CO12-1 Preliminary Experiments of Coherent Cherenkov Radiation Matched to the Circular Plane at KURRI-LINAC

N. Sei, T. Takahashi[1]

Research Institute for Measurement and Analytical Instrumentation, National Institute of Advanced Industrial Science and Technology
[1]Research Reactor Institute, Kyoto University

INTRODUCTION: The coherent Cherenkov radiation (CCR) is one of the intent light sources in the terahertz (THz) region. However, it is difficult to concentrate the CCR beam efficiently because the CCR propagates in a conical shape. Then, one of the author proposed a new method for matching the wave front of the CCR beam to the basal plane of a hollow conical dielectric by turning the apex of the hollow conical dielectric toward the incident electron beam [1]. When the angle between the generatrix and the rotation axis is half of the radiation angle of the CCR generated on the inner surface of the hollow conical dielectric, the CCR undergoes total reflection from the conical surface and the CCR phase is matched to the basal plane. We challenge to demonstrate the intent THz wave source using the CCR matched to a circular plane wave (CCR-MCP) at a linac at the Kyoto University Research Reactor Institute (KURRI-LINAC).

EXPERIMENTS: In order to generate the CCR-MCP beam, we use hollow conical dielectrics made of the high density polyethylene (HDPE). The refractive index and the absorption coefficient of the HDPE are 1.53 and 0.02 cm^{-1} at the wavelength of 1 mm. Because the absorption coefficient is low, an intent CCR beam can be expected to use the long hollow conical dielectric. Then, we prepared two hollow conical dielectrics with the lengths of 40 and 80 mm. The inner diameter of the hollow conical dielectrics was 10 mm. The angle between the generatrix and rotation axis was set to approximately 25°, which was a half of the Cherenkov angle for the HDPE. Figure 1 shows the photograph of the hollow conical dielectric used in the experiments. An aluminum collimator, whose length and inner diameter were 150 and 8 mm, was set in front of the hollow conical dielectric not to expose it to the electron beam. A kapton film with a thickness of 50 μm, which was located at 0.4 m from the hollow conical dielectric downstream, was used to separate the CCR beam and the electron beam. Because coherent transition radiation was not generated at the kapton film, it could reduce the background in the THz region. The CCR beam was transported in the vacuum, and observed with a Martin-Puplett-type interferometer and a Si bolometer [2].

RESULTS: We performed experiments using an electron beam with the energy of 42 MeV at the KURRI-LINAC. The beam current passed the aluminum collimator was approximately 35 nA. Figure 2 shows interferograms measured with the Martin-Puplett-type interferometer. It is noted that satellite pulses appeared away from the zero pass difference (ZPD). The distance between the satellite pulse and the ZPD was proportional to the length of the hollow conical dielectric, and the proportionality coefficient was the refractive index of the HDPE. Therefore, these pulses were generated by the interference between the CCR beam and coherent diffraction radiation generating at the exit of the aluminum collimator. The intensity of the CCR beam can be measured by the increment of the base of the interferogram. The measured CCR intensity indicated that the absorption coefficient of the HDPE was 0.02 cm^{-1}. We plan to measure the two-dimensional spatial distribution of the CCR beam and to demonstrate the CCR beam to be the CCR-MCP.

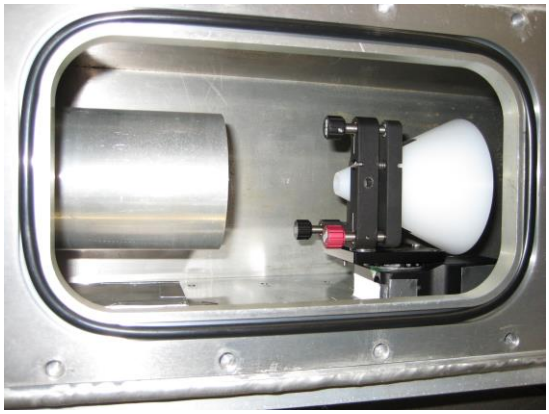


Fig. 1 Photograph of the hollow conical dielectric.

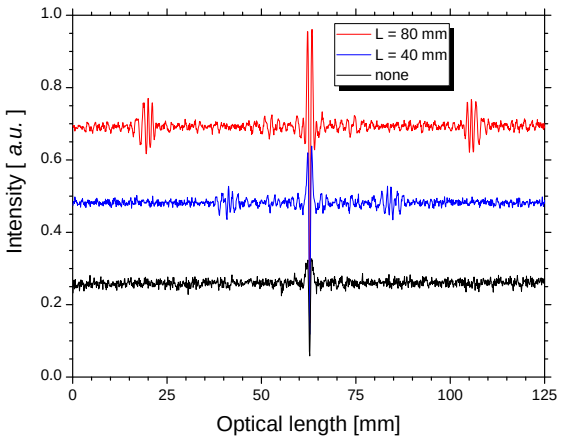


Fig. 2 Interferograms measured with the Martin-Puplett-type interferometer.

REFERENCES:

[1] N. Sei *et al.*, Phys. Lett A, **379** (2015) 2399-2404.
[2] T. Takahashi and K. Takami, Infrared Phys. & Technol. **51** (2008) 363-366.

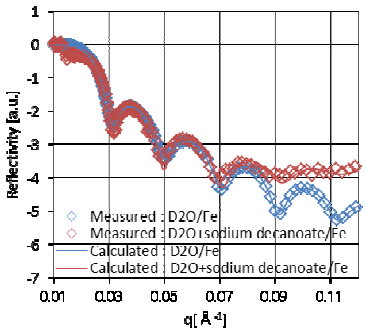
CO12-2 Structural Analysis of Solid-Liquid Interface for Tribological Study by Means of Multi-Analytical Methods Involving Neutron Reflectometry

T. Hirayama, N. Akamatsu[1], H. Hattori[2], F. Takagi[2], M. Hino[3], N. Yamada[4]

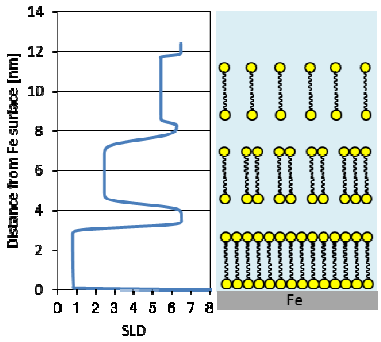
Dept. of Mechanical Eng., Doshisha University
[1]Dept. of Mechanical Eng., Graduate School of Doshisha University
[2] Idemitsu Kosan Co., Ltd.
[3]Research Reactor Institute, Kyoto University
[4]Institute of Materials Structure Science, KEK

INTRODUCTION: In recent years, reduction of friction and wear in machines is one of the most important subjects from the viewpoint of global environmental issues, energy conservation and resource saving. Especially, the development of materials having excellent tribological properties is required to extend the life of machine parts by reducing friction loss. Particularly, under the boundary lubrication regime, oiliness additives and extreme pressure agents are used to reduce friction and wear.
Sodium carboxylate is one of the most common additives for friction reduction and anticorrosion, for example. This report shows the structure of sodium carboxylate on the metal surface estimated by neutron reflectometry (NR) and its nanotribological properties measured by atomic force microscope (AFM) with a colloidal probe.

EXPERIMENTAL RESULTS: To investigate the structure of sodium decanoate as one of sodium carboxylates on Fe surface in water, NR experiment was conducted. The obtained reflectivity profiles and estimated structure are shown in Fig. 1. From the fitting operation, it was confirmed that the molecules of sodium decanoate formed multilayer structure shown in Fig. 1(b) when the concentration of sodium decanoate was comparatively large. On the other hand, when disodium sebacate was used as a target additive, the fitting operation for the NR profile presented the existence of higher-concentrated molecule layer on the Fe surface, but multilayer structure was not seen.
The friction forces measured by AFM with SiO_2 colloidal probe were shown in Fig. 2. We can see that the friction forces decreased when the additives were mixed into water. The friction force when the sodium decanoate was mixed into water was smaller than that when the disodium sebacate was used. The reason why was due to the formation of multilayer structure obtained by the sodium decanoate molecules. It was confirmed that the formation of multilayer structure of molecules brings large friction reduction, and we finally succeeded to make a correlation between the interfacial additive structure and the trend of friction force.

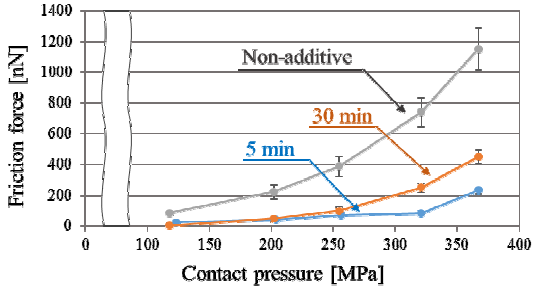


(a) NR profile

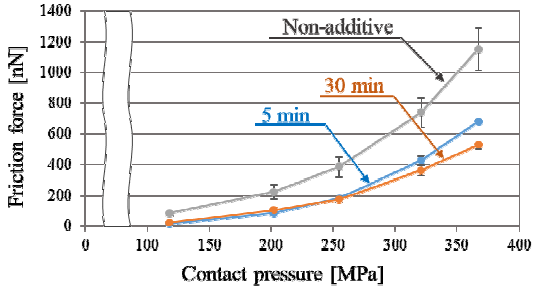


(b) Estimated structure

Fig. 1. NR experimental result of sodium decanoate on Fe surface in water



(a) With sodium decanoate



(b) With disodium sebacate

Fig. 2. Friction forces measured by AFM with SiO_2 colloidal probe in water

CO12-3 Effective Measures on Safety, Security, Hygiene and Disaster Prevention in Laboratories

T. Iimoto, R. Hayashi, Y. Seki, A. Fujimoto, M. Ishida, T. Takahashi[1] and S. Takahashi[1]

The University of Tokyo
[1]Research Reactor Institute, Kyoto University

INTRODUCTION:

Important research aspects can be found in the following keywords such as safety, security, hygiene and disaster prevention. Nuclear research reactor is one of representative facilities together with these keywords under their operation. It is effective to investigate the latest status on practical measures on these keywords in various facilities including nuclear research reactors, to compare each other among facilities, and to discuss more optimized ones for our positive safety management. Through this process, it is also essential to investigate the latest international and/or national regulations and the movement of revision of them. This total discussion contents and its fruit are directly useful for all relating laboratories.

RESEARCH APPROACH:

General research approach is as follows.

- Measures of safety management during operation or standstill status of the real facilities would be investigated. This information would be used for our research discussion on the positive and more optimized safety management.
- It would not be a single year research, but maybe two to three years research for one theme.
- Information source of facilities would not be only KUR, KUCA or the other facilities in Kyoto University, but also the Kinki university research nuclear reactor or the facility of National Institute of Fusion Science, etc. This research is an active joint-research with these relating facilities and positive researchers on safety management.
- One of the distinctive features of this research is to involve office staffs as cooperators as well as researchers and technical staffs. In The University of Tokyo, most of the members in Division for Environment, Health and Safety are office staffs who knows real situation of safety management in laboratories very well.

Discussion target in FY of 2016 was determined as two items; “education framework, curriculum and textbooks for safety managers and users as well as relating officers to fill up the nuclear material controlling sheet for the use of small amount of U and Th” and “safety culture improvement in radiation facilities” through our member discussion.

EDUCATION FRAMEWORK FOR SMALL AMOUNT OF URANIUM AND THORIUM

Safety education for the users of small amounts of U and Th is not legally required. According to our survey in the universities in Japan, most of the universities use small amount of U and Th without education and/or training to staffs and students. However, since 2012, when new regulatory standards are applied, it has been required to establish an organizational structure, which ensures both user's technology securing and safety management for the use of U and Th. Currently, each university tries to establish a new system of education and has begun to examine the contents of education.

LATEST SITUATION ON RADIATION SAFETY CULTURE IMPROVEMENT:

We started to gather the real activities information on the improvement of safety culture in international and domestic radiation or chemical facilities. Here are examples in The University of Tokyo.

- As a university headquarters, there is a mechanism to gather information on accidents and incidents occurring inside the university and to horizontally share the information. We are discussing countermeasures etc. for them at regular meetings.
- We publish a mail-magazine as a university headquarters and distribute it once a month for the purpose of making it easy for all members to understand the content of accidents or troubles occurring inside the university and the domestic trends related to it. It is also possible to browse back issues at the environmental safety portal website of the university.

Good practices will be listed up, and how to sustain and improve the motivation, skill and knowledge of the radiation safety officers will be the next target.

NEXT RESEARCH TARGETS:

We started to discuss on various activities for improvement of safety culture in radiation facilities. Related international and/or domestic investigation and discussion should be continued next year.

We express our gratitude for their strong support and active discussion of Dr. K. Yasuda (Kyoto University), Dr. M. Takahashi, T. Saze (National Institute of Fusion Science) and Dr. H. Yamanishi (Kinki University) and others.

CO12-4 Development of a Micro-cell MWPC for a Muon-electron Conversion Search Experiment, DeeMe

H. Natori, N. Abe[1], M. Aoki[2], Y. Furuya[3], S. Mihara, F. Morimoto[3], D. Nagao[2], Y. Nakatsugawa, T. M. Nguyen[2], H. Nishiguchi, Y. Seiya[3], T. Takahashi[1],Y. Takezaki[3], N. Teshima[3], K. Yamamoto[3]

High Energy Accelerator Research Organization (KEK)
[1] *Research Reactor Institute, Kyoto University*
[2] *Department of Physics, Osaka University*
[3] *Department of Physics, Osaka City University*

INTRODUCTION: Discovery of Higgs boson filled the last piece of the Standard Model (SM) of elementary particle physics. The next coming issue is the physics beyond the SM (BSM). A discovery of mu-e conversion may be a clear clue to the BSM. DeeMe is going to search for mu-e conversion in J-PARC. The detector is required to tolerate to prompt burst pulses with an instantaneous hit rate of approximately 100GHz/mm^2 and width of 200ns and to detect electron signal with delay time of O(μ s) from the burst pulse. We have invented a new technique of dynamic gain control of wire chamber to avoid a long dead time by space charge effect.

EXPERIMENTS: Experimental setup is shown schematically in Fig. 1. Electron beam collimated to 18mm x 20mm penetrates a Multi-Wire Proportional Chamber (MWPC) and beam counters. Beam rate is tuned changing current of electron gun heater.

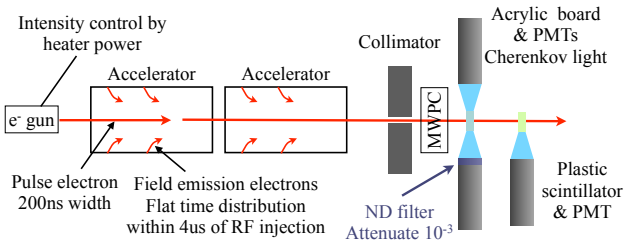


Fig. 1. Experimental setup

The pulsed electron beam with tuned beam rate generated from the beam gun emulates the prompt burst pulse. Delayed electron signals are emulated by field emission electrons.
DC high voltage (HV) is applied to anode wires. MOSFET based switching module makes a pulsed HV to be applied to potential wires of the MWPC. During a main pulse comes, HV is applied to potential wires to make voltage difference between wires 0V. Soon after the main pulse passes the MWPC, potential wires are switched to ground level to make large voltage difference between anode-potential wires to detect delayed electrons. We developed this HV switching technique, which enables sweeping electrons generated by a burst pulse without giving avalanche multiplication and enables the chamber to give avalanche multiplication for delayed signal electron without suffering gain reduction by space charge effect. This, on the other hand, induce large current on the cathode strip readouts by the rapidly changing voltage on the potential wires. Amplifier should cope with this input. Fig. 2 shows the circuit of our amplifier. We tuned the circuit elements not to make the amplifier saturated by the large current input. Pole zero cancelation circuit is implemented between 2-staged amplifiers to compensate slow tail by ion movement. We have manufactured the final version of the chamber and the amplifier. This experiment was planned to be a test of the final detector system under the condition equivalent to the final DeeMe condition.

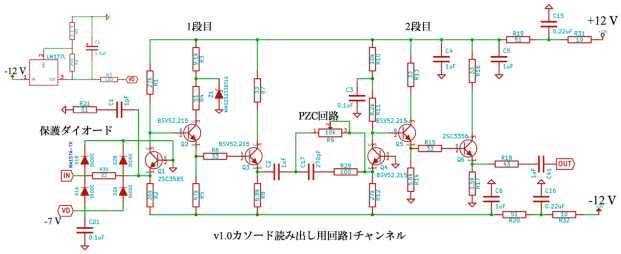


Fig. 2. Circuit diagram of the amplifier

RESULTS: The DeeMe MWPC with HV switching worked stably under the DeeMe final experiment compatible condition, electron pulse with instantaneous hit rate of 100GHz/mm2 , width of 200ns and repetition of 25 Hz. Delayed electron from field emission electrons was observed by the MWPC without gain reduction by space charge effect. We also performed tuning of Pole-Zero Cancellation circuit in our amplifier. We could confirm our final chamber works well in the final experiment compatible condition.

REFERENCES:
[1] H. Natori, *et al.*, Prog Theor Exp Phys (2017) 2017 (2): 023C01.
"A fast high-voltage switching multiwire proportional chamber"

CO12-5 Electron Beam Test of Avaranche Photodiode for Ganymede Laser Altimeter of Jovian Icy Satellite Exploerer

M. Kobayashi, O. Okudaira, K. Ishibashi, M. Fujii[1], T. Takahashi[2] and N. Abe[2]

Planetary Exploration Research Center, Chiba Institute of Technology
[1]FAM science
[2]Research Reactor Institute, Kyoto University

INTRODUCTION: The Ganymede Laser Altimeter (GALA) as part of the JUICE (Jovian Icy Satellite Explorer) payload is one of the instruments focusing on aspects related to the presence and characterizations of subsurface water oceans [1] [2]. For the first time the time-variability of the global figure of a moon due to tides exerted by Jupiter will be detected by altimetry measurements.

Japan team of GALA has a responsibility for back-end optics, optical sensor and analog electronics module of the receiver part of GALA instrument. We adopted an avalanche photo diode (hereafter APD) product manufactured by Excelitas Technologies, Montreal in Canada. Their APD product that are customized for space use have been adopted for many space missions due to its compactness and heritage in space.

The APD has also sensitivity to radiation that induces hole-electron pair in the depression layer. In space environment, the induced signal may affect light detection as background noise, called radiation noise. Jupiter has a strong magnetosphere and previous studies revealed energetic electrons are trapped in the magnetosphere and major component among the other ionizing radiation like proton and the other energetic ion. The APD will be shielded up against to the Jovian radiation environment however some of electrons can penetrate the shield into the APD. In this study, we used KURRI-LINAC as an electron beam source to emulate electrons irradiating the APD to investigate how energetic electron induces signals and interferes the returning laser pulse signal.

EXPERIMENTS: As device under test, we used a commercial APD module, LLAM-1060-R8BH of Excelitas Technologies, on which the flight APD module is based. The module is designed as commercial product but the sensor used in the module is one from a sensor chip lot selected as the flight lot. The APD sensor has a diameter of 0.8 mm and an enhanced sensitivity in infrared range, about 0.4 of quantum efficiency at 1064 nm. They commercially manufacture APD product particularly a hybrid module of APD which contains an APD sensor, a preamplifier, a thermo-electric controller and a temperature sensor in a package.

We performed twelve runs of the LINAC and electrons was accelerated to six different energies for irradiation to the DUT, 3, 5, 10, 20, 30 and 40 MeV. Irradiation angle is changed to be 0^o (straight forward), 60^o and 180^o (backward). For a run with 40MeV, stainless steel plate was set in the front of the DUT, simulating the structure of focal lane assembly in which multiple scatter of electron was expected to occur. The output signals of the amplifier were recorded with a digital oscilloscope.

RESULTS: The pulse shape of radiation induced noise might be similar to the stop pulse of GALA, the pulse width ranges 10 – 200 nsec. If radiation induced noise features such pulse shape as that, RFM (range Finder Module) may detect it as false detection.

In the test, the single short pulse per electron hit on the APD sensor has a rise time of 2 – 3 nsec and a fall time of 2 – 3 nsec for any energies and any incident angle of electrons. The DUT of LLAM-1060-R8BH has a system bandwidth of 200MHz, so the rise time and fall time are expected to be 1 – 2 nsec, while the results in this test show slower rise and fall times.

Fig. 1 shows examples of signal waveform of typical signal events from the test. In the figure, the signal height of 5 MeV and 0deg is almost same as one of 40MeV and 0deg, while the signal with 5MeV and 60deg has a higher signal height that the others. For 0deg irradiation, most events for typical 0deg incident (whatever its energy is) show short width, 2nsec for rise time and 2nsec for fall time. The slower rise and fall times than expected would be caused by signal delay in a cable connecting the APD module output to the oscilloscope for readout, the cable length was 50 cm. GALA APD has a system bandwidth of 100MHz, and the cable length between the APD module output and the following amplifier will be 15cm at maximum, therefore, radiation induced noise on GALA APD has similar pulse shape to the results of this test.

The pulse shape of radiation induced noise is typically similar to one of the start pulse of GALA laser, but not stop pulse (receiving from the Ganymede). The timing of real start pulse is known, so the false start pulse can be distinguished by timing.

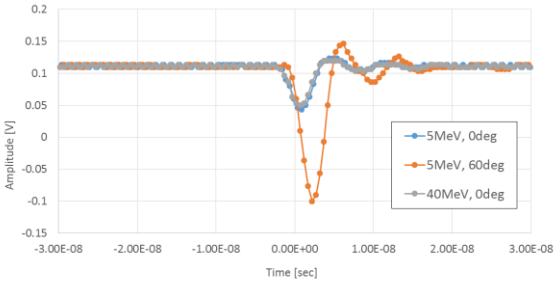


Fig. 1. An example of output signal pulse from the APD.

REFERENCES:

[1] Althaus, C. *et al.*, LPI Contribution No. 1980, id.4015, (2016).
[2] Steinbrügge, G. *et al.*, Planet. Space Sci. 17, 184-191 (2015).

CO12-6 Single Event Test using ^{252}Cf for On-board Computer used in Lean Satellite

H. Masui, H. Fukuda, S. Kawano, A. H. Kafi, M. Cho and K. Takamiya[1]
Laboratory of Spacecraft Environment Interaction Engnieering, Kyushu Institute of Technology
[1]Research Reactor Institute, Kyoto University

INTRODUCTION: Kyushu Institute of Technology (Kyutech) has been developing nano satellites since 2010. Kyutech are developing the suitable radiation test method for Lean satellite as nano/micro satellite. In the Lean satellite, it is more important to evaluate the reliability of the system than to evaluate the reliability of chips and parts. In other words, the implementation of the reliable reset system is important for the Lean satellite. In the radiation effect on the microprocessor, Single Event Latchup (SEL) is the most critical problem. The bas system such as on-board computer (OBC), electrical power system (EPS) and communication (COM) of Horyu-4[1] developed by Kyutech was tested in Kyoto University in 2015. However, the radiation effect on the mission part was not tested. In order to guarantee a long time mission, the radiation test on the mission part is essential. In FY2016, we conducted the checking reset system during mission part operating. In addition, Kyutech are developing cubesat as "BIRDS-1"[2]. BIRDS-1 has on-board computer almost similar to Horyu-4. The purpose of this test is to improve the stability of satellite system under the effects of radiation. This doc-ument reports the detail of testing and test results of Horyu-4 .

EXPERIMENTS: Figure 1 shows the experimental set-up. Circuit boards used in this test were Engineering Model for Horyu-4 and BIRDS-1. These boards have two H8 microprocessors (H8-1 and H8-2). The plastic package of microprocessors was removed so that the core of the microprocessors was directly exposed to ^{252}Cf source. The circuit boards were set in a vacuum chamber. The pressure during the test was approximately 30 Pa. The voltage and current fed from the power supply were measured by a DAQ and oscilloscope and the operation of the micropro-cessors was verified by a PC with RS232 communication. An over-current protection (OCP) was implemented in the power line between each sub-system and EPS in the circuit boards. Once OCP detects over current due to SEL on the OBC, OCP sends a reset signal to EPS. To recover from the hang-up state of OBC by SEL, EPS automatically cuts the current from EPS to OBC. In this experiment, ^{252}Cf source was mounted on XYZ stage. According to Horyu-4, we found that the satellite system operation becomes unstable during operating Attitude and Orbit Determina-tion System (AODS) in preliminary test results. We spe-cifically checked that the operation of the reset system when main mission, sub-system and AODS were operated. In the test, ^{252}Cf source was moved above microprocessors and radiation was irradiated to two microprocessors after operating each system. We investigated whether the satellite system can automatically be recovered or can be recovered by the reset command from the PC from the SEL state.

RESULTS: Table 1 shows the summary of test results for Horyu-4. Horyu-4 system could automatically recover from SEL state during operating main mission and AODS. However, the satellite system could not recover when SEL occurred during simultaneous operation of AODS and sub-system (camera etc.). In addition, the satellite could not recover when SEL occurred during operating some sub-systems. Therefore, it was found that simultaneous operation of the main mission and AODS for a long time is possible. On the other hand, we must take into account of the high possibility of SEL failure for simultaneous operation of AODS and sub-system.

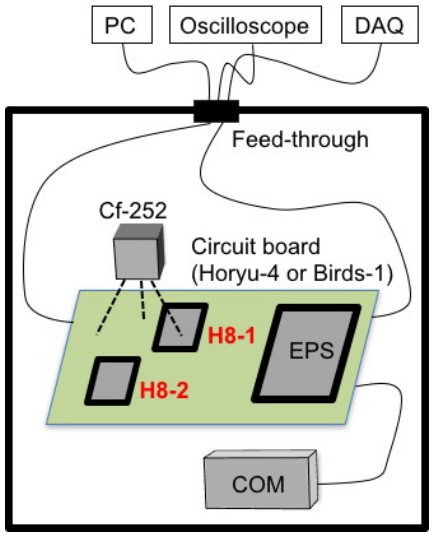


Fig. 1 Test setup of Horyu-4 and BIRDS-1

Table 1 Summary of Horyu-4 test results

	Operating part	H8-1	H8-2
1	Main mission	Pass	Pass
2	AODS	Pass	Pass
3	Main mission + AODS	Pass	Pass
4	AODS + Sub-system	Fail	Fail
5	Sub-system	Fail	Fail
6	Main mission + Sub-system	Fail	Fail

"Pass" means that satellite could recover from SEL state by automatically or command.

REFERENCES:

[1] T. Shimizu *et al.*, J. Spacecraft and Rockets. **54,** 2497-499 (2016).
[2] G. Maeda *et al.*, 67th International Astronautical Con-gress IAC-16.B4.1.4 (2016).