New measurement of the ^{62}Ni(n,γ) cross-section with n_TOF at CERN

Claudia Lederer

VERA-Laboratory, Faculty of Physics, University of Vienna

E. Berthoumieux, M. Calviani, D. Cano-Ott, N. Colonna, I. Dillmann, C. Domingo-Pardo, G. Giubrone, C. Guerrero, F. Gunsing, M. Heil, F. Käppeler, H. Leeb, C. Massimi, A. Mengoni, J.L. Tain, V. Vlachoudis, A. Wallner,

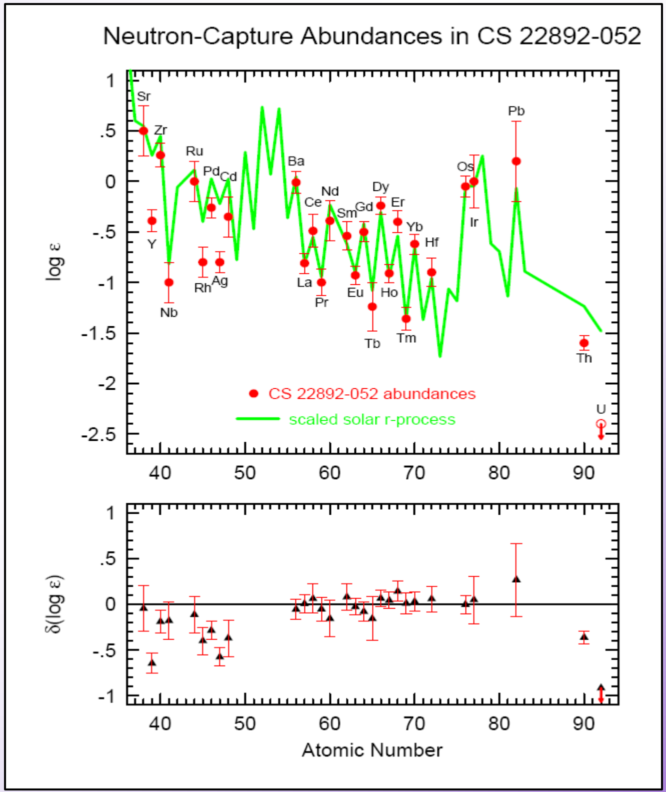
and the **n_TOF Collaboration**

Motivation

Observation of old halo star CS22892-052:

- A>120: scales with solar r-residuals
- A<120: systematically lower

(Sneden et al.)



Sneden at al. APJ533 (2000)

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n_TOF

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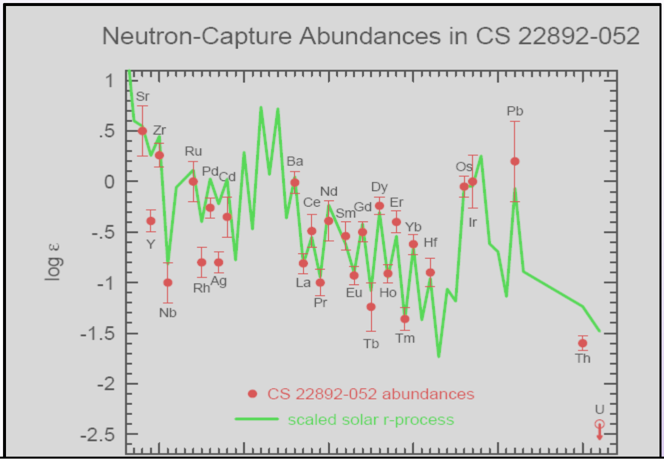
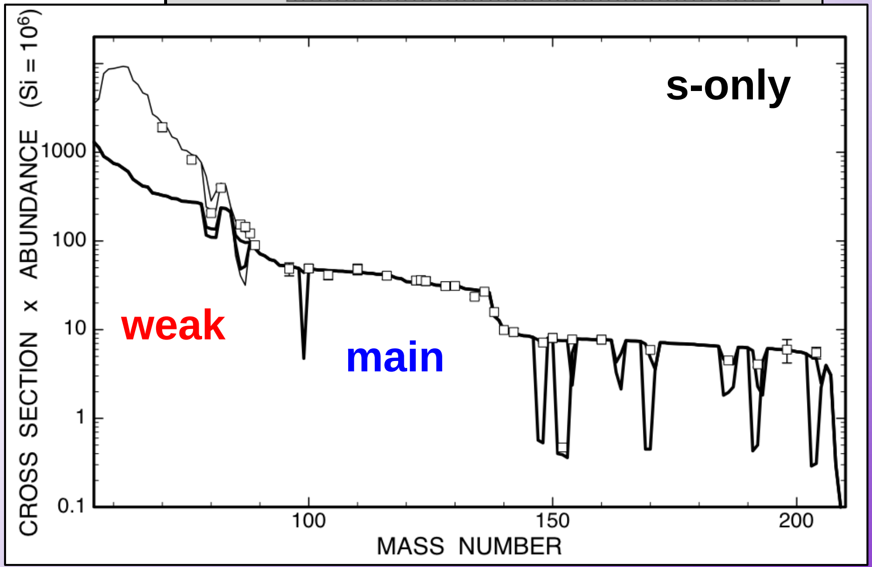


- determination of r-process residuals via

$$N_r = N_{\odot} - N_s$$

2 components in s-process:

- main s-process: $N\sigma_{n,\gamma}$=const.
- weak s-process (A<90): no equilibrium



F. Käppeler, Prog. Part. Nucl. Phys. 43 (1999)

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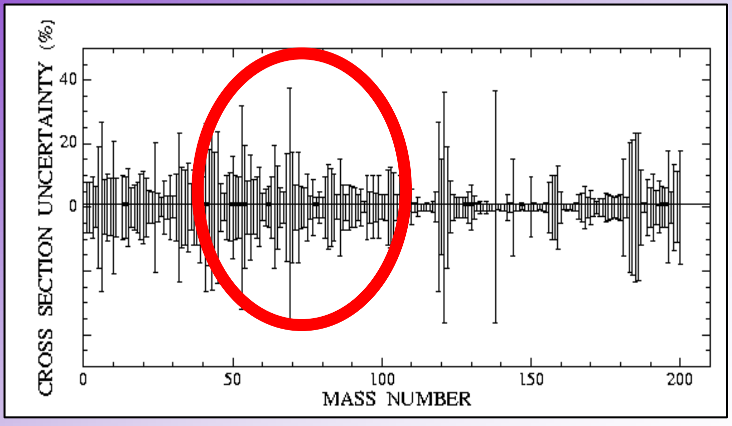

Bao et al. (2000)

High uncertainties of (n,γ) cross-sections in medium mass region directly enter into r-process calculations.

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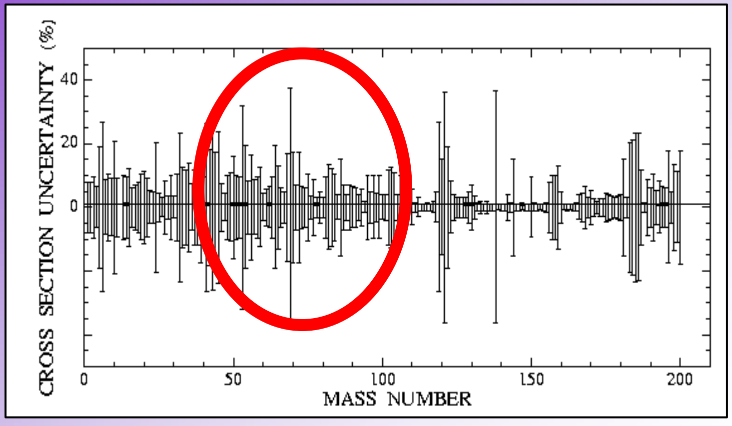

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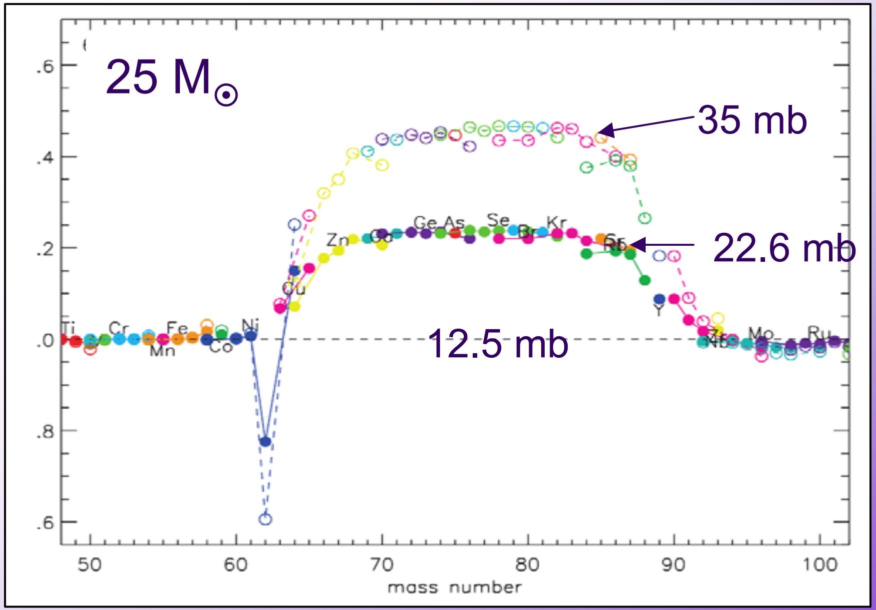

Nassar et al. (2005)

Neutron capture cross-section of ^{62}Ni influences abundance of following isotopes up to A=90 !

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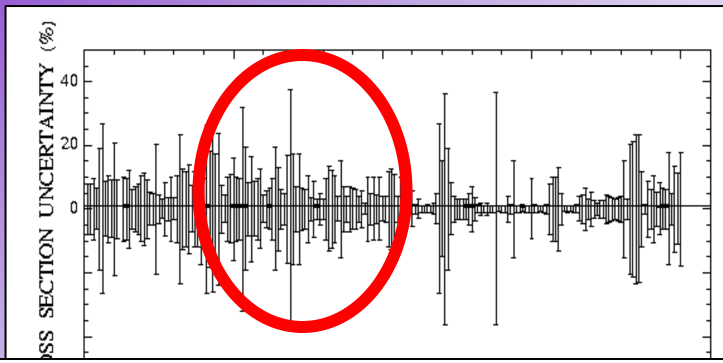

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Campaign to measure capture cross-sections of all stable isotopes of Fe and Ni at n_TOF

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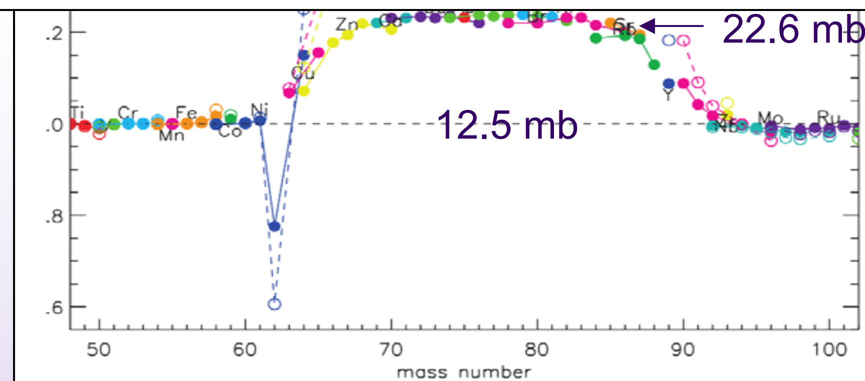

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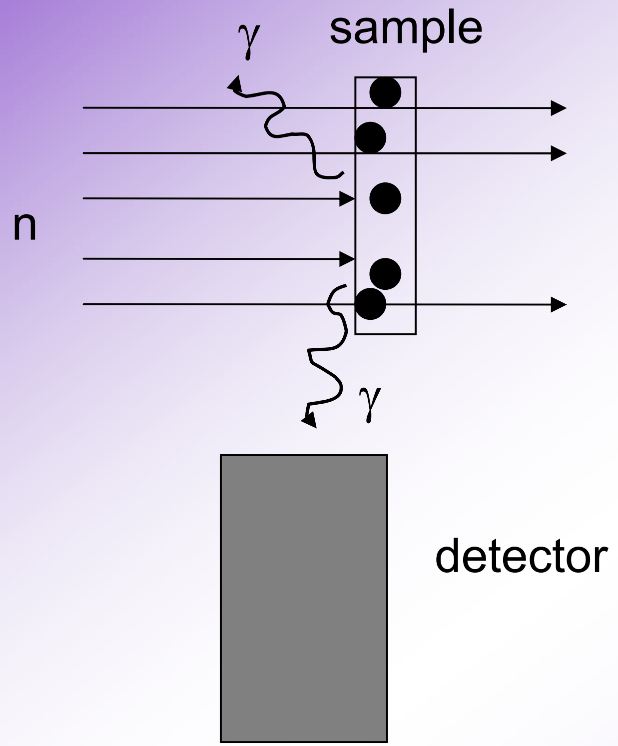
How to measure capture cross-section?



$^{62}Ni + n \rightarrow {}^{63}Ni^{*} \rightarrow {}^{63}Ni + \gamma$

Extract cross-section by determining **reaction-yield $Y_R(E_n)$**:

$$Y_R = \frac{C - B}{\varepsilon \cdot f \cdot \Phi}$$

$$Y_R \cong (1 - e^{-n\sigma_{tot}}) \frac{\sigma_R}{\sigma_{tot}}$$

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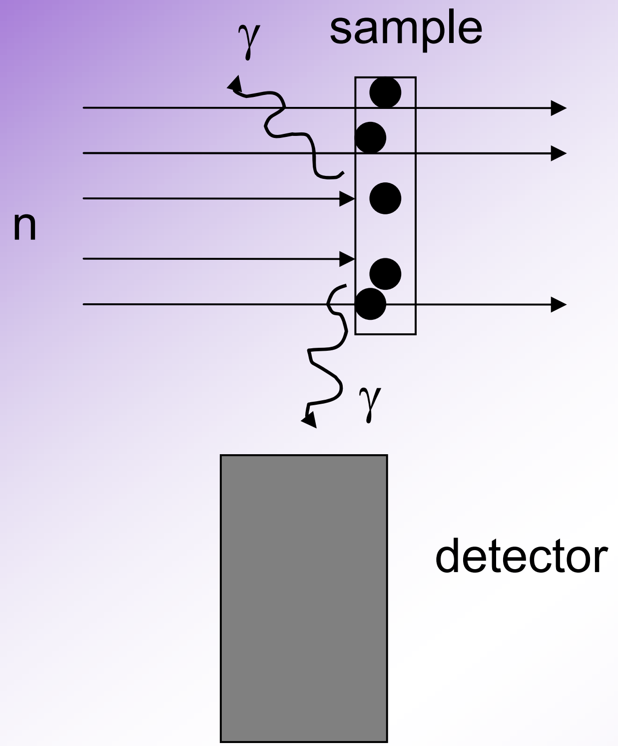

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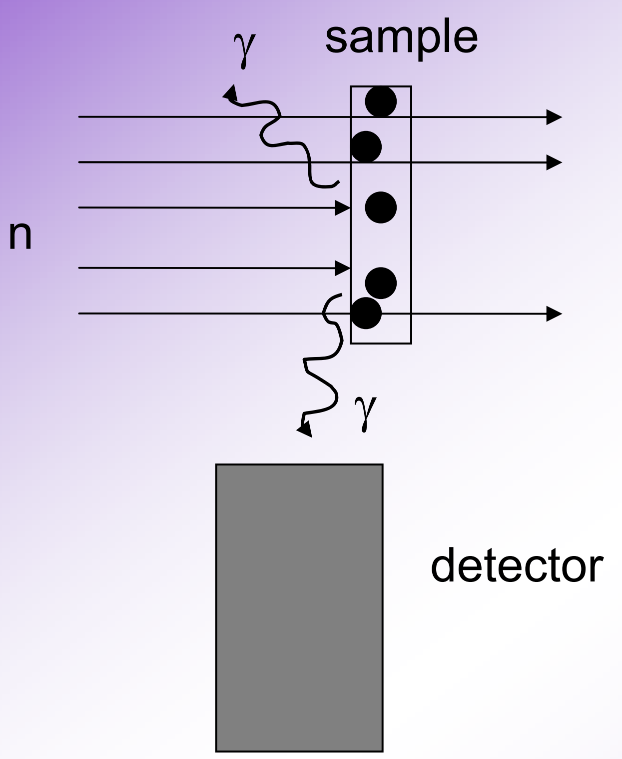

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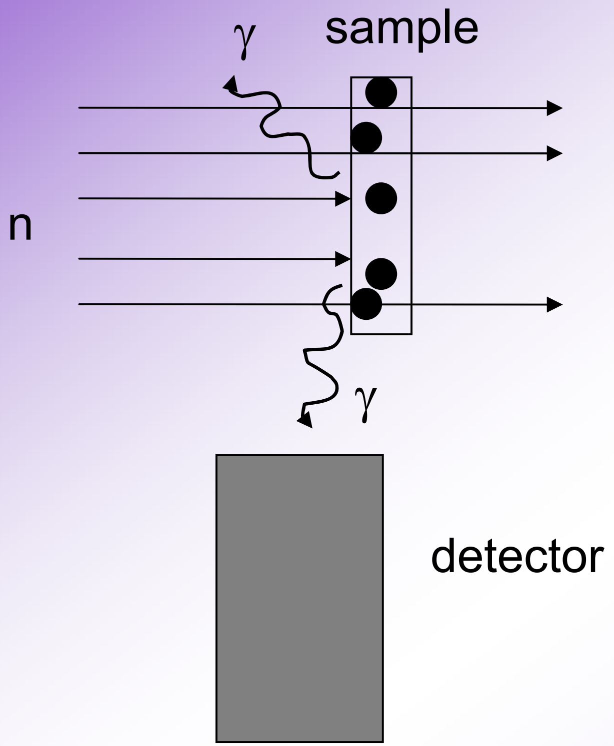

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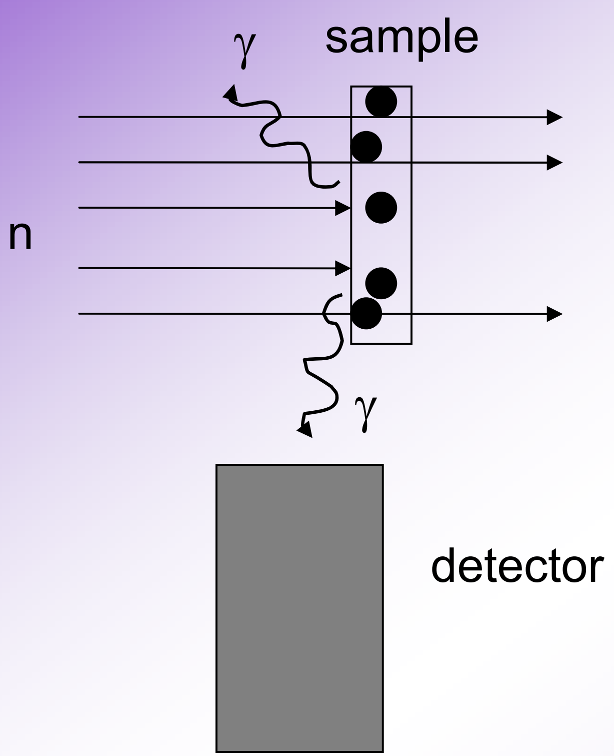

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n_TOF

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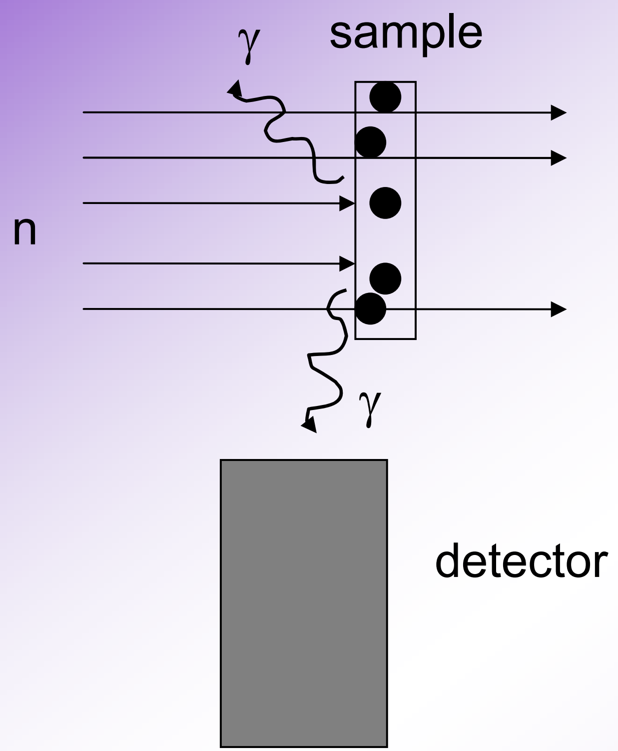

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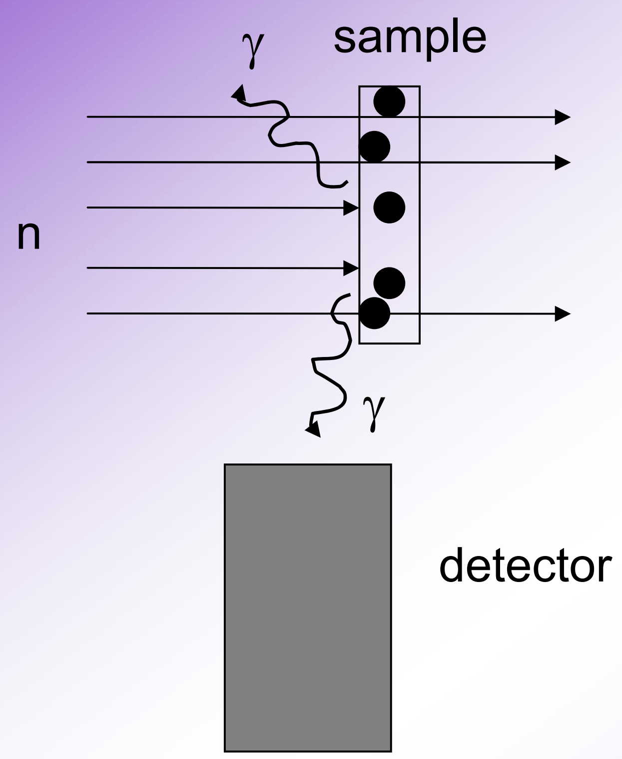

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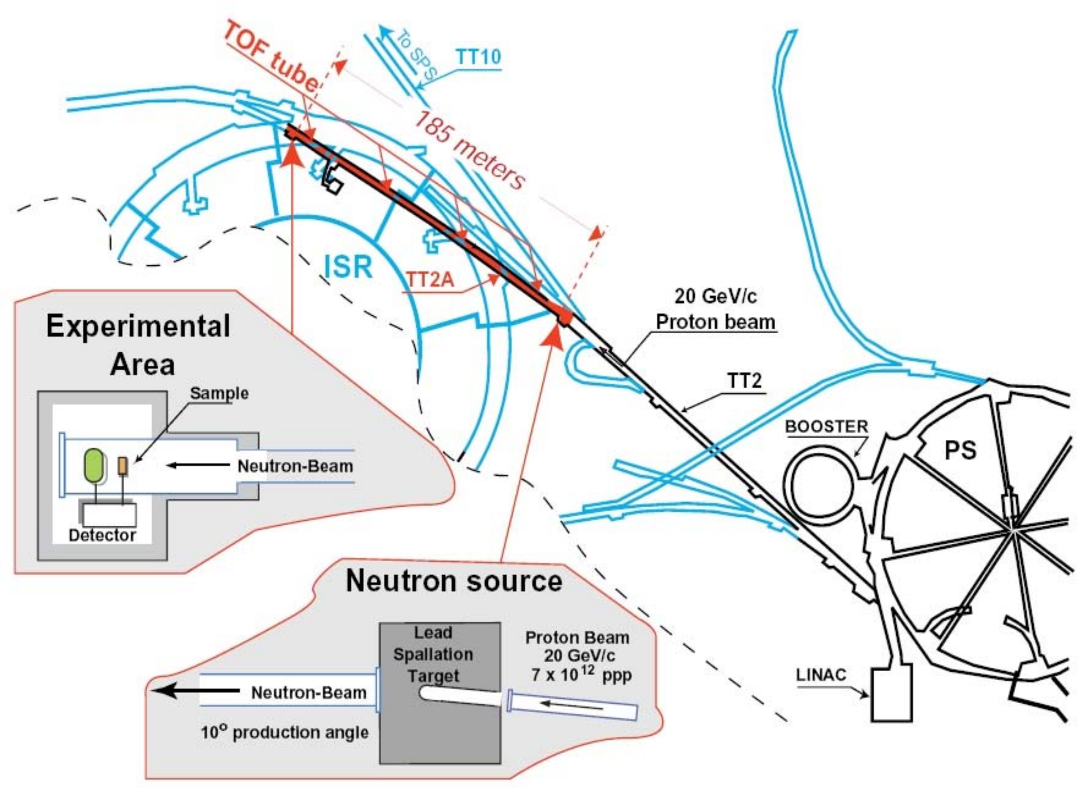
Φ....neutron flux → neutron detectors

B....background → dedicated runs

Experimental setup: n_TOF facility at CERN



20 GeV/c protons on Pb-target

Pulse width: 7 ns

Intensity: $7 \cdot 10^{12}$ protons per pulse

Flight path: 185 m

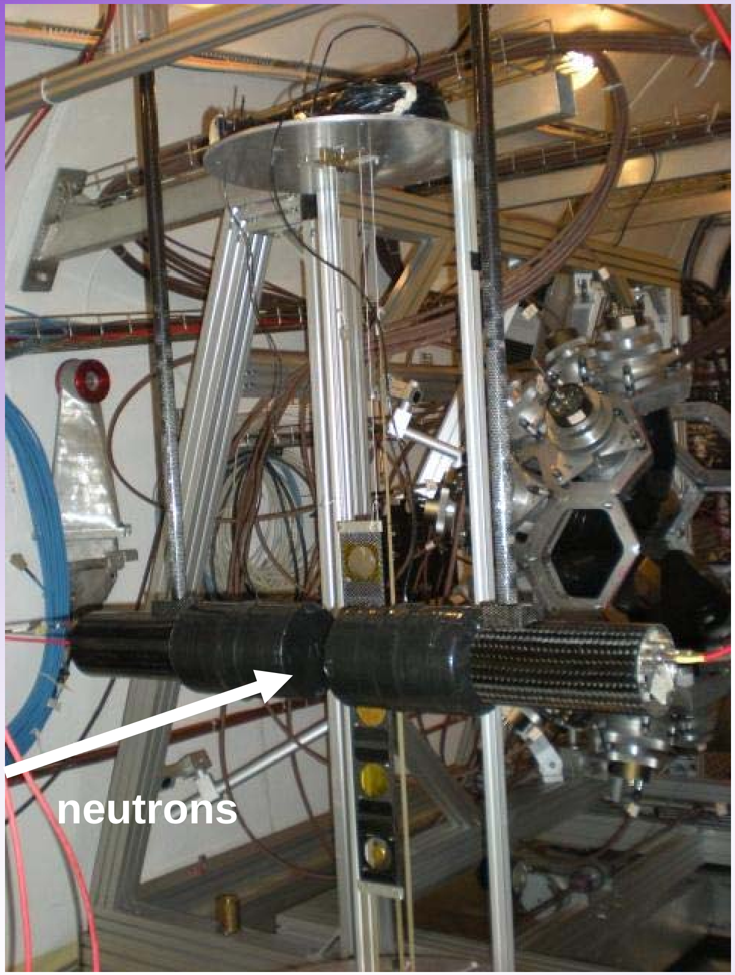
Neutron energy: 10^{-3}-10^{10} eV

Beam size at capture setup: Ø~4 cm

2 setups for capture measurements:

- total absorption calorimeter: 4π geometry (ε~100%)
- **two C_6D_6 detectors**

Experimental setup: n_TOF facility at CERN



C_6D_6 setup:

- detectors optimized for low neutron sensitivity ($\varepsilon_n/\varepsilon_\gamma$<$4\cdot10^{-5}$) [Plag et al., 2002]
- remotely controllable sample exchanger

Samples for ^{62}Ni measurement:

- enriched Ni pellet; 2 cm Ø; 2 g

	^{58}Ni	^{60}Ni	^{61}Ni	**^{62}Ni**	^{64}Ni
sample (%)	0.005	0.035	0.91	**97.95**	1.1
natural (%)	68.08	26.22	1.14	3.63	0.93

- ^{197}Au, 2 cm Ø, 0.6 g
- ^{nat}Pb, 2 cm Ø, 0.3 g
- ^{nat}C, 2 cm Ø, 5 g

Background

Components

- Neutron scattering (< 200 eV)
- γ– scattering (200 eV – 200 keV)
- Inelastic neutron-scattering: limits higher neutron energy to about 1 MeV

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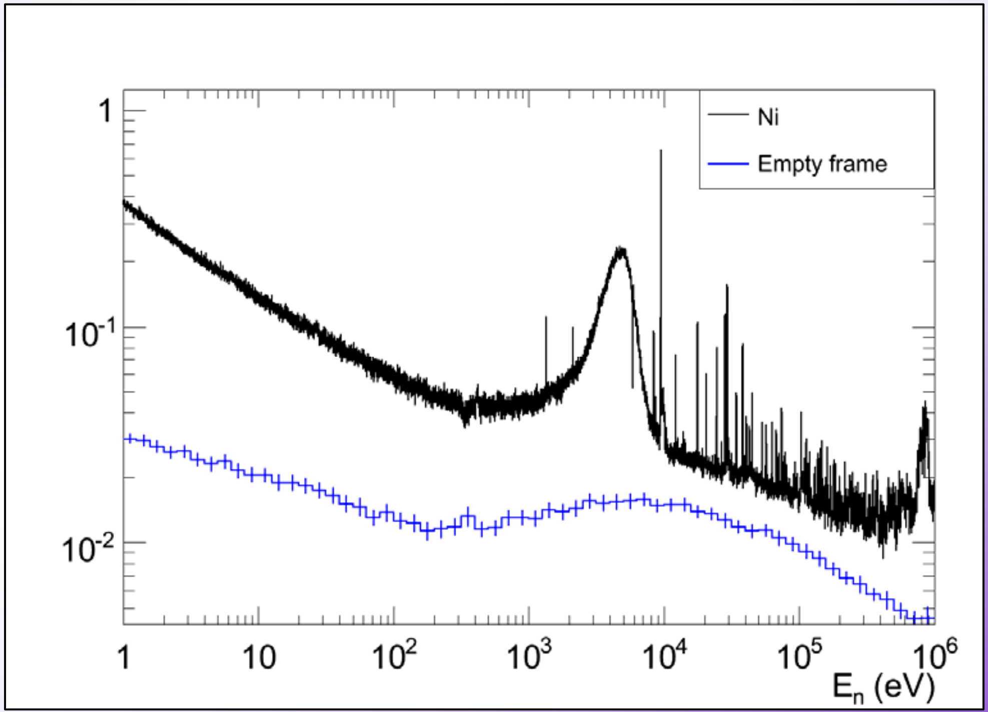

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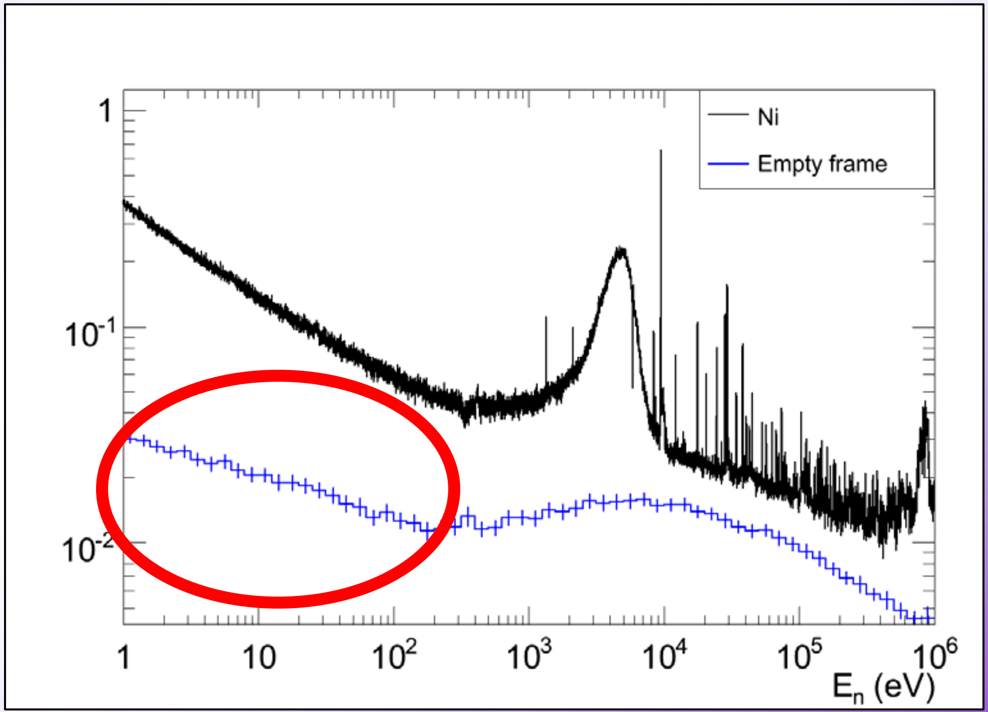

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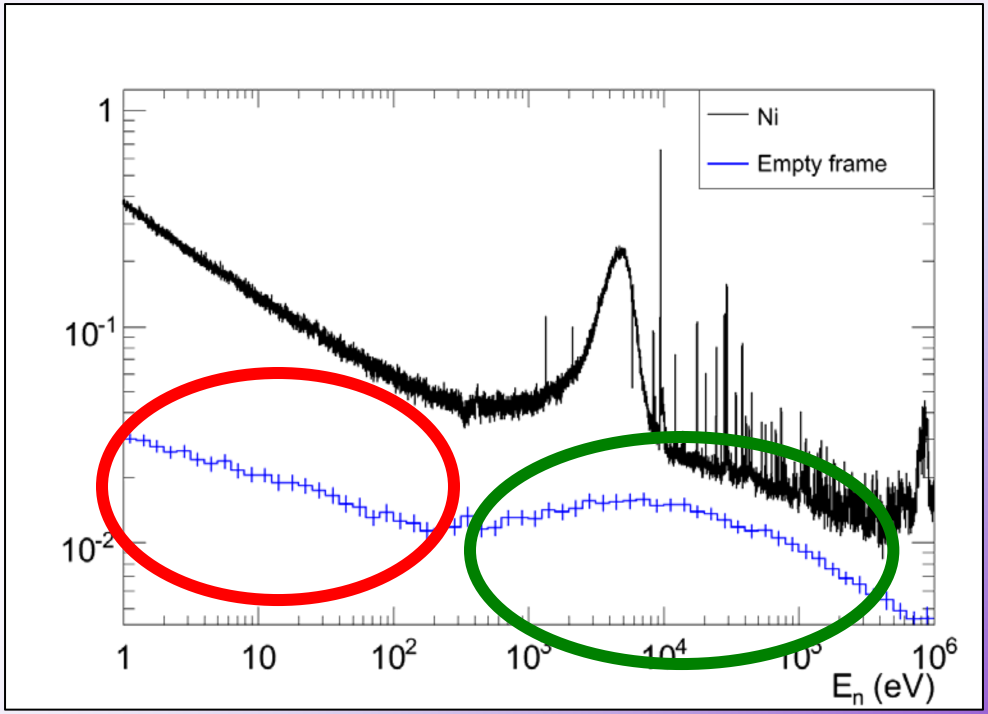

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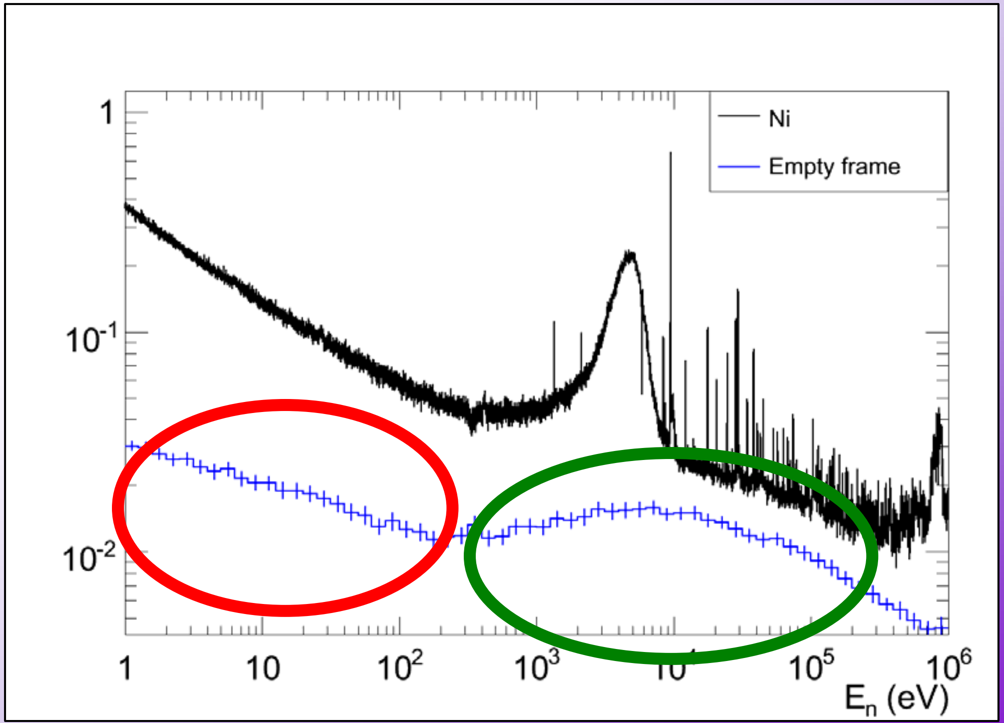
Sample-dependent:

- **Carbon**: $\sigma_{n,\gamma}\downarrow$, no resonances
- **Pb**: $\sigma_{\gamma,\gamma'}\uparrow$ and $\sigma_{n,\gamma}\downarrow$, no resonances



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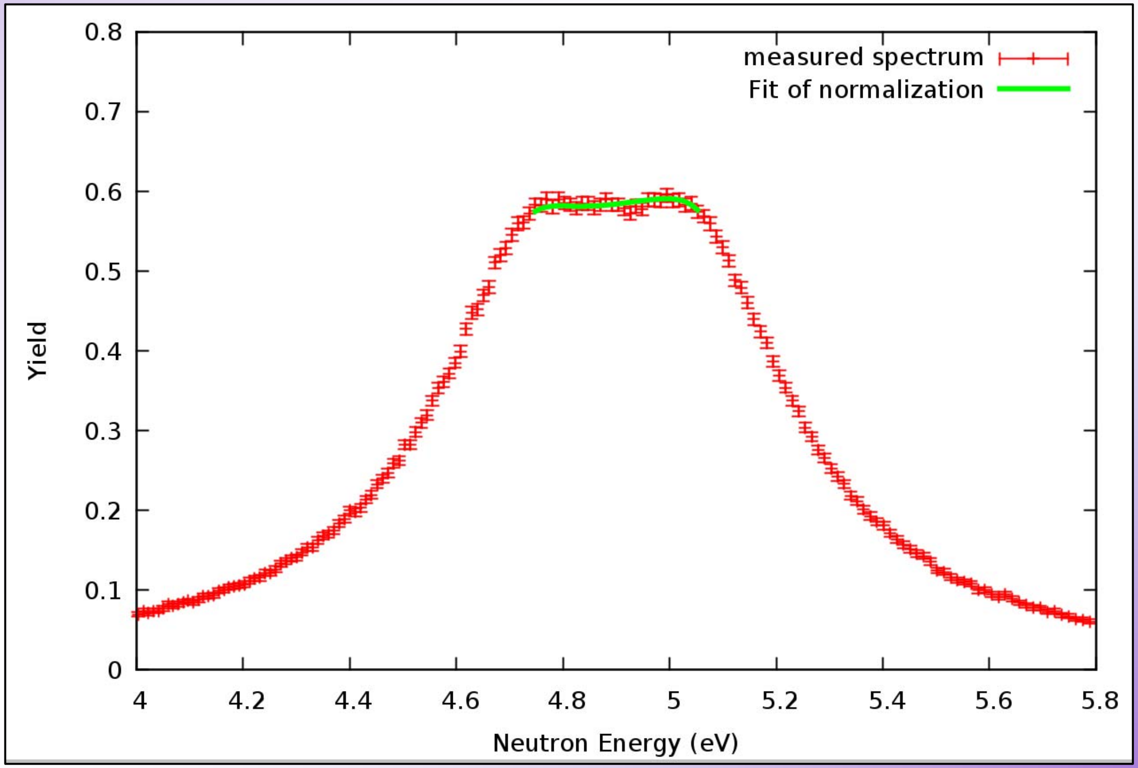
Normalization

- Neutron beam does not cover entire sample
- Determination of normalization factor via „saturated resonance technique“:
- 4.9 eV neutron resonance in Au: $n\sigma_{tot}$>>1 and Γ_γ/Γ_n>>1 → Y_c ~1
- Fit at top of resonance normalization while fixing resonance parameters:



MACS at 30 keV

• **prompt γ-detection**:

Beer and Spencer (1975): 26.8 ± 5.0 mb

Tomyo et al. (2005): 37.0 ± 3.2 mb

Alpizar-Vicente et al. (2008): 25.8 ± 3.7 mb

• **activation followed by Accelerator-Mass-Spectrometry (AMS*)**

Nassar et al. (2005): 26.1 ± 2.6 mb**

Dillmann et al. (2010): 23.4 ± 4.6 mb

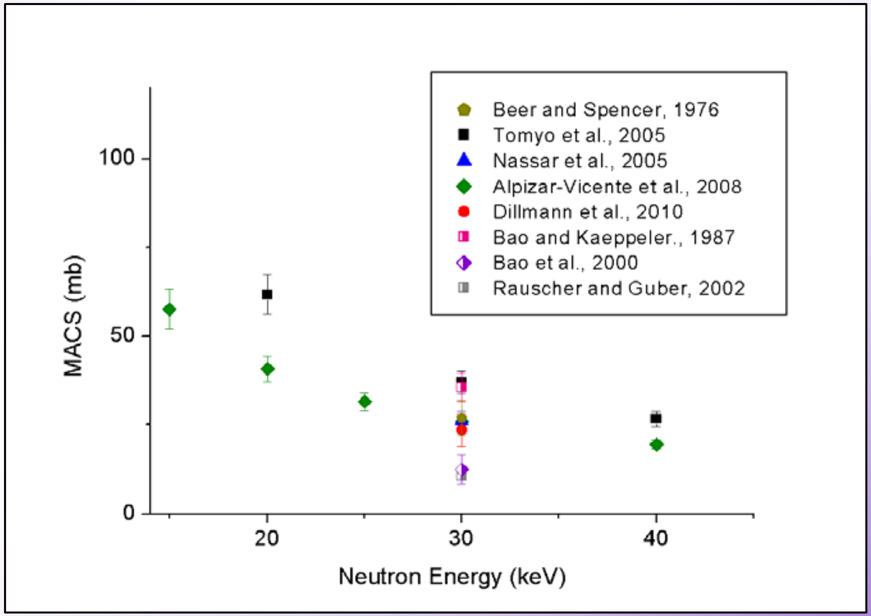
• **evaluations:**

Bao and Käppeler (1987): 35.5 ± 4.0 mb

Bao et al. (2000): 12.5 ± 4.0 mb

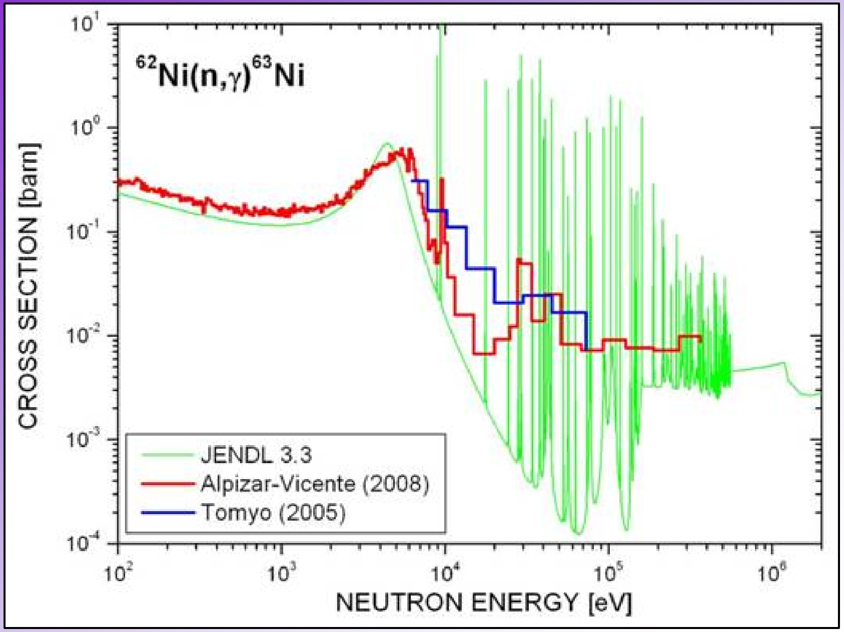
Rauscher and Guber (2002): 10.6 ± 0.8 mb

Maxwellian-averaged cross sections



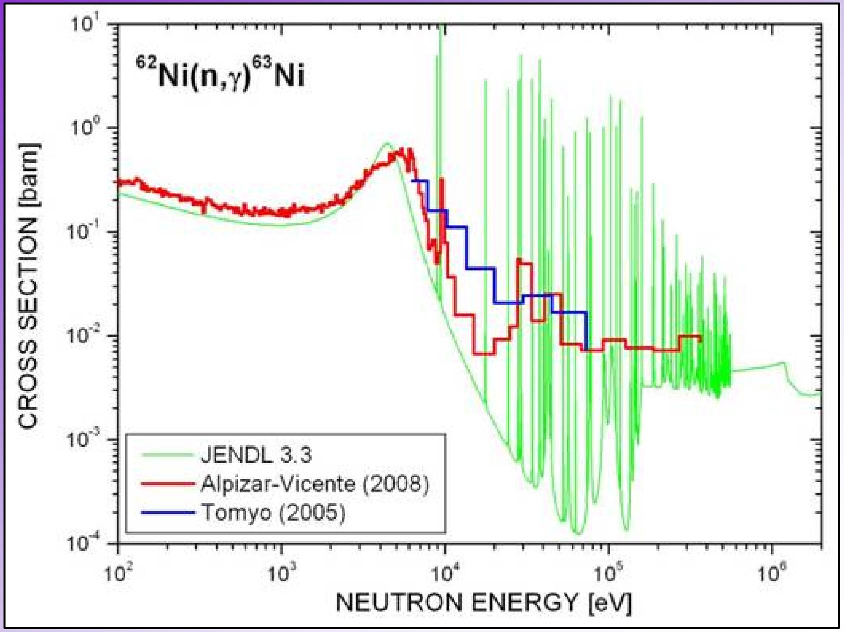
*see also poster of Wallner et al. NIC_XI_375

**extrapolated from 25 keV



previous measurements

(figure by I. Dillmann)



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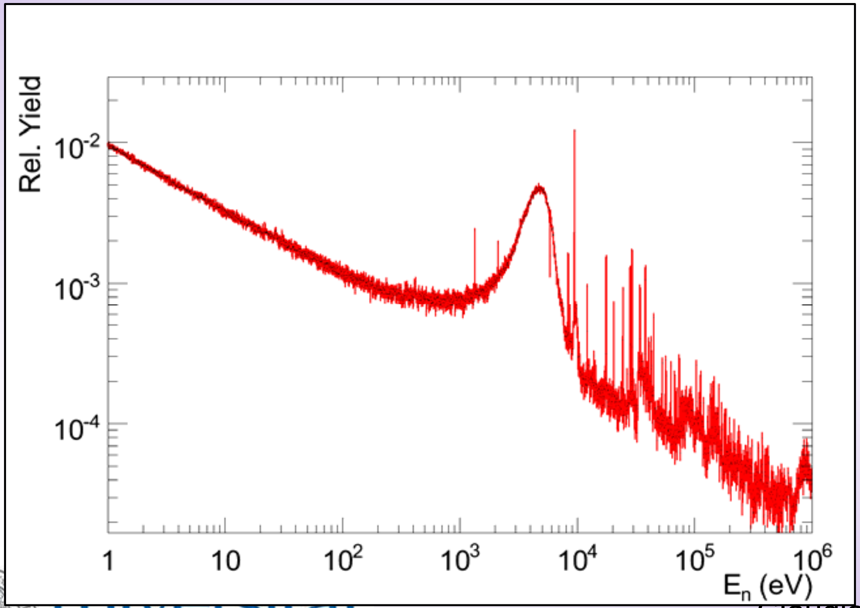

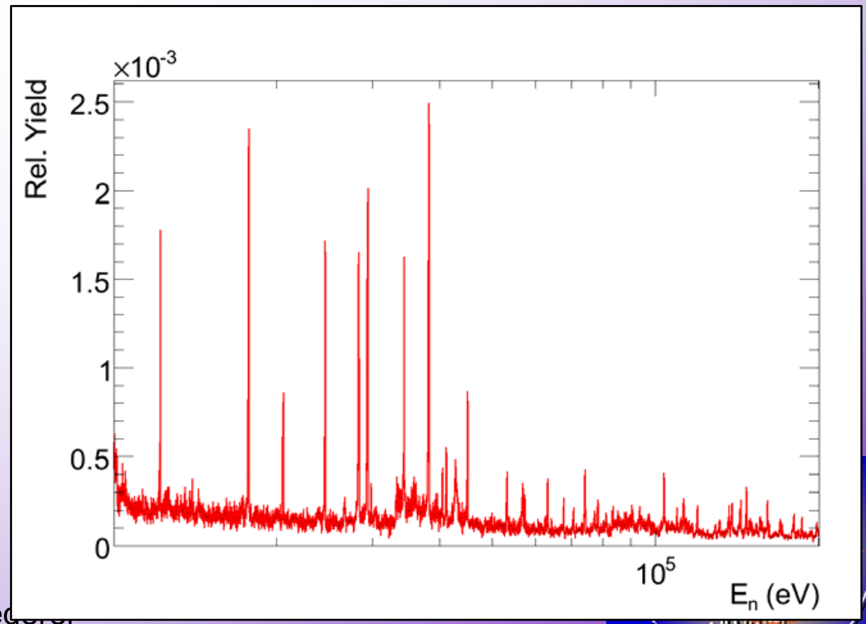

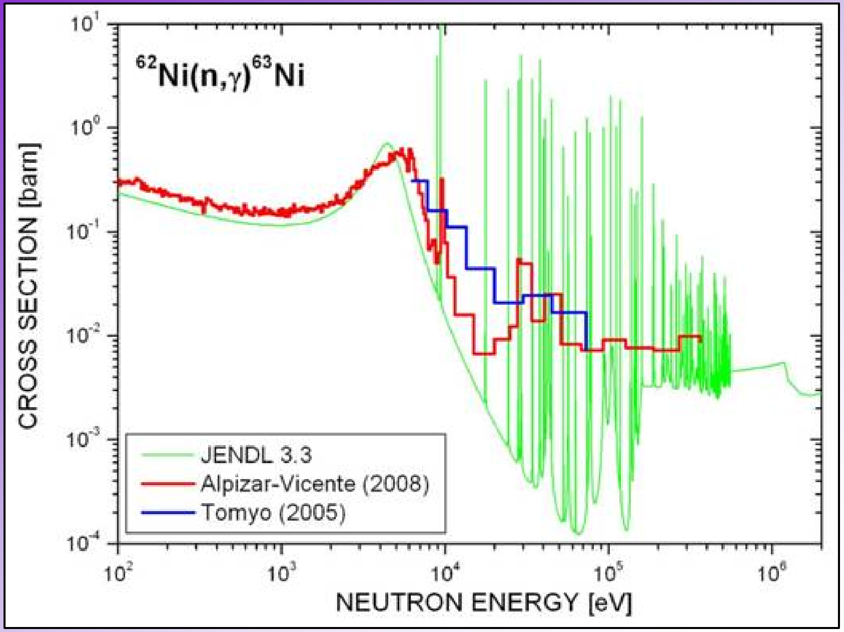

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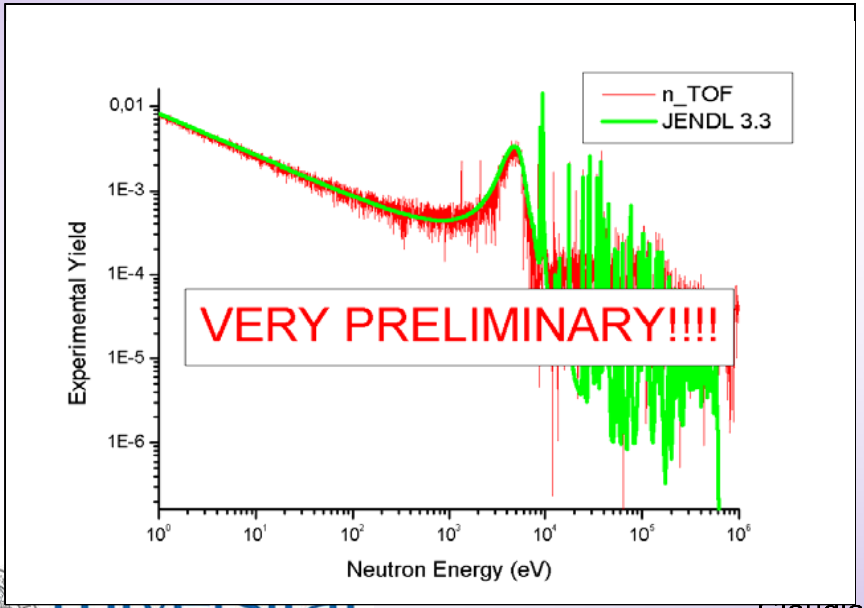

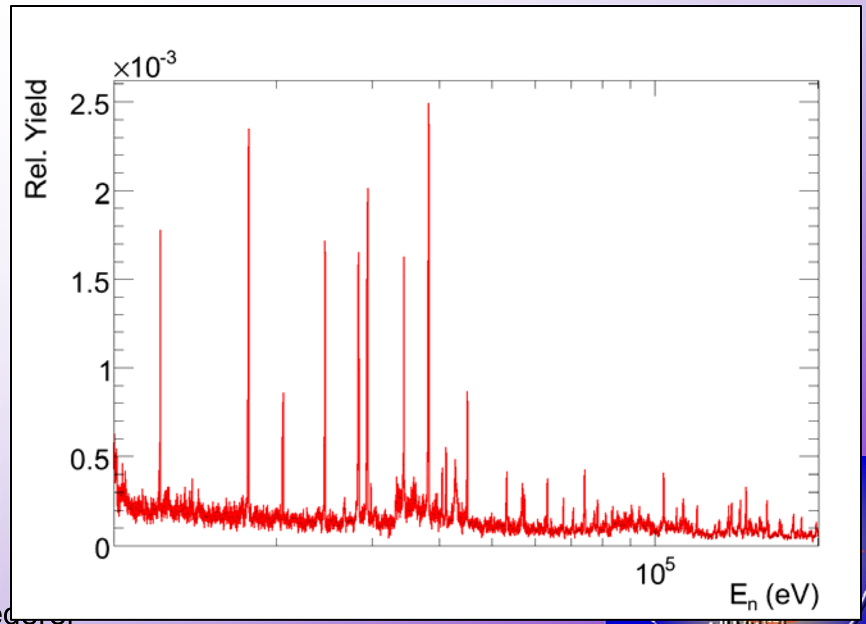

Summary

- last year, measurement of $^{56}Fe(n,\gamma)$ and $^{62}Ni(n,\gamma)$ sucessfully finished at n_TOF, now data taking for $^{54}Fe(n,\gamma)$
- data analysis in progress → new and precise data ante portas
- preliminary results for $^{62}Ni(n,\gamma)$ show unique energy resolution
- data seem to agree with JENDL library

THANKS TO:

- n_TOF collaboration
- Austrian Science fund (FWF)
- EFNUDAT (European Facilities for nuclear data measurement)
- H. Danninger and C. Gierl (Vienna University of Technology) for preparing the Ni sample

and you for your attention!