Simulation Results on Detector Concept

PAX Collaboration

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OUTLINE

- History of the performed work - rough event rate estimations for $\bar{p}p$ (AD experiment) and pp (COSY experiment) elastic scattering.
- Work in progress - first simulation results for pp elastic scattering at COSY.

Task: Rate estimation
(see pax Note N.1 from pax home page).

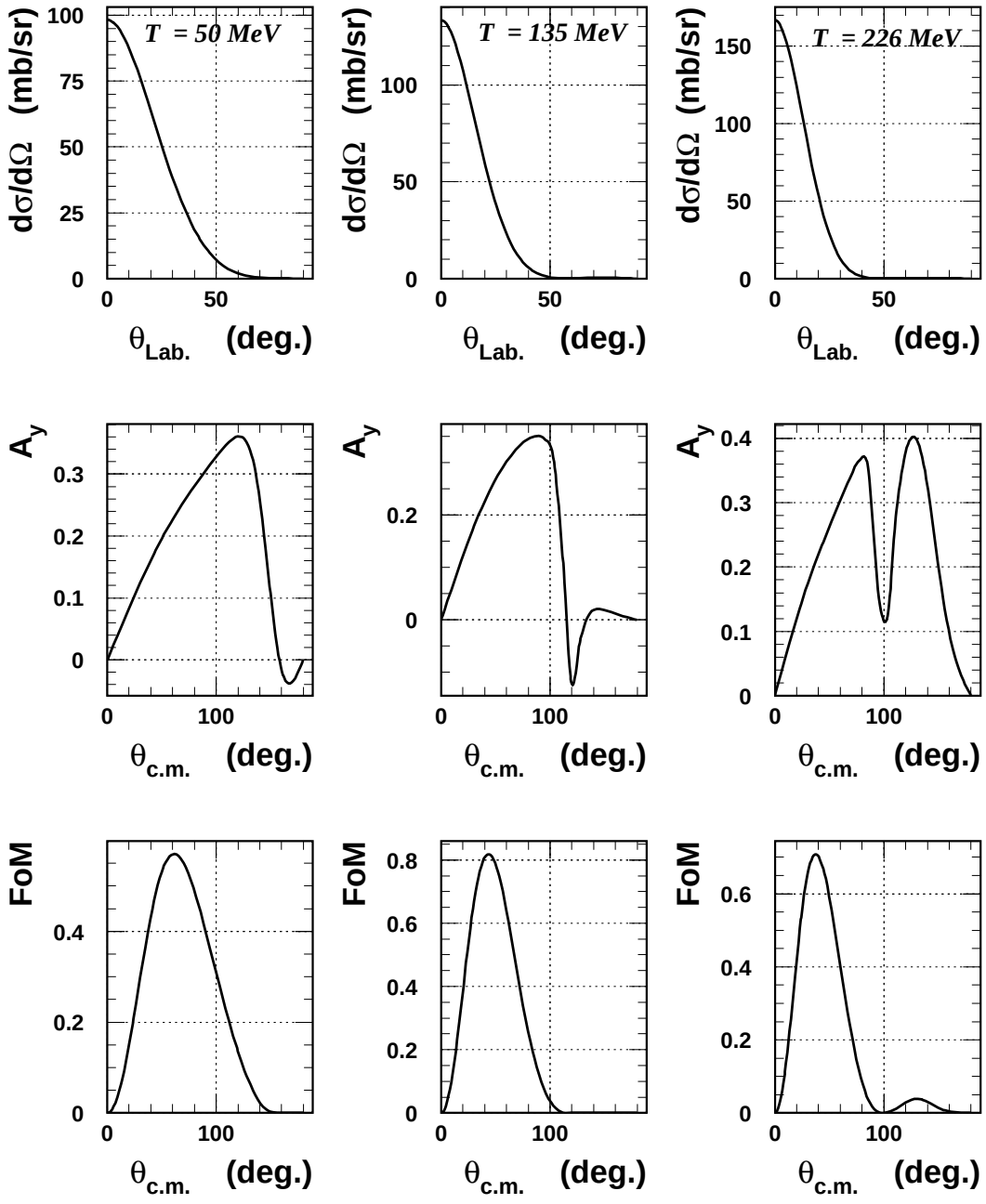
The PAX collaboration suggests to study the polarization buildup in an antiproton beam at the AD-ring (CERN). The polarization buildup by spin filtering of stored $\bar{p}$ by multiple passage through a polarized internal hydrogen target gives a direct access to the spin dependence of the $\bar{p}p$ total cross section. For such a study $\bar{p}p$ elastic scattering process in energy range 50–200 MeV can be used. For the analysis a model for the nucleon–nucleon interaction based on the meson–baryon dynamics (Haidenbauer model A) can be used.

For each beam energy Figure of Merit (FoM) distributions *vs* antiproton polar angle (θ) was calculated and the value of maximum FoM have been founded.

$$FoM(\theta) = A_y^2(\theta) \cdot \frac{d\sigma}{d\Omega} \tag{1}$$

A_y from SAID and $d\sigma/d\Omega$ from Haidenbauer model.

PbarP Elastic



With the known luminosity L, dead–time factor f_{dt} and detected cross–section σ_{det}, we can calculate count rate R in the following way:

$$R = L \cdot \sigma_{det} / f_{dt} \tag{2}$$

We use the following form for the detected cross section σ_{det} calculation:

$$\sigma_{det} = 2\pi \cdot \sum_i (\frac{d\sigma}{d\Omega})_i \cdot sin\theta_i \cdot \Delta\theta_i \cdot \frac{N^{det}(\theta_i)}{N^0(\theta_i)} \tag{3}$$

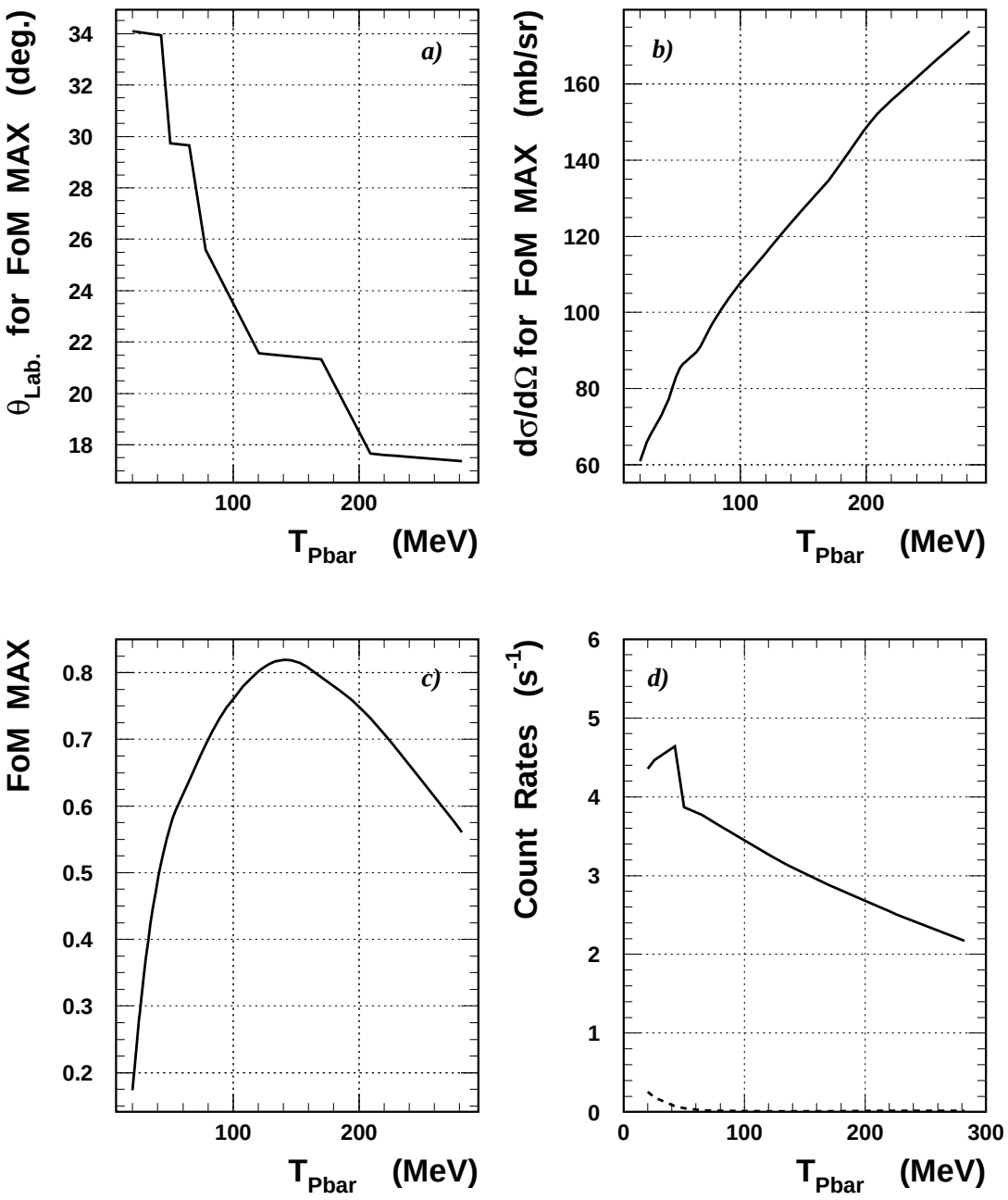
To estimate antiproton–proton elastic rates luminosity $\mathrm{L} = 10^{27}\ cm^{-2} s^{-1}$ has been used.

$L = N_{\bar{p}} \cdot f \cdot d_t = 10^8 \cdot 10^6\,\mathrm{s}^{-1} \cdot 10^{14}\,\mathrm{atoms/cm}^2 = 10^{28}$ cm^{-2}s^{-1}.

Such a density will be achivable with cell hydrogen target. Estimated luminosity decreasing factor due to spin filtering process $\sim$ 10.

To detect recoil protons the ANKE Silikon Tracking Teleskop (STT) system has been considered. For each beam energy telescop system will cover in the laboratory system polar angle θ around $(60 - 90)^\circ$. Recoil protons can be identified via the ΔE/E method over an energy range from 2.5 MeV to 25 MeV with the resolution of 150–250 keV.

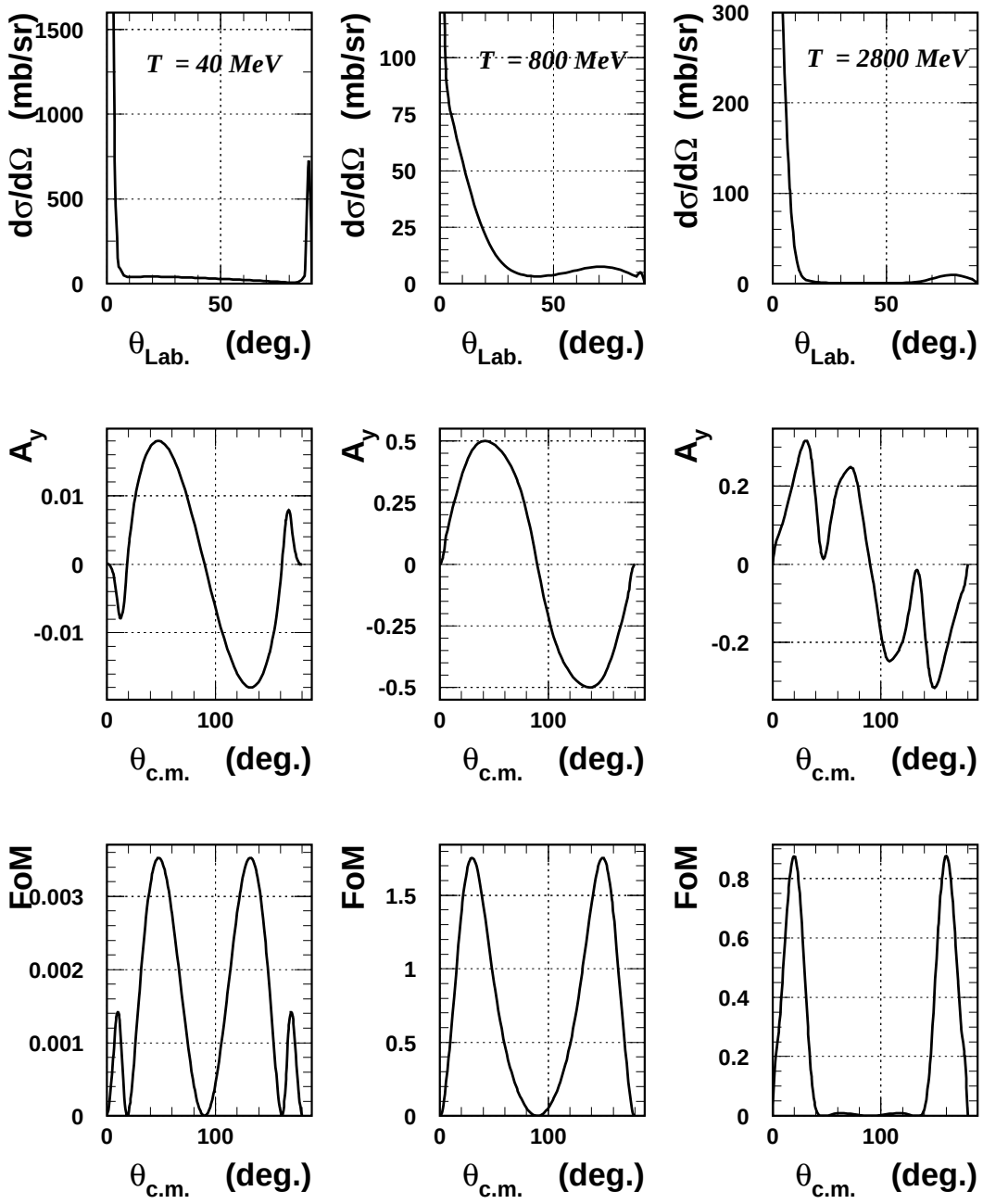
PbarP Elastic



Result: estimated event rate about 2–4 s^{-1}.

The ideology described above, can be applied for the case of proton–proton elastic rate estimations for COSY-ANKE measurements. Input (A_y and $d\sigma/d\Omega$) for this analysis in energy range 50-3000 MeV was taken from SAID dabase.

PP Elastic


dσ/dΩ (mb/sr)
T = 40 MeV
T = 800 MeV
T = 2800 MeV
θLab. (deg.)
Ay
θc.m. (deg.)
FoM
θc.m. (deg.)

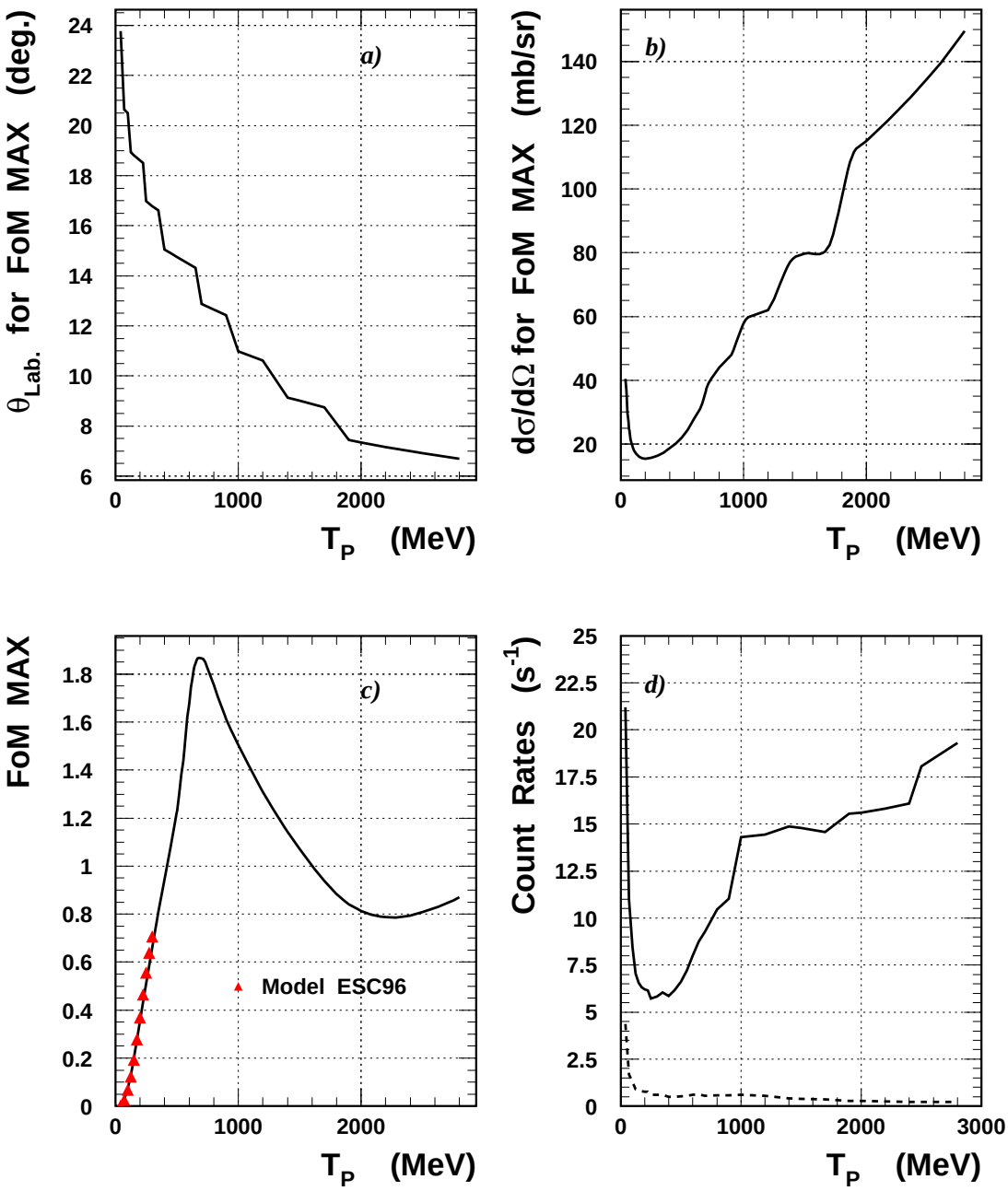
To estimate proton–proton elastic rates luminosity

$L = N_p \cdot f \cdot d_t = 10^8 \cdot 5 \cdot 10^6\,\mathrm{s}^{-1} \cdot 2 \cdot 10^{13}\,\mathrm{atoms/cm}^2 = 10^{28}$ cm^{-2}s^{-1} has been used.

Considered luminosity decreasing factor doe to spin filtering $\sim$ 150 (in 5 beam lifetime).

To detect recoil protons the ANKE Silicon Tracking Teleskop (STT) system has been considered. Telescope system will cover polar angles θ corresponding to the (maximum FoM angle $\pm 5^\circ$).

PP Elastic



Result: estimated event rate about 6–20 s^{-1}.

Optimisation of the Detector System.

Main issues to be adressed by the simulation are:

- to define number and special position of the recoil telescopes
- to define pich, thickness and number of active layers in telescope
- to choose forward detector conception (telescope??.)
- Event generator for signal (including density distribution of a storage cell target)
- Event generator for background

pp-elastic spin-dependent cross section for polarized target and transversely polarized beam is given:

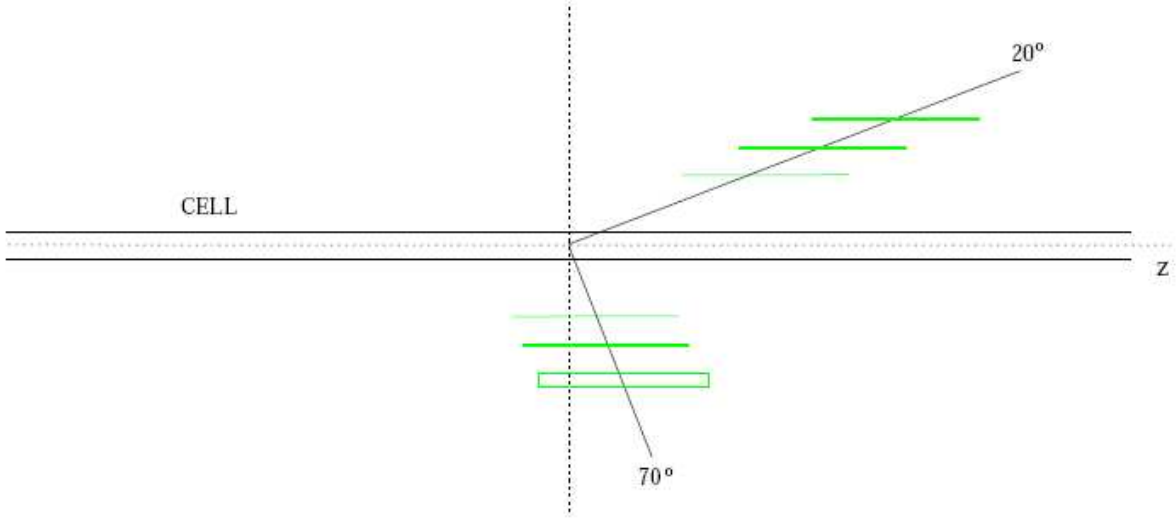
$$\sigma/\sigma_0 = 1 + A_y[(P_y + Q_y)cos\phi - Q_x sin\phi]$$
$$+ A_{xx}[P_y Q_y sin^2\phi + P_y Q_x sin\phi cos\phi]$$
$$+ A_{yy}[P_y Q_y cos^2\phi - P_y Q_x sin\phi cos\phi]$$
$$+ A_{xz} P_y Q_z sin\phi$$

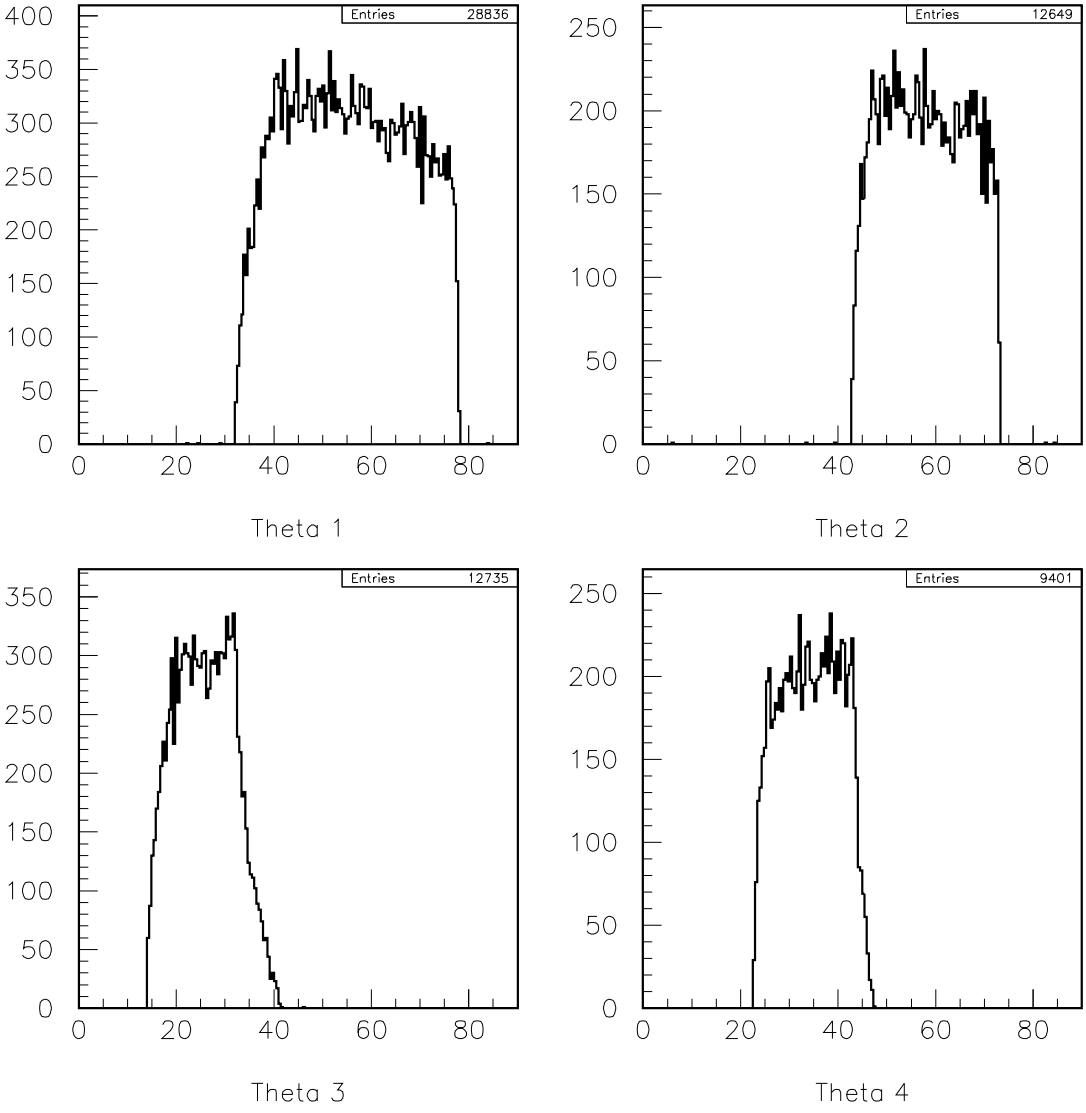
Measurement: Polarimetry.

- Filtering with tranvserse polarized target at T_p = 40 MeV.
  P_y determined from $\epsilon = P_y \cdot Q_y \cdot A_{xx} < sin^2\phi >$.
- Determination of target polarization Q_y from measurement with P_y at T_p = 800 MeV using for P_y the asimetry $\epsilon = P_y \cdot A_y < cos\phi >$ and for Q_y then $\epsilon = P_y \cdot Q_y \cdot A_{xx} < sin^2\phi >$.

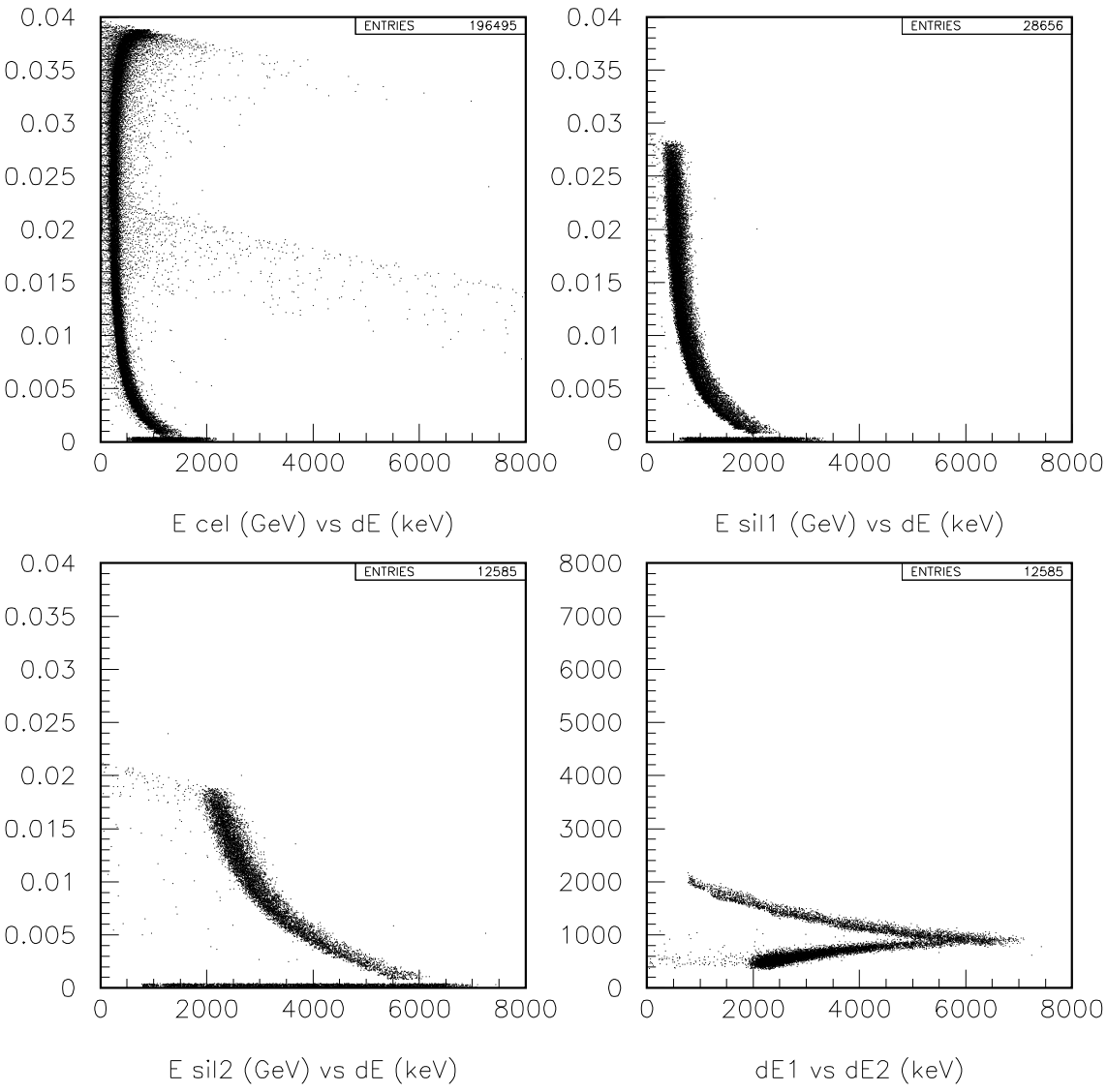
PLUTO - event generator for pp elastic scattering.

ANKE-GEANT4 - detector simulation tool.


20°
CELL
z
70°



Acceptance in polar angle θ.



Energy loss in cell walls and Silicon layers.

30 μm Al cell, 70 μm and 300 μm Silicon layers

Summary:

- For AD case estimated antiproton–proton elastic scattering rates was found about 2–4 s^{-1}.
- For COSY case estimated proton–proton elastic scattering rates was found about 6–20 s^{-1}.
- numer of secondary interactions in cell walls is less then 0.15 $\%$.
- There are no significant improvement in case tilted telescopes to be perpendicular to the incoming tracks (David Iamanidze).

  Decreasing distance between I and II layers from 2cm to 1cm efficiency increased $\sim 5\%$.
- Work in progress!