Gem Tracking Update

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Resolving Single Hits

Single hits are able to be resolved by finding the centroid using the weighted integral.

$$C = \frac{\sum i \cdot s_i}{\sum s_i}$$

C is the centroid, s is signal, and i is channel number.

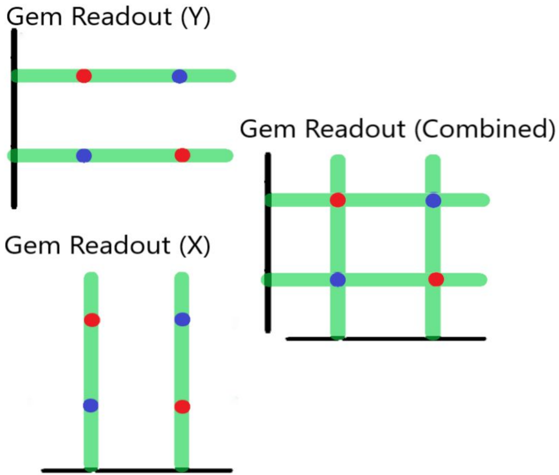
The uncertainty in the centroid is propagated based off of the uncertainty in the signal in any given channel (assumed to be a constant).

$$\frac{\delta C}{C} = \sqrt{\left(\frac{\delta \sum i \cdot s_i}{\sum i \cdot s_i}\right)^2 + \left(\frac{\delta \sum s_i}{\sum s_i}\right)^2}$$

Resolving Multiple Hits

- GEMs output 2 1 dimensional datasets
  - This allows ambiguities when 2+ hits register in the same trigger.
  - In the below figure, whether the two hits were the red ones or blue ones is ambiguous.
- We resolve this based off of Tao's analysis:
  - There is a strong correlation between energy deposited in the X strips and energy deposited in the Y strips

Therefore, peak height and integral should be similar for correlated hits.



Resolving Tracks

Unfortunately, energy deposited in any GEM is independent of energy deposited in a different GEM for the same particle

To resolve this ambiguity, we use geometric constraints and check if the track is a straight line within uncertainty

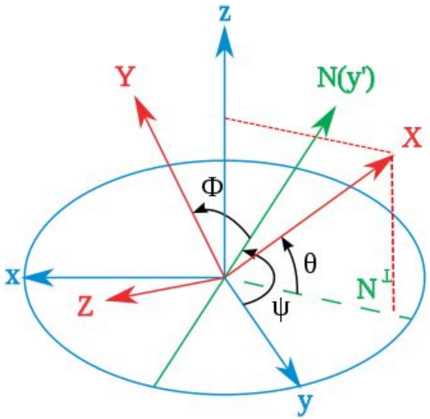
When there are multiple hits, if any track resolution is ambiguous (i.e. any hit can be a part of two physically possible tracks) discard the data

Offsets

Offsets are read from a file containing 36 data points-- 3 translations per GEM, 3 rotations per GEM, and their 6 uncertainties.

Rotation offsets are applied first and use Tait-Bryan angles (ZYX)

In order to keep the axis of rotation at the GEM's center, translations are applied afterward.



Propagating uncertainty

Uncertainty is introduced in finding the centroid and applying the offsets.

It is propagated through the relevant rotation matrix using the formula below

$$Z_1Y_2X_3 = \begin{bmatrix} c_1c_2 & c_1s_2s_3 - c_3s_1 & s_1s_3 + c_1c_3s_2 \\ c_2s_1 & c_1c_3 + s_1s_2s_3 & c_3s_1s_2 - c_1s_3 \\ -s_2 & c_2s_3 & c_2c_3 \end{bmatrix}$$

$$\delta q = \sqrt{\left(\frac{\partial q}{\partial x}\delta x\right)^2 + \ldots + \left(\frac{\partial q}{\partial z}\delta z\right)^2}$$

Propagated uncertainty

Uncertainty in rotation seems to be linear for small angles and relatively small

Rotational Uncertainty (about all axes)	Max Uncertainty Contribution
0.1°	0.12mm
0.5°	0.6mm
1°	1.2mm

Therefore, for small rotational uncertainties, translational uncertainty dominates the track uncertainty.

As Z should be measured to a higher precision, track uncertainty is limited primarily by XY translation uncertainties.