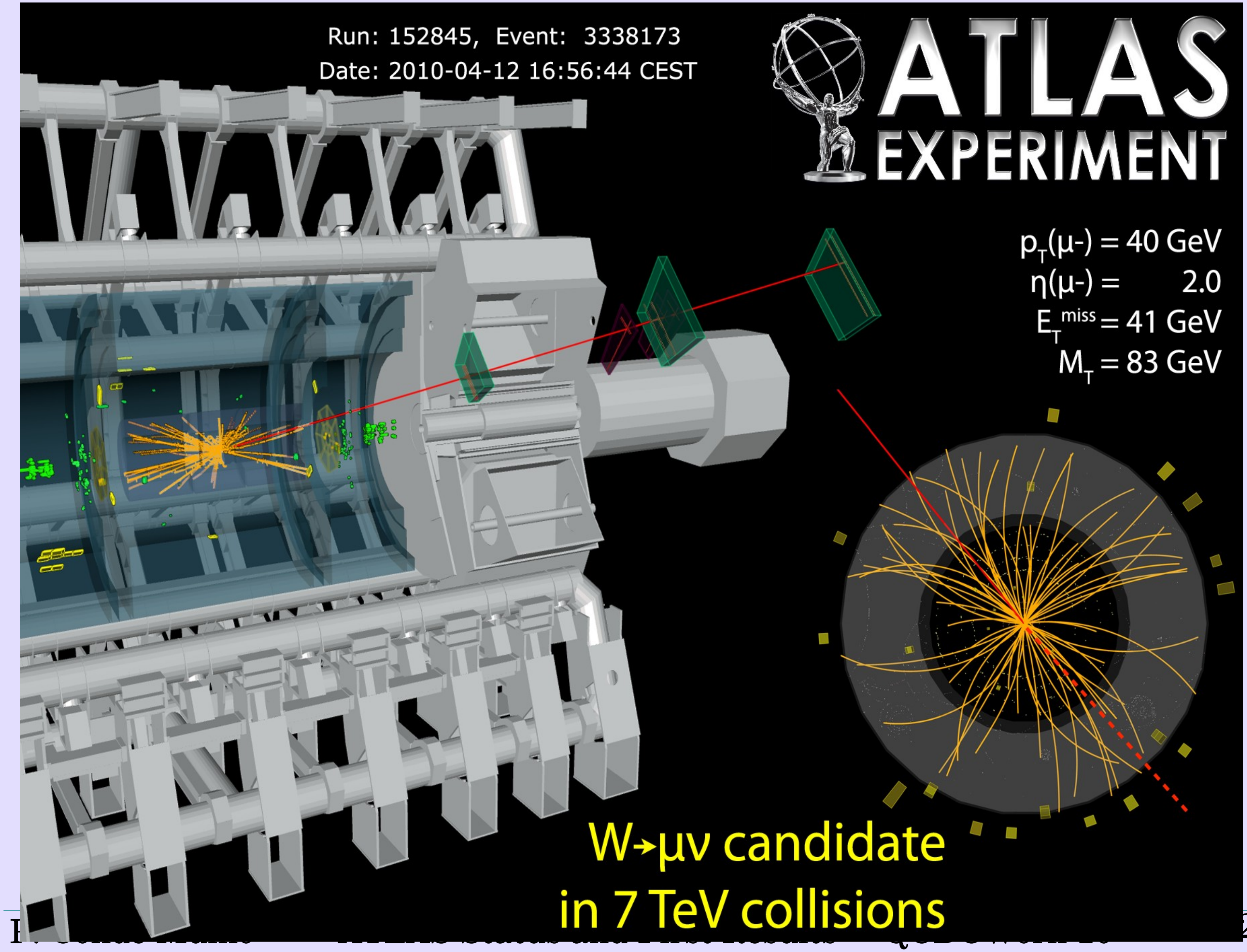
- $p_T^l > 20$ GeV
- Isolation
- $\not{E}_T > 25$ GeV



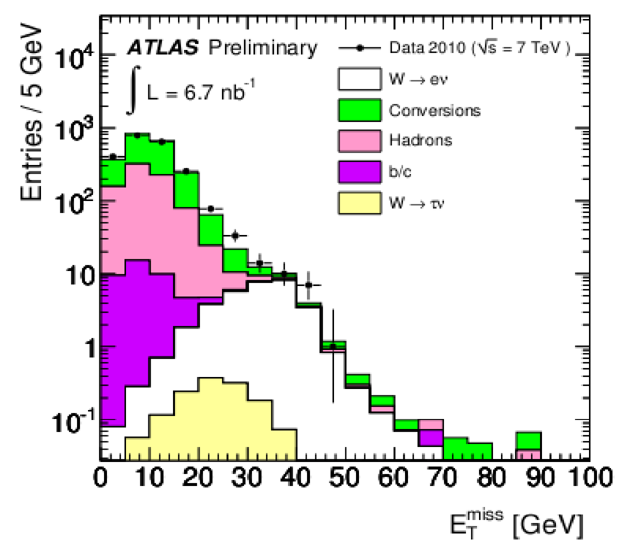
	$W \to \mu\nu$ channel
Observed	40
Expected	28.7 ± 0.5(stat) ± 3.9(syst) ± 5.7(lumi)
Signal	25.9 ± 3.6(syst) ± 5.2(lumi)
Bkg	2.8 ± 0.5(stat) ± 0.8(syst) ± 0.6(lumi)



W→μν candidate

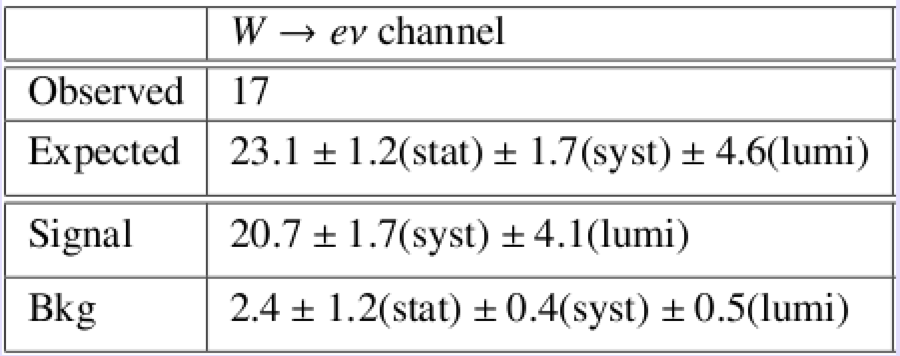


W→eν observation

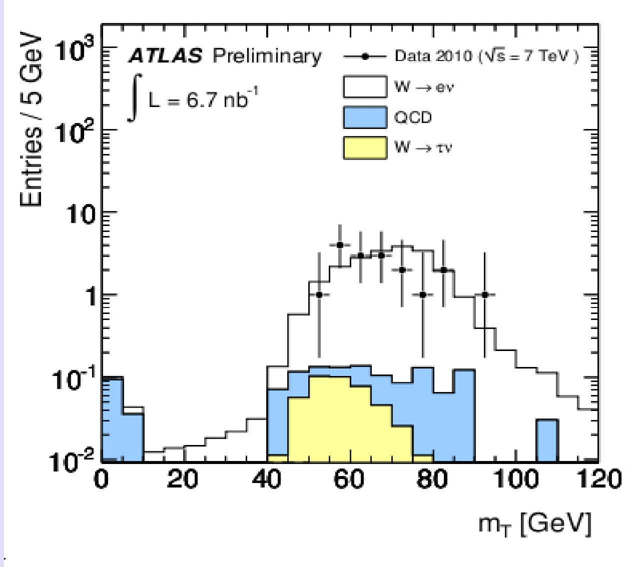


MC normalized to data, softer lepton identification,

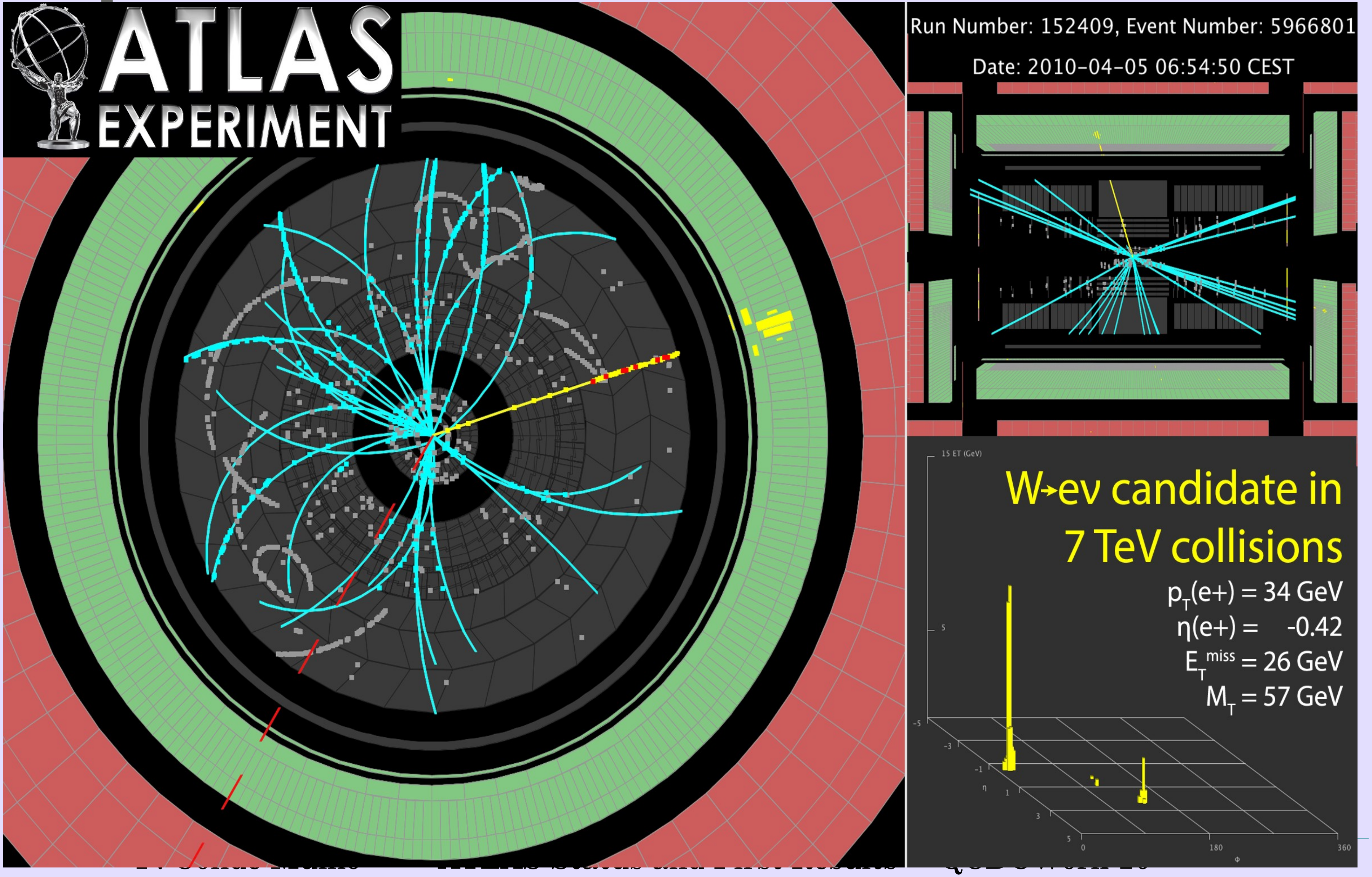
- First level trigger: E_T > 2 counts ~ 2 GeV
- Tight electron identification
- Primary vertex, > 3 tracks, consistent with beam spot
- p_T^l > 20 GeV
- $\not{E}_T$ > 25 GeV



	$W \to e\nu$ channel
Observed	17
Expected	23.1 ± 1.2(stat) ± 1.7(syst) ± 4.6(lumi)
Signal	20.7 ± 1.7(syst) ± 4.1(lumi)
Bkg	2.4 ± 1.2(stat) ± 0.4(syst) ± 0.5(lumi)



W→eν candidate



Run Number: 152409, Event Number: 5966801

Date: 2010-04-05 06:54:50 CEST

W→eν candidate in 7 TeV collisions

$p_T(e+) = 34$ GeV

$\eta(e+) = -0.42$

$E_T^{miss} = 26$ GeV

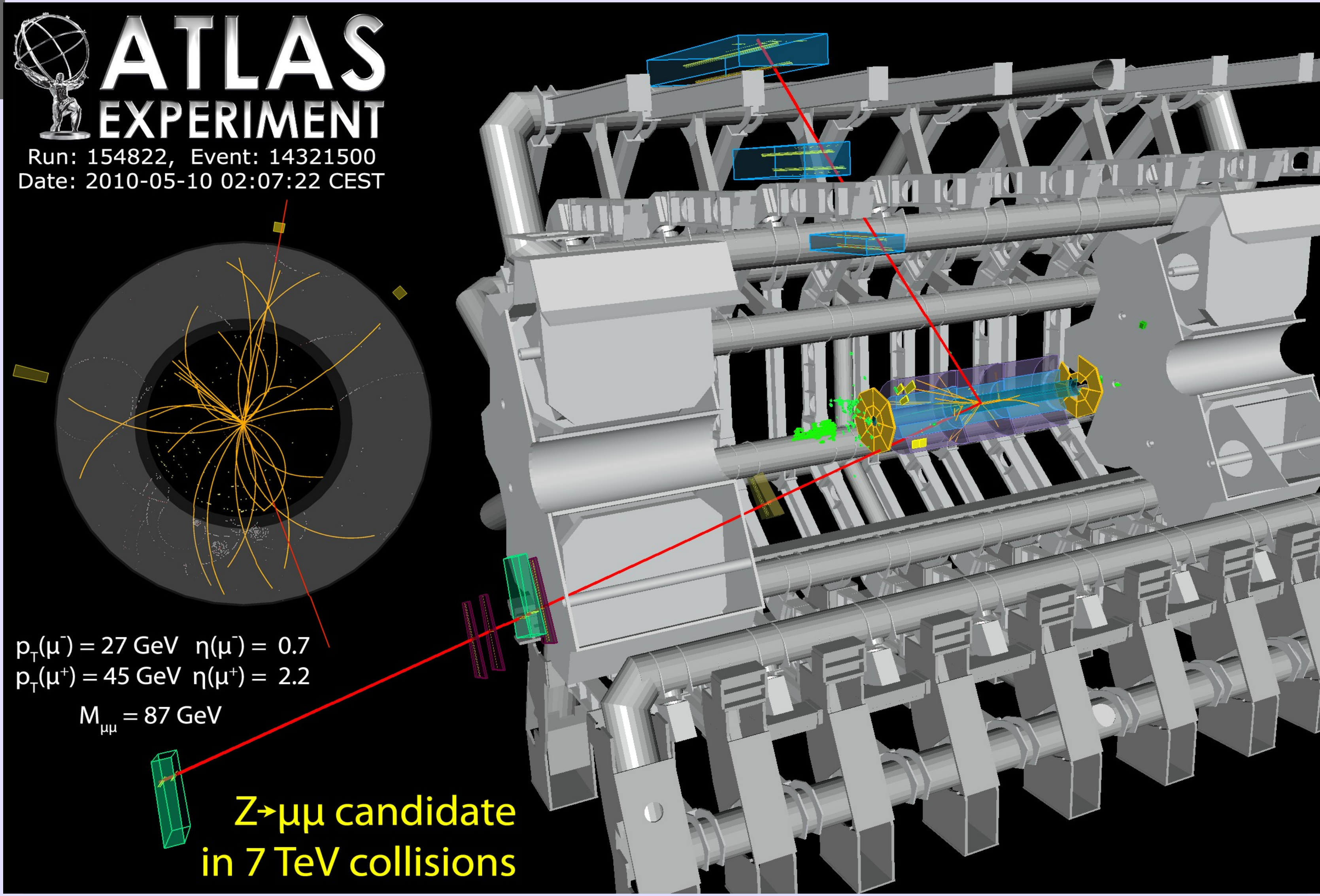
$M_T = 57$ GeV

Z boson observation

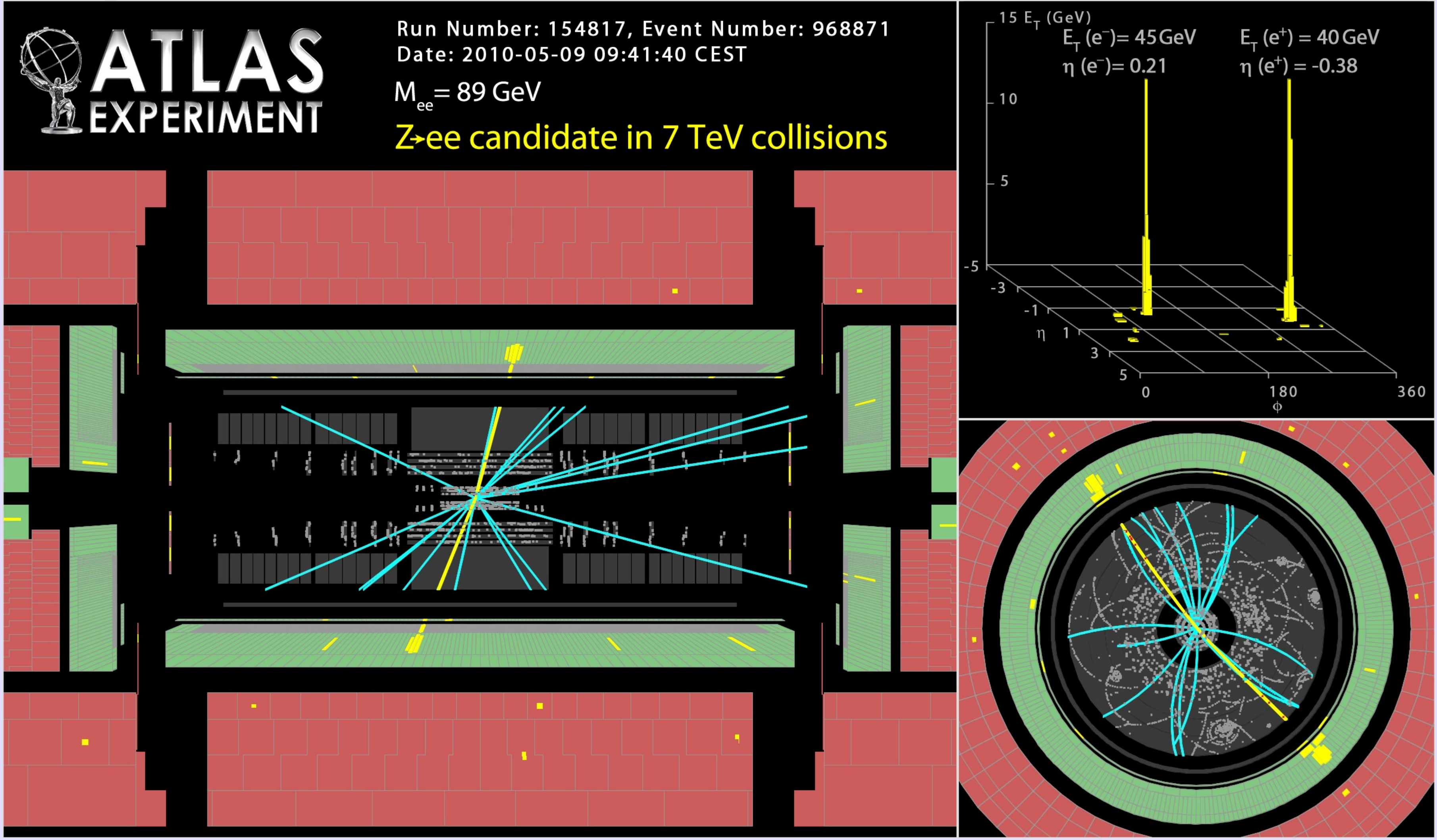
- Same preselection as for W's.
- Additional requirements for muons:
    - Central μ, $p_T^{\mu 1} > 15$ GeV, $p_T^{\mu 2} > 20$ GeV
    - isolation
- Softer lepton identification for electrons

	$Z \rightarrow e^+e^-$	$Z \rightarrow \mu^+\mu^-$
Analysed Int. Luminosity	6.7nb^{-1}	7.9nb^{-1}
Observed 80 – 100 GeV	1	2
Observed outside 80 – 100 GeV	0	1
Total expected	1.6 ±0.1(syst)±0.3 (lumi)	3.2 ±0.8(syst)±0.6 (lumi)
Background	0.01 events From combination of MC and data driven technique	<0.01 events From Monte Carlo

Z→μμ candidate



Z→ee candidate



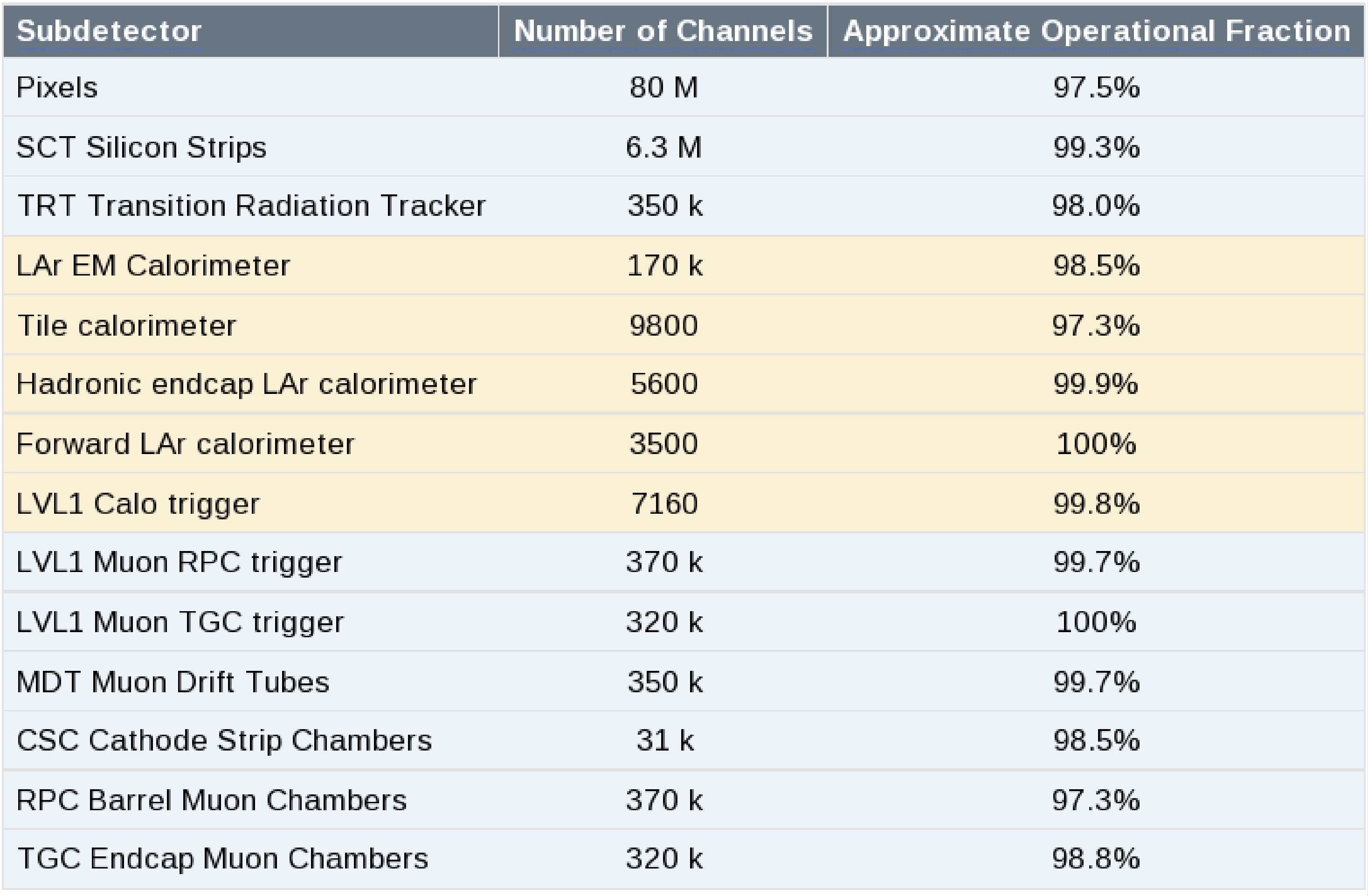
Summary and conclusions

- After years of hard work, ATLAS has seen the first 7 TeV collisions
  - Recorded about 15 nb^{-1} of integrated luminosity at 7 TeV
- With this data the ATLAS detector is being intensively studied
- The detector is performing remarkably well
  - Good understanding of the momentum scale, material, track parameters
  - Good understanding of the electron, photon, muon, jets and missing E_T reconstruction
  - Overall description of the detector in the MC simulation very good
- The first SM physics studies are being prepared
- A lot more to come in the near future

Backup

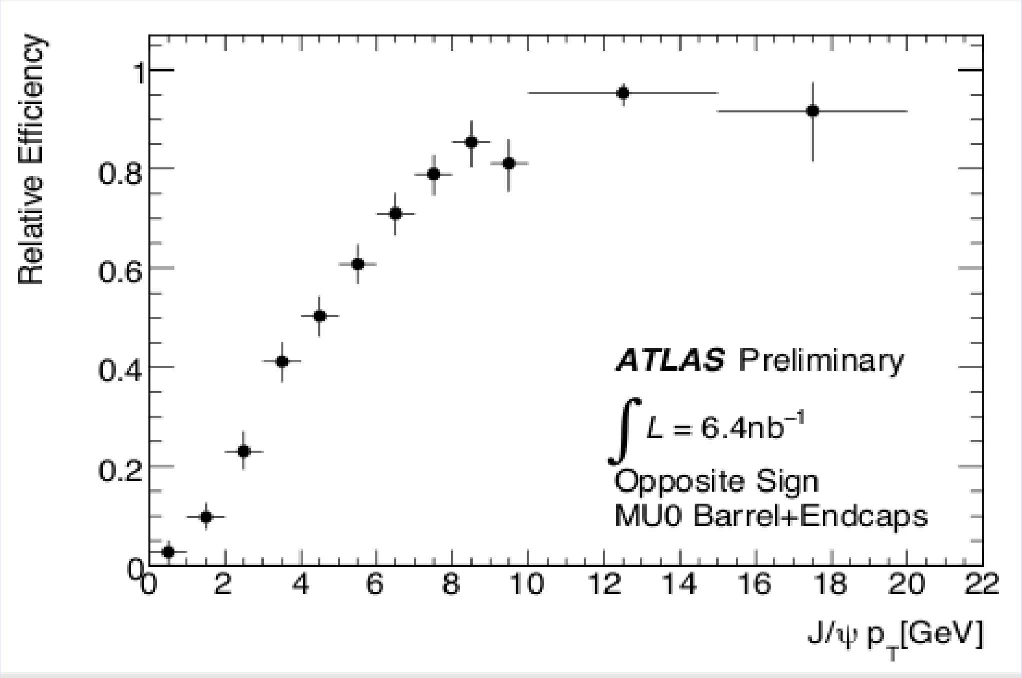
ATLAS Overal Detector Performance

- Detector operating with very high efficiency



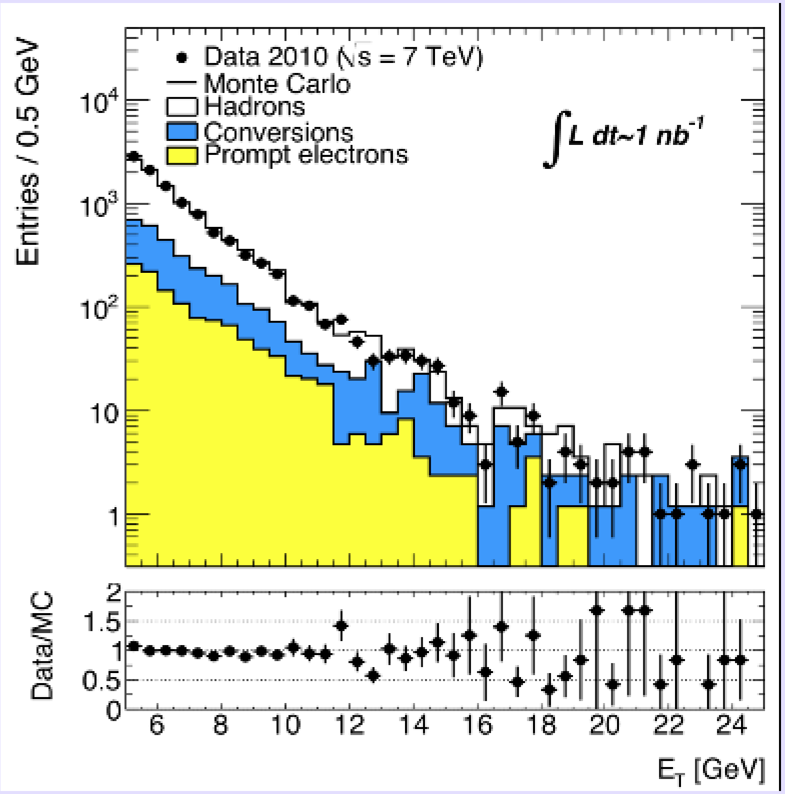
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.5%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	98.0%
LAr EM Calorimeter	170 k	98.5%
Tile calorimeter	9800	97.3%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.8%
LVL1 Muon RPC trigger	370 k	99.7%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.3%
TGC Endcap Muon Chambers	320 k	98.8%

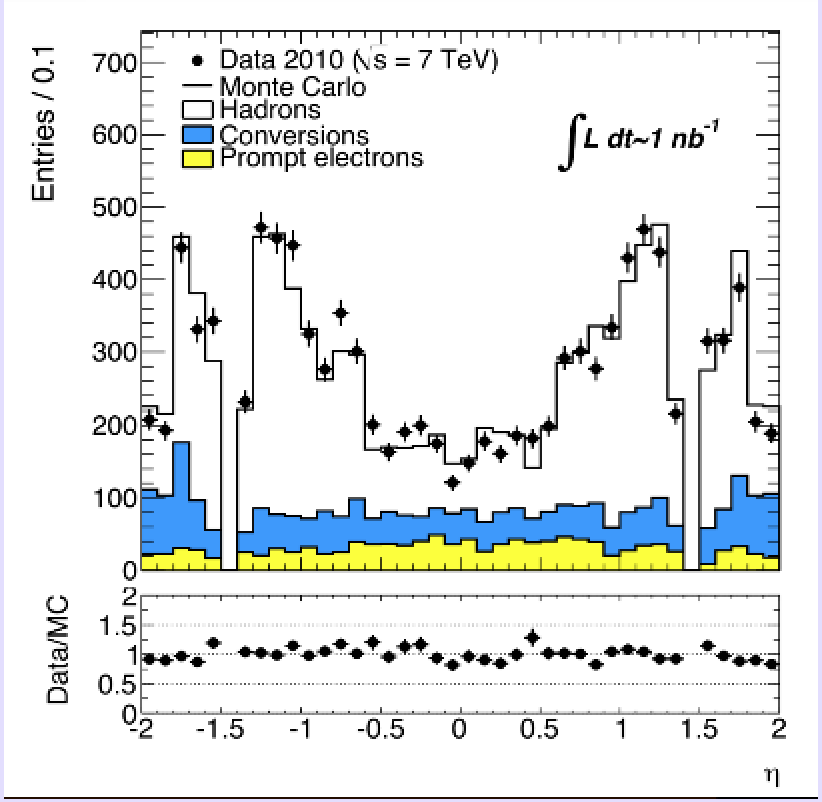
Muon trigger efficiency



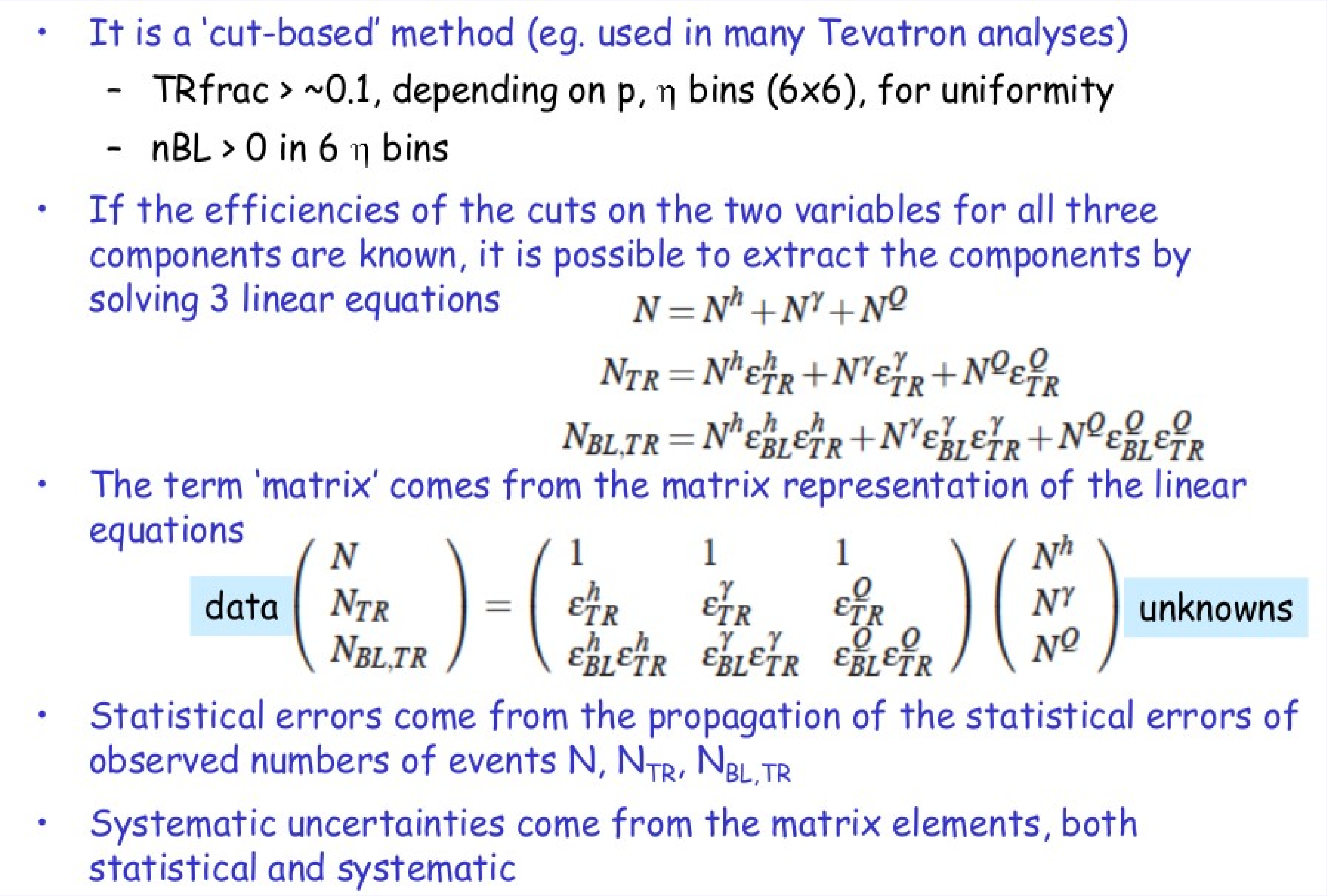
Electrons

- Medium electron identification
- Spectrum





Matrix method



- It is a 'cut-based' method (eg. used in many Tevatron analyses)
  - TRfrac > ~0.1, depending on p, η bins (6x6), for uniformity
  - nBL > 0 in 6 η bins
- If the efficiencies of the cuts on the two variables for all three components are known, it is possible to extract the components by solving 3 linear equations

$$N = N^h + N^\gamma + N^Q$$

$$N_{TR} = N^h \varepsilon^h_{TR} + N^\gamma \varepsilon^\gamma_{TR} + N^Q \varepsilon^Q_{TR}$$

$$N_{BL,TR} = N^h \varepsilon^h_{BL} \varepsilon^h_{TR} + N^\gamma \varepsilon^\gamma_{BL} \varepsilon^\gamma_{TR} + N^Q \varepsilon^Q_{BL} \varepsilon^Q_{TR}$$

- The term 'matrix' comes from the matrix representation of the linear equations

$$\text{data} \begin{pmatrix} N \\ N_{TR} \\ N_{BL,TR} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 \\ \varepsilon^h_{TR} & \varepsilon^\gamma_{TR} & \varepsilon^Q_{TR} \\ \varepsilon^h_{BL}\varepsilon^h_{TR} & \varepsilon^\gamma_{BL}\varepsilon^\gamma_{TR} & \varepsilon^Q_{BL}\varepsilon^Q_{TR} \end{pmatrix} \begin{pmatrix} N^h \\ N^\gamma \\ N^Q \end{pmatrix} \text{unknowns}$$

- Statistical errors come from the propagation of the statistical errors of observed numbers of events N, N_{TR}, $N_{BL,TR}$
- Systematic uncertainties come from the matrix elements, both statistical and systematic