Tracker Geometry

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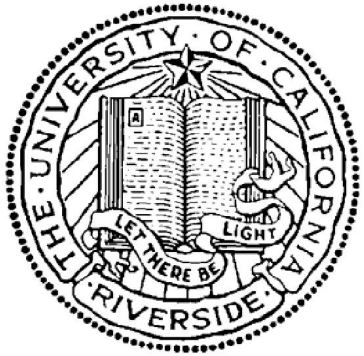
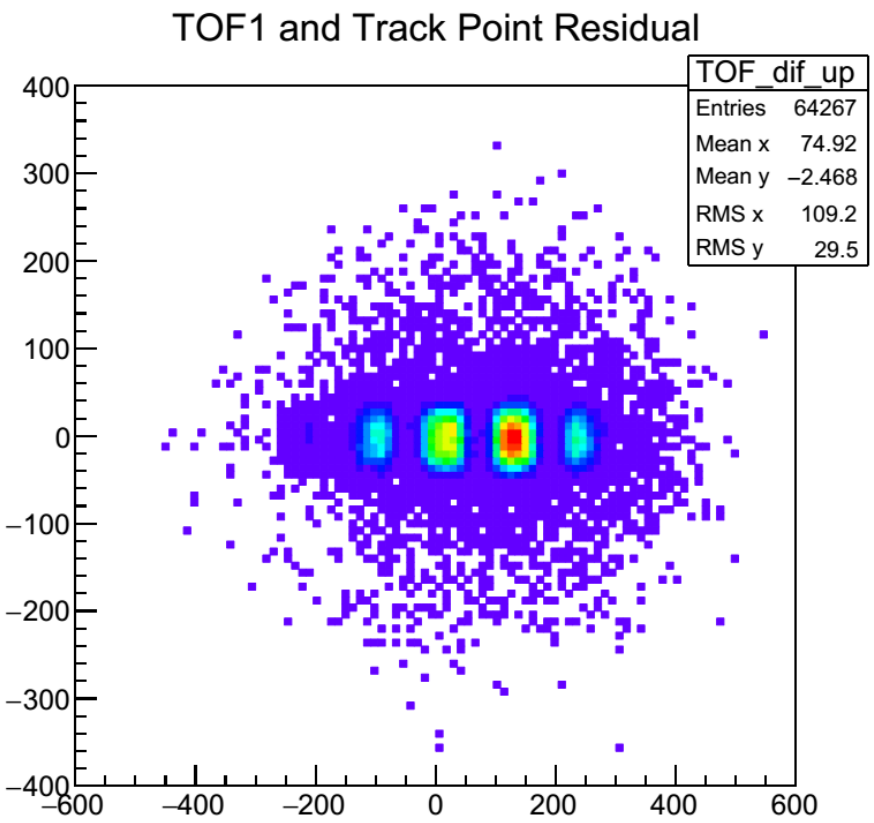


Outline

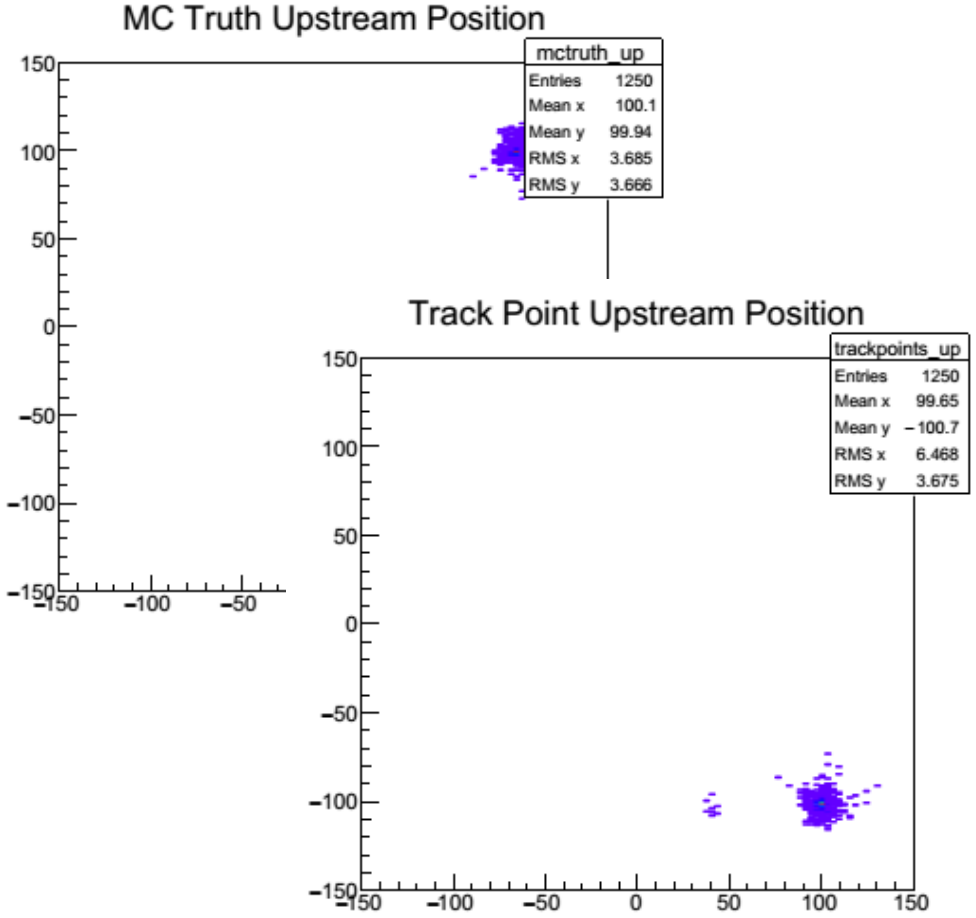
- Flips
  - The problem
  - Space point reconstruction
  - Single bulkhead tests
  - Playing around with math
    - Fiber positioning
    - Plane rotations
    - Coordinate system
  - Solutions
- Finishing up
  - Star
    - MC fiber positioning
  - Slide
    - Tracker rotations (again)

The Problem

X-Flip in Data



Y-Flip in MC

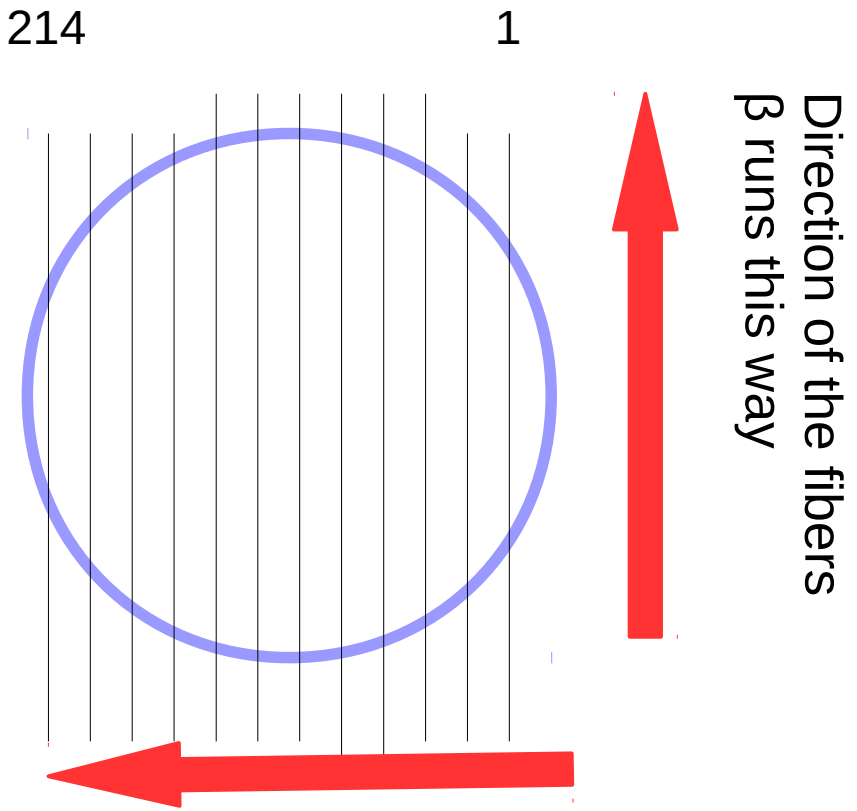


Space Point Reconstruction

- A particle travels through a plane at a position in the plane reference frame (α,β)
- A rotation through an angle (-120, 120, or 0) gives us the position in the station reference frame (x,y)

$$R = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}$$

$$\begin{pmatrix} x \\ y \end{pmatrix} = R \begin{pmatrix} \alpha \\ \beta \end{pmatrix}$$



Runs from channel 1 to 214(212), increases in α

$$\alpha = 3.5\ fp\ (channel - central)$$

*Direction of plane coordinate as described in reconstruction

Space Point Reconstruction

- No way with a single plane hit to determine the plane reference coordinate β
  - Need to look for a crossing of two hit fibers

$$R_\varphi \begin{pmatrix} \alpha_1 \\ \beta_1 \end{pmatrix} = \begin{pmatrix} x \\ y \end{pmatrix} = R_\theta \begin{pmatrix} \alpha_2 \\ \beta_2 \end{pmatrix}$$

$$\begin{pmatrix} \alpha_1 \\ \beta_1 \end{pmatrix} = R_\varphi^{-1}\, R_\theta \begin{pmatrix} \alpha_2 \\ \beta_2 \end{pmatrix}$$

$$R_\varphi^{-1}\, R_\theta = S_{(\varphi,\theta)} = \begin{pmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{pmatrix}$$

- Coefficients take on the values
  - Counter-Clockwise
    0-> 120-> -120(240)-> 0

$$S_{(\varphi,\varphi+120)} = \begin{pmatrix} -1/2 & -\sqrt{3}/2 \\ \sqrt{3}/2 & -1/2 \end{pmatrix}$$

  - Clockwise
    0-> -120-> 120(-240)-> 0

$$S_{(\varphi,\varphi-120)} = \begin{pmatrix} -1/2 & \sqrt{3}/2 \\ -\sqrt{3}/2 & -1/2 \end{pmatrix}$$

Space Point Reconstruction

- With these two points we can solve for station and plane position

$$\beta_2 = \frac{\alpha_1 - \alpha_2 \, s_{11}}{s_{12}}$$

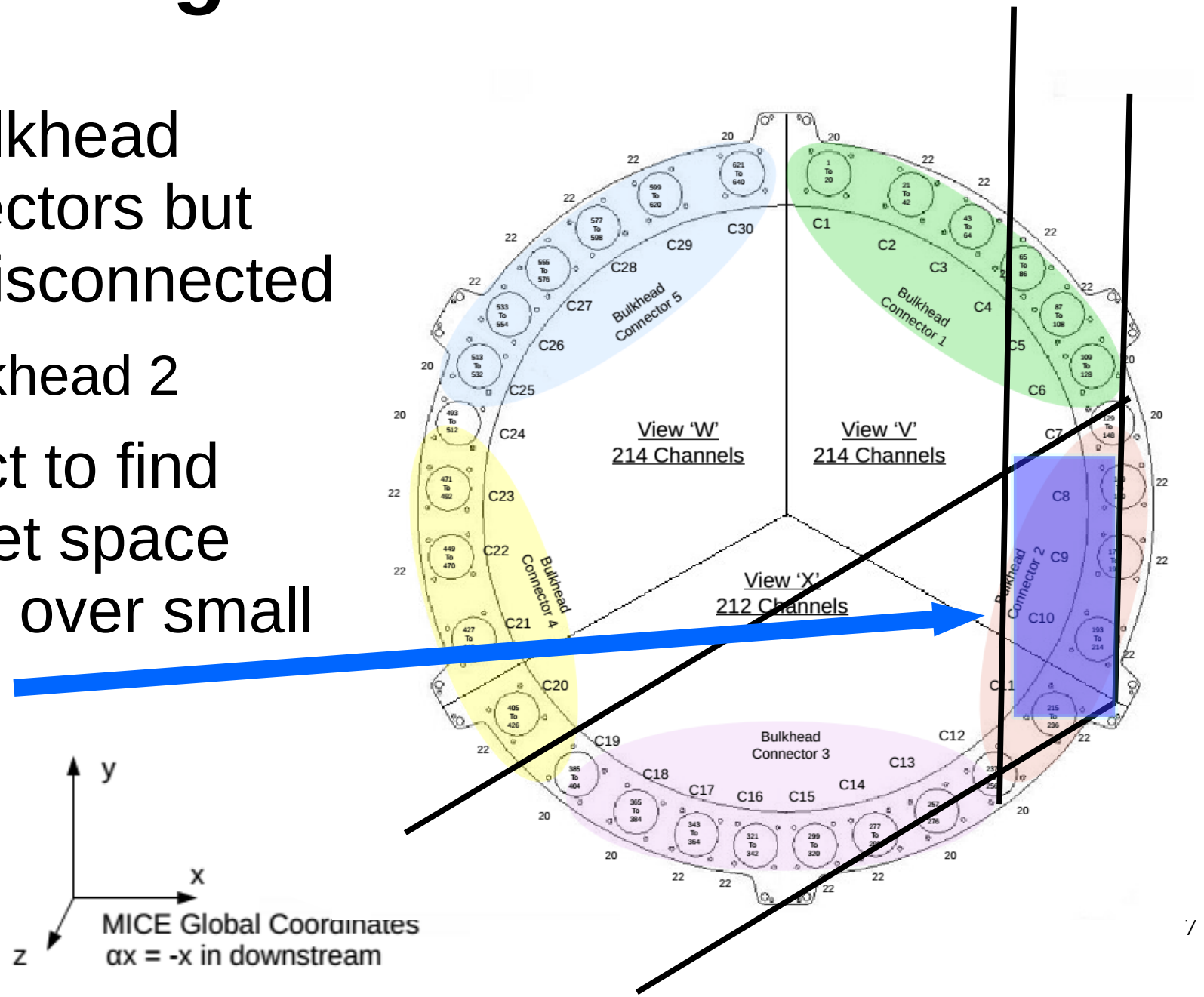
$$\beta_1 = \alpha_2 \, s_{21} + \beta_2 \, s_{22}$$

- All solutions worked out here will be solved for the u-plane as crossing plane number two (u-plane is still plane 0, nothing is changing!). This just simplifies the math.

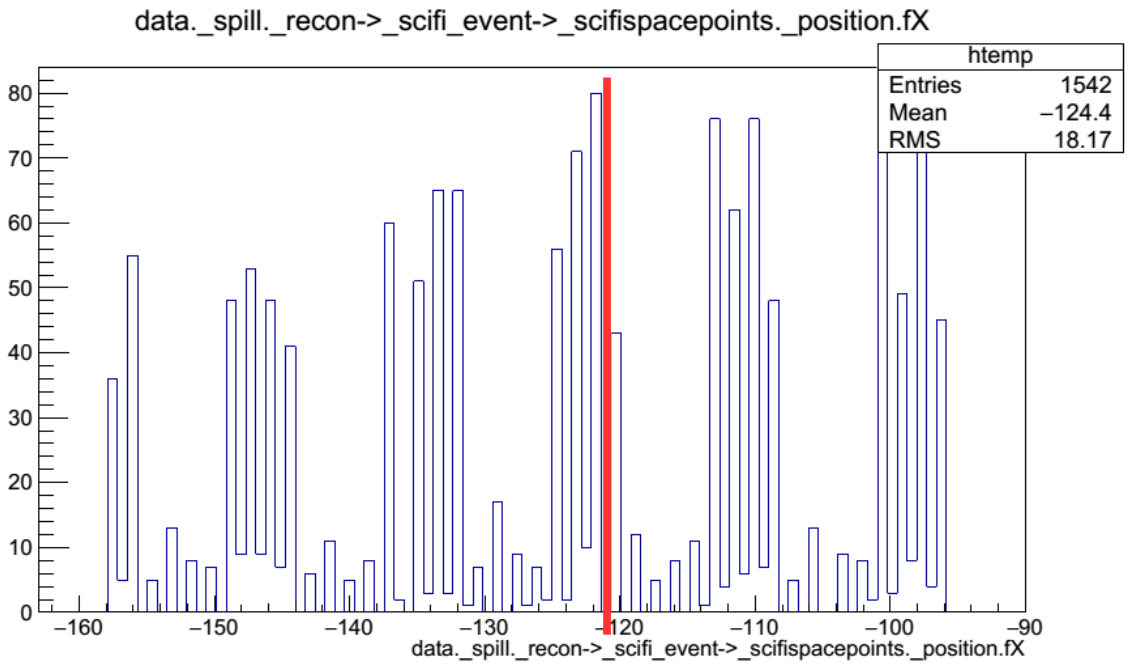
$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \alpha_2 \\ \frac{\alpha_1 - \alpha_2 \, s_{11}}{s_{12}} \end{pmatrix}$$

Single Bulkhead Test

- All bulkhead connectors but one disconnected
  - Bulkhead 2
- Expect to find doublet space points over small area

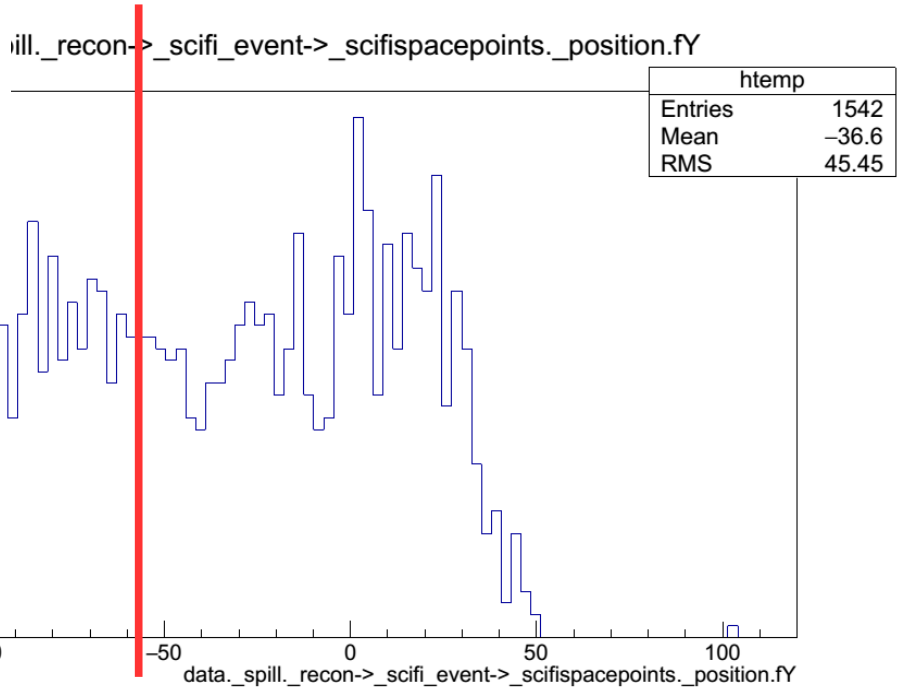


Run 4798 Upstream Bulkhead Connector 2 On, Everything Else Off



V-plane channels: 128 – 213
V-rotation: 120
X-plane channels: 0 – 48
X-rotation: 0

X values clearly negative, Y values run from about -120 to 50 mm



Take middle channels x:24 and v:180
a1 = 109.85 a2 = -121.80

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} -121.80 \\ \dfrac{109.85 - (-121.80)\,(-1/2)}{-\sqrt{3}/2} \end{pmatrix}$$

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} -121.8 \\ -56.52 \end{pmatrix}$$

Space Point Reconstruction

- What happens when we make a mistake?
  - Only two things inputs.
    - φ the direction of rotation
    - α_1 direction along the plane
  - (x',y') and (α',β') denote actual positions.
  - (x,y) and (α,β) denote measured positions
- First Case: The coordinate system is reversed: α = -α'

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} -\alpha_2' \\ \dfrac{-\alpha_1' + \alpha_2' \, s_{11}}{s_{12}} \end{pmatrix}$$

$$\begin{pmatrix} x \\ y \end{pmatrix} = -\begin{pmatrix} x' \\ y' \end{pmatrix}$$

- Second: Planes are rotated reversed: φ = -φ'

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \alpha_2' \\ \dfrac{\alpha_1' - \alpha_2' \, s_{11}}{-s_{12}} \end{pmatrix}$$

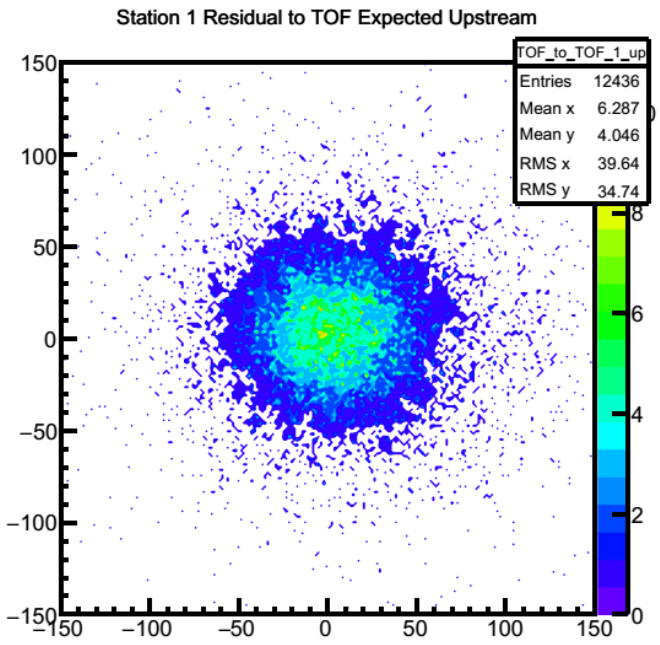
$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} x' \\ -y' \end{pmatrix}$$

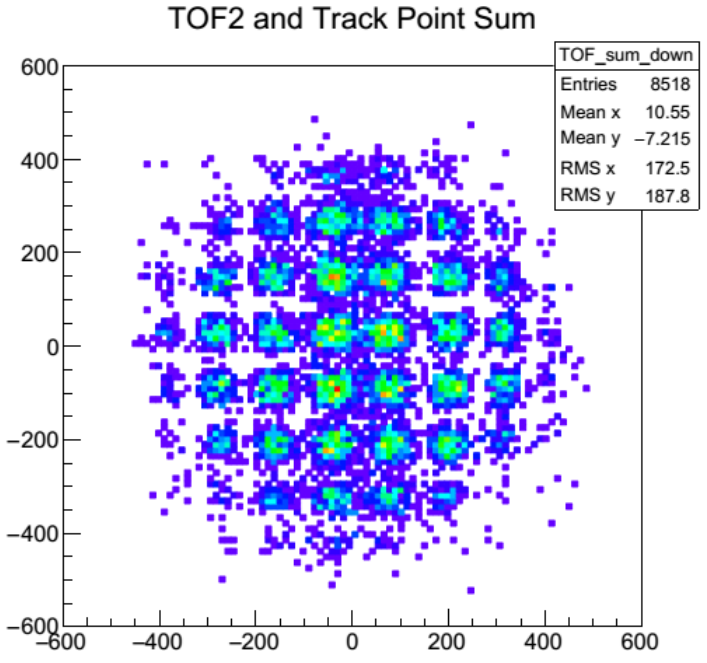
Solution

- How can we then get a flip in x in data?
  - An error in counting direction flips x and y
  - An error in rotations corrects the flip in y
  - Leaves just a flip in x!
- How can we then get a flip in y in MC?
  - An error in rotations flips the y
- How do these two differ?
  - Same reconstruction (α)
  - Different geometries (φ, fiber placement)

Solution

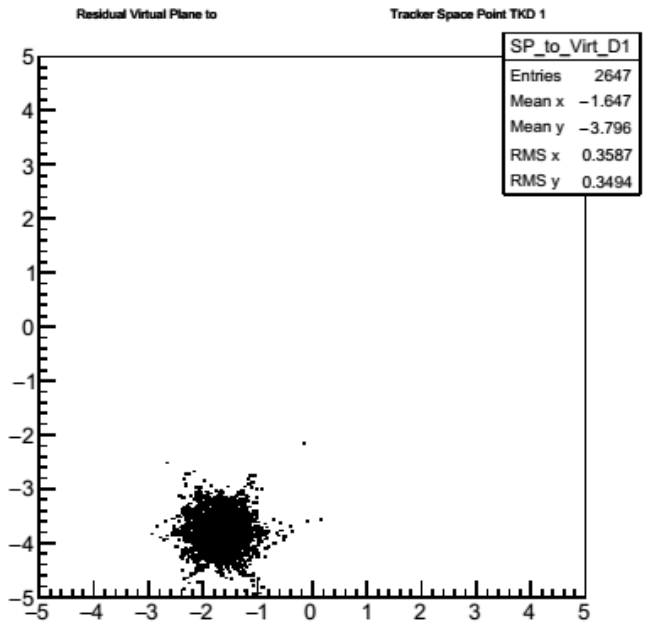
- Change in fiber ordering in MC
  - Fibers entered incorrectly!
- Change α in reconstruction
  - Documented and implemented incorrectly!
- Change simulation geometry from reconstruction geometry
  - Active v passive rotations

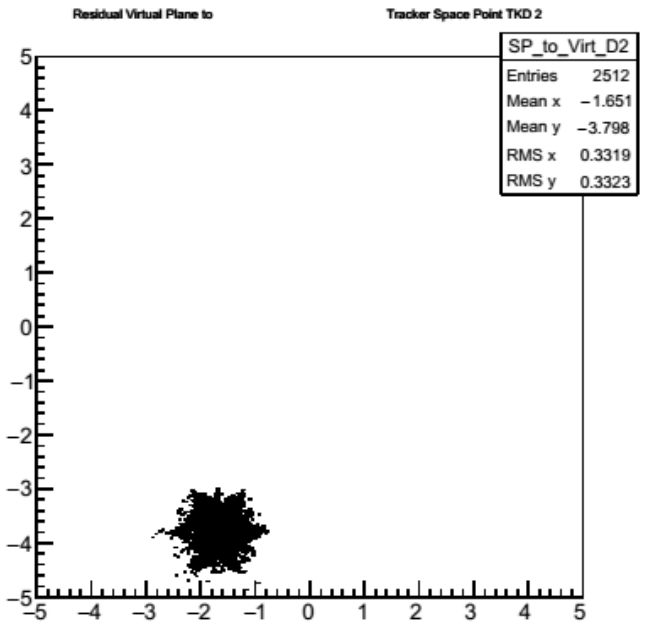


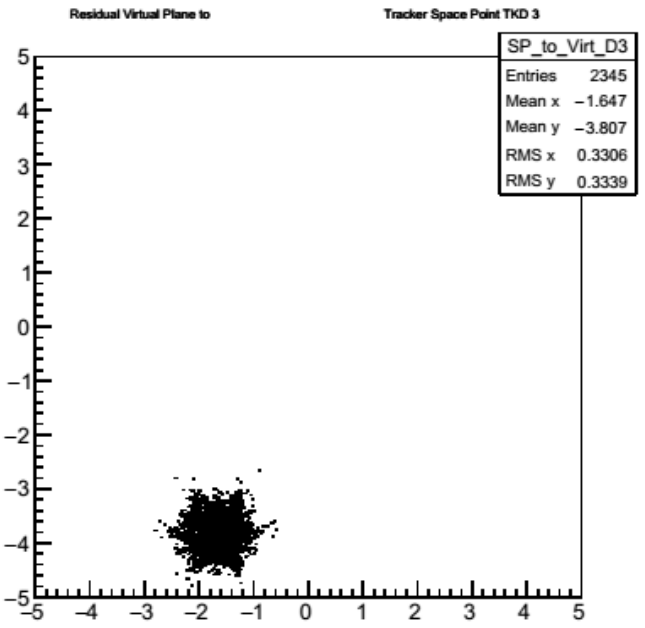


Finishing Up: Slide Problem

- Survey added to geometry
  - Addition of angular position of tracker
- Two geometries didn't match
  - Simulation: Tracker in solenoid reference frame
  - Reconstruction: Tracker in global reference frame

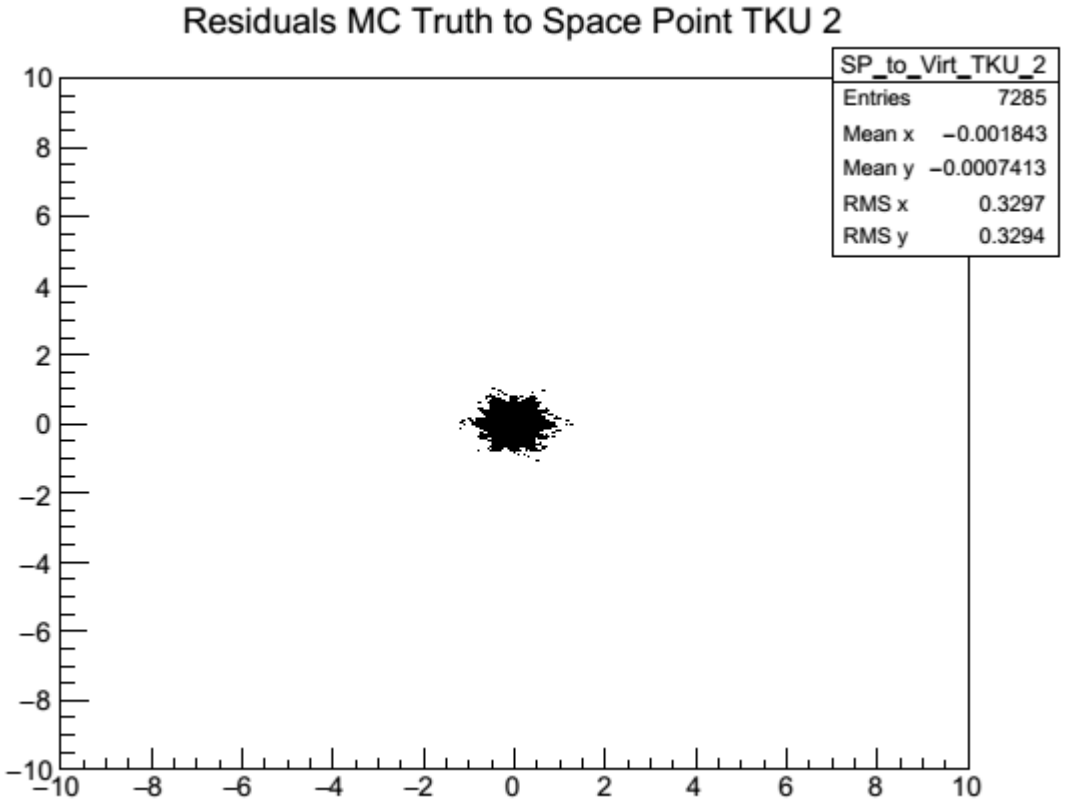






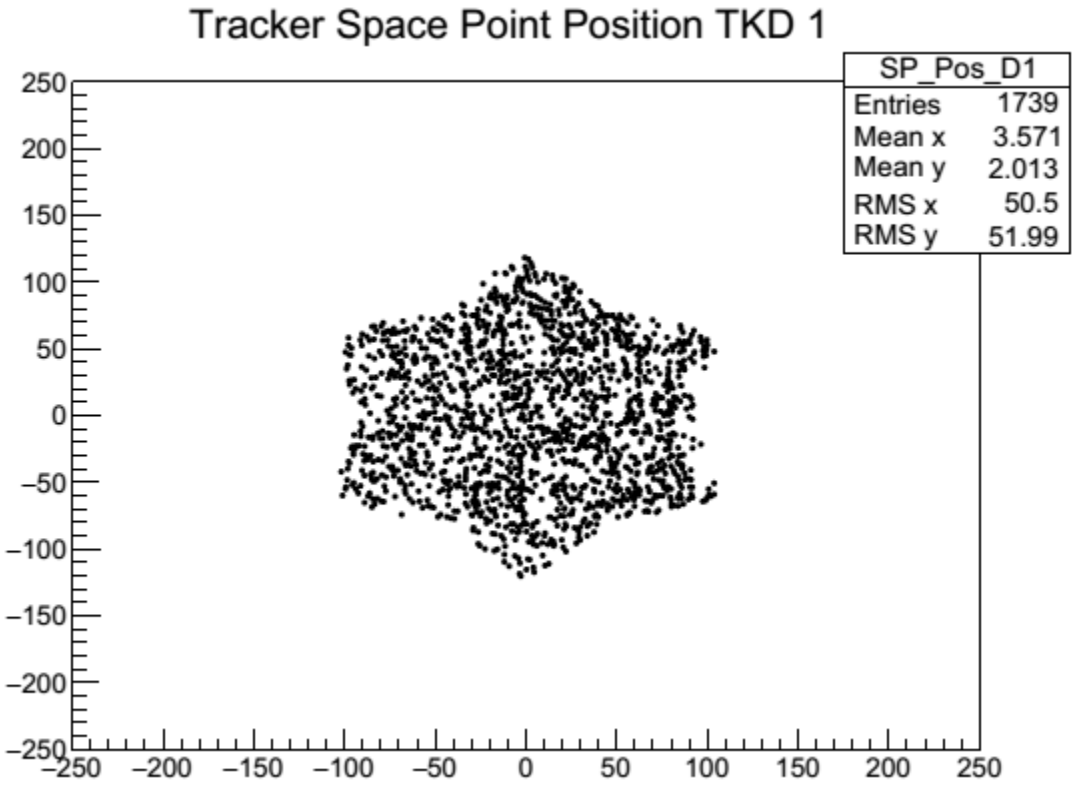
Finishing Up: Slide Problem

- Offset due to active v passive rotation problem
  - Again
  - This time in tracker rotations not plane rotations
- Made the decision to write everything in terms of passive rotations
  - Geometry helper sits between geometry and reconstruction to translate between the two.



Finishing Up: Star Problem

- Redefined MC fiber placement
  - Previously: Fibers placed from one end of plane area to other
  - Now: Central fiber placed and correct number of fibers placed on each side of plane
- Star problem arose from entering half length of fibers
  - Easily corrected



Conclusion

- Good agreement between:
  - TOF to tracker space points
  - Tracker to TOF space points
  - Reconstruction and Truth
- Survey results in geometry
- Tracker to tracker analysis done
- Station to station analysis being handled by:
  - Chris Hunt (Kalman)
  - John Nugent (Millipede)
  - Chris Heidt (space points)