Japanese Activities in Nuclear Data Measurement

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Nuclear Data Projects in Japan

◎ Previous Project (2002.12-2007.3)
  Measurement, Evaluation, Utilization System

- Capture Measurement at KURRI
  Tokyo Tech (TIT), JAEA (JAERI, JNC), KURRI

- Fission Measurement at KURRI & Tohoku
  Tohoku, KURRI
Nuclear Data Projects in Japan

Current Project (2005.12-2010.3)
Measurement, Evaluation, Sensitivity Analysis System, Benchmark Calculation

- Capture Measurement at J-PARC, etc.
  Hokkaido, Tokyo Tech, JAEA, KURRI
- Fission Measurement at KURRI & Tohoku
  Tohoku, KURRI
- Photo Nuclear Reaction Measurement at AIST
  JAEA, Konan, AIST
- Decay Data Measurement at JAEA & KURRI
  Nagoya, JAEA
Nuclear Data Projects in Japan

◎ Previous Project (2002.12-2007.3)
  • Capture: Np-237, Am-241, 243
  • Fission: Np-237, Am-241, 242m, 243

◎ Current Project (2005.12-2010.3)
  • Capture: Cm-244, 246, LLFP
  • Photo Nuclear Reaction: Se-80, etc.
  • Fission: Cm isotopes, etc.
  • Decay Data: U-238, etc.
Construction of a Beam Line at J-PARC MLF

- Neutron-Nucleus Reaction Instrument (NNRI)
- NNRI has been completed, and spectrometers will be placed in August and November.
- The first proton beam impinged the Hg target on May 30, 2008. (single pulse: 0.4 T protons)
- Beam line tests are scheduled in June, September, and October.
- Capture measurement will start in December. Cm-244, 246, LLFP
Capture & Photo Nuclear Reaction

1. JAEA, Konan, AIST
2. Kyushu & KURRI
3. KURRI, JAEA, Tokyo Tech
4. Tokyo Tech
### Examples of recent results

<table>
<thead>
<tr>
<th></th>
<th>Half life</th>
<th>Previous data</th>
<th>JAEA data</th>
<th>References</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1.3 $&lt; \sigma_0 &lt;$ 4 b (Pomerance 1952)</td>
<td>$\sigma_0$ = 0.63 ± 0.02 b (Lower Limit)</td>
<td>JNST, 44, 21 (2007)</td>
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<tr>
<td><strong>$^{93}$Zr</strong></td>
<td>$1.53 \times 10^6$ y</td>
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<tr>
<td></td>
<td></td>
<td>1.8 ± 0.2 b (Mughabghab 1981)</td>
<td>$\sigma_0$ = 9.16 ± 0.27 b (Lower Limit)</td>
<td>JNST, 44, 103 (2007)</td>
</tr>
<tr>
<td><strong>$^{107}$Pd</strong></td>
<td>$6.5 \times 10^6$ y</td>
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</table>
Measurements of photon induced cross sections using Laser Compton scattering (LCS) photons and High-resolution High-energy photon Spectrometer, HHS, at AIST

1) Precise measurements of $(\gamma, n)$ cross sections: Recent results for $^{152}$Sm
2) High resolution measurements of $(\gamma, \text{abs})$ cross sections: $^{28}$Si et al.
3) Precise measurements of photo-atomic cross sections: on going

Measurements of thermal neutron capture cross sections using Multiple Prompt Gamma-ray Detector Apparatus, STELLA, at JAEA JRR-3

1) Nuclear level construction: Demonstration for $^{15}$N, $^{27}$Mg, etc.
2) Identification of ground-state transitions: $^{62}$Ni, etc.
3) Precise measurements of thermal neutron capture cross sections: on going
Inclusive ($\gamma$, X) Cross Sections

Difficult-to-measure nuclei: $^{129}$I, $^3$H, $^{14}$C, ... ($\beta$ emitter)
Change $\beta$ emitter to $\gamma$ emitter
Application to non-destructive assay of nuclear waste
Kyoto Univ. Electron Linac Facility
30 MeV $e^-$ + Ta or Pt target
Bremsstrahlung X ray (continuous energy)
Sample: $^{129}$I, $^{99}$Tc, $^{238}$U, $^{88}$Y, $^{90}$Zr, $^{93}$Nb
Detector: Ge detector

$\gamma$ ray spectrum for $^{129}$I($\gamma$, n)$^{128}$I
and $^{129}$I(n, $\gamma$)$^{130}$I

Kyushu Univ. & KURRI

Sample preparation and counting setup with electron, Ta target, sample, gamma-ray, and neutron interactions.
Sn & Se Isotopes (Sn-126, Se-79)
Cross Sections
Gamma-Ray Spectra

Se-77 →

← Se-74
Capture gamma-ray spectrum of Se-77

Capture gamma-ray spectrum of Se-74
Fission

Tohoku University & KURRI
Decay Data

Nagoya University & JAEA
Beta-decay energy \( (Q_\beta) \) measurements of fission products by development of total absorption detector

For \( Q_\beta \) determination for new-isotopes, 3 types total absorption detectors have been developed.

**Objective:**
- \( Q_\beta \) determination without decay scheme information of new isotopes!!

**1st:** Large volume BGO detectors (12cm\( \phi \) \( \times \) 10cm\( t \) \( \times \) 2)

In total absorption spectrum, the highest energy point indicates the \( Q_\beta \).

**Objective:**
- \( Q_\beta \) determination without decay scheme information of new isotopes!!

High efficiency, but energy resolution is \( \approx \)60~100 keV

High efficiency, but energy resolution is \( \approx \)60~100 keV

Determination of \( Q_\beta \) for fission products of \( ^{238}U(p,f) \) with on-line mass separator

New isotopes!!
- \( ^{163-165}Eu, \ ^{166}Tb, \) etc.

Others

1. Kyushu University
   (n,xn), (p,xp)

2. Osaka University & JAEA
   DDX of $\alpha$-particle emission
(n, xn) DDX @ LANSCE

LANSCE WNR: Spallation neutron source (< 800 MeV)
Sample: Thin C, Al, Fe, In, Pb
        Thick Fe, Pb
Detector: NE213, Phoswich type NaI(Tl)
Incident neutron: TOF
Outgoing neutron: Unfolding

unfolding using moving source model
Experiments at RCNP and JINR (Russia)

- Measurement of charged particle production cross sections at 300-600 MeV with crystal detectors

![Images of experiments at JINR, RCNP, and NIRS]

**DDX of $^{208}\text{Pb}(p,xp')$ reaction**

$E_p = 392$ MeV

[Graph showing DDX of $^{208}\text{Pb}(p,xp')$ reaction]
Experiments at HIMAC, NIRS

- Development of innovative detector systems for medical application
- Medical data measurement at 200-400 MeV/u
Recent activities of Osaka University group

I. Murata, H. Miyamaru, K. Kondo*
Division of Electric, Electronic and Information Engineering,
Graduate School of Engineering, Osaka University
under the collaboration with FNS group of JAEA

- Nuclear data measurements for fusion reactor development have been carried out with a pencil-beam DT neutron source of FNS, JAEA.
- Precise $\alpha$-particle emission double differential cross section (DDX$\alpha$) for carbon has been measured.
- The branching ratio has been determined based on the kinematics analysis of the experimental results including the DDXn data by Takahashi et al.

* Post doctoral fellow of JAEA from 2008 April.
Experimental arrangement for α emission DDX measurement

FNS facility of JAEA

Energy: 14.2 MeV
Flux: $6 \times 10^5$ n/s/cm$^2$

Background flux is kept around several tens n/s/cm$^2$ !

Ti-T target
Pre-collimator

Polyethylene

Pb

D$^+$ beam
350keV
20mA(max.)

200cm

Vacuum Chamber

Concrete Wall

Sample
Obtained DDX$\alpha$ for carbon

$12^C(n,n'+3\alpha)$

$E_\alpha \geq 1.0$ MeV

Emission angle in LAB system [cos unit]
Reaction kinematics analysis with Monte Carlo technique for the $^{12}$C$(n,n'+3\alpha)$ reaction

- Aim at experimental determination of the branching ratio for inelastic scattering of $^{12}$C and $^{12}$C$(n,\alpha)^{9}$Be* reactions.
- The branching ratio was determined by fitting measured DDX$\alpha$ (Present) and DDX$n$ (by Takahashi et al.).

Can contribute to nuclear data evaluation and nuclear model construction.