Luminosity Determination at ANKE with Different Reference Reactions

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Motivation

η meson production	Study of the ABC-effect
$d + p \rightarrow {}^3He + \eta$	$d + p \rightarrow {}^3He + \pi^+ + \pi^-$

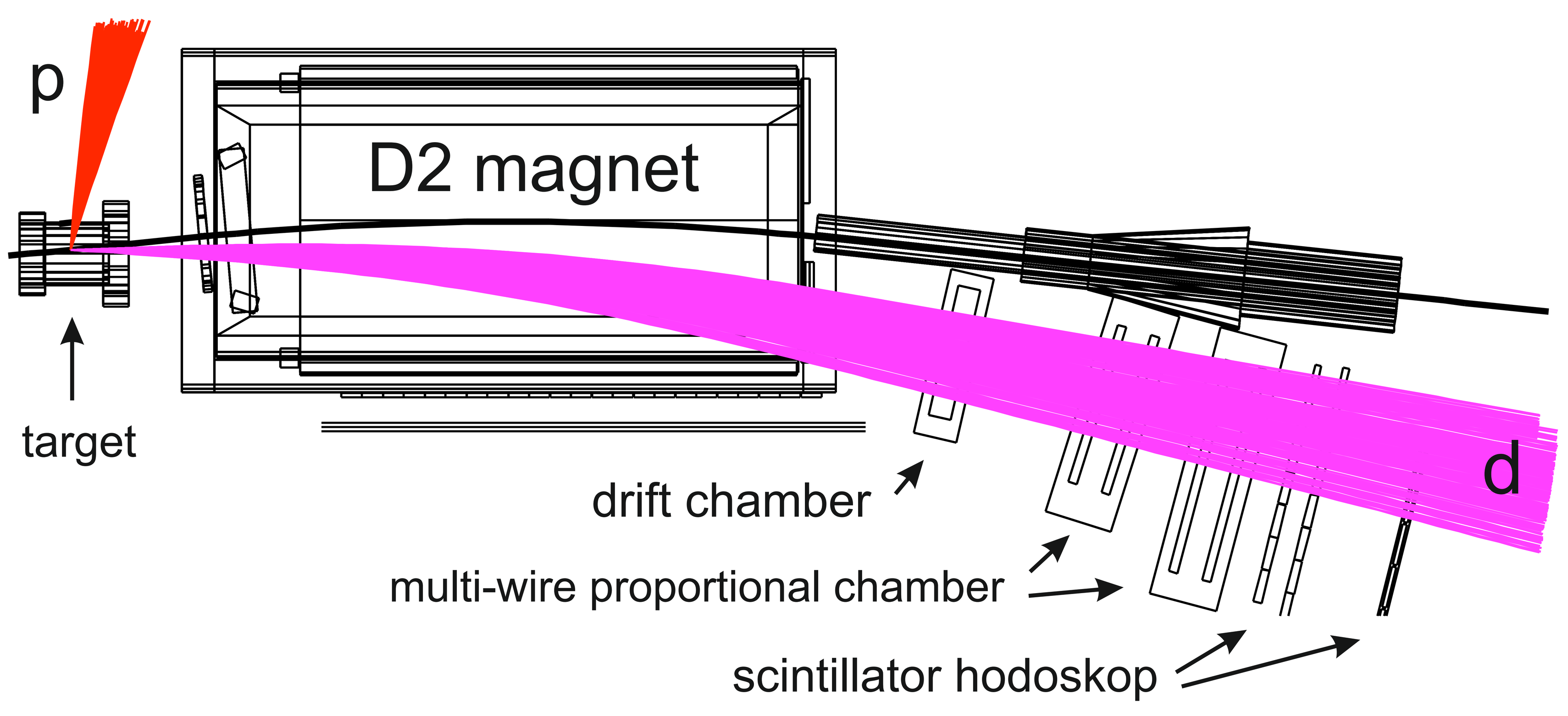
- Data obtained at ANKE allow for studies on total and differential cross sections for these reactions at 16 excess energies

$\Rightarrow$ A careful luminosity determination is required

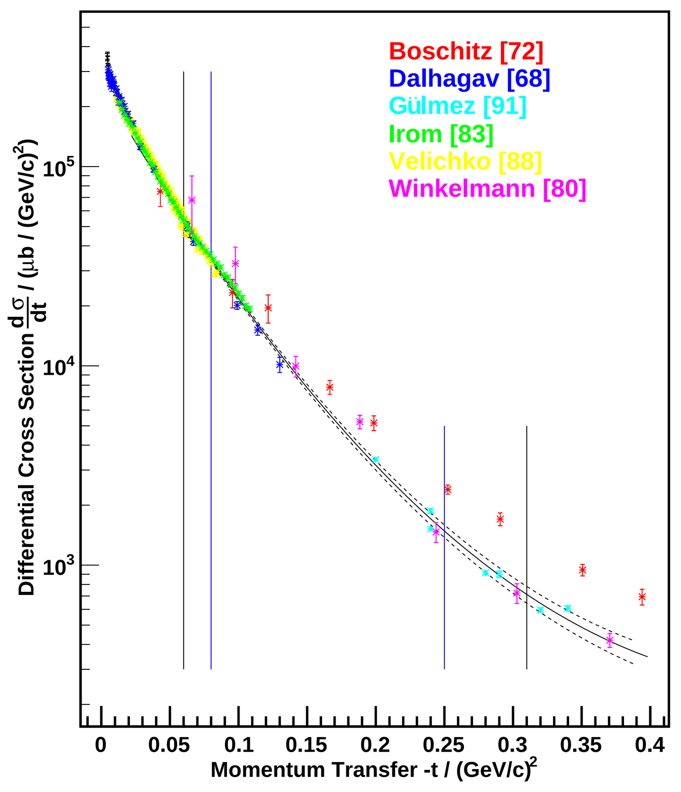
- The luminosity L of an accelerator is the ratio of the event rate N and the cross section σ
- A commonly used reference reaction is dp-elastic scattering
- Additional normalization channel: $d + p \rightarrow {}^3He + \pi^0$

Experimental setup

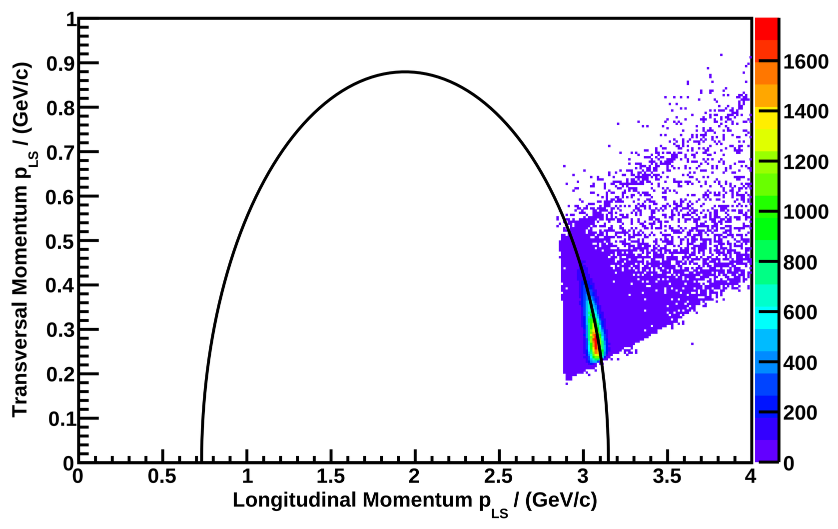
- Magnetic spectrometer with Cluster-Jet-Target

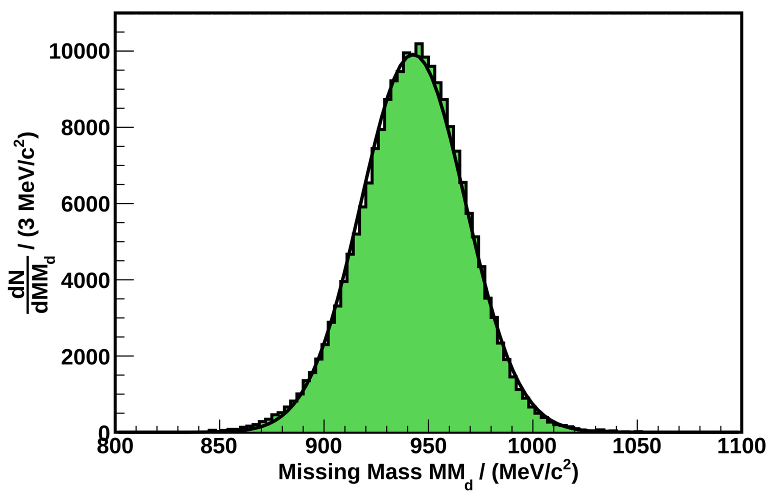


Luminosity determination: dp-elastic scattering



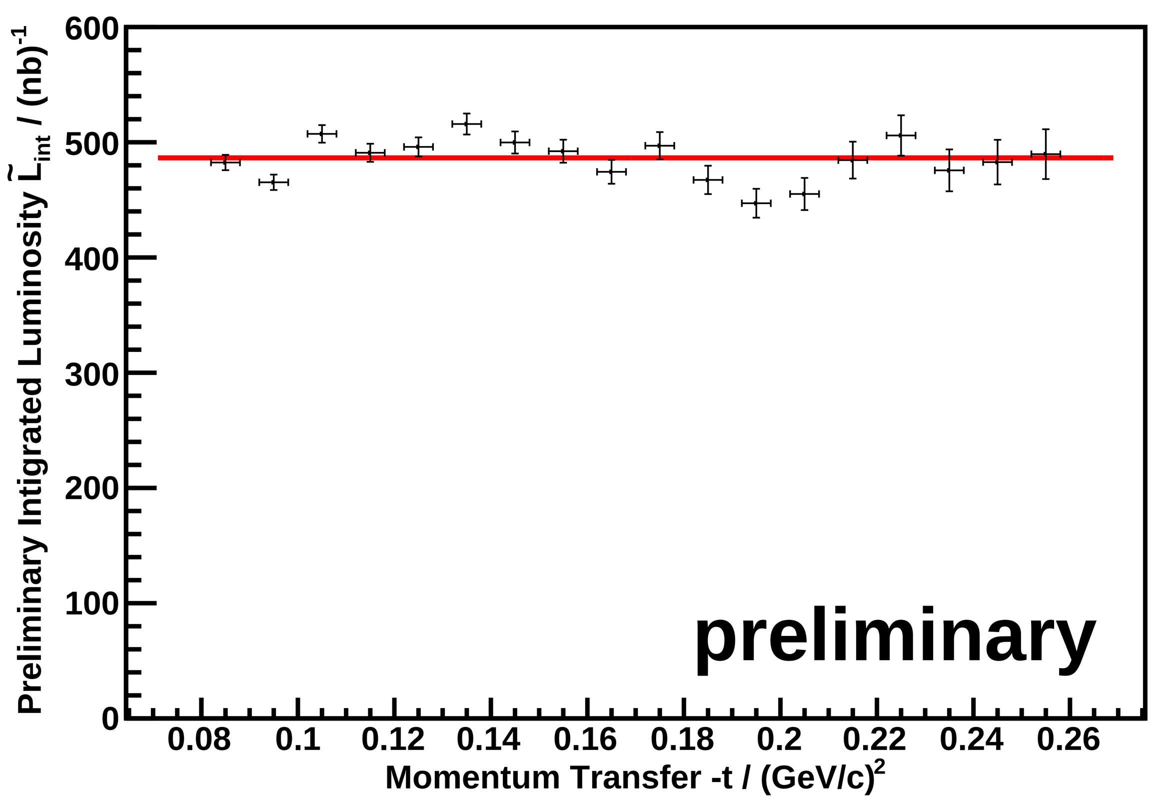
- Why dp-elastic scattering?
  - $\Rightarrow$ Wide base of available differential cross sections
  - $\Rightarrow$ High differential cross sections ensure good statistics
  - $\Rightarrow$ Excellent signal-to-noise ratio
- Differential cross sections as functions of momentum transfer
  - $\Rightarrow$ independent of beam momentum
- Selection of fast deuterons (low momentum transfer) via momentum cut
- Identification and quantification via the missing mass technique





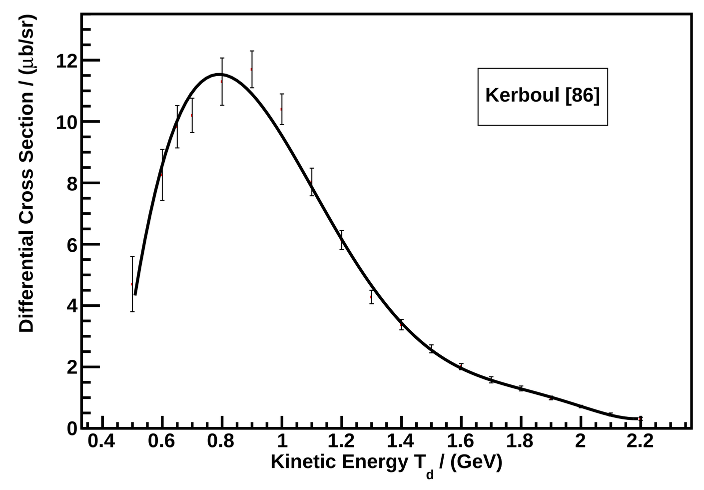
Use counts to calculate integrated luminosity vs. momentum transfer

$$\tilde{L}_{int} = \frac{1024 \cdot \Delta t}{4p_f^2 \cdot \int (\frac{d\sigma}{dt}(t))_{ref} dt} \cdot \epsilon_{akz} \cdot N_{detected}^{\Delta t}$$

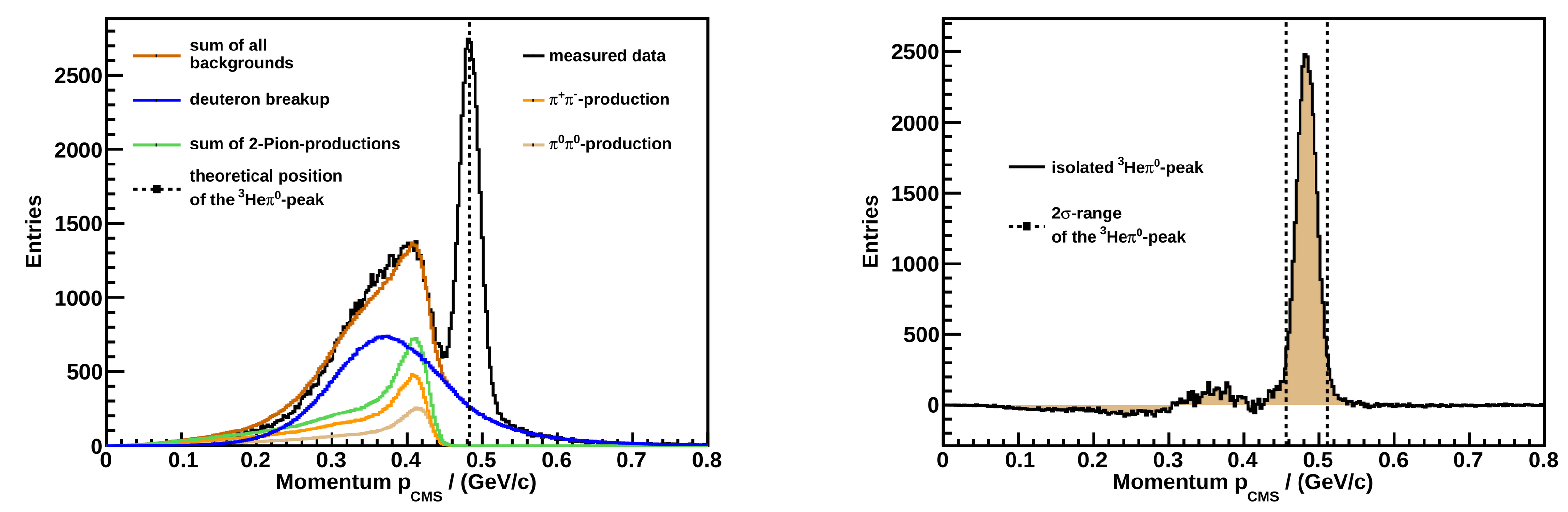


Beam momentum / (MeV/c)	Preliminary integrated luminosity / $(nb)^{-1}$
3120.17	$945.0 \pm 4.1 \pm 141.6$
3146.41	$481.3 \pm 2.4 \pm 72.2$
3148.45	$486.5 \pm 2.4 \pm 73.0$
3152.45	$470.2 \pm 2.4 \pm 70.6$
3158.71	$473.8 \pm 2.4 \pm 71.1$
3168.05	$479.8 \pm 2.4 \pm 72.0$
3177.51	$438.1 \pm 2.2 \pm 65.7$

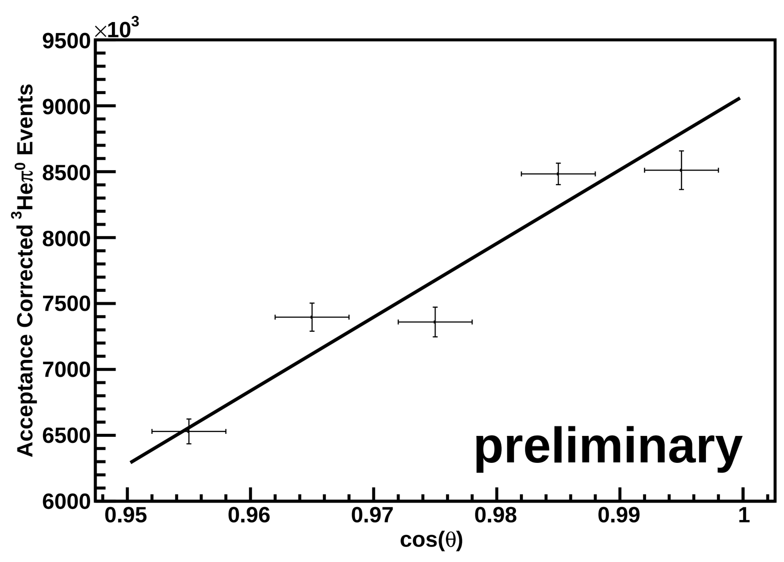
Second determination: The dp $\rightarrow {}^3$He π^0 final state



- Additional independent normalization channel
- Differential cross sections available for $\cos\theta = 1$
- Extrapolate differential cross section for used beam energies
- Quantitative signal analysis
  - $\Rightarrow$ Describe background via simulations
- Counting the events of the isolated ^{3}He π^0-peak for different $\cos\theta$-bins



- ^{3}He π^0 events for each $\cos\theta$-bin correlate with differential cross sections in this bin



Use counts and extrapolated $\frac{d\sigma}{d\Omega}(\Delta(\cos\theta))$ to calculate integrated luminosity vs. $\cos\theta$

$$\tilde{L}_{int} = \frac{1}{2\pi\Delta(\cos\theta)} \cdot \frac{N(\Delta(\cos\theta))}{\frac{d\sigma}{d\Omega}(\Delta(\cos\theta))}$$

Conclusions and Outlook

- Luminosity determination: dp-elastic scattering
  - $\Rightarrow$ dp-elastic scattering is routinely used for determination of the integrated luminosity
  - $\Rightarrow$ Determined integrated luminosities for the first half of obtained beam momenta show consistent results
- Second determination: The dp $\rightarrow {}^3$He π^0 final state
  - $\Rightarrow$ Concept for a new normalization method for ANKE is developed
  - $\Rightarrow$ Very promising results for forward scattered ^{3}He nuclei
  - $\Rightarrow$ Data in the backward hemisphere will be analysed soon and allow for a third way of normalization

Independent methods to evaluate the integrated luminosities will allow to extract high precision data on e. g. the dp $\rightarrow {}^3$He η excitation function