

supported by



cooperations



# acts Fatras

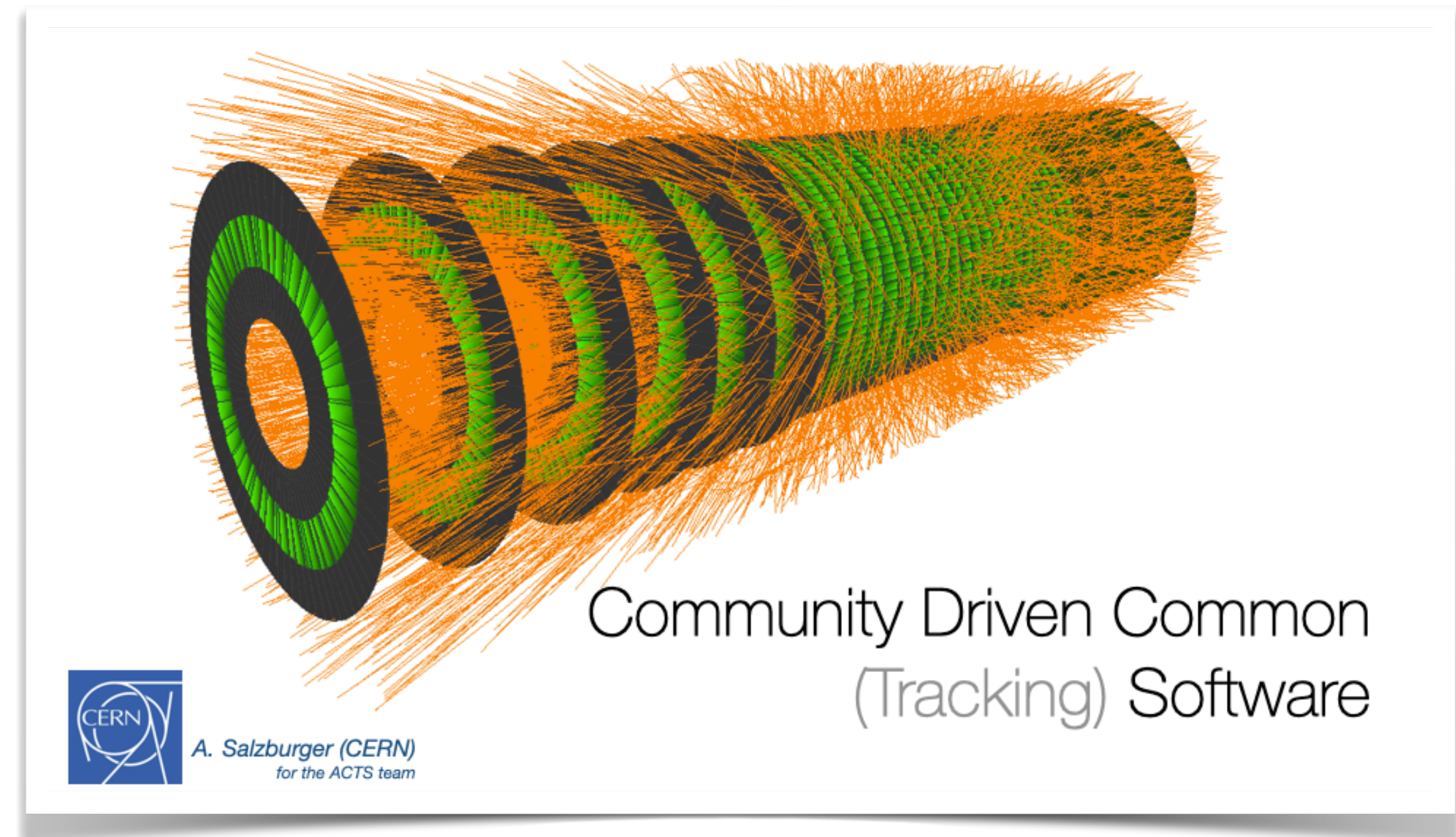


A. Salzburger (CERN) for the ACTS project

@SaltyBurger

# acts project - Mission statement

- **Preserve & advance** LHC state of the art track reconstruction software
- Develop & deploy **production ready software** for HL-LHC and beyond
- Establish **R&D testbed** for algorithms, technology advance (e.g. ML, GPU, detectors)
- **Work & educate** in state of the art technology/workflows



[AS, Community Driven Common Tracking Software, Plenary, CHEP2018](#)

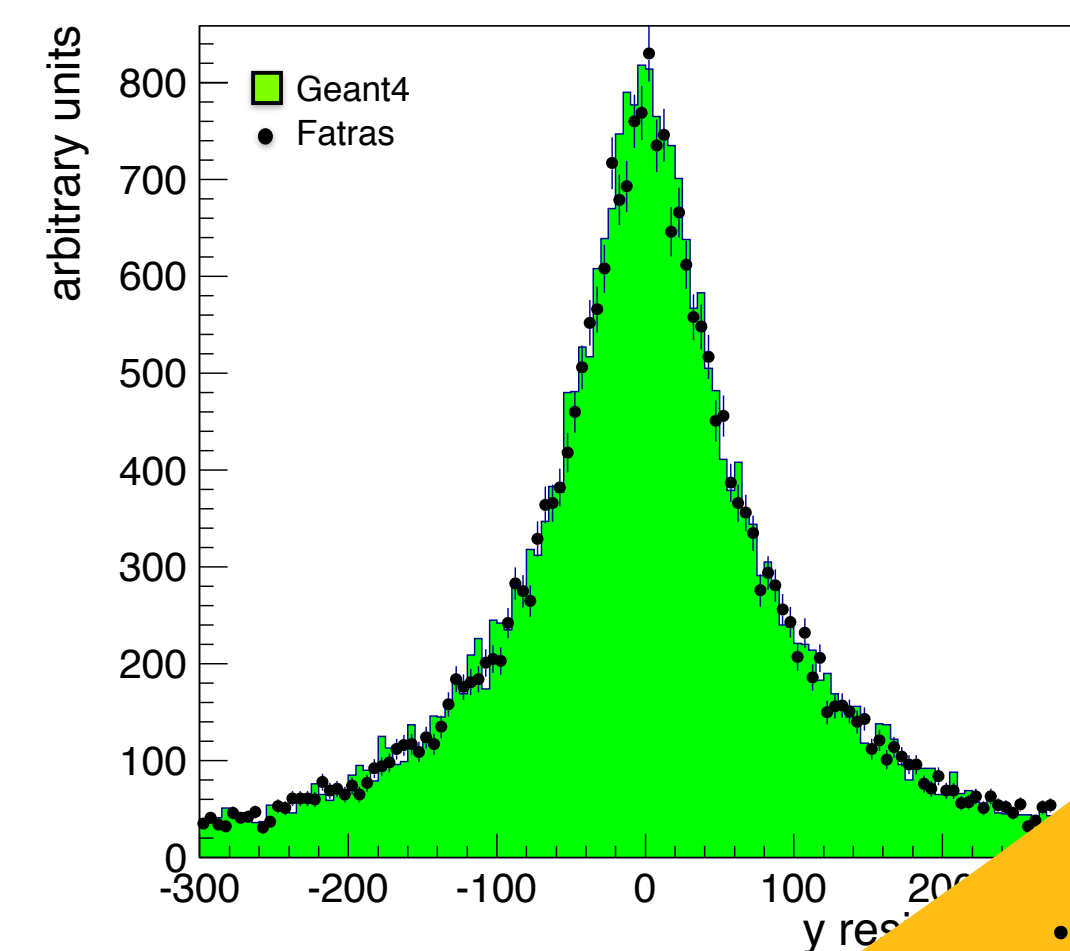
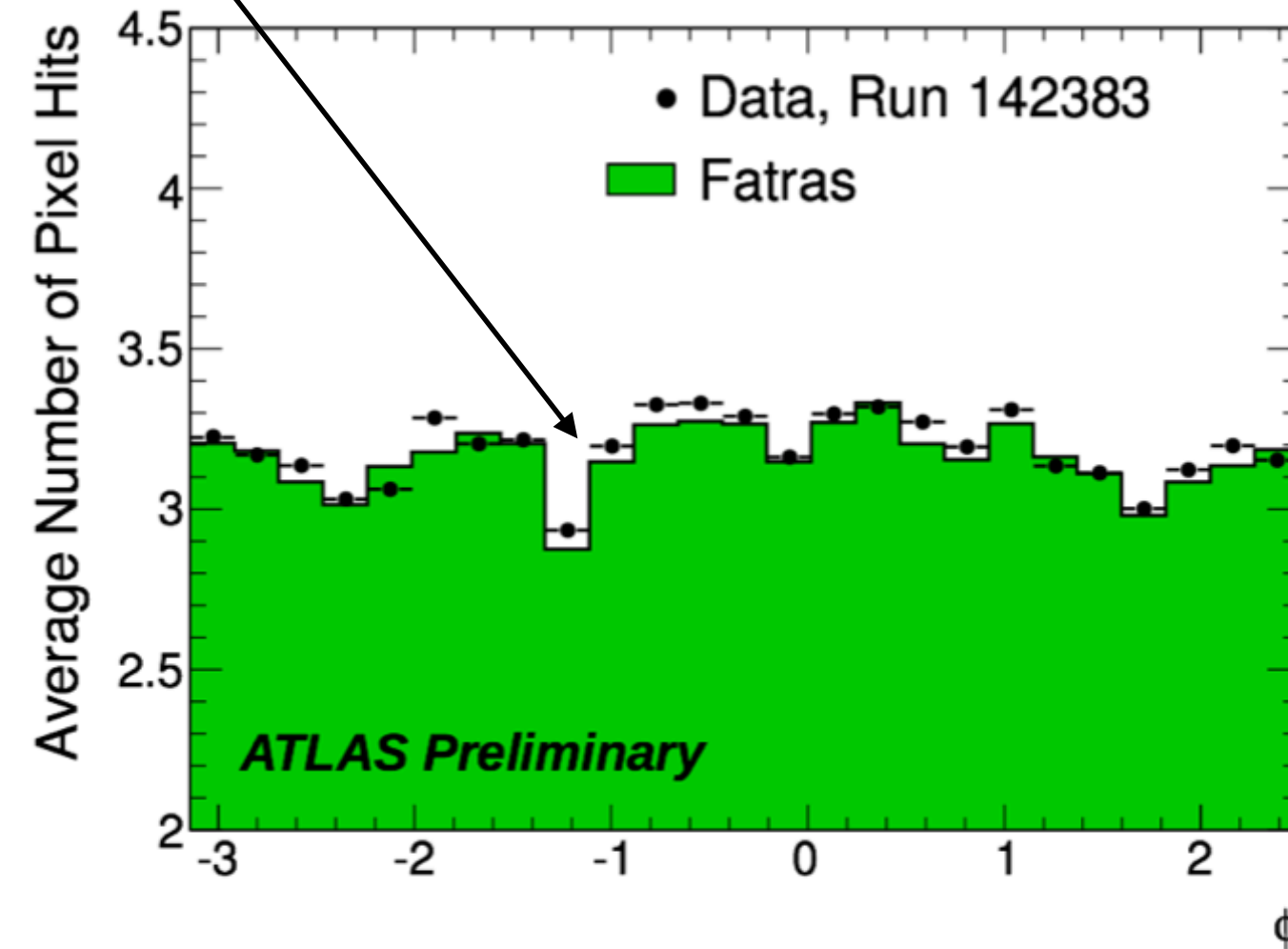
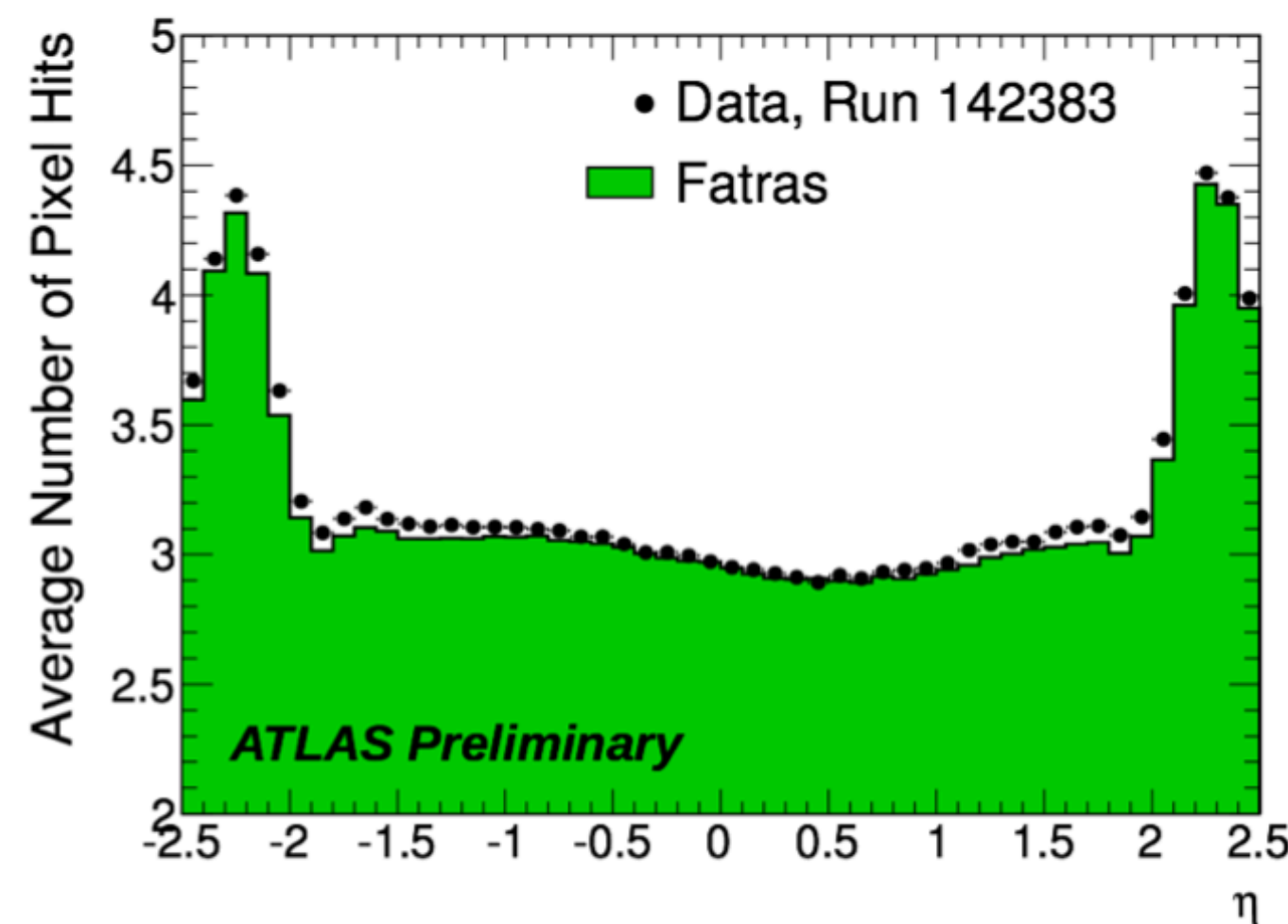
# Fast Track Simulation (Fatras)

- **ACTS re-implements the ATLAS fast track simulation (Fatras)**
  - ▶ **MC particle tracking based simulation**
    - relies on internal navigation transport in **tracking geometry**
    - simplified, yet extendable physics models in **parameter transport**
  - ▶ **Can serve as input to reconstruction algorithms**
- **ATLAS Fatras - “the original one”**
  - ▶ **Runs as part of ATLFAST-2F**
    - inside the ATLAS Integrated Simulation Framework (ISF)
  - ▶ References: <https://cds.cern.ch/record/1091969>  
<https://cds.cern.ch/record/1458503>

We are still in the process  
of completing the ATLAS  
functionality in ACTS

# Fast Track Simulation (Fatras)

- **Fatras shows/ed great agreement with Geant4 and data in ATLAS**
  - **Managed to reproduce hit deficiencies due to even inactive sensors**



<https://cds.cern.ch/record/1091969>

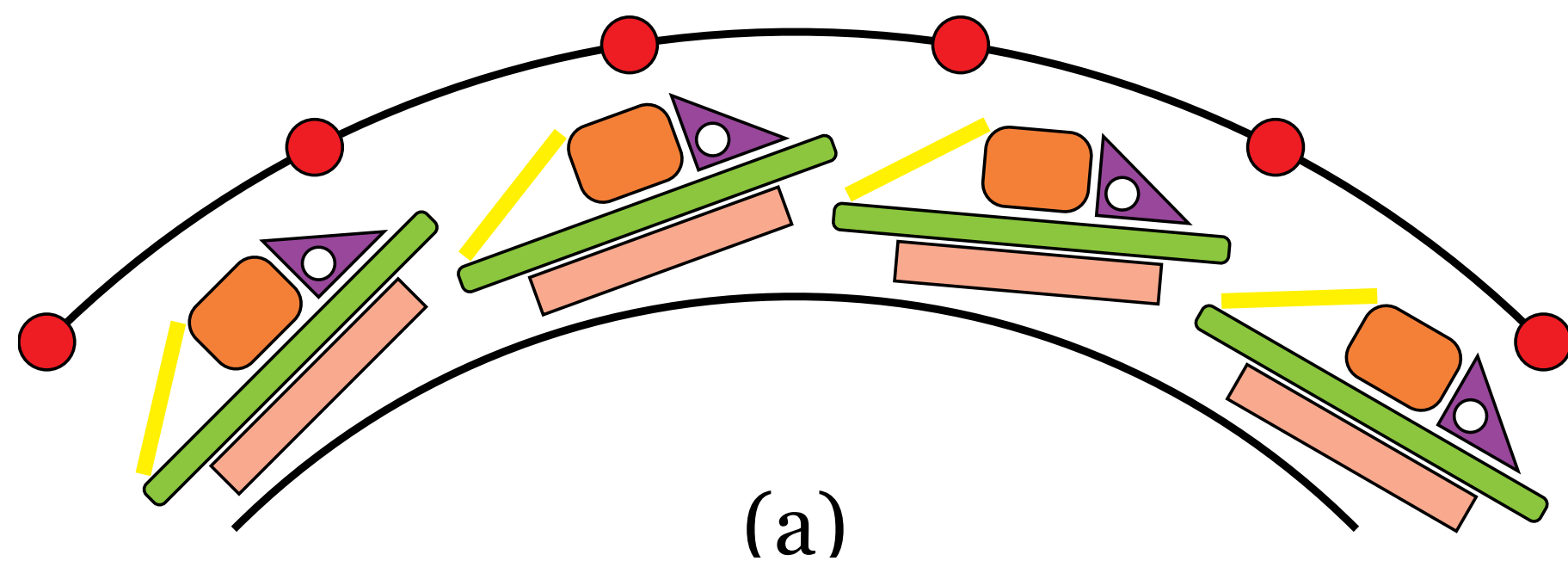
<https://cds.cern.ch/record/1458503>

We are still in the process  
of completing the ATLAS  
functionality in ACTS

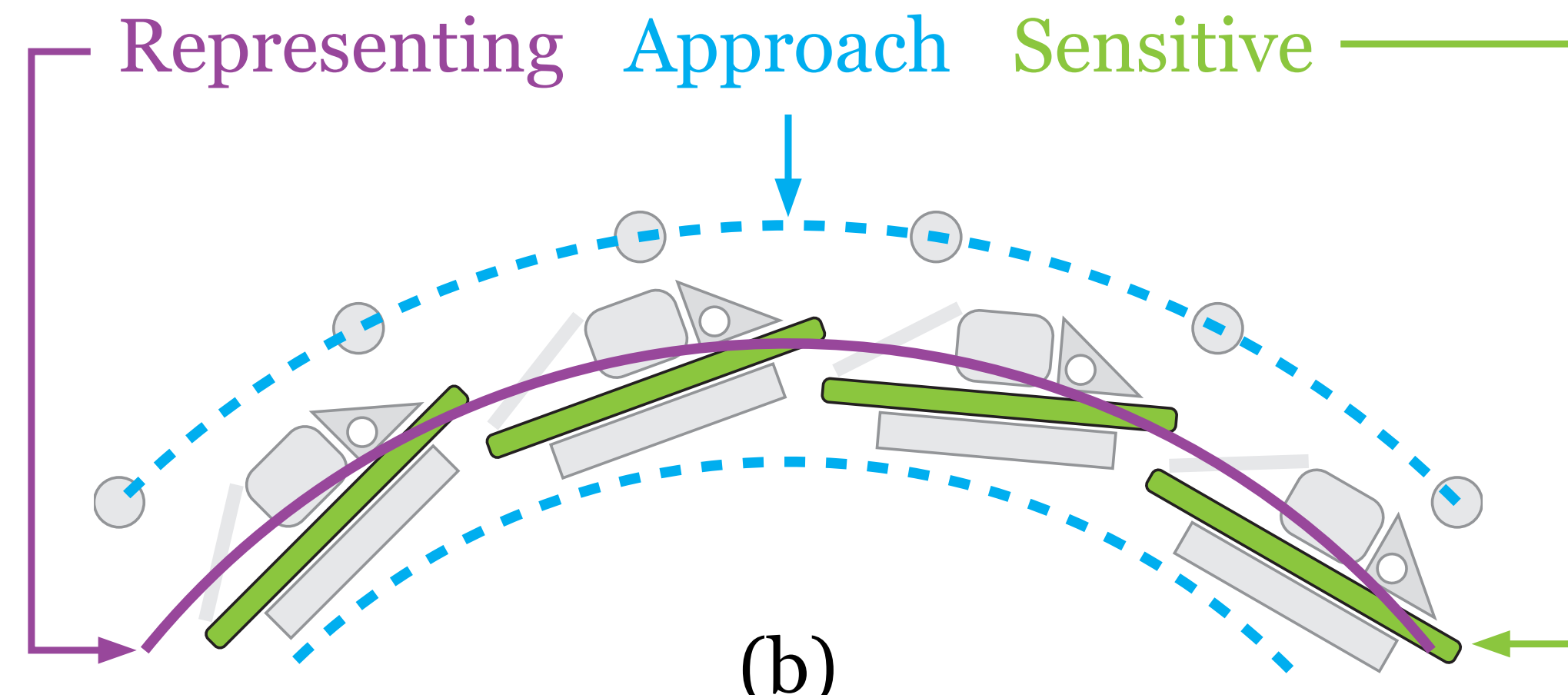
# ACTS Geometry description (1)

**ACTS TrackingGeometry is a surface based geometry that implements an intrinsic navigation**

- Surfaces between attaching volumes act as portals between them in order to minimise navigational search



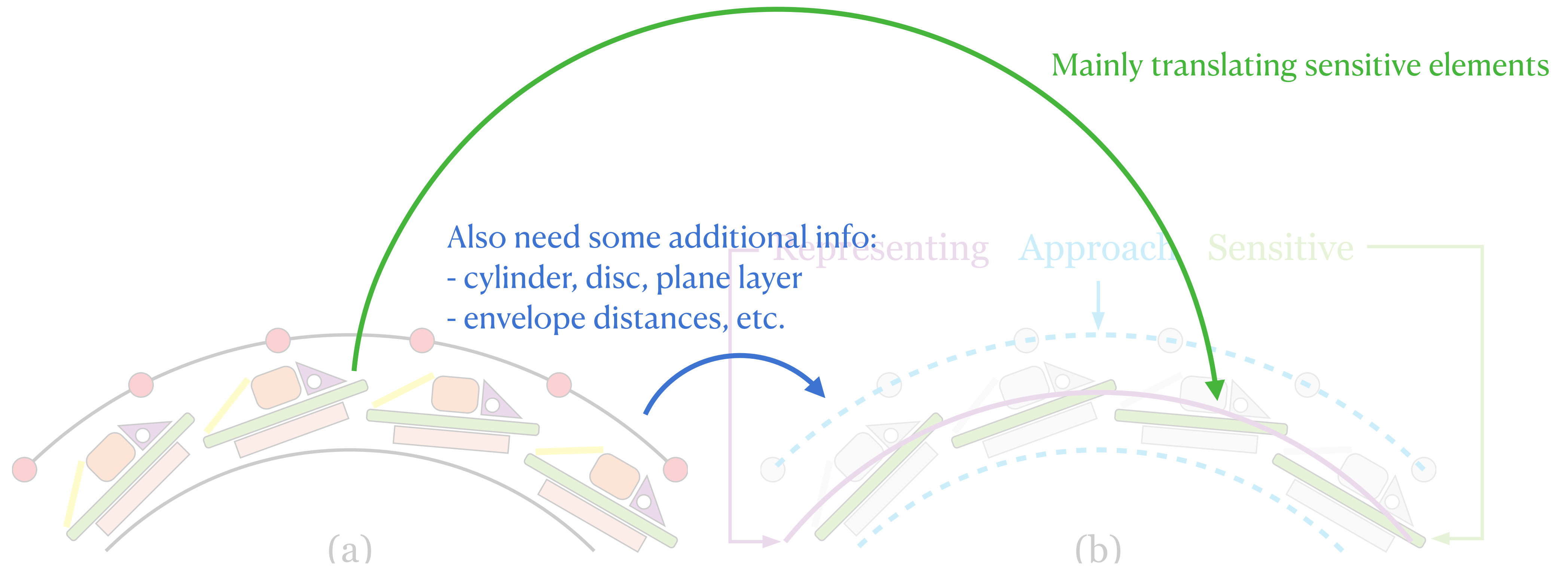
Detailed Geometry  
(DD4hep, Geant4, GeoModel, TGeo ...)



Acts::TrackingGeometry

# ACTS Geometry description (2)

**Dedicated converters exist to translate sensitive elements and material\***

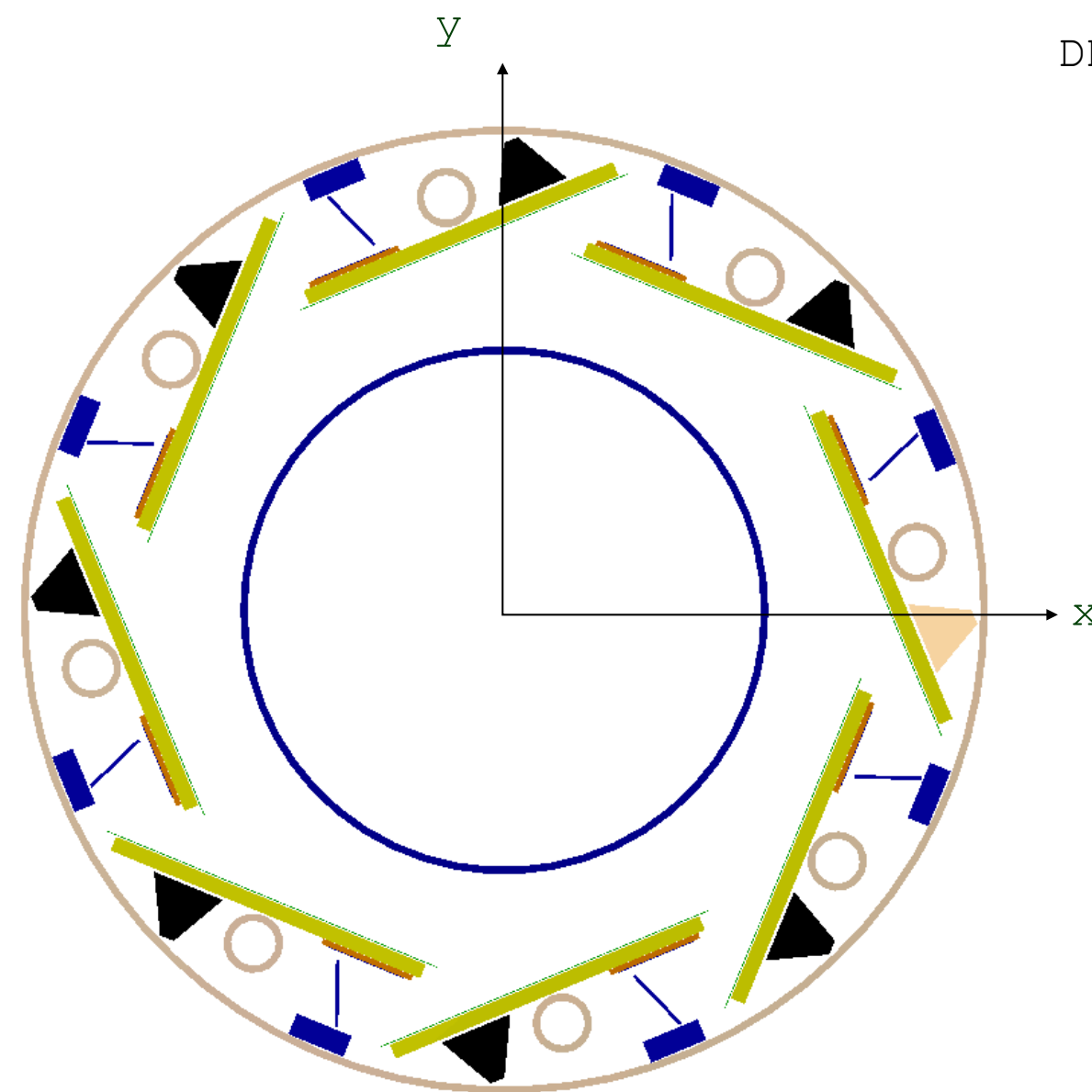


Detailed Geometry  
(DD4hep, Geant4, GeoModel, TGeo ...)

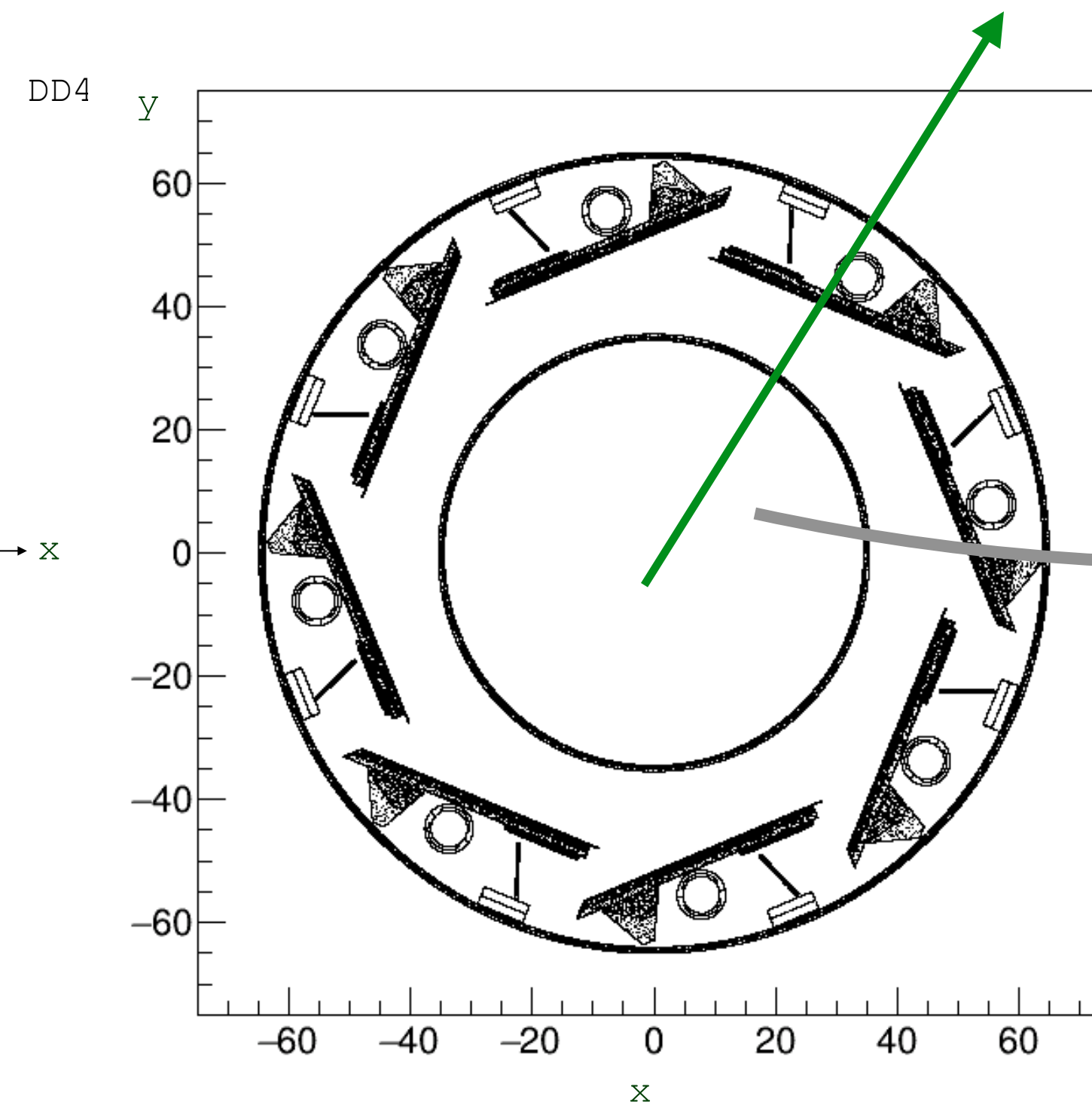
Acts::TrackingGeometry

# ACTS Material description

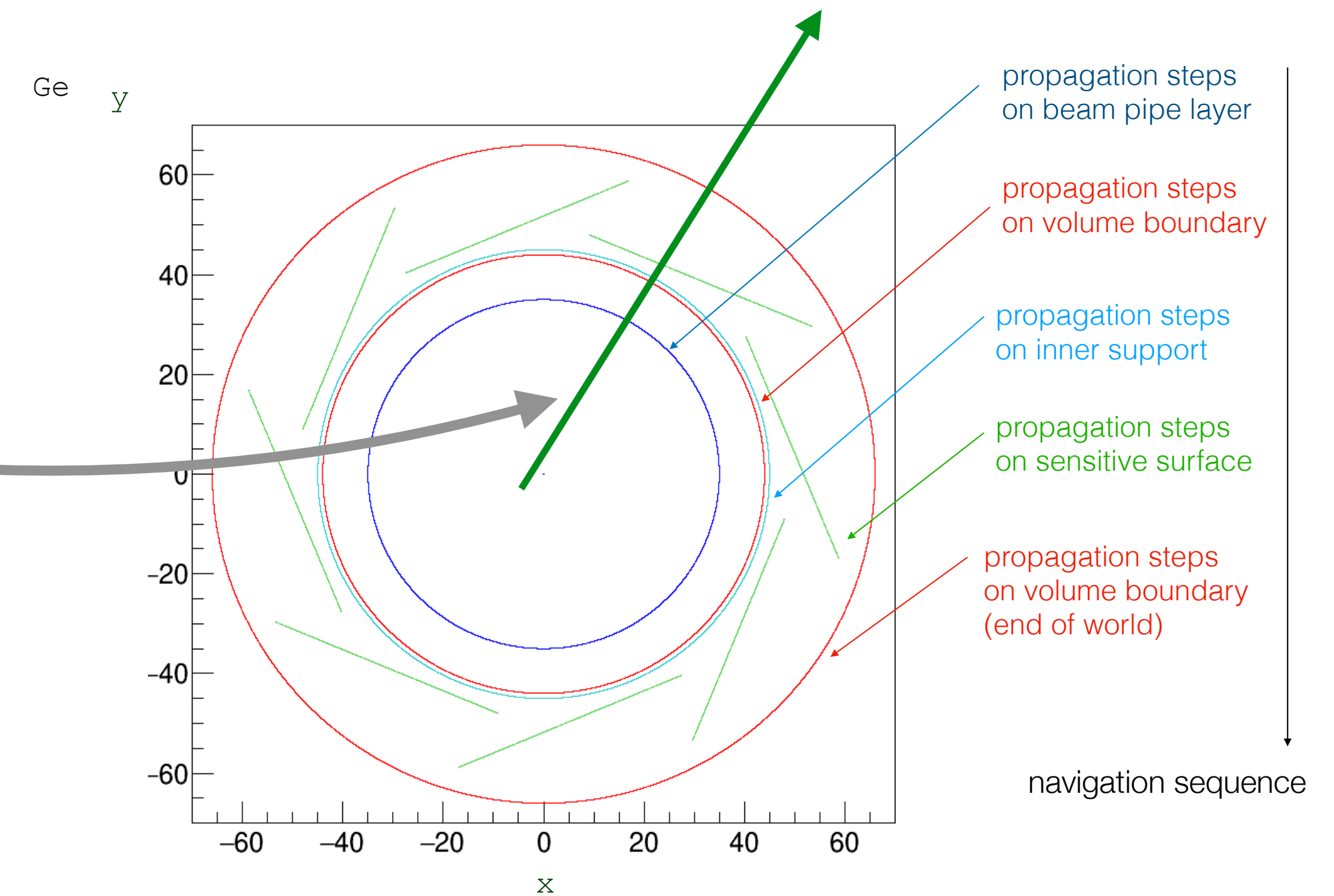
Geometric modeller



Geant4 hitmap



ACTS TrackingGeometry

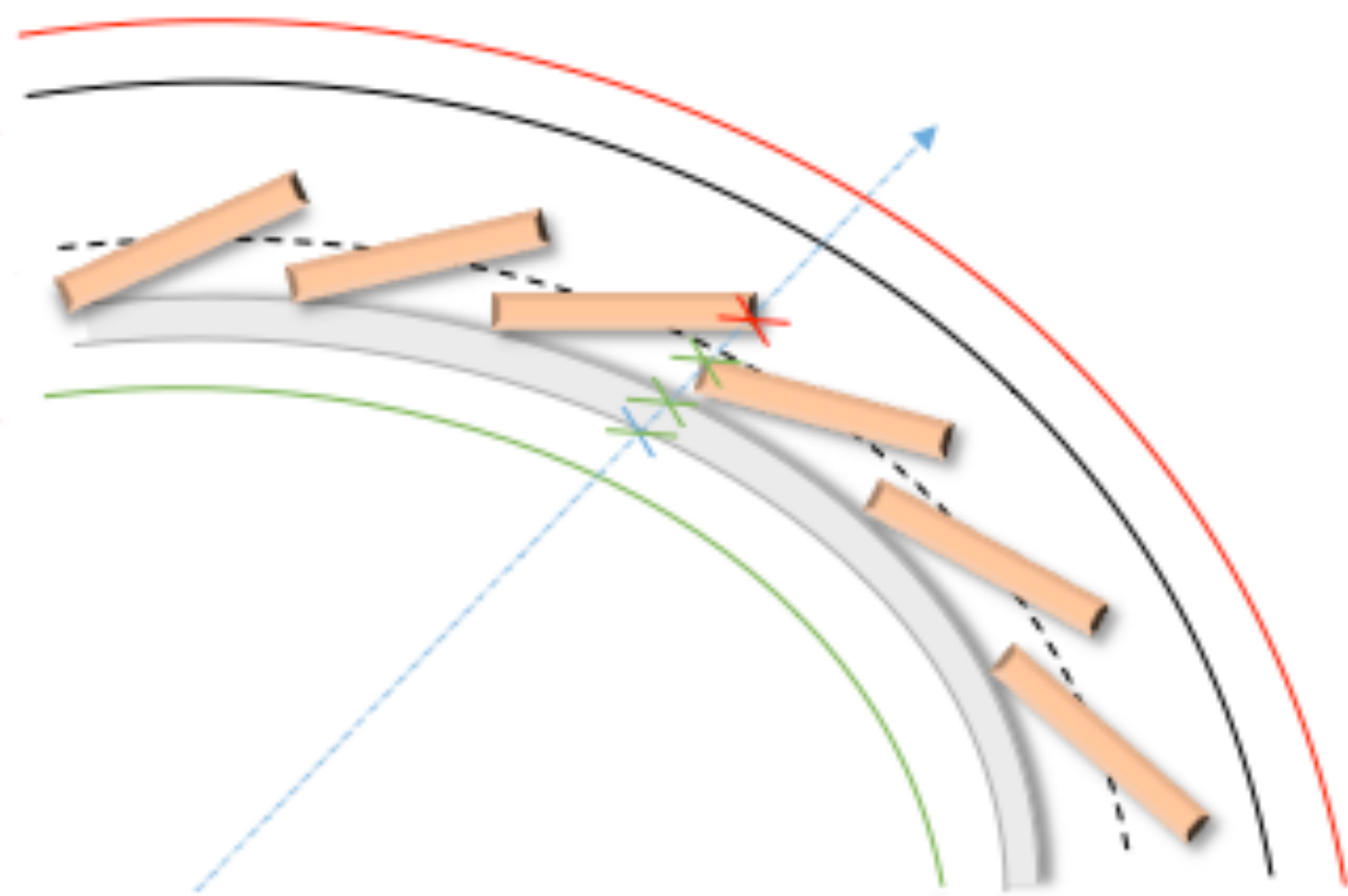


Automated mapping translation from Geant4 to Acts material maps

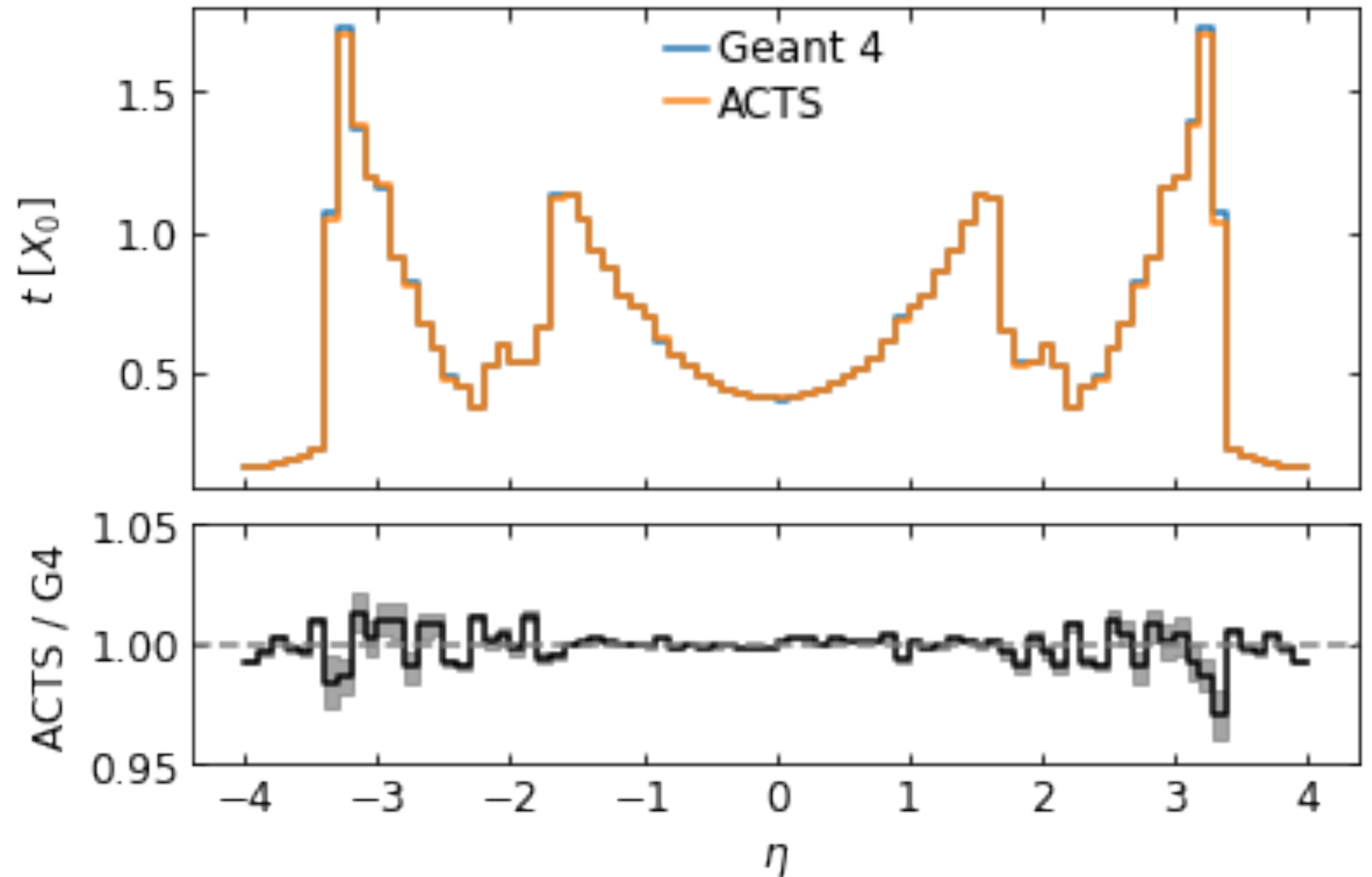
# ACTS Material description

**Sub % level agreement can be achieved**

- Higher statistics and higher number of mapping bins and surfaces allow to fine tune the description



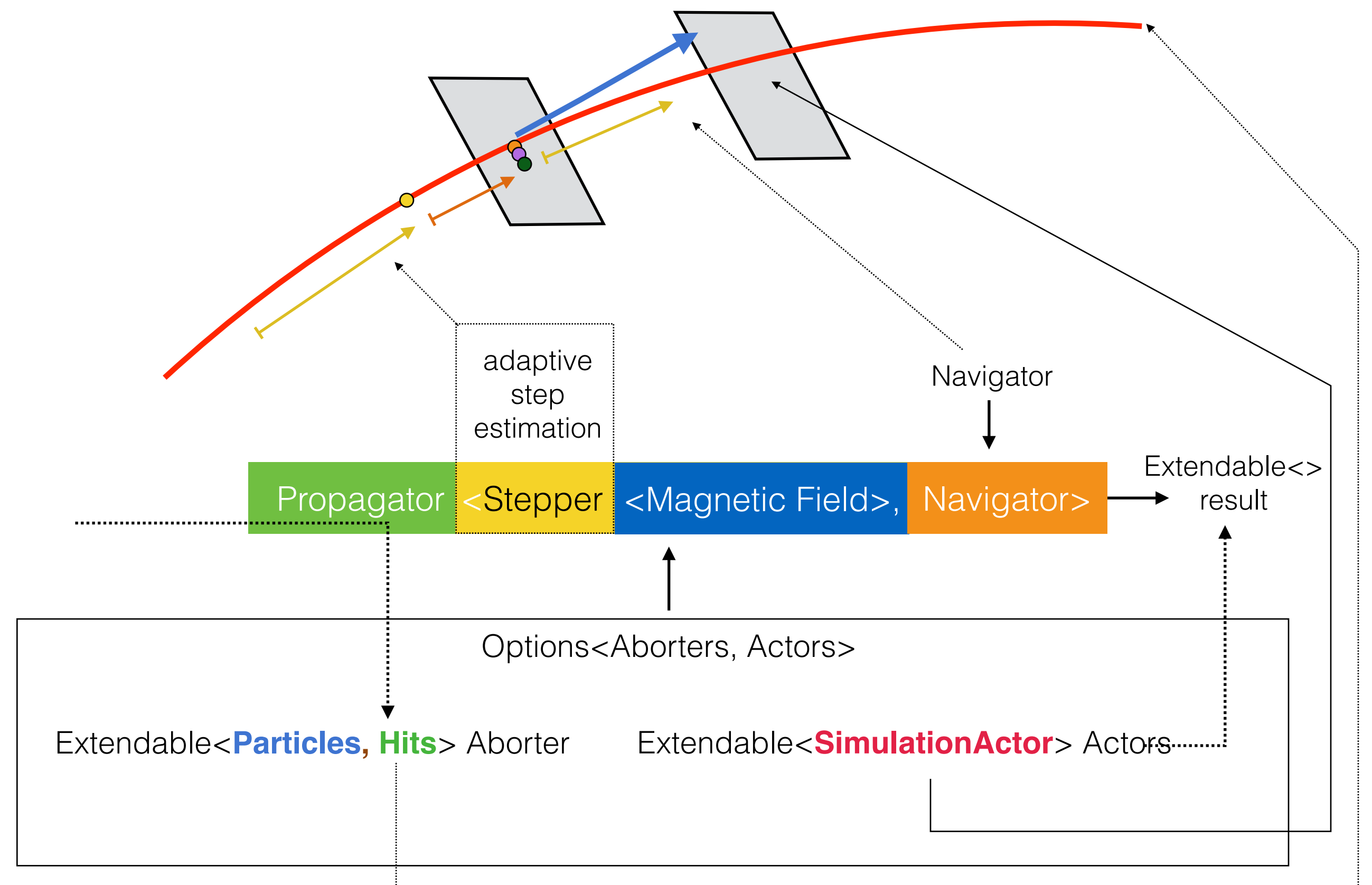
Open Data Detector, optimised for tracker coverage





# ACTS Fatras - Basic principles

- **Track propagation in ACTS**
  - ▶ **Propagator module**  
i.e. steering of the process
  - ▶ **Stepper module**  
i.e. field integration & transport
  - ▶ **Actors**  
e.g. material interaction, hit recording



# ACTS Fatras - Physics List (1)

- **Physics processes are implemented:**
  - as part of the material interaction
  - as other actors (e.g. path length stopping for decay, etc.)

EM Physics	Implementation
Multiple Scattering	Gaussian, Gaussian Mixture, Gaussian + Tail models
Ionization	Bethe Bloch model
Bremstrahlung	Bethe Heitler model
Photon conversion	Kinematic model

# ACTS Fatras - Physics List (2)

- **Physics processes are implemented:**
  - as part of the material interaction
  - as other actors (e.g. path length stopping for decay, etc.)

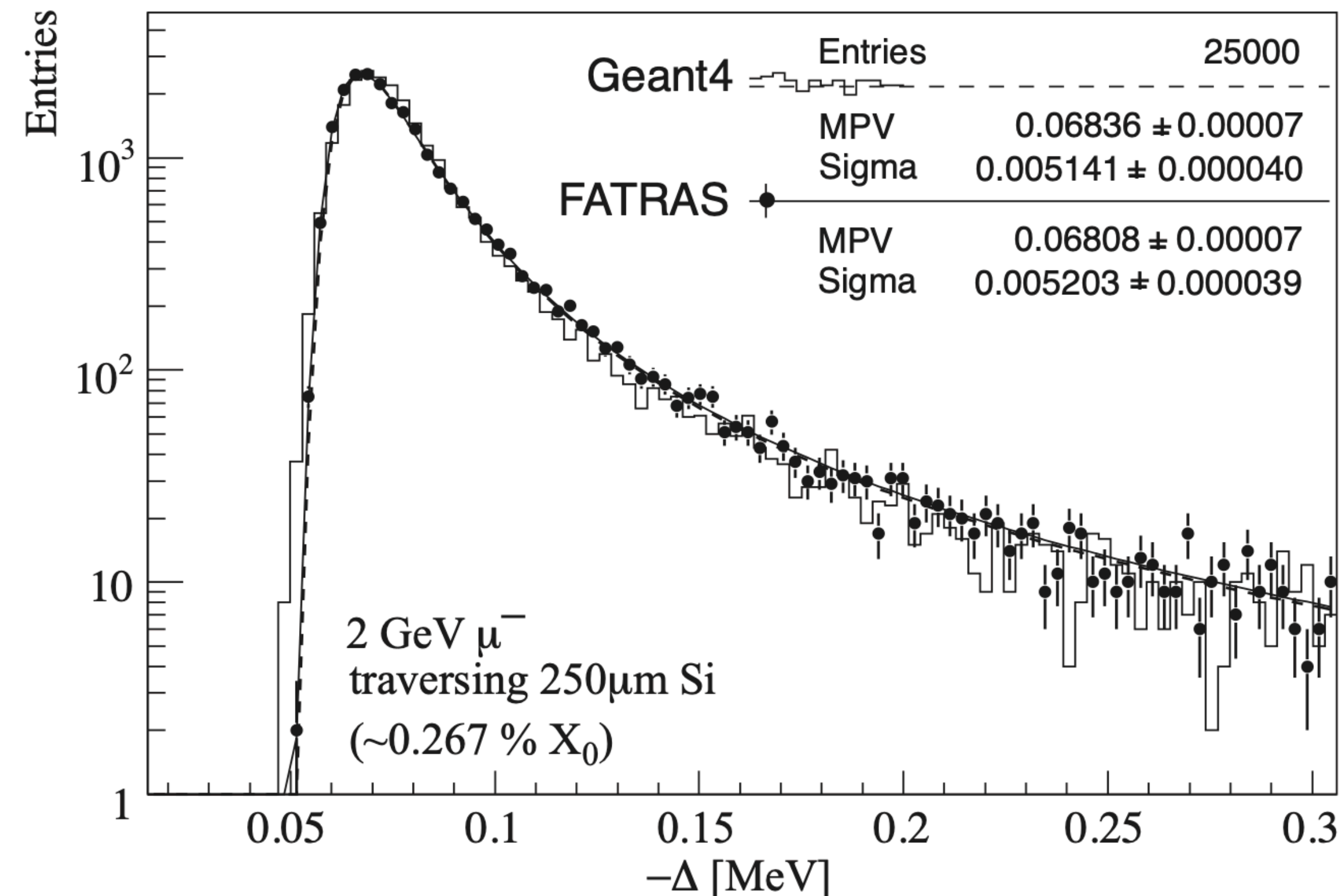
Hadronic Physics	Implementation
Nuclear interaction	Parameterized model, <b>Geant4 model (missing)</b>

Geant4 4.10 already should give access to this

Particle Decay	Implementation
Decay model	Outsourced to Geant4 (i.e. needs Geant4 installation)

# ACTS Fatras - Physics List Validation (1)

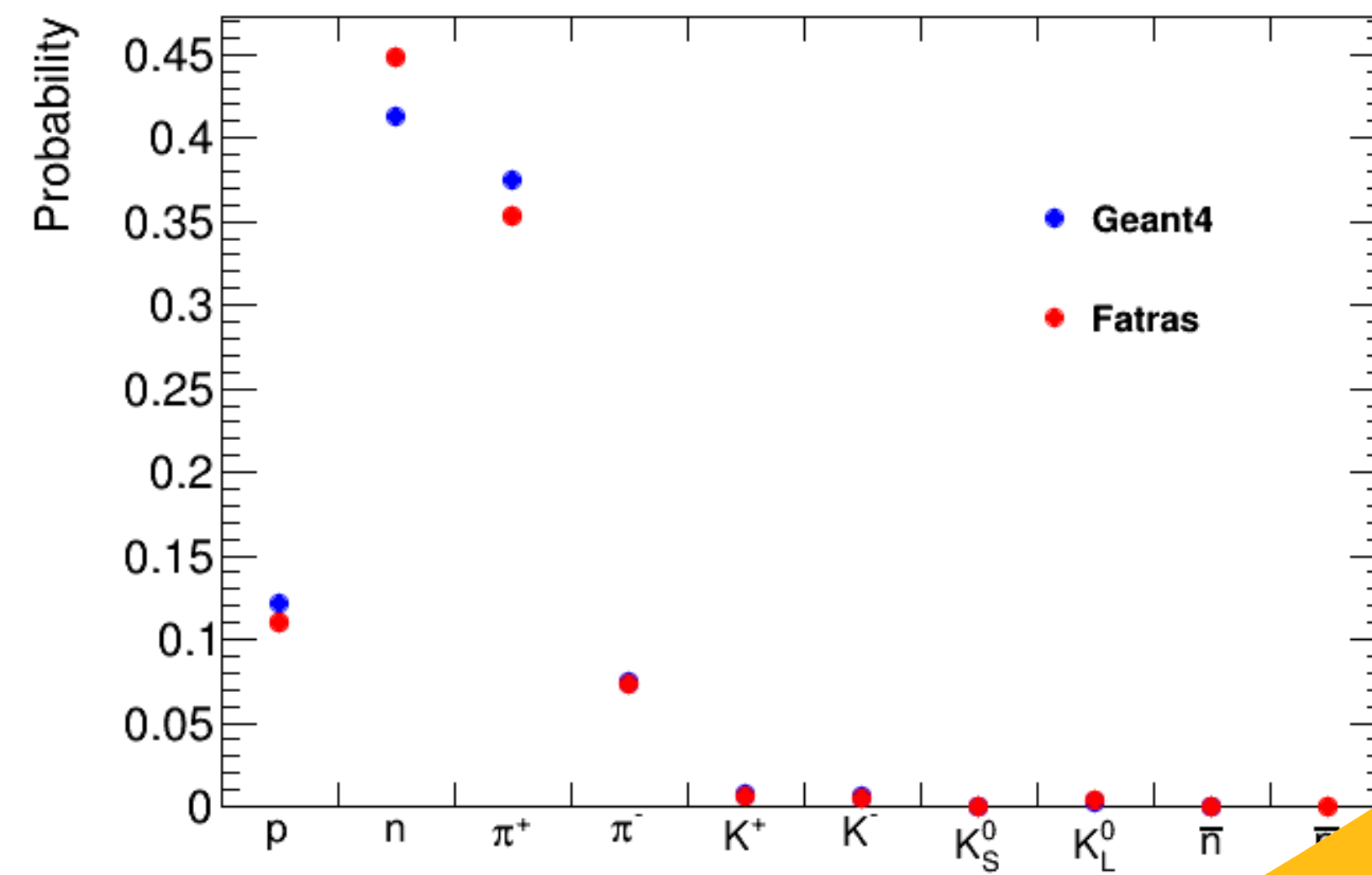
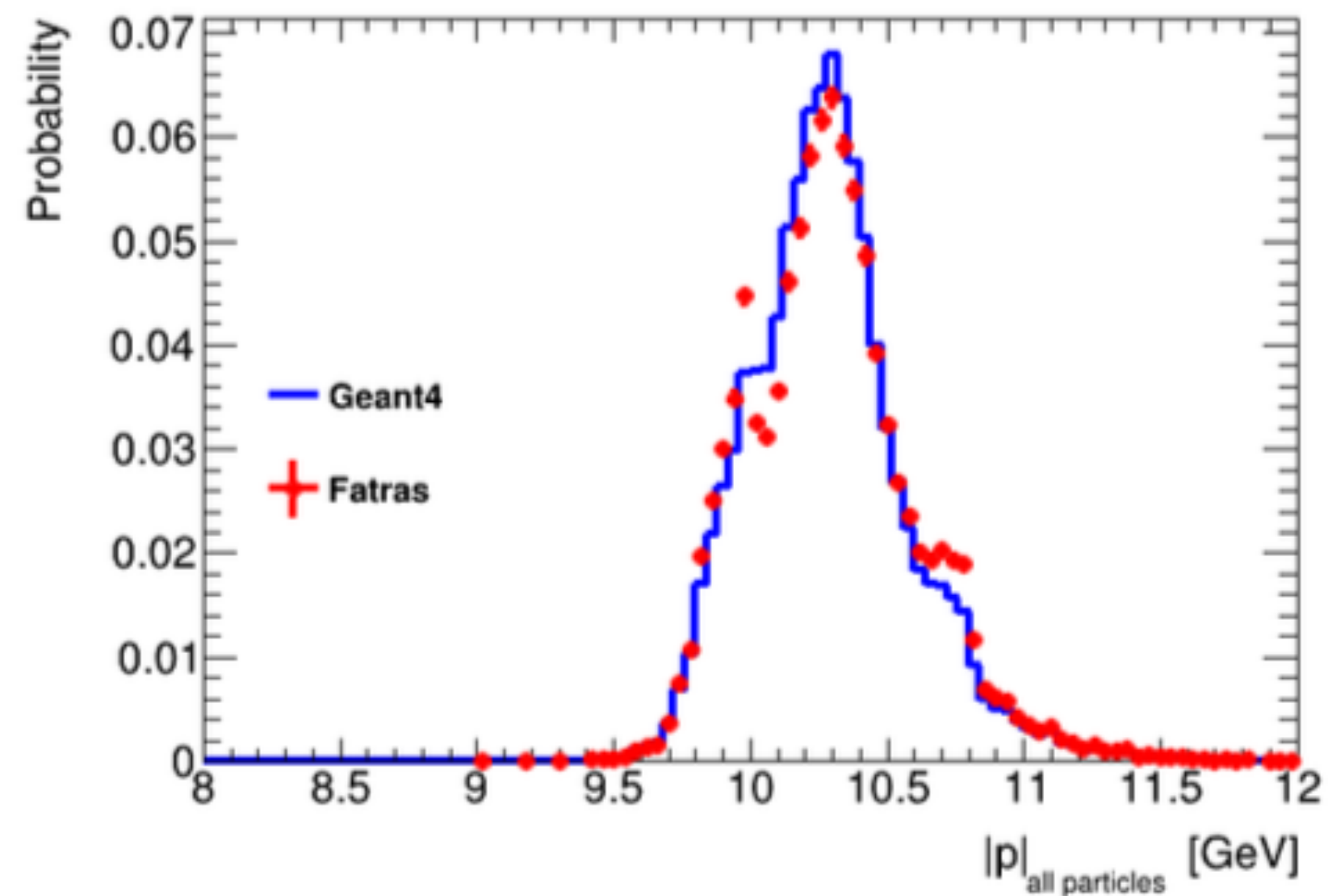
- EM physics models have been in detail validated in ATLAS
  - ▶ ACTS Fatras basically has **one-to-one transcripts** (checked again with ACTS implementation)
  - ▶ **Tuning parameters are available to adjust parameterisation** (to some extent)



<https://cds.cern.ch/record/1091969>

# ACTS Fatras - Physics List Validation (2)

- Hadronic interaction models have been recently parametrized
  - Interaction probability given by nuclear interaction length
  - Type, particle multiplicity from parameterisation

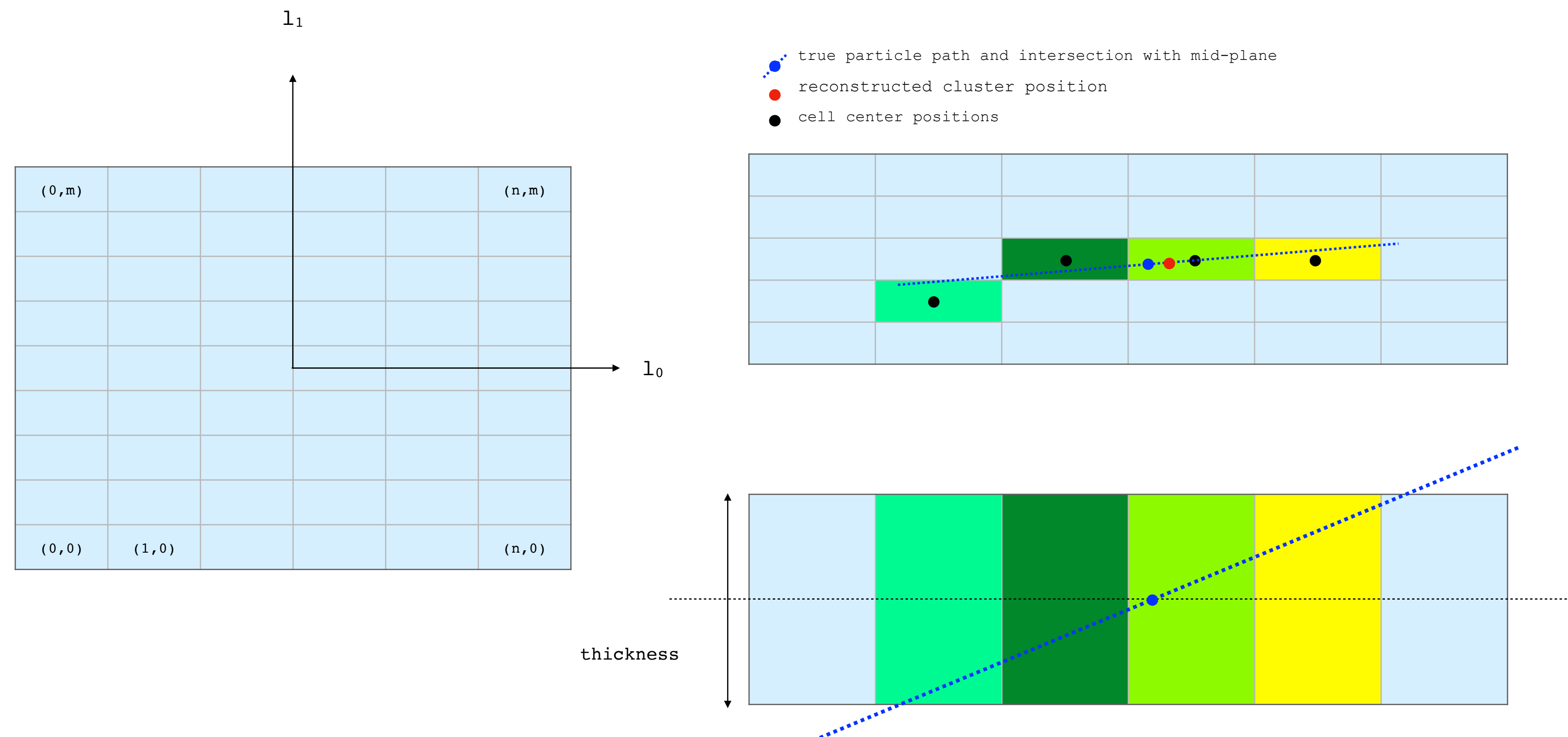


[ [Fabian Klimpel, PhD thesis](#) ]

Code still needs merging  
into the repository

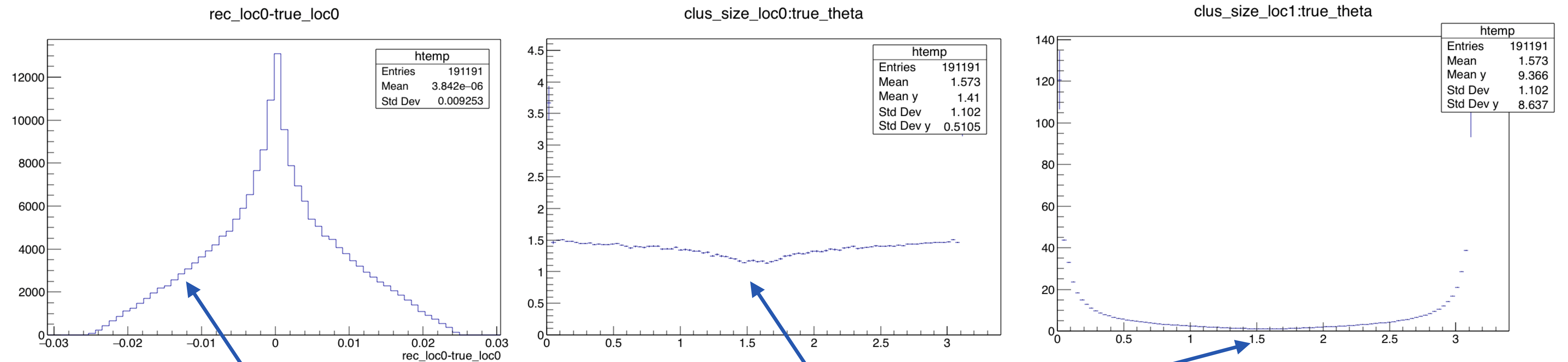
# ACTS Fatras - Digitization (1)

- Fatras deploys a geometric digitization
  - Supports segmented readout structure & time measurement



# ACTS Fatras - Digitization (2)

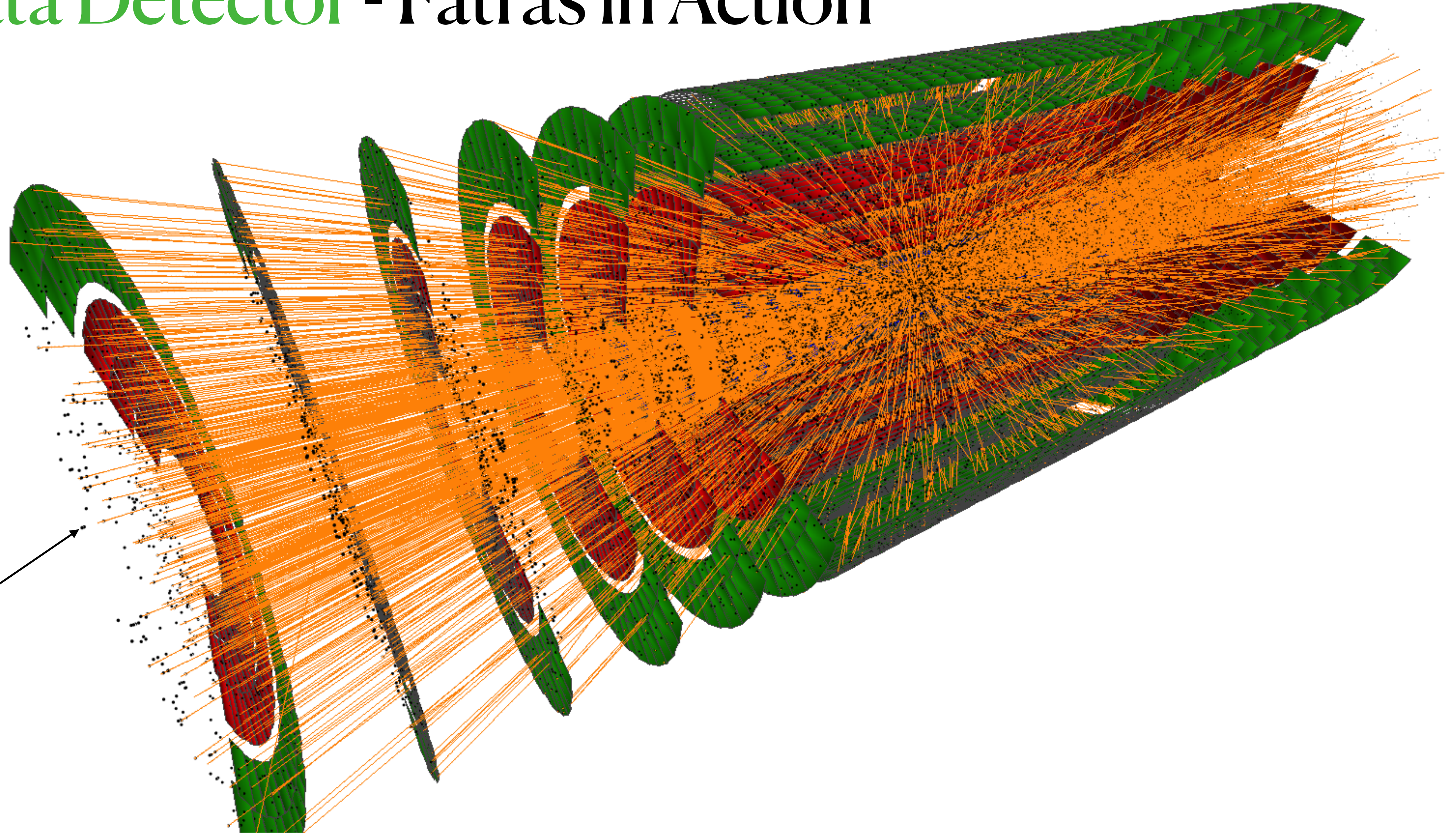
- Fatras deploys a geometric digitization
  - Supports segmented readout structure & time measurement



Non-tuned resolution

Reasonable cluster sizes vs. Incident angle

# Open Data Detector - Fatras in Action

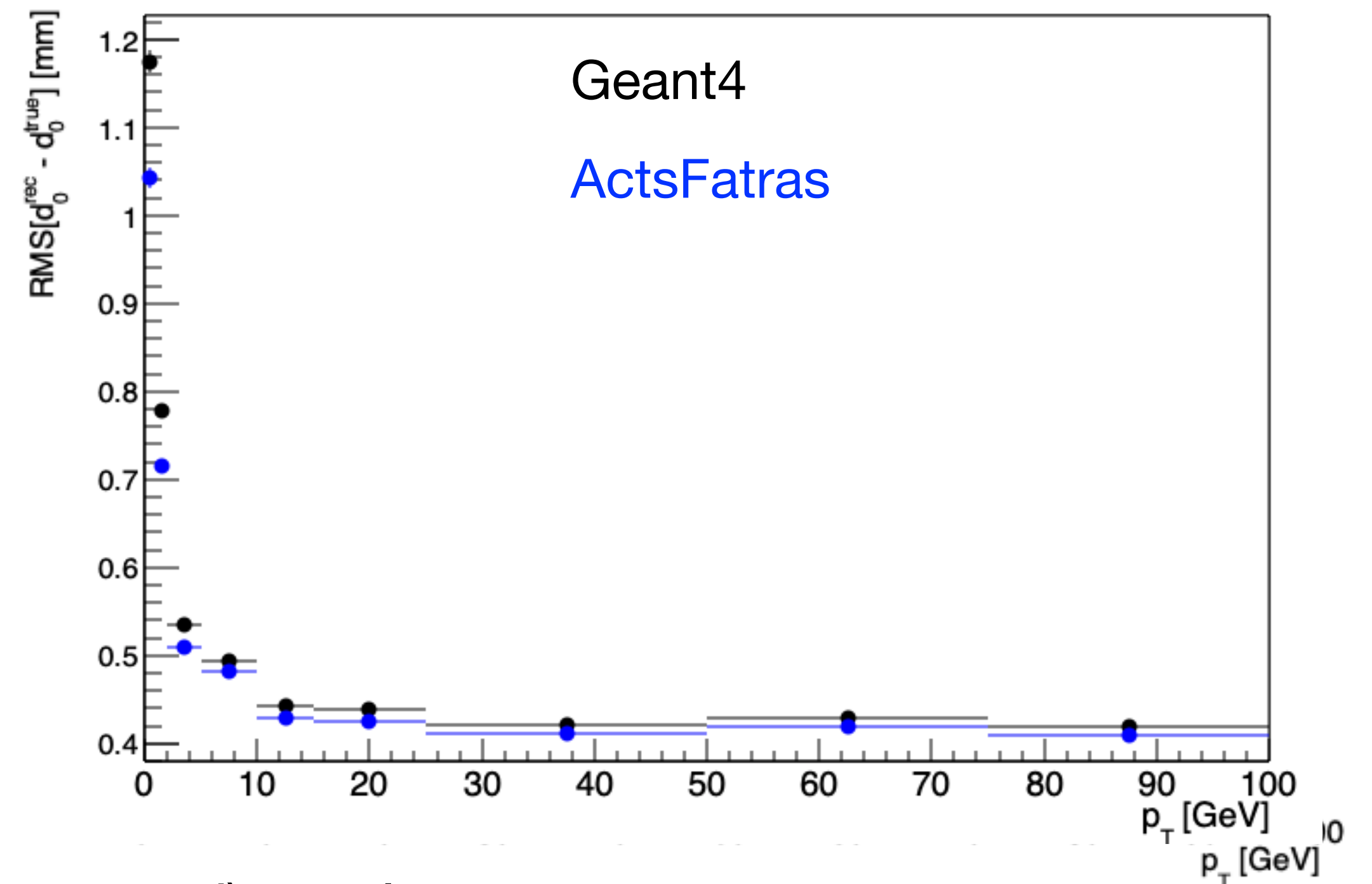
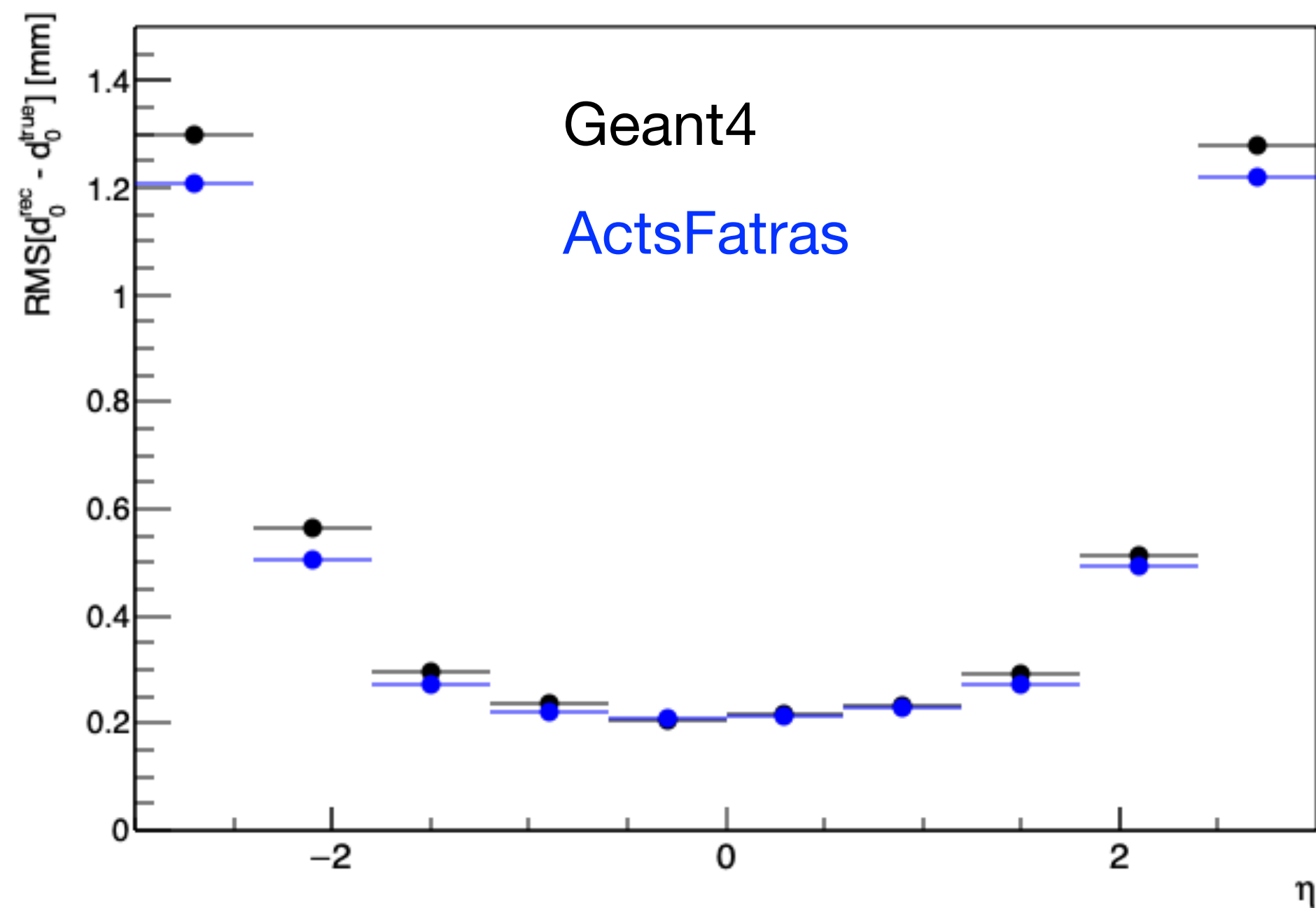


Hit created by  
Fatras



# Open Data Detector - Fatras/Geant4 comparison

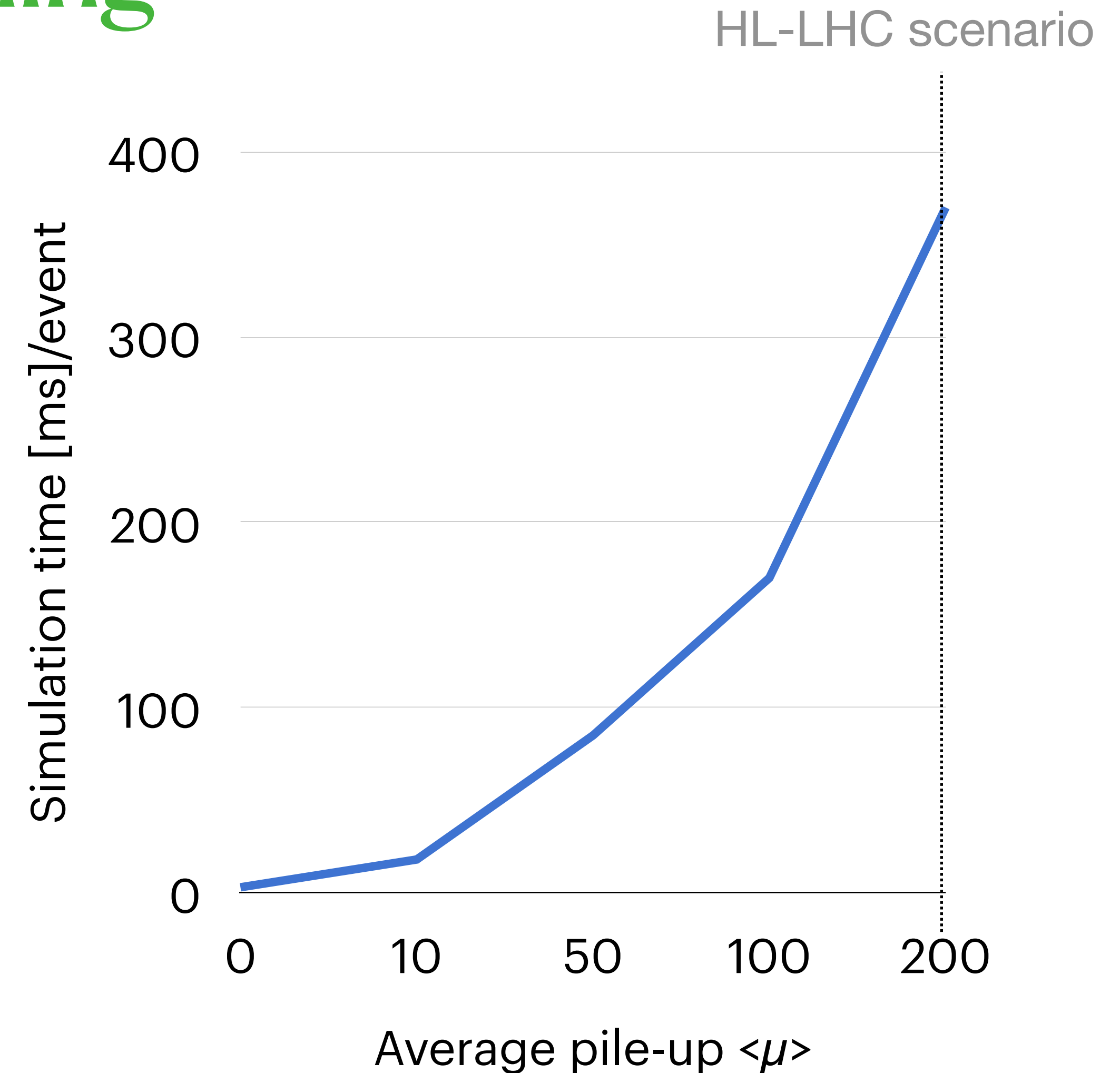
- **Open Data Detector is the follow-up detector of the TrackML detector**
  - implemented in DD4hep, with support of Geant4 simulation and ActsFatras
  - validation campaign ongoing



10 million  $\mu$  tracks with refitting, out-of-the box (untuned) result

# ACTS Fatras - Experience & Timing

- **Full dataset of TrackML Challenge was simulated using ACTS Fatras**
  - ▶ Millions of events done, great validation feedback
- **ACTS Fatras allows sub-Hz level simulation of HL-LHC environment**
  - ▶ Targets detector design development with fast turn around



MacBook M1 2020, single-threaded,  
Pythia8 hardQCD:all,  $p_T = 50$  MeV particle  
threshold, simulation only

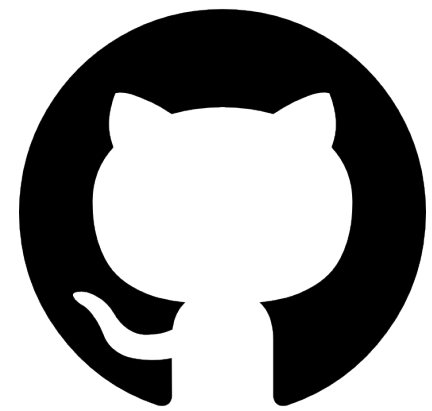
# ACTS Fatras - Conclusion/Outlook

- **ATLAS Fast Track Simulation (Fatras) being re-implemented in Acts**
  - **Same concepts, new code, thread safe**
  - **Full transport based fast simulation & hit creation**
    - allows to feed into reconstruction algorithm, but also supports reconstruction by-passing by truth trajectory building
    - allows direct comparison with Geant4
- **Most implementations are done, but not everything is merged yet**
  - **Full validation with Open Data Detector vs. Geant4 planned**



<https://arxiv.org/abs/2106.13593>

(to be appear in CSBS shortly)



<https://github.com/acts-project/acts>