EXFOR data in resonance region and spectrometer's response function

(Summary of the Consultants' Meeting,
8 – 10 October 2013, Vienna)

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EXFOR Compilation Workshop,
6 – 10 October 2014, Vienna

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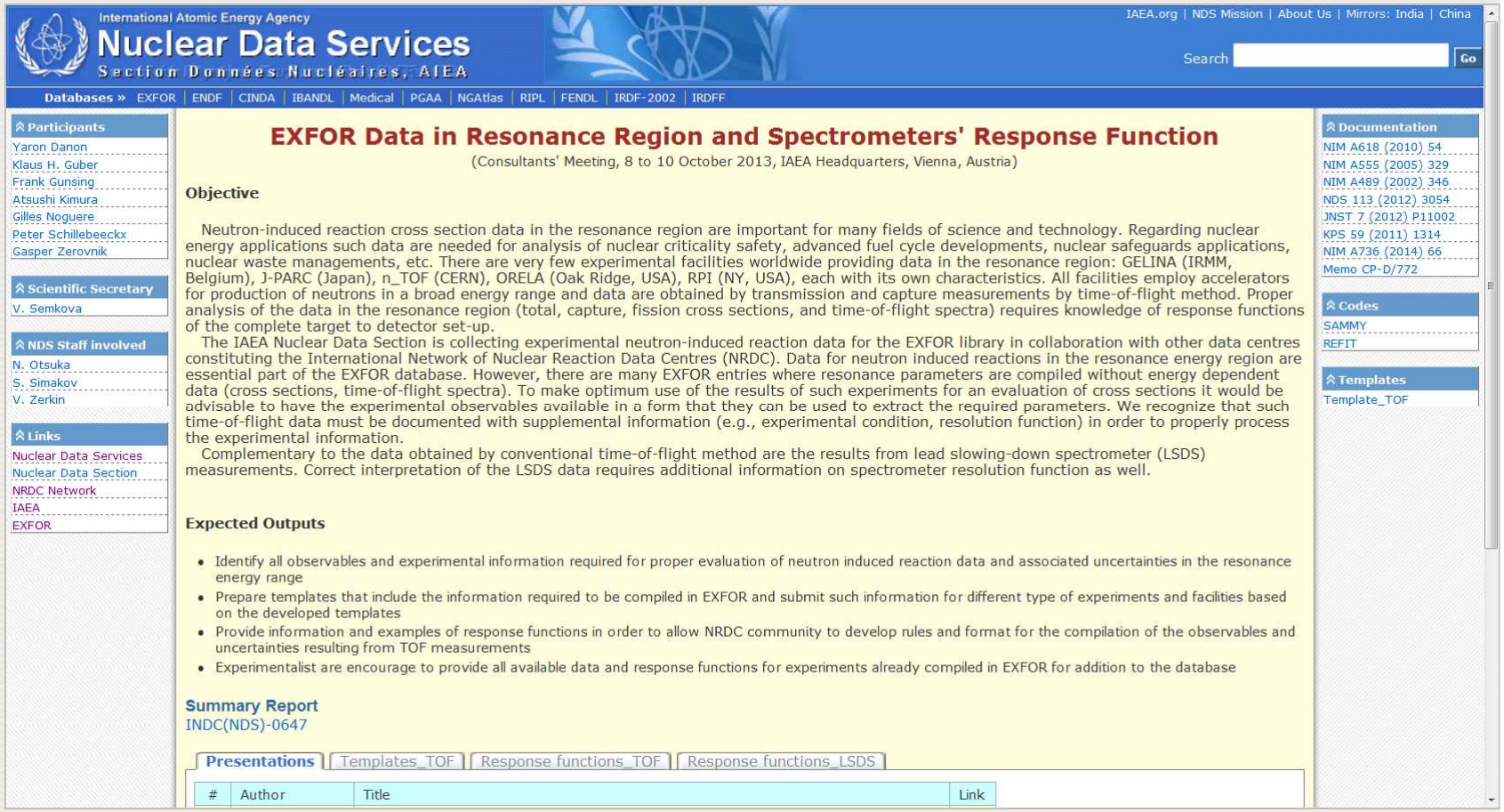
The webpage https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/ contains extensive collection of experimental information for neutron-induced reaction measurements by time-of-flight technique and corresponding EXFOR compilations.



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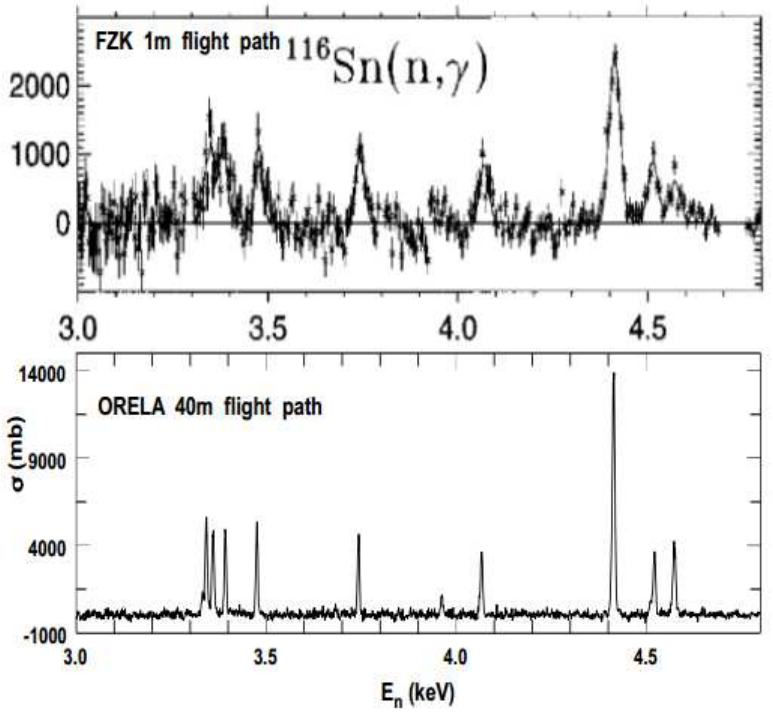
Differences between response functions have to be taken into account if the same quantity has been measured at different experimental facility.

https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/docs/Guber.pdf

Better S/N

- Measured using BaF_2 ball at FZK.
- Measured using C_6D_6 at ORELA.



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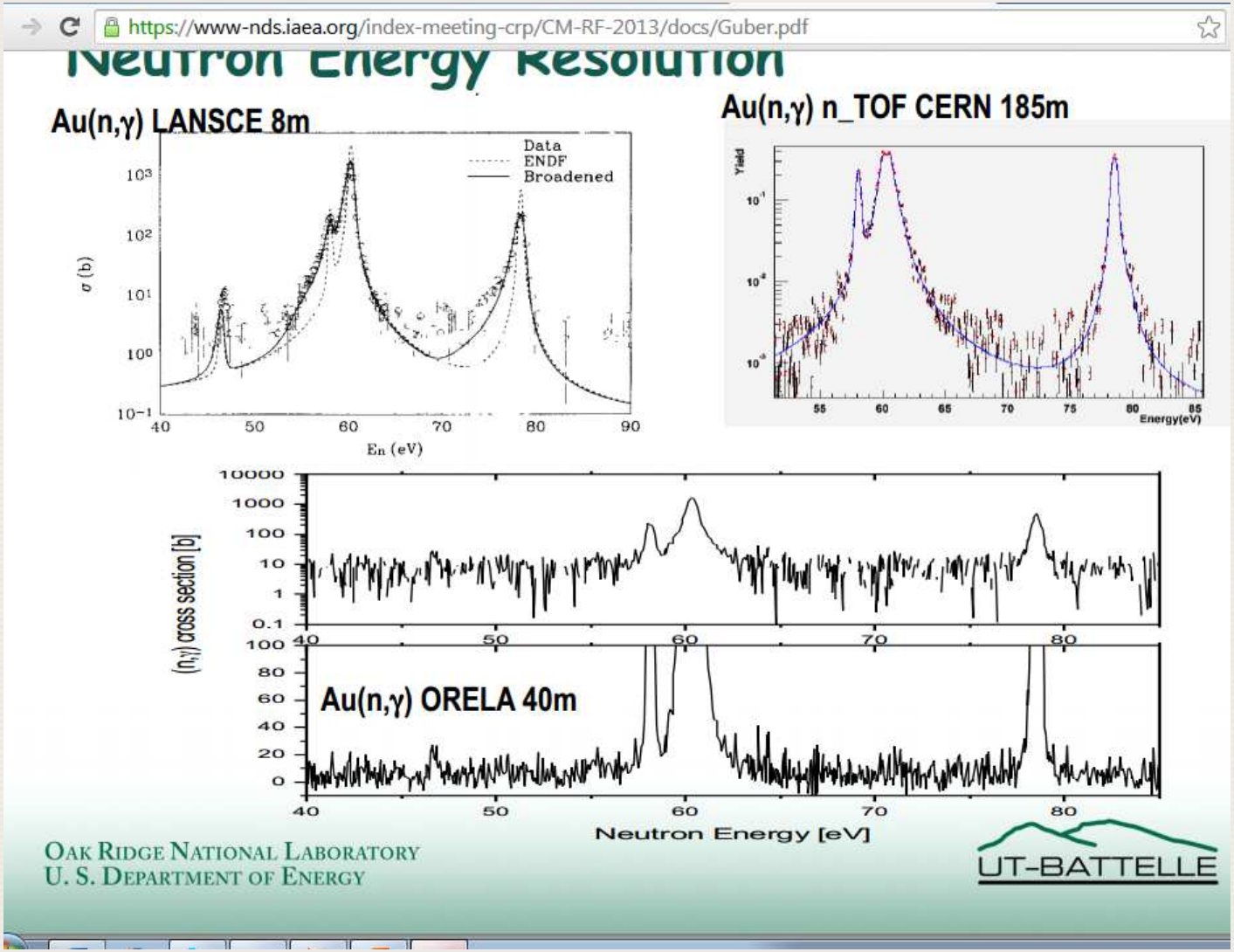
Resolution broadening have to be applied to the evaluated data in order to compare experimental data with an evaluation.



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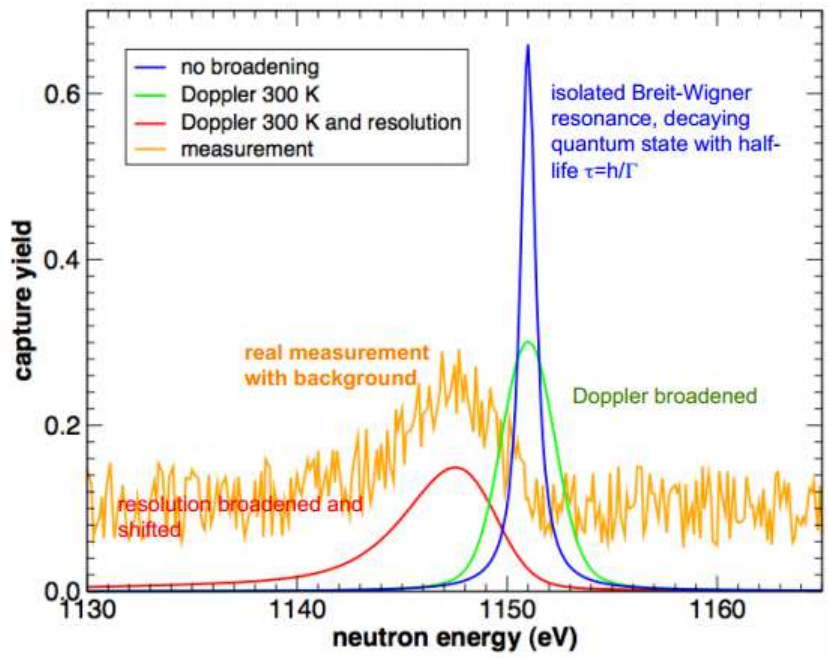
Broadening of isolated Breit-Wigner resonance due to different components

https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/docs/Gunsing.pdf

Broadening of ^{56}Fe 1.15 keV resonance



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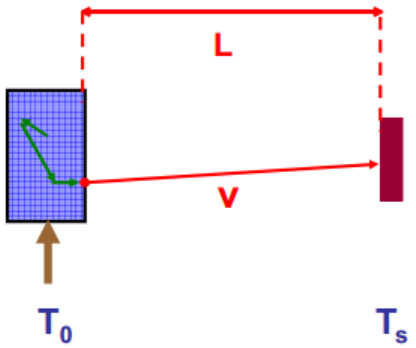
Schematic view of neutron interactions in TOF spectrometer

https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/docs/PSCHIL2.pdf

Response of TOF-spectrometer

$$v = \frac{L}{t} \quad \Rightarrow \quad E = m\,c^2(\gamma - 1)$$

$$\frac{\Delta v}{v} = \sqrt{\frac{\Delta t^2}{t^2} + \frac{\Delta L^2}{L^2}} \quad \Rightarrow \quad \frac{\Delta E}{E} = (\gamma + 1)\gamma \frac{\Delta v}{v}$$



- ΔL (~ 1 mm)
- Δt
  - Initial burst width ΔT_0
  - Time jitter detector & electronics ΔT_s
  - Neutron transport in target - moderator Δt_t
  - Neutron transport in detector Δt_d

$$t = t_m - (t_t + t_d)$$

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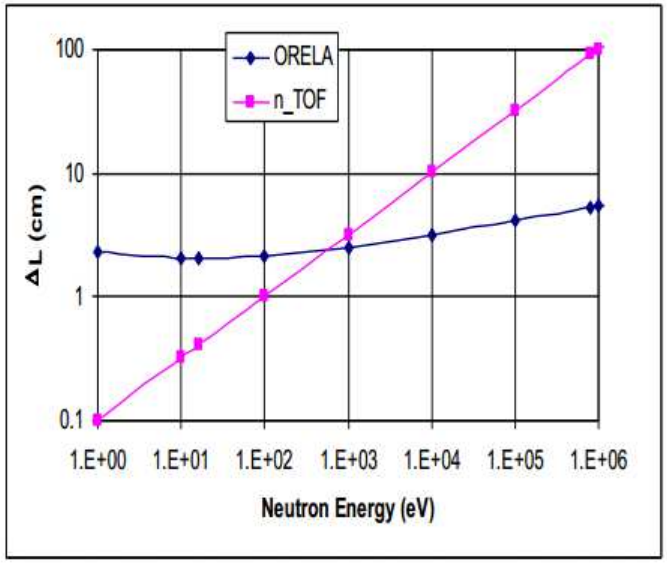
Resolution energy dependence in terms of neutron flight path

https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/docs/Guber.pdf

Average Moderation Distance



- Due to moderation the neutron flight path is energy dependent.

$$L(E) = L_0 + \Delta L$$

- n_TOF [cm]:

$$\Delta L = 0.101 \cdot \sqrt{E}$$

- ORELA [mm]:

$$\Delta L = 22.1 - 1.6 \cdot \ln E + 0.283 \cdot (\ln E)^2$$

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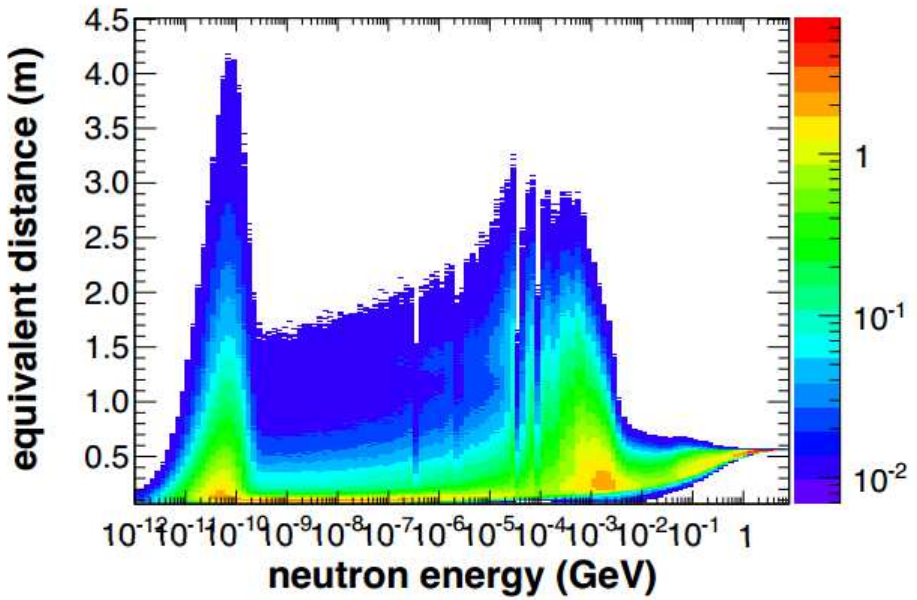
https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/docs/Gunsing.pdf

n_TOF CERN: Simulated resolution function



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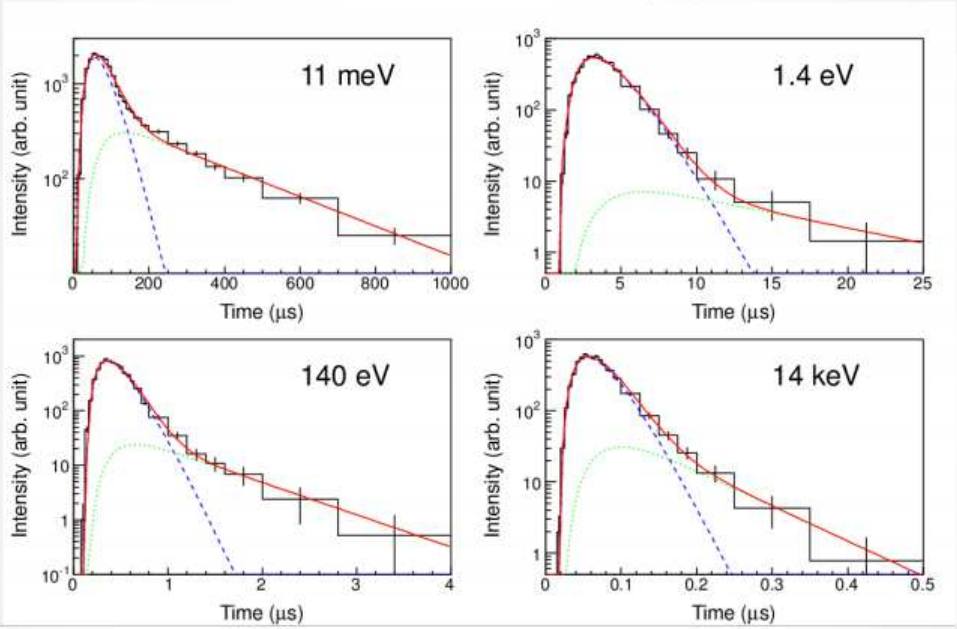
~ Resolution Function(1)~

By Dr. Kino



The resolution function was obtained by simulating neutron pulse shapes with a Monte-Carlo simulation code, PHITS.

The solid lines are fitted "Ikeda-Carpenter function".

The dashed and dotted lines are the slowing-down and storage terms, respectively.

- $\frac{\alpha}{2}\left\{(1-R)(\alpha t)^2 e^{-\alpha t} + 2R\frac{\alpha^2\beta}{(\alpha-\beta)^3}\left[e^{-\beta t} - e^{-\alpha t}\left(1+(\alpha-\beta)t+\frac{1}{2}(\alpha-\beta)^2 t^2\right)\right]\right\}$

K.Kino et. al.,、Nucl.Instr.Meth. A、to be published.

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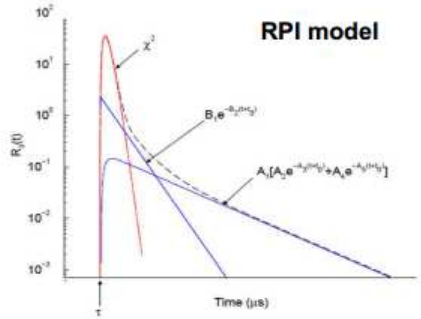
Fitting parameters for the resolution functions of different experiments have been recently provided to EXFOR and compiled.

https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/docs/Noguere.pdf

Nuclear data codes capabilities

For the **target-moderator assembly,** the SAMMY code provide analytic models for the ORELA, RPI and nTOF facilities. The RPI and nTOF facilities share the same analytic model (extension of the RPI model proposed by Frank Gunsing)



The REFIT and CONRAD codes provide a set of analytic models able to describe each contributions

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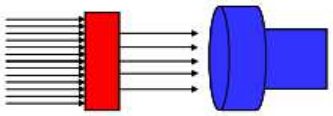
For the compilation of capture cross sections the following comment from F.H.Froehner (20370) should to be taken into account:

“Capture cross section data are capture yields divided by sample thickness (atom/b), equal to true cross section only where effects of sample thickness (self- shielding, multiple collisions) and resolution are negligible.”

https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/docs/PSCHIL1.pdf

Experimental observables

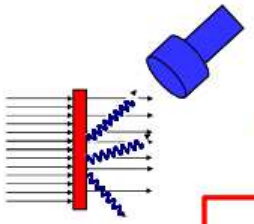
Transmission



$$T_{exp} = N \frac{C'_{in} - B'_{in}}{C'_{out} - B'_{out}}$$

$$T_m \propto e^{-n x \sigma_{tot}}$$

Reaction cross section



$$C = \varepsilon_r \, \Omega_r \, F_r \, Y_r \, A_r \, \varphi$$

$$Y_{exp} = N \frac{Y_\varphi}{\varepsilon_r} \frac{C'_w - B'_w}{C'_\varphi - B'_\varphi}$$

$$Y_m \propto \frac{\sigma_r}{\sigma_{tot}} (1 - e^{-n x \sigma_{tot}}) + \ldots$$

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Recommendations of the Consultants' Meeting for NDS of IAEA, NRDC and EXFOR compilers

- Set up and maintain a repository where information on response functions of different facilities can be collected.
- No constraints on the format of response and resolution function should be given, but an implementation in existing codes (e.g., CONRAD, REFIT, SAMMY) could be supplied when possible.
- The repository should foresee support for 2-dimensional histograms to report numerical response functions $R(t_m,E_n)$ (or in equivalent distance) as a function of time-of-flight and real neutron energy.
- NDS should inform the NRDC Network about decisions of the meeting in order to establish rules for compilation of all information relevant to the spectrometers' response function.
- Compilers should send a request to authors to provide information according to the template and include all data in the compilation of the experiment.

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