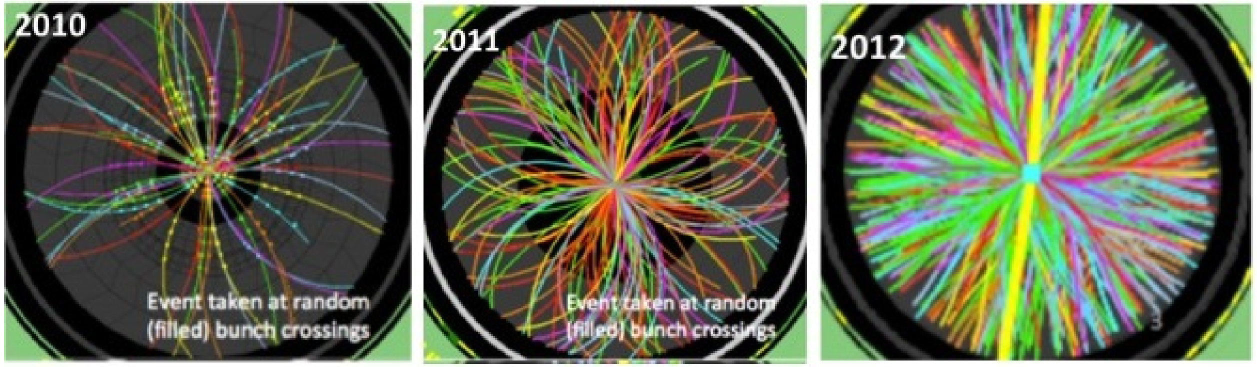


. . .?

Detector Performance Challenges in Run 2 – ATLAS –

Peter Wagner
Universität Bonn

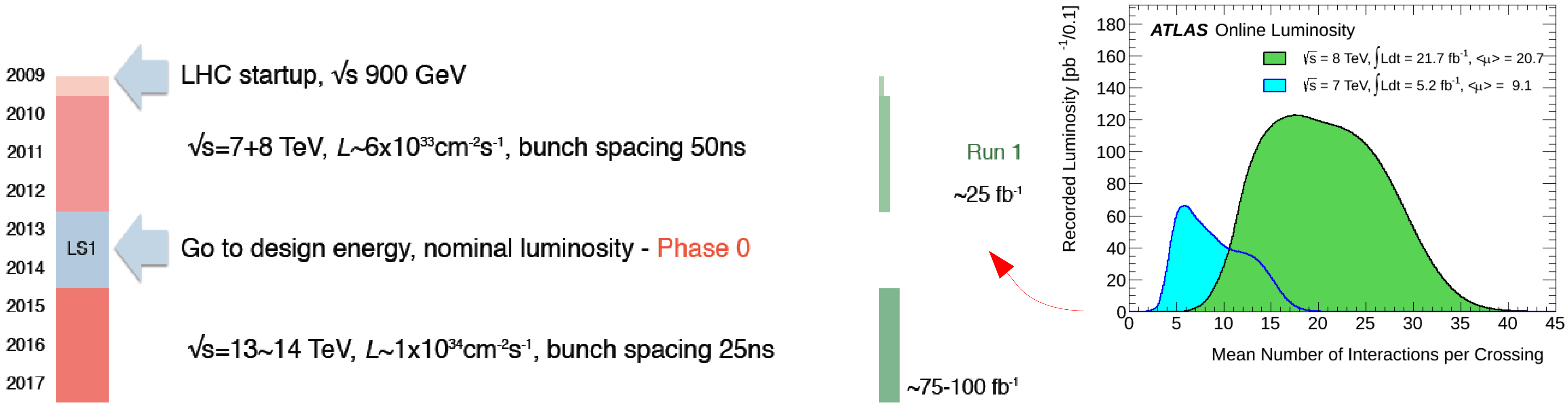
On behalf of the ATLAS Collaboration

universitätbonn

Overview

- Run 2 conditions
- ATLAS Detector upgrades
- Challenges and preparations reported by the performance groups
- Conclusions

Luminosity & Hardware Upgrades



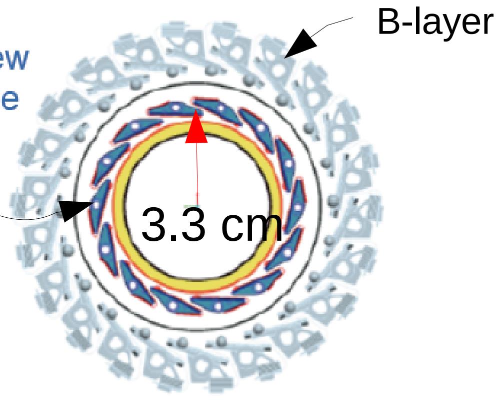
→ in Run 2:

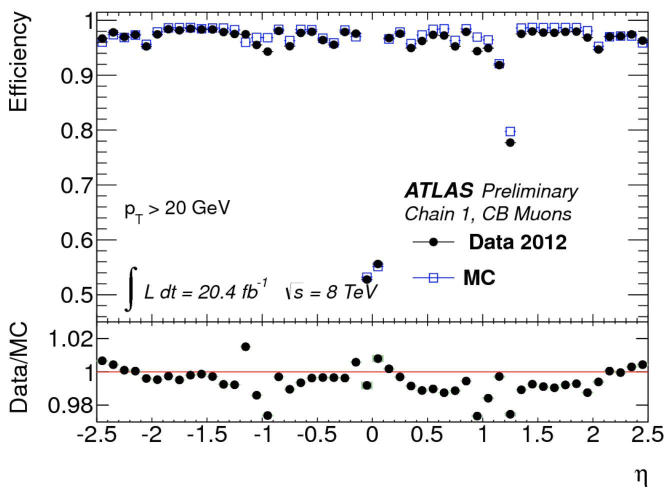
- Center-of-mass energy up by factor ~2 → can probe heavier resonances
- Pile-up expected to be reduced initially compared to Run 1, eventually going up to <μ> ~ 40 (factor ~2 higher than Run 1)

Goal: Maintain at least same performance as current detector

Hardware Upgrades & Consolidation

- Fourth (innermost) Pixel detector layer ("IBL") being installed during current shutdown
- Will improve tracking, vertexing and b-tagging performance



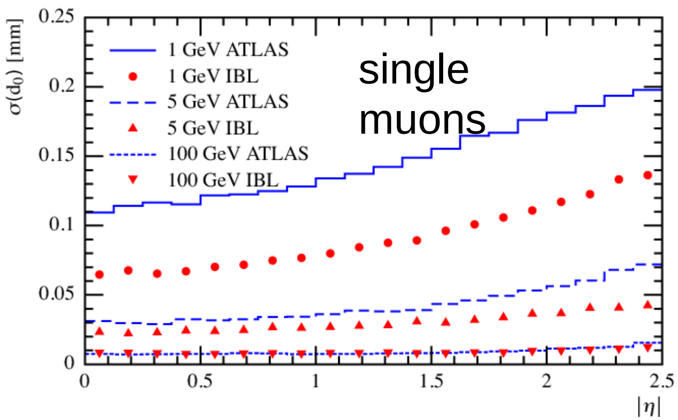


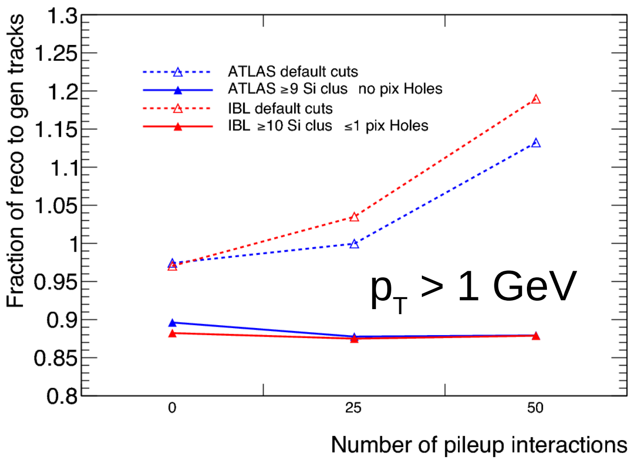
ATLAS Upgrade talk @ LHCP

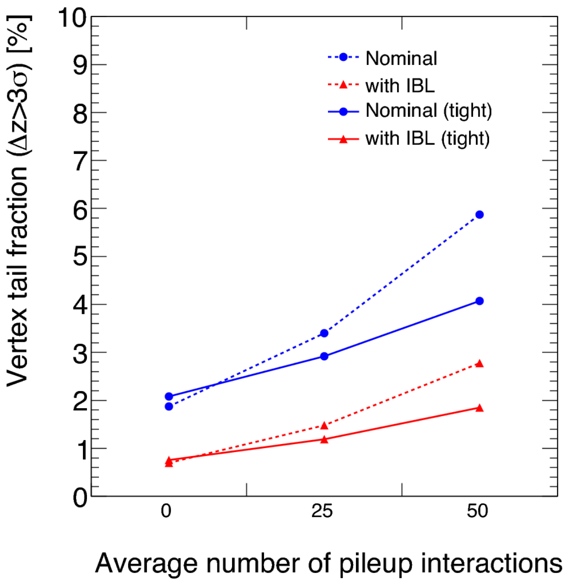
- Installation of muon chambers at $1.0 < |\eta| < 1.3$ to recover lower efficiency
- New hardware-trigger component for Run 2: "Fast Tracker"
- Other trigger & software upgrades shown in upcoming talks

Tracking Performance

- IBL improves esp. track position measurement at vertex → improves fake track rejection and vertexing performance
- Need to retune track quality cuts and re-commission Inner Detector alignment
- Working on new vertexing algorithm to improve reconstruction of nearby vertices
- Probe heavier resonances ⇒ higher-p_T decay particles: Work ongoing to improve tracking efficiency in dense environments (high-p_T jets, b- and τ-decays)
- More pile-up ⇒ more tracks: Need to watch CPU timing of reconstruction and event data size



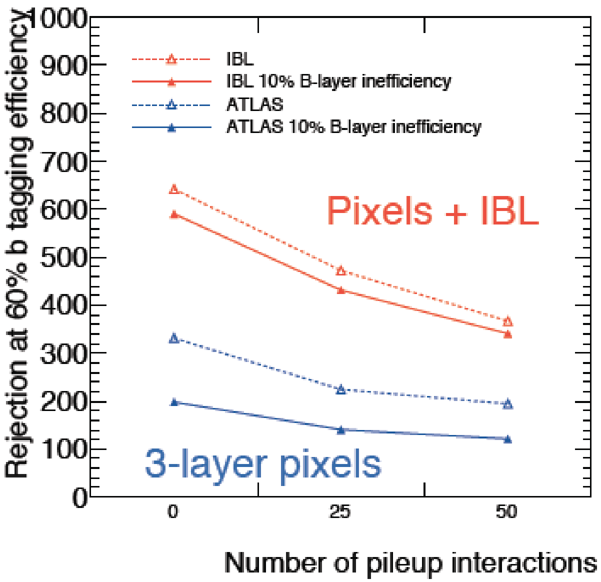




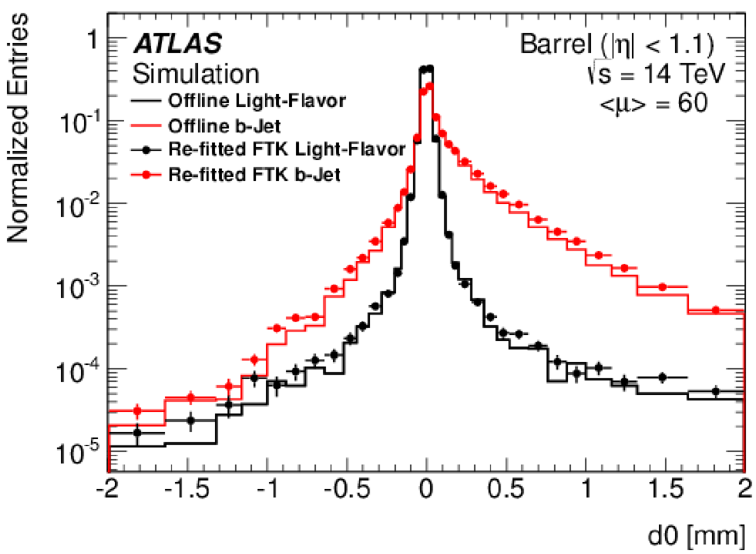
CERN-LHCC-2010-013

Flavor Tagging Performance

- IBL improves b-tagging performance
- Re-optimization of b-tagging algorithms for inclusion of IBL and higher pile-up
- Improve high-p_T tagging in close coordination with tracking group: optimizing algorithms for decays before and after first pixel layer
- New “Fast Track” trigger:
  - Improves b-tagging performance at trigger level
  - Permits tagging at much larger trigger rate ⇒ can lower jet p_T requirement



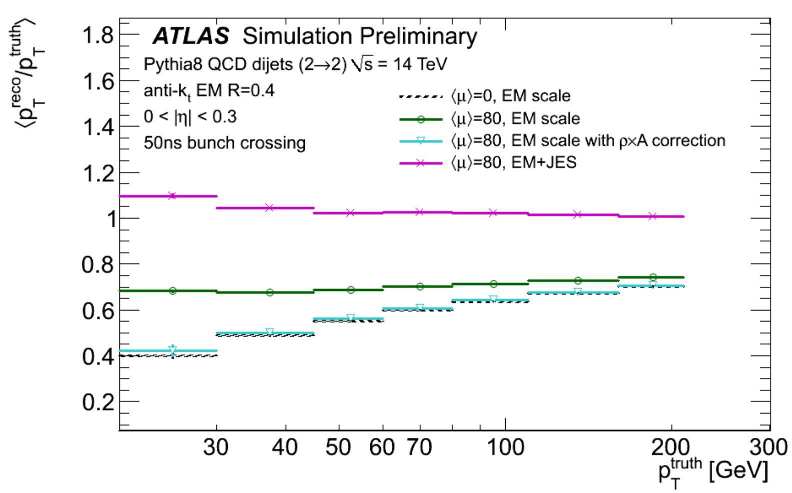
CERN-LHCC-2010-013



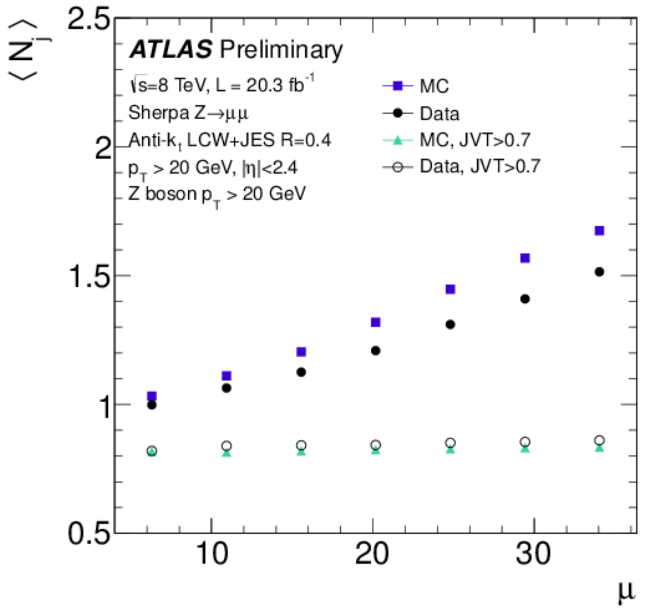
FTKPublicResults twiki

Jets and Missing-E_T Performance

- Jet response without pile-up largely restored with higher noise thresholds and pile-up subtraction based on jet area
- Reject pile-up jets using an MVA with track and vertex information, e.g. requiring minimum track-p_T fraction to come from hard-scatter vertex
- Also being studied: particle flow jet reconstruction → less sensitive to local pile-up fluctuations



JetEtmissApproved2013HighMuPileup twiki



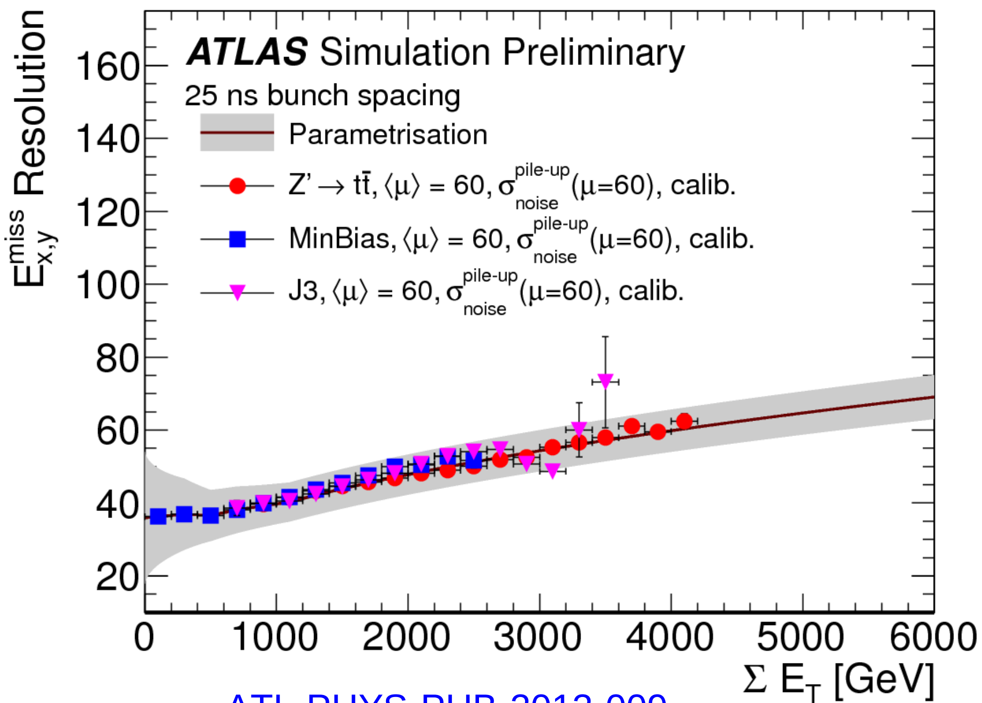
ATLAS-CONF-2014-018

Jets and Missing-E_T Performance

EtMiss = calibrated physics objects + tracks and clusters not associated to objects

- Pile-up suppression using tracks: Use only tracks for unmatched objects

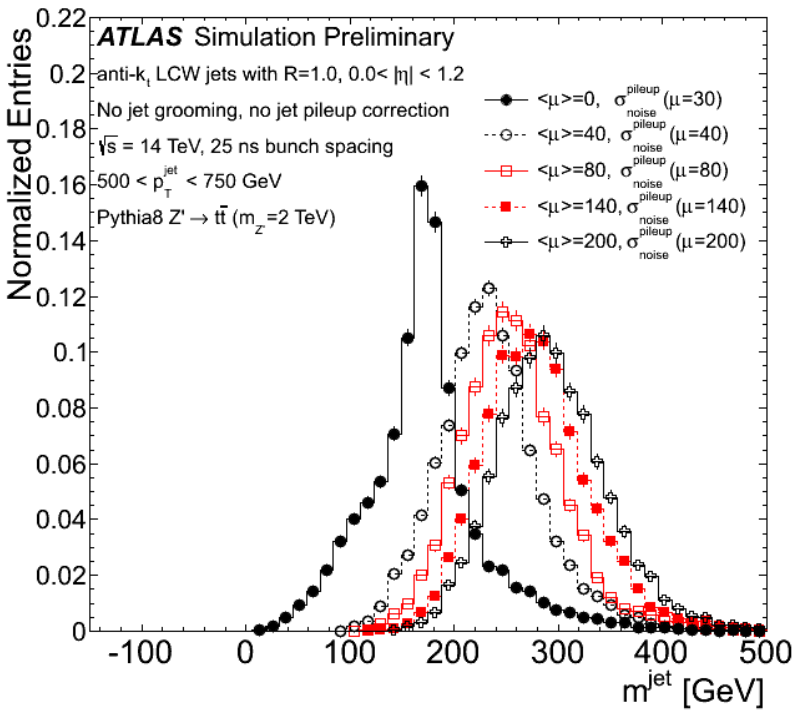
Note: Plot uses calorimeter clusters for unmatched objects

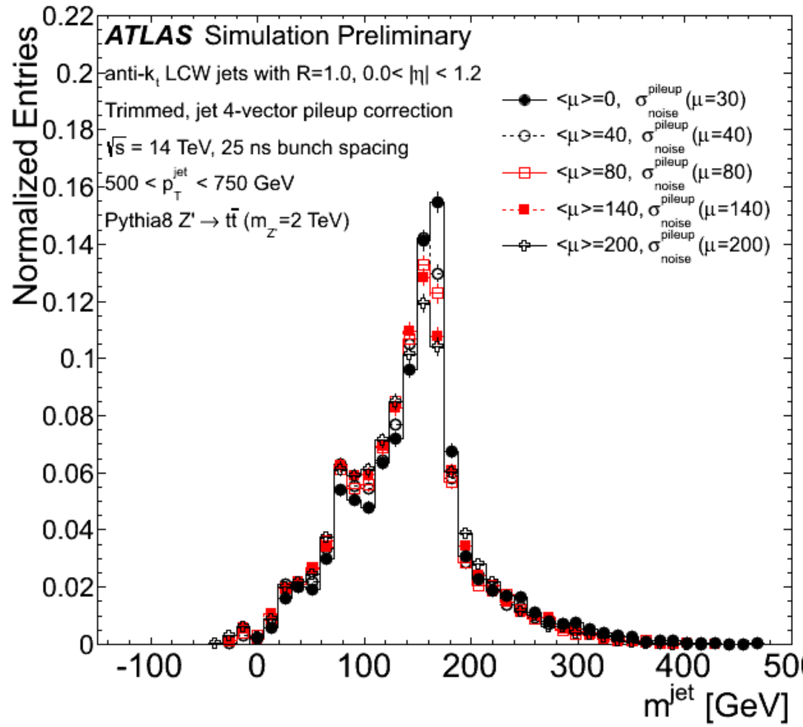


ATL-PHYS-PUB-2013-009

Jets and Missing-E_T Performance

Jet substructure: Jet mass shape retained at high <μ> after rejecting subjets with low-p_T fraction (“trimming”) and pileup correction



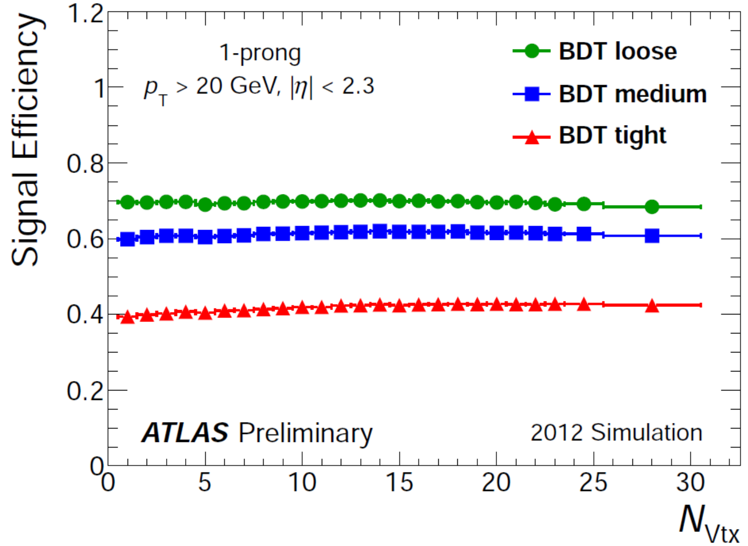


JetEtmissApproved2013HighMuSubstructure twiki

Tau Performance

Run 2 preparation:

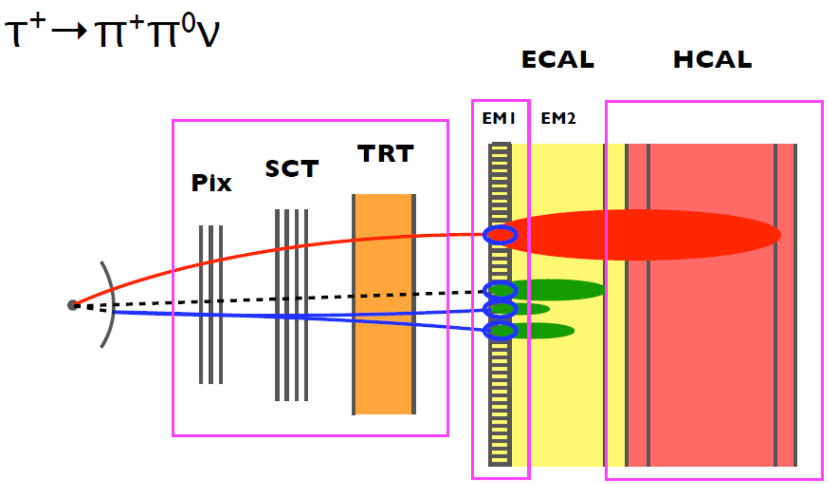
- Reconstruction efficiency depends on tracking → don't expect performance degradation
- Identification efficiency stable
- Energy resolution expected to be stable
- Optimize track and vertex quality criteria in high pile-up environment
- Fast Tracker improves tau selection at trigger



ATLAS-CONF-2013-064

New for Run 2: Substructure reconstruction

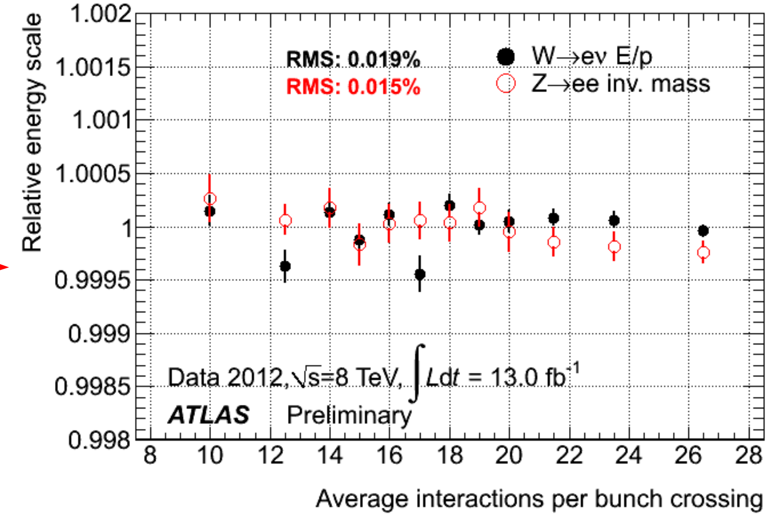
- Use track measurement for charged particles
- Reconstruct neutral pions from calorimeter
- Large improvement in tau energy resolution
- Access to tau spin through decay kinematics

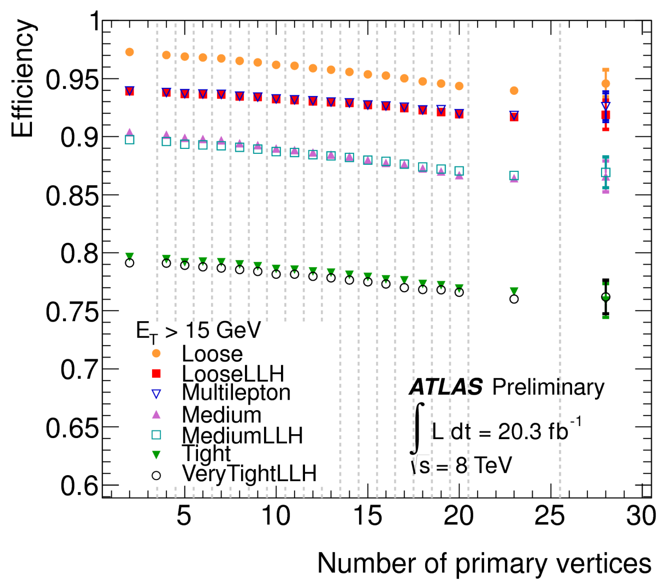


Electron/Photon Performance

- Improve e & γ identification at high pile-up e.g. isolated shower shapes look more background-like vs. pile-up → relax cuts or develop correction
- Good stability of electron energy scale vs. pile-up
- Studying pile-up robust methods to estimate energy isolation and to tag conversions

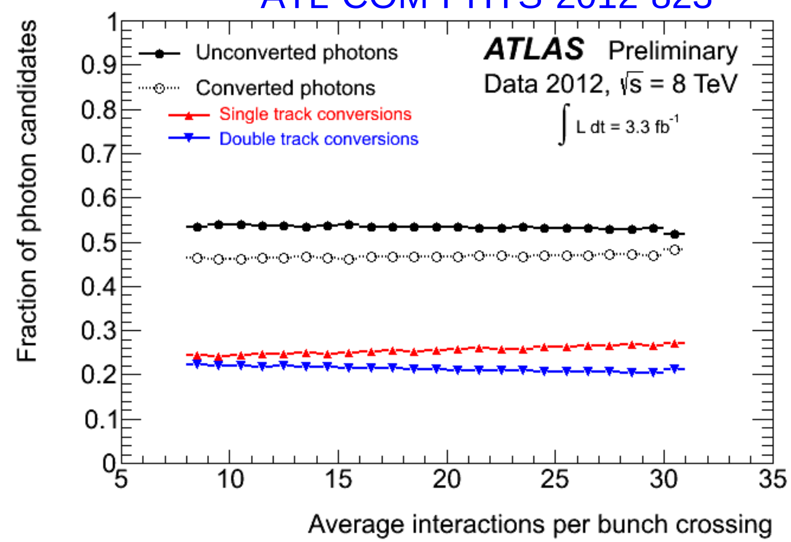
ATL-COM-PHYS-2012-1668





ATLAS-CONF-2014-032

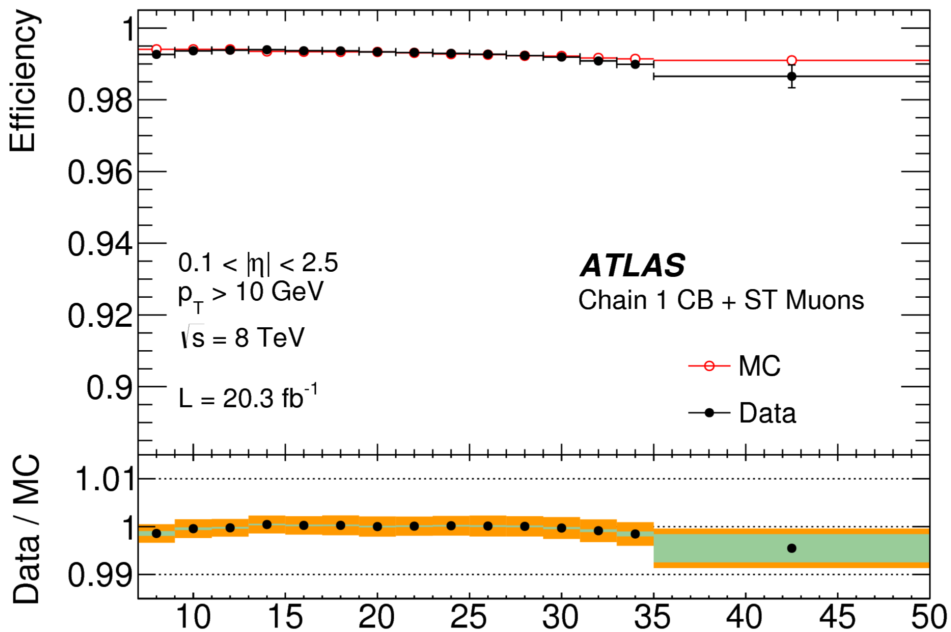
ATL-COM-PHYS-2012-823



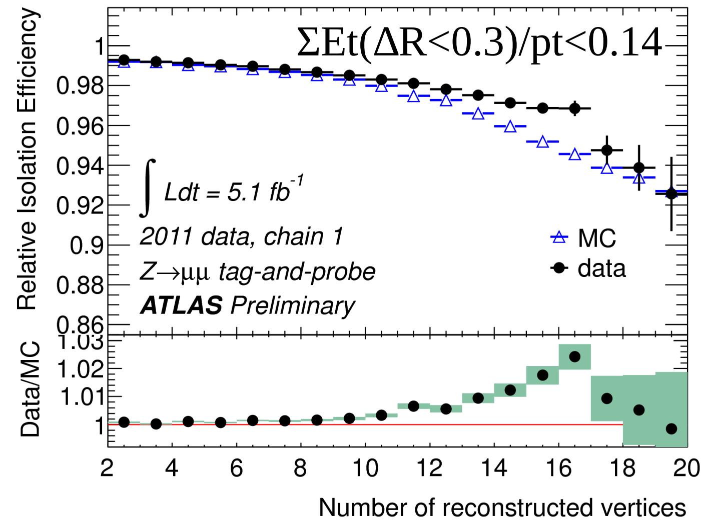
Muon Performance

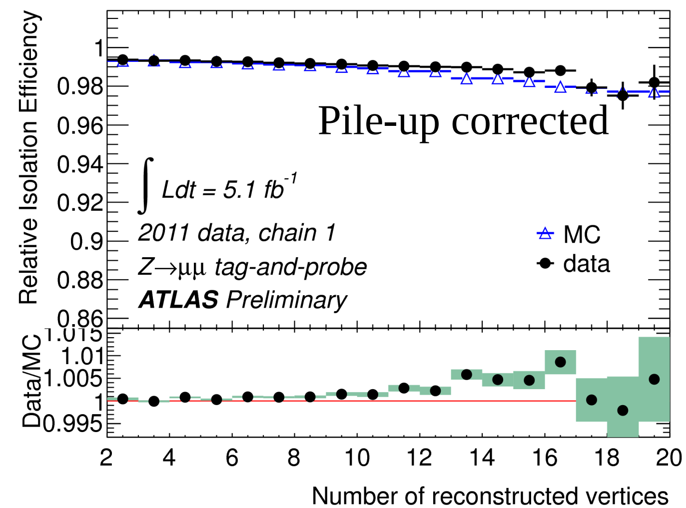
- Stable reconstruction efficiency vs. pileup, well reproduced in MC
- Studying corrections to muon isolation in context of VH analyses

Muon Public Plots



arXiv:1407.3935



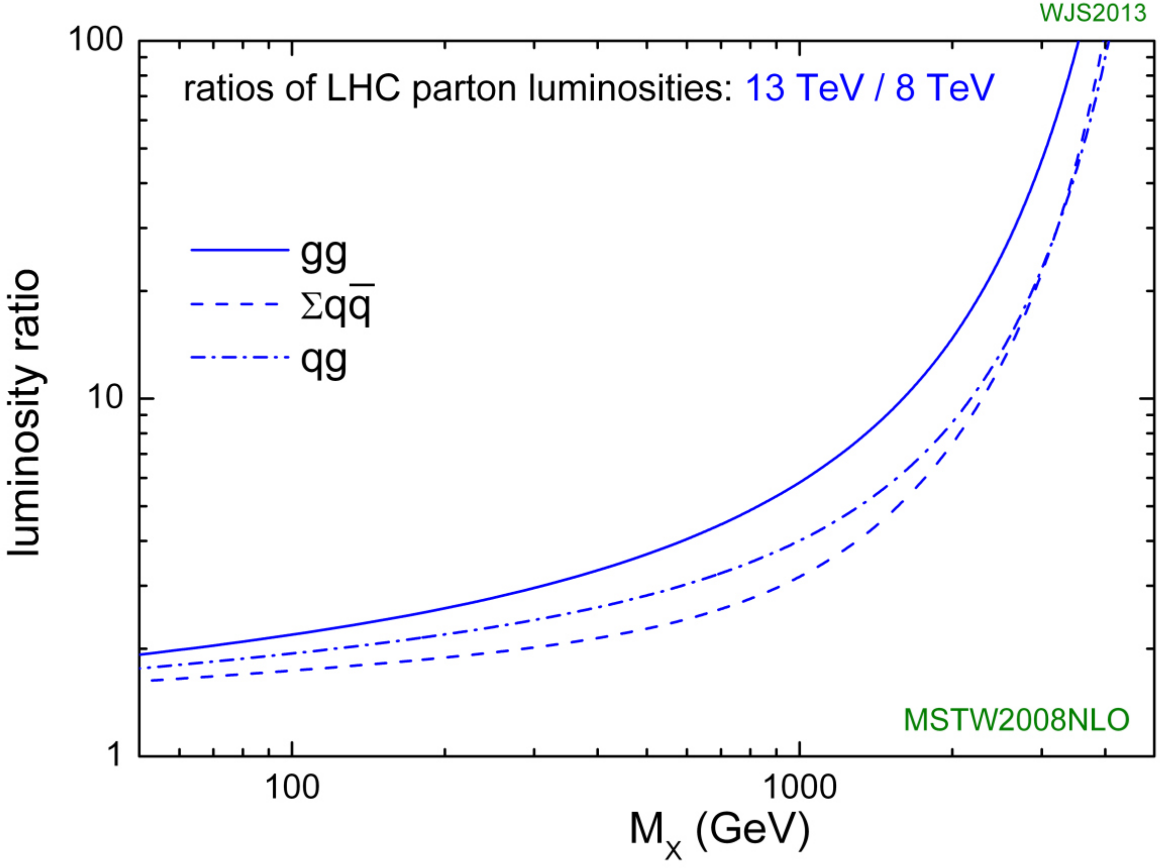


Conclusions

- Presented a selection ongoing activities and results
- Lots of studies ongoing → Pileup stability already achieved in various aspects
- IBL installation improves tracking, vertexing and b-tagging and has impact on various physics objects
- ATLAS is well prepared for Run 2!

Bonus

Parton Luminosity Ratio



Phase-0: LHC and ATLAS Plans

LHC prepares for ~design energy and nominal luminosity, consolidation of the superconducting splices.

$\sqrt{s}$ = 13-14 TeV, Bunch spacing: 25 ns

$\mathcal{L} \sim 1 \times 10^{34}\ cm^{-2}s^{-1}$, $\langle\mu\rangle \sim 28$; Integrated luminosity: ~50 fb^{-1}

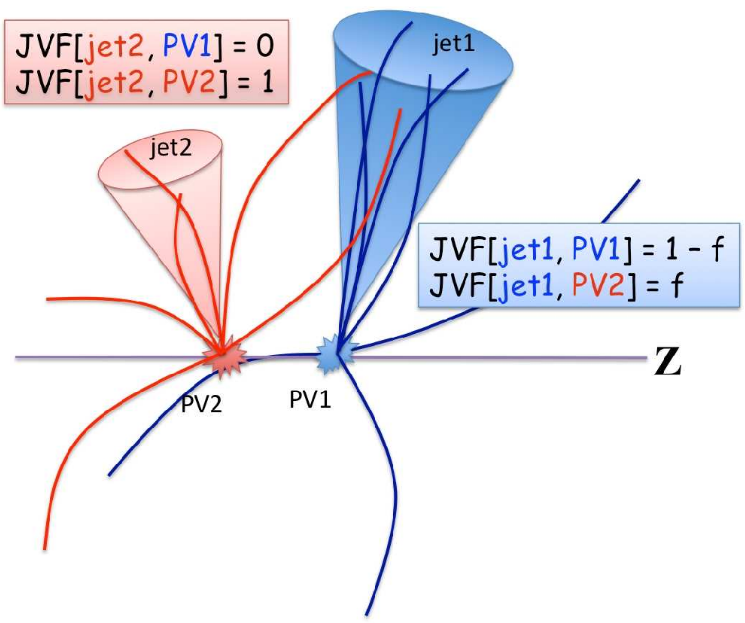
✓ New components:

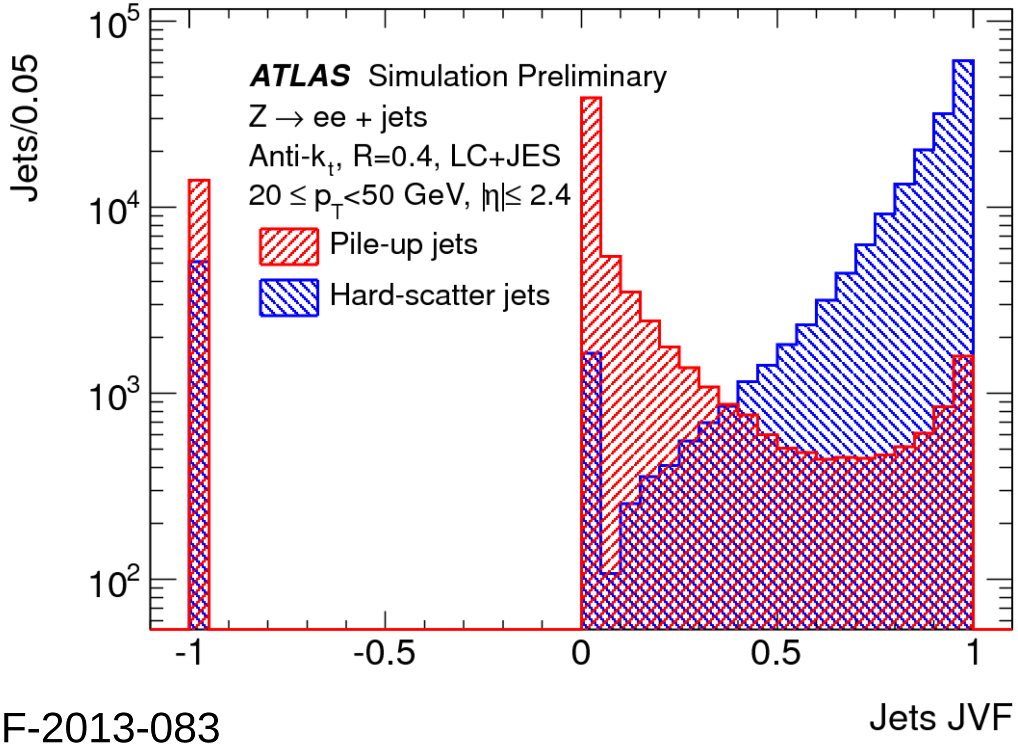
- Additional Pixel layer (IBL) and Be small radius beam pipe.
- Diamond Beam Monitor (DBM).
- Improved coverage of Muon Spectrometer

✓ Consolidation:

- New calorimeter Power supplies, Inner detector cooling, power network, magnet cryogenics, improved neutron shielding.
- New Al beam pipes to reduce muon background.
- Replacement of Pixel internal services (nSQP).
- Usage of outermost layer of Tile Calorimeter for L1 Muon trigger.

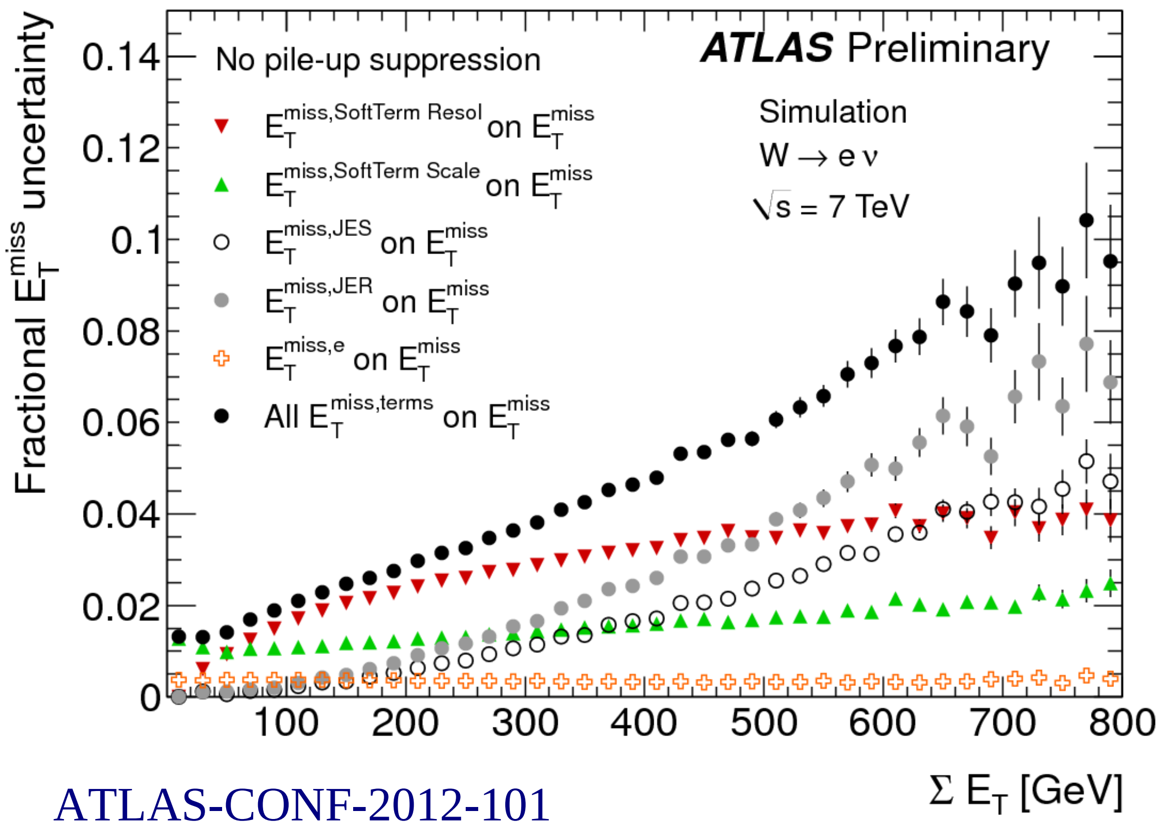
Jet Vertex Tagging





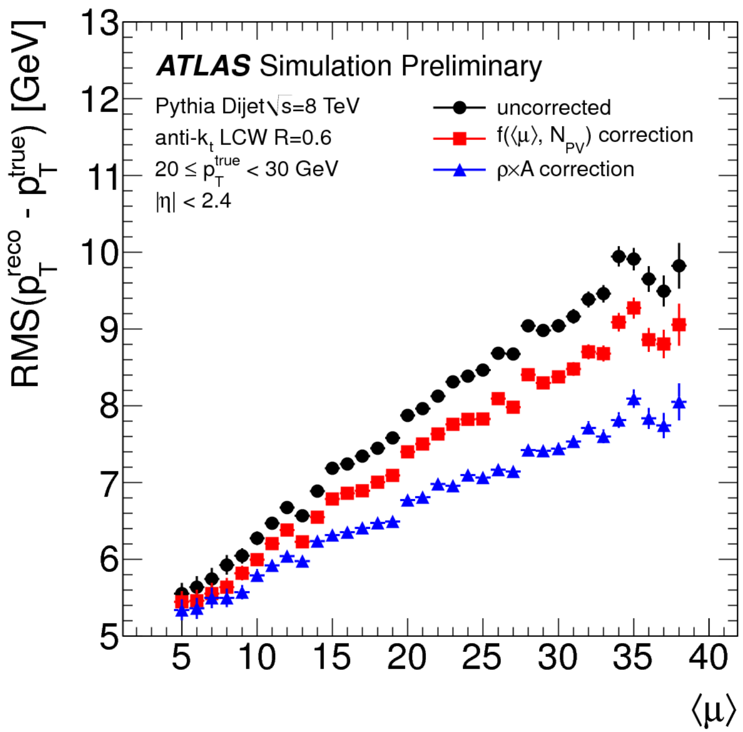
ATLAS-CONF-2013-083

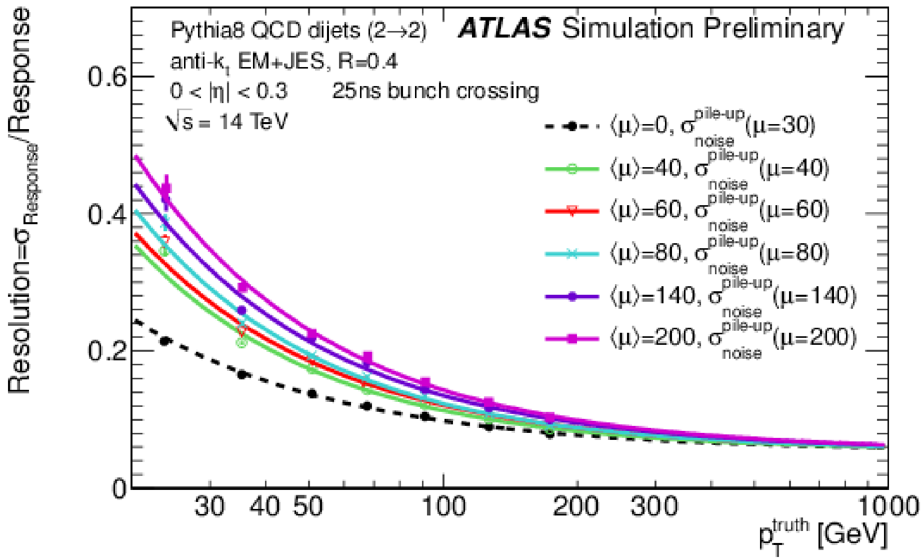
Etmiss



ATLAS-CONF-2012-101

Jet resolution at high pileup

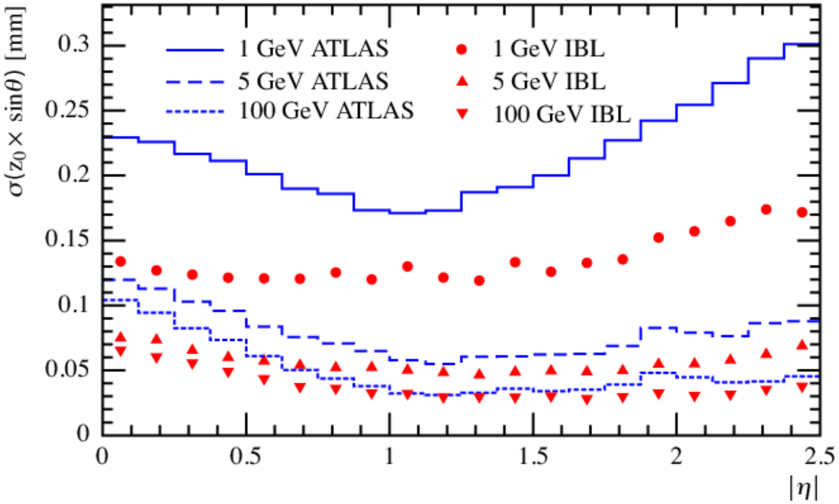




JetEtmissApproved2013HighMuPileup

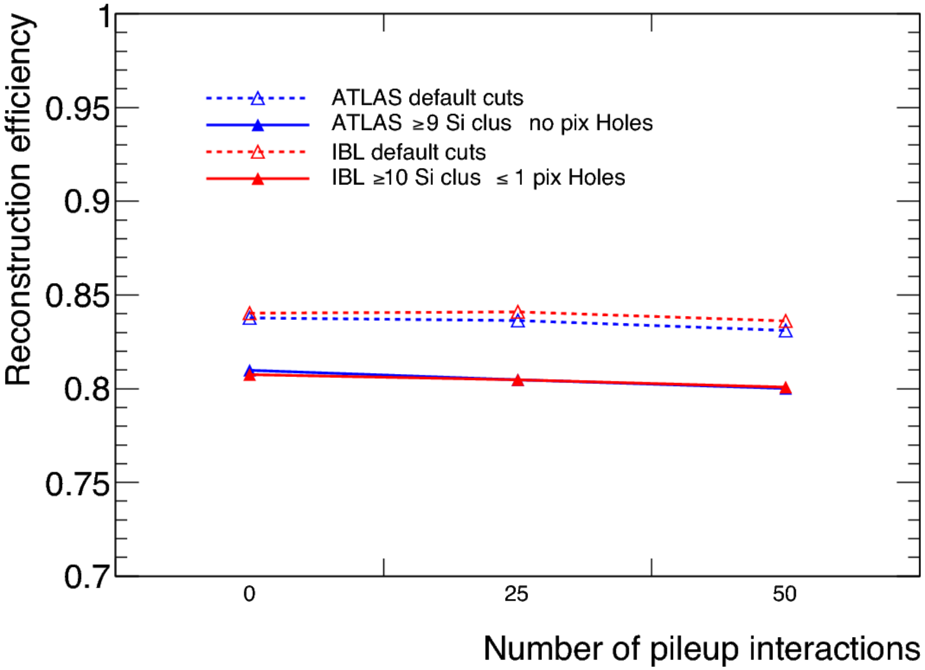
Track parameter resolution at high pileup

single muons



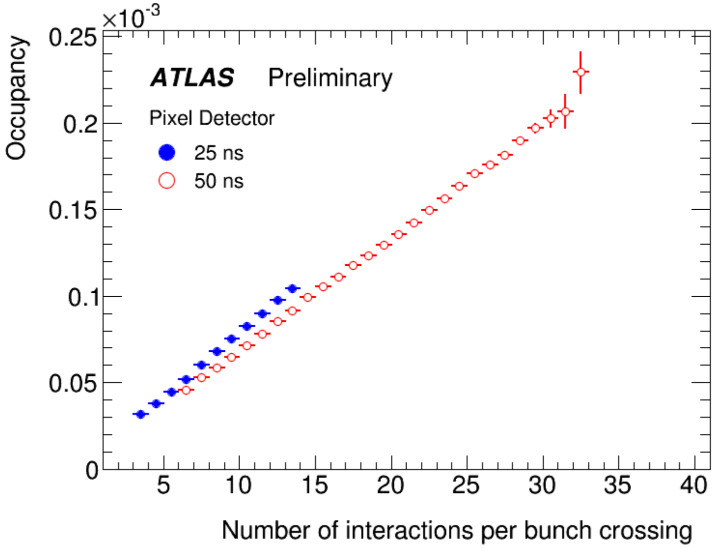
CERN-LHCC-2010-013

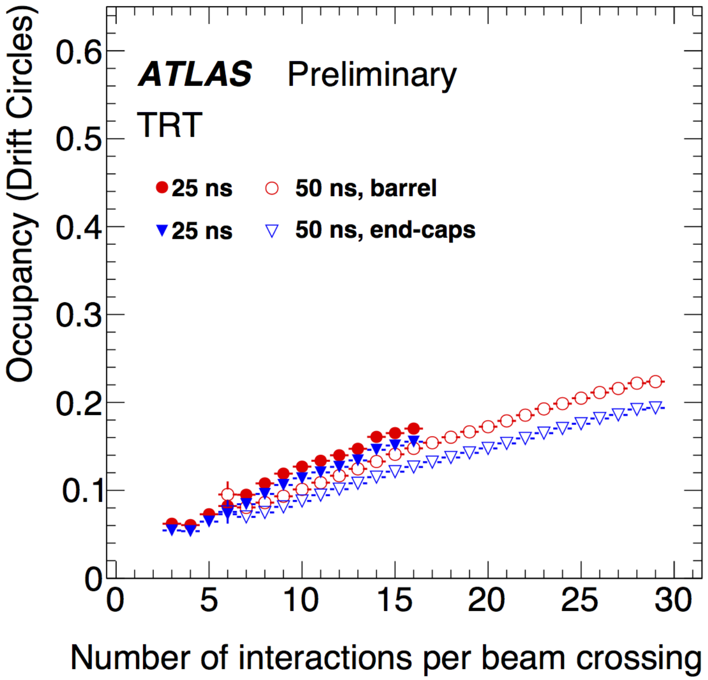
Track reco efficiency vs. pileup

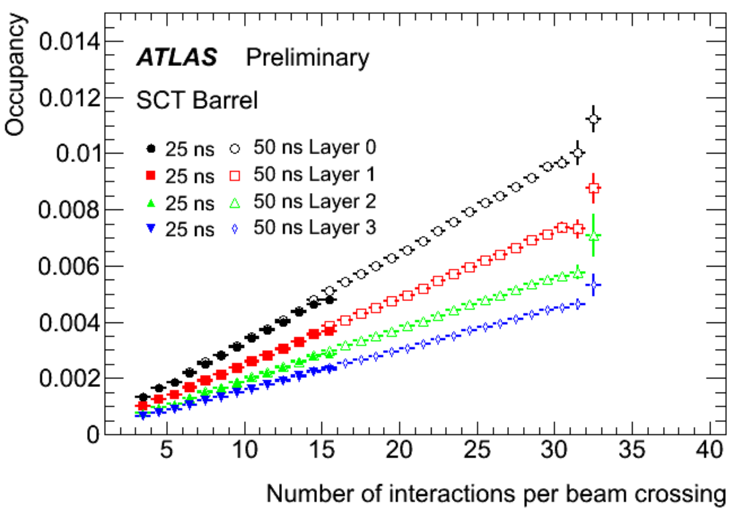


CERN-LHCC-2010-013

ID occupancy vs. pileup



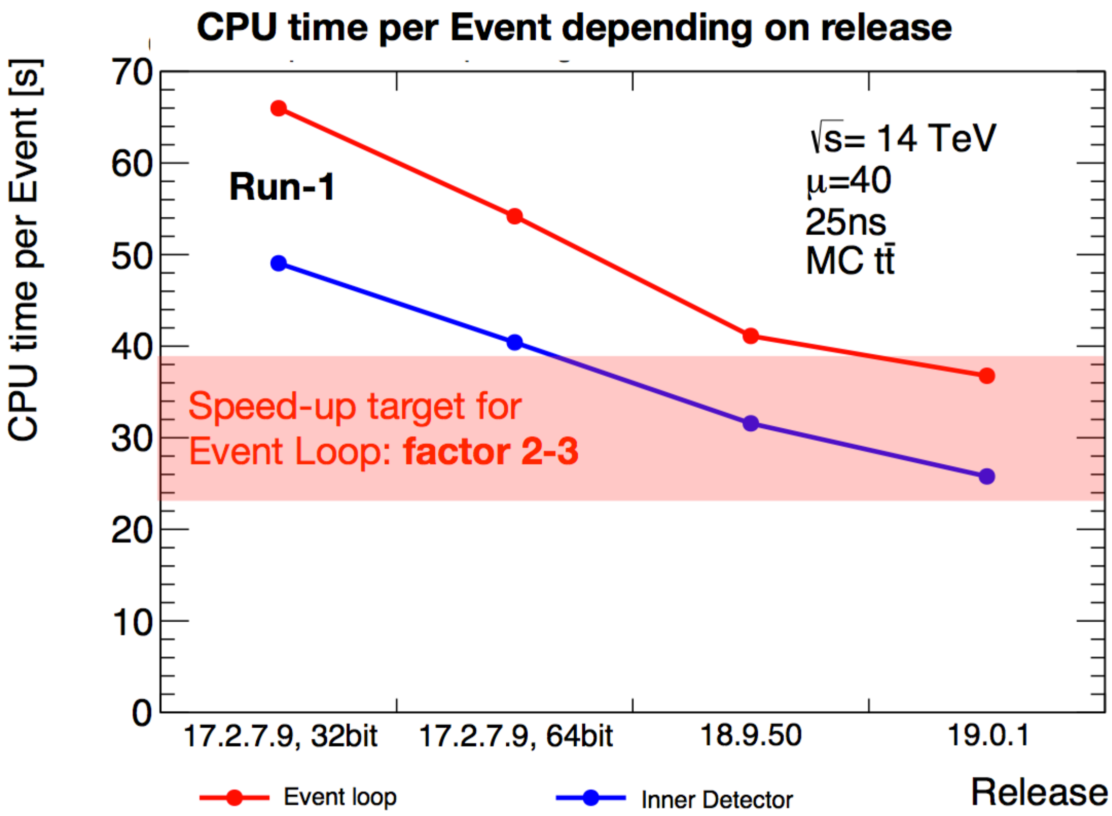




After reducing the readout window size from 75ns to 25ns

ATL-COM-PHYS-2013-1348

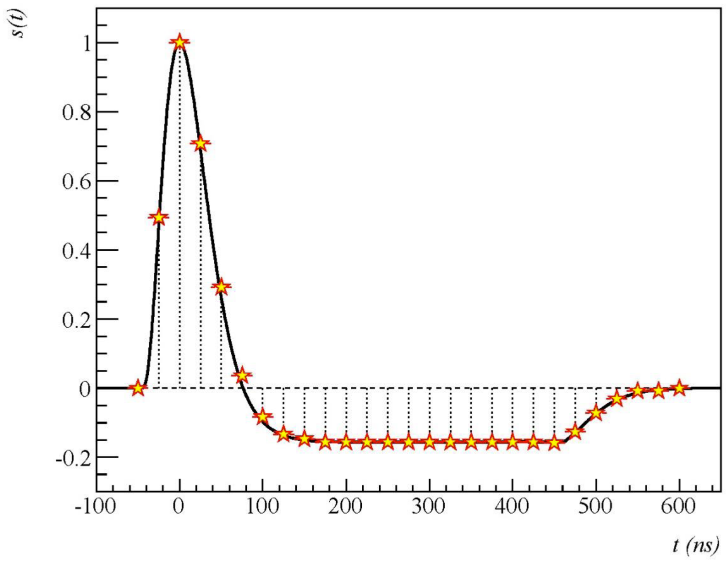
Tracking CPU Timing



ATL-COM-PHYS-2014-709

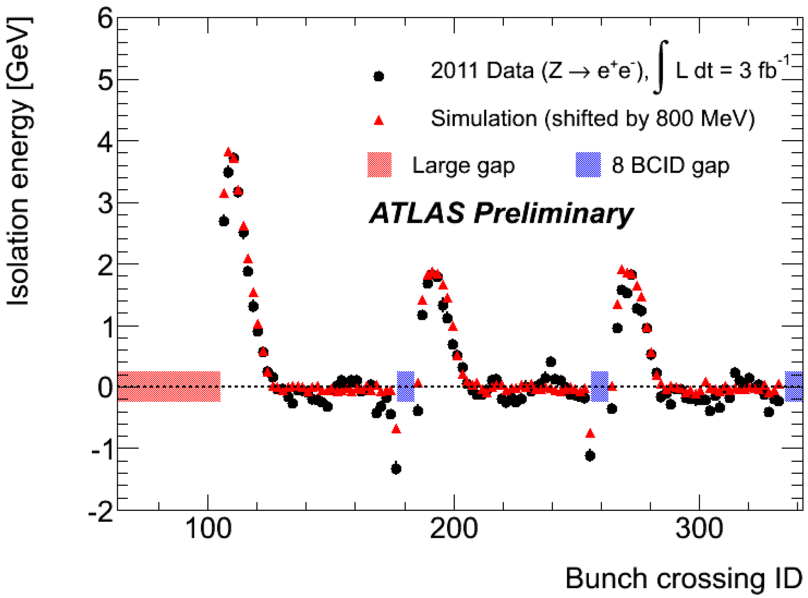
Signal shape EM calo

Bipolar signal shape and long integration time in EM calorimeter $\Rightarrow$ jet response depends on out-of-time pile-up



Egamma Calorimeter Isolation

cell-based



cluster-based