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Activity Report of Radiation Science Center in Fiscal 2017

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Radiation Science Center
Applied Research Laboratory
High Energy Accelerator Research Organization

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放射線科学センター
2017 年度　活動報告

高エネルギー加速器研究機構

共通基盤研究施設　放射線科学センター

PREFACE

The Radiation Science Center is concerned with the management of both radiation and chemical safety in KEK. In addition to the tight routine work, R&D work in this field is conducted. The first part is the R&D activities reported in English and the second part is the studies related to the routine work written in Japanese. The third part is the data related to our activities including awards, name of outside committees we are engaged in, workshops and symposia, publications, and funds we got.

In FY 2017, effort for earthquake disaster reconstruction was continued in the field of measurement and estimation of radioactivity which was released in Fukushima Daiichi Nuclear Power Plant Accident. This includes radioactivity measurement for samples from Fukushima prefecture, setting up of radiation monitor, estimation of radioactivity in air just after the accident, and talks on basic knowledge regarding radiation in schools.

Yoshihito Namito

Head, Radiation Science Center

High Energy Accelerator Research Organization

Contents

Chapter 1 Research Activity

The feature of the research activities in the Radiation Science Center (RSC), KEK is a wide coverage of the research fields. Radiation physics, radiation measurements, radiochemistry, radiation chemistry, health physics, radiation shielding, nuclear engineering, analytical chemistry and environmental science are included in the research fields of the RSC's staff members. The status of these research activities carried out in fiscal year 2017 is described.

1. Reasearch in Radiation Physics and Detector Development

1.1 Systematic measurement of double-differential neutron production cross sections for deuteron-induced reactions at an incident energy of 102 MeV

S. Araki[1], Y. Watanabe[1], M. Kitajima[1], H. Sadamatsu[1], K. Nakano[1], T. Kin[1], Y. Iwamoto[2], D. Satoh[2], M. Hagiwara[3], H. Yashima[4], T. Shima[5]
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Double-differential neutron production cross sections (DDXs) for deuteron-induced reactions on Li, Be, C, Al, Cu, and Nb at 102 MeV were measured at forward angles ≤25° by means of a time of flight (TOF) method with NE213 liquid organic scintillators at the Research Center of Nuclear Physics (RCNP), Osaka University. The experimental DDXs and energy-integrated cross sections were compared with TENDL-2015 data and Particle and Heavy Ion Transport code System (PHITS) calculation using a combination of the KUROTAMA model, the Liege Intra-Nuclear Cascade model, and the generalized evaporation model. The PHITS calculation showed better agreement with the experimental results than TENDL-2015 for all target nuclei, although the shape of the broad peak around 50 MeV was not satisfactorily reproduced by the PHITS calculation.

Published at Nucl. Insrum. Meth. Phy. Res., A 842 62-70 (2017)

1.2 Applicability of the two-angle differential method to response measurement of neutron-sensitive devices at the RCNP high-energy neutron facility

A. Masuda[1], T. Matsumoto[1], Y. Iwamoto[2], M. Hagiwara[3], D. Satoh[2], T. Sato[2], H. Iwase[3], H. Yashima[4], Y. Nakane[2], J. Nishiyama[1],T.Shima[5], A. Tamii[5], K. Hatanaka[5], H. Harano[1], T. Nakamura[6]
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Quasi-monoenergetic high-energy neutron fields induced by 7Li(p,n) reactions are used for the response evaluation of neutron-sensitive devices. The quasi-monoenergetic high-energy field consists of high-energy monoenergetic peak neutrons and unwanted continuum neutrons down to the low-energy region. A two-angle differential method has been developed to compensate for the effect of the continuum neutrons in the response measurements. In this study, the two-angle differential method was demonstrated for Bonner sphere detectors, which are typical examples of moderator-based neutron-sensitive detectors, to investigate the method's applicability and its dependence on detector characteristics. Experiments were performed under 96–387 MeV quasi-monoenergetic high-energy neutron fields at the Research Center for Nuclear Physics (RCNP), Osaka University. The measurement results for large high-density polyethylene (HDPE) sphere detectors agreed well with Monte Carlo calculations, which verified the adequacy of the two-angle differential method. By contrast, discrepancies were observed in the results for small HDPE sphere detectors and metal-induced sphere detectors. The former indicated that detectors that are particularly sensitive to low-energy neutrons may be affected by penetrating neutrons owing to the geometrical features of the RCNP facility. The latter discrepancy could be consistently explained by a problem in the evaluated cross-section data for the metals used in the calculation. Through those discussions, the adequacy of the two-angle differential method was experimentally verified, and practical suggestions were made pertaining to this method.

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1.3 Development of the high-energy neutron fluence rate standard field in Japan with a peak energy of 45 MeV using the $^{7}Li(p,n)^{7}Be$ reaction at TIARA

T. Matsumoto[1], A. Masuda[1], H. Harano[1], Y. Shikaze[2], Y. Tanimura[2], H. Seito[2], S. Kurashima[2], S. Nishino[2], H. Yoshitomi[2], J. Nishiyama[1], M. Hagiwara[3], Y. Unno[1], M. Yoshizawa[2]
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In this study, we developed a 45 MeV neutron fluence rate standard of Japan. Quasi-monoenergetic neutrons with a peak energy of 45 MeV in the neutron standard field were produced by the 7Li(p,n)7Be reaction using a 50-MeV proton beam from an azimuthally varying field (AVF) cyclotron of the Takasaki Ion Accelerators for Advanced Radiation Application (TIARA). The neutron energy spectrum was measured using an organic liquid scintillation detector and a 6Li-glass scintillation detector by the time-of-flight method, and using a Bonner sphere spectrometer by the unfolding method. The absolute neutron fluence was determined using a proton recoil telescope (PRT) composed of the liquid scintillation detector and a Si(Li) detector that was newly developed in the present study. The detection efficiency of the PRT was obtained using the MCNPX code. The peak neutron production cross section for the 7Li(p,n)7Be reaction was also derived from the neutron fluence in order to confirm the neutron fluence of the TIARA high-energy neutron field. The peak neutron production cross section obtained in the present study was in good agreement with those of previous studies. The characteristics of the 45-MeV neutron field in TIARA were successfully evaluated in order to calibrate high-energy neutron detectors and high-energy neutron dosimeters.

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1.4 Uncertainty evaluation of fluorescent nuclear track detectors (FNTDs) for neutron dose measurements

T. Hashizume[1,4], T. Okazaki[1], T. Sanami[2,4], M. Hagiwara[2,4], H. Monjushiro[2,4], H.Hayashi[3], I. Kobayashi[1]

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Fluorescent nuclear track detectors (FNTDs) developed by Landauer Inc. are used as passive dosimeters for neutron dose measurements. Commercial FNTD readers are operated in a track counting mode for low dose neutrons (up to 50 mSv). In order to evaluate the ability of the reader to detect recoil proton tracks, the relationship between track densities of FNTDs and etch pit densities of CR-39 plastic nuclear track detectors (PNTDs) for 241Am-Be neutrons was compared. The relationship was linear in the range of the measured doses from 0.63 mSv to 13.30 mSv. The correlation indicates that both neutron dosimeters similarly detect the recoil proton tracks. The low limit of detection (LLD) using the reader was 1.44 tracks/mm2. In this measurement, the uncertainty of track counting was also evaluated. The relationship between track counts and coefficients of variation (CVs) agreed well with the Poisson distribution. According to the theoretical estimation and the LLD, more than 11.11 counts per 2.08 mm2 are needed to obtain CVs below 30%. In addition, decreasing the CV value was demonstrated by expanding the scan area. Therefore, there is a possibility to improve the measurement accuracy for the LLD with a wider scan area.

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1.5 Shielding experiments of concrete and iron for the 244 MeV and 387 MeV quasi-mono energetic neutrons using a Bonner sphere spectrometer (at RCNP, Osaka Univ.)

T. Matsumoto[1], A. Masuda[1], J. Nishiyama[1], H. Iwase[2], Y. Iwamoto[3], D. Satoh[3], M. Hagiwara[2], H. Yashima[4], T.Shima[5], T. Nakamura[6] H. Harano[1], A. Tamii[5], K. Hatanaka[5]

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Neutron energy spectra behind concrete and iron shields were measured for quasi-monoenergetic neutrons above 200 MeV using a Bonner sphere spectrometer (BSS). Quasi-monoenergetic neutrons were produced by the 7Li(p,xn) reaction with 246-MeV and 389-MeV protons. Shielding materials are concrete blocks with thicknesses from 25 cm to 300 cm and iron blocks with thicknesses from 10 cm to 100 cm. The response function of BSS was also measured at neutron energies from 100

MeV to 387 MeV. In data analysis, the measured response function was used and the pingpong scattering effect between the BSS and the shielding material was considered. The neutron energy spectra behind the concrete and iron shields were obtained by the unfolding method using the MAXED code. Ambient dose equivalents were obtained as a function of a shield thickness successfully.

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1.6 Characterization of the PTW 34031 ionization chamber (PMI) at RCNP with high energy neutrons ranging from 100 – 392 MeV

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Radiation monitoring at high energy proton accelerators poses a considerable challenge due to the complexity of the encountered stray radiation fields. These environments comprise a wide variety of different particle types and span from fractions of electron-volts up to several terra electron-volts. As a consequence the use of Monte Carlo simulation programs like FLUKA is indispensable to obtain appropriate field-specific calibration factors. At many locations of the LHC a large contribution to the particle fluence is expected to originate from high-energy neutrons and thus, benchmark experiments with mono-energetic neutron beams are of high importance to verify the aforementioned detector response calculations. This paper summarizes the results of a series of benchmark experiments with quasi mono-energetic neutrons of 100, 140, 200, 250 and 392 MeV that have been carried out at RCNP - Osaka University, during several campaigns between 2006 and 2014.

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1.7 Experimental analysis of neutron and background gamma-ray energy spectra of 80-400 MeV ^{7}Li(p,n) reactions under the quasi-monoenergetic neutron field at RCNP, Osaka University

Y. Iwamoto[1], T. Sato[1], D. Satoh[1], M. Hagiwara[2], H. Yashima[3], A. Masuda[4], T. Matsumoto[4], H. Iwase[2], T. Shima[5], T. Nakamura[6]
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To develop the 100 to 400 MeV quasi-monoenergetic neutron field, we measured neutron and gamma-ray energy spectra of the 7Li(p,n) reaction with 80-389 MeV protons in the 100-m time-of-flight (TOF) tunnel at the Research Center for Nuclear Physics (RCNP) cyclotron facility. Neutron energy spectra with energies above 3 MeV were measured by the TOF method, which had been reported in our previous papers, and photon energy spectra with energies above 1 MeV were measured by the automatic unfolding function of the radiation dose monitor DARWIN. For neutron spectra, the contribution of peak intensity to the total intensity integrated with energies above 3 MeV varied between 0.38 and 0.48 in the proton energy range of 80–389 MeV. For gamma-ray spectra, high-energetic gamma-rays at around 70 MeV originated from the decay of π^0 were observed with proton energies higher than 200 MeV. For the 246-MeV proton incident reaction, the ratio of gamma-ray flux above 20 MeV to total gamma-ray flux is 0.31 and the gamma-ray flux is almost same with neutron flux at energies around 70 MeV. The experimental data will be useful to consider the contribution of high-energetic gamma-rays on the neutron response of the radiation monitor.

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1.8 Neutron spectrometry and dosimetry in 100 and 300 MeV quasi-monoenergetic neutron field at RCNP, Osaka University, Japan

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This paper describes the results of neutron spectrometry and dosimetry measurements using an extended range Bonner Sphere Spectrometer (ERBSS) with 3He proportional counter performed in quasi-mono-energetic neutron fields at the ring cyclotron facility of the Research Center for Nuclear Physics (RCNP), Osaka University, Japan. Using 100 MeV and 296 MeV proton beams, neutron fields with nominal peak energies of 96 MeV and 293 MeV were generated via 7Li(p,n)7Be reactions. Neutrons produced at 0° and 25° emission angles were extracted into the 100 m long time-of-flight (TOF) tunnel, and the energy spectra were measured at a distance of 35 m from the target. To deduce the corresponding neutron spectra from thermal to the nominal maximum energy, the ERBSS data were unfolded using the MSANDB unfolding code. At high energies, the neutron spectra were also measured by means of the TOF method using NE213 organic liquid scintillators. The results are discussed in terms of ambient dose equivalent, H*(10), and compared with the readings of other instruments operated during the experiment.

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1.9 Shielding experiments of concrete and iron for the 244 MeV and 387 MeV quasi-mono energetic neutrons using an organic scintillator (at RCNP, Osaka Univ.)

M. Hagiwara[1], H. Iwase[1], Y. Iwamoto[2], D. Satoh[2], T. Matsumoto[3], A. Masuda[3], H. Yashima[4], Y. Nakane[3], H. Nakashima[3], Y. Sakamoto[3], T. Shima[5], A. Tamii[5], K. Hatanaka[5], T. Nakamura[6]

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A shielding benchmark experiment has been performed using a quasi-monoenergetic 7Li(p,n) neutron source with the peak energies of 244 and 387 MeV at the Research Center for Nuclear Physics (RCNP) of Osaka University, in order to assess the accuracy of nuclear data and calculation codes used in high-energy accelerator shielging design. Energy spectra behind bulk shields of 10- to 100-cm-thick iron, 25- to 300-cm-thick concrete and their composite are measured using a NE213 organic liquid scintillator with a diameter and thickness of 25.4 cm each with a time-of-flight and an unfolding method. The neutron attenuation lengths are illustared for iron and concrete as a function of the incident energy.

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1.10 Dose measurements through the concrete and iron shields under the 100 to 400 MeV quasi-monoenergetic neutron field (at RCNP, Osaka Univ.)

Y. Nakane[1], Y. Iwamoto[1], M. Hagiwara[2], H. Iwase[2], T. Sato[1], A. Masuda[3], T. Matsumoto[3], T. Nunomiya[4], H. Yashima[5], D. Satoh[1], H. Nakashima[1], T. Shima[6], A. Tamii[6], K. Hatanaka[6], T. Nakamura[7]

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Shielding benchmark experiments are useful to verify the accuracy of calculation methods for the radiation shielding designs of high-energy accelerator facilities. In the present work, the benchmark experiments were carried out for 244- and 387-MeV quasi-monoenergetic neutron field at RCNP of

Osaka University. Neutron dose rates through the test shields, 100-300 cm thick concrete and 40-100 cm thick iron, were measured by four kinds of neutron dose equivalent monitors, three kinds of wide-energy range monitors applied to high-energy neutron fields above 20 MeV and a conventional type rem monitor for neutrons up to 20 MeV, placed behind the test shields. Measured dose rates were compared one another. Measured results with the wide-energy range monitors were in agreement one another for both the concrete and the iron shields. For the conventional type rem monitor, measured results are smaller than those with the wide-energy range monitors for the concrete shields, while that are in agreements for the iron shields. The attenuation lengths were obtained from the measurements. The lengths from all the monitors are in agreement on the whole, though some differences are shown. These results are almost same as those from others measured at several hundred MeV neutron fields.

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1.11 Double differential cross section for light mass fragment production on tens of MeV proton, deuteron, helium and carbon induced reactions

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Double differential cross sections (DDXs) for light mass fragment production should be modeled properly to evaluate amount of energy deposition in a finite volume due to single ion incidence. Systematic experimental data are desired to evaluate nuclear reaction models not only for various energy but also incident particles. The DDXs were measured for tens of MeV proton, deuteron helium and carbon induced reactions. The experiments were performed using Cyclotron facility of National Institute of Radiological Sciences, Japan. Protons with energies of 24, 50 and 70 MeV, deuteron with 24 and 50 MeV, helium with 50, 70 and 100 MeV, and carbon with energies 50, 72 and 144 MeV were prepared as incident particles. The data for the energies allow us the comparison of DDXs with same energy, 50 MeV, with different particles (p, d, He and C) and 70 MeV (p,He,C), and, the comparison of DDXs with same energy per nucleon, 12 MeV/n with different particles (d, He, C), 24 MeV/n (p, d, He). Targets were C, Al, Ti and Cu self-supported foils with thicknesses less than 1 μm. The targets were set on a target changer ladder at the center of a scattering chamber. Bragg curve counters placed at 30, 60 and 90 degrees of the scattering chamber are employed to measure light mass fragments. DDXs for Li, Be, B, C, N, O, F and Ne production were obtained for the targets. Evaporation like energy spectra are observed except for the fragment the mass of which is close to the incident ion. The results are summarized to study incident particle type dependency on DDX for each target nuclei.

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1.12 Neutron production in deuteron-induced reactions on Li, Be, and C at an incident energy of 100 MeV

S. Araki[1], Y. Watanabe[1], M. Kitajima[1], H. Sadamatsu[1], K. Nakano[1], T. Kin[1], Y. Iwamoto[2], D. Satoh[2], M. Hagiwara[3], H. Yashima[4], T. Shima[5]

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In recent years, deuteron-induced reaction is considered as one of the effective reactions to produce high intensity neutron beam for neutron application fields such as radiation damage evaluation for fusion materials, boron neutron capture therapy and medical radioisotope production. Neutron production data from neutron converter materials such as Li, Be and C are essentially important. However, the experimental data are not sufficient, especially at incident energies above 60 MeV, therefore the theoretical models are not validated. Under this situation, we measured the double differential (d, xn) cross sections (DDXs) for Li, Be and C at 100 MeV and analyzed them with theoretical models. The experiment was performed using the Time of Fight course at the Research Center for Nuclear Physics in Osaka University. A deuteron beam accelerated to 102 MeV was transported to the neutron experimental hall and focused on the thin lithium, beryllium and carbon targets in natural compositions. The targets were placed on a beam swinger magnet. The DDXs were measured at six angles (0, 5, 10, 15, 20 and 25 degrees) by changing the target position in the swinger magnet. NE213 liquid organic scintillators were adopted as neutron detectors. The detected neutrons were recorded event by event as a function of their time of flight. In the measured DDXs, a broad peak due to deuteron breakup process is observed at approximately half of the deuteron incident energy. The experimental results are compared with the calculations by PHITS. The calculated DDXs have the broad peak structure, but the shape and magnitude do not necessarily reproduce the experimental ones. Detailed analysis with an alternative theoretical model calculation is also presented. In the calculation, elastic breakup and continuum stripping reactions are described by the Continuum Discretized Coupled Channels (CDCC) theory and the Glauber model, respectively. In addition, the DWBA is employed for the stripping reaction to bound state. The Hauser-Feshbach theory and exciton model are adopted for statistical decay process.

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1.13 Systematic measurements of double-differential (d,xn) cross sections at an incident energy of 200 MeV

H. Sadamatsu[1], S. Araki[1], Y. Watanabe[1], K. Nakano[1], S. Kawase[1], T. Kin[1], Y. Iwamoto[2], D. Satoh[2], M. Hagiwara[3], H. Yashima[4], T. Shima[5]
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Double-differential neutron production cross sections (DDXs) for deuteron-induced reactions on Li, Be, C, Al, Cu, Nb, In, Ta, and Au at 200 MeV were measured at forward angles ≤ 25° by means of a time of flight (TOF) method with EJ301 liquid organic scintillators at the Research Center of Nuclear Physics (RCNP), Osaka University. The measured DDXs at 0° were compared with theoretical model calculations by the DEURACS and PHITS codes. The DEURACS calculation showed better agreement with the measured DDXs than the PHITS calculation.
This work was funded by ImPACT Program of Council for Science, Technology and Innovation (Cabinet Office, Government of Japan).

Presented at 2017 Symposium on nuclear data, Tsukuba, Japan

1.14 Measurement of scintillation and ionization in helium mixed with xenon

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He-3 proportional counter is widely used as a neutron detector. However, the time resolution is in the order of several microseconds because it measures signal caused by collecting charges produced by ionization. On the other hand, scintillation generally has a good time resolution because of a fast rise and decay time. Scintillation photons in He lie in 70 nm with long decay time (about 10 μs). Therefore, it is difficult to use helium as a scintillator. To solve these problems, we have investigated the exchange of luminescence from He to Xe by adding a small amount of Xe to He. The reason for selecting Xe is that the decay time of an excited Xe dimer is the fastest (about 99 nsec) among all noble gases. Moreover, the peak wavelength in luminescence from the excited dimer of Xe is located at 173 nm, which shows that it is easier to detect the luminescence of the excited dimer of Xe than that of He. The purpose of this study is to understand scintillation and ionization property in He mixed with Xe.
We measured the scintillation time profiles, scintillation yield, and ionization yields in He/Xe mixture to understand the scintillation properties in anticipation of the development of neutron

detector using a ^{3}He/Xe mixture. The observed rise and decay time of scintillation in He/Xe mixture depends on partial pressure of He and Xe. The scintillation yields are saturated when the concentration of Xe exceeds 10%. The measurements of ionization yields show to correspond with the theoretical values.

Presented at ISRD2018, Tsukuba, Japan

1.15 Experiment on board the international space station using position sensitive tissue-equivalent proportional chamber "PS-TEPC"

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Radiation effects on human body are commonly evaluated using a dose equivalent H, defined as a product of an absorbed dose D and a quality factor Q given as a function of the Linear Energy Transfer (LET). In space, there exist many kinds of cosmic radiations, where primary charged particles and neutrons generated secondarily are the main components contributing to the radiation dose. Since the LET values of these radiations spreads over a wide range, it is essential to measure it directly in order to evaluate H. We have been developing a space dosimeter named as "PS-TEPC (Position Sensitive Tissue Equivalent Proportional Chamber)" .
PS-TEPC consists of a miniaturized μ-PIC with a detection volume of 2.6×2.6×5.0cm3 and tissue-equivalent materials. PS-TEPC works as a 3D time projection chamber. It allows to measure not only the energy deposit but also to record the trajectories of the incident charged particles. Thus, an event-by-event LET can be directly measured.
On December 9, 2016, a flight model of PS-TEPC was launched by a H-II transfer vehicle from Tanegashima Space Center in Japan. It was installed on a wall in the Japanese experiment module aboard the ISS on December 14, 2016. After starting up the flight system, configuring parameters and performing initial tests, we started an experimental operation from December 28, 2016. From the house-keeping data, it is recognized that the PS-TEPC has been operated well without fatal trouble. From analyses of the detector data, we already have confirmed that the PS-TEPC has been operated with typical gas gain without fatal discharge and three-dimensional trajectories of incident particles have been successfully reconstructed. Including these results, we will report the initial results of the experiment on board the ISS.

Presented at ISRD2018, Tsukuba, Japan

1.16 Measurement for accurate extrapolation in $4\pi\ \beta$-γ coincidence counting method using plastic scintillator

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For accurate measurement of absolute value in radioactivity, apparatus to conduct the $4\pi\ \beta$-γ coincidence counting method is usually composed of beta ray and gamma ray detector. Uncertainty related with the extrapolation technique in beta ray counting efficiency to determine the absolute value is often a dominant source of uncertainty. Higher beta ray counting efficiency make the extrapolation uncertainty smaller as shown in our previous study. We aimed to develop new apparatus for the $4\pi\ \beta$-γ coincidence counting with high beta ray counting efficiency.

A plastic scintillation detector was chosen for the beta ray counting because the high counting efficiency was realized in a way that samples were placed in the sealed plastic scintillator as well as Kawada (2004). Furthermore, pulse height distribution corresponding to emitted beta ray energy spectrum could be obtained. In our previous setup, the plastic scintillator (ELJEN, EJ-212) was optically connected with two facing large photomultiplier (Hamamatsu, H3177-50) via a light guide. In the present study, another thimble-sized photomultiplier (Hamamatsu, R9880U-210) was selected as a result of competition in the beta ray counting efficiency that was 93 % to radioactivity of Cs-134 (previously, 74 %). Combination with a gamma ray detector was considered in the point of size of photomultiplier. The high efficiency was achieved by direct optical contact to two facing photomultipliers in addition to inherent high sensitivity of the photomultiplier. It means that large solid angle and short flight length of scintillation light strengthened signals to be detected. The facing setup of two photomultipliers were useful to reject self-noise of the photomultiplier and clarify threshold level in pulse height distribution.

To use this beta ray detector in the $4\pi\ \beta$-γ coincidence counting method with sufficient counting statistics, a through-hole type NaI(Tl) scintillation detector was used. The through-hole have a 20 mm diameter at the center of side of ϕ 3” x 3” size cylindrical NaI(Tl) crystal. The beta ray detector was inserted in the through-hole completely. The hole made pulse height resolution obtained by the NaI(Tl) scintillation detector worse actually (17% in FWHM at 662keV), but that had no concern for the accuracy. The extrapolation uncertainty for absolute measurement of Cs-134 radioactivity was evaluated at 0.3 % (k=1) at most. The result was comparable to ones in Kawada (2004). In discussion about lower level limit to detect low energy beta ray, the result was reasonably explained by calculation from the number of produced scintillation photons to electrical pulse heights.

Presented at International Conference on Radionuclide Metrology and its Applications, Buenos Aires, Argentina

1.17 Measurements and FLUKA Simulations of Bismuth and Aluminum Activation at the CERN Shielding Benchmark Facility (CSBF)

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The CERN High Energy AcceleRator Mixed field facility (CHARM) is located in the CERN PS East Experimental Area. The facility receives a pulsed proton beam from the CERN PS with a beam momentum of 24 GeV/c with 5×10^{11} protons per pulse with a pulse length of 350 ms and with a maximum average beam intensity of 6.6×10^{10} p/s. The shielding of the CHARM facility also includes the CERN Shielding Benchmark Facility (CSBF) situated laterally above the target. This facility consists of 80 cm of cast iron and 360 cm of concrete with barite concrete in some places. Activation samples of bismuth and aluminum were placed in the CSBF and in the CHARM access corridor in July 2015. Monte Carlo simulations with the FLUKA code have been performed to estimate the specific production yields for these samples. The results estimated by FLUKA Monte Carlo simulations are compared to activation measurements of these samples. The comparison between FLUKA simulations and the measured values from gamma spectrometry gives an agreement better than a factor of 2.

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1.18 Neutron energy spectrum measurement using an NE213 scintillator at CHARM

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To establish a methodology for neutron spectrum measurement at the CERN High energy AcceleRator Mixed field facility (CHARM), neutron spectra were measured using an NE213 scintillator on top of the CHARM roof shielding where is the CERN Shielding Benchmark Facility (CSBF). The spectra were derived as fluences into the scintillator by the unfolding method using an iterative Bayesian algorithm. The methodology was verified based on the agreement of two spectra measured for different positions and directions of incident neutrons by changing the detector orientation. Since the spectra on the roof-top were obtained within a reasonable beam-time, this methodology is suitable for measuring the spectrum when there is less shielding material. Thus, experimental data for neutron transition can be obtained as a function of shielding thickness using this facility.

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1.19 Characterizing the Position Sensitivity in Plastic Scintillators

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A linear energy transfer (LET) spectrometer or a space dosimeter based on LET measurement can be developed using plastic scintillators. Then, energy deposition and path length due to incident radiation are necessary to be measured to calculate the LET in plastic scintillators. In this study, the position sensitivity characteristic of plastic scintillators is examined. For this purpose, multi-segmented photomultiplier tubes (PMT) are attached to the both ends of four square-aligned plastic scintillator rods (NE102A) irradiated by radioactive sources which are placed at several positions along the scintillator rod. The obtained signals from the measurement system can establish a dependence of signals on the distance between the radioactive source and PMT. Thus, the position of radiation incidence in the respective scintillator rod is evaluated. Based on the incident position, the path length of radiation in the plastic scintillator rod can be determined. The experiments and results will be presented in detail in our presentation.

Presented in Oral presentation at the 78th JSAP Autumn Meeting, 5 – 8 September, 2017, Fukuoka, Japan.

1.20 Scintillation Efficiency and Position Sensitivity for Radiation Events in Plastic Scintillators

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Plastic scintillators are potential materials for the development of a dosimeter based on linear energy transfer (LET) measurement for mixed radiation fields, such as the surroundings of accelerator facilities and in space because plastic scintillators are composed mainly of hydrocarbon molecules, and have the effective atomic number and density similar to those of water and human tissues. Additionally, plastic scintillators have a wide range of application in particle physics experiments, owing to their response to all types of radiation (photon, neutron, and charged particles). To use plastic scintillators in designing and constructing a LET spectrometer, essential characteristics of PLSs, such as light yields as a function of deposited energy and radiation species, and the position sensitivity to observe trajectories of incident radiation must be studied. Previously, we performed a procedure for determining the energy deposited in a plastic scintillator (EJ-200) for gamma rays from a ^{137}Cs radiation source using Compton Coincidence Technique. In that measurement, the scintillation efficiency, which was determined as a function of Compton electron energy, approaches a saturation value in the high-energy region and decreases in the low energy region. The decrease in efficiency possibly suggests the nonproportionality between the light yield and deposited energy. In this study, the scintillation efficiencies, as well as the absolute light yield of plastic scintillators (EJ-200, EJ-212, and EJ-252) are investigated. In addition, the position sensitivity characteristic is studied by using a plastic scintillator rod, and photomultiplier tubes are attached to both ends of the rod, and the position of radiation incidence in the rod can be evaluated by using signals from the photomultiplier tubes.

Presented in 14th International Conference on Scintillating Materials and Their Applications, 18 – 22 September, 2017, Chamonix, France

1.21 Characterizing the Electron Response and Position Sensitivity for Radiation in Plastic Scintillators

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To develop a tissue-equivalent dosimeter based on LET measurement, we examine the characteristics of a candidate material, plastic scintillators. The energy resolutions of plastic scintillators are examined by using the measured electron responses defined as the relative light output per unit energy of three plastic scintillators EJ-200, EJ-212, and EJ-252. The position sensitivity characteristic is examined by using a square-aligned plastic scintillator rod, and multi-segmented photomultiplier tubes are attached to both ends of the respective rod. The relation between signals from both end PMTs and the position of radiation incidence in the rod are obtained.

Presented in 2017 IEEE Nuclear Science Symposium and Medical Imaging Conference, 21 – 28 October, 2017, Atlanta, USA

1.22 Some Properties of Plastic Scintillators to Construct a LET Spectrometer

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The properties of plastic scintillators as candidate materials for constructing a dosimeter based on LET spectrometry are studied. In order to obtain LET, it is necessary to determine the deposited energy and the trajectory of the incident radiation. For determining the deposited energy, energy resolution is an important factor which must be evaluated. In this study, the energy resolution of plastic scintillators EJ-200, EJ-212, and EJ-252 are determined based on the results of electron response and the absolute light yield. Additionally, in the progress of determining the trajectory of radiations, we examine the relationship between the incidence positions of radiation in the plastic scintillator and signals from the photomultiplier tube.

Presented in the 2nd International Symposium on Radiation Detectors and Their Uses, 23 – 26 January

1.23 Neutron spectrum measurements at CHARM/CSBF facility

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Neutron spectrum measurements have been carried out at the CHARM/CSBF mixed-field facility, generating a radiation field through the interaction of a 24 GeV/c proton with a copper target. By employing several type of neutron detectors such as a liquid scintillator, Bonner spheres and activation foils, we successfully obtained neutron spectra measurements and reaction rates for a broad range of shielding thicknesses and materials. The measured spectra and reaction rates were compared with those obtained through Monte-Calro simulations to evaluate models for production and transport. This lecture will cover outlines of the experiment, neutron detectors, simulation and results; also providing a link to secondary particle evaluation on damage studies.

Presented at RADSAGA seminar, CERN, 6 Oct 2017

1.24 Spectrum measurement down to 1 MeV/u particles with hydrogen-identification using bragg curve counter

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We have developed a low threshold detector consisting of Bragg curve counter (BCC) and two built-in solid-state detectors (SSDs) to measure spectra of low energy charged particles emitted by nuclear reactions. Since the BCC, ionization chamber offers advantages of self particle identification capability and a few μm-thick entrance window, the threshold energy less than 1 MeV/u is expected with particle identification. The detector is tested using 70 MeV protons for measurement of double-differential cross sections (DDXs) of charged particle production. Protons produced down to 1 MeV have been identified and resultant DDXs for proton production have been obtained down to 1.5 MeV.

Presented in the 2nd International Symposium on Radiation Detectors and Their Uses, 23 – 26 January

1.25 Cross comparison on neutron spectra obtained by time-of-flight and unfolding methods with liquid organic scintillator

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The consistency of neutron energy spectra derived from unfolding light output from a liquid organic scintillator and those using the time-of-flight (TOF) method were studied by measuring the production of neutron double-differential cross sections (DDXs) for 100- and 290-MeV/nucleon ^{28}Si ion beams on silicon targets at Heavy Ion Medical Accelerator in Chiba (HIMAC), National Institute of Radiological Sciences (NIRS). For neutron spectra ranging between 10 and 300 MeV, the unfolding results were consistent with the experimental results obtained using the TOF method. Both energy spectra were compared with those obtained with the PHITS Monte Carlo code.

Presented in the 2nd International Symposium on Radiation Detectors and Their Uses, 23 – 26 January

2. Experimental Technology and Monte Calro Simulation Related to Radiation Shielding

2.1 A revised Jenkins formula for electron induced neutron deep penetration calculation

H. Iwase, Y. Namito, H. Hirayama
KEK

In electron accelerator facility, neutron production induced by high energy electron above 1 GeV hitting on thick target, and the neutron deep penetration for concrete shielding can be calculated by the Jenkins formula. In the formula, the neutron source term is divided into three energy regions of GR, MID, and HE, and neutron deep penetration is solved by summing up the attenuation of the three individual source terms with different attenuation length. In this study, the concept of Jenkins formula is verified by using recent Monte Carlo codes with evaluated data and cross sections, and some parameters of Jenkins formula are revised.

Presented at ISORD-9

2.2 Study of personal dosimeters used for 3 mm dose equivalent due to β-rays

H. Hirayama
KEK

The reduction in the dose limit for the lens of the eye was recommended from the International Commission on Radiological Protection (ICRP) in ICRP Publication 118, Part 2 (August 2012). This recommendation is discussing at “The subcommittee of Radiation Protection of the Lens of the Eye”.
One of the issue in this subcommittee is the personal dosimeters to measure absorbed dose of the lens of the eye. Personal dosimeters to measure 3 mm dose equivalent for X-rays were developed mainly at Europe, like Dosiris developed at IRNS (France). Responses of dosimeters (“Dosiris” and “nanodot”) to measure 3 mm dose equivalent for parallel beam of mono energy electrons and β-rays from Y-90, which must be considered at Fukushima Daiichi Nuclear Power Station, were studied using the egs5 Monte Carlo code. Calculated absorbed doses of Al2O3 used at “nanodot” for Sr-90/Y-90 β-rays agreed well with measured ones in absolute comparison. It became clear that the calculated absorbed dose of “Dosiris” was generally agreed with 3 mm dose equivalent due to β-rays from Y-90 after various thickness of polycarbonate.

Presented at 2017 Fall Meeting of the Atomic Energy Society of Japan, Sapporo, September 13-15, 2017.

2.3 Anisotropic parameter of photo-neutron from Au in giant resonance region

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An anisotropic parameter of the direct component of photo-neutrons generated from the gold target in the gigantic resonance region was determined and compared with the value reported by the past measurement and the calculated value by Courant's equation. We measured the spectrum of photon neutrons generated when 17 MeV linearly polarized photons entered the gold target and reported at the annual meeting of AESJ in the spring of 2017. We obtained an angular distribution of direct components above 4 MeV as $a + b \cos^2 \Theta = a + b (2 \sin^2 \theta \cos^2 \varphi - 1)$, $a = 2.75$ e - 4, $b = 9.66$ e - 5. Here, Θ is the angle between the direction of the linearly polarized photon and the neutron emission direction, θ and φ are the polar angle and the azimuth angle of the neutron emission (the direction of the linearly polarized light is the origin). On the other hand, in the past measurement, when only electric dipole transition is considered, the angular distribution at the incidence of unpolarized photons is expressed as $1 + a_2 P_2 (\cos \theta)$. Since linearly polarized photon was used in our measurement, we convert it to unpolarized photon with $\varphi = 45^\circ$, $-a_2$ is obtained as 0.26±0.04 from the values of a and b, and compared with a_2 obtained in past measurements. A comparison of anisotropic parameter $-a_2$ is performed. E_0 and E_n are the incident photon energy and the neutron energy, respectively. When an incident photon has a bremsstrahlung photon spectrum, energy is indicated with the maximum energy and "- brems". The calculated value by Courant's formula is converted to $-a_2$ using Mutchler's equation (82), which is shown in the same table.

$-a_2$	E_0 (MeV)	Method	E_n (MeV)	References
0.26±0.03	22-brems	Al(n,p)	>1.8	Price
0.30±0.12	22-brems	Si(n,p)	>3.9 (>6)	Tabliabue
0.15±0.05	55-brems	Si(n,p)	>3.9 (>6)	Reinhardt
0.45±0.03	14	TOF	>4	Mutchler
0.38±0.03	13	TOF	>4	Mutchler
0.26±0.04	17	TOF	>4	Present work
0.4		<Calc>		Courant

Presented at 2018 Spring Meeting of the Atomic Energy Society of Japan, Osaka, Mar 26-28, 2018.

3. Radiation Protection Study in Accelerator Facilities

3.1 Monitoring system for the gold target by radiation detectors in Hadron experimental facility at J-PARC

R. Muto, K. Agari, K. Aoki, K. Bessho, M. Hagiwara, E. Hirose, M. Ieiri, R. Iwasaki, Y. Katoh, JI. Kitagawa, M. Minakawa, Y. Morino, K. Saito, Y. Sato, S. Sawada, Y. Shirakabe, Y. Suzuki, H. Takahashi, K. Tanaka, A. Toyoda, H. Watanabe, Y. Yamanoi

KEK

At the Hadron Experimental Facility in J-PARC, we inject a 30 GeV proton beam into a gold target to produce secondary particle beams required for various particle and nuclear physics experiments. The gold target is placed in a hermetic chamber, and to monitor the soundness of the target, the chamber is a hematic chamber, and helium gas is circulated in the chamber to monitor the soundness of the target. The radioactivity in helium gas is continuously monitored by gamma-ray detectors such as a germanium detector and a NaI(Tl) detector. Beam operations with those target-monitoring systems were successfully performed from April to June and from October to December, 2015, and from May to June 2016. In this paper, the details of the helium gas circulation system and the gamma-ray detectors, and the analysis results of the obtained gamma-ray spectra are reported.

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3.2 Measurement of residual activities induced in copper by 148 MeV carbon

H. Yashima[1] , M. Hagiwara[2], T. Sanami[2], S. Yonai[3]

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The decommissioning of old accelerator facilities requires activation cross section data to estimate the residual activities induced in the accelerator components. But experimental data of activation cross section are very scarce for low energy (lower than several tens MeV) heavy ions which were required for decommissioning of accelerator facilities such as tandem accelerator and cyclotron.

We therefore irradiated 148 MeV (12.3 MeV/nucleon) carbon ions onto a Cu target to obtain experimental data of residual radioactivities for low energy heavy ions. Irradiation experiment was performed at cyclotron facility (NIRS-930), National Institutes for Quantum and Radiological Science and Technology. The Cu target was composed of a stack of natural Cu foils and total thickness of Cu target was thicker than the range of projectile carbon ions. The average carbon beam intensity was 5 pnA and irradiation time was 1 hour. After irradiation, we measured the gamma-ray spectra from Cu samples with a HPGe detector. The reaction rates of radionuclides produced in Cu samples which were identified from the gamma-ray spectra and the decay curves were estimated after being corrected for the peak efficiency of the HPGe detector.

From the reaction rates, the spatial distribution of residual activities within Cu target depth was obtained. For heavier mass products than Cu, residual activities increase with the Cu target thickness. On the other hand, residual activities decrease with the Cu target thickness for lighter mass products than Cu. In this symposium, excitation functions of residual products will also be presented.

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3.3 In-situ determination of residual specific activity in activated concrete walls of a PET-cyclotron room

H. Matsumura[1], A. Toyoda[1], K. Masumoto[1], G. Yoshida[1], T. Yagishita[2], T. Nakabayashi[2], H. Sasaki[2], K. Matsumura[2], Y. Yamaya[2] and Y. Miyazaki[3]

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In the decommissioning work for concrete walls of PET-cyclotron rooms, an in-situ measurement is expected to be useful for obtaining a contour map of the specific activity on the walls without destroying the structure. In this study, specific activities of γ-ray-emitting radionuclides in concrete walls were determined by using an in-situ measurement method employing a portable Ge semiconductor detector, and compared with the specific activity obtained using the sampling measurement method, at the Medical and Pharmacological Research Center Foundation in Hakui, Ishikawa, Japan. Accordingly, the specific activity could be determined by the in-situ determination method. Since there is a clear correlation between the total specific activity of γ-ray-emitting radionuclides and contact dose rate, the specific activity can be determined approximately by contact dose-rate measurement using a NaI scintillation survey meter. The specific activity of each γ-ray-emitting radionuclide can also be estimated from the contact dose rate using a NaI scintillation survey meter. The in-situ measurement method is a powerful tool for the decommissioning of the PET cyclotron room.

Presented at 4th International Workshop on Accelerator Radiation Induced Activation (ARIA'17), Lund, Sweden, May 22-24, 2017.

3.4 Evaluation of induced activity in various components of a PET-cyclotron

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For decommissioning a cyclotron facility, it is important to evaluate the induced activity of the various components of the cyclotron; however, activation of the metal components has been rarely investigated. In this study, two types of cyclotrons were examined; one is a proton acceleration type using a deflector, and another is a hydride ion (H-) acceleration type using a carbon stripper foil for beam extraction to the target port. The samples were obtained from various metal components such as the yoke, sector magnet, coil, and vacuum chamber by the core boring method, and the depth distribution of the radioactivity was determined via a germanium semiconductor detector. The activities of ^{54}Mn and ^{60}Co were detected from the surface to a deeper site of the yoke and sector magnet. Most of the observed activities of the cyclotron components were higher than the clearance levels, suggesting that a clearance system should not be applied to the yoke and sector magnet. In the case of a high activity sample, we have to wait for 30 years to reach the clearance level.

Presented at 4th International Workshop on Accelerator Radiation Induced Activation (ARIA'17), Lund, Sweden, May 22-24, 2017.

3.5 Establishment of measurement and evaluation procedure of activated materials for decommissioning of accelerator facilities

H. Matsumura, T. Miura, G. Yoshida, A. Toyoda, K. Bessho, H. Nakamura, K. Masumoto

KEK

In order to make a plan for decommissioning of accelerator facility, we proposed the three important key points, such as (1) the defining of activated area of accelerator room and parts of accelerator components, (2) the standard procedure for the evaluation of actvation levels and (3) the manual for the decommissioning work.

(1) As the research target of this year, four facilities of electrstatic type acceleretors were selected such as 1.7MV tandem accelerator of Kobe Univ., 4.5MV dynamitron of Tohoku Univ., 6MV tandem of Univ of Thsukuba and 20MV tandem of JAEA,Tokai. As neutrons are major souce of activation of surrounding materials, Au foils, TLD and CR-39 were used for neutron detection during operarion of accelerators. After irradiation, Surface dose and induced activity after

operation were measured by survey meter and gamma-ray spectrometer, respectively. As the results, activation was very low except for target, slit and beam pipe. Neutron flux on the wall, floor and accelerator tank was 10^{2-4} $cm^{-2}s^{-1}$during operation.

(2) As the model facility, the cyclotron facilitiies of the Advanced Medical and Pharmaceutical Research Center, Ishikawa pref., and National Cerebral and Candiovascular Center was selected. At the former facility, we tried to perform the evaluation scheme of residual activity in the concrte wall and floor by using the in-situ gamma-ray spectrometry and several types of survey meter. We also evaluated the suitable shield thickness for detector. At the latter facility, we measure the neutron flux in the cyclotron vault during the production of ^{18}F and ^{11}C by proton and deuteron irradiation, respectively. And we also obtained the concrete core samples and measure depth profiles of residual activity.

In order to grasp the activity profiles on accelerator magnets, three types of imaging detectors such as mask method, Compton method and collimeter method were compared.

(3) In order to discuss and make the manual for the decommsionig work, we organized the editorial committee.

3.6 Measurements of depth profile of activity in the concrete and contained elements shielding wall of the J-PARC MR accelerator tunnel

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J-PARC consists of three accelerator facilities and three experimental facilities, and it generates the world-class high-intensity proton beams. Large beam loss present around the beam injection points where activation of the beam lines including the collimator is remarkable. Activation of the concrete wall is relatively weak compared to those of the accelerator components, but it is also detected around such beam-loss points. Concrete core samples were installed in the concrete walls at the accelerator tunnels to survey production of radionuclides in the concrete materials at these environments.

In this study, concentrations of radionuclides produced in the concrete samples installed near the beam injection point at the J-PARC MR facility were investigated into detail. The depth profile of gamma-emitting radionuclides in the concrete core was obtained by radioactivity measurement with a Ge detector. In addition, Monte Carlo method was also applied to study the transportation of neutrons inside the concrete wall. Observed depth-profiles for thermal-neutron producing nuclides and fast-neutron producing nuclides can be explained by the neutron-transportation mechanism simulated by the calculations.

Presented in the 19th Workshop on Environmental Radioactivity, Tsukuba, March, 2018.

3.7 Analysis of the radionuclides produced in the circulating helium gas for inspecting the gold target installed in the J-PARC Hadron Experimental Facility

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R. Muto[1,2], K. Saito[1,2], Y. Kasugai[1]
[1] J-PARC, [2] KEK

At the J-PARC Hadron Experimental Facility, a gold target bombarded with proton beam is placed in a hermetic chamber, which is filled with circulating helium gas. The radioactivity of the circulating helium gas is continuously monitored in order to confirm the soundness of the target with a Ge detector and a NaI(Tl) detector.
Various γ-emitting nuclides such as C-10, O-19, O-20, F-20, Ne-23, Ne-24, Na-24 (daughter of Ne-24), Ar-41, Hg-191m, Hg-192, Hg-193m, Hg-195, Hg-195m, Au-192 (daughter of Hg-192), and annihilation peak are detected with the Ge detector. Detected activity in gas phase and calculated activity produced in the solid components were obtained for various nuclides, and the rates released to gaseous phase was compared for various nuclides. The results indicate that C, N, O, F, Ne, Ar and Hg nuclides are selectively released to gas phase reflecting their elemental volatility. The rates released to gaseous phase were analogous for C, N, O, Ne and Ar nuclides. On the other hand, corresponding rates for F-20 and those for Hg nuclides were smaller compared to those of C, N, O, Ne, Ar nuclides, which suggest that F and Hg nuclides tend to remain partially on the target and window surfaces. It is possible that these characteristics are related with fluoride formation for F-20 on the metal surface and low volatility for Hg nuclides reflecting their vapor pressure depending on the target temperature.

Presented in the 19th Workshop on Environmental Radioactivity, Tsukuba, March, 2018.

3.8 Radiation control of radioactive mercury at high intensity proton accelerator

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In J-PARC, various kinds of radionuclide are generated due to activation of not only the accelerator components but also the air in the accelerator tunnel that are induced by the intense proton beam accelerated to high energy and its beam loss followed by production of a number of secondary particles. In this study, we focused on a radioactive mercury (^{197}Hg), which was detected in the air of most of the accelerator tunnels in J-PARC and investigated the migration characteristics by measuring the ^{197}Hg concentration in the air before and after air ventilation of the tunnel which was confined during beam operation.

The ^{197}Hg concentration in air of the accelerator tunnels in J-PARC is generally between N.D. and 5.0×10^{-4} Bq/cm^3. The concentrations 24 and 96 hours after ventilation of the air were 9.0×10^{-6} Bq/cm^3 and 2.9×10^{-6} Bq/cm^3, respectively. The decrease of the ^{197}Hg concentration is slower than an expectation based on the ventilation capacity.

We suppose that ^{197}Hg may be continuously supplied from the wall of the accelerator tunnel as a cause of the slow ventilation of ^{197}Hg. We therefore measured the amount of ^{197}Hg released from a wall of a tunnel and confirmed that 4.5×10^{-3} Bq/(cm^2 · h) of ^{197}Hg was released from a wall of a tunnel 9 hours after stopping the beam operation.

In conclusion, ^{197}Hg released from walls of the accelerator tunnels could affect the slow ventilation of ^{197}Hg in air. To understand the migration of radioactivity mercuries in the air of tunnel, we will continue to investigate the source and dynamics of radioactivity mercuries in air.

Presented at 16th Annual Meeting of Japanese Society of Radiation Safety Management

3.9 Evaluation of radioactivity in mouse body induced by neutron exposure from epi-thermal neutron source of accelerator-based boron neutron capture therapy system using a solid Li target

S. Nakamura[1], S. Imamichi[1], K. Masumoto[2], M. Ito[1], A. Wakita[1], H. Okamoto[1], S. Nishioka[1], K. Iijima[1], K. Kobayashi[1], Y. Abe[1], H. Igaki[1], K. Kurita[3], T. Nishio[4], M. Masutani[1], J. Itami[1]
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This study aimed to evaluate residual radioactivity in mice induced by neutron irradiation with an accelerator-based boron neutron capture therapy (BNCT) system using a solid Li target. The radionuclides and their activities were evaluated with a high-purity germanium (HP-Ge) detector. Saturated radioactivity of the irradiated mouse was estimated to consider the radiation protection in case of using the accelerator-based BNCT system. The ^{24}Na, ^{38}Cl, ^{80m}Br, ^{82}Br, ^{56}Mn, and ^{42}K were detected, and their saturated radioactivities were $1.4\pm0.1\times10^2$, $2.2\pm0.1\times10^1$, $3.4\pm0.4\times10^2$, 2.8 ± 0.1, 8.0 ± 0.1, and $3.8\pm0.1\times10^1$ Bq/g/mA, respectively. When the thermal neutron fluence in the mouse was $2.4\pm0.2\times10^{11}$ to $1.2\pm0.1\times10^{12}$ n/cm^2, total activity of ^{24}Na induced in a mouse was $8.9\pm0.2\times10^2$

Bq at the end of irradiation, and its activity was similar to the reported value of BNCT experiment using a thermal column of reactor. The induced activity of each nuclide can be estimated by substituting inputed saturated activity of each nuclide, sample mass, irradiation time, and proton current into the deliverd activation equation in our accelerator-based BNCT system.

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4. Nuclear Chemistry and Radiochemistry

4.1 Improvement of a high-frequency induction furnace combined with a size-analysis system for metallic aerosols generated from molten metals

Y. Oki[1], T. Miura[2] and H. Matsumura[2]
[1]KUR, [2]KEK

In this work, a new system of high-frequency induction furnace has been developed for simulation of radioactive aerosol release in accidents. The furnace was connected to a low-pressure impactor system to analyze the size of the aerosol particles. The radioactive aerosols were released to the environment in both accidents of the J-PARC in 2013 and Fukushima Daiichi Nuclear Power Plant (FDNPP). The release occurred due to melting of the metallic target or the highly radioactive nuclear fuel. The particle size of the aerosols is very important information to clarify their formation mechanism. Highly pure carbon crucibles were used for melting of the metal samples. To minimize the concentration of back ground aerosol particles emitted from the heated crucibles, their aerosol concentration was precisely measured in various heating conditions with a condensation particle counter. The back ground particles rapidly increased in number above 1,400 ^{o}C under the nitrogen atmosphere. The concentration was largely affected by the applied power; however, the concentration could be decreased by pre-heating of the crucible in the furnace.

Presented in the 19th Workshop on Environmental Radioactivity, Tsukuba, March, 2018.

4.2 Development of muonic atom beam generation system and the first assessment using intense negative muon beam of J-PARC MUSE

G. Yoshida[1], N. Kawamura[1], Y. Miyake[1], K. Ninomiya[2], M. Inagaki[2], J. Aoki[2], M. Toyoda[2], A. Shinohara[2]
[1]KEK, [2]Osaka Univ.

Muonic atom is an atomic system which has a negative muon substituted an orbital electron. Because a muon mass is 200 times heavier than an electron, the radius of muonic orbital is much smaller than that of electronic orbital. Orbital muon strongly shields a charge of nucleus (Z), thus, muonic atom behaves as if Z-1 atom. However, electron structure of muonic atom is slightly different from Z-1 atom [K. Ninomiya *et al*., J. Radioanal. Nucl. Chem. **272** 661 (2007)]. Our research group aims to provoke a chemical reaction of muonic atom as a novel chemical species. In the initial stage of this purpose, we developed muonic atom beam extraction system.

When a muonic atom formation, the muonic atom becomes highly positively charged ion due to emission of Auger electrons [L.Bacher *et al.,* Phys. Rev. Lett. **54** 2087 (1985)]. Using this property of muonic atom, we had developed the muonic atom extraction system by electric field. The system consists of vacuum chambers, electrodes for muonic atom acceleration, muonic atom ion production target (poly tetra fluoro ethylene: PTFE and graphite) and micro channel plate for muonic atom ion detection. Some muonic atoms which are created very close to the target surface may escape to vacuum from the target material and accelerated by the electric fields. Muonic atom can be identified using a time of flight mass spectrometer (TOF-MS) technique. Our system is expected to be able to create muonic atom beam which is whole new type of quantum beam.
After development of the system, the first evaluation was performed by laser ablation. Various ions which were generated by laser bombardment for the target surface were accelerated by the electric fields, and ion yield and mass resolution were optimized. We could obtain resolution of R>260; this is sufficient for the detection of μF^{8+}. Also, we performed the beam experiments for assessment of the system using high intensity negative muon beam of J-PARC. In the first experiment, background signals originated from various particles which were accompanied to muon beam were observed, and the signal which was attributed to muonic atom beam was not detected. From this result, the beam bending system was installed for reduce background noises. We performed the second experiment and succeeded to remove the noises significantly. In the presentation, we would like to report the other results of the beam experiments, and details of developed system.

Presented at The 14th International Conference on Muon Spin Rotation, Relaxation and Resonance (μSR2017)

4.3 Further examination for the chemical environmental effect in muon transfer by using low pressure gaseous carbon sulfide samples

G. Yoshida[1], K. Ninomiya[2], M. Inagaki[2], W. Higemoto[3], N. Kawamura[1], K. Shimomura[1], Y. Miyake[1], T. Miura[1], M.K. Kubo[4], and A. Shinohara[2]

[1]KEK, [2]Osaka Univ., [3]JAEA, [4]ICU

Muonic atom is an atomic system which has a negative muon substituted an electron. A coulomb field of nucleus captures a muon then the muonic atom is formed. There are two different ways for muonic atom formation, one is an atom captures muon directly, another is firstly a muon is captured by a hydrogen atom then the muon transfers to heavier atom ($Z > 2$). The later process is called muon transfer. Although the radius of the muon in muonic atom is very small due to its heavy mass, muonic atom formation processes are influenced by orbital electrons. When a muon is captured by a molecule, muon capture probability for constituent atom and initial quantum state of the captured muon are changed by chemical environment such as molecular structure (K. Ninomiya *et al.,* J. Korean Phys. Soc. 2011). It is known as the chemical effect for muon capture. On the other hand, it has been believed that the chemical effect hardly appears in muon transfer, because binding energy of the muon in muonic hydrogen is too large to interact with orbital electrons. However, our result which is obtained from the experiments in MLF suggests appearance of chemical effect in muon transfer. Unfortunately, due to not enough statistics, we could not discuss in detail.

In this study, we performed muon irradiation to H_2+COS (1%) and H_2+CS_2 (1%) gases at sub-atmosphere conditions, and obtained good statistical data of muonic X-rays. The experiment was performed at D1 experimental area in J-PARC/MUSE. The experimental setup was written in elsewhere (G. Yoshida *et al.,* J. Radioanal. Nucl. Chem. 2015). Muonic X-ray spectrum derived from H_2+CS_2 was described in Figure 1. A precise spectrum could be obtained with high intensity and high quality negative muon beam of J-PARC. Transition series from μS-K_α to μS-K_ι (n=10 to 1) could be determined from the spectrum. Currently, we are analyzing muonic X-ray spectra and discussing the chemical environmental effect on the muon transfer process.

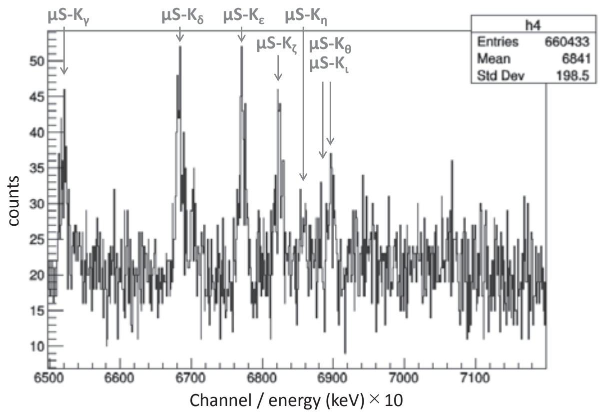

Figure 1: Muonic X-ray spectrum of H_2+CS_2(1%) sample

The experiment was performed at J-PARC:2017B0150

5. Environmental and Analytical Chemistry at Accelerator

5.1 Adsorption behavior of trace beryllium (II) onto metal oxide nanoparticles dispersed in water

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[1]Chiba Univ.,[2]KEK

Radioactive trace ^{7}Be produced in cooling water systems for high-energy accelerators is known to be captured by metal-oxide colloidal nanoparticles generated through corrosion of metal components in water. This study is aimed at investigating the adsorption behavior of trace Be^{2+} onto various oxide nanoparticles (Al_2O_3, SiO_2, TiO_2, Fe_2O_3, CoO, and CuO) dispersed in water at 25 °C in order to clarify the tendency and features of the interaction of Be^{2+} with metal oxides. From pH dependence of the distribution ratio of Be^{2+} between the nanoparticle phase and the aqueous solution phase, the surface complexation constants ($\beta_{s,n}$) have been determined for the reaction of Be^{2+} with the hydroxyl groups on the oxide surface (>S−OH), *i.e.*, $Be^{2+} + n\ {>}S{-}OH \rightleftarrows ({>}S{-}O)_nBe^{(2-n)+} + n\ H^+$. The n values are generally 1 and 2 and the sequences of the $\beta_{s,n}$ values are $Fe_2O_3 > TiO_2 \approx Al_2O_3 > SiO_2$ for $\beta_{s,1}$ and $Fe_2O_3 > TiO_2 > SiO_2 > Al_2O_3 >> CoO \approx CuO$ for $\beta_{s,2}$. The dependences of the the $\beta_{s,n}$ values on the kind of oxide are explained based on the electronegativity of the metal (or Si) composing the oxide.

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6. Research related to Accident of Fukushima Daiichi Nuclear Powere Station

6.1 Relationship between age and ^{137}Cs concentration in Japanese dace from lakes in Fukushima Prefecture after the Fukushima fallout

K. Takasaki[1], A. Tomiya[2], T. Wada[3], H. Nakakubo[1], T. Sato[1], G. Kawata[1], I. Matsumoto[1], K. Masumoto[4]

[1]Fukushima Pref. Inland Water Fisheries Experimental Station,[2] Fukushima Pref. Agricultural Promoion. Div. [3]Inst. Environ. Radioactivity, Fukushima Uni. [4] KEK

It is revealed that size effect may be observed because of the difference of the age in fish. We collected Japanese dace from lakes in Fukushima Prefecture and Their ^{137}Cs concentration, body weight and age were measured. The age assessment was conducted by counting the number of the rings of the otolith.

Correlation between age and ^{137}Cs concentration was observed for 19 cases within the 27 cases where the correlation of body weight and ^{137}Cs concentration was confirmed. No correlation was found between body weight and ^{137}Cs concentration for 71 groups within 84 cases collected in the same year. From these, it is thought that size effect of Japanese dace can illustrate by age well.

As the next step of our research, feeding habit and metabolism should be examined to make use for the prediction in the future of ^{137}Cs concentration of Japanese dace.

Chapter 2　研究支援活動

放射線科学センターは、機構における放射線安全、並びに化学安全を含む環境安全に責任を有する。対象となる施設の規模が大きいこと、個々の課題が未解決や未知の課題を複雑に含んでいることから、その業務内容は研究的側面を持っている。管理業務に直接関連した研究テーマが発展していく場合もあるが、それ以外にも純粋な学問的研究テーマとして至らないまでも関連分野として有益な課題が多い。

このほかに、放射線科学センターのスタッフは、放射線関連、化学関連の専門家として機構の内外から個々の課題について相談を受けること多々あり、これに取り組んできた事項もある。

本章では、2017 年度の研究支援活動に関連して放射線科学センターが取り組んだ活動について報告する。

1.　体制

1.1　放射線管理体制

1.1.1　　つくばキャンパス

放射線取扱主任者	波戸　芳仁
放射線取扱主任者代理	佐波　俊哉
放射線管理室長	三浦　太一
放射線管理室長代理	松村　宏
統括（管理区域担当）	佐波　俊哉 松村　宏

管理区域	氏　名	職　名　等
PS 施設（1,2,3,7 区域）・電子加速器施設(4A 区域)・試験加速器施設（5E, 6 区域）	松村　宏	統括管理区域責任者
電子加速器施設（4B, 5A,5B,5C,5D 区域）	佐波　俊哉	統括管理区域責任者
第 1 区域 PS 施設 （前段加速器＋ディジタル加速器）	 飯島　和彦 吉田　剛 高原　伸一	 管理区域責任者 管理区域副責任者 管理区域業務担当
第 2 区域 PS 実験施設 東カウンターホール（ERL 開発棟） 北カウンターホール	 松村　宏 吉田　剛 大山　隆弘	 管理区域責任者 管理区域副責任者 管理区域業務担当
第 3 区域 PS 施設 （旧中性子ミュオン科学研究施設）	 飯島　和彦 吉田　剛 大山　隆弘	 管理区域責任者 管理区域業副責任者 管理区域業務担当
第 4 区域 放射光科学研究施設（４A） 電子陽電子入射器（４B）	 穂積　憲一 吉田　剛 岸本　祐二 豊田　晃弘 岩瀬　広	 管理区域責任者 管理区域副責任者 管理区域業務担当 管理区域責任者

	穂積　憲一 豊田　晃弘	管理区域副責任者 管理区域業務担当
第 5 区域 SuperKEKB 施設（5A） DR（5B） BT ライン（5C） 大強度放射光施設（5D） ATF（5E）	 佐波　俊哉 飯島　和彦 大山　隆弘 大山　隆弘 岩瀬　広 穂積　憲一 佐波　俊哉 岩瀬　広 穂積　憲一 岸本　祐二 飯島　和彦 大山　隆弘 豊田　晃弘 岸本　祐二 高原　伸一	 管理区域責任者 管理区域副責任者、 管理区域業務担当 管理区域責任者 管理区域副責任者 管理区域業務担当 管理区域責任者 管理区域副責任者 管理区域業務担当 管理区域責任者 管理区域副責任者 管理区域業務担当 管理区域責任者 管理区域副責任者 管理区域業務担当
第 6 区域 超伝導リニアック試験施設（STF）棟	大山　隆弘 岸本　祐二 高原　伸一	管理区域責任者 管理区域副責任者 管理区域業務担当
第 7 区域 RI 実験準備棟、放射化物加工棟、 放射性廃棄物第 2,3,4 保管棟、 電子陽電子放射性排水処理施設、 12GeVPS 放射性廃液処理施設、 放射線管理棟、放射性試料測定棟、 放射線照射棟、放射化物使用棟、 熱中性子標準棟、PS ｴﾈｾﾝ排水設備	 豊田　晃弘 穂積　憲一 高原　伸一	 管理区域責任者 管理区域副責任者 管理区域業務担当

1.1.2　東海キャンパス

放射線取扱主任者	沼尻　正晴
放射線取扱主任者代理	山崎　寛仁
放射線安全セクション副ディビジョン長	別所　光太郎
放射線安全セクションサブリーダー	沼尻　正晴

50GeV シンクロトロン施設	管理区域責任者 管理区域責任者代理	中村　一 山崎寛仁
放射線測定棟	管理区域責任者 管理区域責任者代理	山崎寛仁 中村　一
ハドロン実験施設	管理区域責任者 管理区域責任者代理	萩原雅之 斎藤　究
ニュートリノ実験施設	管理区域責任者 管理区域責任者代理	高橋一智 萩原雅之 斎藤　究

1.2　放射線業務分担

1.2.1　つくばキャンパス

業　　務	担当者氏名
管理事務（書類管理を含む）	三浦　太一
（女子放射線業務従事者対応）	豊島　規子
(管理システム)	豊田　晃弘
（管理事務・従事者登録）	豊島　規子
出入管理システム	穂積　憲一 佐波　俊哉 岩瀬　広 豊田　晃弘
放射性物質等	三浦　太一 桝本　和義
（密封・非密封 RI）	吉田　剛 豊田　晃弘 穂積　憲一
（核燃）	松村　宏
（廃棄物）	豊田　晃弘
（表示付認証機器）	大山　隆弘 岸本　祐二
（チェッキングソース)	大山　隆弘 岸本　祐二
（放射化物)	豊田　晃弘 飯島　和彦 吉田　剛
環境放射能	豊田　晃弘 高原　伸一 吉田　剛
安全管理設備　（集中放射線監視システム モニターサーベメーター等）	佐波　俊哉 岸本　祐二 穂積　憲一 飯島　和彦 大山　隆弘
放射能測定器等　（Ge 検出器、サンプルチェンジャー、 液体シンチレーションカウンター、 イメージングプレート)	松村　宏 飯島　和彦 高原　伸一

	豊田　晃弘 吉田　剛
放射線較正施設　　　（放射線照射棟） （熱中性子準備棟）	穂積　憲一 飯島　和彦 岸本　祐二 佐波　俊哉
線量計等　　　　　　（線量計評価、OSL、APD、PD 等）	三浦　太一 飯島　和彦 豊田　晃弘 大山　隆弘
機構長の指定する発生装置等　　（PS 系） （電子系） （システム）	松村　宏 岩瀬　広 佐波　俊哉
安全教育（オンライン教育開発　含む）	波戸　芳仁 伴　　秀一
出版物等 （安全ビデオ） （安全の手引き、パンフレット等)	桝本　和義 穂積　憲一 波戸　芳仁 松村　宏
広報（WEB 管理・更新） (サーバー管理) (管理業務ページ) (サーバー管理、環境ページ) (トップページ更新情報) (サーバー管理、研究ページ)	三浦　太一 佐波　俊哉 松村　宏 佐藤　充 豊田　晃弘 岩瀬　広
作業環境測定（内部被ばく評価を含む）	豊田　晃弘 佐波　俊哉 三浦　太一

発生装置責任者

中性子発生装置　　穂積　憲一

X 線発生装置　　穂積　憲一

1.2.2　東海キャンパス

業務	担当氏名
従事者登録、線量管理、教育訓練、UO 対応	高橋一智 西川功一
環境放射線管理、廃棄物管理、放射性物質等管理（表示付認証機器、チェッキングソース）	萩原雅之 西川功一
放射線安全管理設備（出入管理システム、放射線モニター、監視システム）	斉藤　究 萩原雅之 山崎寛仁 長畔誠司 穂積憲一 飯島和彦 岸本祐二
変更申請、委員会等の所内手続事務	山崎寛仁 中村　一 斉藤　究

1.3　化学安全管理体制

1.3.1 化学安全関係責任者等

環境安全管理室長	文珠四郎秀昭
環境安全管理室員	平 雅文
環境安全管理室員	古宮 綾
環境安全管理室員	佐藤 充
J-PARC 安全ディビジョン副ディビジョン長	別所光太郎
化学薬品等取扱主任者	平 雅文
危険物屋内貯蔵所保安監督者	平 雅文
除害施設等管理責任者	文珠四郎秀昭
PCB 特別管理産業廃棄物管理責任者	文珠四郎秀昭
特別管理産業廃棄物管理責任者（PCB 以外）	平 雅文
超伝導空洞電解研磨設備管理責任者	沢辺元明

1.3.2 化学安全業務分担

化学安全管理業務（総括）	文珠四郎秀昭
水質検査	佐藤 充
化学薬品管理	平 雅文 佐藤 充
依頼分析	平 雅文 文珠四郎秀昭 古宮 綾 佐藤 充
実験廃液処理	平 雅文
RI 廃水処理	古宮 綾
作業環境管理	古宮 綾
環境管理	平 雅文
広報	古宮 綾 佐藤 充
加速器超伝導空洞電解研磨設備運転管理	沢辺元明

2. 放射線安全管理関係

2.1 つくばキャンパス

2.1.1　概要

今年度、放射線発生装置や放射性同位元素の取扱いや被ばく線量等に関して、放射線安全のための法及び機構の諸基準を逸脱するような事例は無かった。

陽子加速器施設では、デジタル加速器での出力増強の変更申請を行った。PS 主リング室内をはじめ、放射化物の整理作業が進められた。

電子加速器では、SuperKEKB のフェーズ２にむけて、陽電子ダンピングリング、AR への新入射路の新設や HER 及び LER の使用再開が行われた。

放射性同位元素の使用に関しては、放射性試料測定棟の密封線源使用について変更申請が行われた。

2.1.2　放射線管理業務

（１）機構所属の放射線業務従事者

機構所属の従事者数は 765 名（女性は 80 名）であった。管理区域内作業にかかわる被ばくがあったものは 9 名（0.1 mSv が 3 名、0.2 mSv が 1 名、0.3 mSv が 3 名、0.4mSv が 2 名）であった。職員の被曝は、J-PARC、東北大等全て他機関の利用によるものである。

（２）共同利用者、業者の受入

今年度登録された本機構所属以外の放射線業務従事者数は 4,715 名で、内訳は　業者 : 1,352 名（新規 357 名、更新 995 名）、共同利用者 : 3.363 名（新規 1,827 名、更新 1,536 名）であった。今年度の被ばく状況は、業者では、0.1 mSv が 1 名であり、放射化物の整理作業によるものである。共同利用者では、7 名に 0.1～0.5 mSv の被ばくがあったが、これは 6 名が低速陽電子実験施設の、他 1 名が放射光実験施設の利用者である。低速陽電子の共同利用者の被ばくに関しては、作業場所の放射線線量率測定結果から、KEK が共同利用者の被ばく管理に使用している個人線量計では過大評価の可能性が考えられたため、個人線量計の種類を変更したところ、それ以降被ばくは認められなかった。従って低速陽電子の共同利用者の被ばくに関しては、使用した個人線量計システムの被ばく線量評価方法の検討を進めている。

（３）女性の被ばく

今年度の女性の放射線業務従事者被ばく状況としては、低速陽電子実験施設の共同利用者 1 名が 0.1 mSv 被ばくしたが、上記同様の理由から精査中となっている。

（４）放射性同位元素、核燃料物質等の受入払出

密封放射性同位元素の受入れ 2 件、払出し 1 件を行った。

核燃料及び核原料物質の受入れと払出しは 3 件あり、すべて放射光実験で使用された。

2.1.3 申請関係

（１）変更申請（防止法関係）

ア）第 19 回放射線安全審議委員会で審議された以下の内容で、平成 29 年 3 月 24 日付で変更承認申請を行い、6 月 15 日付で承認を得た。

１）電子陽電子入射器の使用方法の変更に係る放射線安全対策

・電子入射器と電子陽電子加速器をまとめ、電子陽電子入射器とする。

・入射器棟トンネル室上流部と下流部の間の区画を撤去する。

・陽電子ダンピングリングとのビーム授受を開始する。

・陽電子ダンピングリングとの間にビームダクトを設置する。

・インターロックシステムを変更する。

２）陽電子ダンピングリングの新設に係る放射線安全対策

・使用を開始する。

３）直線加速装置入射路の変更に係る放射線安全対策

・HER 入射路, LER 入射路の使用を再開する。

・インターロックシステムを変更する。

４）SuperKEKB フェーズ 2 に係る放射線安全対策

・HER と LER の使用を再開する。

・筑波実験棟 B1 回廊部分と電源棟 D2 に管理区域を設定する。

・富士実験棟 B4 の管理区域の一部を解除する。

５）陽子加速器施設の使用変更に係る放射線安全対策(デジタル加速器における出力の変更)

・デジタル加速器の最大エネルギーを 100keV/核子から 2.0MeV/核子に、最大出力を 0.0002MeV・pμA から 0.004MeV・pμA に変更する。

・NML ビームライン室の放射化物保管設備について、トンネル迷路入口部分を含むよう拡張する。

６）放射性試料測定棟における密封された放射性同位元素の使用の変更に係る放射線安全対策

・密封された放射性同位元素の使用時の遮蔽方法を変更する。

・密封された放射性同位元素の使用室としてモニター照射試験室を追加する。

イ）平成 29 年 12 月 7 日付けで変更承認申請を行い, 平成 30 年 1 月 5 日付で承認を得た。

１）陽電子ダンピングリングの新設に係る放射線安全対策

・記載の適正化

（２）規制法関係

以下の内容で、平成 29 年 11 月 30 日付で核燃料の変更使用申請を行い、12 月 21 日に承

認を得た。

1） PF 研究棟と先端計測開発棟を使用場所として追加する。

2） PF-AR の図面を適正化する。

2.1.4 検査関係

（1）防止法関係

ア）使用施設等(陽電子ダンピングリング)について、平成 30 年 2 月 21 日付けで施設検査の申請を行い、2 月 27 日に受検し、3 月 1 日付けで合格した。

（2）規制法関係

ア） 国際原子力機関(IAEA)による査察が平成 29 年 4 月 19 日に実施された。対象施設はデジタル加速器と PF BL27 であった。コンパクト ERL についても査察中および査察後に問い合わせがあった。

2.1.5 放射線安全審議委員会

ア）第 20 回放射線安全審議委員会

平成 30 年 3 月 22 日に開催され、主な議題は以下の通りであった。

1) 陽子加速器施設管理区域縮小に係る放射線安全対策

2) ERL 開発棟管理区域縮小に係る放射線安全対策

3) 大強度放射光リング南棟管理区域出入口の変更に係る放射線安全対策

4) SuperKEKB 6SM4 棟管理区域解除に係る放射線安全対策

2.1.6 その他

ア）機構内検査等

・ 「機構長の指定する発生装置」として申請のあった下記装置について放射線取扱主任者による機構内検査を実施し、安全を確認し使用開始を許可した。検査日を[ ]内に記す。
  - PF-AR 実験準備棟 封入型 X 線発生装置 CN4027A1 [平成 29 年 4 月 4 日]
  - PF-AR 実験準備棟 小型 X 線回折装置 MiniFlex 600 [平成 29 年 4 月 4 日]

・ 放射性試料測定棟における使用室の新設(モニター照射実験室)の承認に伴い、平成 29 年 6 月 22 日で使用室の新設を行った。

・ 富士実験棟 B4 の放射線管理区域の解除の承認に伴い、平成 29 年 7 月 20 日で管理区域の解除を行った。本解除に関する施設の廃止措置報告は 8 月 7 日付で受理された。

・ 電子陽電子入射器の使用方法の変更の承認に伴い、平成 29 年 10 月 4 日付で主任者による機構内検査を行い、同日付で使用を許可した。

・ 陽電子ダンピングリングの新設に係る承認に伴い、主任者検査を平成 29 年 10 月 4 日

（インターロック）と 12 月 6 日（区域設定、標識、遮蔽など）に行い、平成 30 年 1 月 12 日付けで使用開始を許可した。

- Super KEKB Phase 2 に係る承認に伴い、主任者検査を平成 30 年 1 月 11 日（インターロック）、2 月 20 日（筑波実験棟と電源棟 D2 の放射線管理区域の変更）、3 月 15 日(区域設定、標識、遮蔽)に行い、3 月 15 日付で使用を許可した。
- PF 研究棟及び先端計測開発棟における核燃料物質使用施設新設の承認に伴い、平成 30 年 2 月 6 日に機構内検査を行い、同日付で使用を許可した。

イ）教育訓練等

- つくばキャンパスにおける平成 29 年度放射線安全教育訓練第 1 回を平成 29 年 11 月 9 日に、第 2 回目を平成 30 年 2 月 20 日に行った。本教育訓練は既認定者の再教育および新規認定者の追加教育を目的としている。第 1 回と第 2 回の受講者数はそれぞれ、482 名と 148 名であった。
- つくばキャンパス安全業務連絡会が平成 30 年 3 月 7 日に開催され、つくばキャンパスに於ける放射線安全の状況について説明を行った。
- 安全環境衛生諮問委員会が平成 30 年 3 月 26 日に開催され、つくばキャンパスにおける放射線安全の状況について説明を行った。

2.2 東海キャンパス（J-PARC）

2.2.1 J-PARC の進行状況と当放射線科学センターの役割

J-PARC は、日本原子力研究開発機構と高エネルギー加速器研究機構との共同プロジェクトであり、主としてJ-PARC センターが運営を担っている。当放射線科学センターからはJ-PARCセンターの安全ディビジョン・放射線安全セクションに別所、沼尻、山崎、齋藤、萩原、中村、高橋、長畔、西川の9名が専任として所属し、岸本、穂積、飯島が兼任として所属している。

2.2.2 放射線安全セクションの関連業務

関連業務としては、放射線障害防止法に関わる申請、届出、施設検査対応、規程等の改訂、放射線安全に関する委員会活動、放射線安全教育がある。2017年度も施設検査、点検、訓練、講習会、規程改訂等の対応が行われた。

2.2.3 放射線申請関係

2017年度は、1回の変更申請が行われた。原子力規制委員会に12月18日付で申請し、2018年2月26日付で許可を得た。主な変更内容は、物質生命科学実験施設（MLF）のRAM棟新設、ニュートリノ実験施設ビーム出力増強(600kW→650kW)等であった。

J-PARCの各施設は、原科研敷地内に建設するため、茨城県との原子力安全協定により放

射線施設の建設前及び規制庁への申請前に新増設等計画書を、建設後に工事完了報告書を県に提出し了解を得る必要がある。2017年には、物質生命科学実験施設RAM棟新設について新増設等計画書を提出し口頭了解を12月15日に得た。

2016年9月27日に許可を得たハドロン実験施設のビームライン設置準備のための遮蔽体変更に対する施設検査を5月31日に受検し、6月2日付けで合格となった。

2.2.4 内部規程の改訂、委員会活動

放射線安全に関する内部規程の見直しを行い、放射線障害予防規程細則と事業所内運搬規則、エックス線装置保安規則の改訂を各１回行った。各施設の運転手引きを改定し、高リスクMPSが発報した場合の対応、事故現場指揮所の移転に伴う修正を行った。また、諸手続等をまとめた「放射線安全ガイドブック」、放射線管理実務をまとめた「放射線管理要領」の改訂を行った。

JAEA、KEKの２者で申請を行うため、両機関で一元的に検討するための諮問会議として放射線安全委員会が設置されており、2回開催した。また、Ｊ－ＰＡＲＣセンター内で放射線安全に関する事項を検討する放射線安全評価委員会が設置されており、3回開催された。放射線安全評価委員会には特定の技術的項目を審議するための作業部会が設けられている。作業部会である運転手引専門部会を3回、 インターロック専門部会を2回、3NBT-材料科学実験特別部会を2回開催した。

2.2.5 放射線安全教育

2017年度の入域前教育訓練は、KEK・JAEA職員等 78名、外来業者 1512名、ユーザー 1293名が受講した。職員等の再教育訓練は2017年度に2回実施し、年度内に対象者全員の620名が受講した。

3. 化学安全・環境関係

3.1 依頼分析

環境安全管理室では、機構職員、共同利用者から種々の化学分析の依頼、相談などを受け付けており、本年度は33件の分析依頼を受け付けた。試料の量が極端に少ない物が多く、ほとんどの分析で卓上顕微鏡及び電子顕微鏡を使用した。この他にX線回折装置、FT-IR分光装置、ラマン分光装置などを主に使用した。FT-IR分光装置については、古い装置を更新した。個々の分析内容、結果については部内レポートCHEM-Aにまとめてある。

3.2 環境管理

環境安全管理室員の他、環境・地球温暖化・省エネ対策連絡会を中心として、「環境報告2017」を作成し、機構HP上に公開した。さらに印刷した冊子体を関係機関に送付するとともに、機構内の関係部署に配布した。

3.3 実験廃液処理

所内各所の化学実験室等から排出される洗浄廃水は、実験廃液処理施設において凝集沈殿及び各種樹脂塔への通水により全量を処理している。処理水は汚水排除基準（排水基準）を満たしていることを確認し、放流を行っている。本年度は、機構内の洗浄廃液貯留槽からの廃水、および、KEKB地区の各機械室の冷却系統のメンテナンス及び試運転に伴う廃水、計 227.1 m^3 を受け入れ、処理を行った。

また、超伝導空洞電解研磨設備より排出されるフッ素系洗浄廃水についても実験廃液処理施設で無害化処理を行った。受け入れたフッ素系洗浄廃水は、計 38.4 ㎥であった。

廃液処理装置の保守としては、フィルタープレス脱水機のろ布交換、ボイラー軟水器のイオン交換樹脂再生、中和槽pH電極の交換等を行った。更に安全対策として、無機ヤード内の通路脇の段差をオレンジ色で塗装し、作業の安全性向上を図った。装置や配管、架台等老朽化している箇所が多く、今後、設備の更新を検討していく必要がある。

Chapter 3　資料

　ここでは、2017 年度における放射線科学センターにおける外部資金獲得状況、共同研究の展開、大学院生等の人材育成、センター開催の研究会及びシンポジウム、教育活動、機構外委員会等活動、社会貢献活動等の現状を具体的な資料として年度毎に示す。また、2017 年度の放射線科学センター名簿を示した。

1.　外部資金導入状況

1.1　科学研究費補助金

(1)　基盤研究(A)

研究課題名：多種の長寿命放射性核種を超高感度で検出可能な加速器質量分析法の開発

研究代表者：笹公一

研究分担者：松村宏

(2)　基盤研究(C)

研究課題名：He ビームを用いた医療用 Mo-99/Tc-99m の製造技術にかかる基礎研究

研究代表者　萩原雅之

(3)　基盤研究(C)

研究課題名：低エネルギー荷電粒子の核反応による誘導放射能の系統的測定とデータベース化

研究代表者　八島浩(京大炉)

研究分担者　萩原雅之

(4)　基盤研究(C)

研究課題名：大強度加速器施設の気体中に生成される放射性核種の存在状態と挙動の解明

研究代表者：別所光太郎

1.2　受託研究等

(1)　平成 29 年度放射線安全規制研究推進事業

研究課題名：加速器施設の廃止措置に係わる測定、評価手法の確立

研究代表者：松村　宏

1.3　共同開発研究

(1)　研究課題名：LET 測定に基づく新型宇宙線量計開発とそれを用いた線量測定システムの確立、並びに加速器混合放射線場測定への適用

研究代表者　　佐々木慎一

研究分担者　岸本祐二、齋藤究、高橋一智

1.4　その他

(1)　日米科学技術協力事業（高エネルギー物理学）

研究課題名：大強度陽子ビーム生成標的・窓材料に関する先端的研究

研究代表者：石田卓

研究分担者：萩原雅之

(2)　TIA 連携プログラム探索推進事業「かけはし」

研究課題名：携帯型土壌中セシウム汚染濃度測定器の住民利用および活用に対する検討とリ(7)スクコミュニケーション

研究代表者：岩瀬広

研究分担者: 佐波 俊哉、波戸 芳仁、平山 英夫

2．共同研究等

2.1　大学等との共同研究

2.1.1　共同研究（覚え書き等によるもの）

(1)　研究課題名：はじき出し原子エネルギースペクトルに関する実験研究
共同研究先：日本原子力研究開発機構、東北大学 CYRIC
研究代表者：萩原雅之(KEK)、岩元洋介(JAEA)、渡部浩司(CYRIC)

(2)　研究課題名：ワイドバンドギャップ半導体を用いた高効率放射線検出器の高性能化に関する研究
共同研究先：日本原子力研究開発機構
研究代表者：田中真伸、大島武
メンバー：萩原雅之

(3)　研究課題名：核反応により生成する微量放射性核種の放射能分析法に関する研究
共同研究先：筑波大学
研究代表者：松村宏

(4)　研究課題名：：簡易な放射性ストロンチウム放射能測定装置の校正と不確かさに関する研究
共同研究先：産業技術総合研究所
研究代表者：佐々木慎一
研究分担者：松村宏，岩瀬広，近藤健次郎，平山英夫

(5)　研究課題名：加速器及び原子力施設における放射線業務従事者の眼の水晶体等末端部被ばく線量評価とその低減に関する研究
共同研究先：日本原子力研究開発機構
研究代表者：萩原雅之
研究分担者：佐波俊哉

(6)　研究課題名：位置有感生体等価比例係数箱（PS-TEPC）による宇宙ステーション内での線量等量計測技術の確立
共同研究先：JAXA
研究代表者：佐々木慎一、坂下哲也
研究分担者：岸本祐二、齋藤究、高橋一智

(7)　研究課題名：希ガスシンチレータの研究
共同研究先：横浜国大
研究代表者：中村正吾、佐々木慎一
メンバー：齋藤究、三原智（素核研）

2.1.2　大学、研究所等との共同研究（2.1.1 以外）

(1)　研究課題名：CERN/CHARM施設での24GeV陽子からの二次中性子の遮蔽透過実験
共同研究先：CERN
研究代表者：Robert Froeschl(CERN)、佐波俊哉(KEK)
メンバー　萩原雅之、山崎寛仁

(2)　研究課題名：ILC用ニオブ加速空洞の電解研磨に関する基礎的研究
共同研究先：国立大学法人岩手大学
研究代表者：文珠四郎秀昭

2.2　民間との共同研究

(1)　研究課題名：高エネルギー加速器を用いた生成粒子と遮蔽透過の測定
　共同研究先：清水建設株式会社
　研究代表者：佐波俊哉
　研究分担者：山崎寛仁、萩原雅之

(2)　研究課題名：放射線発生装置使用施設に係る放射化機構の研究及びクリアランス等の検認技術の開発
　共同研究先：東京ニュークリア・サービス株式会社
　研究代表者：波戸芳仁
　研究分担者：三浦太一、松村　宏

(3)　研究課題名：研究用加速器の放射化量の測定及び評価手法の開発
　共同研究先：（株）日本環境調査研究所
　研究代表者：松村宏
　研究分担者：豊田晃弘、桝本和義

(4)　研究課題名：超伝導加速空洞表面処理技術の開発
　共同研究先：マルイ鍍金工業　千葉.柏工場、姫路工場、開発研究施設
　研究代表者：早野仁
　メンバー：文珠四郎秀昭、沢辺元明

2.3　共同利用研究（施設利用）

(1)　研究課題名：軽核破砕片生成二重微分断面積の測定
　共同研究先：放射線医学総合研究所, 九州大学
　研究代表者：佐波俊哉

(2)　研究課題名：重粒子によるしきいエネルギー付近の核反応に関する研究
　共同研究先：放射線医学総合研究所
　研究代表者：萩原雅之
　研究分担者：佐波俊哉

(3)　研究課題名：中性子線量計の単色中性子に対する応答評価
　共同研究先：日本原子力研究開発機構
　研究代表者：萩原雅之
　研究分担者：佐波俊哉、飯島和彦

(4)　研究課題名：He ビームを用いた医療用 RI の製造技術にかかる基礎研究
　共同研究先：放射線医学総合研究所
　研究代表者：萩原雅之
　研究分担者：佐波俊哉

(5)　研究課題名：粒子・重イオン輸送計算コード PHITS の高度化に関する研究(III)
　共同研究先：(独)日本原子力研究開発機構、(財)高度情報科学技術研究機構
　研究代表者：佐藤 達彦
　研究分担者：佐藤 達彦、高橋 史明、岩元 洋介、橋本 慎太郎、野田 秀作、小川 達彦、松田 規宏、佐々木 慎一、波戸 芳仁、岩瀬 広、萩原 雅之、二宮 博正、仁井田 浩二、武田 和雄

3. 大学院生等の人材育成

3.1 学位論文の指導（総合研究大学院大学）

(1) 総研大博士後期課程
博士：Ngan Tran
指導教員：佐々木慎一、佐波俊哉、岸本祐二

(2) 総研大博士後期課程
博士：橋詰拓弥
指導教員：佐波俊哉、萩原雅之、文珠四朗秀昭

(3) 総研大博士後期課程
博士：竹内章博
指導教員：齋藤究、岸本祐二、佐波俊哉

3.2 学位論文等の指導（他大学）

(1) 九州大学
研究課題：陽子入射による二次荷電粒子生成二重微分断面積の測定
修士：山口雄二
指導教員：佐波俊哉

(2) 九州大学
研究課題：高エネルギー二次粒子の遮蔽透過実験
博士：李恩智
指導教員：佐波俊哉、萩原雅之、山崎寛仁

(3) モロッコ国 Sultan Moulay Slimate大学大学院
博士：Brady Hamza：PHITSを用いた高線量率小線源治療モデルの研究
指導教員：岩瀬広

3.3 学術指導

学術指導題目：福島第一原子力発電所における放射線管理に関わる学術指導
学術指導対象：東京電力ホールディングス株式会社
学術指導代表者：波戸 芳仁
学術指導分担者：平山 英夫

4. センター開催の研究会及びシンポジウム

4.1 第 24 回 EGS4 研究会

主催：高エネルギー加速器研究機構放射線科学センター
開催場所：高エネルギー加速器研究機構（茨城県つくば市）
開催期間：2017 年 8 月 6 日～8 月 8 日
出版物：KEK Proceedings 2017-4, “Proceedings of the Twenty-Fourth EGS Users' Meeting in Japan”.
参加者数：36 名

4.2　第 19 回「環境放射能」研究会

主催：KEK 放射線科学センター、日本放射化学会 α 放射体・環境放射能分科会

共催：日本原子力学会保健物理・環境科学部会、日本放射線影響学会、日本放射線安全管理学会

開催期間および場所：2018 年 3 月 13 日～3 月 15 日、KEK つくばキャンパス

参加者：188 名

プロシーディング編集：(Edited) K. Bessho, K. Tagami, K. Takamiya, T. Miura : "Proceedings of the 18th Workshop on Environmental Radioactivity", KEK Proceedings in press.

4.3　The Second International Symposium on Radiation Detectors and Their Users (ISRD2018)

主催：ISRD2018 組織委員会

共催：日本学術振興会 186 委員会、日本原子力学会、応用物理学会

開催日時：2018 年 1 月 22 日（火）-24 日（金）

開催場所：高エネルギー加速器研究機構（KEK）　研究本館 小林ホール

参加者：117 名

5. 教育活動

5.1　総合研究大学院大学

(1)　総研大共通専門科目加速器概論 II／同演習 II（"Radiation Interaction and Detection"）
(2)　加速器科学専攻「加速器工学特別演習」（学位論文指導）
(3)　総研大共通科目放射線物理学
(4)　KEK スチューデント・デイ 2017　実行委員

5.2　非常勤講師等

(1)　首都大学東京・大学院人間健康科学研究科非常勤講師
(2)　首都大学東京健康福祉学部非常勤講師
(3)　成蹊大学大学理工学研究科非常勤講師
(4)　中央大学　理工学部非常勤講師

6.　機構外活動・社会貢献活動等

6.1　外部委員会等委員

(1)　J-PARC High-p /COMET 特別部会委員
(2)　J-PARC MLF 過酷事象 TF 委員
(3)　J-PARC 放射線安全評価委員会委員
(4)　J-PARC 放射線安全委員会委員
(5)　J-PARC FIFC (Facilities Impact and Finance Committee) 委員
(6)　東京大学大学院工学系研究科原子力専攻原子力機構施設利用共同研究委員会委員
(7)　つくば市放射線懇話会委員

(8) 筑波放射線安全交流会 会長
(9) 放射線安全フォーラム理事
(10) つくば市環境都市推進委員会委員
(11) 放射線医学総合研究所共用施設運営委員会委員
(12) 京都大学複合原子力科学研究所共同利用審査委員

6.2 学会等委員

(1) 日本原子力学会核データ部会委員
(2) 国際会議「放射線検出器とその応用」 (ISRD2016) 組織委員会委員長、プログラム委員会委員、現地委員会委員長
(3) 応用物理学会放射線分科会幹事会幹事
(4) 日本原子力学会放射線工学部会幹事
(5) 核データ測定戦略検討 WG 委員
(6) 日本原子力学会遮蔽計算の応用技術」研究専門委員会委員,
(7) 日本原子力学会標準委員会遮蔽分科会委員遮蔽分科会委員
(8) 日本原子力学会放射線工学部会・部会長, 代議員
(9) ISORD-9, International Symposium on Radiation Safety and Detection Technology 組織委員会委員
(10) 日本保健物理学会　放射線防護標準化委員会委員
(11) 日本放射線安全管理学会顧問
(12) 日本放射線安全管理学会「放射線施設廃止の確認手順と放射能測定マニュアル」改訂専門委員会委員長
(13) 日本アイソトープ協会安全取扱部会本部運営委員
(14) 日本アイソトープ協会安全取扱部会法令検討委員長
(15) 日本学術会議総合工学委員会原子力事故対応分科会“原発事故による環境汚染調査に関する検討小委員会”委員
(16) 日本分光学会　代議員
(17) 大学等放射線施設協議会 理事、常議員
(18) 大学等環境安全協議会　監事

6.3 講習会等

(1) 除染情報プラザ登録専門家派遣
(2) マレーシア原子力研究所 KEK 総研大原子力機構共催 PHITS 講習会

6.4　社会貢献等

(1) 福島支援：福島県飯舘村の復興に向けた放射線測定支援
(2) 福島支援：福島県内水面水産試験場：水産物の試験研究にかかわる放射能測定協力
(3) 福島支援：福島県林業研究センター：樹木、果樹、土壌等の放射能測定協力
(4) 福島支援：除染情報プラザ登録専門家派遣

7.　受賞記録

(1) 優秀ポスター賞 (日本保険物理学会第 50 回研究発表会・日本放射線安全管理学会第 16 回学術大会合同大会)

発表題目：超伝導加速空洞からの暗電流に起因する中性子・γ線測定
受賞者：大山隆弘、佐波俊哉、飯島和彦、山本康史、町田武、根本斉

(2) ポスター賞 (KEK スチューデント・デイ 2017)
受賞者：橋詰拓弥

8. 放射線科学センター名簿

波戸　芳仁*	吉田　剛	藤原　一哉[a]
三浦　太一	平　雅文	西川　功一[a]
文珠四郎　秀昭	穂積　憲一	近藤　健次郎[c]
佐波　俊哉	中村　一[#]	平山　英夫[c]
沼尻　正晴[#]	高原　伸一	佐藤　充[b]
松村　宏	飯島　和彦	伴　秀一[e]
別所　光太郎[#]	高橋　一智[#]	桝本　和義[e]
山崎　寛仁[#]	豊田　晃弘	道川　太一[f]
齋藤　究[#]	古宮　綾	Tran Ngan[d]
萩原　雅之[#]	大山　隆弘	橋詰　拓弥[d]
岩瀬　広	長畔　誠司[#]	竹内　章博[d]
岸本　祐二	沢辺　元明[a]	豊島　規子[b]

(*) 放射線科学センター長
(#) J-PARC センター所属
(a) 特別技術専門職
(b) 研究支援員
(c) ダイヤモンドフェロー
(d) 総合研究大学院大学
(e) 研究員
(f) 協力研究員

Chapter 4 Publication List

1. Papers （2017.1.1～2017.12.31）

(1) K. Terada, A. Sato, K. Ninomiya, Y. Kawashima, K. Shimomura, G. Yoshida, Y. Kawai, T. Osawa, S. Tachibana : "Non-destructive elemental analysis of a carbonaceous chondrite with direct current Muon beam at MuSIC", Scientific Repots **7** (2017) 15478.

(2) S. Hosoya, K. Sasa, T. Matsunaka, T. Takahashi, M. Matsumura, H. Matsumura, M. Sundquist, M. Stodola, K. Sueki : "Optimization of a ΔE-E detector for ^{41}Ca AMS", Nucl. Instrum. Meth. Phys. Res., B**406** (2017) 268-271.

(3) M. Kumagai, K. Sodeyama, Y. Sakamoto, A. Toyoda, H. Matsumura, T. Ebara, T. Yamashita, K. Masumoto : "Activation Reduction Method for a Concrete Wall in a Cyclotron Vault", J. Radiat. Protect. Res. **42** (2017) 141-145.

(4) S. Nakamura, S. Imamichi, K. Masumoto, M. Ito, A. Wakita, H. Okamoto, S. Nishioka, K. Iijima, K. Kobayashi, Y. Abe, H. Igaki, K. Kurita, T. Nishio, M. Masutani, JItami : "Evaluation of radioactivity in the bodies of mice induced by neutron exposure from an epi-thermal neutron source of an accelerator-based boron neutron capture therapy system", Proc. Jpn. Acad. Ser. **B93** (2017) 821-831.

(5) S. Katsuta, N. Kanaya, K. Bessho, H. Monjushiro : "Adsorption behavior of trace beryllium (II) onto metal oxide nanoparticles dispersed in water", Int. J. Chem. **9** (2017) 62-70.

(6) T. Hashizume, T. Okazaki, T. Sanami, M. Hagiwara, H. Monjushiro, H. Hayashi, I. Kobayashi : "Uncertainty evaluation of fluorescent nuclear track detectors (FNTDs) for neutron dose measurements", Radiat. Meas. **106** (2017) 602-606.

(7) T. Matsumoto, A. Masuda, H. Harano, Y. Shikaze, Y. Tanimura, H. Seito, S. Kurashima, S. Nishino, H. Yoshitomi, J. Nishiyama, M. Hagiwara, Y. Unno and M. Yoshizawa : "Development of the high-energy neutron fluence rate standard field in Japan with a peak energy of 45 MeV using the 7Li(p,n)7Be reaction at TIARA", J. Nucl. Sci. Technol. **54** (2017) 529-538.

(8) A. Masuda, T. Matsumoto, Y. Iwamoto, M. Hagiwara, D. Satoh, T. Sato, H. Iwase, H. Yashima, Y. Nakane, J. Nishiyama, T. Shima, A. Tamii, K. Hatanaka, H. Harano and T. Nakamura : “Applicability of the two-angle differential method to response measurement of neutron-sensitive devices at the RCNP high-energy neutron facility”, Nucl. Instrum. Meth. **A849** (2017) 94-101.

(9) S. Araki, Y. Watanabe, M. Kitajima, H. Sadamatsu, K. Nakano, T. Kin, Y. Iwamoto, D. Satoh, M. Hagiwara, H. Yashima and T. Shima : “Systematic measurement of double-differential neutron production cross sections for deuteron-induced reactions at an incident energy of 102 MeV”, Nucl. Instrum. Meth. **A842** (2017) 62-70.

(10) Q. He, J. Ai, T. Ishikawa, T. Li, L. Ma, J. Ma, M. Miyabe, N. Muramatsu, H. Shimizu, Y. Tsuchikawa, Y. Xiang, H.Yamazaki, and Y. Zhang : “A study of event mixing for two-pion Bose–Einstein correlations in the $\gamma p \rightarrow \pi^0\pi^0$ p reaction”, Prog. Theor. Exp. Phys. (2017) 033D02 .

(11) T. Ishikawa, H. Fujimura, H. Fukasawa, R. Hashimoto, Q. He, Y. Honda, T. Iwata, S. Kaida, H. Kanda, J. Kasagi, A. Kawano, S. Kuwasaki, K. Maeda, S. Masumoto, M. Miyabe, F. Miyahara, K. Mochizuki, N. Muramatsu, A. Nakamura, K. Nawa, S. Ogushi, Y. Okada, K. Okamura, Y. Onodera, K. Ozawa, Y. Sakamoto, M. Sato, H. Shimizu, H. Sugai, K. Suzuki, Y. Tajima, Y. Taniguchi, Y. Tsuchikawa, H. Yamazaki, R. Yamazaki, H.Y. Yoshida : “First measurement of coherent double neutral-pion photoproduction on the deuteron at incident energies below 0.9 GeV”, Phys. Lett. **B772** (2017) 398-402.

(12) T. Ishikawa, Y. Takeda, Y. Honda, Y. Inoue, H. Kanda, S. Kido, Y. Matsumura, M. Miyabe, I. Nagasawa, H. Shimizu, T. Takeda, A.O. Tokiyasu, Y. Tsuchikawa, H. Yamazaki : “Charge-to-time converting leading-edge discriminator for plastic-scintillator signals”, Nucl. Instr. and Meth. **A875** (2017) 193-200.

2. Publication in Japanese（2017.1.1～2017.12.31）

(1) 八島浩, 萩原雅之, 佐波俊哉, 米内俊祐 :“重粒子によるしきいエネルギー付近の核反応に関する研究”, 平成28年度放医研サイクロトロン利用報告書, QST-M-6.

(2) 山口雄司, 佐波俊哉, 魚住祐介, 古場祐介 :“核破砕片生成二重微分断面積の測定”, 平成28年度放医研サイクロトロン利用報告書, QST-M-6.

(3) 寺沢和洋, 岸本祐二, 佐々木慎一, 高橋一智, 俵裕子, 齋藤究, 身内賢太朗, 永松愛子, 勝田真登, 桝田大輔, 中村裕広, 松本晴久, 込山立人, 布施哲人, 島田健, 西啓輔, 谷森達, 窪秀利, 北村尚, 寺門康男, 桑田金佳, 河本泰成 :“位置有感比例計数管の重イオンに対する応答”, 平成28年度放射線医学総合研究所・重粒子線がん治療装置等共同利用研究報告書.

3. Proceedings （2017.1.1～2017.12.31）

(1) C. Theis, P. Carbonez, E. Feldbaumer, D. Forkel-Wirth, L. Jaegerhofer, M. Pangallo, D. Perrin, C. Urscheler, S. Roesler, H. Vincke, M. Widorski, Y. Iwamoto, M. Hagiwara, D. Satoh, H. Iwase, H. Yashima, T. Matsumoto, A. Masuda, J. Nishiyama, H. Harano, T. Itoga, T. Nakamura, T. Sato, Y. Nakane, H. Nakashima, Y. Sakamoto, S. Taniguchi, N. Nakao, A. Tamii, T. Shima and K. Hatanaka : “Characterization of the PTW 34031 ionization chamber (PMI) at RCNP with high energy neutrons ranging from 100 – 392 MeV”, EPJ Web Conf., **153** (2017) 08018.

(2) T. Sanami, Y. Yamaguchi, Y. Uozumi, M. Hagiwara and Y. Koba : “Double differential cross section for light mass fragment production on tens of MeV proton, deuteron, helium and carbon induced reactions”, EPJ Web Conf., **146** (2017) 11007.

(3) Y. Nakane, Y. Iwamoto, M. Hagiwara, H. Iwase, T. Sato, A. Masuda, T. Matsumoto, T. Nunomiya, H. Yashima, D. Satoh, H. Nakashima, T. Shima, A. Tamii, K. Hatanaka and T. Nakamura : “Dose Measurements through the Concrete and Iron Shields under the 100 to 400 MeV Quasi-Monoenergetic Neutron Field (at RCNP, Osaka Univ.)”, EPJ Web Conf., **153** (2017) 08022.

(4) R. Muto, K. Agari, K. Aoki, K. Bessho, M. Hagiwara, E. Hirose, M. Ieiri, R. Iwasaki, Y. Katoh, J.-I. Kitagawa, M. Minakawa, Y. Morino, K. Saito, Y. Sato, S. Y. Sawada, Y. Shirakabe, Y.

Suzuki, H. Takahashi, K. Tanaka, A. Toyoda, H. Watanabe and Y. Yamanoi : "Monitoring System for the Gold Target by Radiation Detectors in Hadron Experimental Facility at J-PARC", EPJ Web Conf. **153** (2017) 07004.

(5) T. Matsumoto, A. Masuda, J. Nishiyama, H. Iwase, Y. Iwamoto, D. Satoh, M. Hagiwara, H. Yashima, T. Shima, T. Nakamura, H. Harano, A. Tamii and K. Hatanaka : "Shielding experiments of concrete and iron for the 244 MeV and 387 MeV quasi-mono energetic neutrons using a Bonner sphere spectrometer (at RCNP, Osaka Univ.)", EPJ Web Conf. **153** (2017) 08016.

(6) V. Mares, S. Trinkl, Y. Iwamoto, A. Masuda, T. Matsumoto, M. Hagiwara, D. Satoh, H. Yashima, T. Shima and T. Nakamura : "Neutron spectrometry and dosimetry in 100 and 300 MeV quasi-mono-energetic neutron field at RCNP, Osaka University, Japan", EPJ Web Conf., **153** (2017) 08020.

(7) Y. Iwamoto, T. Sato, D. Satoh, M. Hagiwara, H. Yashima, A. Masuda, T. Matsumoto, H. Iwase, T. Shima and T. Nakamura : "Experimental analysis of neutron and background gamma-ray energy spectra of 80-400 MeV ^{7}Li(p,n) reactions under the quasi-monoenergetic neutron field at RCNP", Osaka University, EPJ Web Conf. **153**(2017) 08019.

(8) M. Hagiwara, H. Iwase, Y. Iwamoto, D. Satoh, T. Matsumoto, A. Masuda, H. Yashima, Y. Nakane, H. Nakashima, Y. Sakamoto, T. Shima, A. Tamii, K. Hatanaka and T. Nakamura : "Shielding experiments of concrete and iron for the 244 MeV and 387 MeV quasi-mono energetic neutrons using an organic scintillator (at RCNP, Osaka Univ.)", EPJ Web Conf. **153** (2017) 08021.

(9) S. Araki, Y. Watanabe, M. Kitajima, H. Sadamatsu, K. Nakano, T. Kin, Y. Iwamoto, D. Satoh, M. Hagiwara, H. Yashima and T. Shima : "Neutron production in deuteron-induced reactions on Li, Be, and C at an incident energy of 102 MeV", EPJ Web Conf. **146** (2017) 11027.

(10) T. Itoga, H. Nakashima, T. Sanami, Y. Namito, Y. Kirihara, S. Miyamoto, A. Takemoto, M. Yamaguchi, Y. Asano : "Measurement of neutron energy spectra for Eγ=23.1 and 26.6 MeV mono-energetic photon induced reaction on ^{nat}C using laser electron photon beam at

NewSUBARU", EPJ Web Conf. **153** (2017) 07010.

(11) Y. Kirihara, T. Itoga, T. Sanami, H. Nakashima, Y. Namito, S. Miyamoto, A. Takemoto, M. Yamaguchi, Y. Asano : "Measurement of neutron spectra for photonuclear reaction with linearly polarized photons", EPJ Web Conf. **153** (2017) 01019.

(12) H. Matsumura, H. Nakamura, A. Toyoda, K. Hozumi, H. Sakai, K. Enami, T. Furuya, K. Shinoe, K. Umemori, K. Haga, S. Sakanaka, M. Sawamura, E. Cenni : "Indirect measurement of field emission electron current from the main superconducting cavities of compact ERL at KEK" EPJ Web Conf. **153** (2017) 07011.

(13) R. Muto, K. Agari, K. Aoki, K. Bessho, M. Hagiwara, E. Hirose, M. Ieiri, R. Iwasaki, Y. Katoh, J. Kitagawa, M. Minakawa, Y. Morino, K. Saito, Y. Sato, S. Sawada, Y. Shirakabe, Y. Suzuki, H. Takahashi, K. Tanaka, A. Toyoda, H. Watanabe, Y. Yamanoi : "Monitoring system for the gold target by radiation detectors in Hadron Experimental Facility at J-PARC", EPJ Web Conf., **153** (2017) 07004.

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4. Reports （2017.1.1～2017.12.31）

(1) G. Yoshida, K. Ninomiya, M. Inagaki, T. U. Ito, W. Higemoto, P. Strasser, N. Kawamura, K. Shimomura, Y. Miyake, T. Miura, M. K. Kubo, A. Shinohara, “Chemical Environmental Effect on Negative Muon Capture by an Atom Targeted to Gaseous Simple Carbon Oxides: CO, CO_2”, MLF Annual Report 2016, Research and Development Highlights, (2017) 57-59.

(2) 飯本武志, 木下哲一, 坂口綾, 杉原真司, 　高宮幸一, 田上恵子, 長尾誠也, 別所光太郎, 松村宏, 三浦太一, 安田健一郎, “東京電力福島第一原子力発電所事故以降の５年間における環境放射能研究のとりまとめ －「環境放射能」研究会における発表を中心に －”, 　KEK Report 2016-3　(ISBN 978-4-9907232-9-3)　(2017).

5. Presentation at Conferences（2017.4.1～2018.3.31）

5.1 International Conference

(1) The 14th International Conference on Muon Spin Rotation, Relaxation and Resonance (μSR2017), 25-30th June, 2017, Sapporo, Hokkaido, Japan.

1) G. Yoshida, K. Ninomiya, M. Inagaki, M. Toyoda, J. Aoki, N. Kawamura, Y. Miyake and A. Shinohara : "Development of muonic atom beam generation system and the first assessment using intense negative muon beam of J-PARC MUSE".

(2) 4th International Workshop on Accelerator Radiation Induced Activation (ARIA'17), Lund, Sweden, May 22-24, 2017.

1) K. Masumoto et al. : "Present status of accelerator decommissioning project in Japan".
2) A. Toyoda et al. : "Evaluation of radioactivity induced in various components of PET-cyclotron".
3) H. Matsumura, A. Toyoda, K. Masumoto, G. Yoshida, T. Yagishita, T. Nakabayashi, H. Sasaki, K. Matsumura, Y. Yamaya and Y. Miyazaki : "In-situ determination of residual specific activity in activated concrete walls of a PET-cyclotron room".

(3) International Technical Safety Forum 2017 (ITSF 2017), September 18-22, 2017, TRIUMF, Vancouver, Canada.

1) K. Bessho, Y. Makida, M. Ukai, K. Kasuya : "Safety guidelines on liquid hydrogen target systems for particle and nuclear physics experiments at J-PARC".

(4) SRF2017 18th Int. Conf. on RF Superconductivity (SRF'17), Lanzhou, China, July 17-21, 2017.

1) K.N. Nii, V. Chouhan, Y. I. Ida, T. Y. Yamaguchi, H. Hayano, S. Kato, H.Monjushiro, T. Saeki, M. Sawabe : "Nb Single-cell Cavity Vertical Electro-polishing with Ninja Cathode and Evaluation of its Accelerating Gradient".
2) V. Chouhan, Y. Ida, K. Nii, T. Yamaguchi, H. Hayano, S. Kato, H. Monjushiro, T. Saeki, M. Sawabe : "Study on Vertical Electropolising of 9-Cell Niobium Coupon Cavity".
3) V. Chouhan, Y. Ida, K. Nii, T. Yamaguchi, H. Hayano, S. Kato, H. Monjushiro, T. Saeki, M. Sawabe : "Analysis of Niobium Surface and Generated Particles in Vertical Electropolishing of Single-Cell Coupon Cavity".

(5) 27th International Conference on Nuclear Tracks and Radiation Measurements, Strasbourg,

August 28th to September 1st, 2017

1) T. Hashizume, T. Okazaki, T. Sanami, M. Hagiwara, H. Monjushiro, H. Hayashi, I. Kobayashi : "Evaluation of interceptive effect of gamma rays on alpha particle track readout for fluorescent nuclear track detectors".

(6) The Ninth International Symposium On Radiation Safety and Detection Technology (ISORD-9), Nagoya, Japan, 10-14, July 2017.

1) M. Hagiwara, A. Kanai, J. Kitagawa, T. Oyama, S. Nagaguro, H. Nakamura, K. Seki, T. Miura : "Measurements of activation profile in the concrete shield of the J-PARC accelerator tunnel".
2) T. Oyama, H. Iwase, A. Toyoda, N. Yoshihara, T. Sanami："Thermal neutron distribution in the beam line tunnel of the KEK electron/positron injector linac"
3) K.Iijima, T.Ishikawa, Y.Kishimoto, H.Iwase, T.Sanami, S.Sasaki : "Ambient Dose Rate Monitoring at Several Site in Iitate".
4) H. Iwase, Y. Namito, H. Hirayama : "A revised Jenkins formula for electron induced neutron deep penetration calculation".

(7) 2017 IEEE Nuclear Science Symposium and Medical Imaging Conference, Atlanta, U.S.A., 21-28, October, 2017

1) Y. Kishimoto, S. Sasaki, K. Saito, K. Takahashi, K. Terasawa, K. Miuchi, A. Nagamatsu, M. Katsuta, T. Fuse, H. Matsumoto, T. Tanimori, H. Kubo, Y. Uchihori, H. Kitamura : "The Initial Results of Experiment on board the International Space Station using Position Sensitive Tissue-Equivalent Proportional Chamber 'PS-TEPC'"

(8) The Second International Symposium on Radiation Detectors and Their Uses (ISRD2018), Tsukuba, Japan, 22-24, January 2018

1) A. Takeuchi, K. Saito, Y. Kishimoto, T. Oyama, T. Sanami : "Measurement of scintillation and ionization in helium mixed with xenon".
2) Y. Kishimoto, S. Sasaki, K. Saito, K. Takahashi, K. Terasawa, K. Miuchi, A. Nagamatsu, M. Katsuta, T. Fuse, H. Matsumoto, T. Tanimori, H. Kubo, Y. Uchihori, H. Kitamura : "Experiment on board the International Space Station using Position Sensitive Tissue-Equivalent Proportional Chamber 'PS-TEPC'".
3) T. Hashizume, T. Okazaki, T. Sanami, M. Hagiwara, H. Monjushiro, H. Hayashi, I.

Kobayashi : “Gamma ray effect on reading alpha particle tracks using fluorescent nuclear track detectors (FNTDs) ～Track angle dependency～”.

4) Y.Yamaguchi, T. Sanami, Y. Koba, Y. Uozumi : “Spectrum measurement down to 1 MeV/u particles with hydrogen-identification using bragg curve counter”.

5) E.J. Lee, N. Shigyo, T.Sanami, T. Kajimoto, N. Matsufuji : “Cross comparison on neutron spectra obtained by time-of-flight and unfolding methods with liquid organic scintillator”.

6) Ngan N. T. Tran, S.Sasaki, T. Sanami, Y. Kishimoto, E. Shibamura : “Some Properties of Plastic Scintillators to Construct a LET Spectrometer”.

7) T.Sanami, R.Froeschl, E.Iliopoulou, S.Roesler, A.Infantino, M.Brugger, T.Kajimoto, N.Nakao, E.J.Lee, N.Shigyo, H. Yashima, T.Oyama, M.Hagiwara, H.Yamazaki : “Neutron spectrum measurement for 24 GeV/c proton on thick copper target at CERN/CHARM”.

8) T. Okazaki, T. Hashizume, Y. Hashimoto, M. Shirakata, H. Nakamura, H. Yamazaki, V. LE Cruz, C. Wei Hsin, H. Hayashi, I. Kobayashi : “Evaluation of dose response characteristics of a small type optically stimulated luminescence dosimeter irradiated with more than 10 Gy”.

5.2 Invited talk

(1) 第4回粒子線治療施設運転・維持管理ワークショップ (群馬大学昭和キャンパス, 2017年6月9日)

1) 別所光太郎 : ”J-PARC における安全の取り組み”.

5.3 Domestic Conference

(1) 日本原子力学会　2017年秋の大会 (北海道大学)　2016年9月13日～15日

1) 李恩智, 執行信寛, 梶本剛, 佐波俊哉, 中尾徳晶, 萩原雅之, 八島浩, 山崎寛仁, R. Froeschl, M. Brugger : “CERN/CHARM における 24GeV 陽子を用いた遮蔽実験 (4)中性子エネルギースペクトルの遮蔽体厚さ依存性”.

2) 萩原雅之, 長畔誠司, 西川功一, 金井敦史, 光野冬樹, 渡辺丈晃 : “高エネルギー中性子による放射化ベンチマーク実験”.

3) 定松大樹, 渡辺幸信, 中野敬太, 川瀬頌一郎, 金政浩, 岩元洋介, 佐藤大樹, 萩原雅之, 八島浩, 嶋達志 : “LLFP 安定核種化・短寿命化のための核変換法の開発 (9)リチウムに対する 200MeV 重陽子入射中性子生成二重微分断面積測定”.

4) 橋詰拓弥, 岡崎徹, 佐波俊哉, 萩原雅之, 文珠四郎秀昭, 林裕晃, 小林 育夫 : “蛍光飛跡検出器 (FNTD) の斜め入射した粒子飛跡読み取りにおける γ 線影響”.

5)　平山英夫 : "β 線による 3 ミリメートル線量当量測定用個人線量計の検討"

6)　波戸芳仁, 平山英夫, 杉田武志 : "EGS5 の最近の改良について"

(2)日本原子力学会　2018 年春の年会（大阪大学）　2018年3月26日～28日

1)　萩原雅之, 八島浩, 佐波俊哉, 米内俊祐 : "Heビームを用いた医療用 Mo-99/Tc-99m の製造技術の基礎研究（1）^{96}Zr(α,n) ^{99}Mo 反応の励起関数測定".

2)　橋詰 拓弥, 岡崎 徹, 佐波 俊哉, 萩原 雅之, 林 裕晃, 文珠四郎 秀昭, 小林 育夫 : "蛍光飛跡検出器 (FNTD) の斜め入射した粒子飛跡の読み取りにおけるγ線影響"

3)　大山隆弘, 萩原雅之, 佐波俊哉, 八島浩, 中尾徳晶, 李恩智, R. Froeschl, E. Iliopoulou, S. Roesler, A. Infantino : "CERN/CHARMにおける24 GeV陽子を用いた遮蔽実験（7）金箔放射化法による熱中性子空間分布の測定".

4)　波戸芳仁, 桐原陽一, 佐波俊哉, 糸賀俊朗, 中島宏, 宮本修治, 浅野芳裕 : "巨大共鳴領域で金から発生する光中性子の非等方性パラメータ".

5)　佐波俊哉, 糸賀俊朗, 桐原陽一, 波戸芳仁, 中島宏, 宮本修治, 浅野芳裕 : "光中性子エネルギースペクトルに対する入射光子エネルギー依存性の測定".

6)　中尾徳晶, 佐波俊哉, 八島浩, 萩原雅之, 大山隆弘, 梶本剛, 李恩智, 執行信寛, R. Froeschl, M. Brugger : "CERN/CHARMにおける24GeV陽子を用いた遮蔽実験（5）放射化検出器による遮蔽内中性子減衰分布測定".

7)　李恩智, 執行信寛, 佐波俊哉, 中尾徳晶, 梶本剛, 萩原雅之, 八島浩, 大山隆弘, R. Froeschl, E. Iliopoulou : "CERN/CHARMにおける24GeV陽子を用いた遮蔽実験（6）鉄の遮蔽体厚みに対するエネルギースペクトルと減弱係数".

8)　大山隆弘, 萩原雅之, 佐波俊哉, 八島浩, 中尾徳晶, 李恩智, R. Froeschl, E. Iliopoulou, S. Roesler, A. Infantino : "CERN/CHARMにおける24GeV陽子を用いた遮蔽実験（7）金箔放射化法による熱中性子空間分布の測定".

9)　山口雄司, 荒木優佑, 藤井基晴, 渡邉岳, 佐波俊哉, 松藤成弘, 古場裕介, 岩元洋介, 魚住裕介 : "数百MeV/u α粒子入射における分解反応の研究".

10)　岩瀬 広, 波戸 芳仁, 平山 英夫 : "携帯型土壌中セシウム汚染濃度測定器の開発"

(3) 応用物理学会　第78回応用物理学会秋季学術講演会(福岡国際会議場)　2017年9月5日～8日

1)　竹内章博, 大山隆弘, 岸本祐二, 佐波俊哉, 齋藤究 : "He/Xe混合ガスにおけるシンチレーション測定".

2) 岸本祐二, 佐々木慎一, 高橋一智, 齋藤究, 寺沢和洋, 身内賢太朗, 永松愛子, 勝田真登, 松村祐介, 伊藤裕一, 松本晴久, 森國城, 谷森達, 窪秀利, 内堀幸夫, 北村尚, "位置有感型比例計数箱PS-TEPCの開発：機上試験の初期結果".

(4) 応用物理学会　第65回応用物理学会春季学術講演会(早稲田大学・ベルサール高田馬場) 2018年3月17日～20日

1) 竹内章博, 齋藤究, 大山隆弘, 岸本祐二, 佐波俊哉 : "He/Xe混合ガスにおける電離収量測定".

(5)日本原子力学会北関東支部 若手研究発表会 (東海村産業・情報プラザ（iVil）) 2017年4月14日

1) 橋詰拓弥, 岡崎徹, 佐波俊哉, 萩原雅之, 林裕晃, 文珠四郎秀昭, 小林育夫 : "γ 線照射による FNTD の粒子飛跡読み取りへの影響".
2) 大山隆弘, 岩瀬広, 豊田晃弘, 吉原直人, 佐波俊哉 : "高エネルギー電子加速器施設における空気の放射化：熱中性子空間分布と Ar-41 生成量の測定".

(6) 日本保健物理学会第50回研究発表会/日本放射線安全管理学会第16回学術大会合同大会, ホルトホール大分, 大分県大分市, 2017年6月28日～30日

1) 橋詰拓弥, 岡崎徹, 佐波俊哉, 萩原雅之, 林裕晃, 文珠四郎秀昭, 小林育夫 : "γ 線照射による FNTD の粒子飛跡画像への影響".
2) 豊田晃弘, 桝本和義, 松村宏, 柳下俊行, 中林貴之, 佐々木博之, 宮崎吉春 : "加速器室放射化コンクリート壁中の放射性核種の非破壊放射能濃度測定法の検討(1)－サイクロトロン室の廃止措置のためにー".
3) 中林貴之, 柳下俊行, 佐々木博之, 松村一博, 山谷義幸, 豊田晃弘, 松村宏, 桝本和義, 宮崎吉春 : "加速器室放射化コンクリート壁中の放射性核種の非破壊放射能濃度測定法の検討(2)－サイクロトロン室の廃止措置のためにー".
4) 熊谷雅章, 袖山康祐, 山下大地, 坂本幸夫, 桝本和義, 松村 宏, 豊田晃弘 : "構造体コンクリート向け放射化低減用中性子遮蔽体の性能評価について".
5) 延原文祥, 豊田晃弘, 中村一, 桝本和義, 坂間稔, 佐瀬卓也 : "自己遮蔽体有り PET 用サイクロトロンの中性子束評価".
6) 桝本和義, 遠藤正志, 古澤哲, 松村一 : "放射線施設廃止マニュアルの改訂状況".
7) 武田智津子, 畔柳誠, 桝本和義, 豊田晃弘 : "イメージングプレートを用いた花崗岩中放射能分布の解析".

8) 中村 一, 萩原 雅之, 長畔 誠司, 豊田 晃弘, 吉富 寛 : “J-PARC 陽子シンクロトロンのトンネル内でのファントムを用いた被ばく量の測定”.

9) 高橋 一智, 萩原 雅之, 佐藤 浩一, 春日井 好己, 光野 冬樹, 三浦 太一 : “大強度陽子加速器施設における水銀の放射性同位体の放射線管理”.

10) 大山隆弘, 佐波俊哉, 飯島和彦, 山本康史, 町田武, 根本斉 : “超伝導加速空洞からの暗電流に起因する中性子・γ線測定”.

(7) 日本放射線安全管理学会 12 月シンポジウム，東京大学農学部弥生講堂一条ホール，東京都文京区，2017 年 11 月 30 日～12 月 1 日

1) 桝本和義 : “規制対象施設・規制対象範囲の明確化”

2) 松村 宏 : “非汚染・非放射化の評価手順の検討”

(8) 日本物理学会 2017年秋季大会（宇都宮大学峰キャンパス）2017年9月12日～15日

1) 石川貴嗣, 藤村寿子, 橋本亮, 何慶華, 甲斐田俊, 神田浩樹, 前田和茂, 桝本新一, 宮部学, 村松憲仁, 中村聡彦, 小沢恭一郎, 清水肇, 鈴木耕拓, 土川雄介, 山崎寛仁, 山崎竜司, 他 FOREST collaboration : “$\gamma d \rightarrow \pi^0\pi^0 d$ 反応によるダイバリオンの研究 II”.

(9) 2017 日本放射化学会年会・第 61 回放射化学討論会，筑波大学筑波キャンパス，茨城県つくば市，2017 年 9 月 6 日～9 月 8 日

1) 別所光太郎，松村宏，三浦太一，飯本武志，木下哲一，坂口綾，杉原真司，高宮幸一，田上恵子，長尾誠也，安田健一郎，“「環境放射能」研究会における東京電力福島第一原子力発電所事故関連研究報告のとりまとめ”

(10) 第14回加速器学会年会 (北海道大学クラーク会館， 学術交流会館，2017年8月1日～3日)

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2) T. Hashizume, T. Okazaki, T. Sanami, M. Hagiwara, H. Monjushiro, H. Hayashi, I. Kobayashi : “Research of fluorescent nuclear track detectors for practical use as personal neutron dosimeters - Evaluation of interceptive effect of gamma rays on reading alpha particle tracks - “.

(13) 筑波放射線安全交流会 総会・講演会（筑波交流センター）　2017年7月11日

1) 岸本祐二 : “宇宙線による被ばくと線量計測”.

(14) 放射線科学とその応用第186委員会第24回研究会（東京大学）　2017年7月31日

1）岸本祐二 : “位置有感型比例計数箱PS-TEPCの開発”

(15) 第14回MPGD研究会（岩手大学）　2017年12月2日

1) 岸本祐二 : “位置有感型比例計数箱PS-TEPCによる国際宇宙ステーションでの動作実証試験”.

(16) 平成28年度放射線医学総合研究所・重粒子線がん治療装置等共同利用研究成果発表会（ホテルポートプラザちば）　2017年4月17日～18日

1) 寺沢和洋, 岸本祐二, 佐々木慎一, 高橋一智, 俵裕子, 齋藤究, 身内賢太朗, 永松愛子, 勝田真登, 桝田大輔, 中村裕広, 松本晴久, 込山立人, 布施哲人, 島田健, 西啓輔, 谷森達, 窪秀利, 北村尚, 寺門康男, 桑田金佳, 河本泰成 : “位置有感比例計数管の重イオンに対する応答”.

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(18) 第 24 回 EGS 研究会(KEK, 8/6-8)

1) 波戸芳仁, 平山英夫 ："EGS5 用ベータ線ライブラリの続報".

(19) 第32回 固体飛跡検出器研究会, 2018年3月29日(木)・30日(金), 量子科学技術研究開発機構 関西光科学研究所・多目的ホール

1) 橋詰拓弥, 岡崎徹, 佐波俊哉, 萩原雅之, 林裕晃, 文珠四郎秀昭, 小林育夫 ："蛍光飛跡検出器 FNTD の中性子測定に向けた飛跡検出能の評価".

(20) 第 19 回「環境放射能」研究会, 2018 年 3 月 13 日～15 日, 高エネルギー加速器研究機構（茨城県つくば市）

1) 吉田剛, 松村宏, 桝本和義, 三浦太一, 豊田晃弘, 中村一, 別所光太郎 ："放射線安全規制研究推進事業「加速器施設の廃止措置に係わる放射化物の測定, 評価手法の確立」の活動について".

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