



**The ATLAS Experiment in the era of data
Jan Strube
PPD - Rutherford Appleton Laboratory**

Collaboration in numbers

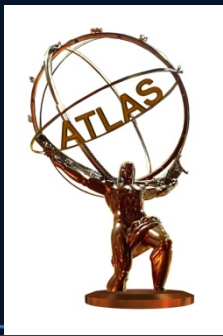
3000 members

27 of which in PPD

38 countries

174 universities

1000 students



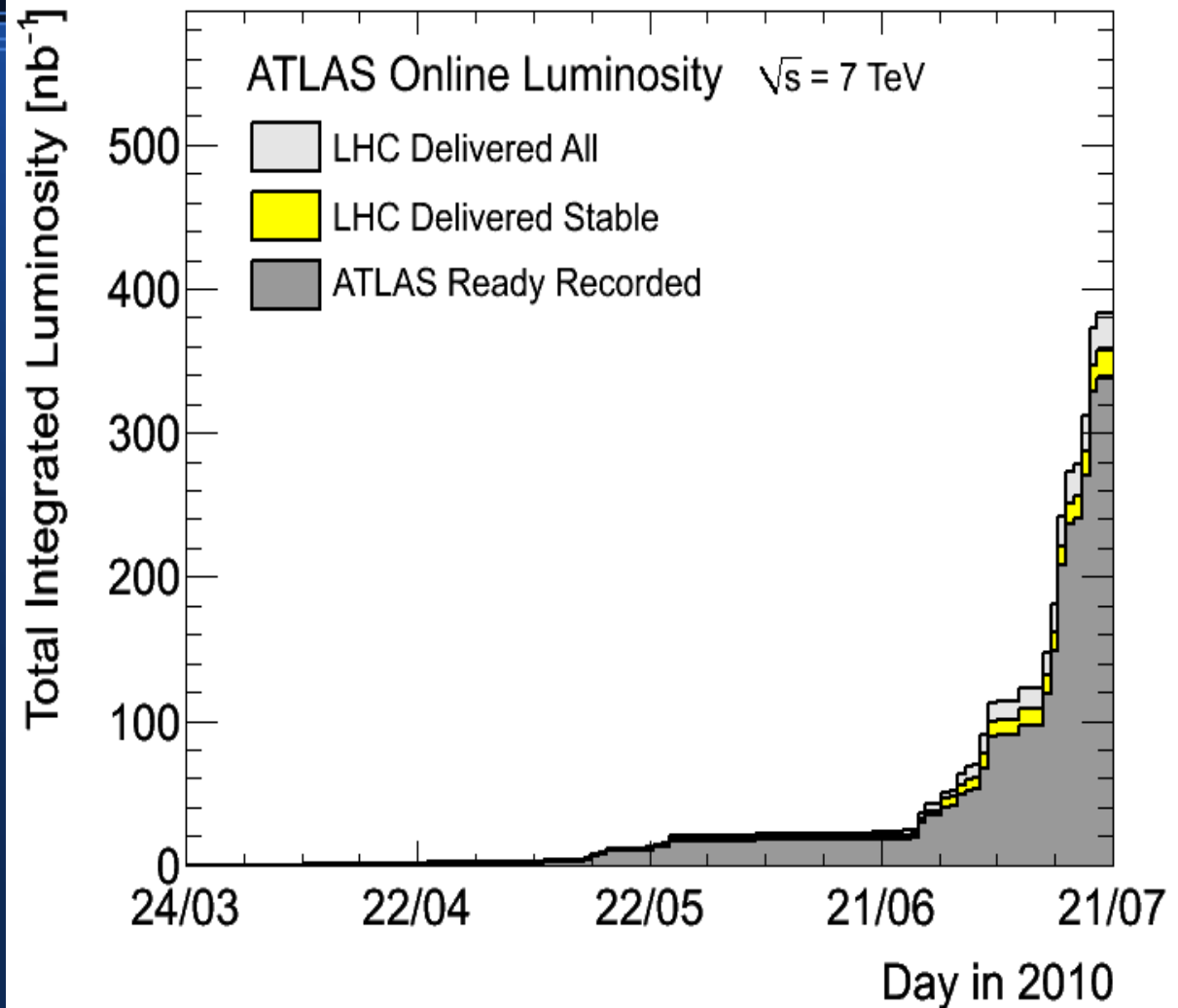
Outline

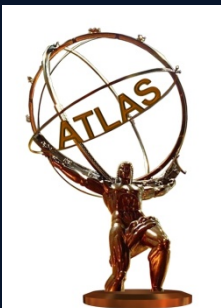
- LHC and ATLAS
- The Detector
- Results from physics analyses



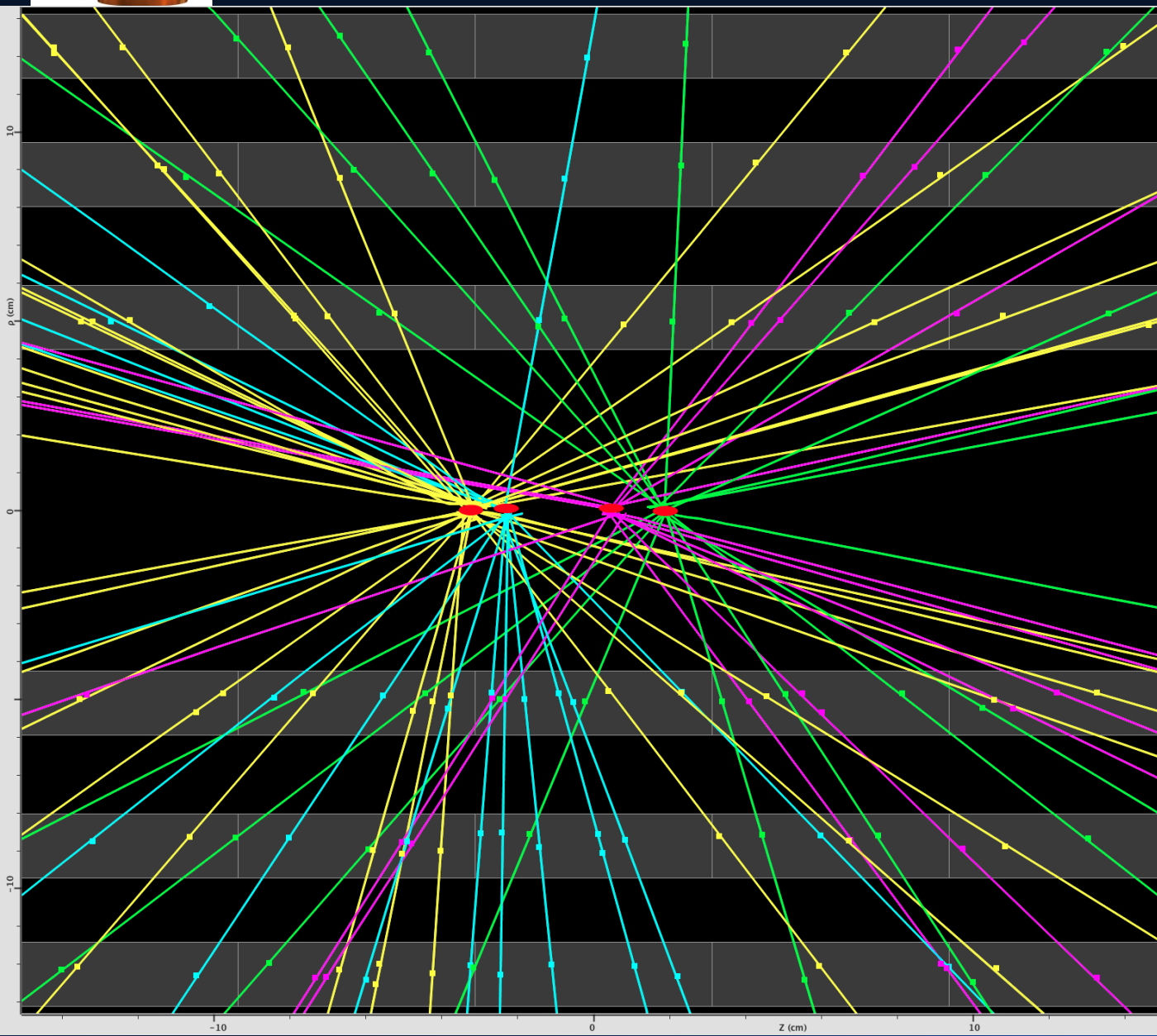
Data Taking Records

- Peak Luminosity:
 - $1.6 \times 10^{30} \text{ cm}^{-2}\text{s}^{-1}$
- Stable beams:
 - 356.7 nb^{-1}
- ATLAS recorded:
 - 338.1 nb^{-1} (95%)





Pileup events

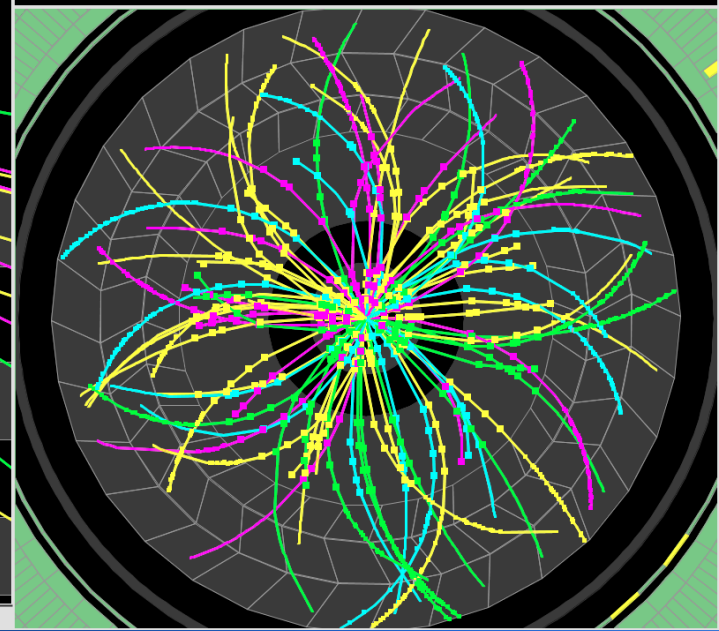


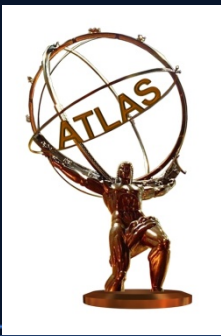
ATLAS
EXPERIMENT

Run Number: 153565, Event Number: 4487360

Date: 2010-04-24 04:18:53 CEST

**Event with 4 Pileup Vertices
in 7 TeV Collisions**



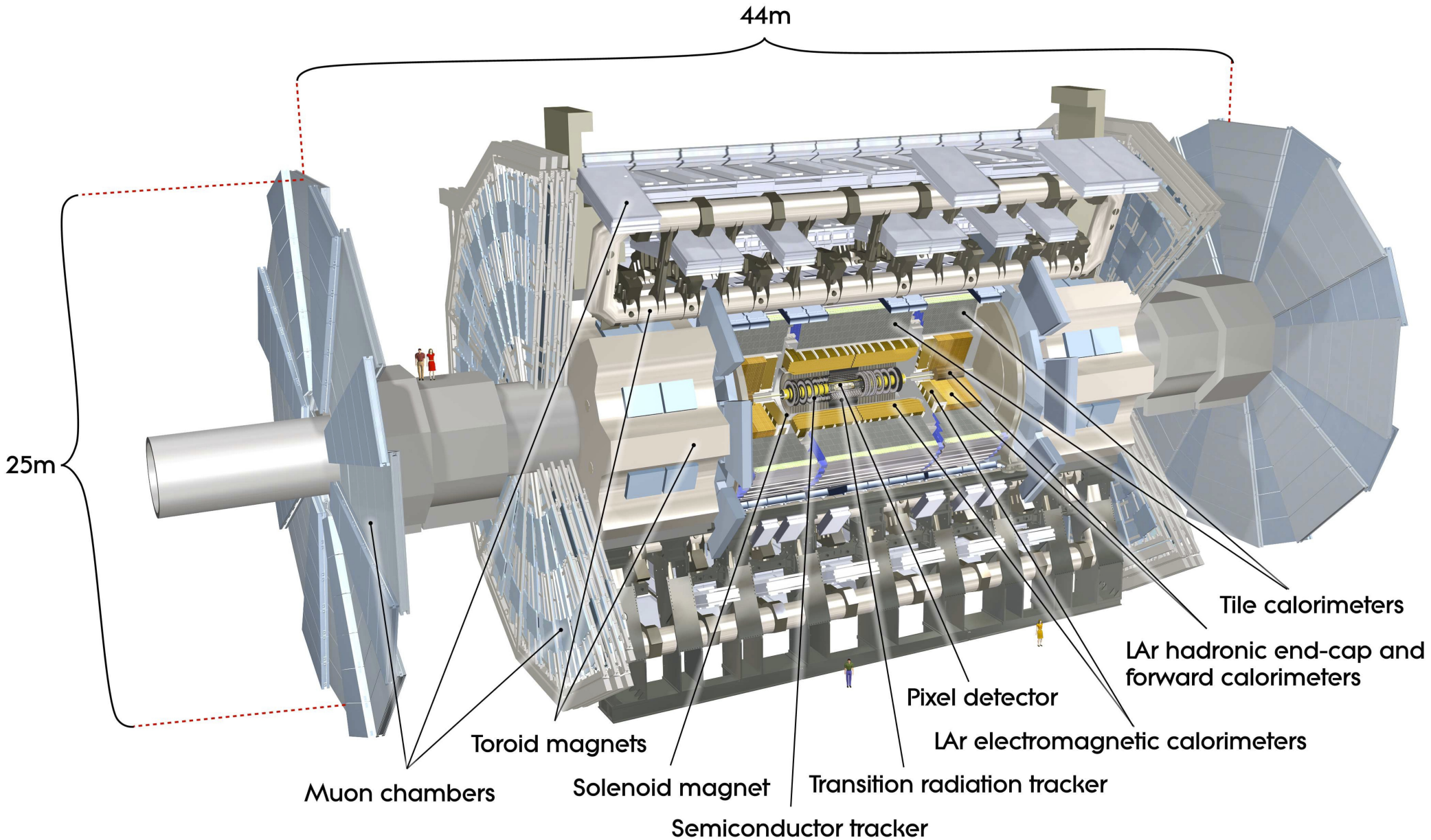


The ATLAS Detector

- The Inner Detector
 - Pixels
 - SCT
 - TRT
- Material Mappings
 - By Hand
 - Photon Conversions
 - Hadronic Interactions
- Calorimeters
- Muons



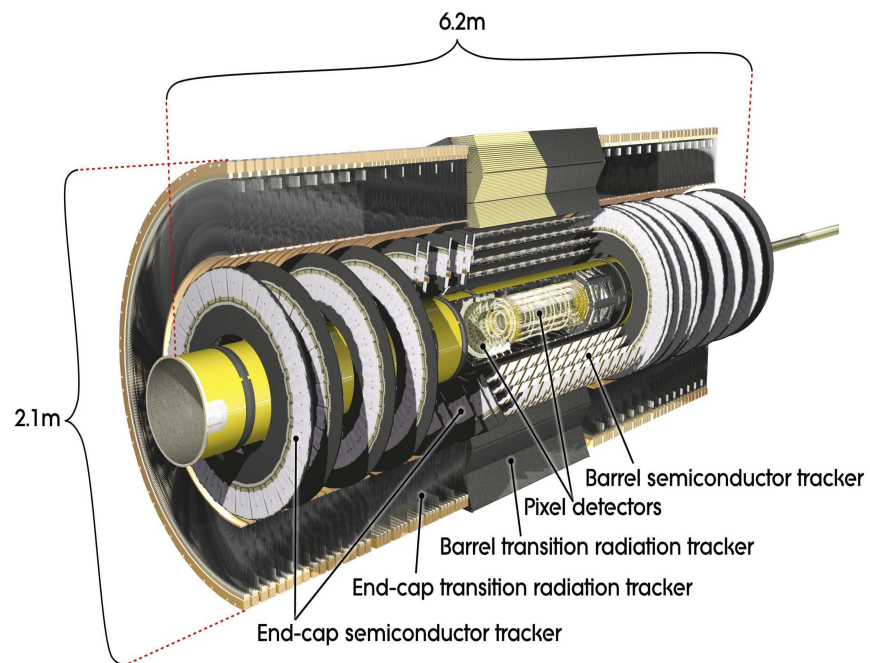
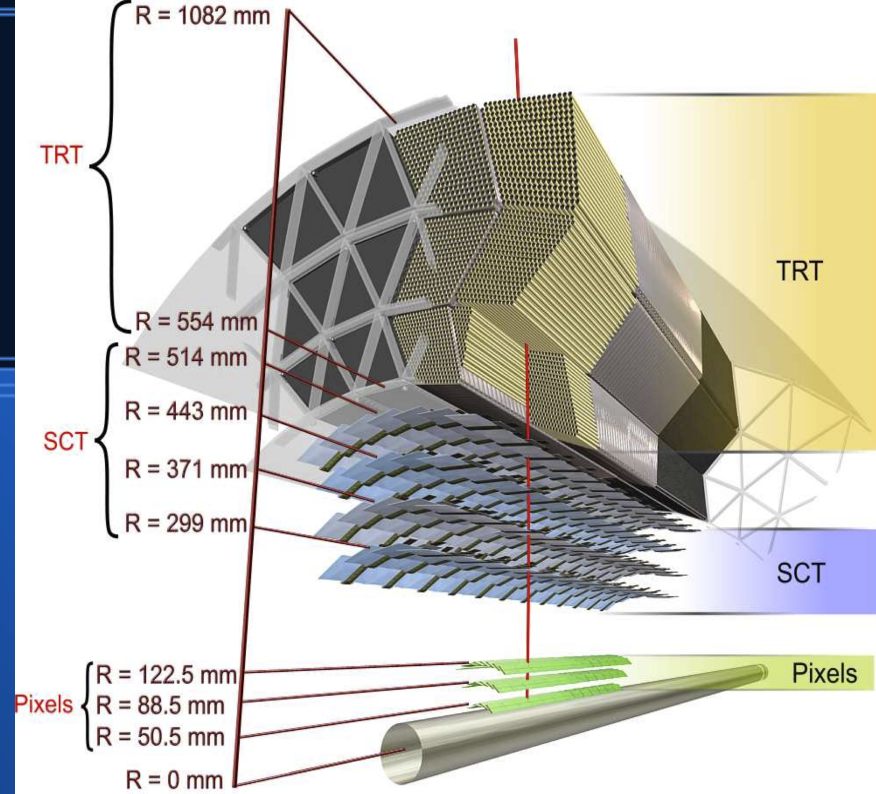
The ATLAS Detector





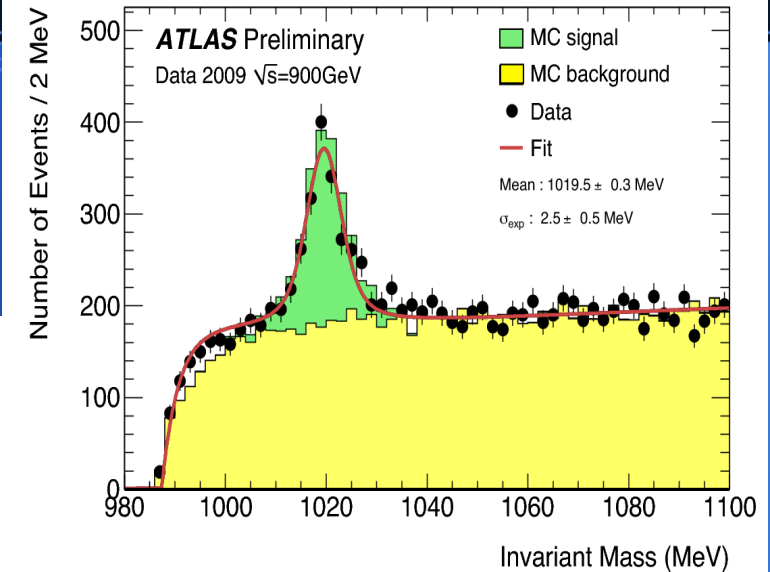
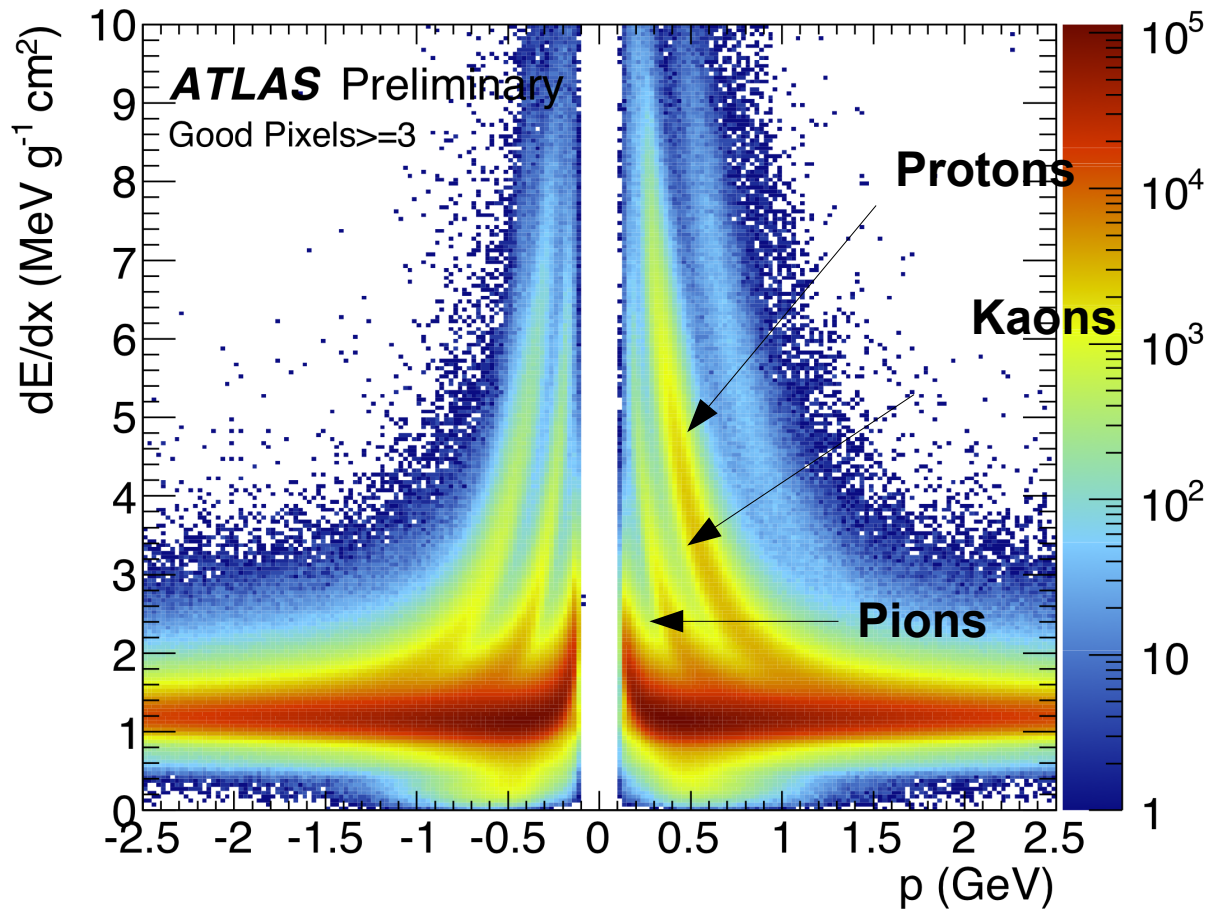
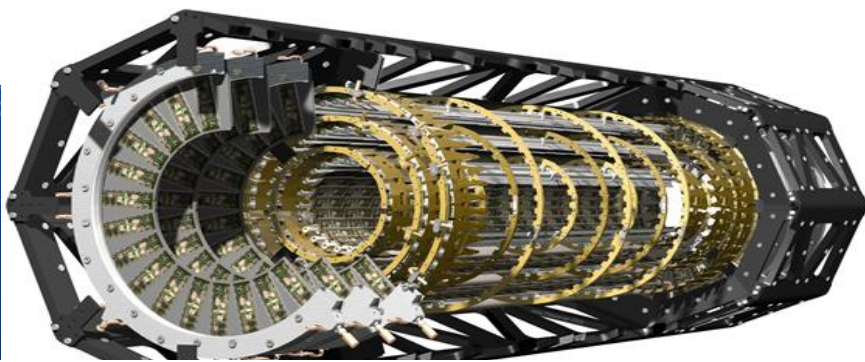
The ATLAS Inner Detector

- 3 Layers $|\eta| < 2.5|$ (3 disks x 2) Pixels:
 - 3D space points
 - dE/dx (PID)
- 4 Layers $|\eta| < 2.5|$ (9 disks x 2) SCT:
 - 2D measurements for high precision Tracking
- > 30 hits in TRT $|\eta| < 2|$: Standalone tracking and separation of e/π



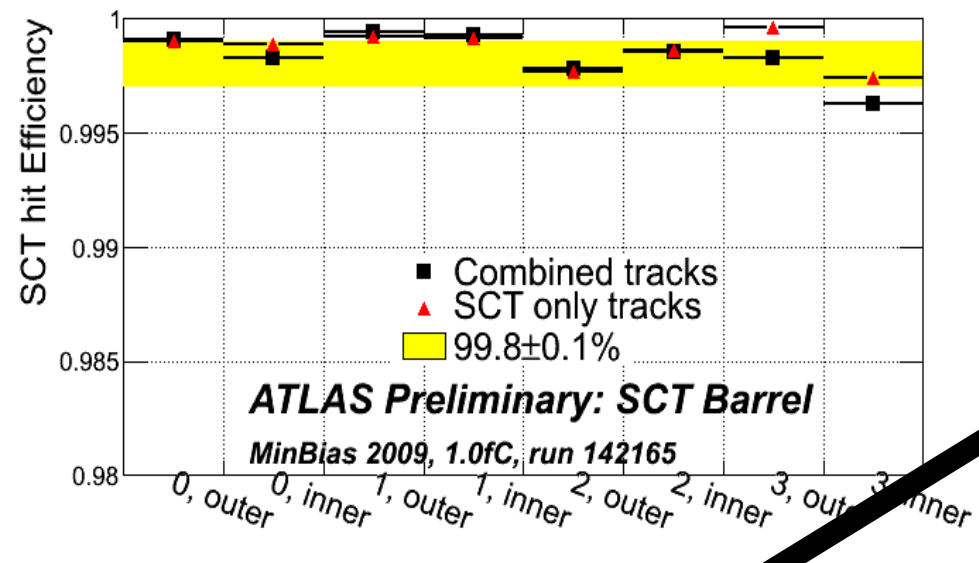
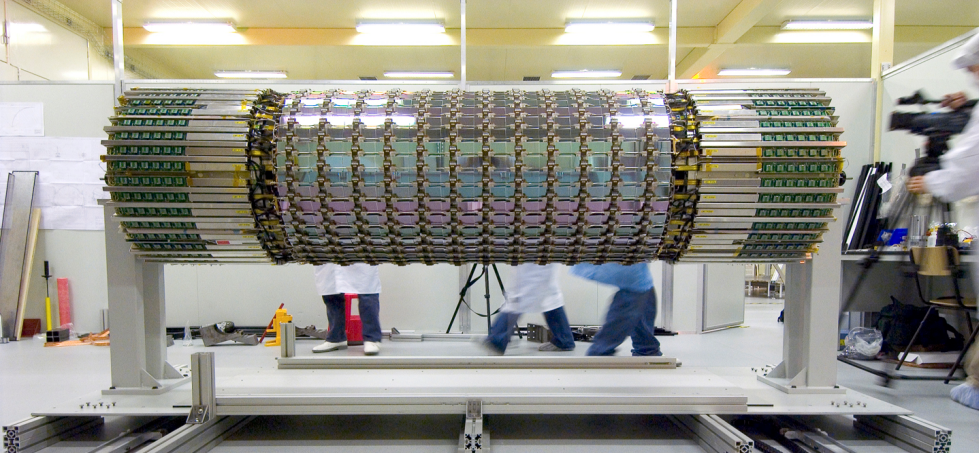


Particle ID in the Pixel detector

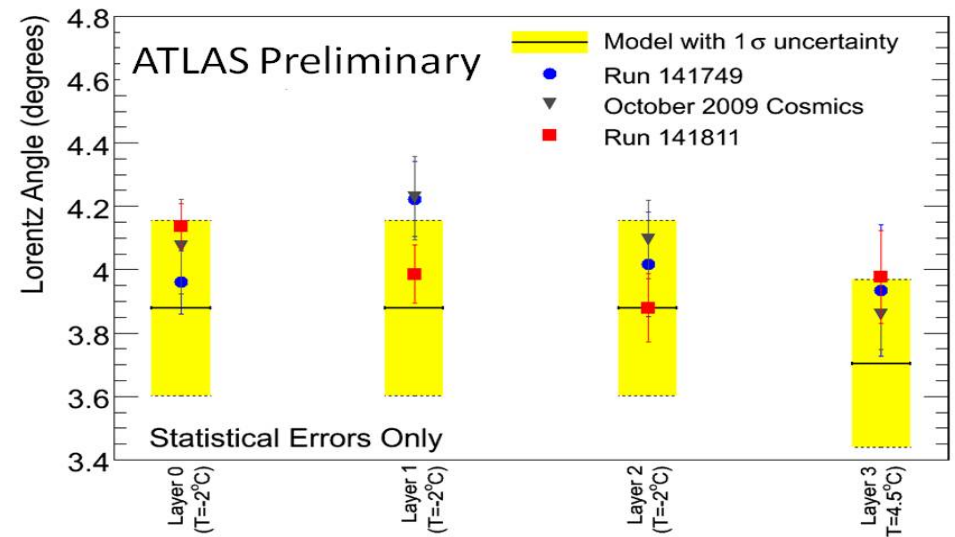
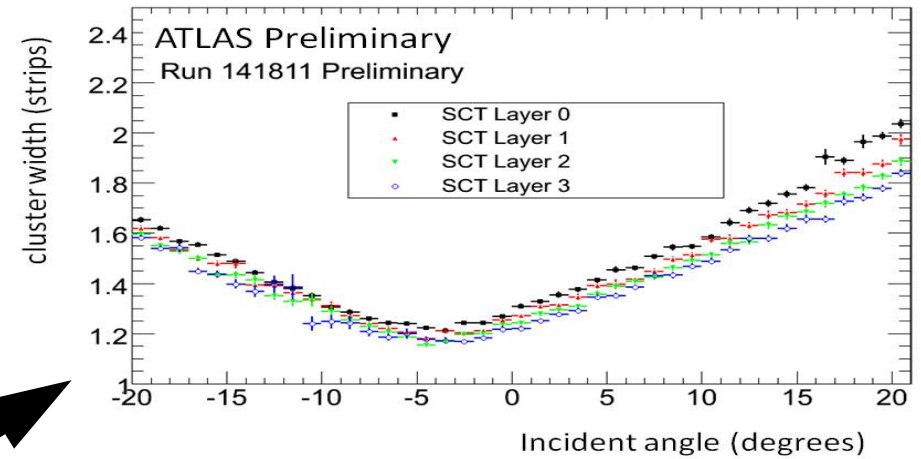


Particle ID
enhances S/B

Performance of the Silicon Tracker



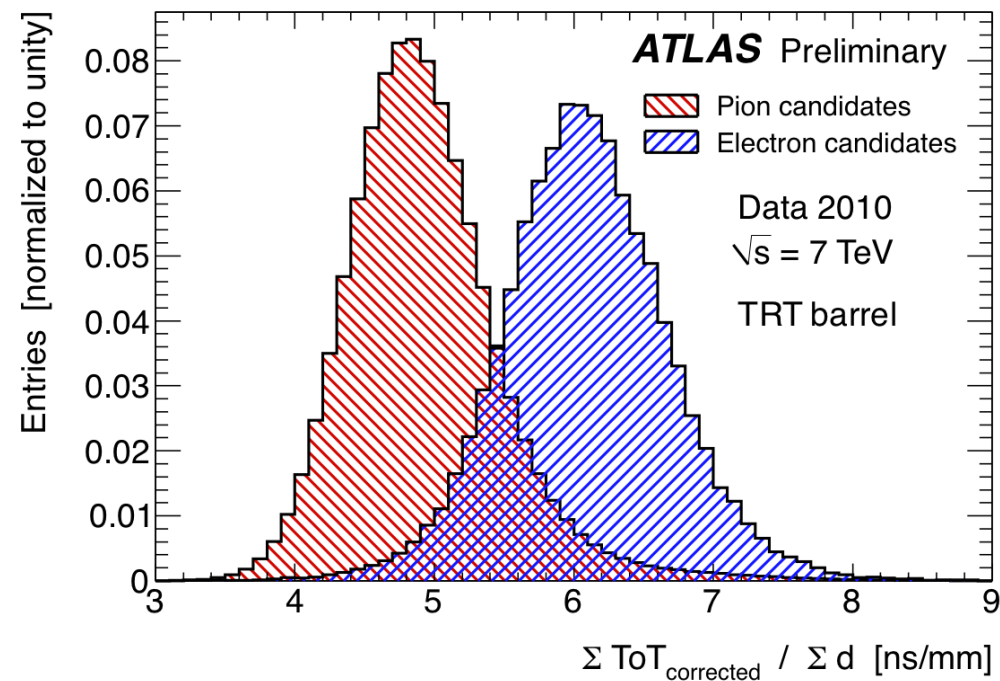
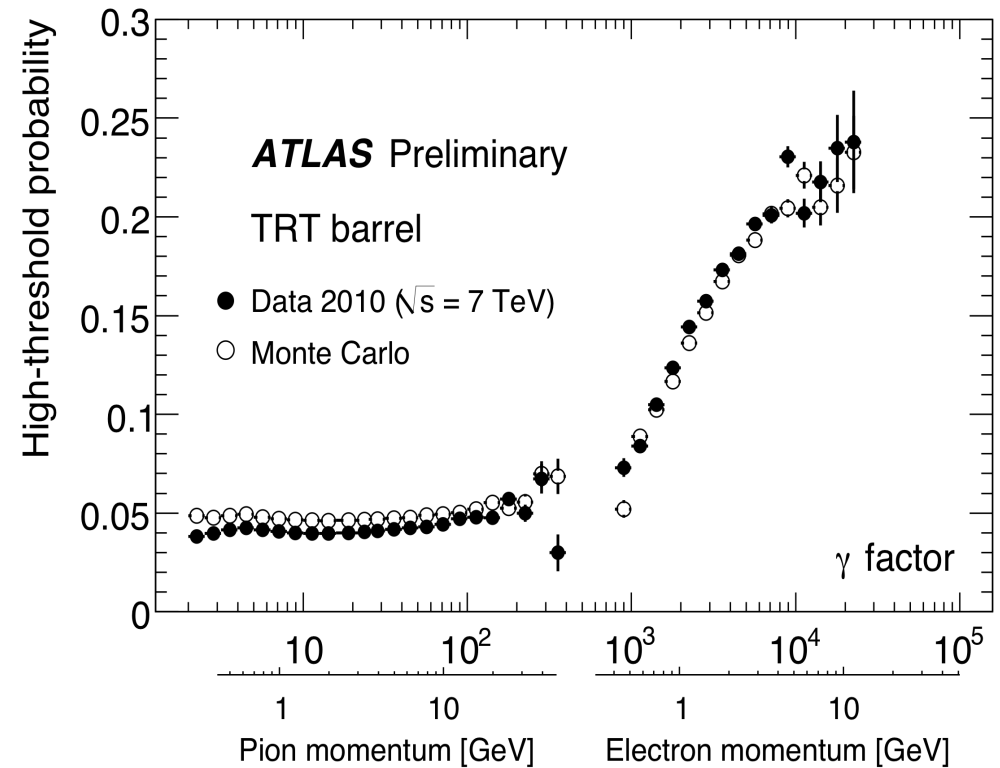
- Lorentz angle determined from the cluster size vs. incident angle



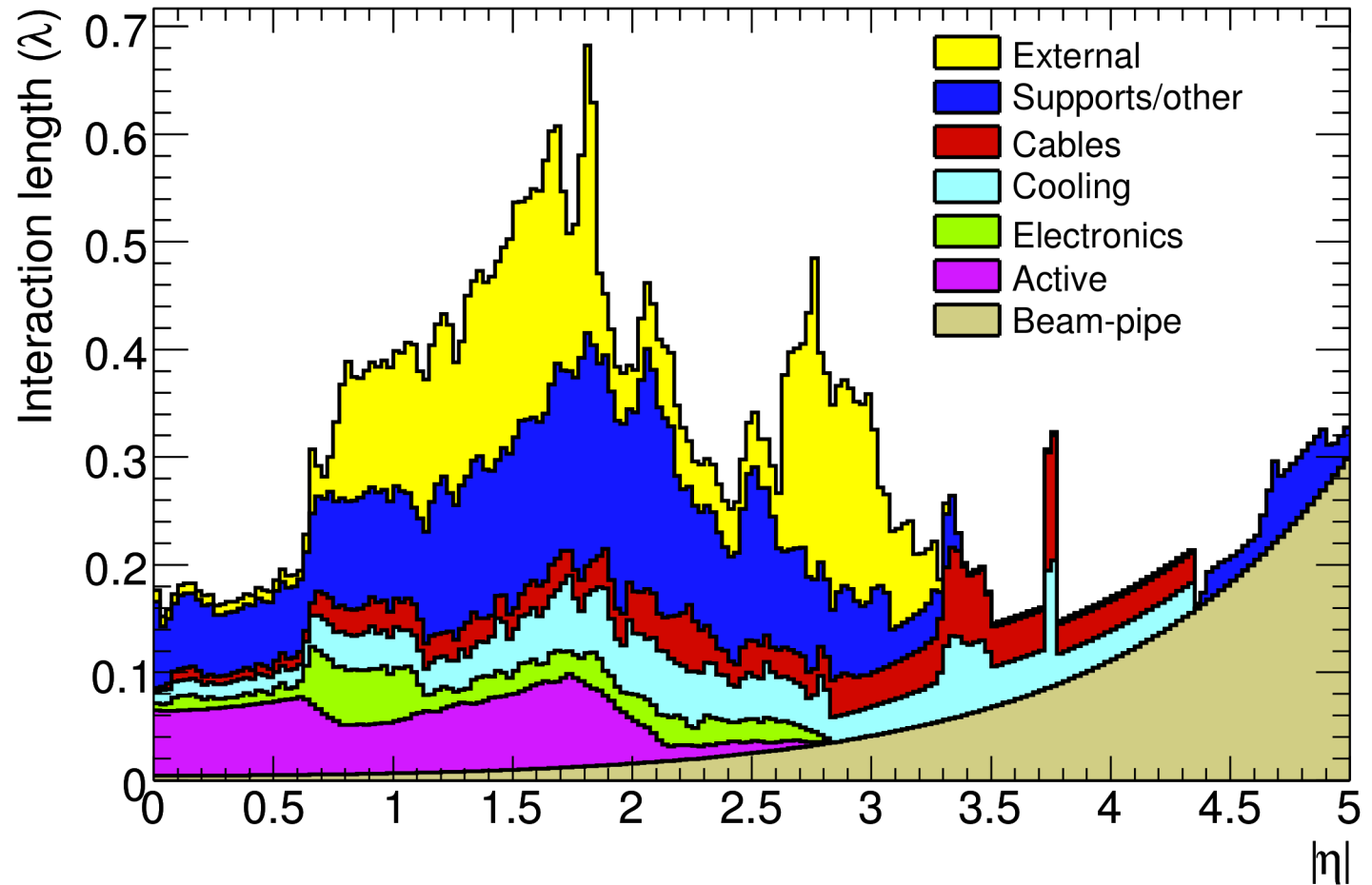
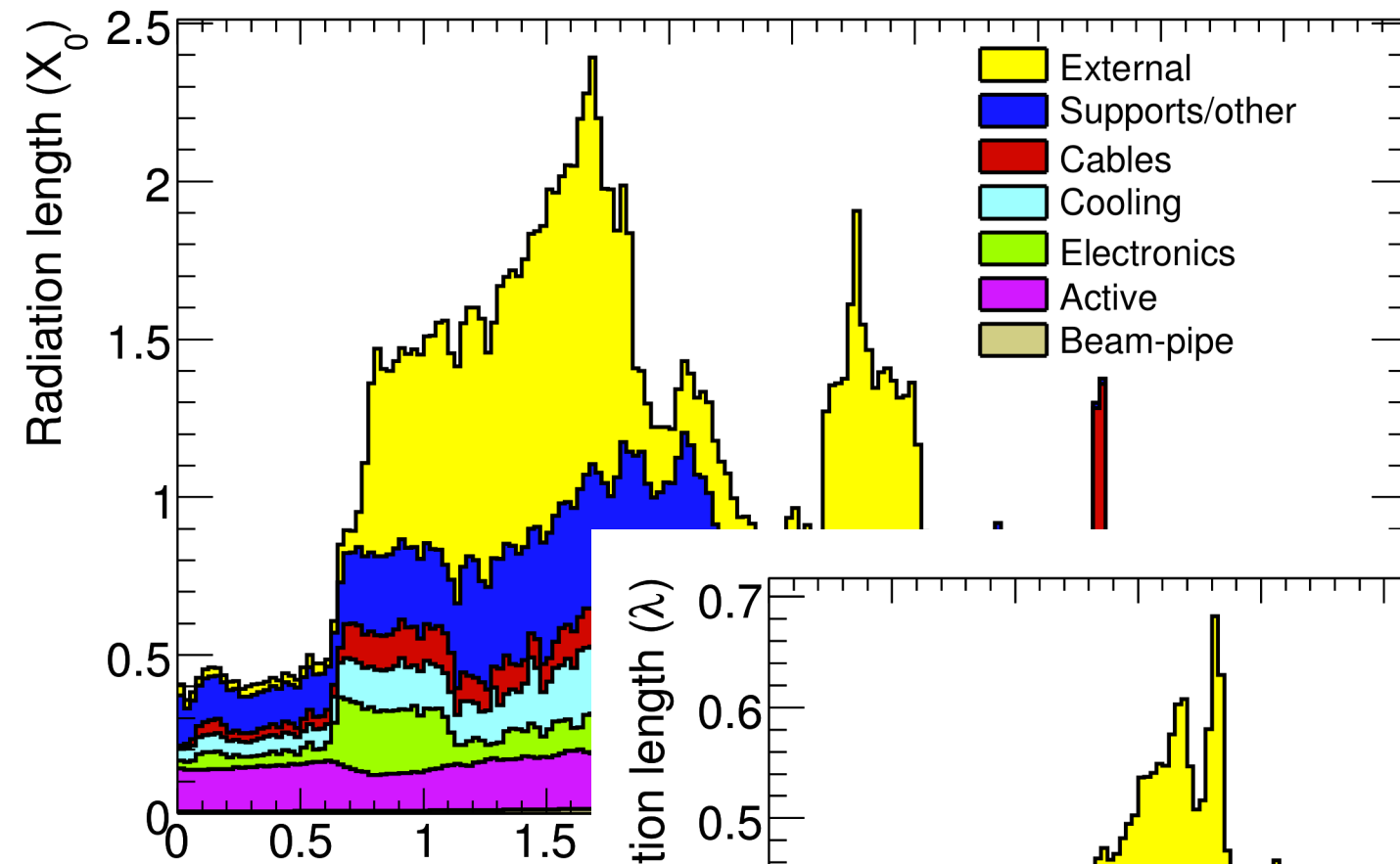


TRT for PID

- Transition radiation in polypropylene foil and fibres generates hits
- Larger energy loss \rightarrow larger time over threshold.

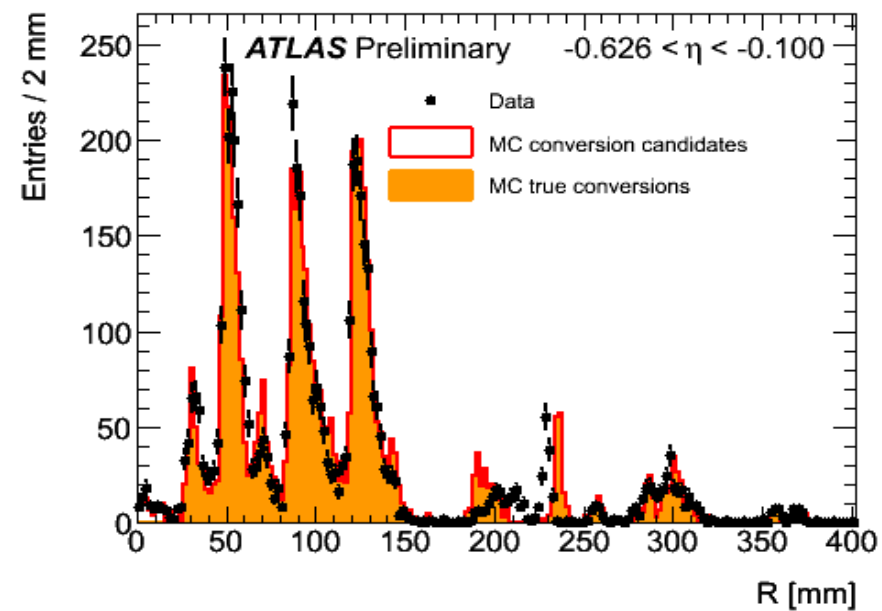
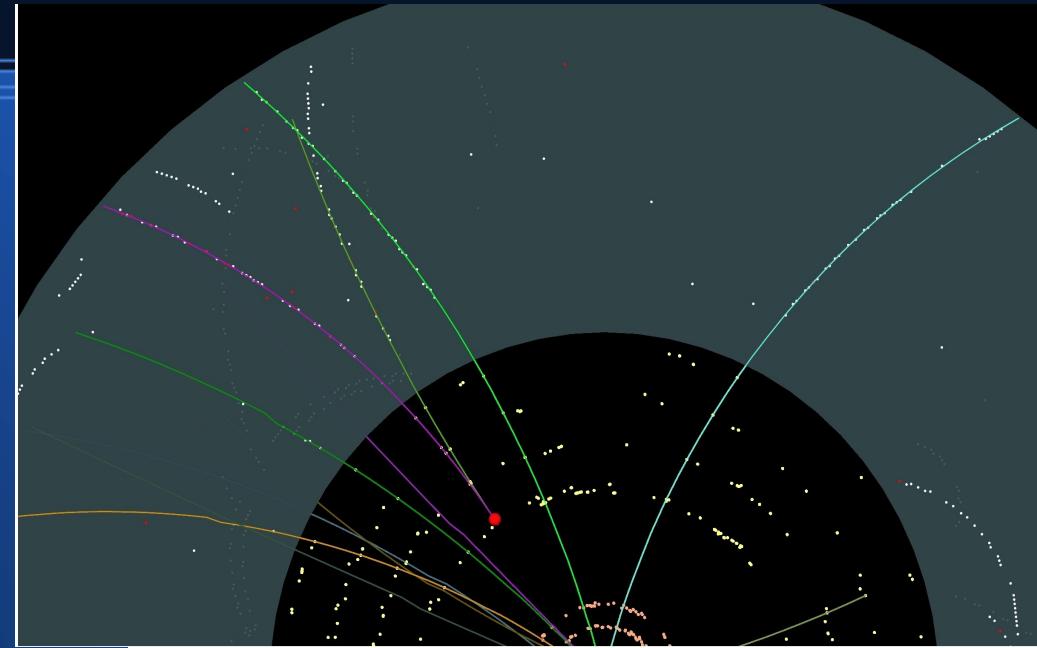
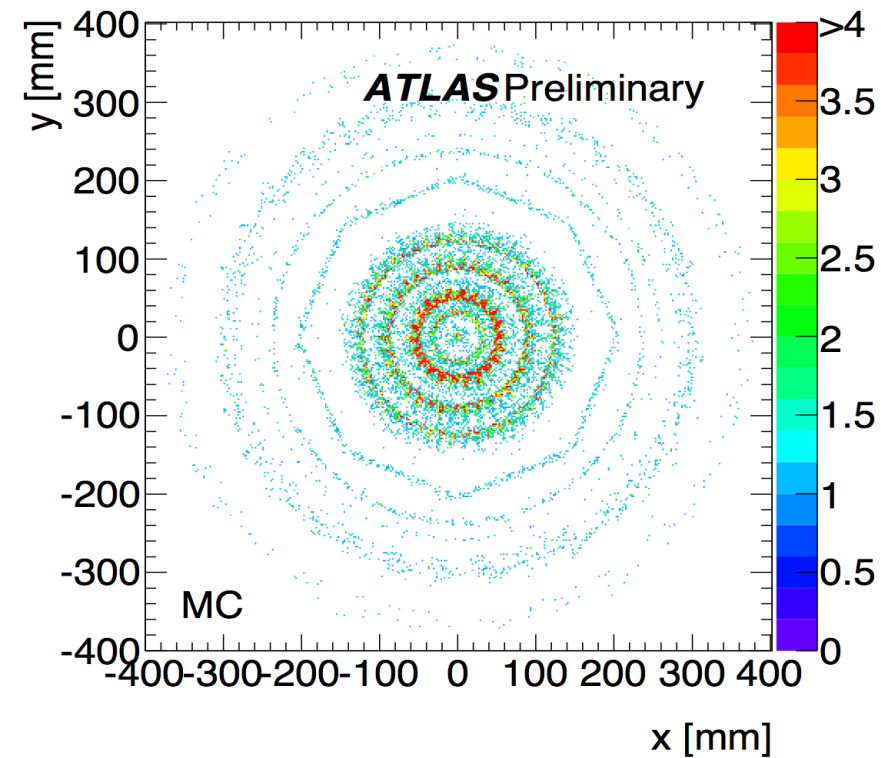
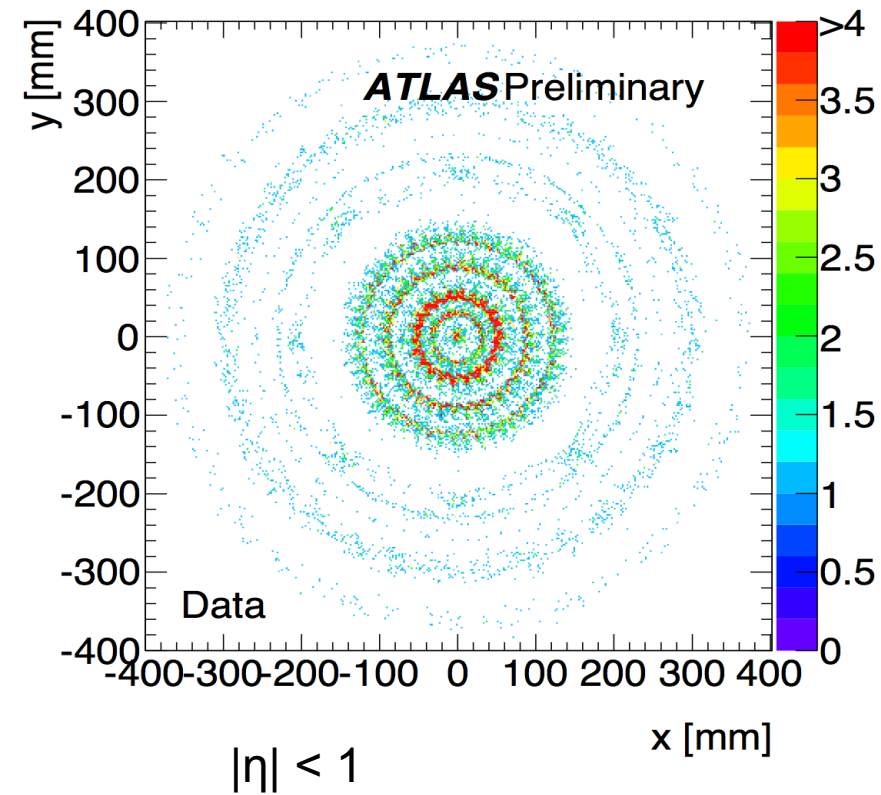


Inner Detector Material



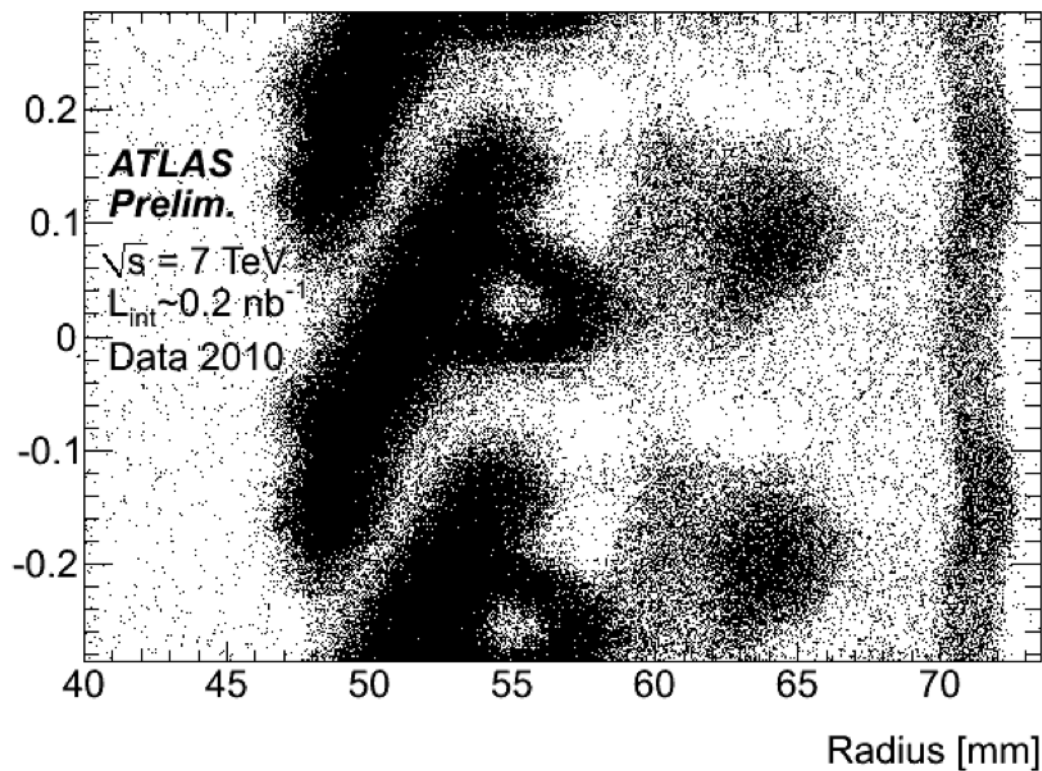
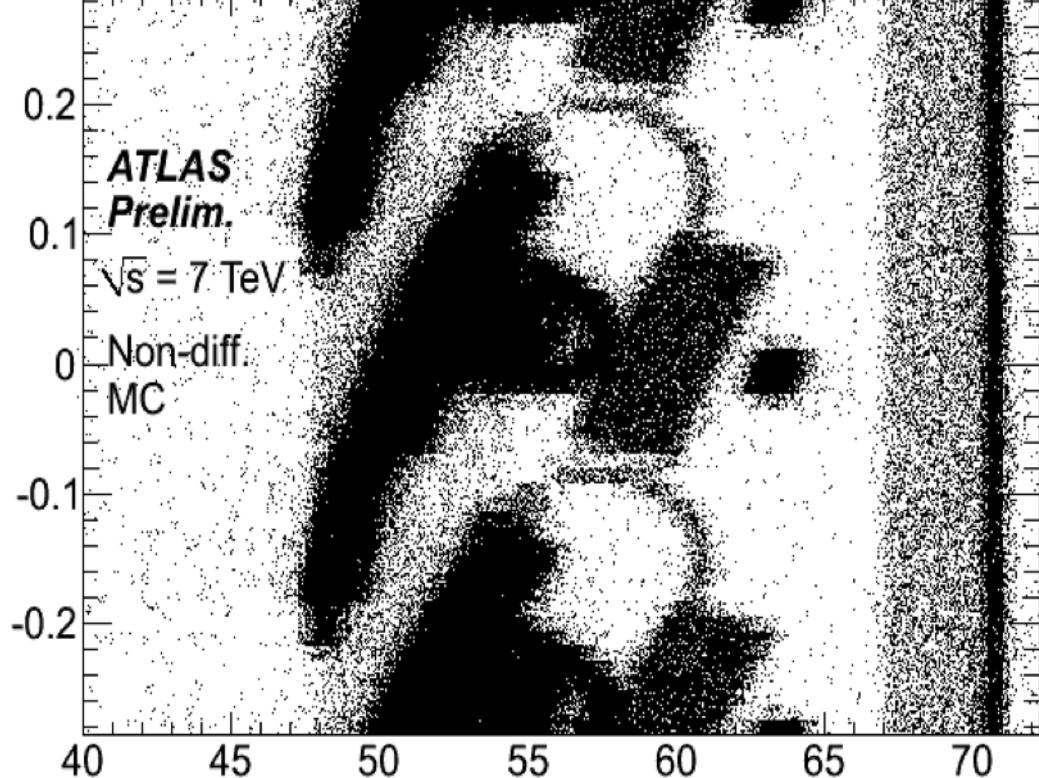
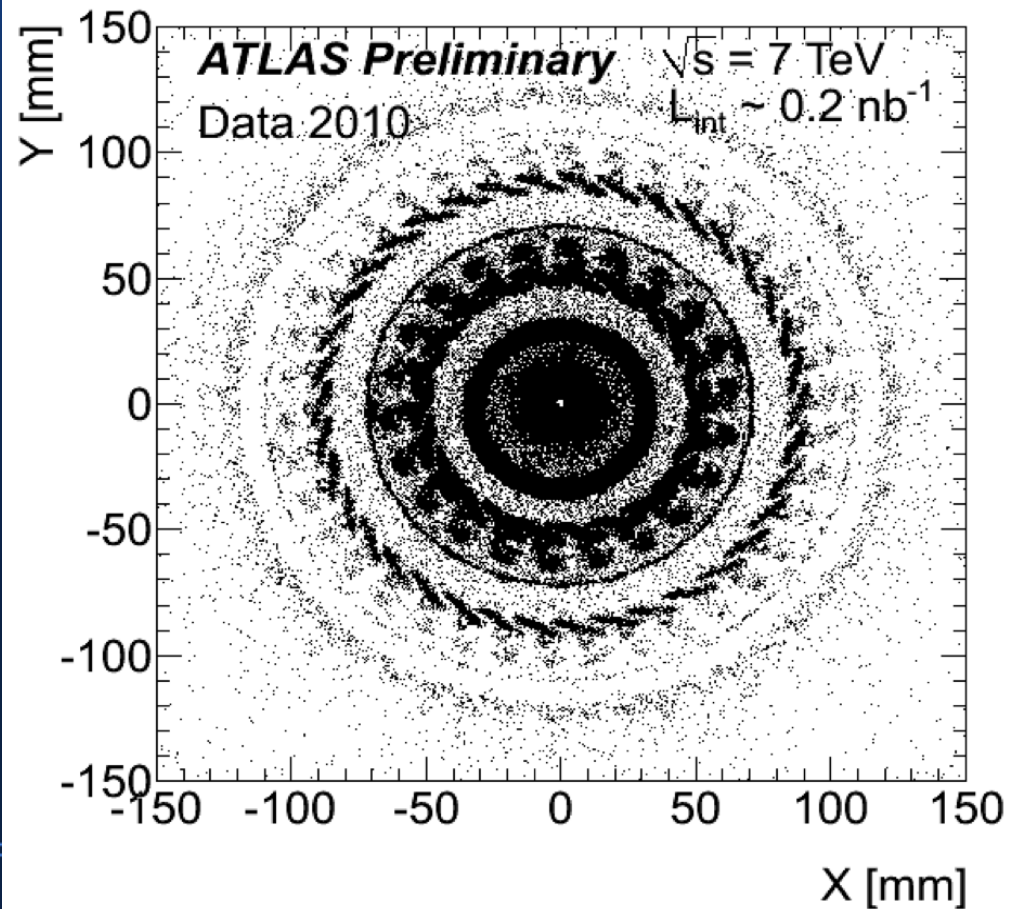
Mapping done
by looking at
engineering
reports

Mapping w/ photon conversions





Mapping w/ hadronic interactions



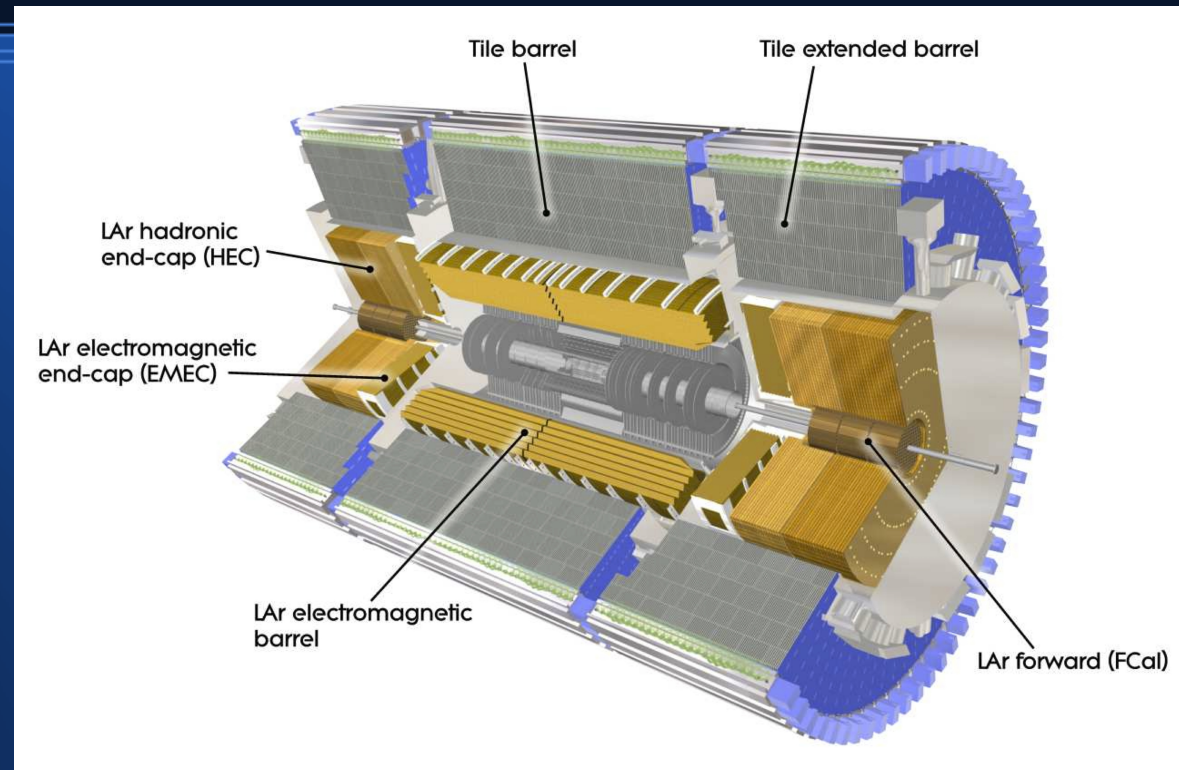


ATLAS Calorimeter

Liquid Argon

- Electromagnetic (EM):
- Pb-LAr accordion geometry
- e/γ trigger, ID and measurement
- $\sigma_E/E \approx 10\% / \sqrt{E}$

- Hadronic:
- Endcaps and FCal
- Cu/W - LAr

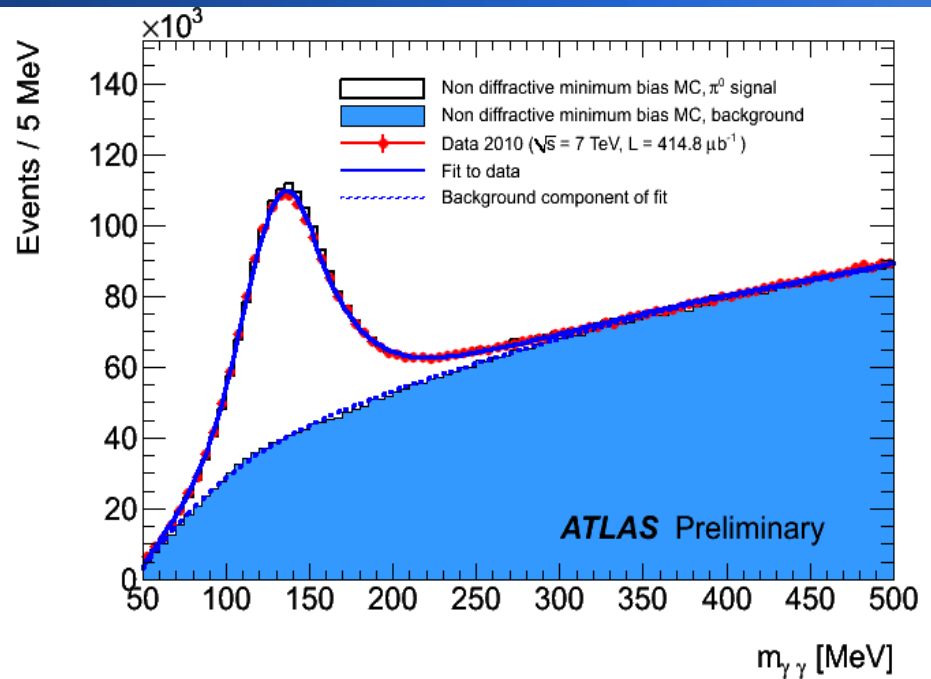
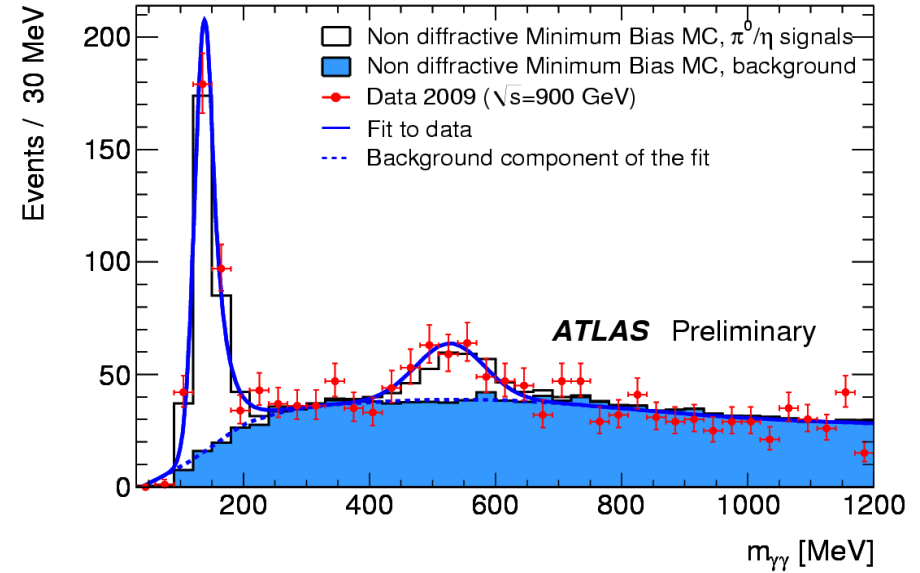
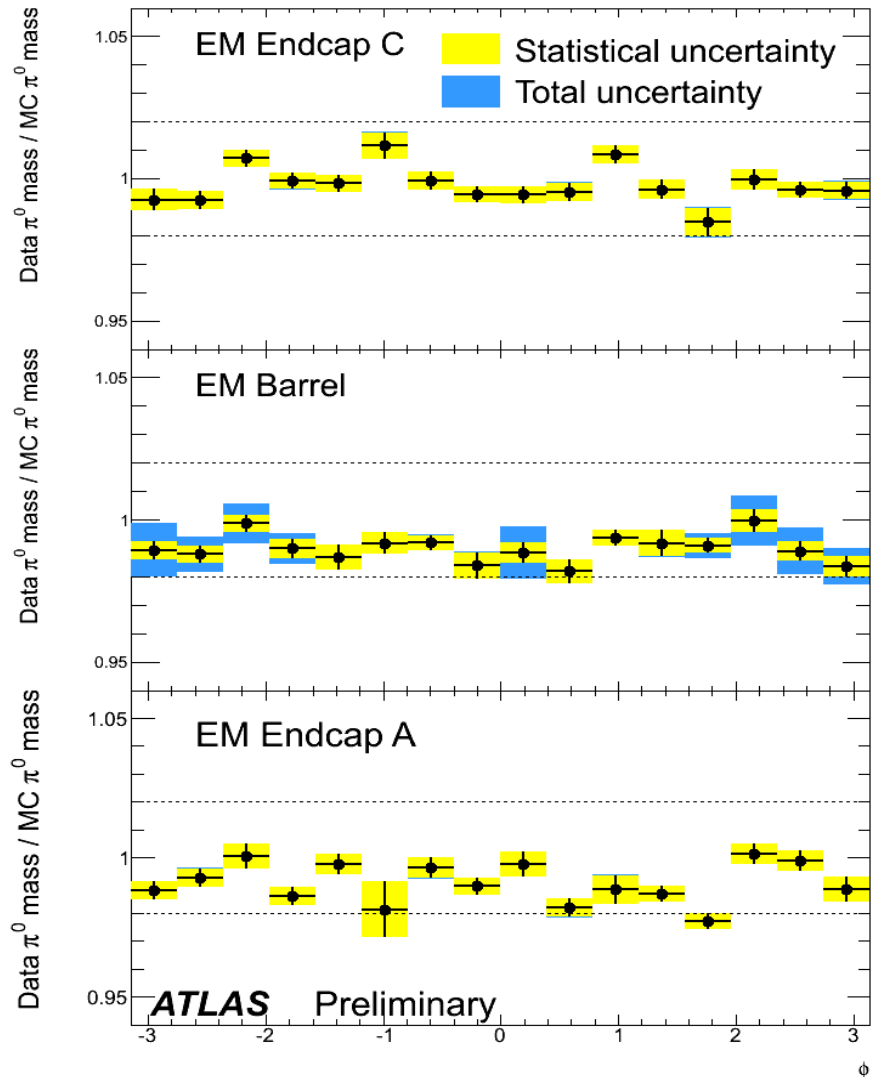


Tile Calorimeter

- Fe/Scintillators
- Jets and Emiss trigger, measurement
- $\sigma_E/E \approx 50\% / \sqrt{E} + 0.03$

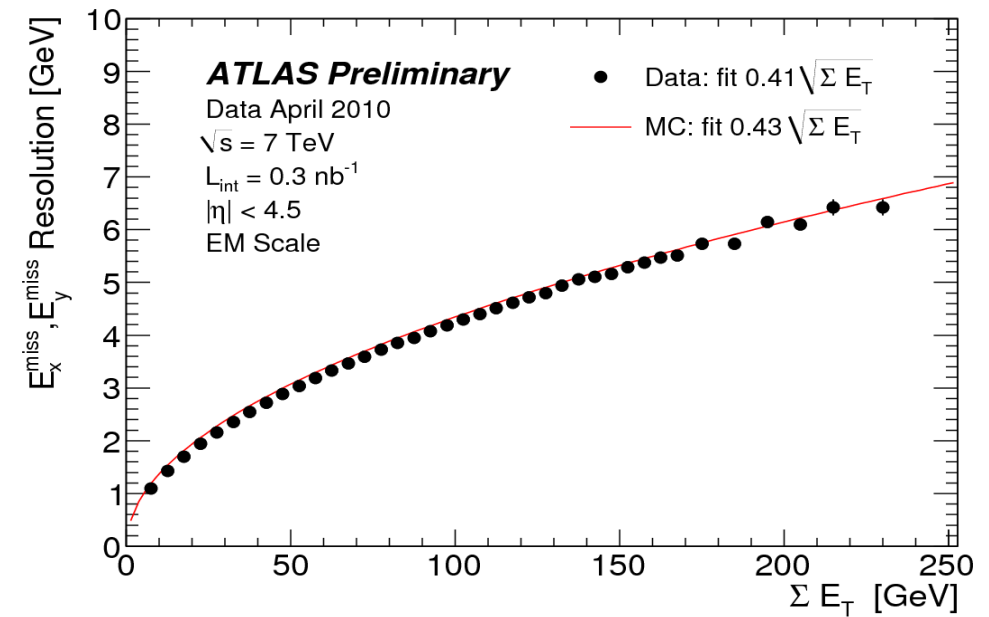
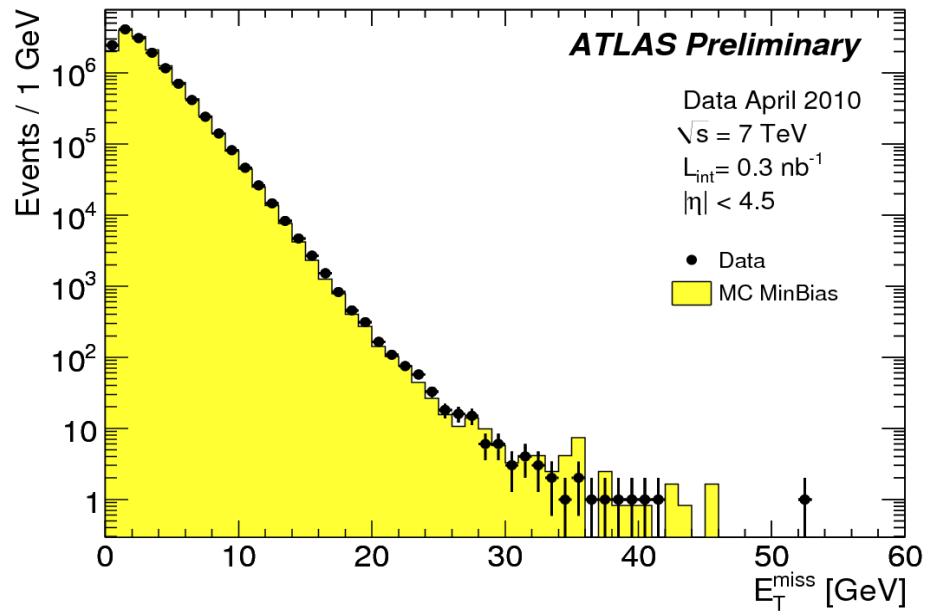


Neutral Pions





Missing Energy



$$E_x^{\text{miss}} = \sum_{i=1}^{N_{\text{cell}}} E_i \sin \theta_i \cos \phi_i$$

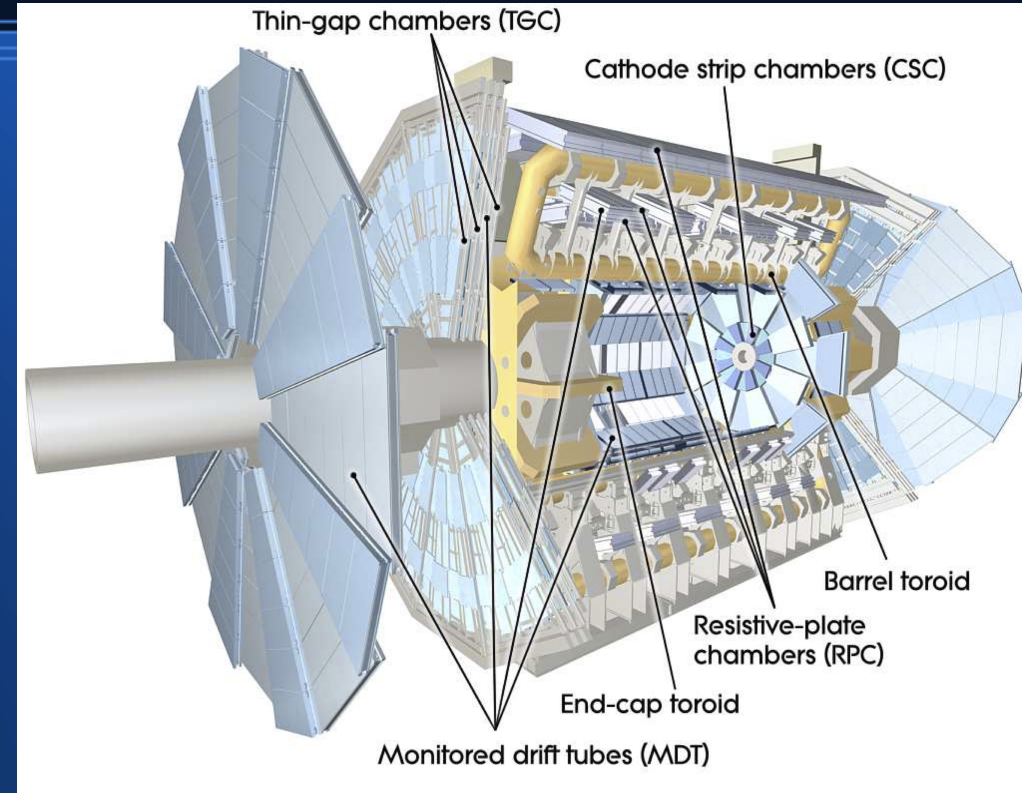
$$E_y^{\text{miss}} = \sum_{i=1}^{N_{\text{cell}}} E_i \sin \theta_i \sin \phi_i$$

$$E_T^{\text{miss}} = \sqrt{(E_x^{\text{miss}})^2 + (E_y^{\text{miss}})^2}$$



Muon System

- Four different technologies of gaseous detectors
- For Precision:
 - Monitored Drift Tubes
 - Cathode Strip Chambers
- Triggering:
 - Resistive Plate Chambers
 - Thin Gap Chambers
- $\sigma_{pt} / pt < 10\%$ for $pt < 1\text{ TeV}$





Detector Operational Performance

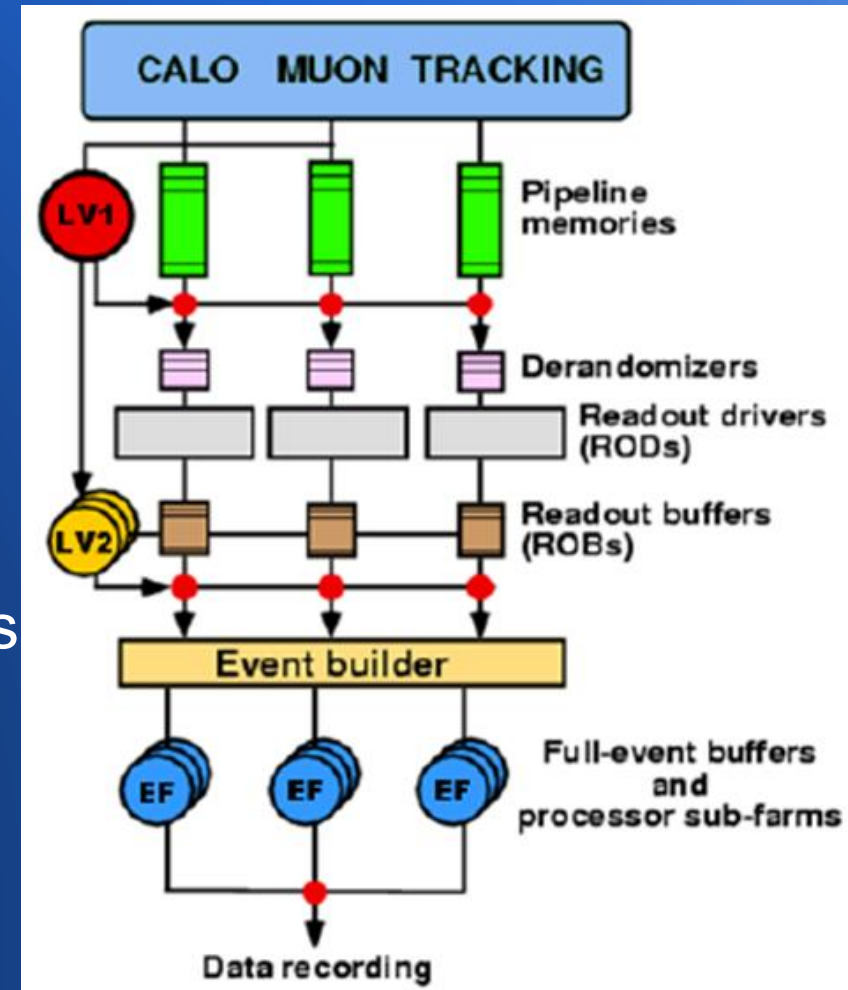
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.40%
SCT Silicon Strips	6.3 M	99.20%
TRT Transition Radiation Tracker	350 k	98.00%
LAr EM Calorimeter	170 k	98.50%
Tile calorimeter	9800	97.30%
Hadronic endcap LAr calorimeter	5600	99.90%
Forward LAr calorimeter	3500	100.00%
LVL1 Calo trigger	7160	99.90%
LVL1 Muon RPC trigger	370 k	99.50%
LVL1 Muon TGC trigger	320 k	100.00%
MDT Muon Drift Tubes	350 k	99.70%
CSC Cathode Strip Chambers	31 k	98.50%
RPC Barrel Muon Chambers	370 k	97.00%
TGC Endcap Muon Chambers	320 k	98.60%



The ATLAS Trigger system

- Design goal:
reduce data from ≈ 1 GHz to 200 Hz
- Three Levels
 - L1: Hardware, latency $< 2.5 \mu\text{s}$
Reduces rate to 75 kHz
 - L2: Software
Mean processing time ≈ 40 ms
Reduces rate to 2 kHz
 - Event Filter: partial
reconstruction based on L2
outputs
Mean Processing time ≈ 4 s

→ 300 MB/s to disk



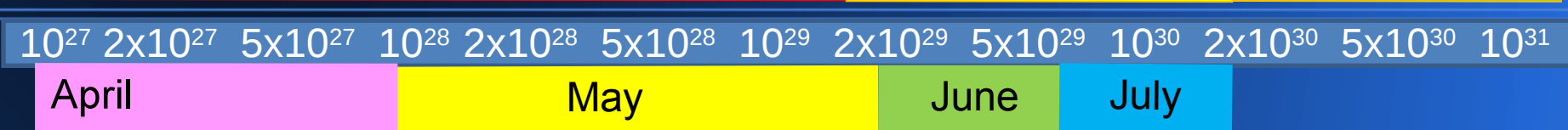


Trigger Commissioning and Evolution

- Cosmics, single beam 2008-2009
 - Commissioning timing of L1 signals
- First Collisions, $L < 2 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$
 - No HLT rejection
 - except min. bias since exceeding 300 Hz
- 7 TeV Collisions $2 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1} < L < 2 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$

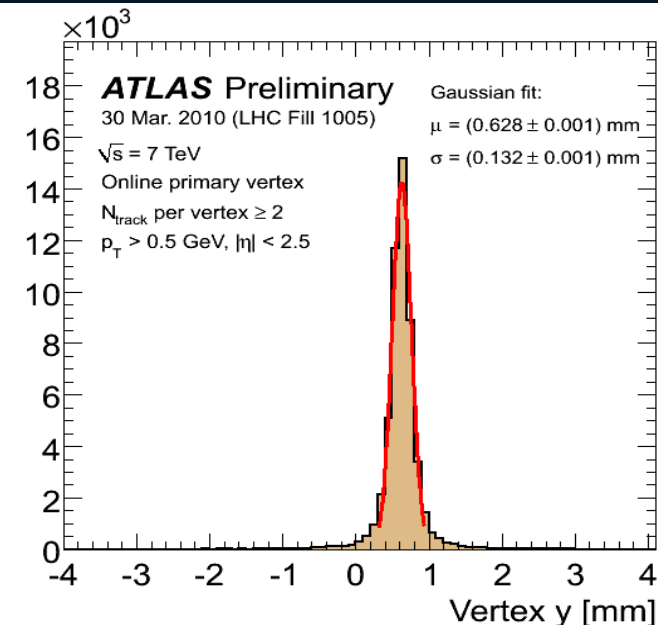
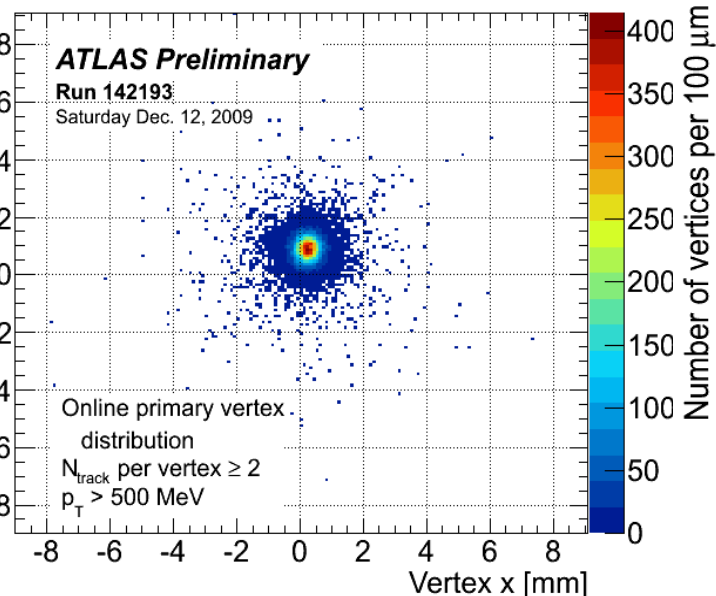
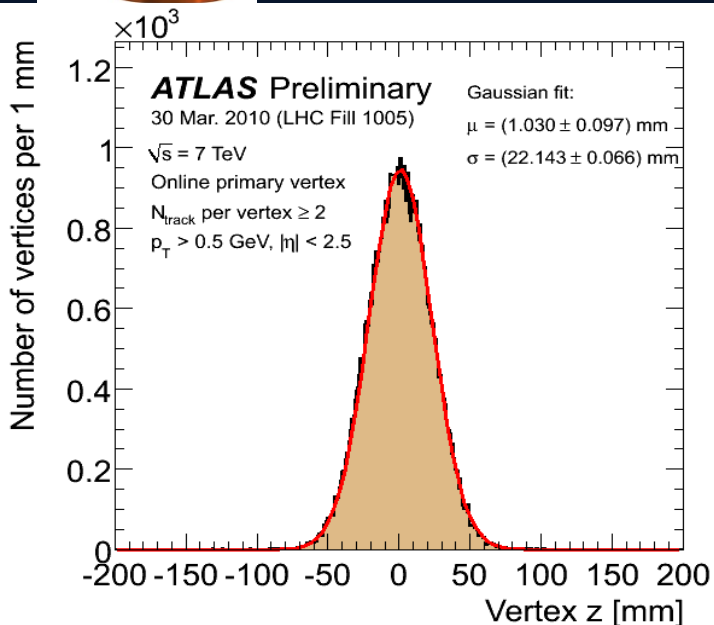
Progressive enabling of HLT

1.5×10^{29} : e/ γ 4×10^{29} : τ 6×10^{29} : μ 1×10^{30} : Missing E_T

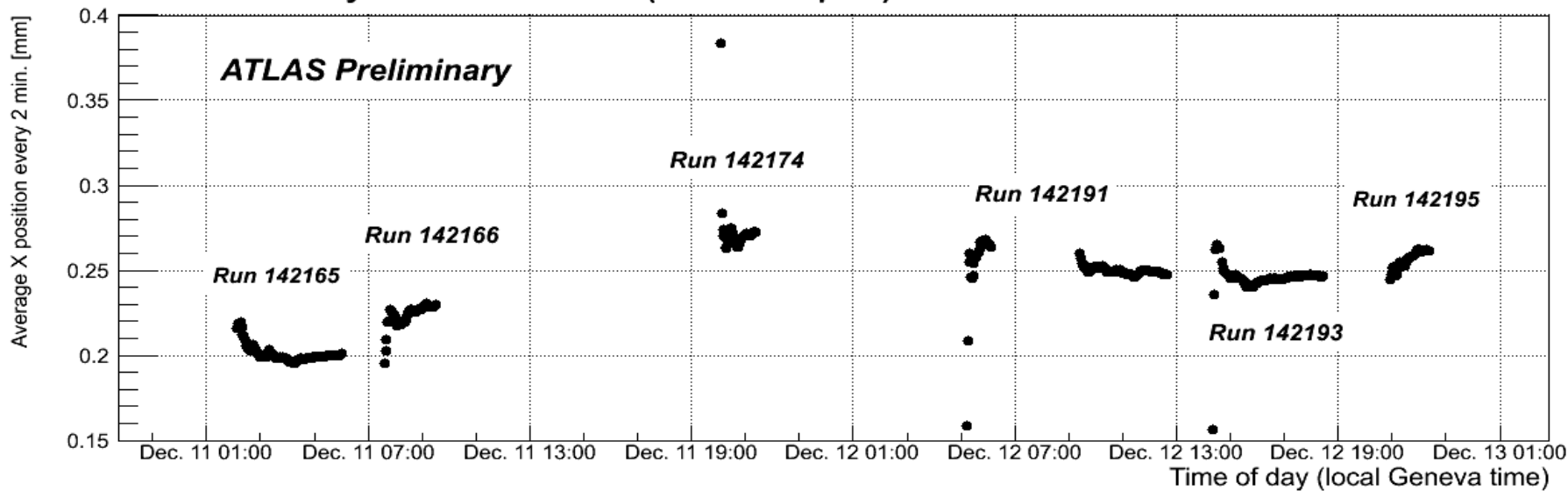




Online Beam position

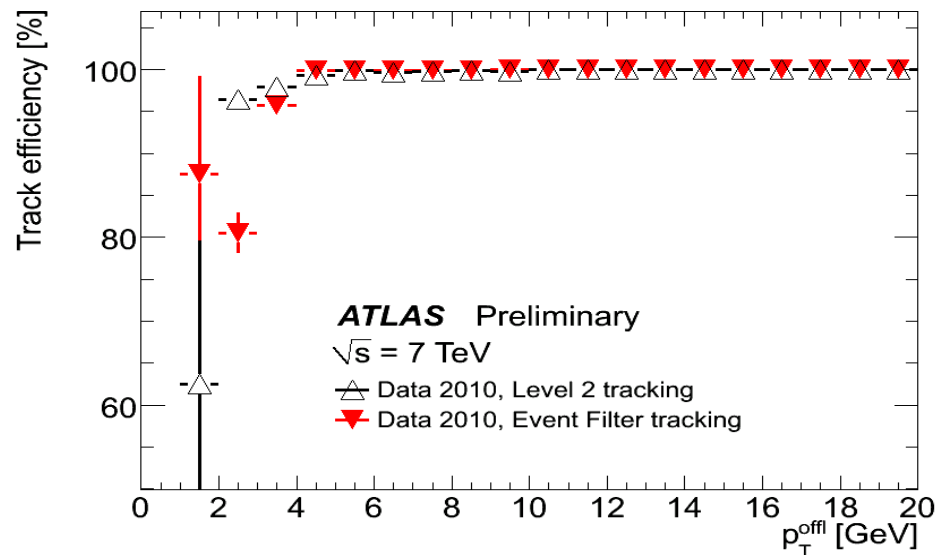
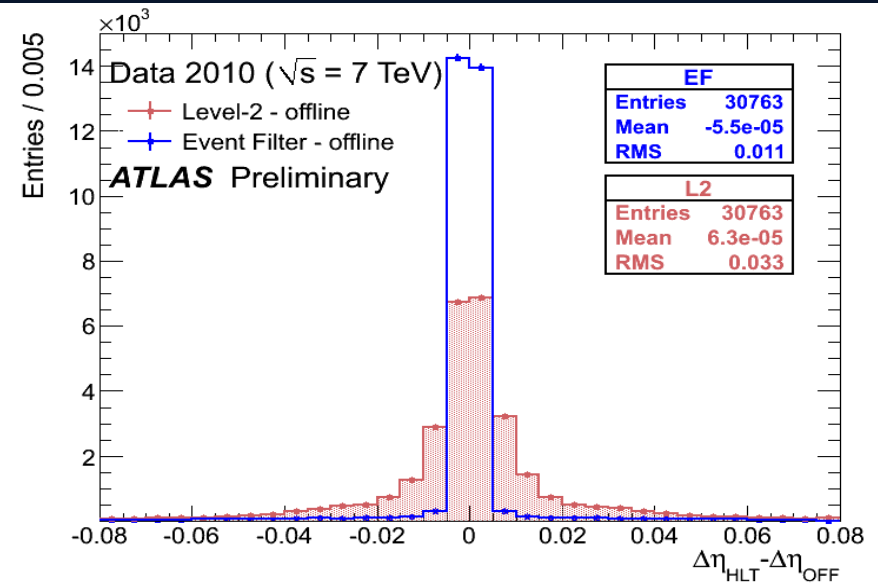
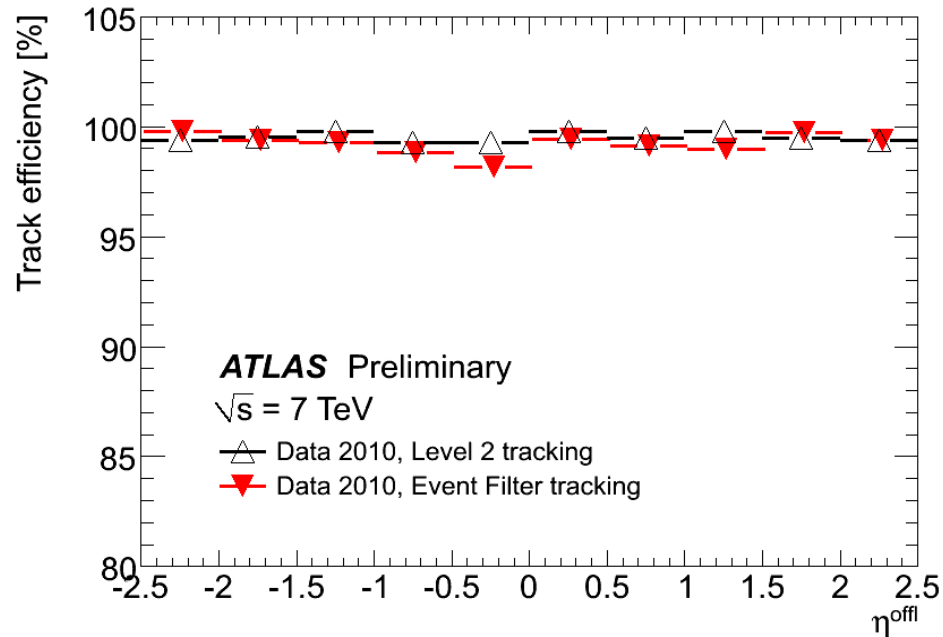


Online Primary Vertex X Position (2 min Samples)





e/ γ trigger

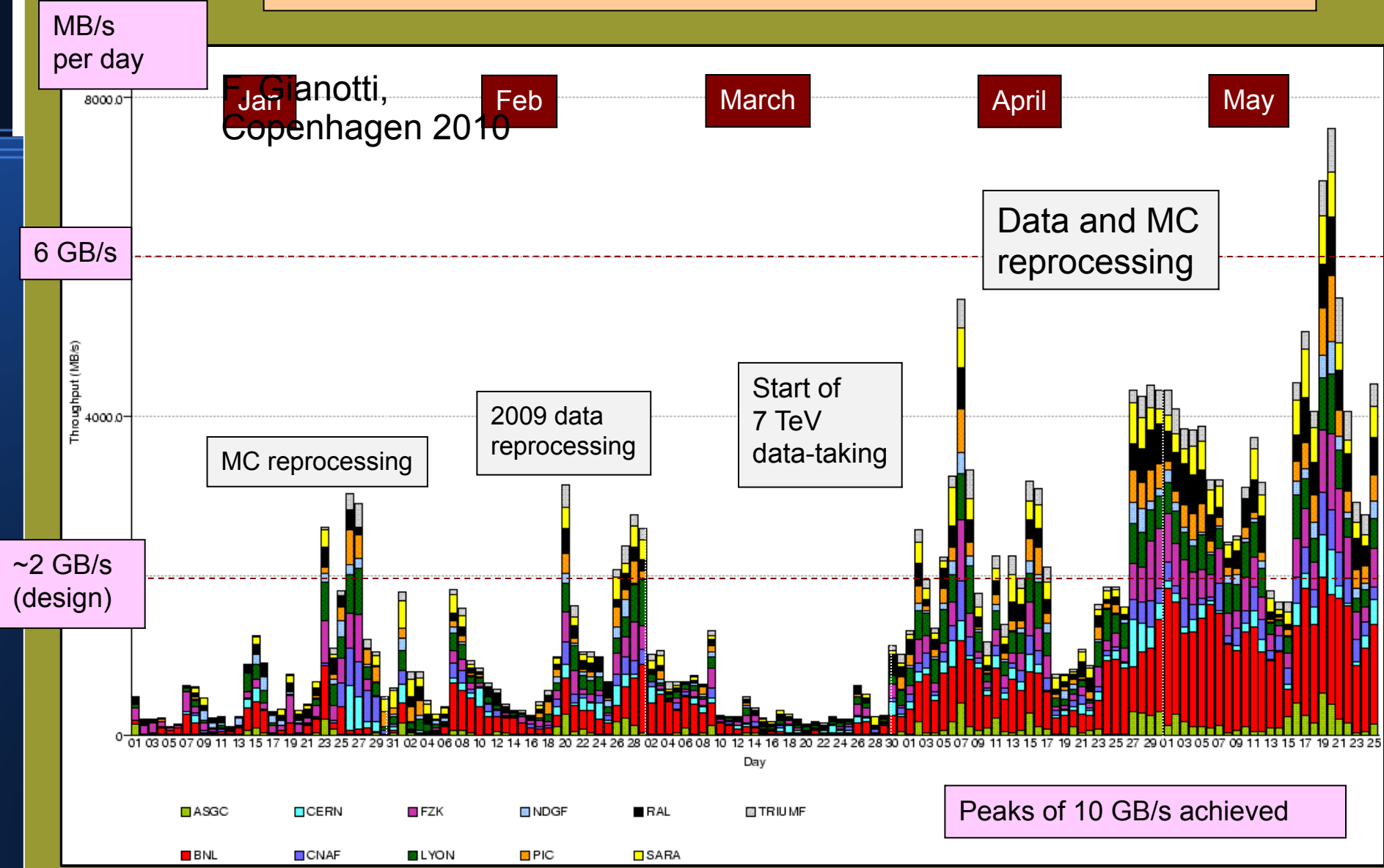


- Matching between charged track and EM cluster
- L2 has no access to full offline tracking

Worldwide data distribution and analysis



Total data throughput through the Grid: 1st January to 25th May 2010

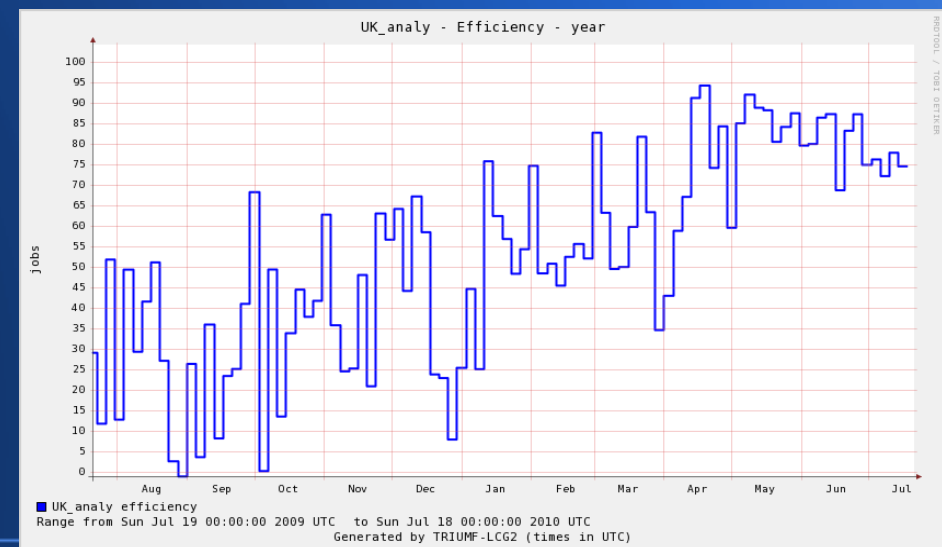
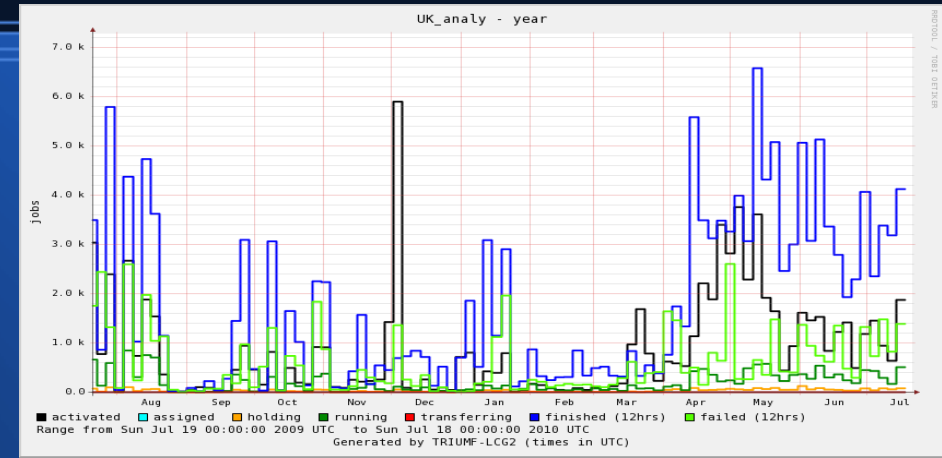


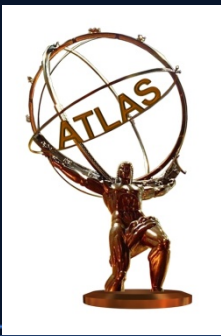
GRID-based analysis in April-May 2010:
~ 900 different users, ~ 6 million jobs completed; > 45 billion events analyzed



UK Tier-2 statistics

- Number of user jobs that reached a UK Tier-2 centre
 - Spot the day of first collisions
- Analysis efficiency = $\frac{\text{number completed}}{\text{number submitted}}$



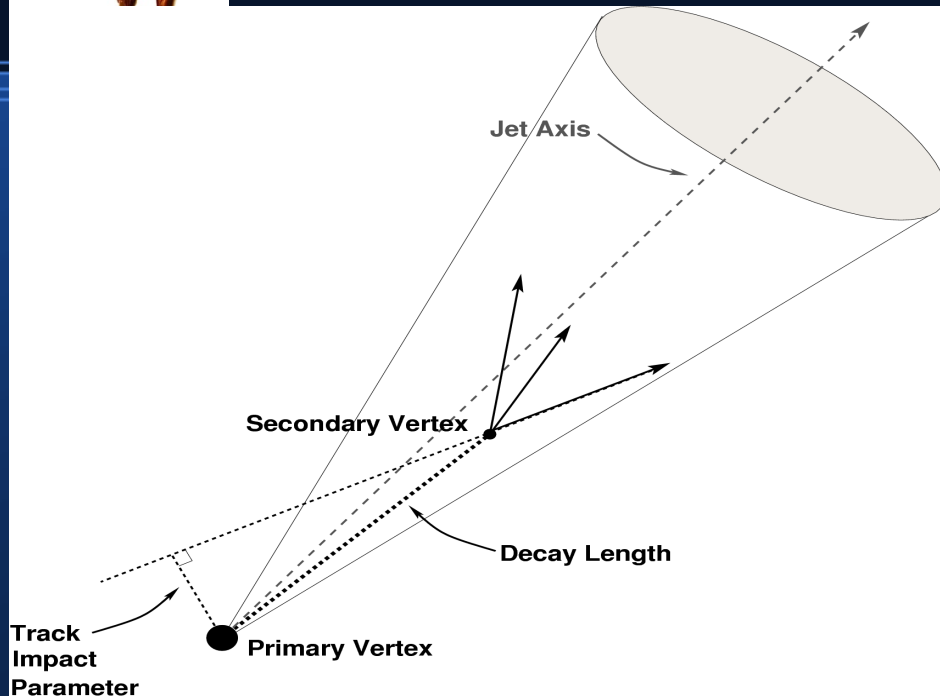


Physics

- B tagging
- Resonances
- Min Bias
- Jets
- W/Z

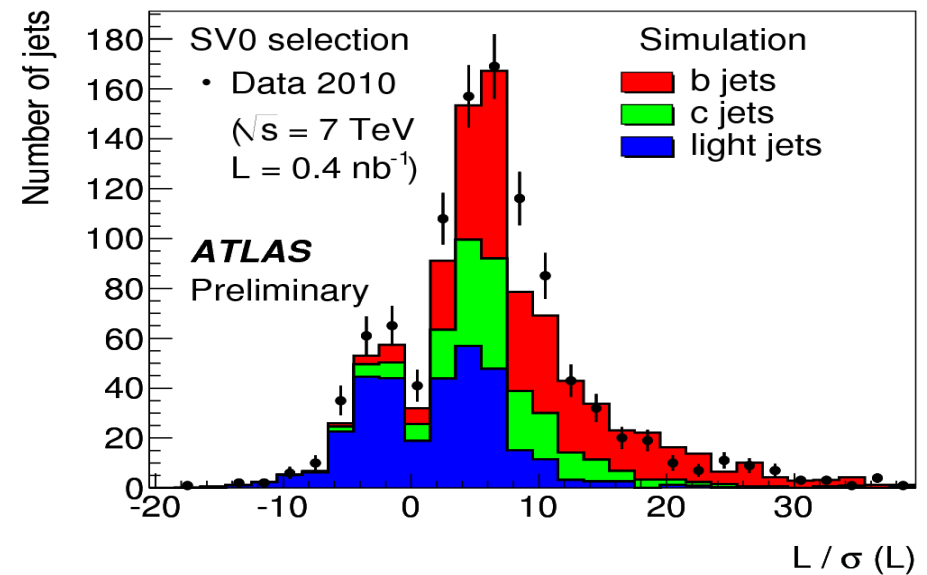
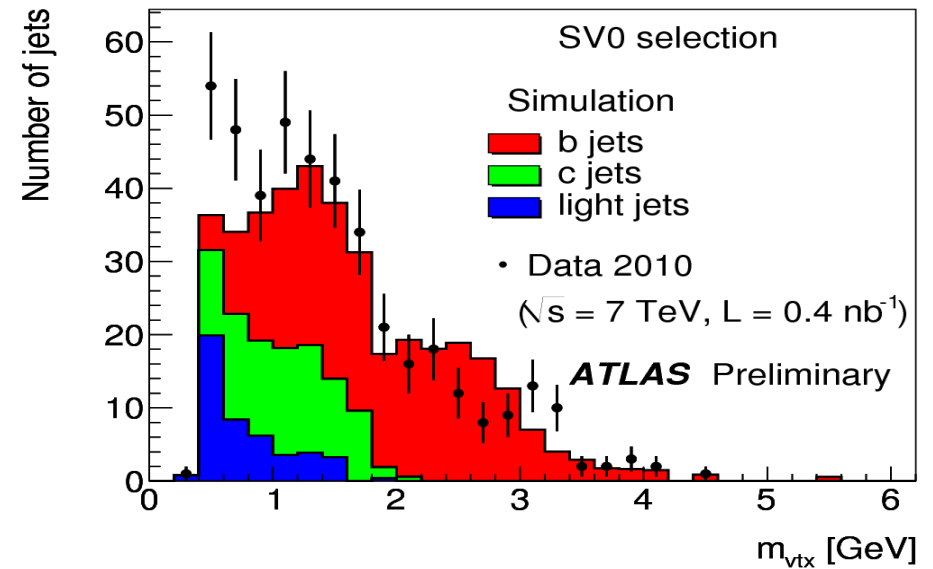


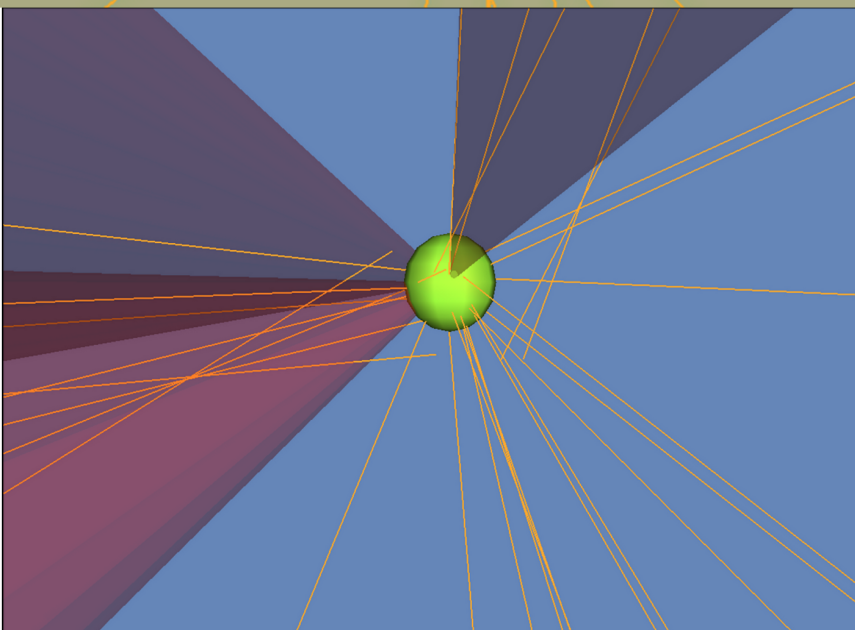
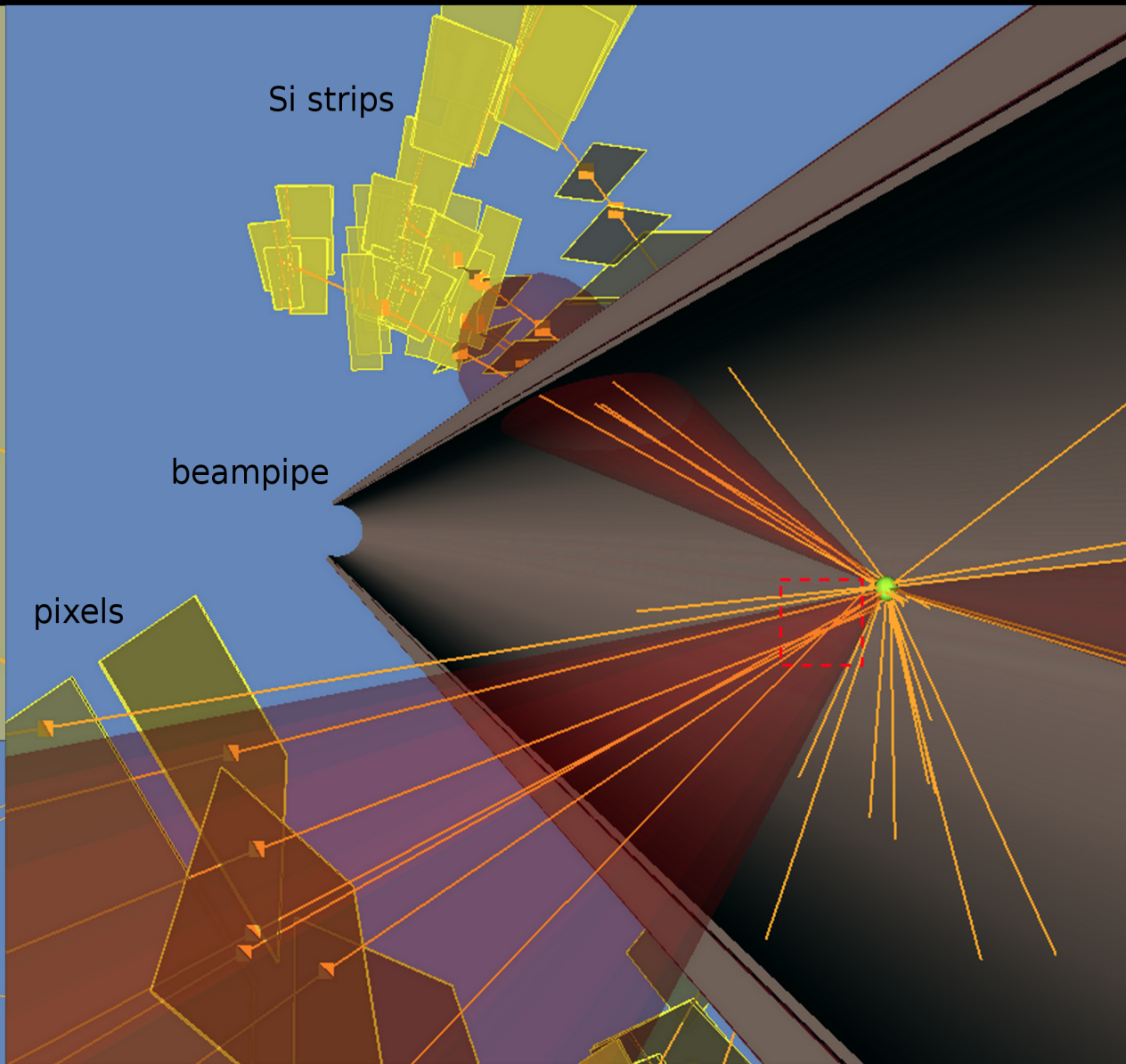
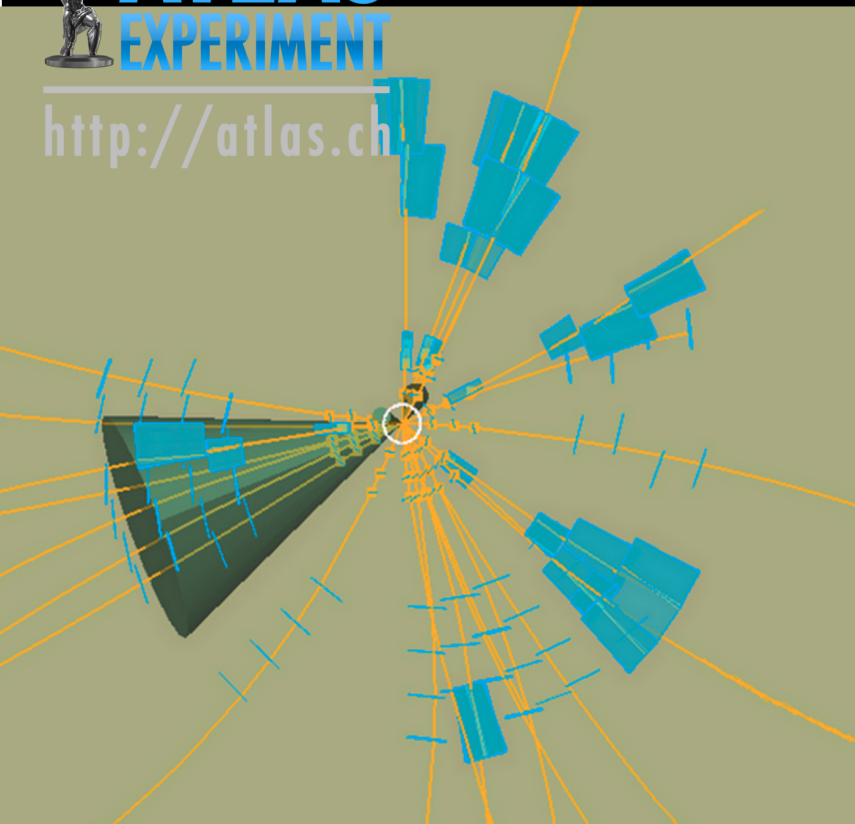
B tagging



- Associate tracks to a jet
- Find secondary vertices inside the jet

Jan Strube - RAL





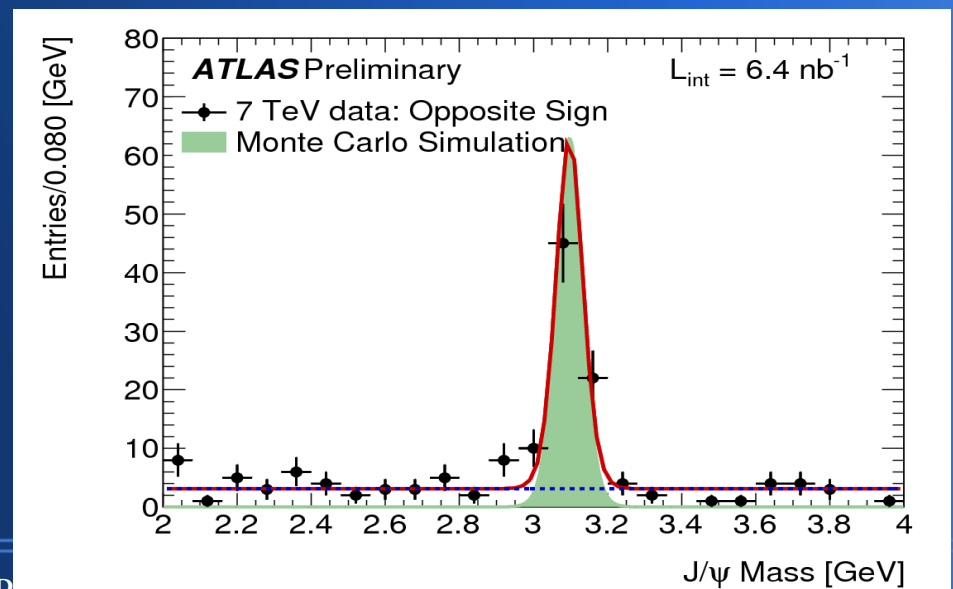
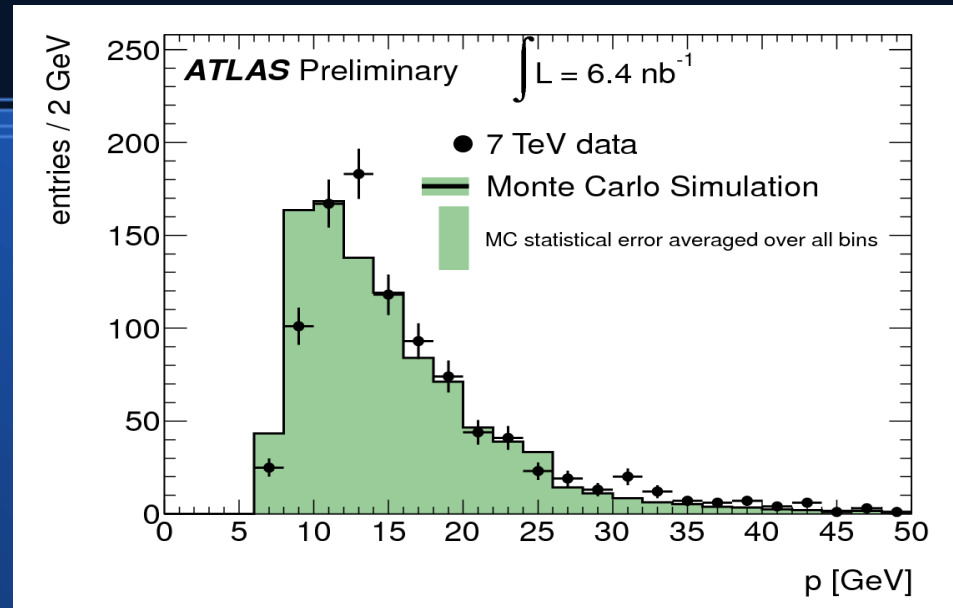
jet
 $p_T = 19$ GeV (measured at electromagnetic scale)

4 b-tagging quality tracks in the jet



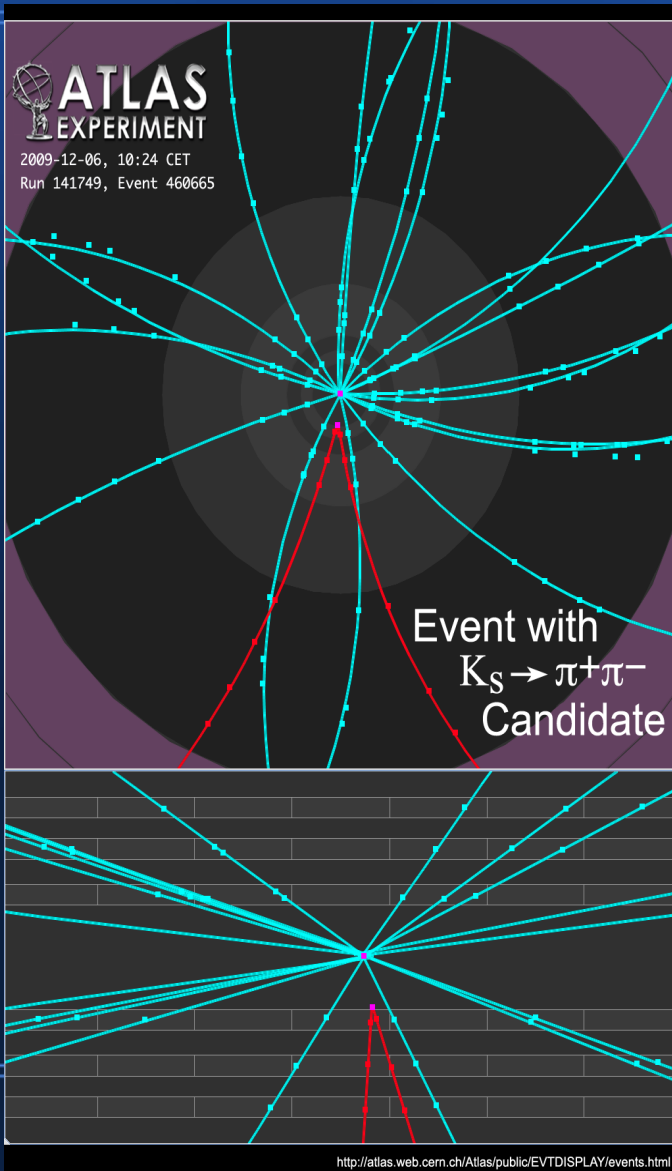
J/Psi

- Top: momentum distribution of J/Ψ
- MC both minbias and prompt
- Bottom: Mass of J/Ψ with both muons in barrel
- MC prompt J/Ψ only



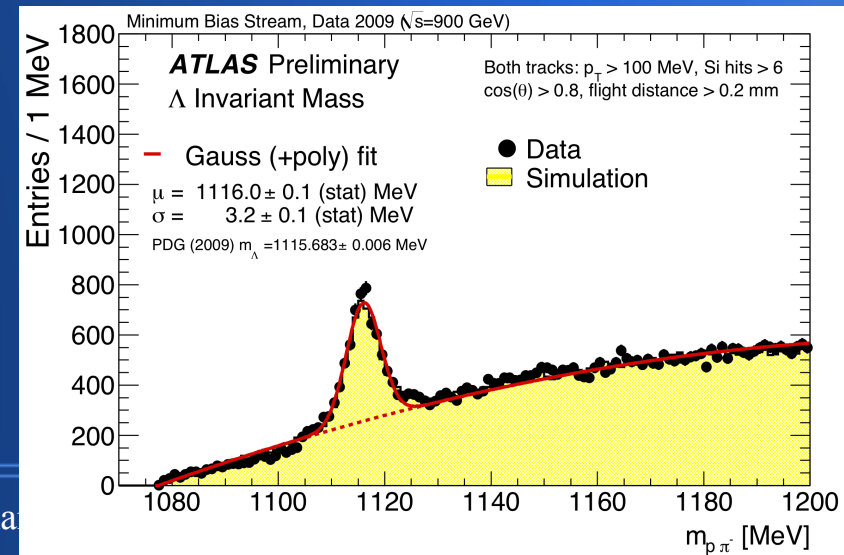
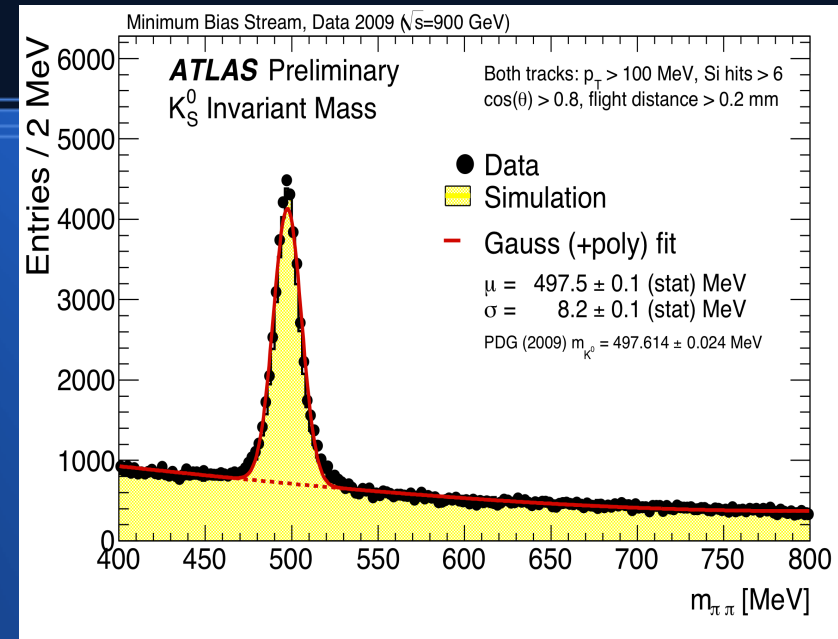


K_S , Lambda



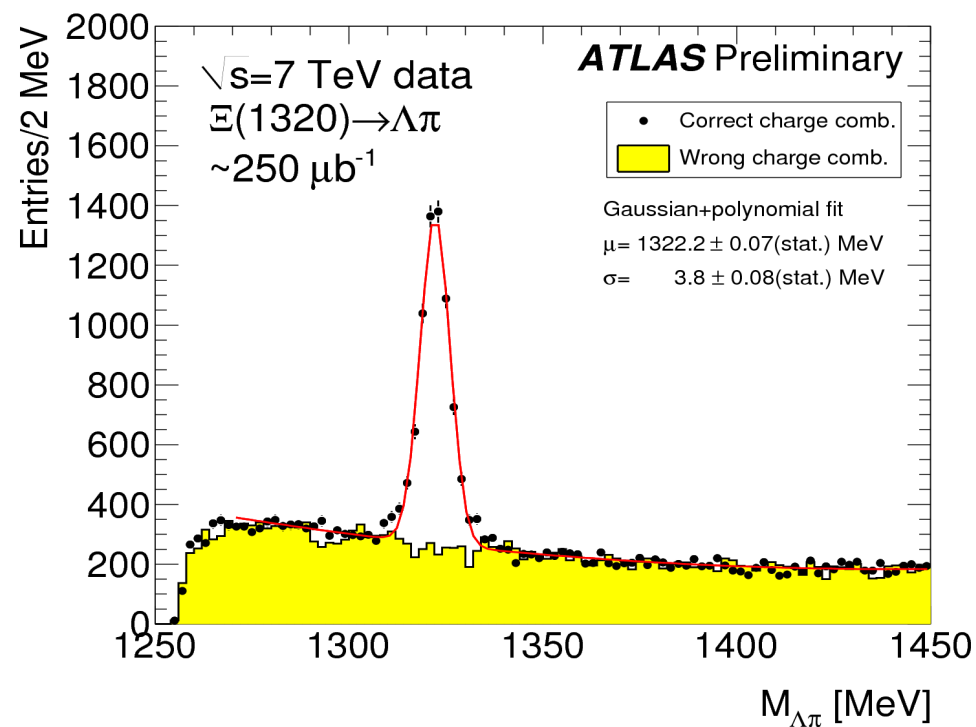
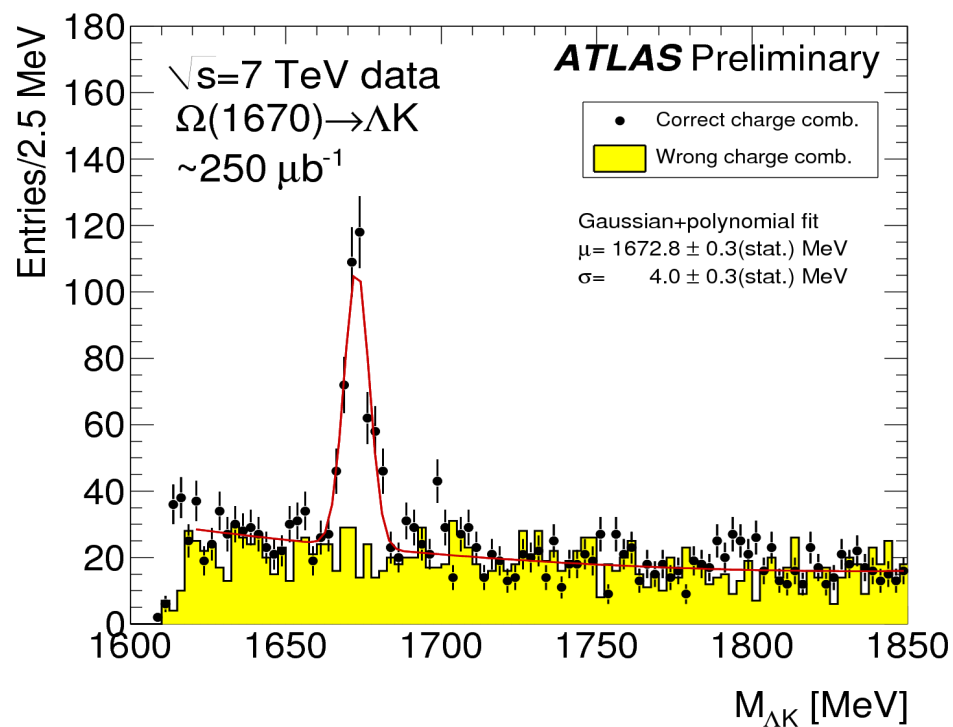
- Standard V0 finder
- V0 to point to IP
- Low pt tracking for 900 GeV data

Jan Strube - RAL PPD Semina



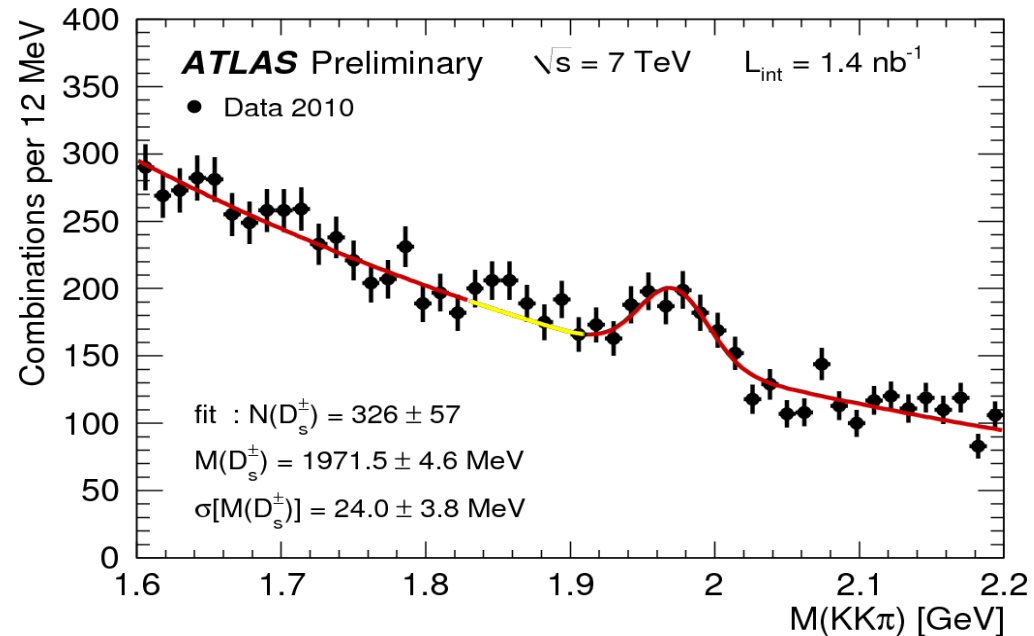
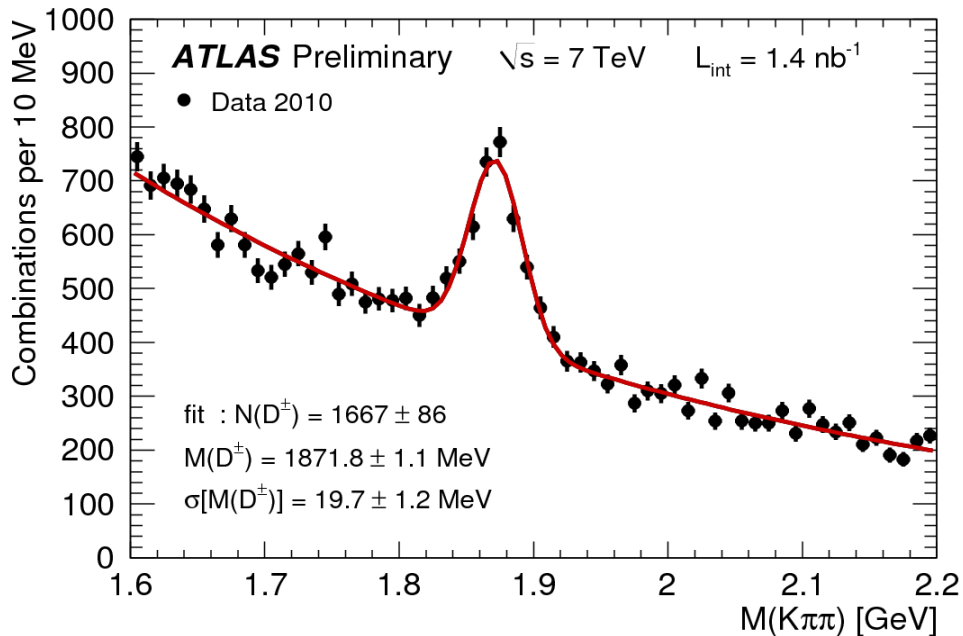
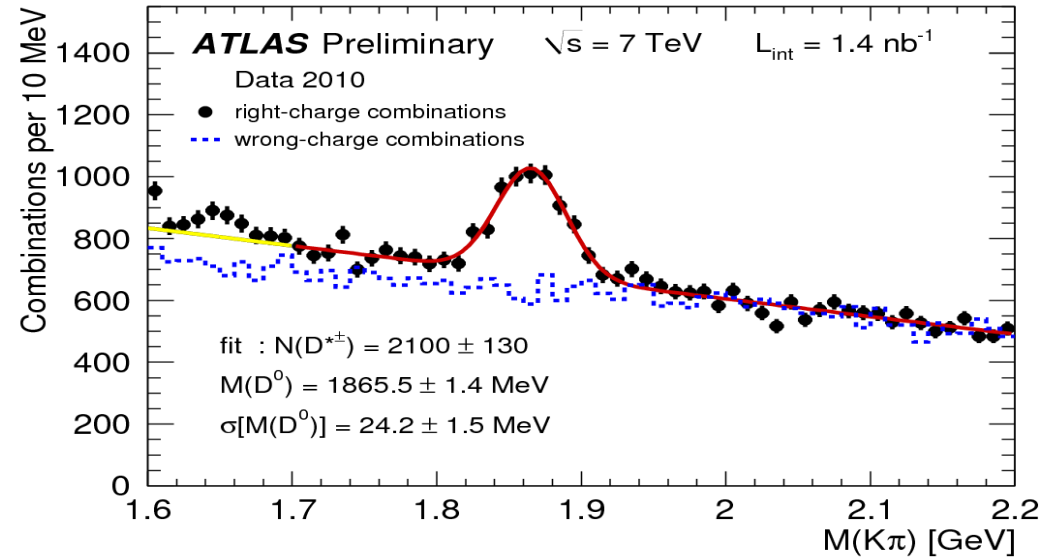
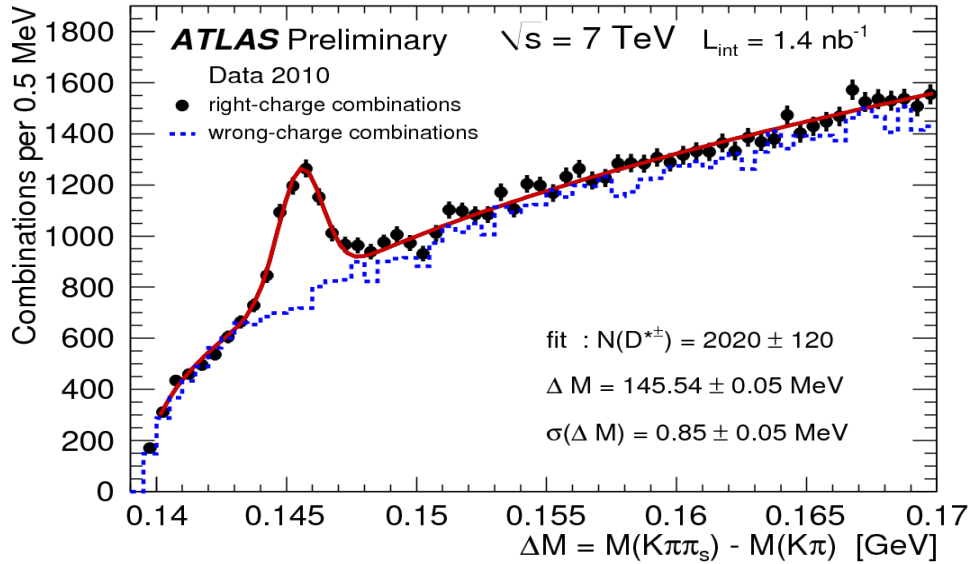


Omega, Xi





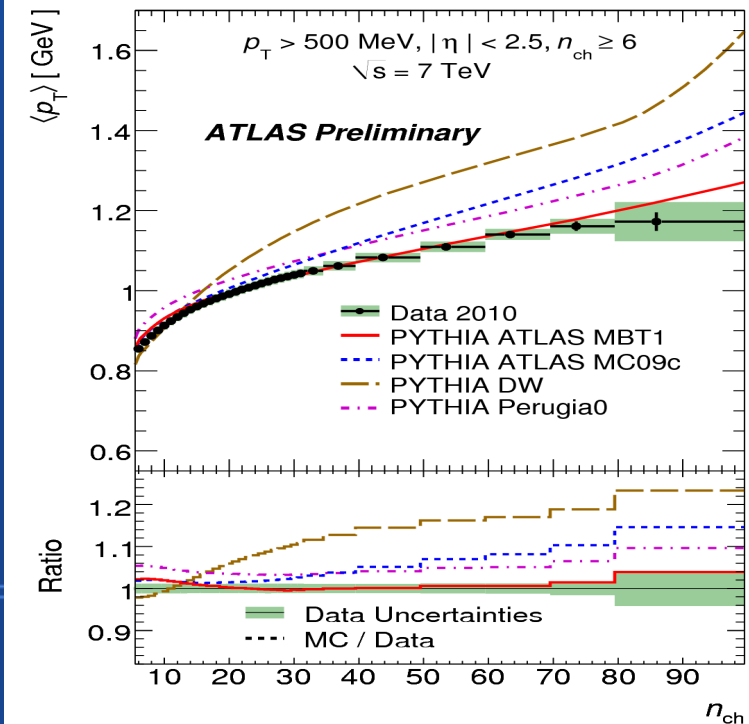
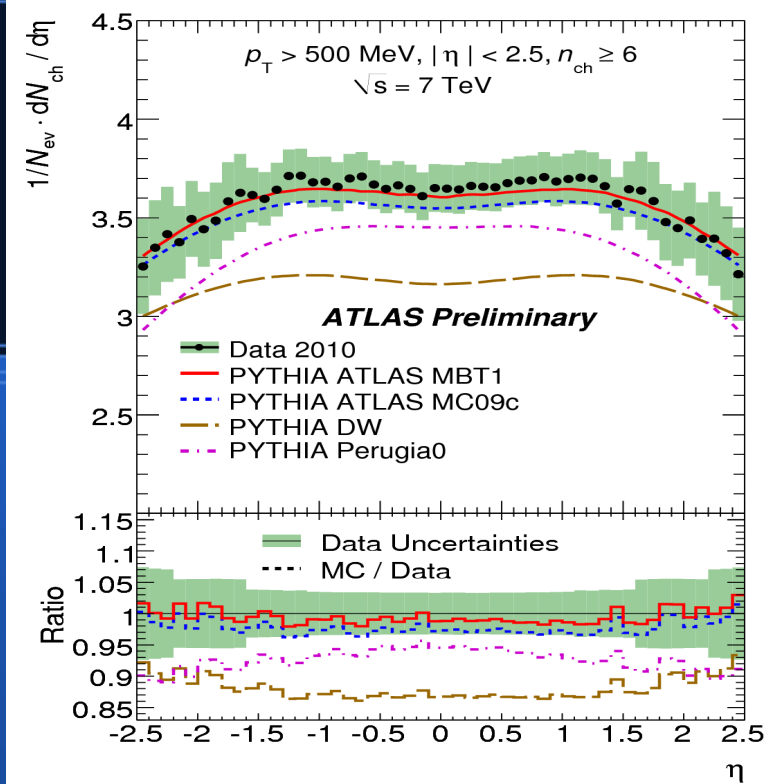
D mesons





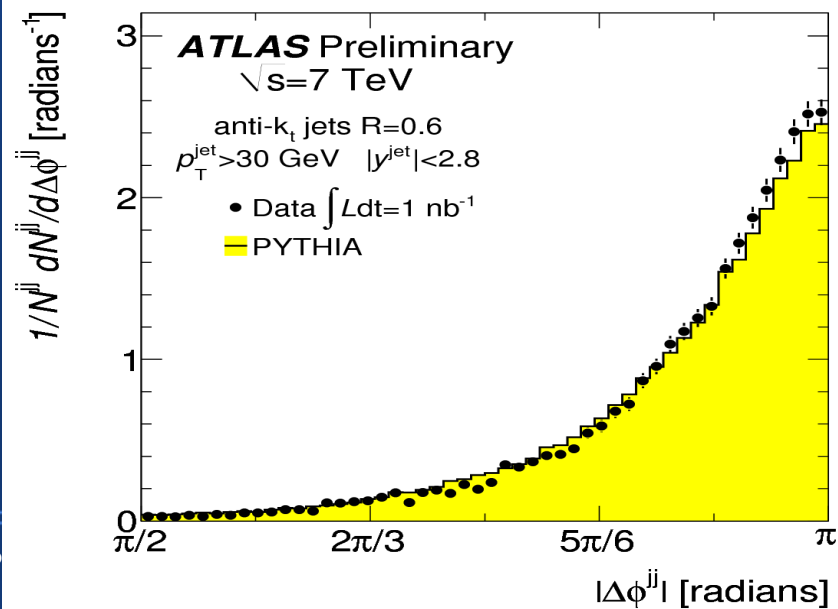
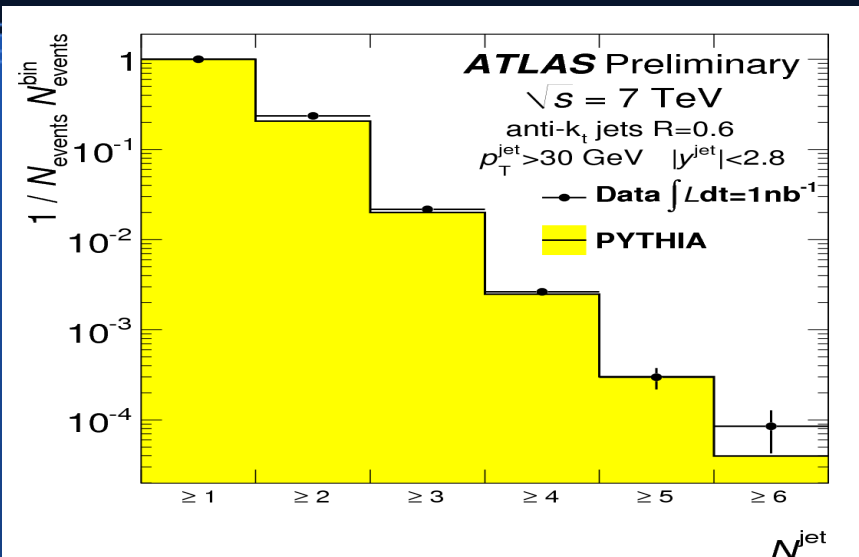
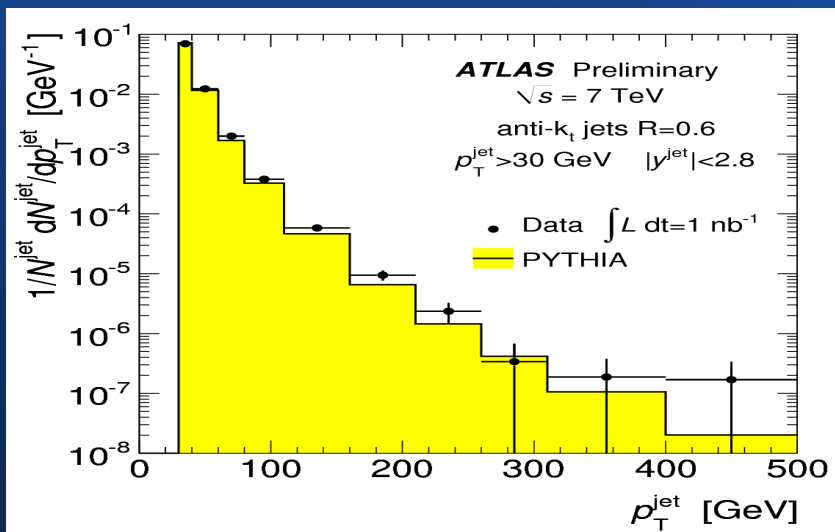
Minimum Bias

- Minimum Bias was first ATLAS paper on 900 GeV
- New Pythia tune
- Much better agreement since 900 GeV data





ATLAS observation of energetic jets

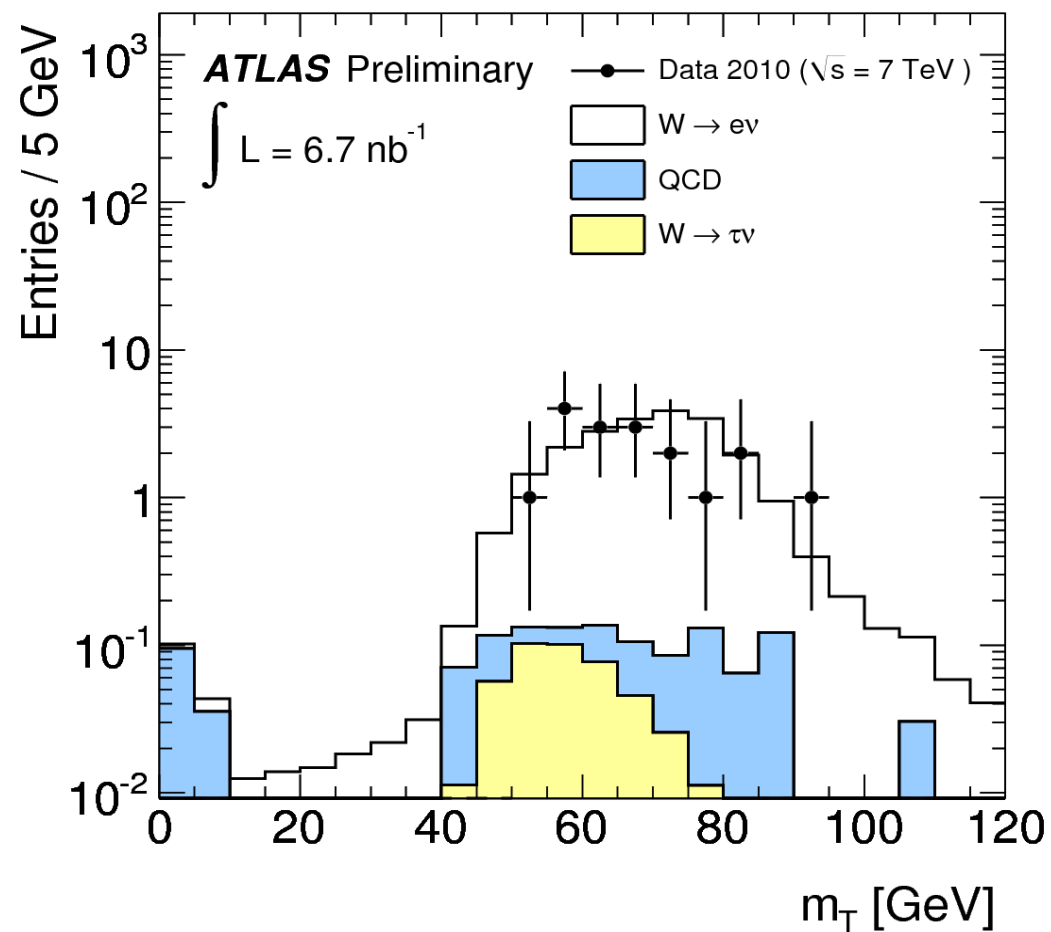
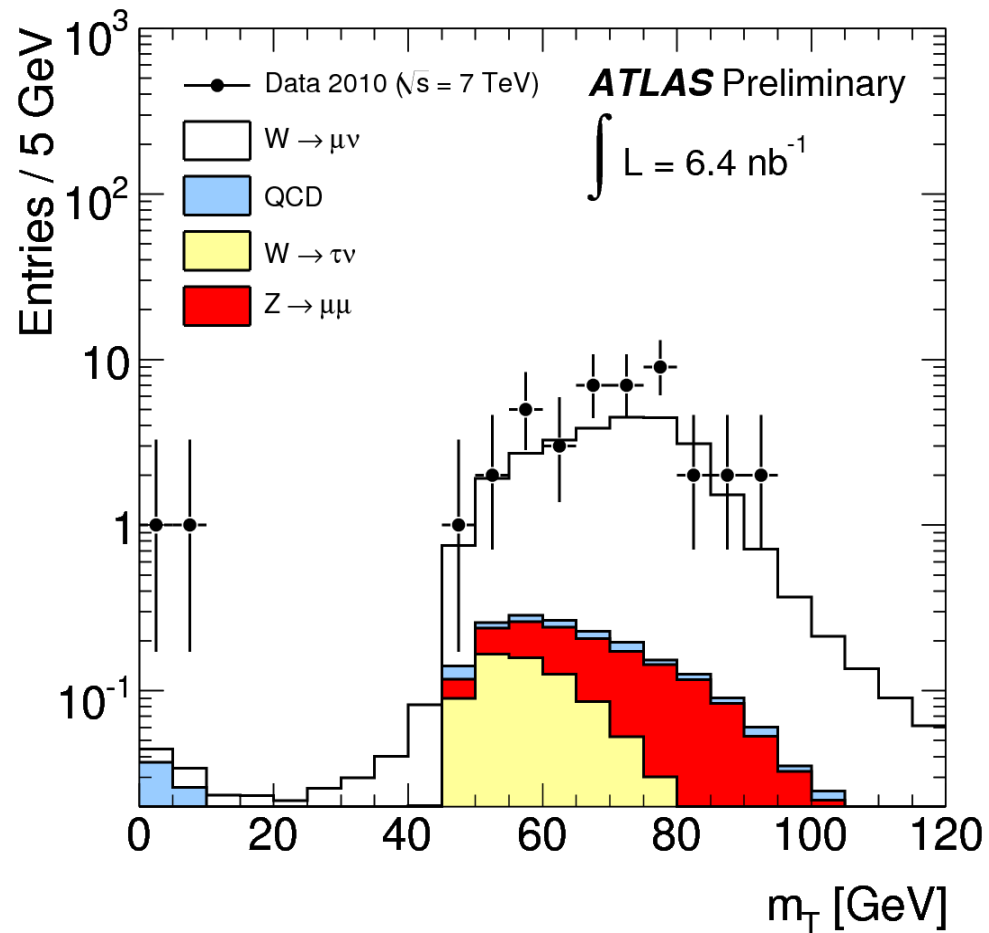


- Jets are reconstructed using the anti-kt algorithm
- $p_T > 30 \text{ GeV}$ (EM scale)



Observation of W events

$$m_T = \sqrt{2 p_T^l p_T^\nu (1 - \cos(\phi^l - \phi^\nu))}$$

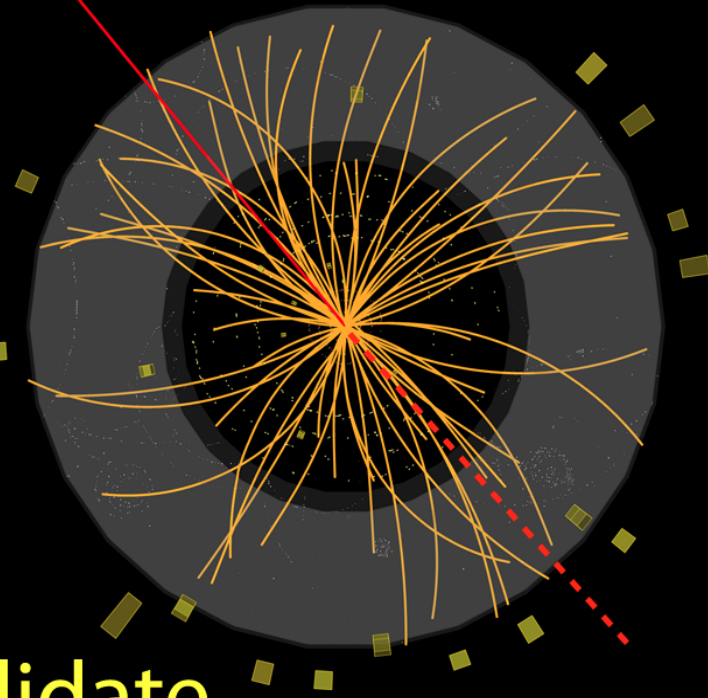
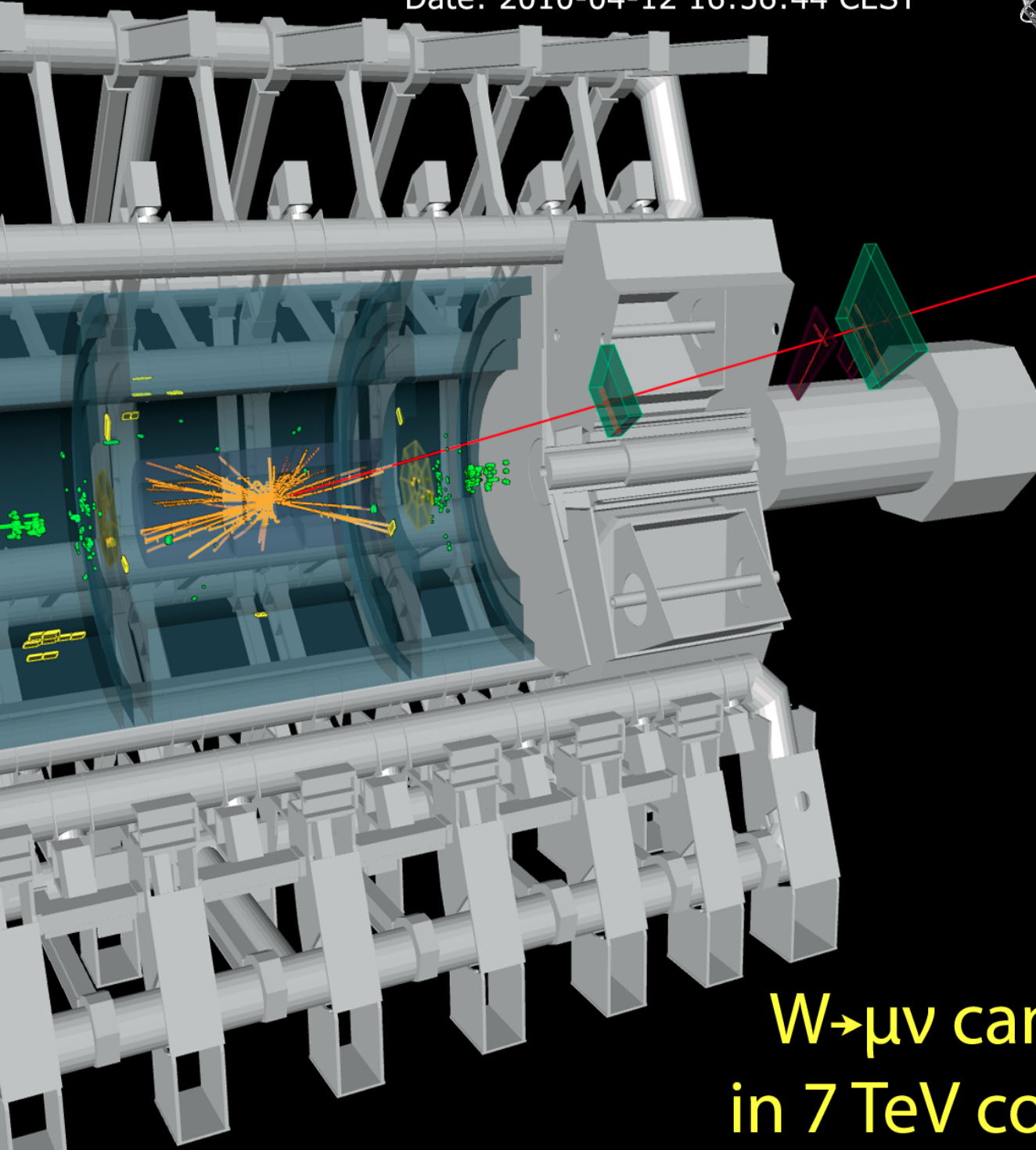


Run: 152845, Event: 3338173
Date: 2010-04-12 16:56:44 CEST



ATLAS EXPERIMENT

$p_T(\mu^-) = 40 \text{ GeV}$
 $\eta(\mu^-) = 2.0$
 $E_T^{\text{miss}} = 41 \text{ GeV}$
 $M_T = 83 \text{ GeV}$



**$W \rightarrow \mu\nu$ candidate
in 7 TeV collisions**



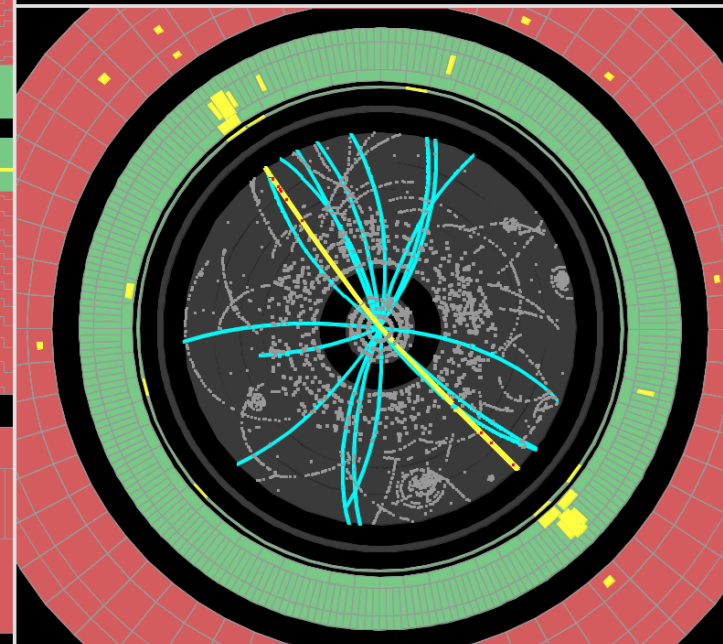
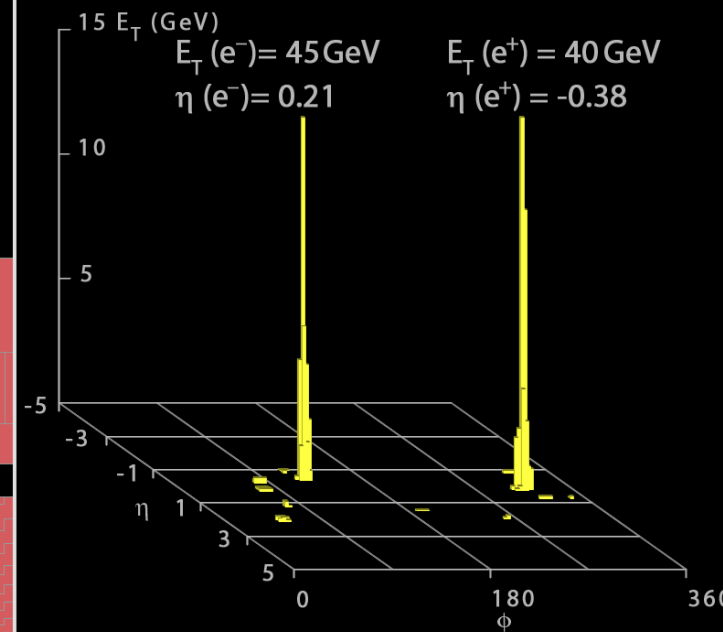
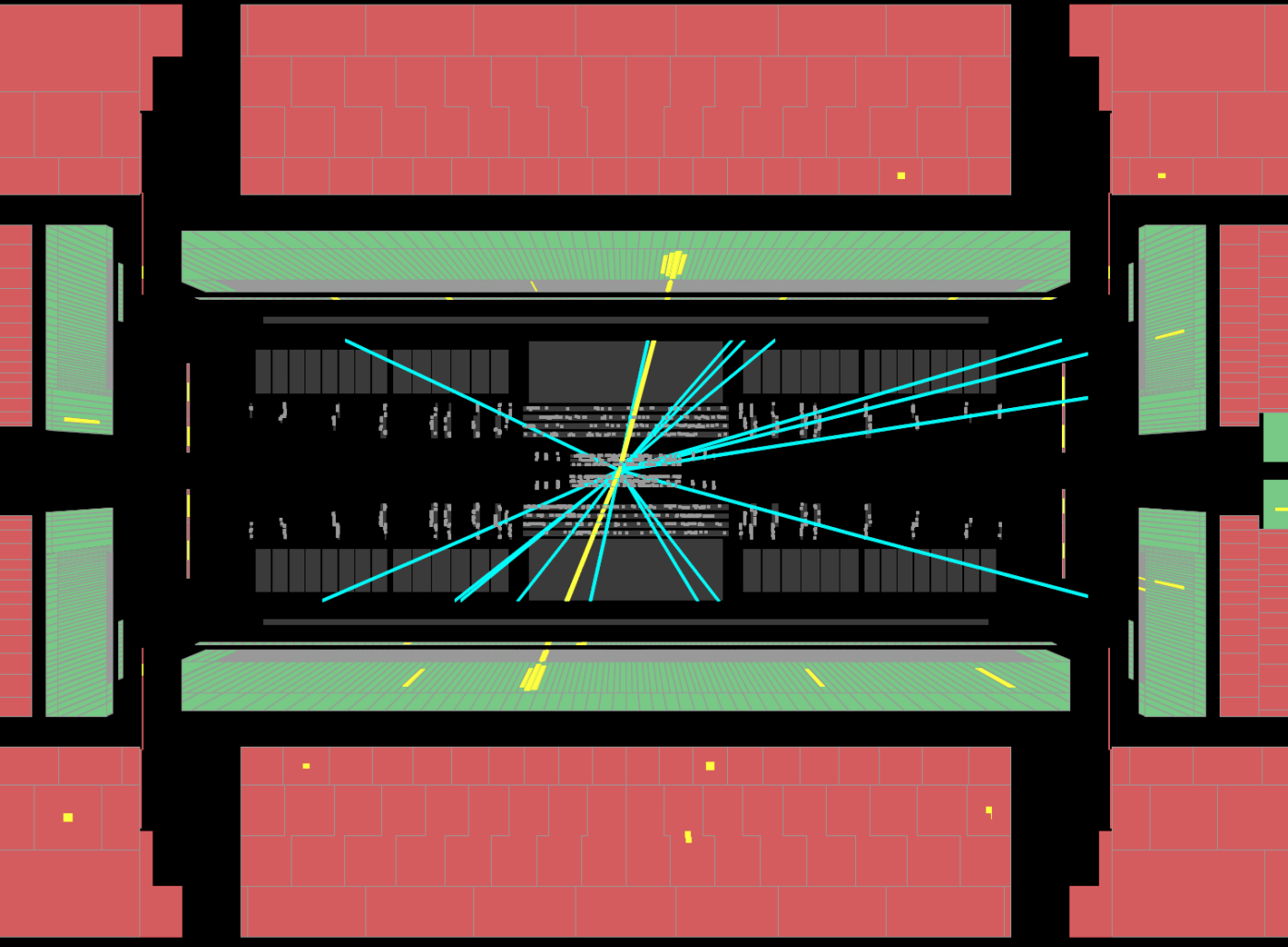
 **ATLAS**
EXPERIMENT

Run Number: 154817, Event Number: 968871

Date: 2010-05-09 09:41:40 CEST

$M_{ee} = 89 \text{ GeV}$

Z \rightarrow ee candidate in 7 TeV collisions



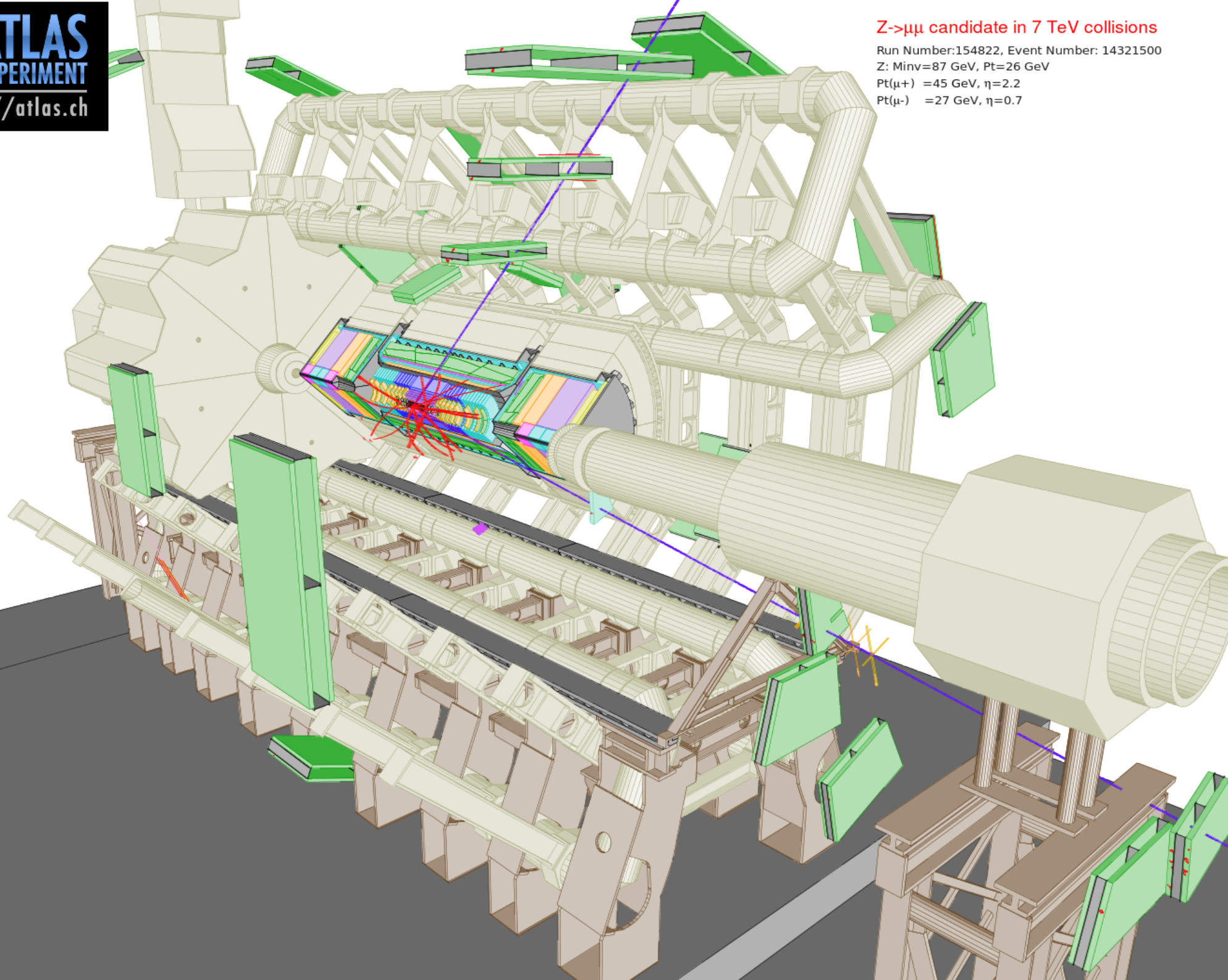
Z $\rightarrow\mu\mu$ candidate in 7 TeV collisions

Run Number:154822, Event Number: 14321500

Z: $M_{\text{inv}}=87$ GeV, $P_{\text{T}}=26$ GeV

$P_{\text{T}}(\mu^+) = 45$ GeV, $\eta=2.2$

$P_{\text{T}}(\mu^-) = 27$ GeV, $\eta=0.7$

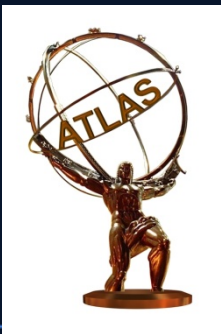




Summary

- ATLAS has successfully made the transition from commissioning to operations.
- Physics programme is well on track and keeping pace with increasing luminosity.
- LHC permitting, we are ready to explore new areas of the physics landscape.

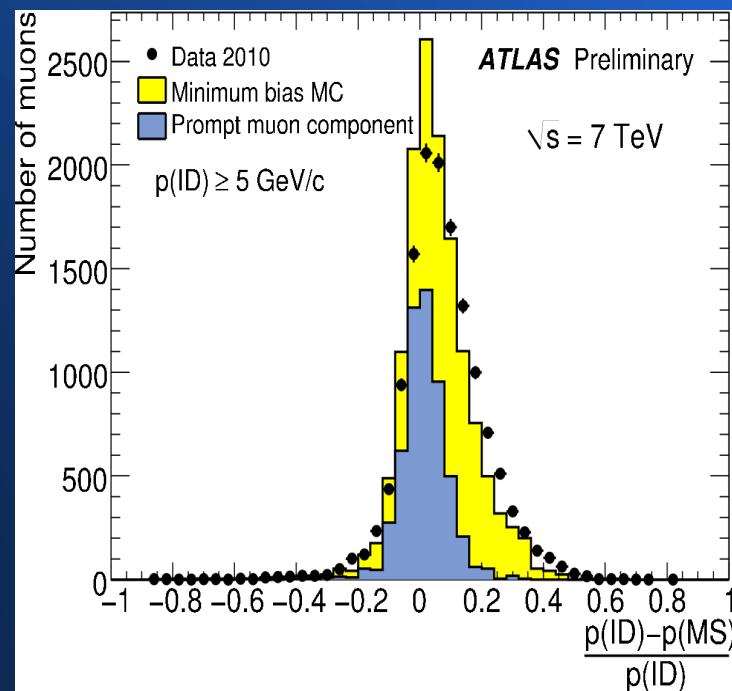
Thank you



Backup



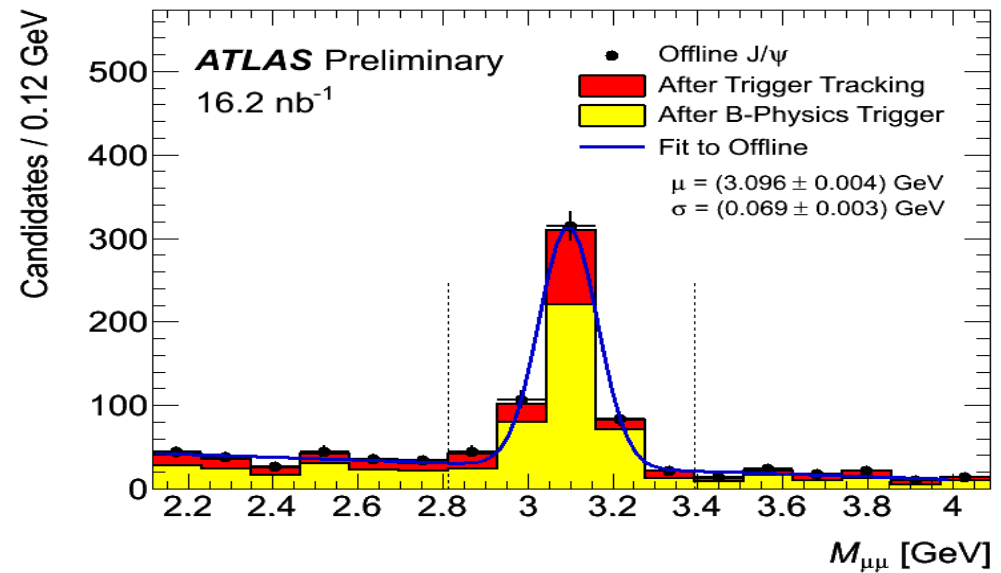
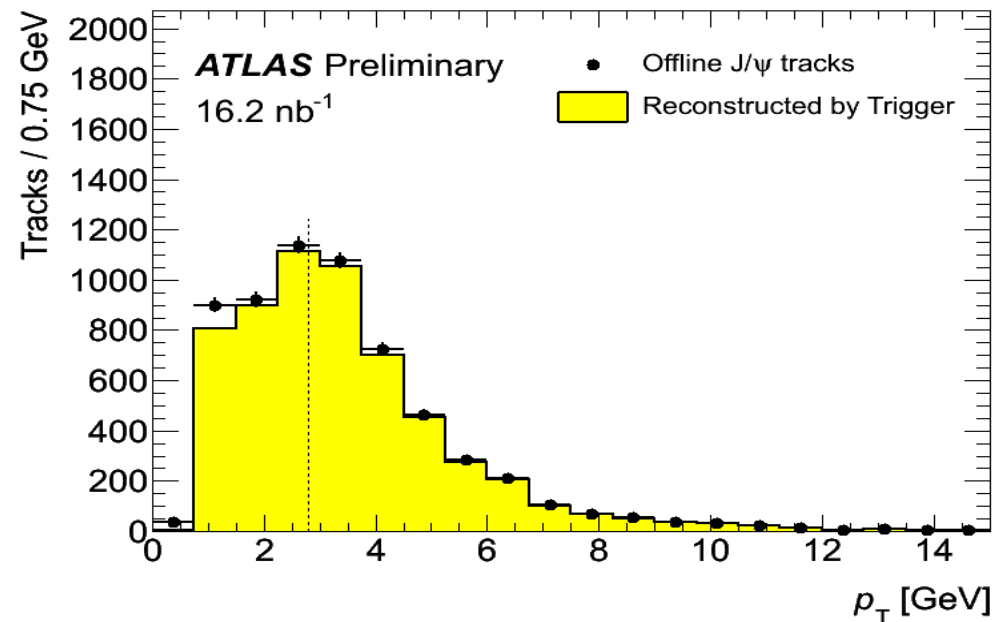
Muon performance





B physics trigger

- $J/\Psi \rightarrow \mu \mu$
- Offline tracks
- Analysis cut $p_T > 2.8$ GeV
- B-Physics trigger uses identified muons, $p_T > 4$ GeV





The ATLAS Trigger

Level 1 (LVL1)

- Fast custom-built electronics
- Latency: $< 2.5 \mu s$

High Level Trigger = Level-2 + Level-3:

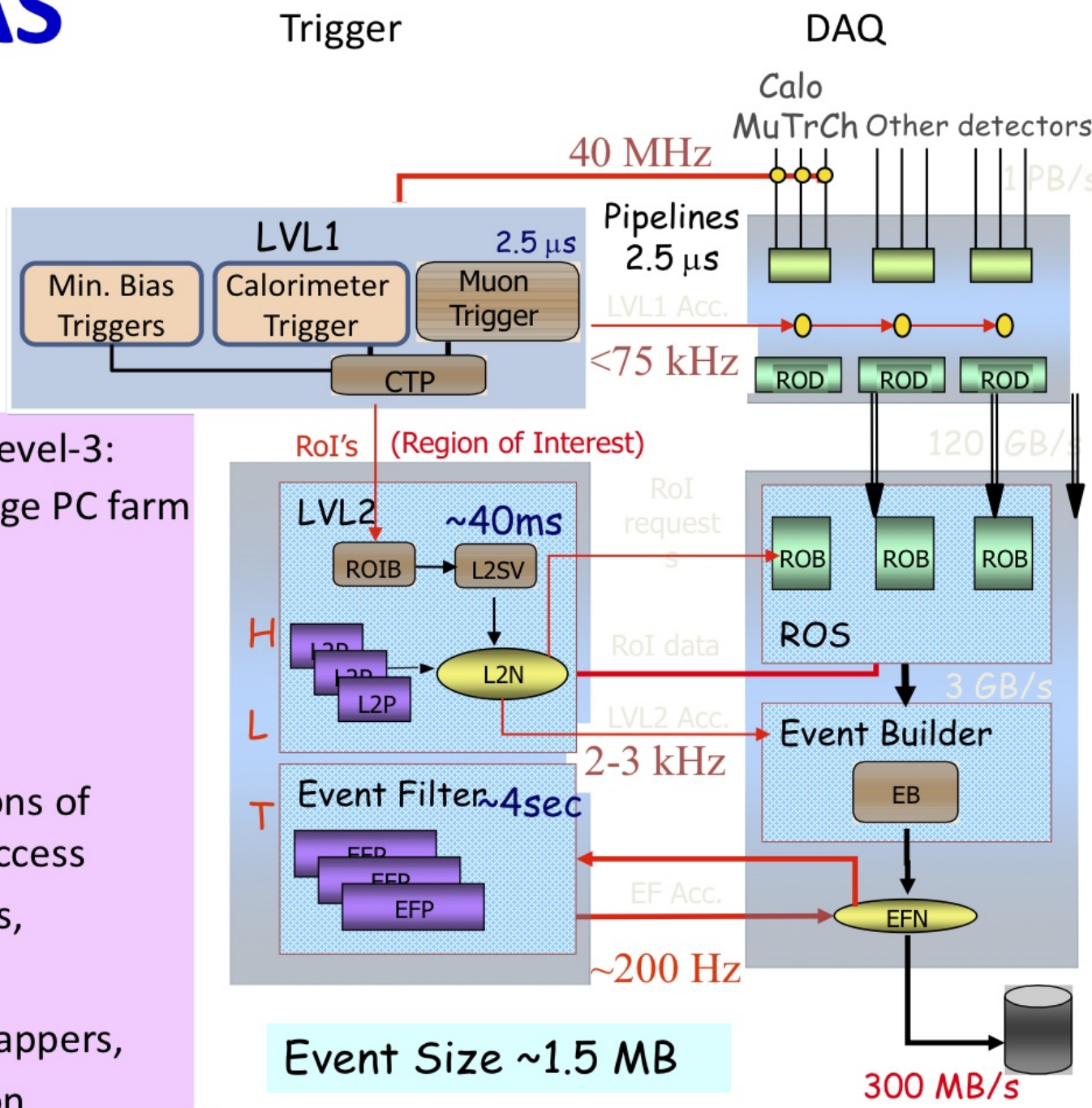
- Software based running on large PC farm
- ~ 1000 CPU cores at Level-2
- ~ 5000 Cores at Event Filter

Level-2:

- Fast custom algorithms
- reconstruction mainly in Regions of Interest (RoI) \Rightarrow limited data access
- Mean Processing Time ~ 40 ms,

Level 3 – Event Filter (EF)

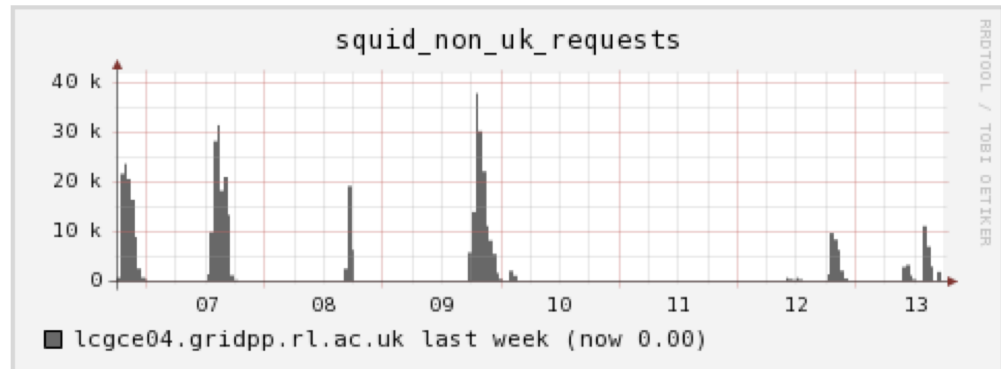
- Offline tools inside custom wrappers,
- Access to full event information
- Mean Processing Time $\sim 4s$



Non UK activity

- Surprising amount of activity from non UK sources given we aren't aware we are a fail-over for anyone.
- In the last week there have been requests from different machines at the following sites:

152779 wnXXX.pleiades.uni-wuppertal.de
 108318 fw-nat-inside-outside.gridka.de
 54868 grid-wnXXXX.desy.de
 73877 *.ifh.de
 2365 goliathXXX.farm.particle.cz
 1696 barbunXX.ulakbim.gov.tr
 1696 wnXXX.datagrid.cea.fr
 2120 gridgw.nipne.ro
 1892 dns.grid.cyf-kr.edu.pl
 946 atlas-wn-204.roma1.infn.it

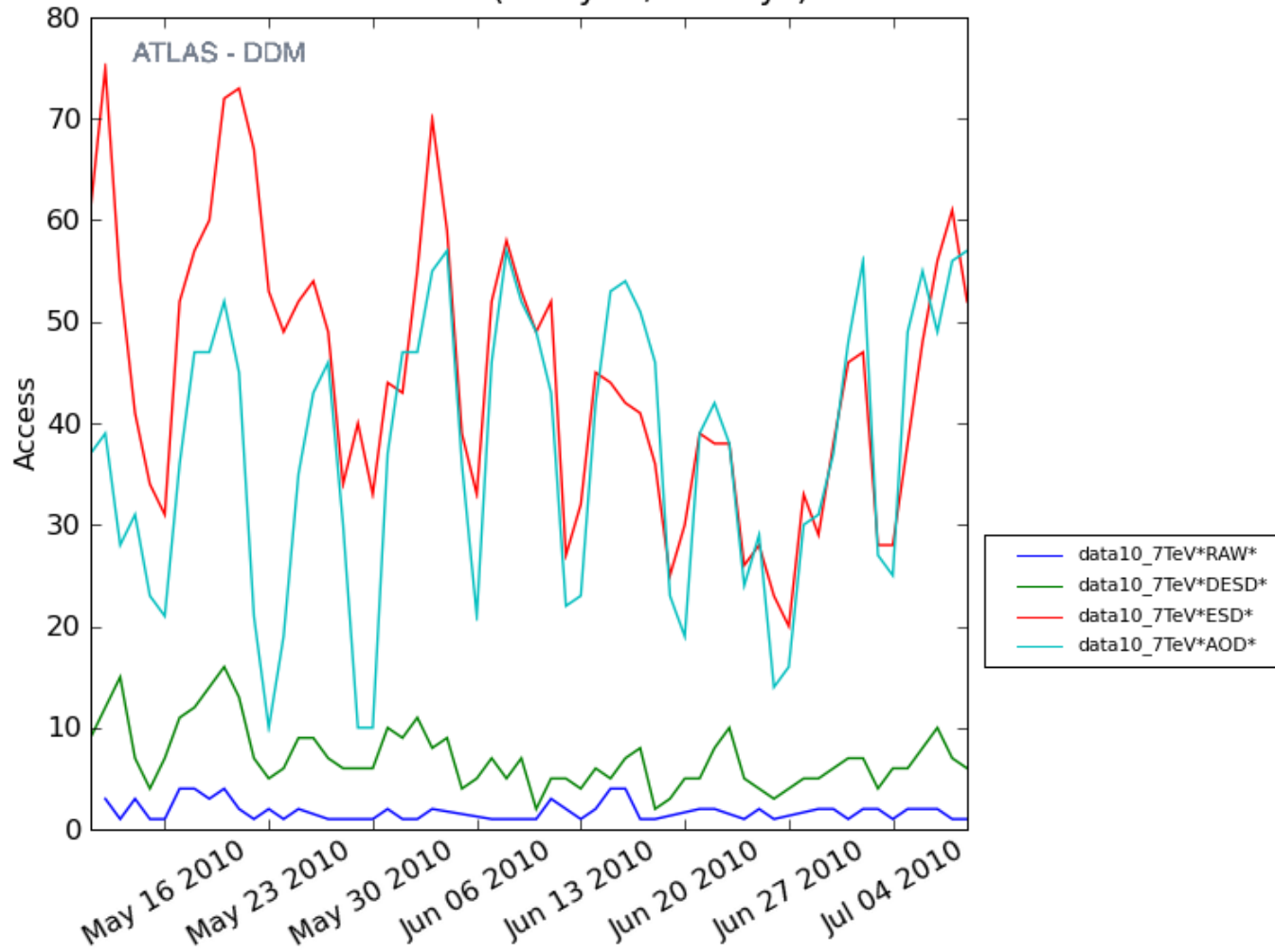


- Although not this week we have seen spikes of requests from WNs at CERN.
- We have seen connections from Worker Nodes as far away as Japan. (Can't be good for job efficiency!)
- This access is currently not an issue for our service but the sites in question might have a configuration issue. Who do we inform?



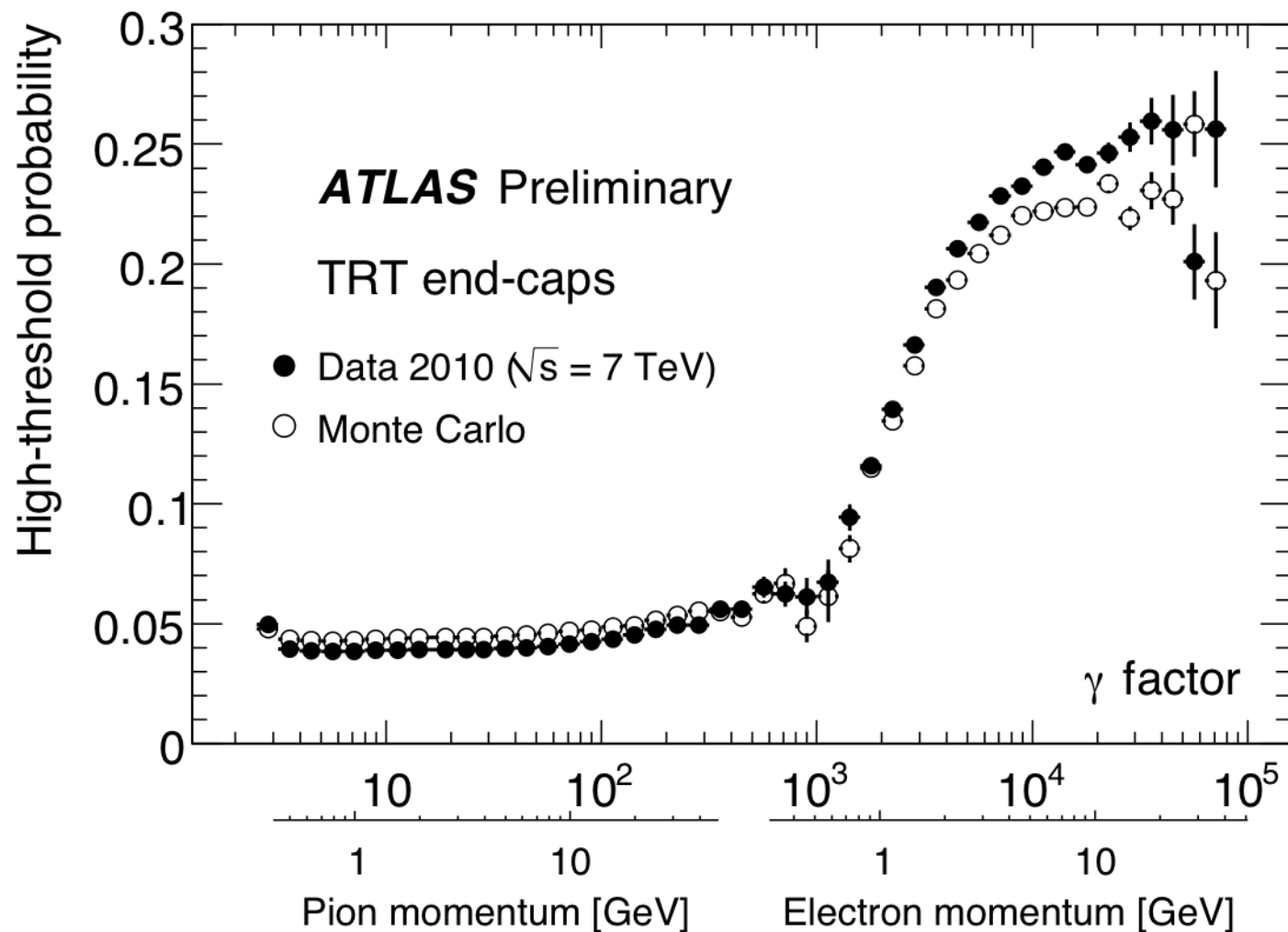
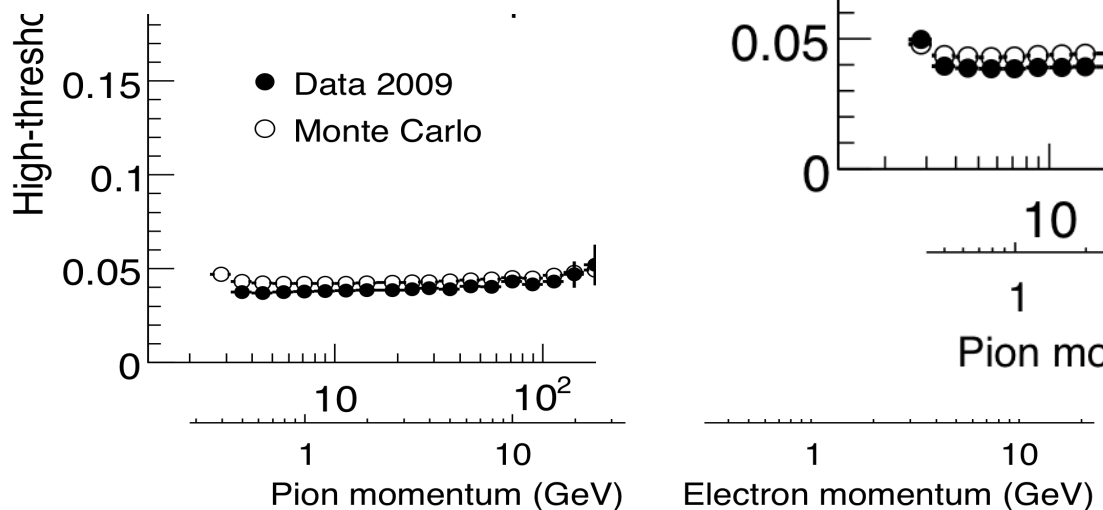
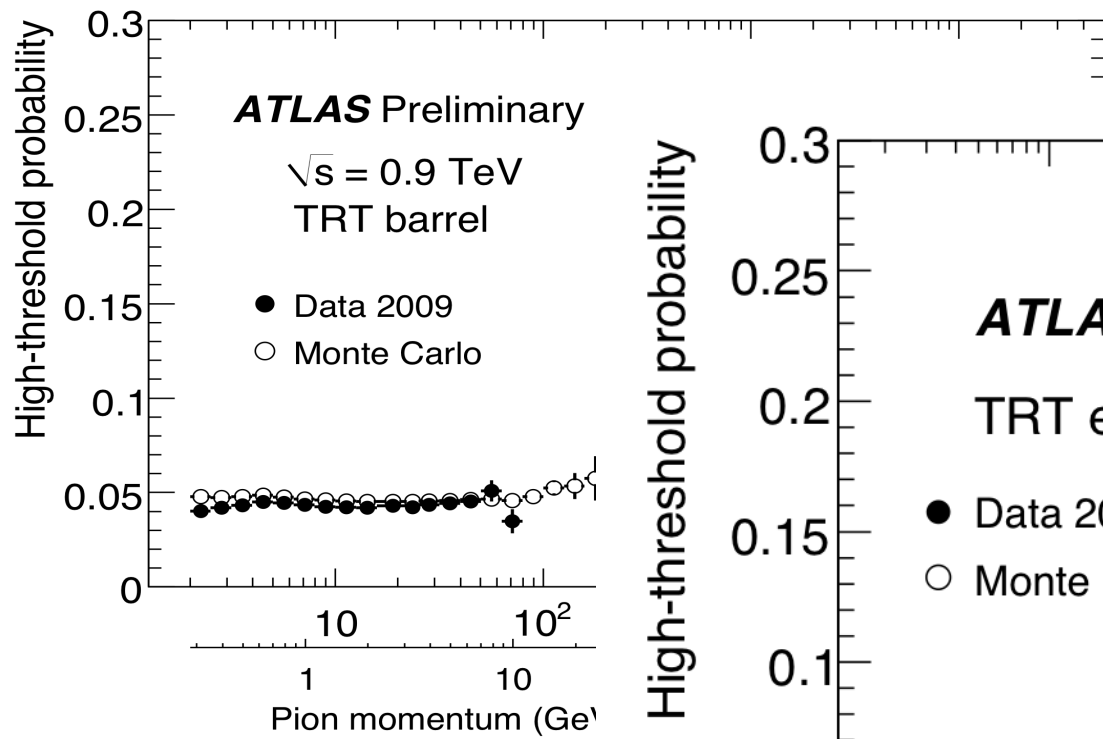


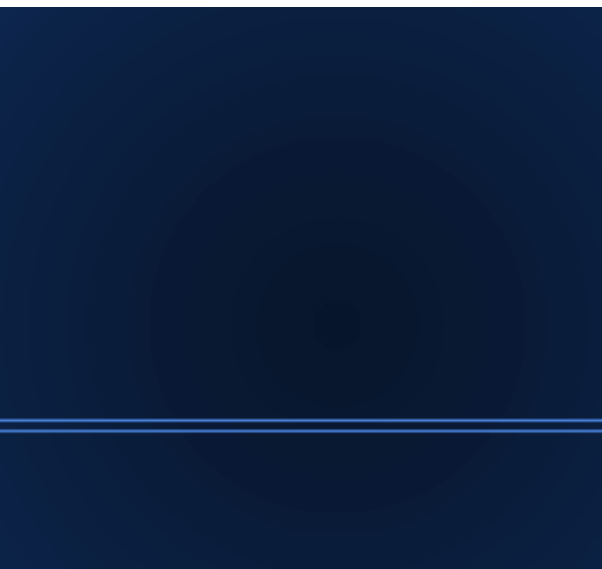
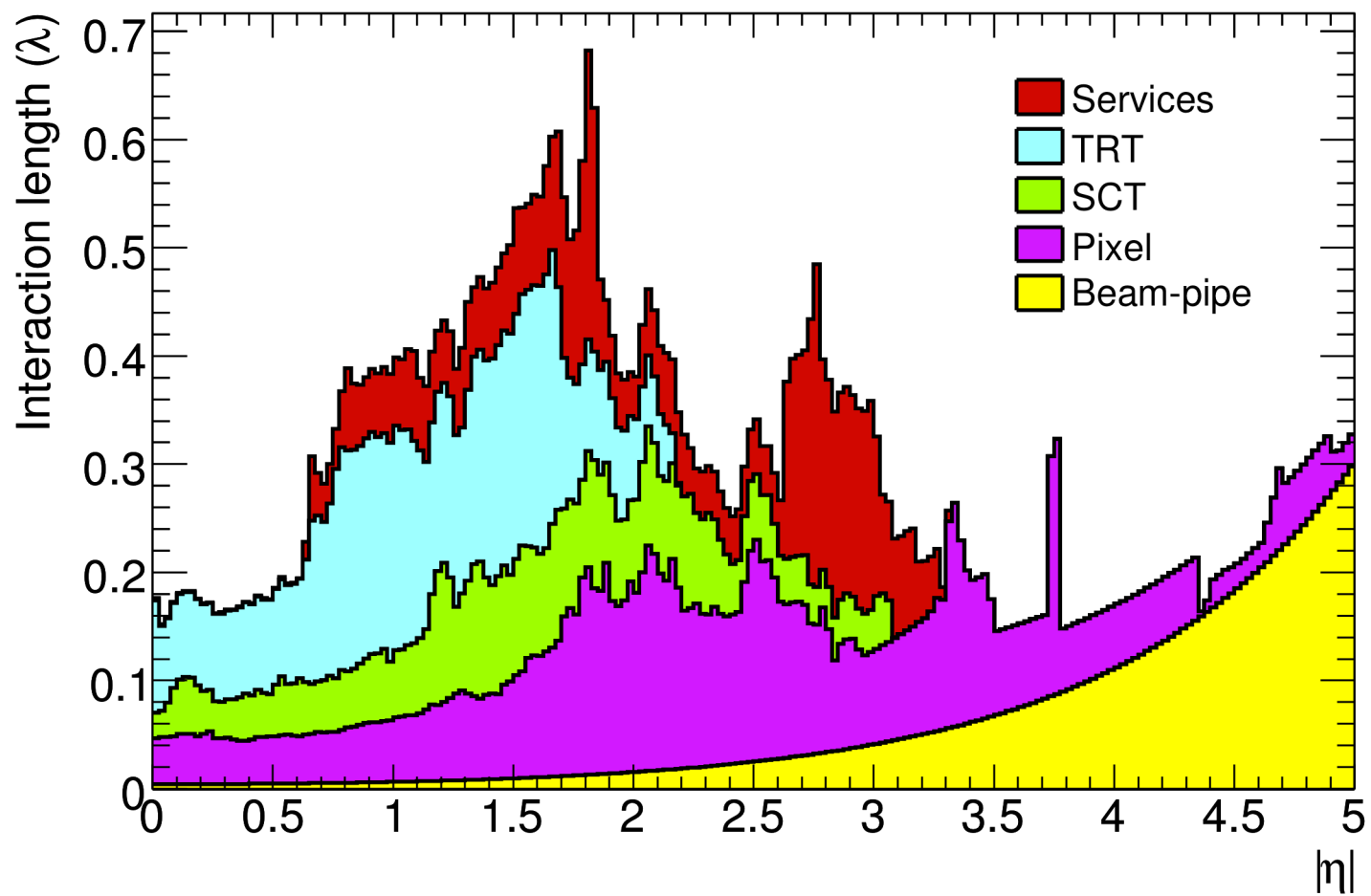
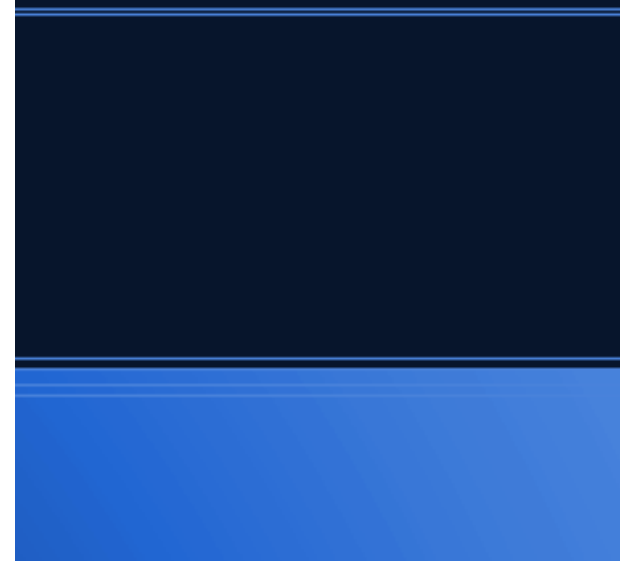
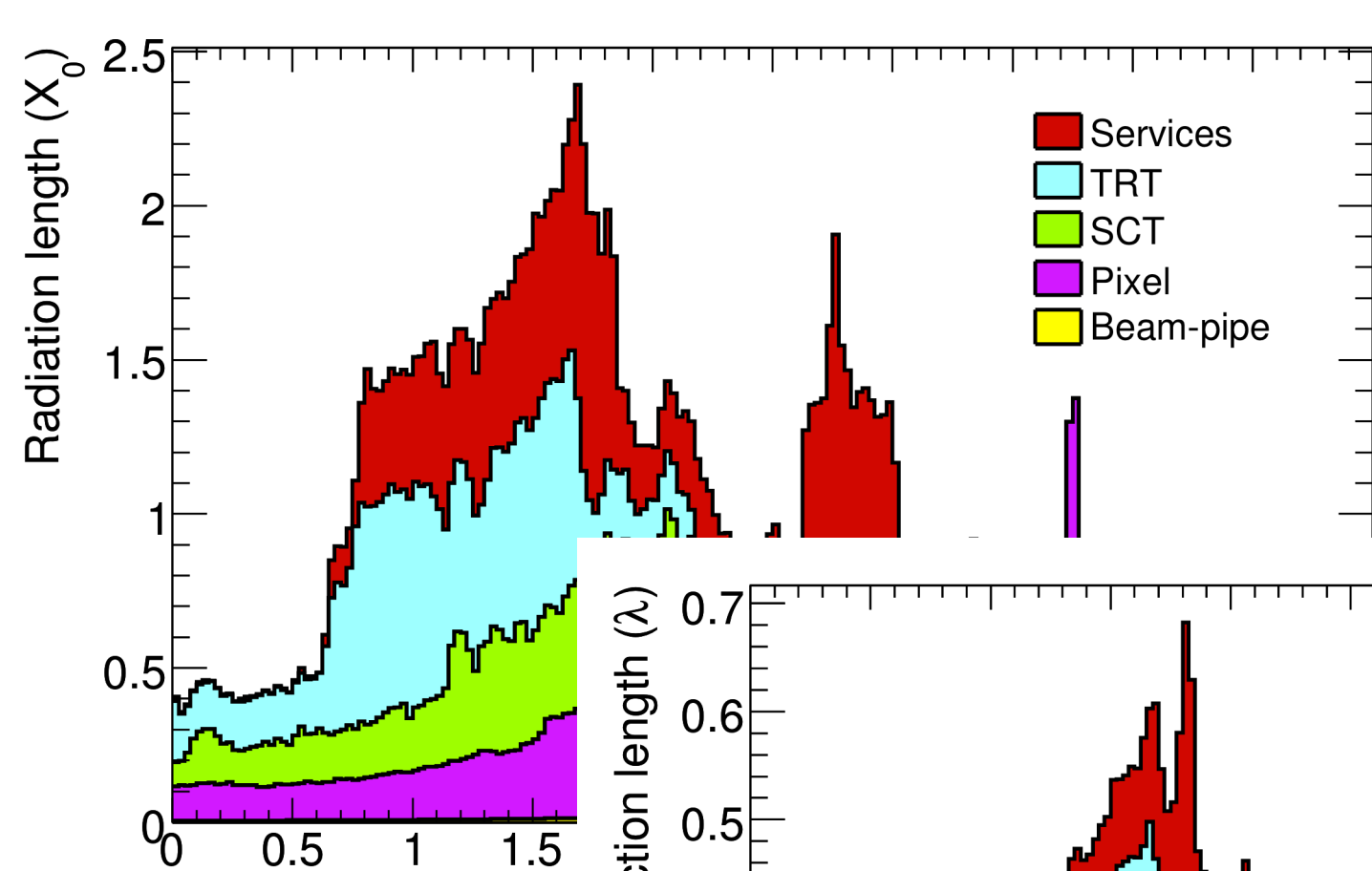
Distinct Users (Analysis, 60 days)



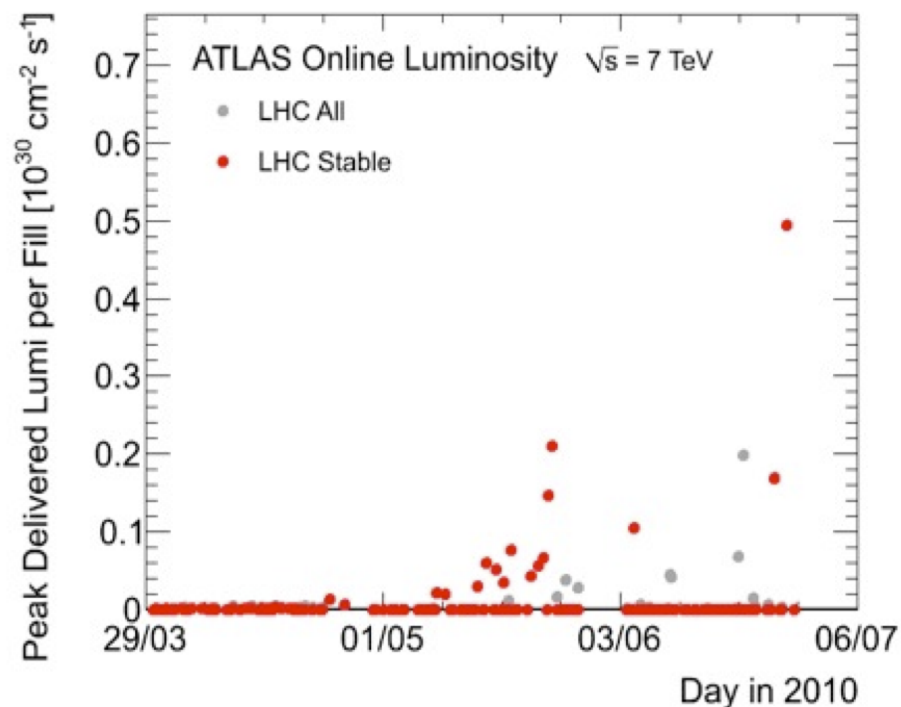
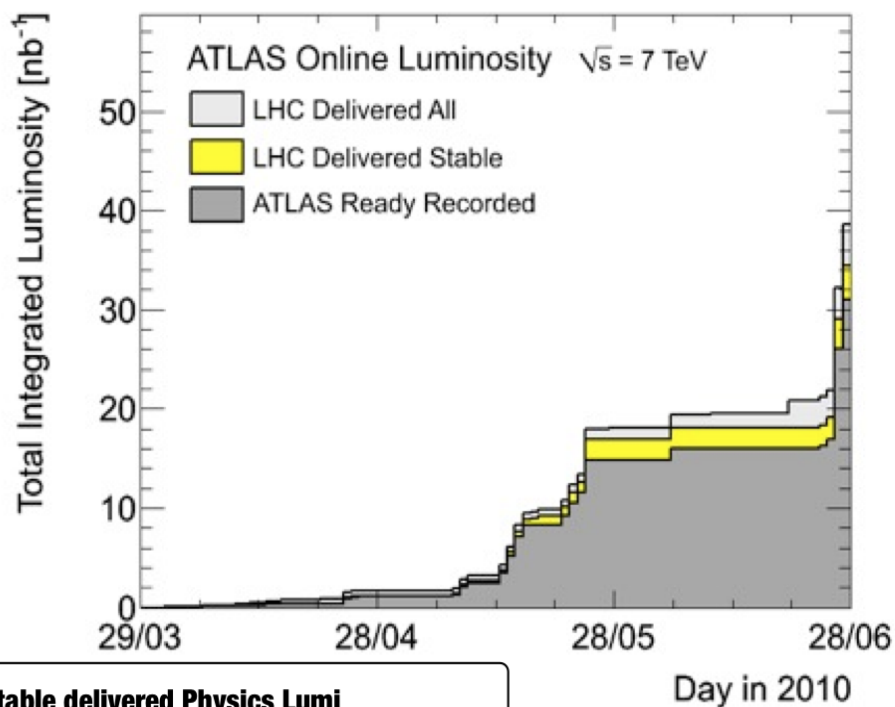


TRT for particle ID





Total Integrated Luminosity



Stable delivered Physics Lumi

Luminosity delivered during stable beam in collision bunch group +any luminosity delivered when no bunch group is defined, i.e. ATLAS is non recording

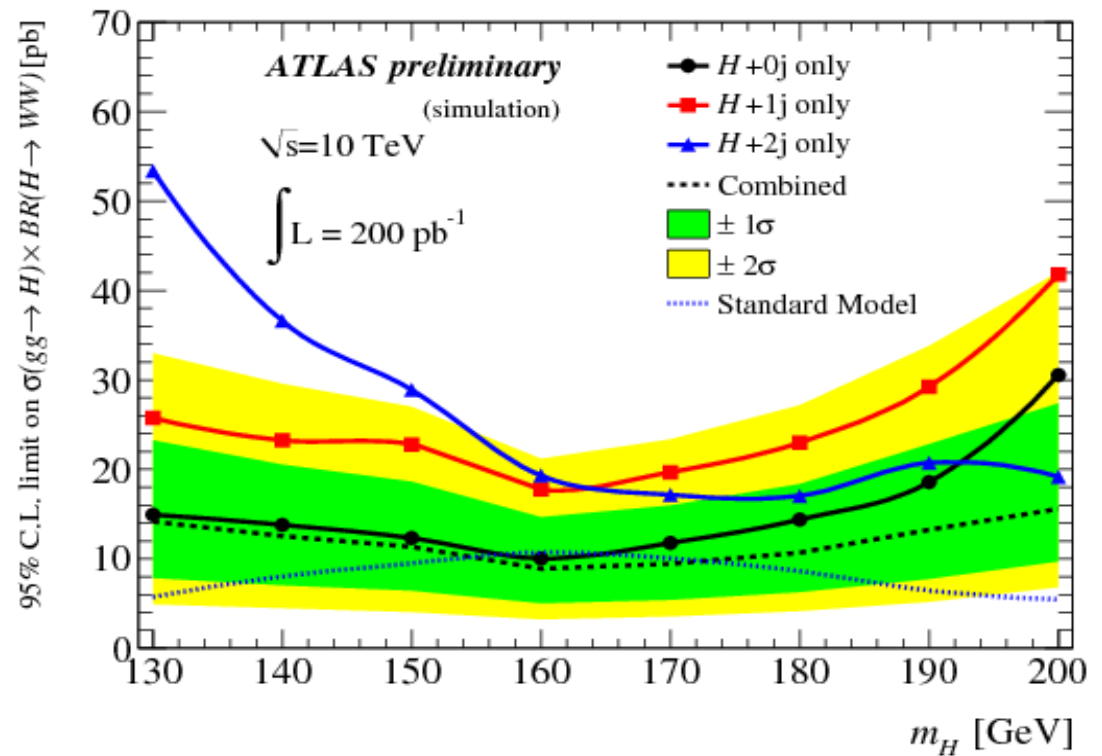
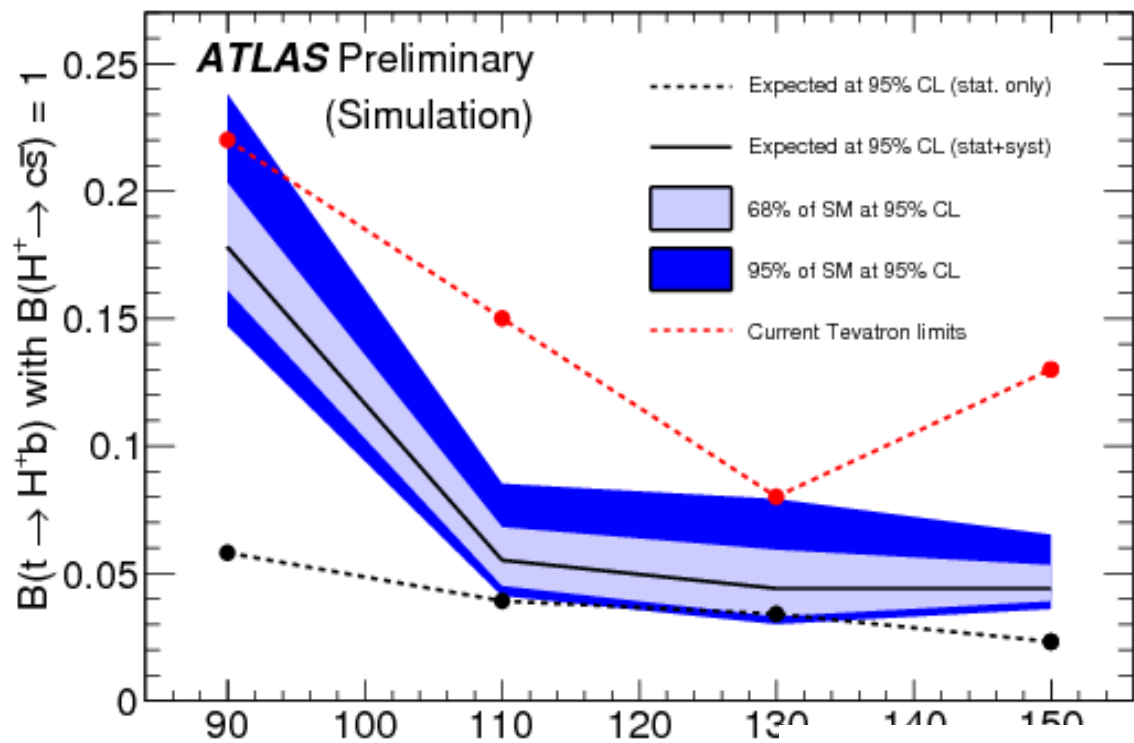
ATLAS recorded Live Fraction

Luminosity after taking into account L1 live fraction (after veto). This quantity is computed using L1_RDO_FILLED trigger rate observed after and before veto

ATLAS Recorded Ready

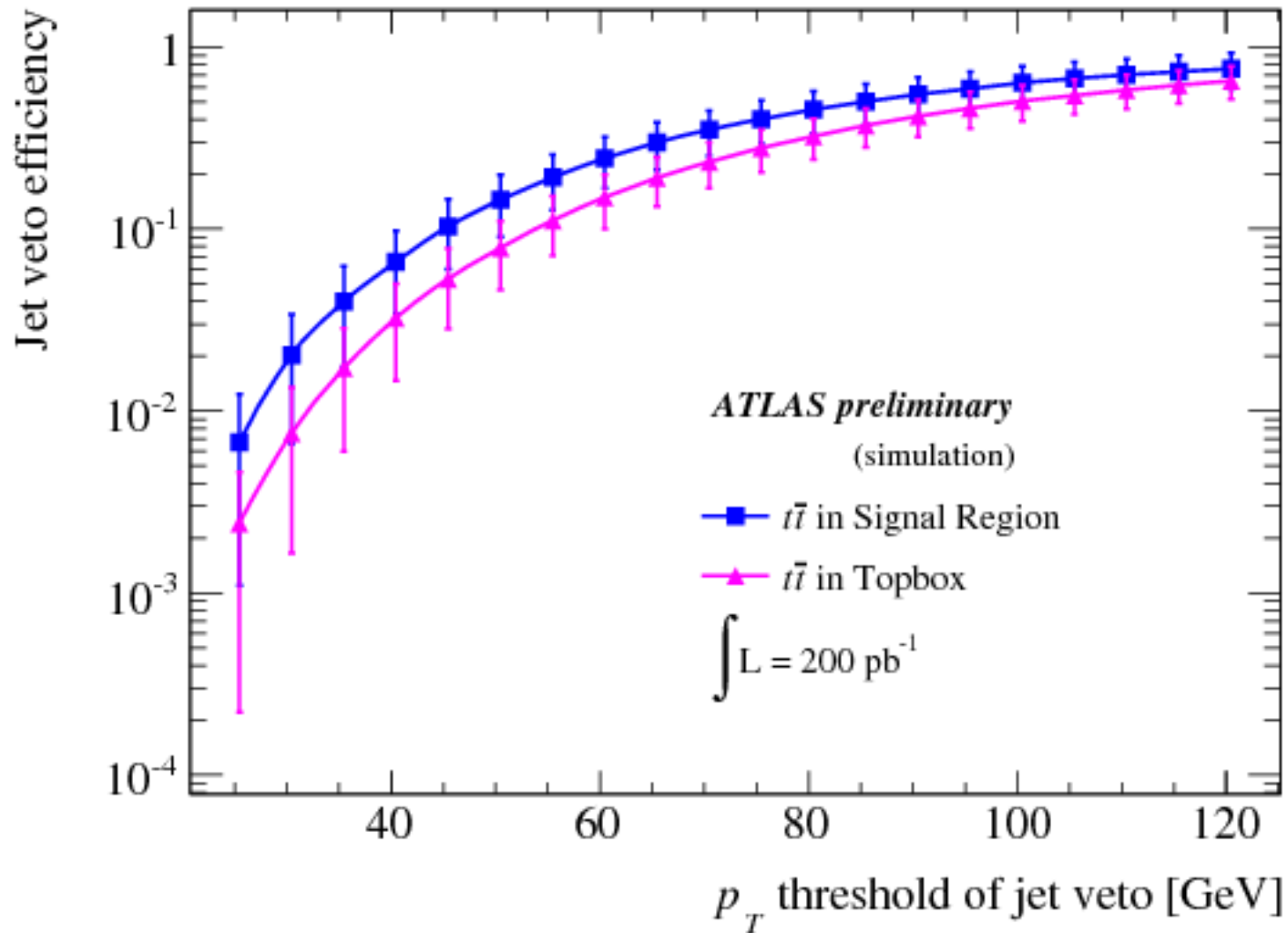
Luminosity recorded while the ATLAS Ready flag is set to TRUE, i.e. end of warm start and start of normal data taking

Peak Stable Lumi ($\text{cm}^{-2} \text{s}^{-1}$)	4.94×10^{29}	
Stable Beams Del. (nb^{-1})	33.385	100,0%
ATLAS Stable Rec. (nb^{-1})	31.975	95,8%
ATLAS Ready Rec. (nb^{-1})	31.043	93,0%



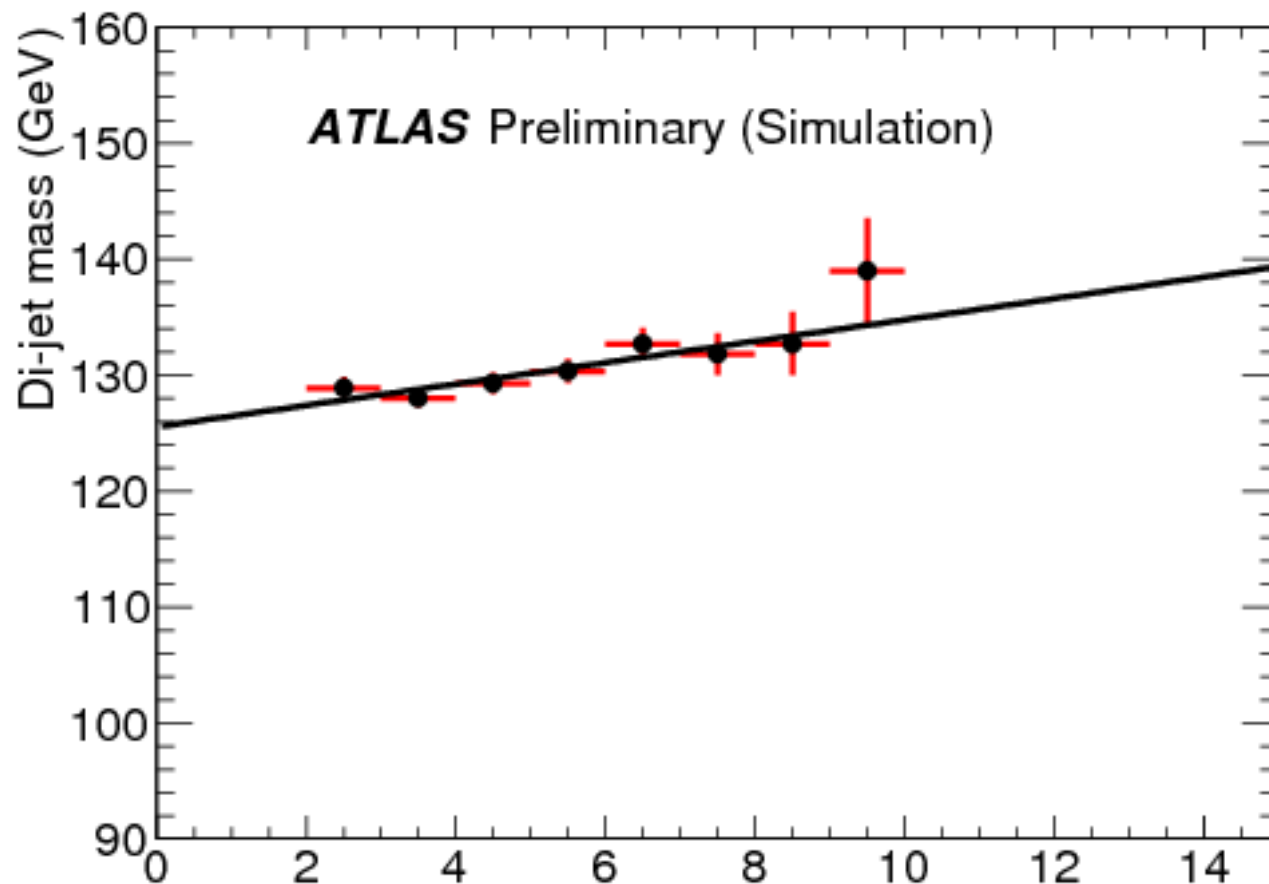


Physics – Higgs - WW

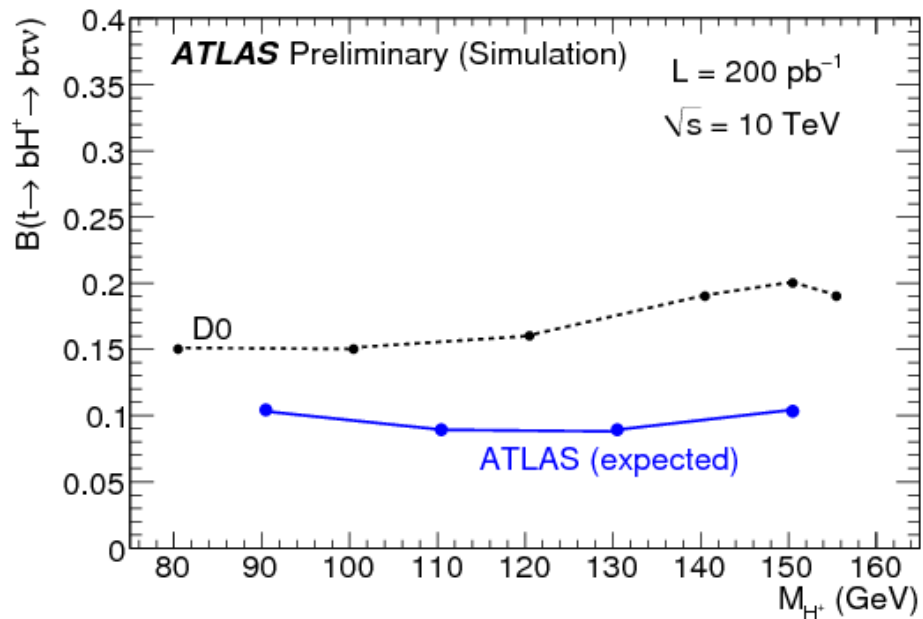
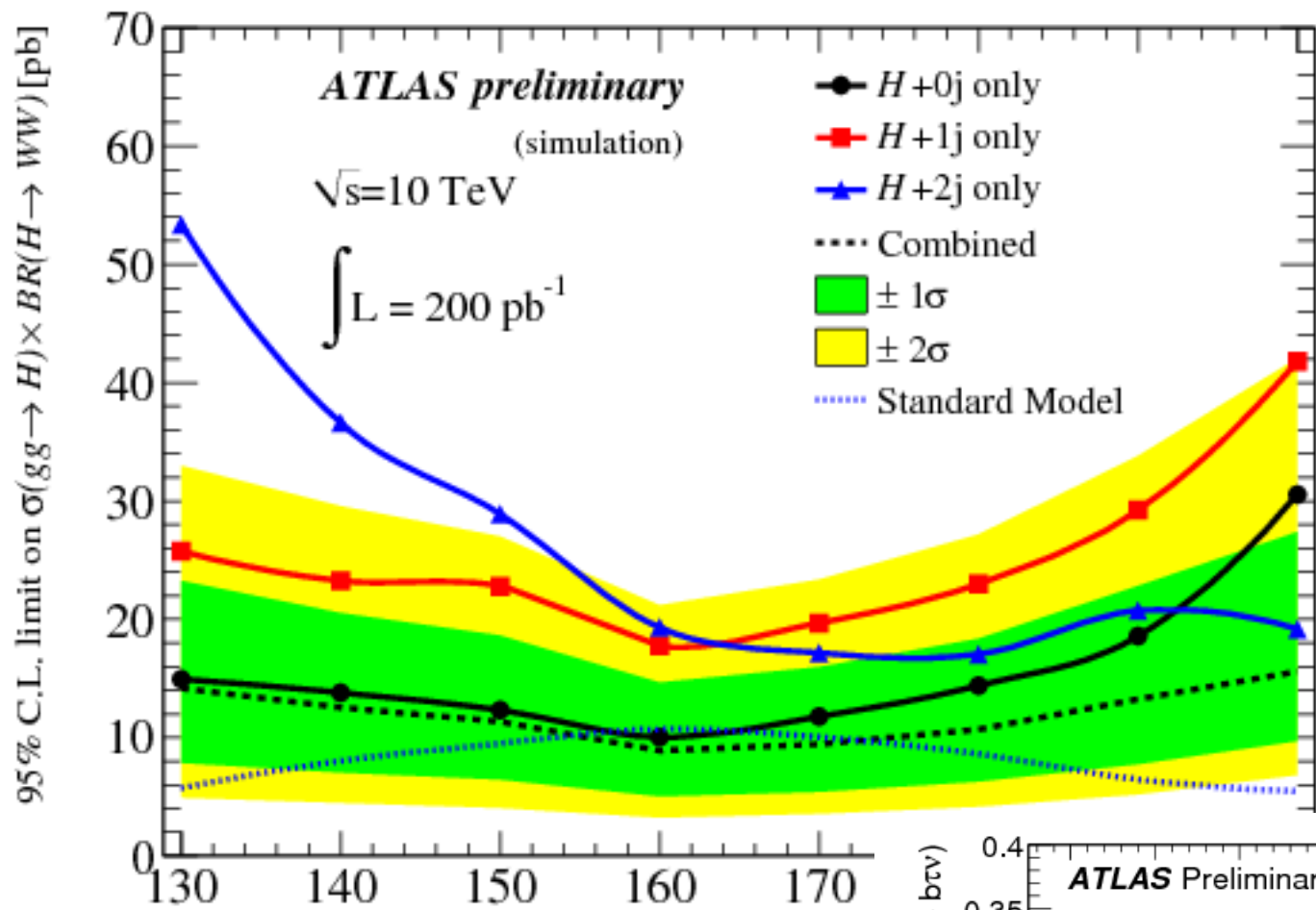




Physics – Higgs – light charged

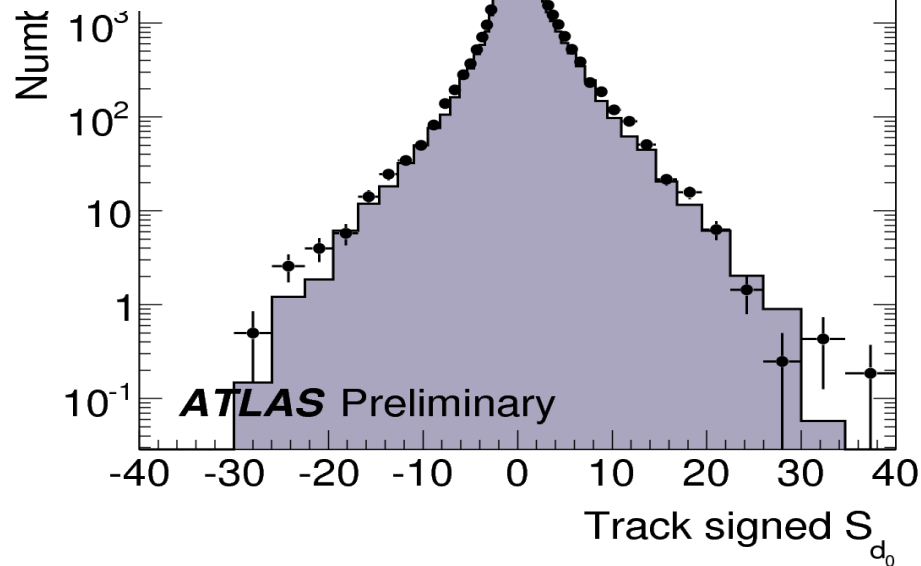
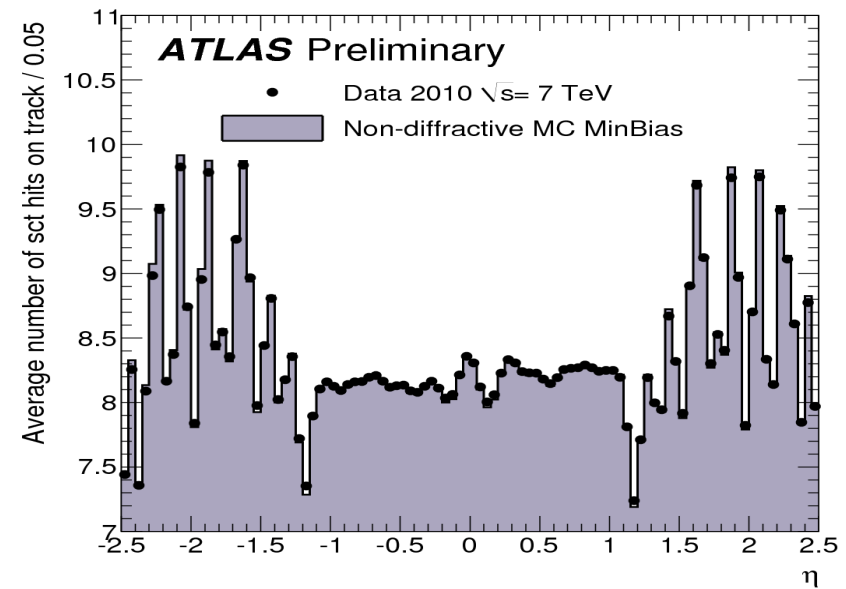
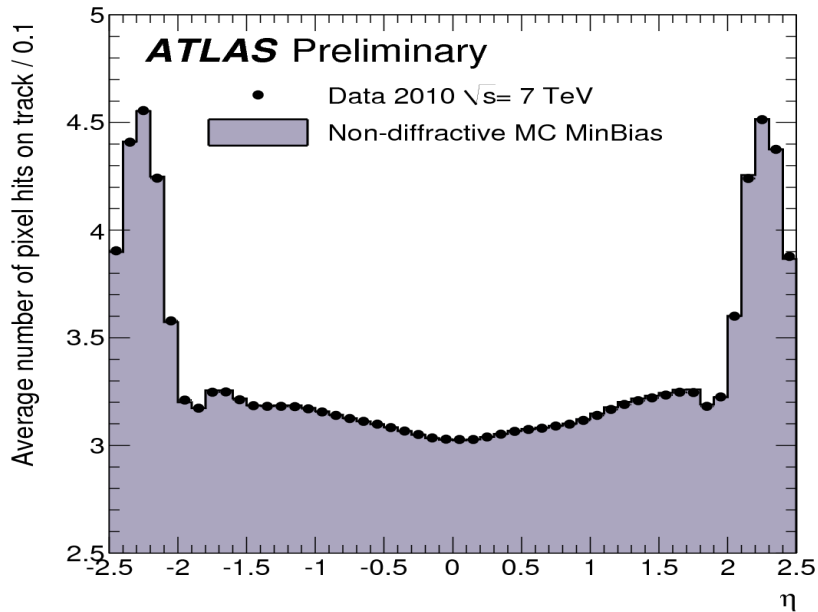


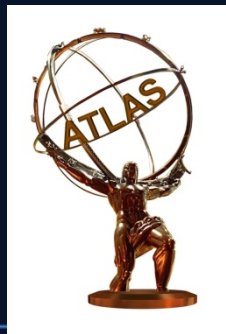
<https://twiki.cern.ch/twiki/bin/view/Atlas/PublicHGPlotsAtPhysPub2010006>





ID performance relevant for b tagging





The Pixel Detector

1.4 m

ATLAS

SLD VXD3
(not to scale)

