Task 2.6: Common Event Filter Infrastructure

F. Barba (ETH Zurich)

A. Krasznahorkay (UMass)

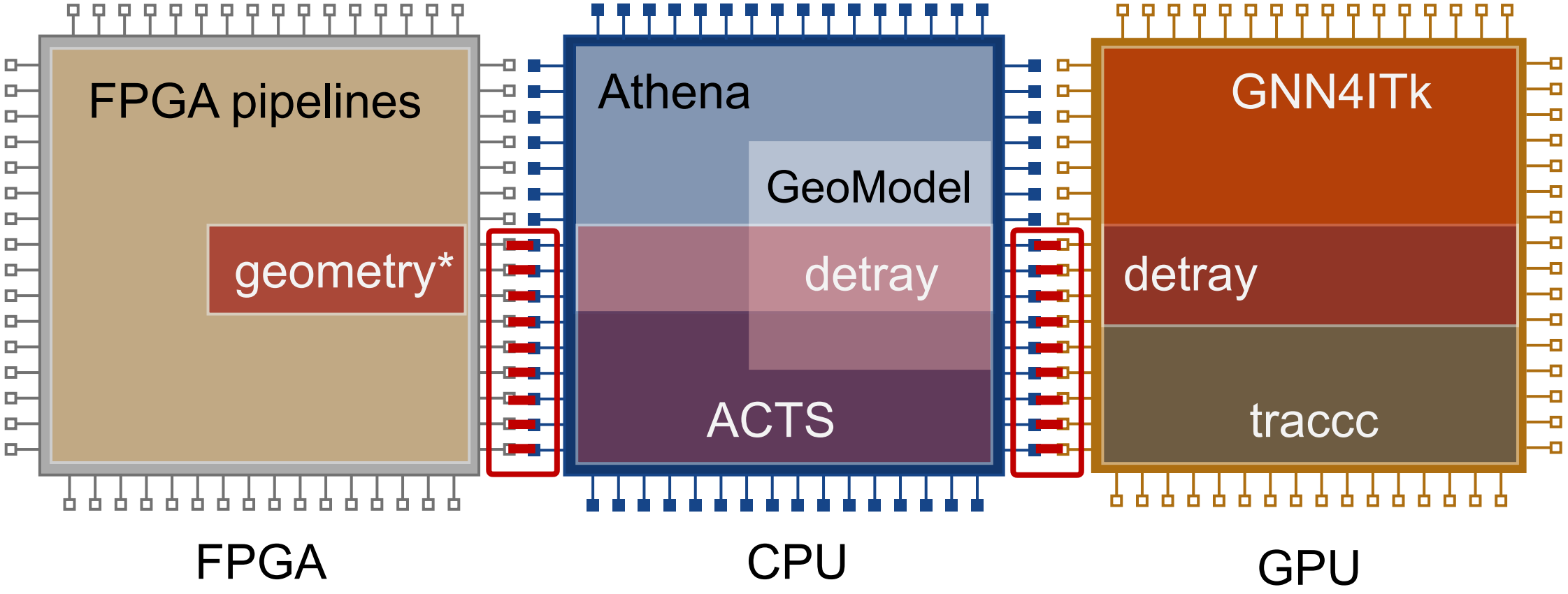
P. Gessinger-Befurt, A. Salzburger, S. N. Swatman (CERN)

Task 2.6 Overview

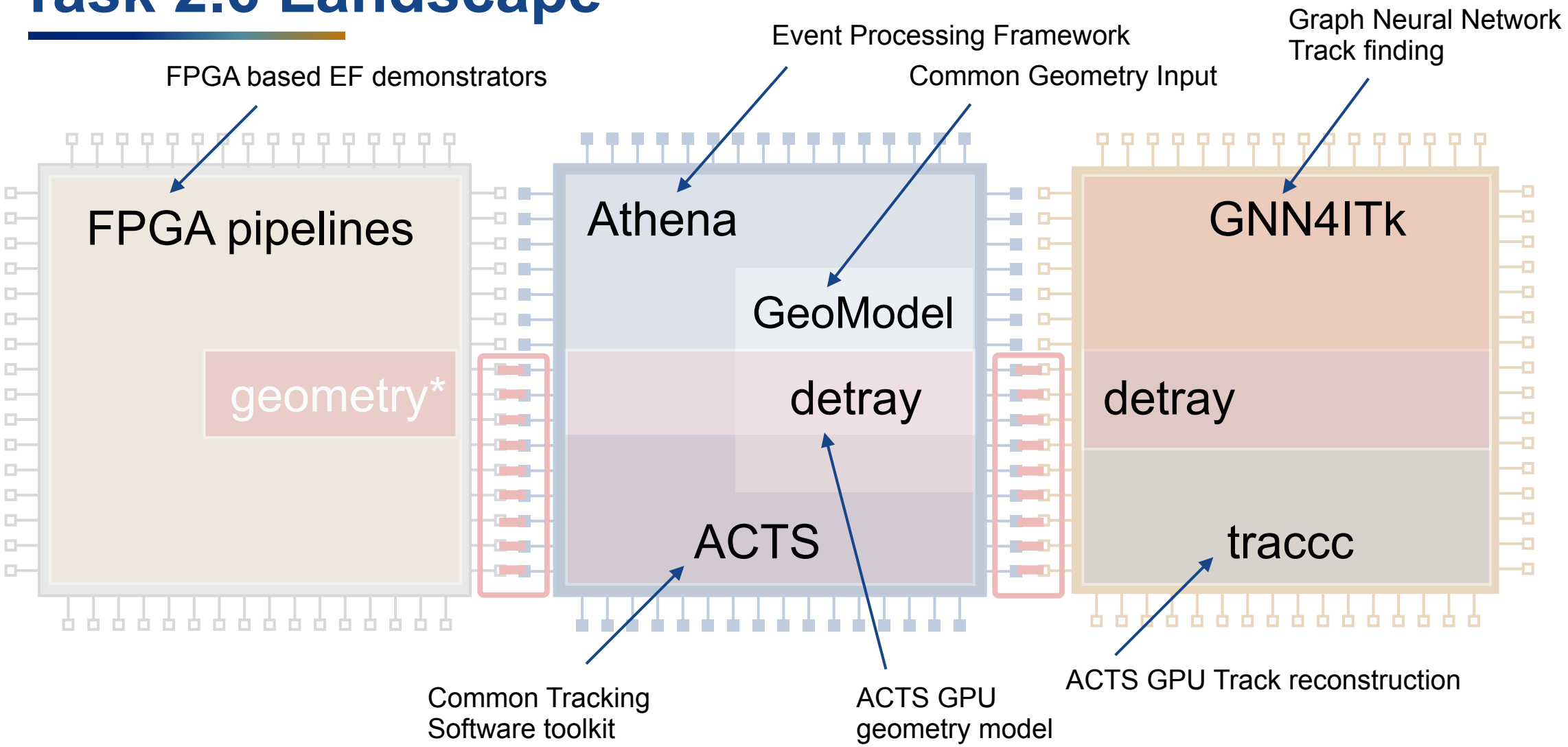
Main objective of Task 2.6

- Provide **infrastructure support** for the various ATLAS Event Filter prototypes within ACTS
  - Technical support
  - Event data model
  - Geometry integration (e.g. Muon System geometry model, GPU geometry model)
- **Improve integration of GPU/CPU** (and eventual **FPGA** based) demonstrators
- Help with **interfacing ML/AI pipelines** with ACTS
- **Optimise data structures** for heterogeneous pipelines
- **Optimise throughout** of candidate CPU/GPU EF applications

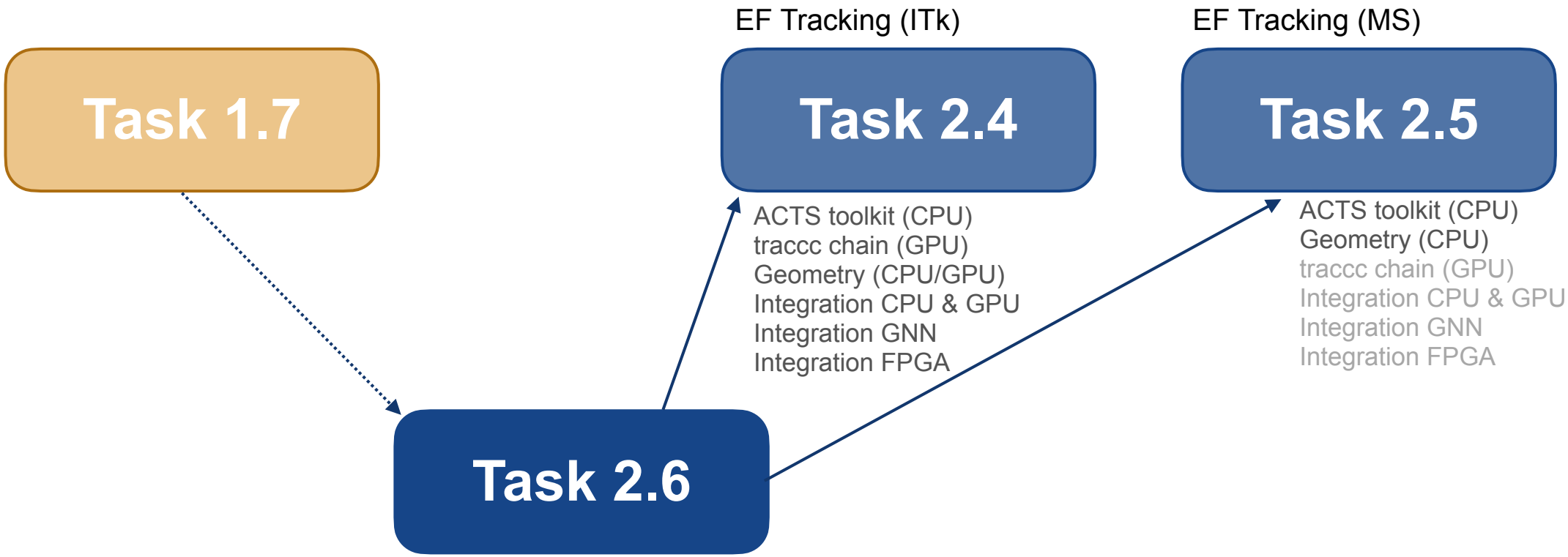
Task 2.6 Landscape



Task 2.6 Landscape



Task 2.6 Interconnects



Task 2.6 Team

Attila Krasznohorkay
Task co-lead

Andreas Salzburger
Task co-lead

Paul Gessinger-Befurt
LD, start: June 2024

Stephen N. Swatman
QUEST, start: June 2024

Frederik Barba
TS, Mar-July 2024

Performance optimisation: CPU

Major effort to improve ACTS track reconstruction chain

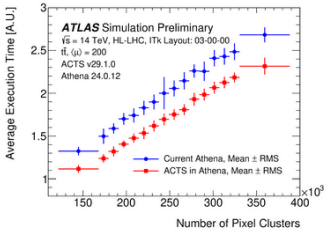
- Close cooperation with Task 2.4
- Currently focus on ACTS toolkit
- Future dedicated focus on EF Fast Tracking chain

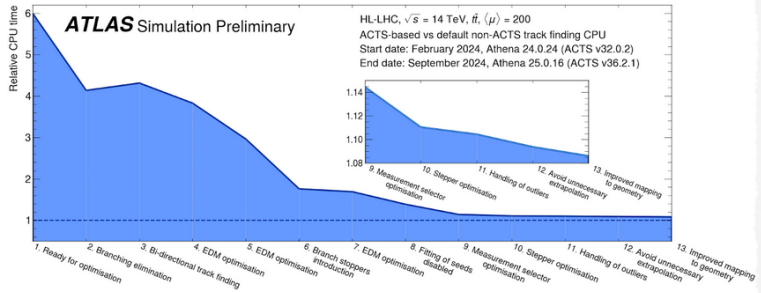
Dedicated performance hackathon organised (Nov 22, 2024)

- Main organizer: Paul Gessinger-Befurt
- Educational impact on ACTS developers at large

Current activities in CPU EF Tracking

- All components of the ITk tracking chain are **deployed and validated against athena counterparts [IDTR-2023]**
  - e.g. for clustering 10-20% speed up is achieved by ACTS implementation at ⟨μ⟩ = 200
- **Track finding** is based on the **ACTS Combinatorial Kalman Filter (CKF)**
  - Shows **very promising physics performance** results, and is **undergoing optimisation**
- **Very intensive ongoing optimization campaign of both ACTS and the ATLAS software**
  - Part of the ACTS integration effort
    - Contribution at CHEP 2024





Task 2.4 talk

Next generation geometry support

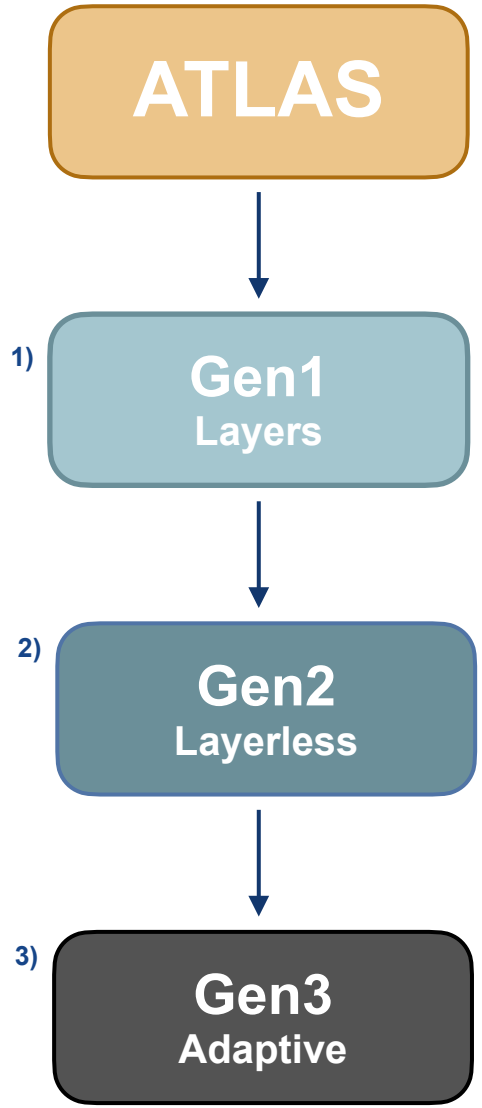
Original[1] geometry model of ACTS stems initially from ATLAS (~20 years ago)

- Rigid design of Volume - Layer - Surface hierarchy
- Relatively brittle/restricted building code
- Limited support for non-layer-based detectors

Re-implementation for the GPU R&D line (detray library)

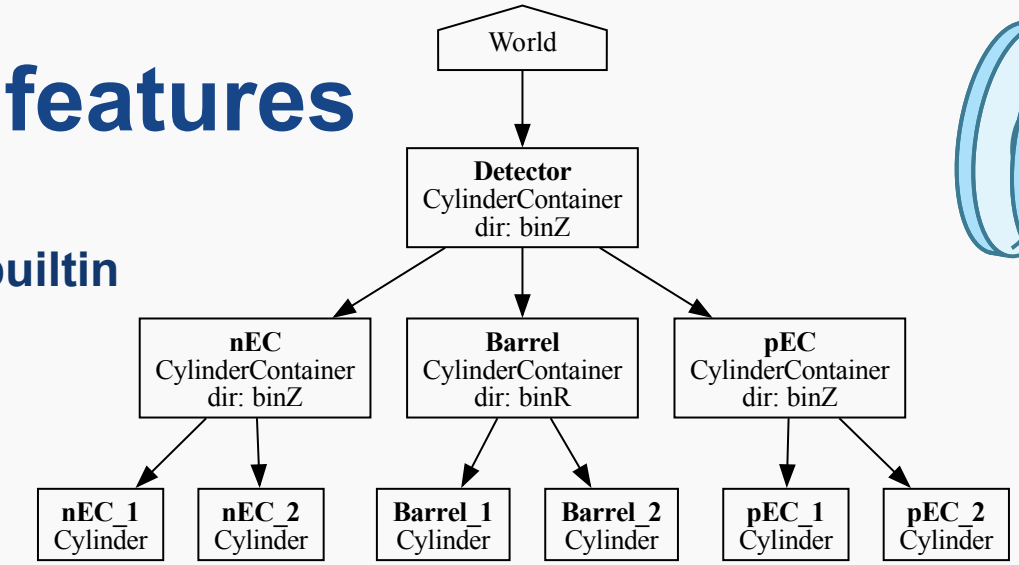
- Omit layer concept in favour of Volume - Surface hierarchy
- Huge simplification in navigation code
- Led to **experimental[2] geometry model** with blueprint build instruction

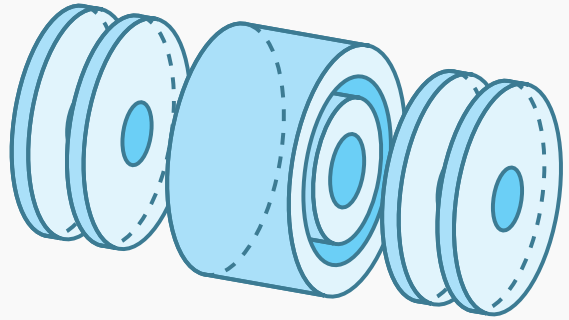
Merge of original and experimental geometry model to next generation[3] model



Gen3
Adaptive

geometry features





Programatic building interface with builtin Blueprint model developed

- Flexible building infrastructure

Support for different navigation model delegates

- Enhancing non-layered detector types (Muon System chamber navigation)

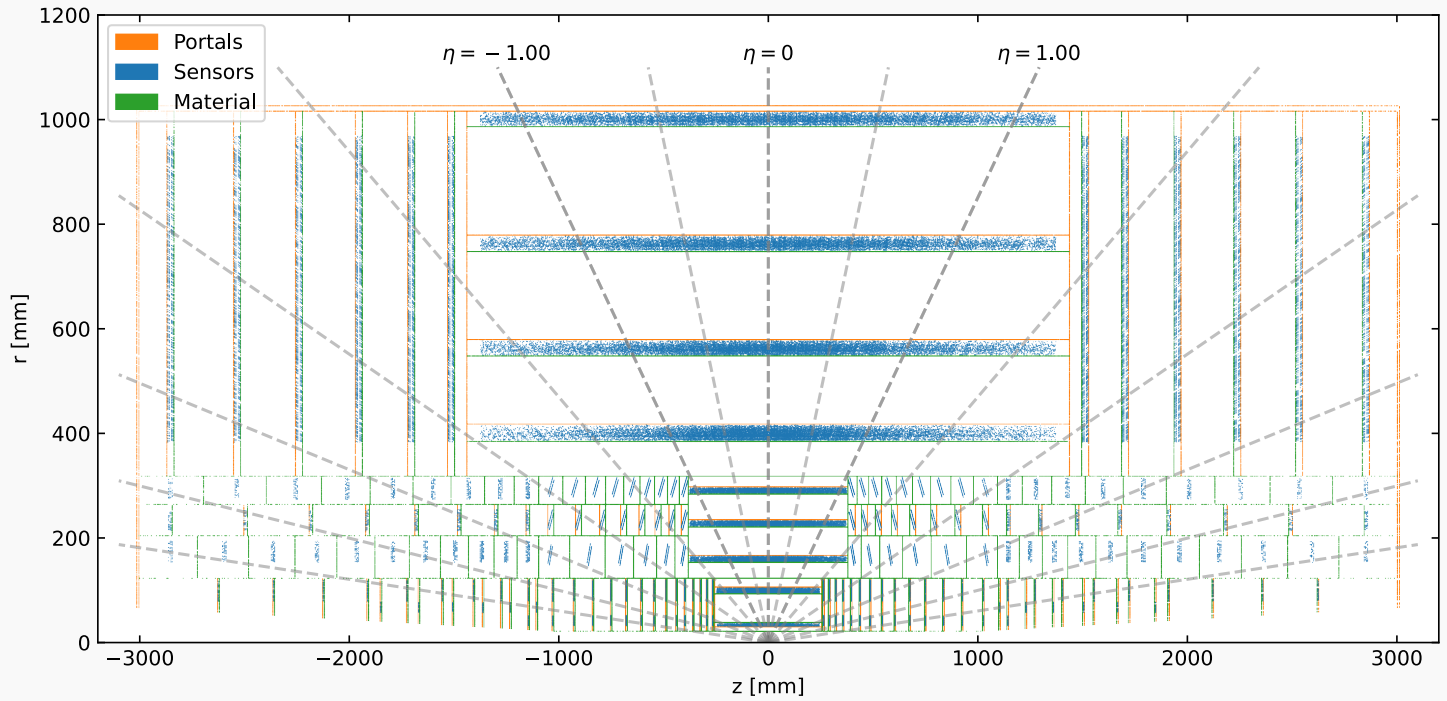
Direct translation into detray geometry model foreseen

- By directing the Blueprint into either ACTS or detray geometry building

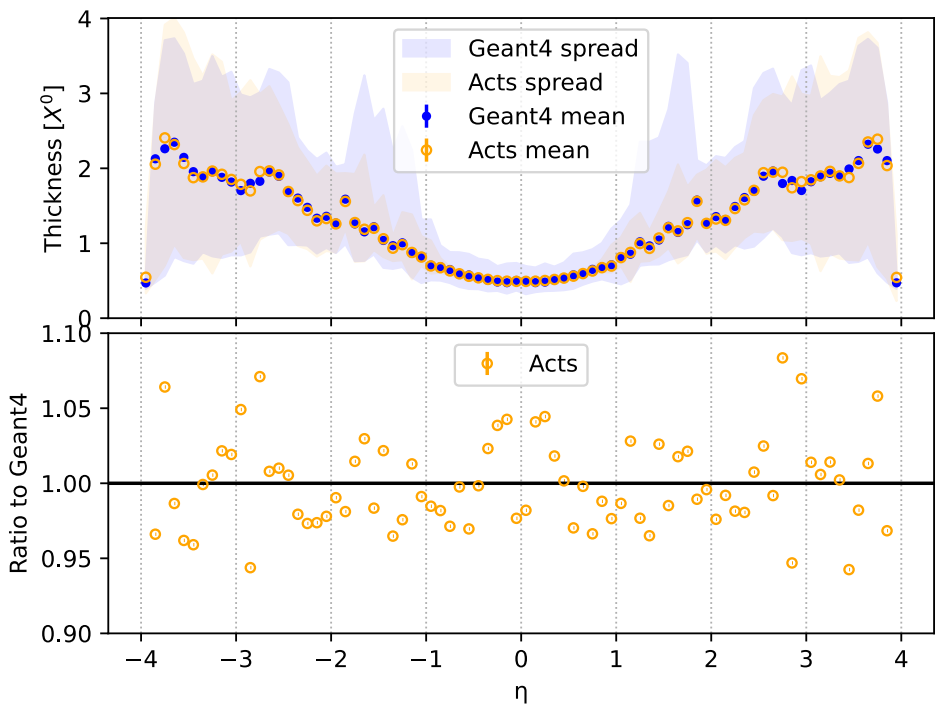
P. Gessinger-Befurt, A. Salzburger:
Next generation geometry model for Tracking in ACTS, CHEP2024

Gen3
Adaptive

ITk geometry & material prototype



ATLAS ITk modelled with ACTS Gen3 geometry model.



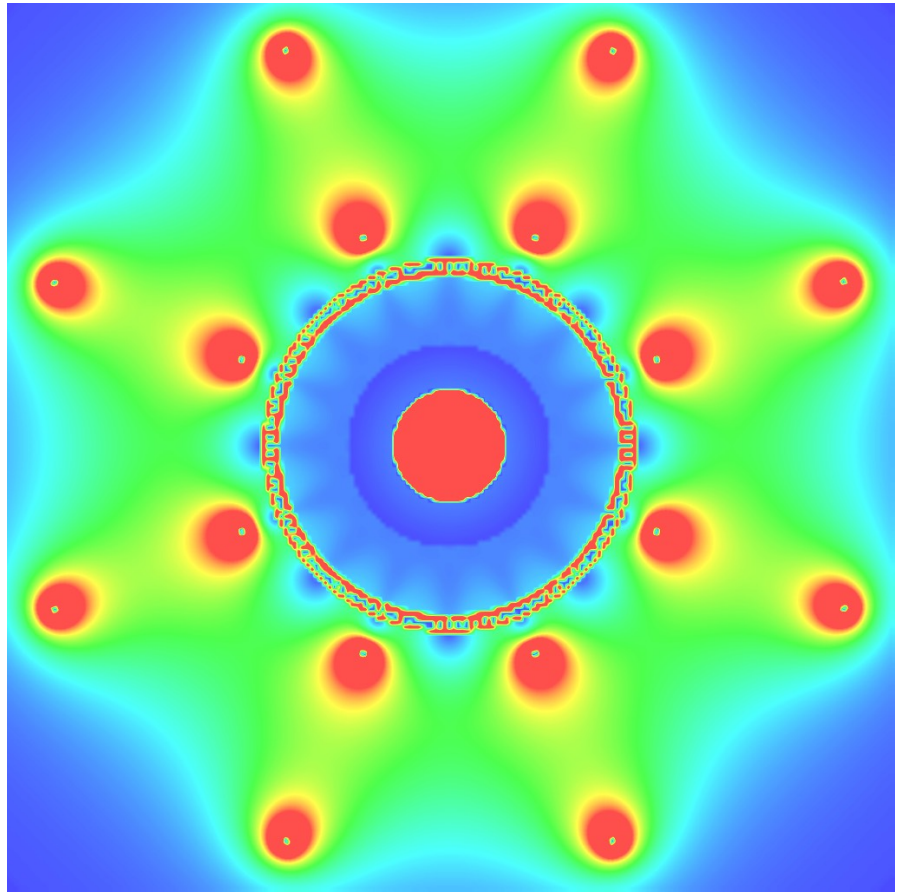
Material comparison Geant4/ACTS Gen3 geometry model (Non-optimised binning).

P. Gessinger-Befurt, A. Salzburger:
Next generation geometry model for Tracking in ACTS, CHEP2024

GPU pipeline integration: traccc & friends

Direct translation layer between ACTS & traccc

- Allows to run traccc chain as **part of ACTS**
  - Alternative way to text-file based execution
- Geometry, Material (detray) Magnetic field (covfie) and Event Data model **converters implemented**
- Prototyped with **Open Data Detector (ODD)**
- **First prototype in Athena for ITk established**

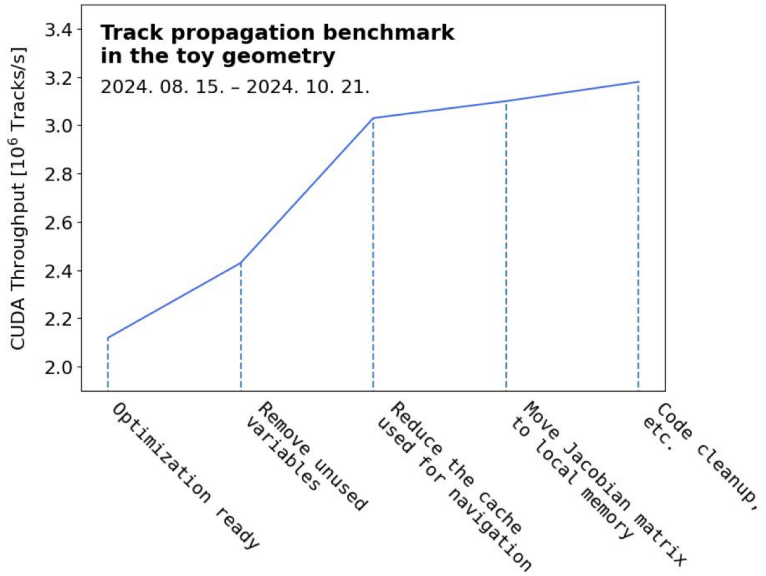


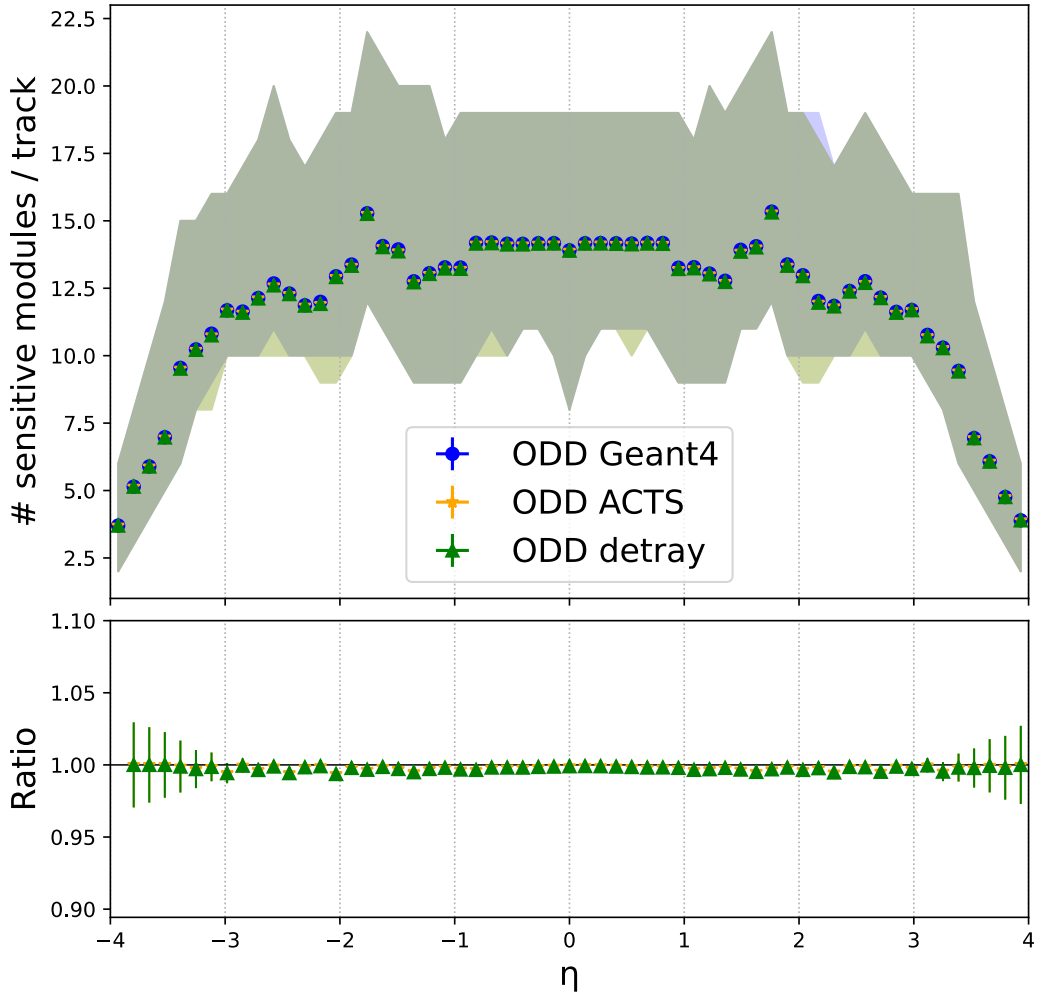
ATLAS magnetic field slice at z=0 as `covfie` instance, Interpolated and rendered fully on device code.

GPU pipeline optimisation

Ongoing optimisation for the GPU pipeline

- **Propagation** validation and throughput optimisation (prep. for Gen3 geometry)





Navigation validation for the ODD comparing the reachable sensitive surfaces in Geant4, ACTS & detray.

H. Gray, A. Krasznahorkay, C. Leggett, J. Niermann, A. Salzburger, S. N. Swatman, B. Yeo: traccc: GPU track reconstruction library for HEP experiments, CHEP2024

First throughput comparison of traccc on various GPUs conducted

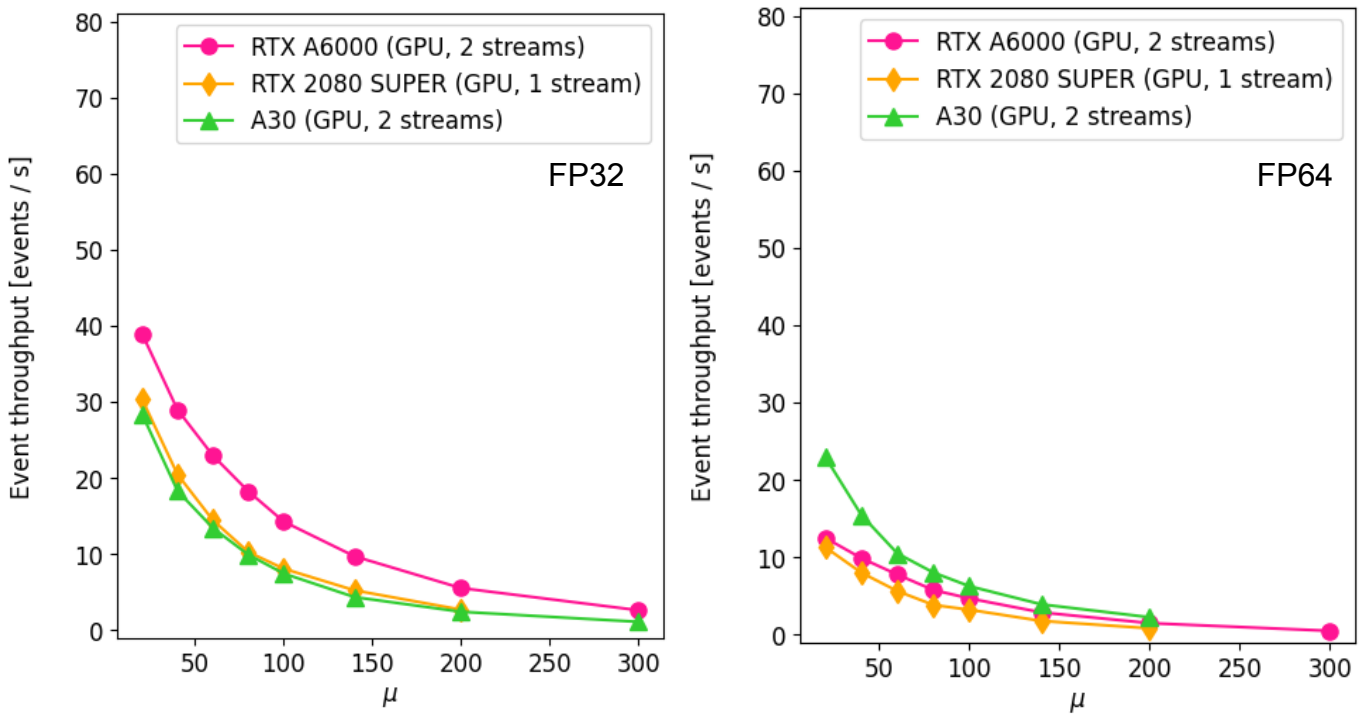
- Focus on ODD chain at the moment
- ITk chain is also deployed in a first version

Starting point for optimisation campaign

- Understand dependency on floating point precision

Contribute to the ATLAS Event Filter technology choice

- Currently foreseen for Q4/2025



Traccc throughput versus pile-up for the ODD chain (cells->tracks) on different hardware and in different floating point precision

H. Gray, A. Krasznahorkay, C. Leggett, J. Niermann, A. Salzburger, S. N. Swatman, B. Yeo: traccc: GPU track reconstruction library for HEP experiments, CHEP2024

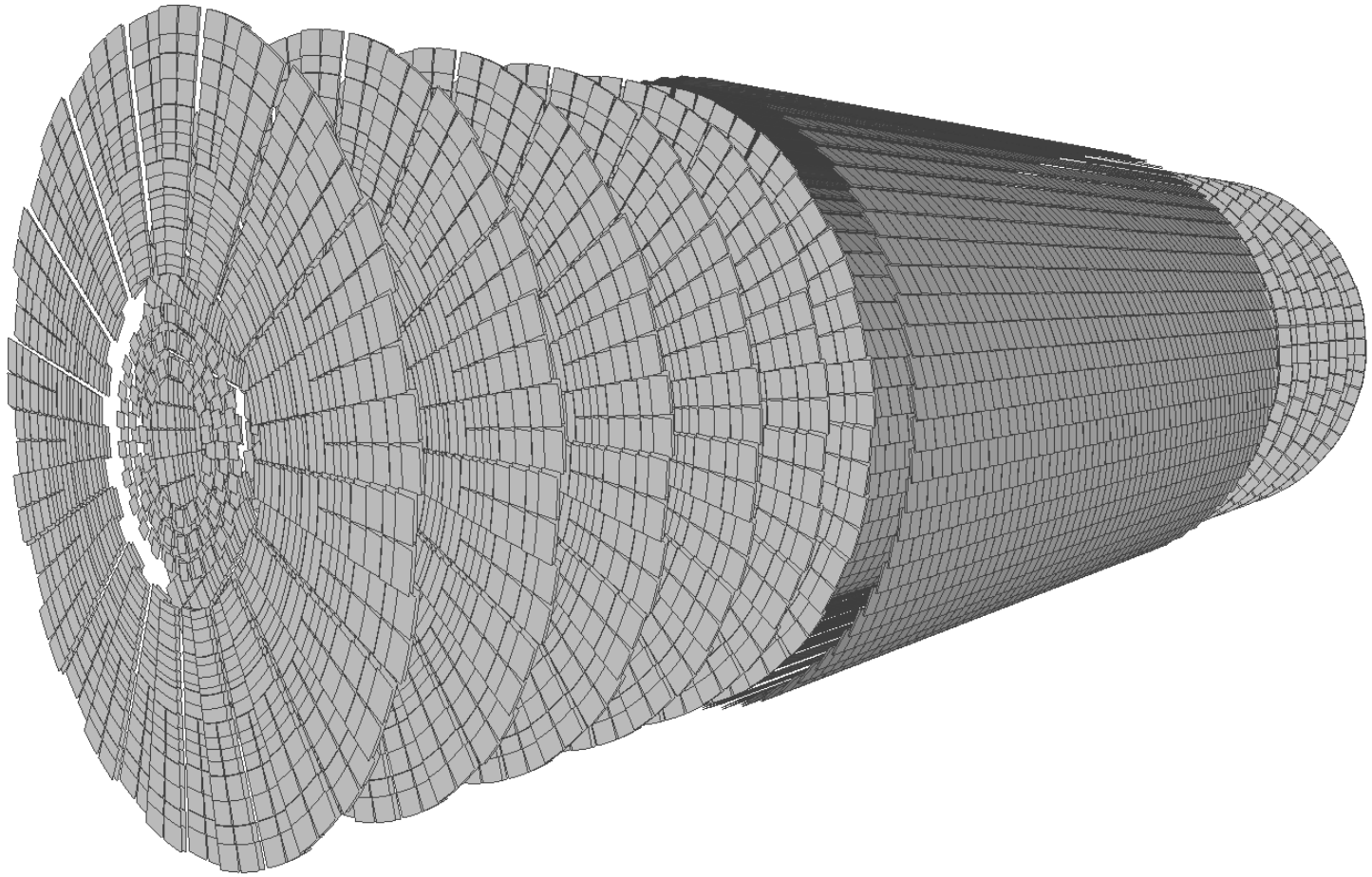
2025 Outlook

Great kick-start of the NextGen Trigger project in 2024

- **Several concrete results** already established by the Task 2.6 team

Good baseline for 2025 objectives

- Finish the **Gen3 geometry model**, deploy, and integrate ATLAS Run-4 geometry (including MS)
- Further **optimise ACTS Fast Tracking** and offline chain in physics and computational performance
- Establish a full **ITk traccc pipeline** with comprehensive performance evaluation
- Create support for **GNN4ITk + ACTS/traccc** chain
- Enable **refitting interface to eventual FPGA** based track finding



ATLAS ITk detector described in the detray library,


CERN
NexTGen
Next Generation Triggers