Track Reconstruction with PANDA at FAIR

W. Ikegami Andersson, **M. Papenbrock**, J. Regina

Department for Physics and Astronomy
Uppsala University

for the PANDA collaboration

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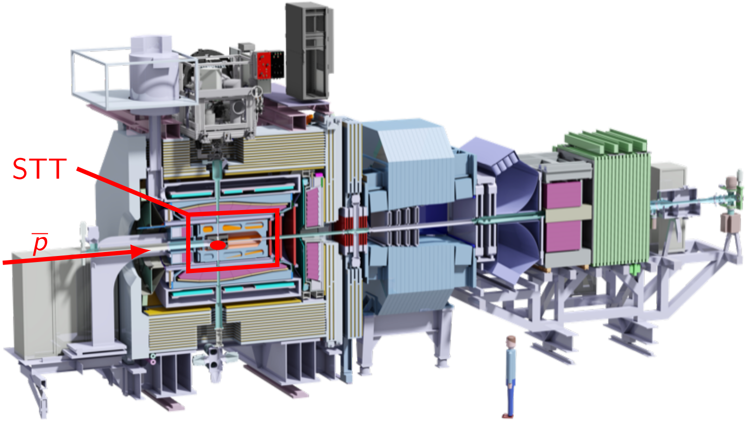
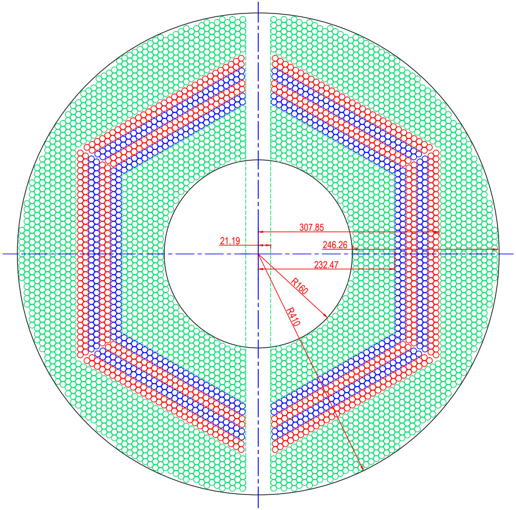
The PANDA detector at FAIR

antiProton ANnihilation in DArmstadt

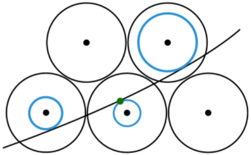


- Nearly 4π coverage
- Event rates up to 20 MHz
- Continuous $\overline{p}$ beam
- Online reconstruction
- Software-based event filtering

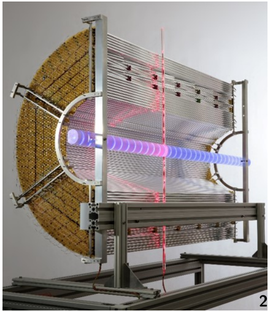
Straw Tube Tracker



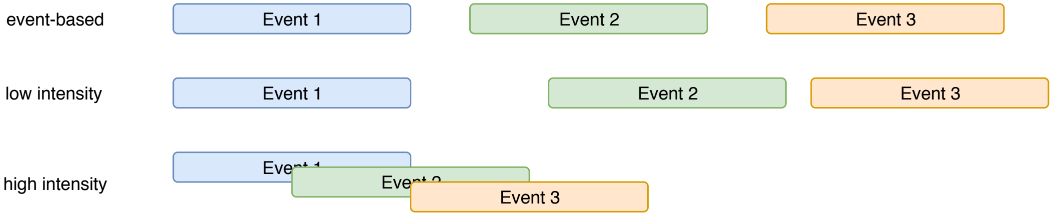
- 4224 straws
- 19 axial layers (green)
- 8 stereo layers ($\pm3^\circ$ blue/red) for z-reconstruction
- 10 mm tube diameter
- 150 μm isochrone resolution



isochrones

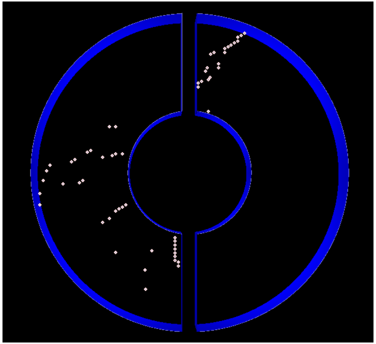


Event mixing: Low and high intensity

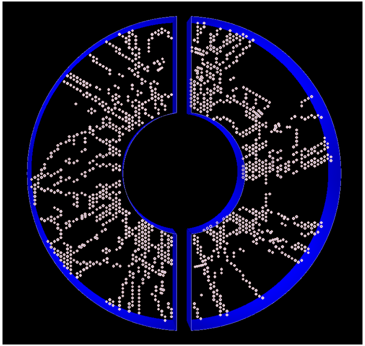


- Low intensity
  - Events separated in time
  - Similar to event-based processing
- High intensity
  - Events start to overlap
  - New reconstruction challenge: Associate data with correct event

Event mixing: Low and high intensity



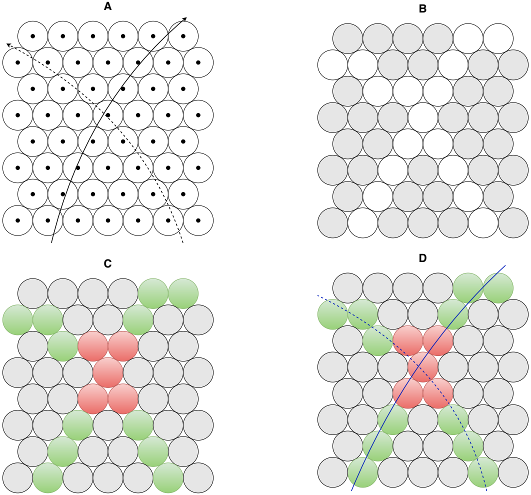
- Collision rate $\sim$ 2MHz
- Good spatial separation between tracks



- Collision rate $\sim$ 20MHz
- Event mixing becomes more prominent

Cellular Automaton

J. Schumann



A Tracks traverse detector

B Hits are marked as active cells

C Active cells are classified as

- unambiguous: ≤ 2 active neighbours
- ambiguous: > 2 active neighbours

D Ambiguities are resolved using track fits

- GPU version has been implemented

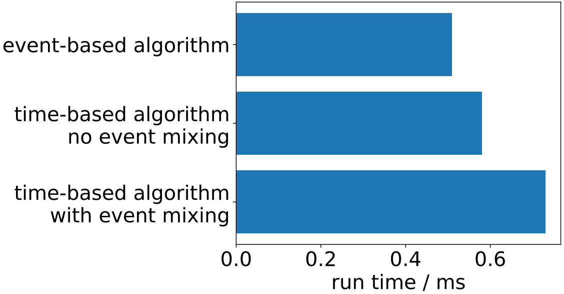
Cellular Automaton: Clustering with time information

J. Regina

- Extend spatial clustering to use time information

→ Hits are only combined if $\Delta t < 250$ns (based on detector response time)

- Small computational footprint ($\sim 1\%$)



- Full (serial) event reconstruction $\approx$ 10ms (Intel Core i7 3.4 GHz)

Longitudinal reconstruction with stereo layers

W. Ikegami Andersson

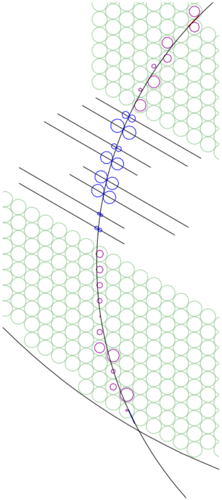
Procedure

- Obtain isochrone from stereo layer
- Align isochrone with track fit by varying z-position
- Transform locations to (z, ϕ) space
- ! Two solutions for each straw

How to solve ambiguity?

Three approaches

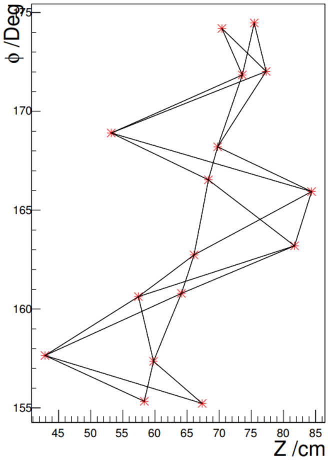
- Combinatorial path finder
- Hough transformation
- Recursive annealing fit



Reconstruction of longitudinal track component

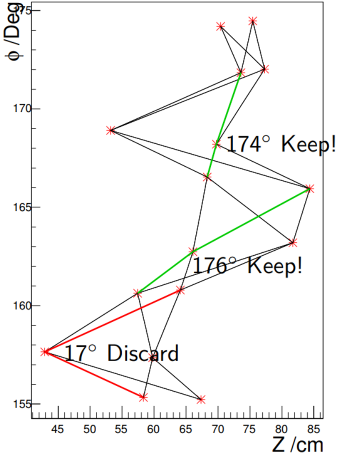
Combinatorial approach

- Determine all possible connections between layers



Reconstruction of longitudinal track component
Combinatorial approach

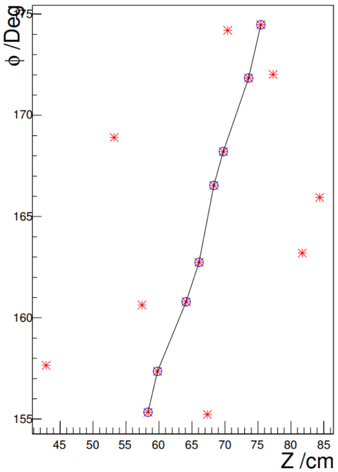
- Determine all possible connections between layers
- Calculate angles between neighboring lines
- Reject paths with $\theta < 90^\circ$



Reconstruction of longitudinal track component

Combinatorial approach

- Determine all possible connections between layers
- Calculate angles between neighboring lines
- Reject paths with $\theta < 90^\circ$
- Select path by minimising $\sum (\theta_i - 180^\circ)^2$

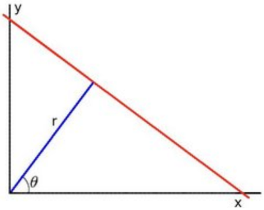


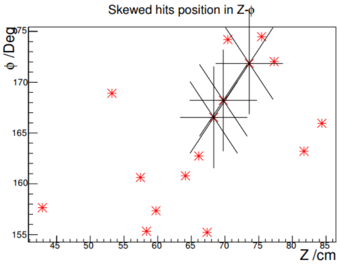
Reconstruction of longitudinal track component

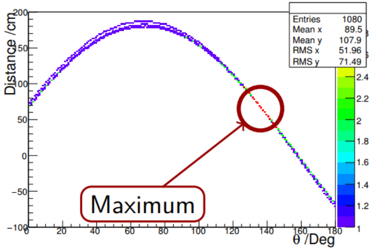
Hough transformation

- Generate set of lines around point
- Fill line parameters in accumulator
- Repeat for all points
- Select maximum in accumulator

→ Maximum selects track parameters



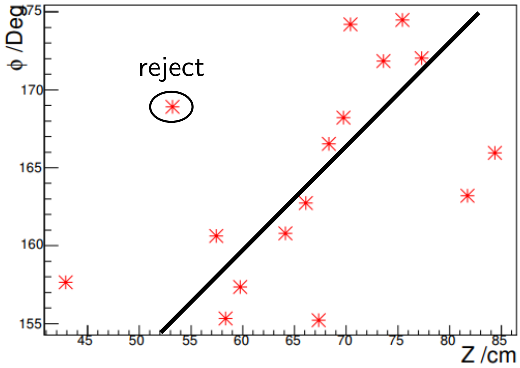




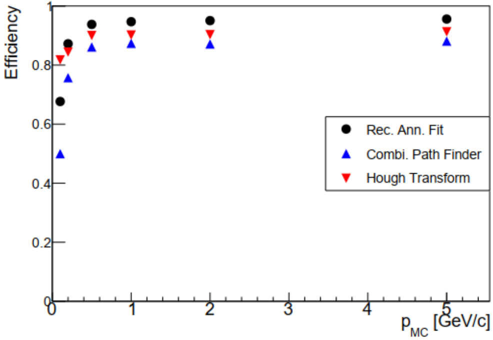
Reconstruction of longitudinal track component

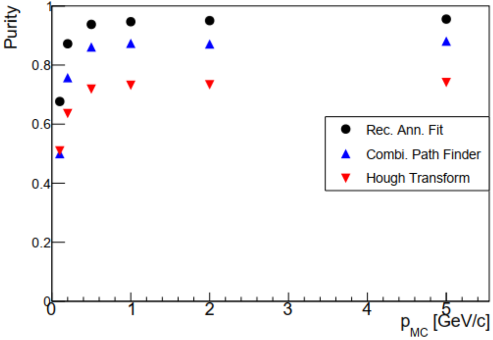
Recursive annealing fit

- Fit line to all points
- Remove point with largest residual
- Calculate new line fit
- Repeat until one point has been rejected for each straw tube



Comparison





- Efficiency $= \frac{N_{\text{correctly found hits}}}{N^{\text{MC}}_{\text{all hits}}}$
- Purity $= \frac{N_{\text{correctly found hits}}}{N_{\text{all found hits}}}$

- Benchmark with reconstructed, prompt muons
- Observables before using Kalman filter
- Recursive annealing fit best in all categories

Summary

- Track and event reconstruction at PANDA challenging task
- Cellular Automaton has been adapted to continuous data stream
- Algorithms for longitudinal parameter extraction have been developed
  - Combinatorial path finding
  - Hough transformation
  - Recursive annealing fit (best performance)

Outlook

- Apply recursive annealing fit to hit rejection in other detectors
- Vectorise/parallelise algorithms
- Port to hardware accelerators

Thank you for your attention!