Polarisationstransferobservablen aus inelastischer Streuung polarisierter Protonen unter 0° *

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RCNP

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Outline

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- Motivation
- Theoretical principles
- Experimental setup at RCNP in Osaka, Japan
- Results
- Outlook

New experimental tool: $(\vec{p}, \vec{p}')$ at 0°

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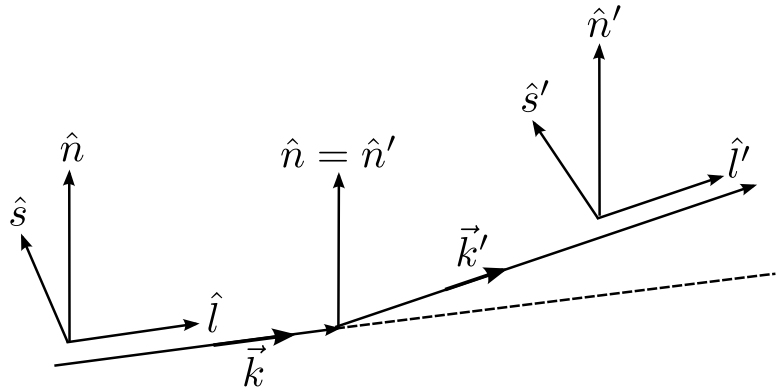
- What can be learned?
  - at 0° selectivity to transitions with low ΔL
  - E1 mediated by Coulomb excitation
  - spin-M1 by the spin-isospin-term of the proton-nucleus interaction
- consistent measurement below and above the particle separation threshold
- high energy resolution ($\Delta E/E \approx 8 \cdot 10^{-5}$)
- two independent methods for the separation of E1 and spin-M1 contributions to the cross section
  - Multipole decomposition analysis of the angular distributions
  - Polarization transfer observables

Theoretical principles - Polarization transfer observables



Total spin transfer

$$\Sigma = \frac{3 - (D_{nn'} + D_{ss'} + D_{ll'})}{4}$$

at 0°: $D_{ss} = D_{nn}$

$$\Sigma = \frac{3 - (2D_{ss} + D_{ll})}{4} = \begin{cases} 1 \text{ spinflip} \\ 0 \text{ non-spinflip} \end{cases}$$

Determination of the contributions to the cross section:

$$\frac{d\sigma}{d\Omega}(\Delta S = 1) \equiv \Sigma \left(\frac{d\sigma}{d\Omega}\right) \quad \rightarrow \text{spin} - \text{M1 excitation}$$

$$\frac{d\sigma}{d\Omega}(\Delta S = 0) \equiv (1 - \Sigma) \left(\frac{d\sigma}{d\Omega}\right) \quad \rightarrow \text{E1 excitation}$$

T. Suzuki, Prog. Theor. Phys. 321, 859 (2000)

Measurement of polarization transfer observables

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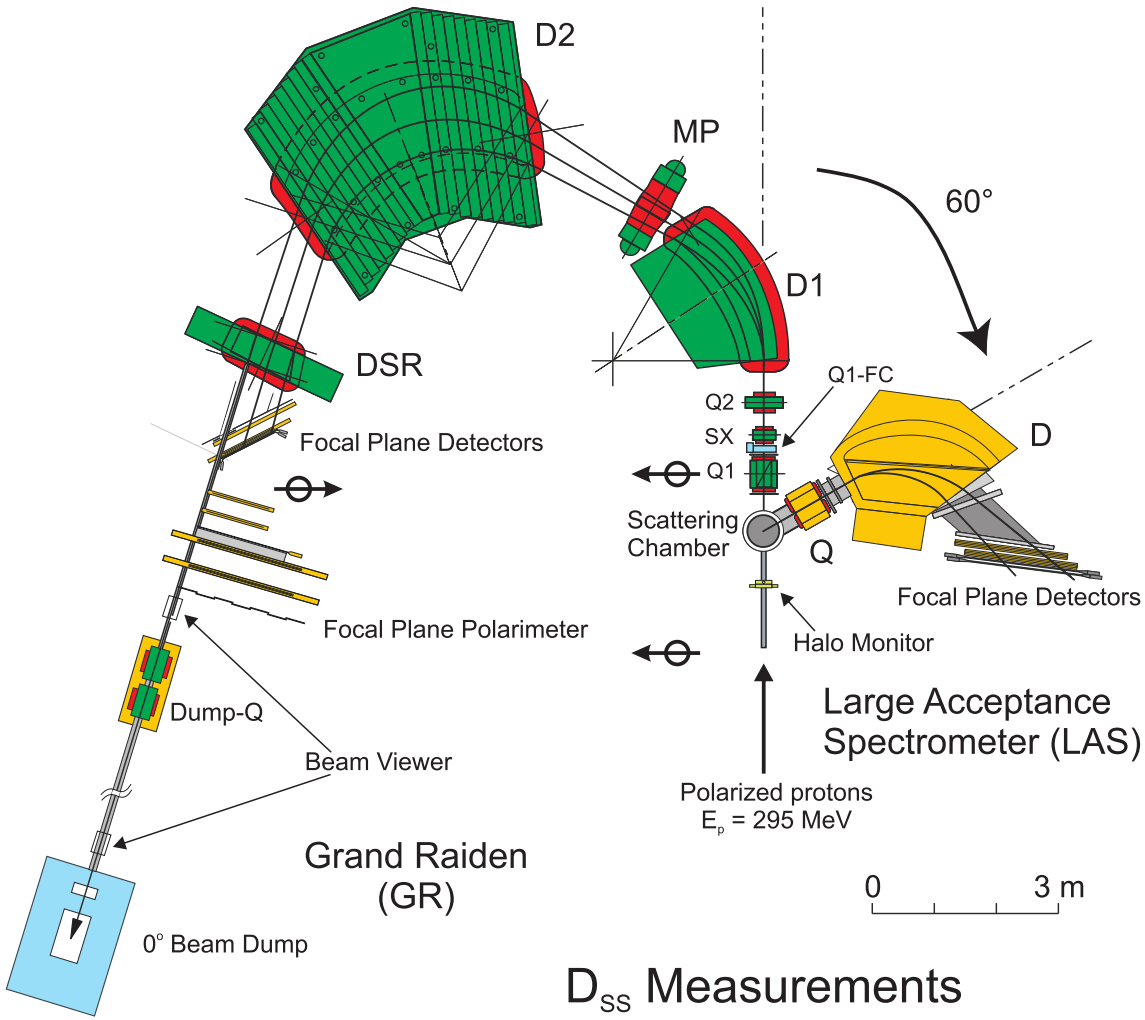
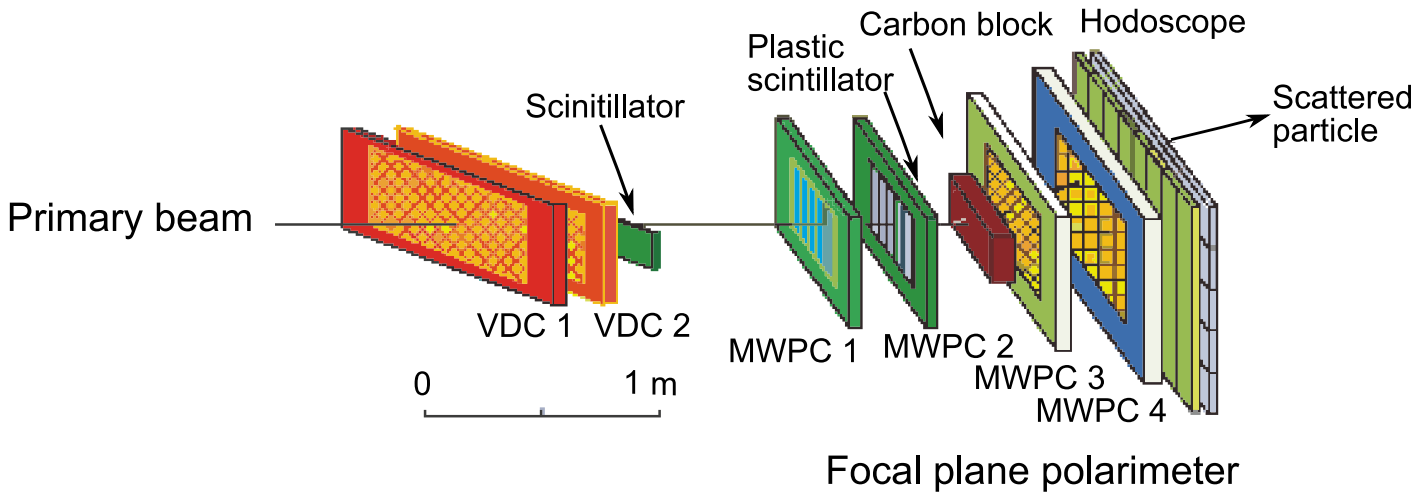
Experimental setup at RCNP



D_{SS} Measurements

- $I_p = 1 - 5\,\mathrm{nA}$
- polarization: 70 %

Grand Raiden - detector system



- Focal plane detectors:

  Measurement of crossing points x_{fp}, y_{fp} and scattering angles θ_{fp}, ϕ_{fp}

- Focal plane polarimeter:

  Measurement of sidewards polarization p_S'' after second scattering process in carbon block

Determination of polarization transfer observables

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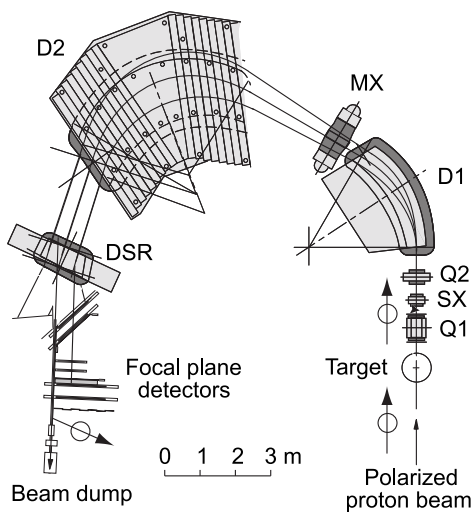
- sidewards polarization after second scattering process:

$$p_S''^t = \cos(\theta_p) D_{SS} p_S + \sin(\theta_p) D_{LL} p_L ,$$
$$p_S''^b = \cos(\theta_p) p_S + \sin(\theta_p) p_L$$

- θ_p: precession angle in Grand Raiden spectrometer
- p_S, p_L: sidewards, longitudinal beam polarization
- assumption for background events: no contribution to depolarization $D_{SS} = D_{LL} = 1$



Extraction of polarization transfer observables - Comparison of methods

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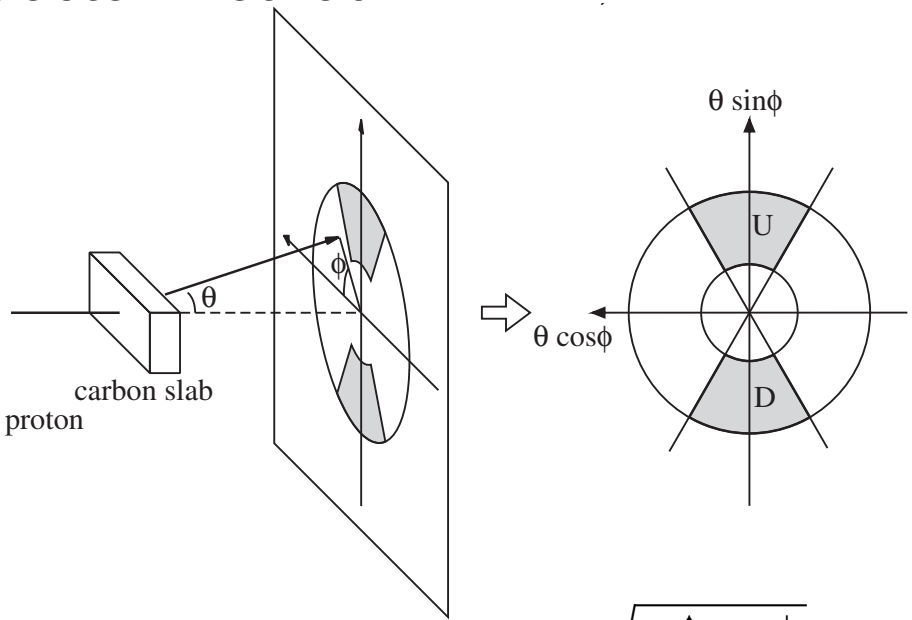
Sector method



$$p''_S = \frac{1}{\langle A_y \rangle^{fpp}} \frac{1-\alpha}{1+\alpha} \text{ mit } \alpha = \sqrt{\frac{N_U^{\uparrow} \cdot N_D^{\downarrow}}{N_D^{\uparrow} \cdot N_U^{\downarrow}}}$$

- selection of angle range
- easiest evaluation method
  A. Tamii, Ph.D. thesis, Kyoto University, Japan (1999)

Estimator method

$$\frac{\varepsilon_S^t}{\varepsilon_S^b} \text{ mit } \varepsilon_S^t = -p_S''^t \langle A_y \rangle^{fpp}$$

$$\text{und } \varepsilon_S^b = -p_S''^b \langle A_y \rangle^{fpp}$$

- calculation of statistical uncertainty from covariant matrix $V(\hat{\varepsilon})$
- close to the maximum use of the data

Besset et al., Nucl. Instr. Meth. 166, 515 (1979)

Test case - $^{12}\mathbf{C}(\vec{p}, \vec{p}')$ at 0°

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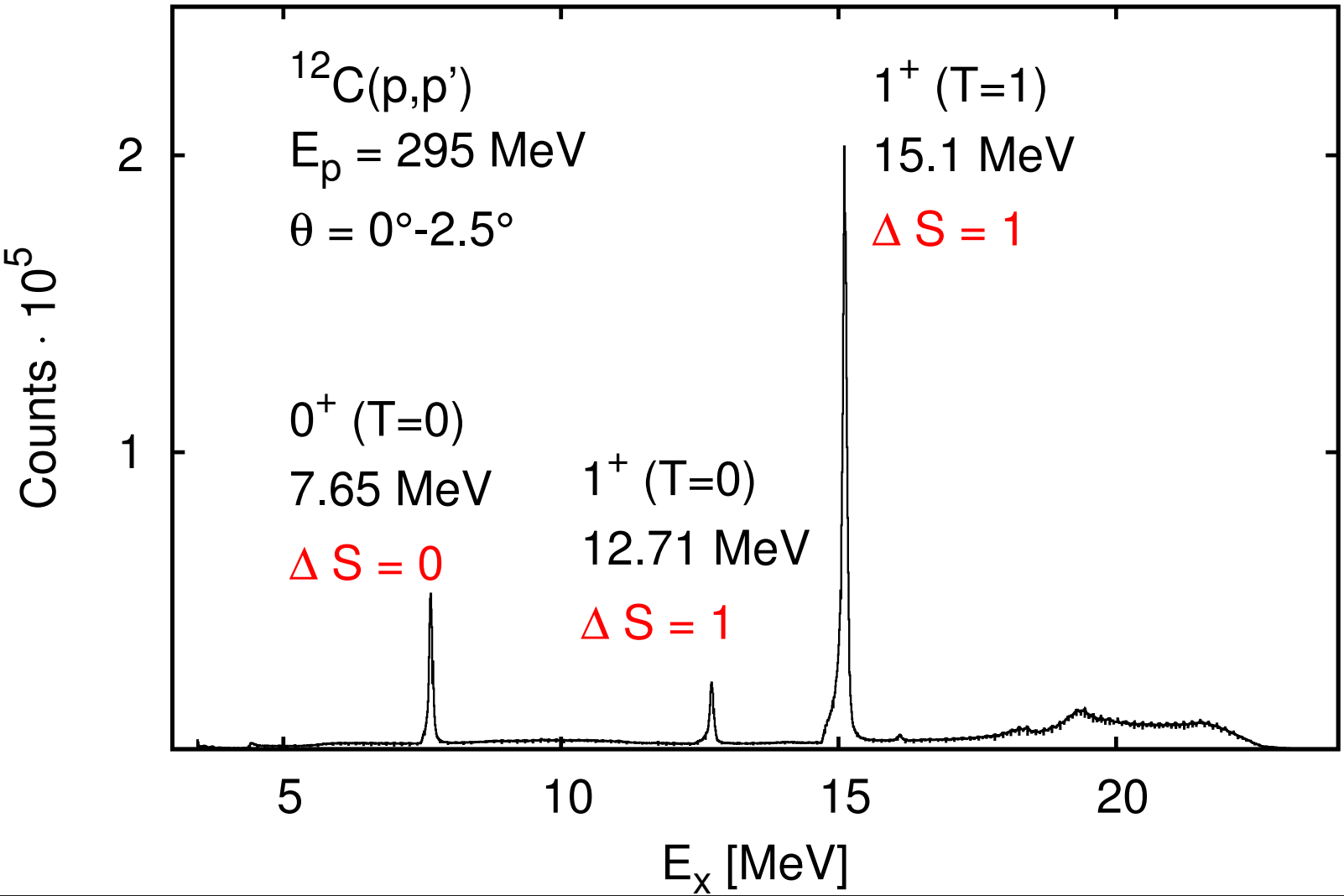

Polarization transfer observables - $^{12}\mathbf{C}(\vec{p}, \vec{p}')$ at 0°

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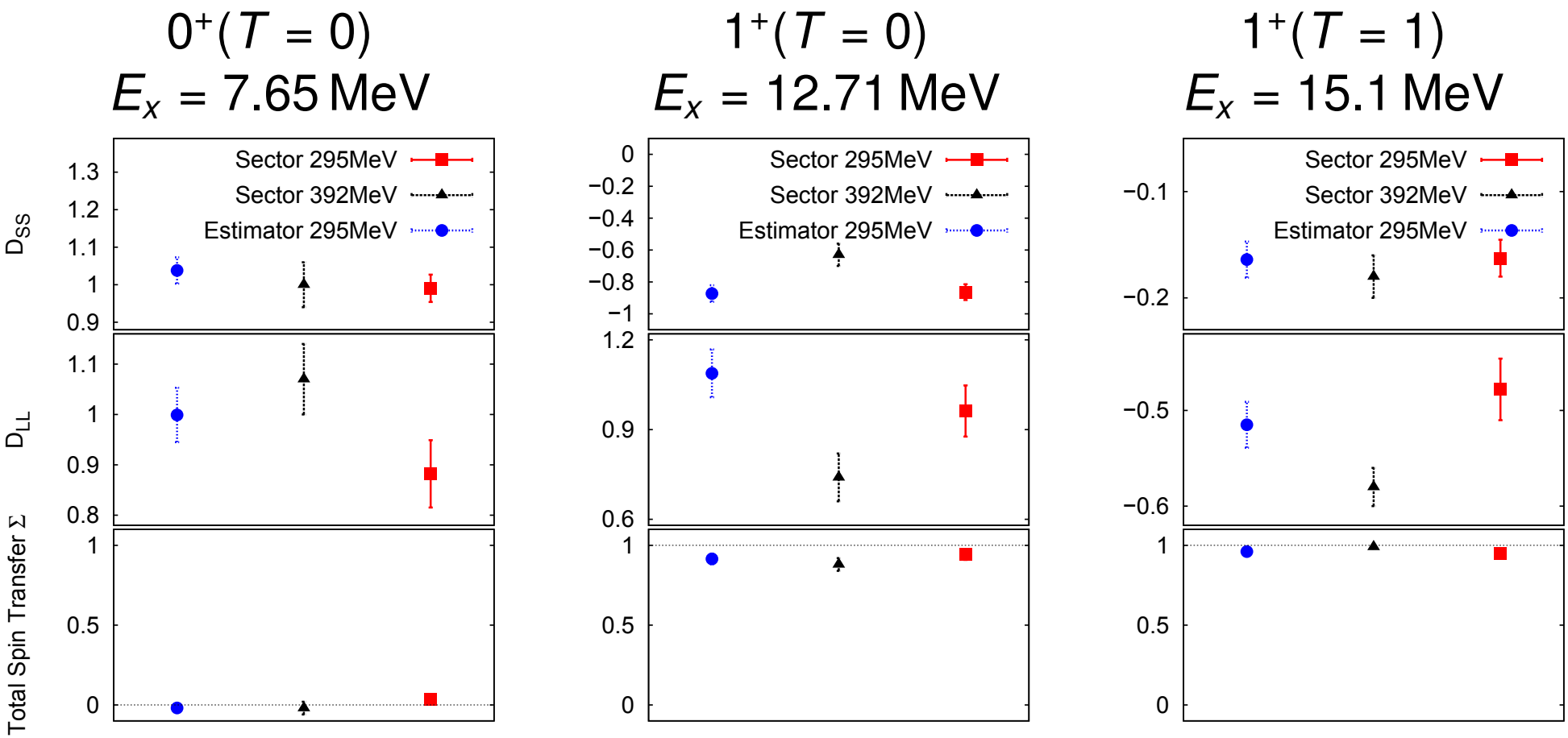

A. Tamii et al., Phys. Lett. B 459, 61 (1999)

Reference case - $^{208}\mathbf{Pb}(\vec{p}, \vec{p}')$ at 0°

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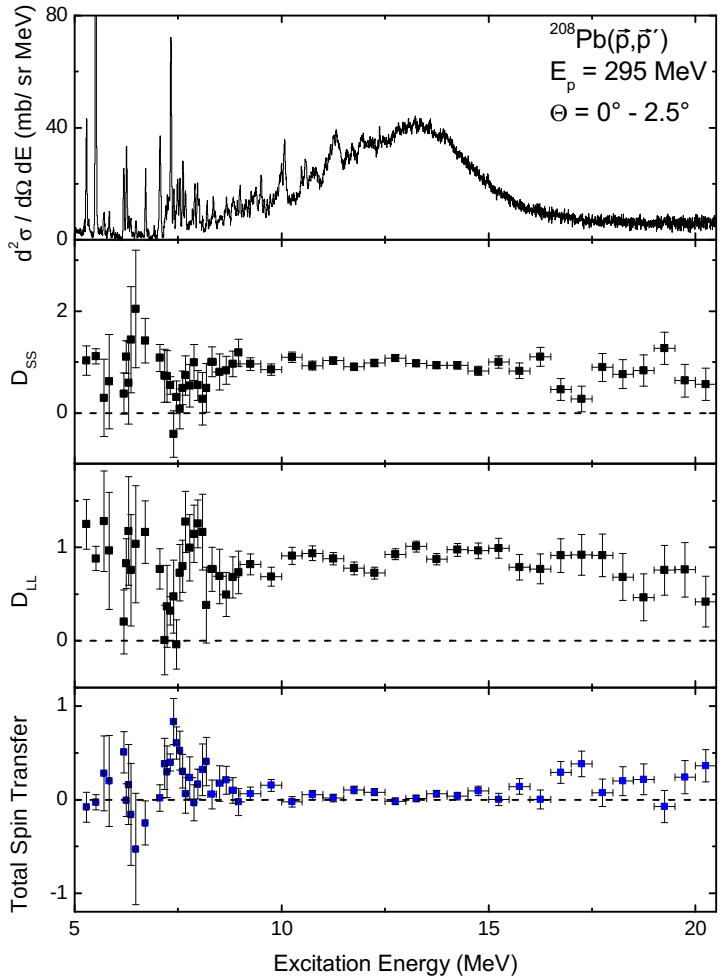
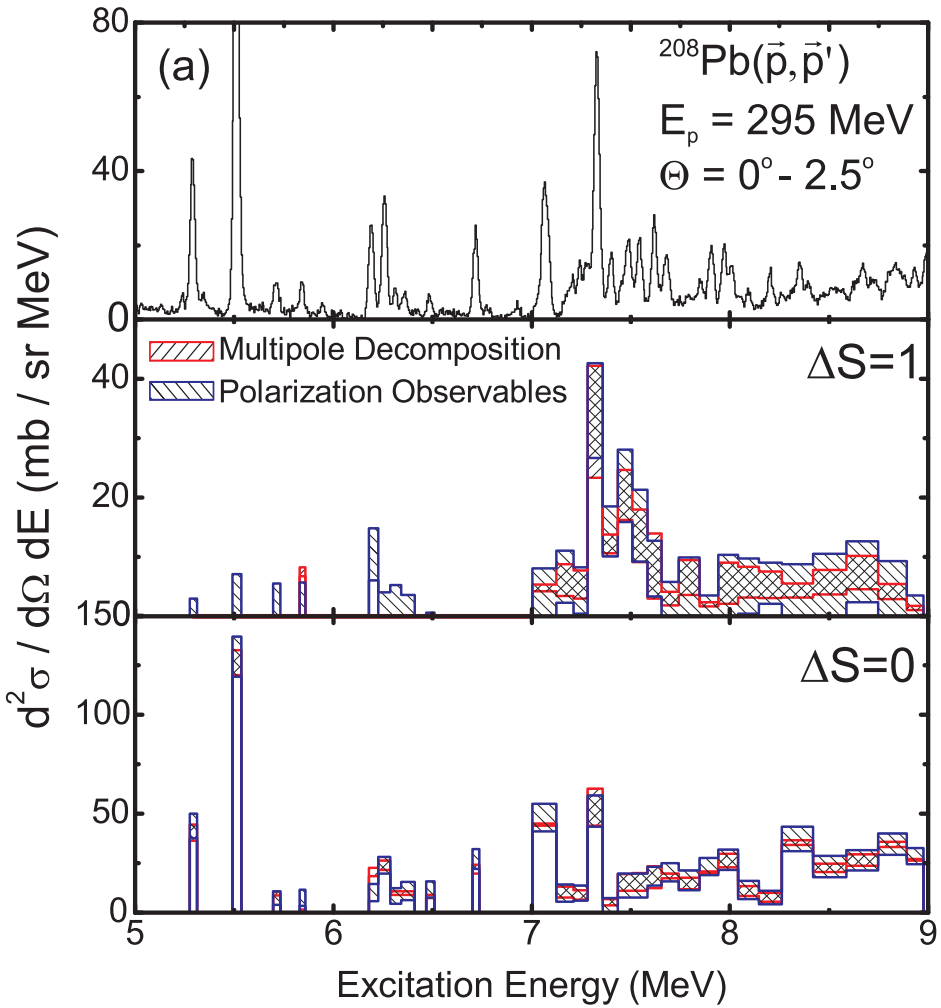
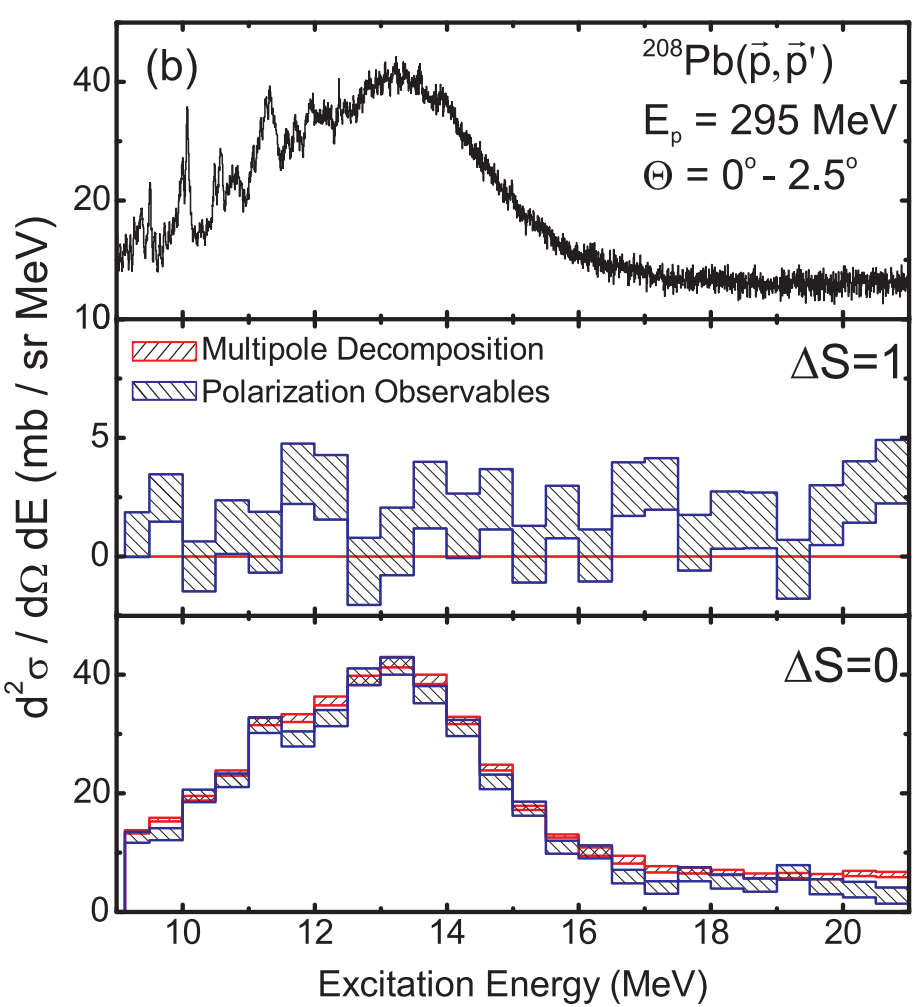


A. Tamii et al., Phys. Rev. Lett. 107, 062502 (2011)

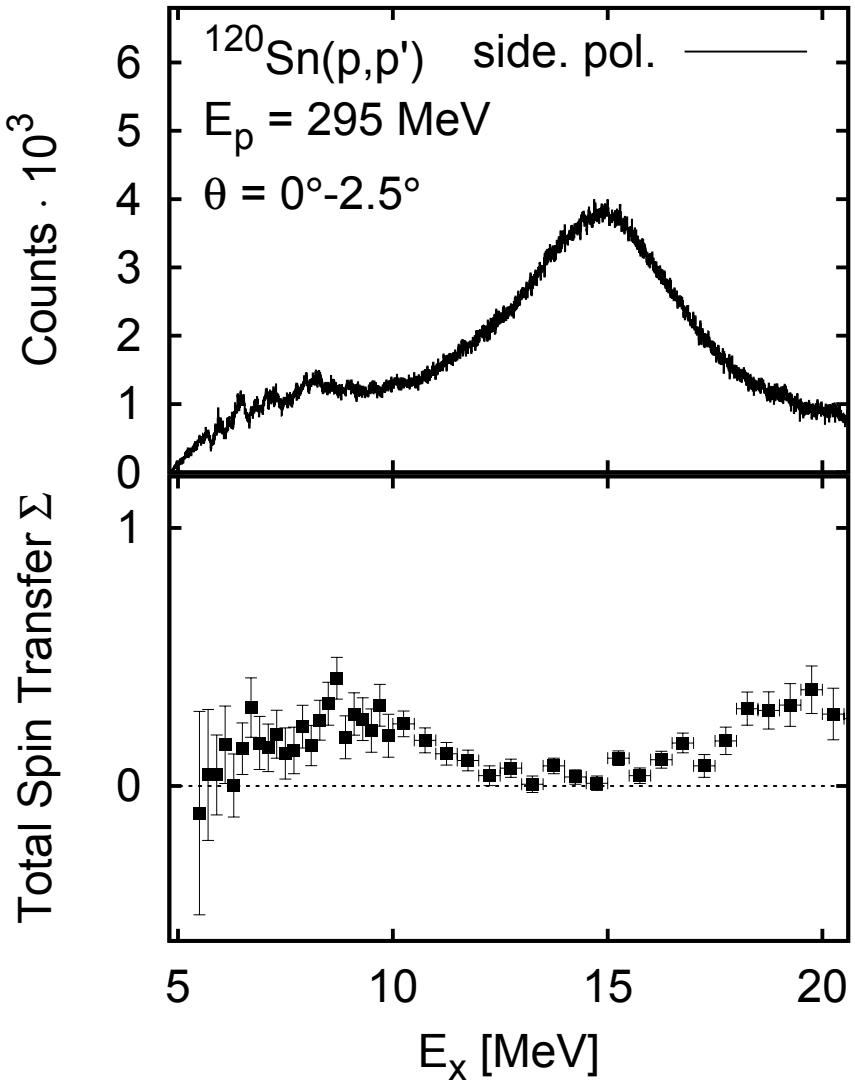
Comparison of methods





I. Poltoratska, Doctoral thesis, TU Darmstadt, (2011)

Polarization transfer observables - ^{120}Sn($\vec{p}, \vec{p}'$) at 0°



^{120}**Sn**$(\vec{p}, \vec{p}')$ **at** 0°

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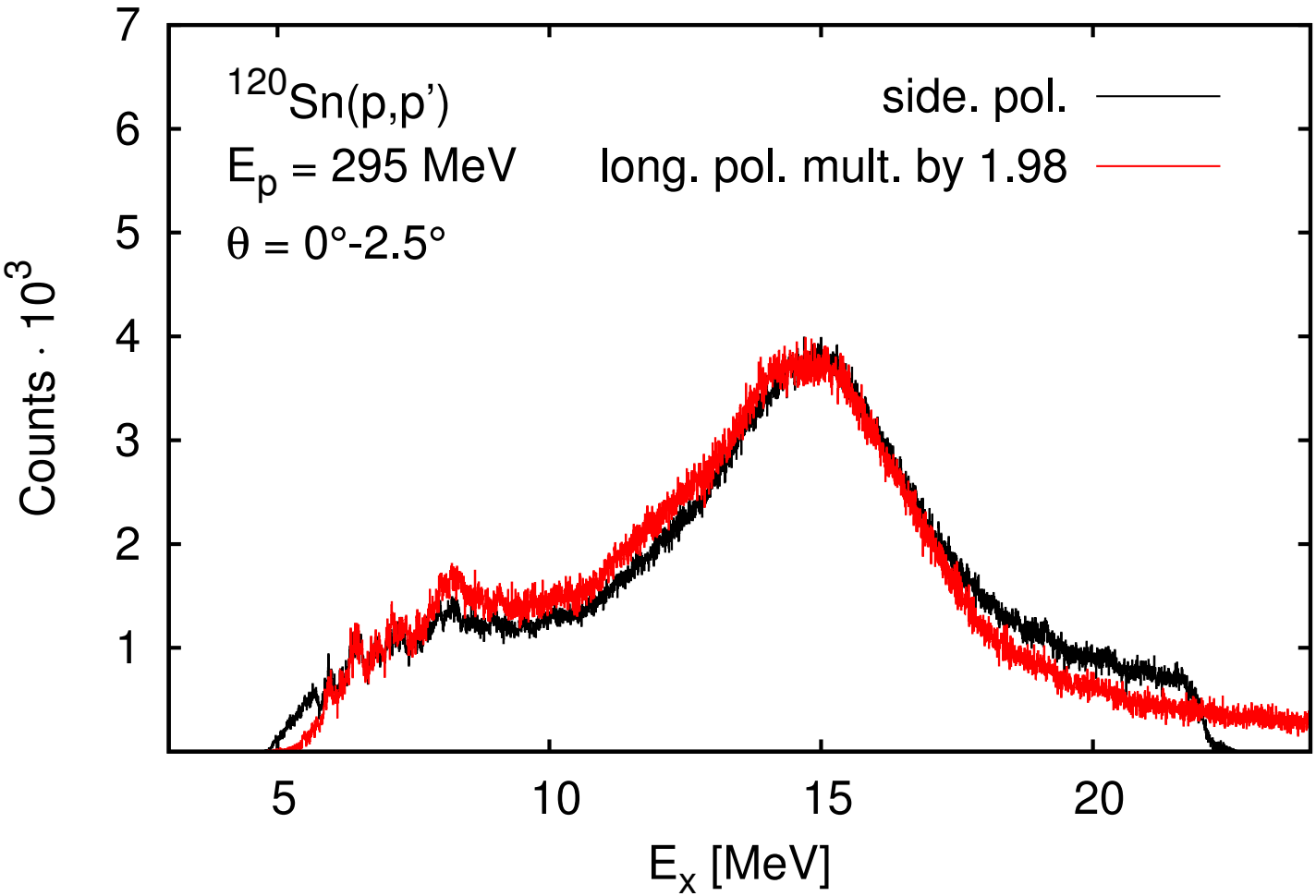

background subtraction? → A. M. Krumbholz HK 13.5

Summary & Outlook

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- Polarized intermediate energy proton scattering at 0°: spinflip / non-spinflip cross section separation with polarization transfer observables
- completion of analysis for ^{120}Sn
- application to ^{154}Sm $\rightarrow$ A. Krugmann HK 6.5

Thank you for your attention!

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