Studies for Barrel ToF with $\phi\phi\pi^0$

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Outline

$\overline{\text{P}}$ANDA Barrel ToF

- Pro
  - Barrel ToF in the $\overline{\text{P}}$ANDA Detector would improve PID capabilities
  - Especially for pion/kaon separation at low momentum
  - Thin design for using minimum on space and material budget
- Contra
  - Every subdetector adds material which particles have to pass
  - Total resolution for photon reconstruction is decreased
  - Total efficiency is also decreased

MC simulations give us the opportunity to pre-estimate the advantages and disadvantages of such a subdetector.

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Signal

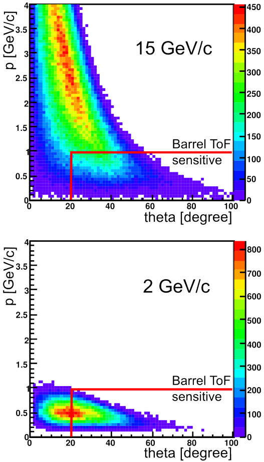
$$p\bar{p} \rightarrow \phi\,\phi\,\pi^0\,(\phi \rightarrow K^+\,K^-)$$

- possibility for glueballs in $\phi\phi$ decay
- at $p = 2\,\mathrm{GeV/c}$ (close to threshold)
- slow kaons in final state
- dataset with $100\,\mathrm{k}$ events

Background

$$p\bar{p} \rightarrow K^+\,K^-\,\pi^+\,\pi^-\,\pi^0$$

- pion/kaon separation important
- $\sigma_B \approx 51\,\mu\mathrm{b}$
- dataset of $10\,\mathrm{M}$ events



Distribution of kaons in Monte Carlo data of signal

$\phi\phi\pi^0$ signal and background

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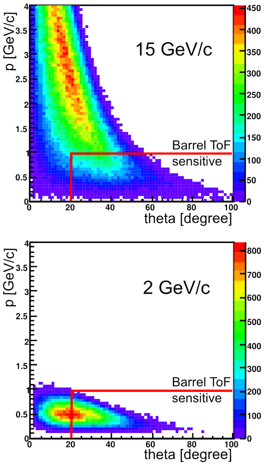


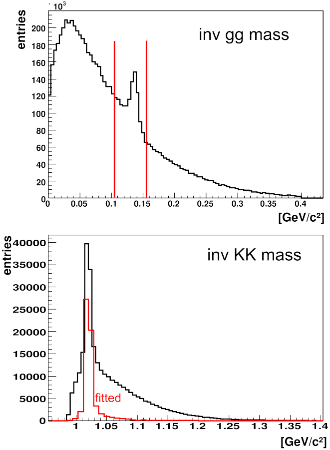
Distribution of kaons in Monte Carlo data of signal

Detector setup and software

- the analysis was done with a detector setup described in the $\overline{\text{P}}$ANDA Physics Book
- a Barrel ToF device is **not** considered
- PID is not taken into account
- the analysis was done with the BaBar-like software
- for comparison the analysis was redone with the latest stable revision of PandaRoot (Aug 09)

Event reconstruction and selection

- the decay chain is recombined from its detected final state particles
- **no PID**: all charged tracks as kaon candidates
- mass window to select π^0
- constraints: π^0 mass, beam energy, momentum and vertex
- selection of best candidate per event
- analysis of background decay with same selection criteria



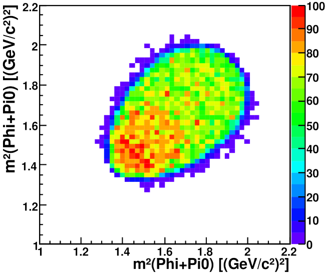
Results

Signal

- Efficiency for signal: 19 %
- Dalitz plot: only slight fluctuations in efficiency
- Less efficiency for kaons with low momentum

Background

- All events are suppressed
  $\rightarrow$ suppression $\eta_B > 10^7$ w/o PID



Dalitz plot of signal.

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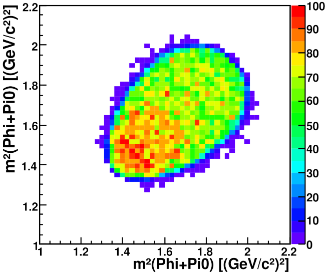

Dalitz plot of signal.

Signal to background ratio is:

$$\frac{S}{N} = \sigma_S\, \epsilon_S\, \mathcal{B}_S \cdot \frac{\eta_B}{\sigma_B\, \mathcal{B}_B} \quad \Longleftrightarrow \quad \sigma_S = \frac{S}{N} \cdot \frac{\sigma_B \mathcal{B}_B}{\epsilon_S\, \mathcal{B}_S\, \eta_B} \tag{1}$$

for $\frac{S}{N} = 10$ this analysis would be sensitive for the signal up to[1]

$$\sigma_S \approx 1.11\,\mathrm{nb} \tag{3}$$

estimate for additional cut on Kaon PID (5% miss ID per pion):

$$\sigma_S \approx 2.8 fb \tag{4}$$

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[1]

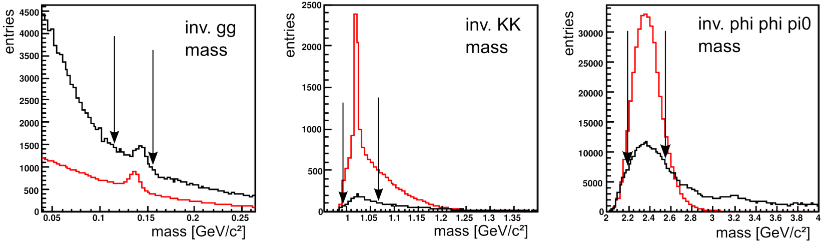
$$\begin{array}{llclcl} \text{branching fraction} & \mathcal{B}_S & = & \mathcal{B}_{(\phi\phi\pi^0)} & = & 0,2392 \pm 0,0058 \\ & \mathcal{B}_B & = & \mathcal{B}_{(\pi^0)} & = & 0,98798 \pm 0,00032 \\ \text{efficiency} & \epsilon_S & = & & & 19\,\% \\ & \eta_B & > & & & 10^7 \\ \text{cross section} & \sigma_B & \approx & & & 51\,\mu\mathrm{b} \end{array} \tag{2}$$

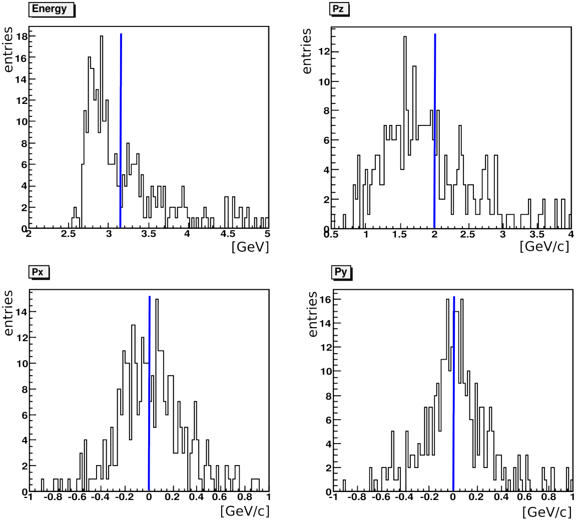
PandaRoot

Redo of this analysis with PandaRoot.
There were several issues, which make it impossible to reproduce the whole analysis:

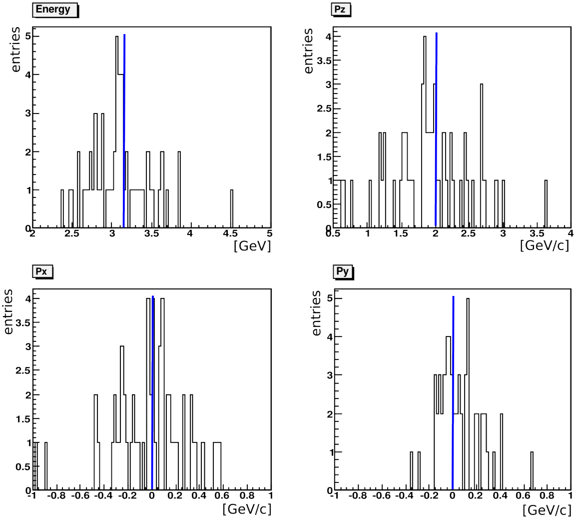
- frequent crashes in full simulation
- workaround needed to generate 3 k events of signal and same for background
- invariant mass cuts used for selection
- selection of best candidate per event by self defined χ^2
- kinematic fitting on beam and vertex not yet available

PandaRoot, BaBar-like (normalized)





Components of 4vector at the vertex, w/o cuts on masses.



Same diagrams, but with selections on invariant masses like shown before.

Results with PandaRoot

- efficiency for signal is $\epsilon_S = 2\%$
- some background events passed the selection
- background suppression is $\eta_B = 231$

$$\sigma_S \approx 456\,\mu\text{b} \quad (5)$$

- central workdir would be useful
- a lot of files have to be handled

Conclusions

- analysis of $\phi\phi\pi^0$ at $2\,\mathrm{GeV/c}$ considering $\pi^+\pi^-K^+K^-\pi^0$ as background
- PID was not taken into account
- reached background suppression of $\eta_B > 10^7$

$\Rightarrow$ **Barrel ToF not necessary**

- redo of analysis with PandaRoot
- only small datasets available
- vertex and kinematic fitting not available
- insufficient background suppression of $\eta_B = 231$

$\Rightarrow$ **analysis and detector studies not yet possible with PandaRoot**