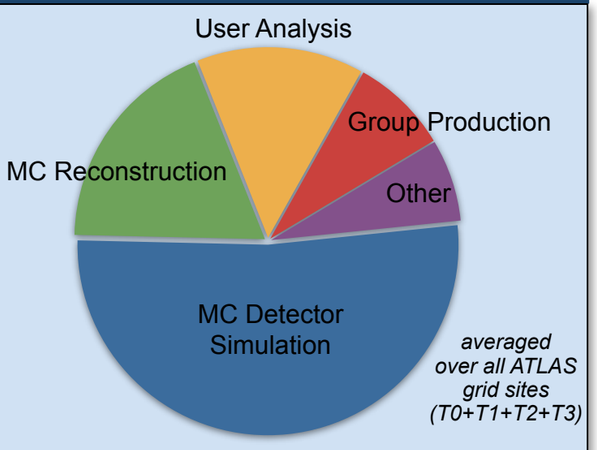
# LHCC Poster Session - CERN, 13 March 2013

# The ATLAS Integrated Simulation Framework

## *Fast and Flexible Large Scale Detector Simulation*

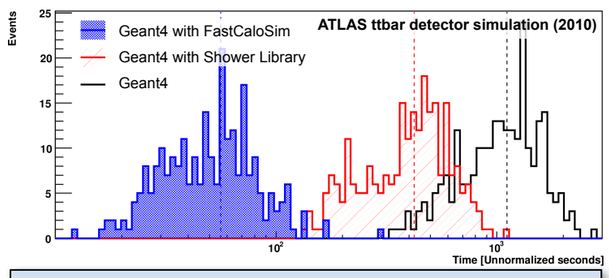
## Motivation to speed up ATLAS Detector Simulation

### ATLAS Grid Usage 2012




The Monte Carlo (MC) detector simulation step dominates CPU consumption on ATLAS Grid resources. This limits the MC sample sizes that can be produced within a certain period of time. Already, some physics studies, require larger MC samples than is feasible to produce in a timely fashion.

### ATLAS Simulation Time




Various efforts have been undertaken to speed up ATLAS detector simulation. The Calorimeter is by far the most computationally intensive part of the ATLAS Geant4 [1,2] detector simulation. This motivated the development of the following ATLAS detector simulation setups used in MC production as of now:

- **Geant4**
- **Geant4 with Frozen Shower Libraries**
- **Geant4 with FastCaloSim (parameterized Calorimeter)**

### Fast Detector Simulation

In general, fast detector simulation differs in the following ways from full detector simulation:

- **faster**
- **less detailed**
- **easier to tune to data**

### References


[1] The ATLAS Collaboration, *The ATLAS Simulation Infrastructure*, Eur. Phys. J. **C 70** (2010) 823–874

[2] S. Agostinelli et al., *Geant4 - A Simulation Toolkit*, Nucl. Instr. Methods Phys. Res. **A 506** (2003) 250–303

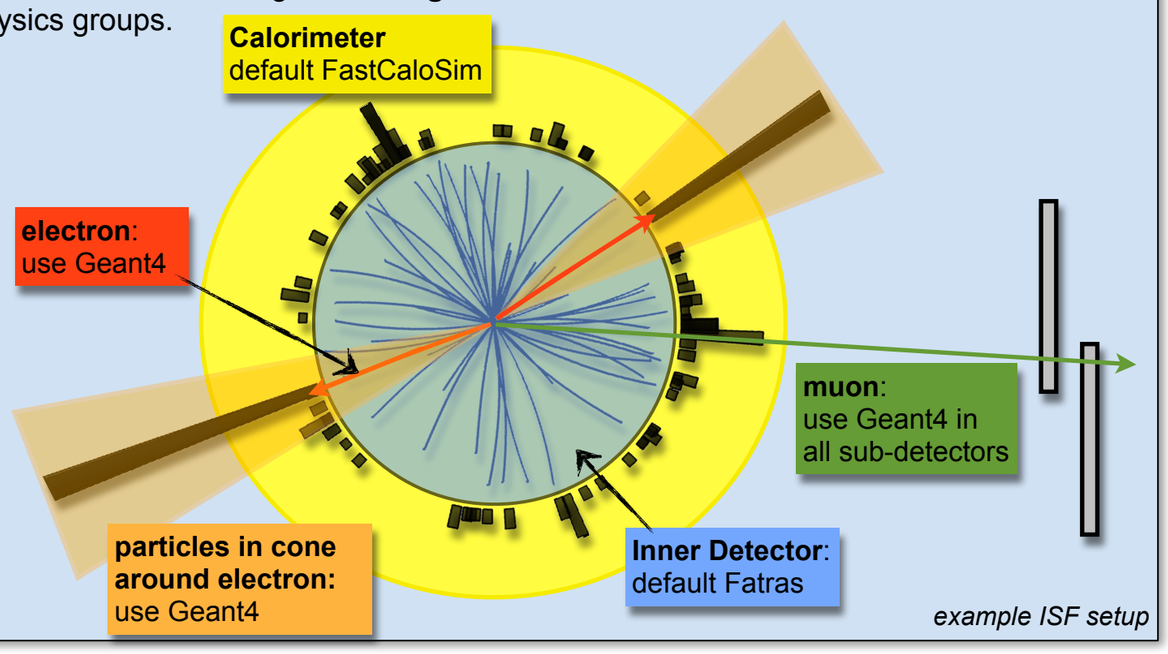
[3] J. Mechnich (on behalf of the ATLAS Collaboration), *FATRAS - the ATLAS Fast Track Simulation project*, J. Phys.: Conf. Ser. **331** (2011) 032046

[4] The ATLAS Collaboration, *The simulation principle and performance of the ATLAS fast calorimeter simulation FastCaloSim*, ATL-PHYS-PUB-2010-013 (2010)

[5] E. Ritsch, *Fast Calorimeter Punch-Through Simulation for the ATLAS Experiment,* CERN-THESIS-2011-112 (2011)

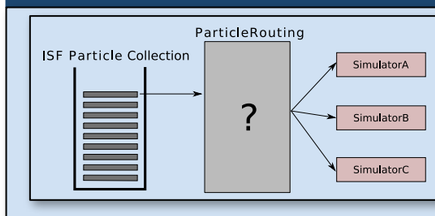

## The Integrated Simulation Framework (ISF)

The ISF is an ATLAS detector simulation framework optimized to **simulate particles within one event with different simulators**. Some of the simulators might be very accurate but slow, whereas others might be very fast but less accurate. The framework allows the user to configure **routing rules** that can be tailored to the needs of various physics groups.

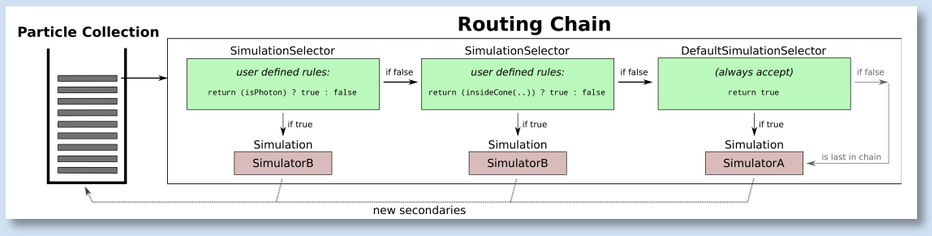



*example ISF setup*

### ISF Particle Routing Chain

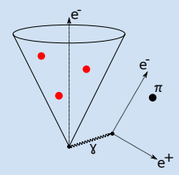



The particle routing algorithm is the essential part of the ISF framework. For each particle a decision has to be made as to which simulator to use.




The ISF **particle routing chain** gives the user complete flexibility to configure the framework to their needs. The chain is made of a series of SimulationSelectors. Each particle is handed through the chain until the first SimulationSelector picks it. The particle will then be simulated with the simulator corresponding to that Simulation-Selector

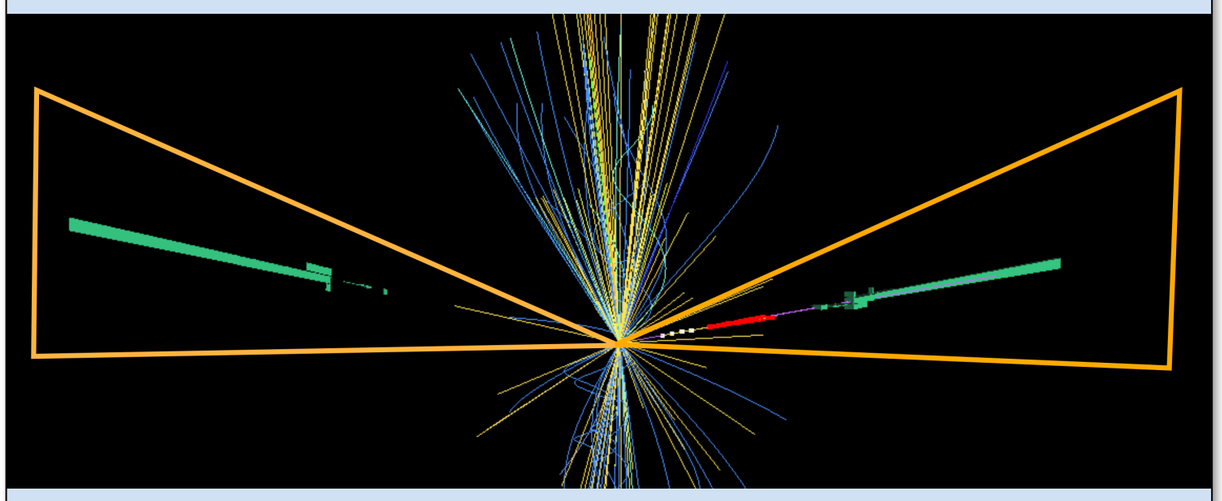
### Partial Event Simulation




The ISF routing chain allows for simulation selectors that will pick particles close to other particles, e.g. all particles inside a cone around an electron. These particles can then be simulated by any supported ATLAS detector simulator, full or fast.

Ongoing validation for fast simulation of Higgs → γγ events:

➡ simulate particles inside cones around photons only, skip everything else

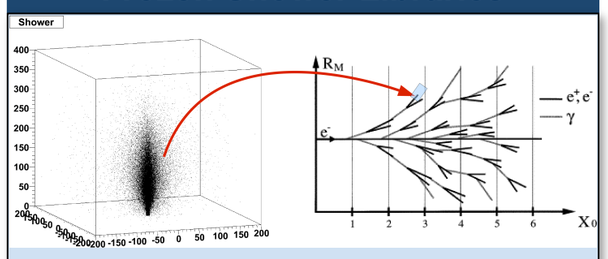


| ISF Simulation Setup | speedup |
|---|---|
| all sub-detectors: **Geant4** | **1** |
| ID* and MS**: **Geant4**<br>calorimeter: **FastCaloSim** | **~25** |
| ID and MS: **Fatras**<br>calorimeter: **FastCaloSim** | **~750** |
| simulate only particles in **cones around photons**<br>ID and MS: **Fatras**<br>calorimeter: **FastCaloSim** | **~3000** |

**ID = Inner Detector  **MS = Muon Spectrometer*  *ggH→γγ event simulation*

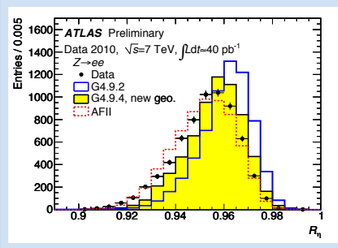
## Fast ATLAS Detector Simulators

### Frozen Shower Libraries




For EM calorimeter simulation, low energetic particles get replaced by pre-simulated EM showers from a lookup library [1]. ATLAS Geant4 simulation uses these shower libraries by default in the forward calorimeters.

### FastCaloSim



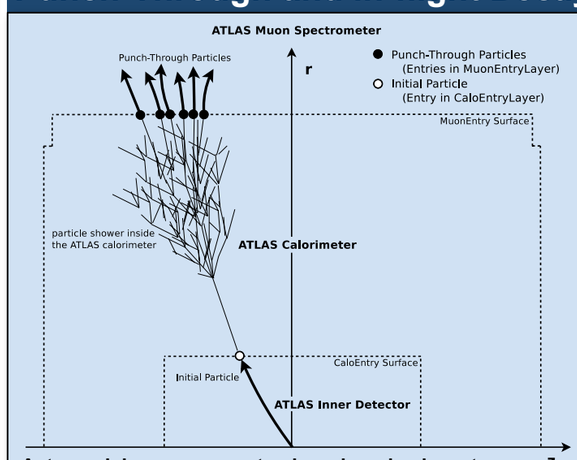

Energy ratio $R_\eta$ in a $\Delta\eta^*\Delta\varphi$ = 3x7 cells cluster with respect to a 7x7 cells cluster size in the bulk EM calorimeter layer 2.

FastCaloSim [2,4] is a parameterized ATLAS calorimeter simulation. The parametrization is based on Geant4 simulation results.

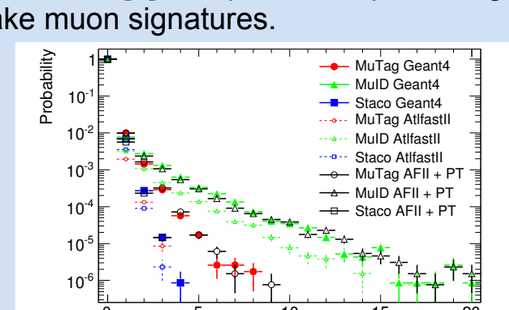
### Fatras

Fatras [3] is a fast tracker simulation for the ATLAS inner detector and muon spectrometer. The gain in speed comes from a simplified geometry description and simplified interaction models.

### Parameterized Calorimeter Punch-Through and in-flight Decay




A tunable parameterized calorimeter punch-through and decay in-flight simulation [5] is capable of reproducing fake muon signatures.




Reconstructed number of muons inside jet cone (size $\sqrt{(\Delta\eta^2*\Delta\varphi^2)}$=0.6) obtained from different reconstruction algorithms and simulation setups (the AtlfastII setup uses Geant4 and a parameterized calorimeter simulation). A clear improvement due to the punch-through simulation is visible.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