Track reconstruction with Acts for MPDRoot

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Acts: A Common Tracking Software

- Open-source, being developed by CERN
- Experiment-independent toolkit for particle track reconstruction
- Implemented in modern C++ (`-std=17`) without minimal dependencies
- Designed for multi-threaded data processing (GPU accelerators)
- Machine-learning approaches

- https://github.com/acts-project/acts
- https://acts.readthedocs.io

Acts Tracking Stages

- Digitization

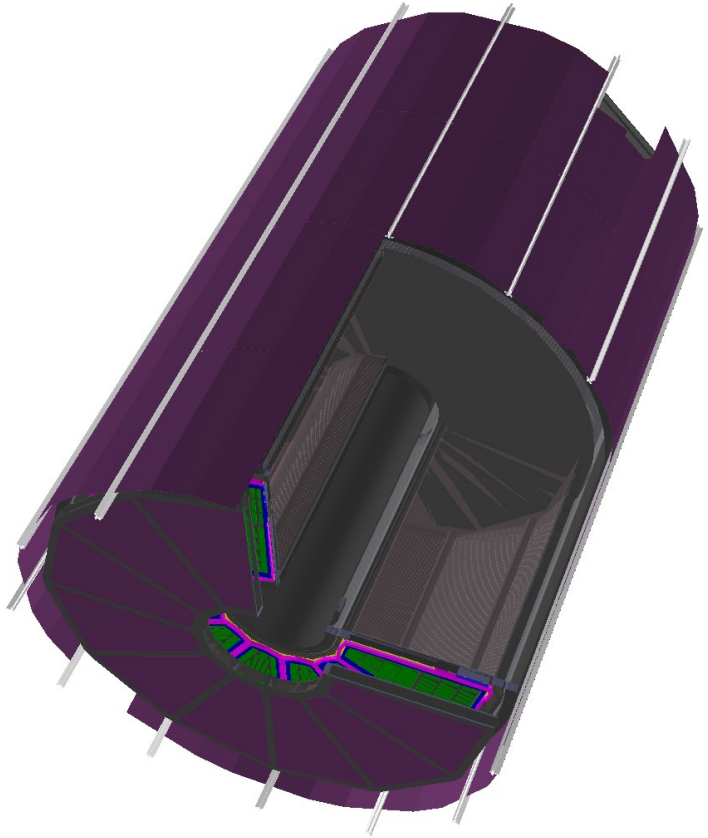
  ⇒ measurements (local coordinates, bound to surfaces)
- Space point making

  ⇒ space points (global coordinates)
- Seeding

  ⇒ seeds (3-point tracklets)
- Track parameter estimation

  ⇒ initial track parameters
- Track finding

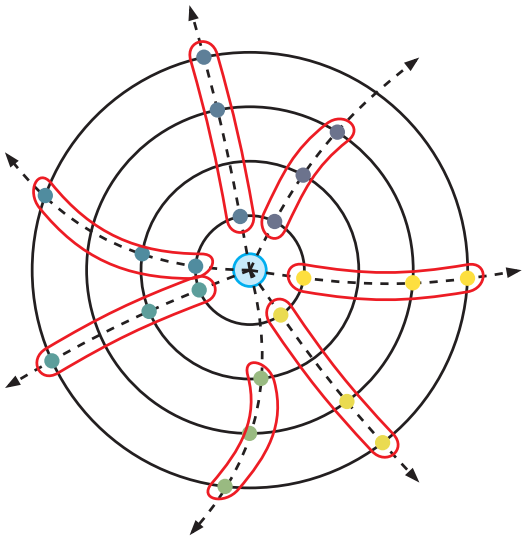
  ⇒ tracks (array of measurements)



Seeding Parameters (Part 1)

- Seed is a triplet of space points

Parameter	Description	Value
DeltaRMin	Minimum distance in R between two measurements within one seed	10 mm
DeltaRMax	Maximum distance in R between two measurements within one seed	60 mm
MaxSeedsPerSpM	How many seeds can one SP be the middle SP	3
DeltaZMax	Maximum value of delta R between SPs	10 cm



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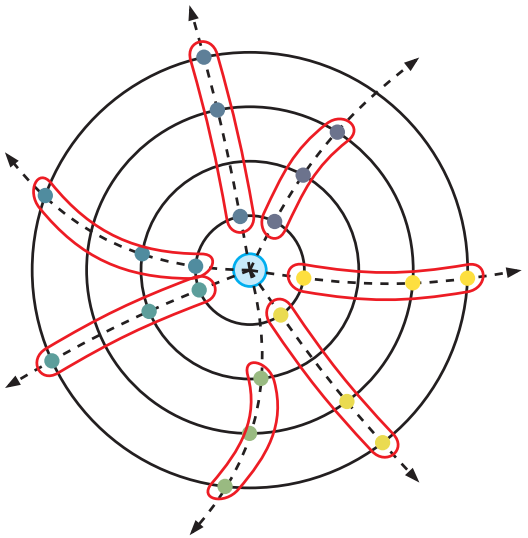
Seeding Parameters (Part 2)

- Seed is a triplet of space points

Parameter	Description	Value
CotThetaMax	Cotangent of the maximum θ angle	2.0
SigmaScattering	How many sigmas of scattering angle should be considered	5
radLengthPerSeed	Average radiation lengths of material on the length of a seed. Used for scattering	0.05
MaxPtScattering	Upper limit for scattering calculation	5 GeV
ImpactMax	Maximum impact parameter	3 cm



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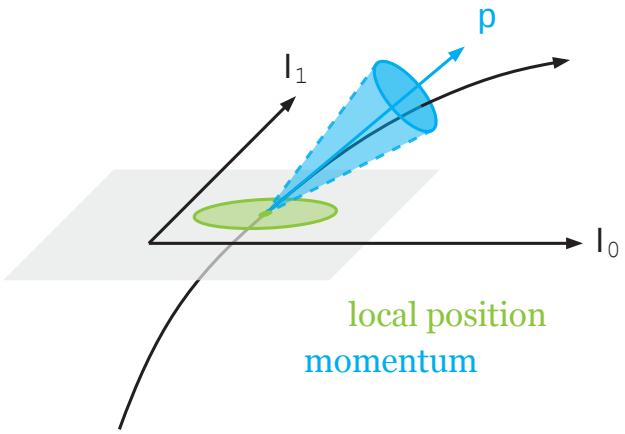
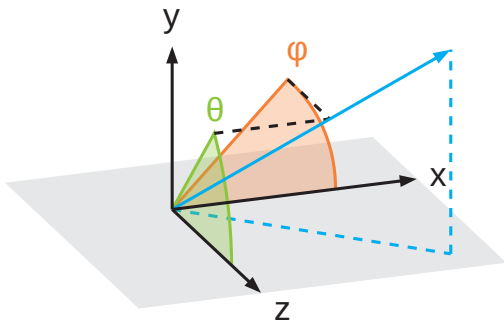
Track Parameter Estimation

- Tracking parameters: (l_0, l_1, φ, θ, q/p_T, t)

Parameter	Value
σ (l_0)	0.5 mm
σ (l_1)	0.5 mm
σ (φ)	0.5 degree
σ (θ)	0.5 degree
σ (q/p_T)	0.1 GeV



(a)



(b)

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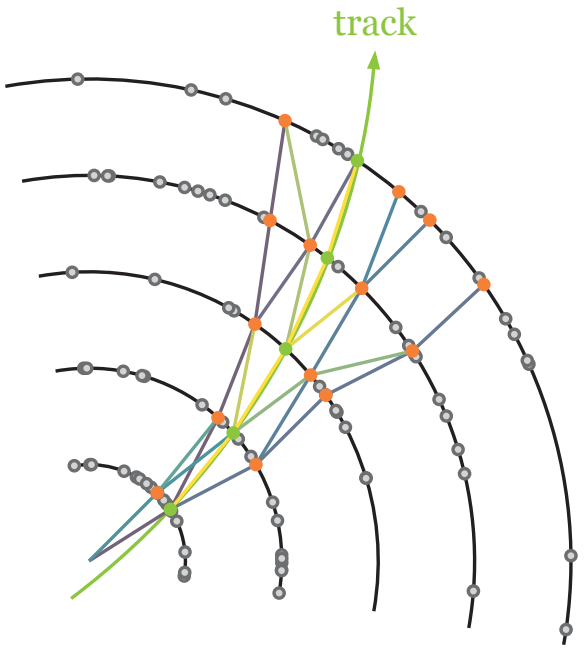
Track Finding

- Track is a sequence of measurements
- Approach:

  Combinatorial Kalman Filter

Parameter	Value
PropagationMaxSteps	1000
χ^2_{max}	30



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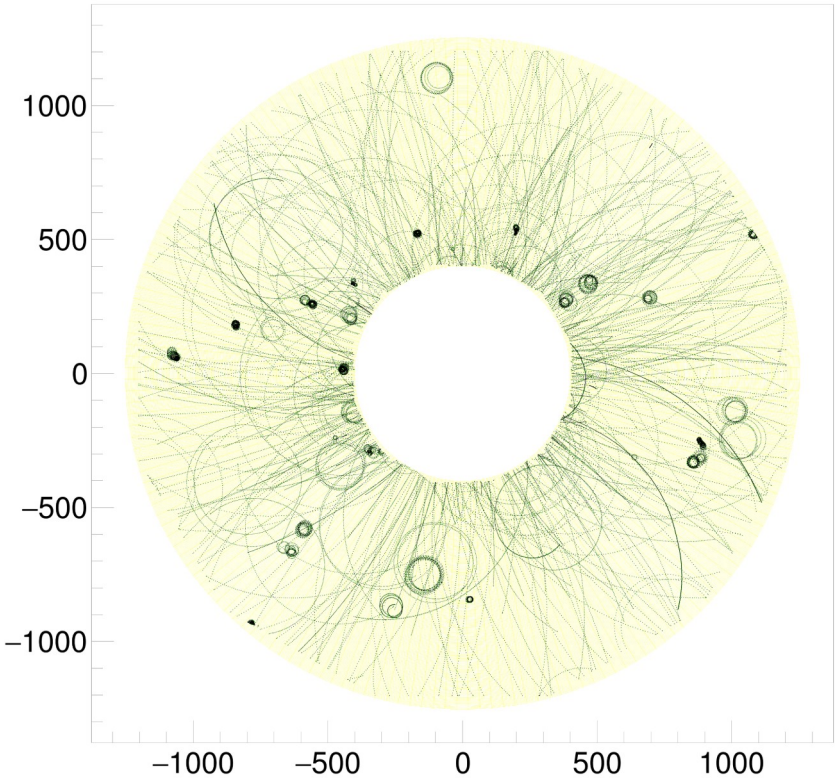
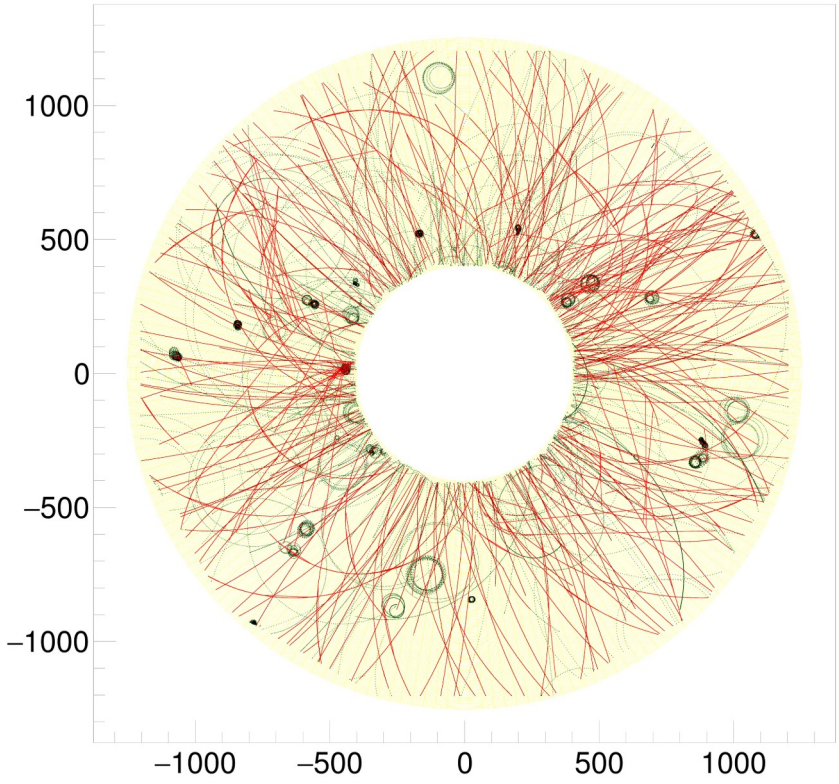
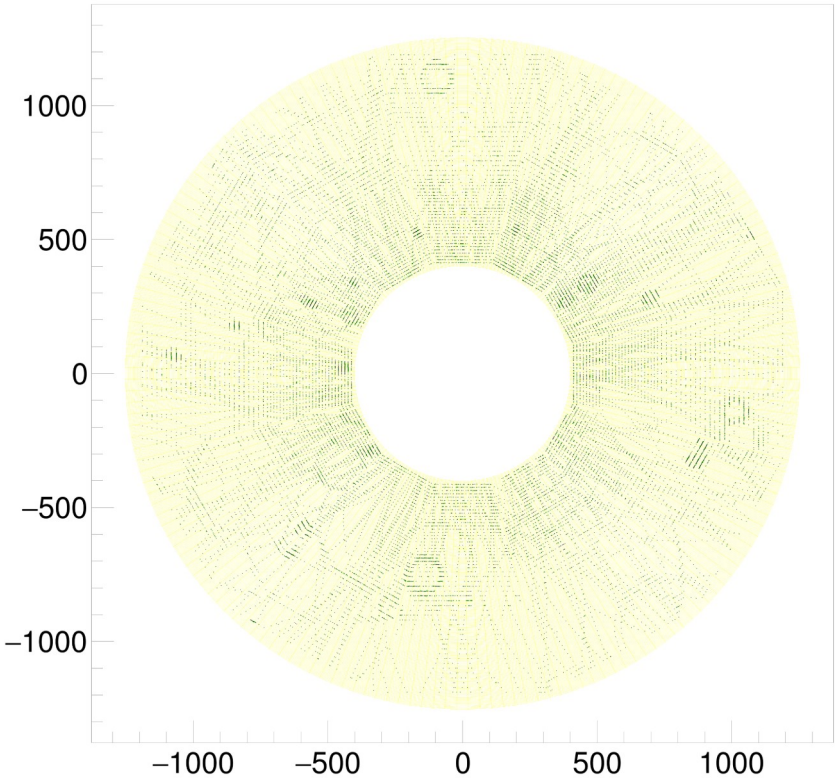
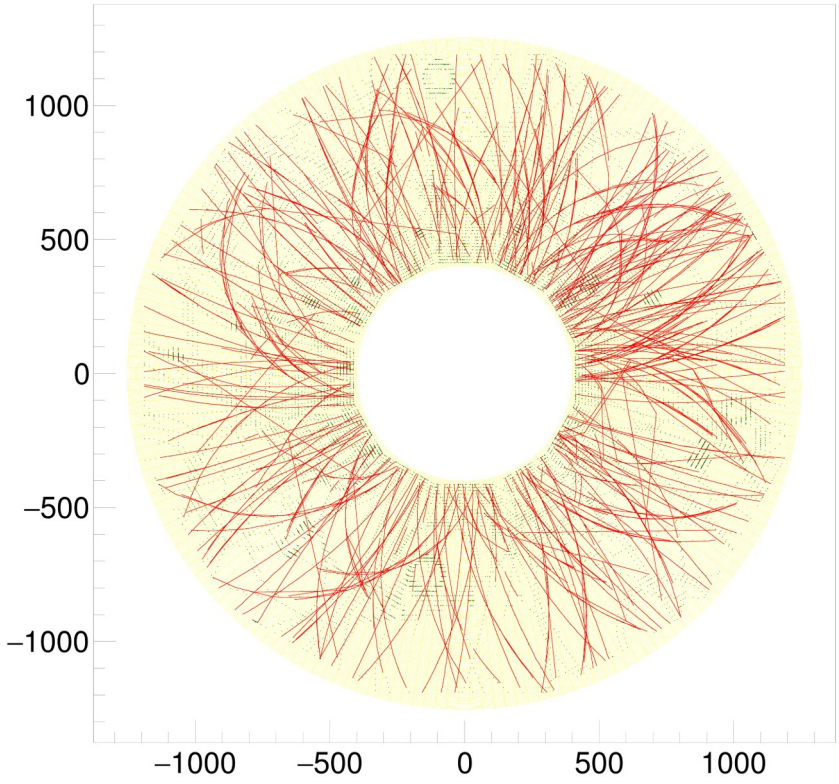
Example 1: Raw Monte Carlo Points (XY)





Example 2: Geometry Aware Hits (XY)





Previous To Do

- At the previous Meeting, such tasks were set:
  - ✚ A deeper study of the effectiveness of track search
  - ✚ Bringing virtual sensors in line with the geometry of real sites
  - ± Methods of disambiguation and combining tracks
  - ━ Comparison with the existing track search module

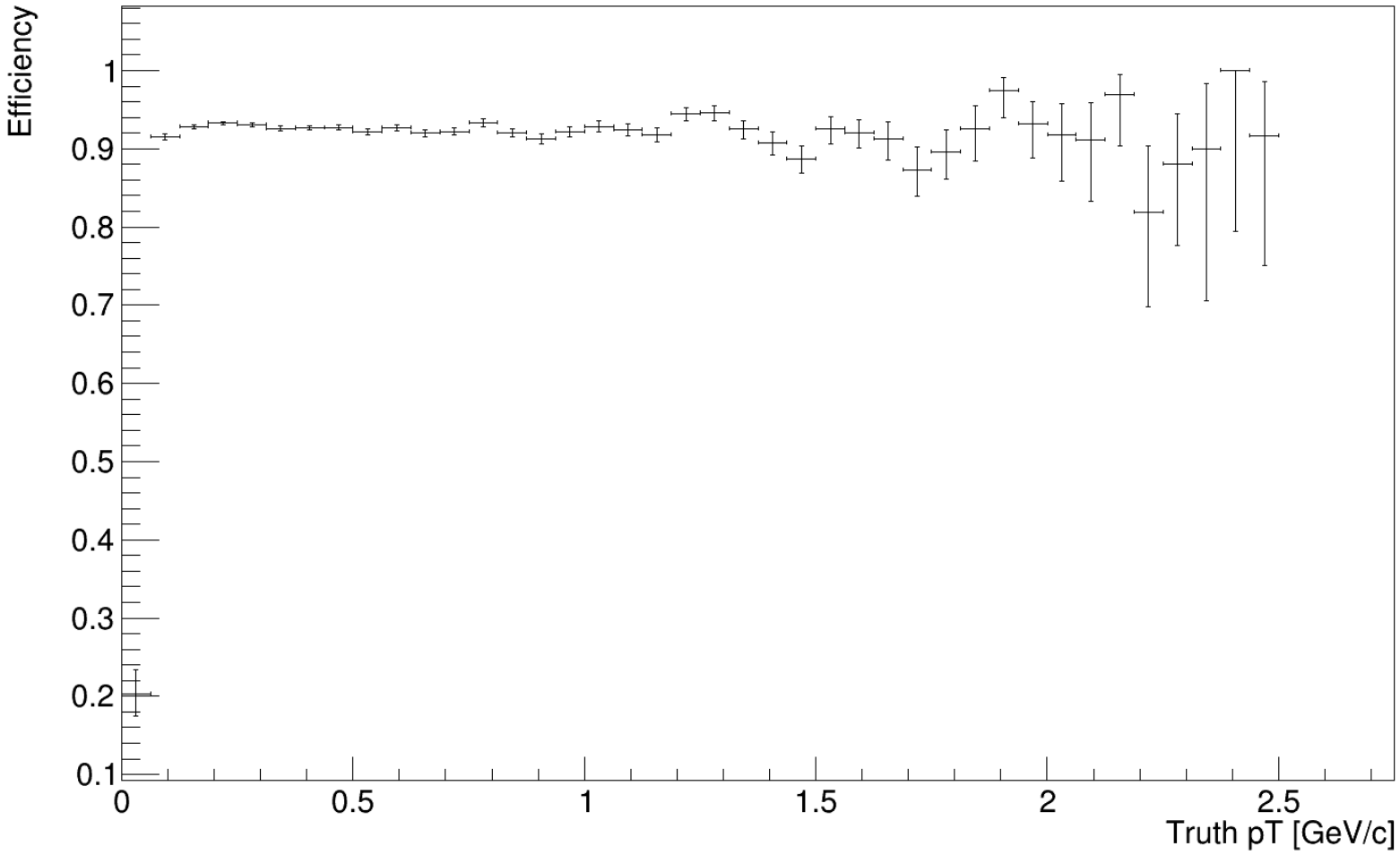
Statistics creation

- The Acts statistics was connected to tracker
- Statistics example:
  - Generator: UrQMD
  - Au-Au
  - Energy: 7 GeV
  - The number of events: 1000
  - Measurements
  - $| \eta | < 1.2$
  - $0.02 < p_T \text{ (GeV)} < 2.5$

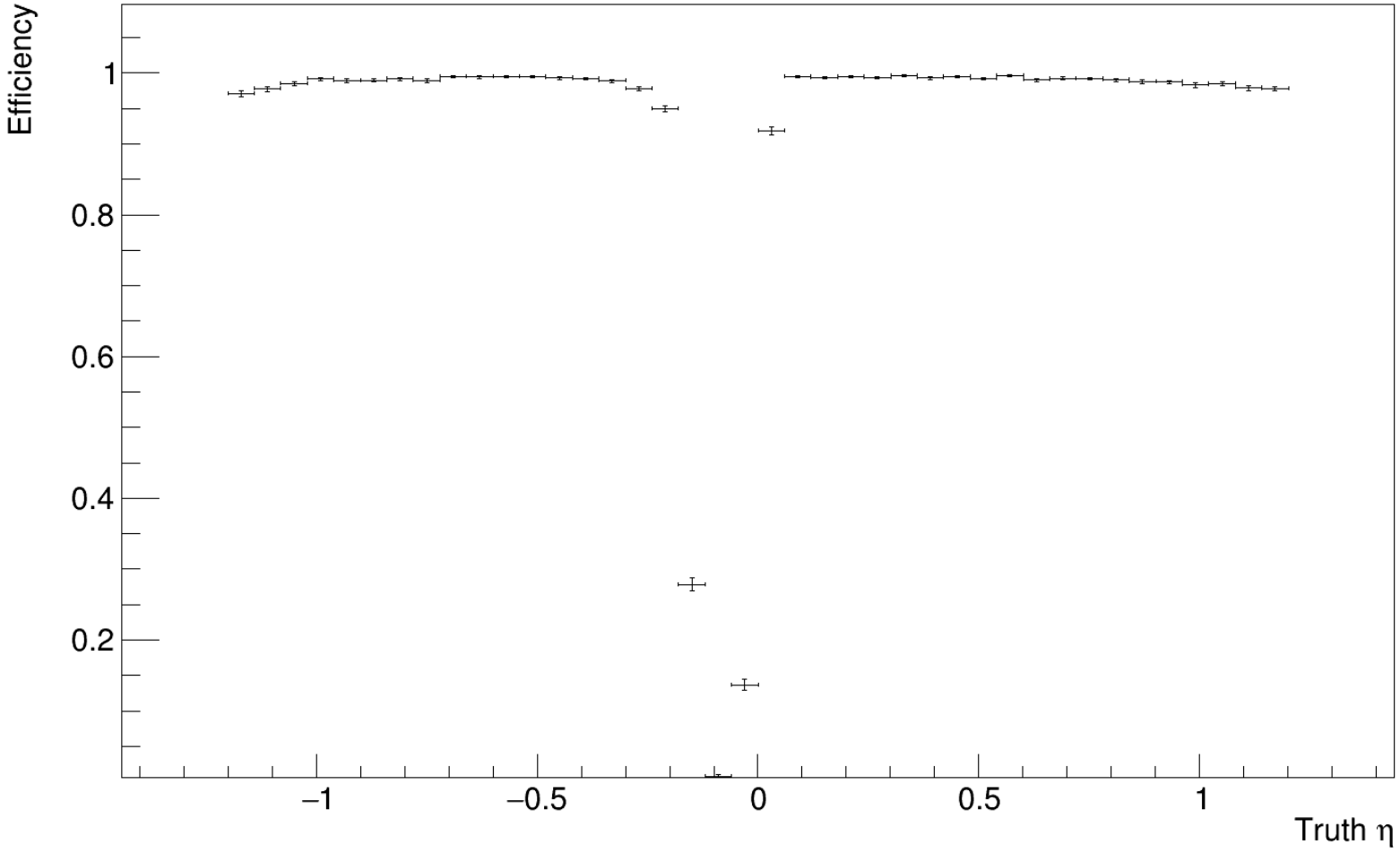
Particles:

- Kaons
- Muons
- Protons

Statistics: Efficiency vs p_T

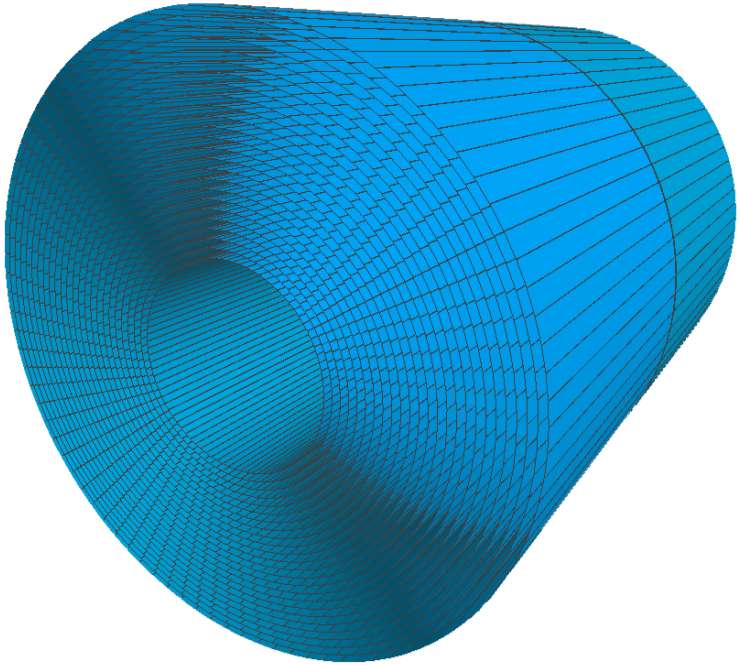


Statistics: Efficiency vs η

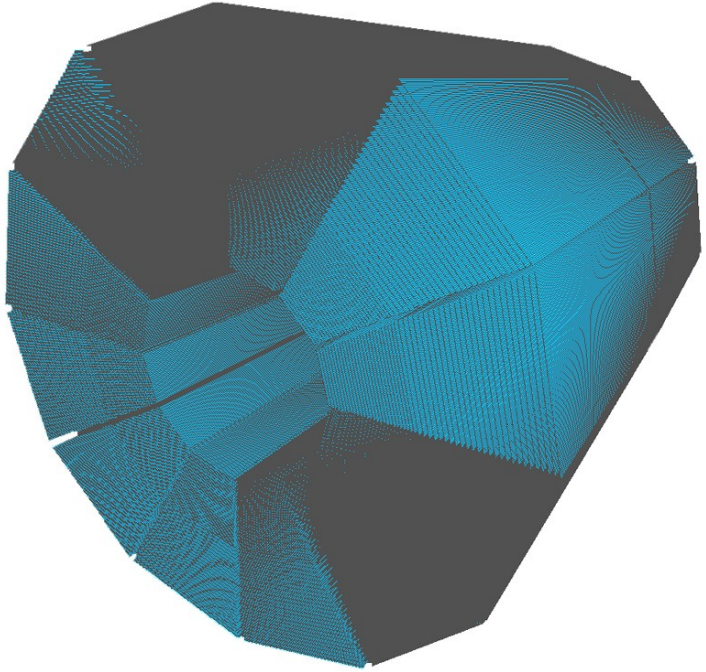


Geometry

- Measurements are bound to surfaces ⇒ virtual sensors must be introduced



Cylinder-based



Sector-based

J.D. Osborn, A.D. Frawley, J. Huang, S. Lee, H.P. Da Costa, M. Peters, C. Pinkenburg, C. Roland, H. Yu. Implementation of ACTS into sPHENIX Track Reconstruction. Computing and Software for Big Science, 2021.

Geometry: Compare Results

- The number of events: 100
- Measurements

Geometry type	The number of layers (rows or cylinders)	Tracking efficiency
Sector-based	52	0.59
Cylinder-based	50	0.96
Cylinder-based	100	0.98
Cylinder-based	200	0.99

Ambiguity Resolution (Work In Progress)

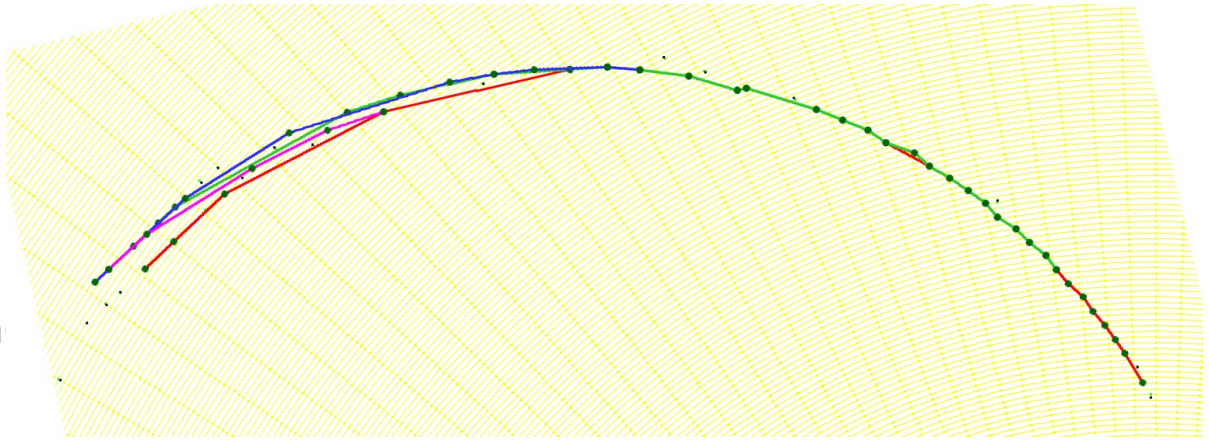
- Ambiguity resolution
  - Post processing
    - Merge tracks
    - Drop fake tracks
- Performers:
  - Students (Plekhanov RUE)
    - Erkenova
    - Kozmin
    - Mikhalevich

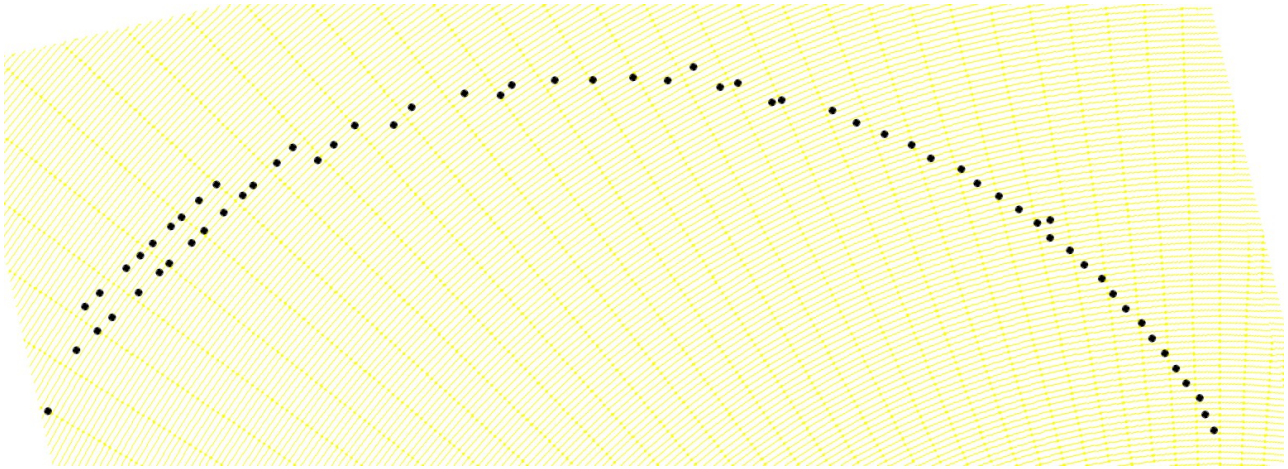
Post processing stages:

- Cleaning
- Merging
- Smoothing

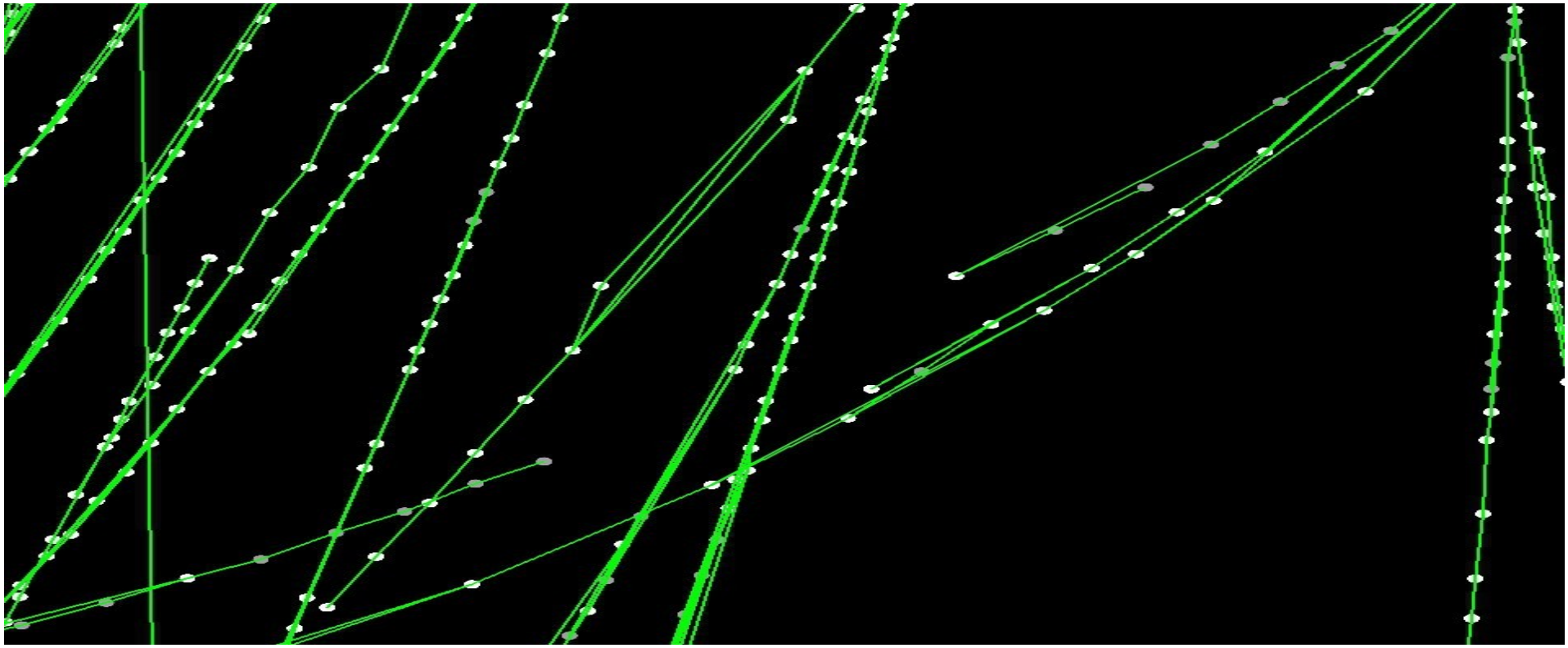
Post processing

- Typical problem:
  - Measurements, belongin
    to the same trajectory

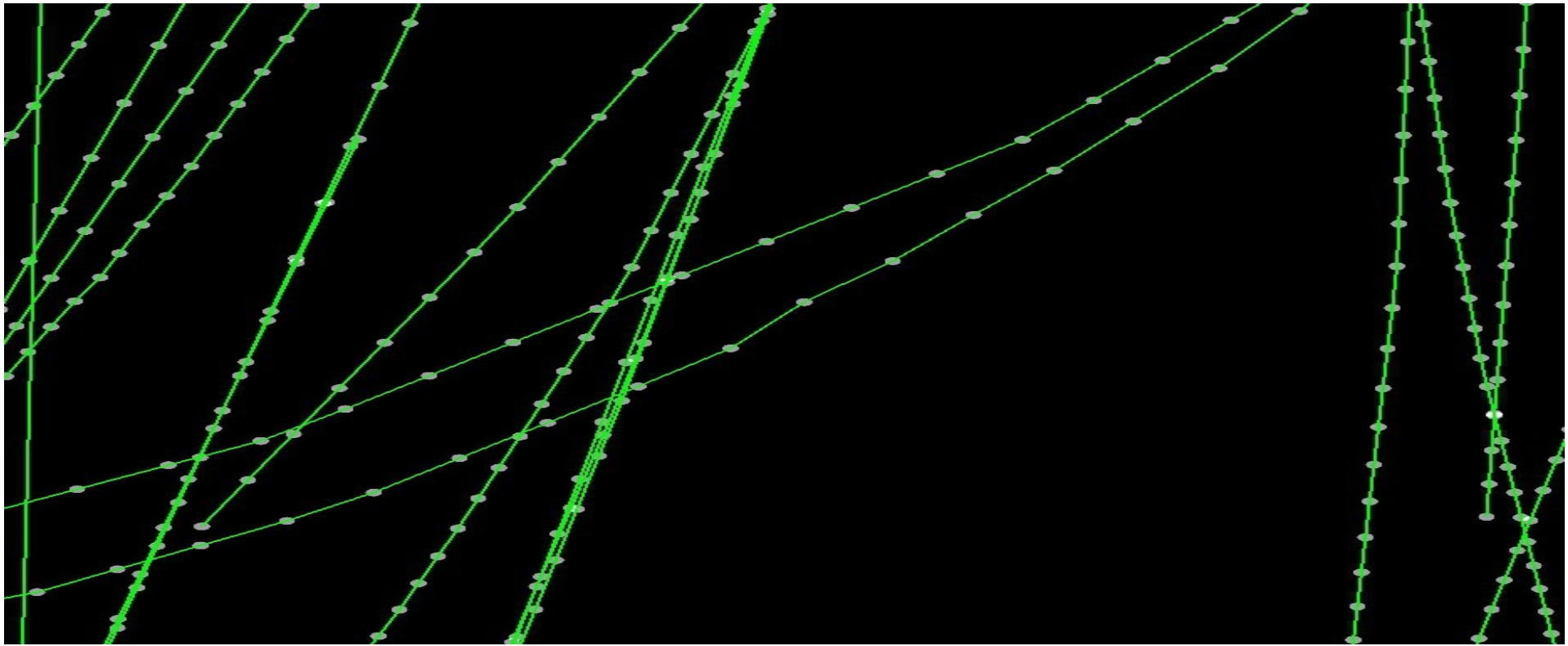




Post Processing: Example



Post Processing: Example (Solved)



Further research

- Methods of disambiguation and combining tracks
  - Configure tracker options
  - Post-processing
- Comparison with the existing track search module

Thank you!