Development of Active Space Radiation Detector, A-DREAMS-2 at NIRS

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Introduction

- Our active detector, **A-DREAMS**, has been developed for future space radiation measurement experiments and the first version, **A-DREAMS-1**, was calibrated with heavy ion beams and proton beams in NIRS. The results of these beam experiments are shown.
- The prototype for MATROSHKA-III experiment, **A-DREAMS-2**, is now developing with a private company. The design and the future plan will be presented.
- The design of the **A-DREAMS-MTR** for the MATROSHKA-III experiment, will be proposed.

A-DREAMS

- **A-DREAMS** (Active Dosimeter for Radiation Environment and Astronautic Monitoring in Space), it is name of active dosimeters for space environment at NIRS.
- The first version, **A-DREAMS-1**, was designed by NIRS and produced by an private electronics company, Techno AP, Co., LTD., in Japan.

A-DREAMS-1

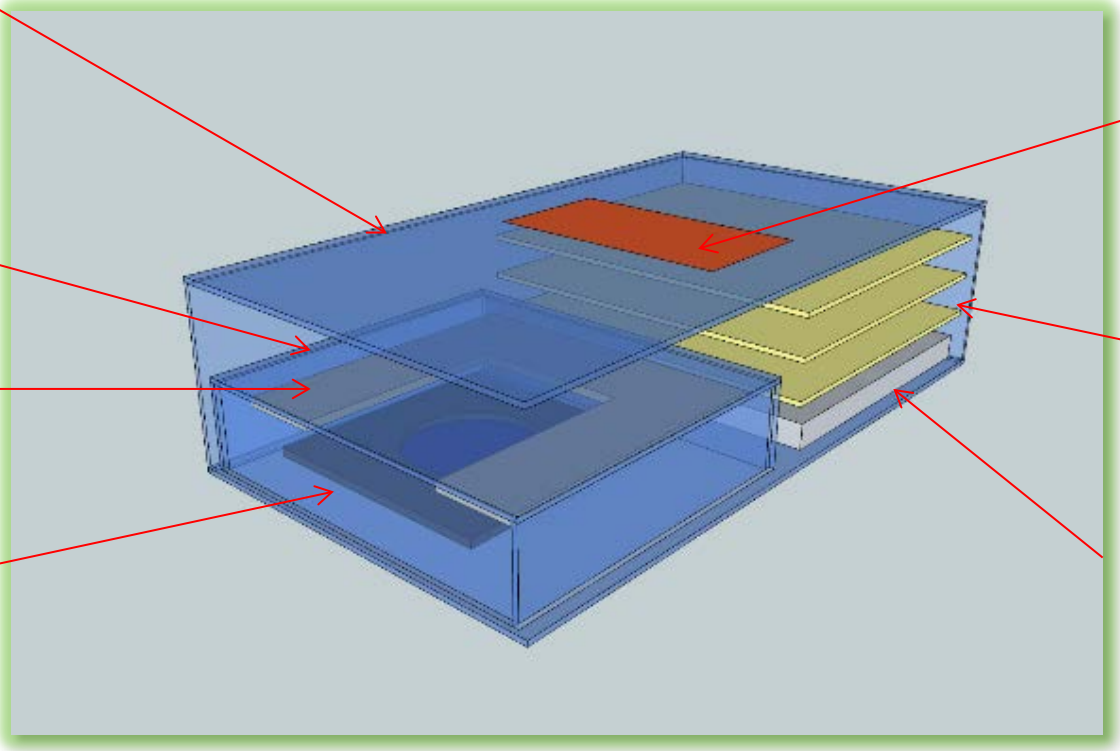
Specification of A-DREAMS-1 (Hardware)

- Size: 135 x 75 x 35 mm^3
- Weight: 250 g
- Detector: 24mm dia., Silicon Semi-Conductor (Active area 20mm dia., 300μm thickness, Micron MSD-020)
- ADC: 12 bits
- Display: Organic Electro-Luminescence Display
- Connection: Mini-USB
- Battery: Li-ion (10 hrs operation)
- Power: 0.5A(max.) @ 3.7V
- Software: dE distribution, Effective Dose, LLD(Low Level Discriminator) can be shown on Display

Specification of A-DREAMS-1 (Software and etc.)

- dE distribution, Effective Dose and LLD(Low Level Discriminator) can be shown on OEL Display.
- Data and other information including ADC channel distributions can be taken by a personal computer through Mini-USB connection.
- Amplitude of amplifiers are tuned to measure dE/dx~100 keV/μm.
- LLD can be controlled by a front panel bottom and computer control.
- Peak search function has been installed to find peaks on ADC spectrum.

A-DREAMS-1 Schematic

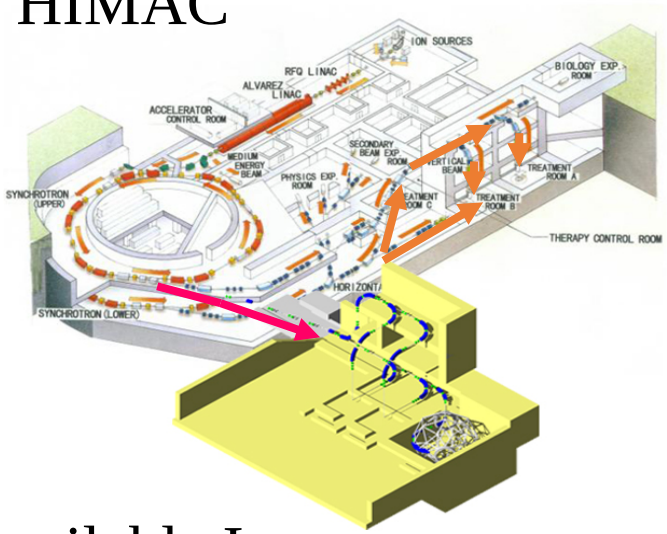


Pictures of A-DREAMS-1

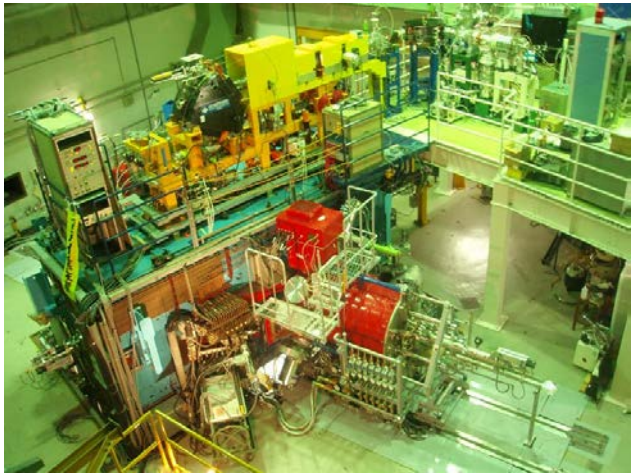
Calibration of A-DREAMS-1

HIMAC and AVF Cyclotron in NIRS

HIMAC



AVF Cyclotron

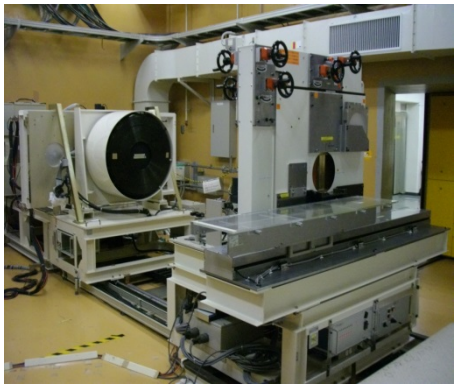


Available Ions

p, He, C, N, O, Ne, Si, Ar, Fe, Kr, Xe, …
(Only Carbon for Therapy)

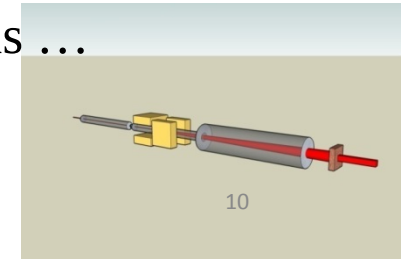
Energies

100~800MeV/u

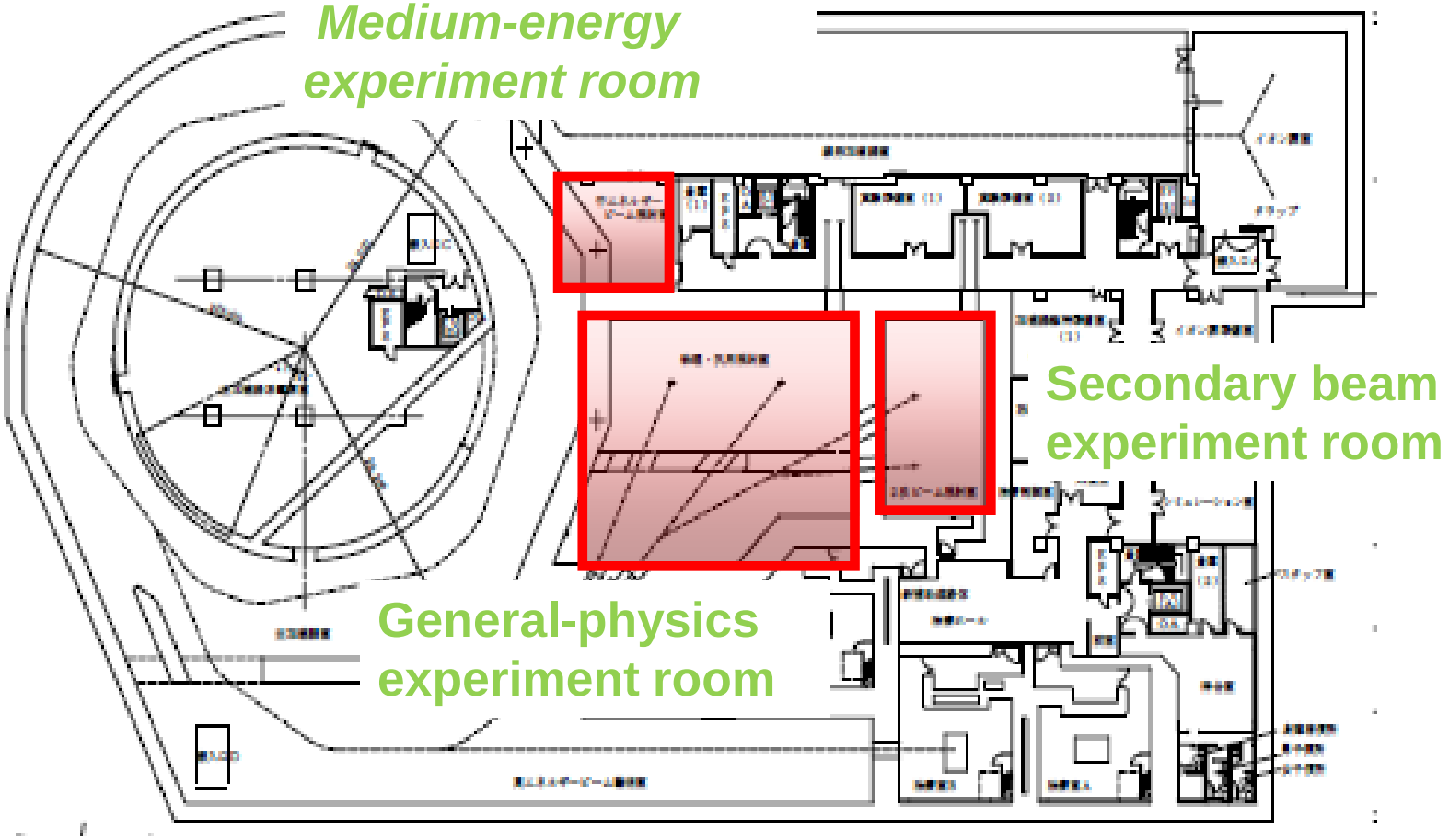


Available Beams:

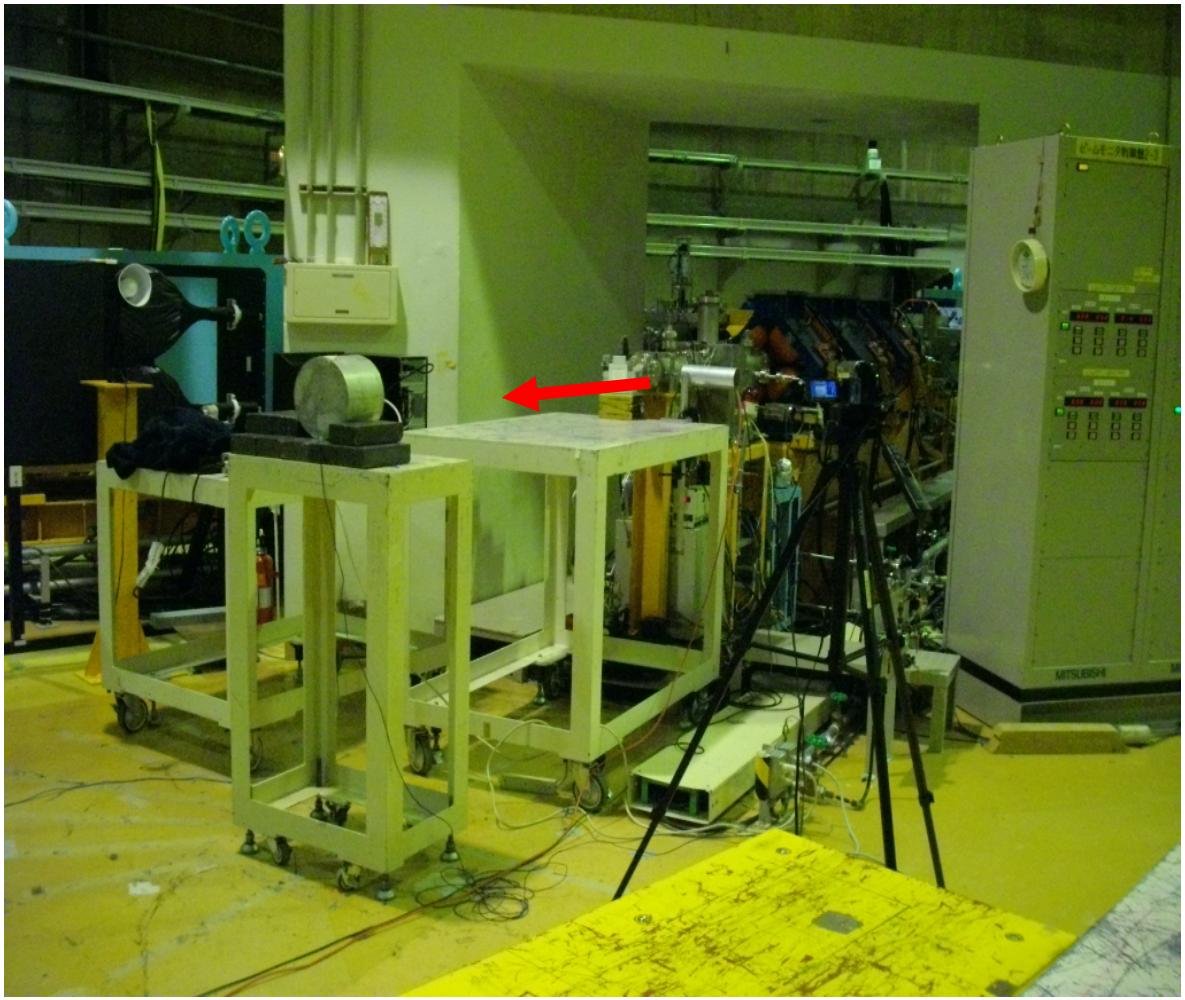
proton 5-80 MeV
Deuteron 10-55 MeV
^{3}He 18-147 MeV
^{4}He 20-110 MeV
Heavy ions …



Experiment rooms (HIMAC B2F)

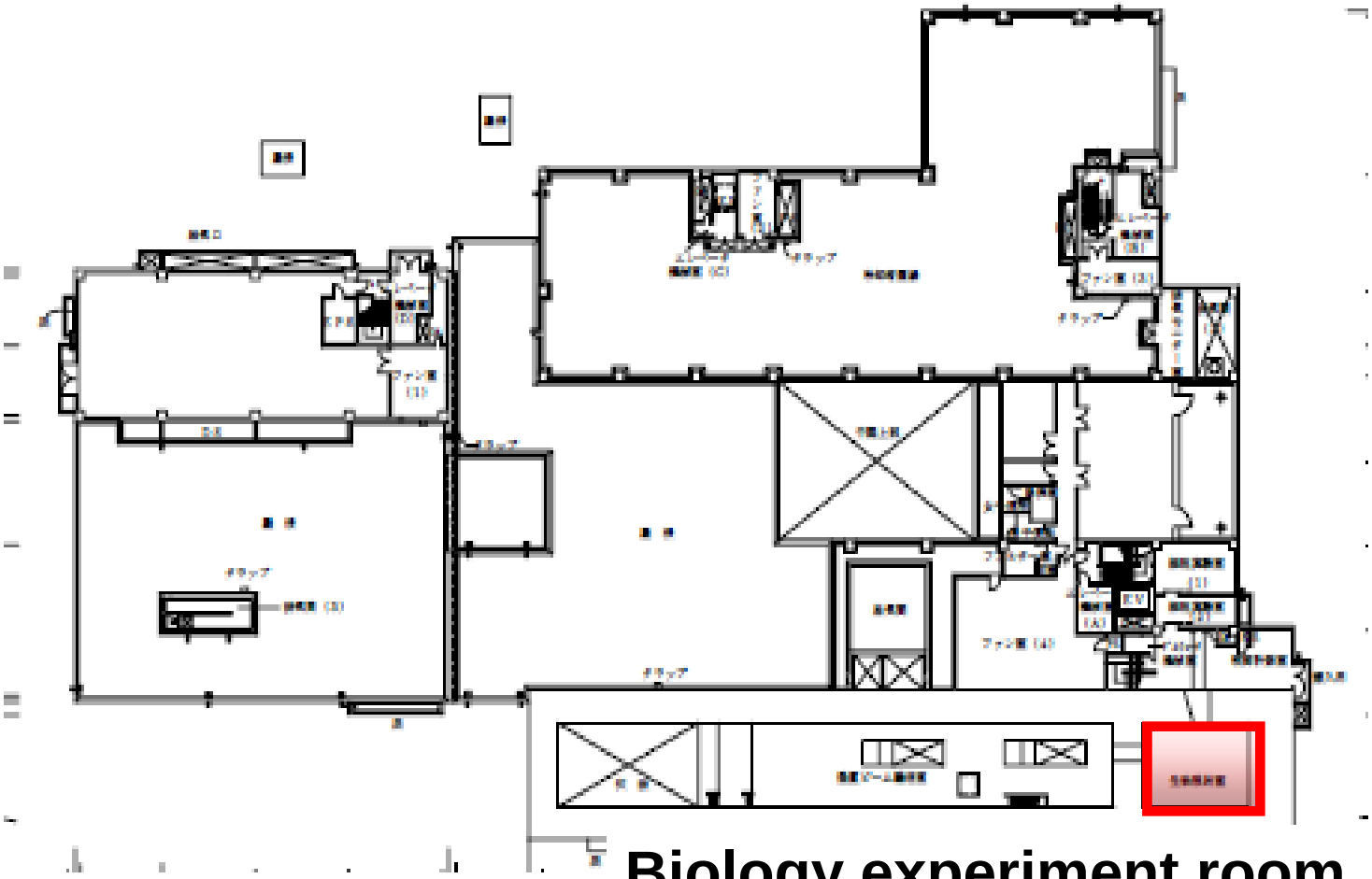


General-Physics Experiment Room

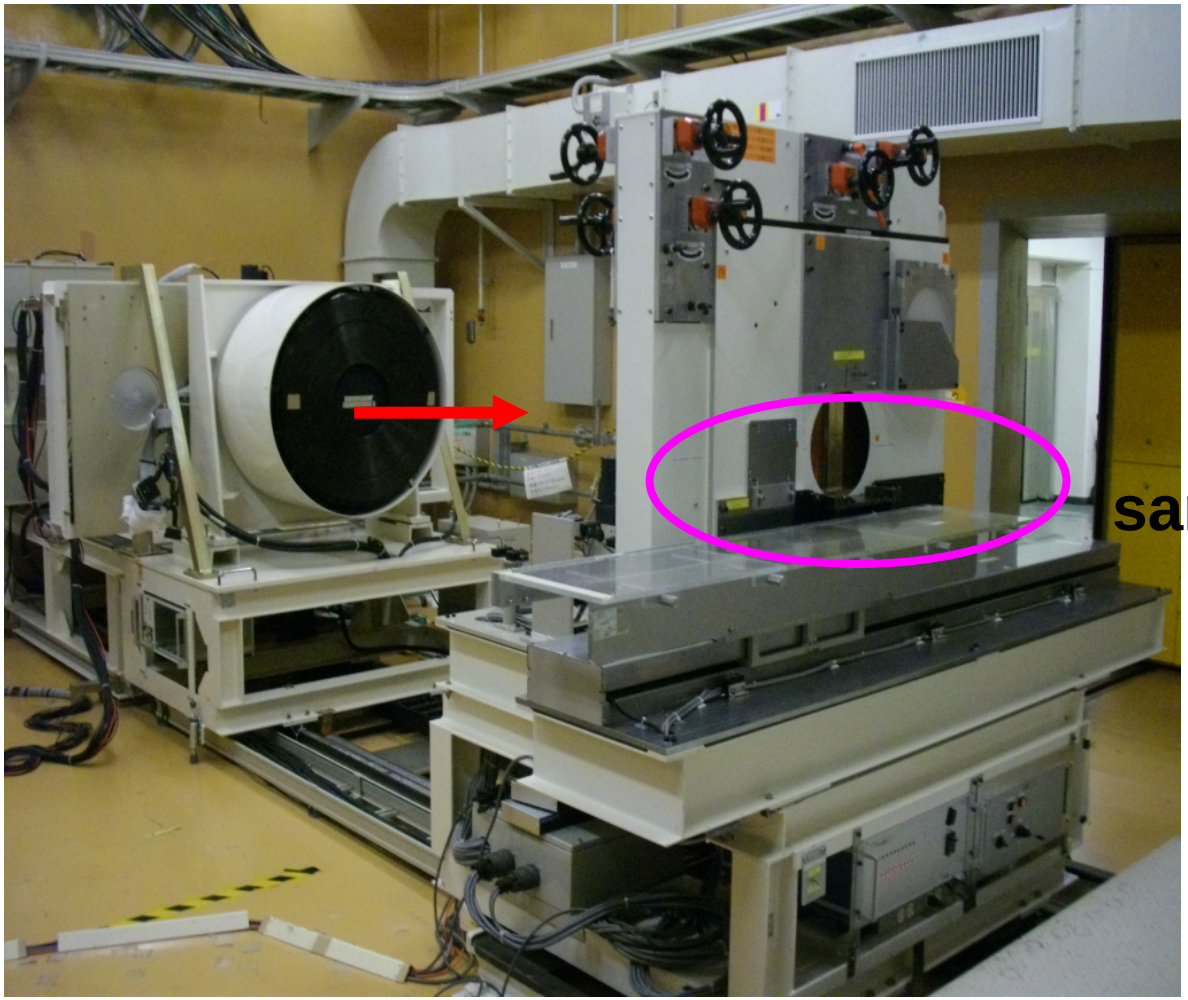


PH2

Biology experiment room (HIMAC 2F)



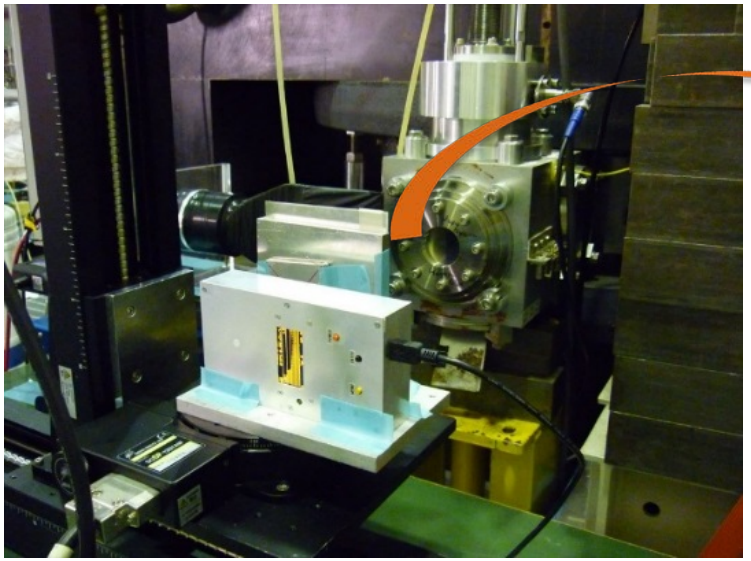
Biology Experiment Room

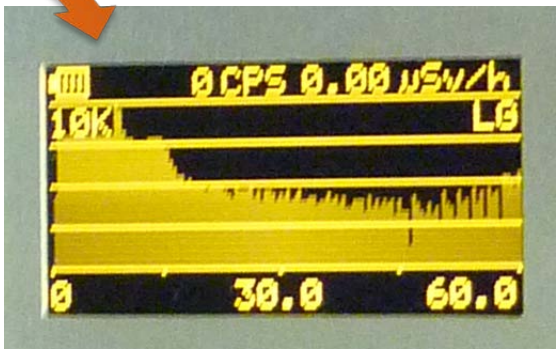


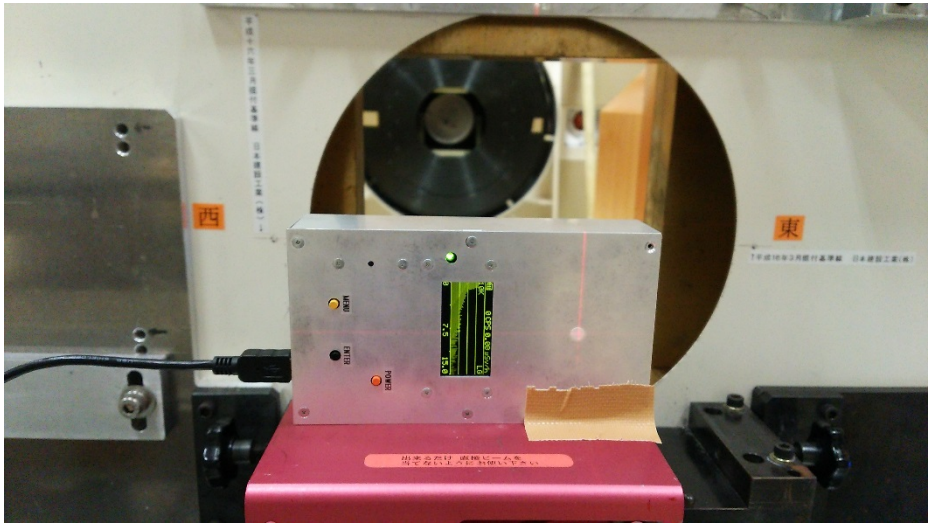
Accelerator and Radiation Sources in NIRS

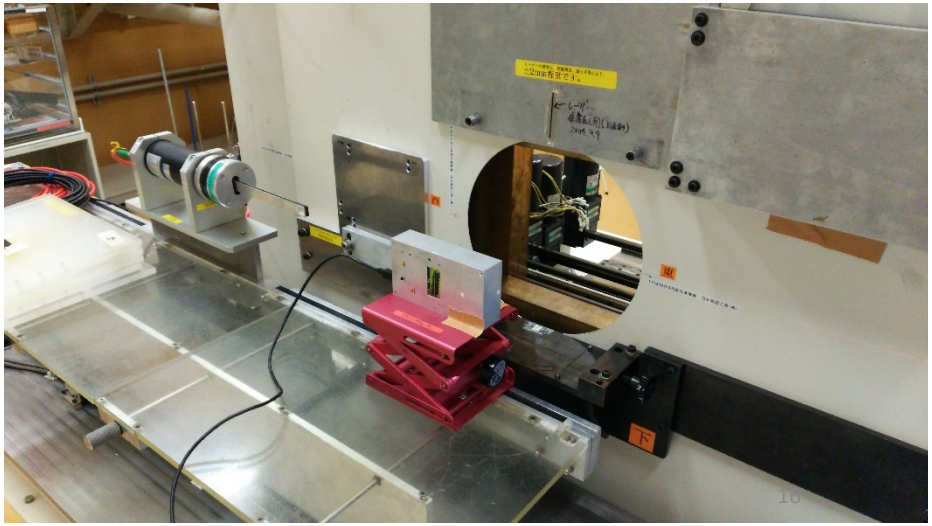
Facility	Name	Source and activity	Irradiation area	Dose rate
Accelerator	Heavy Ion Medical Accelerator in Chiba (HIMAC)	6MeV/u, 100~800MeV/u, H, He, C, O, Ne, Si, Ar, Fe, Kr, Xe	conventional	$<10^{12}$ ions/s $<10^{10}$ ions/s
	Medical Cyclotron (AVF-930)	p:5~80 MeV D, ^{3}He, ^{4}He, C:~330MeV	conventional	<10μA
	Medical Cyclotron (HM-18)	p:18MeV D:10MeV	conventional	p:<70μA D:<50μA
	Neutron accelerator system (NASBEE)	Be(D,n) (accelerator) 2.0MeV neutron	SPF, conventional	maximum 0.1Gy/min
Radiation Source	Low dose rate gamma-ray system (1)	^{137}Cs, 111GBq	SPF	150mGy/min
	Low dose rate gamma-ray system (2)	^{137}Cs, 1.11TBq	SPF	1.3mGy/min
	Gamma-cell irradiator	^{137}Cs, 115TBq	SPF	620mGy/min
	Gamma-ray (Co) irradiation system	^{60}Co, 1.85TBq,	conventional	60~4000 μGy/min
	Gamma-ray (Cs) irradiation system	^{137}Cs, 3.7TBq	conventional	60~4000 μGy/min
	Gamma-ray(Co) irradiation system <hospital>	^{60}Co	conventional	around 1 Gy/min
	Two way gamma-ray irradiator	^{137}Cs, 296GBq	conventional	0.4~1 mGy/min
X-ray Generator	TITAN-320 X-ray generator	250kVp, 13mA	conventional	1.0Gy/min
	PANTAK HF-320S X-ray generator	250kVp(max), 13mA	conventional	1.0Gy/min
	PANTAK HF-320 X-ray generator	250kVp(max), 13mA	conventional	1.0Gy/min
	PANTAK HF-320 X-ray generator	250kVp(max), 13mA	SPF	1.0Gy/min
	Xylon (Philips) X-ray generator	225 kVp(max), 13.5 mA	conventional	1.0Gy/min
	KX15E-X-ray generator	130 kVp	conventional	
	SOFTEX-ray (70)	70 kVp (max)	conventional	
	SOFTEX-ray (40)	40 kVp (max)	conventional	
Micro-Beam	SPICE (single particle irradiation system to cell)	3.4 MeV proton	microbeam irradiation	6~8 cells per second
	Name	Beam specification	Condition	Samples
Analysis System	PIXE analysis system (PASTA)	Tandem accelerator; p:2.6~3.4 MeV and He 5.1 MeV	conventional	vacuum
			In-air	in-air
			Droplet	liquid
			microbeam scanning	2D elemental analysis

Photos of Calibration Experiments

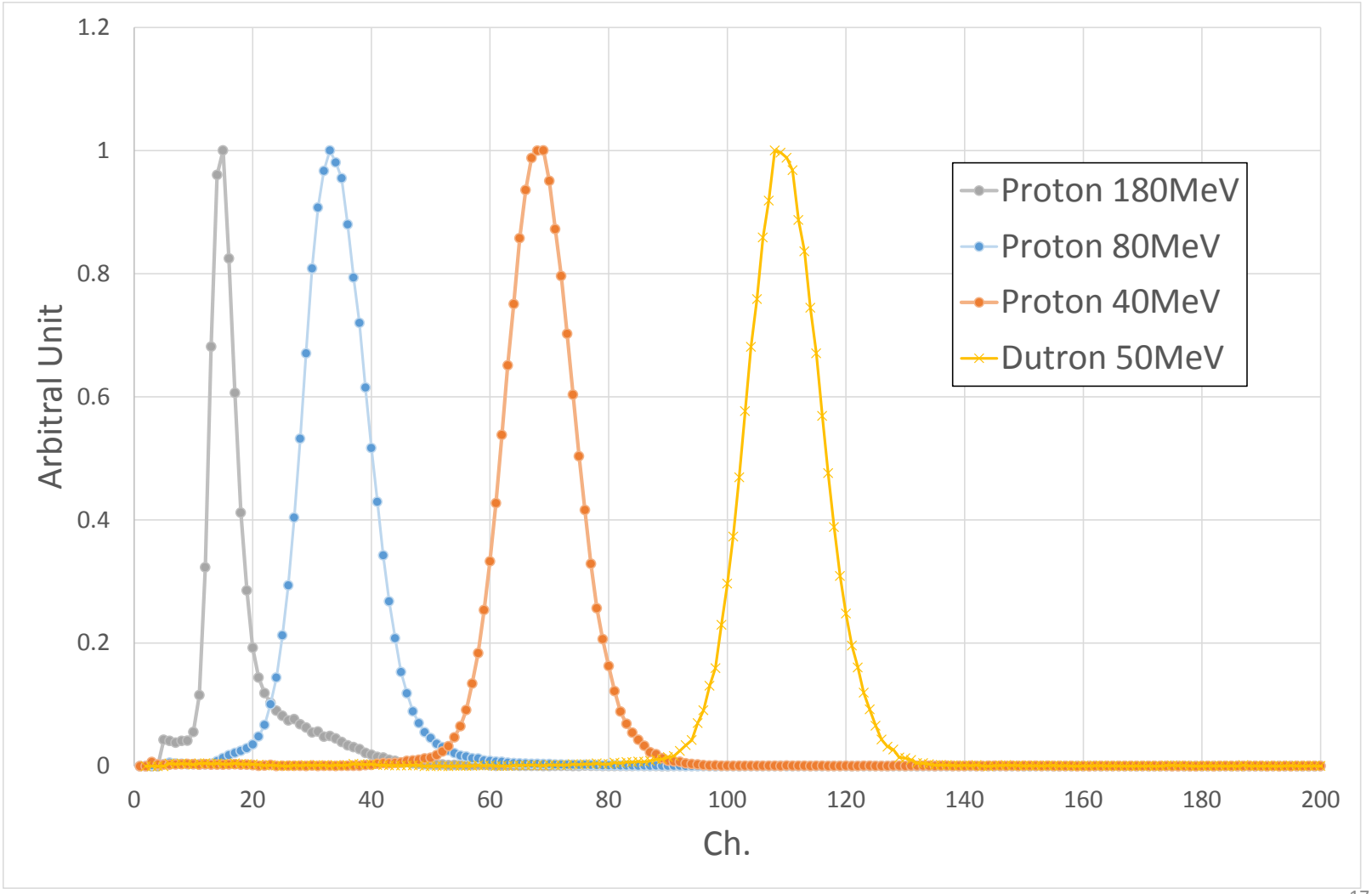




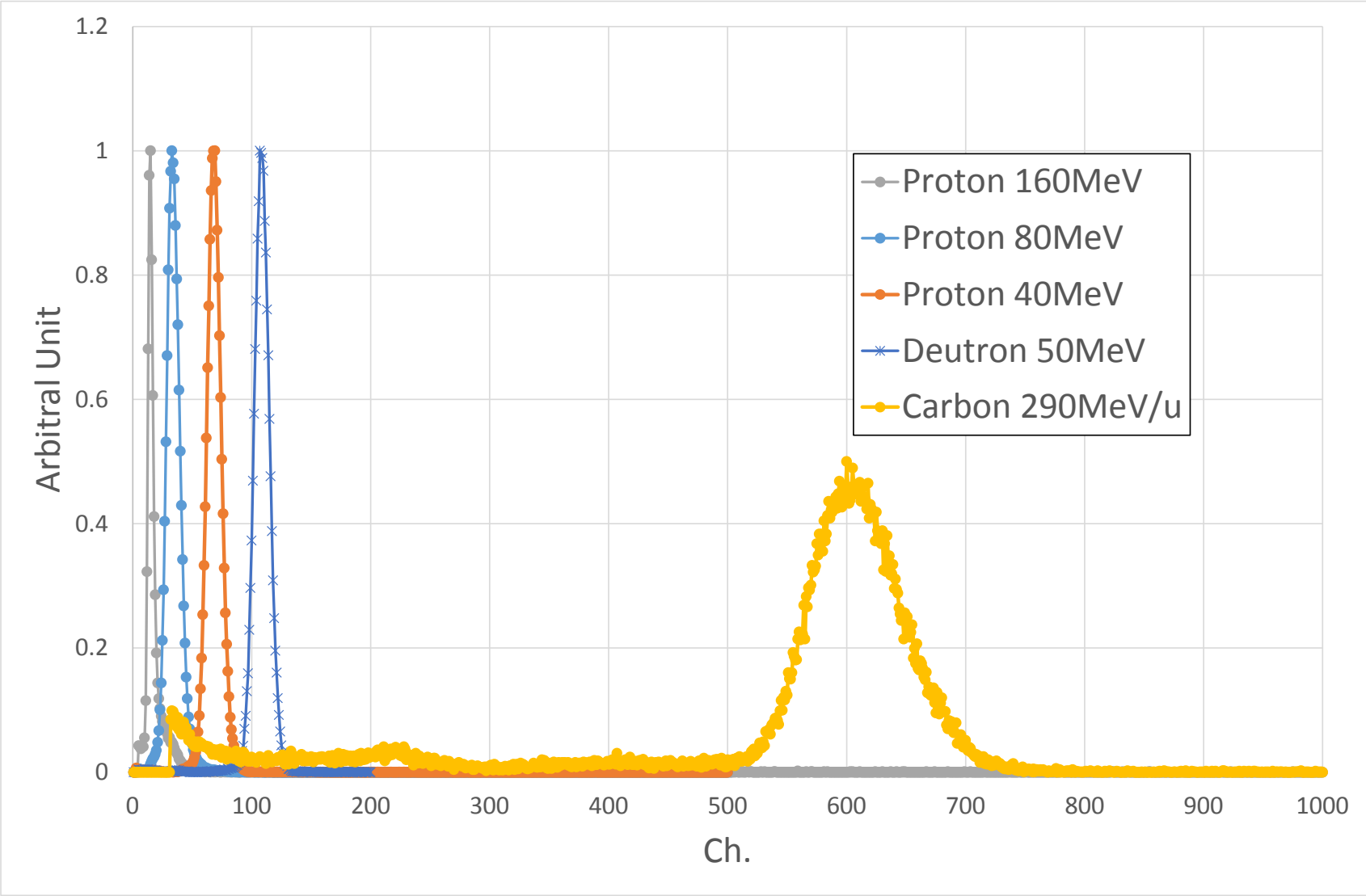




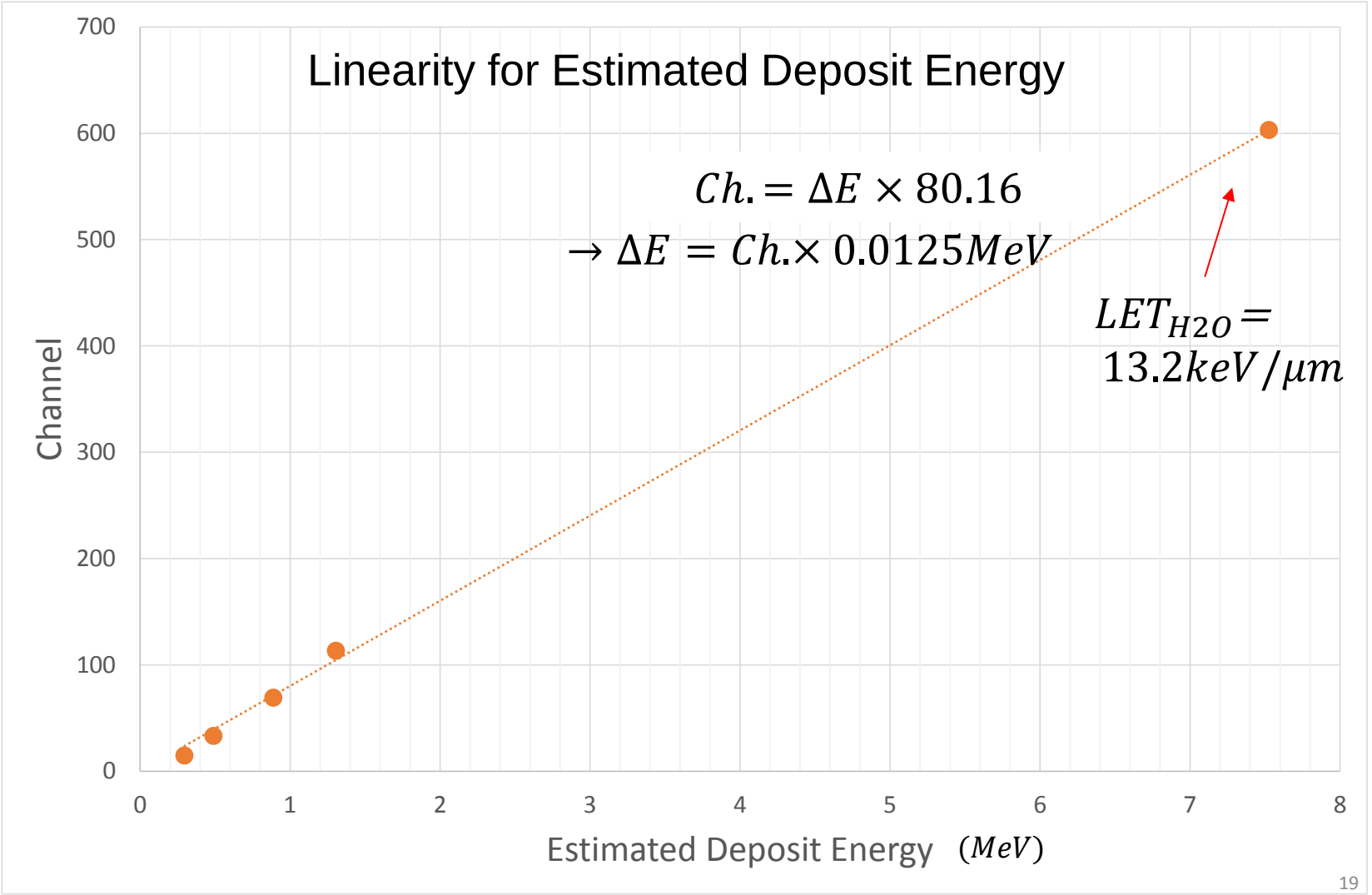
Calibration Results (1)



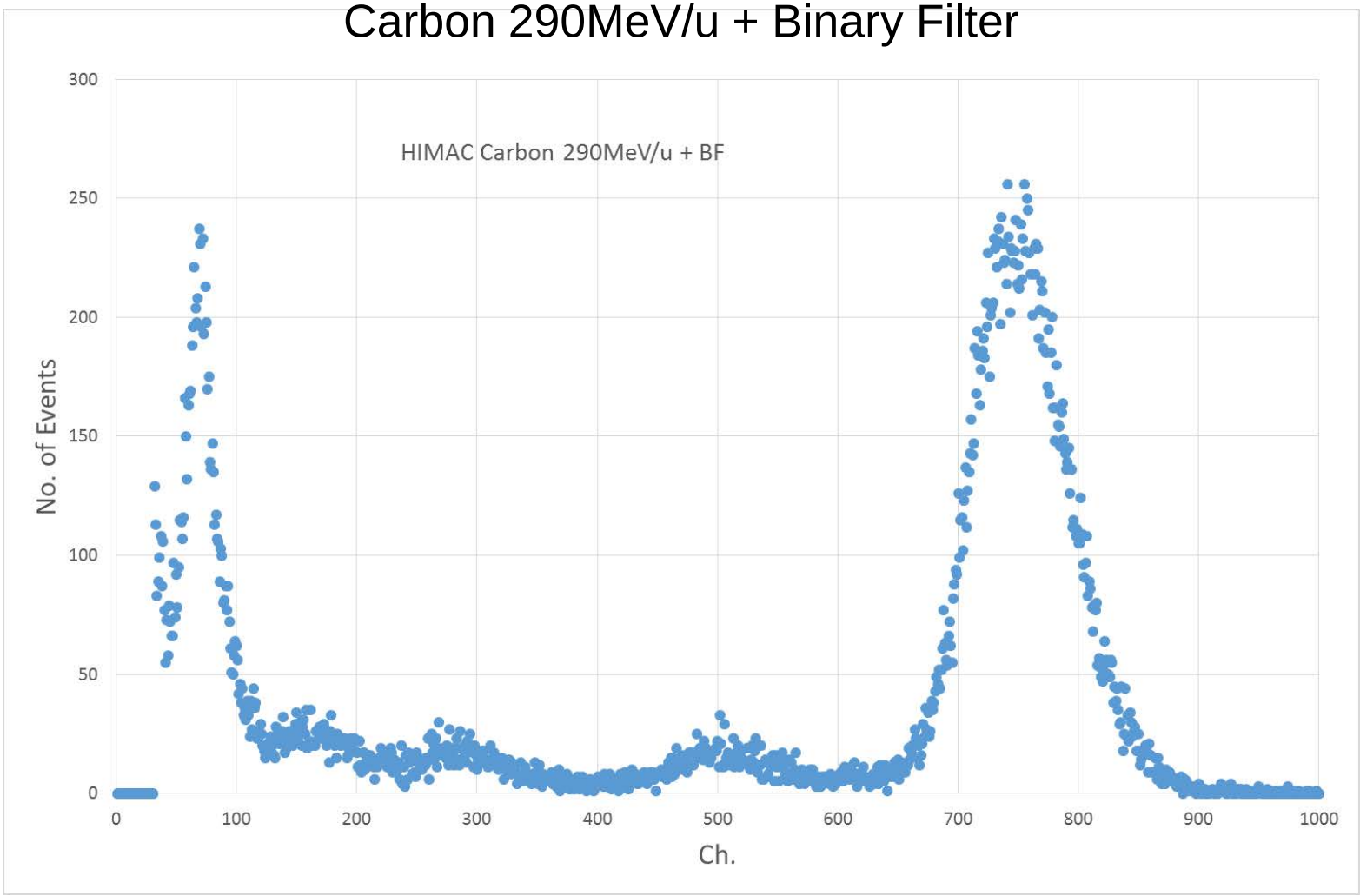
Calibration Results (2)



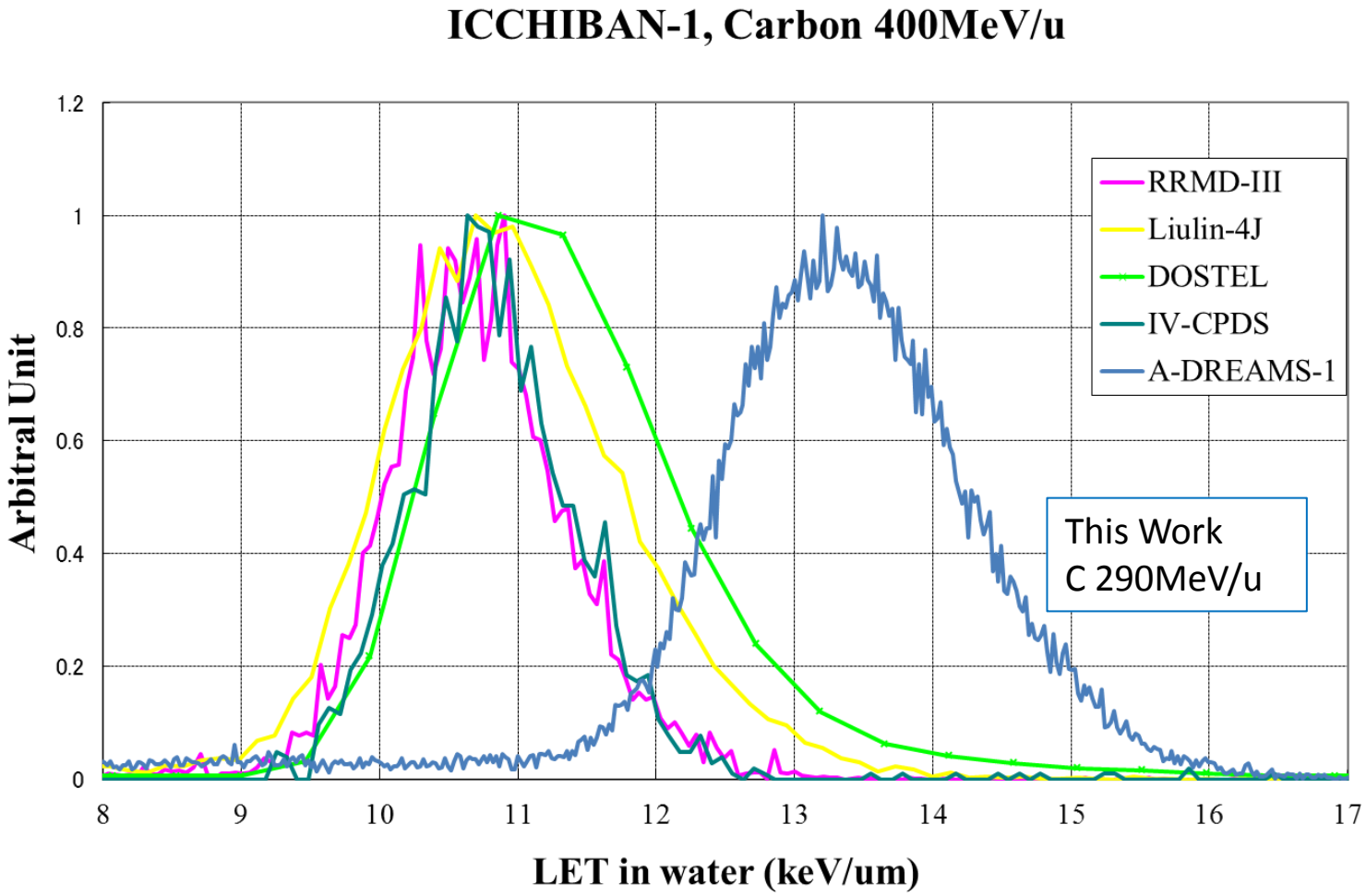
Calibration Results (3)



Calibration Results (4)



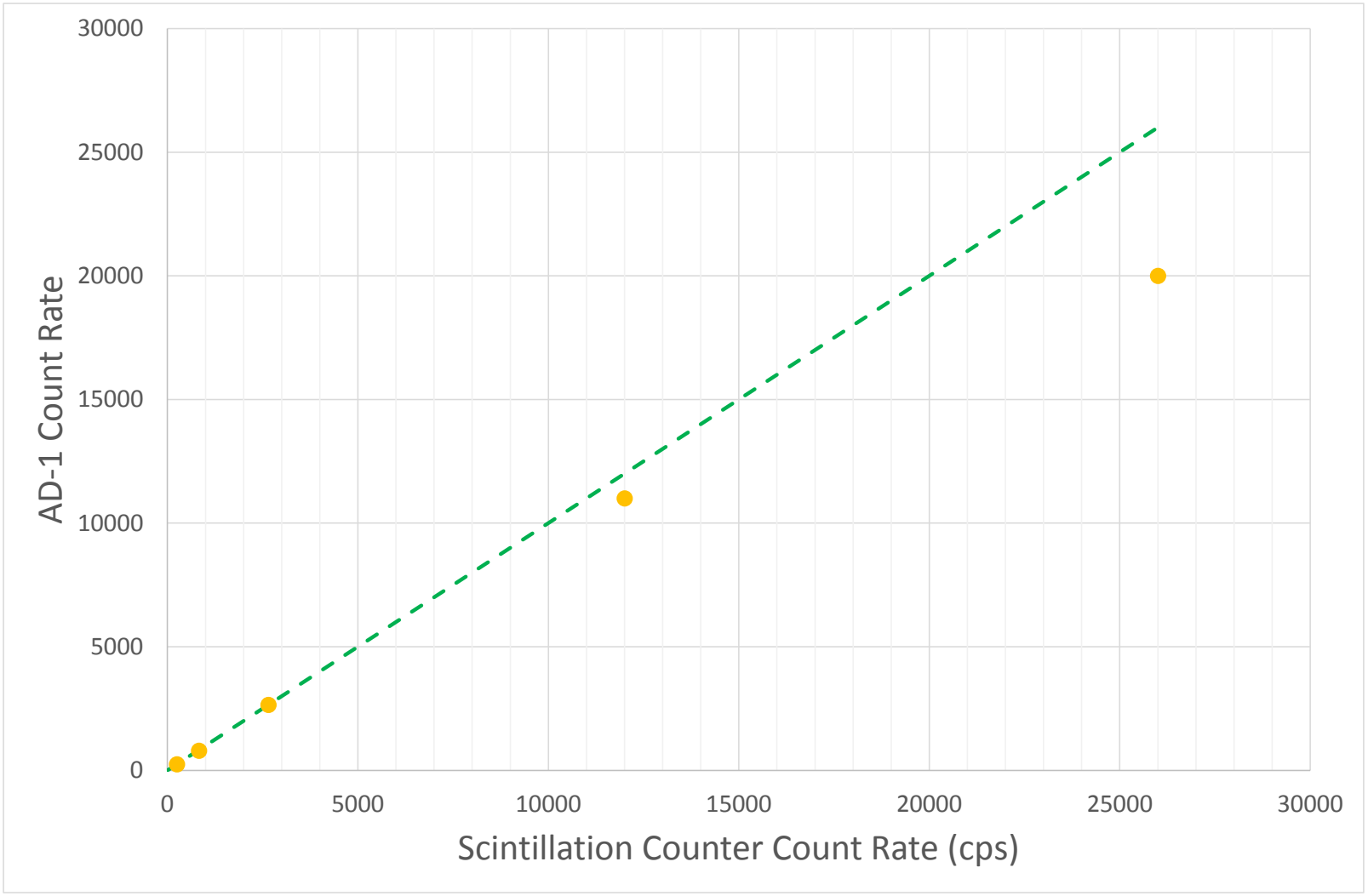
Comparison with ICCHIBAN-1 Results



Modified Presentation by Uchihori in WRMISS13, Krakow (http://wrmiss.org/workshops/thirteenth/

"Results from the first two InterComparison of dosimetric instruments for cosmic radiation with Heavy Ion Beams at NIRS (ICCHIBAN-1&2) Experiments", Eds. Y.Uchihori and E.R.Benton, HIMAC Report-078, NIRS Chiba, pp. 1-281, NIRS, 2004.

Count Rate Calibration



Future Plan

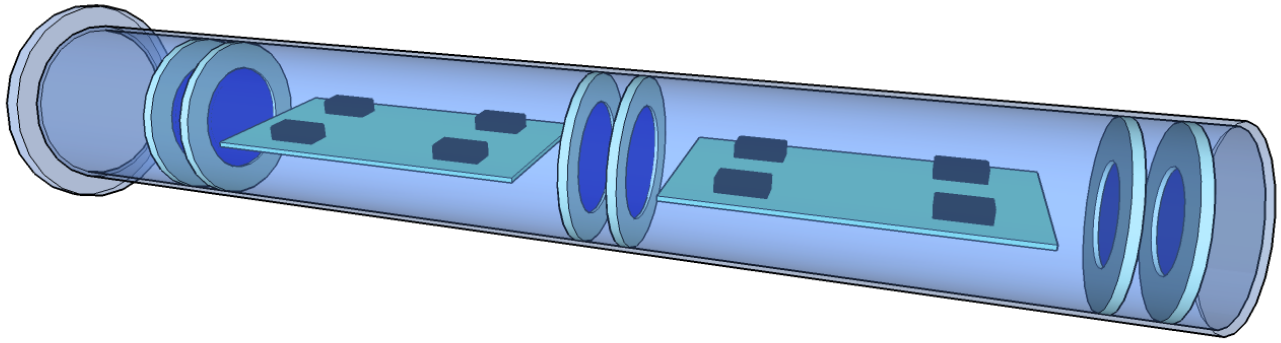
Future Plan

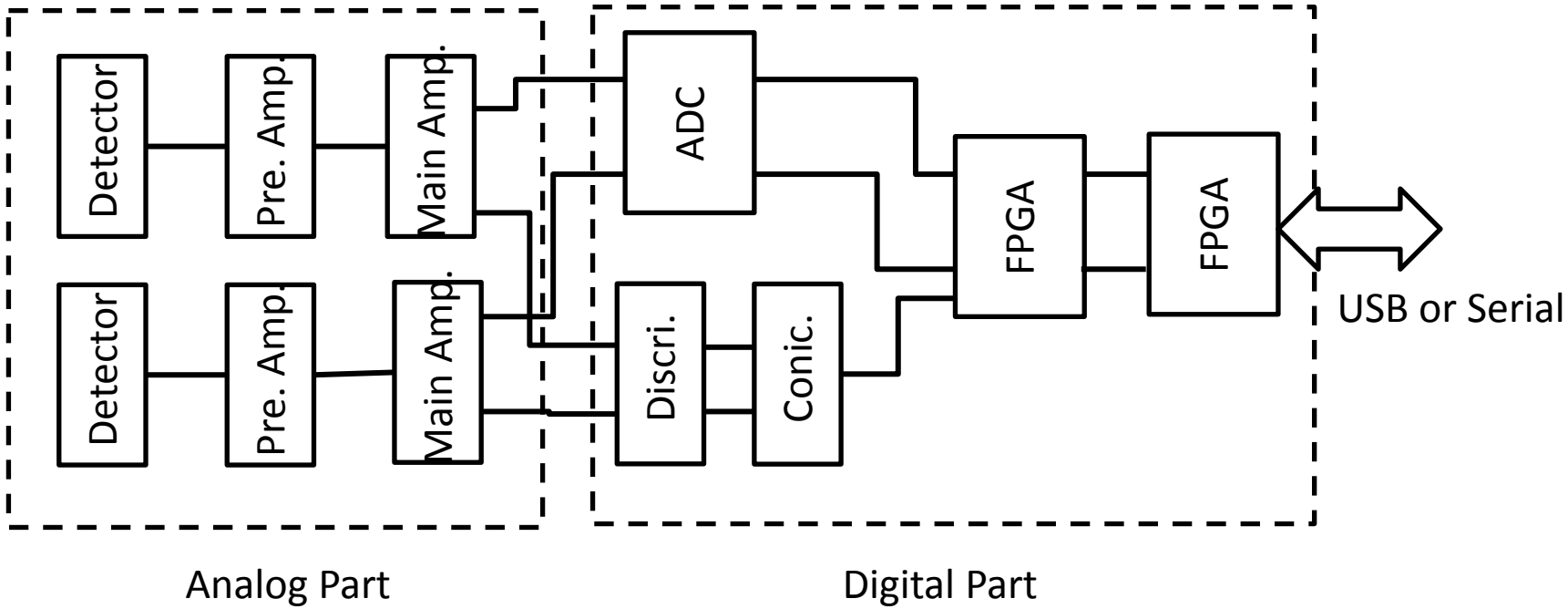
- For MATROSHKA-III experiment, we are planning to prepare **A-DREAMS-MTR** In near future.
- A-DREAMS-MTR are planning to be installed in a phantom torso to be measured depth dose distribution. For this purpose, it has multiple silicon detectors to obtain coincident events.

- In order to confirm the design and specification, we are developing prototype active detector, **A-DREAMS-2**.

A-DREAMS-MTR (Detector Part, Plan)

- Telescope, 6 or 4 silicon detectors (20mm dia. x 0.3mmt)
- External Size: 250 mm x 38 mm dia.
- Aluminum Cover
- Weight: unknown
- Power Cons.: unknown

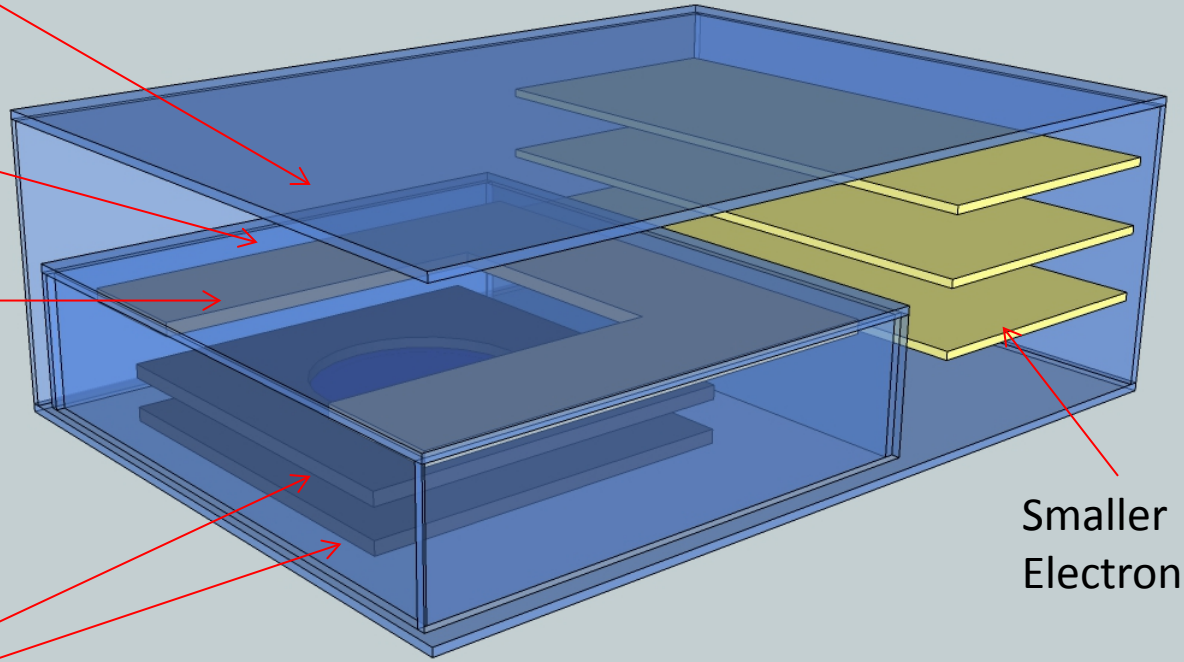



Detector
Pre. Amp.
Main Amp.
Detector
Pre. Amp.
Main Amp.
ADC
Discri.
Conic.
FPGA
FPGA
USB or Serial
Analog Part
Digital Part

Prototype

A-DREAMS-2

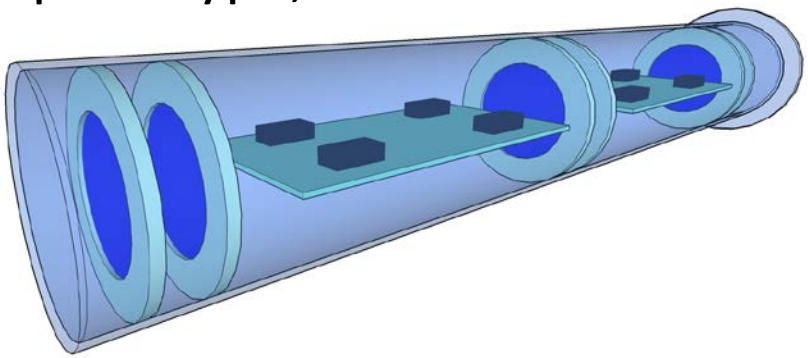
A-DREAMS-2 Schematic

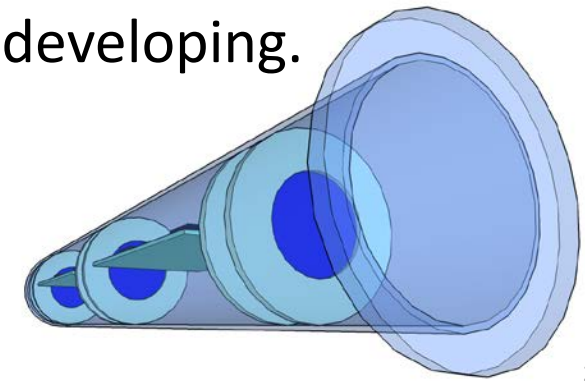


AD-2 will be ready on the next January.

Conclusion

- An active detector, A-DREAMS-1, has been developed and calibrated with the accelerator facilities, HIMAC and the cyclotron in NIRS.
- The capability of A-DREAMS-1 has been confirmed to measure space radiation.
- The next generation, A-DREAMS-MTR which will be a silicon telescope, will be developed to be installed in the phantom torso.
- The prototype, A-DREAMS-2 are now developing.





Acknowledgement

- We would like to thank the members for Matroshka-III projects, especially, **Drs. G. Reitz, V. Shurshakov and T. Berger**.
- We would like to thank **ICCHIBAN participants** for their input on space radiation measurements.
- Because we are learned very much about active detectors for space environment by **Dr. Tsvetan Dachev, Dr. Jordanka Semkova and their colleagues**, we would like to thank them.
- The calibration experiments were performed as a collaboration research of **HIMAC and Cyclotron facilities** in NIRS.

QST (Japan Agency of Quantum and Radiological Science and Technology)

- A part of JAEA (Japan Atomic Energy Agency) will be combined with NIRS. They are ‘Quantum Beam Science Center’ and ‘Sector of Fusion Research and Development’.
- So, the new agency will be called ***Japan Agency of Quantum and Radiological Science and Technology (QST)***.
- However, the institute in Chiba will be called ***National Institute of Radiological Sciences (NIRS)*** continuously.

Thank you for your attention!