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JÜLICH
FORSCHUNGSZENTRUM

Hyperon Spectroscopy Status Report

Jun 8, 2017 | Albrecht Gillitzer, IKP Forschungszentrum Jülich

PANDA Collaboration Meeting 17/2, GSI Darmstadt, June 6-9, 2017

Items

I. Production of zero-width resonances in FTF & G4

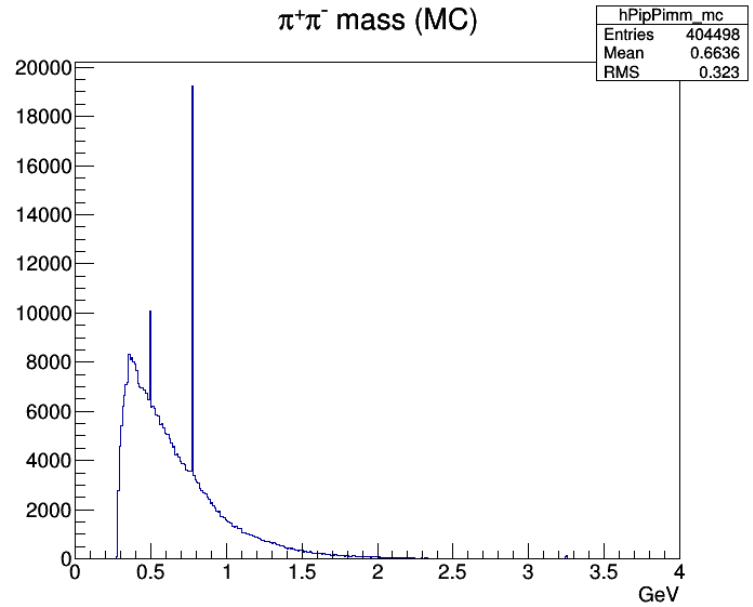
II. Simulation & analysis of $\bar{p}p \rightarrow \Xi^{-}\bar{\Xi}^{+}\pi^{0}$

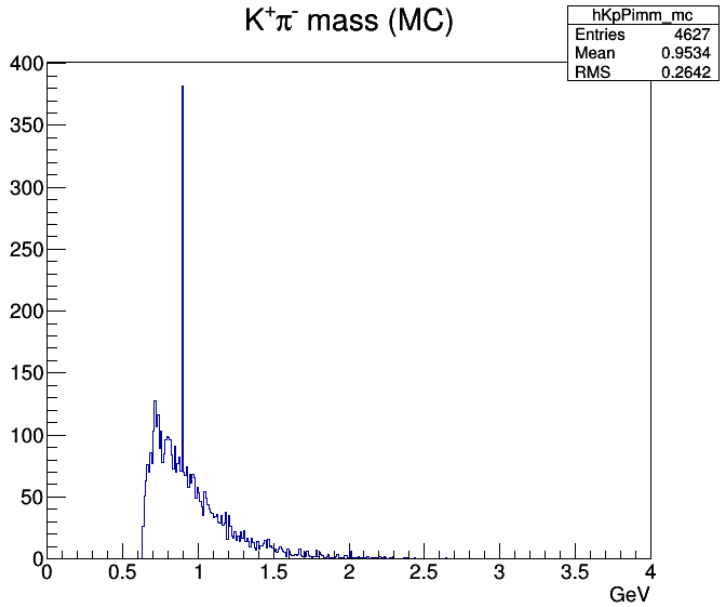
III. ‚Strange' decays / interactions seen in MC truth list

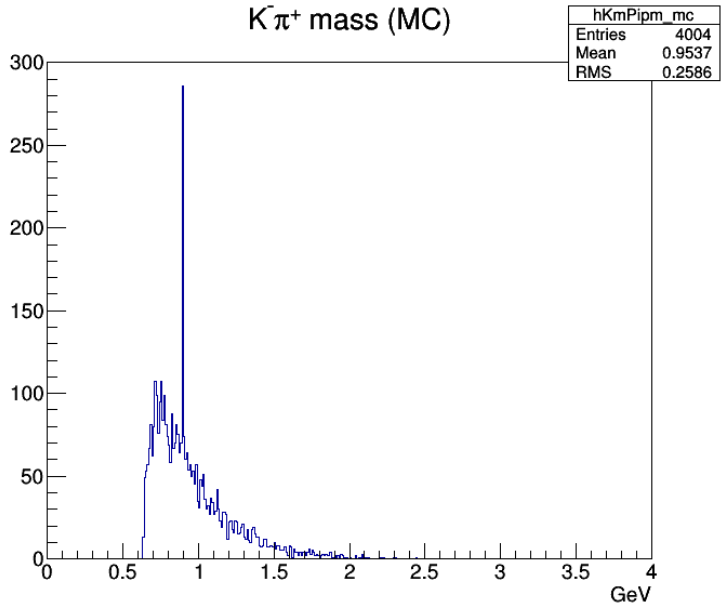
I: How to validate DPM & FTF simulation?

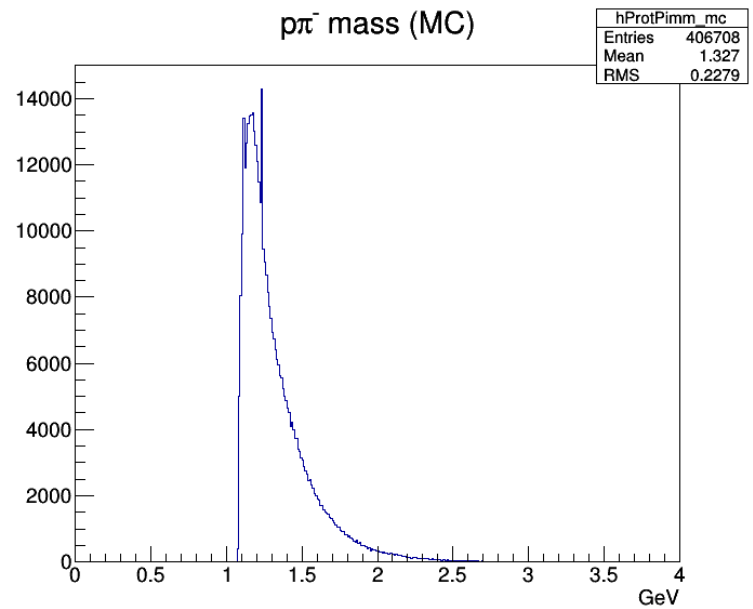
- Macros in …/macro/qa/dpm4 (and …/dpm3)
- Found that macros are useless since they attempt to reconstruct J/ψ and ψ(2S)
- Which are the appropriate criteria?
- Idea: try to reconstruct composite particles
  - 10^5 DPM events;
  - MC Truth primary & secondary particles
  - Combination of two particles coming from same vertex

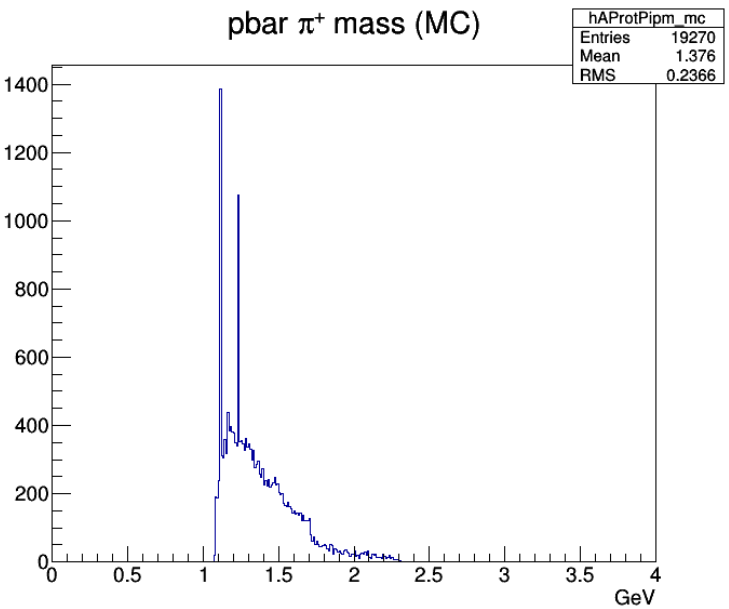
DPM 4.6 GeV/c $\bar{p}p$ prim. & sec. MC truth 2-body masses

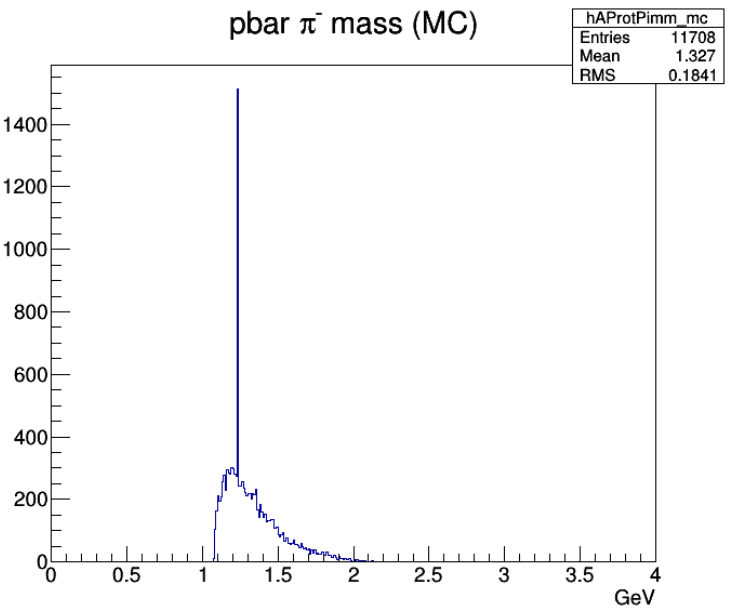












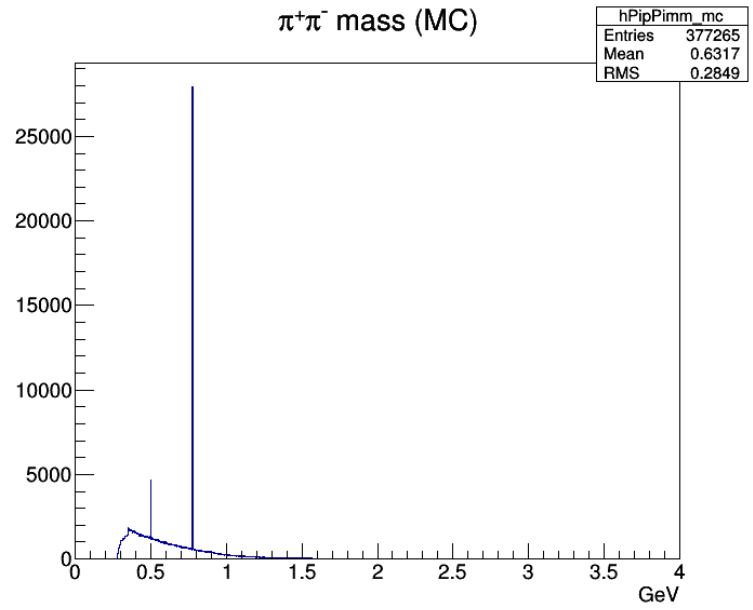
Direct Test of DPM and FTF Generator Output

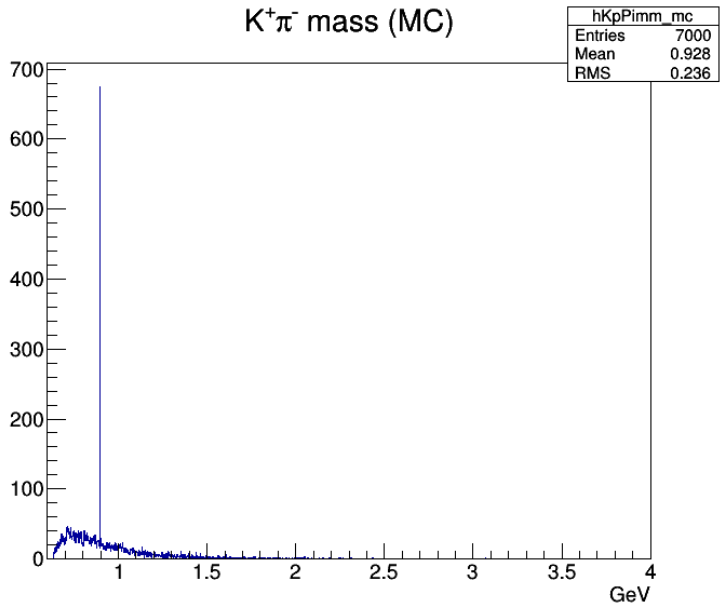
- 1.0 M events
- 4.6 GeV/c
- Generator output
- Result:
  - DPM does not produce these zero-width states
  - FTF produces the zero-width resonances

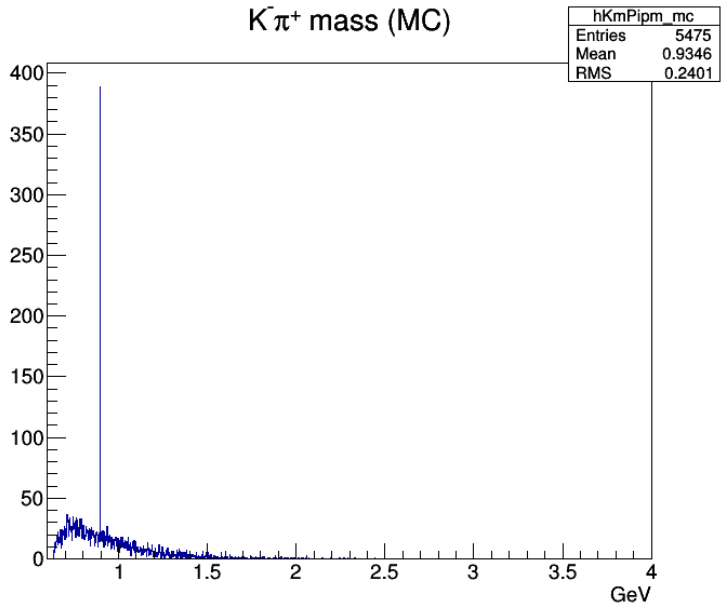
Final test with Box Generator Events

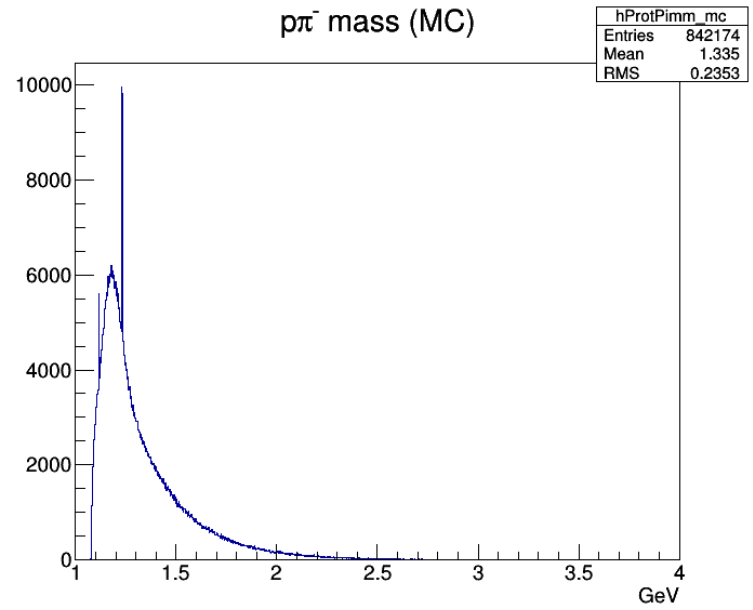
- 0.1 M events
- 4.6 GeV/c $\bar{p}$, then later also 15 GeV/c p
- 1 $\bar{p}$ per event → all particles except one are secondary
- θ range: 5^o – 45^o
- φ range: 0^o – 360^o
- build 2-particle invariant mass spectra
- condition: common start point

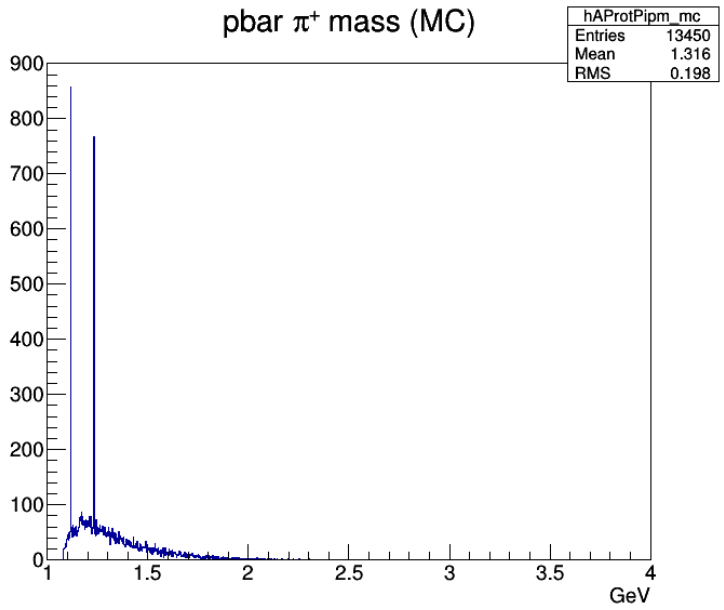
Box Gen 4.6 GeV/c $\bar{p}$ prim. & sec. MC truth 2-body masses

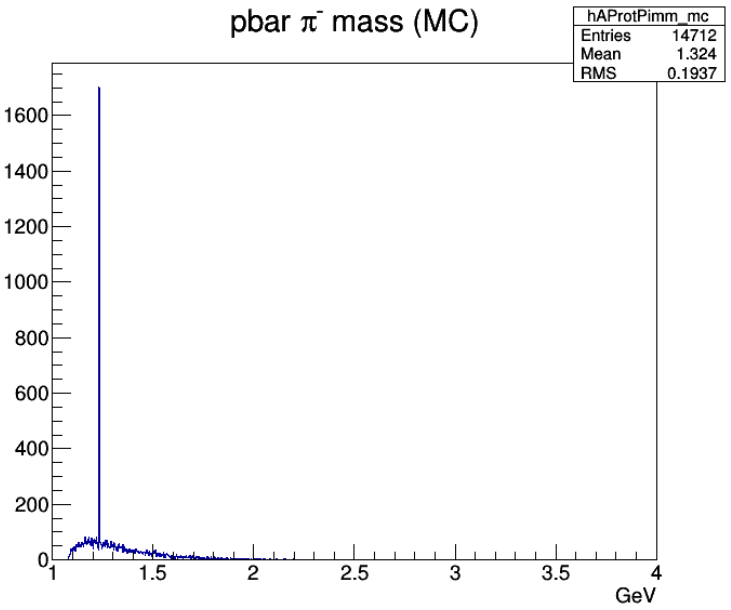




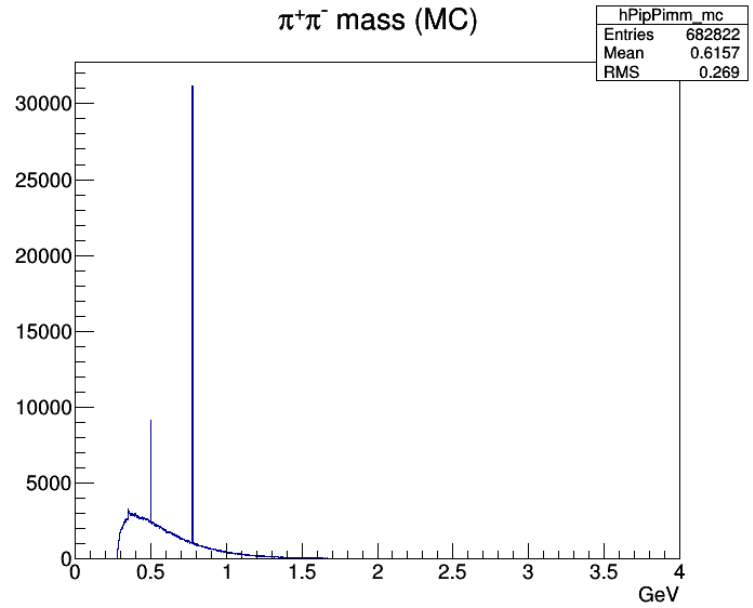


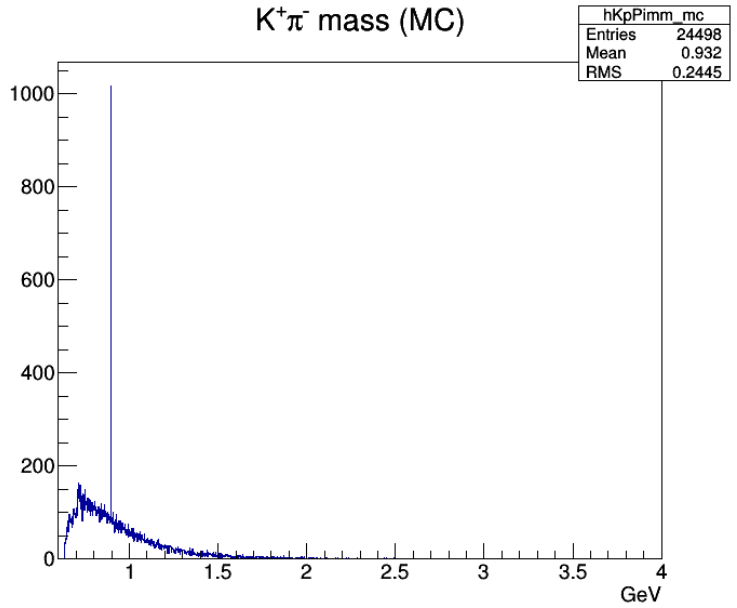


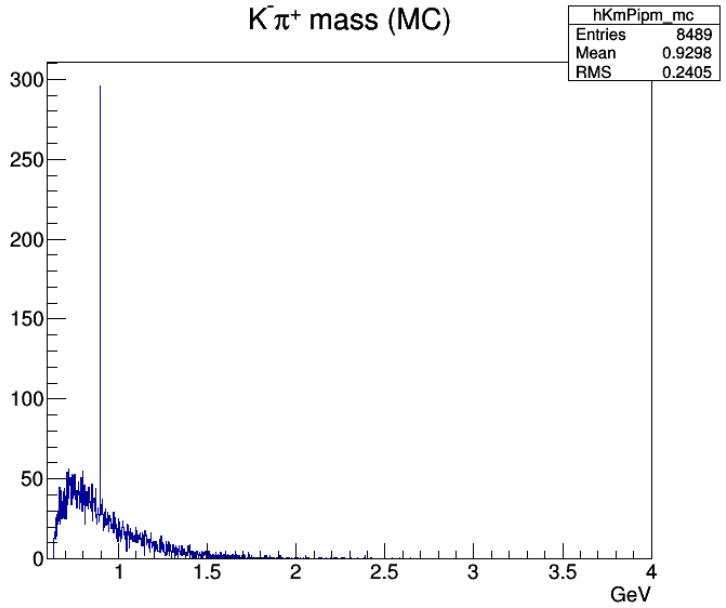


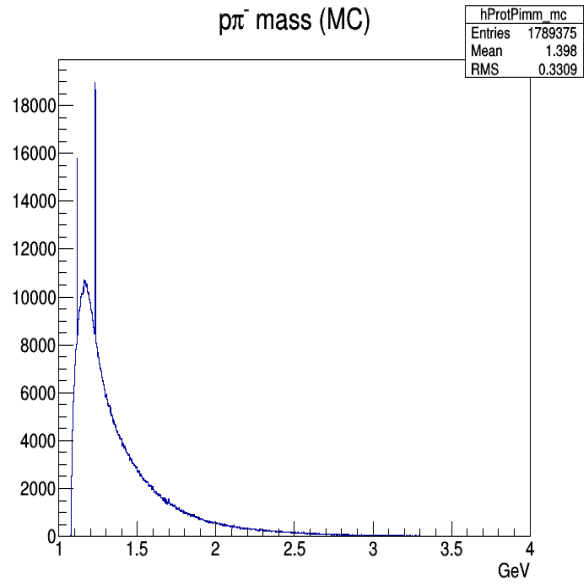


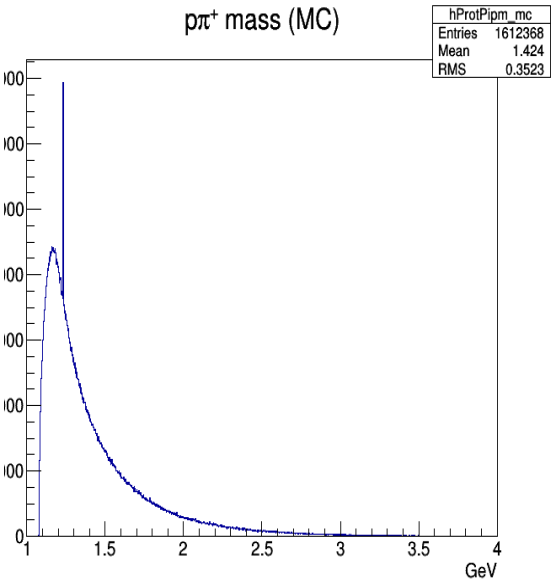
Box Gen 15 GeV/c p prim. & sec. MC truth 2-body masses

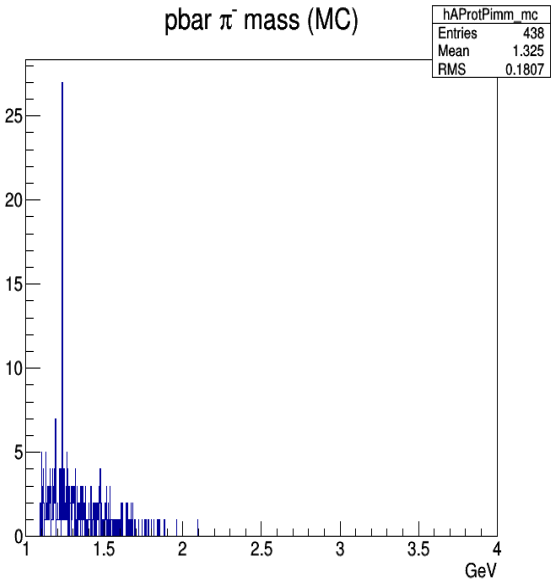


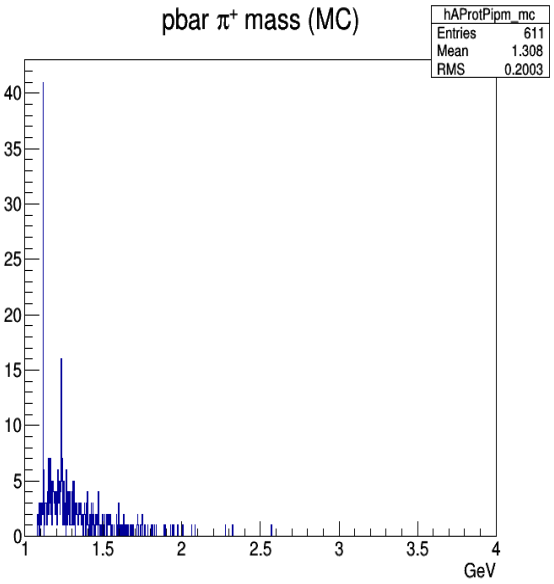




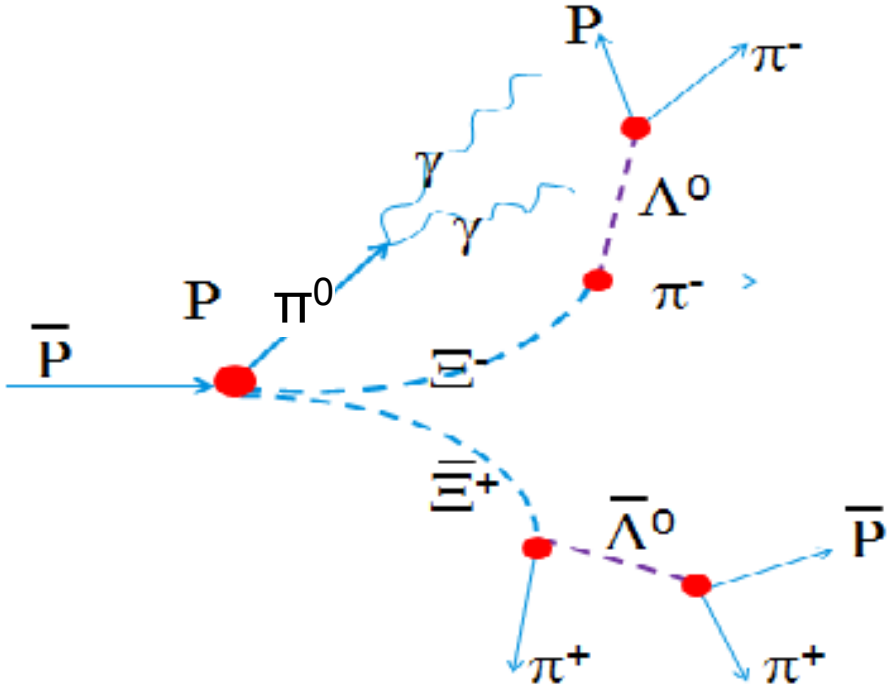






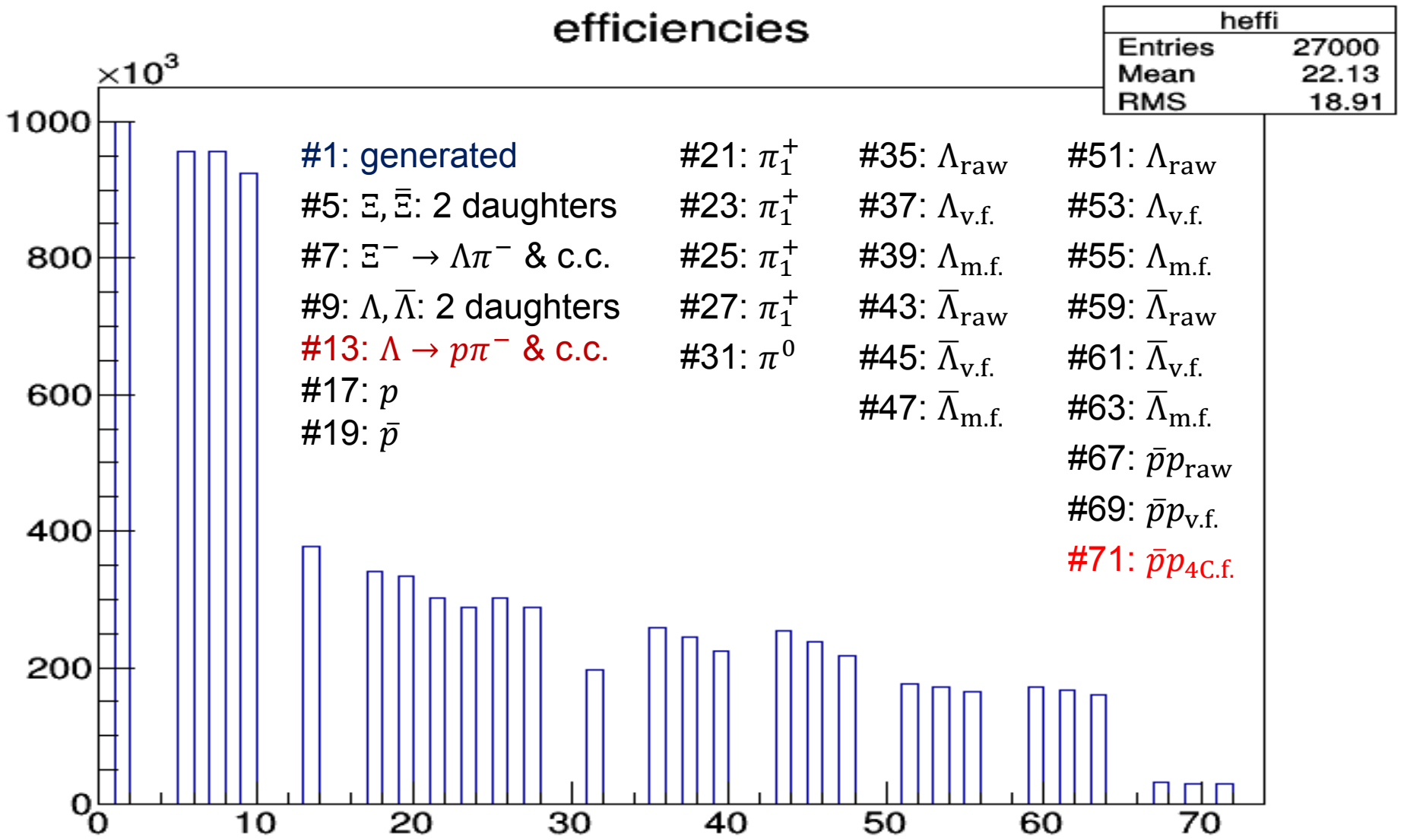


II: Simulation of $\bar{p}p \to \Xi^-\bar{\Xi}^+\pi^0$



- 4.6 GeV/c $\bar{p}p \to \Xi^-\bar{\Xi}^+\pi^0$ (PHSP)
- $1 \cdot 10^6$ events simulated (trunk 29773)
- $\bar{\Xi}^+, \Xi^-$ ‚stable' in EvtGen
- $\Lambda \to p\pi^-$ & $\bar{\Lambda} \to \bar{p}\pi^+$(~40%) analyzed
- focus on reconstruction efficiency and momentum & position resolution
- charged and composite particles: MC truth matched (correct PID, correct mother)
- photons: include neutral candidates whose mother is a photon and whose grandmother is pbarpSystem

Event Statistics

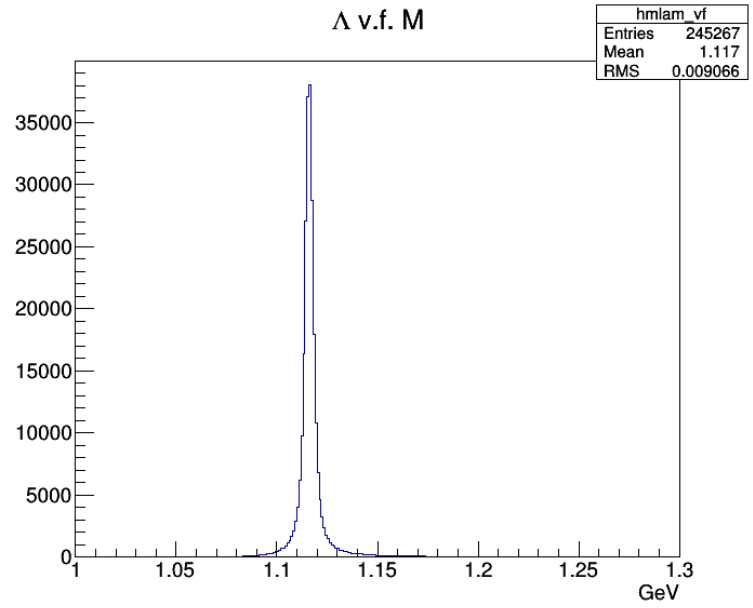


Reconstruction Efficiencies

reconstruction efficiencies in % :

p	$\bar{p}$	π^-	π^+	π^0	Λ	$\bar{\Lambda}$	Ξ^-	$\bar{\Xi}^+$	$\bar{p}p$
90.8	88.7	78.3	78.3	52.0	59.3	57.3	44.0	42.5	7.8

- note:
  - Ideal tracking, no condition on #hits yet
  - ideal PID
  - MC truth matching (correct mother)
- KinVtxFitter → vertex, KinFitter → M, 4CFitter → initial p4
- composite particles: losses due to mass & probability cut


Λ v.f. M
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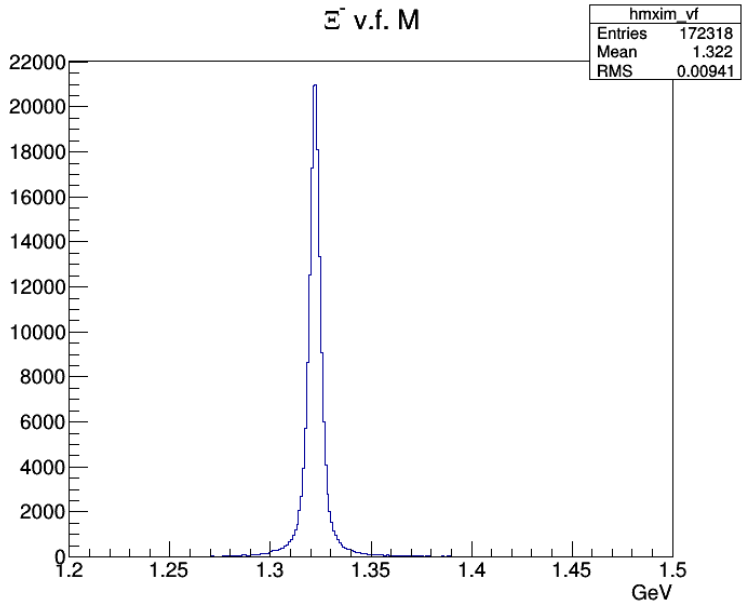
Entries 245267
Mean 1.117
RMS 0.009066
GeV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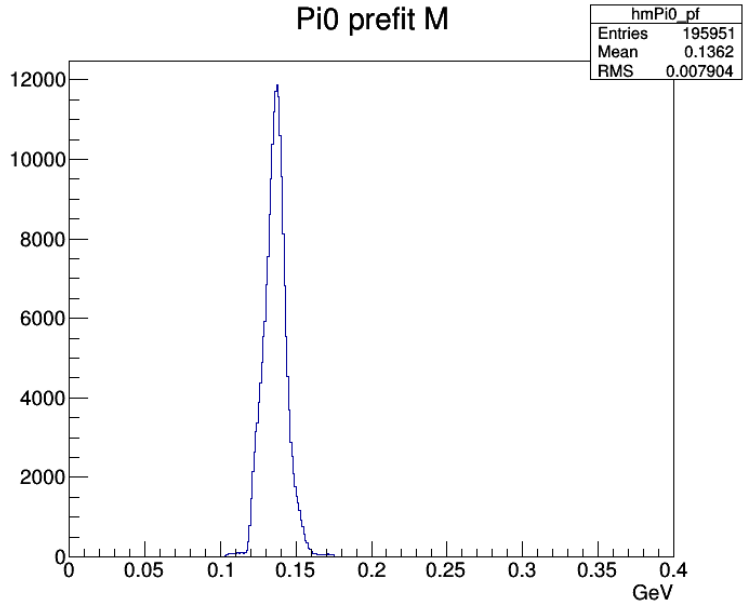
Entries 172318
Mean 1.322
RMS 0.00941
GeV


Pi0 prefit M
hmPi0_pf
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RMS 0.007904
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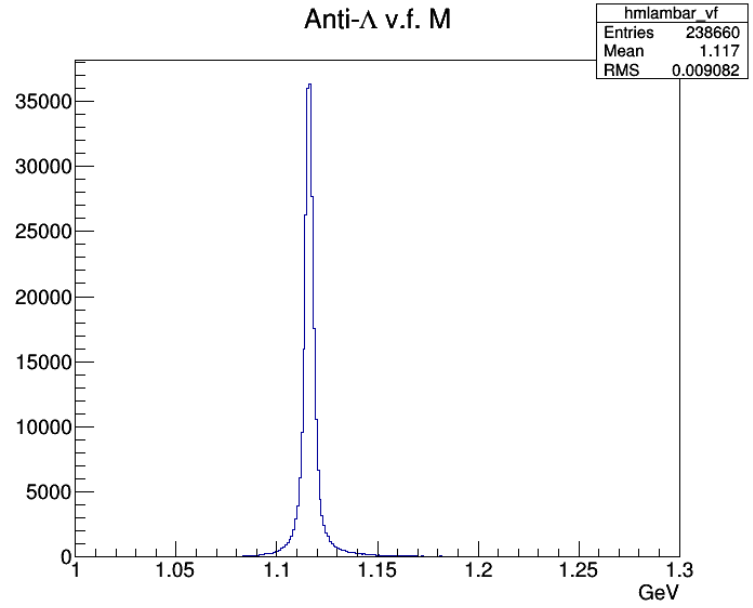
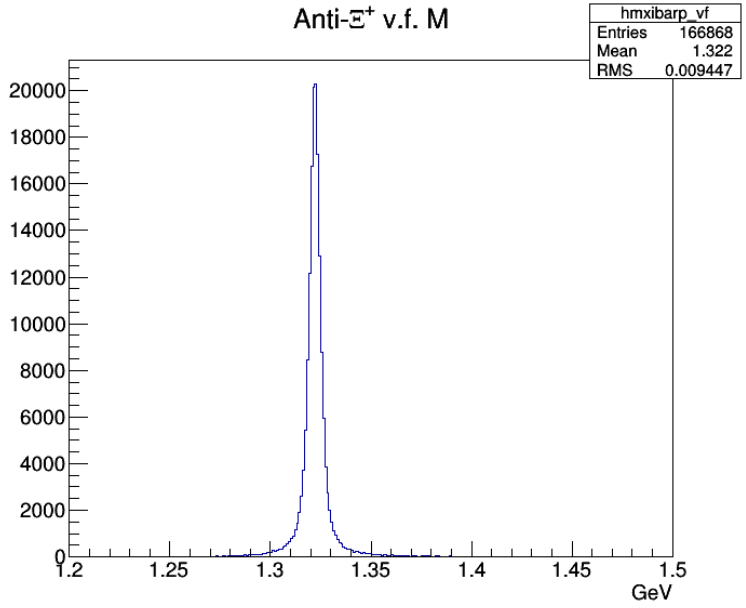

Anti-Λ v.f. M
hmlambar_vf
Entries 238660
Mean 1.117
RMS 0.009082
GeV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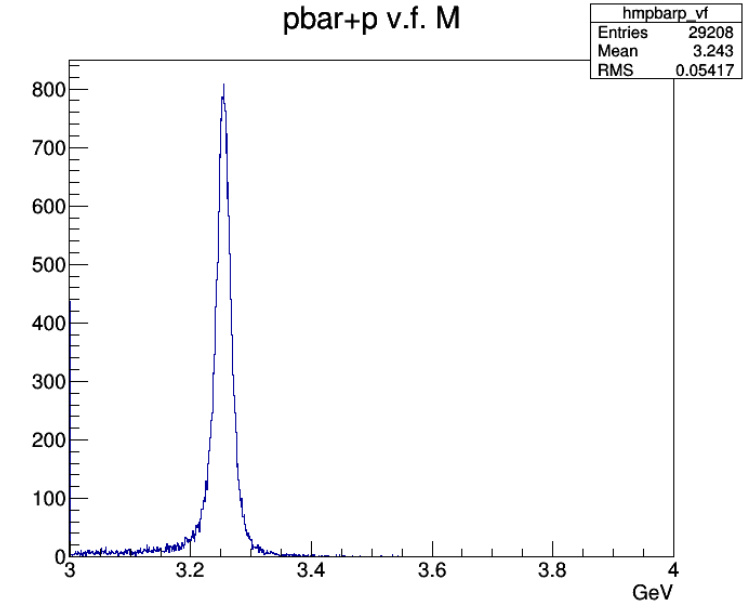
RMS 0.009447
GeV


pbar+p v.f. M
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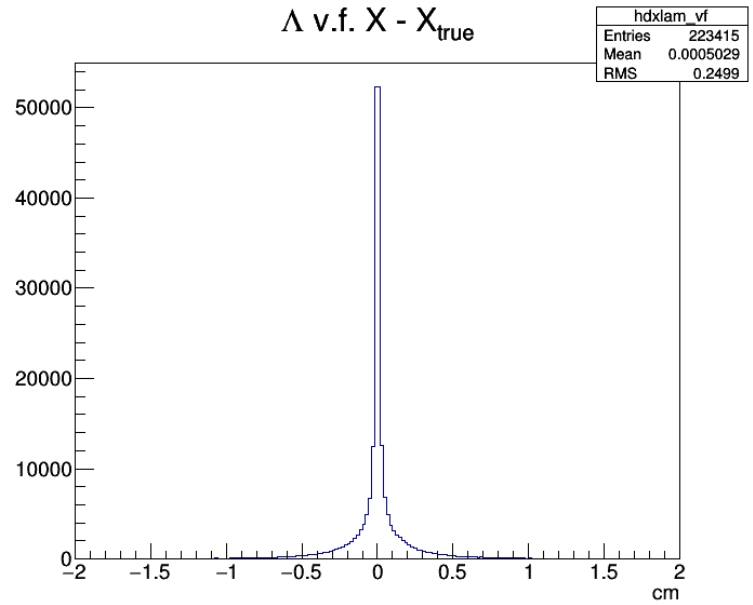
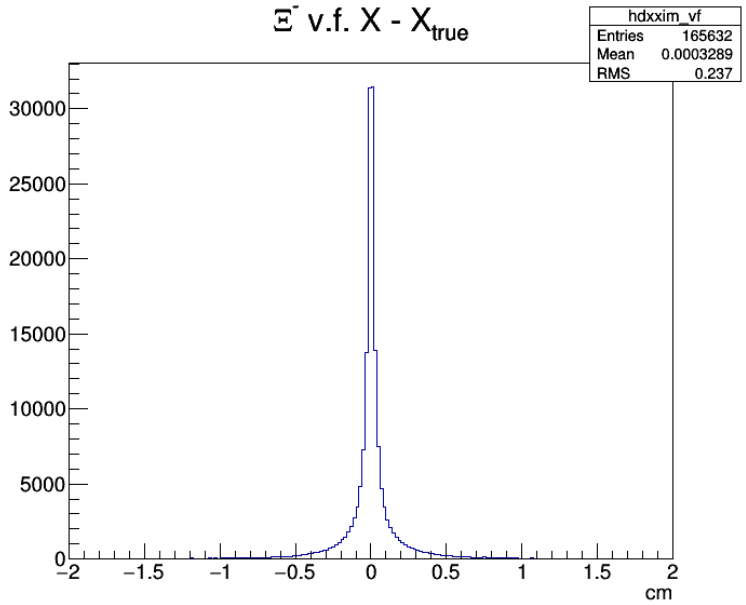
RMS 0.05417
GeV


Λ v.f. X - X_true
hdxlam_vf
Entries 223415
Mean 0.0005029
RMS 0.2499
cm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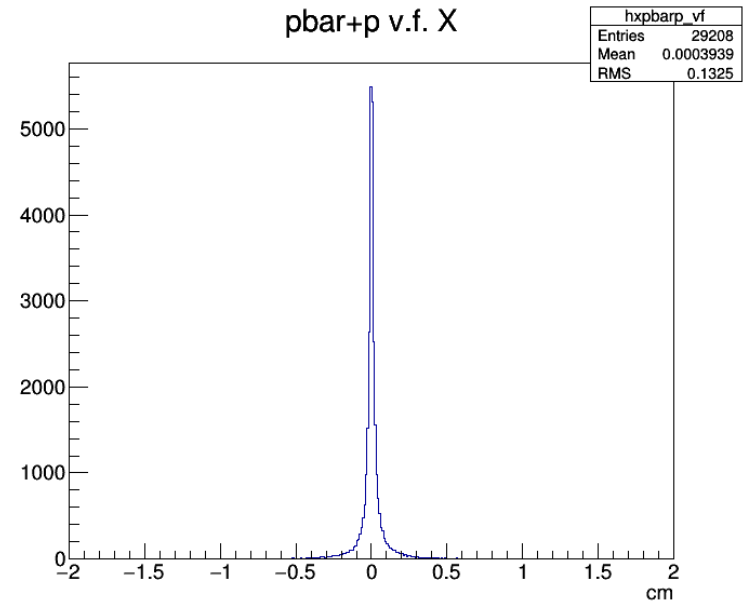
RMS 0.237
cm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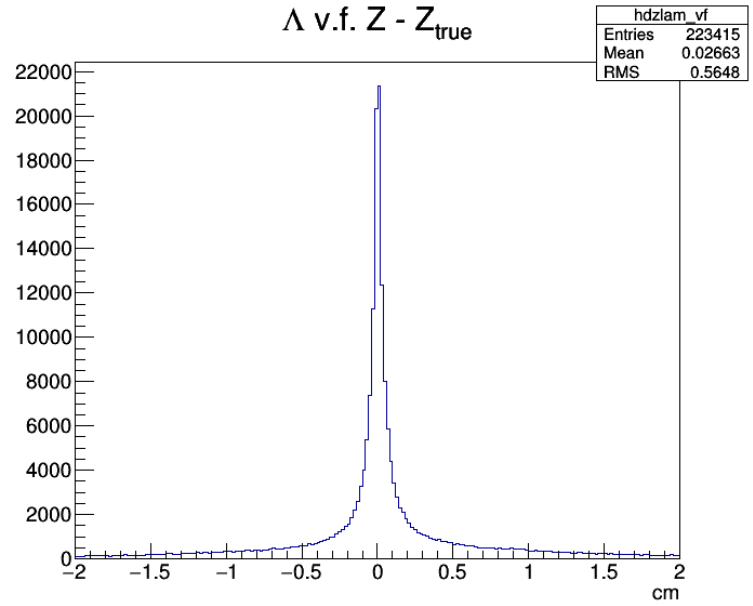
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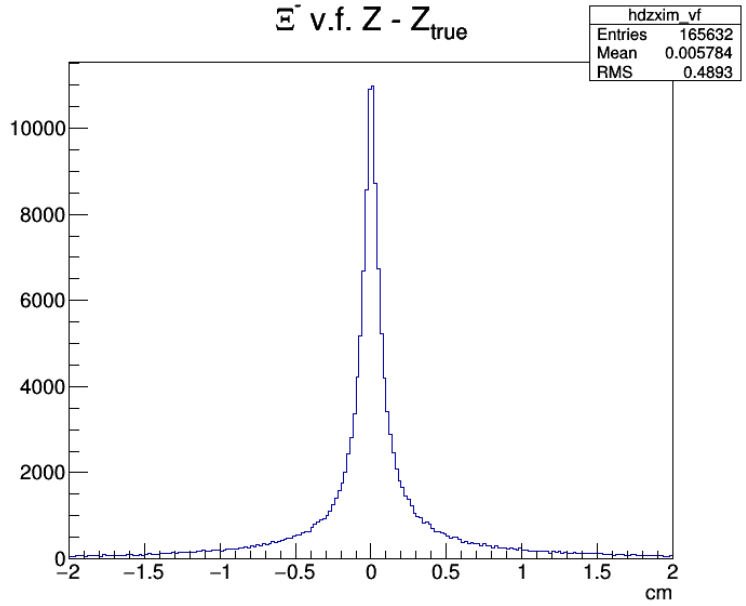
Mean 0.02663
RMS 0.5648
cm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RMS 0.4893
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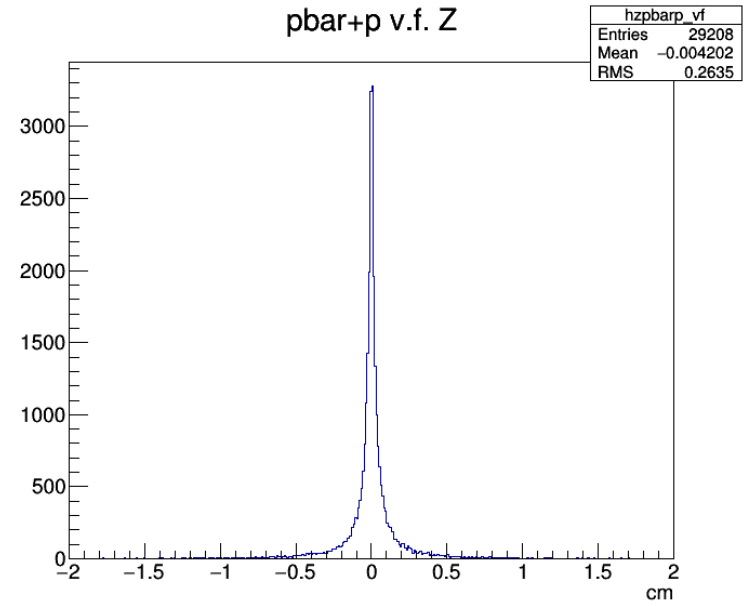
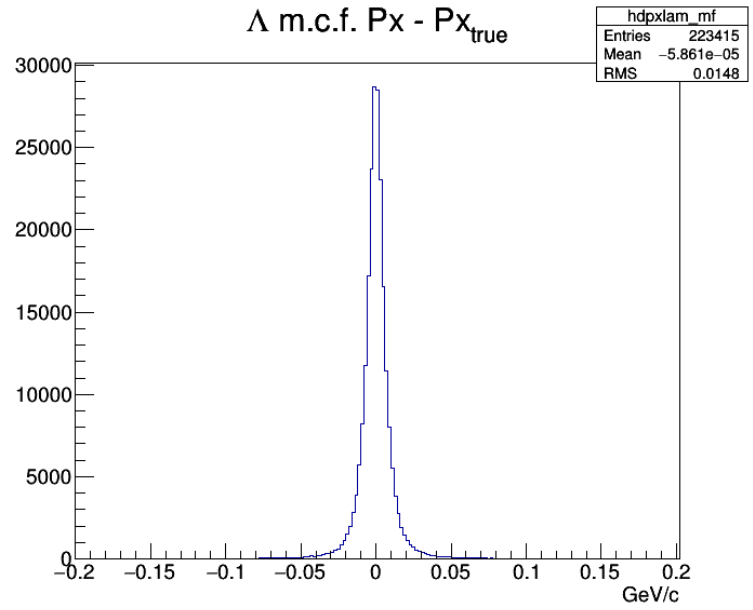

pbar+p v.f. Z
hzpbarp_vf
Entries 29208
Mean −0.004202
RMS 0.2635
cm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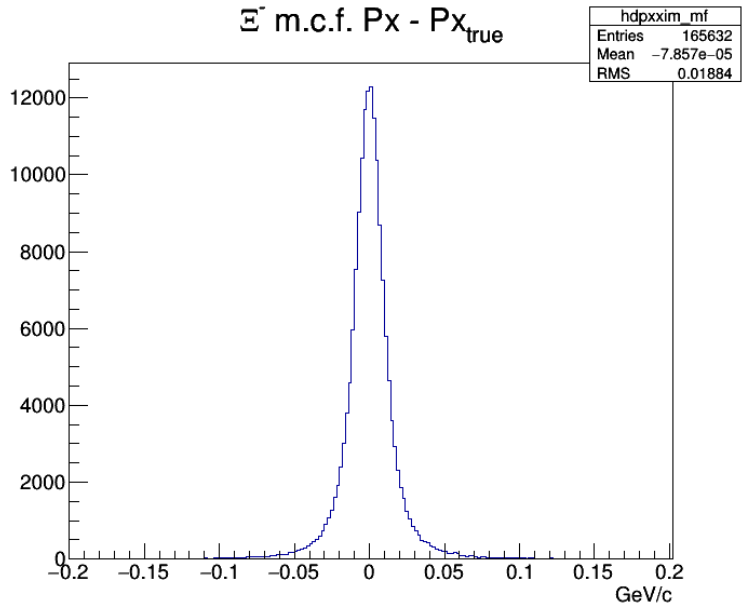
RMS 0.0148
GeV/c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Mean −7.857e−05
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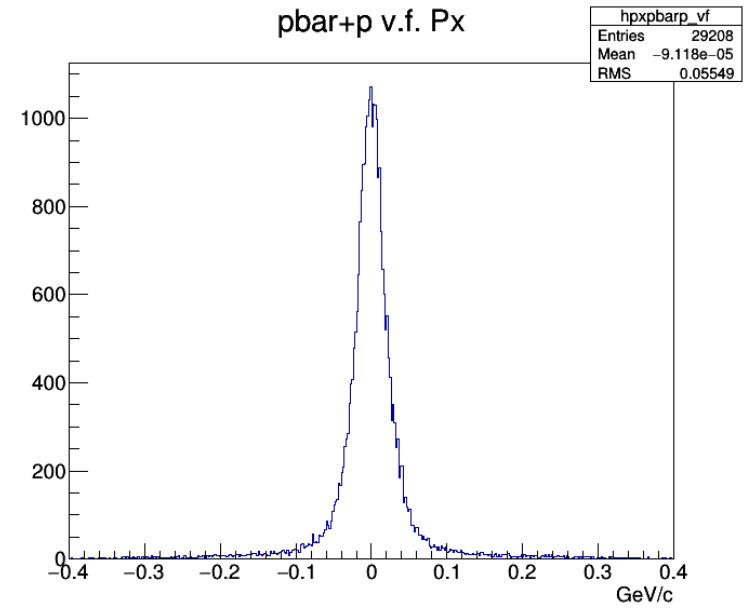
GeV/c


pbar+p v.f. Px
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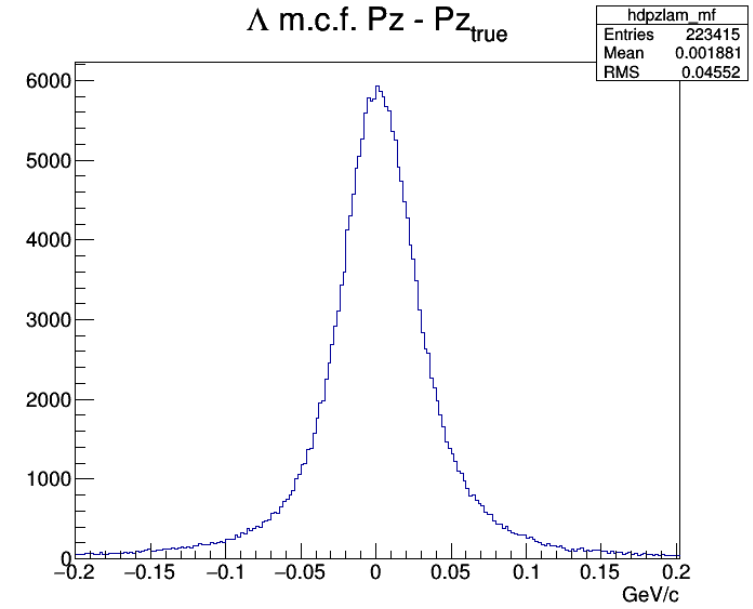
GeV/c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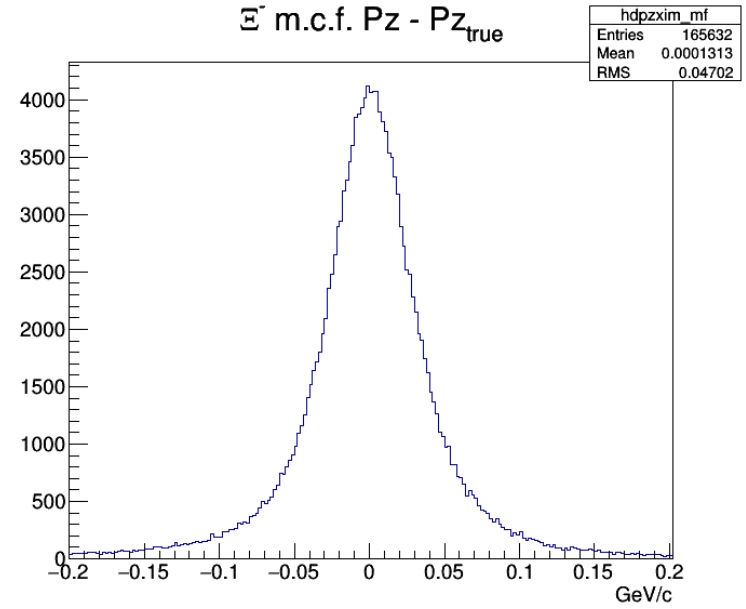
Mean 0.001881
RMS 0.04552
GeV/c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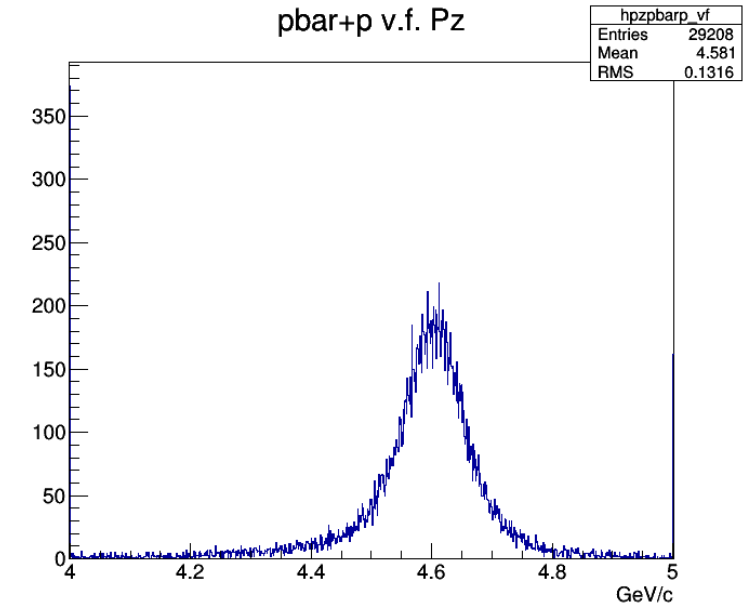
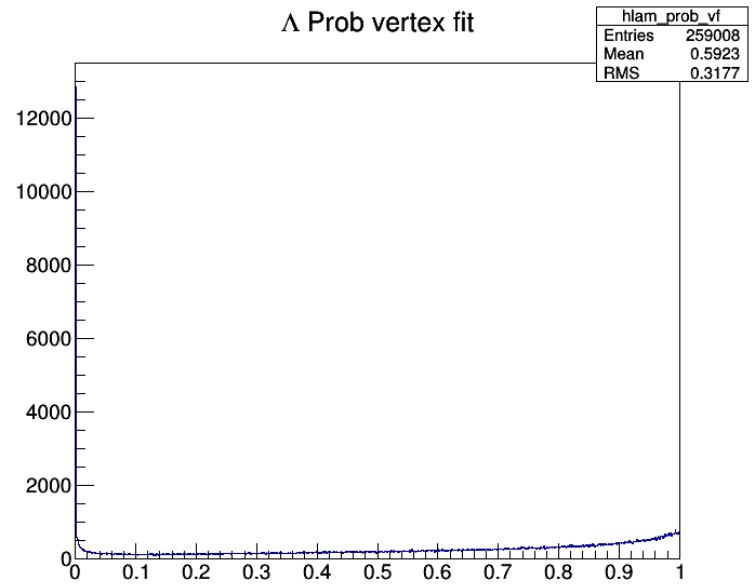
Mean 0.0001313
RMS 0.04702
GeV/c


pbar+p v.f. Pz
hpzpbarp_vf
Entries 29208
Mean 4.581
RMS 0.1316
GeV/c


Λ Prob vertex fit
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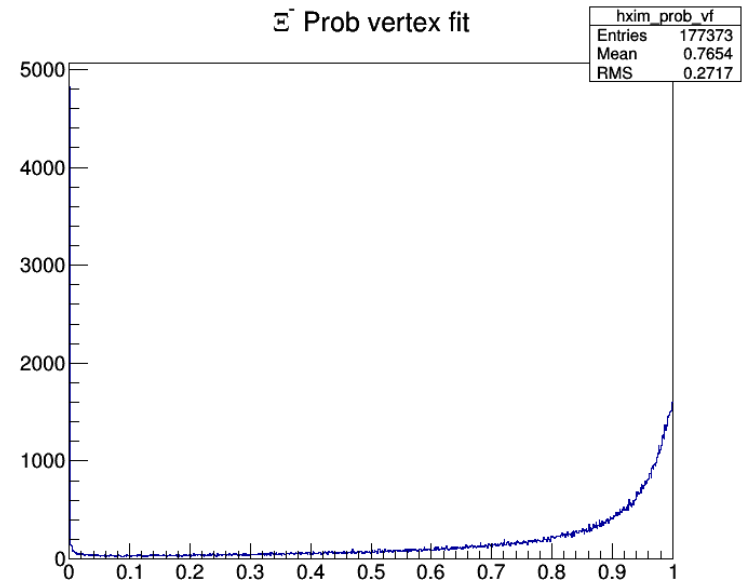
Mean 0.5923
RMS 0.3177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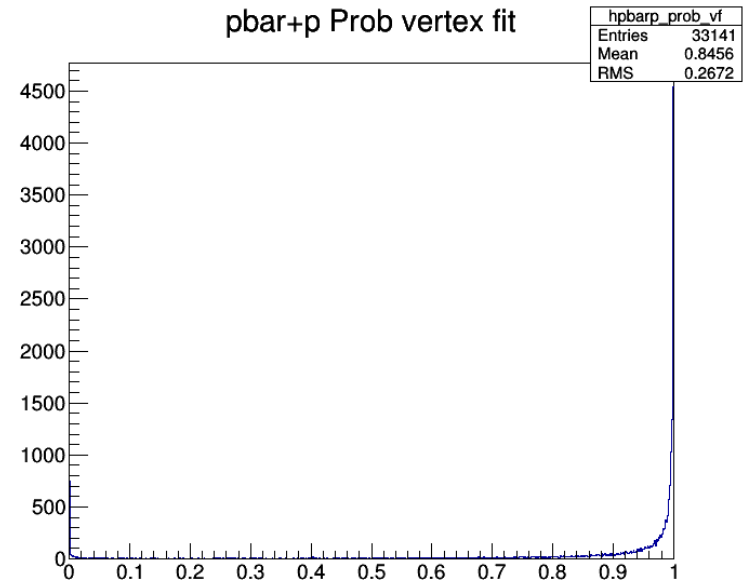
RMS 0.2717


pbar+p Prob vertex fit
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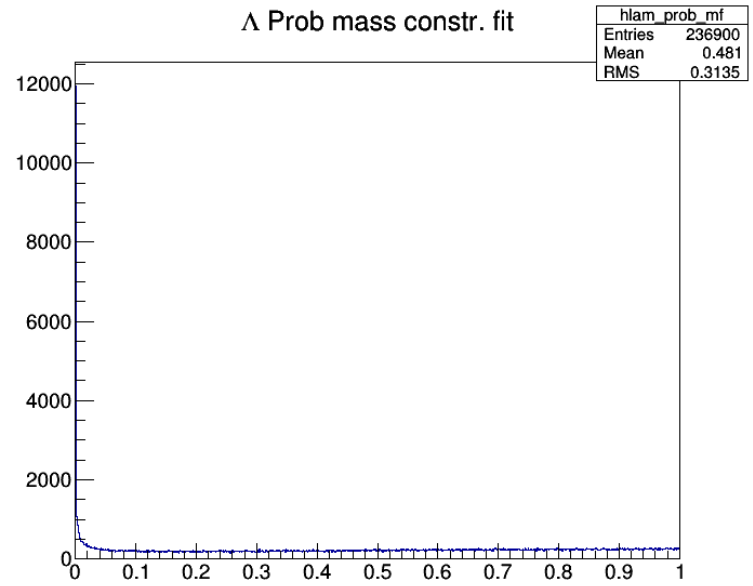
Entries 33141
Mean 0.8456
RMS 0.2672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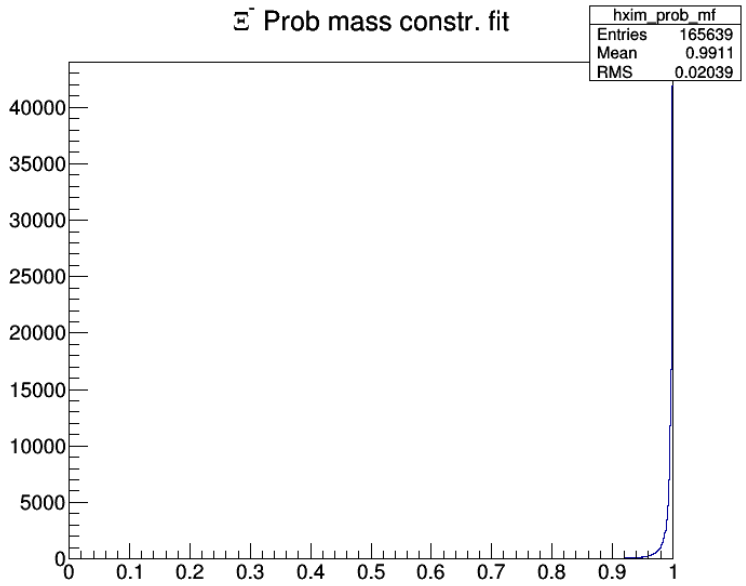
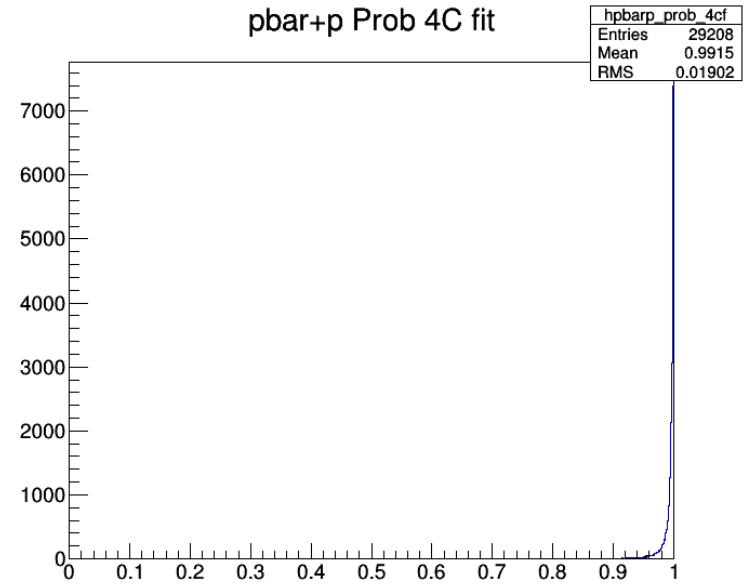
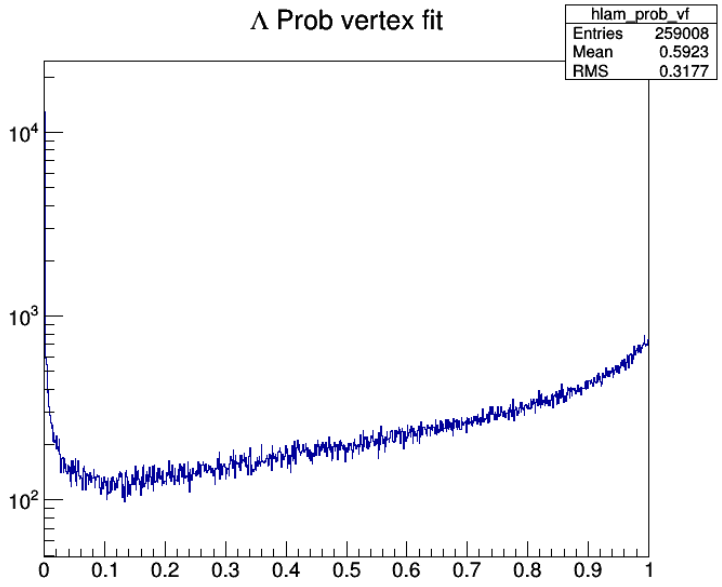
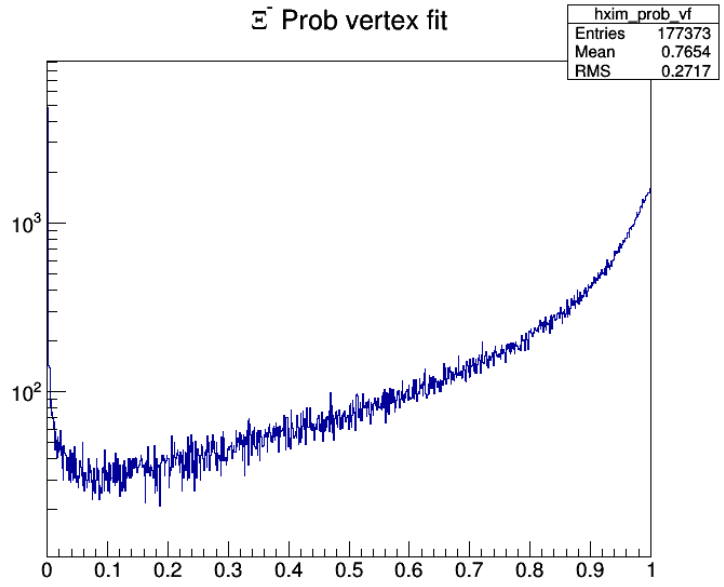
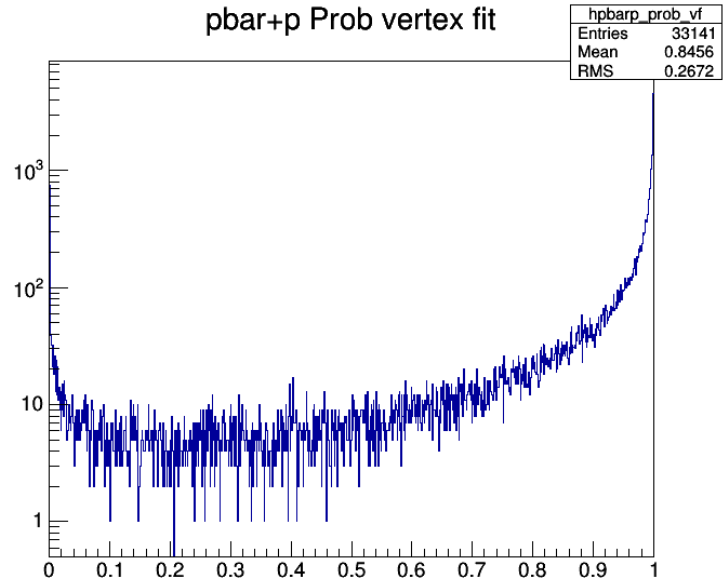
hlam_prob_mf
Entries 236900
Mean 0.481
RMS 0.3135

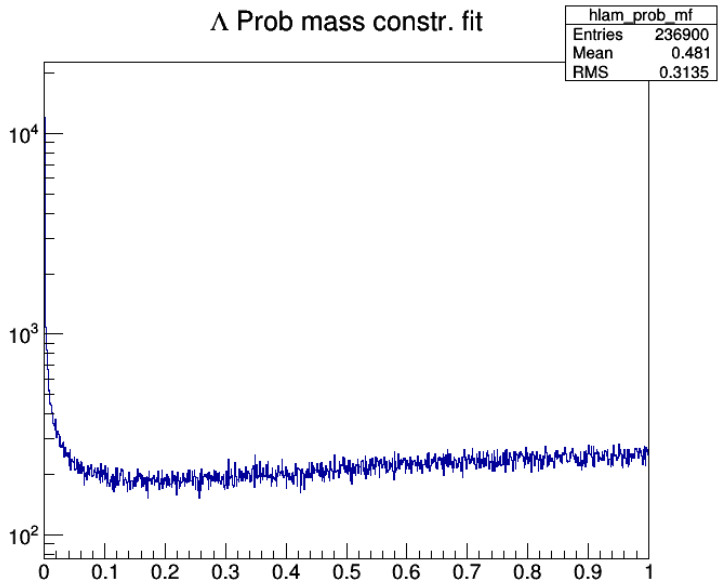

Ξ⁻ Prob mass constr. fit
hxim_prob_mf
Entries 165639
Mean 0.9911
RMS 0.02039

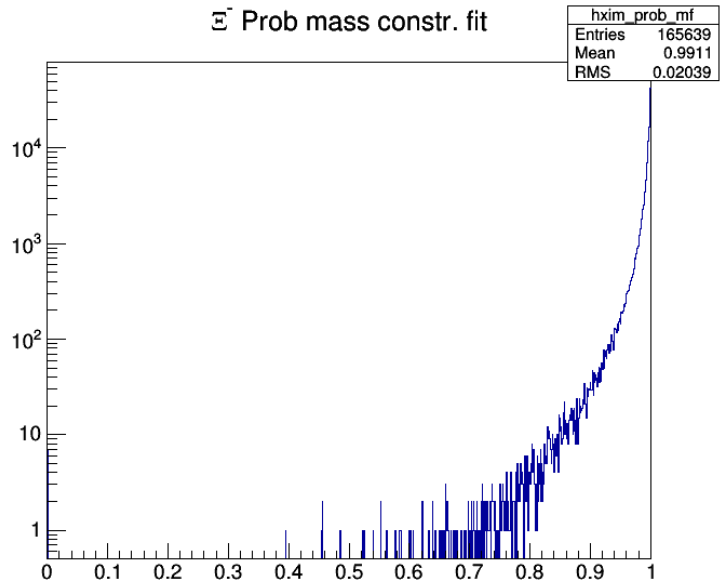

pbar+p Prob 4C fit
hpbarp_prob_4cf
Entries 29208
Mean 0.9915
RMS 0.01902

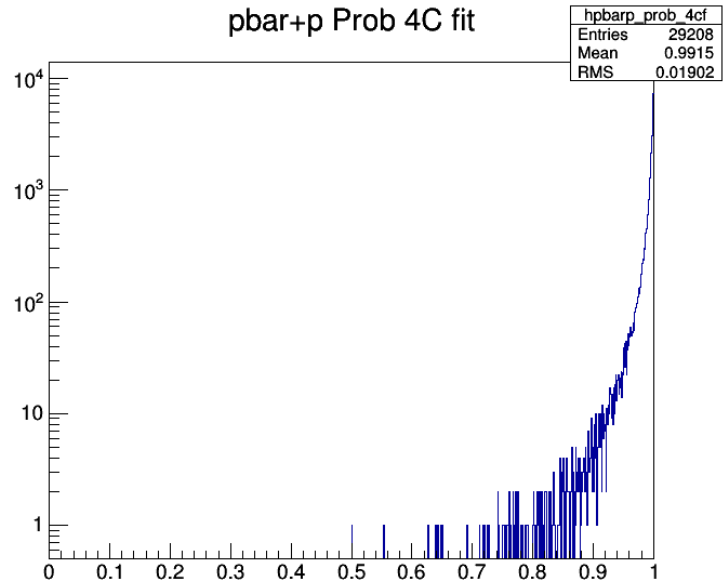

Λ Prob vertex fit
hlam_prob_vf
Entries 259008
Mean 0.5923
RMS 0.3177


Ξ⁻ Prob vertex fit
hxim_prob_vf
Entries 177373
Mean 0.7654
RMS 0.2717


pbar+p Prob vertex fit
hpbarp_prob_vf
Entries 33141
Mean 0.8456
RMS 0.2672

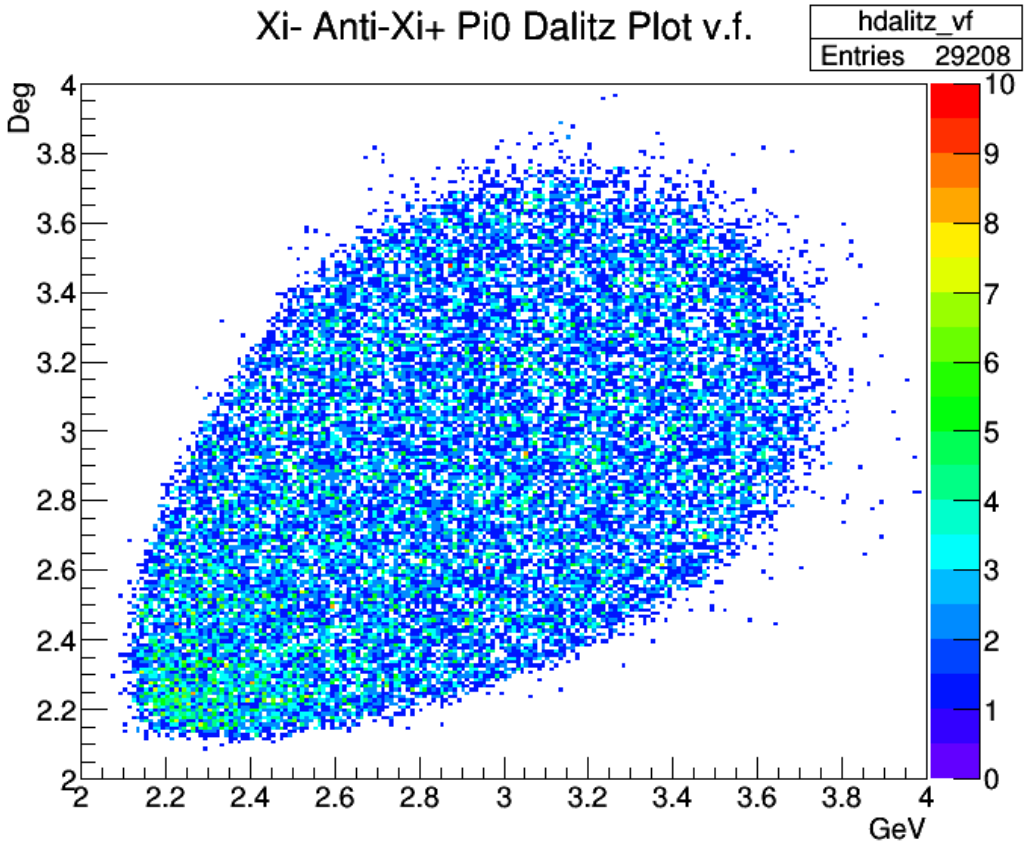

Λ Prob mass constr. fit
hlam_prob_mf
Entries 236900
Mean 0.481
RMS 0.3135

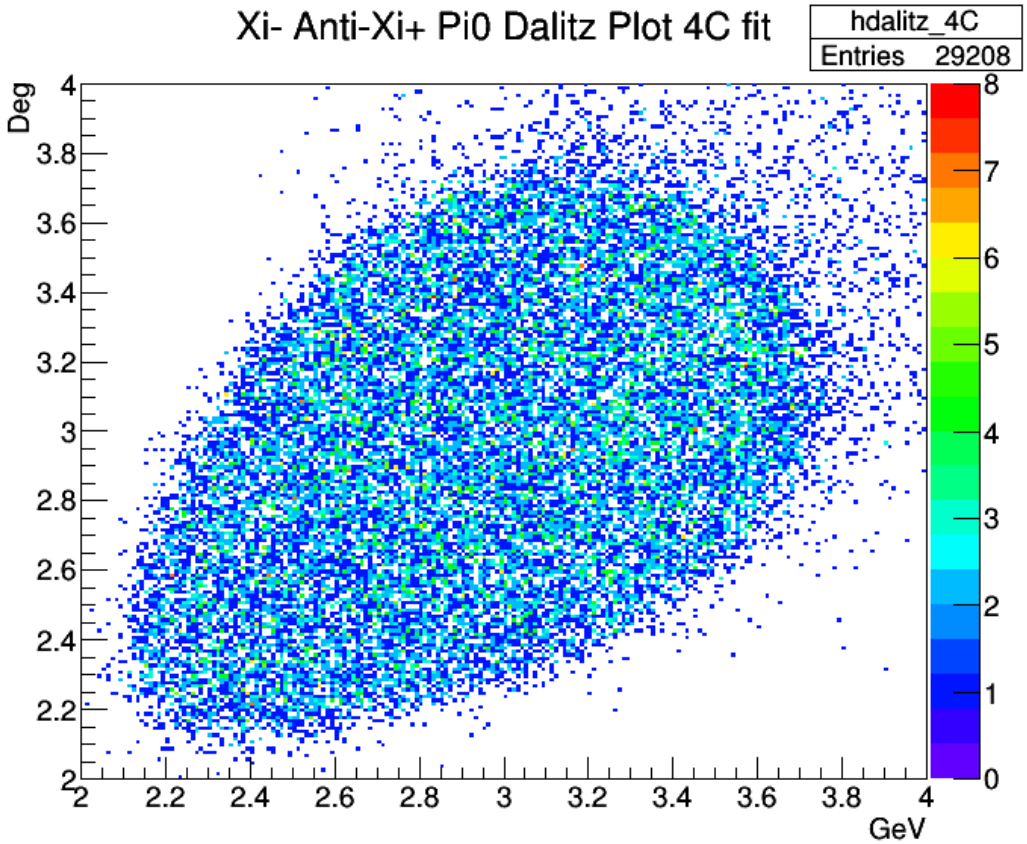

Ξ⁻ Prob mass constr. fit
hxim_prob_mf
Entries 165639
Mean 0.9911
RMS 0.02039


pbar+p Prob 4C fit
hpbarp_prob_4cf
Entries 29208
Mean 0.9915
RMS 0.01902

$\Xi^-\bar{\Xi}^+\pi^0$ Dalitz Plot

- Here: still problem of entries at wrong masses ***after*** mass and 4C fits (meanwhile solved by Xinying)





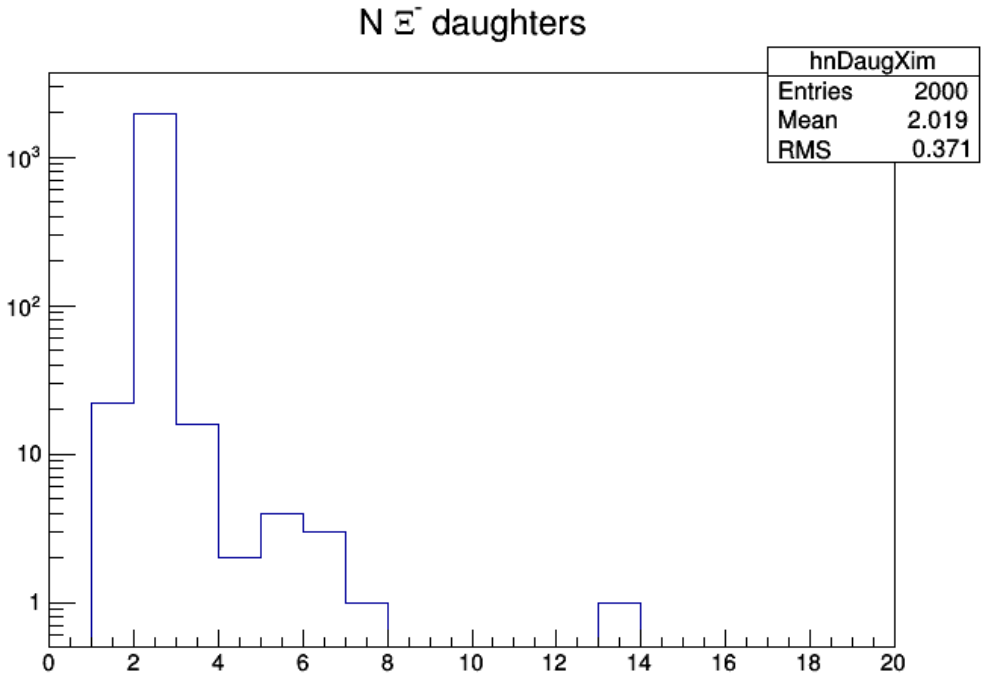
III: ‚Strange' Decays / Interactions in MC Truth List

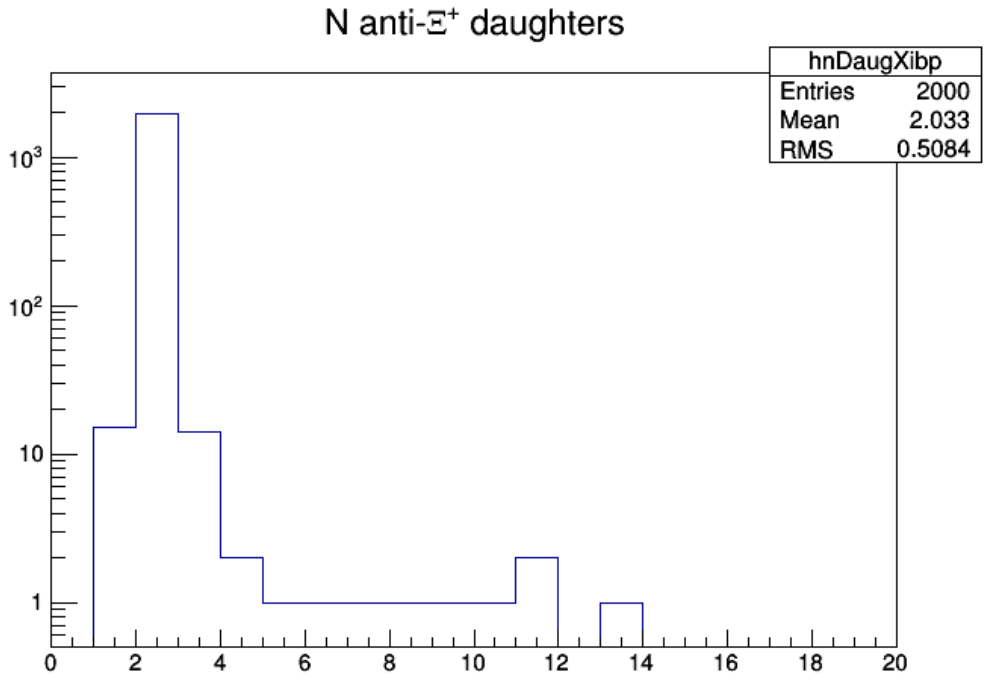
- Recent improvement:
  option to select specific decay modes in Geant4 by using „UserDecayConfig" file (Dominik Steinschaden)
- Set $\Lambda \to p\pi^-$ & $\overline{\Lambda} \to \bar{p}\pi^+$ decay modes to 100%
- $\Xi^- \to \Lambda\pi^-$ & $\overline{\Xi}^+ \to \overline{\Lambda}\pi^+$ is already ~100%
- Expect ~100% $\Lambda \to p\pi^-$ & $\overline{\Lambda} \to \bar{p}\pi^+$ final state
- However: find only 92.4% in this final state

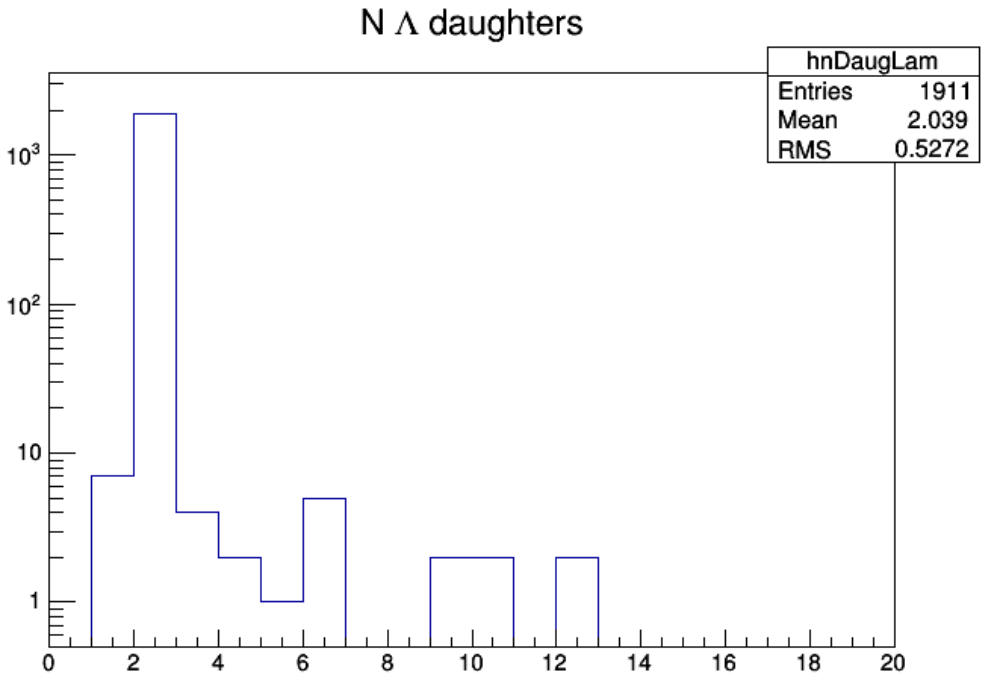
➢ What happened to the missing events?

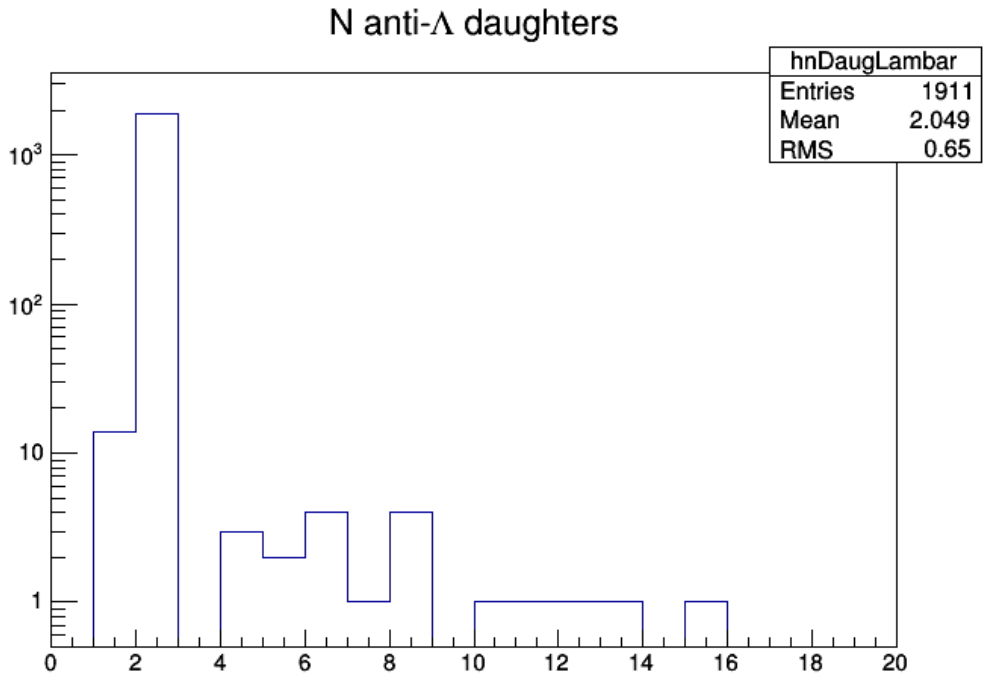
Checking the MC Truth List

- Print all decays / interactions with deviations from selected pattern
  - # daughters, pid, $\vec{X}$, $\vec{p}$
- Found deviations:
  - all particle species: $\Xi^-, \bar{\Xi}^+, \Lambda, \bar{\Lambda}$
  - Most cases not explainable by interaction with material
  - number of daughters differs from 2: e.g. 1, 3, … > 10
  - not all daughters have the same start vertex (???)
- Problem either in G4 or in filling of MC list, but further study required


N Ξ⁻ daughters
hnDaugXim
Entries 2000
Mean 2.019
RMS 0.371


N anti-Ξ⁺ daughters
hnDaugXibp
Entries 2000
Mean 2.033
RMS 0.5084


N Λ daughters
hnDaugLam
Entries 1911
Mean 2.039
RMS 0.5272


N anti-Λ daughters
hnDaugLambar
Entries 1911
Mean 2.049
RMS 0.65

Event Scan: ‘Mysterious‘ Cases

- $\bar{\Xi}^+ \to e^- \bar{\Lambda} \pi^+$ (many)
  - electron added to the decay final state
  - different start vertex, always upstream of other particles
  - analogous for Ξ^-, $\bar{\Lambda}$, Λ
- $\bar{\Xi}^+ \to \bar{\Lambda}$ (many)
  - one single daughter, missing pion
  - analogous for Ξ^-, $\bar{\Lambda}$, Λ
- $\Lambda \to \pi^- \gamma n$ (1); $\Lambda \to 3p\ 7n\ 2\gamma$ (1)
  - violate *Q* and *S* !
  - all daughters have same start vertex
- All others are explainable as interaction with material

Summary

- Zero-width resonances in G4 and FTF
- Preliminary analysis of $\bar{p}p \to \Xi^{-}\bar{\Xi}^{+}\pi^{0}$ at 4.6 GeV/c
- Found cases in the MC particle list which are incompatible with ‚decays' or ‚interactions'

Finding solutions is nicer than finding problems
but
Finding problems is still better than finding nothing !