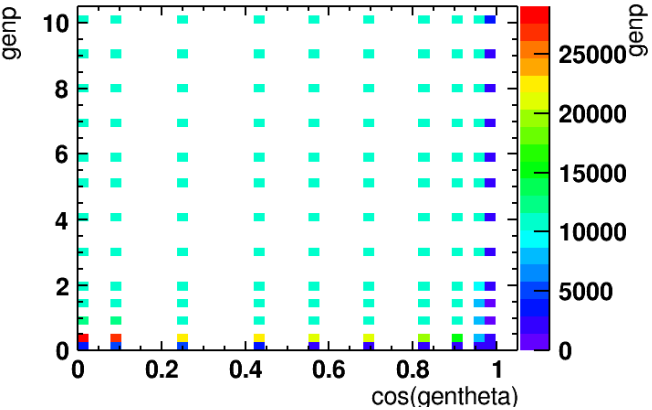
PID efficiency study -- Status

- PID efficiency updates under CEPCSW_tdr25.1.2
  - No dip at 45 degree around 6 GeV
  - TPC PID efficiency at 15 degree not larger than combined
- ParticleGun K combined PID efficiency/purity summary
  - Performance of ITKTOF at 15/45/85 degree
  - Suppose track pi:k:p=10:3:1 to calculate purity
  - 2-10GeV and 35/45/55/65/75/85/89 degree: ~ 88.2%/91.8%
  - 2-10GeV and 25 degree: ~ 85.9%/86.5%
  - 2-10GeV and 15 degree: ~ 50.6%/44.2%
  - Cut optimization of maximizing eff*purity
    - Former 2-10GeV and 45 degree: ~ 91.2%*94.8%=86.5%
    - Optimization could reach 95.6%*92.8%=88.7% ideally (gauss integral)
    - Optimization could reach 93.1%*89.9%=83.7% actually (combined chi distribution cut)
    - 25 degree optimization: 91.7%*86.7%=79.5% (ideally)

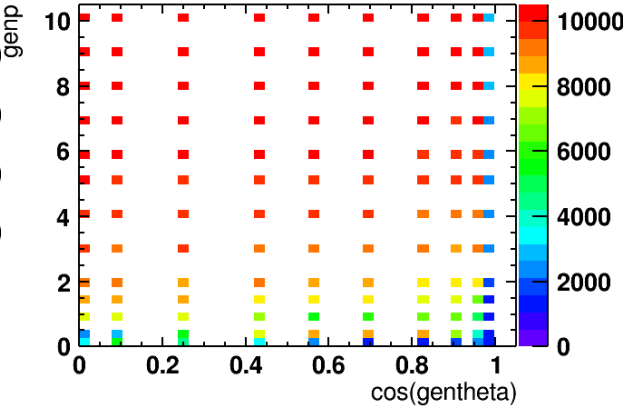
      87.4%*81.8%=71.5% (actually)

MCparticle: 1400000 = 10000*10*14

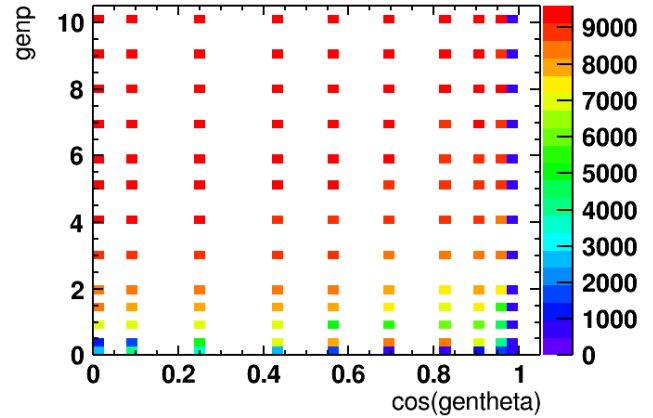
ParticleGun K- track truth phase space



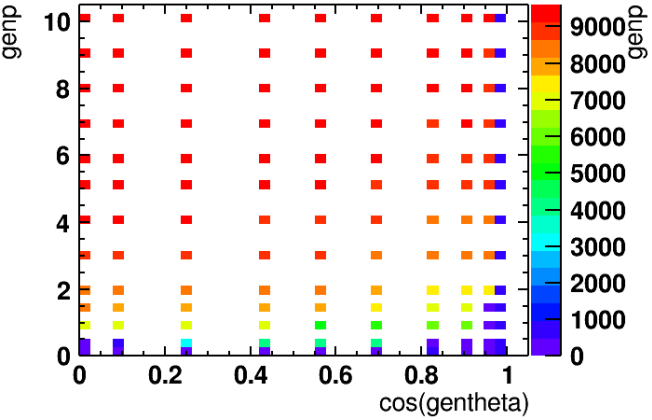
All tracks: 1318172



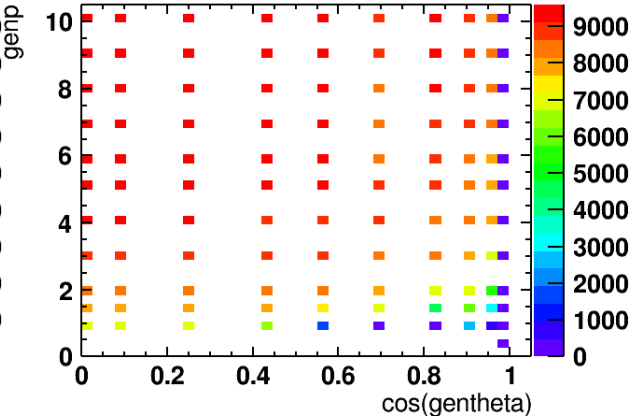
No decay: 1034409



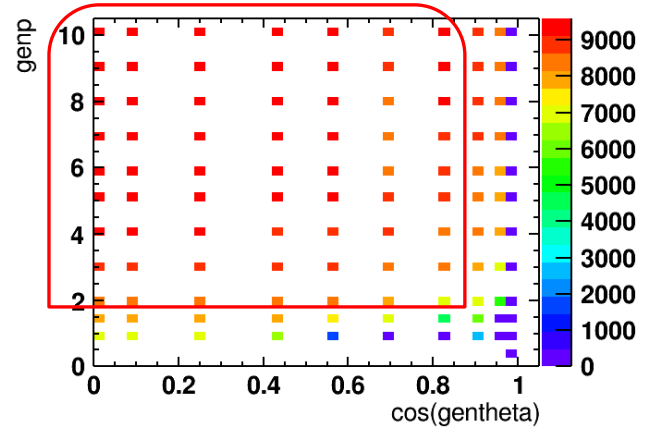
No decay &&
Nfulltrk==1: 934320



No decay &&
Nfulltrk==1 &&
Ndndxtrk==1: 871516



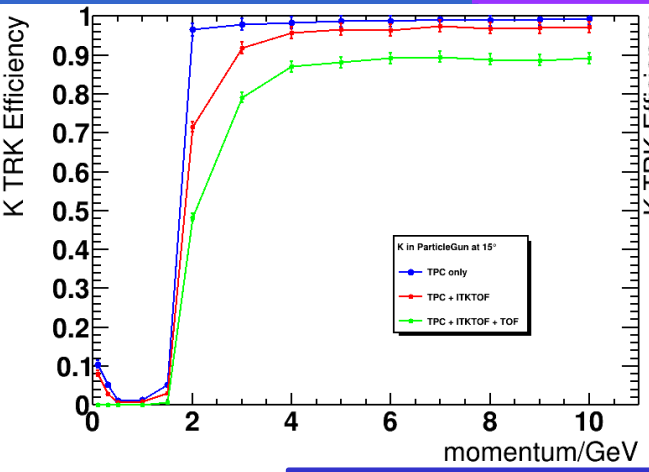
No decay &&
Nfulltrk==1 &&
Ntoftrk==1: 806801

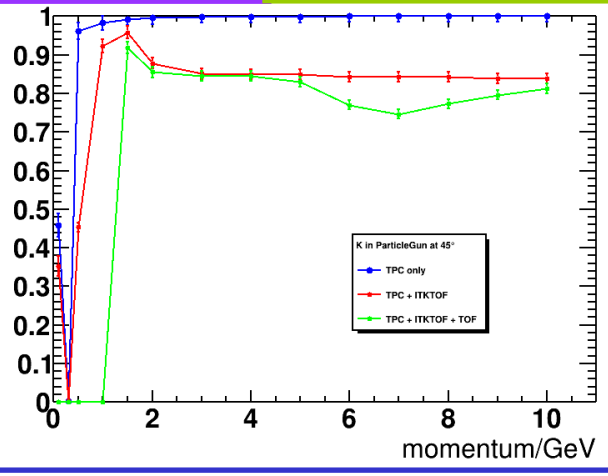


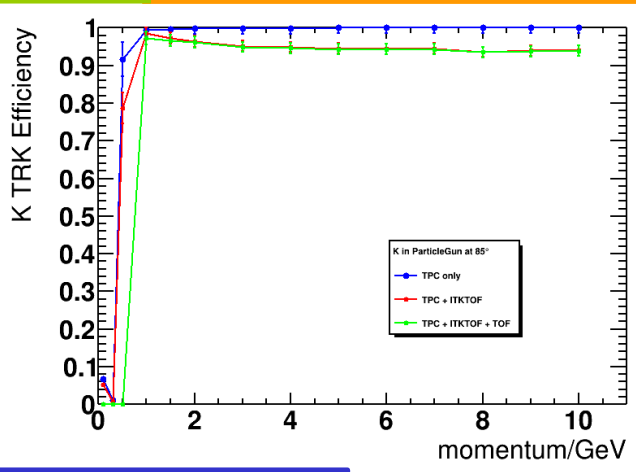
No decay && Nfulltrk==1
&& Ndndxtrk==1 &&
Ntoftrk==1: 802976

K PID efficiency of 25.1.2 with ITKToF

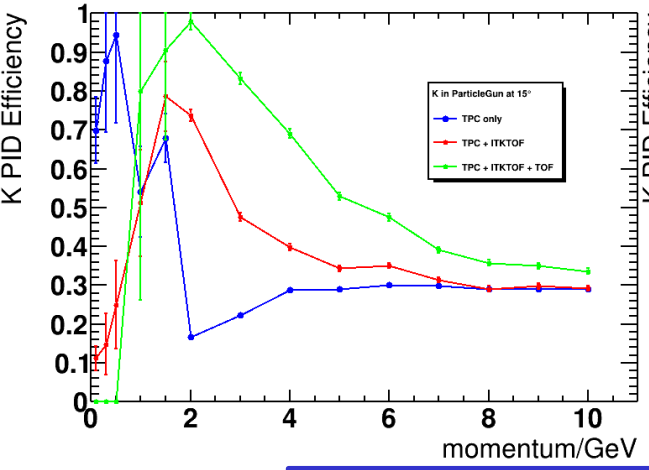
select particles without decay and with 1 track, only identify pi/k/p

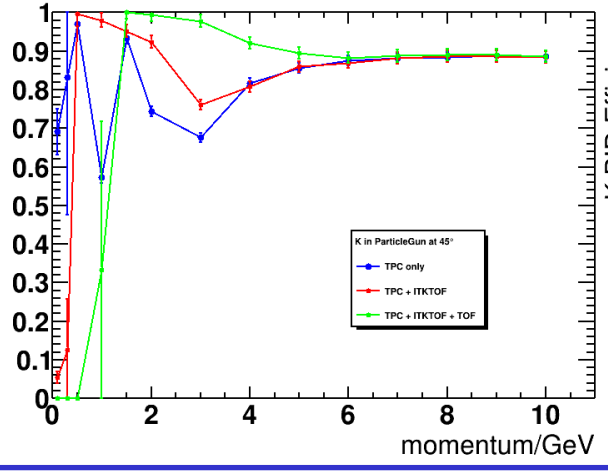


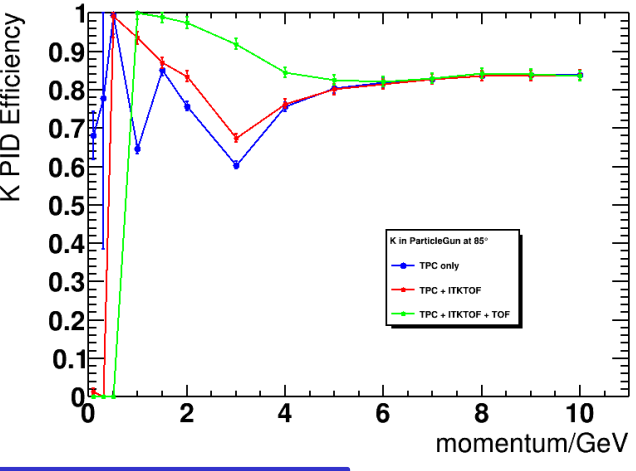




15 degree (left) VS 45 degree (middle) VS 85 degree (right)
ParticleGun K- TRK efficiency of having TPC/ToF track in reco tracks

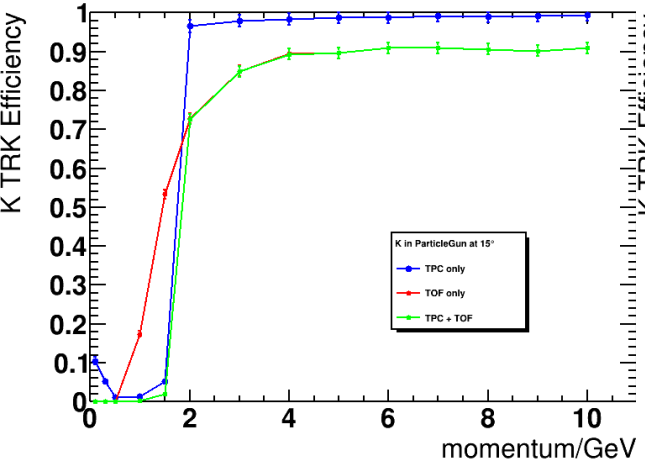


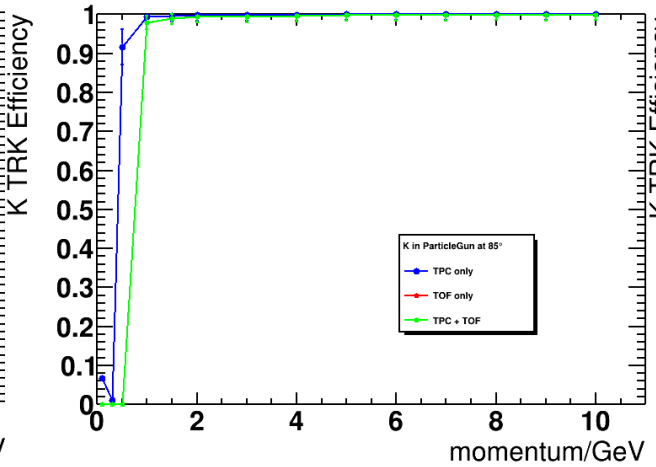


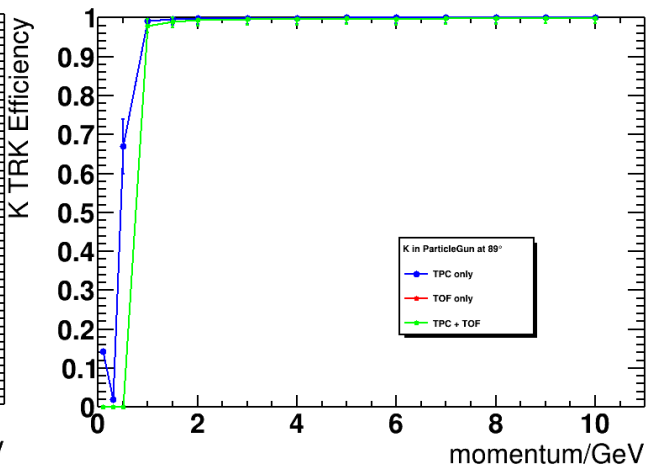


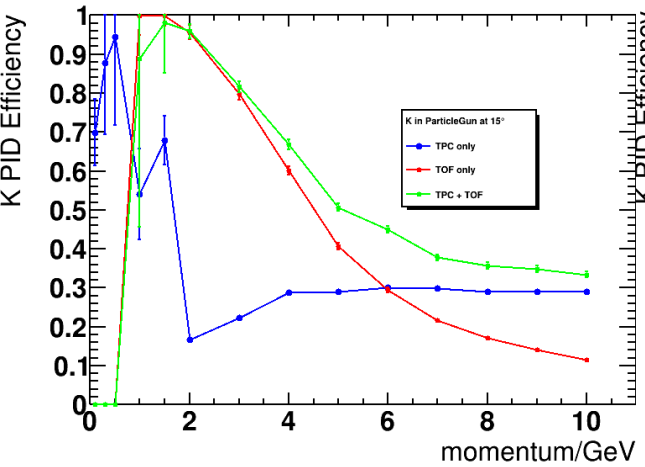
15 degree (left) VS 45 degree (middle) VS 85 degree (right)
ParticleGun K- PID efficiency of right PID

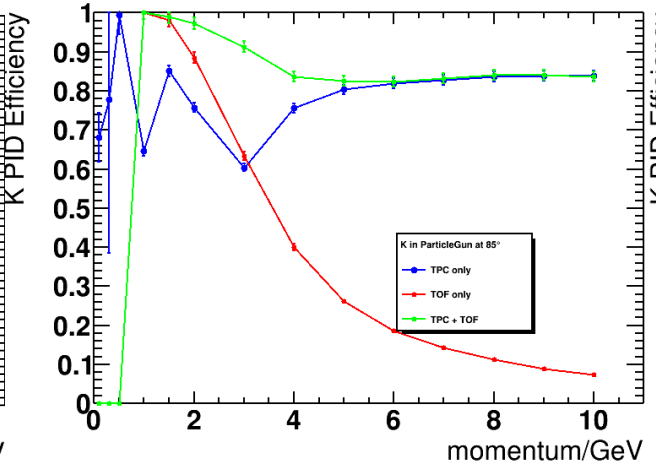
PID efficiency of 25.1.2

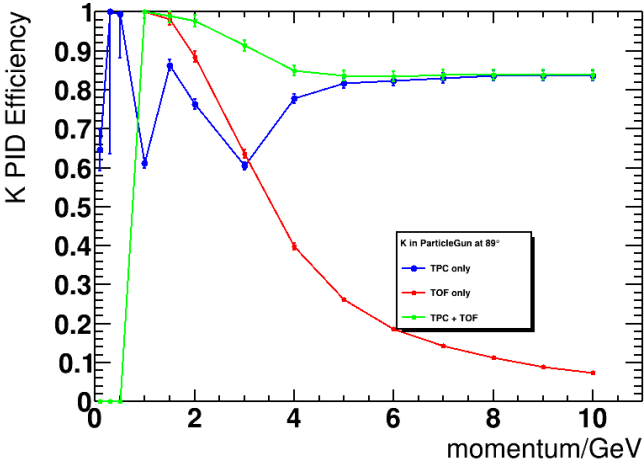






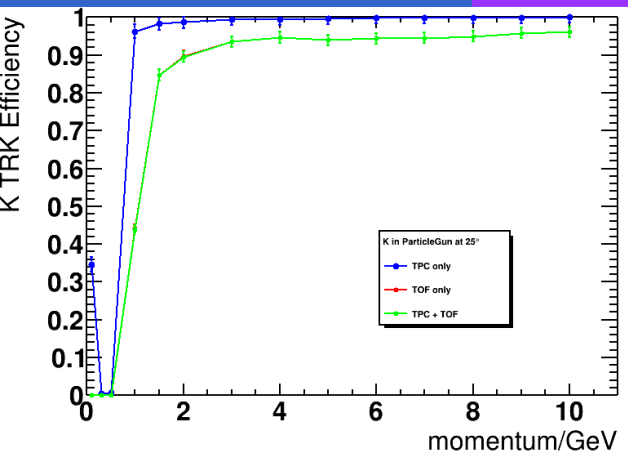


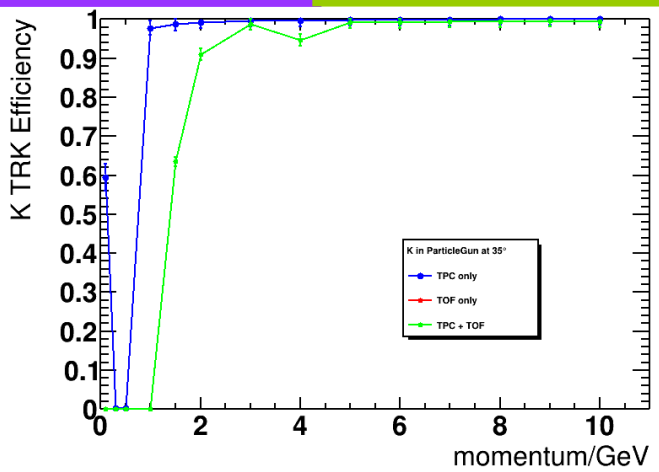


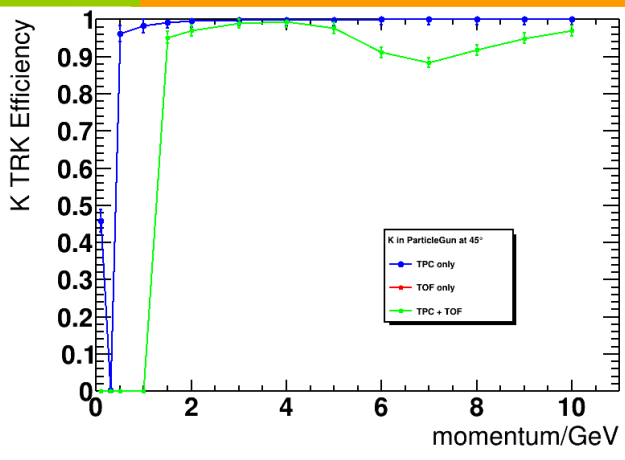


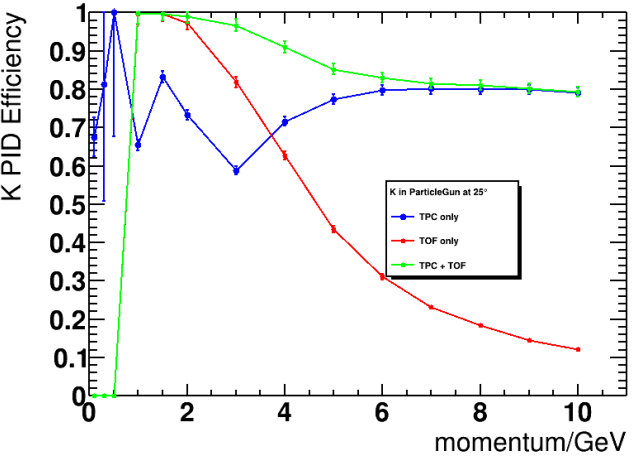
15 degree (left) VS 85 degree (middle) VS 89 degree (right)
ParticleGun K- TRK/PID efficiency

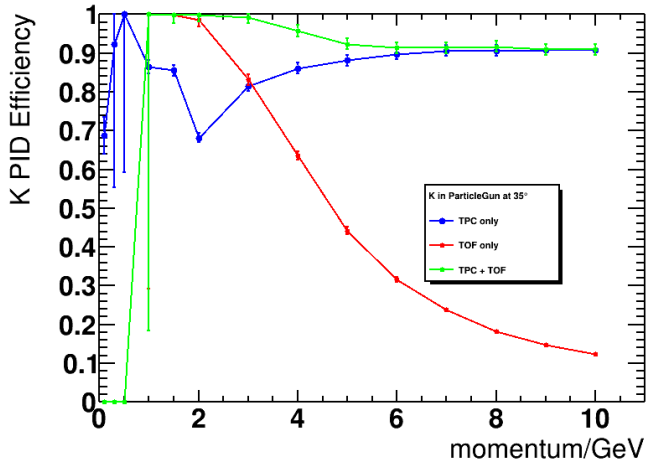
PID efficiency of 25.1.2

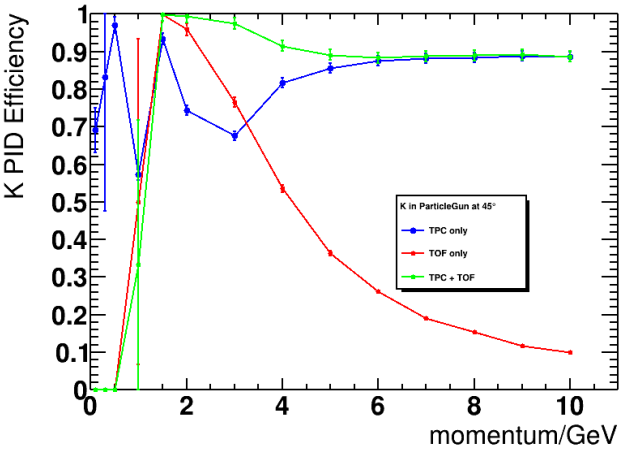






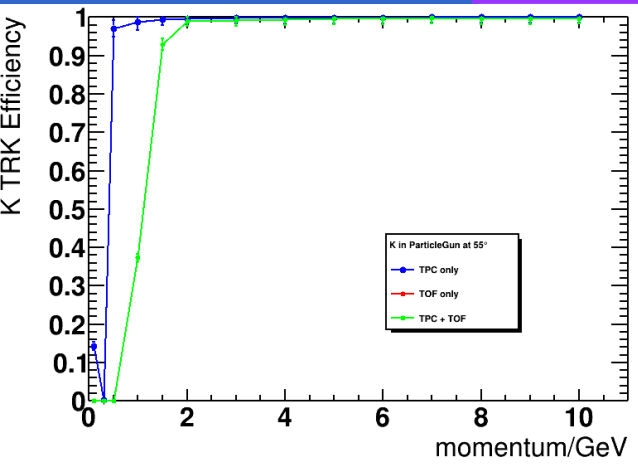


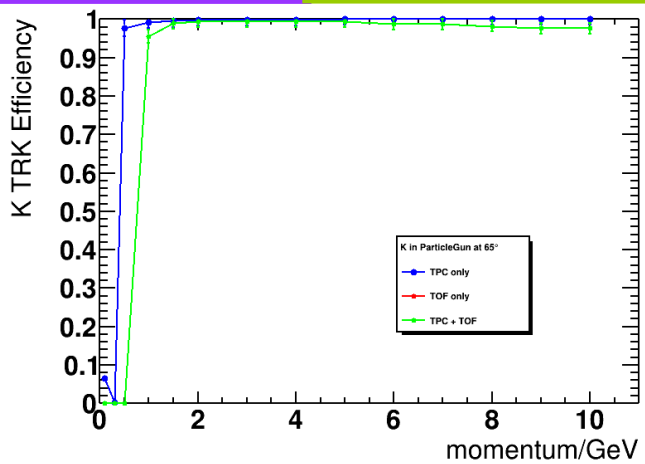


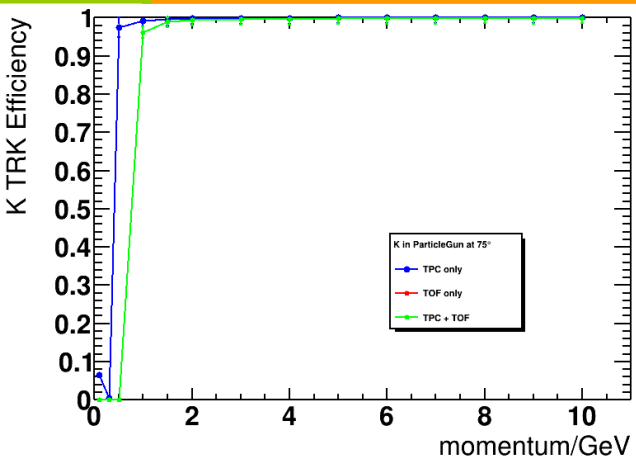


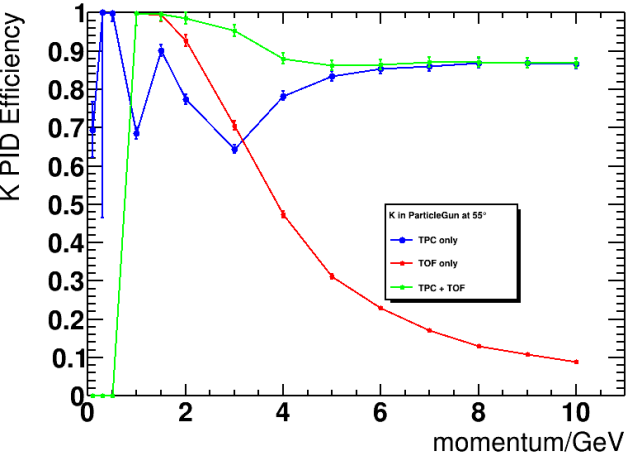
25 degree (left) VS 35 degree (middle) VS 45 degree (right)
ParticleGun K- TRK/PID efficiency

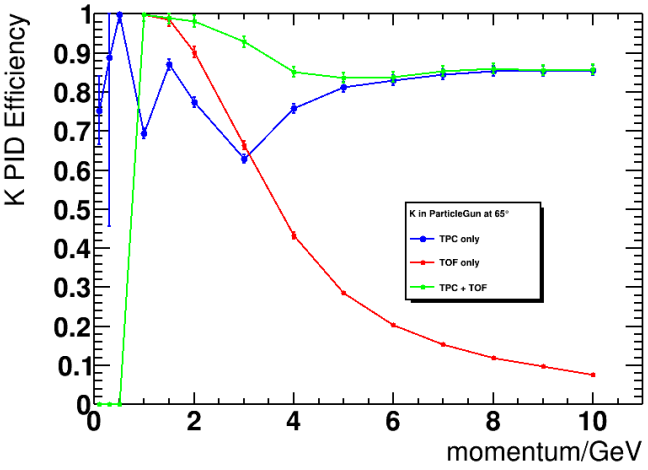
PID efficiency of 25.1.2

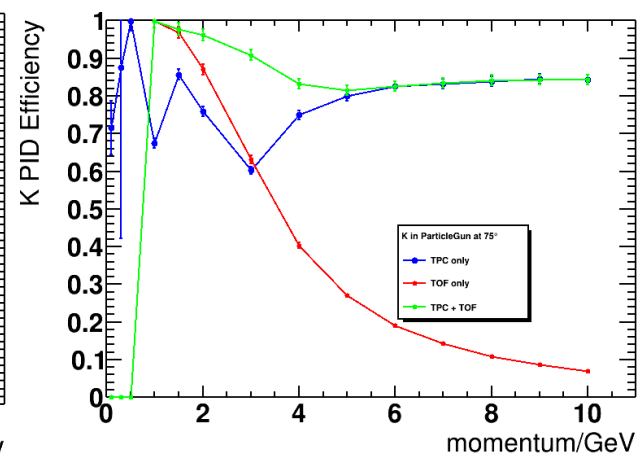








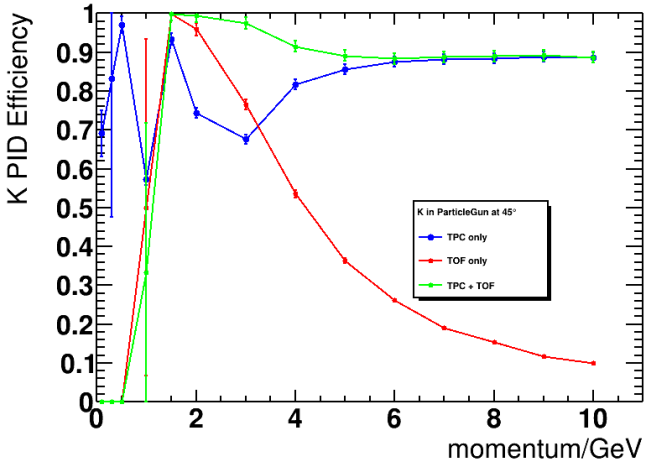




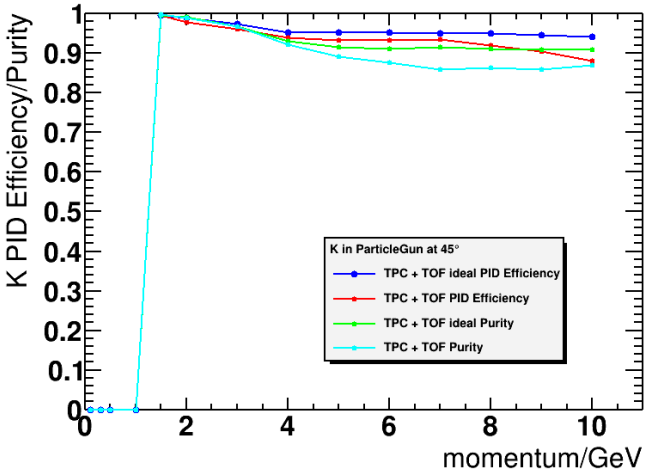
55 degree (left) VS 65 degree (middle) VS 75 degree (right)
ParticleGun K- TRK/PID efficiency

Ref.

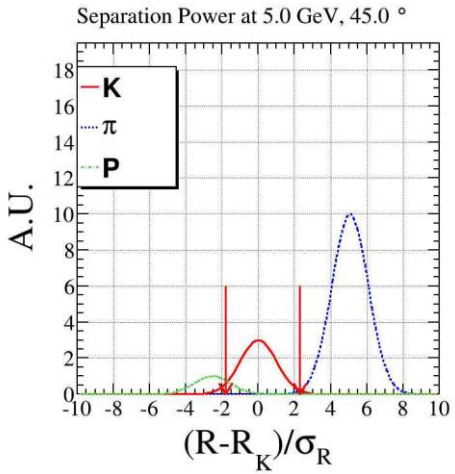
Cut optimization at 45 degree

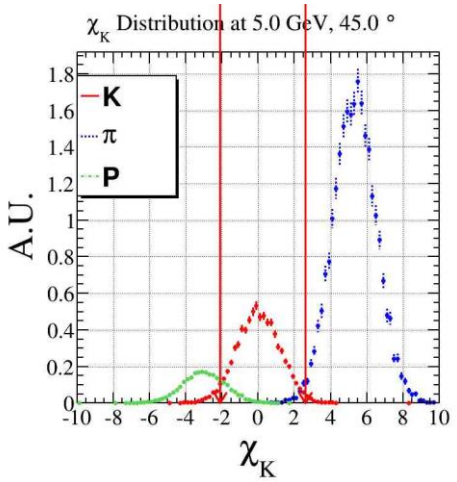


PID Efficiency



PID Efficiency / Purity after optimization





track pi:K:p=10:3:1

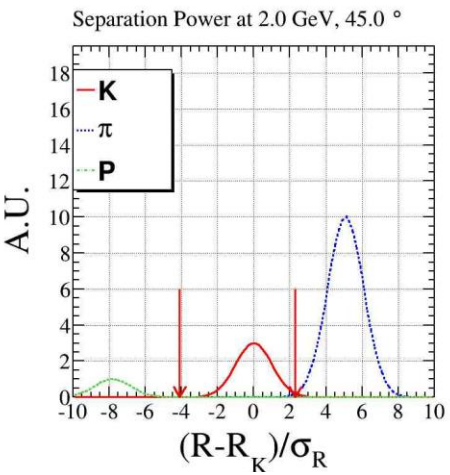
- Ideally, this equals to chi(?->K) distribution * num
- Cut to maximize eff*purity

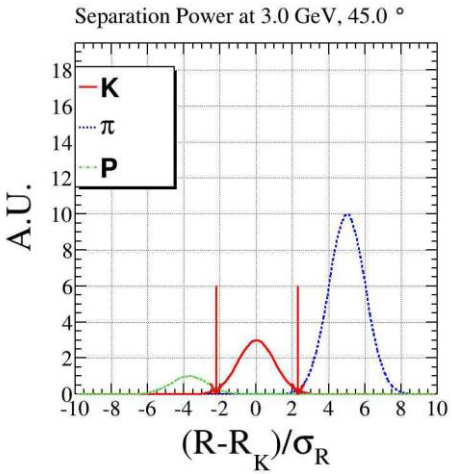
$$\chi(K \to K) = \frac{\chi_{\mathrm{TPC}}(K \to K) - \chi_{\mathrm{TOF}}(K \to K)}{\sqrt{2}}$$

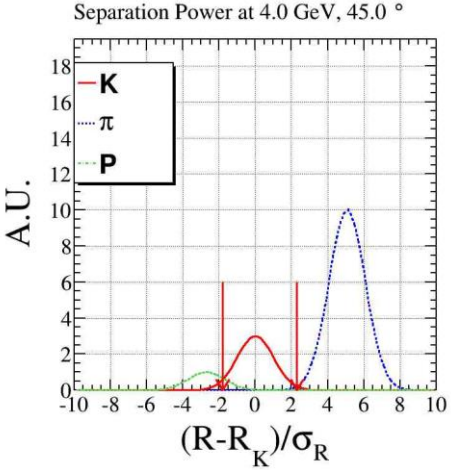
$$\chi(\pi \to K) = \frac{\chi_{\mathrm{TPC}}(\pi \to K) - \chi_{\mathrm{TOF}}(\pi \to K) - SP_{\pi K}^{\mathrm{TPC}} - SP_{\pi K}^{\mathrm{TOF}}}{\sqrt{2}} + SP_{\pi K}$$

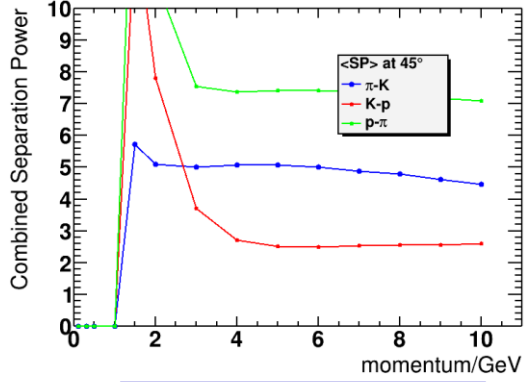
$$\chi(p \to K) = \frac{\chi_{\mathrm{TPC}}(p \to K) - \chi_{\mathrm{TOF}}(p \to K) + SP_{pK}^{\mathrm{TPC}} + SP_{pK}^{\mathrm{TOF}}}{\sqrt{2}} - SP_{pK}$$

Combined chi calculation

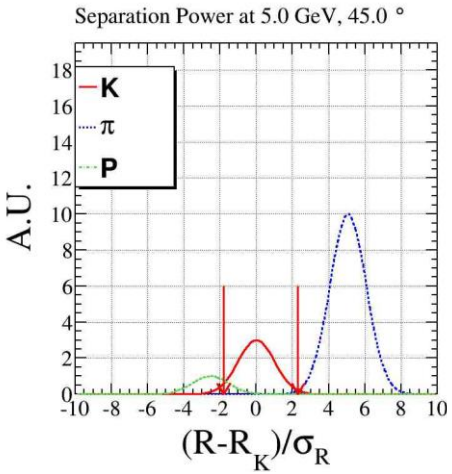


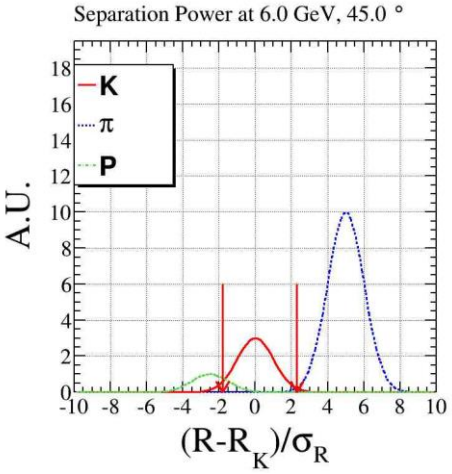


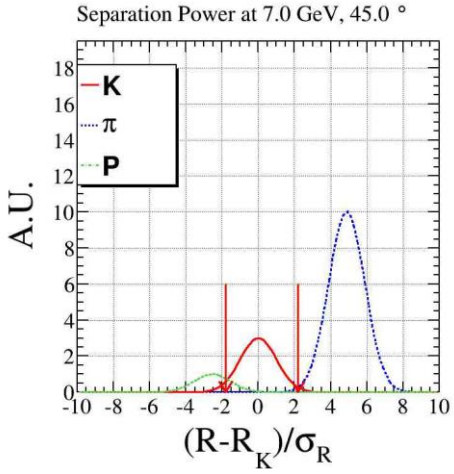


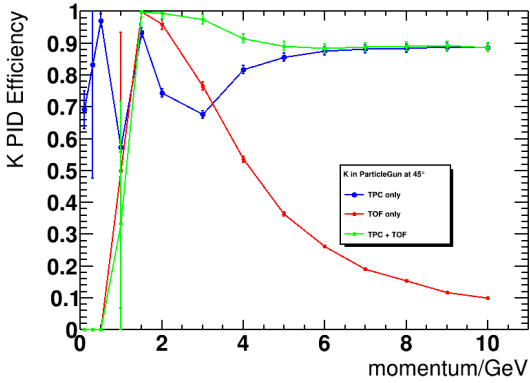


Separation Power

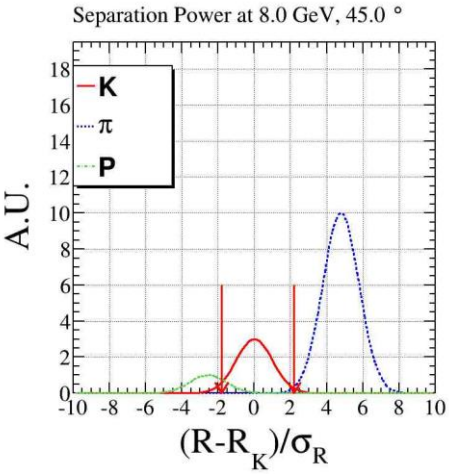


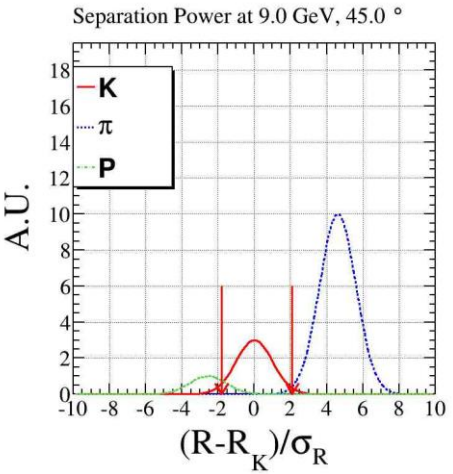


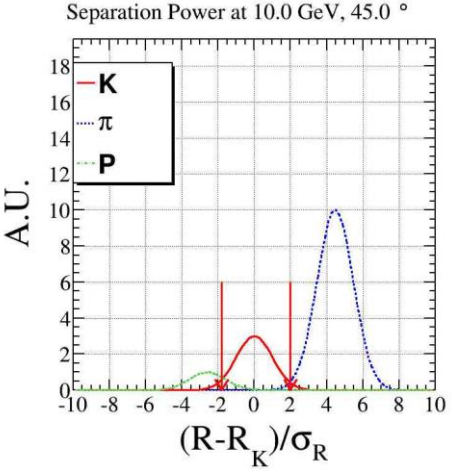


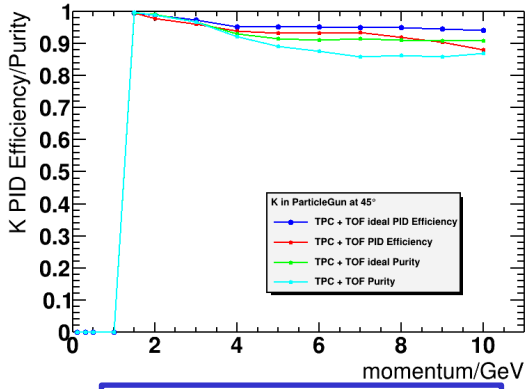


PID Efficiency

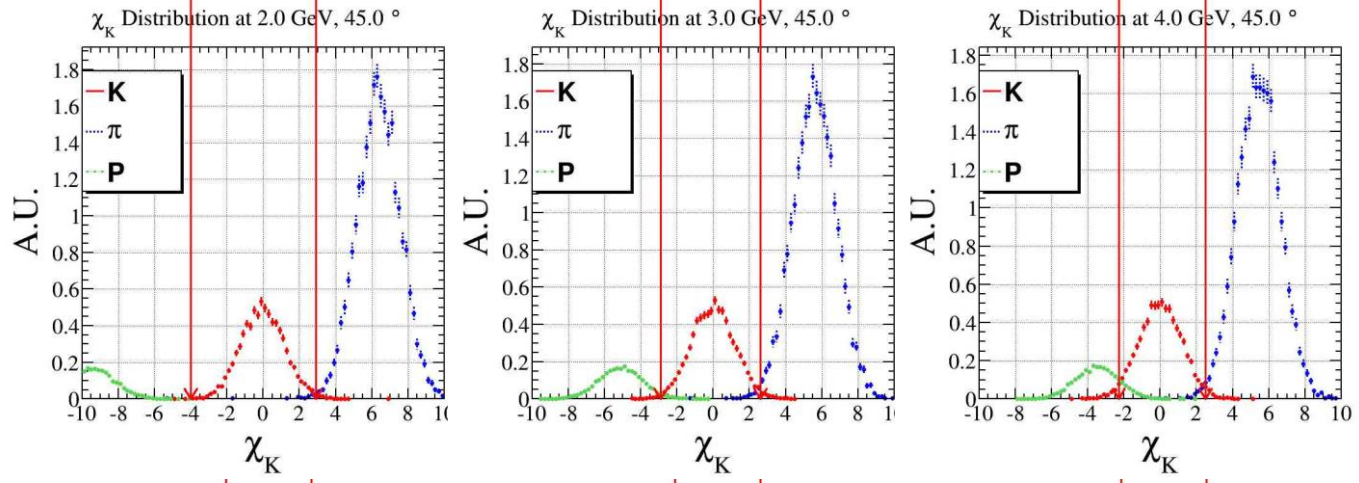


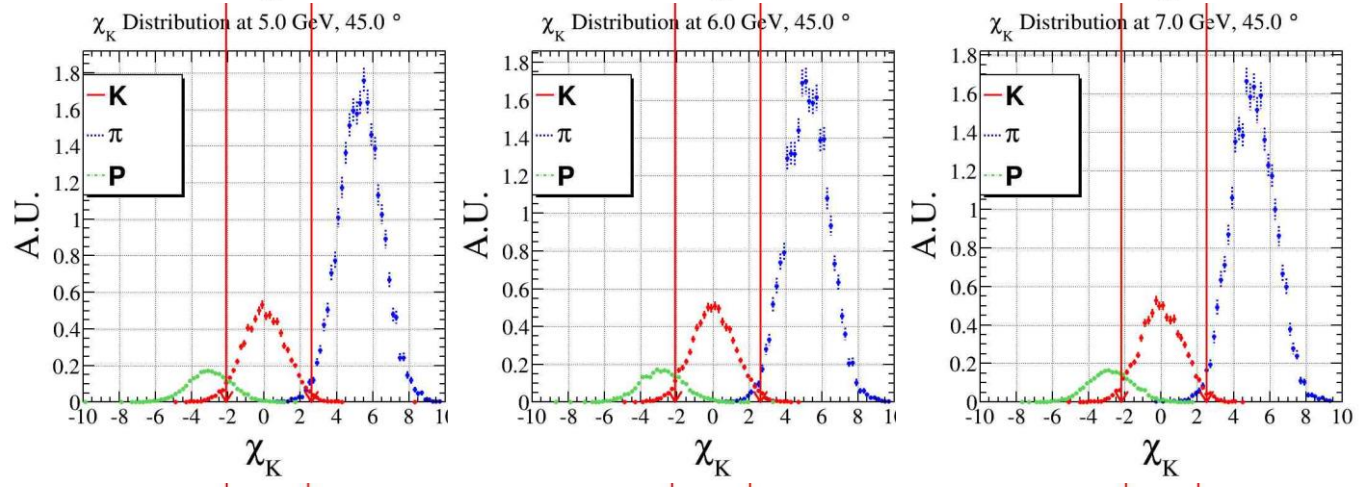


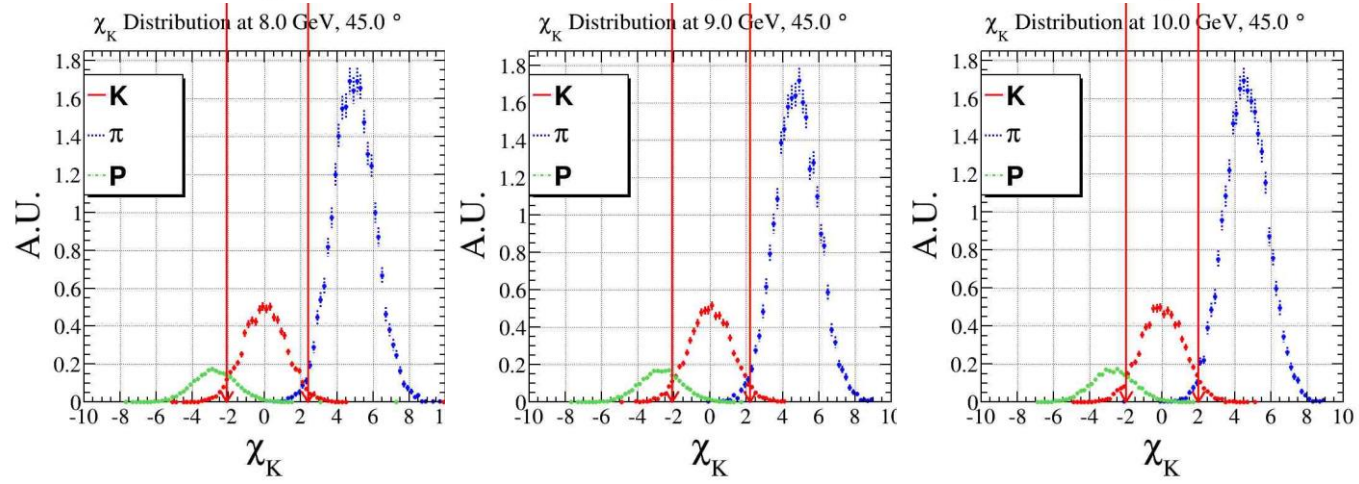


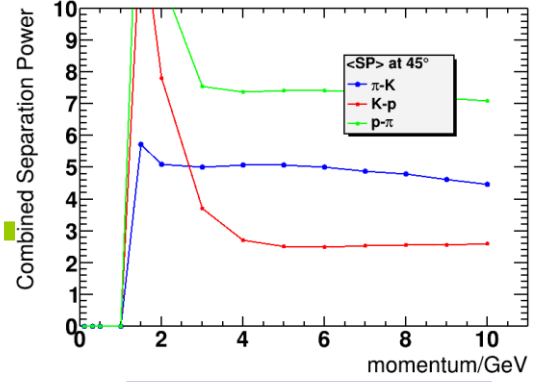


Optimized PID Efficiency and purity

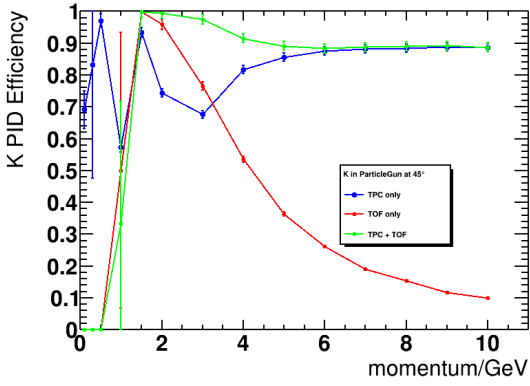




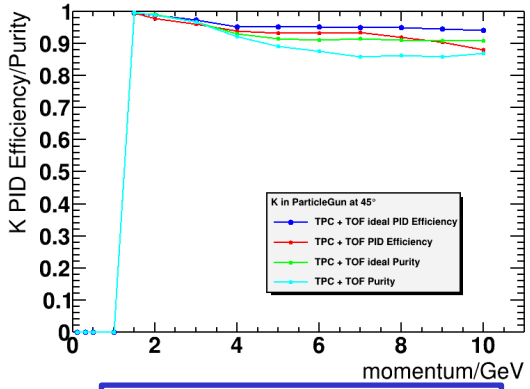




Separation Power

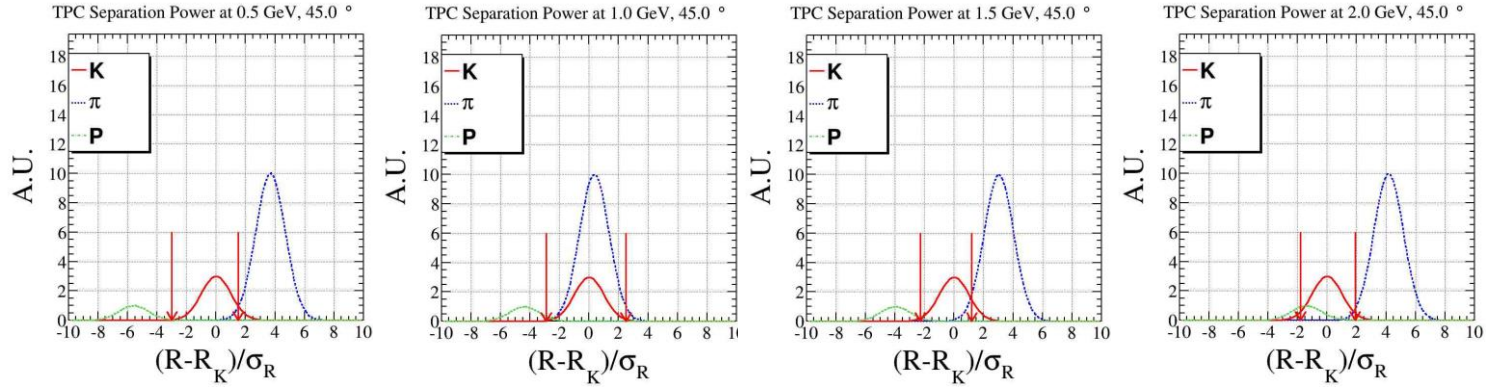


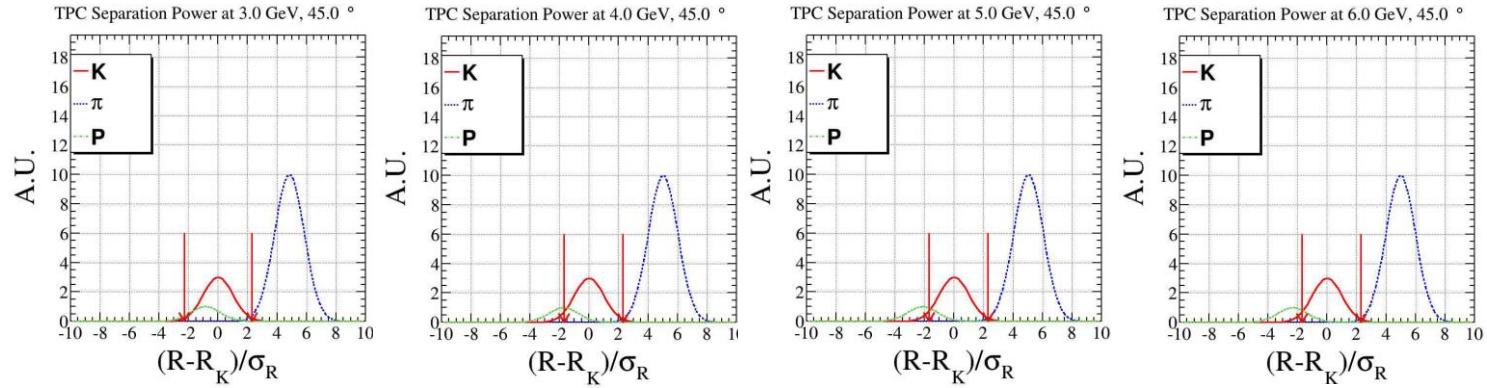
PID Efficiency

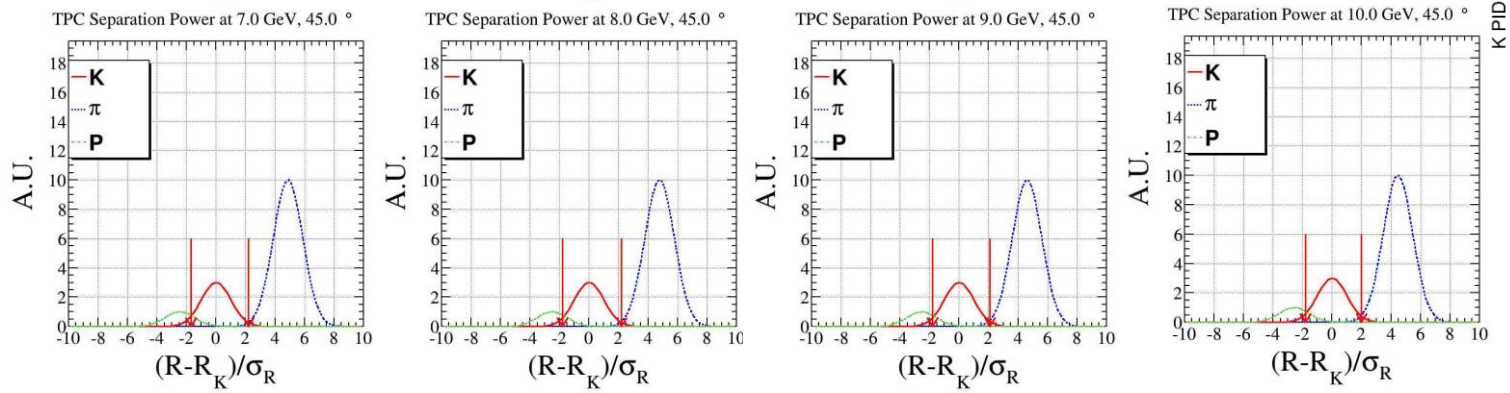


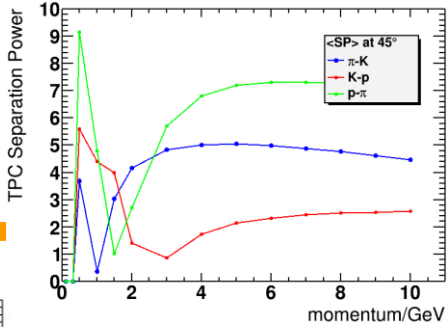
Optimized PID Efficiency and purity

TPC only

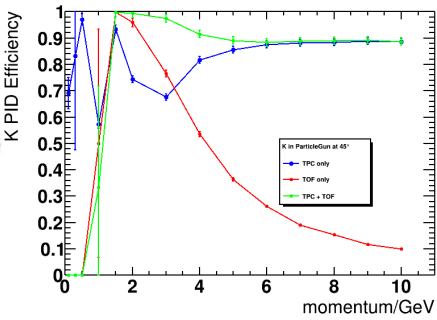




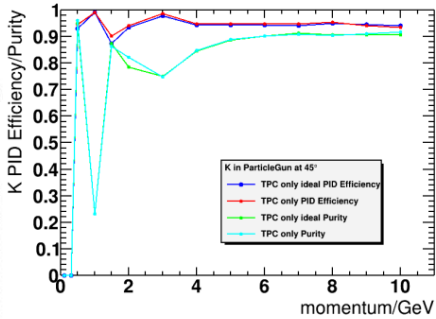




Separation Power

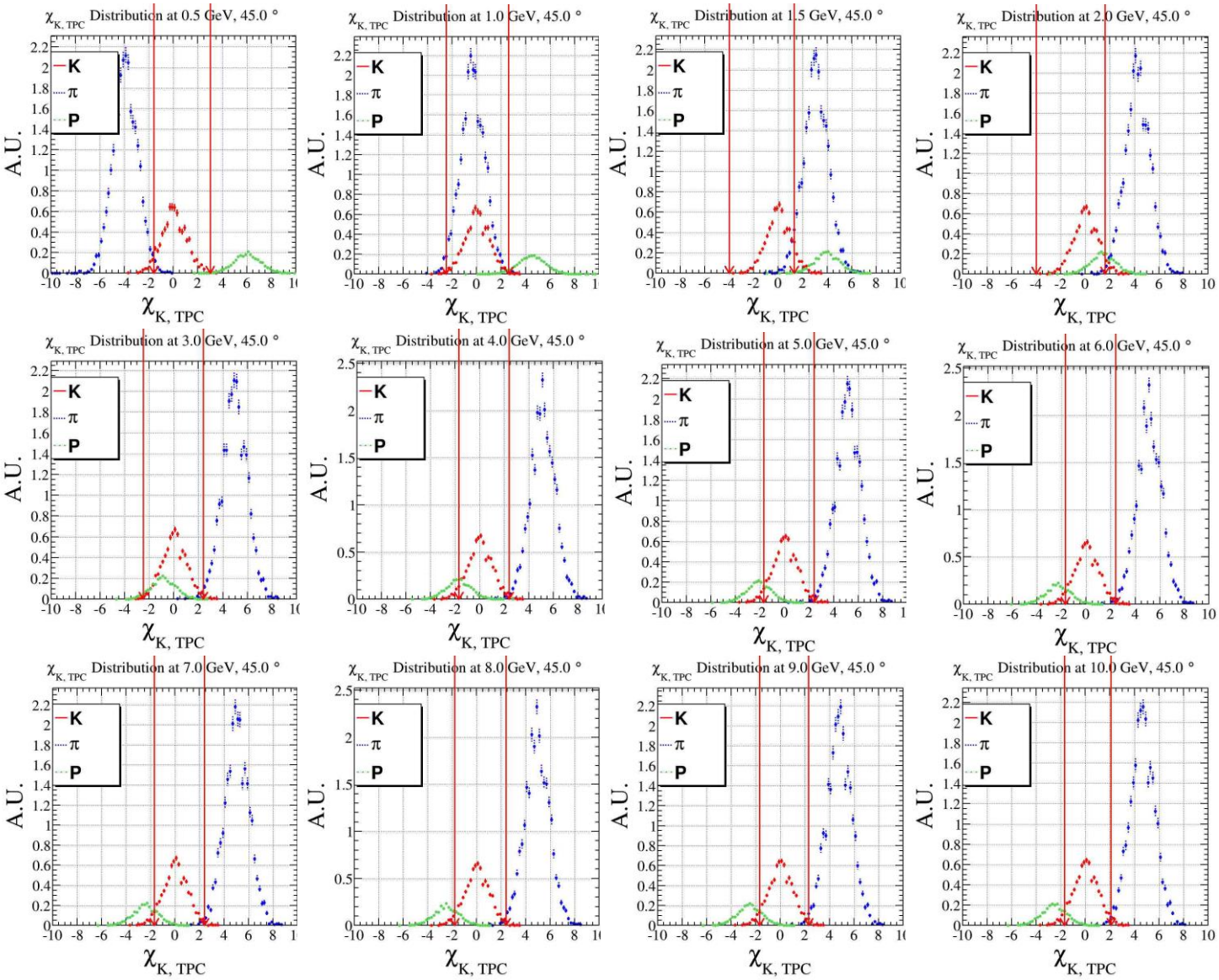


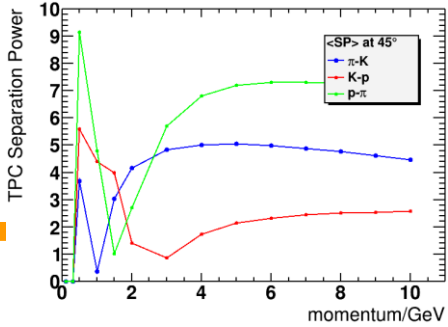
PID Efficiency



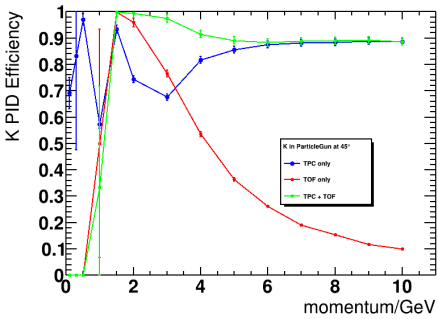
Optimized TPC PID Efficiency and purity

TPC only

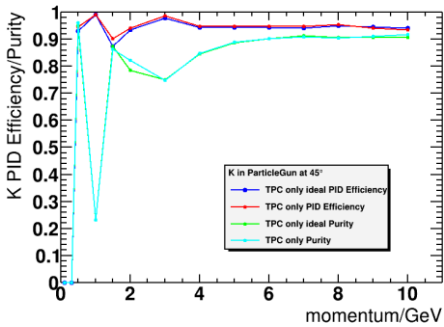




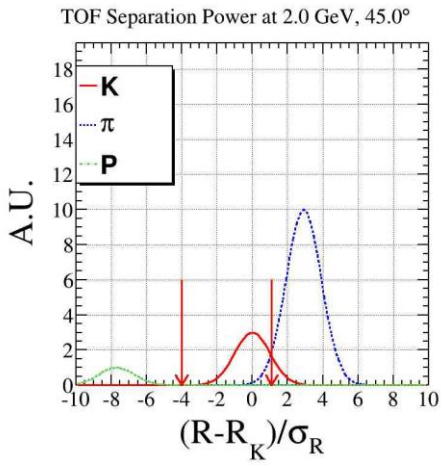
Separation Power

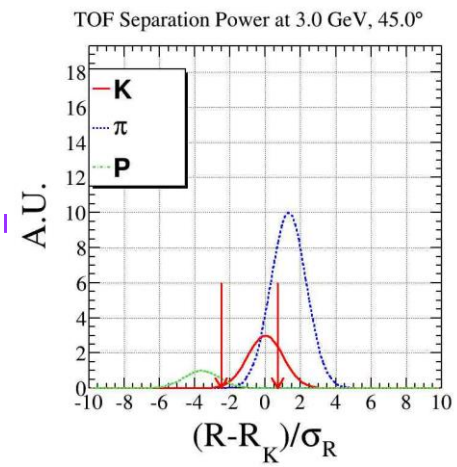


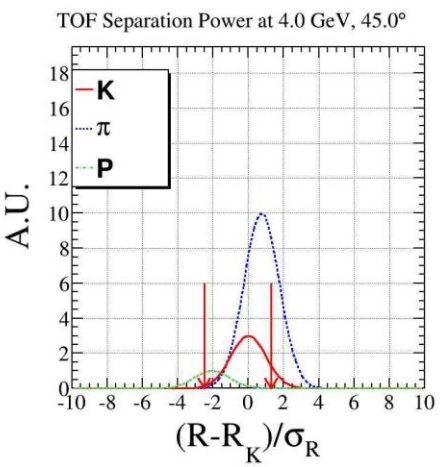
PID Efficiency



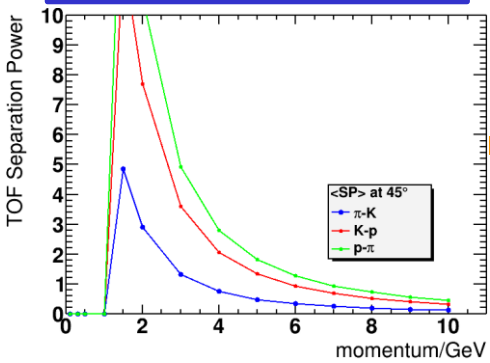
Optimized TPC PID Efficiency and purity

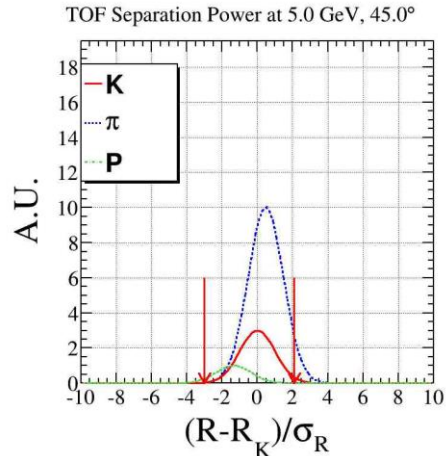


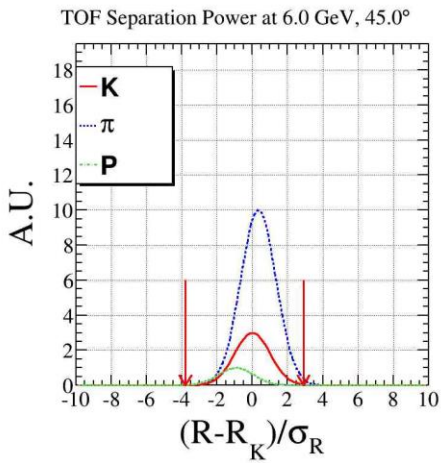


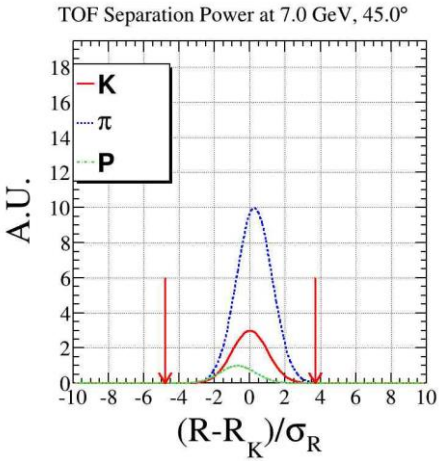


TOF only

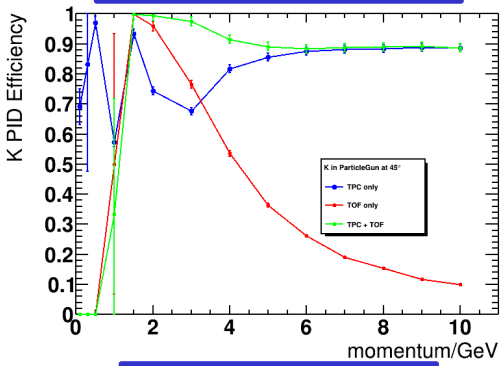


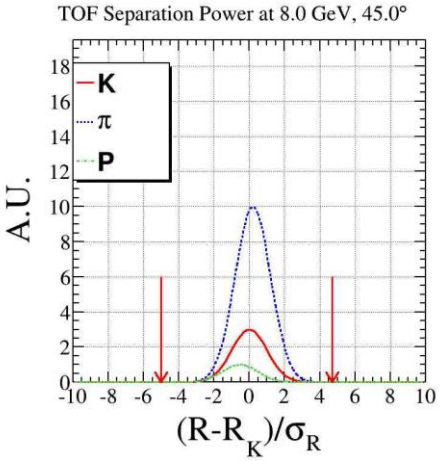


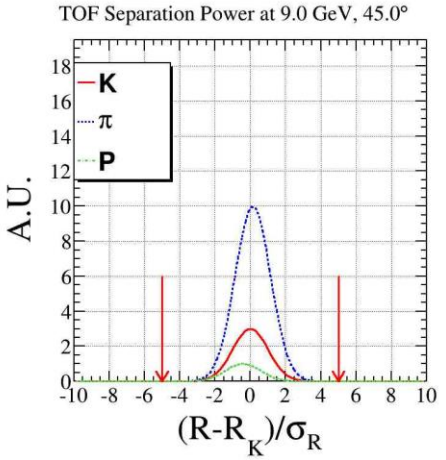


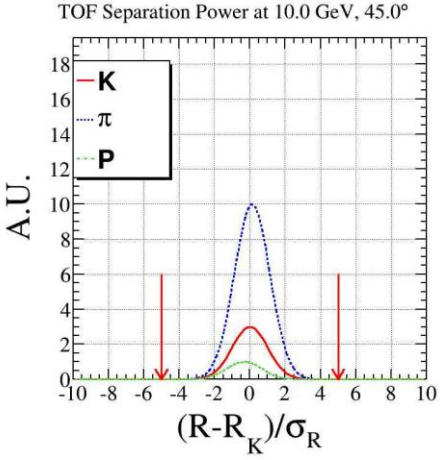


Separation Power

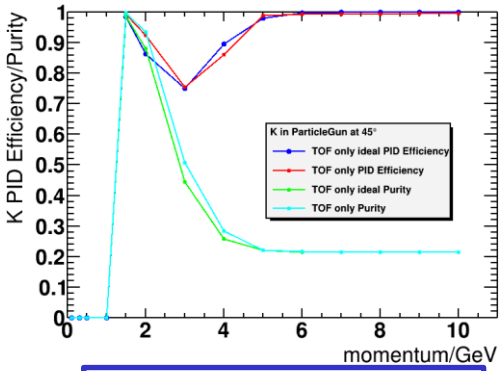




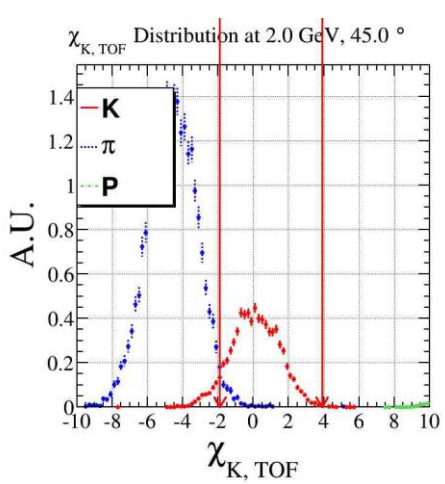


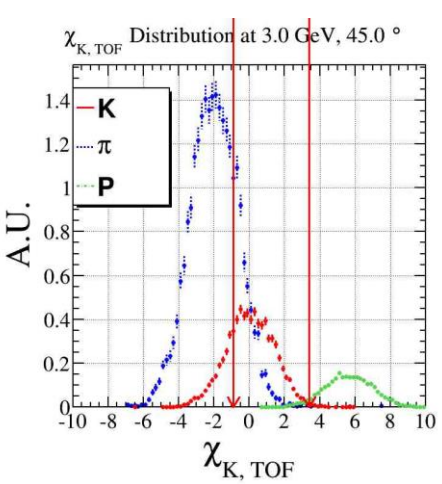


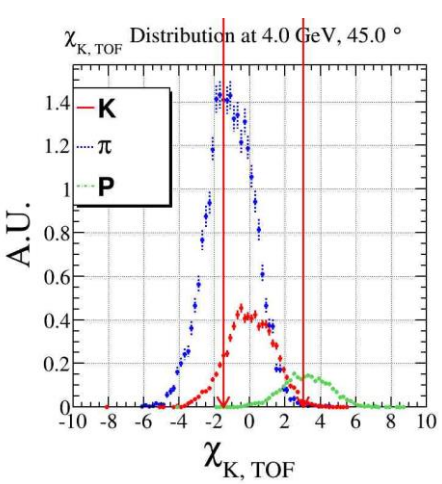
PID Efficiency

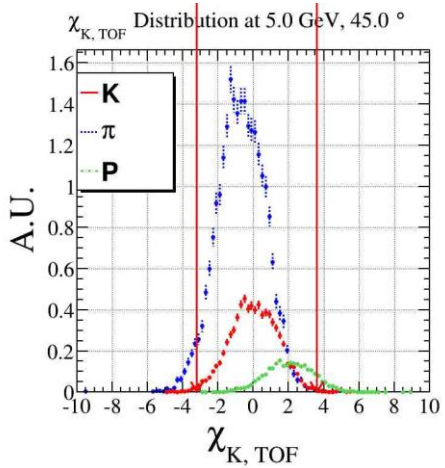


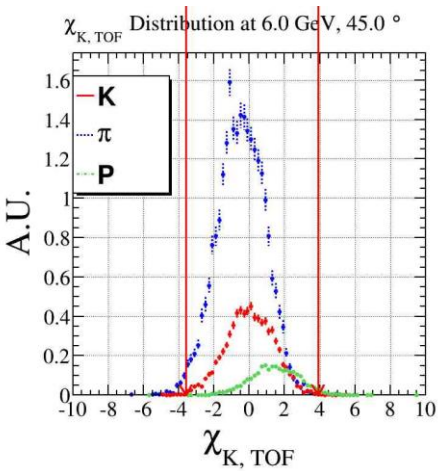
Optimized TPC PID Efficiency and purity

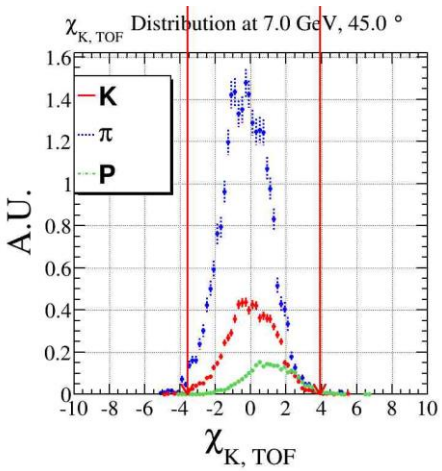


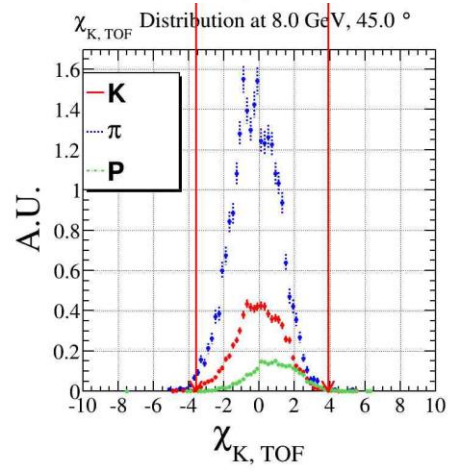


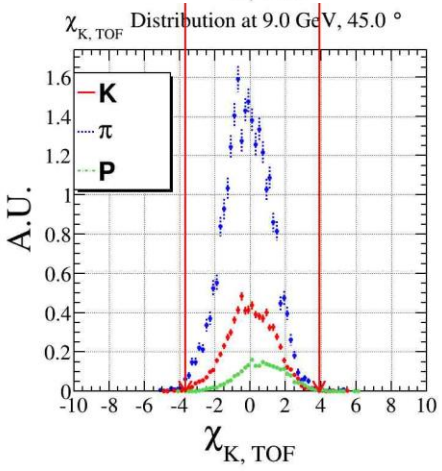


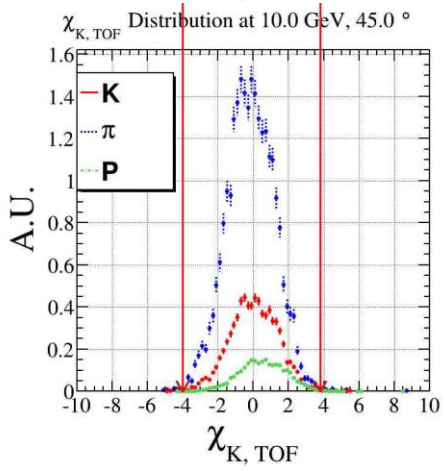




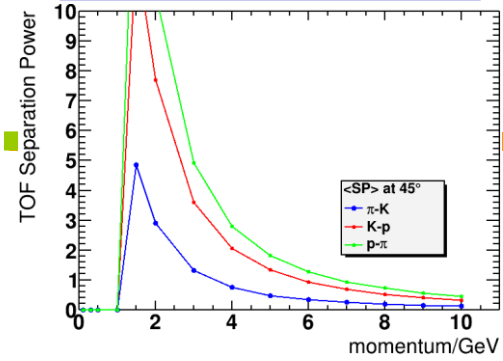




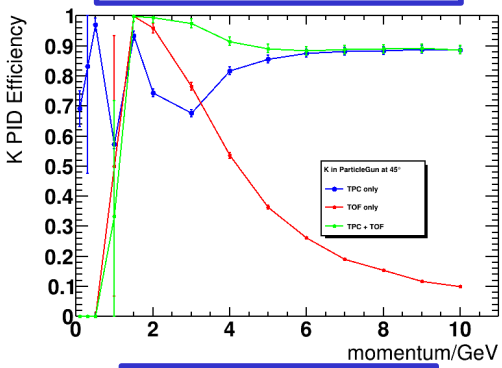




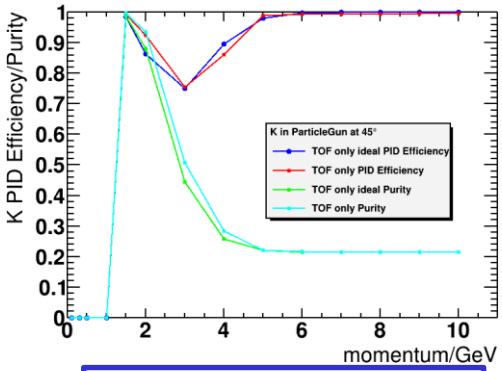
TOF only



Separation Power



PID Efficiency



Optimized TPC PID Efficiency and purity

Backup

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

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

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

$$\mathrm{Efficiency}_{\mathrm{trk}}(\mathrm{TPC}) = \frac{N^{\mathrm{TPC}}_{\mathrm{trk}}}{N^{\mathrm{reco}}_{\mathrm{trk}}}$$

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

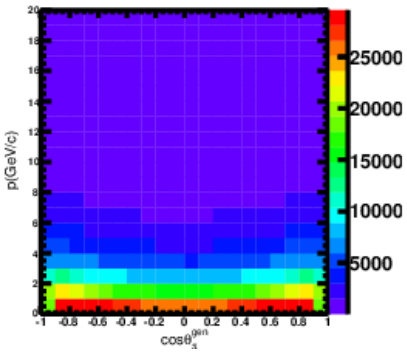
$$\mathrm{purity}(K) = \frac{N_{K\to K}}{N_{K\to K} + N_{\pi\to K} + N_{p\to K}}$$

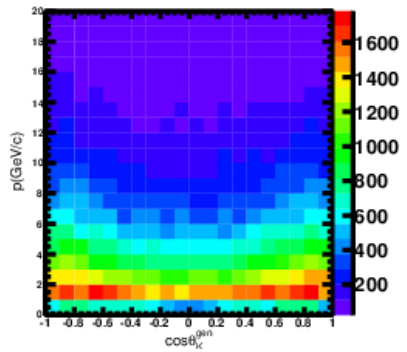
$$\mathrm{Efficiency}_{\mathrm{opti.\ PID}}(i) = \frac{N^{\mathrm{TPC}}_{\mathrm{trk}(i)}(a < \chi(i\to i) < b)}{N^{\mathrm{TPC}}_{\mathrm{trk}(i)}}$$

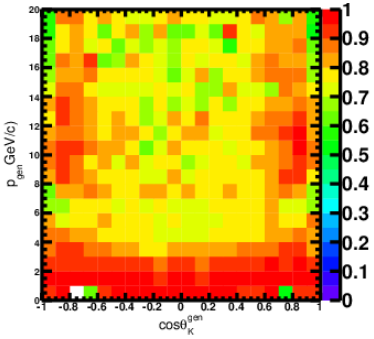
$$\text{Separation power: } O_{AB} = \frac{|\mathrm{A} - \mathrm{B}|}{\sqrt{(\sigma_A^2 + \sigma_B^2)/2}}$$

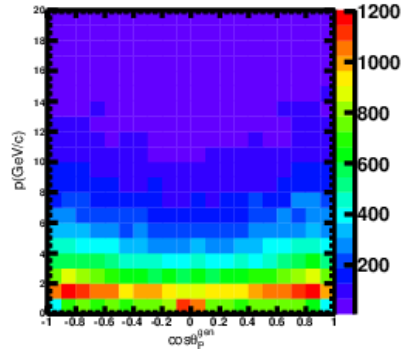
$$\text{Combined: } \sqrt{O^2_{AB,\,\mathrm{TPC}} + O^2_{AB,\,\mathrm{TOF}}}$$

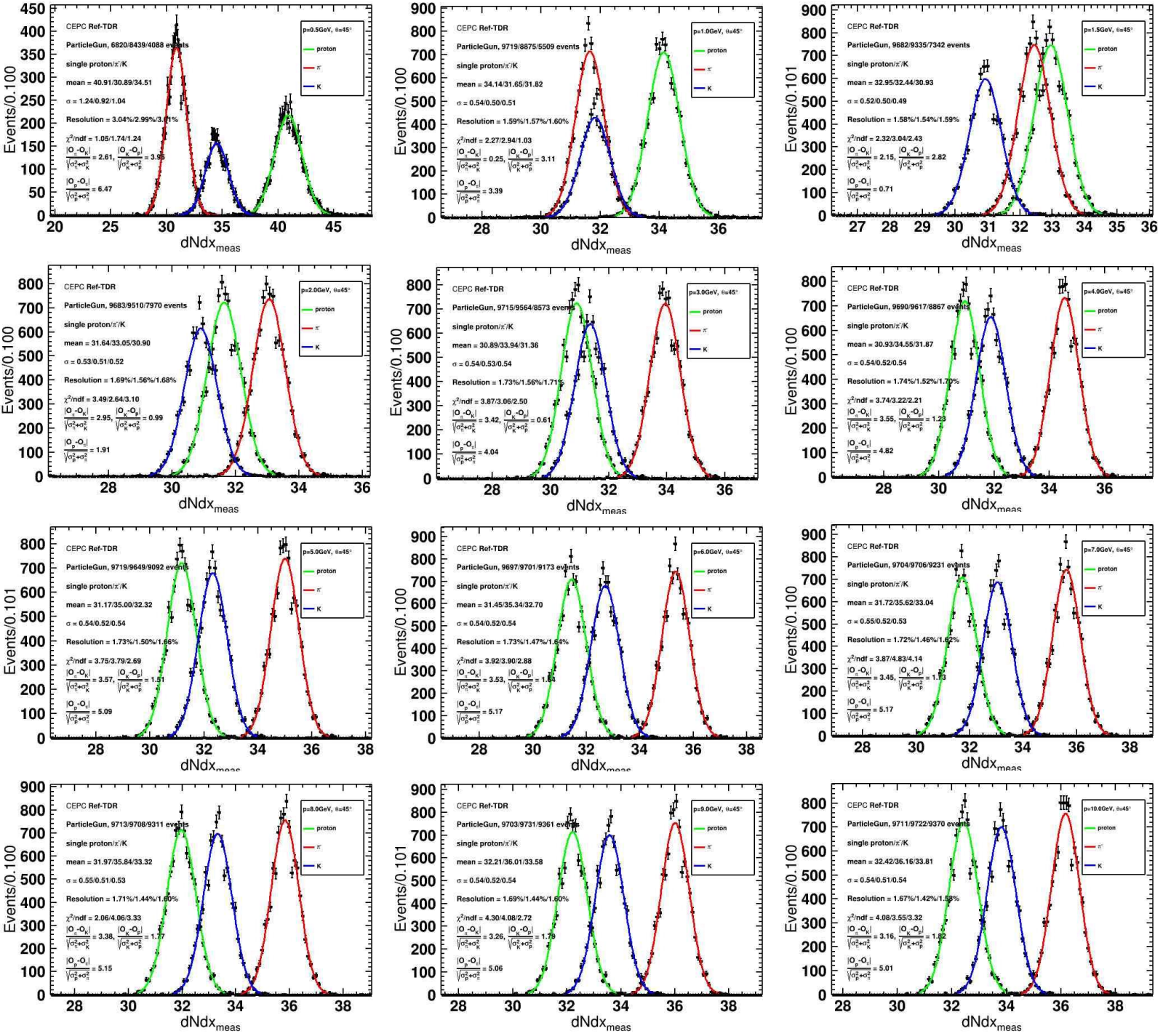
Track phase space and combined PID efficiency in $Z \to qq$ in tdr24.12.0



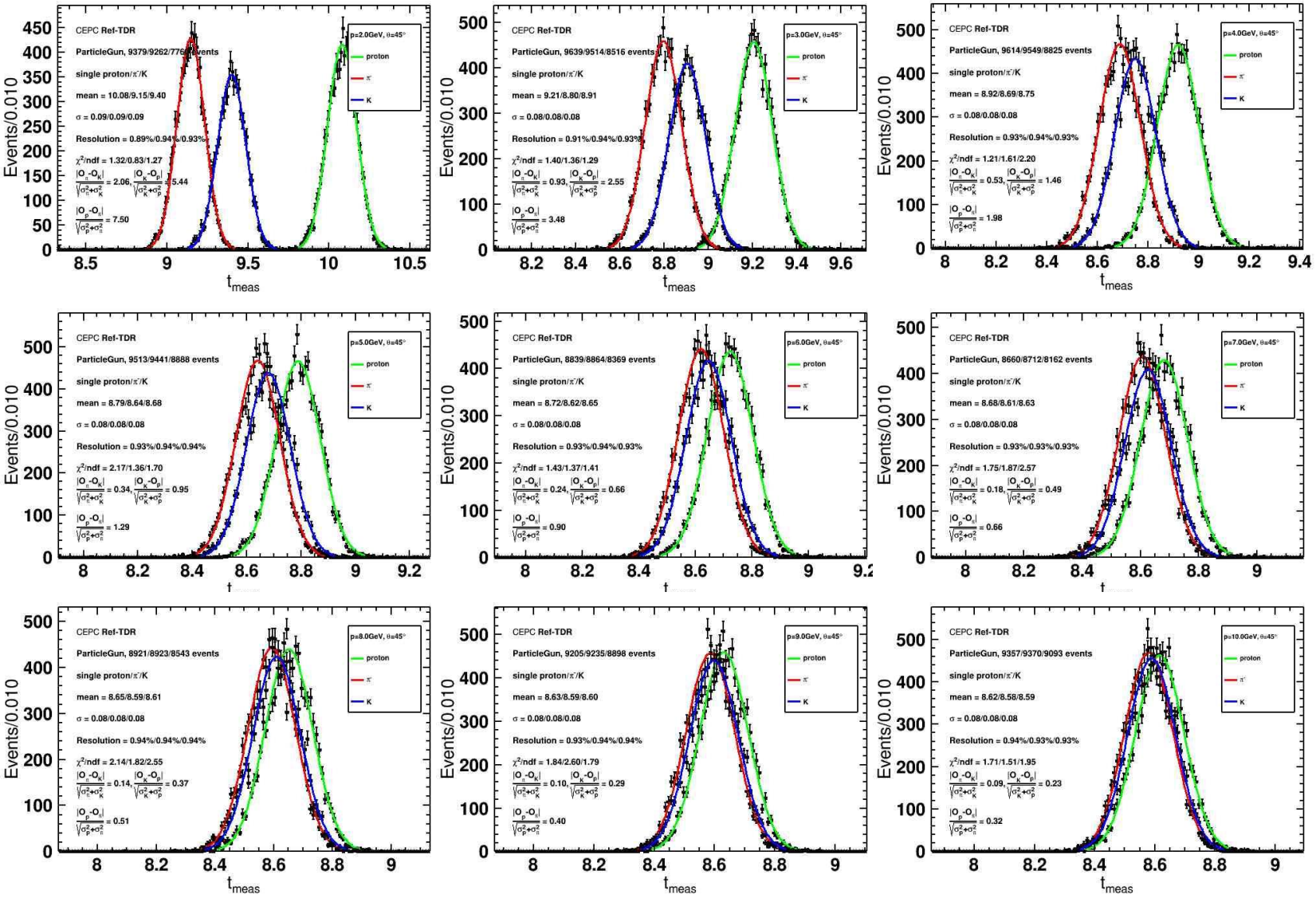






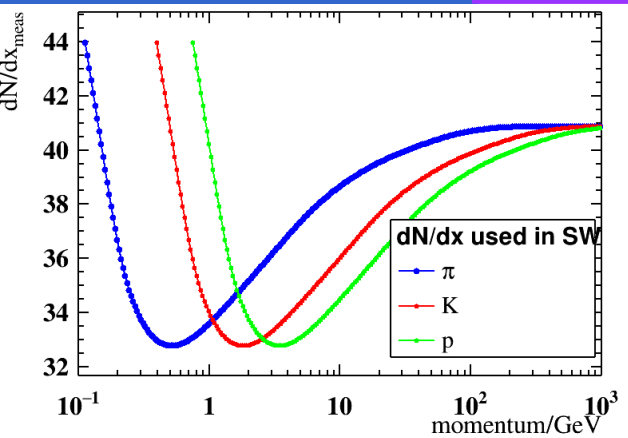


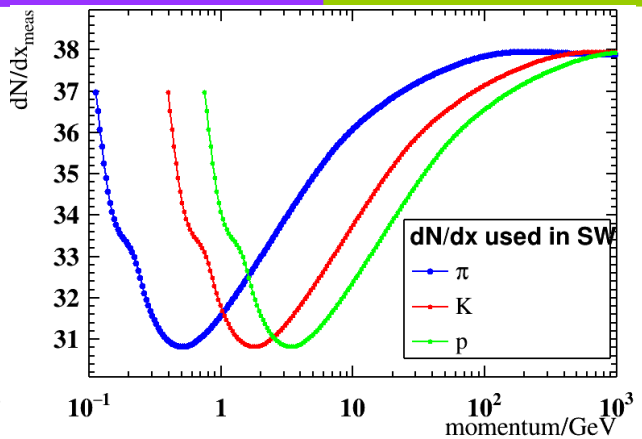
dNdx of pi/k/p at 45 degree tdr25.1.2

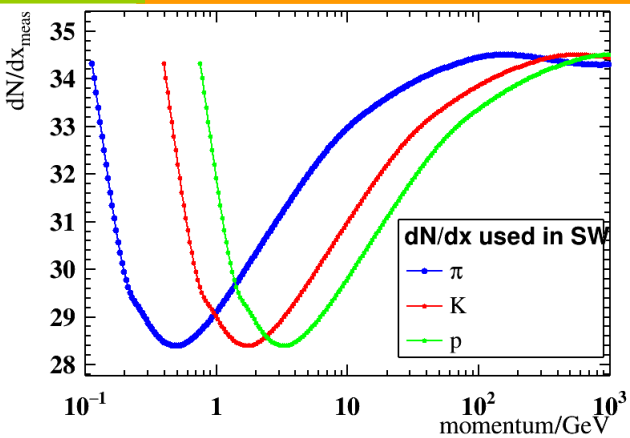


t of pi/k/p at 45 degree tdr25.1.2

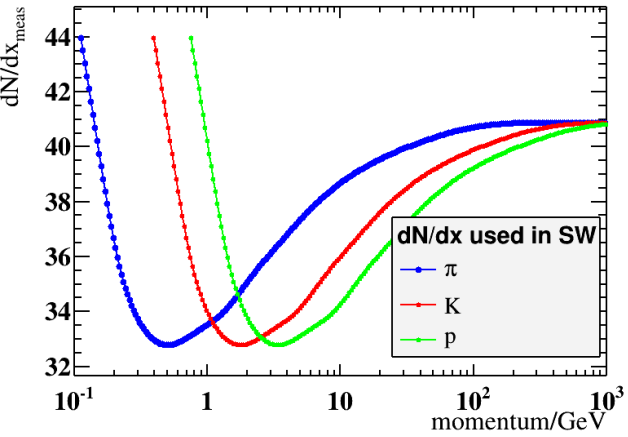
dNdx -- LUT

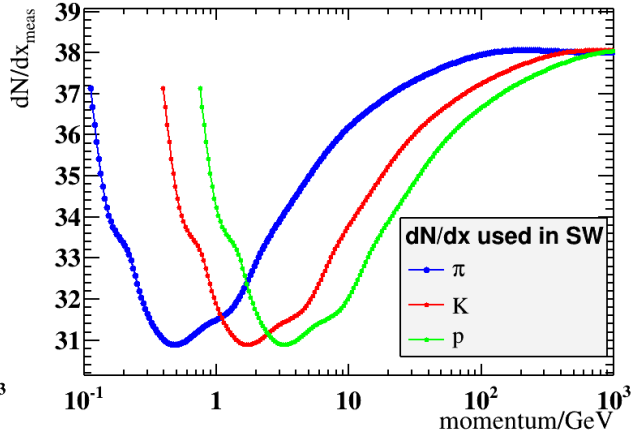


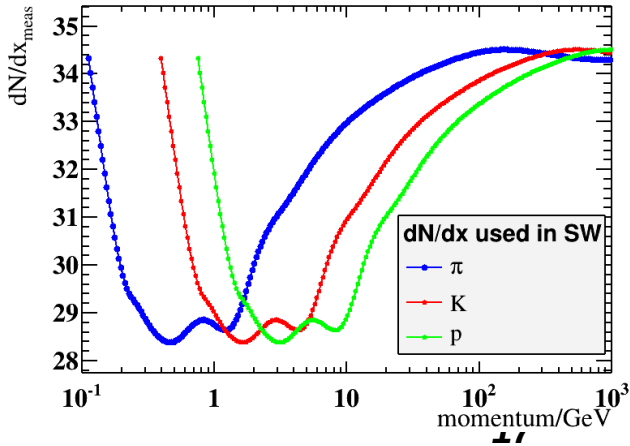




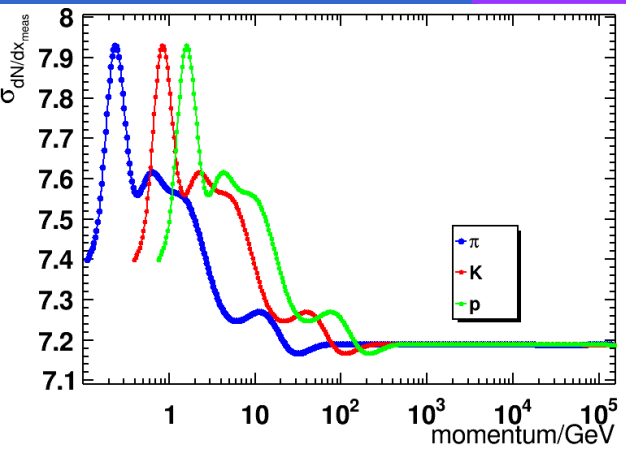
tdr25.1.1
LUT at 50/45/40 degree
tdr25.1.0

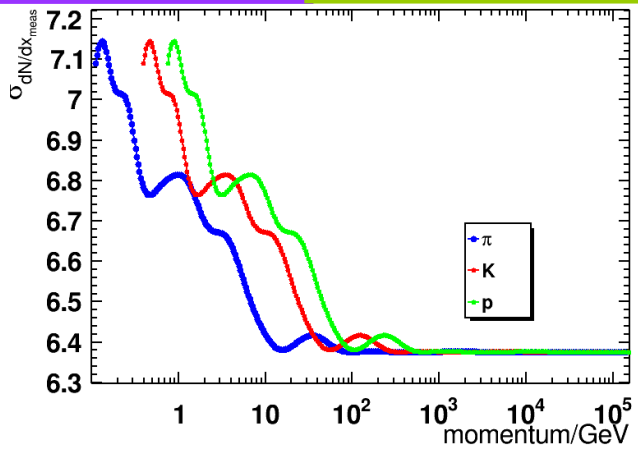


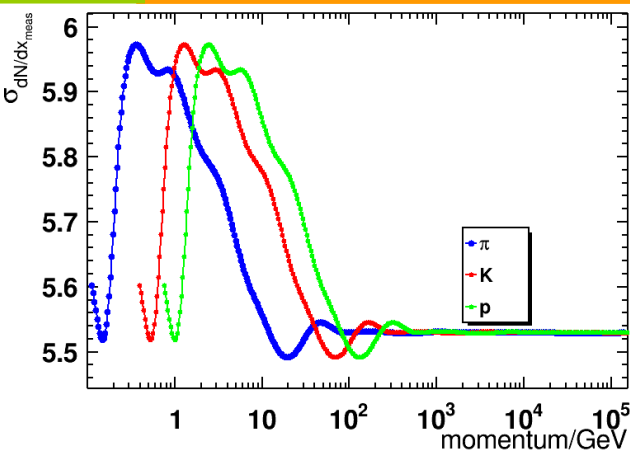




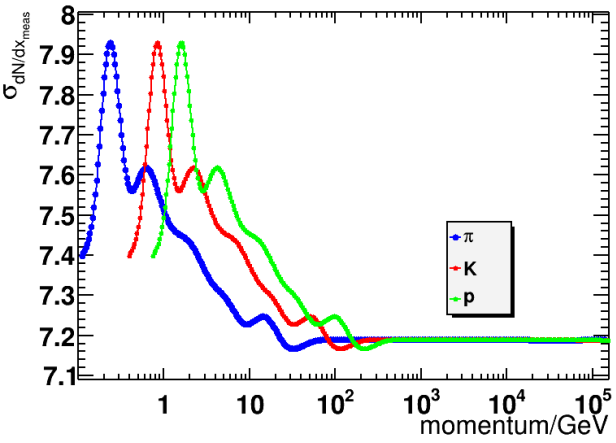
dNdxerr – without length -- LUT

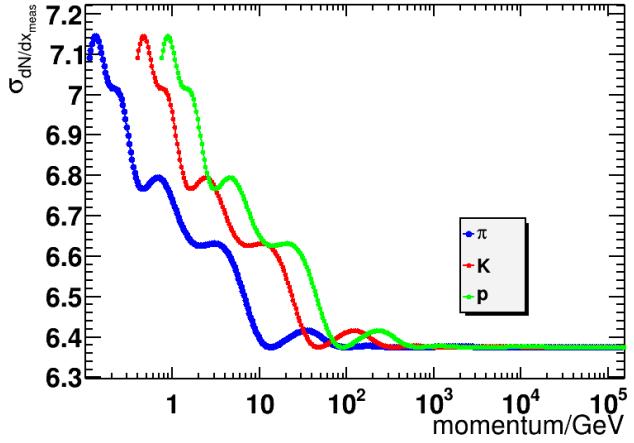


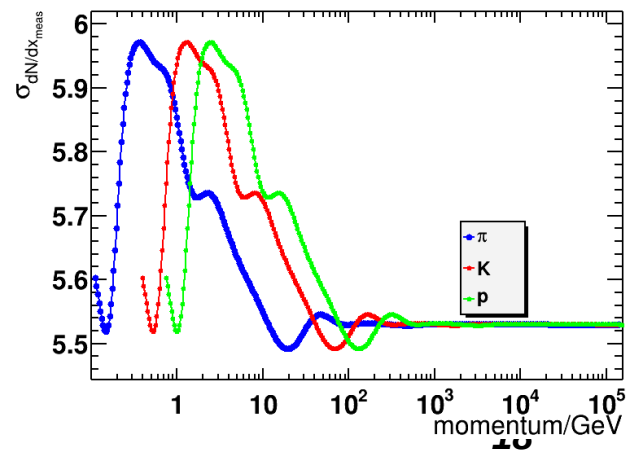




tdr25.1.1
LUT at 50/45/40 degree
tdr25.1.0

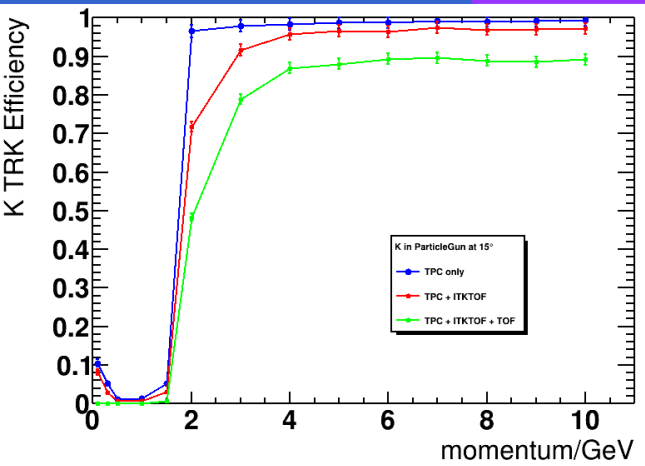


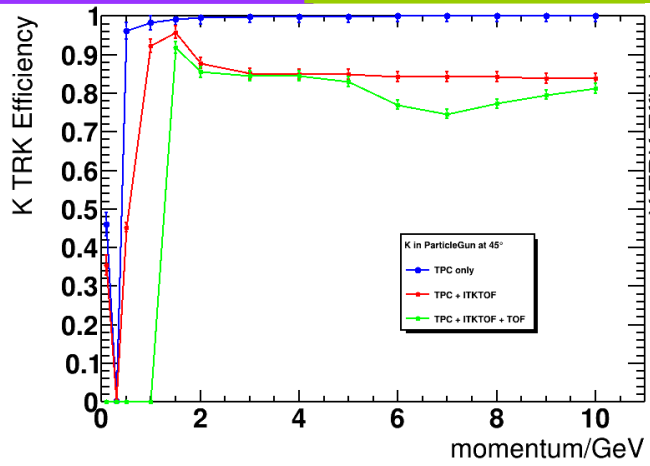


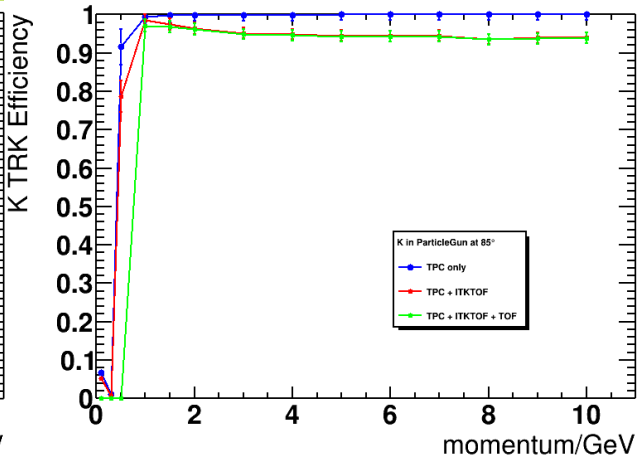


K PID efficiency of 25.1.0 with ITKToF

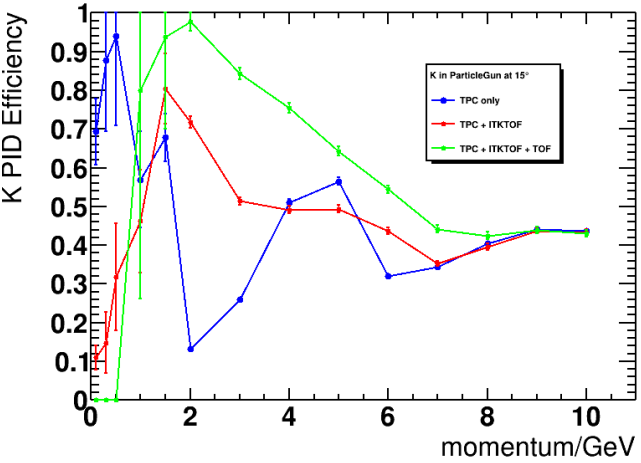
select particles without decay and with 1 track, only identify pi/k/p

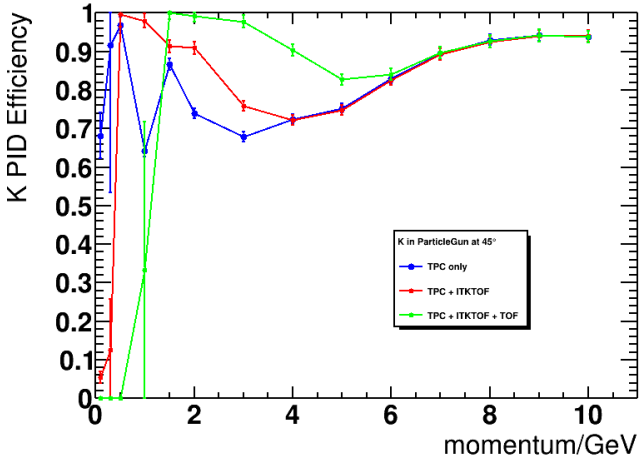


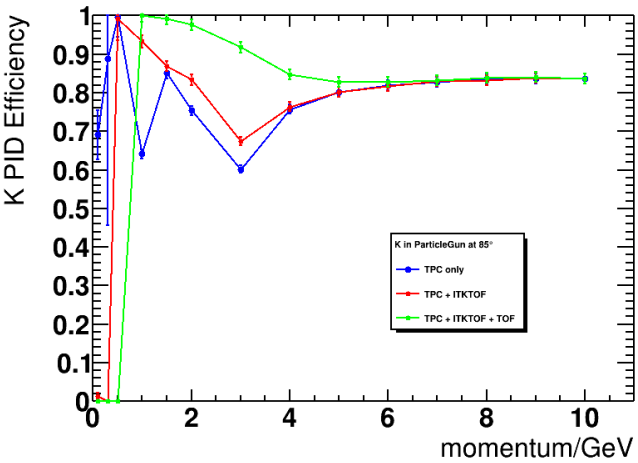




15 degree (left) VS 45 degree (middle) VS 85 degree (right)
ParticleGun K- TRK efficiency of having TPC/ToF track in reco tracks



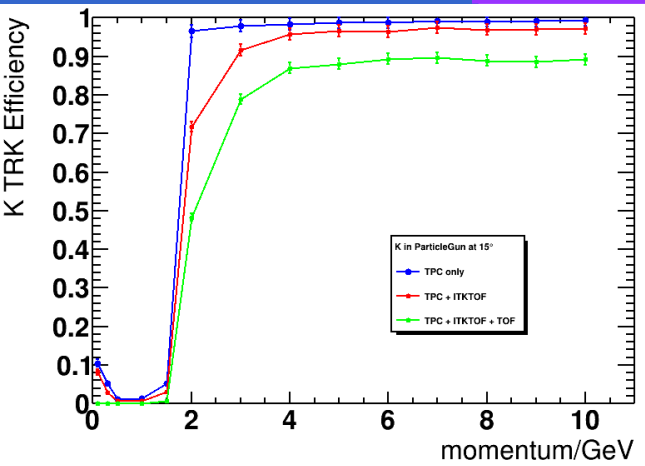


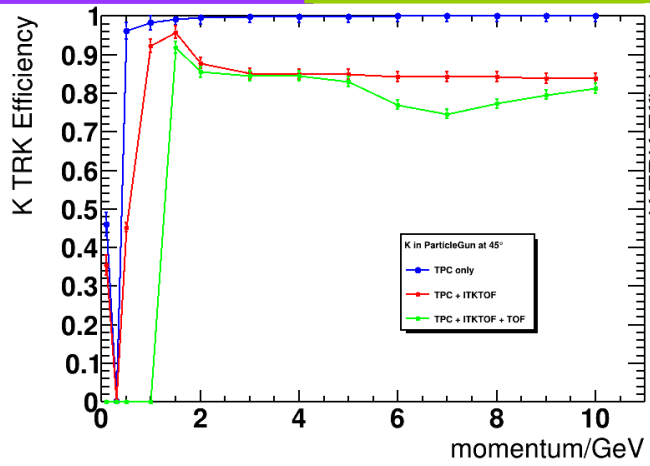


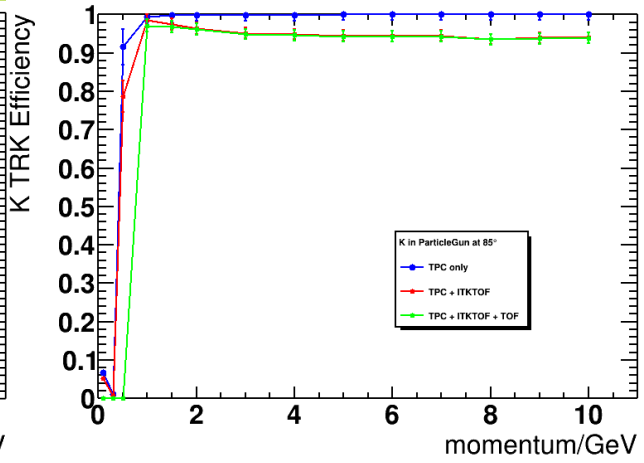
15 degree (left) VS 45 degree (middle) VS 85 degree (right)
ParticleGun K- PID efficiency of right PID

K PID efficiency of 25.1.0 with ITKToF

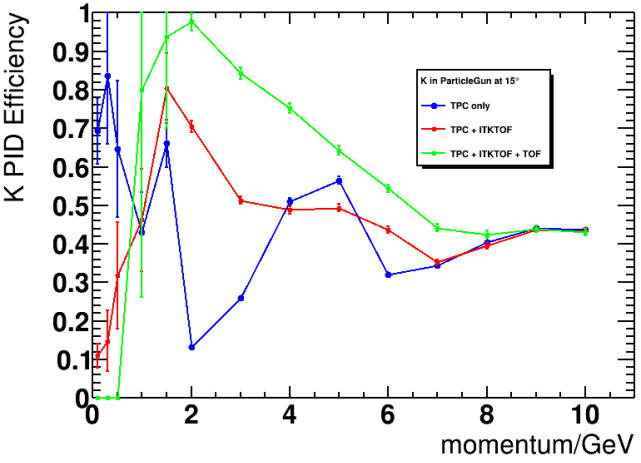
select particles without decay and with 1 track, identify e/mu/pi/k/p

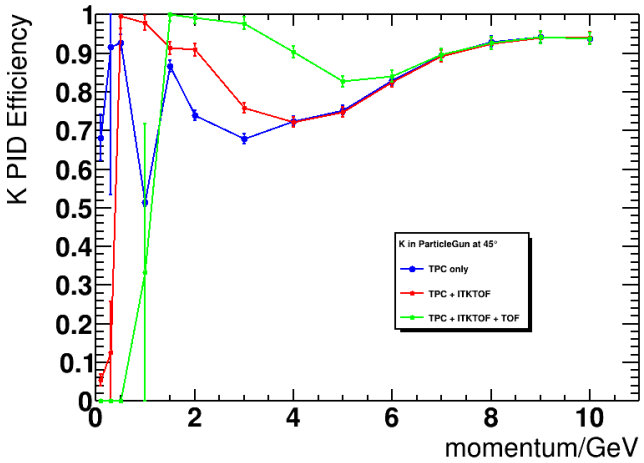


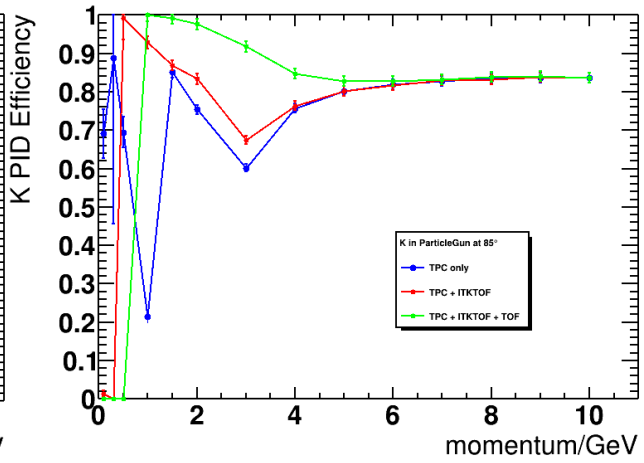




15 degree (left) VS 45 degree (middle) VS 85 degree (right)
ParticleGun K- TRK efficiency of having TPC/ToF track in reco tracks

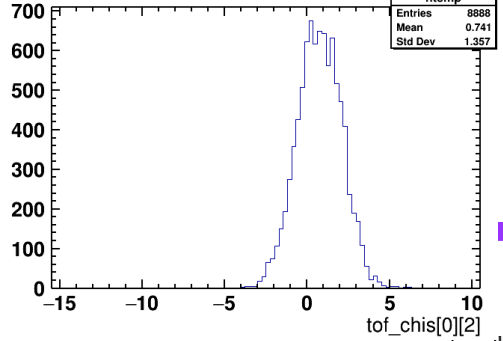


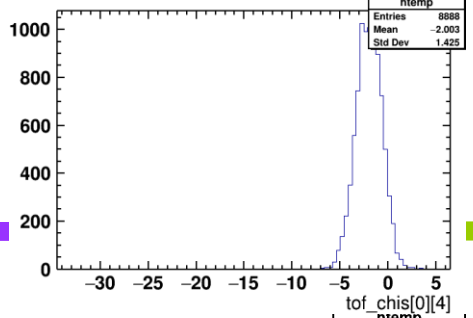


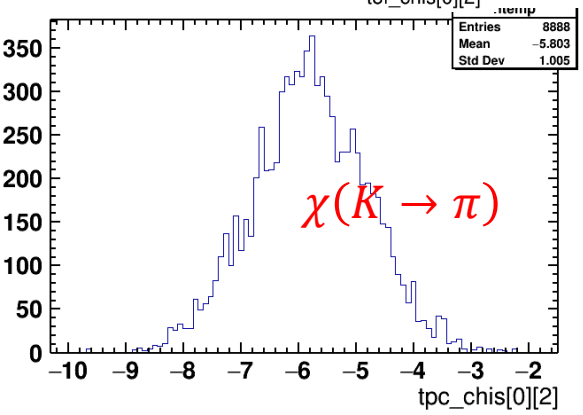


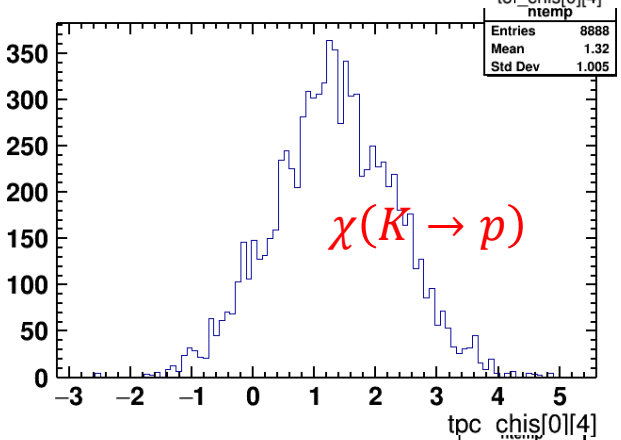
15 degree (left) VS 45 degree (middle) VS 85 degree (right)
ParticleGun K- PID efficiency of right PID

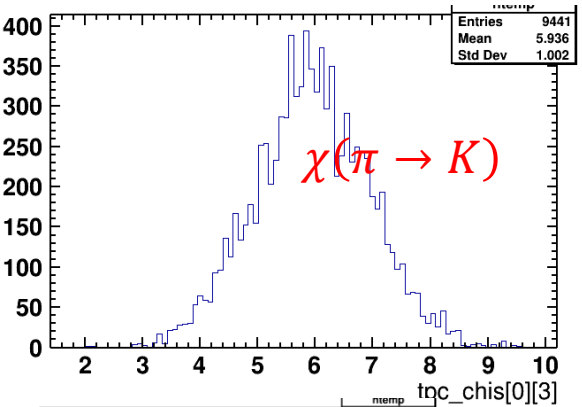
25.1.0

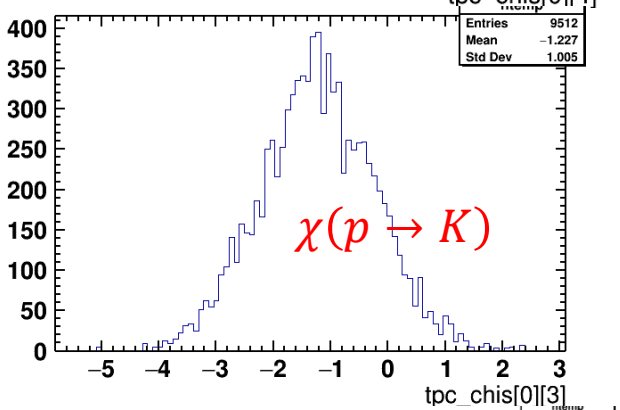


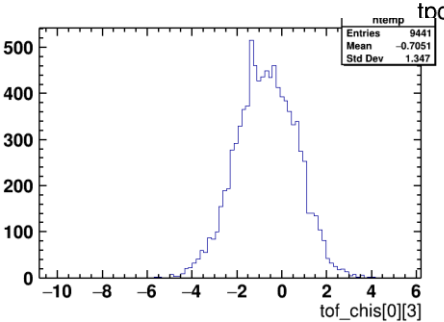


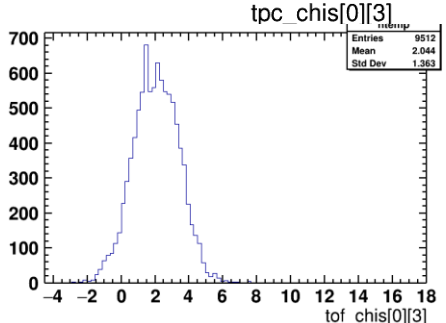










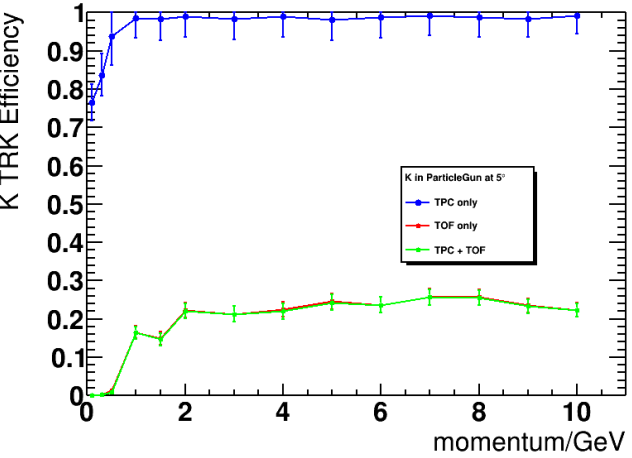


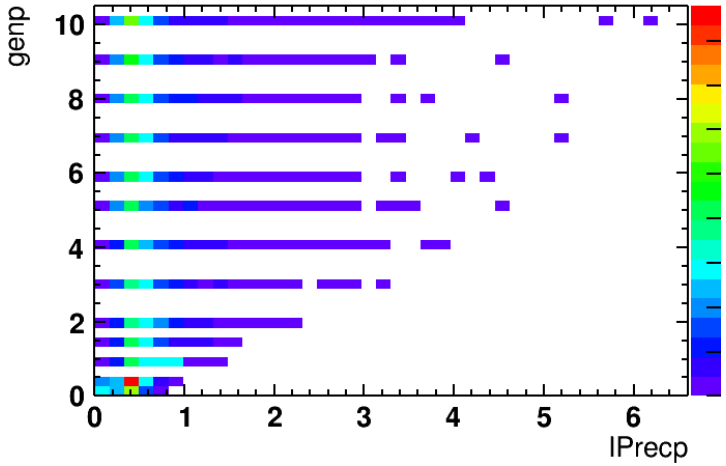
$$\chi_{\mathrm{ToF}}(i) = \frac{t_{\mathrm{meas}} - t^{i}_{\mathrm{exp}}}{\sigma_{t_{\mathrm{meas}}}}, \sigma_{t_{\mathrm{meas}}}$$

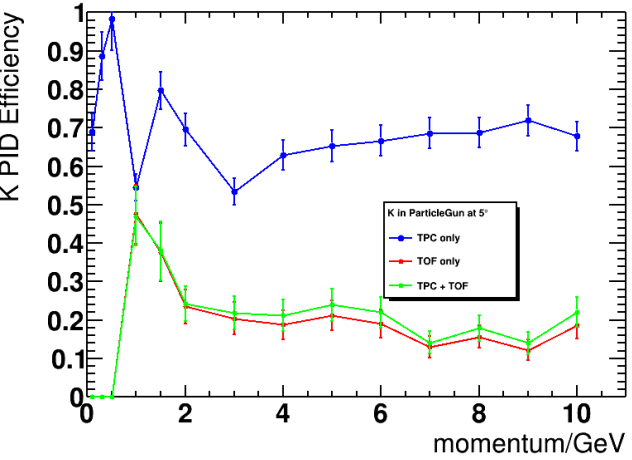
$$= \sqrt{0.05^2 + 0.02^2}$$

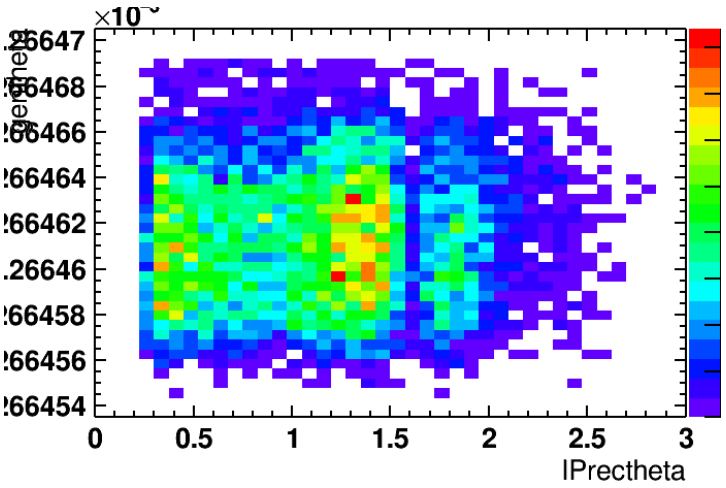
texp = l/v follows some kind of distribution, which causes chi_tof don't follow Gaus(sp,1)

K PID efficiency of 25.1.2





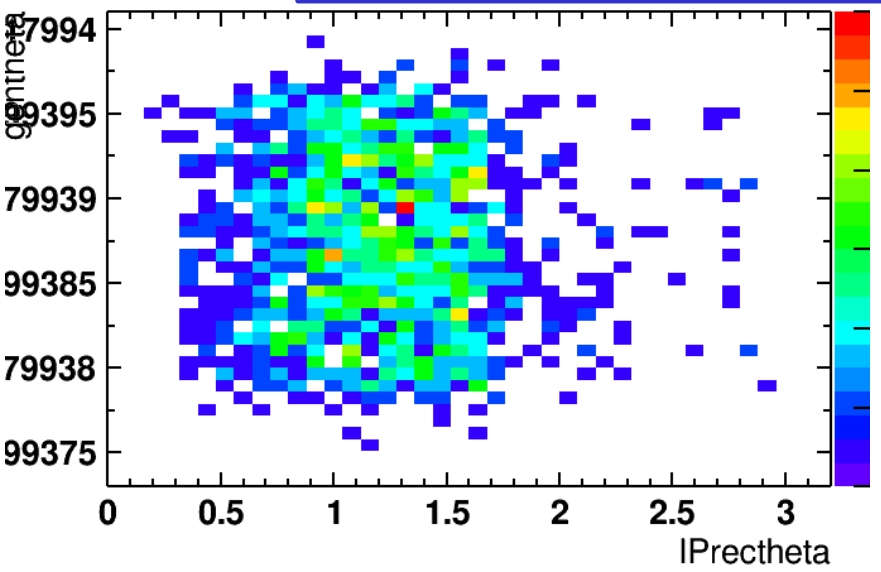


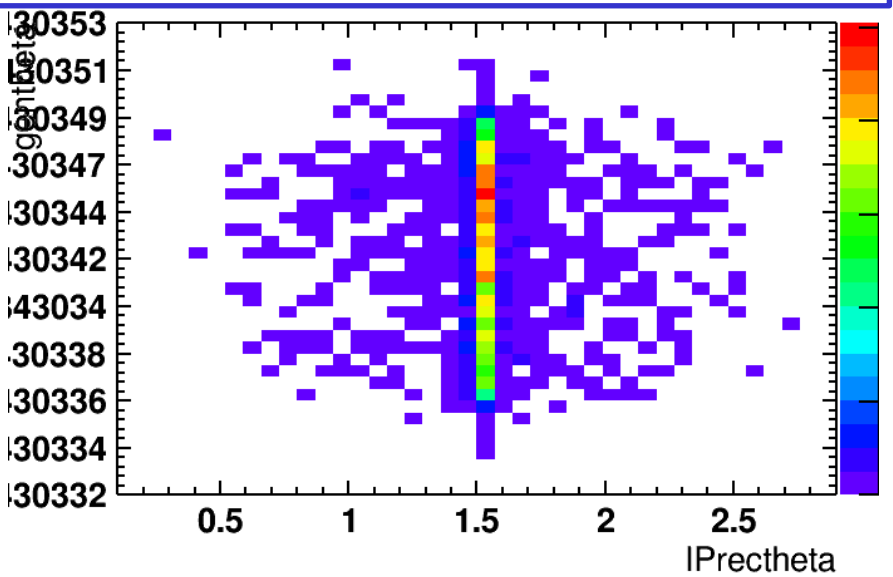


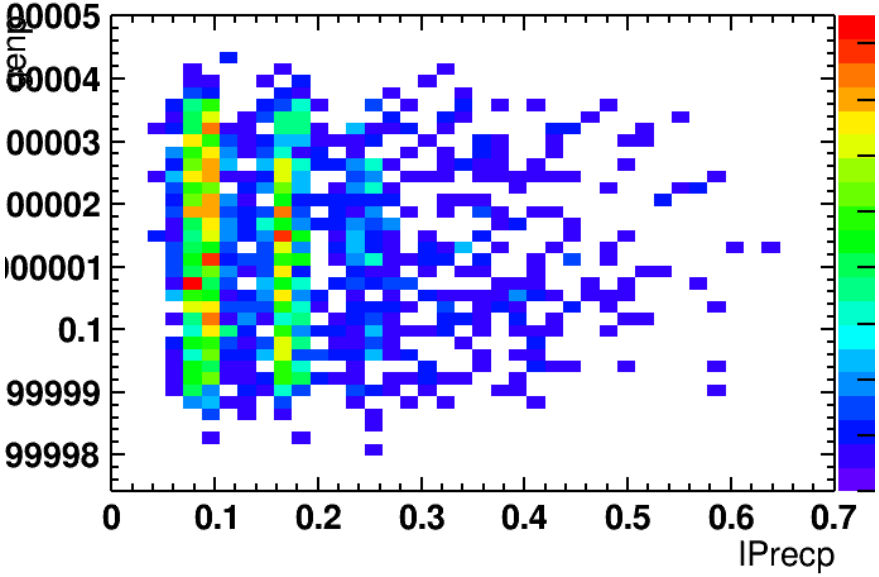
5 degree (left)
ParticleGun K- TRK/PID efficiency

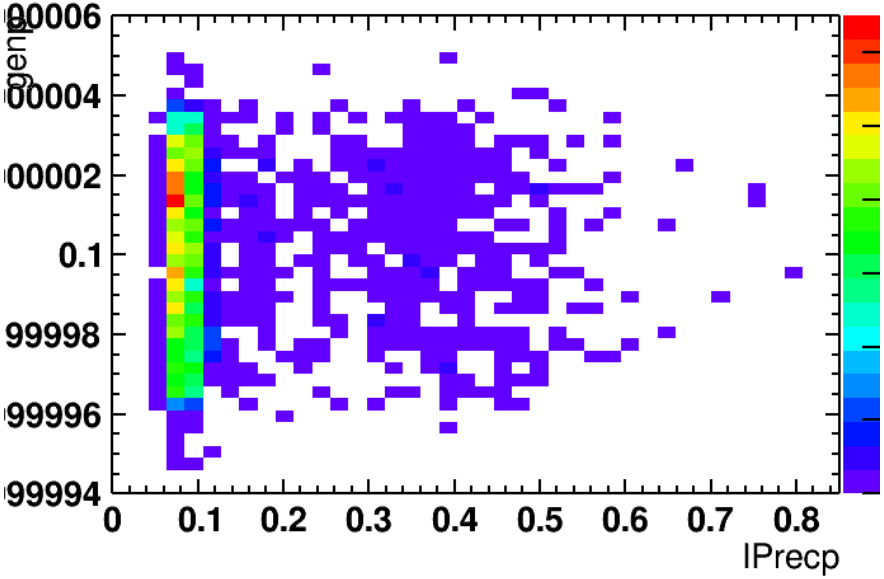
Abnormal TRK efficiency at 100 MeV of 25.1.2

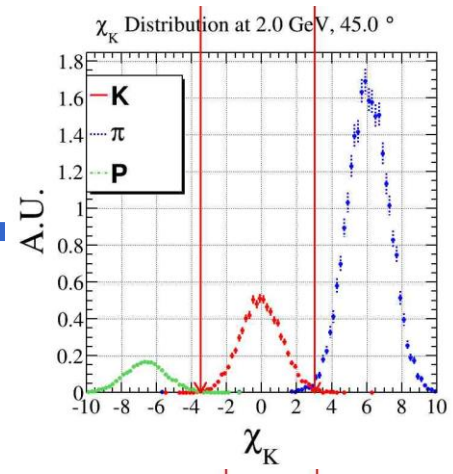
At 15(left)/89(right) degree, select particles without decay and with 1 track

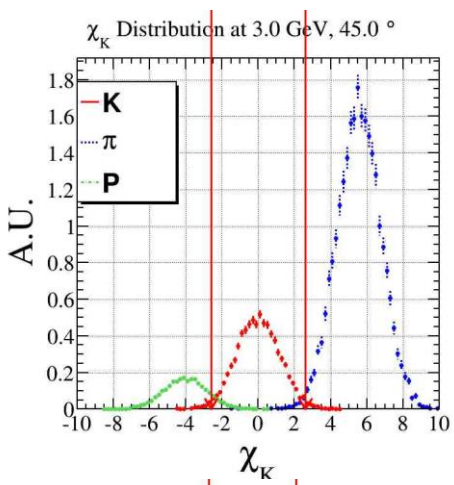


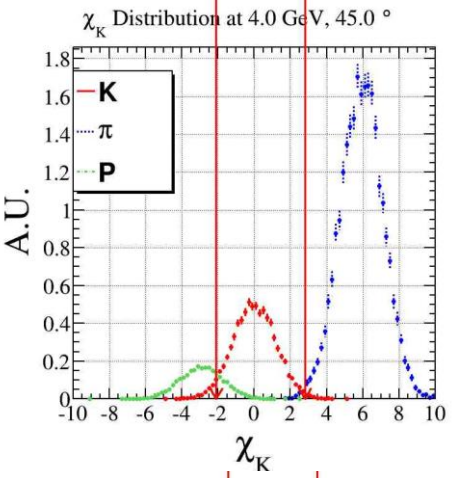




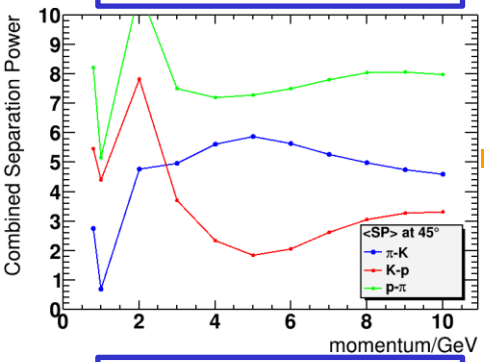




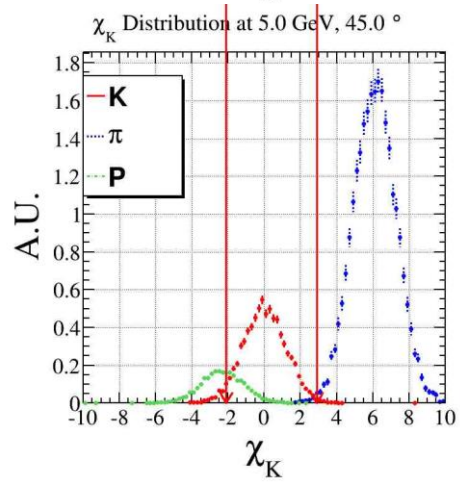


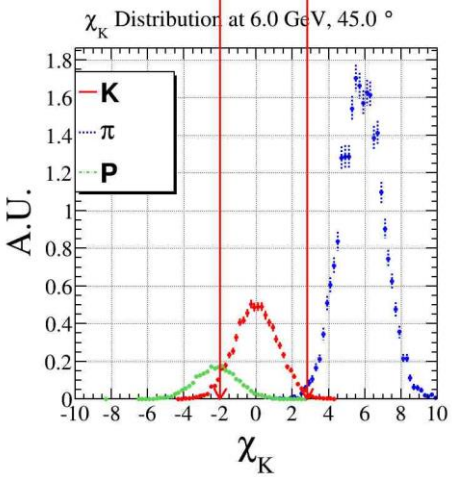


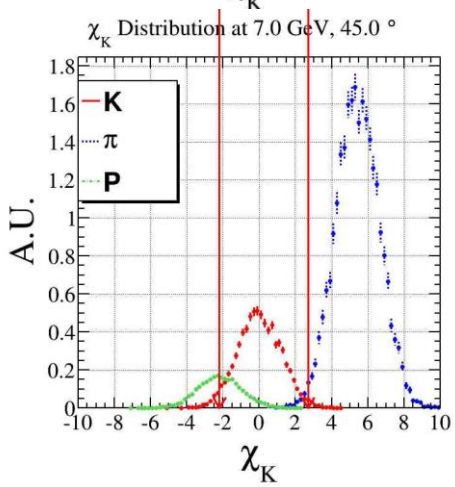
25.1.0 cut optm.

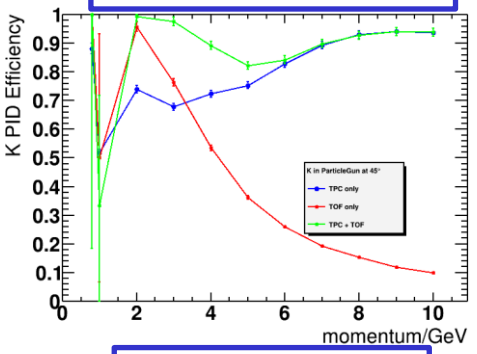


Separation Power

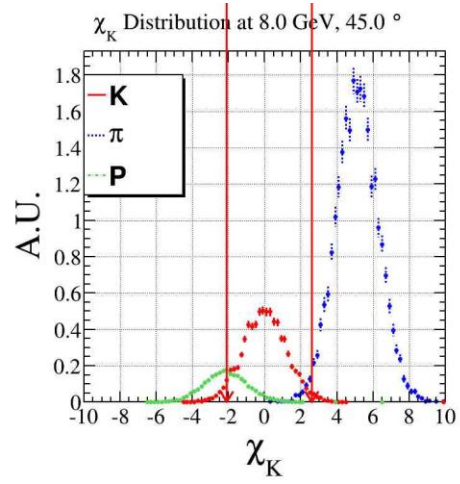


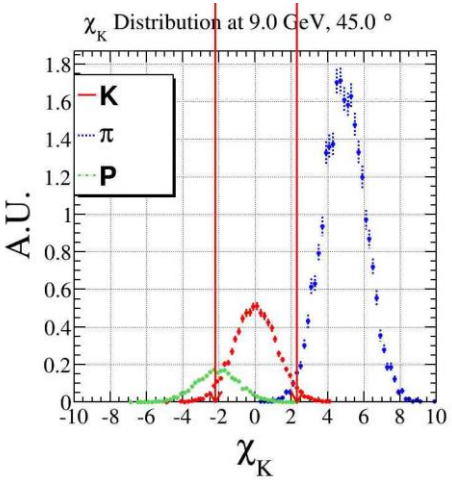


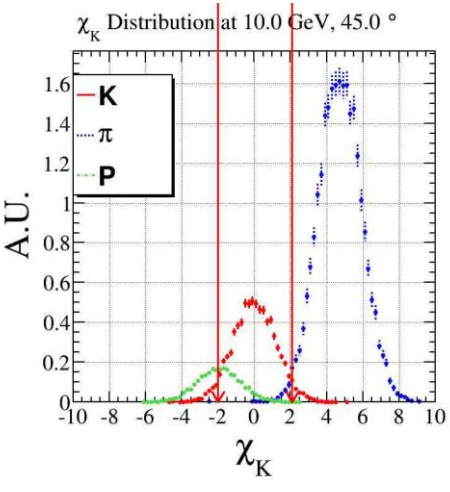


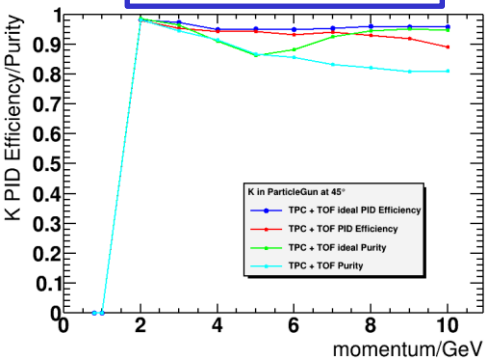


PID Efficiency









Optimized PID Efficiency and purity