

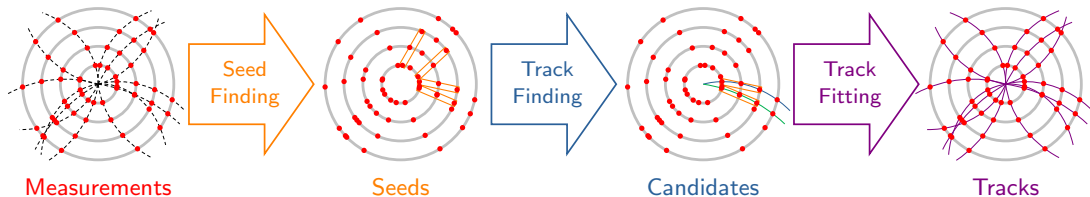
Track reconstruction with ACTS in modern high-energy physics experiments

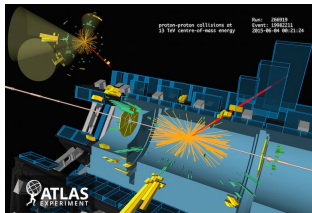
Gundolf Haase, Alexander J. Pflieger, Andreas Salzburger



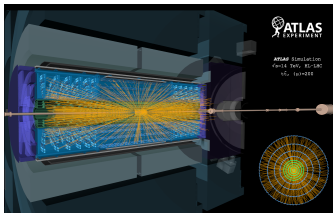
22nd of September 2026

- ▶ Which hits belong together?
- ▶ Which candidates describe the same particle?
- ▶ How many possibilities can we afford to test?





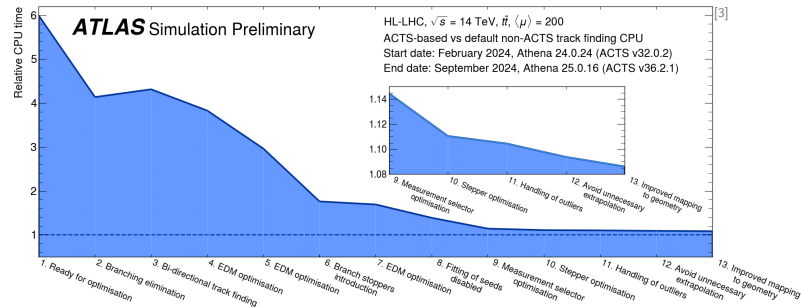
[1]



[2]

- ▶ Denser collisions
- ▶ Larger data volumes
- ▶ More combinations
- ▶ Natively single-threaded
- ▶ New tracker
- ▶ Redesign while ATLAS keeps running

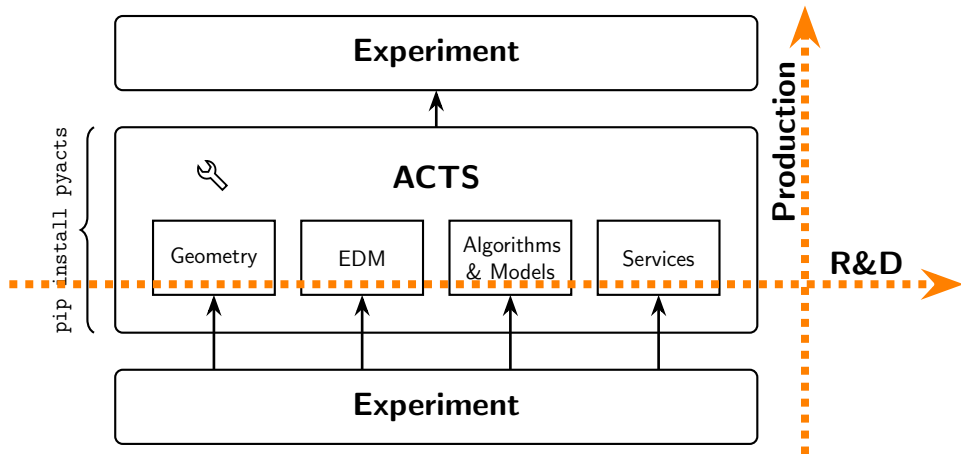
2016: ACTS starts as a standalone tracking toolkit.



[1] ATLAS Collaboration

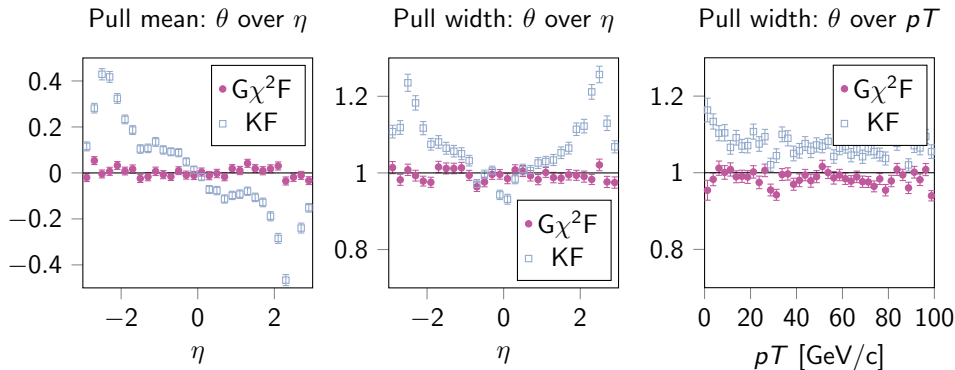
[2] ATLAS Collaboration

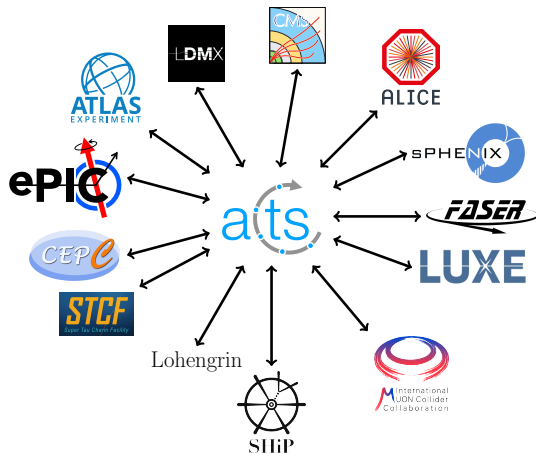
[3] ATL-PHYS-PUB-2024-017



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

- ▶ Open Data Detector (ODD)
- ▶ 10^5 events, $|\eta| \leq 3$, $\phi \in [0, 2\pi)$
- ▶ $pT \in [1, 100]$ GeV/c, randomised charge (to reduce biases)





- ▶ Fix issues once, benefit across experiments
- ▶ Different detectors expose hidden assumptions
- ▶ Share development and maintenance

- ▶ Can machine learning reduce candidate combinations?
- ▶ Can reconstruction run efficiently on GPUs?
- ▶ Can we use it in the future?

Towards a realistic track reconstruction algorithm based on graph neural networks for the HL-LHC

Implementation of ACTS for STCF track reconstruction

Auto-tuning capabilities of the ACTS track

Track reconstruction as a service for collider physics

traccc: GPU track reconstruction library for HEP experiments

Paul Gessinger¹, Heather M. Gray^{2,3}, Attila Krasznahorkay⁴, Charles Leggett³, Joana Niermann¹, Andreas Salzburger¹, Stephen Nicholas Swatman¹, and Beomki Yeo^{2,3,*}

Status of ACTS Tracking for FCC detectors

- ▶ ACTS is ATLAS run-4 standard and deployed
- ▶ International community – Austria contributes too
- ▶ R&D: machine learning, GPU tracking, future detectors, ...

Extra Slides



Enhancing CMS Passive Material Modeling in Track Reconstruction Using ACTS

Lorenzo Damenti

ACTS Workshop, 20-24 April 2026, NIKHEF

Proof of Concept

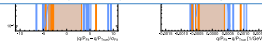
- First test: Perform track refits on simulated muons ($p_T = 100\text{ GeV}$)
- Purpose: Validate geometry built and identify major showstoppers
- Note:** Test performed using all algorithms from ACTS (i.e. propagation and refit)
- Results show a good agreement between ACTS and CMSSW



Problem: Potential improvements in passive material treatment could be hidden by non-optimized ACTS algorithms for CMS
Solution: Import only the ACTS passive material treatment into a new CMSSW propagator

Advantages:

- Facilitates extending ACTS to other reconstruction stages
- Simplifies ACTS adoption within the CMS community



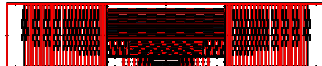
- Next Step:** decrease the p_T to probe passive material effects? Yes, but...

CMS Tracking Geometry in ACTS

- All sensitive surfaces from a TrackerGeometry in CMSSW are selected and converted into ACTS DetectorElements (DetEls)
- Note:** $detID_{CMSSW} \leftrightarrow detID_{ACTS}$
- DetEls are organized in tracking layers; **Note:** not always tracking layers correspond to physical layers



- Layers are arranged into volumes following a hierarchical structure
- Full CMS blueprint:



- Open Points:**

- Is the number of material layers too high?
- Is the layers placement correct?
- Is the binning appropriate?

Geometry Optimization

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Summary and Next Steps

- Description of passive material effects in CMSSW is suboptimal $\rightarrow$ verify if it can be improved by importing the passive material treatment approach adopted by ACTS defining a new ACTS propagator within the CMS Data Analysis Framework
- Build (and validate) the CMS Geometry within ACTS ✓
- Validate material maps used to decorate material layers ✓
- Write a new CMSSW propagator using ACTS ✓
- Validate the new propagator:
 - Compare refit performance (pulls and residuals distributions) *Ongoing*
 - Compare Track Efficiency (Using ACTS propagator in all track reco steps)
- Reconstruction of $K_S^0 \rightarrow \pi^+ \pi^-$ decays and comparison between ACTS and CMSSW



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<https://indico.cern.ch/event/1577742/contributions/7005748/>

- ▶ Full algorithm
- ▶ Already explored by experiments
- ▶ Austrian Doctoral Student Programme
- ▶ PhD at Uni Graz at CERN

Symmetries & Unambiguous Ambiguities

Track Fitting with the Global χ^2 Fitter in ACTS

Alexander J. Pfeiffer¹, Paul Gessinger-Befurt¹, Gundolf Haase²
¹ Uni Graz, Austria | CERN

Open Data Detector

(The ODD is symmetric)

Let's compare the performance of the $G_{\chi^2}F$ and the Kalman Filter Fitter (KF) on the ODD. We start with $10^5 \mu^-$. To make it more realistic vary the energy between $1 - 100 \text{ GeV}$ and include material effects.

Results:

- Drop unreachable measurements
- Unstable tracks improve
- Fit quality independent of direction and momentum
- Slower: Propagation is done multiple times

Drift Tubes

(Drift tube measurements are ambiguous)

DTs provide very precise spatial information, but each drift measurement has an **inherent left/right ambiguity**.

We only know how far the particle passed from the wire, not on which side.

The z-position (along the wire) is determined by additional strip detectors mounted above and below the tubes.

But how does the $G_{\chi^2}F$ know which side to choose?

- Prediction: Ignore which side we are passing
- Calculate residuals with absolute values
- Additional strip / pixel detectors restrict the possible trajectory
- The $G_{\chi^2}F$ naturally selects the correct configuration, and the ambiguity disappears

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 github.com/AJPfeiffer/acts

Connecting the Dots
 10-14 Nov 2025, Tokyo

<https://indico.cern.ch/event/1499357/contributions/6628643/>