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Book of Abstracts

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Studies at J-PARC and JAEA / O1

A Plan of Proton Irradiation Facility at J-PARC and Possibilities of Application to Nuclear Data Research

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The partitioning and transmutation (P-T) technology has promising potential for volume reduction and mitigation of degree of harmfulness of high-level radioactive waste. JAEA is developing the P-T technology combined with accelerator driven systems (ADS) [1]. One of critical issues affecting the feasibility of ADS is the proton beam window (PBW) which functions as a boundary between the accelerator and the sub-critical reactor core. The PBW is damaged by a high-intensity proton beam and spallation neutrons produced in the target, and also by flowing high-temperature liquid lead bismuth eutectic alloy which is corrosive to steel materials. To study the materials damage under the ADS environment, J-PARC is proposing a plan of proton irradiation facility which equips with a liquid lead-bismuth spallation target bombarded by a 400 MeV – 250 kW proton beam. The facility is also open for versatile purposes such as soft error testing of semi-conductor devises, RI production, materials irradiation for fission and fusion reactors, and so on. Application to nuclear data research with using the proton beam and spallation neutrons is also one of such versatile purposes, and we welcome unique ideas from the nuclear data community.

[1] T. Sugawara, et al., "Research and development activities for accelerator-driven system in JAEA," Prog. Nucl. Energy, 106, pp. 27–33 (2018).

Studies at J-PARC and JAEA / O2

Status and prospects on light sterile neutrino searches

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There have been indications on existing sterile neutrinos since 1990's. Those indications are based on the accelerator neutrino (numu >nue) experiments, reactor neutrino (nuebar -> X) experiments and calibrations of solar neutrino experiments (nue->X) The sterile neutrinos do not have weak interactions, therefore the measurements on the sterile neutrinos usually use the neutrino oscillations between usual active three neutrinos (e, mu, tau) and sterile neutrinos in the short distance. It is the hot topic for about 20 years. In this presentation, the status and prospects of the recent sterile neutrino searches in the world are shown. It includes the activities in J-PARC, especially for the JSNS^2 (J-PARC Sterile Neutrino Search at J-PARC Spallation Neutron Source). The JSNS^2 started data taking from Jan-2021.

Studies at J-PARC and JAEA / O3

Research reactor JRR-3 restart !! -Invitation to the various neutron utilization-

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The research reactor JRR-3 submitted an application for a modification of the installation permit to confirm compliance with the new regulatory standards on September 26, 2014, and received the permit on November 7, 2008, after an examination that lasted about four years. Subsequently, over a period of about two years from April 1991, the plant completed seismic reinforcement work, safety measures, and other work necessary to comply with the new regulatory standards, and passed all inspections by the Nuclear Regulation Authority, etc., to confirm the safety of the reactor, and resumed operation on February 26, 2021, for the first time in 10 years and 3 months. The facility resumed operation in July 2021, and a variety of neutron experiments have been actively conducted by researchers from inside and outside JAEA. In cooperation with the neighboring J-PARC, the facility is expected to contribute to the development of cutting-edge science and technology and industry as a world center of neutron science. In this talk, we will introduce JRR-3, which has restarted its operation after 10 years, and its various neutron applications.

Studies at J-PARC and JAEA / O4

Recent activities for nuclear data measurements in ANNRI

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Accurate data of neutron-capture cross sections of minor actinides (MAs) and long-lived fission products (LLFPs) are important in detailed engineering designs and safety evaluations of innovative nuclear reactor systems. However, accurate measurements are very difficult due to high radioactivity of these samples.
To satisfy these demands, Accurate Neutron-Nucleus Reaction measurement Instrument (ANNRI) has been developed by the collaboration of Hokkaido University, Tokyo Institute of Technology and JAEA. ANNRI is located on the Beam Line No. 04 of the Materials and Life science experimental Facility (MLF) at the J-PARC. Measurements of neutron-capture cross sections of MAs and LLFPs with high intensity pulsed neutrons have been started from 2009. Neutron capture cross sections of Cm-244, Cm-246, Am-241, Np-237, Zr-93, Tc-99 and many stable isotopes were reported. These results will make significant contributions in the field of developing innovative nuclear systems.
In recent years, Li-glass detectors were installed in ANNRI and neutron total cross section measurements have been started. Furthermore, to expand neutron energy range of measurements to keV region, new high-speed DAQ system, and neutron filter system were also developed and installed. In this presentation, the current status, a brief view, measurement activities and results, and future plans are presented.

Current Status and Prospects of Nuclear Data Study 1 /O5

Outline of JENDL-5

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The next version of JENDL general purpose library, JENDL-5, is almost ready to be released. JENDL-5 increases variety and amount of data from the current version JENDL-4.0. Regarding the neutron induced reaction data, which is the most important for reactor applications, the number of the stored nuclides will be around 800, which is almost double of 406 as of JENDL-4.0. They cover not only all stable isotopes but also a large number of unstable isotopes that are much enough for various applications of radiation simulations. The data from light to heavy nuclides have been revised reflecting up-to-date experimental knowledge such as new measurements of cross sections by ANNRI at J-PARC. Fission yield and decay data are also revised with new experimental and theoretical knowledge. New evaluations of thermal scattering law data based on molecular dynamics are adopted for many of materials in JENDL-5 including light and heavy water. The data of other incident particles than neutron that have been developed as special-purpose files are integrated into JENDL-5. For proton, deuteron, alpha-particle and photon induced reactions, the data of JENDL-4.0/HE, JENDL/ImPACT-2018, JENDL/DEU-2020, JENDL/AN-2005, JENDL/PD-2016.1 are adopted. Since JENDL/AN-2005 contains only neutron-emission related data, date needed for radiation transportation codes are complemented. Regarding neutron induced reaction, the data of high energy reaction above 20 MeV and activation cross section are also integrated from JENDL-4.0/HE, JENDL/ImPACT-2018 and JENDL/AD-2017. We hope JENDL-5 will facilitate wide spreading research and developments for nuclear technologies.

Current Status and Prospects of Nuclear Data Study 1 /O 6

Integral Tests of Preliminary JENDL-5 for Critical and Shielding Experiments

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The latest version of Japanese Evaluated Nuclear Data Library, JENDL-5, is planned to be released in 2021. To this end, we have performed integral tests of preliminary versions of JENDL-5 since 2018. In this presentation, we show the integral test results of JENDL-5 beta 3 update 1 for critical and shielding experiments. The critical test calculations have been done for experiments mainly in the International Criticality Safety Benchmark Evaluation Project (ICSBEP) handbook and conducted at JAEA. The shielding benchmark tests have been done mainly for FNS experiments at JAEA and OKTAVIAN experiments. We have confirmed that JENDL-5 beta 3 update 1 gives better than or the same prediction accuracy as the previous version of JENDL-4.0 in many test cases for the critical and shielding experiments.

Tutorial 1 /T1

New developments in TALYS and TENDL-2021

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At the end of every second year, a new version of both the nuclear model code TALYS and its accompanying nuclear data library TENDL is released. Both are foreseen for December 2021. TALYS-1.96 contains new features such as - explicit evaporation of fission fragments to obtain fission product

yields and related neutron observables such as nubar, nu(A) and PFNS - the latest photon strength function models, both phenomenological and microscopic, and a new technique to use these for neutron capture cross sections in the fast neutron range - the ability to read in the RIPL OMP parameters for actinides - an improved deuteron break-up model by M. Avrigeanu. The next version of the TALYS Evaluated Nuclear Data Library, TENDL-2021, contains various enhancements over the previous version - an improved overall description of all charged-particle libraries, thanks to improved numerical binning in multiple emission and - adjusted global fitting parameter for strip- ping for (alpha,n) cross sections - adjusted break-up parameter for deutron-induced library - notable improvement of the proton library, especially for (p,n) cross sections - addition of improved resonance parameters for several nuclides from the JEFF community - a globally improved descritpion of neutron-induced capture cross sections in the fast energy range by applying the new PSF models and automated fitting via the TASMAN code. - a photonuclear data library based on the SMLO2019 photon strength function, bringing the results close to the latest IAEA-PD library - a good global description of subactinide fission. As production into ENDF and GNDS format has been automated, TENDL-2021 is particularly useful for general application in nuclear technology.

Poster - Board: P01

[P01] ^{241}Am Neutron Capture Cross Section Measurement and Resonance Analysis

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Advanced nuclear systems are expected to use Pu-containing nuclear fuel alongside Minor Actindes (MAs). Accelerator-Driven System (ADS) is a proposed sub-critical advanced nuclear system to lessen the current amount of MAs by means of nuclear transmutation into short-lived or even stable nuclei. The effect of the current nuclear data uncertainty to the criticality assessment of ADS facilities has been quantified in recent studies, including the effect of the neutron capture cross section in the keV region [1]. ^{241}Am ($t_{1/2}$ = 432 yr) is one of the most profuse MAs present in spent nuclear fuel. A preliminary ADS nuclear transmutation study has been performed assuming the MA isotope concentration of 20.72% for ^{241}Am in the core, the second highest after ^{237}Np. Current JENDL-4.0 uncertainties for the neutron capture cross section of ^{241}Am are larger than 12%, much larger than the requirements of below 5% in the energy range from 0.454 keV to 1.35 MeV [2]. In addition, ^{241}Am is continuously produced in the nuclear fuel of advanced reactors, as they comprise Pu, due to the β-decay of ^{241}Pu ($t_{1/2}$ = 14.4 yr). Hence, an accurate characterization of the neutron capture cross section is of paramount for the design of advanced nuclear systems. Neutron capture cross section measurements were performed in the Accurate Neutron Nucleus Reaction Measurement Instrument (ANNRI) at the Materials and Life Science Facility (MLF) of the Japan Proton Accelerator Research Complex (J-PARC). The time-of-flight (TOF) methodology was employed in a non-filter condition experiment to determine the neutron capture cross section from thermal to about 100 eV. Moreover, experiments were performed using the neutron filtering system to determine the neutron capture cross section at the energy of 23.5 keV using Fe as filter material[3]. A sample of 241Am with a mass of 7.5 mg was used for the measurements with an activity of 950 MBq. The neutron spectrum was reconstructed using the 478 keV gamma-rays from the ^{10}B(n, $\alpha\gamma$)^{7}Li reaction with a boron sample containing enriched ^{10}B up to 90% in the no-filter condition. In this study, the preliminary results of the ^{241}Am neutron capture cross section from 10 meV to about 100 eV determined in TOF experiments and at 23.5 keV from Fe filter experiments are presented. In the TOF experiments, the ^{241}Am neutron capture cross section was normalized by means of the saturated resonance method using a Au sample with a mass of 1.5 g. In addition, for the Fe filter experiments, the capture cross section of ^{241}Am at the energy of 23.5 keV was determined relative to the ^{197}Au yield obtained from a measurement using the same Au sample. Moreover, early-stage results of a resonance analysis of the ^{241}Am capture resonances are also presented.

[1] H. Iwamoto, K. Nishihara, T. Sugawara, and K. Tsujimoto, Nucl. Data Sheets, vol. 118, no. 1, pp.

519–522, 2014.
[2] M. Salvatores and R. Jacqmin, vol. 26, no. NEA/WPEC-26. 2008.
[3] G. Rovira et al., Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip., vol. 1003, no. April, p. 165318, 2021.

Poster - Board: P02

[P02] Development of a method for calculating displacement damage dose of semiconductors by space radiation using PHITS code

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In the space environment, semiconductors used in many devices are irradiated with particles such as protons, neutrons, electrons, and heavy ions. The atomic displacement caused by these particles degrades the electrical performance of the devices. The atomic displacement of a semiconductor is proportional to the Displacement Damage Dose (DDD), which is expressed as the integral of the non-ionizing energy loss (NIEL) and the particle fluence. In order to simulate DDD of semiconductors in space, we have developed a method for calculating DDD in the Monte Carlo Particle and Heavy Ion Transport code System (PHITS), using the same calculation method as that for the number of Displacements Per Atom (DPA) of metals over a wide energy range [Y. Iwamoto et al. J. Nucl. Mater. 538, 152261 (2020)]. This method includes the calculation of the Coulomb scattering cross section between charged particles and a target, the calculation of nuclear reactions, and the calculation of charged particle productions under neutron irradiation. For proton, neutron and electron irradia- tion of silicon, PHITS results are consistent with numerical data obtained by the Screened Relativistic (SR) Nuclear and Electronic Stopping Power Calculator for semiconductors. The defect production efficiencies obtained from the recent molecular dynamic simulations for SiC, InAs, GaAs, and GaN semiconductors [F. Gao et al. Phys. Rev. Mater. 5, 033603 (2021)] were also implemented in PHITS. Results show that, among these semiconductors, GaAs is the most sensitive to displacement damage and SiC is the most resistant to damage when irradiated with 10 MeV protons. This work was supported by JSPS KAKENHI Grant Number JP19H02652.

Poster - Board: P03

[P03] Estimation of fission fragment yields using random-walk models on microscopic mean-field potentials

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Microscopic calculation is one of the effective approaches to complement nuclear data due to its prediction power, firmly based on knowledge of the nuclear physics. To estimate the fission fragment yields (FFY), we suggest a theoretical model composed of the Metropolis random-walk method and microscopic calculations in which the potential energy surface (PES) is deduced from the mean-field model in terms of the Skyrme Hartree-Fock + BCS model represented in the three-dimensional Cartesian coordinate space. The random-walks on the PES correspond to the shape evolution during

the fission process in our model. The PES is calculated considering the quadrupole and octupole deformations as constraints which are important for nuclear elongation and mass asymmetric fission. In this work, we apply three different Skyrme effective interactions to calculate the PES and different energy-dependent random-walks, and show how the FFY depends on these different choices of computational methods. Then, we discuss the peak shapes of FFY through the comparison among our calculations and experimental data.

Poster - Board: P04

[P04] The optical potential for neutron-nucleus scattering derivedby Bayesian optimization

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We are working on a combination of nuclear reaction calculation code CCONE and machine learning libraries to generate and improve the accuracy of nuclear data. In this presentation, we will show an example of optimizing the parameters of the optical potential to reproduce elastic and inelastic scatterings of neutron-54Fe. The elastic scatterings and inelastic scatterings to the first excited state at several incident energies were calculated using CCONE, and the optical parameters were optimized to reproduce the experimental data by Bayesian optimization. The optimized parameters are the depth of the real and imaginary parts of the central force potential, its energy dependence, radius, and diffuseness parameter. Using the obtained optical potential, we estimated the cross sections at energies different from the input, and found that the calculations reproduced the experiments well. In this presentation, we will introduce these calculation examples and also discuss the future prospects.

Poster - Board: P05

[P05] Small-angle scattering measurements for cement paste sam-ples using X-rays and neutrons in Hokkaido University

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Small-angle X-ray scattering (SAXS) measurements for cement paste samples have been conducted in order to obtain the time-evolution of nanostructure under the cement hydration process. In the measurements, it is important to avoid drying the cement paste because the SAXS profile of cement paste is affected by drying. By combining a sample cell, a laboratory-based SAXS instrument in Hokkaido University allows us to do an in-situ SAXS measurement of cement paste at the curing time from initial- to long-term. On the other hand, a small-angle neutron scattering (SANS) measurement have been prepared with a heavy-water cement paste sample at an accelerator-driven neutron source facility in Hokkaido University. As a complementary approach, we are planning to estimate the composition of nanostructure of cement paste by utilizing the difference between the electron and neutron scattering length densities. In this presentation, mainly, the measured SAXS profiles andthe experimental procedures using X-rays and neutrons are reported.

Poster - Board: P06

[P06] Design of a new shadow bar to improve the accuracy of benchmark experiments of large-angle elastic scattering reaction cross sections by 14MeV neutrons

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The elastic scattering reaction cross section data commonly show smaller in backward angles compared to those of forward angles when the energy of incident neutron is high. However, in a high neutron flux field, such as fusion reactor, the effect of back-scattering reaction cross section is becoming not negligible on the calculation result. Until now, there were differences reported between experimental and calculated values of neutron benchmark experiments using a DT neutron source, which focused on back-scattering phenomena like a gap streaming experiment [1]. For this problem, the author's group developed a benchmark method for large-angle scattering cross sections using two types of shadow bars with different thicknesses (thin and thick ones) [2] and has carried out experiments with an iron sample for the last few years [3]. The benchmark method was successfully established based on the activation of Nb foil having a large activation cross section at around 14 MeV. In the experiment, we used a disk-shaped tritium target that was locally irradiated with a D+ beam to generate neutrons as many as possible. In the calculation, we considered it as a point source, however in reality it is a surface source having an intensity distribution on the target. If the position and shape of the surface source varies in each experimental system, the correct results cannot be obtained. Therefore, we decided to irradiate the D+ beam to the tritium target uniformly rather than locally. But it was found, since the current thin shadow bars is too thin (3 cm) compared to the target diameter (2.5 cm), it could allow neutrons to enter directly into Nb foil due to a small error in the installation during the preparation of the experiment. This may lead to an overestimation of the reaction rate. In order to solve this problem, we have designed a new thin shadow bar that does not allow neutrons to enter the Nb foil directly. The design was carried out using MCNP5, changing only the thickness of the thin shadow bar from the present experimental system, i.e., that of the thick shadow bar was not changed. The thickness of the shadow bars was determined so that the number of "neutrons scattered only from the target", which we wanted to see, would be large and that the Nb foil activity would be sufficient with an appropriate irradiation time. As a result of the design calculation, the lower bottom of the thin shadow bar was changed from 3 cm to 4 cm. In the future, we will conduct the experiment again using the newly designed shadow bar.
reference
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[3] Atsuki Yamaguchi, Kazuki Fukui, Yuki Fujiwara, Shingo Tamaki, Sachie Kusaka, Fuminobu Sato & Isao Murata, Benchmark experiment of large-angle scattering reaction cross section of iron at 14 MeV using two shadow bars – Comparison of experimental results with ENDF/B-VIII. Journal of Nuclear Science and Technology, 2021; 58: 80 – 86.

Poster - Board: P07

[P07] Problem on gammas emitted in capture reaction of TENDL-2019 and JEFF-3.3

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We reported that energy distribution data for secondary gammas from the capture reaction of a lot of nuclei in TENDL-2017 had no high-energy gamma peaks, which other nuclear libraries have, at the IAEA FENDL meeting in 2018 [1, 2]. It caused drastically small damage energy production cross sections at incident neutron energies below a few keV. In the process of JENDL development we examined whether the latest TENDL, TENDL-2019, and other latest nuclear data libraries had this issue or not. As a result, we found that a lot of nuclei in TENDL-2019 still had no high-energy gamma peaks in secondary gamma spectra from the capture reaction and several nuclei in JEFF-3.3 also have, while other nuclear data libraries such as JENDL-4.0 and ENDF/B-VIII.0 had those peaks. This problem causes not only drastically small damage energy production cross sections for radiation damage calculations at incident neutron energies below a few keV but also smaller gamma productions in shielding calculations. The problematic energy distribution data for secondary gammas in TENDL- 2019 and JEFF-3.3 should be revised.

References

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Poster - Board: P08

[P08] Measurement of 107-MeV proton-induced double-differential neutron yields for iron for research and development of accelerator- driven systems

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For accurate prediction of neutronic characteristics for accelerator-driven systems (ADS) and a source term of spallation neutrons for reactor physics experiments for the ADS at Kyoto University Critical Assembly (KUCA), we have launched an experimental program to measure nuclear data on ADS using the Fixed Field Alternating Gradient (FFAG) accelerator at Kyoto University. As part of this program, the proton-induced double-differential thick-target neutron-yields (TTNYs) and cross-sections (DDXs) for iron have been measured with the time-of-flight (TOF) method. For each measurement, the target was installed in a vacuum chamber on the beamline and bombarded with 107-MeV proton beams accelerated from the FFAG accelerator. Neutrons produced from the targets were detected with stacked, small-sized neutron detectors composed of the NE213 liquid organic scintillators and photomultiplier tubes, which were connected to a multi-channel digitizer mounted with a field-programmable gate array (FPGA), for several angles from the incident beam direction. The TOF spectra were obtained from the detected signals and the FFAG kicker magnet’s logic signals, where gamma-ray events were eliminated by pulse shape discrimination applying the gate integration method to the FPGA. Finally, the TTNYs and DDXs were obtained from the TOF spectra by relativistic kinematics. The measured TTNYs and DDXs were compared with calculations by the Monte Carlo transport code PHITS with its default physics model of INCL version 4.6 combined with GEM (INCL4.6/GEM) and those with the JENDL-4.0/HE nuclear data library. Details of the TTNY and DDX measurements and their experimental results will be presented.

Poster - Board: P09

[P09] TOF measurement of neutron capture cross section of Re-185 in keV region

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The neutron capture cross section of Re-185 in keV region is important in the various fields such as astrophysics and nuclear data. There are limited number of experimental data currently available, most of which are with large uncertainties. In this work, Time-of-Flight measurement of neutron capture cross sections of Re-185 was carried out by using 3 MV Pelletron accelerator at Laboratory for Advanced Nuclear Energy of the Tokyo institute of technology. Using pulse height technique, the cross sections at four different average neutron energies were measured. With the current results, the nuclear data of Re-185 was re-evaluated, showing consistency with the Evaluated Nuclear Data File (ENDF/B-VII). Maxwellian averaged cross section was also calculated, which results in 15% smaller than the Karlsruhe Astrophysical Database of Nucleosynthesis in Stars (KADoNIS) recommendation at 30 keV.

Poster - Board: P10

[P10] Benchmark Experiment for Large Angle Scattering Cross Sections for Tungsten with 14 MeV Neutrons

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Cross sections of large angle scattering reaction in nuclear data are commonly smaller than those of forward scattering when energy of an incident neutron is high. However, in a high intensity neutron field, such as fusion reactor, contribution of cross sections of large angle scattering is not negligible on calculation results. Actually, difference between experimental and calculated values in benchmark experiments for large angle scattering cross sections has been reported until today[1]. In the previous research, the author's group developed a benchmark method for large angle scattering cross sections[2] and carried out experiments with an iron target[3]. In this study, we carried out benchmark experiment for large angle scattering cross section for tungsten and neutron transport calculations in our experimental system with Monte Carlo code, MCNP5. By comparing the experimental values with calculated results, we discussed accuracy of the cross sections of large angle scattering in ENDF/B-7, JEFF-3.3 and JENDL-4. As a result, we found that the cross section data of large angle scattering of tungsten in JEFF-3.3 most agreed with the experimental values.

Reference:
[1] S. Ohnishi et al.: New integral experiments for large angle scattering cross section data benchmarking with DT neutron beam at JAEA/FNS, Fusion Engineering and Design, 87, pp. 695-699, (2012)
[2] Naoya HAYASHI, Seiki OHNISHI, Yuki FUJIWARA, Sachie KUSAKA, Fuminobu SATO, Isao MURATA "Optimization of Experimental System Design for Benchmarking of Large Angle Scattering Reaction Cross Section at 14 MeV Using Two Shadow Bars" Plasma and Fusion Research, 13, 2405002, (2018)
[3] Atsuki Yamaguchi, Kazuki Fukui, Yuki Fujiwara, Shingo Tamaki, Sachie Kusaka, Fuminobu Sato, Isao Murata " Benchmark experiment of large-angle scattering reaction cross section of iron at 14 MeV using two shadow bars – Comparison of experimental results with ENDF/B-VIII –" Journal of Nuclear Science and Technology, 58. pp. 80-86.(2019)

Keywords: 14MeV neutron, large angle scattering cross section, backscattering, tungsten, bench- mark experiment, MCNP5, foil activation method

Poster - Board: P11

[P11] Energy dependence of total kinetic energy of fission frag- ments for the standard and superlong modes analyzed separately by 4D Langevin model

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TKE (Total Kinetic Energy) of fission fragments is the main source of energy (Q-value) released by fission. Therefore, it is important to understand deeply behavior of the TKE in the nuclear fission of uranium, plutonium, and so on from the viewpoint of nuclear power utilization and to understand the fission process as a basic research. From the experimental results, it is known that the TKE decreases as the excitation energy increases. Traditionally, it has been understood that the reason for the decrease of the TKE is due to increase of the fraction of (symmetric) superlong mode, which has TKE smaller than that of the (asymmetric) standard mode. On the other hand, we have shown that decrease of the TKE was brought by change of the heavy fragments from nearly-spherical to prolate shape by washing-out of the shell effects as the excitation energy increases [1]. In this study, we have studied how the TKEs of the standard and superlong mode change separately as functions of the excitation energy by the four-dimensional (4D) Langevin model that can individually describe the deformation of each fragment. It was found that decrease of the TKE is caused primarily by the change of TKE of the standard mode, namely, change of the shape of the heavy fragments, rather than increase of the fraction of the superlong mode. Therefore, we could draw a new picture on the energy dependence of the TKE of the fission fragments.
[1] K.Shimada, C.Ishizuka, F.A.Ivantyukand S.Chiba, submitted to Phys. Rev. C.

Poster - Board: P12

[P12] Development of activation detector for ultra-long term DT neutron irradiation

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In the material integrity test of fusion reactors, neutron irradiation and cooling are repeatedly per- formed. In the test, it is indispensable to obtain the neutron fluence by some method. Commonly, Nb foil is used for neutron flux measurement, however one Nb foil cannot record a long irradiation period of about one year, because the half-life of produced RI is about 10 days. Relative measurement with an MCS is available, however it is often complicated due to instability of the detector output and data processing. In this study, we develop an activation detector to determine the neutron fluence, even if the irradiation period is extremely long, using nuclides with very long half-lives. First, we selected nuclides whose produced radioisotopes emit γ-rays similar to Nb foil. As a result of selection, 33 nuclides were selected as possible γ-ray emitters. For one year irradiation of ITER materials at the DT neutron source facility, OKTAVIAN, only ^{103}Rh was found to be effective. ^{103}Rh(n,2n) reaction produces 102 mRh having a half-life of 3.7 years. However, for various irradiation conditions of various durations and neutron intensities, e.g., irradiation in ITER, only γ-ray emitting nuclides were found to be insufficient. In order to increase the number of candidates, β-ray emitters were also examined. As a result, 15 β decay nuclides were selected. ^{158}Tb, which is produced by (n,2n) reaction of ^{159}Tb, has a half-life of 180 years and can be applied to ITER for an irradiation period of several tens years. At present, we are measuring the accurate cross sections of ^{103}Rh(n,2n) and ^{159}Tb(n,2n) reactions at 14 MeV by a short-term irradiation. In addition, long-term irradiation of several months is being carried out with these foils. By the long-term irradiation experiment, we aim to prove the applicability of these foils as activation detectors in an ultra-long-term DT neutron irradiation.

Poster - Board: P13

[P13] Semi-empirical nuclear fission yield model for astronomical use based on the four-dimensional Langevin approach

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Nuclear fission plays an essential role in nuclear reactors and the r-process nucleosynthesis, which produces heavy elements like gold and uranium via the fission recycling process. Fission fragments of superheavy nuclei can be the seed nuclei of the r-process. However, there has been considerable ambiguity among theoretical predictions for the fission yields of superheavy nuclei. For a more precise evaluation of the fission contribution to the r-process, we have developed a semi-empirical fission yield model by fitting the results of our four-dimensional Langevin model with six Gaussians. Our Langevin model can reproduce both fission fragment mass distributions and the total kinetic energy very well. We performed the Langevin calculations for nuclei with Z=92-122 from neutron-deficient side to neutron-rich side. In our semi-empirical model, we provide a fission fragment mass distribution Y(Z, A) with the combination of the six Gaussians Y(A) described above, and normalized Gaussian distribution for Y(Z) on each Y(A) evaluated by the abundant experimental data of actinides[1]. This poster will mainly show the parameter study of the six Gaussians fitted by the Langevin calculations.

Poster - Board: P14

[P14] Development of counter telescopes for light charged particles emitted from muon nuclear reaction on Si

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Soft errors caused by cosmic-ray have been recognized as a possible major threat to the operation of advanced semiconductor devices on the ground level. The soft error is caused by an upset of memory information induced by the energy deposition in semiconductor devices by energetic ionizing radiation. Recently, the soft errors induced by cosmic-ray muon have received much attention because of the reduction of soft error tolerance on random access memories. Our previous work clarified that probabilities of occurrence of single event upsets (SEUs) of negative muons which stopped in the device chips are 2 to 4 times higher than positive muons one [1]. It is because of the emission of light ions after the muon capture reaction on Si nuclei. In particular, it is considered that the hydro- gen isotopes and alpha particles have effects on soft errors because they have higher linear energy transfer than the negative muon itself. However, there are no experimental data of energy spectra of the low-energy hydrogen isotopes and alpha particles emitted after the muon capture reaction on Si. Therefore, there is uncertainty in the estimation of the muon-induced soft error rate. To overcome this situation, we plan an experiment (μNC exp) to measure the energy spectra of the low energy hydrogen isotopes and alpha particles after the muon capture reaction on Si. To detect and measure the energy of these light charged particles, we are developing two types counter telescopes. The first telescope aims to detect high energy charged particles, and consists of an n-type Si (dE) detector and a CsI (E) detector for the dE-E technique. The second telescope aims to detect low energy charged particles that would stop in the dE detector. This telescope is composed of a neutron Transmutation Doped (nTD) Si detector and an n-type Si detector which is used as a veto detector. The nTD-Si detectors are suitable for particle identification (PID) using Pulse Shape Analysis (PSA) technique. To obtain enough experimental statistics, the nTD-Si detector has to be close to a Si target in the μNC exp. This will result in wider incident angle of charged particles to the nTD-Si detectors. To make sure the PID performance using PSA under this situation, we performed a preliminary experiment at Center for Accelerator and Beam Applied Science of Kyushu University. In this presentation, the detail of the preliminary experiment, results and the status of preparations for the μNC exp will be discussed.

[1] S. Manabe et al., IEEE Trans. on Nucl. Sci., vol. 65, 8, pp.1742 – 1749, 8, 2018.

Poster - Board: P15

[P15] Study on JQMD and INCL models for α particle incident neutron production

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At RIKEN, new beam line of generating ^{211}At for targeted alpha therapy is being constructed. Astatine-211 is produced via the ^{209}Bi(α, 2n)^{211}At reaction at the beam line. The energy of incident α beam is chosen to be 7.2 MeV/u to avoid producing ^{210}Po, a toxic nucleus. For the radiation shielding of the new beam line, the neutron production thick target yields were measured. The measured data was compared with the INCL and JQMD models implemented in PHITS. Through the comparison, it is found that the prediction accuracy of INCL is better than that of JQMD. Better agreement between INCL and measured data could be explained by "Local E procedure". In the INCL calculation, a target nucleus is created under the well potential of 45 MeV depth. Near the target nucleus surface, the depth of the well potential is greater than that of Woods-Saxon (WS) potential. Thus, nucleons with higher energy than the depth of the WS potential stays in the well potential. Nucleons with higher energies leads to underestimation of reaction cross section. This underestimation is corrected by the "Local E procedure" from INCL-4.5. In the "Local E procedure", energy of nucleons in the target nucleus is recalculated under an approximately phenomenological potential. In the JQMD calculation, beam and target nuclei are prepared under the Fermi gas model, in which the depth of the nuclear force potential is equal to the Fermi energy. However, the Fermi energy and the depth of the potential for the α nucleus as the incident particle is not the same. Due to the difference, the energy distribution of the nucleons of α nucleus does not satisfy the condition of the Fermi gas model. This means that the initial condition is not described

properly in the JQMD calculation. Thus, it is concluded that the improvement of the initial conditions is required to improve the prediction accuracy of JQMD.

Poster - Board: P16

[P16] Theoretical Evaluation of neutron thermal scattering laws of heavy water for JENDL-5

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Thermal neutron scattering law data were calculated for the heavy water molecule toward the fifth version of the Japanese evaluated nuclear data library, JENDL-5. The scattering laws for deuterium and oxygen atoms were computed using the molecular dynamics simulation. The simulations have been performed in the temperature range from 283.6 K to 600 K. The scattering law data have been evaluated in the neutron incident energies between 0.01 meV and 10 eV. With the obtained scattering laws, we calculated neutron angle-differential and total cross sections for the heavy water molecule. We confirmed that the experimental data at room temperature were well reproduced with our scattering laws. Also, in the computed temperature range, the total cross sections were almost consistent with the ENDF/B-VIII.0 evaluations.

Poster - Board: P17

[P17] Study of thermal scattering law of hydrogen in water with analysis of TCA critical experiments

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From a number of the critical experiments performed at the Tank-type Critical Assembly (TCA), a series of experiments proper to validation of S(α, β) was selected and analyzed by the continuous- energy Monte Carlo code MVP3 with JENDL-4.0. In the experiments, the critical water levels were measured changing the number of water holes in the center of the core. As a result, the calculated k_{eff} values systematically decreased along with the critical water levels. When the same analysis was performed with the free-gas-model scattering cross-section of hydrogen in place of S(α, β), the k_{eff} values increased with the critical water levels. From this fact, a slightly smaller S(α, β) was expected to cancel the decreasing trend of the k_{eff} values. Using the perturbation function of MVP3, the reactivity changes for the perturbation in the atomic number densities of hydrogen were calculated. They corresponded to the reactivity changes for the perturbation in the neutron-flux-weight total cross-sections ($\langle\Phi\sigma\rangle$). Decreasing $\langle\Phi\sigma\rangle$ of hydrogen by about 2% almost cancel the trend. The main part of the total reaction rate of hydrogen in water is the thermal scattering. The modification of $\langle\Phi\sigma\rangle$ would be obtained by modifying S(α, β) in 10^{-2} to 10^{-1} eV.

Poster - Board: P18

[P18] Formulation of a shell–cluster overlap integral with the Gaussian expansion method

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We formulate a computational method to evaluate the overlap integral of the shell-model and cluster- model wave functions. The framework is applied to the system of the core plus two neutrons, and the magnitude of the overlap of the shell-model configuration (core + n + n) and the di-neutron cluster one (core + 2n) is explored. We have found that the magnitude of the overlap integral is prominently enhanced when two neutrons occupy shell-model orbits with low orbital angular momenta, such as s- and p-wave orbits. The shell–cluster overlap is calculated in systems with jj-closed cores plus two neutrons, and the enhancement due to occupation of the s or p orbit also occurs in the systematic calculation. The effect of the configuration interaction on the shell–cluster overlap integrals is also discussed

Poster - Board: P19

[P19] Design of real-time absolute epi-thermal neutron flux intensity monitor with LiCaF detector

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In recent years, BNCT, a new radiation therapy for cancers, has attracted attention. A boron com- pound that can accumulate only in cancer cells is administered into tumor cells in a human body and irradiated with low-energy neutrons. Then ^{10}B and low-energy neutron cause a (n,α) reaction to kill only the cancer cells with produced charged particles. In BNCT epi-thermal neutrons are used aiming at treatment of deep-seated cancers. The number of epithermal neutrons irradiated determines the therapeutic effect. Therefore, it is crucial to know the absolute intensity of the epi-thermal neutrons. In this study, we aim to develop a novel monitor that measures the absolute intensity of the epithermal neutron flux on the human body surface in real time. As the elemental detection device, we used a scintillator called LiCaF. LiCaF has sensitivity to neutron via ^{6}Li(n,α)^{3}H reaction. Thus, the number of neutrons cannot be estimated directly from the measured value, because the sensitivity has an energy dependence. Therefore, we are developing a monitor having a flat efficiency for neutron energy by covering a neutron absorber around LiCaF. As a result of design, the detectionefficiency of the monitor was successfully made flat with various-thickness boron absorbers.

Poster - Board: P20

[P20] Measurement of ^{nat}In(g, xn) reaction cross sections withthe 63 MeV bremsstrahlung

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Abstract Precise nuclear data information is important to evaluate the production method, cross -sections and impurities in medical radioisotopes [1,2]. In this study, the ^{nat}In(g, nx) reaction cross sections were measured with the 63 MeV bremsstrahlung. The experiments were performed at the 100 MeV electron linac facility of the Pohang Accelerator Laboratory (PAL), Korea. Natural indium foils with a thickness of 0.1 mm and weight 0.08 g (isotope composition: In-113 4.3%, In-115 95.7%) were irradiated with the bremsstrahlung end-point energy of 63 MeV for 30 mins. Gold and aluminum foils with the thickness of 0.1 mm were used to evaluate the number of incident photons. The gamma rays emitted from the target after irradiation were measured using an HPGe detector connected to a PC based 4096 channel analyzer. Obtained averaged cross sections for the ^{nat}In(g, nx)In-110,111 reactions were compared with the theoretically calculated values based on TALYS 1.6 code. In this talk, we will report the experiment and analysis. This presentation was partly reported in AtomicEnergy Society Japan 2018 Spring meeting [3].
References
[1] F. Tarkanyi, et. al., Nucl. Instrum. Methods B 351 (2015) 6-15.
[2] Md. Shakilur Rahman et. al., Nucl. Instrum. Methods B 268 (2010) 13-19.
[3] A. Makinaga et. al., Atomic Energy Society Japan 2018 Spring meeting.

Poster - Board: P21

[P21] Shielding design for 3 GeV next generation synchrotron radiation facility

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A compact 3 GeV light source is currently constructed at Aoba campus of Tohoku university in Miyagi prefecture, in which both soft and hard x-rays are to be available. In this facility, an area outside of optical hatch is set to a non-restricted area. For that purpose, gas bremsstrahlung radiation that is generated by interacting electrons with residual gas in the beam pipe must be shielded. On the other hand, the design of the beam dump of 3 GeV electron at LINAC is also designed. We present shielding design for optical hatch and LINAC beam dump.

Poster - Board: P22

[P22] Design and Construction of Epi-thermal Neutron Field witha Am-Be Source for Basic Researches for BNCT

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Recently, Boron Neutron Capture Therapy (BNCT) has been attracting more and more attention as a new type of radiation therapy. BNCT is a method for cancer treatment by irradiating tumor cells with the low-energy neutrons from outside of the human body after accumulating boron in the tumor cells. This therapy can selectively kill tumor cells suppressing the damage of normal cells. In BNCT, it is important to evaluate the characteristics of the neutron field of Accelerator Based Neutron Source (ABNS). This is because the characteristics of the neutron field, such as the neutron spectrum generated by ABNS, vary depending on the acceleration energy of the beam, the types of targets and moderators. Therefore, it is necessary to establish a method to evaluate the neutron field characteristics using a neutron spectrometer for ABNS-BNCT. To solve this problem, our research group has been developing a new low-energy neutron spectrometer using a position- sensitive proportional counter [1]. It is however difficult to carry out the experimental validation of the spectrometer, and thus it is essential to prepare an epi-thermal neutron field which is to be used also for basic researches of BNCT. The purpose of this study is to design and construct an epi- thermal neutron field. We employed an AmBe neutron source and the epi-thermal neutron field was designed by using Monte Carlo N-Particle Transport code (MCNP-5). The epi-thermal neutron flux and η value (ratio of epi-thermal neutron flux to fast neutron flux) were selected as the design in- dices to realize the optimal epi-thermal neutron field. In the design, various materials of aluminum fluoride, Teflon, carbon, iron and titanium were used as moderators, and covered with reflectors of lead and graphite. As a result of the design, the epi-thermal neutron flux was 13.7 n/cm^2/sec, and the η value was 10.4. After the design the actual epi-thermal neutron field was constructed. Now, the experimental verification of the neutron field is in progress.

References

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Poster - Board: P23

[P23] Visualization of nuclear data used in PHITS and utilizationof a tool to convert EXFOR to PHITS-readable format

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Monte Carlo particle transport code PHITS uses nuclear data with A Compact ENDF (ACE) format to simulate nuclear reactions. The current PHITS has only a limited functionality to display data given in ACE, and many of users do their work without knowing nuclear reaction cross-sections. To improve this situation, I have developed a functionality to display cross-sections, including double- differential ones, of ACE loaded in PHITS. I compared cross-sections obtained by simulations with a thin-target and directly derived from ACE, and confirmed that they agree. This functionality will encourage general PHITS-users to have familiarity with nuclear data and think about validity oftheir simulations.

Current Status and Prospects of Nuclear Data Study 2 / O7

Development of FRENDY version 2

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FRENDY (From Evaluated Nuclear Data library to any application) is a nuclear data processing code for the evaluated nuclear data libraries JENDL, ENDF/B, JEFF, TENDL, and so on. The first version of FRENDY was released in 2019 as an open-source software under the 2-clause BSD license. FRENDY Version 1 generates the ACE files which is used for the continuous energy Monte Carlo codes such as PHITS, Solomon, Serpent, and MCNP. FRENDY Version 2 generates the multi-group neutron cross-section files from the ACE file. This presentation explains the characteristics of FRENDY and new capabilities implemented in FRENDY version 2.

Current Status and Prospects of Nuclear Data Study 2 / O8

Utilization and Promotion of Covariance Data of Nuclear Data

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A lot of works on uncertainty quantification of various parameters of nuclear systems have been actively carried out in recent years, and importance of covariance data of nuclear data have been recognized in the nuclear engineering community. In order to promote covariance data application to actual problems such as design studies and safety assessments of nuclear systems, the Covariance Data Use Promotion Working Group was established under the JENDL committee in FY2018. Information exchanges, discussions and setting of required future works had been done among domestic experts on the nuclear data measurement/evaluation/application fields through the activities of this working group, and a final report has been published this year as an official JAEA report. Several issues about covariance data of nuclear data, which were discussed in the meeting of this working group, are presented in this talk. In addition, review of the previous works about sensitivity analyses,uncertainty quantification, and data assimilation is presented.

Nuclear Data Section Award in 2021 / A1

Energy and angular distribution of photoneutron for 16.6 MeV polarized photon on medium-heavy targets

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Photoneutrons produced from (γ,xn) reactions in high energy accelerators are essential in radiation shielding. In this report, we study the double differential cross sections (DDXs) of (γ,xn) on medium- heavy-mass targets (Pb, Au, Sn, Cu, Fe, and Ti) using a 16.6 MeV monoenergetic linearly polarized photon beam. The photon beam was produced using laser Compton scattering (LCS) technology with high intensity at the BL01, NewSUBARU, Hyogo, Japan. Photoneutrons on each target are detected by six neutron detectors filled with liquid scintillator NE213, positioned at different angles. The pulse shape discrimination and time-of-flight techniques were used to select and measure the energy of neutrons. For every target, we can identify the low energy and high energy components on the DDXs. For the low energy component, we observe a flat angular distribution, while a cos(2Θ) angular distribution was observed for the high energy component. The parameters from fitting the angular distribution of experimental data were compared with those from previous studies.

Nuclear Data Section Award in 2021 / A2

Study of thick target neutron yields from deuteron- and triton-induced reactions at 6.7 MeV/u

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Deuteron-induced reaction is a candidate of accelerator-based neutron source for various applications such as radiation damage evaluation for fusion materials, medical radioisotope productions, etc. For the design of such neutron sources, the data of double-differential thick target neutron yields (DDTTNYs) from (d,xn) reactions have been systematically measured at Kyushu University. On the other hand, Drosg et al. recently addressed the production of neutrons using (t,xn) reactions, and measured the DDTTNYs with 6.7 MeV/u tritons[1]. Since a triton has one more neutron than a deuteron, tritons are expected to generate more neutrons than deuterons. However, no comparison of DDTTNYs from (d,xn) and (t,xn) reactions has been reported ever because their DDTTNY data is only available due to difficulty of triton handling. In this work [2], we have measured DDT- TNYs with 6.7 MeV/u deuterons for LiF, C, Si, Ni, Mo, and Ta targets, compared the measured data with the previous triton data at the same incident energy per nucleon, and performed a theoretical analysis of the (d,xn) and (t,xn) reactions. The experiment was conducted with 8-MV Tandem accelerator at the Center for Accelerator and Beam Applied Science at Kyushu University. The 6.7 MeV/u deuteron beam was irradiated on the targets, all of which had enough thicknesses to stop the incident deuterons completely. The emitted neutrons were detected using an EJ-301 liquid organic scintillator (5.08 cm in diam, × 5.08 cm in length). The neutron spectra were derived with the unfolding method using FORIST code. The detail of the experimental procedure was described in Ref. [2] In the presentation, the results of the (d,xn) spectra will be compared with the (t,xn) spectra, and further discussion on the reaction mechanisms of deuteron- and triton-induced incidences will be given.

[1] M. Drosg et al., Nucl. Sci. Eng. 182 (2016) pp. 256

[2] H. Takeshita et al., Nucl. Instrum. Meth. A, 983, 164582, (2020)

Nuclear Data Section Award in 2021 / A3

Neutron beam filter system for fast neutron cross-section measurement at the ANNRI beamline of MLF/J-PARC

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In the Accurate Neutron-Nucleus Reaction Measurement Instrument (ANNRI) beamline of the Materials and Life Science (MLF) experimental facility at the Japan Proton Accelerator Research Complex (J-PARC) continuous efforts have been ongoing in order to measure the neutron-induced cross sections of long-lived minor actinides (MAs) and fission products (FP) by means of the time-of-flight (TOF) methodology. The J-PARC accelerator is currently operated in double bunch mode in which two 0.1 μs wide proton bunches impinge into a Hg spallation target with a time difference of 0.6 μs in order to increase the thermal pulsed neutron fluence. In the present state, cross section measurements in the keV regions are unattainable as this time difference introduces serious ambiguities when measuring neutron-induced reactions. The reason for this is that the 0.6 μs time difference is not negligible since it is comparable to the TOF of keV-neutrons e.g., 100 and 120 keV neutrons have a TOF of 5.8 and 6.4 μs, respectively. In order to circumvent the current double-bunch predicament in the keV region, a neutron filtering system involving the use of filter material with the intrinsic characteristic of a sharp minima in the neutron total cross section was implemented at the ANNRI beamline. Quasi-monochromatic neutron beam can be created using such materials with the appropriate thickness as only the neutrons with the energy of the sharp minima can be transmitted through. ^{nat}Fe, ^{nat}Si, ^{nat}Cr have been selected as suitable candidates to tailor quasi-monoenergetic neutron peaks with averaged energies of 23.5 keV (Fe); 54 and 144 keV (Si); and 46 and 136 keV (Cr). In this presentation, the main features of the neutron filtering system together with performance evaluations will be presented. A complete analysis for the Si and Fe neutron filters has already been published [1]. The time distribution of the incident filtered neutron flux at ANNRI was measured in both capture experiments with a NaI(Tl) spectrometer and transmission experiments involving the use of Li-glass detectors. In addition, the neutron energy distribution within the filtered peaks was determined from Monte-Carlo simulations with the PHITS code[2]. Finally, the first cross section results using the neutron filtering system will be shown and discussed in order to assess the performance in neutron capture cross section measurements.

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Nuclear and Particle Physics / O9

Study of radii of proton and nuclei by electron scattering

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The size (radius) and shape (density distribution) are fundamental ground-state properties of atomic nuclei, which are essential inputs for any structure model. I will discuss the following three topics that we are currently studying by electron scattering. 1) proton charge radius, 2) charge radius (and density distribution) of exotic nuclei, 3) neutron-distribution radius of nuclei.

Nuclear and Particle Physics / O10

A nuclear periodic table: from elementouch to nucletouch

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The magic numbers due to closures of the nucleonic shells, that correspond to noble gases in elements, have played a crucial role in nuclear physics. In this talk, we shall discuss our recent invention of a periodic table for atomic nuclei, called "Nucletuch". This is in a sense an extention of the 3D periodic table "Elementouch" invented by Y. Maeno in 2001. While the Elementouch recovers features of Mendeleev's periodic law, the "Nucletouch" provides a nice visualization of nuclear de- formation. By comparing the two 3D periodic tables, we show that there is an accidental coincidence between them concerning the alignments of elements.

Tutorial 2 2 / T2

Role of ADS and its development issues

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By listening this tutorial, the audience will understand a role of accelerator-driven system (ADS) in the nuclear fuel cycle and necessity of nuclear data to realize the ADS. After an overview of Japanese nuclear fuel cycle and government direction, geological disposal concept of high-level waste (HLW) will be described. By partitioning problematic elements from the HLW and transmuting, utilizing or storing them, geological disposal can be changed. ADS plays a role of transmuting minor actinide (MA) separated from HLW to fission products, which are less radio-toxic than MA. The principle of ADS will be introduced with technological issues, and finally utilization of nuclear data for R&D on ADS will be introduced.

Medical, Radioisotope Production, Analysis / O11

Production of At-211 using a cyclotron and an import plan of Ac-225

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Targeted alpha-particle therapy (TAT), using short-lived alpha emitters such as At-211, Ac-225 and Ra-223, is one of remarkable cancer treatment methods especially for refractory cancer. At-211 with a half-life of 7.2 hours is produced by the nuclear reaction of ^{209}Bi(^{4}He,2n)^{211}At. The energy of a $^{4}He^{2+}$ ion beam should be tuned to 29 MeV or less to avoid production of At-210 which decays to a toxic element of Po-210. Several hundreds MBq of At-211 can be obtained by irradiation of a few particle-micro-A 29 MeV $^{4}He^{2+}$ ion beam. Small amounts of At-210 are now available only for academic studies, provided from "Supply Platform for Short-lived RI" called RI-PF. Ac-225 with a half-life of 10 days is also one of the most powerful alpha emitters for TAT, commonly obtained from the parent nucleus Ra-225 by a milking method. In recent years, an accelerator-based Ac-225 production technique using an around 500 MeV proton beam has been developed at TRIUMF in Canada. A Th-232 target placed at the beam dump was used for production of RIs such as Ac-225 and Ra-225 by the spallation reaction of ^{232}Th(p,x). We have a plan to import the generator Th-229 or Ra-225 for milking Ac-225 in near future. In this paper, the details of At-211 production and Ac-225 import will be presented.

Medical, Radioisotope Production, Analysis / O12

Production of an alpha-emitting radionuclide At-211 for medical use at JAEA tandem accelerator

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In general, the ^{211}At nuclide, a prospective candidate for targeted alpha radiotherapy, has been produced through the ^{208}Bi(^{4}He,2n)^{211}At reaction. In contrast, our project is focused on the production in the ^{208}Bi(^{7}Li,2n)^{211}At reaction using the JAEA tandem accelerator [1,2]. This enables us to supply ^{211}At in a ^{211}Rn/^{211}At generator system. The daughter ^{211}At of 7.2 h in half-life is generated through EC decay of the parent ^{211}Rn of 14.7 h, expanding time-frame for transportation and use of ^{211}At. In this project, chemical procedures based on dry- and wet-chemistry have been studied to develop the ^{211}Rn/^{211}At generator system. In addition, research subjects relating to the development of the ^{211}Rn/^{211}At generator system, namely, production of astatine and iodine radioisotopes [3, 4], astatine chemistry [5, 6, 7] as well as the analytical method of ^{211}At using an alpha-scintillation camera and thin-layer chromatography [8] have been studied using the JAEA tandem accelerator. In the presentation, some experimental results in the project, e.g., production of astatine and iodine radioisotopes [2, 3, 4], the chemical procedure based on dry-chemistry for the ^{211}Rn/^{211}At generator system, and astatine chemistry [5, 6], will be presented.

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Medical, Radioisotope Production, Analysis / O13

Development of the injector for heavy-ion therapy using laser-driven ion acceleration

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Laser driven ion acceleration is one of the novel mechanism for compact ion acceleration. However, this mechanism have problems which are multi ions species and broad energy in the acceleration beam. Beam for medical application, especially, must be constructed with a monochromatic energy and one nuclide by safety controlling the quality of laser-driven accelerated beams. We report how to approach these problems at QST laser system.

Medical, Radioisotope Production, Analysis / O14

Challenging studies by accelerator mass spectrometry for the development of environmental radiology

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Accelerator mass spectrometry (AMS) is an analytical method that combines mass spectrometry with a tandem accelerator, which has been used mainly in nuclear physics experiments. AMS is used to measure radionuclides with half-lives of 10^3-10^8 years. For radionuclides with half-lives of this order, the method of measuring their mass is 10^3-10^6 times more sensitive than measuring their activity [1]. Because of this advantage, AMS has been widely applied in Earth and planetary sciences, atomic energy research, and other fields. Among the various studies, Wallner et al. (2021, 2016) have achieved excellent work in Earth and planetary sciences [2, 3]. For example, they have attained the ultra-sensitive analysis of ^{60}Fe and ^{244}Pu in environmental samples. These are radionuclides produced by rapid-neutron-capture (r-process) nucleosynthesis. Our recent work shows that a new AMS system (VERA, University of Vienna), which combines laser isobaric separation and a typical AMS system, has been successfully applied to the ultra-sensitive determination of ^{90}Sr and ^{125}Cs in environment. For ^{90}Sr in environmental samples, the β-ray measurement by the milking of the daughter nuclide ^{90}Y is still the principal method, which takes 3-6 weeks. The new AMS method has a detection limit of < 0.1 mBq, which is comparable to that of β-ray measurement, with a more straightforward chemical treatment than β-measurement [4]. Our achievement demonstrates that AMS can be a practical new method for determining ^{90}Sr in the environment. This presentation will report the technical development on ultra-sensitive analysis, focusing on ^{90}Sr and ^{135}Cs AMS.

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