

EXFOR data in resonance region and spectrometer's response function

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

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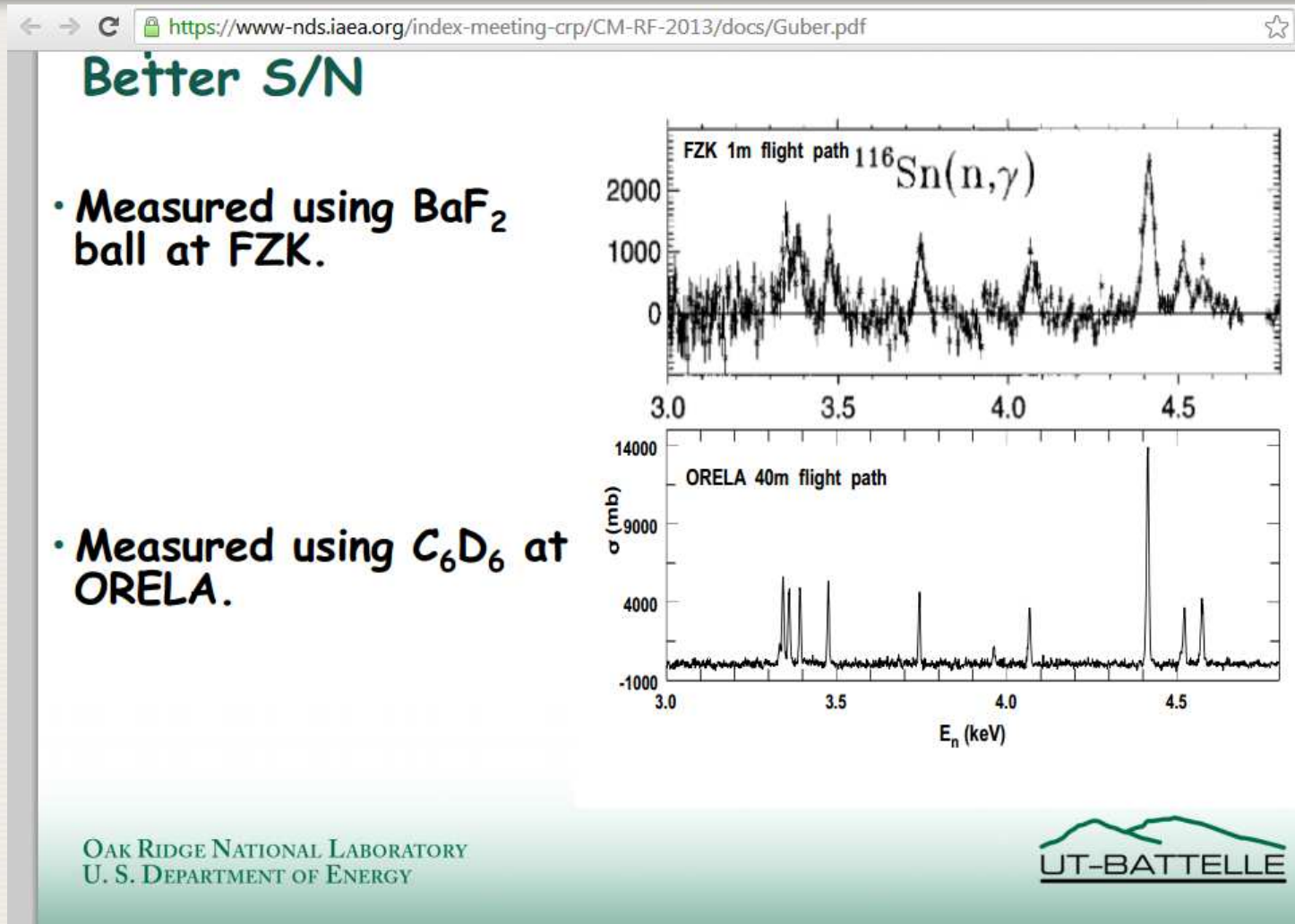
IAEA

International Atomic Energy Agency

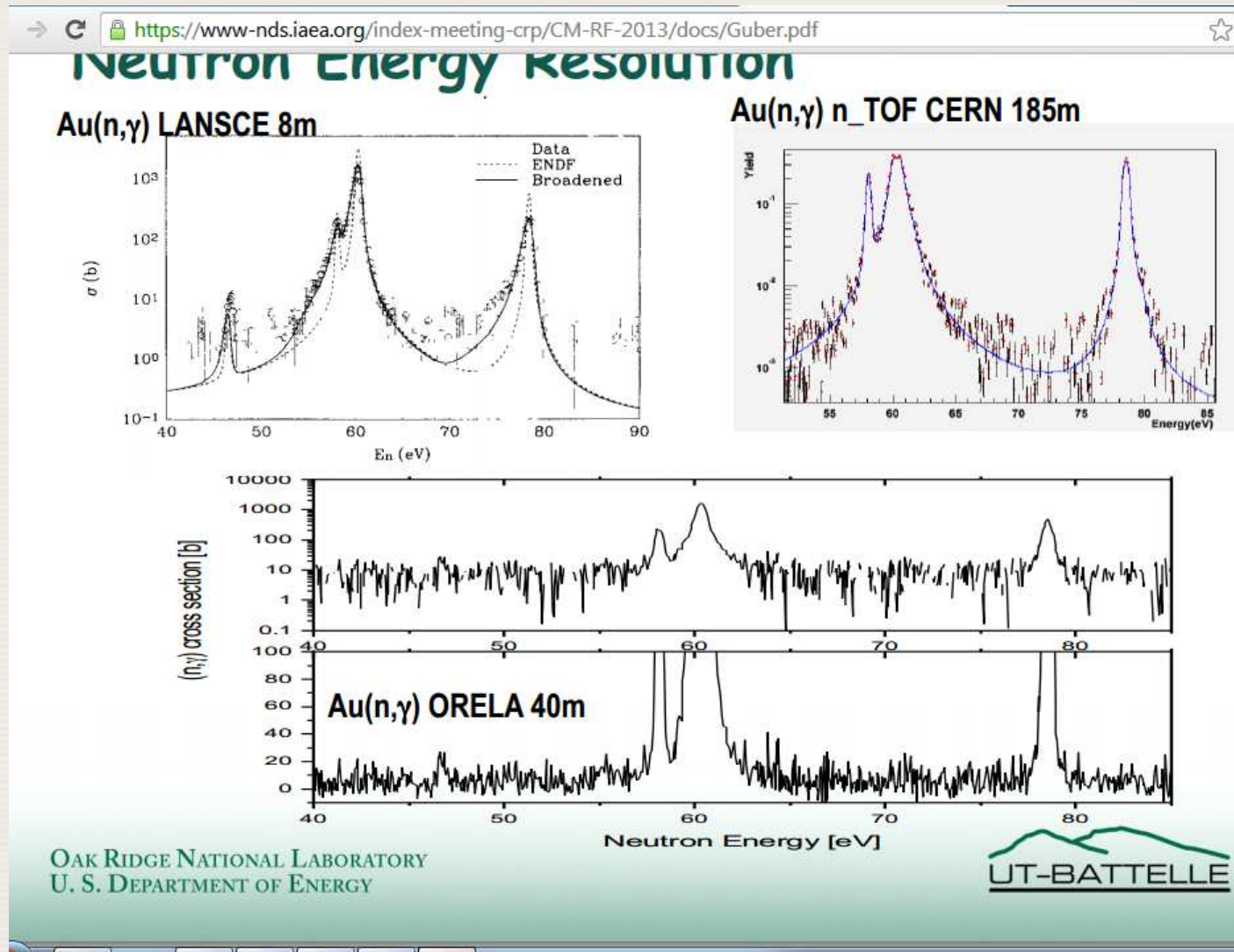
The webpage <https://www-nds.iaea.org/index-meeting-crp/CM-RF-2013/> contains extensive collection of experimental information for neutron-induced reaction measurements by time-of-flight technique and corresponding EXFOR compilations.

The screenshot shows the Nuclear Data Services website interface. At the top, there is a navigation bar with the IAEA logo and the text 'International Atomic Energy Agency Nuclear Data Services'. Below this is a search bar and a menu of databases including EXFOR, ENDF, CINDA, IBANDL, Medical, PGAA, NGAtlas, RIPL, FENDL, IRDF-2002, and IRDF. The main content area is titled 'EXFOR Data in Resonance Region and Spectrometers' Response Function' and includes a sub-header '(Consultants' Meeting, 8 to 10 October 2013, IAEA Headquarters, Vienna, Austria)'. The page is divided into several sections: 'Objective', 'Expected Outputs', and 'Summary Report'. The 'Objective' section discusses the importance of neutron-induced reaction cross section data in the resonance region and the role of the EXFOR library. The 'Expected Outputs' section lists four key tasks: identifying observables, preparing templates, providing response function examples, and encouraging data submission. The 'Summary Report' section identifies the report as INDC(NDS)-0647. On the left side, there are navigation menus for 'Participants', 'Scientific Secretary', 'NDS Staff involved', and 'Links'. On the right side, there are menus for 'Documentation', 'Codes', and 'Templates'. The 'Documentation' menu lists various reports such as NIM A618 (2010) 54, NIM A555 (2005) 329, and NIM A489 (2002) 346. The 'Codes' menu lists SAMMY and REFIT. The 'Templates' menu lists Template_TOF.

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



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

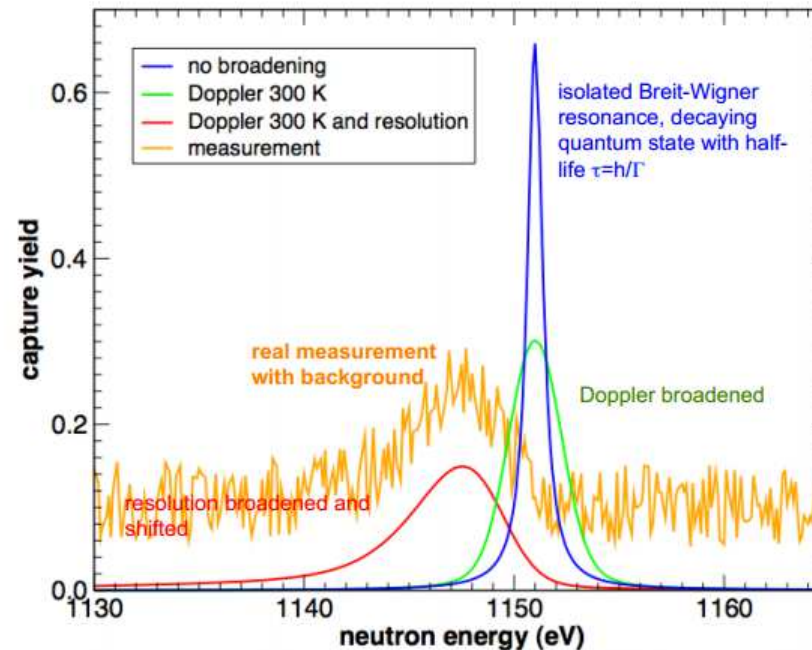


Broadening of isolated Breit-Wigner resonance due to different components

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



Broadening of ^{56}Fe 1.15 keV resonance



Frank Gunsing, CEA/Saclay

CM IAEA, Vienna, 2013-10-7, EXFOR and RF

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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

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

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

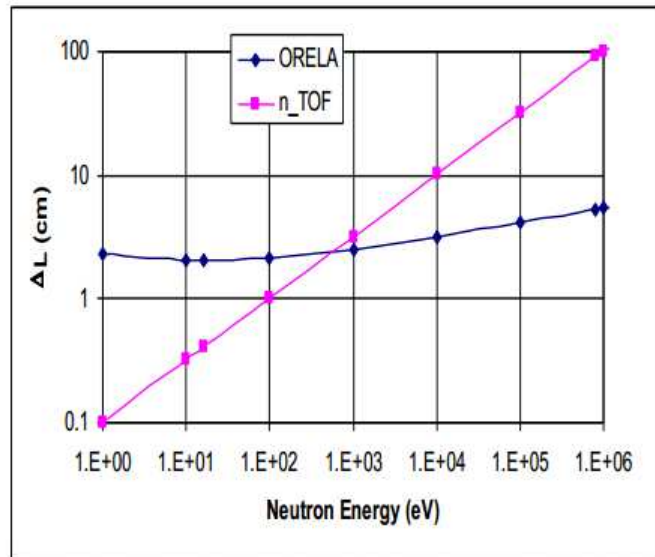
- ΔL (~ 1 mm)
- Δt
 - Initial burst width ΔT_0
 - Time jitter detector & electronics ΔT_s
 - Neutron transport in target - moderator Δt_t
 - Neutron transport in detector Δt_d

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

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]:

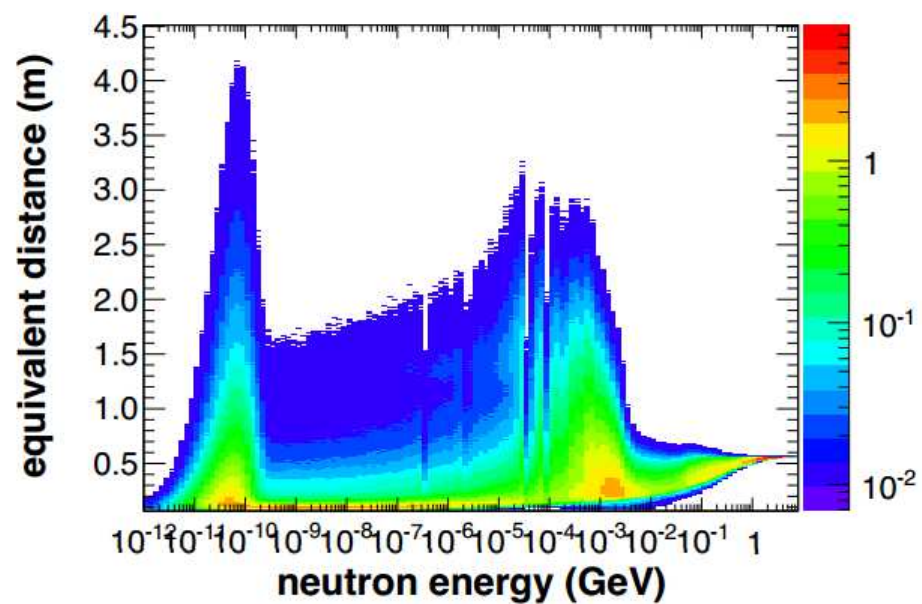
$$\Delta L = 0.101 \cdot \sqrt{E}$$

- ORELA [mm]:

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

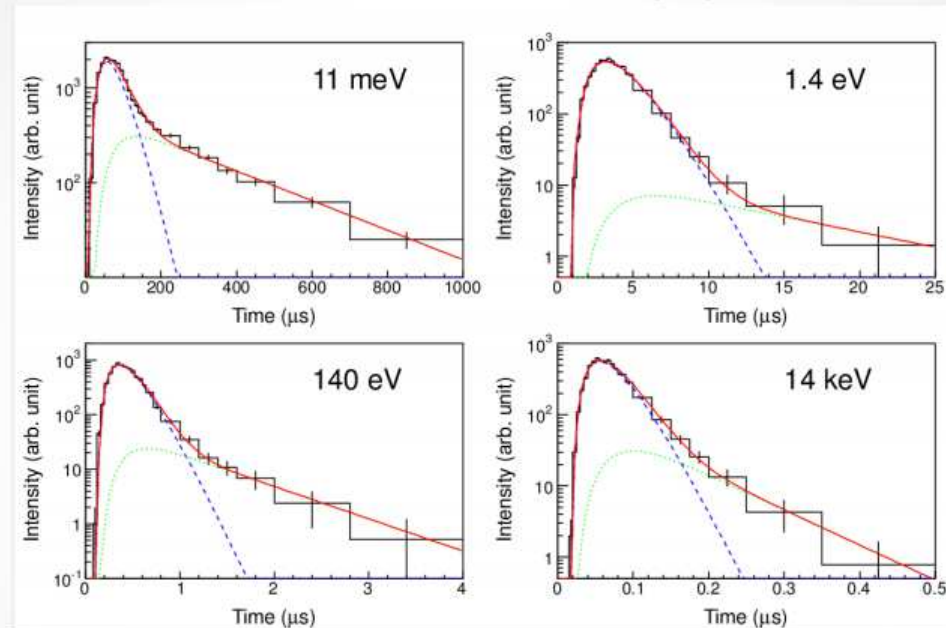


n_TOF CERN: Simulated resolution function



~ 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.

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

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

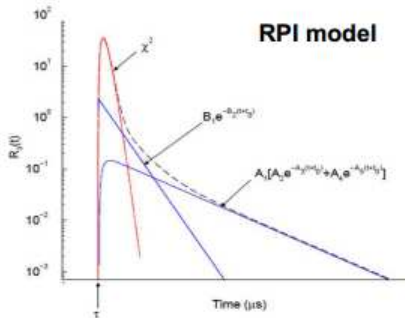
Fitting parameters for the resolution functions of different experiments have been recently provided to EXFOR and compiled.

<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 Gusing)

RPI model



The graph shows the resolution function $R_p(t)$ on a logarithmic y-axis (from 10^{-3} to 10^2) versus Time (μs) on a linear x-axis. A vertical line marks time t . Three curves are shown: a red curve labeled χ^2 peaking at t ; a blue curve labeled $B \cdot e^{-B_p(t)/\tau_p}$ decaying from t ; and a purple curve labeled $A \cdot [A_p \cdot e^{-A_p(t)/\tau_p} + A_n \cdot e^{-A_n(t)/\tau_n}]$ which is the sum of two decaying exponentials.

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

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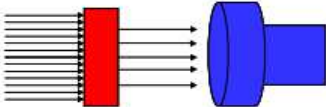
For the compilation of capture cross sections the following comment from F.H.Froehner (20370) should to be taken into account:

“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

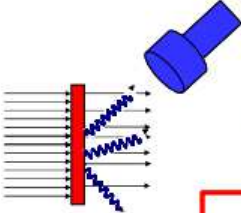
Transmission



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

$$T_m \propto e^{-n_x \sigma_{\text{tot}}}$$

Reaction cross section



$$C = \varepsilon_r \Omega_r F_r Y_r A_r \phi$$

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

$$Y_m \propto \frac{\sigma_r}{\sigma_{\text{tot}}} (1 - e^{-n_x \sigma_{\text{tot}}}) + \dots$$

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.