35t/FD Sim, Reco and Analysis

Counter Alignment and Unique t_0 Update

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October 21, 2015

Topics to discuss.

- Improvements to the straight line track fitter.
- Results of the counter alignment study with complete error propagation.
- Inclusion of photon detector times to the alignment study.

The straight line fitter.

Original algorythm:

- For $p_0, p_1, p_2, p_3, p_4, p_5 \in \mathbb{R}$ and N spacepoints in the track.

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} p_0 \\ p_2 \\ p_4 \end{pmatrix} + t \begin{pmatrix} p_1 \\ p_3 \\ p_5 \end{pmatrix}$$

$$\frac{x - p_0}{p_1} = \frac{y - p_2}{p_3} = \frac{z - p_4}{p_5} \quad \Longrightarrow \quad \kappa^2(p_0, p_1, p_2, p_3, p_4, p_5) = \frac{1}{N\sigma^2} \sum_{\text{points}}^{N} d^2$$

$$\sigma^2 = \sigma_{\text{x}}^2 + \sigma_{\text{yz}}^2 \quad , \quad \sigma_{\text{x}} = 0.4\text{cm} \quad , \quad \sigma_{\text{yz}} = 0.3\text{cm}$$

New algorythm:

- Rather than choosing an arbitrary point (p_0, p_2, p_4) on the line, instead consider the point at which the line crosses the plane $z = 0$. Allows us to take $p_4 = 0$.
- Walk up and down the line by chosing different values of t, meaning we are completely free to scale vector (p_1, p_3, p_5). Dividing through by p_5 and relabeling leaves $(p_1, p_3, 1)$.

$$\kappa^2(p_0, p_1, p_2, p_3, p_4, p_5) \rightarrow \kappa^2(p_0, p_1, p_2, p_3)$$

Propagation of errors in extrapolation.

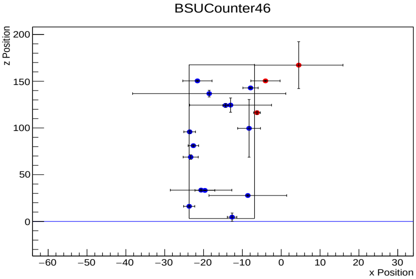
- Assume that we know the position of the counter in the plane of the counter. For example the roof of the cryostat is constant y, we say therefore there is no error in the BSU y position.
- **To calculate the error in the x coordinate of counter at y position $\mathbf{y_c}$.**

$$x = p_0 \ + \ tp_1 \quad , \quad t = \frac{y_c \ - \ p_2}{p_3} \qquad \Longrightarrow \qquad x = x(p_0, p_1, p_2, p_3)$$

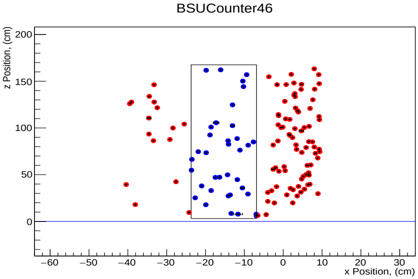
- **Therefore:**

$${\sigma_x}^2 = \left(\frac{\partial x}{\partial p_a}\right)^2 {\sigma_{p_a}}^2 + \left(\frac{\partial x}{\partial p_a}\right)\left(\frac{\partial x}{\partial p_b}\right) \mathrm{cov}_{ab}$$

Counter in the 6 parameter formalism.

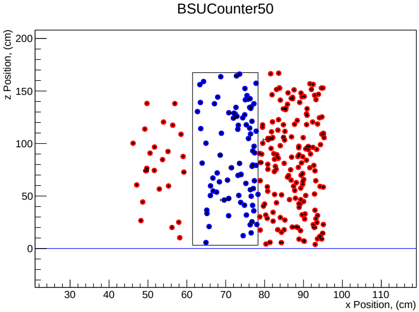


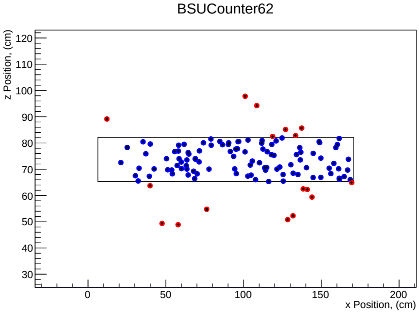
Counter in the 4 parameter formalism.

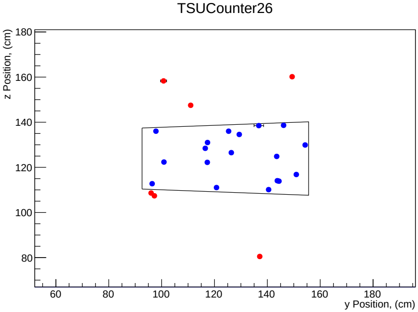


- Rewriting the equation for TMinuit to minimise in this way has greatly reduced the size of most error bars.
- Having problems with large error in y and z when dealing with the TSUs.

Counter Alignment, $\kappa^2 \leq 0.1$



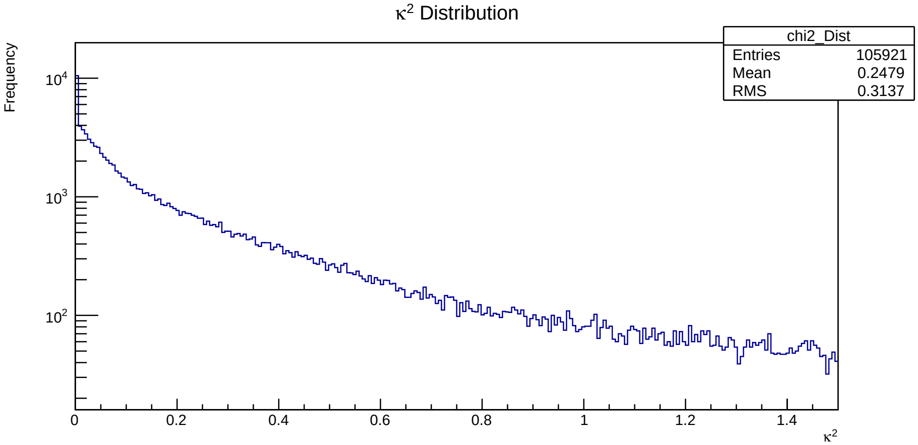




Blue points represent tracks which have a t_0 corresponding to the same counter as the track extrapolates to.

Red points represent tracks which have a t_0 corresponding to the counter shown in the plot, but extrapolate to a region nearby and whose error falls within a counter width either side of the counter. This assumes we know the position towithin a counter width.

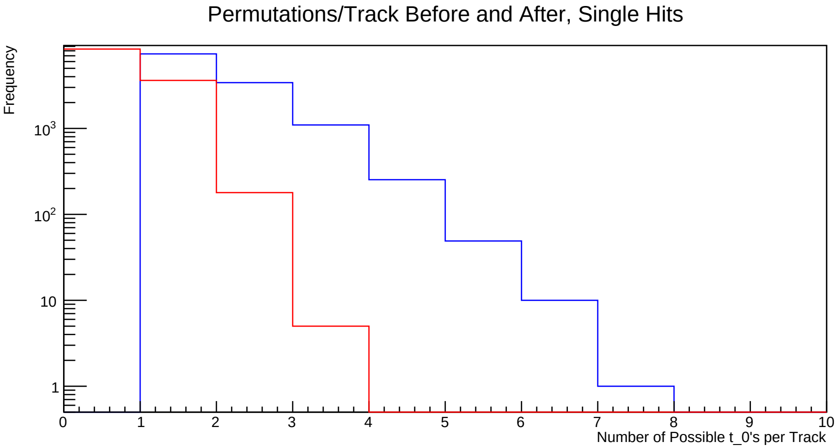
κ^2 Distribution



- The full κ^2 distribution contains 133300 tracks.
- Around 30000 tracks pass the κ^2 cut of 0.1.

Using error bars to extract a unique t_0.

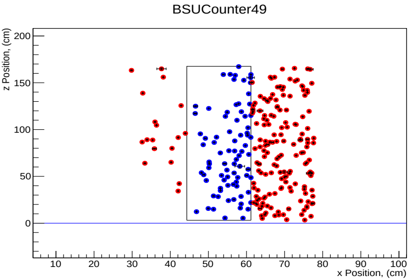
- Enforcing that the entirety of a track be within the physical volume of the TPC, is not a strong enough constraint to determine a unique t_0 for that track.
- Blue represents number of possible t_0's/track with only this restriction.



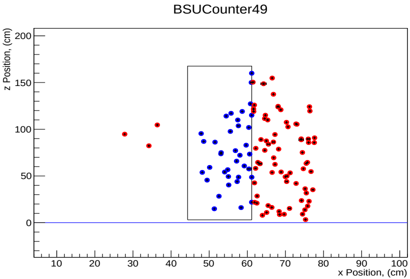
- We enforce that for a given t_0 and associated counter trip, the track must extrapolate to that same tripped counter within one counter width, allowing for the error bars.
- Red represents number of possible t_0 after making this cut.
- Any tracks with more than one t_0 after this point are simply cut from the alignment plots.

Requiring coincidences.

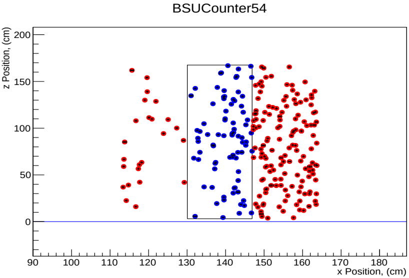
Single hits.



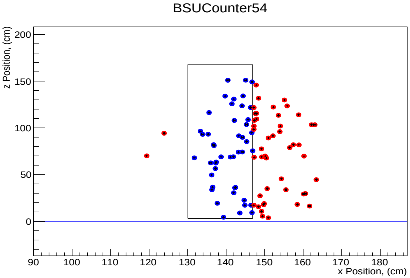
Just coincidences.



Single hits.



Just coincidences.



Inclusion of the photon detectors.

- The end goal of the counter alignment study was to support a method to monitor the efficiecy of the external counters, as the 35 ton is run.
- To do this, the physical x position of a straight line track is obtained using the photon counter times. The line is then extrapolated outwards towards the counters. If a counter is extrapolated to, we can check back through the event window to see whether there was a trigger in that counter.
- Can then look at how many triggers are suggested by the photon counters, opposed to how many triggers there actually were.
- Using trees made by Karl Warburton with these photon detector times included, the code currently extrapolates with these times and associates possible triggers. Nothing yet has been written to compare these possible triggers with the triggers from the external counter study.
- Would like to compare the parameters found by the straight line fitter with the Monte Carlo information. Using the Monte Carlo start position and momentum to draw a straight line track.