JÜLICH
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The Effect of the Transverse Emittance of the HESR Beam on the Luminosity Monitor

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Outiline

Introduction and Motivation

- Event generators used in pandaroot assume the primairy interaction is at $x = y = z = 0$, and each beam particle has exactly 4-momentum vector.
- This is not the actual situation:
  - Beam particles in a beam do not have the same 4-momentum:
    $\implies$ Angular smearing.
  - Collision may take place at various points
    $\implies$ Vertex smearing.
- Ignoring the emittance of the beam affects the luminosity measurement.

Antiproton Beam Properties

- At the IP, the emittance ε of the $\bar{p}$-beam is 1 *mm mrad* .
- $\varepsilon = 2\sigma_x \cdot 2\sigma_\theta$
  - σ_x : RMS of the transversal divergance of the beam.
  - σ_θ : RMS of the angular divergance of the beam.
- For $\sigma_x \leq 0.8mm$, $\mathcal{L}_{eff} \geq 0.8\mathcal{L}_{max}$ because of the beam-target overlap (pellet target).

Smear of the DPM Output

Event-by-event smearing:

- Choose $\sigma_x = \sigma_y = 0.8\,mm$.
- If $\sigma_x \leq 0.5 \times R$
  $\implies$ Homogeneous "square" distribution of $\bar{p}$ in the beam
  with a side of $(2 \times \sigma_x)$.
  D. Reistad, B. Galnander, K. Rathsman, A. Sidorin, "Calculations on High-Energy Electron Cooling in the
  HESR", Proceedings of COOL 2007, Bad Kreuznach.
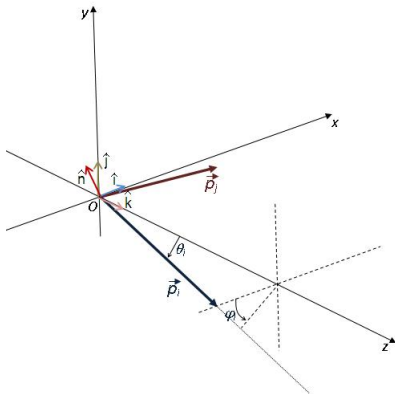 V.Ziemann, NIMA 556 (2006) 641.

  where R is the cross section radius of the pellet flux
  ($R \sim 2\,mm$).

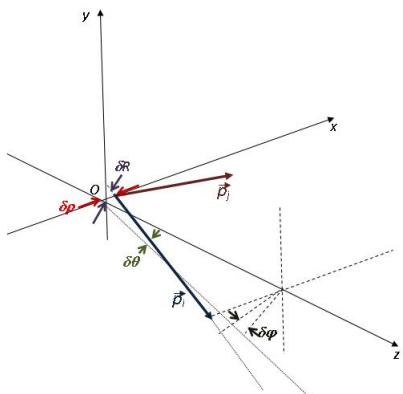- Gaussian smearing in the z-direction with
  $\sigma_z = R/2 = 1\,mm$.

For the 3-momentum vectors $\vec{p}_i$ ($i = \{p, \bar{p}\}$):

- Rotation of $\delta\theta$ around $\hat{n} = \frac{\vec{p}_i \times \hat{k}}{|\vec{p}_i| \cdot |\hat{k}|}$

  $\delta\theta$ is a Gaussian distribution with $\sigma_\theta = 0.3\,mrad$.

- Rotation of $\delta\varphi$ around $\vec{p}_i$.

  $\delta\varphi$ is an uniform distribution $[-\pi, +\pi]$.

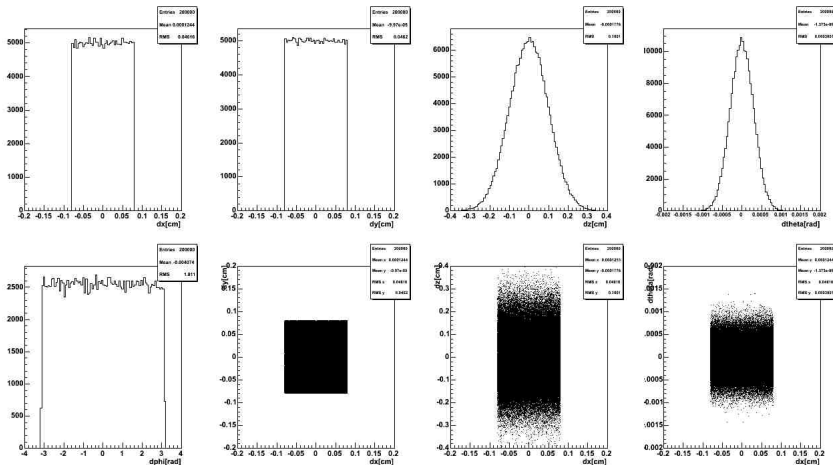- No correlation between $\delta\theta$ and $\delta\varphi$.
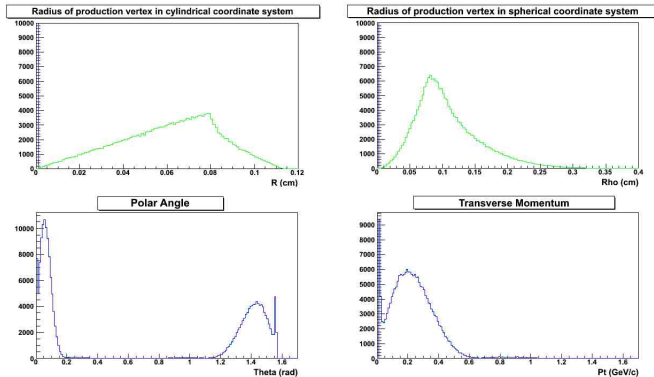
Before smearing

After smearing

Simulated vertex and divergance distributions

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Some aspects of the output of the DPM smeared (green curves) in comparison with the zero emittance DPM (blue curves) at $3.7\,GeV/c$ beam momentum
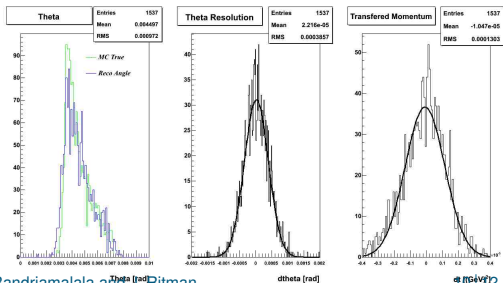
Effect on the Luminosity Monitor

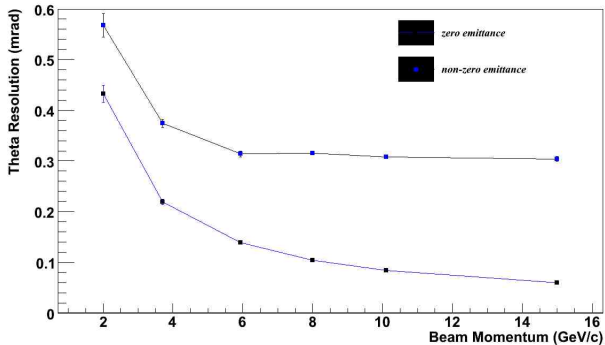At 3.7 *GeV/c* beam momentum:

Reconstructed tracks vs MC-true

- Theta distribution and transfered momentum for zero-emittance DPM
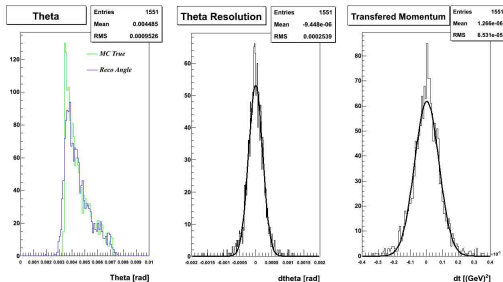
- Effect of the transverse emittance on the luminosity monitor

Resolution vs Beam Momentum

Conclusion

- Transverse emittance of the $\bar{p}$-beam has been considered.
- Smearing of the original DPM elastic scattering has been described
  - Smearing of the primary vertex, rotation on θ and φ of the 3-momentum vectors of the outgoing p and $\bar{p}$.
  - A new ROOT-file has been created.
- Effect on the luminosity monitor has been shown
  $\Rightarrow$ Angular resolution $\geq$ 0.3$mrad$.