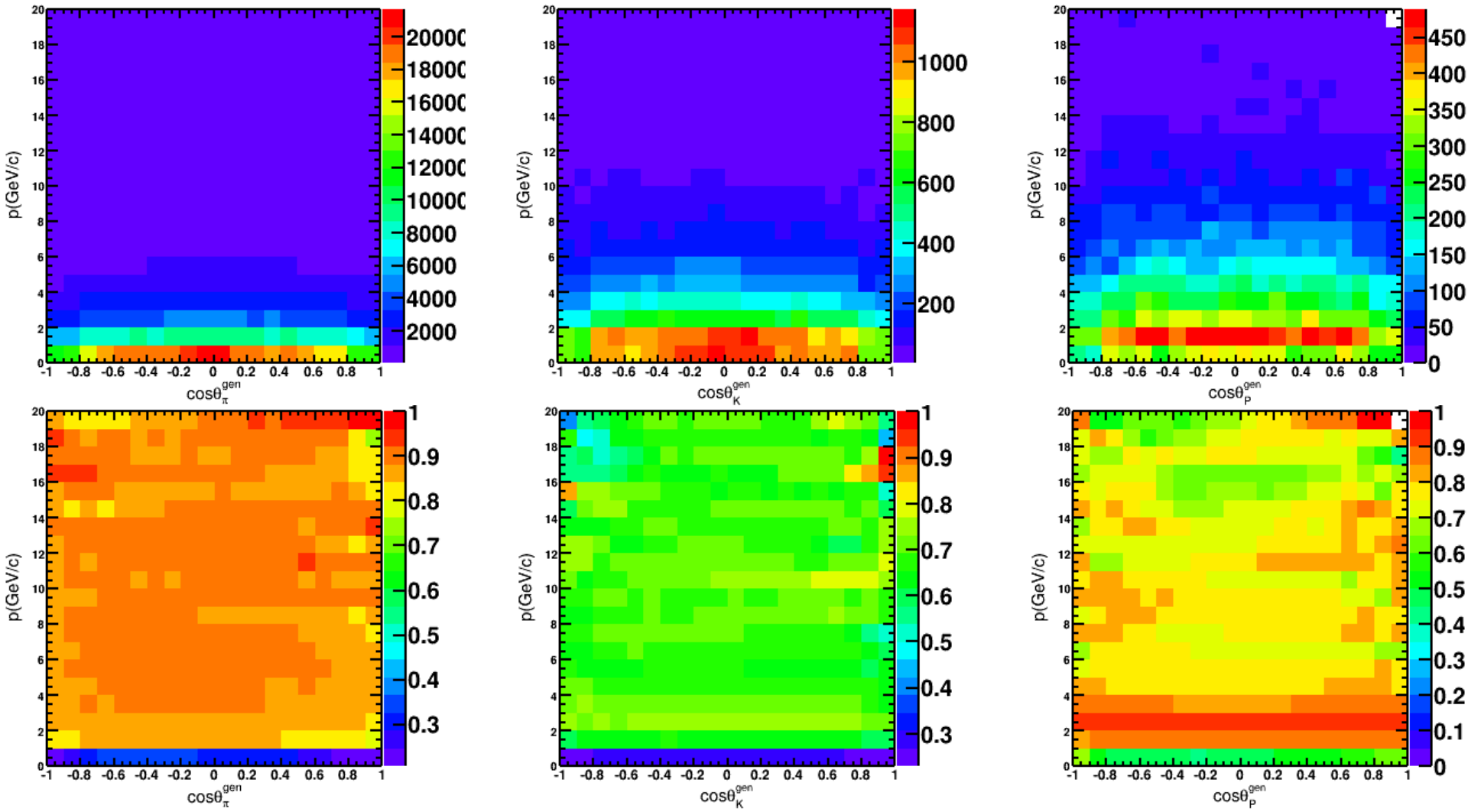
PID efficiency study

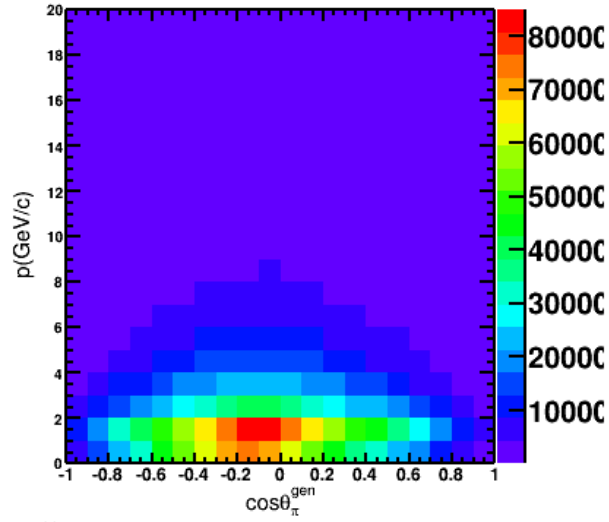
- Perform efficiency study in physical process $ZH \to \nu\nu gg$
  - Modify TofRecAlg based on previous code for particlegun's single particle
  - Calculate efficiency and purity in all phase space using minimum χ^2 PID
- Apply optimal cut with maximum efficiency times purity
  - Use real $\chi_{\mathrm{TPC}}(i \to K)$ to do optimal cut j.nima.2022.167835
  - Use ideal gaussian functions ($\sqrt{2}$ × separation power, 1) to do integrals
- Samples used
  - Release version: CEPCSW_tdr24.10.0
  - single $\pi/K/p$ samples at $p(1-10\mathrm{GeV})$ and $\theta(45^\circ)$, (10000) events generated by ParticleGun
  - $ZH \to \nu\nu gg$ 24200 events (π: K: p = 751889: 82220: 44497)

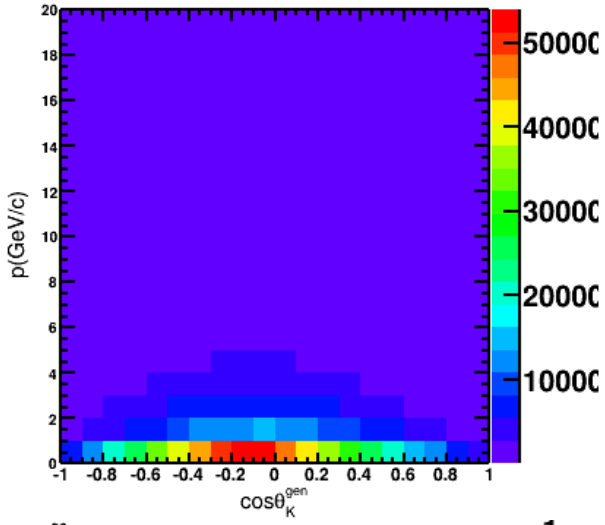
Efficiency study in physical process $ZH \to \nu\nu gg$

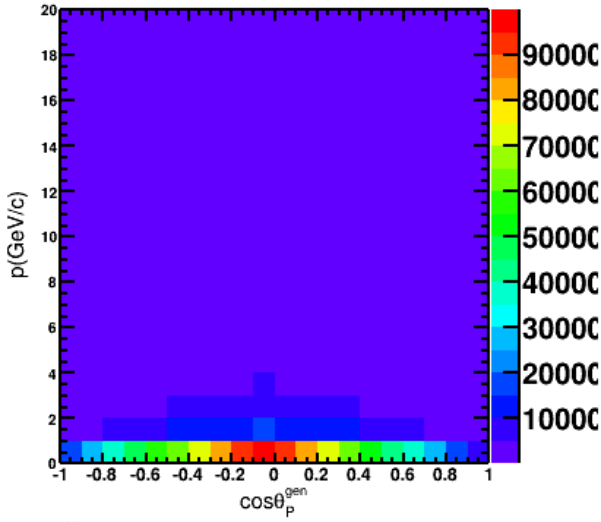


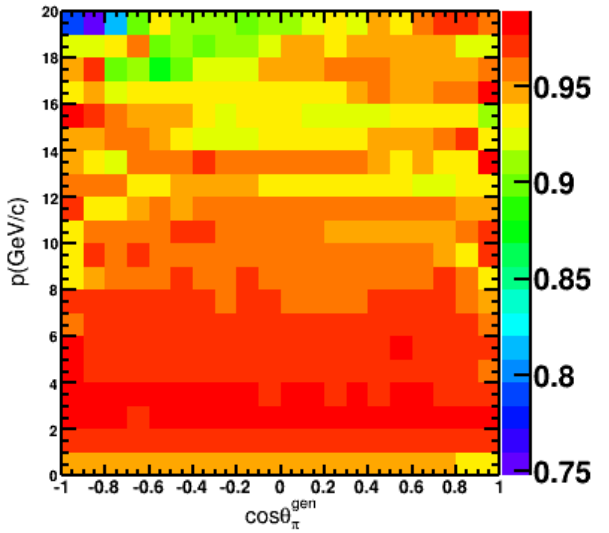
- Phase space ($p_{\mathrm{gen}}, \cos\theta_{\mathrm{gen}}$) and efficiency distribution of truth $\pi/K/p$

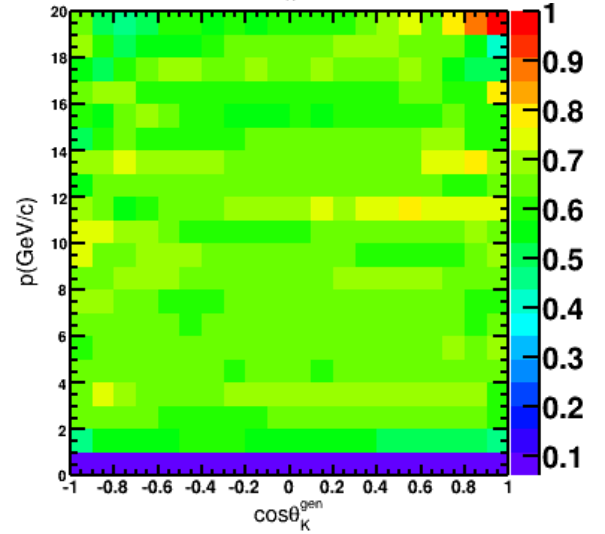
Efficiency study in physical process $ZH \rightarrow \nu\nu gg$

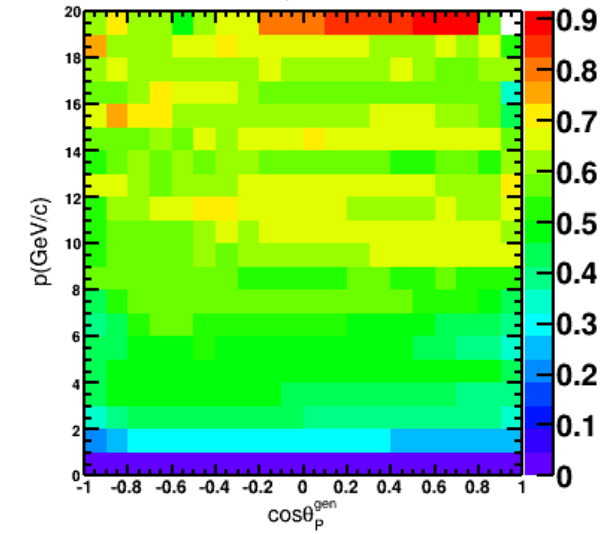






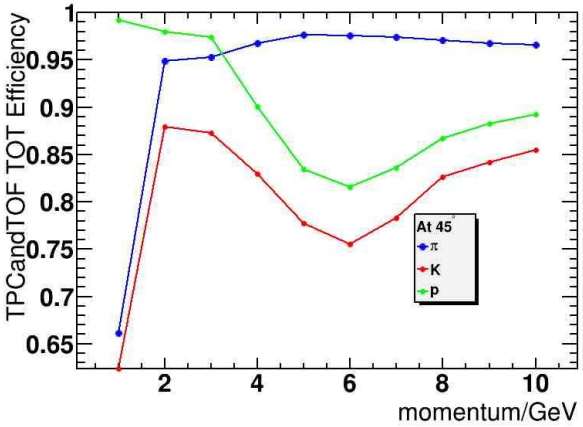


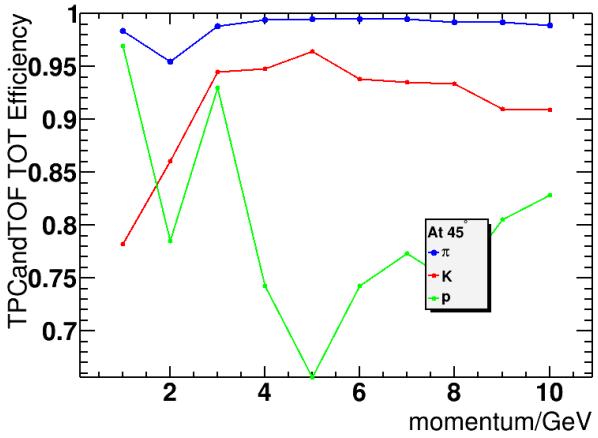


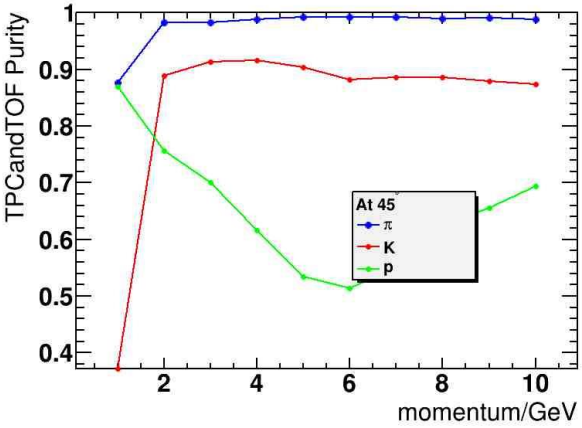


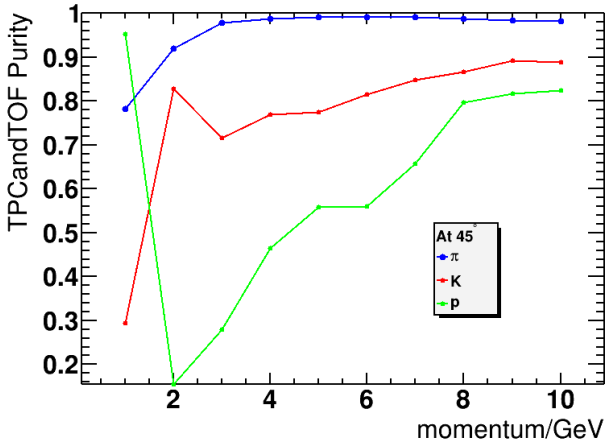
- Phase space ($p_{\mathrm{gen}}, \cos\theta_{\mathrm{gen}}$) and purity distribution of reco $\pi/K/p$

Comparison of optimal cut results and former results







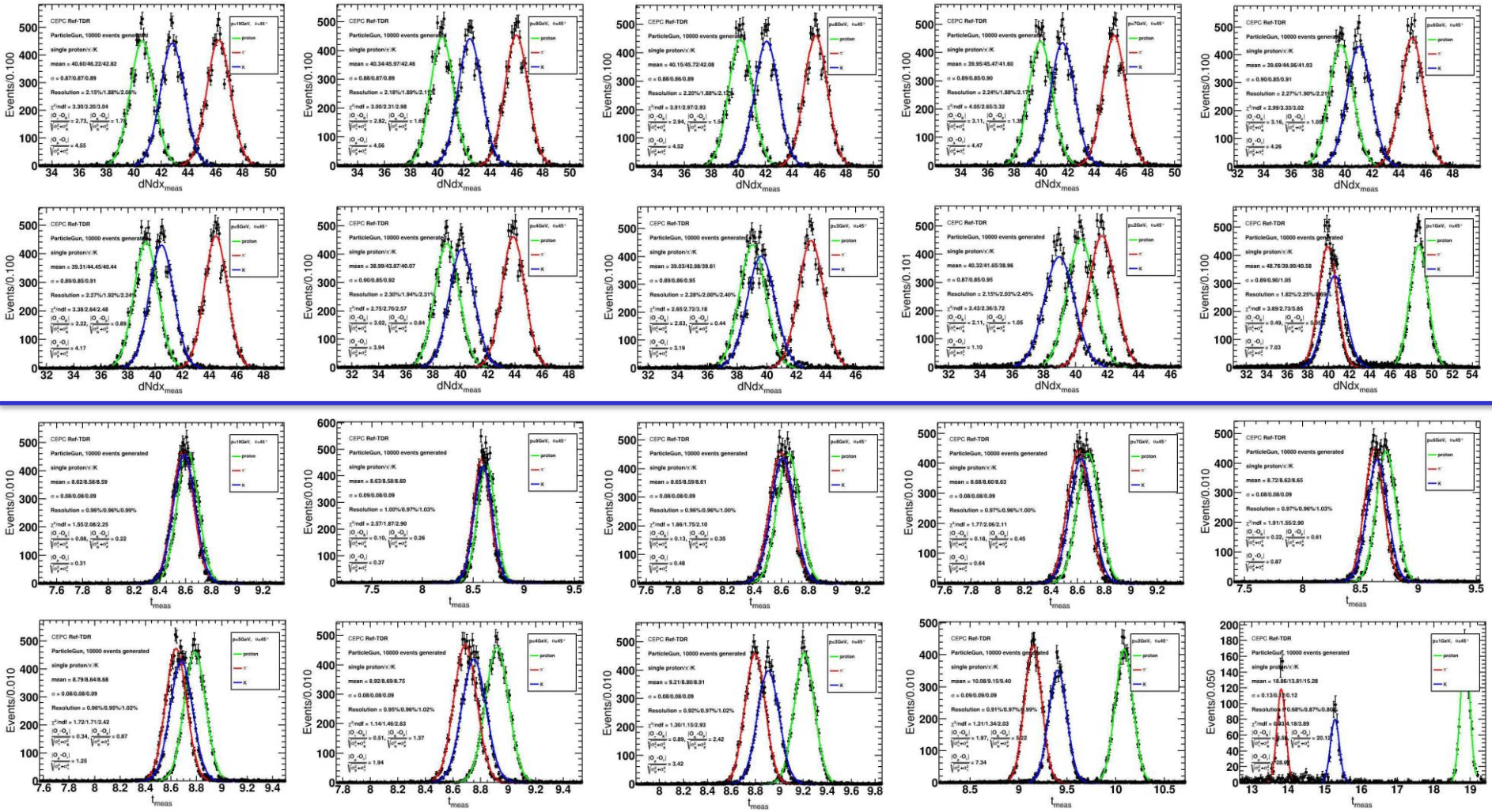


former efficiency and purity

optimal cut results

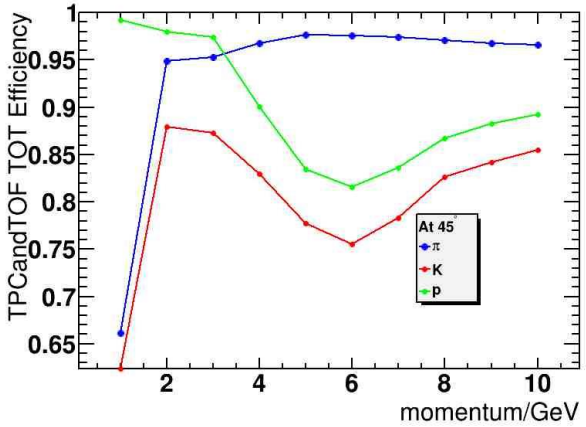
- Optimal cut maximizes efficiency times purity for $\chi_{TPC}(i \to K)$ distribution to select K
- Former results choose the minimum combined χ^2 to select K

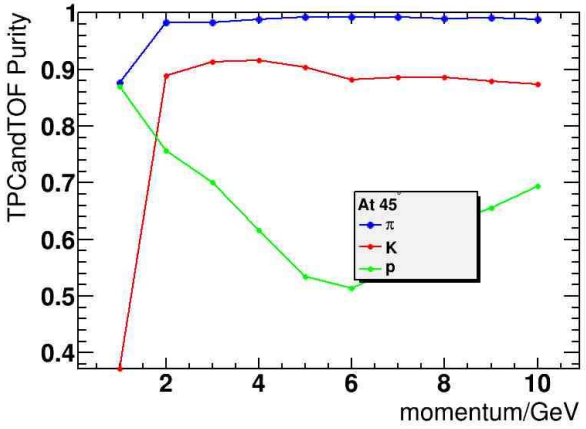
Separation powers



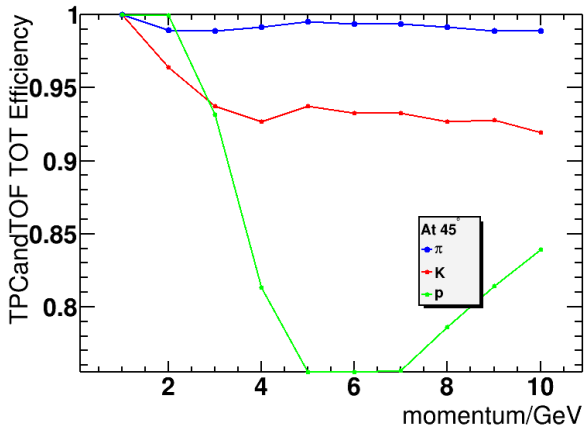
- Separation powers $O_{AB} = \dfrac{|A-B|}{\sqrt{\sigma_A^2+\sigma_B^2}}$ combined $\sqrt{O_{AB,\,\mathrm{TPC}}^2 + O_{AB,\,\mathrm{TOF}}^2}$

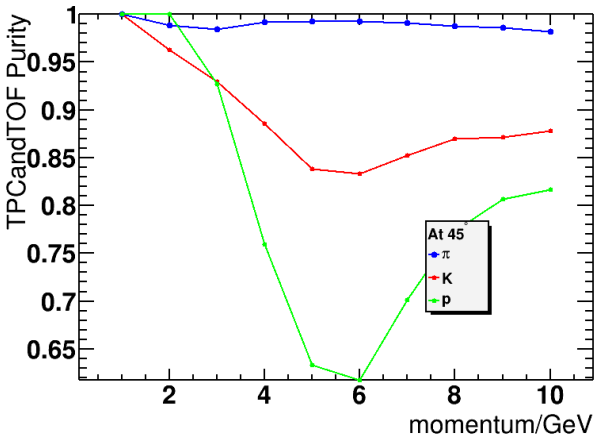
Comparison of optimal cut results and former results





former efficiency and purity





optimal cut results

- Optimal cut just calculate the expected efficiency and purity as the article did
  - Can't get ideal combined χ
- Former results choose the minimum combined χ^2 to select K

Backup

$$\chi_{\mathrm{TPC}}(i) = \frac{(dN/dx)_{\mathrm{meas}} - (dN/dx)^{i}_{\mathrm{exp}}}{\sigma_{(dN/dx)_{\mathrm{meas}}}}, i = \pi/K/p$$

$$\chi_{\mathrm{TOF}}(i) = \frac{t_{\mathrm{meas}} - t^{i}_{\mathrm{exp}}}{\sigma_{t_{\mathrm{meas}}}}, \sigma_{t_{\mathrm{meas}}} = \sqrt{0.05^2 + 0.02^2}$$

$$\chi^2(i) = \chi^2_{\mathrm{TOF}}(i) + \chi^2_{\mathrm{TPC}}(i)$$

$$\chi(i) = \sqrt{\chi^2(i)}$$

$$\mathrm{Efficiency}_{\mathrm{tot}}(i) = \mathrm{Efficiency}_{\mathrm{trk}}(i) \times \mathrm{Efficiency}_{\mathrm{PID}}(i)$$

$$\mathrm{Efficiency}_{\mathrm{trk}}(i) = \frac{N_i^{\mathrm{reco}}}{N_i^{\mathrm{gen}}}$$

$$\mathrm{Efficiency}_{\mathrm{PID}}(i) = \frac{N_i^{\mathrm{reco}}\left(\chi^2(i) < \chi^2(j)\right)}{N_i^{\mathrm{reco}}} (j \neq i)$$

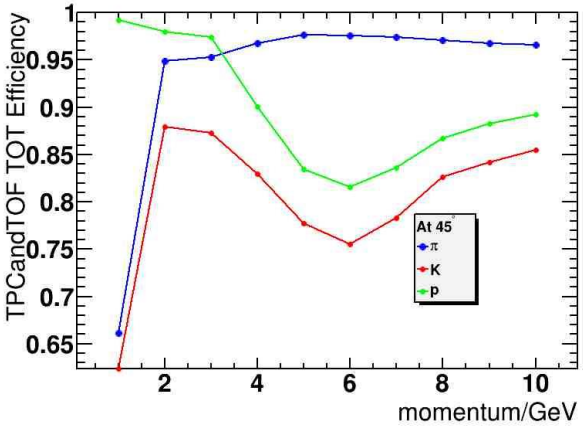
$$\mathrm{purity}(K) = \frac{N_{K\to K}}{N_{K\to K} + N_{\pi\to K} + N_{p\to K}}$$

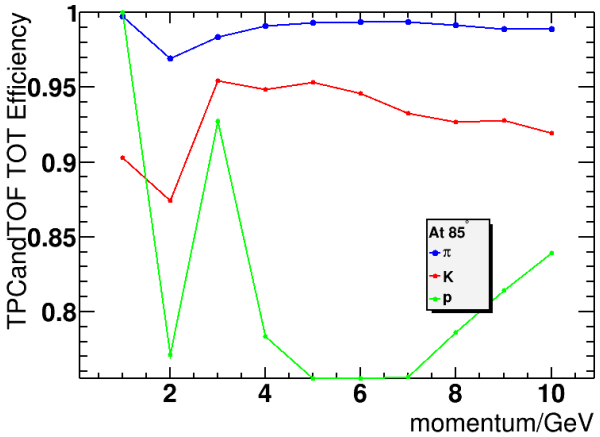
$$= \frac{3 \times \mathrm{Efficiency}_{K\to K}}{3 \times \mathrm{Efficiency}_{K\to K} + 10 \times \mathrm{Efficiency}_{\pi\to K} + 1 \times \mathrm{Efficiency}_{p\to K}}$$

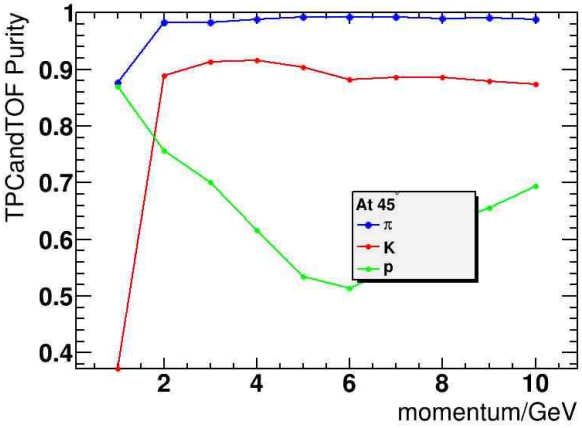
$$\mathrm{Efficiency}_{\mathrm{opti.\ PID}}(i) = \frac{N_i^{\mathrm{reco}}(a < \chi(i \to i) < b)}{N_i^{\mathrm{reco}}}$$

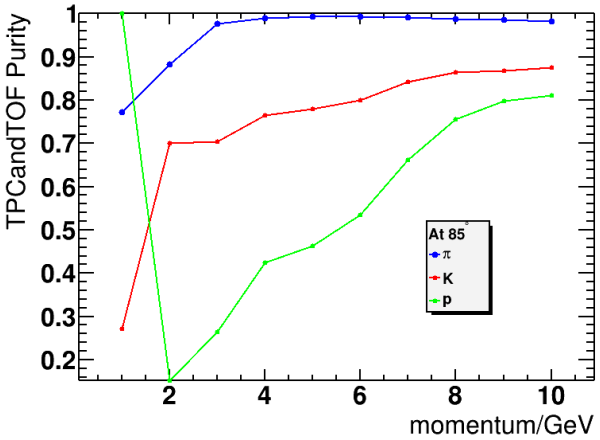
$$\mathrm{purity}_{\mathrm{opti.}}(K)$$

Comparison of optimal cut results and former results







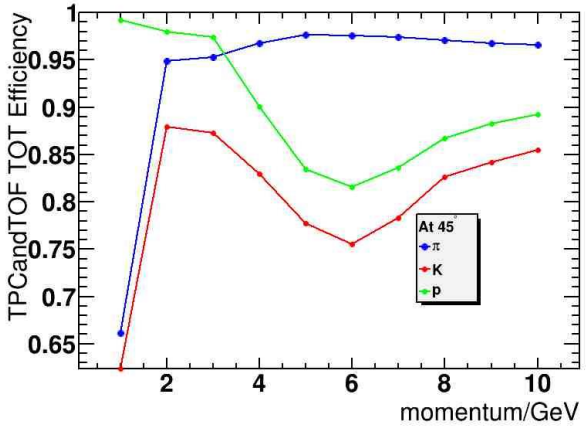


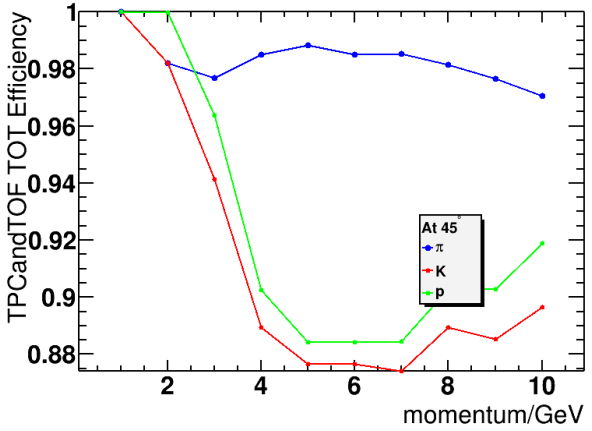
former efficiency and purity

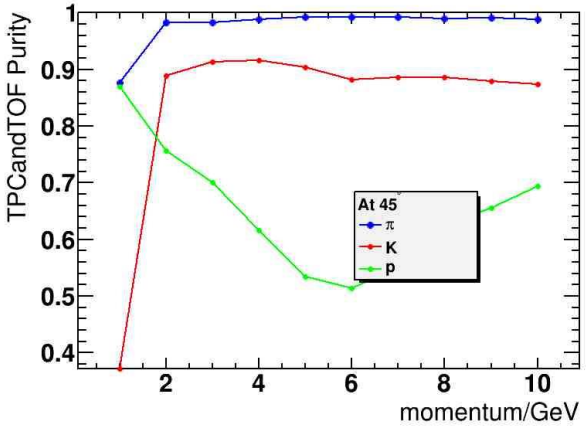
optimal cut results

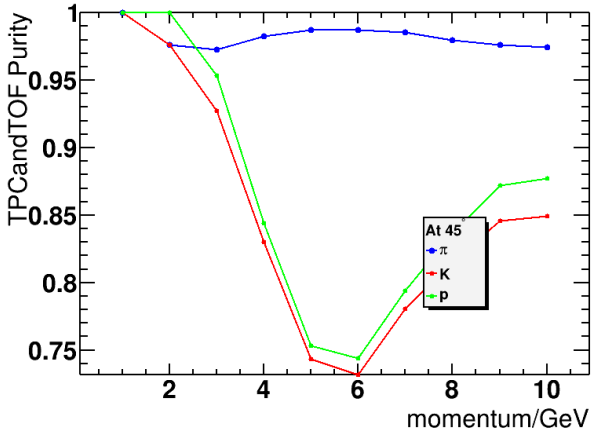
- Optimal cut just calculate the expected efficiency and purity as the article did but using TPC only
- Former results choose the minimum combined χ^2 to select K

Comparison of optimal cut results and former results







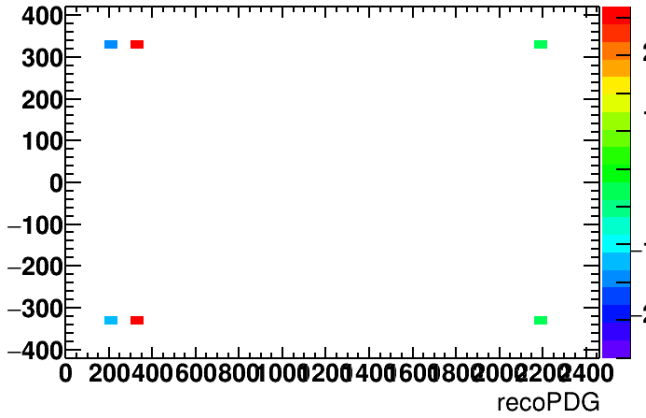


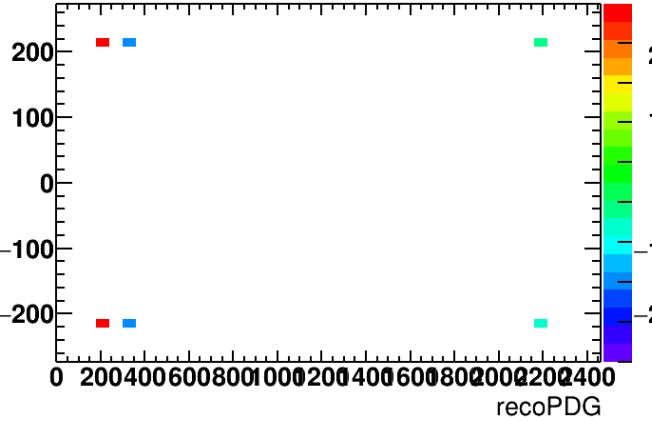
former efficiency and purity

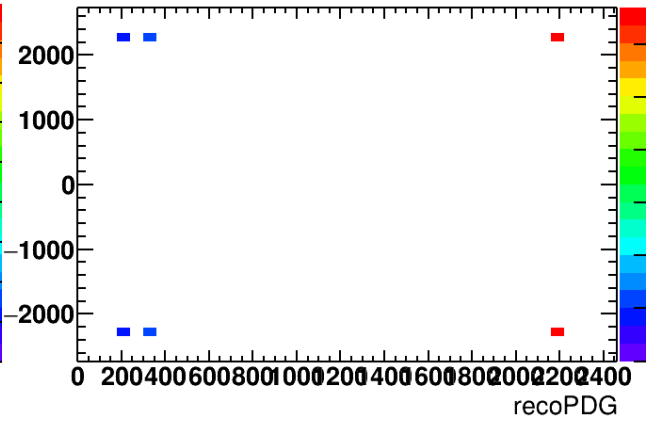
optimal cut results

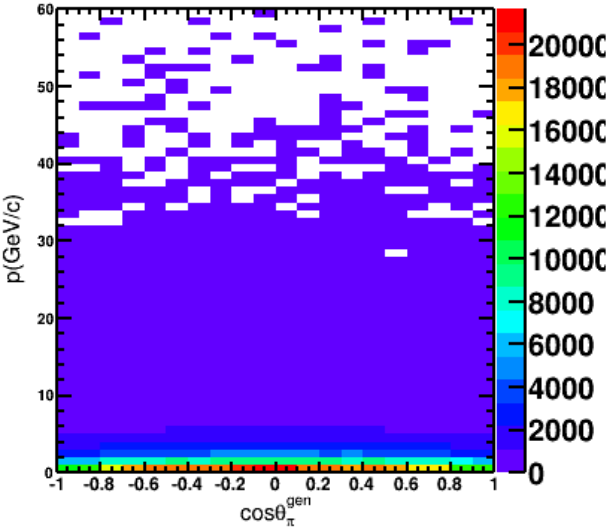
- Optimal cut just calculate the expected efficiency and purity as the article did (1: 1: 1)
- Former results choose the minimum combined χ^2 to select K

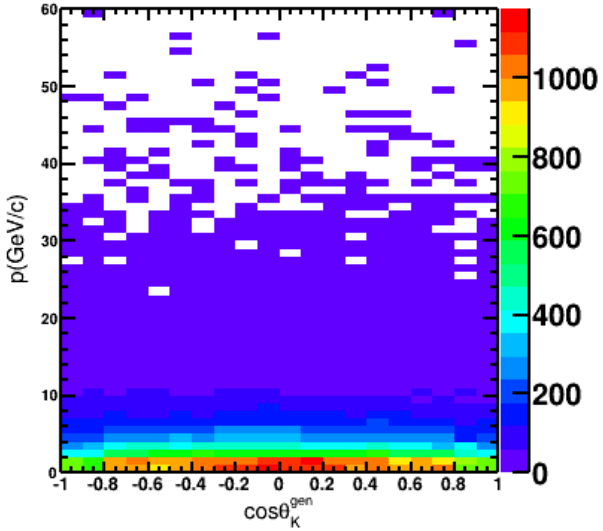
Pid distributions: PDG vs recoPDG

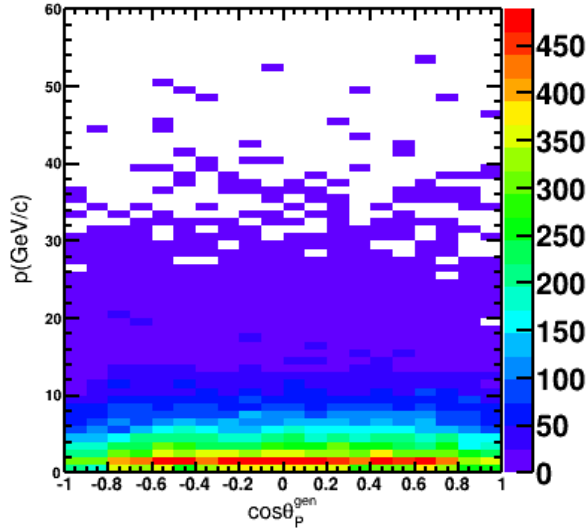




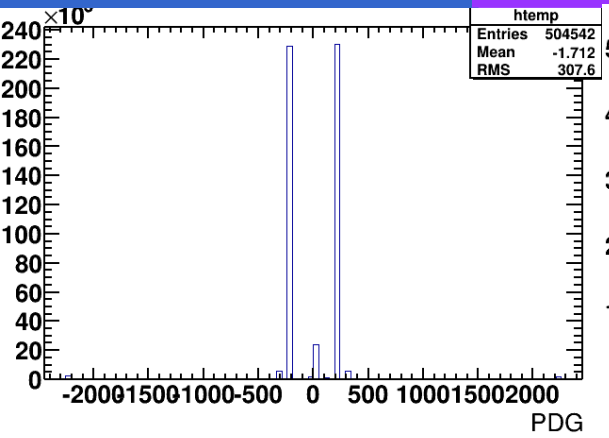




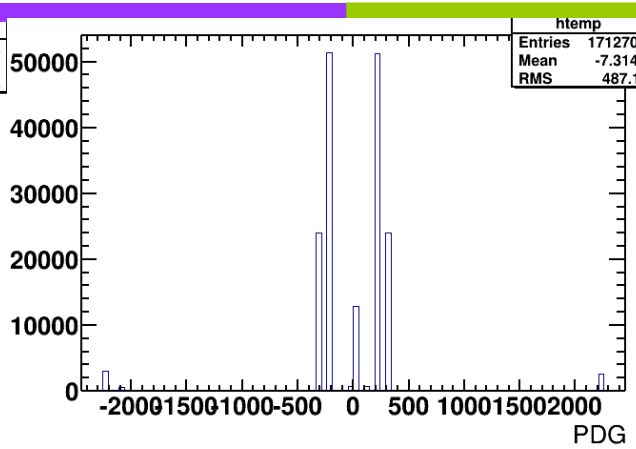




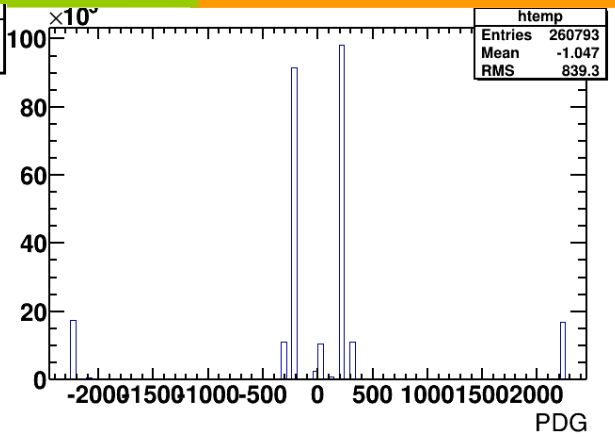
Pid distributions: PDG vs recoPDG



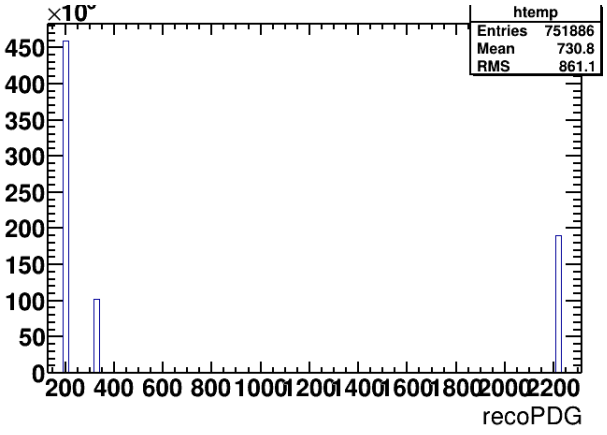
recoPDG==211



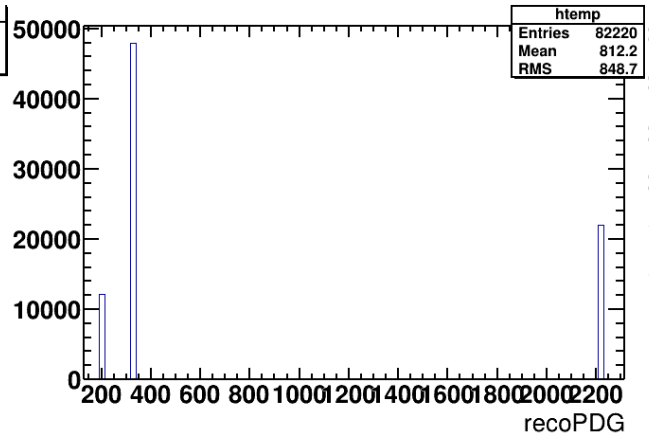
recoPDG==321



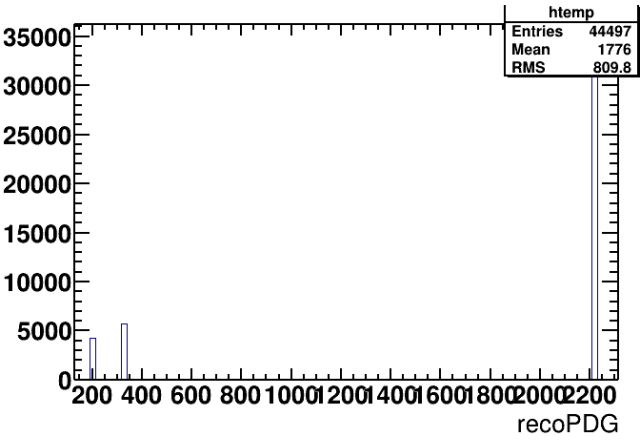
recoPDG==2212



|PDG|==211



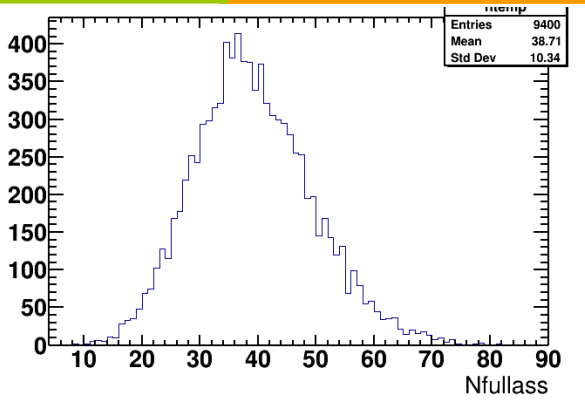
|PDG|==321

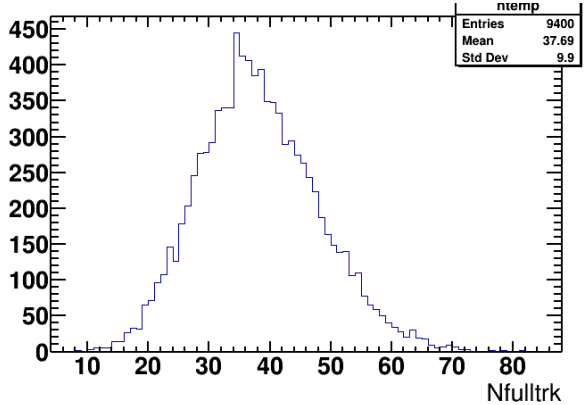


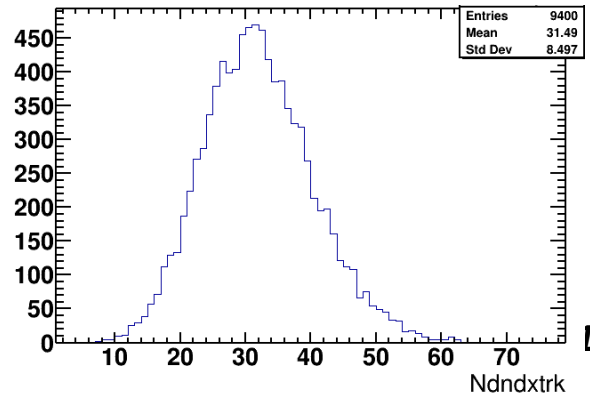
|PDG|==2212

Some questions

Row	Instance	tpc_measd	tof_meast	PDG	recoPDG	matched	genstatus
0	0	51.107086	8.6199679	321	321	1	1
0	1	59.680671	6.1927746	211	211	1	1
0	2	53.844883	6.1145436	-2212	321	1	1
0	3	48.785884	7.5975103	211	211	1	1
0	4	61.447052	6.0422692	-211	211	1	1
0	5	52.738571	6.1608037	-321	321	1	1
0	6	51.651748	6.3811856	-211	211	1	1
0	7	51.120758	6.4509272	-211	211	1	1
0	8	48.125991	6.4785755	-211	211	1	1
0	9	54.576847	5.9683414	-211	211	1	1
0	10	52.157760	7.6625414	211	211	1	1
0	11	52.888366	6.1930843	-211	211	1	1
0	12	53.508129	6.4038282	211	211	1	1
0	13	52.783321	6.2560671	211	211	1	1
0	14	38.325408	6.3772555	-211	211	1	1
0	15	48.117954	6.9025398	211	211	1	1
0	16	43.497562	8.7945294	211	211	1	1
0	17	53.363933	7.7332012	-211	211	1	1
0	18	51.543678	7.1476258	-211	211	1	1
0	19	53.103466	6.5415543	211	211	1	1
0	20	55.952568	6.7199440	211	211	1	1
0	21	55.952568	6.6532353	-211	211	1	1
0	22	52.645298	6.7709353	211	2212	1	1
0	23	38.487655	13.146230	-211	2212	1	1
0	24	53.990890	13.158494	211	211	1	1
<CR> to continue or q to quit ==>							
0	25	34.742462	13.177686	22	2212	1	1
0	26	47.75214	8.4187820	211	2212	1	1
0	27	50.979942	29.476913	211	2212	1	1
0	28	-1	29.569070	211	2212	0	1
0	29	-1	29.616743	-211	2212	0	1
0	30	-1	29.682722	211	2212	0	1







l2