(n, xn) cross sections on ^{56,57}Fe

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Overview

Introduction: why iron?

Experimental setup

Experimental particularities

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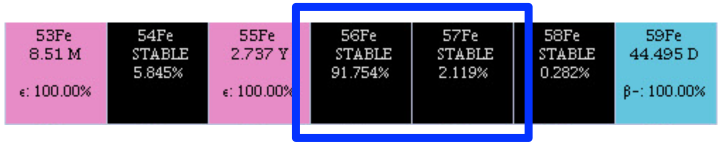
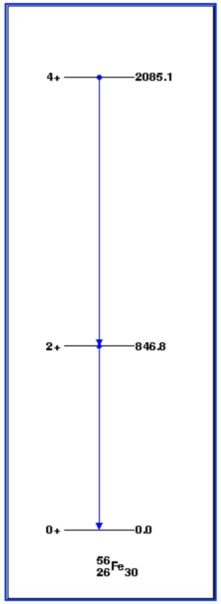
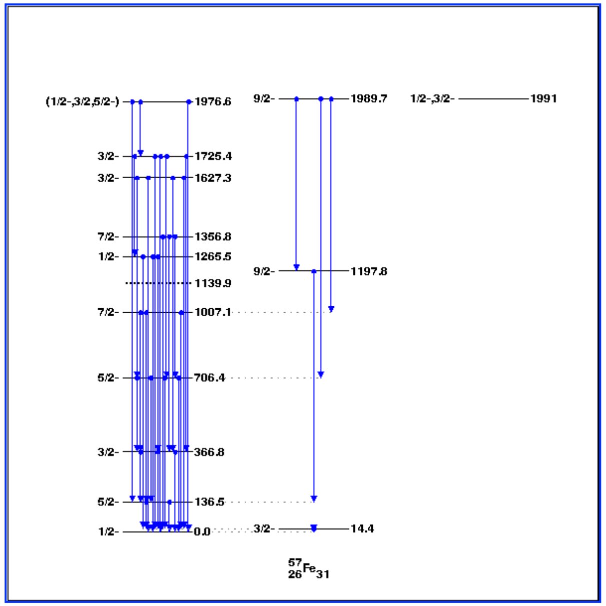
Iron is an essential structural material for all nuclear installations.
Inelastic scattering is the main mechanism allowing neutrons to slow down.



At small energies the inelastic scattering occurs only on ^{57}Fe.





Introduction: why iron?

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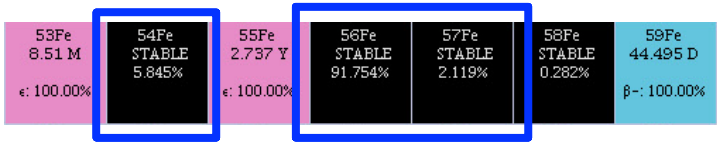


At small energies the inelastic scattering occurs only on ^{57}Fe.

When a ^{nat}Fe target is used, at high energies the ^{56}Fe(n,ng) is “contaminated” by ^{57}Fe(n,2ng):

$$^{56}\mathrm{Fe} + n \longrightarrow {}^{56}\mathrm{Fe}^{*} + n$$

$$^{57}\mathrm{Fe} + n \longrightarrow {}^{56}\mathrm{Fe}^{*} + 2n \qquad \text{when } E_n > S_n(^{57}\mathrm{Fe}) = 7.6\ \mathrm{MeV}$$

Experimental setup

Experimental setup and method

Pulsed neutron source
GELINA of EC-JRC Geel

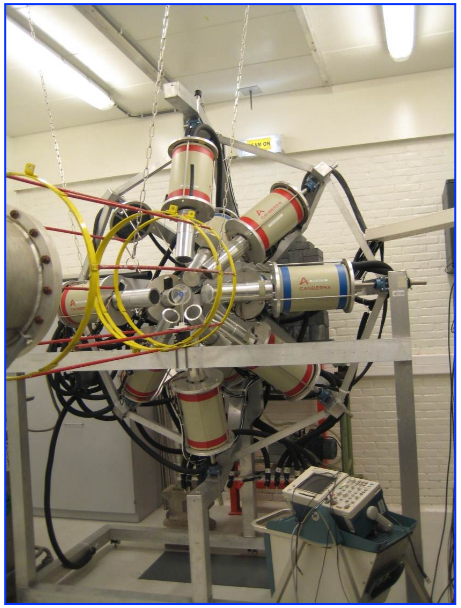
- Electron linac (140 MeV) + ^{238}U target
- Pulse width ~1 ns
- Repetition rate: 800 Hz
- Energy range: 0 – 20 MeV
- Gamma flash from bremsstrahlung
- Flight path: 200 m (~550 neutrons/cm^{2}s)

Sample to be measured + detection system GAINS

200 m flight path

Neutron source

Experimental setup and method



GAINS: Gamma array for Inelastic neutrons scattering

12 HPGe detectors, able to measure:

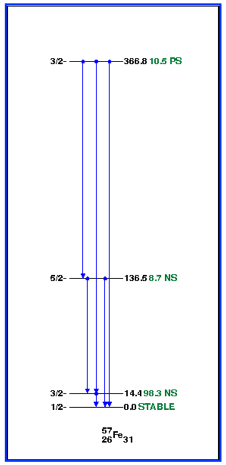
- Very precisely the energy of g rays
- The time of g rays with a precision of 10 ns => neutron energy

One Fission Chamber (^{235}U) for beam monitoring

For more details on the experimental setup please see the presentations of:

Catalin BORCEA
Markus NYMAN
Adina OLACEL

Experimental method: g spectroscopy + time of flight



Primary experimental result:

g production cross sections.

Then, knowing the level scheme, we determine:

Level cross sections
Total inelastic cross section.

Experimental particularities

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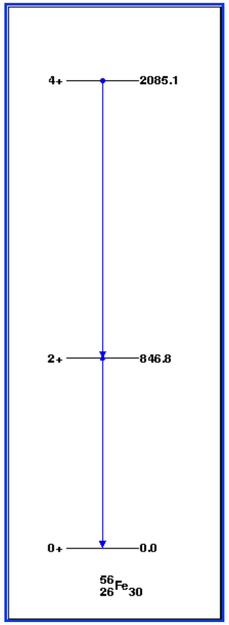
Particularities and difficulties



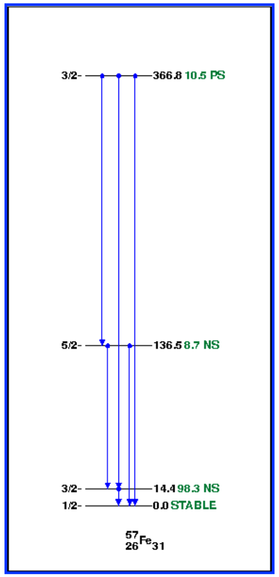
Main experimental issues:

^{56}Fe - extreme precision and reliability required for the results.

- The main transition (847 keV) may be contaminated by the 844-keV γ line from ^{27}Al or the 834 keV+E_{recoil} neutron-induced triangle from the HPGe detectors.

^{57}Fe - expensive, very thin target (this is also the case for ^{54}Fe).

- first level at 14 keV.
  conversion coefficient α = 8.5(3)
  level half-life $T_{1/2}$ = 98.3(3) ns

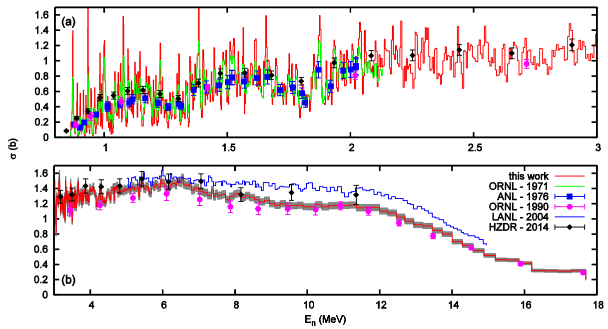


Particularities: ^{56}Fe - multiple checks

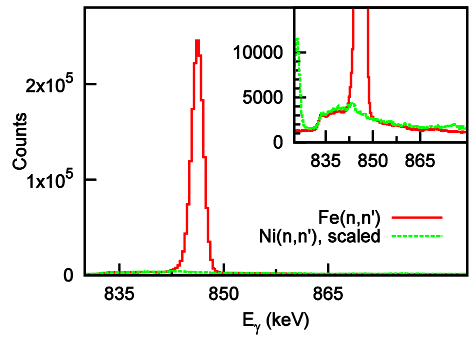
The ^{56}Fe results were published in *Physical Review C90, 034602 (2014)*.

What is mentioned there (but perhaps not sufficiently emphasized) is the multiple checks we performed to produce reliable data:

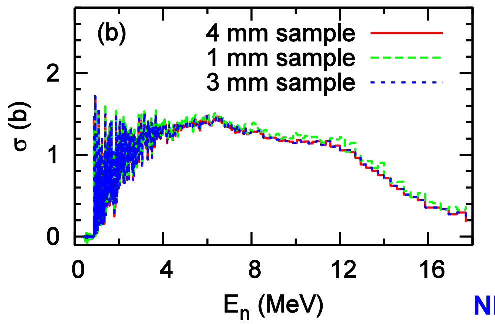
- First we made a long time measurement (2 months) using a 3-mm thick ^{nat}Fe target. These data are shown in the article and are included in EXFOR.



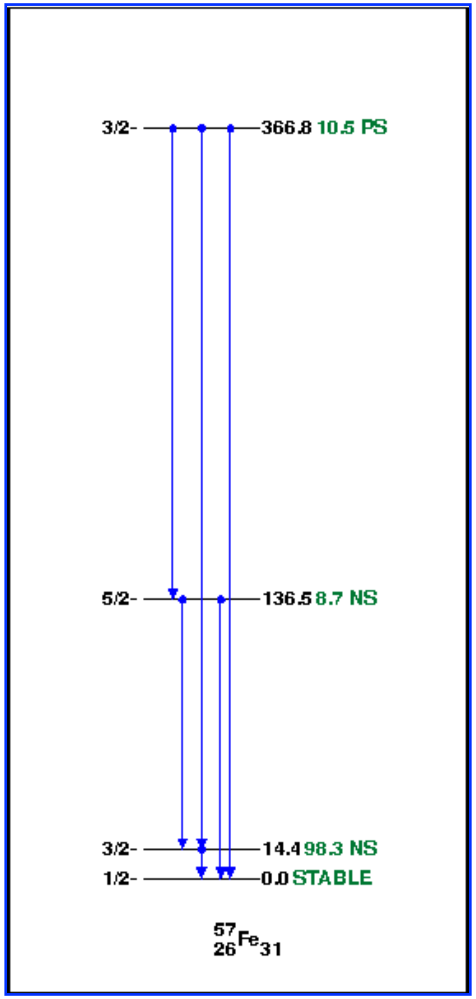
- Then we performed measurements with various targets to check the background conditions:
  - Al (one day)
  - Ni (one week)
  - Pb (one week)
  - Empty frame (one week)

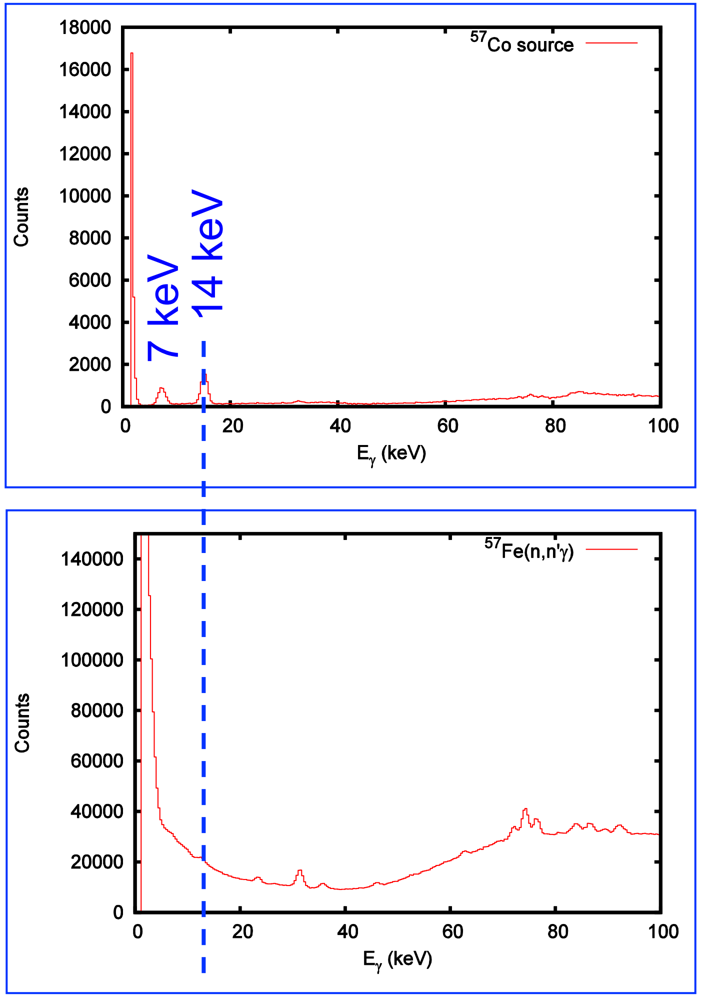


- Then we performed measurements with ^{nat}Fe targets of various thicknesses:
  - 4 mm (3 weeks)
  - 1 mm (2 weeks)



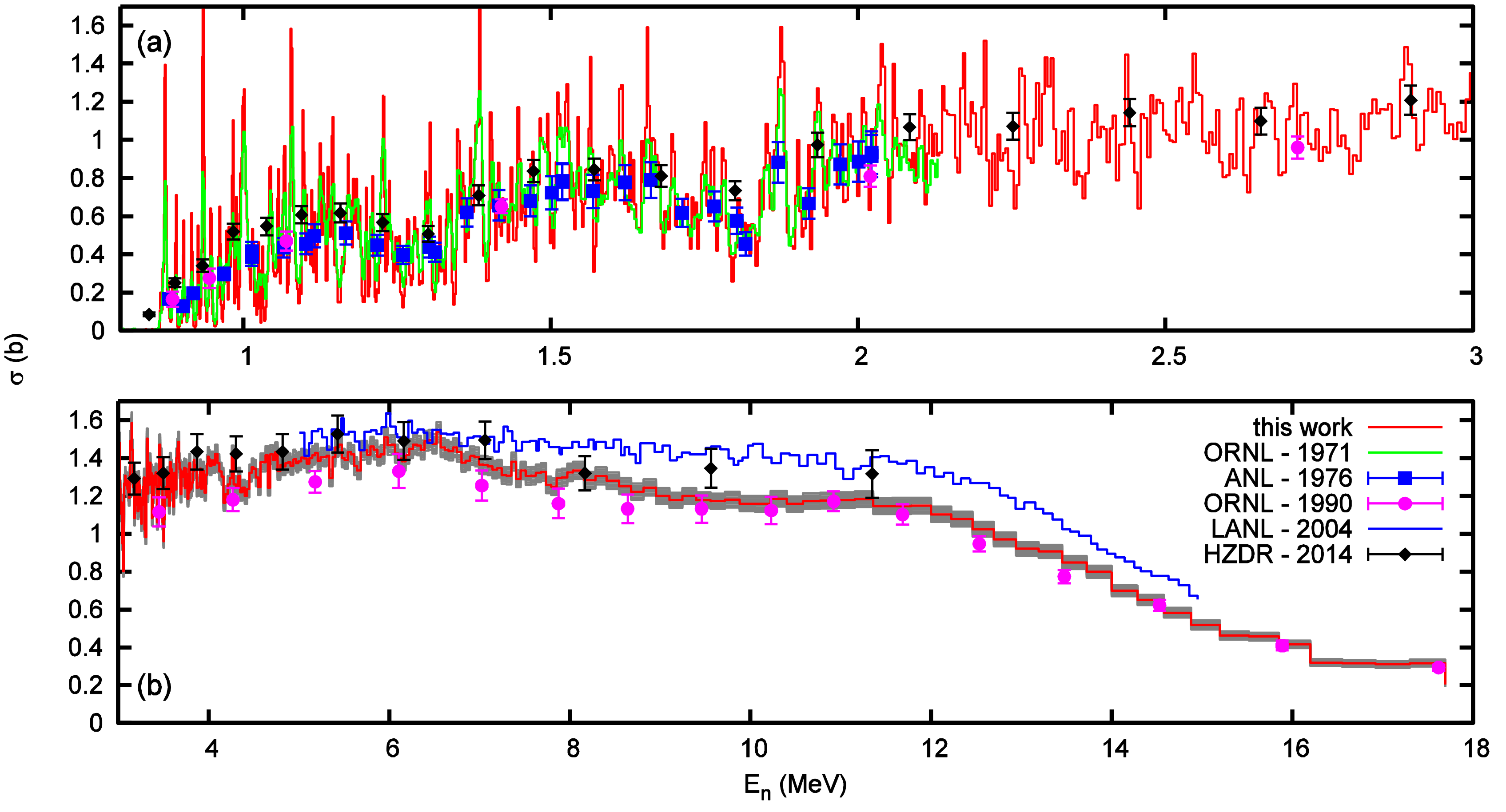
Particularities: ^{57}Fe – the 14-keV transition





Results

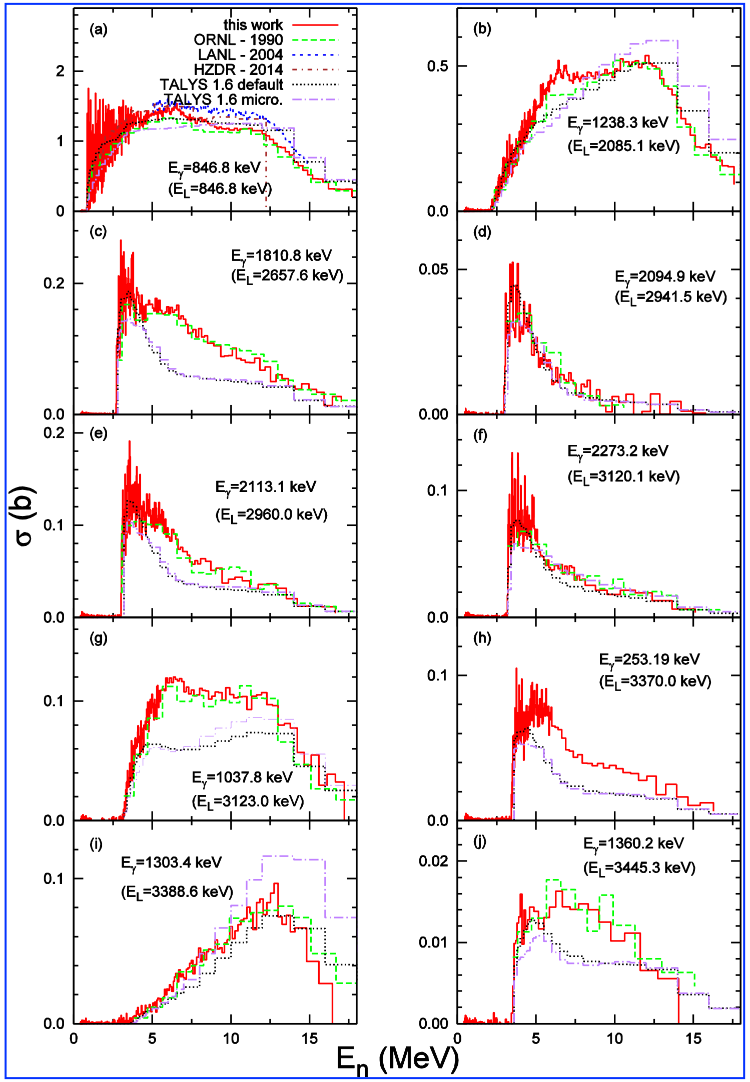
^{56}Fe: 847-keV g production cross section

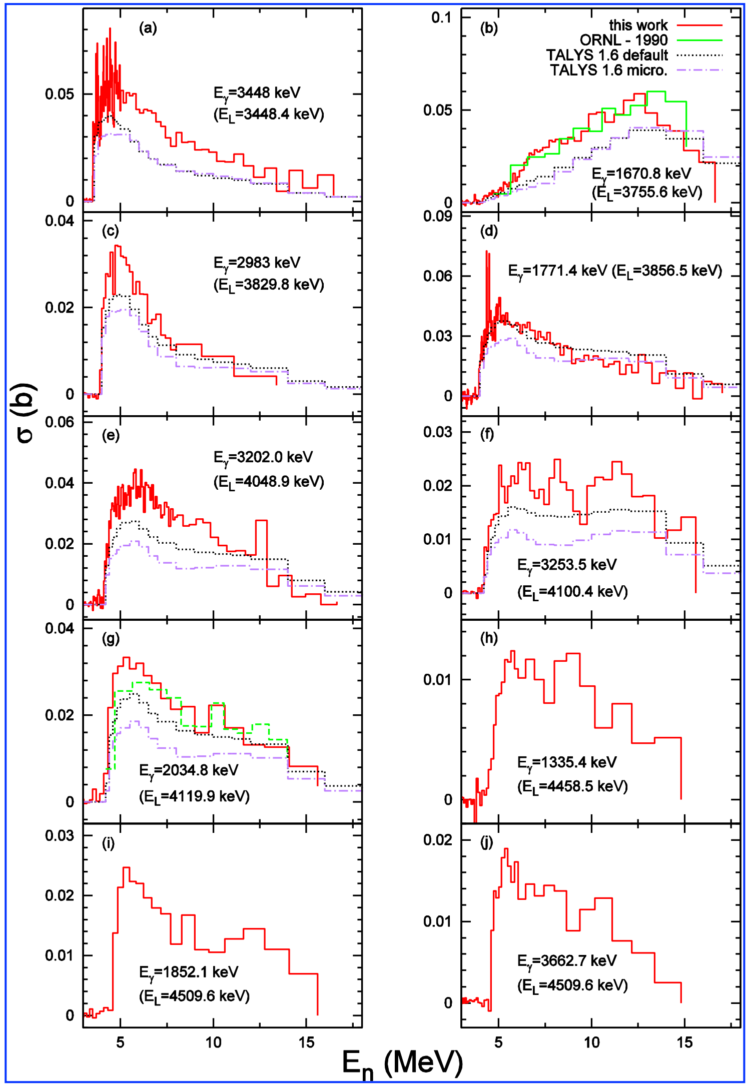


A. Negret et al, Physical Review C90, 034602 (2014)

IFIN-HH

^{56}Fe: other g production cross sections





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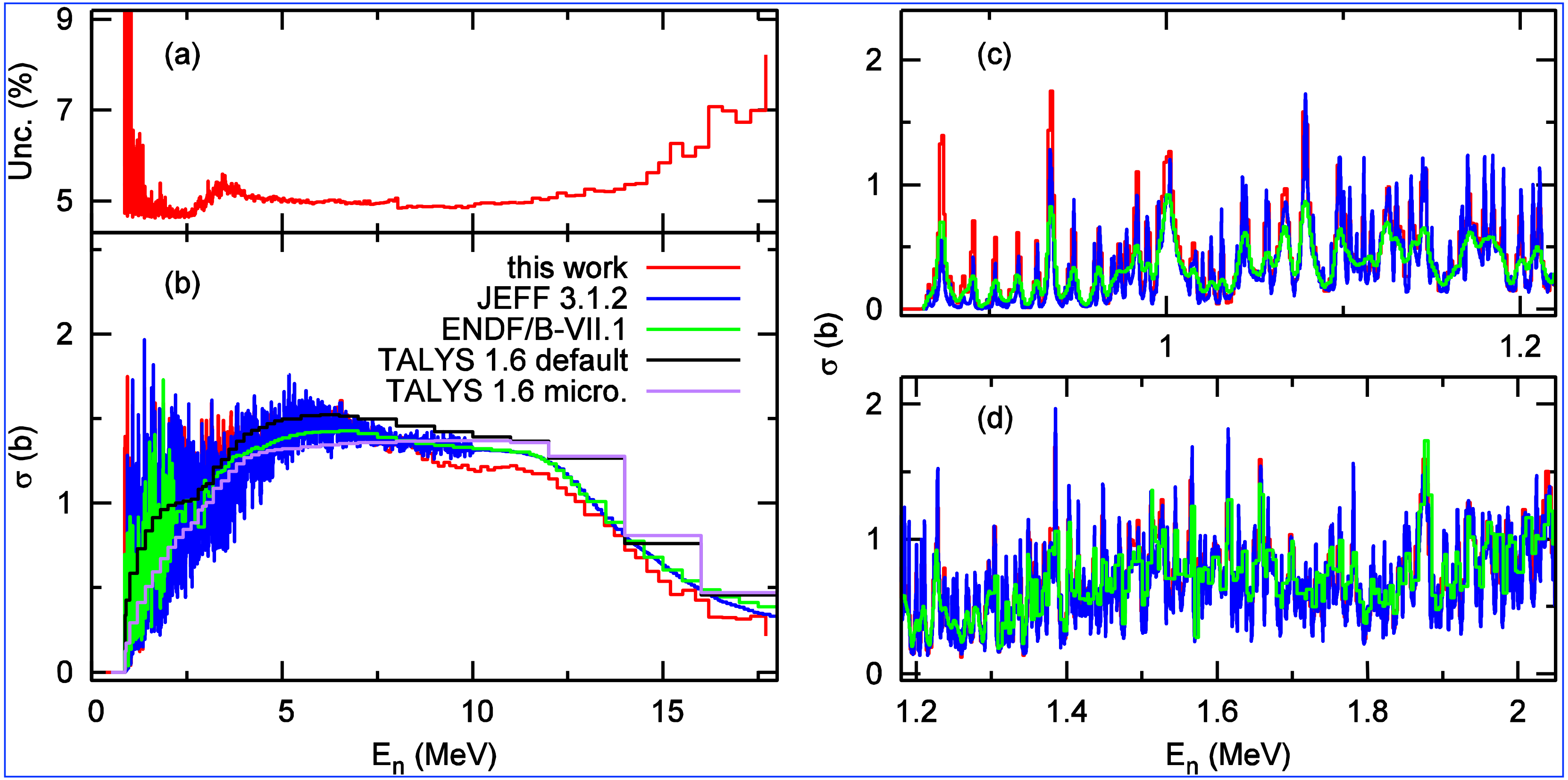
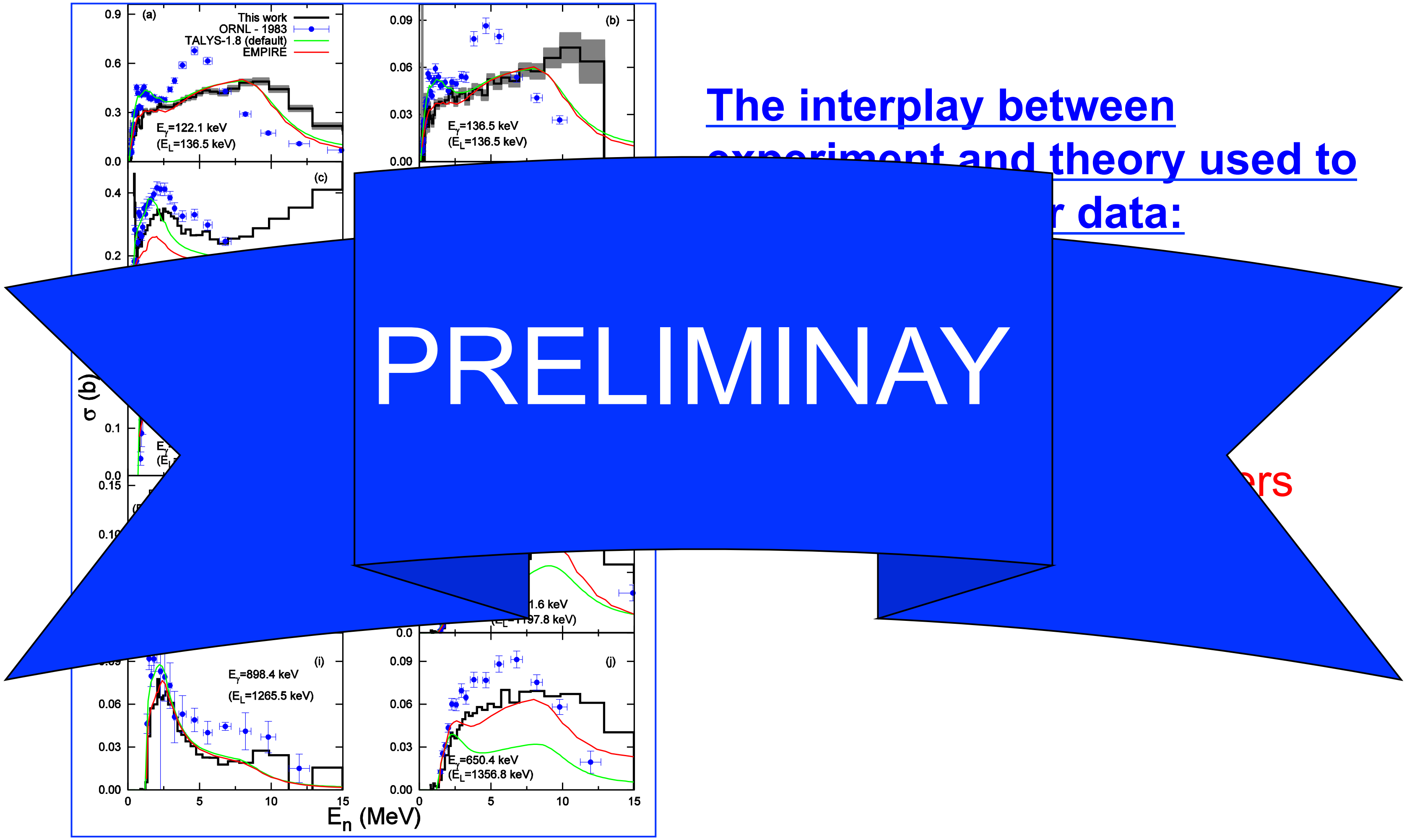
^{56}Fe: total inelastic cross section



A. Negret et al, Physical Review C90, 034602 (2014)

^{57}Fe: preliminary results



The interplay between experiment and theory used to ... r data:

...rs

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- Neutron inelastic cross sections on $^{56,57}Fe$ were measured at GELINA using the GAINS spectrometer.
- High-precision, reliable data are available for ^{56}Fe.
- In case of 57Fe an interplay between theory and experiment is required in order to determine the total inelastic cross section.