

ATLAS Physics

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Outline

Introduction

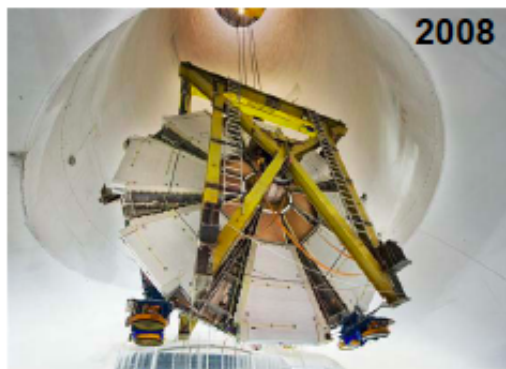
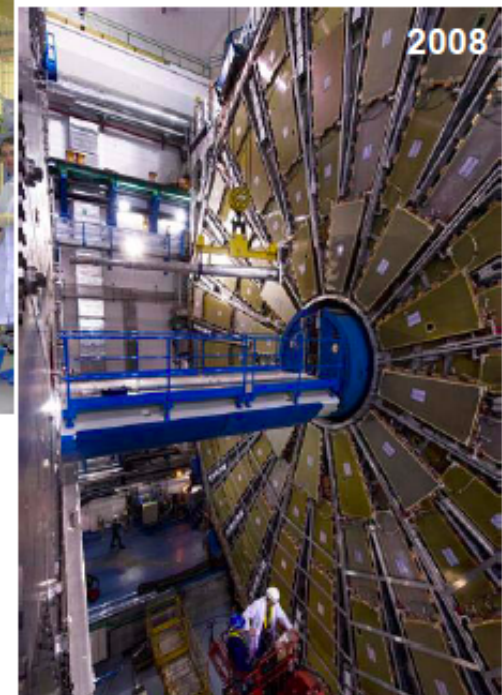
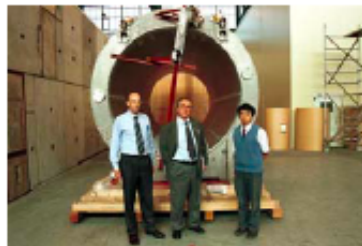
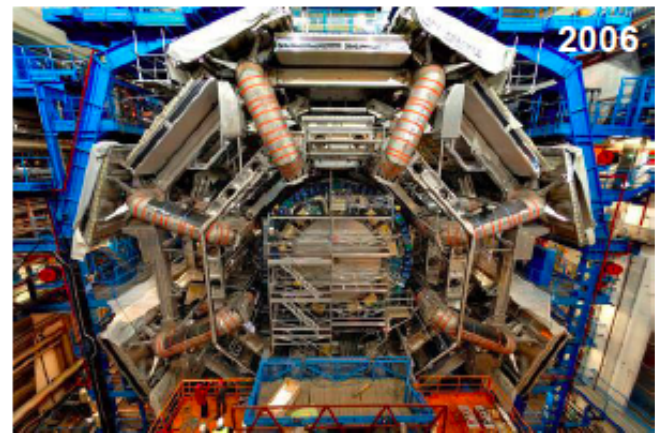
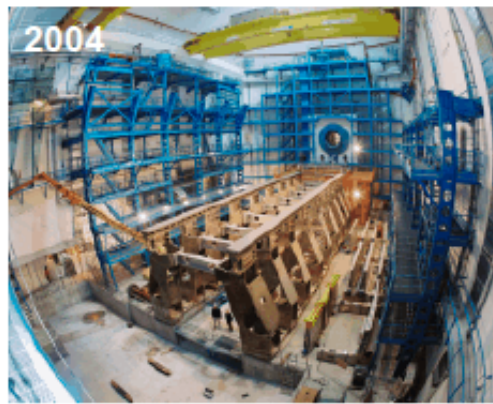
Detector Performance

1st Collider Physics Result

Physics at $E_{\text{cm}} = 7 \text{ TeV}$

ATLAS Computing & Expected Analysis Models

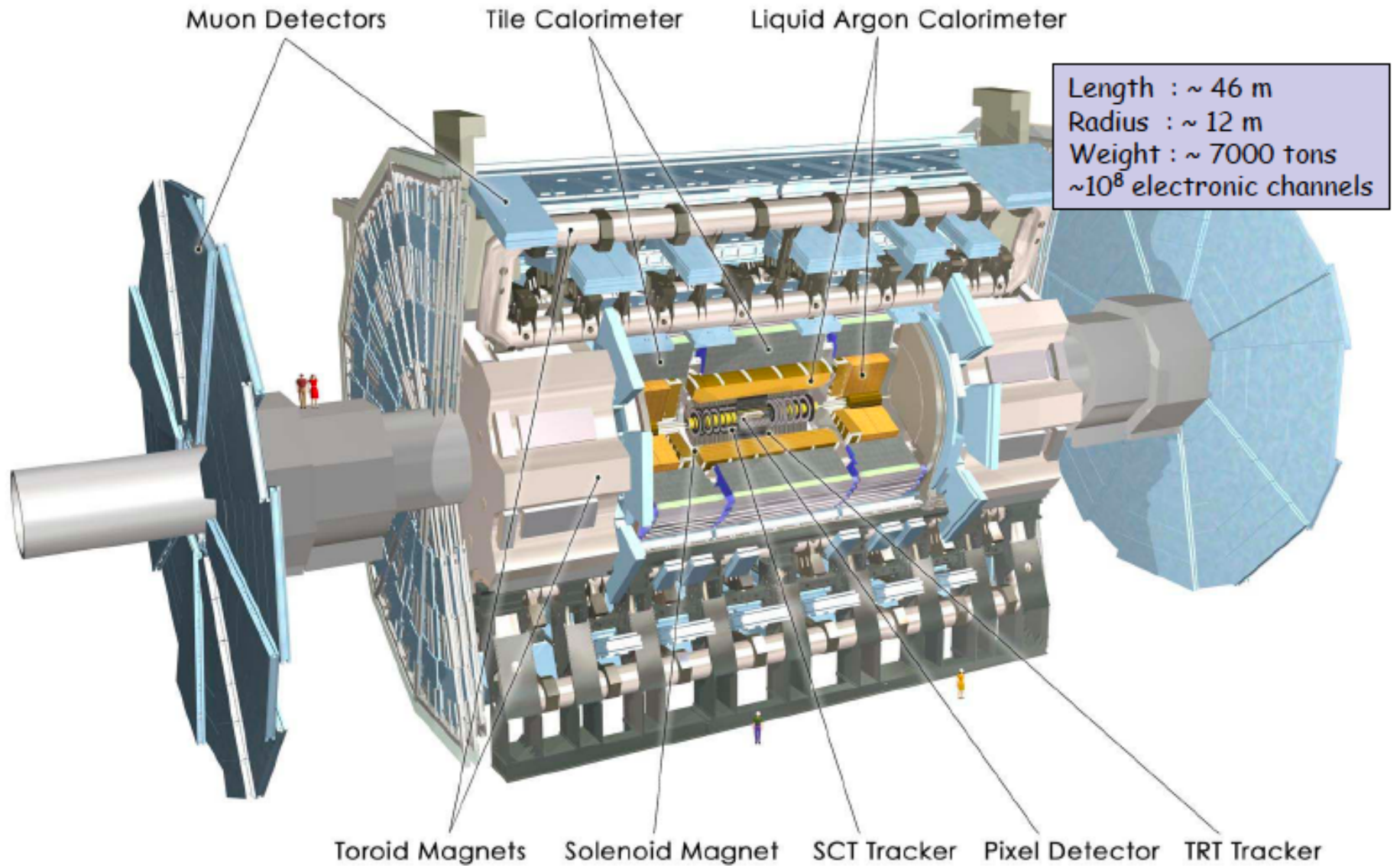
ATLAS is the product of >20 years of sustained activity by a worldwide scientific community



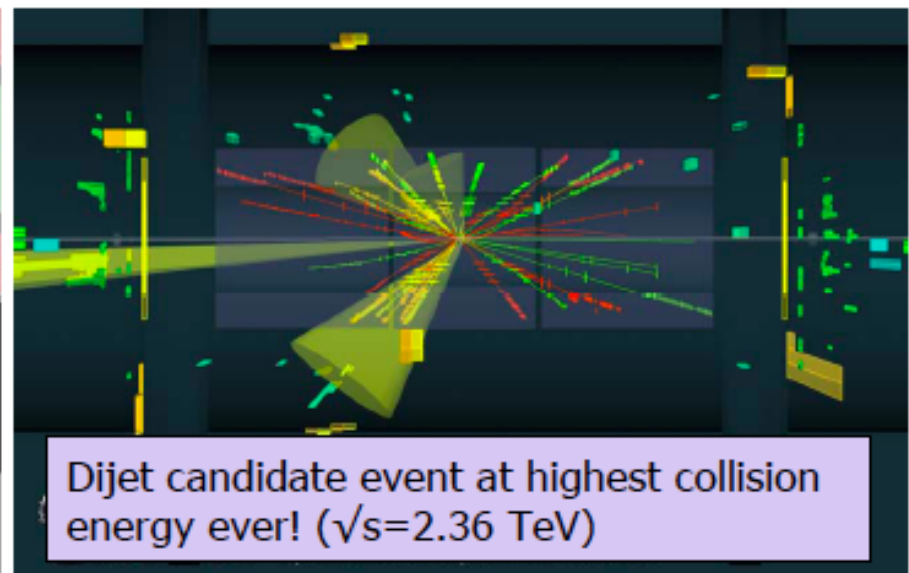
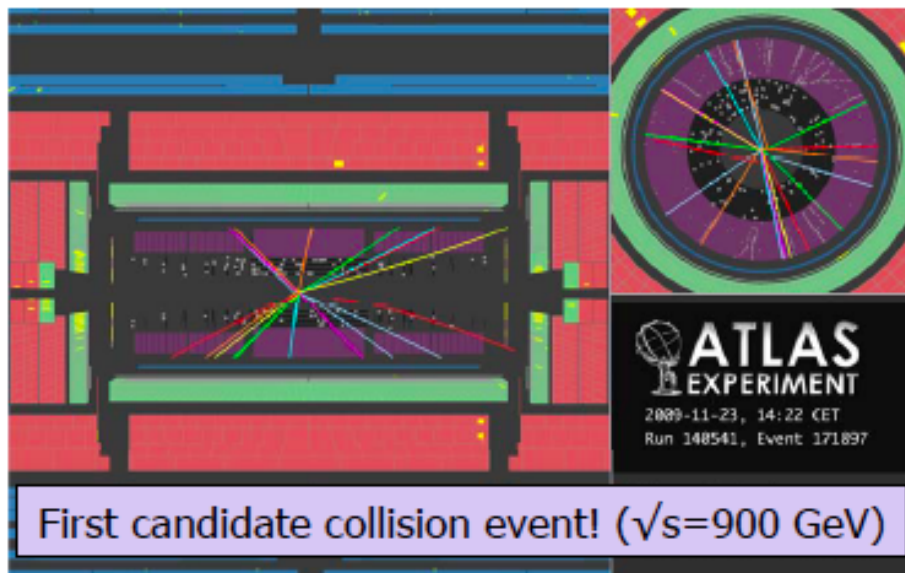
Apr 6, 2010

DOSAR Workshop IX - Johannesburg

ATLAS Detector

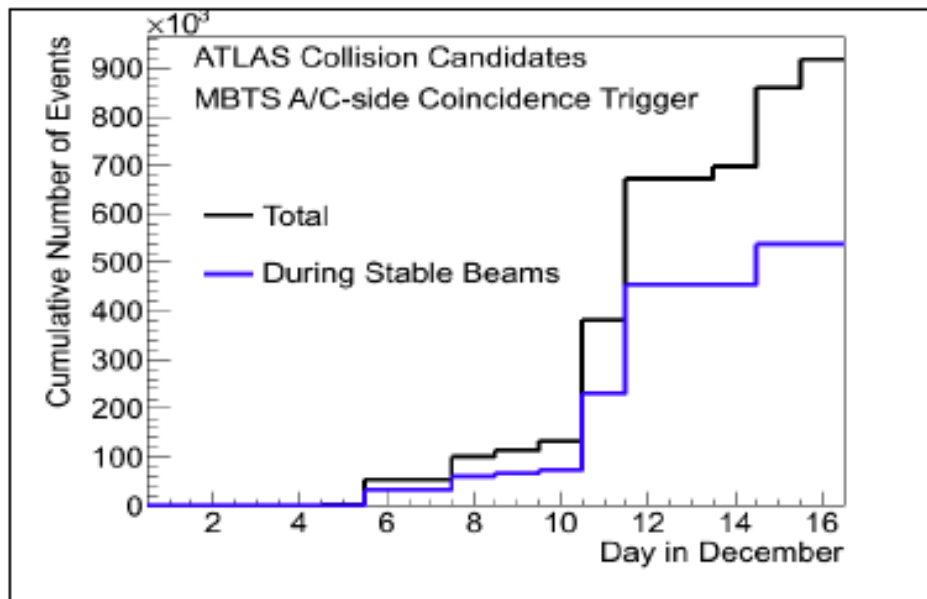


First Collision Run! (Nov. - Dec. 2009)



2009 Run Summary

Recorded data samples	Number of events	Integrated luminosity ($< 30\%$ uncertainty)
Total	9.2×10^5	$\sim 20 \mu\text{b}^{-1}$
Stable beam (Full ID on), good quality	3.8×10^5	$\sim 9 \mu\text{b}^{-1}$
At $\sqrt{s}=2.36$ TeV (ID not fully on)	3.4×10^4	$\sim 1 \mu\text{b}^{-1}$

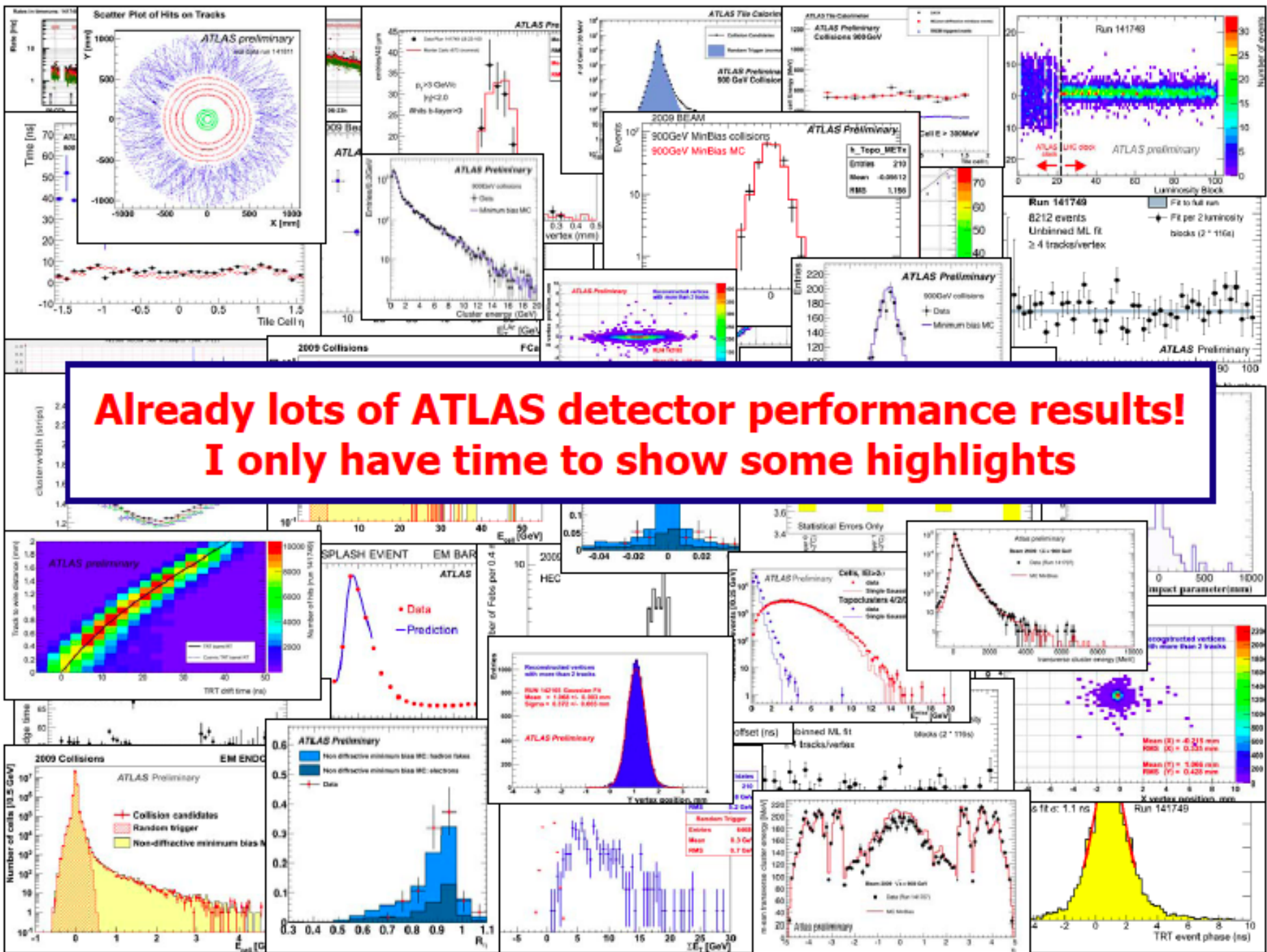


- Max peak luminosity seen by ATLAS: $\sim 7 \times 10^{26} \text{cm}^{-2}\text{s}^{-1}$
- Average ATLAS data-taking efficiency: $\sim 90\%$
- Efficient offline computing
 - 99.98% prompt reconstruction efficiency
 - Data at analysis farm (Tier-2) ~ 4 hours after collection

ATLAS was fully operational

Status of December 2009

Subdetector	Number of Channels	Operational Fraction
Pixels	80 M	97.9%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	98.2%
LAr EM Calorimeter	170 k	98.8%
Tile calorimeter	9800	99.2%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.4%
RPC Barrel Muon Trigger	370 k	98.5%
TGC Endcap Muon Trigger	320 k	99.4%
LVL1 Calo trigger	7160	99.8%

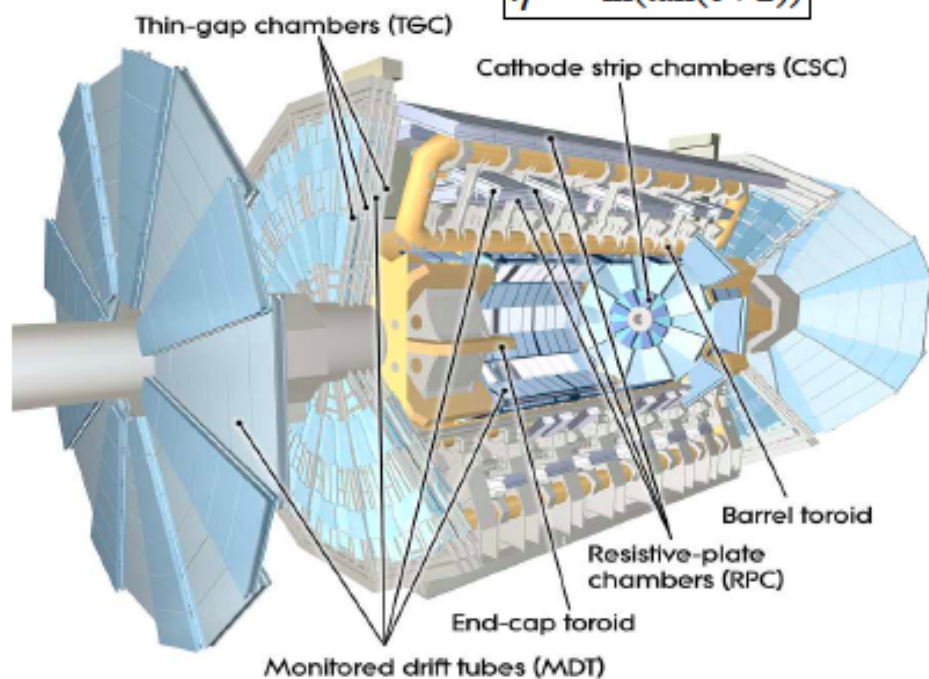


**Already lots of ATLAS detector performance results!
I only have time to show some highlights**

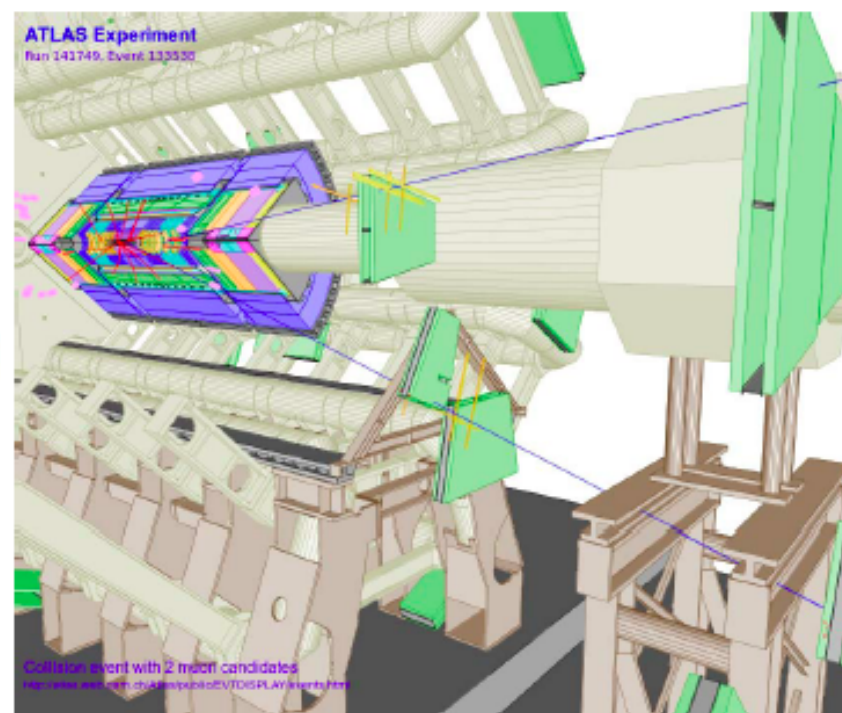
Muon Spectrometer

Muon trigger and momentum resolution < 10% up-to $E_{\mu} \sim \text{TeV}$
Coverage: $|\eta| < 2.7$

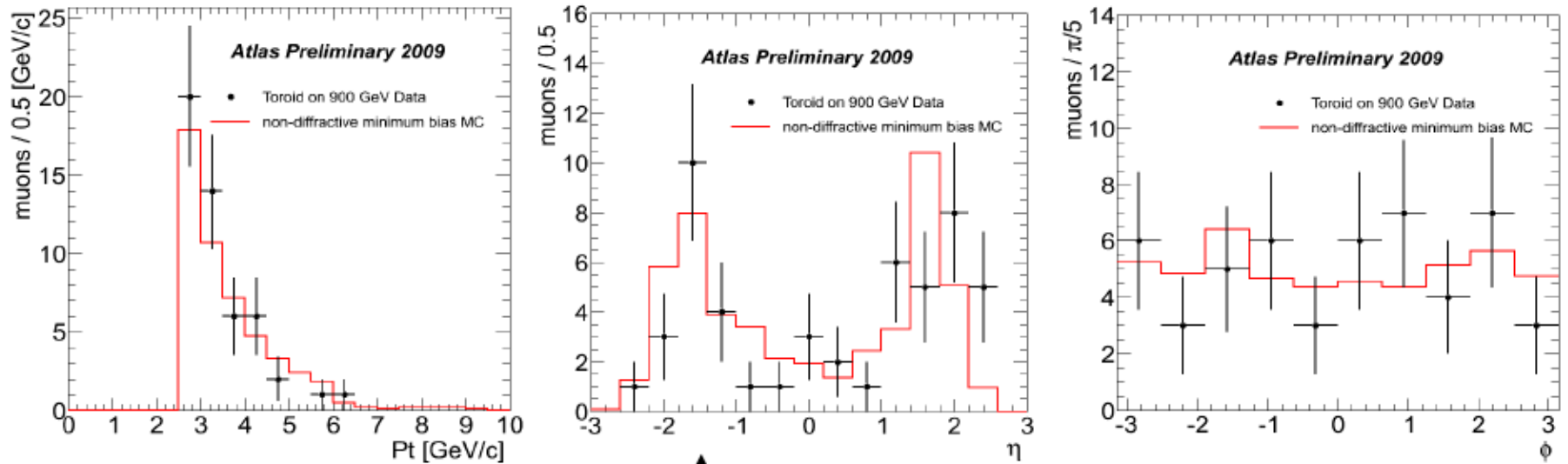
$$\eta = -\ln(\tan(\theta/2))$$



Collision di-muon candidate event

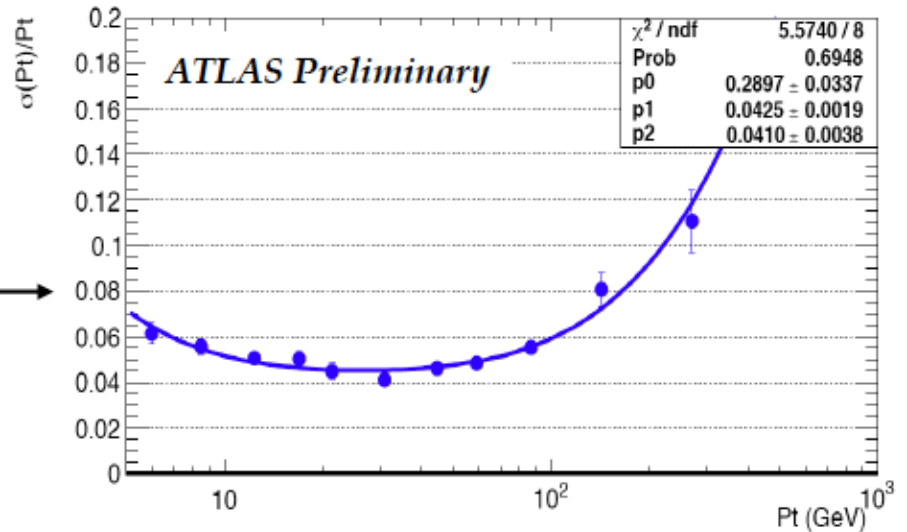


Muon Spectrometer Performance



Collision muon candidates distributions:
 Good agreement within limited statistics
 (50 candidates)

2008-09 Cosmic Ray Commissioning:
 ~half-billion muon-triggered events!
 Example: resolution better than 10% up-to a
 few hundred GeV
 (Above that: resolution limited by asynchronous
 cosmic ray arrival time and mis-alignment)



Calorimeter

EM Calo: LAr/Pb

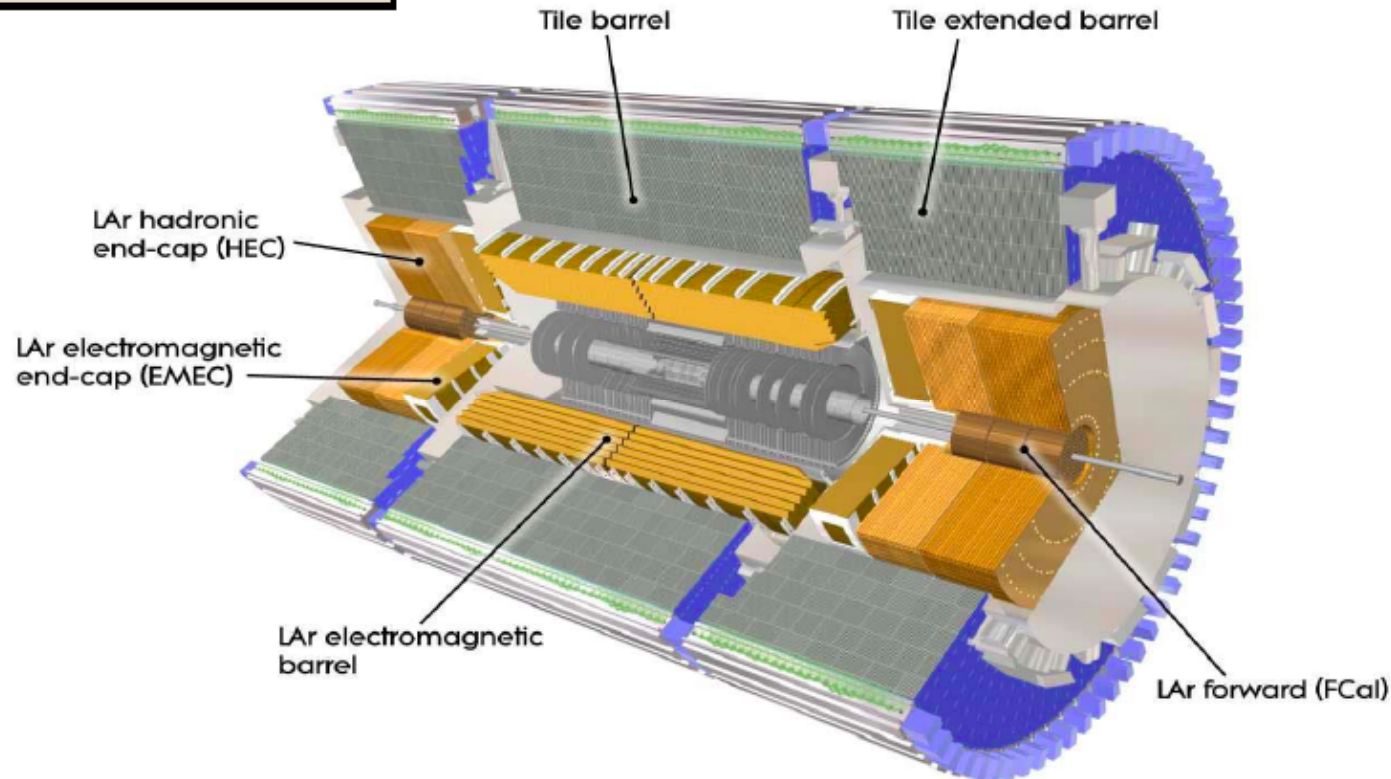
$|\eta| < 3.2$

$\sigma(E)/E (e/\gamma) \sim 10\%/\sqrt{E} \oplus 0.7\%$

Hadronic barrel: Scin/Fe

$|\eta| < 1.7$

$\sigma(E)/E (\text{jet}) \sim 50\%/\sqrt{E} \oplus 3\%$



Hadronic endcap: LAr/Cu

$1.5 < |\eta| < 3.2$

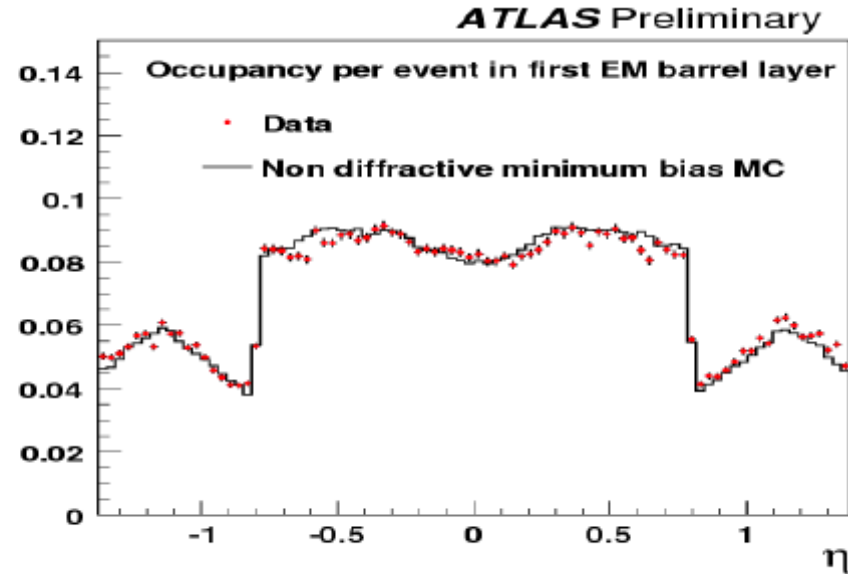
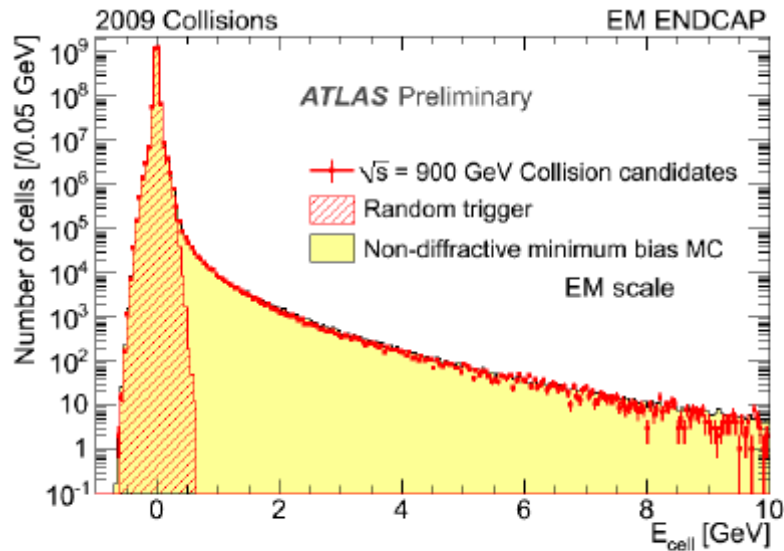
$\sigma(E)/E (\text{jet}) \sim 50\%/\sqrt{E} \oplus 3\%$

Hadronic Forward: LAr/Cu,W

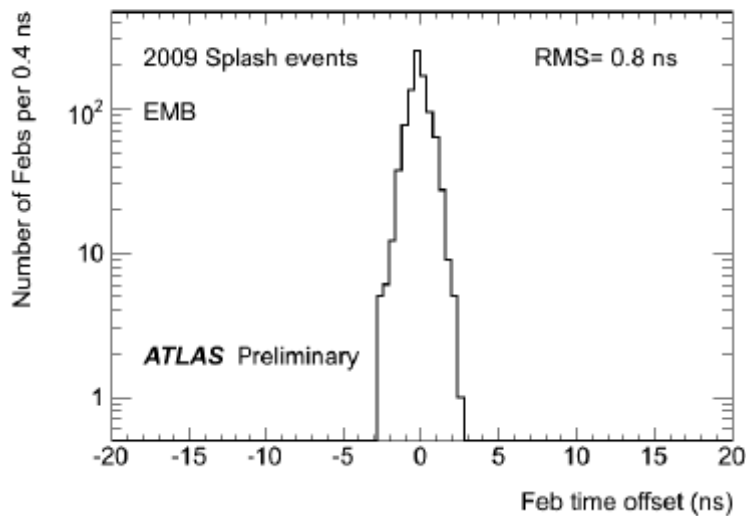
$3.1 < |\eta| < 4.9$

$\sigma(E)/E (\text{jet}) \sim 100\%/\sqrt{E} \oplus 10\%$

Calorimeter Performance



Good agreement data/MC of raw cell energy and detector occupancy



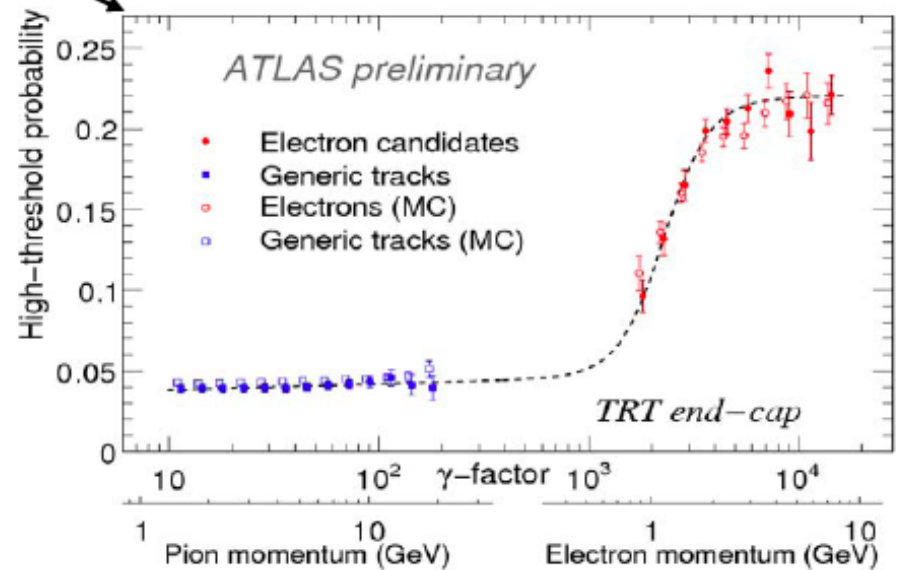
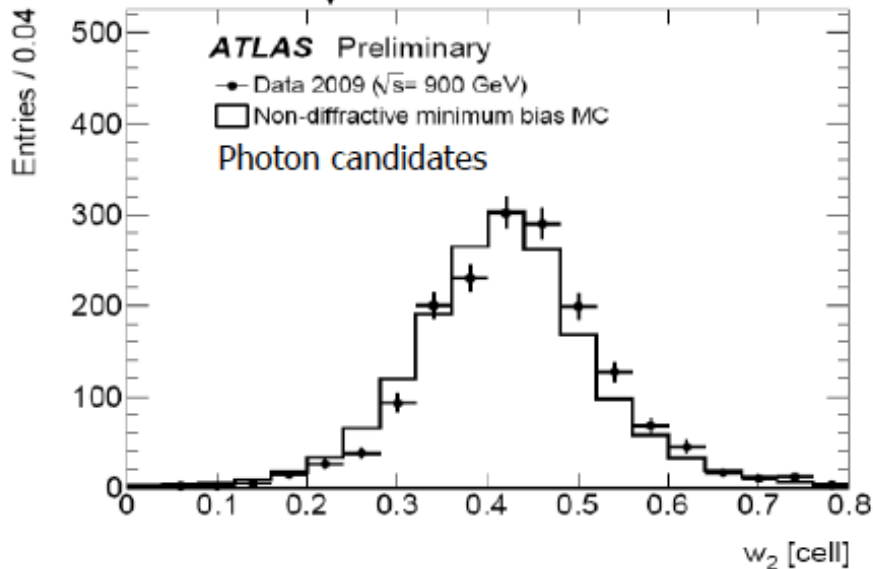
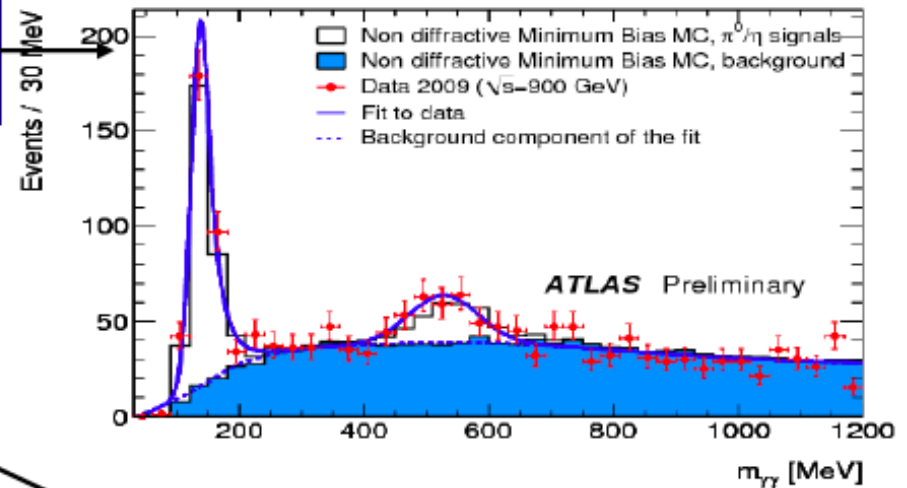
Relative timing adjusted to < 1ns
(important for E resolution)

Electron/Photon Reconstruction

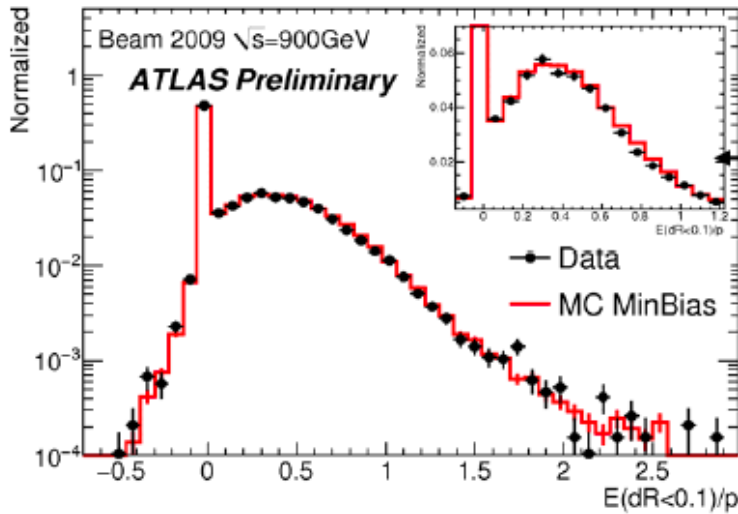
Diphoton mass distribution (π^0 and η)
Widths and positions well described by MC

Validation of e/γ ID variables:

- Ex.: 1: cluster width at shower max
- Ex.: 2: Transition Radiation Tracker



Jet Reconstruction

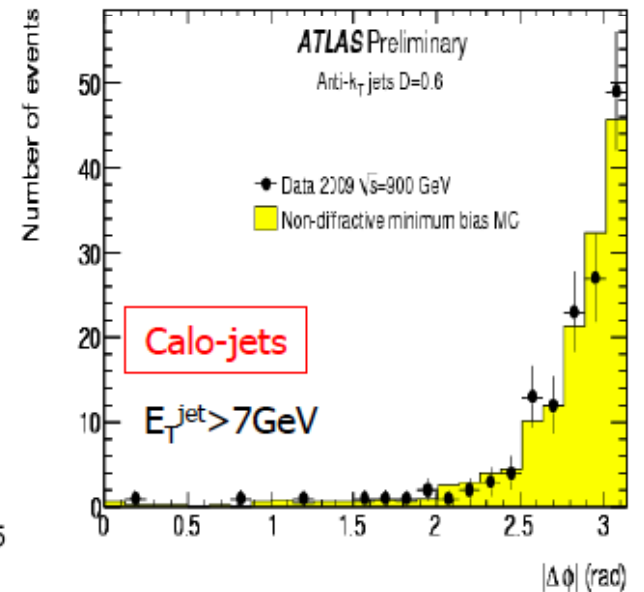
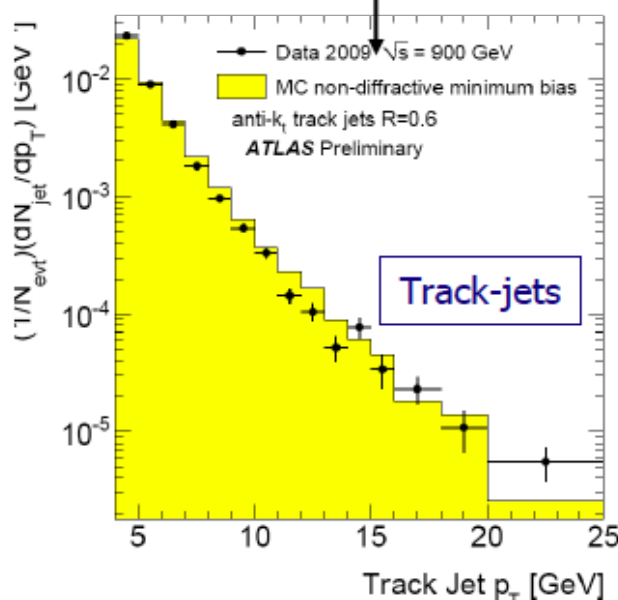
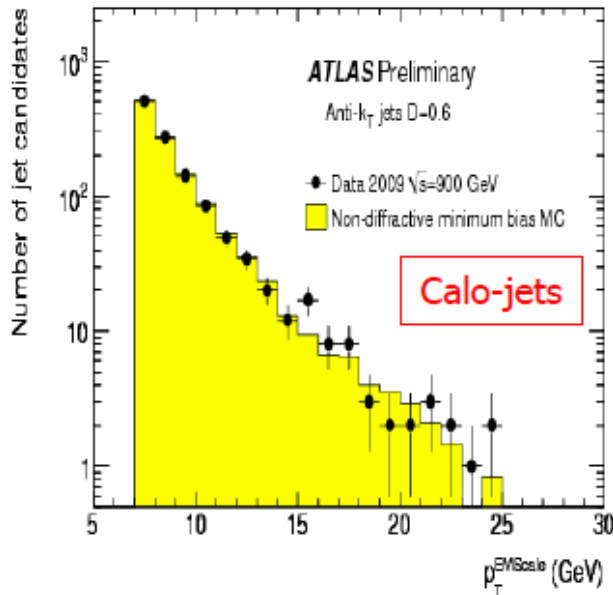


E/p(pions): excellent simulation of calo response

- Promising for jet energy calibration
- Years of test beams and tuning of simulation

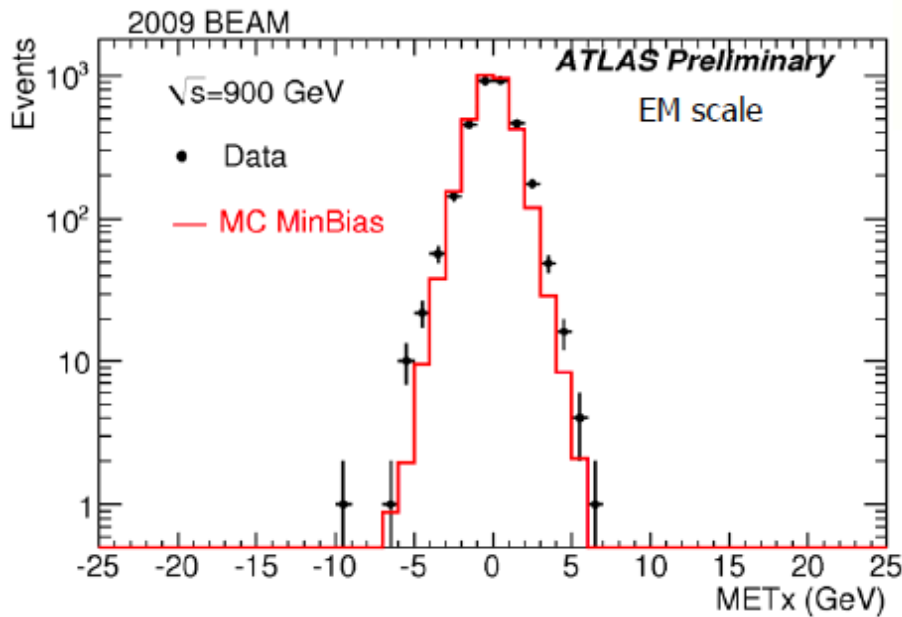
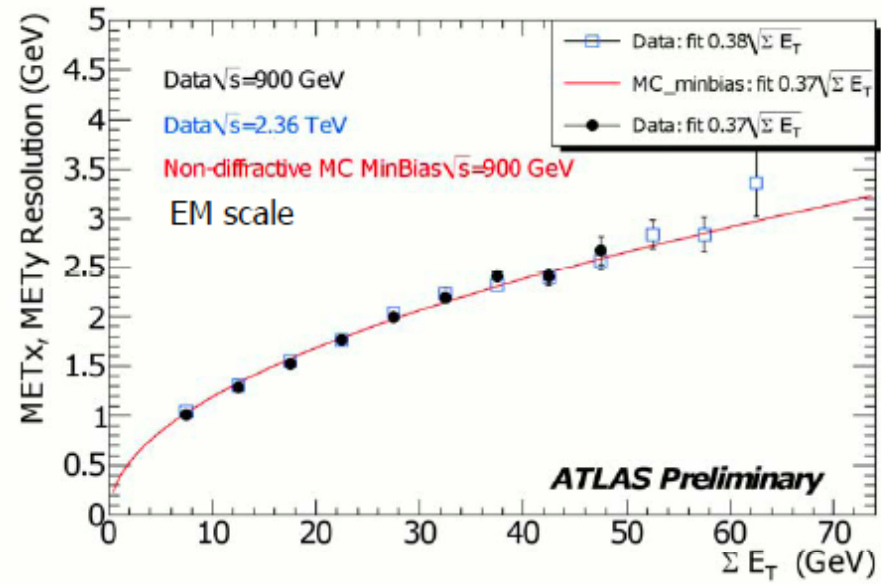
Hadronic jet reconstruction: Good agreement

- p_T spectrum of calo- and track-jets (different syst.)
- $\Delta\phi$ distribution (sensitive to soft QCD radiation)



Missing E_T Performance

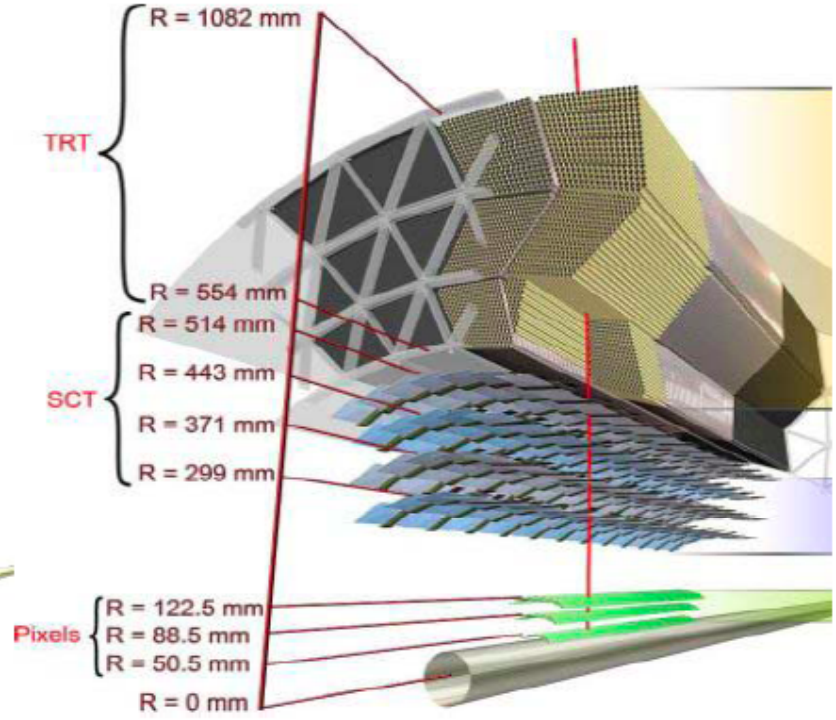
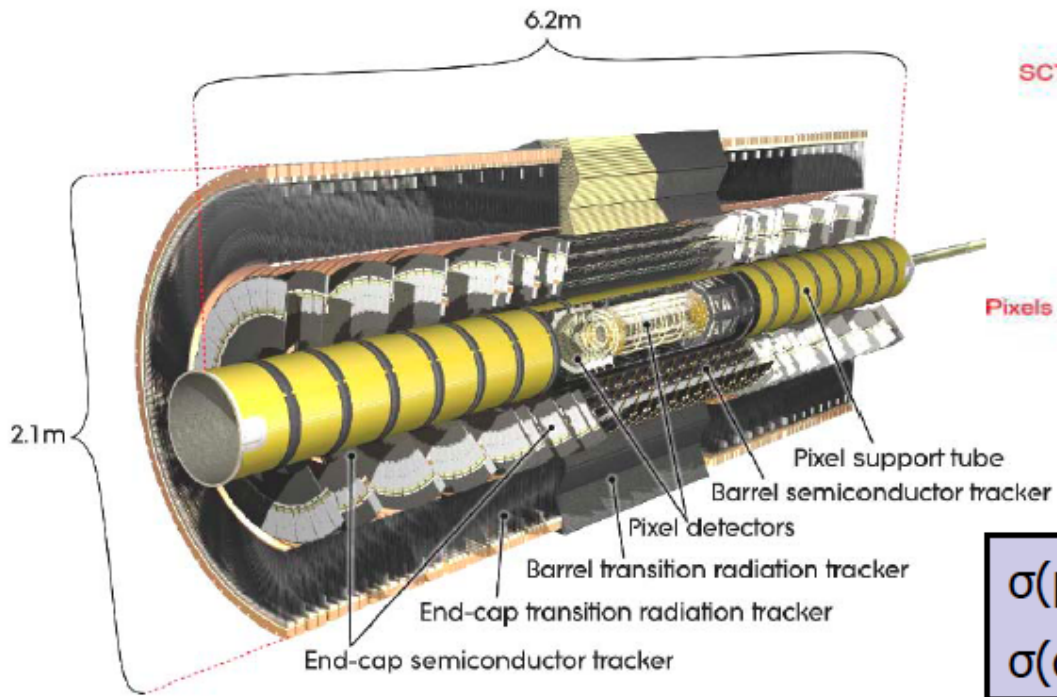
Missing E_T gaussian resolution:
 Excellent agreement up-to available total deposited $E_T \sim 60$ GeV



Missing E_T component:
 Good description, no large tails

Inner Detector

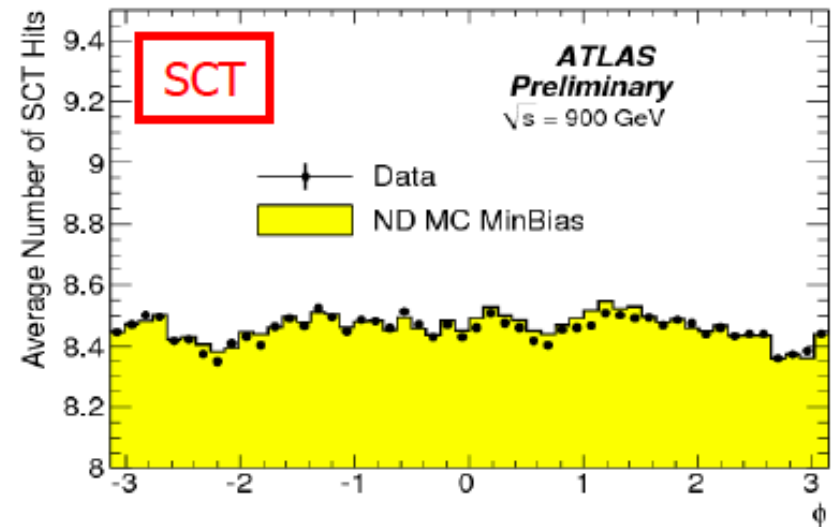
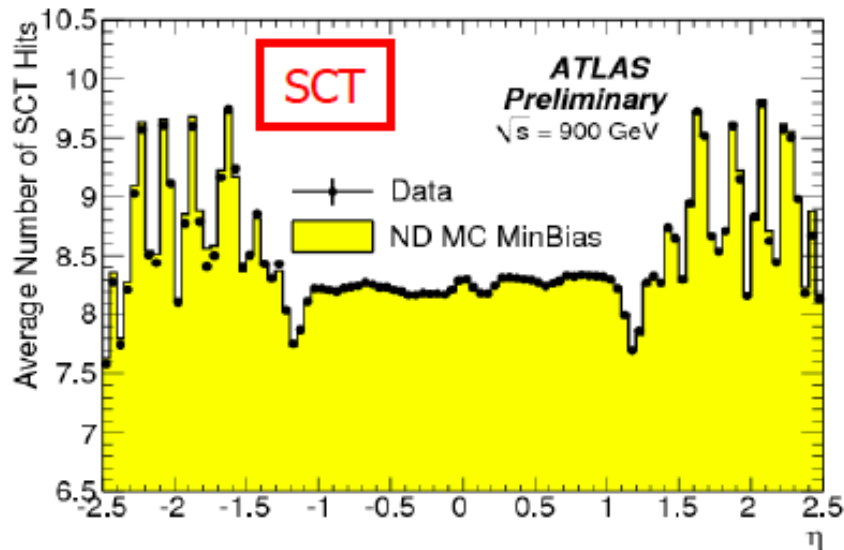
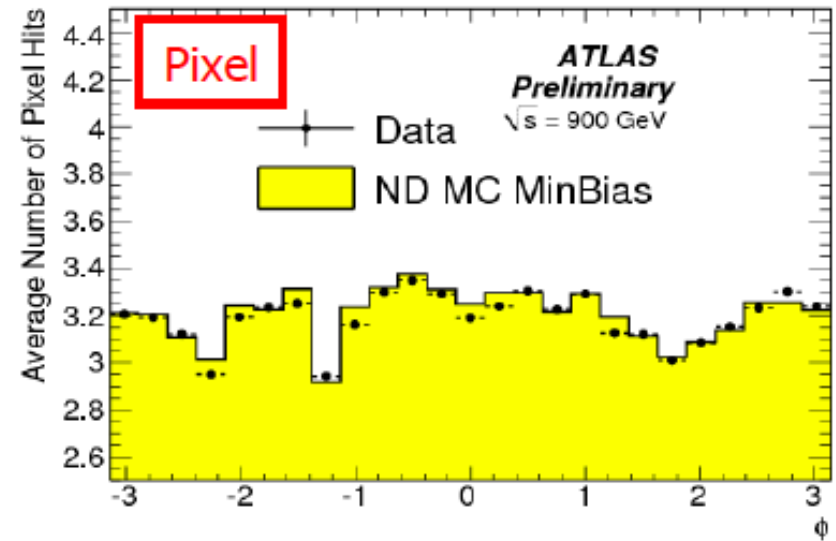
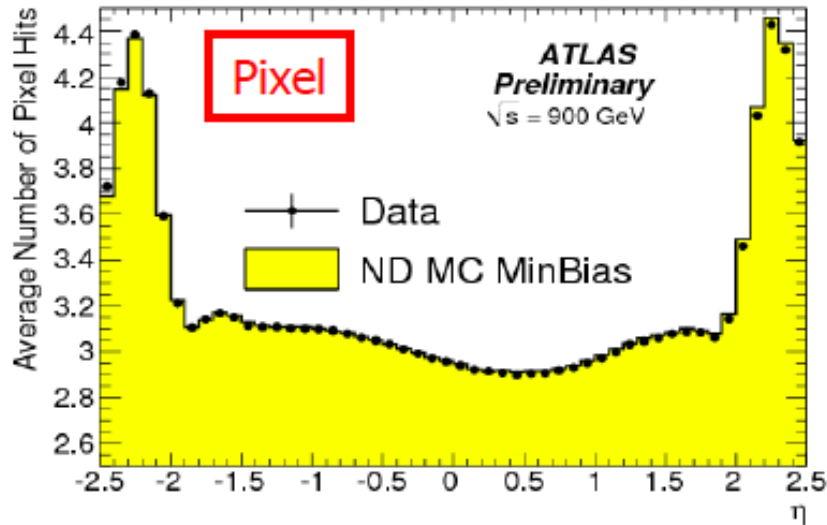
Purpose: charged-particle tracking, particle ID
 Coverage: $|\eta| < 2.5$
 Embedded in 2T solenoidal field



$$\sigma(p_T)/p_T \sim 3.4 \times 10^{-4} x (p_T/\text{GeV}) \oplus 0.015$$

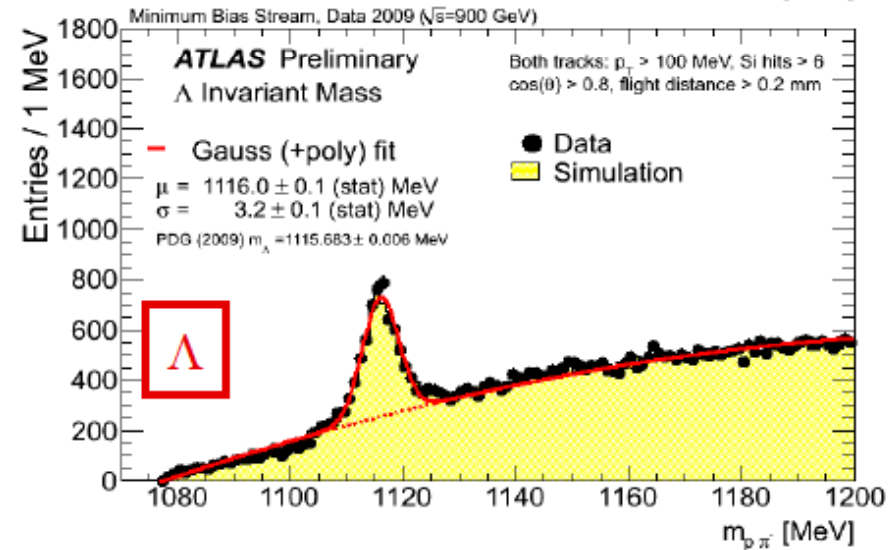
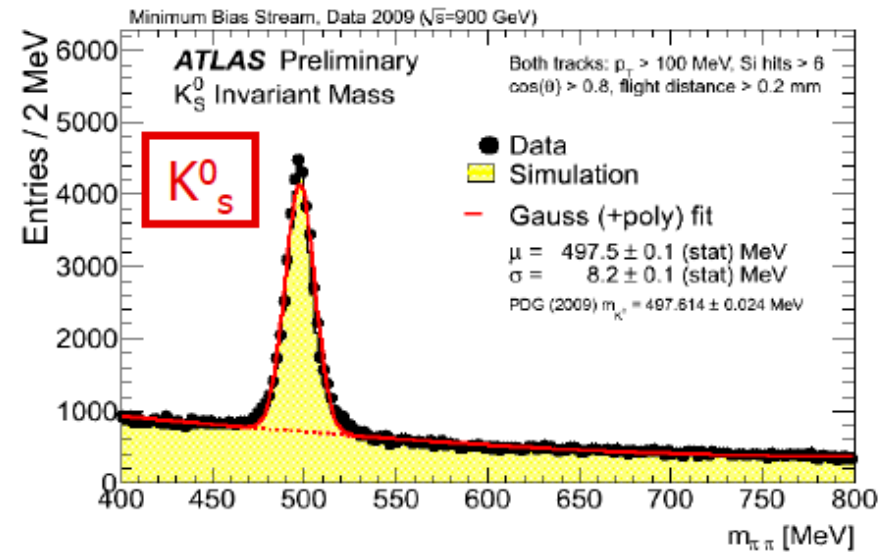
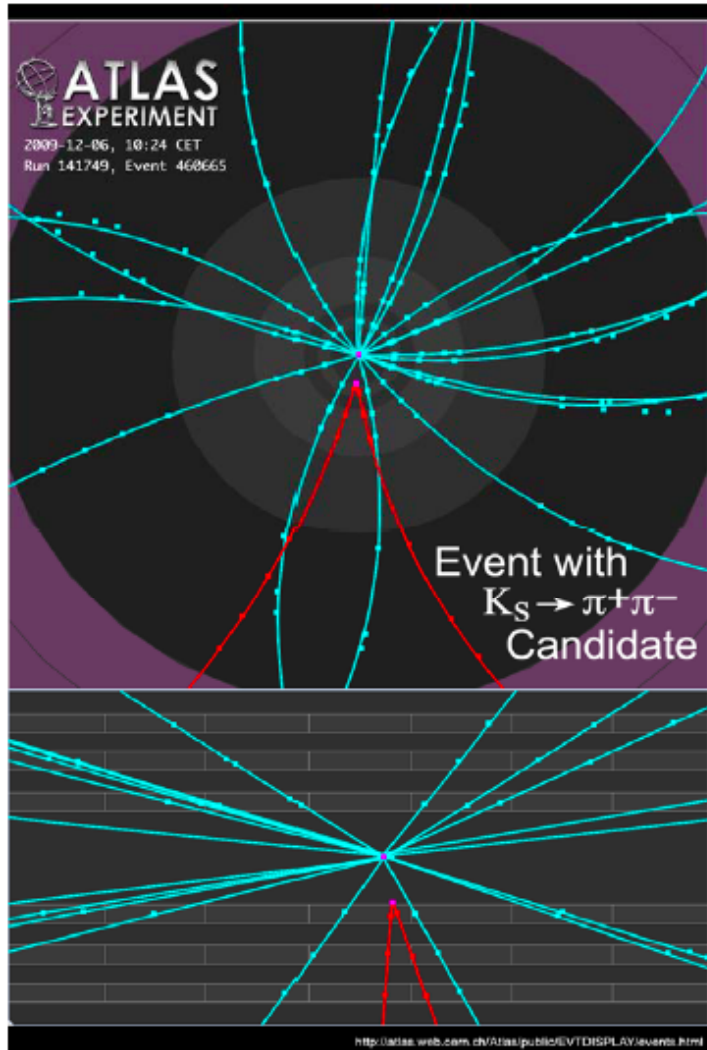
$$\sigma(d_0) \sim 10 \oplus 140/(p_T/\text{GeV}) \mu\text{m}$$

Number of Hits on Track



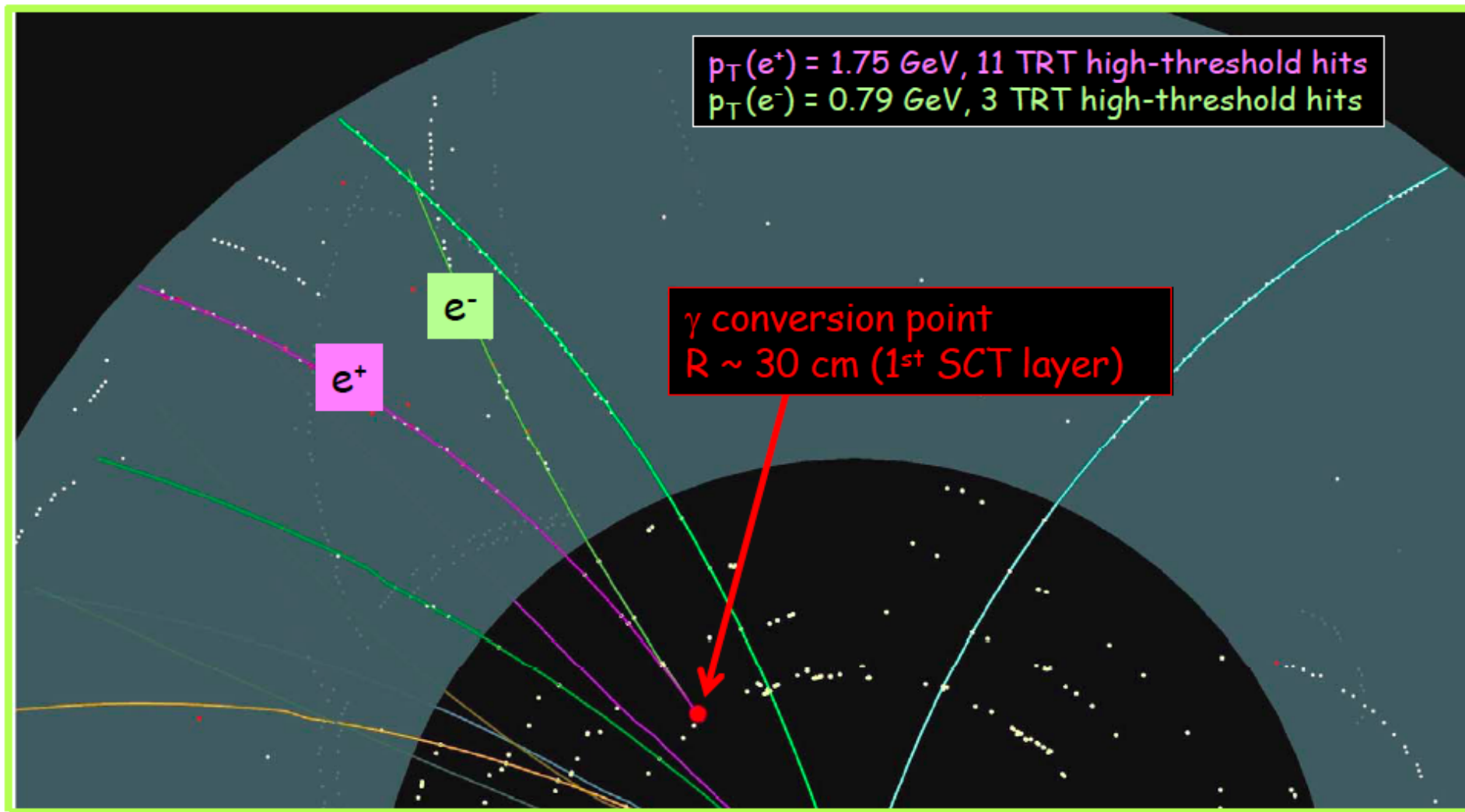
Sensitive to MC description of geometry, material, beamspot, dead modules → **excellent agreement**

Inner Detector Performance: K_S^0 & Λ

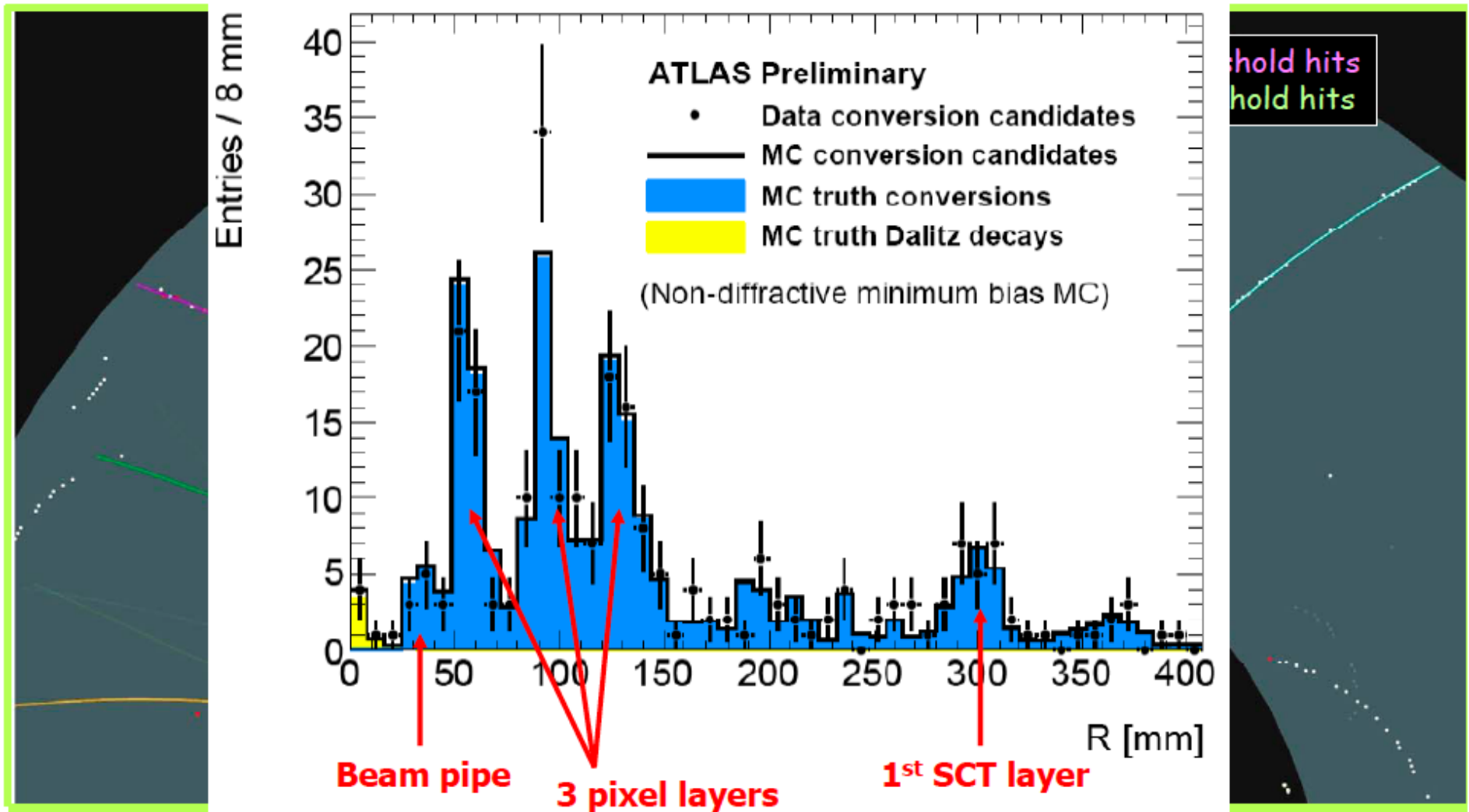


Test of vertexing, momentum scale and resolution \rightarrow excellent agreement

Conversion Reconstruction

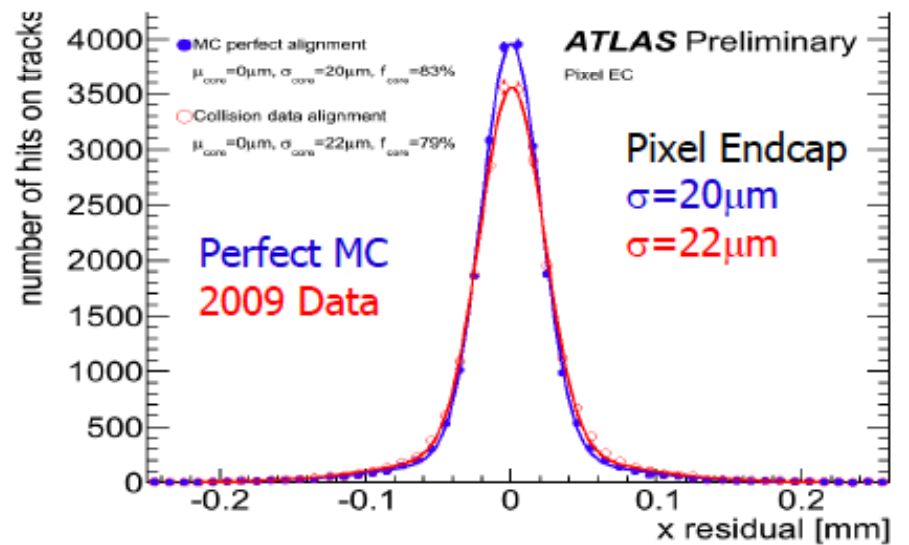
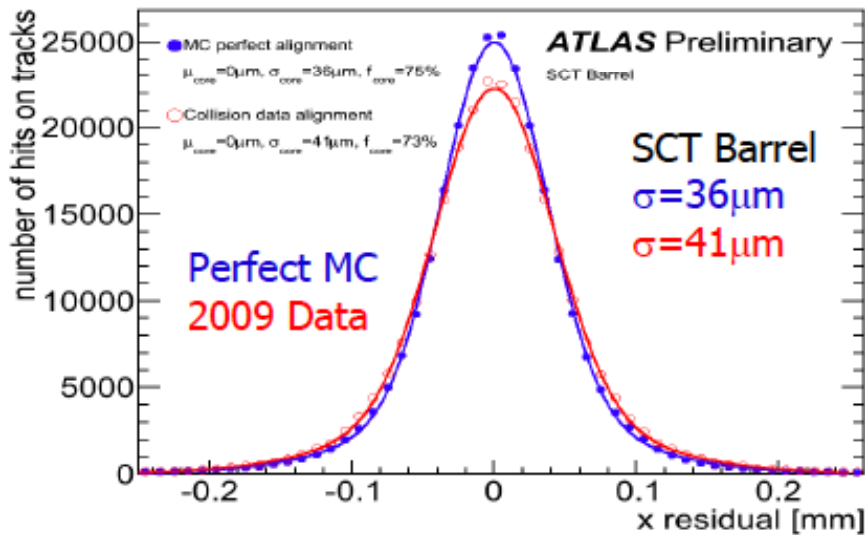
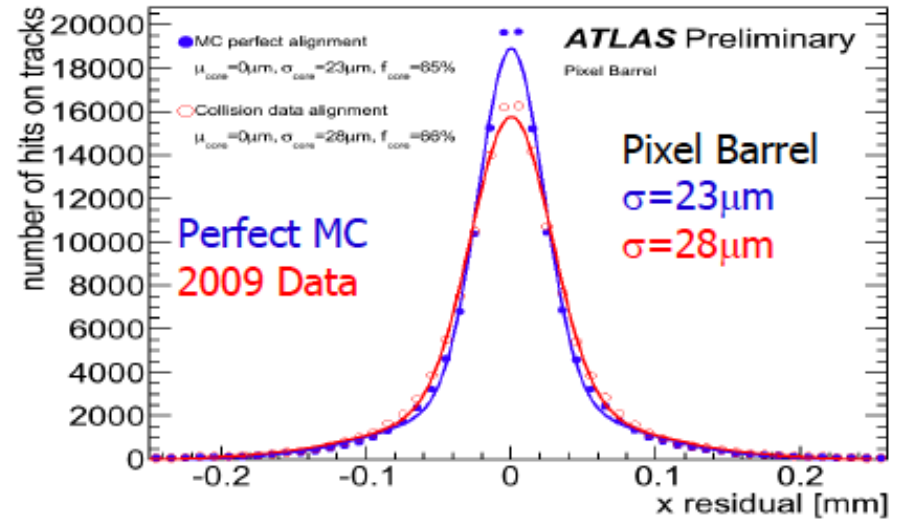
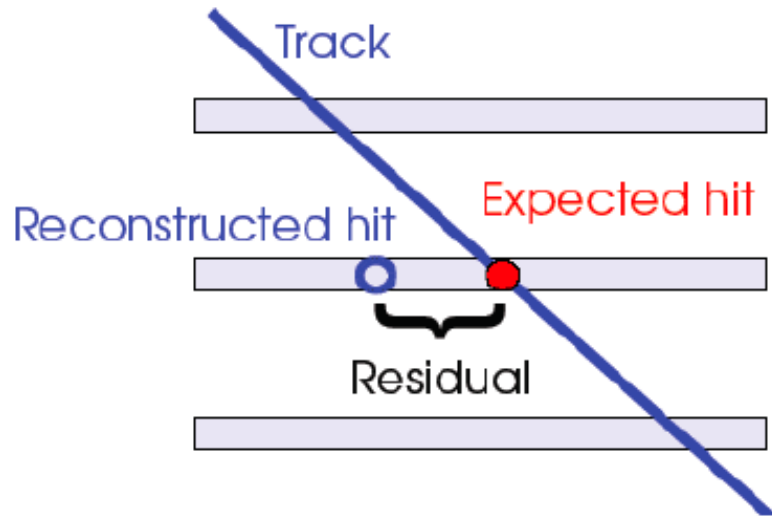


Conversion Reconstruction



Validation of MC material description → crucial for tracking efficiency

Inner Detector Alignment: Track Residual



Detector resolutions already close to ideal simulation

First Collider Physics Result: Charged-Particle Multiplicity

Motivation: constrains soft QCD models (underlying event "tunes")

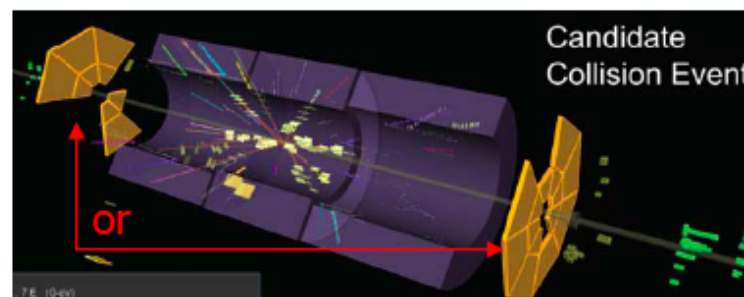
→ **important for high- p_T physics measurements!**

What we measure: inclusive inelastic distributions of charged-particles with $p_T > 0.5$ GeV, $|\eta| < 2.5$

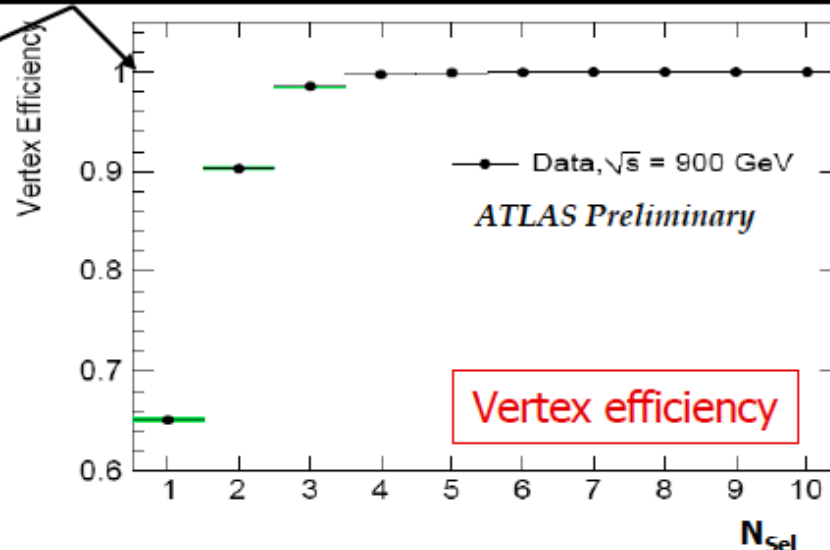
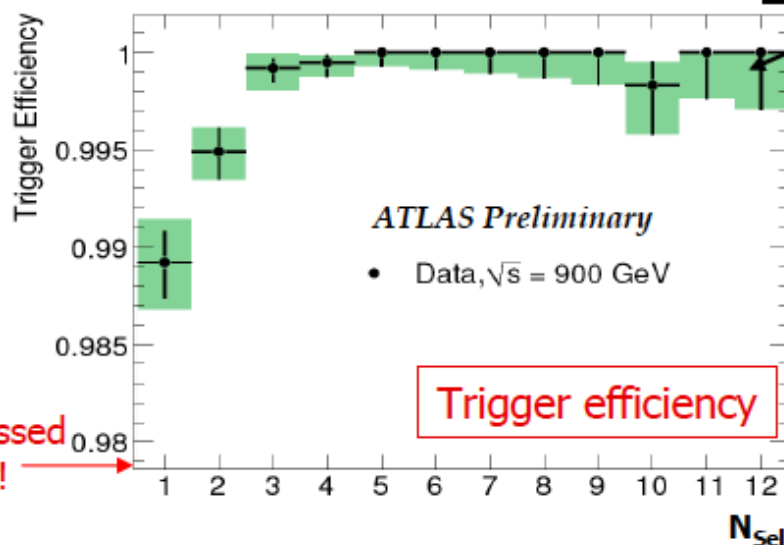
Note: we do not attempt to extrapolate outside our phase space (avoid model dependence)

Event selection:

- One-arm MBTS trigger
 - Reconstructed primary vertex
 - ≥ 1 track with $p_T > 0.5$ GeV, $|\eta| < 2.5$
 - $|d_0| < 1.5$ mm, $|z_0| \sin\theta < 1.5$ mm
- Sample of ≈ 326 k events



Extract **corrections** for detector inefficiencies

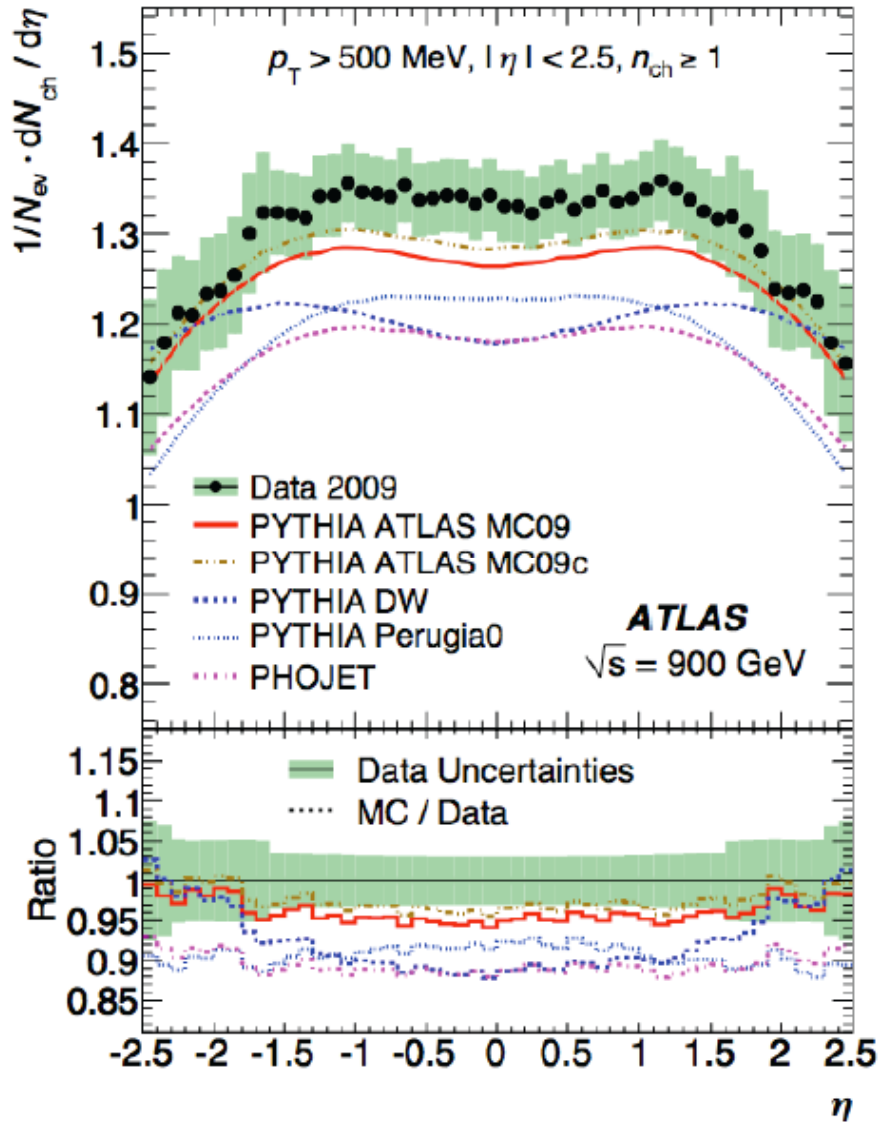


Note:
suppressed
y-scale!

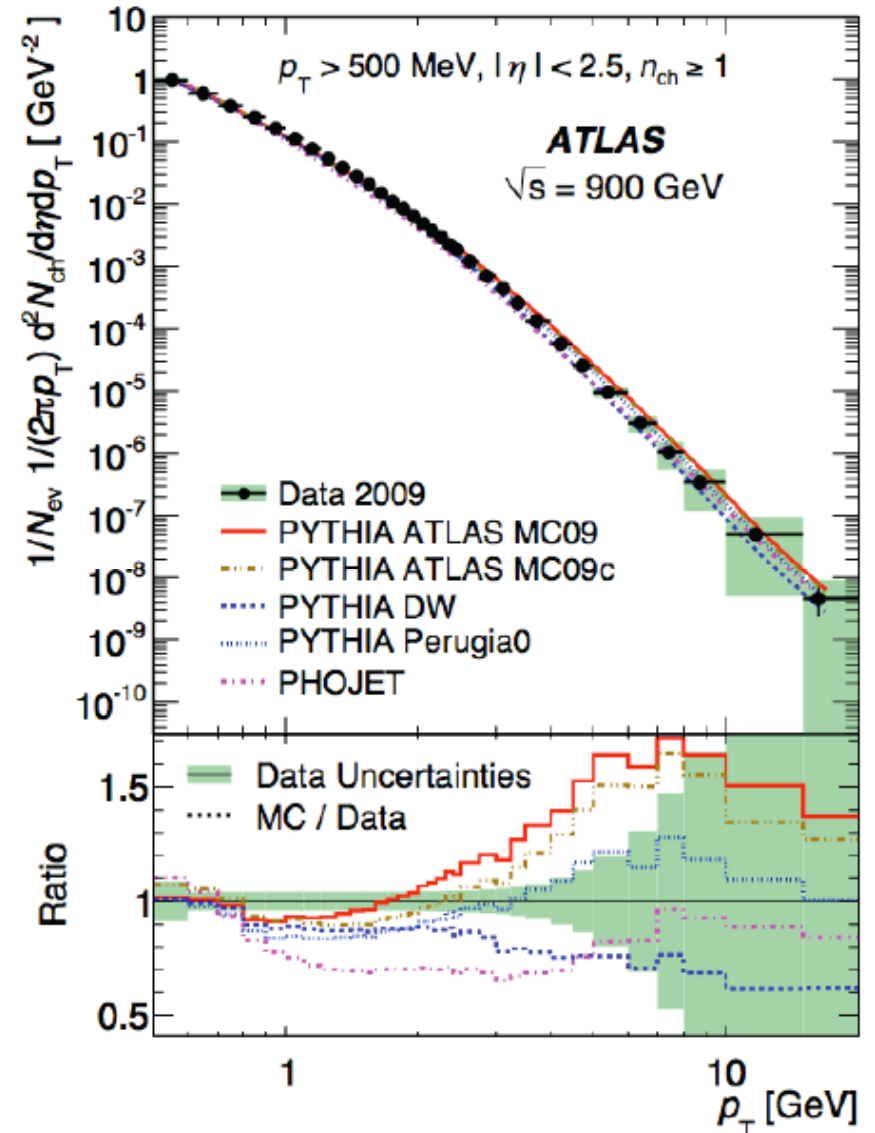
Systematic Uncertainties

Systematic uncertainty on the number of events, N_{ev}	
Trigger efficiency	$< 0.1\%$
Vertex-reconstruction efficiency	$< 0.1\%$
Track-reconstruction efficiency	1.1%
Different MC tunes	0.4%
Total uncertainty on N_{ev}	1.2%
Systematic uncertainty on $(1/N_{ev}) \cdot (dN_{ch}/d\eta)$ at $\eta = 0$	
Track-reconstruction efficiency	4.0%
Trigger and vertex efficiency	$< 0.1\%$
Secondary fraction	0.1%
Total uncertainty on N_{ev}	-1.2%
Total uncertainty on $(1/N_{ev}) \cdot (dN_{ch}/d\eta)$ at $\eta = 0$	2.8%

$$dN_{ch}/d\eta$$

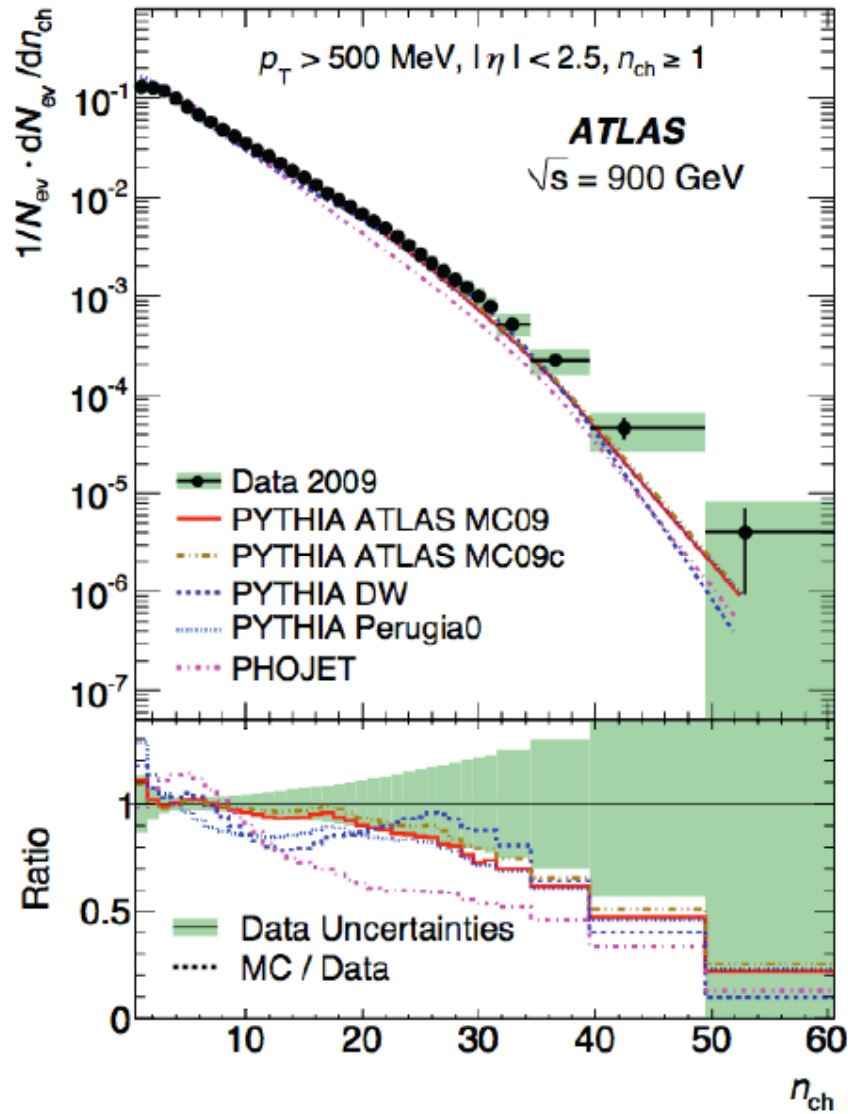


$$1/p_T dN_{ch}/dp_T$$

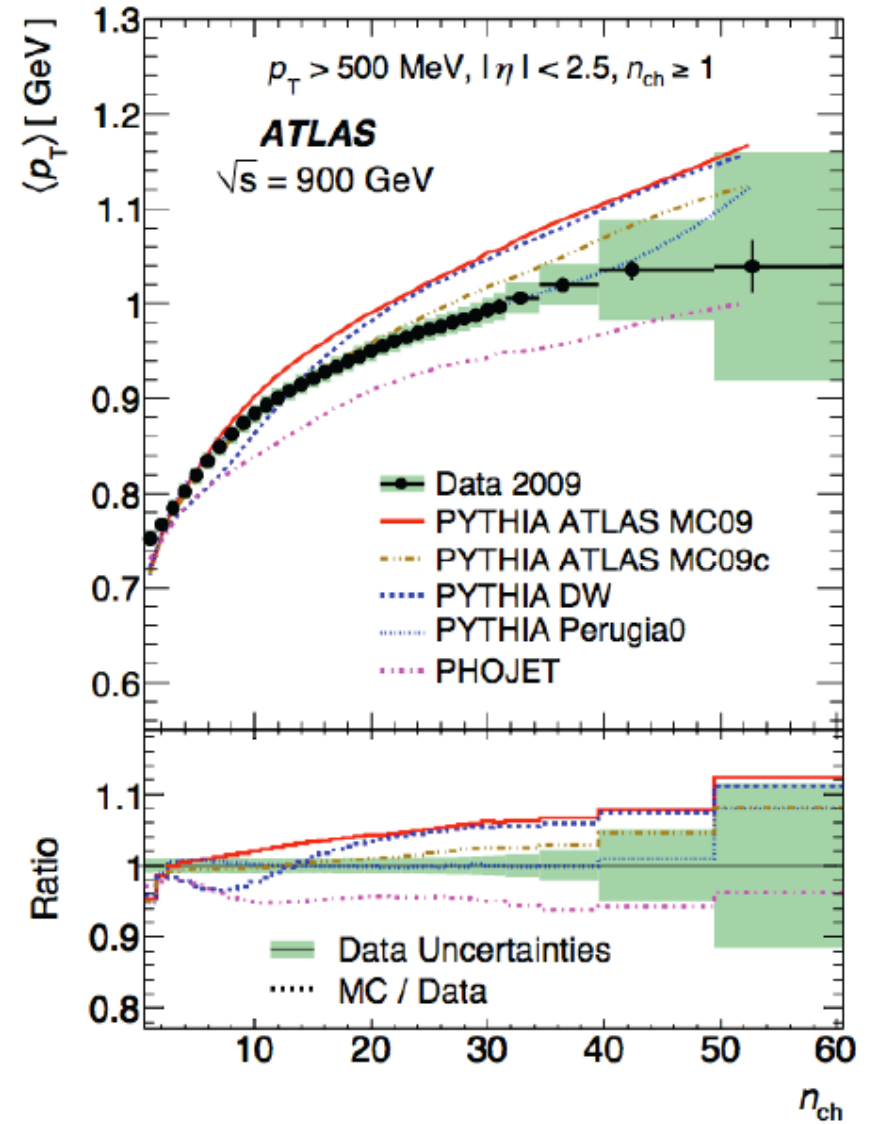


data is 5-15% (1-4 σ) above MC Workshop IX - Johannesburg

$$dN_{ev}/dn_{ch}$$

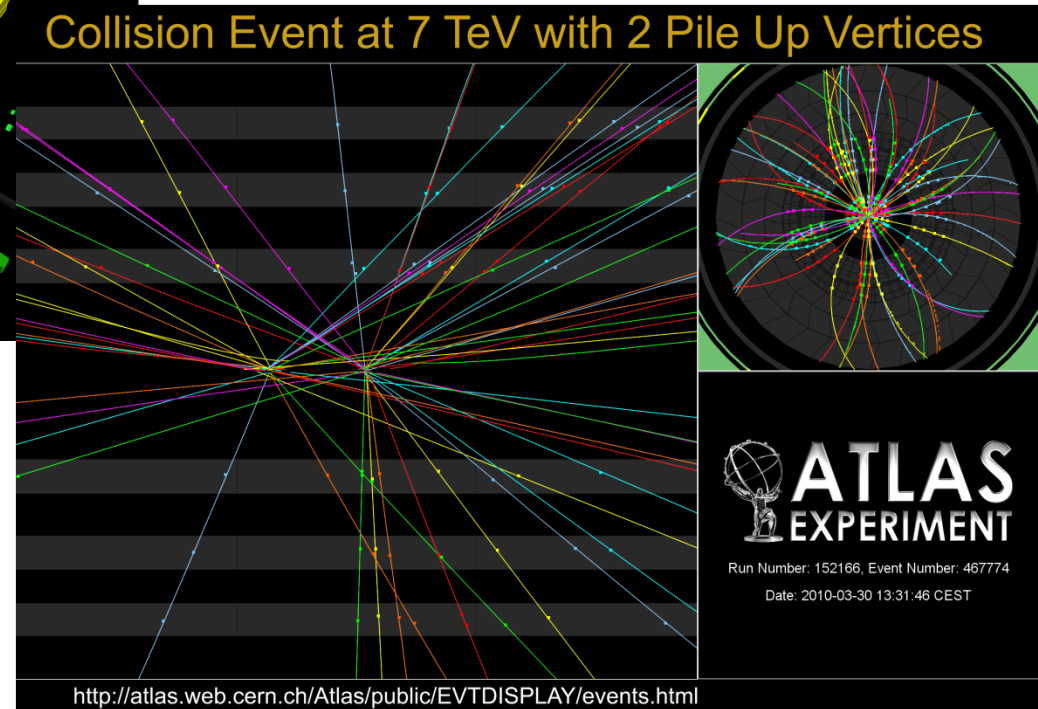
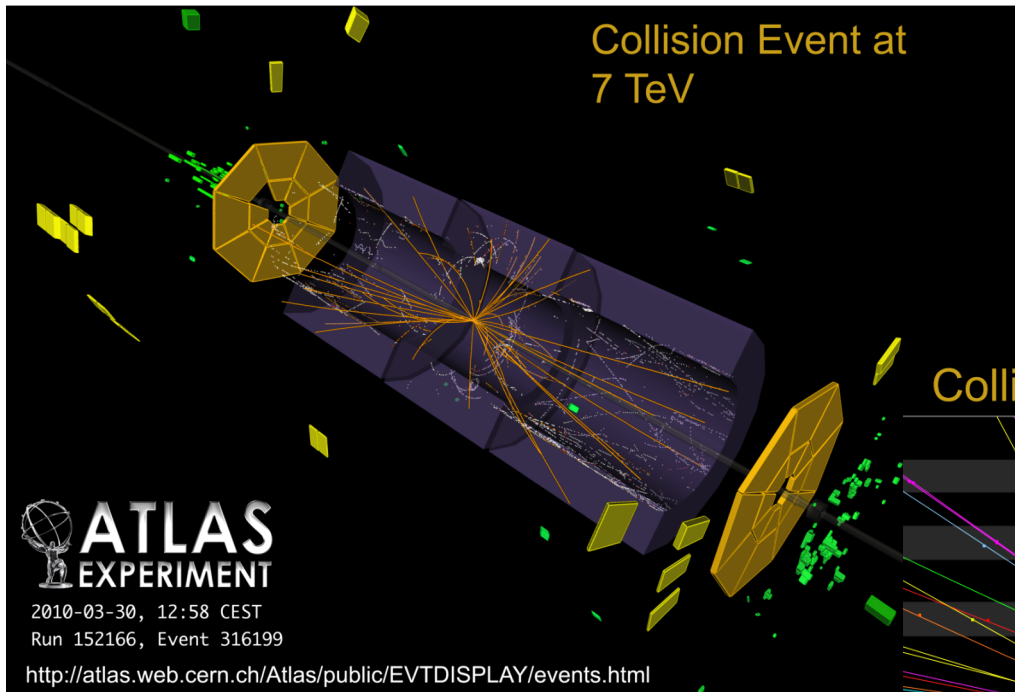


$$\langle p_T \rangle \text{ vs } n_{ch}$$



7 TeV Collision Events!

Started just 1 week ago today



Prospects for Physics at $E_{\text{cm}} = 7 \text{ TeV}$ (1 fb^{-1})

Expected Number of Standard Model Events (After Selections)

Process	Number Events
$W^{\pm} \rightarrow l^{\pm} \nu$	4M
$Z^0 \rightarrow l^+ l^-$	400k
ttbar l+jets	6000
ttbar dilepton	2500

Samples comparable or larger than Tevatron!

- Commissioning of the detector
- Tests of the Standard Model

Significant discovery potential

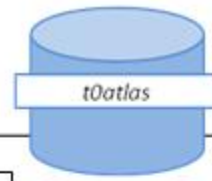
- Ex. 1: Supersymmetry $\rightarrow 5\sigma$ discovery above current Tevatron limit with a few hundred of pb^{-1}
- Ex. 2: Can discover up-to $\sim 1.5 \text{ TeV}$ $Z' \rightarrow \mu\mu$
- Ex. 3: 3σ evidence for SM Higgs in mass range $\sim 145\text{-}180 \text{ GeV}$

LHC Schedule

- A bit like crystal ball gazing...
- 7 TeV data taking has started!
- Detailed luminosity profile not known (need running experience), but near term schedule
 - 2010: run at low luminosity (7 TeV), “technical stop” over Christmas break
 - 2011: run through the fall (7 TeV), goal is 1 fb⁻¹ integrated
 - 2012: yearlong shutdown to affect repairs to allow ~14 TeV
 - 2013: start running at ~14 TeV
 - Beyond: not defined, hopefully some clarity on June timescale, although many think that is optimistic

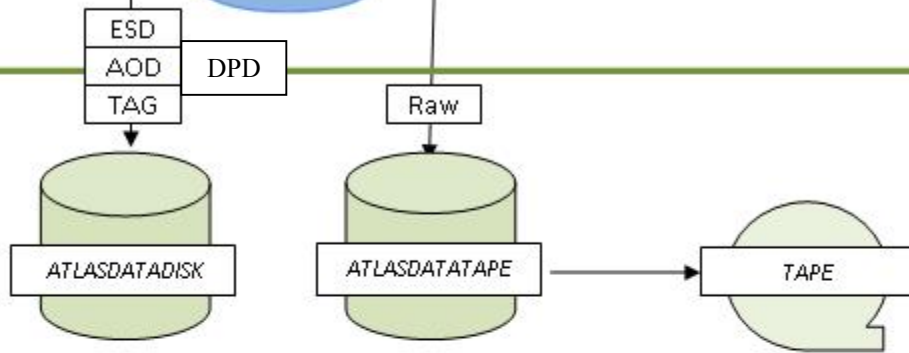
ATLAS Computing Model

Tier-0



Tier-1

DPD = dESD/dAOD

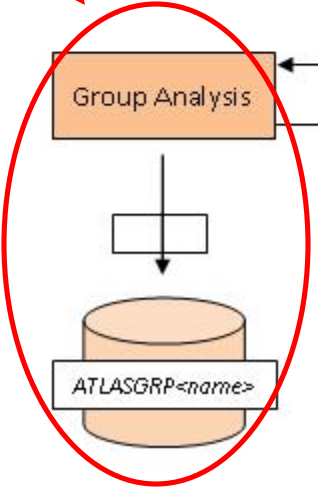


analysis focus

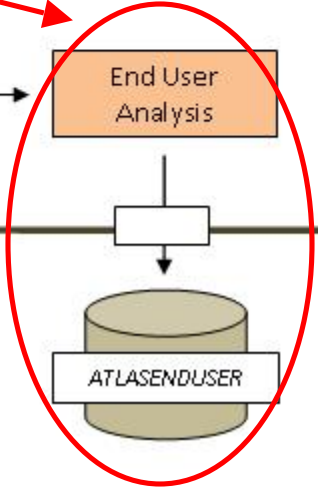
Note that user analysis on T1 **not** part of Computing Model



Tier-2



expect different for early data (i.e. ESDs @ T2)



Tier-3

Expected analysis patterns for early data

Assume bulk of user activity will happen on T2s and T3s
(if available, define user accessible area of T1 as a T3)

Assume final stage of analysis (plots) happens on T3s (T2s are not interactive)

Two primary modes:

- (1) user/group runs job on T2s to make reduced dataset (usually ntuple)
(potential inputs: ESD,dESD, AOD, dAOD)
reduced dataset is then transferred to user's T3 for further analysis
- (2) user/group copies input files to user's T3 (potential inputs: ESD,dESD,AOD,dAOD)
On T3 user/group either generates reduced dataset for further analysis or
performs final analysis on input data set

Choice depends strongly on capabilities of T3, size of input data sets, etc.