Report on TOF Simulation Studies

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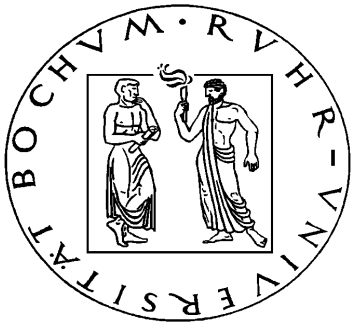
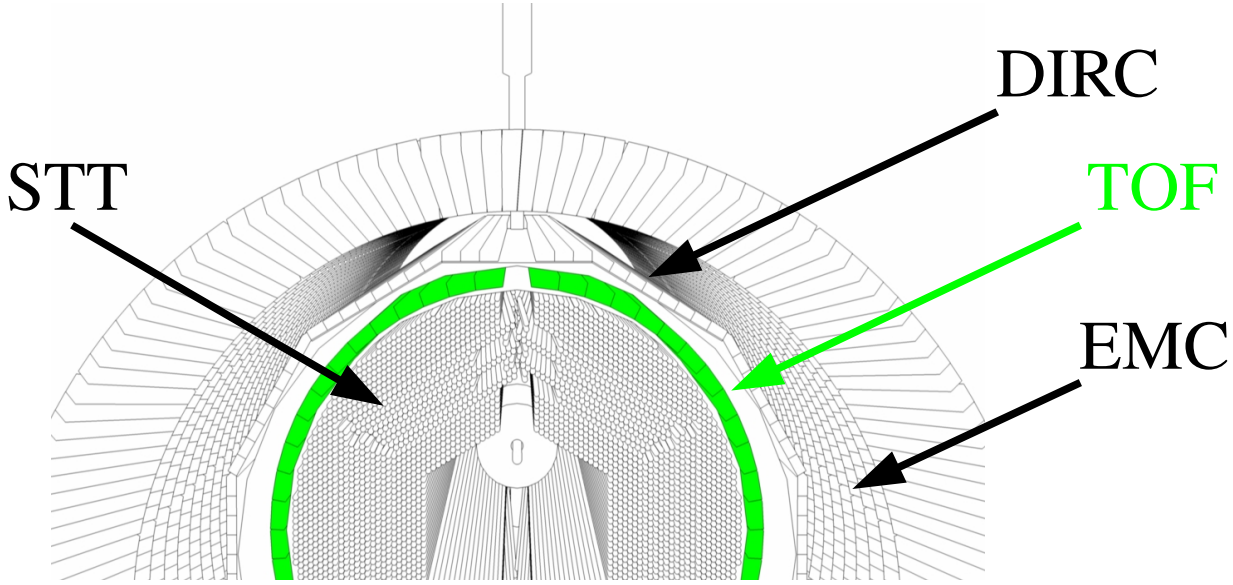


Outline

- Simulations
  - geometry, digitization, reconstruction
- PID Performance
  - Global PID w/ and w/o TOF
- Influence on the EMC
  - single π^0 studies
  - benchmark channels: $\bar{p}p \to \gamma\gamma$ and $\bar{p}p \to \tilde{\eta}_{c1}\eta \to \chi_{c1}\pi^0\pi^0\eta$
- Summary and Outlook

Simulations

- G4 simulations with Physics Book setup
- Geometry of Barrel TOF
  - 1 layer of bars (width: 5 cm, length: 190 cm, inner radius: 38.5cm)
  - between STT and DIRC
  - radiation length: 10% X_0 (default), 20% X_0 (for single π^0 studies)



Simulations

Digitization

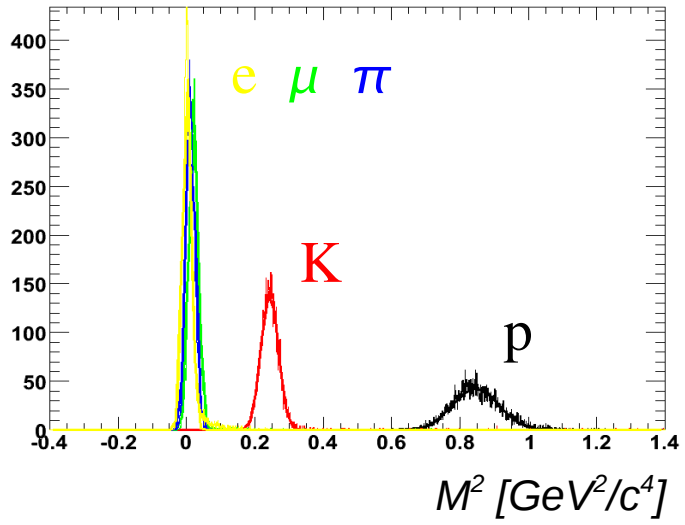
- TOF time resolution: 80 ps (Gaussian)
- Start time t_0
  - no start detector
  - relative timing with at least 2 tracks
  - simple assumption: 80 ps resolution for t_0
- Total time resolution for each track: $\sigma_{t_0} = \sqrt{2} \cdot 80\,ps$

Simulations

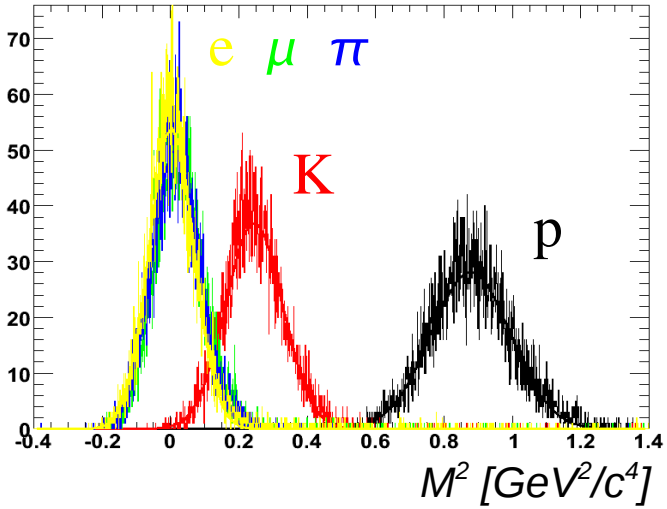
Reconstruction

- Reconstructed Mass: $M^2 = M^2(p, l, t)$
  - p = average reconstructed momentum (Kalman)
  - l = reconstructed path length (Kalman)
  - t = measured time of flight

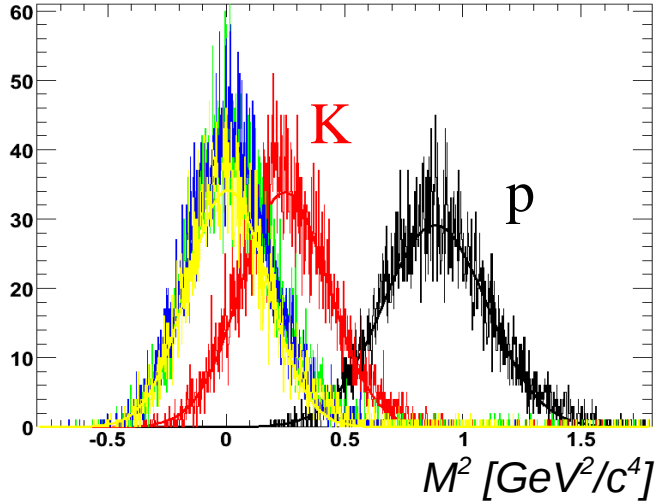
p = 0.3 GeV/c



p = 0.7 GeV/c



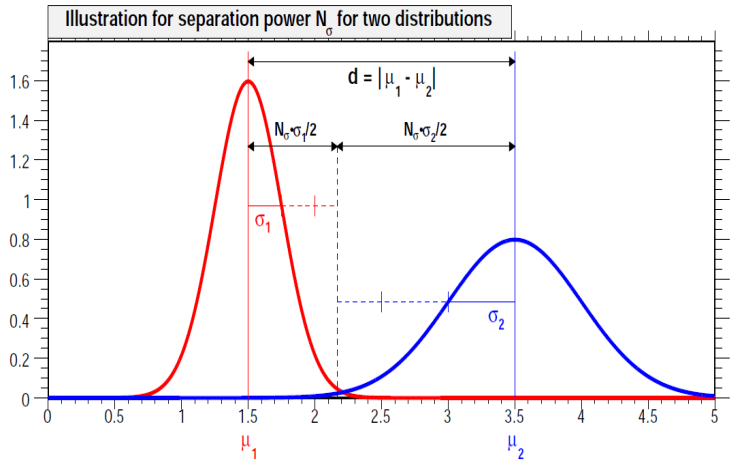
p = 1.1 GeV/c



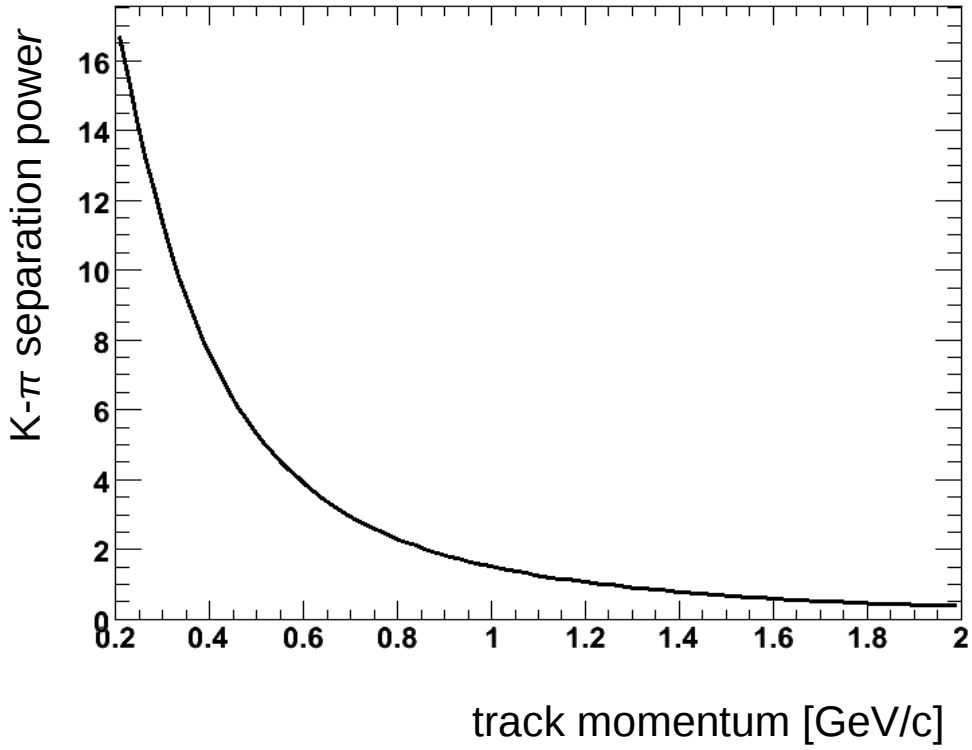
Pid Performance

TOF-PID: K-π- Separation-Power

- Definition from PID-TAG-Report:



$$N_\sigma = \frac{|\mu_1 - \mu_2|}{\sigma_{\text{avg}}} = \frac{|\mu_1 - \mu_2|}{(\sigma_1/2 + \sigma_2/2)}$$

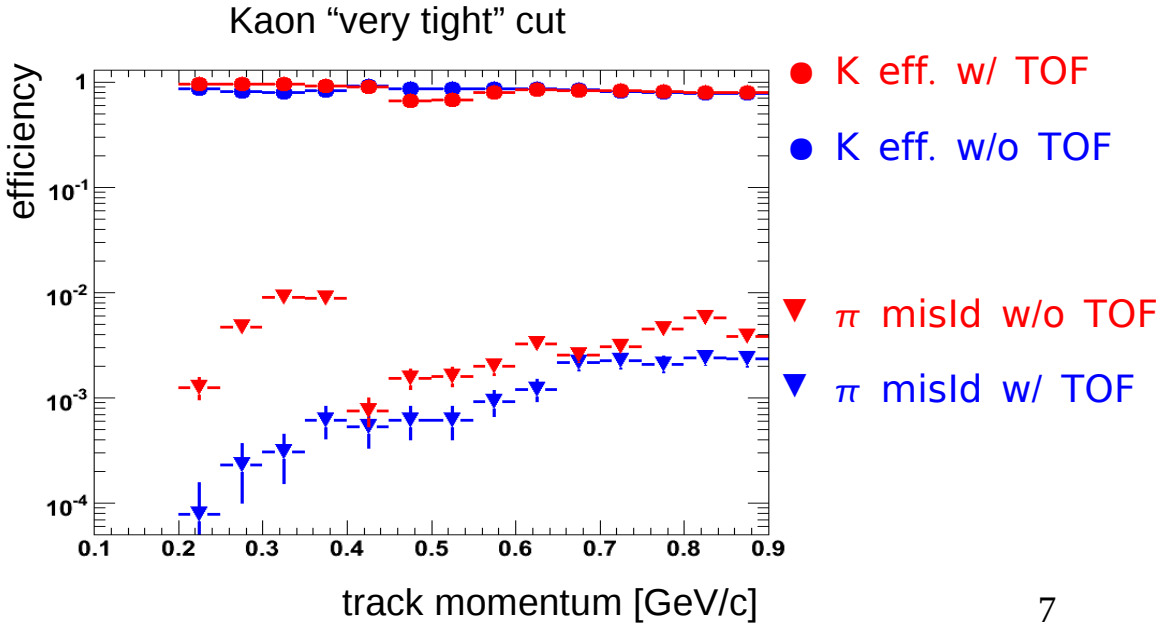


Pid Performance

Global PID: K eff. & π misID

- Comparison of PID performance between setup w/o and w/ TOF
  - Detectors contributing to global PID (see Physics Book)
    - w/o TOF: MVD, STT, EMC, (Disk) DIRC, MUON
    - w/ TOF : MVD, STT, EMC, (Disk) DIRC, MUON and TOF
  - realized with standard likelihood method: $p(k) = \frac{\prod_i p_i(k)}{\sum_j \prod_i p_i(j)}$

- p < 0.4 GeV/c:
  10x better suppression w/ TOF
- p > 0.4 GeV/c:
  slight improvement w/ TOF



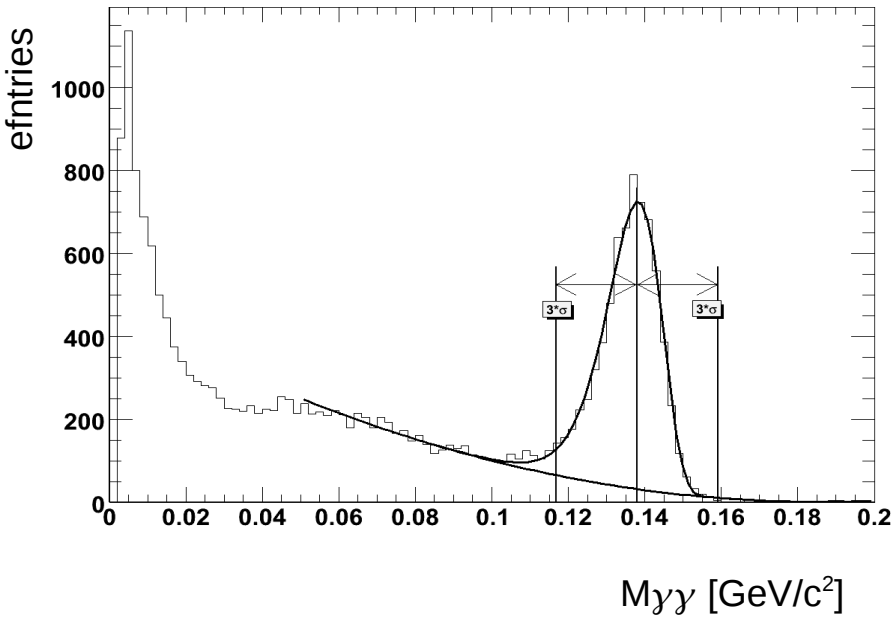
Influence on the EMC

Single π^0 Studies

(Julian Pychy, RUB)

- Generated particles: single π^0 , 10 MeV – 1.5 GeV, $\cos(\theta)$ = [-0.7, 0.9]
- Energy and Θ dependent efficiency and background studies

Definition of efficiency and background

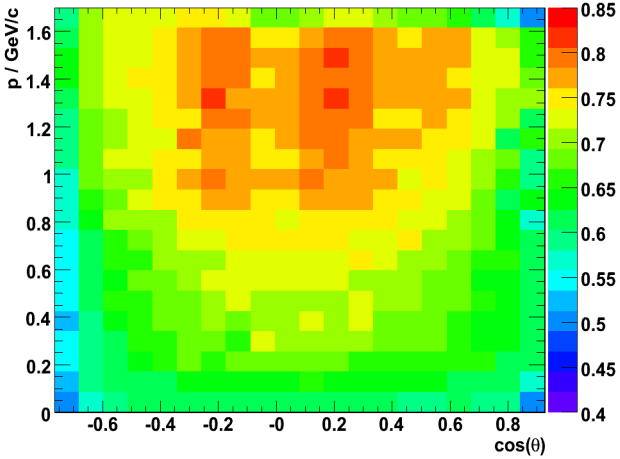


- Novosibirsk fit for signal
- Polynomial for background
- $N_{\pi 0}$: entries within 3σ above background
- Background: entries within 3σ below signal

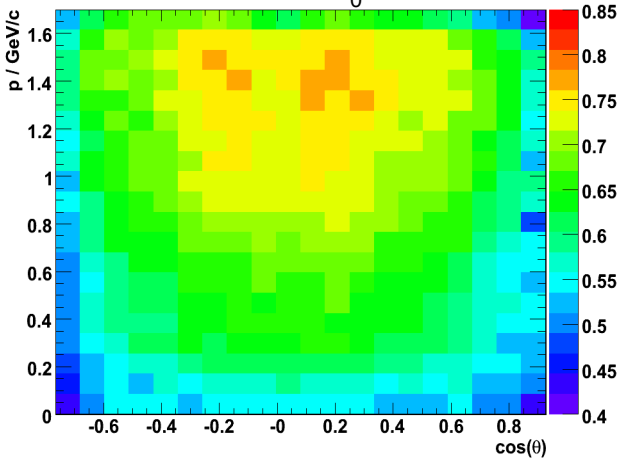
Influence on the EMC

Single π^0 Studies: Efficiency

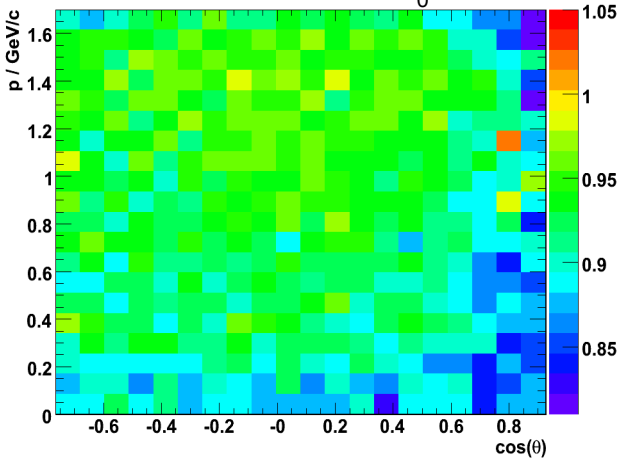
no TOF



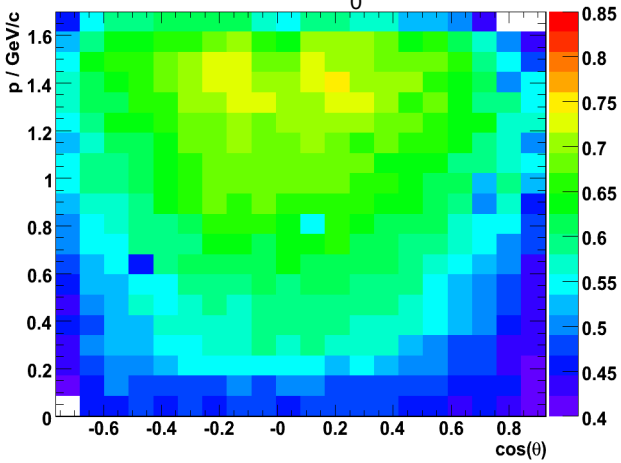
w/ 10% X_0 TOF



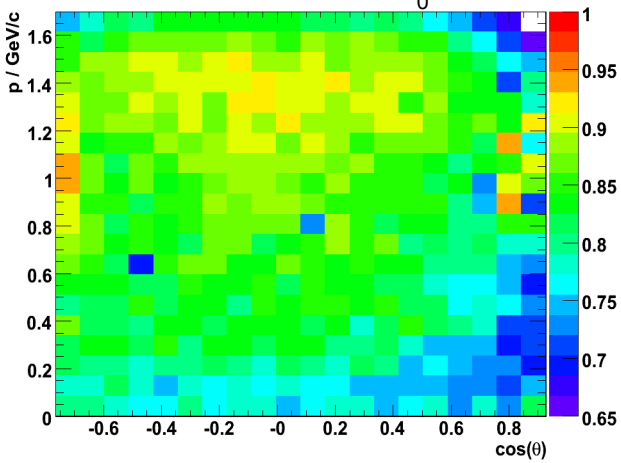
ratio: no / 10% X_0 TOF



w/ 20% X_0 TOF



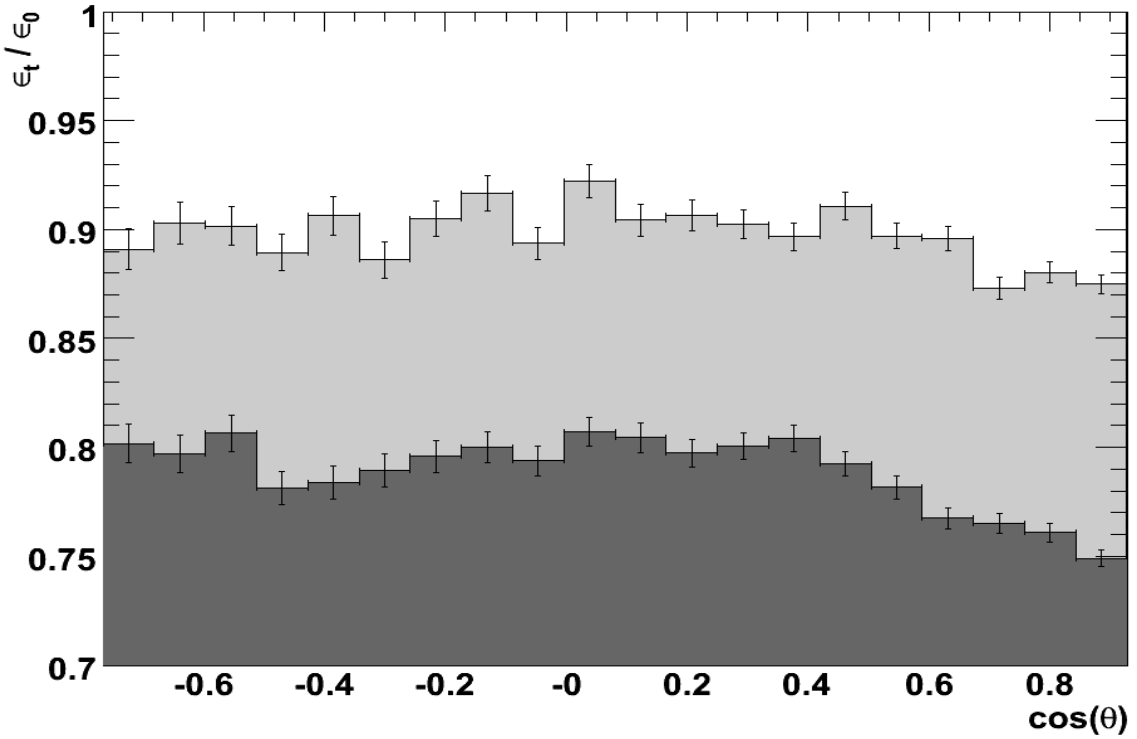
ratio: no / 20% X_0 TOF



Influence on the EMC

Single π^0 studies: average efficiency

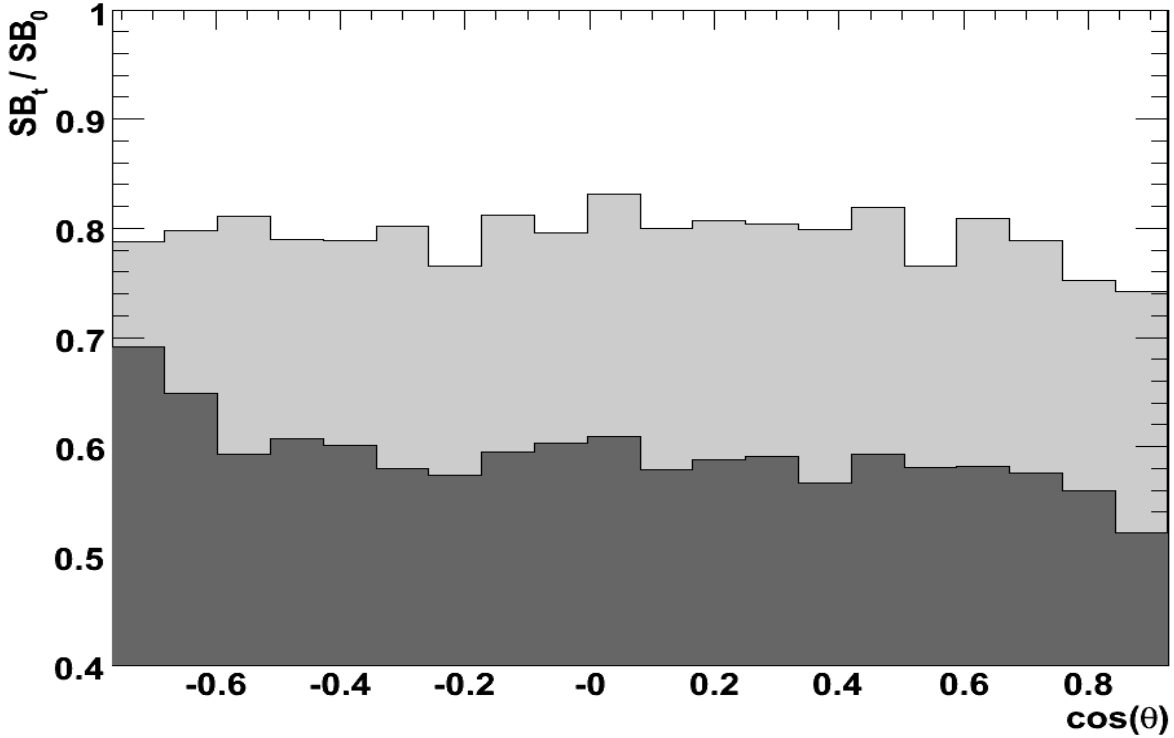
- 10% X_0 TOF: ~10% efficiency loss
- 20% X_0 TOF: ~20% efficiency loss



Influence on the EMC

Single π^0 studies: average signal/background ratio

- 10% X_0 TOF: S/B ratio increased by 20%
- 20% X_0 TOF: S/B ratio increased by 40%



Influence on the EMC

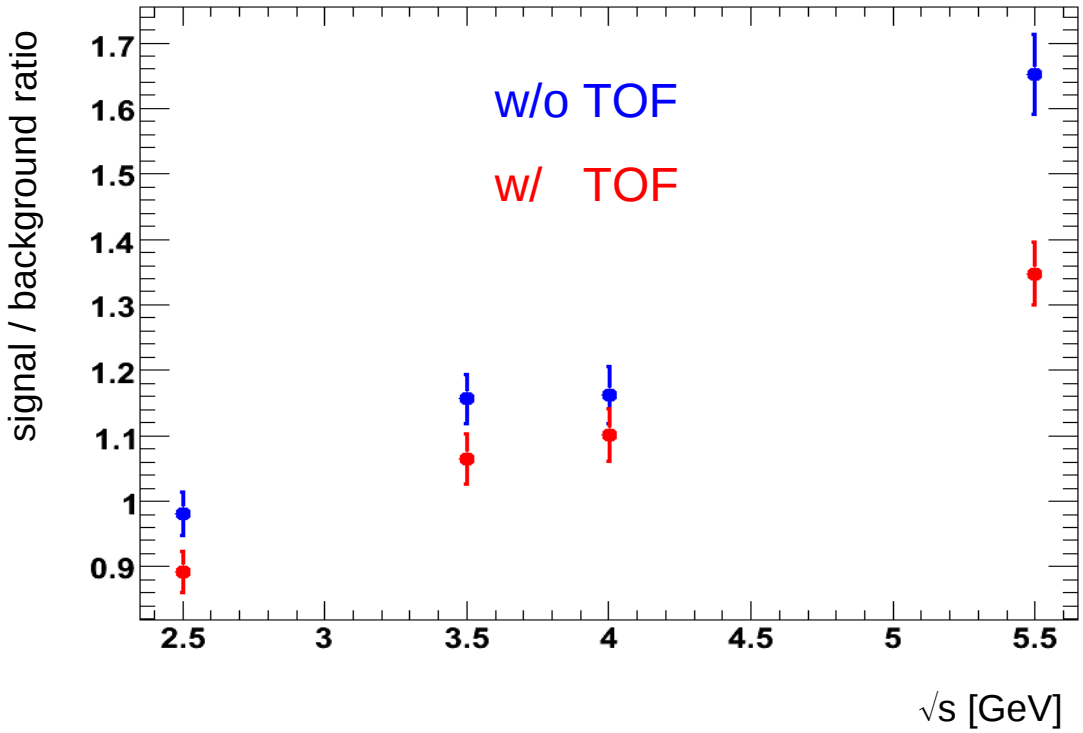
Benchmark channel: $\gamma\gamma$ (Bernhard Roth, RUB)

- Events generated for 4 different $\bar{p}$ mom. ($\sqrt{s}$ = 2.5, 3.5, 4.0 & 5.5 GeV)
- G4 simulations w/o and w/ TOF (10% X_0)
- Applied cuts
  - no charged particle
  - γ multiplicity exactly 2
  - 4C fit with $\gamma\gamma$ final state hypothesis
    - requirement: CL($\gamma\gamma$) > 10%
  - missing γ-fit with $\pi^0\,\gamma$ hypothesis
    - requirement: CL($\pi^0\,\gamma$) < 1.3 * CL($\gamma\gamma$)
  - invariant shower mass of the cluster < 130 MeV
  - -0.6 < cos(Θ*) < 0.6

Influence on the EMC

Benchmark channel: $\gamma\gamma$

- $\sqrt{s}$ <= 4 GeV: S/B ratio decreased by 10%
- $\sqrt{s}$ = 5.5 GeV: S/B ratio decreased by 20%



Influence on the EMC

Benchmark channel: $\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow \chi_{c1}\pi^0\pi^0\eta$

(Marc Pelizäus, RUB)

- Multi γ final state: e+ e- 7γ
- G4 simulation w/ and w/o TOF (10% X_0)
- Analysis as described in Physics Book

Results

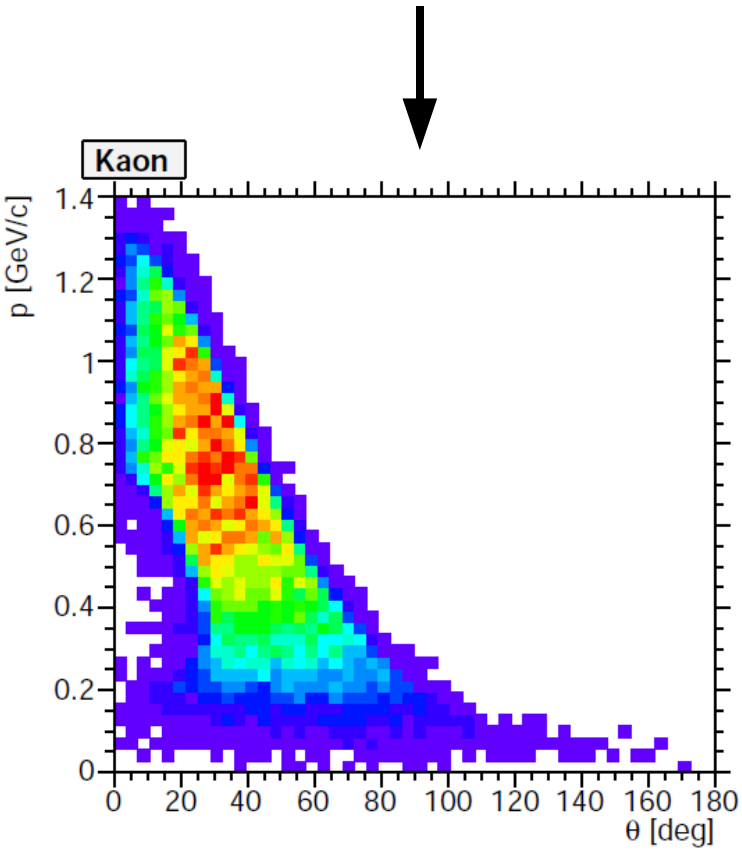
- Reconstruction efficiency
  - w/o TOF: 7%, w/ TOF: 5.38%
  - 23% less efficiency w/ TOF
- Similar background contamination

Summary

- Global PID: Kaon-Pion separation w/ TOF
  - huge improvement for p < 0.4GeV/c: 10x less pion contamination
  - slight improvement for p > 0.4GeV/c
- Influence on the EMC
  - single π^0
    - ➔ efficiency: 10% (20%) less w/ TOF material of 10%X_0 (20%X_0)
    - ➔ S/B ratio: decrease by 20% (40%) w/ TOF material of 10% X_0 (20%X_0)
  - $\bar{p}p \rightarrow \gamma\gamma$
    - ➔ S/B ratio: decreased by 10% for √s<4.5 GeV & by 20% for √s=5.5 GeV
  - $\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow \chi_{c1}\pi^0\pi^0\eta$
    - ➔ 23% less efficiency w/ TOF

Outlook

- Studies of additional benchmark channels
  - what are relevant channels where Barrel TOF can help?
    - ➔ Kaon identification below 400 MeV/c !
    - ➔ PB: only $\bar{p}p \rightarrow \phi\phi \rightarrow K^+K^-K^+K^-$



Outlook

- Global PID: not considered so far
  - Kalman fit probability for different particle hypotheses
  - Kaon identification with EMC
    - ➔ afterpulse K^+ identification
    - ➔ K+ identification via $\pi+$ $\pi-$ decay