Toward event reconstruction in an active-target TPC with strip readout

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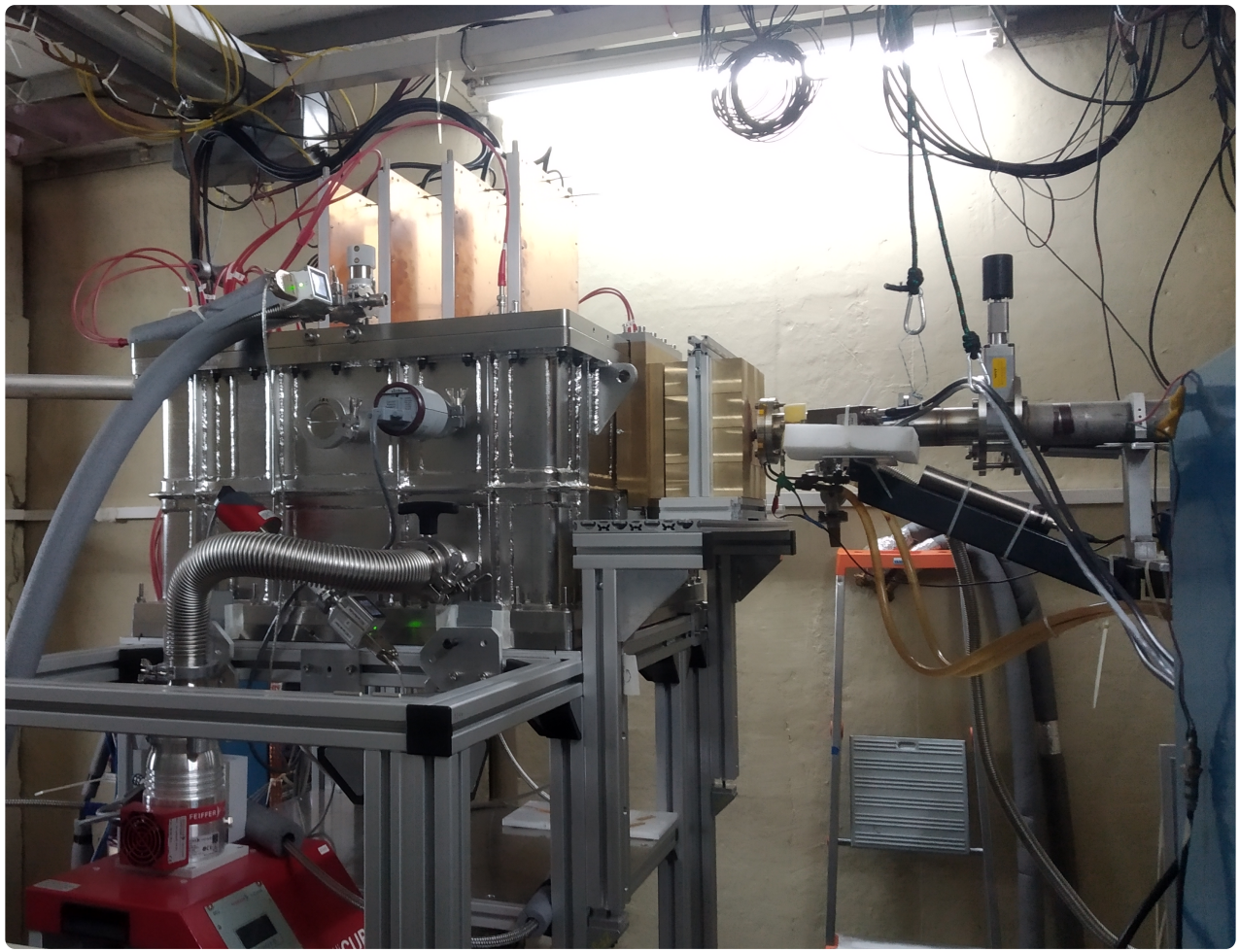
FACULTY OF PHYSICS
UNIVERSITY OF WARSAW

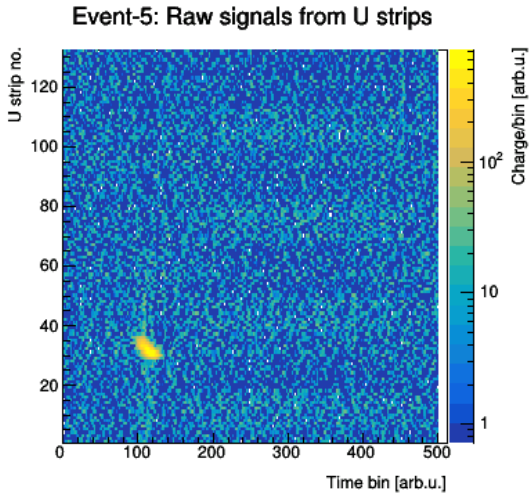
ELITPC

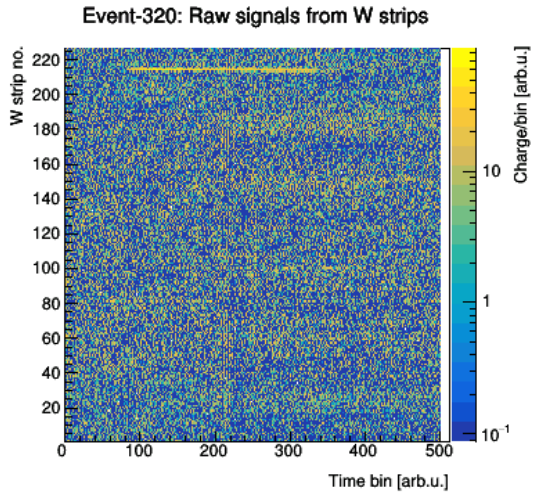
Processing data from TPC developed at UW

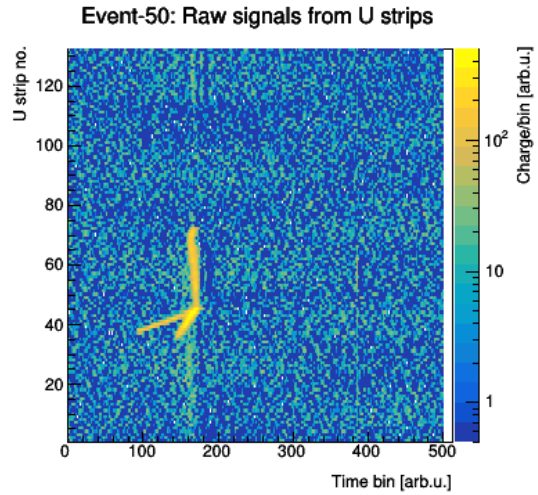


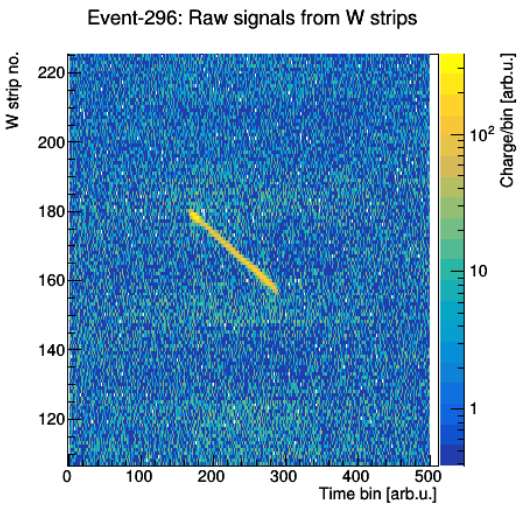
Detector design → talk by Mikolaj Cwiok
Experiments at IFJ PAN → talk by Zenon Janas

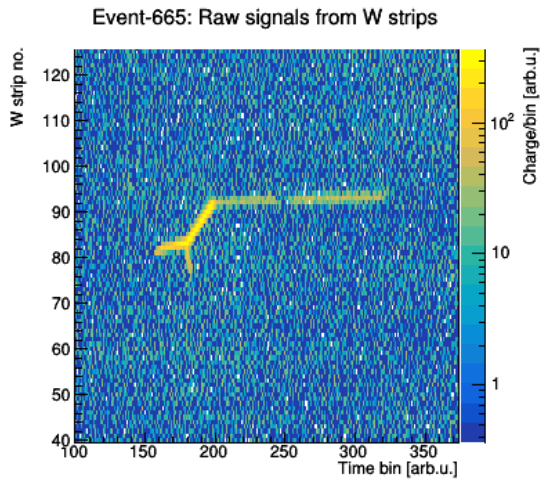
Filtering

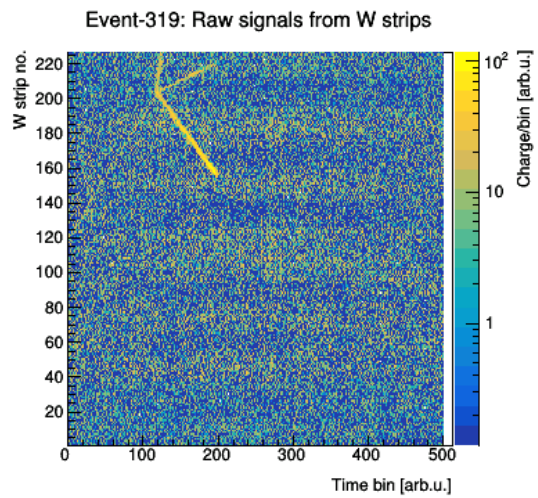








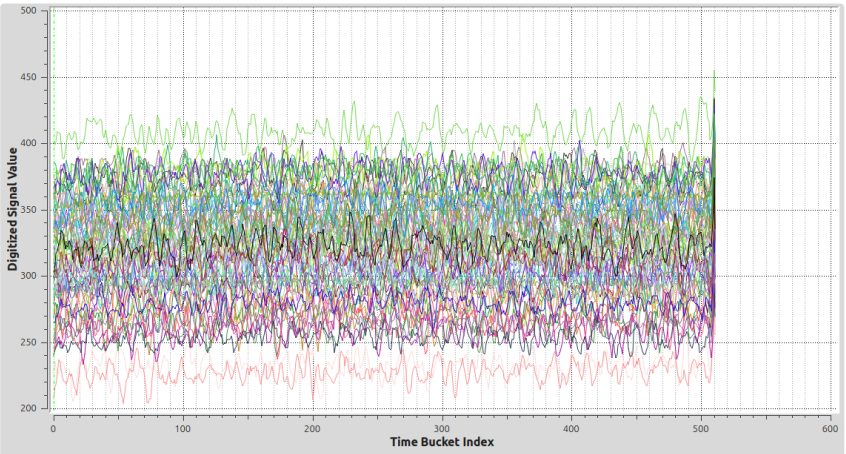


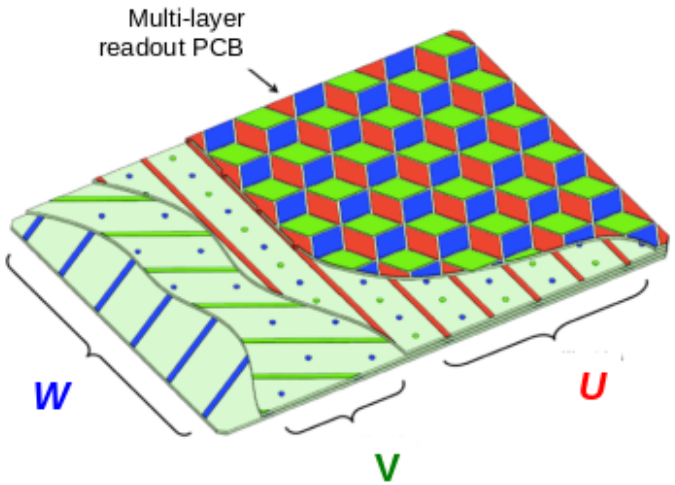


Our data contains various topologies of events.

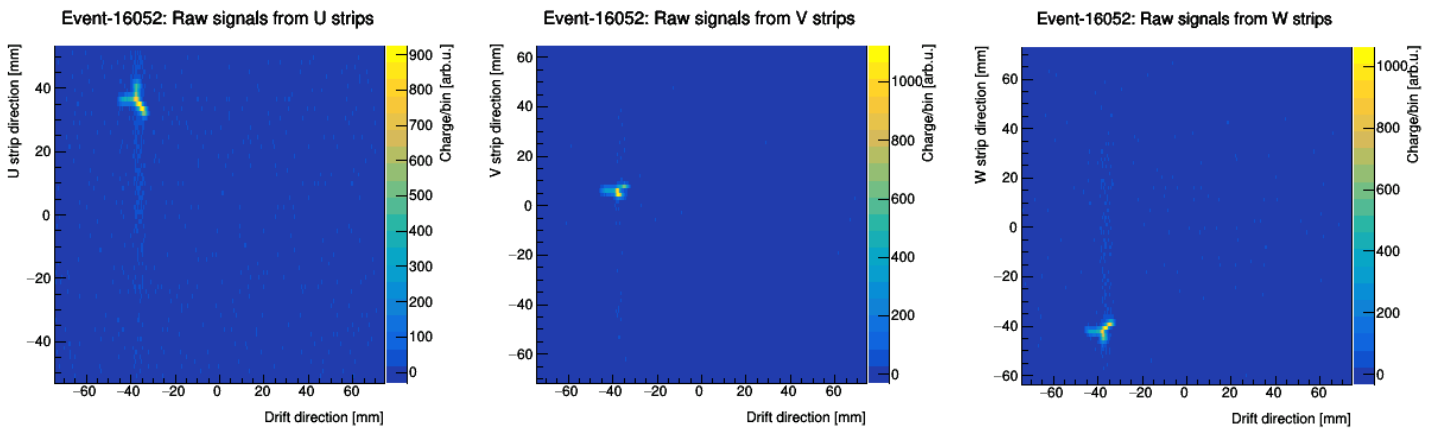
Strip readout

$$\begin{pmatrix} u \\ v \\ w \\ t \end{pmatrix} = \begin{pmatrix} \cos(0) & \sin(0) & 0 \\ \cos\left(-\frac{2\pi}{3}\right) & \sin\left(-\frac{2\pi}{3}\right) & 0 \\ \cos\left(-\frac{\pi}{3}\right) & \sin\left(-\frac{\pi}{3}\right) & 0 \\ 0 & 0 & \frac{1}{v_d} \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

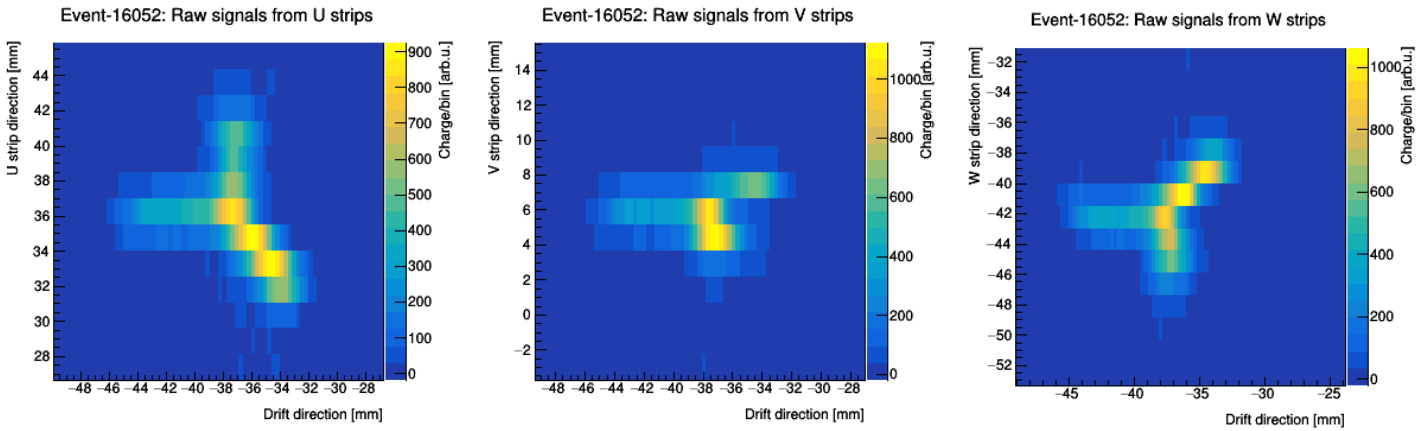




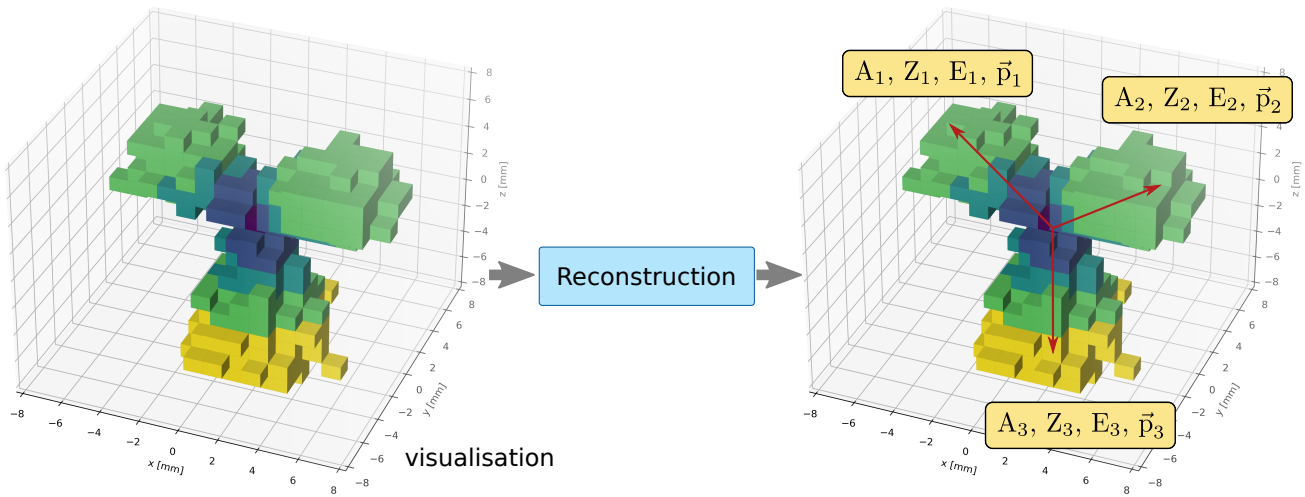
Rather than 3D picture our detector registers only 2D projections on strip directions sampled over time.



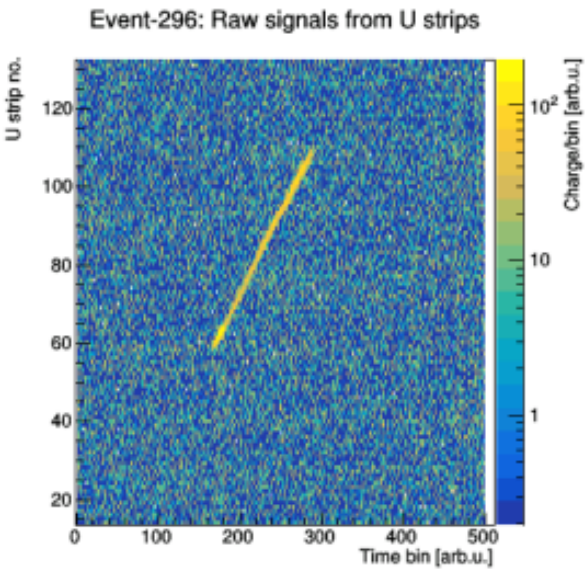
Kinematic reconstruction

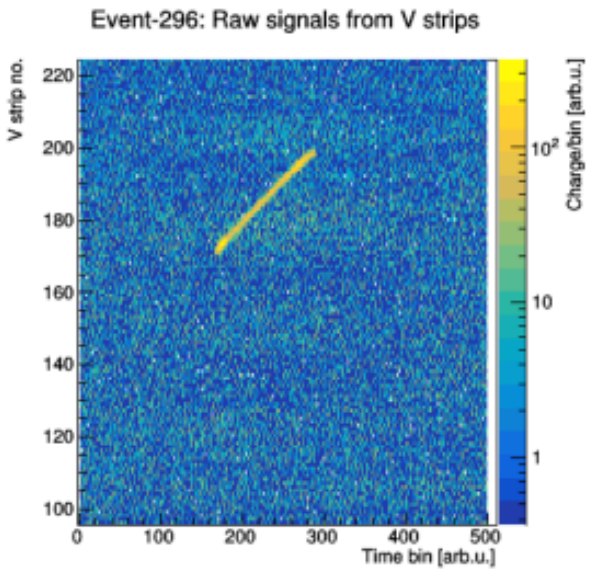


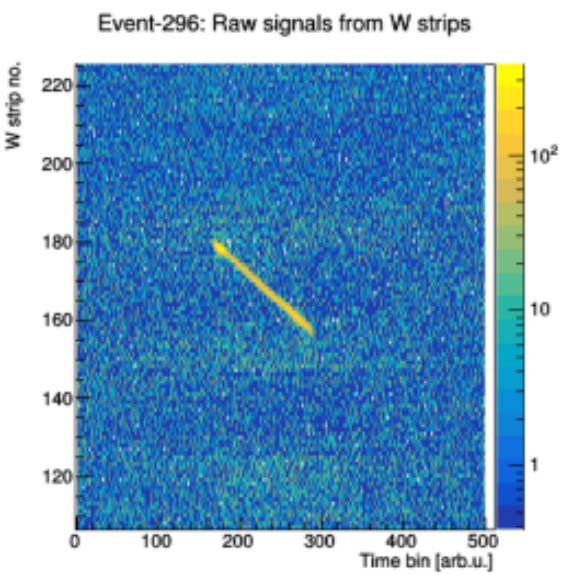
Reconstruction should be capable of identifying particles and obtaining their energies and momenta.

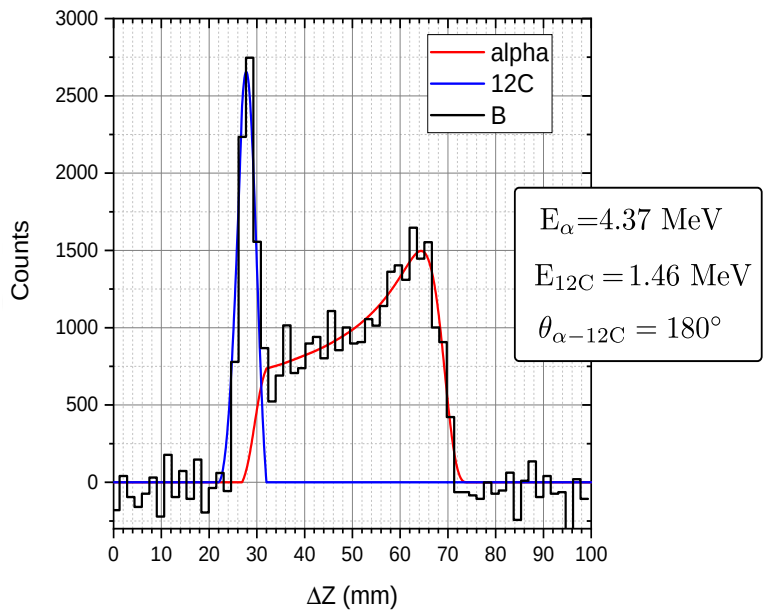


Kinematic reconstruction





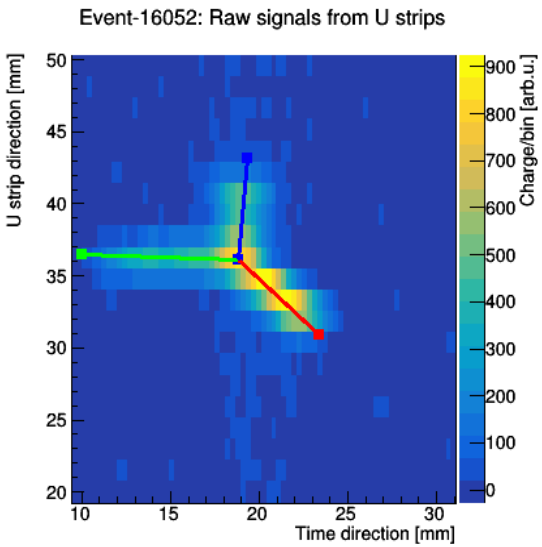


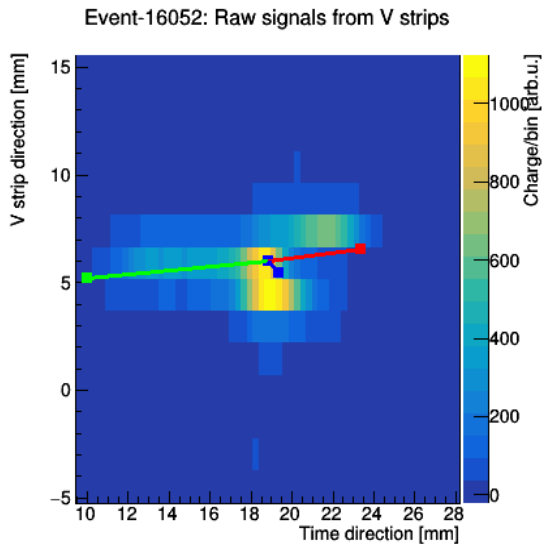


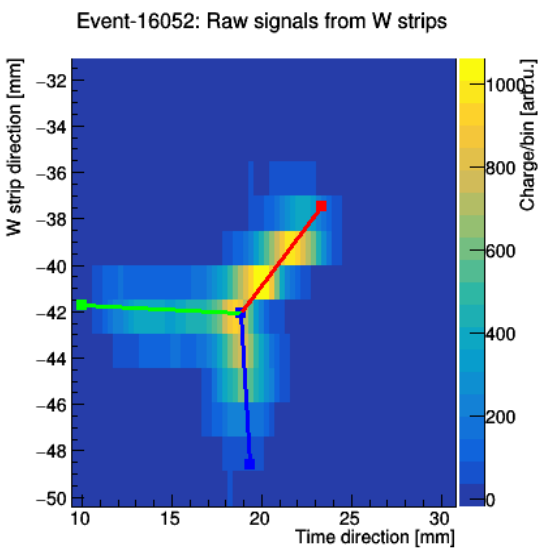
Particle identification, energy and momentum can be obtained from:

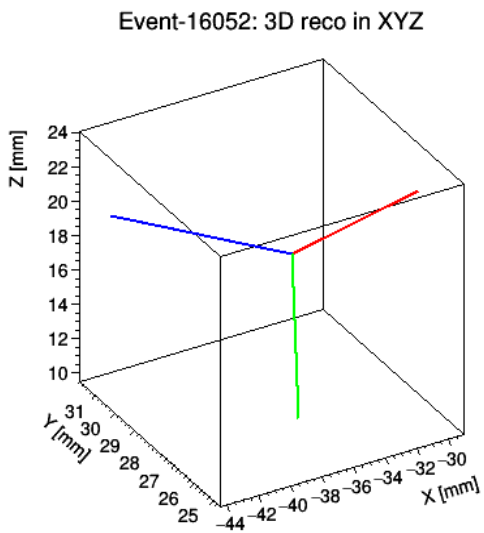
- track length (range in medium)
- ionization along the track (Bragg curve)

Manual reconstruction









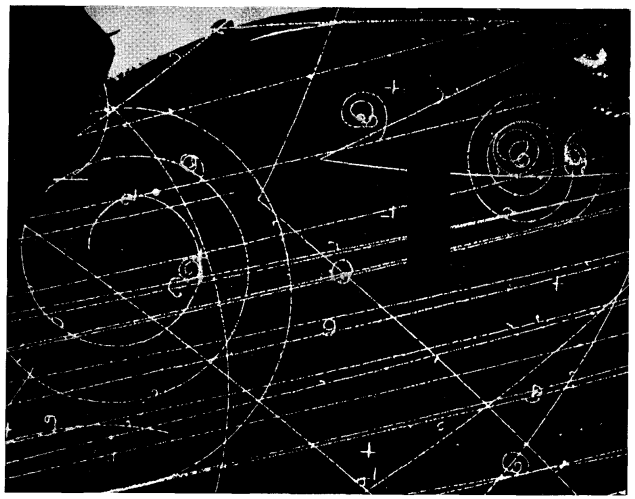
Tracks can be hand-picked and transformed to Cartesian coordinates.

α-track lengths [mm]:
7.4, 8.0, 8.1
α-LAB kin. en. [keV/c^2]:
82, 92, 94
3α LAB momentum [MeV/c]:
12.0
3α invariant mass [MeV/c^2]:
11186

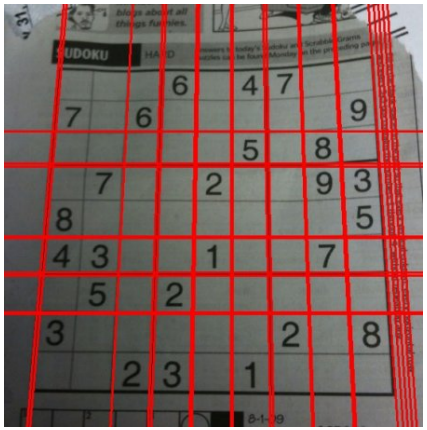
runs @ VdG: 2 TB
($\sim 2 \cdot 10^6$ events)

runs @ IGN-14: 12 TB
($\sim 12 \cdot 10^6$ events)

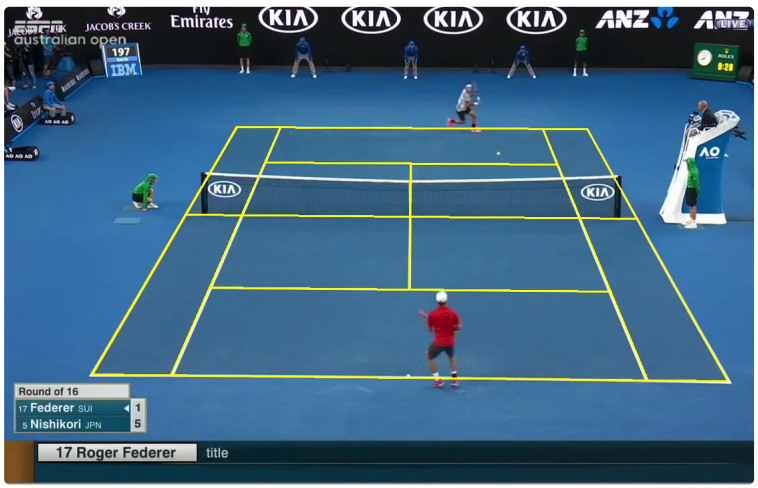
Line detection – examples



Hough, P. V. C., Conf. Proc. C 590914 (1959)



OpenCV tutorial

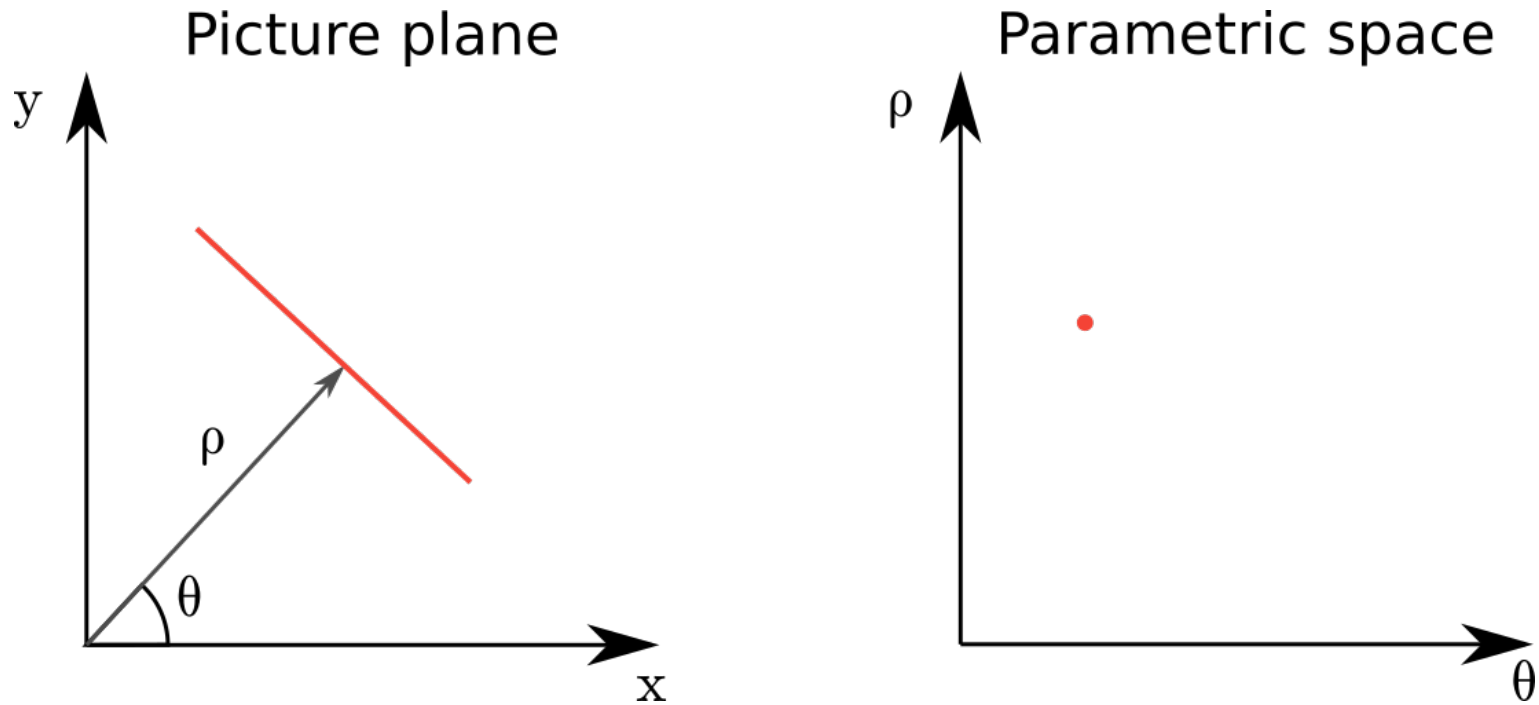


https://github.com/gchlebus/tennis-court-detection

road line detection example

Hough transformation

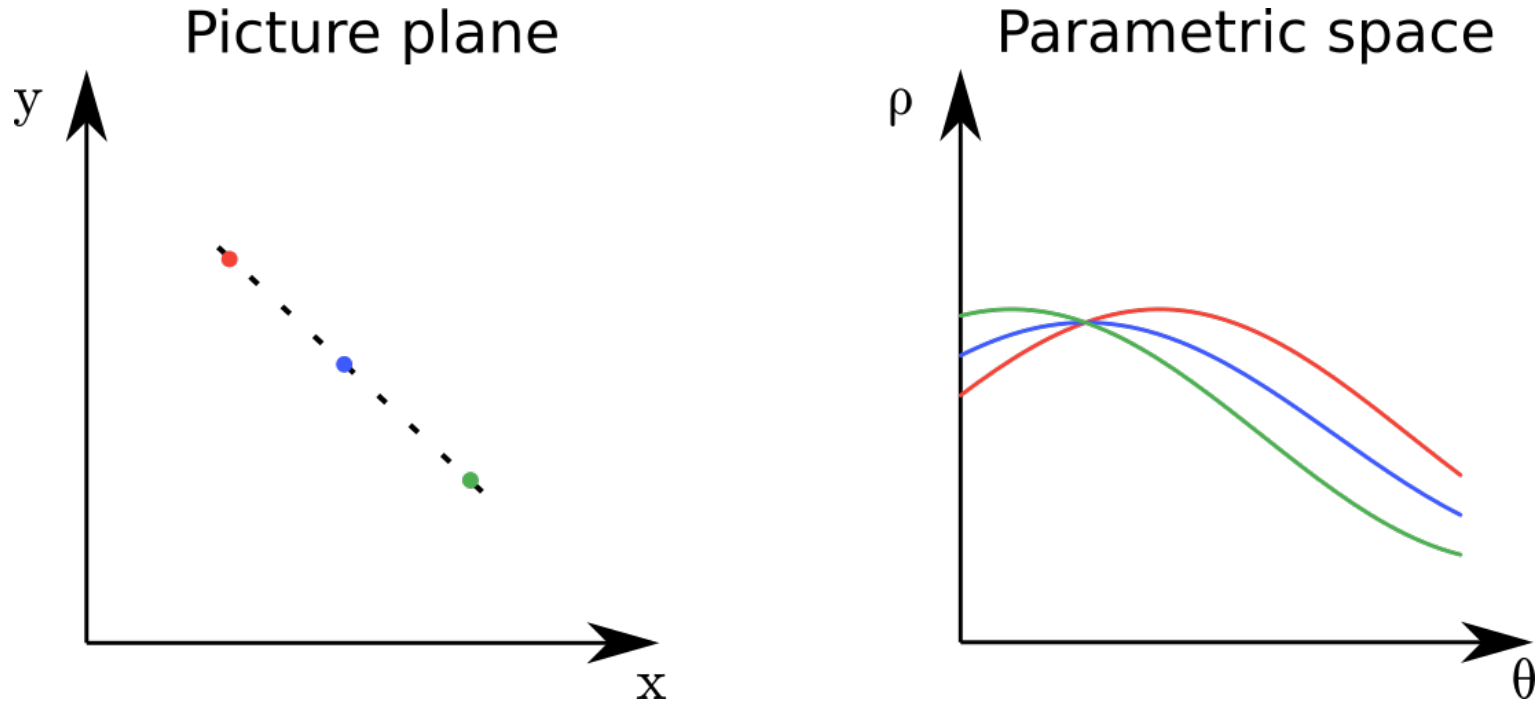
Line parametrization: $\rho = x \cos\theta + y \sin\theta$



- Hough transformation: $(x, y) \rightarrow (\rho, \theta)$
- A single line on the picture is mapped to a point in the parametric space.

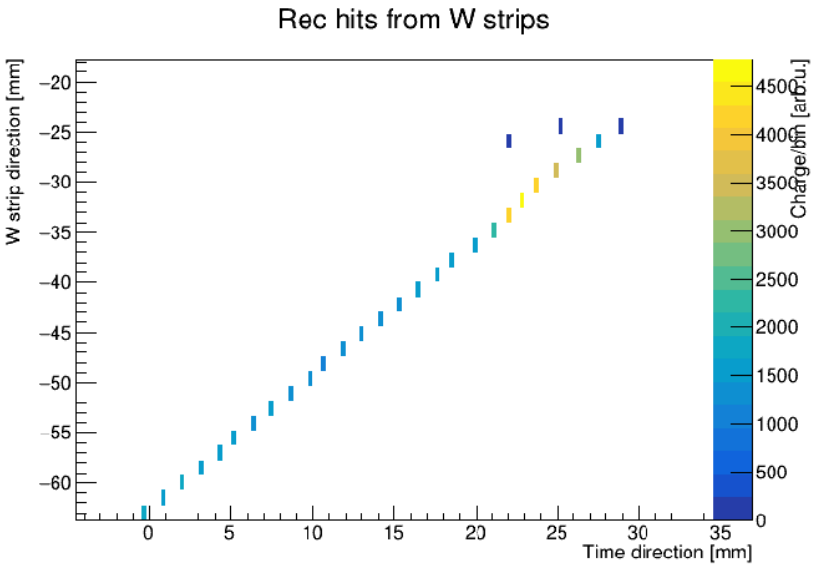
Hough transformation

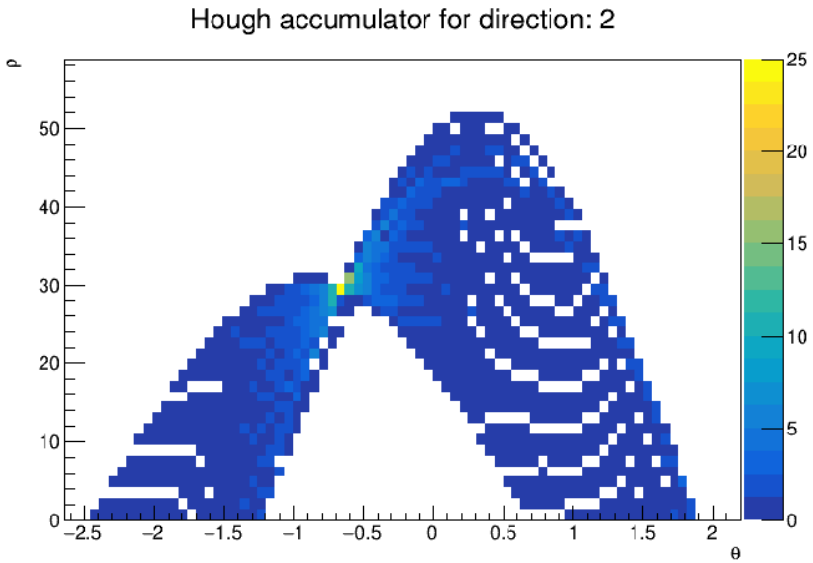
Line parametrization: $\rho = x \cos\theta + y \sin\theta$



- A single point on the picture is mapped to a sinusoid in the parametric space.
- Sinusoids corresponding to collinear points have common crossing point.

Hough transformation

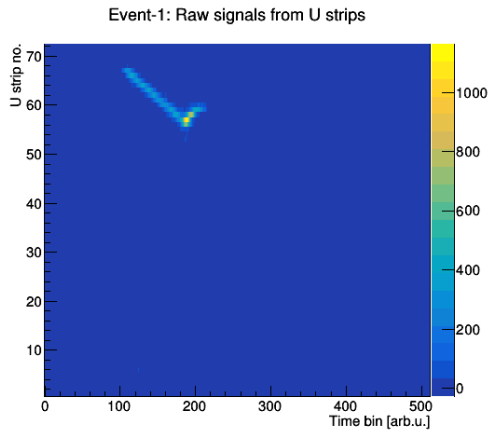


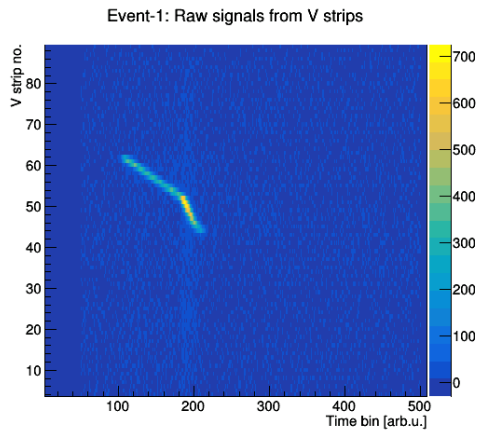


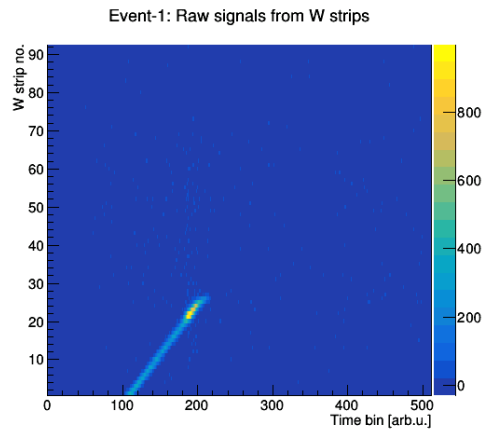
- Hough accumulator: (ρ, θ) histogram
- Maxima in the accumulator corresponds to the lines on the picture

Reconstruction algorithm

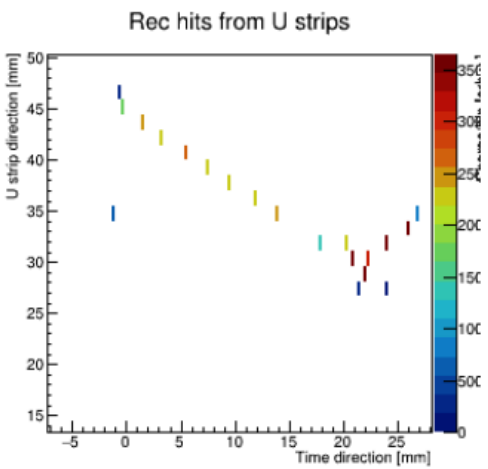
Raw data

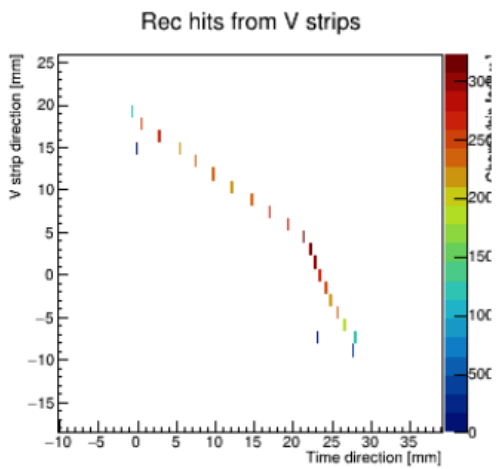


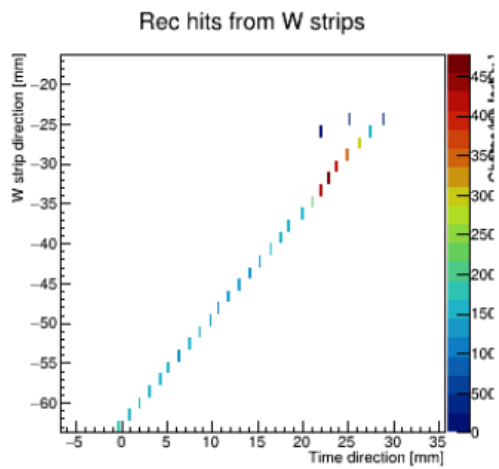




Hit seeds



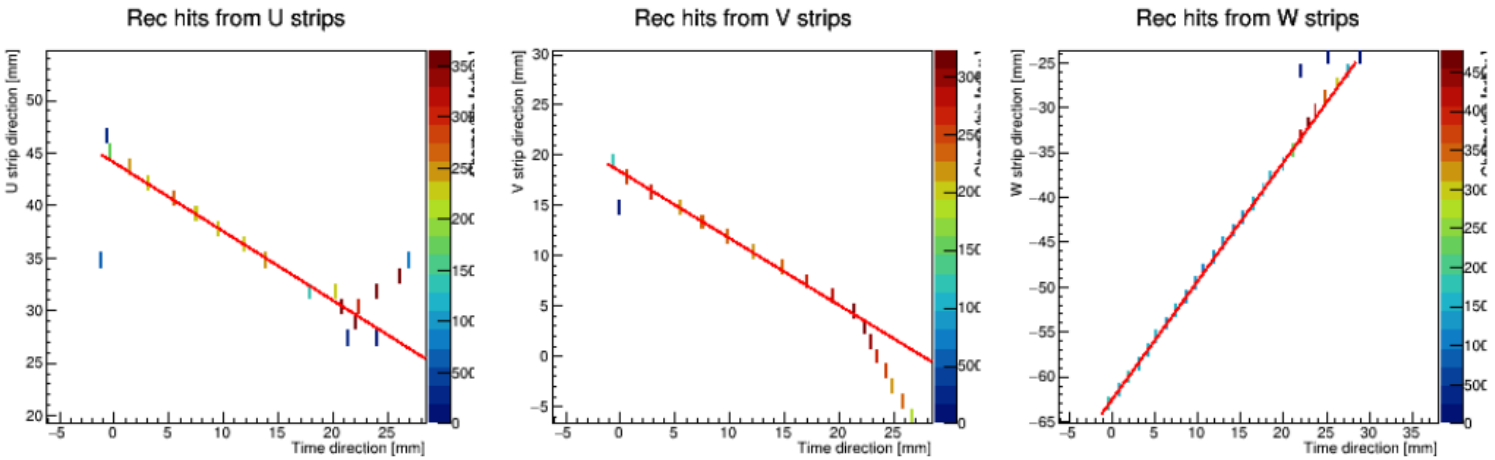




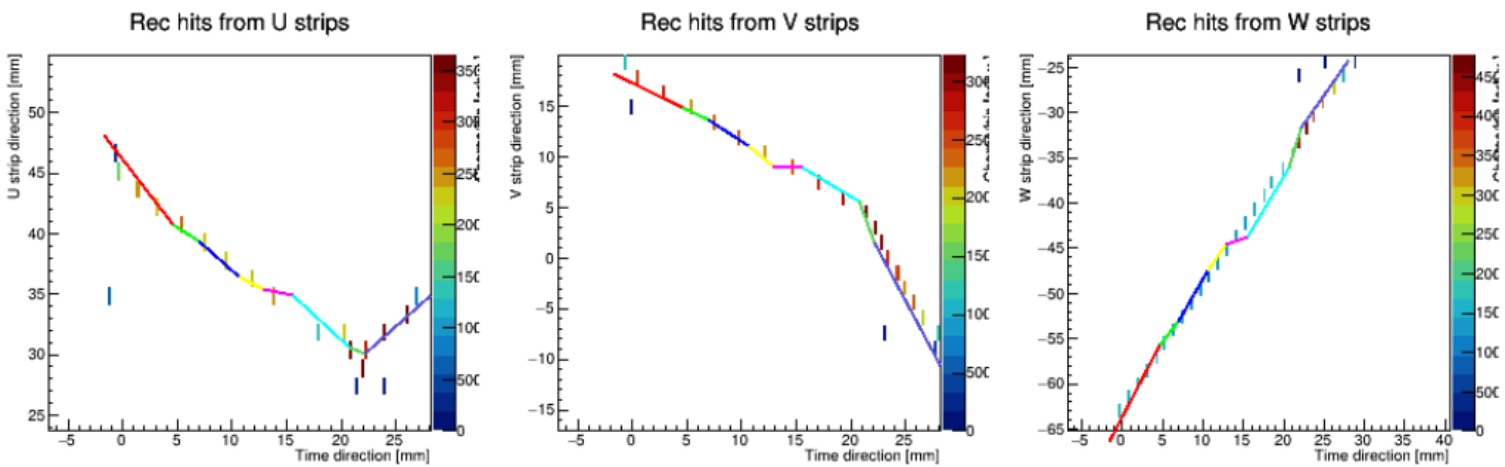
based on algorithm used in ICARUS detector

Reconstruction algorithm

Line detection



3D-segments fitting



Summary

- Ionization tracks left by charged particles can be used to reconstruct the event kinematics.
- Computer vision algorithms can be applied to automatize particle track detection.
- Automatic reconstruction of events is under development.

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