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

Claudia Lederer

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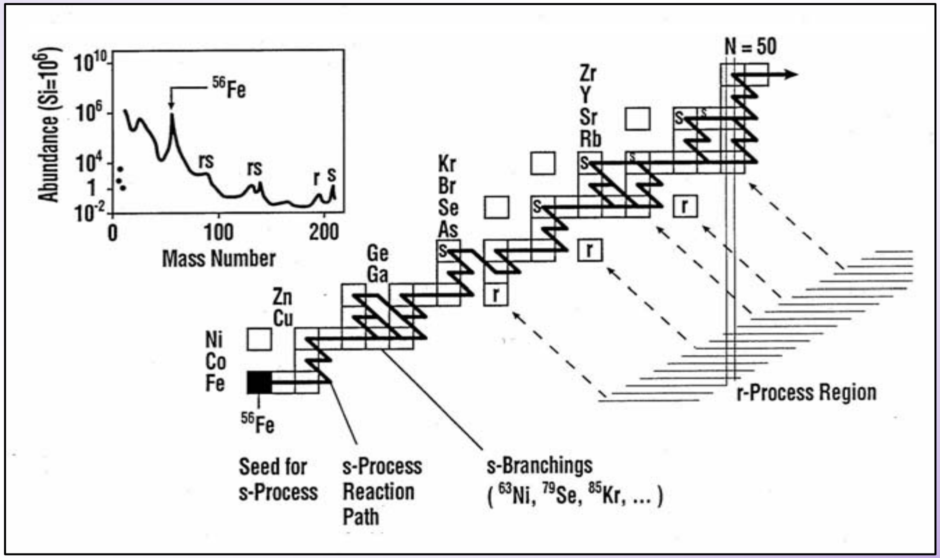
on behalf of the **n_TOF Collaboration**

www.cern.ch/ntof

Motivation: nuclear astrophysics

Nucleosynthesis in stars beyond Fe:

- neutron capture reactions
- slow neutron capture (s-process)
- rapid neutron capture (r-process)



F. Käppeler, A. Mengoni, Nucl. Phys. A **777** (2006)

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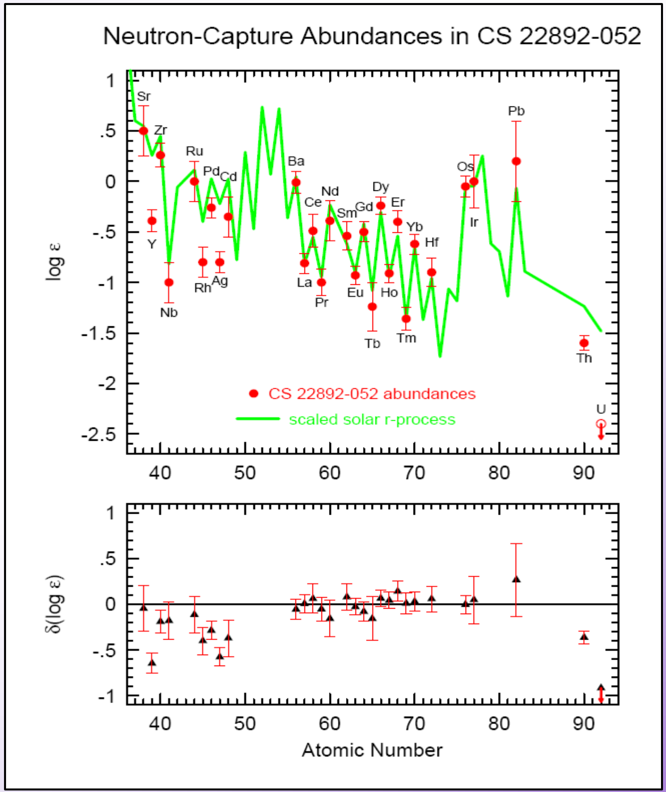
Observation of old halo star CS22892-052:

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

(Sneden et al.)



Sneden et al. APJ533 (2000)

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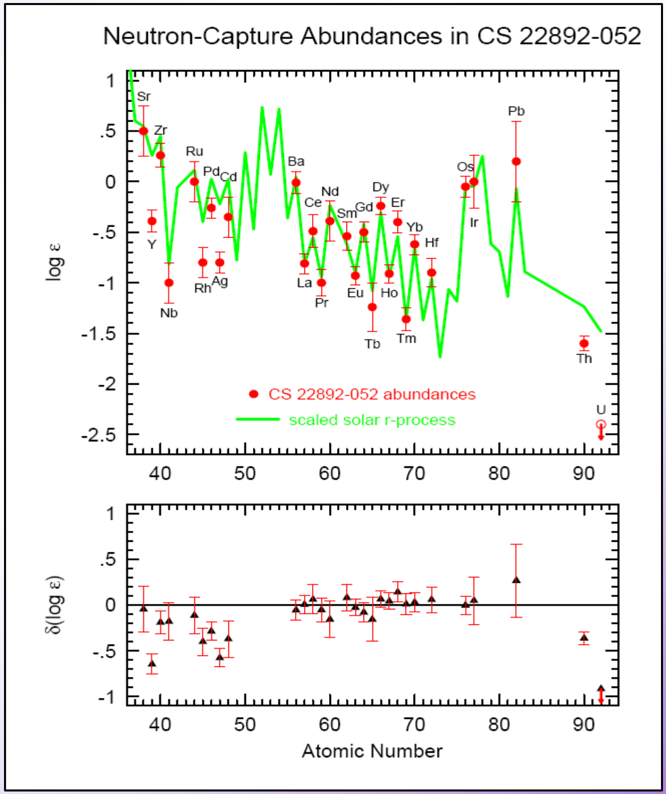
- determination of r-process residuals via

$$N_r = N_\odot - N_s$$



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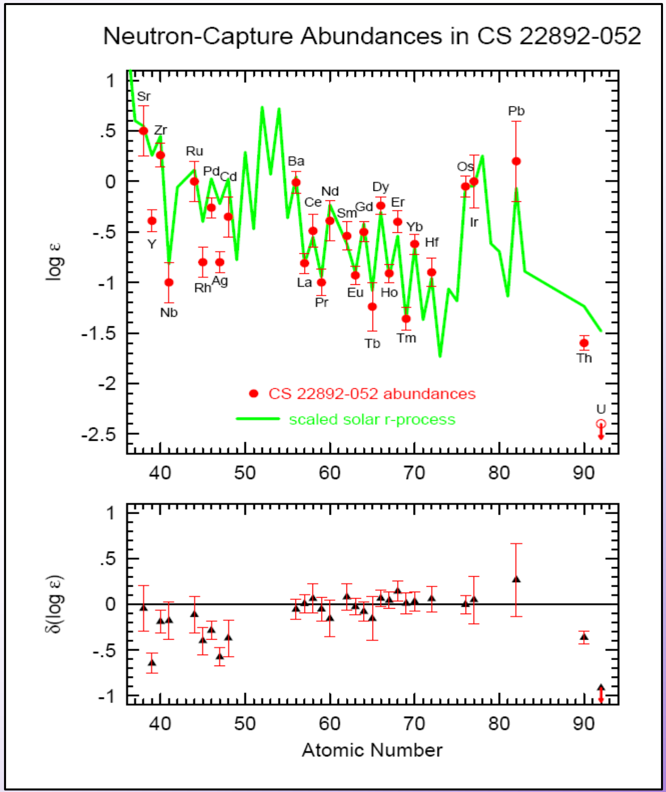
nuclear physics input: $T_{1/2}$, $\sigma(n,\gamma)$



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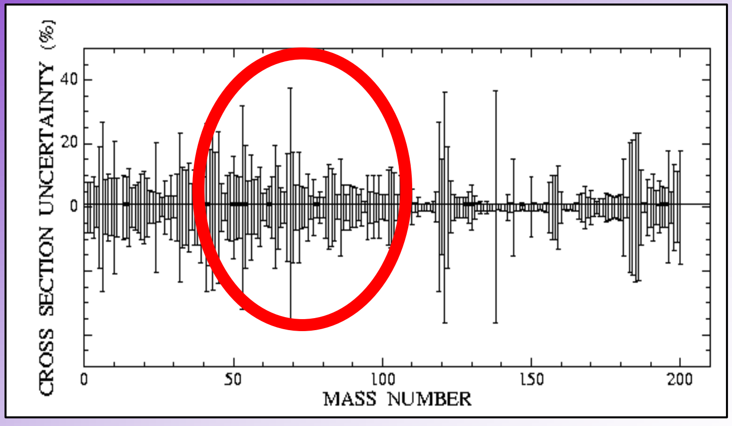

Bao et al. (2000)

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

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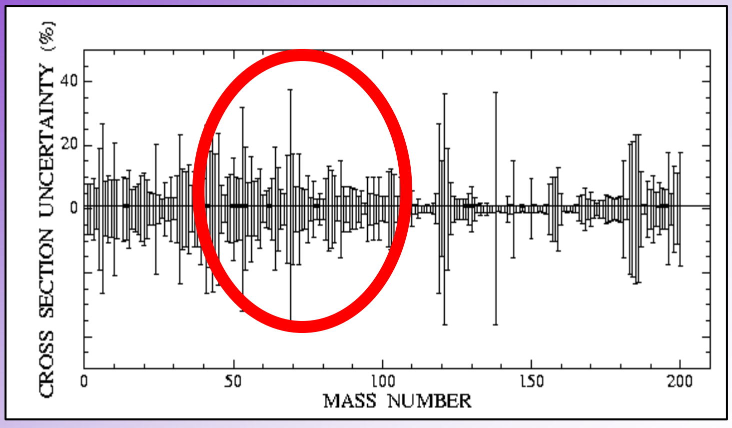

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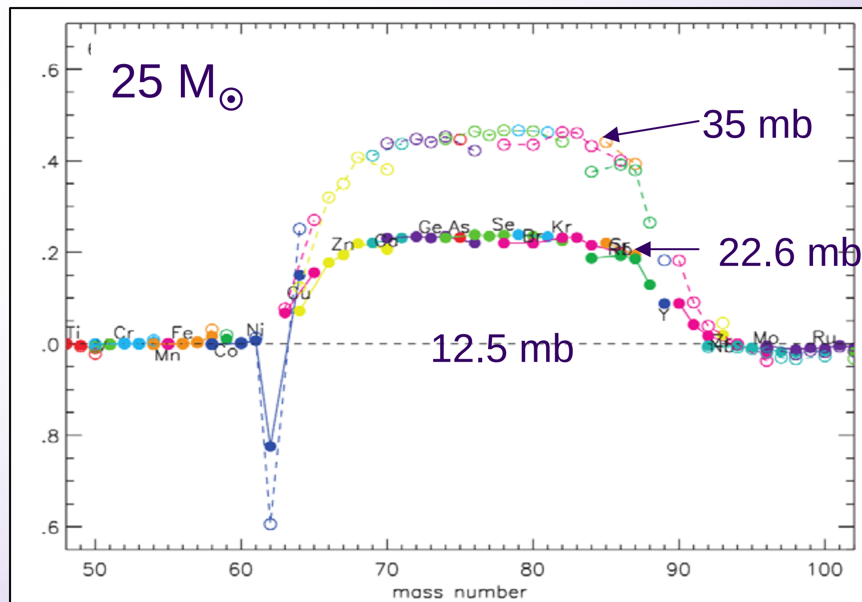
MACS at 30 keV



Nassar et al. (2005)

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

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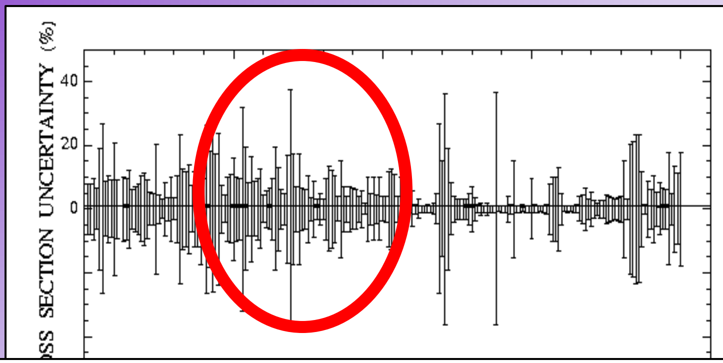

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Campaign to measure capture cross-sections of all stable isotopes of Fe and Ni at n_TOF

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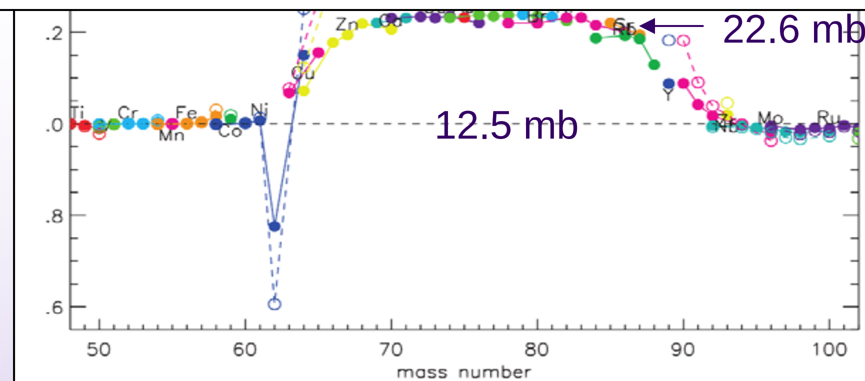

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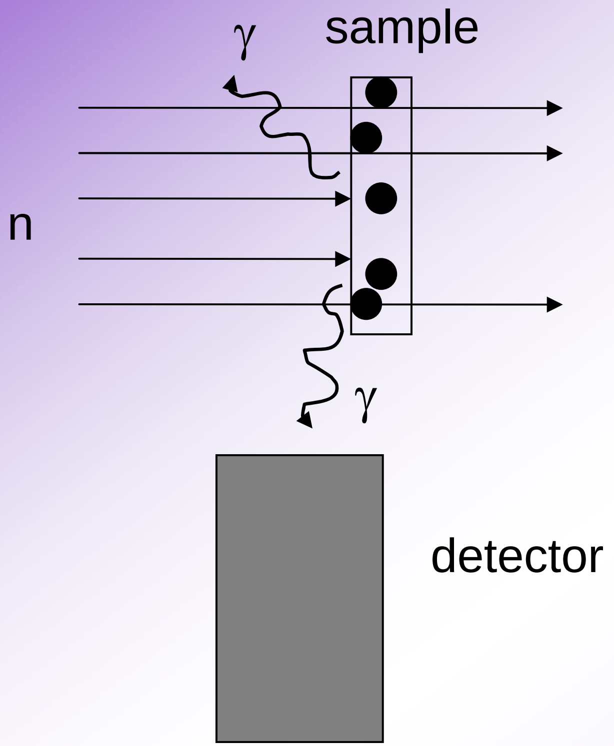
How to measure capture cross-section?



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

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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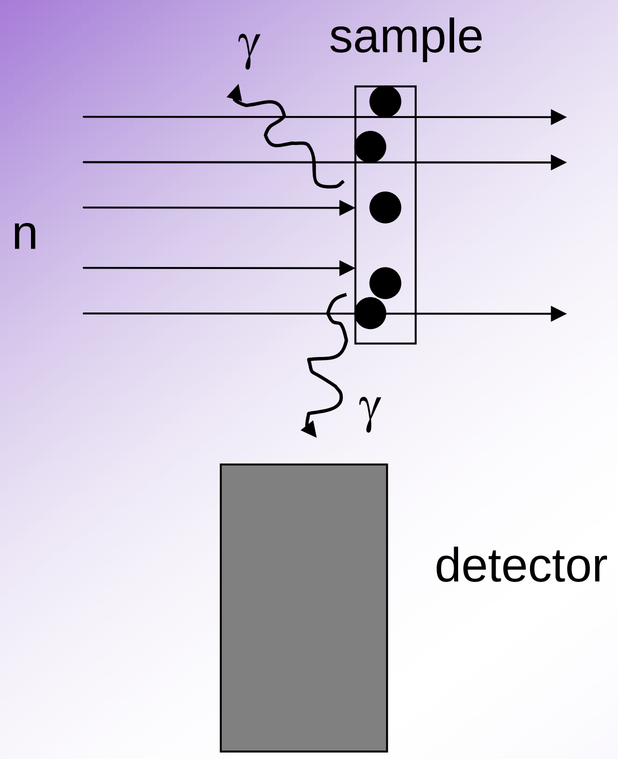

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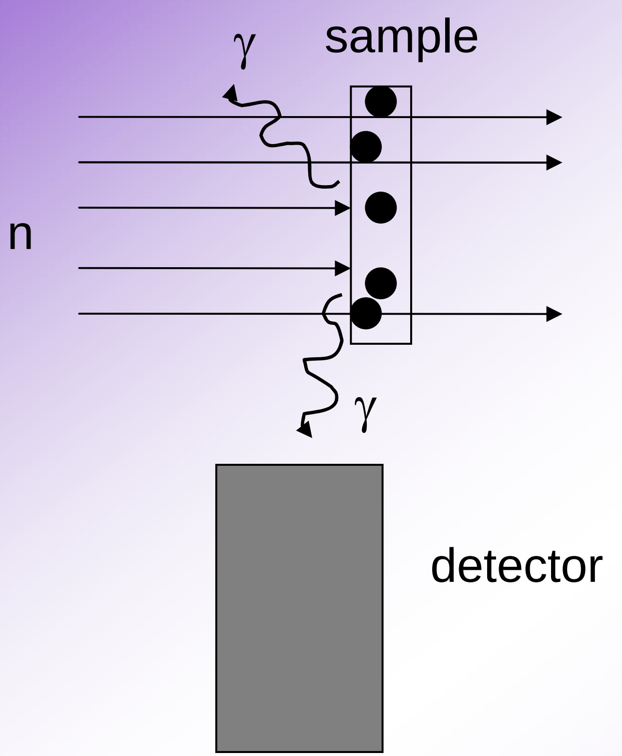

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n_TOF

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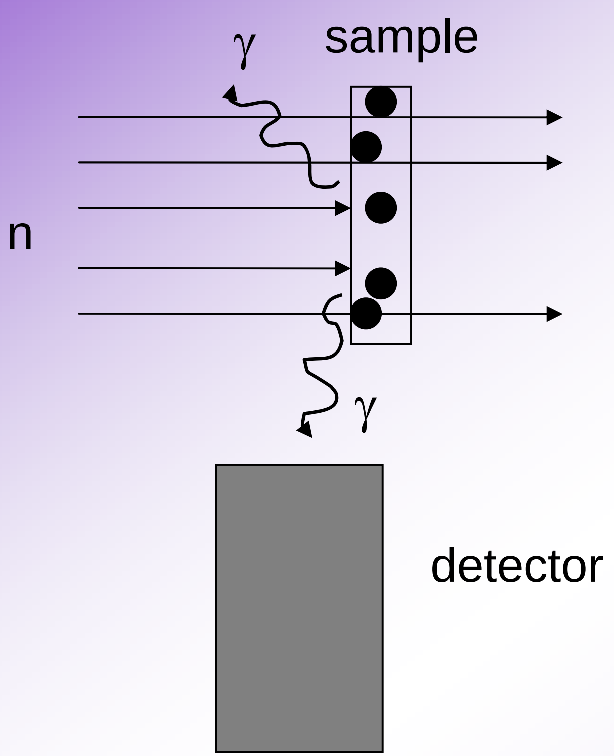

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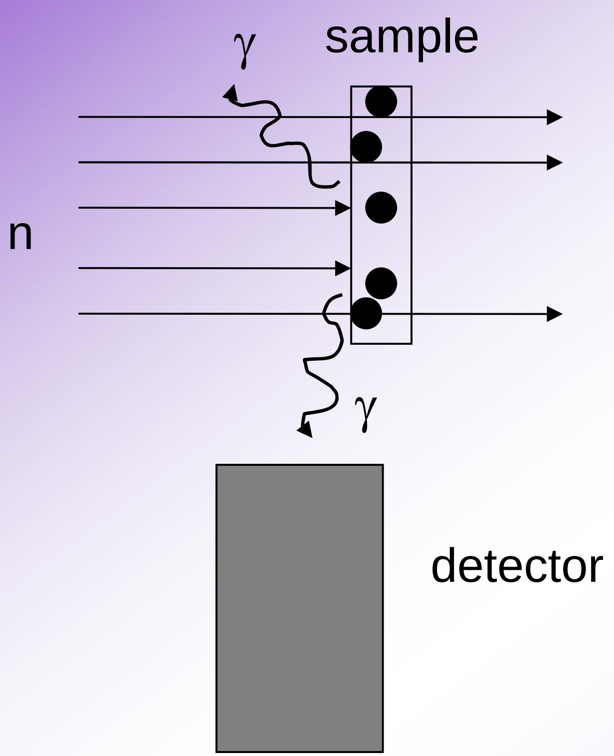

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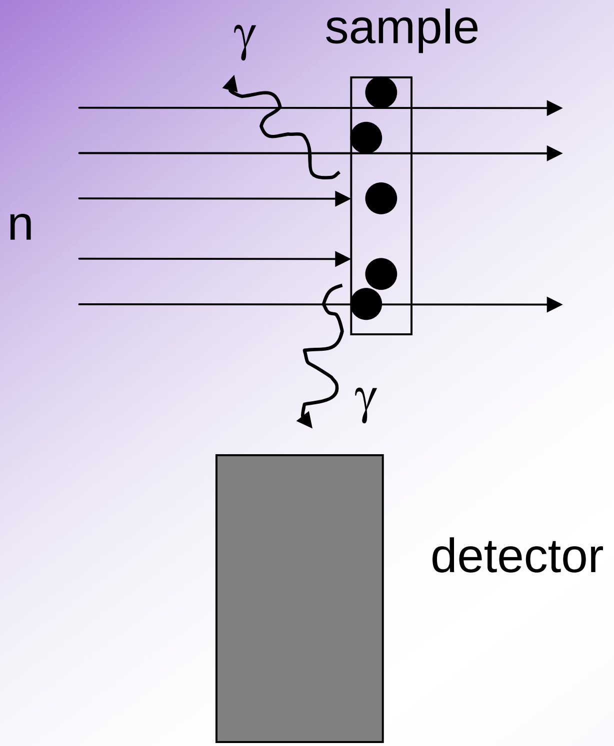

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n_TOF

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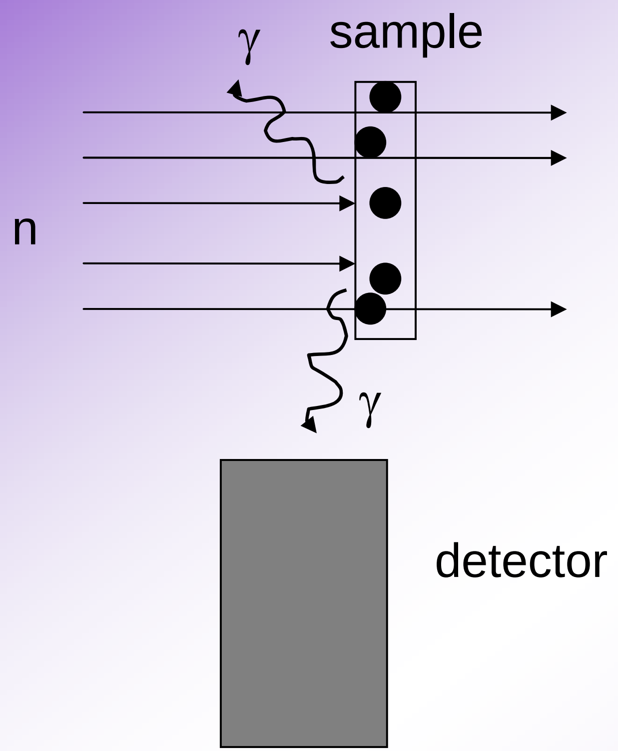

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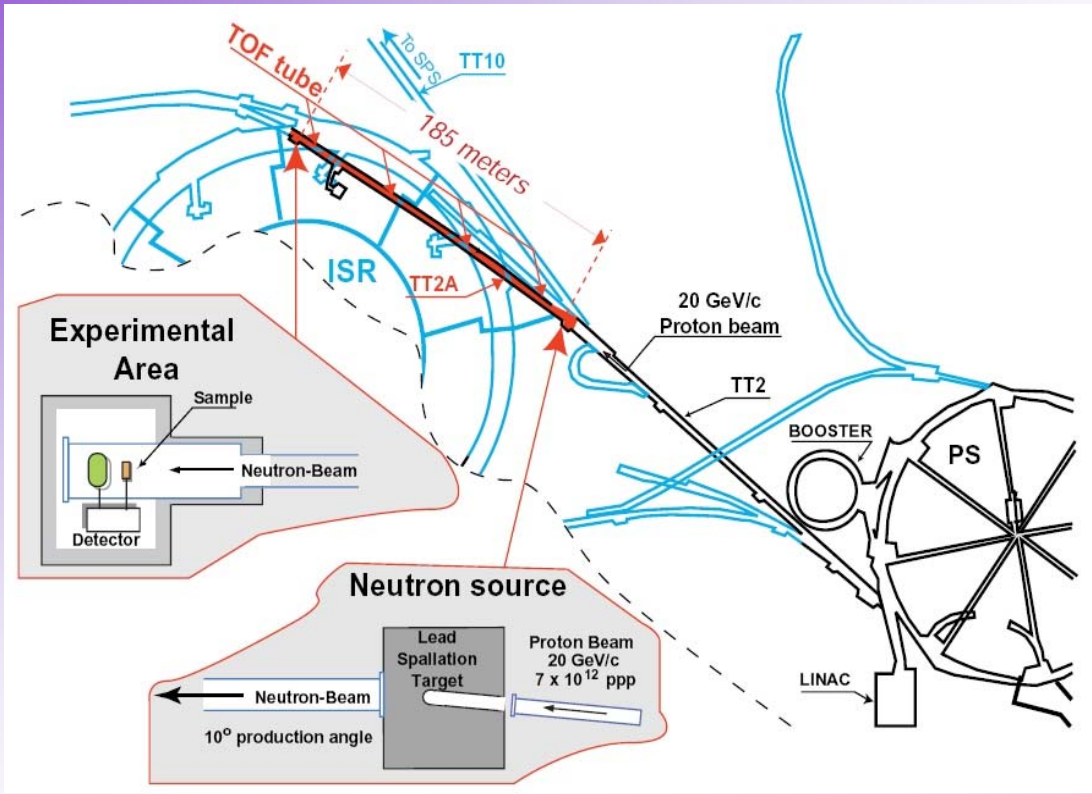
Φ....neutron flux → neutron detectors

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

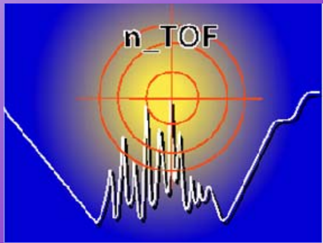
Flight path: 185 m

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**



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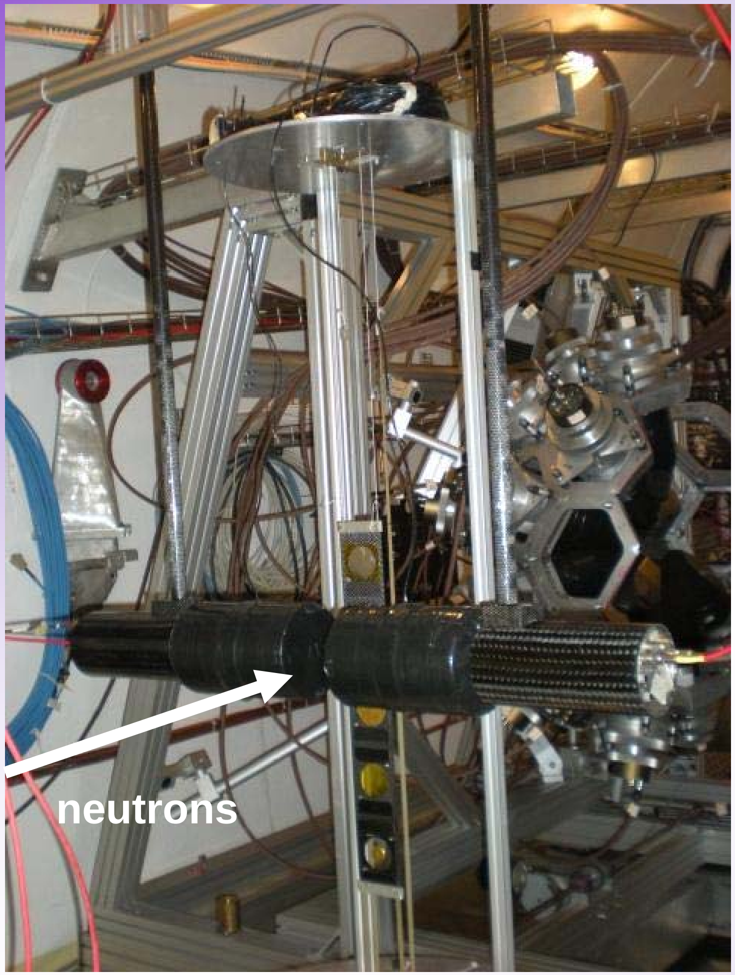


C_6D_6 setup:

- 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

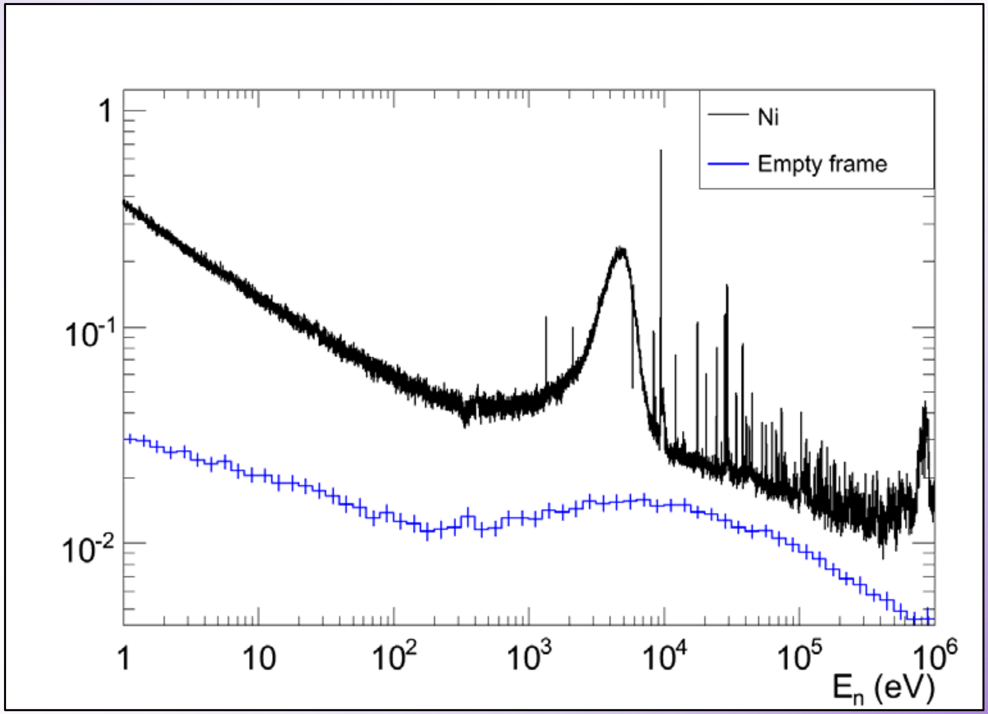
	^{58}Ni	^{60}Ni	^{61}Ni	**^{62}Ni**	^{64}Ni
sample (%)	0.005	0.035	0.91	**97.95**	1.1
natural (%)	68.08	26.22	1.14	3.63	0.93

- ^{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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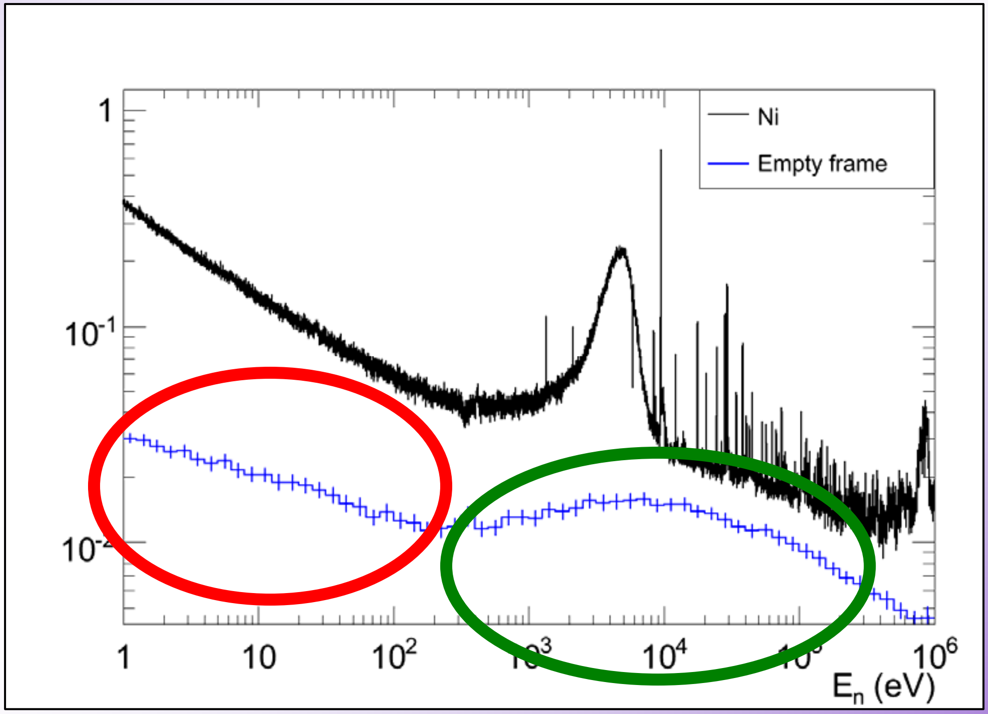


MACS at 30 keV

- **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

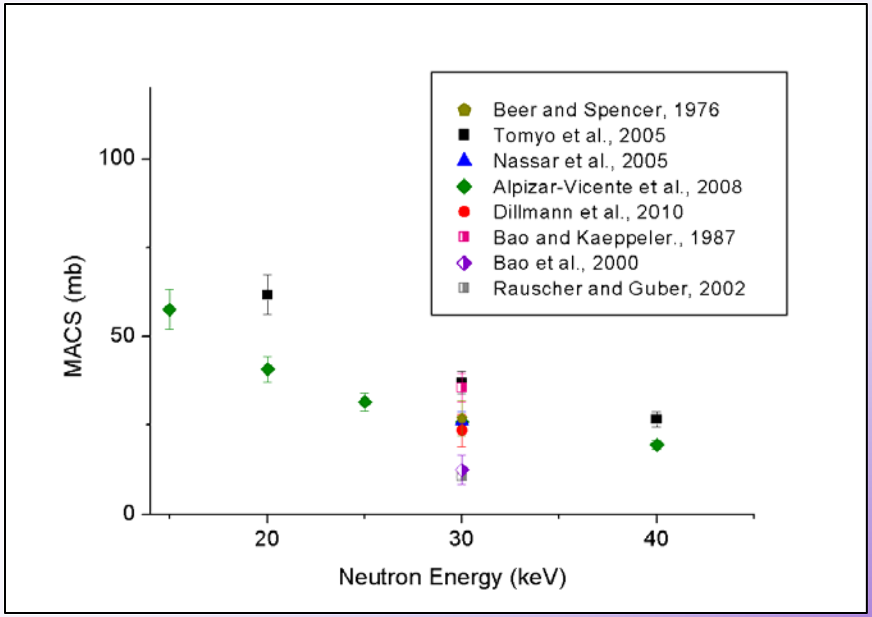
- **evaluations:**

Bao and Käppeler (1987): 35.5 ± 4.0 mb

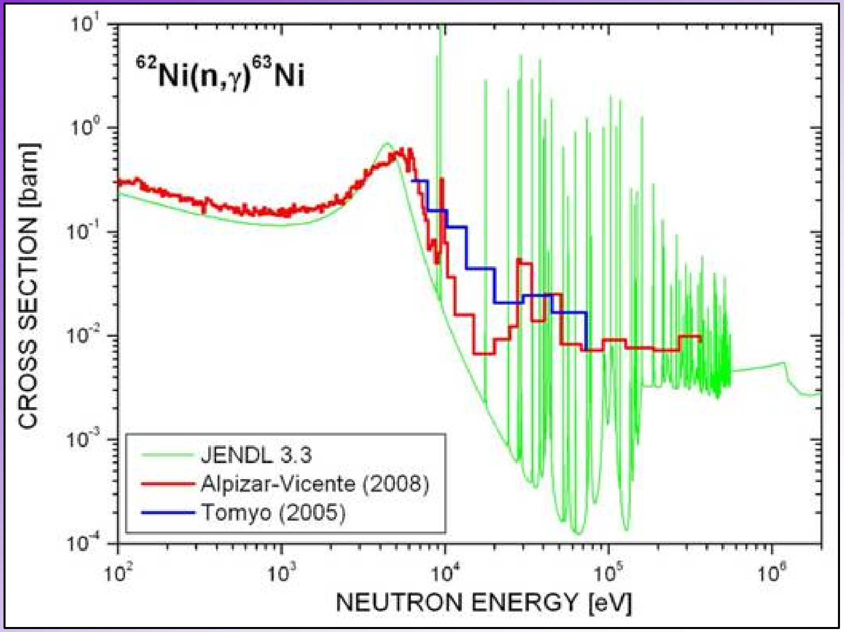
Bao et al. (2000): 12.5 ± 4.0 mb

Rauscher and Guber (2002): 10.6 ± 0.8 mb

Maxwellian-averaged cross sections

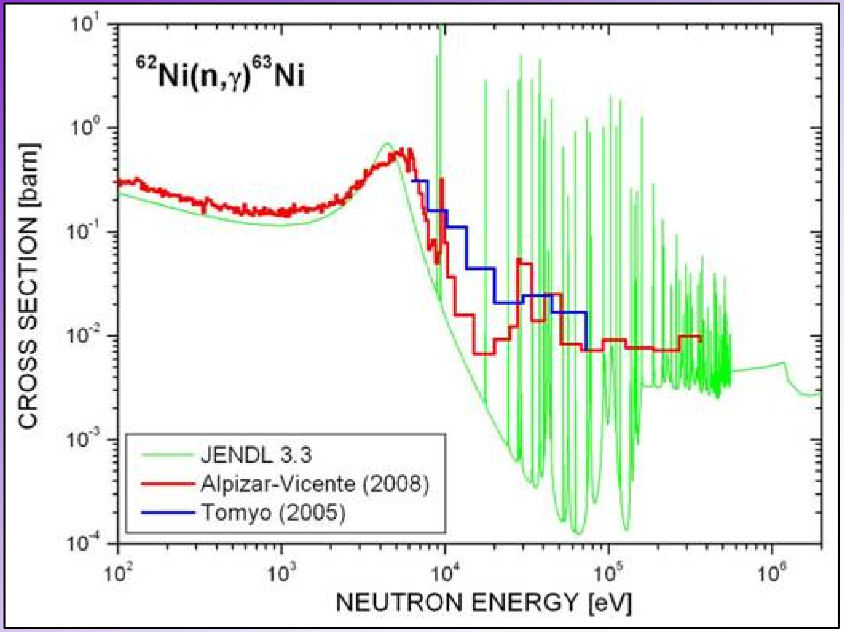


*extrapolated from 25 keV



previous measurements

(figure by I. Dillmann)



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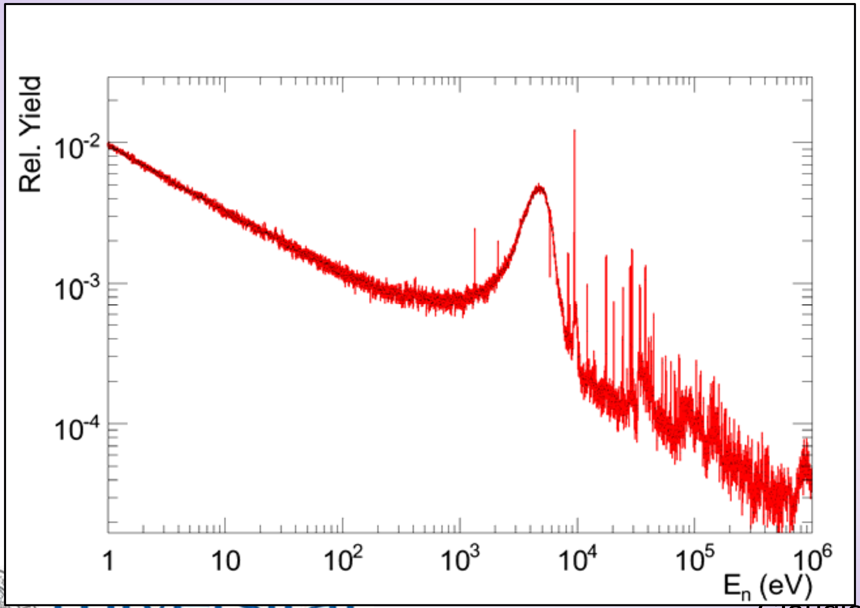

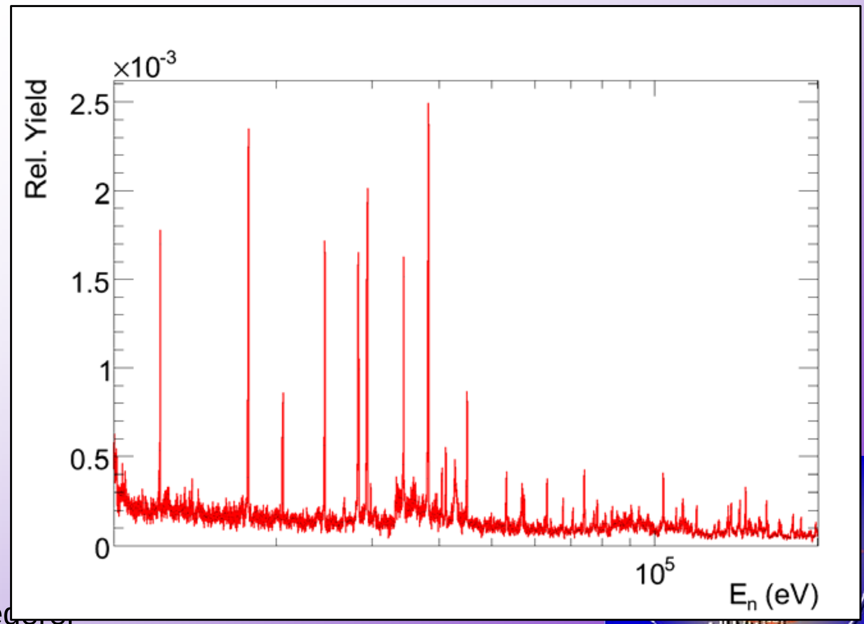

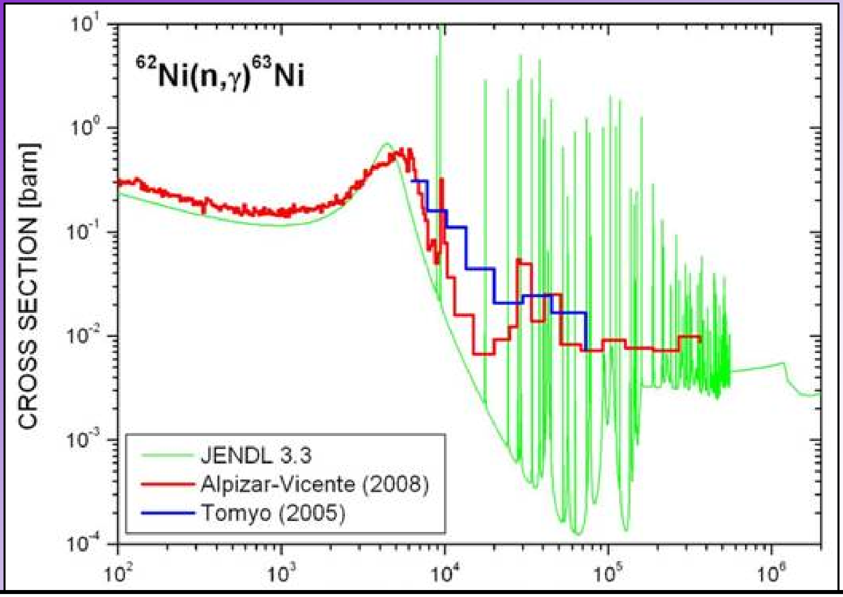

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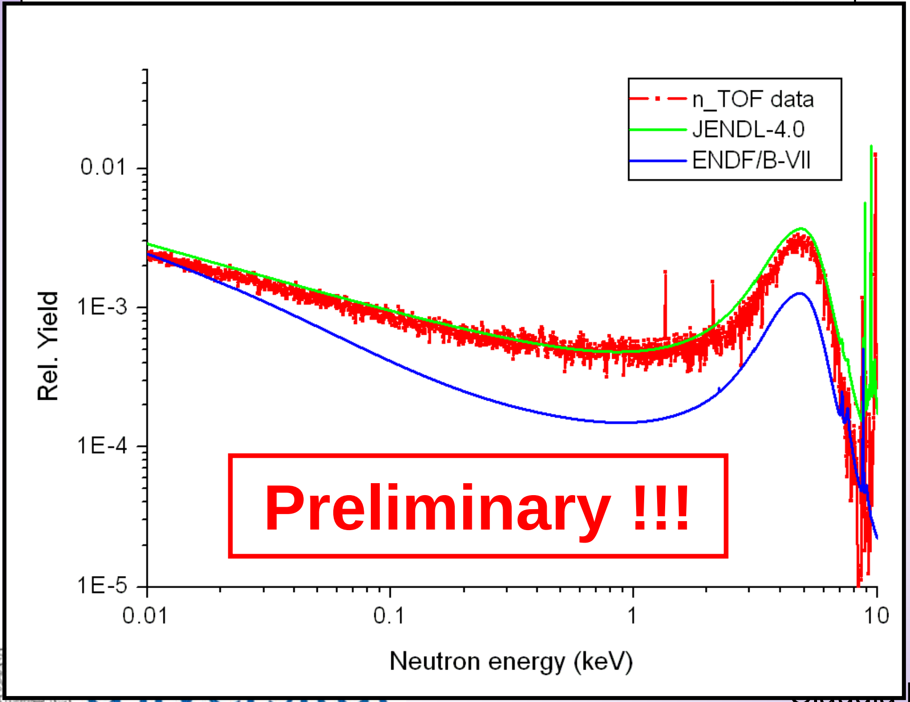

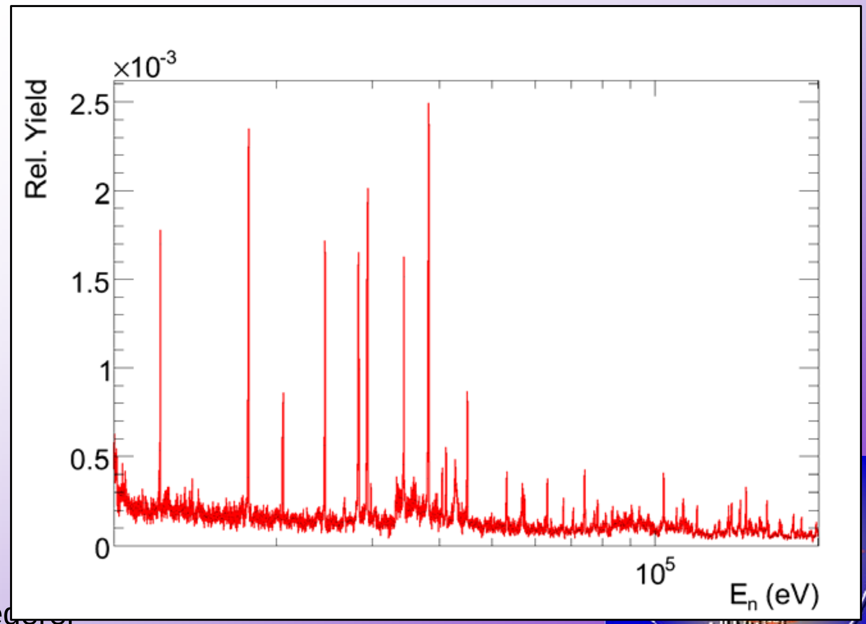

Summary

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

THANKS TO:

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

FWF
Der Wissenschaftsfonds.

EFNUDAT
European Facilities for Nuclear Data Measurements

and you for your attention!