

NEUTRON TRANSMISSION: A very powerful technique at small accelerator-based neutron sources

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SOME RESEARCH ACTIVITIES AT N&R LAB

Total Cross Section Measurement and Calculation
(subthermal to epithermal range) [+T]

Neutron Diffraction [+T]

Deep Inelastic Neutron Scattering [+T]

Non Destructive Hydrogen Content Determination

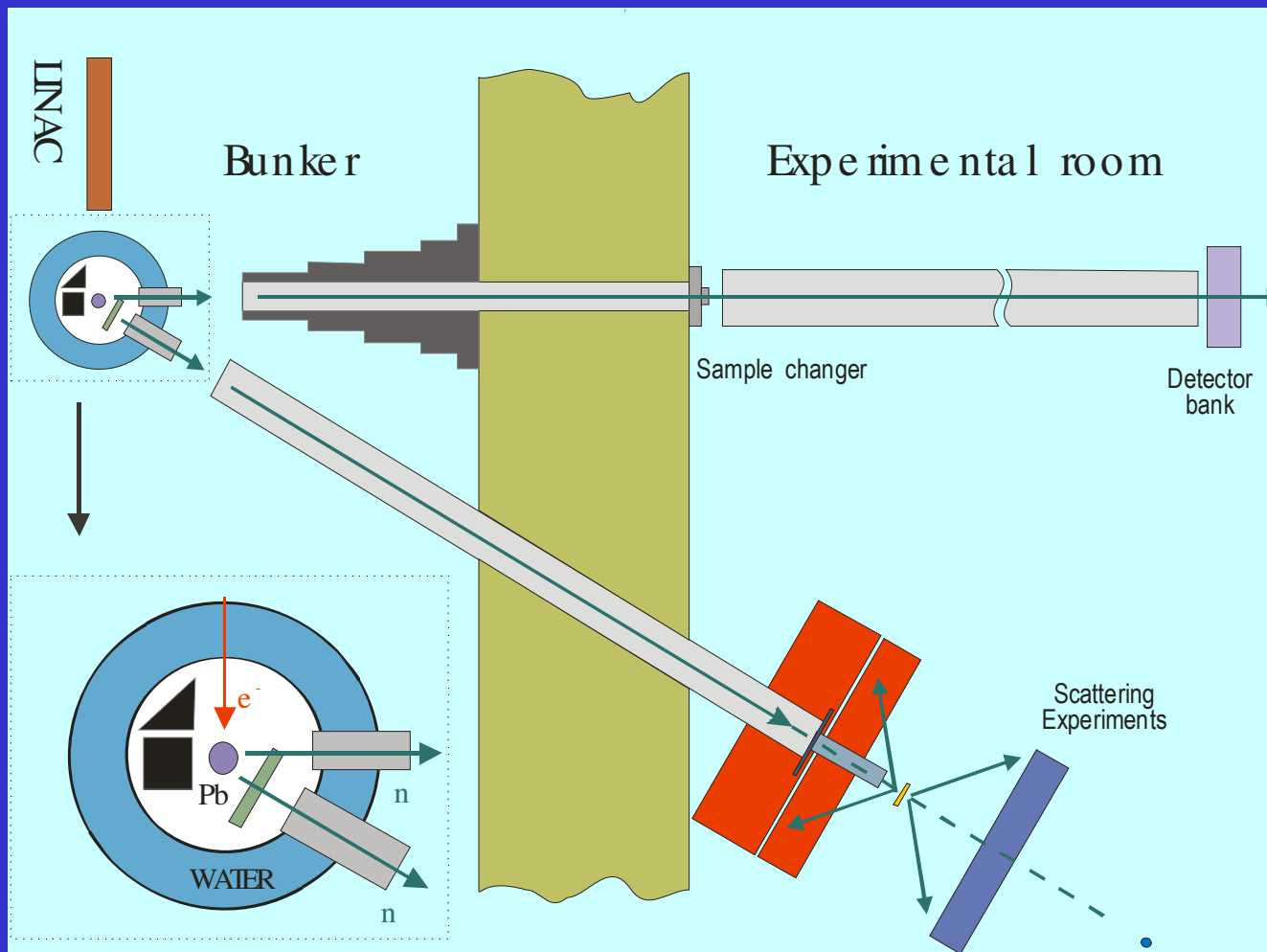
Cryogenic Moderator Materials Testing
(for cold neutron sources)

Scattering Kernels for Hydrogeneous Materials

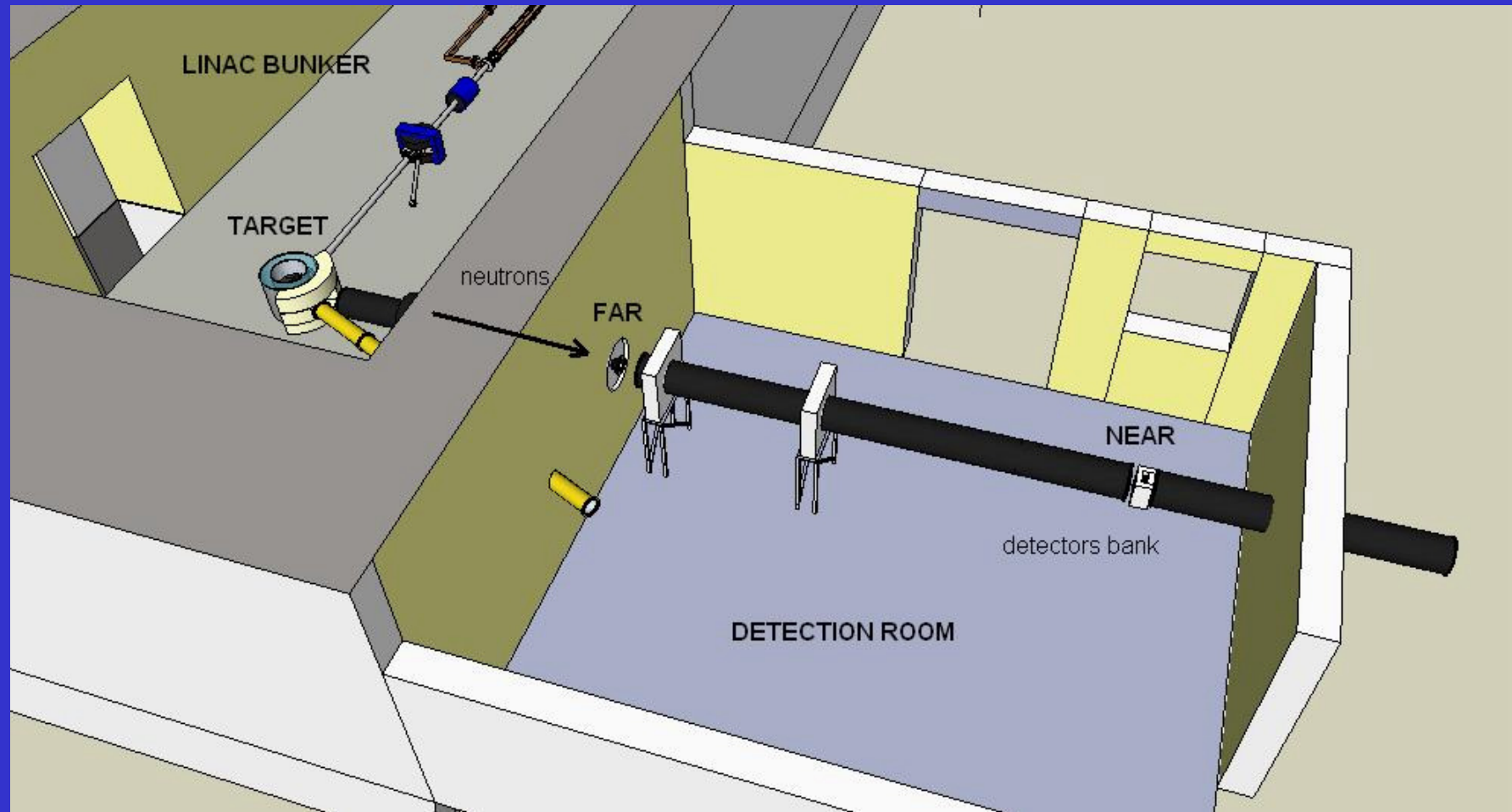
25 MeV e-LINAC



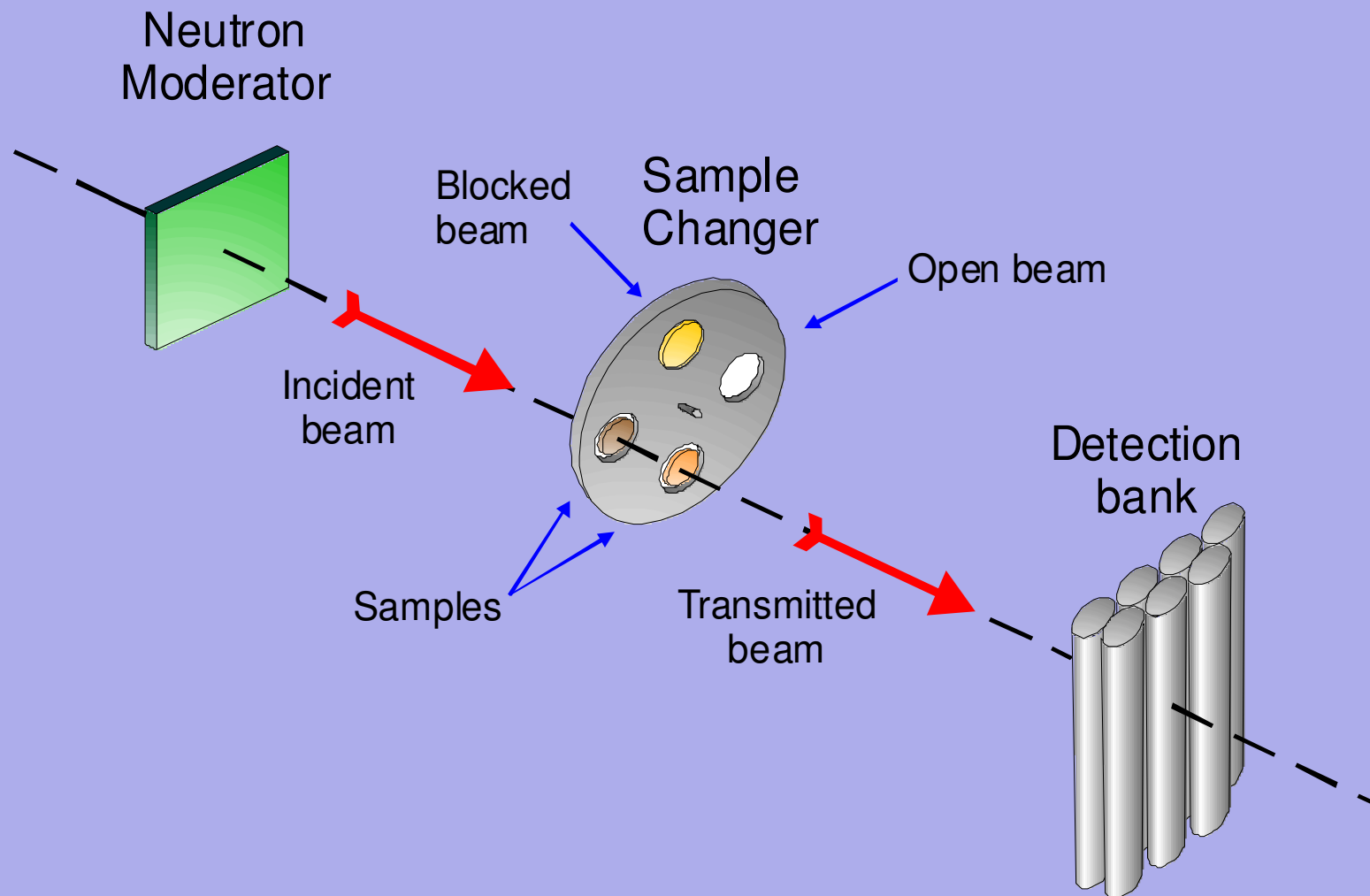
25 MeV e-LINAC



25 MeV e-LINAC



TRANSMISSION EXPERIMENT



TOTAL CROSS SECTION



Some simple motivations!

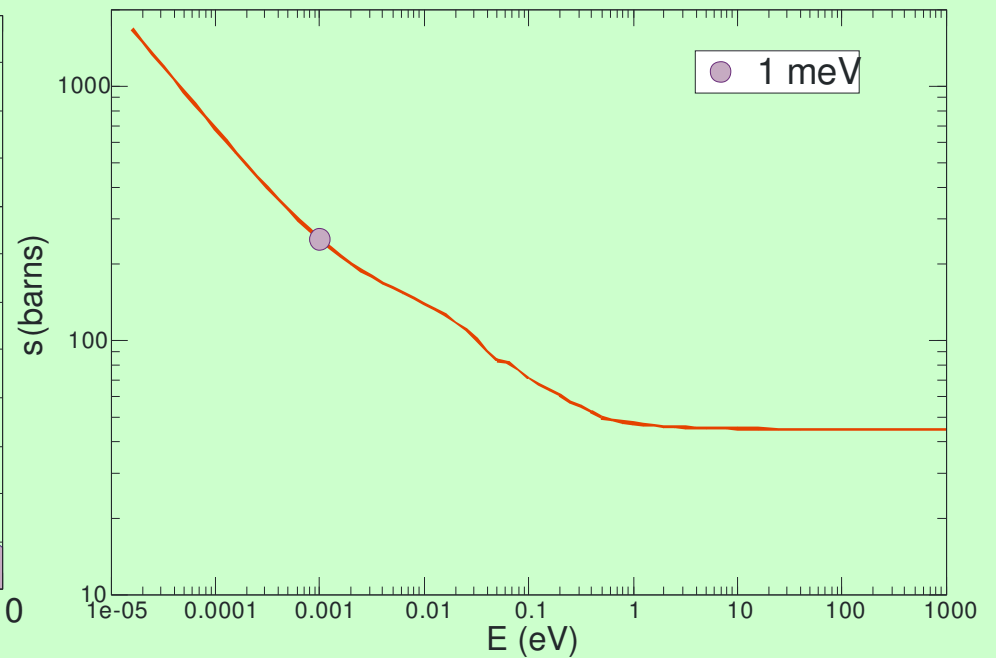
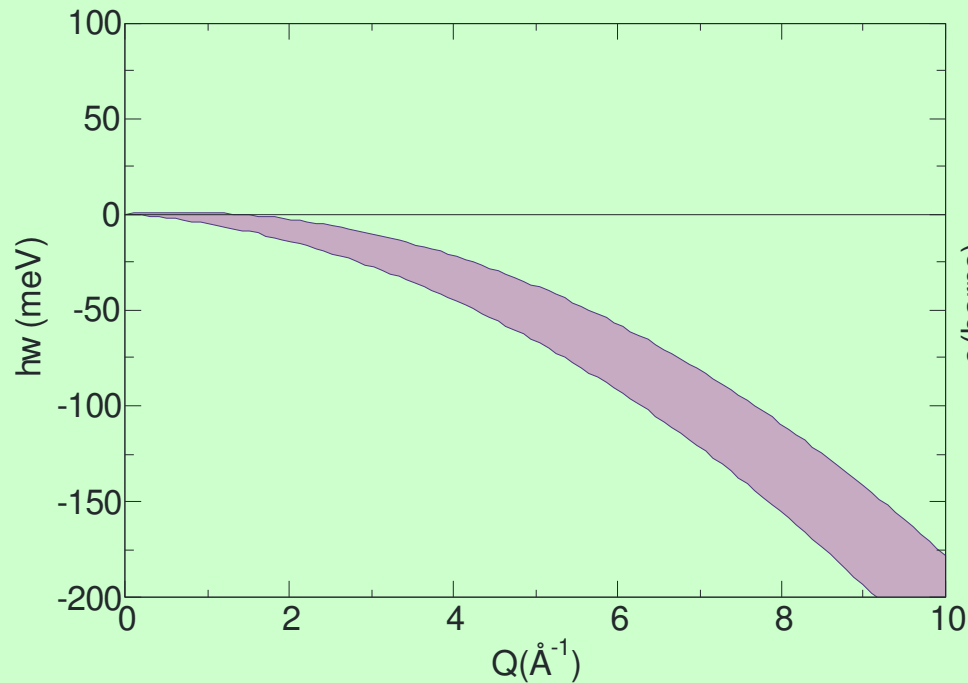
- ➔ Non existent or poor quality data for present applications
- ➔ Refinement of scattering length values
- ➔ Exploring broad dynamical features of a condensed system
- ➔ Determining structural properties of systems
- ➔ Study of fundamental n properties (n -e, α)
- ➔ Development of computer codes for the precise evaluation of Total X-sections
- ➔ Primary validation of new Scattering Kernels



$$\sigma(E_0) = \frac{\sigma_b}{2k_0^2} \int_0^\infty Q \int_{\epsilon_{\min}}^{\epsilon_{\max}} S(Q, \epsilon) d\epsilon,$$

1 meV

Polyethylene

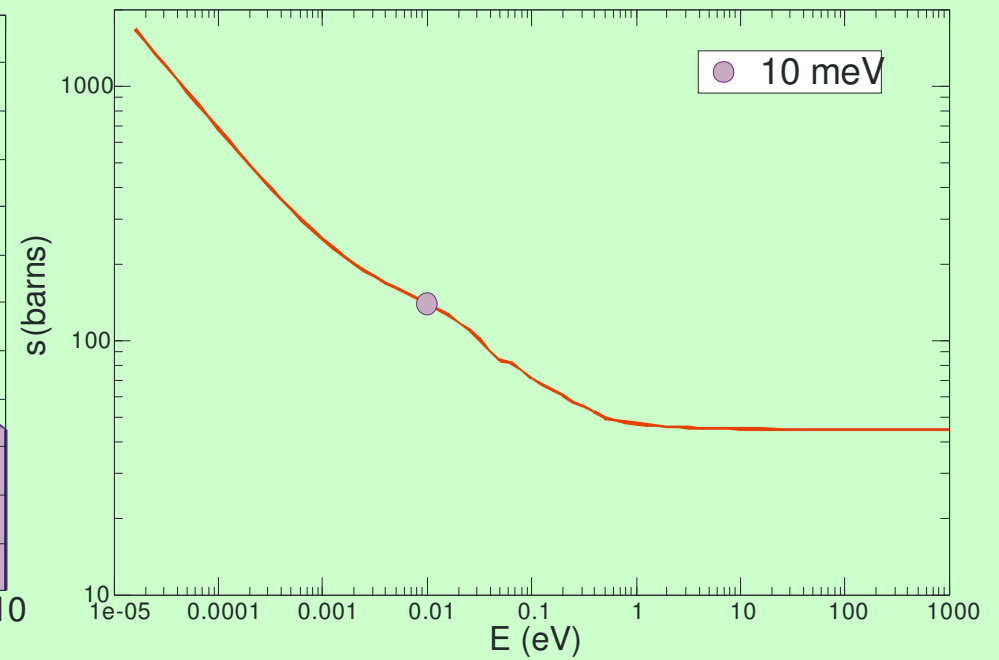
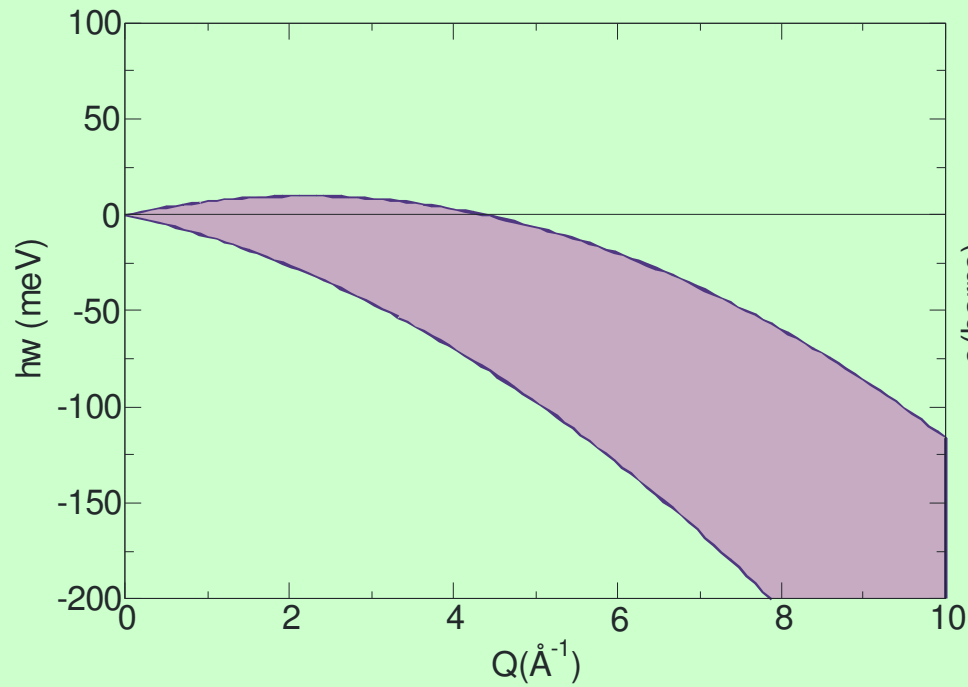




$$\sigma(E_0) = \frac{\sigma_b}{2k_0^2} \int_0^\infty Q \int_{\epsilon_{\min}}^{\epsilon_{\max}} S(Q, \epsilon) d\epsilon,$$

10 meV

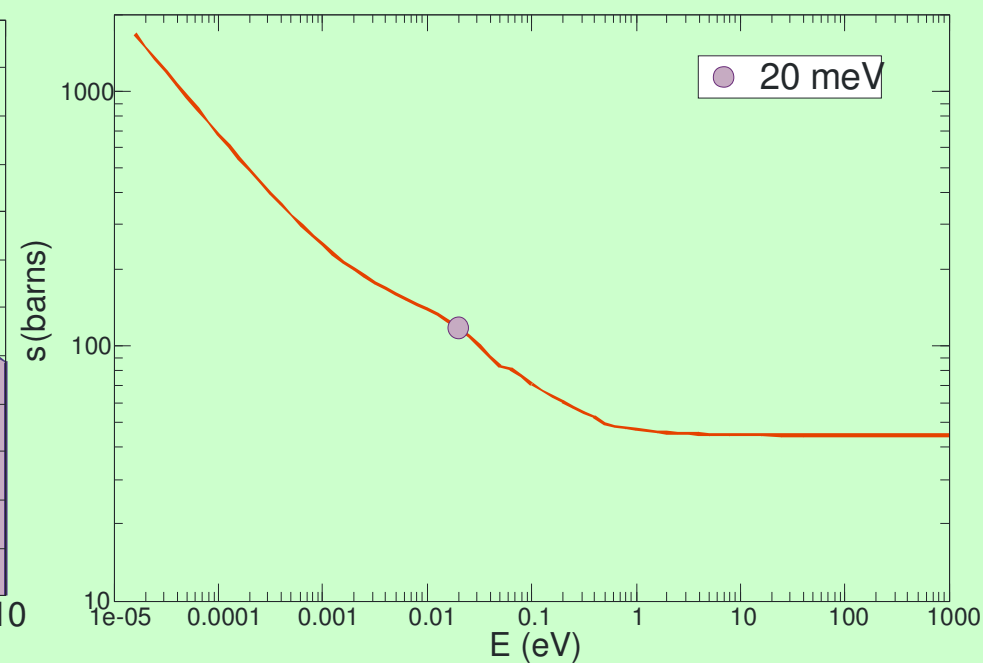
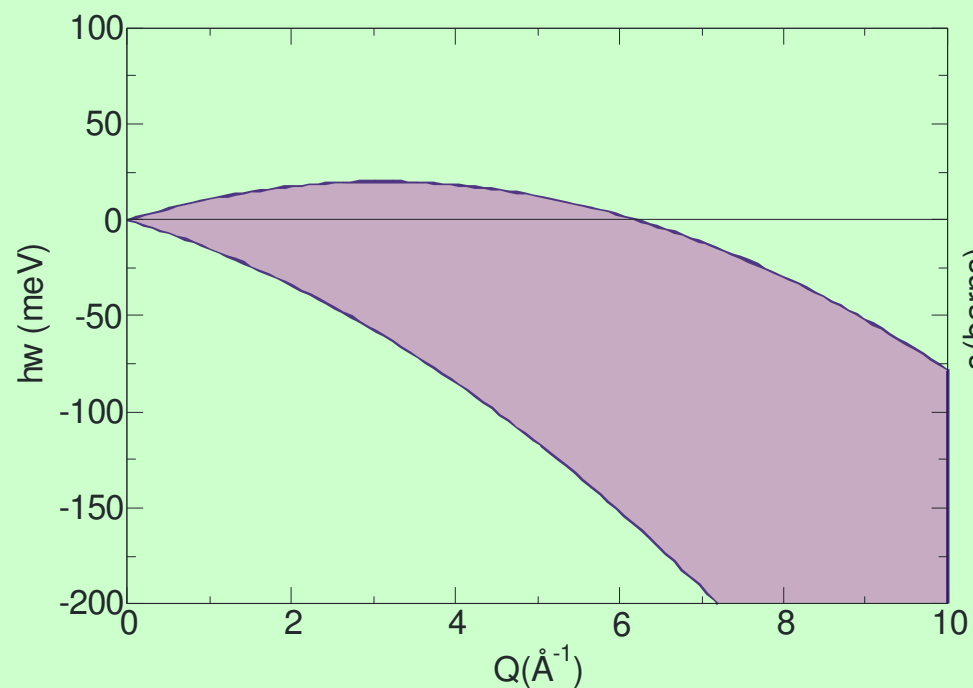
Polyethylene



$$\sigma(E_0) = \frac{\sigma_b}{2k_0^2} \int_0^\infty Q \int_{\epsilon_{\min}}^{\epsilon_{\max}} S(Q, \epsilon) d\epsilon,$$

20 meV

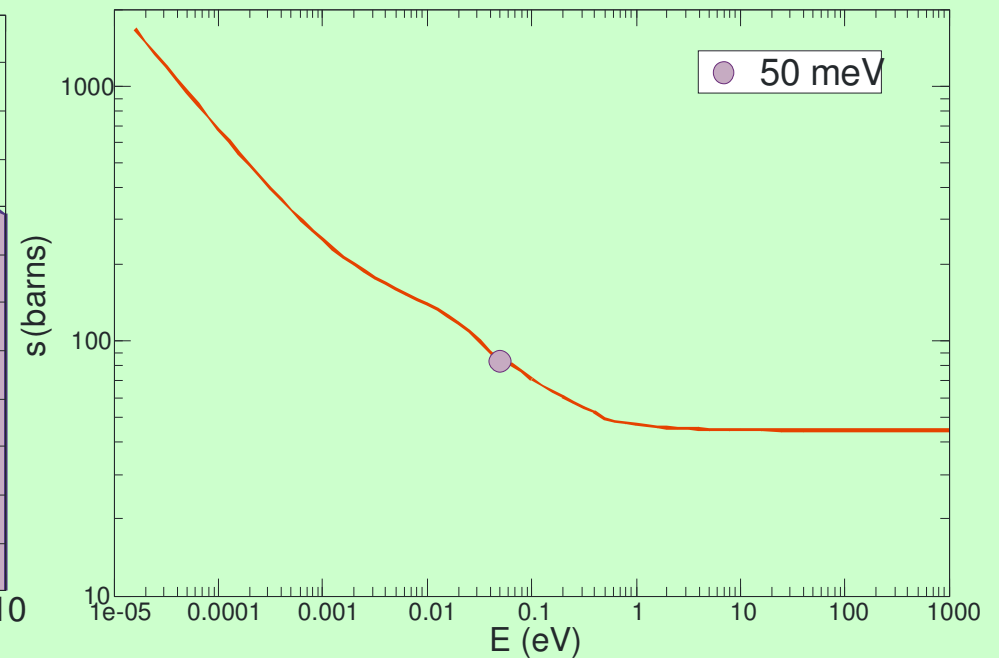
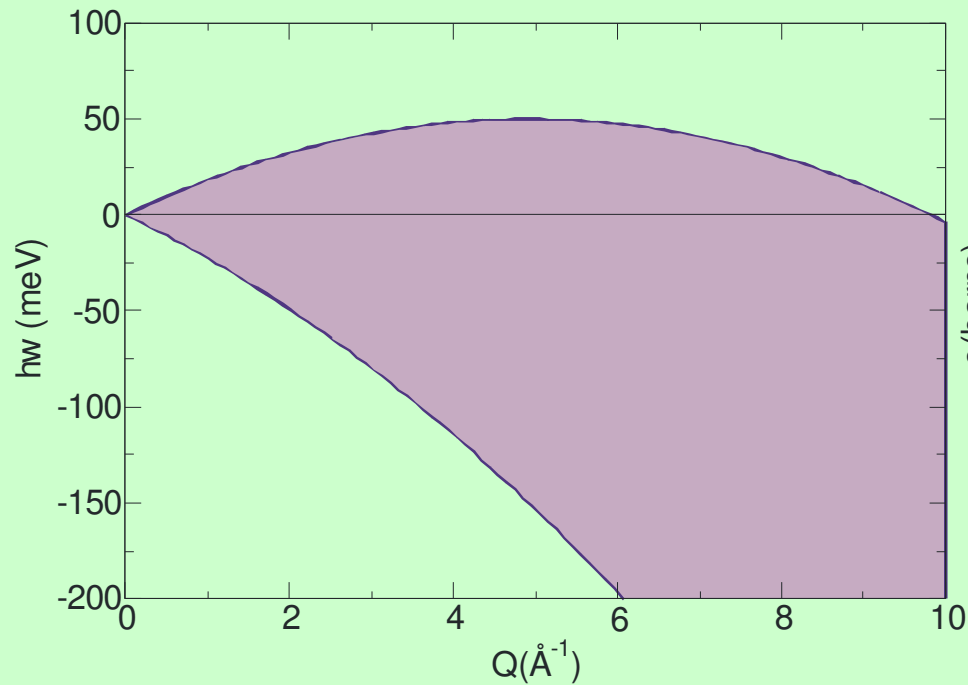
Polyethylene



$$\sigma(E_0) = \frac{\sigma_b}{2k_0^2} \int_0^\infty Q \int_{\epsilon_{\min}}^{\epsilon_{\max}} S(Q, \epsilon) d\epsilon,$$

50 meV

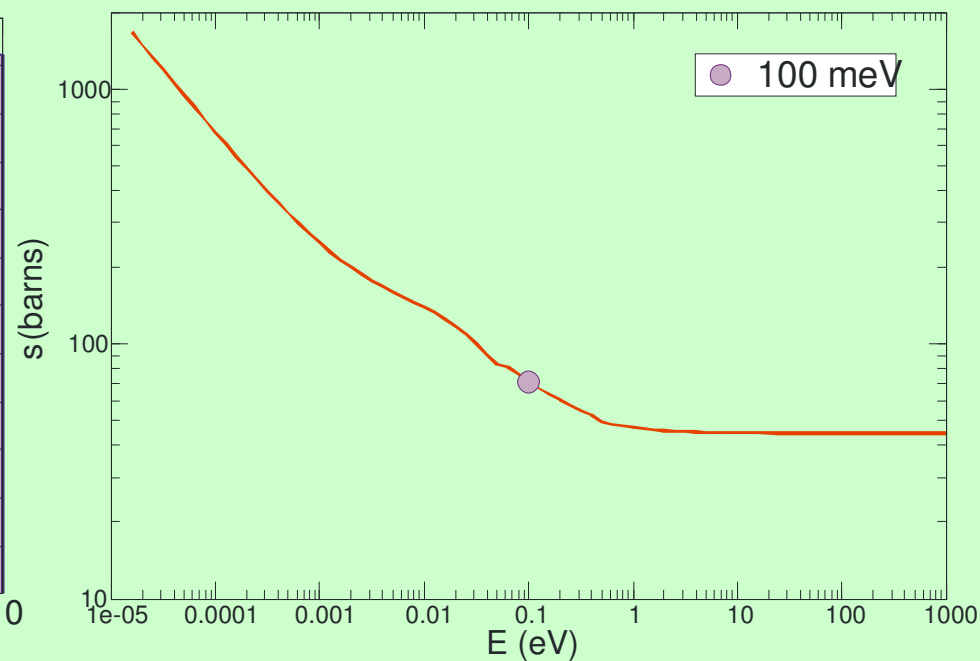
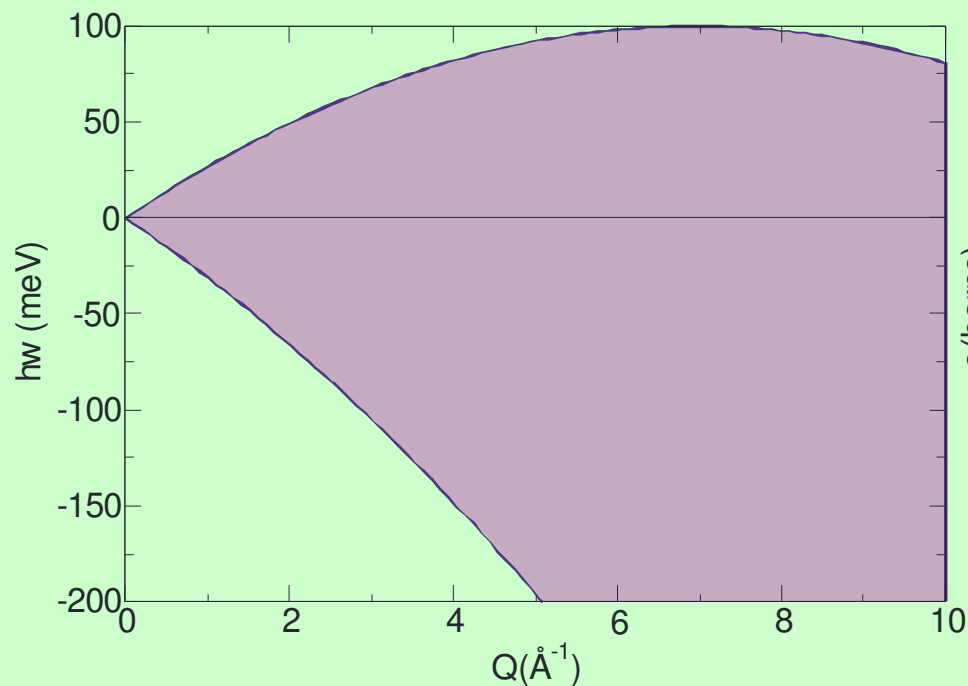
Polyethylene



$$\sigma(E_0) = \frac{\sigma_b}{2k_0^2} \int_0^\infty Q \int_{\varepsilon_{\min}}^{\varepsilon_{\max}} S(Q, \varepsilon) d\varepsilon,$$

100 meV

Polyethylene

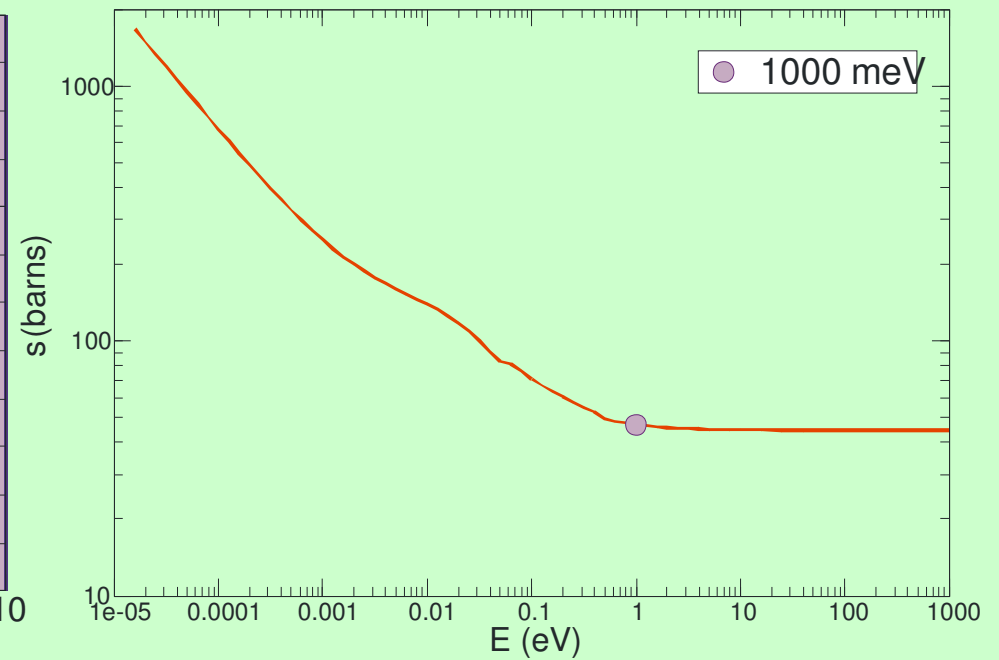
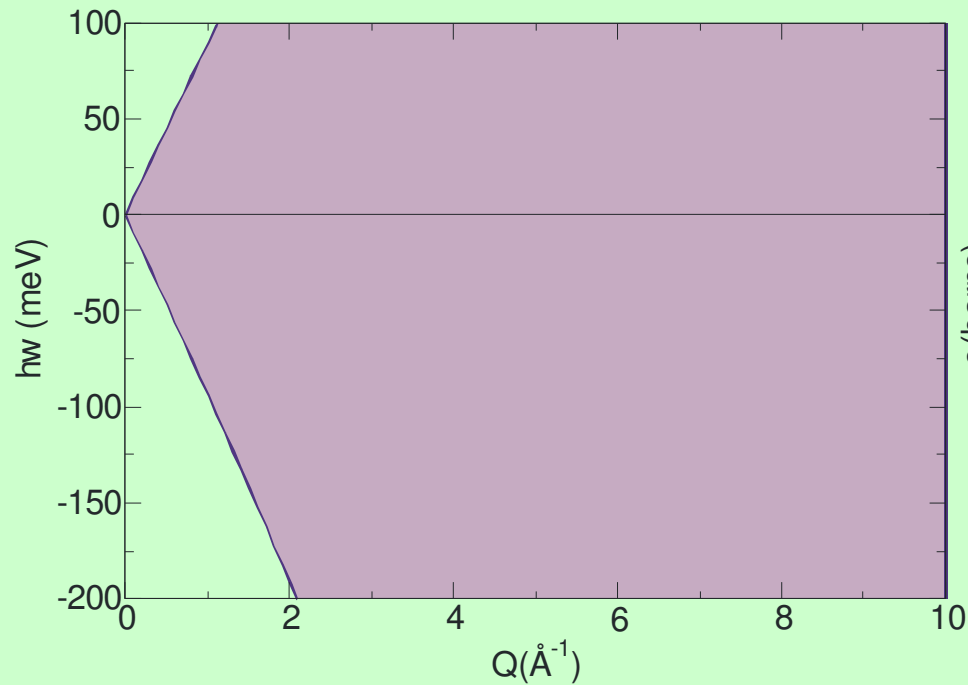




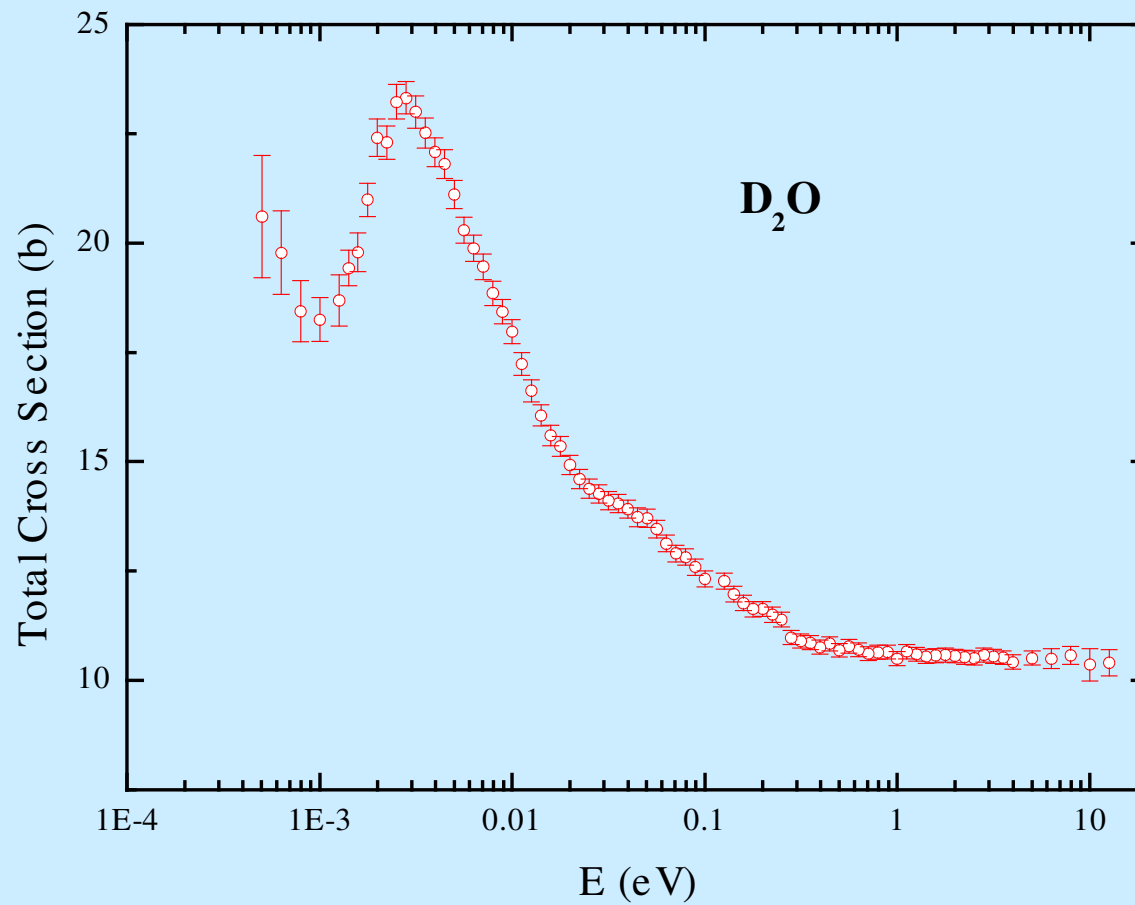
$$\sigma(E_0) = \frac{\sigma_b}{2k_0^2} \int_0^\infty Q \int_{\epsilon_{\min}}^{\epsilon_{\max}} S(Q, \epsilon) d\epsilon,$$

1000 meV

Polyethylene



TOTAL CROSS SECTIONS



IAEA, EXFOR 30283 (1974)

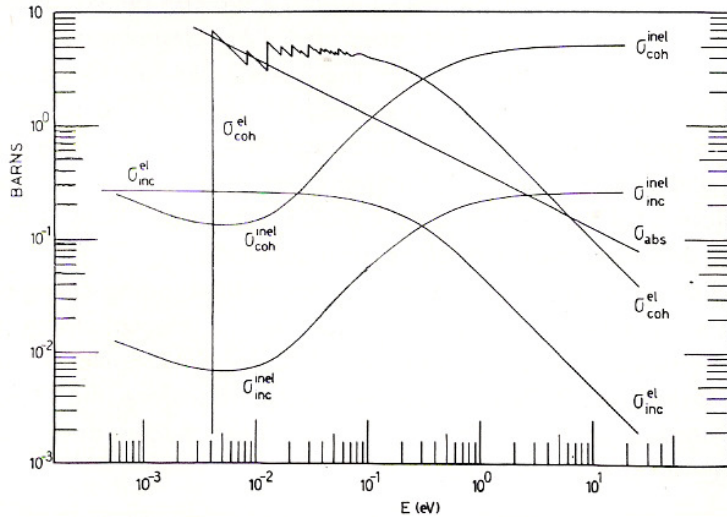
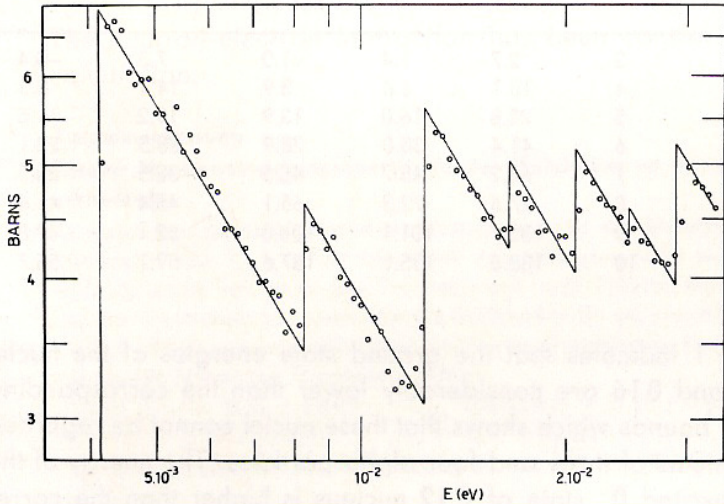
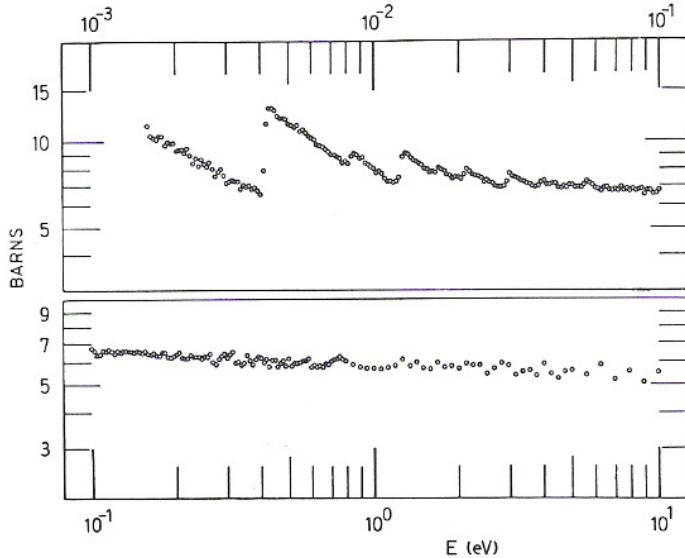
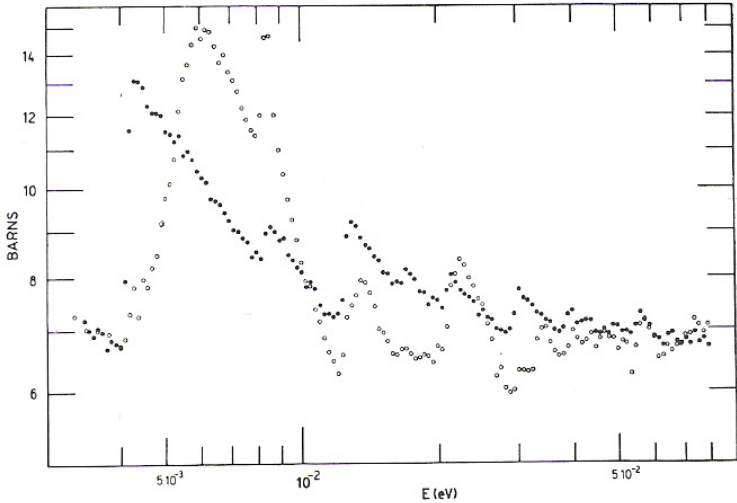
TOTAL CROSS SECTION of Polycrystals



We performed transmission experiments to get a set of consistent parameters for scattering and absorption. The experimental total cross section curve for polycrystalline molybdenum is shown, and was fitted theoretically in the whole energy range using our code CRIPO, from which all the nuclear constants - σ_c , σ_i , σ_{bound} - were obtained. This procedure was used for several elements and isotopes.



TOTAL CROSS SECTION of Mo





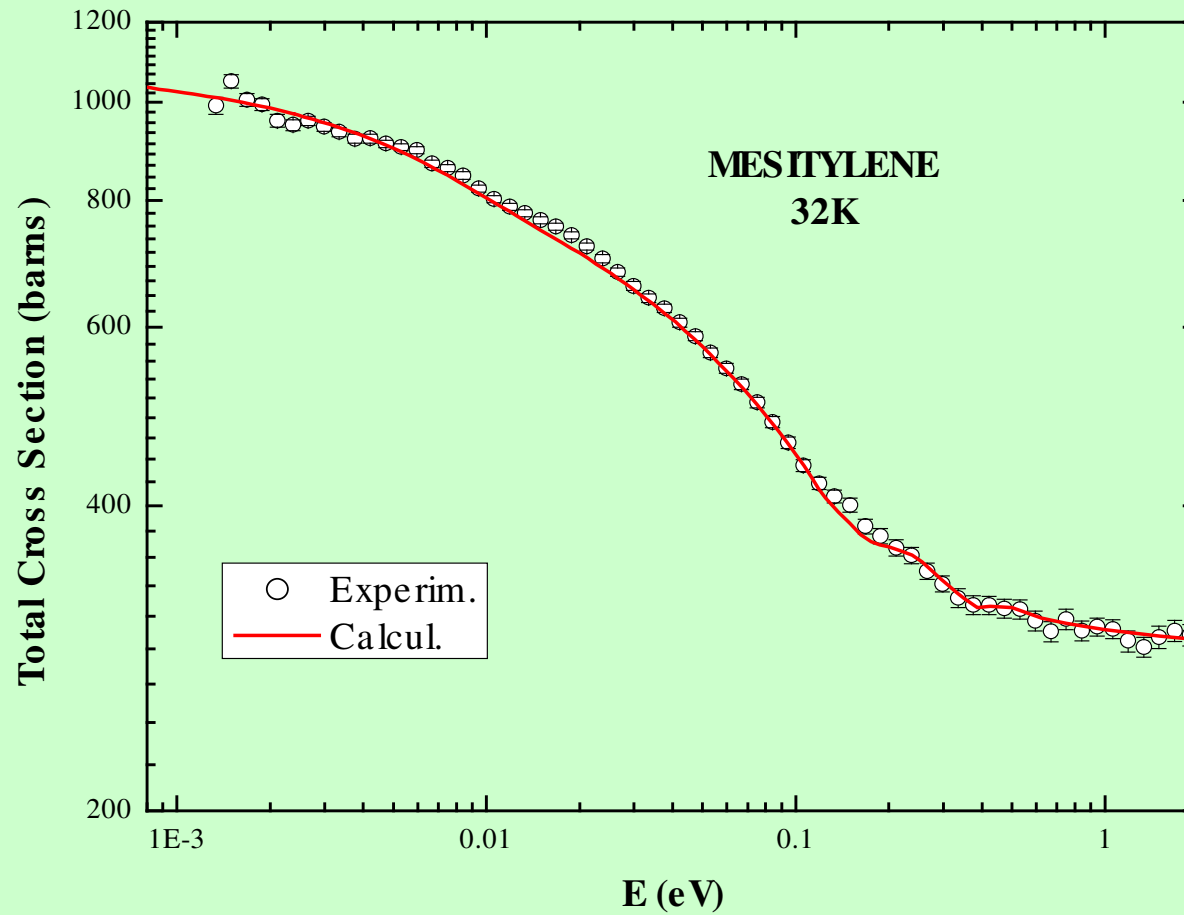
The measurement of neutron total cross section for heavy elements over an energy range from zero up to several KeV, permits a determination of the **neutron-electron scattering length** and the **neutron electrical polarizability**. We have used our facility and the KURRI Linac (Kyoto University, Japan) based pulsed source to perform transmission experiment on Pb and Bi, over epithermal neutron energies, together with a full calculation of the different electromagnetic interactions and their corresponding contributions to the scattering length.

TOTAL CROSS SECTIONS

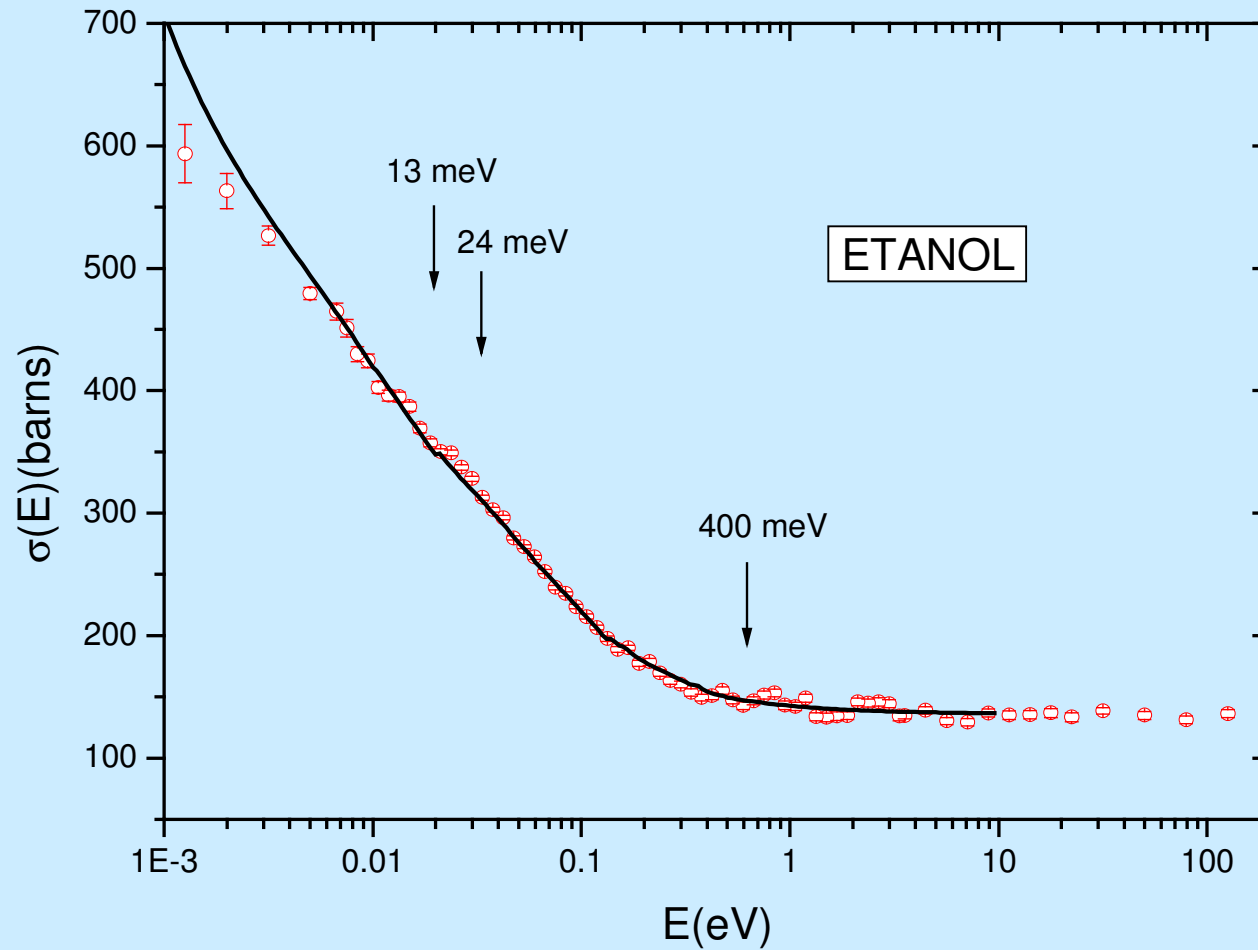


After the development of a Synthetic Scattering Model to describe the interaction of slow neutrons with molecular systems, we used total scattering cross section measurements to refine some model's parameters before generating the scattering kernel for a material. Conversely, that kind of measurements represent the first validation test for any calculation.

TOTAL CROSS SECTIONS



TOTAL CROSS SECTIONS

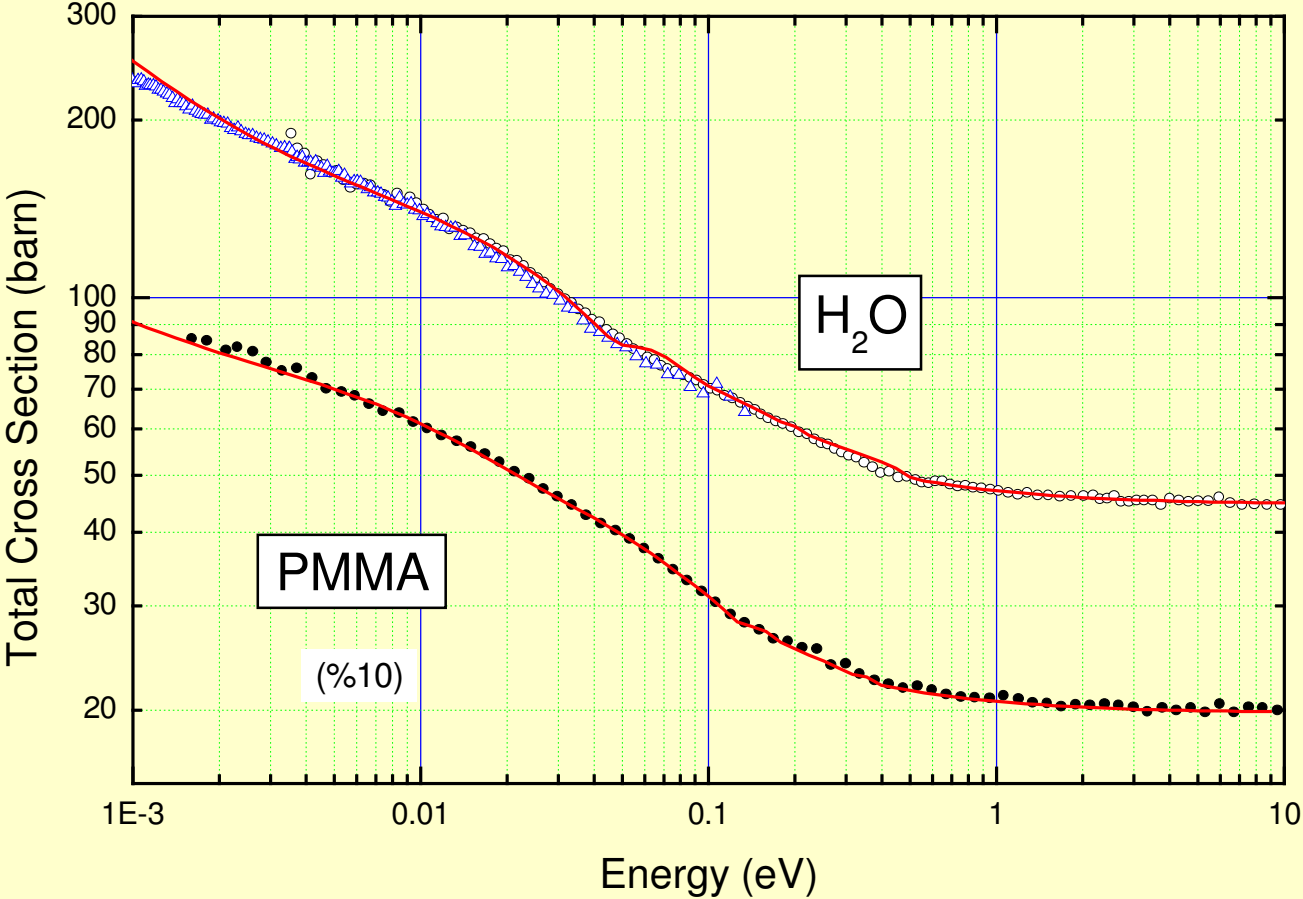


Nucl.Instr.Meth. **B 168**, 462 (2000)



TOTAL CROSS SECTIONS

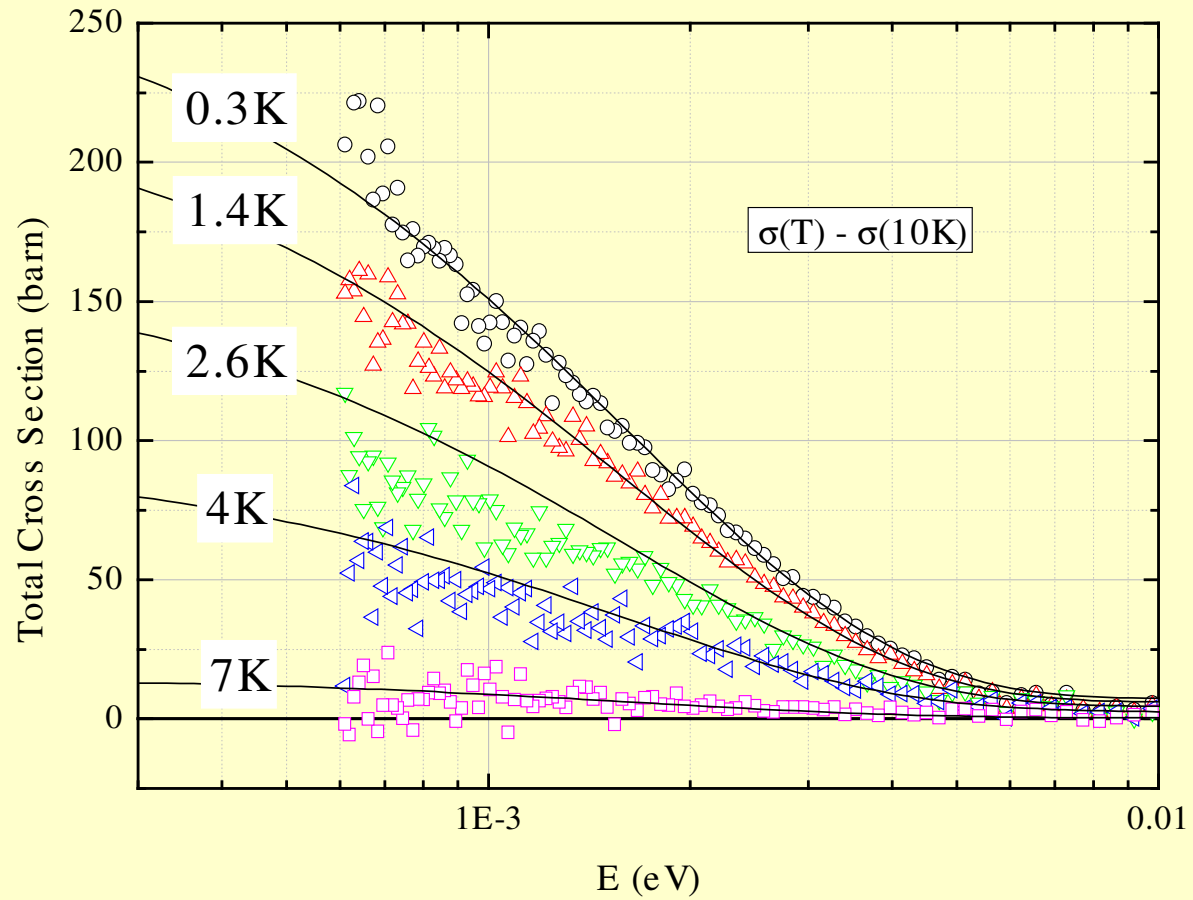
Light water and plexiglass
at room temperature





TOTAL CROSS SECTIONS

Solid Methane in phase II



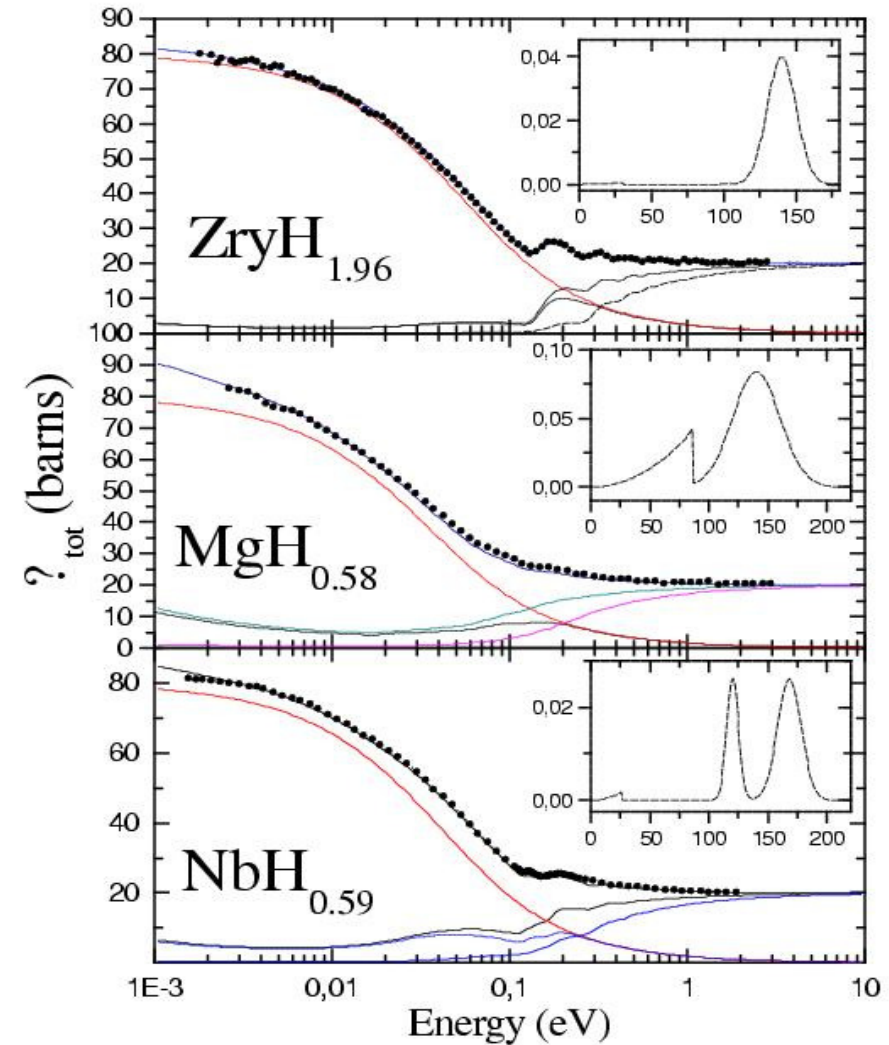


We showed that **dynamic information** can be obtained from total cross-section measurements, and a method was introduced to obtain the density of states (DOS) from the incoherent part of the inelastic total cross section.

Frequency Spectra Derived from Total X-Sections

Total and its Elastic and Inelastic
Cross Sections.

Inelastic component is separated
in one-phonon and multiphonon
contributions.

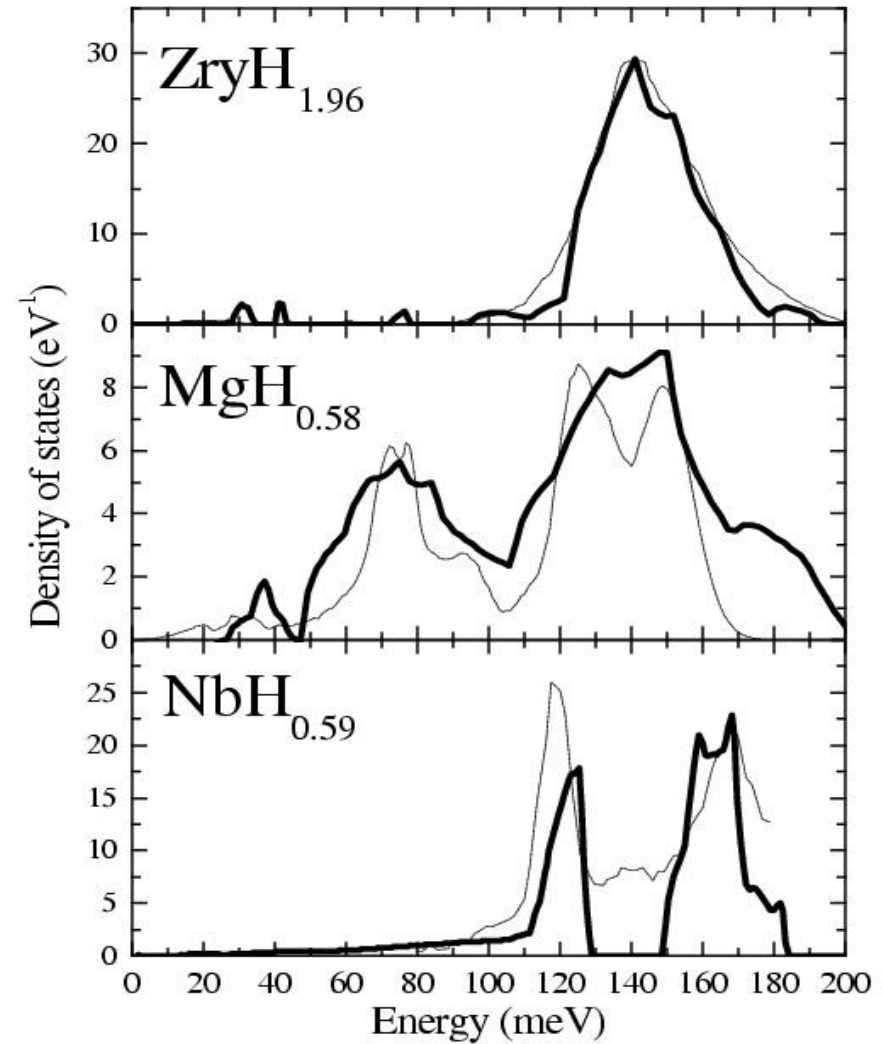


Frequency Spectra Derived from Total X-Sections

Frequency Spectra.

Comparison between those
derived from Total X-Section and
from Inelastic measurements

Physica **B 271**, 212 (1999)

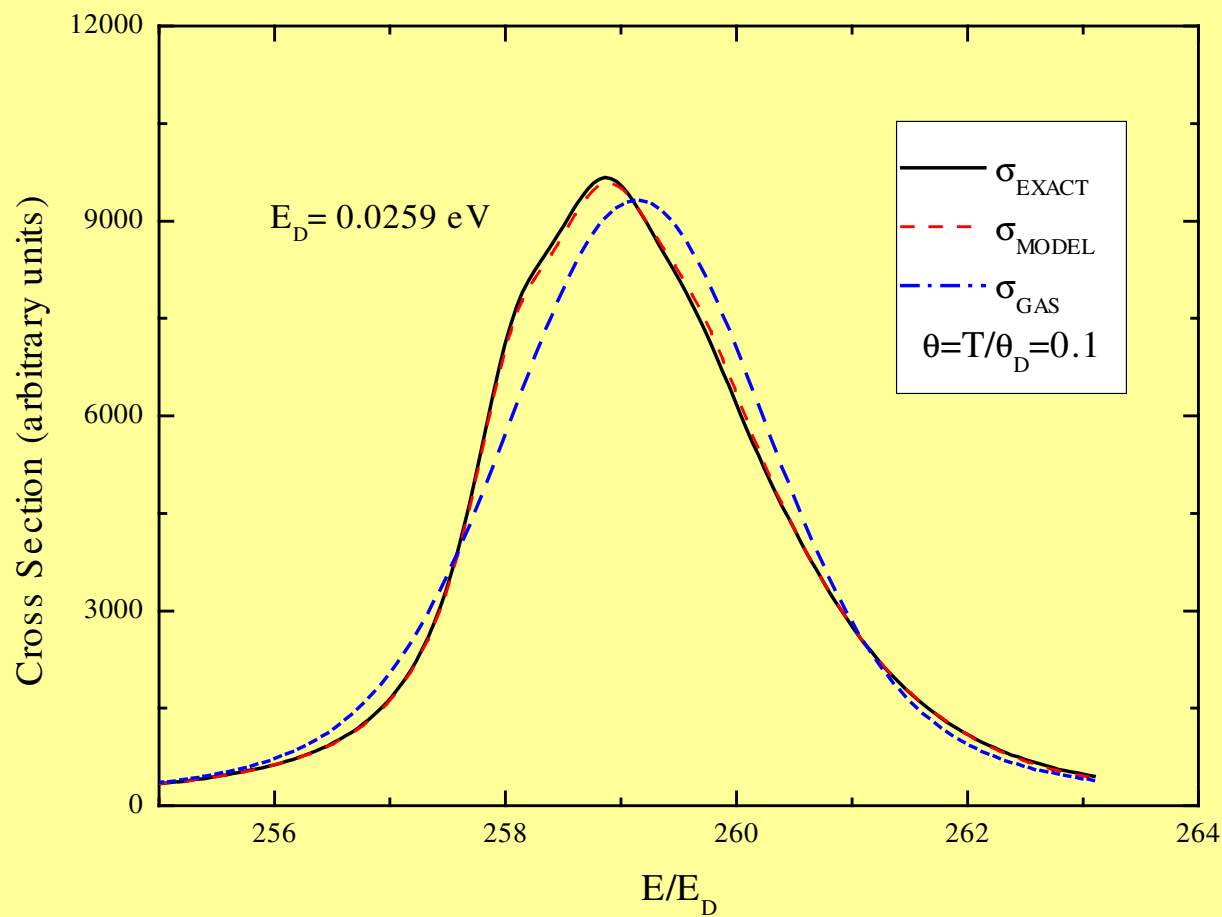




The development of accurate yet simple algorithms to describe **Doppler broadening** effects on the natural line-width, able to cover the whole range of energies and temperatures, can be applied to the field of **thermometry**, improving and extending to the low temperature range the predictions that can be made with the use of the traditional effective temperature gas model.

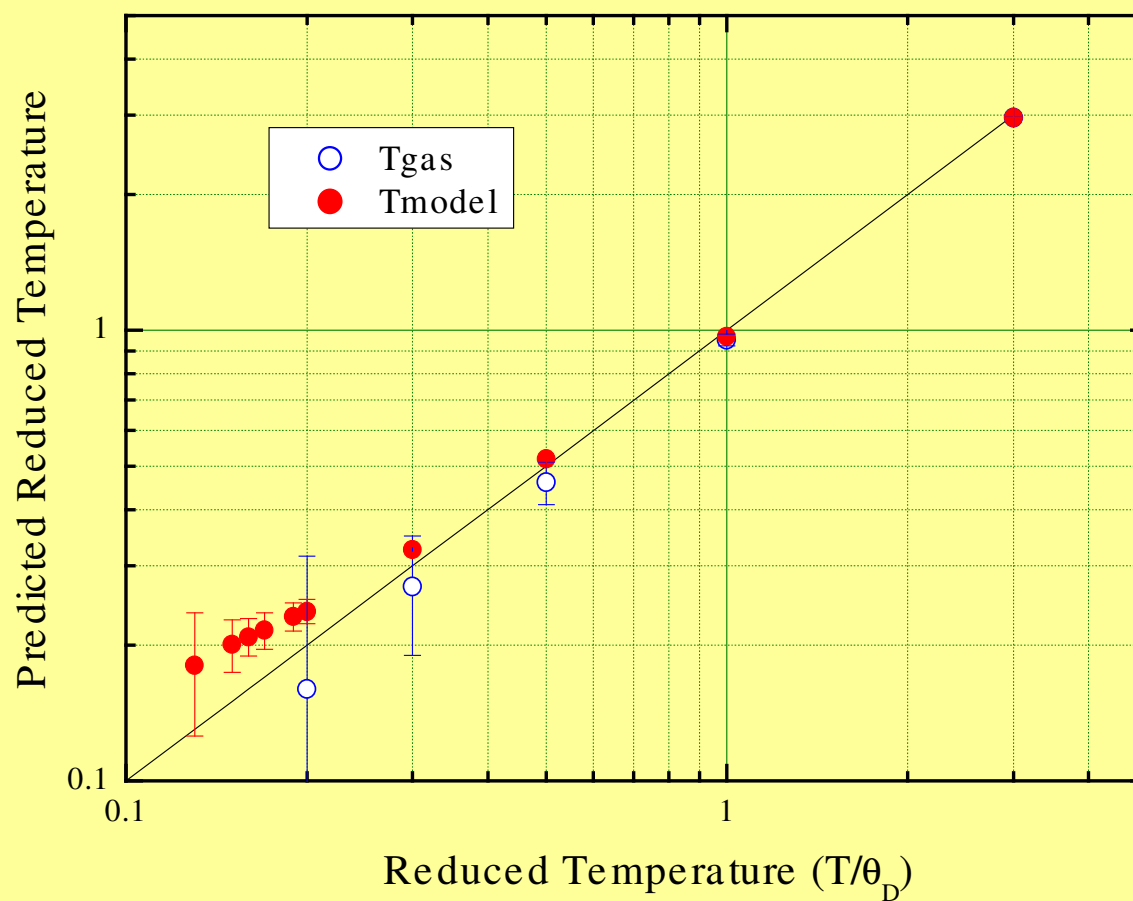


Effective cross section calculated with our model (σ_{MODEL}),
with all the phononic contributions (σ_{EXACT}) and with the effective temperature gas model (σ_{GAS})



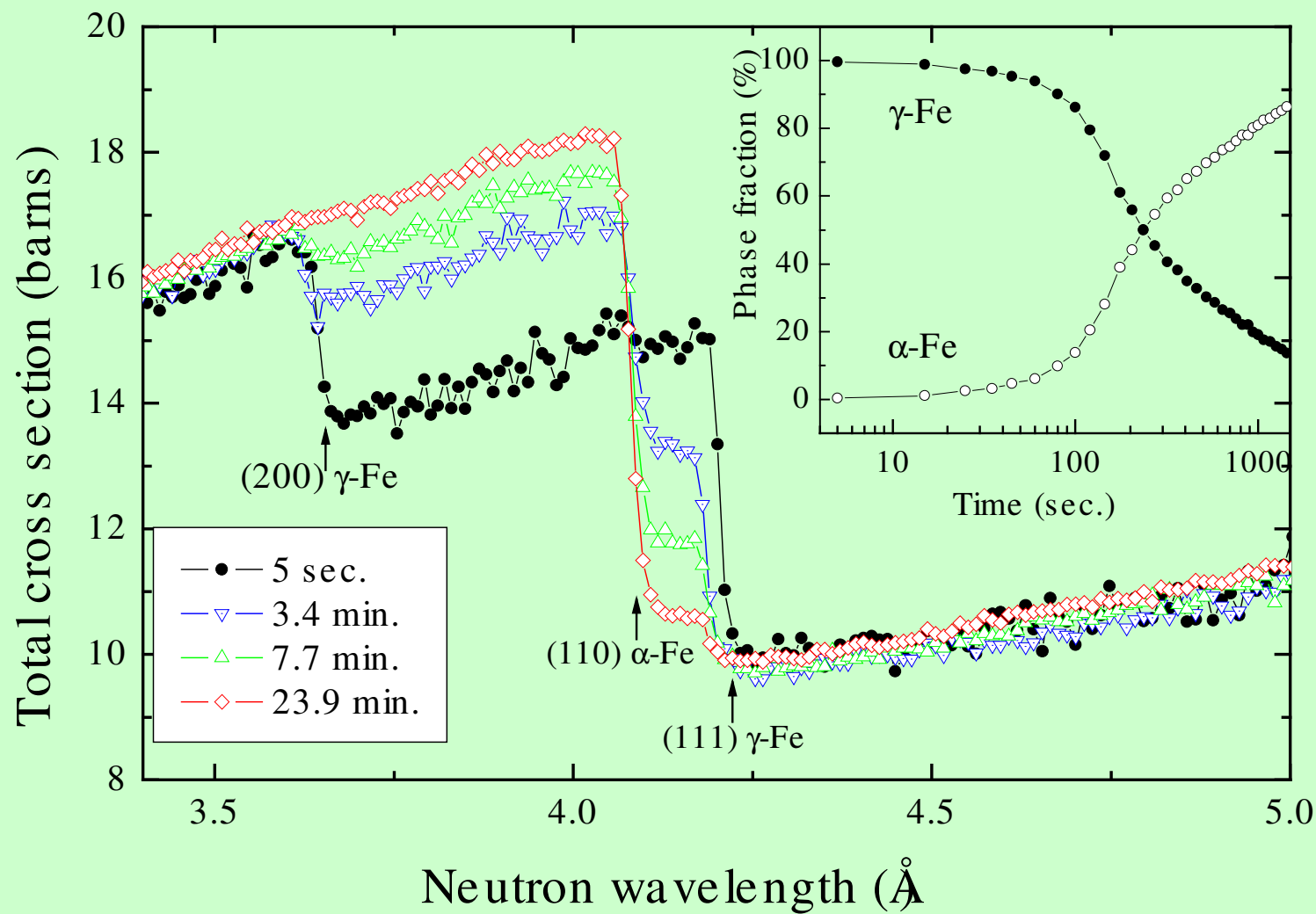


Temperature prediction of our model (T_{model}) and of the effective temperature gas model (T_{gas}) fitting the exact numerical calculation.





Total cross section of EN24 steel at 380°C after austenisation at 830°C





FINAL REMARK

We wish to emphasize that although a low intensity pulsed neutron source is clearly not competitive with an accelerator orders of magnitude more intense, for most of the possible applications, it is nevertheless very useful to test ideas and the ensuing methods born from the successful ones. This is particularly true for total cross section measurements.

MANY THANKS!



