
SIMP KF Track Isolation Cut

First Look

Alic Spellman

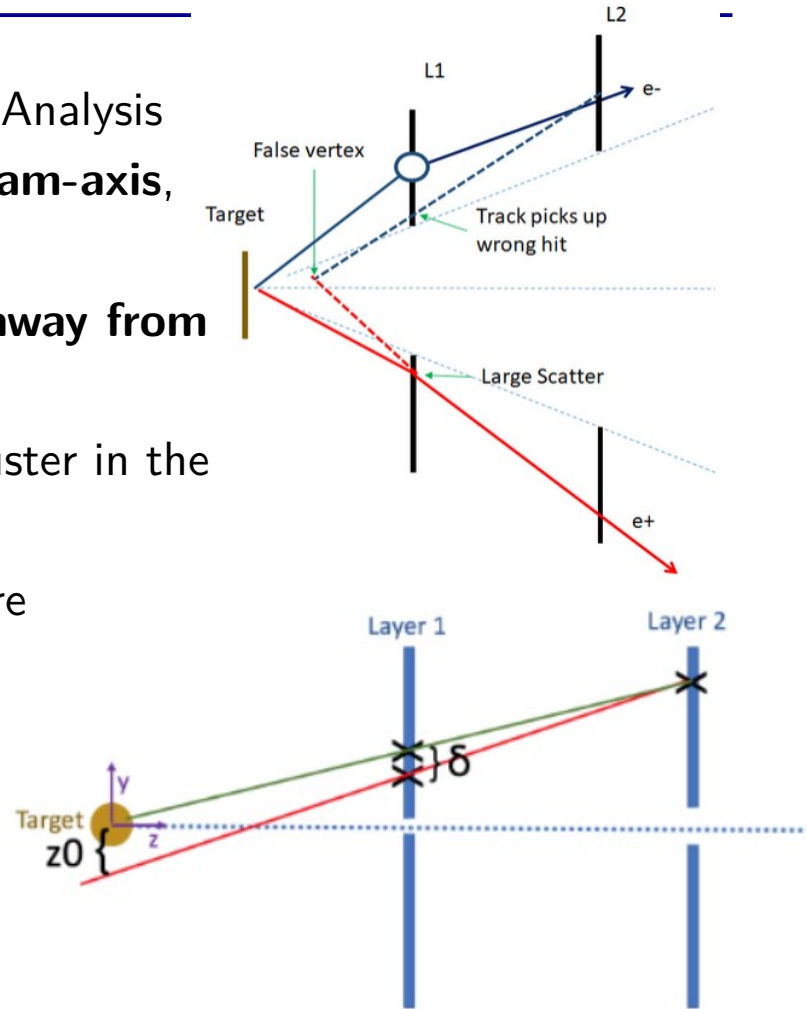
06/26/2023



Isolation Cut

- Matt S. developed Isolation Cut for 2016 Displaced Vertex Analysis
- If Track picks up wrong hit in L1 **that is closer to the beam-axis**, can falsely pull reconstructed vertex downstream
- 'Isolation' value δ is distance of next closest hit on sensor **away from beam-axis**
- Take Track, get L1 hit, check if there's an alternative SiCluster in the event that could have ended up in the Track
- If Track uses alternative L1 SiCluster instead, is Vertex more consistent with prompt event?
- Use geometric relationship between δ and z_0 (instead of refitting)

$$\delta + \frac{1}{2} z_0_{corr} > 0$$

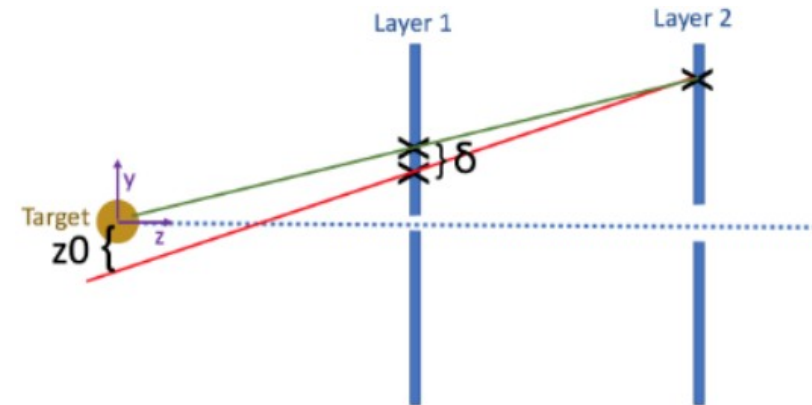
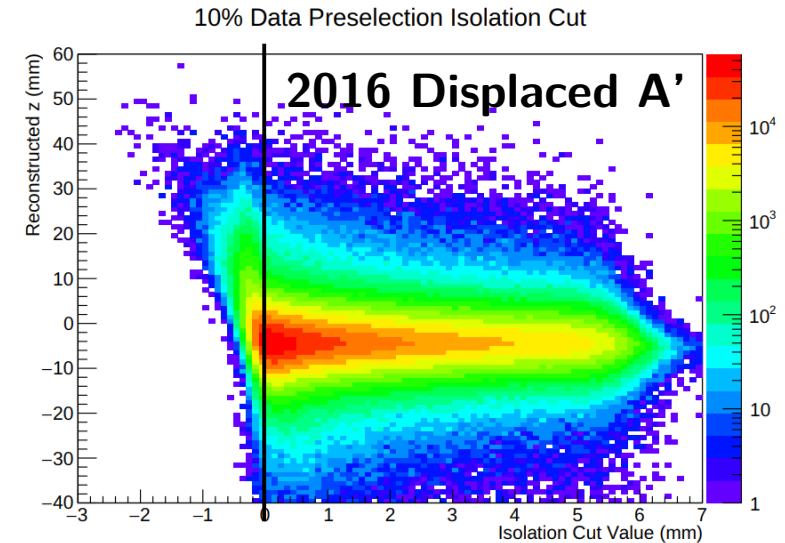


Isolation Cut

- Cut requires Z0 track parameter at Target
 - Added KF TrackState at target to hps-java
- Also uses Z0 error to account for multiple scattering
 - Added covariance extrapolation to target TrackState in hps-java
- 2016 Isolation Cut:

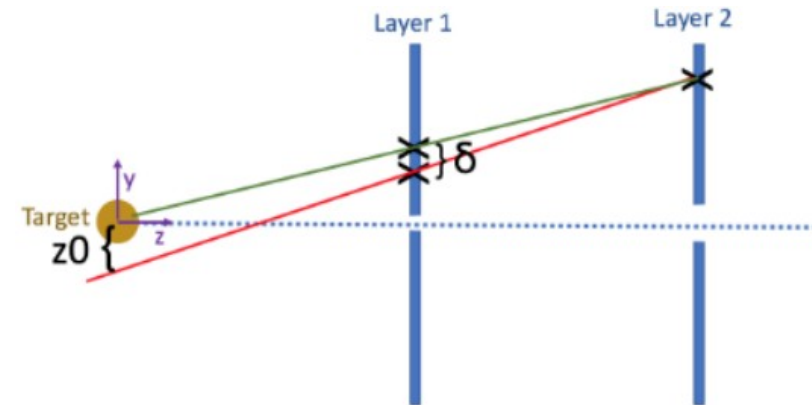
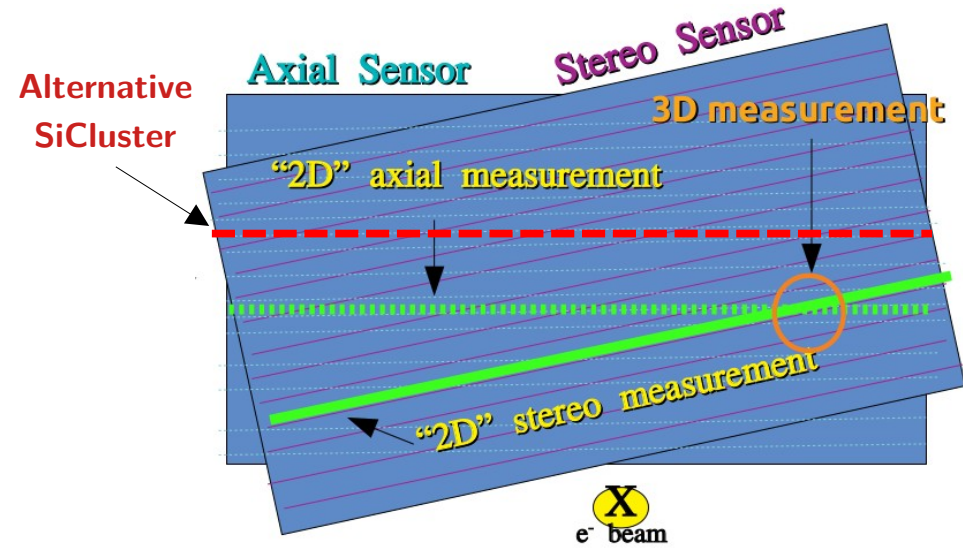
$$\delta + \frac{1}{2} (z0_{corr} - n_{\sigma} \Delta z0_{corr}) > 0$$

- 2016 analysis uses $n_{\text{sigma}} = 3.0$



Isolation Cut – KF Isolation Value

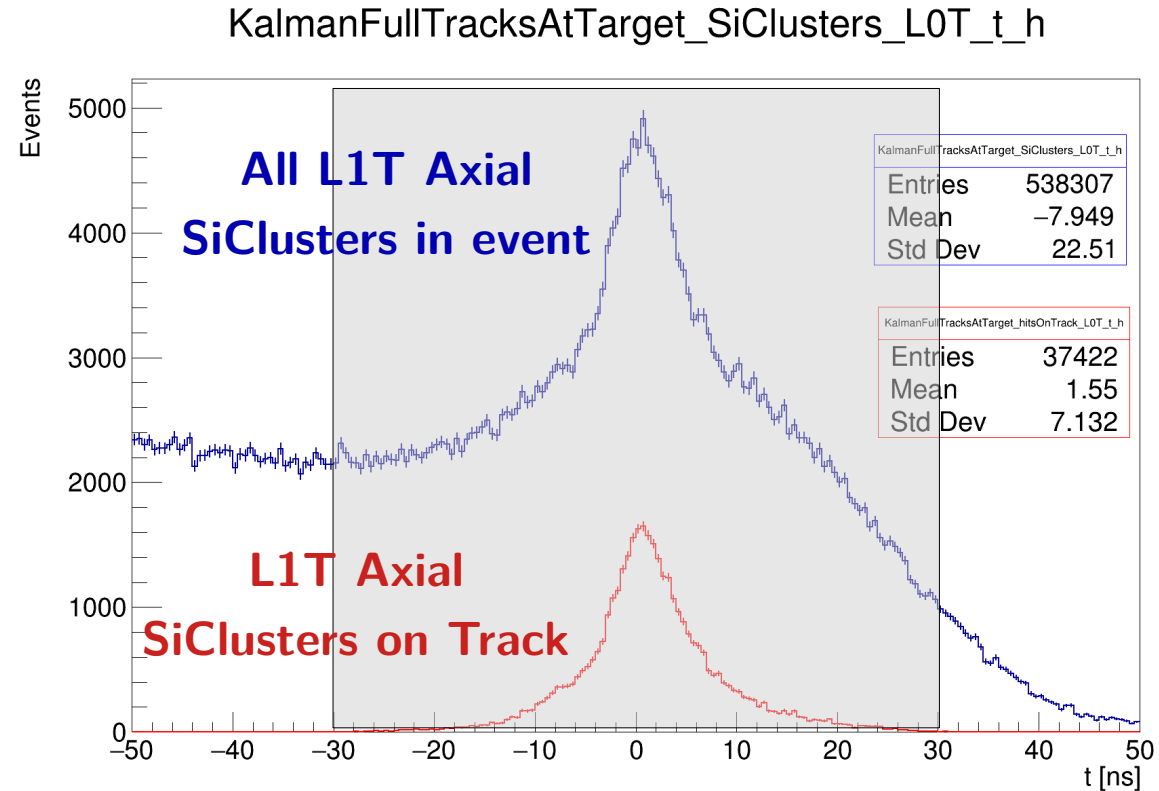
- 2016 Displaced A' use GBL Tracks (3D hits)
- **KF tracks use 2D hits**
 - Requires new calculation of 'isolation' δ
- **Axial hit determines Global Y position (Z0)**
- New KF Track Isolation:
 - Get KF track 2D SiClustersOnTrack
 - Select L1 Axial SiClusterOnTrack
 - Use SiCluster Global Y position
 - Look at all other L1 Axial SiClusters in event
 - Select alternative SiCluster to measure track 'isolation' δ
- Need to determine alternative SiCluster position/time/charge/quality constraints...



KF Track Isolation Requirements

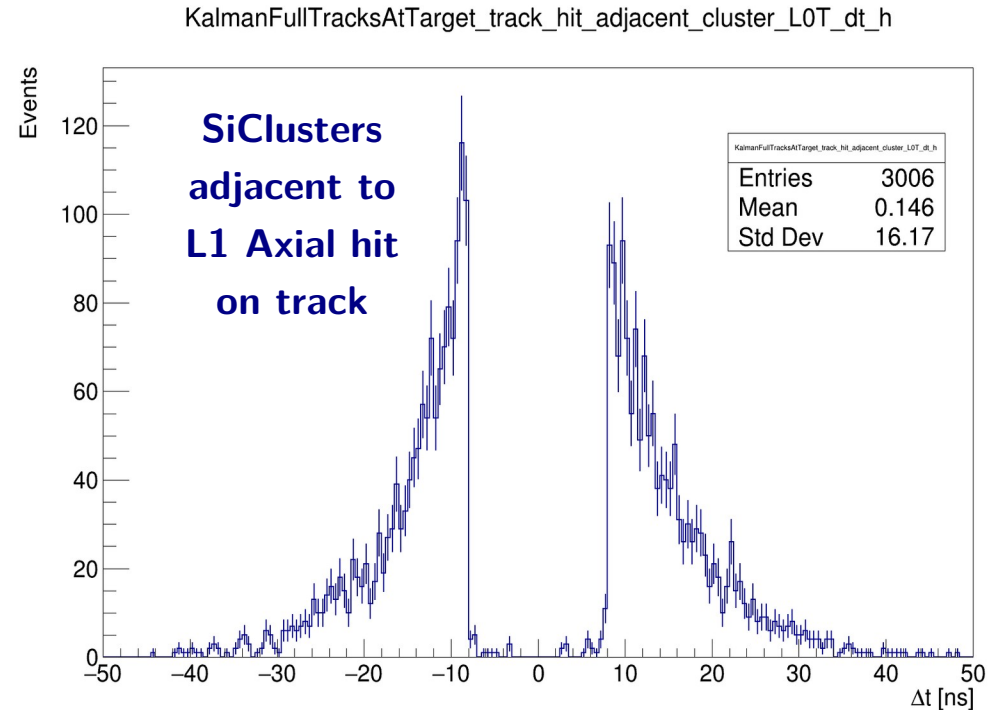
$$n \text{ 2dhits} > 9$$
$$-10 \text{ ns} < t < 10 \text{ ns}$$

- Look at SiCluster times
- Note: 'L0T' is L1T_Axial
- Apply loose time cut on potential alternative SiClusters of $\pm 30 \text{ ns}$
- **Could probably tighten this...**



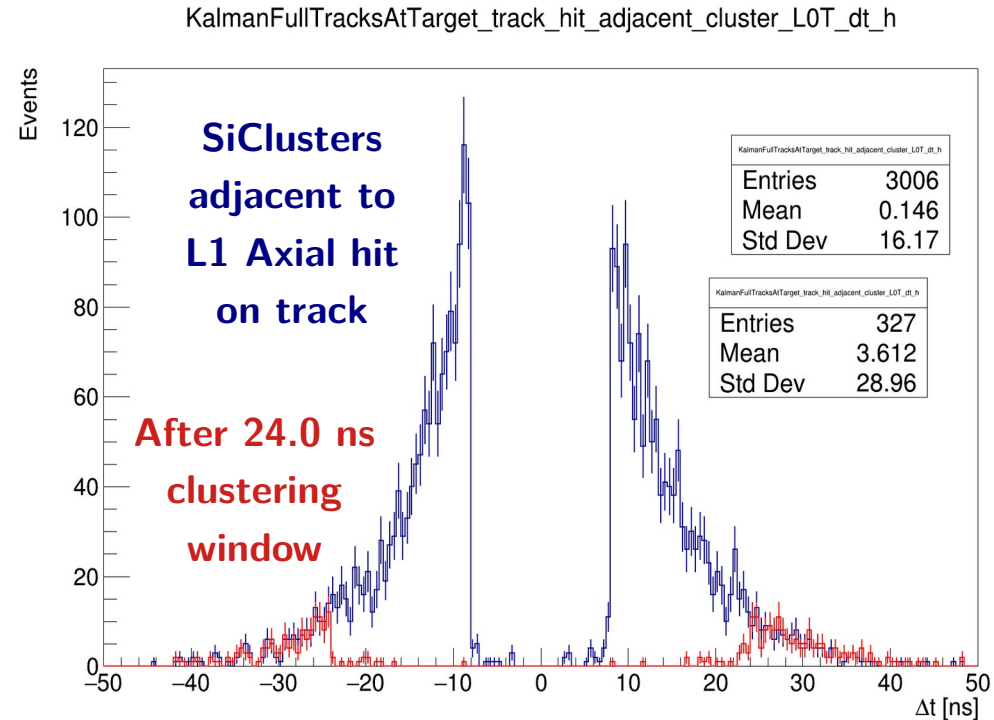
KF Track Isolation Requirements

- **Don't select 'adjacent' SiCluster as isolation hit**
 - Adjacent hit likely belongs with hit on track
- Plot shows: given SiClusterOnTrack, look for alternative SiCluster that contains **adjacent RawHit** (use RawHit strip number)
- Hit recon uses 8.0ns hit cluster time window
- Clustering time window looks like it could be larger...
- Increase recon cluster time window to 24.0 ns



KF Track Isolation Requirements

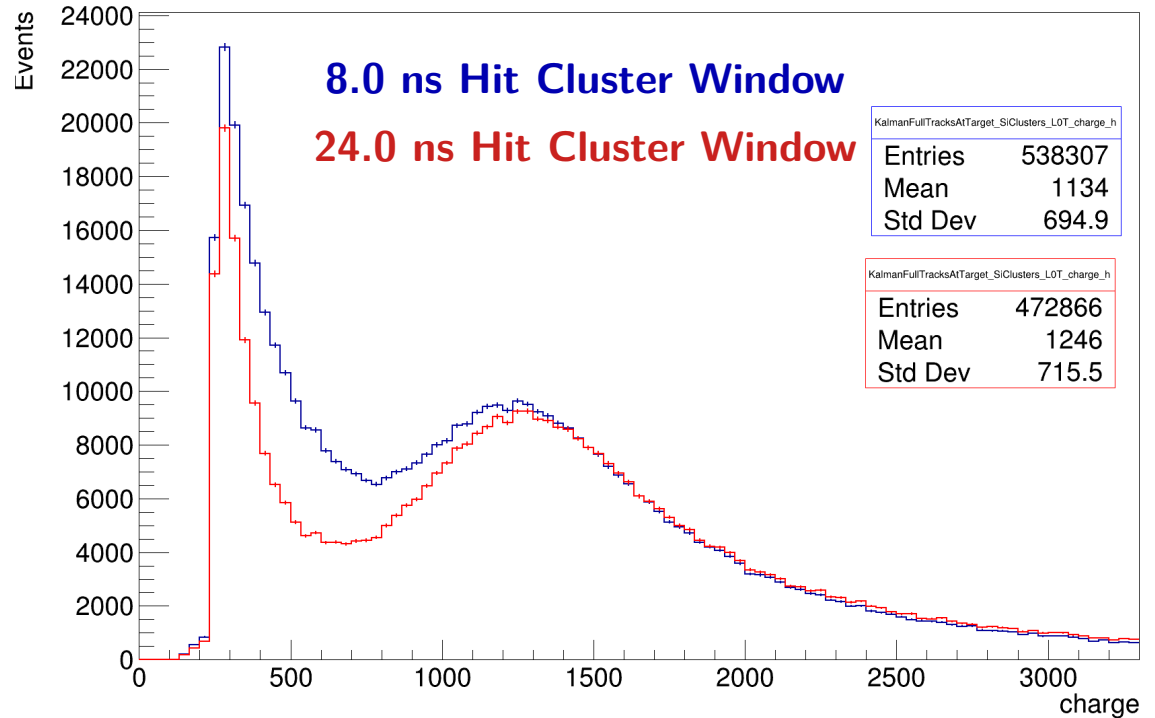
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- Hit recon uses 8.0ns hit cluster time window
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- Increase recon cluster time window to 24.0 ns
- How does this change impact Tracking and Vertexing?



8.0 to 24.0 ns Hit Cluster Window

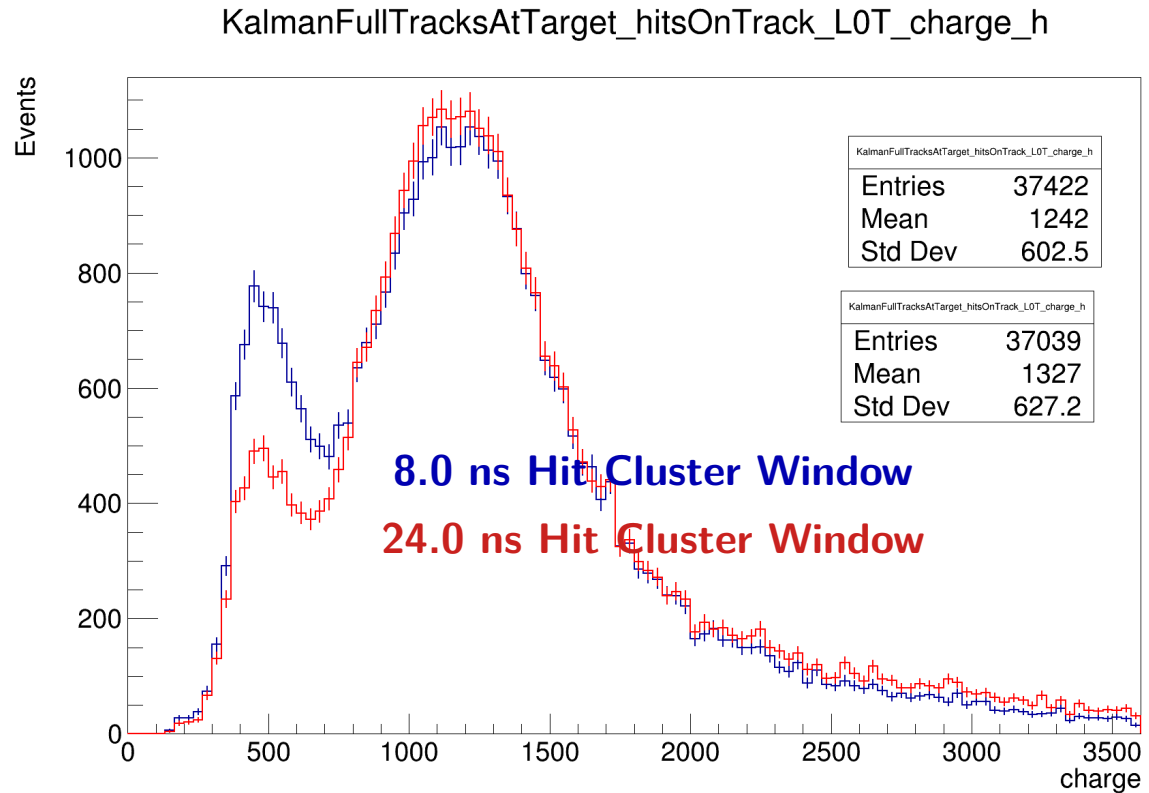
- Plot shows all SiClusters charge (for L1T Axial)
- Less SiClusters (ofc) with larger cluster window
- Better resolution between low charge (noise-ish) hits, and signal...(I think...)

KalmanFullTracksAtTarget_SiClusters_L0T_charge_h



8.0 to 24.0 ns Hit Cluster Window

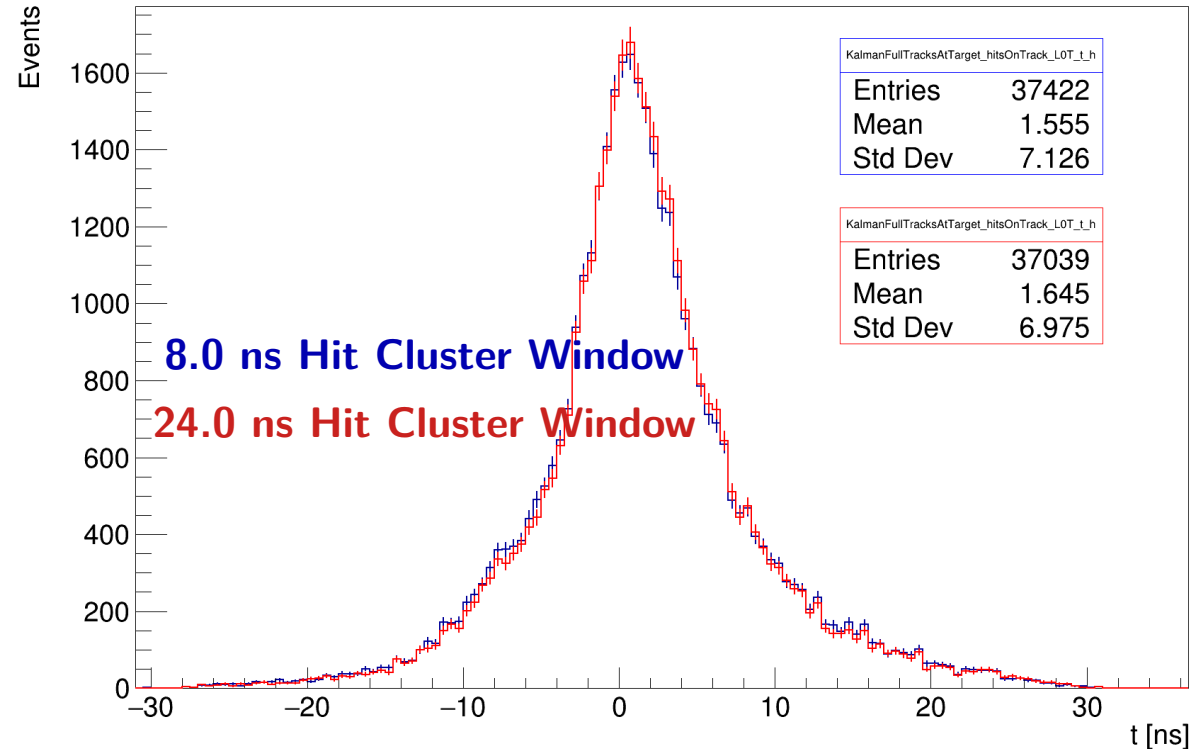
- Plot shows SiClusters On Track charge (for L1T Axial)
- Less 'apparent' noise hits on Track
- At least as much signal



8.0 to 24.0 ns Hit Cluster Window

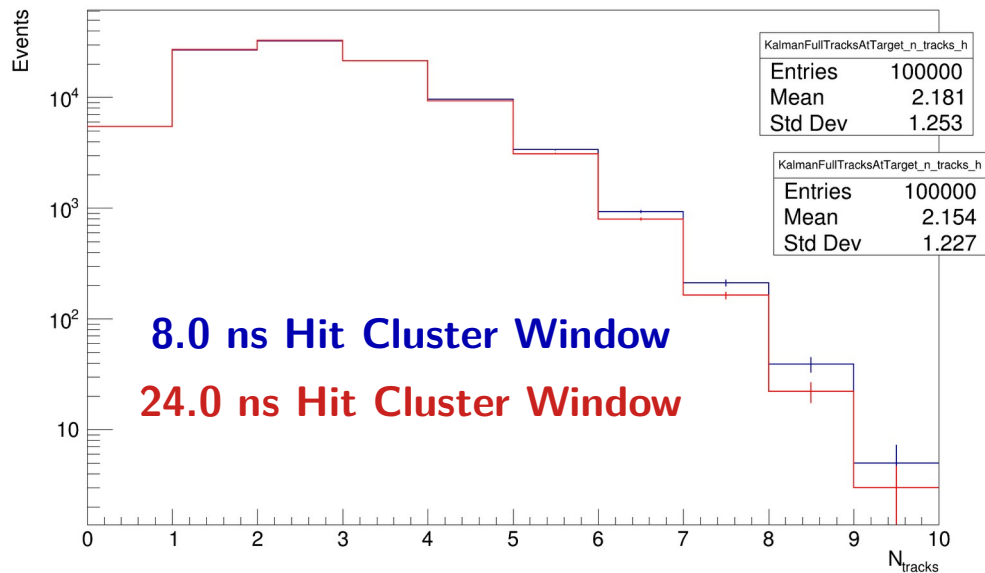
- Plot shows Track time for L1T Axial
- No loss in track time resolution using larger clustering window (at least for this sensor...)
- Slight reduction in N Tracks
~1%

KalmanFullTracksAtTarget_hitsOnTrack_L0T_t_h

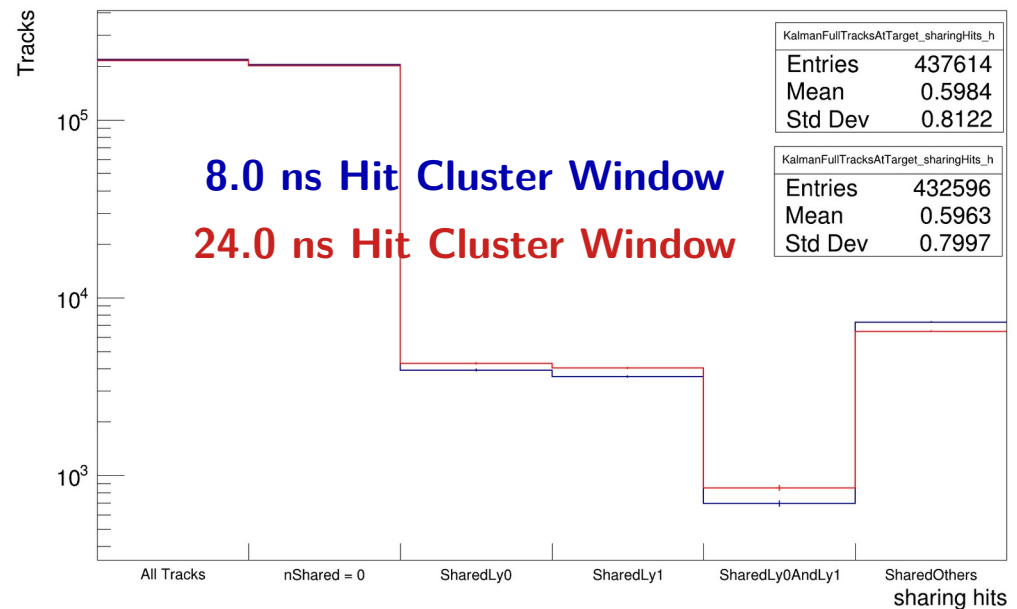


8.0 to 24.0 ns Hit Cluster Window

KalmanFullTracksAtTarget_n_tracks_h

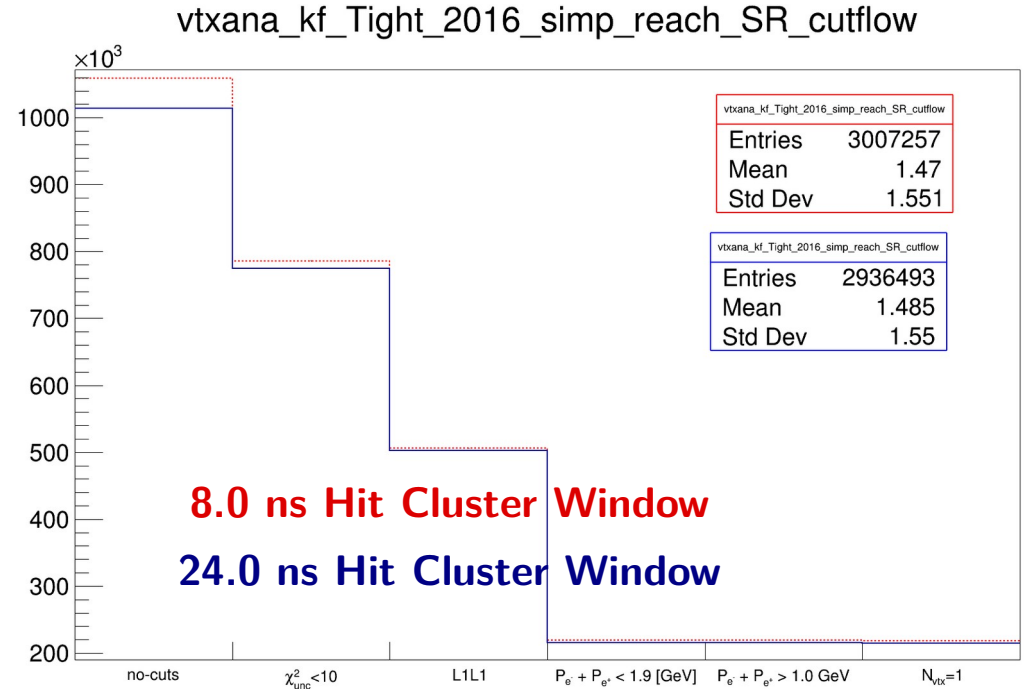
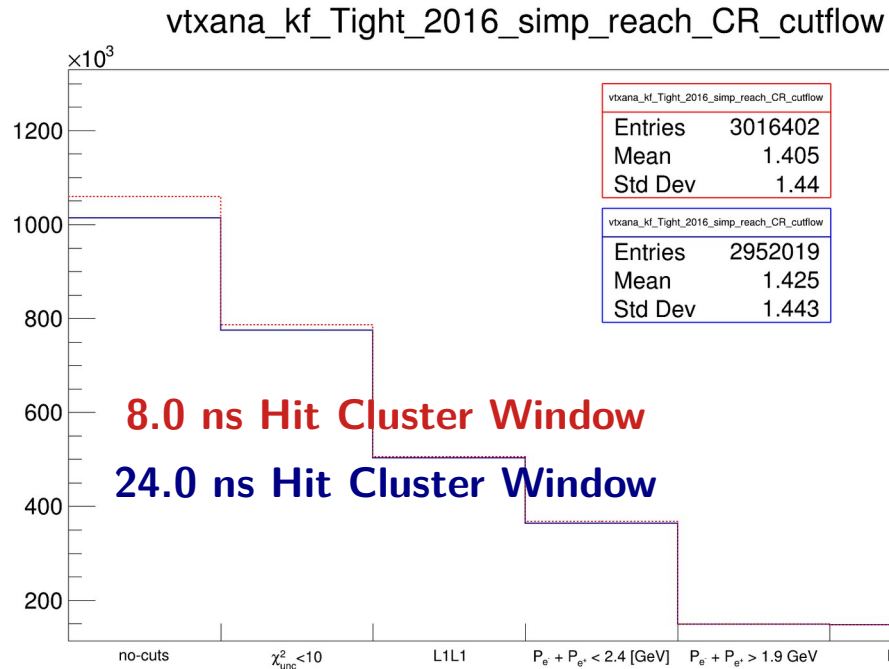


KalmanFullTracksAtTarget_sharingHits_h



- No more events with 0 Tracks using 24ns window
- Fewer events with high track multiplicity using 24ns window
- Slight increase in Shared L1, L2, and L1+L2 hits on Track

8.0 to 24.0 ns Hit Cluster Window



- Check impact of window change on Vertexing
- Note: Red and Blue colors swapped (whoops)
- Not much change in final number of vertices

Isolation Cut Definition

Isolation Cut Definition

- 2016 Displaced A' Isolation approximates ratio $(L2_z - L1_z)/(L2_z - Z_{\text{target}}) = 1/2$

$$\delta + \frac{1}{2}(z_0 - n_\sigma \Delta z_0) > 0$$

- Actual ratio ~ 0.41 , replace $1/2$ with 'R'

$$\delta + R(z_0 - n_\sigma \Delta z_0) > 0$$

- Can be re-arranged into a square cut on n_{sigma}

$$\frac{1}{R} \left(\frac{\delta}{\Delta z_0} \right) + \left(\frac{z_0}{\Delta z_0} \right) > n_\sigma$$

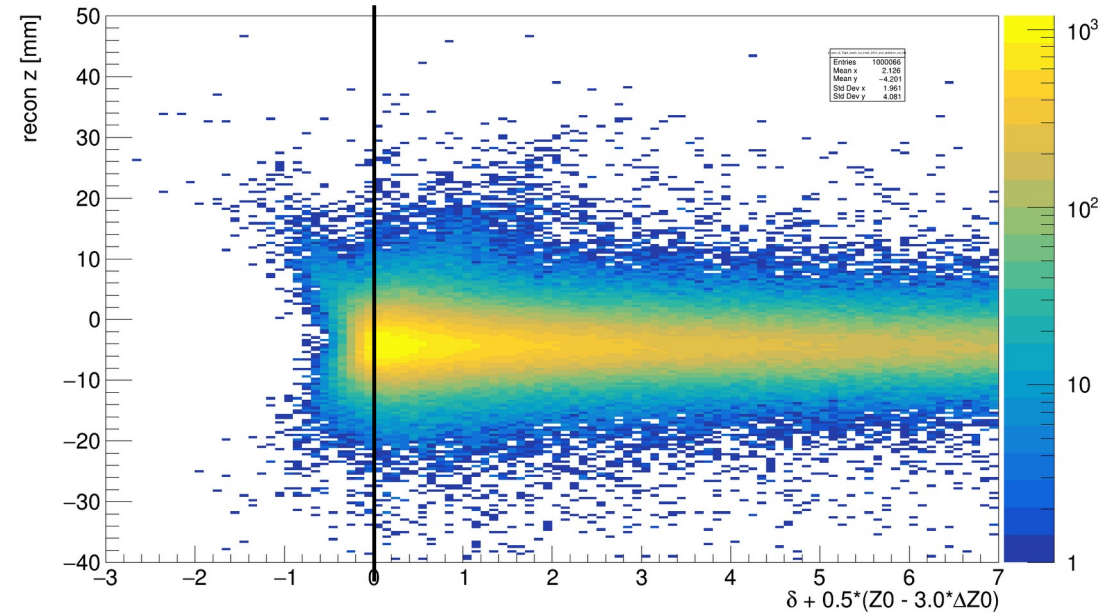
$$\mathbf{A} + \mathbf{B} > n_\sigma$$

- Square cut on sum of two variables $A + B > n_{\text{sigma}}$
- Look at each component...

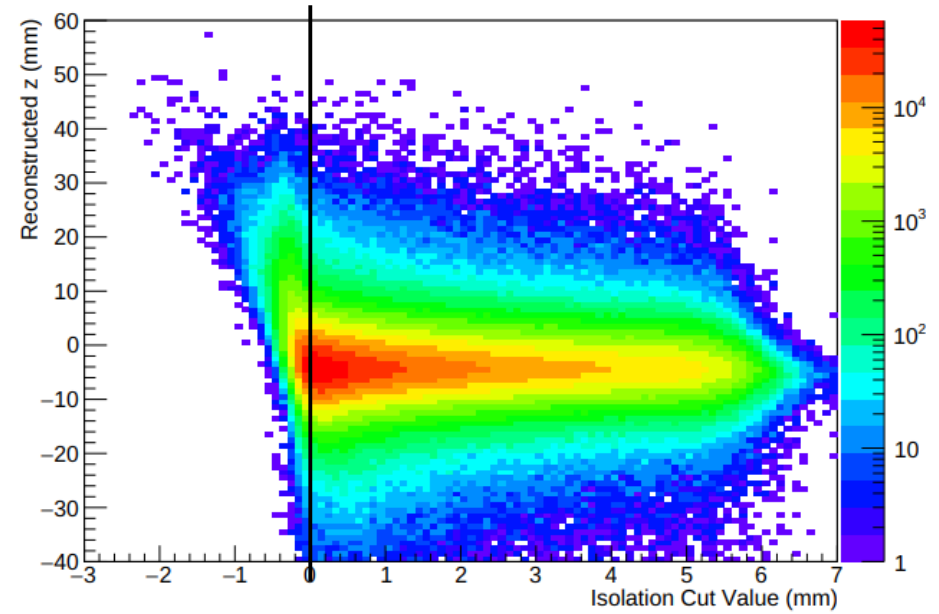
Isolation Cut

- Run Vertex Analysis on KF data sample

vtxana_kf_Tight_loose_vtx_track_2016_ana_isolation_cut_hh



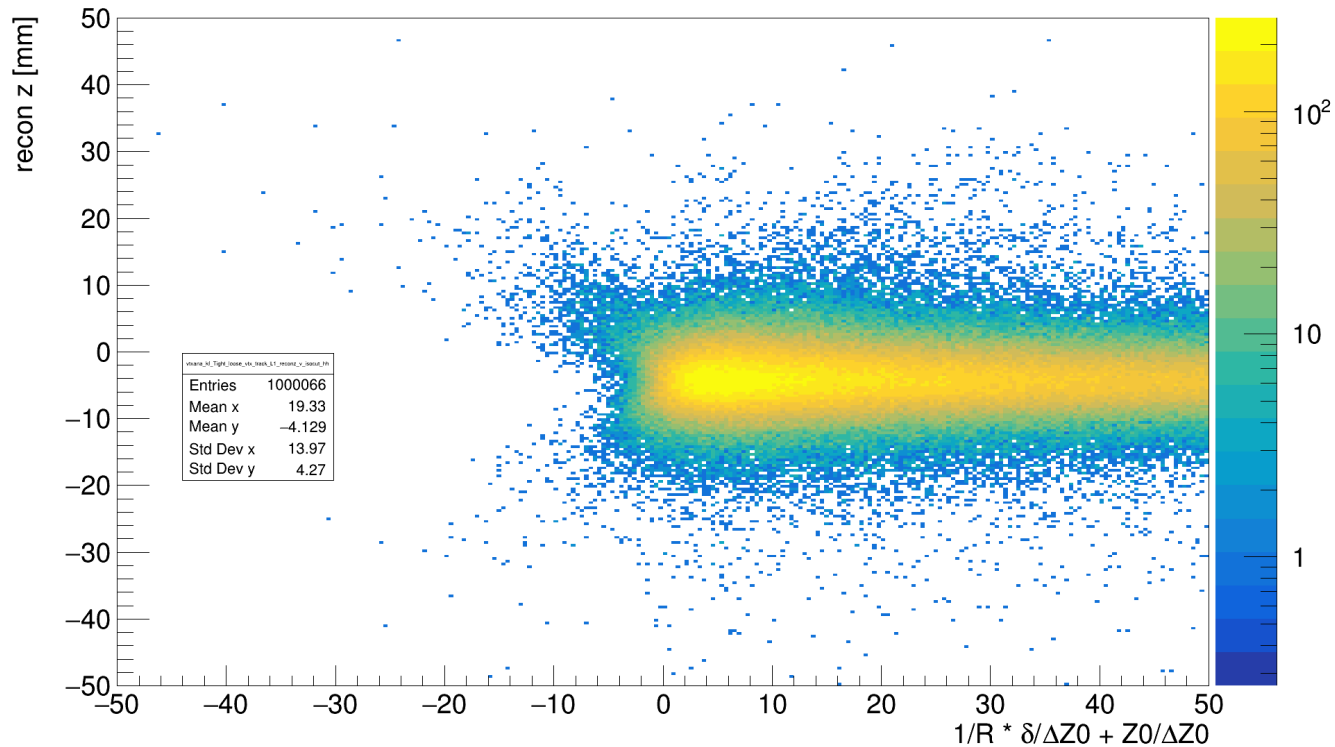
10% Data Preselection Isolation Cut



Isolation Cut

- Rearranged Isolation Cut Variable $\frac{1}{R} \left(\frac{\delta}{\Delta z_0} \right) + \left(\frac{z_0}{\Delta z_0} \right) > n_\sigma$
A + B > n_σ

vtxana_kf_Tight_loose_vtx_track_L1_reconz_v_isocut_hh

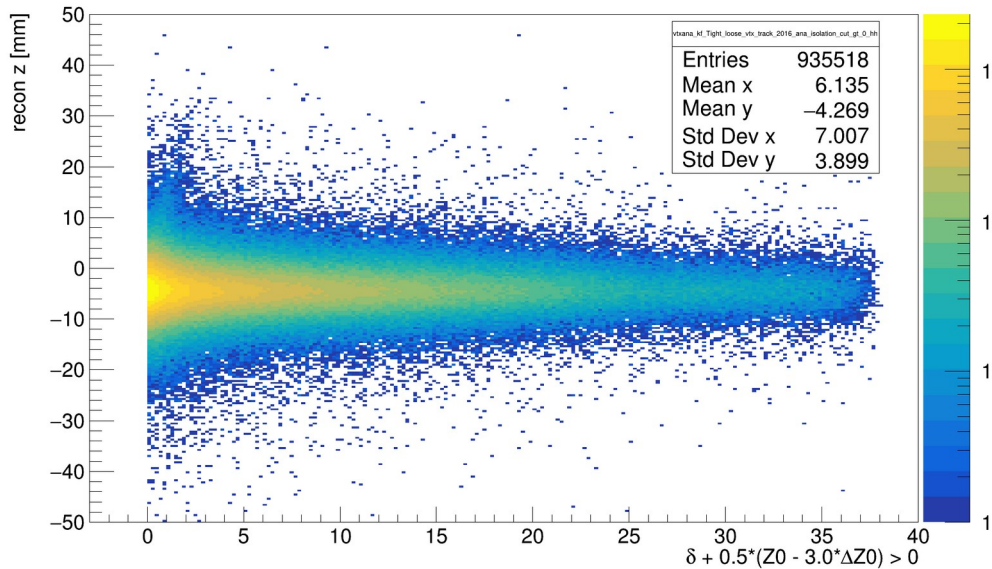


Isolation Cut

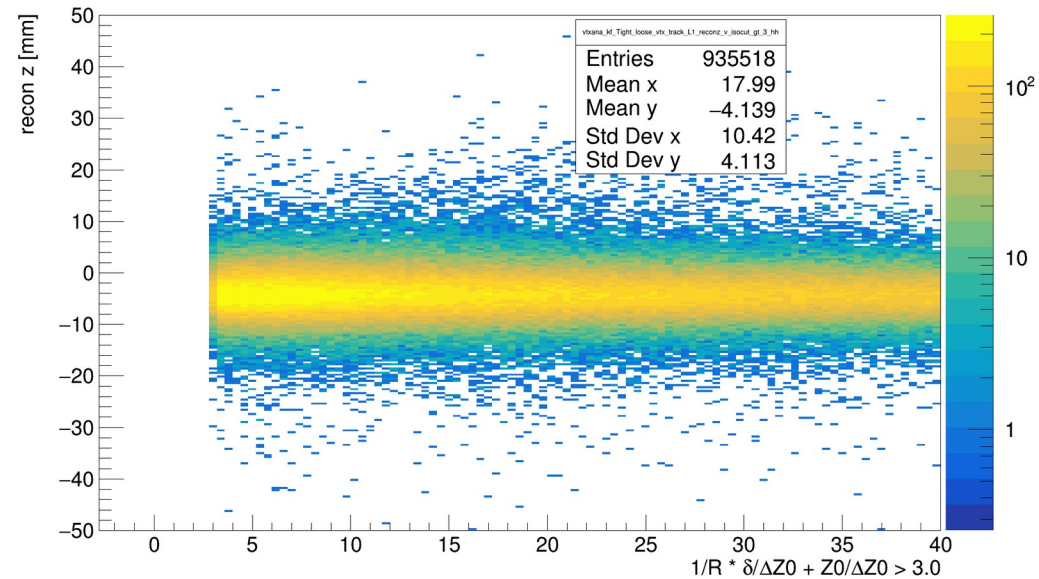
- Compare Displaced A' Isolation Cut ($n_{\text{sigma}} = 3.0$) > 0

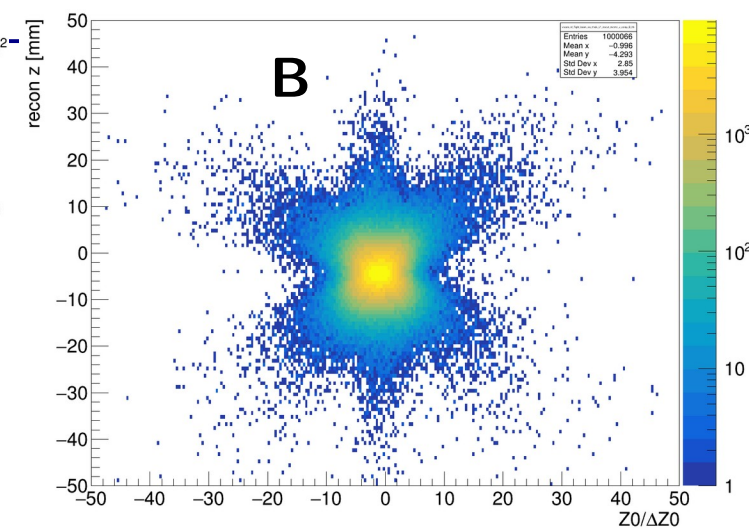
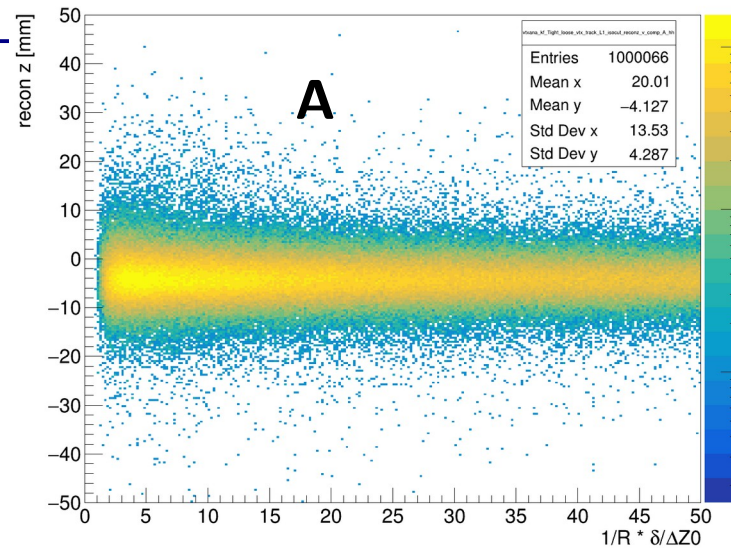
- To new arrangement ($n_{\text{sigma}} = 3.0$) $\frac{1}{R} \left(\frac{\delta}{\Delta z_0} \right) + \left(\frac{z_0}{\Delta z_0} \right) > n_{\sigma}$

vtxana_kf_Tight_loose_vtx_track_2016_ana_isolation_cut_gt_0_hh



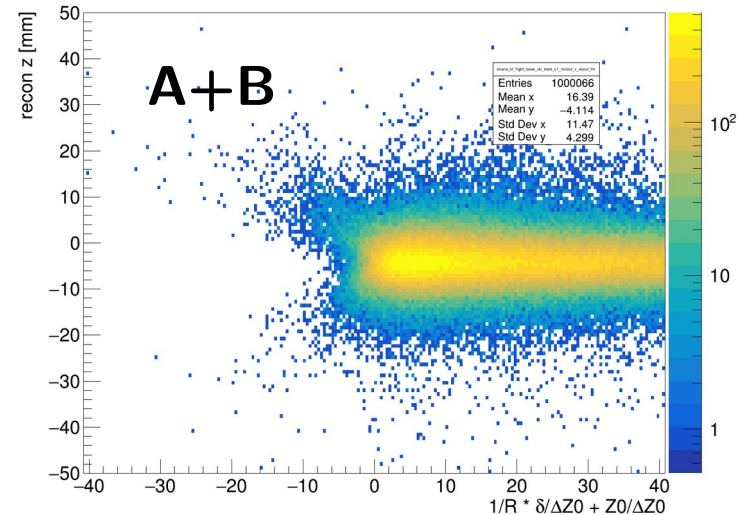
vtxana_kf_Tight_loose_vtx_track_L1_reconz_v_isocut_gt_3_hh





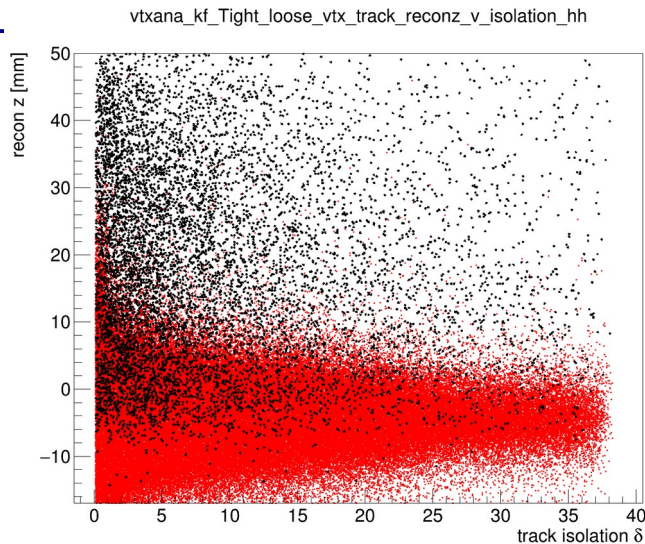
- Look at components (A and B) of new Isolation Cut variable arrangement
- Component A $f(\delta)$ doesn't look very discerning on its own
- Component B (z_0/z_{0_err}) may be useful on its own...

vtxana_kf_Tight_loose_vtx_track_L1_reconz_v_isocut_hh



Isolation Cut

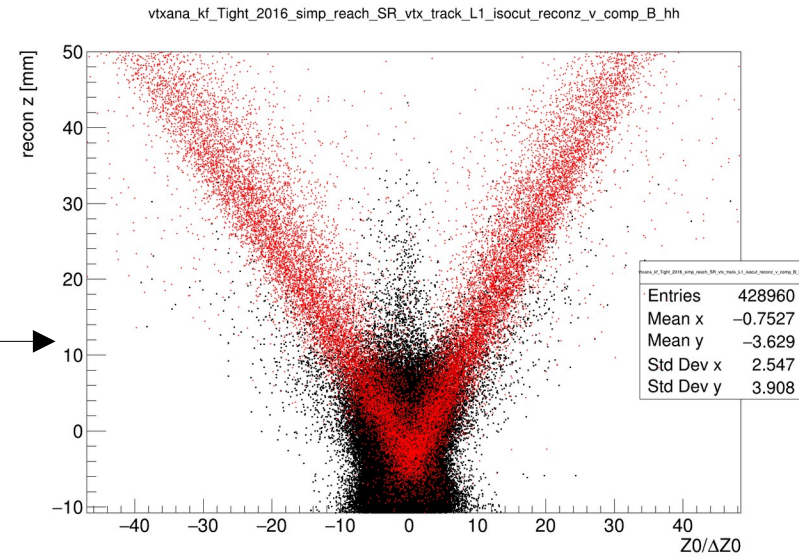
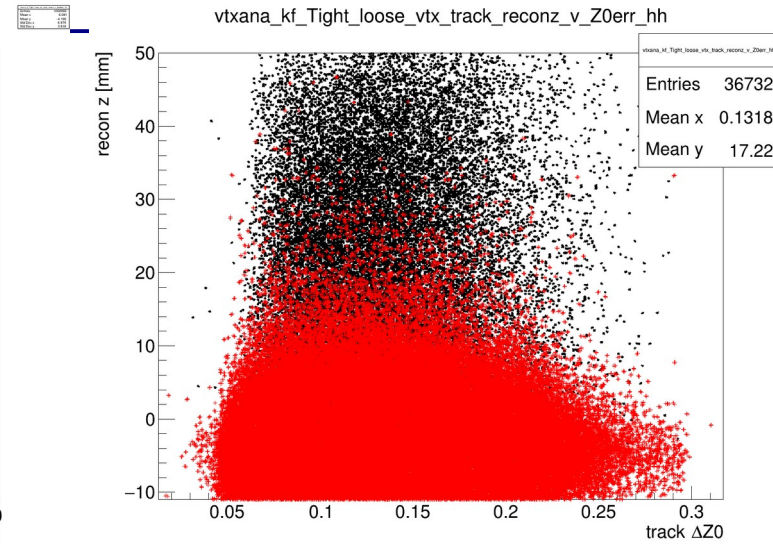
- Quick look at 60 MeV V_D signal vs background
- Checking simple square cut on track isolation δ , and track z_0 error
- Need to run these through the ZBi cut software...let them compete against each other
- Check how isolation cut performs **in addition to Impact Parameter Cut** (not applied here)



Signal

Background

Basically 'Impact Parameter' cut...maybe using Δz_0 gains us something...



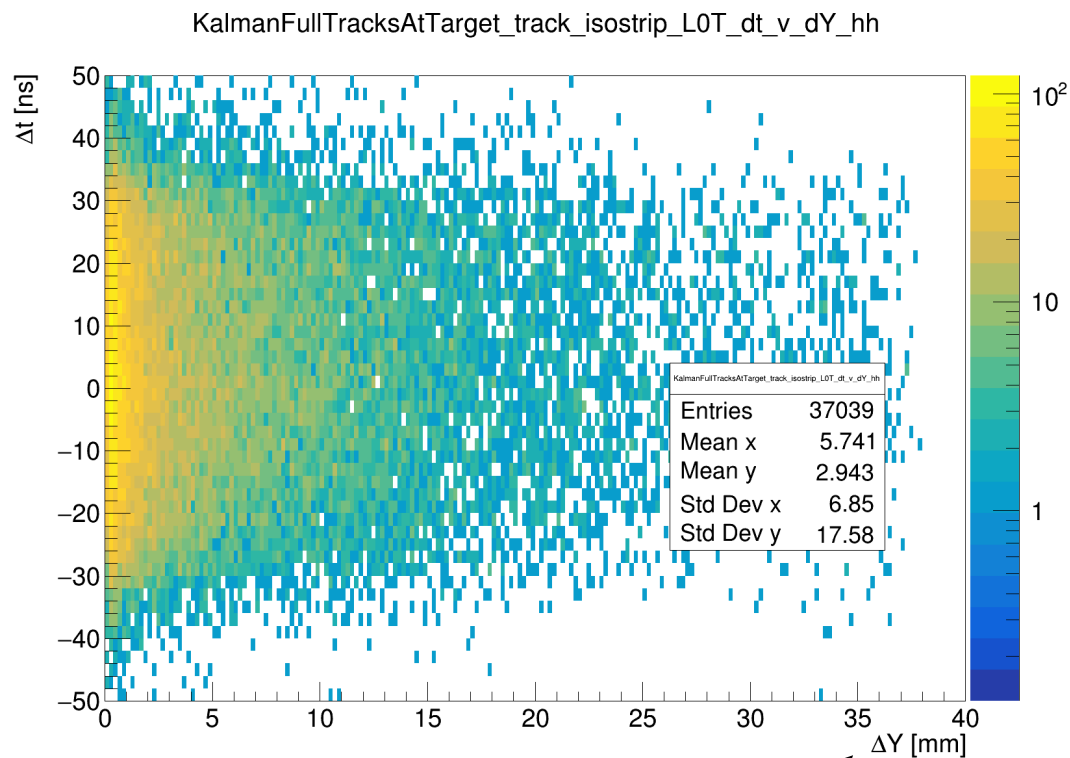
Summary + Next Steps

- Have track parameters and errors defined at target
- Opened hit recon clustering window from 8.0ns to 24.0ns
 - Looks like an improvement to me...thoughts??
- Track isolation slightly different for 2D hits (KF) than 3D hits (GBL)
 - Added to hpstr
- Isolation Cut can be rewritten as square cut on n_σ
- Plan on testing Isolation Cut value with ZBi Optimizer Tool
- Test components of Isolation Cut against each other
 - Does Track isolation add much, or is z_0 error pulling the weight
- Test Isolation Cut against Impact Parameter cut
- Test Isolation Cut for a few masses
- What does Invariant mass vs Recon Z look like with 10% data given Impact Parameter (Z_α) and Isolation Cuts at this stage?

Backup

KF Track Isolation

- Isolation δ is just ΔY between SiClusterOnTrack and next closest (non-adjacent) SiCluster
- Plot shows isolation versus dt
- Pretty wide time residuals...
 - Not sure how common it is for there to be another SiCluster that is further away, but closer in time to the hit on track (hence more appropriate to choose)
 - Time resolution isn't great anyways...probably cant make that call



Isolation δ



KF Track Isolation

- Plot shows isolation vs dCharge for all alternative SiClusters
- If $dCharge > 0$, alternative SiCluster has more charge than hit on track
- If $dCharge < 0$, alternative hit has less charge than hit on track
- No conclusions here, but reminder to think about using SiCluster charge in the decision making maybe...?

