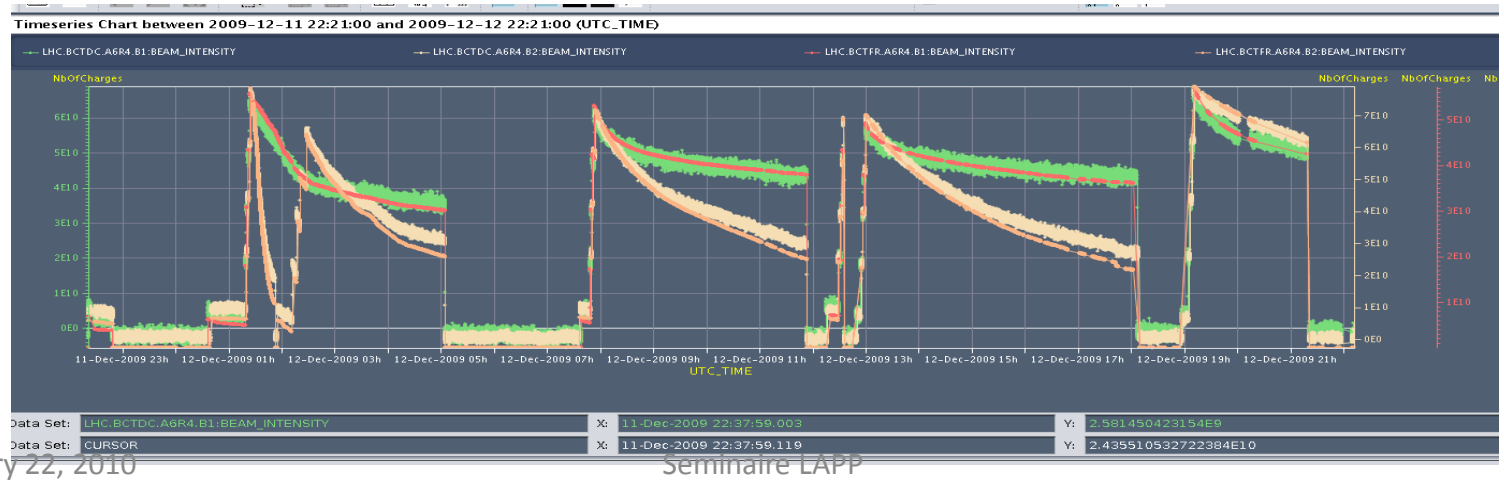
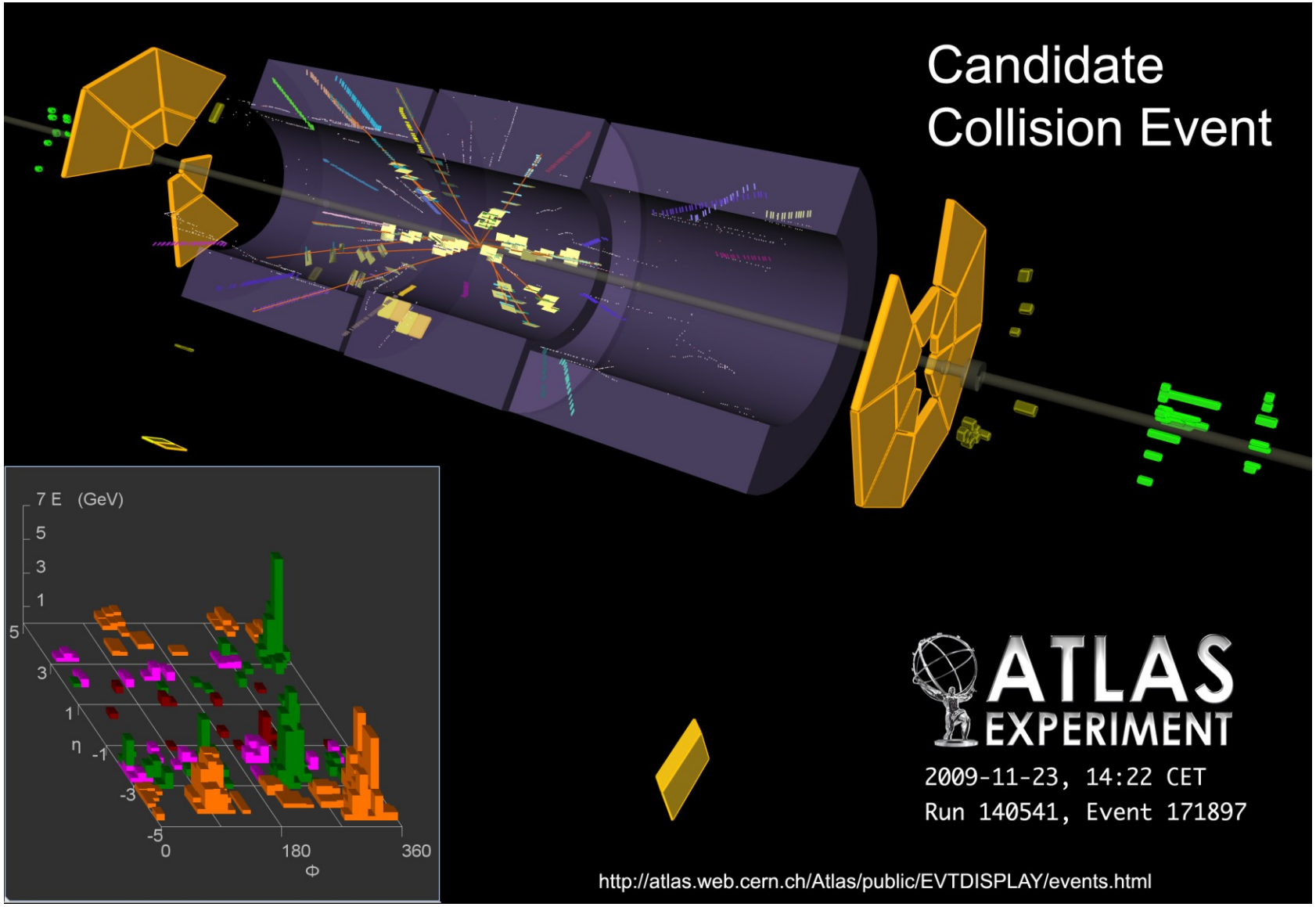
LHC milestones

Summary of an exciting month after… months for repairing and consolidation

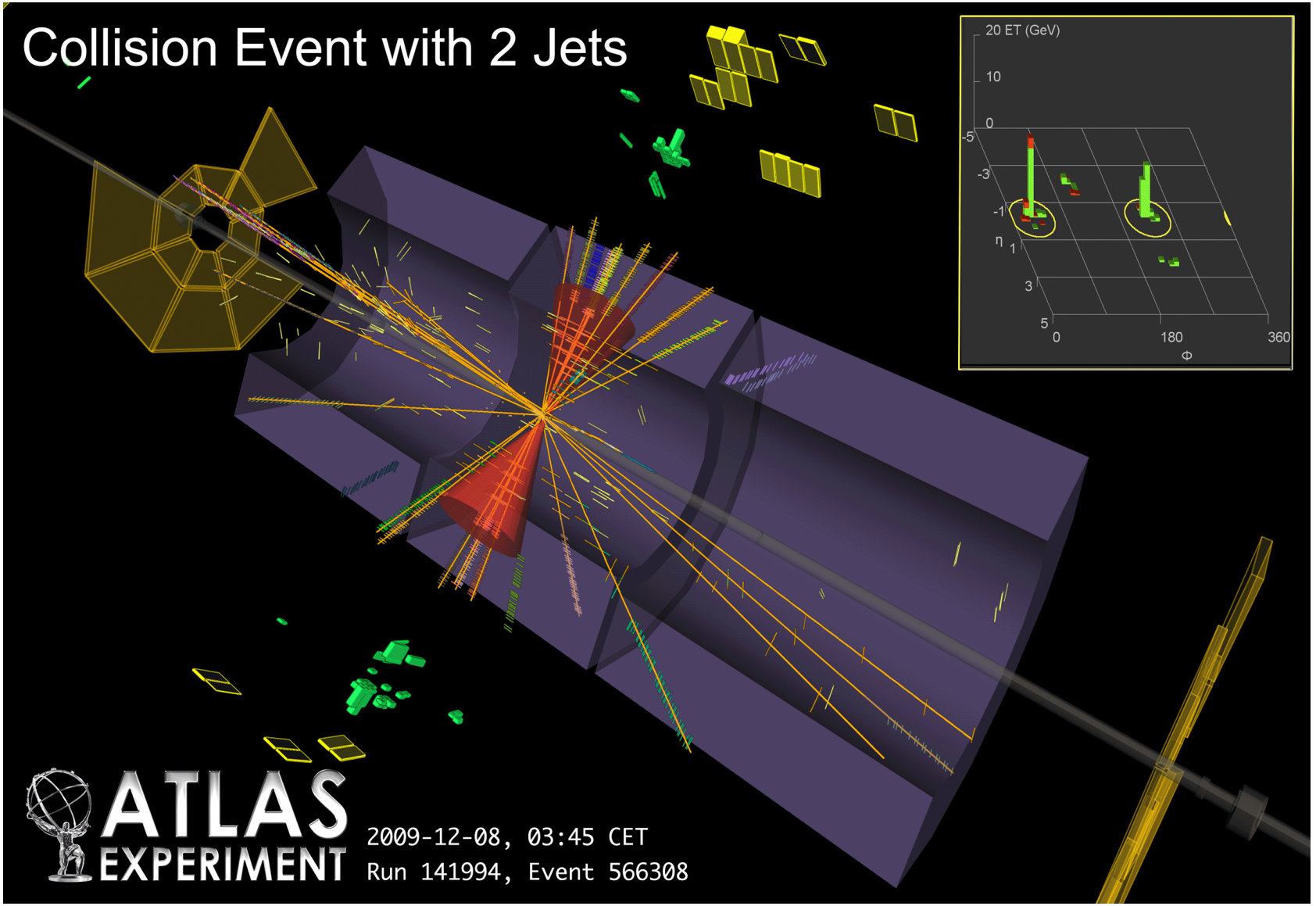
- Nov. 20 2009: First ‘splash’ event in ATLAS
- Nov. 23 2009: First collisions at 450+450 GeV; first ramp up to 560 GeV
- Nov. 29 2009: Ramp to 1.18 TeV
- Nov. 30 2009: Experiments solenoids ON
- Dec. 06 2009: First collisions with stable beams, 4x4 bunches at 450+450 GeV
- Dec. 11 2009: Protons per colliding bunch up to >10^{10}
- Dec. 13 2009: Collisions with 2 bunches per beam at 1.18+1.18 TeV
- Dec. 14 2009: Collisions with 16 bunches per beam at 450+450 GeV
- Dec. 16 2009: Ramp 4 bunches per beam to 1.18 TeV
- Dec. 16 2009: LHC shut-down



The first collision candidate at 900 GeV (Nov. 23rd)

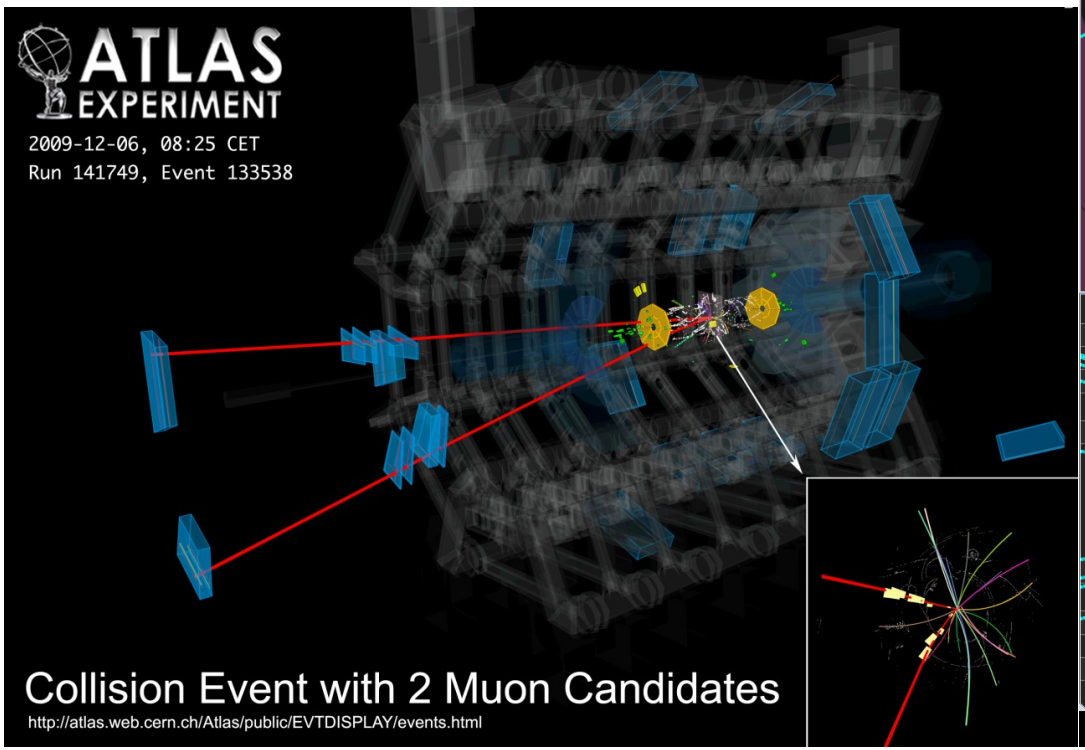


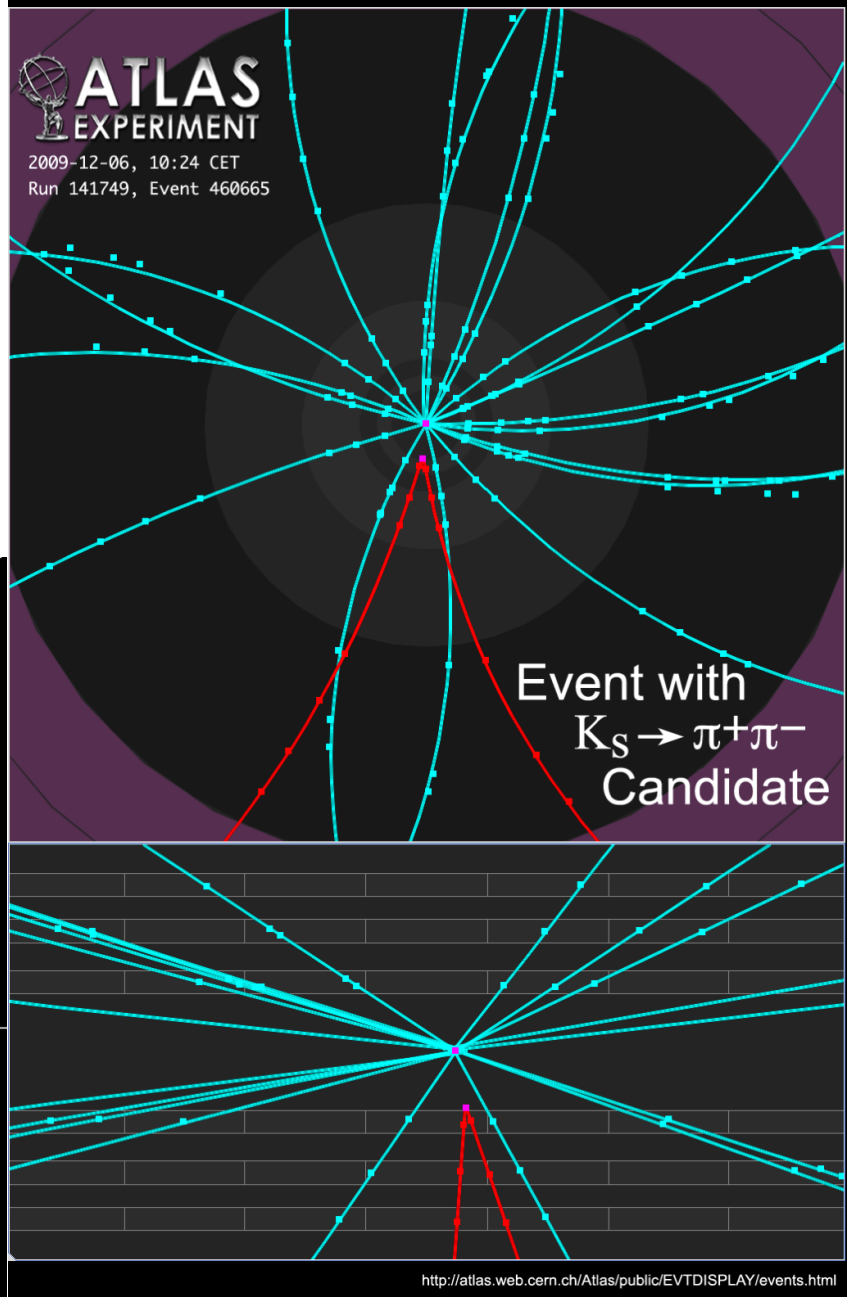
Two jet event at 2.36 TeV (Dec. 8th)



Two more events

- $K_s \rightarrow \pi^+\pi^-$
- Dimuon event





ATLAS detector during 2009 collisions

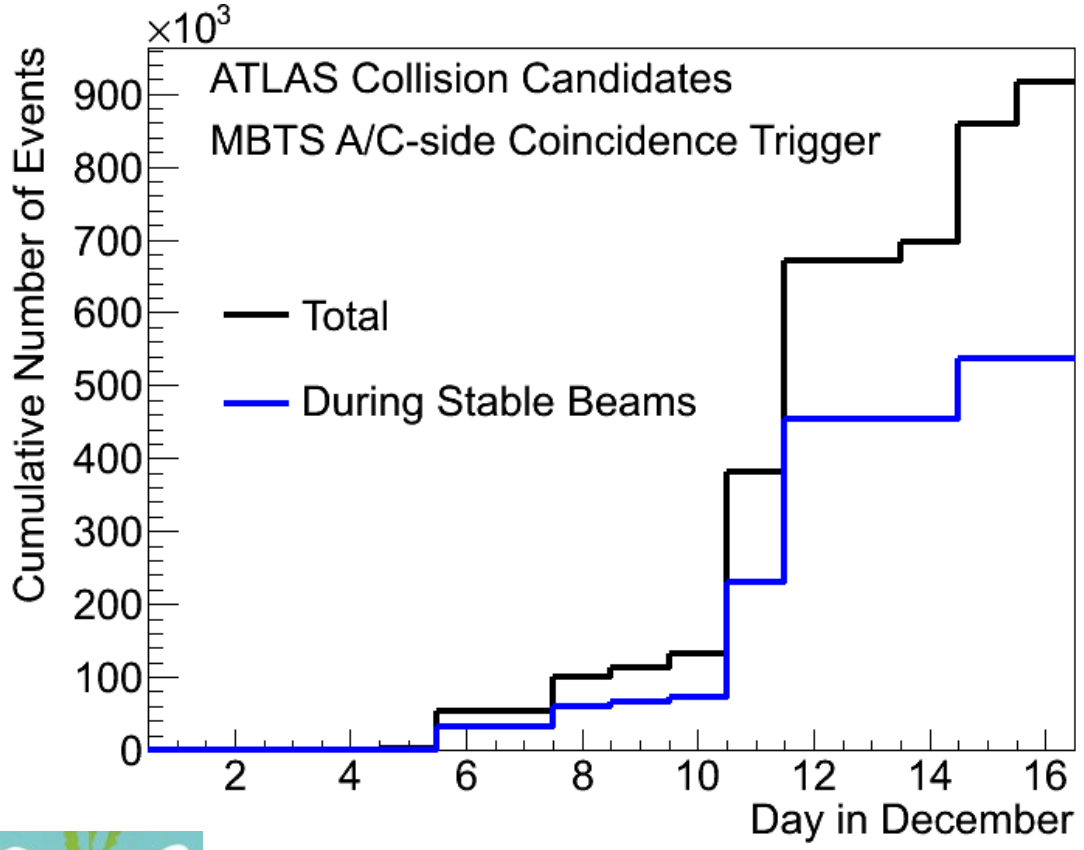
Subdetector	Number of Channels	Operational Fraction
Pixels	80 M	97.9%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	98.2%
LAr EM Calorimeter	170 k	98.8%
Tile calorimeter	9800	99.2%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
MDT Muon Drift Tubes	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%

- All sub-detectors in good health
- LAr almost fully operational
- Precautions were taken to avoid damages during the first operations
- Inner Detector HV on only during stable beam periods (flag from LHC)
- Human power (cosmics/splash/collisions):
  - > 20 shifters 24/7
  - 8 run coordinators
  - > 50 on-call experts

Events collected in 2009

- Total collision candidates: 917K
- Collision candidates with stable beam: 538K
- Collision candidates at 2.36 TeV: 34K

- Total integrated luminosity in 2009: 20 μb^{-1}
- Integrated luminosity with stable beam: 12 μb^{-1}
- Max luminosity in ATLAS ~$7 \cdot 10^{26}$ $cm^{-2}s^{-1}$

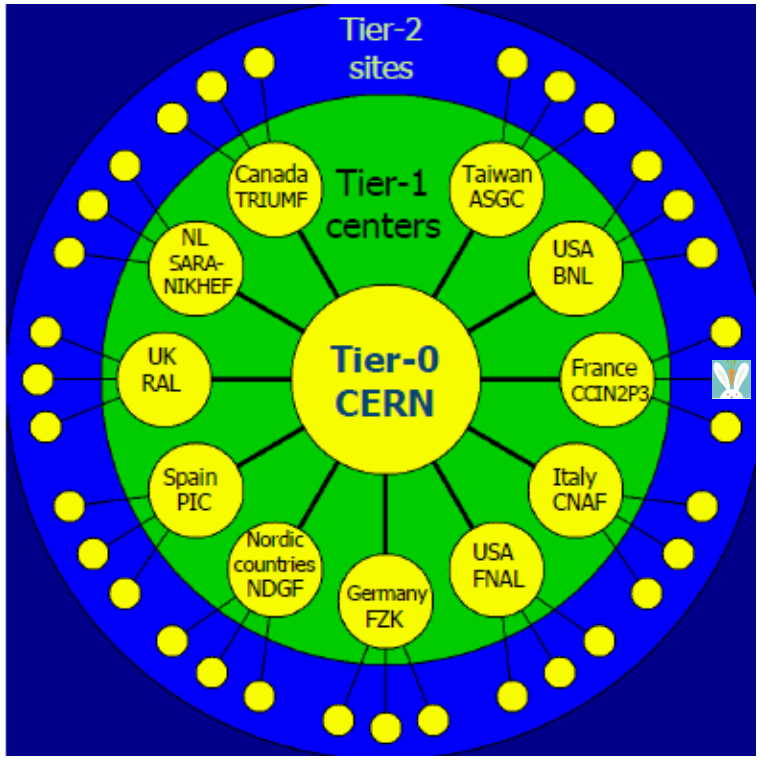


Average data taking efficiency ~90%

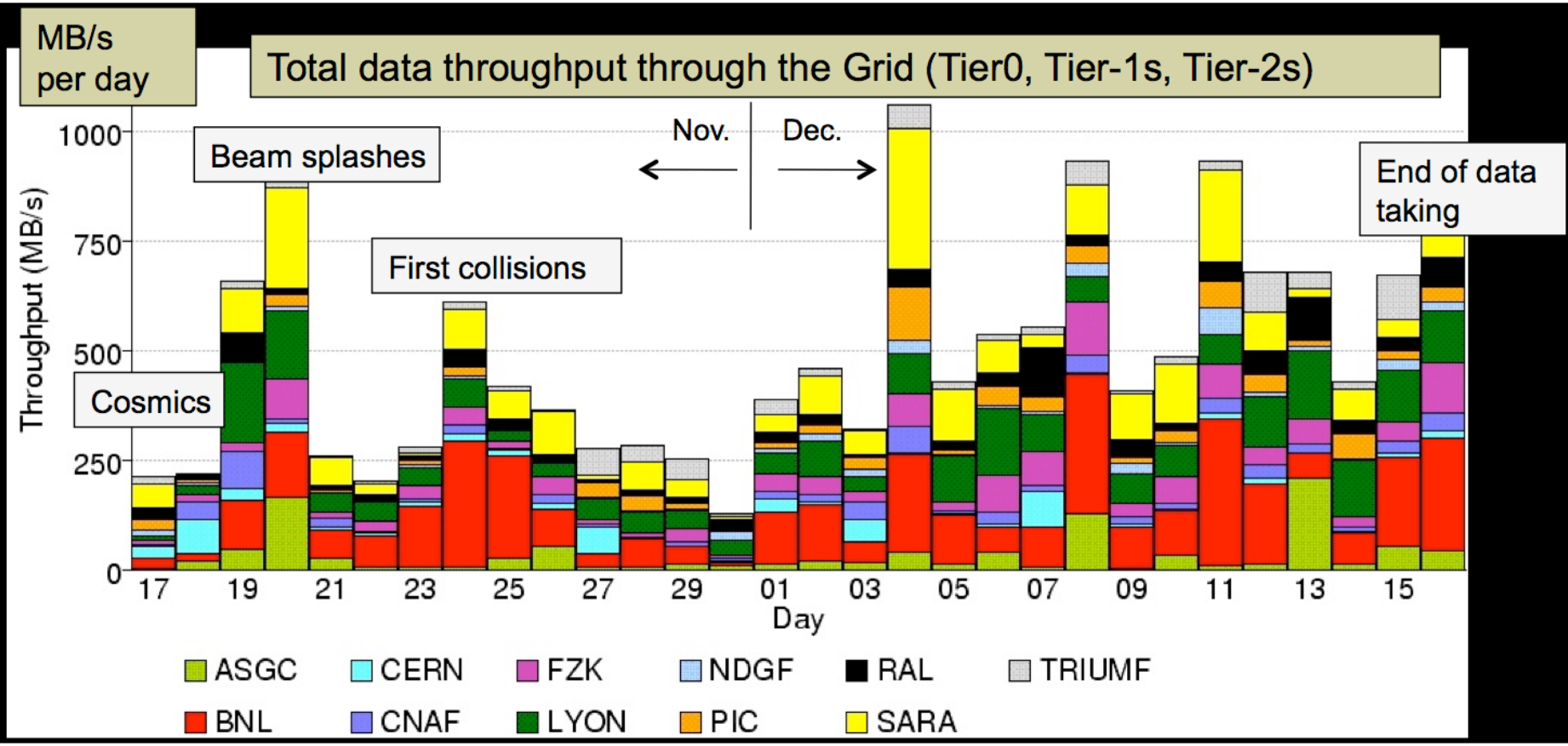
Not a single permanent busy from LAr read-out

ATLAS Computing Infrastructure

- Hierarchical organization:
  - 1 Tier-0 (CERN)
    - 11 Tier-1 (Lyon for IN2P3)
      - 38 Tier-2 centers (7 France - LAPP)
        - » Many Tier-3 (LAPP)
- LHC computing needs:
  - Storage:
    - 20 Pb/y on tape
    - 1 Pb/y on disk for analysis
  - Computing power: ~100000 PCs
  - Data accessibility from everywhere
- Use of LHC Computing Grid (LCG)
  - Distributed analysis



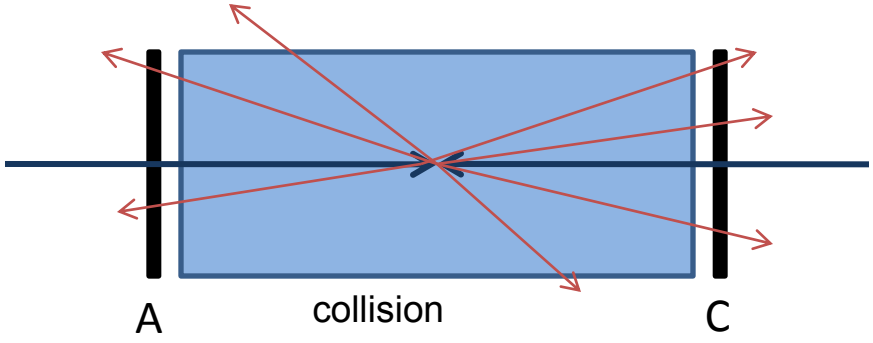
ATLAS Computing with data

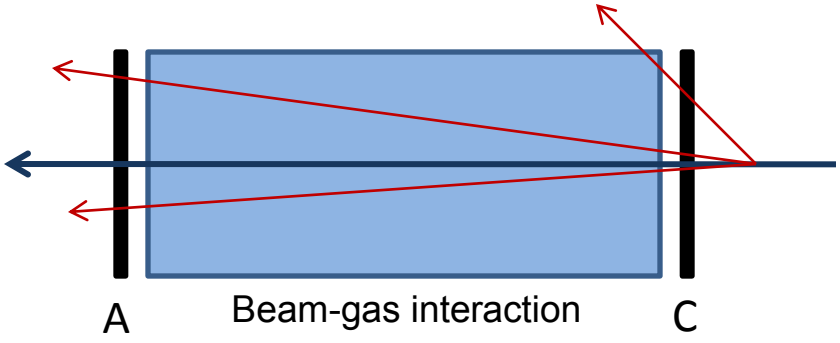


- 200 Tbytes data recorded
- Fast reconstruction at Tier-0
- Data sent to Tiers-2 for analysis within ~8h

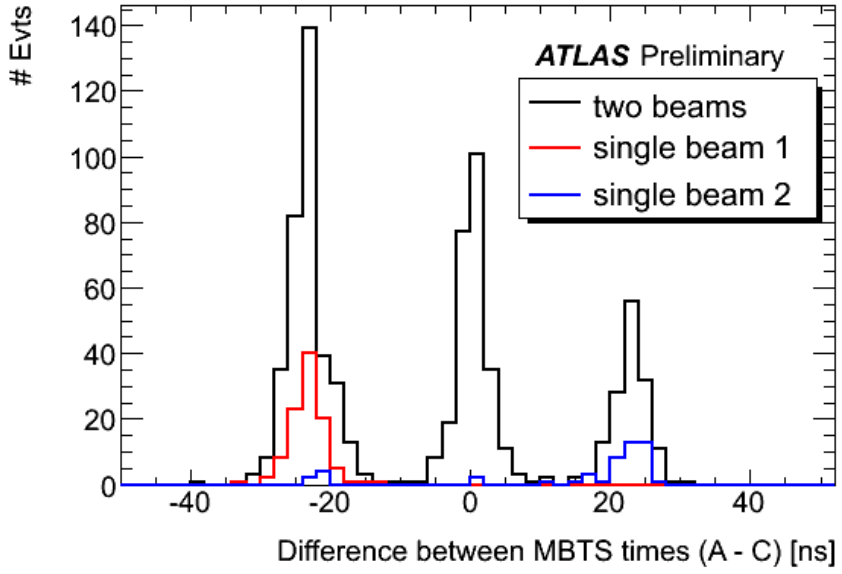
Collision candidates selection

Time difference between side A and C

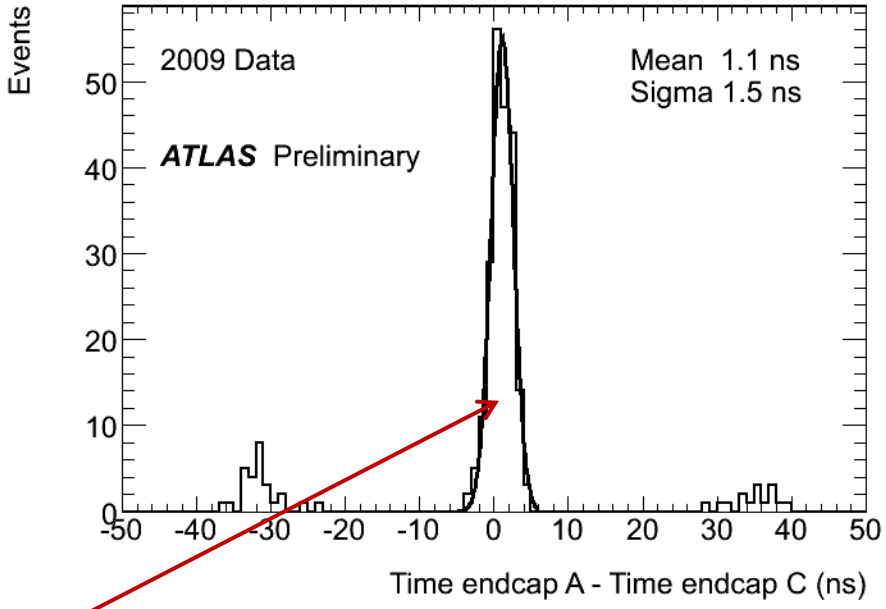




Minimum Bias Trigger Scintillators



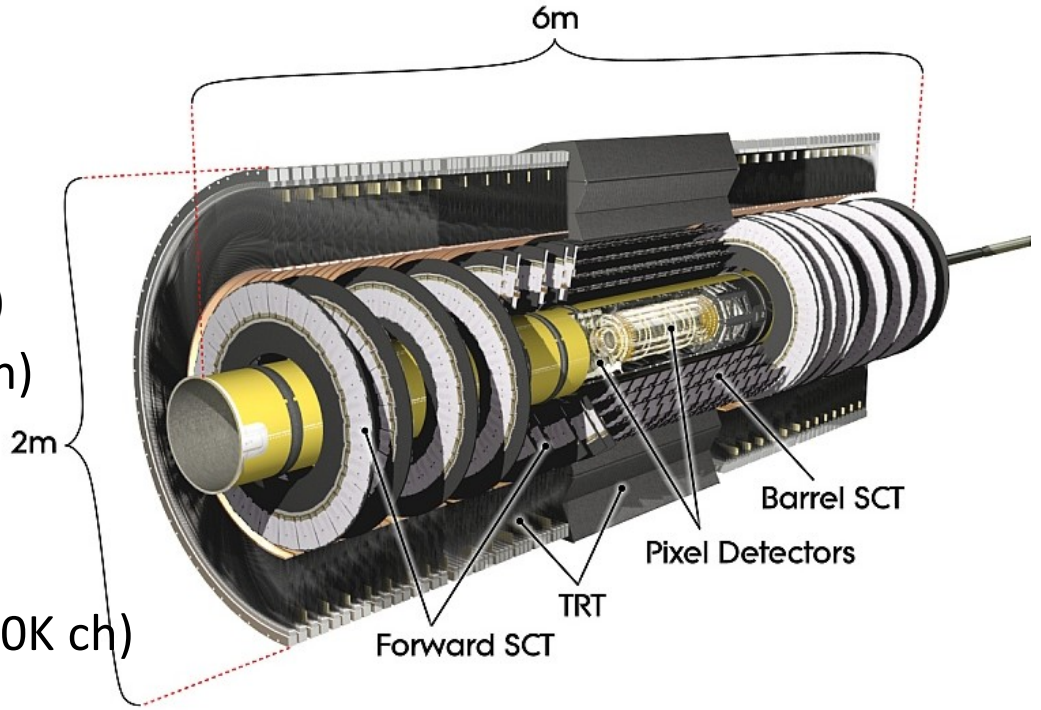
LAr EndCap Detector



'In-time' events ($|T_A - T_C| < 10$ ns) = collision candidates

Inner Detector

- First physics results mainly from ID and Calorimeters
- Three technologies:
  - Pixels (80M ch)
    - 3 layers in barrel
    - 5 disks in each end-cap
    - Dimensions: 50μm×300μm (Rφ×z)
  - Semiconductor Tracker (6.3M ch)
    - Silicon strips 80μm pitch
    - 4 layers in barrel
    - 9 wheels in each end-cap
  - Transition Radiation Tracker (350K ch)
    - Straw tubes 4mm diameter
    - Axial in barrel, radial in end-cap
    - ~36 hits per track
- Solenoid magnet (2 T)

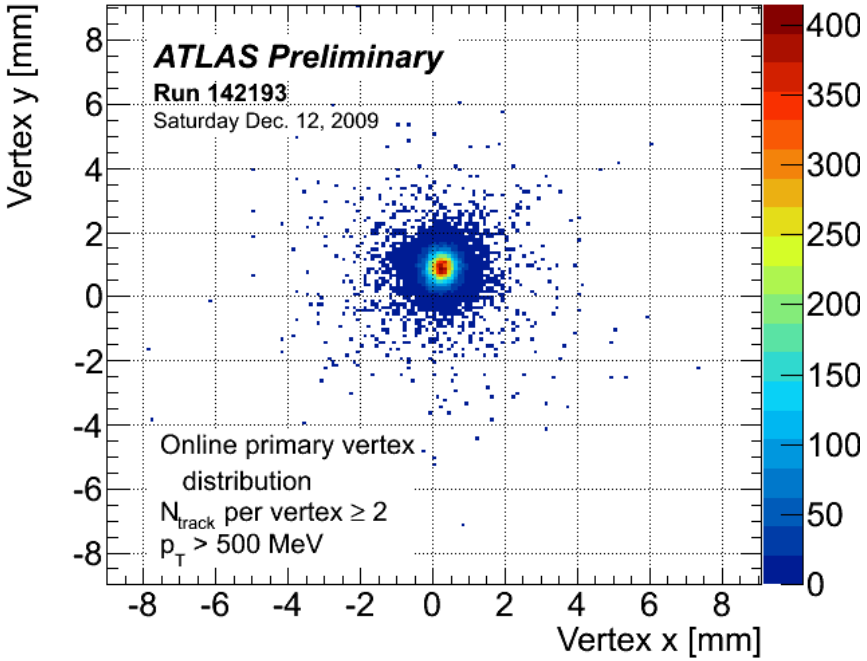


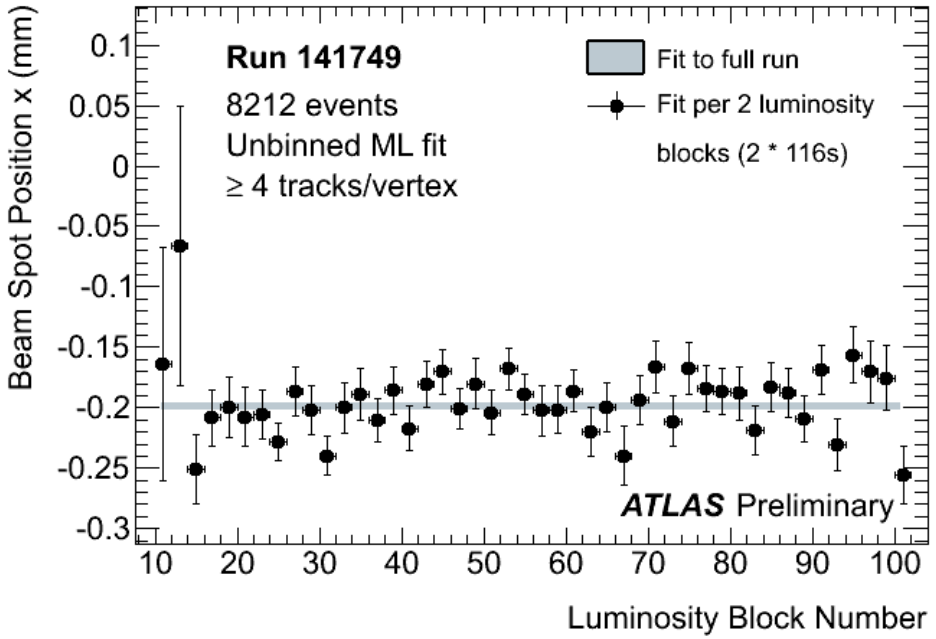
- Resolution:
  - $\sigma(p_T)/p_T \sim 3.4\text{x}10^{-4} p_T(\text{GeV}) \oplus 0.015$
  - $\sigma(d_0) \sim 10 \oplus 140/p_T(\text{GeV})$ μm

Beam spot determination

Done with the ID

Online distribution of the primary vertex position





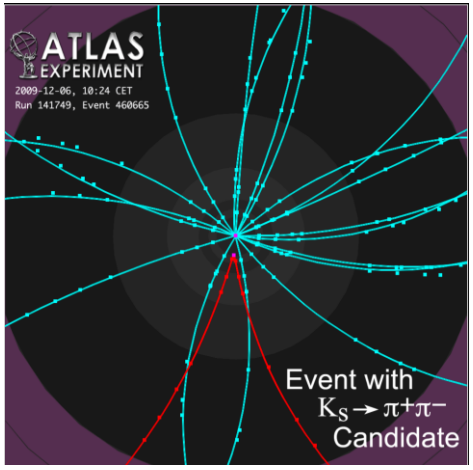
Beam spot stability

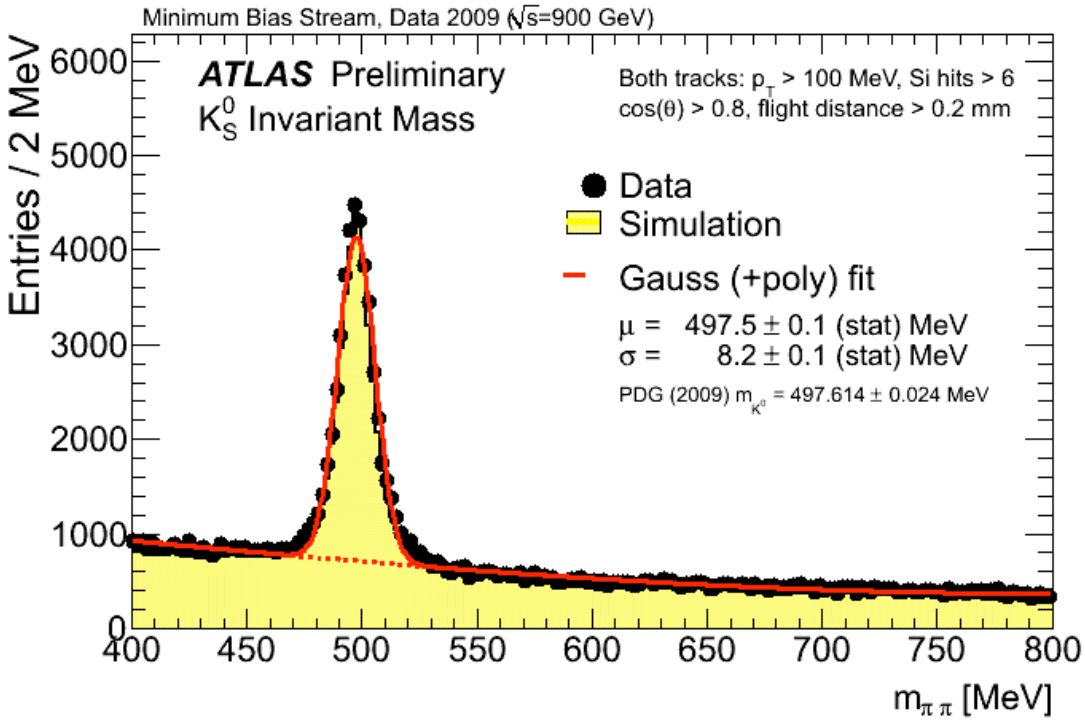
Offline vertex reconstruction

1 Luminosity Block ~ 2 min.

$K_s \rightarrow \pi^+\pi^-$ reconstruction

- Pion candidate tracks:
  - > 6 hits in Si detector
  - PT > 100 MeV
  - cos(θ) > 0.8
  - Flight distance > 0.2mm
  - No mass constraint for the two charged tracks in vertex fit
- Resolution agrees with expectations
- Limited by statistics and multiple scattering

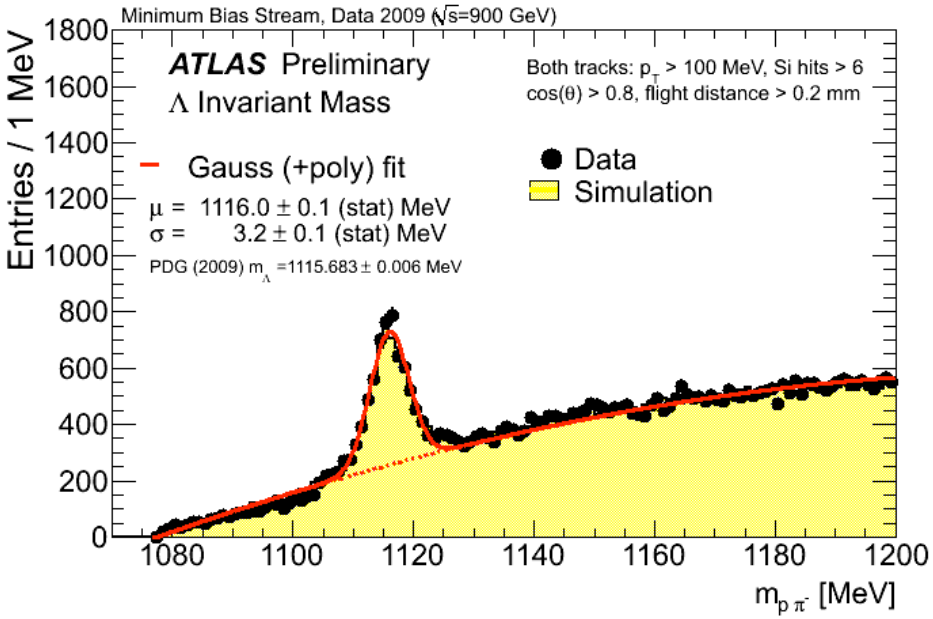


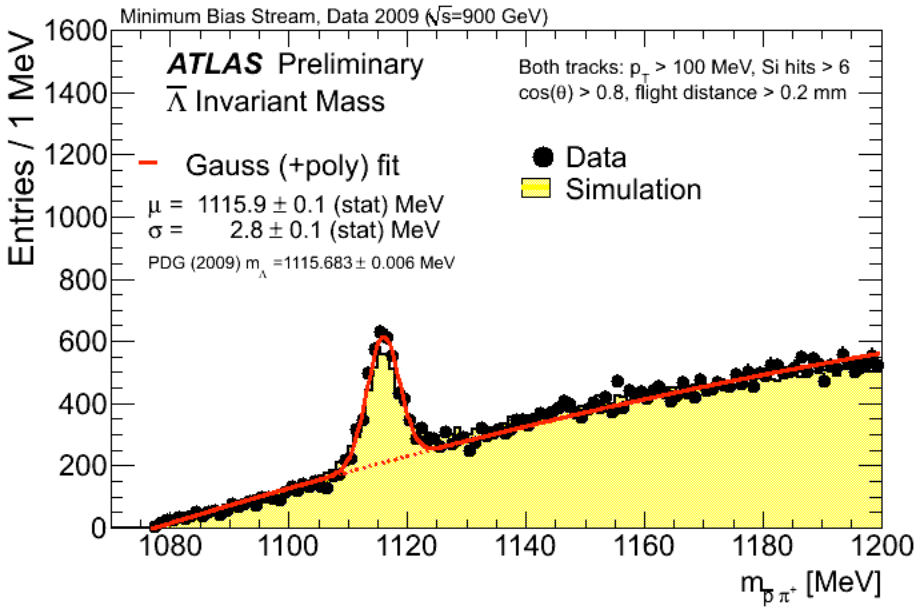


Good agreement with PDG values

Resolution (stat) ~ 5 times larger than PDG

$\Lambda \rightarrow p\,\pi$ reconstruction

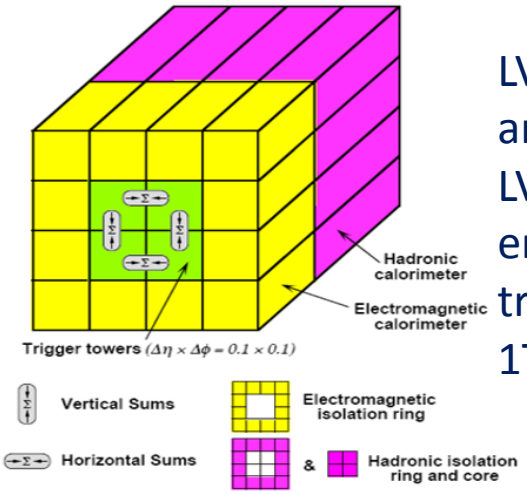




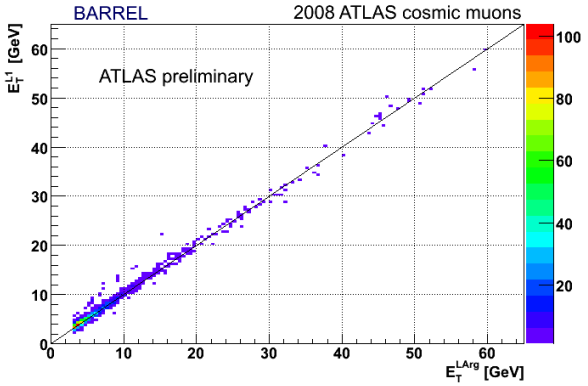
Same selection cuts on charged tracks as for $K_s \rightarrow \pi\pi$

Resolution agrees with expectations

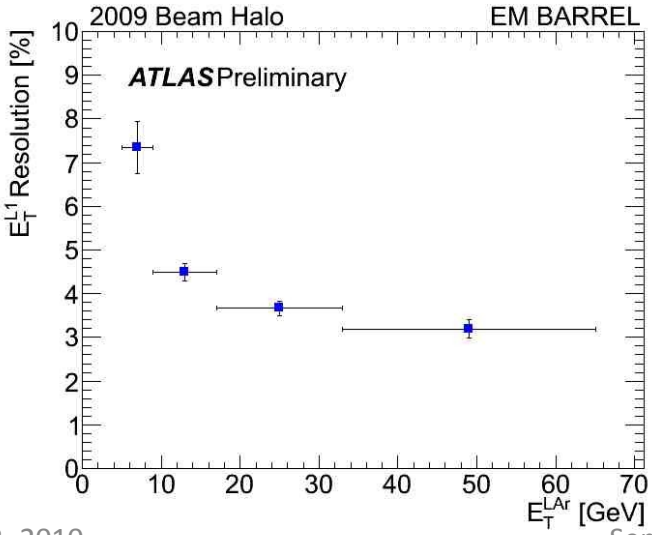
Level-1 Calorimeter Trigger



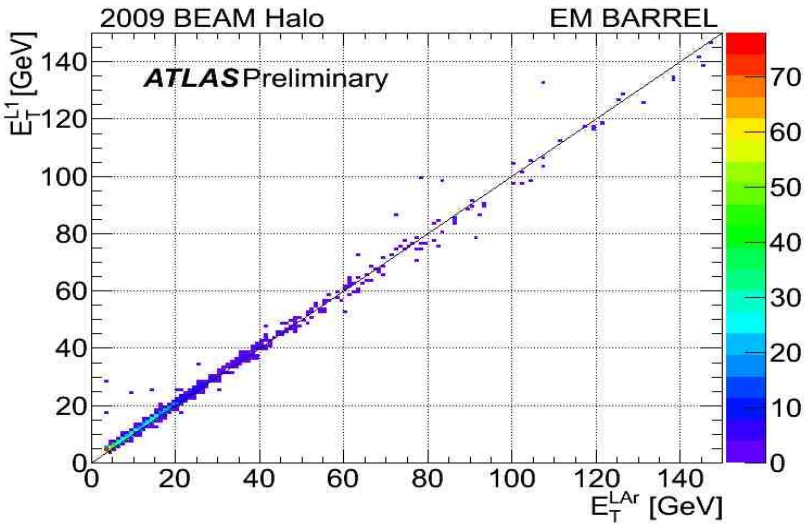
LVL1 trigger of ATLAS given by Calo and Muon systems
LVL1 Calo trigger based on the energy sum of cells belonging to a trigger tower reconstructed online
1TT = 0.1×0.1 η×φ



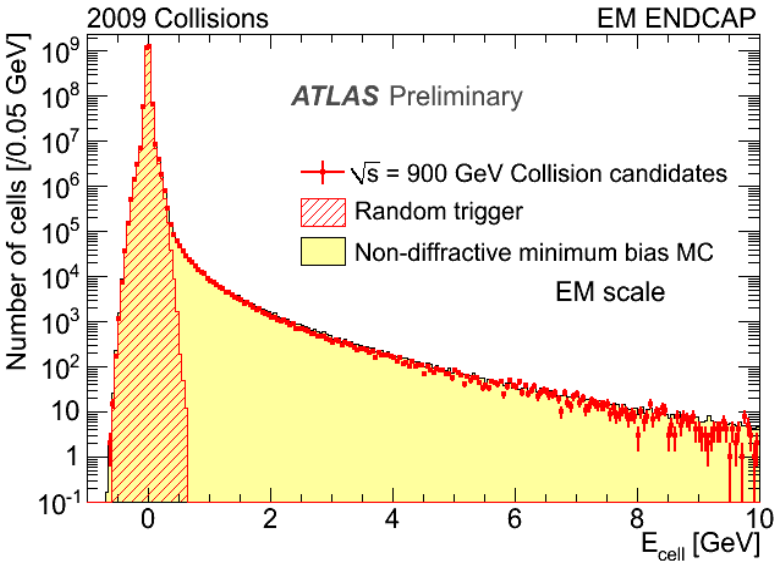
E^{L1}_T resolution as function of E^{LAr}_T
Requirement of <5% resolution at E>10 GeV

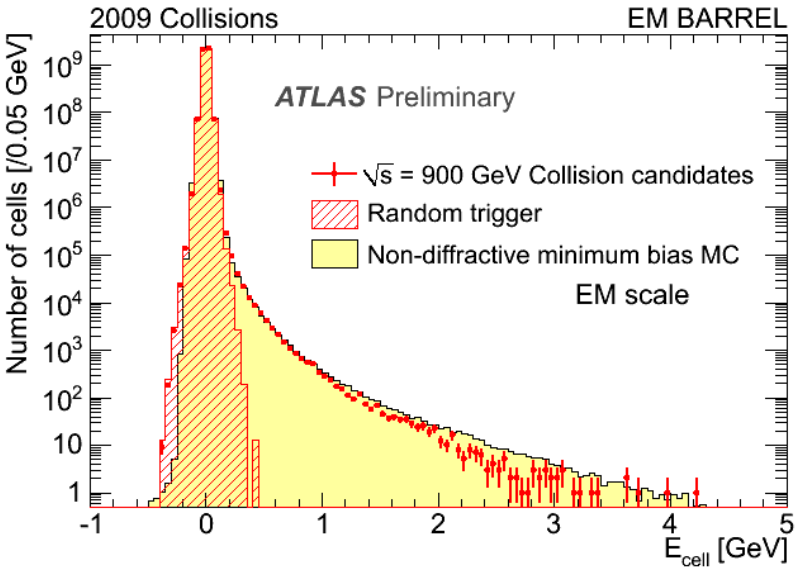


Correlation of E^{L1}_T and $\sum E(TT)$ computed offline

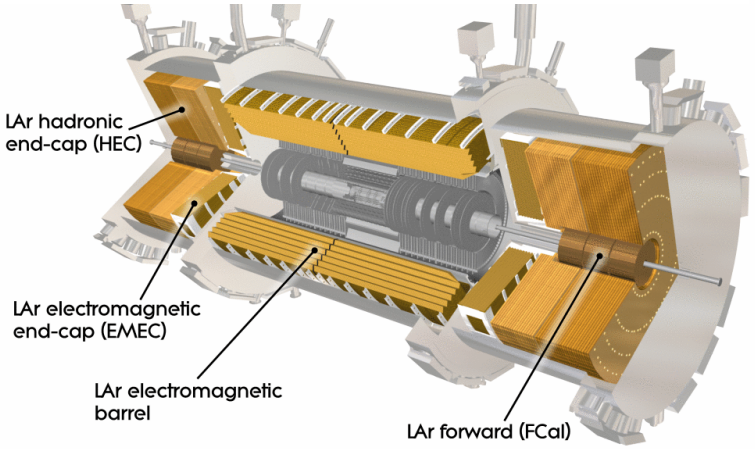


Calorimeter cell energy distribution

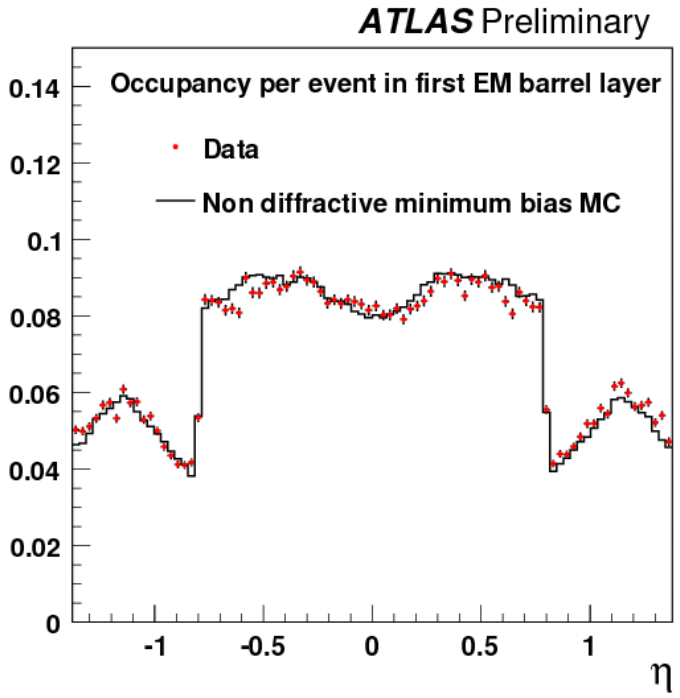




- Good agreement between data and MC
- No correction for dead material applied on the individual cells

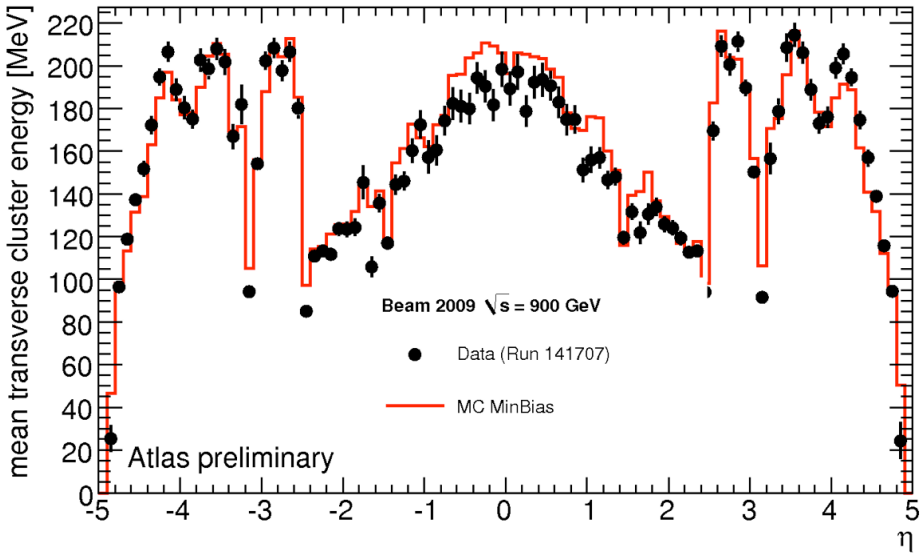


Occupancy & transverse cluster energy



Occupancy in the first LAr EM barrel layer
Noise threshold applied: E>5σ (50 MeV)

Mean transverse energy in calo clusters

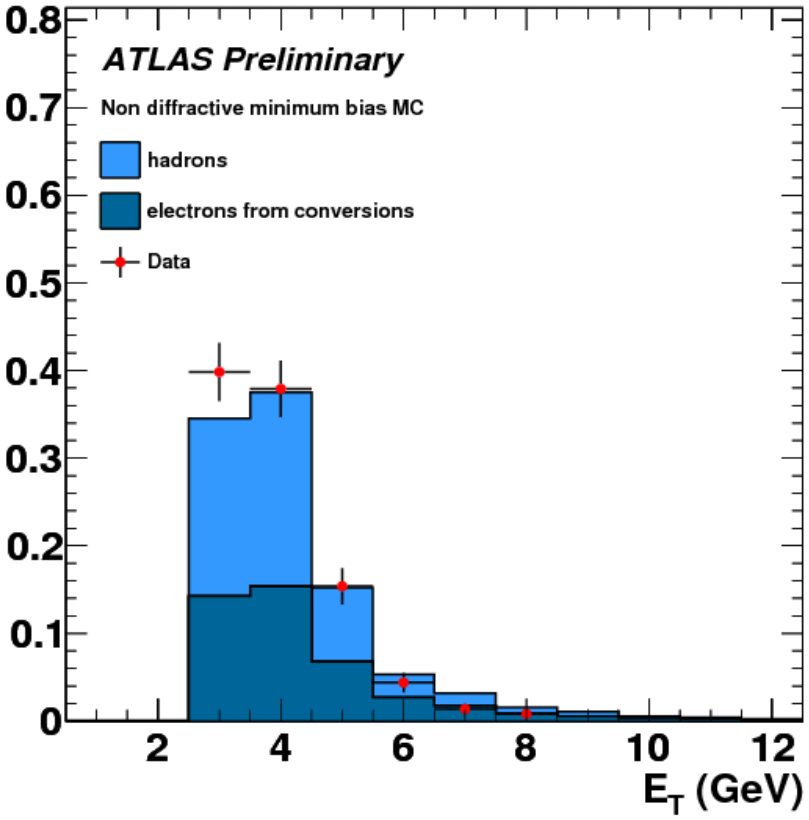


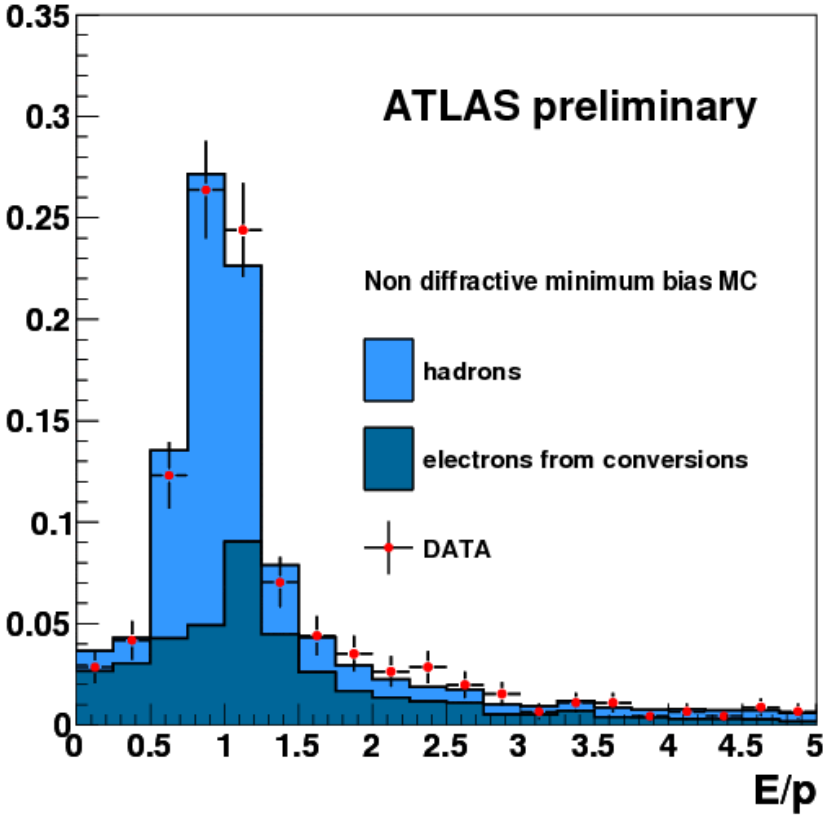
Clusters seeded by cells with E>4σ
No correction for dead material

Electrons

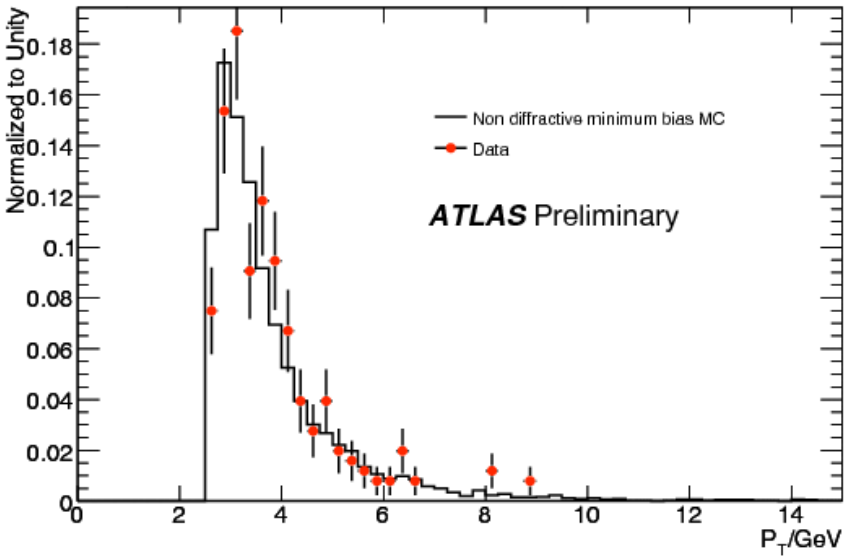
Examples of distributions of electron identification variables

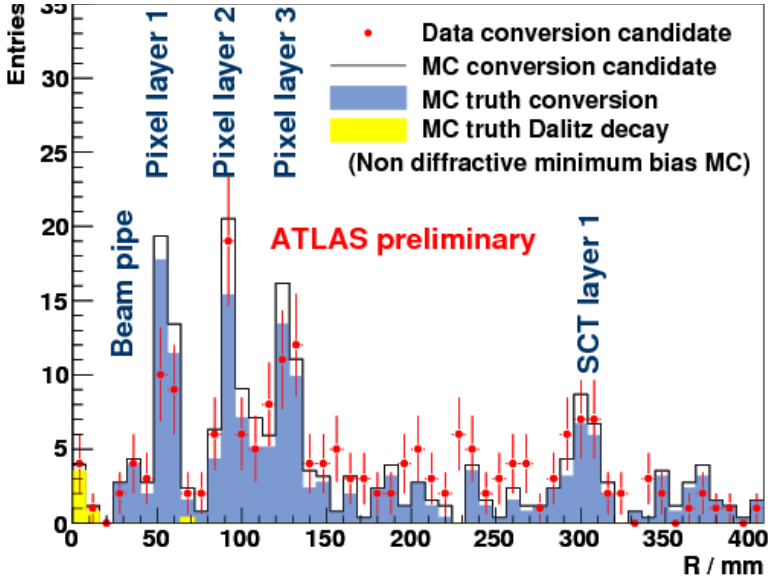
- Transverse energy (cut at 2.5 GeV loose match to a reconstructed track with p_T>0.5 GeV)
- E/p ration



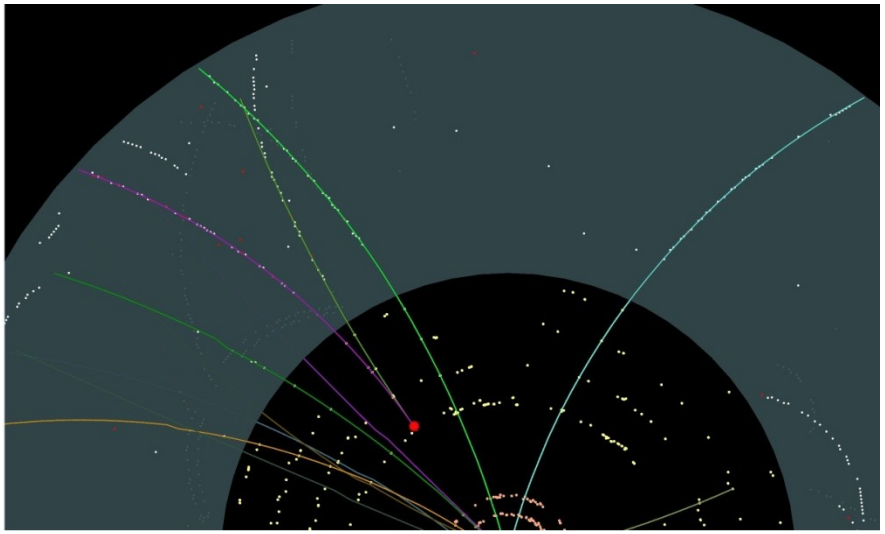


Photons





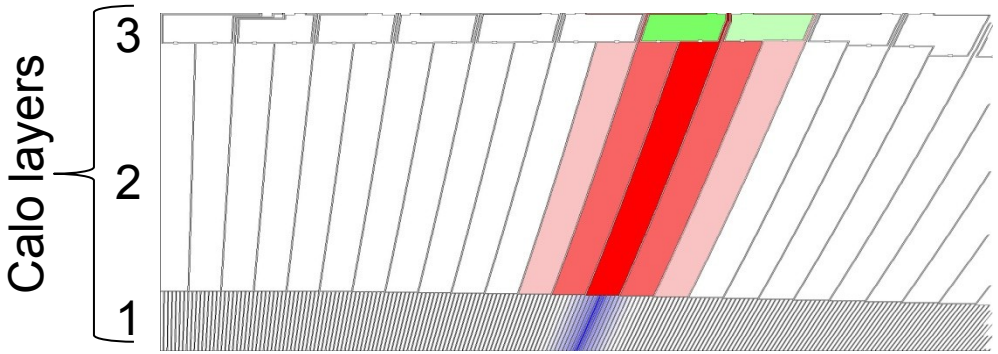
Transverse momentum spectrum for photon candidates (cut at 2.5 GeV)



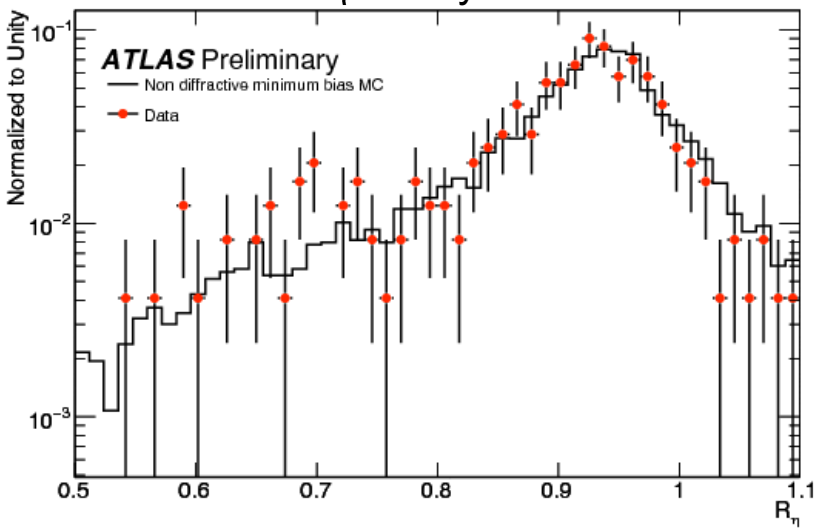
Photon conversion radial distribution (from Si det.)
Effect from beam pipe and pixels layers clearly visible
Need to improve material description (to correct EM energy calibration)

Shower Shape

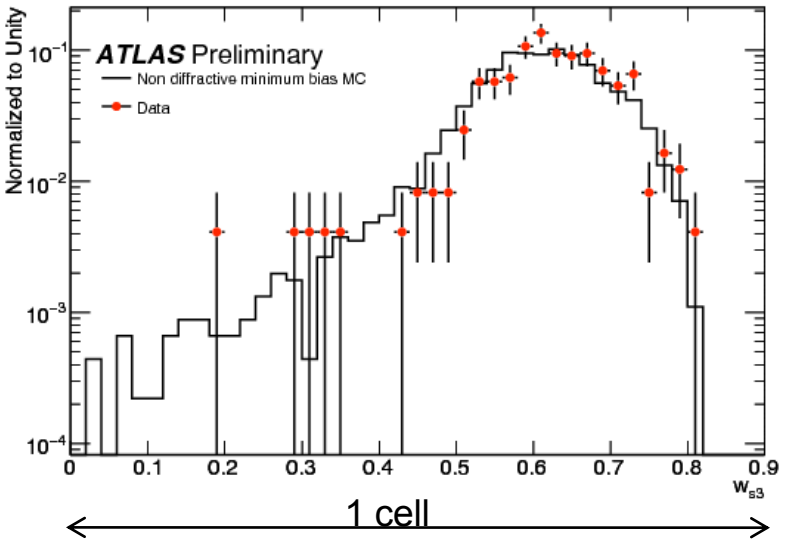
Calorimeter shower shapes for photon identification

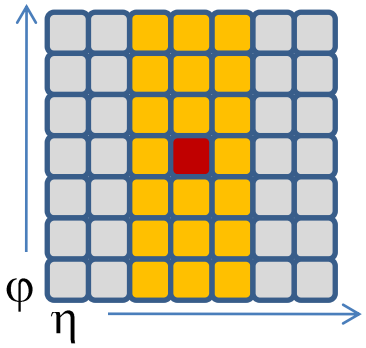


Rη for layer 2



Transverse shower width over 3 cells in layer 1





$$R\eta = \frac{\sum E(\Delta\eta \times \Delta\varphi = 3\times 7)}{\sum E(\Delta\eta \times \Delta\varphi = 7\times 7)}$$

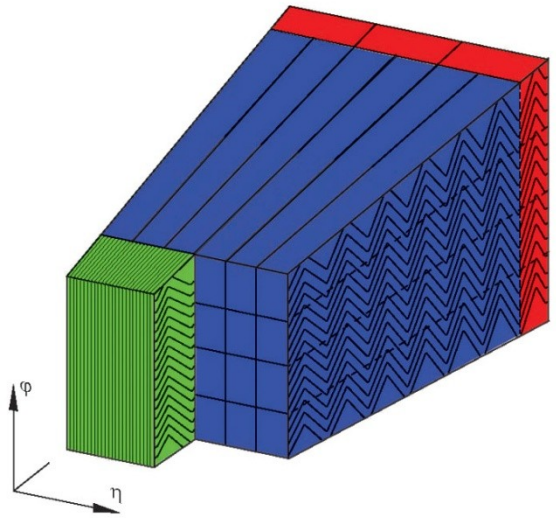
π^0 signal

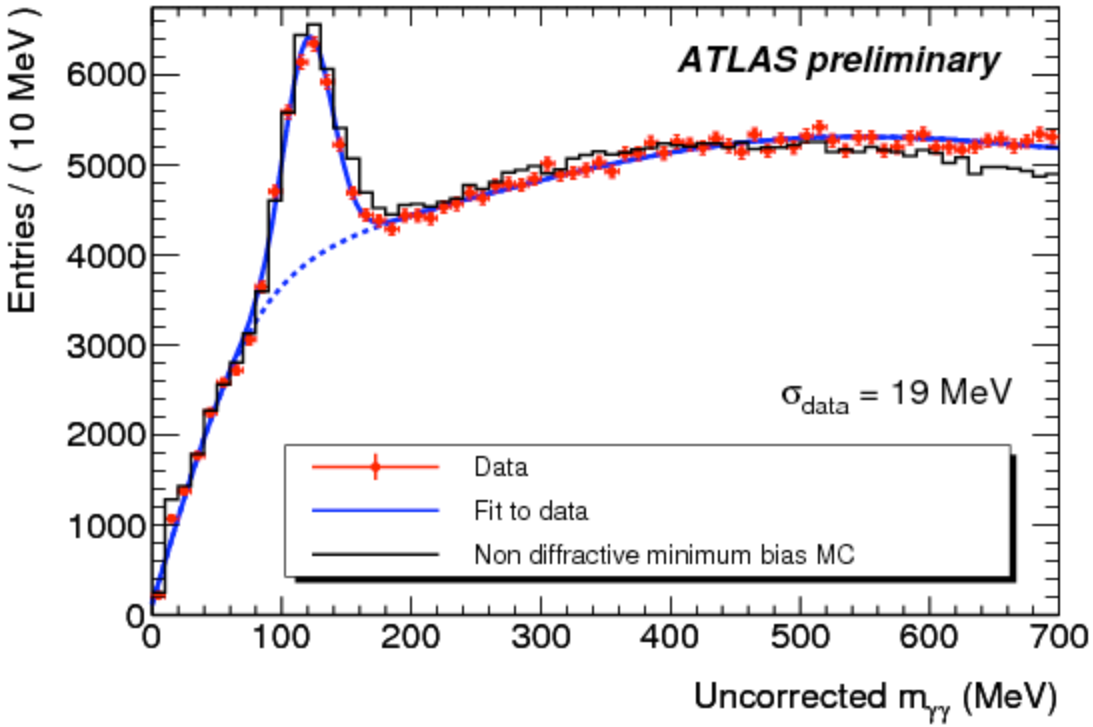
$\pi^0 \rightarrow \gamma\gamma$

Et(EM cluster) > 300 MeV

Et(π^0 candidate) > 900 MeV

No correction for dead materia



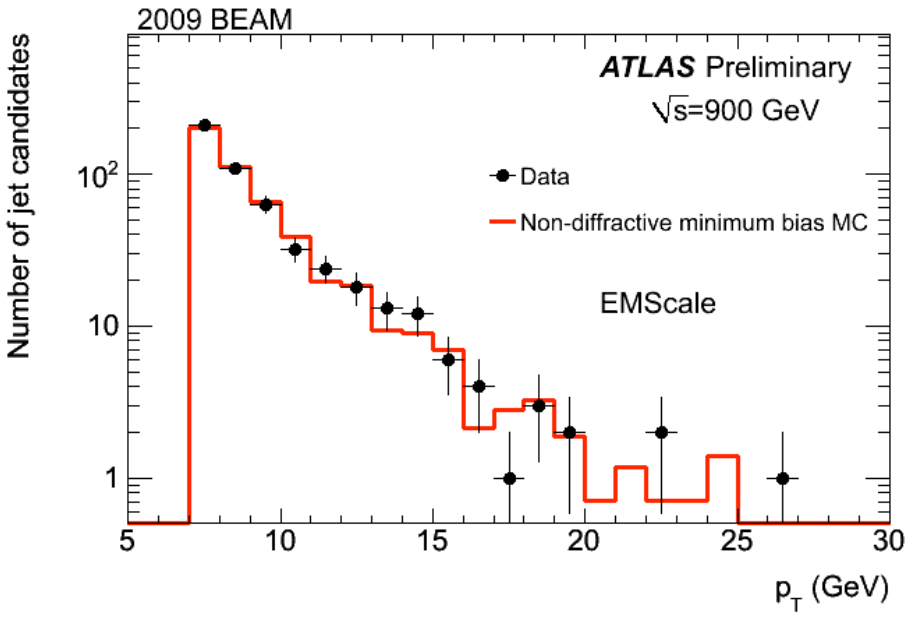


Resolution 19 MeV as expected from MC

LAr performs well in separating γ/π^0

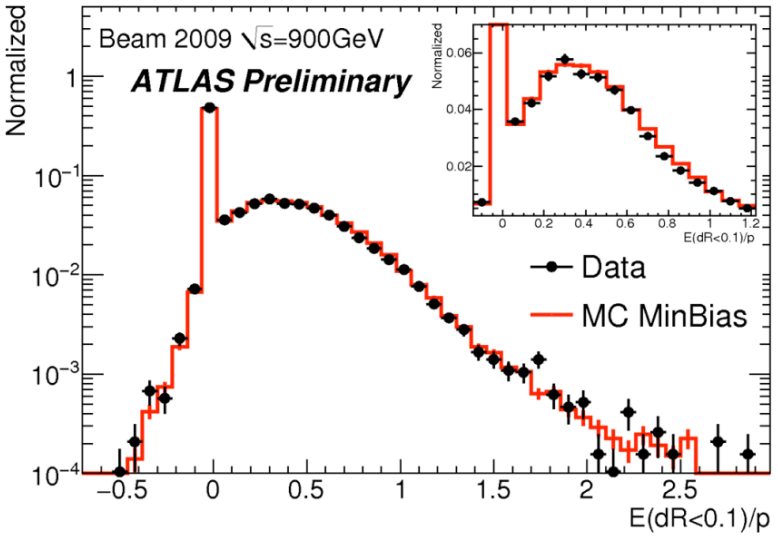
Jets

Jet transverse momentum distribution



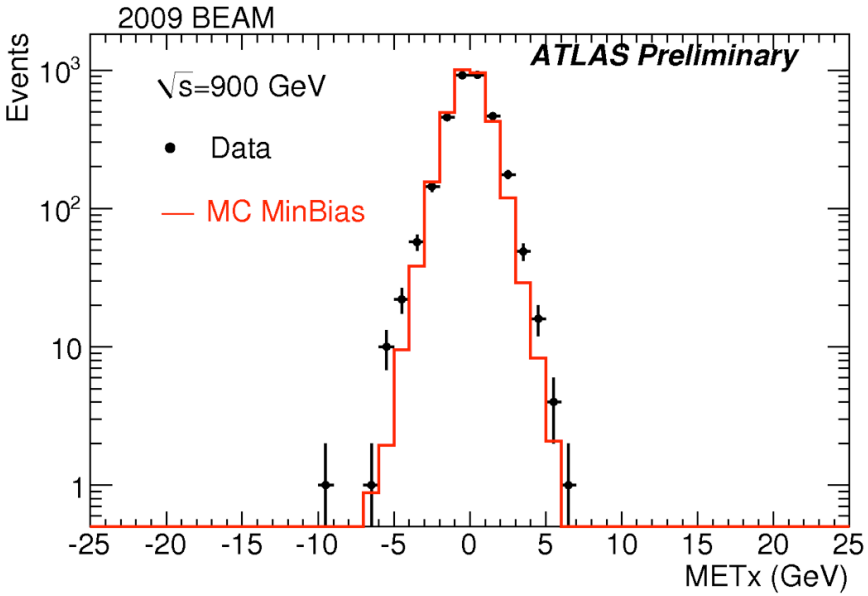
Jet reconstructed from clusters using AntiKt alg.
No calibration applied
Only cells in clusters are used (noise suppression)

E/p for isolated track (cone R<0.4)
With 0.5<pt<10 GeV
Only cells in clusters are used (noise suppression)

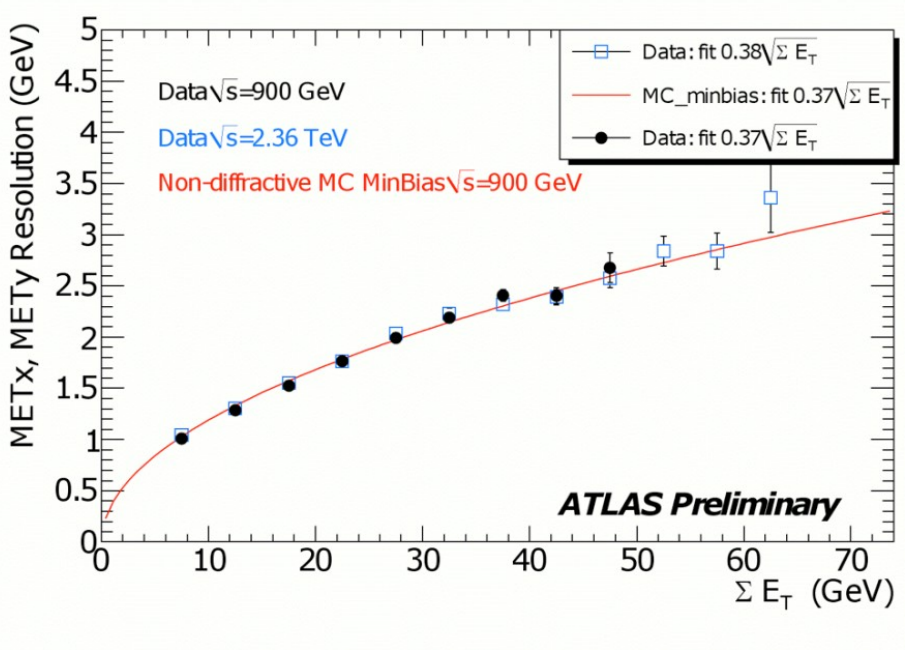


Missing E_T

Missing x-component transverse energy in collision data



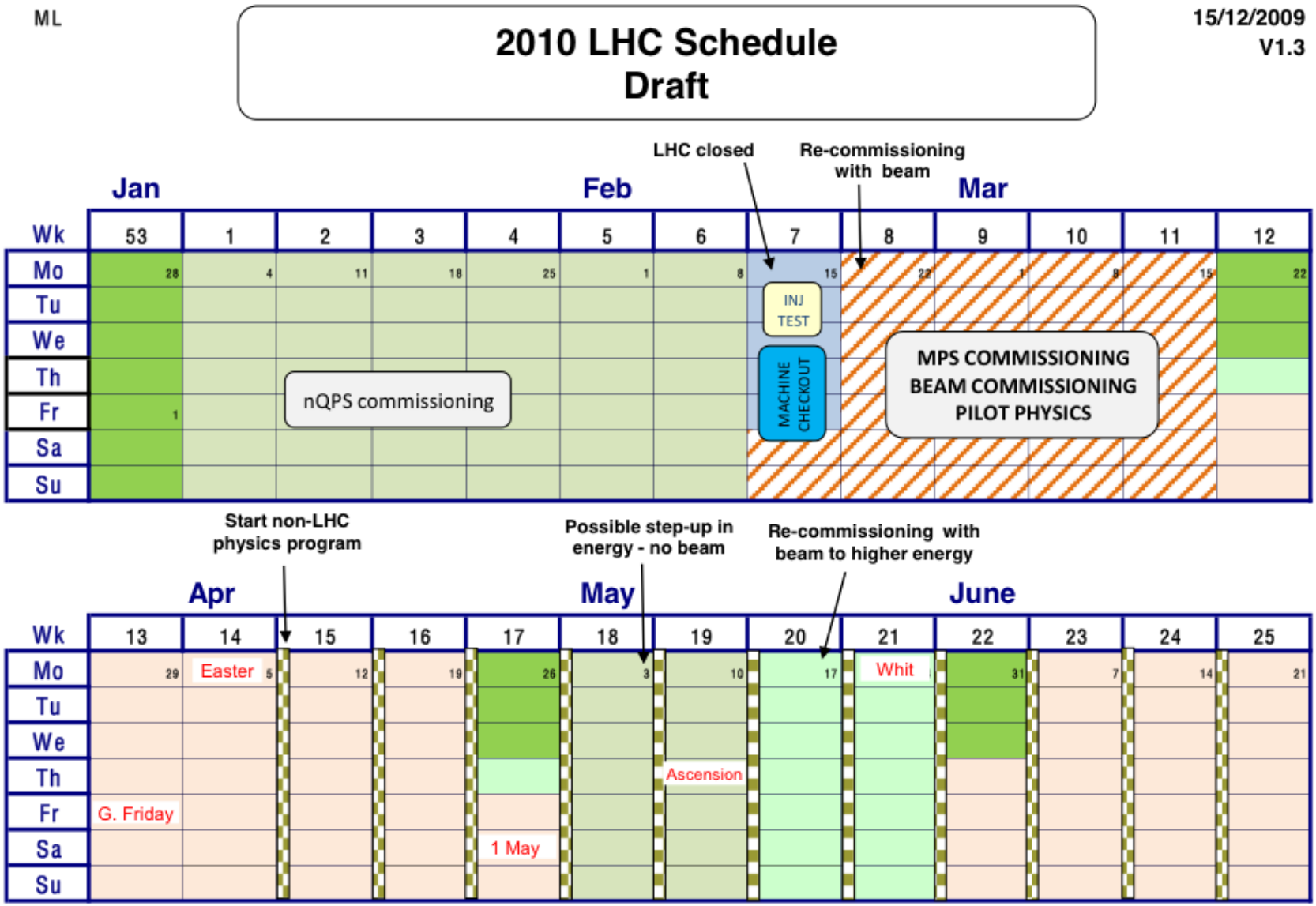
MET resolution vs ∑Et



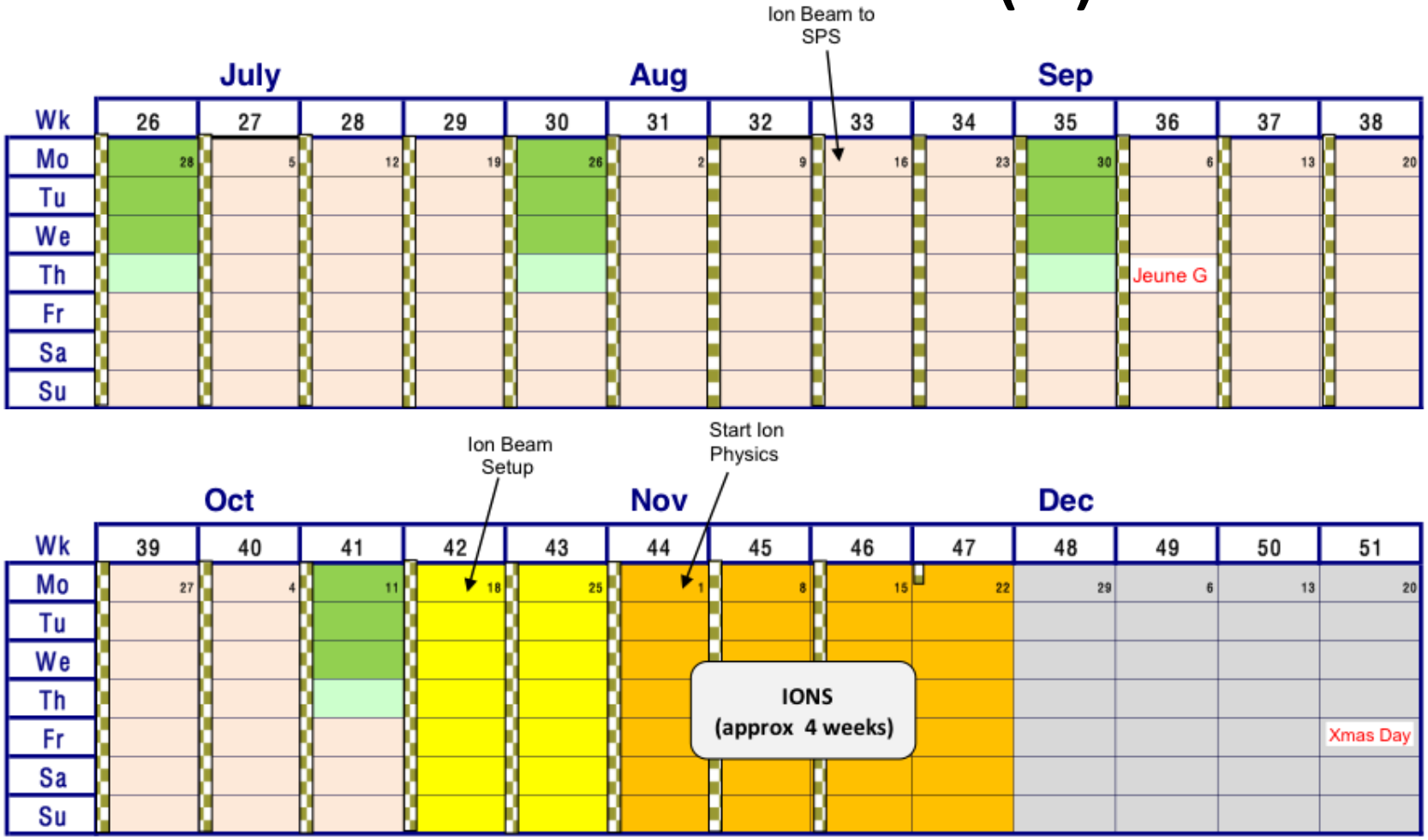
No calibration applied

Only cells in clusters are used (noise suppression)

What's next (I)


ML
2010 LHC Schedule
Draft
15/12/2009
V1.3
LHC closed
Re-commissioning with beam
Jan
Feb
Mar
Wk
53 1 2 3 4 5 6 7 8 9 10 11 12
Mo
Tu
We
Th
Fr
Sa
Su
INJ TEST
MACHINE CHECKOUT
nQPS commissioning
MPS COMMISSIONING
BEAM COMMISSIONING
PILOT PHYSICS
Start non-LHC physics program
Possible step-up in energy - no beam
Re-commissioning with beam to higher energy
Apr
May
June
13 14 15 16 17 18 19 20 21 22 23 24 25
Easter
Whit
G. Friday
Ascension
1 May

What's next (II)



Expected ~200 pb^{-1} at 7TeV

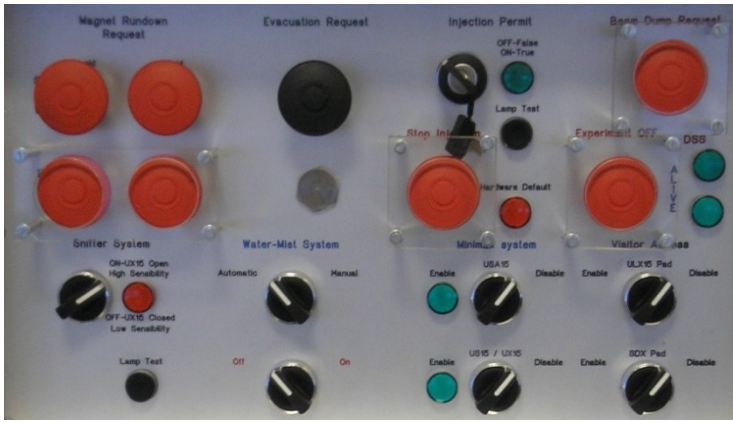
51000 Z→ee important for calorimeter calibration

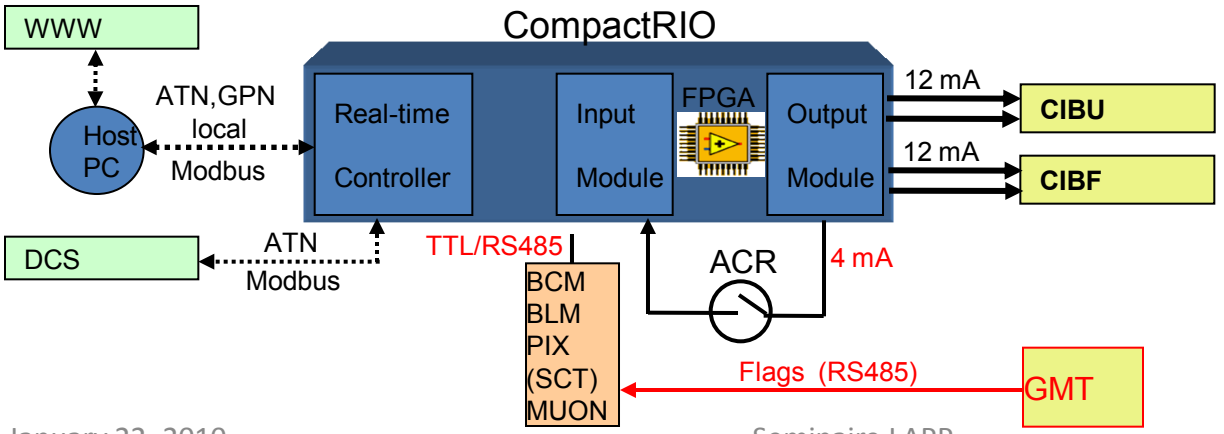
First competitive physics results

Other scenario possible (energy up to 10 TeV)

ATLAS Beam Interlock

- Energy per beam = 350MJ !
- Objective: detector protection complementar to LHC protection system:
  - During the injection in case of bad machine set-up (loss of pilot bunch)
  - During stable operation in case of problems (beam dump)
- Priority: high security level
- Double independent material system:
  - Injection stop if detector not ready or beam unstable
  - Beam dump if dangerous for the detector
- Fast system (<10µs), reliable (redundance), deterministic (post-mortem analysis)
- Based on FPGA + real time controller





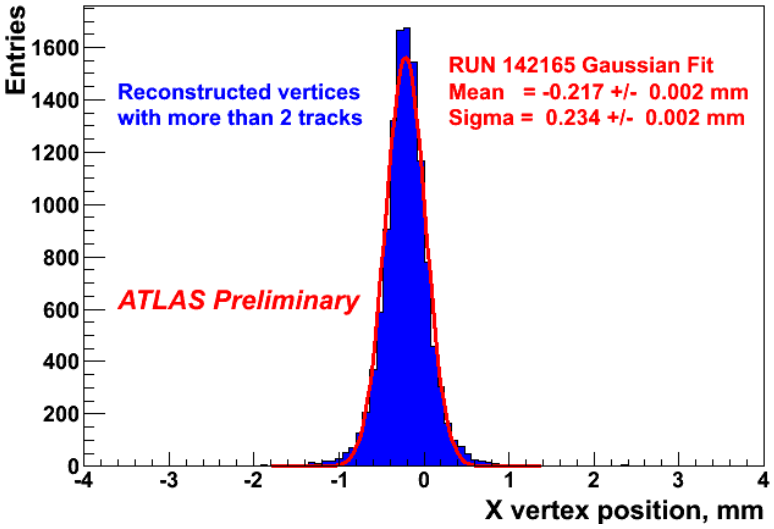
Conclusions

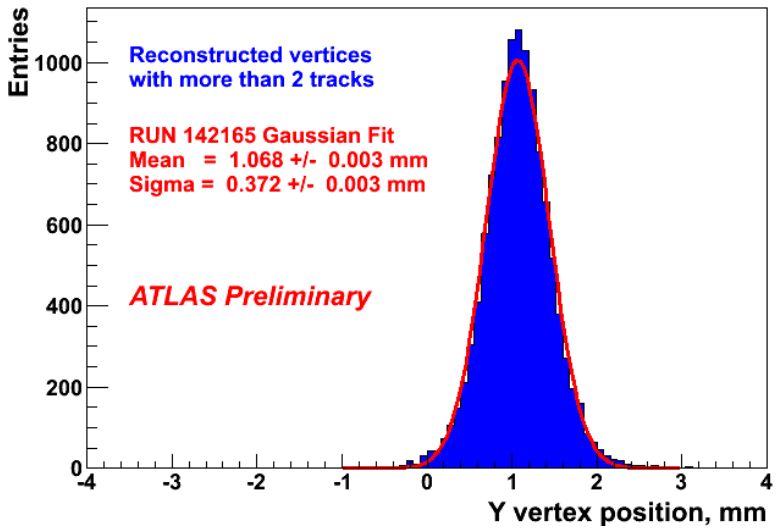
- After 15 years since the proposal ATLAS is finally fully working and waiting for more data
- LHC repaired and provided first collision at 900 GeV and 2.36 TeV in fall 2009
- LAr calorimeter in very good shape
- First results agree surprisingly well with simulations
- LAPP group deeply involved in many crucial activities
- LHC is about to restart...

…keep on praying!

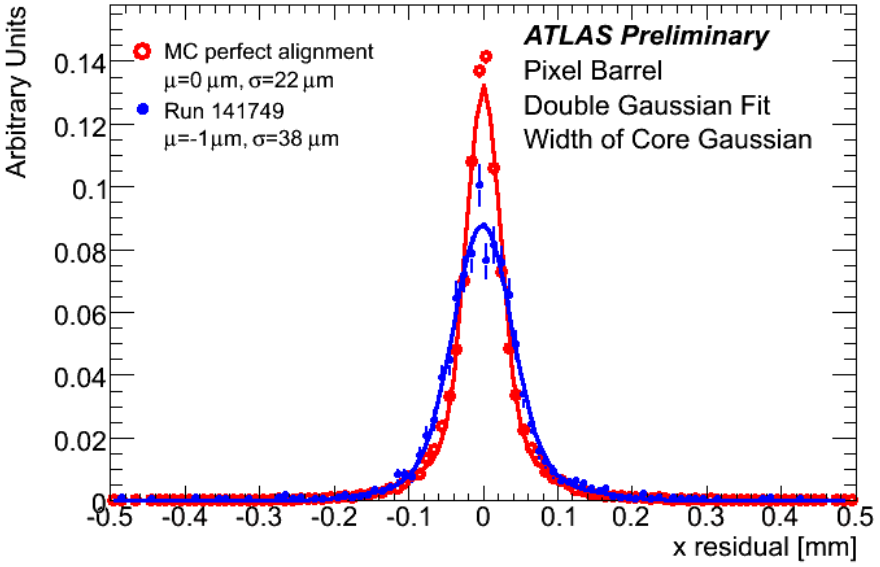
Back-up slides

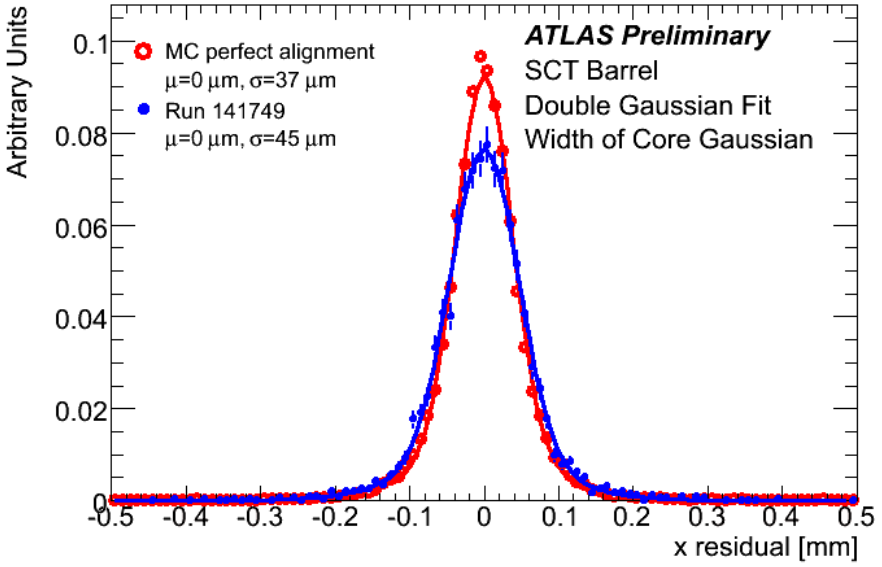
Primary vertex reconstruction



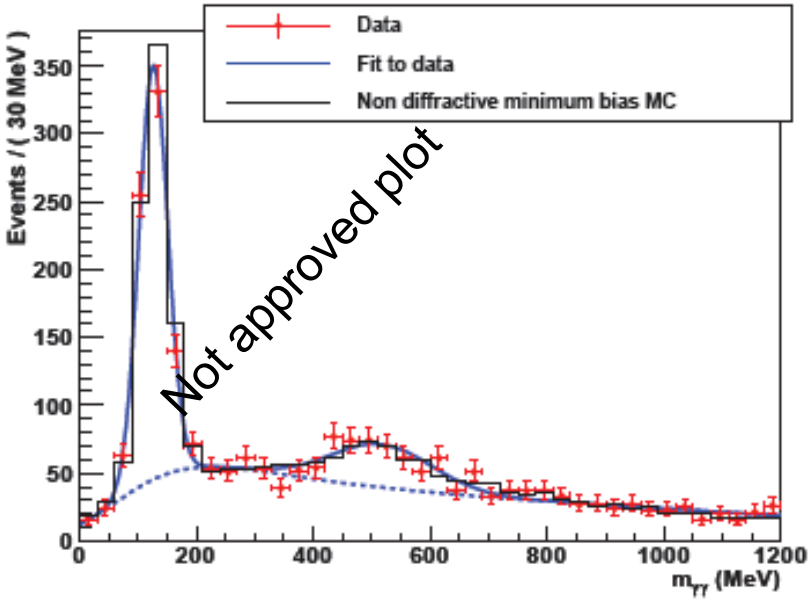


ID resolution on data





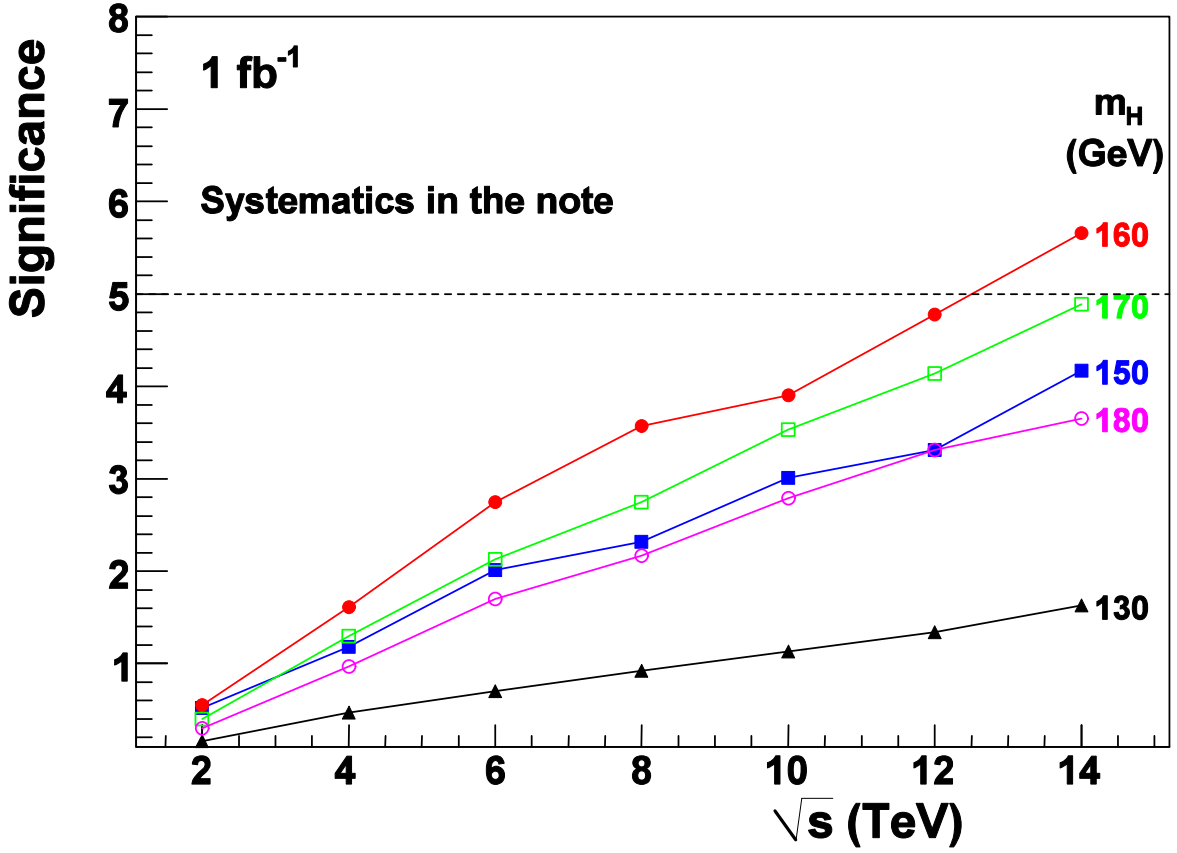
π^0 and η



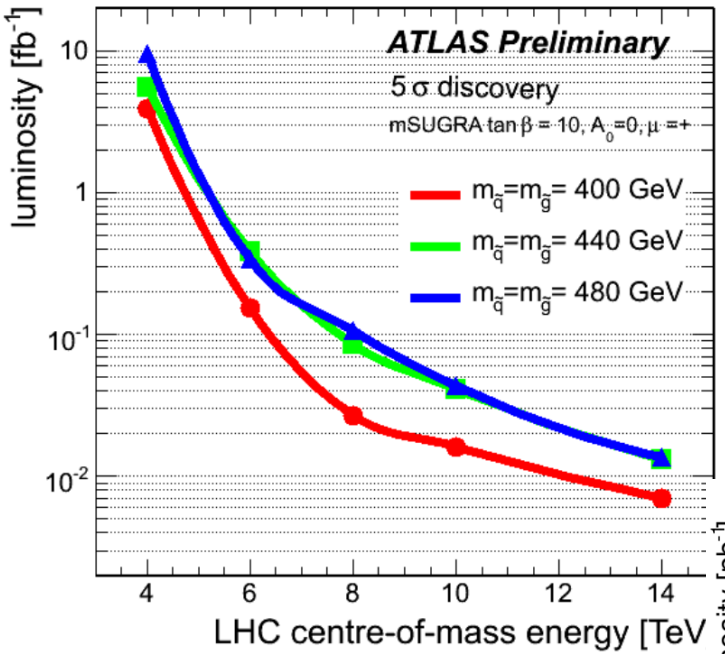
- Using 2 highest energetic clusters
- $E_T^{\text{EMTopoCluster}} > 300\text{MeV}$
- $E_T^{\text{pair}} > 1500\text{MeV}$
- Moments cuts
- $\Delta\eta < 0.6$
- Track veto
- Using GoodRunList

Higgs

- Some sensitivity to Higgs at 7 TeV
- With 1 fb^{-1} ATLAS can exclude,but not discover.
  - Combination with CMS could get to 5σ



Susy and BSM signals

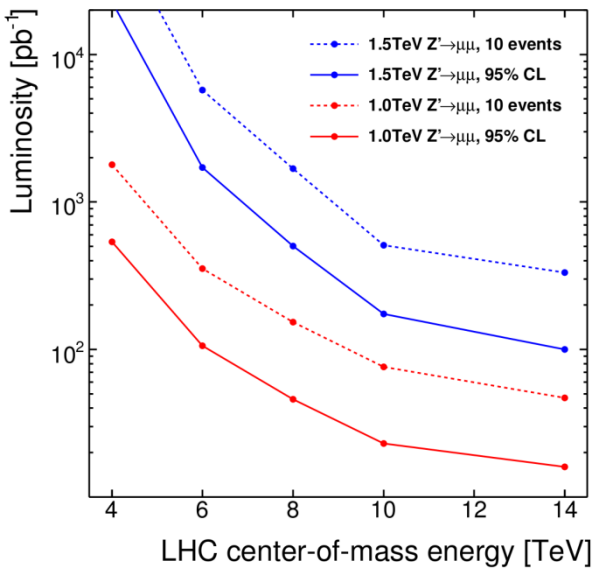


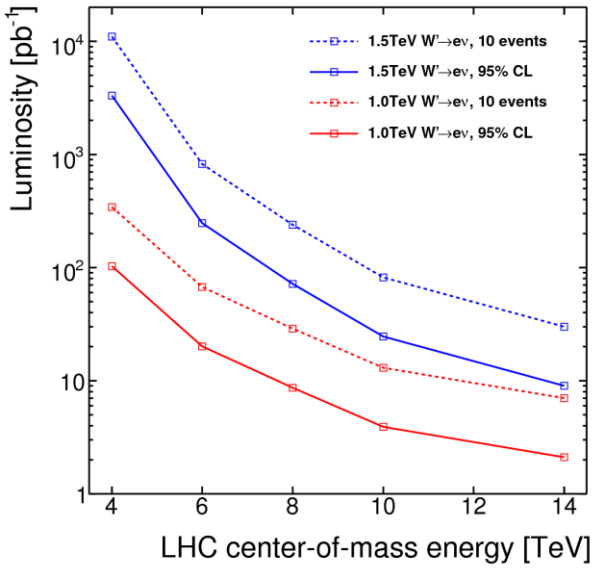
Z': Heavy partner of the Z (SSM)
Very clean experimental signal: Z'→ℓℓ

Tevatron 95% CL limit at m=1 TeV

W': Tevatron 95% CL limit also at m=1 TeV

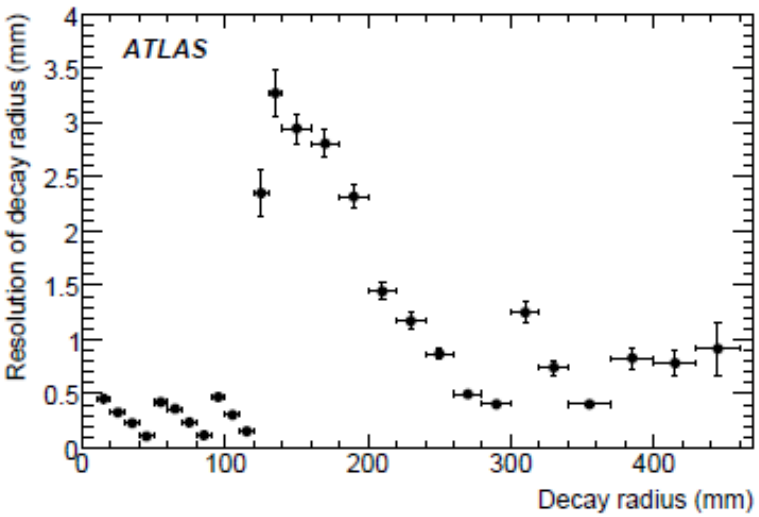
Tevatron limit for
Susy~ 400 GeV



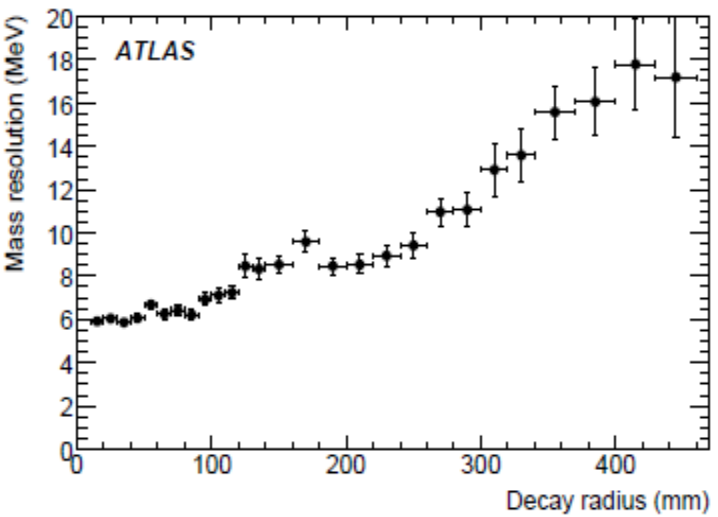


$K_s \rightarrow \pi^+\pi^-$ expected performances

Radial resolution of vertex



Mass resolution



Reconstruction efficiency