3D Event Reconstruction for LArTPCs

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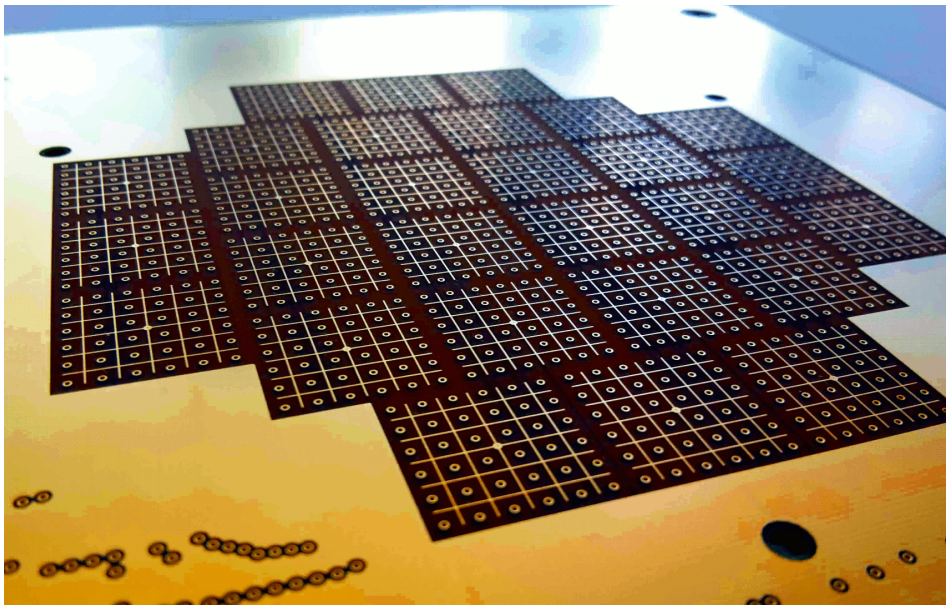
DEEP UNDERGROUND NEUTRINO EXPERIMENT

Near Detector Workshop November 2017

ArgonCube

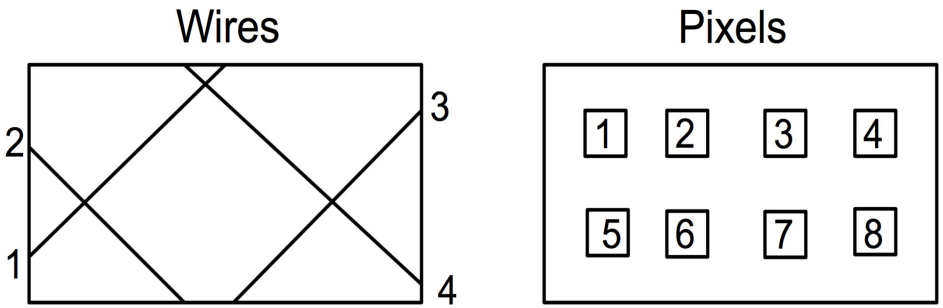
Pixelated charge readout

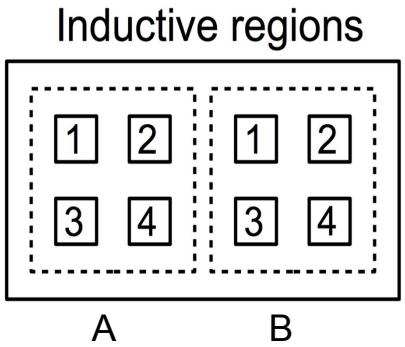
Enabling true 3D tracking



- Charge collecting pixels
  - ↪ PCB VIAs
    - low capacitance
- Biased charge focussing grids
  - ↪ PCB traces

Handling high channel numbers



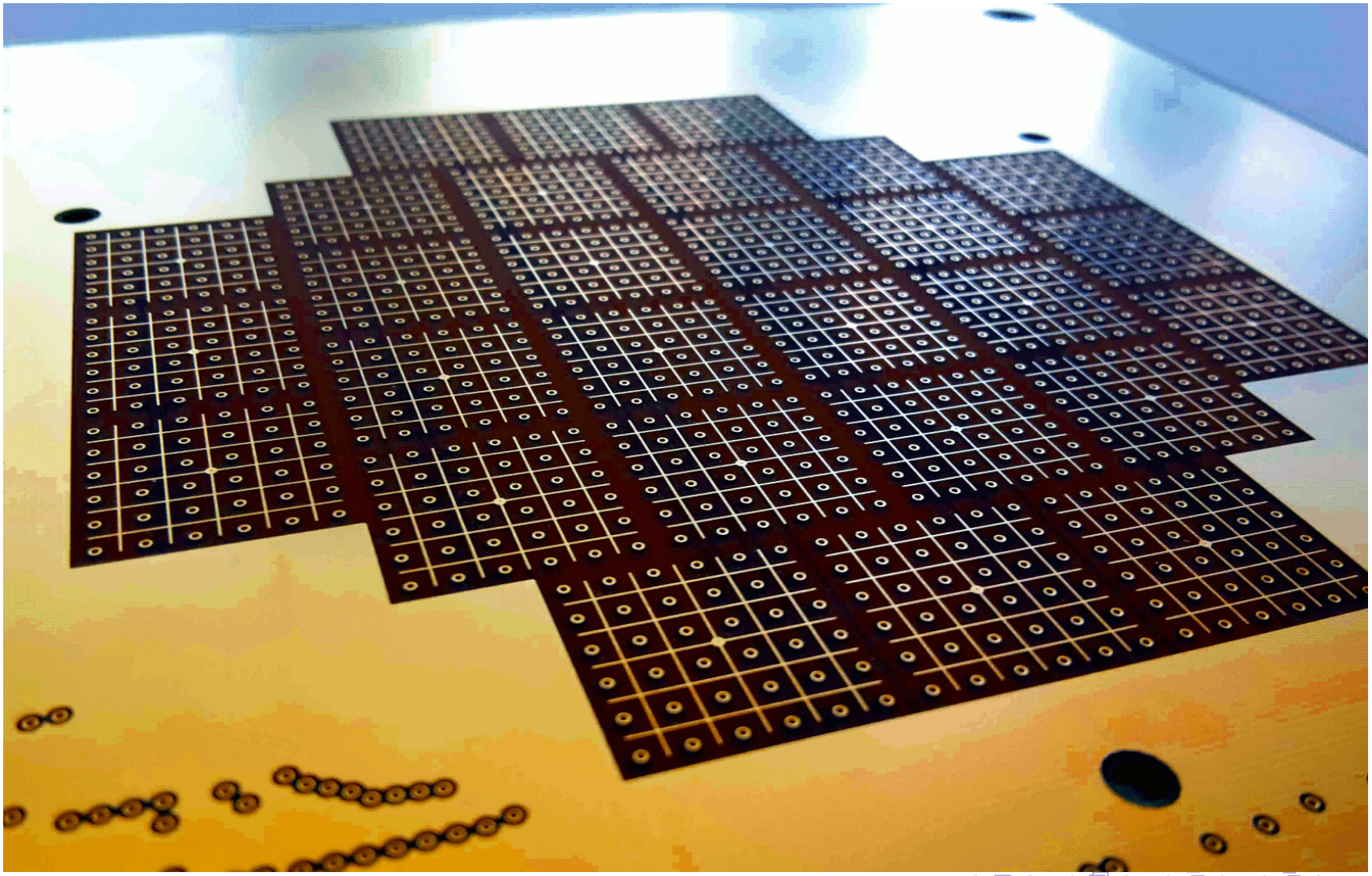


Multiplexing

- Cold digitisation
  - \+ ideal
  - – complex cold electronics
  - ↪ Dan Dwyer's LArPix talk
- Reduce number of DAQ channels by multiplexing
  - \+ existing cold electronics
  - – ambiguities

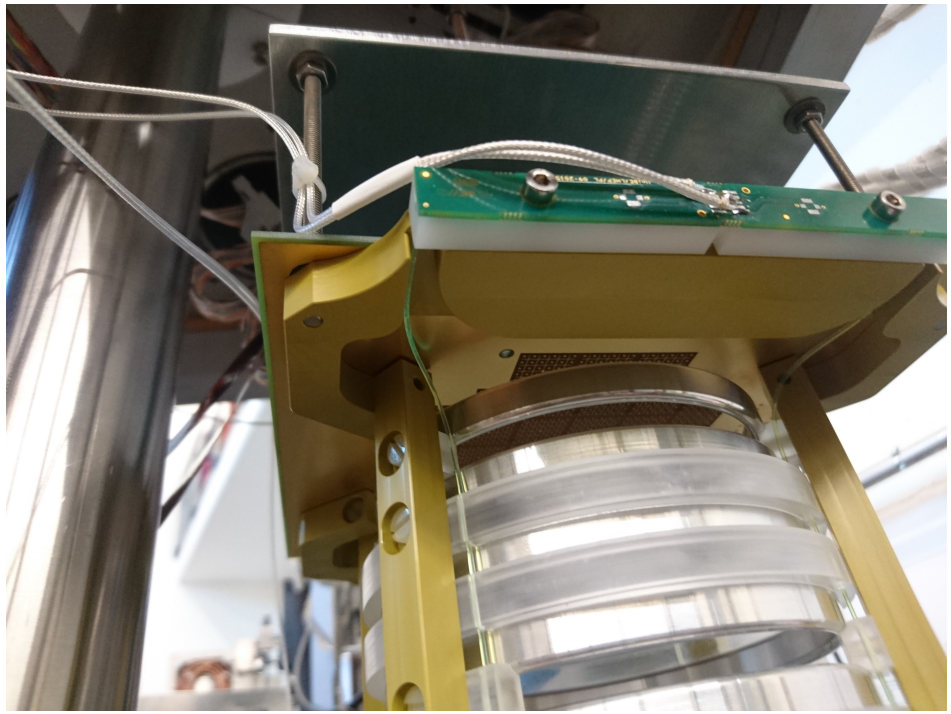
Pixelated charge readout prototype PCB

28 ROIs, each 6×6 pixels $\Rightarrow$ 1008 pixels total @ 2.54 mm pitch

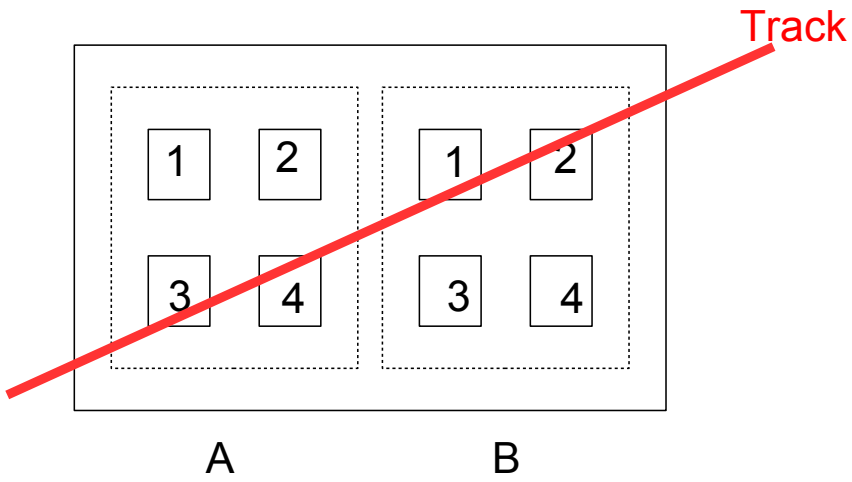


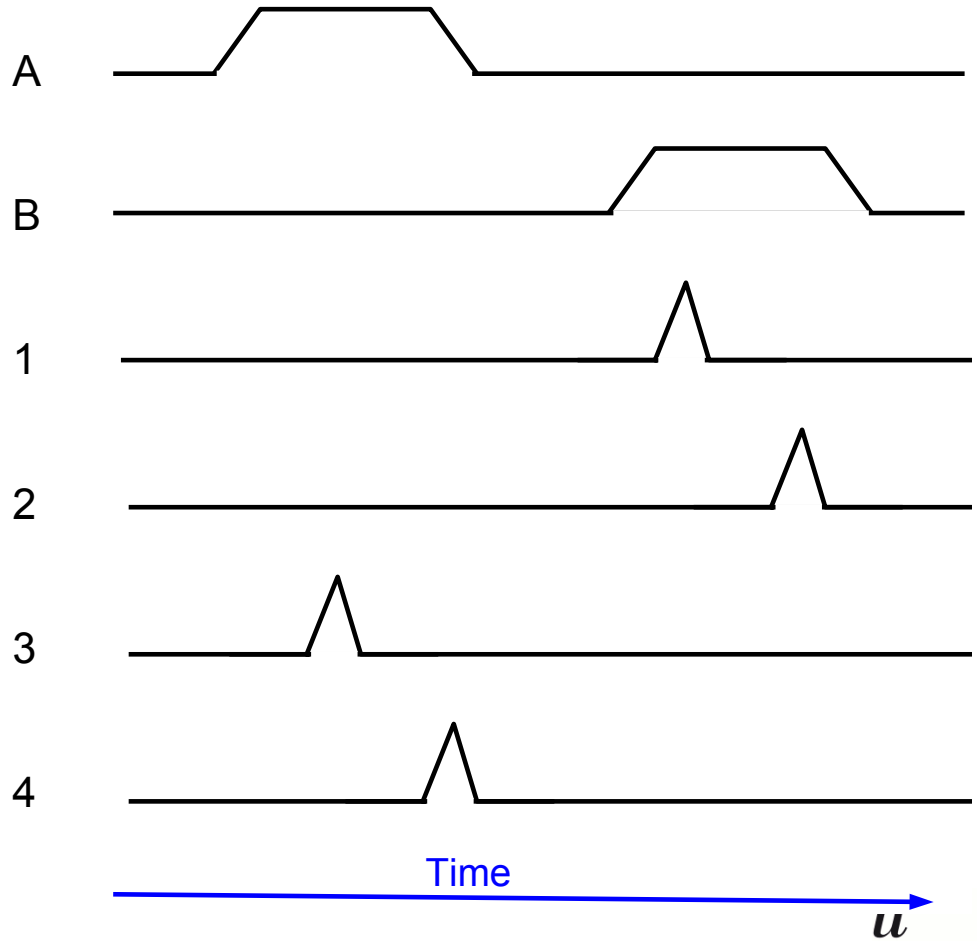
ArgonCube prototype TPC

$\varnothing = 100\,\text{mm}$, $L = 600\,\text{mm}$, $E_{\text{Drift}} = 0.1\,\text{kV}\,\text{mm}^{-1}$, $t_{\text{Drift}} = 300\,\mu\text{s}$

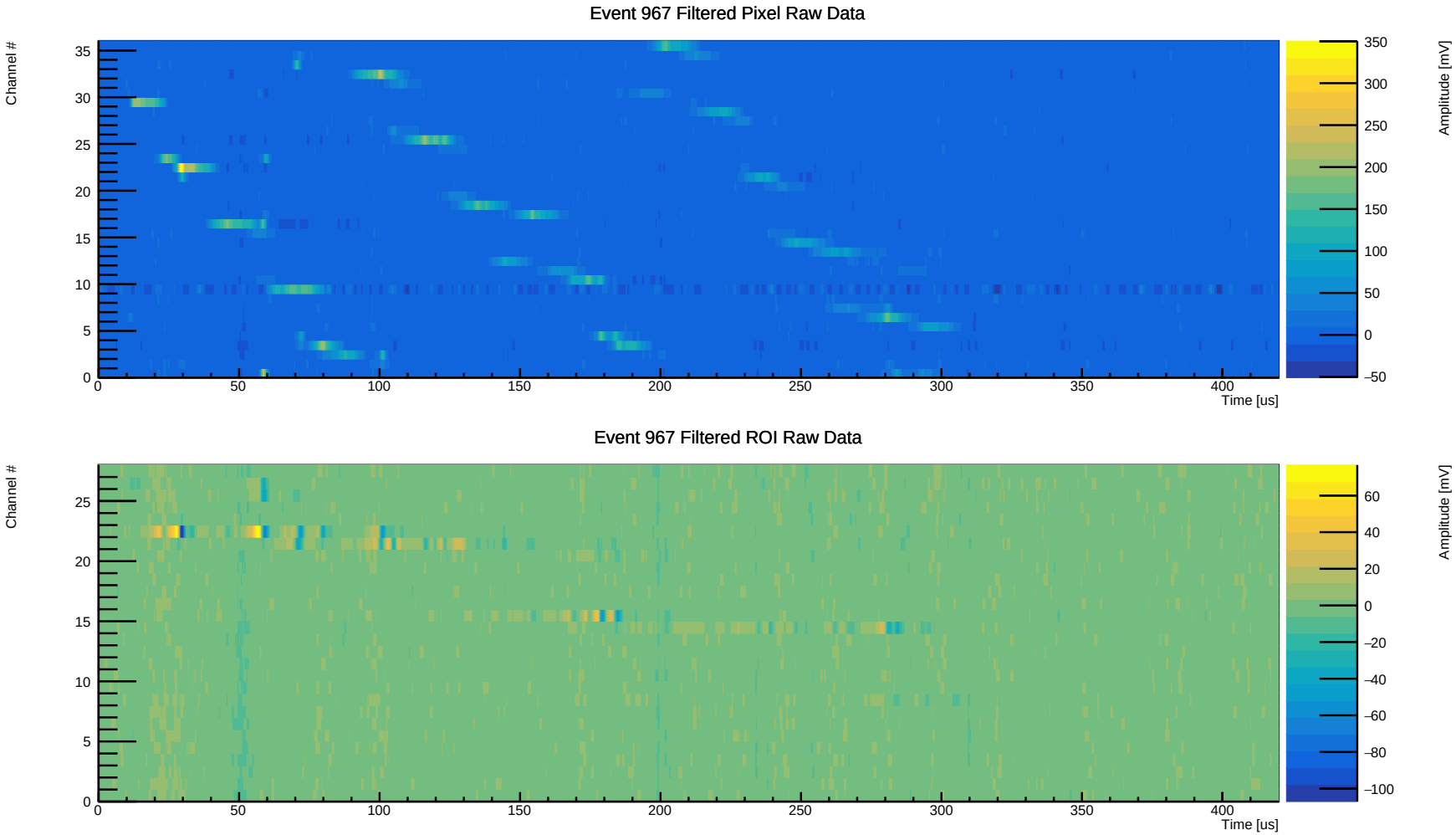


Regions of interest (ROI)

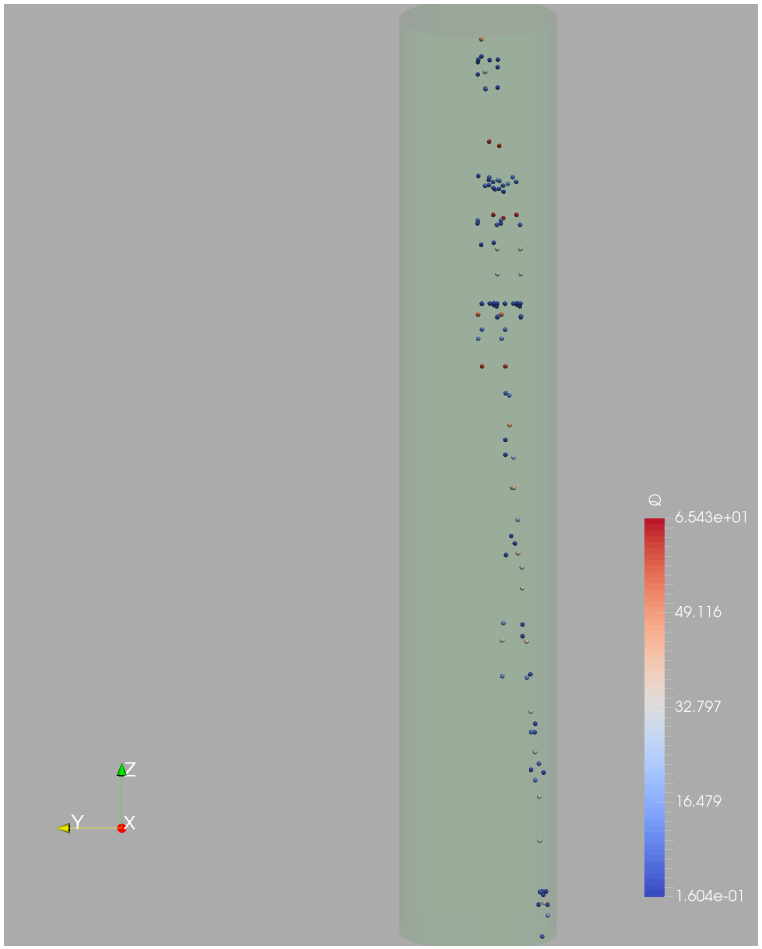


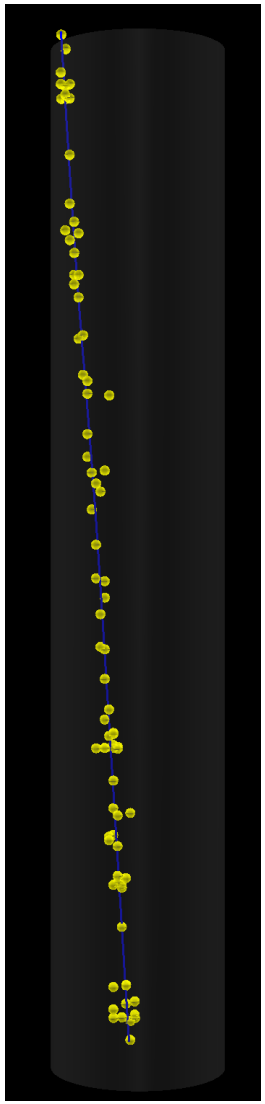


Raw charge data



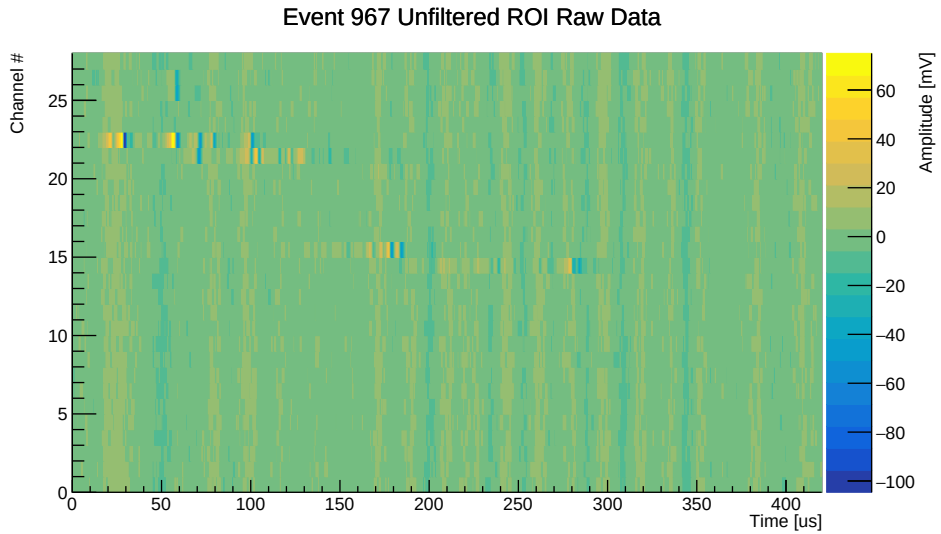
Reconstructed 3D event

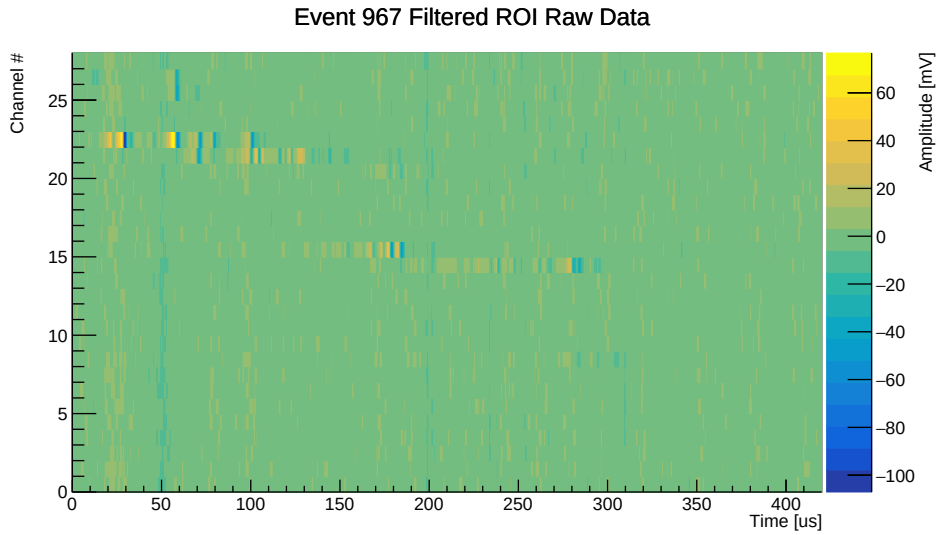




Reconstruction steps

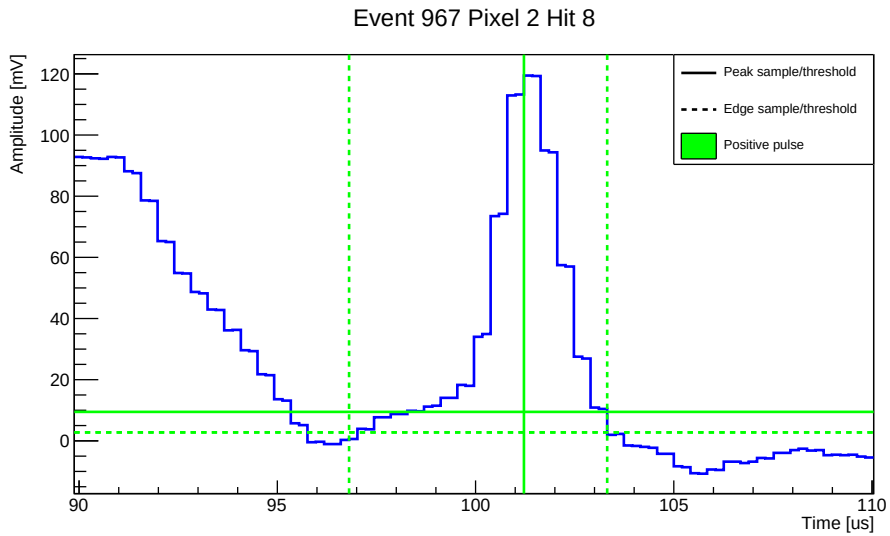
1. Noise filter
   - Subtract common mode noise

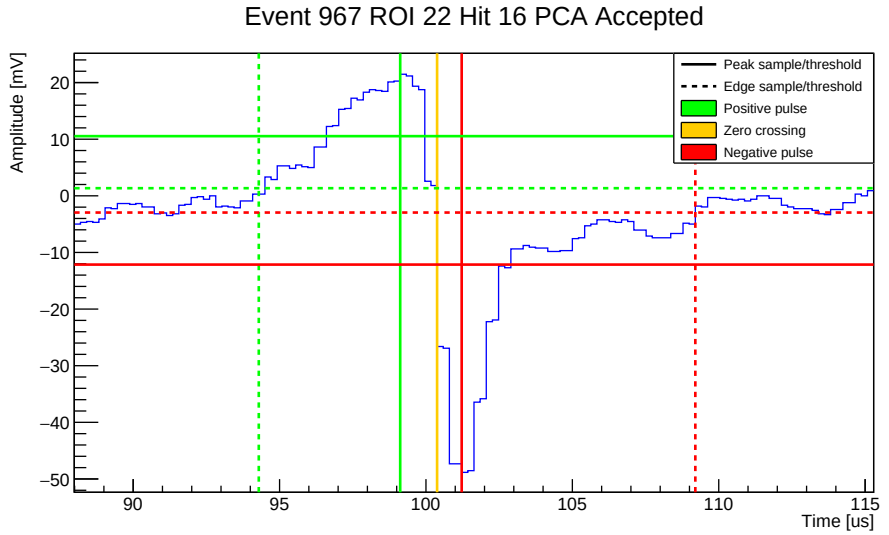




Reconstruction steps

1. Noise filter
   - Subtract common mode noise
2. Hit finder
3. Hit matcher
   - Combine pixel and ROI hits into 3D hits





Reconstruction steps

1. Noise filter
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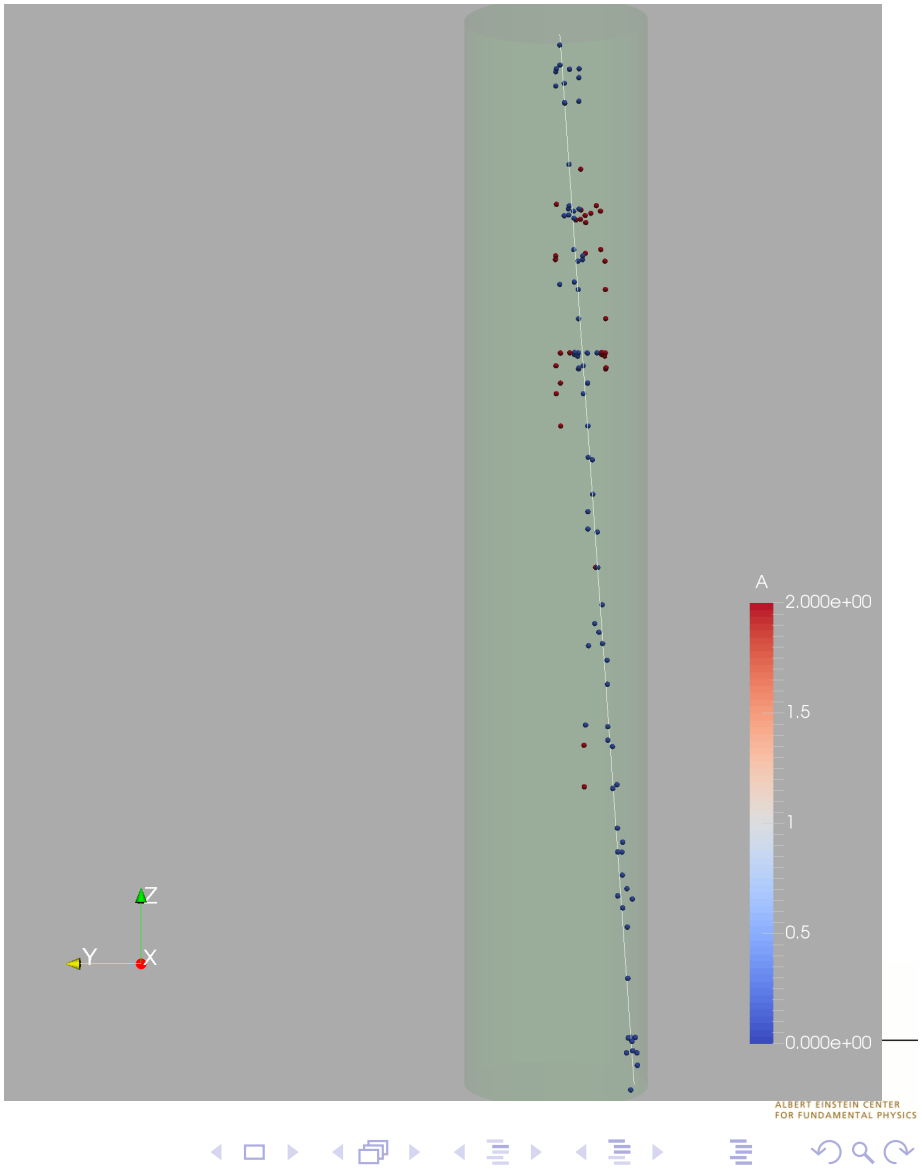
4. Principal Component Analysis
   - Solve multiplexing ambiguities
   - Remove outliers



Reconstruction steps

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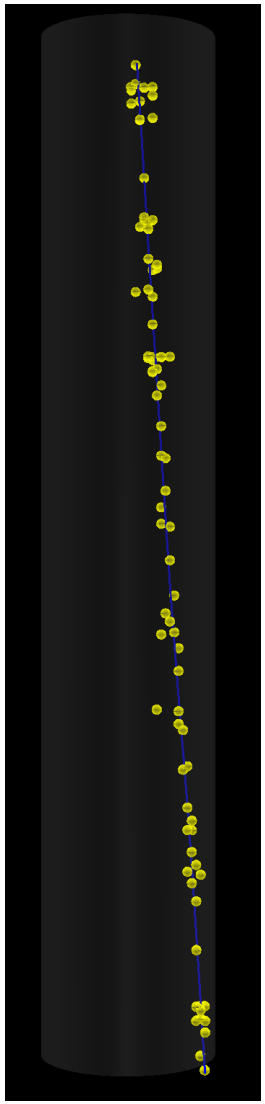
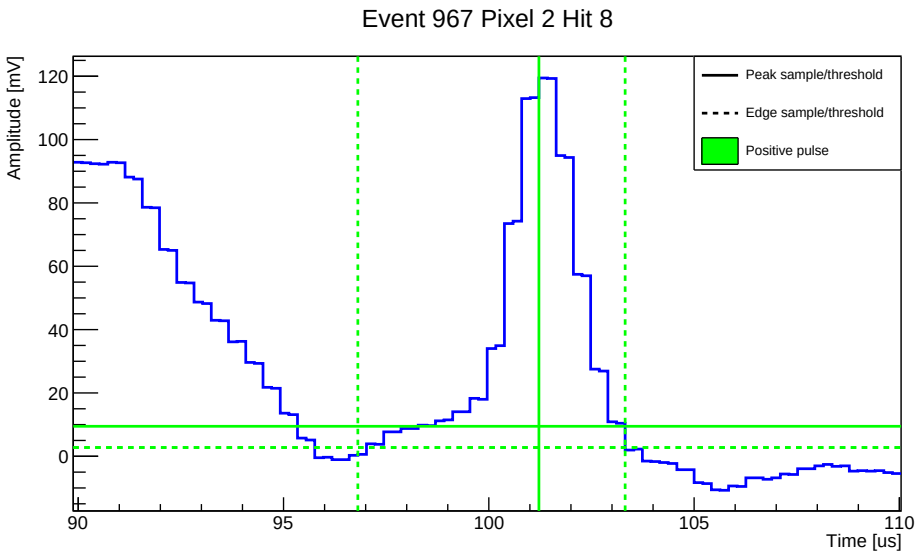
   - Remove outliers
5. Kalman fitter
   - Fit μ hypothesis to 3D spacepoints
   - arXiv: 0911.1008, 1410.3698 GENFIT



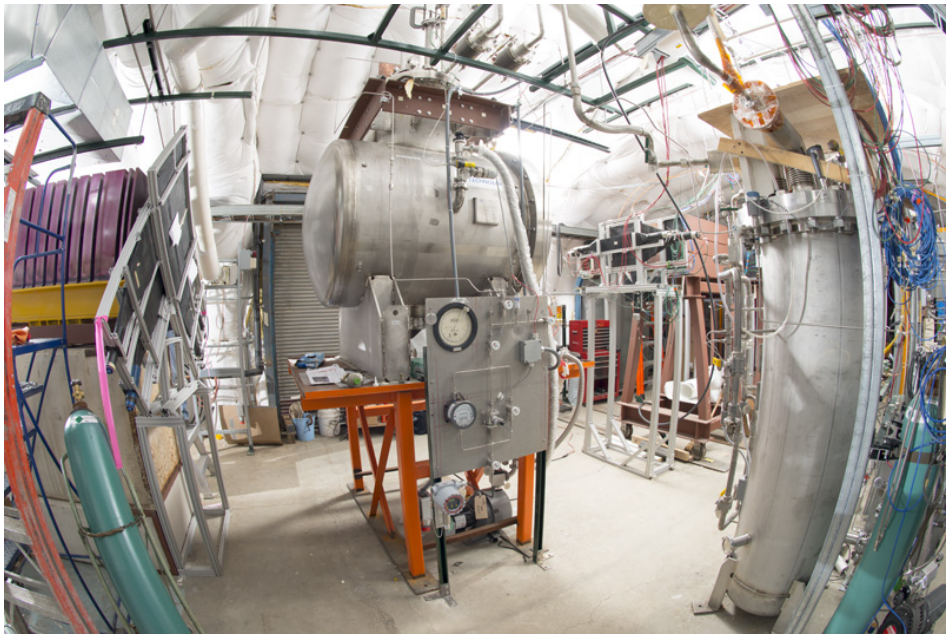
Performance



- MIP signal-to-noise ratio: ≈ 13
- Double-track spatial resolution in XY: 2.54 mm
- Double-track spatial resolution in Z: 2.1 mm
- Successfully reconstructed single tracks
- Potentially momentum and PID from Kalman
- Main challenge are multiplexing ambiguities

Outlook / Wishlist

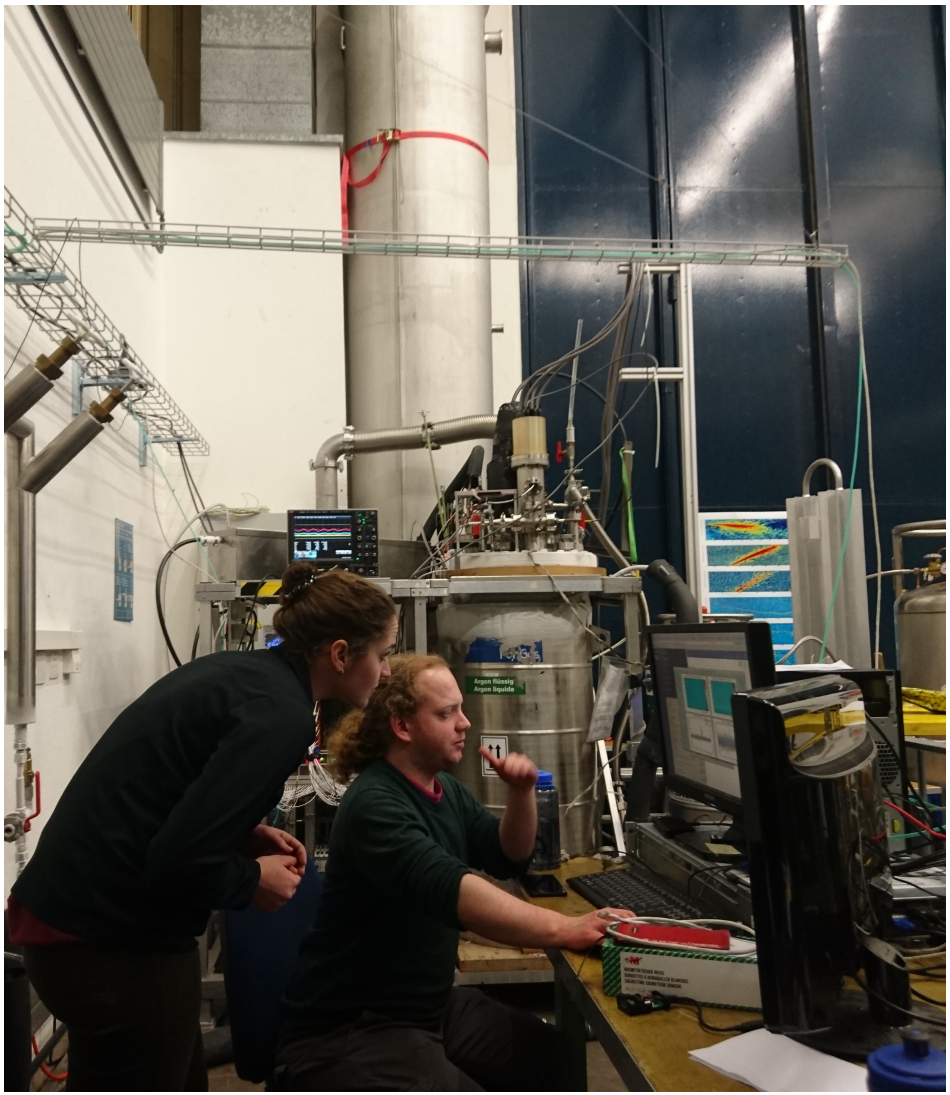
Lots of opportunities for collaboration



LArIAT

- Test beam studies in LArIAT
- Tune hit finder
- Momentum and PID from Kalman filter
- Multiple tracks / vertices
- Shower reconstruction
- Integration with other software
  - Simulation
  - DAQ
- Adapt to ambiguity-free LArPix readout

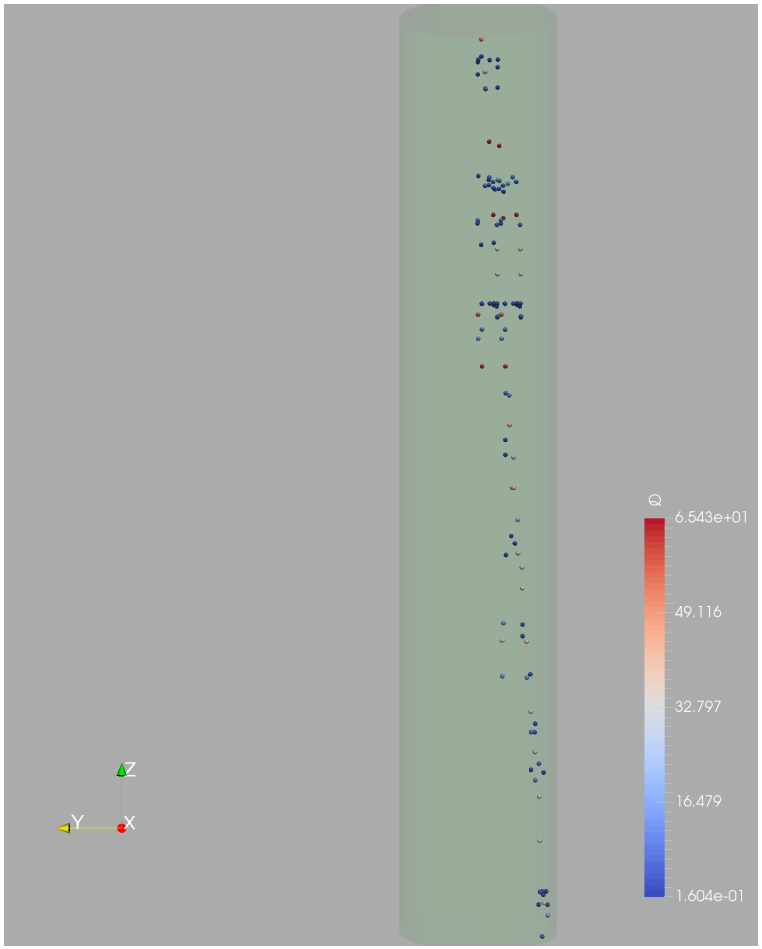
Summary

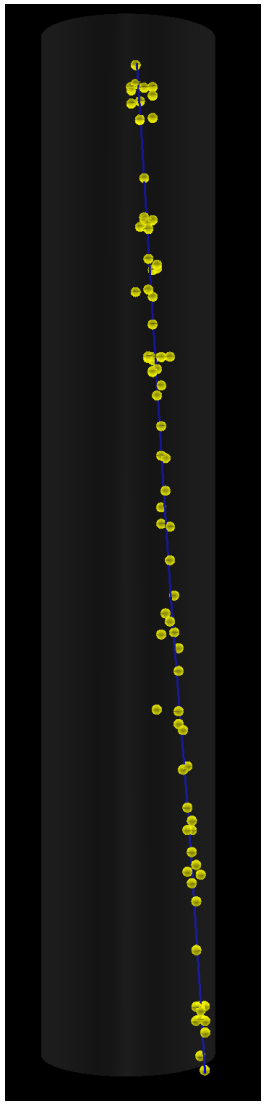


- Successful reconstruction of single tracks
- Main limitation from multiplexing
- Need ambiguity-free LArPix:
  - Improve reco efficiency
  - Fully exploit Kalman fit
  - More complex topologies
- Analysis source code on GitHub:

  https://github.com/70rc/pixy_roimux

Thank you





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