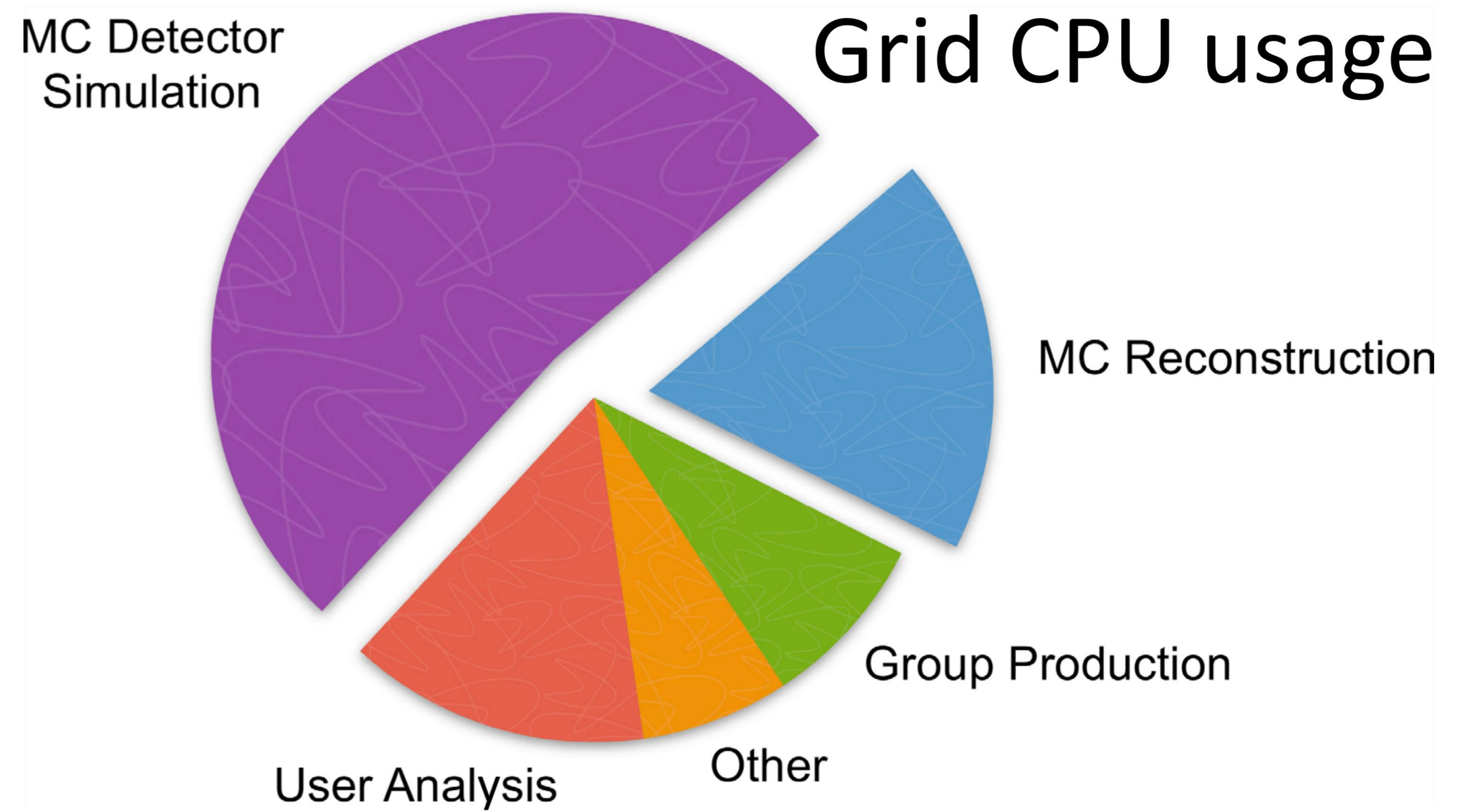


## Introduction

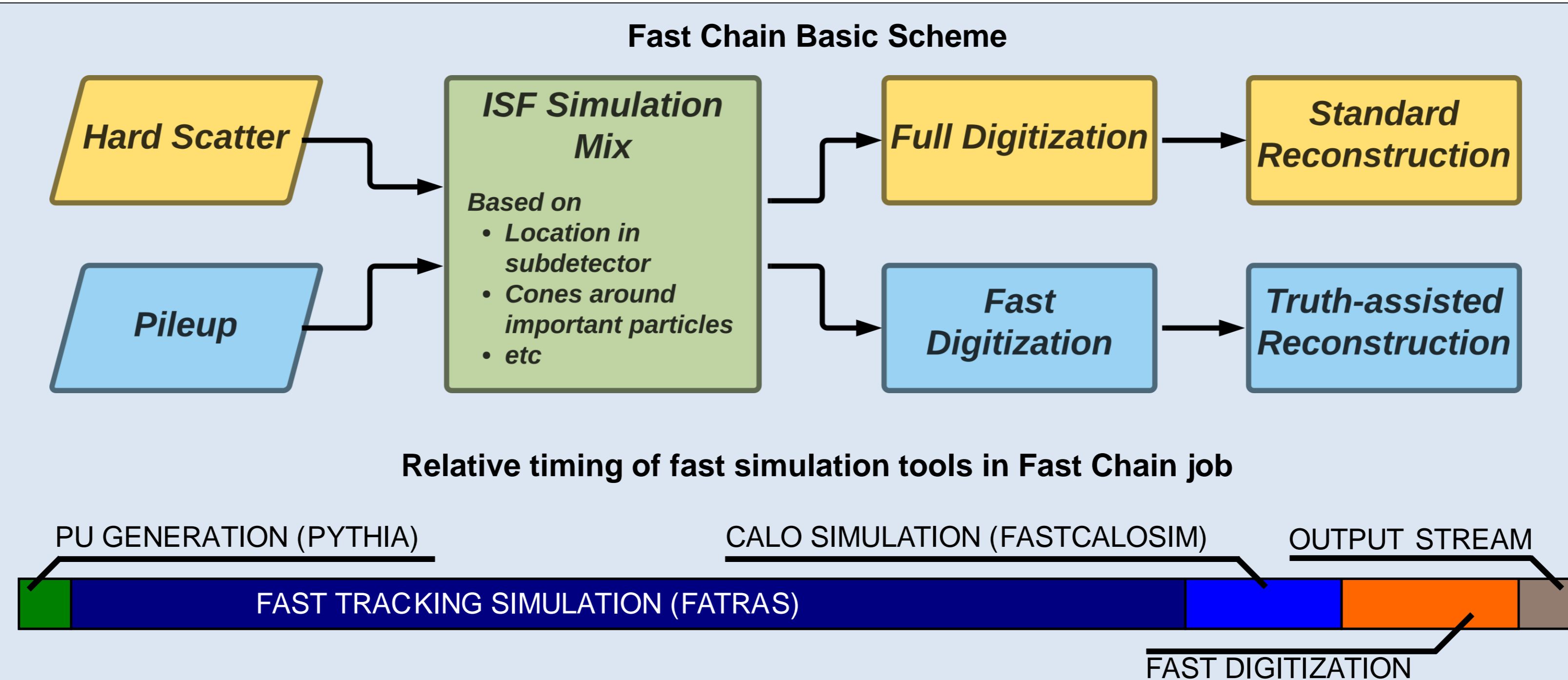
- **Huge number** of Monte Carlo simulated events will be required by ATLAS over the next several years.
- A **very fast** simulation is **critical**.
- Fast detector simulation alone is **insufficient**.
- **Very high** numbers of simultaneous collisions (**pile-up, PU**) expected in Run 3 and beyond.
- The **digitization** (detector response emulation) and event **reconstruction time** become **comparable** to the **simulation time**
- The **Fast Chain** solves this problem with modules for **fast simulation, fast digitization, and fast track reconstruction**.
- **Several orders of magnitude faster** than the standard simulation.
- PU generated in the job: Pythia8 runs with the rest of the algorithms, **lower job I/O**.
- The Fast Chain is extremely **modular** and **flexible**, samples can be tailored to match the needs of an analysis.
- Ideal for analysis **templating, systematic uncertainty evaluation, signal parameter space scans**, simulation with **alternative detector configurations** (e.g. upgrade), among other applications.



## Fast Chain Overview

The **ultimate aim** is to use **any combination** of fast and standard (full) simulation, digitization and reconstruction saving high precision where necessary and overall reducing CPU time.

- **Step 1:** Develop/validate Fast Chain with split between event of interest (hard-scatter, HS) and pile-up (PU), use full sim/digi/reco for HS and fast sim/digi/reco for PU
- **Step 2:** Use ISF [3] in Fast Chain to mix full and fast simulation for HS
- **Step 3:** Fold DxAOD [6] production into the Fast Chain



### Fast Chain Tool Development Status

Component	Status
ATLFASTII	Validated
Fatras	Finalizing validation
Pileup on the fly	Development
Truth tracking	Ongoing validation
TRT fast digitization	Validated
Silicon fast digitization	Ongoing validation
Pileup on the fly + truth tracking validation	Upcoming
Full Fast Chain validation	Upcoming

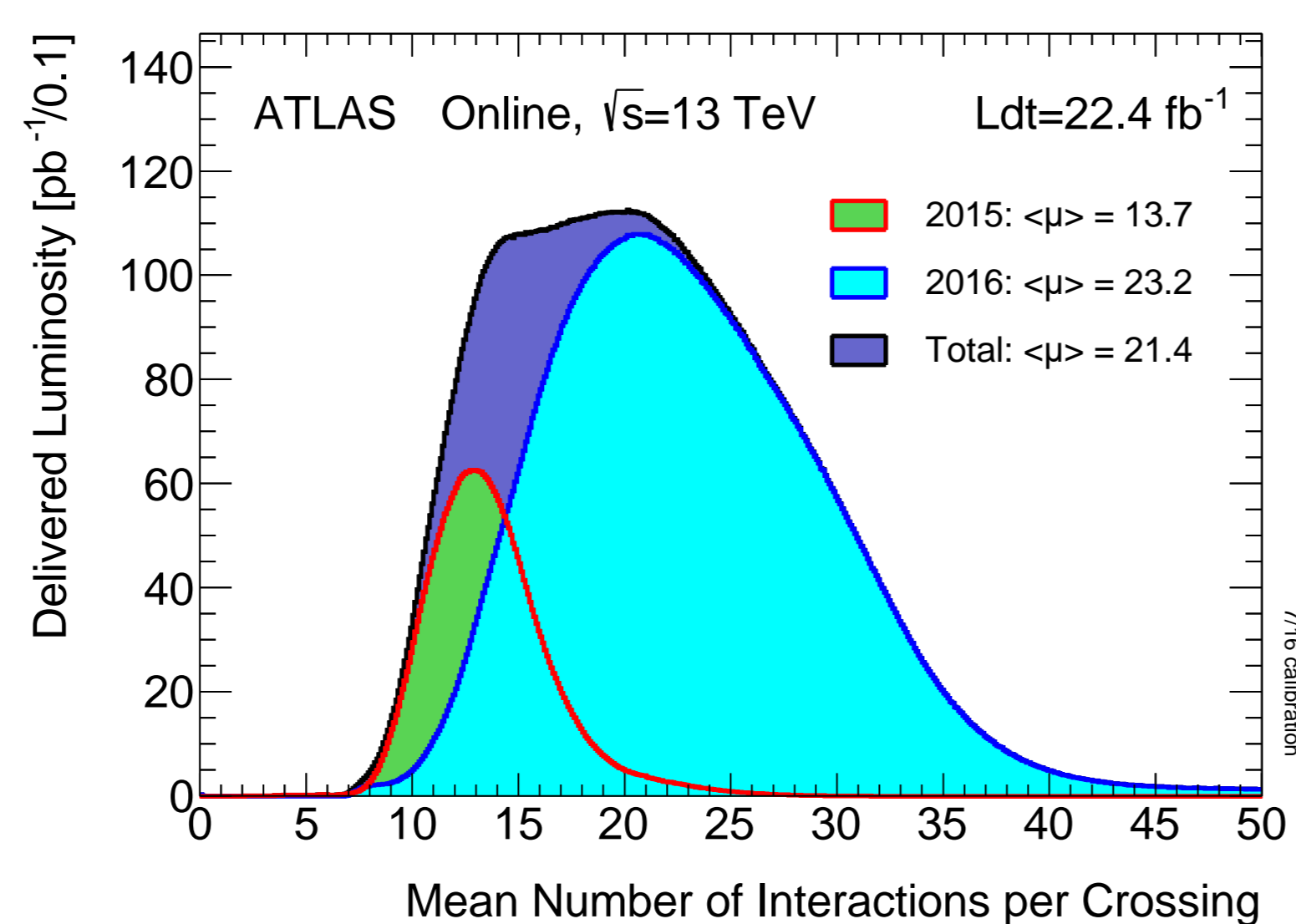
## Generation

Initial distribution of **products of proton collisions** and **decays** of short-lived particles are simulated in ATLAS using various **external event generation packages** (e.g. POWHEG, Pythia, SHERPA, etc).

In **standard approach**, PU and HS **generated separately** and PU then overlaid on HS during simulation step.

In **Fast Chain**, PU events are **generated on the fly** with **Pythia 8** during simulation step.

Preliminary timing estimates show that PU generation with Pythia 8 **takes just a few percent of job time** — possible for emulation of effects of subsequent and previous events (**out of time pile-up**).



## Digitization

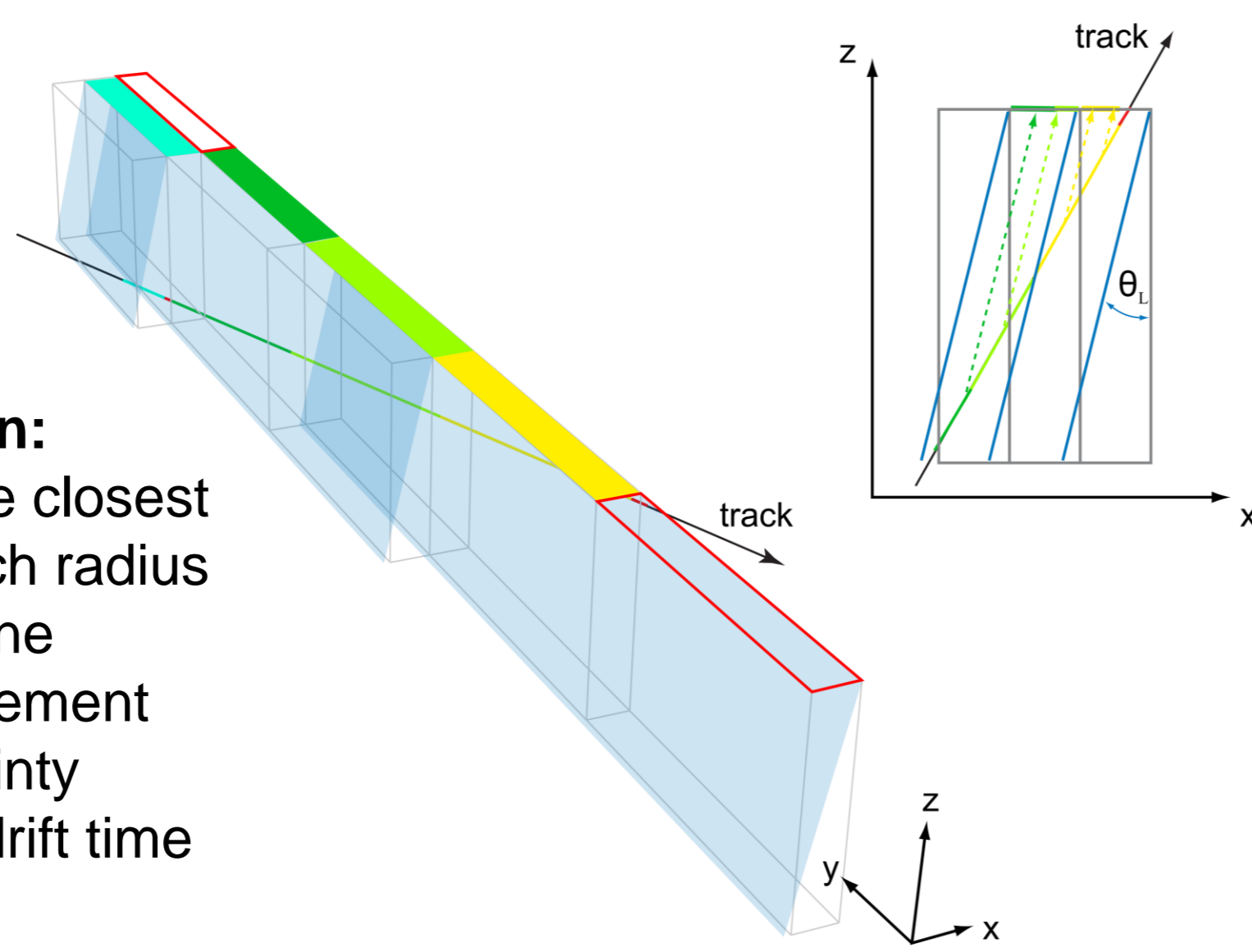
Information about **hits position** in tracking detectors and **energy deposits** in calorimeter is converted in a format of **detector signals** in a process of **digitization**. The output can then be used with standard reconstruction algorithms.

### Fast Silicon (Pixel, SCT) Digitization:

- estimate charge deposition per channel
- project simulated track length in silicon onto read-out surface
- Lorentz angle drift correction
- scattering → charge smearing

### Fast TRT Digitization:

- evaluate closest approach radius
- determine measurement uncertainty
- smear drift time



## References

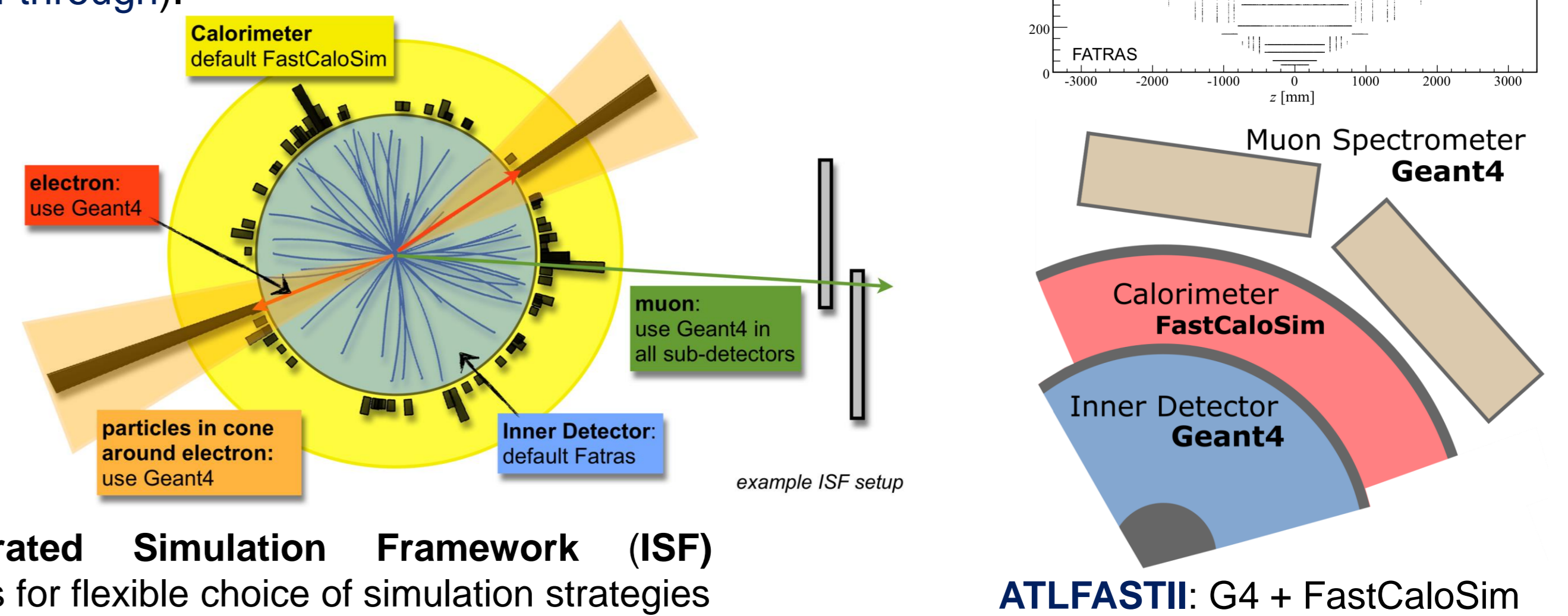
1. Fast Chain: ATL-SOFT-PROC-2015-007
2. FastCaloSim: ATL-PHYS-PUB-2010-013
3. ISF: "ATLAS Detector Simulation in the Integrated Simulation Framework applied to the W Boson Mass Measurement" Ritsch, E., PhD Thesis.
4. Truth based Reconstruction: CERN-THESIS-2013-194
5. Fatras: ATL-SOFT-PUB-2008-001
6. DxAOD: ATL-SOFT-PROC-2015-041

## Simulation

**Well-studied** and **very reliable Geant4 (G4)** package is traditionally used in ATLAS for simulation of particle propagation through the detector.

However there are actively developed **alternatives** for faster but more coarse simulation:

- **Fatras (100x faster** than G4) package for tracking (simplified geometry, simplified interaction models)
- **FastCaloSim (20x faster** than G4) for calorimeter response (cell response parametrization, no decays and punch-through).



**Integrated Simulation Framework (ISF)** allows for flexible choice of simulation strategies

ATLFASTII: G4 + FastCaloSim

## Reconstruction

**Reconstruction** is used to **find tracks** and associate them to physical objects (particles, jets) in detector data as well as MC simulation.

Most time consuming steps:

- pattern recognition
- track seeding
- ambiguity treatment

**Truth-assisted reconstruction:**

- Skip pattern recognition → track seeding using information about original simulated tracks
- Improves with pileup: 1.7-7.3 times speedup over standard reco for  $\mu=0$  to  $\mu=40$

