Upgrade Simulation Status.

Progress towards SCT Endcap Upgrade Simulation Studies

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ATLAS DESY Upgrade Meeting
Hamburg 10/12/2010

HELMHOLTZ
GEMEINSCHAFT

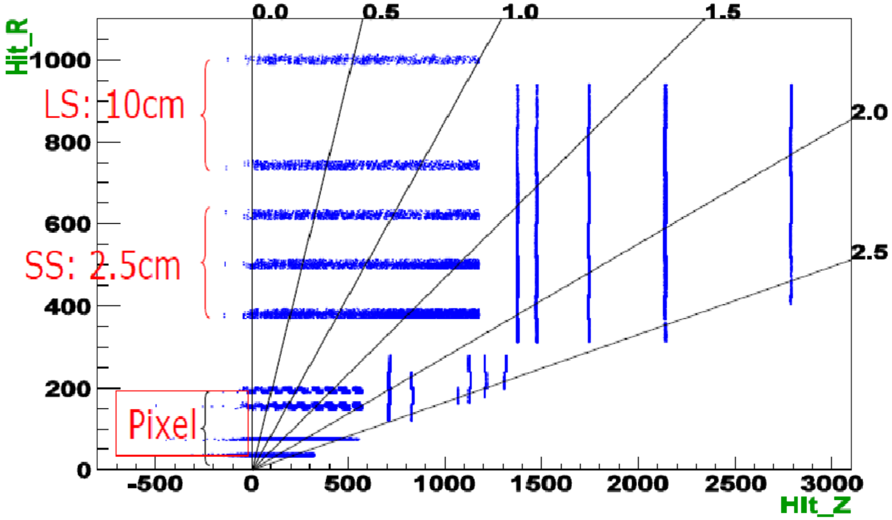
DESY

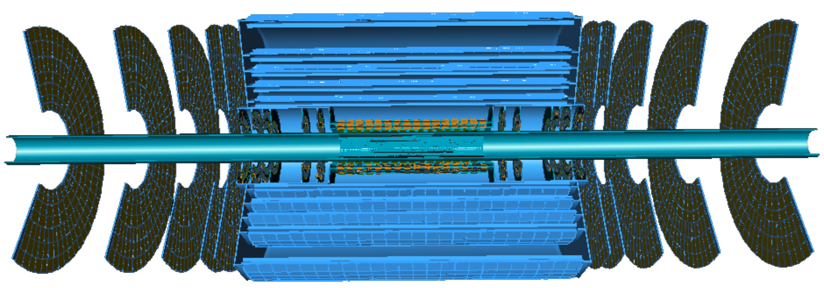
ATLAS High Luminosity Upgrade

- Current ATLAS Inner Detector will be insufficient for high luminosity operation following LHC upgrade (2020)
  - Insufficient radiation hardness, and already significant damage following 10 years of irradiation
  - Granularity of pixels and strips too low
  - Occupancy too high (for TRT in particular)
  - Readout not fast enough
- Pixels and strips will be replaced; TRT will be removed altogether
  - Strip detector will be extended to fill space left by TRT
  - Aim to achieve performance comparable to current ATLAS Inner Detector
- Letter of Intent for ATLAS Upgrade planned for end of 2011
- Work on Upgrade Simulation is picking up steam again
- DESY will contribute simulation studies for the Strip (SCT) endcap

Utopia Layout

- Geometry developed by “Utopia” taskforce
- Detector description version SLHC-19-13 is closest to “Utopia”
- Barrel: 4 Pixel & 5 Strip layers
- Endcap: 6 Pixel & 5 Strip layers
  - SCT endcap disks: outer radius 950 mm, at z = +/- 1400, 1500, 1750, 2150 & 2800 mm
- Baseline endcap disk geometry still not fully implemented (see later)





SLHC-19-13 Inner Detector

Utopia Layout

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- Barrel: 4 Pixel & 5 Strip layers
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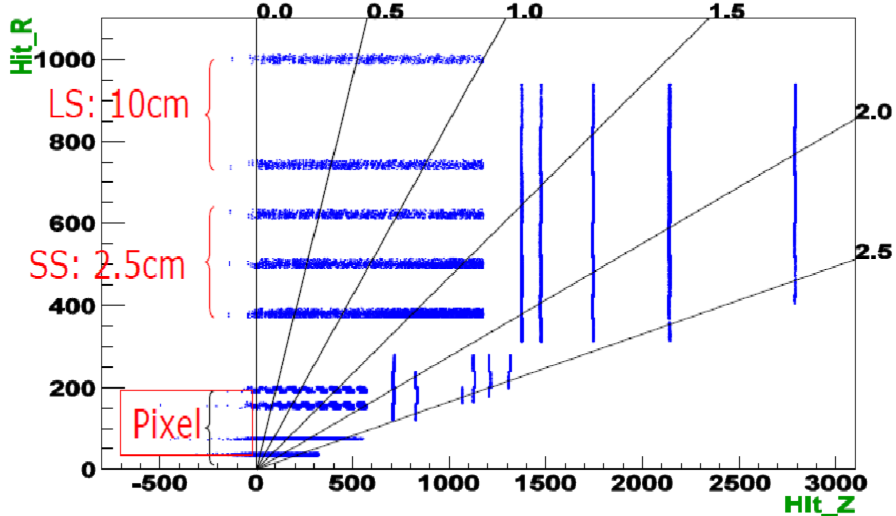
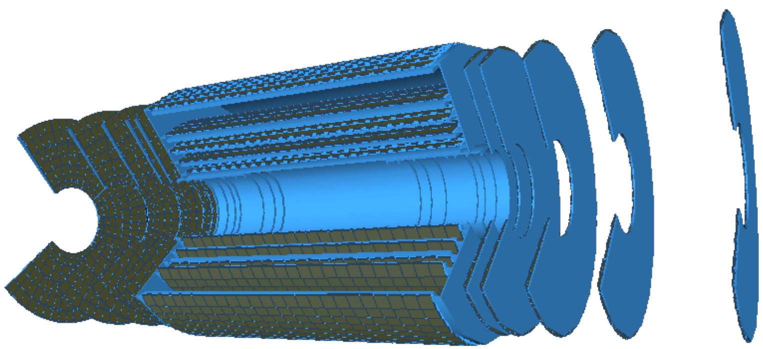




SLHC-19-13 SCT

Software Status

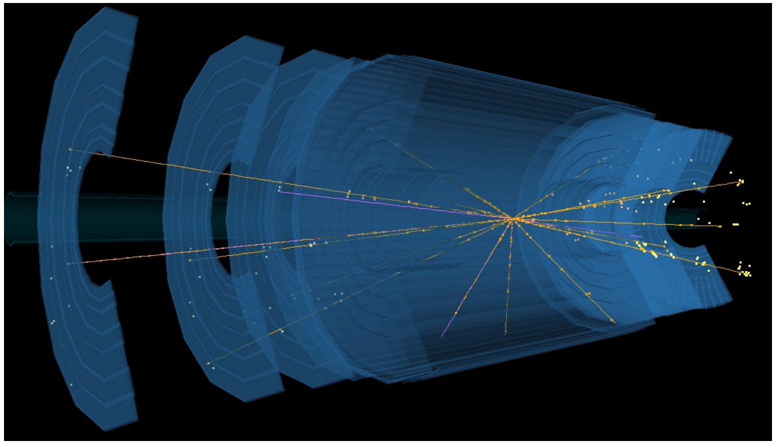
- Latest nightlies, 16.4.X
  - Currently being developed
  - Will eventually lead to a full series 17 Athena release, including all subdetectors
  - Standard Simulation jobs do not currently run in this release
  - This is being worked on, hopefully will be resolved soon...
- Frozen nightly, 15.X.0-SLHC
  - Installed on NAF
  - Still used as stable version for running standard jobs
  - > 1 year old at this point

Progress so far...

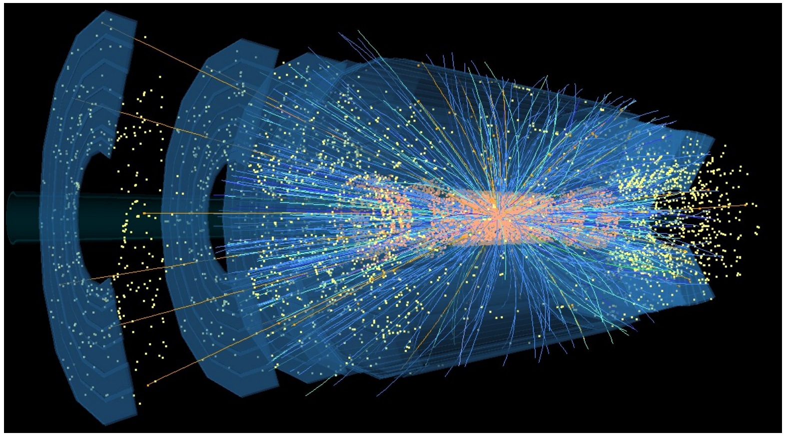
- Running full chain for current SLHC geometries – Generation, Simulation, Digitization, Tracking
  - Single particles
  - Multi-muon/Multi-electron (10 particle/anti-particle pairs per event)
  - Signal + pile-up

Data Samples

- Large (10,000 events) Multi-muon/multi-electron files produced at several transverse momenta
  - 5 GeV
  - 50 GeV
  - 200 GeV
- Small samples of events with signal + pileup
  - Mainly as 'proof of principle' that we can run these jobs
  - Will require a large amount of minimum bias events
  - Discussed further later...



10 e+/e- pairs



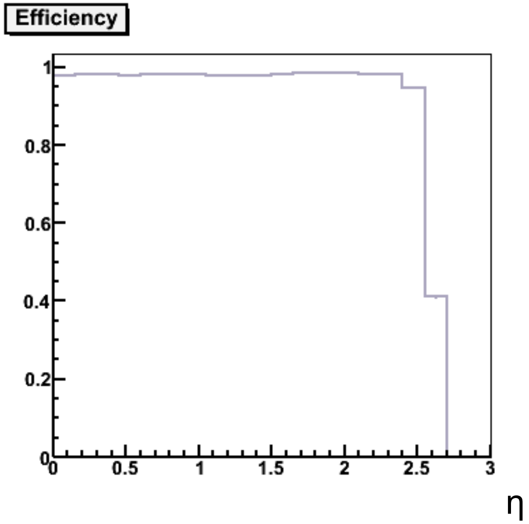
Single muon + 10 pileup events

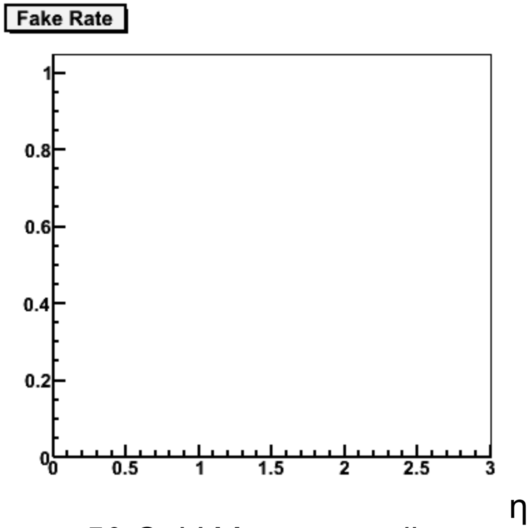
Progress so far...

- *Running full chain for current SLHC geometries – Generation, Simulation, Digitization, Tracking*
  - *Single particles*
  - *Multi-muon/Multi-electron (10 particle/anti-particle pairs per event)*
  - *Signal + pile-up*
- Producing "standard" performance plots
  - Efficiency
  - Fake Rate

Standard Plots

- For 50 GeV Muons
  - Efficiency approaching ~1 over most of η range
  - No fake tracks

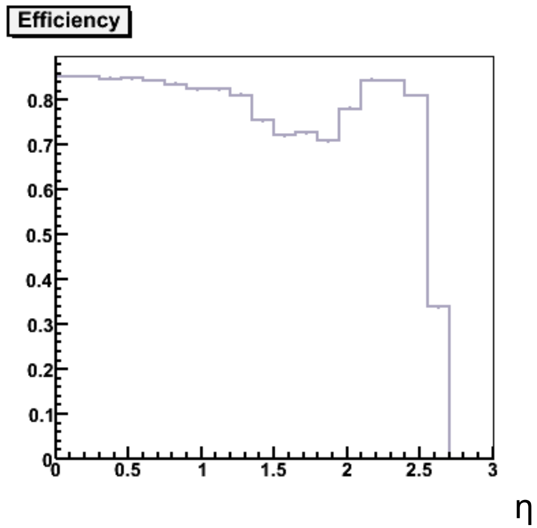


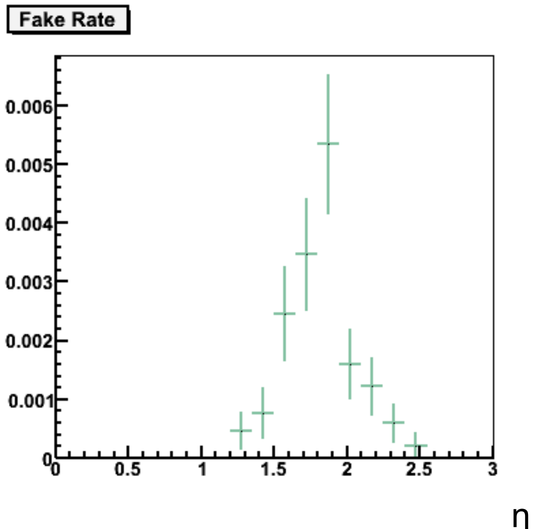


50 GeV Muons, no pileup

Standard Plots

- *For 50 GeV Muons*
  - *Efficiency approaching ~1 over most of η range*
  - *No fake tracks*
- For 50 GeV Electrons
  - Drop in efficiency and increase in fake rate for ~ $1.5<\eta<2$





50 GeV Electrons, no pileup

Standard Plots

> *For 50 GeV Muons*

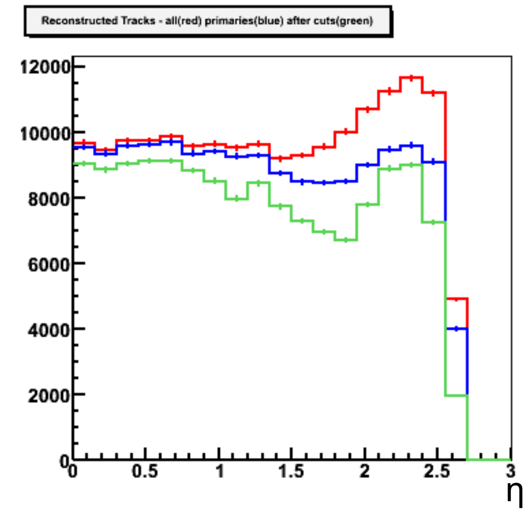
- *Efficiency approaching ~1 over most of η range*
- *No fake tracks*

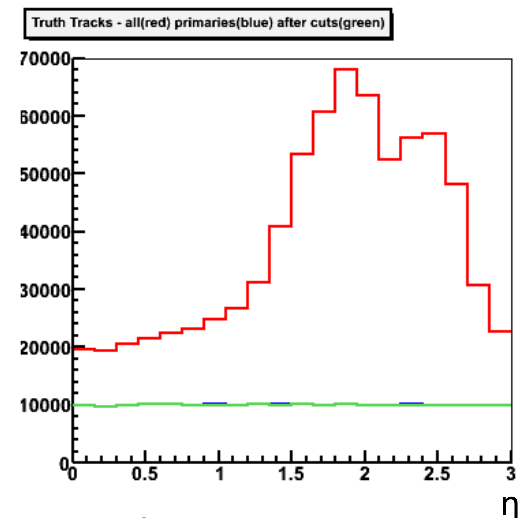
> *For 50 GeV Electrons*

- *Very large drop in efficiency and increase in fake rate for ~ 1.5<η<2*

> Material effects

- All tracks (including secondary particles generated within Geant4) shown in red
- Checking particle “barcode” allows track from pythia-generated particles (blue) – i.e. the ones we *want* to track - to be differentiated
- Pythia tracks following cuts on MC match probability, z0, d0, Chi^2, nHits, shown in green.





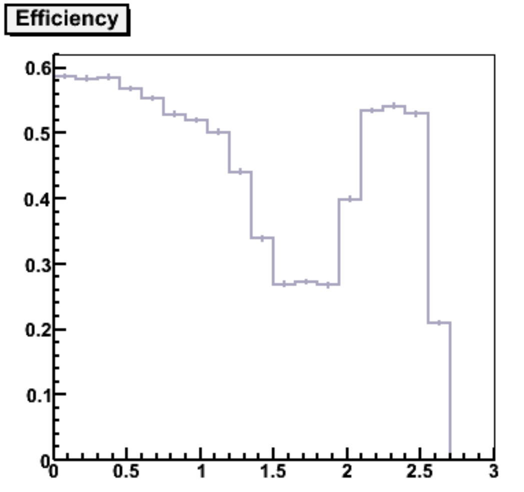
50 GeV Electrons, no pileup

Standard Plots

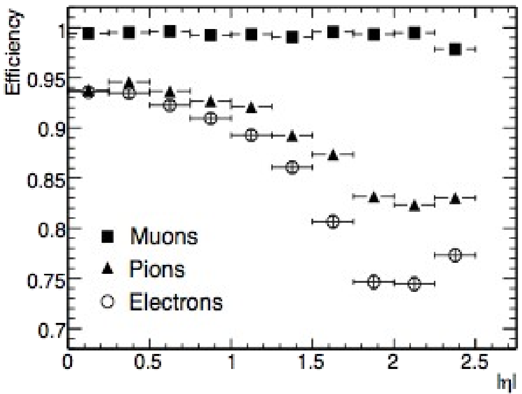
> For 5 GeV electrons, efficiency drops considerably and “dip” is more pronounced

> Compare with equivalent plots for current ATLAS Inner Detector

- Similar features
- Large discrepancy in efficiency
- Needs to be understood



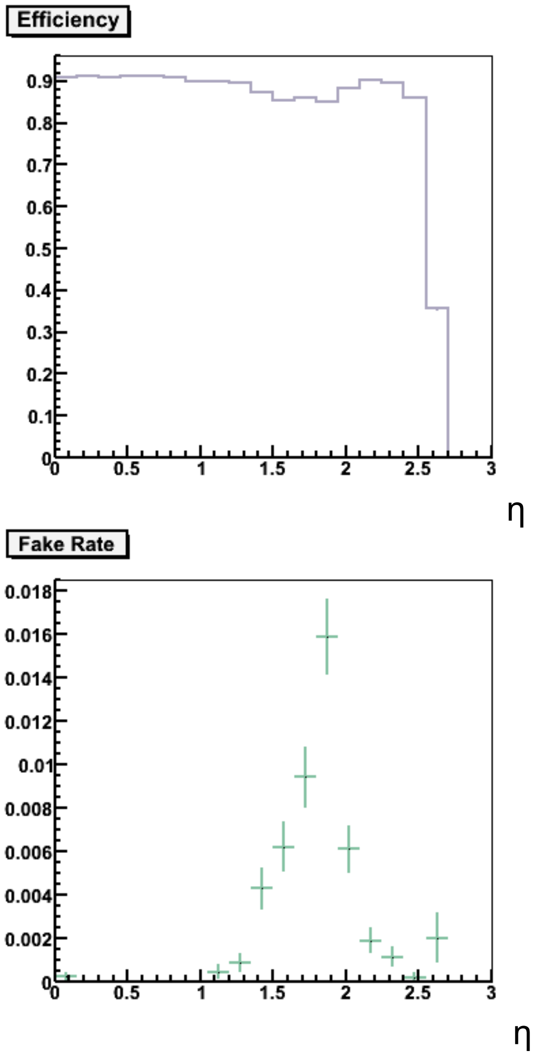
5 GeV Electrons, no pileup



5 GeV Muons/Pions/Electrons with current Inner Detector (from ATLAS Detector Paper)

Standard Plots

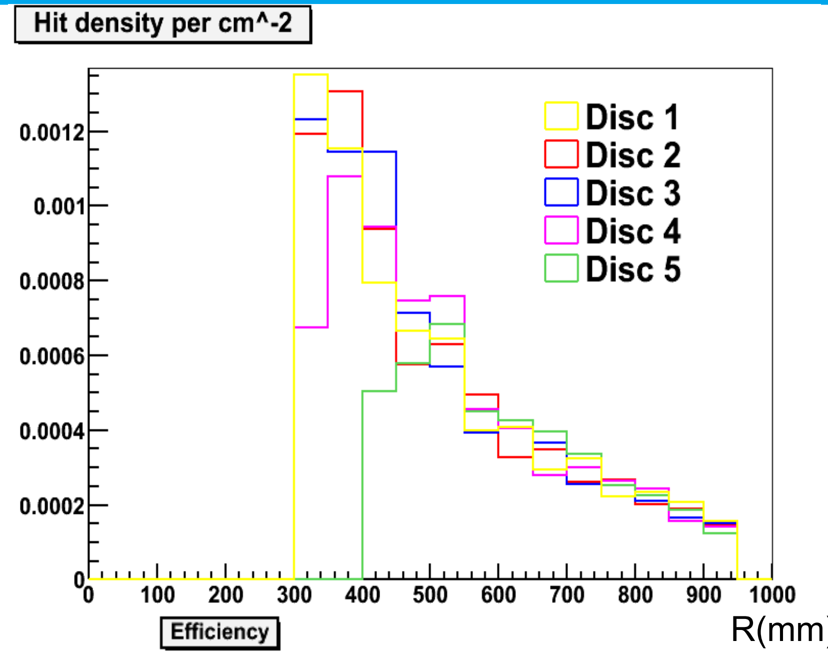
- *For 5 GeV electrons, efficiency drops considerably and “dip” is more pronounced*
- *Compare with equivalent plots for current ATLAS Inner Detector*
  - *Similar features*
  - *Large discrepancy in efficiency*
  - *Needs to be understood*
- For 200 GeV electrons, efficiency rises again, as does track fake rate

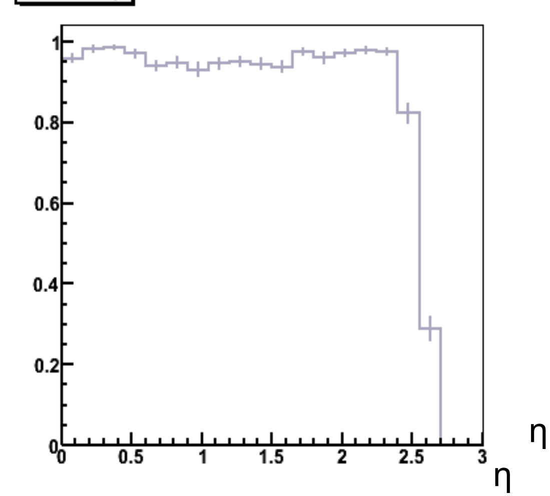


200 GeV Electrons, no pileup

Standard Plots

- Shared datasets available, multimuon with varying levels of pileup (5 – 400 collisions/event)
  - P_T in range 2 – 100 GeV
  - 250 events for each setting
- Useful to test running over events with pileup
- Located at /castor/cern.ch/atlas/atlascerngroupdisk/detslhc/jtseng/rel6



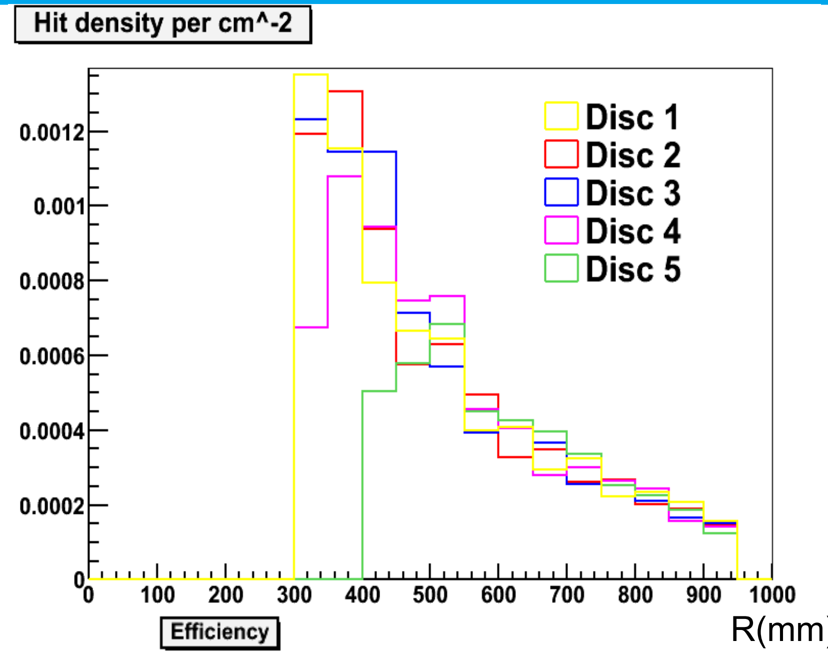


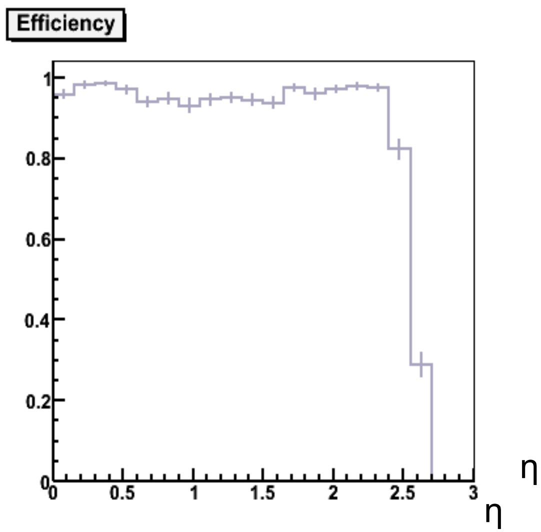
Muons + 150 pileup collisions

DESY

Standard Plots

- *Shared datasets available, multimuon with varying levels of pileup*
  - *P_T in range 2 – 100 GeV*
  - *250 events for each setting*
- *Useful to test running over events with pileup*
- *Located at /castor/cern.ch/atlas/atlascerngroupdisk/detslhc/jtseng/rel6*
- Would also like to study occupancies
  - Hit information at sensor level required, not currently available in the Tracking Ntuples were are using





Muons + 150 pileup collisions

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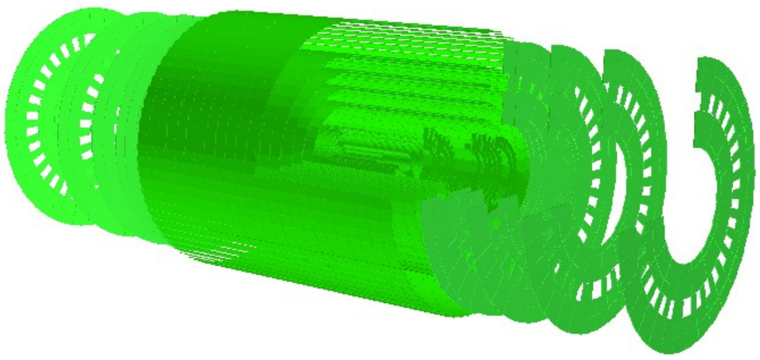
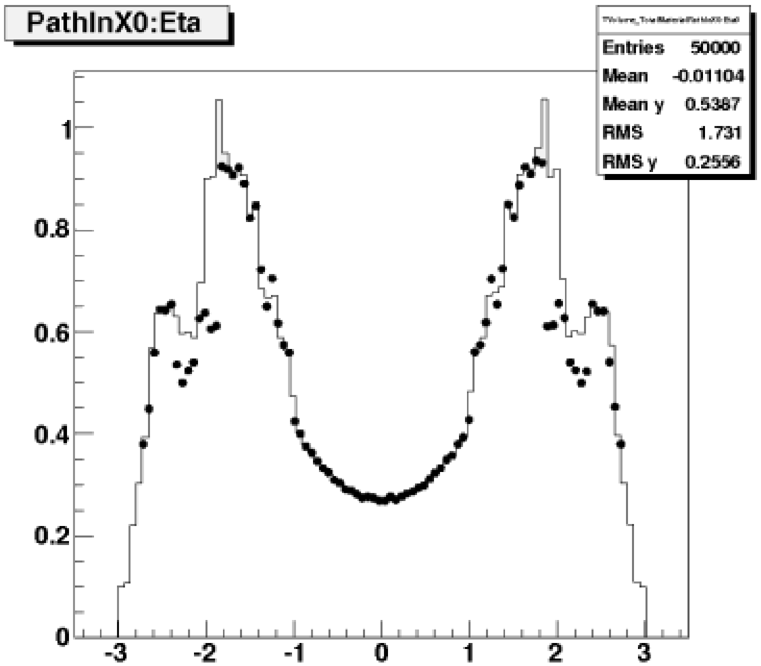
- *Running full chain for current SLHC geometries – Generation, Simulation, Digitization, Tracking*
  - *Single particles*
  - *Multi-muon/Multi-electron (10 particle/anti-particle pairs per event)*
  - *Signal + pile-up*
- *Producing "standard" performance plots*
  - *Efficiency*
  - *Fake Rate*
- Tracking Geometry
  - Producing Material Maps

Tracking Geometry



Tracking Geometry surfaces for SLHC-19-20



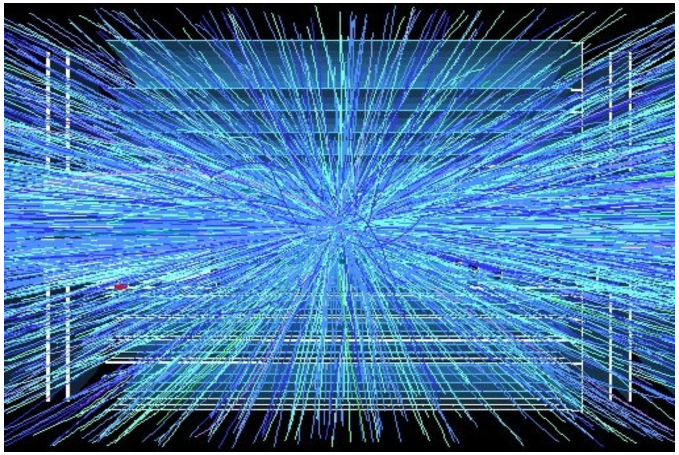
> Tracking Geometry provides simplified detector description to be used in Reconstruction
  - Provides information on amount of material traversed by a particle for a given track

> Generated by tracking non-interacting "geantino" particles through full Geant4 geometry

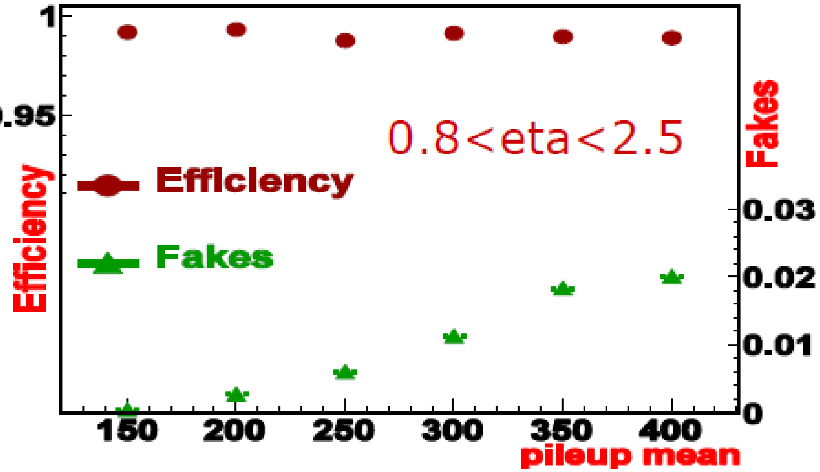
What are the next tasks we need to look at?

Pile-up data set production

- Previous Upgrade studies considered 400 pileup collisions/event as baseline.
  - 100-200 pileup collisions/event is now considered to more likely scenario
- Minimum bias events take ~ 1 minute per event to simulate
- ~4Mb per event with 150 pileup collisions
- Large samples of events including pileup will be required
  - High fake rate in endcap is an important issue to investigate
  - Must ensure that these samples are produced in a sensible, efficient way



Simulated SLHC event with L= $10x10^{34}$ $cm^{-2}s^{-1}$ (400 pileup collisions)

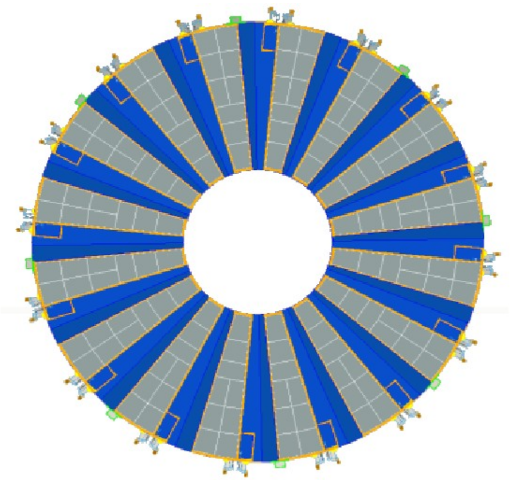


Muon fake rate & efficiency as a function of pileup

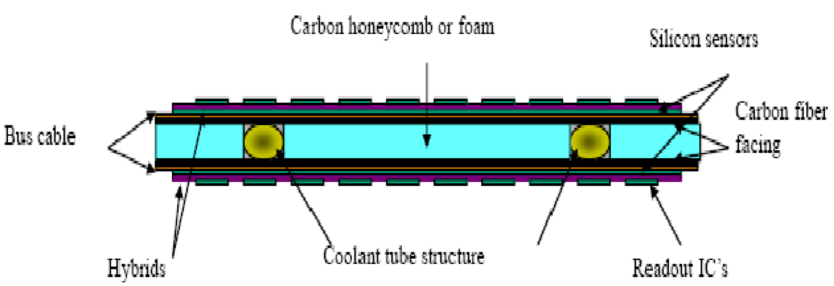
(A. Abdesselam)

Geometry Modifications

- Currently implemented SCT endcap description is based on modules in rings
- Want to implement radial geometry, with Petals
  - Few months “expert time”
  - Several people prepared to put time in to this, but far from experts!
- Many other facets of geometry can also be studied
  - Disk: radii, support structure, overlap
  - Petal: geometry, sensor shapes ...
  - Sensor: strip length
- FATRAS fast track simulation could be a useful tool for studying different geometries



Petal Endcap Design



Stave Layout

ID Upgrade Management

- Preliminary document produced (A. Clark, M. Elsing, P. Maettig)
- Can be found on Indico agenda page for Upgrade Simulation meeting, 8th December
  - Meeting every other Wednesday at 5pm. Via Skype, contact Jeff Tseng to be included
- Preliminary set of questions to be addressed. Includes:
  - Redundancy/how many layers (cost vs. performance)
  - What rapidity coverage do we want/need
  - Material of services
  - What would one gain/lose from a long barrel?
  - Layout of endcap detector discs? Continuous shape?
- Suggestions regarding datasets for studying performance criteria
  - e, μ, π with p_T = 1, 5, 10, 20, 100 GeV
  - with/without pileup (L= 10×10^{34} $cm^{-2}s^{-1}$, 50 ns bunch spacing)
  - Isolated/embedded inside jets

Conclusions

- Progress has been made in studies of current geometry
  - Running generation/simulation/digitization/tracking
  - Producing performance plots
- Necessary tasks becoming better defined
  - Hope to meet with Jeff Tseng in January to discuss this further
- Expert input still needed before work on geometry modifications can be started
  - Very limited documentation available on producing new detector descriptions
  - Need to sit down with people who know how to do this

Backup Slides

Tracking cuts for Efficiency calculation

> Truth Track Cuts

- Truth z0 < 150 mm
- Truth d0 < 1.0 mm
- Barcode indicates “signal” particle

> Reconstructed track cuts

- Reco track with best match to truth track
- Match probability > 0.5
- Total number of hits > 11
- p_T > 3 GeV
- Chi^2/dof < 5
- Rec z0 < 150 mm
- Rec d0 < 1.0 mm