Simulation Studies for the KOALA Experiment

Jens Frech

Ruhr-Universität Bochum
Institut für Experimentalphysik I

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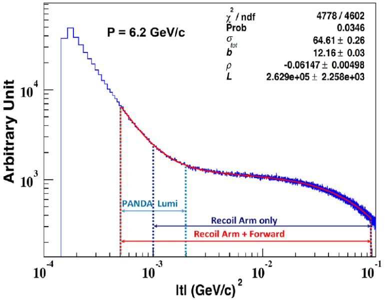
RUHR UNIVERSITÄT BOCHUM RUB

Luminosity Determination

- Largest uncertainty from model function of the differential cross section
- Coulomb part calculated from QED
- Hadronic part parametrized with σ_{tot}, ρ and b
- Data missing for $\overline{\text{P}}$ANDA energy range
- KOALA will measure over a large range of momentum transfer t to determine the cross section parameters precisely

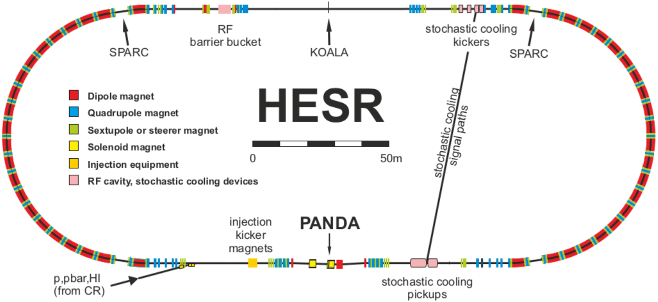


Eur. Phys. J. A. 50 (2014)

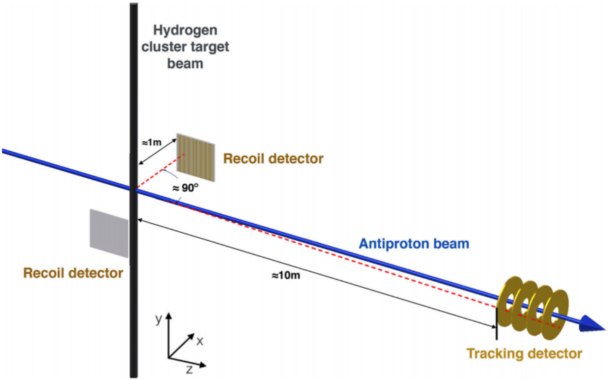
KOALA

- @COSY
- P_{beam}=(1.5-3.2) GeV/c
- pp elastic scattering

- @HESR
- P_{beam}=(1.5-15) GeV/c
- $\bar{p}$p elastic scattering



KOALA



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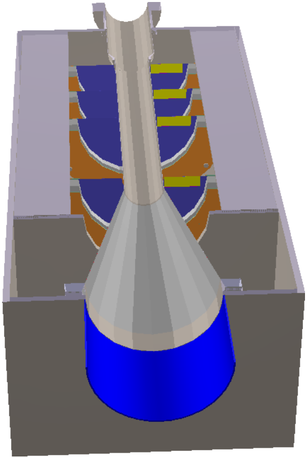
- Forward scattered proton measurement by Lumi prototype
- Backwards scattered proton measurement by KOALA

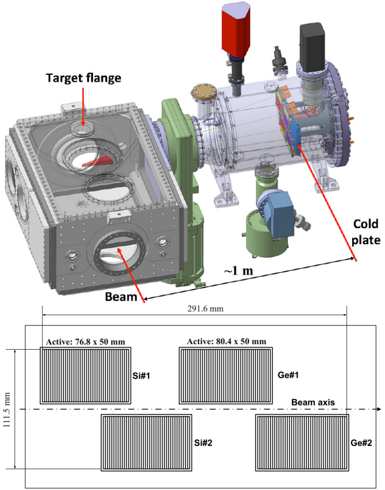
Prototype of Luminosity Detector

- MC model
- One sensors module per plane with 4 sensors each
- Distance from IP: 401 cm at COSY
- No magnetic field



KOALA Detector

- 90° angle to the beam direction
- One layer of two germanium and two silicon strip detectors
- Distance from beam-axis: 101 cm at COSY
- Covers recoil angles between 0° and 19°
- Energy measurement by completely stopping recoil particles



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Event reconstruction

KOALA:

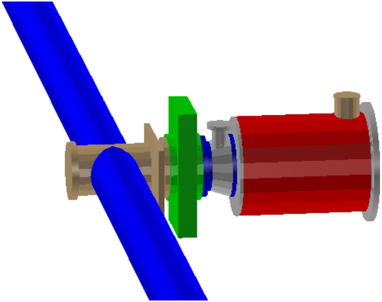
- Hit in strip defines z-coordinate

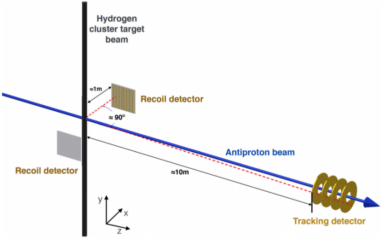
Lumi:

- Hit reconstruction in center of pixel
- Tracks out of 4 hit combinations with one hit per plane
- Backpropagation to the IP

→ Straight line extrapolation

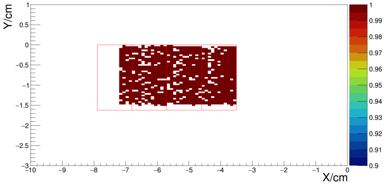
KoalaSoft package



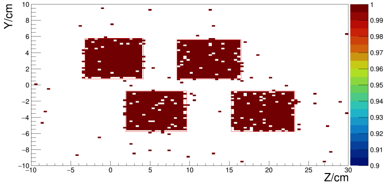


Reconstruction efficiency

Lumi



KOALA

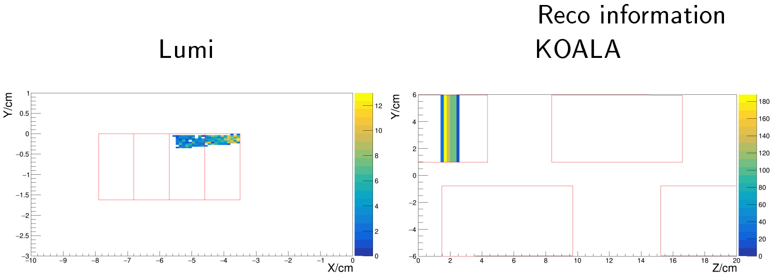


$$\varepsilon = \frac{\#(\text{tracks})}{\#(\text{generated tracks})} > 94\ \%$$

$$\varepsilon = \frac{\#(\text{hits reconstructed})}{\#(\text{generated tracks})} > 99\ \%$$

Finding coincidence

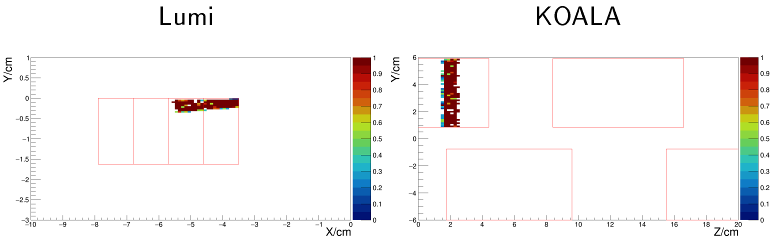
- Requires a reconstructed track from the Lumi prototype and a hit in the KOALA detector
- No criteria for the time frame of an event set
  only one event is expected per time frame



Coincidences in the Lumi prototype and the KOALA detector for elastic pp events @3.2 GeV/c

Reconstruction Efficiency

Generated information

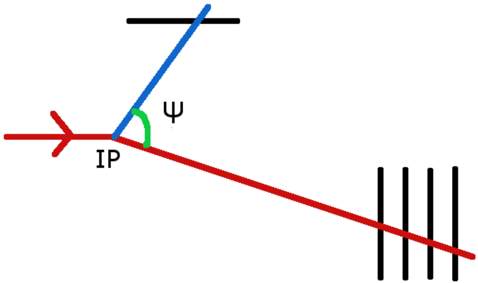


$$\varepsilon = \frac{\#(\text{hits reconstructed with coincidences})}{\#(\text{generated tracks})} > 94\ \%$$

- Lower efficiency areas in the KOALA setup are due to binning effects

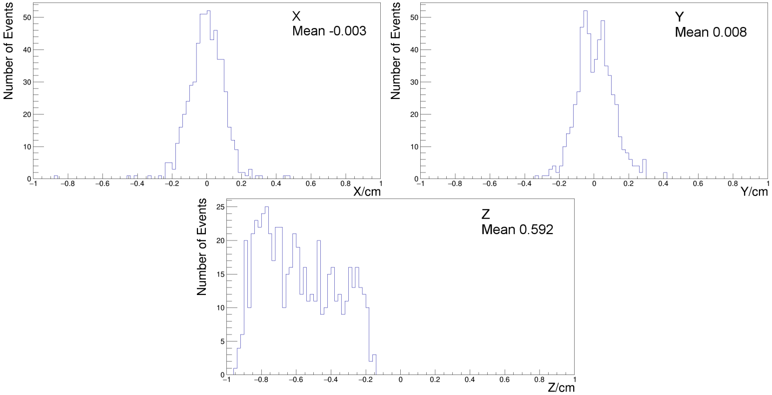
IP determination

- IP position effects luminosity determination
- IP determination by backpropagation of Lumi tracks to the POCA to position (0,0,0) is insufficient
- Lumi track defines a line, on which the IP is located
- Combination of KOALA hit position and opening angle ψ between the two particles defines IP on that line



IP determination - Results

Generated IP (0, 0, -0.6)

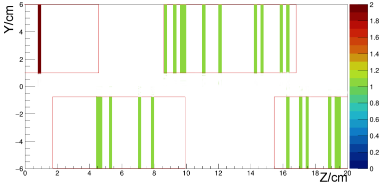


- Good agreement
- Wide distribution in Z as expected
- Checking of this method in realistic conditions e.g. with beam tilts still ongoing

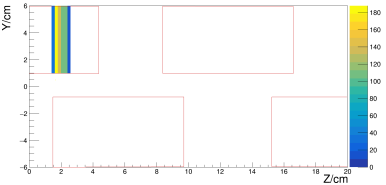
Background analysis - pp events

Coincidences for 10^8 inelastic and 10^6 elastic pp events @ 3.2 GeV/c

background events



elastic events

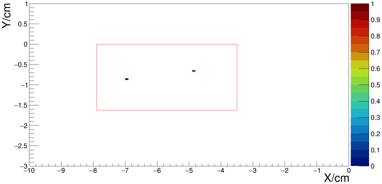


- No overlap with areas of coincidences of elastic scattering
- Coincidences close at region of interest: pp $\rightarrow$ pp$\pi^+\pi^-$

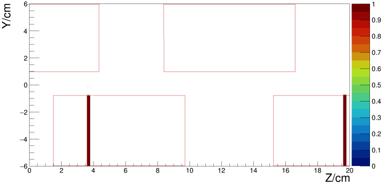
Background analysis - pp events

Coincidences for 10^6 pp $\rightarrow$ pp$\pi^+\pi^-$ events @ 3.2 GeV/c

Lumi



KOALA



- Only two coincidences found outside the area of elastic events
- Background contribution is very low

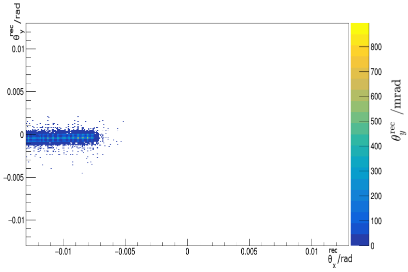
LumiFit

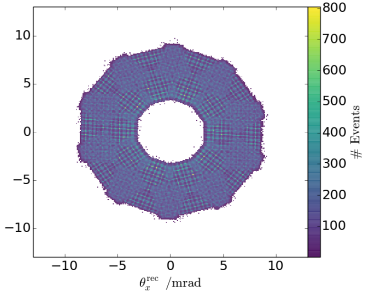
Standard software for luminosity determination

- Input
  - Reconstructed tracks with coincidence condition
  - Efficiency distribution (2D) } Target and Beam properties
  - Resolution distribution (2D) } Target and Beam properties
- Output
  - Determination of the luminosity by fit of the model elastic cross section to data

LumiFit

Fit results for reconstructed angular distributions





KoalaSoft @3.2 GeV/c

PandaRoot @15 GeV/c

- Results are similar
- Smear stems from larger resolution from multiple scattered events at lower momenta

Summary & Outlook

- Reconstruction of coincidences
- High efficiency for coincidences in overlapping areas
- Background contributions very low

Next steps:

- Testing viability of the IP determination method
- Updating KoalaSoft to be compatible with LumiFit
- Change LumiFit to extract the model parameters of the elastic cross section instead of the luminosity