

Investigation of the $^{15}\text{N}(p,n)$ Reaction for Use as a Neutron Source in Scattering Experiments

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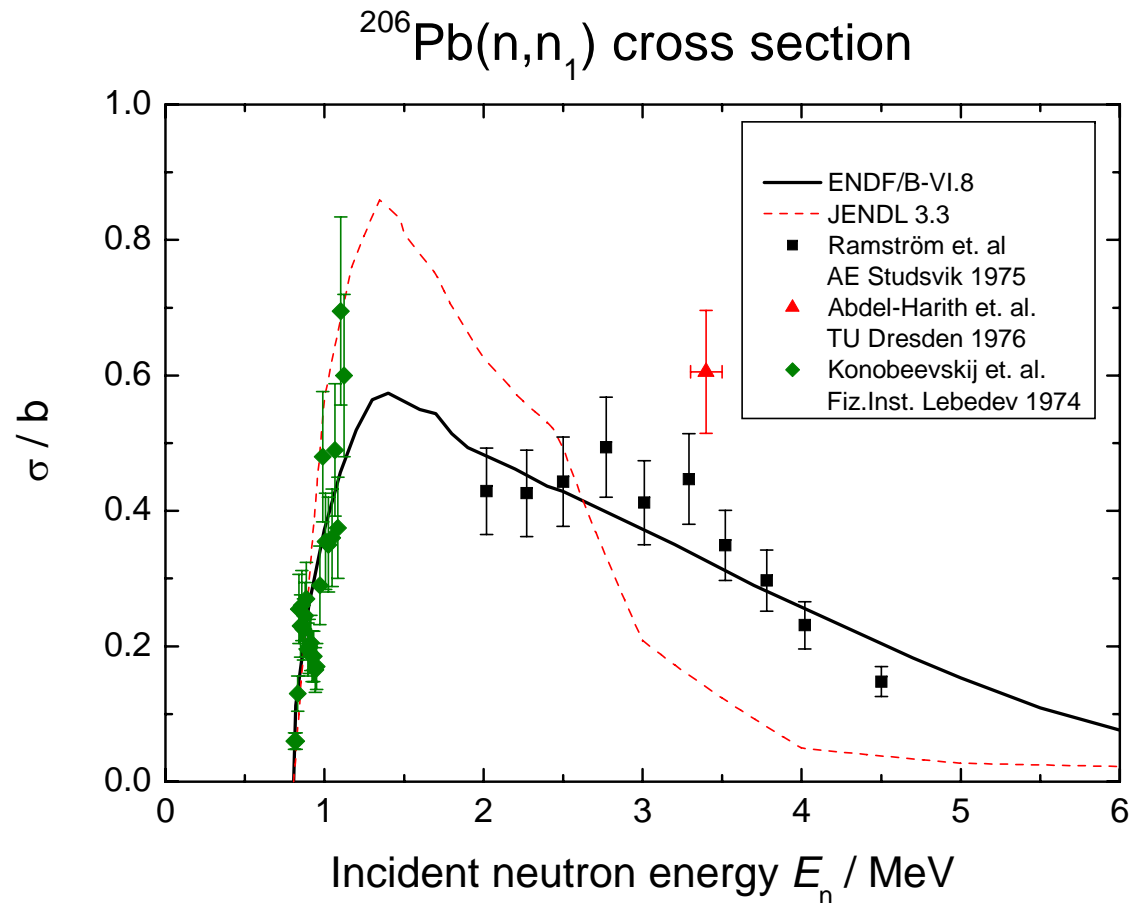
Embid et. al.: Sensitivity Analysis for ADS with Th+TRU fuel and liquid lead coolant and spallation source:

k_{eff} dependence on the cross section database

Material / database	k_{eff}
All JENDL 3.2	0.9444
All JENDL 3.2 except Pb (ENDF/B-VI)	0.9677

Important impact of k_{eff} on accelerator requirements !

Discrepancies in inelastic scattering cross sections



⇒ More and better experimental cross section data required!

PTB TOF Spectrometer

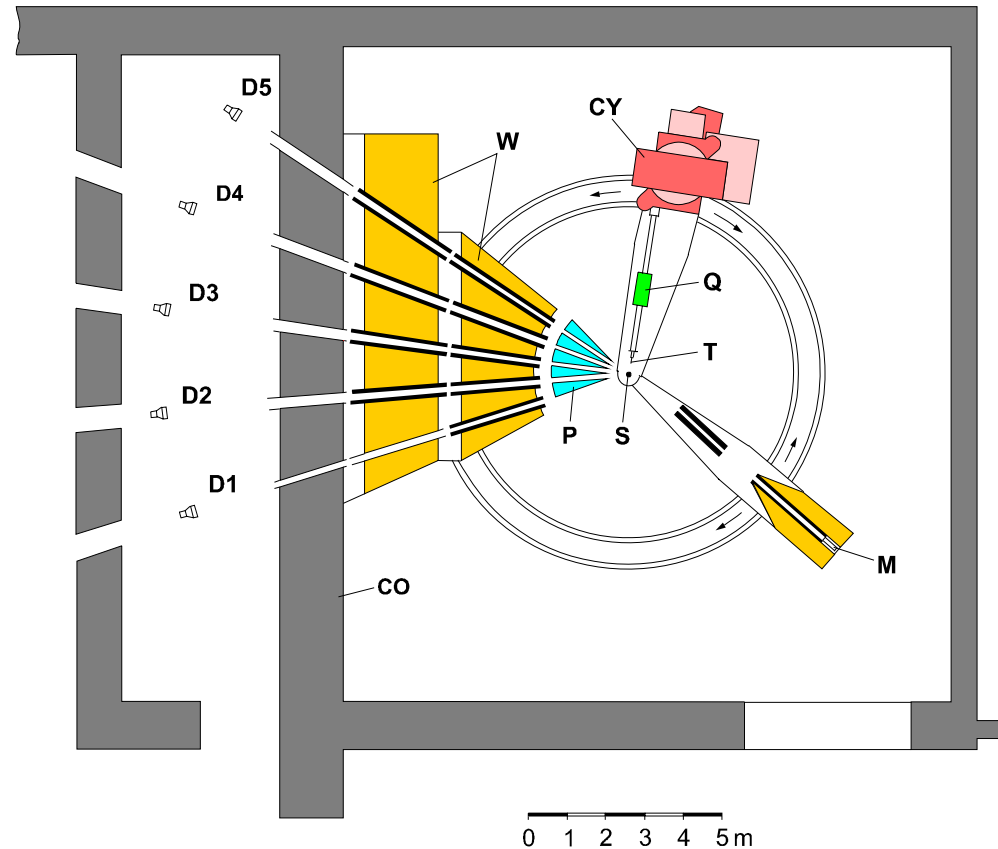
Detectors:

NE213 liquid scintillation detectors

D1: $\text{\O} 4'' \times 1''$

D2 – D5: $\text{\O} 10'' \times 2''$

Flight path: 12 m



Projectile energies:

d 3 MeV – 13 MeV

p 2 MeV – 19 MeV

Reaction:

$D(d,n)$, $Q = +3.27$ MeV

$^{15}\text{N}(p,n)$, $Q = -3.54$ MeV

Energy range:

6 MeV – 15 MeV

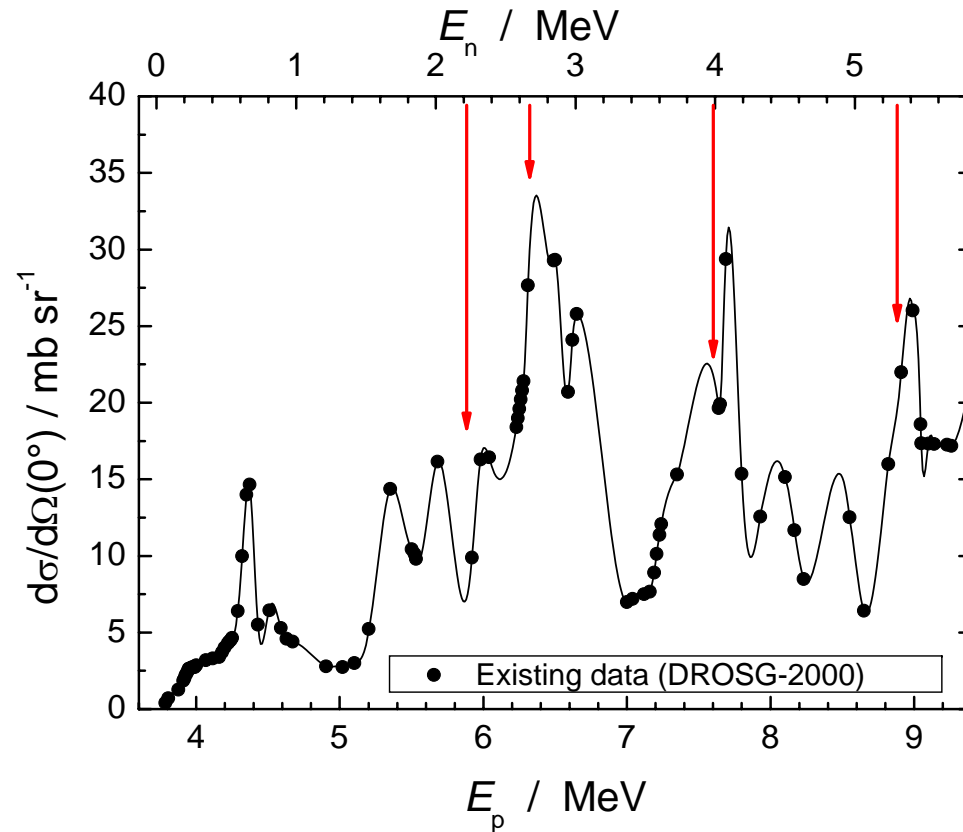
The $^{15}\text{N}(p,n)^{15}\text{O}$ Reaction

Advantages:

- stable
- monoenergetic neutrons
 $E_n \leq 5.7$ MeV
- gas target allows background subtraction (gas-in/gas-out)

Disadvantages:

- cross section has strong resonance structure
- high energy loss
 $S = -dE/dx$



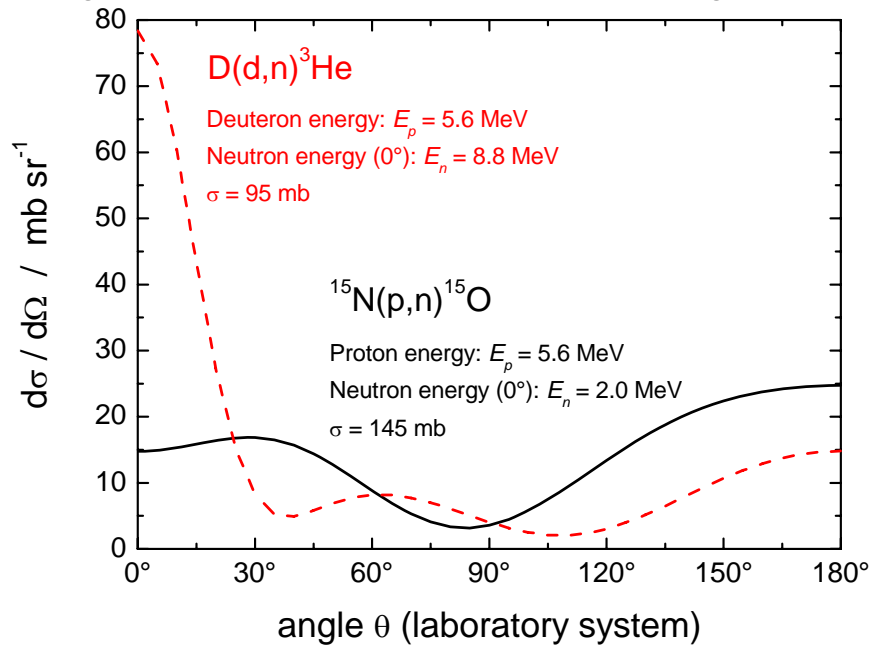
Which energies suited for scattering experiments?

Optimum gas pressure? Neutron yield vs. energy resolution!

Improvement of $^{15}\text{N}(p,n)$ cross section data?

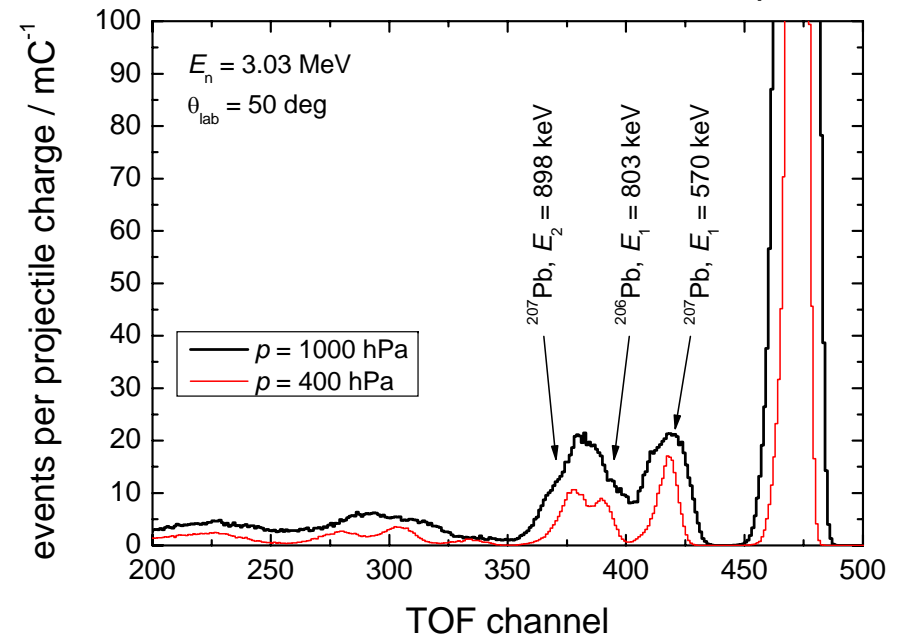
The $^{15}\text{N}(p,n)$ Reaction

Angular distributions of neutron producing reactions



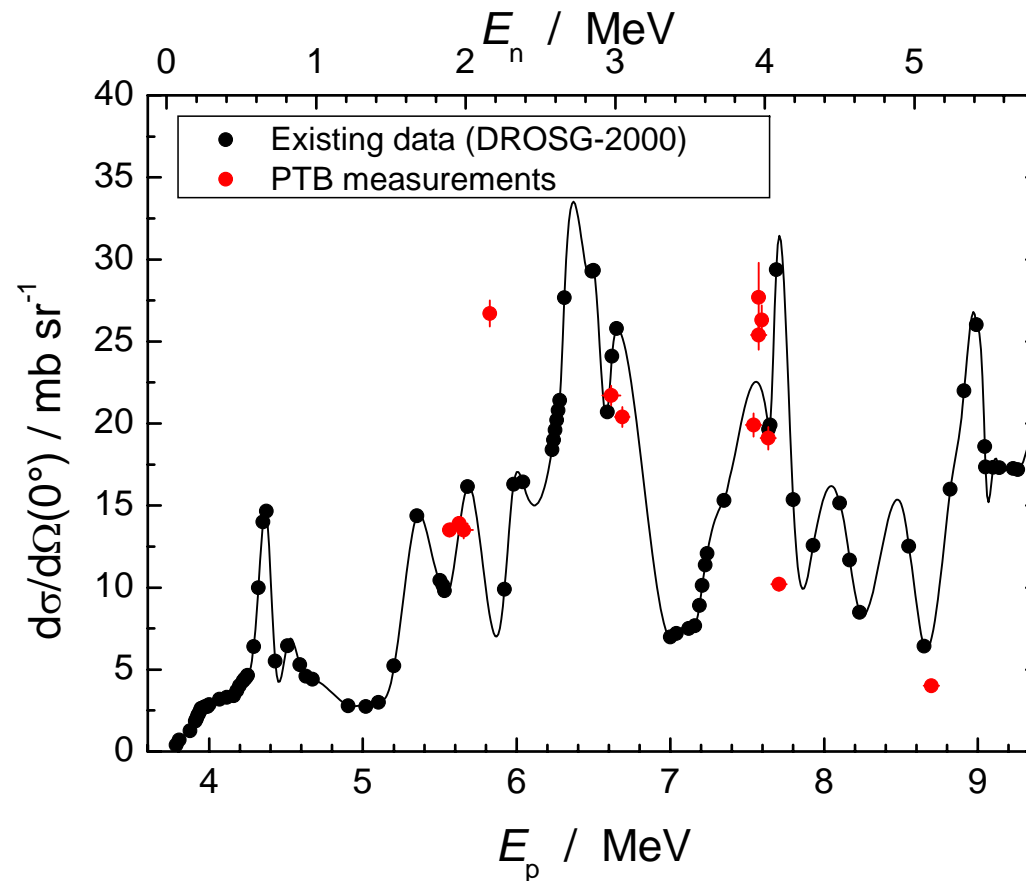
⇒ Experiments meaningful only at selected energies

STREUER calculations, ^{nat}Pb sample



⇒ Compromise between neutron yield and energy resolution

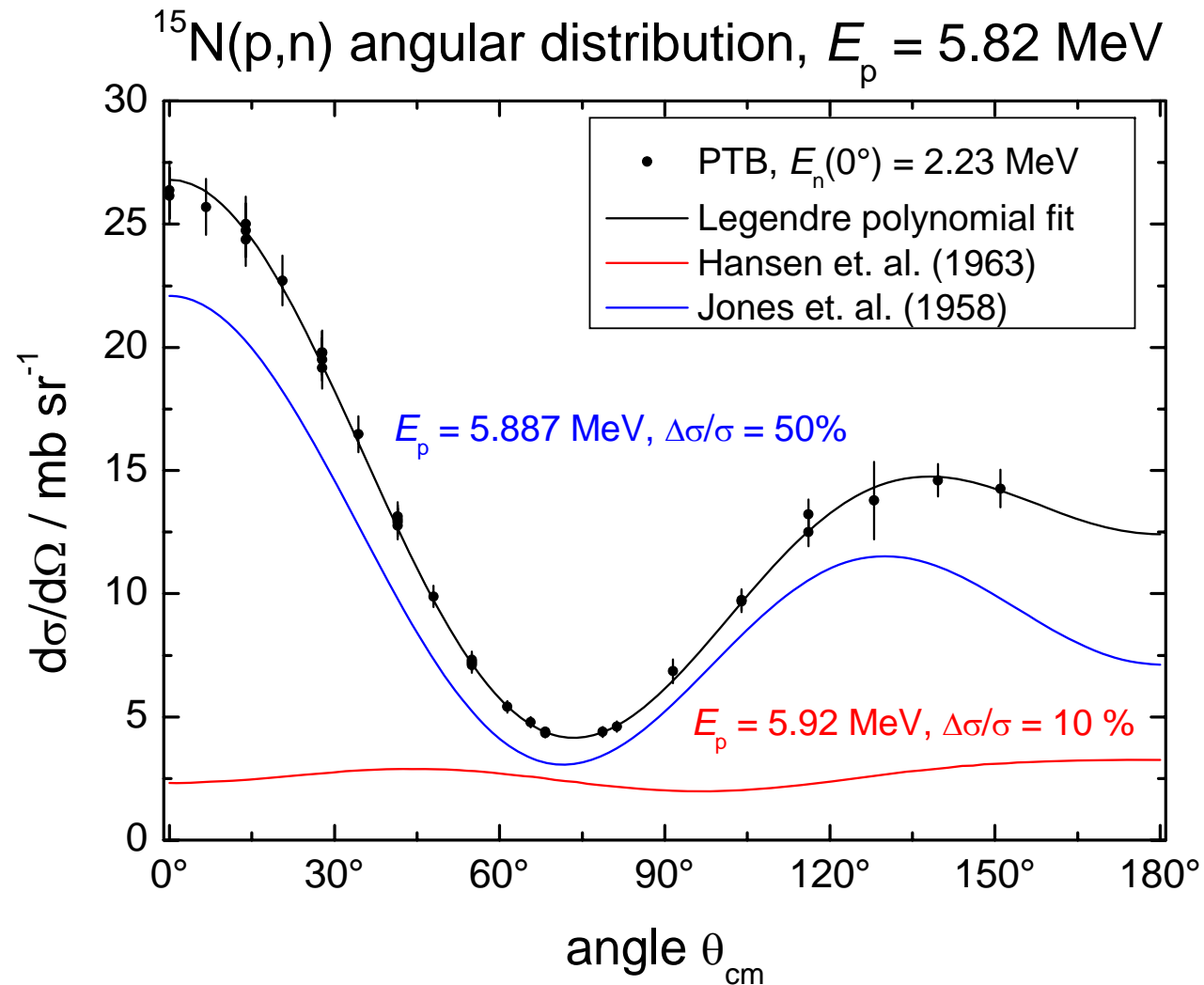
Neutron yield $dY/d\Omega(0^\circ)$ approx. one order of magnitude smaller than for $\text{D}(d,n)$ reaction!



Measurement of $^{15}\text{N}(p,n)$ angular distributions to

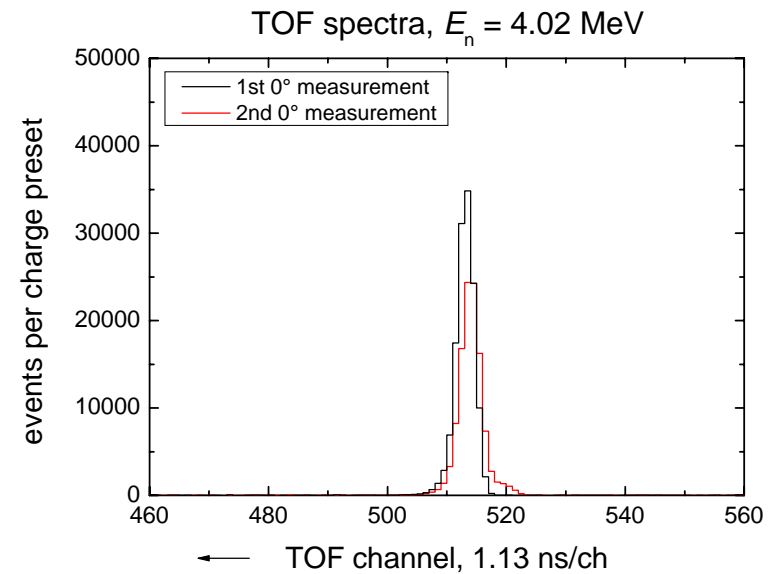
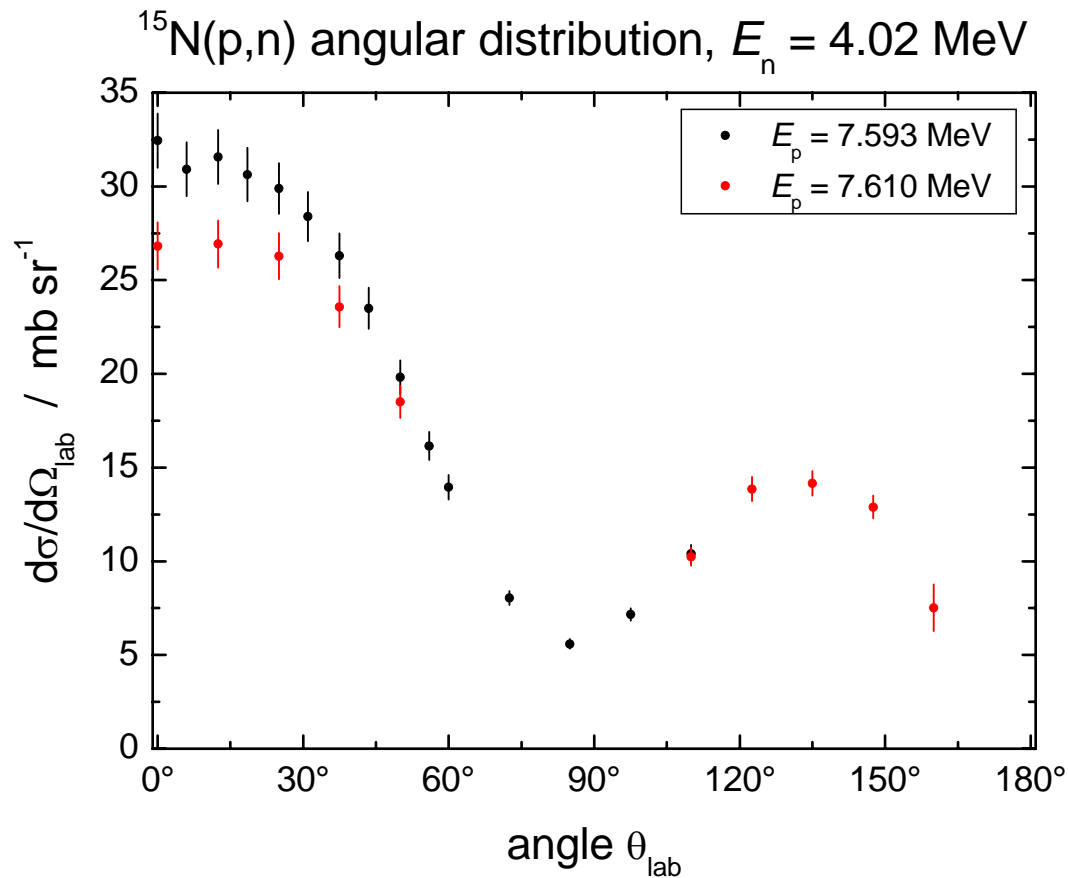
- improve existing cross section data
- identify potential problems in scattering experiments

Cross Section Measurements



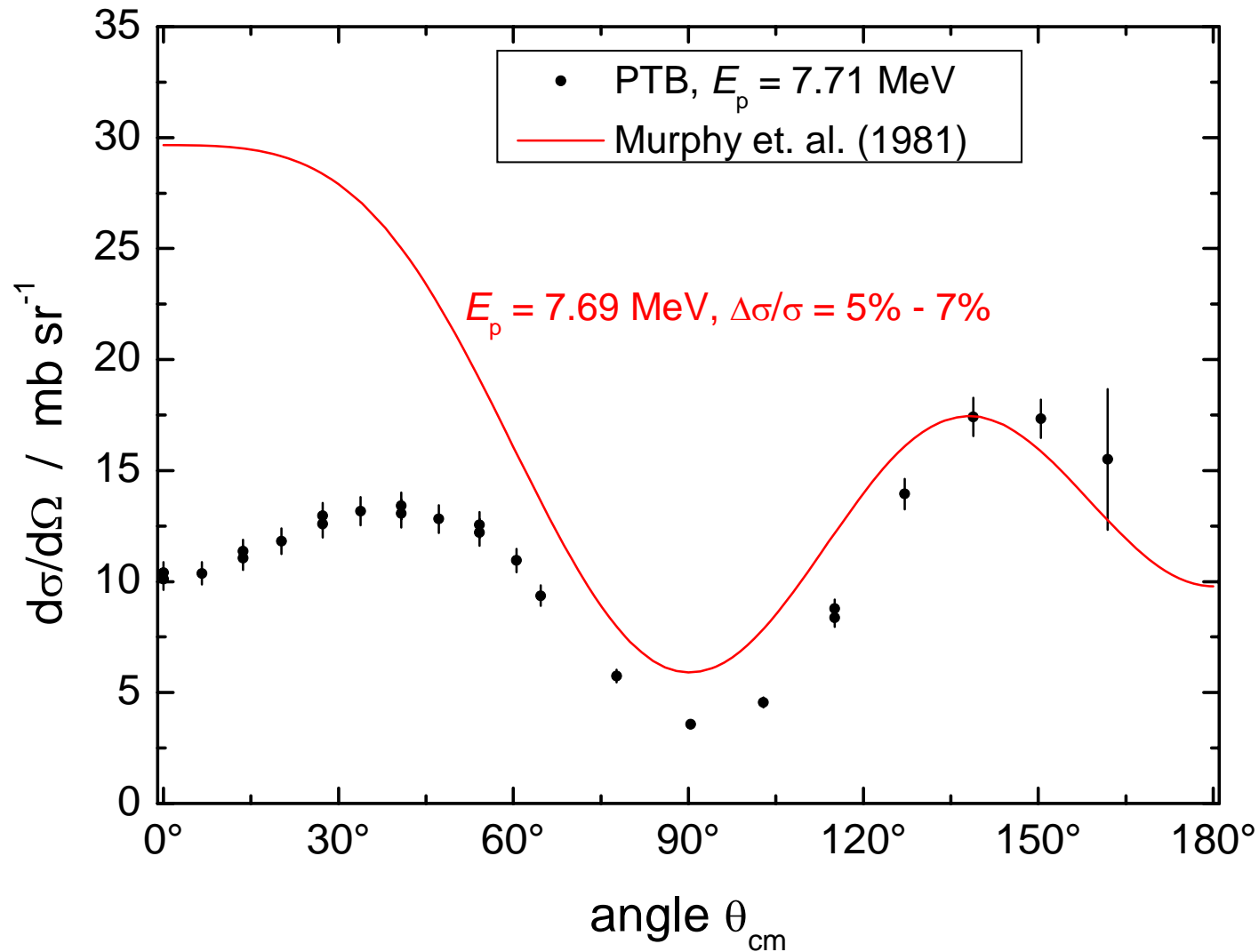
Good data...

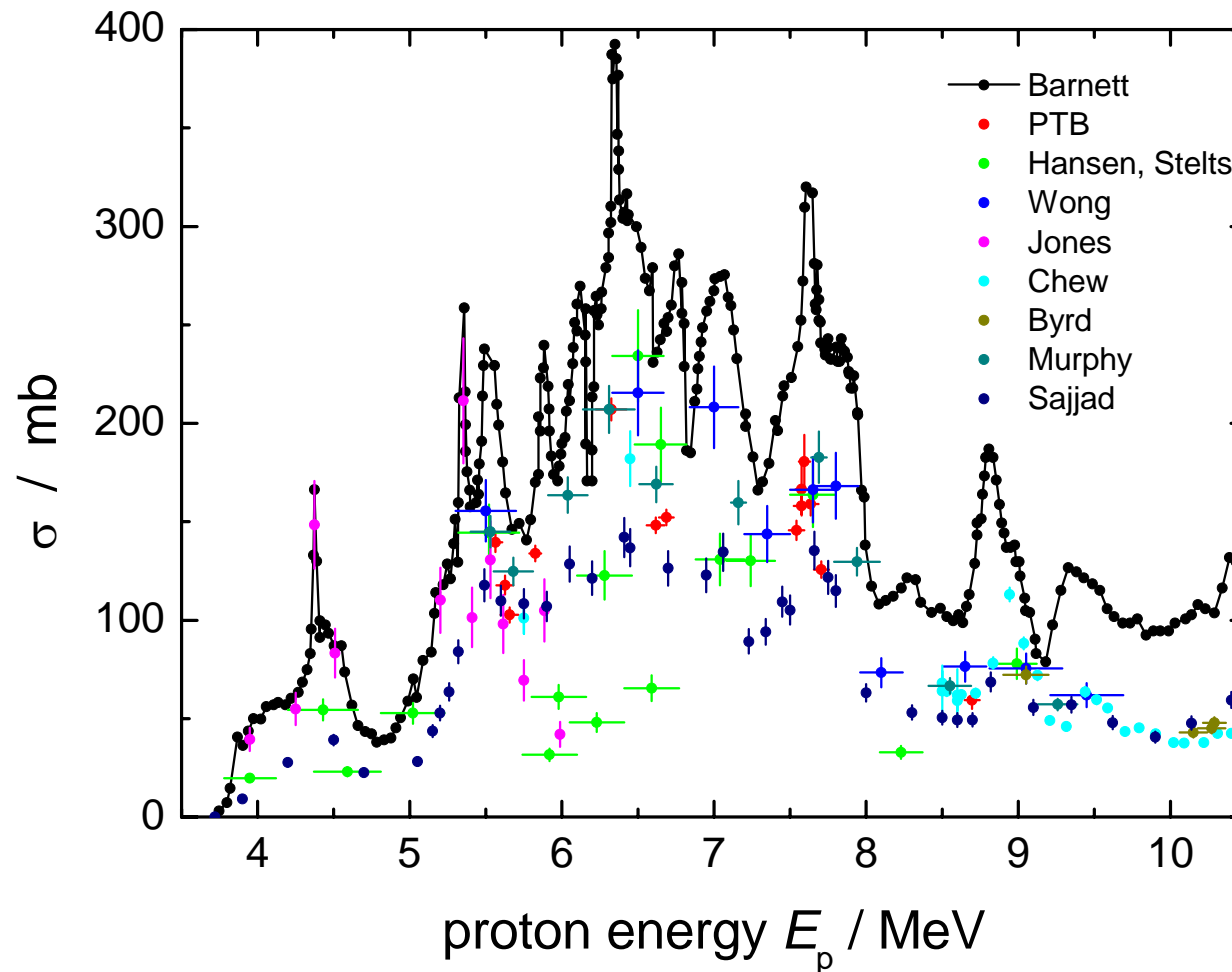
Cross Section Measurements



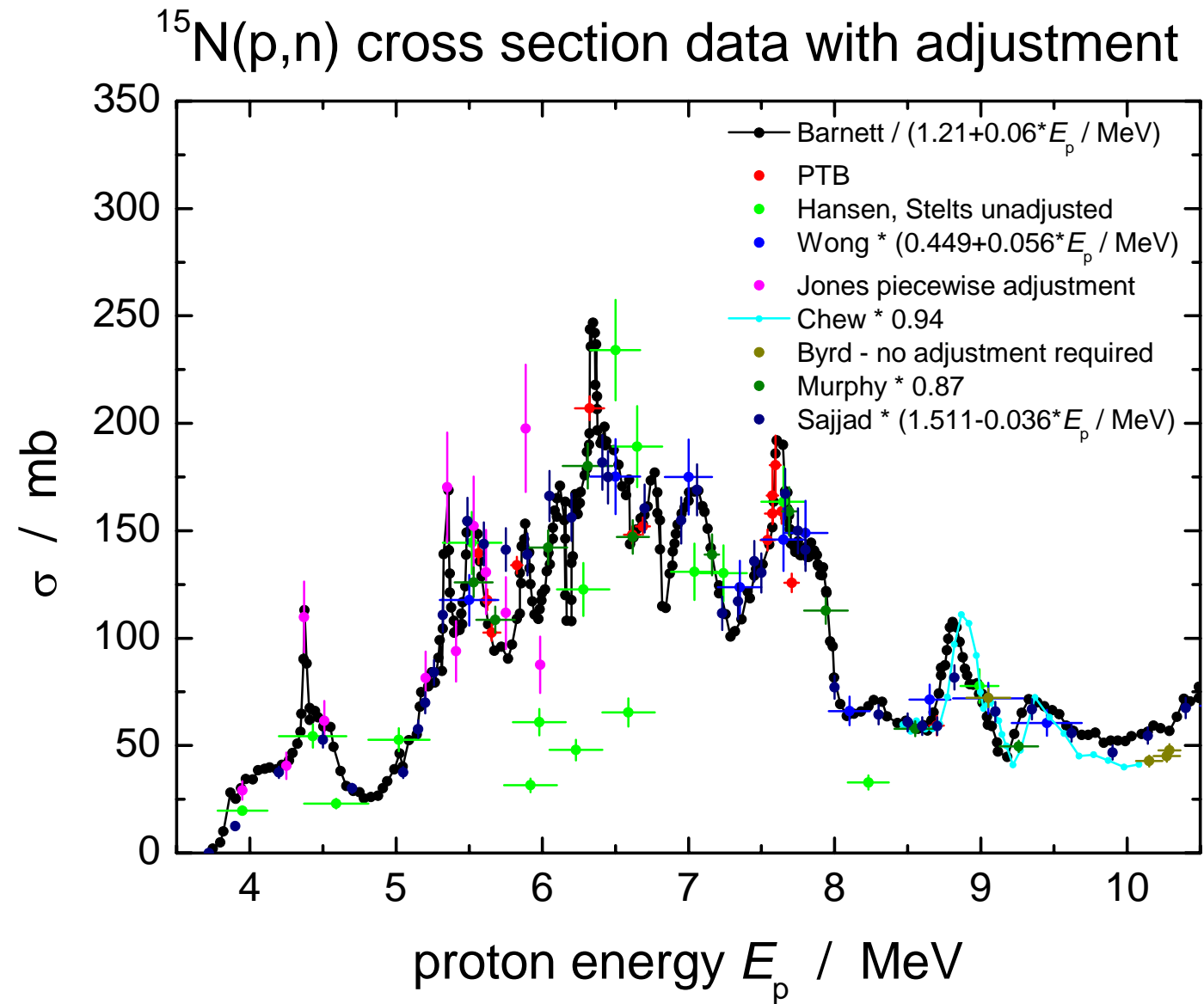
... and bad data.

$^{15}\text{N}(p,n)$ angular distribution



Existing $^{15}\text{N}(p,n)$ cross section data

“data cloud” \Rightarrow adjustment possible ?



Study of $^{15}\text{N}(p,n)$ reaction allows to

- **select optimum target conditions (gas pressure) and**
- **select optimum energies for scattering experiments**

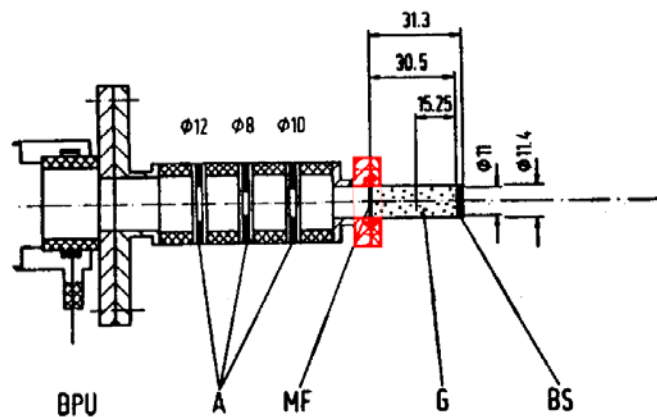
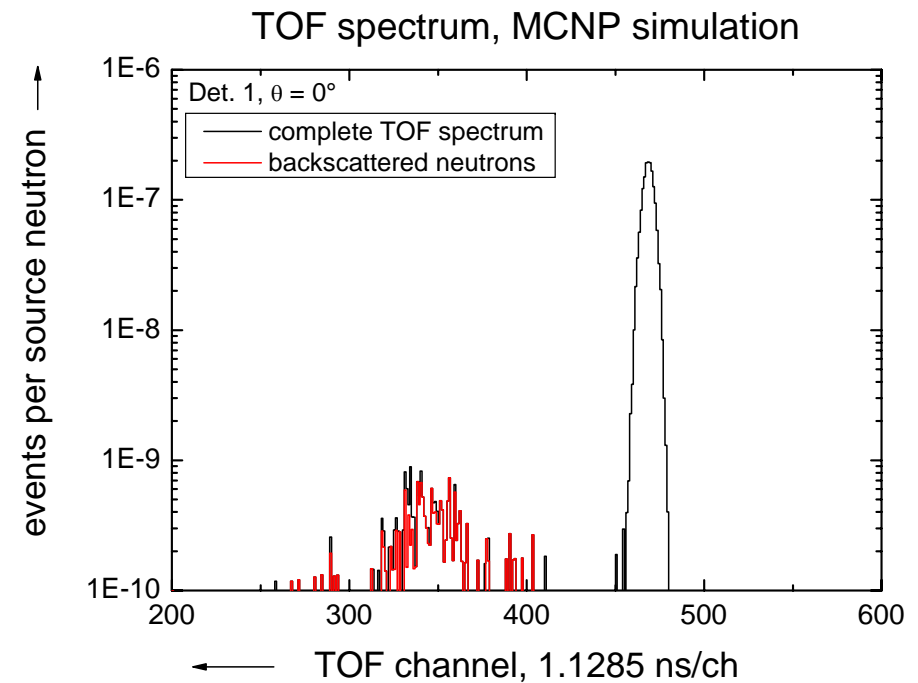
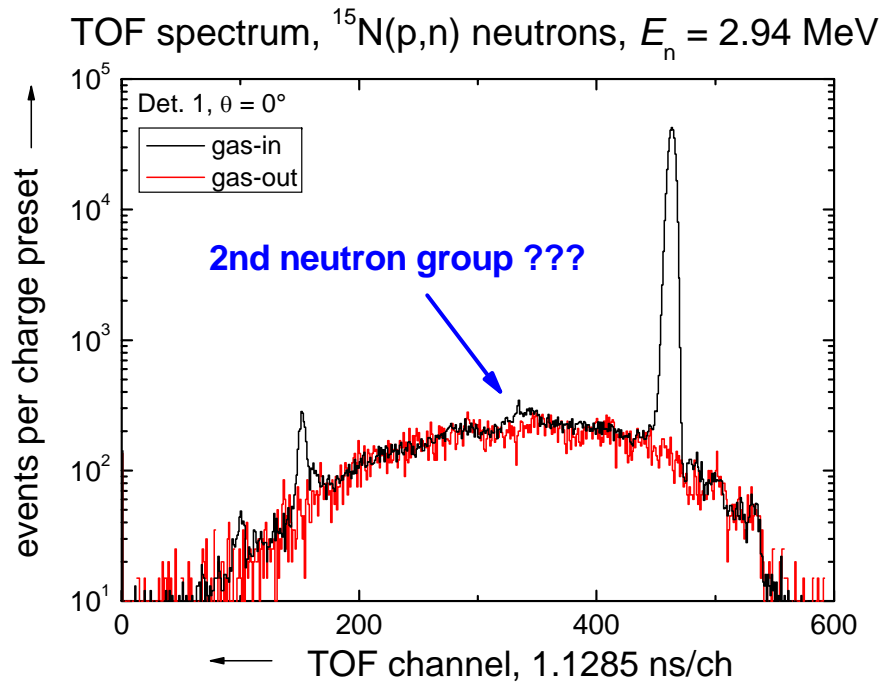
Measurement of 14 angular distributions:

- **improvement of cross section data base**
- **“Lessons learned”**
- **More measurements ???**

Scattering experiments

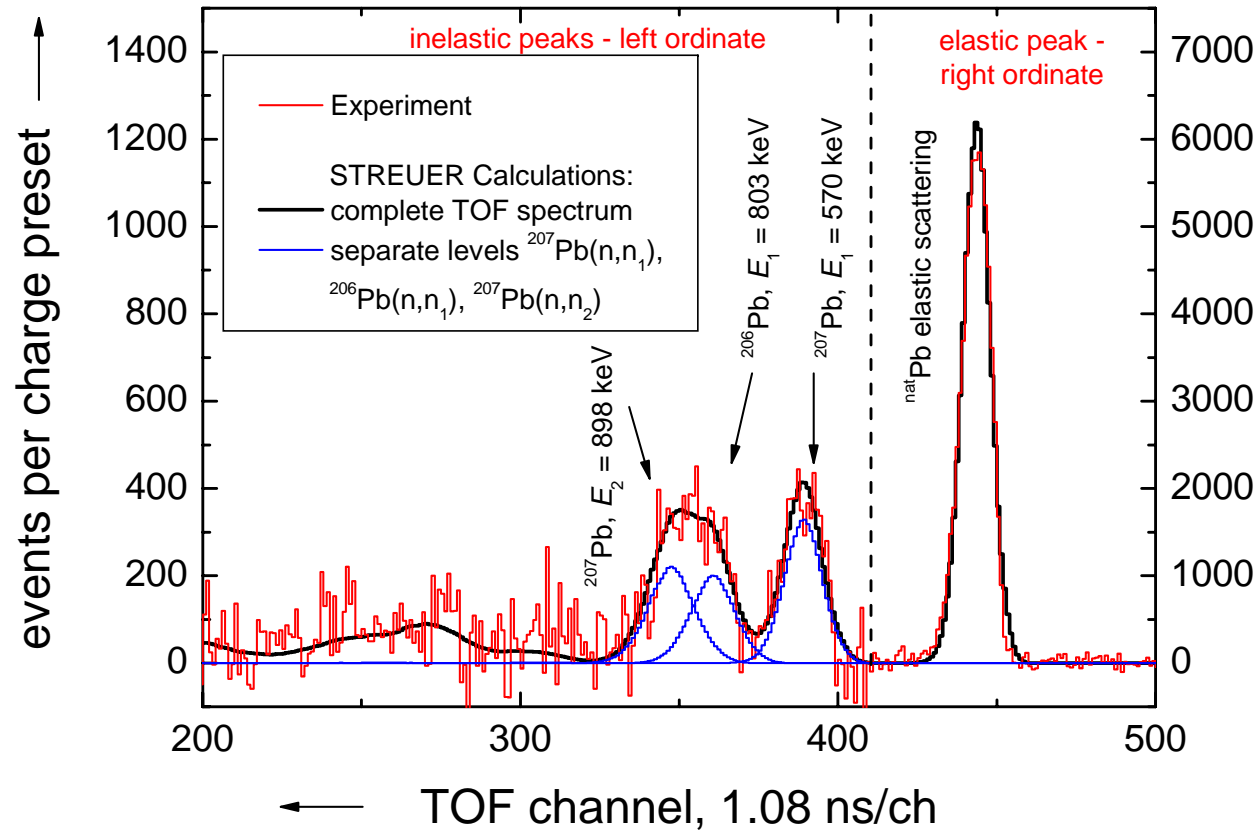
- **$^{15}\text{N}(p,n)$ successfully used in scattering experiments**
- **data analysis still in progress**

Neutron TOF Spectra

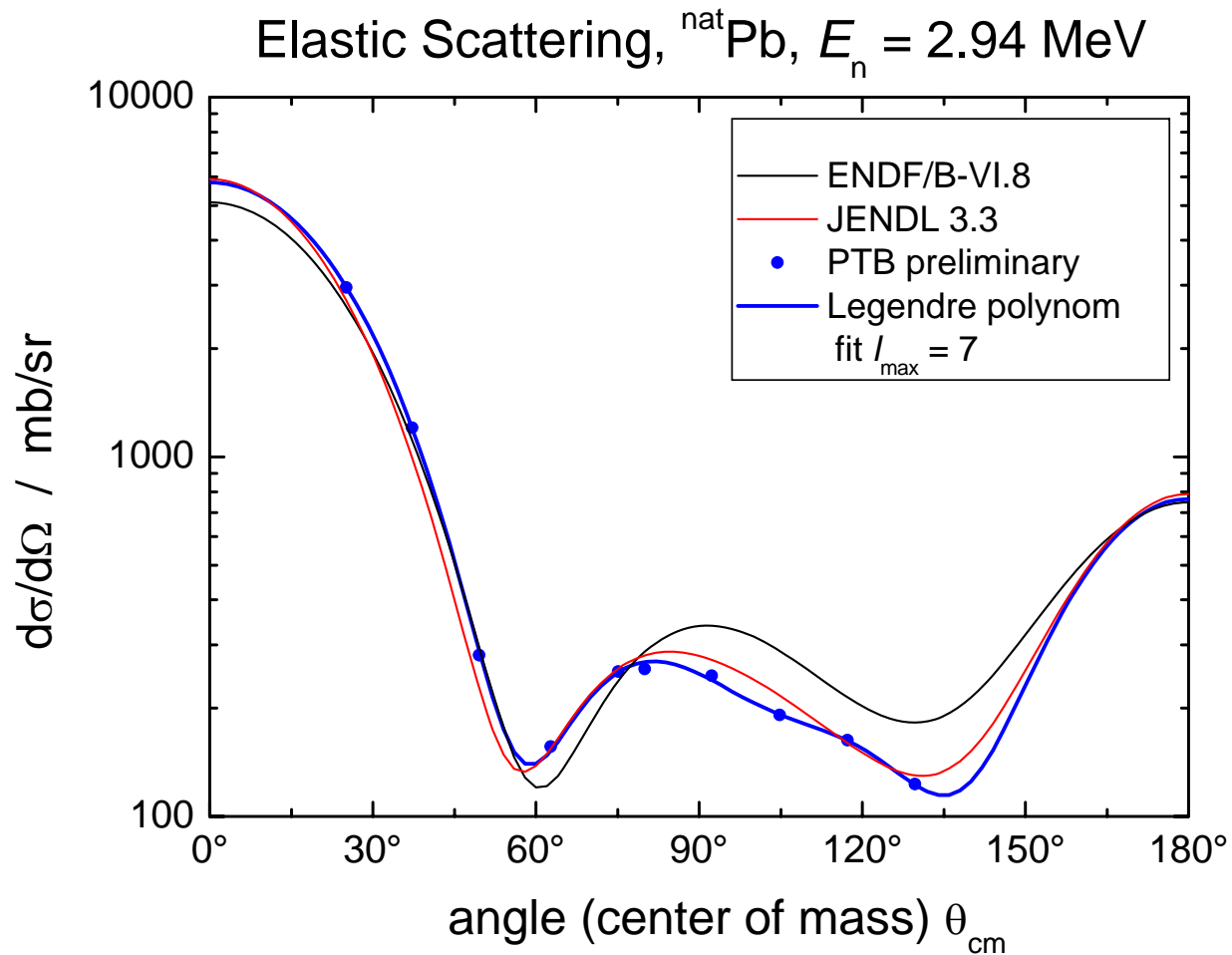


⇒ Neutrons emitted in backward direction and scattered in forward direction

TOF spectra, Det. 5, Pb sample, $\theta_{\text{lab}} = 130^\circ$

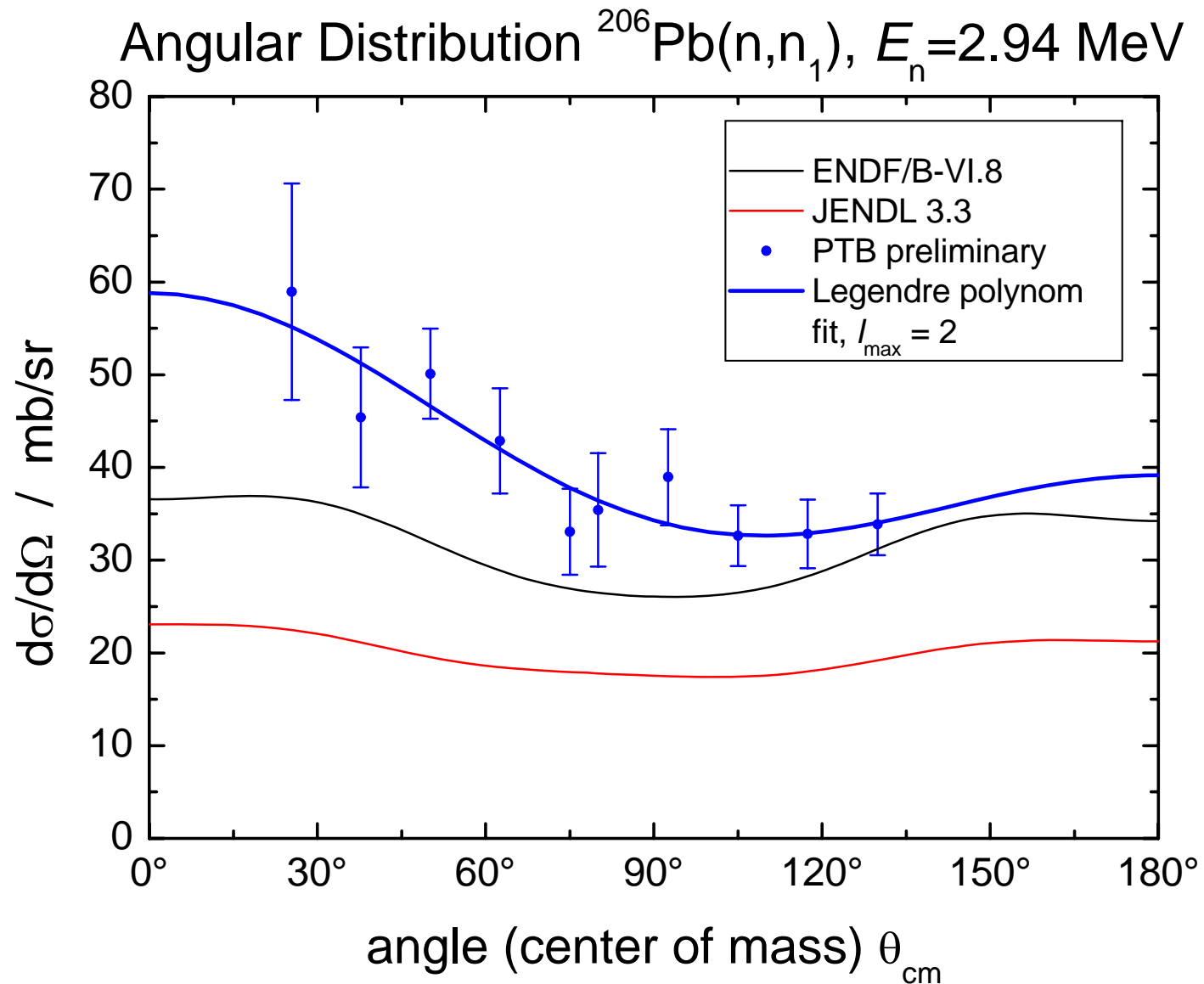


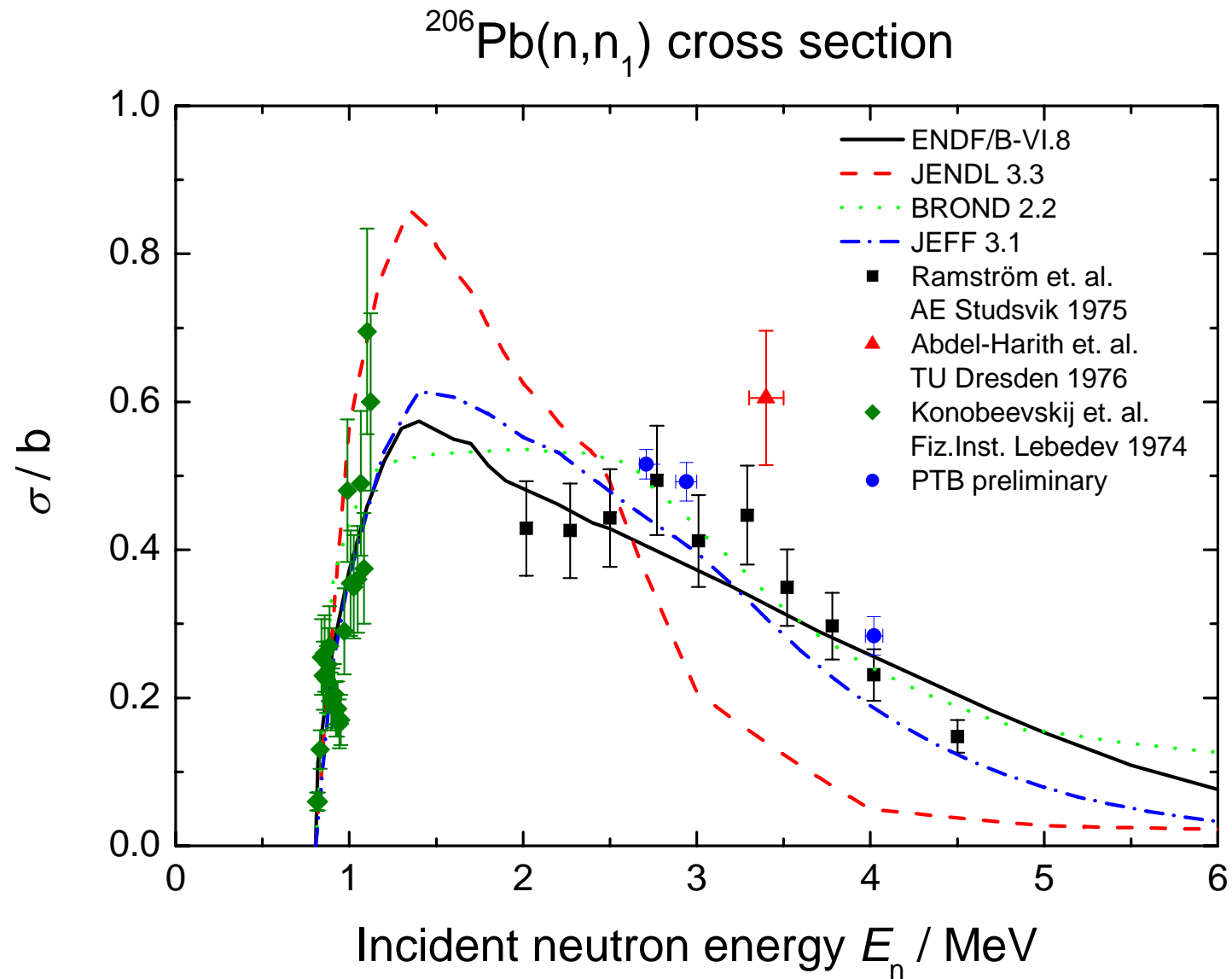
**Comparison of experimental with simulated TOF spectra
(Monte-Carlo code STREUER):
Iterative improvement of cross section data**



Experiment: $\sigma_{\text{el}} = (6.70 \pm 0.15) \text{ b}$
ENDF: $\sigma_{\text{el}} = 6.72 \text{ b}$
JENDL: $\sigma_{\text{el}} = 6.45 \text{ b}$

Results





$^{207}\text{Pb}(n,n_1)$ cross section