2022年度　14)国際技術交流　目次詳細

2022　14)International Technical Exchange Program List

4 件

＊所属・職名は2023年3月現在
＊Affiliation and Department displayed are current as of March 2023.

(注1)：新型コロナウイルスの影響で中止／Cancelled due to COVID-19
(注2)：中止／Cancelled

(Form 14-2)

Modeling the Source Region of the Extreme Space Weather Event of 1921 May 14-15

Bernhard Kliem
University of Potsdam,
Germany
Institute of Physics & Astronomy

Cancelled due to COVID-19

(Form14-2)

SuperDARN Hokkaido Pair of Radars (HOP) system hardware and software development

Kevin Krieger (University of Saskatchewan)

Please write your research summary including purpose, methods, periods of stay in ISEE / International stay, achievements obtained from the program, and list of publications in maximum two pages.
日本語または英語のどちらかで作成してください。

Please use A4 paper (210×297 mm) with margin (top and bottom 20 mm, left and right 20 mm).

The Super Dual Auroral Radar Network (SuperDARN) is a network of high-frequency (HF) radars located in the high- and mid-latitude regions of both hemispheres. The network is used to study the dynamics of the ionosphere and upper atmosphere on a global scale. As of March 1, 2023, there are a total of 39 SuperDARN radars, 25 in the northern hemisphere and 14 in the southern hemisphere. One great advantage of the SuperDARN is that the radars use similar hardware, software and experiment schedules (during the common time, which accounts for over 50% of the total time). They also produce the same output data format, providing crucial information for geospace dynamics studies on a global scale. It is thus essential to maintain cooperation between different SuperDARN institutes, both on hardware, software, and operational aspects.

The purpose of this technical exchange between the University of Saskatchewan SuperDARN Canada Head engineer Kevin Krieger and the SuperDARN team at ISEE at Nagoya University was to discuss and exchange technical information about new imaging capabilities in development for both the Canadian Borealis radar systems and the Hokkaido pair of radars (HOP). The new imaging capabilities are made possible by off-the-shelf software-defined radios that are used in the Canadian SuperDARN radars as well as in development for the Hokkaido pair of SuperDARN radars.

The period of stay in ISEE was from February 15th until February 27th, inclusive. During this period several meetings between technical staff were held, as well as discussions between other visiting scientists in ISEE and other SuperDARN colleagues located in Japan. Based on these meetings, work was done to improve the documentation for the Canadian Borealis system including interfacing the system with existing SuperDARN sites' hardware, limitations and capabilities and the software and hardware architecture.

During the technical meetings, first, an overview of the Borealis system was given. Then, more details on the different software modules were discussed including design choices and software architecture. Some hardware issues and design choices were also discussed. Problems that were overcome to create a reliable and correct system were discussed such as:

- proper timing required for radar pulses
- how to interface with the software-defined-radio driver (UHD – USRP Hardware Driver)
- radio noise issues when testing and what hardware choices to use to reduce noise
- how to scale the system from 1 to 20 receive channels and the software architecture used to handle a large amount of streaming data (ring buffer and continual sampling)

Limitations and capabilities of the system were also discussed such as:

- frequency choice
- bandwidth limitations
- signal processing (filtering) limitations

After technical discussions, the ISEE SuperDARN hardware lab was toured. In this lab, development is occurring on the HOP imaging receiver system as well as individual receiver systems at both ISEE and Rikubetsu. The existing SuperDARN system was also modified to extract important information on transmissions from the HOP radars and this was demonstrated in the lab.

Based on the discussions, many updates to the Borealis system documentation were made and can be seen here: https://borealis.readthedocs.io/en/docs_refactor. Importantly, a major section was added called 'Transmitter interfacing' which is important to understand when updating an existing SuperDARN radar.

Finally, several meetings were held with other colleagues within Japan during the trip. This included Dr. Akira Sessai Yukimatu at NIPR (National Institute of Polar Research) who is the PI for two SuperDARN radars at Syowa station, as well as Dr. Hermann Opgenoorth of Umea university, who is a user of SuperDARN data, among other instruments. During the meeting with Dr. Yukimatu, potential updates to the Syowa station radars were discussed. During the meeting with Dr. Opgenoorth, potential new modes and capabilities of the imaging radar were illustrated, which would benefit users of the SuperDARN data.

(Form 14-2)

将来の地球・惑星探査機に向けた超低エネルギー中性大気分析器の共同技術開発

下山　学 (スウェーデン宇宙物理研究所)

1. 活動の背景・目的

我々は地球および惑星超高層大気観測のための超低エネルギー中性大気分析器の共同開発を計画している。この領域は、下層の中性大気と上層のプラズマの相互作用で特徴付けられ、エネルギー及び運動量輸送において極めて重要な役割を果たしているが、その物理過程の理解には中性大気速度（風速）の測定が必要とされている。しかし精密な測定が可能な“その場観測”の手法は未だ確立されておらず、その開発が強く求められている。ここで提案する超低エネルギー中性大気分析器は、探査機から中性粒子を直接観測することで中性大気の二次元速度分布を測定するものである。主要粒子種毎の二次元速度分布関数、温度、二次元バルク速度（風速)、数密度を導出可能である。

これまで当該機器の開発検討は ISEE の内部プロジェクトとして進められてきたが、新規開発要素が多く、ISEE とスウェーデン宇宙物理研究所（IRF）との共同開発を行うことでより効率的な開発推進が可能になると考えられる。本活動では主に、三次元イオン光学シミュレーションの開発環境の構築を主目的とし、今後のプロトタイプモデル開発に必要な詳細なシミュレーションを可能にすることを目指す。

2. メンバー

名前	所属	役割
下山　学	IRF	三次元分析器シミュレーションモデル・コード開発
平原　聖文	ISEE	シミュレーション環境管理・分析器設計アドバイス
田中　誠志郎	ISEE(大学院生)	分析器 CAD モデル開発

3. 開発手法

近年の PC の高速化及び RAM の大容量化に伴い、詳細な三次元 CAD モデルを元にしたイオン光学シミュレーションモデルの構築が可能となった。本開発では、イオン光学シミュレーションソフトウェア SIMION を用い、分析器の三次元 CAD モデルから三次元イオン光学モデルのシミュレーション環境を構築する。開発は次の 4 ステップで行う。

STEP 1：これまでの研究によって得られた設計を元にして、設計パラメータ（分析器サイズ、電極への印加電圧等）の決定

STEP 2：三次元 CAD モデル作成

STEP 3：三次元イオン光学シミュレーションモデル構築

STEP 4：三次元イオン光学シミュレーションコード開発

4. ISEE 出張期間

2022 年 11 月 22 日～2022 年 11 月 30 日

5.　成果

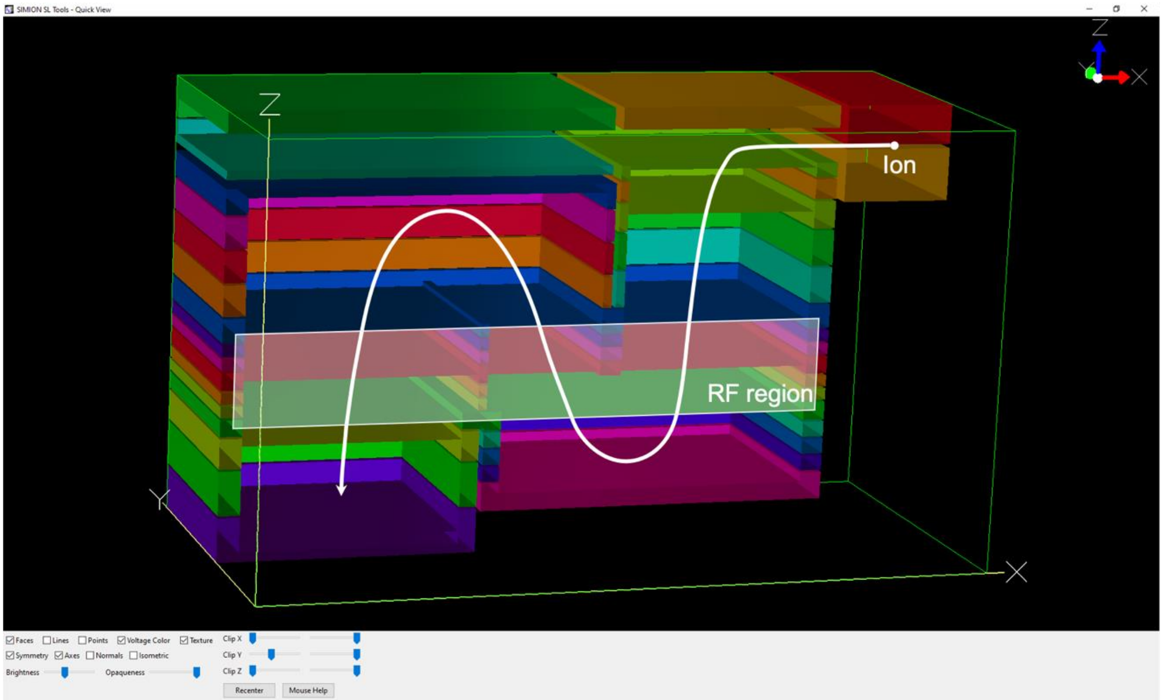

Fig. 1 三次元イオン光学シミュレーションモデル断面図。白枠で囲まれた領域が高周波電場が生成される領域である。

分析器の三次元 CAD モデルを元にイオン光学シミュレーションモデルを構築することで、分析器特性の理解に不可欠な詳細なイオン光学シミュレーション環境を開発した（Fig.1）。これにより、電極の終端効果等による非理想的電場分布が粒子軌道に与える影響を定量的に評価することが可能となった。今後のシミュレーション及びプロトタイプ試験によって分析器の設計変更や最適化が必要となった場合でも、三次元 CAD モデルの変更を即座にシミュレーション環境に反映させることができる。

また本分析器の質量分析部では、高周波電場（~1MHz）を使用する。粒子の軌道計算ではそのステップ毎に電場分布を解く必要があるため、三次元シミュレーションの実現には電場分布計算の高効率化が大きな課題であった。今回開発したシミュレーション環境では、高周波電圧が引加される領域を静電場領域から切り出して独立にシミュレーションを行うことで、その効率化を図った。

今回の国際技術交流で得られた技術は、本分析器の設計・開発に留まらず、今後荷電粒子分析器の開発においても広く活用できると考えている。

(Form 14-2)

Technical exchange on accelerator mass spectrometry (AMS) for accurate and precise ^{14}C measurement

Masayo Minami (ISEE, Nagoya University)

The aim of this international technical exchange on accelerator mass spectrometry (AMS) is to achieve high-accuracy, high-precision ^{14}C measurements by discussing the advantages and disadvantages of various AMS systems. The project members are Dr. Hong Wan of the Korea Institute of Geoscience and Mineral Resources (KIGAM), Korea; Prof. Yoko Kokubu of the Tono Geoscience Center, Japan Atomic Energy Agency (JAEA-Tono); Mr. Jun Kuwabara and Mr. Naoki Kinoshita of the Aomori Research and Development Center, JAEA (JAEA-Mutsu); Prof. Hiroyuki Kitagawa of the Institute for Space–Earth Environmental Research (ISEE) Nagoya University; and myself.

Nagoya University has a 3 MV high-performance Tandetron AMS system manufactured by High Voltage Engineering Europa (HVEE, B.V., Amersfoort, the Netherlands), which was installed in 1996. This system is equipped with a recombinator (simultaneous injection system) dedicated for ^{14}C measurement and can stably perform a large number of ^{14}C measurements at a terminal voltage of 2.5 MV. The following year, JAEA-Mutsu installed the same type of HVEE AMS system, which is equipped with both a recombinator and a biased injector magnet (bouncer) for measuring ^{129}I. Furthermore, KIGAM installed an HVEE AMS system with a lower energy of 1 MV in 2007. The 1 MV AMS for measurements of ^{10}Be, ^{26}Al, and ^{14}C is compact with a much lower running cost and lower manpower requirements than the 3 MV AMS system. In 2019, JAEA-Tono also installed a HVEE AMS system with an even lower energy of 0.3MV, by which multiple elements, including ^{14}C, ^{10}Be, ^{26}Al, and ^{129}I, can be measured. Thus, the members of this project have various HVEE AMS systems with energies ranging from 0.3 to 3 MV. By understanding the similarities and differences between the systems, it is important to exchange information about best-practices, technical advances, and operational challenges to optimize the performance of each institute's system.

First, we had an online meeting on 19 July 2022 to report on the current status of each facility: Dr. Wan presented the automatic sample preparation system and data analysis software used at KIGAM; Prof. Kokubu showed the newly installed 0.3 MV AMS system and an operating 5 MV AMS manufactured by NEC (National Electrostatics Corp., Wisconsin, USA) at JAEA-Tono; and Mr. Kuwabara reported on the current status of the 3 MV AMS system at JAEA Mutsu. I reported on the status of the ISEE joint usage and research and the 3 MV AMS system. Subsequently, the project schedule, including the facility tours, was set.

Dr. Wan visited Japan from the 17th to 27th October, 2022. He and I toured the facilities at JAEA-Tono on the 19th October and JAEA-Mutsu on the 21st October. Dr. Wan, Prof. Kokubu, and I held meetings to discuss how best to achieve high-precision and high-accuracy ^{14}C measurements. At JAEA-Mutsu, Dr. Wan, Prof. Kitagawa, and I received a detailed explanation of the 3 MV AMS system from Mr. Kinoshita, and exchanged information on equipment specifications, measurement techniques, and maintenance and operation methods (Fig. 1). After the visit to JAEA-Mutsu, we went to the Mutsu Science Museum to see the reactor room of the nuclear ship "Mutsu" and finally to Rokkasho Village in Aomori Prefecture to see the reprocessing process of spent nuclear fuel generated at nuclear power plants at the Rokkasho Nuclear Fuel PR Centre.

After inspecting the facilities at JAEA-Tono and JAEA-Mutsu, we discussed the sustainable operation and maintenance of AMS equipment and the training of the next generation. After Dr. Wan returned to Korea, I sent some ^{14}C graphite targets prepared at ISEE to KIGAM for ^{14}C measurement. We are now in the process of comparing and evaluating the results obtained at KIGAM with those obtained at ISEE.

It was very meaningful to have technical discussions on AMS in person and observing AMS equipment at each site. We also gained information on the sustainable operation of AMS systems, efficient maintenance and management, and training of the next generation. In the next fiscal year, the Japanese side will visit Korea to see KIGAM's 1 MV AMS system and MICADAS (mini carbon dating system), an ultra-compact ^{14}C AMS system with an energy of 0.2 MV manufactured by IonPlus, which was installed at the National Research Institute of Cultural Heritage, Korea. The plan is to continue technical exchanges on AMS and to establish guidelines for future AMS measurement and operation.

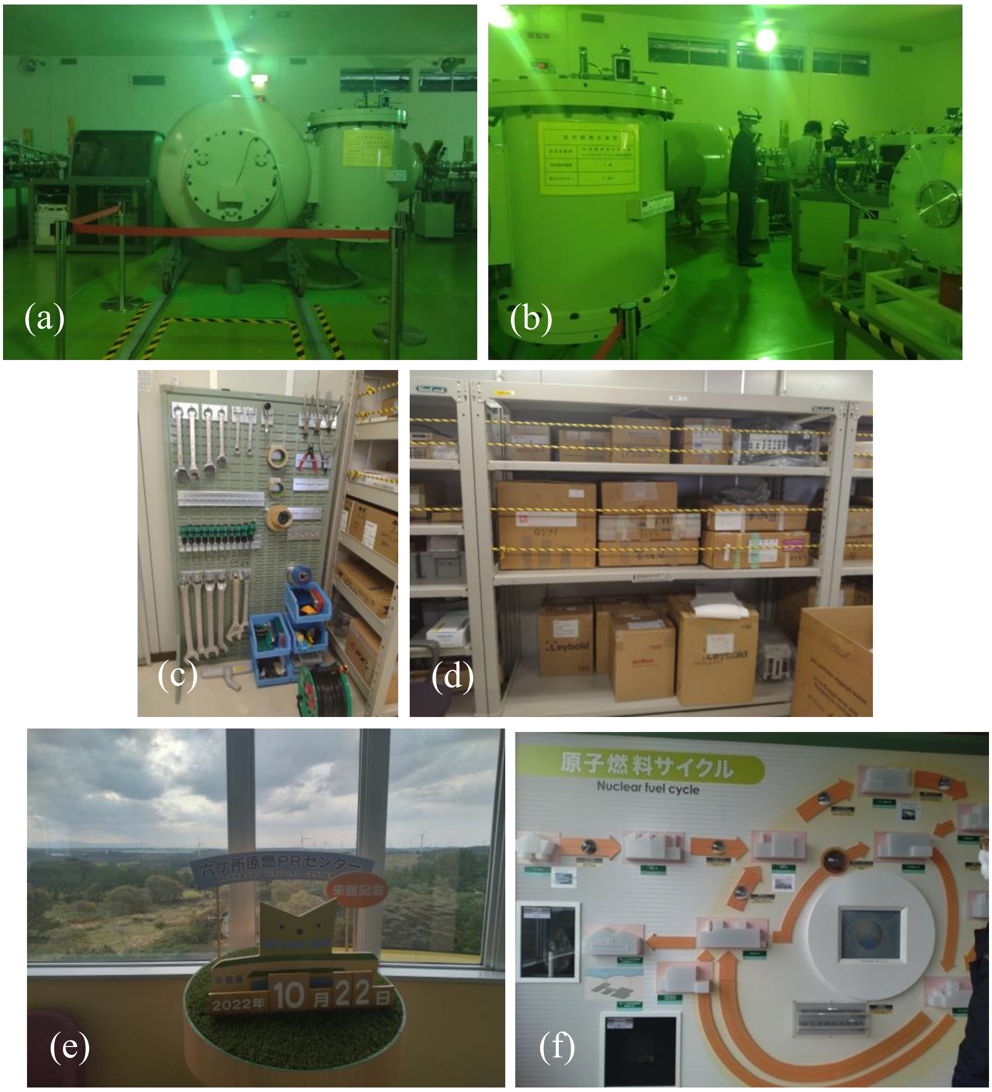

Fig. 1. Visit to JAEA-Mutsu
(a) HVEE 3 MV AMS system; (b) Dr. Wan, Prof. Kitagawa, Mr. Kinoshita, and I discussing the AMS system; (c) Tools maintained for the AMS maintenance; (d) A full range of replacement parts of the AMS system; (e) View of the reprocessing plant from the Rokkasho Nuclear Fuel PR Center; (f) Panel for explaining the nuclear fuel cycle.