Reconstruction of the position of interaction region for experiments with WASA detector at COSY

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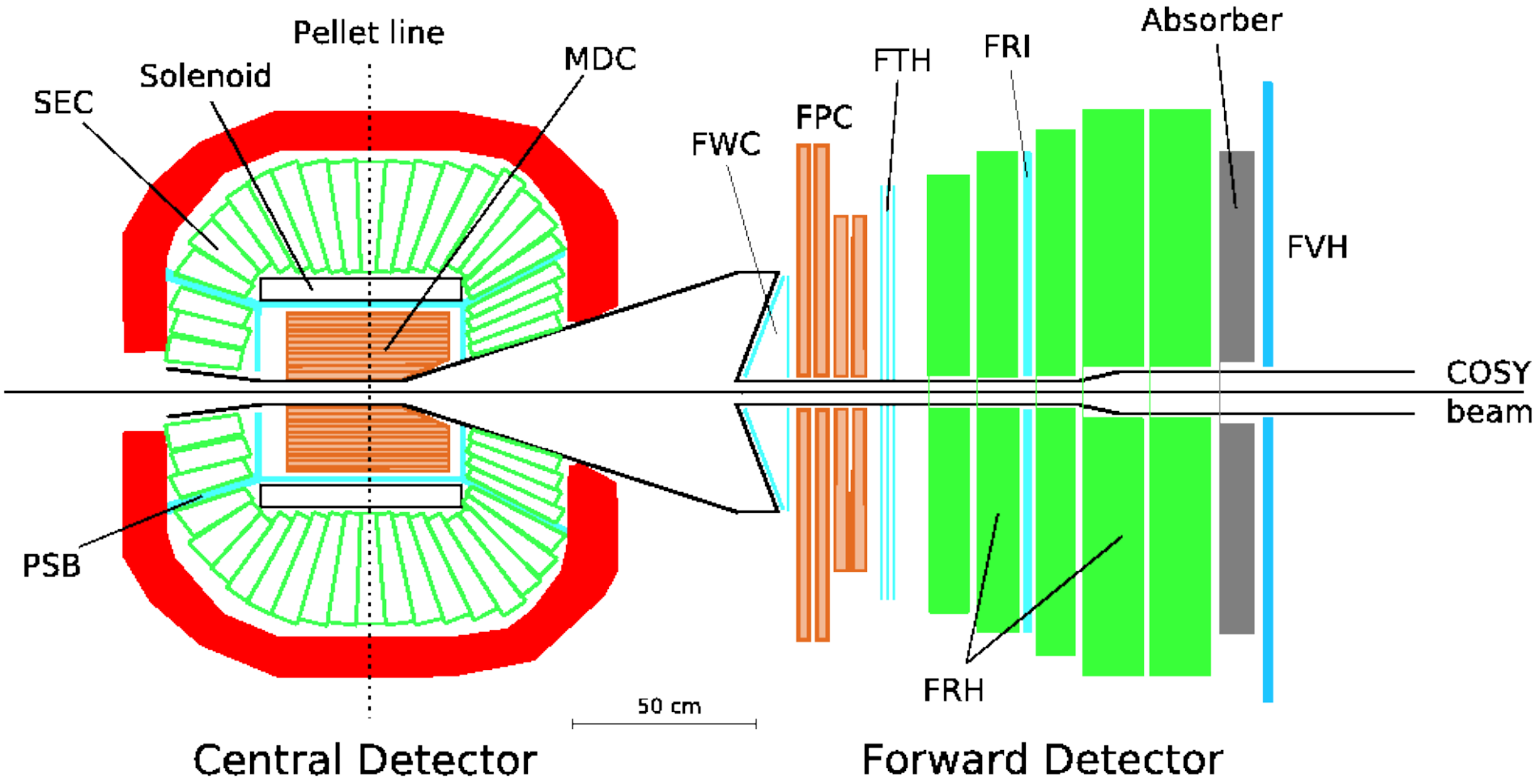
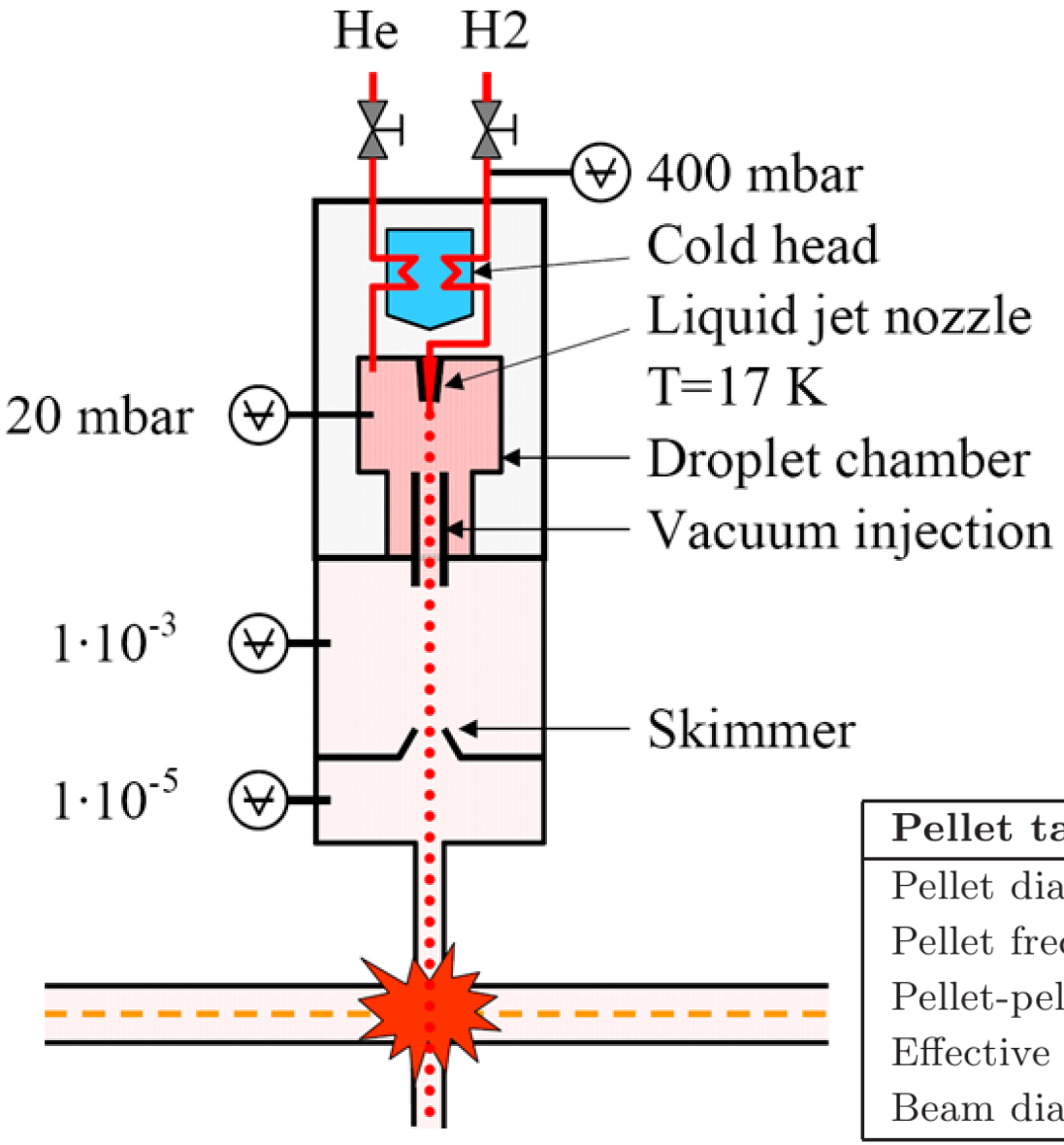
Plan of the talk

1. Getting acquainted to the structure of the WASA detector
2. Showing method(s) to determine the vertex location
3. Presenting the simulation results and first look into experimental data
4. Vertex position as the possible source of the systematic error in the extraction of beam polarization
5. Summary and outlook

Schematic view of the WASA detector



Pellet Target



Liquid hydrogen injected through nozzle into droplet chamber

Droplet generation by piezo-electric transducer

Vacuum injection via capillary tube

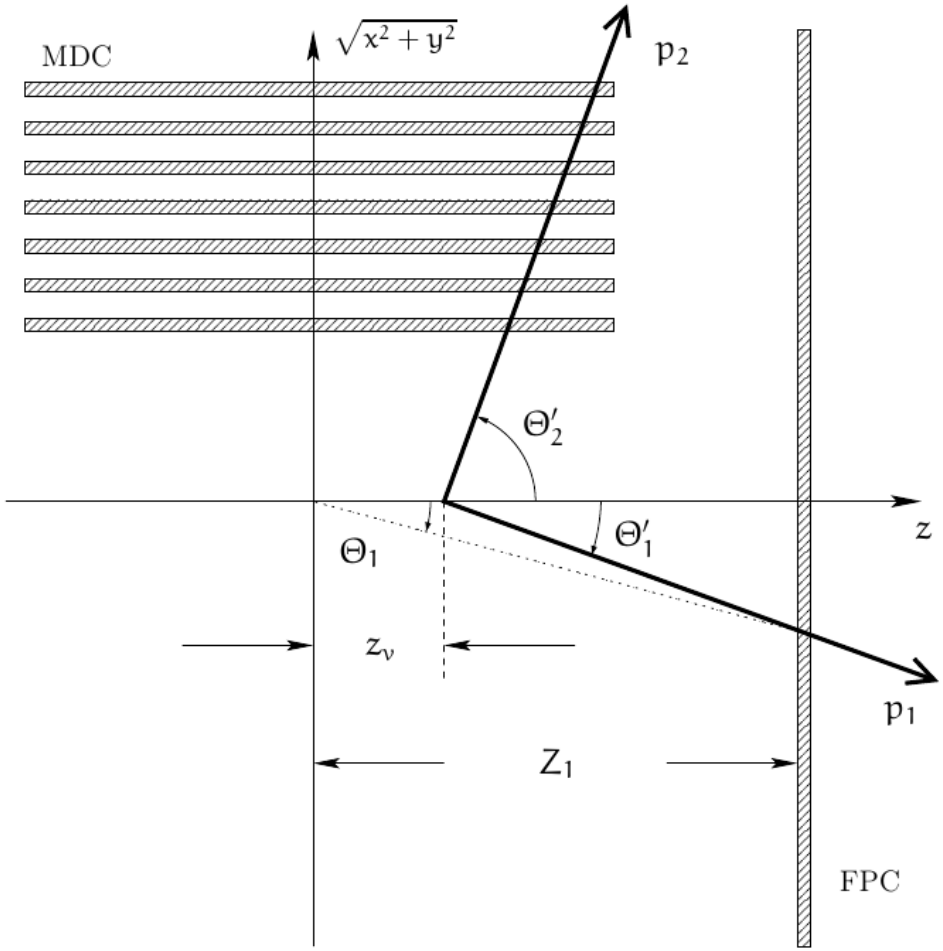
Droplets freeze to pellets (Ø ≈ 25 µm) due to evaporation cooling

Skimmer defines final pellet beam

Pellet target parameters	Present performance
Pellet diameter	25 - 35 μm
Pellet frequency	5-12 kHz
Pellet-pellet distance	9-20 mm
Effective target thickness	$> 10^{15}$ atoms/cm^2
Beam diameter	$2 - 4$ mm

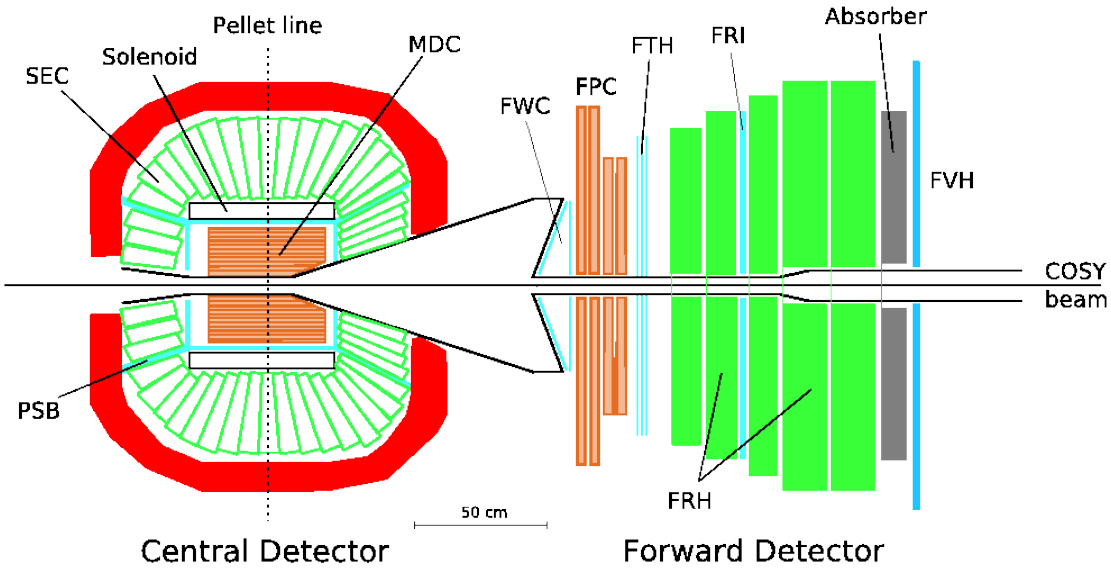
[Adam:2004ch]

Determination of the *z* vertex coordinate



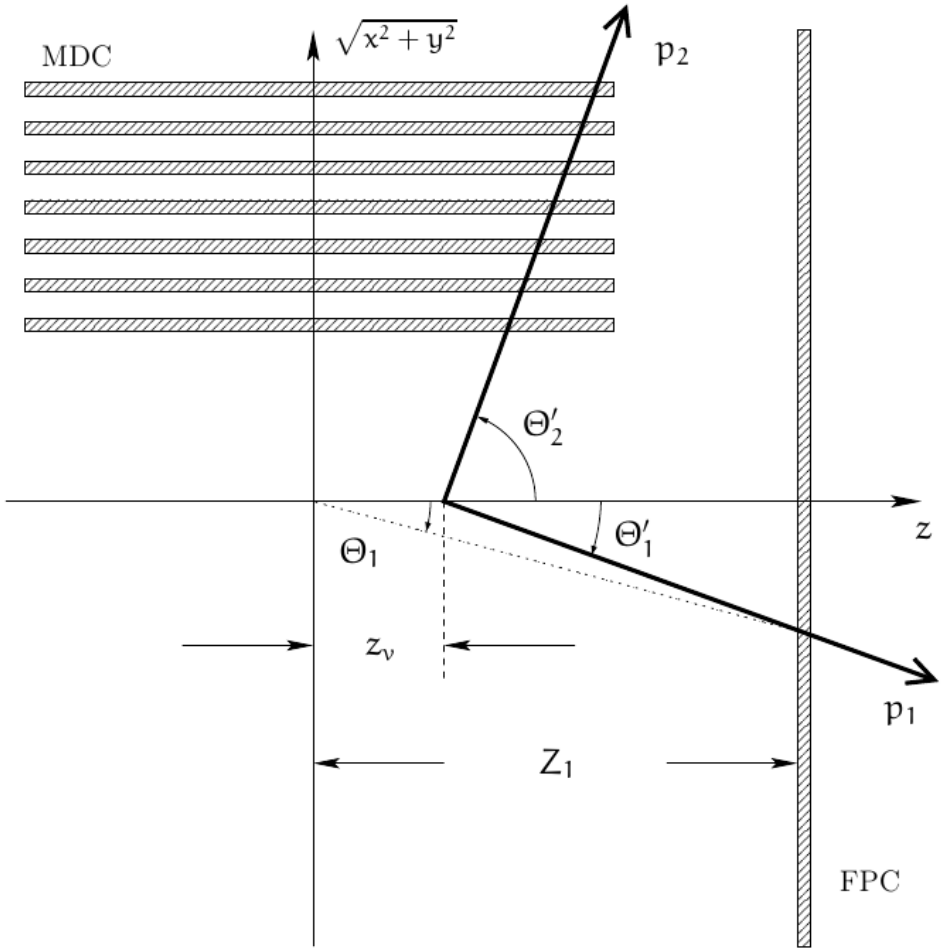
Θ'_2 – reconstructed without vertex assumption

Θ_1 – reconstructed to the (0, 0, 0) point

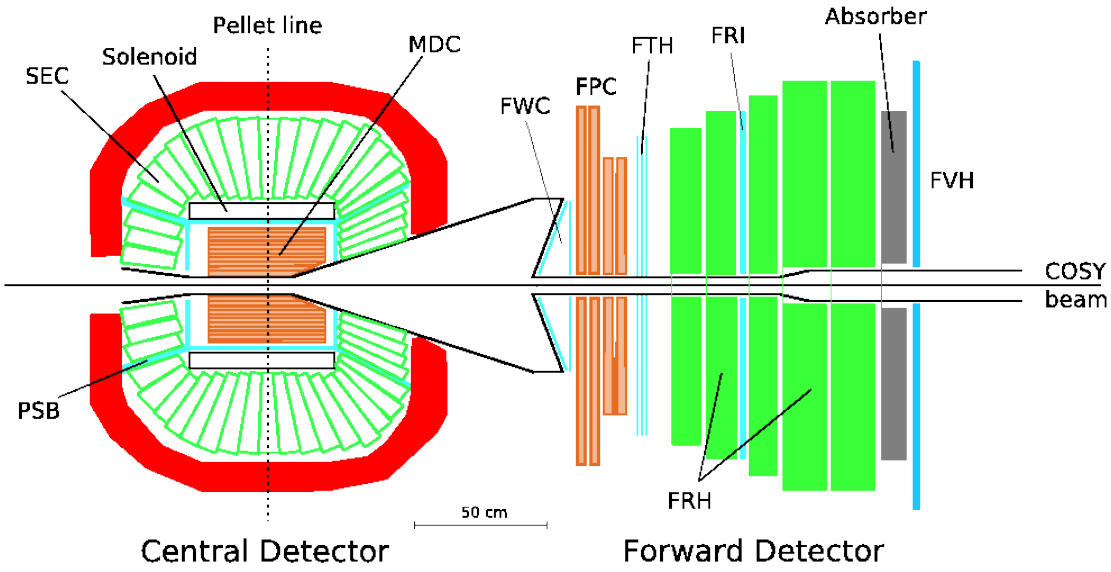


Levent Demirors, *Investigating interactions of deuterons and protons with the hydrogen pellet target of the CELSIUS / WASA experiment*, (2005)

Determination of the *z* vertex coordinate



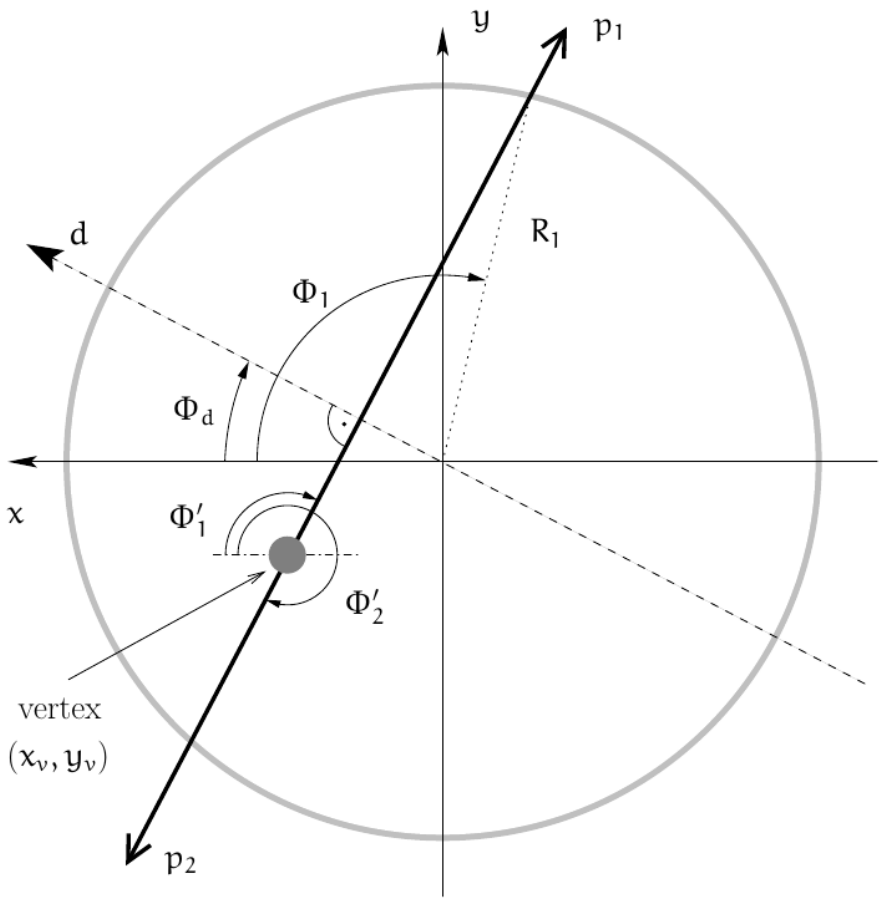
$$tg(\theta_2') = \frac{1-(z^{vertex}/z_{FTH})}{tg(\theta_1)} \bullet \gamma_{CMS}^2$$



Fit of the $\theta_2'(\theta_1)$ distribution → *z* - vertex coordinate

Levent Demirors, *Investigating interactions of deuterons and protons with the hydrogen pellet target of the CELSIUS / WASA experiment*, (2005)

Determination of the *x* and *y* vertex coordinates



p_1: forward going proton,

Φ_1: reconstructed azimuthal angle (FD),

Φ'_2: reconstructed azimuthal angle (CD),

R_1: radius of intersection with FTH

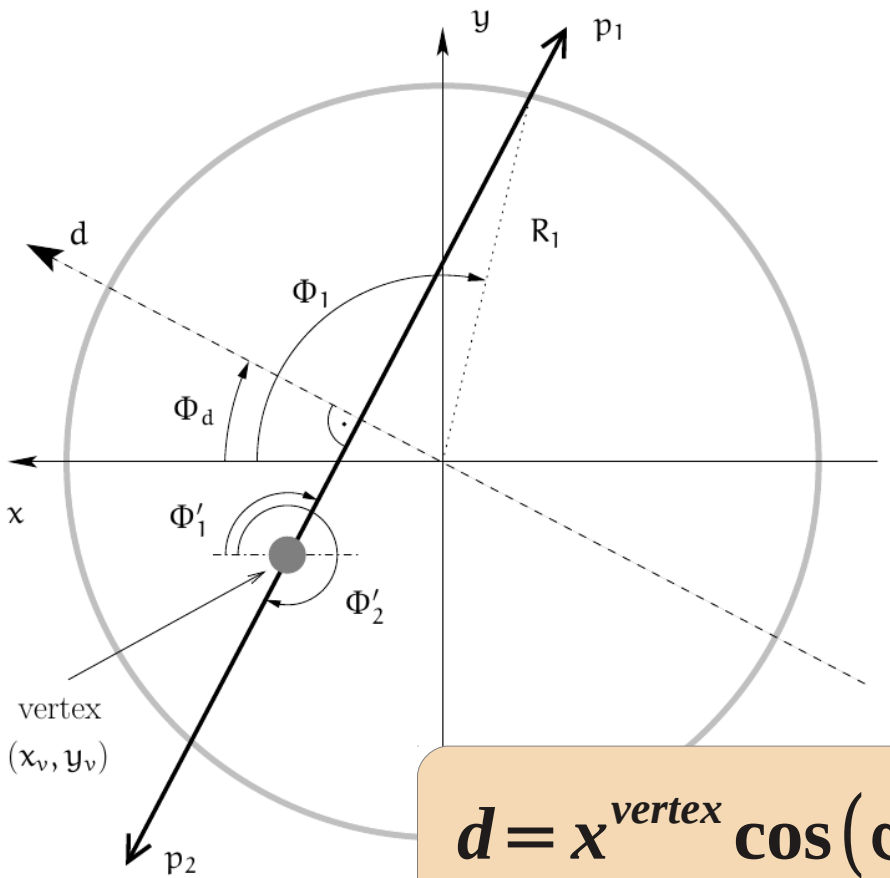
and

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

fzFTH = 148.33

Levent Demirors, *Investigating interactions of deuterons and protons with the hydrogen pellet target of the CELSIUS / WASA experiment*, (2005)

Determination of the *x* and *y* vertex coordinates



p_1: forward going proton,

Φ_1: reconstructed azimuthal angle (FD),

Φ'_2: reconstructed azimuthal angle (CD),

R_1: radius of intersection with FTH

and

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

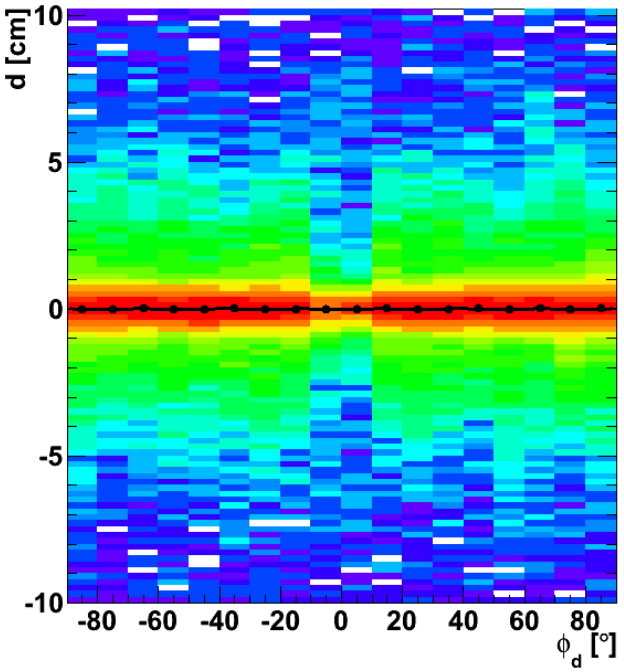
fzFTH = 148.33

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

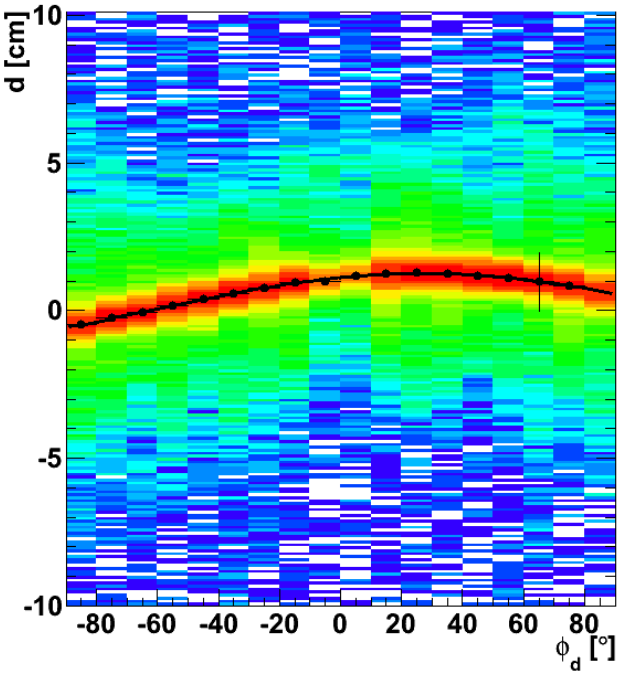
Fit of the $d(\varphi_d)$ distribution → (x, y)- vertex coordinates

Levent Demirors, *Investigating interactions of deuterons and protons with the hydrogen pellet target of the CELSIUS / WASA experiment*, (2005)

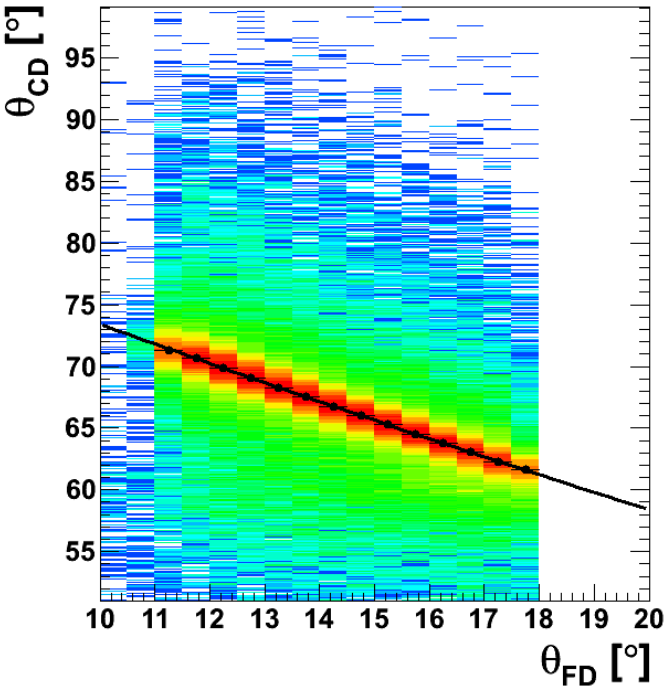
Examples of distributions



$(x,y,z)_{vertex}$ = (0.0, 0.0, 0.0) cm



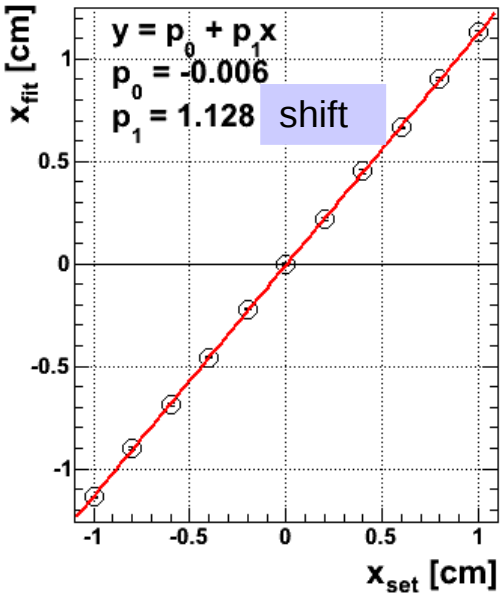
$(x,y,z)_{vertex}$ = (1.0, 0.5, 1.0) cm

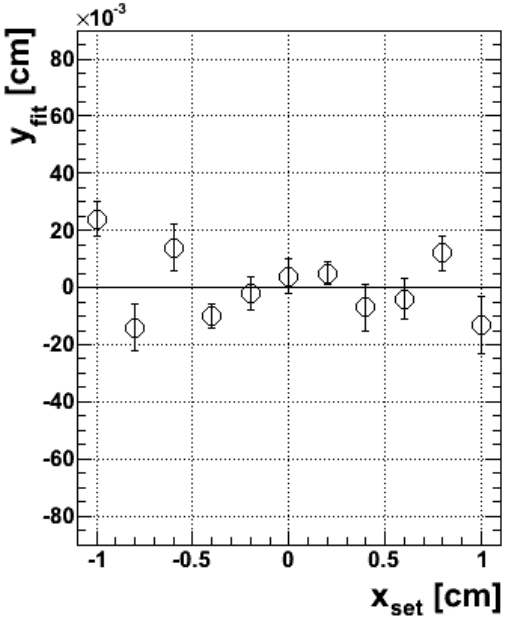


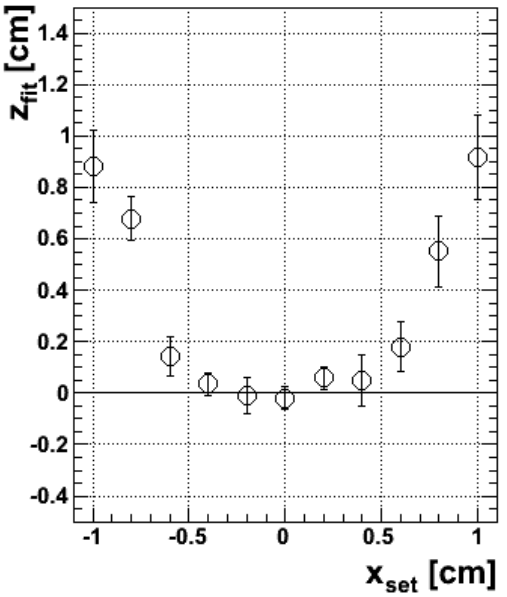
$(x,y,z)_{vertex}$ = (0.0, 0.0, 0.0) cm

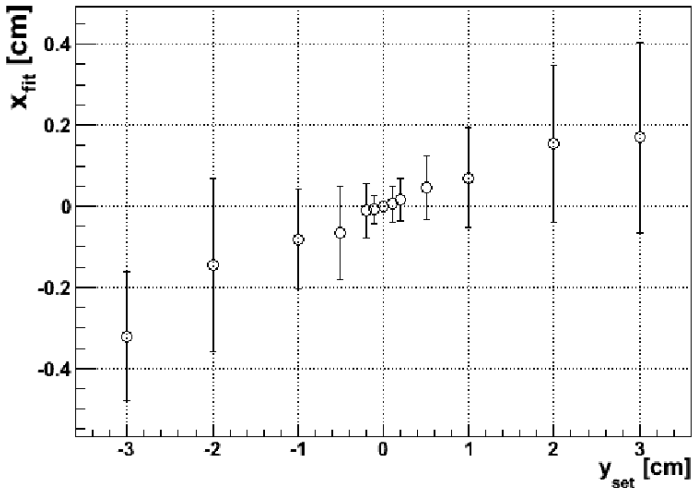
Simulation of $\vec{p}\,p \rightarrow pp$ scattering process at p_{beam} = 2.026 GeV/c

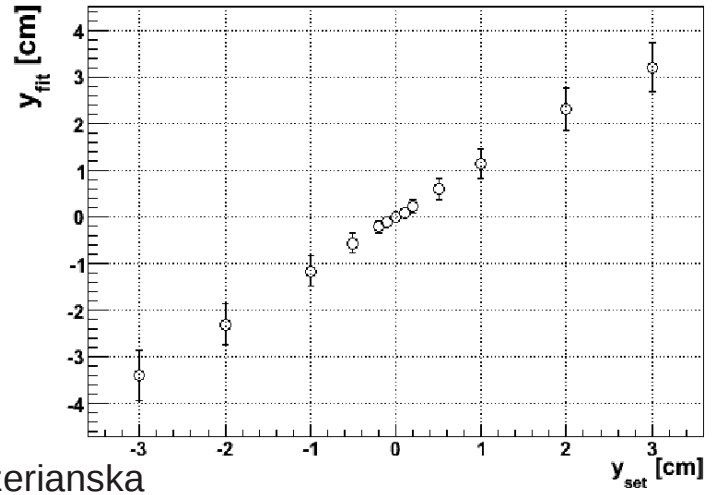
Monte Carlo studies - results



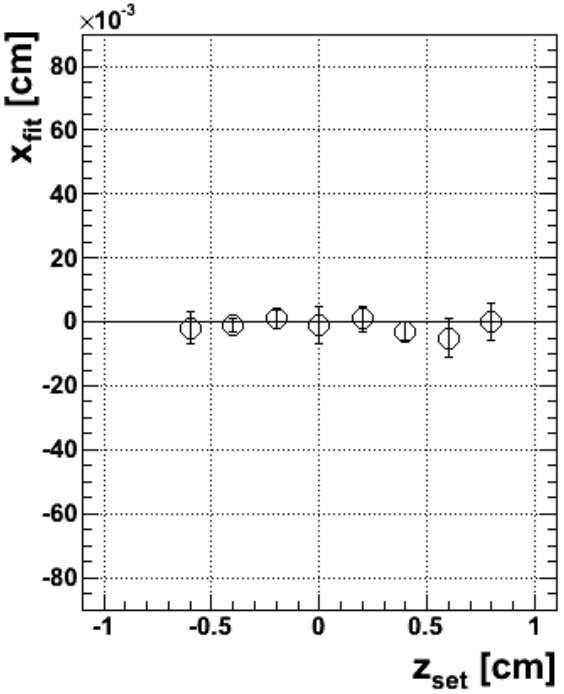


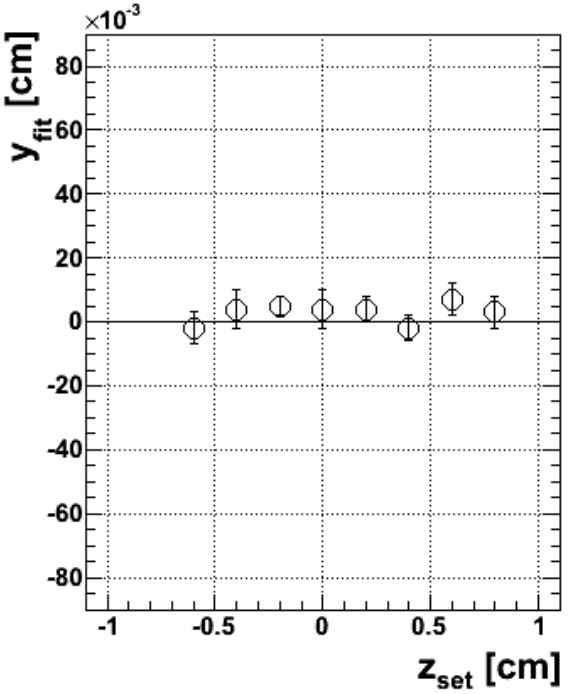


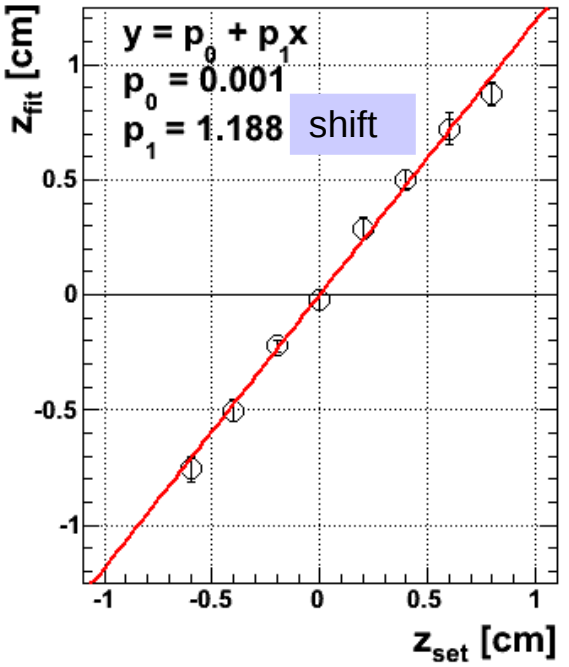




Monte Carlo studies - results

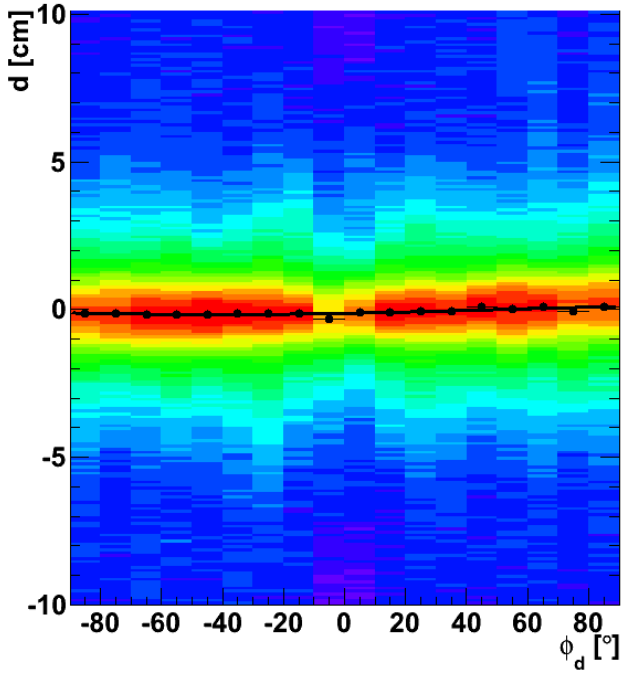


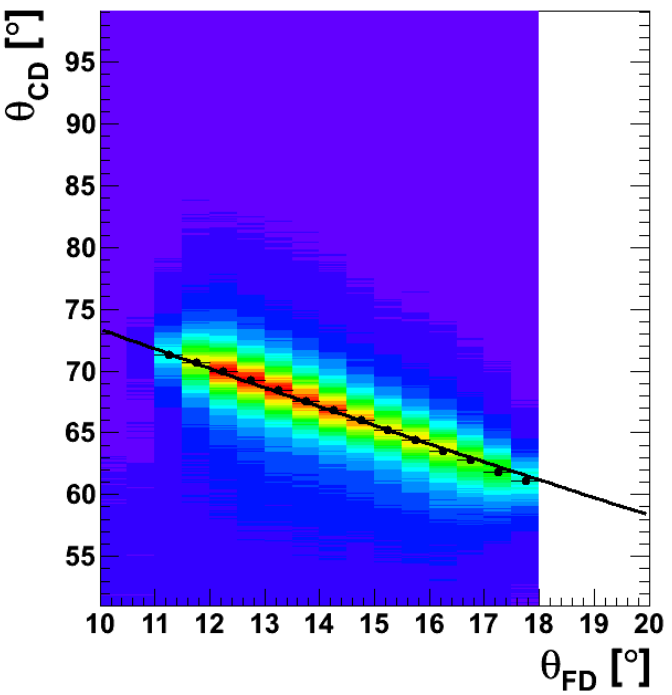




- Up to 0.5 cm, the method to find the vertex returns reliable results on all three coordinates simultaneously.
- One has to take into account the observed shift of the fit values.

Experimental data – first look





Fit result:

$$x^{vertex} = (-0.127 \pm 0.019)\,cm$$
$$y^{vertex} = (\ \ 0.109 \pm 0.021)\,cm$$

Fit result:

$$z^{vertex} = (0.31 \pm 0.35)\,cm$$

Vertex position and the beam polarization

$\vec{p}\,p \to pp$ reaction

Polarization, needed to determine the analyzing power of the $\vec{p}\,p \to pp\,\eta$ reaction

Objective: keep the systematic uncertainty of polarization at the level of 1%

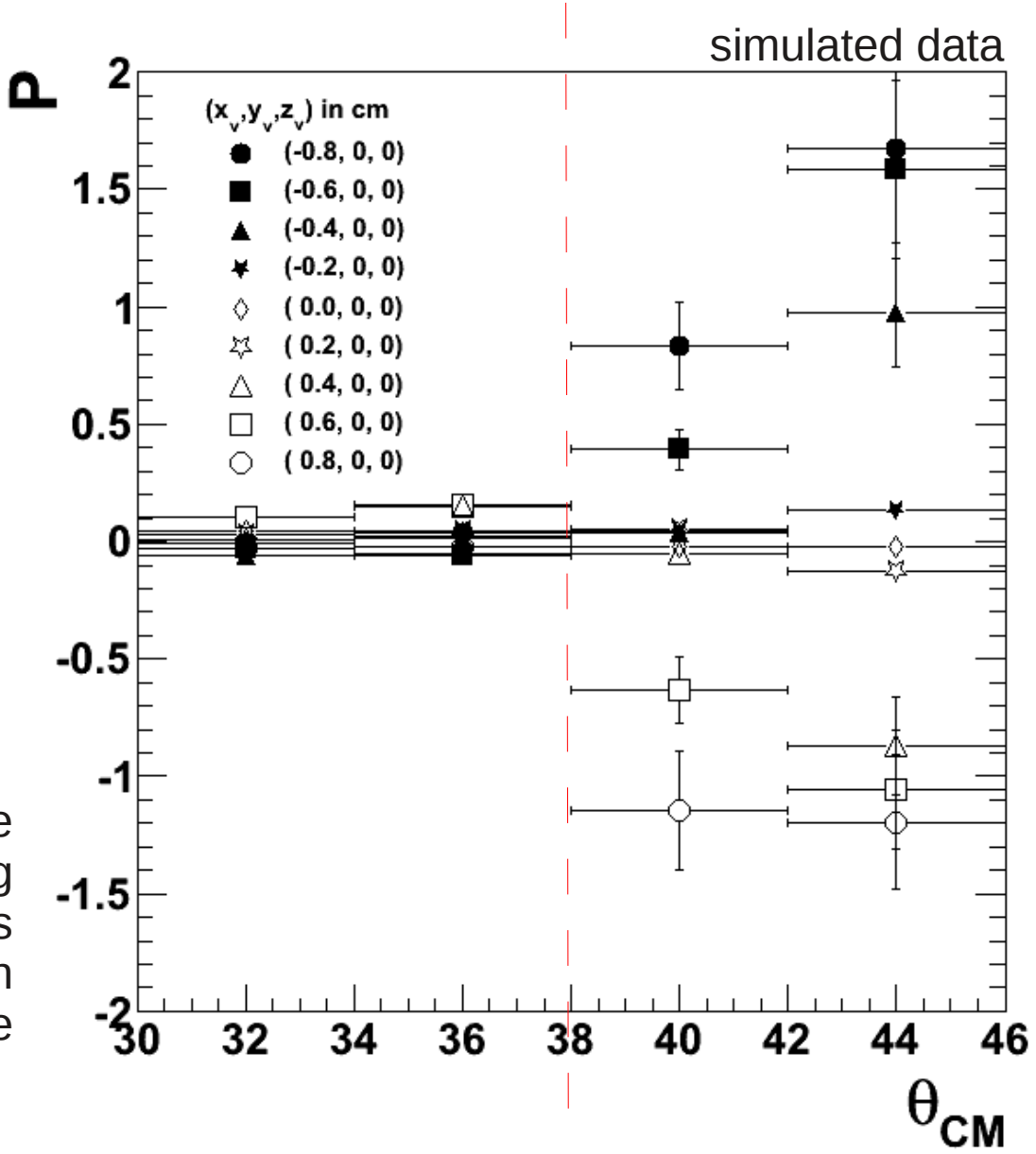


Fig. Polarization as a function of the scattering angle of the forward going proton (calculated in the center of mass frame), obtained in simulations with different values of the x−coordinate of the interaction point (see the legend).

Summary and outlook

- the statistics will allow us to obtain error of polarization lower than 1%. Therefore, we need to control the systematic uncertainty at least at the same level,

- the systematical errors may be due to the wrong assumption of the vertex position (the systematic uncertainty of polarization), the systematic uncertainty of luminosity, production rates...

- in order to have systematic uncertainty of the polarization smaller than 1%, we need to control the position of the interaction point with the precision higher than 0.3 cm,

- due to the large sensitivity of the result to the scattering angle it is better to calculate polarization taking into account the scattering angle not bigger than 38°.