LArPix Straight-Line Track Reconstruction

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Why pixels are so great for reconstruction

True 3D space points - no projections

Maximal information content on event geometry

Worst case scenario - can always project down to 2D views to use existing (wire-based) algorithms

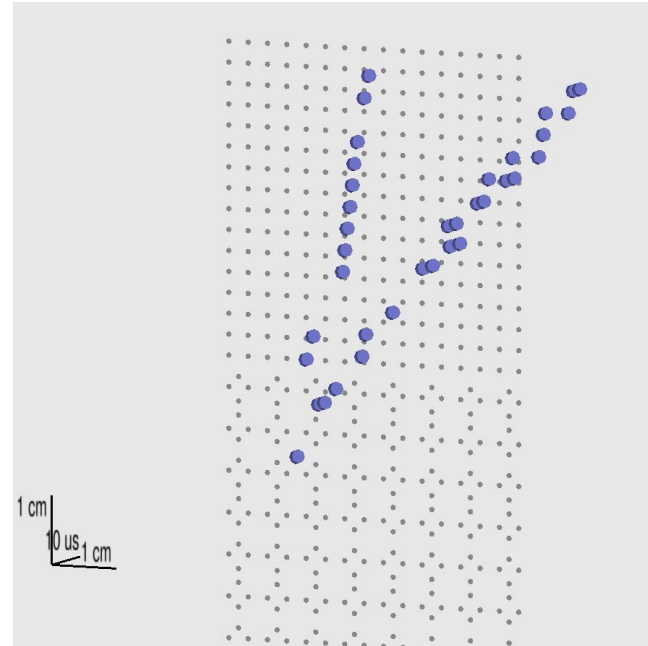But I think we'll stay up here in 3-space

LArPix data properties

Low noise from cryostat system → very few fake hits to confuse reco

Cosmic ray data → high incidence of muon tracks at MIP energies

Small TPC (compared to mean free path) → muon tracks are straight

1 cm

10 us 1 cm

Proof of concept: true 3D track reco

2* steps from event 3D hits to straight-line tracks (based on [1])

Not intended to be production-quality

Demonstrating that true 3D hits make life easier

Naive algorithm built for straight-line track segments in simple geometries

Not optimized for efficiency

* there is a loop

[1] Christoph Dalitz, Tilman Schramke, and Manuel Jeltsch, *Iterative Hough Transform for Line Detection in 3D Point Clouds*, Image Processing On Line, Z (2017), pp. 184–196. https://doi.org/10.5201/ipol.2017.208
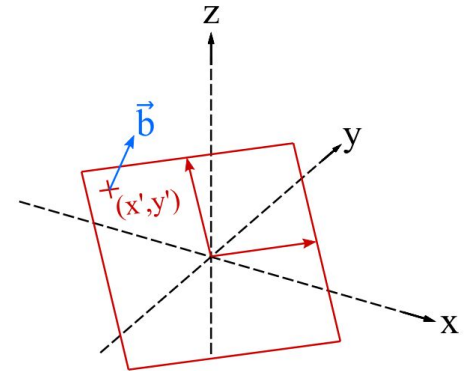
Step 1: Hough transformation

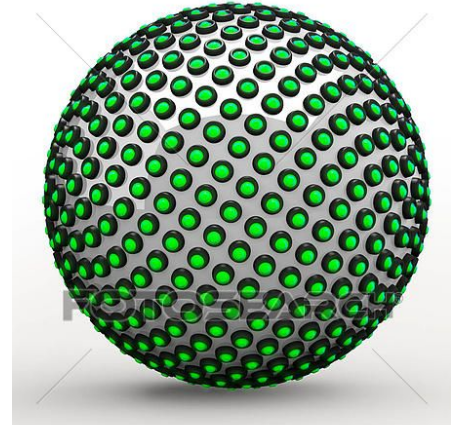Perform Hough transformation of all hits in event

- 3D line parametrization : "Roberts' optimal representation"
- 1000 test directions chosen using the Fibonacci sphere algorithm
- x' and y' accumulator bins have width 3mm (pixel pitch)

Fill accumulator bins corresponding to 1000 lines going through each point

Find bin with most "votes" → track with most hits on it (within 3mm)

(b) meaning of x' and y'

k9226114 www.fotosearch.com

Step 2: Least-squares fit

Perform least-squares fit to all points within 3mm of the line identified by the Hough transform

Exact solution is:

- anchor point given by "center of mass"
- direction given by first principal component a.k.a. principal eigenvector of covariance matrix

All points within 3mm of best fit line are assigned to be part of the track

Identify endpoints by projecting each hit onto the line - pick the two most distant projected hits

Loop

Repeat until no bin in the voting array has 5 or more votes:
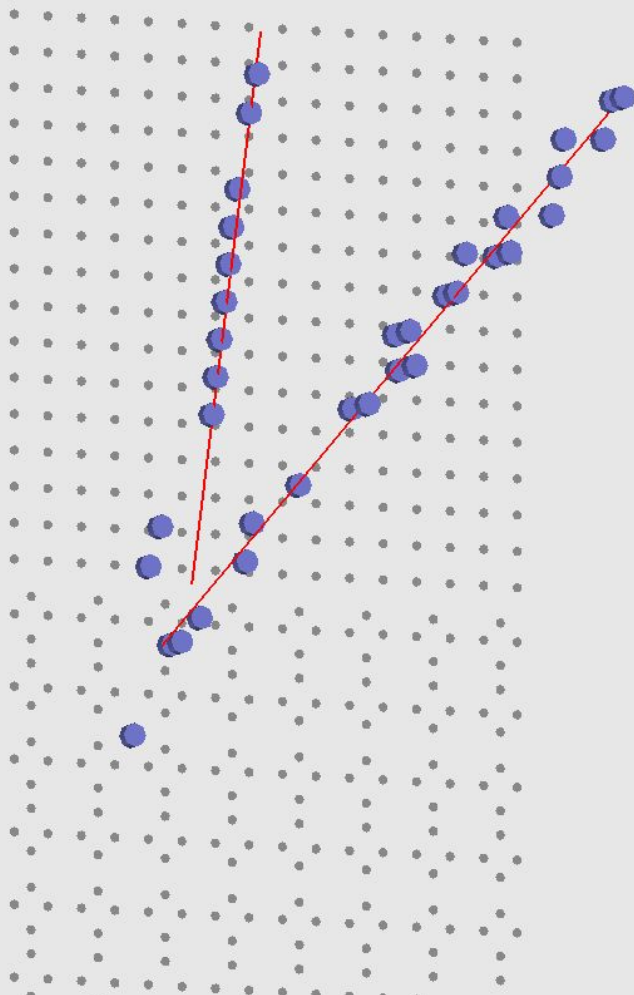
    Remove the hits corresponding to the newly found track from the event

    (Step 1) Undo their votes in the Hough transformation

    Find the new "best" track with the new Hough transformation voting array

    (Step 2) Perform a least-squares fit to those points

Some thoughts

Is this reconstruction perfect? No.

But it does demonstrate how easy it is to work with data from our pixelated LArTPC

See Vanessa's talk for in-depth analysis of reconstruction and reconstructed data

Working with reconstructed data

Reco output stored in HDF5 data files (ROOT coming soon)

File structure

- hits: 'hid', 'px', 'py', 'ts', 'q', 'iochain', 'chipid', 'channelid', 'geom', 'event_ref', 'track_ref'
- events: 'evid', 'track_ref', 'hit_ref', 'nhit', 'q', 'ts_start', 'ts_end'
- tracks: 'track_id', 'event_ref', 'hit_ref', 'theta', 'phi', 'xp', 'yp', 'nhit', 'q', 'ts_start', 'ts_end', 'sigma_theta', 'sigma_phi', 'sigma_x', 'sigma_y', 'length', 'start', 'end'

Each entry contains information about one physics object and references to related objects