XXVI Meeting of the Space Resources Round Table, 2026/6/2 15:20-15:40
Session 4 – Resource Prospecting & Exploration (II)

CSRI
Center for Space Resources and Innovation

Neutron Counting for Water Detection on Planetary Bodies: Development of the Flight-Ready RANCH Instrument and a Measurement Technique

Yuta Shimizu[1, 2*], Hideaki Miyamoto[1, 2], Teppei Takemoto[1, 2], Makito Kobayashi[1, 2], Taichi Ikenaga[3], Kei Kashiwagi[3], Yuki Mitsuya[1], Yuna Isobe[1, 2], Alvin Preat[1, 2], Hiroyuki Takahashi[1]

[1] The University of Tokyo, [2]Center for Space Resources and Innovation, [3]Soil and Rock Engineering Co., Ltd.

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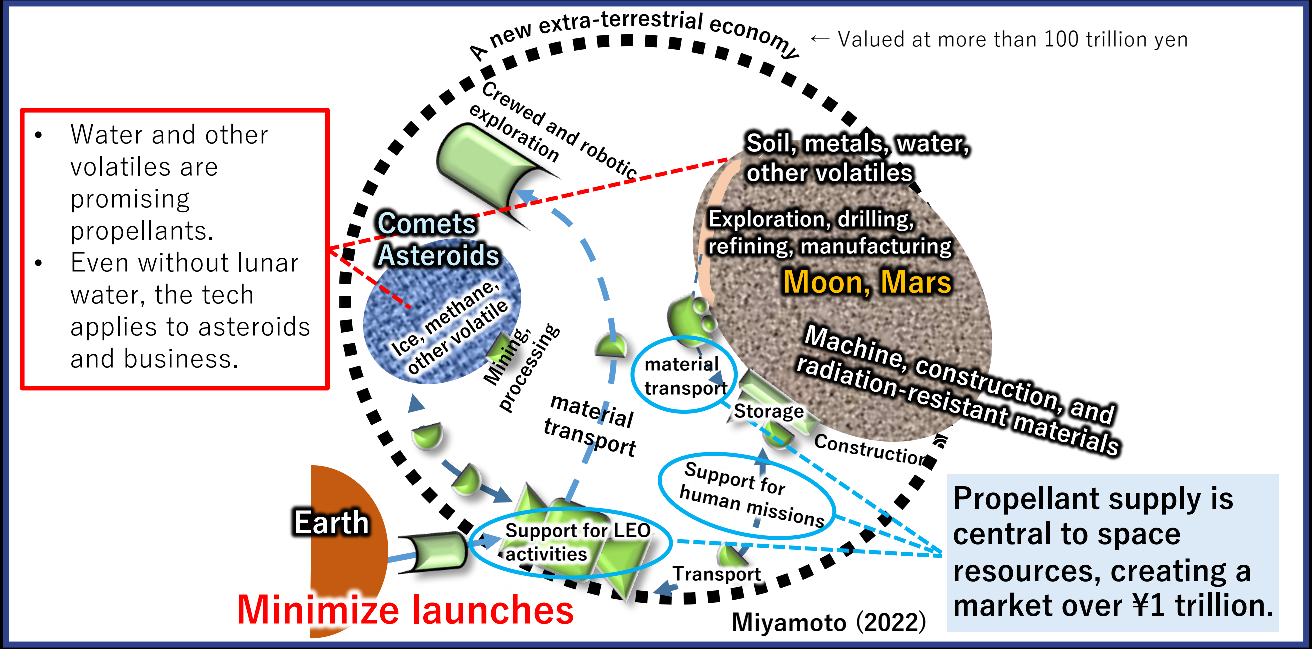
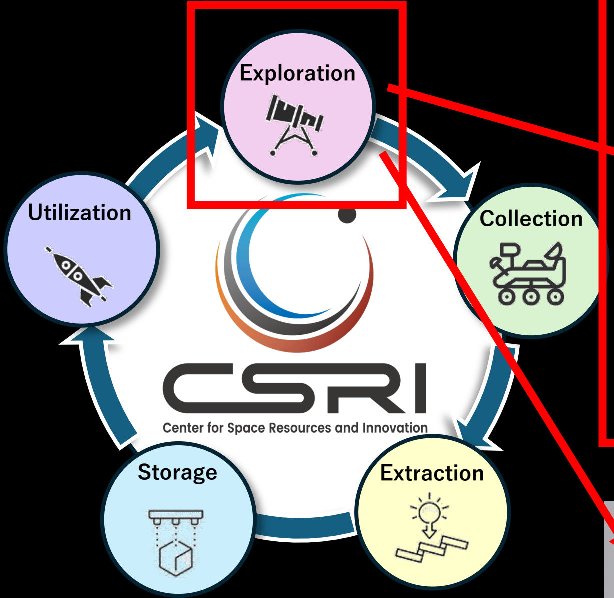
In October 2025, CSRI was established to advance space resource development on the Moon and other bodies

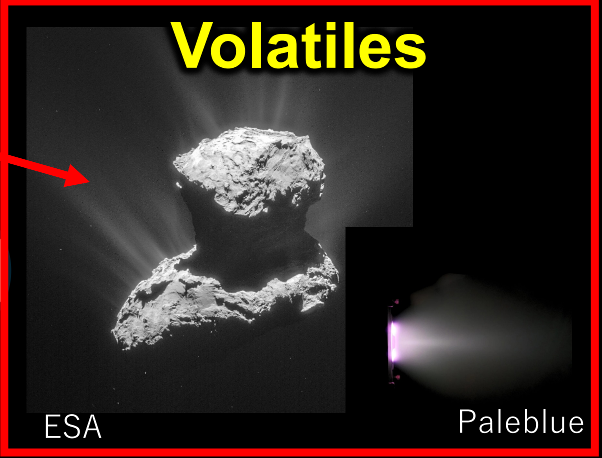
CSRI

Center for Space Resources and Innovation

~40 faculty members, >100 people

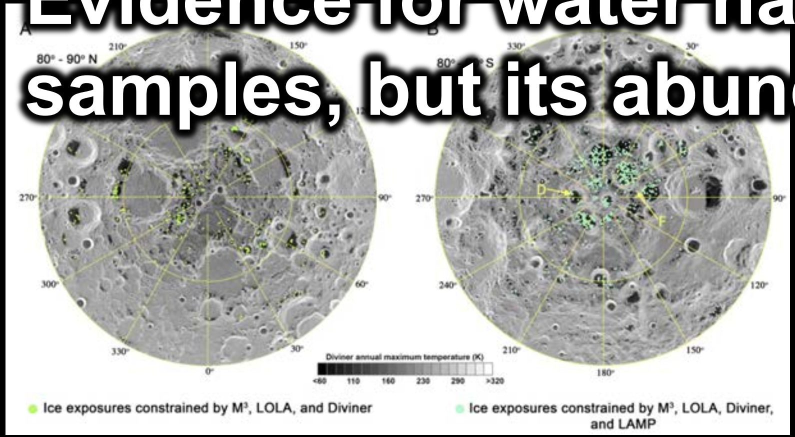






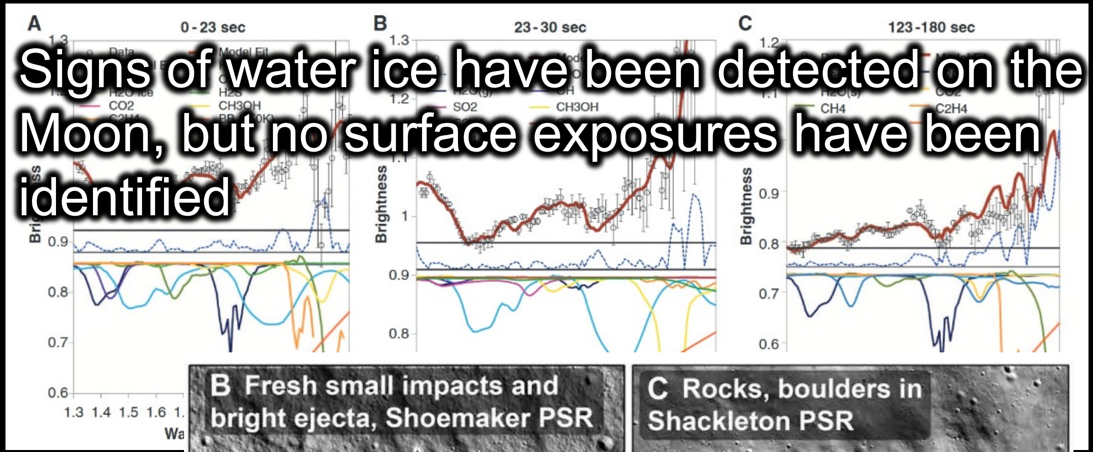
We cover technologies spanning the full cycle of space resource development

Evidence for water has been found on the **Moon** and in **asteroid samples**, but its abundance and distribution remain uncertain

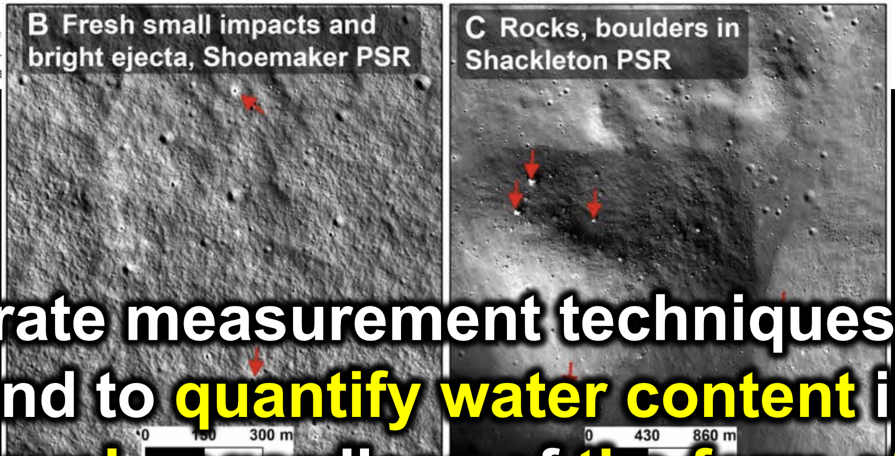


[Li et al., 2018]

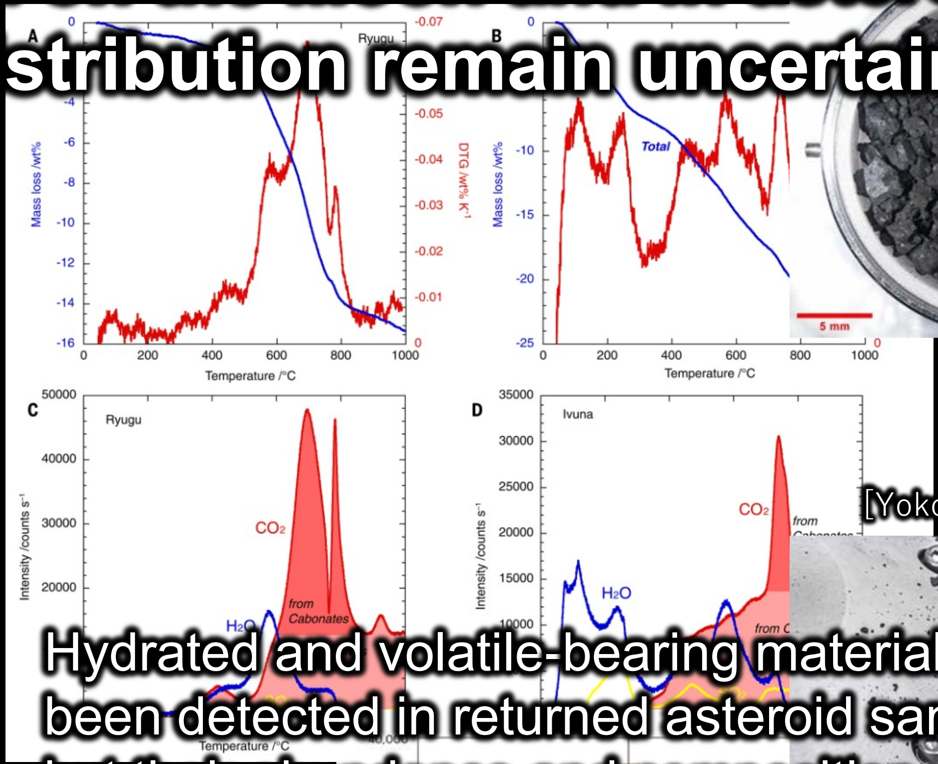
[Colaprete et al., 2009]



Signs of water ice have been detected on the Moon, but no surface exposures have been identified

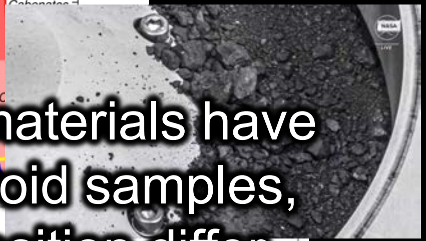


[Li et al., 2026]



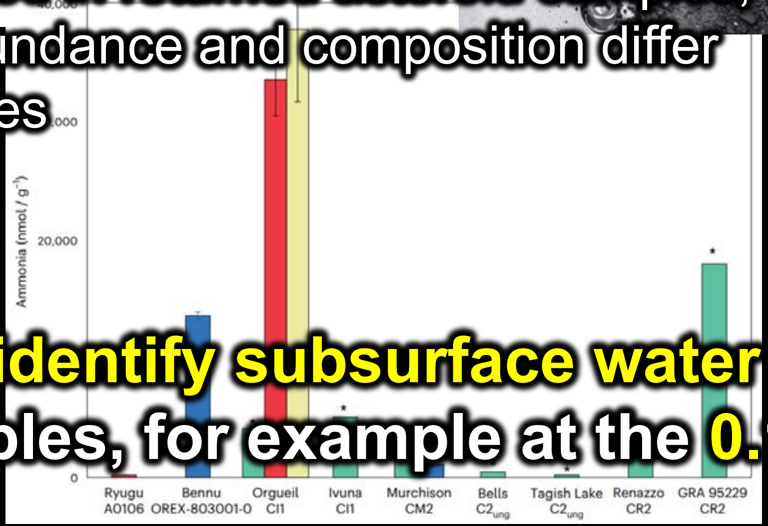
JAXA

[Yokoyama et al., 2022]



NASA

Hydrated and volatile-bearing materials have been detected in returned asteroid samples, but their abundance and composition differ among bodies

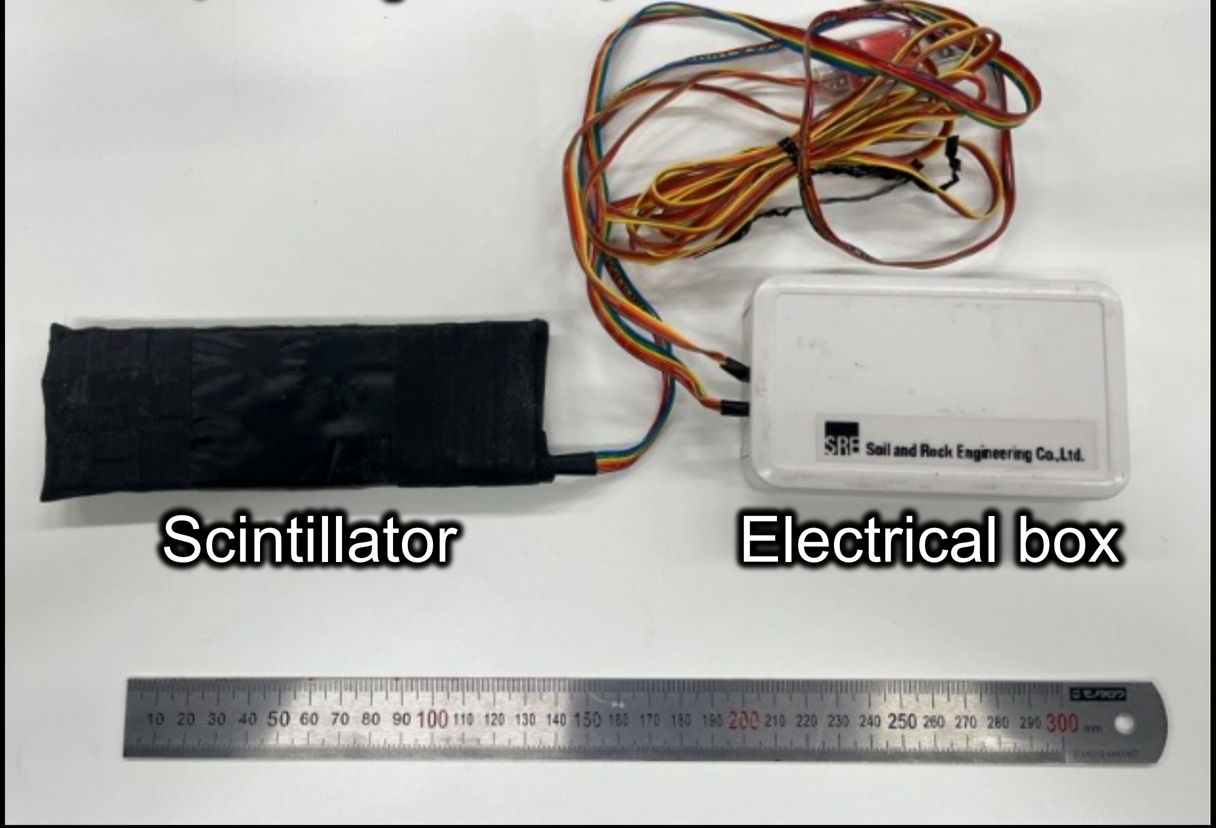


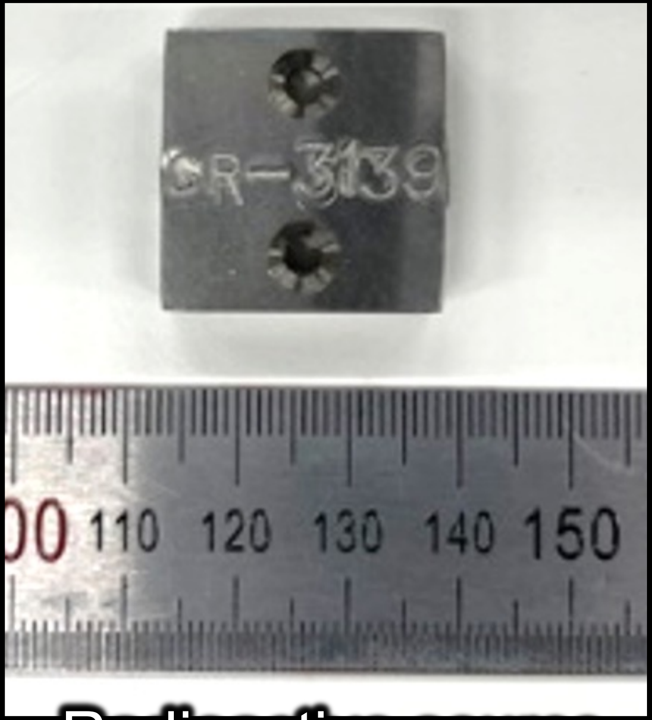
[Glavin et al., 2025]

Accurate measurement techniques are required to identify subsurface water in situ and to quantify water content in collected samples, for example at the 0.1 wt% level, regardless of the form of water.

RANCH: Regolith Active Neutron Counter for Hydrogen

Low-mass, low-power, and rapid water content estimation



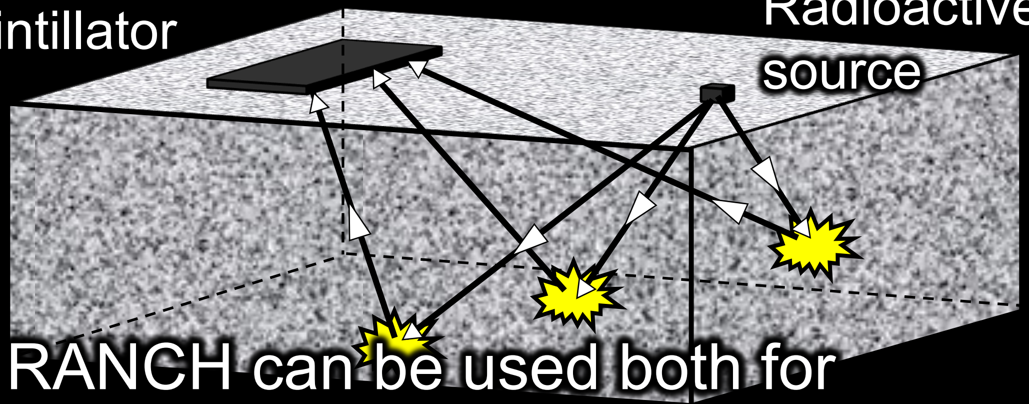


Radioactive source

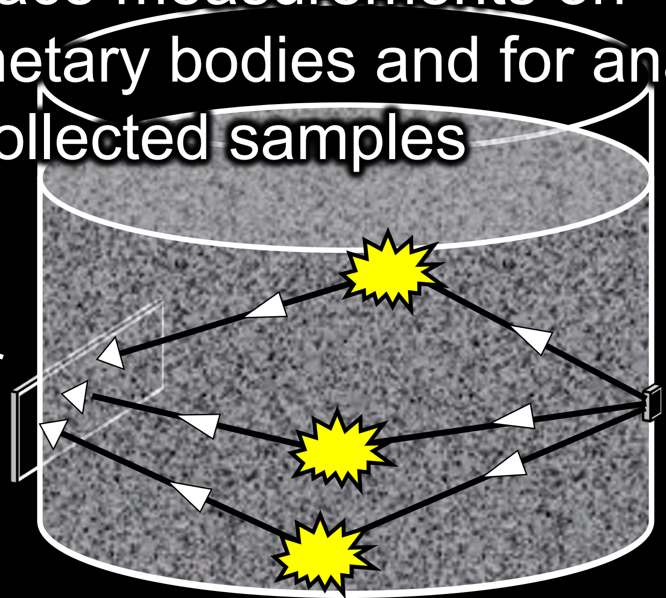
Component	Mass	Dimensions
Scintillator	~200g	165x50x10 mm
Radioactive source	~50g	20x20x8 mm
Electrical box	~50g (TBD)	70x50x5 mm (TBD)

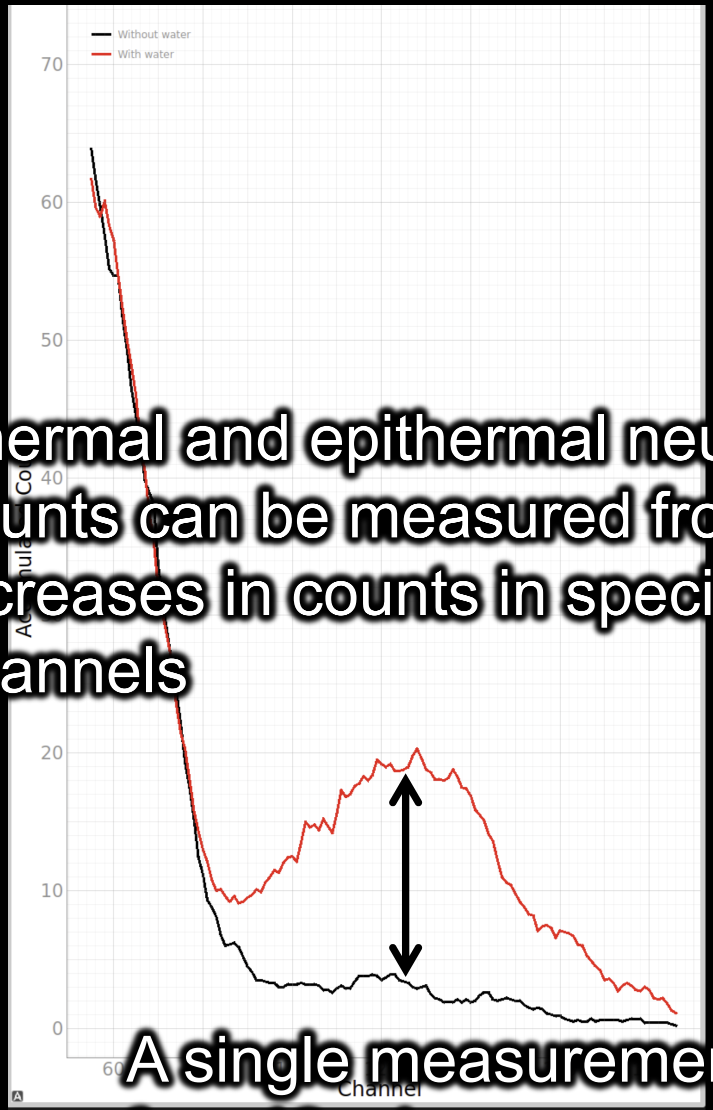
Total mass: ~200-300 g
Power consumption: ~0.5 W

RANCH counts thermal (<0.5 eV) and epithermal neutrons (<~100 keV) generated through the interaction of fast neutrons and hydrogen



RANCH can be used both for surface measurements on planetary bodies and for analysis of collected samples



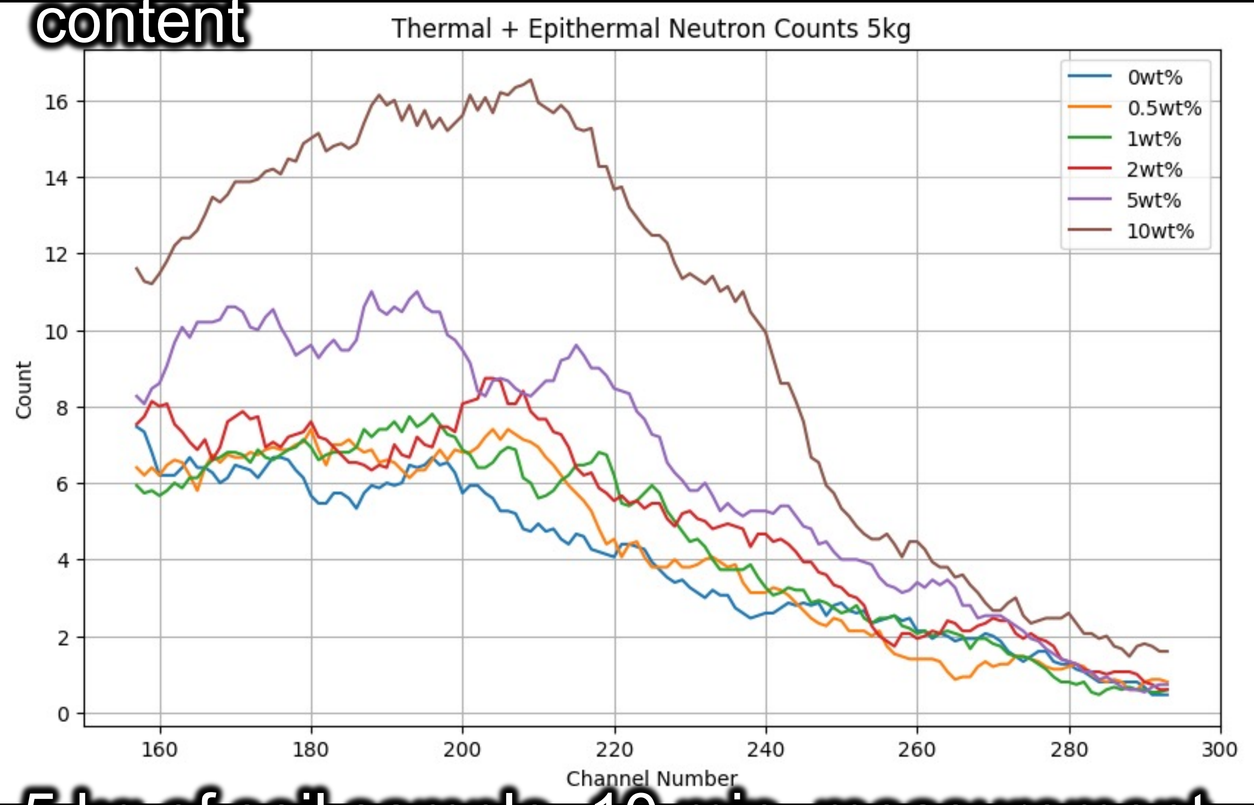


Thermal and epithermal neutron counts can be measured from increases in counts in specific channels

A single measurement takes for ~10 min

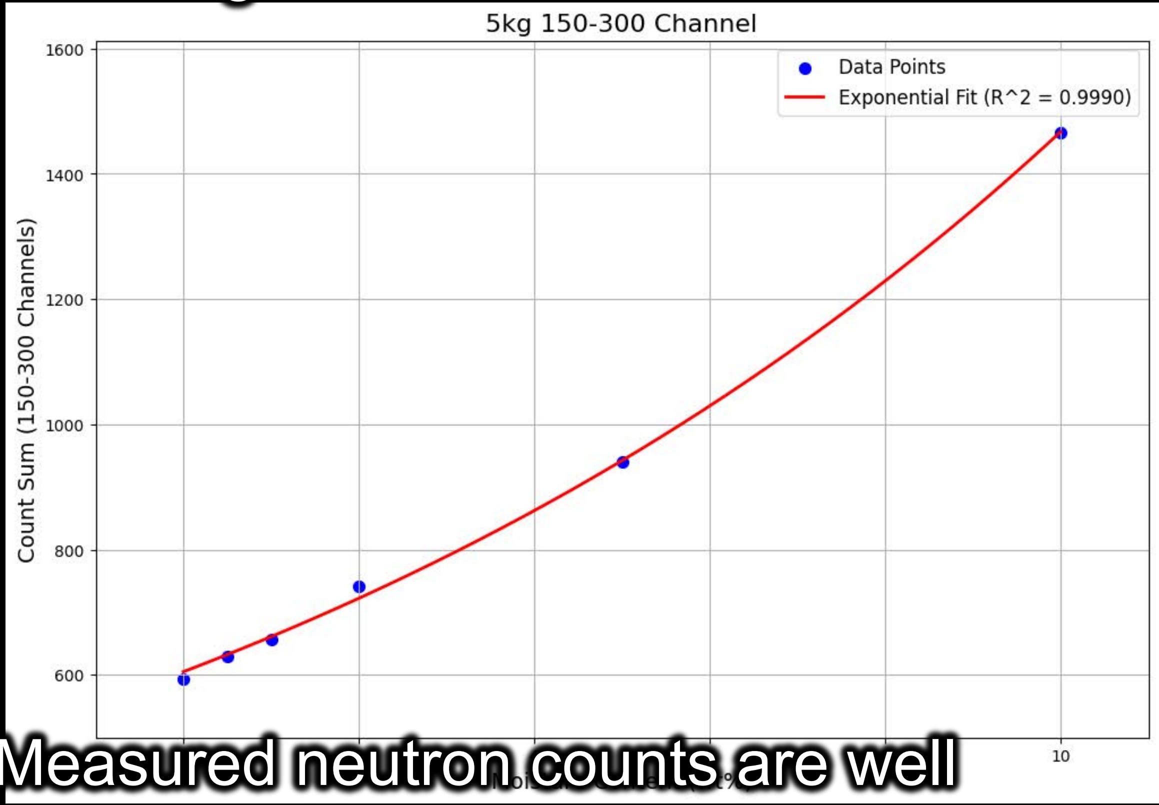
Measured neutron counts are well fitted by the calibration curve

Spectral response varies with soil water content



5 kg of soil sample, 10 min. measurement

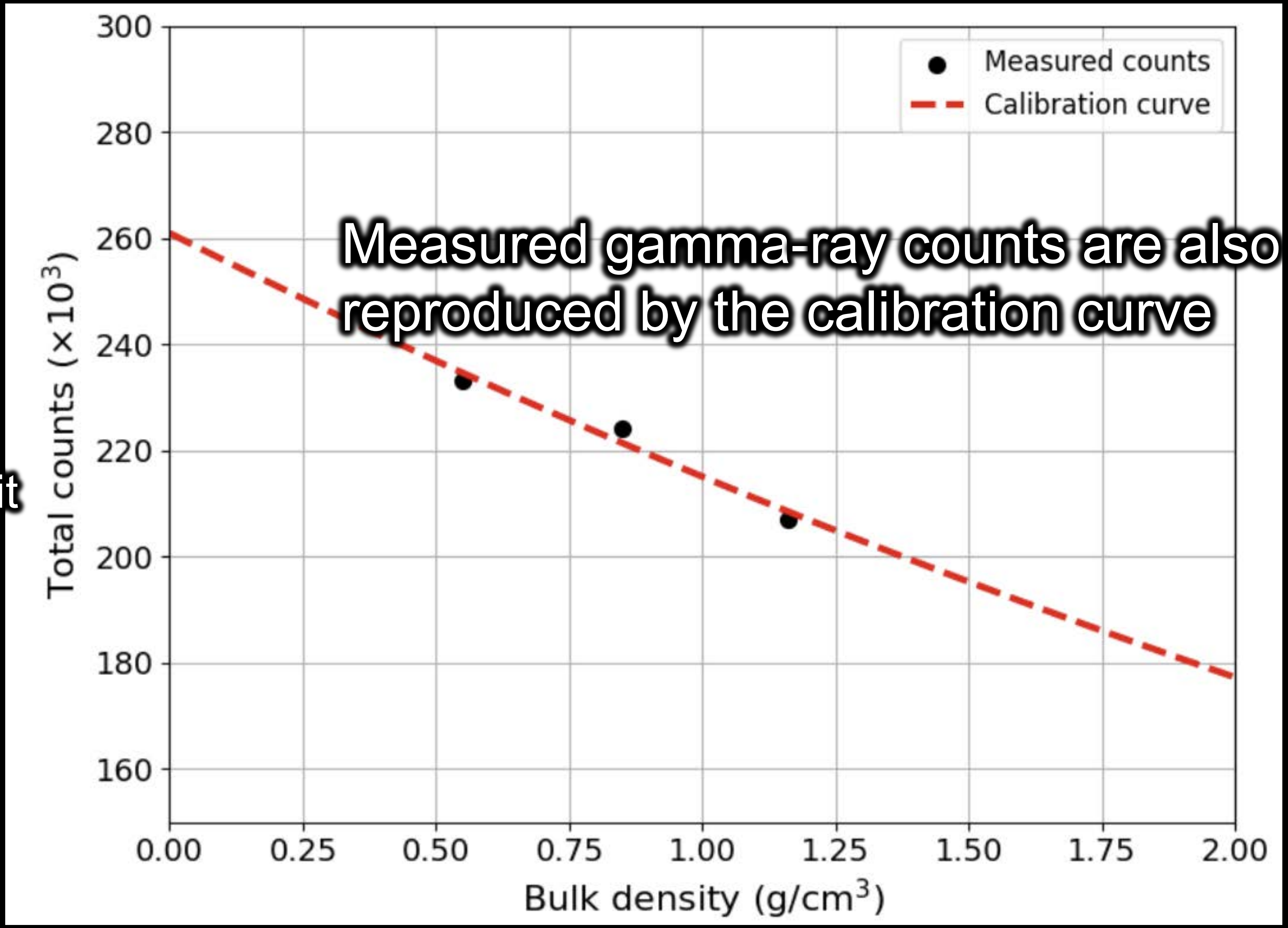
Counts in specific channels increase with increasing water content



Measured neutron counts are well reproduced by the calibration curve (R^2 = 0.999)

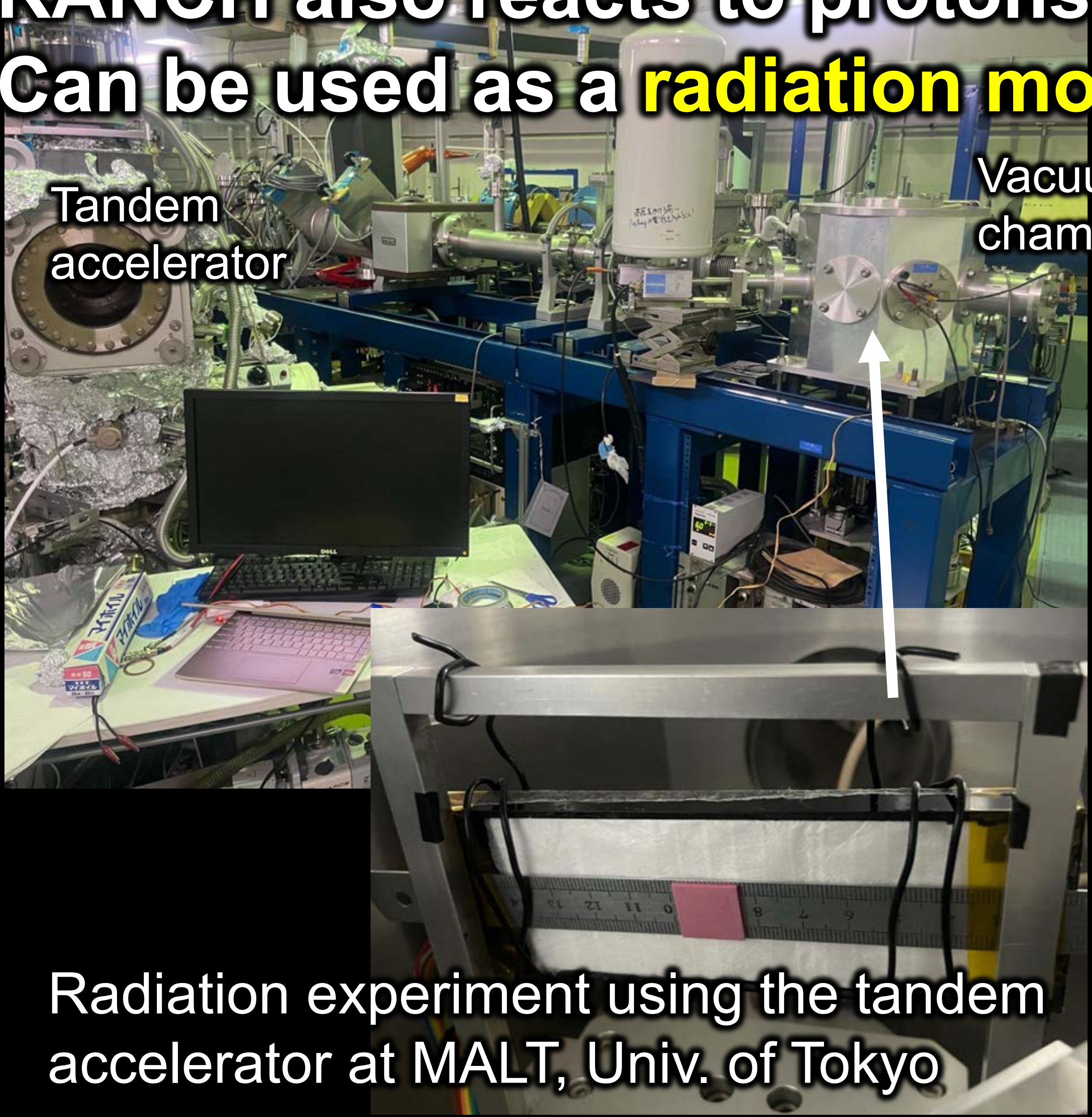
RANCH is also sensitive to high-energy charged particles

Bulk density of samples can be estimated using gamma-ray measurements

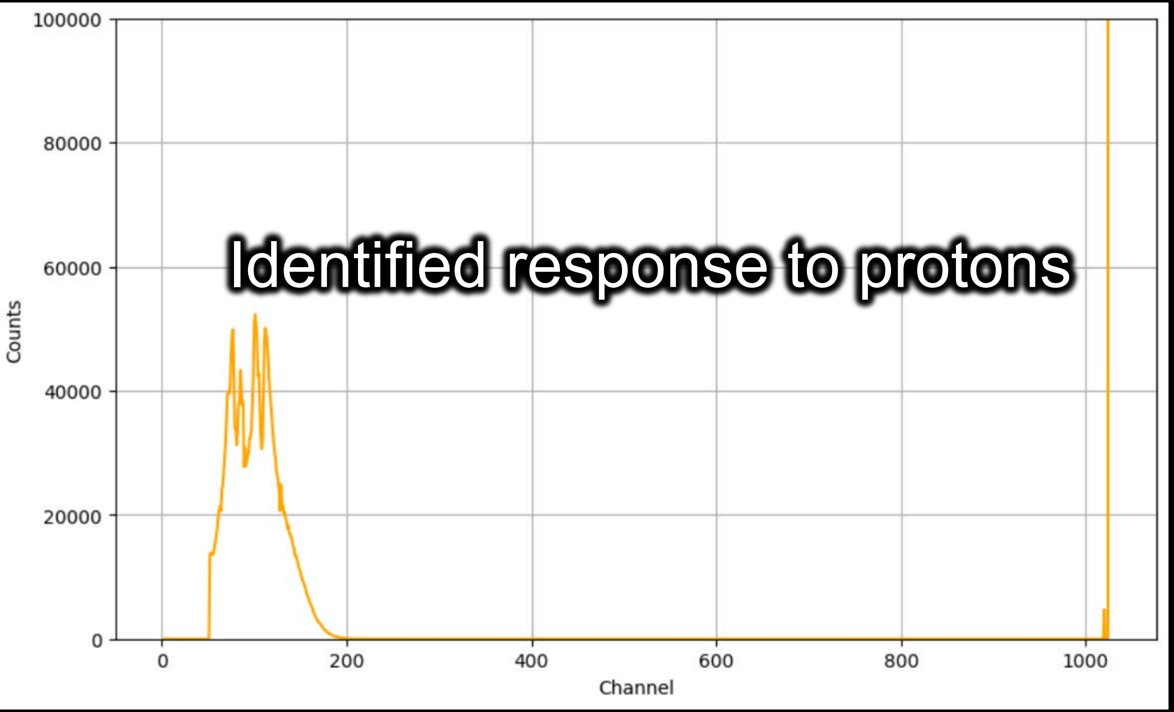


Measured gamma-ray counts are also well reproduced by the calibration curve

RANCH also reacts to protons and α particles
Can be used as a **radiation monitor for SEP and GCR**

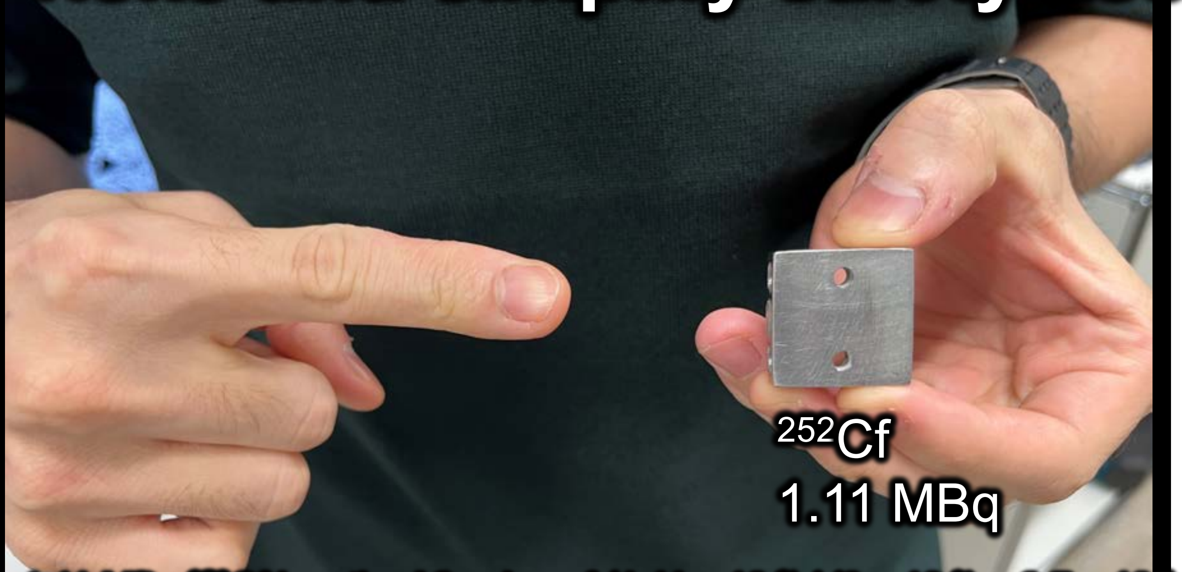


Radiation experiment using the tandem accelerator at MALT, Univ. of Tokyo



We sincerely thank Prof. Matsuzaki and the MALT members for their support with the irradiation experiment.

Low-activity radioactive source designed to minimize safety risks and simplify safety assessment



1.11 MBq ^{252}Cf has the A2 value of: $(1.11 \times 10^{-6}) / (3 \times 10^{-3}) = 3.7 \times 10^{-4} \times A2$

The total value is ~0.00037 x A2 < 0.001 x A2

ser Requirements Quick Reference.

Requirements	Non-Tiered Missions				Tiered Missions		
	< A2×0.001	≥ A2×0.001	≥ A2	≥ A2×500	Tier I	Tier II	Tier III
Reports							
NEPA	✓	✓	✓	✓	✓	✓	✓
Initial Notice		✓	✓	✓	✓	✓	✓
Annual Report to AFSEC				✓	✓	✓	✓
Annual Briefing						✓	✓
Safety Analysis							
SAS				✓			
SAR					✓	✓	✓
Safety Review							
NSR			✓	✓	✓		
INSRB/SER						✓	✓
Authorization							
LAA Launch Authorization		✓	✓	✓	✓	✓	✓
DEL/CC Launch Authorization		✓	✓	✓	✓	✓	✓
Protection Practice							
Risk Constraint			✓	✓	✓	✓	✓
Safety Guidelines	✓	✓	✓	✓	✓	✓	✓
Contingency Plans		✓	✓	✓	✓	✓	✓
Support							✓

[DAFMAN 91-110]

Table 3.1. Tiered and Non-Tiered Thresholds.

Tiers		Thresholds
Non-Tiered Missions	≥ A2×0.001 < A2	- Quantity of radioactive material is ≥ A2×0.001 < A2
	≥ A2 < A2×500	- Quantity of radioactive material is ≥ A2 < A2×500
	≥ A2×500 < A2×1,000	- Quantity of radioactive material is ≥ A2×500 < A2×1,000
Tiered Missions	Tier I	- Quantity of radioactive material is ≥ A2×1,000 ≤ A2×100,000
	Tier II	- Quantity of radioactive material is > A2×100,000 - Probability of exposure of 5 rem to 25 rem to any member of the public is ≥ 1 in 1,000,000 - Nuclear fission systems using low-enriched uranium
	Tier III	- Probability of exposure of > 25 rem to any member of the public is ≥ 1 in 1,000,000 - Nuclear fission systems using other than low-enriched uranium

[DAFMAN 91-110]

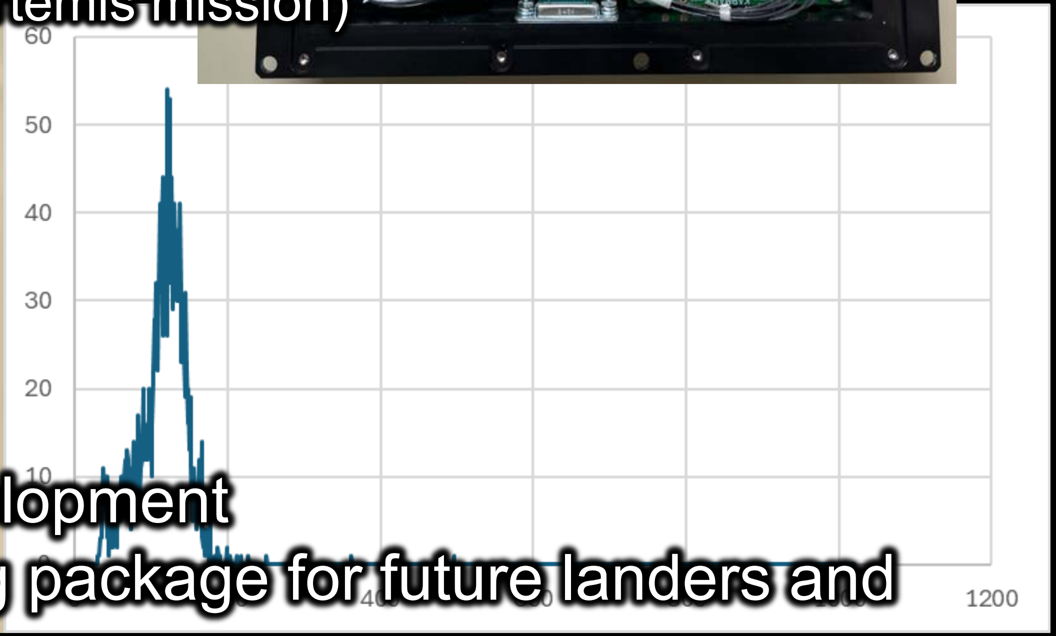
- ✓ With appropriate handling and containment, the source does not pose a risk to personnel or onboard instruments, reducing the pre-launch safety review burden
- ✓ The launch provider indicated that the payload could fly on a rideshare mission, provided that an independent payload review is completed and approved several months before launch

Through the CACE alliance, we have been discussing possible approaches to comply with U.S. and international regulatory frameworks for the radioactive source

A Radiation Safety Officer (RSO) is required for appropriate handling of sealed radioactive sources. We are exploring a potential collaboration that combines UTokyo's instrument development expertise with regulatory expertise from the School of Mines.

RANCH has been integrated as UTokyo Instrument as an integrated payload package targeting a launch opportunity in 2027

SDA+ (Surface Dielectric Analyzer; Heritage from LDA for Artemis mission)



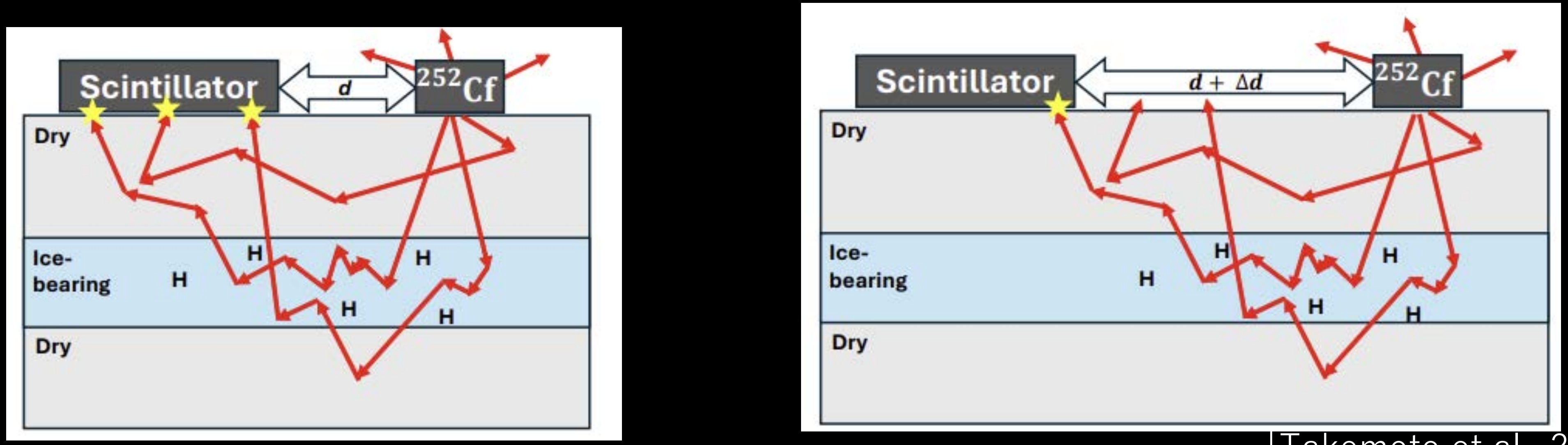
A simplified RANCH package is also under development

We aim to provide a flight-ready neutron sensing package for future landers and rovers

Performing a series of environmental tests (radiation, thermal-vacuum, EMC, vibration, acoustic etc.)

Radiation test with protons and α particles up to 220 MeV at the Wakasa Wan Energy Research Center

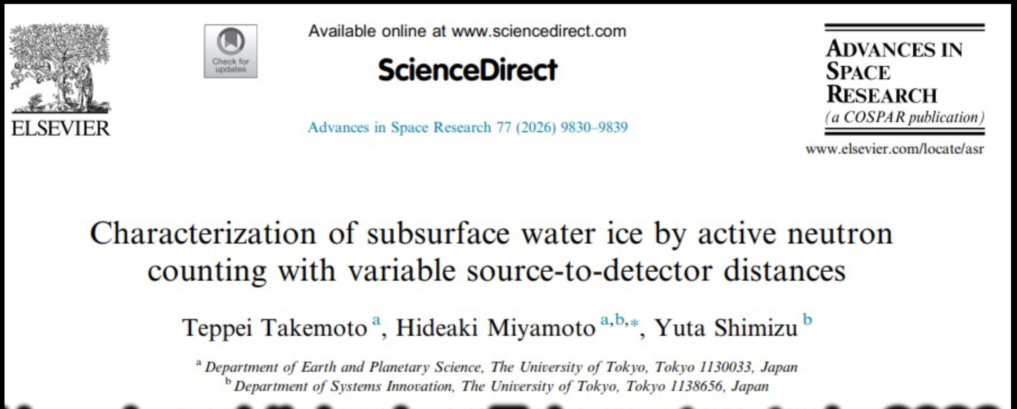
We are also developing a simple, fast, and effective measurement technique to maximize the scientific return of RANCH



[Takemoto et al., 2026]

A neutron source and a scintillator are placed on the surface.
The source–to-detector distance is varied, and the attenuation of detected neutron counts is analyzed to estimate:

・**Depth** of the ice-bearing layer
・**Water content** in the subsurface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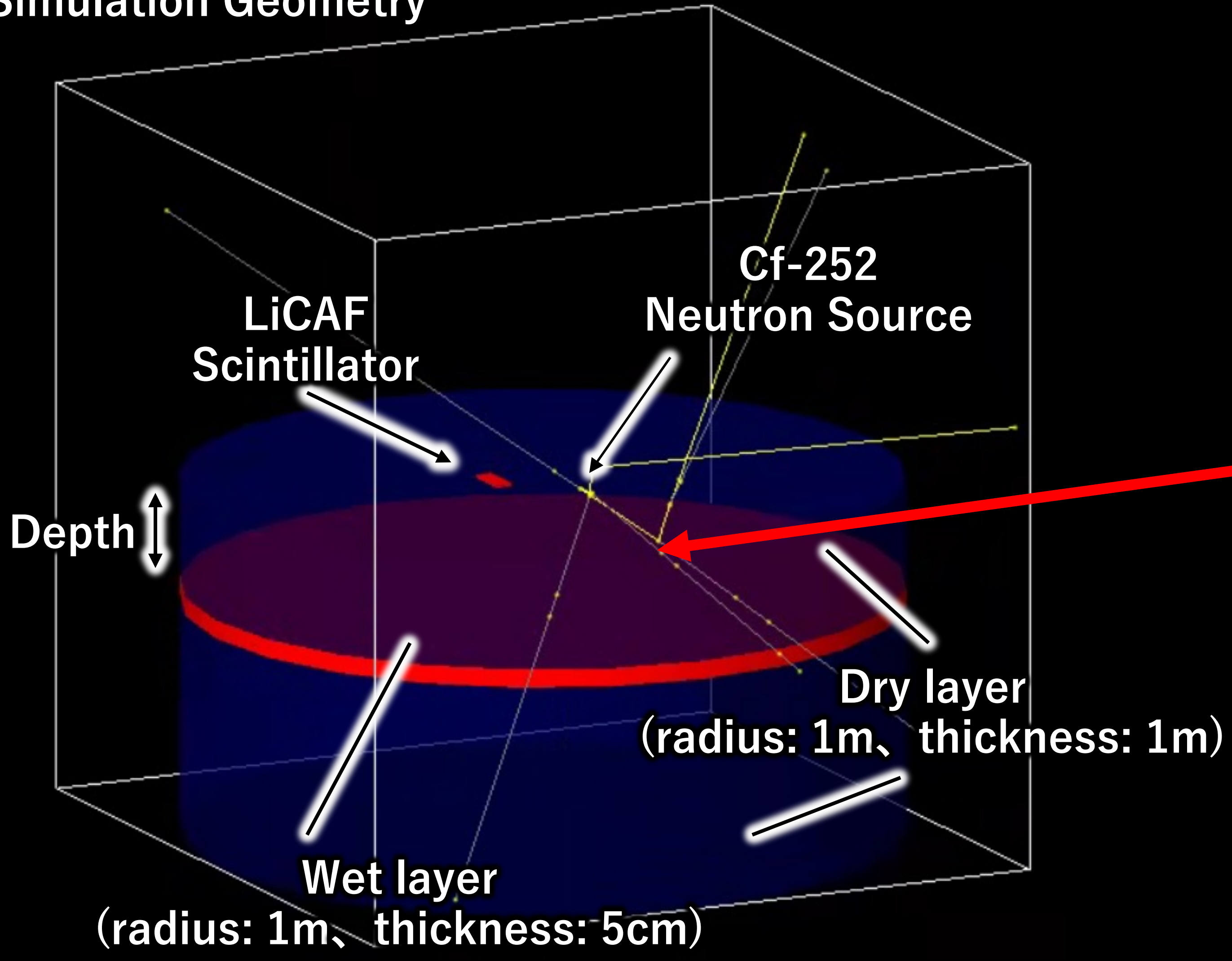
Characterization of subsurface water ice by active neutron counting with variable source-to-detector distances

Teppei Takemoto [a], Hideaki Miyamoto [a,b,*], Yuta Shimizu [b]
[a] Department of Earth and Planetary Science, The University of Tokyo, Tokyo 1130033, Japan
[b] Department of Systems Innovation, The University of Tokyo, Tokyo 1138656, Japan

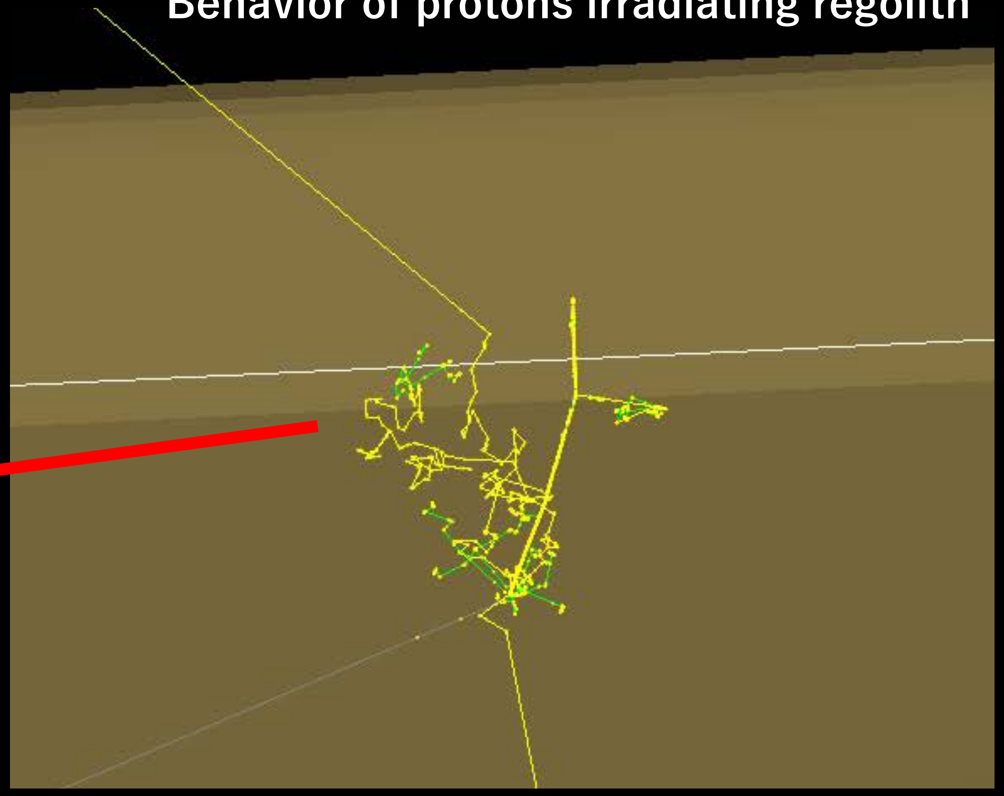
Already published as Takemoto et al., 2026 in peer reviewed journal

We perform Monte Carlo simulations to estimate the behavior of energetic particles and measurements by RANCH

Simulation Geometry



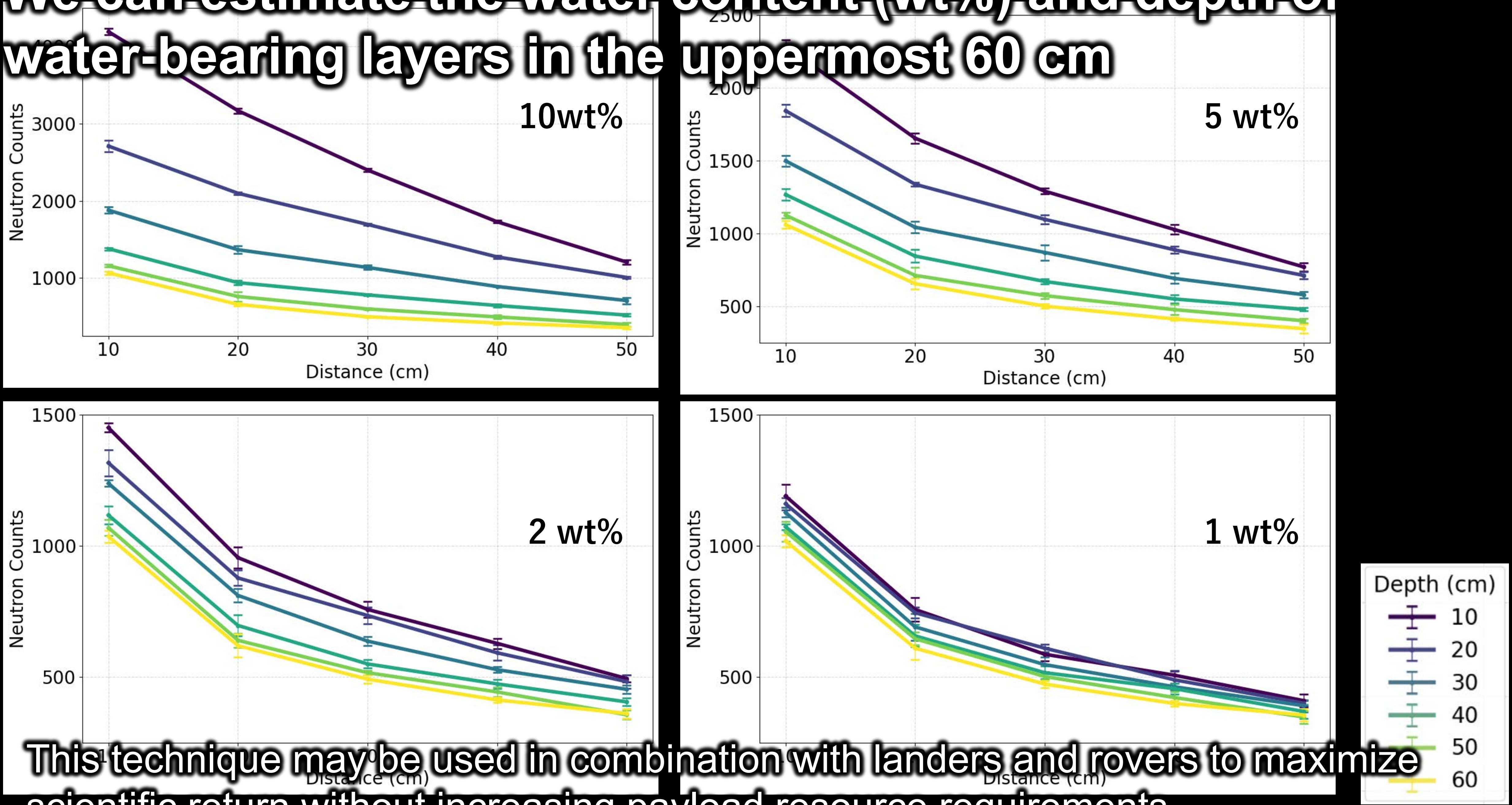
Behavior of protons irradiating regolith



Yellow: proton
Green: γ-ray

[Takemoto et al., 2026]

We can estimate the water content (wt%) and depth of water-bearing layers in the uppermost 60 cm



This technique may be used in combination with landers and rovers to maximize scientific return without increasing payload resource requirements

[Takemoto et al., 2026]

Summary

- Developed RANCH, a compact, lightweight neutron counting instrument
- Measures water content (wt%) in regolith, both in situ and in collected samples from the Moon, asteroids, and other bodies
- Also provides constraints on regolith bulk density and the radiation environment
- Flight model developed, targeting a launch opportunity in 2027
  - Low-activity radioactive source can be handled under an appropriate regulatory framework, classified as "non-tiered mission"
  - Regulatory discussions are ongoing through CSRI and School of Mines

~300 g, <0.5 W, Maximum science return

RANCH: a flight-ready package for water, density, and radiation measurements