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Robust Tracking at the High Luminosity LHC

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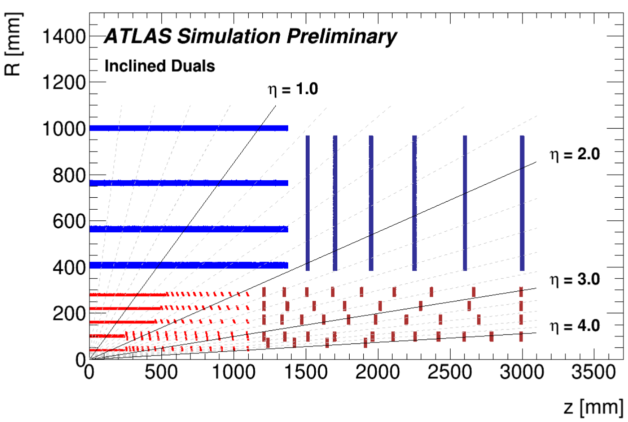
ATLAS ITk

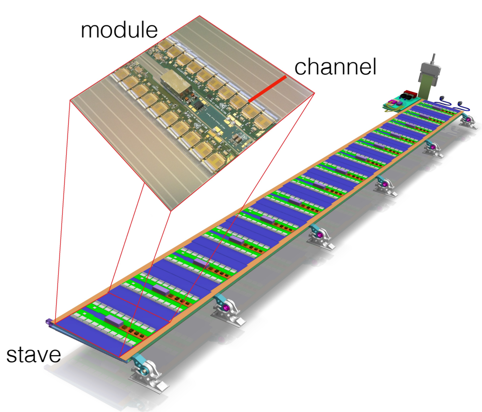
Motivation

- High Luminosity LHC (HL-LHC) will collect 4000/fb of data, enabling precise Higgs boson measurements. It will reach luminosities up to 7.5×10^{34} cm^{-2} in the presence of up to 200 pileup interactions.
- To mitigate the increased radiation doses and pileup, the ATLAS Inner Detector (ID) will be replaced with an all-Silicon Inner Tracker made of Silicon Pixel and Silicon Strip systems
- ITk improves tracking resolution and segmentation relative to the ID in order to cope with increased pileup
- Simulating tracking performance for different failure scenarios in the Strip system ensures design robustness

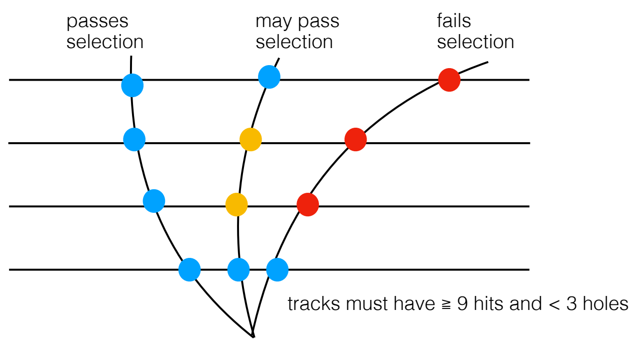


Setup

- mask Strip system components before tracking
- multivariate tracking algorithms account for system failures and implement track quality cuts
- testing $t\bar{t}$ events with 200 additional interactions per crossing



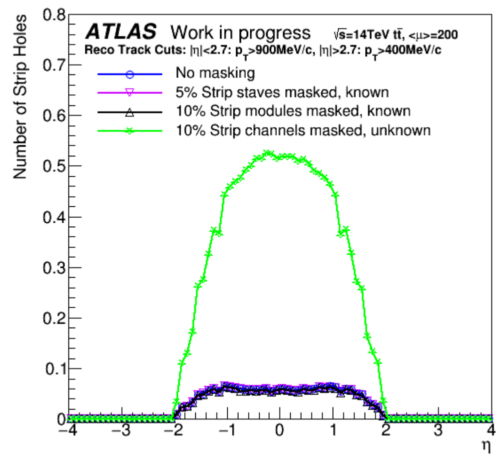
Results



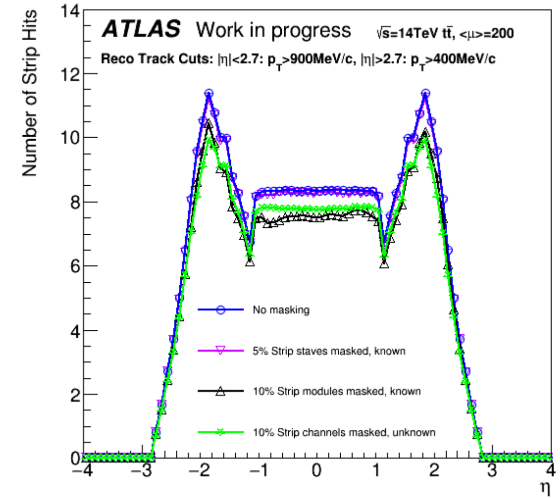
- hit in functioning component used in tracking
- hit in dead module, **known** failure
- hit in dead channel, **unknown** failure

Known failure: stored in detector database which is used in track reconstruction. Hits in dead modules or staves count neither as a hit or hole, degrading track quality.
Sources: electronics, cooling, and power failures
Expected rates during HL-LHC operation up to ~10%

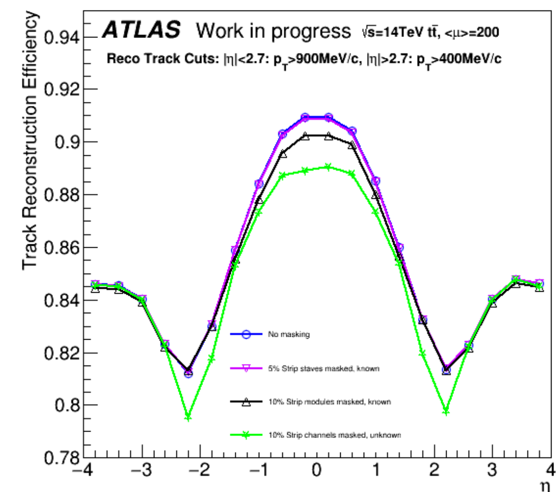
Unknown failure: not stored in detector database. Missing hits in dead channels can cause a track cluster to be missing from a track (hole).
Sources: irradiation damage, bond wire failure
Expected rates during HL-LHC operation up to ~1%



Tracks intersecting dead channels can lead to ***holes on track***. Tracks intersecting known dead modules or staves generally do not lead to holes.



Tracks intersecting dead modules, staves, or channels ***do not count as hits.***



Dead components degrade track quality, which worsens tracking efficiency. Fake rates for the no masking scenario are ≤ 10^-5. The increase in fake rates for all masking scenarios is consistent with the default within the errors. The system is least robust against unknown failures (dead channels) which dramatically decrease the track efficiency due to the impact on cluster formation, which can lead to holes on track.

Conclusions

Channel Masking, unknown failure
layout is robust against < 3% random strip channel failures
Module Masking, known failure
layout robust against < 10 % strip module failures
Stave Masking, known failure
layout is robust against < 5% random stave failures

References: CERN-LHCC-2017-005

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