Fast Simulation

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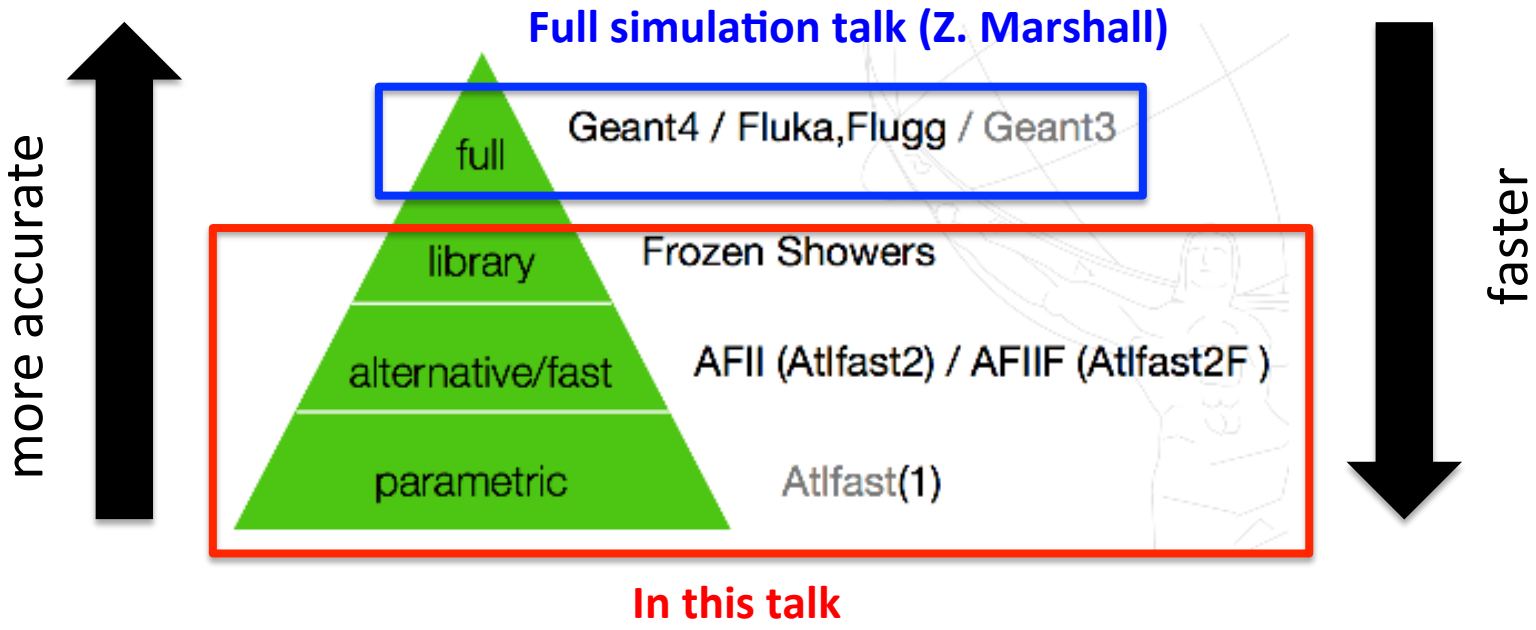
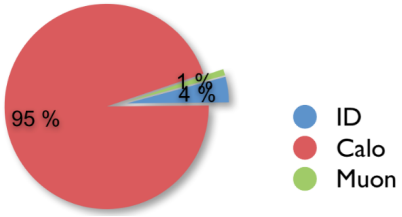
Introduction



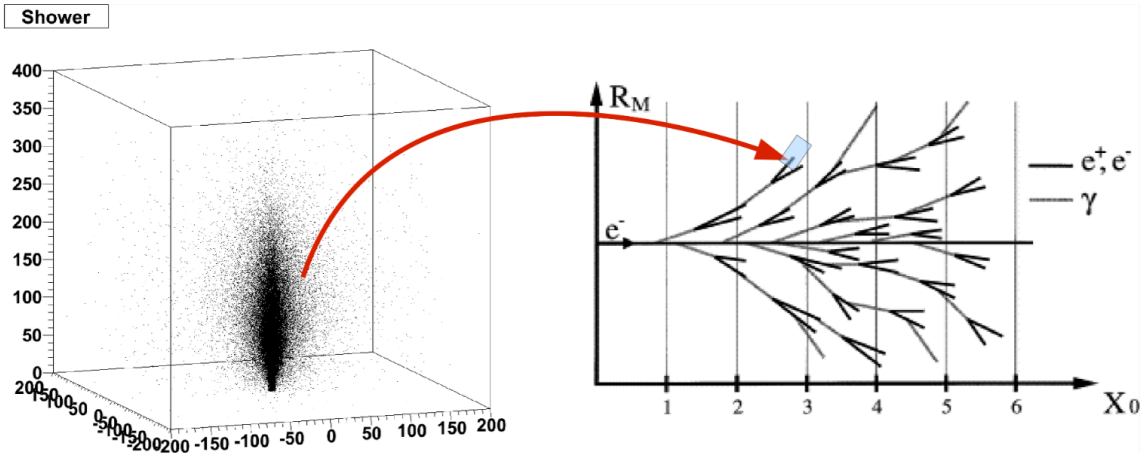
Frozen Showers

- Most of the CPU consumption in Geant4 simulation is spent in the **EM calorimeter**

G4 simulation time per subdetector:



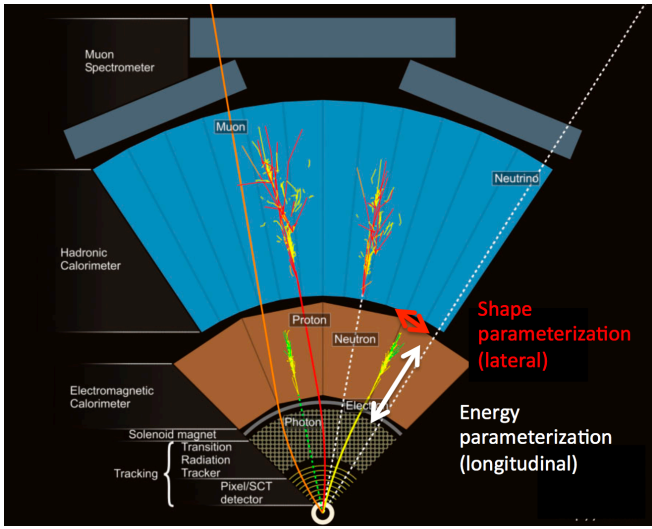
- **Frozen showers** to optimize speed in the forward EM calorimeters: Low energetic particles get replaced by pre-simulated EM showers



- **Shower library** generated with Geant4 simulation
- Used **by default** for full simulation MC campaigns

FastCaloSim

- The fast simulation used in ATLAS up to now (**Atlfast-II**) : parameterization of the **showers in the calorimeter**
  - Longitudinal : **energy parameterization** as a function of calorimeter layers, taking into account the correlations between the layers
  - Lateral : **shape parameterization** to get the average shape and lateral fluctuations



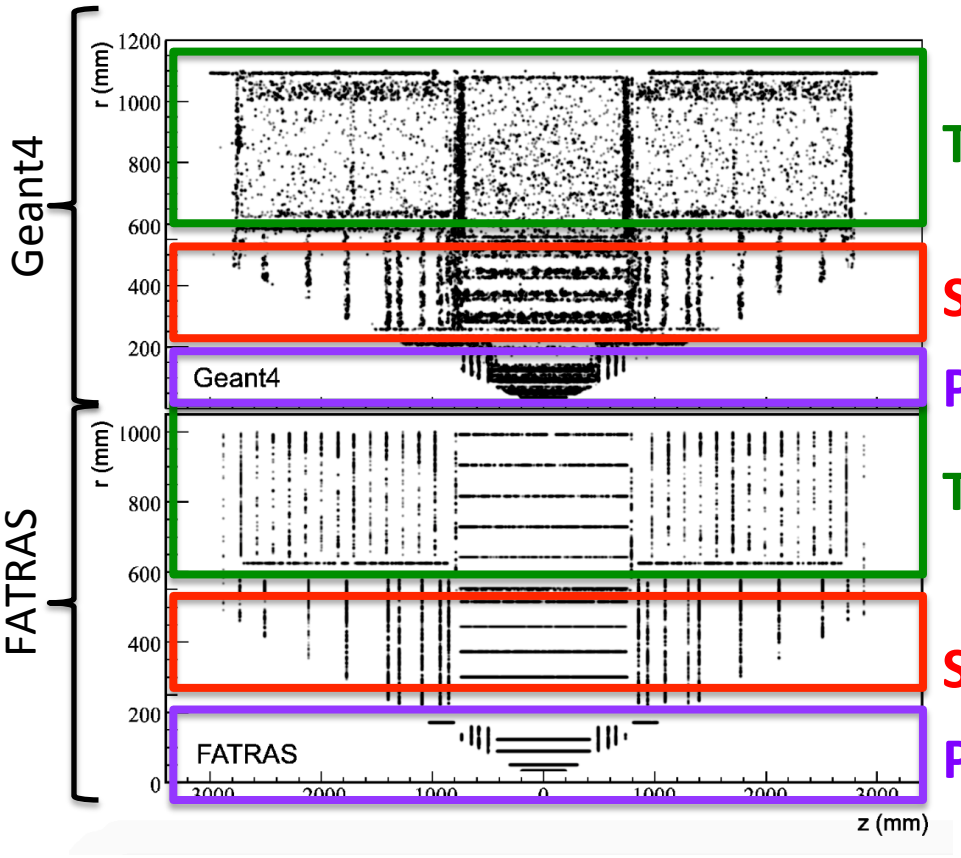
- Inputs are Geant4 samples for **π, e and γ** of different energies and η
  - μ are full Geant4 simulation when we run Atlfast-II

- Can be **tuned to data** more easily than Geant4

- A few **caveats** :
  - No detailed shower shapes in the **forward region**
  - Not great at **modeling detailed jet substructure** or **τ substructure**
    - but seems to be good enough for tau ID with some scale factors
  - No **punch through**, but it does get response tails right

FATRAS

Coming soon

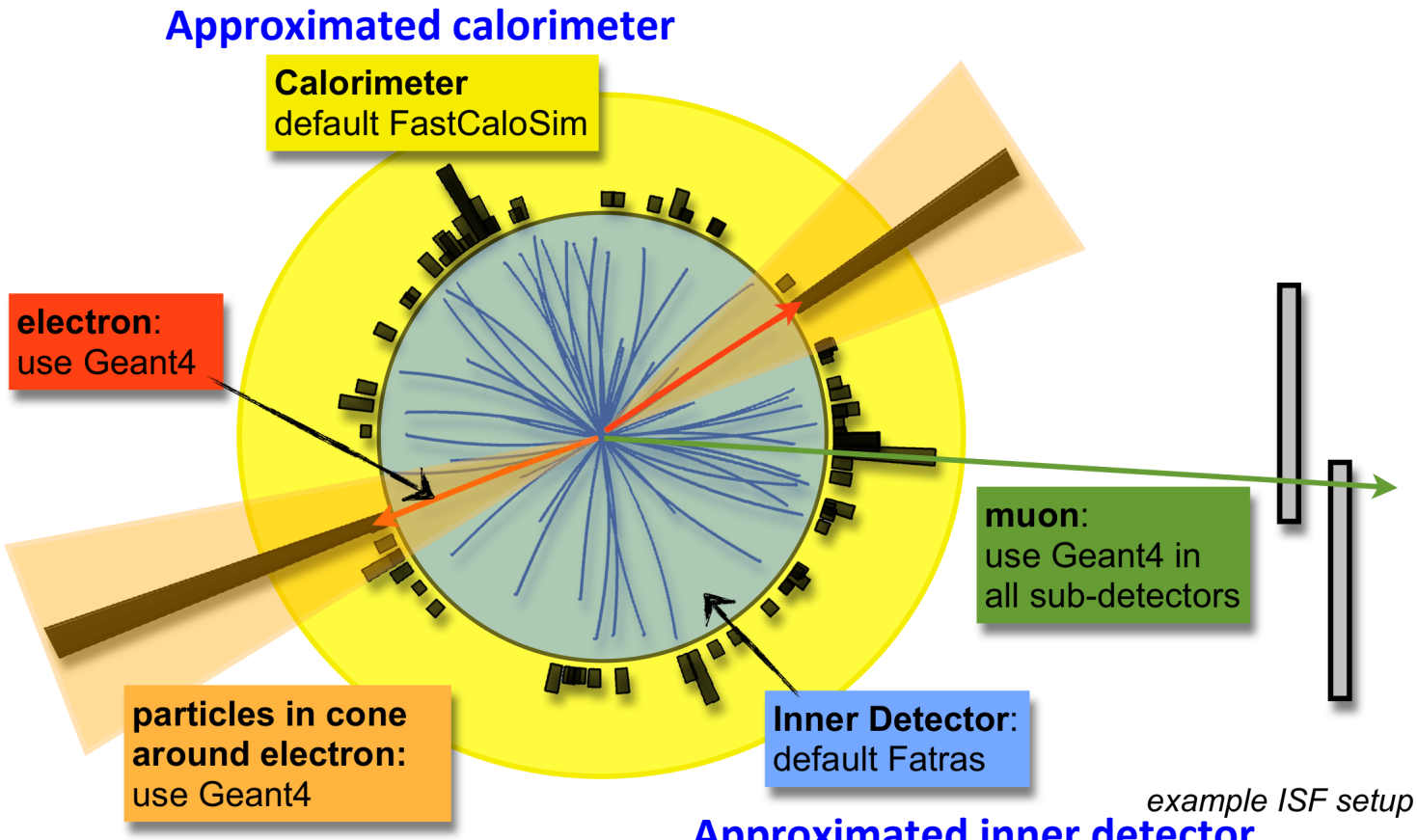


- **FAst TRacker Simulation (FATRAS)** for Inner Detector
- **Simplified detector geometry** and **physics interaction processes**
- Dense material projected onto **thin surfaces**

Integrated Simulation Framework (ISF)

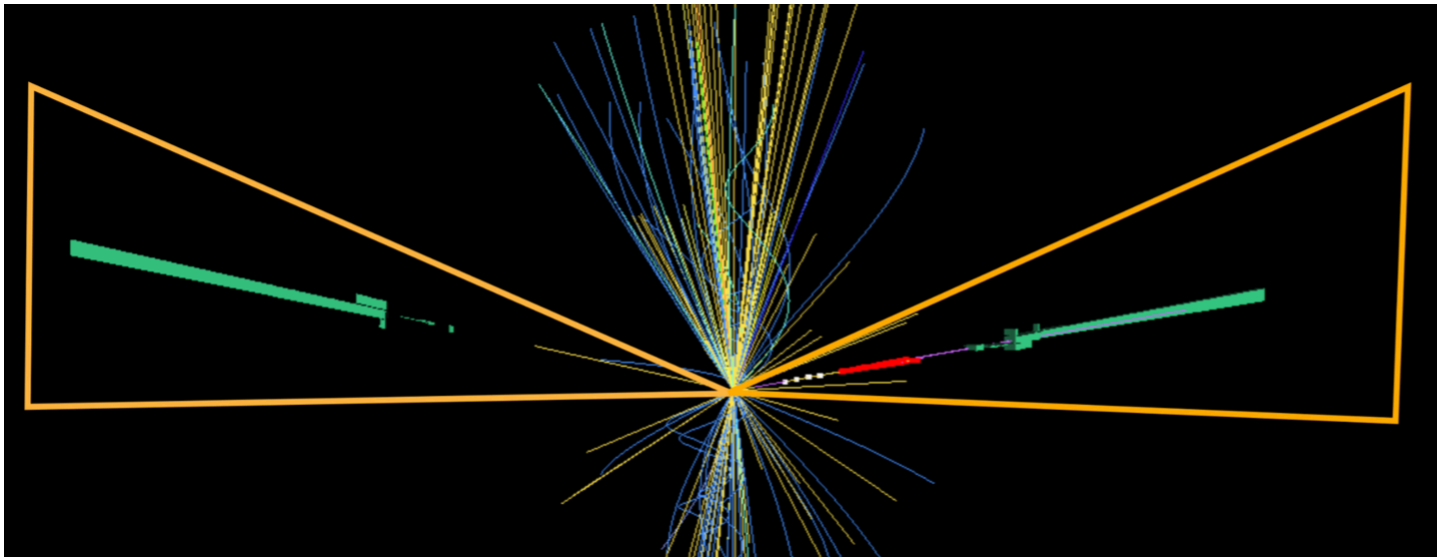
- ISF is the **framework** in which the other simulators can run
  - Geant4 (with frozen showers), FastCaloSim, FATRAS

- An **example** of a mixed-mode simulation that can be run in ISF :



example ISF setup

ISF Usecase : H→γγ fast simulation

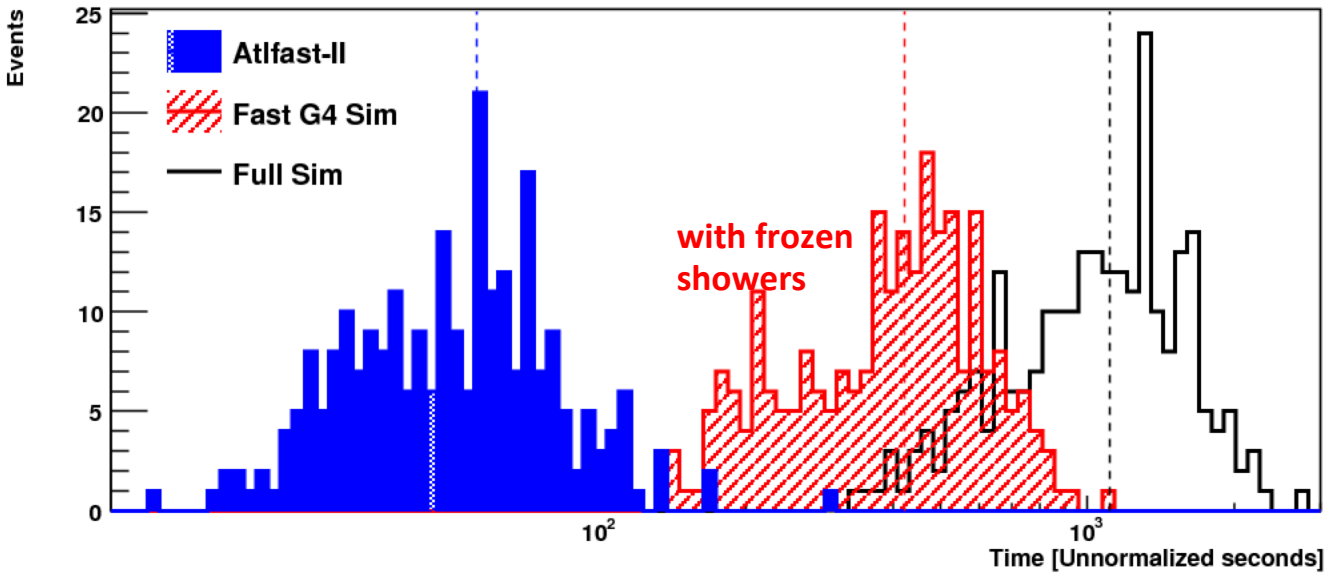


- **Large statistics** needed for background shape studies
- ISF setup based **on partial event simulation**
  - Simulate only generator photons and particles in cone around them
  - Only need a **simulation good enough for the physics we're interested in**
- Various ISF setups studied (combinations of G4, FastCaloSim and FATRAS)
- Other groups (like SUSY) need **a lot of different signal points**

ISF Time Measurements

ISF Simulation Setup	Speedup	Accuracy
Full Geant4	1	best possible
Geant4 with FastCaloSim	~25	approximated calorimeter
Fatras with FastCaloSim	~750	all subdetectors approximated
Fatras with FastCaloSim only simulating particels inside cones around photons	~3000	all subdetectors approximated + partial event simulated

ggF Higgs $\rightarrow \gamma\,\gamma$ sample, no pileup

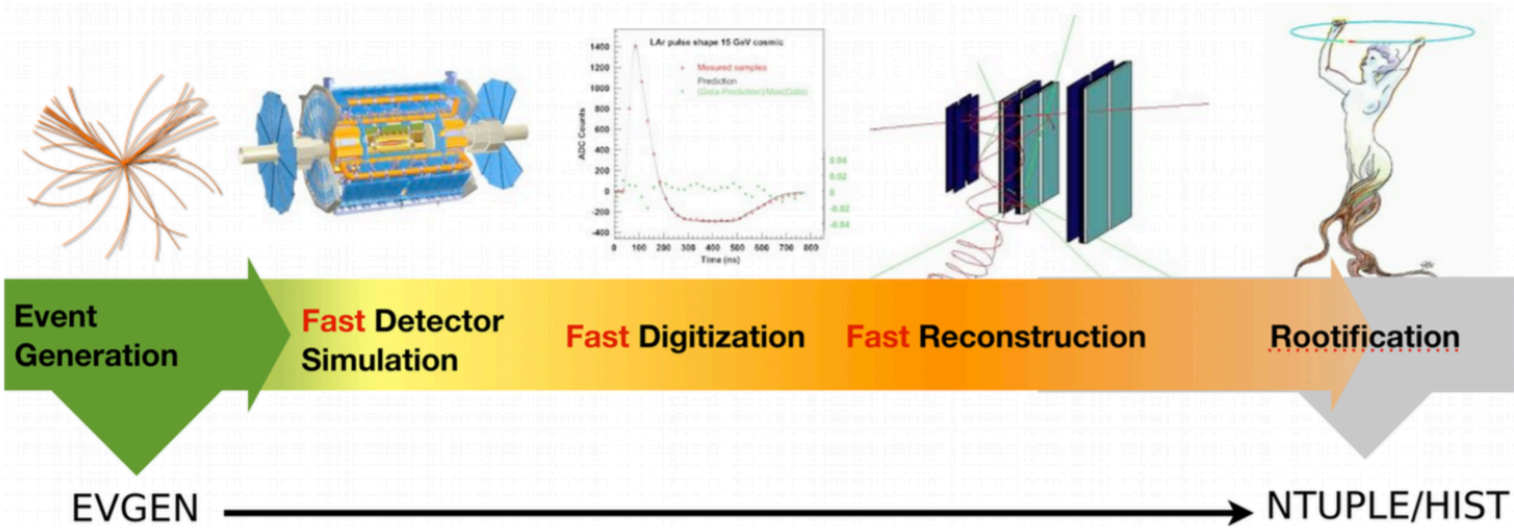


Time per ttbar event

Fast Chain

Coming soon

- Have a EVNT→xAOD transformation per event **of 5-10 seconds**



- **Combines** fast simulation (FATRAS, FastCaloSim), fast digitization for ID (full for MS/CALO) and fast reconstruction

- **Extremely important** for upgrade studies, generator systematics, large signal space scans,…

Conclusions

- **Fast simulation** to gain in speed compared to Geant4 (up to a factor 3000!)
  - Needed for more statistics, more samples, upgrade studies
- **Frozen showers** help optimize speed in the forward EM calo for the low energetic particles
- **FastCaloSim (AtlFast-II)** provides a longitudinal and transverse parameterization of the showers in the calorimeter
- **FATRAS** is a simplified simulation for the Inner Detector

Coming soon

- **FastChain** combines the different aspects to produce xAOD events from EVNT in 5-10 seconds !