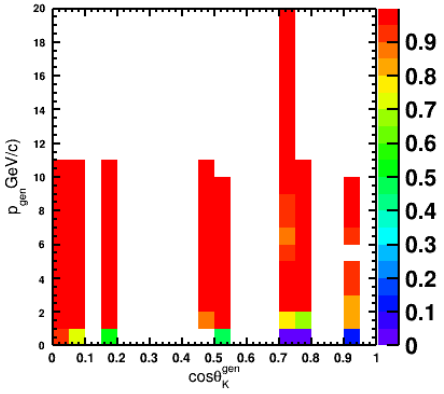
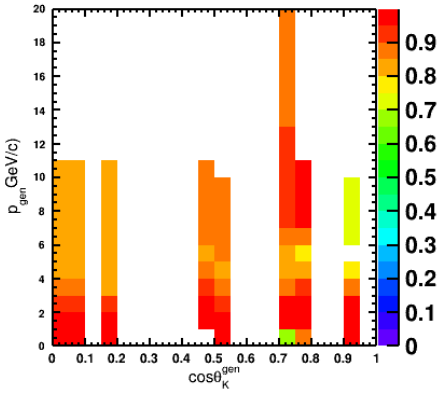
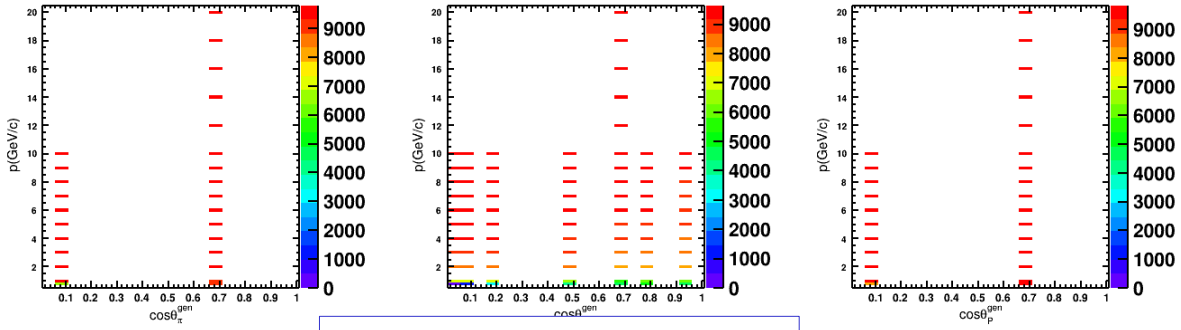
PID efficiency study -- Status

- PID efficiency updates under CEPCSW_tdr25.1.0
  - K combined PID efficiency
    - 2-10GeV and 40/45/60/80/85/89 degree: ~87%
    - 2-10GeV and 20 degree: ~77%
    - Cut optimization could reach 95%/90% ideally (45 degree 10:3:1 gauss)
  - Comparison with tdr24.12.0 at 45/85 degree
    - tdr24.12.0 at 2-10GeV and 45/85 degree: ~82%
    - TPC only PID efficiency: <2GeV: worse, 2-10GeV: better
    - TOF only PID efficiency almost the same
    - K/pi, K/p separation power: <2GeV: worse, 2-10GeV: better
  - ParticleGun pi-/K-/p, select particles without decay and with 1 track

TRK Efficiency: efficiency of having TPC/ToF track in reco tracks
PID Efficiency: efficiency of right PID

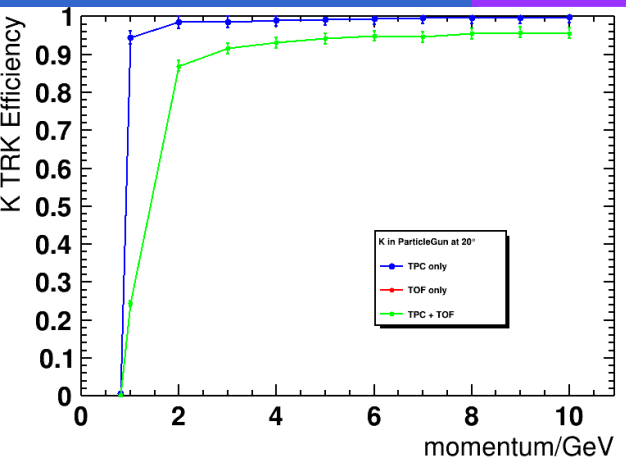


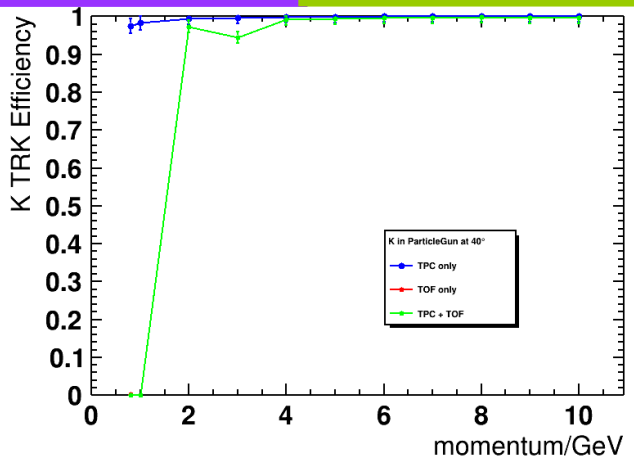


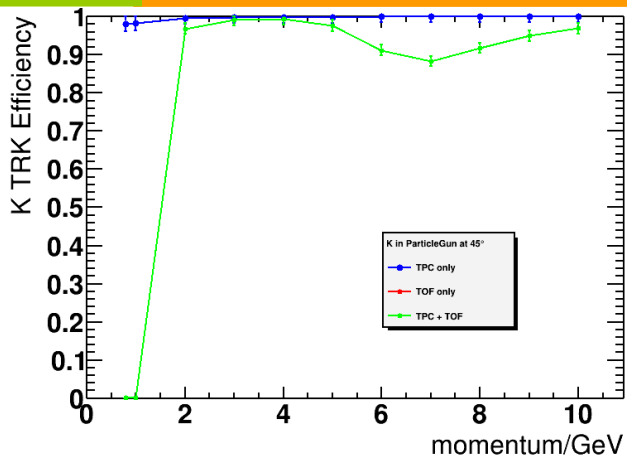


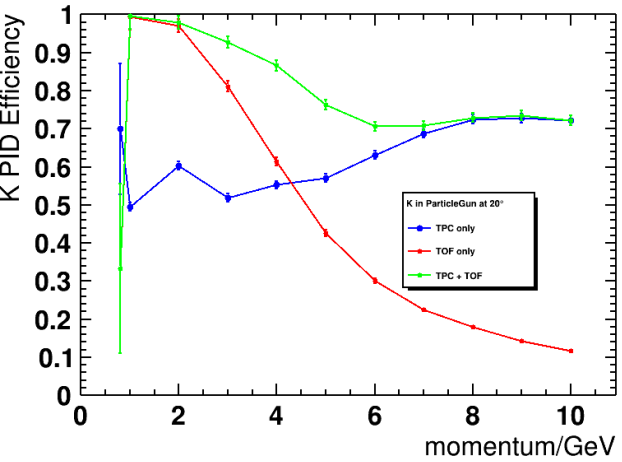
TRK truth phase space

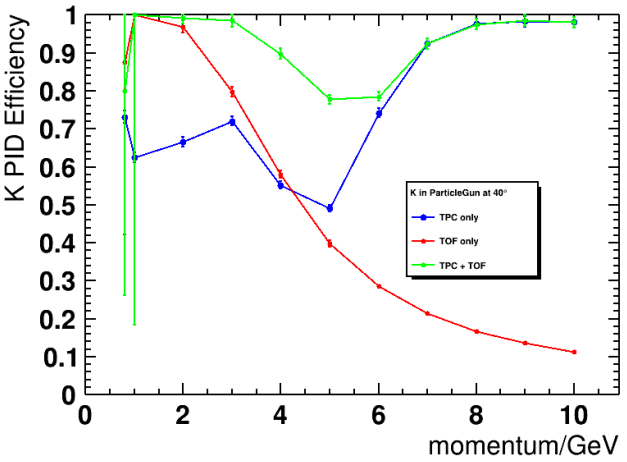
PID efficiency

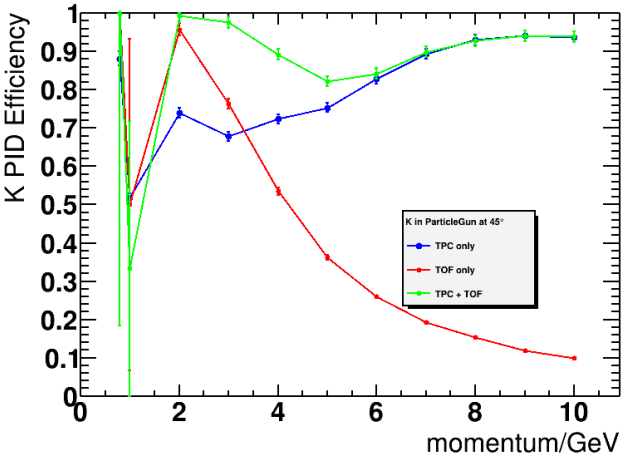






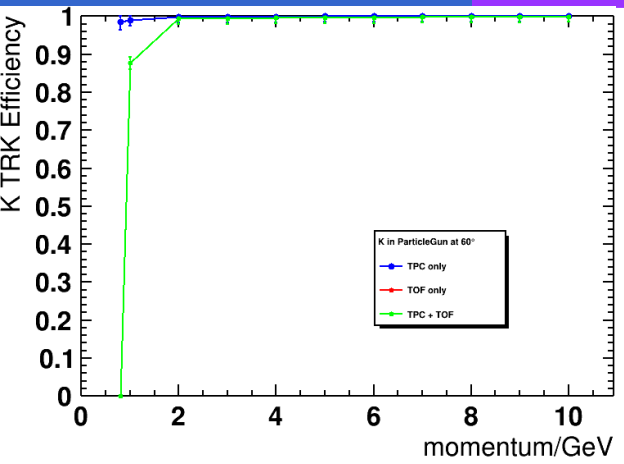


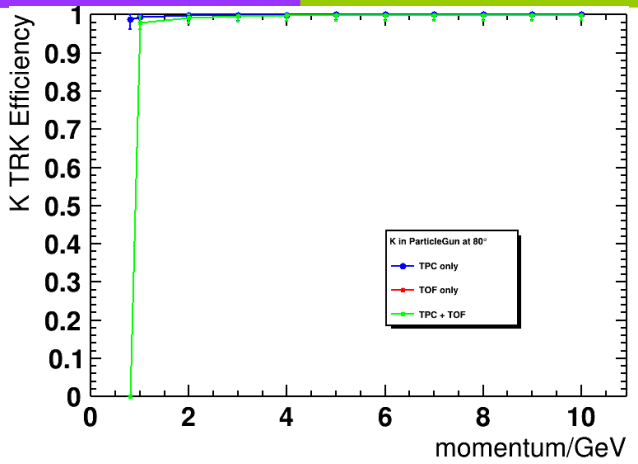


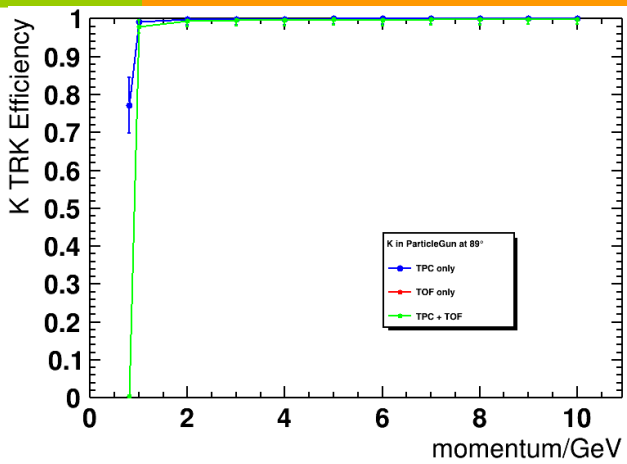


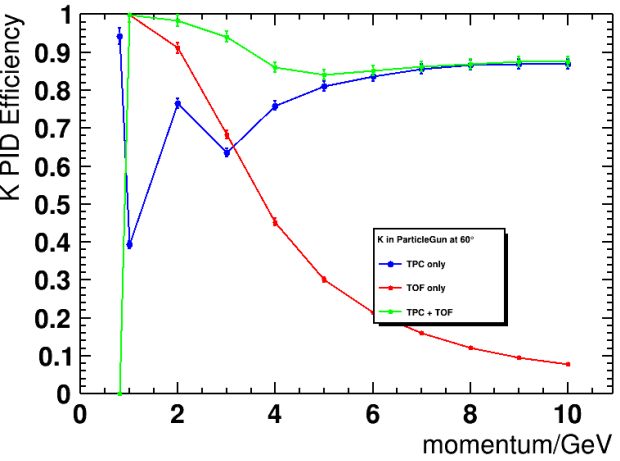
20 degree (left) VS 40 degree (middle) VS 45 degree (right)
ParticleGun K- TRK/PID efficiency

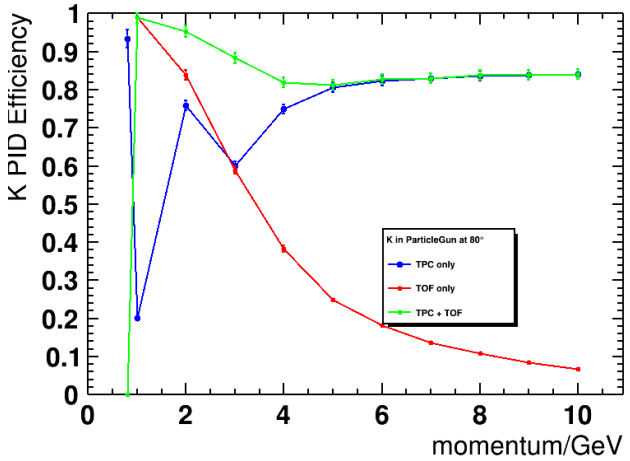
PID efficiency

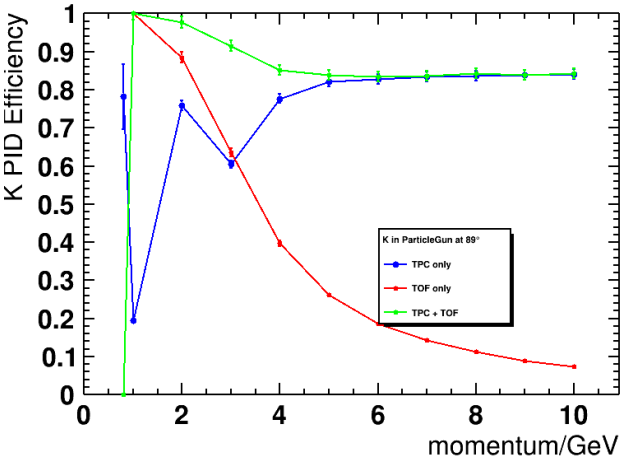






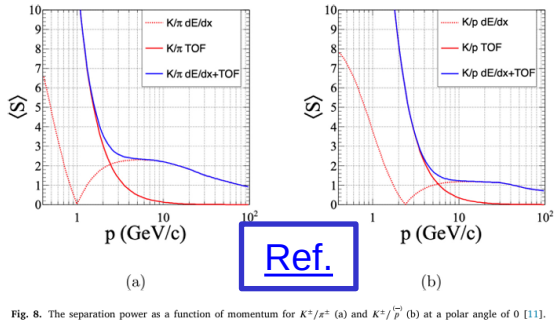






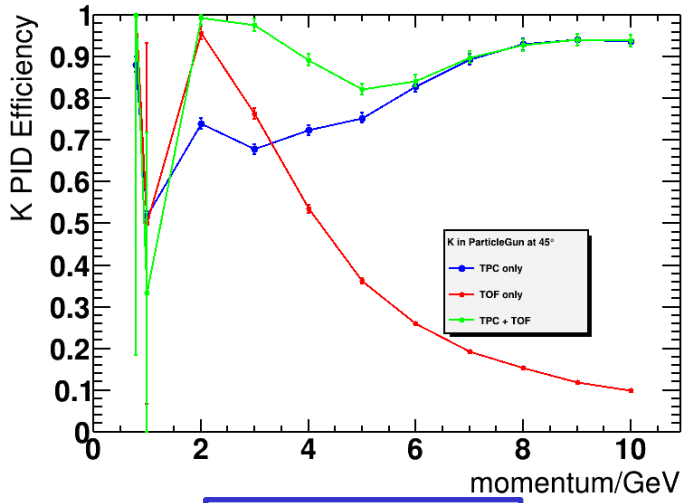
60 degree (left) VS 80 degree (middle) VS 89 degree (right)
ParticleGun K- TRK/PID efficiency

Cut optimization

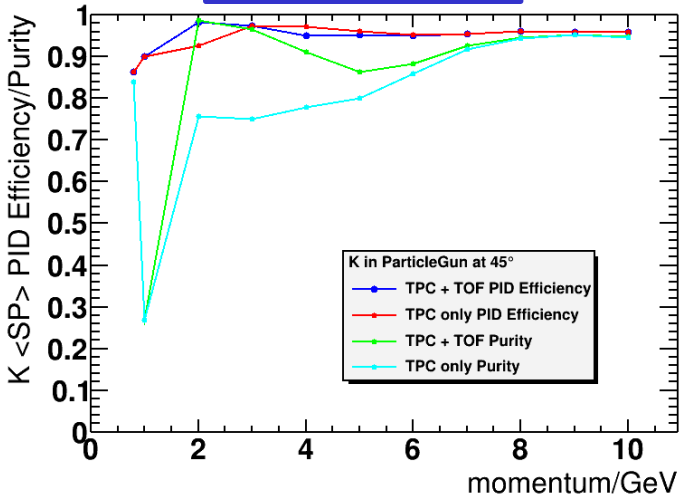


Ref.

Fig. 8. The separation power as a function of momentum for $K^{\pm}/\pi^{\pm}$ (a) and $K^{\pm}/\overline{p}$ (b) at a polar angle of 0 [11].



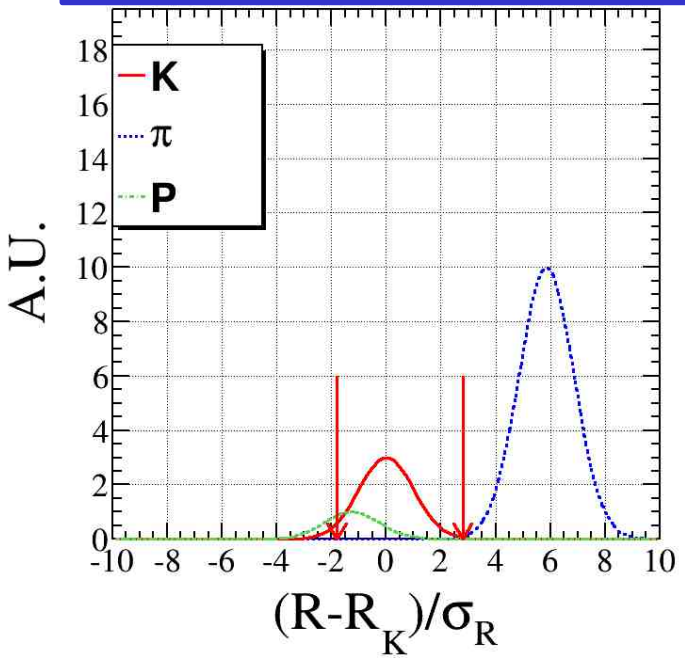
PID Efficiency



PID Efficiency / Purity after optimization

At 45 degree
Comparison between chi2 cut and ideal separation ability cut optimization

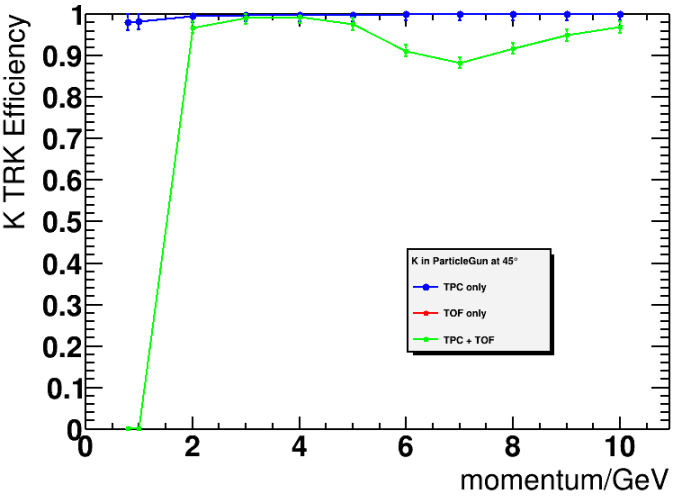
- 2-10GeV K ideal combined PID efficiency/purity could reach 95%/90% level
- Check in real chi_K cut or just apply real pi/k/p ratio to calculate according to <SA> function
- Combined chi_K?

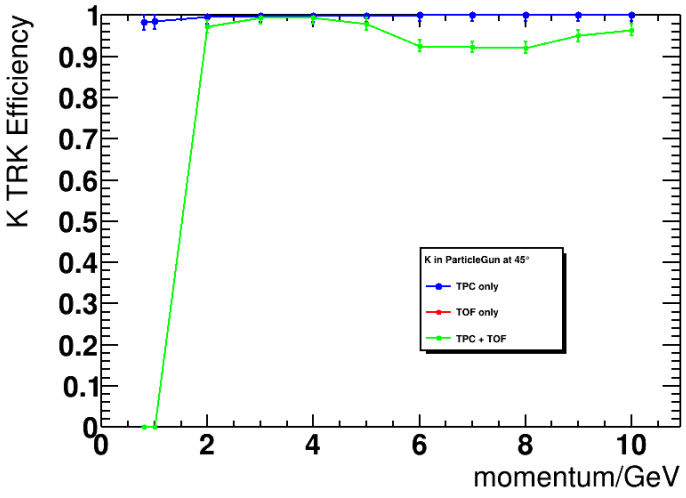


At 5GeV 10:3:1
Separation ability:=$\sqrt{2}$ * Separation power

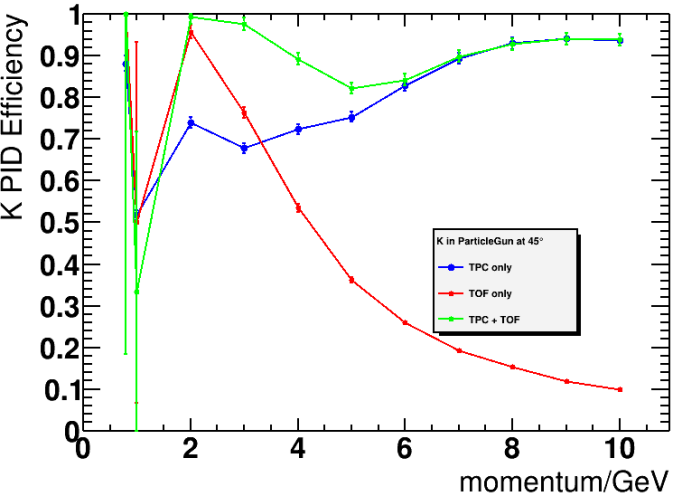
- Ideally, this equals to chi_K distribution * number for a pi/K/p particle
- Maximize eff*purity

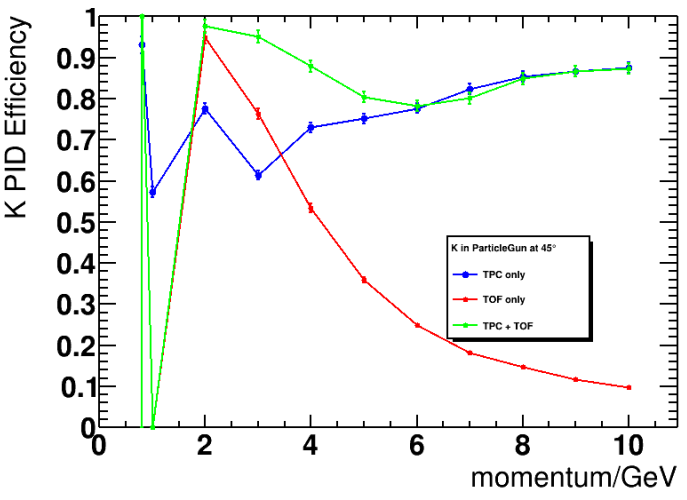
Efficiency comparison at 45 degree



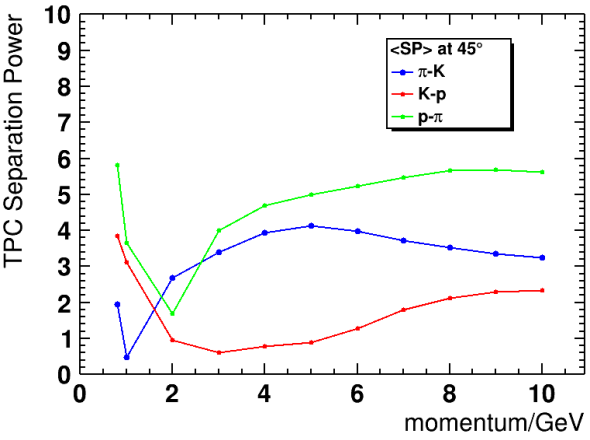


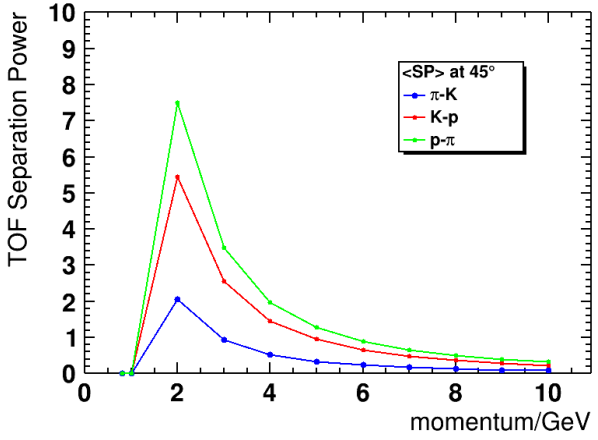
25.1.0 (left) VS 24.12.0 (right)

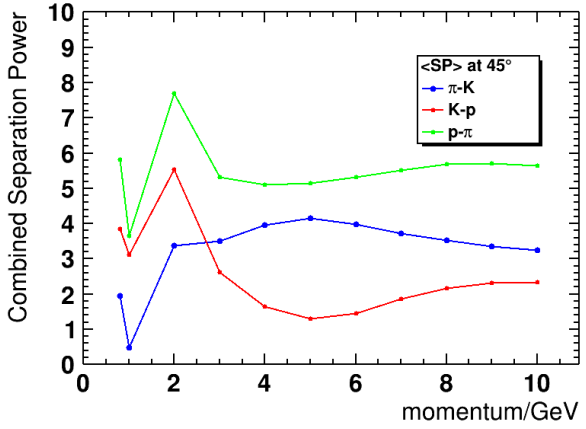




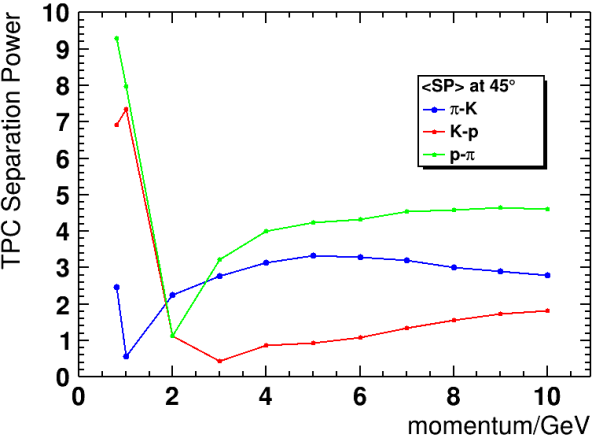
Separation power comparison at 45 degree

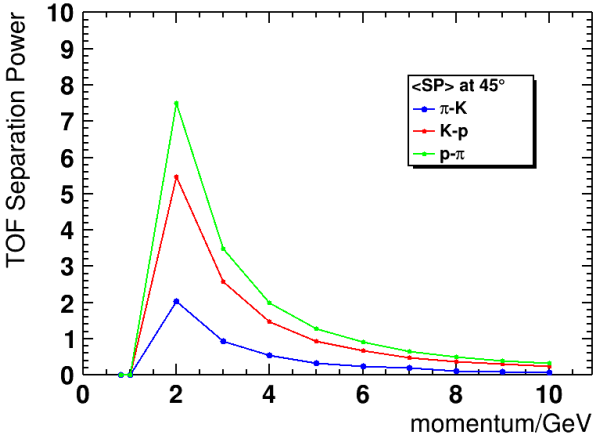


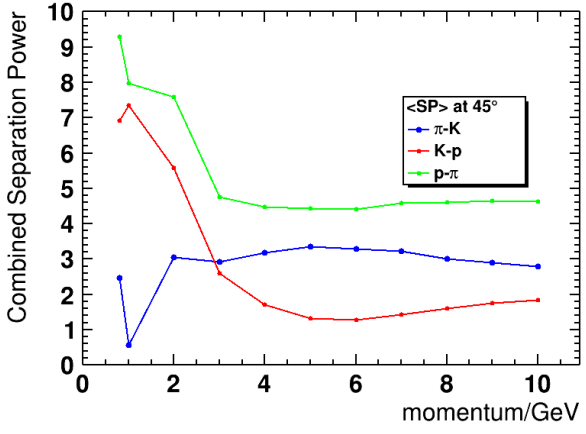


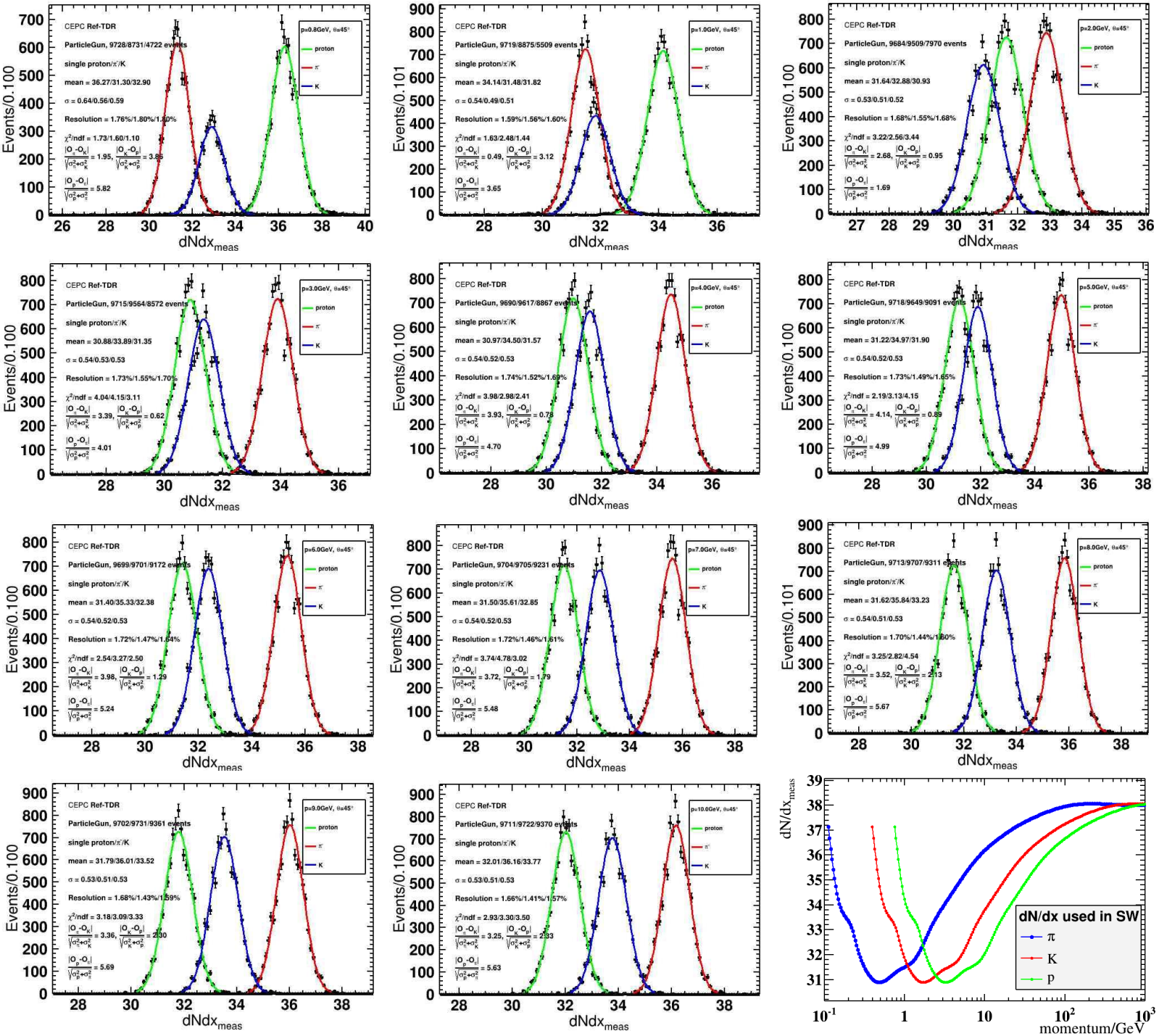


25.1.0 (up) VS 24.12.0 (down)



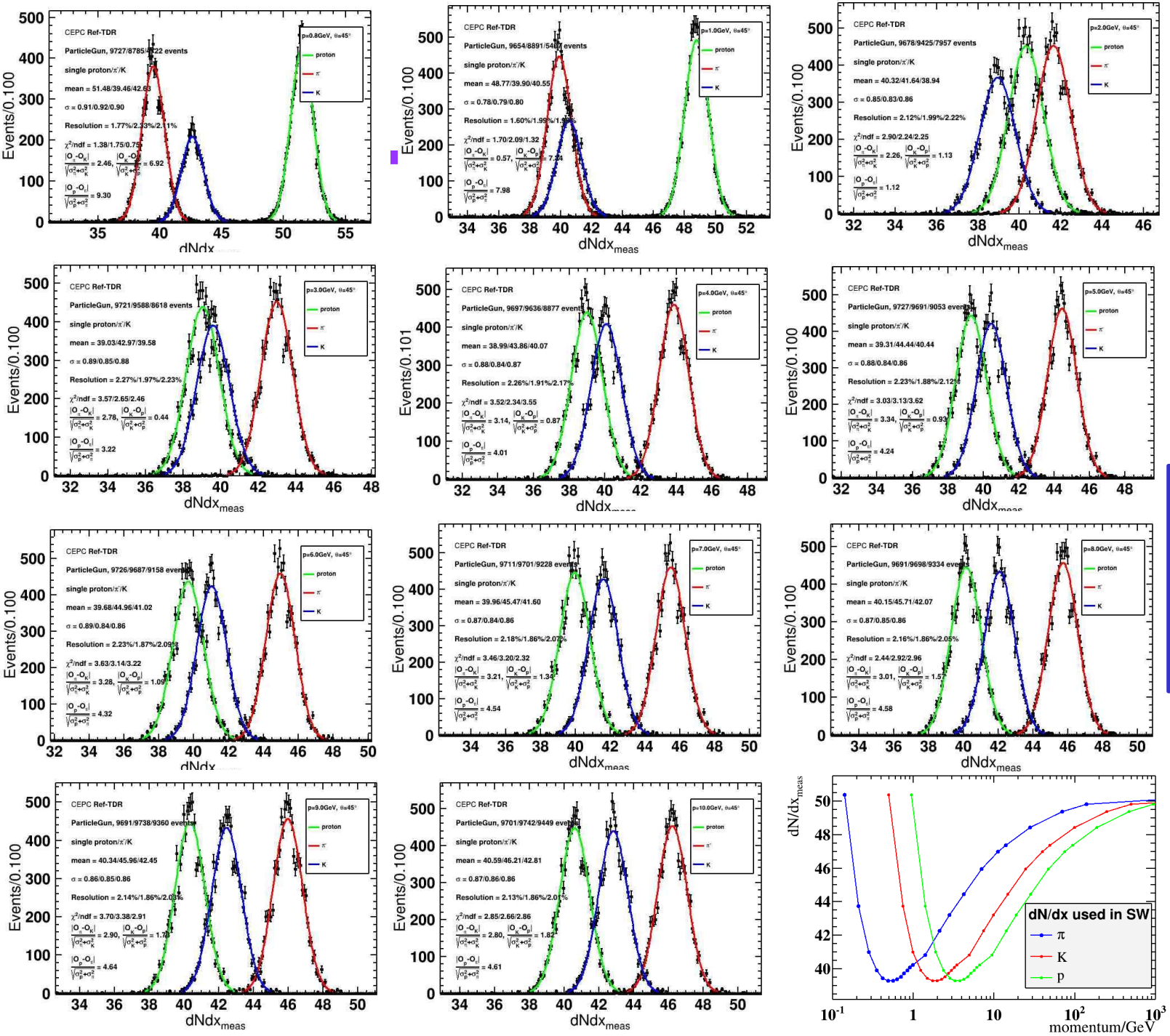




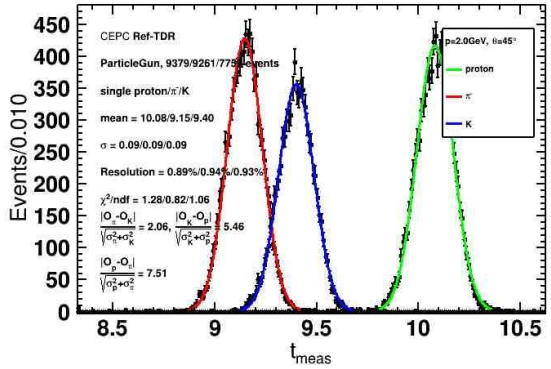


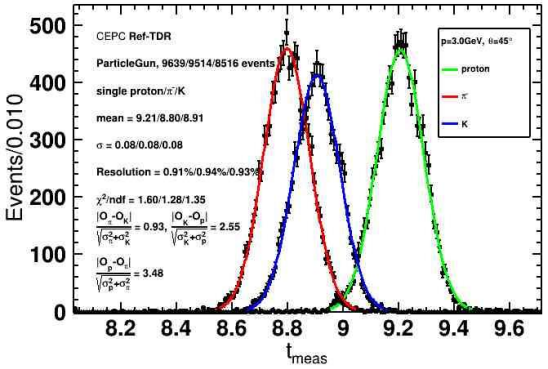
dNdx at 45 degree tdr25.1.0

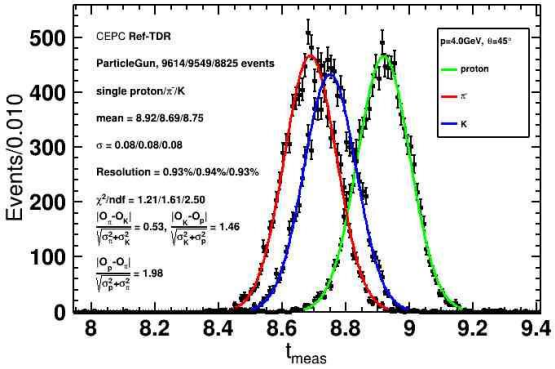
- Match with LUT
- resolution <2%

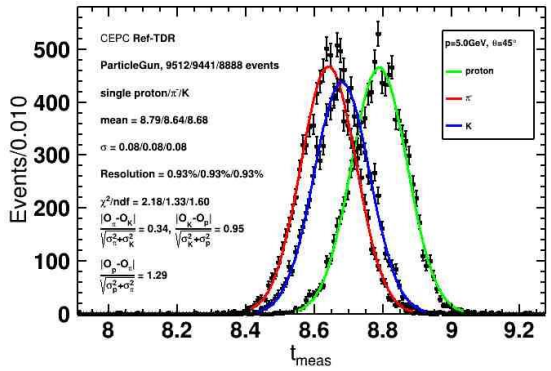


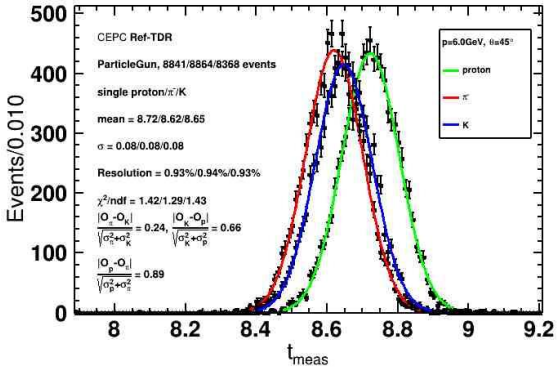
dNdx at 45 degree tdr24.12.0 Match with LUT

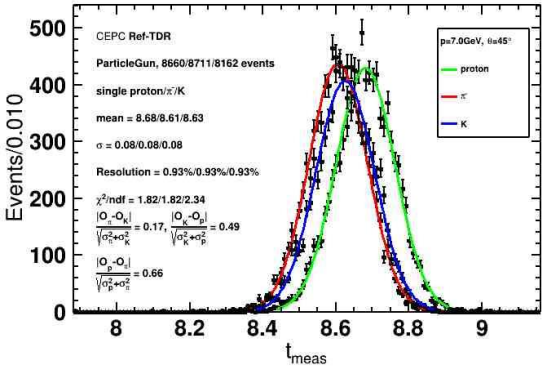


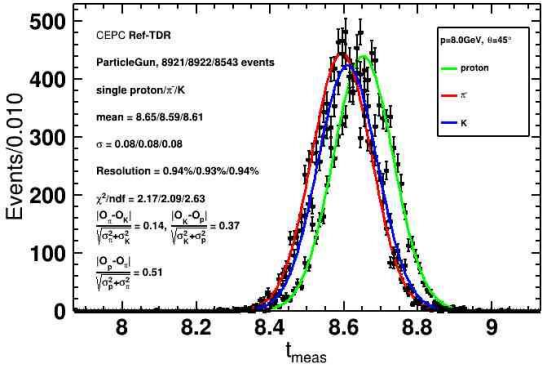


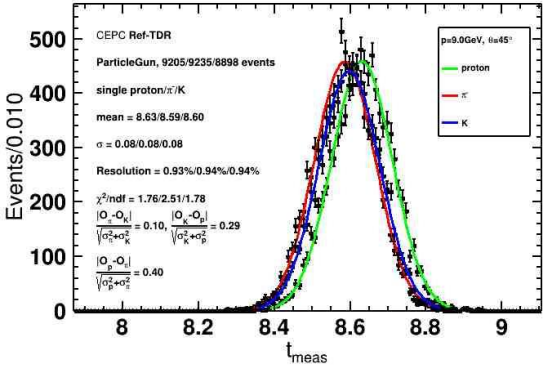


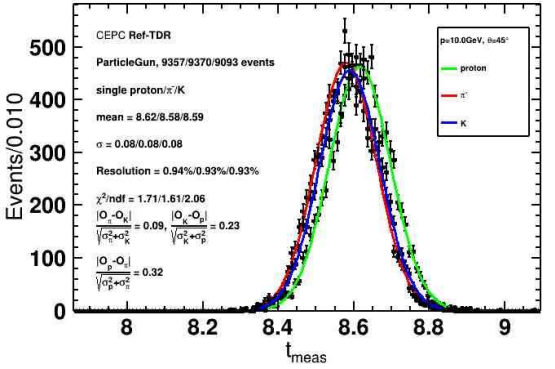




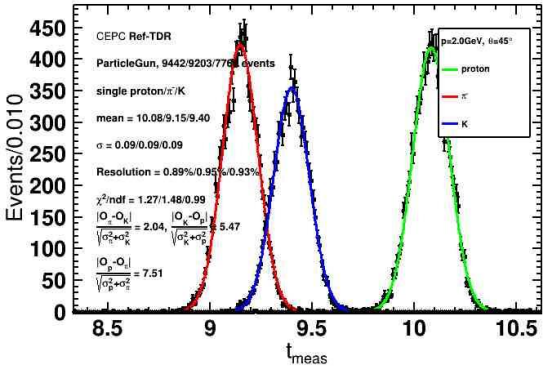


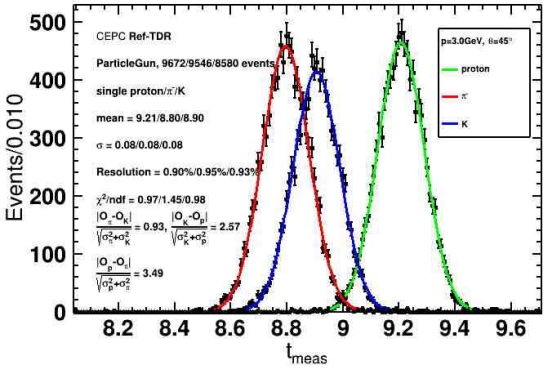


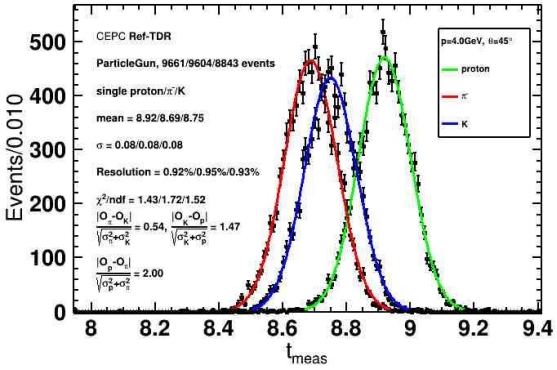


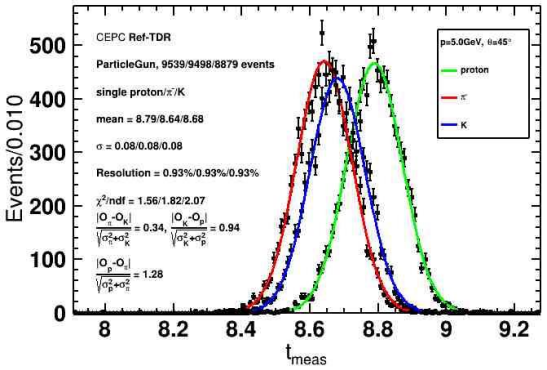


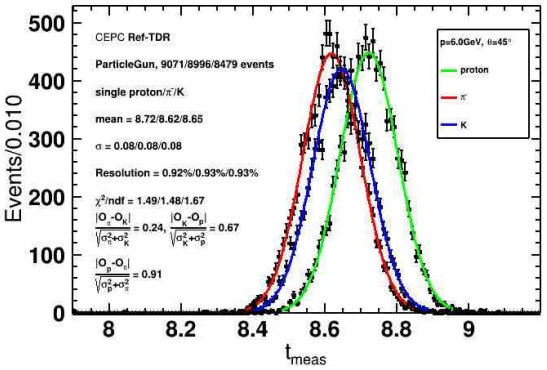
t at 45 degree tdr25.1.0

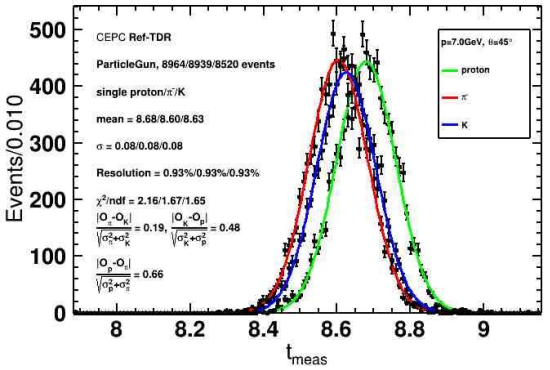


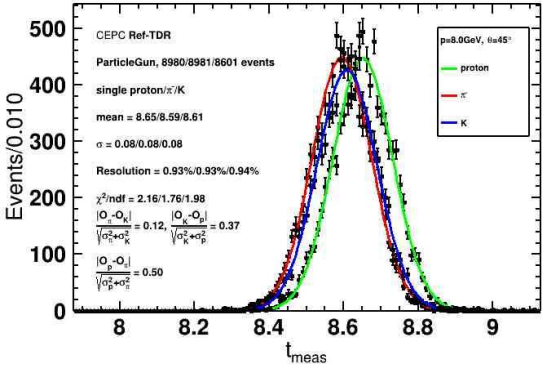


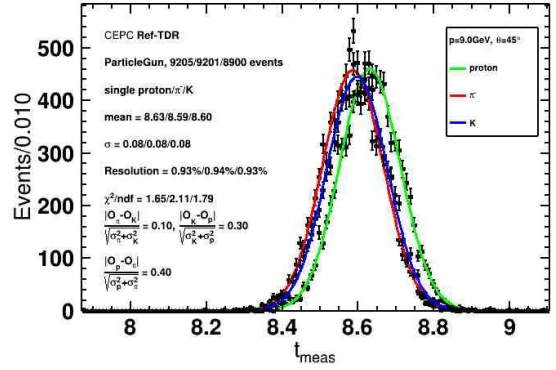


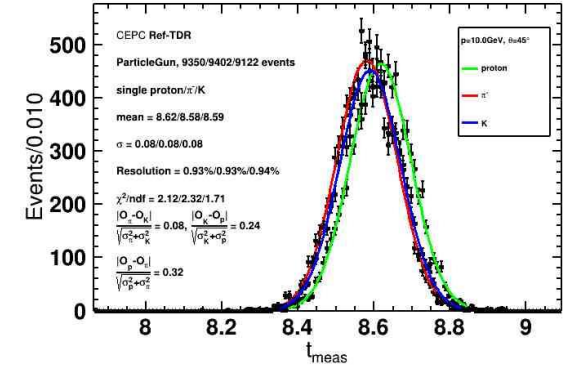






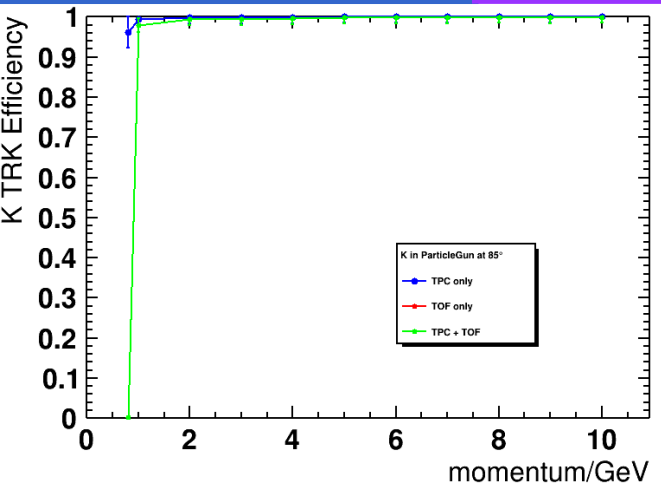


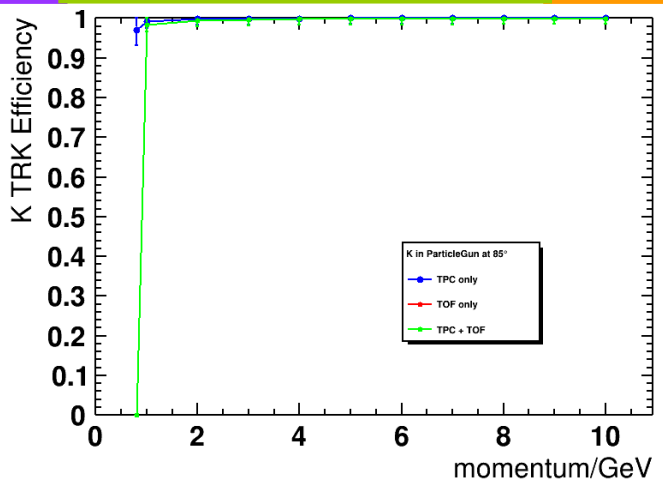




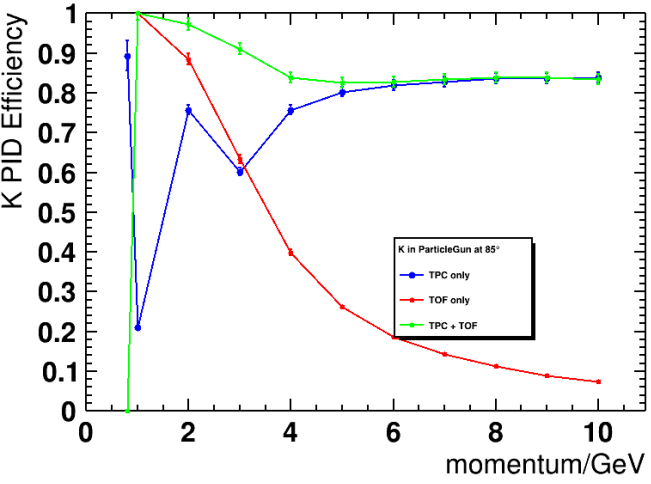
t at 45 degree tdr24.12.0

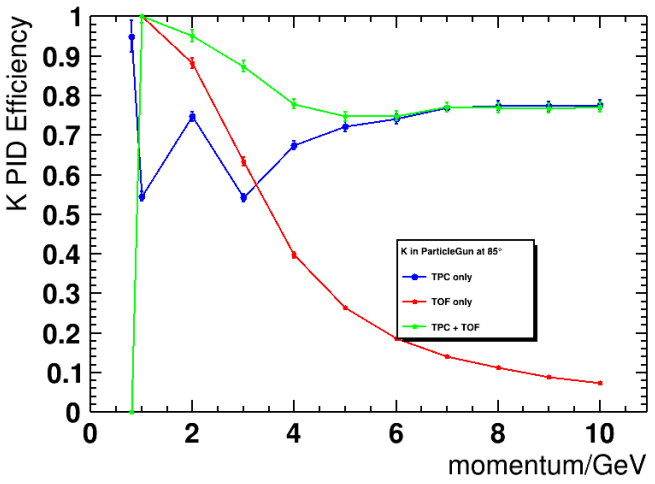
Efficiency comparison at 85 degree



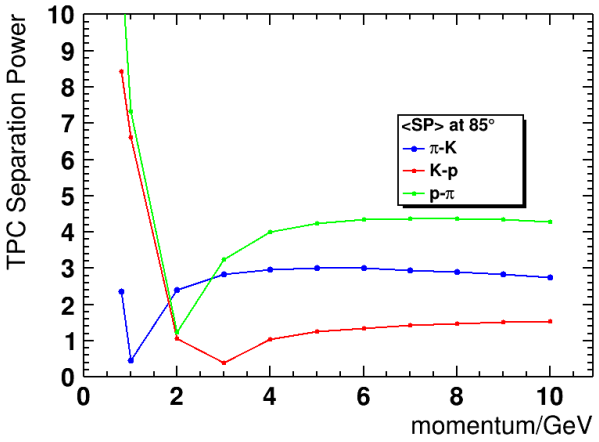


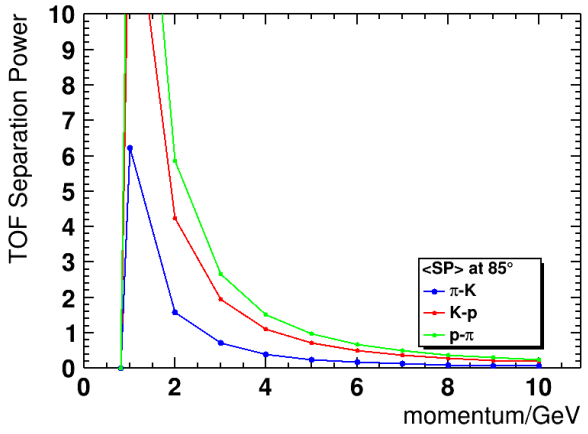
25.1.0 (left) VS 24.12.0 (right)

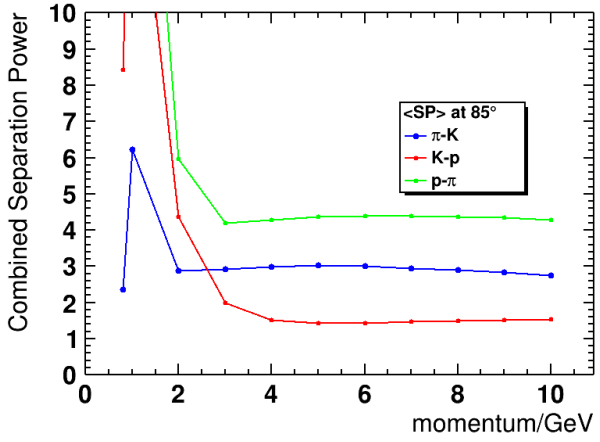




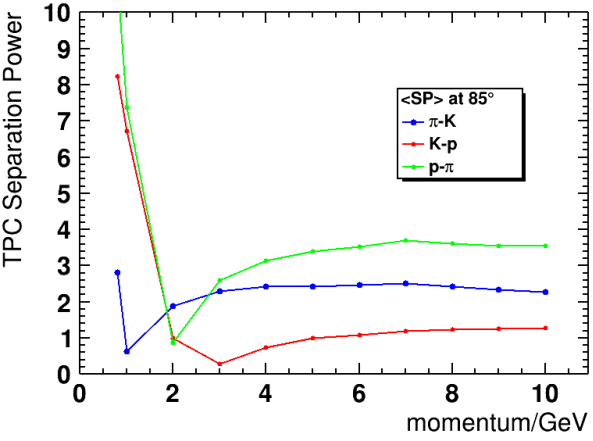
Separation power comparison at 85 degree

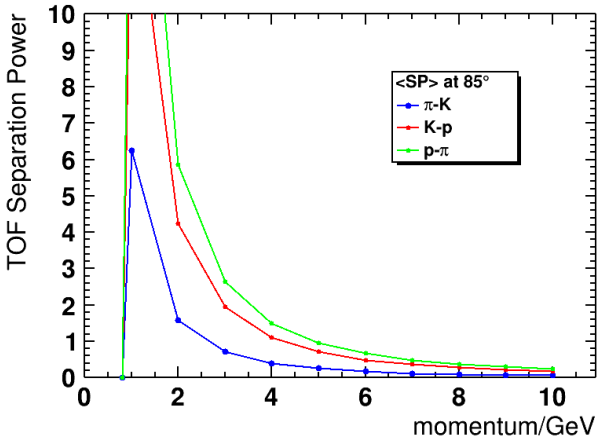


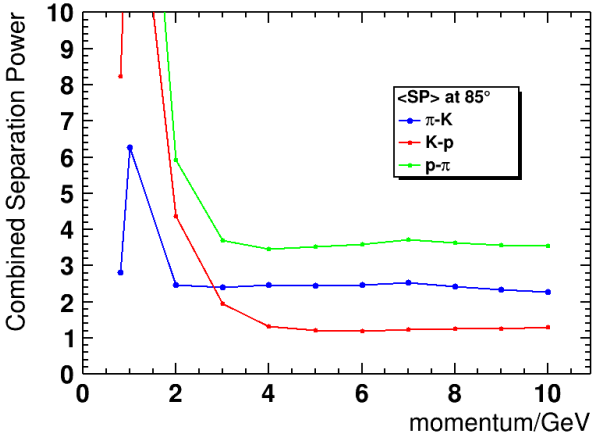




25.1.0 (up) VS 24.12.0 (down)







Backup

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

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

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

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

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

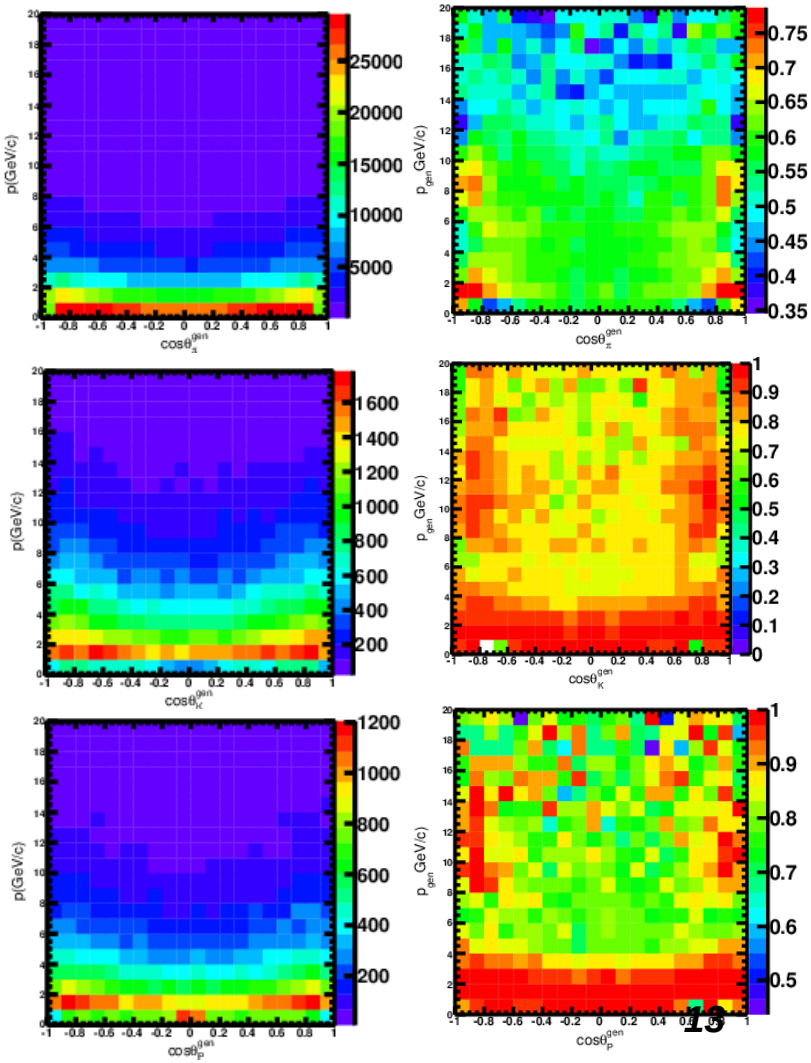
$$\mathrm{purity}(K) = \frac{N_{K\to K}}{N_{K\to K} + N_{\pi\to K} + N_{p\to K}}$$

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

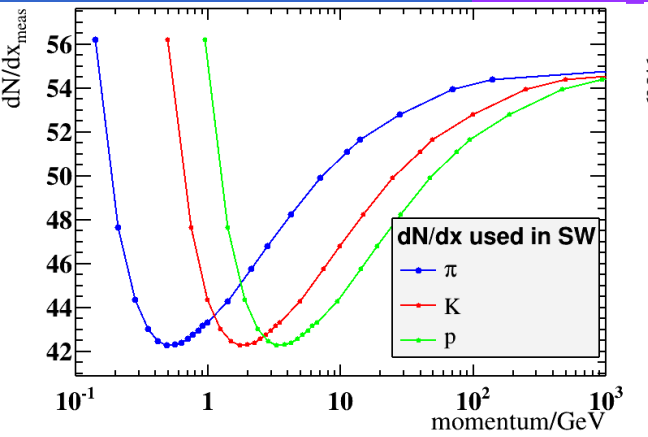
$$\text{Separation power: } O_{AB} = \frac{|\mathrm{A} - \mathrm{B}|}{\sqrt{\sigma_A^2 + \sigma_B^2}}$$

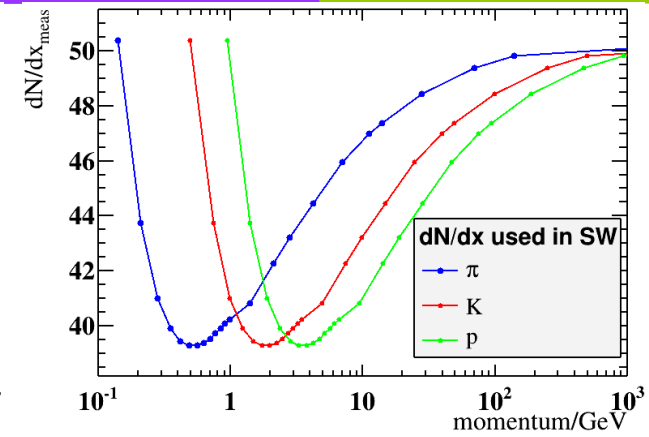
$$\sqrt{O^2_{AB,\,\mathrm{TPC}} + O^2_{AB,\,\mathrm{TOF}}}$$

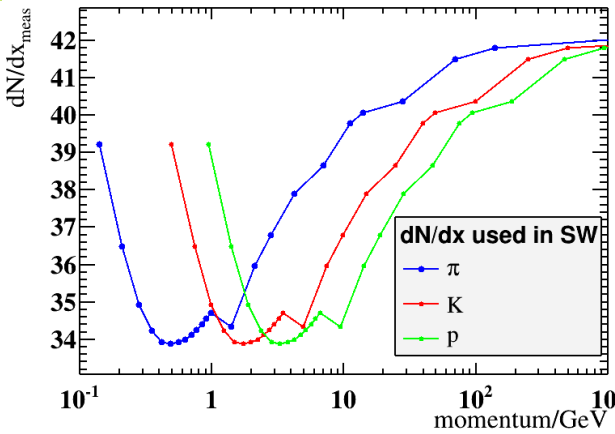
Track phase space and combined PID efficiency in $Z \to qq$ in tdr24.12.0



dNdx -- LUT



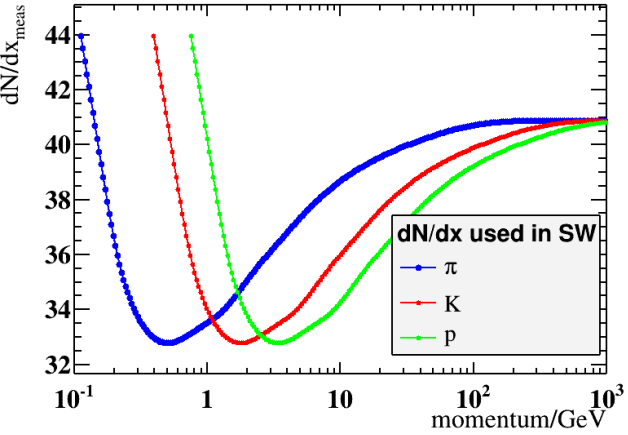


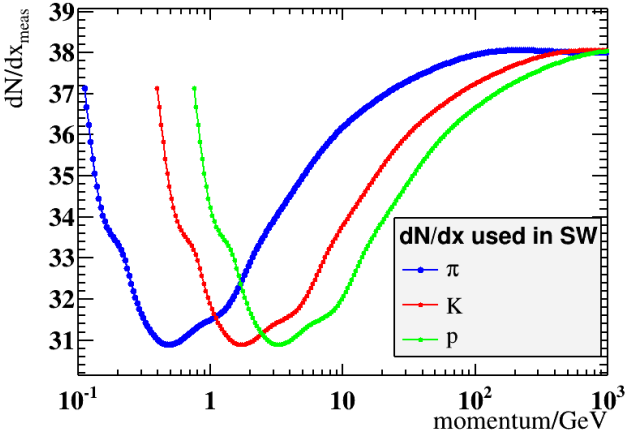


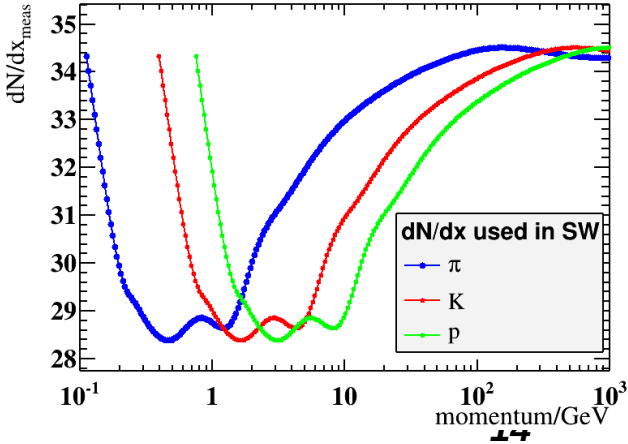
tdr24.5.0

LUT at cosθ = 0.643 0.707 0.766

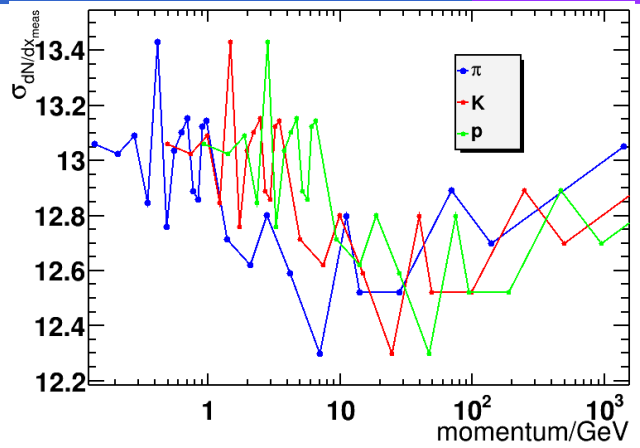
tdr25.1.0

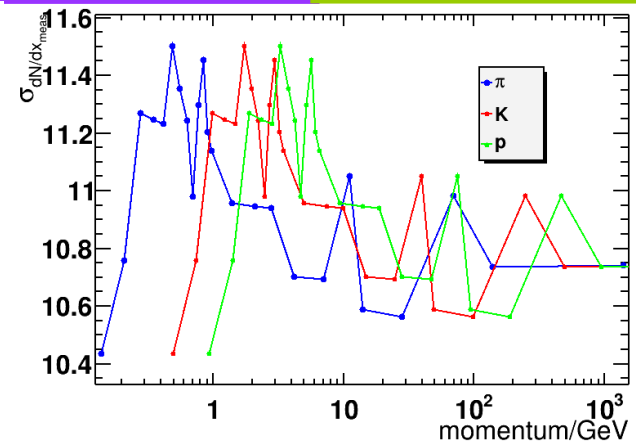


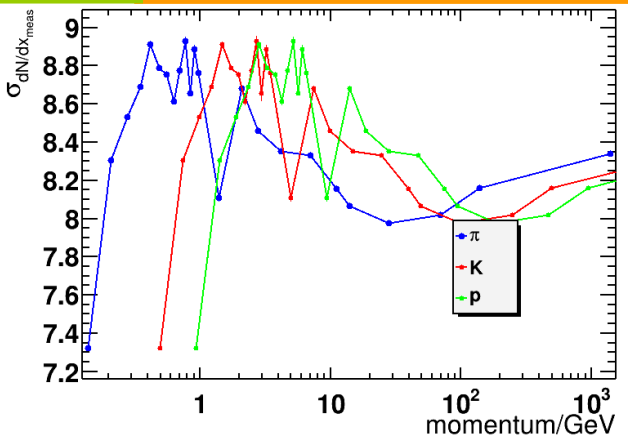




dNdxerr – without length -- LUT







tdr24.5.0

LUT at cosθ = 0.643 0.707 0.766

tdr25.1.0