JÜLICH FORSCHUNGSZENTRUM

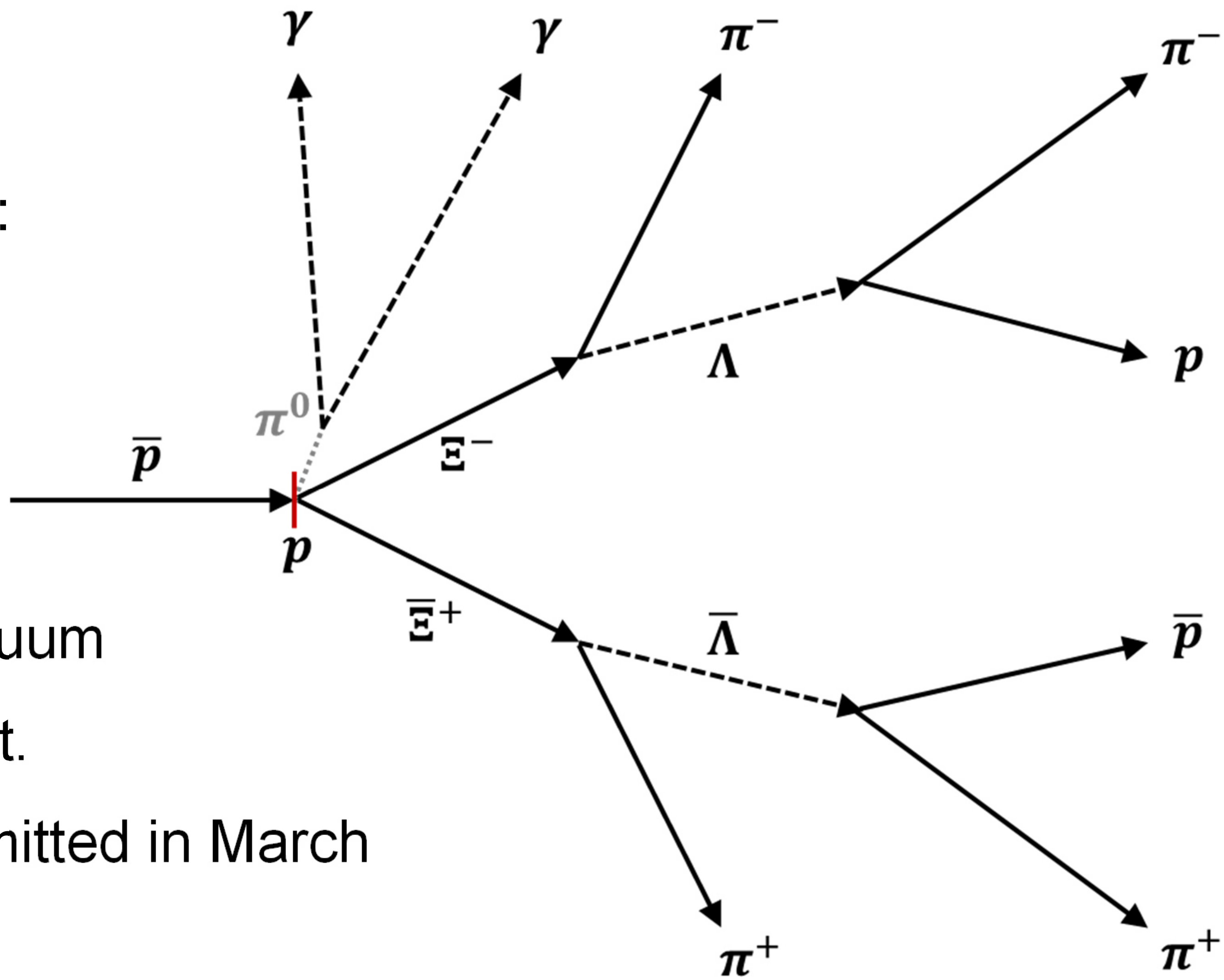
Status: Resonances in $\bar{p}p \rightarrow \bar{\Xi}^{+}\Xi^{-}\pi^{0}$

Nov 8, 2018 | Albrecht Gillitzer

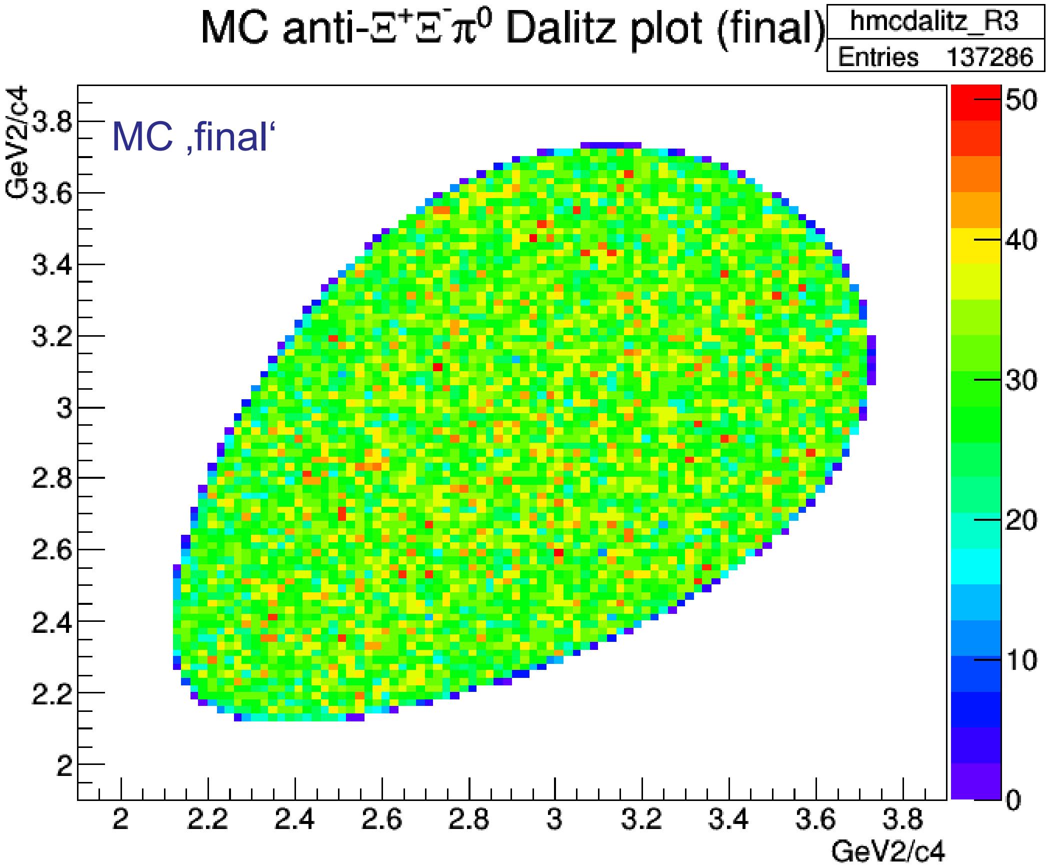
PANDA Collaboration Meeting 3/18, GSI Darmstadt

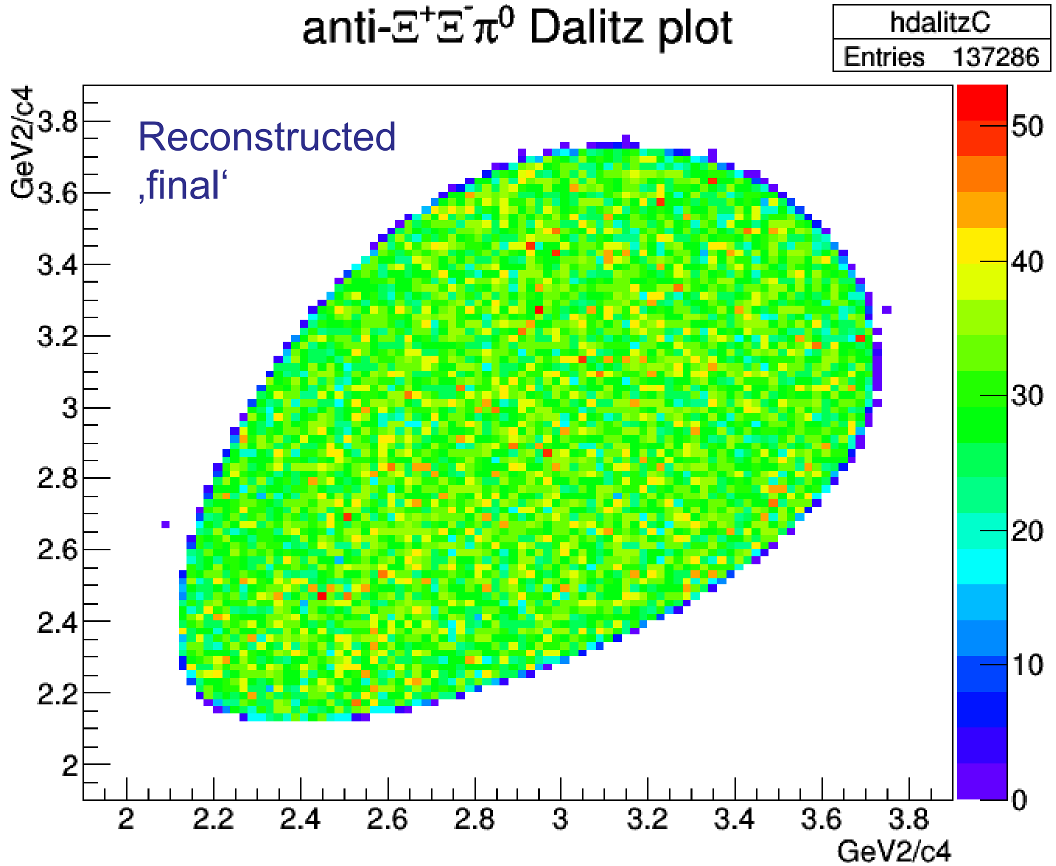
Review: Resonances in $\bar{p}p \to \bar{\Xi}^+\Xi^-\pi^0$

- $p_{\bar{p}} = 4.6\ \mathrm{GeV}/c$
- Contributing states:
  - $\Xi(1530)$
  - $\Xi(1690)$
  - $\Xi(1820)$
- Phase Space
- 4 M $\bar{\Xi}^+\Xi^-\pi^0$ continuum
- 5 M Ξ^{*-}, $\bar{\Xi}^{*+}$ & cont.
- Release Note submitted in March (status: pending)



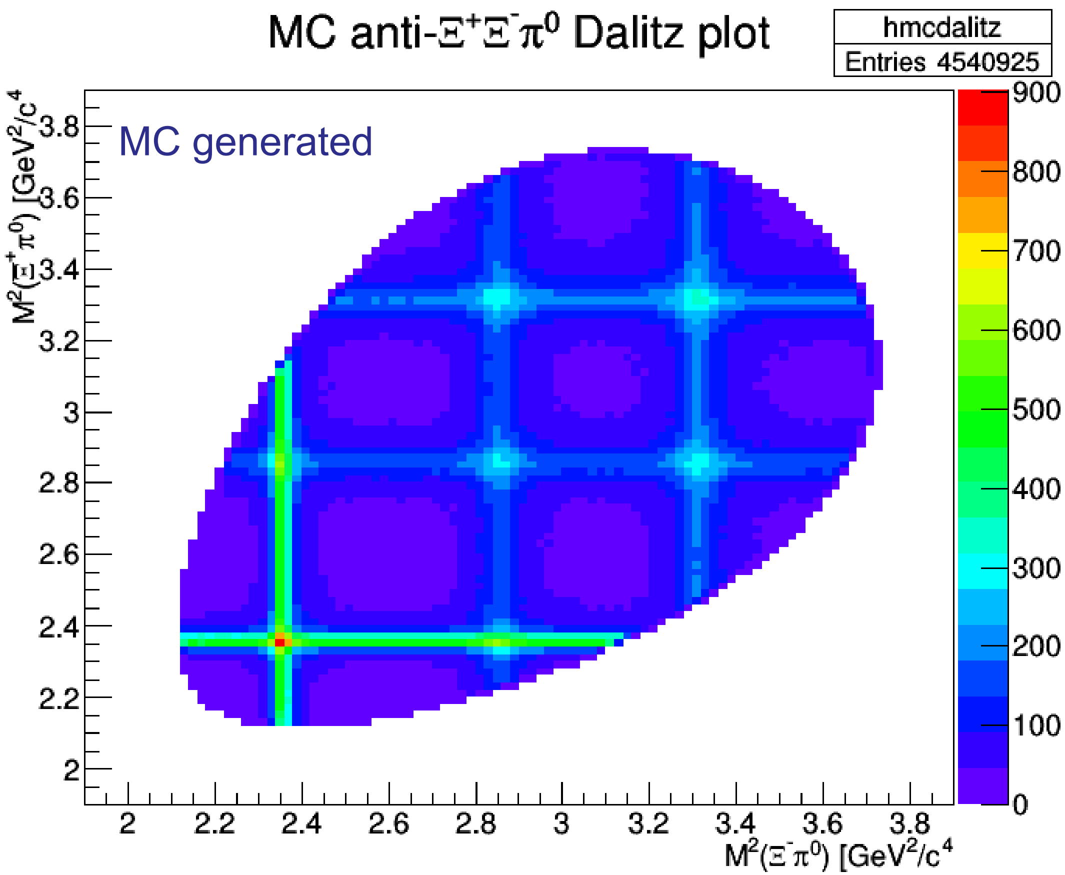
Results: $\bar{p}p \to \bar{\Xi}^+\Xi^-\pi^0$ Continuum

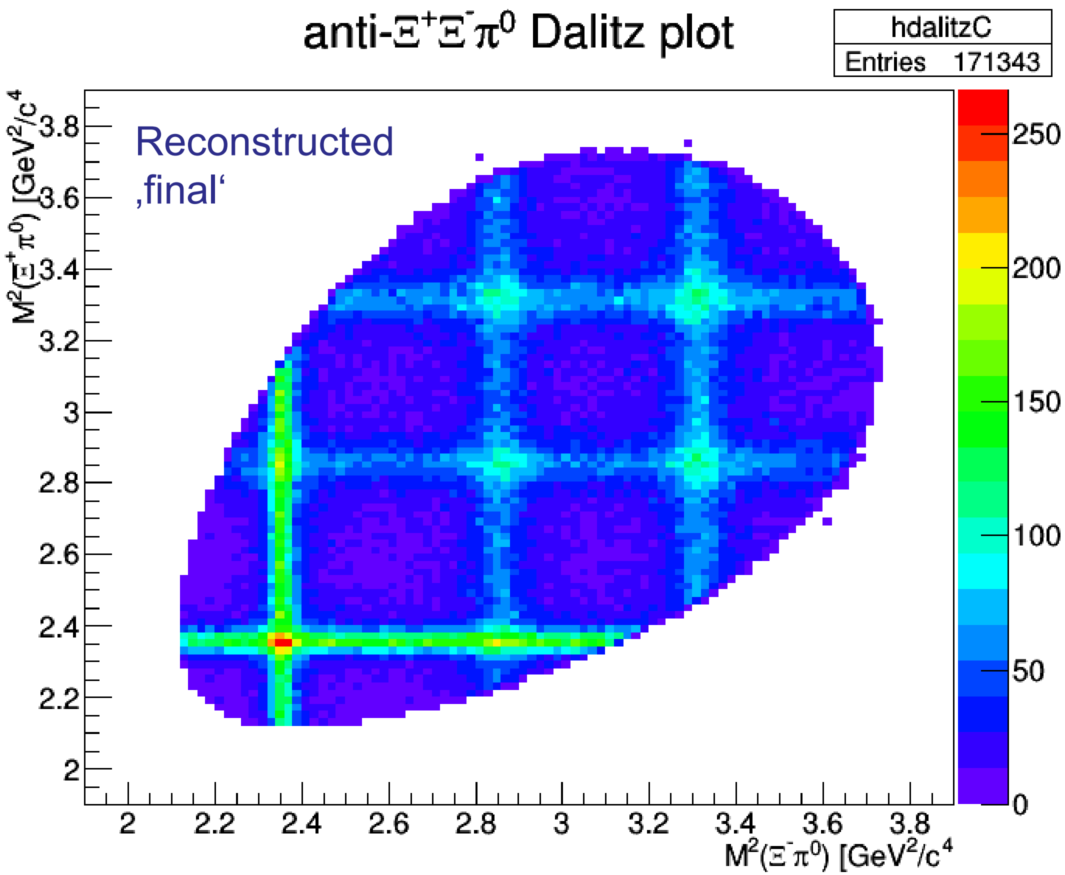




→ PANDA has *perfectly flat acceptance* for the 3-body final state

Results: $\bar{p}p \rightarrow \overline{\Xi}^{+}\Xi^{-}\pi^{0}$ with Resonances





→ All Ξ^{*-}, $\overline{\Xi}^{*+}$ states clearly seen in reconstructed sample

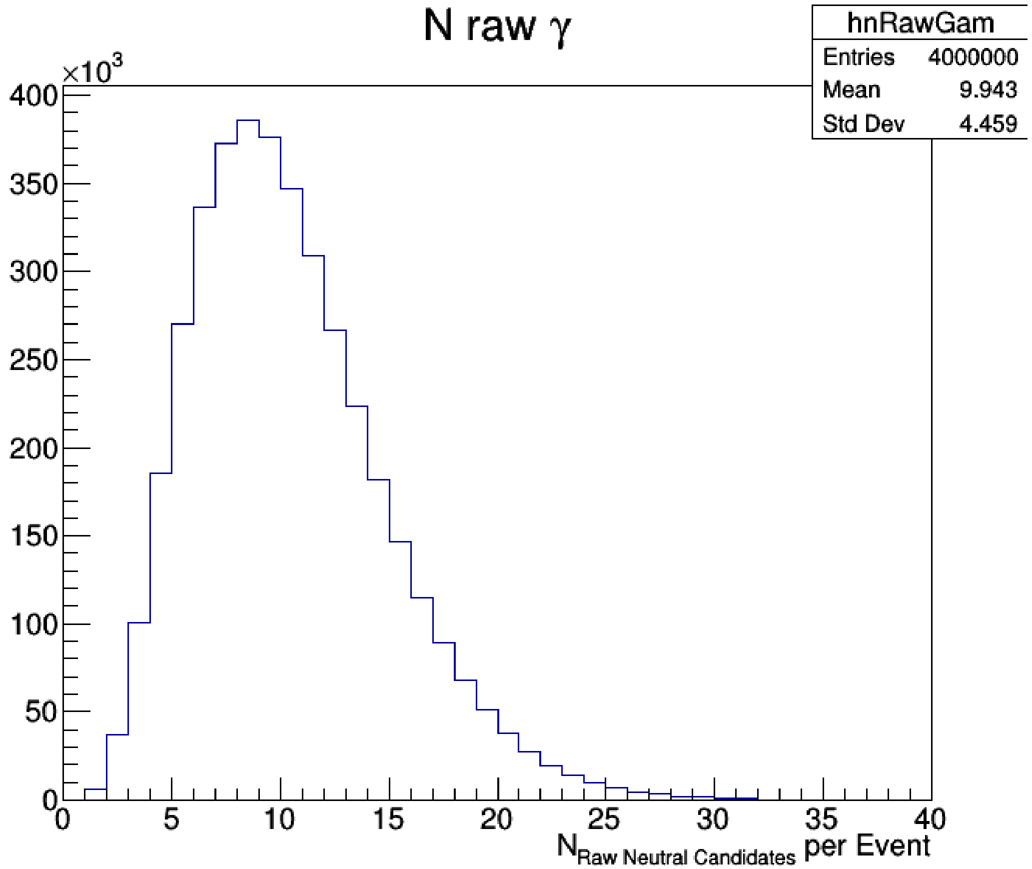
Summary Slide March Meeting

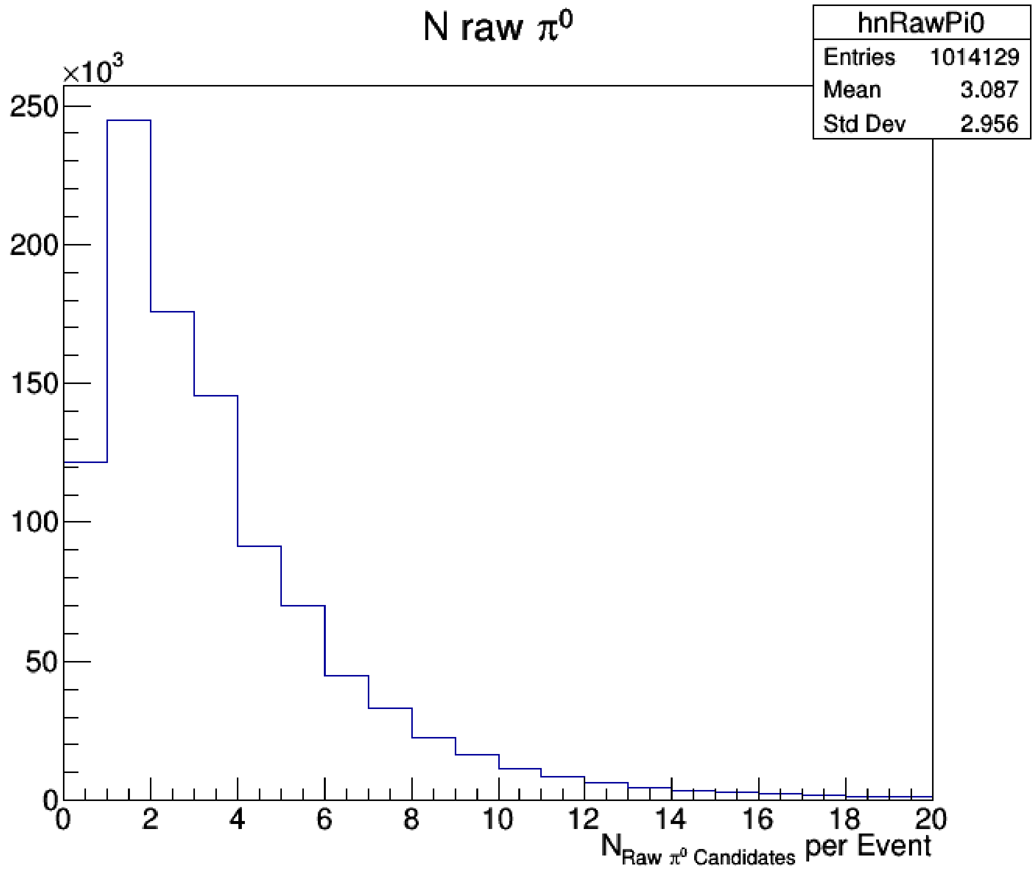
- comprehensive analysis of 4.6 GeV/c $\bar{p}p \rightarrow \bar{\Xi}^{+}\Xi^{-}\pi^{0}$ including background studies
- over-all reconstruction efficiency: ~3.5 %
- π^{0} reconstruction significantly contributes to efficiency losses (~43% MC true) and to ‚fake' combinations in the final data sample (~5%)
- acceptance and reconstruction uniform across $\bar{\Xi}^{+}\Xi^{-}\pi^{0}$ phase space
- 22 M DPM background events → S/B > 4.6
- 6.6 M $\bar{p}p\pi^{+}\pi^{+}\pi^{-}\pi^{-}\pi^{0}$ events → S/B = 47
- release note ready for distribution to the collaboration (03/2018)

What to Improve ?

1) Too much combinatorial background in π^0 candidates
2) Ideal PID
3) Ideal Pattern Recognition (with $\geq$ 4 hits in inner tracking det.)
4) Problems in PndKinVtxFitter and PndKin4CFitter: χ^2 / prob. distribution, constraint not always fulfilled

Problems in Photon Reconstruction





photon energy cut $E_\gamma > 15\ \mathrm{MeV}$

π^0 coarse mass cut $|M_{\mathrm{cand}} - m_\pi| < 50\ \mathrm{MeV}$

Problems in Photon Reconstruction

- Many ‚non-photon' neutral candidates
- Enhanced at low photon energies
- Huge combinatorial background in π^0 candidates
  - too many fake π^0 candidates
  - some true π^0 candidates not found

➢ Possible solution: use EMC time information for γ's !

How to Get the Photon Time?

***New** simulation with pandaroot #30122,30127*

RhoCandidate → RecoCandidate → EmcCluster (digi_file) → TimeStamp, Position (using FairLinks)

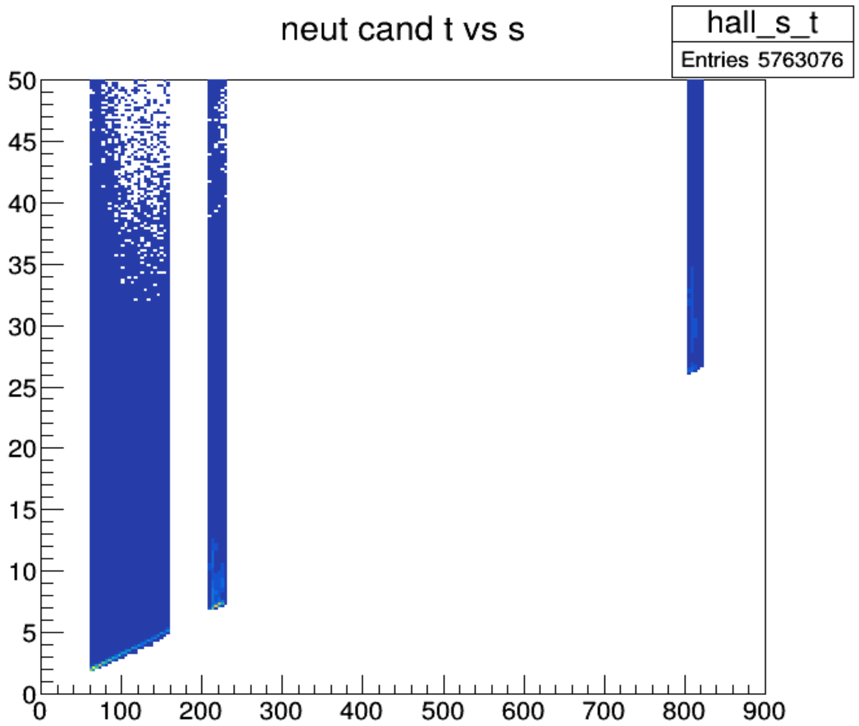
- **time and flightpath for neutral candidates**
- **new simulation:**
  - **p = 4.6 GeV/c**
  - **4.4 M $\bar{\Xi}^{+}\Xi^{-}\pi^{0}$ continuum events**
  - **5 M $\bar{\Xi}^{+}\Xi^{-}\pi^{0}$ events with resonances**

1) Analysis of EmcCluster Time

2) Analysis of EmcHits

3) Analysis of EmcPoints

4) Use EmcCluster Time with Corrected Position

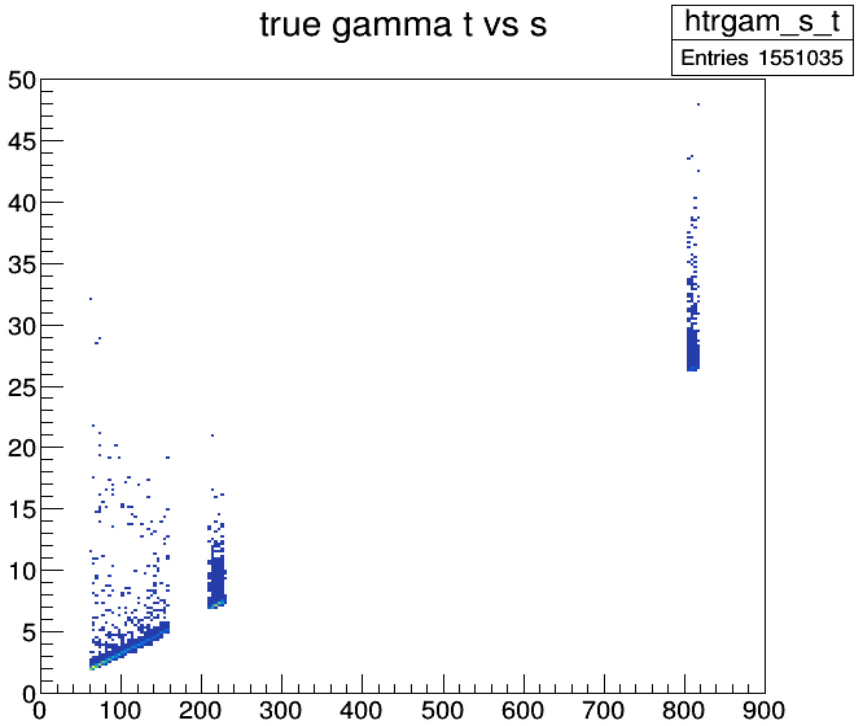


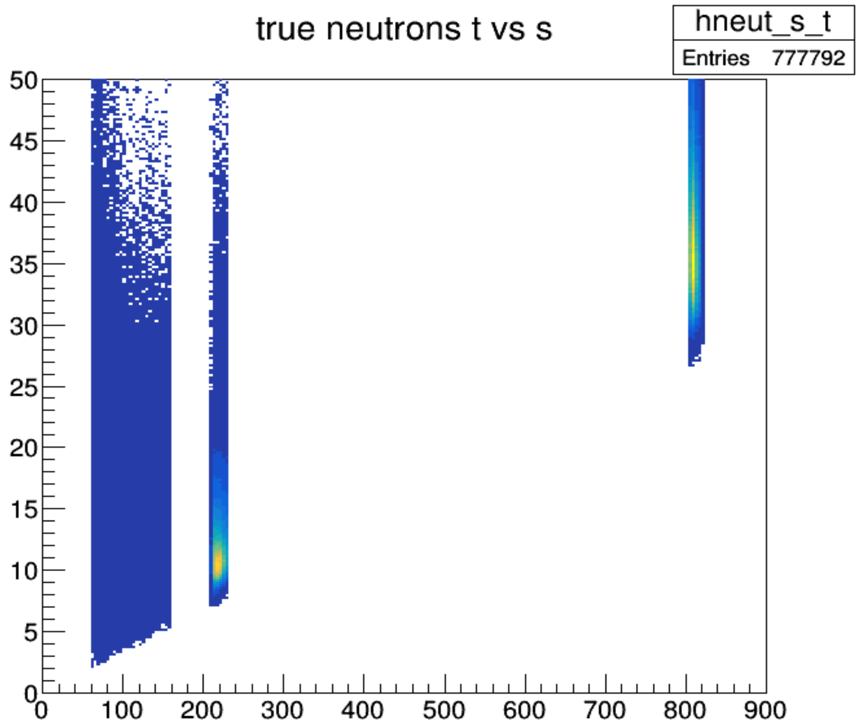
4.4 M events

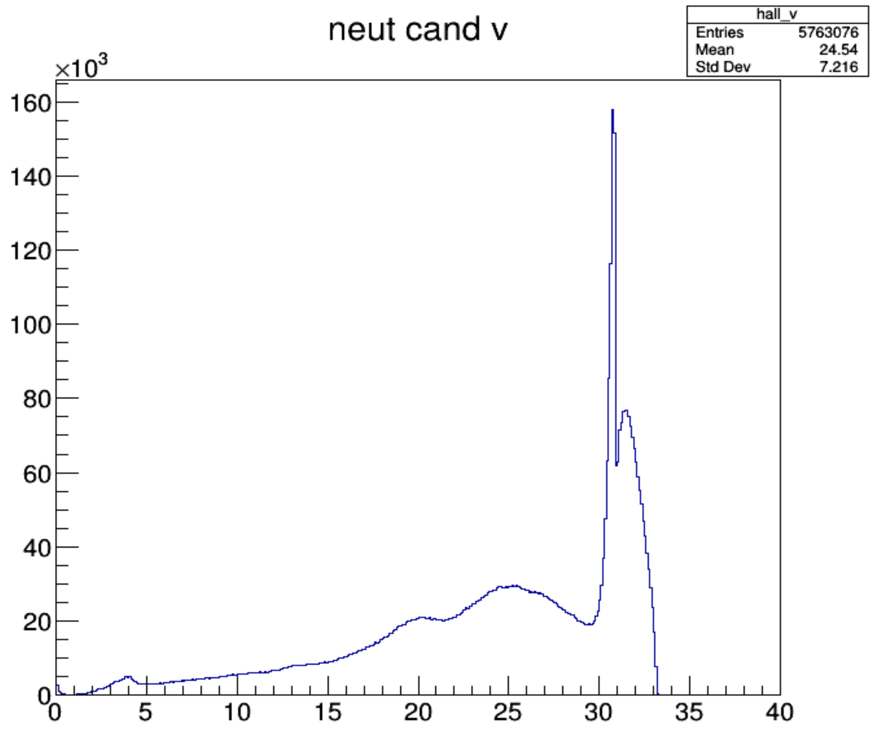
Neutral Candidate EmcHit:

Time vs Flightpath

true gamma ≡ true signal photons !





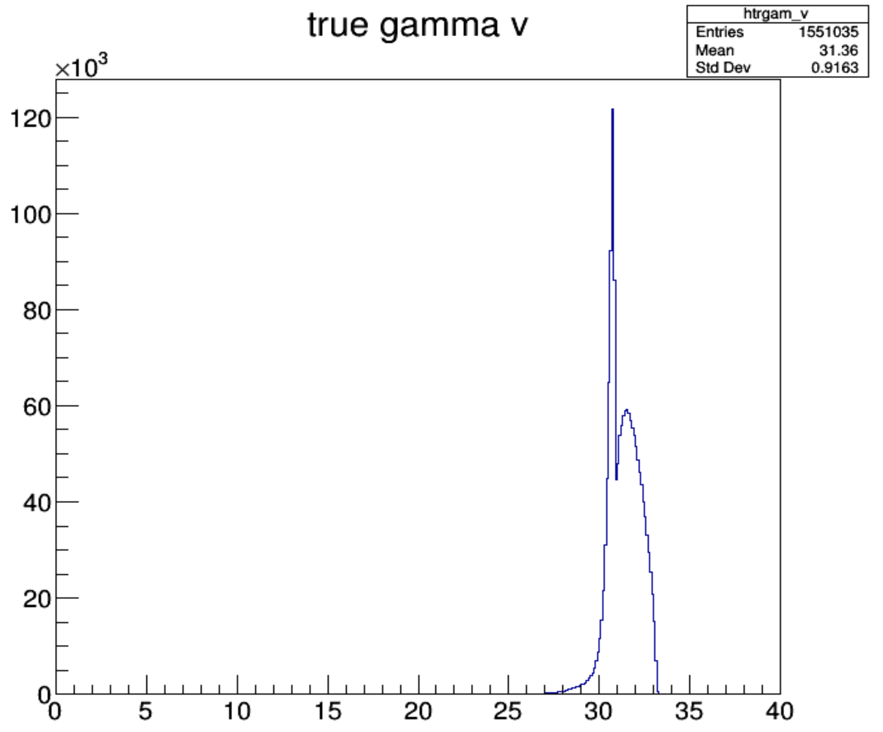


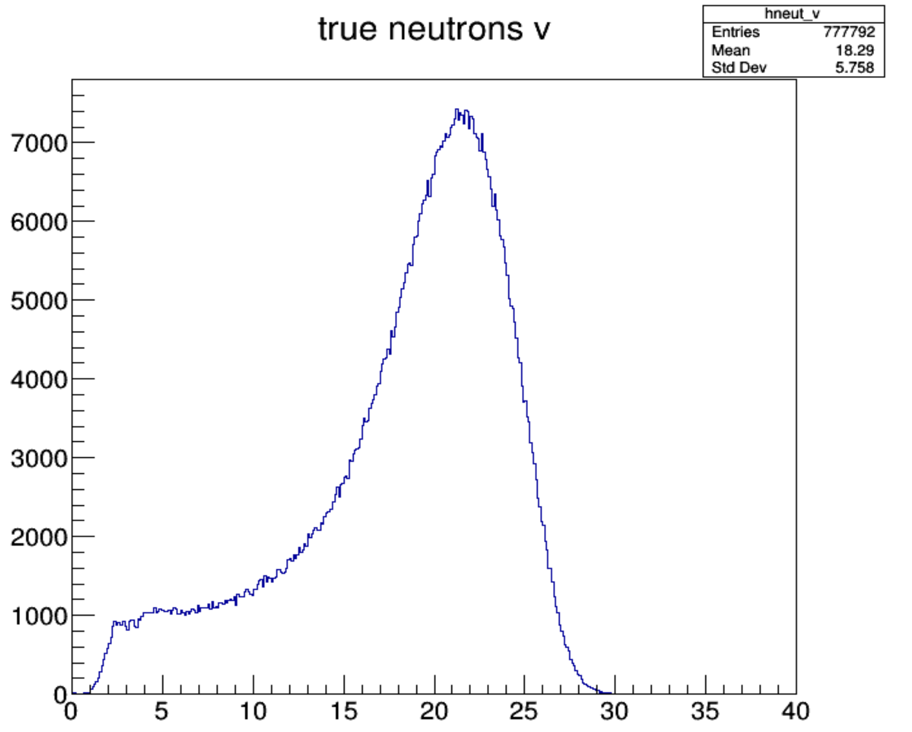
4.4 M events

Neutral Candidate EmcHit:

Velocity in cm/ns

true gamma ≡ true signal photons !





Conclusion from 1st Step

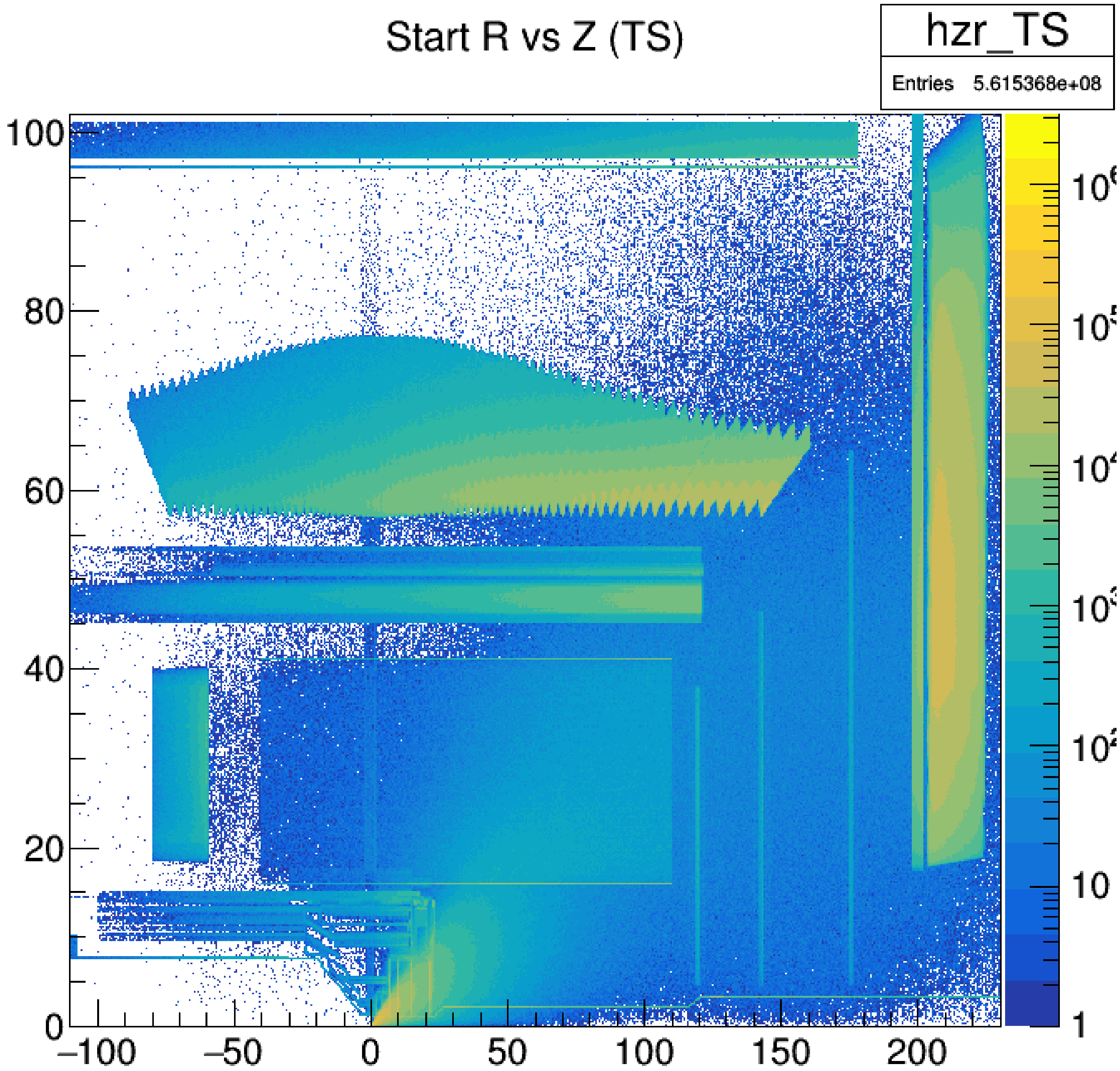
- large fraction of neutral candidates has velocities < 30 cm/ns
- true primary photons are close to $v = c$, but some seem to be too fast or too slow

➢ mismatch between time and position

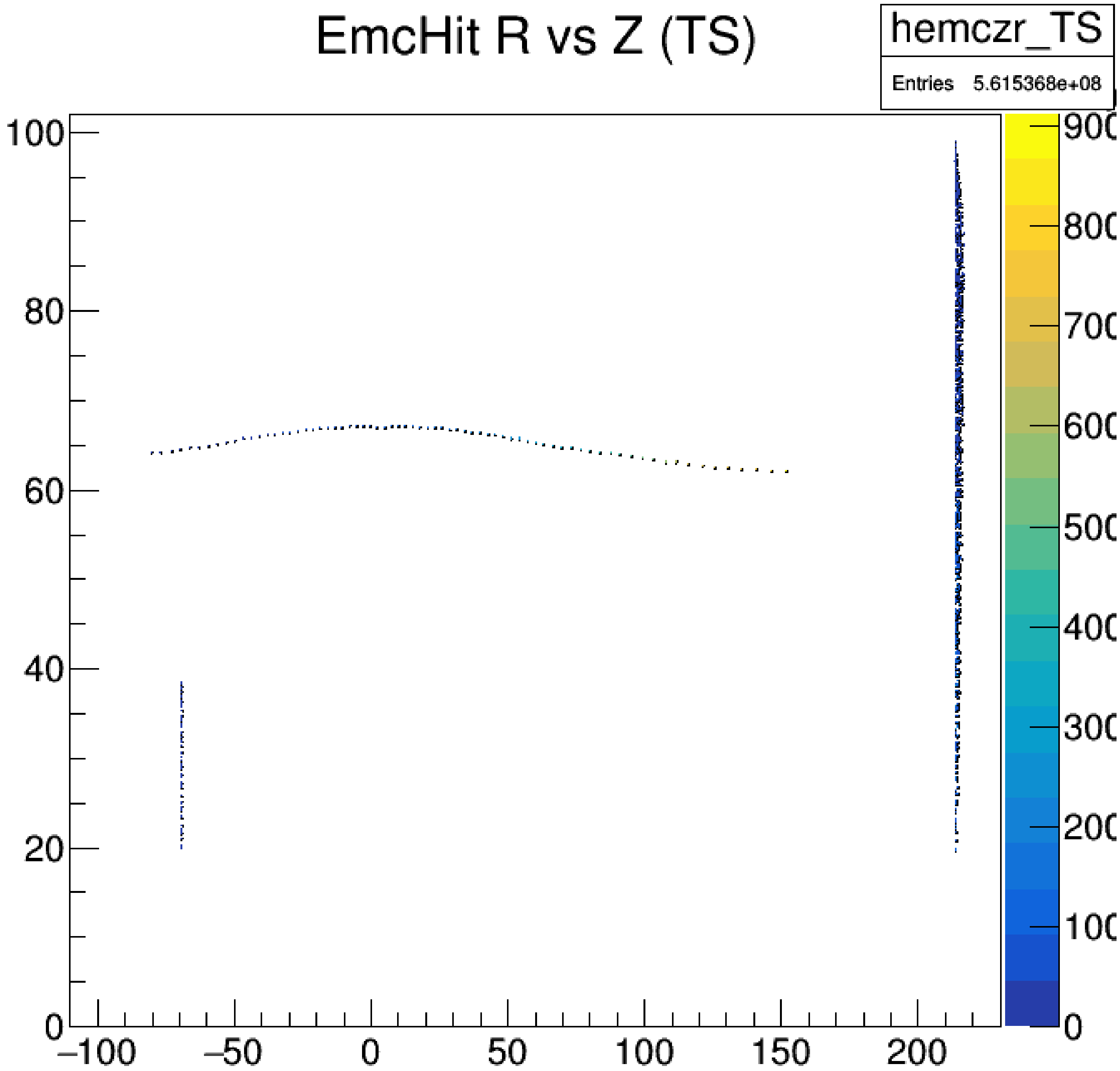
➢ better look at $\Delta t = t - t_{v=c}$

New Analysis of EmcHit Information (sim_complete.root)

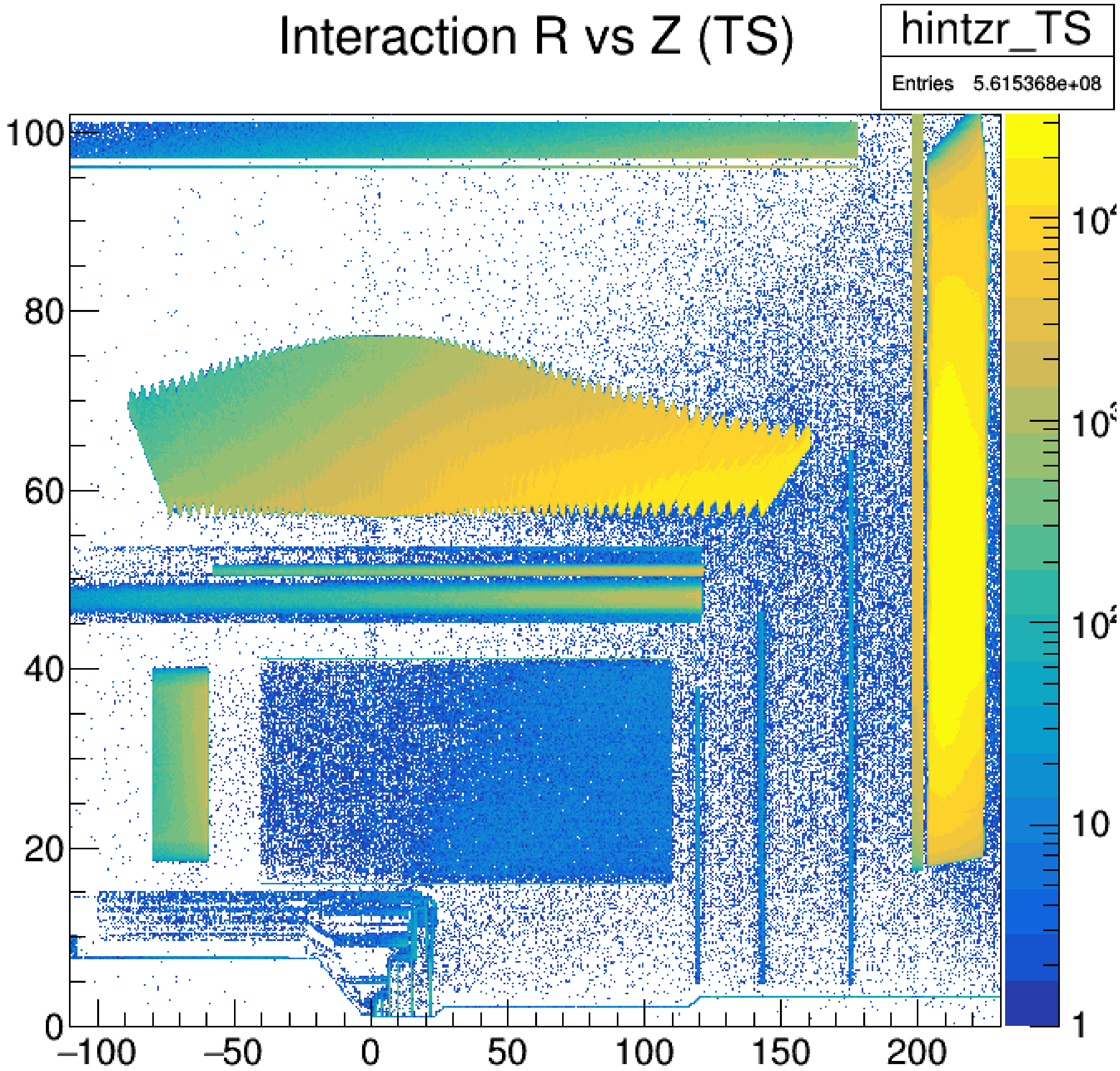
- find MC track for each EmcHit
- loop over all MC Tracks with higher track numbers and find daughter track → interaction
- idea: use start position and start time of daughter track for velocity determination if inside crystal



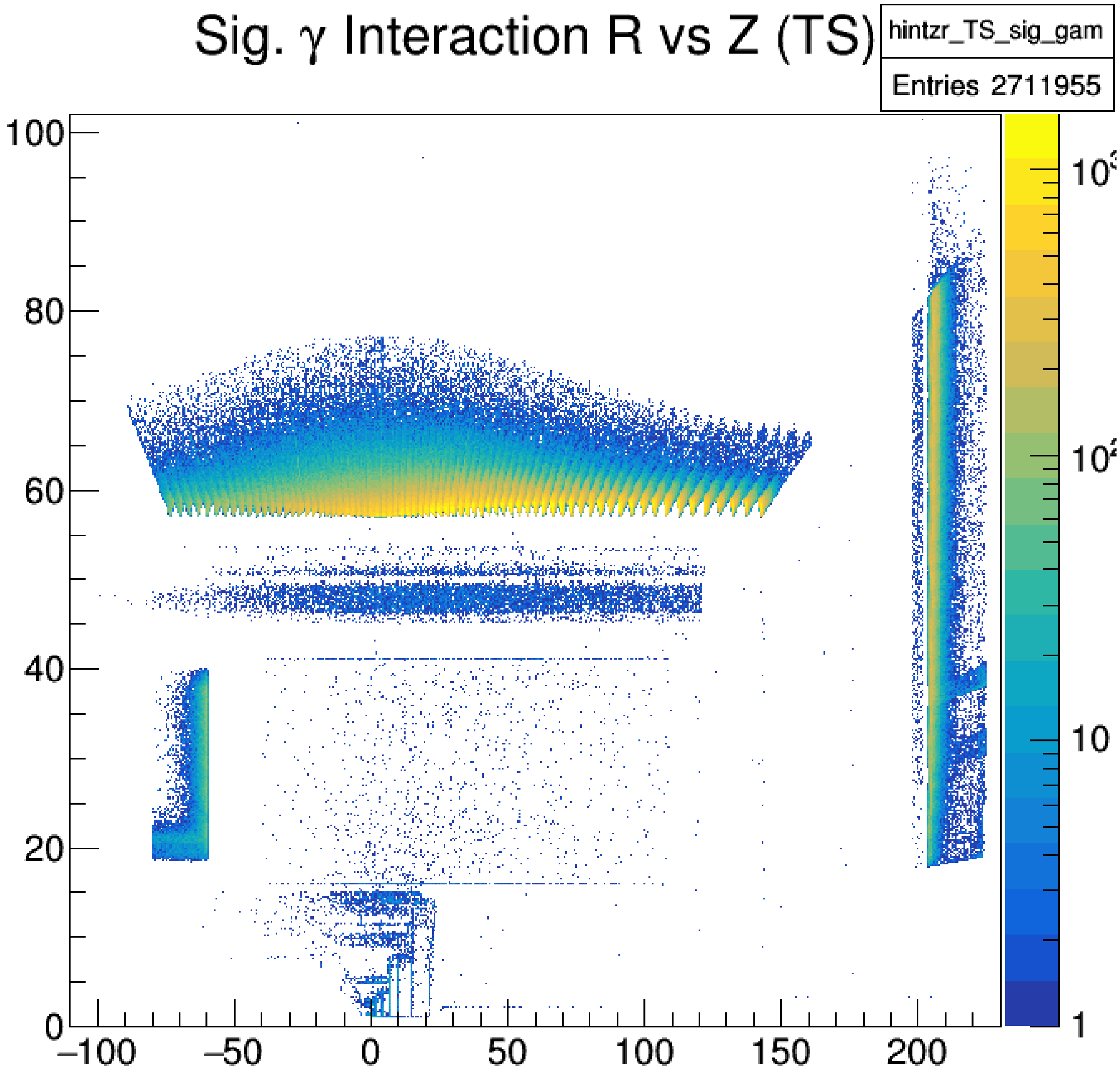
start position of MC tracks creating an EmcHit



position of EmcHits (T.S.): defined by crystal center



Position of interactions of MC tracks causing an EmcHit



Position of interactions of primary photon MC tracks

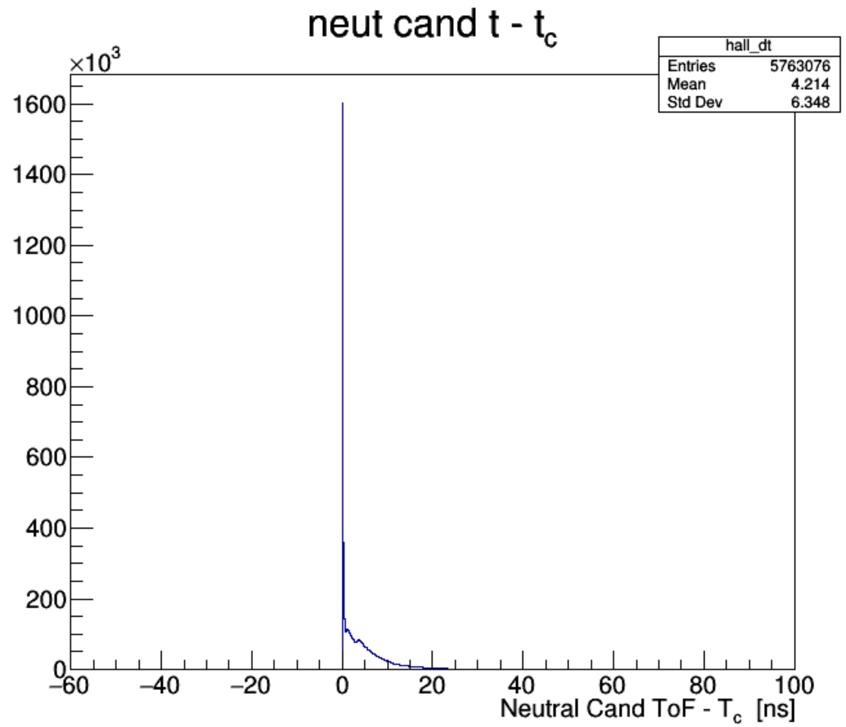
Conclusion from 2nd & 3rd Step

- position of first EmcPoint and first interaction are in general not identical
- there are EmcPoints with & without interaction
- there are MC tracks which continue downstream of an interaction
- in most cases the EmcHit time is close ($\sim 10 \ldots 50$ ps) to the time of the first EmcPoint
- in most cases the first EmcPoint is very close ($\sim$ mm ... ~ 1 cm) to the crystal surface

Analysis with Corrected EmcCluster Position

- Solution without need to analyze EmcPoints (sim_file.root):
  - shift EmcCluster position by fixed Δs towards IP
  - $\Delta s = -0.45 \times L_{\mathrm{cryst}}$
  - $L_{\mathrm{cryst}} = 20\ \mathrm{cm}$ for TS PWO, $L_{\mathrm{cryst}} = 68\ \mathrm{cm}$ for FS Shashlyk

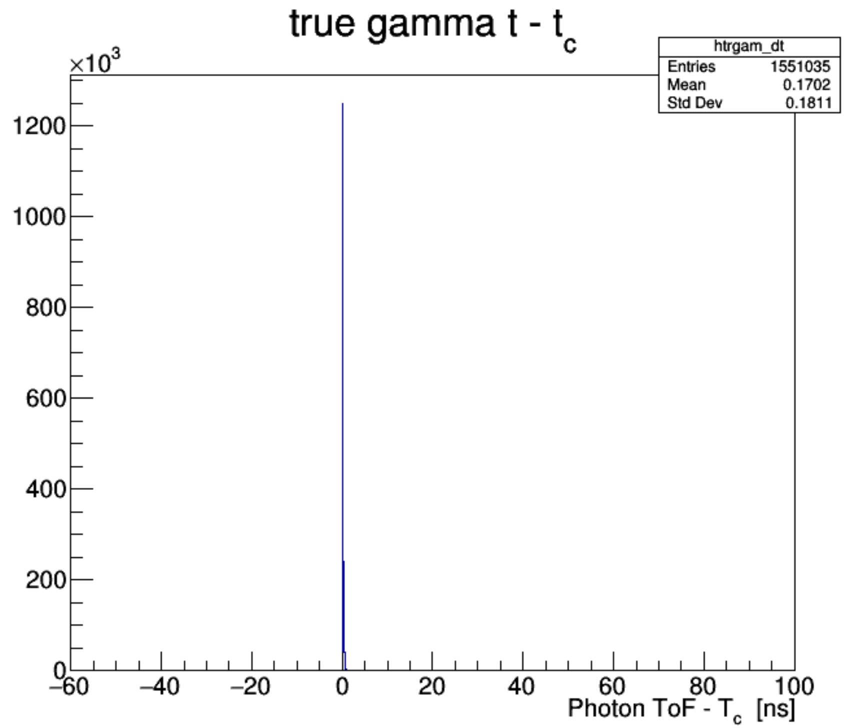
- Two analyses: (1) no time smearing, (2) 1 ns time smearing

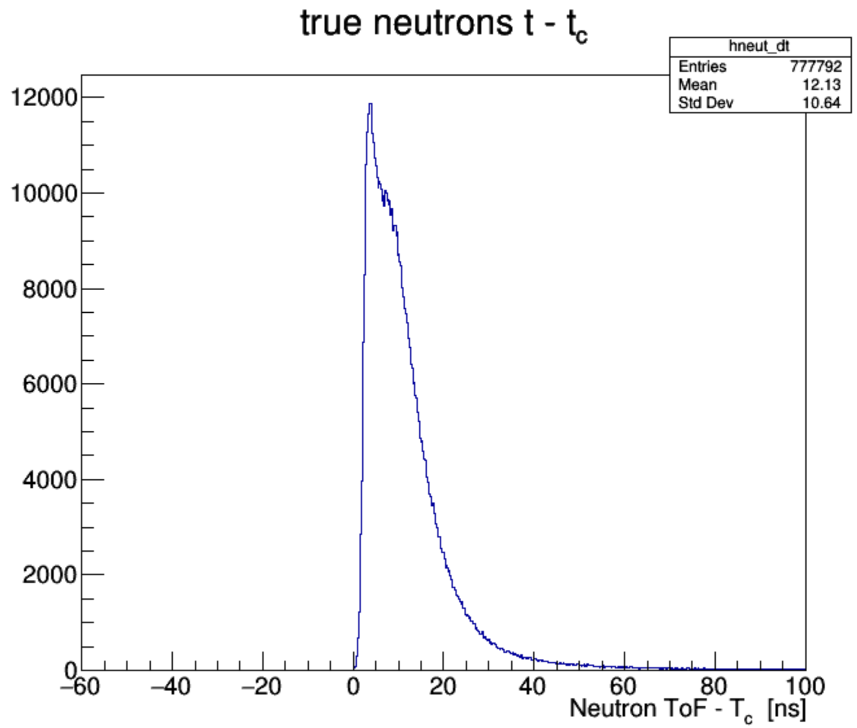


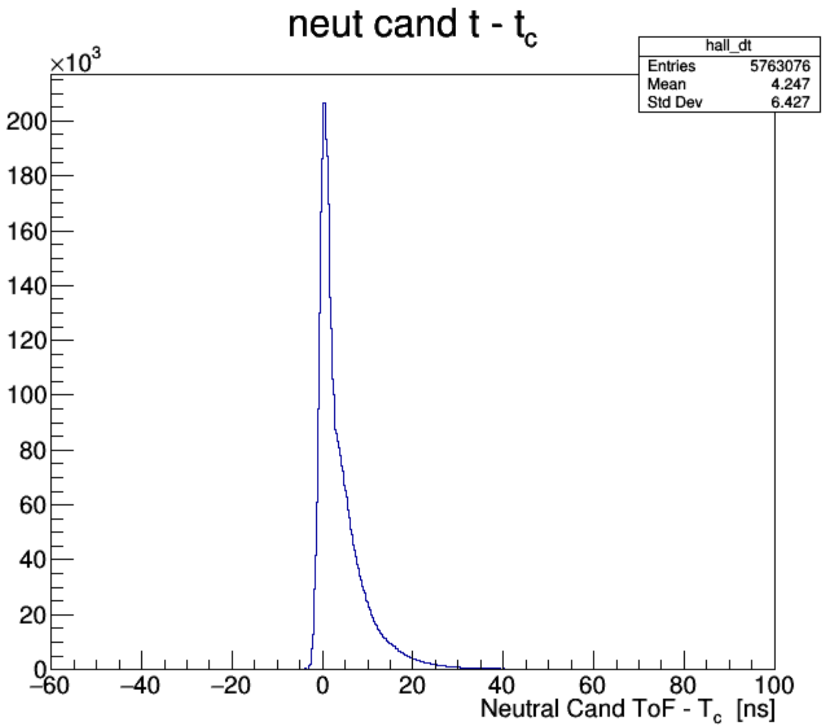
Time Difference

$T - T_{v=c}$ [ns] :

$\sigma_{\mathrm{ToF}} = 0$ ns





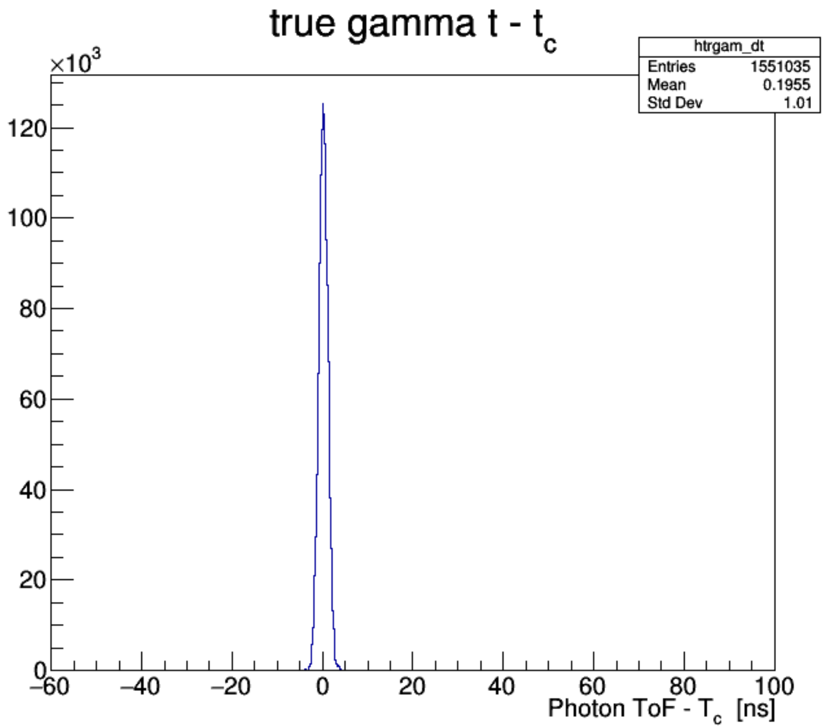


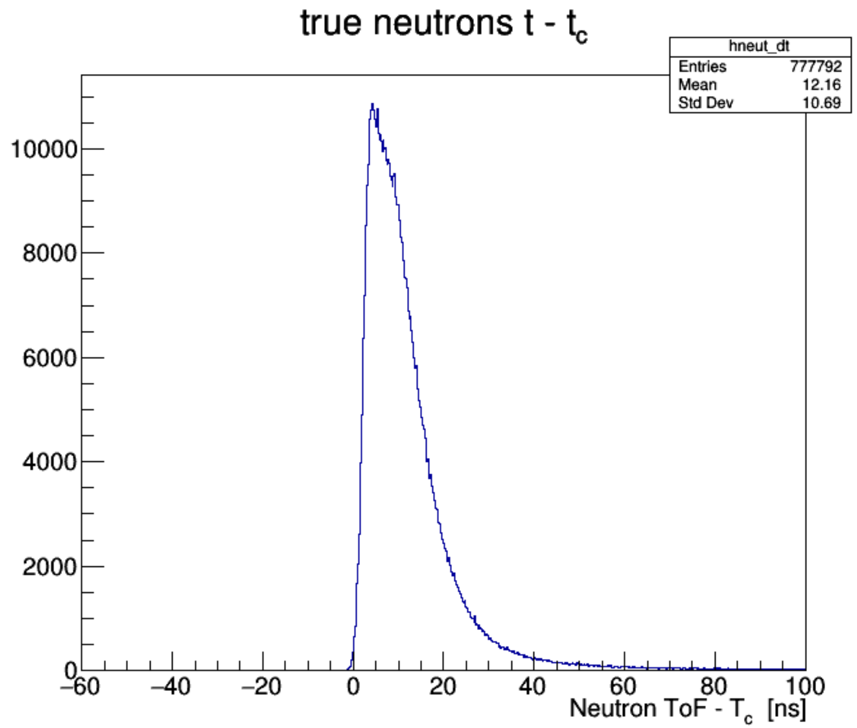
$T - T_{v=c}$ **[ns]**

$\sigma_{\mathbf{ToF}} = 1$ **ns**

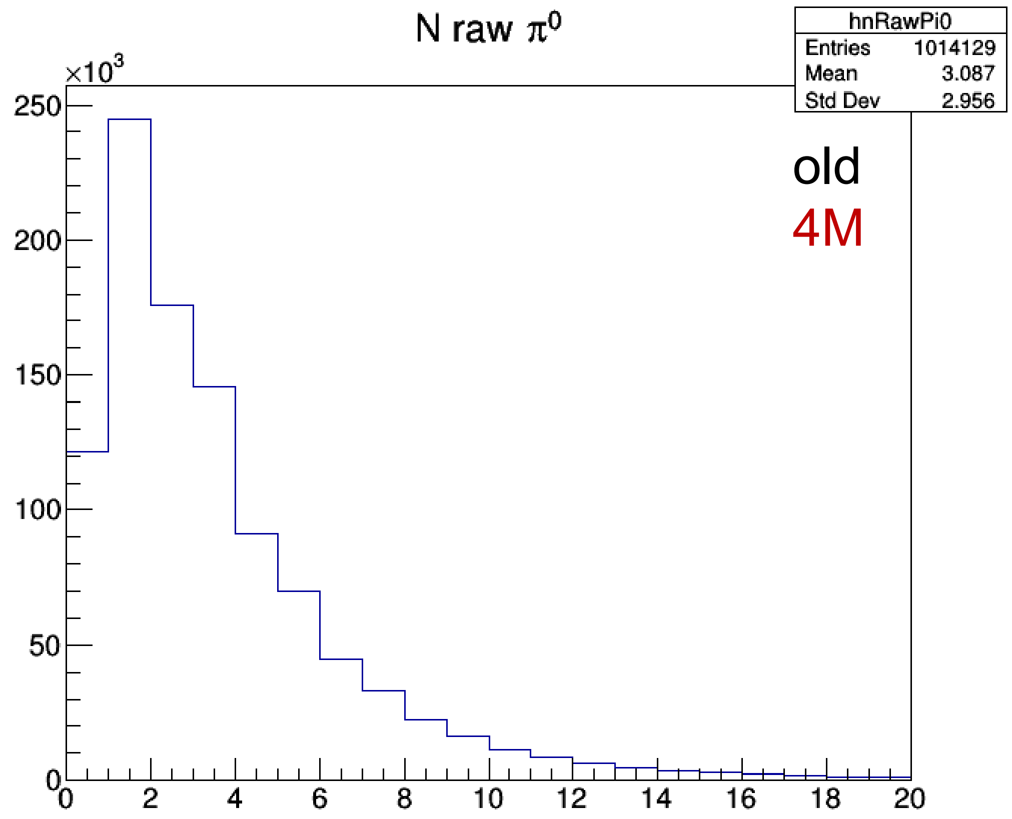
→ photon selection:

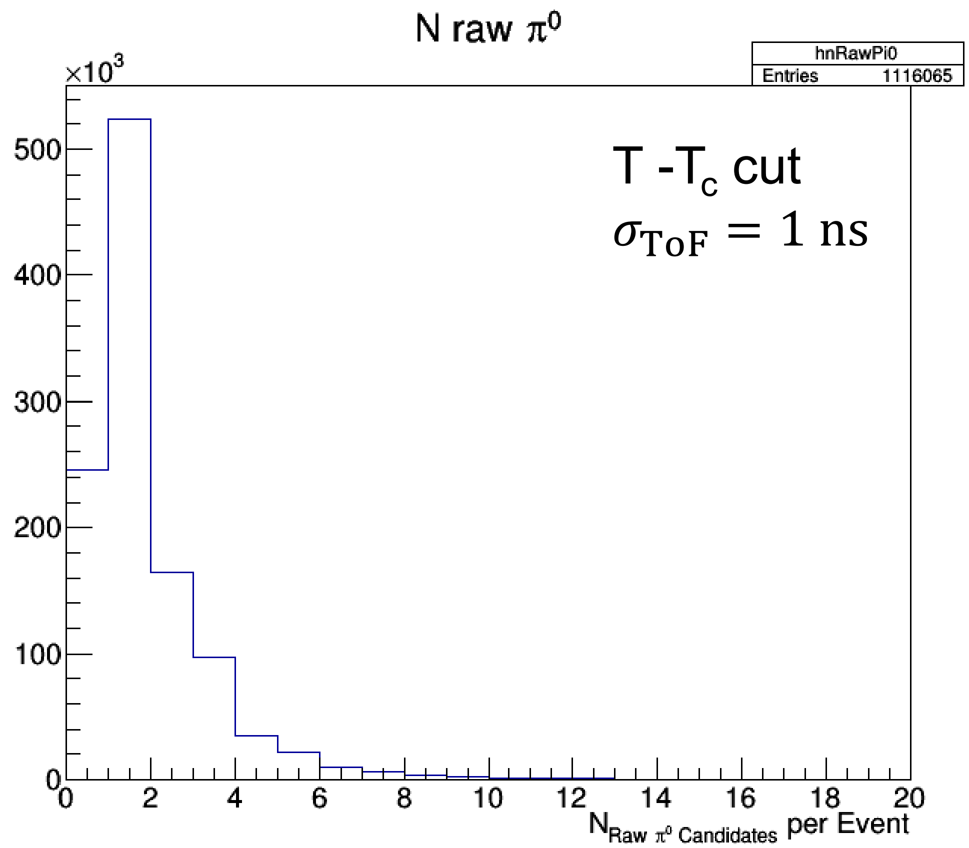
Δt Cut $T - T_{v=c} < 3$ **ns**





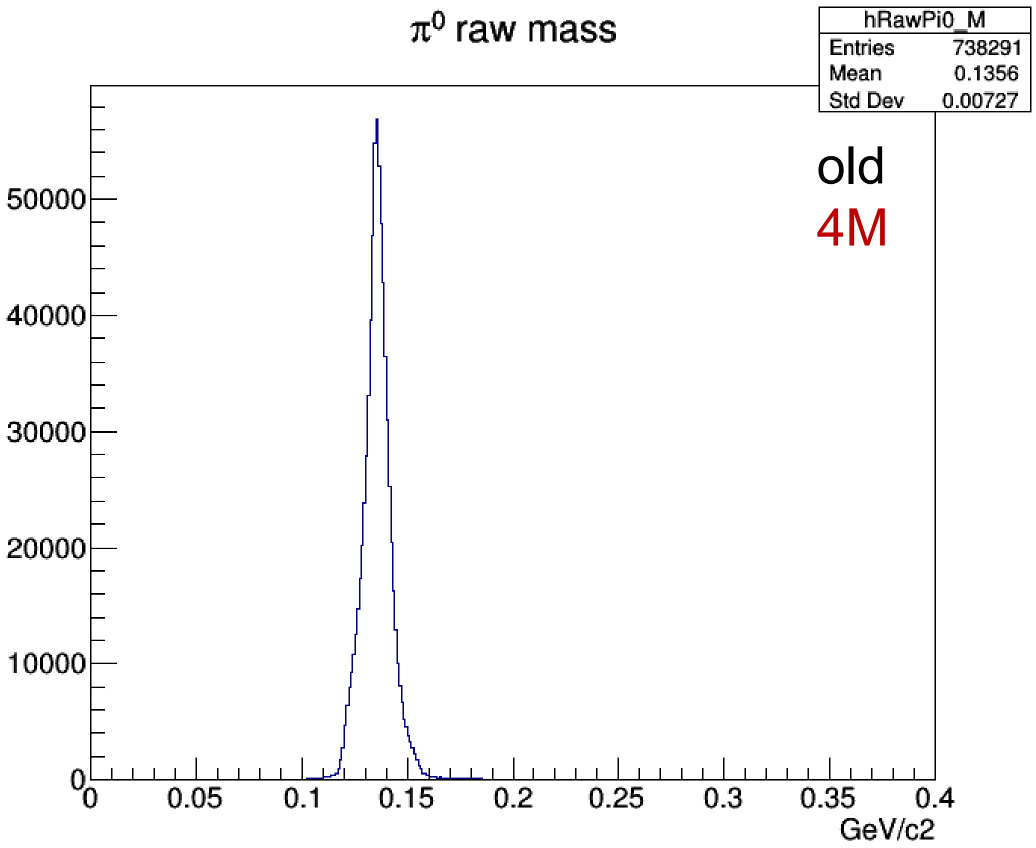
Effect of T-T_c Cut : π^0 Cand Multiplicity $\sigma_{\mathrm{ToF}} = 1$ ns

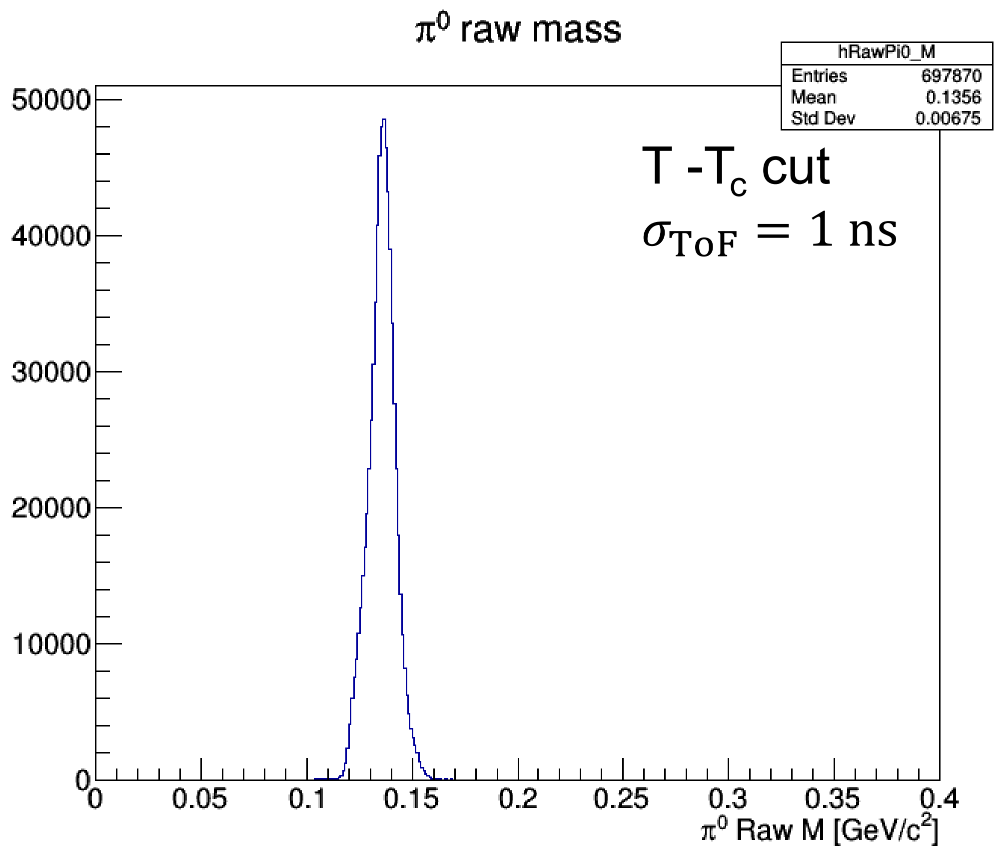




→ Number of raw π^0 candidates significantly reduced

T-T$_c$ Cut : π^0 Cands Passing Mass Fit ($\sigma_{\mathrm{ToF}} = 1$ ns)

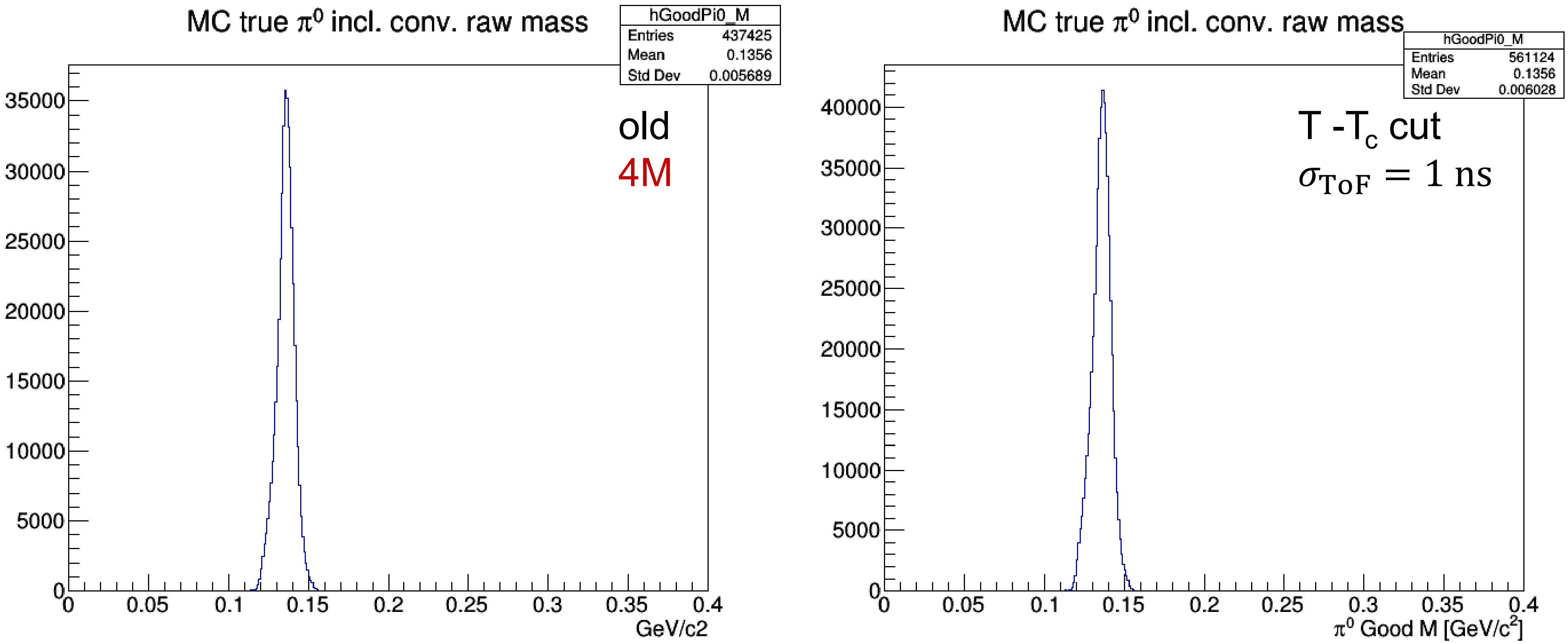




→ Reduced number of π^0 candidates per generated event:

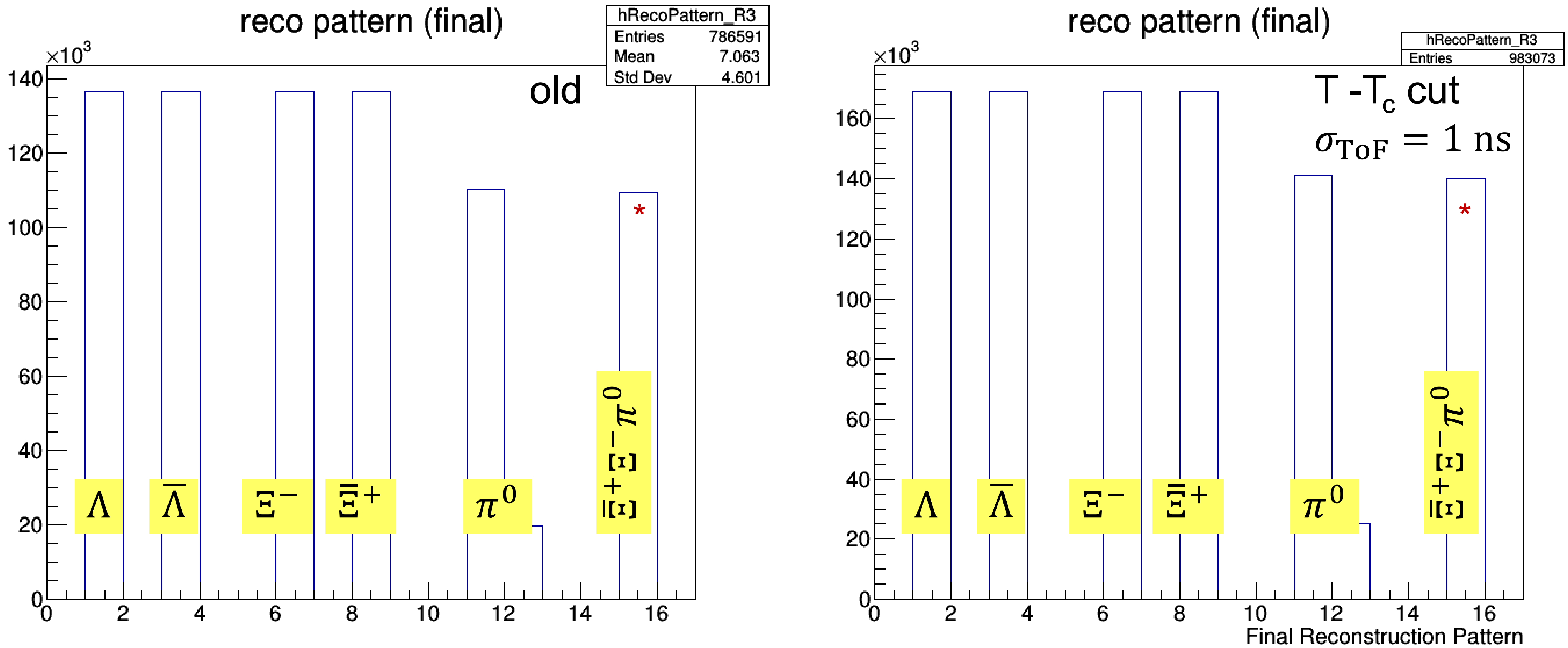
old: 18.7%, new: 16.1% ($\sigma_{\mathrm{ToF}} = 1$ ns) no smearing: 16.2%

T-T_c Cut : π^0 'Good' Cands after Mass Fit ($\sigma_{\mathrm{ToF}} = 1$ ns)



- → fraction of π^0 ‚good' candidates after m.c.fit increased
- → ratio ‚good'/all increased from 59.2% to 80.4%

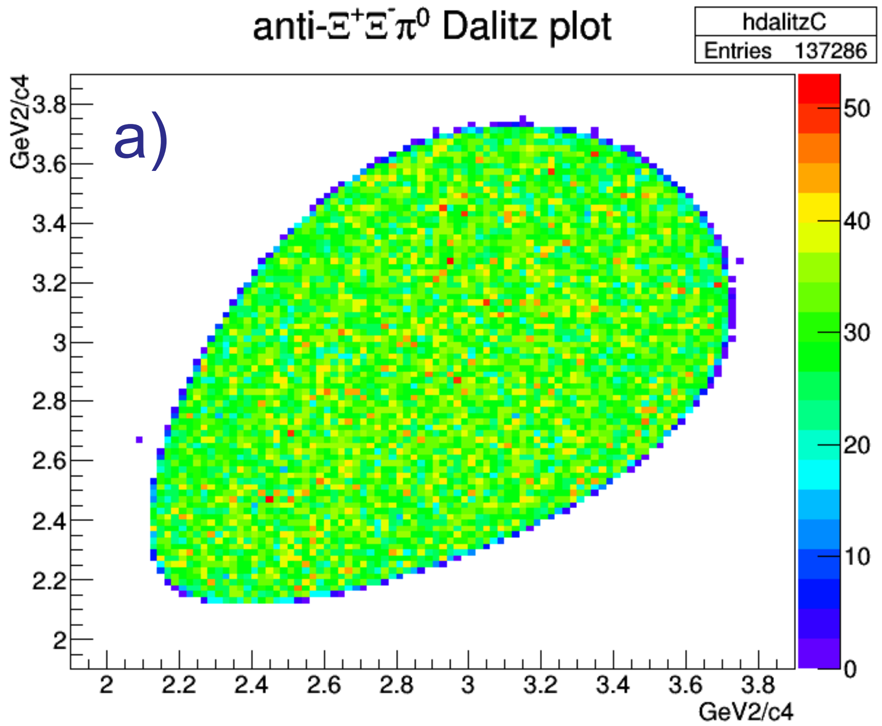
T – T_c Cut : McTruth Cands in Final Signal ($\sigma_{\mathrm{ToF}} = 1$ ns)



→ final reco eff. increased from 3.48% to 3.91%

McTruth* fraction in π^0 increased from 94.9% to 97.2% !

* incl. conv.



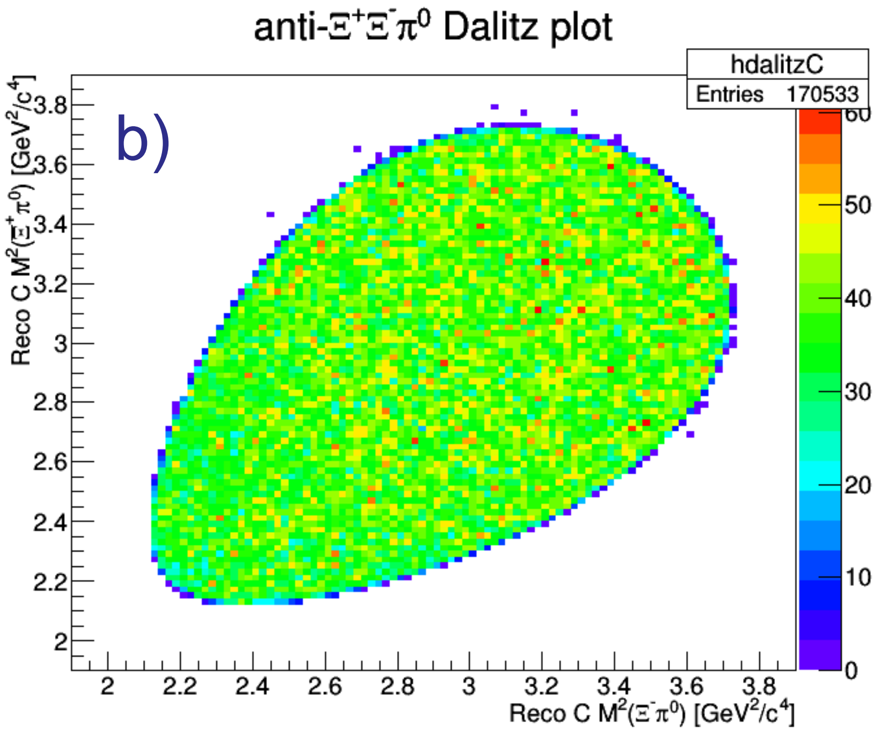
Reconstr. ‚final‘ $\bar{\Xi}^+\Xi^-\pi^0$ Dalitz Plot

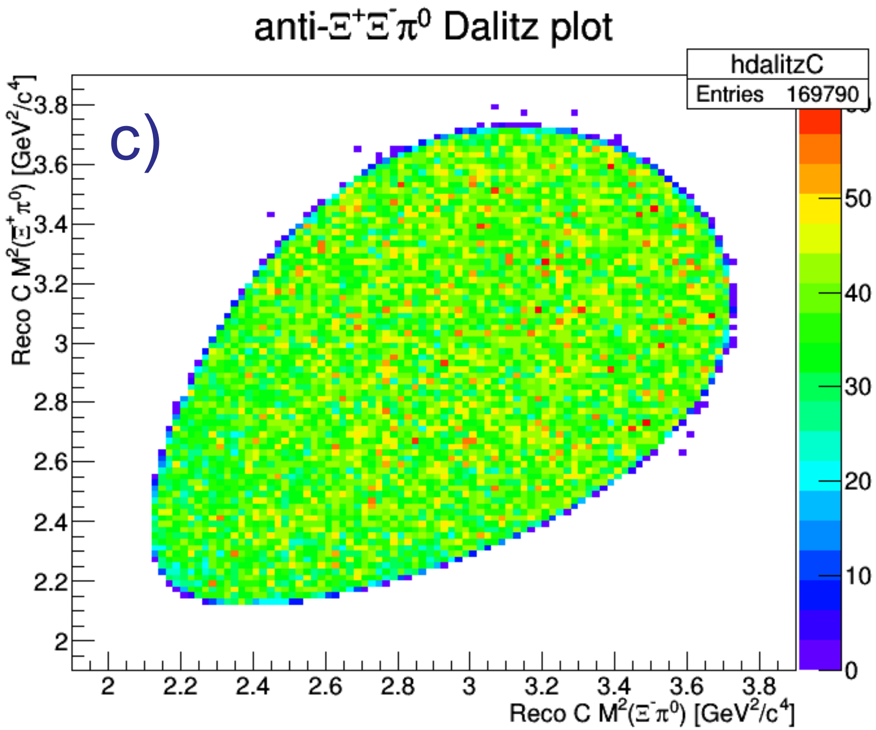
a) old: 137,286 evts / 4.0 M

b) $\sigma_T = 0$ ns: 170,533 evts / 4.4 M

c) $\sigma_T = 1$ ns: 169,790 evts / 4.4 M

c) / b) = 99.85%



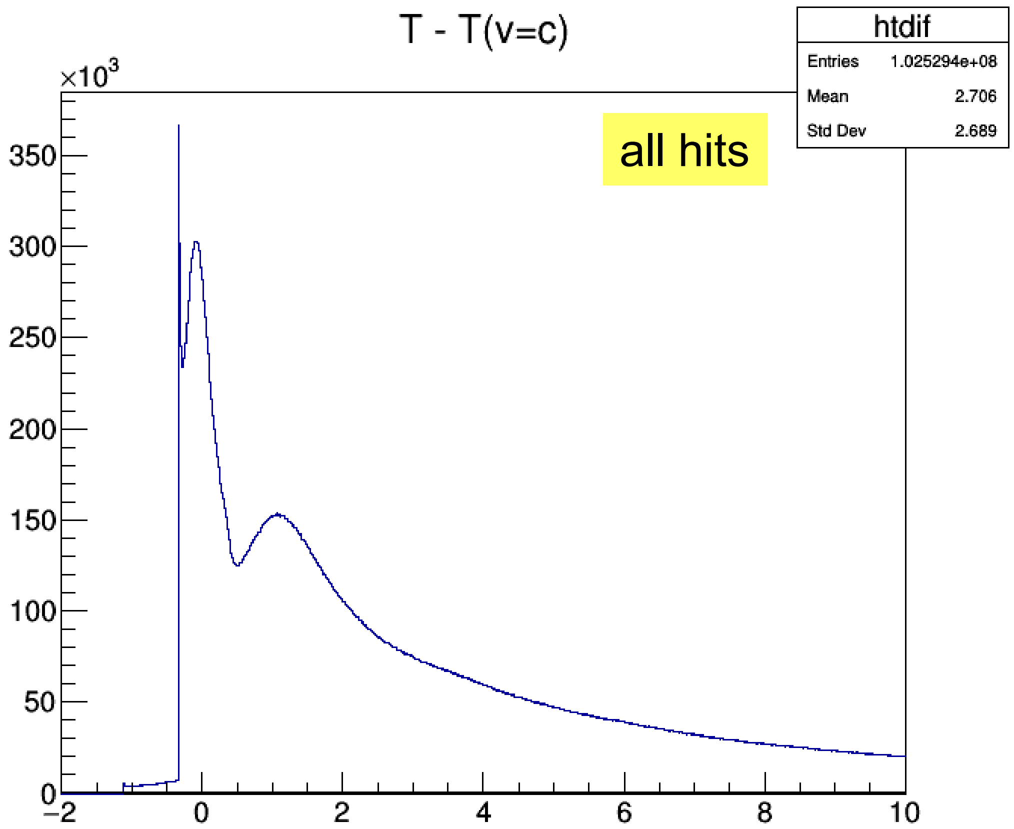


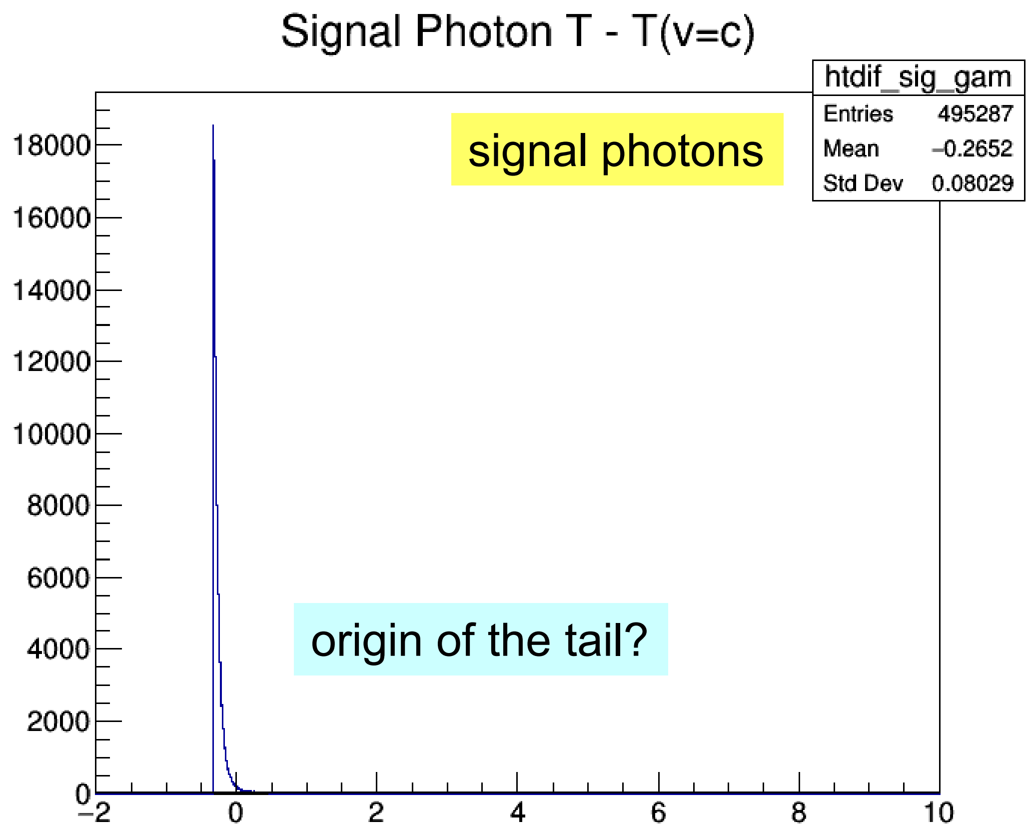
Conclusion & Outlook

- Using EMC time information significantly improves π^0 reconstruction
- Still true with time smearing $\sigma_T = 1\ \mathrm{ns}$
- Next:
  - use decay tree fitter (close to completion)
  - use realistic PID
  - repeat analysis with new PandaRoot version

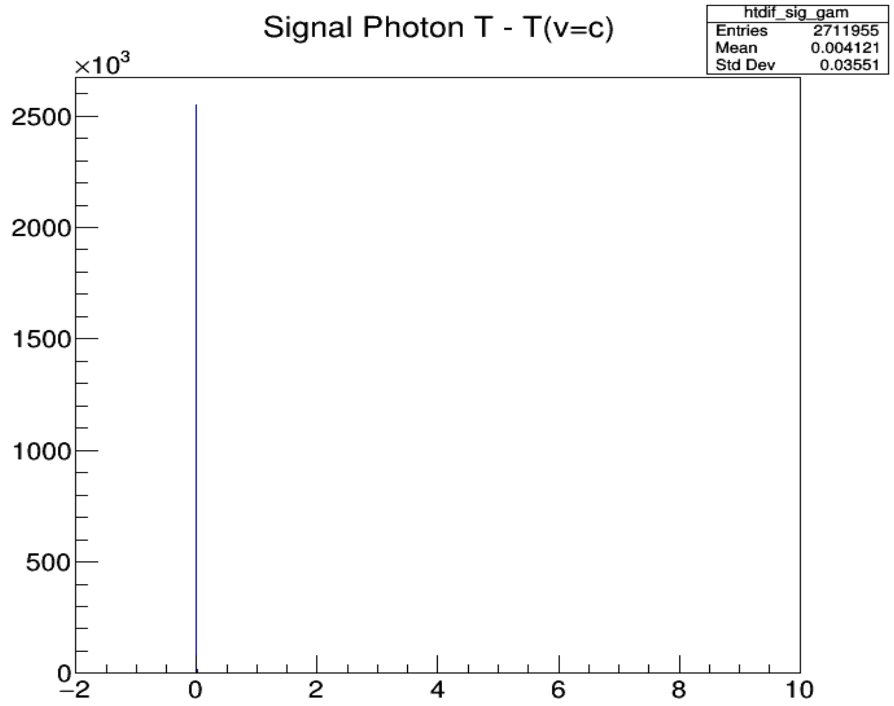
Backup

Analysis of EMC Hits: Time Spectra





- negative Δt values & tail to larger positive Δt values


Signal Photon T - T(v=c)
htdif_sig_gam
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Std Dev 0.03551
×10^3
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1000
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0
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0
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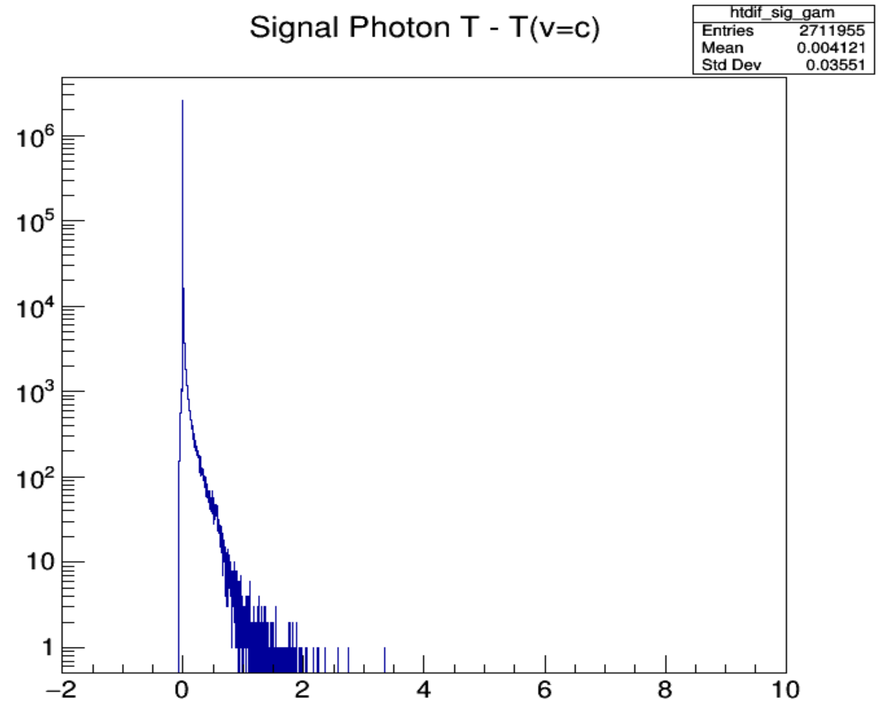
4
6
8
10


Signal Photon T - T(v=c)
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Entries 2711955
Mean 0.004121
Std Dev 0.03551
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10^5
10^4
10^3
10^2
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−2
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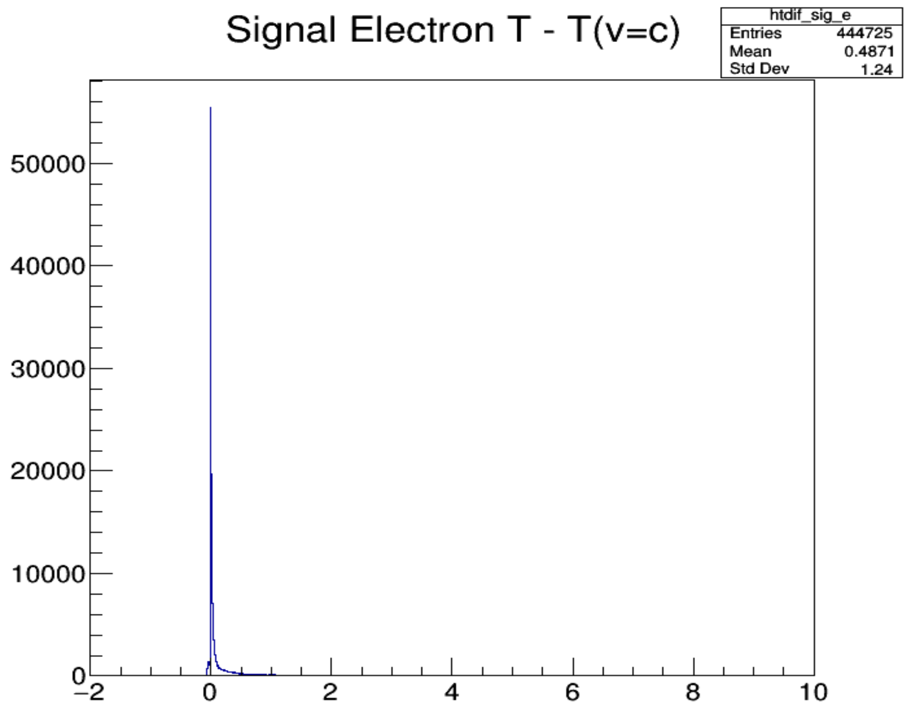
4
6
8
10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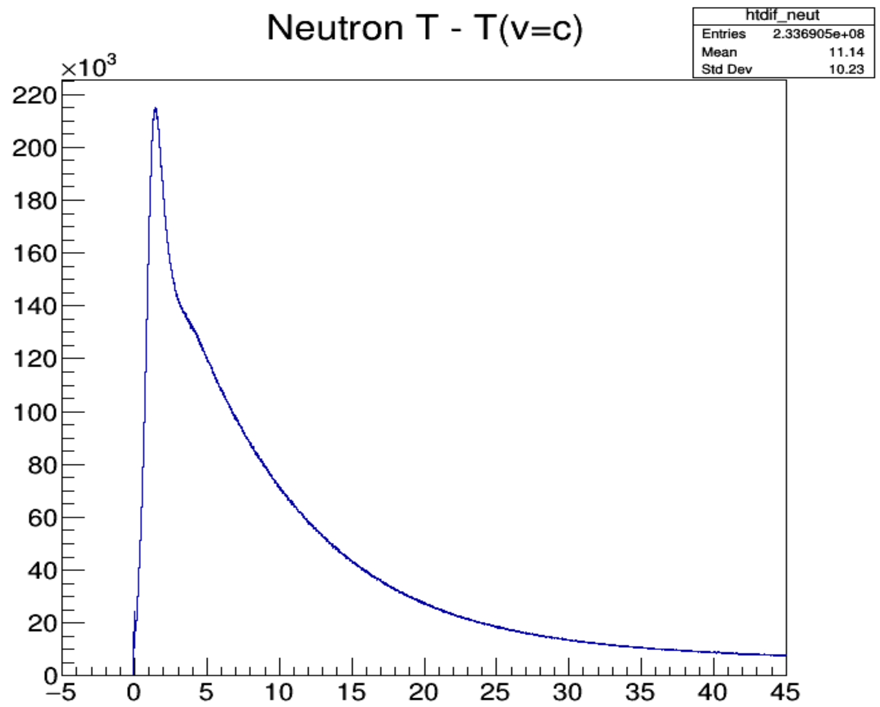
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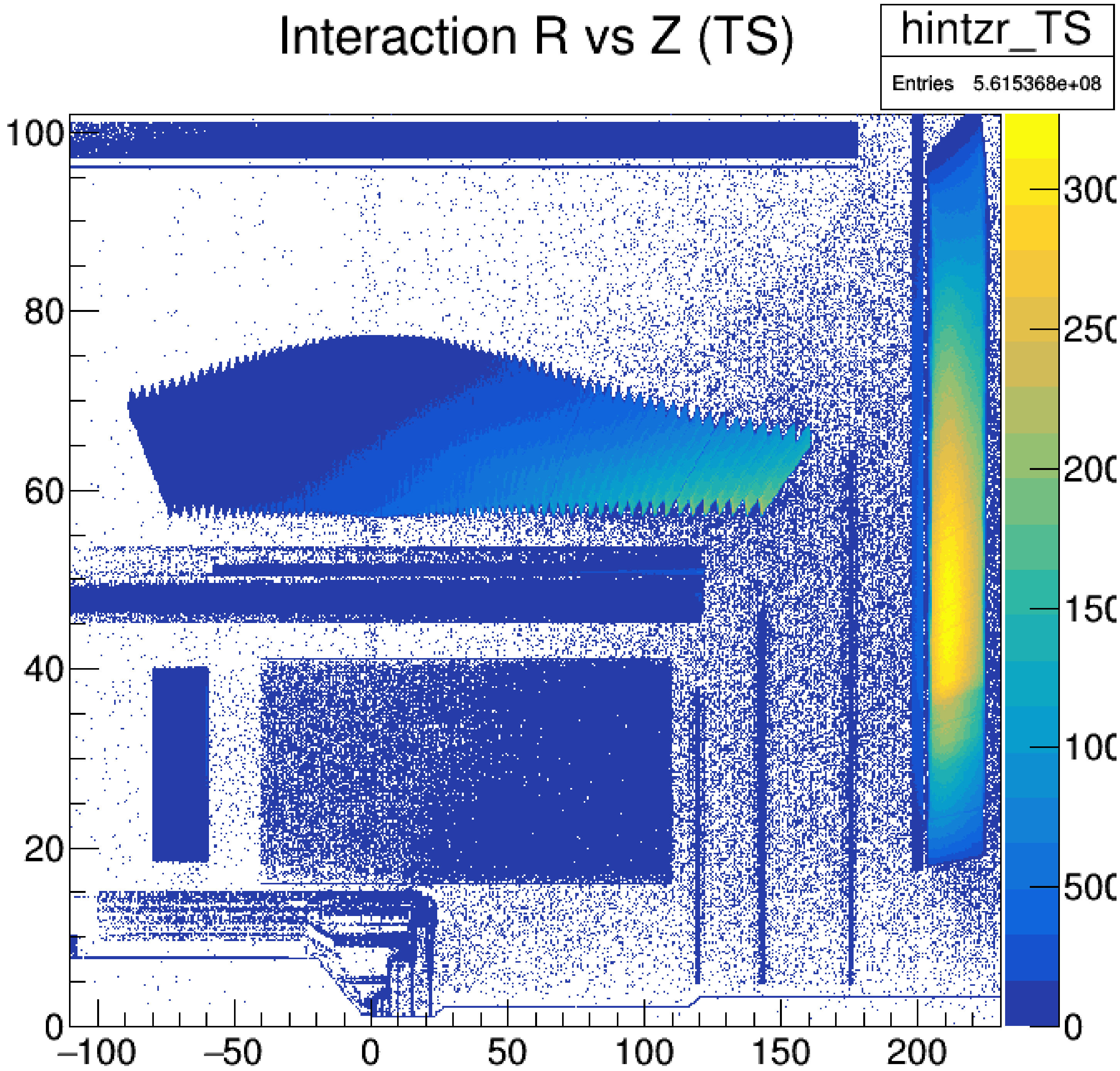
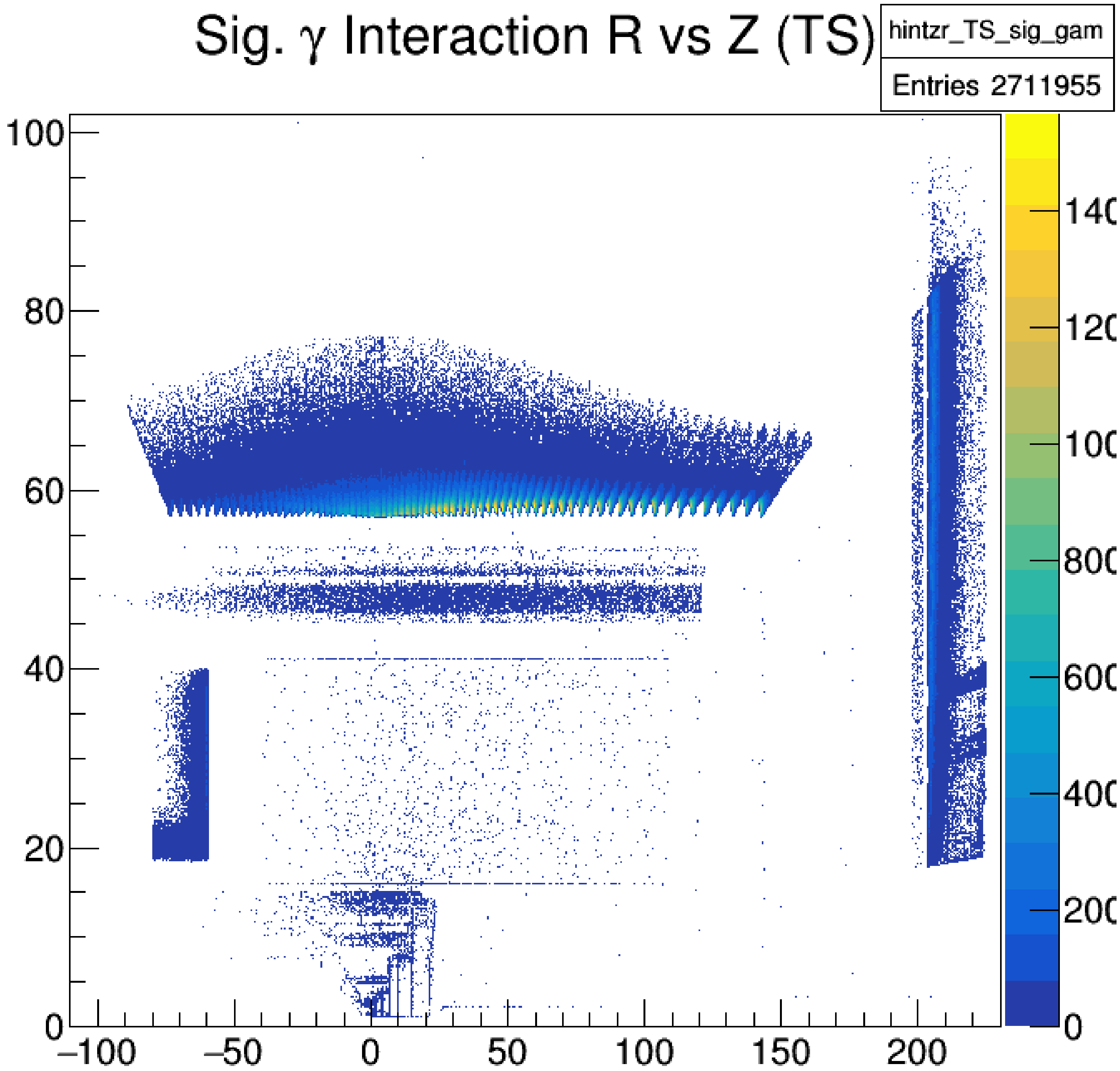


Position of interactions of MC tracks causing an EmcHit



Position of interactions of primary photon MC tracks