Study of the eta meson production with the polarized proton beam

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p+p->p + p + eta *COSY-PAC38 Proposal 209*

Motivation

- Dynamics of the eta meson production in pp→ppη reaction.
- Interaction of the η meson with nucleons.
- Mechanism of η meson production.

For the studies, a precise knowledge about contributions from different partial waves is required.
We would like to learn about it from the Analyzing power (Ay) measurement.

Vector of Ay may be understood as a measure of the relative deviation between the differential cross section for the experiment with and without polarized beam.

$$\sigma(\zeta, P) = A_y(\zeta) \cdot P \cdot \sigma_0(\zeta) + \sigma_0(\zeta)$$

where $\zeta = \{m_{pp}, m_{p\eta}, \phi, \theta, \psi\}$

Method to extract Ay for experiment.

- 1 step: $\vec{p}$**+p-> p+p** *we know* from EDDA experiment **Ay**
we calculate Polarization ***P***

- 2 step: $\vec{p}$**+p-> p+p+eta** *we calculate*

$$N_\eta(\theta,\phi) = \sqrt{\frac{N_\eta^{\uparrow}(\theta,\varphi)\cdot N_\eta^{\downarrow}(\theta,\varphi+\pi)}{\varepsilon^{\uparrow}(\theta,\varphi)L^{\uparrow}\cdot\varepsilon^{\downarrow}(\theta,\varphi+\pi)L^{\downarrow}}}$$

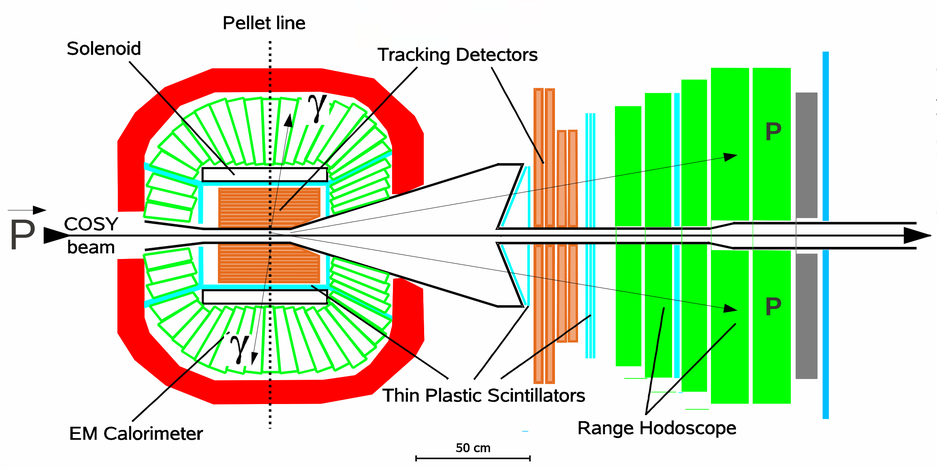
$$N_\eta(\theta,\phi+\pi) = \sqrt{\frac{N_\eta^{\uparrow}(\theta,\varphi+\pi)\cdot N_\eta^{\downarrow}(\theta,\varphi)}{\varepsilon^{\uparrow}(\theta,\varphi+\pi)L^{\uparrow}\cdot\varepsilon^{\downarrow}(\theta,\varphi)L^{\downarrow}}}$$

we know Polarization **P**

- 3 step: So, we calculate Ay for $\vec{p}$**+p-> p+p+eta** reaction.

$$\frac{N_\eta(\theta,\varphi) - N_\eta(\theta,\varphi+\pi)}{N_\eta(\theta,\varphi) + N_\eta(\theta,\varphi+\pi)} \cdot \frac{1}{P\cdot cos\varphi} = A_y(\theta).$$

WASA-at-COSY Detector

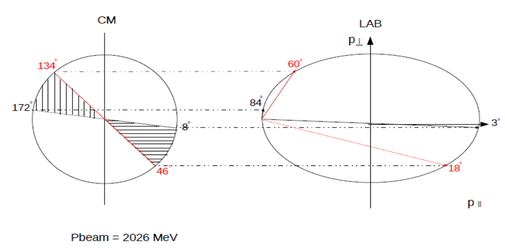


•Protons from pp → ppη reaction are registered in the Forward Detector an gamma quanta from η meson decay are detected in the electromagnetic calorimeter.

• WASA detector covers following polar angular ranges:
- Forward Detector [3°, 18°];
- Central Detector [60°, 84°].

Beam parameter and expected number of events for each excess energy

Q Mev/c	P MeV/c	σ_{tot}[mb]	Acc	$N_{\eta\to\gamma\gamma}$	$N_{\eta\to 3\pi^0}$
15	2026	10^3	0.55	99770	81861
72	2188	$5*10^3$	0.63	447739	375580



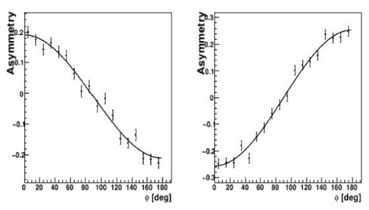
Asymmetry for pp ->pp reaction

The degree of polarization was determined based on the elastic scattering pp->pp for which values of analyzing power have been determined by the EDDA[1,2] experiment.
After identication of events corresponding to elastically scattered protons, number of pp->pp events for each angular bin, N(θ,φ) was determined.
The polarization, P, can be written as:

$$P \equiv \frac{1}{A_y} \cdot \epsilon(N(\theta,\varphi), N(\theta,\varphi+\pi))$$

where Є is a asymmetry.

$30^\circ < \theta < 34^\circ$



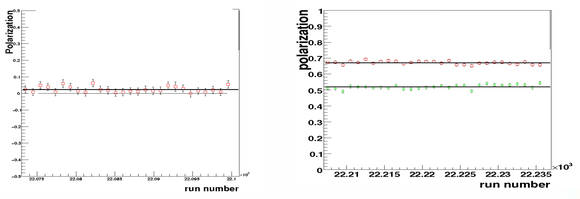
We have really strong asymmetry in experiment!

$$\frac{N(\theta,\varphi) - N(\theta,\varphi+\pi)}{N(\theta,\varphi) + N(\theta,\varphi+\pi)} \equiv \epsilon(N(\theta,\varphi), N(\theta,\varphi+\pi))$$

Cuts & Conditions

1. Identification of protons which registered in the FD;
2. Threshold for PS 2 MeV;
3. Difference in azimuthal angle;
4. Graphical cut on polar angle for the $\vec{p}$p ->pp reaction

In practice the polarization of the COSY beam can depend on the spin orientation. Therefore, it is determined for both spin orientations separately.

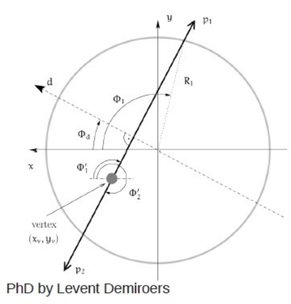


Polarization is stable in time

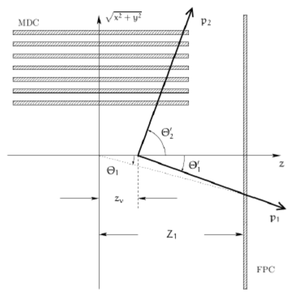
Study of the systematic uncertainty in the polarization determination

Reconstruction of the vertex position of the interaction point:

xy vertex coordinate method



z vertex coordinate method



p_1: forward going proton

Φ_1: reconstructed azimuthal angle (FD)

Φ'_2: reconstructed azimuthal angle (CD)

R_1: radius of intersection with FTH

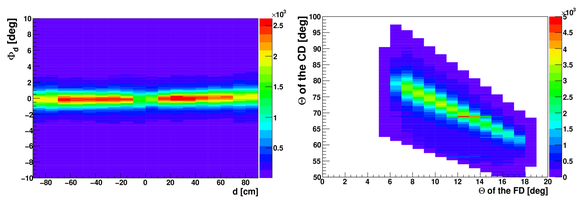
$$d = fzFTH \cdot tg(\theta_1) \cdot \cos(\phi_1 - \phi_d)$$

fzFTH = 148.33

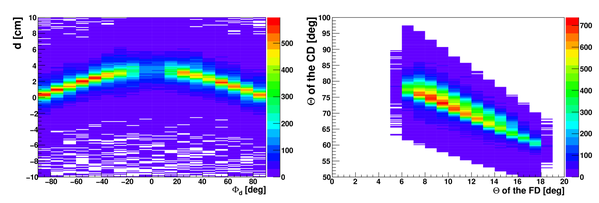
$$d = x^{vertex}\cos(\phi_d) + y^{vertex}\sin(\phi_d)$$

$$tg(\theta_2') = \frac{1-(z^{vertex}/z_{FTH})}{tg(\theta_1)} \cdot \gamma_{CMS}^2$$

Histograms for extraction vertex position

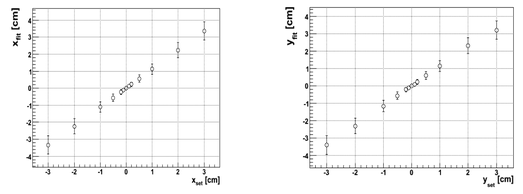


DATA



MC x=1cm y=0 z=0

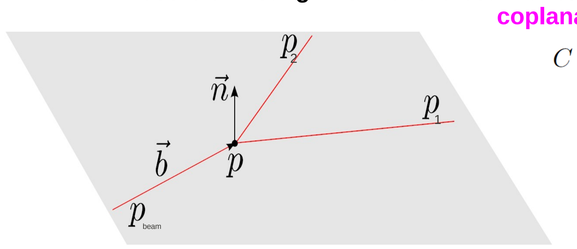
To study how a shifted interaction point is reflected on the reconstructed value of x,y,z MC simulations were done, which show that we need to control the position of the interaction point with the precision higher than 0,3 cm.



Result of extracted value for DATA

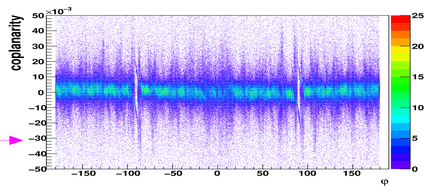
X = (-0.13± 0.02)cm
Y = (0.11 ± 0.02)cm
Z = (0.31 ± 0.35)cm

Possible misalignment of the beam and/or target's position also controlled by coplanarity.



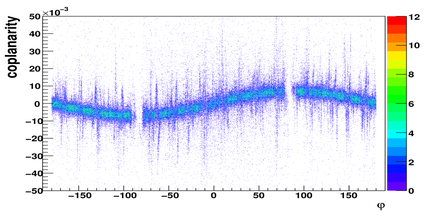
$$C = |\ (\hat{p}_1 \times \hat{p}_2) \cdot \hat{p}_{beam}\ |$$

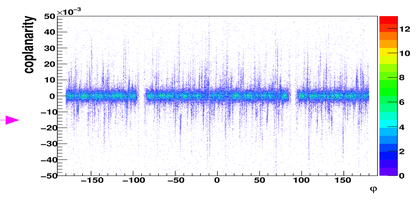
DATA



MC
(x=1 cm y=0 z=0)

MC
(x=o y=0 z=0)





Outlook

- analysis of November 2010 data
- obtain Luminosity
- calculate number of Left/Right scattered eta mesons
- extract Ay for $\vec{p}\vec{p}\to pp\eta$ experiment

References:
[1] R. Czykiewicz et al., Phys. Rev. Lett. 98 (2007) 122003.
[2] F. Balestra et al. Phys. Rev. C 69 (2004) 064003.
[3] I. Ozerianska, P. Moskal, M. Hodana, FZJ-IKP Annual Report 2011, JUEL-4349 (2012).
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2 Jülich Research Centre

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