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

Bernhard Roth

Experimentelle Hadronenphysik
Ruhr-Universität Bochum

$\bar{\text{P}}$ANDA Collaboration Meeting
Jülich, 2009

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.

$\overline{\text{P}}$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.

Signal

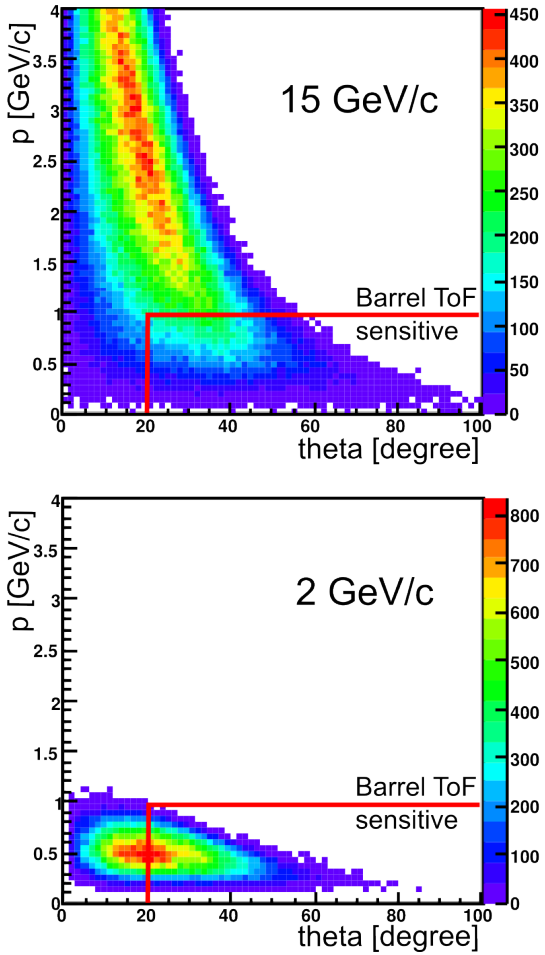
$$p\bar{p} \rightarrow \phi\,\phi\,\pi^0\,(\phi \rightarrow K^+\,K^-)$$

- 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

Signal

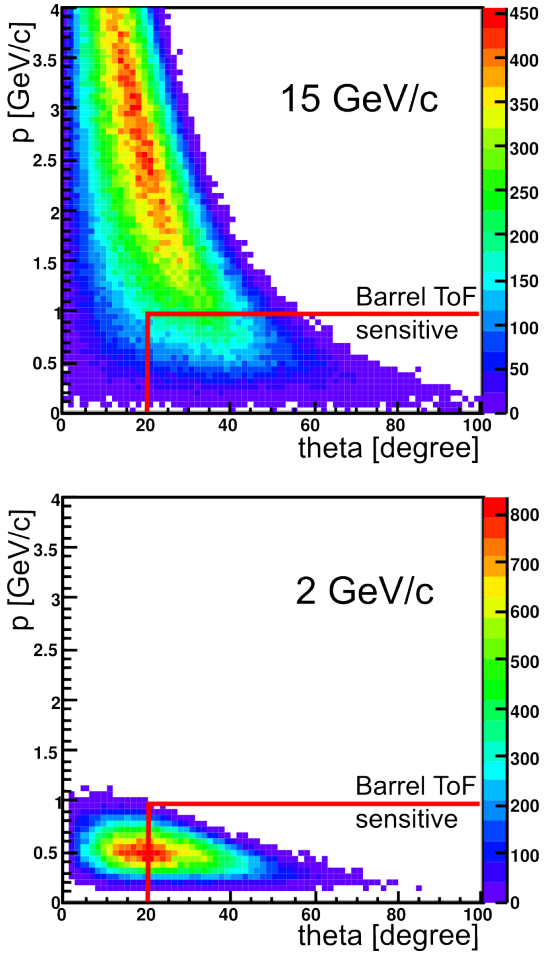
$$p\bar{p} \rightarrow \phi\,\phi\,\pi^0\,(\phi \rightarrow K^+\,K^-)$$

- 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



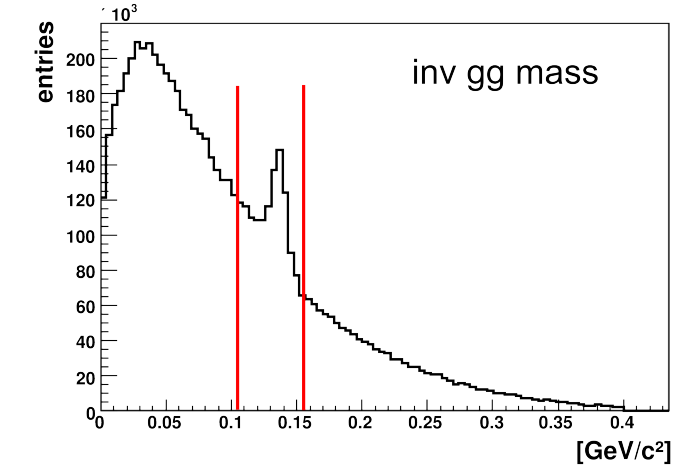
Distribution of kaons in Monte Carlo data of signal

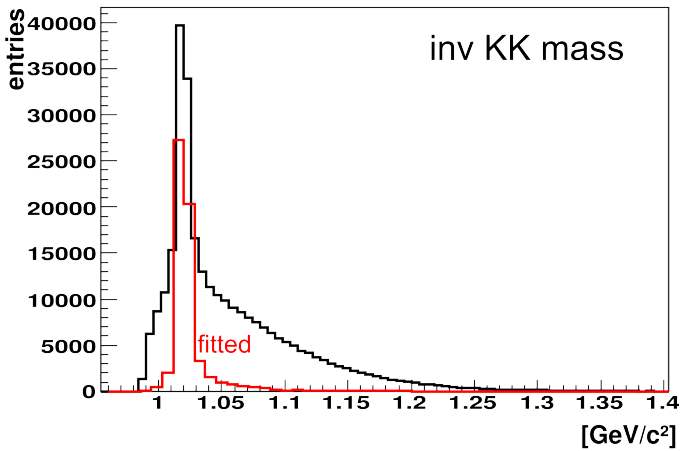
Detector setup and software

- 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

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





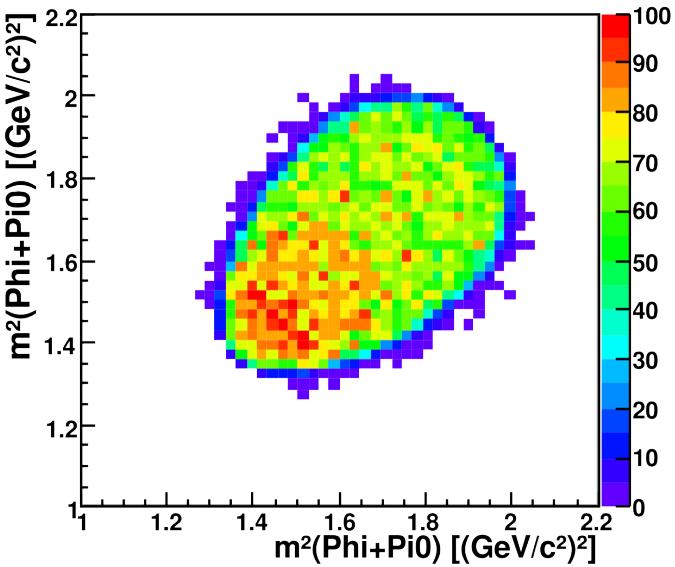
Results

Signal

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

Background

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



Dalitz plot of signal.

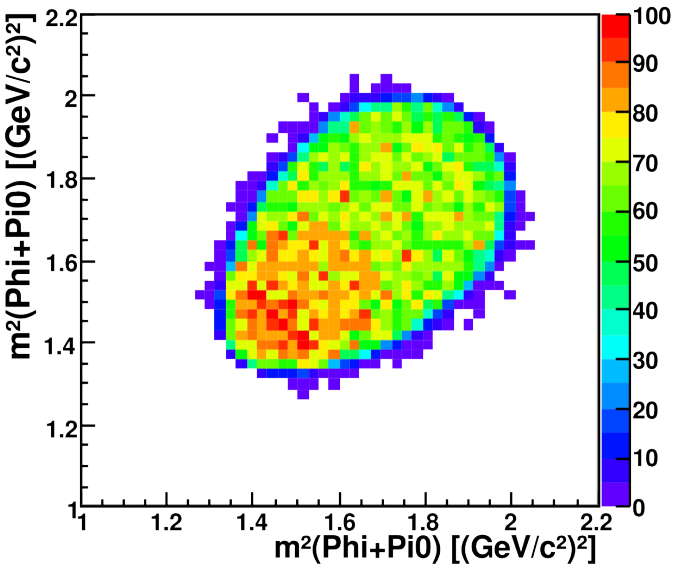
Results

Signal

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

Background

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



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):

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

[1]

branching fraction	$\mathcal{B}_S$	$=$	$\mathcal{B}_{(\phi\phi\pi^0)}$	$=$	$0,2392 \pm 0,0058$	
	$\mathcal{B}_B$	$=$	$\mathcal{B}_{(\pi^0)}$	$=$	$0,98798 \pm 0,00032$	
efficiency	ϵ_S	$=$			$19\,\%$	(2)
	η_B	$>$			10^7	
cross section	σ_B	$\approx$			$51\,\mu\mathrm{b}$	

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 $\eta_B > 10^7$
- $\overline{\text{P}}$ANDA is sensitive up to $\sigma_{\phi\phi\pi^0} \approx 1.11\,\mathrm{nb}$

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