The performance of the ATLAS Inner Detector Trigger in pp collisions at $\sqrt{s}$ = 900 GeV at the LHC

Mark Sutton
University of Sheffield

on behalf of the
ATLAS Collaboration

31st March 2010

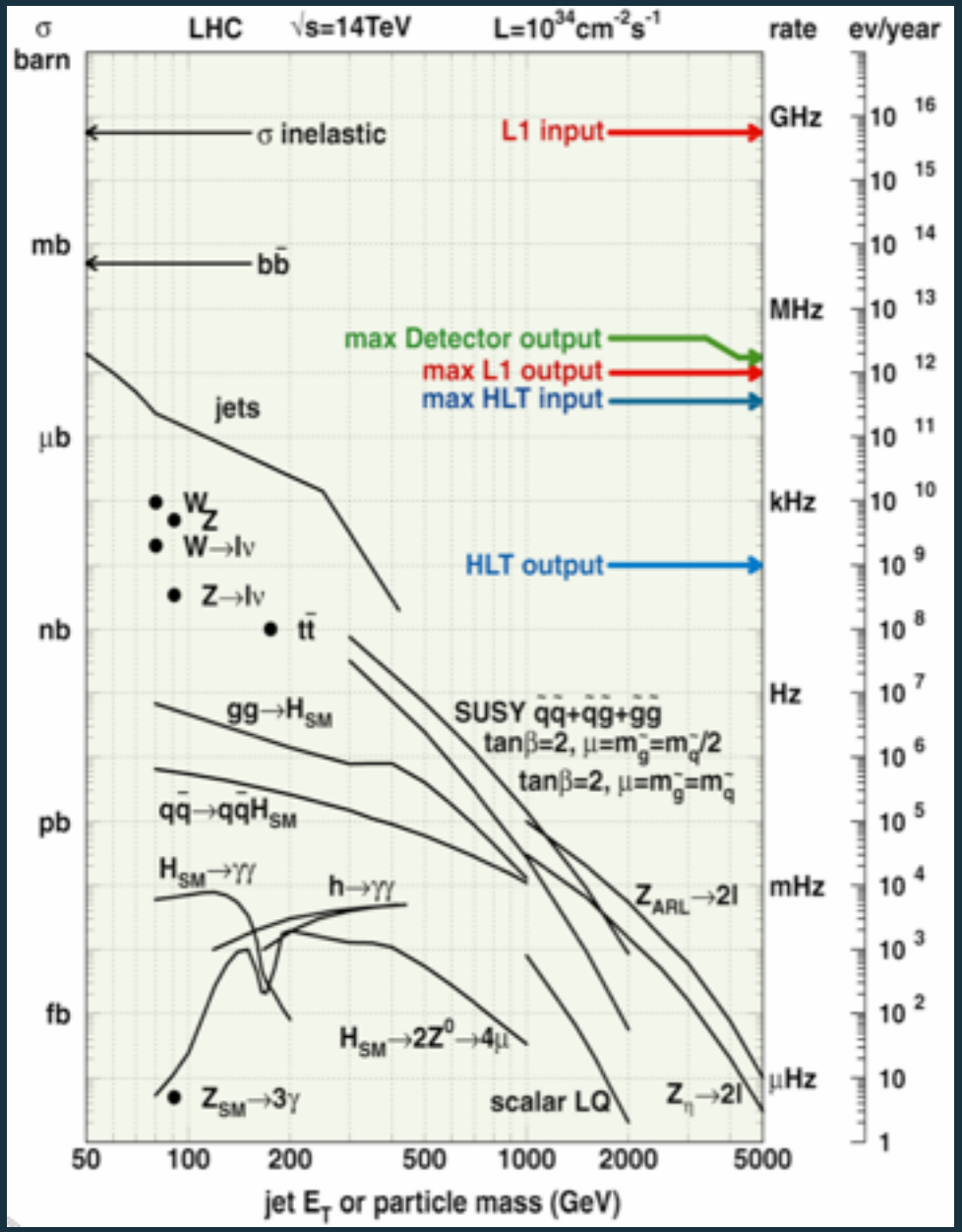
Preface

- LHC took it first collisions at 900 GeV in November-December last year.
  - L=~9 μb^{-1} at 5×10^{26} $cm^{-2}s^{-1}$

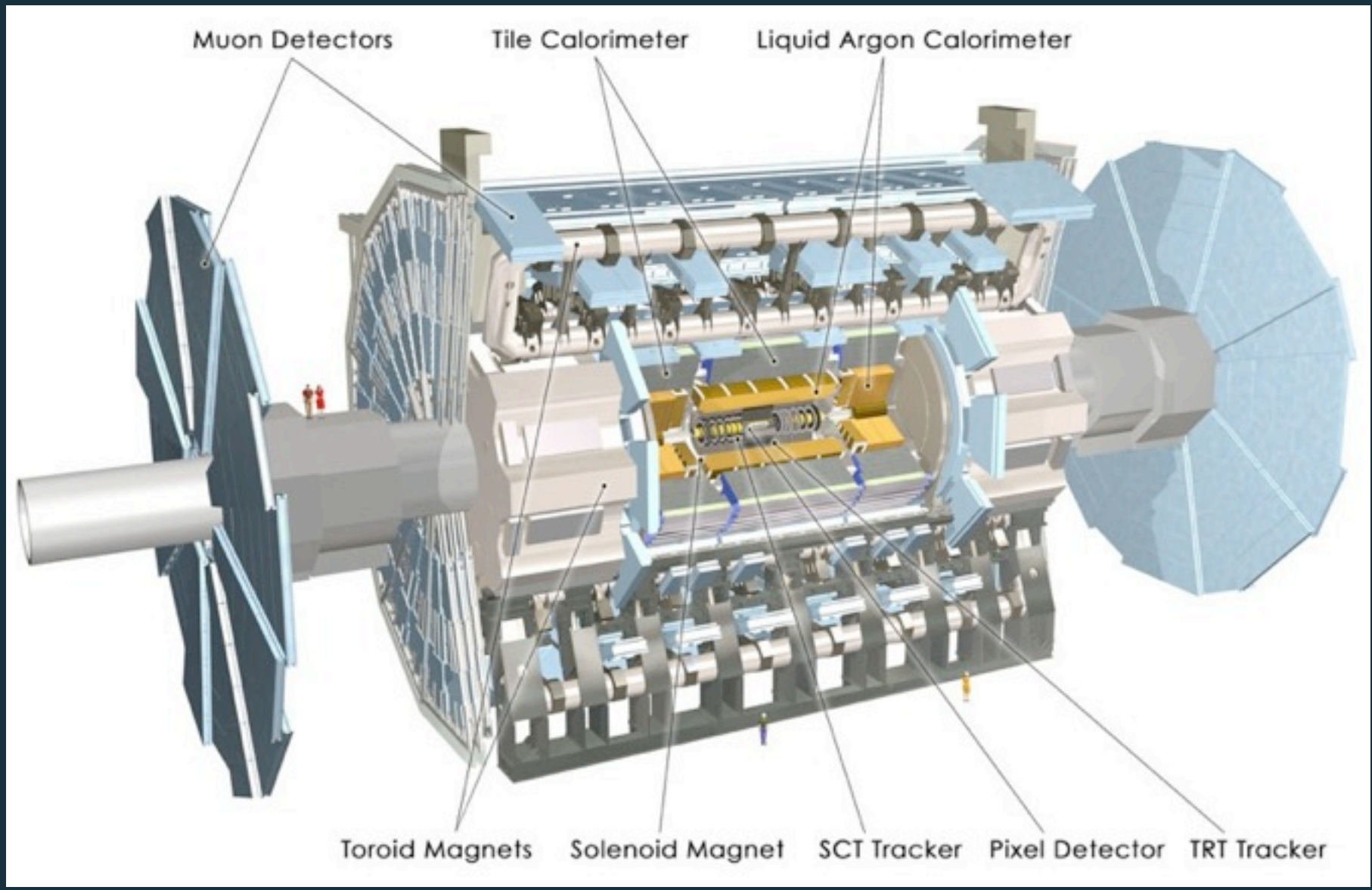
- Bunch crossing every 25 ns – 40 MHz rate
  - Data storage capability ~200 Hz
  - Reduction of around 200000 to 1 required

- Eventually expect up to ~25 (soft) *pp* interactions per bunch crossing
  - Interesting high p_T interactions complicated by "pile-up"

- Essentially all interesting signatures contain leptons or high momentum tracks

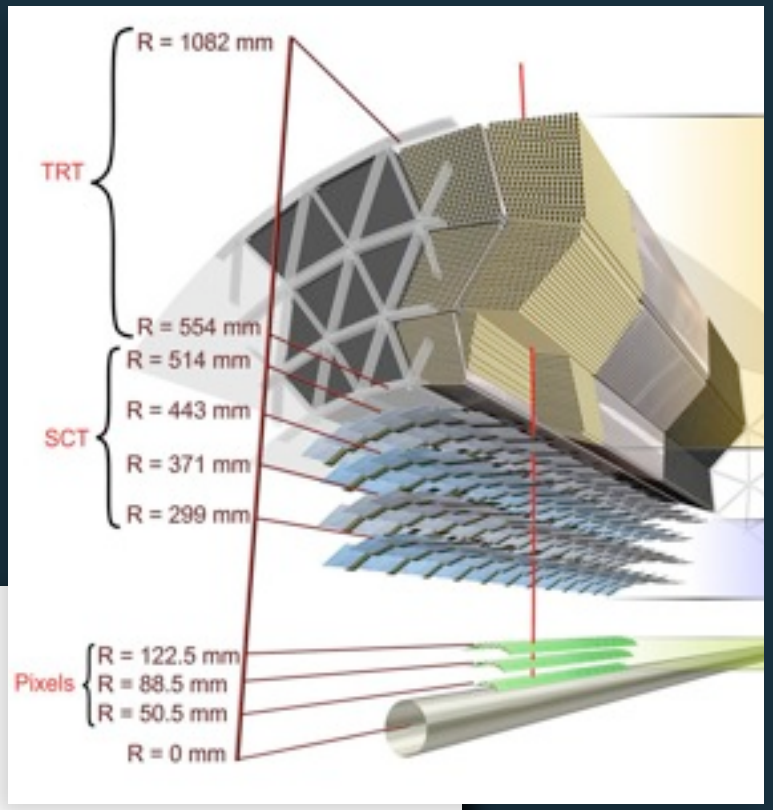


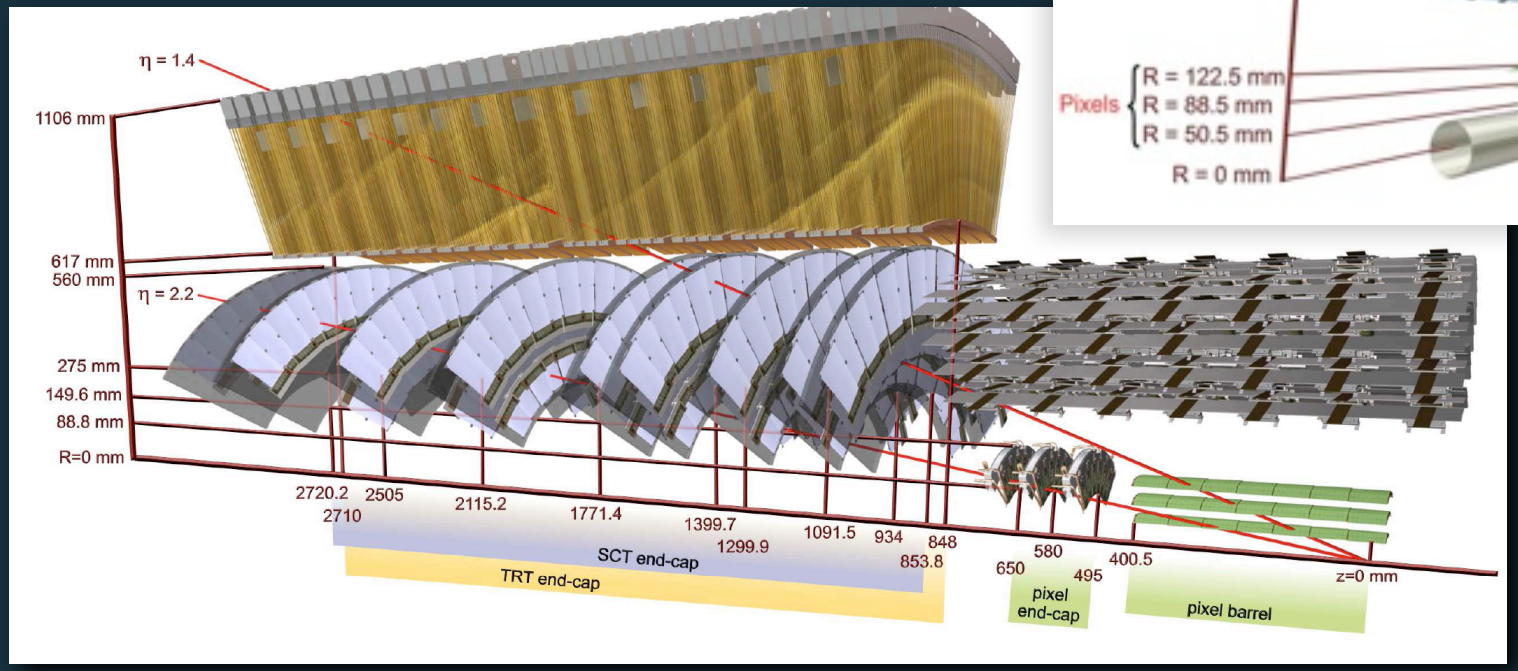
The ATLAS Detector



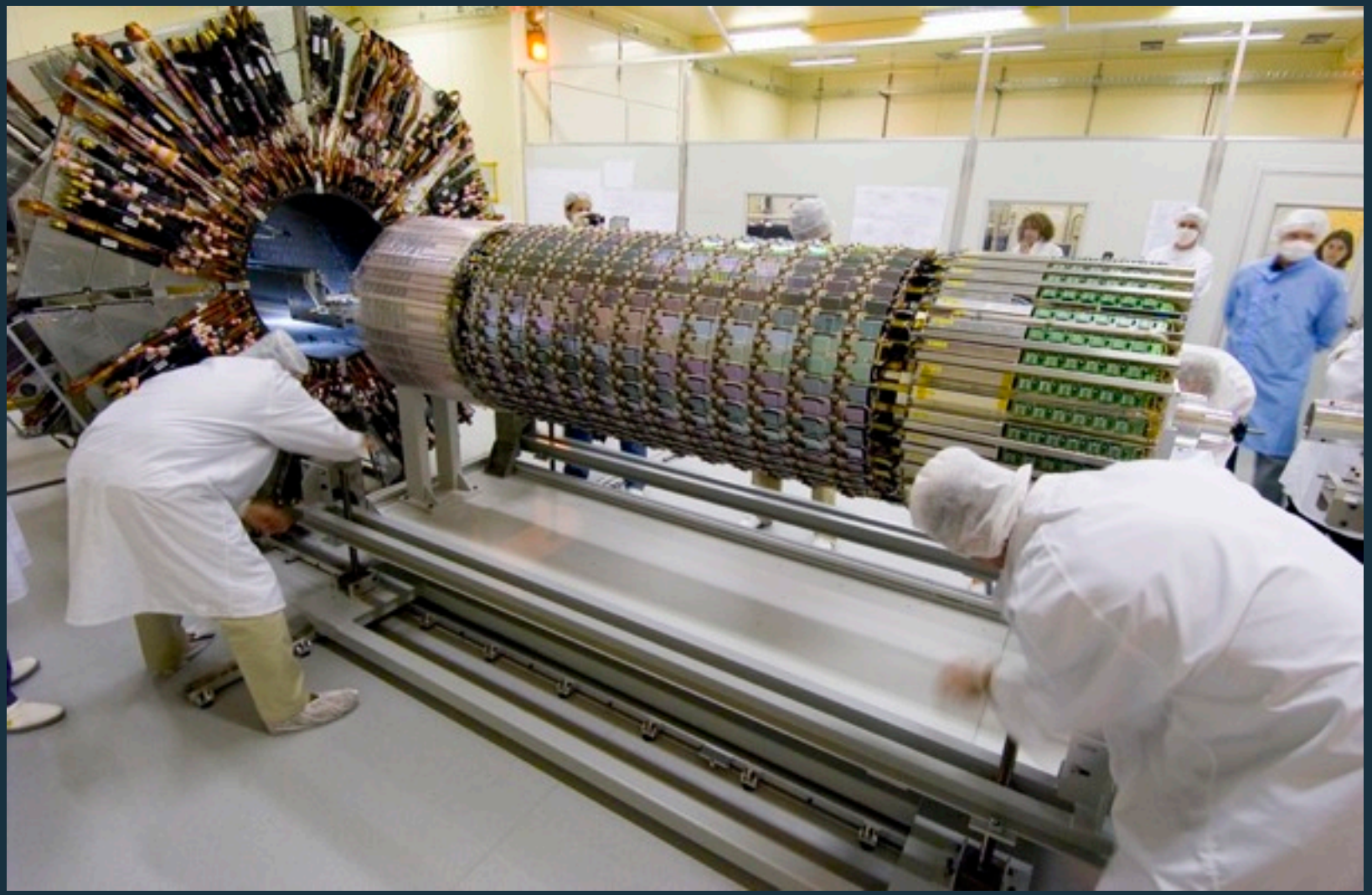
The Inner Detector

- Transition Radiation Tracker (TRT)
  - Radius 2 mm straw tubes
- Silicon Central Tracker (SCT)
  - 80 μm pitch Silicon strip detectors, 40 mrad stereo
- Pixel Detector
  - Silicon pixel detector 50×400 μm pixels



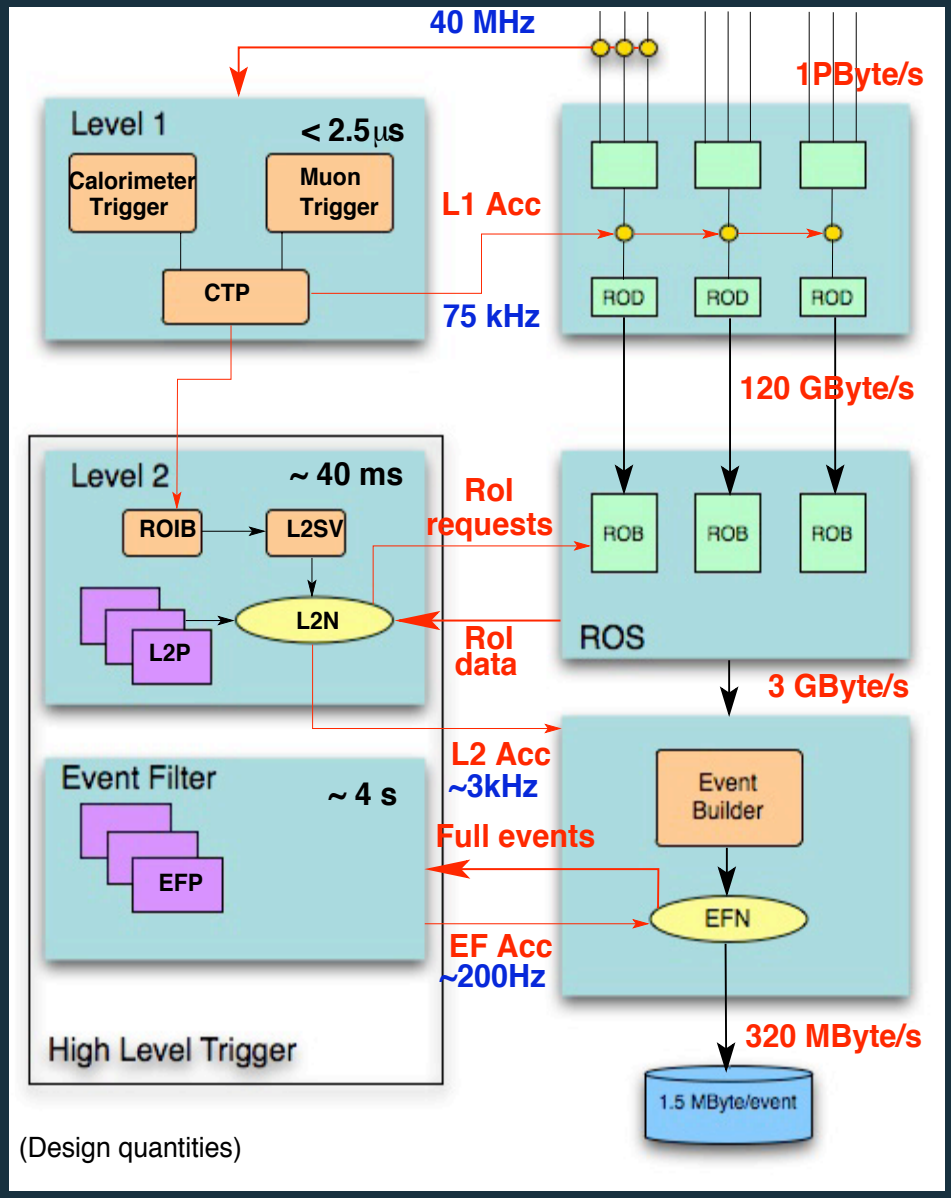


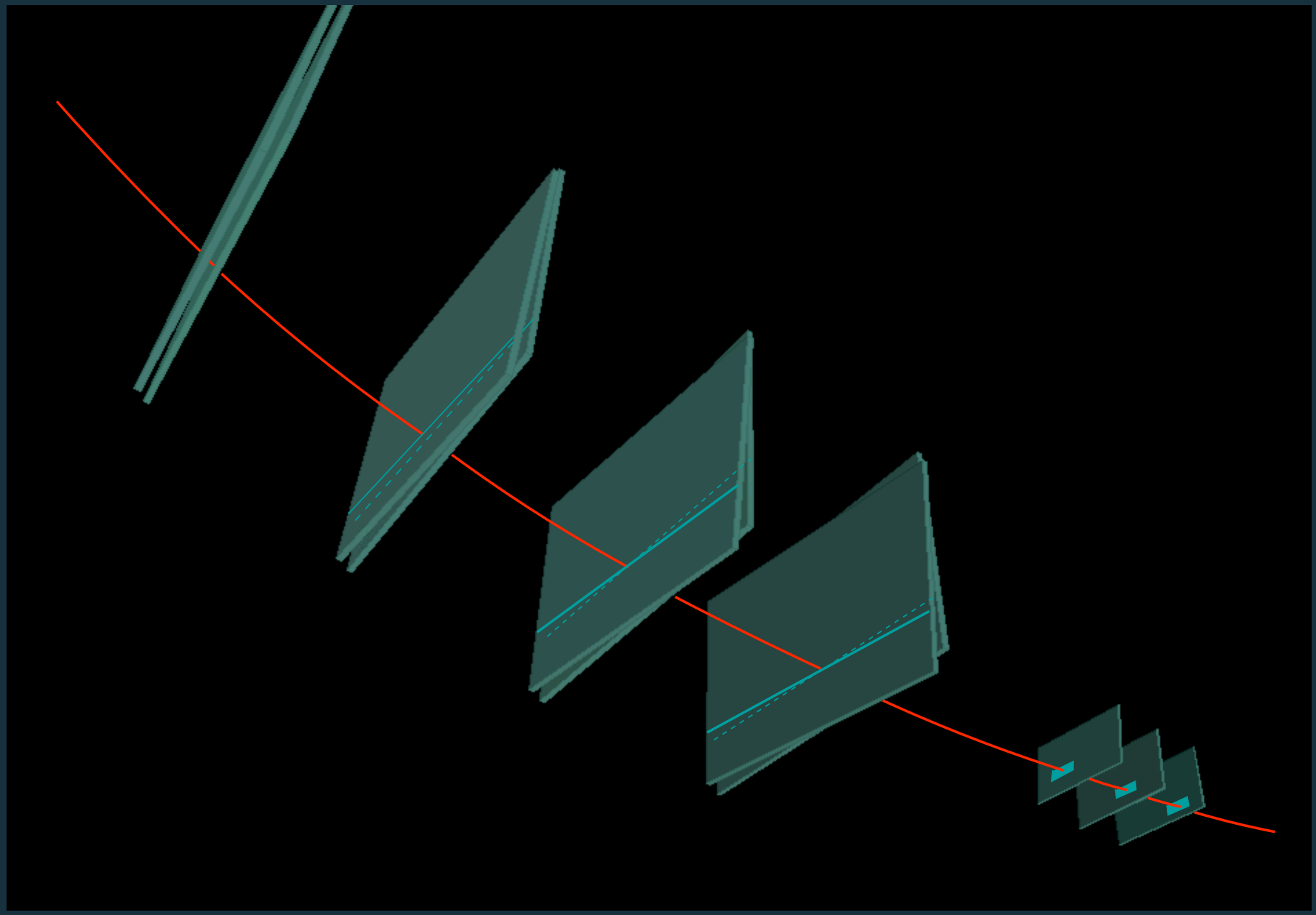
The ATLAS Semiconductor Tracker



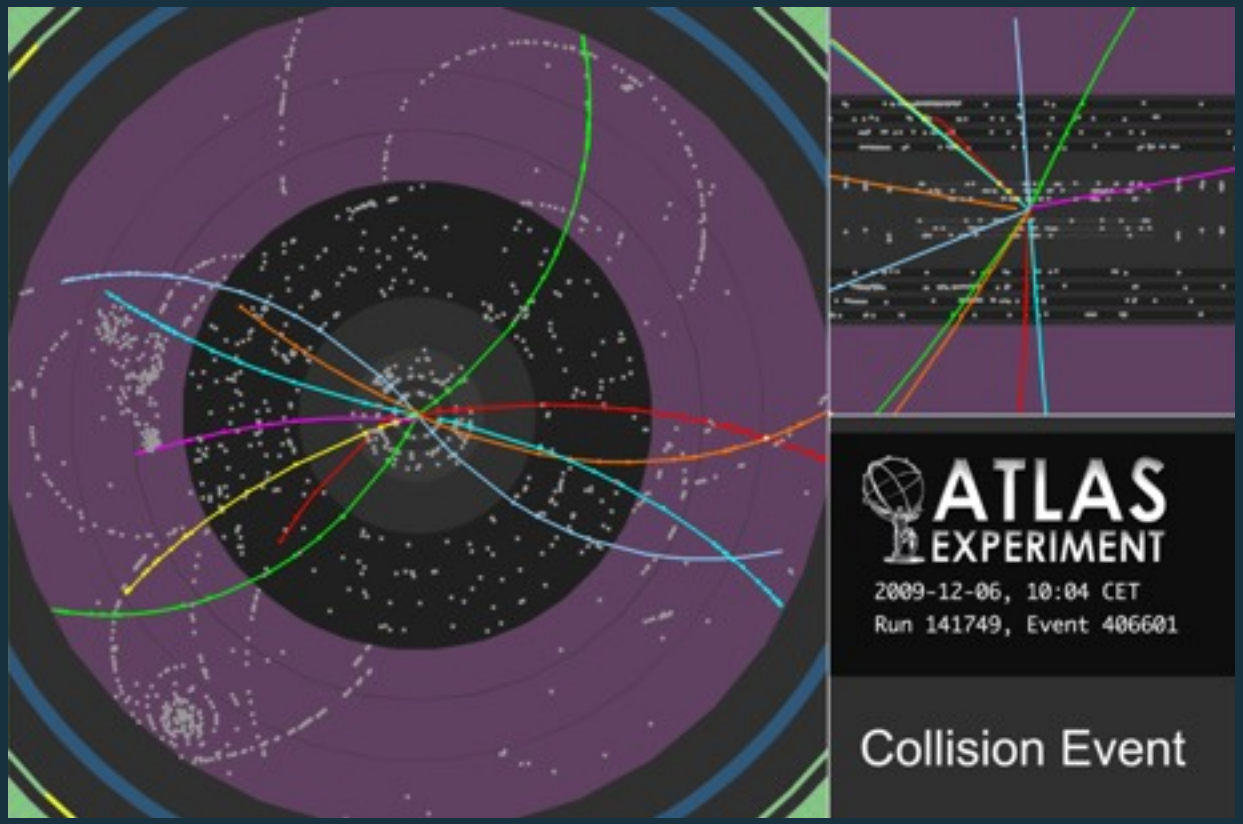
The ATLAS Trigger System

- Level 1
  - Hardware based, pipelined trigger, coarse granularity, largely Calorimeter and Muon system based.
  - 2.5 microsecond latency
- High Level Trigger - Level 2 and Event Filter
  - Software based, farms of commodity CPU's and ethernet
- Level 2
  - Seeded by Level 1 in Regions of Interest
  - Full detector granularity, all detector subsystems
- Event Filter
  - Seeded by Level 2
  - Access to complete event, reconstruction similar to Offline





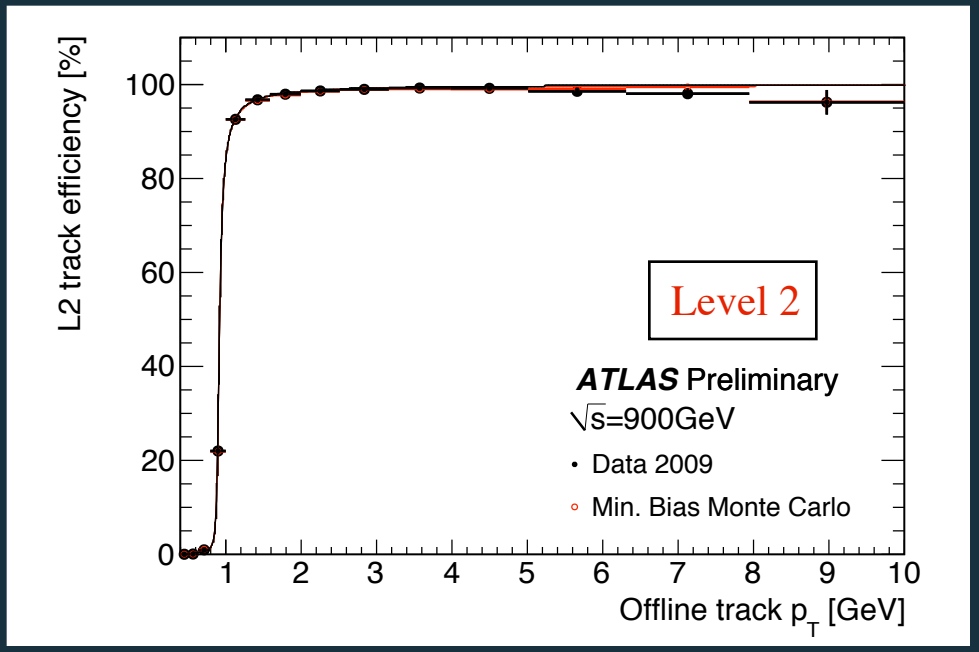
Track Selection

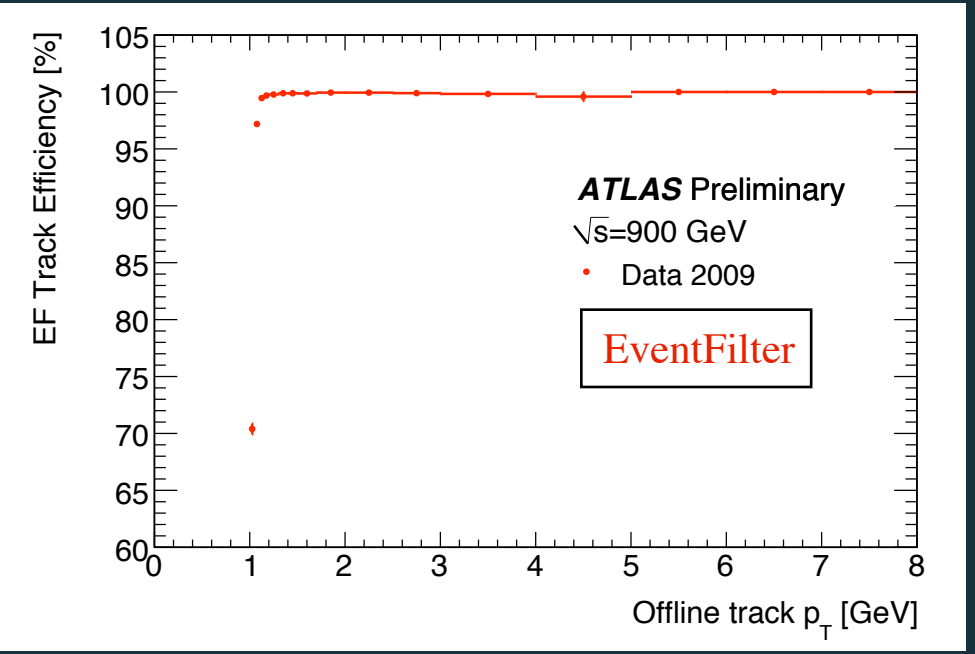


- Good Offline tracks were selected from collisions at 900 GeV taken in December last year
  - $|\eta| < 2.5$, $p_T > 1\text{GeV}$
  - Number of pixel hits > 0, Number of SCT clusters > 5

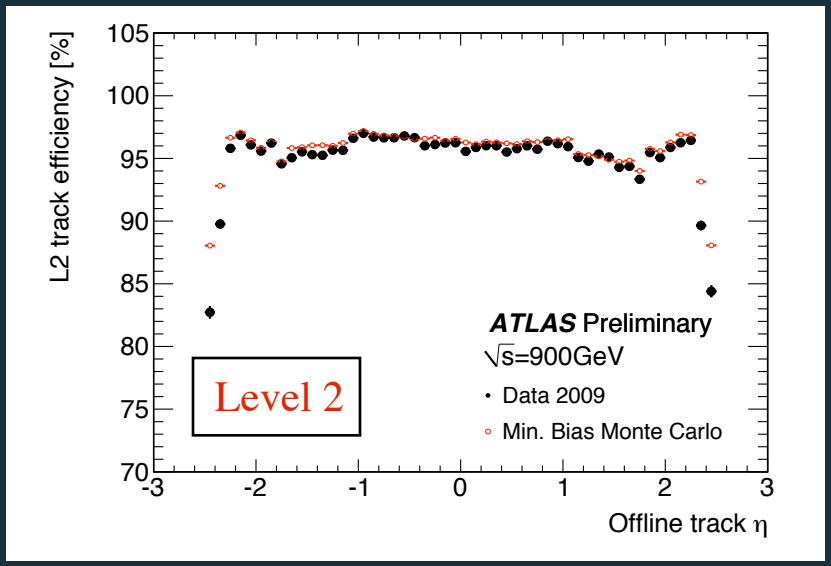
- The performance of the HLT Level 2 and EventFilter tracking was evaluated by matching with these selected Offline tracks.

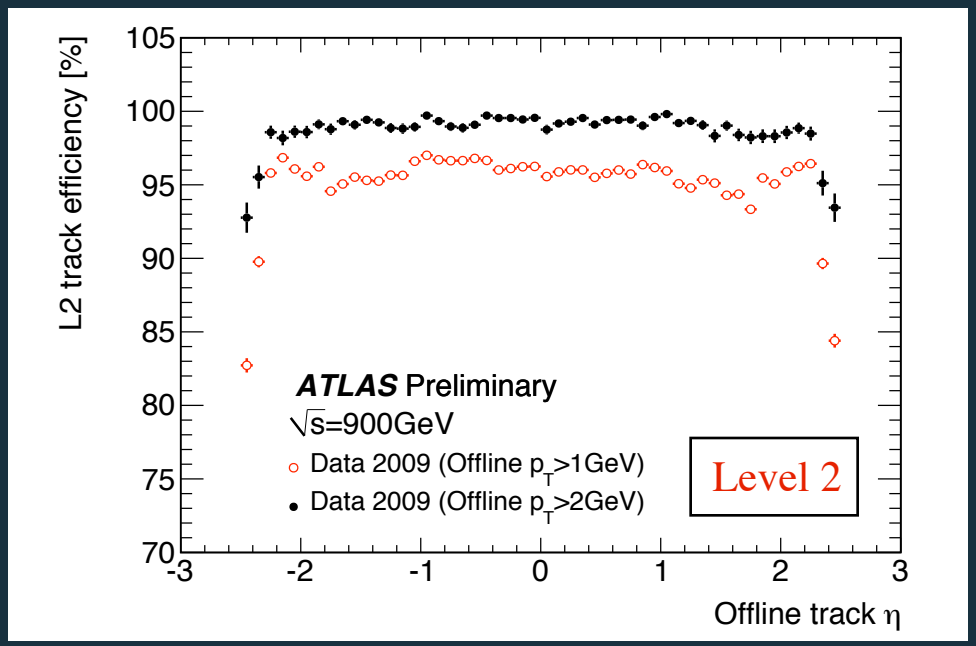
Efficiency versus Offline track p_T





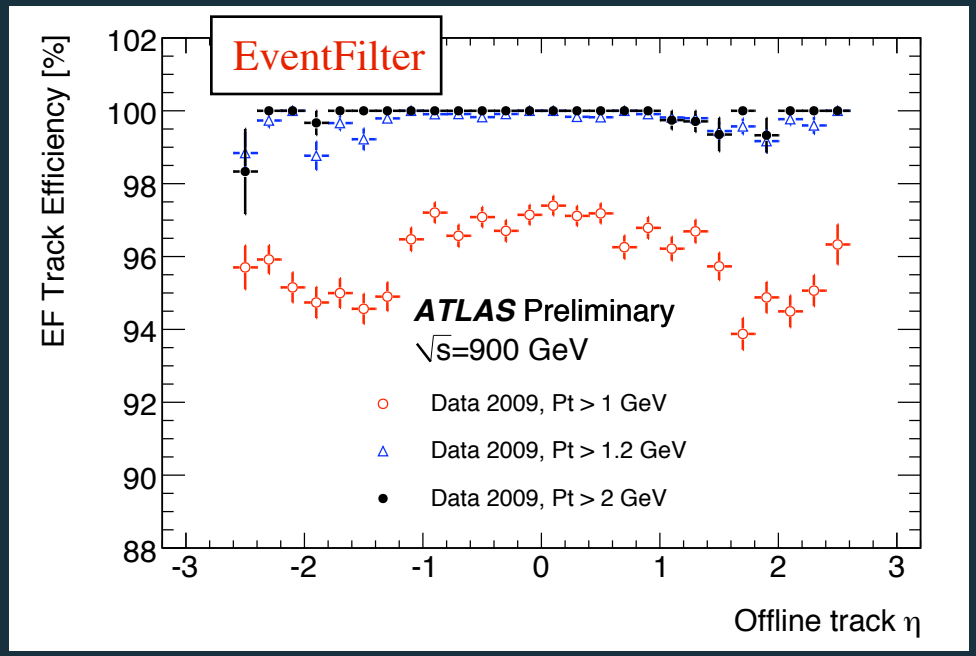
- Slight fall Level 2 efficiency at high p_T
  - due to loss at high $|\eta|$ in the Endcaps
  - barrel region flat for large p_T
- EventFilter plateaus near 100%



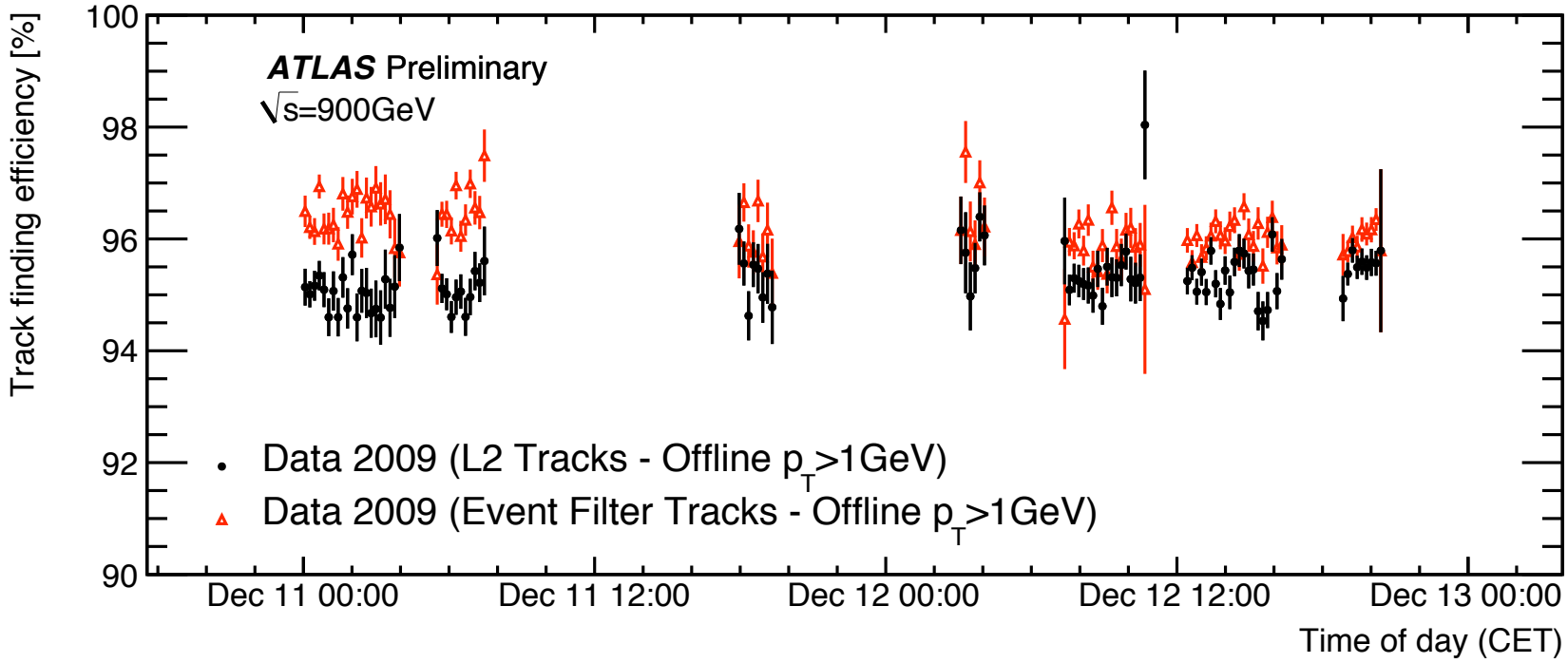


Efficiency versus Offline track η

- Loss of efficiency at large |η| due to hit losses in SCT Endcaps
- Well reproduced by the Monte Carlo, except at large |η|
- Reasonably flat efficiency versus η (EventFilter ~ 100% for p_T>1.2 GeV)

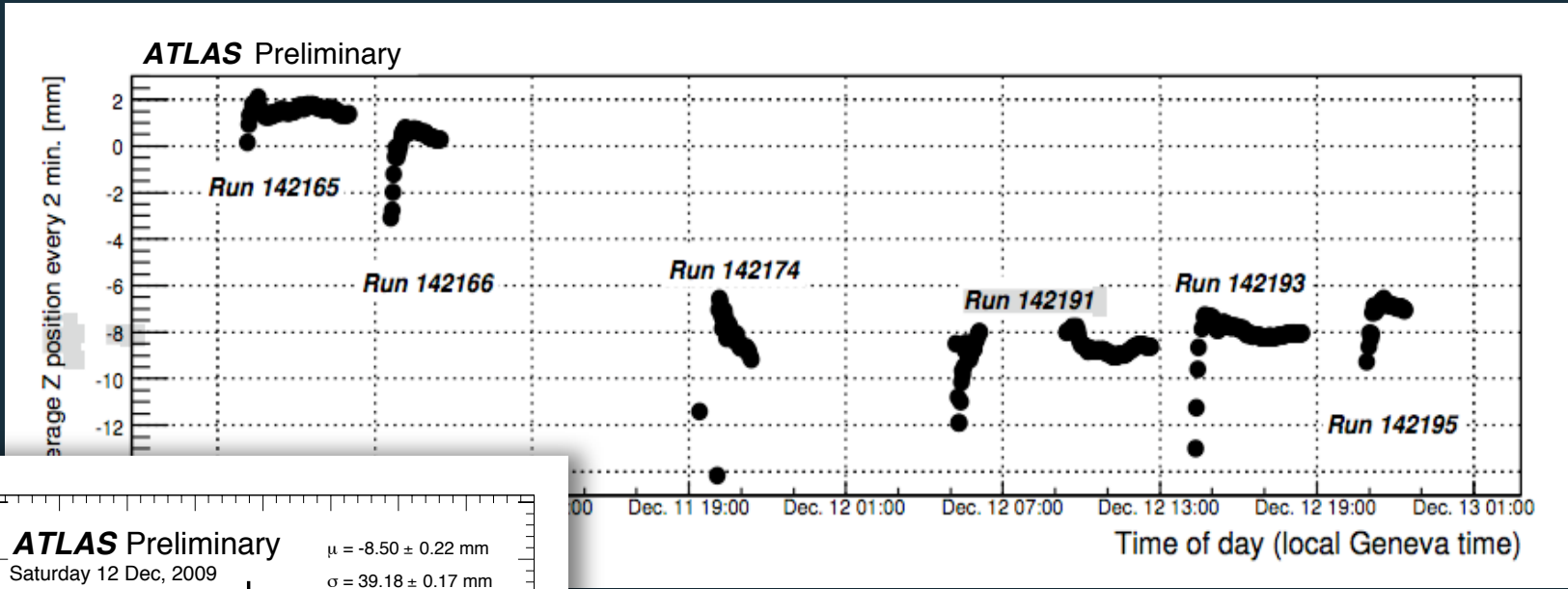


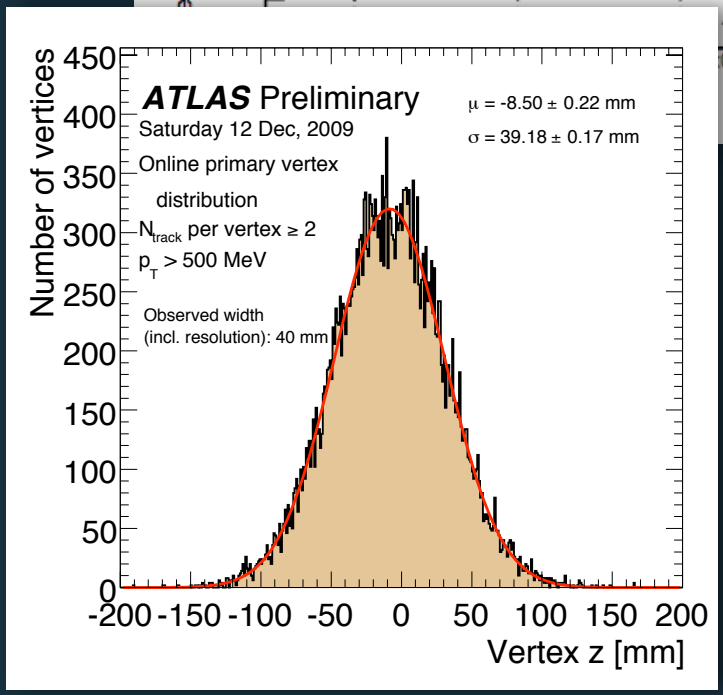
Efficiency vs time



- Good stability of trigger over time
- Small correlations between Level 2 and EventFilter,

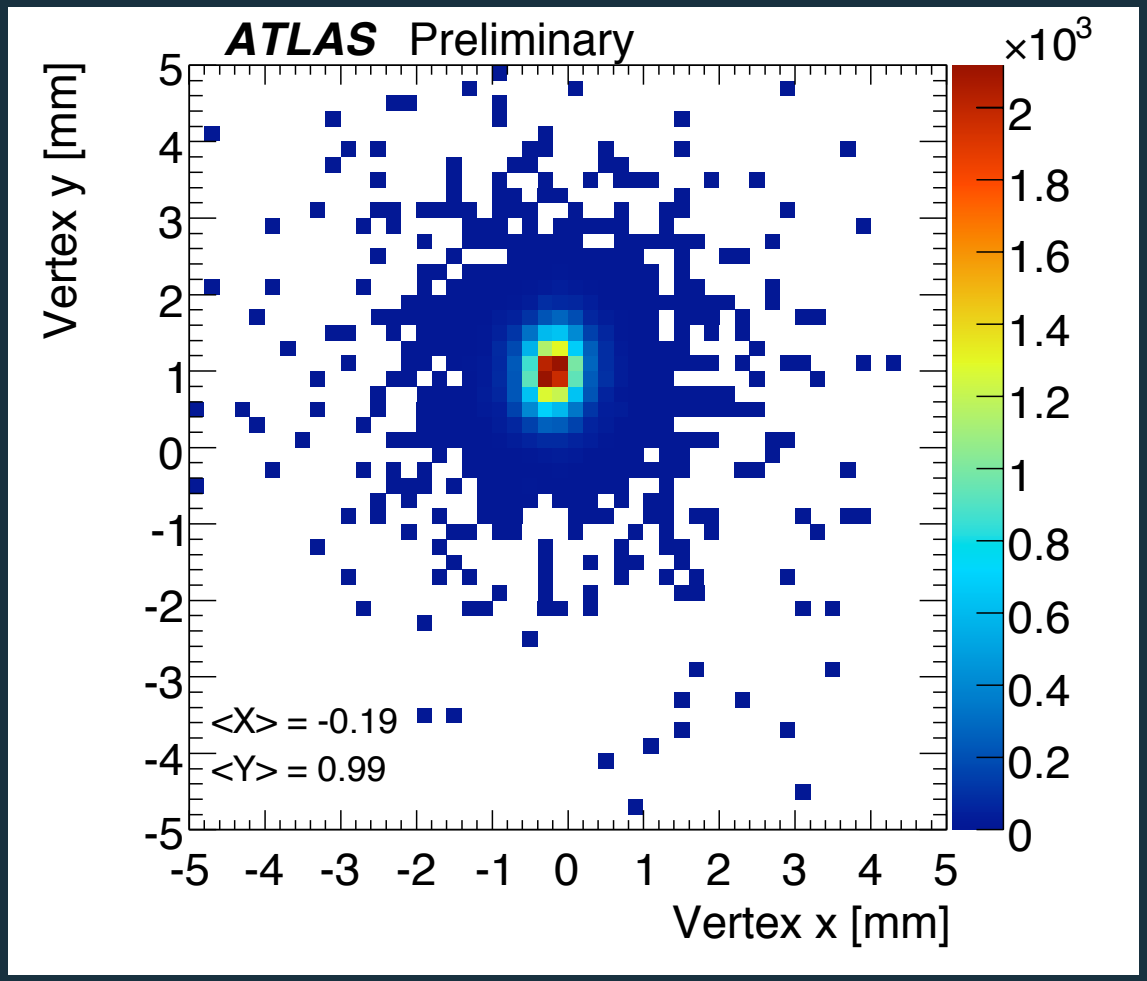
Online vertex reconstruction

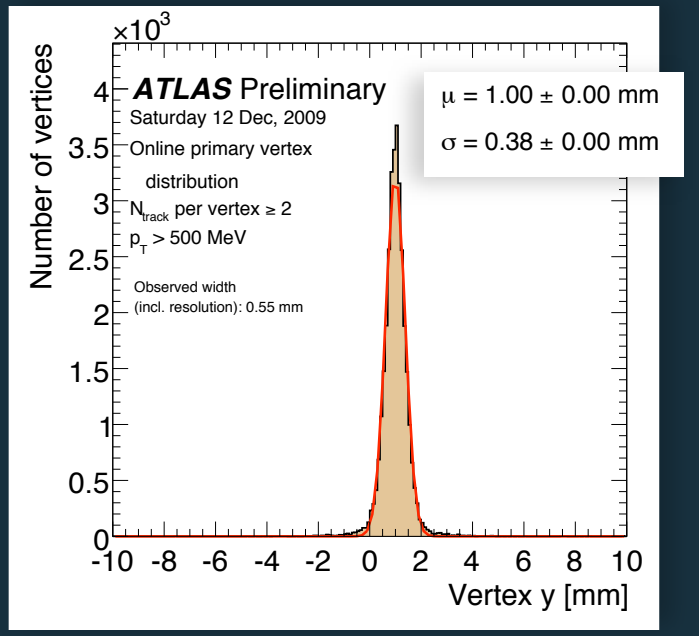


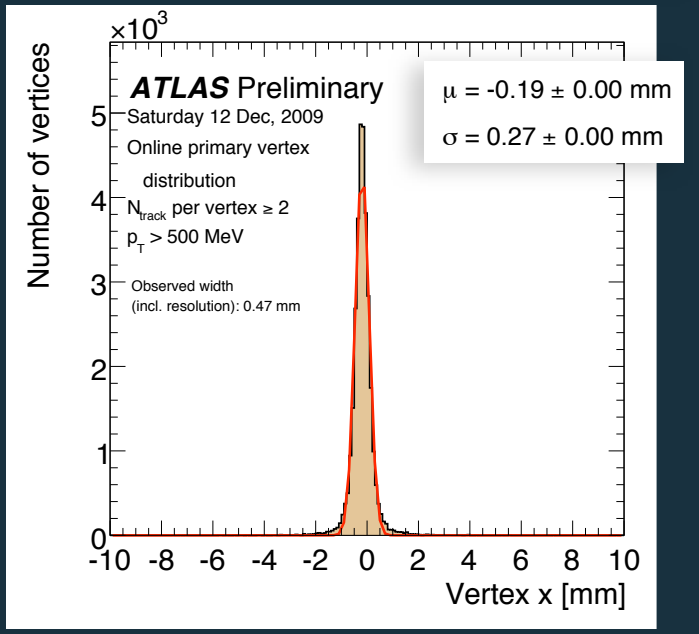


- Very good experience with 2009 data
- Accurate online determination of beamspot position, for real time feedback to the machine and other HLT algorithms (B-tagging etc)
- Vertex counting for luminosity measurement also available

Transverse position at 900 GeV

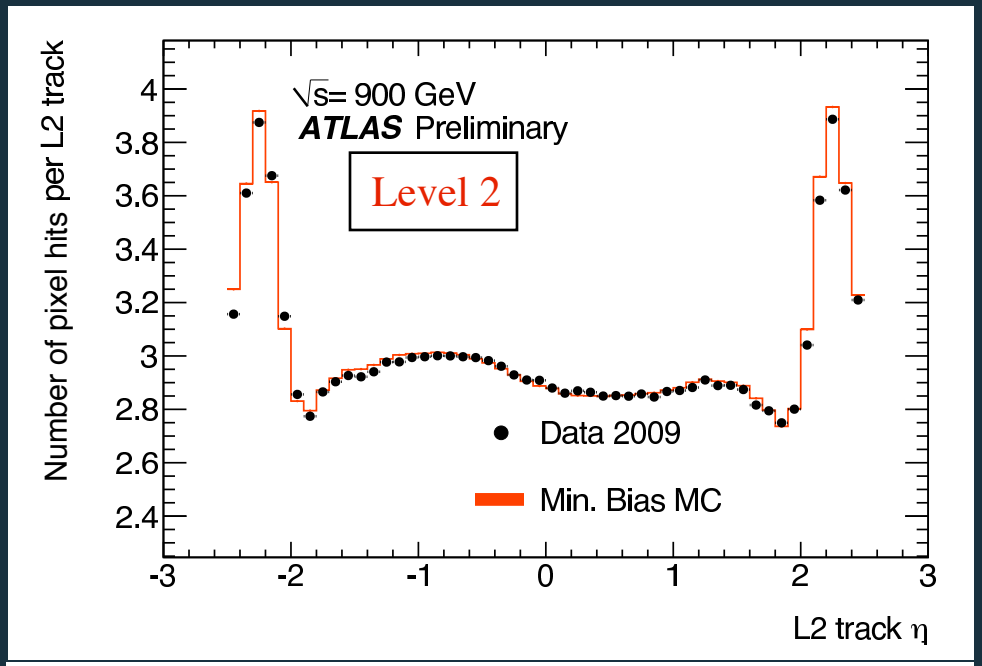


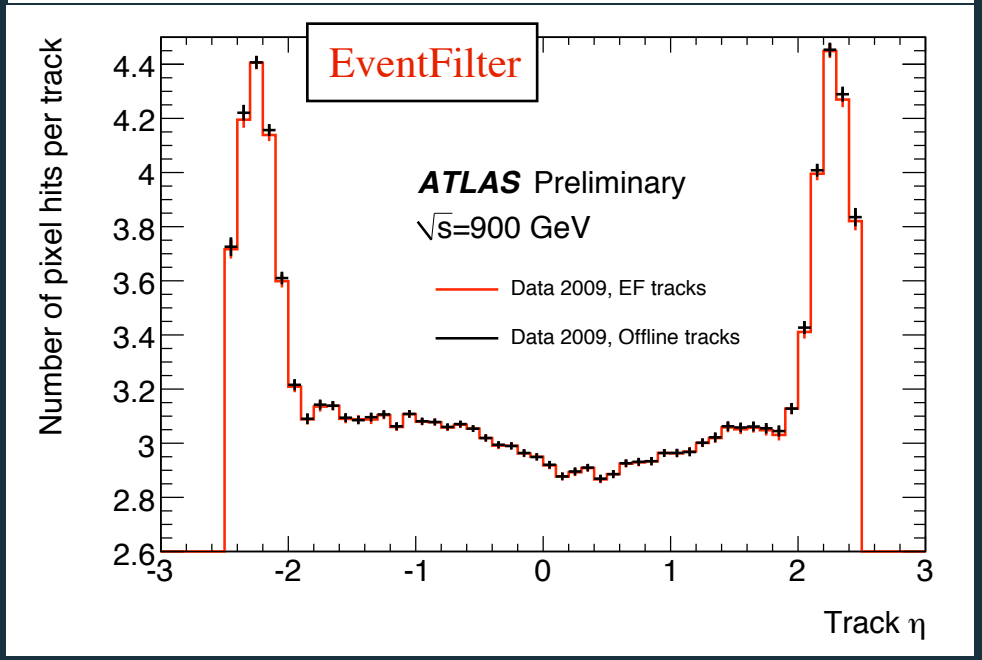




- Accurate position in the transverse plane

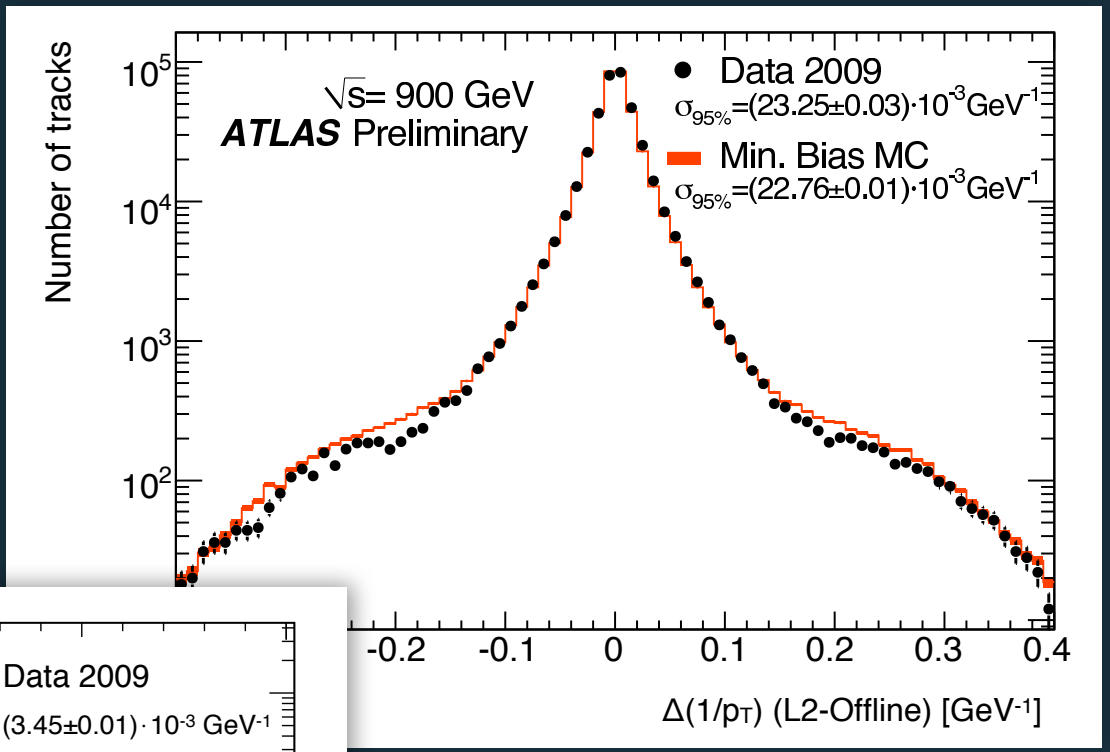
Pixel hit multiplicities

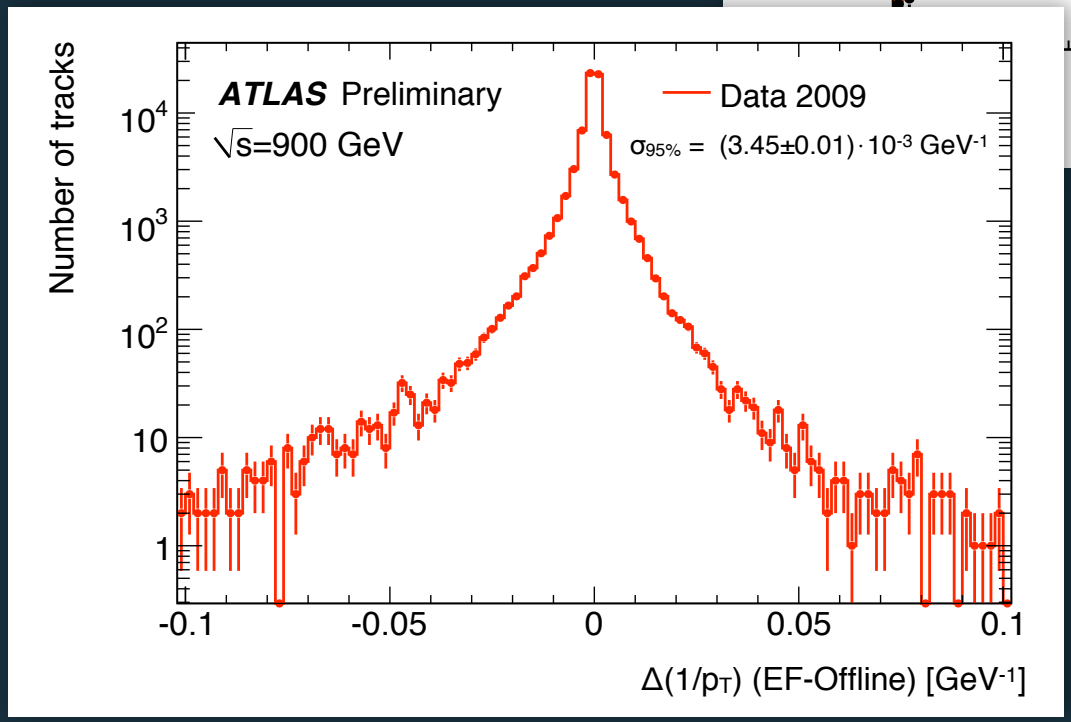




- Mean number of Pixel clusters on tracks in each η bin
- Data well described by the Monte Carlo, including small number of dead Pixel modules
- EventFilter reproduces Offline very well

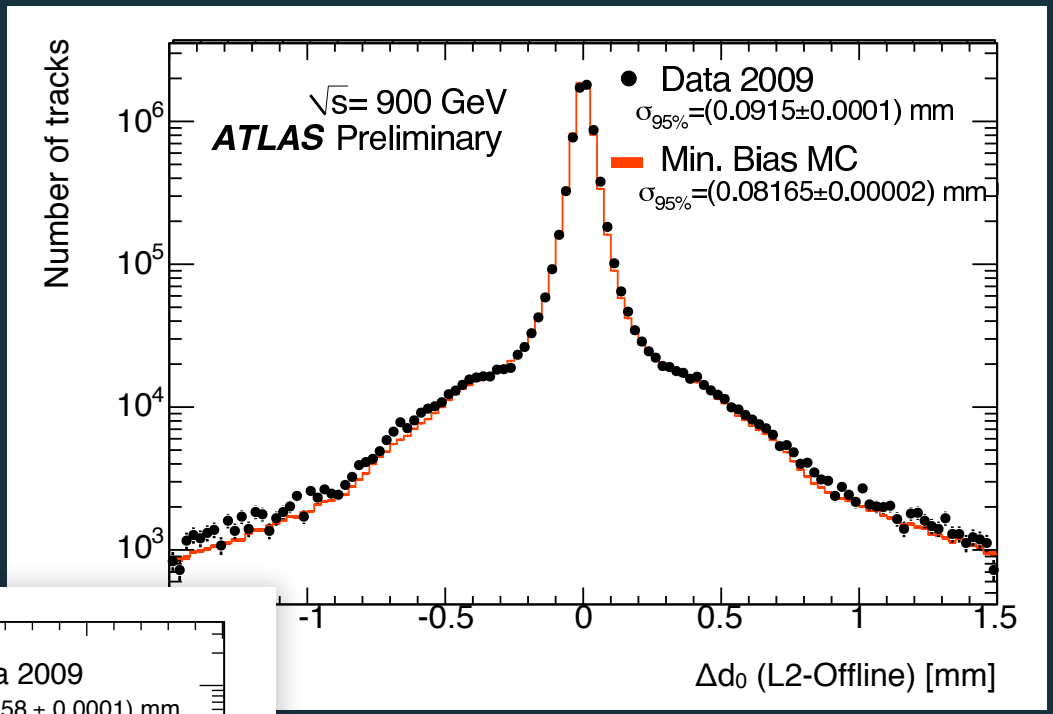
Resolution with respect to Offline track $1/p_T$

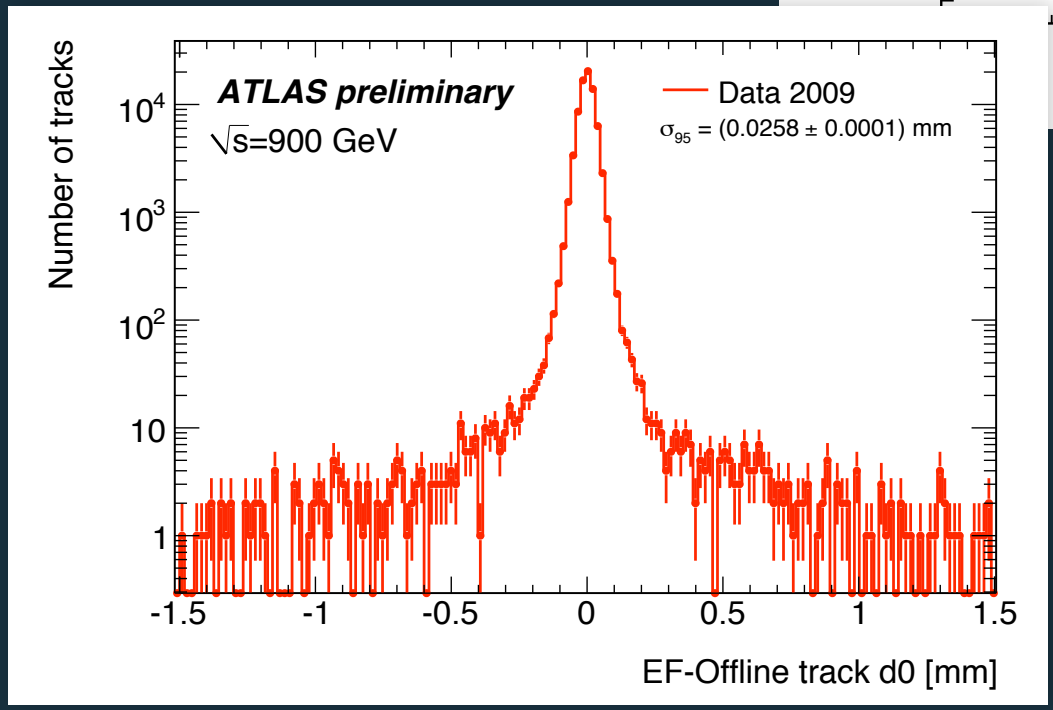




- Note different axis scale
- General good agreement with Monte Carlo, except in tails
- Level 2 performance approaches that of EventFilter at high p_T

Resolution with respect to Offline track impact parameter





- EventFilter within about 25μm of the Offline
- Level 2 within about 90μm for these mainly low p_T tracks, but approaches EventFilter performance at high p_T

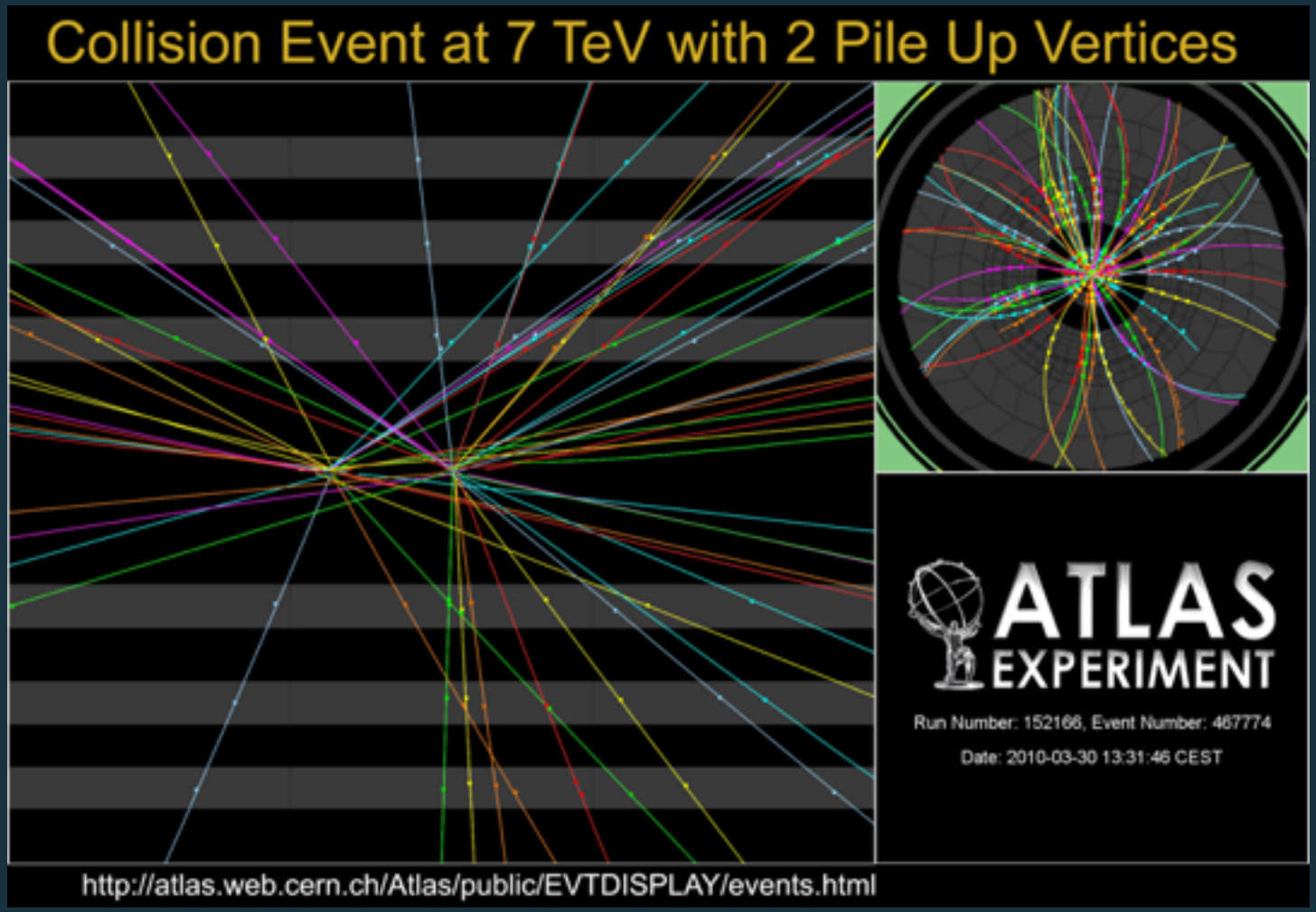
Summary and Outlook I

- The ATLAS HLT tracking algorithms ran successfully during data taking with pp collisions in December 2009.

- During this first period of data taking, the L2 tracks were used successfully to provide an accurate online determination of the LHC beam position and interaction region in ATLAS.

- Comparing with reference tracks reconstructed by the Offline tracking, the performance of the HLT tracking algorithms is very good and remarkably well described by the Monte Carlo.

Summary and Outlook II



- Have seen the first collisions at 7 TeV and look forward to studying the performance at even higher transverse momenta - have already seen events with pileup and tracks with p_T around 50 GeV.