Fast Neutron-Induced Gamma-Ray Reference Cross Sections

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IAEA Consultants Meeting

On Cross Section Standards

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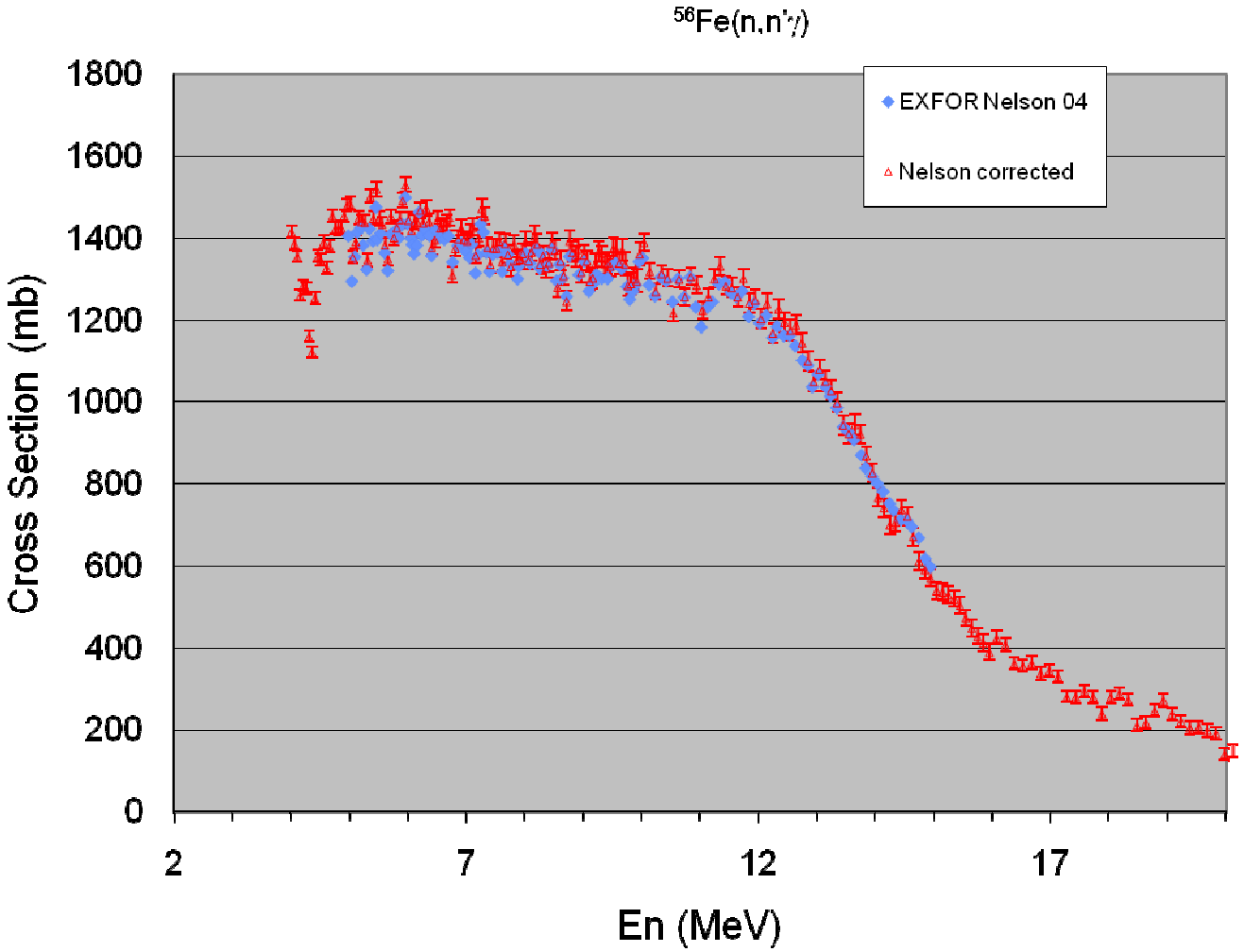
Fast Neutron-Induced Gamma-Ray Reference Cross Sections – Previous Status & Goals

- Fe(n,n'γ) 2+ -> 0+ Cross Section – resolve discrepancies
  - LANL data
  - GEEL data
- Cr(n,n'γ) 2+ -> 0+ Cross Section – resolve discrepancies
  - LANL data
  - GEEL data
- Identify improved gamma-ray reference cross section candidates and accurately characterize them
  - Nb
  - Au
  - Ti

Good Progress on Fe(n,n'γ) Cross Sections

- **LANL - Background subtractions were performed on the LANSCE data reported in 2004 (ND2004)**
  - **Results agree very well with EXFOR Nelson data (= renormalized 2004 data)**
  - **Background was due to neutrons hitting Fe in setup, thus similar effect to change in normalization**
  - **JEF 3.1, ENDF/B-VII.0, and LANL data agree well from 4 to 15 MeV, some small differences to 20 MeV**
- **GEEL (A. Plompen) – normalization issues due to fission chamber were discovered**
  - **Investigated and corrected signal issues, reduced cross section values – closer, but not in agreement**
  - **Efficiency issues –fragment losses in foils - of GEEL fission chamber (A. Carlson identified) are being corrected now**
  - **Corrections will reduce cross sections for better consistency with other results**
  - **Final cross sections expected by Dec 2010**

Comparison of EXFOR Nelson 2004 data and background subtracted data – excellent agreement



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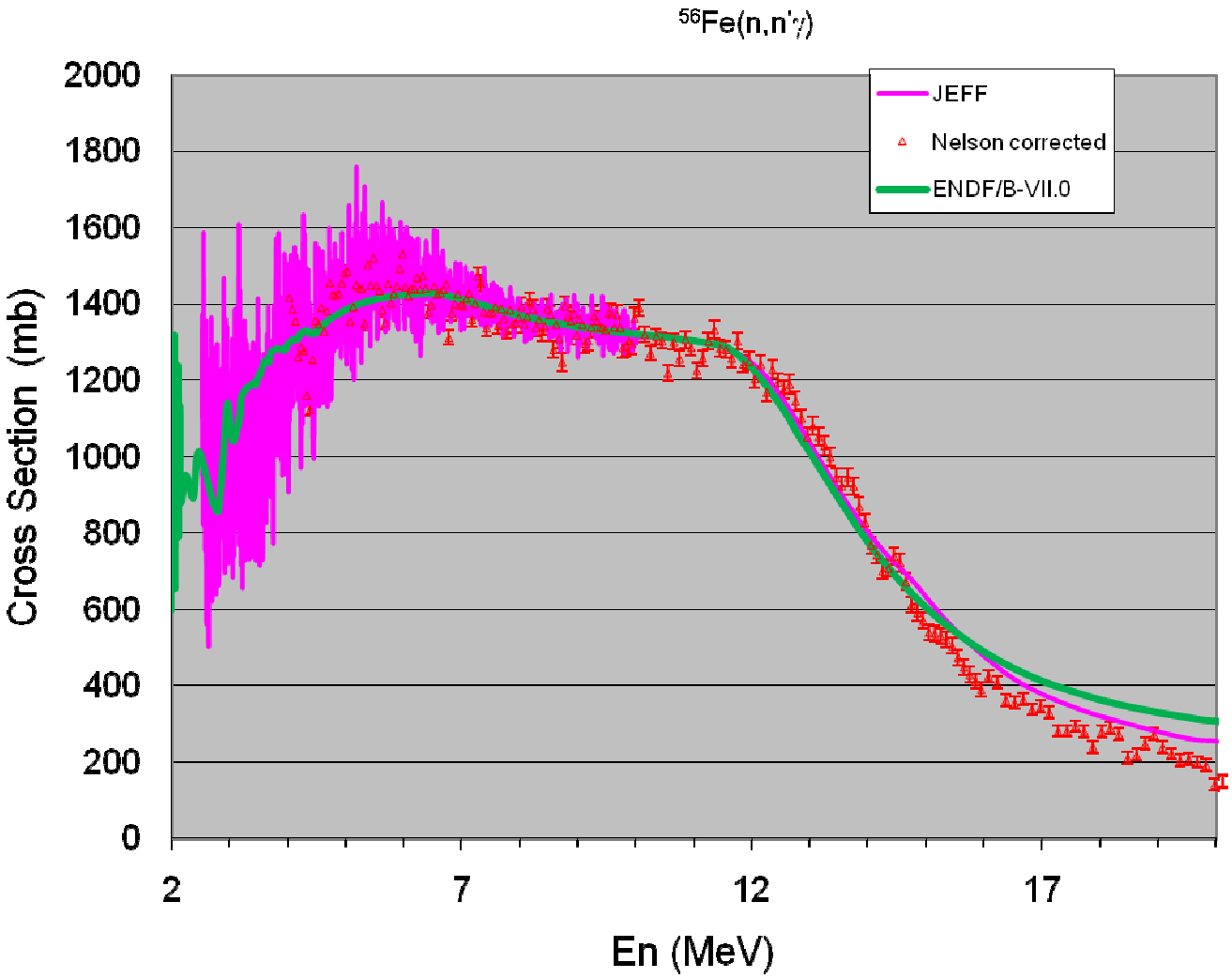
Comparison of LANL data with JEF 3.1 and ENDF/B-VII.0 – good agreement is observed



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Progress on Cr(n,n'γ) Cross Sections

- **LANL – work is still needed on the Cr data sets**

  Good agreement with other data sets at 14 MeV

- **GEEL – excitation function shape is somewhat different from expectations and other data**
  - **Same fission chamber issues as Fe data**
  - **Shape difference may be due to problems with the selection of background gates, but not certain**
  - **Work is still needed**

Potential Neutron-Induced-Gamma-Ray Cross Section Standards Gamma Rays and Cross Sections

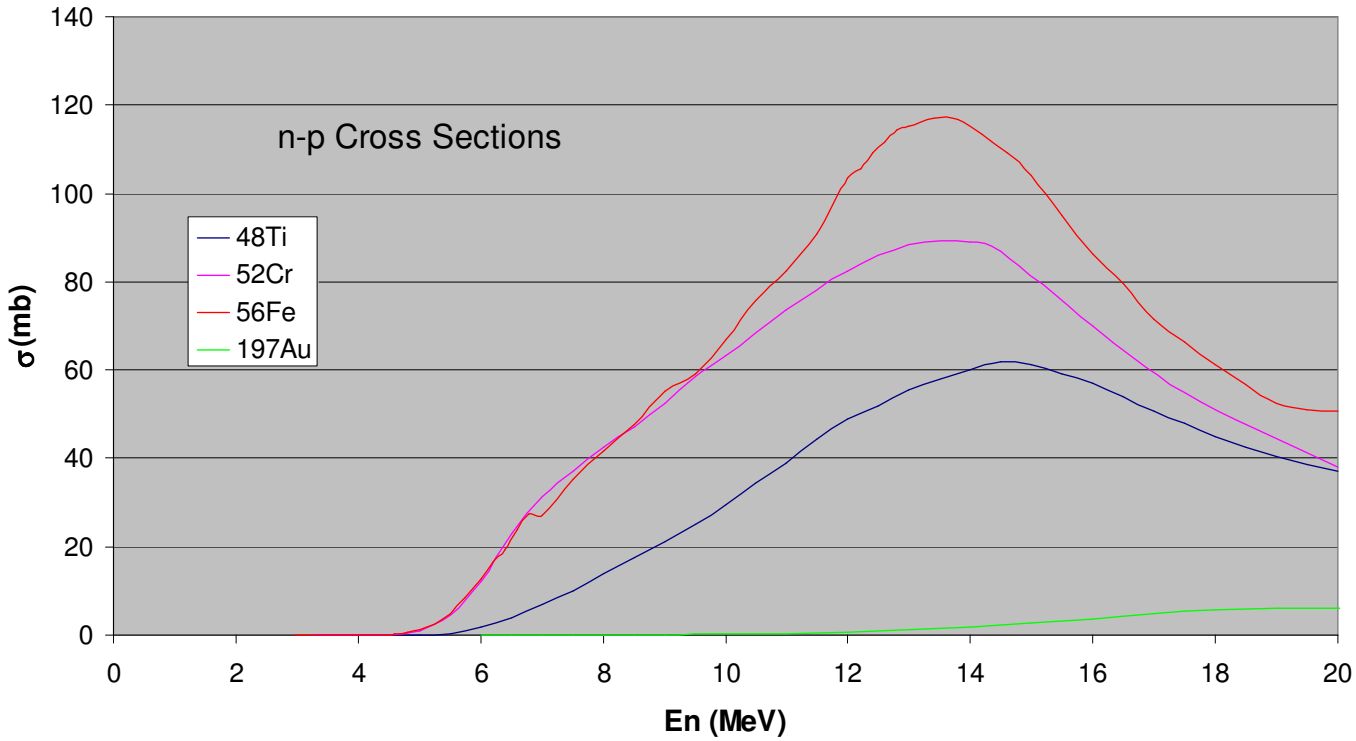
- **"Best" reference cross sections for (n,n') and (n,2n) reactions**

Element	Isotope		Eγ	reaction	σ(14 MeV)	Eγ	reaction	σ(14 MeV)	Eγ	reaction	σ(14 MeV)
Niobium	93		**949**	**(n,n')**	**264**	**501**	**(n,2n)**	**263**	**357**	**(n,2n)**	**239**
Gold	197		**147.8**	**(n,2n)**	**490**	**547.5**	**(n,n') 5.0**	**358**			
Titanium	48		**984**	**(n,n')**	**666**	**160**	**(n,2n+n')**	**404**			
Iron	56		847	(n,n')	785	**1238**	**(n,n'+2n)**	**393**			
Chromium	52		1434	(n,n')	695	**935**	**(n,n'+2n)**	**210**			
Manganese	55		156	(n,2n)	542	126	(n,n')	383	212	(n,2n)	299
Magnesium	24		1369	(n,n')	450	472	(n,p) 20ms	105			
Vanadium	51		226	(n,2n)	368	320	(n,n')	313			
Bismuth	209		1006	(n,2n)	210	565.3	(n,2n)	125	650.7	(n,2n)	130

GEANIE data was acquired on Nb, Au, and Ti, preliminary analysis results

- GEANIE – measured single elements and relative to Cr
- Nb – not suitable as cross section standard
  - 949 keV gamma shows feeding from unknown long-lived isomer
  - Work to identify properties of long-lived level for structure knowledge
- Au – poor as reference standard
  - 547.5 keV gamma is very close to strong background lines, making separation an issue
  - Feeding from isomers is also a problem
- Ti – appears to be suitable
  - Better physical properties than Cr
  - Less abundant in shielding, structures, etc. than Fe
  - (n,p) beta background exists, but (n,p) cross section is roughly ½ that for Fe, and half life is 43.7 h (vs 2.6 h for Fe) resulting in reduced gammas during experiment

The (n,p) cross sections and β-decay half life determine production of neutron-induced gamma ray backgrounds



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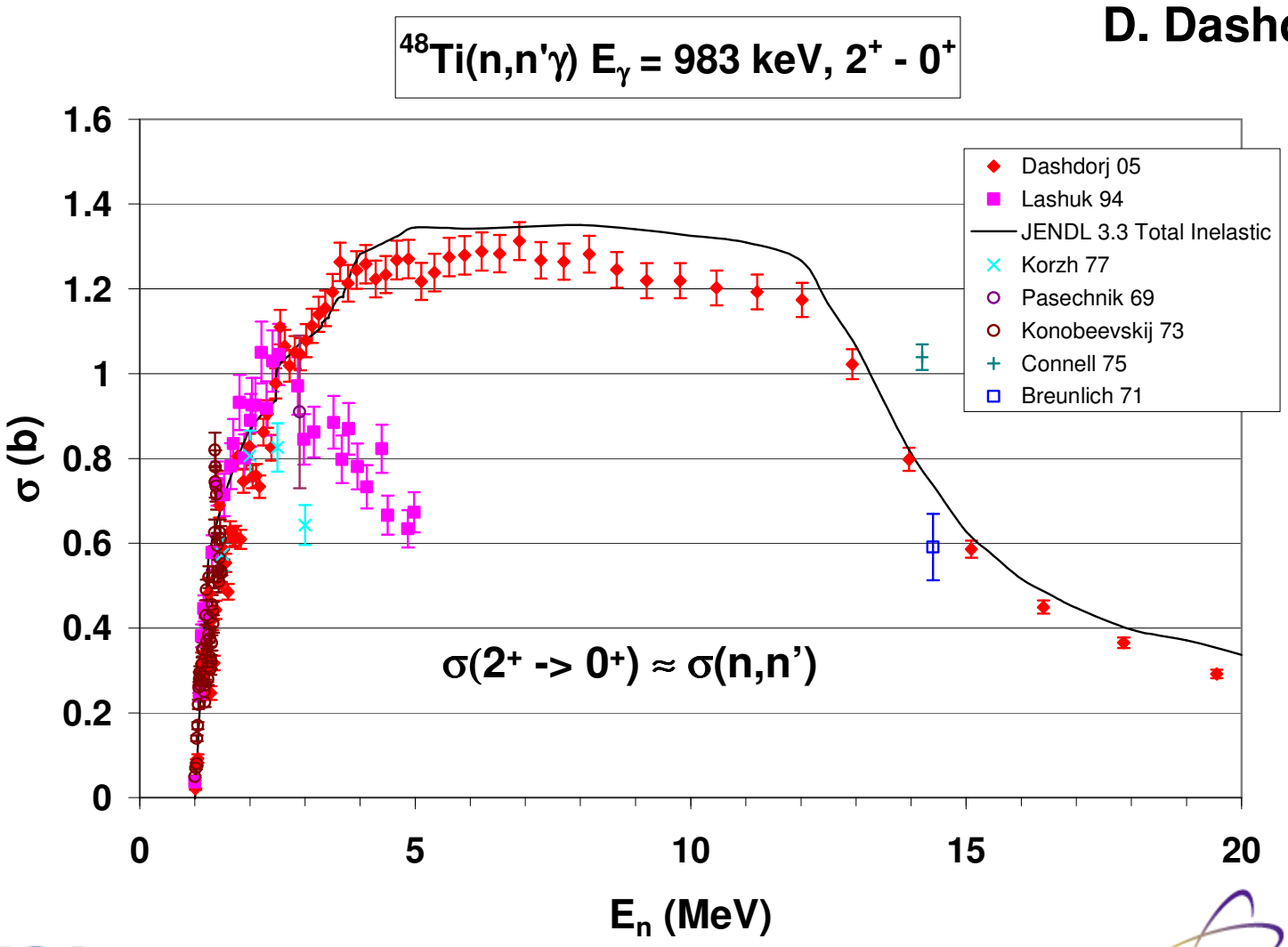
Neutron Inelastic Scattering Cross Section for $^{48}Ti(n,n'\gamma)$ Are Similar to ^{56}Fe



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Summary

- LANL Fe cross section data was corrected, good agreement with JEF 3.1 and ENDF/B-VII.0 – to be published
- GEEL (A. Plompen) Fe data – problems with fission chamber flux have been identified correction work is continuing
- Work on LANL Cr data is continuing
- GEEL Cr data have same normalization issues as Fe and excitation function shape differences are unresolved
- Nb, Au, and Ti were investigated at potential reference cross sections using GEANIE at LANSCE
  - Nb, Au – look unsuitable due to isomers and backgrounds
  - Ti is promising for reference cross sections
- New relative cross section data on Cr-Ti was acquired with GEANIE at LANSCE – analysis is planned