

ProtoDUNE Beamline Tracking Information

Jake Calcutt

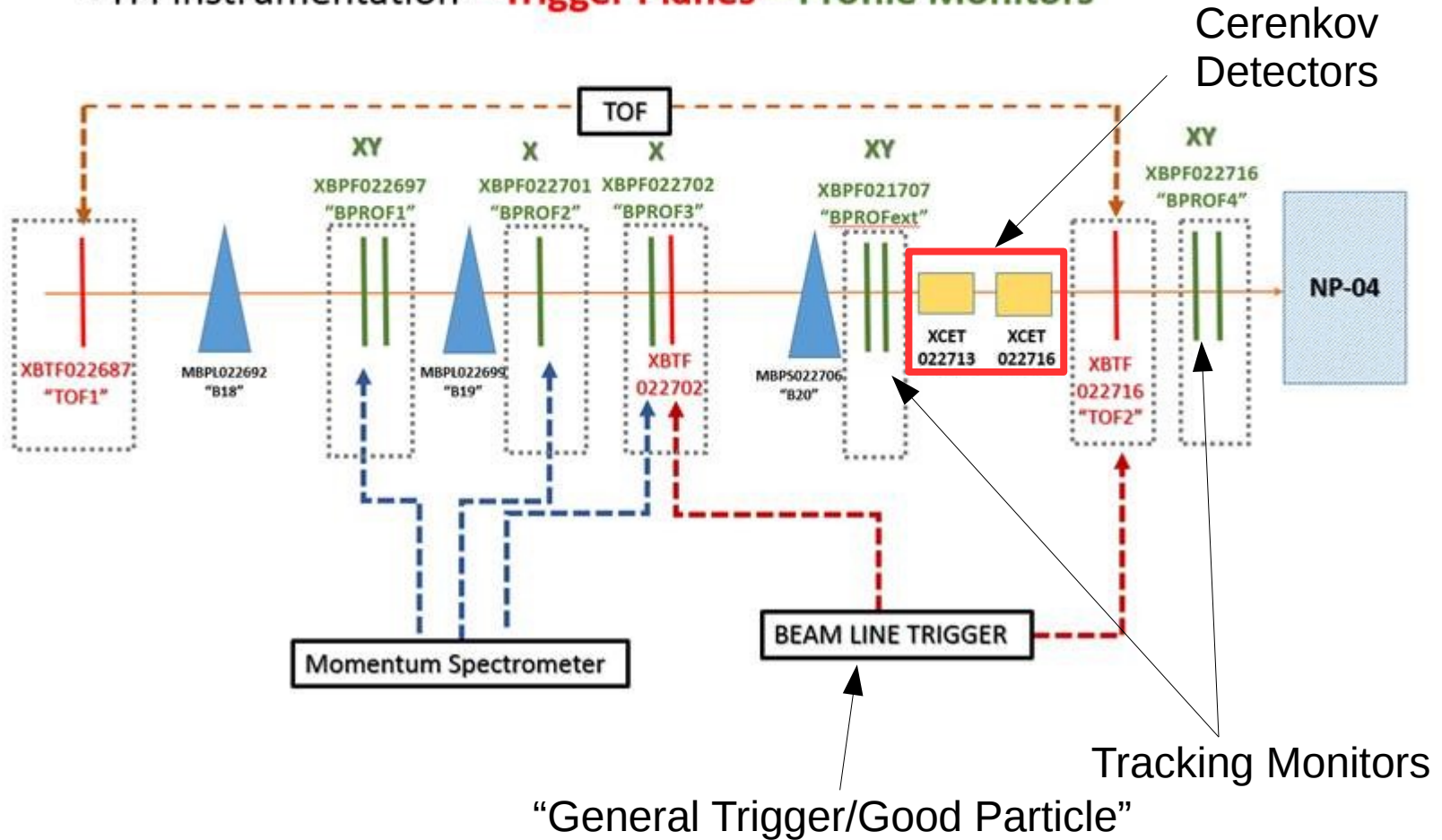
April 10, 2019

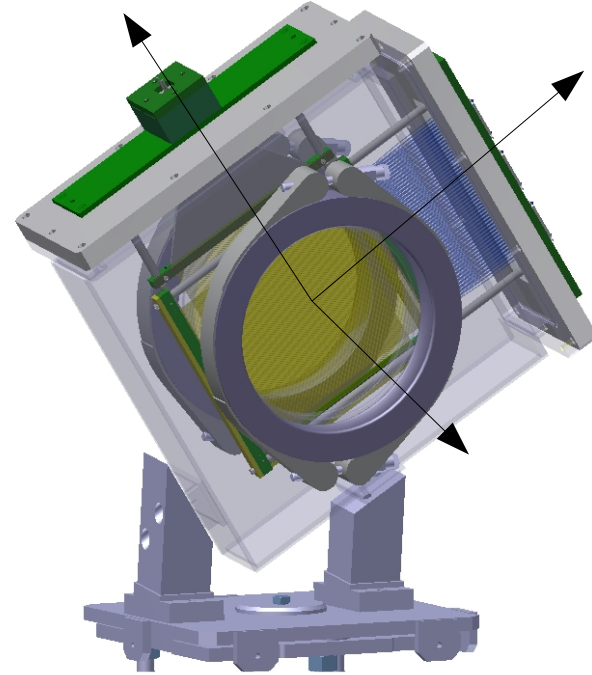
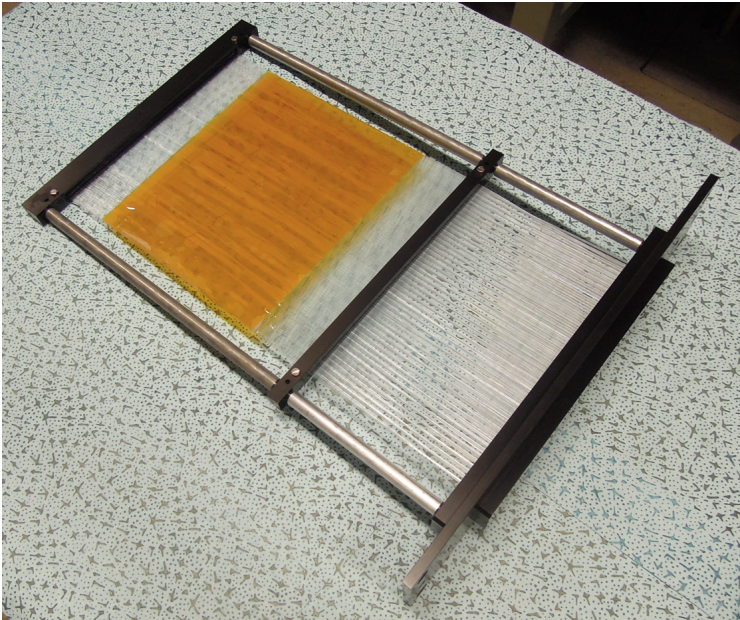
- The goal of this talk is to give some insight into differences seen between old and new versions of the beamline
- Outline
 - Description of how the beamline tracks are produced
 - What has changed
 - Position of tracking monitors

H4-VLE Beam Instrumentation Data

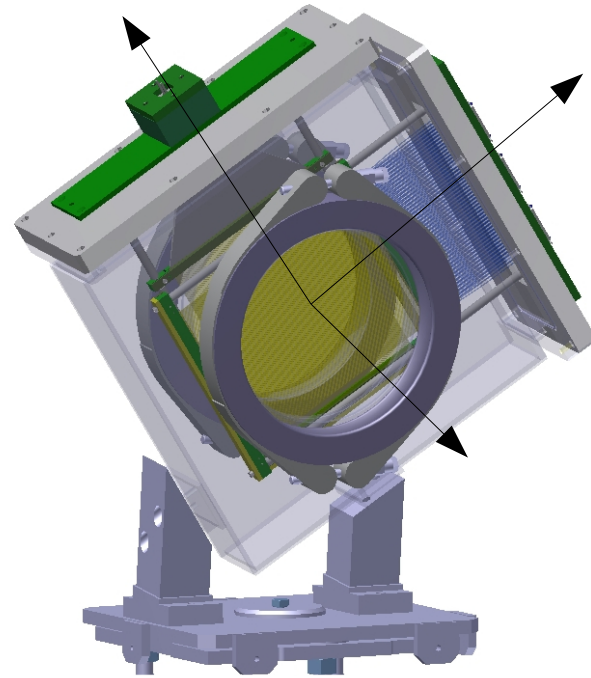
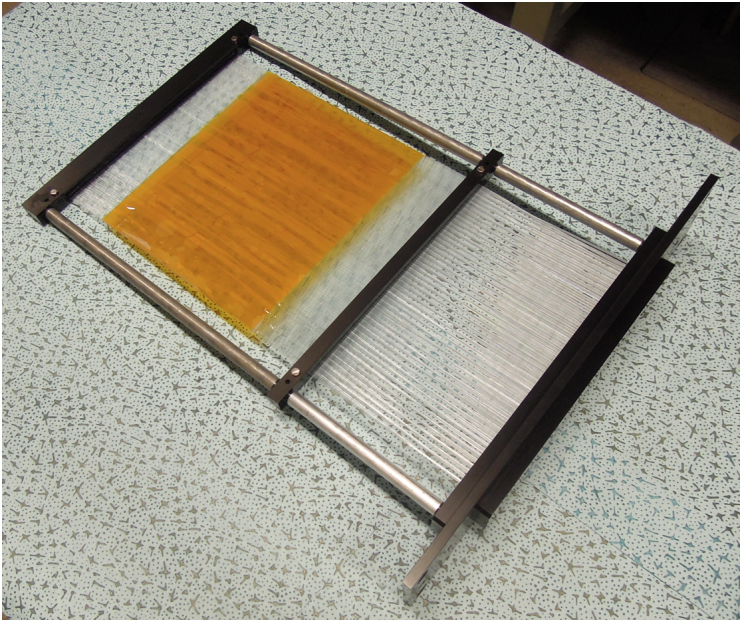
N. Charitonidis
I. Ortega-Ruiz
April 2018

- H4 instrumentation – **Trigger Planes** – **Profile Monitors**

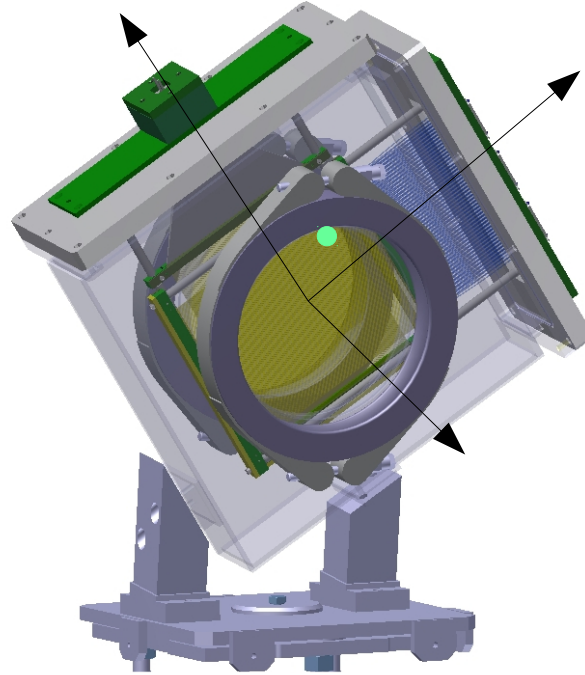




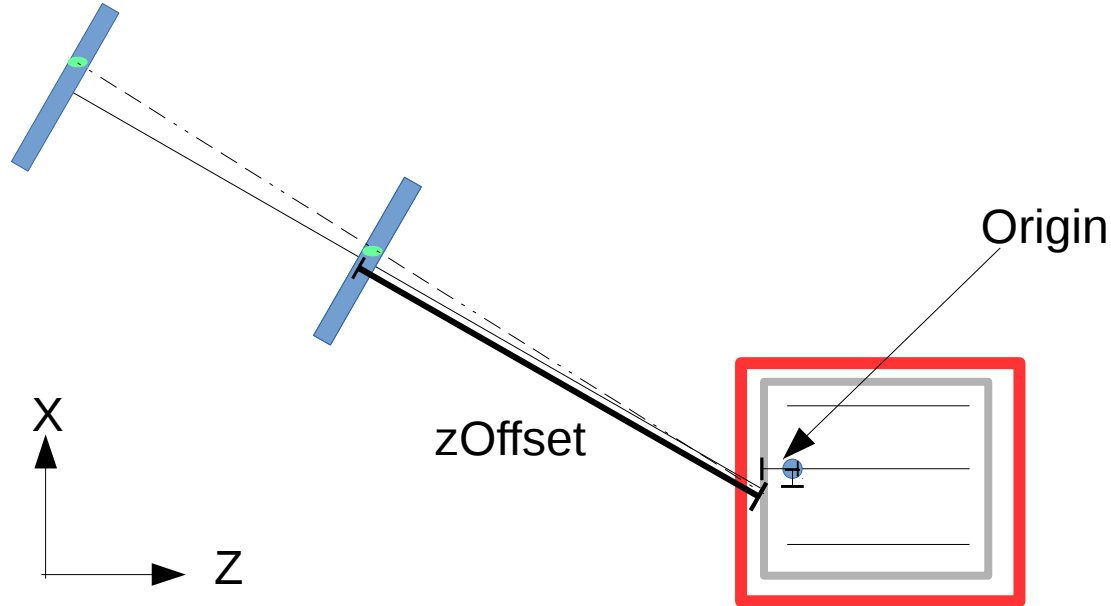
- 192 Scint. Fibers
- 8 throughout beamline
- 4 used in tracking section
 - 2 each for up- and downstream



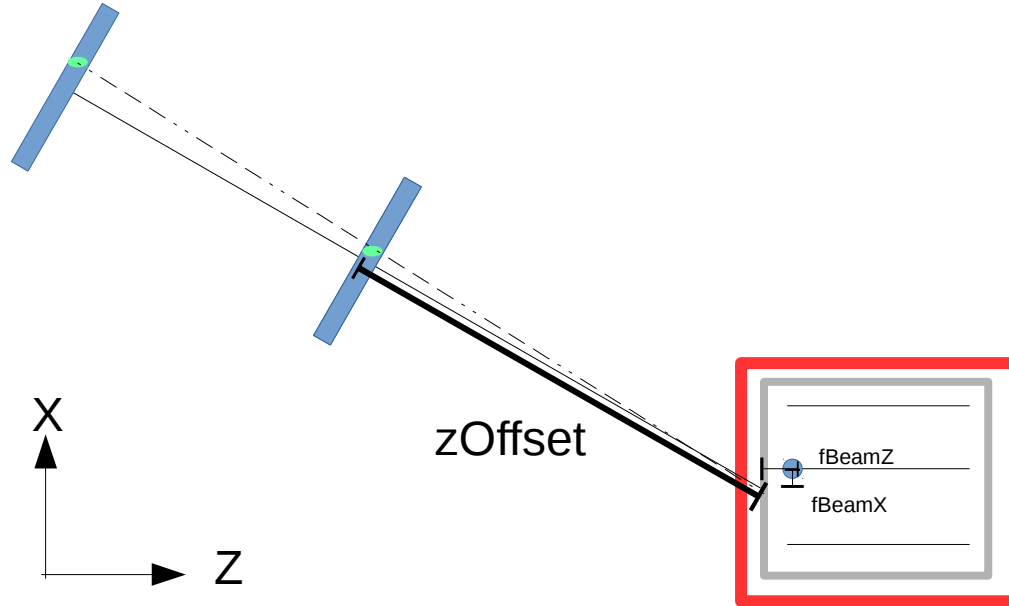
- BI DAQ registers all fibers activated at trigger time
 - Saved in database as 6x32 bit numbers
 - Decode to set of 192 bits
 - Multiple active fibers → degeneracies in momentum/tracks



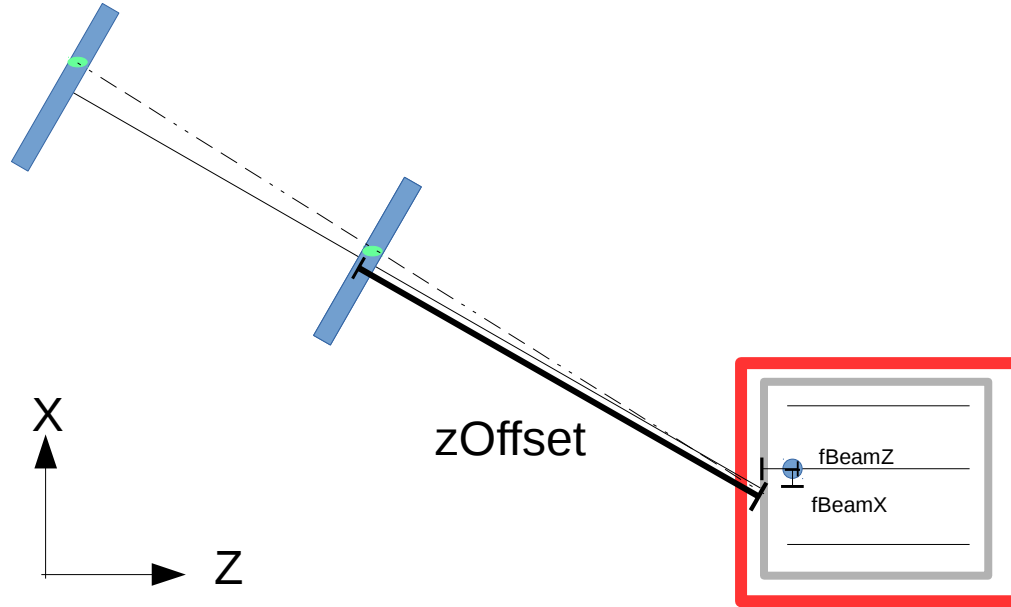
- Translate active fibers in each plane to x, y positions ($dx_{\text{FBM}}, dy_{\text{FBM}}$)
 - Fiber width: 1mm



- Translate x, y positions in monitors to (TPC) positions
 - Use distances defined in
 - Survey file: beamline positions relative to beam window
 - Geometry files: beam window position relative to TPC origin
 - TPC origin: Bottom, upstream corner of CPA

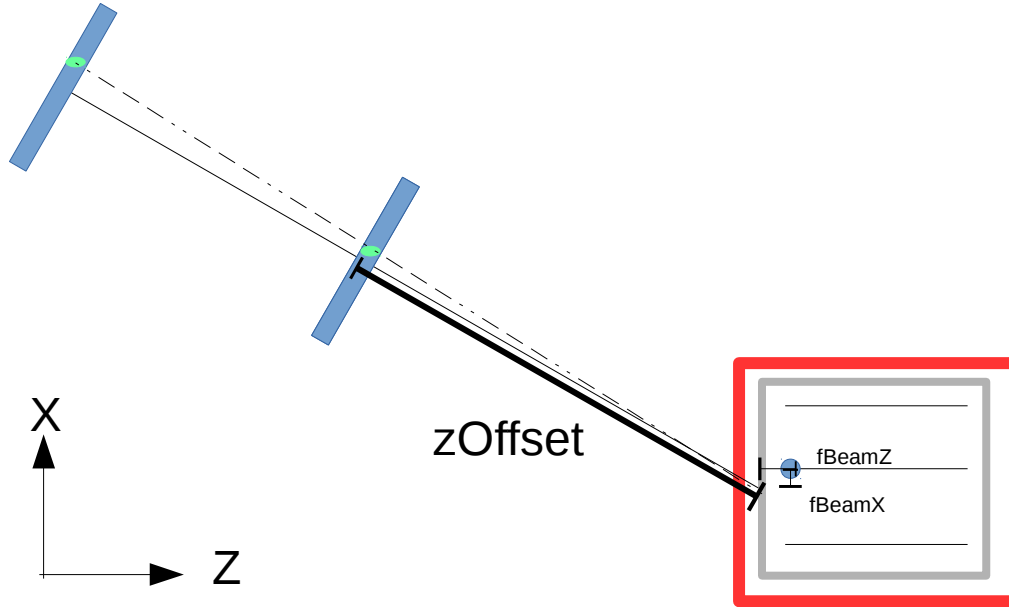


$$\begin{aligned}
 x &= fBeamX + (\hat{x} \cdot_{Beam,x} * dx_{FBM}) + (\hat{y} \cdot_{Beam,x} * dy_{FBM}) + (\hat{z} \cdot_{Beam,x} * zOffset) \\
 y &= fBeamY + (\hat{x} \cdot_{Beam,y} * dx_{FBM}) + (\hat{y} \cdot_{Beam,y} * dy_{FBM}) + (\hat{z} \cdot_{Beam,y} * zOffset) \\
 z &= fBeamZ + (\hat{x} \cdot_{Beam,z} * dx_{FBM}) + (\hat{y} \cdot_{Beam,z} * dy_{FBM}) + (\hat{z} \cdot_{Beam,z} * zOffset)
 \end{aligned}$$



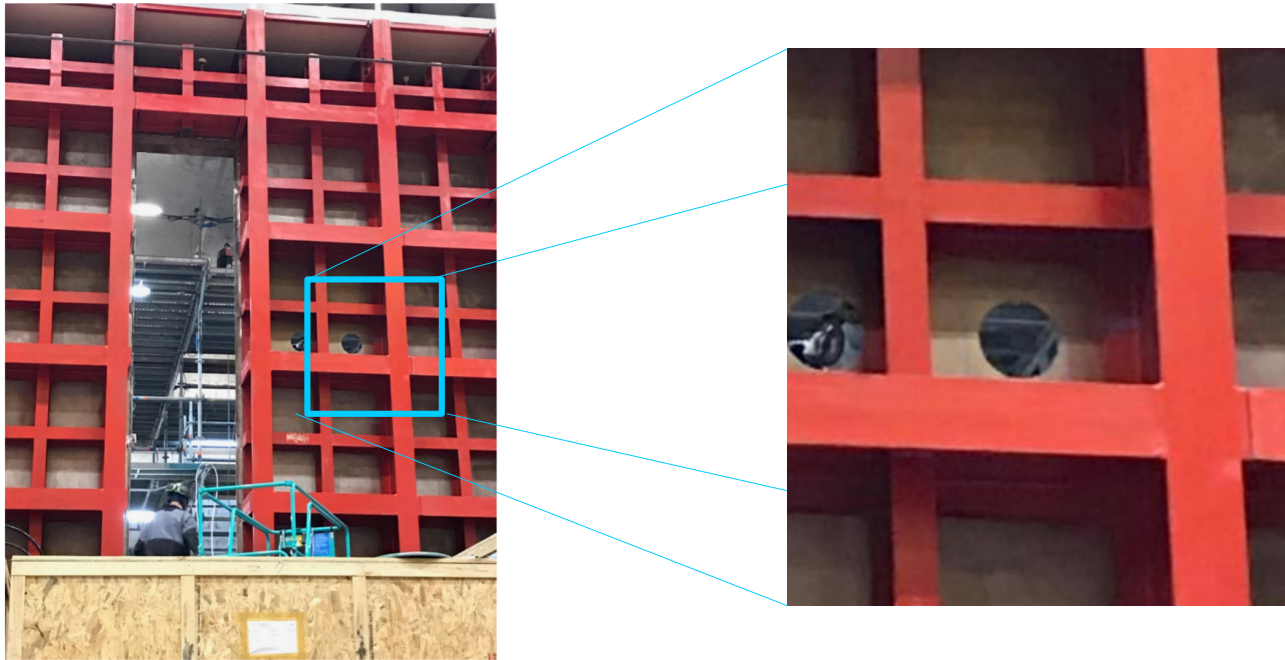
$$\begin{aligned}
 x &= fBeamX + (\hat{x}_{Beam,x} * dx_{FBM}) + (\hat{y}_{Beam,x} * dy_{FBM}) + (\hat{z}_{Beam,x} * zOffset) \\
 y &= fBeamY + (\hat{x}_{Beam,y} * dx_{FBM}) + (\hat{y}_{Beam,y} * dy_{FBM}) + (\hat{z}_{Beam,y} * zOffset) \\
 z &= fBeamZ + (\hat{x}_{Beam,z} * dx_{FBM}) + (\hat{y}_{Beam,z} * dy_{FBM}) + (\hat{z}_{Beam,z} * zOffset)
 \end{aligned}$$

Distance from TPC origin to beam window

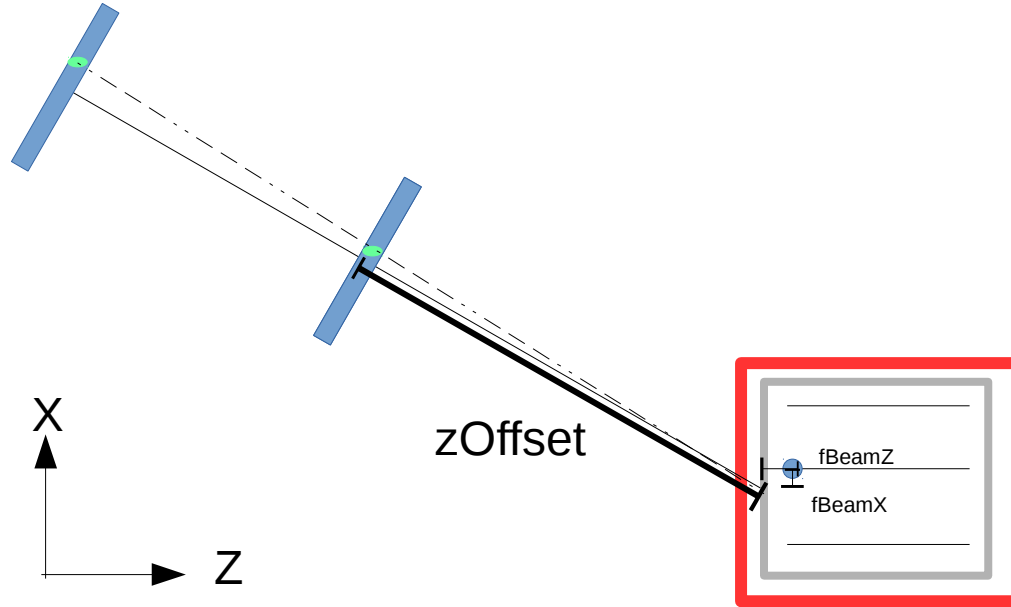


$$\begin{aligned}
 x &= fBeamX + (\hat{x}_{Beam,x} * dx_{FBM}) + (\hat{y}_{Beam,x} * dy_{FBM}) + (\hat{z}_{Beam,x} * zOffset) \\
 y &= fBeamY + (\hat{x}_{Beam,y} * dx_{FBM}) + (\hat{y}_{Beam,y} * dy_{FBM}) + (\hat{z}_{Beam,y} * zOffset) \\
 z &= fBeamZ + (\hat{x}_{Beam,z} * dx_{FBM}) + (\hat{y}_{Beam,z} * dy_{FBM}) + (\hat{z}_{Beam,z} * zOffset)
 \end{aligned}$$

Distance from beam window to center of beam monitor

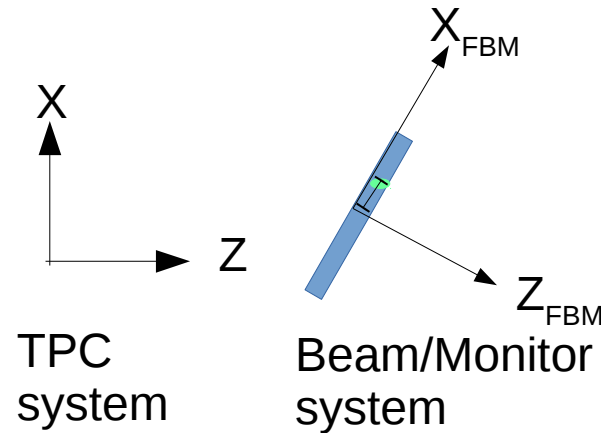


- Beam window survey point
 - Used to find the offset to the monitors along the beam
 - Defined in survey file
 - Martin Tzanov gave me the position of this point relative to TPC origin in Protodune geometry
 - (-4.994 cm, 448.449 cm, -129.804 cm)



$$\begin{aligned}
 x &= fBeamX + (\hat{x} \cdot_{Beam} x * dx_{FBM}) + (\hat{y} \cdot_{Beam, x} * dy_{FBM}) + (\hat{z} \cdot_{Beam, x} * zOffset) \\
 y &= fBeamY + (\hat{x} \cdot_{Beam} y * dx_{FBM}) + (\hat{y} \cdot_{Beam, y} * dy_{FBM}) + (\hat{z} \cdot_{Beam, y} * zOffset) \\
 z &= fBeamZ + (\hat{x} \cdot_{Beam, z} * dx_{FBM}) + (\hat{y} \cdot_{Beam, z} * dy_{FBM}) + (\hat{z} \cdot_{Beam, z} * zOffset)
 \end{aligned}$$

Positions in fiber monitors



$$\begin{aligned}
 x &= f_{BeamX} + (\hat{x}_{Beam,x} * dx_{FBM}) + (\hat{y}_{Beam,x} * dy_{FBM}) + (\hat{z}_{Beam,x} * zOffset) \\
 y &= f_{BeamY} + (\hat{x}_{Beam,y} * dx_{FBM}) + (\hat{y}_{Beam,y} * dy_{FBM}) + (\hat{z}_{Beam,y} * zOffset) \\
 z &= f_{BeamZ} + (\hat{x}_{Beam,z} * dx_{FBM}) + (\hat{y}_{Beam,z} * dy_{FBM}) + (\hat{z}_{Beam,z} * zOffset)
 \end{aligned}$$

TPC-system components of
beam/monitor-system unit vectors

- Original production had some values for locations/directions that I took from MC
 - Development during this period was hasty (my apologies)
- Some development occurred during/shortly after the Jan. 2019 Collaboration meeting
 - Positions of monitors: better understanding of the survey file
 - Beam direction: dug up lost email containing more accurate value
 - Location of beam window was clarified by Martin

- Beam Window
 - Old: (8.076 cm, 461.06 cm, -196.11 cm)
 - New: (-4.994 cm, 448.449 cm, -129.804 cm)
- Surveyed locations along beamline
 - First Tracking Monitor
 - 707.479 m → 707.555 m
 - Second Tracking Monitor
 - 716.048 m → 717.123 m
 - Note: relative distance between Monitors did not change. Only their absolute position in the beamline
- Beam Direction
 - Old: (-0.1788, -0.1995, 0.9634)
 - New: (-0.1836, -0.1982, 0.9628)

- Showed how the tracking is done in the Beamline reconstruction module
- Detailed what changed between first production and now