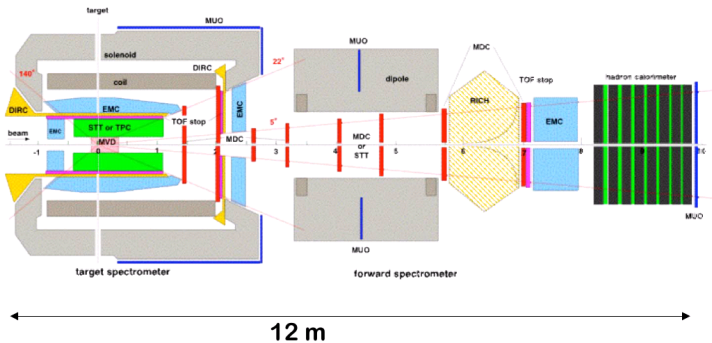


Monte Carlo Simulation of $p\bar{p} \rightarrow \gamma\gamma$ and $p\bar{p} \rightarrow \gamma\pi^0$ for Panda

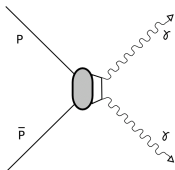
Irina Brodski

January 18, 2008

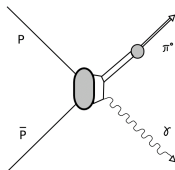
The PANDA Detector



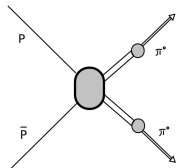
Interesting Uncharged Processes and Background



$$p\bar{p} \rightarrow \gamma\gamma$$

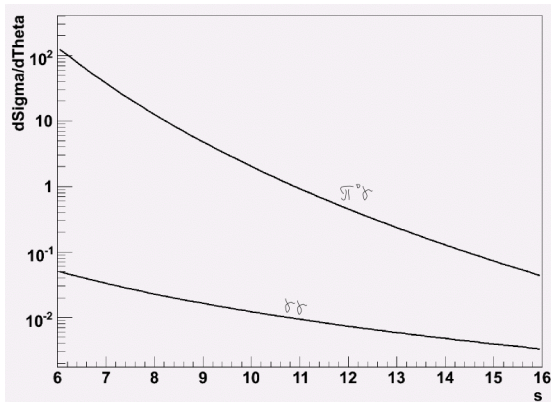


$$p\bar{p} \rightarrow \gamma\pi^0$$



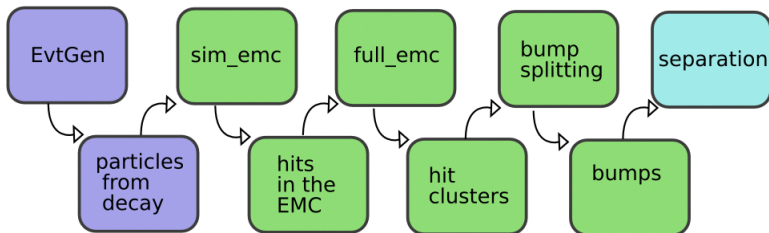
background process: $p\bar{p} \rightarrow \pi^0\pi^0$

Cross Section of the Processes at an Angle of 45°

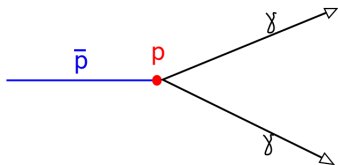


P. Kroll & A. Schaefer (2005)

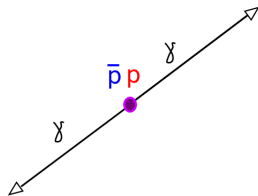
Monte Carlo Simulation with PandaROOT



How to Separate the Process $p\bar{p} \rightarrow \gamma\gamma$ from Background?



$p\bar{p} \rightarrow \gamma\gamma$ in lab-system



$p\bar{p} \rightarrow \gamma\gamma$
in cms of p and \bar{p}

Ideas

- ▶ Only two large clusters
- ▶ 180° angle in cms.
- ▶ The sum of energies of the two largest clusters is close to \sqrt{s} .

Challenges

- ▶ Very rare process: $\sigma = 5pb$ at $\sqrt{s} = 2.9GeV$
- ▶ Sometimes we lose a photon when it leaves the detector.
- ▶ Sometimes two particles which are close are misidentified as one.
- ▶ Energy fluctuations in the EMC
- ▶ High momenta of incoming \bar{p} and resolution.

Cuts to Separate $p\bar{p} \rightarrow \gamma\gamma$ from Background

► **Angle cut:**

The angle between the momentum vectors of the two largest clusters shall be near to π :

$$|\angle(\vec{p}_1, \vec{p}_2) - \pi| < 0.01$$

► **Energy cut:**

$\gamma\pi^0$ and $\pi^0\pi^0$ events have more than 2 clusters with relevant energy. Whole expected energy can not be reached with the sum of the two largest of them:

$$E_1 + E_2 > 0.965 \cdot \sqrt{s}$$

Cuts to Separate $p\bar{p} \rightarrow \gamma\gamma$ from Background

► **Angle cut:**

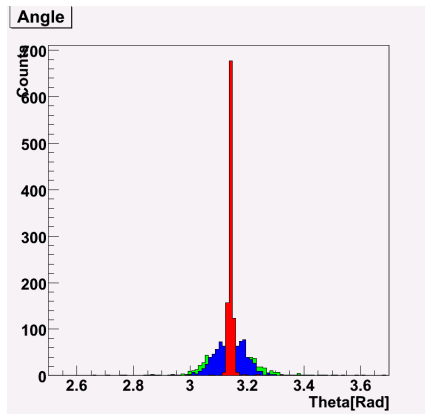
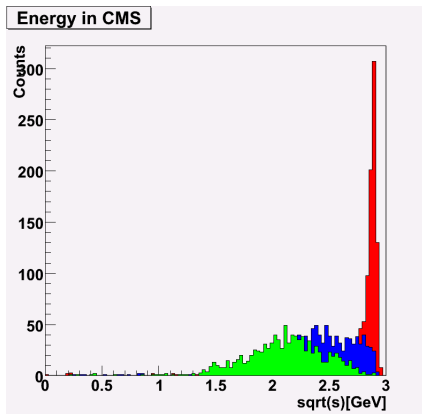
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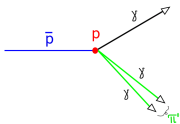
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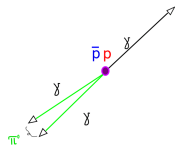


red: 1000 $\gamma\gamma$ events at $\sqrt{s} = 2.95668$
 blue: 1000 $\pi^0\gamma$ events at $\sqrt{s} = 2.95668$
 green: 1000 $\pi^0\pi^0$ events at $\sqrt{s} = 2.95668$

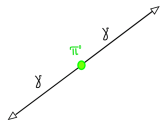
Recognizing $p\bar{p} \rightarrow \gamma\pi^0$ Events



event in lab-system



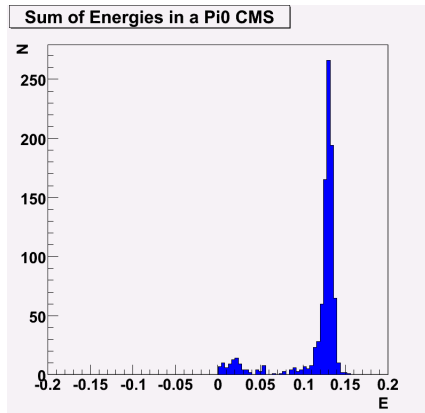
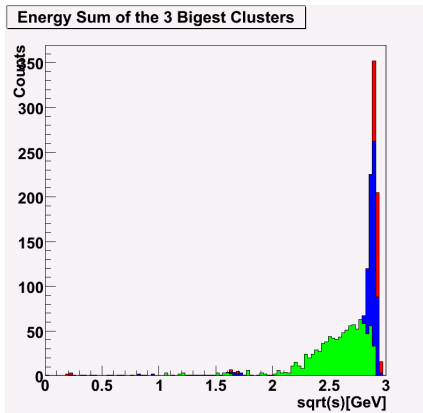
event in cms of $p\bar{p}$



event in cms of π^0

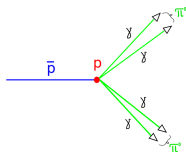
Cutting criteria

- ▶ 3 clusters with relevant energy in cms of $p\bar{p}$.
- ▶ Sum of the momentum vectors of the 3 clusters in cms of $p\bar{p}$ is almost 0.
- ▶ Angle between the momentum vectors of the second and third largest clusters in expected cms of the π^0 is 180° .

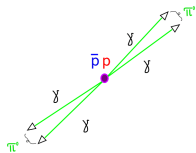


red: 1000 $\gamma\gamma$ events at $\sqrt{s} = 2.95668$
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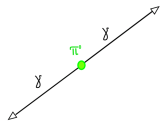
Recognizing $p\bar{p} \rightarrow \pi^0\pi^0$ Events



event in lab-system



event in cms of $p\bar{p}$



event in cms of π^0

Cutting creteria

- ▶ 4 clusters with relevant energy in cms of $p\bar{p}$.
- ▶ Sum of the momentum vectors of the 4 clusters in cms of $p\bar{p}$ is almost 0.
- ▶ Energy sum of two pairs of clusters in their cms is close to the mass of π^0 .
- ▶ Angle between momentum vector sums of two pairs of clusters in the cms of $p\bar{p}$ is 180° .

Calculation Regarding Cross Section at $\sqrt{s}=2.95\text{GeV}$ for

$\gamma\gamma$

$$\frac{N_1}{N} \cdot C = C^*$$

N_1 number of events left after cut

N number of all generated events.

C cross section of the decay

C^* cross section reduced by cut

$$\gamma\gamma \quad \frac{584}{1000} \cdot 5pb \simeq 2.9pb$$

$$\pi^0\gamma \quad \frac{21}{1000} \cdot 2 \cdot 10^2 pb \simeq 4.2pb$$

$$\pi^0\pi^0 \quad \frac{2}{1000} \cdot 2 \cdot 10^4 pb \simeq 40pb$$

(1:1.4:13) signal/background relation for $\gamma\gamma$ events

Calculation Regarding Cross Section at $\sqrt{s}=2.95\text{GeV}$ for $\gamma\pi^0$

$$\frac{N_1}{N} \cdot C = C^*$$

$$\gamma\gamma \quad \frac{0}{1000} \cdot 5pb \lesssim 0.005pb$$

$$\pi^0\gamma \quad \frac{500}{1000} \cdot 2 \cdot 10^2 pb \simeq 100pb$$

$$\pi^0\pi^0 \quad \frac{70}{1000} \cdot 2 \cdot 10^4 pb \simeq 140pb$$

(1:1.4) signal/background relation for $\gamma\pi^0$ events

Outlook

- ▶ Optimize the cuts.
- ▶ Study the cross sections of $p\bar{p} \rightarrow \pi^0\pi^0$ and $p\bar{p} \rightarrow \gamma\pi^0$.
- ▶ Simulations at higher energies.
- ▶ More sensitive bump splitting (change parameters?)
- ▶ Higher statistics!
- ▶ ...