Status of ATLAS Strip Endcap Simulations

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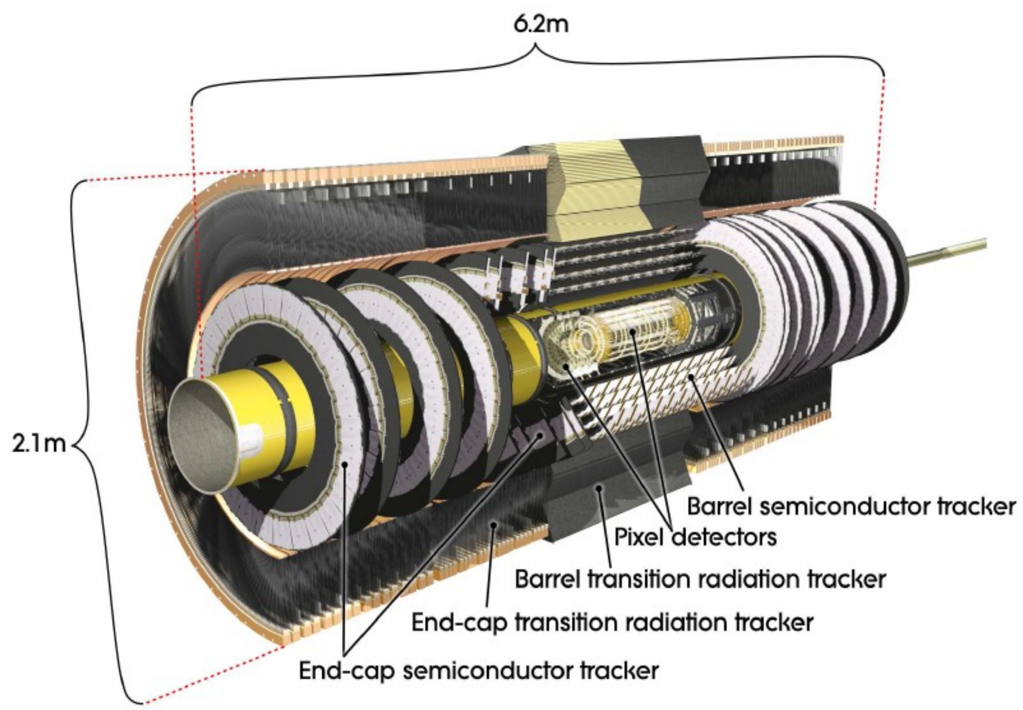
Motivation (I)

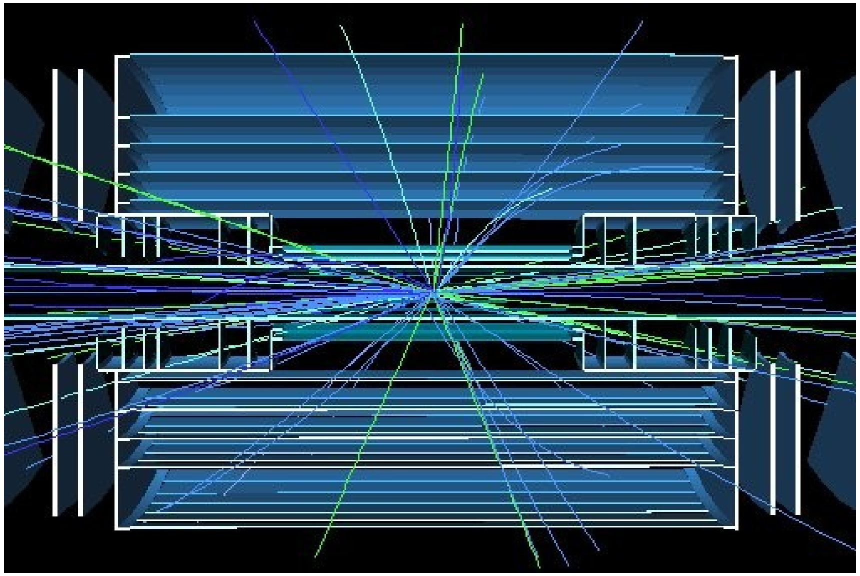
- Current ATLAS tracker:

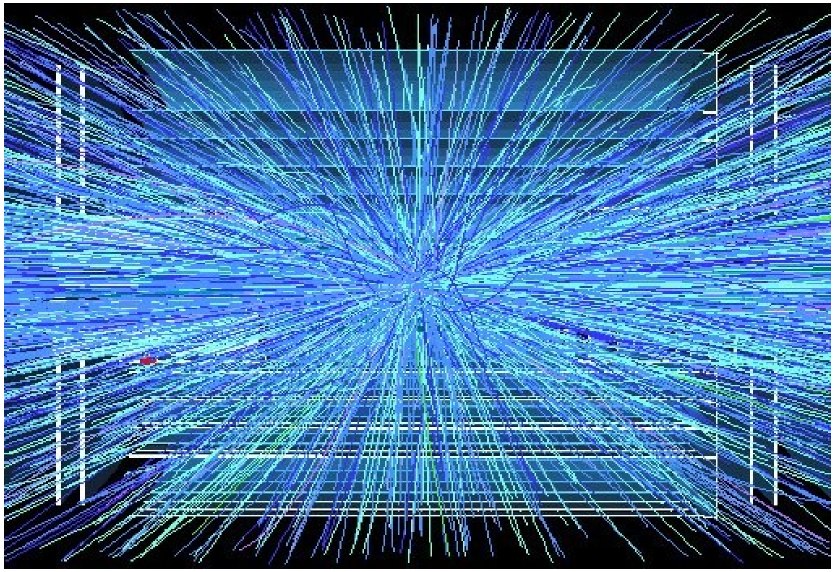


- Pixel detector: 3 barrel and 3 endcap layers
- Strip detector (SCT): double-sided modules, 4 barrel layers, 9 endcaps
- Transition radiation tracker (TRT): proportional drift tubes
- Tracks up to $|\eta| < 2.5$ reconstructed

Motivation (II)

$L=0.2\cdot10^{34}\ cm^{-2}s^{-1}$ — Upgrade (2020) → $L=10\cdot10^{34}\ cm^{-2}s^{-1}$

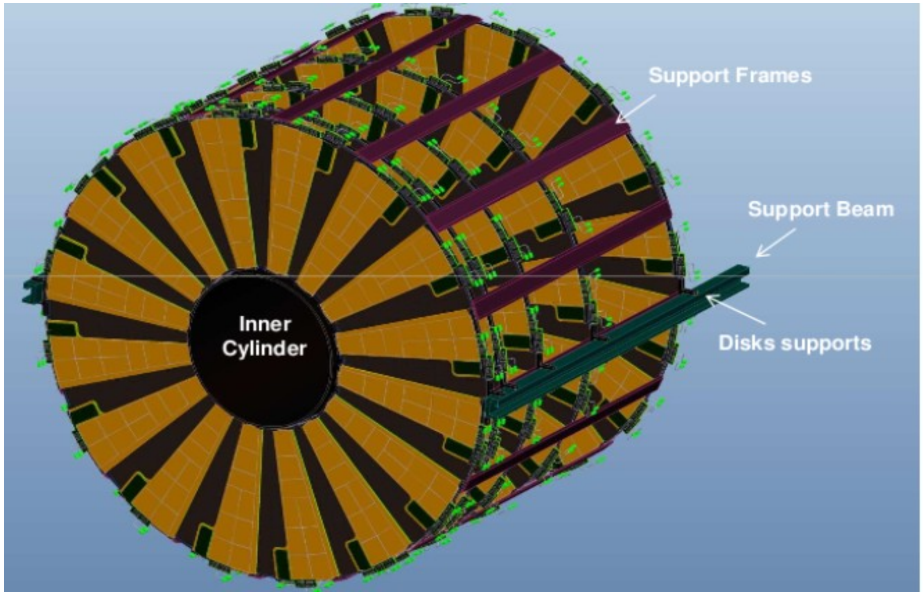


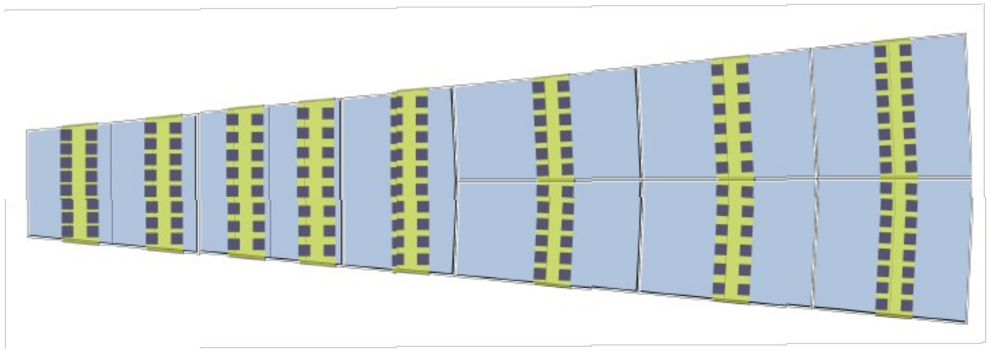


- Granularities of pixels and strips will be too low
- Radiation hardness of pixels and strips not sufficient and already radiation damage after 10 years of running
- Occupancies and therefore fake rates would be much too high with the current detector, most in TRT
- Readout not fast enough for high luminosity upgrade

Motivation(III)

- Goal: achieve performance comparable to current detector
- Remove TRT, replace silicon pixel and strip detector
- Strip detector will be larger than in the current layout and fill the space where the TRT has been
- Current detector: strip modules are individually mounted on large support structure
- Upgrade: several strip modules will be mounted together on carbon fiber support (endcaps: petals, barrel: staves), module readout and services are bundled
- 32 petals per endcap disk (16 on each side)





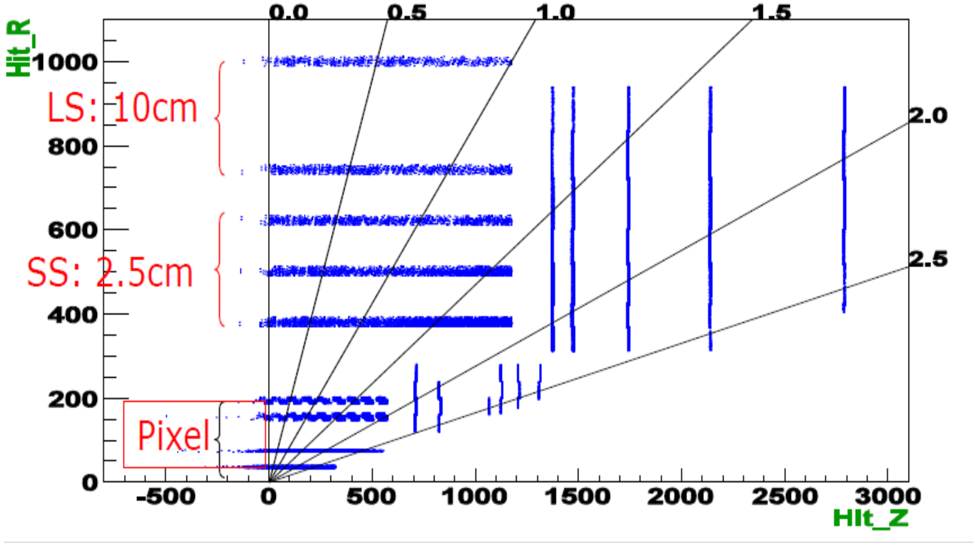
Software Status

- SLHC releases in Athena used
- Maintainance of SLHC software not good at the moment but improving
- Currently using frozen release from last November (15.X.0-SLHC, rel_6), less problems
- Would be good to run on grid because CPU times are large, but no SLHC release installed yet on the grid
- However, frozen stable release is installed on the DESY NAF and running succesfully on the batch system there

Utopia Layout

- Layout SLHC-19-13
- Barrel: 4 pixel and 5 strip layers
- Endcaps: 6 pixel and 5 strip disks

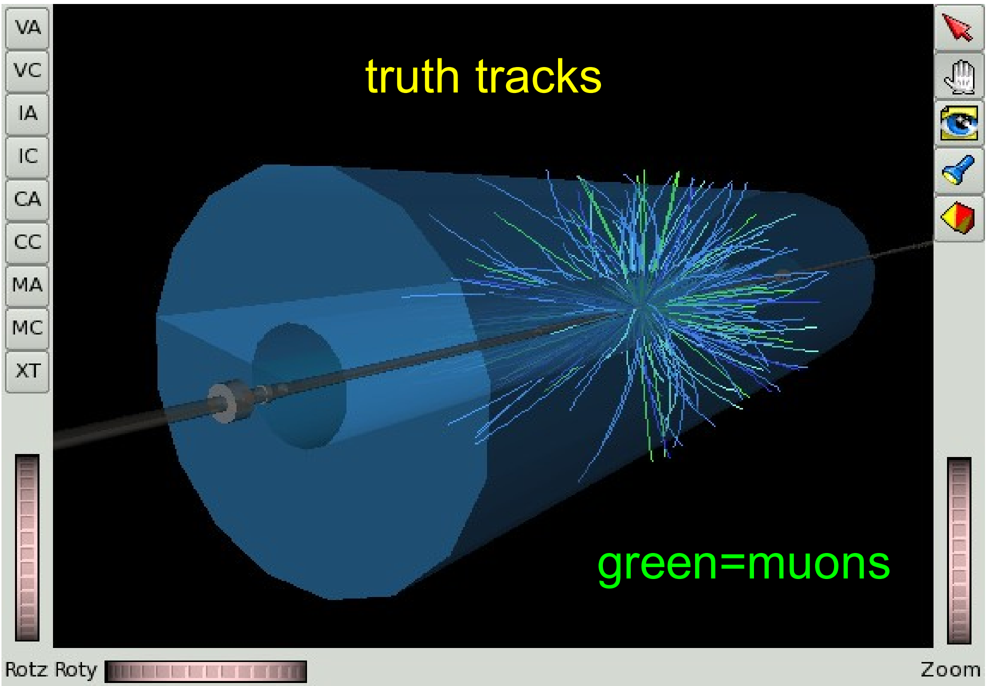
SLHC-XX-YY:
XX=pixel layout
YY=strip layout

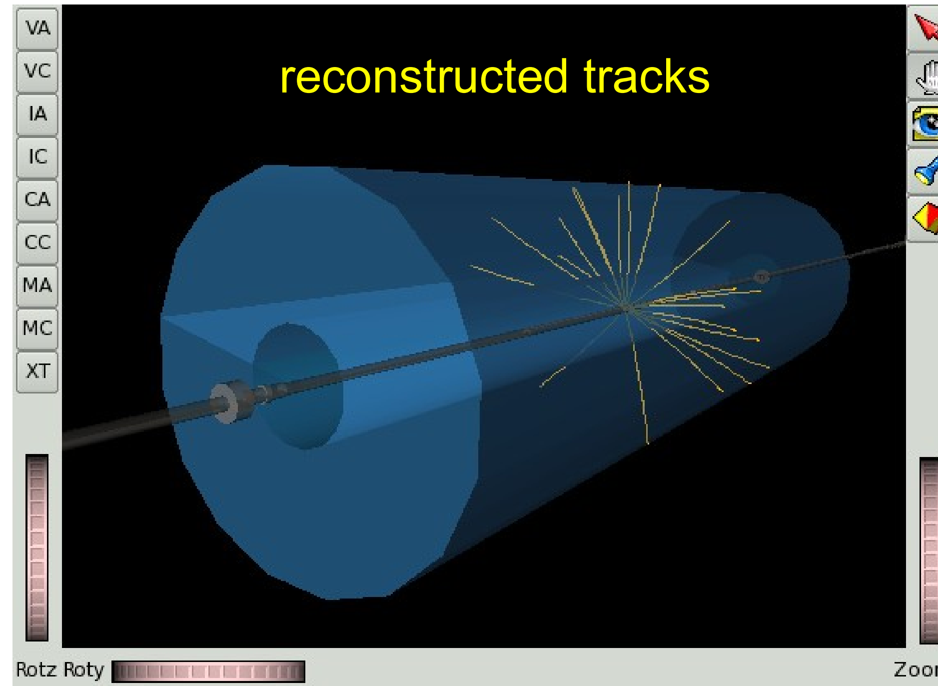


- Utopia layout not fully implemented in the software yet, SLHC-19-13 is the geometry closest to Utopia
- **Differences to Utopia :**
  - Petals for strip endcaps are not implemented yet, circumferential design instead
  - Trapezoid sensors like in current detector are used in the strip endcaps

Event Simulation

- Multi muon/electron events overlayed with pileup (minimum bias events)





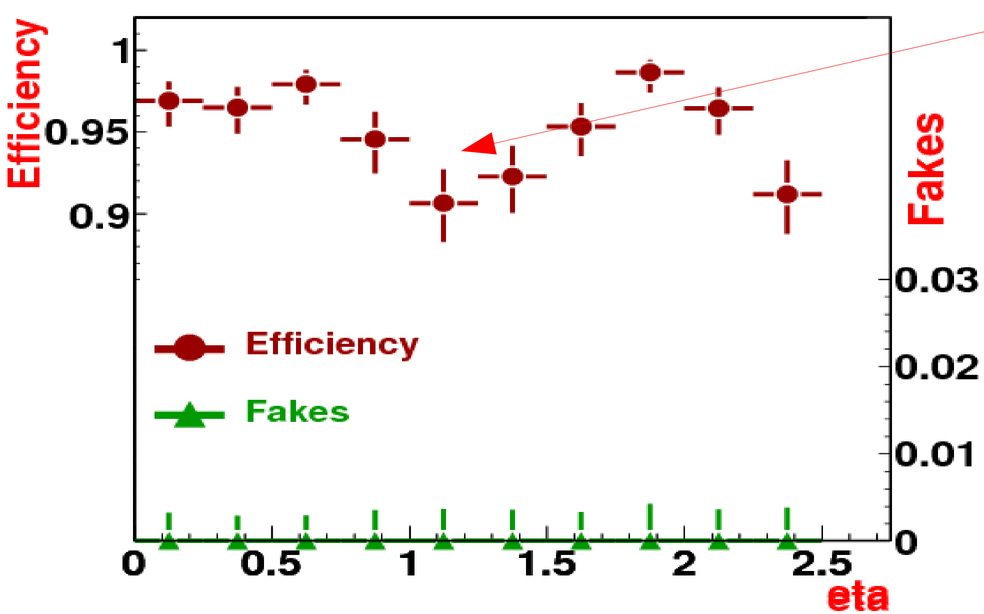
Multi muon event with 10 $\mu^+\mu^-$ pairs, overlayed with 10 minimum bias events

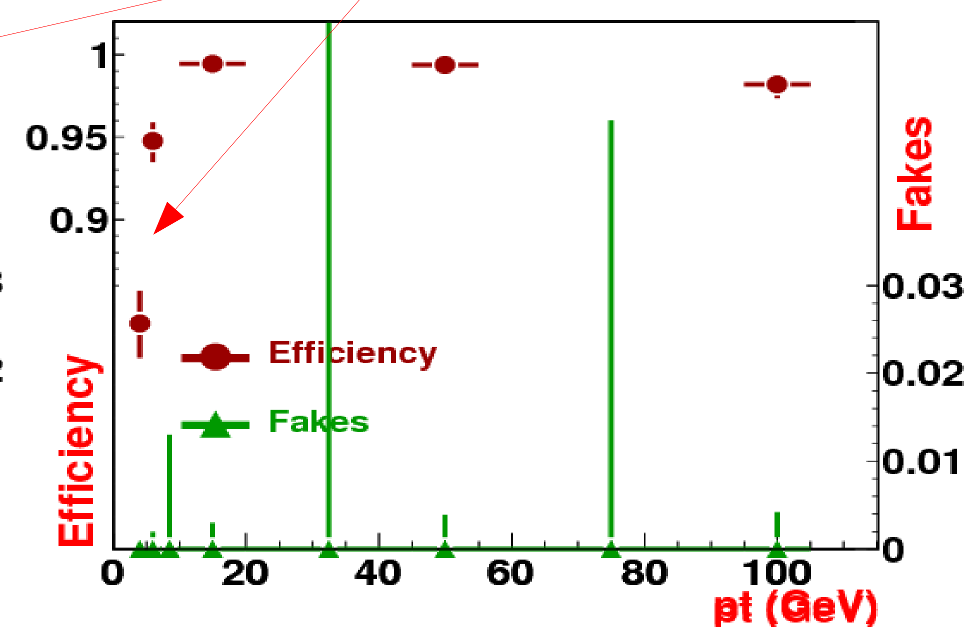
- Need to increase pileup (memory problem) and run larger samples

Tracking Cuts

- pT > 3 GeV
- d0 < 1.0 mm (transverse impact parameter)
- z0 < 150 mm (longitudinal impact parameter)
- $|\eta| < 2.5$
- Number of hits ≥ 11
- χ^2/ndf <5
- Track matching probability > 0.5
- Only muons considered for efficiency calculation

Analysis not optimized yet!

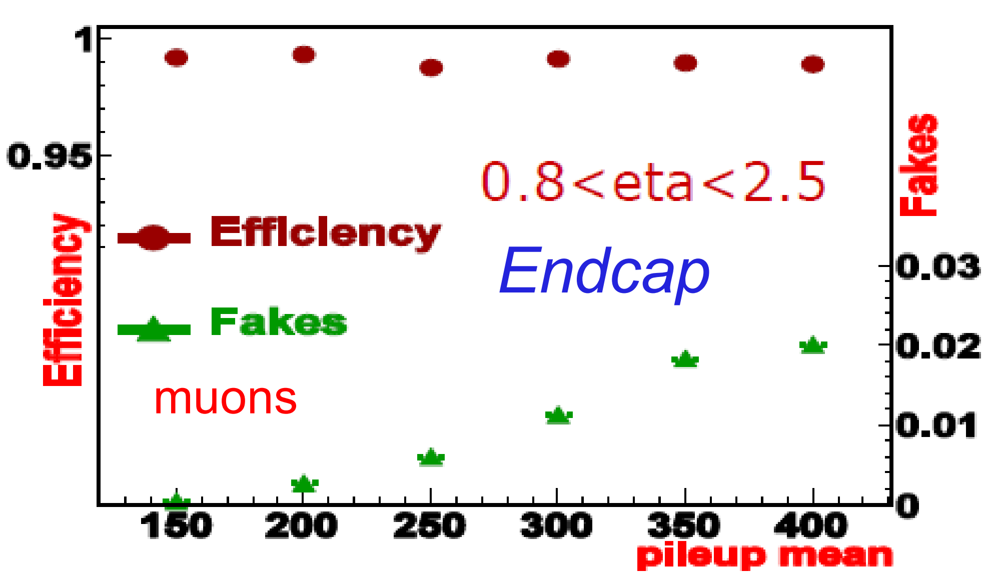


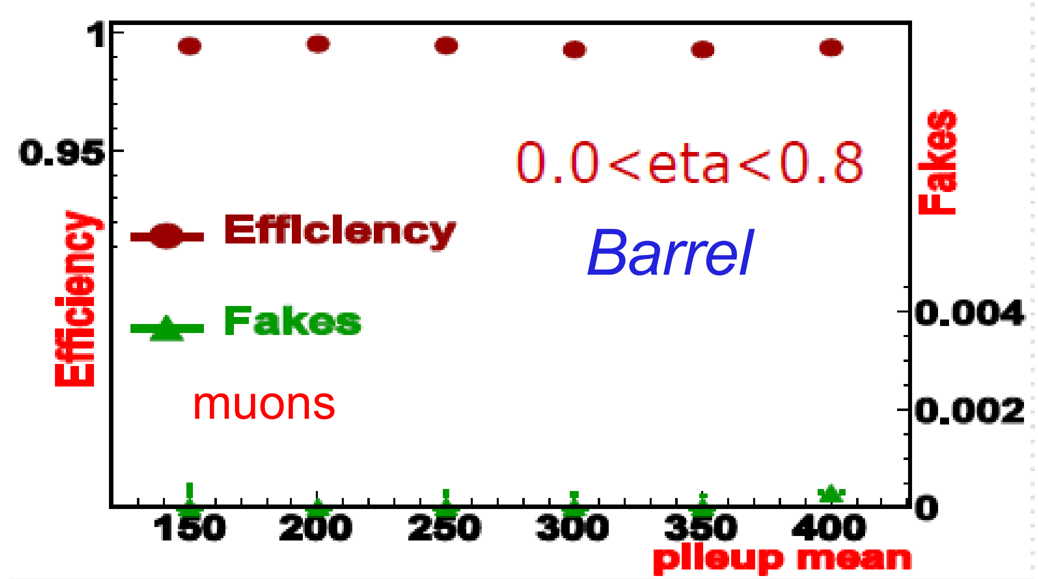


Multi muon events (10 $\mu^+\mu^-$) overlayed with ~20 minimum bias events

Procedure

- Look at occupancies, fake rates, efficiencies etc. for the currently best SLHC layout
- Improve these quantities by changing the endcap geometry
- Major problems to be solved:
  - Increase in fake rate with increasing pileup (see below for muons)
  - Drop in electron efficiency (see next slide)
- Compare to current detector

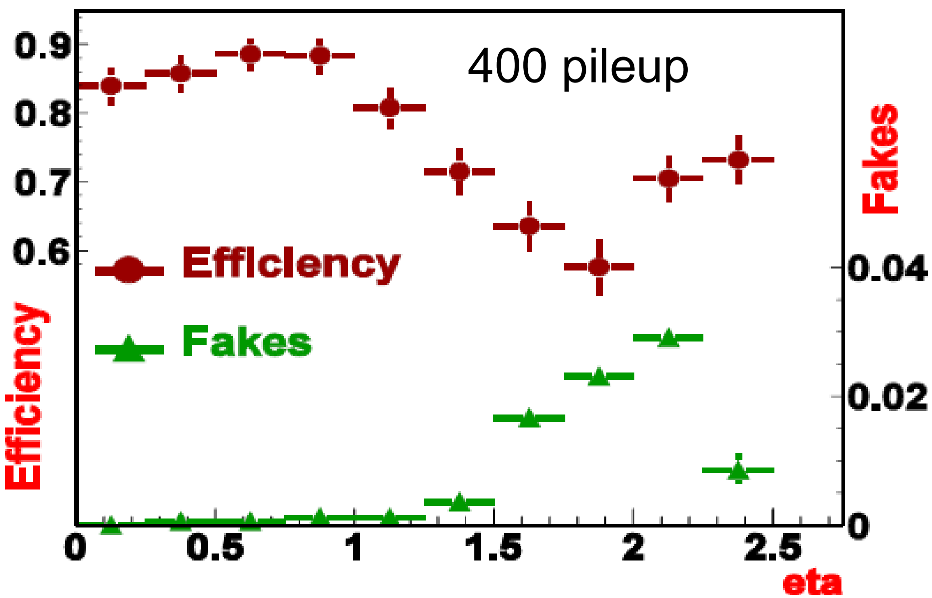


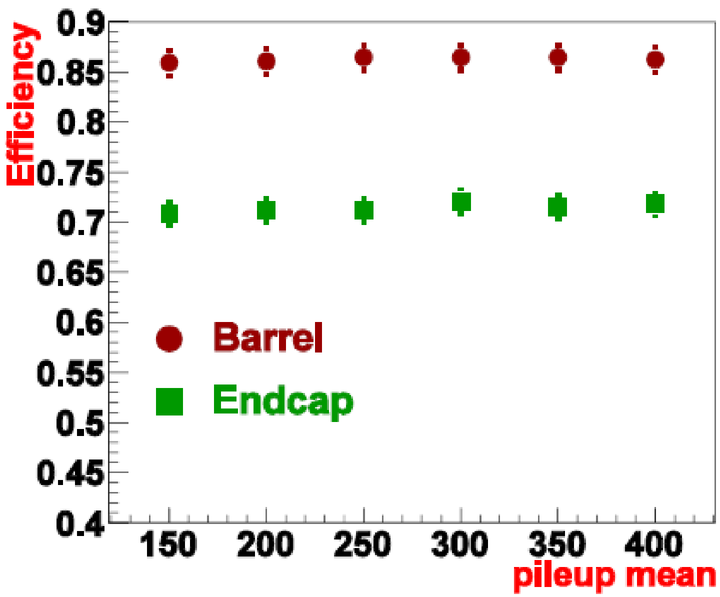


Plots from Abdel Abdesselam

Electron Efficiency

- Electron efficiency decreases in the endcap region
- Efficiency insensitive to amount of pileup
- Electrons are more sensitive to material than muons (bremsstrahlung)

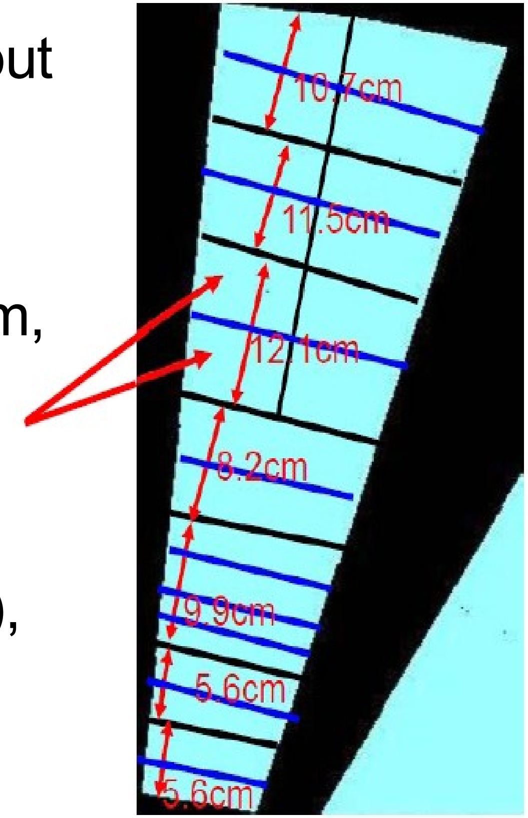




Plots from Abdel Abdesselam

Geometry Modification

- No new developments for endcap geometry existing, but Utopia layout not fully implemented yet!
- Non-trivial, was postponed by last simulation crew
- Other study: dividing strips (done by Abdel Abdesselam, layout SLHC-19-20) → fake rate reduced, but still too high
- Find out why endcap fake rate is so high (e.g. hit resolution, material in barrel-endcap-transition, cracks), then decide how to proceed:
  - Implement petals to reduce the overlap?
  - Move disks?
- Reducing material per layer would help to increase the electron efficiency



Future Plans

- DESY is splitting the work based on location:
- Hamburg: geometry layout
  - Disk: radii, support structure, overlap
  - petal:geometry, sensor shapes,...
  - Sensor: strip length
- Zeuthen: digitization
  - Energy deposition
  - Electronic response, charge sharing, cross talk, radiation damage,...
- Procedure: first understand what is already implemented and then decide where one starts the optimization