JÜLICH
FORSCHUNGSZENTRUM

Ξ Spectroscopy: Status of Physics Analysis

Jun 26, 2019 | Albrecht Gillitzer

PANDA Collaboration Meeting 19/2, GSI Darmstadt

Simulation & Analysis

Present status

Group Talk at DPG 2019, München

decay mode (cc)	final state (cc)	conv.	tree fit	PID	new vn	analyst
$\Xi^{*-} \to \Lambda K^-$	$\bar{\Xi}^+ \Lambda K^-$	✓	✓	✓	✓	Jennifer Pütz
$\Xi^{*-} \to \Xi^- \pi^+ \pi^-$ $\Xi^{*0} \to \Xi^- \pi^+$	$\bar{\Xi}^+ \Xi^- \pi^+ \pi^-$	✓	✓	●		Alessandra Lai, AG
$\Xi^{*-} \to \Xi^- \pi^0$	$\bar{\Xi}^+ \Xi^- \pi^0$	✓	●			AG
$\Xi^{*-} \to \Xi^- \eta$	$\bar{\Xi}^+ \Xi^- \eta, \eta \to \gamma\gamma$	x	●			Kevin Luckas[a]
	$\bar{\Xi}^+ \Xi^- \eta$, $\eta \to \pi^+ \pi^+ \pi^0$	x				

further decay modes: $\Xi^{*-} \to \Xi^- \pi^0 \pi^0$, $\Xi^{*-} \to \Sigma^0 K^-, \Sigma^0 \to \Lambda\gamma$

‚conv.' = step by step fit, ‚new vn' = up-to-date PandaRoot

[a] Univ. Bonn

Simulation & Analysis Present Status

decay mode (cc)	final state (cc)	conv.	tree fit	PID	new vn	analyst
$\Xi^{*-} \to \Lambda K^-$	$\bar{\Xi}^+ \Lambda K^-$	✓	✓	✓	✓	Jennifer Pütz
$\Xi^{*-} \to \Xi^- \pi^+ \pi^-$ $\Xi^{*0} \to \Xi^- \pi^+$	$\bar{\Xi}^+ \Xi^- \pi^+ \pi^-$	✓	✓	+		Alessandra Lai, AG
$\Xi^{*-} \to \Xi^- \pi^0$	$\bar{\Xi}^+ \Xi^- \pi^0$	✓	+	+		AG
$\Xi^{*-} \to \Xi^- \pi^0 \pi^0$ $\Xi^{*-} \to \Xi^- \pi^0$	$\bar{\Xi}^+ \Xi^- \pi^0 \pi^0$		●	●		AG
$\Xi^{*-} \to \Xi^- \eta$	$\bar{\Xi}^+ \Xi^- \eta, \eta \to \gamma\gamma$	x	+		+	Kevin Luckas[a]
	$\bar{\Xi}^+ \Xi^- \eta,$ $\eta \to \pi^+ \pi^+ \pi^0$	x				

further decay modes: $\Xi^{*-} \to \Sigma^0 K^-, \Sigma^0 \to \Lambda\gamma$

‚conv.' = step by step fit, ‚new vn' = up-to-date PandaRoot

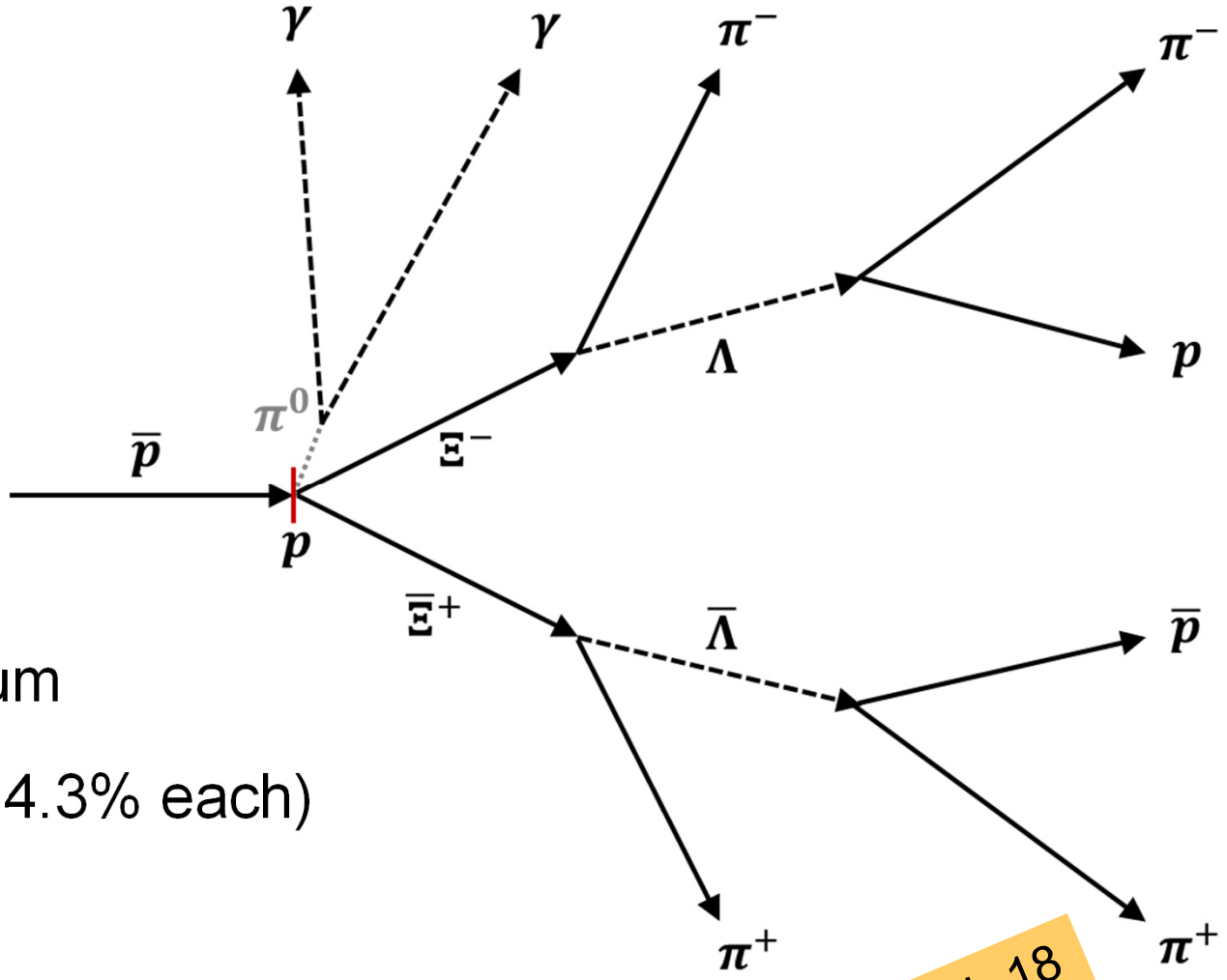
[a] Univ. Bonn

JÜLICH Forschungszentrum

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

Reconstruct $\pi^0 \to \gamma\gamma$

- $p_{\bar{p}} = 4.6\ \mathrm{GeV}/c$
- Contributing states:
  - $\Xi(1530)$
  - $\Xi(1690)$
  - $\Xi(1820)$
- 4.4 M $\bar{\Xi}^+\Xi^-\pi^0$ continuum
- 5 M Ξ^{*-}, $\bar{\Xi}^{*+}$ & cont. (14.3% each)
- Ideal PID
- Step-by-step reconstruction of decay tree
- Added: photon time information



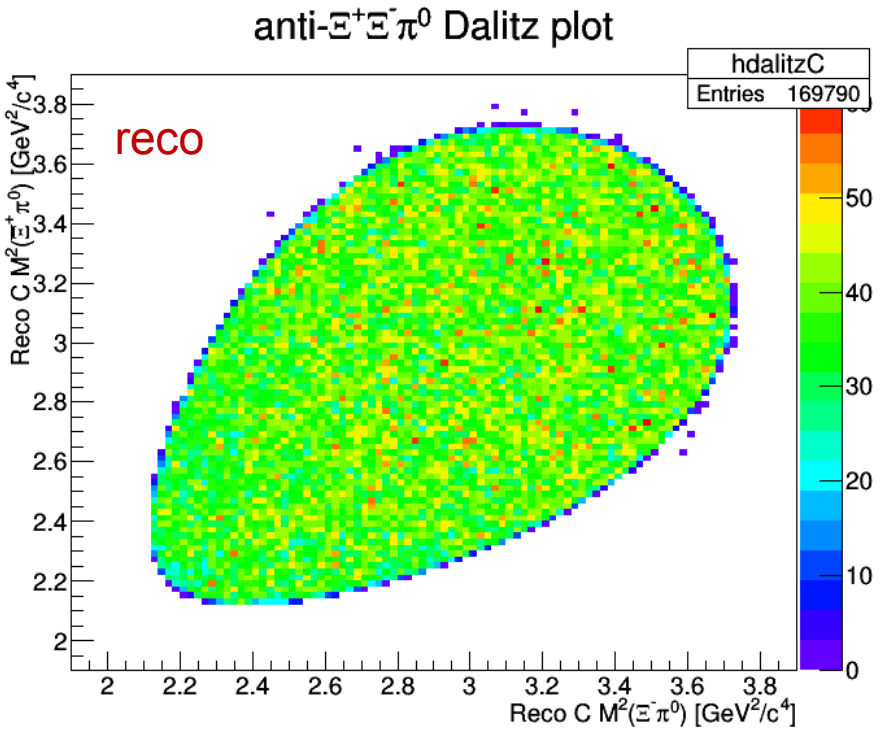
Release Note March 18 (Pending)

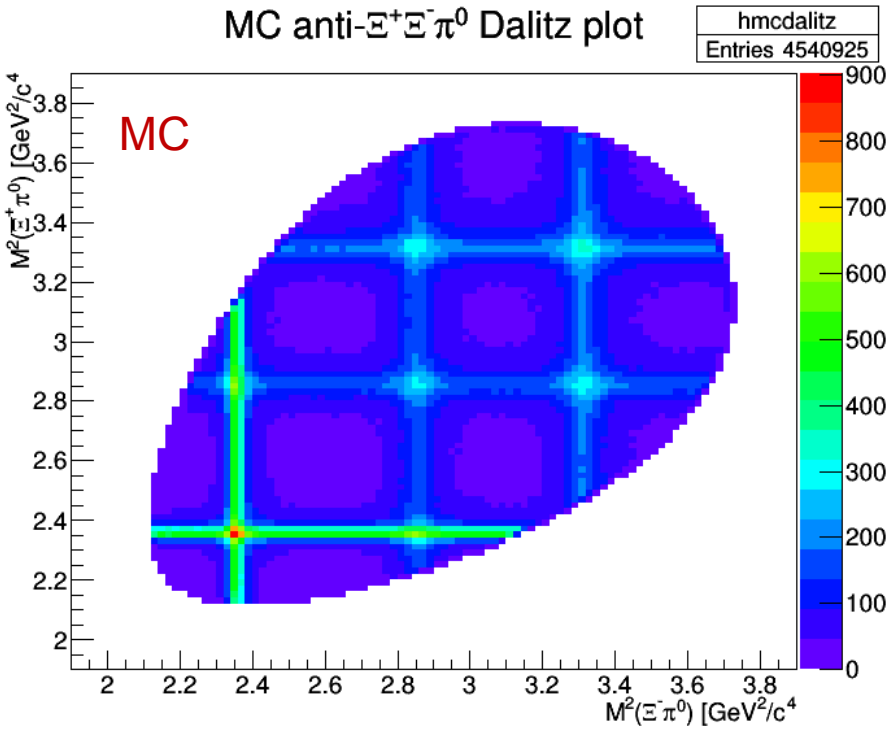
JÜLICH Forschungszentrum

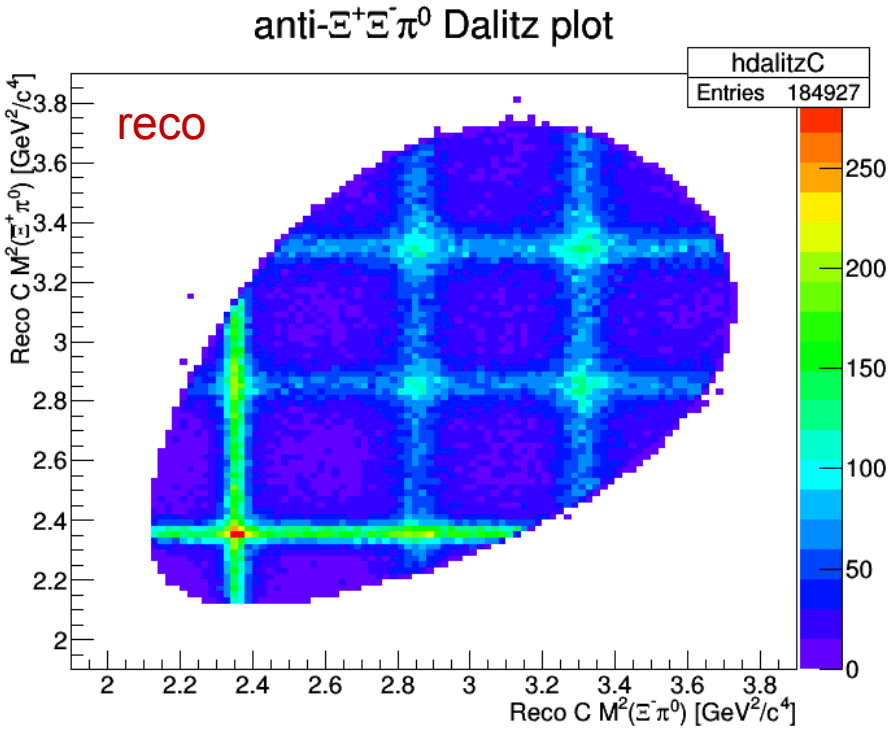
$\bar{\Xi}^+\Xi^-\pi^0$

Two samples: continuum, w. Ξ^* resonances

- $\bar{\Xi}^+\Xi^-\pi^0$ continuum: no deviation from flat acceptance
- $\Xi(1530), \Xi(1690), \Xi(1820)$ clearly visible

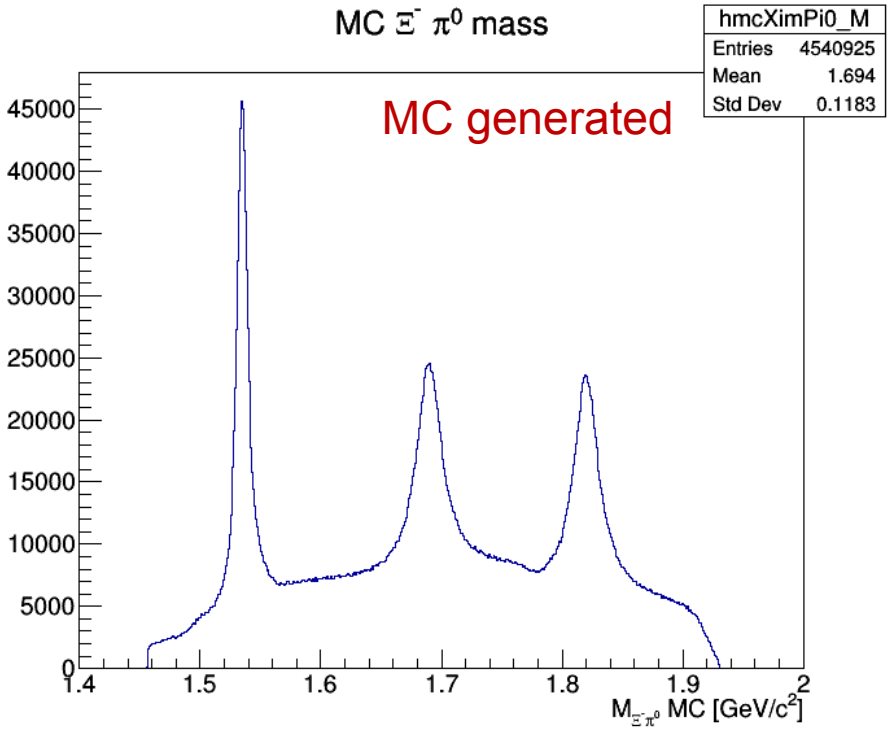


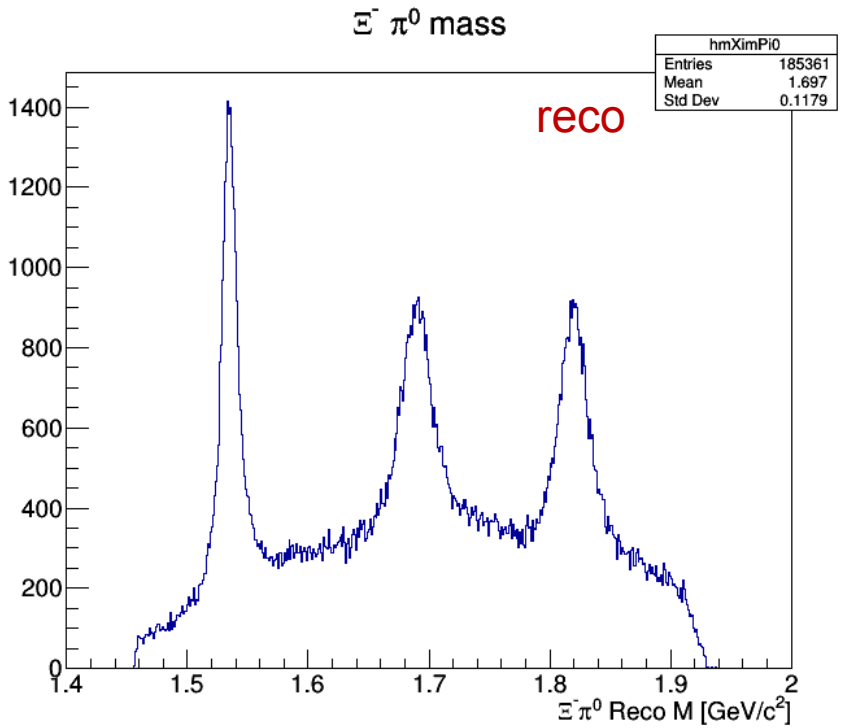




$\bar{\Xi}^{+}\Xi^{-}\pi^{0}$

$\Xi^{-}\pi^{0}$ system invariant mass





Reco eff: 3.9% with photon time

Purity: 97.2% (using time information)

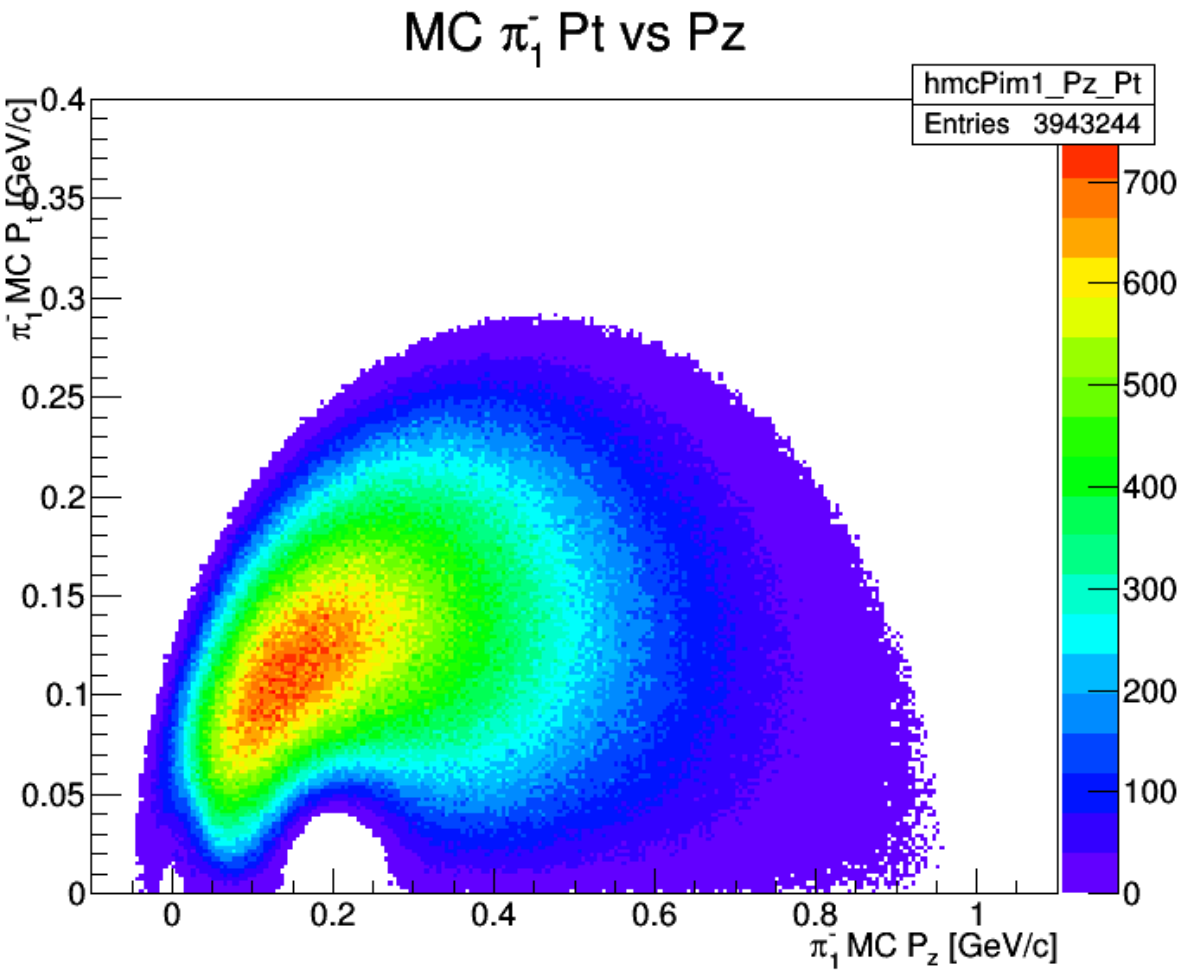
Impurity mostly in π^{0} reconstruction

RN: 3.3% / 94 %

‚treefitter' & ‚open' PID: Reduce Combinatorics!

- Photon energy cut
- Photon time
- π^0 candidate: tight mass cut
- π^0 best & 2nd-best candidate from mass constraint fit
- Particle ID: exclude prob(π) > 0.9 for $p, \bar{p}$, prob(p) > 0.9 for $\pi^{\pm}$
- Final state particles $(p, \bar{p}, \pi_1^+, \pi_1^-, \pi_2^+, \pi_2^-)$: kinematical constraints on P_t vs P_z
- Composite particles $(\bar{\Xi}^+, \Xi^-, \bar{\Lambda}, \Lambda)$: tight mass cut
- $\bar{\Xi}^+\Xi^-\pi^0$ system candidate: P4 cut on each component

P_t vs P_z Cut



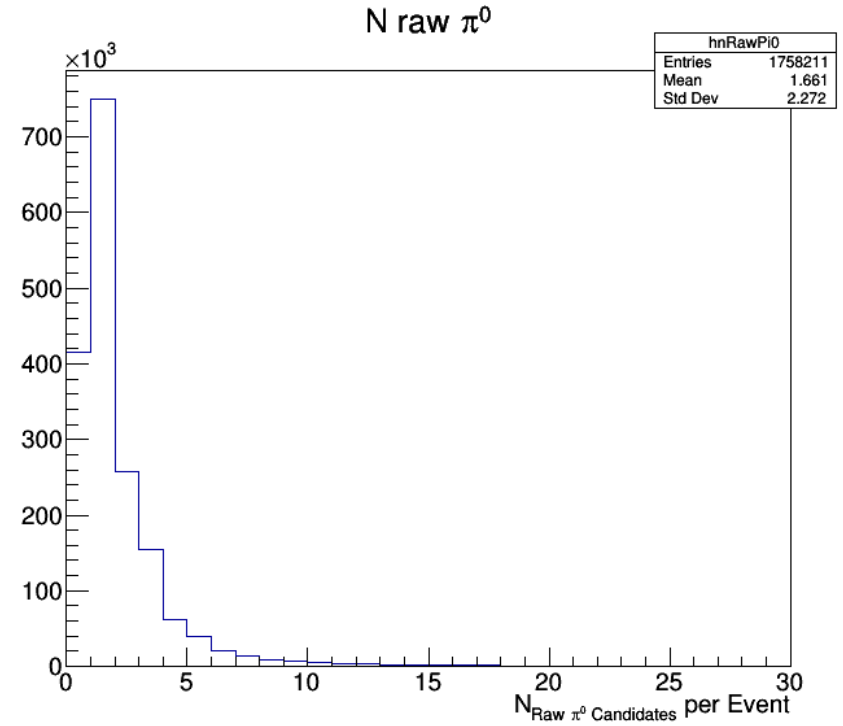
Elliptic boundary given by $\frac{(x-x_0)^2}{a^2}+\frac{y^2}{b^2}=1$ with

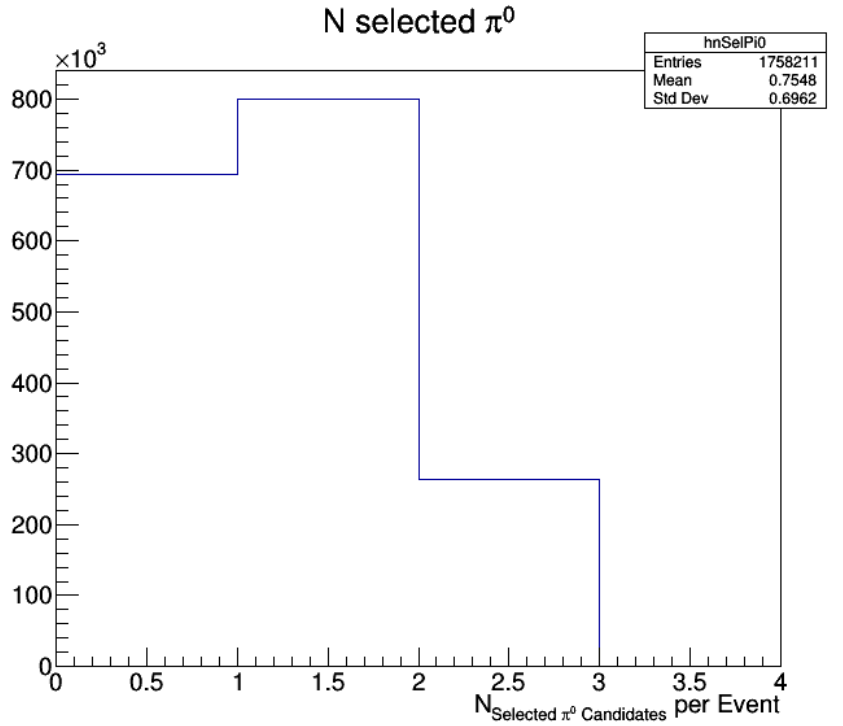
$$x_0 = \left(p_{z,\max} + p_{z,\min}\right)/2$$

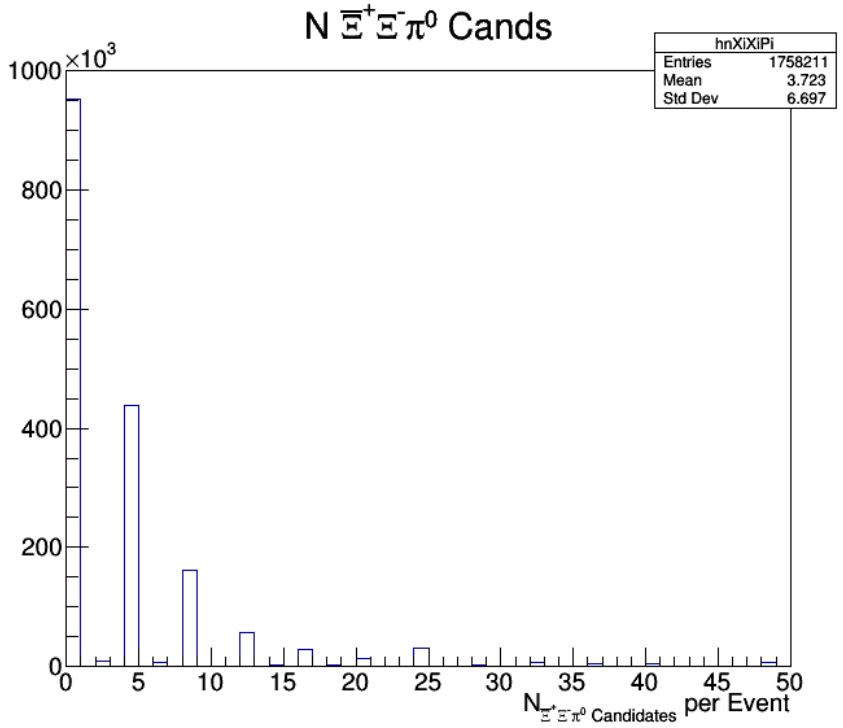
$$a = \left(p_{z,\max} - p_{z,\min}\right)/2$$

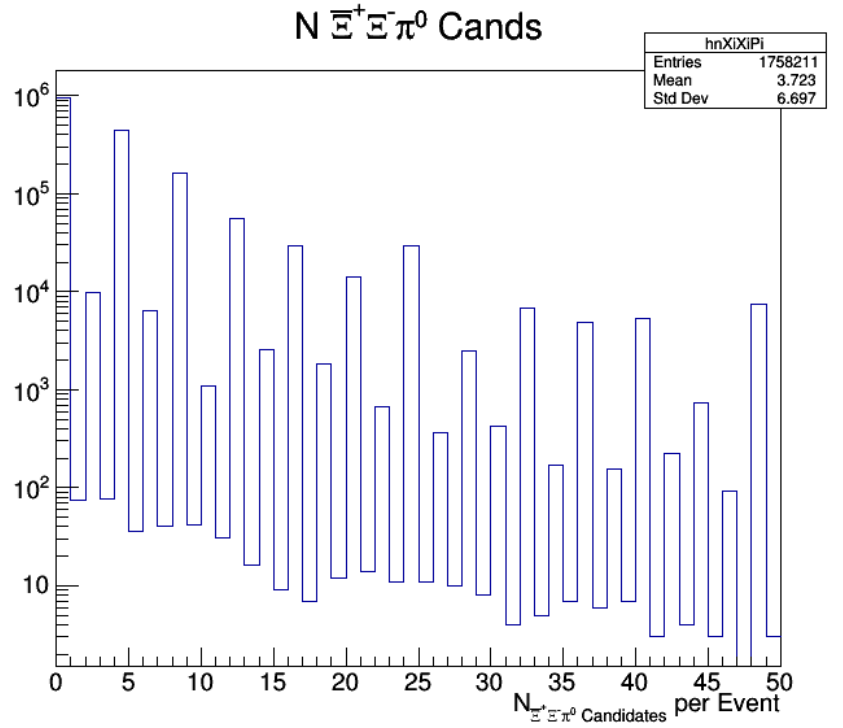
$$b = p_{t,\max}$$

for all stable charged particles

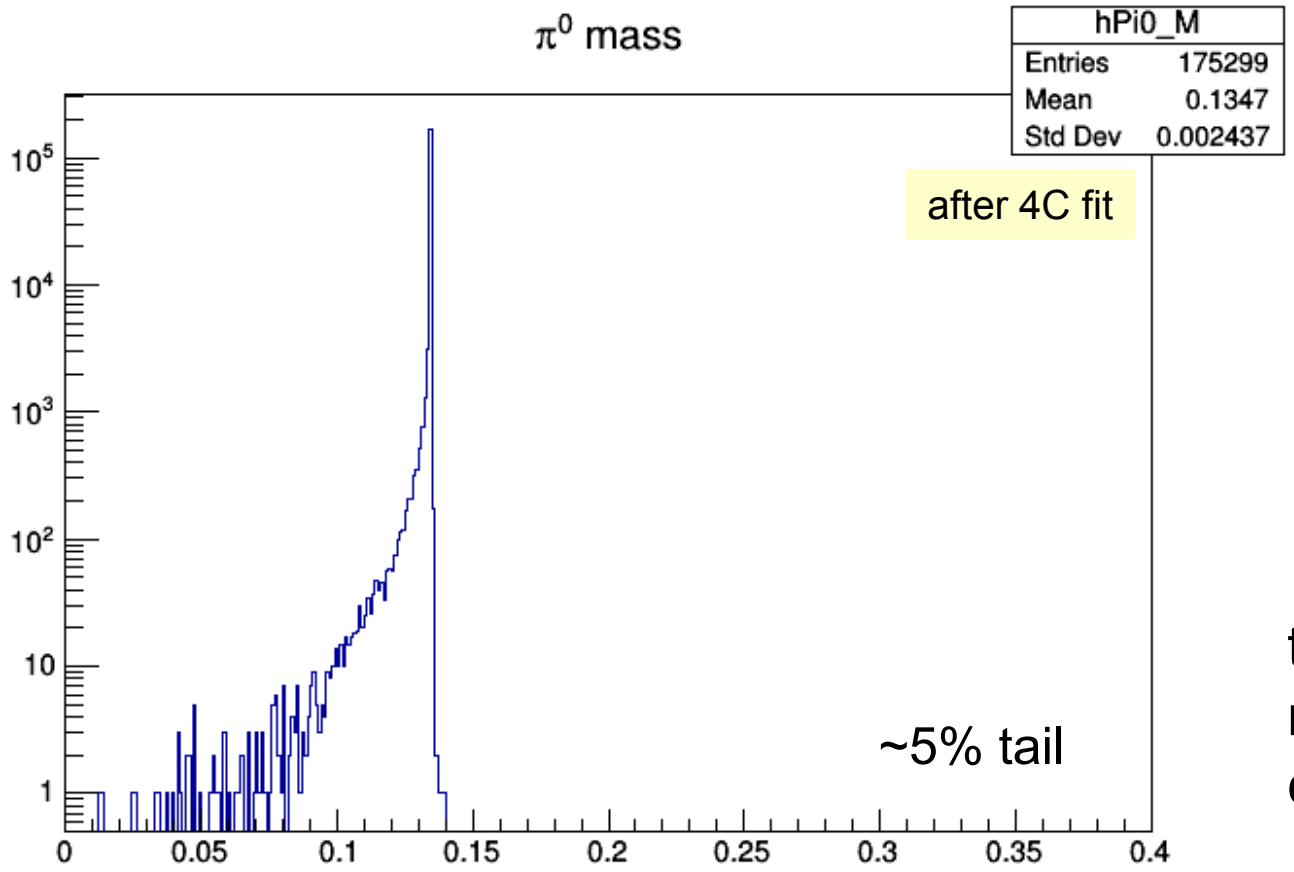

N raw π0
hnRawPi0
Entries 1758211
Mean 1.661
Std Dev 2.272
×10^3
N Raw π0 Candidates per Event


N selected π0
hnSelPi0
Entries 1758211
Mean 0.7548
Std Dev 0.6962
×10^3
N Selected π0 Candidates per Event


N Ξ̄+Ξ-π0 Cands
hnXiXiPi
Entries 1758211
Mean 3.723
Std Dev 6.697
×10^3
N Ξ̄+Ξ-π0 Candidates per Event

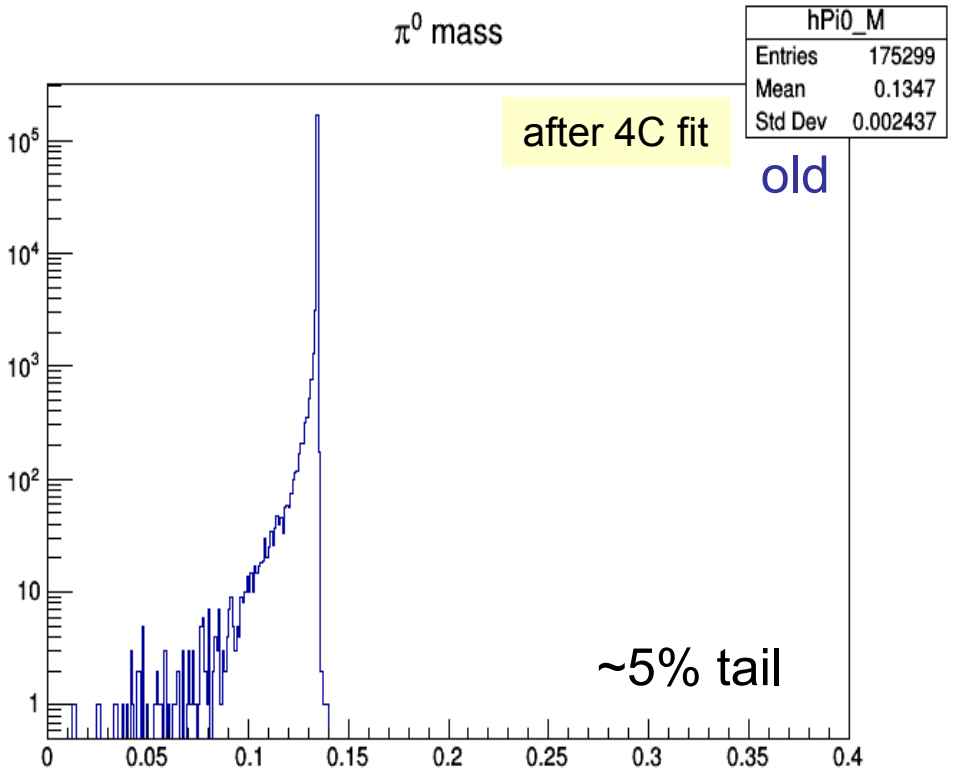

N Ξ̄+Ξ-π0 Cands
hnXiXiPi
Entries 1758211
Mean 3.723
Std Dev 6.697
N Ξ̄+Ξ-π0 Candidates per Event

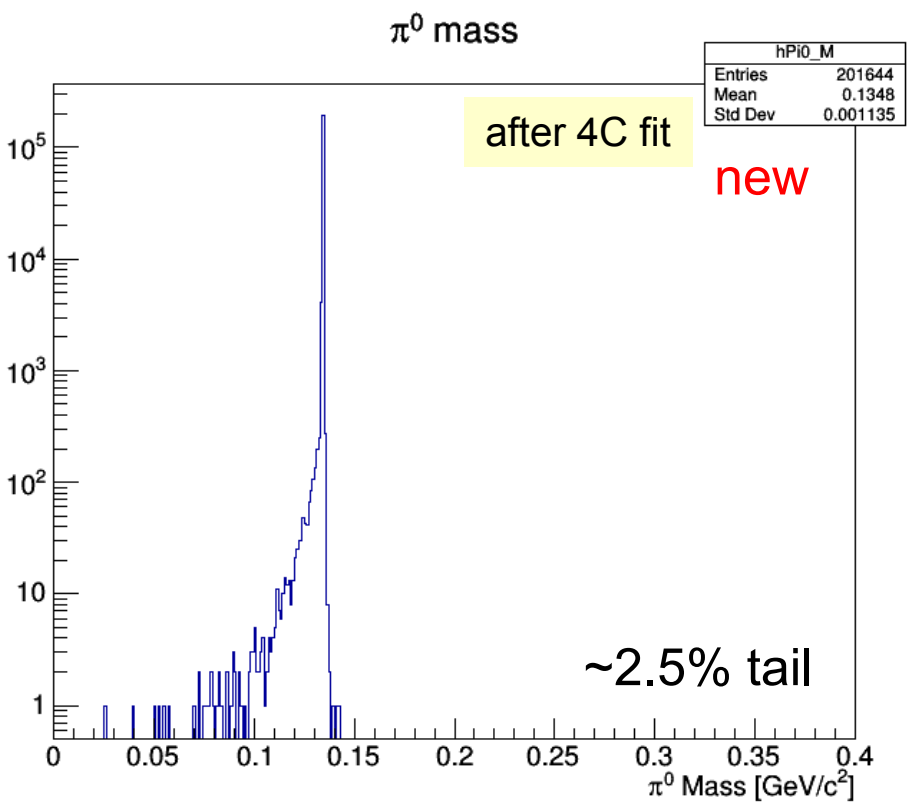
Problem of ‚treefitter' with Neutral Candidates



treefitter does not respect the π^0 mass constraint

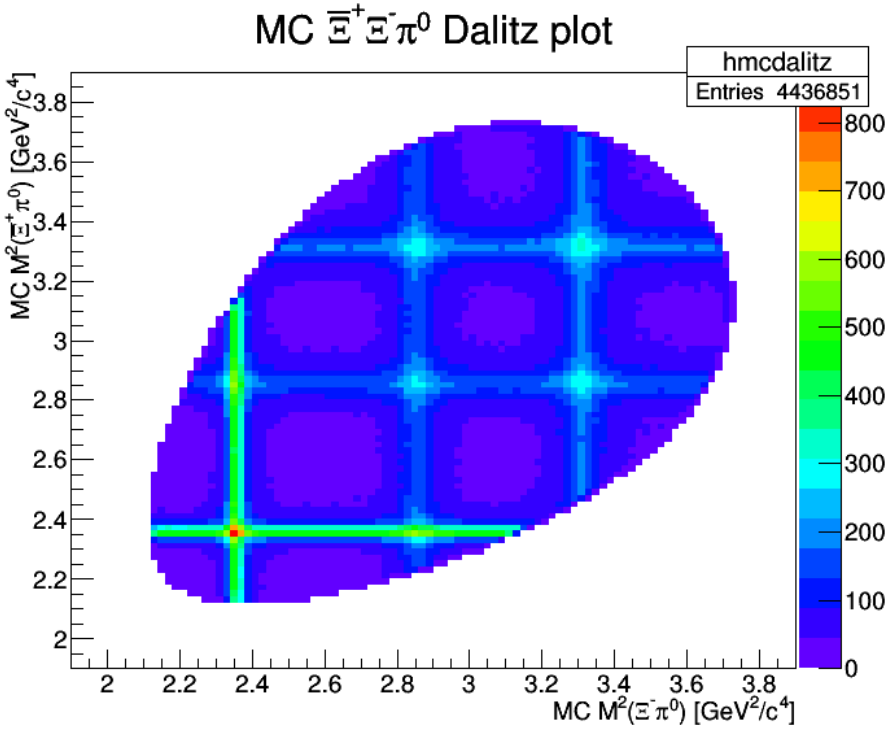
π^0 Mass Constraint in ‚treefitter‘

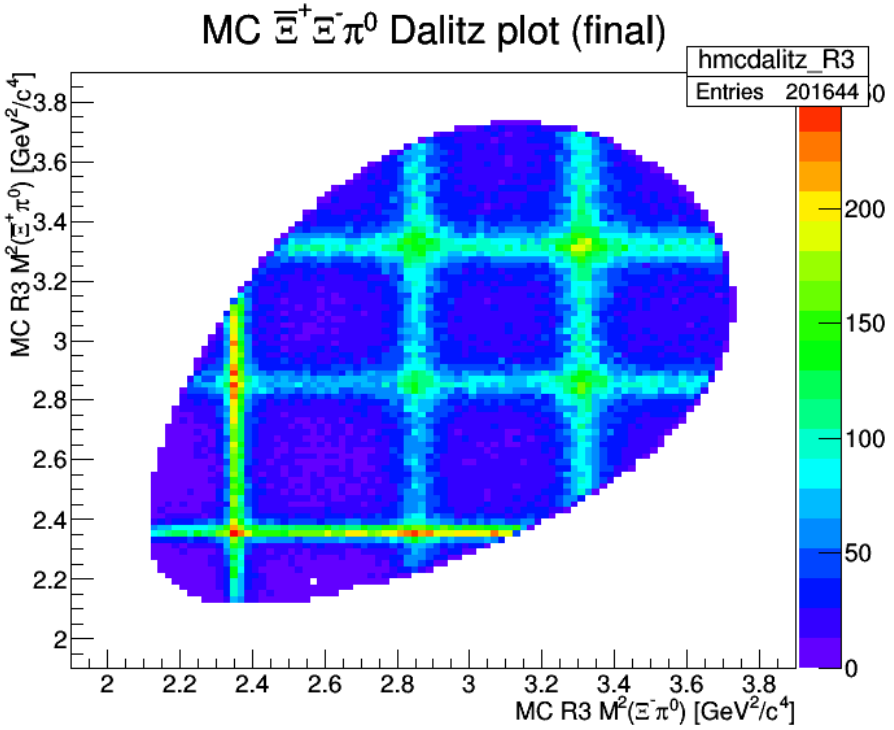


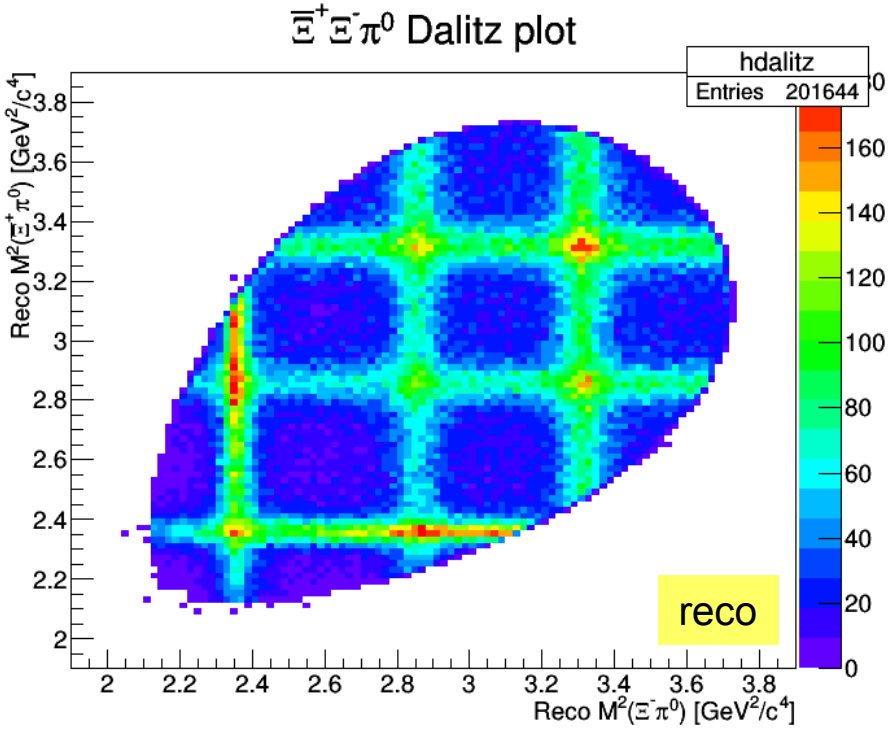


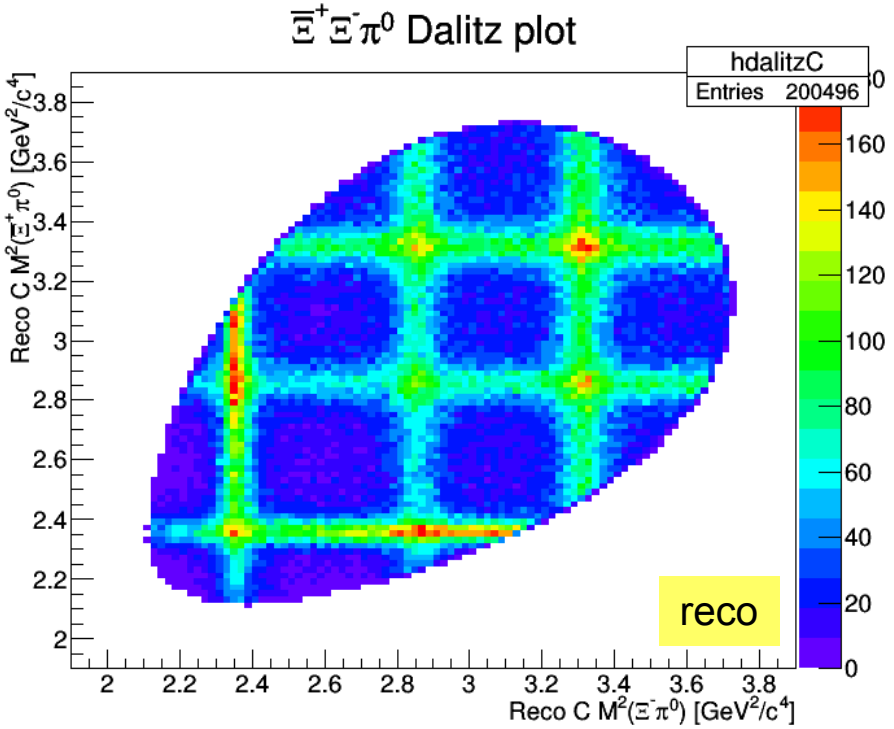
idea: redo the fit for candidates with too low mass with corrected E component & ‘lock’ the candidate

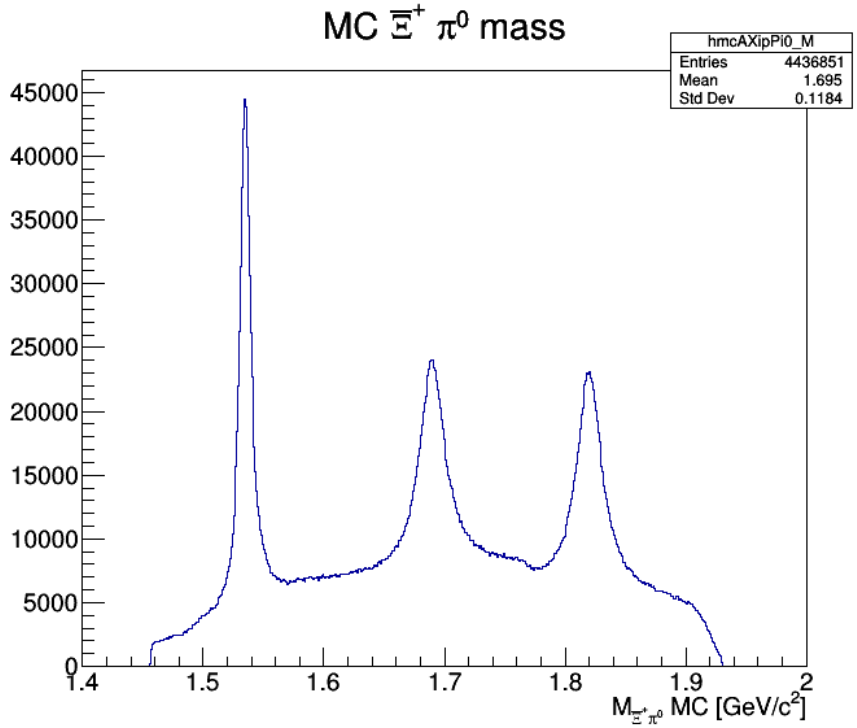
→ ‚lock‘ is ignored, but some improvement visible (factor ~2)

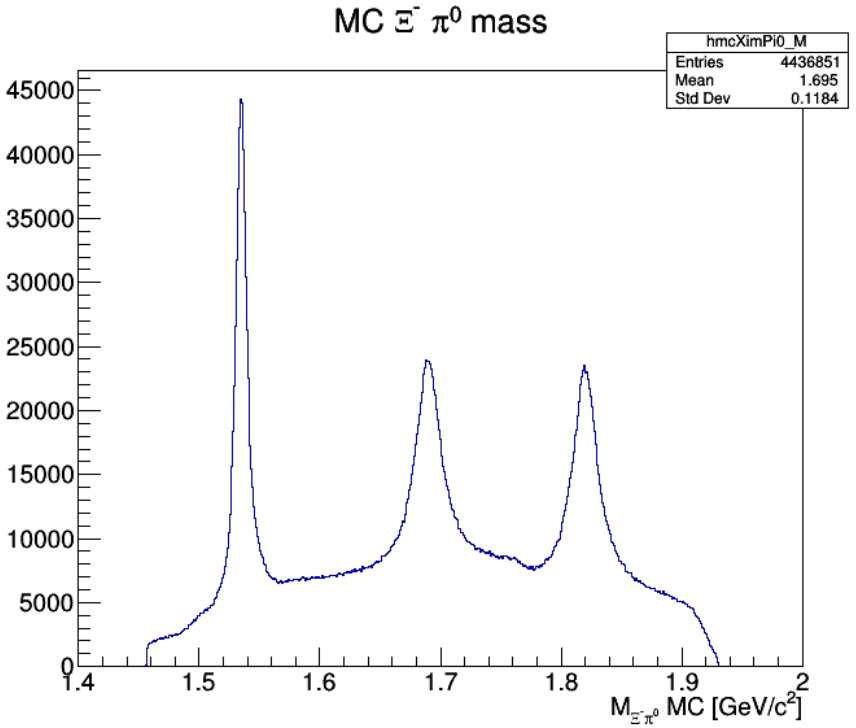

MC $\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot
hmcdalitz
Entries 4436851
MC $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
MC $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]

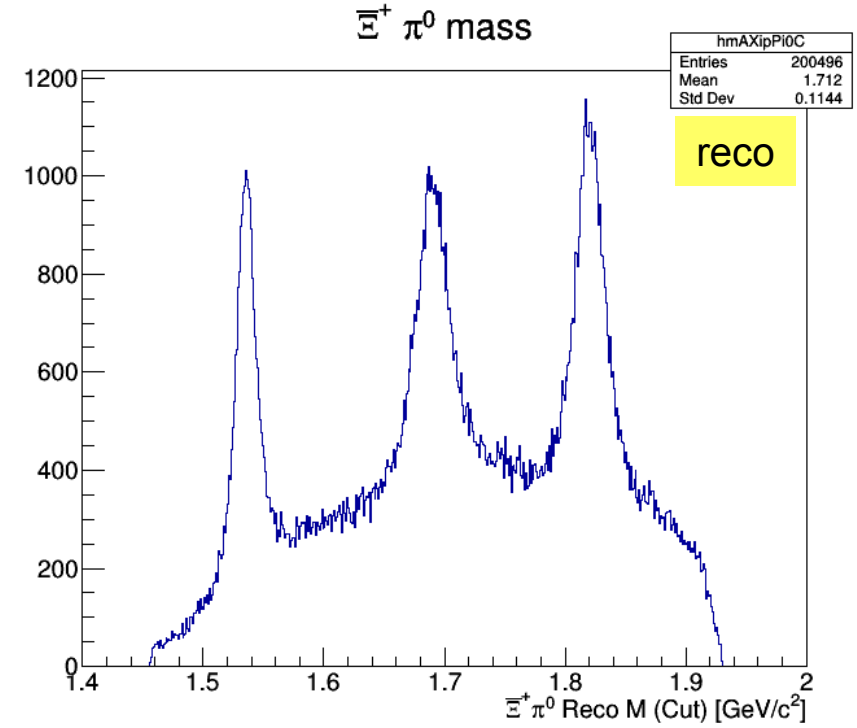

MC $\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot (final)
hmcdalitz_R3
Entries 201644
MC R3 $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
MC R3 $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]

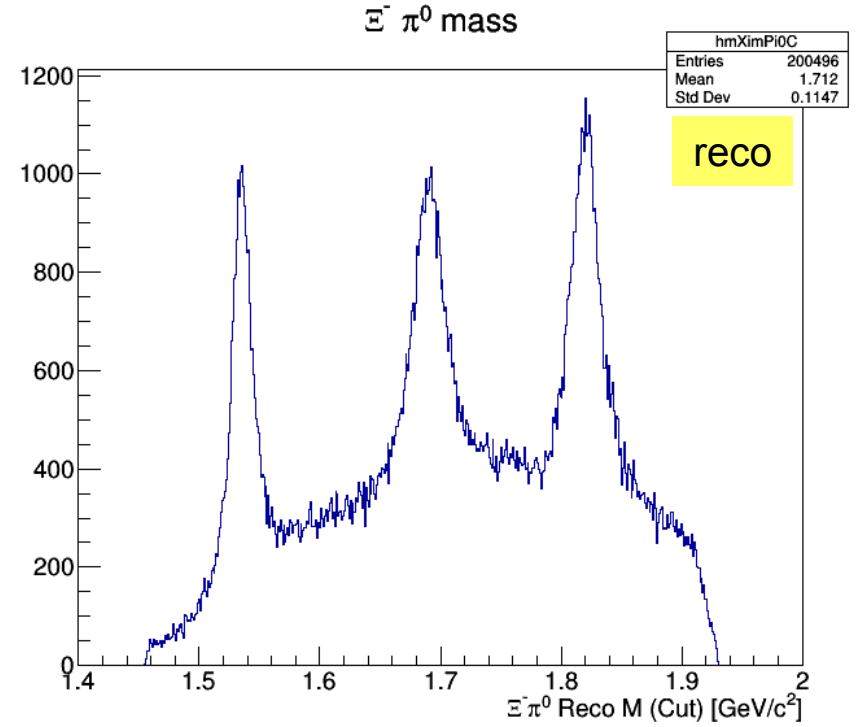

$\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot
hdalitz
Entries 201644
reco
Reco $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
Reco $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]

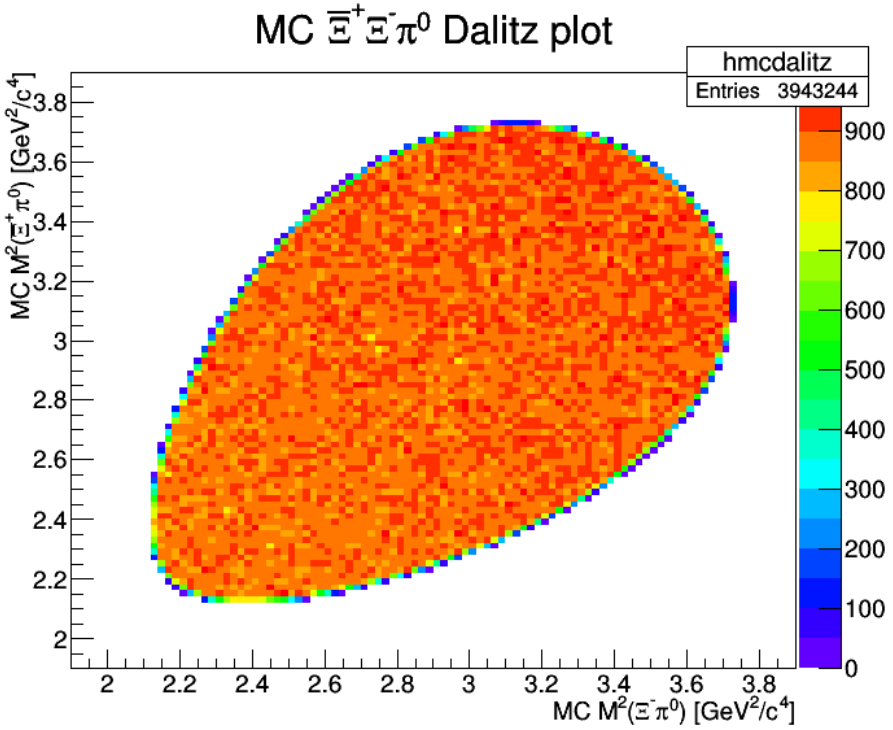

$\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot
hdalitzC
Entries 200496
reco
Reco C $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
Reco C $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]

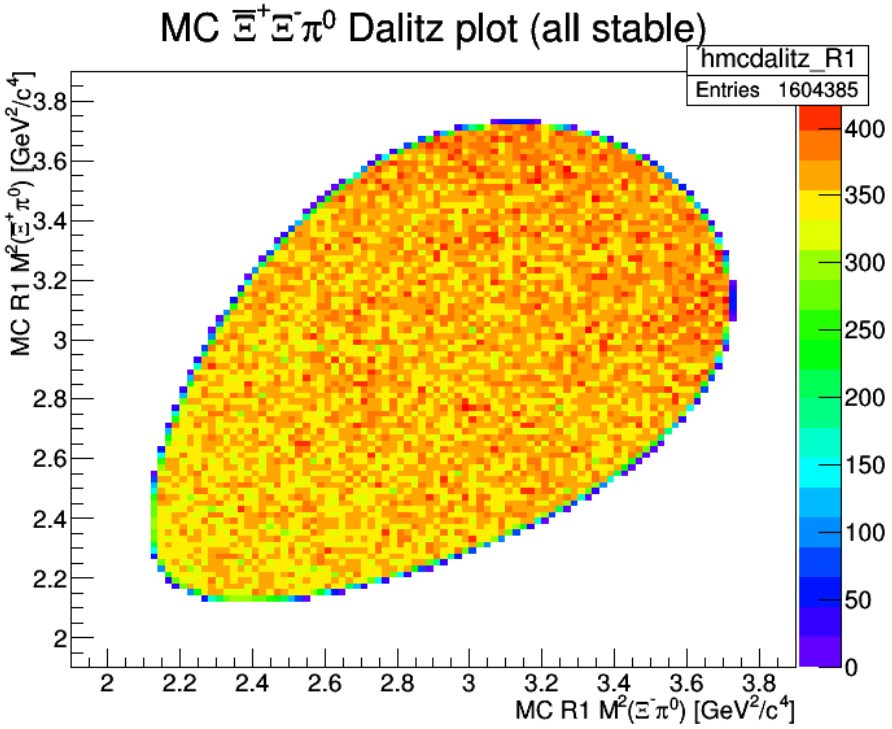

MC Ξ⁺ π⁰ mass
hmcAXipPi0_M
Entries 4436851
Mean 1.695
Std Dev 0.1184
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1.4
1.5
1.6
1.7
1.8
1.9
2
M_Ξ⁺π⁰ MC [GeV/c²]

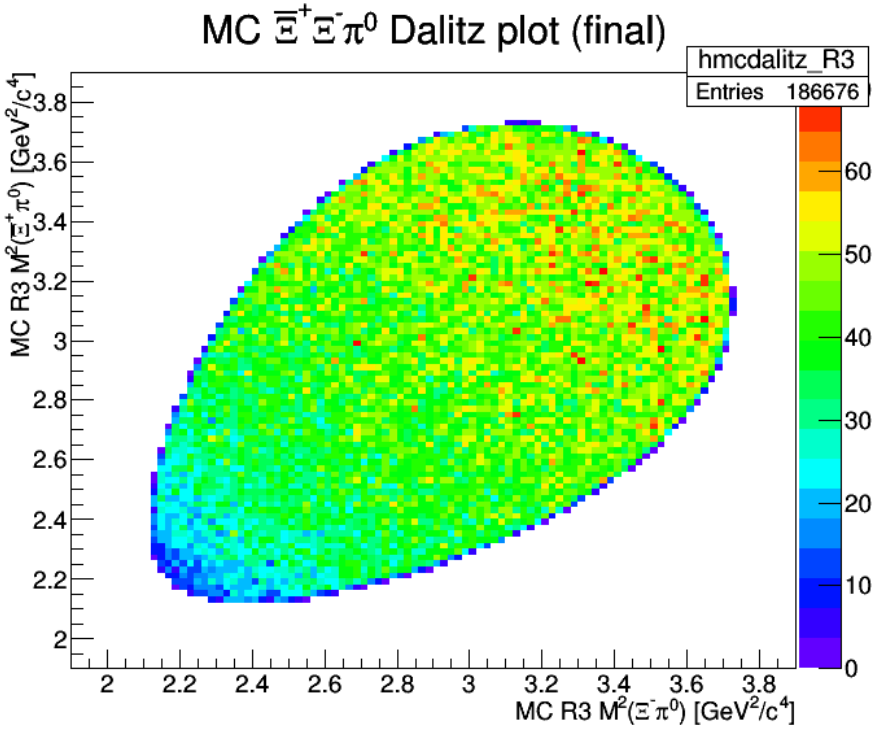

MC Ξ⁻ π⁰ mass
hmcXimPi0_M
Entries 4436851
Mean 1.695
Std Dev 0.1184
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1.4
1.5
1.6
1.7
1.8
1.9
2
M_Ξ⁻π⁰ MC [GeV/c²]

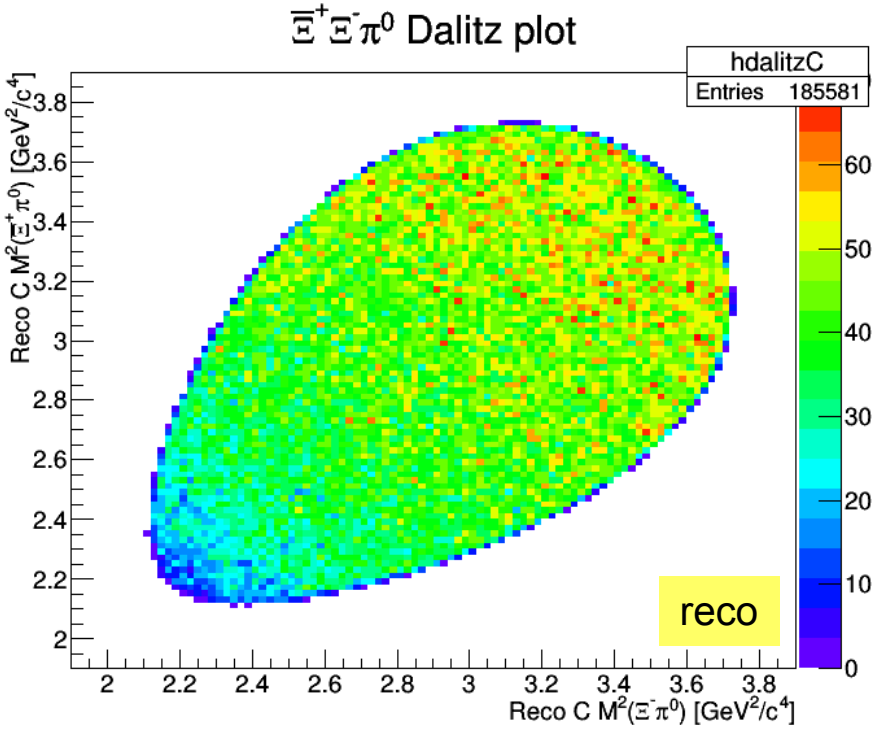

Ξ⁺ π⁰ mass
hmAXipPi0C
Entries 200496
Mean 1.712
Std Dev 0.1144
reco
1200
1000
800
600
400
200
0
1.4
1.5
1.6
1.7
1.8
1.9
2
Ξ⁺π⁰ Reco M (Cut) [GeV/c²]

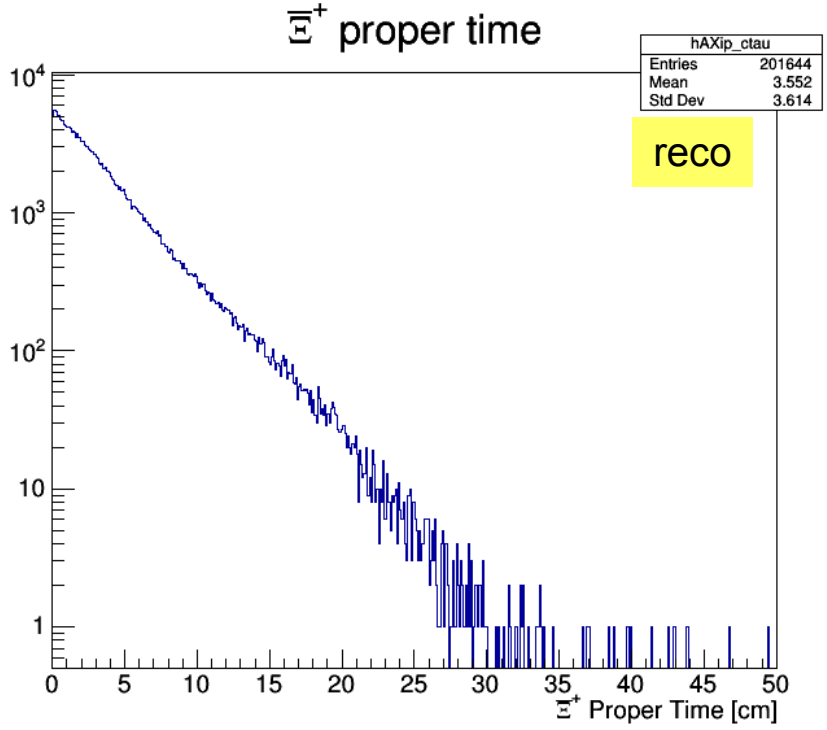

Ξ⁻ π⁰ mass
hmXimPi0C
Entries 200496
Mean 1.712
Std Dev 0.1147
reco
1200
1000
800
600
400
200
0
1.4
1.5
1.6
1.7
1.8
1.9
2
Ξ⁻π⁰ Reco M (Cut) [GeV/c²]

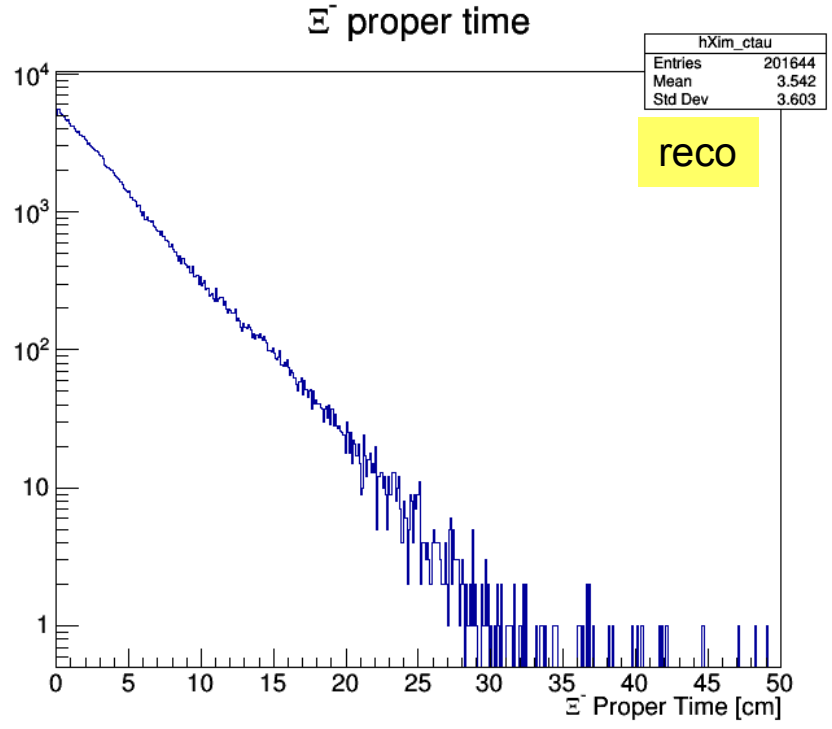

MC $\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot
hmcdalitz
Entries 3943244
MC $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
MC $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]

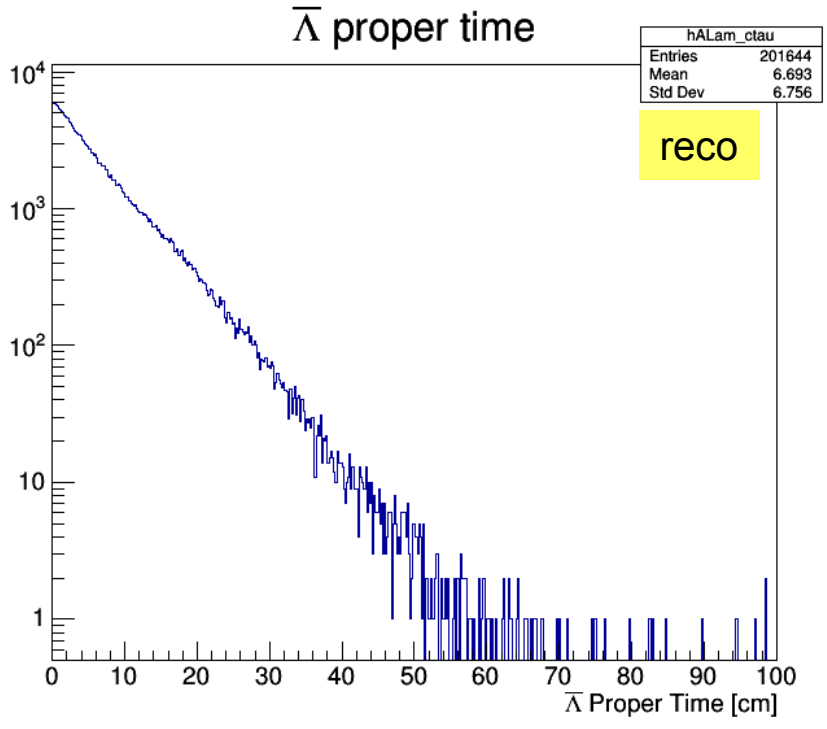

MC $\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot (all stable)
hmcdalitz_R1
Entries 1604385
MC R1 $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
MC R1 $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]

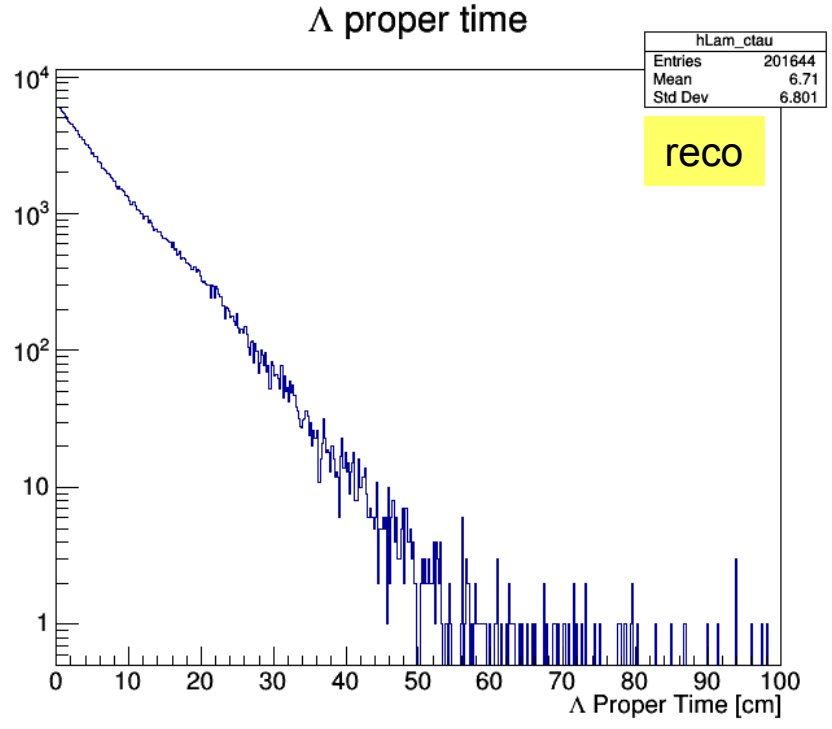

MC $\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot (final)
hmcdalitz_R3
Entries 186676
MC R3 $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
MC R3 $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]

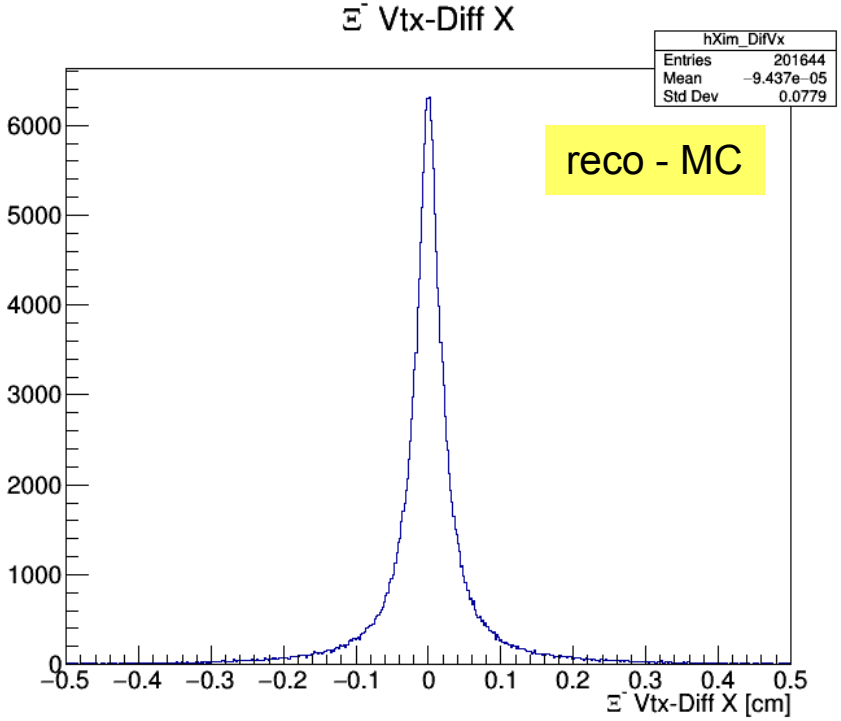

$\bar{\Xi}^+\Xi^-\pi^0$ Dalitz plot
hdalitzC
Entries 185581
Reco C $M^2(\Xi^-\pi^0)$ [GeV^2/c^4]
Reco C $M^2(\bar{\Xi}^+\pi^0)$ [GeV^2/c^4]
reco

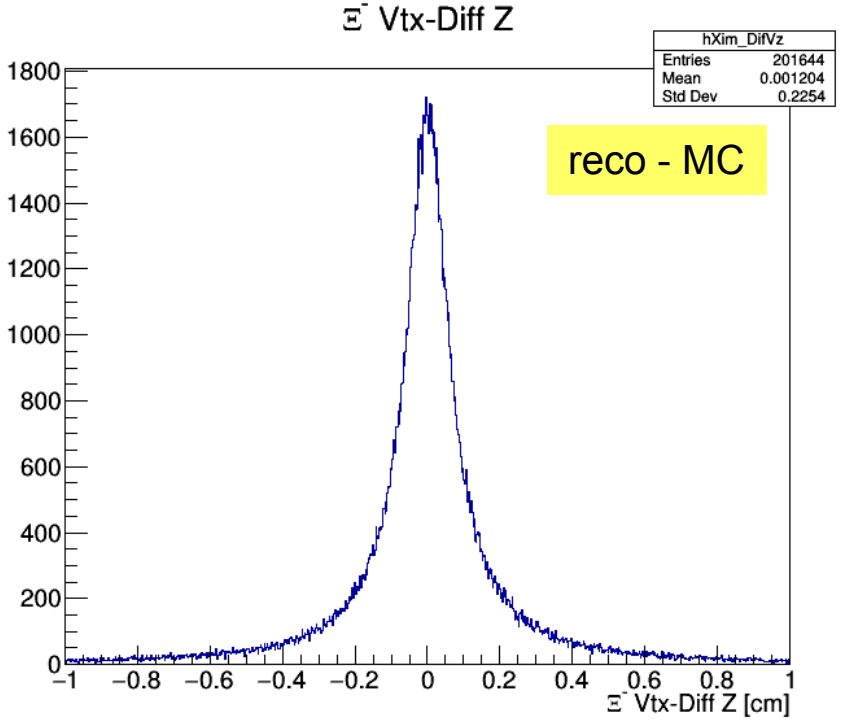

$\bar{\Xi}^+$ proper time
hAXip_ctau
Entries 201644
Mean 3.552
Std Dev 3.614
reco
$\bar{\Xi}^+$ Proper Time [cm]

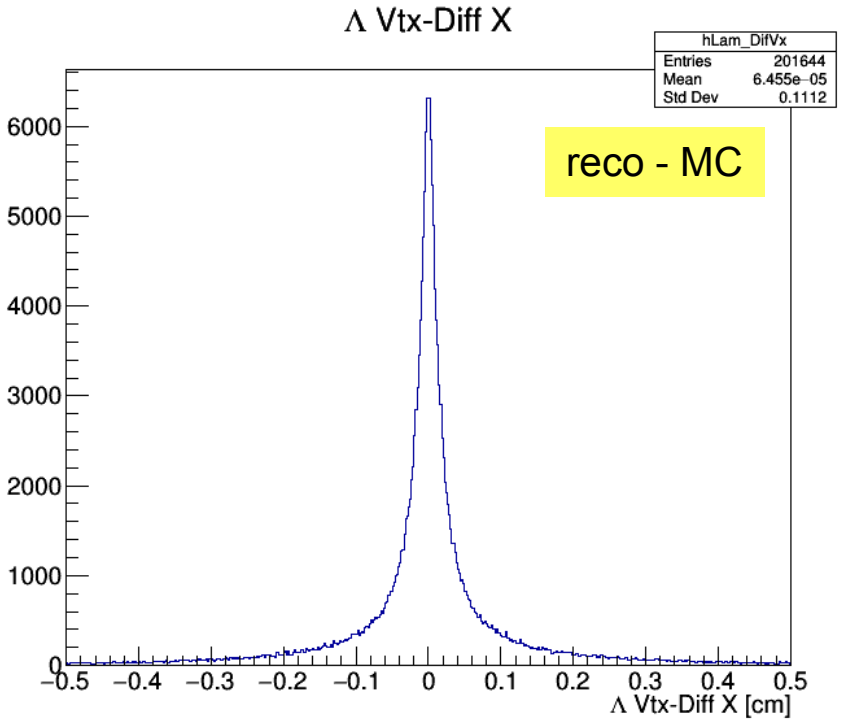

Ξ^- proper time
hXim_ctau
Entries 201644
Mean 3.542
Std Dev 3.603
reco
Ξ^- Proper Time [cm]

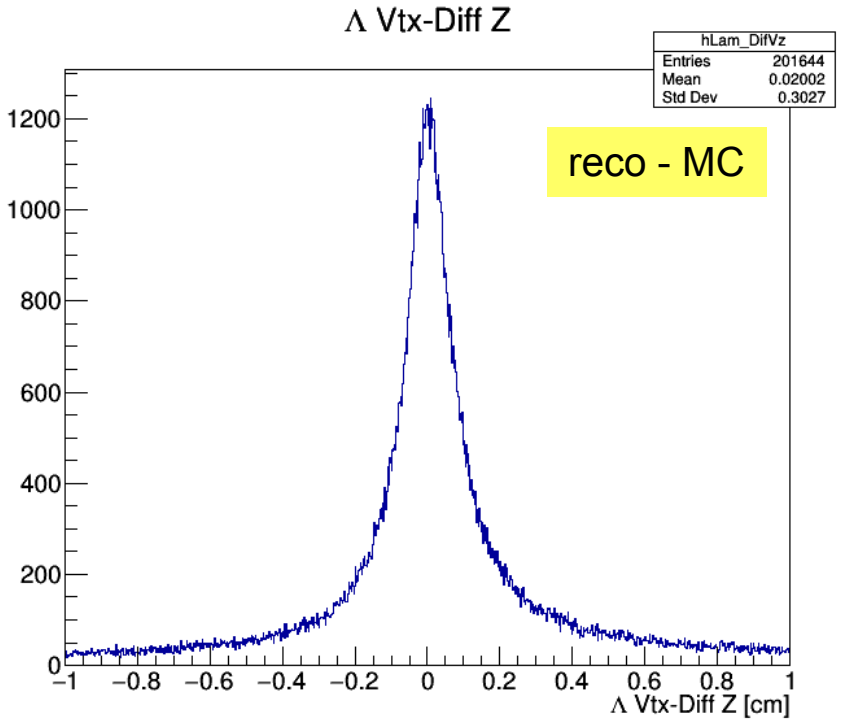

$\bar{\Lambda}$ proper time
hALam_ctau
Entries 201644
Mean 6.693
Std Dev 6.756
reco
$\bar{\Lambda}$ Proper Time [cm]

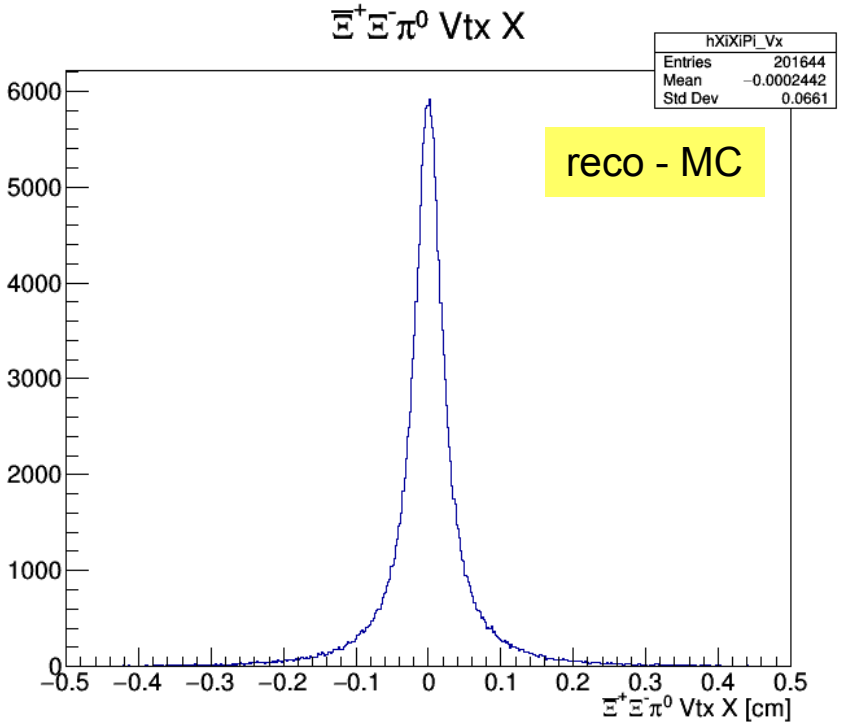

Λ proper time
hLam_ctau
Entries 201644
Mean 6.71
Std Dev 6.801
reco
Λ Proper Time [cm]

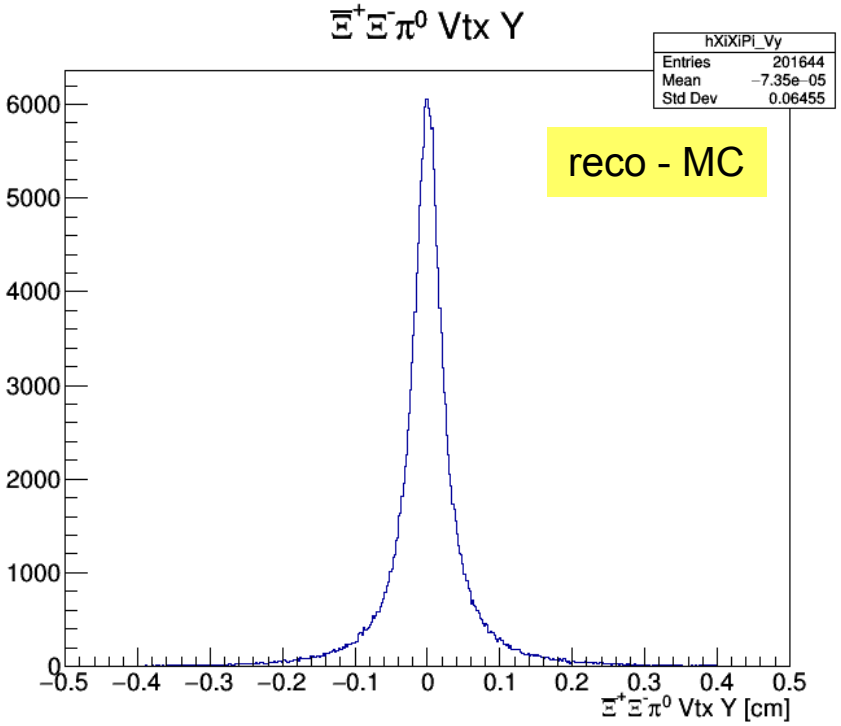

Ξ⁻ Vtx-Diff X
hXim_DifVx
Entries 201644
Mean −9.437e−05
Std Dev 0.0779
reco - MC
Ξ⁻ Vtx-Diff X [cm]

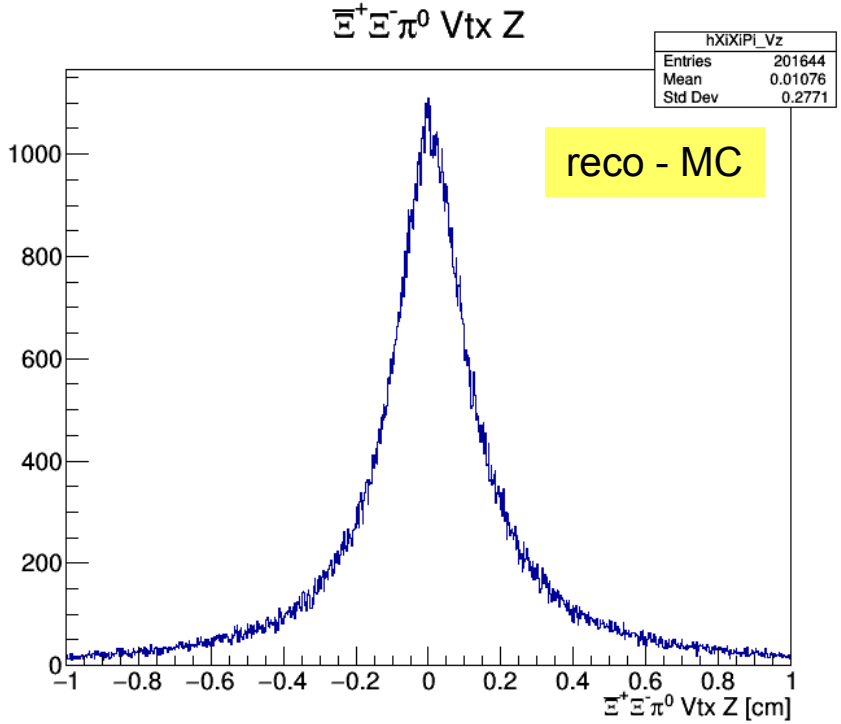

Ξ⁻ Vtx-Diff Z
hXim_DifVz
Entries 201644
Mean 0.001204
Std Dev 0.2254
reco - MC
Ξ⁻ Vtx-Diff Z [cm]

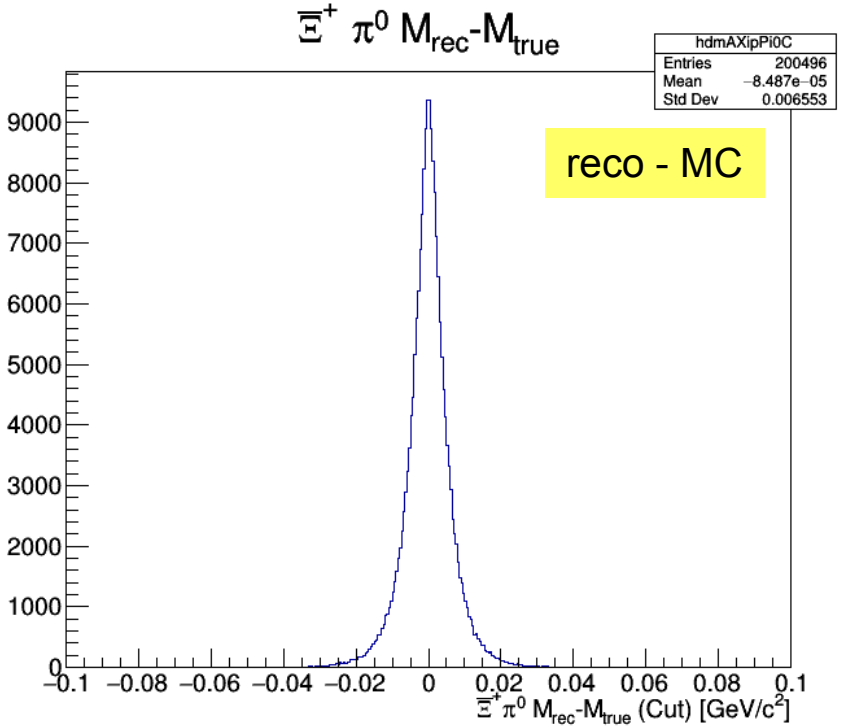

Λ Vtx-Diff X
hLam_DifVx
Entries 201644
Mean 6.455e−05
Std Dev 0.1112
reco - MC
Λ Vtx-Diff X [cm]

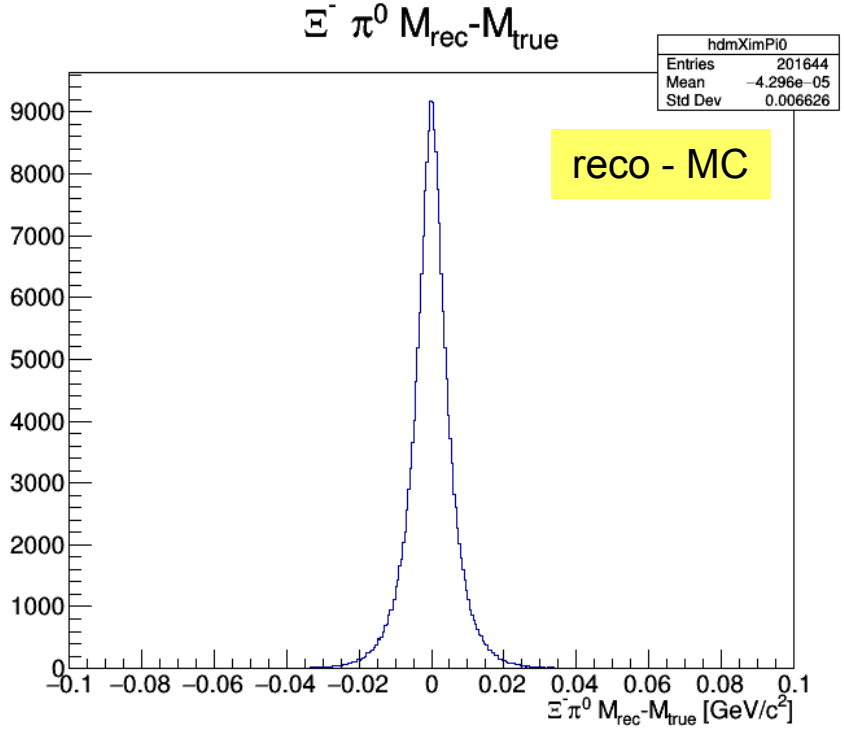

Λ Vtx-Diff Z
hLam_DifVz
Entries 201644
Mean 0.02002
Std Dev 0.3027
reco - MC
Λ Vtx-Diff Z [cm]

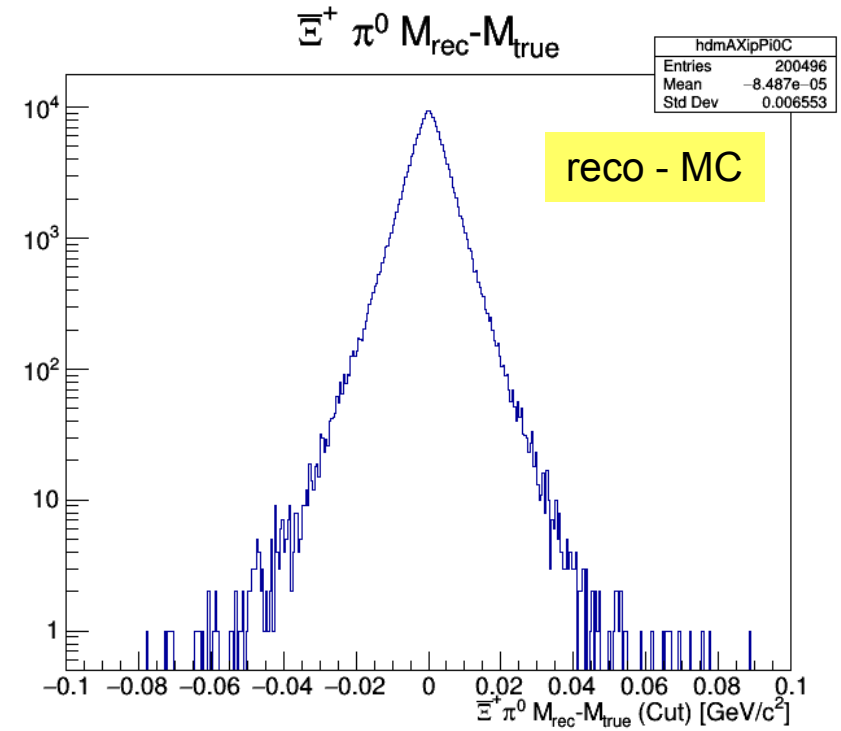

$\bar{\Xi}^+\Xi^-\pi^0$ Vtx X
hXiXiPi_Vx
Entries 201644
Mean −0.0002442
Std Dev 0.0661
reco - MC
$\bar{\Xi}^+\Xi^-\pi^0$ Vtx X [cm]

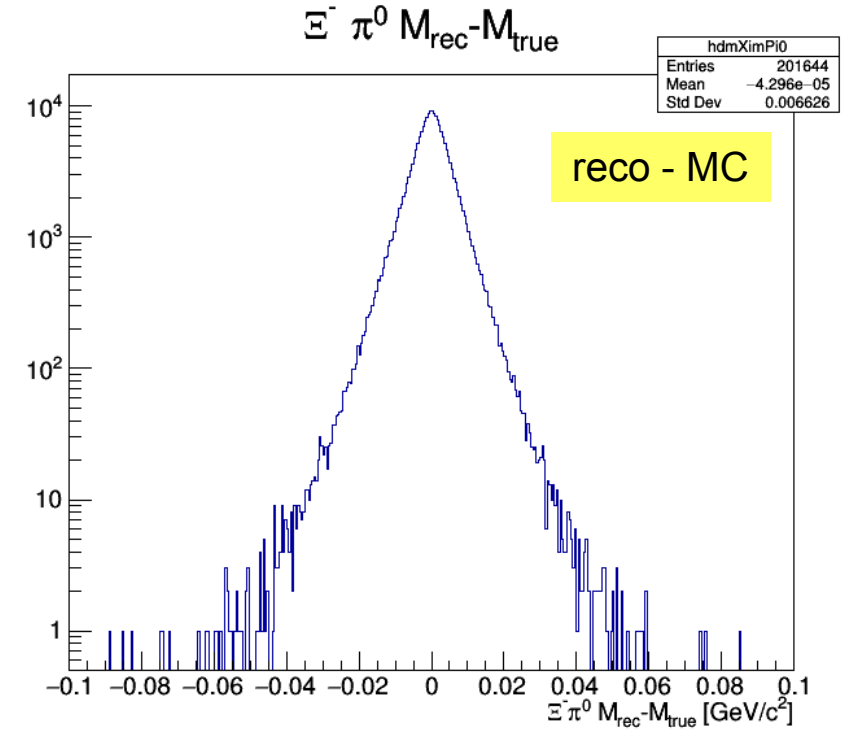

$\bar{\Xi}^+\Xi^-\pi^0$ Vtx Y
hXiXiPi_Vy
Entries 201644
Mean −7.35e−05
Std Dev 0.06455
reco - MC
$\bar{\Xi}^+\Xi^-\pi^0$ Vtx Y [cm]

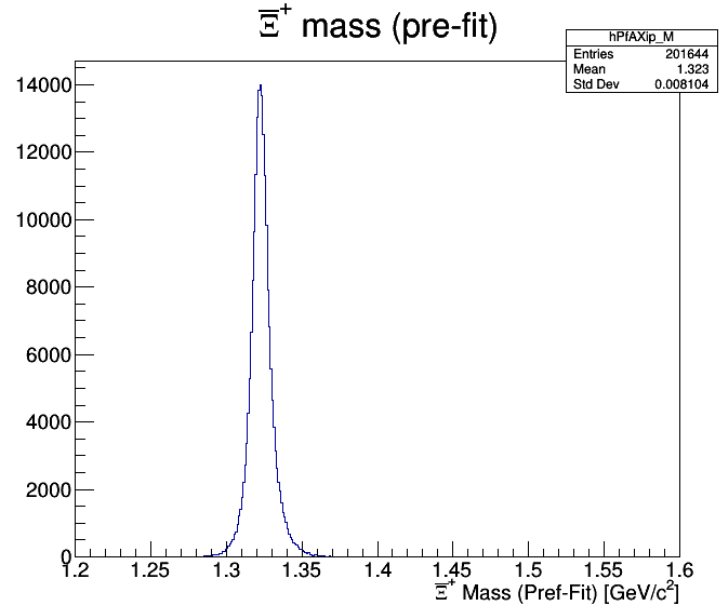

$\bar{\Xi}^+\Xi^-\pi^0$ Vtx Z
hXiXiPi_Vz
Entries 201644
Mean 0.01076
Std Dev 0.2771
reco - MC
$\bar{\Xi}^+\Xi^-\pi^0$ Vtx Z [cm]

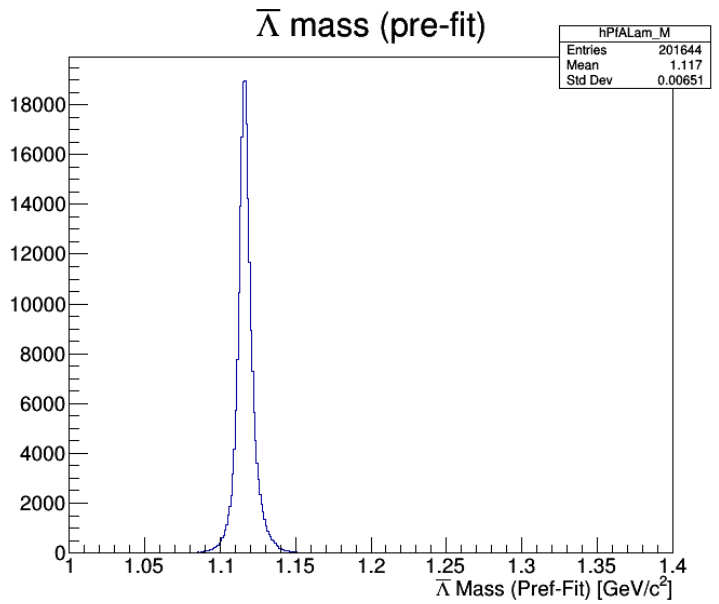

$\bar{\Xi}^+ \pi^0$ M_{rec}-M_{true}
hdmAXipPi0C
Entries 200496
Mean −8.487e−05
Std Dev 0.006553
reco - MC
$\bar{\Xi}^+\pi^0$ M_{rec}-M_{true} (Cut) [GeV/c^2]

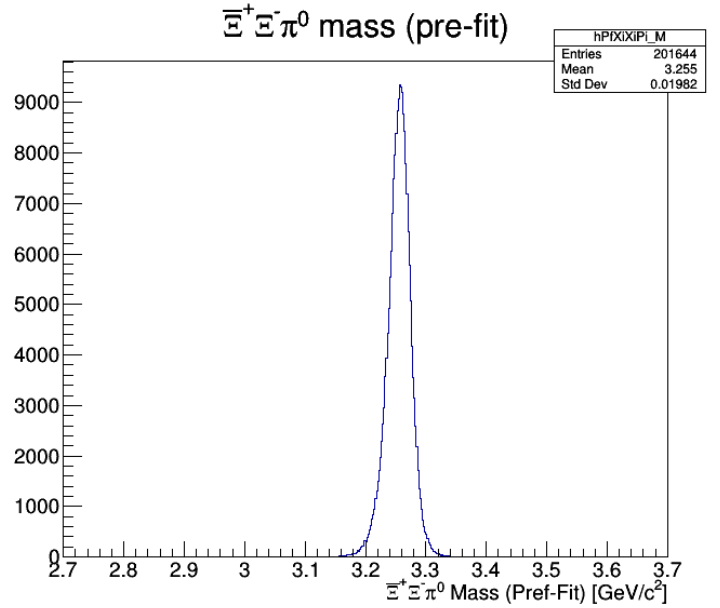

$\Xi^- \pi^0$ M_{rec}-M_{true}
hdmXimPi0
Entries 201644
Mean −4.296e−05
Std Dev 0.006626
reco - MC
$\Xi^-\pi^0$ M_{rec}-M_{true} [GeV/c^2]

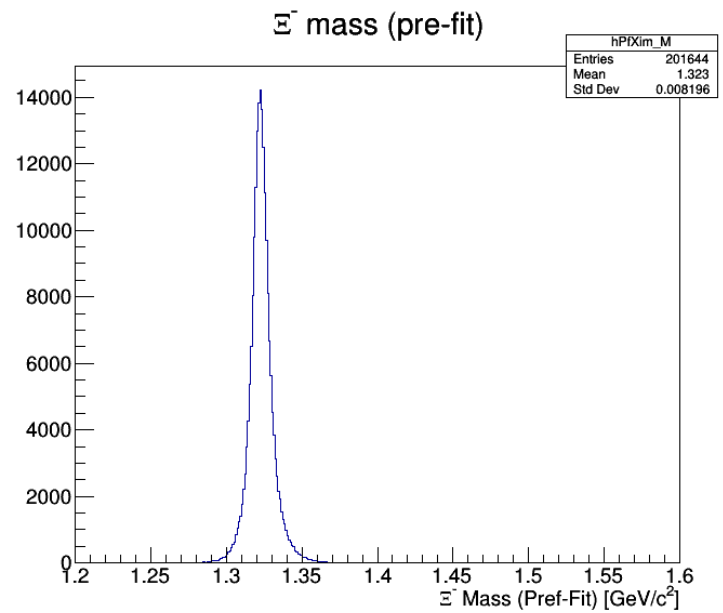

$\bar{\Xi}^+ \pi^0$ M_{rec}-M_{true}
hdmAXipPi0C
Entries 200496
Mean −8.487e−05
Std Dev 0.006553
reco - MC
$\bar{\Xi}^+\pi^0$ M_{rec}-M_{true} (Cut) [GeV/c^2]

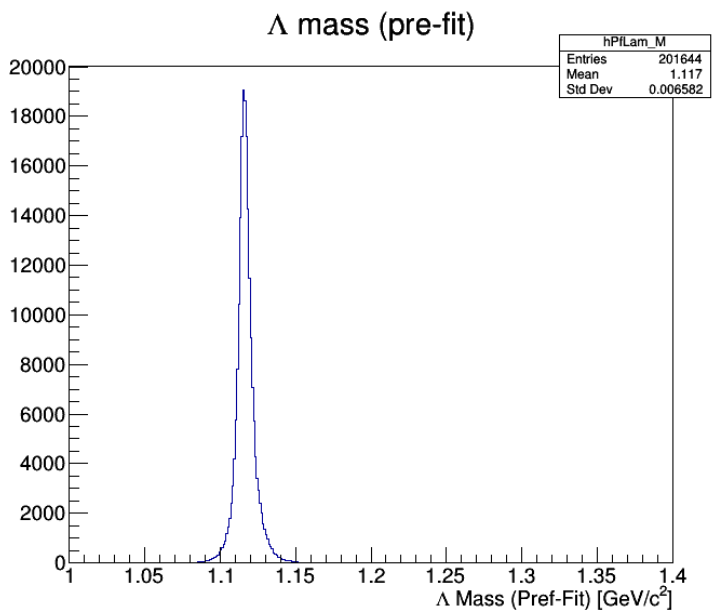

$\Xi^- \pi^0$ M_{rec}-M_{true}
hdmXimPi0
Entries 201644
Mean −4.296e−05
Std Dev 0.006626
reco - MC
$\Xi^-\pi^0$ M_{rec}-M_{true} [GeV/c^2]

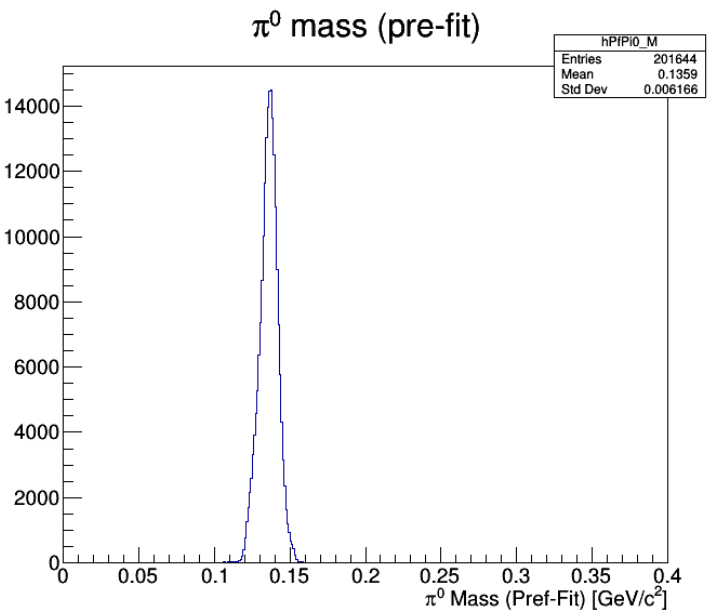

$\overline{\Xi}^{+}$ mass (pre-fit)
hPfAXip_M
Entries 201644
Mean 1.323
Std Dev 0.008104
$\overline{\Xi}^{+}$ Mass (Pref-Fit) [GeV/c^2]

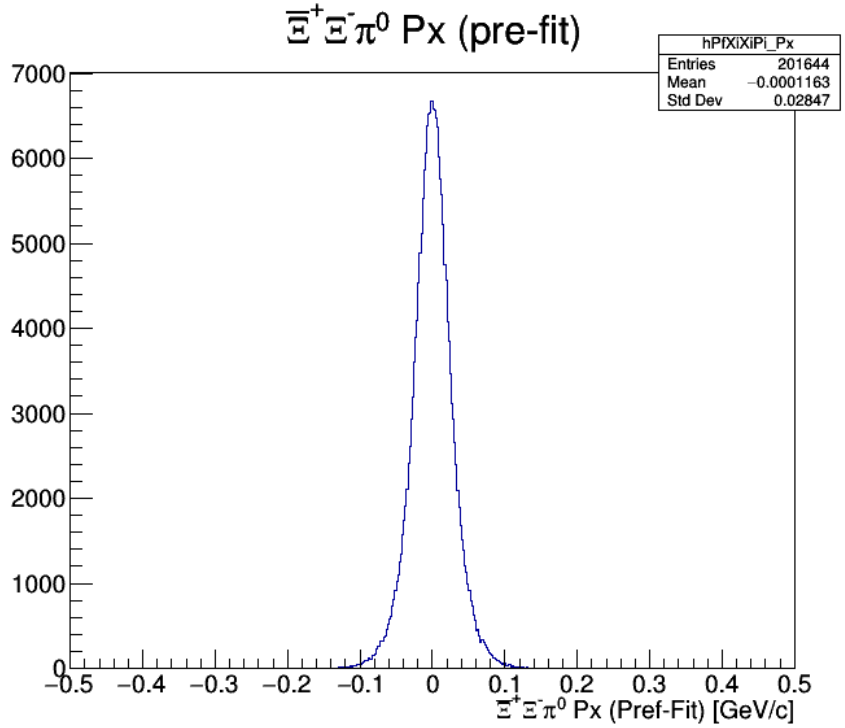

$\overline{\Lambda}$ mass (pre-fit)
hPfALam_M
Entries 201644
Mean 1.117
Std Dev 0.00651
$\overline{\Lambda}$ Mass (Pref-Fit) [GeV/c^2]

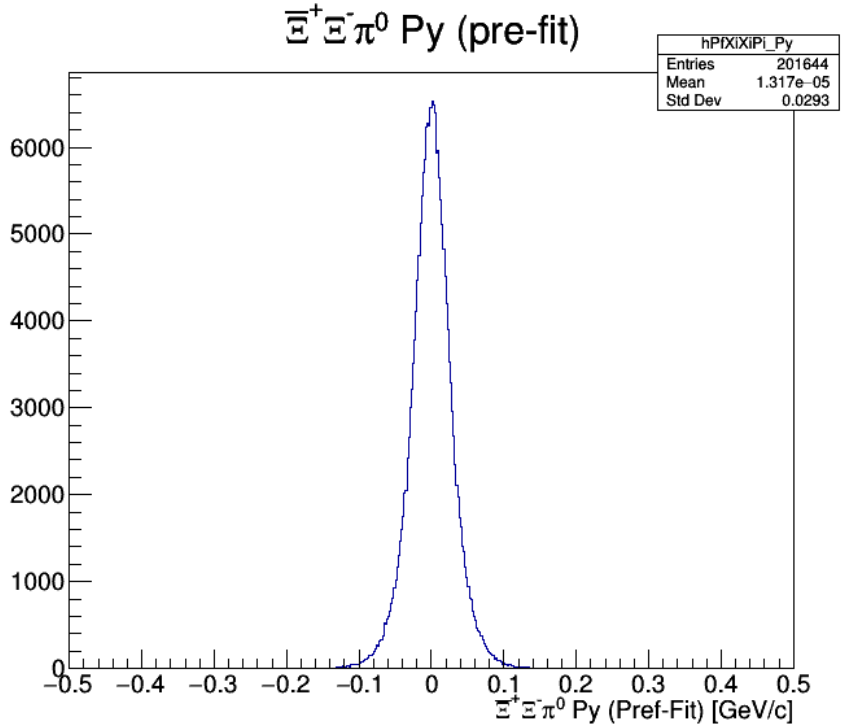

$\overline{\Xi}^{+}\Xi^{-}\pi^{0}$ mass (pre-fit)
hPfXiXiPi_M
Entries 201644
Mean 3.255
Std Dev 0.01982
$\overline{\Xi}^{+}\Xi^{-}\pi^{0}$ Mass (Pref-Fit) [GeV/c^2]

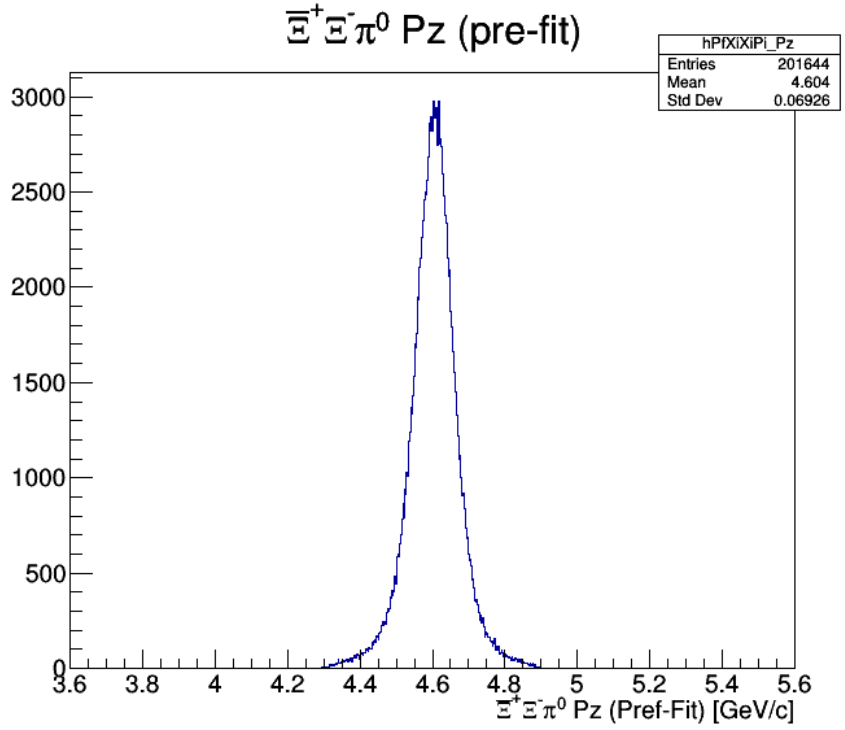

Ξ^{-} mass (pre-fit)
hPfXim_M
Entries 201644
Mean 1.323
Std Dev 0.008196
Ξ^{-} Mass (Pref-Fit) [GeV/c^2]

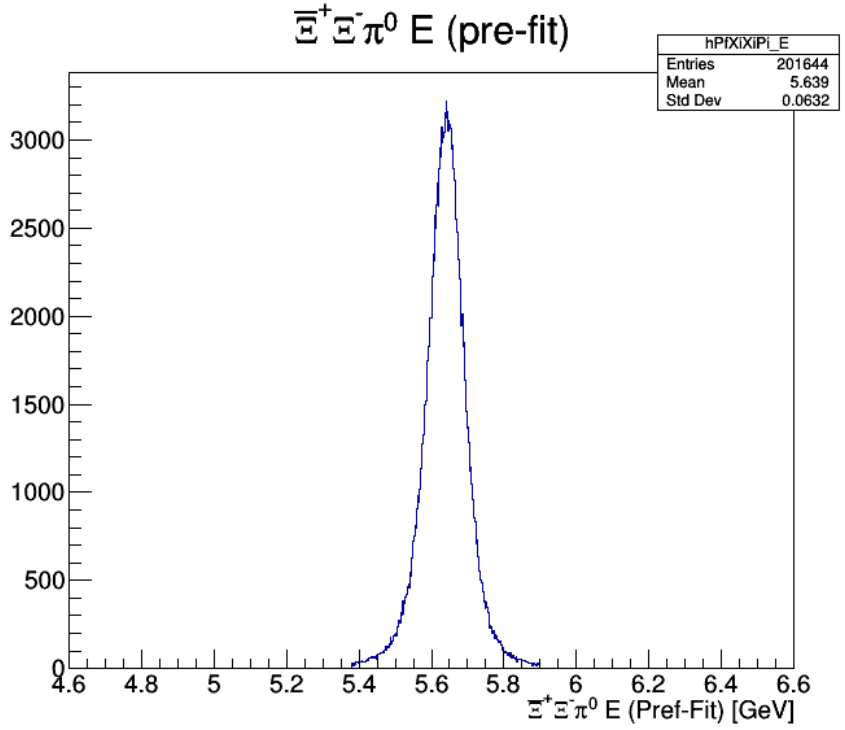

Λ mass (pre-fit)
hPfLam_M
Entries 201644
Mean 1.117
Std Dev 0.006582
Λ Mass (Pref-Fit) [GeV/c^2]

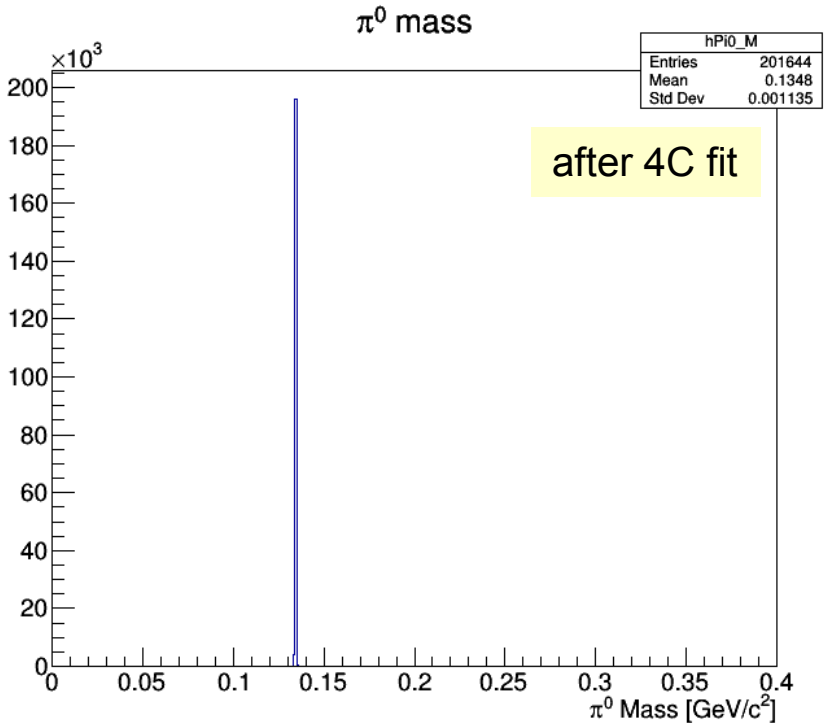

π^{0} mass (pre-fit)
hPfPi0_M
Entries 201644
Mean 0.1359
Std Dev 0.006166
π^{0} Mass (Pref-Fit) [GeV/c^2]

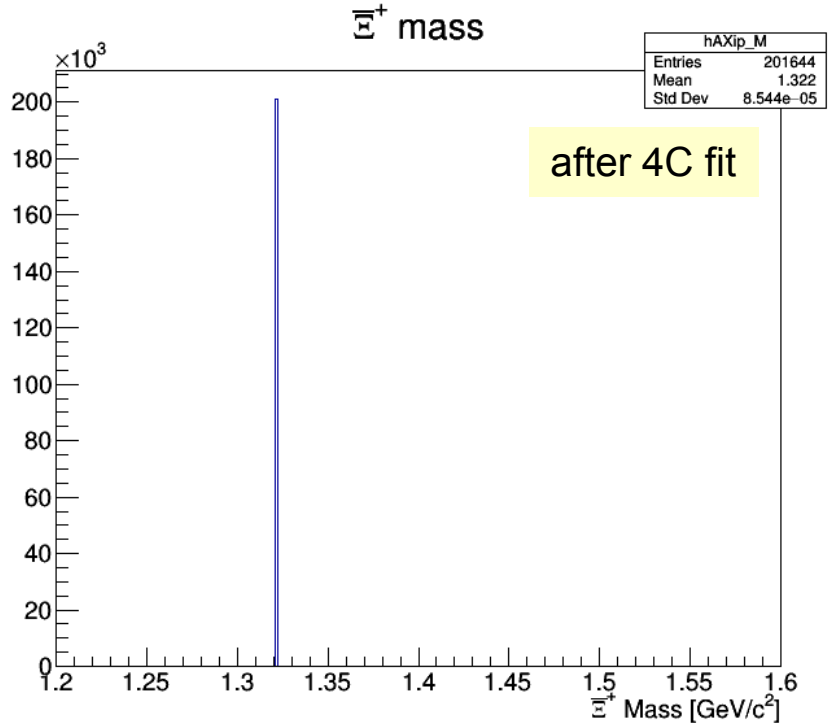

$\overline{\Xi}^{+}\Xi^{-}\pi^{0}$ Px (pre-fit)
hPfXiXiPi_Px
Entries 201644
Mean −0.0001163
Std Dev 0.02847
$\Xi^{+}\Xi^{-}\pi^{0}$ Px (Pref-Fit) [GeV/c]

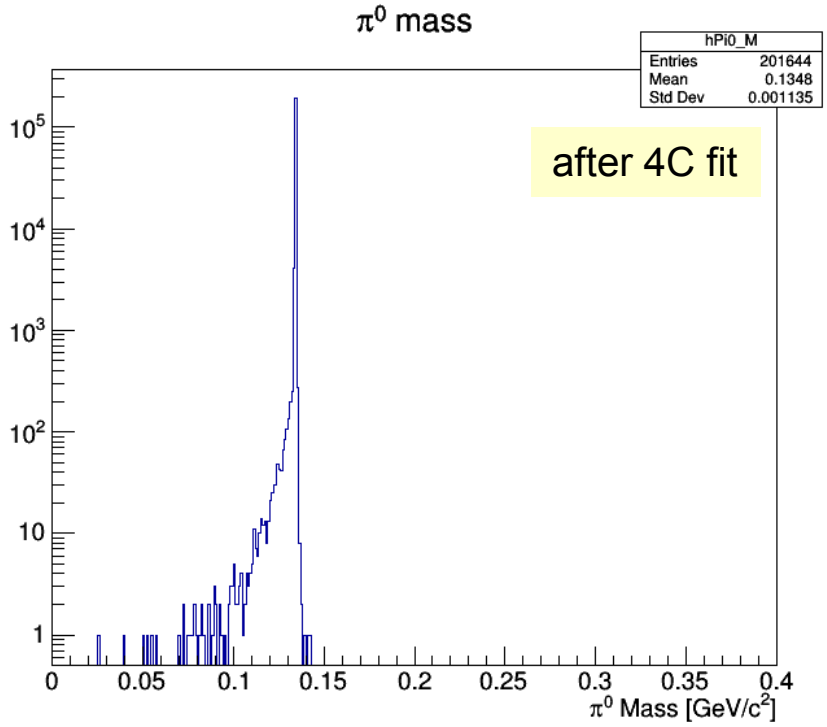

$\overline{\Xi}^{+}\Xi^{-}\pi^{0}$ Py (pre-fit)
hPfXiXiPi_Py
Entries 201644
Mean 1.317e−05
Std Dev 0.0293
$\Xi^{+}\Xi^{-}\pi^{0}$ Py (Pref-Fit) [GeV/c]

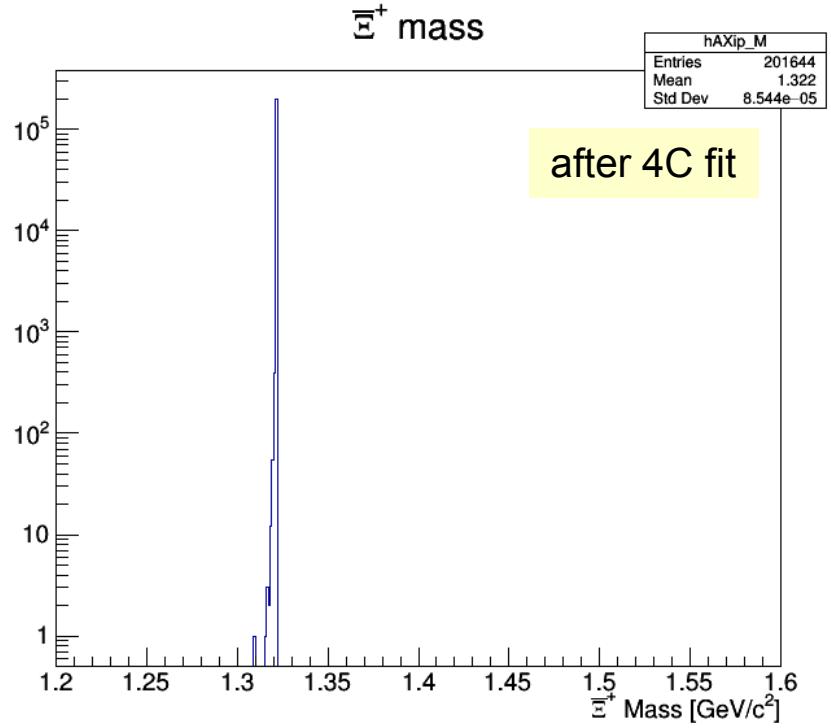

$\overline{\Xi}^{+}\Xi^{-}\pi^{0}$ Pz (pre-fit)
hPfXiXiPi_Pz
Entries 201644
Mean 4.604
Std Dev 0.06926
$\Xi^{+}\Xi^{-}\pi^{0}$ Pz (Pref-Fit) [GeV/c]

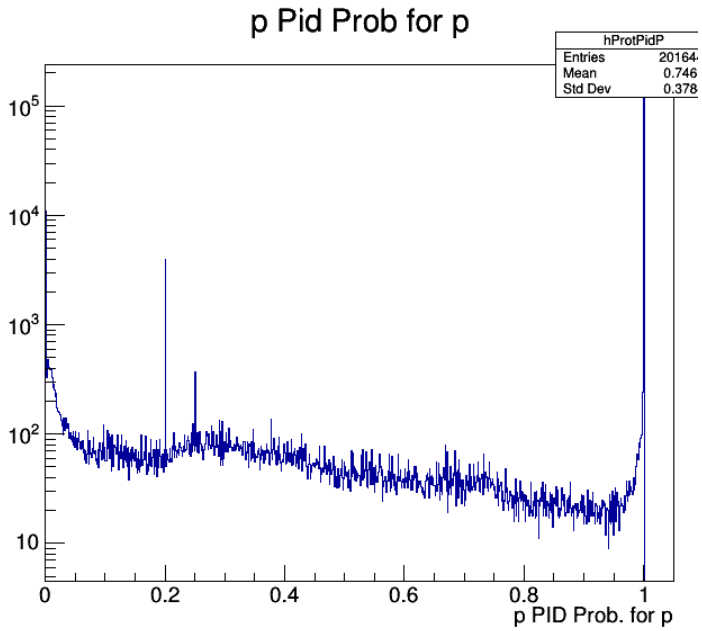

$\overline{\Xi}^{+}\Xi^{-}\pi^{0}$ E (pre-fit)
hPfXiXiPi_E
Entries 201644
Mean 5.639
Std Dev 0.0632
$\Xi^{+}\Xi^{-}\pi^{0}$ E (Pref-Fit) [GeV]

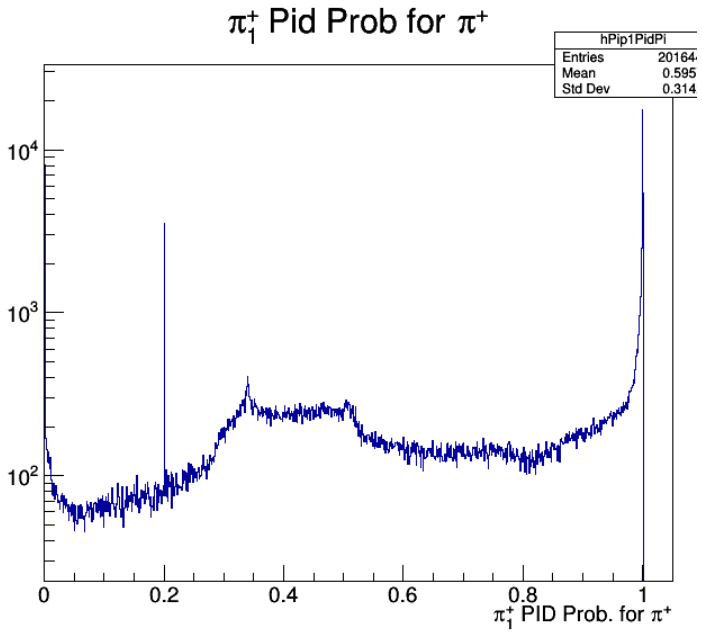

π^0 mass
hPi0_M
Entries 201644
Mean 0.1348
Std Dev 0.001135
after 4C fit
$\times 10^3$
π^0 Mass [GeV/c^2]

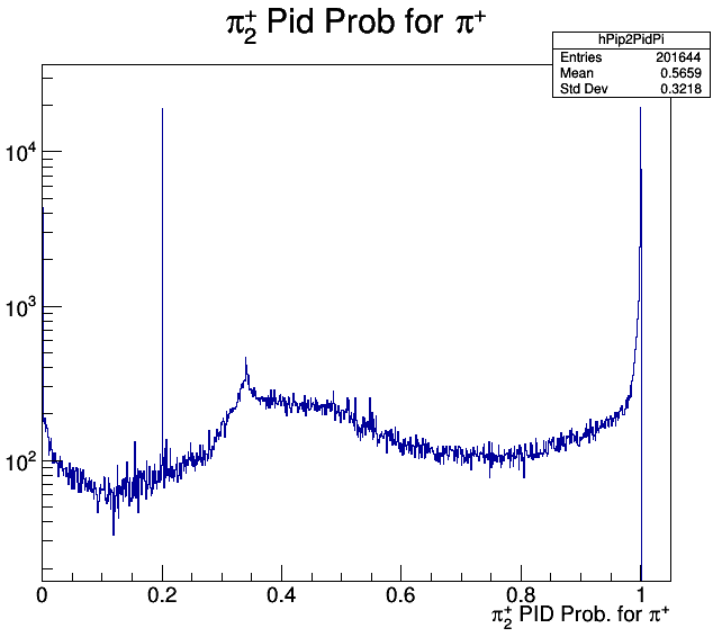

$\bar{\Xi}^+$ mass
hAXip_M
Entries 201644
Mean 1.322
Std Dev 8.544e−05
after 4C fit
$\times 10^3$
$\bar{\Xi}^+$ Mass [GeV/c^2]

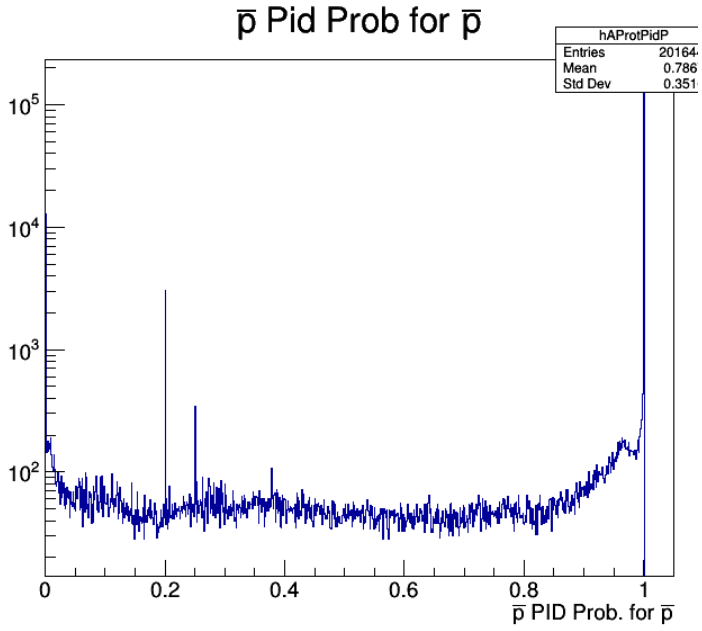

π^0 mass
hPi0_M
Entries 201644
Mean 0.1348
Std Dev 0.001135
after 4C fit
π^0 Mass [GeV/c^2]

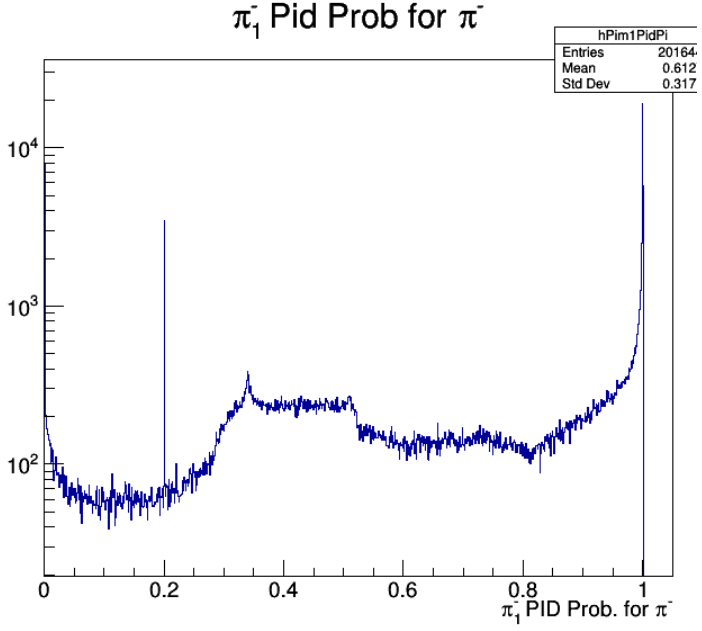

$\bar{\Xi}^+$ mass
hAXip_M
Entries 201644
Mean 1.322
Std Dev 8.544e−05
after 4C fit
$\bar{\Xi}^+$ Mass [GeV/c^2]

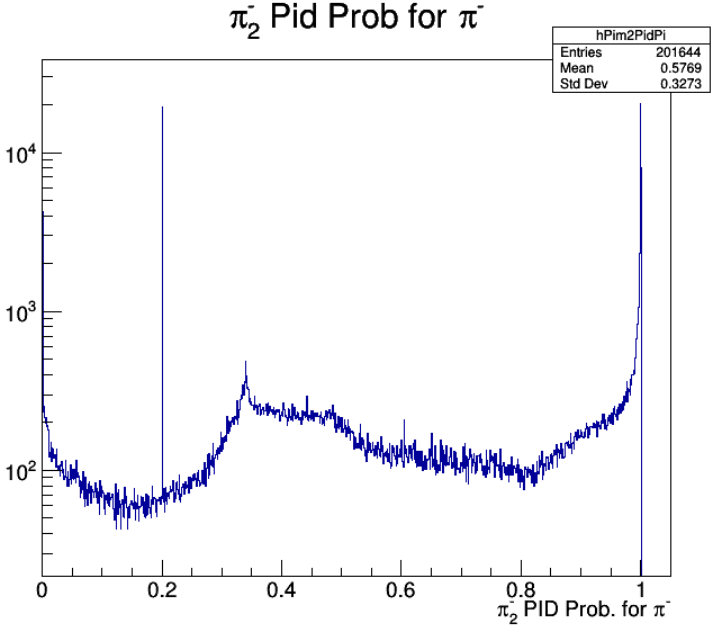

p Pid Prob for p
hProtPidP
Entries 20164
Mean 0.746
Std Dev 0.378
p PID Prob. for p


π_1^+ Pid Prob for π^+
hPip1PidPi
Entries 20164
Mean 0.595
Std Dev 0.314
π_1^+ PID Prob. for π^+

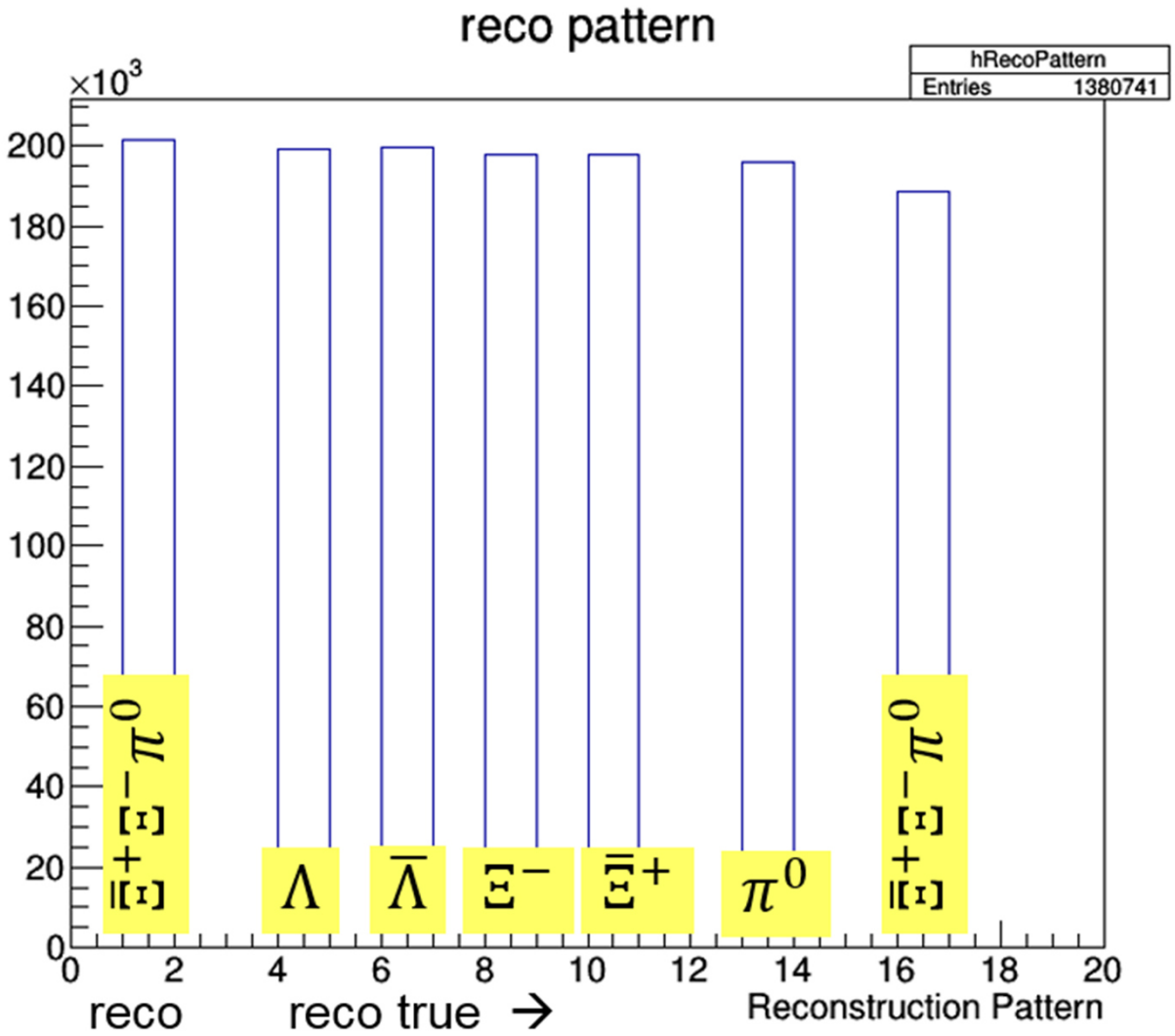

π_2^+ Pid Prob for π^+
hPip2PidPi
Entries 201644
Mean 0.5659
Std Dev 0.3218
π_2^+ PID Prob. for π^+


$\bar{p}$ Pid Prob for $\bar{p}$
hAProtPidP
Entries 20164
Mean 0.786
Std Dev 0.351
$\bar{p}$ PID Prob. for $\bar{p}$


π_1^- Pid Prob for π^-
hPim1PidPi
Entries 20164
Mean 0.612
Std Dev 0.317
π_1^- PID Prob. for π^-


π_2^- Pid Prob for π^-
hPim2PidPi
Entries 201644
Mean 0.5769
Std Dev 0.3273
π_2^- PID Prob. for π^-

Reconstruction Efficiency & Purity



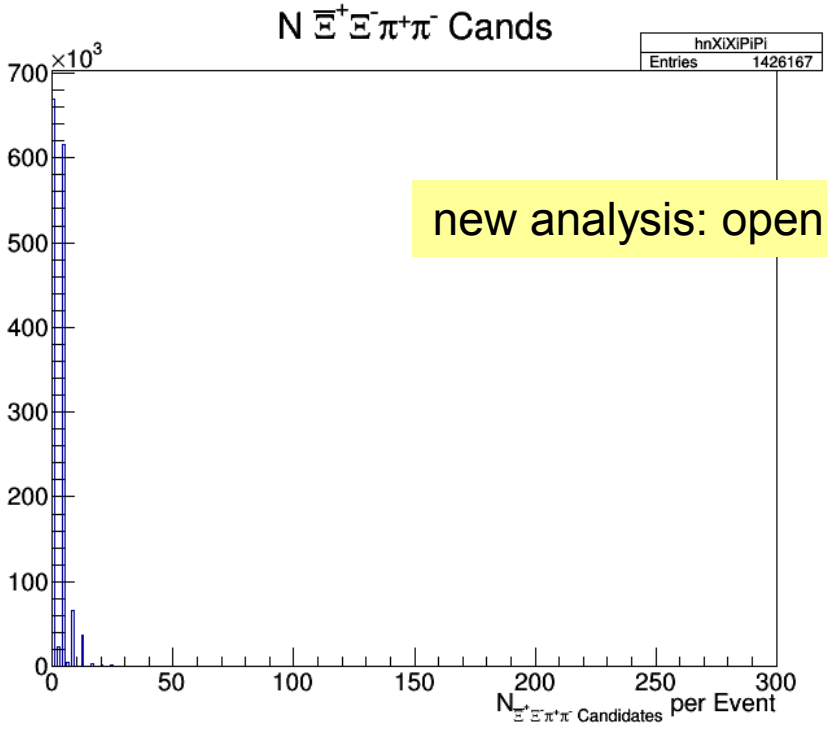
Reco eff. = 3.83%

Purity = 93.5%

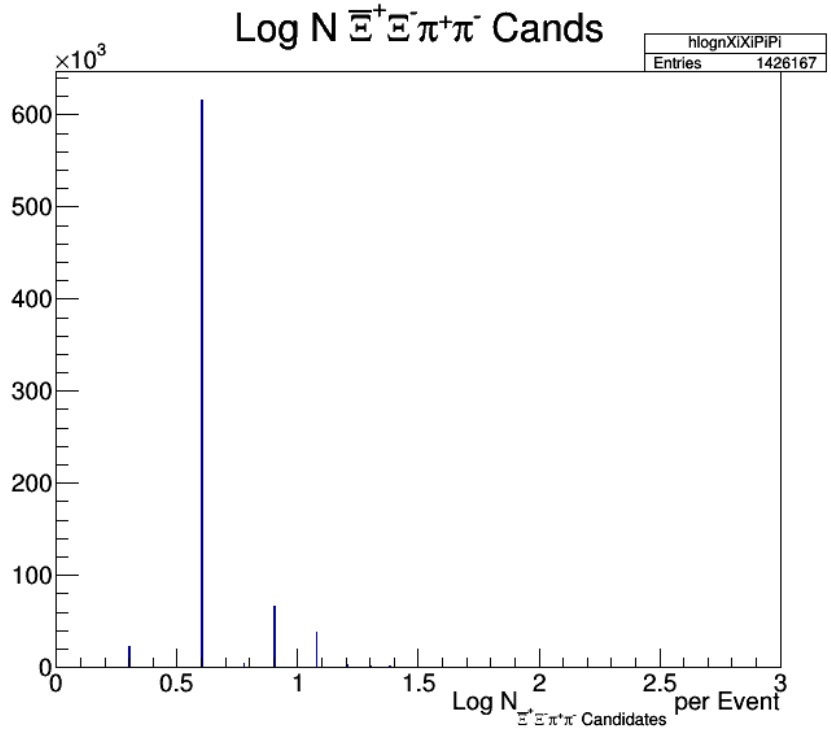
ideal PID: ~3.9% / ~97%

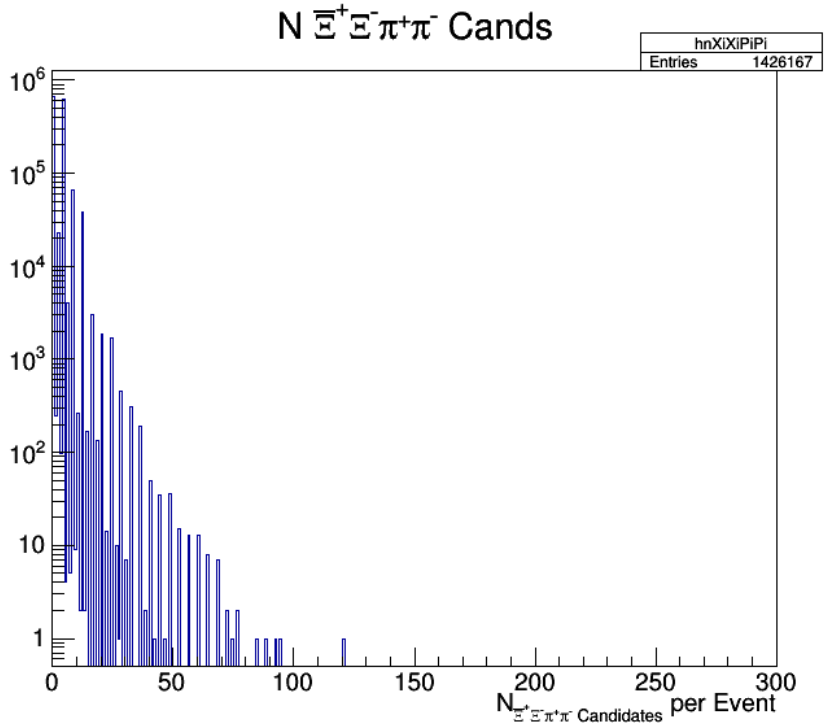
Status $\bar{\Xi}^+\Xi^-\pi^+\pi^-$ Analysis

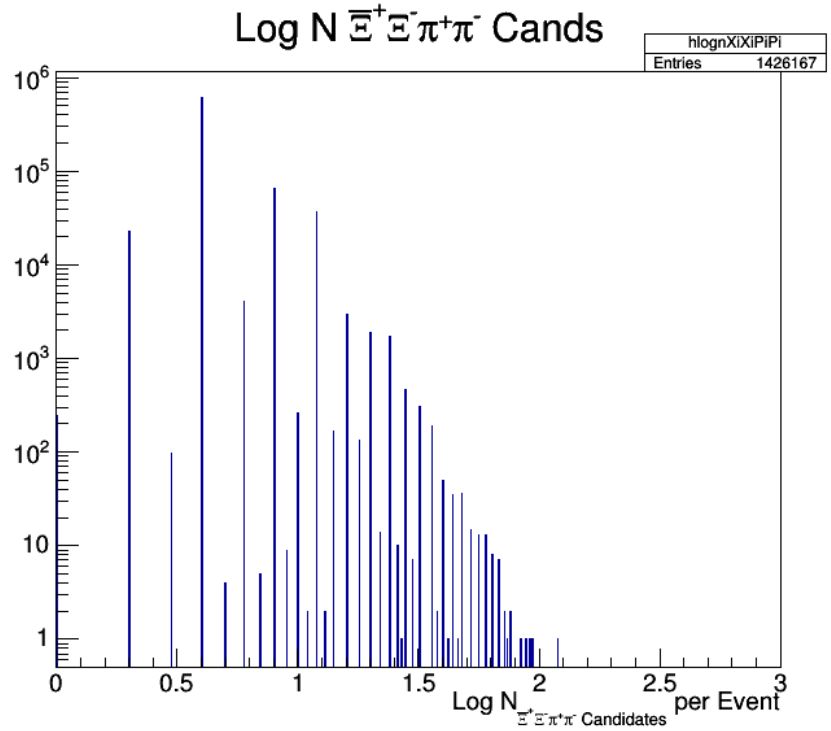
- Reaction channel analyzed by Ale using step-by-step reconstruction of the decay tree
- Used Ale‘s simulation data + new data generated with same conditions → 5.585 M events
- Full decay tree fit → huge number of $\bar{p}p3\pi^+3\pi^-$ combinations !
- Open PID

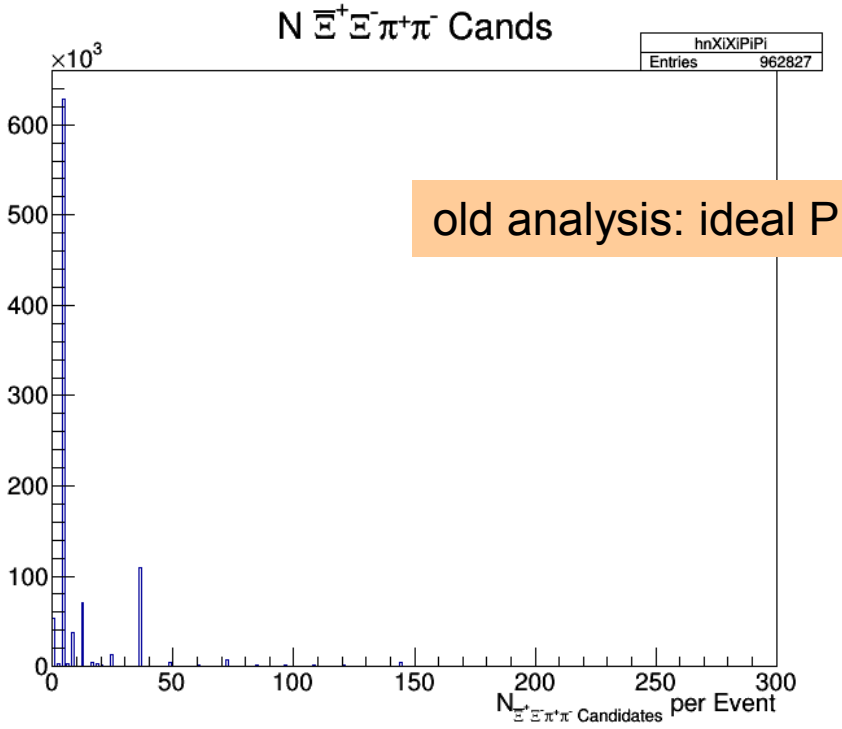


new analysis: open PID

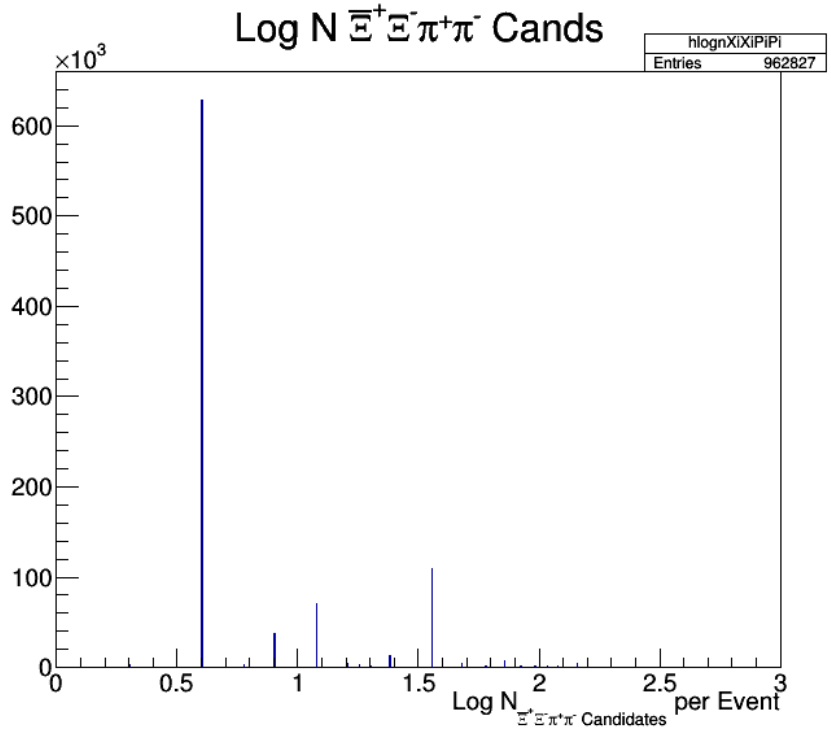


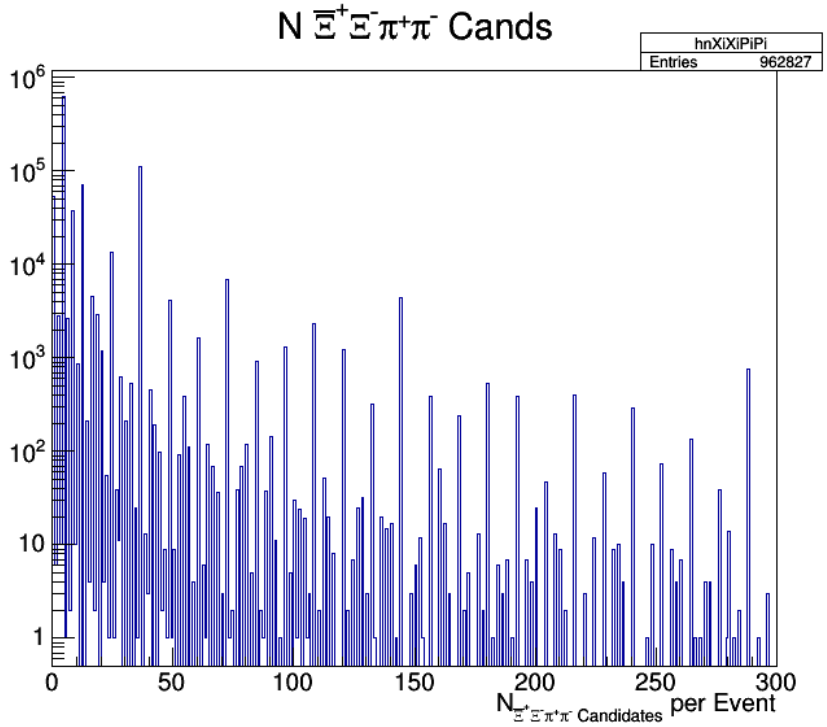


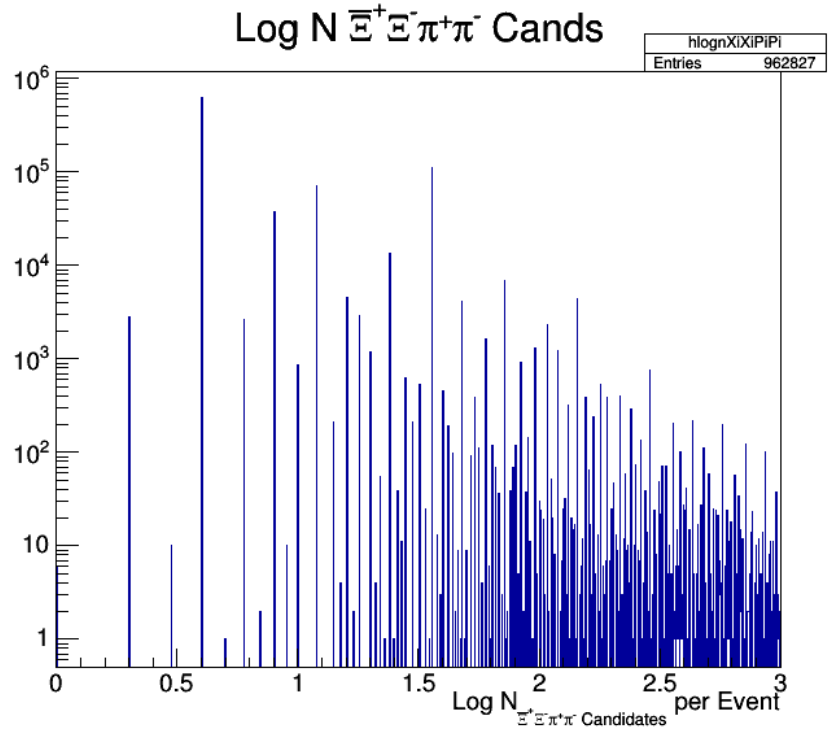


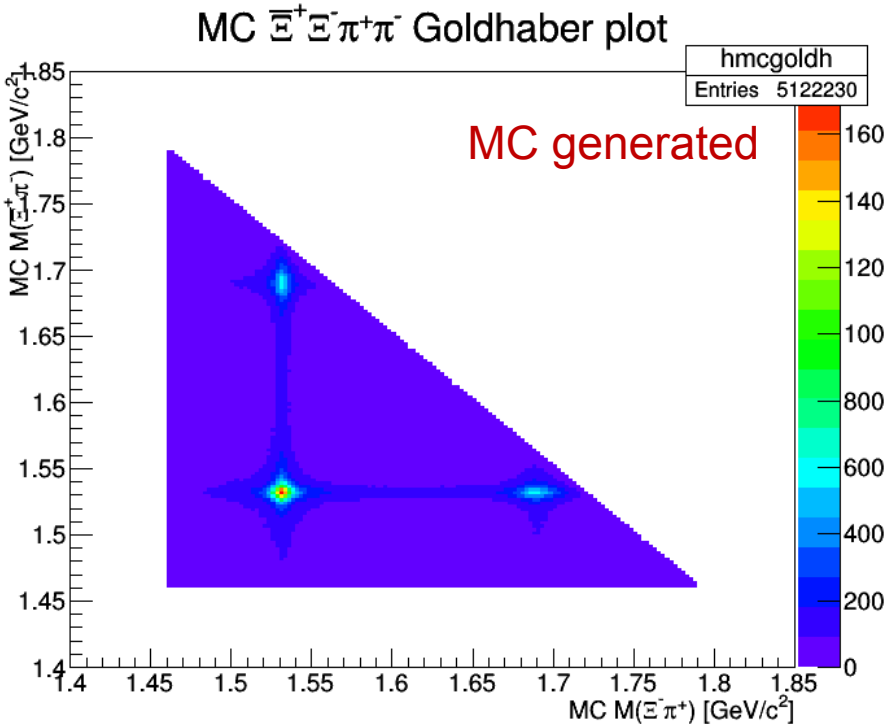


old analysis: ideal PID





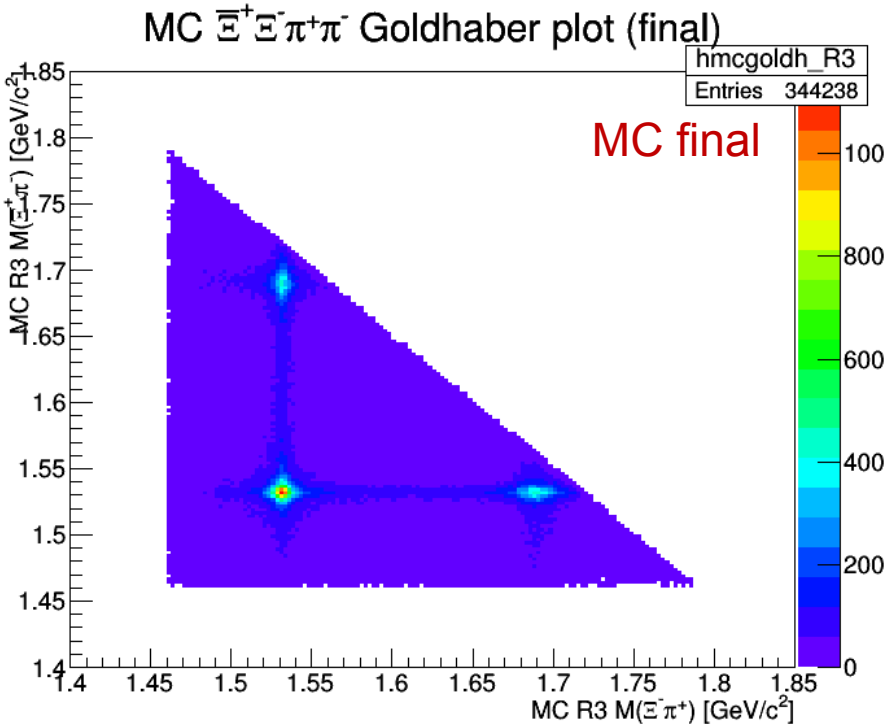


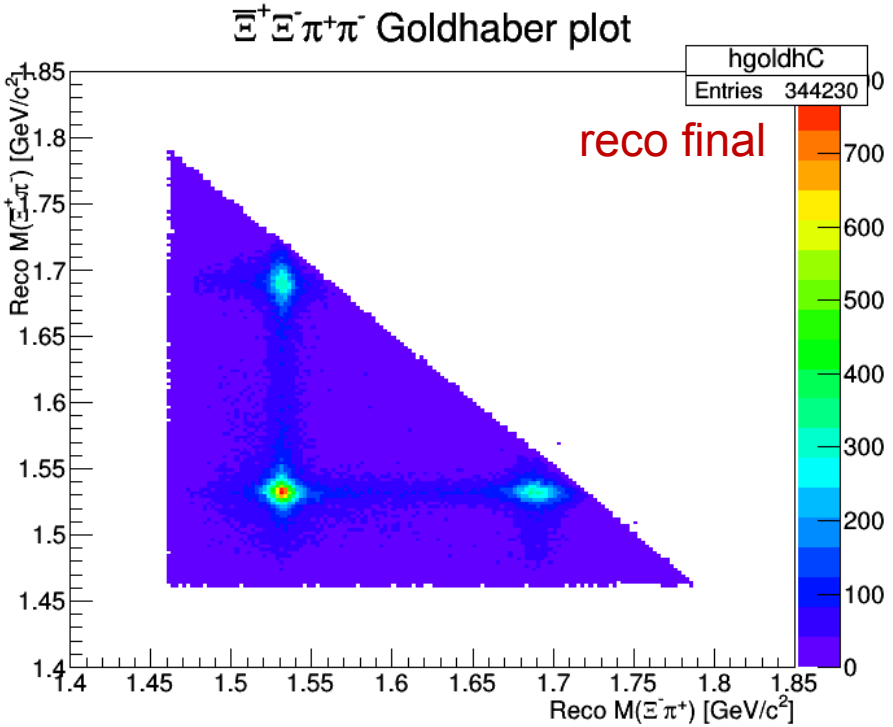


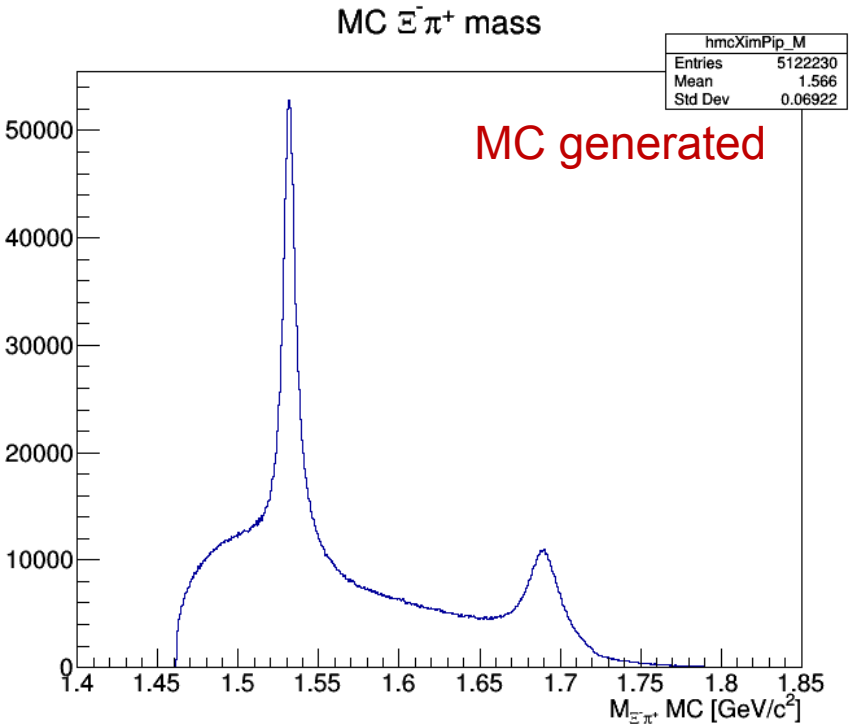
Goldhaber Plot:

$M(\bar{\Xi}^+\pi^-)$ vs $M(\Xi^-\pi^+)$

shows $\Xi^* \to \Xi\pi$ decays



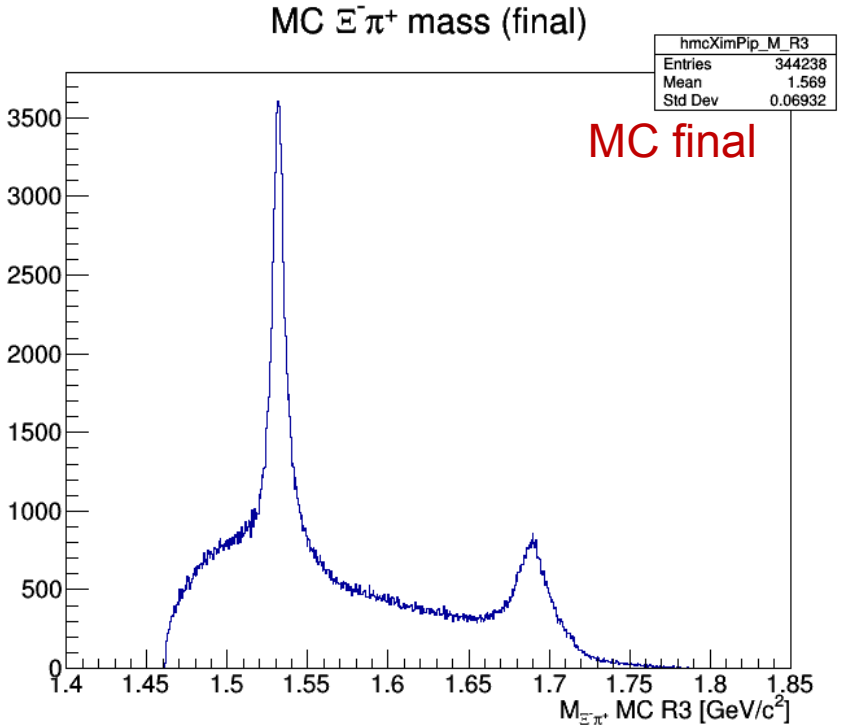


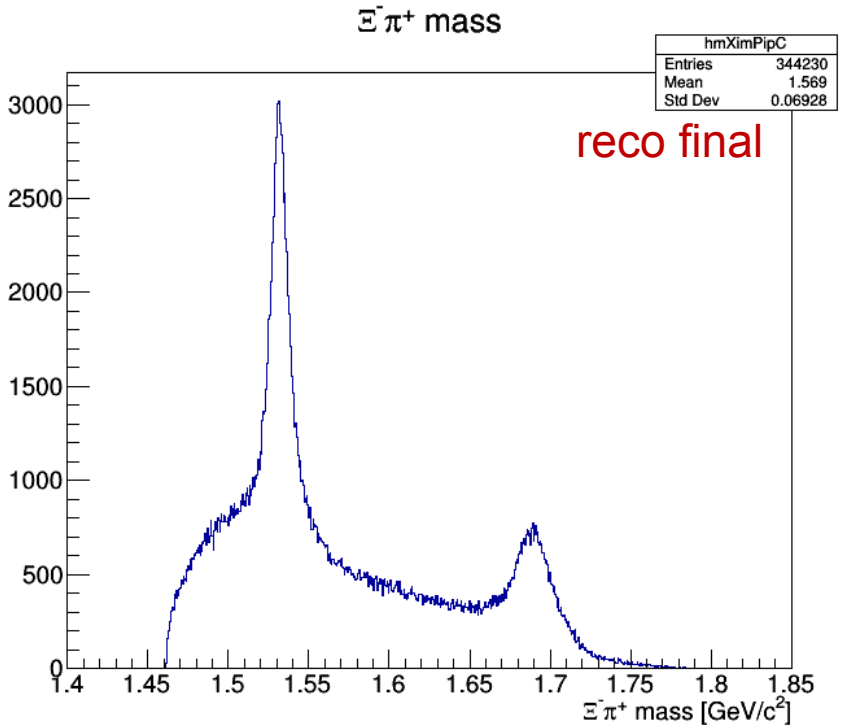


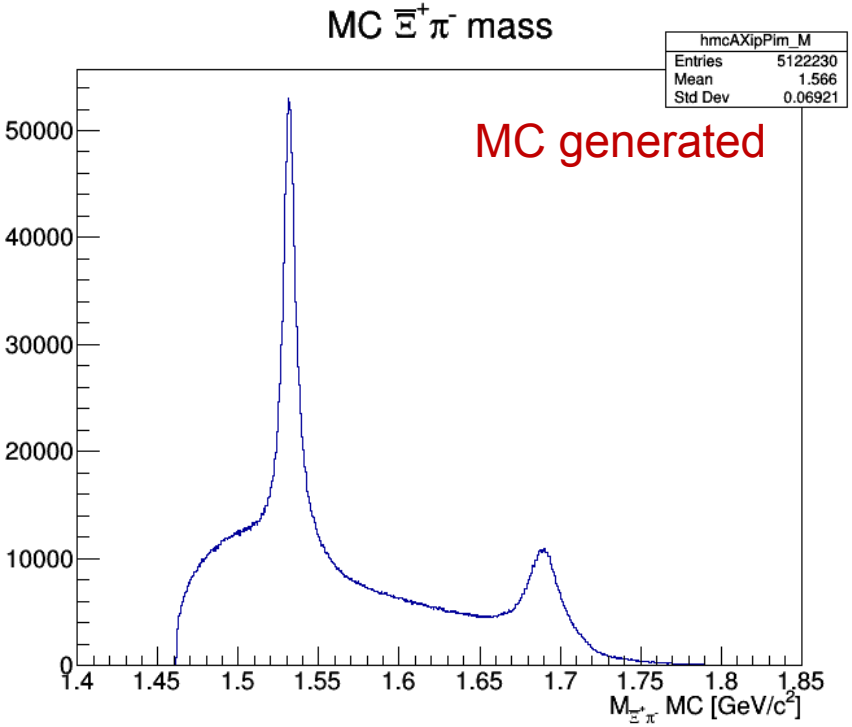
Projections:

$M(\Xi^-\pi^+)$

shows $\Xi^* \rightarrow \Xi\pi$ decays



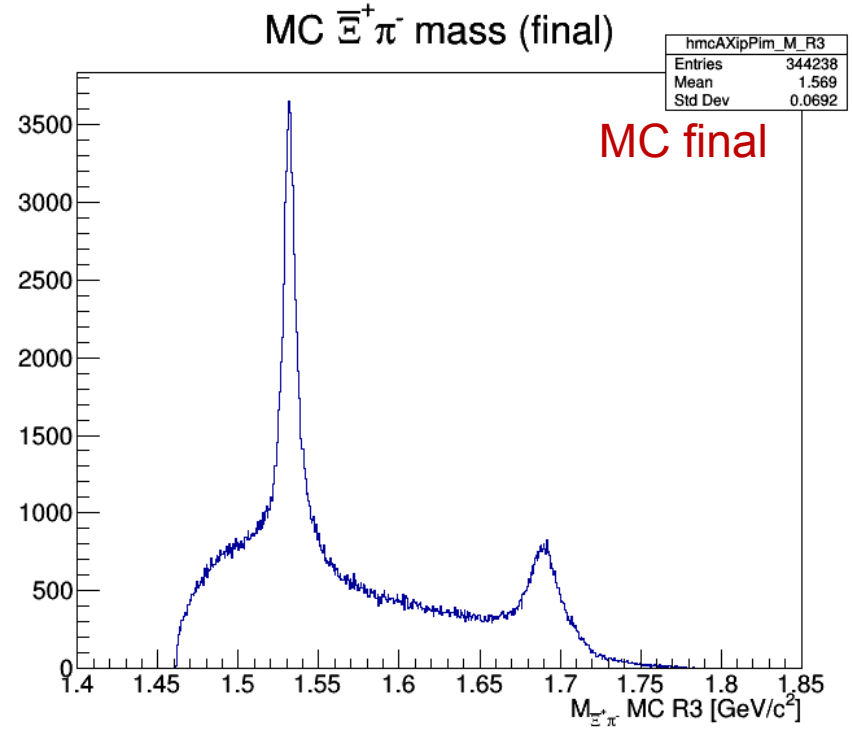


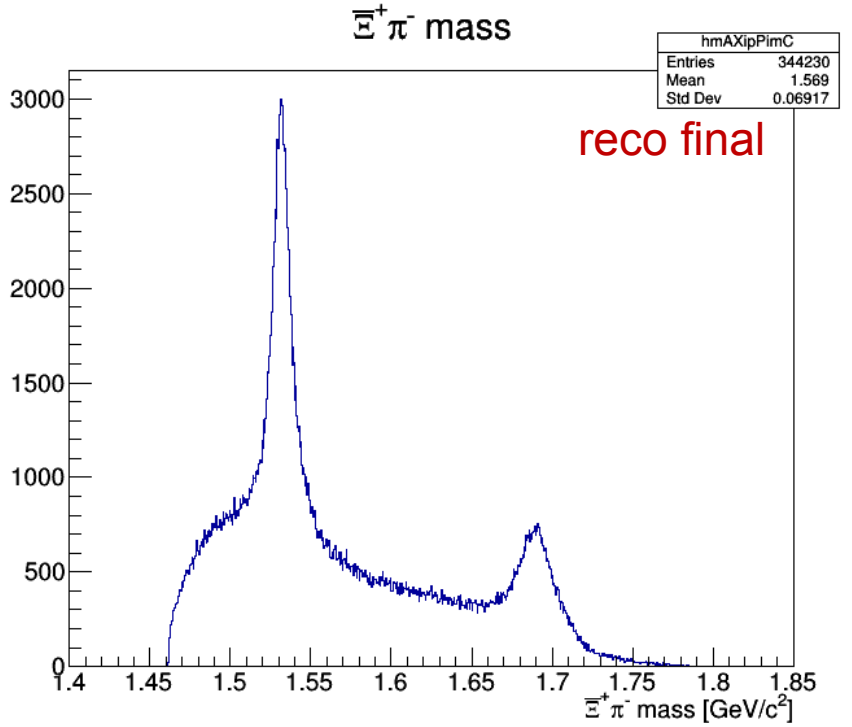


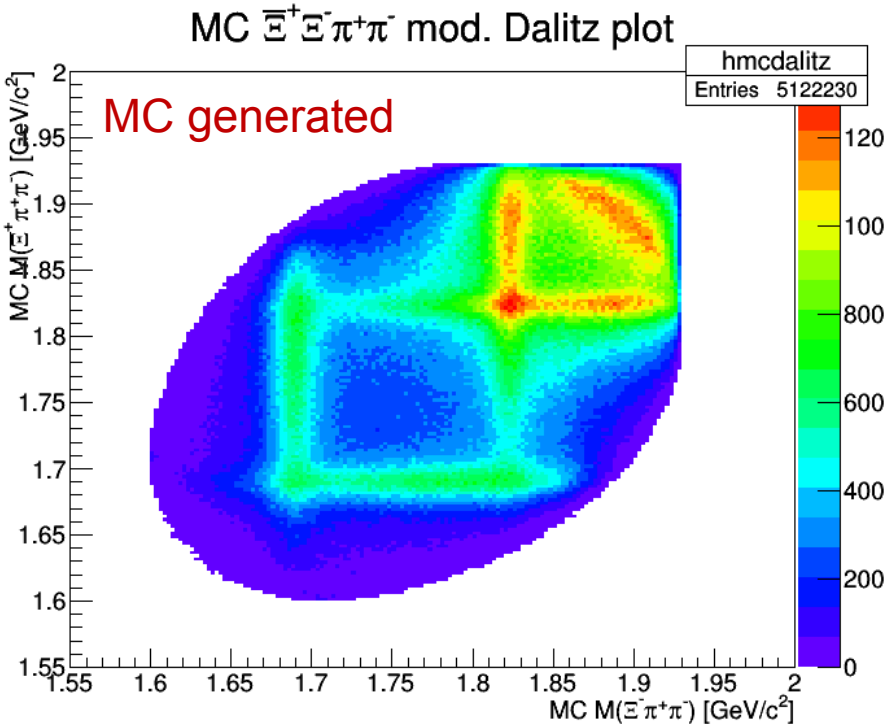
Projections:

$M(\bar{\Xi}^+\pi^-)$

shows $\Xi^* \rightarrow \Xi\pi$ decays



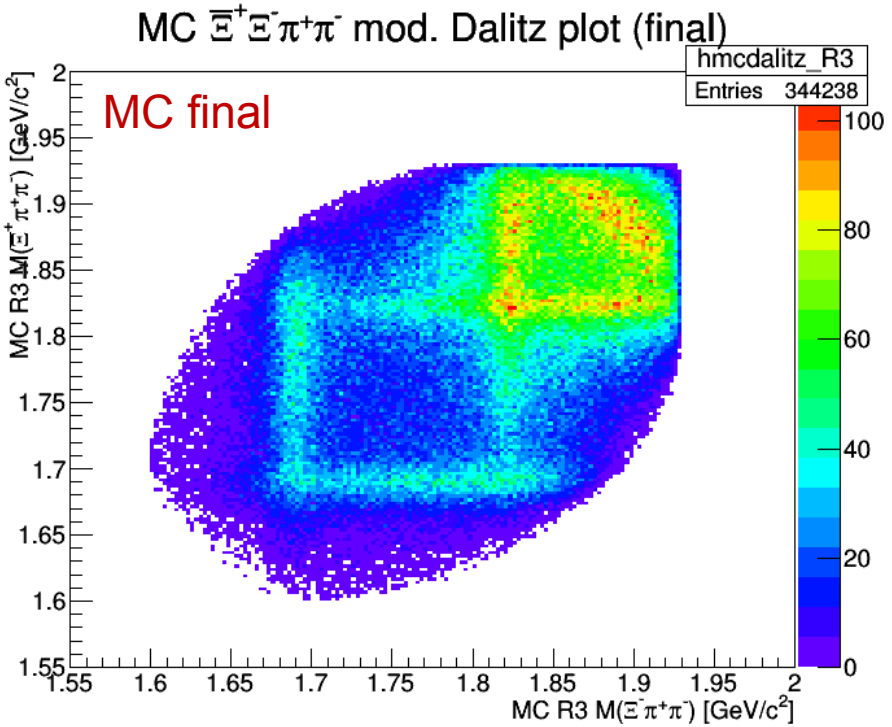


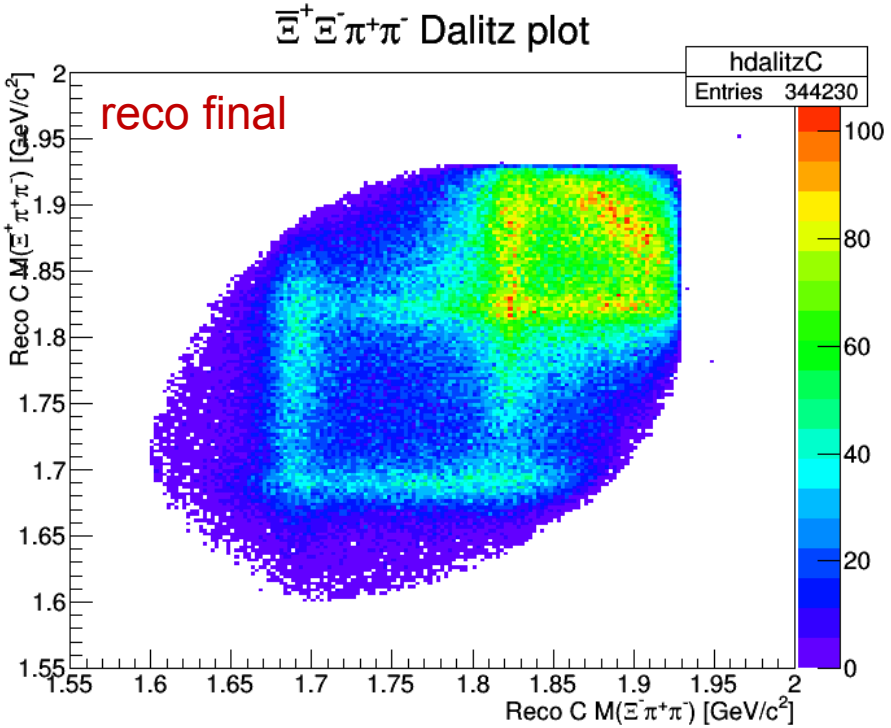


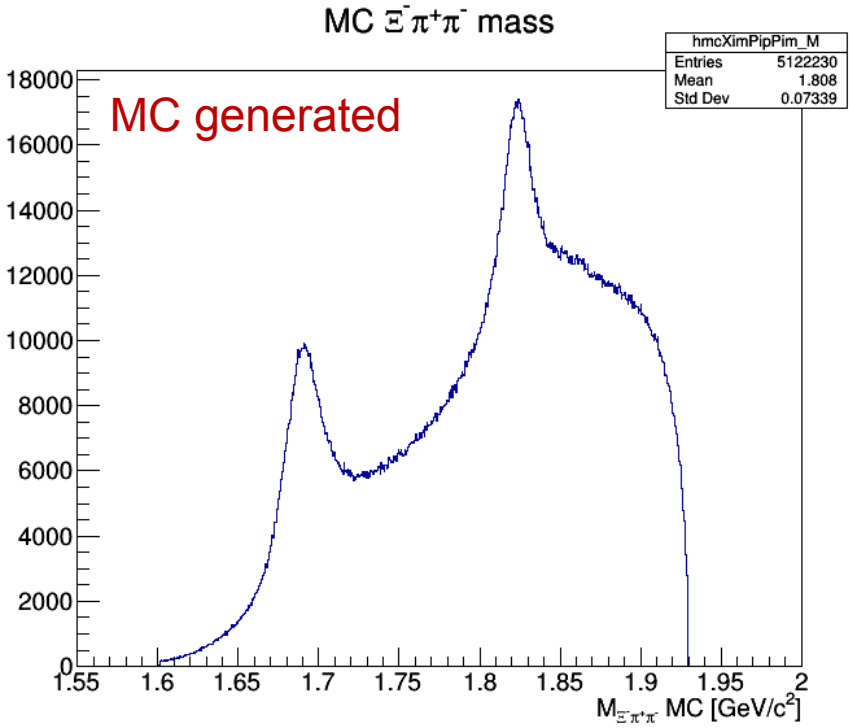
modified Dalitz Plot:

$M(\bar{\Xi}^+\pi^+\pi^-)$ vs $M(\Xi^-\pi^+\pi^-)$

shows $\Xi^* \to \Xi\pi\pi$ decays



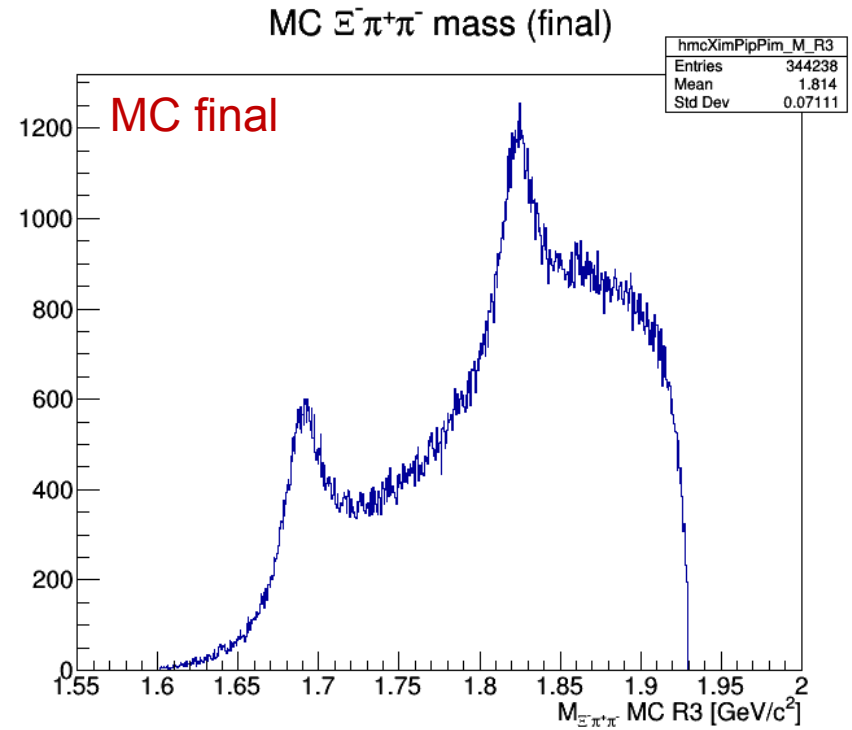


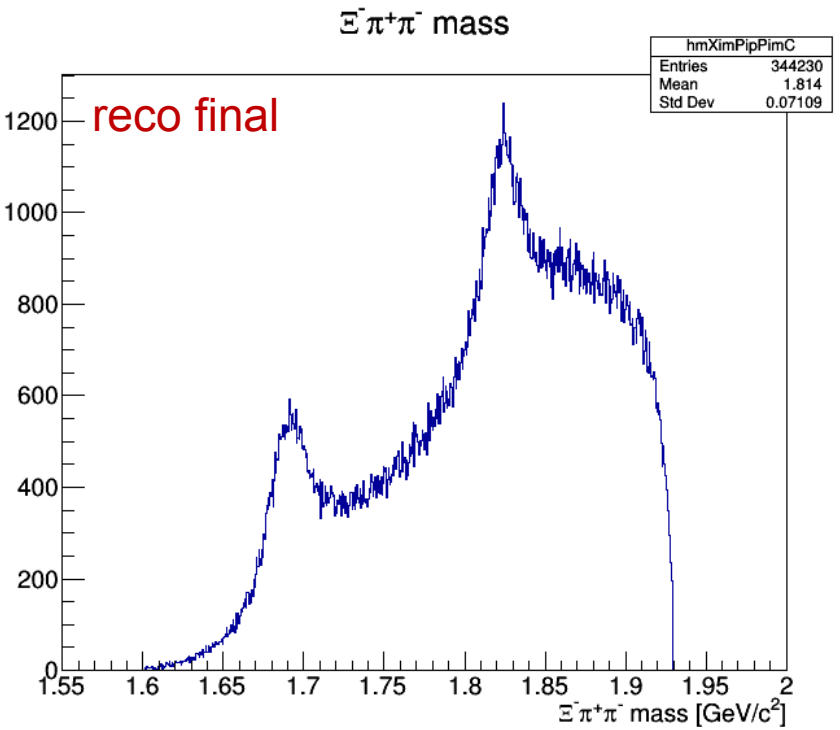


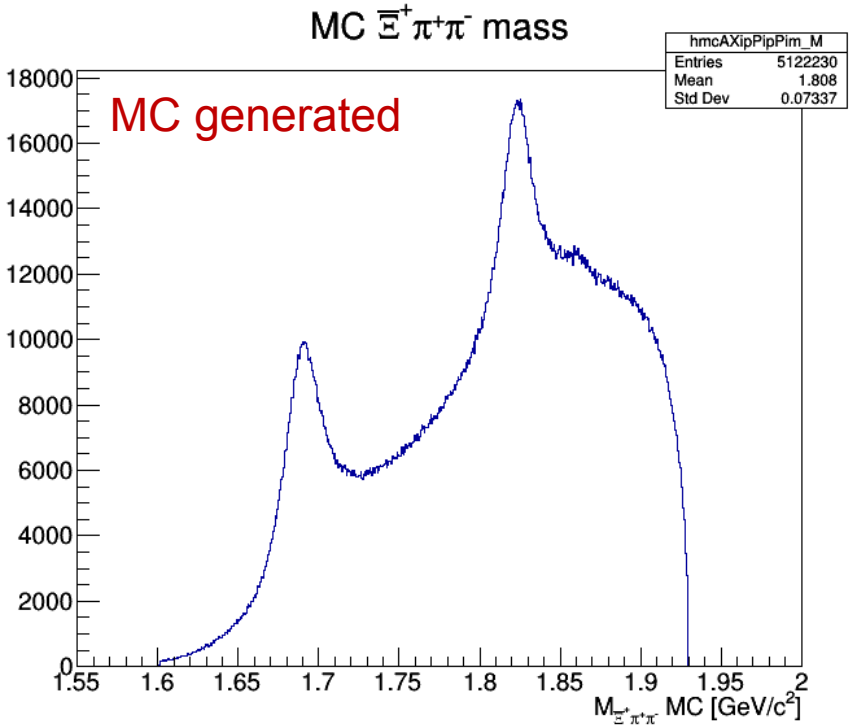
Projections:

$M(\Xi^-\pi^+\pi^-)$

shows $\Xi^* \rightarrow \Xi\pi\pi$ decays



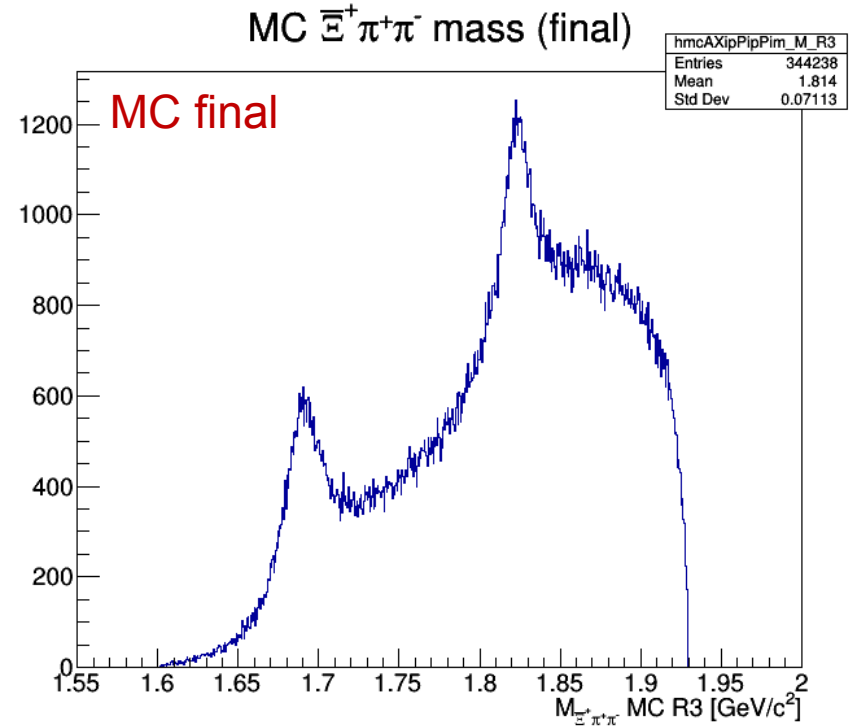


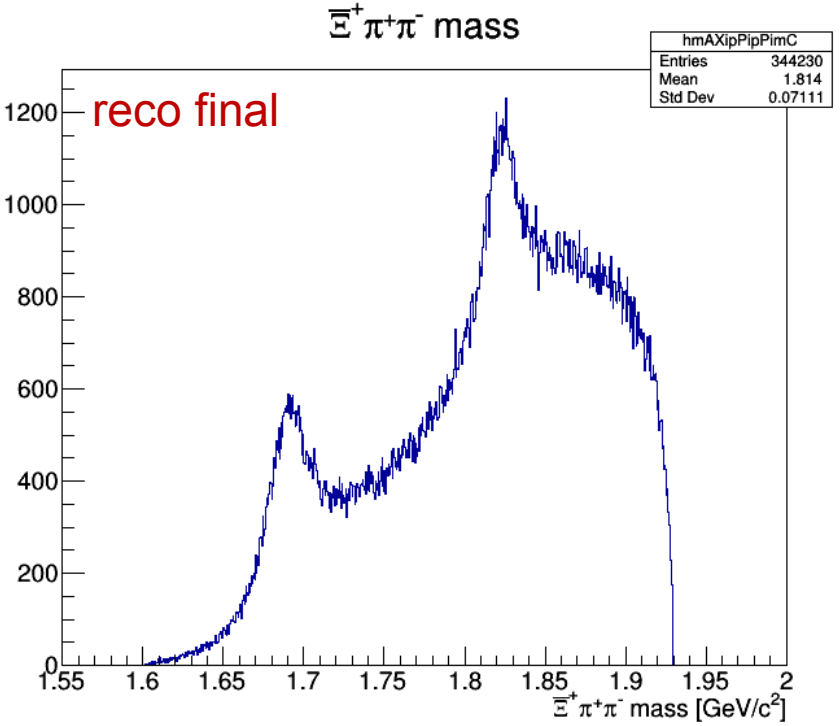


Projections:

$M(\bar{\Xi}^+\pi^+\pi^-)$

shows $\Xi^* \rightarrow \Xi\pi\pi$ decays





MC Signal Efficiencies

MC losses due to:

- interaction
- missing hits of daughter particles

Sample	# Events	n / n_{gen}	n / n_{sig}	
generated	5 585 000	1.000		
signal expected	5 572 385	0.998	1.000	
MC $\bar{\Xi}^+ \to \bar{\Lambda}\pi^+$	5 465 186	0.979		
MC $\Xi^- \to \Lambda\pi^-$	5 468 334	0.979		
MC $\bar{\Lambda} \to \bar{p}\pi^+$	5 374 421	0.962		
MC $\Lambda \to p\pi^-$	5 381 143	0.964		
MC Signal	5 177 950	0.927	0.929	
‚no-int.' flag	5 122 230		0.919	Id. PID
‚reco' tag (R1)	1 441 190		0.259	0.173
‚final' tag (R3)	344 230		0.0618	0.0548

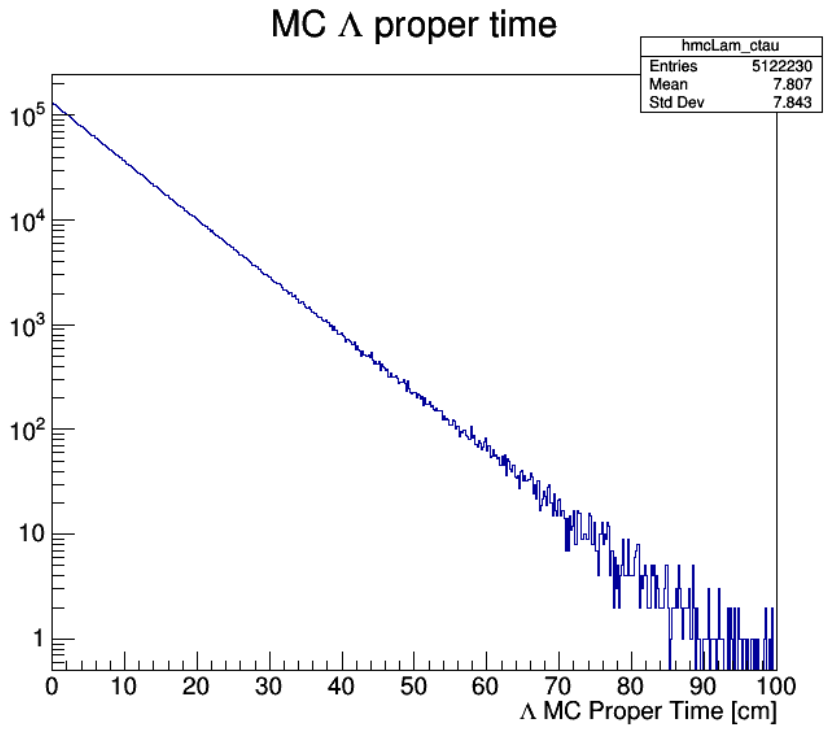
true reco / signal: 0.0585

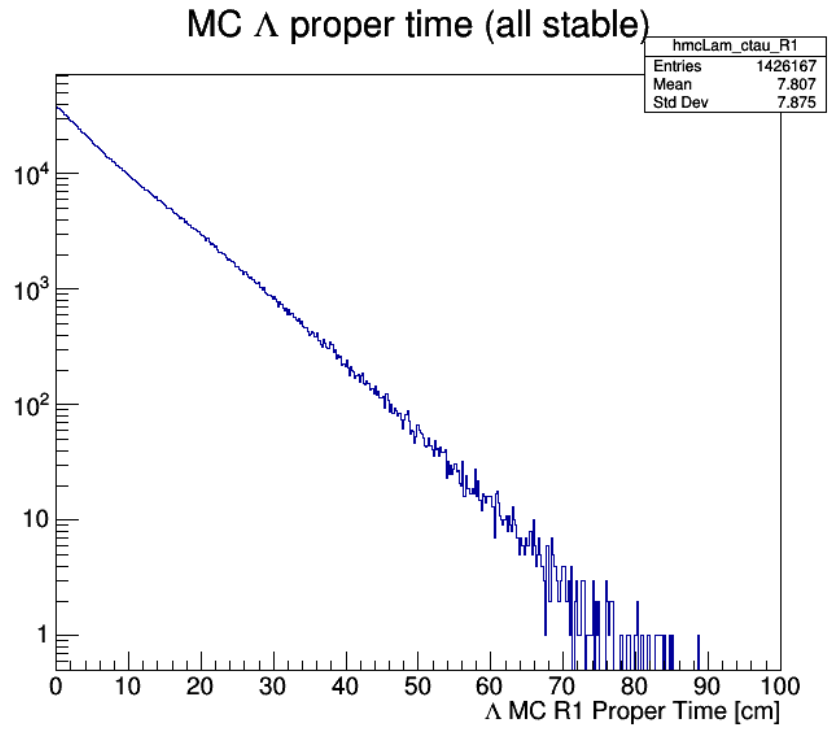
Single Particle Efficiencies & Purities

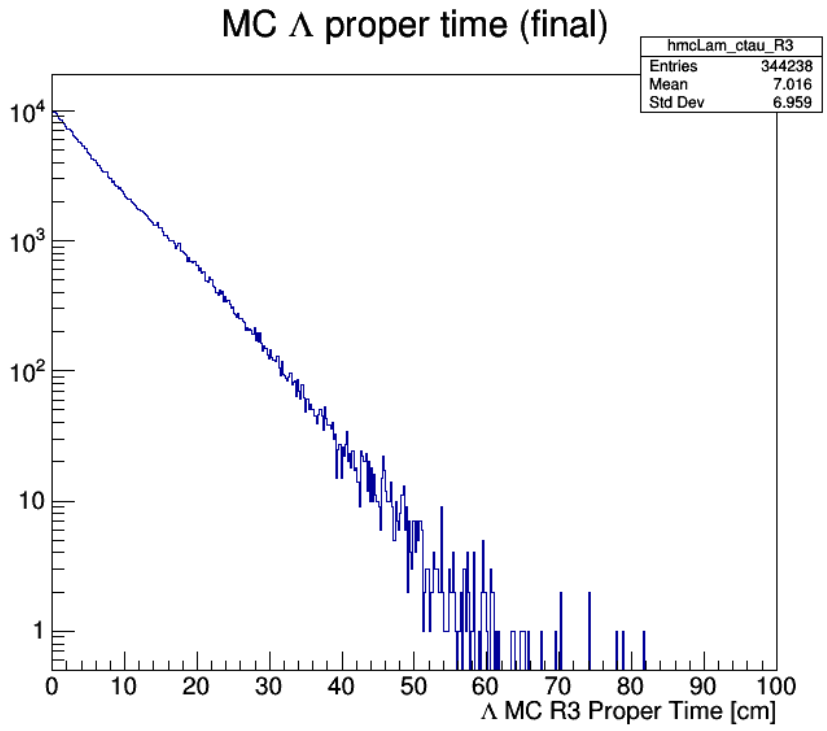
Particle	# Events	n / n_{sig}
p	4 727 542	0.848
$\bar{p}$	4 585 731	0.823
π_0^+	4 613 315	0.829
π_0^-	4 607 924	0.827
π_1^+	4 152 564	0.745
π_1^-	4 145 591	0.744
π_2^+	3 878 110	0.696
π_2^-	3 873 531	0.695

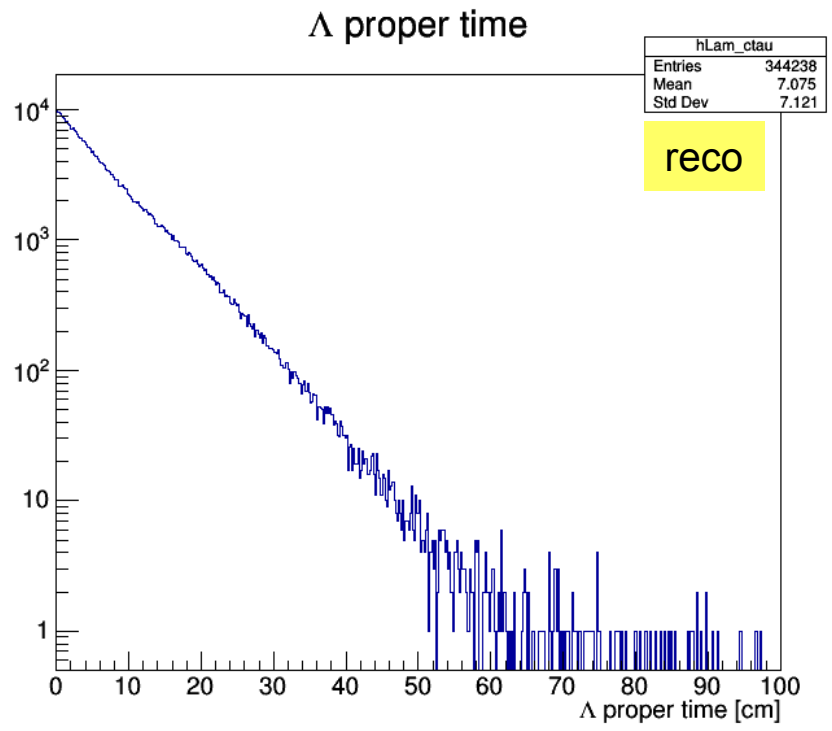
Particle	# Events	n_{true} / n_{rec}
π^+	342 214	0.994
π^-	342 244	0.994
$\bar{\Xi}^+$	335 862	0.976
Ξ^-	335 562	0.974
$\bar{\Lambda}$	340 012	0.988
Λ	339 803	0.987
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$	326 036	0.947

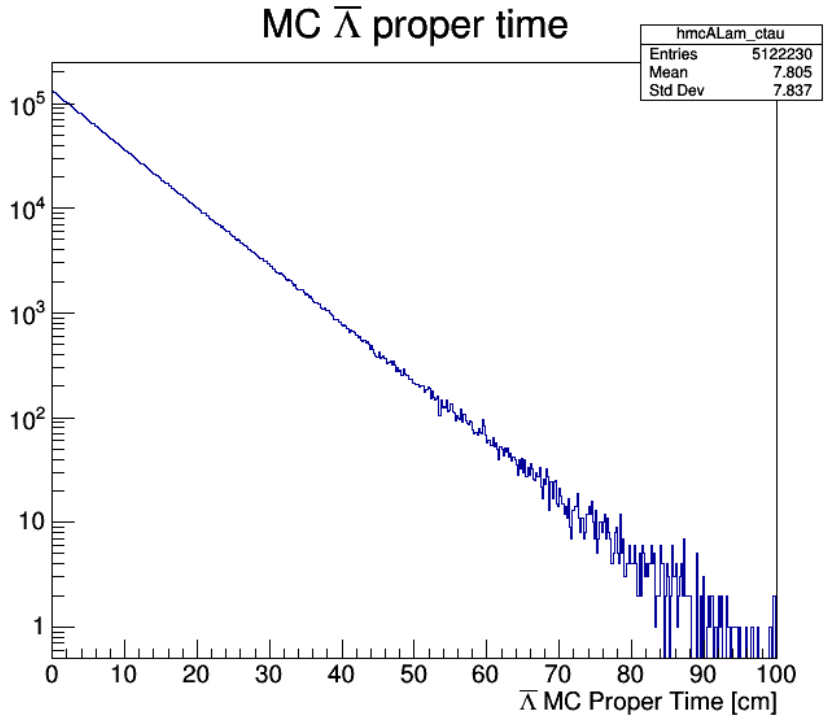
Ideal PID: 0.991

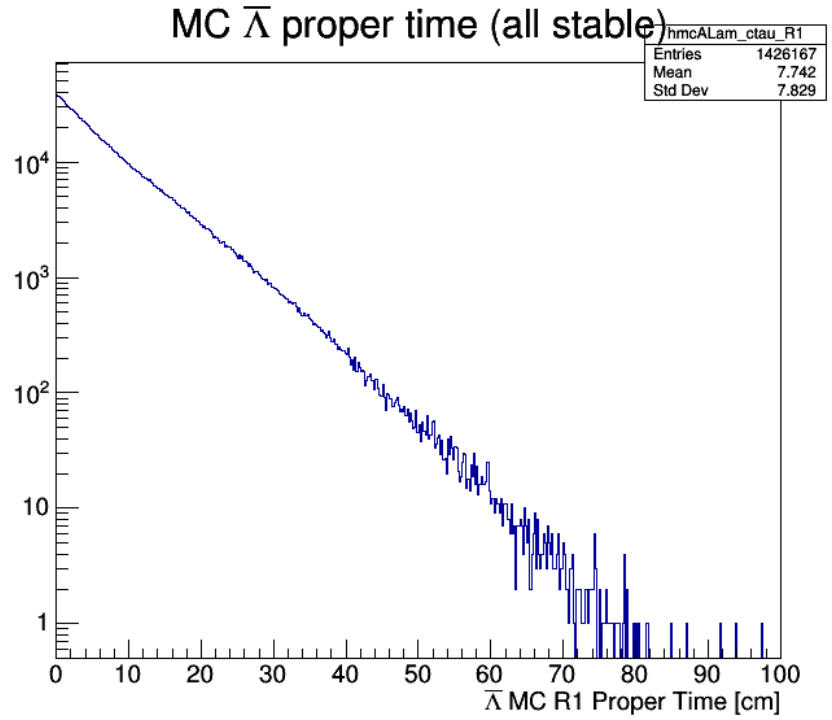

MC Λ proper time
hmcLam_ctau
Entries 5122230
Mean 7.807
Std Dev 7.843
Λ MC Proper Time [cm]

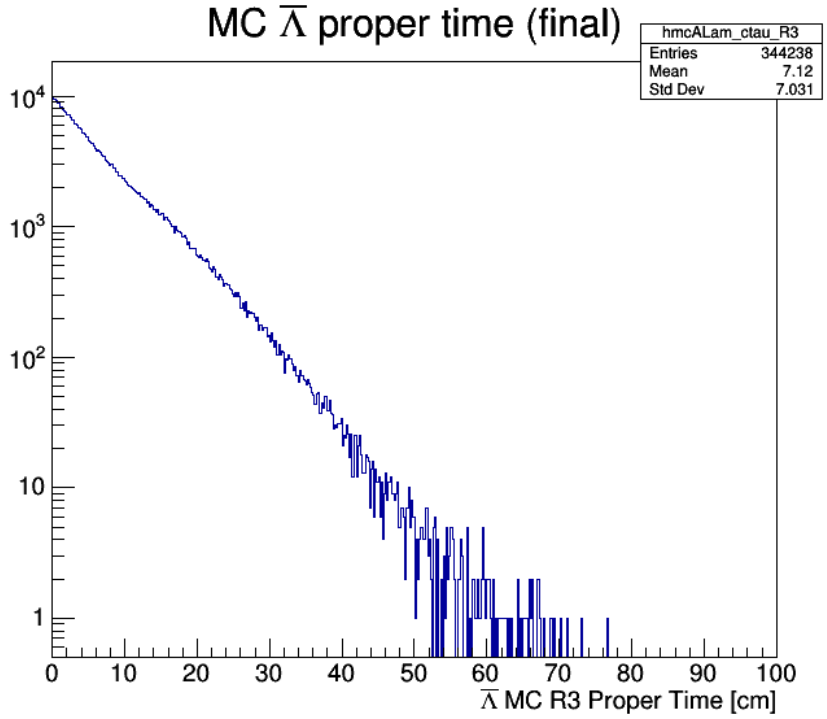

MC Λ proper time (all stable)
hmcLam_ctau_R1
Entries 1426167
Mean 7.807
Std Dev 7.875
Λ MC R1 Proper Time [cm]

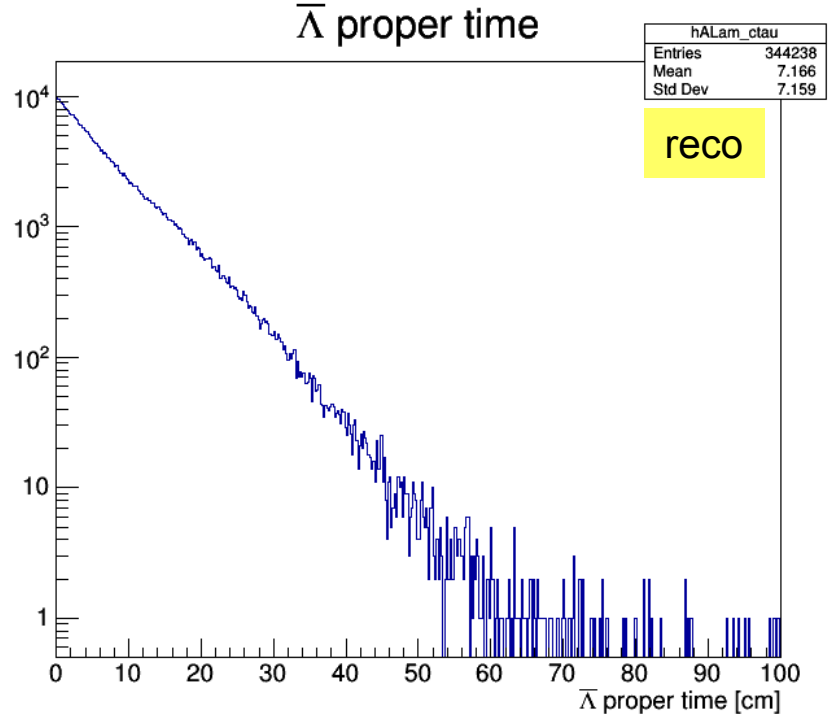

MC Λ proper time (final)
hmcLam_ctau_R3
Entries 344238
Mean 7.016
Std Dev 6.959
Λ MC R3 Proper Time [cm]

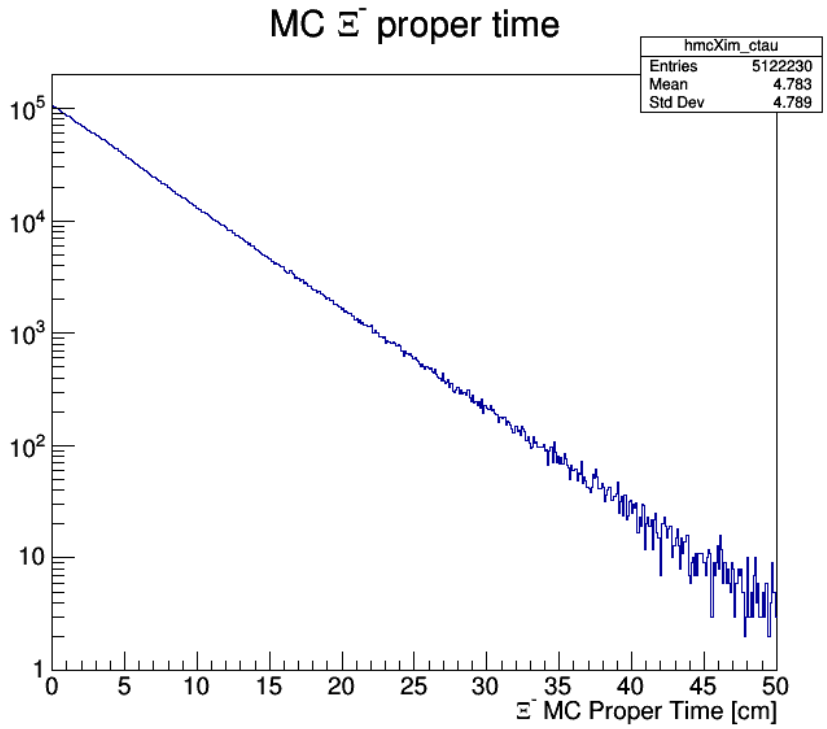

Λ proper time
hLam_ctau
Entries 344238
Mean 7.075
Std Dev 7.121
reco
Λ proper time [cm]

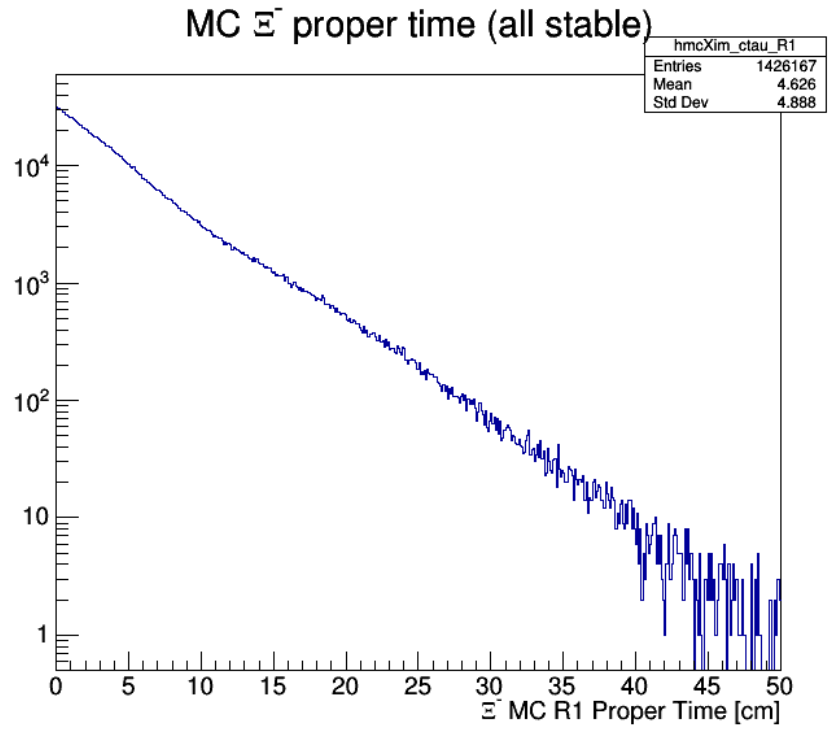

MC $\overline{\Lambda}$ proper time
hmcALam_ctau
Entries 5122230
Mean 7.805
Std Dev 7.837
$\overline{\Lambda}$ MC Proper Time [cm]

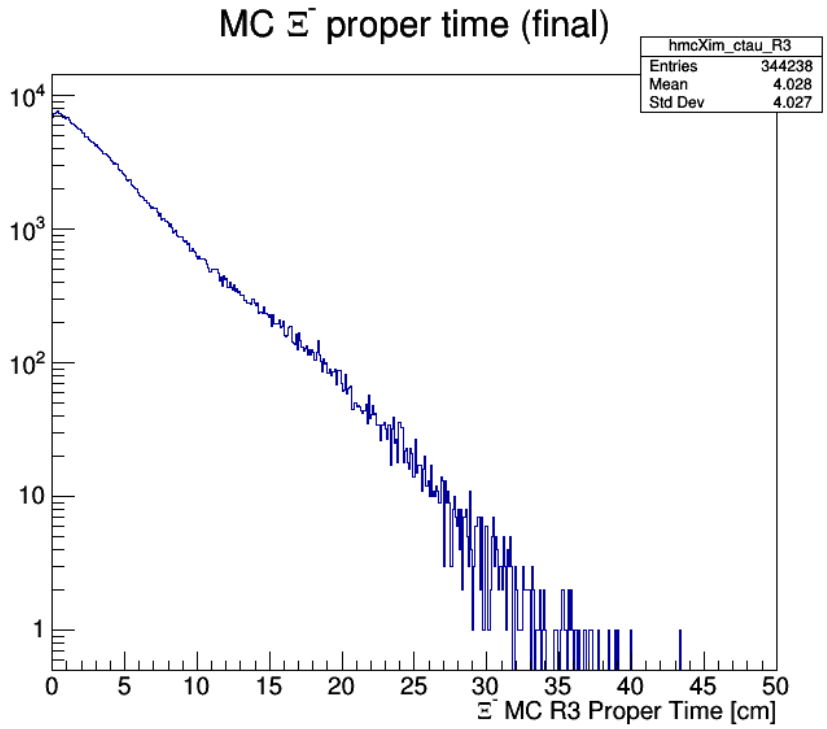

MC $\overline{\Lambda}$ proper time (all stable)
hmcALam_ctau_R1
Entries 1426167
Mean 7.742
Std Dev 7.829
$\overline{\Lambda}$ MC R1 Proper Time [cm]

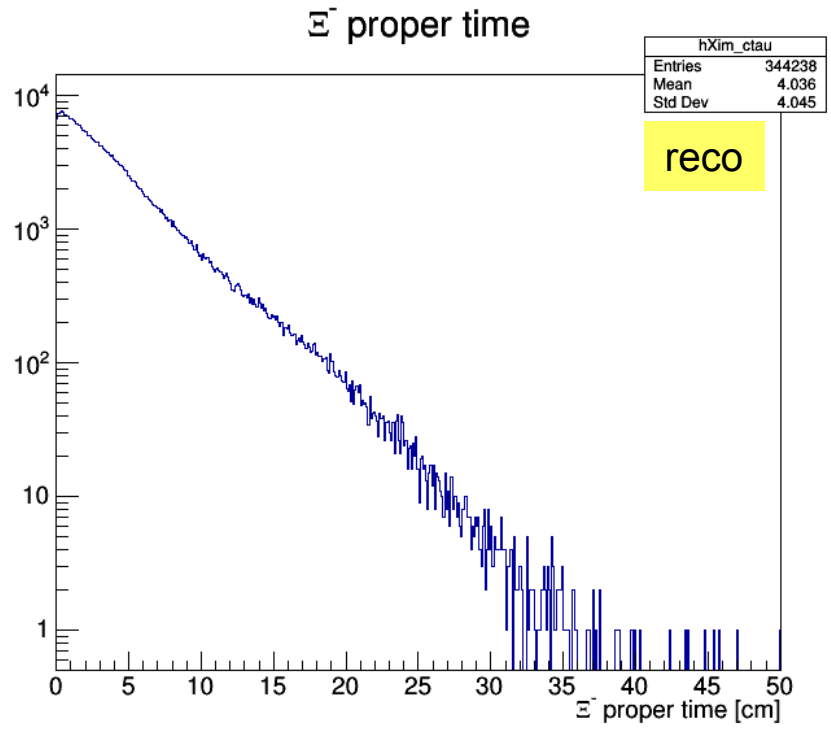

MC $\overline{\Lambda}$ proper time (final)
hmcALam_ctau_R3
Entries 344238
Mean 7.12
Std Dev 7.031
$\overline{\Lambda}$ MC R3 Proper Time [cm]

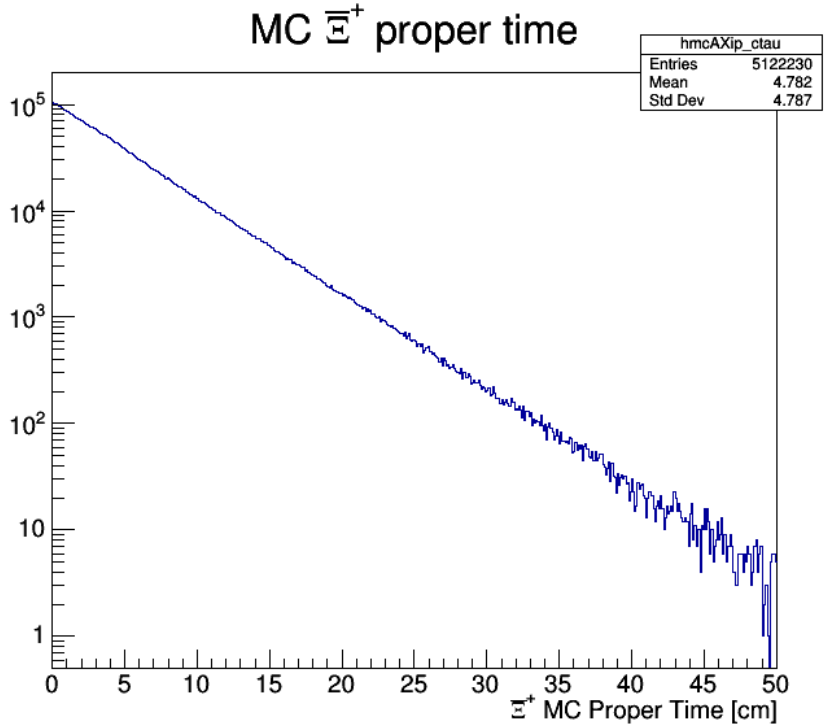

$\overline{\Lambda}$ proper time
hALam_ctau
Entries 344238
Mean 7.166
Std Dev 7.159
reco
$\overline{\Lambda}$ proper time [cm]

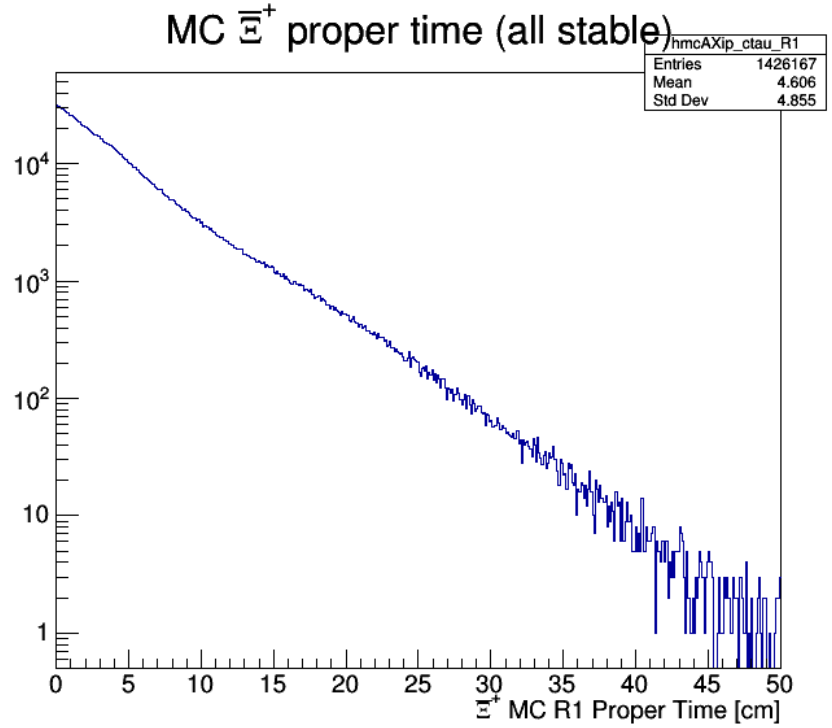

MC Ξ⁻ proper time
hmcXim_ctau
Entries 5122230
Mean 4.783
Std Dev 4.789
Ξ⁻ MC Proper Time [cm]

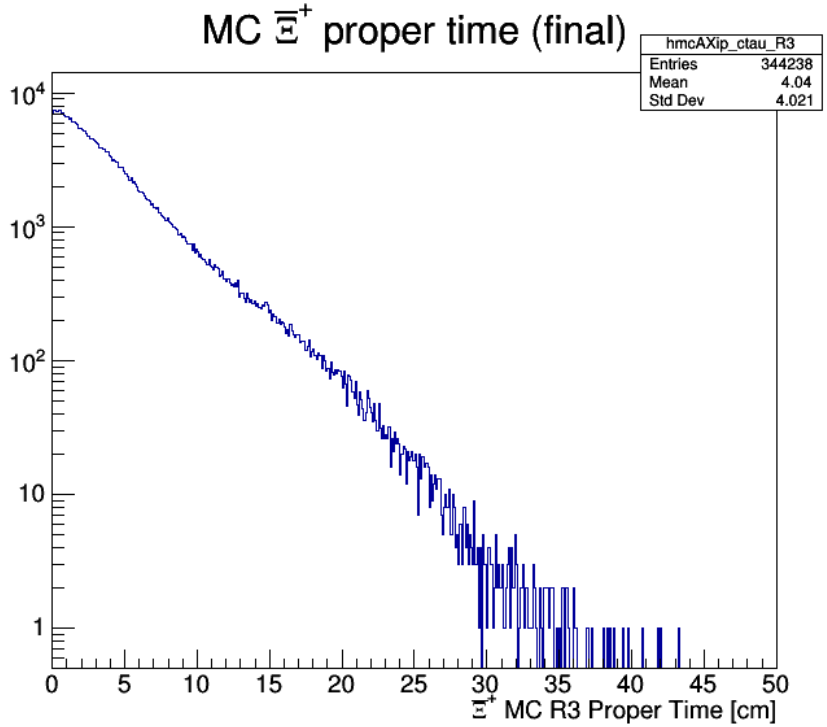

MC Ξ⁻ proper time (all stable)
hmcXim_ctau_R1
Entries 1426167
Mean 4.626
Std Dev 4.888
Ξ⁻ MC R1 Proper Time [cm]

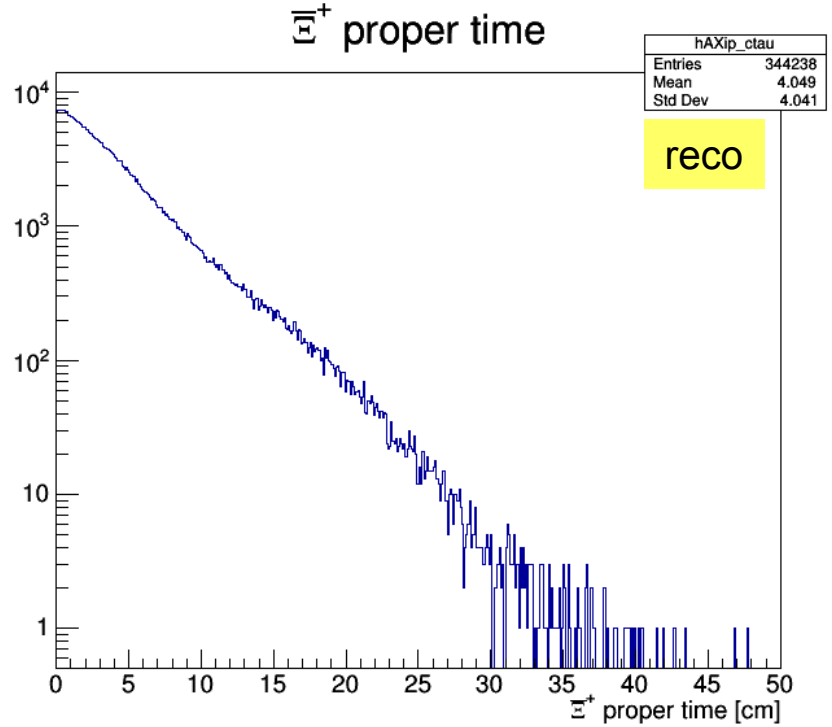

MC Ξ⁻ proper time (final)
hmcXim_ctau_R3
Entries 344238
Mean 4.028
Std Dev 4.027
Ξ⁻ MC R3 Proper Time [cm]

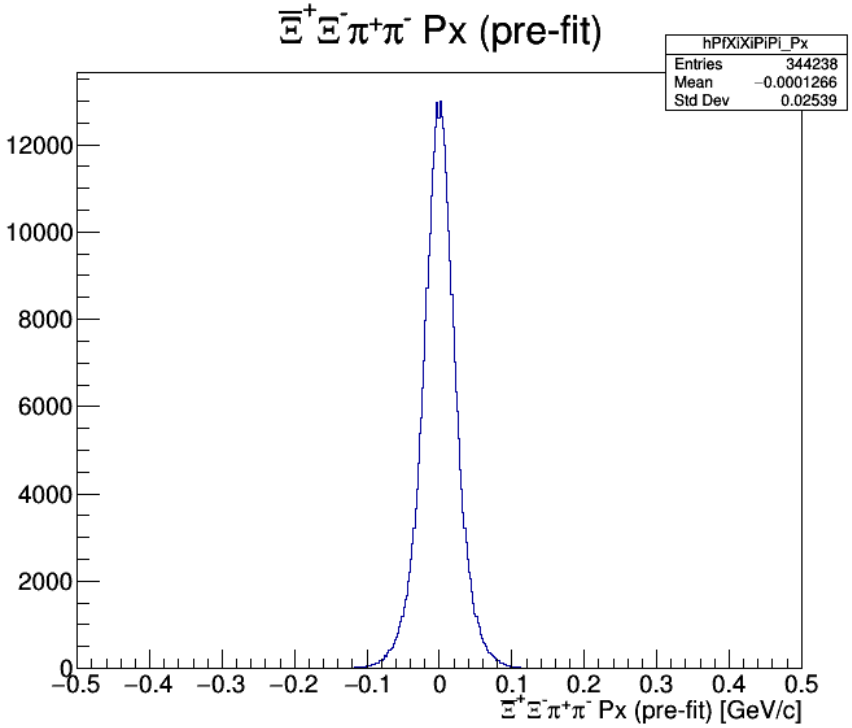

Ξ⁻ proper time
hXim_ctau
Entries 344238
Mean 4.036
Std Dev 4.045
reco
Ξ⁻ proper time [cm]

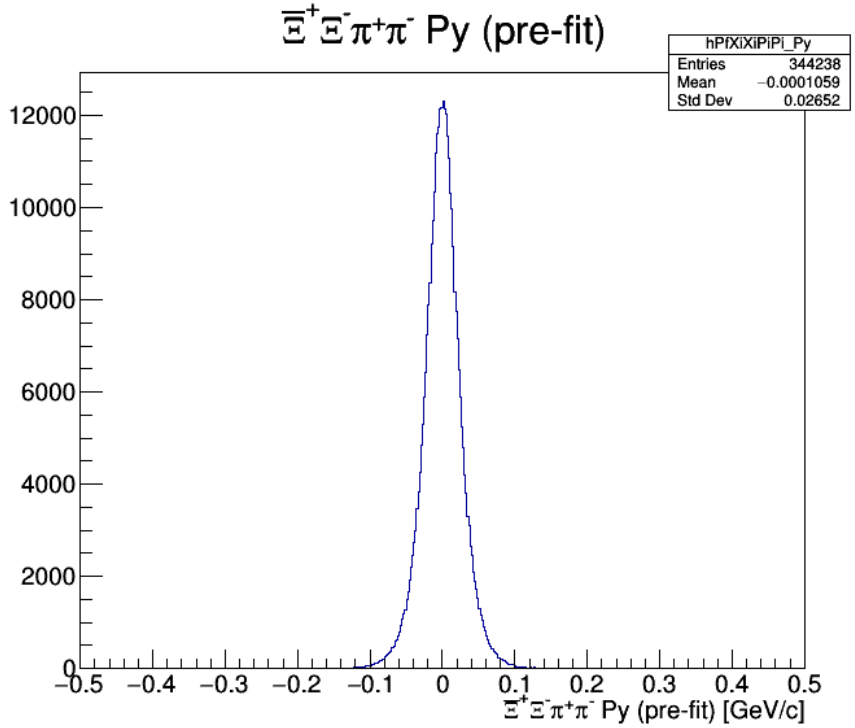

MC $\bar{\Xi}^+$ proper time
hmcAXip_ctau
Entries 5122230
Mean 4.782
Std Dev 4.787
Ξ^+ MC Proper Time [cm]

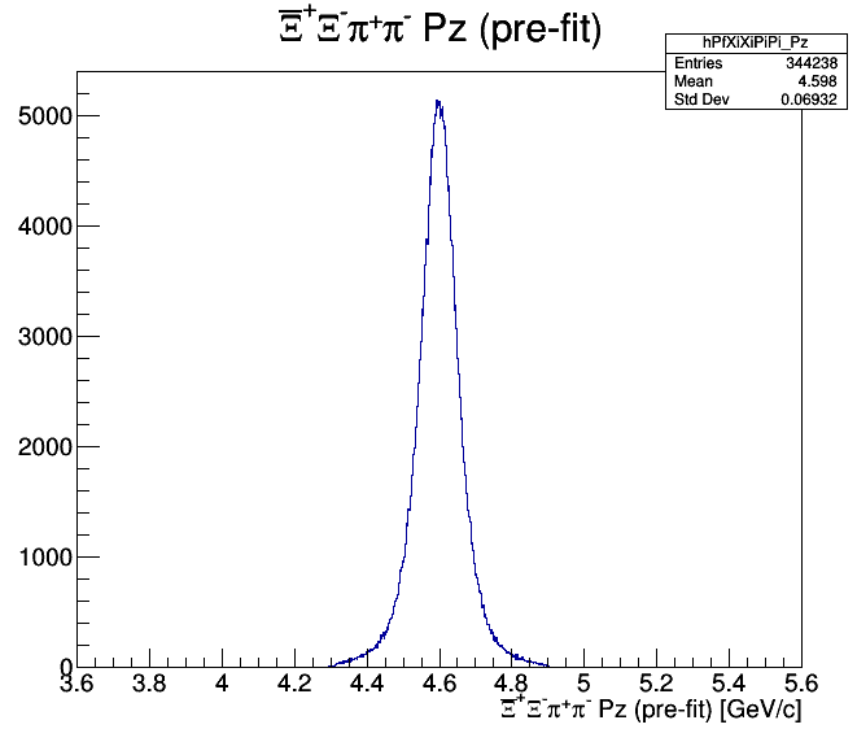

MC $\bar{\Xi}^+$ proper time (all stable)
/hmcAXip_ctau_R1
Entries 1426167
Mean 4.606
Std Dev 4.855
Ξ^+ MC R1 Proper Time [cm]

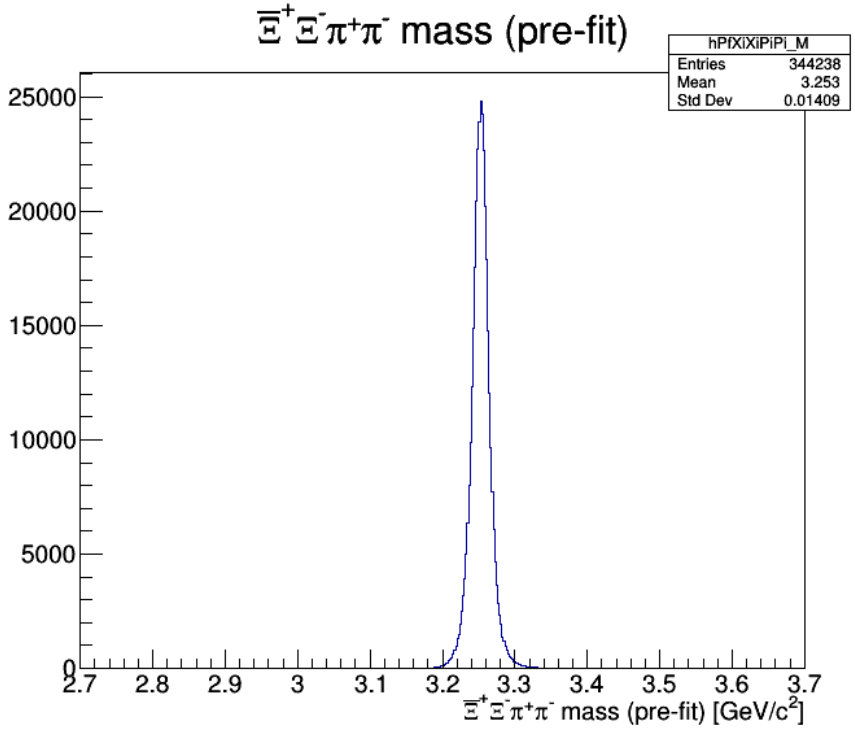

MC $\bar{\Xi}^+$ proper time (final)
hmcAXip_ctau_R3
Entries 344238
Mean 4.04
Std Dev 4.021
Ξ^+ MC R3 Proper Time [cm]

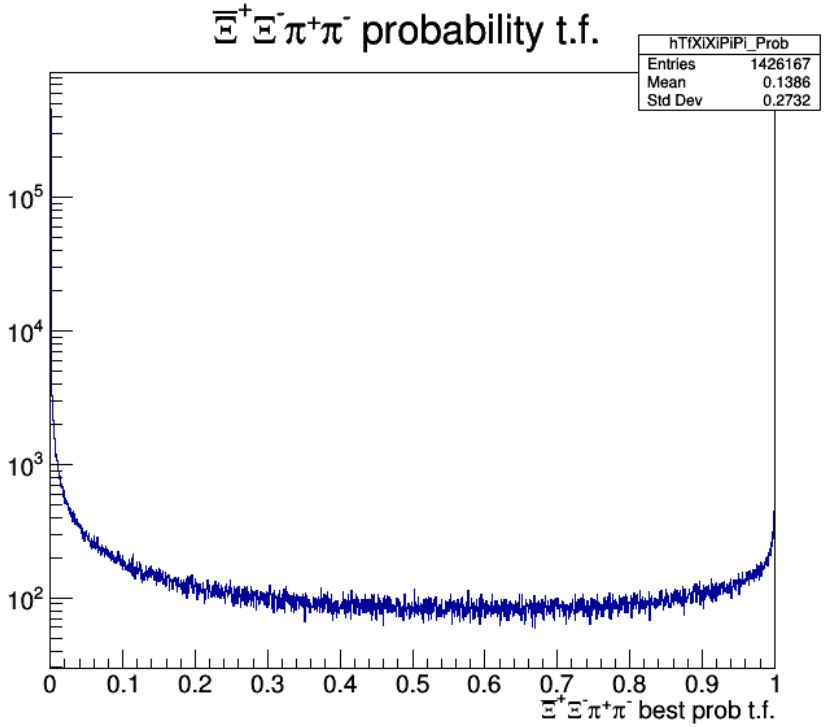

$\bar{\Xi}^+$ proper time
hAXip_ctau
Entries 344238
Mean 4.049
Std Dev 4.041
reco
Ξ^+ proper time [cm]

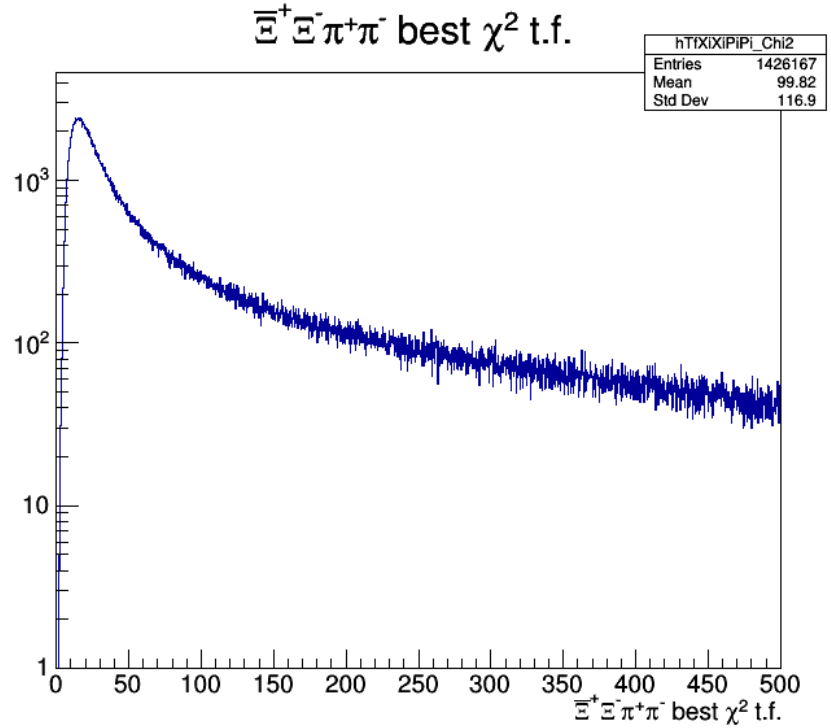

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ Px (pre-fit)
hPfXiXiPiPi_Px
Entries 344238
Mean −0.0001266
Std Dev 0.02539
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ Px (pre-fit) [GeV/c]

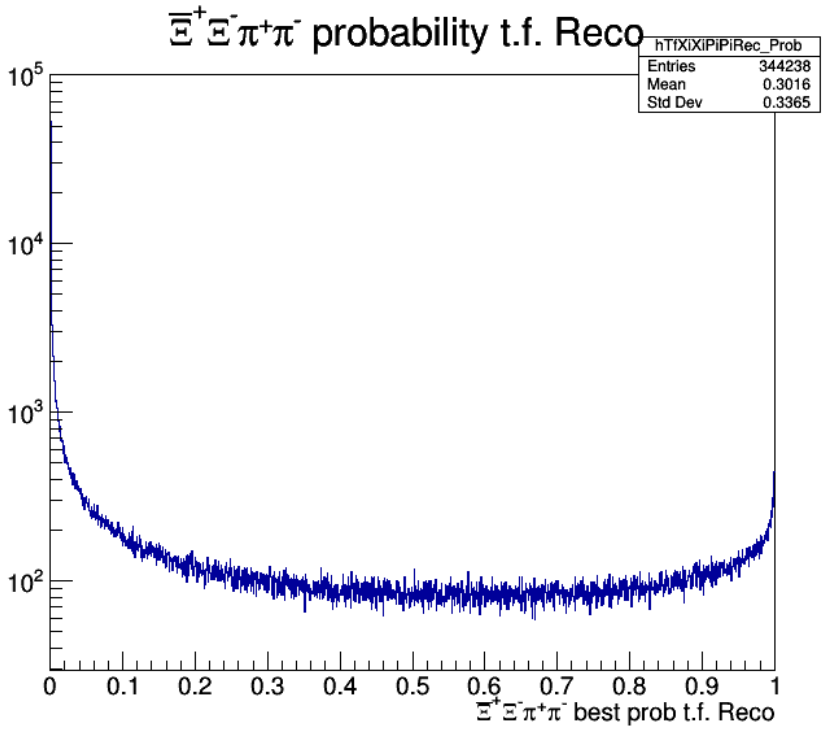

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ Py (pre-fit)
hPfXiXiPiPi_Py
Entries 344238
Mean −0.0001059
Std Dev 0.02652
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ Py (pre-fit) [GeV/c]

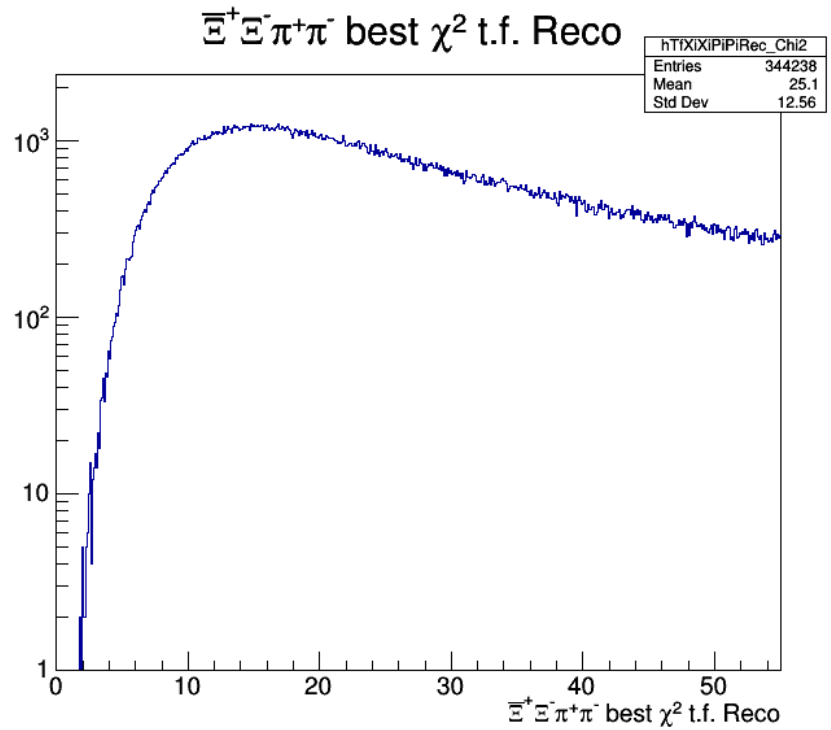

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ Pz (pre-fit)
hPfXiXiPiPi_Pz
Entries 344238
Mean 4.598
Std Dev 0.06932
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ Pz (pre-fit) [GeV/c]

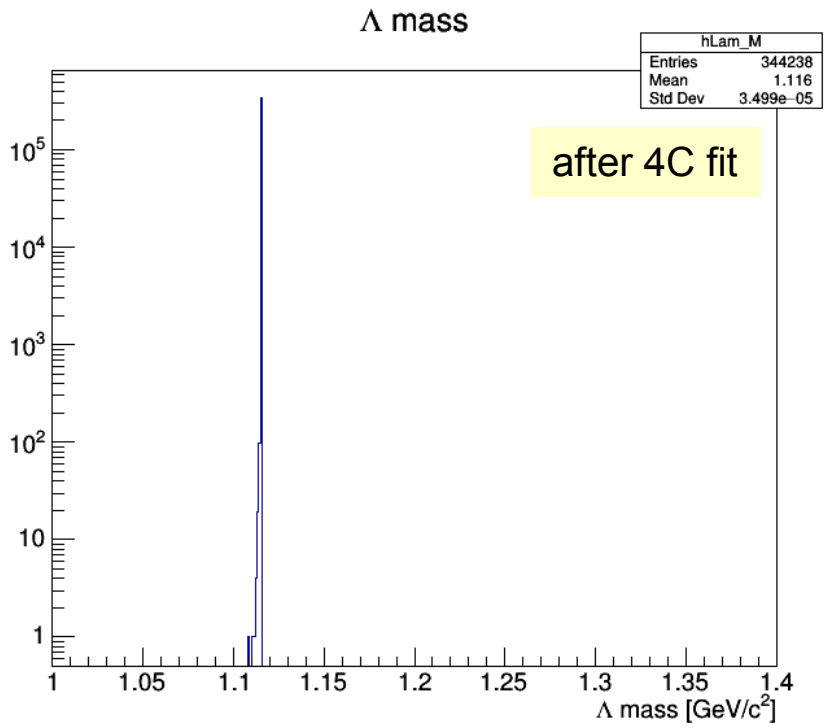

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ mass (pre-fit)
hPfXiXiPiPi_M
Entries 344238
Mean 3.253
Std Dev 0.01409
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ mass (pre-fit) [GeV/c^2]

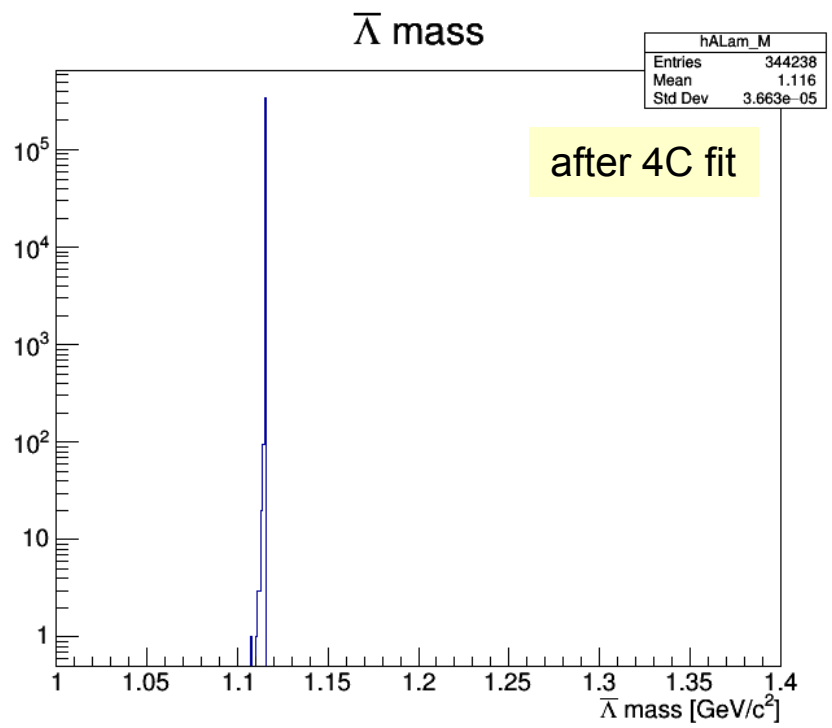

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ probability t.f.
hTfXiXiPiPi_Prob
Entries 1426167
Mean 0.1386
Std Dev 0.2732
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ best prob t.f.

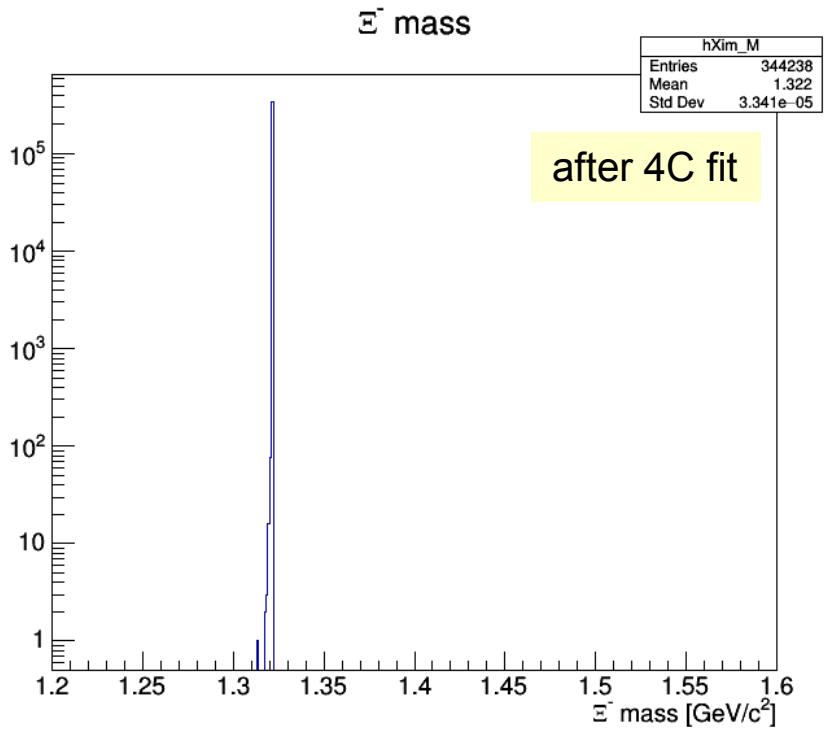

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ best χ^2 t.f.
hTfXiXiPiPi_Chi2
Entries 1426167
Mean 99.82
Std Dev 116.9
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ best χ^2 t.f.

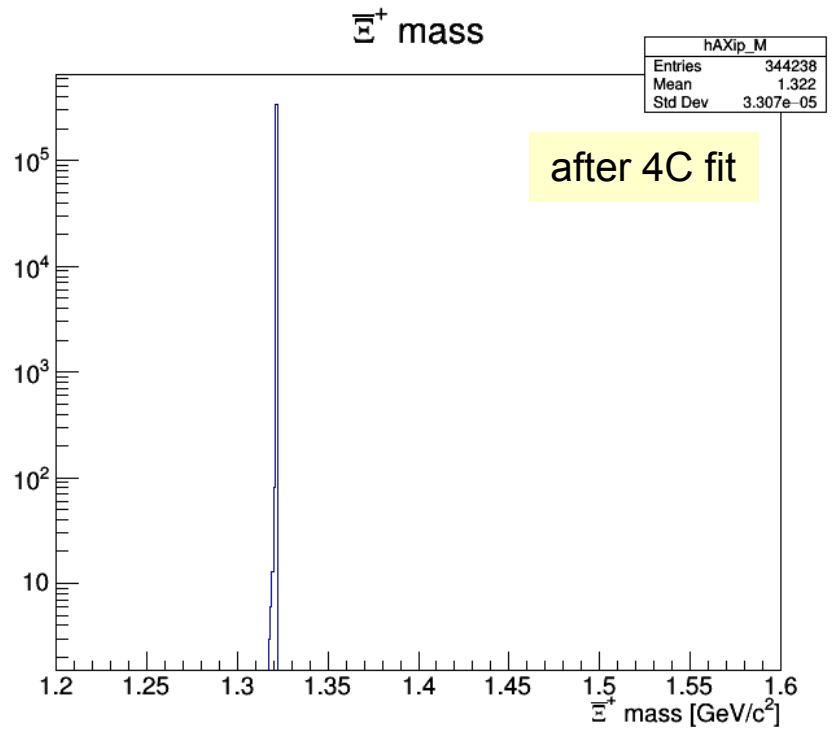

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ probability t.f. Reco
hTfXiXiPiPiRec_Prob
Entries 344238
Mean 0.3016
Std Dev 0.3365
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ best prob t.f. Reco

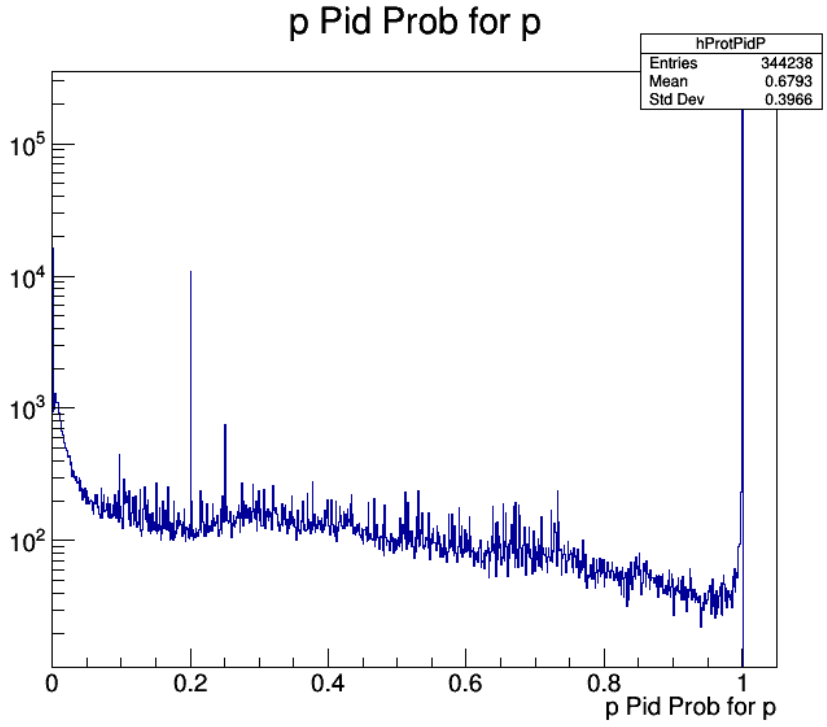

$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ best χ^2 t.f. Reco
hTfXiXiPiPiRec_Chi2
Entries 344238
Mean 25.1
Std Dev 12.56
$\bar{\Xi}^+\Xi^-\pi^+\pi^-$ best χ^2 t.f. Reco

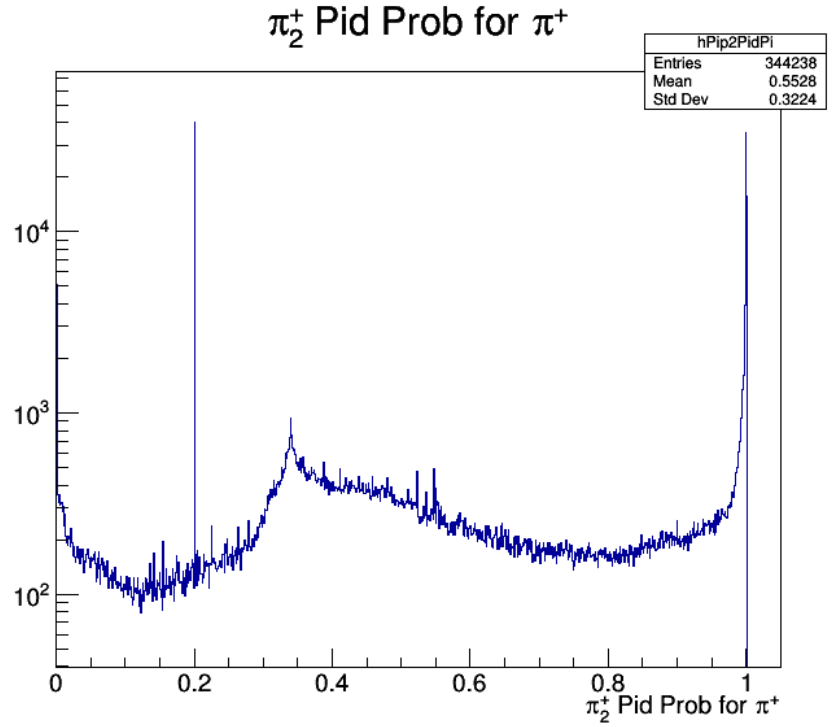

Λ mass
hLam_M
Entries 344238
Mean 1.116
Std Dev 3.499e−05
after 4C fit
Λ mass [GeV/c²]

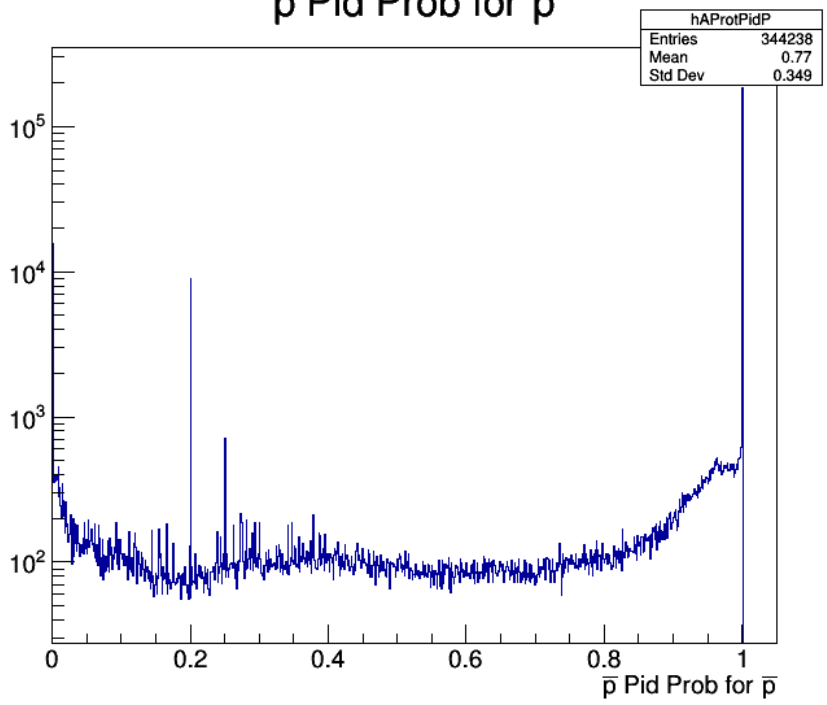

$\overline{\Lambda}$ mass
hALam_M
Entries 344238
Mean 1.116
Std Dev 3.663e−05
after 4C fit
$\overline{\Lambda}$ mass [GeV/c²]

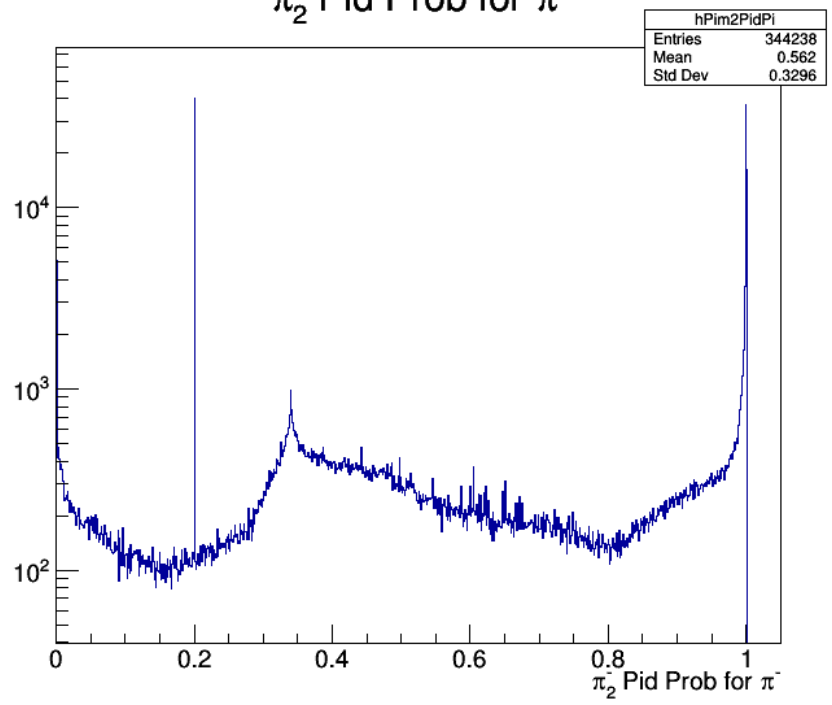

Ξ⁻ mass
hXim_M
Entries 344238
Mean 1.322
Std Dev 3.341e−05
after 4C fit
Ξ⁻ mass [GeV/c²]

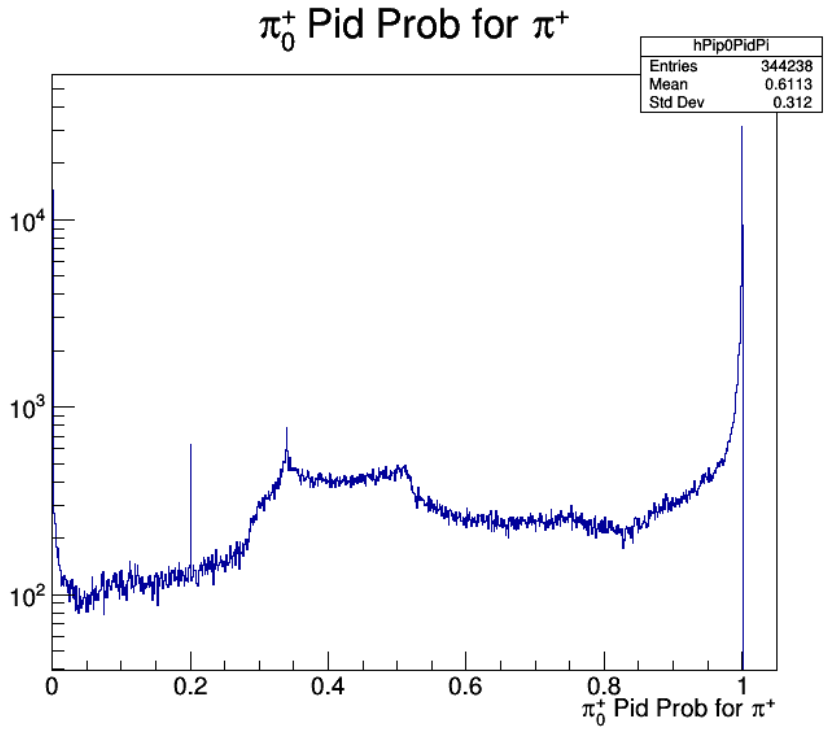

$\overline{\Xi}^{+}$ mass
hAXip_M
Entries 344238
Mean 1.322
Std Dev 3.307e−05
after 4C fit
$\overline{\Xi}^{+}$ mass [GeV/c²]

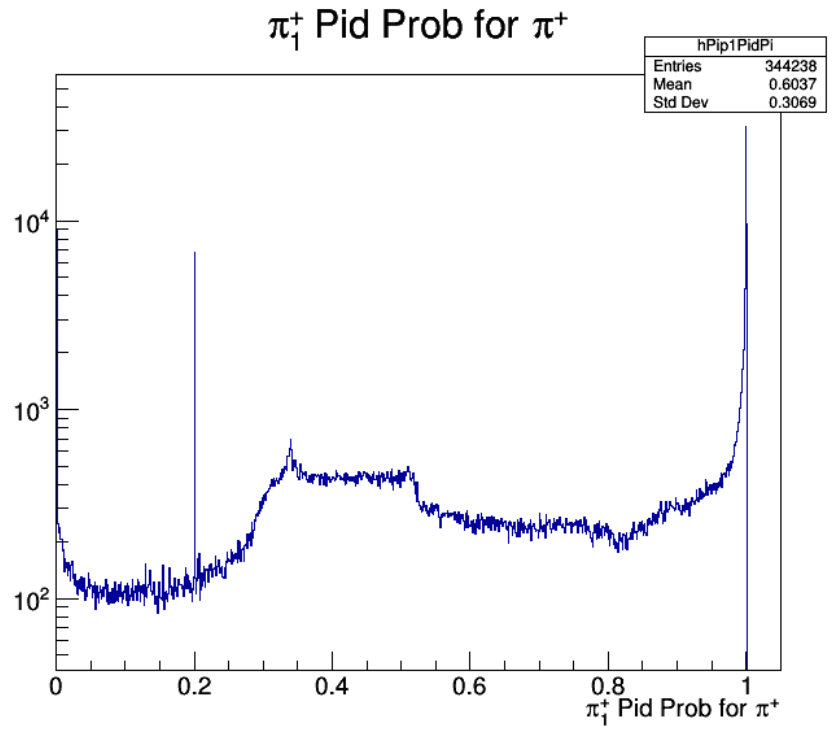

p Pid Prob for p
hProtPidP
Entries 344238
Mean 0.6793
Std Dev 0.3966
p Pid Prob for p

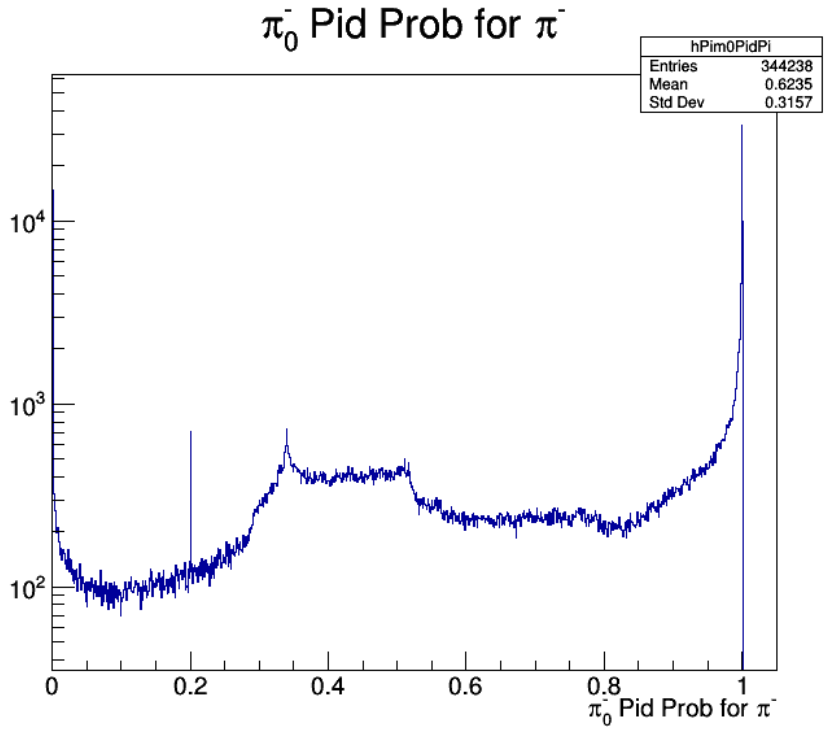

π_2^+ Pid Prob for π^+
hPip2PidPi
Entries 344238
Mean 0.5528
Std Dev 0.3224
π_2^+ Pid Prob for π^+

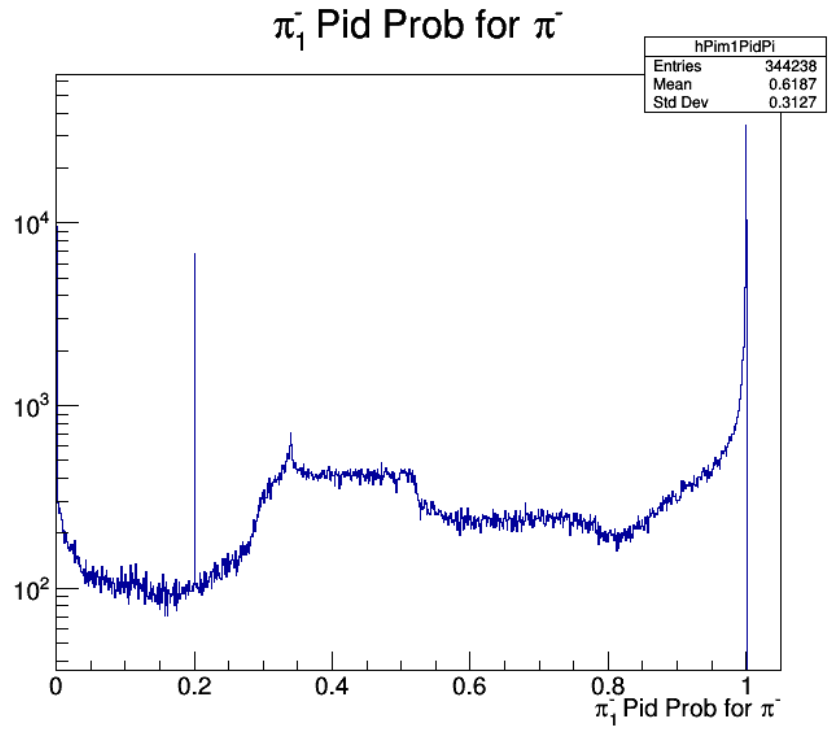

$\bar{p}$ Pid Prob for $\bar{p}$
hAProtPidP
Entries 344238
Mean 0.77
Std Dev 0.349
$\bar{p}$ Pid Prob for $\bar{p}$


π_2^- Pid Prob for π^-
hPim2PidPi
Entries 344238
Mean 0.562
Std Dev 0.3296
π_2^- Pid Prob for π^-


π_0^+ Pid Prob for π^+
hPip0PidPi
Entries 344238
Mean 0.6113
Std Dev 0.312
10^4
10^3
10^2
0
0.2
0.4
0.6
0.8
1
π_0^+ Pid Prob for π^+


π_1^+ Pid Prob for π^+
hPip1PidPi
Entries 344238
Mean 0.6037
Std Dev 0.3069
10^4
10^3
10^2
0
0.2
0.4
0.6
0.8
1
π_1^+ Pid Prob for π^+


π_0^- Pid Prob for π^-
hPim0PidPi
Entries 344238
Mean 0.6235
Std Dev 0.3157
10^4
10^3
10^2
0
0.2
0.4
0.6
0.8
1
π_0^- Pid Prob for π^-


π_1^- Pid Prob for π^-
hPim1PidPi
Entries 344238
Mean 0.6187
Std Dev 0.3127
10^4
10^3
10^2
0
0.2
0.4
0.6
0.8
1
π_1^- Pid Prob for π^-

Conclusion & Outlook

- $\bar{p}p \to \bar{\Xi}^{+}\Xi^{-}\pi^{0}$ and $\bar{p}p \to \bar{\Xi}^{+}\Xi^{-}\pi^{+}\pi^{-}$ now with treefitter & open PID
- $\bar{\Xi}^{+}\Xi^{-}\pi^{0}$: 3.8% reco efficiency, 93.5% purity
- $\bar{\Xi}^{+}\Xi^{-}\pi^{+}\pi^{-}$: 5.9% reco efficiency, 94.7% purity
- issues: neutral candidate mass constraint, PID
- to do: S/B with hadronic background (DPM / **FTF**), up-to-date PandaRoot version