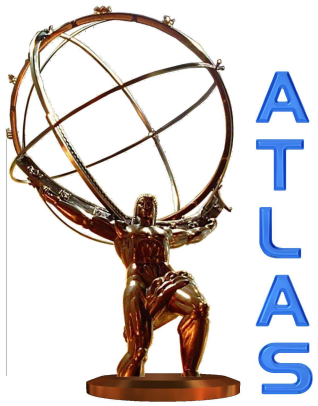
ATLAS Fast Simulation: AtlFast-II and the Integrated Simulation Framework



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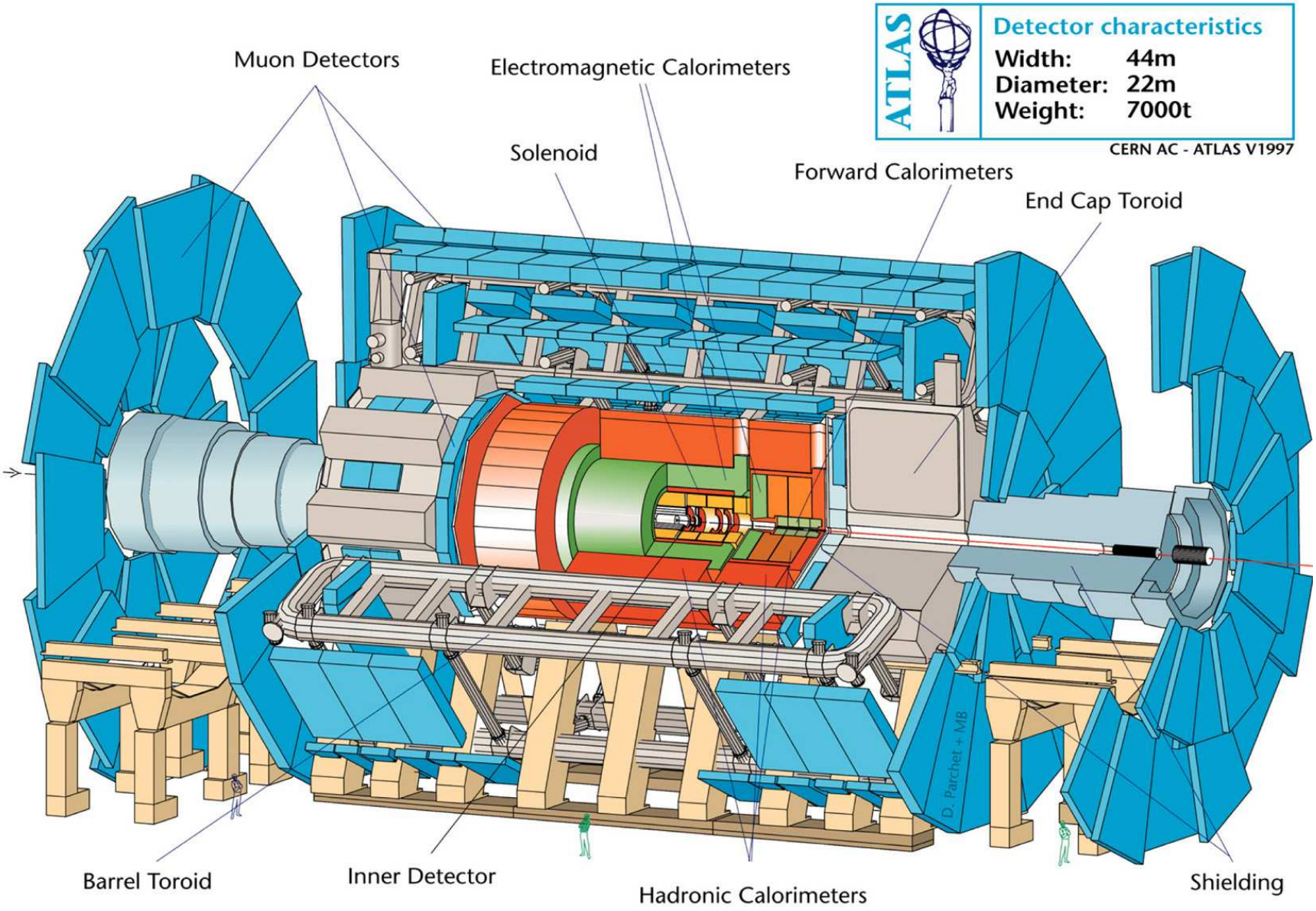
Robert Harrington *on behalf of the ATLAS Collaboration*

Overview

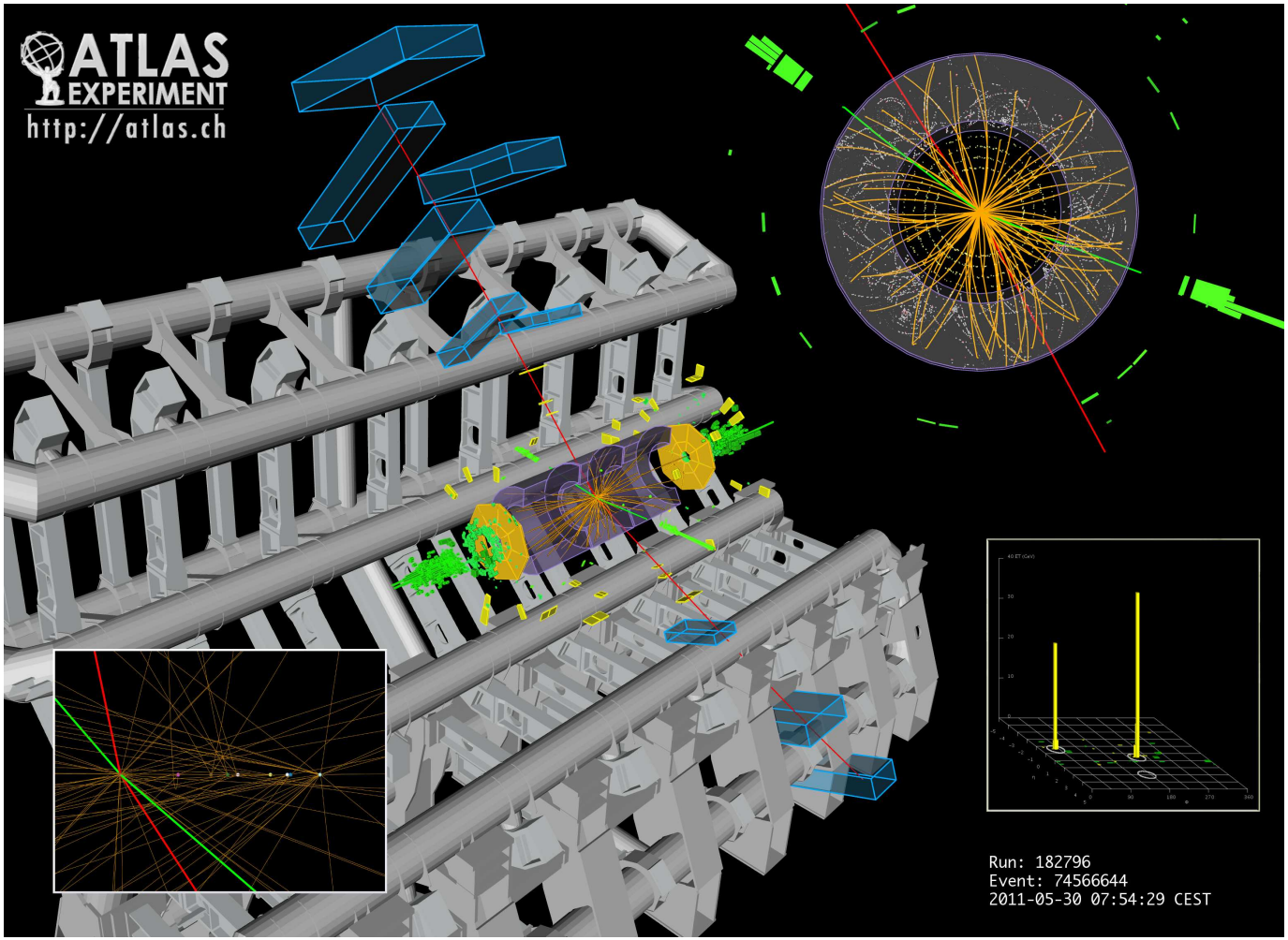
- Monte Carlo and Simulation requirements
- CPU/timing limitations
- Atlfast-II and FastCaloSim
- Integrated Simulation Framework
- Summary

ATLAS Detector



Monte Carlo and Simulation on ATLAS

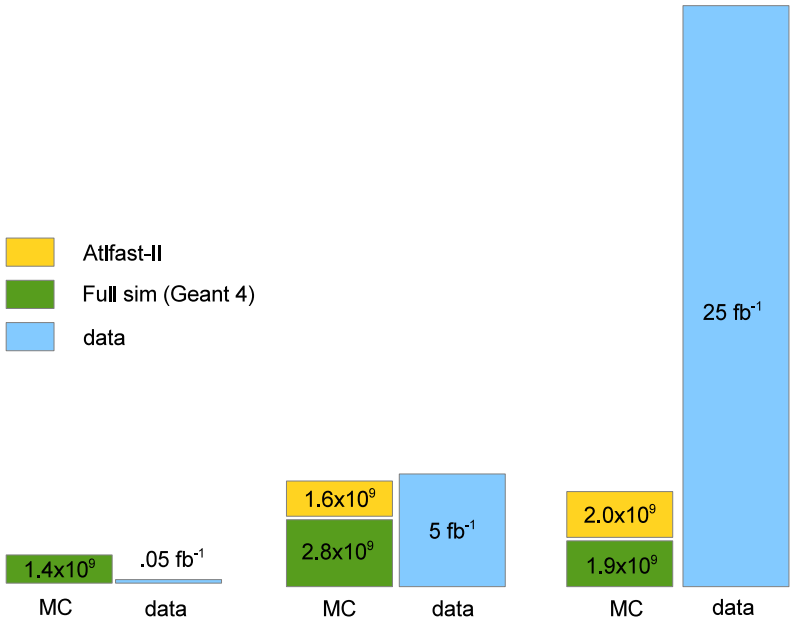
Monte Carlo (MC) techniques used to simulate physics events arising from pp collisions.

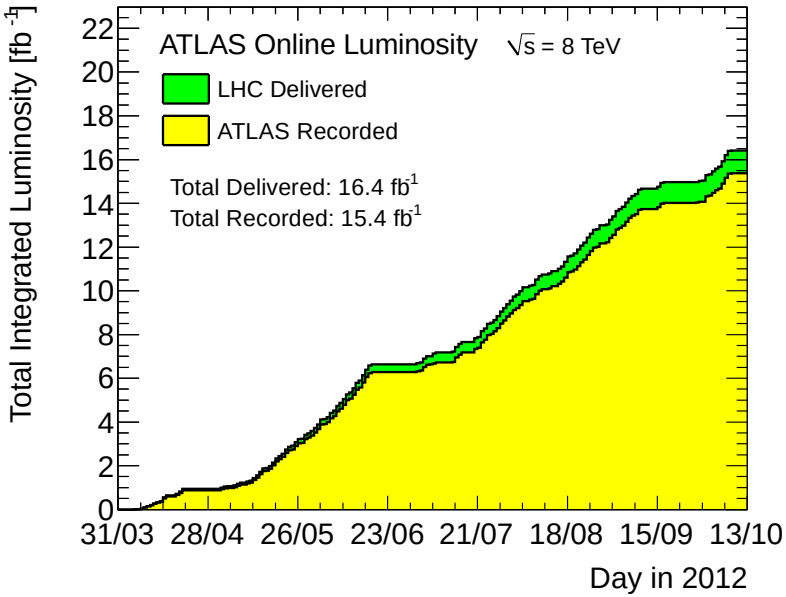


$H \to ZZ^* \to e^+e^-\mu^+\mu^-$ **candidate event**

- For current data-taking, beam bunches cross every 50 ns (20 MHz)
- ∼20-35 collision events per bunch crossing.
- ATLAS *records* ∼400 events per second!

MC samples vs. data



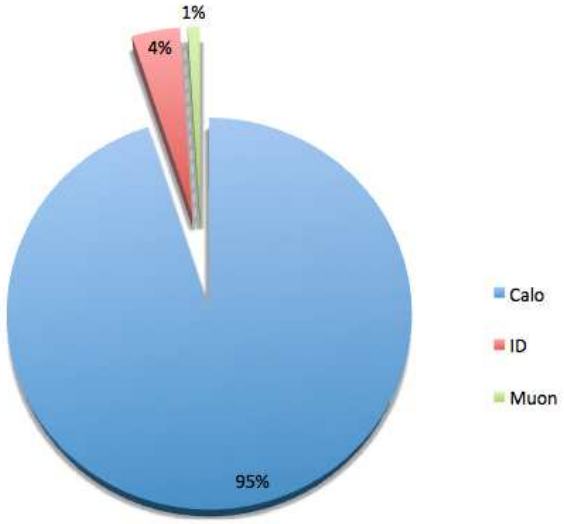


- Data available for physics analysis growing at an impressive rate!
- Ideally, we need much more MC statistics than data.
- Increasingly difficult to keep up with the needs of the experiment.

- Takes ∼1000 seconds to simulate collision events.
- $>$ 50,000 CPU cores running continuously to support ATLAS simulation.

Full and Fast Geant4 Simulation

- Geant4 provides the most accurate simulation, which is essential for some part of every simulated physics event.
- Most of the simulation time is spent in the calorimeter.
- Fast Geant4 simulation able to use pre-calculated "frozen shower" libraries for the electromagnetic (EM) part of the Liquid Argon (LAr) calorimeter.
- For standard simulation, use for forward calorimeter, gives 45% CPU improvement!



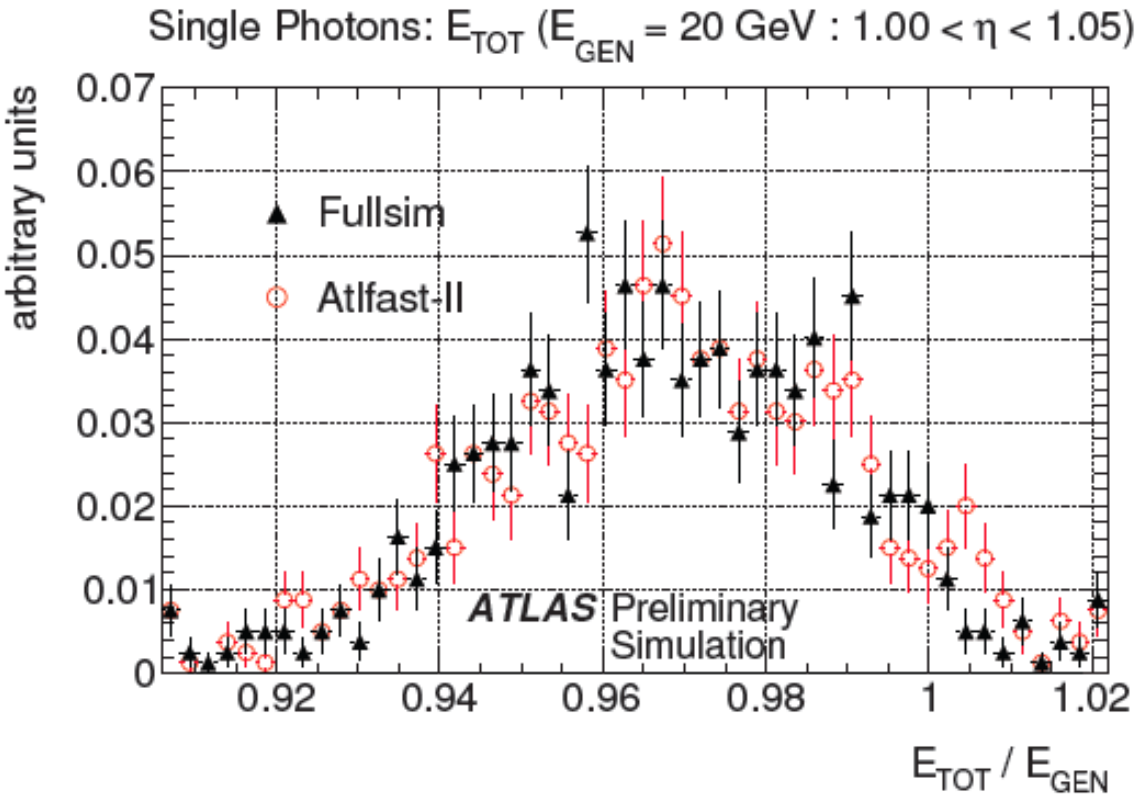
Sample	seconds per event	
	Full G4 Sim	Fast G4 Sim
Minimum bias	551	246
$t\bar{t}$	1990	757
Jets	2640	832
Photons and jets	2850	639
$W^{\pm} \rightarrow e^{\pm}\nu_e$	1150	447
$W^{\pm} \rightarrow \mu^{\pm}\nu_\mu$	1030	438

Atlfast-II and FastCaloSim

- Inner Detector simulated with Geant4.
- Muons in calorimeter and muon spectrometer simulated with Geant4.
- All other particles killed at calorimeter entry.

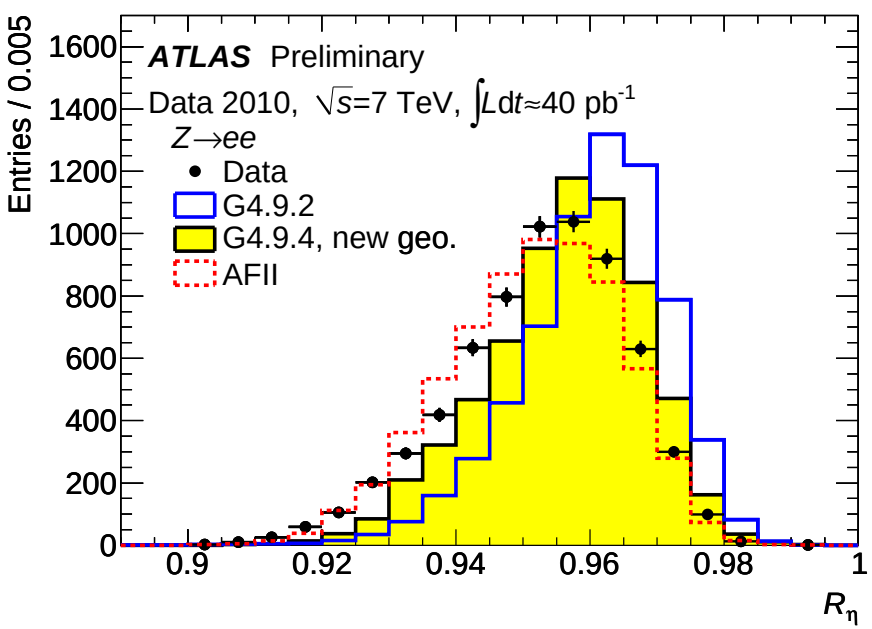
FastCaloSim

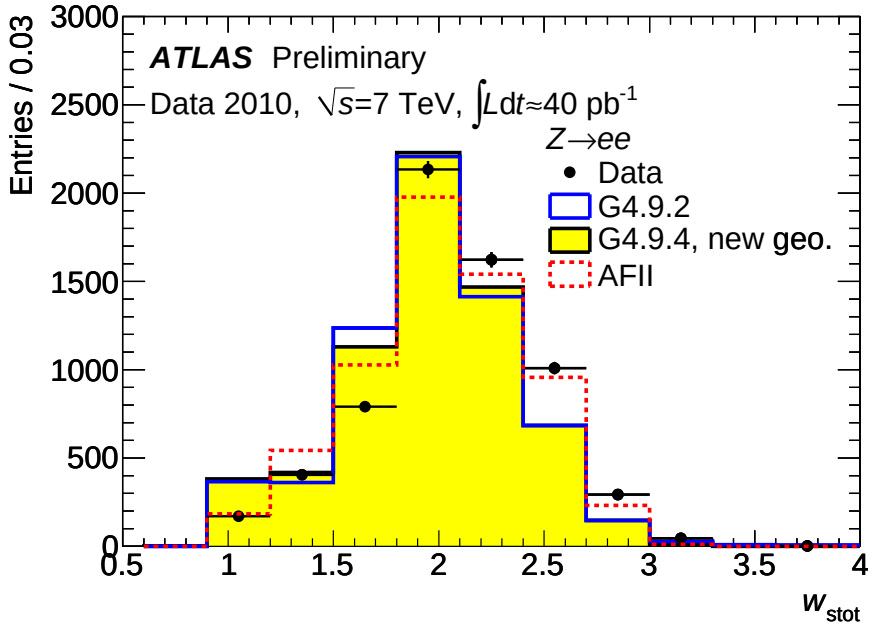
- Used for γ, electrons over 100 MeV, pions over 1 GeV in calorimeter.
- Calorimeter cell response uses parametrisation of longitudinal and lateral energy profiles.
- $> 10\times$ increase in speed for overall simulation!



Atlfast-II and FastCaloSim

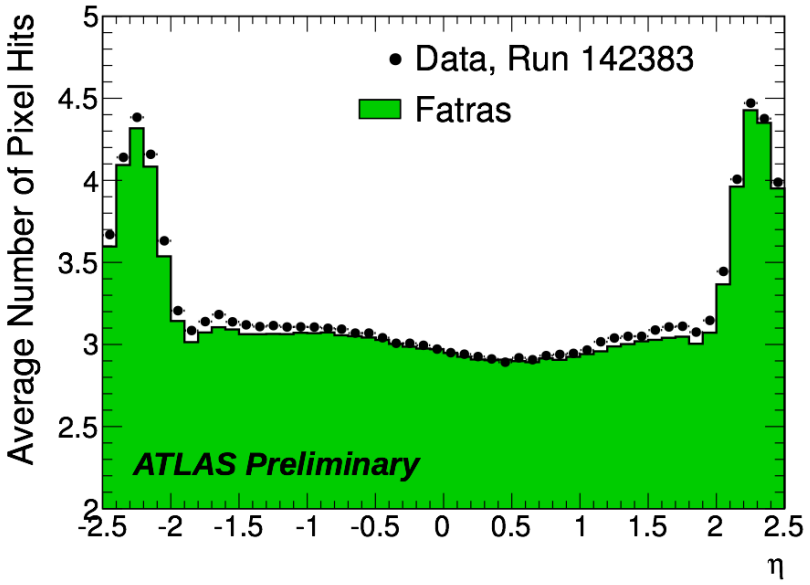
- Parametrisations of shower shape variables for calorimeter response tuned to Geant4.
- Extensive validation done comparing Atlfast-II with Geant4.
- Using parametrisations allows tuning to data.

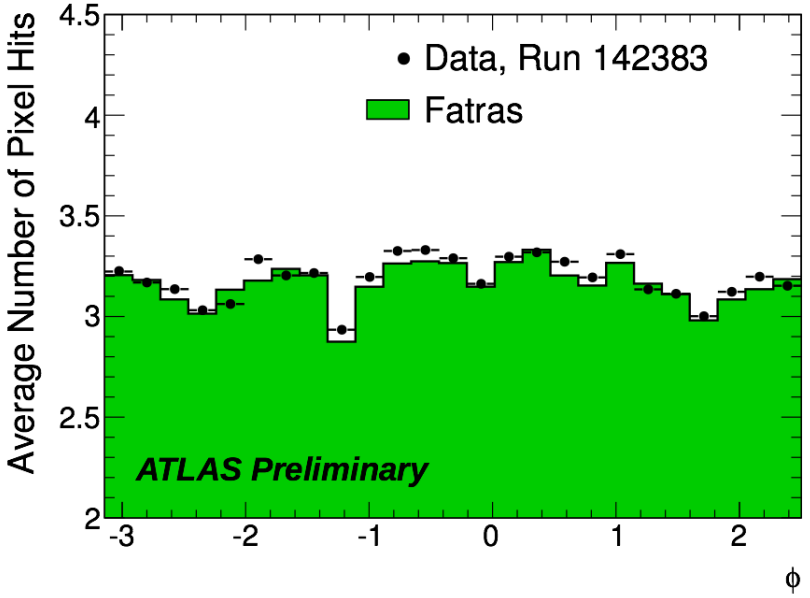




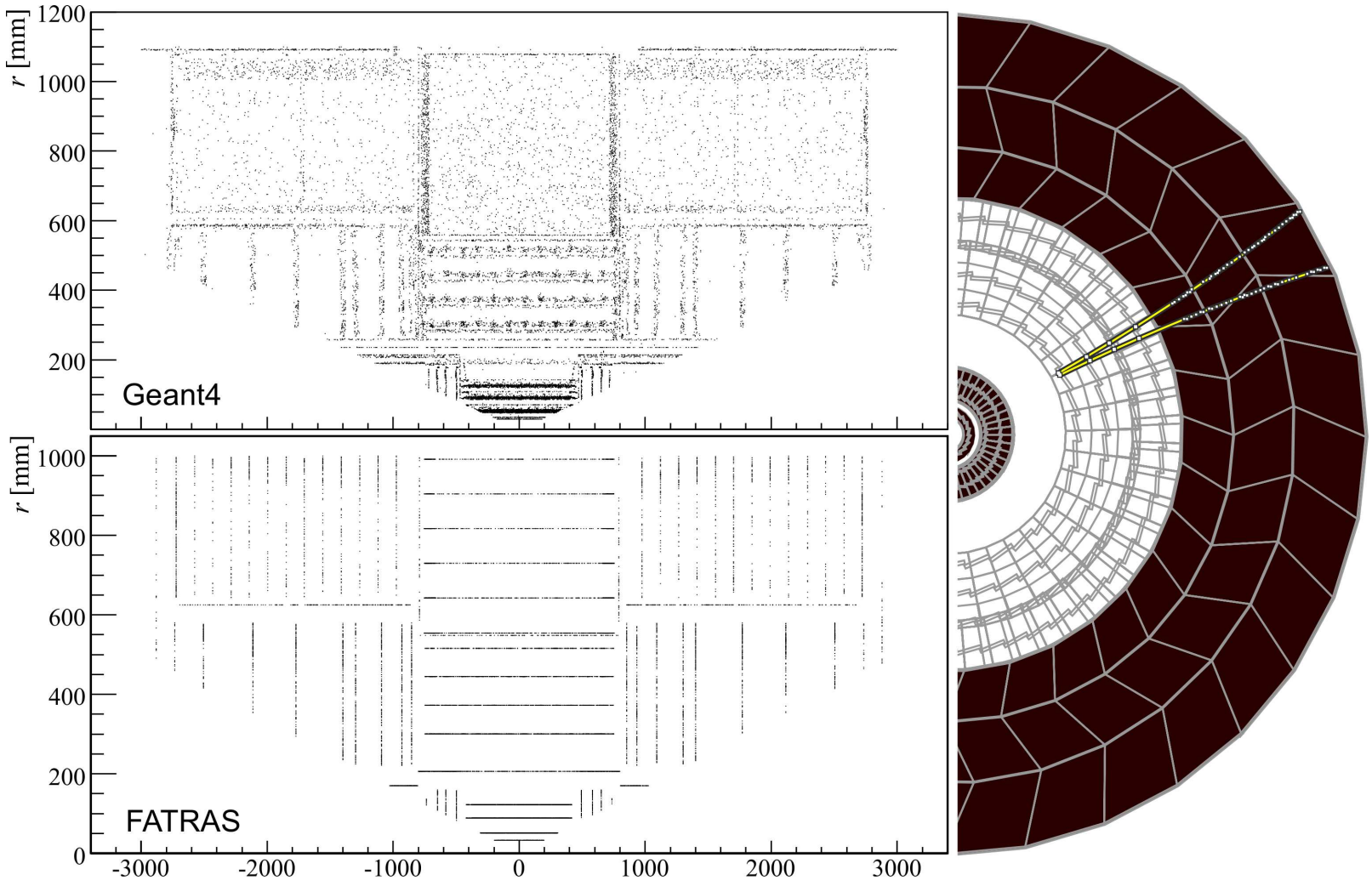
Atlfast-IIF and Fatras

- Fast ATLAS Tracking Simulation (Fatras) is used for the inner detector and muon system.
- Uses simplified physics parametrisations and a simpler reconstruction geometry instead of the full geometry.
- Gives more a factor of 100 increase in speed for simulation of event over full Geant4 simulation!
- Atlfast-IIF is in development to combine Fatras with FastCaloSim



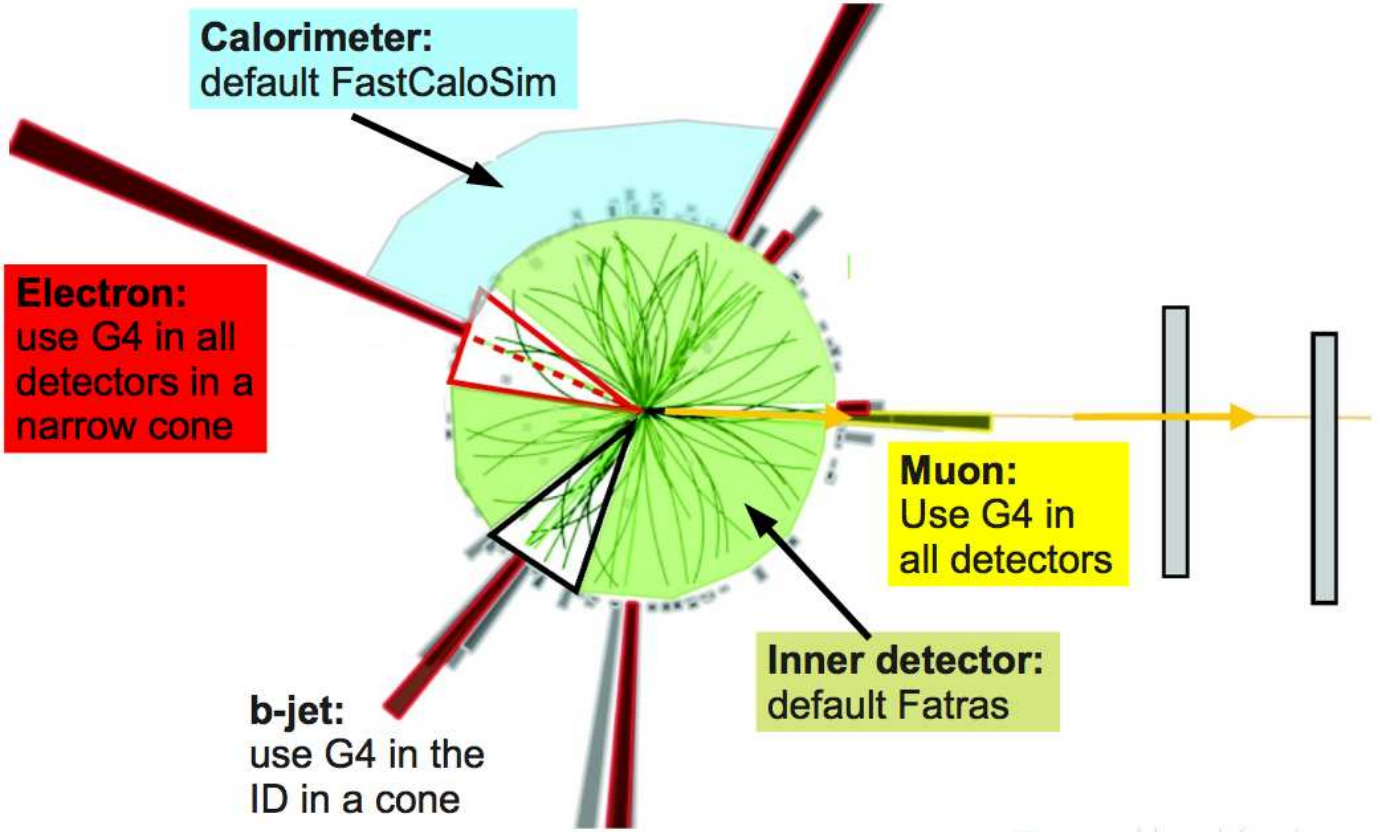


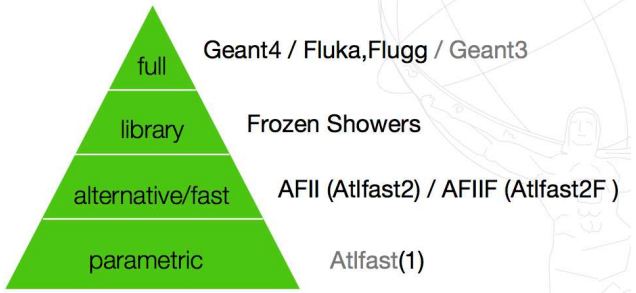
Fatras material map



- Photon conversions show the simplified material used by Fatras.

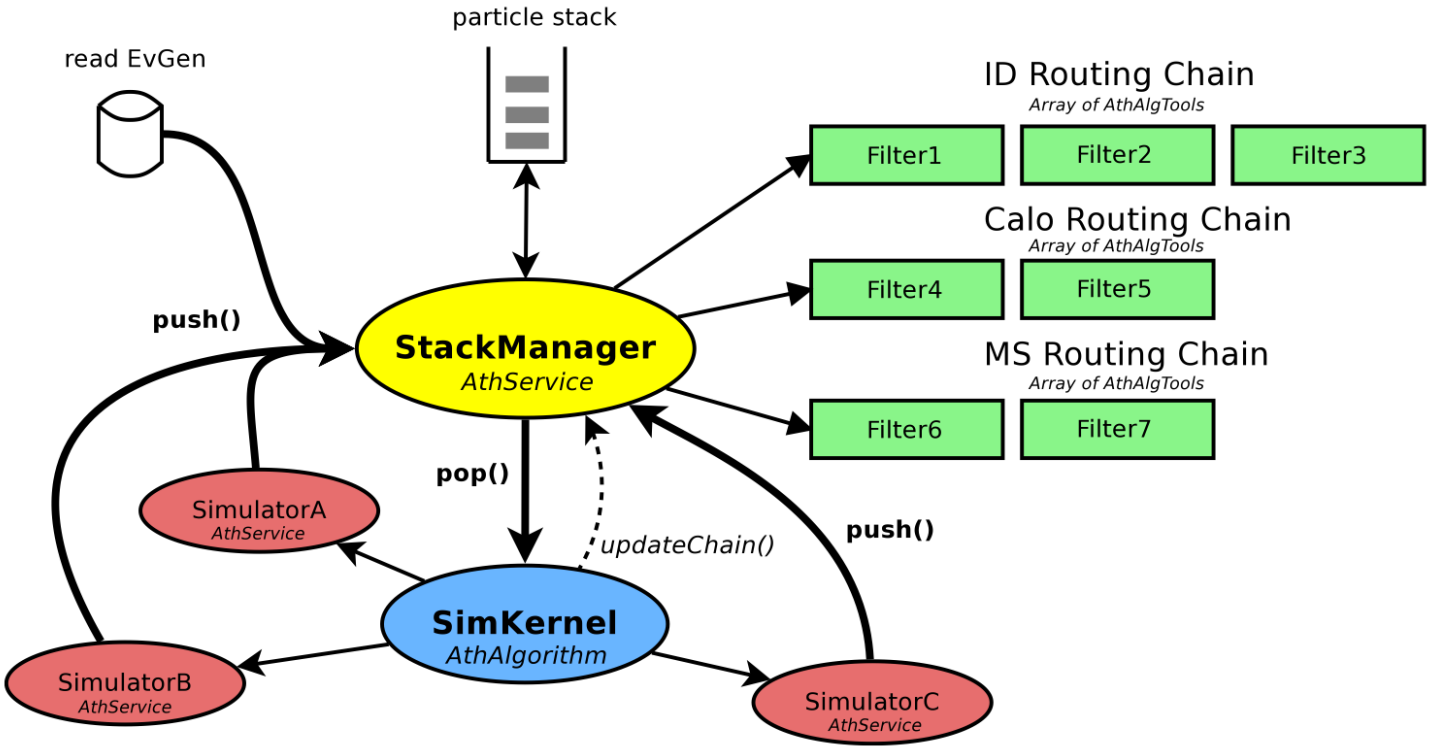
Integrated Simulation Framework (ISF)





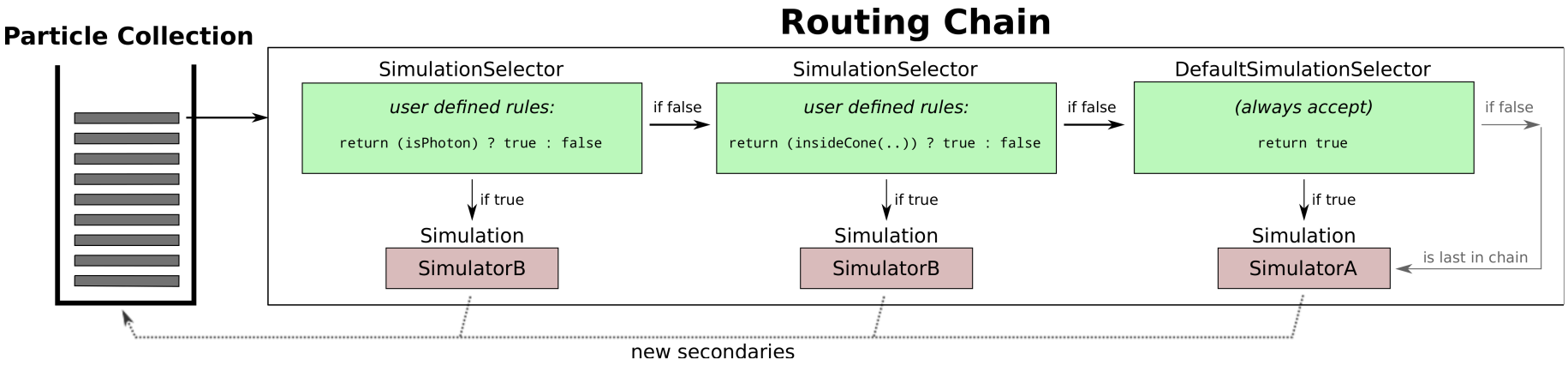
- For most physics analyses, high precision is only needed for some particles and regions within each physics event.
- ISF has been designed to allow mixing full and fast simulation within each physics event.

ISF steering



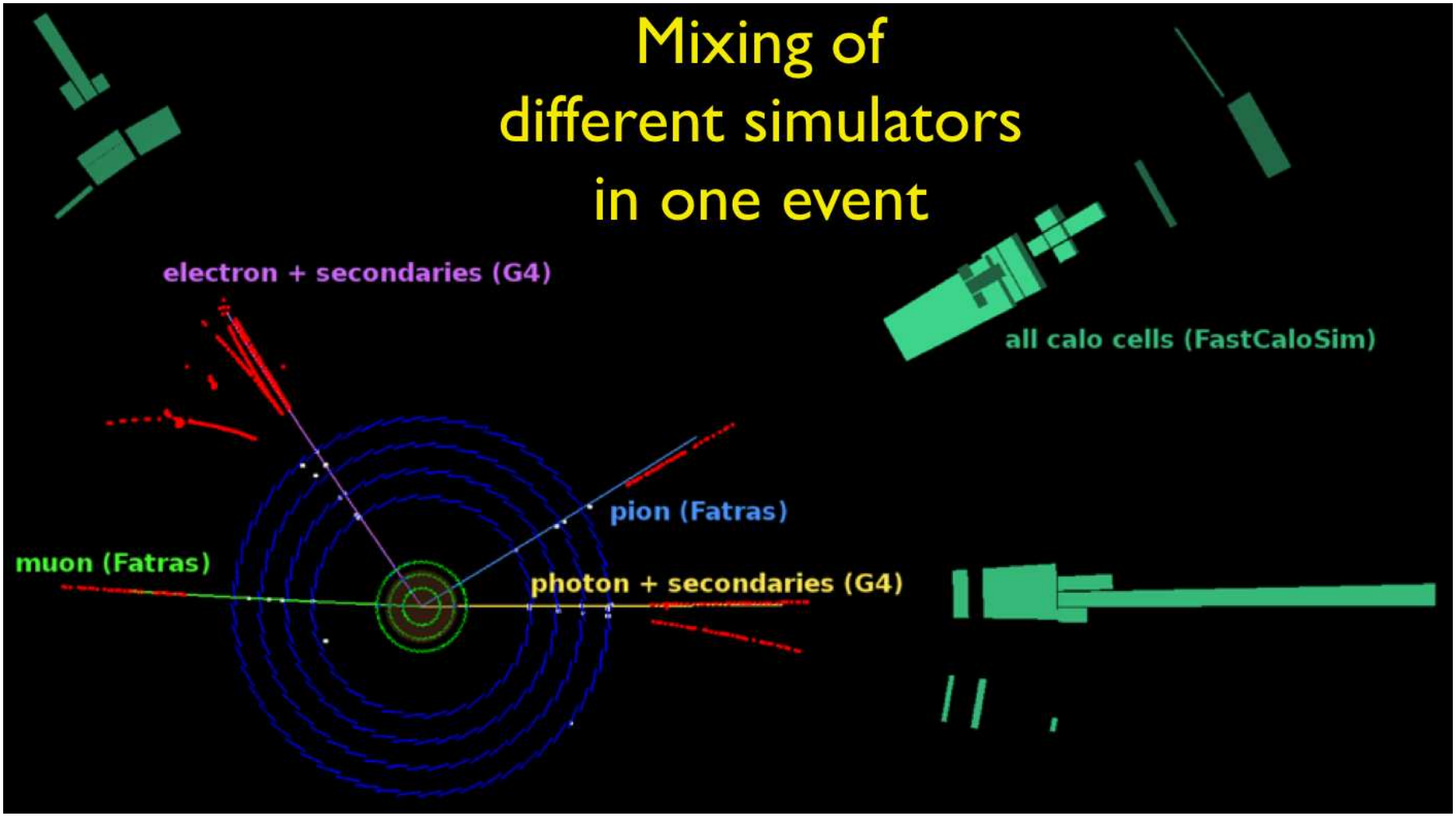
- ISF is fully integrated in the ATLAS software framework (Gaudi Athena).
- Flexible routing scheme allows selection of full and fast simulation depending on particle type, detector region, and other particle properties.
- Geant4 has been fully implemented in ISF. Current effort is in finalising implementation of Atlfast-II and Fatras in ISF.

ISF Routing Chain

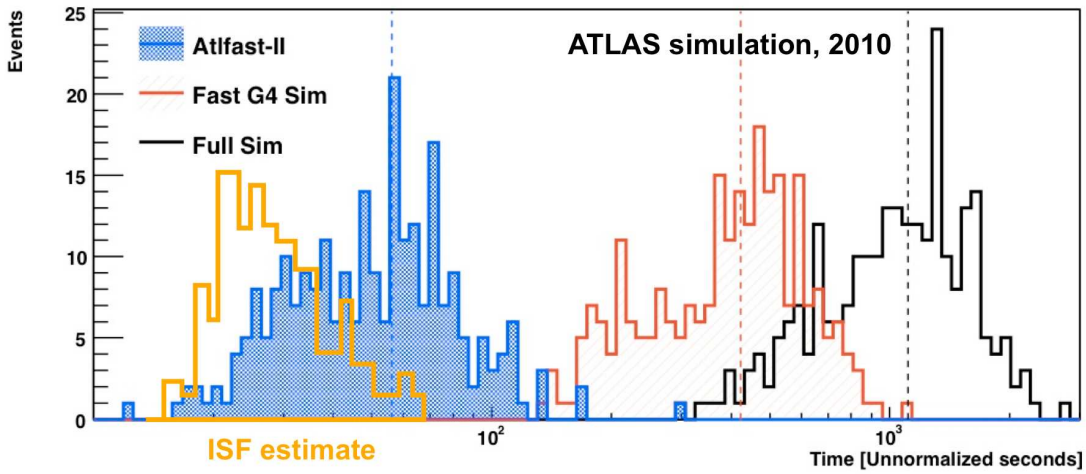


- Particles taken from the particle stack, passed to routing chain specific to each subdetector.
- Series of filter decisions determine which simulator (e.g. Geant4, Atlfast-II, etc.) the particle will be passed to.
- Dynamic filters allow decisions that depend on other particles.
- Secondaries created by the simulator returned to the particle stack.
- Completely configurable by the user based on physics requirements.

ISF Status


Mixing of
different simulators
in one event
electron + secondaries (G4)
all calo cells (FastCaloSim)
pion (Fatras)
muon (Fatras)
photon + secondaries (G4)

Summary



- Atlfast-II has been developed using FastCaloSim (calorimeter showers) and Fatras (tracking) to speed up simulation for ATLAS.

- The Integrated Simulation Framework has been developed to allow a combination of full and fast simulation in individual events to give the optimal balance between accuracy and simulation time.
- ISF expected to be ready for production in 2013/2014, will be used for all simulation from 2015 onwards when LHC luminosities will be even higher than 2012.
- ISF will be the basis for all future developments in ATLAS simulation.