Tracker Channel Flip

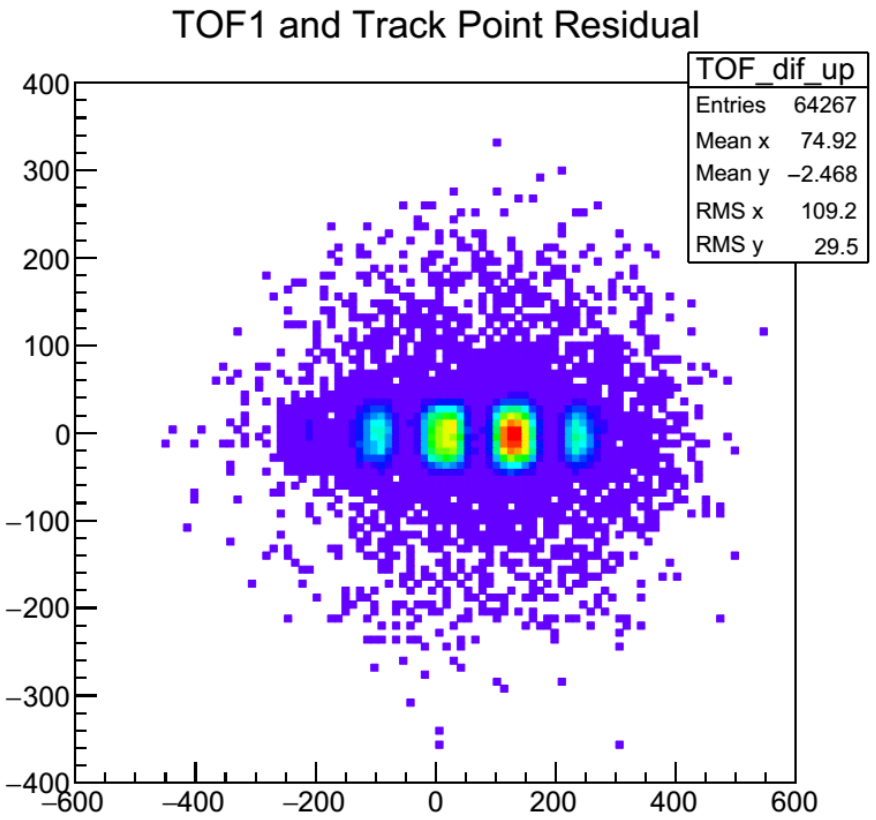
or

How we got our left and right mixed up and how to solve it(?).

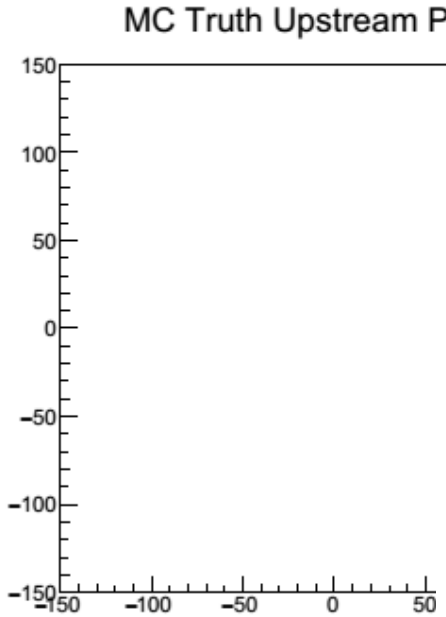
Chris Heidt

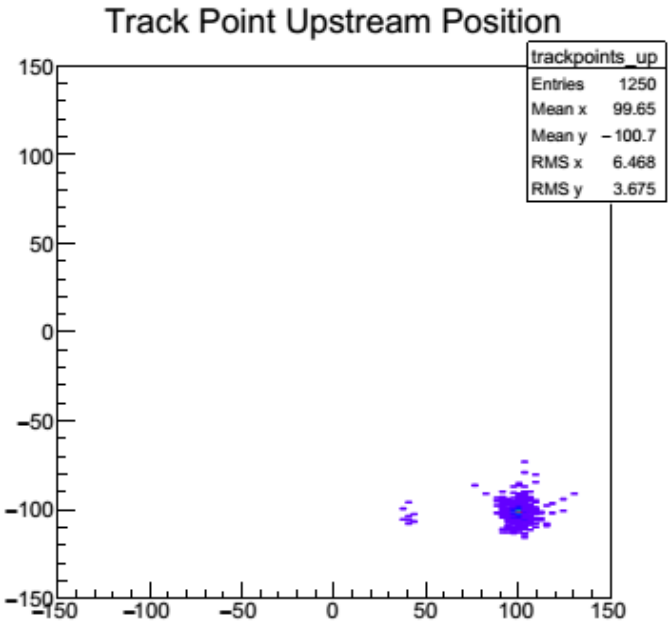
The Problem

X-Flip in Data



Y-Flip in MC



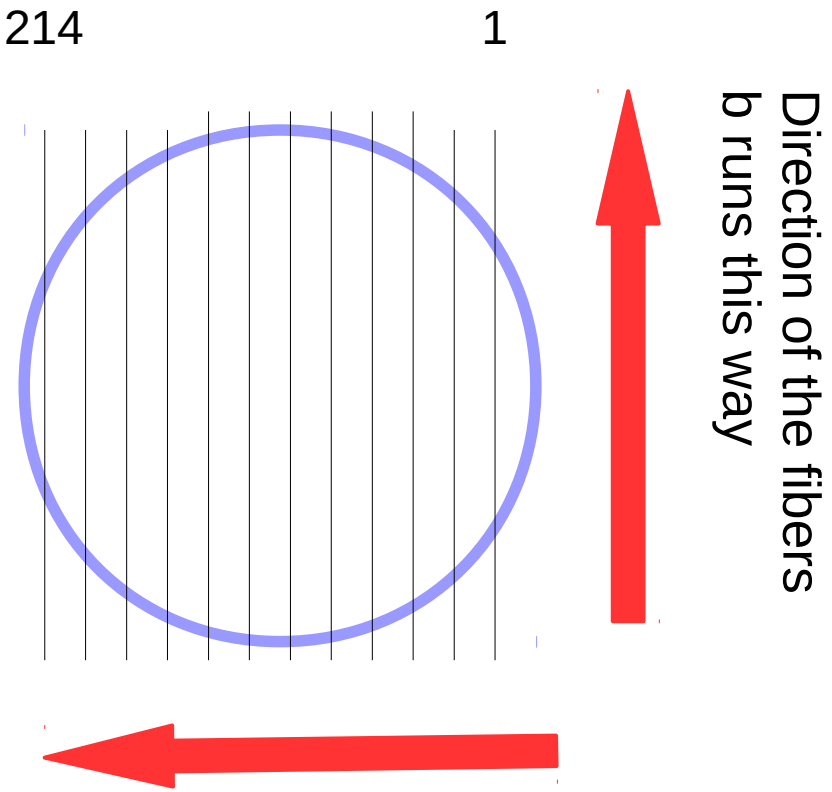


Spacepoint Reconstruction

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

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

$$\begin{pmatrix} x \\ y \end{pmatrix} = R \begin{pmatrix} a \\ b \end{pmatrix}$$



Runs from channel 1 to 214(212)
Increases in a, central fiber is a = 0

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

Direction of plane coordinate as described in reconstruction

Spacepoint Reconstruction

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

$$R_\varphi \begin{pmatrix} a_1 \\ b_1 \end{pmatrix} = \begin{pmatrix} x \\ y \end{pmatrix} = R_\theta \begin{pmatrix} a_2 \\ b_2 \end{pmatrix}$$

$$\begin{pmatrix} a_1 \\ b_1 \end{pmatrix} = R_\varphi^{-1}\, R_\theta \begin{pmatrix} a_2 \\ b_2 \end{pmatrix}$$

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

- Coefficients take on the values
  - Going in order of increasing angle
    0-> 120-> -120(240)-> 0

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

  - Going in the other direction
    0-> -120-> 120(-240)-> 0

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

Spacepoint Reconstruction

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

$$b_2 = \frac{a_1 - a_2\, s_{11}}{s_{12}}$$

$$b_1 = a_2\, r_{21} + b_2\, r_{22}$$

- As you would expect the problem is ***symmetric*** in that the order of planes you choose does not effect the final result.

- 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.

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} a_2 \\ \frac{a_1 - a_2\, s_{11}}{s_{12}} \end{pmatrix}$$

- If you are having trouble accepting that we can only solve this relation and get meaningful results, ***I invite you to check the math yourself!*** I could use the double check.

Spacepoint Reconstruction

- What happens when we make a mistake?
  - Only two things inputs.
    - The direction of a_1 or the direction of theta
  - (x',y') and (a',b') will be the actual positions. (x,y) and (a,b) will be the measured positions
- First: The coordinate system goes one way and 'a' goes the other way: a = -a'

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} -a_2' \\ \dfrac{-a_1' + a_2' s_{11}}{s_{12}} \end{pmatrix}$$

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

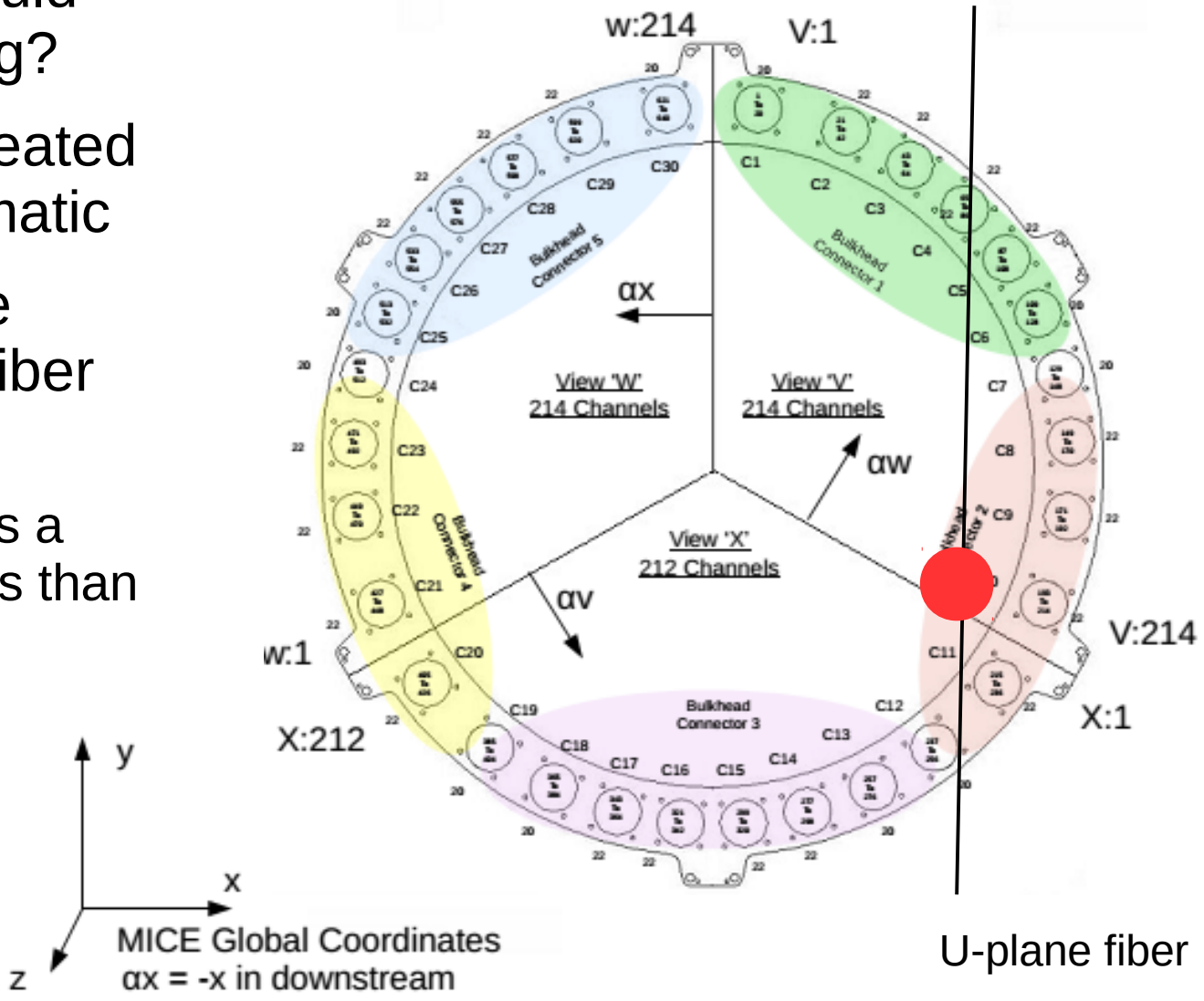
- Second: Planes are rotated clockwise but reconstructed anti-clockwise

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} a_2' \\ \dfrac{a_1' - a_2' s_{11}}{-s_{12}} \end{pmatrix}$$

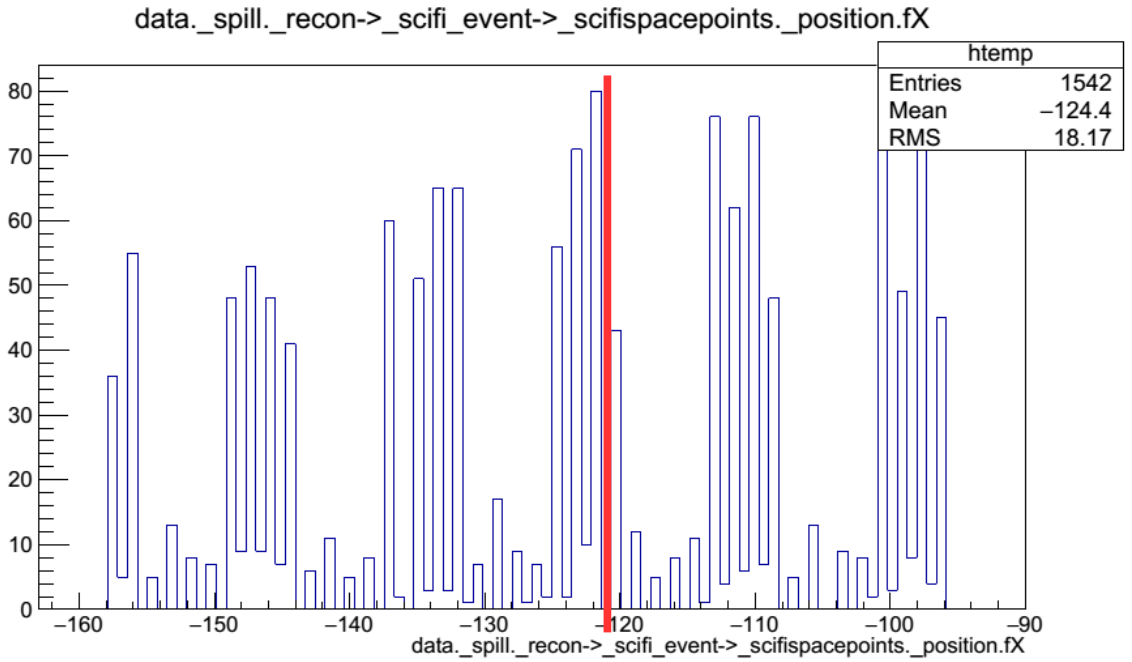
$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} x' \\ -y' \end{pmatrix}$$

Plane Direction

- What direction should the planes be going?
- The drawing Ed created from Geoff's schematic
- Example, a particle passes through a fiber in the x-plane
  - In the u-plane it hits a fiber numbered less than the central fiber (< 105.5)
  - We would expect a positive space point to be reconstructed.

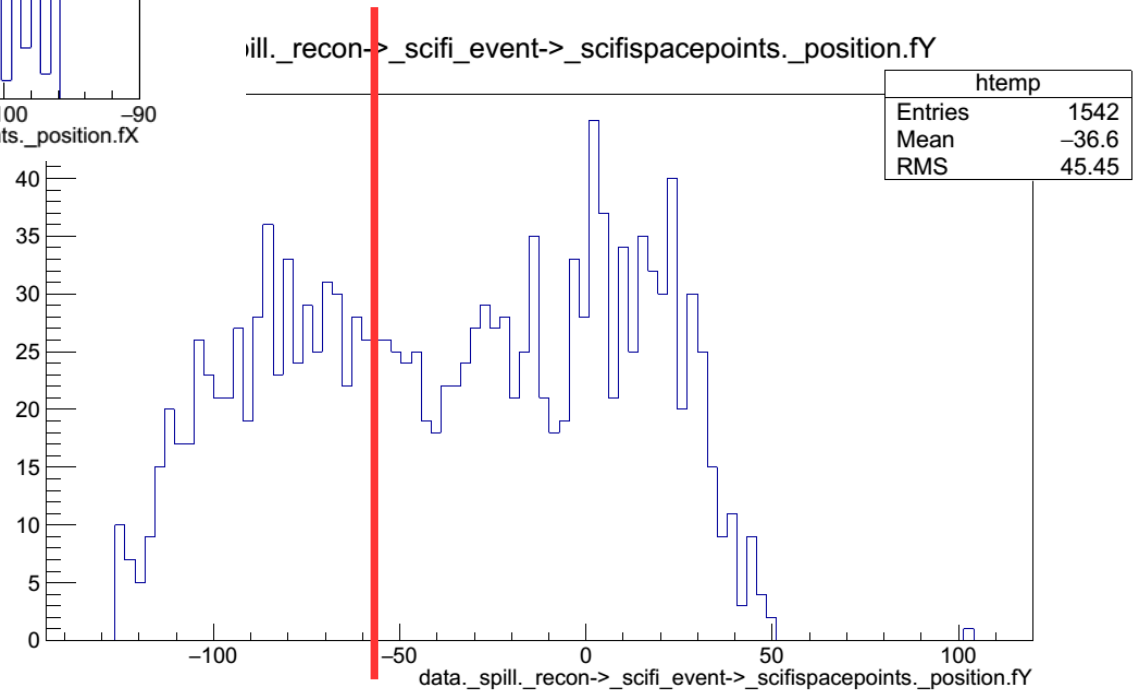


Run 4798 Upstream Bulkhead Connector On, Everything Else Off



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

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



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

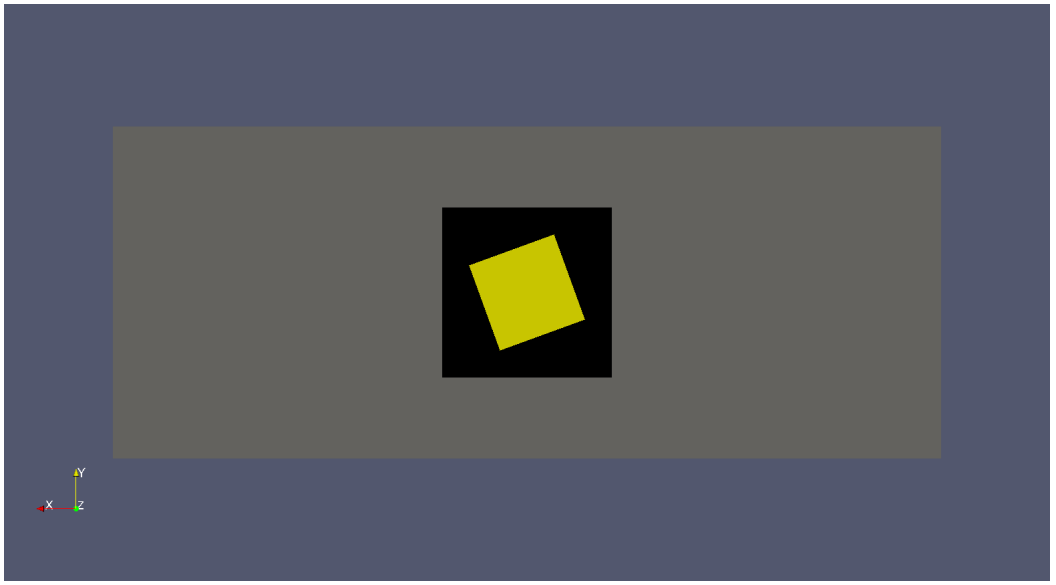
$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} -121.80 \\ \dfrac{109.85 - (-121.80)(-1/2)}{-\sqrt{3}/2} \end{pmatrix}$$

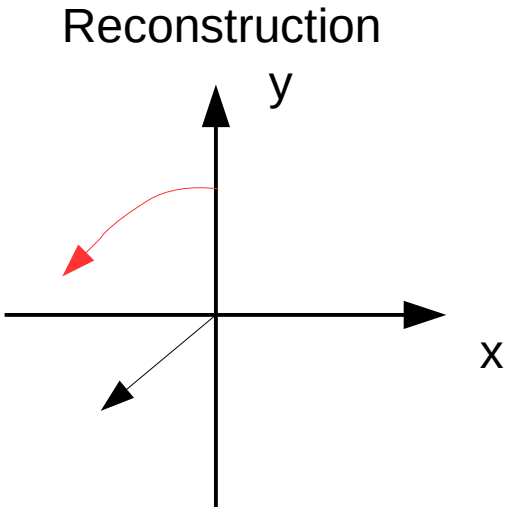
$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} -121.8 \\ -56.52 \end{pmatrix}$$

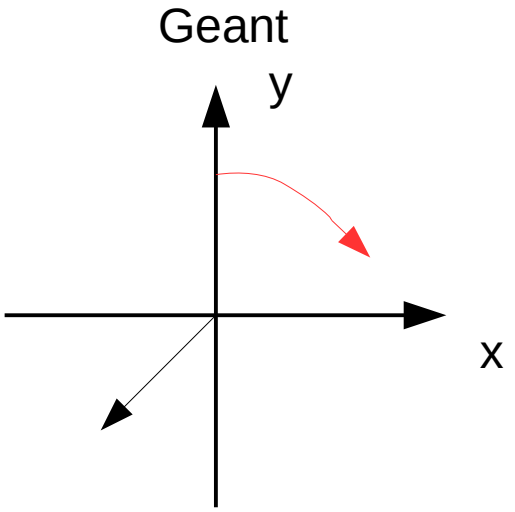
Why do we see a Y-flip in MC

- Reconstruction and Geant handle the angle of rotation differently. In general a positive rotation is defined as pointing from +x-axis to +y-axis. Geant rotates in a counter direction

Yellow box is rotated +20 about the y-axis
z-axis is into the page







Not enough Time

- Loads of MC results to be talked about face-to-face.
- A little code review.