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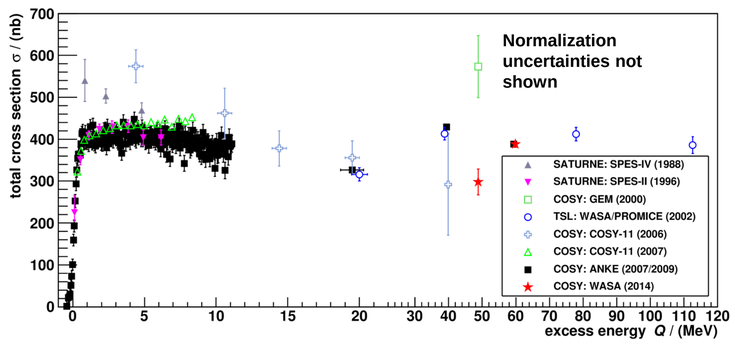
Luminosity determination via dp-elastic scattering at ANKE

Motivation

- Data from ANKE obtained at beam momenta of 3120.17 MeV/c ≤ p ≤ 3204.16 MeV/c allow for studies on total and differential cross sections for $d + p \rightarrow {}^3\mathrm{He} + X$ reactions
- Studies on the total cross sections of the reaction $d + p \rightarrow {}^3\mathrm{He} + \eta$ are of special interest since they strongly differ from pure phase space behaviour (figure 1)
  - ➢ Indication for a quasi bound state of the η^{3}He-system
- New high precision data from ANKE up to an excess energy of 15 MeV rely on a careful luminosity determination to extract precise absolute cross section values
- Final data will be discussed together with results from a further beam time from WASA-at-COSY investigating the behaviour at excess energies of 13 MeV < Q < 81 MeV (see poster of Nils Hüsken)



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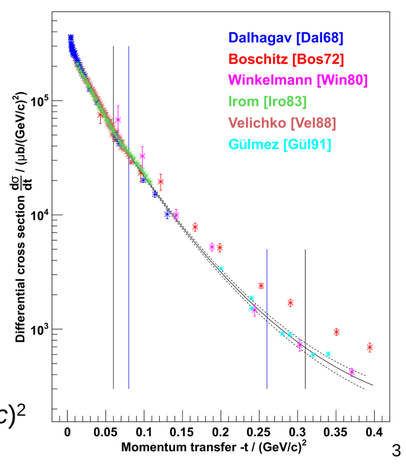
[1] P. Adlarson, European Journal of Physics J. A (2014) 50: 100 DOI 10.1140/epja/i2014-14100-4

Luminosity via $d + p \rightarrow d + p$

- Advantages of the dp-elastic scattering as normalization reaction:
  - ➢ Broad data base of available differential cross sections (figure 3)
  - ➢ High differential cross sections ensure good statistics
  - ➢ Excellent signal-to-background ratio
- Differential cross sections as functions of momentum transfer
  - ➢ Independent of beam momentum in first order
- ANKE acceptance (black lines): $-\mathrm{t} = 0.06 - 0.31$ (GeV/c)^2
- Momentum transfer range used for the selection of fast deuterons in the Fd-System (blue lines): $-\mathrm{t} = 0.08 - 0.26$ (GeV/c)^2



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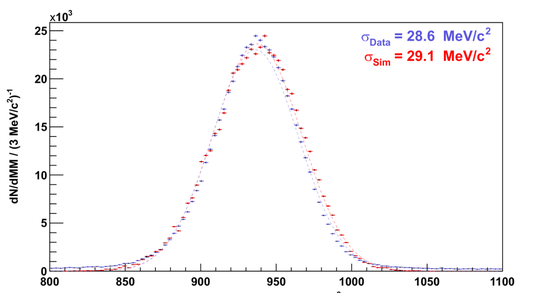

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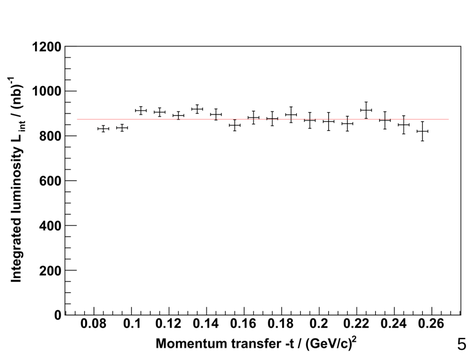
- Identification and quantification via the missing mass technique (figure 4)
- Calculate integrated luminosity for different momentum transfer bins

$$L_{int} = \frac{1024 \cdot N_{det}(\Delta t)}{\int_{t_1}^{t_2} \left(\frac{d\sigma}{dt}(t)\right)_{Ref} dt} \cdot \kappa^{-1} \cdot \epsilon^{-1} \cdot \tau^{-1}$$

- Luminosity should be independent of momentum transfer (figure 5)
- Determination performed for 18 momentum transfer bins for each of the 19 beam momenta of the beam time

➢ Luminositiy determination with high precision:

$\Delta L_{stat} = 1\%$
$\Delta L_{sys} = 6\%$



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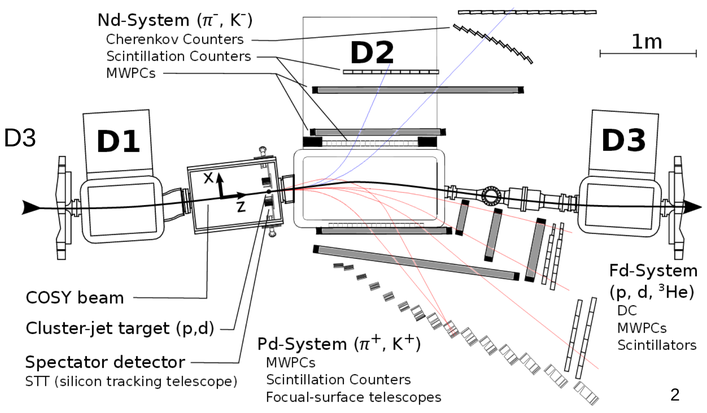
ANKE Detection Setup

- Internal experiment at the **CO**oler **SY**nchrotron in Jülich
- Main components:
  - ➢ Three dipole magnets D1 - D3
  - ➢ Target: E.g. unpolarised hydrogen or deuterium cluster-jet target
  - ➢ Three detection systems (Nd-, Pd- and Fd-System)
- Fd-System used for luminosity determination
  - ➢ Consists of a multiwire drift chamber, two multiwire proportional chambers (track reconstruction) and two layers of scintillation hodoscopes (energy loss measurements)



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[2] S. Barsov, Nuclear Instruments and Methods in Physics Research A 462 (2001) 364-381

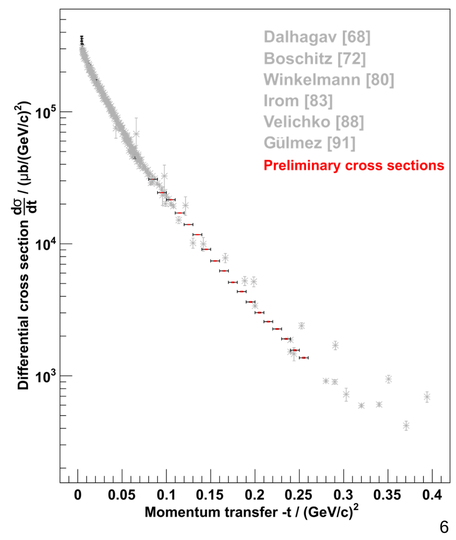
Differential Cross Sections

- Reference data base at higher momentum transfers (≥ 0.12 (GeV/c)^2)
  - ➢ Limited number of data points
  - ➢ Discrepancies between some data sets

Idea: Provide new data set of differential cross sections

- Compare relative normalization of L_{int} with results from the reactions $d + p \rightarrow p_{sp} + X$
  - ➢ Good understanding of the point-to-point systematics
    - ➢ Possible: Determination of differential cross sections using the identified events from the luminosity determination
- Method:
  - ➢ Fitting reference cross sections from 0.05 (GeV/c)^2 to 0.09 (GeV/c)^2
  - ➢ Lowest momentum transfer bin: Scale number of events to the differential cross section
  - ➢ Scaling factor can be used for subsequent bins
  - ➢ Will be done for each beam momentum
- Good understanding of the systematics
  - ➢ Determination of an average value of $d\sigma/dt$ for each momentum transfer bin (figure 6)
- Estimated precision:

$\Delta \sigma_{stat} \approx 1\% - 2\%$
$\Delta \sigma_{sys} \approx 2\% - 3\%$



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Summary & Outlook

- Luminosities were determined via dp-elastic scattering with high precision
  - ➢ Luminosities were used already to determine differential and double differential cross sections for the reaction $d + p \rightarrow {}^3\mathrm{He} + \pi^+ + \pi^-$ [7]
- Differential cross sections for the dp-elastic scattering could be extracted
- Independent methods to evaluate the integrated luminosities will allow to extract high precision data on e. g. the $d + p \rightarrow {}^3\mathrm{He}\ \eta$ excitation function

[7] M. Mielke et al., European Journal of Physics J. A50 (2014) 102

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