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 production of η meson.

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:** **p+p-> p+p** *we know* from EDDA experiment **Ay**; *we calculate* Polarization ***P***
- **2 step:** **p+p-> p+p+eta** *we calculate*

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

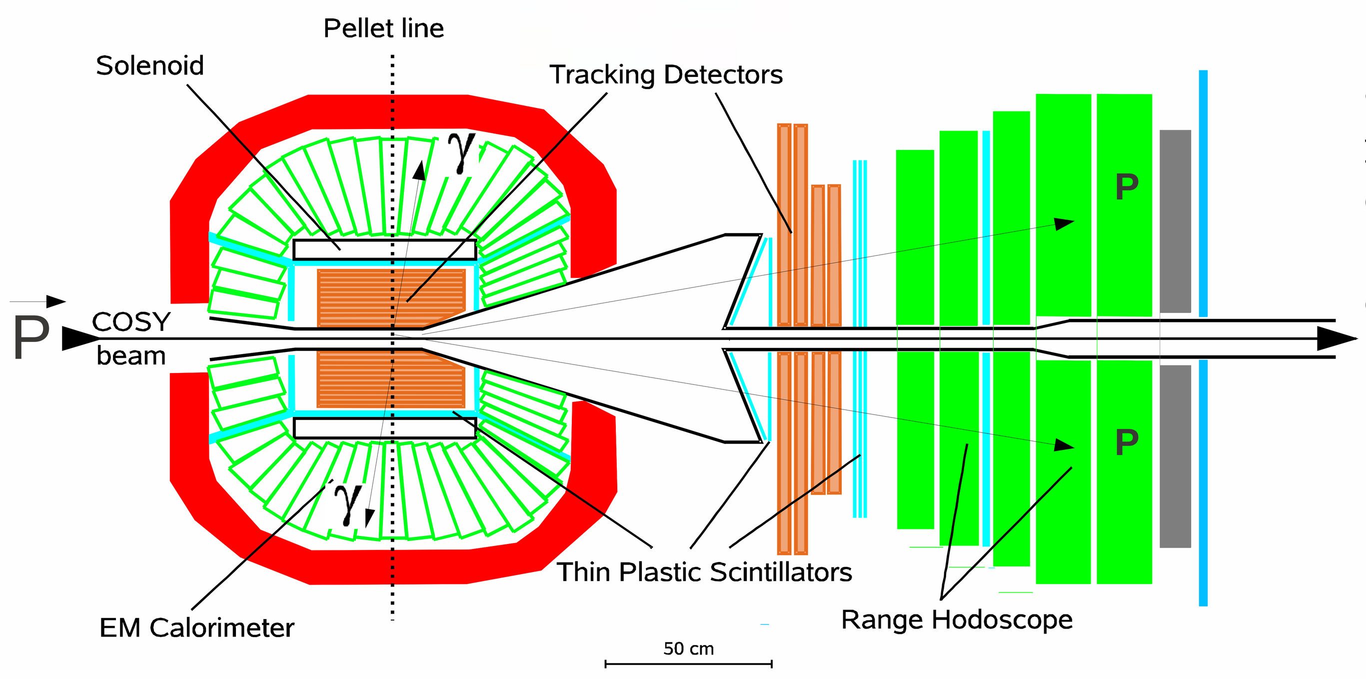
$$N_\eta(\theta,\phi+\pi)=\sqrt{\frac{N_\eta^\uparrow(\theta,\varphi+\pi)\cdot N_\eta^\downarrow(\theta,\varphi)}{\varepsilon^\uparrow(\theta,\varphi+\pi)L^\uparrow\cdot\varepsilon^\downarrow(\theta,\varphi)L^\downarrow}}$$

we know Polarization **P**

- **3 step:** So, we calculate Ay for **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

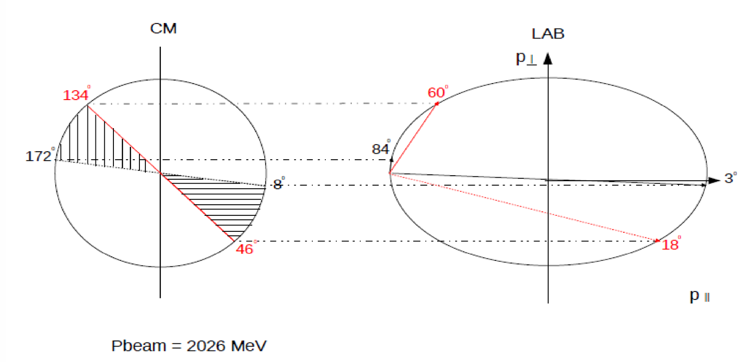


•Protons from pp → ppη reaction are registered in Forward Detector and gamma quanta from η meson decay are detected in the electromagnetic calorimeter.

• WASA detector covers following angular ranges:
- For Forward Detector [3°, 18°];
- For 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	$N_{\eta\to\gamma\gamma}$	$N_{\eta\to3\pi^0}$
15	2026	10^3	0.55	99770	81861
72	2188	$5*10^3$	0.63	447739	375580



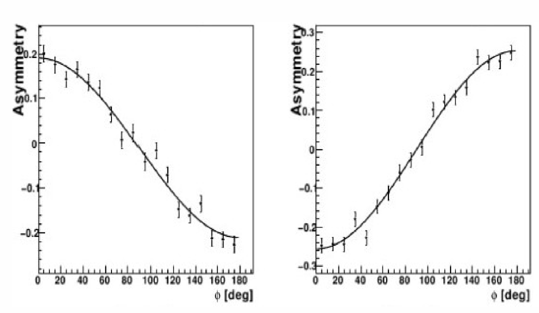
Asymmetry for pp ->pp reaction

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<theta of the FD < 34



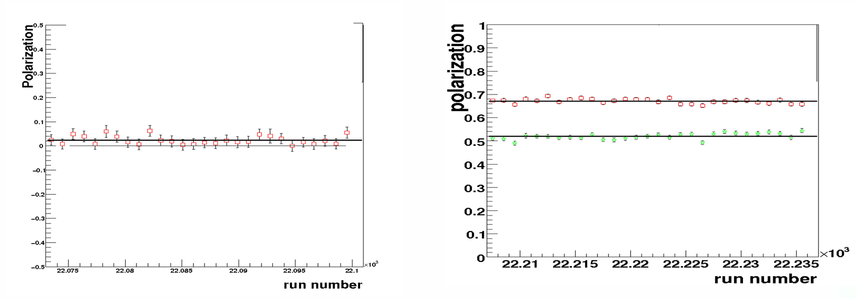
We have really strong asymmetry
In experiment!

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

Cuts & Conditions

1. Identification of protons which register on the FD;
2. Threshold for PS 2 MeV;
3. Difference in azimuthal angle;
4. Graphical cut on polar angle for pp ->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.

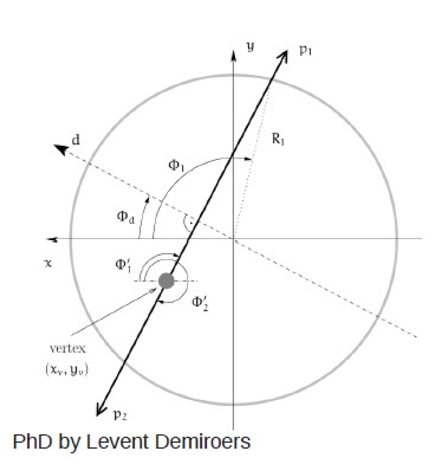


Polarization is stable in time

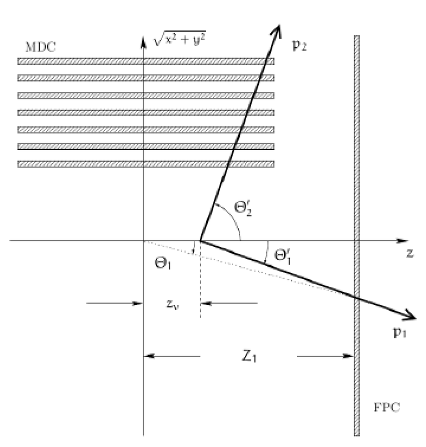
Study of the systematic uncertainty in polarisaton determination

Reconstraction of the vertex position of 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

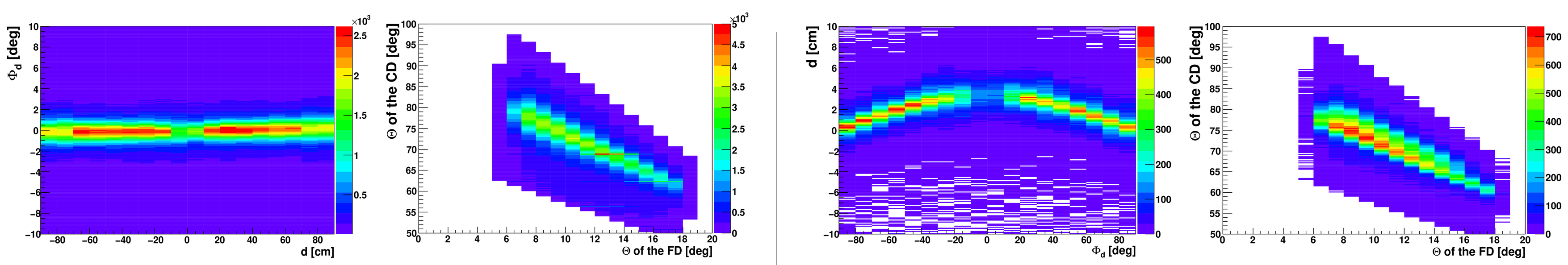
$$d = fzFTH\bullet tg(\theta_1)\bullet\cos(\varphi_1-\varphi_d)$$

fzFTH = 148.33

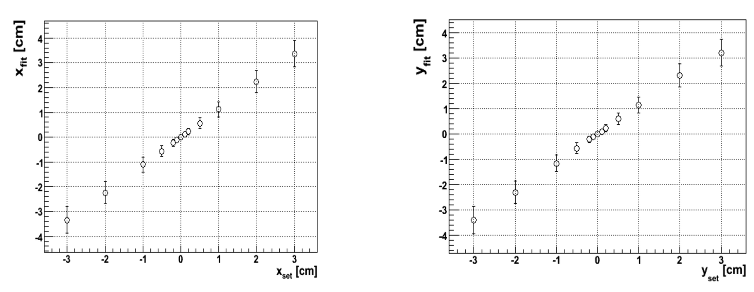
$$d = x^{vertex}\cos(\varphi_d)+y^{vertex}\sin(\varphi_d)$$

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

Histograms for extraction vertex position



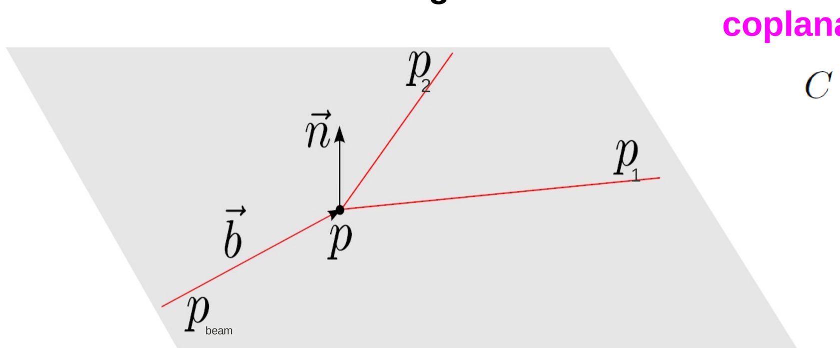
To study how shifted interaction point reflected on reconstructed value of x,y,z were done MC simulations, which show that we need to control the position of the interaction point with the precision higher than 0,3 cm.



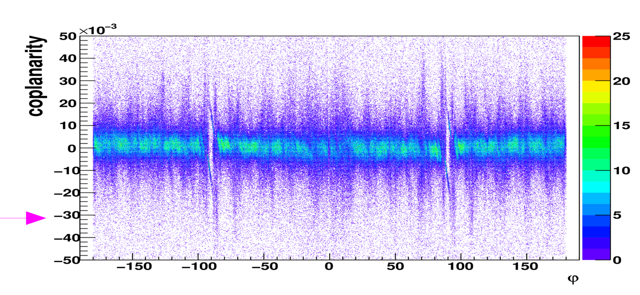
Result of extracted value for DATA

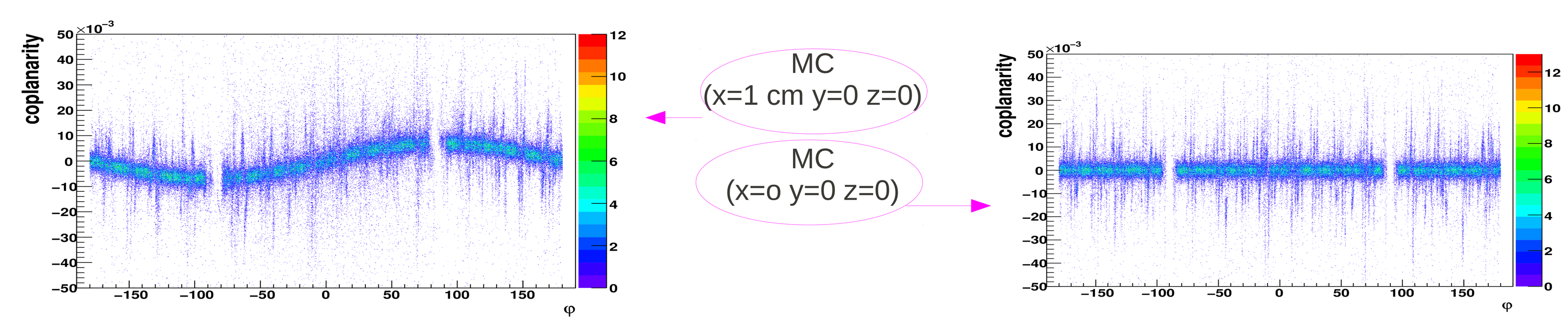
X = (-0.13± 0.02)cm
Y = (0.11 ± 0.02)cm
Z = (0.31 ± 0.35)cm

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



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





Outlook

- analysis of November 2010 data
- obtain Luminosity
- calculate number of Left/Right scattered eta mesons
- extract Ay for pp→ppη experiment

References:

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