Wire-Cell Reconstruction Update

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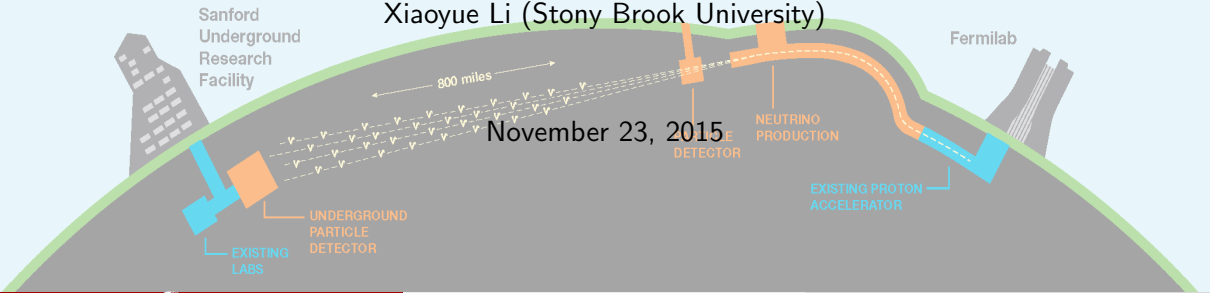
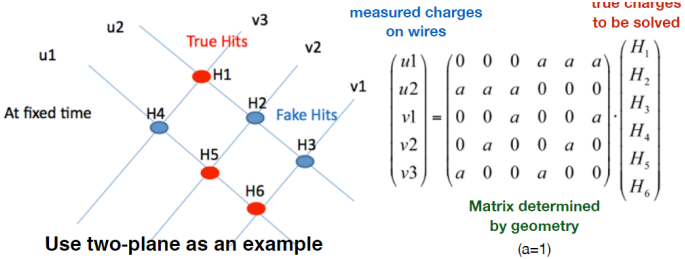


Wire-Cell Reconstruction I

- https://indico.fnal.gov/getFile.py/access?contribId=78&sessionId=21&resId=0&materialId=slides&confId=10100
- Due to wire readout, the measured information is reduced from $\sigma(N^2)$ to $3N$, causing degeneracy.

- Same charge in a voxel is measured 3 times by wires on the three wire planes.
- Equation between measured charge on wires and potentials hits can be formed. Fake hits should be asigned ~ 0 charge if equation can be solved.



Wire-Cell Reconstruction II

- Form time slices (2 μs time bins instead of traditional Gaussian hits, and charge in a time slice on a wire is the sum of its de-convoluted signals)
- Construct Wire-Cell association
- Merge adjacent cells into "blobs"
- Construct χ^2
- Obtain best matched 3D space points through χ^2 minimization.
  - When equation cannot be solved, other algorithms are developed to find minimum χ^2.
- Clustering and tracking...

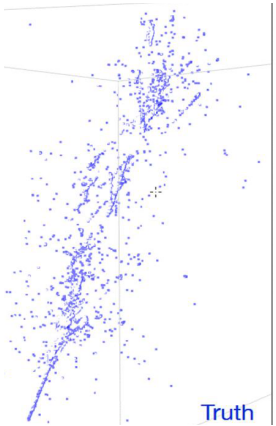
$$\chi^2 = (B \cdot W - G \cdot C)^T {V_{BW}}^{-1} (B \cdot W - G \cdot C)$$

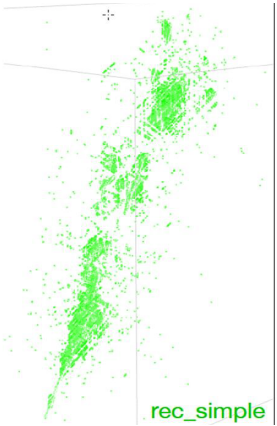
$$\frac{\partial \chi^2}{\partial C} = 0 \Rightarrow C = (G^T {V_{BW}}^{-1} G)^{-1} G^T {V_{BW}}^{-1} B W$$

- C: charge in each blob (merged cell) to be solved
- G: geometry matrix connecting blobs and wires
- W: charge in each single wire
- B: Geometry matrix connecting merged wires and single wires
- V_{BW}: covariance matrix describing uncertainty in wire charge

Wire-Cell Reconstruction III

Example: a 1.5 GeV electron



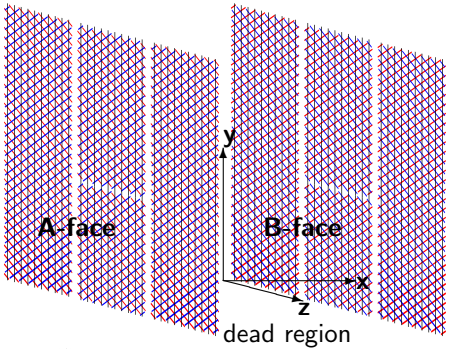


geometry-only

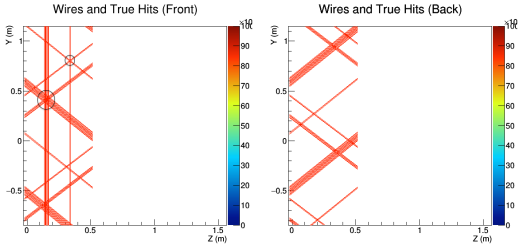
geometry & charge

New developments: parametrized wire-wrapping I

- Wires can be constructed given a few parameters:
  - Number of APAs in each cryostat
  - 3D size of each APA
  - Two wire angles and three wire pitches



- A charge is drifted to the nearest APA; any charge deposits in the middle of an APA are simply ignored.
- Gaps between any two APAs are treated as dead region as well.
- A charge can fire multiple U/V wire segments in both A-face and B-face.



New developments: parametrized wire-wrapping II

- In the case of wrapped wire, wires in the original algorithms are largely replaced by channels.
  - before: cells that have one or more common edges are merged into one blob; wires associated with these cells are grouped accordingly
  - after: cells are constructed and merged in the same way as before according to the geometry; wires associated with merged cells are also merged, and association between merged wires and single channel is constructed.

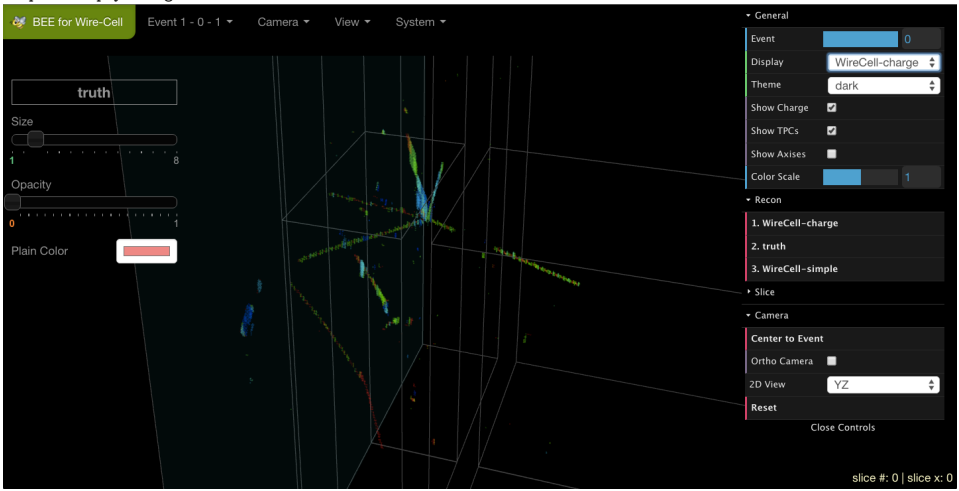
$$\chi^2 = (B \cdot W - G \cdot C)^T {V_{BW}}^{-1} (B \cdot W - G \cdot C)$$

$$\frac{\partial \chi^2}{\partial C} = 0 \Rightarrow C = (G^T {V_{BW}}^{-1} G)^{-1} G^T {V_{BW}}^{-1} B W$$

- C: charge in each blob (to be solved)
- G: geometry matrix connecting blobs and merged wires
- W: charge in each single **channel**
- B: Geometry matrix connecting merged wires and single **channels**
- V_{BW}: covariance matrix describing uncertainty in **channel** charge

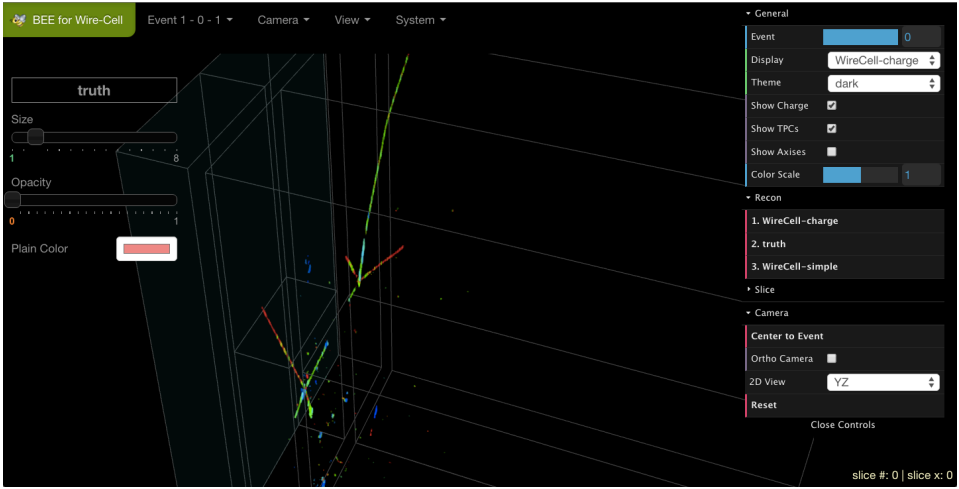
Wire-Cell on 35ton I

http://www.phy.bnl.gov/wire-cell/bee/set/ee2fd0e7-98e7-49b5-951e-a724a10395df/event/0/



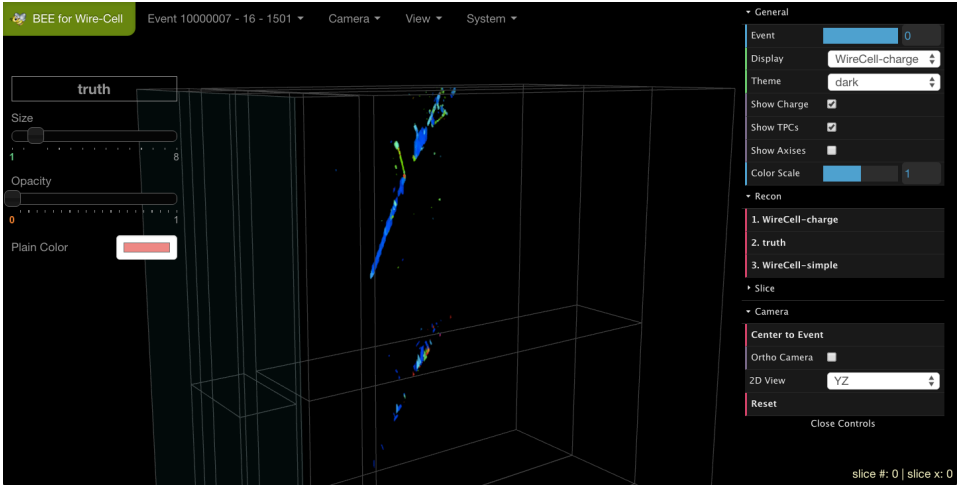
Wire-Cell on 35ton II

http://www.phy.bnl.gov/wire-cell/bee/set/3e8800ad-507e-4f55-8454-caae665482bb/event/0/

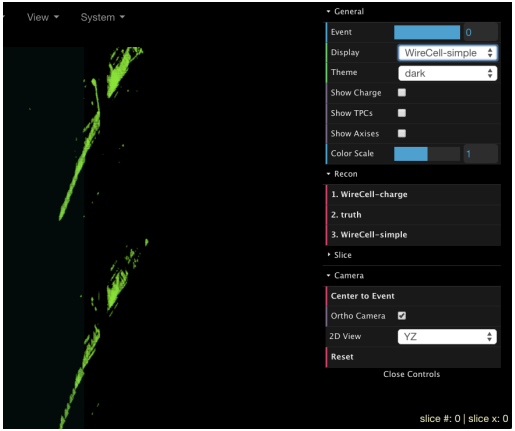


Wire-Cell on 35ton III

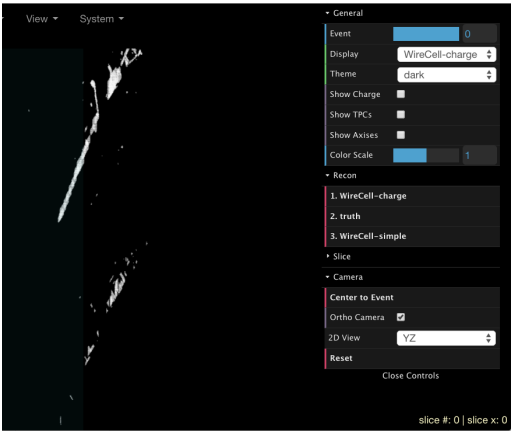
http://www.phy.bnl.gov/wire-cell/bee/set/451b9c39-3312-4aec-a07c-9376ba6b12c8/event/0/



Wire-Cell on 35ton IV



geometry-only



geometry & charge

100 more events: `http://www.phy.bnl.gov/wire-cell/bee/set/20/event/list/`

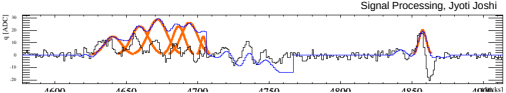
Further studies

- Validation of wire parametrization using MicroBooNE results.
- Use Wire-Cell to analysis 35ton data.
- The implimentation of wrapped wire in Wire-Cell enables studies of far detector optimization:
  - wire pitch 3 mm vs 5 mm
  - wire angle (and consequently how many times a certain wire is wrapped)
  - effects of wire wrapping on reconstruction
  - effects of dead channel
  - orientation of detector w.r.t. beam
- Possible improvements to Wire-Cell:
  - Develop cuts to futher remove fakes hits due to wire wrapping
  - Fix the gap in inital clustering
  - Faster/better equation-solving

BACKUP

Definitions

Definition of Time Slice



- In Wire-Cell reconstruction, we don't use the traditional concept of "Gaussian Hits".
  - Avoids the complications in fitting the waveform (especially for a long signal)
- Instead, we simply define a time slice as a 2-us bin
  - Binning choice matches the shaping time
- Charge in a time slice on a wire is the sum of its de-convoluted signals

Wires, Cells and Blobs

- Wire: a Wire represents a +- pitch/2 rectangular region centered around the wire
- Cell: a Cell is the overlap region of three Wires. This is the smallest area unit on a plane.
- Blob: group of hit cells that are adjacent
  - Merge cells into blob to reduce degeneracy