JENDL Ver. 4

S. Kunieda +

K. Shibata
O. Iwamoto
A. Ichihara
N. Iwamoto
S. Kunieda
S. Chiba
T. Nakagawa
J. Katakura

Overview

- Neutron cross-sections for 406 nuclei
- Re-evaluation was made for ~300 nuclei form JENDL-3.3 (337 nucleus)
  - New RP
  - Coupled-channels OM evaluation
  - Fast-energy cross-sections by new codes
- 70 new materials were added
- JENDL/AC-2008+ for MA

New Materials (70 nuclei)

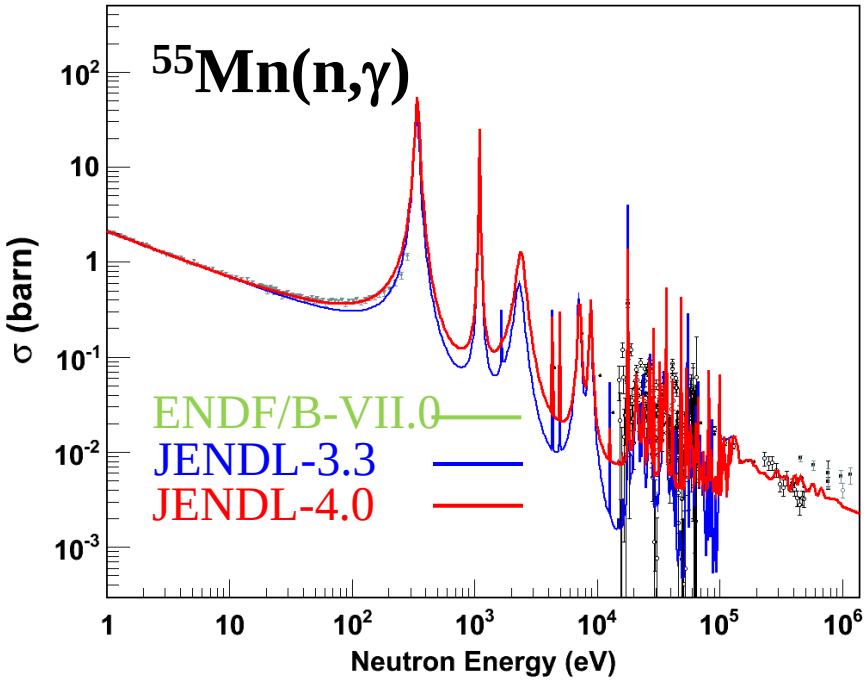
- **V** -50, 51 (Isotopic evaluation)
- **Zn**-64, 65, 66, 67, 68, 70 (fusion relevant ?)
- $^{154\text{-}164}$Dy, ^{169}Tm, $^{168\text{-}176}$Yb, $^{184\text{-}192}$Os, ^{197}Au
- **FP/MA (**$T_{1/2} \geq 10$ days, fission yield $\geq 0.1\%$**)**
- **Minor nuclei** (e.g., Fe-59, Ni-59, W-180, …)

Resolved RP

- **Recent ORNL data with covariance (Mn,Cr)**
- **Recent n-TOF, LANSCE, RPI & …**
- **ATLAS-2006**
- **E_{max} was carefully determined**
- **Adjust negative resonance parameter**
- **Updated for <u>more than 200</u> nuclei**

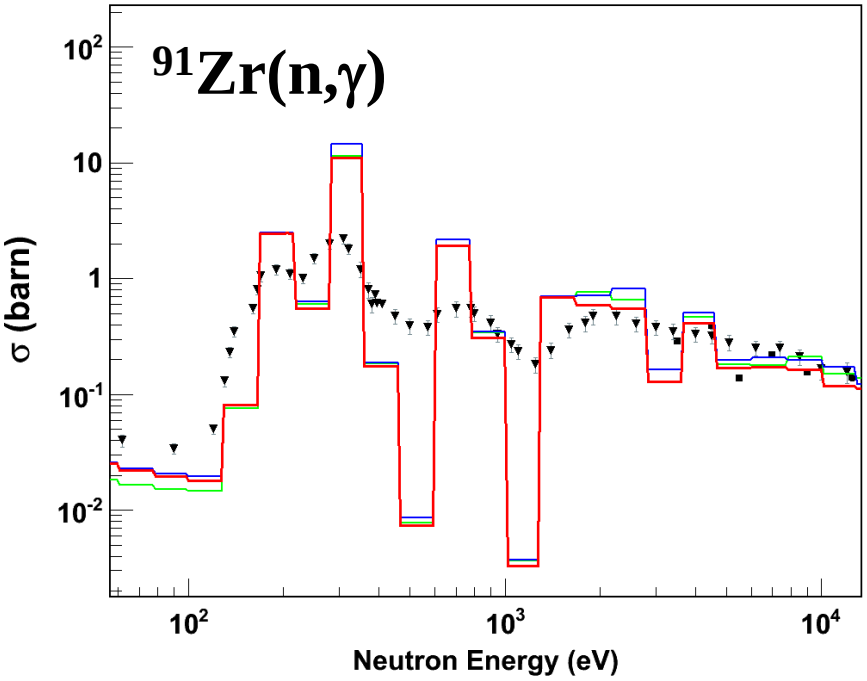
Resolved RP

ORNL data were adopted



Res. Integ.		
JENDL-3.3	11.77	(b)
JENDL-4.0	13.51	(b)
Atlas-2006	13.40±0.5	(b)

n-TOF data were adopted



Res. Integ.		
JENDL-3.3	6.94	(b)
JENDL-4.0	5.73	(b)
Atlas-2006	5.76±0.4	(b)

Unresolved RP

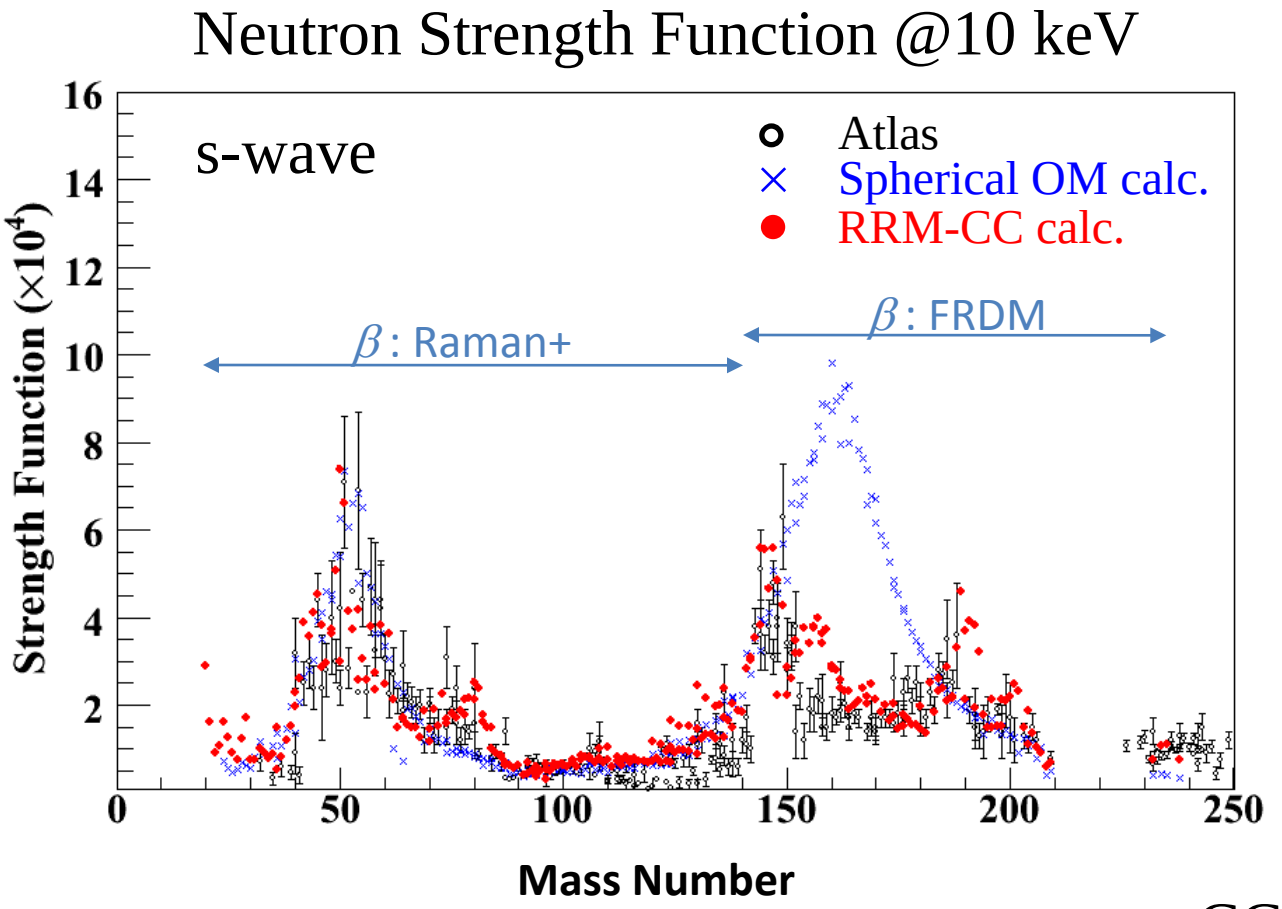
- **E_{max} was extended up to 100 keV – 1 MeV**
- **Re-evaluation for almost all nuclei**
- **Adopt LSSF=1**

Fast-energy Region

Optical Model Evaluation

- Model :
  - Coupled-channels (Soft/Rigid-rotor)
  - SOM+DWBA
- OMP : (nucleons)
  - Kunieda-Chiba+ (2006)
  - Koning-Delaroche (2000)
  - Soukhovitskii+ (200X) MA
- Beta :
  - Tuned values
  - Raman's recommendation values
  - Theoretical prediction, e.g., by FRDM

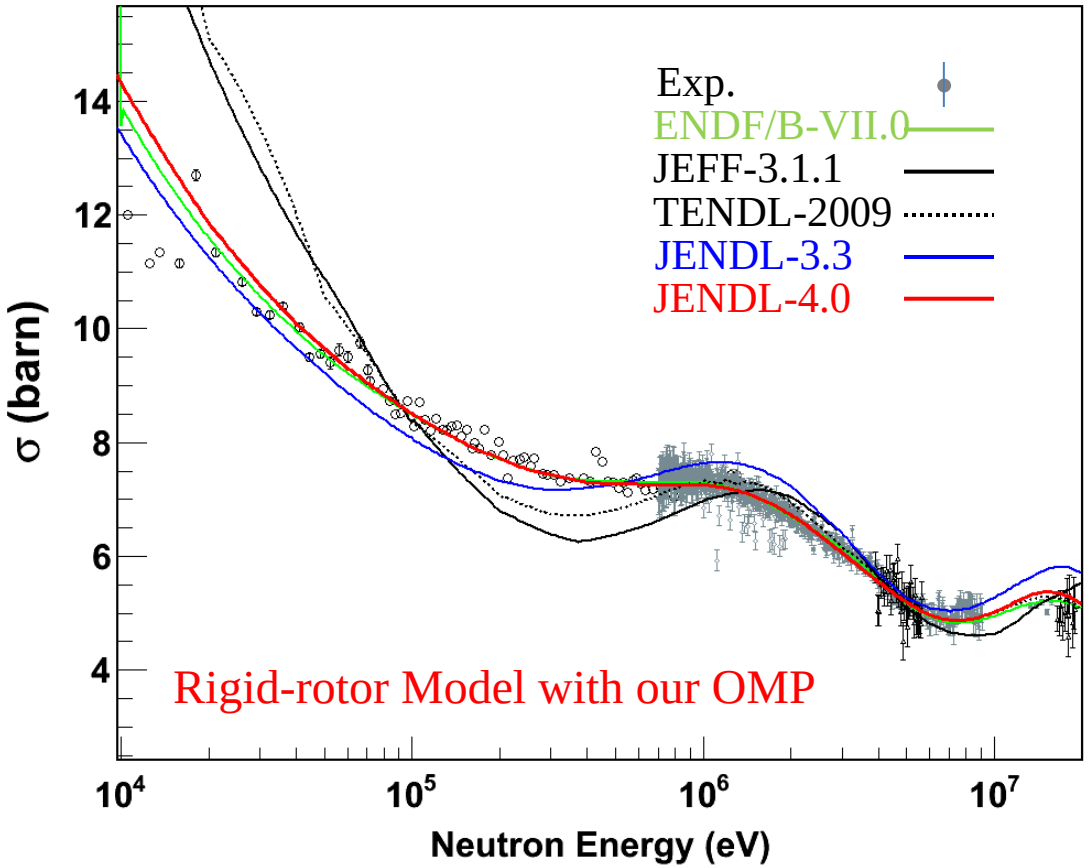
Bulk Test for CC-OM



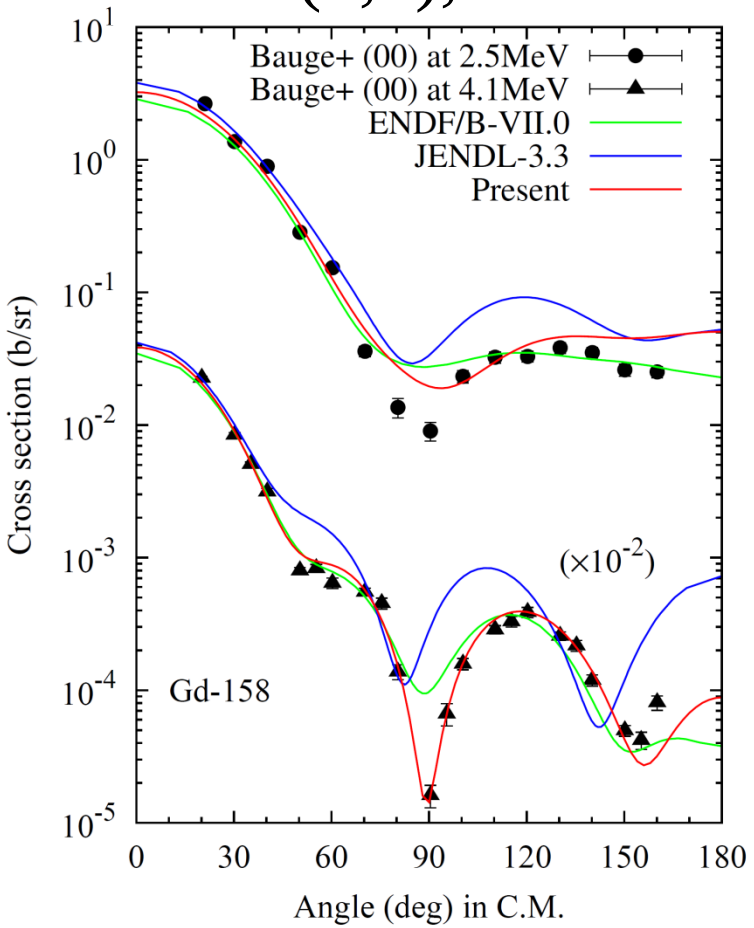
CC is realistic

Optical Model Eval. -examples-

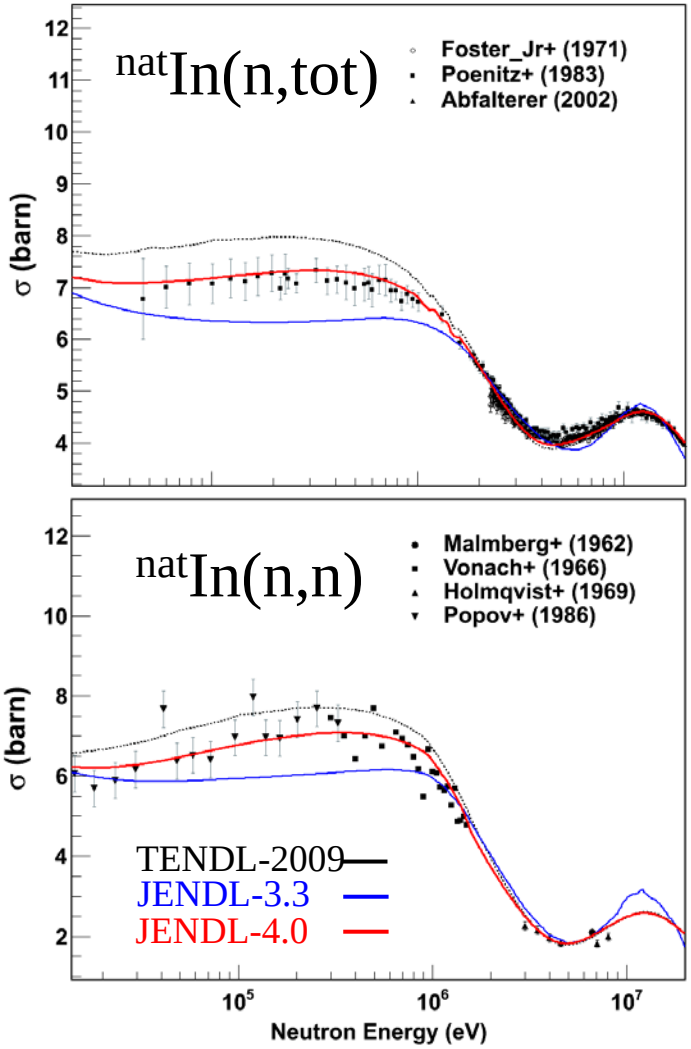
^{nat}Gd(n,total)

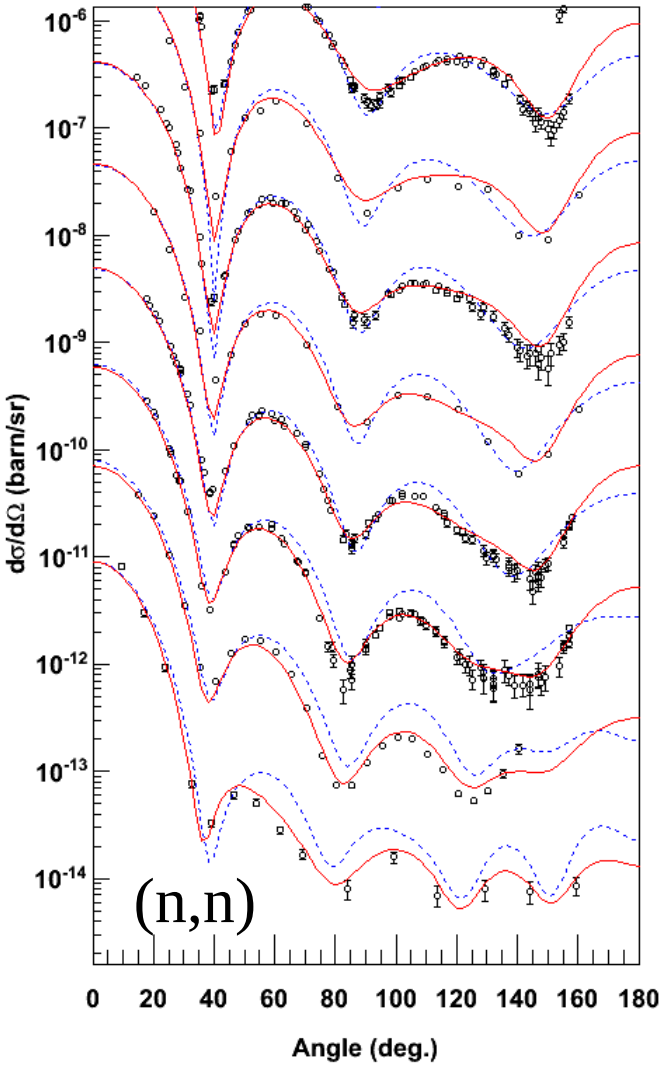


^{158}Gd(n,n),DA



Optical Model Eval. -examples-



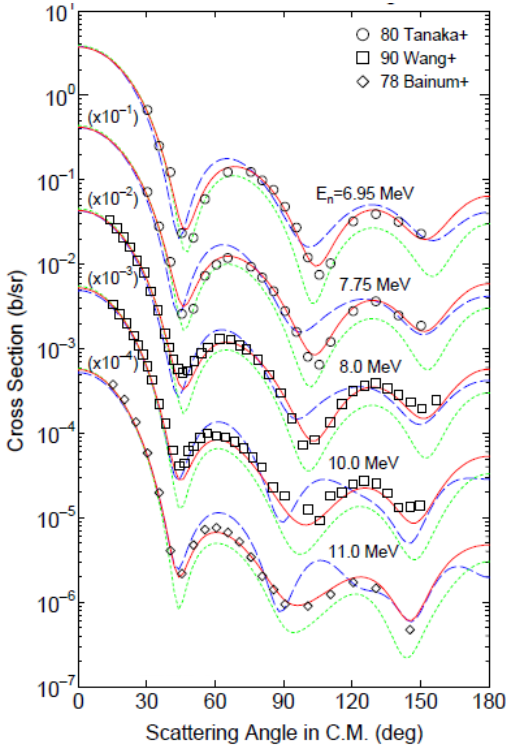


6.5 MeV

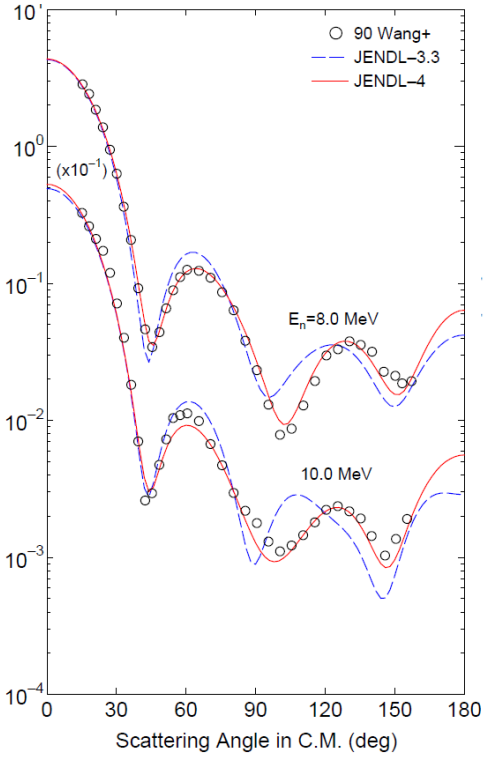
14.6 MeV

Optical Model Eval. -examples-

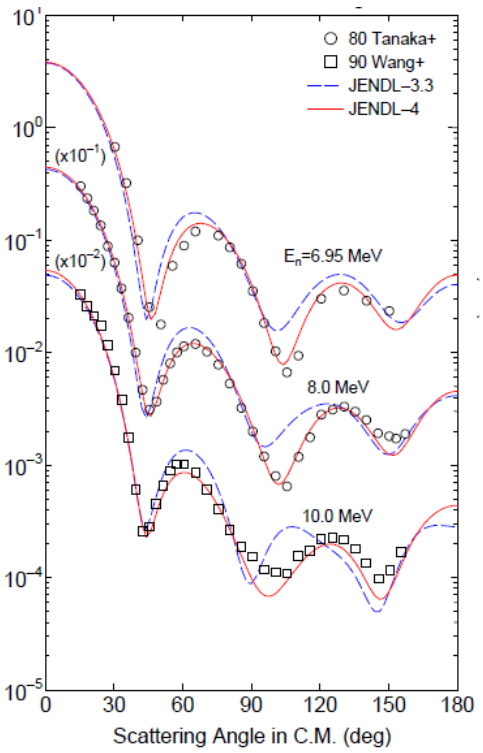
^{90}Zr (n,n)



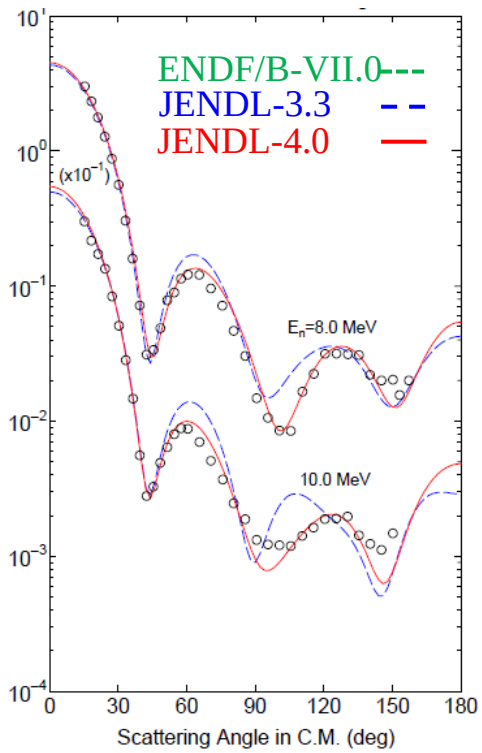
Zr-91



Zr-92



Zr-94



OMP: Koning-Delaroche

Fast-energy Region -II

CCONE / POD evaluation

Models

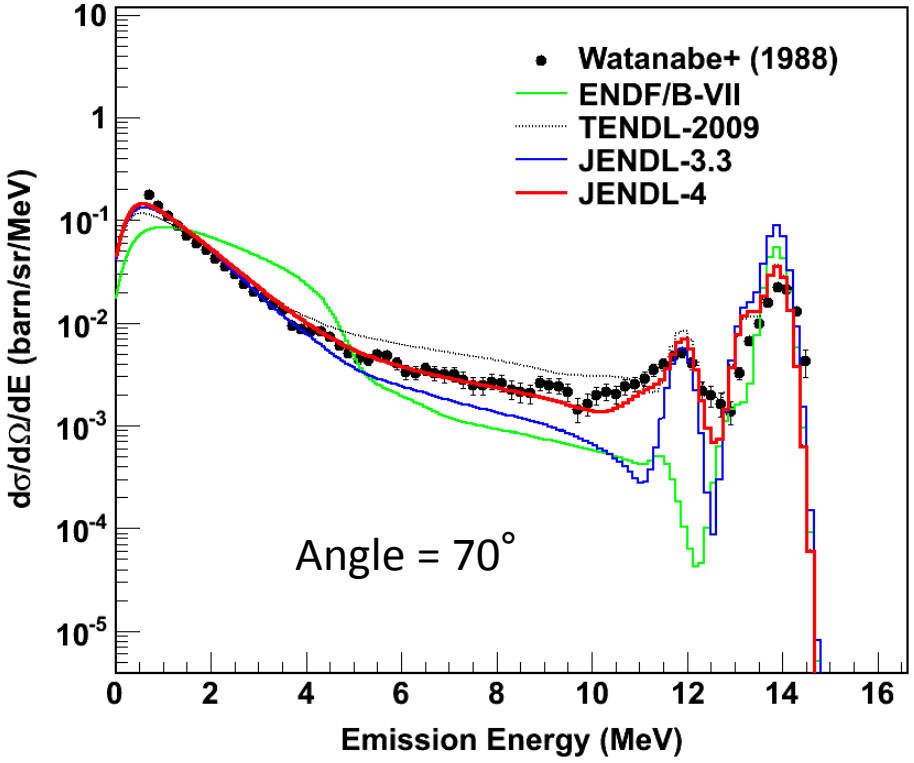
- Multistep statistical decay
- Pre-equilibrium model
- Direct capture

Key parameters

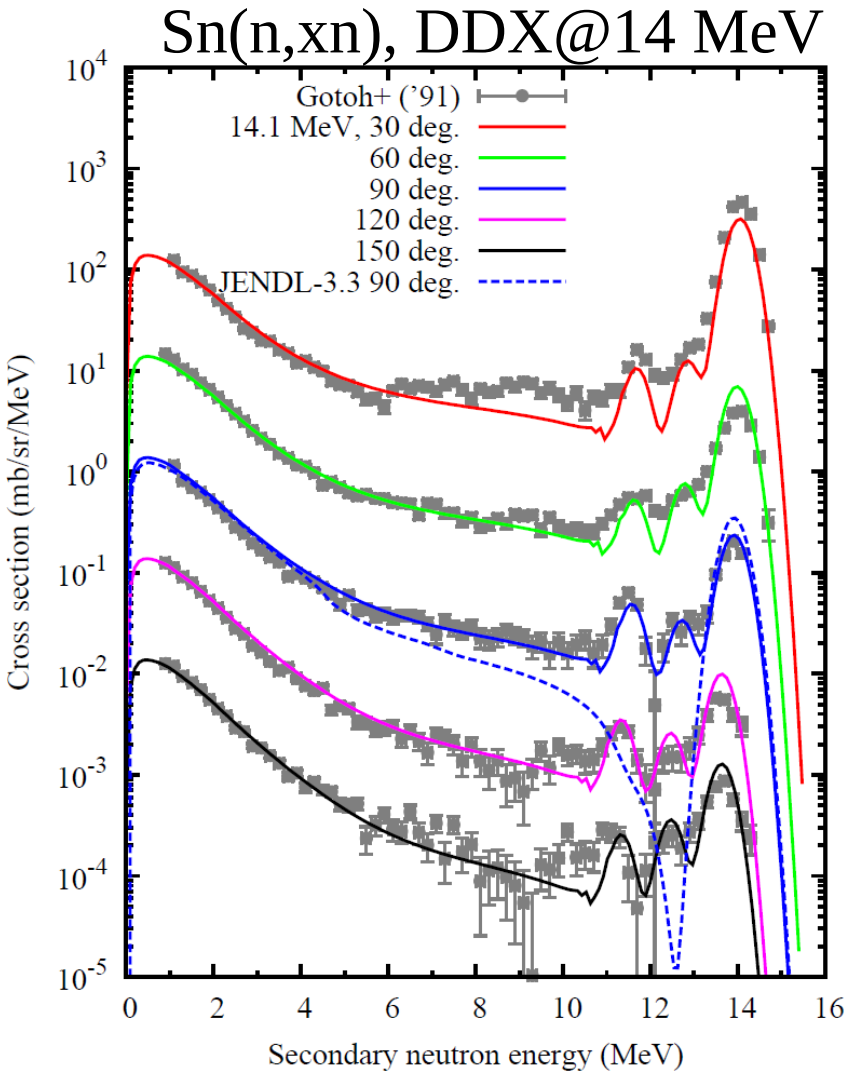
- CC transmission coeff.
- Mengoni-Nakajima a*
- Γ_γ/D_0, Determined from $(n,\gamma)_{exp}$ / Atlas / Syst.

CCONE / POD Evals

Cd(n,xn), DDX@14 MeV

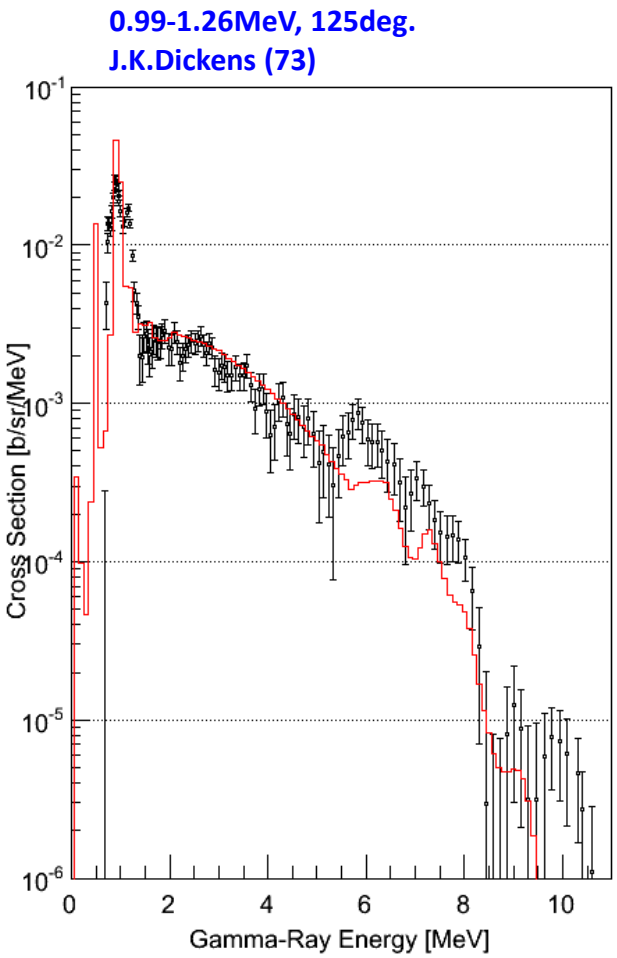


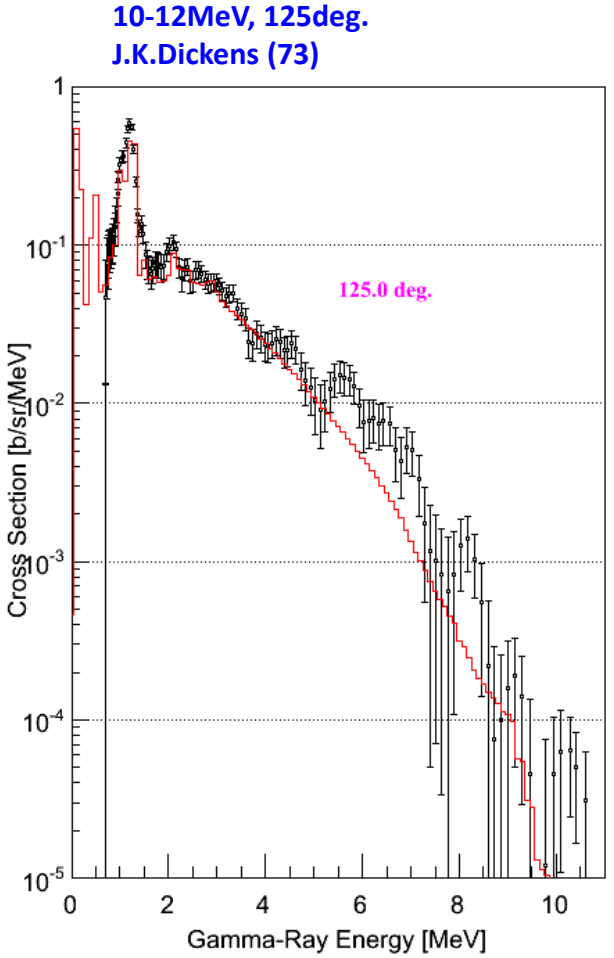
Sn(n,xn), DDX@14 MeV



CCONE / POD Evals

^{nat}Sn γ-ray DDX





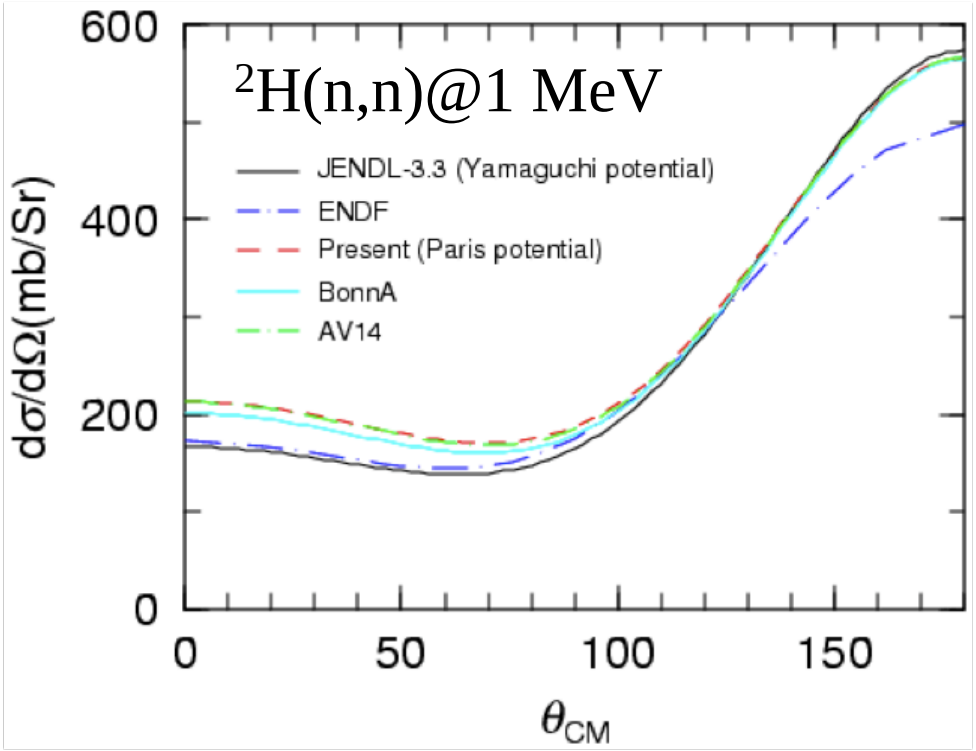
CCONE / POD Evals

~200 nuclei + MA

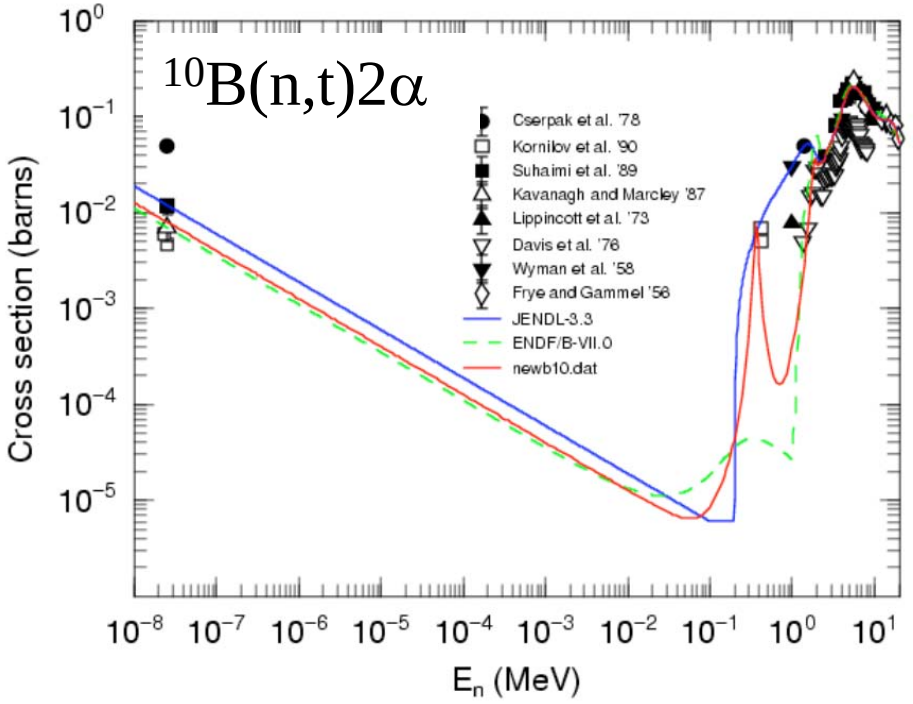
^{28,29,30}Si, $^{40\text{-}48}$Ca, ^{50,51}V, $^{50\text{-}54}$Cr, $^{64\text{-}70}$Zn, ^{75}As, $^{74\text{-}82}$Se,
$^{78\text{-}86}$Kr, ^{85,86,87}Rb, $^{84\text{-}88}$Sr, ^{89,90,91}Y, $^{92\text{-}100}$Mo, $^{102\text{-}110}$Pd,
$^{107\text{-}111}$Ag, $^{106\text{-}116}$Cd, ^{113,115}In, $^{112\text{-}126}$Sn, $^{124\text{-}136}$Xe,
$^{133\text{-}137}$Cs, $^{140\text{-}144}$Ce, $^{142\text{-}150}$Nd,$^{147\text{-}151}$Pm, $^{144\text{-}154}$Sm,
$^{151\text{-}155}$Eu, $^{152\text{-}160}$Gd, ^{159,160}Tb, $^{154\text{-}164}$Dy, $^{162\text{-}170}$Er, ^{169}Tm,
$^{168\text{-}176}$Yb, $^{174\text{-}182}$Hf, $^{180\text{-}186}$W, $^{184\text{-}192}$Os, ^{179}Au, $^{204\text{-}208}$Pb,
^{209}Bi, +MA

Microscopic Approaches

Faddeev calculation by S. Chiba

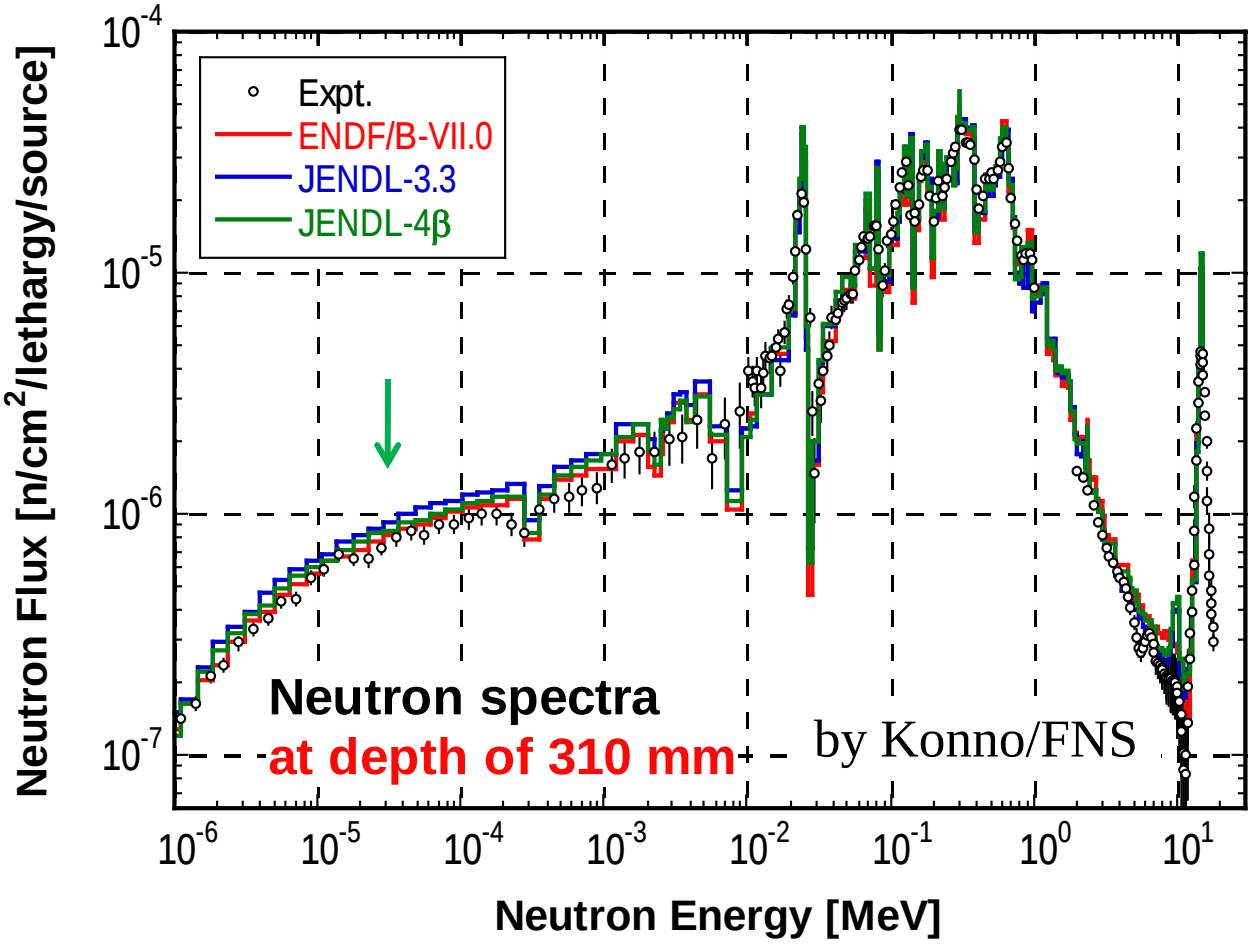


ACM calculation by N. Itagaki



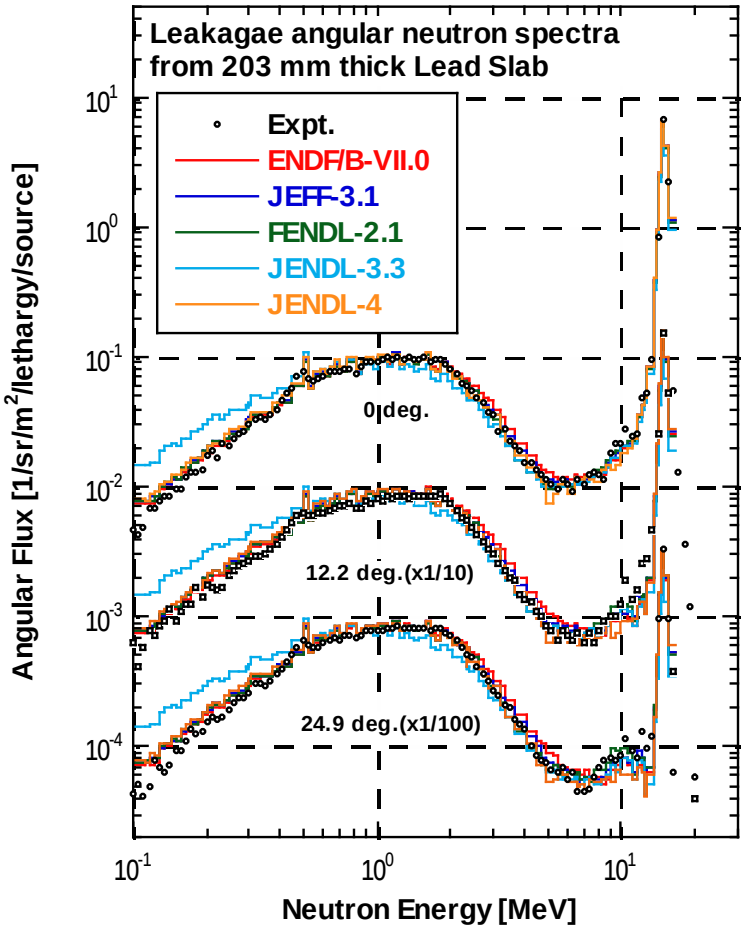
FNS Fe Benchmark

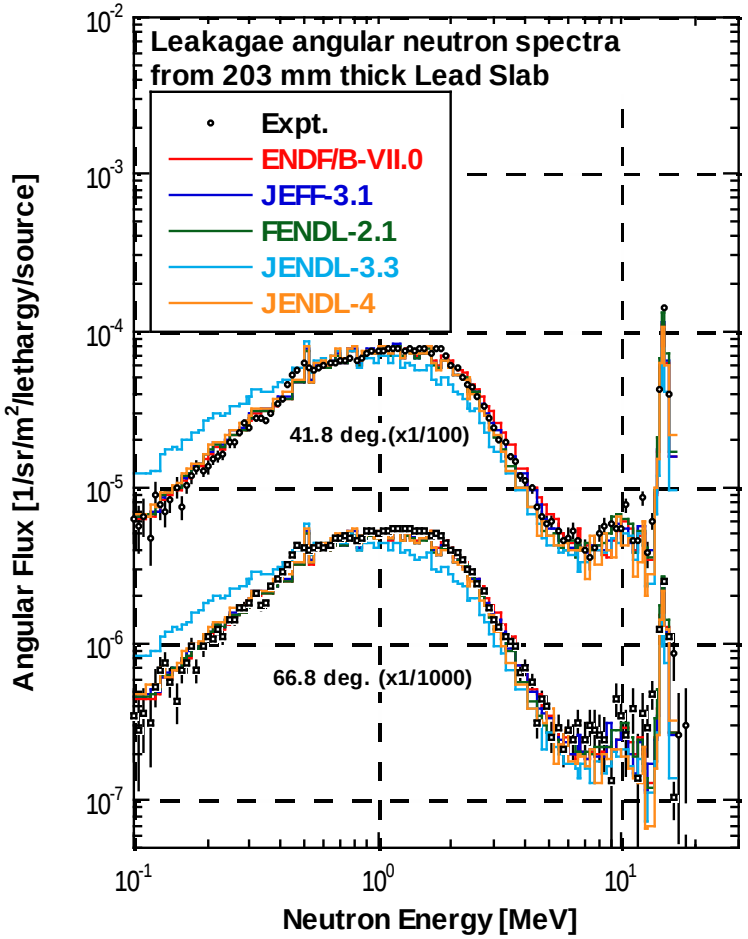
$^{57}Fe(n,n_1')$ was modified for JENDL-4



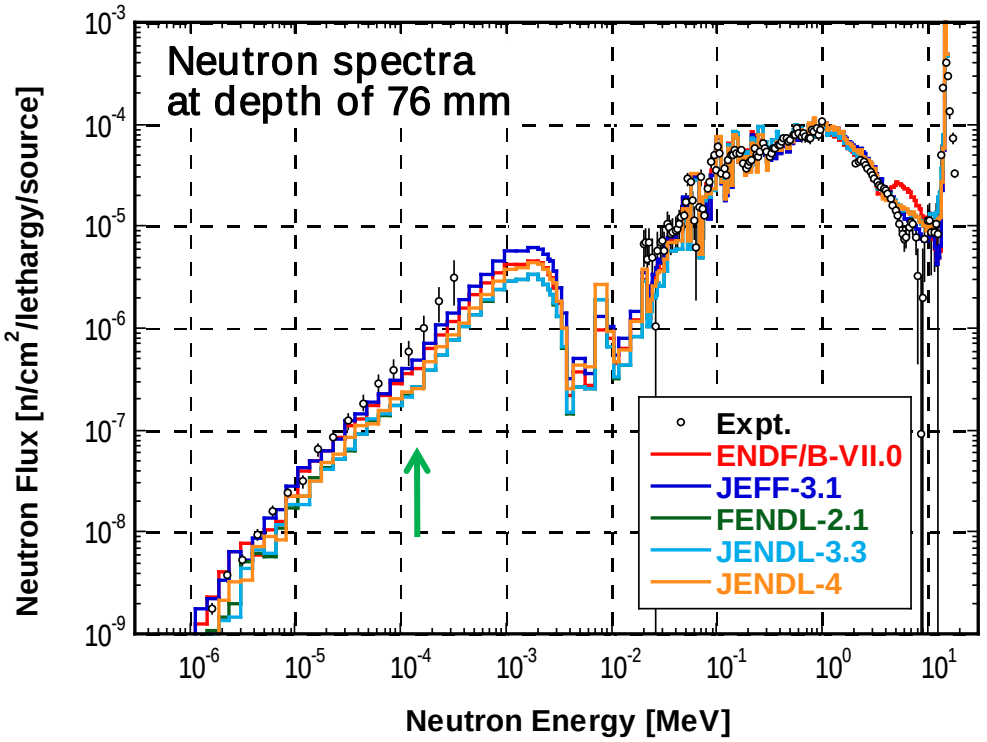
FNS Pb Benchmark

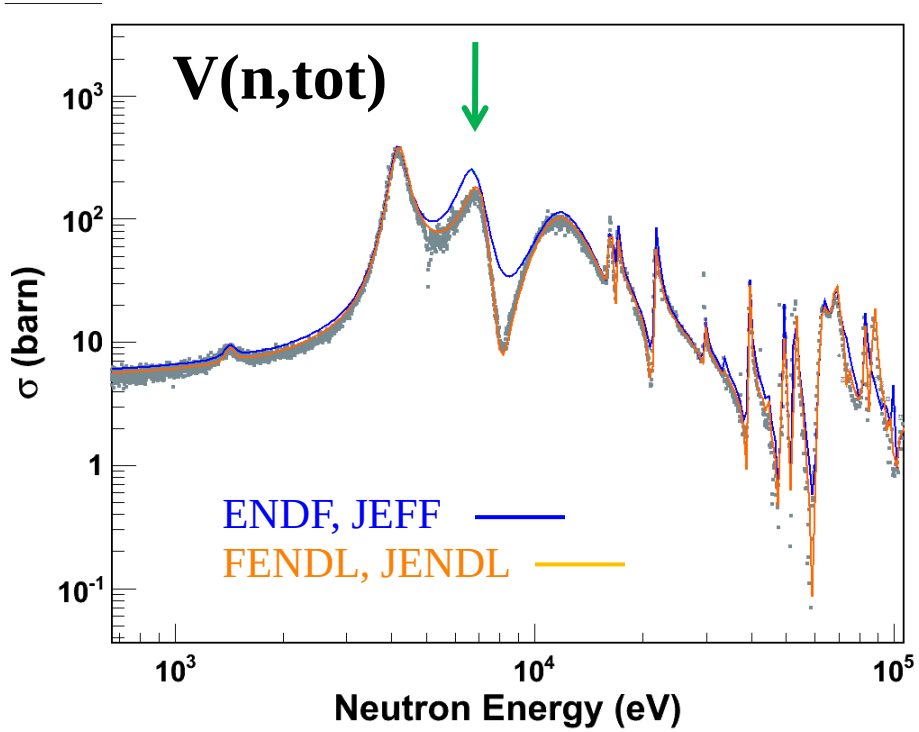
Full-evaluation was performed for JENDL-4





FNS V Benchmark





There is an inconsistency in this case …

Summary

- JENDL-4.0 is now ready to release
  - RRP&URP were updated
  - Adopt CC optical model with recent potential
  - CCONE / POD evaluations (DDX, γ-spectra)
  - Microscopic models were partially applied to
  - FNS benchmarks shows some improved effects

Back up

^{1}H, $^{70\text{-}76}$Ge : ENDF/VII.0

CCONE / POD evaluation

^{28,29,30}Si, $^{40\text{-}48}$Ca, ^{50,51}V, $^{50\text{-}54}$Cr, $^{64\text{-}70}$Zn, ^{75}As, $^{74\text{-}82}$Se, $^{78\text{-}86}$Kr,
^{85,86,87}Rb, $^{84\text{-}88}$Sr, ^{89,90,91}Y, $^{92\text{-}100}$Mo, $^{102\text{-}110}$Pd, $^{107\text{-}111}$Ag, $^{106\text{-}116}$Cd,
^{113,115}In, $^{112\text{-}126}$Sn, $^{124\text{-}136}$Xe, $^{133\text{-}137}$Cs, $^{140\text{-}144}$Ce, $^{142\text{-}150}$Nd,$^{147\text{-}151}$Pm,
$^{144\text{-}154}$Sm, $^{151\text{-}155}$Eu, $^{152\text{-}160}$Gd, ^{159,160}Tb, $^{154\text{-}164}$Dy, $^{162\text{-}170}$Er,
^{169}Tm, $^{168\text{-}176}$Yb, $^{174\text{-}182}$Hf, $^{180\text{-}186}$W, $^{184\text{-}192}$Os, ^{179}Au, $^{204\text{-}208}$Pb, ^{209}Bi

Light Nuclei

^{1}H : ENDF/VII.0

^{9}Be : (n,n), (n,2n)

C : (n,n) was modified

^{14}N : (n,p) with covariance

^{16}O : New R-matrix analysis, (n,α)

^{23}Na : Covariance data were modified

Better results were achieved in typical (reactor/FNS) benchmarks