JÜLICH
FORSCHUNGSZENTRUM

Hyperon Spectroscopy
Status Report

Mar 8, 2017 | Albrecht Gillitzer, IKP Forschungszentrum Jülich

PANDA Collaboration Meeting 17/1, GSI Darmstadt, March 6-10, 2017

Items

I. Requirements to FTS detectors

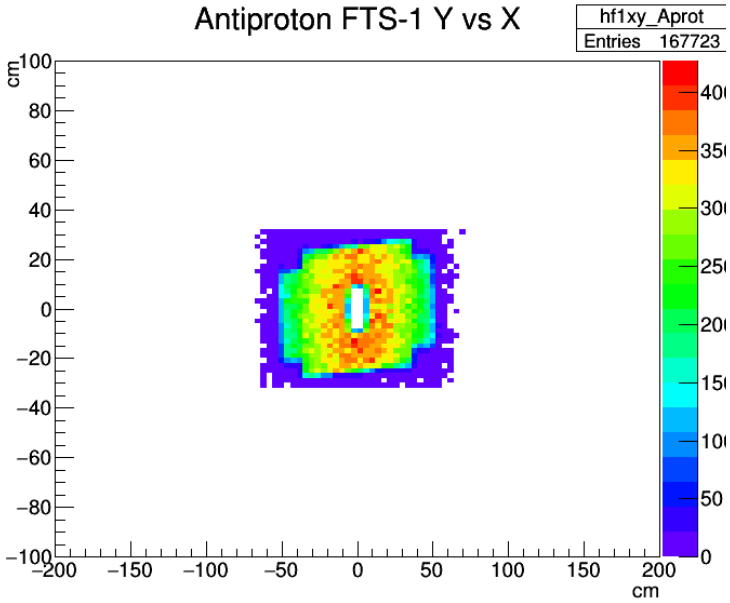
II. Modified EMC acceptance

III. Fitting decay tree with longlived charged particles $(\Xi^-, \Omega^-, \Sigma^\pm)$

IV. First results on simulation & analysis of $\bar{p}p \to \Xi^-\bar{\Xi}^+\pi^0$

Part I: Required Completeness of FTS

- 4.4 GeV/c $\bar{p}p \rightarrow \bar{\Xi}^{+}\Xi(1820)^{-} \rightarrow \bar{\Xi}^{+}\Lambda K^{-} \rightarrow \bar{p}\pi^{+}\pi^{+}p\pi^{-}K^{-}$
- $\sqrt{s} - \sqrt{s_{\mathrm{thr}}} = 52\ \mathrm{MeV}$
- full sim chain for 400000 events, available for analysis
- analysis of sim_complete.root to get detector ‚points'
- analysis #1: combined MCTrack & FTSPoint information with focus on hit distribution on the 6 FTS planes
- analysis #2: combined MCTrack & MVDPoint, STTPoint, GEMPoint, FTSPoint information, focus on overall hit distribution


Antiproton FTS-1 Y vs X
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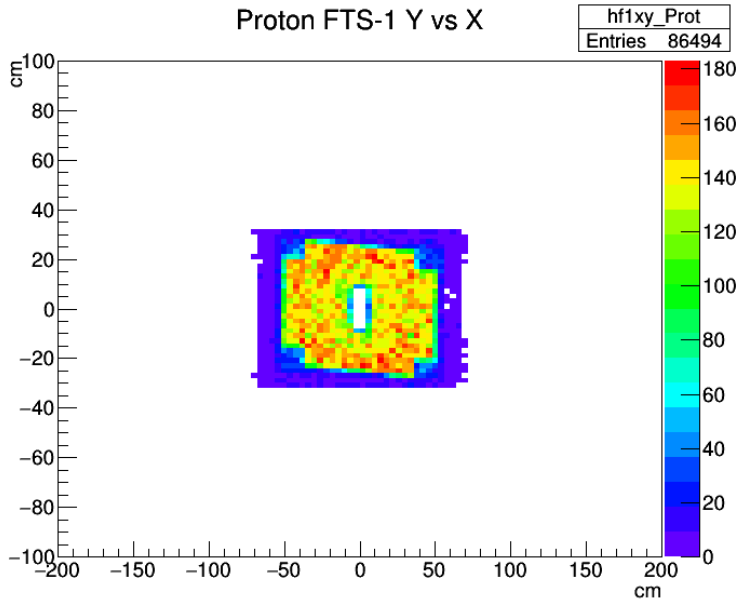
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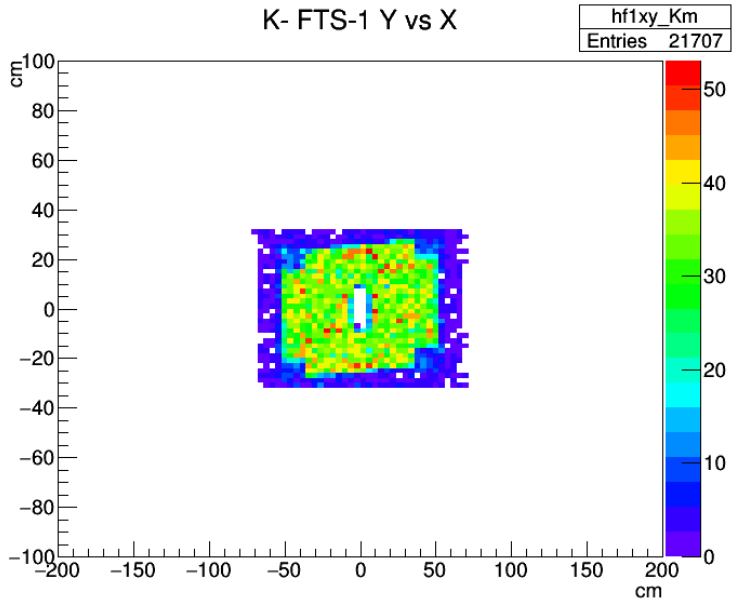
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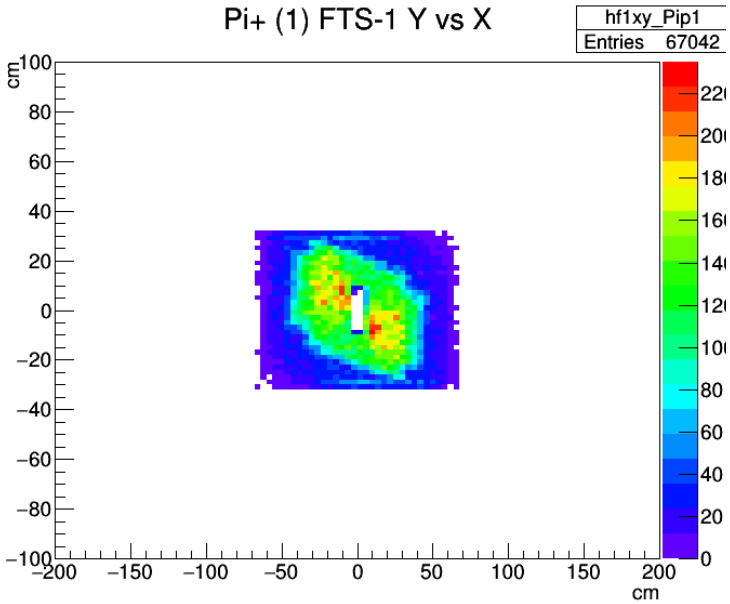
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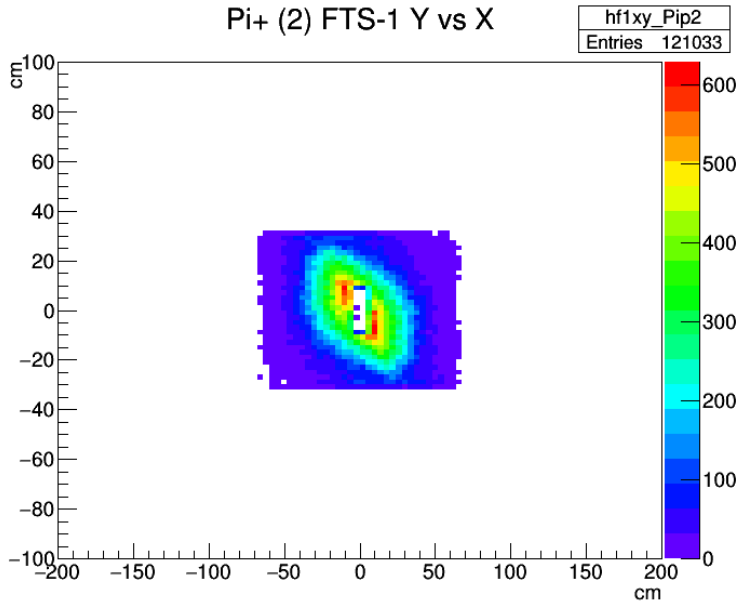
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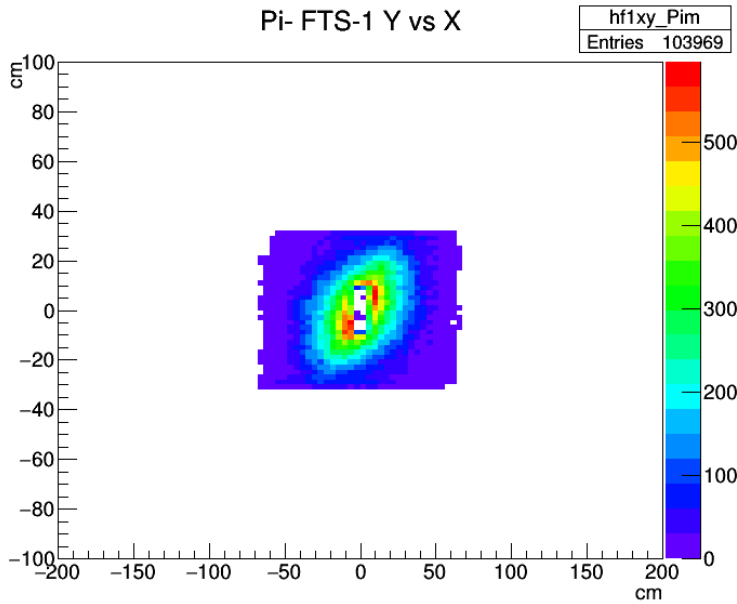
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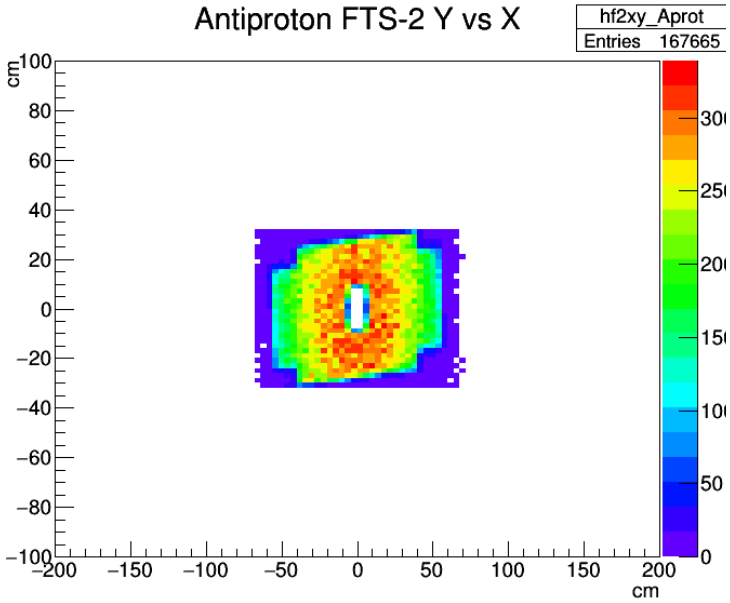
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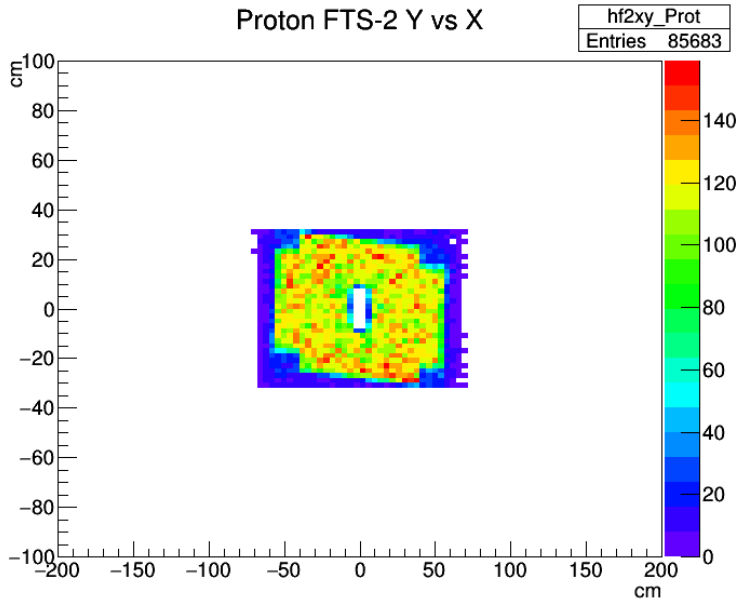
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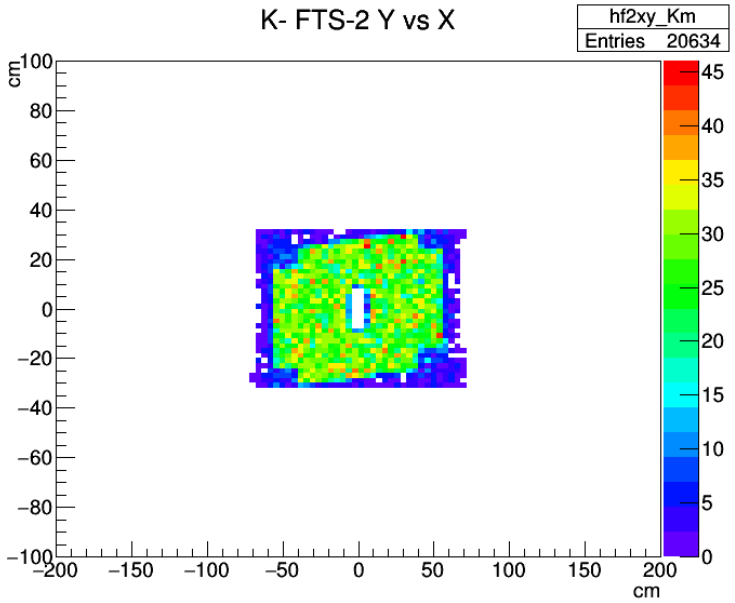
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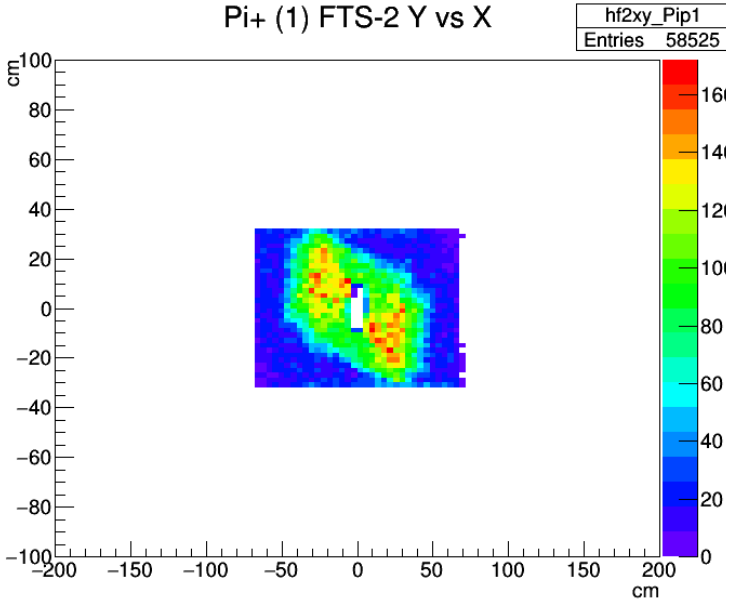
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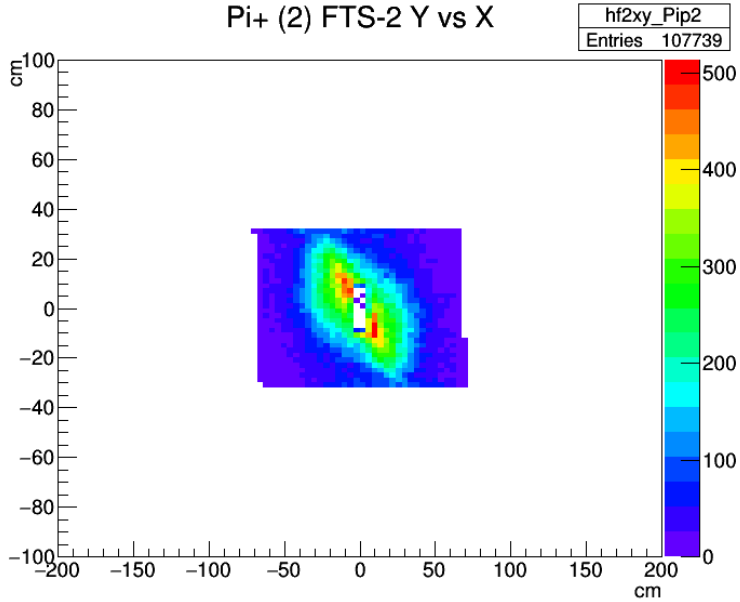
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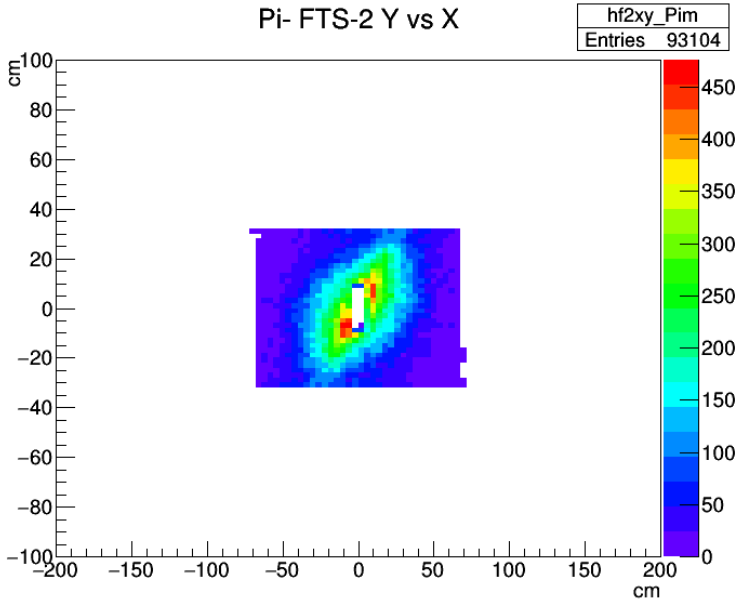
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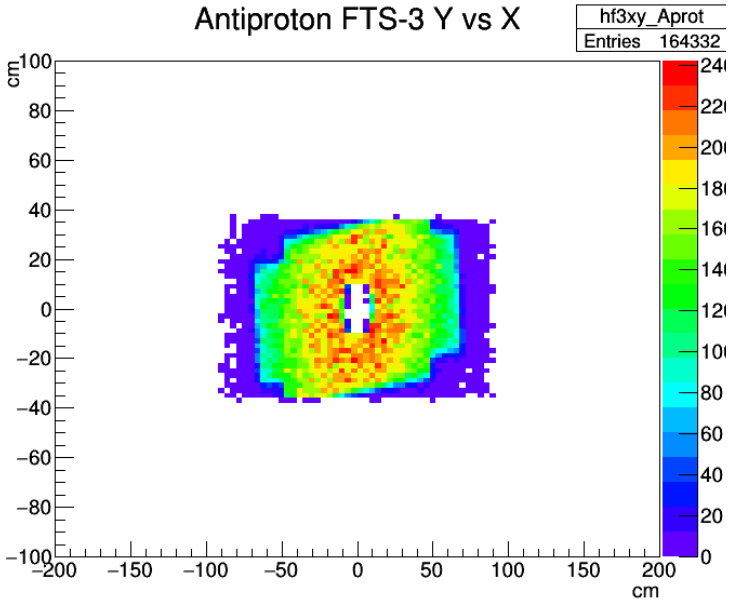
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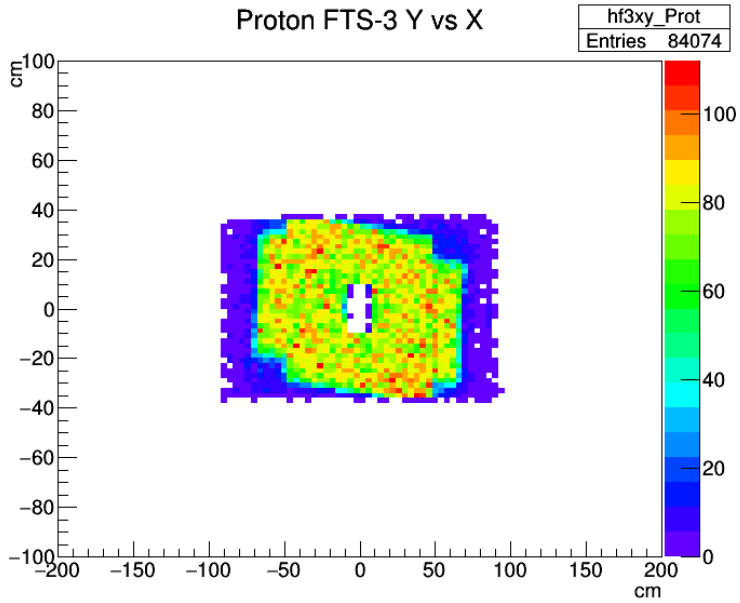
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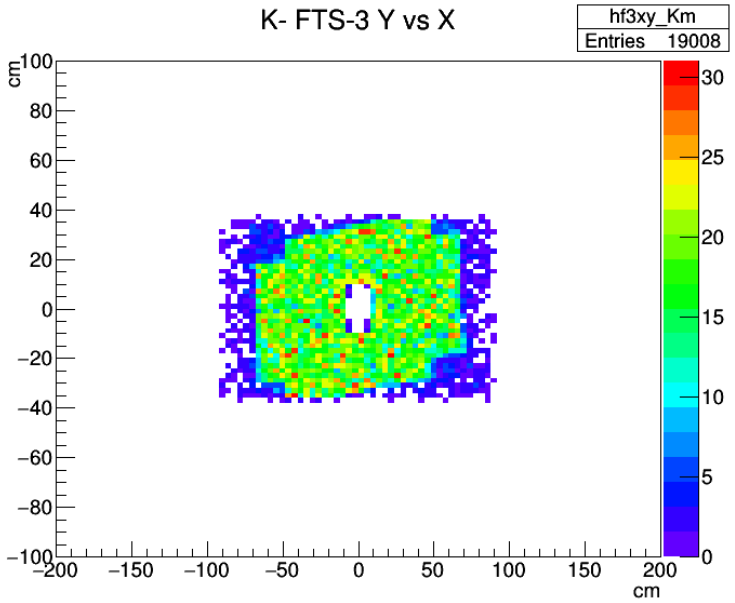
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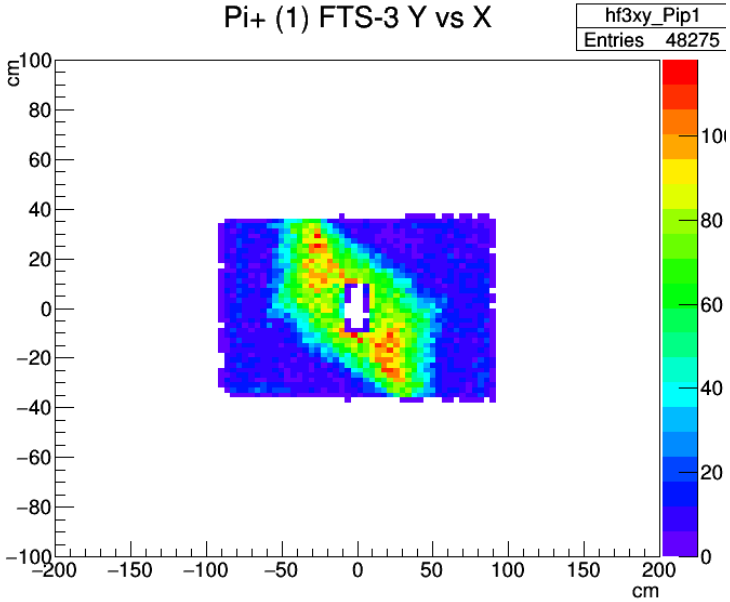
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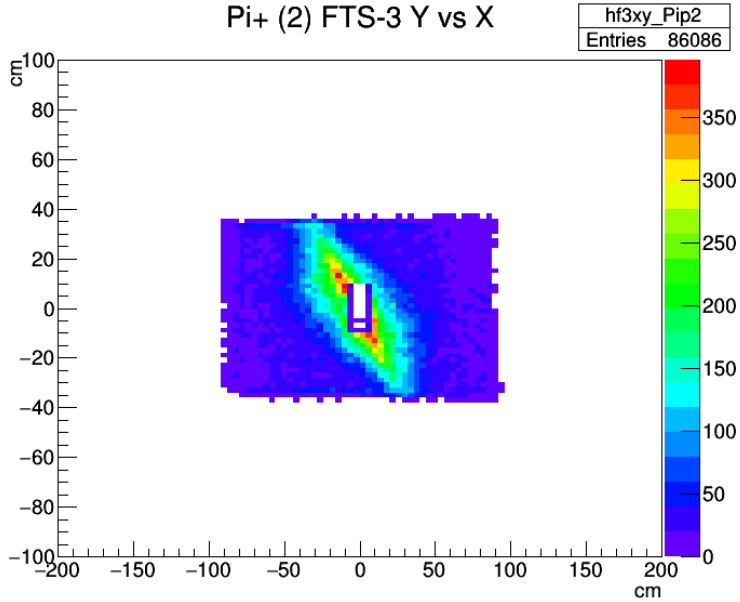
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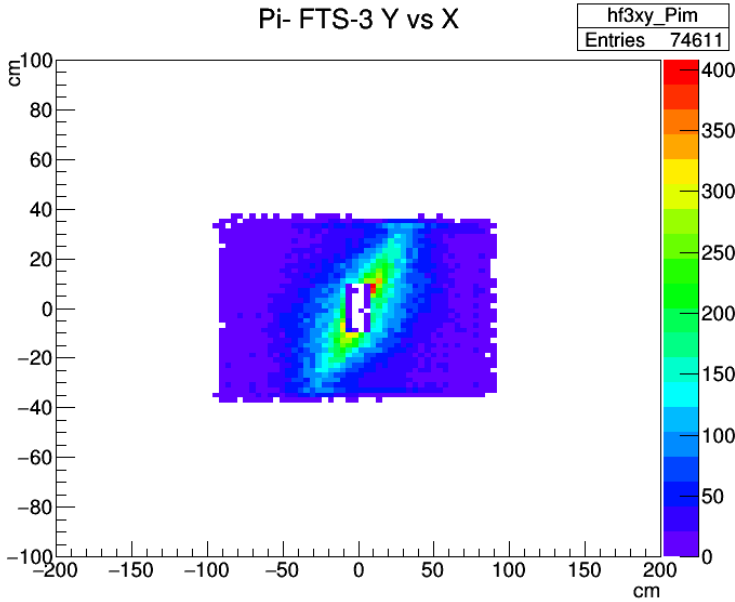
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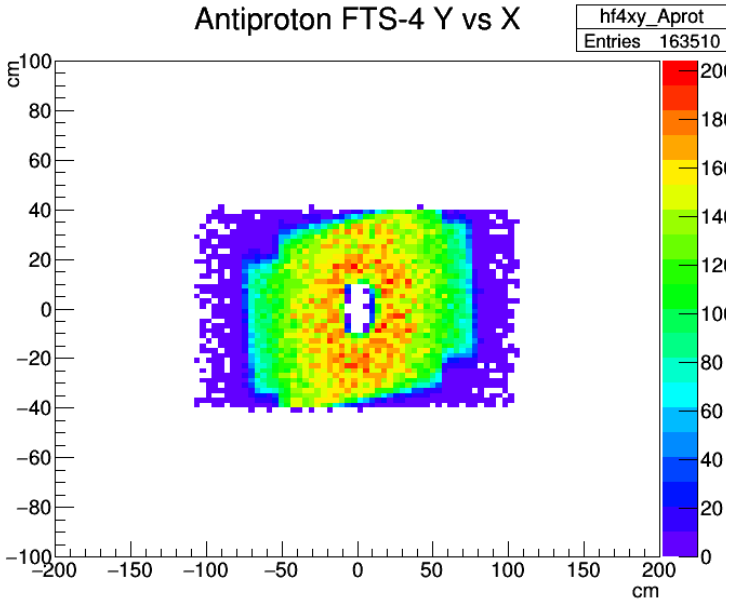
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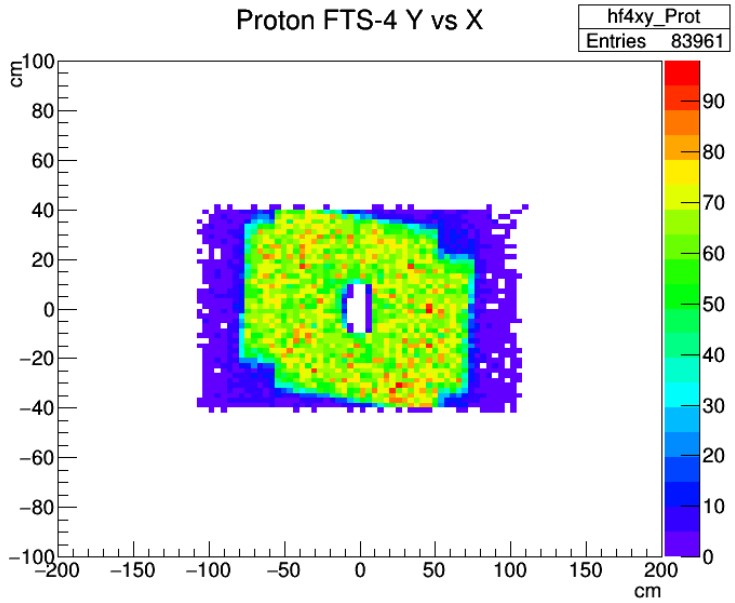
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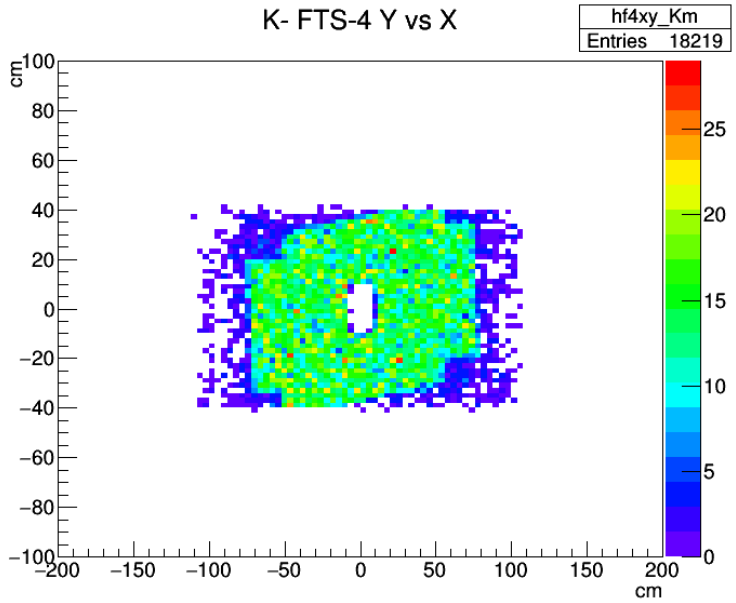
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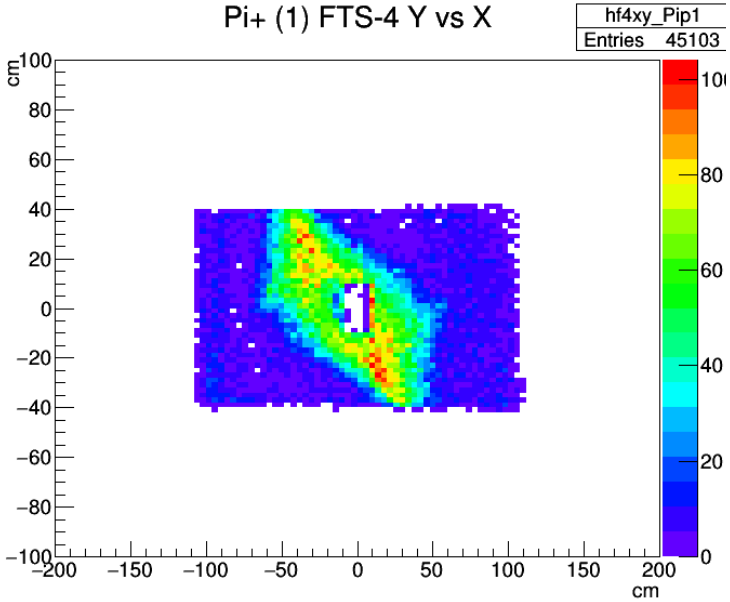
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hf4xy_Pip1
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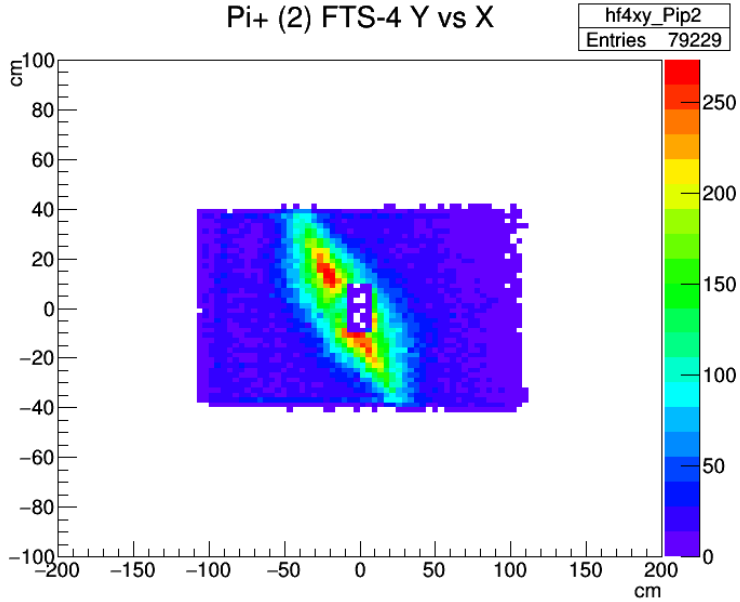
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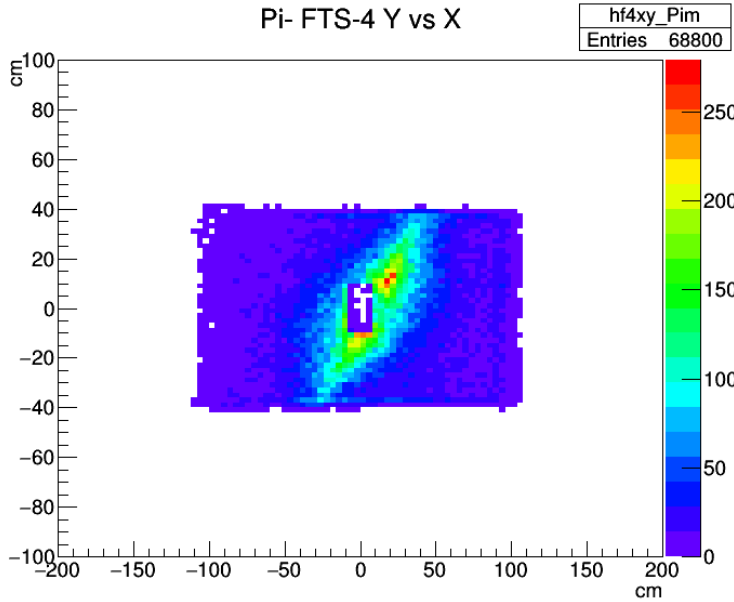
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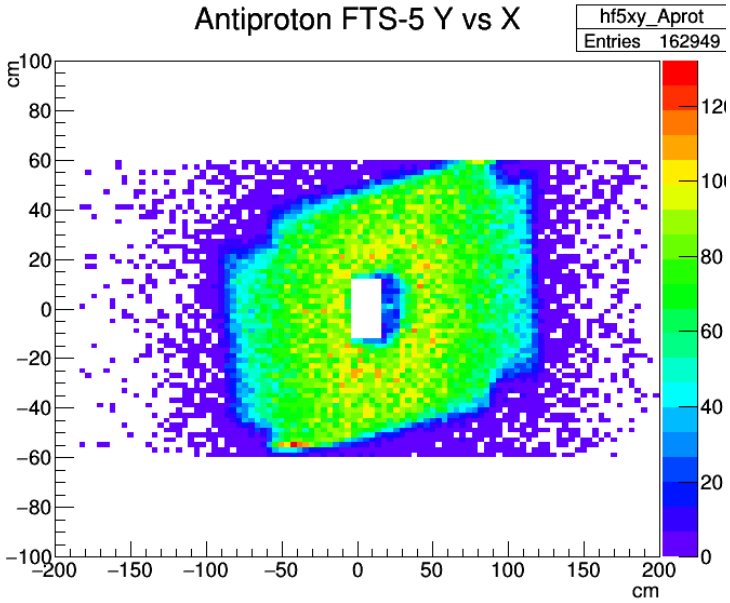
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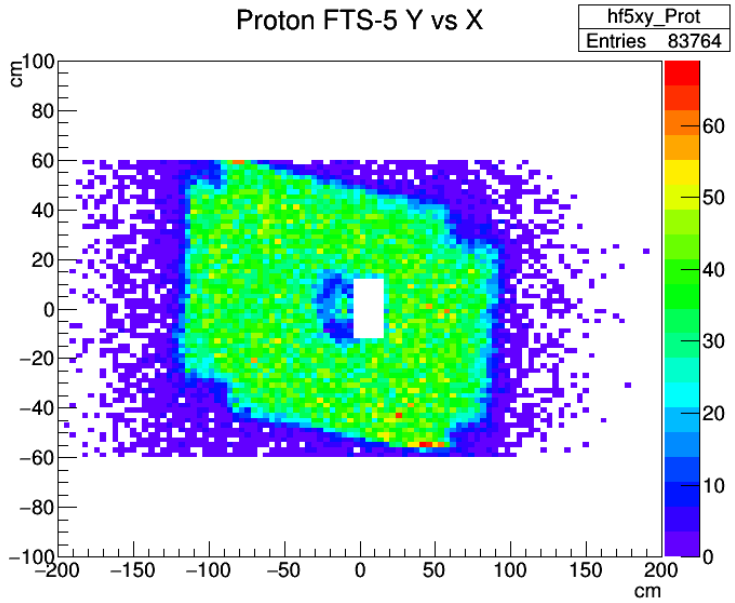
Proton FTS-5 Y vs X
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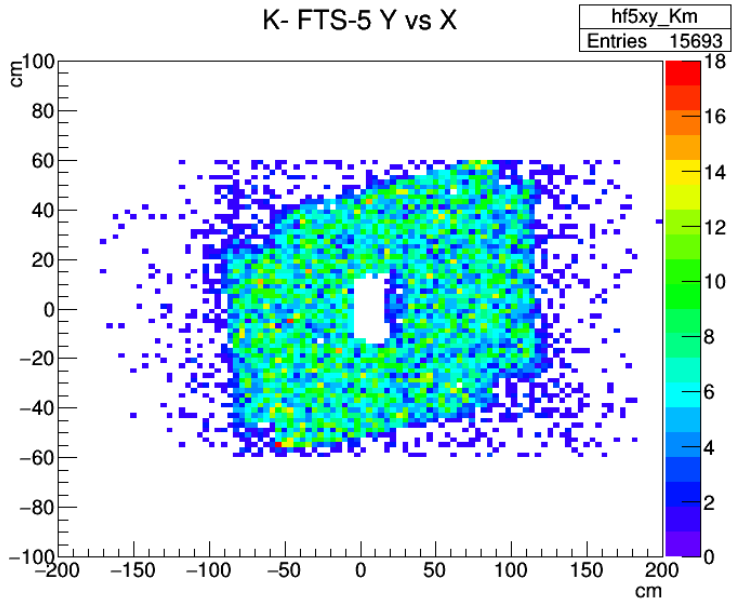
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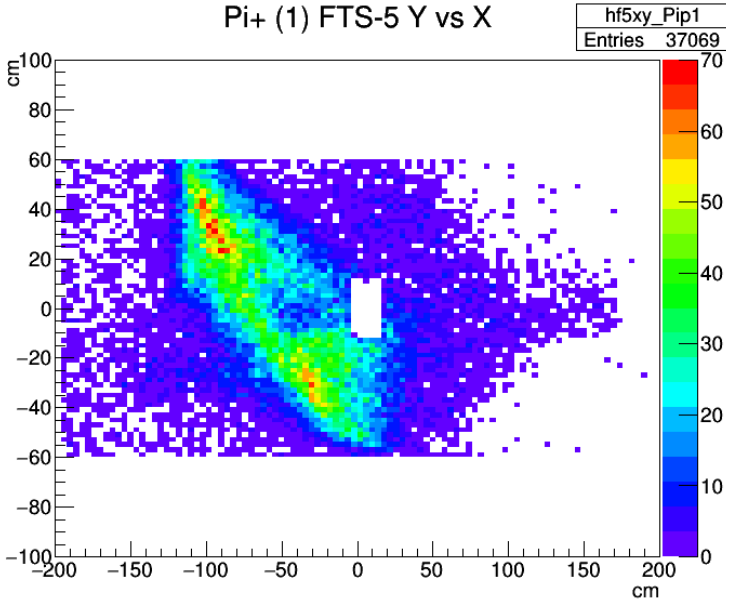
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Entries 37069
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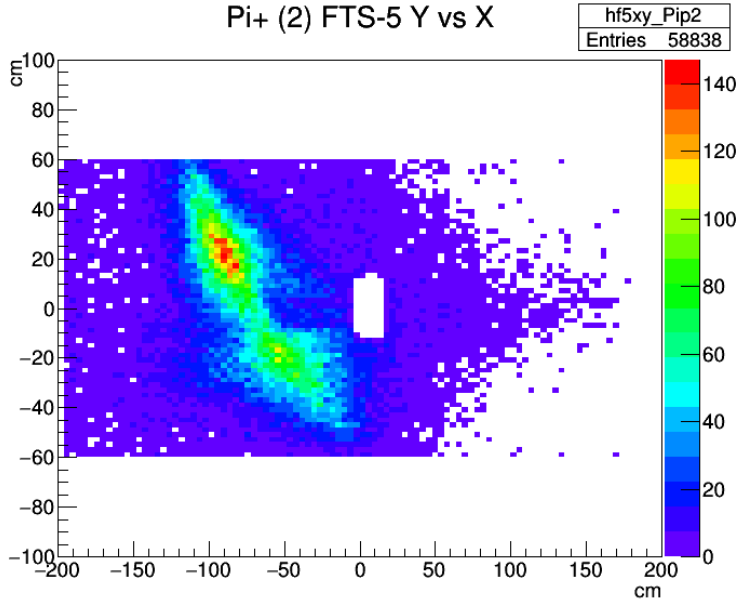
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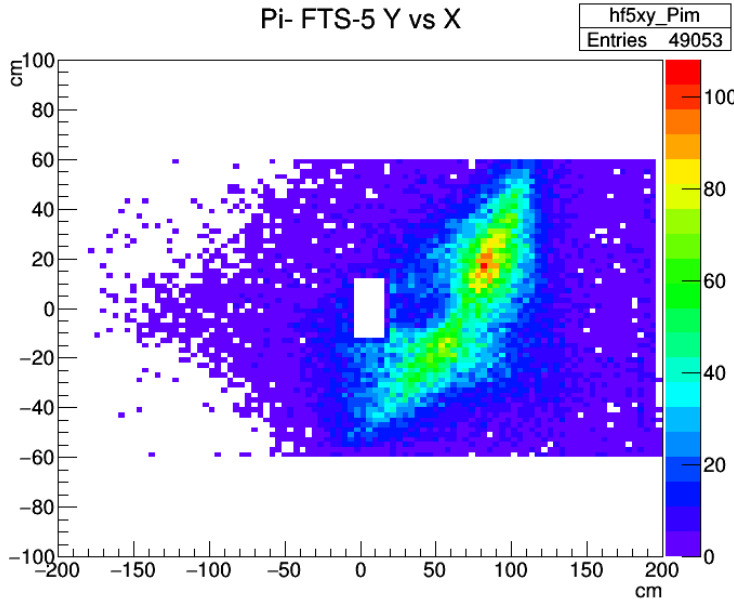
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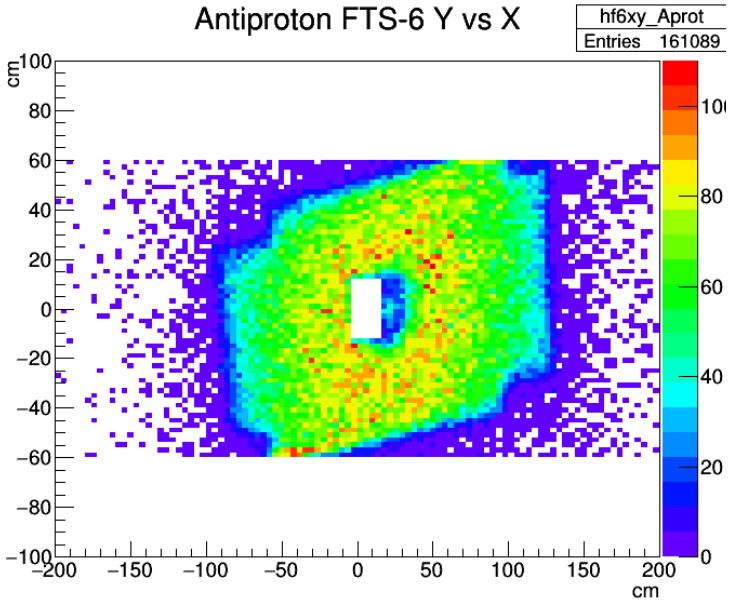
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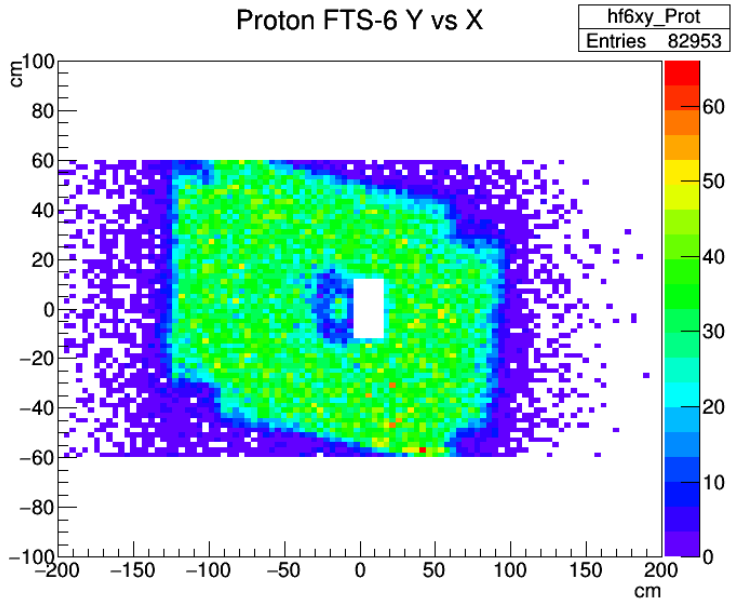
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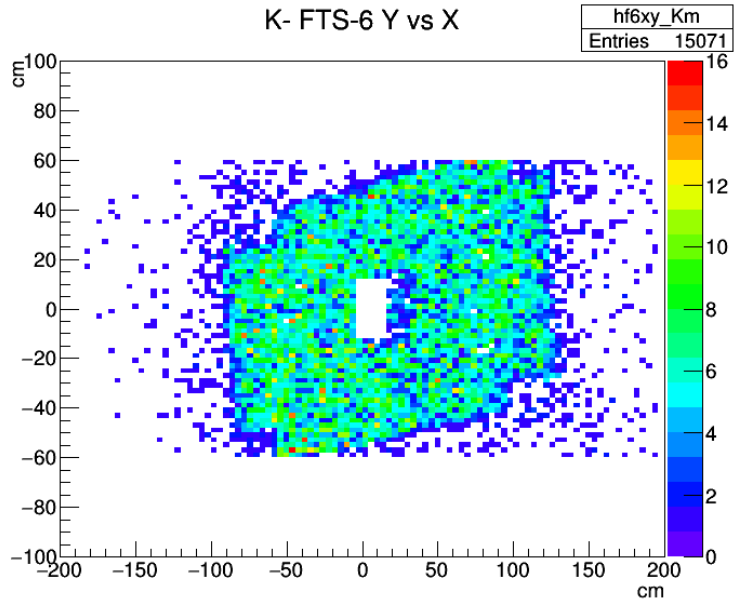
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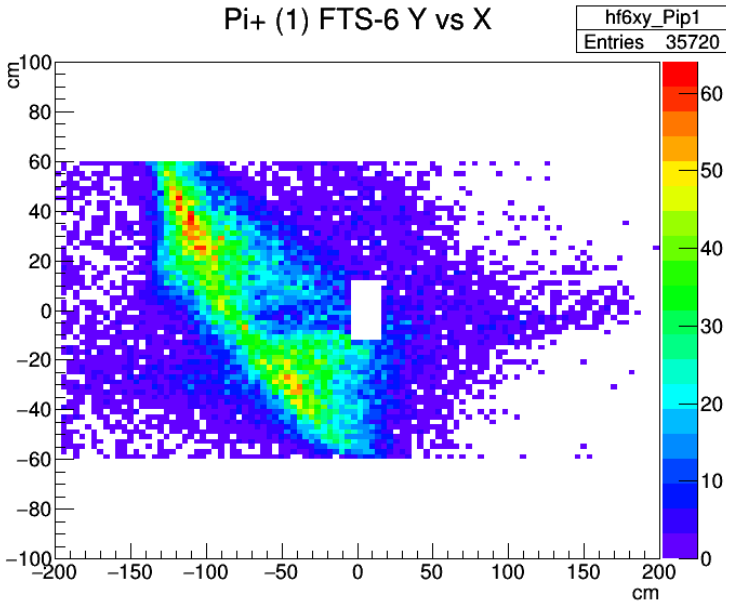
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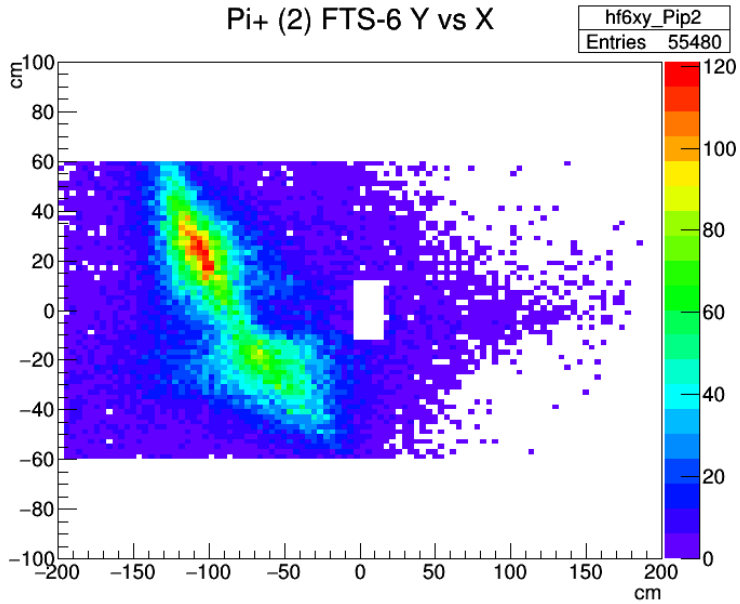
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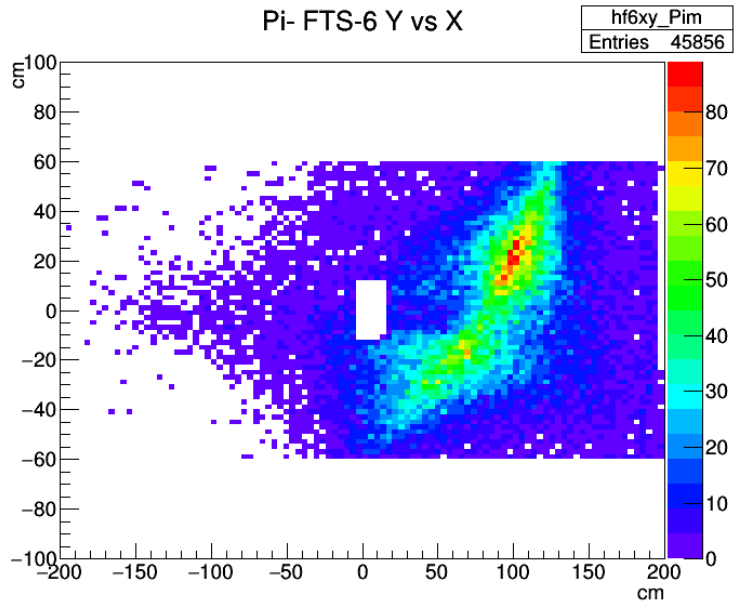
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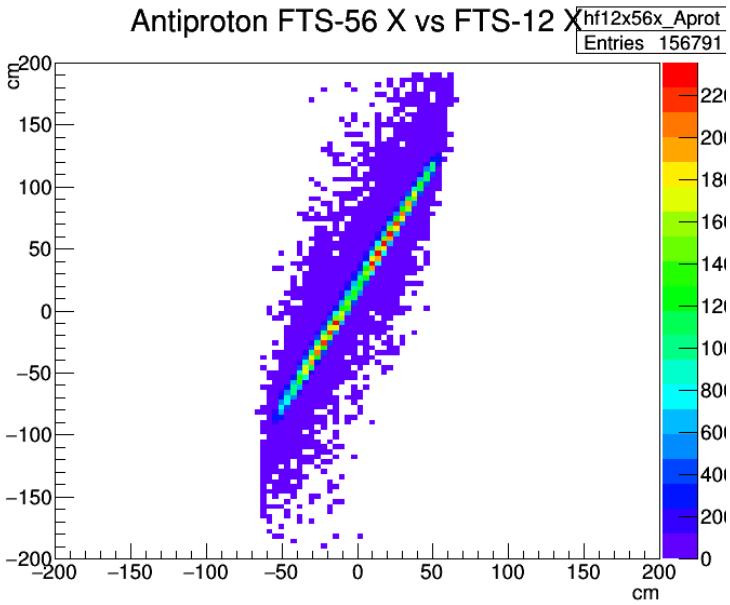
Antiproton FTS-56 X vs FTS-12 X
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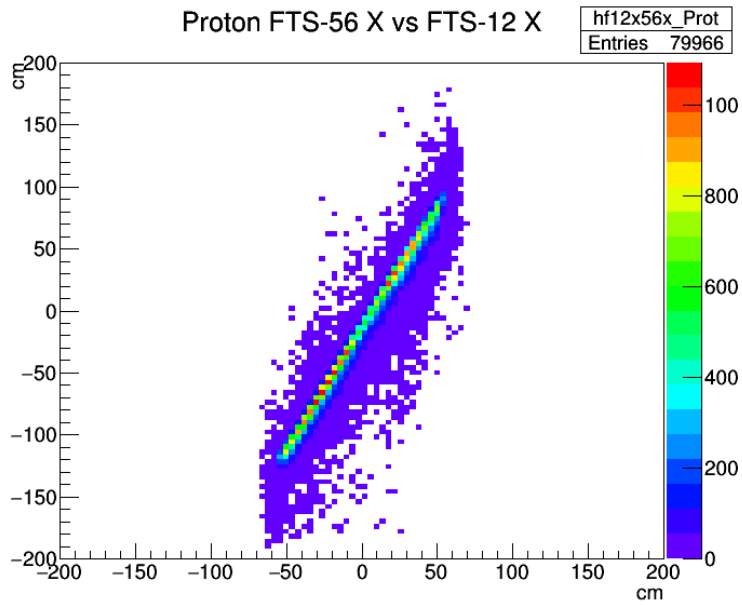
Proton FTS-56 X vs FTS-12 X
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Entries 79966
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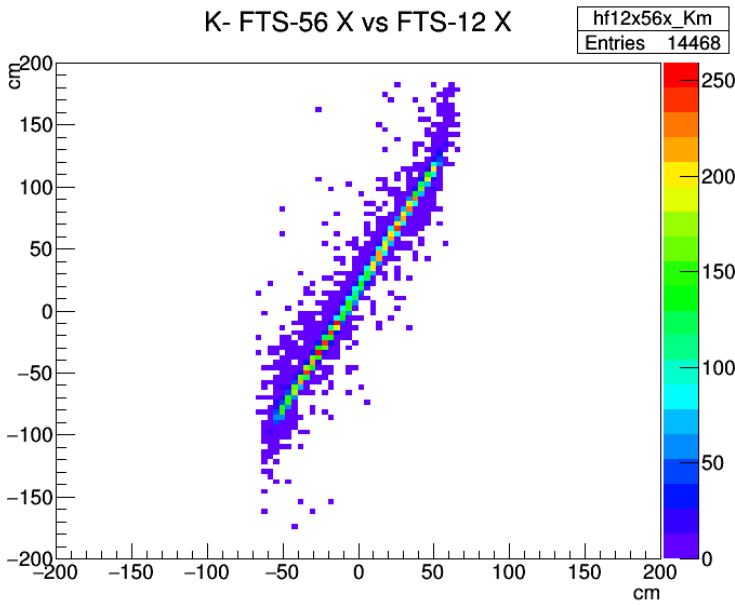
K- FTS-56 X vs FTS-12 X
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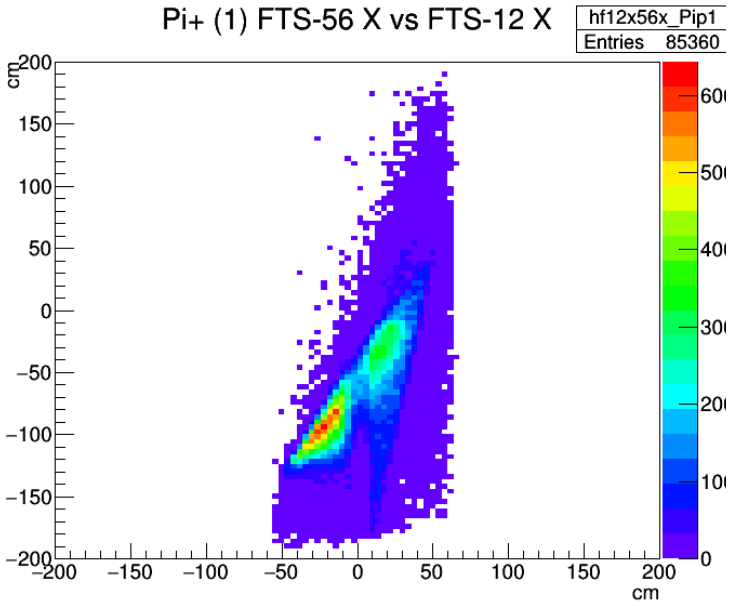
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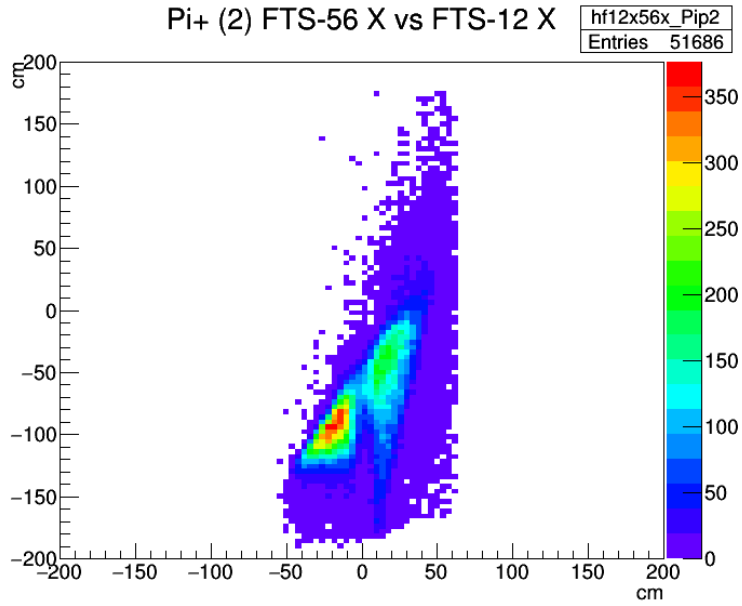
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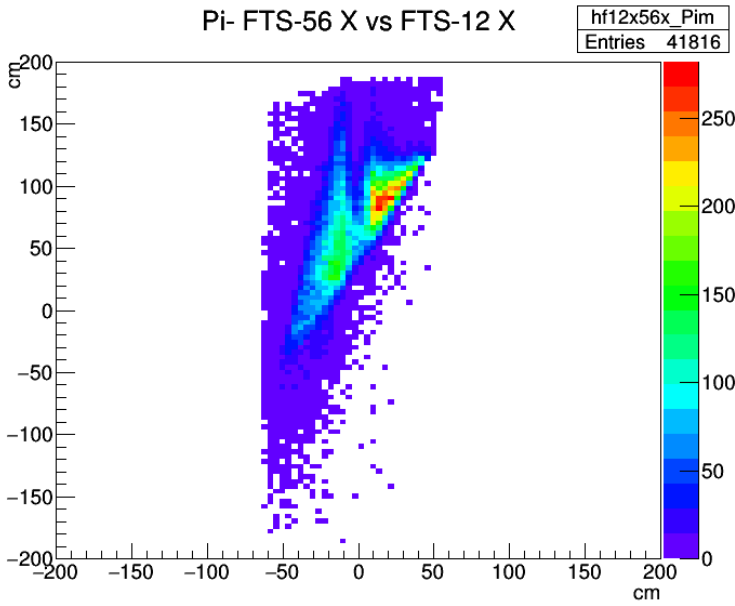
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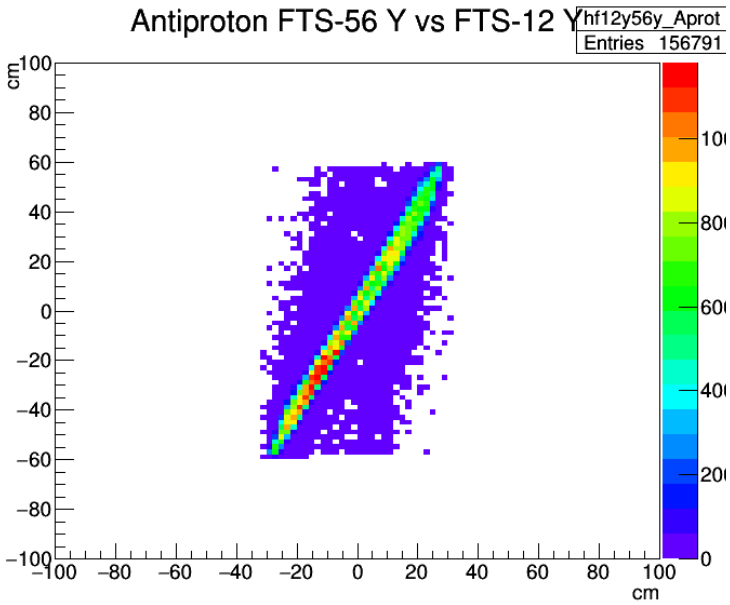
Antiproton FTS-56 Y vs FTS-12 Y
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Entries 156791
cm
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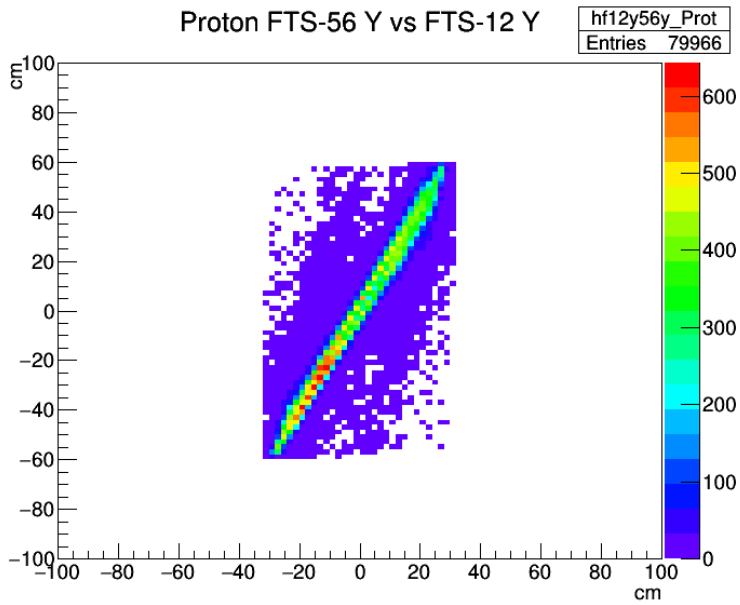
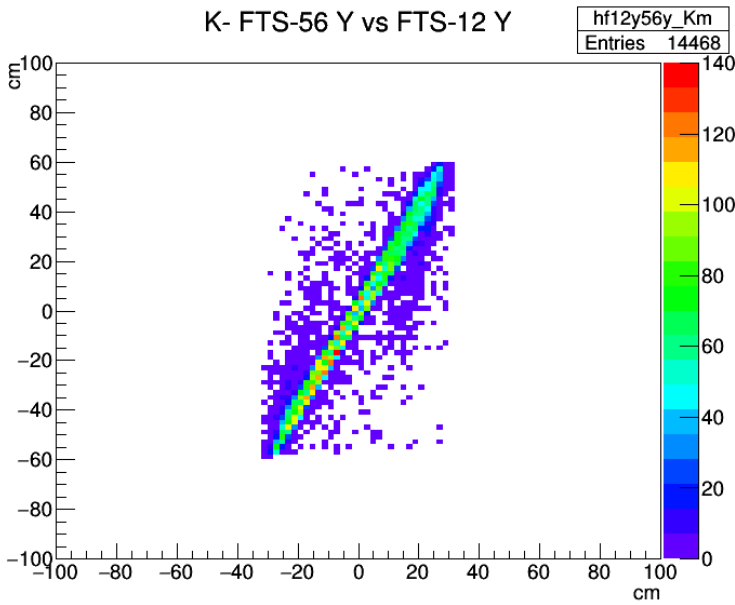
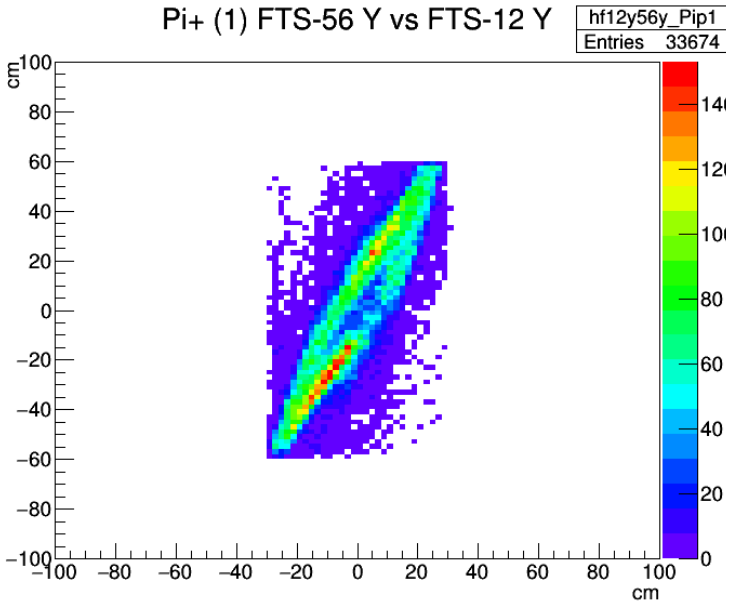

Proton FTS-56 Y vs FTS-12 Y
hf12y56y_Prot
Entries 79966
cm
cm


K- FTS-56 Y vs FTS-12 Y
hf12y56y_Km
Entries 14468
cm
cm


Pi+ (1) FTS-56 Y vs FTS-12 Y
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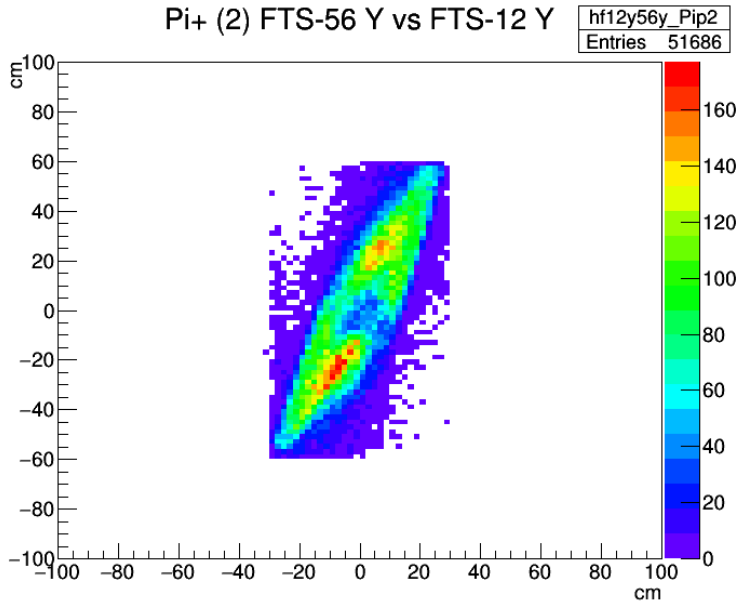
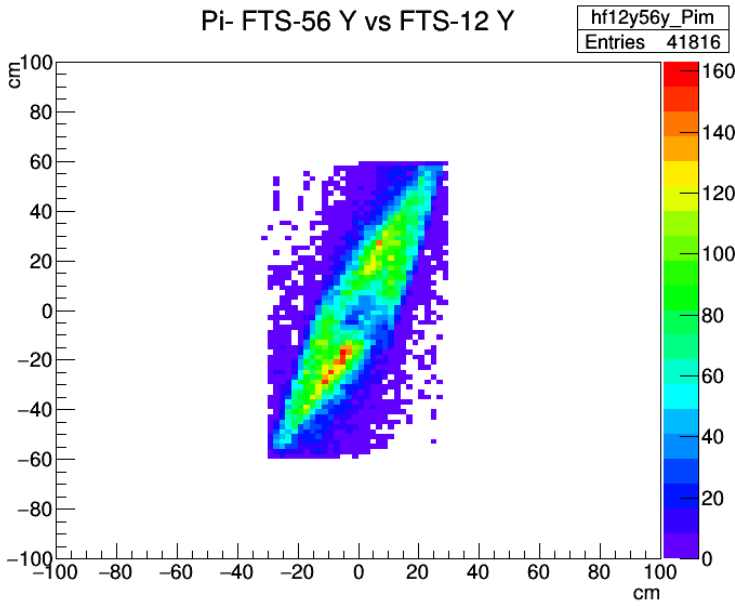
Entries 33674
cm
cm


Pi+ (2) FTS-56 Y vs FTS-12 Y
hf12y56y_Pip2
Entries 51686
cm
cm


Pi- FTS-56 Y vs FTS-12 Y
hf12y56y_Pim
Entries 41816
cm
cm

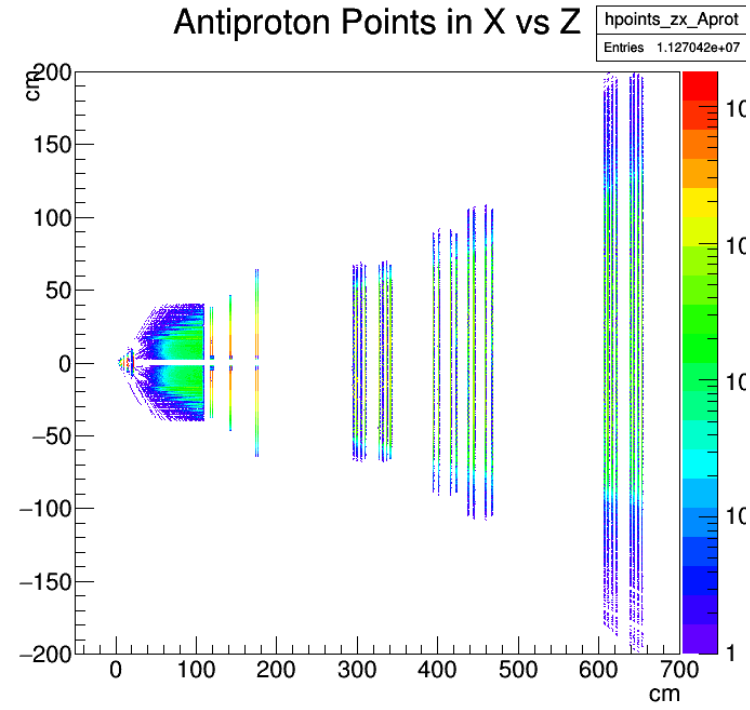
Hits in Subdetectors

particle	N_{MVD} = 0 >= 3	N_{STT} = 0 >= 3	N_{GEM} = 0 >= 3	N_{FTS} = 0 >= 3
$\bar{p}$	0.395 0.158	0.666 0.266	0.118 0.836	0.570 0.429
p	0.210 0.449	0.354 0.588	0.131 0.769	0.777 0.222
K^-	0.037 0.860	0.256 0.720	0.660 0.260	0.944 0.055
$\pi^+{}_1$	0.110 0.526	0.248 0.732	0.289 0.602	0.826 0.171
$\pi^+{}_2$	0.368 0.189	0.325 0.647	0.194 0.742	0.680 0.315
π^-	0.212 0.432	0.332 0.645	0.245 0.663	0.721 0.275

Hits in FTS Planes

FTS-1 - 6: numbers are in % of total number of generated particles

particle	F_{FTS-1}	F_{FTS-2}	F_{FTS-3}	F_{FTS-4}	F_{FTS-5}	F_{FTS-6}	F_6 / F_1
$\bar{p}$	41.9	41.9	41.1	40.9	40.7	40.3	0.960
p	21.6	21.4	21.0	21.0	20.9	20.7	0.959
K^-	5.43	5.16	4.75	4.55	3.92	3.77	0.694
$\pi^+{}_1$	16.8	14.6	12.1	11.3	9.27	8.93	0.533
$\pi^+{}_2$	30.3	26.9	21.5	19.8	14.7	13.9	0.458
π^-	26.0	23.3	18.7	17.2	12.3	11.5	0.441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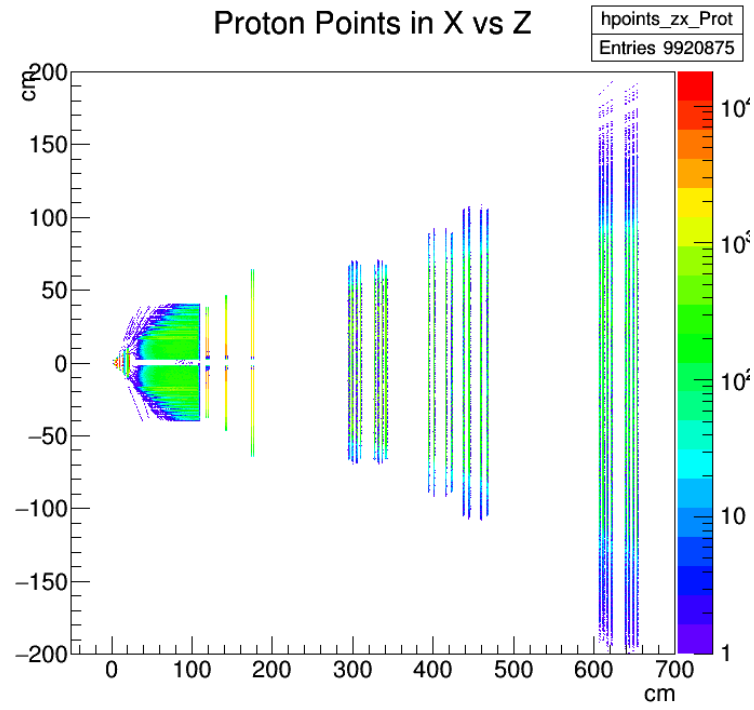
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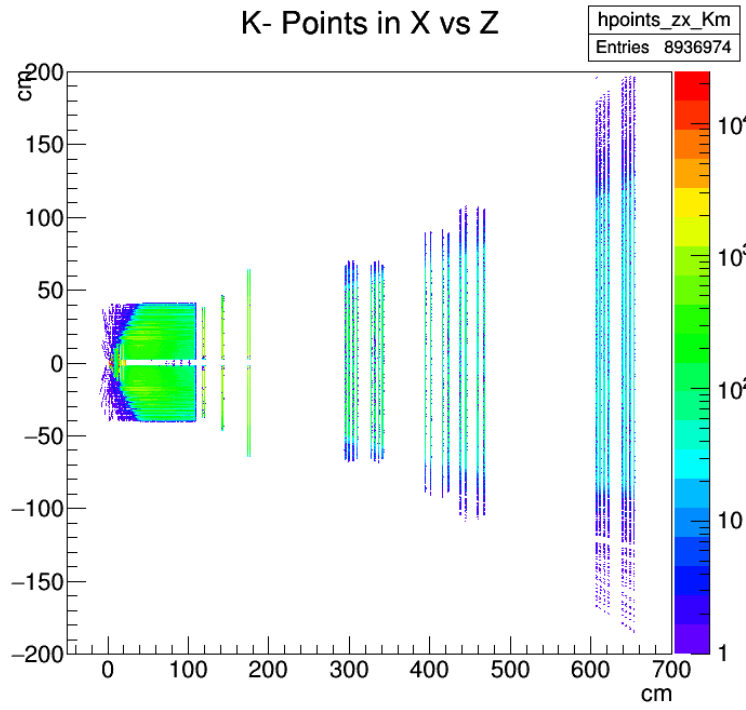
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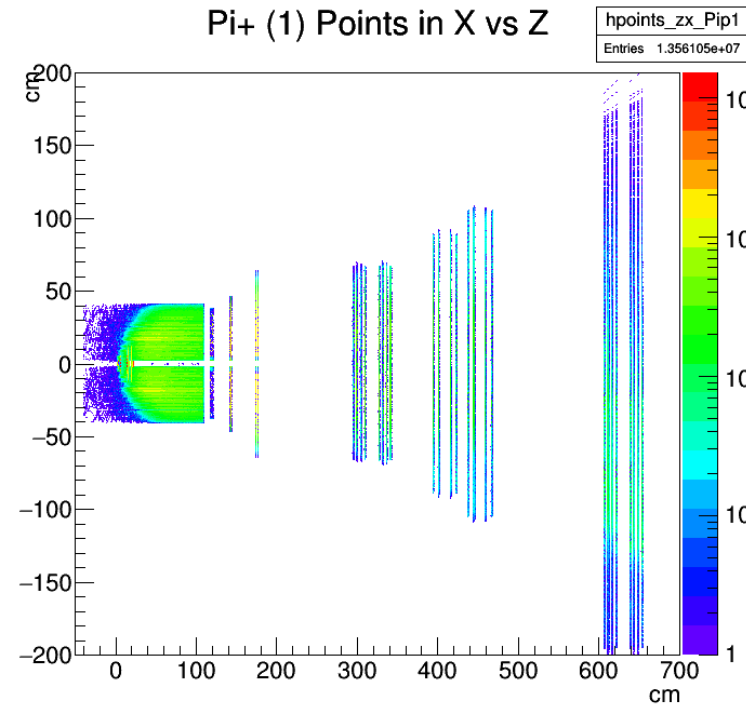
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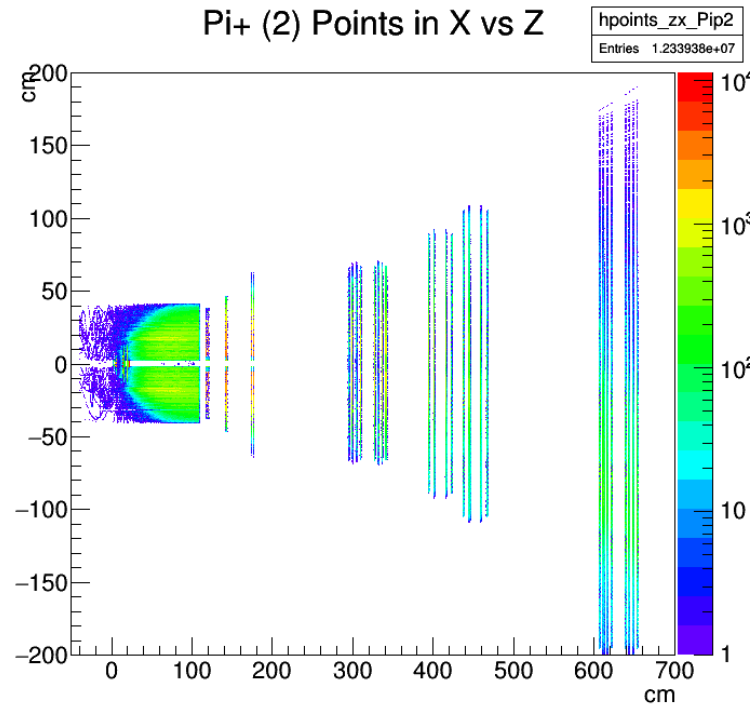
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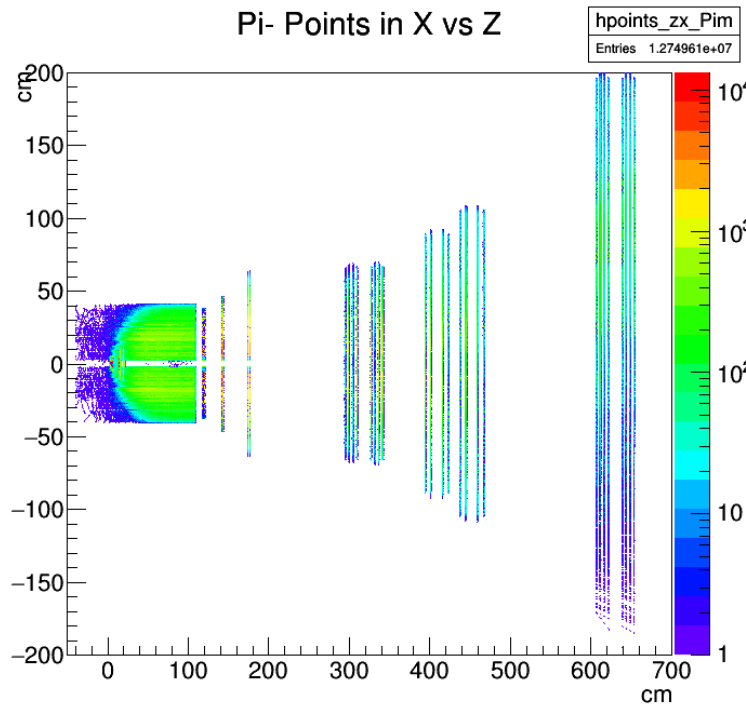
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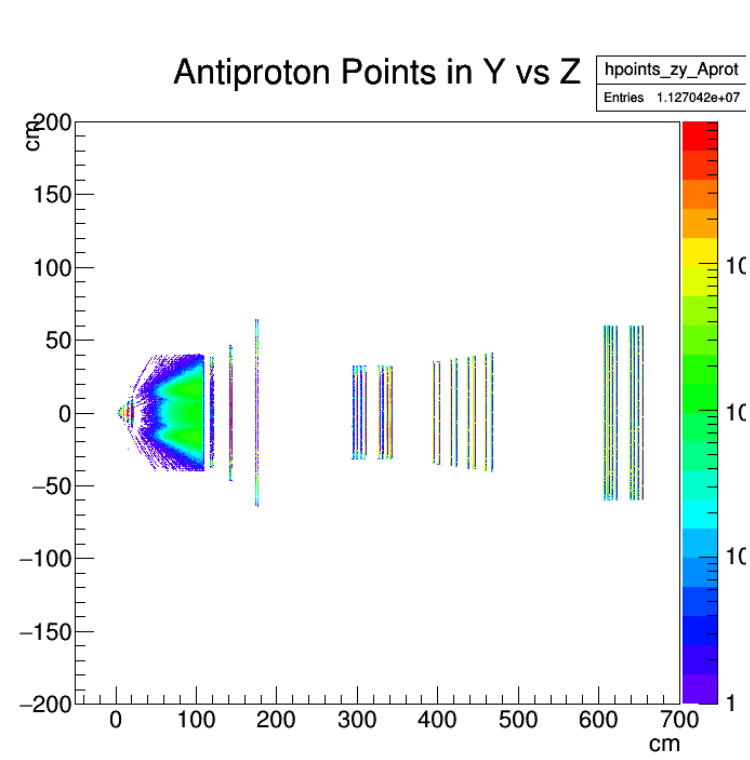
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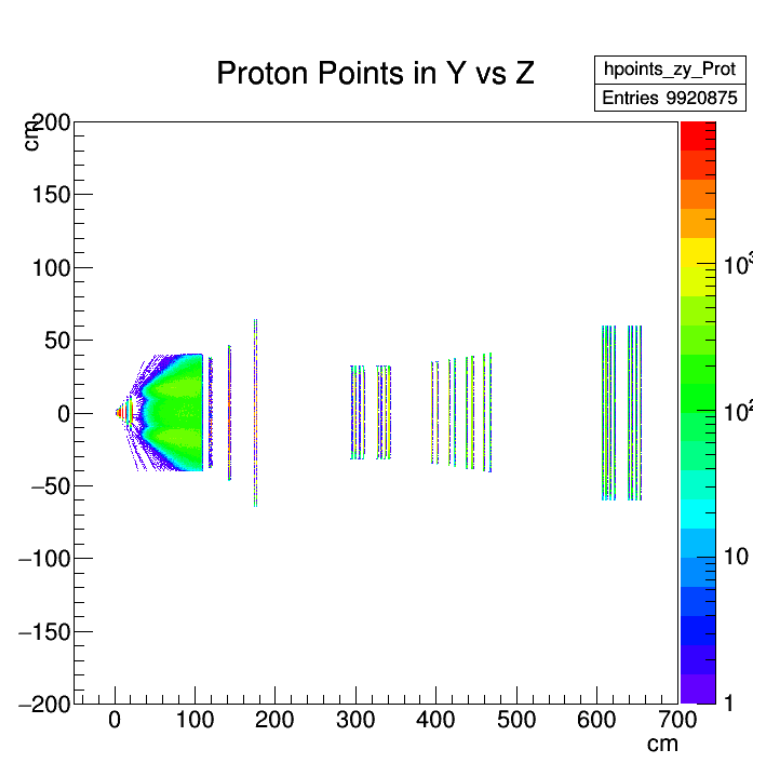
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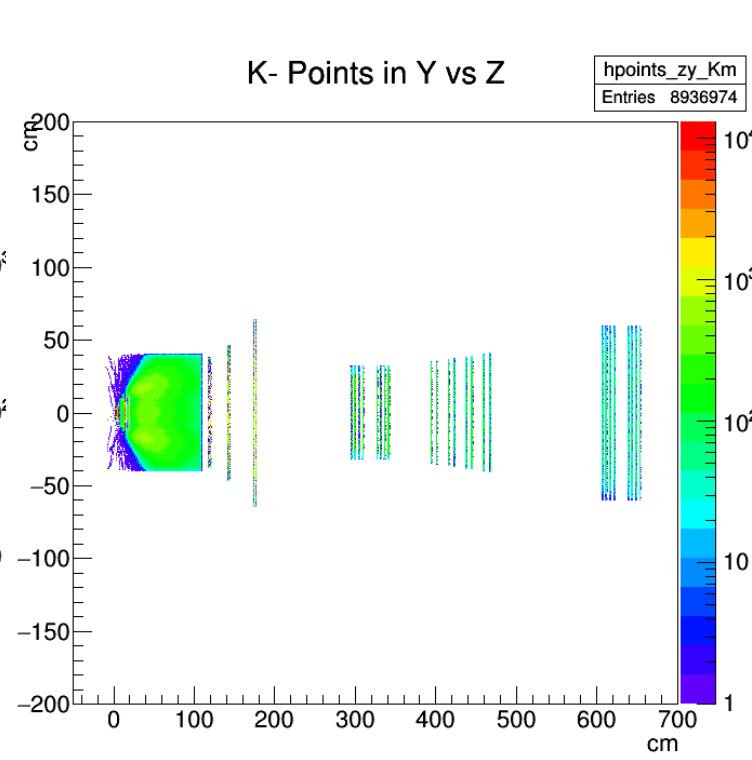
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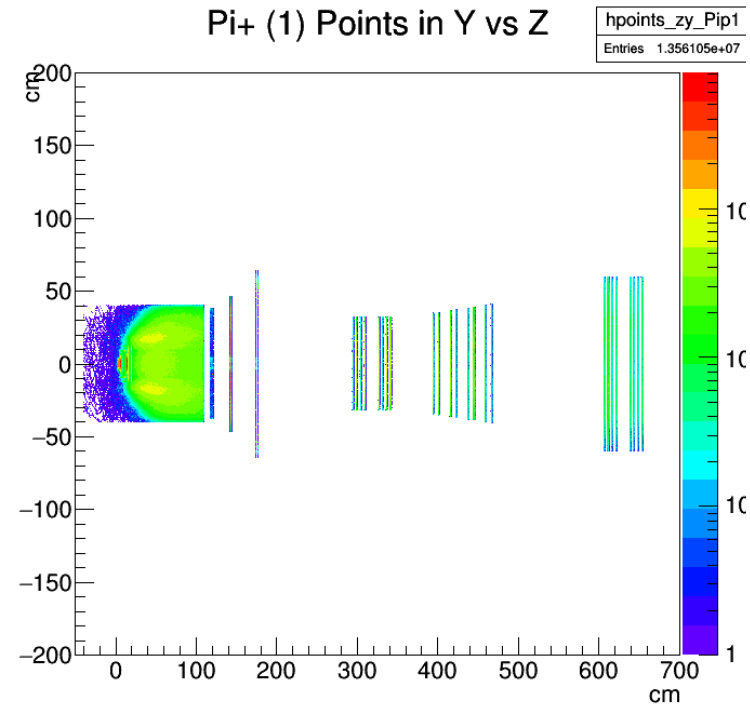
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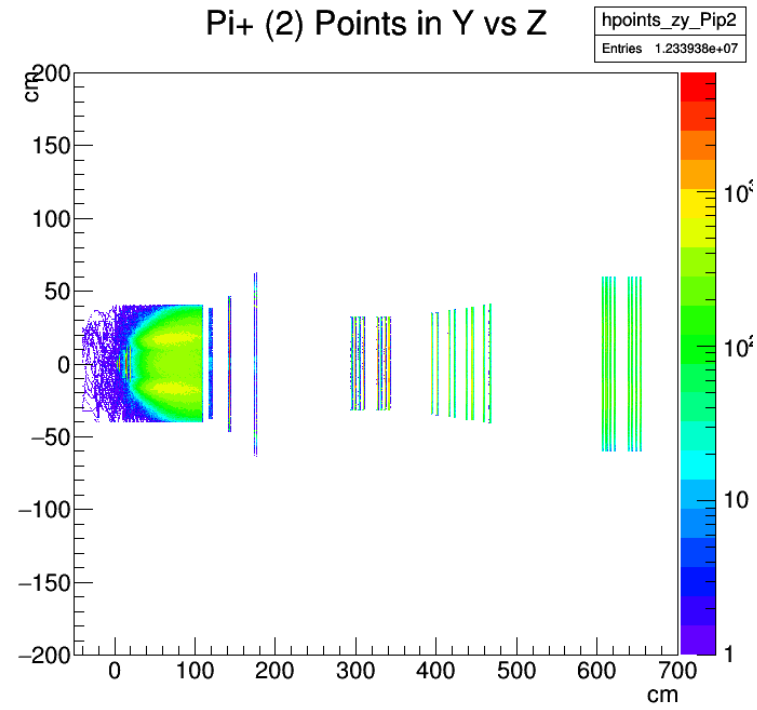
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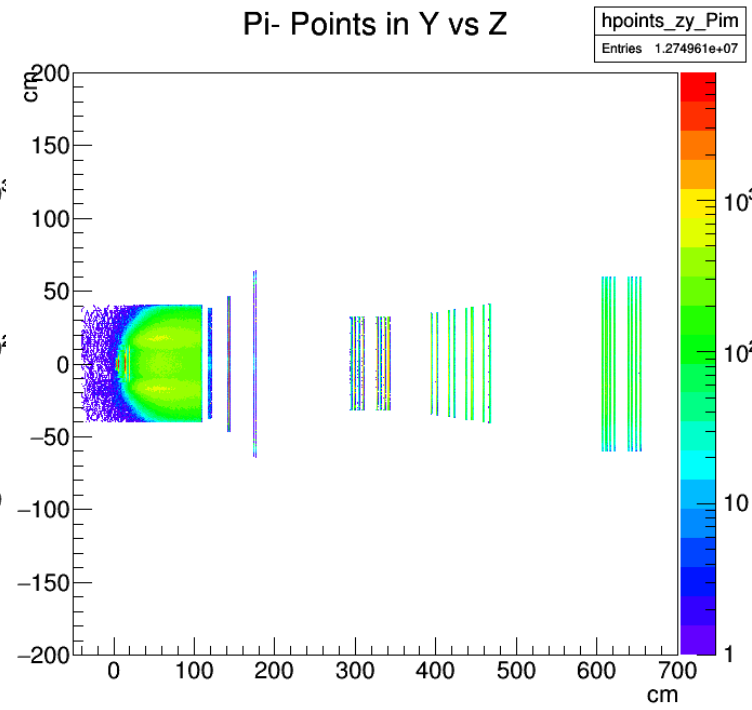
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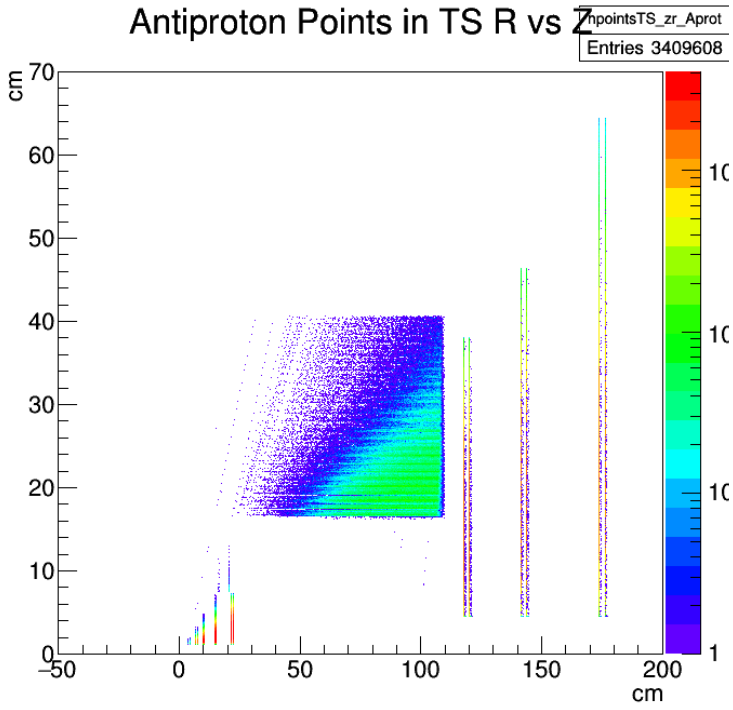
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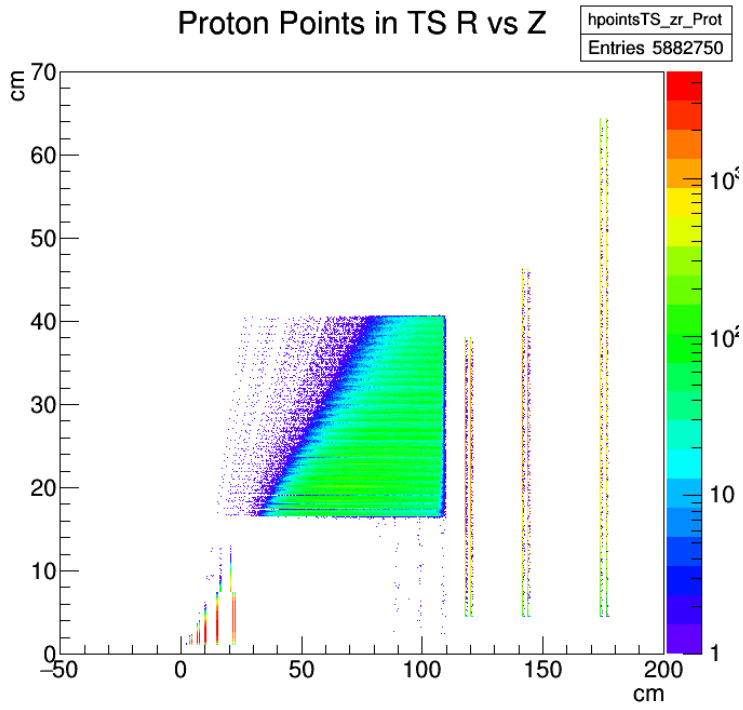
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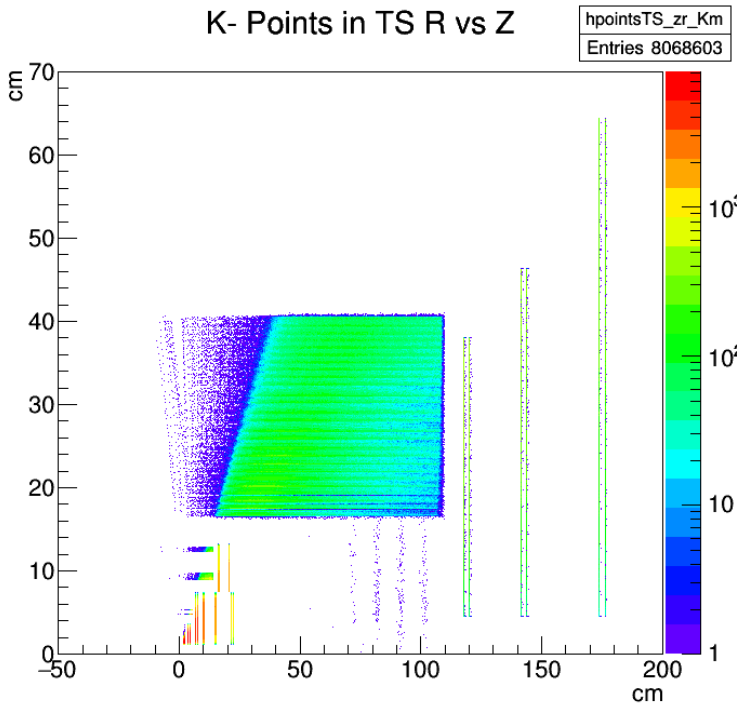
K- Points in TS R vs Z
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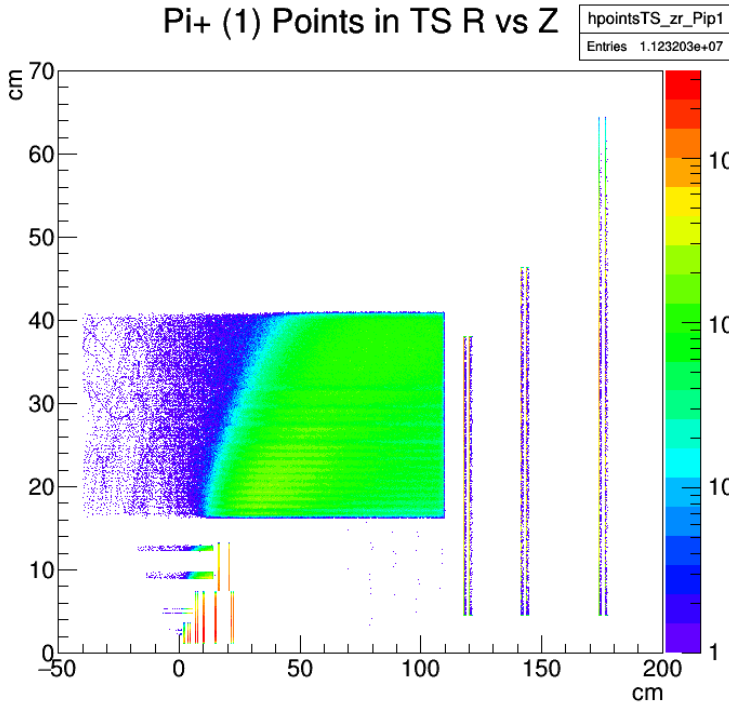
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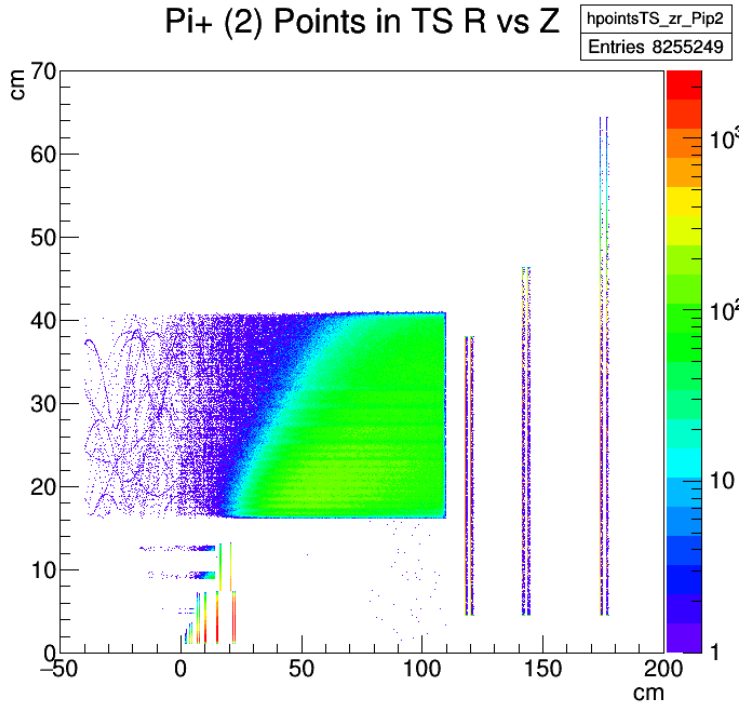
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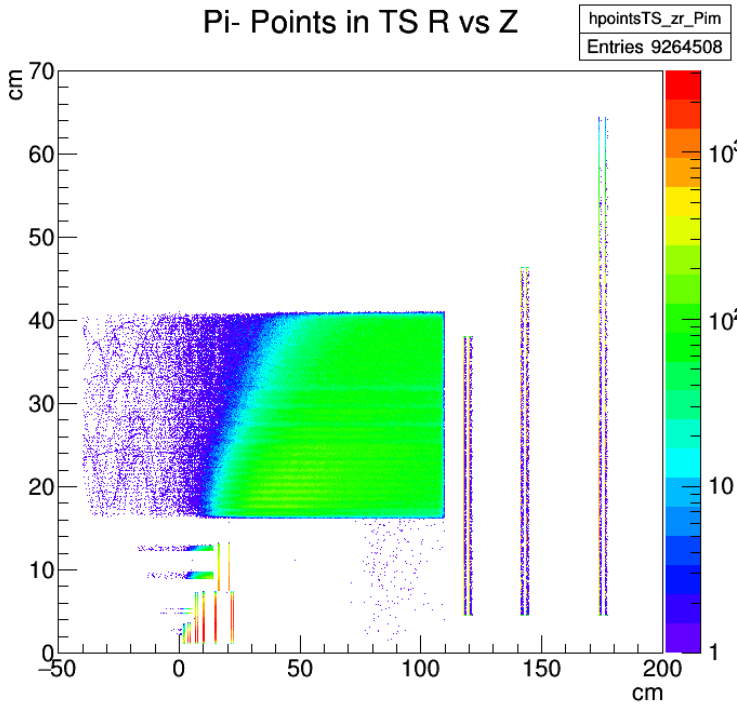
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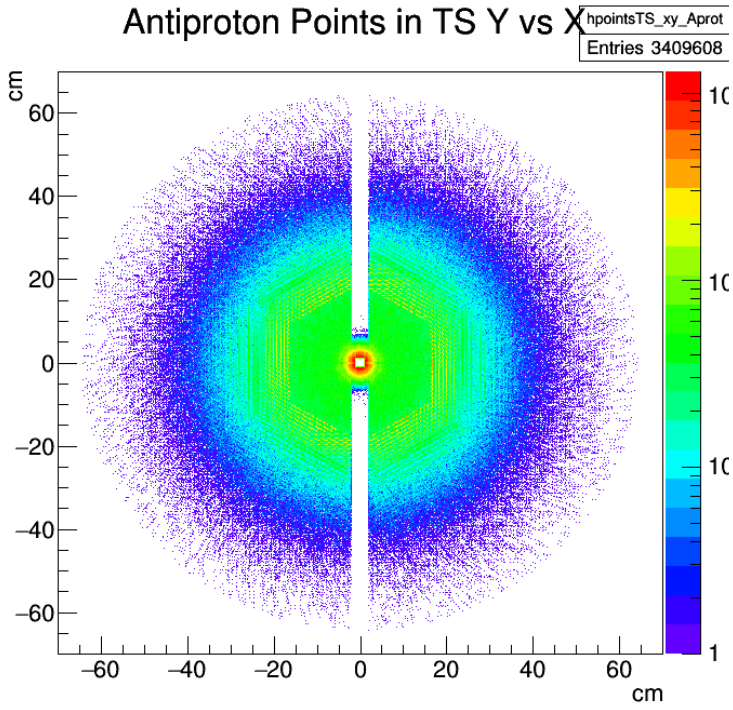
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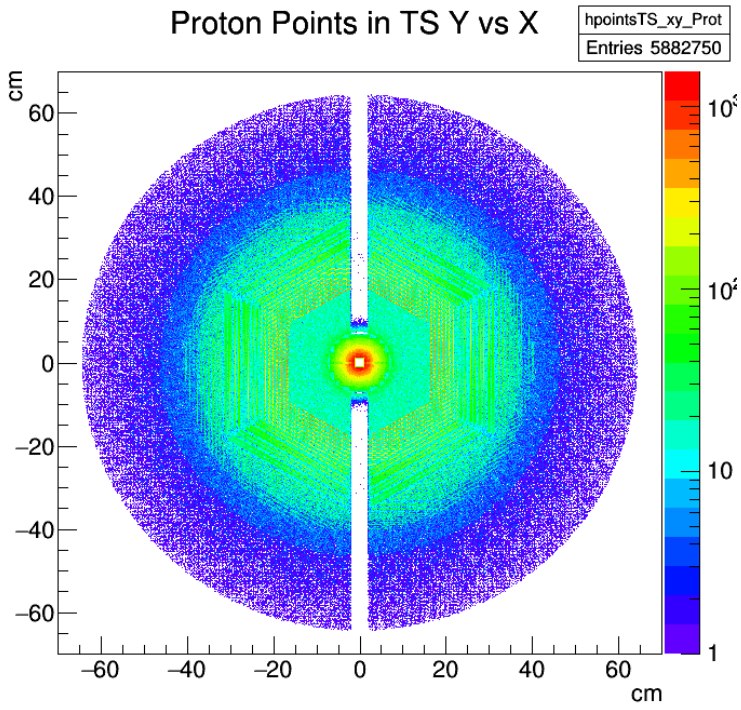
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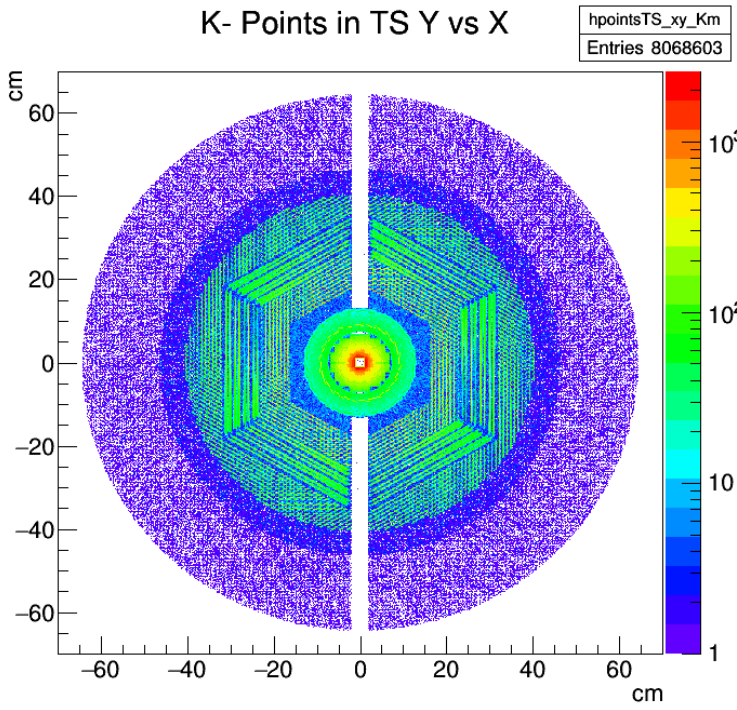
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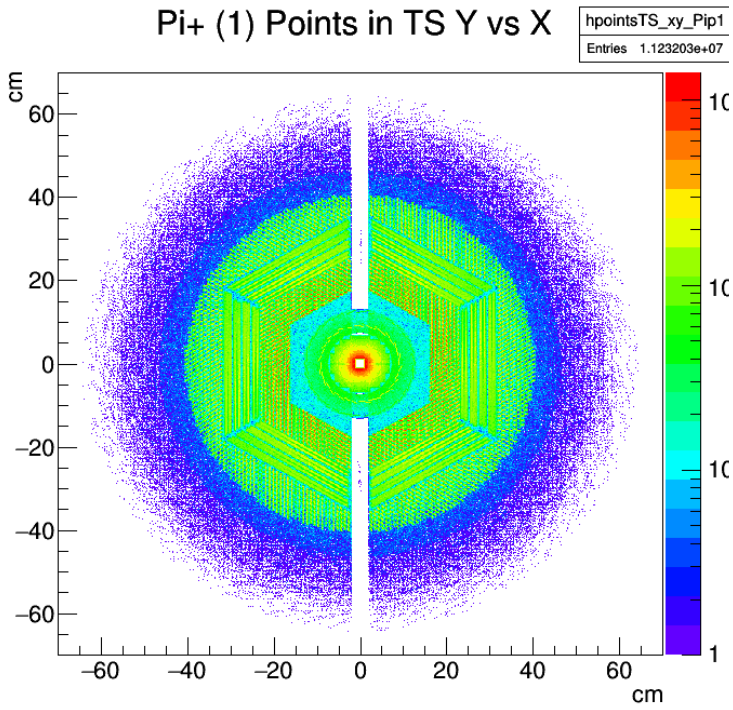
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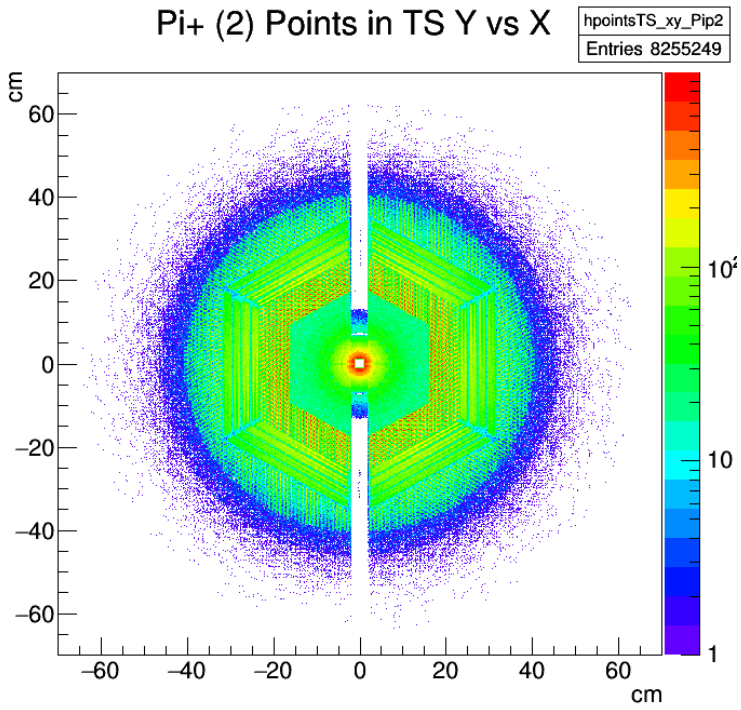
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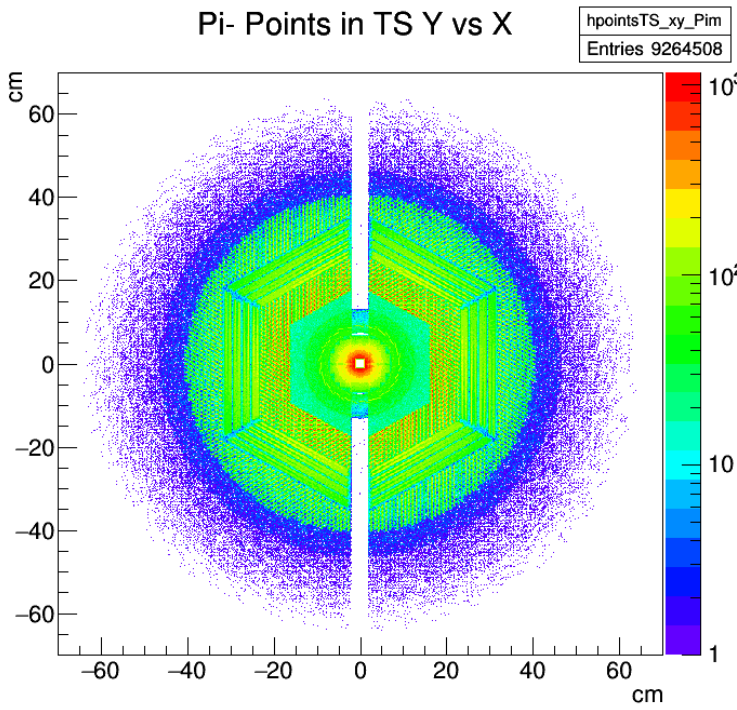
Pi- Points in TS Y vs X
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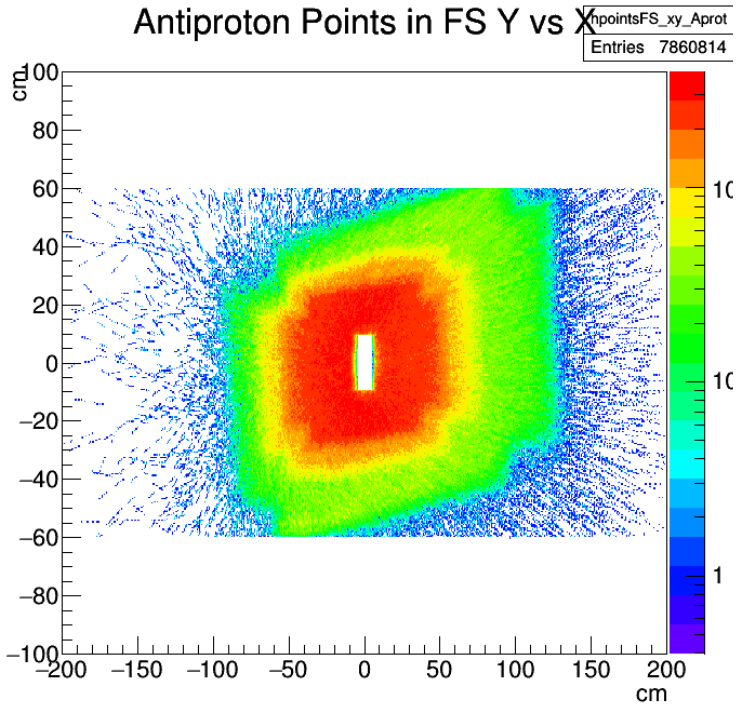
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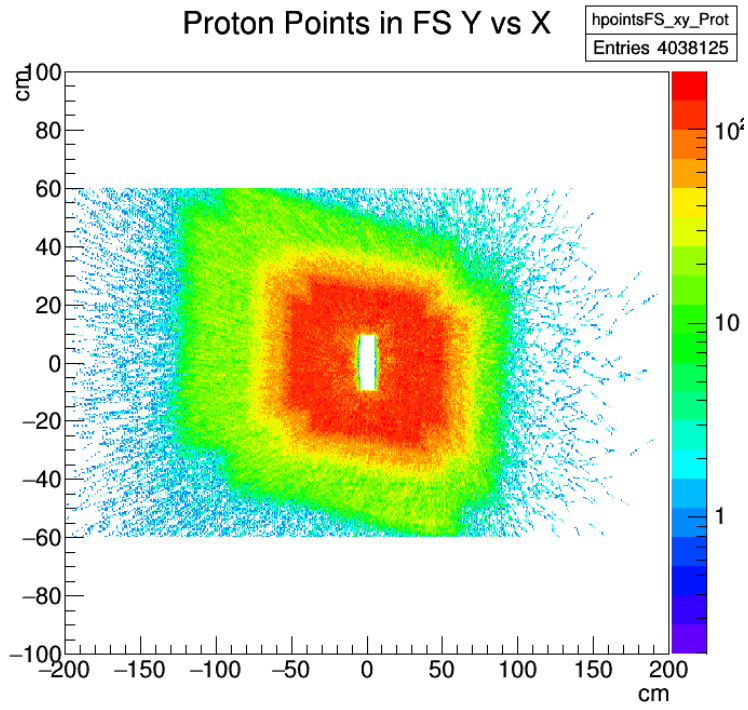
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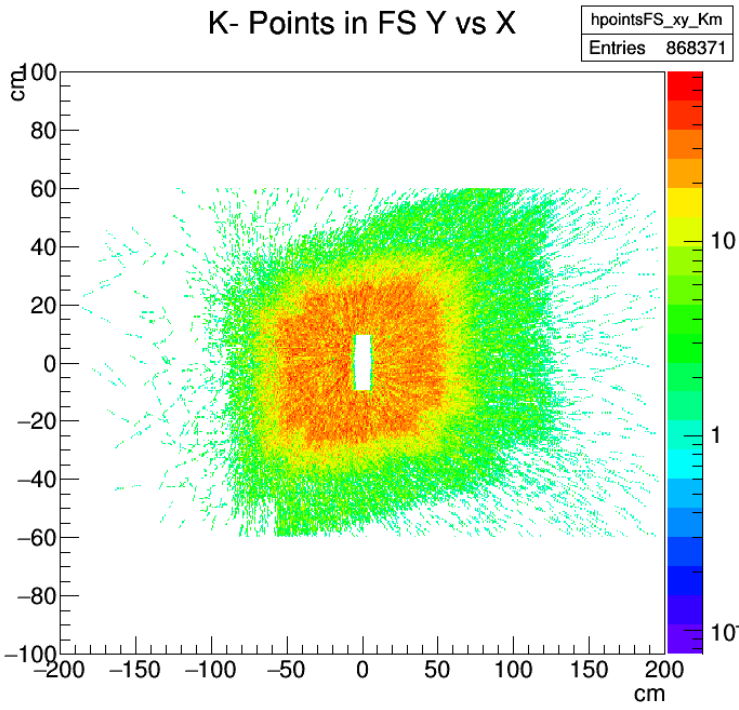
K- Points in FS Y vs X
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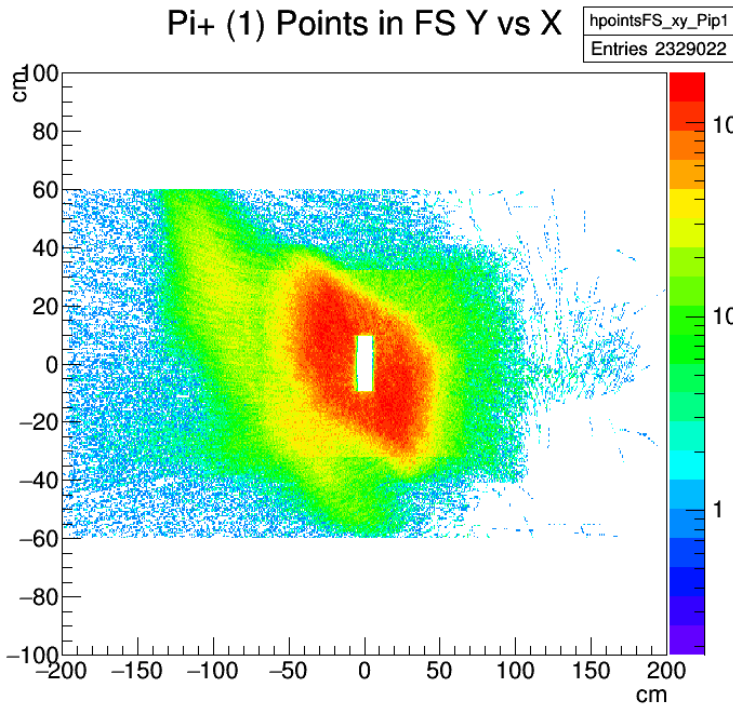
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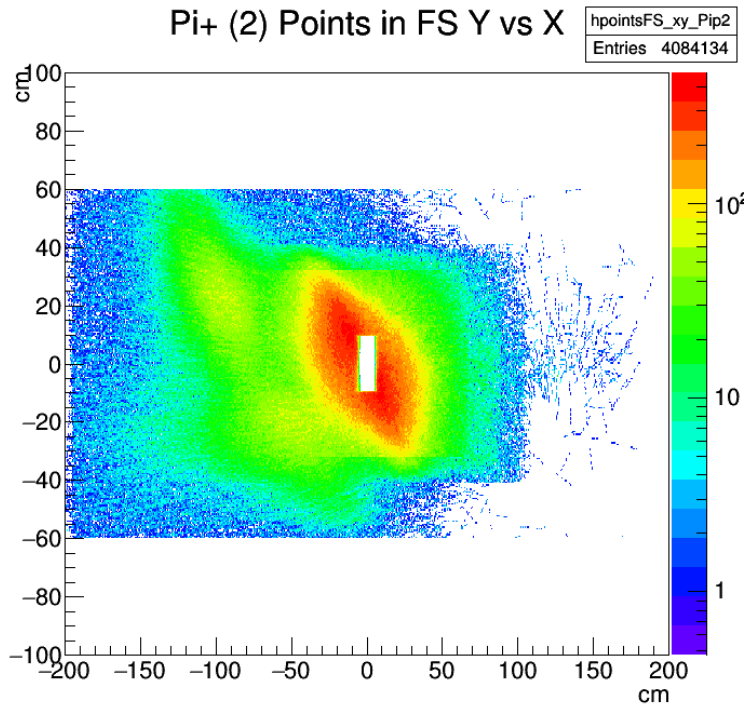
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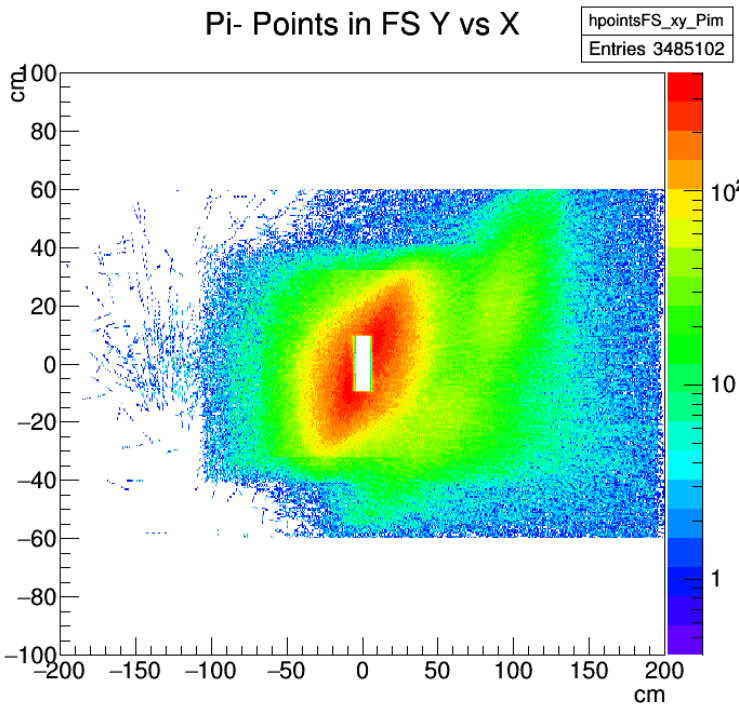
Pi- Points in FS Y vs X
hpointsFS_xy_Pim
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cm
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Summary Part I

- 40% of $\bar{p}$ have no hit in MVD, and 67% of $\bar{p}$ no hit in STT.
- except for K^-, all particles have high probability to hit the GEM detector.
- except for K^- (5%), the probability to hit the FTS is between 17% (π_1^+) and 42% ($\bar{p}$).
- if within the FTS acceptance, the transmission probability to FTS-6 is very high for p and $\bar{p}$ (96%), whereas losses are ~50% for pions.
- p and $\bar{p}$ do not extend the full x range of FTS-5,6

Part II: Modified EMC Acceptance

- Discussion to shift BWEC by 5 cm upstream → gap between Barrel and BWEC
- Discussion to remove the innermost layer of crystals → reduced θ_{max}
- ➢ Gap from $\theta = 142.0^o$ to $\theta = 151.2^o$, $\theta_{\max} = 167.4^o \rightarrow 165.9^o$
- Hyperon spectroscopy also needs to measure decay modes with neutrals: $\Xi^{*-} \rightarrow \pi^0\pi^0, \Xi^-\pi^0\pi^0, \Xi^-\eta$
- Photon detection is important !

Losses for selected channels

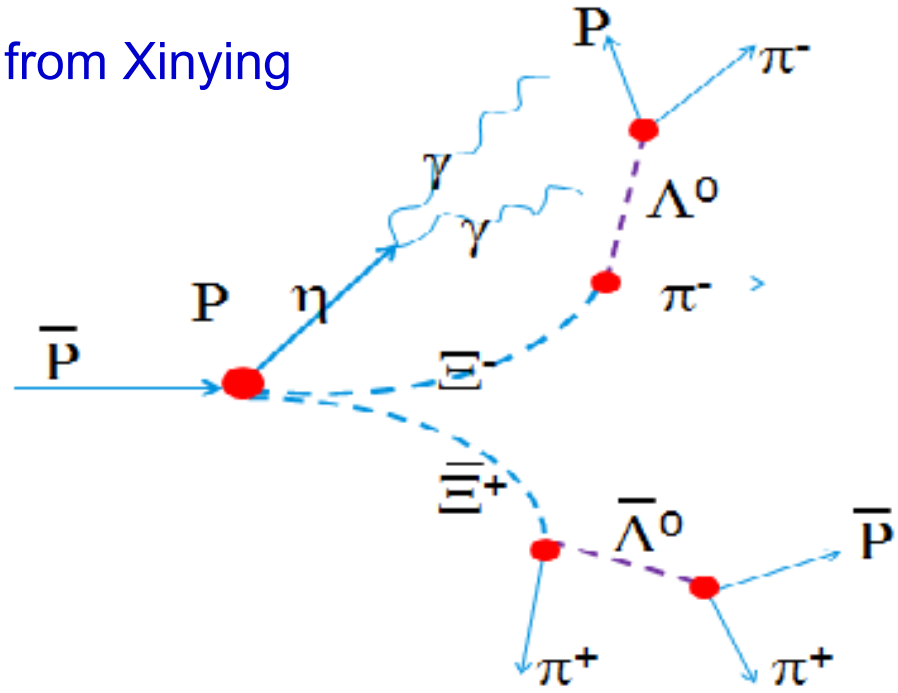
final state	p [GeV/c]	acc_{old} [%]	acc_{new}[%]	rel. loss[%]
$\Xi^-\bar{\Xi}^+\pi^0$	4.6	95.2	95.0	0.25
	5.0	95.0	94.8	0.23
$\Xi^-\bar{\Xi}^+\pi^0\pi^0$	4.6	90.6	90.1	0.49
	5.0	90.2	89.8	0.45
	5.5	89.6	89.2	0.42
$\Xi^-\bar{\Xi}^+\eta, \eta \to 2\gamma$	5.3	94.8	94.6	0.21
	6.0	94.4	94.2	0.19
	7.0	93.7	93.6	0.16

Summary Part II

- The acceptance loss caused by shifting the BWEC and removing the innermost crystal layer for the selected channels *is marginal* (<1%)

Part III: Longlived Charged Particles in EvtGen

from Xinying



- signal events usually generated by EvtGen up to the final state of the decay tree
- decay point of long-lived charged particles such as Ξ^- is chosen along a straight flight path
- in reconstruction of initial $\bar{p}p$ system, Ξ^- and $\bar{\Xi}^+$ are back propagated along a helix trajectory → no common vertex, different relative momenta

➢ the MC generated decay tree is inconsistent with initial $\bar{p}p$ 4-momentum !

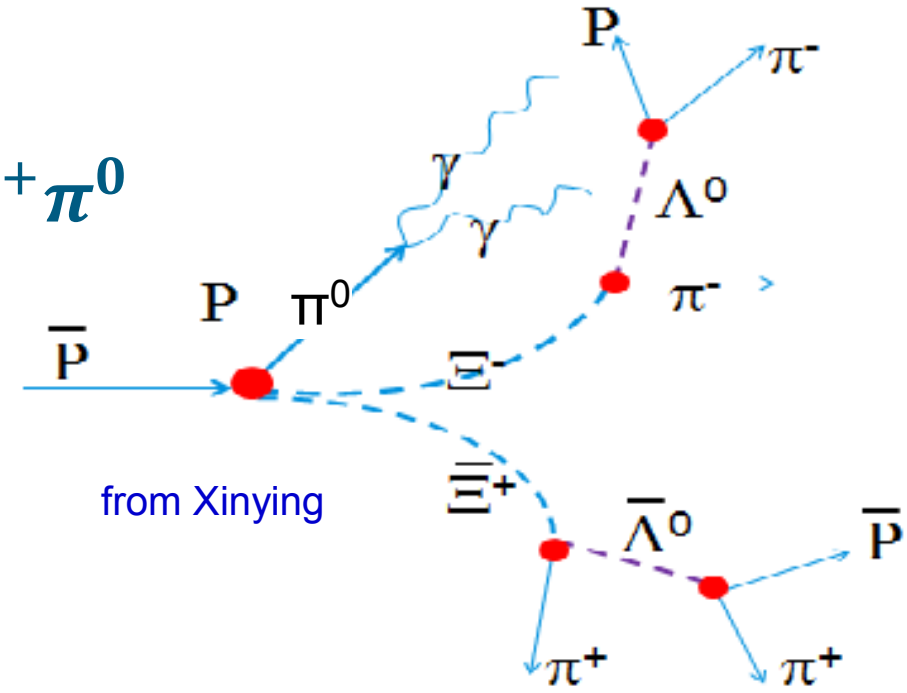
Possible Solution

- stop EvtGen at production of Ξ^- and $\bar{\Xi}^+$ and let them propagate and decay by GEANT3/4
  - either simulate all decay modes, or
  - modify the physics table of GEANT
- apply a correction matrix to transform position and momentum components at Ξ decay and downstream from “straight” to “helix”
- switch off the charge of Ξ^- and $\bar{\Xi}^+$ in vertex and kinematic fitters (I don’t like this)

Summary Part III

- This problem must be solved or proven that the error is marginal (which I don‘t believe)

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



from Xinying

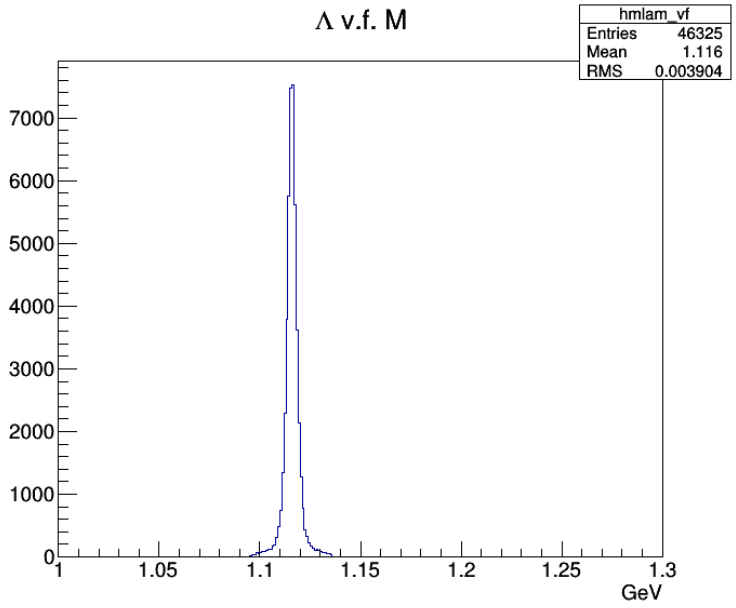
- 4.6 GeV/c $\bar{p}p \to \Xi^-\bar{\Xi}^+\pi^0$ (PHSP)
- $2 \cdot 10^5$ events simulated
- preliminary analysis of $1 \cdot 10^5$ events
- focus on reconstruction efficiency and momentum & position resolution
- charged and composite particles: MC truth matched (correct PID, correct mother)
- photons: include neutral candidates whose mother is a photon and whose grandmother is pbarpSystem

Reconstruction Efficiencies

reconstruction efficiencies in % :

p	$\bar{p}$	π^-	π^+	π^0	Λ	$\bar{\Lambda}$	Ξ^-	$\bar{\Xi}^+$	$\bar{p}p$
83.2	80.0	81.9	81.8	71.8	46.3	44.0	30.4	28.7	4.6

- note:
  - Ideal tracking, no condition on #hits yet
  - ideal PID
  - MC truth matching (correct mother)
- KinVtxFitter → vertex, KinFitter → M, 4CFitter → initial p4
- composite particles: significant loss due to mass & probability cut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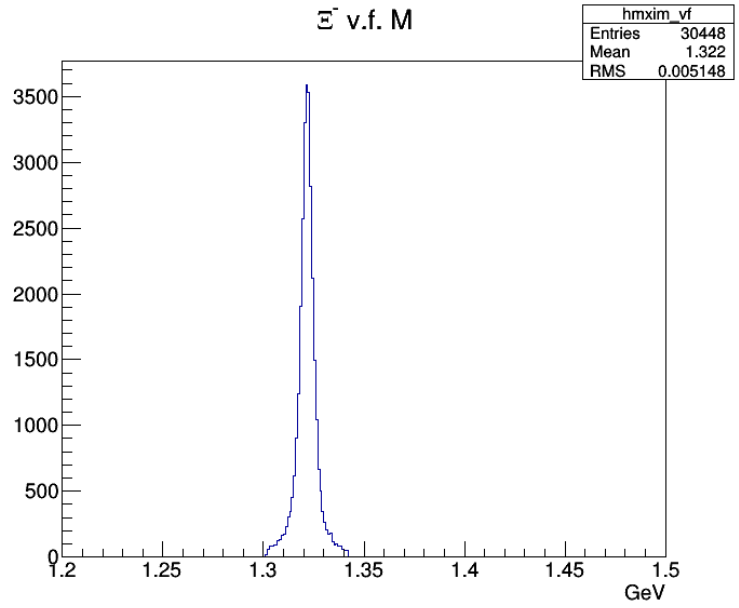
RMS 0.003904
GeV


Ξ⁻ v.f. M
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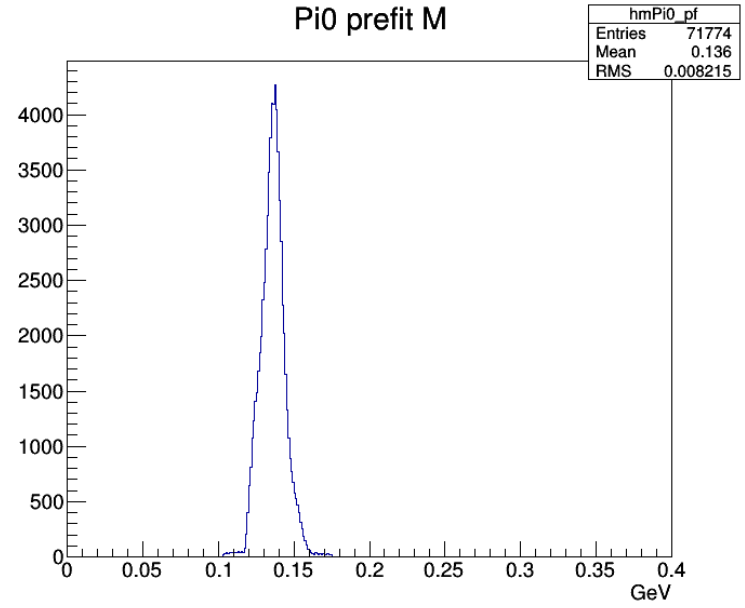
Pi0 prefit M
hmPi0_pf
Entries 71774
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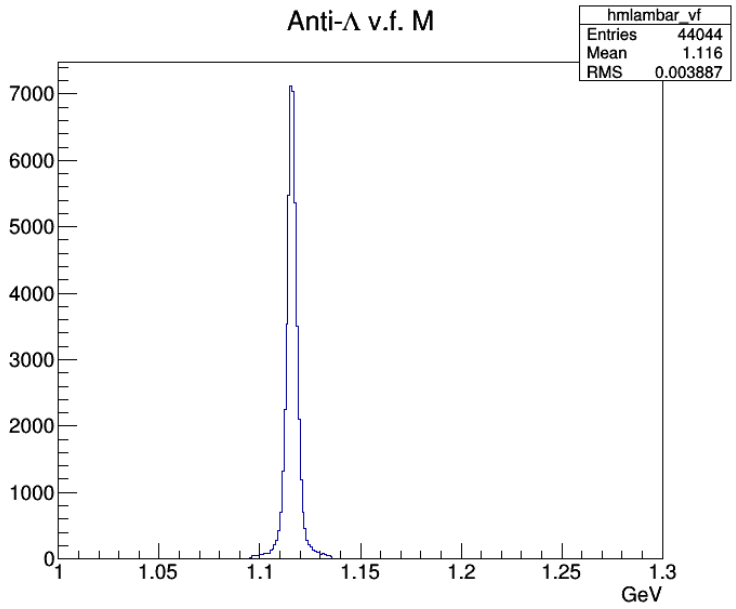
RMS 0.008215
GeV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RMS 0.003887
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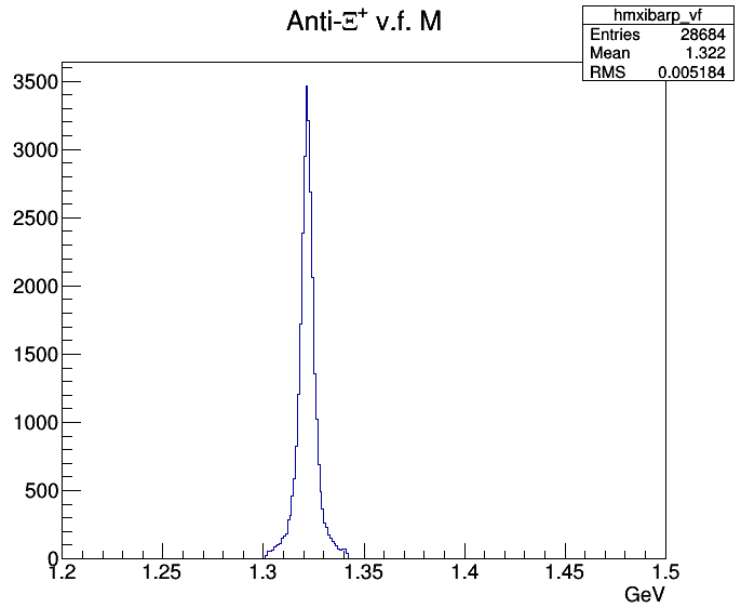
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hmxibarp_vf
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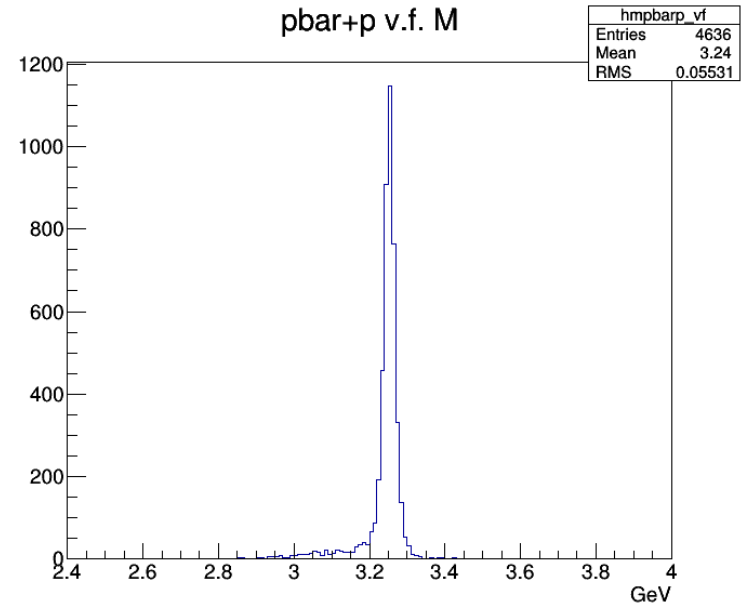
RMS 0.005184
GeV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hmpbarp_vf
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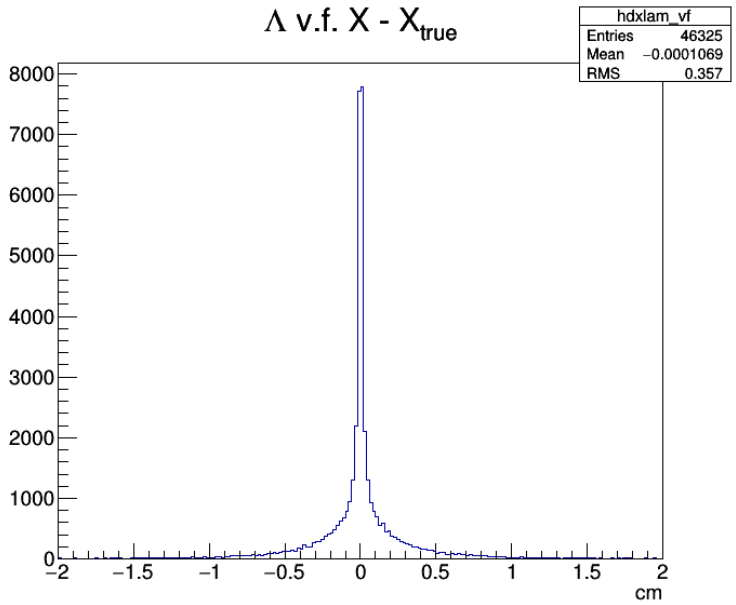
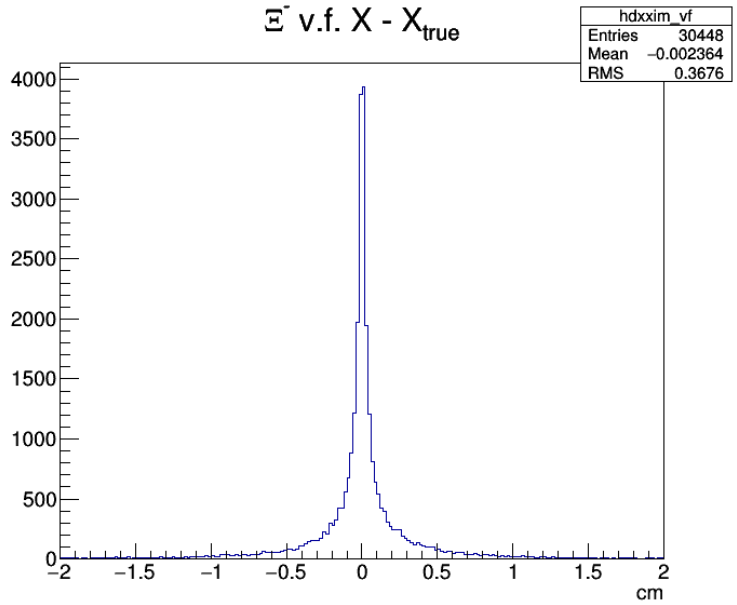
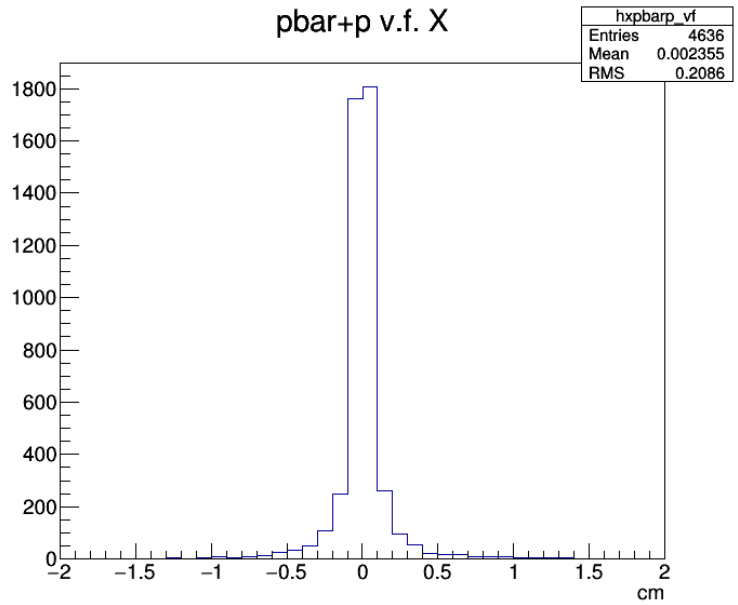
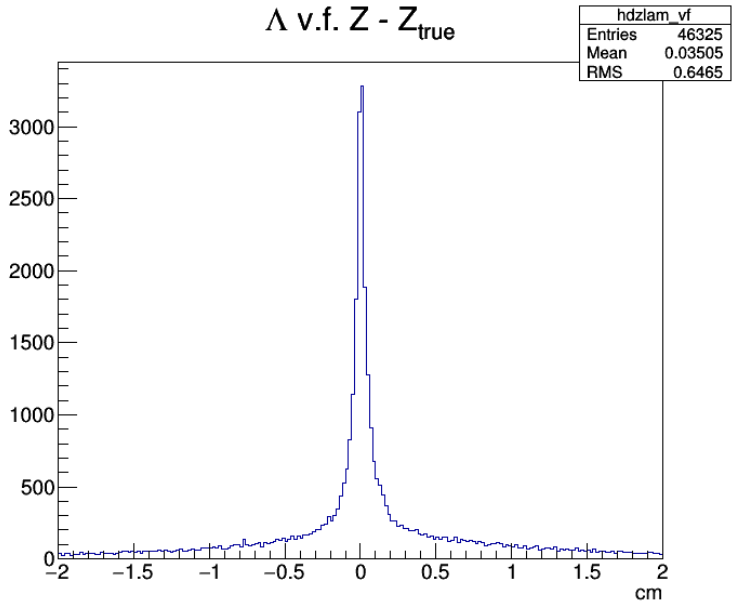
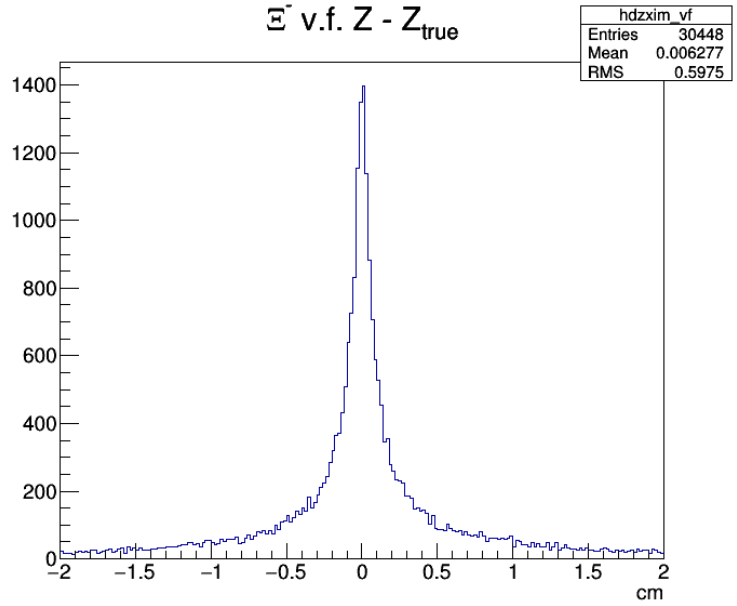
RMS 0.05531
GeV

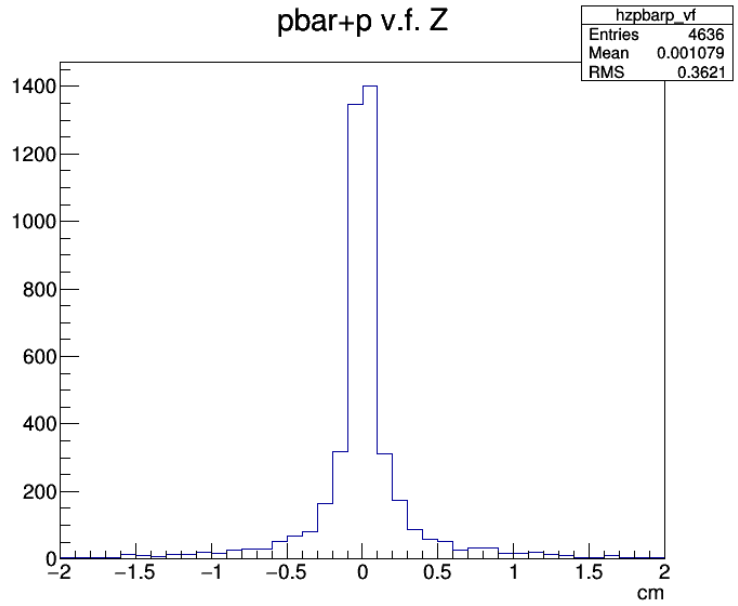

Λ v.f. X - X_true
hdxlam_vf
Entries 46325
Mean −0.0001069
RMS 0.357
cm

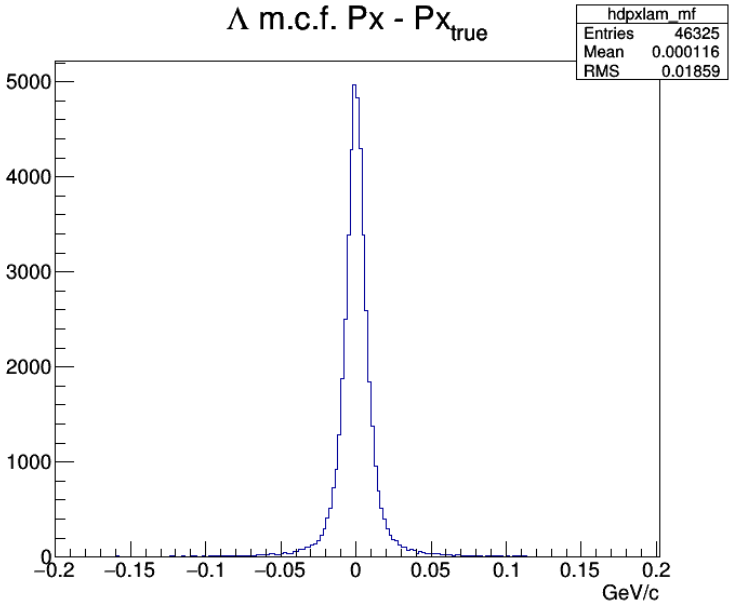

Ξ⁻ v.f. X - X_true
hdxxim_vf
Entries 30448
Mean −0.002364
RMS 0.3676
cm

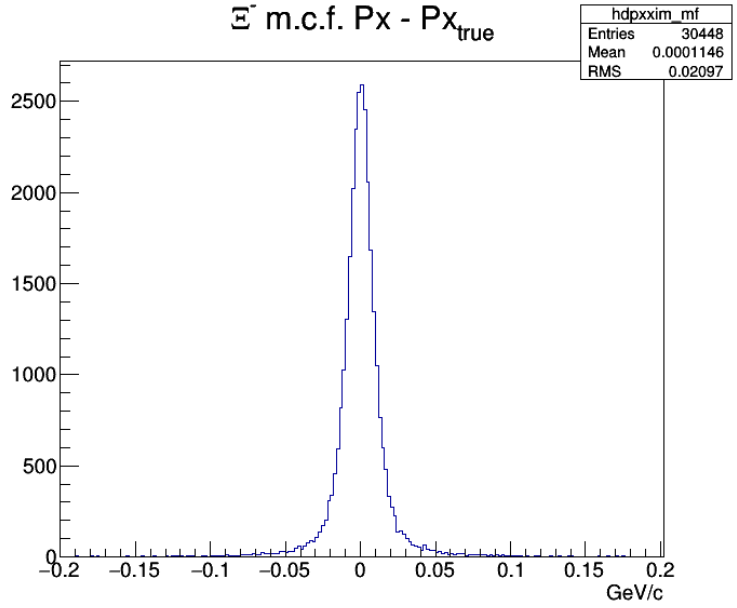

pbar+p v.f. X
hxpbarp_vf
Entries 4636
Mean 0.002355
RMS 0.2086
cm

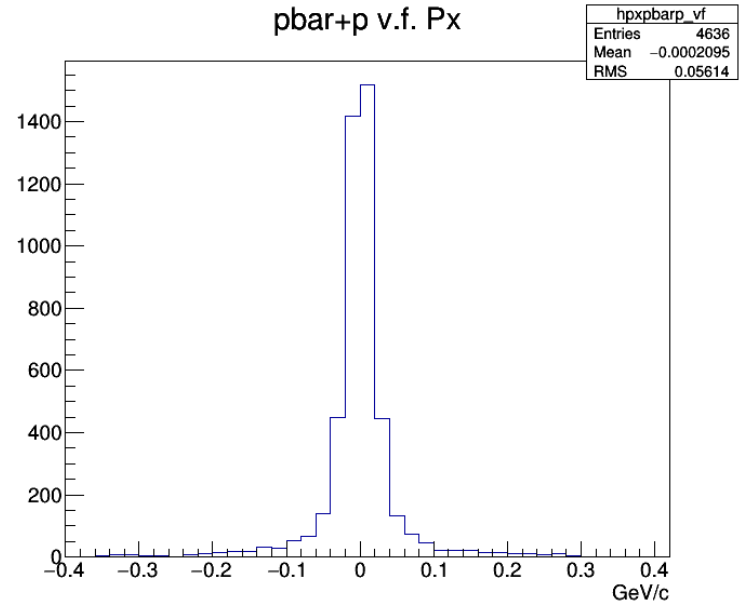

Λ v.f. Z - Z_true
hdzlam_vf
Entries 46325
Mean 0.03505
RMS 0.6465
cm

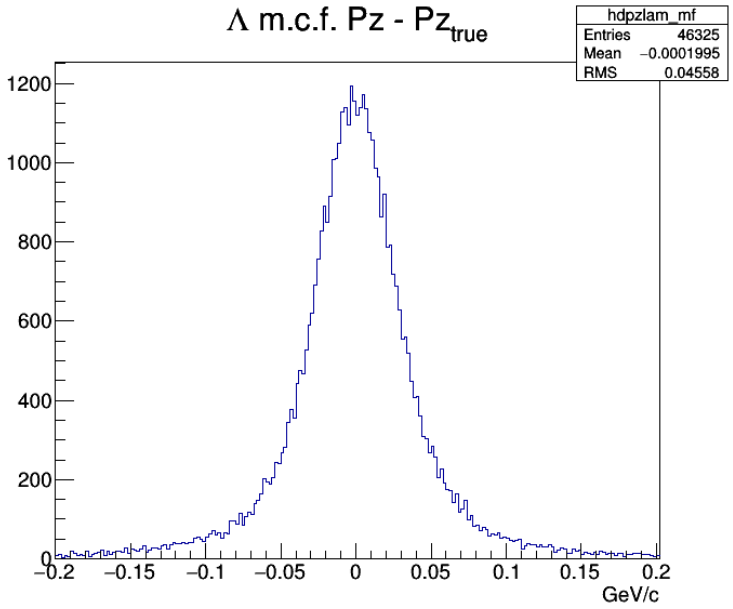

Ξ⁻ v.f. Z - Z_true
hdzxim_vf
Entries 30448
Mean 0.006277
RMS 0.5975
cm

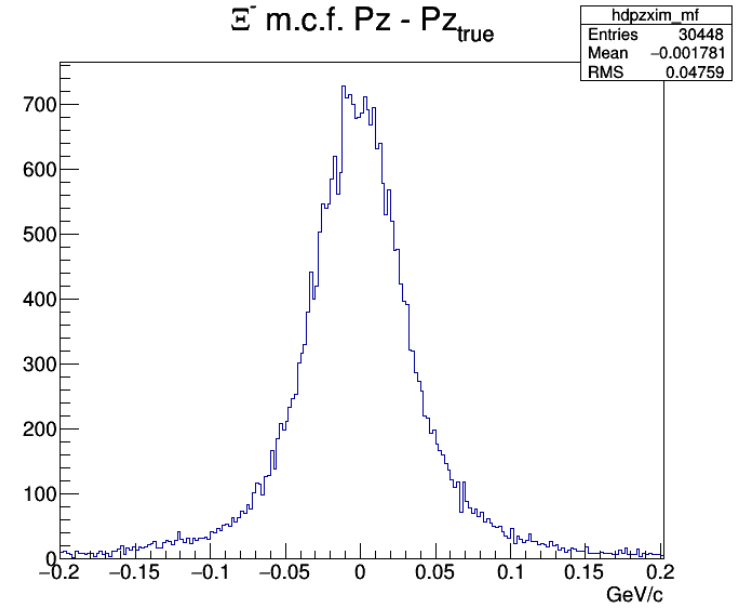

pbar+p v.f. Z
hzpbarp_vf
Entries 4636
Mean 0.001079
RMS 0.3621
cm

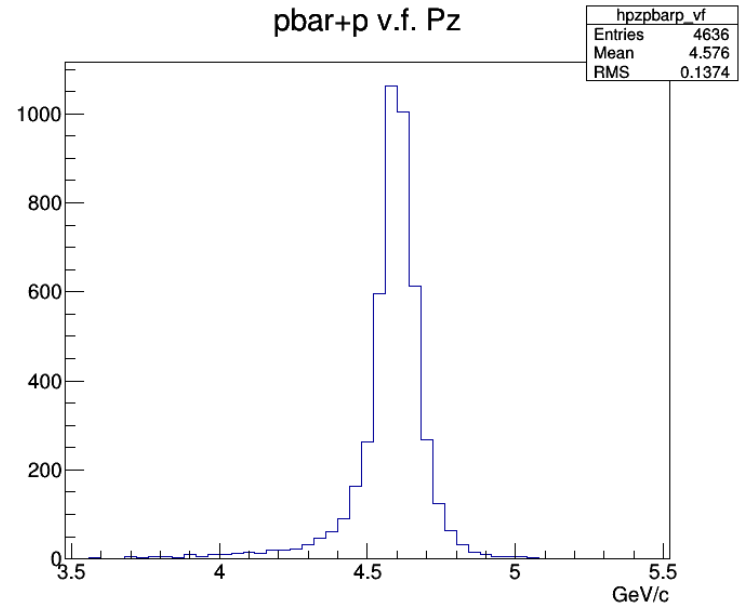

Λ m.c.f. Px - Px_true
hdpxlam_mf
Entries 46325
Mean 0.000116
RMS 0.01859
GeV/c

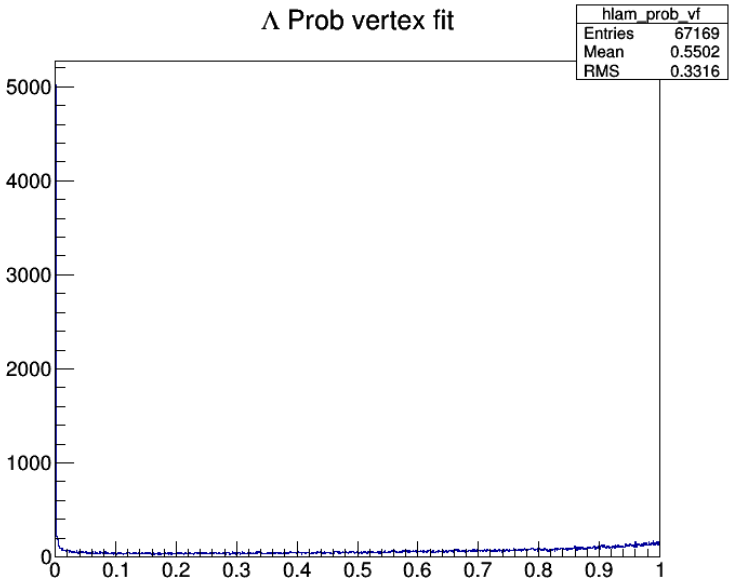

Ξ⁻ m.c.f. Px - Px_true
hdpxxim_mf
Entries 30448
Mean 0.0001146
RMS 0.02097
GeV/c

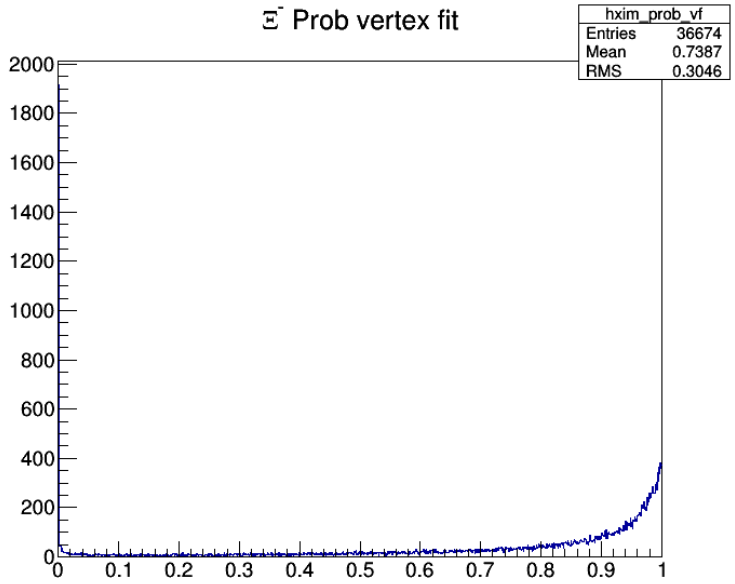

pbar+p v.f. Px
hpxpbarp_vf
Entries 4636
Mean −0.0002095
RMS 0.05614
GeV/c

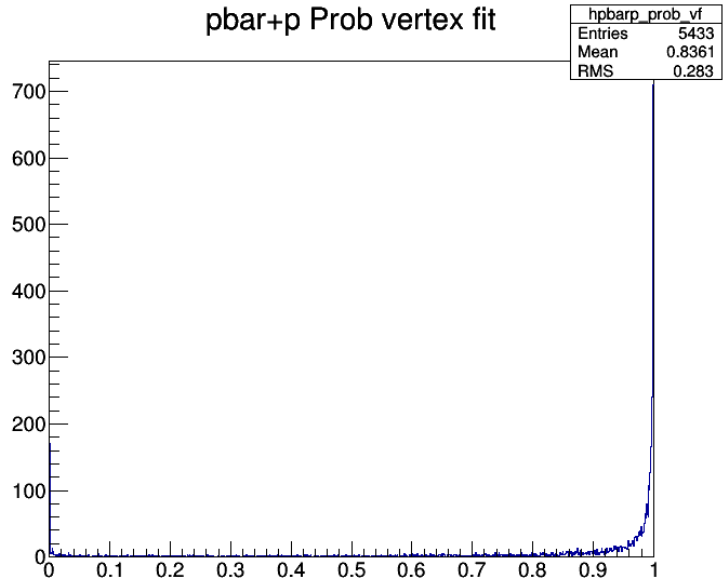

Λ m.c.f. Pz - Pz_true
hdpzlam_mf
Entries 46325
Mean −0.0001995
RMS 0.04558
GeV/c

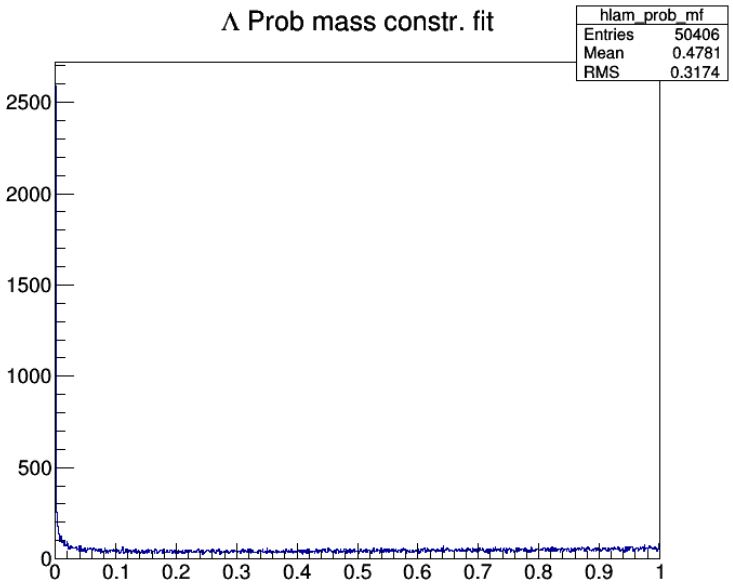

Ξ⁻ m.c.f. Pz - Pz_true
hdpzxim_mf
Entries 30448
Mean −0.001781
RMS 0.04759
GeV/c

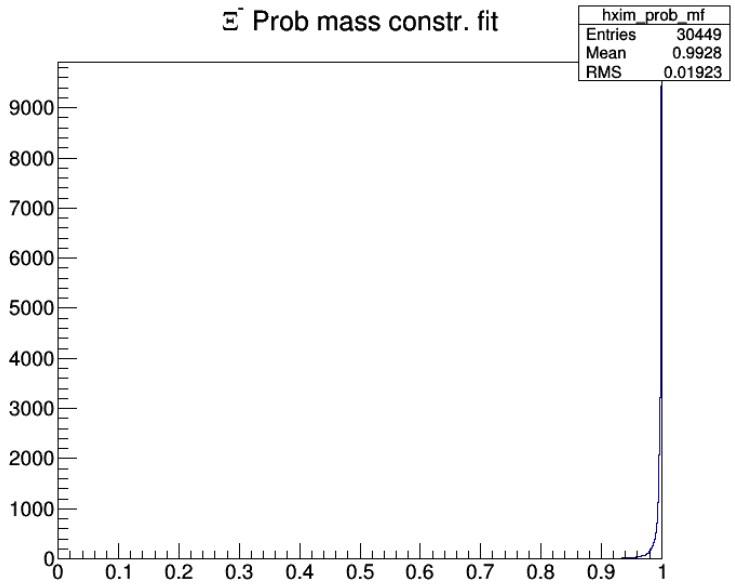

pbar+p v.f. Pz
hpzpbarp_vf
Entries 4636
Mean 4.576
RMS 0.1374
GeV/c

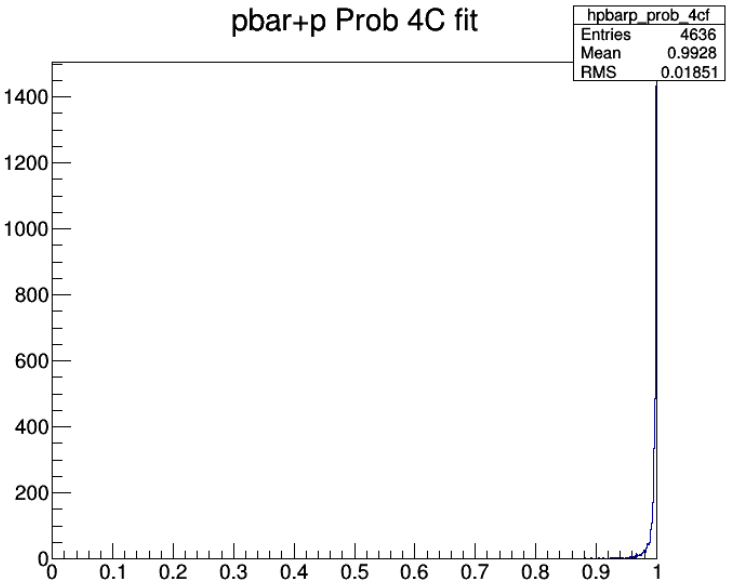

Λ Prob vertex fit
hlam_prob_vf
Entries 67169
Mean 0.5502
RMS 0.3316

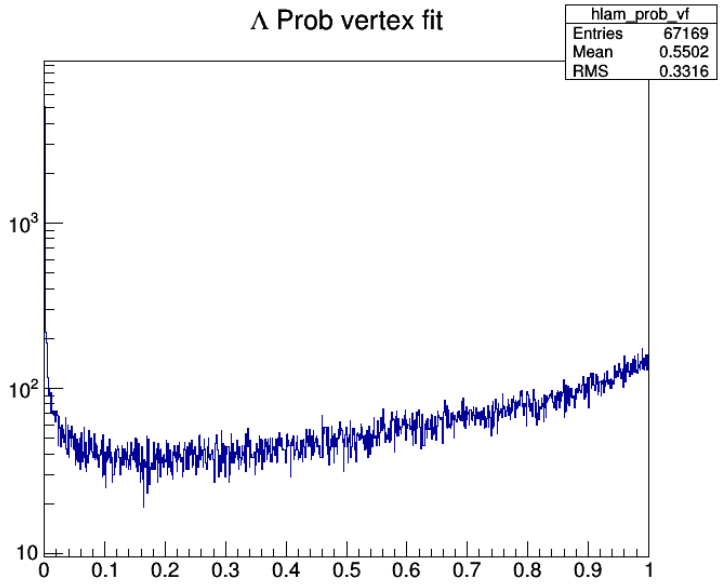

Ξ⁻ Prob vertex fit
hxim_prob_vf
Entries 36674
Mean 0.7387
RMS 0.3046

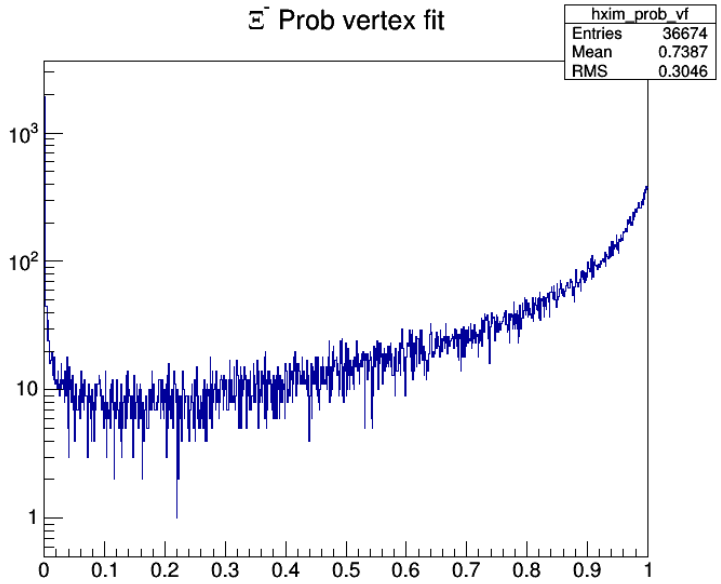

pbar+p Prob vertex fit
hpbarp_prob_vf
Entries 5433
Mean 0.8361
RMS 0.283

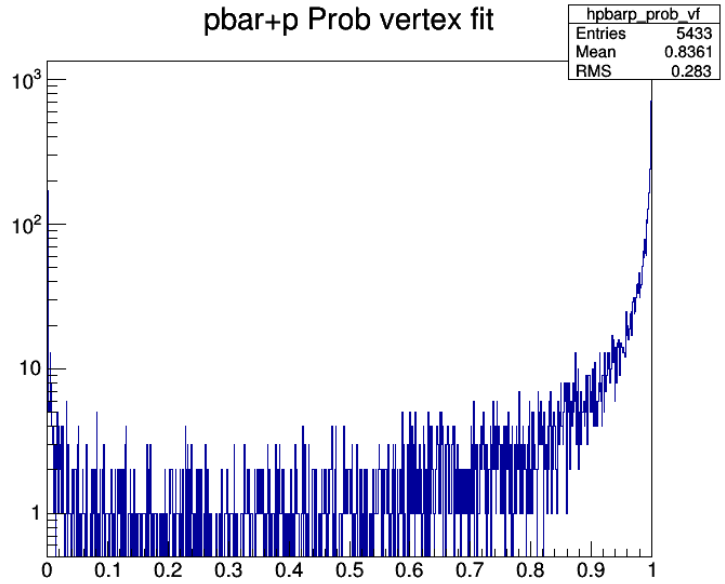

Λ Prob mass constr. fit
hlam_prob_mf
Entries 50406
Mean 0.4781
RMS 0.3174

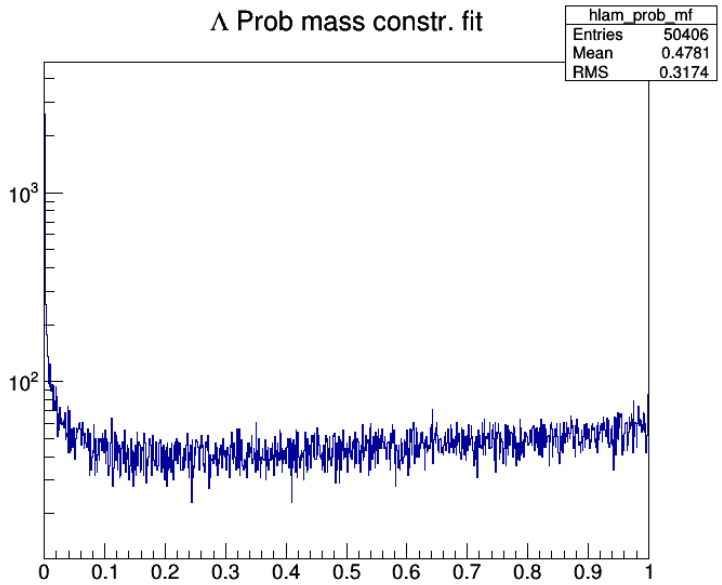

Ξ⁻ Prob mass constr. fit
hxim_prob_mf
Entries 30449
Mean 0.9928
RMS 0.01923

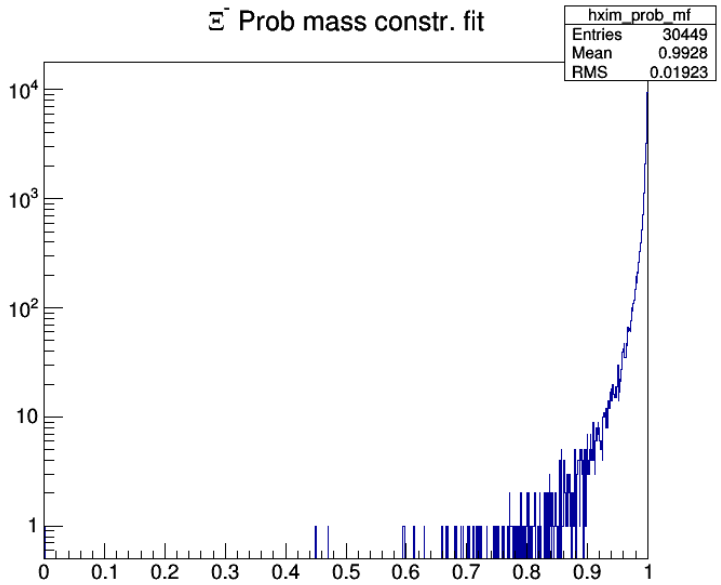

pbar+p Prob 4C fit
hpbarp_prob_4cf
Entries 4636
Mean 0.9928
RMS 0.01851

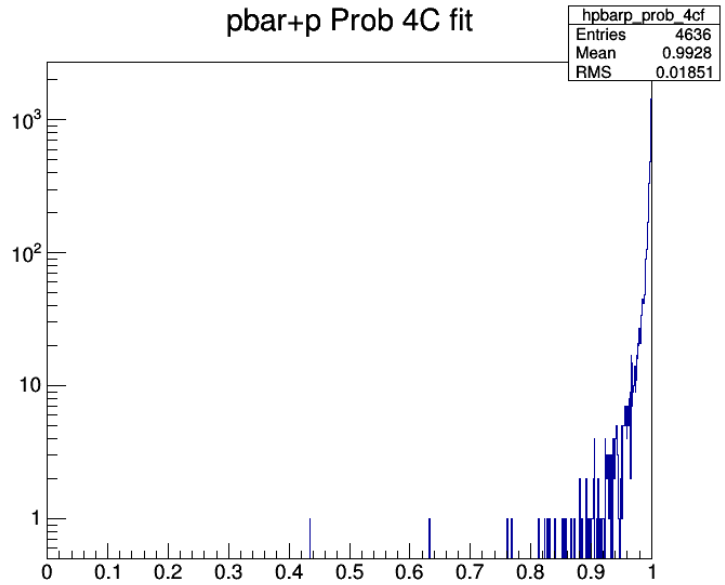

Λ Prob vertex fit
hlam_prob_vf
Entries 67169
Mean 0.5502
RMS 0.3316

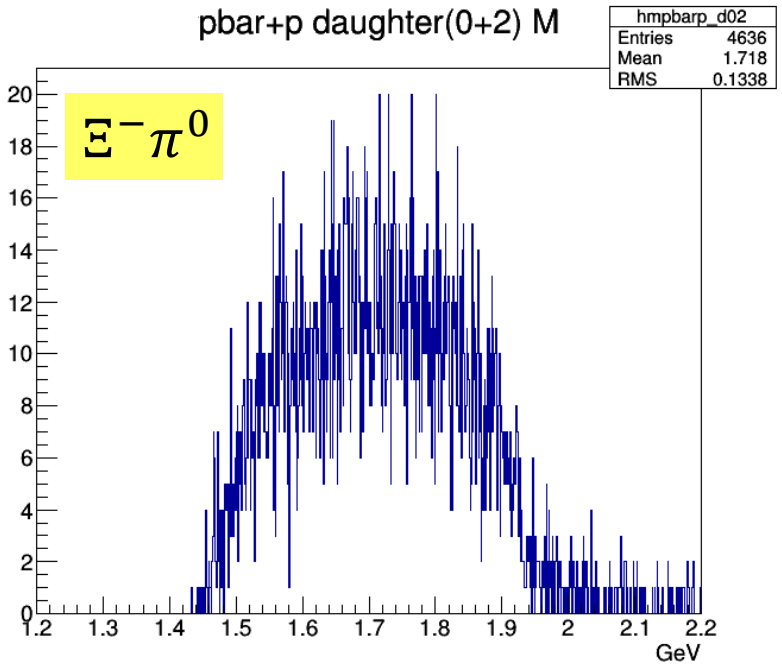

Ξ⁻ Prob vertex fit
hxim_prob_vf
Entries 36674
Mean 0.7387
RMS 0.3046

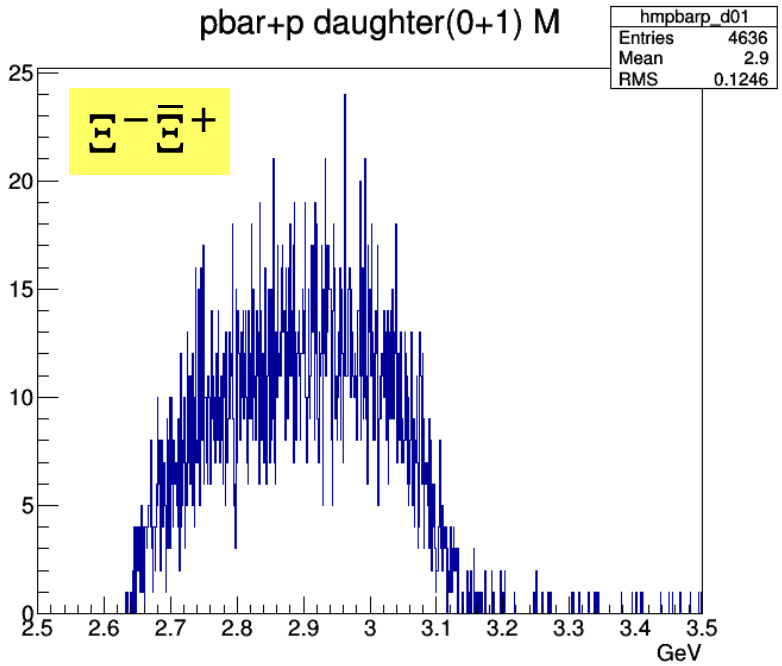

pbar+p Prob vertex fit
hpbarp_prob_vf
Entries 5433
Mean 0.8361
RMS 0.283

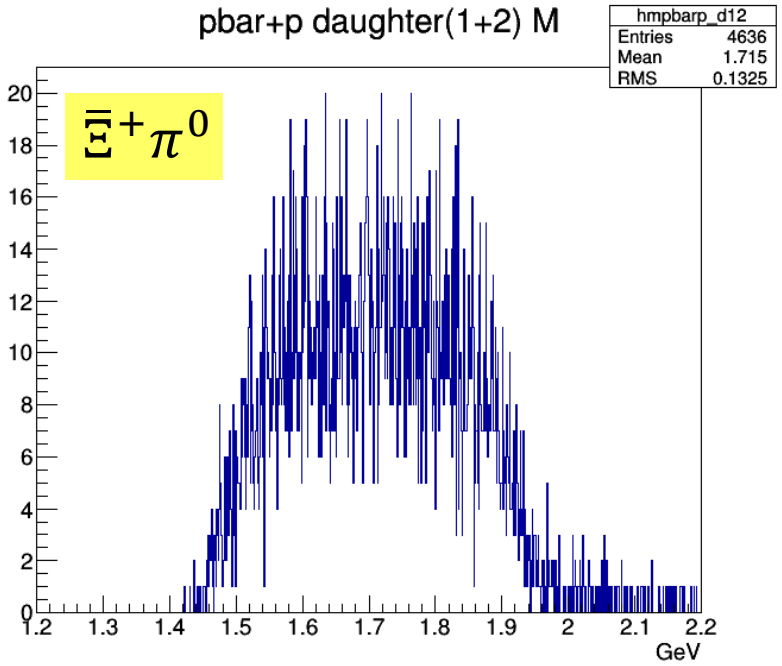

Λ Prob mass constr. fit
hlam_prob_mf
Entries 50406
Mean 0.4781
RMS 0.3174


Ξ⁻ Prob mass constr. fit
hxim_prob_mf
Entries 30449
Mean 0.9928
RMS 0.01923


pbar+p Prob 4C fit
hpbarp_prob_4cf
Entries 4636
Mean 0.9928
RMS 0.01851







- entries in unphysical region above the kinematic limit
- 4C fitter does not conserve masses of composite particles in decay tree

Summary Part IV

- 10^5 events of $\bar{p}p \to \Xi^-\bar{\Xi}^+\pi^0$ analyzed, results still very preliminary
- problems in vertex and kinematic fitting of complex decay tree including neutral particles:
  - inappropriate usage
  - improper functionality
- significant contribution of e^+, e^- in neutral candidates to π^0 yield (~44% → ~72%)
- to do: test Decay Tree Fitter, add required #hits per track, realistic PID