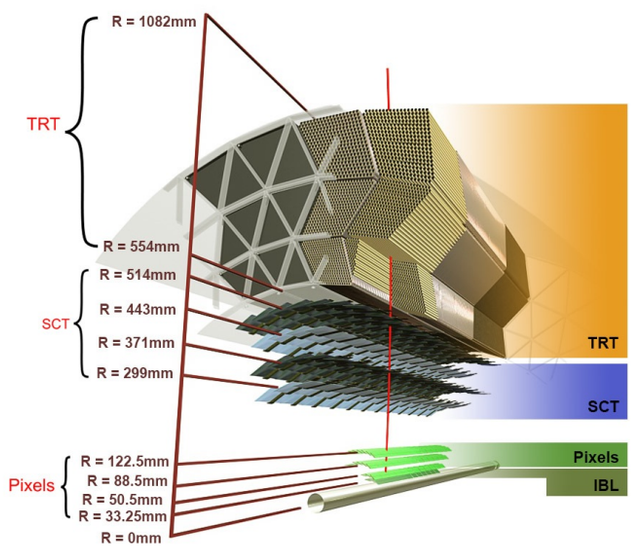
ICHEP 2016, Chicago, 3rd-10th August

THE DESIGN AND PERFORMANCE OF THE ATLAS INNER DETECTOR TRIGGER FOR RUN 2 LHC COLLISIONS AT 13 TEV

The LHC Run 2 provides an increase in energy and luminosity. More rapid and accurate event reconstruction in the trigger systems are at the heart of data taking. The ATLAS Inner Detector is the ATLAS sub-system nearest the beam pipe and is used to reconstruct charged particle tracks. The Inner Detector Trigger rapidly and efficiently reconstructs tracks used in the selection of physics objects for all trigger signatures.

ATLAS INNER DETECTOR AND THE TRIGGER

- The Inner Detector (ID) is comprised of pixel- and strip-based silicon detectors and gas filled straw tubes (TRT) used to detect charged particle hits, with spatial resolutions ranging from 10 to 130 μm
- The Insertable B-Layer (IBL): innermost pixel layer added for Run 2 significantly improves tracking and vertex reconstruction [1]
- The trigger systems must reduce the rate from the 40 MHz input rate to < 1 kHz output, without losing interesting events
- The ID trigger rapidly reconstructs tracks used in the selection of physics objects (electrons, muons, taus, *b*-jets etc) in the trigger systems, for use in the overall trigger decision to retain events to be stored offline



LHC RUN 2

	RUN 1	RUN 2
E_{CM}	7/8 TeV	13 TeV
PEAK LUMINOSITY	$7 \cdot 10^{33}$ cm^{-2} s^{-1}	$2 \cdot 10^{34}$ cm^{-2} s^{-1}
BUNCH SEPARATION	50 ns	25 ns
# INTERACTIONS PER BUNCH CROSSING	~ 21	~ 55
DETECTOR INPUT RATE	20 MHz	40 MHz

Faster data processing is required, and the amount of data per collision to be processed has increased

TRIGGER ARCHITECTURE UPGRADE

RUN 1

LEVEL 1 (L1)
- Hardware based
- No ID
- < 2.5 μs decision
- 70 kHz peak output
- Low detector granularity

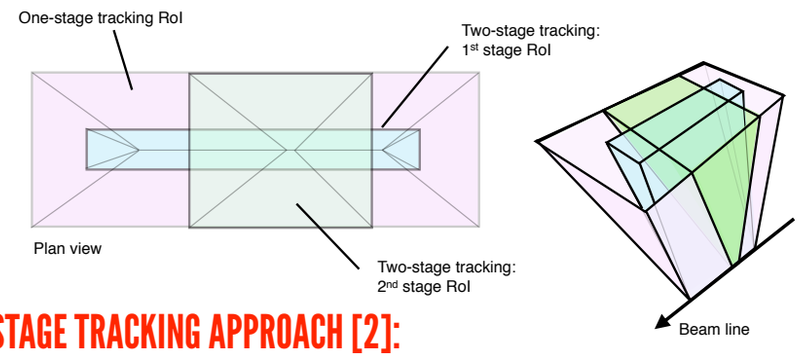
LEVEL 2 (L2)
- Software based
- Fast tracking with ID
- ~75 ms average decision
- 6.5 kHz peak output
- Full detector granularity

EVENT FILTER (EF)
- Software based
- Offline style tracking
- ~1 s average decision
- 0.7 kHz peak output
- Full detector granularity

RUN 2

LEVEL 1 (L1)
- Upgraded hardware
- < 2.5 μs decision
- 100 kHz output
- New topological trigger (L1Topo) for combined object, event level triggering

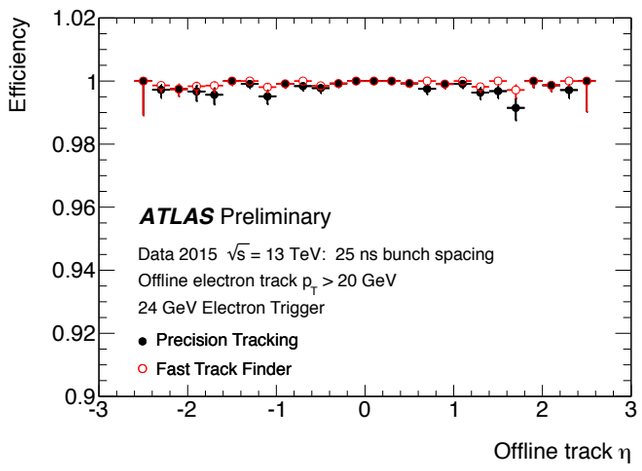
HIGH LEVEL TRIGGER (HLT)
- Merged L2 and EF, to prevent repeated data access and processing
- ~200 ms average decision
- 1 kHz output
- Pre-HLT tracking stage, Fast Tracker (FTK) — commissioning ongoing through 2016-2017
- L2 style FastTrackFinder algorithm
- EF style Precision Tracking algorithms
- Single PC farm, single node per event

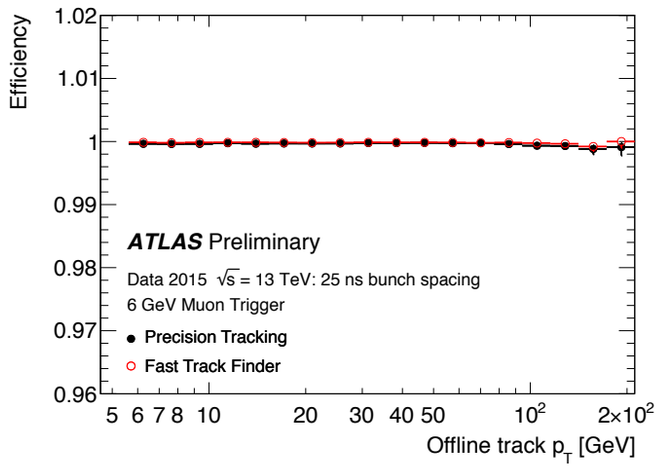


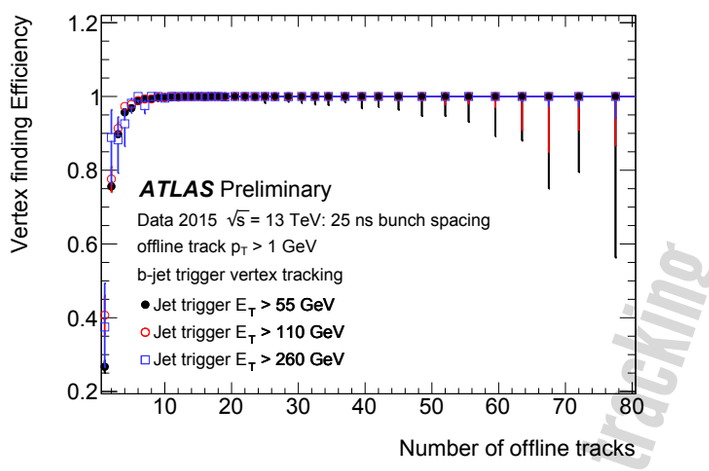
TWO-STAGE TRACKING APPROACH [2]:

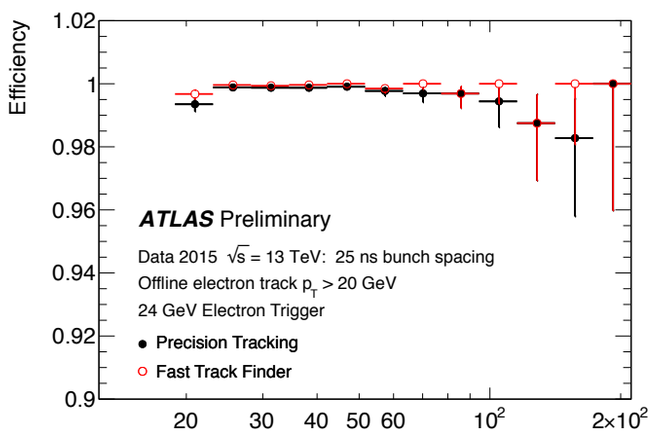
- Run Fast Track Finder within long but narrow first-stage Region of Interest (RoI) to identify leading tracks
- Select leading track to seed second-stage RoI with increased angular width about the leading track
- Reconstruct Precision Tracks in second-stage RoI — significantly smaller volume compared to the single-stage RoI approach from Run 1
- Used for taus and *b*-jets triggers

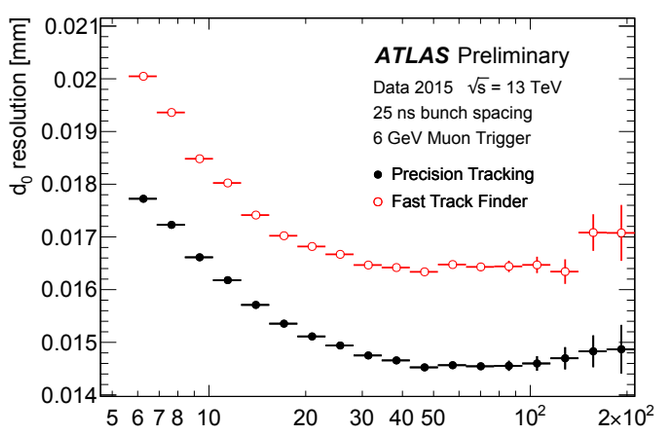
PERFORMANCE RESULTS FROM RUN 2 DATA

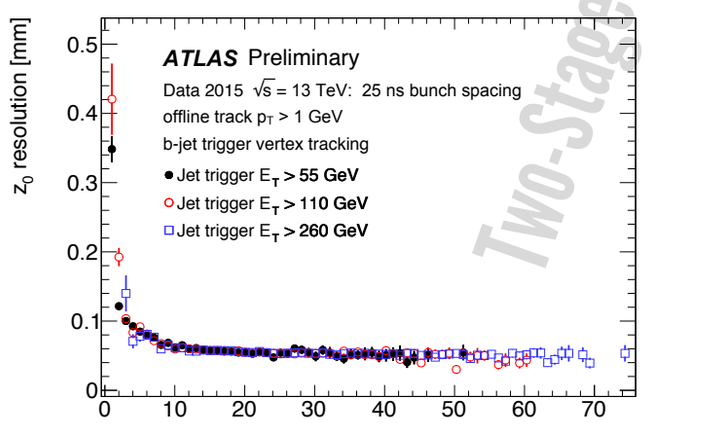












The tracking efficiency for an electron trigger with respect to offline tracks from well reconstructed electron candidates reconstructed offline. The closest matching trigger track within a certain cone of the offline reconstructed track is selected as the matching trigger track and the efficiency is shown as a function of the η (top) and p_T (bottom) of the offline track. In both cases the fast track finder efficiency is better than 98% across the full range.

The efficiency (top) is significantly better than 99% for all p_T for both the fast and precision tracking. The resolution (bottom) of the transverse impact parameter with respect to the beam-line reconstructed in the trigger, using tracks reconstructed offline as a reference, as a function of the offline muon p_T is better than 15 μm for muon candidates with offline p_T > 20 GeV.

The vertex finding efficiency (top) with respect to offline vertices is shown as a function of the number of offline tracks with p_T > 1 GeV that lie within the size of the wider Region of Interest (RoI) from the selected jets in jet events with at least one jet with transverse energy above 55, 110, or 260 GeV and with no additional *b*-tagging requirement. The efficiency rises sharply and is above 90% for vertices with three or more tracks, and rises to more than 99.5% for vertices with five or more tracks. The resolution (bottom) in z with respect to the offline z position is better than 100 μm for vertices with four or more reconstructable offline tracks and improves to 60 μm for vertices with ten or more reconstructable offline tracks.

Fabrizio Miano (University of Sussex), on behalf of the ATLAS Collaboration

All refs. From ATLAS Collaboration:
[1] Tech. Rep. ATL-PHYS-PUB-2015-018, [2] 'HLT Tracking Public Results', 2016, url: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HLTTrackingPublicResults

ATLAS EXPERIMENT