Neutron cross section measurement of MA

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Neutron cross section measurement of MA

① Activities in the World

② Activities in Japan for thermal neutrons

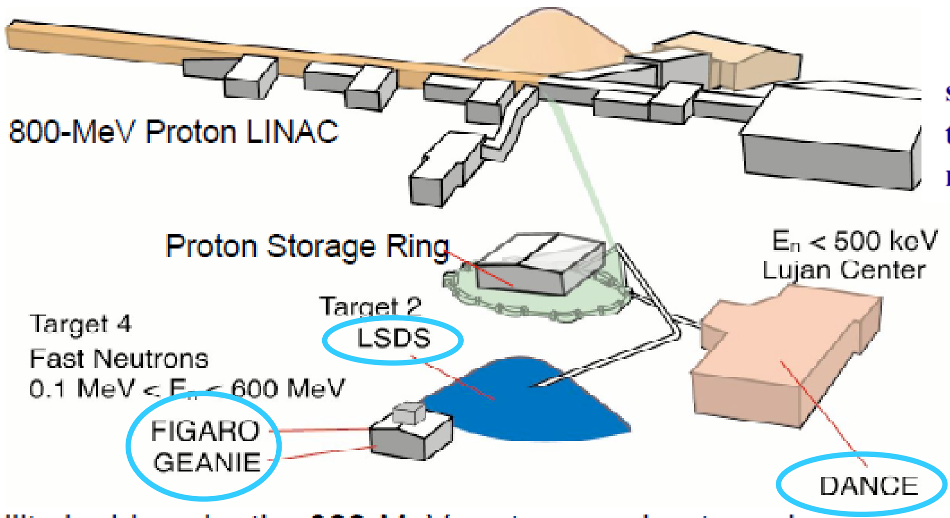
③ Activities in Japan for keV neutrons

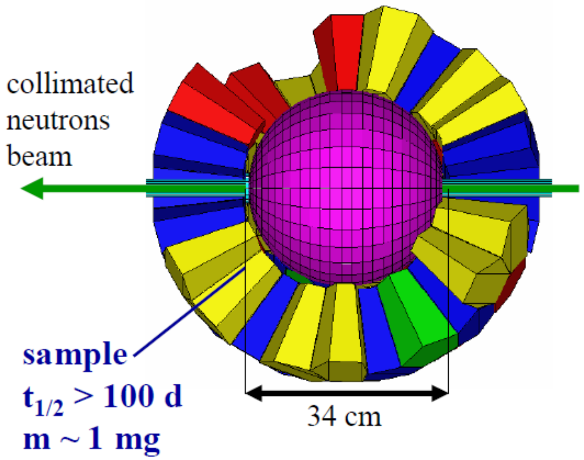
④ Possibilities in Japan for MeV neutrons

⑤ Summary: Toward improvement in the MA data

① Activities in the World

LANL (USA)





neutrons:

- spallation source
- thermal .. 500 keV
- 20 m flight path
- 3 10^5 n/s/cm²/decade

γ-Detector:

- 159 BaF_2 crystals
- 4 different shapes
- R_i=17 cm, R_a=32 cm
- 7 cm ^{6}LiH inside
- $\varepsilon_\gamma \approx$ 90 %
- $\varepsilon_{casc} \approx$ 98 %

- Facility is driven by the 800-MeV proton accelerator using a proton storage ring to accumulate beam, $I_p \approx$ 100 μA, 20 Hz, _t = 200 ns
- Moderated W target gives "white" neutron spectrum, ~14 neutrons/proton
- DANCE is on a 20 m flight path / ~1 cm φ beam after collimation

  $\Phi \approx 8.7 \times 10^4$ n/(cm²-sec) / E_n (eV)

  Integral flux ≈ 2 x 10^5 n/(cm²-sec) per energy decade

Ref. **Dave Vieira**

Los Alamos National Laboratory

SPIRAL-2 Workshop, Caen, Dec. 13-14, 2004

研究者数、化学部門との連携、人材育成、大形予算

① Activities in the World

IRMM (EU)

Van de Graff, Electron L. A.:
Fission, Capture, Total, (n,2n)
TOF: Ge, C_6D_6

Karlsruhe (Germany)

keV neutron capture （FP）
Activation @ keV neutrons
TOF: 4π BaF_2

n-TOF (CERN, EU)

TOF: 4π BaF_2, C_6D_6

ILL (CEA, France)

High flux reactor
activation @ thermal neutrons

TOF method

- Pulse height weighting technique: C_6D_6 , NaI etc
  low neutron sensitivity
- Total absorption detector: 4π NaI, BGO, BaF_2 etc
  high efficiency
- Gamma-spectroscopic method: Ge
  high energy resolution

① Activities in the World

IRMM (EU) Gamma-spectroscopic method: Ge

PR C56, 1266 (1996)

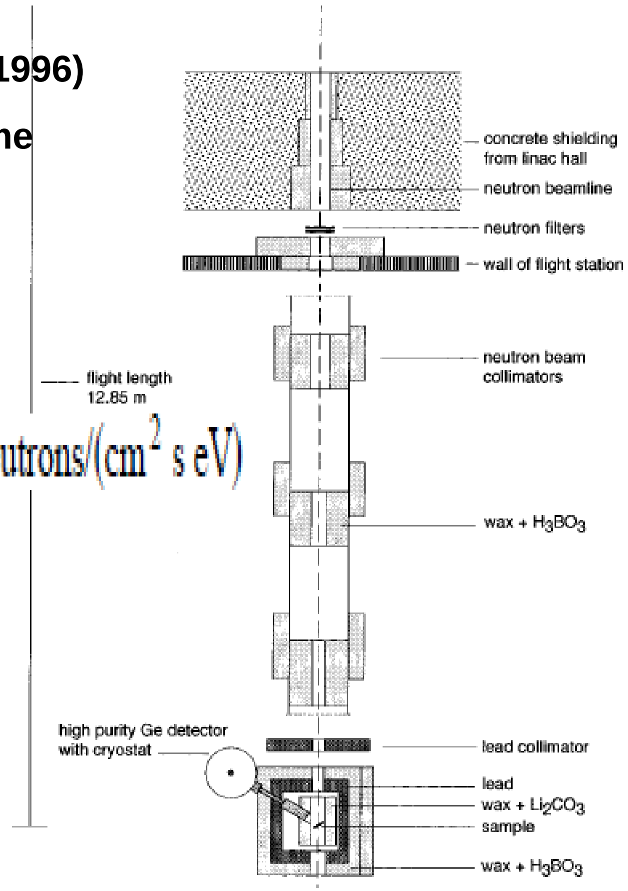
1200h beam time

694g U-238

F.P.=12.85 m

70% Ge

$$\Phi(E)=7.0\times 10^3 E^{-0.9}\ \text{neutrons}/(\text{cm}^2\ \text{s eV})$$



. Resonance spin assignments based on secondary gamma rays using the low-lying level population method

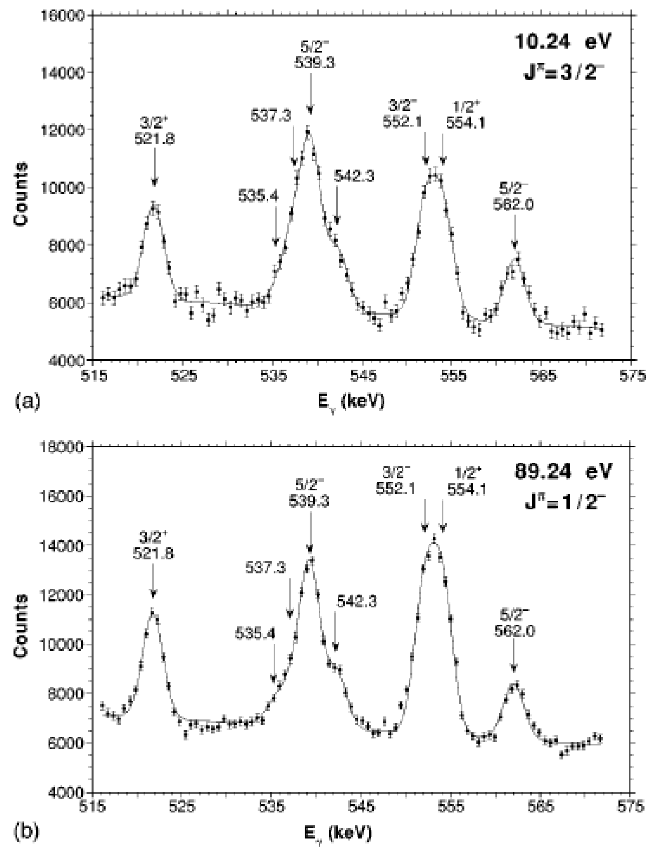


FIG. 5. Two examples of a fit of the capture gamma-ray spectrum in the 515–575 keV region for the p-wave resonances at 10.24 eV and at 89.24 eV having different spin.

Activities in Japan

2002 2003 2004 2005 2006

Fundamental R&D on Neutron Cross Sections for Innovative Reactors Using Advanced Radiation Measurement Technology

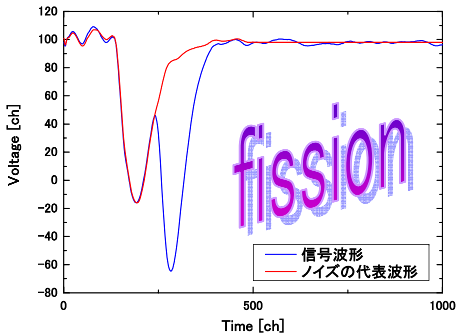
Project Leader: M. Igashira (T.I.T.)

Tohoku: Fission

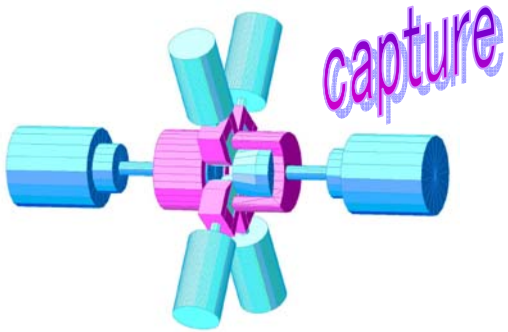
JAEA: Capture, Decay heat

Kyoto: Capture & Fission

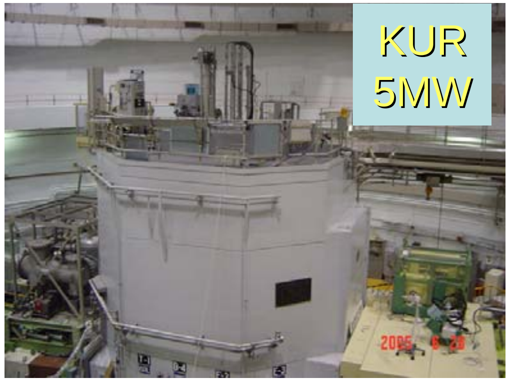
TIT: Capture , γ-spectra

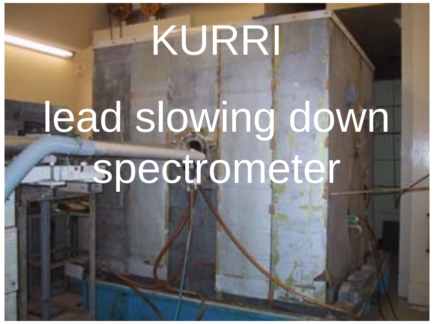


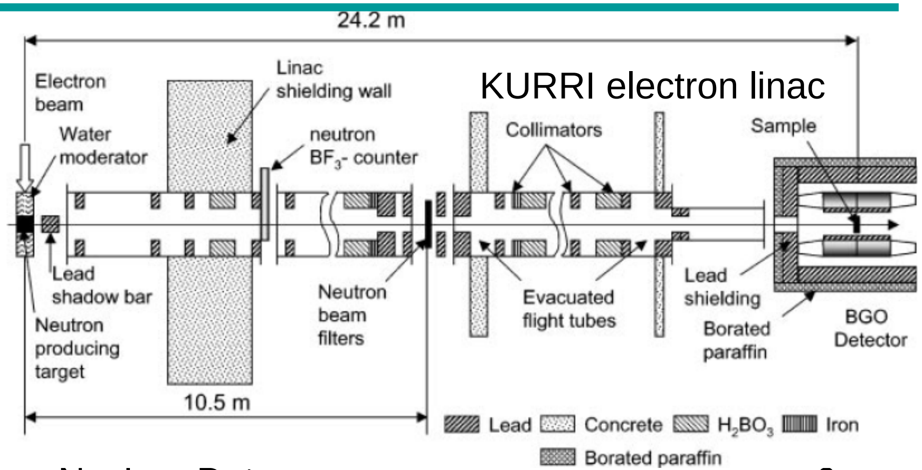
En=1- 100 keV !



4 π Ge spectrometer





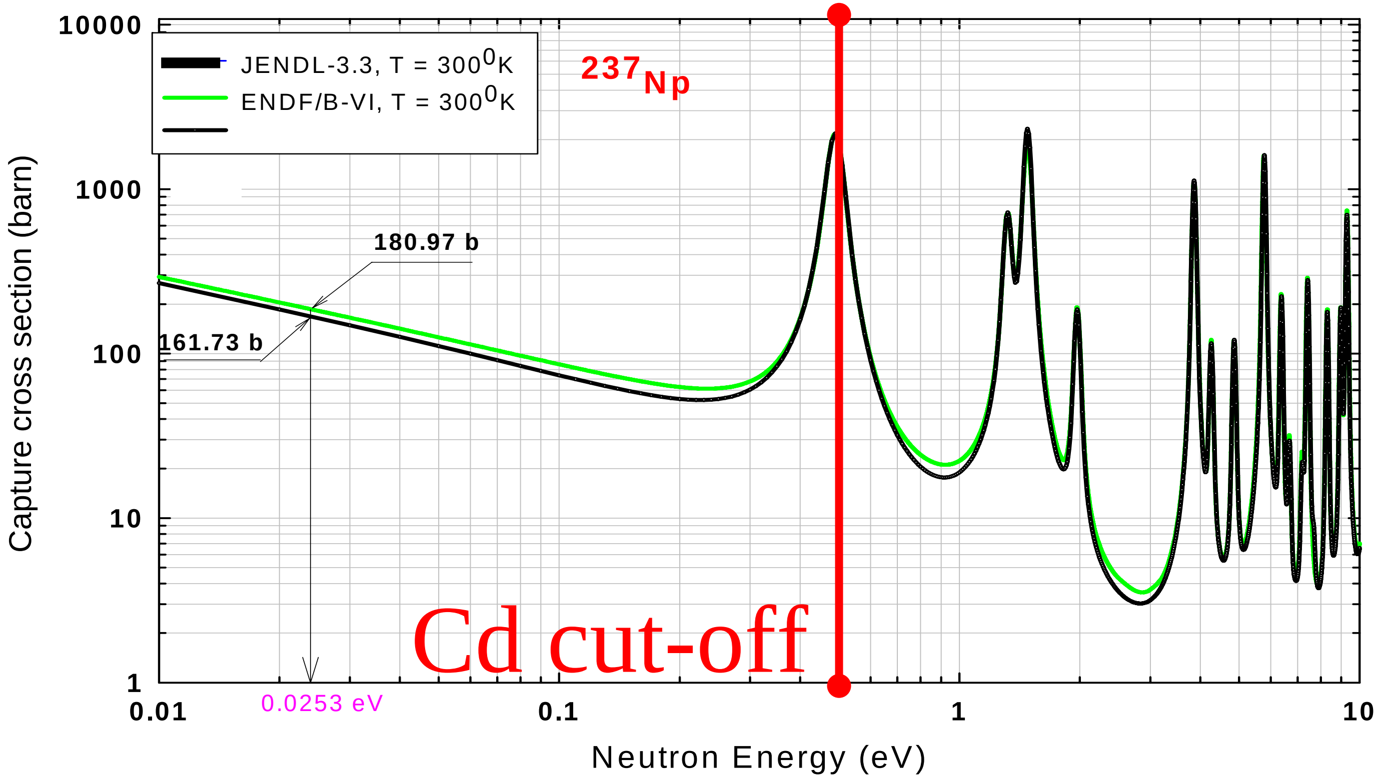


YAYOI 2kW

② Activities in Japan for thermal neutrons

No.1

When there are resonance peaks below 0.5 eV, can we measure σ_0 and resonance integral correctly ?



② Activities in Japan for thermal neutrons

Reaction	Present	JENDL-3	ENDF/B-VII	Mughabghab Atlas 5th ed.
$^{237}Np(n, \gamma)^{238}Np$	σ_0 =169±4 b	161.7 b	162.2 b	175.9±2.9 b
$^{243}Am(n, \gamma)^{244}Am$	σ =174.5±5.3 b	(150 b)		(150 b)
$^{241}Am(n, \gamma)^{242g}Am$	σ_{0g} =628±22 b	σ_0 639.4 b	620.84 b	σ_{0g} 533±13 b σ_0 587±12 b

References:

Harada et al. JNST 43 (2006) 1289.
Ohta et al. JNST 43 (2006) 1441.
Nakamura et al. JNST 44 (2007) Dec.

② Activities in Japan for thermal neutrons

Table 3 Result of effective cross section* for the ^{243}Am(n,γ)^{244}Am reaction

References		σ_0	I_0	$\hat{\sigma}$ (b)
Present result		—	—	174.5±5.3
JENDL-3.3	(2002)[14)]	76.7	1787	150±8
Mughabghab	(1984)[15)]	75.1±1.8	1820±70	150±9
Marie *et al.*	(2006)[16)]	81.8±3.6	(1800)	(156)
			(2250)	(174)

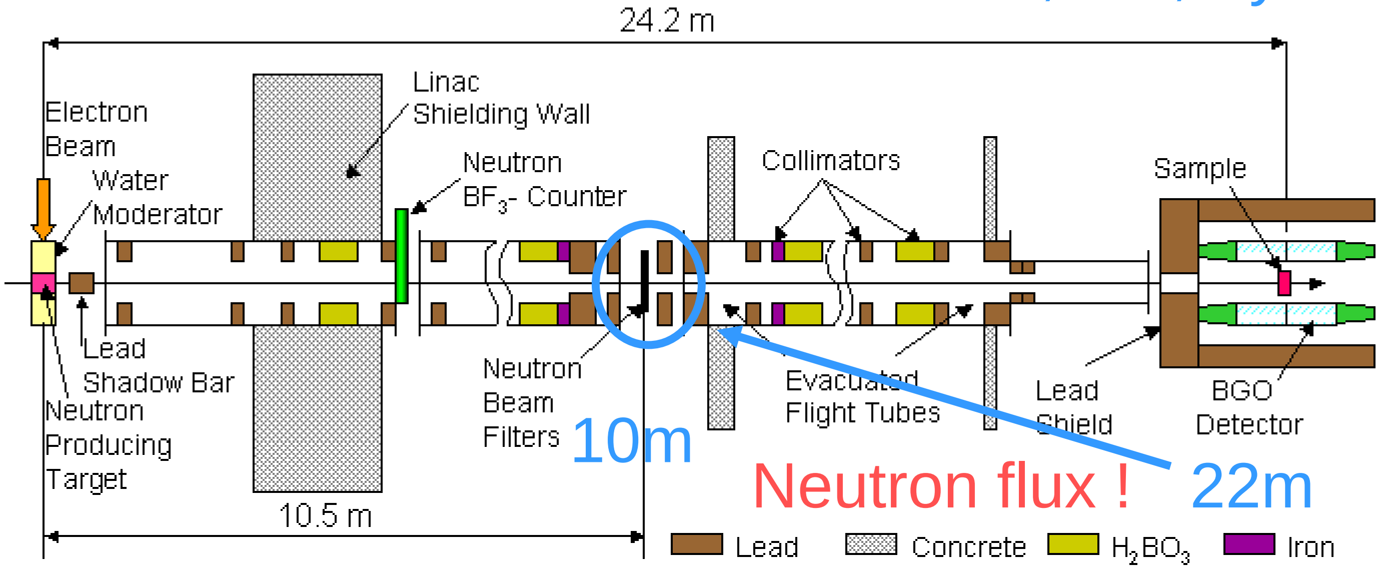
*The effective cross section with the quantity in Westcott's convention $r\sqrt{T/T_0}$=0.037±0.004.

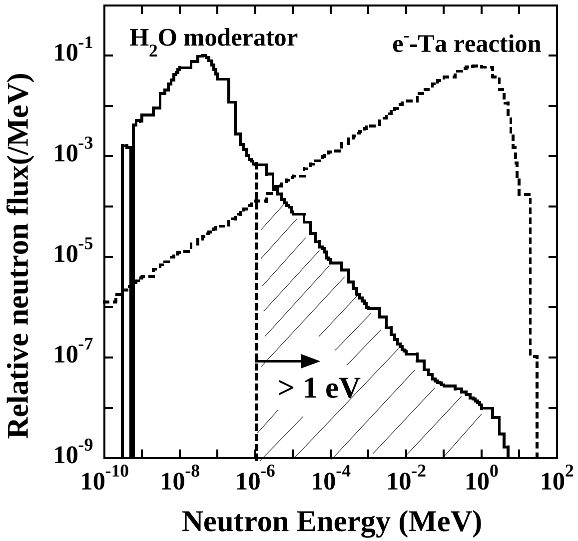
Ohta et al. JNST 43 (2006) 1441.

③ Activities in Japan for keV neutrons

JAEA, TIT, Kyoto

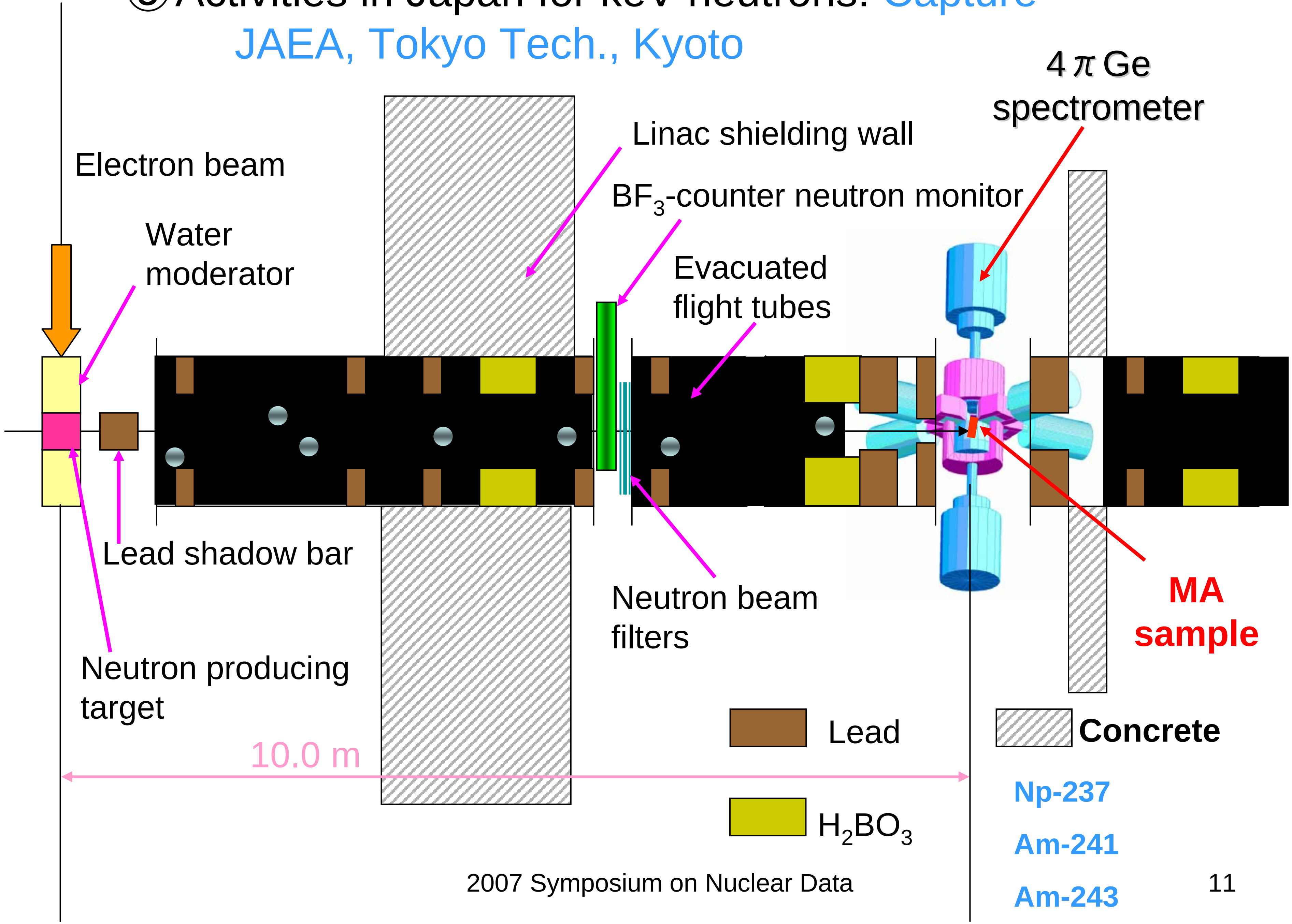
KURRI Linac





③Activities in Japan for keV neutrons: Capture

JAEA, Tokyo Tech., Kyoto



Np-237

Am-241

Am-243

Experiments for Capture

KUR Electron Linear Accelerator Facility

Electron beam：Energy 30 MeV, Ave. Current 31μA

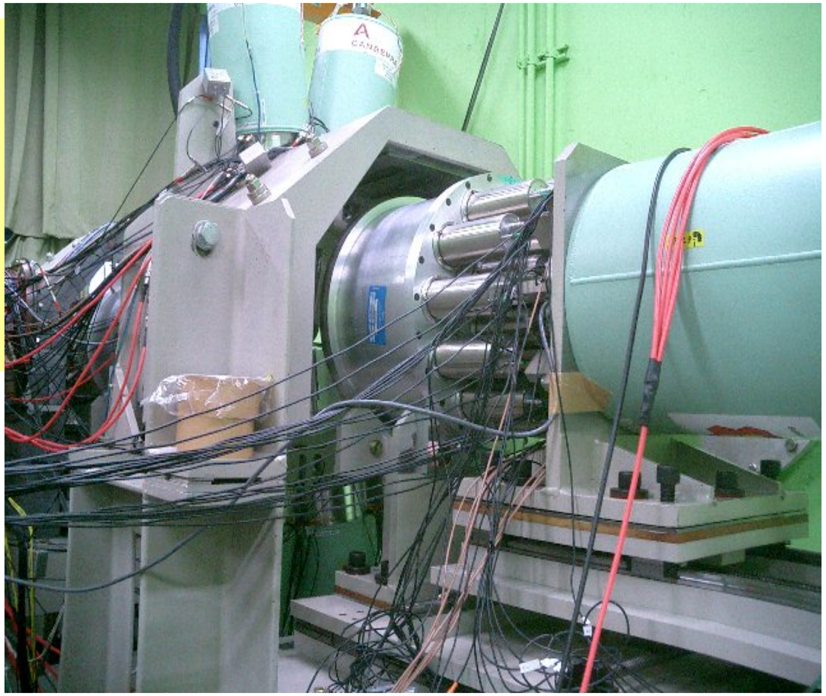
Rep. Rate 100 Hz, Pulse Width 100 ns

4 π Ge spectrometer

Cluster 2 (14 Ge crystals)

Clover 4 (16 Ge crystals)

BGO anti-coincidence shields



③ Activities in Japan for keV neutrons

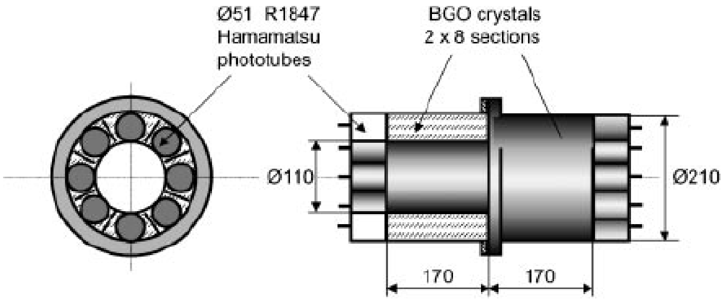
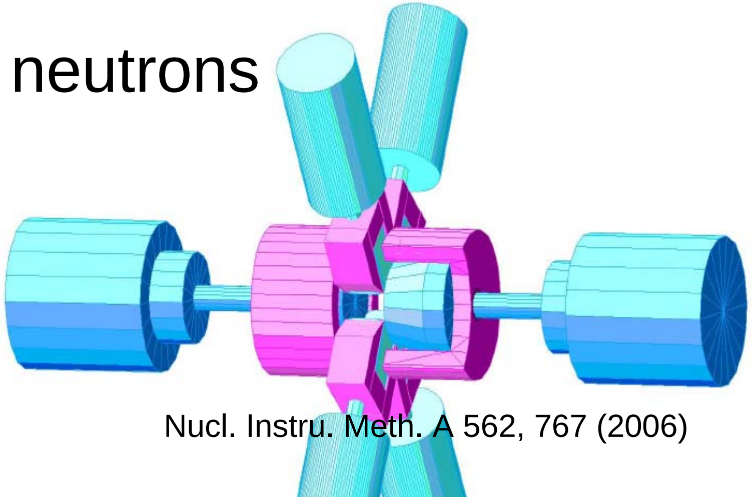


Fig. 2 BGO detector: front view (left) and side view (right) with a vertical cross section of one half. All sizes are given in mm

J. Nucl. Sci. Technol. 42, 135 (2005)



Nucl. Instru. Meth. A 562, 767 (2006)

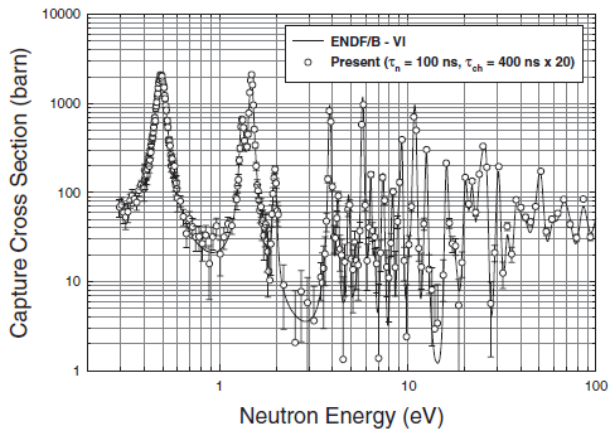
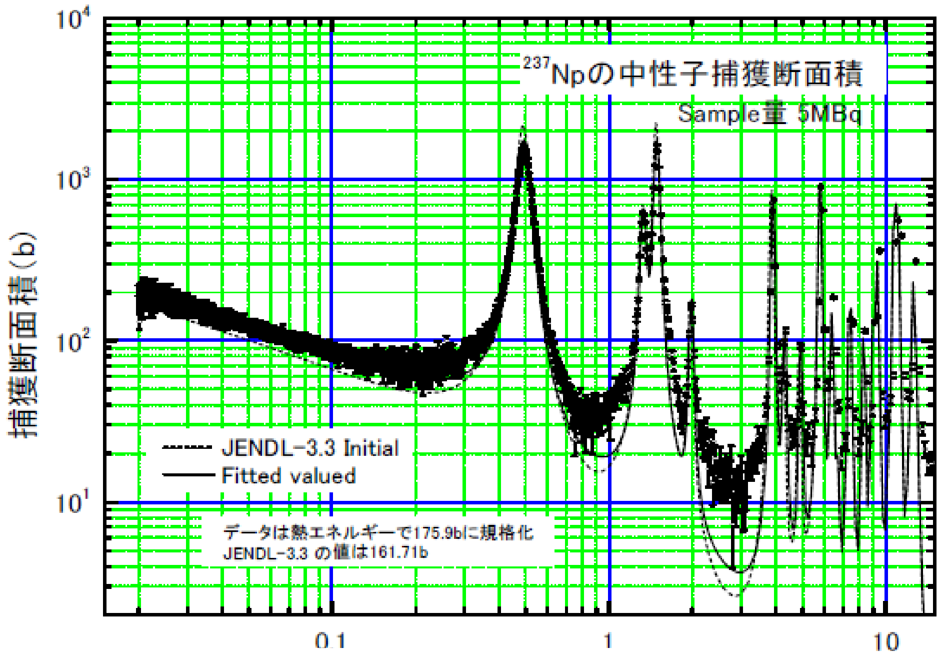


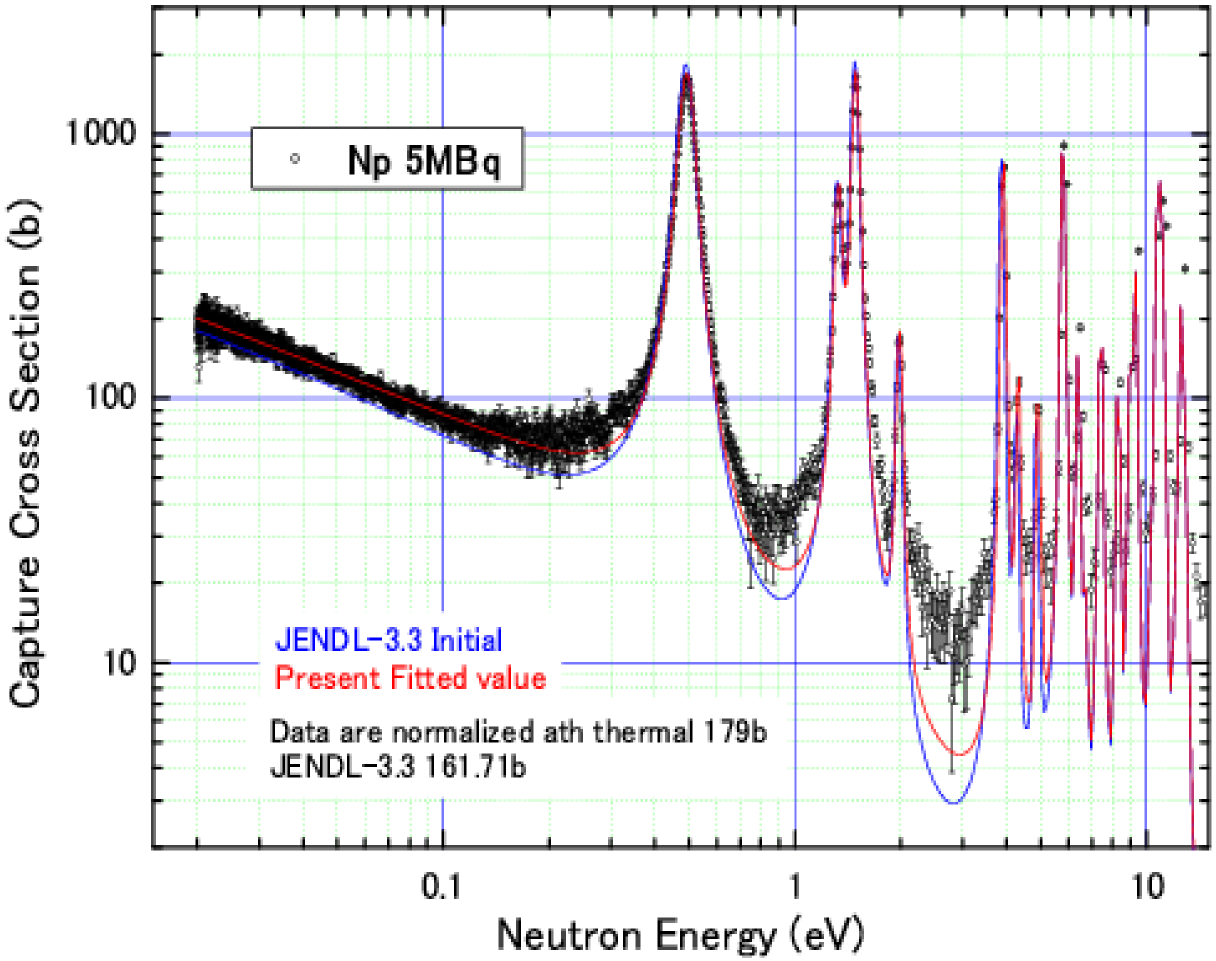
Fig. 10 The ^{237}Np capture cross section of present measurements from 0.2 to 100 eV in comparison with the evaluated data of ENDF/B-VI



水本等、原子力学会2007年秋の大会

図 1 ^{237}Np の中性子捕獲断面積

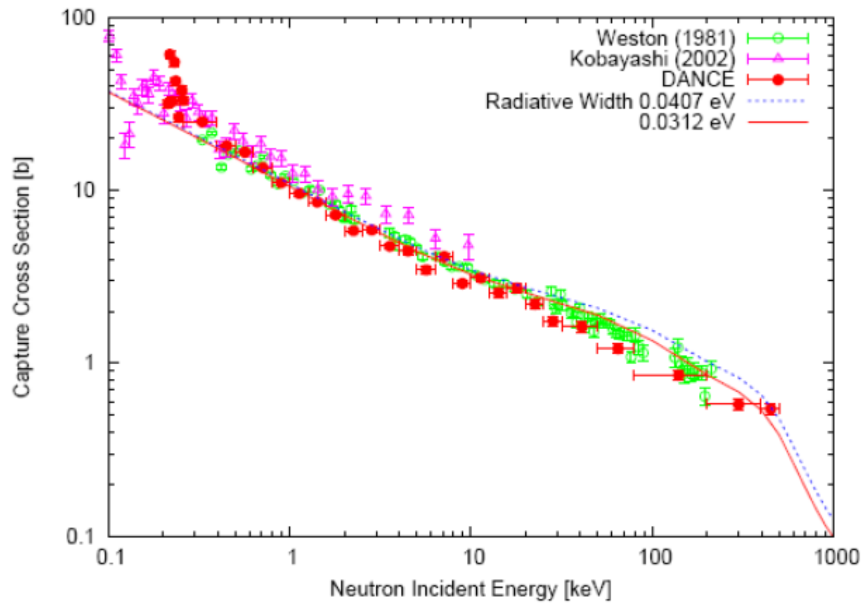
The data were successfully obtained, but needs more statistics for high energy region.



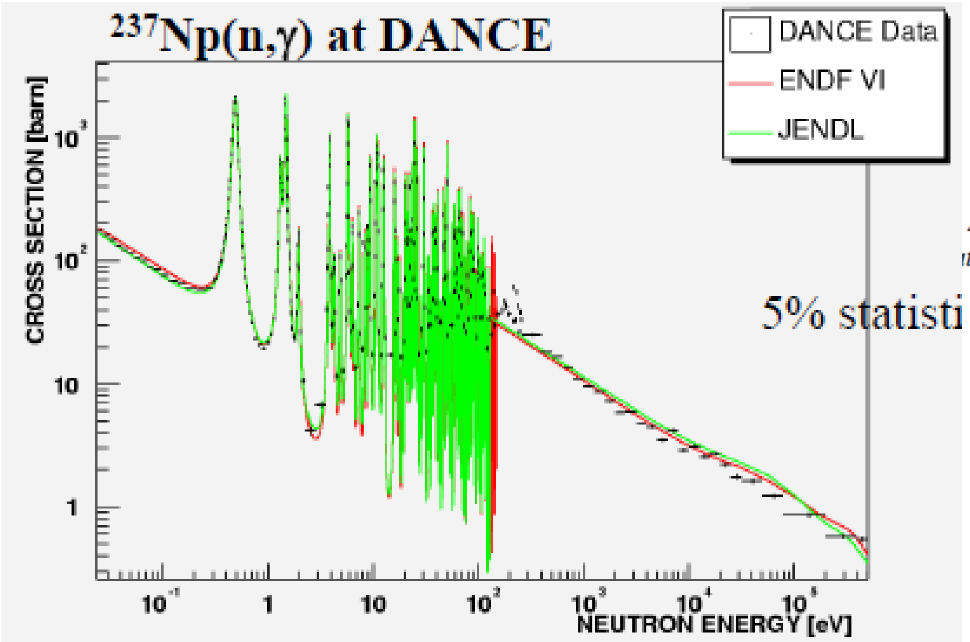
Deduced capture cross section of ^{237}Np (5MBq sample)

Comparisons of data for keV neutrons

Needs more statistics for En>100eV



4. The ^{237}Np data from DANCE compared to other recent measurements. Also shown are ...tions made by Kawano using the code CoH. (From Ref. 8.)



Workshop on Photon Strength Functions and Related Topics
Prague, Czech Republic
17-20 June 2007

Energy [eV]

③ Activities in Japan for keV neutrons Fission

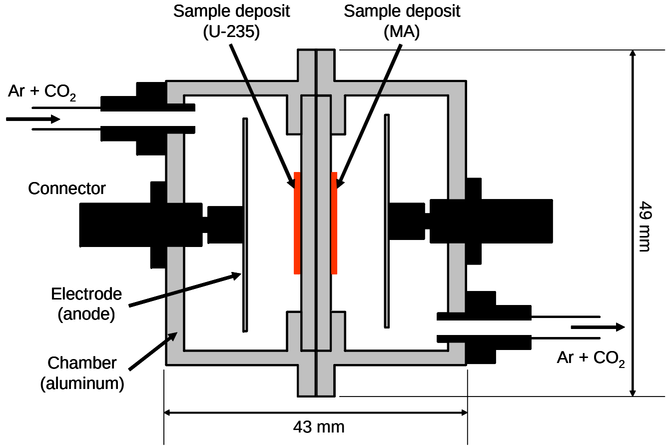
Tohoku, Kyoto

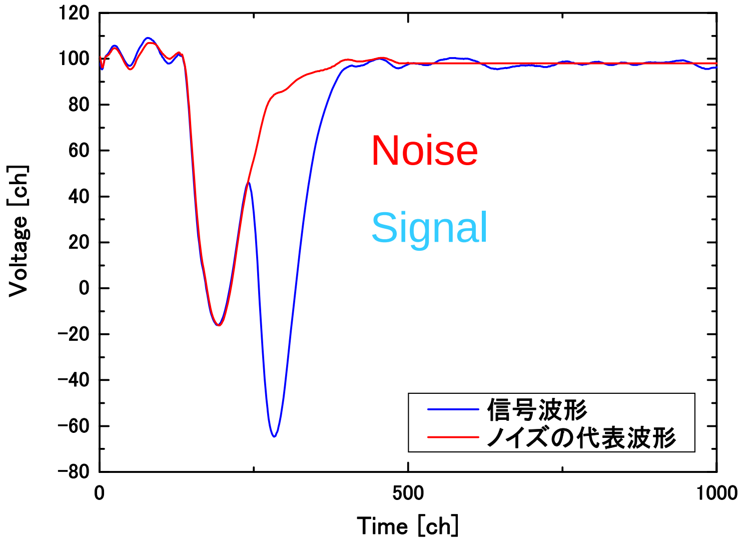
- ^{237}Np, ^{241}Am, ^{242m}Am, ^{243}Am
- En=1- 100 keV
- Kyoto University Lead Slowing Down Spectrometer (KULS)*
  driven by a 46 MeV electron linear accelerator
  **Kobayashi et al; measurements for minor actinide, En< 20 keV*

In the present study

- Back-to-back fission chamber (BTB, Ratio measurement)
  ^{235}U 99.9 %, as a standard
- For extension of energy range to high energy side,
  - Digital signal processing (DSP) technique to eliminate "γ-flash"
  - Heavy electrical shielding of BTB, cable, PA
- Quantitative assay of samples: low geometry α-counting

Fission



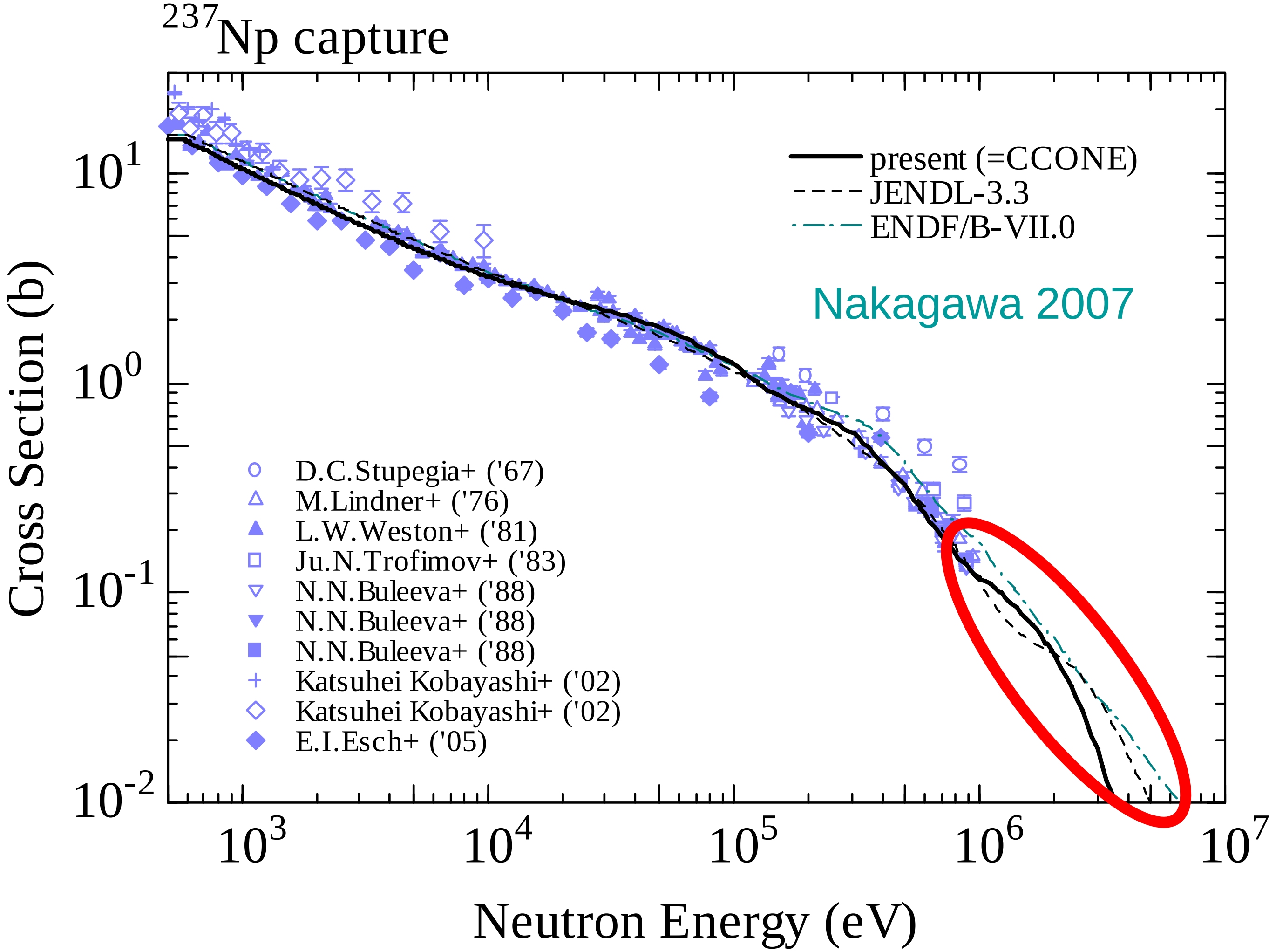


DSP

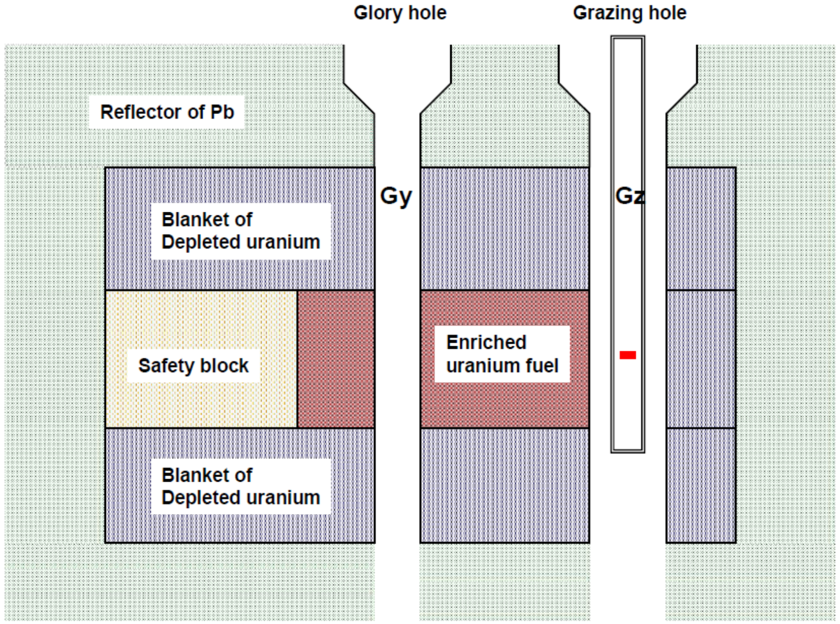
- Wave form analysis for each slowing down time
- Subtraction of “γ-flash” noise from raw signal (noise + signal)

④ Problems in measurement for MeV neutrons

The data is very limited especially for MeV neutrons.



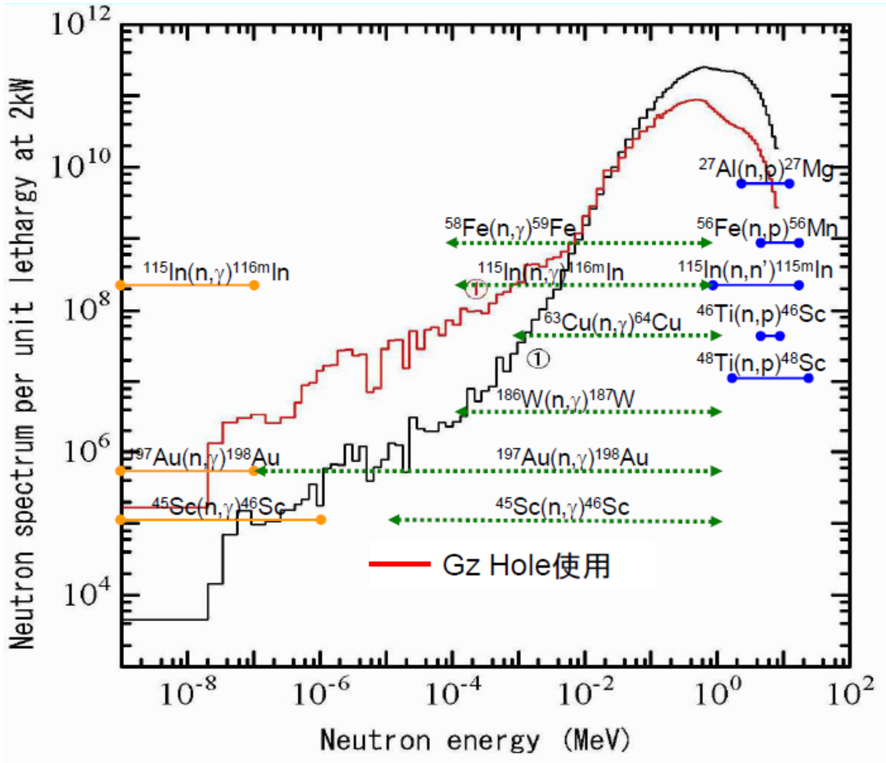
④ Possibilities in Japan for MeV neutrons



2007年原子力学会秋の大会

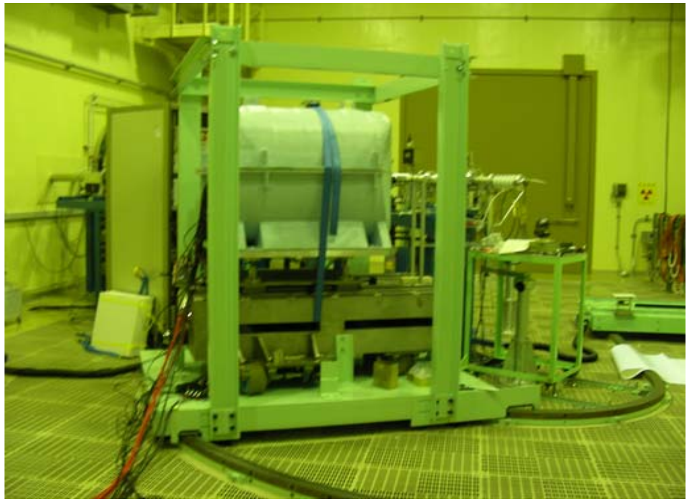
JAEA　〇中村詔司、藤　暢輔、木村　敦、初川雄一、原田秀郎

東大原子力専攻　　岡　芳明、石渡祐樹、斉藤　勲、安見厚志、
間渕幸雄、仲川　勉、林原正志

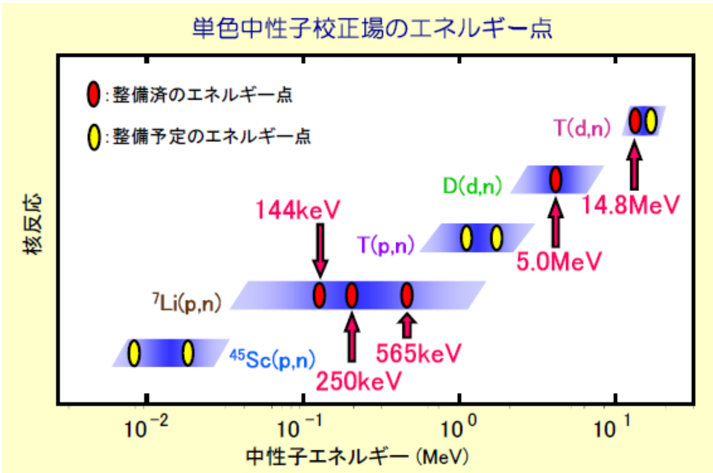


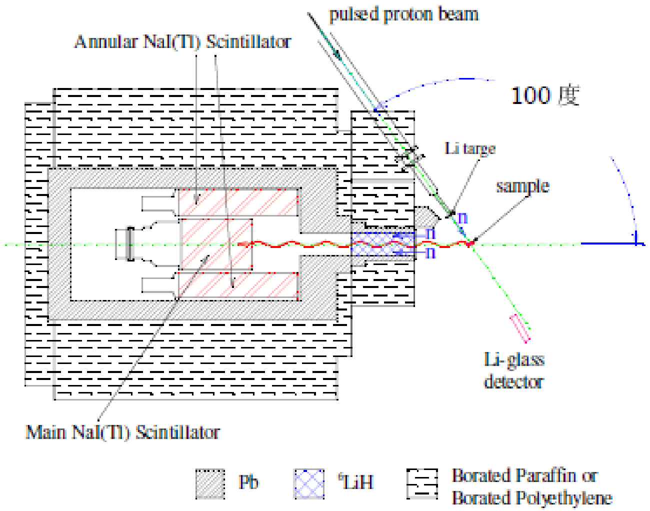
Activation by fast neutrons at Yayoi

④ Possibilities in Japan for MeV neutrons



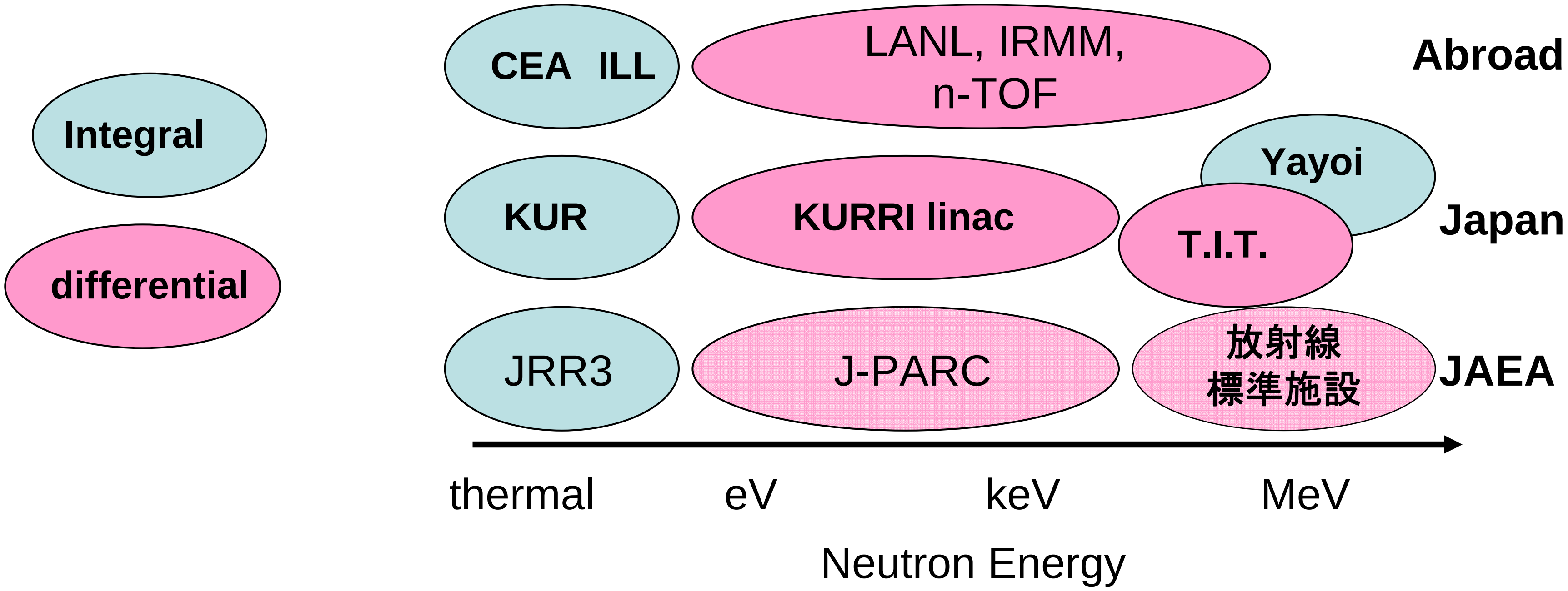
http://www3.tokai-sc.jaea.go.jp/rphpwww/senryo/index2.htm





TOF by fast neutrons at JAEA Tokai

⑤ Toward improvement in the MA data



Several facilities covering a wide energy range are or will be soon available for the measurements of MA cross section in Japan. High flux field will contribute to deduce statistical uncertainties. Efforts to deduce the experimental uncertainties including systematic uncertainties are important. The comparisons of independent measurements will help to notice the unexpected systematic uncertainties.