Present Status of the JENDL Project

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Japanese Nuclear Data Committee

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chaired by N. Yamano, Univ. of Fukui

Subcommittee on Nuclear Data (H.Harada, JAEA)

- Activation Cross Section Evaluation WG (N.Iwamoto, JAEA) (to be established in 2015)
- ENSDF Group (H.Iimura, JAEA)
- Japanese Nuclear Data Measurement Network (Y.Watanabe, Kyushu Univ.)
- High Energy Nuclear Data Evaluation WG, closed in March 2015 (S.Kunieda, JAEA)

Subcommittee on Reactor Constants (N.Yamano, Univ. of Fukui)

- Reactor Integral Test WG (G.Chiba, Hokkaido Univ.)
- Shielding Integral Test WG (C.Konno, JAEA)
- WG on Evaluation of Nuclide Generation and Decay Heat (K.Okumura, JAEA)
- Covariance Utilization WG (T.Iwasaki, Tohoku Univ.)

JENDL-4.0/HE

Evaluated neutron & proton nuclear data for 132 nuclei up to 200 MeV

- New evaluation for ^{2}H, ^{6,7}Li and ^{9}Be

  - ^{2}H : Faddeev 3-body theory with Paris-EST
  - ^{6,7}Li : R-matrix analysis + CCONE, DWBA, etc …
  - ^{9}Be : OPTMAN-10 & CCONE

- CCONE evaluation

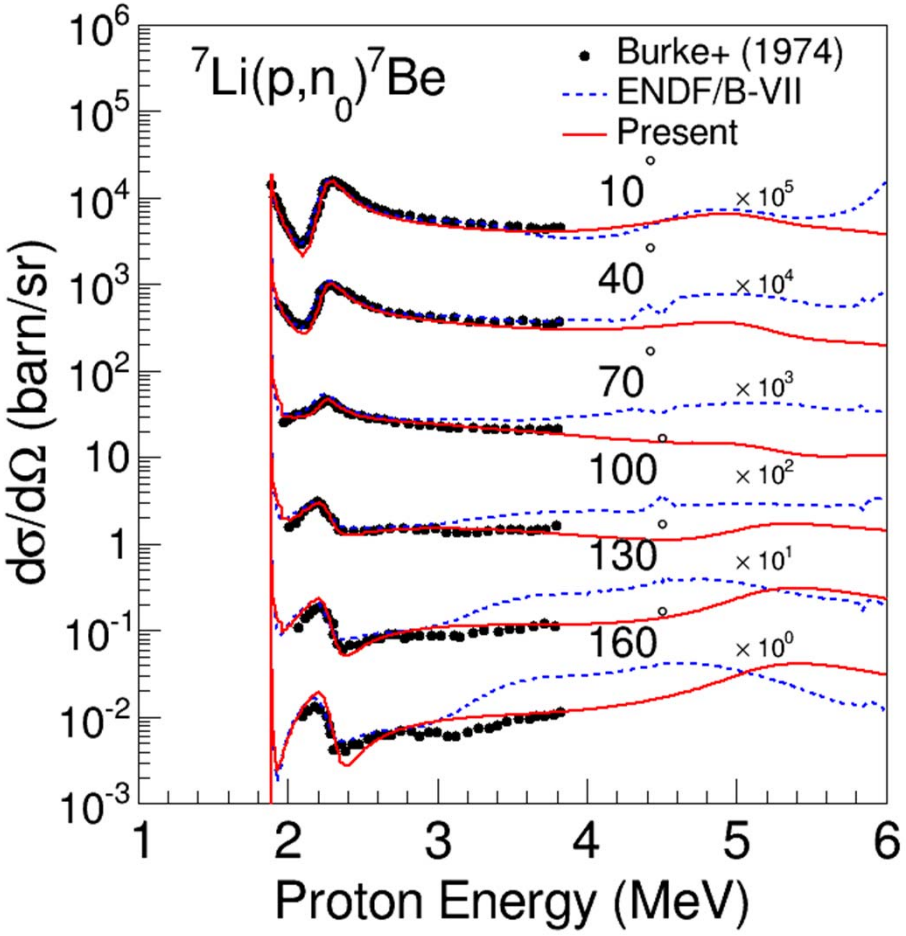
  - Kunieda-OMP for nucleons
  - Modified Iwamoto-Harada model for pre-equilibrium deuteron and alpha-particle emissions
  - CM to Lab. (DDX) conversion with Iwamoto's method

- Inheritances

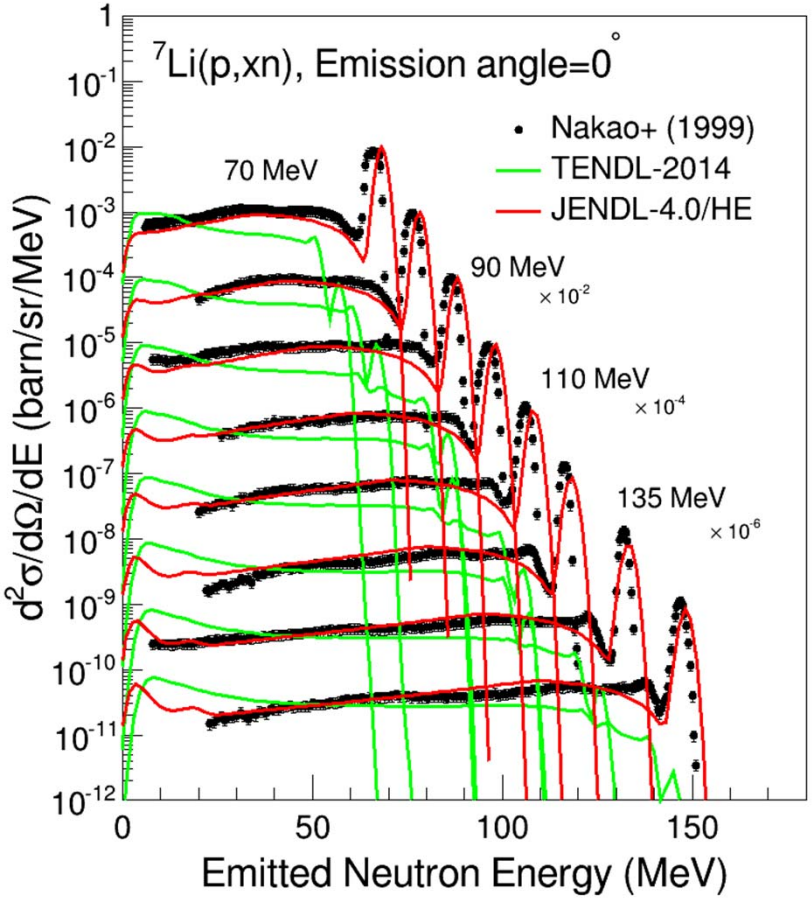
  - JENDL-4.0(u) : all the neutron cross-sections below 20 MeV
  - JENDL/HE-2007 : light and actinide nuclei (~30 nuclei)

Evaluation for Li-7

R-matrix analysis for ^{8}Be system

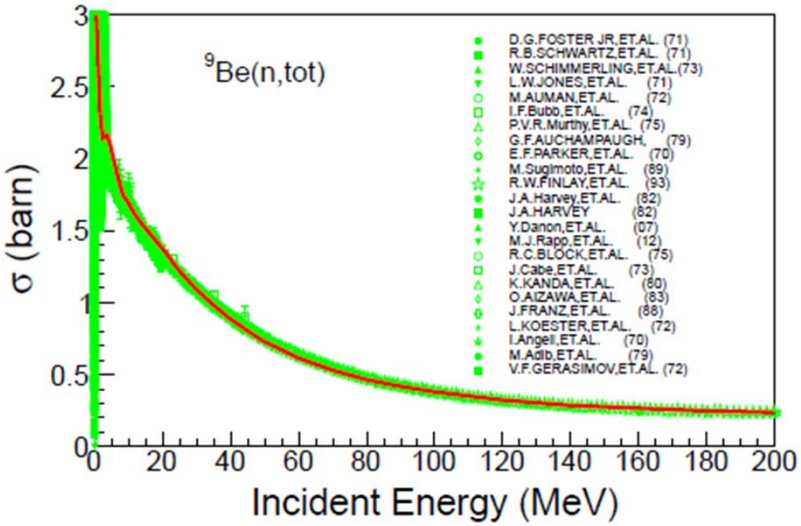


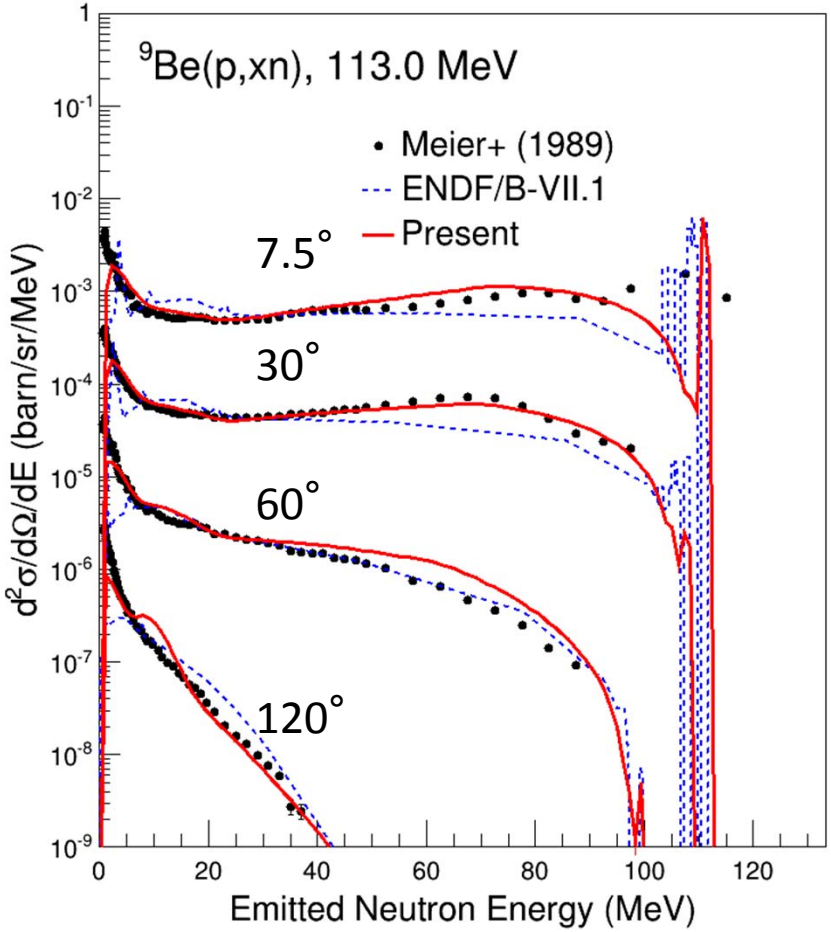
- Continuum spectra : CCONE
- IAS-Peak : Legendre & DWBA fit



Evaluation for Be-9

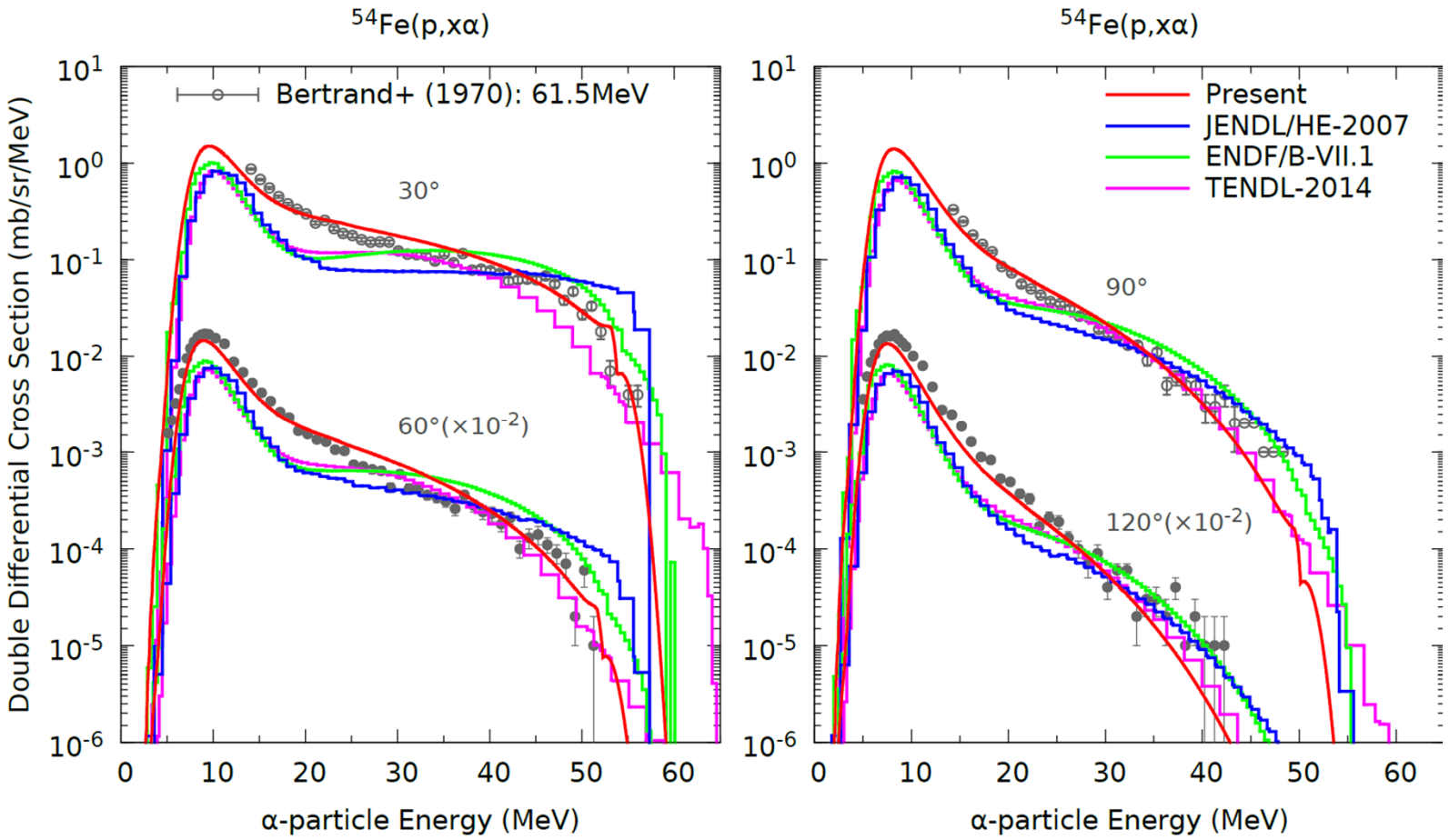
- Optical model analysis with OPTMAN-10 (with local RRM-OMP, IAS direct)
- CCONE evaluation for DDX (much emphasis was placed on (p,n) reaction)





Evaluation for Fe-54

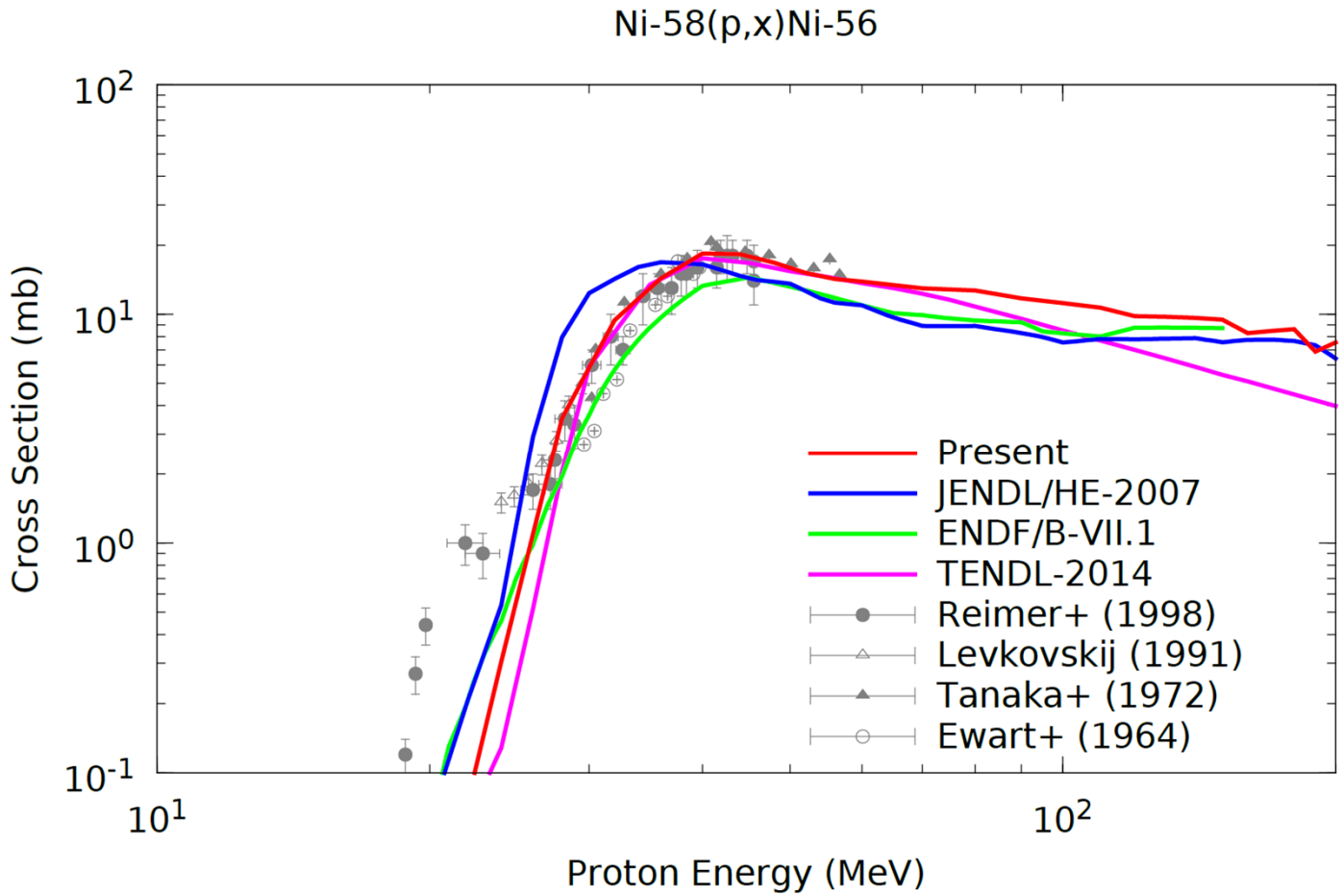
CCONE evaluation (DDX at 61.5MeV) with the modified Iwamoto-Harada model for pre-equilibrium alpha-particle emission



Evaluation for Ni-58

CCONE evaluation

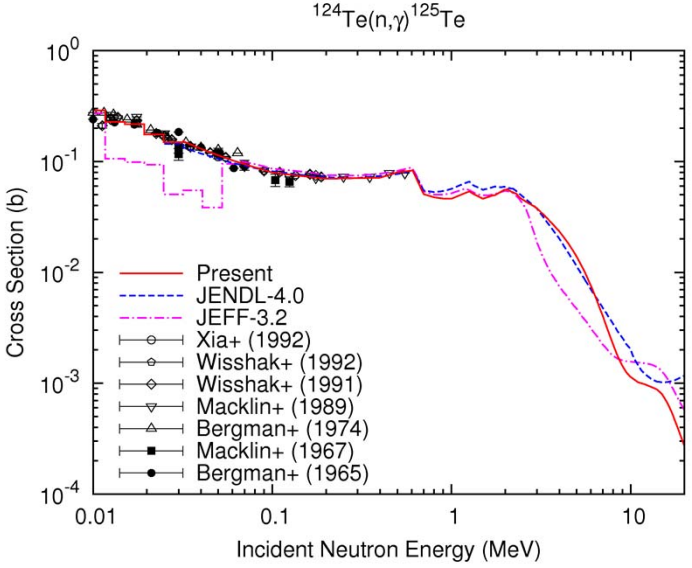
proton induced nuclide production cross section

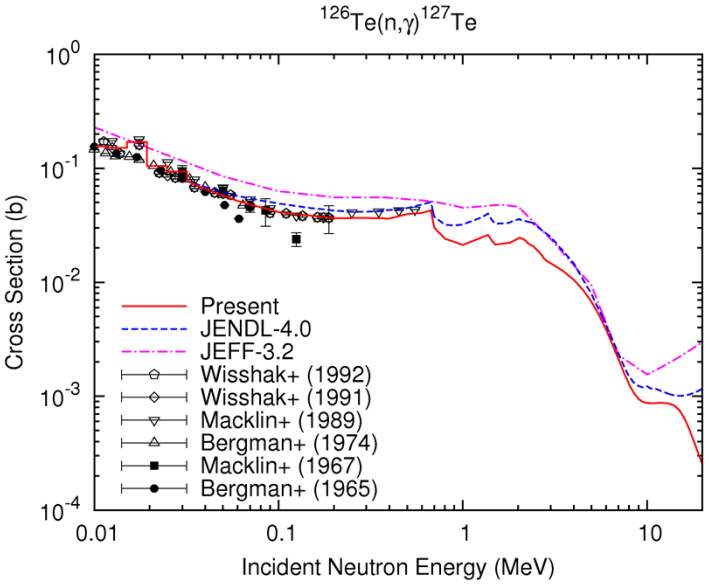


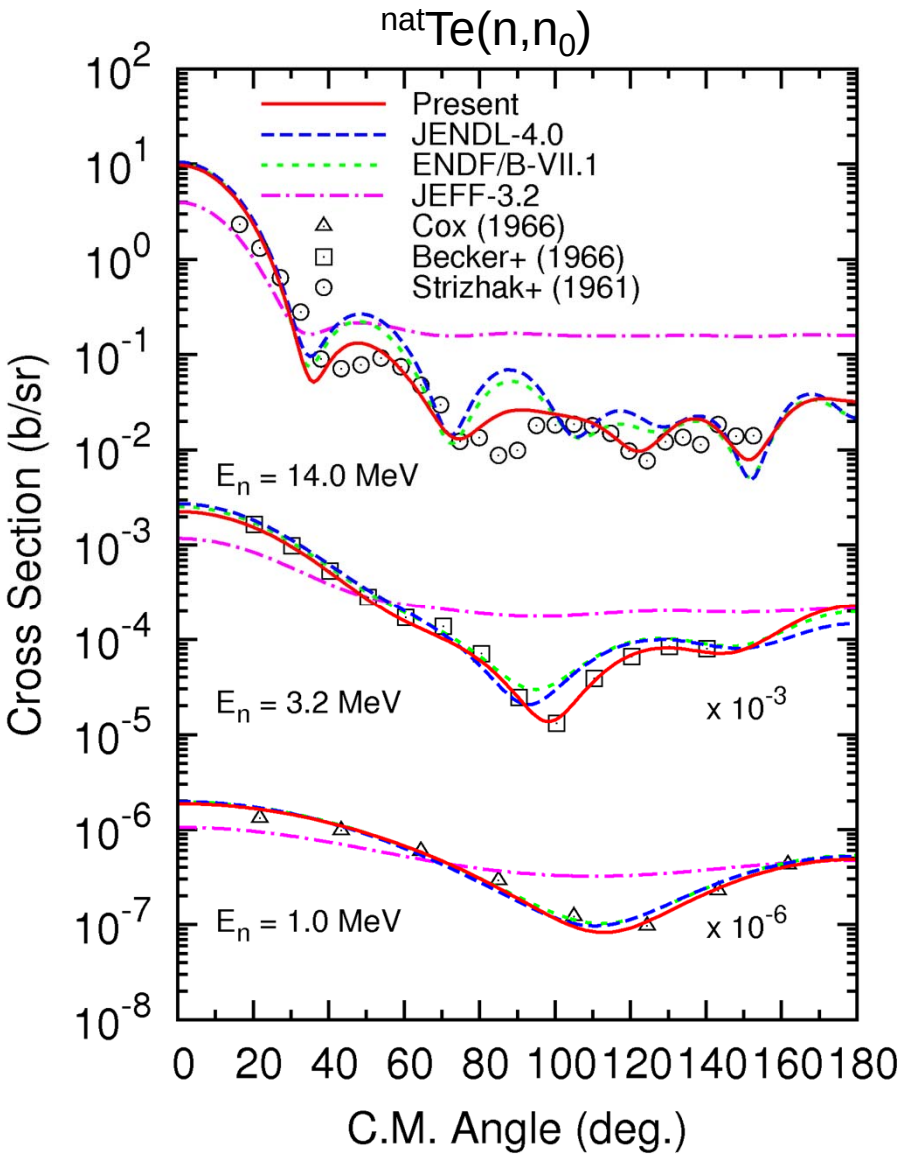
New evaluations for the next JEDNL

- Objectives
  - Updating old FP evaluations
  - Providing activation cross sections for decommissioning of LWRs
- Sb-121, 123-126 (published in JNST 2014)
- Te-120, 121m, 122-126, 127m, 128, 129m, 130, 131m, 132 (published in JNST 2015)
- I-127, 128, 129, 130, 131, 132 (published in JNST 2015)

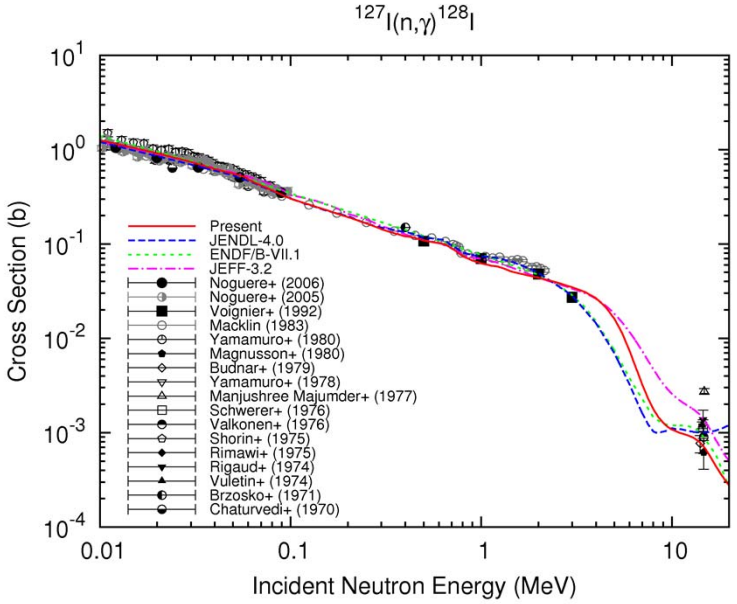
Tellurium

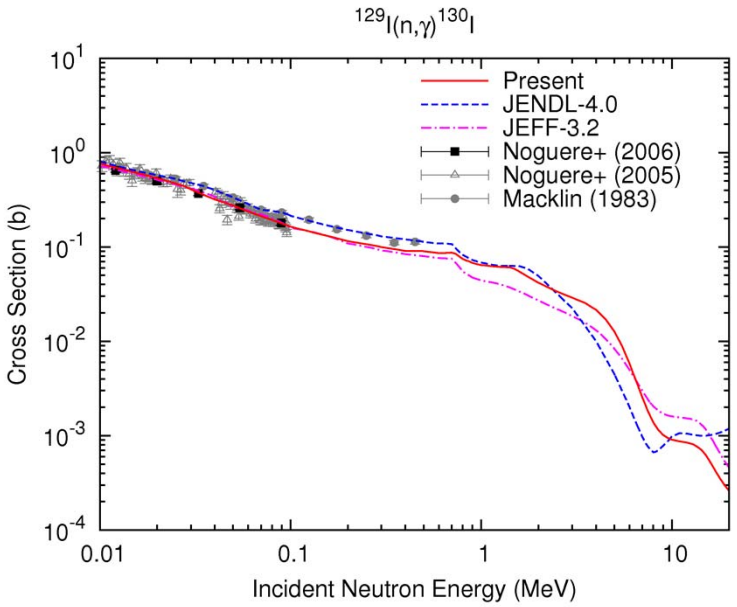

^{124}Te(n,γ)^{125}Te
Cross Section (b)
Incident Neutron Energy (MeV)
Present
JENDL-4.0
JEFF-3.2
Xia+ (1992)
Wisshak+ (1992)
Wisshak+ (1991)
Macklin+ (1989)
Bergman+ (1974)
Macklin+ (1967)
Bergman+ (1965)

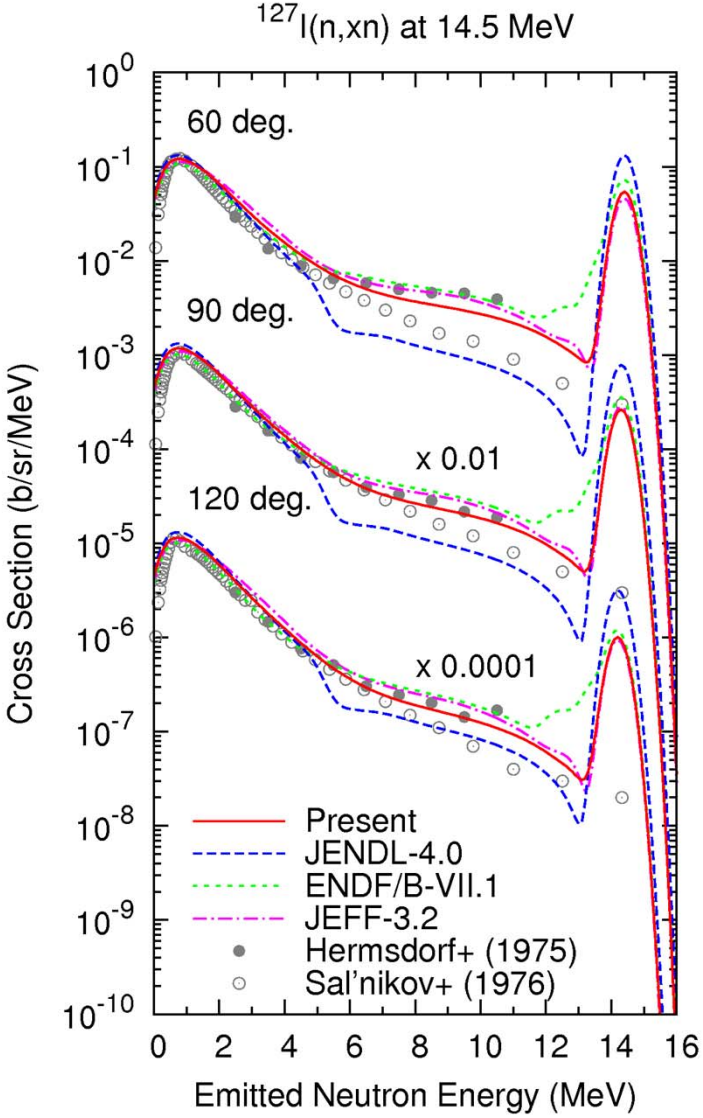

^{126}Te(n,γ)^{127}Te
Cross Section (b)
Incident Neutron Energy (MeV)
Present
JENDL-4.0
JEFF-3.2
Wisshak+ (1992)
Wisshak+ (1991)
Macklin+ (1989)
Bergman+ (1974)
Macklin+ (1967)
Bergman+ (1965)


^{nat}Te(n,n$_0$)
Present
JENDL-4.0
ENDF/B-VII.1
JEFF-3.2
Cox (1966)
Becker+ (1966)
Strizhak+ (1961)
E$_n$ = 14.0 MeV
E$_n$ = 3.2 MeV
x 10^{-3}
E$_n$ = 1.0 MeV
x 10^{-6}
Cross Section (b/sr)
C.M. Angle (deg.)

Iodine


^{127}I(n,γ)^{128}I
Cross Section (b)
Incident Neutron Energy (MeV)
Present
JENDL-4.0
ENDF/B-VII.1
JEFF-3.2
Noguere+ (2006)
Noguere+ (2005)
Voignier+ (1992)
Macklin (1983)
Yamamuro+ (1980)
Magnusson+ (1980)
Budnar+ (1979)
Yamamuro+ (1978)
Manjushree Majumder+ (1977)
Schwerer+ (1976)
Valkonen+ (1976)
Shorin+ (1975)
Rimawi+ (1975)
Rigaud+ (1974)
Vuletin+ (1974)
Brzosko+ (1971)
Chaturvedi+ (1970)

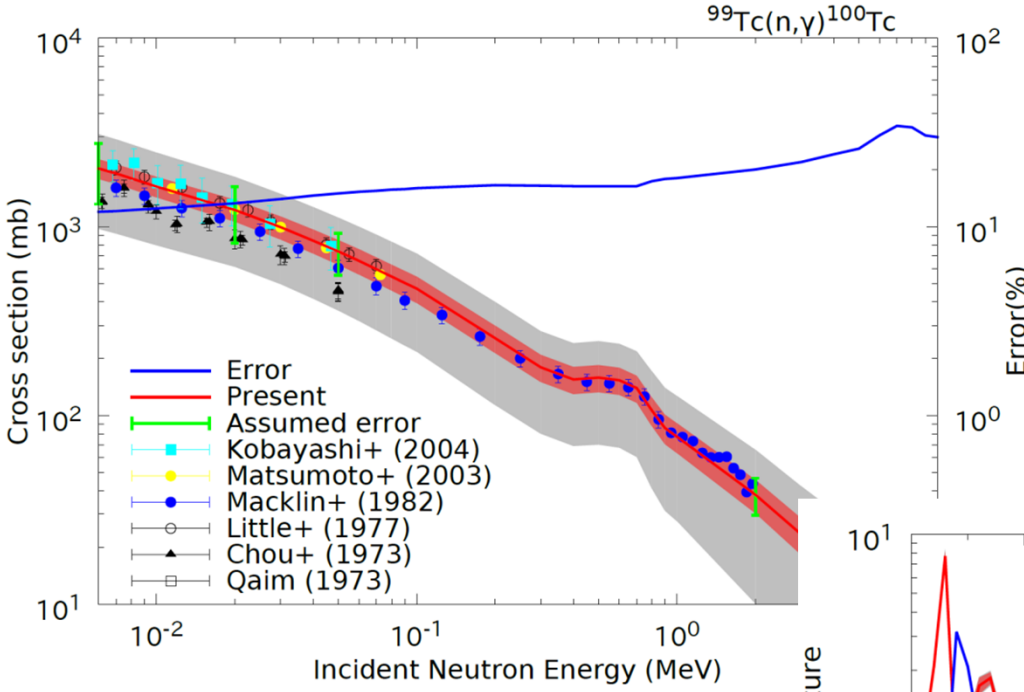

^{129}I(n,γ)^{130}I
Cross Section (b)
Incident Neutron Energy (MeV)
Present
JENDL-4.0
JEFF-3.2
Noguere+ (2006)
Noguere+ (2005)
Macklin (1983)


^{127}I(n,xn) at 14.5 MeV
Cross Section (b/sr/MeV)
Emitted Neutron Energy (MeV)
60 deg.
90 deg.
x 0.01
120 deg.
x 0.0001
Present
JENDL-4.0
ENDF/B-VII.1
JEFF-3.2
Hermsdorf+ (1975)
Sal'nikov+ (1976)

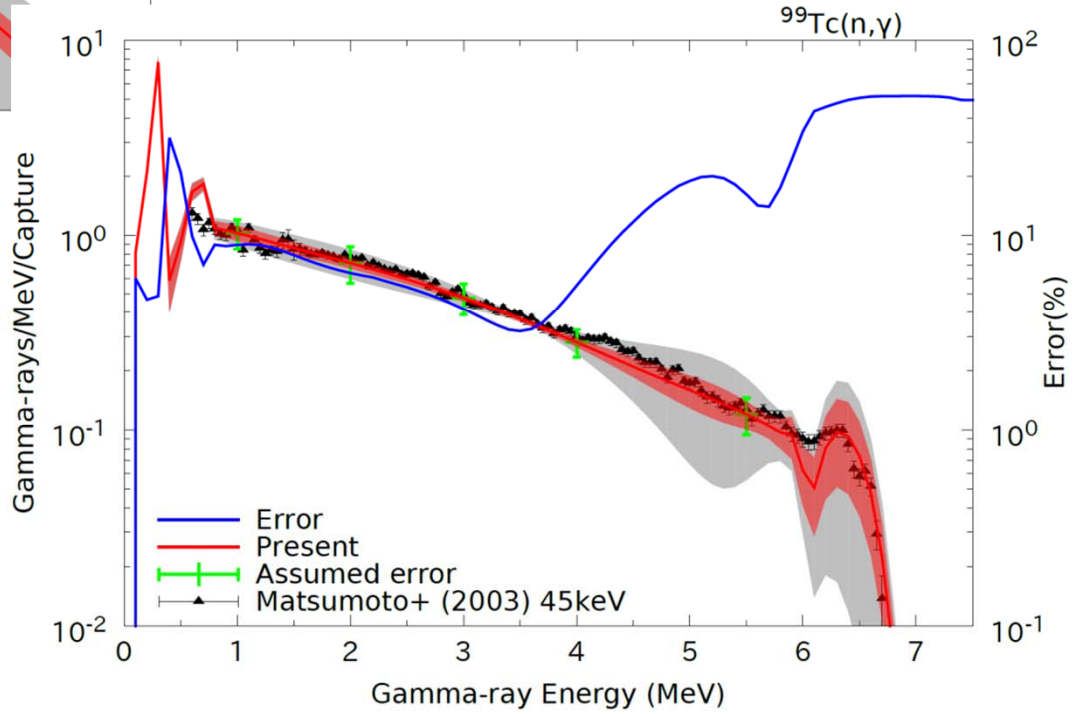
Evaluation of covariance

- **CCONE-KALMAN**
  - Total cross section, neutron capture cross section
  - Gamma-ray emission spectrum
  - Sensitivity calculation
    no. of parameters: 55 for ^{99}Tc, 44 for ^{129}I
    - CC-OMP（Kunieda+ 2007）
    - Level density
    - Gamma-ray strength function
    - Exciton model parameter

Covariance of Tc-99

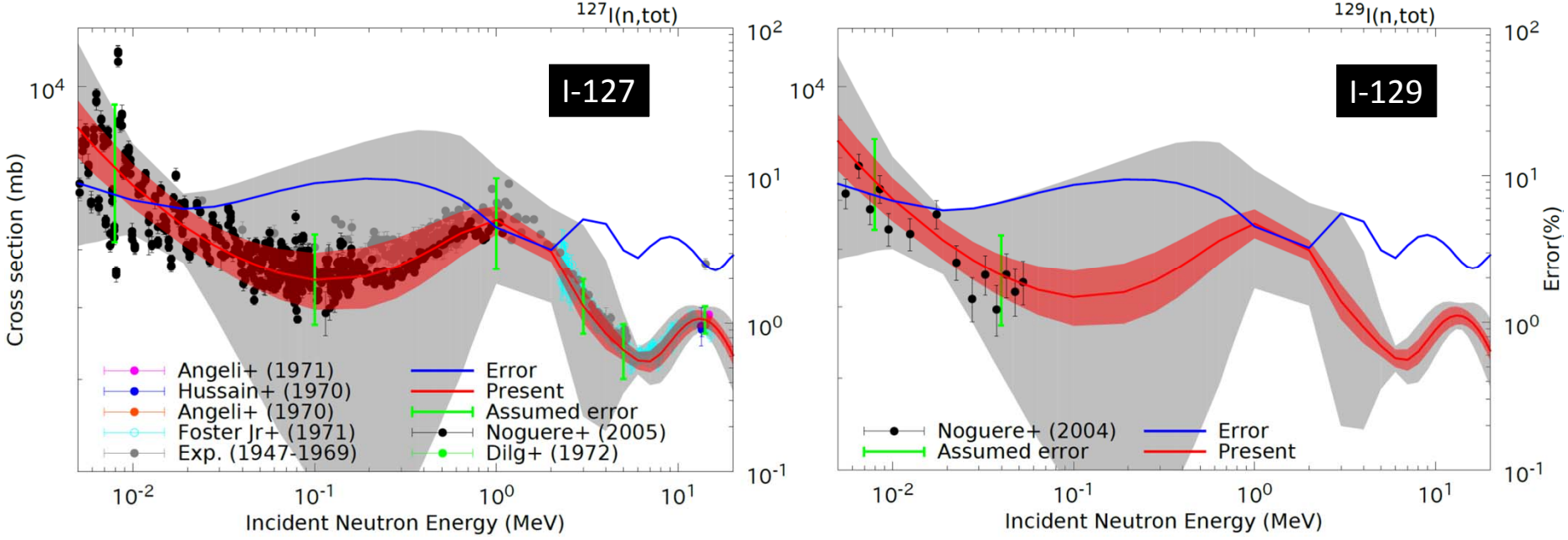


Capture cross section



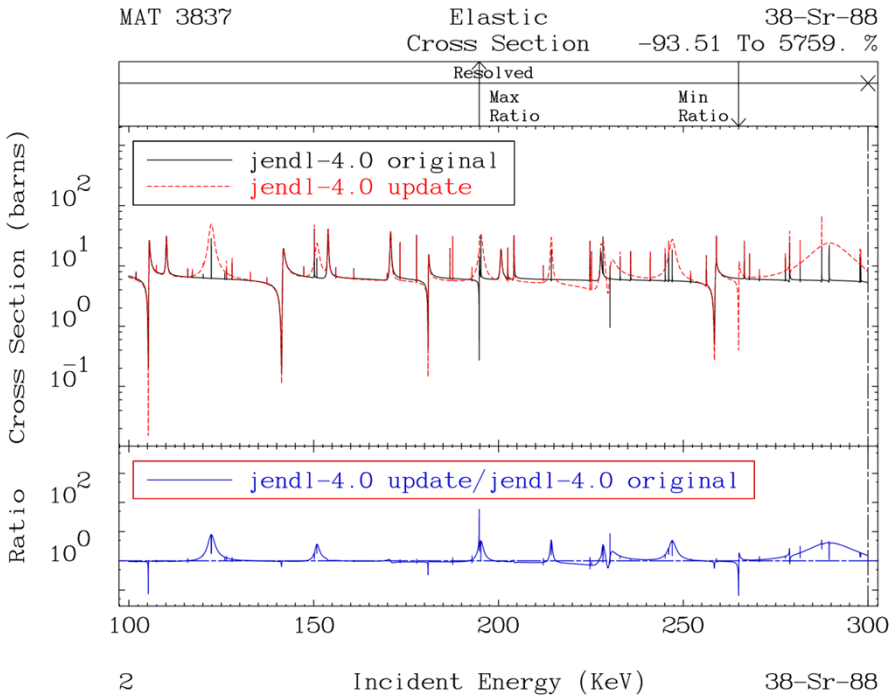
Gamma-ray emission sepctrum

Covariance for I-127, 129 total cross sections



JENDL-4.0 update of ^{88}Sr

- The neutron widths of an s-wave resonance and 10 p-wave resonances were underestimated mistakenly. They were recompiled.



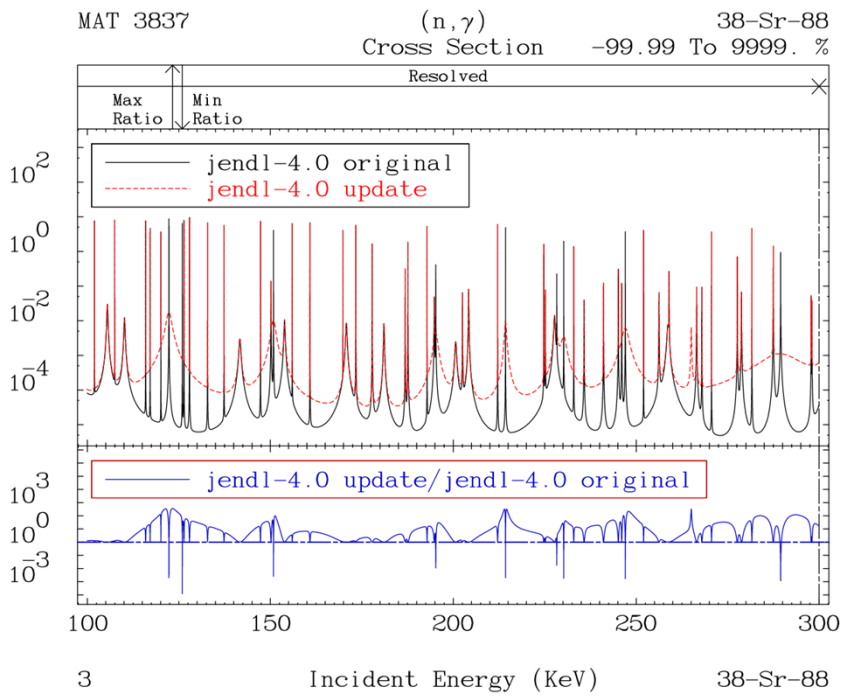
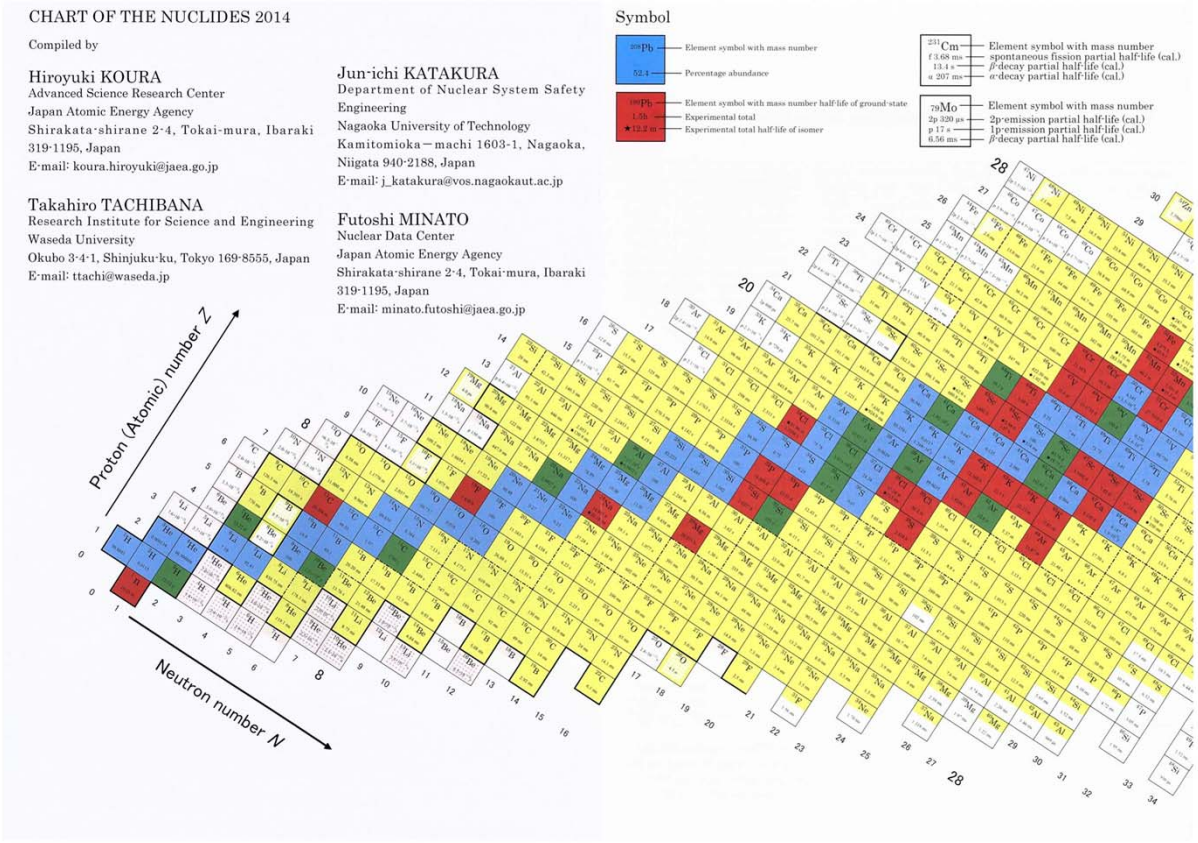


Chart of the Nuclides 2014

A4 accordion book



Web version will be available soon.

http://wwwndc.jaea.go.jp/CN14/index.html

Benchmark of JENDL-4.0

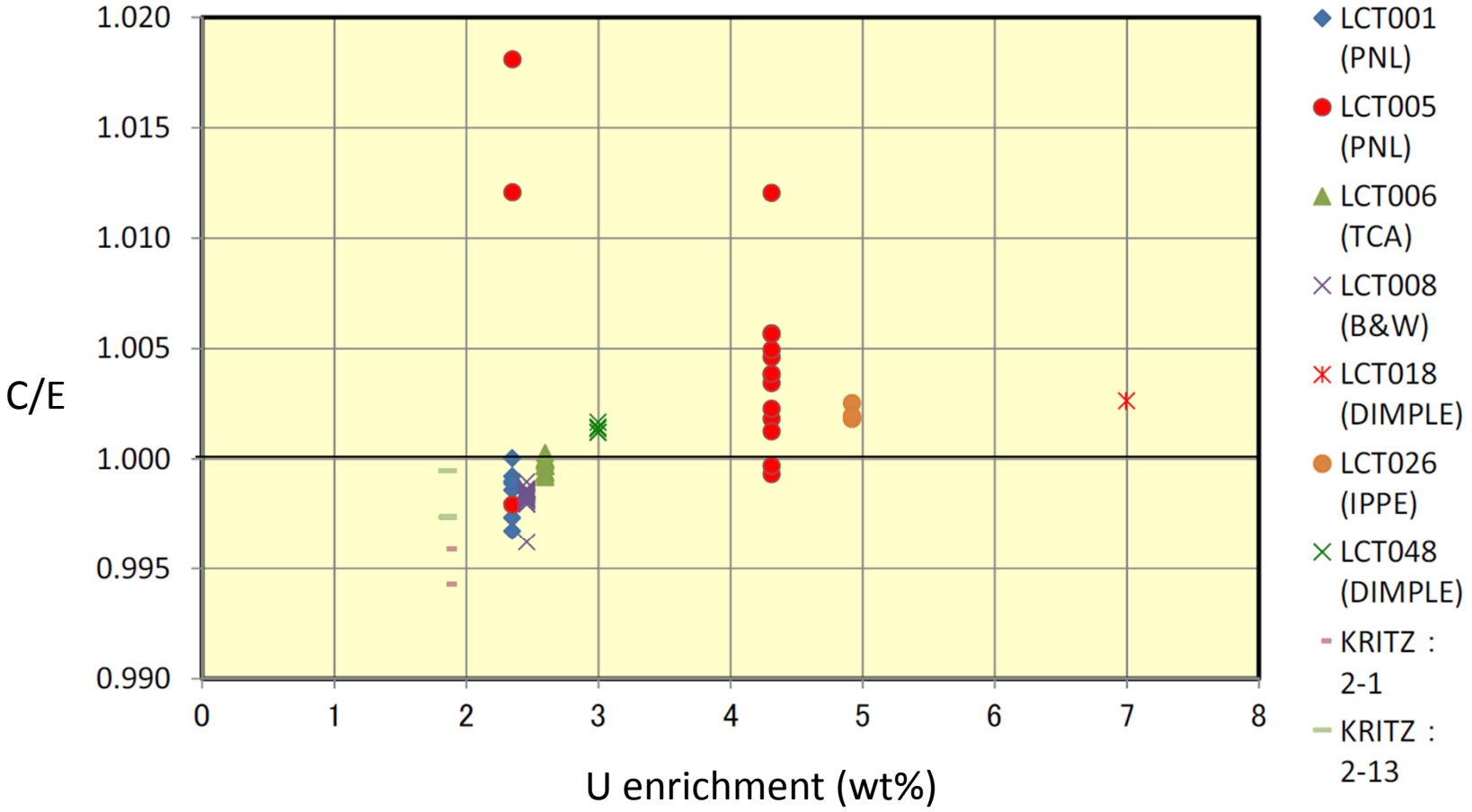
- On-going task of RIT-WG (Reactor Integral Test Working Group) in JENDL committee
  - Development of a comprehensive and ready-to-use standard benchmark set, based on Japanese Monte-Carlo code MVP, for LWR nuclear data by utilizing open and well-evaluated integral experiments, such as ICSBEP and IRPhEP
- Present two main targets
  - Light-water-moderated low-enriched U core
  - Light-water-moderated MOX core
    - Including evaluation of PuO_2 particle size heterogeneous reactivity effect with Monte-Carlo calculation

Light-water-moderated Low-enriched U core benchmark

- Past JENDL-4.0 benchmarking, reported in JNST*
  - 18 data from 10 series of experiments
- Present benchmark set
  - 73 data from 8 series of experiments
  - Including the following parameters:
    - H/U ratio: 1.47 – 8.65
    - U enrichment: 1.86 – 7.0 wt%
    - Boron density: 779 – 1488 ppm
    - Gd density: 0 – 1.48 g Gd / liter
    - Temperature of water: 20 – 280 deg. C

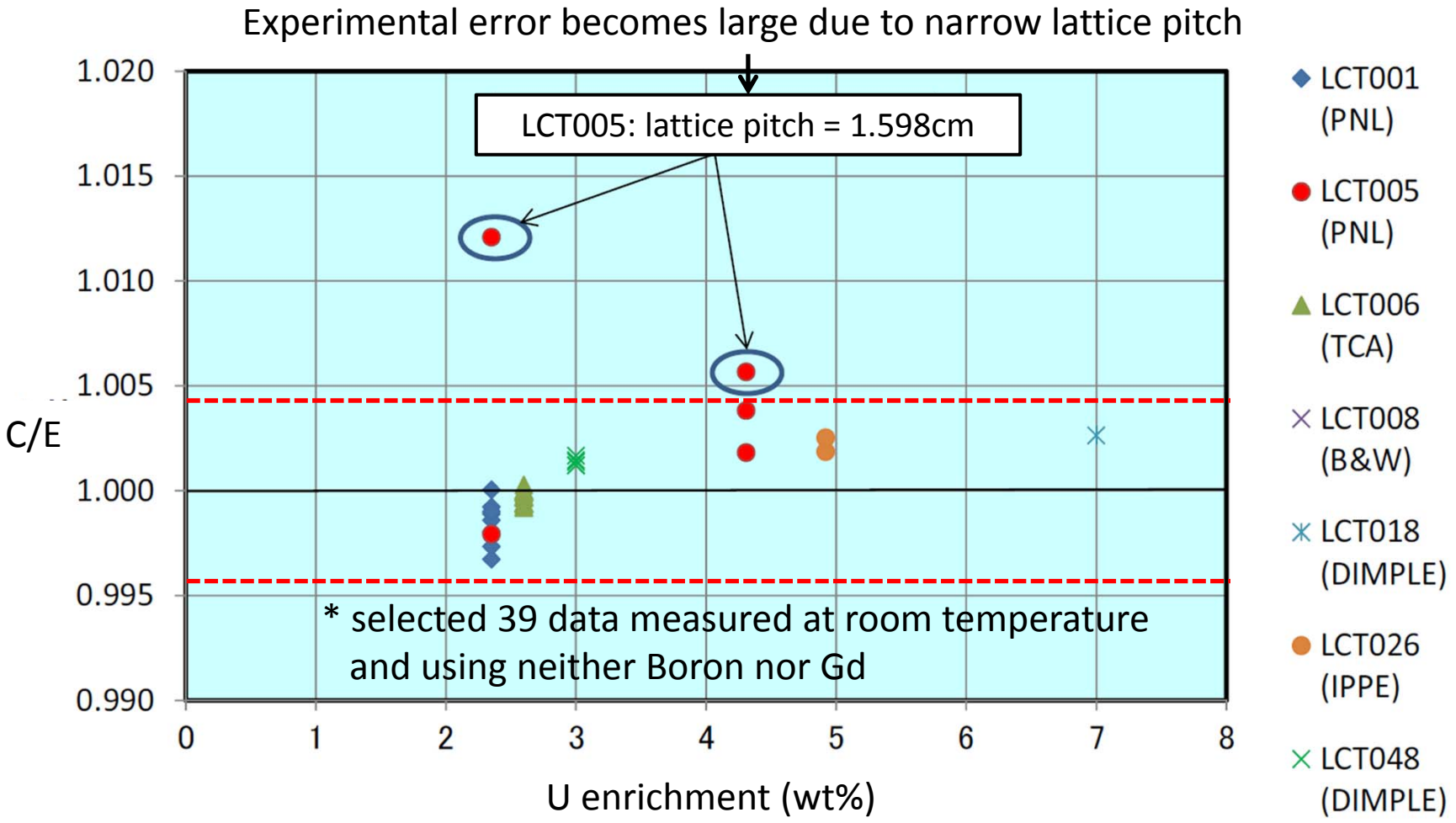
* G. Chiba, et al., "JENDL-4.0 Benchmarking for Fission Reactor Applications," J. Nucl. Sci. Eng., Vol.48, No.2, p. 172-187 (2011)

Dependency on U enrichment (all 73 data)



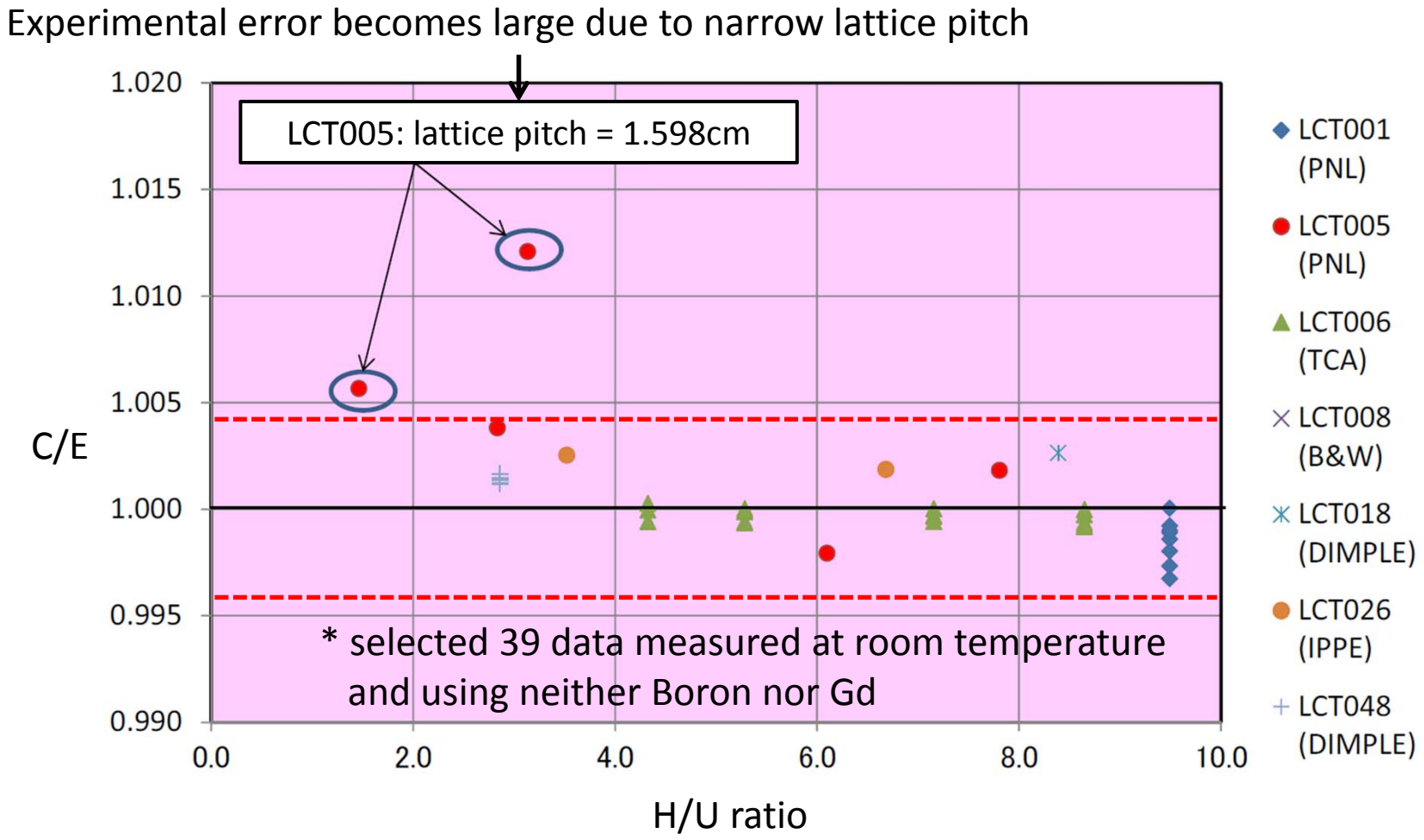
- Large variation is seen due to mixed parameters
- Selection of data are necessary

Dependency on U enrichment (selected 39 data*)



- No significant dependency on U enrichment is seen for the selected data

Dependency on H/U ratio (selected 39 data*)



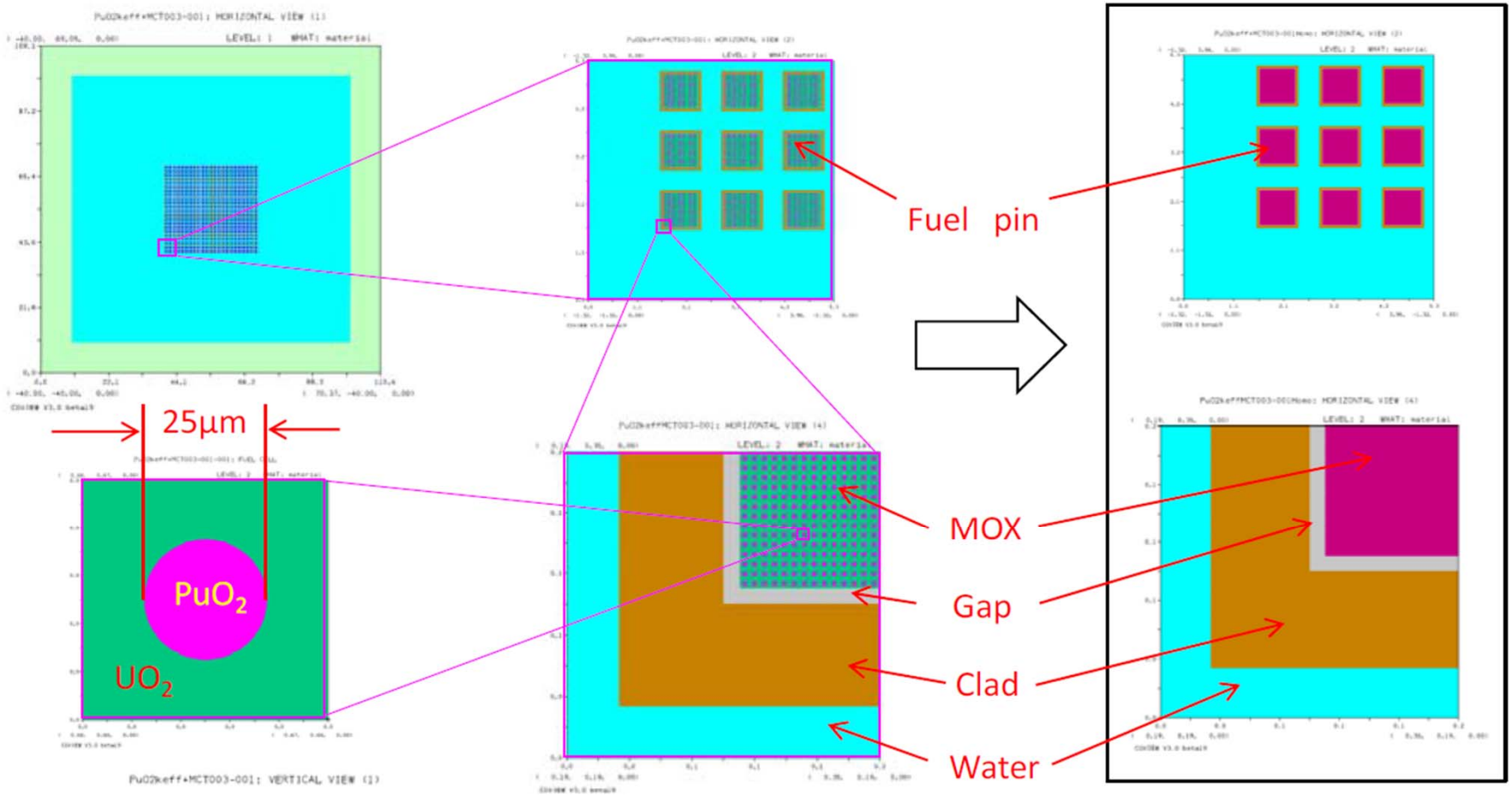
- No significant dependency on H/U ratio (i.e. neutron spectrum) is seen for the selected data

Light-water-moderated MOX core benchmark

- Past JENDL-4.0 benchmarking, reported in JNST*
  - 67 data from 14 series of experiments
- Present benchmark set (on-going)
  - 38 data from 6 series of experiments (for now)
  - with our own evaluation of PuO_2 particle size effect
  - Including the following parameters:
    - H/U ratio: 75 – 1176
    - Pu enrichment: 1.5 – 6.6 wt%
    - Fuel pin pitch / number of fuel pins: 1.321 – 4.318 cm / 121 – 1487
    - Boron density: 0 – 1090.4 ppm
    - Temperature of water: 20 – 235.9 deg. C

* G. Chiba, et al., "JENDL-4.0 Benchmarking for Fission Reactor Applications," J. Nucl. Sci. Eng., Vol.48, No.2, p. 172-187 (2011)

Evaluation of PuO_2 particle size heterogeneous reactivity effect

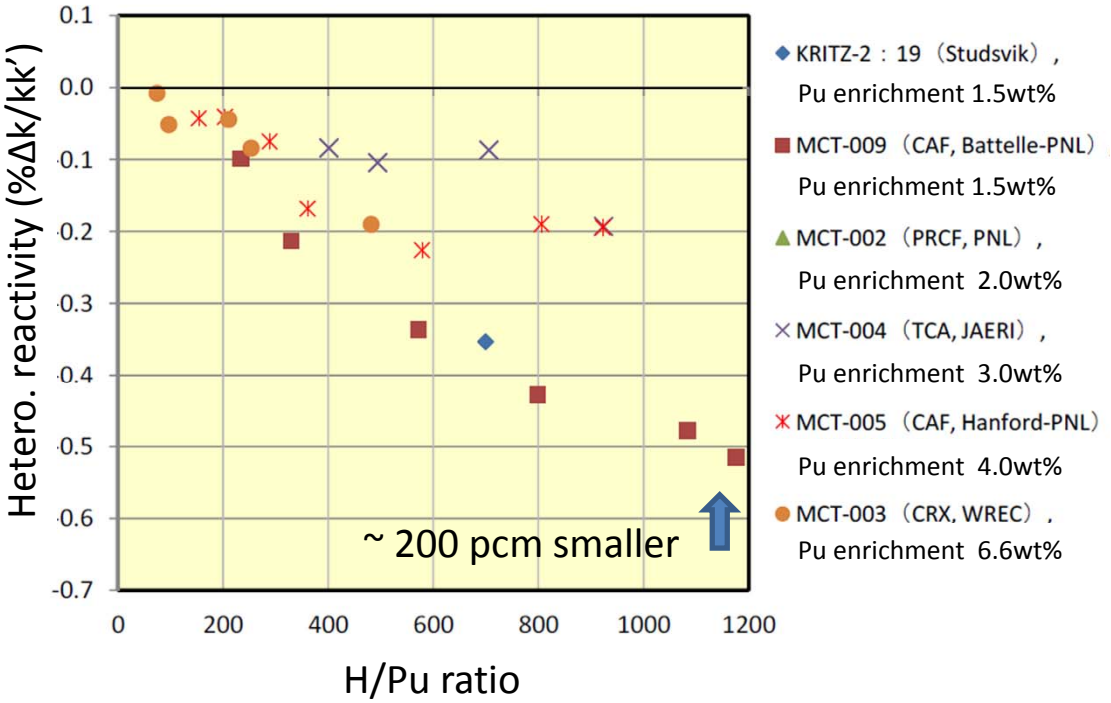


<Heterogeneous model>
(explicitly simulating PuO_2 particles)

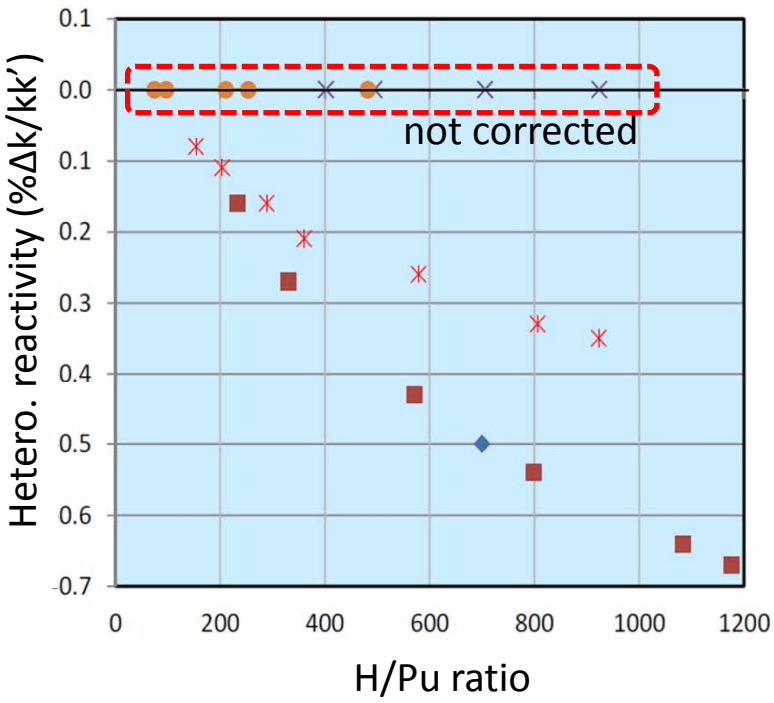
<Homogeneous model>

Fuel pin models of Monte-Carlo calculation (MCT003(CRX) case1)

Impact of PuO_2 particle size heterogeneous reactivity effect



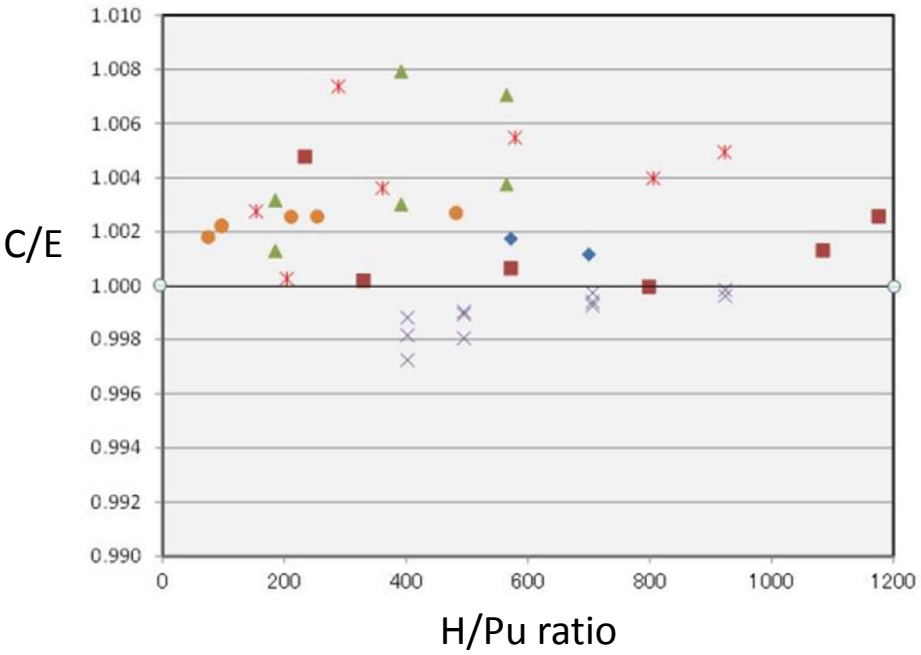
(a) Present values evaluated by Monte-Carlo calculation



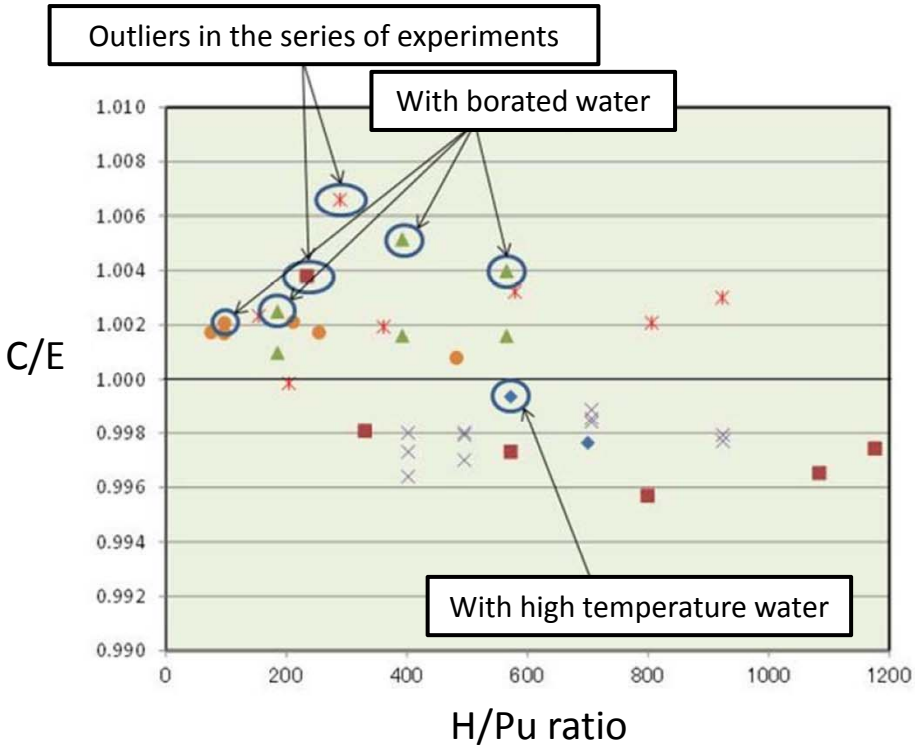
(b) Values adopted by ICSBEP benchmarks

- Corrections of the reactivity effect are consistently applied to all experiments
- Present evaluation gives smaller reactivity effects (max. ~ 200 pcm smaller for high H/Pu ratio)

Correction of PuO_2 particle size heterogeneous reactivity effect



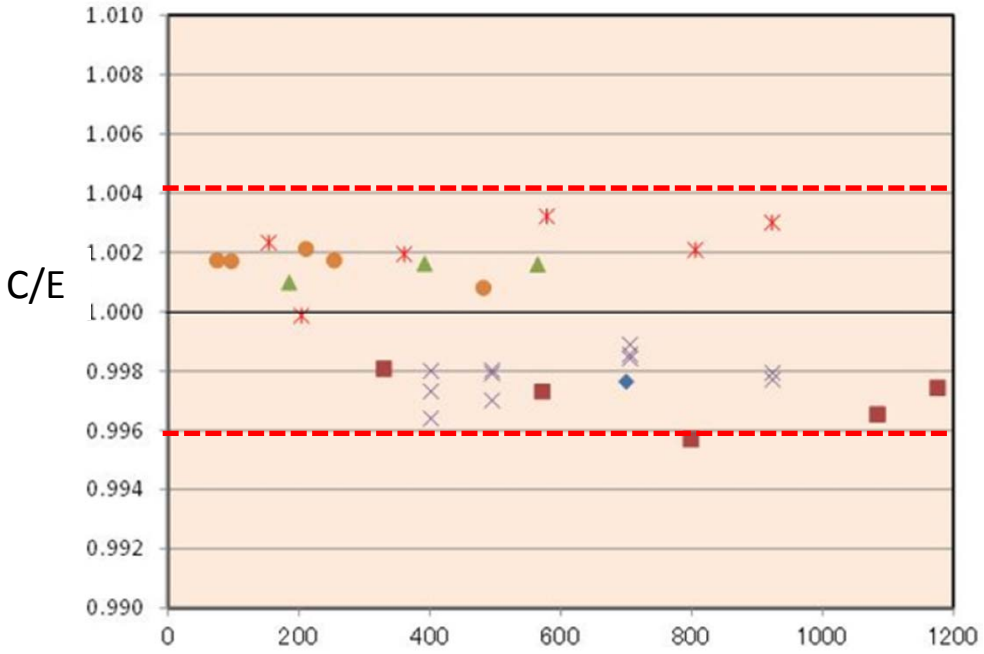
(a) C/E values without correction of PuO_2 heterogeneous reactivity effect (all 38 data)



(b) Corrected C/E values (all 38 data)

- Apparent overestimation is seen when plotting all data without correction and selection
- Correction of the heterogeneous reactivity effect systematically reduces C/E values
- Some odd and different kind of data should be rejected

Dependency on H/Pu ratio (selected 31 data)



(c) C/E values of selected 31 data corrected by heterogeneous reactivity effect

◆KRITZ-2：19（Studsvik），
Pu enrichment 1.5wt%

■MCT-009（CAF, Battelle-PNL），
Pu enrichment 1.5wt%

▲MCT-002（PRCF, PNL），
Pu enrichment 2.0wt%

×MCT-004（TCA, JAERI），
Pu enrichment 3.0wt%

✳MCT-005（CAF, Hanford-PNL），
Pu enrichment 4.0wt%

●MCT-003（CRX, WREC），
Pu enrichment 6.6wt%

- No significant dependency on H/Pu ratio is seen for the corrected and selected 31 data (C/E = 1.0±400pcm)

Future Work

- Completion of developing a comprehensive and ready-to-use standard benchmark set for LWR nuclear data
- Sensitivity analysis for JENDL-4.0 by using the standard benchmark set
- Application of the standard benchmark set to other nuclear data libraries, such as ENDF/B and JEFF, and sensitivity-based cause analysis of library differences (i.e., identification of the important nuclide, reaction and energy range)