Development of the Canadian Active Neutron Spectrometer (CANS)

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This project is undertaken with the financial support of the Canadian Space Agency

CANS Introduction

- The objective is to develop the Canadian Active Neutron Spectrometer (CANS) to monitor neutron radiation on the ISS
- The CANS will collect scientific data that will be used for
  - Refining radiation risk assessment models
  - Validating radiation transport codes
  - Studying the effects of space radiation on shielding materials, electronics, and biological systems
- While the CANS will not be built as an operational instrument, CANS data can be used for operational purposes: to determine the contribution of neutrons to astronauts' total radiation dose
- The CANS will collect data continuously with almost no user interaction and will telemeter data to the ground on a fixed schedule and/or as commanded
- The instrument will initially be deployed onboard the ISS for a Technology Demonstration phase
- The long-term plan is to deploy the CANS on evolving platforms beyond LEO, e.g., at the lunar surface
- The CANS was introduced at last year's WRMISS in a presentation by Leena Tomi and Vincent Cousineau Daoust from the Canadian Space Agency (CSA)

Radi-N and Radi-N2 Experiments

- Radi-N and Radi-N2 experiments were conducted on the ISS from 2009 to 2020
- Detectors were deployed around the ISS to monitor neutrons, correlated with position, time, and influence quantities (e.g., altitude and solar activity)
- 75 week-long measurements were conducted using multiple sets of detectors
- Bubbles were counted with the space mini reader, developed and fabricated by BTI
- A paper describing the results from the US Orbital Segment was recently published online (M.B. Smith et al., Life Sciences in Space Research, in press)



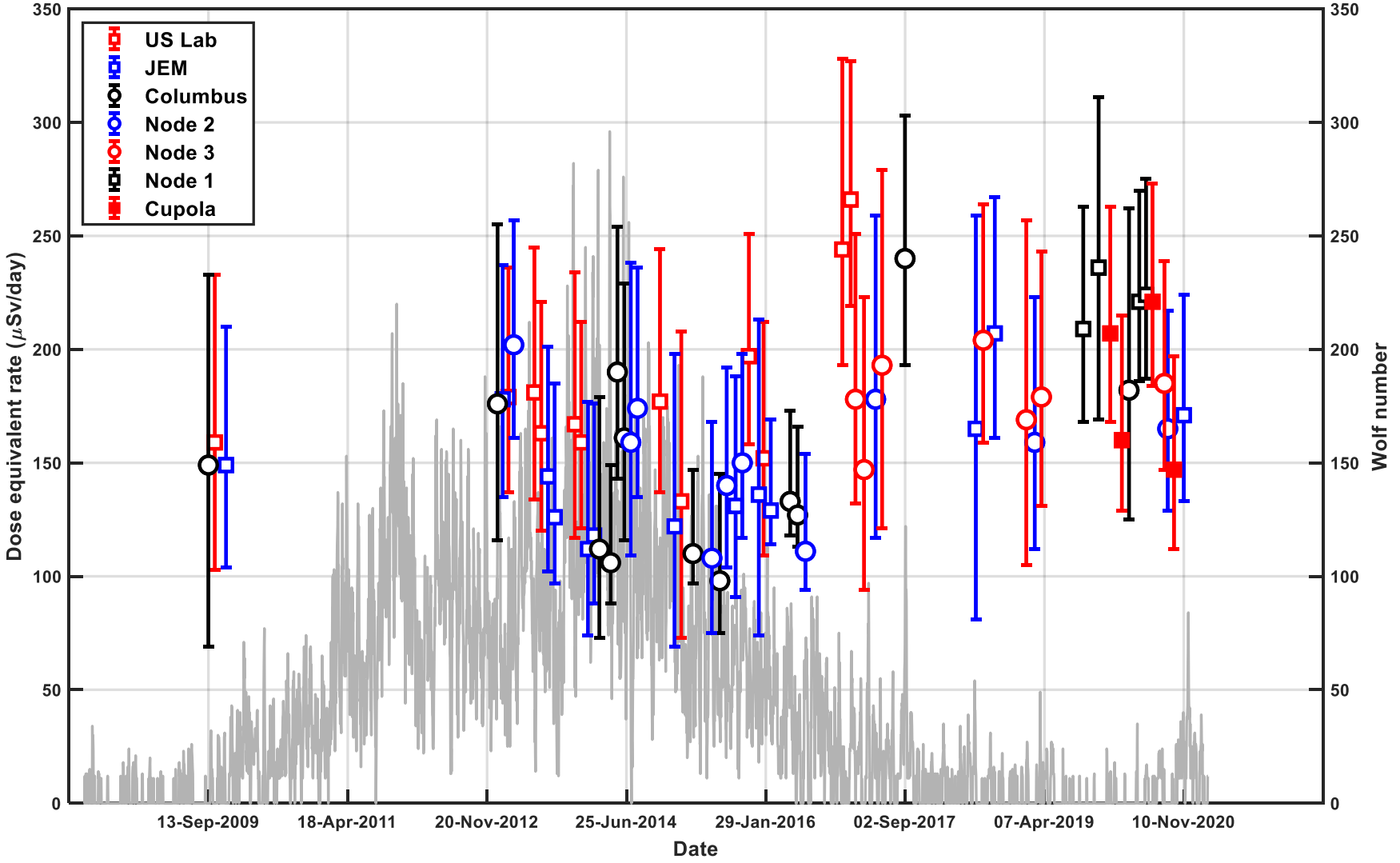




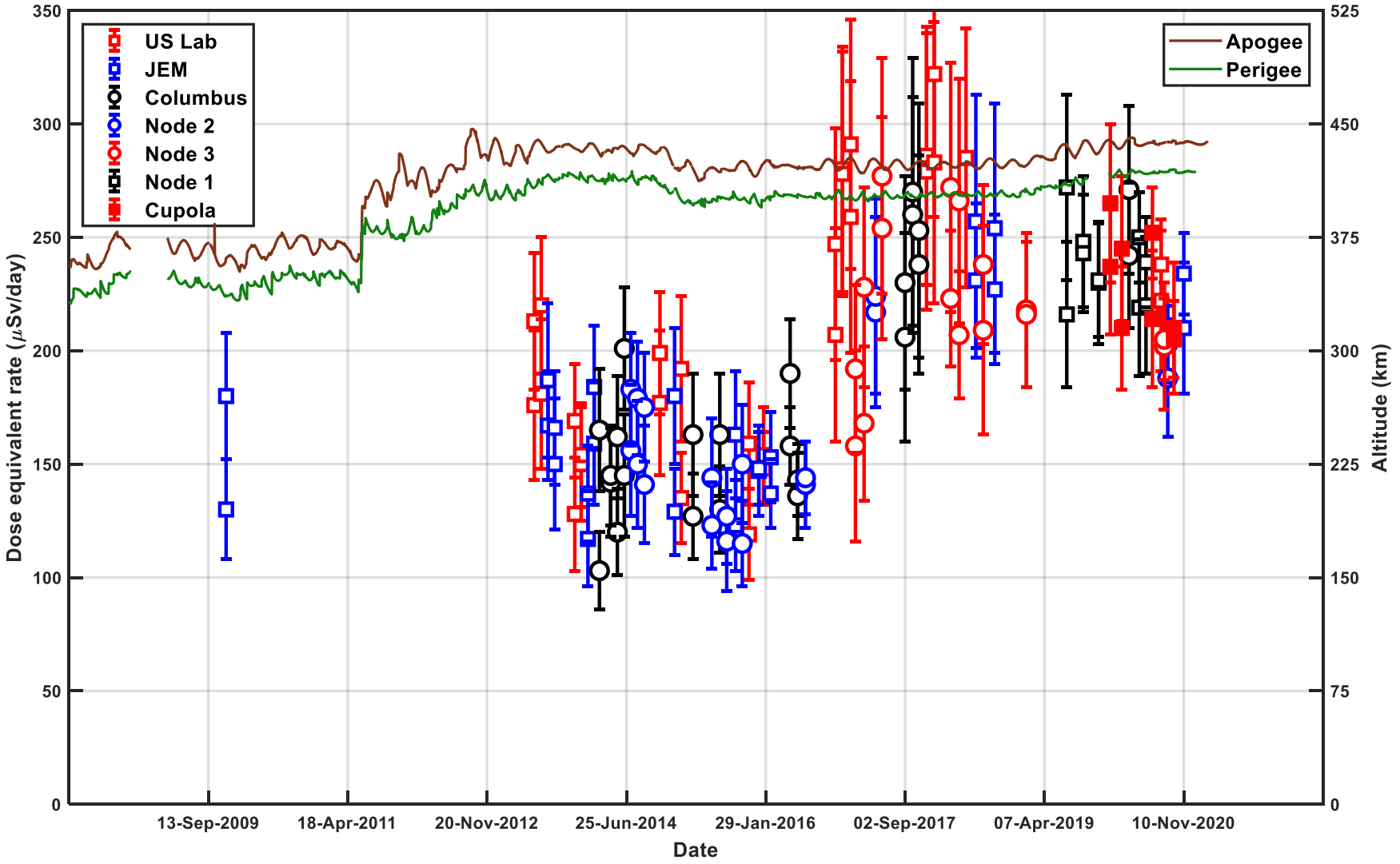


Photo credit: CSA/NASA

Space Bubble Detector Spectrometer (SBDS) Data

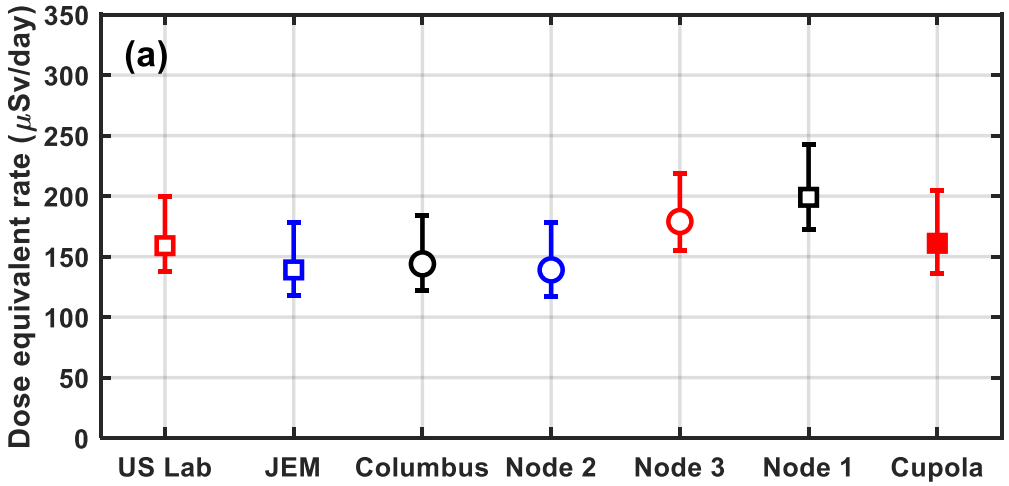


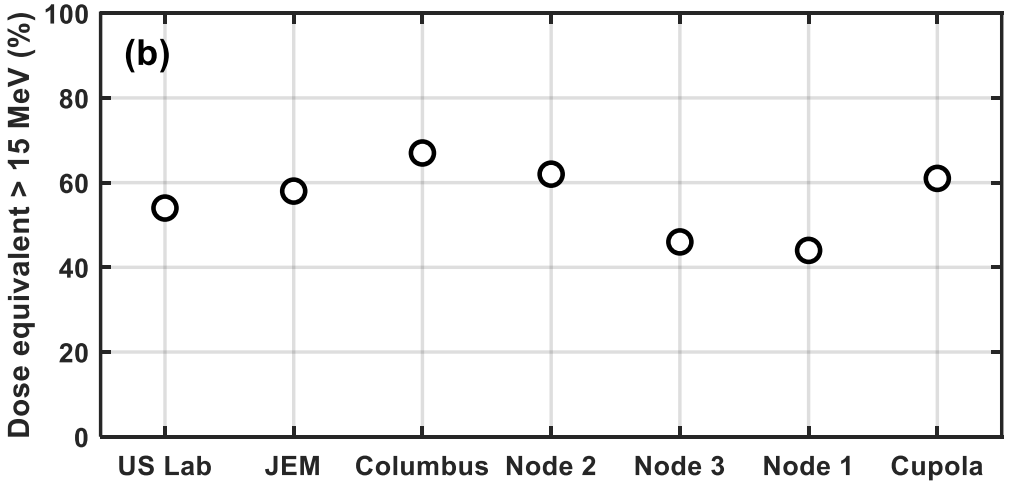
Space Personal Neutron Dosimeter (SPND) Data



Radi-N and Radi-N2 Results

- The neutron dose equivalent, summed over all sessions, shows some variation with location in the US segment
- The energy distribution of neutrons also appears to vary depending on location
- The data suggest that approximately 50% of the dose equivalent is due to neutrons with energy greater than 15 MeV
- This confirms the importance of high-energy neutrons for the health of astronauts and provides motivation for the development of the CANS

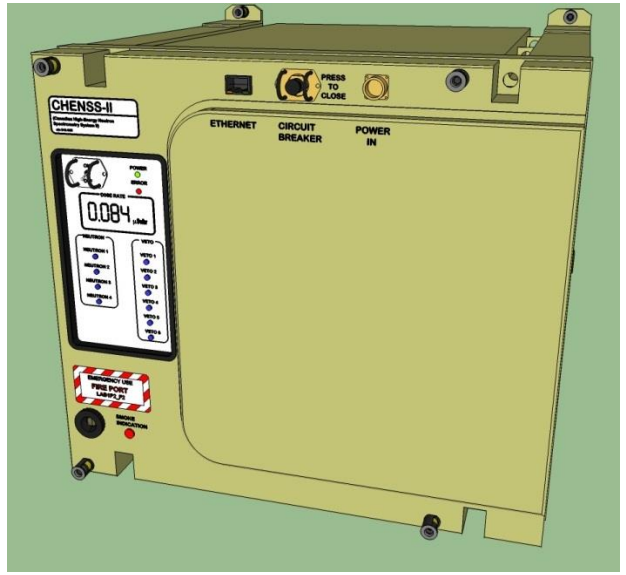


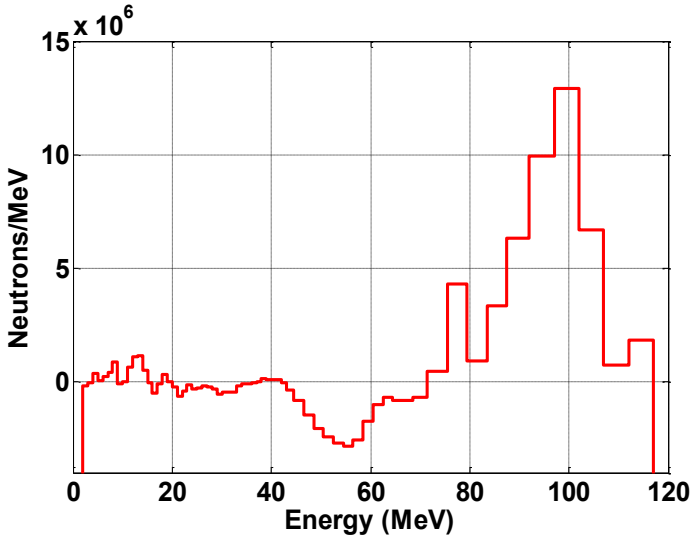


CHENSS and CHENSS-II Development

- A prototype Canadian High-Energy Neutron Spectrometry System (CHENSS) was developed by BTI and the CSA between 1999 and 2010
- The goal was to perform the first accurate measurement of the neutron energy distribution in low-Earth orbit from a few MeV to approximately 100 MeV
  - The original aim was to fly the CHENSS in a GAS (Get-Away Special) Can on the space shuttle
  - A flight opportunity did not occur before the cancellation of the shuttle program
- Ground experiments demonstrated that the system could measure 100-MeV neutrons and was scientifically suitable for measurements in space
- A Concept Study for a CHENSS-II for the ISS was later conducted with the CSA







CHENSS (left) and CHENSS-II (right)

CHENSS data for 100 MeV neutrons from iThemba LABS

CANS Project Overview

- Phase A of the CANS project was completed by BTI in July 2024
- Phase A included the development of the instrument requirements and a baseline instrument design
- Phase B of the project started in February 2026 and spans nine months
- It includes the design, manufacture, and testing of a Demonstration Model (DM) of the CANS
- Phase B concludes with the Preliminary Design Review, to be conducted in October 2026
- A high-fidelity Engineering Model (EM) will be produced in Phase C, which also spans nine months
- The DM and EM will undergo performance characterization at international accelerator facilities
- The output of Phases B and C will be a CANS design that is ready for Proto-Flight Model (PFM) manufacture in Phase D

CANS ISS Deployment

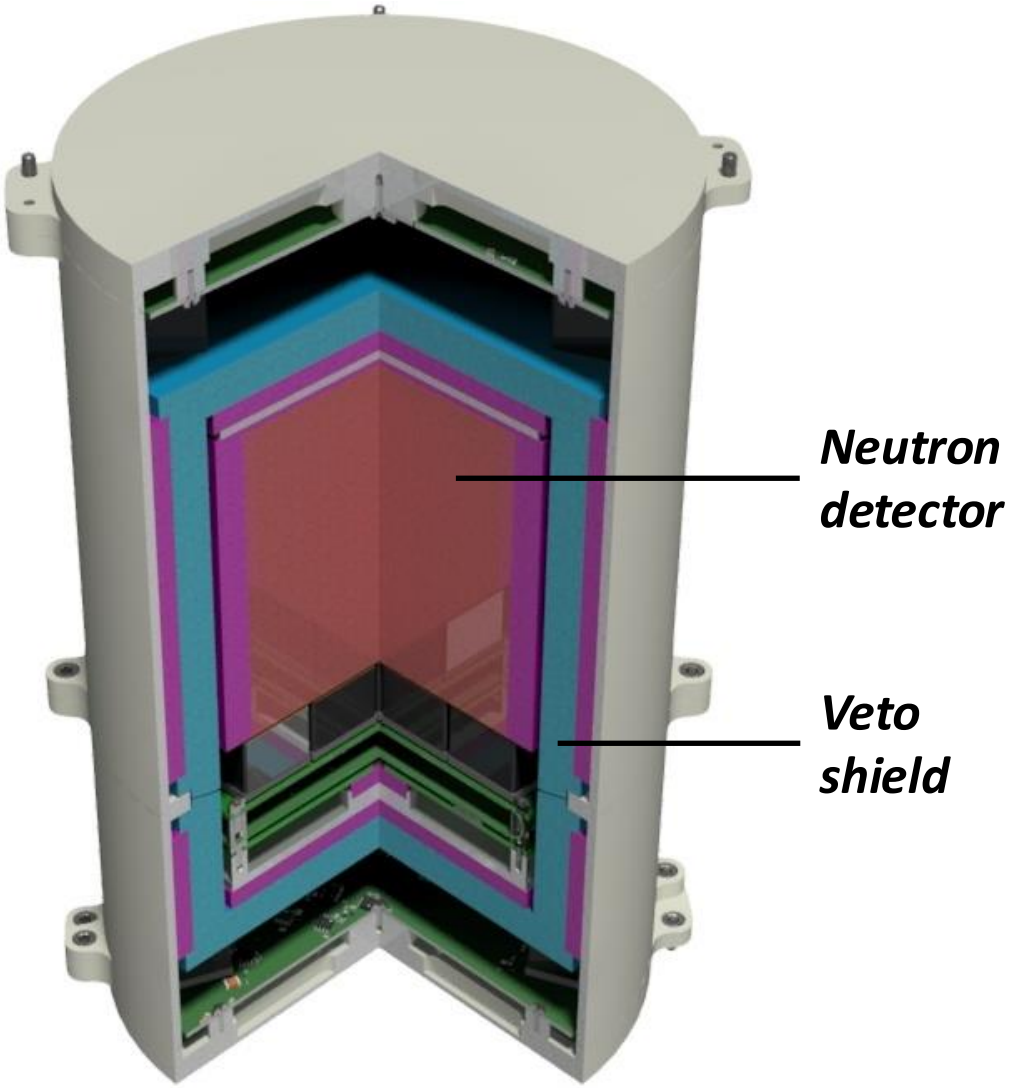
- Launch to the ISS is planned for 2028
- The instrument will be aisle deployed
- The Technology Demonstration includes two months in each of the US Lab, Node 1, and Node 2
- Specific panel locations have been discussed, based on the locations used by NASA's Fast Neutron Spectrometer (FNS) and the Radi-N2 measurements
- Prior results from these instruments will be compared to the CANS data



Estimated mass: 12.5 kg
Estimated power: 13.7 W
Estimated volume: 28.8 × 25.4 × 18.8 cm^3

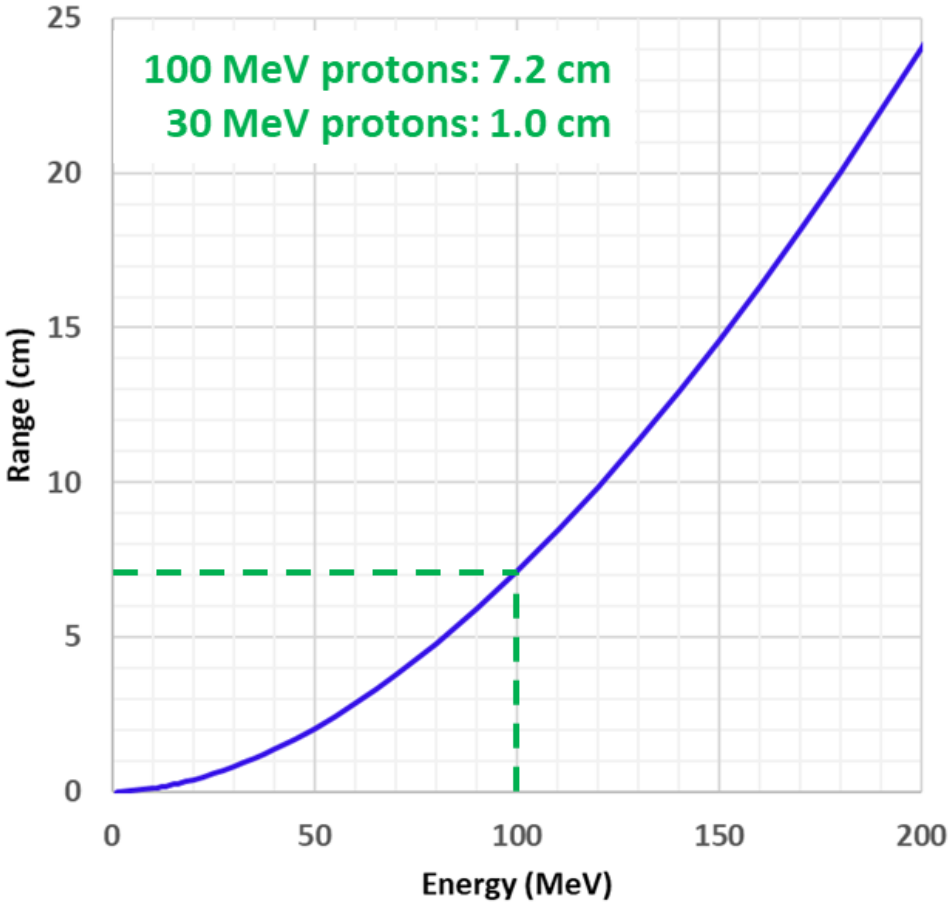
CANS Detector Module

- The CANS neutron detector is based on an EJ-276D plastic scintillator, which detects high-energy (fast) neutrons up to 100 MeV
- EJ-276D is a commercial product from Eljen Technology (Sweetwater, TX)
- The material provides excellent light output and PSD performance, similar to that of a liquid scintillator
- Pulse-shape discrimination (PSD) is performed in the neutron detector to distinguish gamma-ray interactions from neutron events
- A plastic scintillator “veto shield” surrounds the main neutron detector in order to detect and veto charged-particle interactions



Energy Range

- The neutron detector for the CANS is a right cylinder with dimensions 4” × 4” Ø (10.2 cm × 10.2 cm Ø)
- SRIM calculations suggest that this detector will stop 100 MeV protons with good efficiency
- A 5” × 5” Ø scintillator was used in the CHENSS prototype, which demonstrated good performance for 100 MeV neutrons
- The CANS will detect neutrons below 1 MeV; however, separation from gamma rays becomes difficult below 0.5 MeV

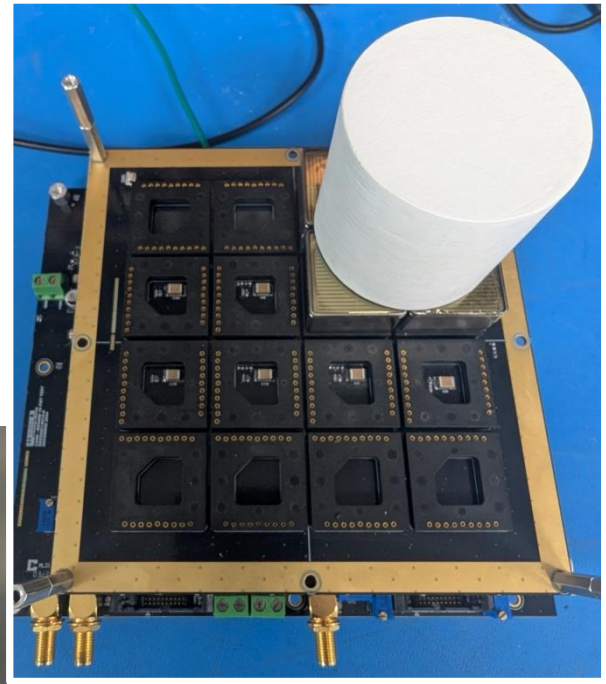


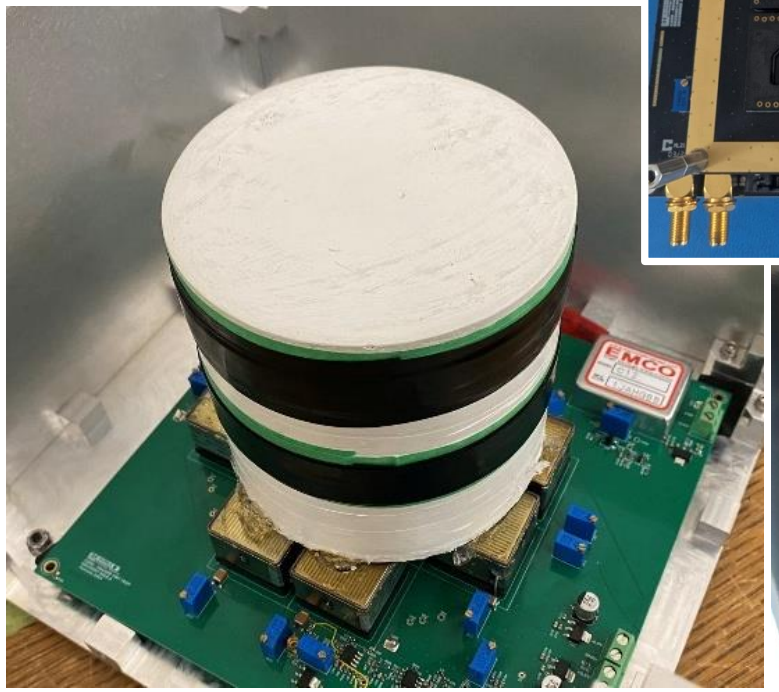
Range for recoil protons in plastic scintillator material

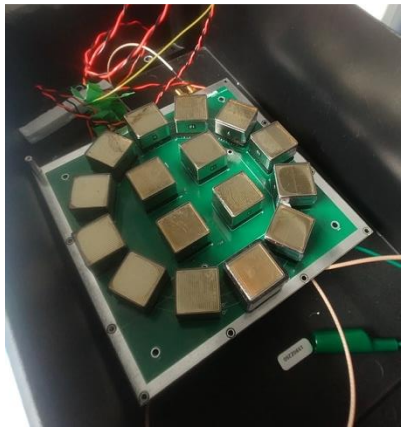
Development of Light Readout

- BTI has conducted measurements to assess the performance of miniaturized photomultiplier tubes (PMTs) and silicon photomultipliers (SiPMs) for use in the CANS
- It was shown that PMTs provide better performance than SiPMs
- PMTs also provide increased reliability, particularly for reduced radiation damage over long duration missions
- PMTs require more mass, power, and volume than SiPMs; however, the current design meets its target requirements

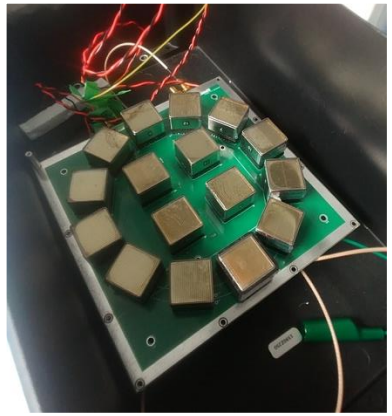
2" and 4" diameter scintillators coupled to arrays of miniaturized square PMTs

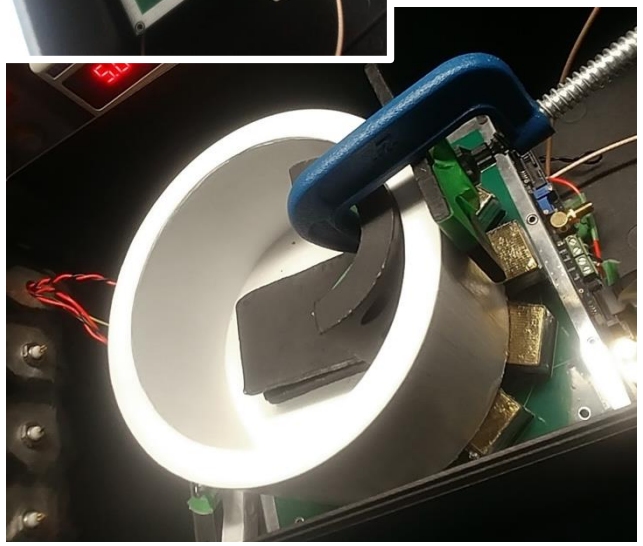


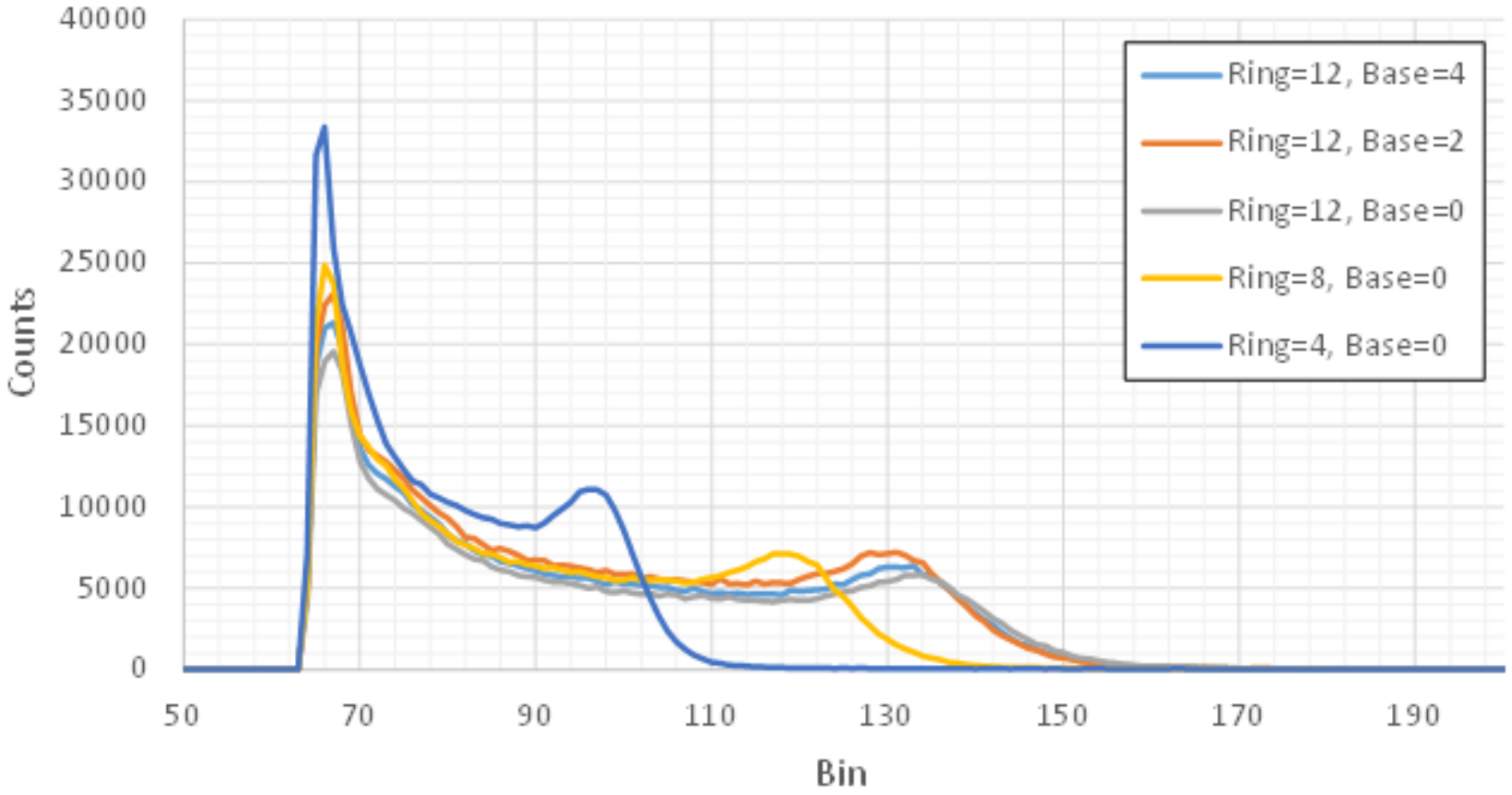




Veto Shield Measurements

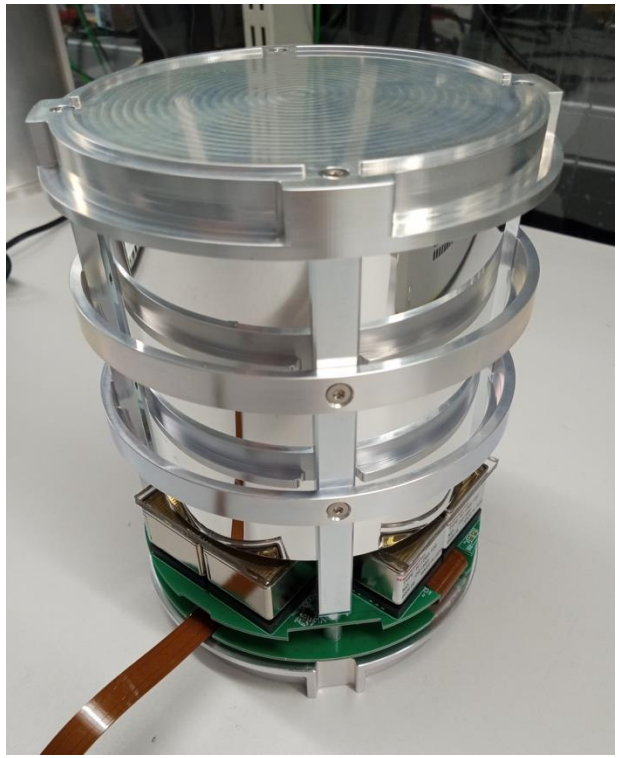




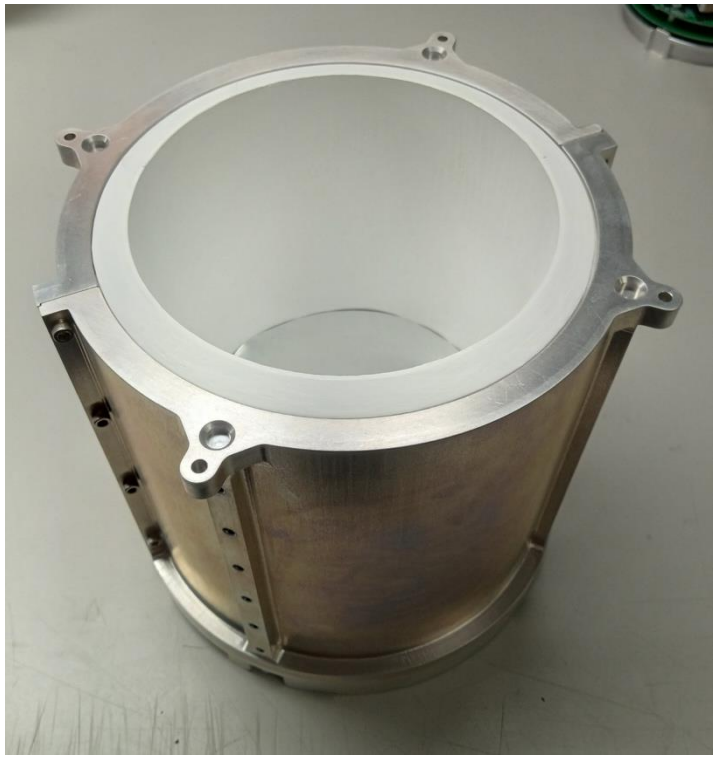


Based on these data, the design is moving forward with eight PMTs on each end of the veto shield

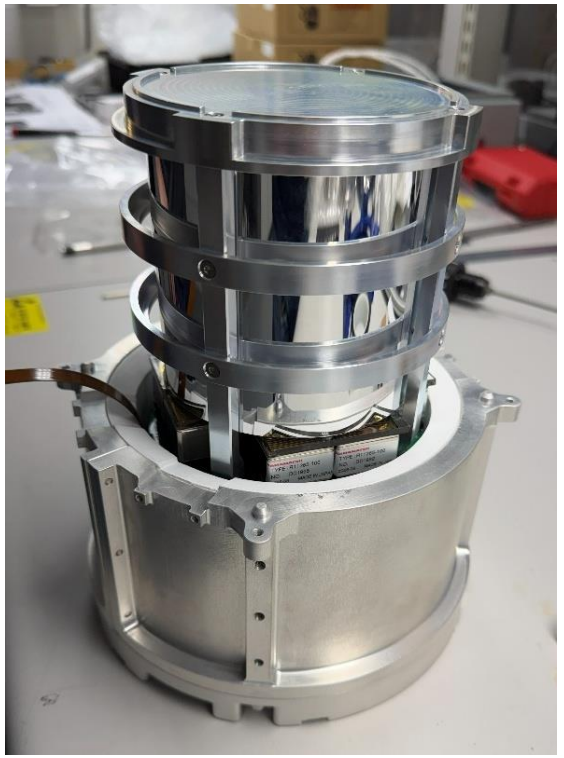
CANS Demonstration Model



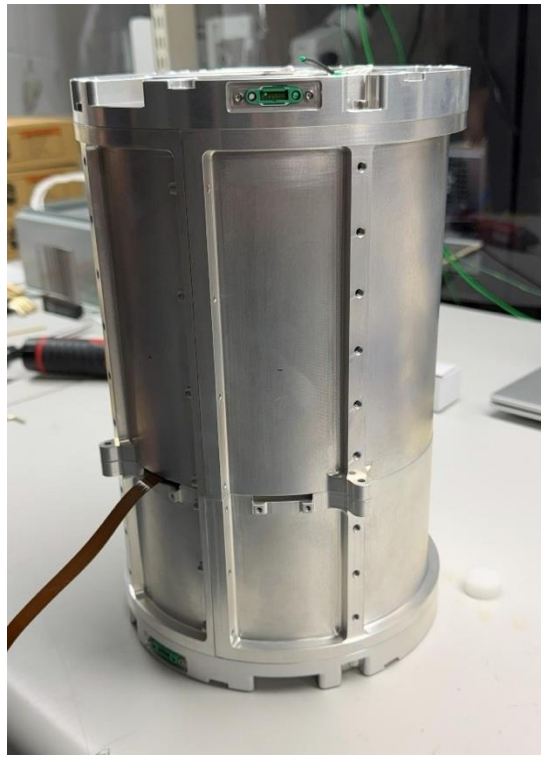
Assembled neutron detector



Veto scintillator inside mechanical enclosure

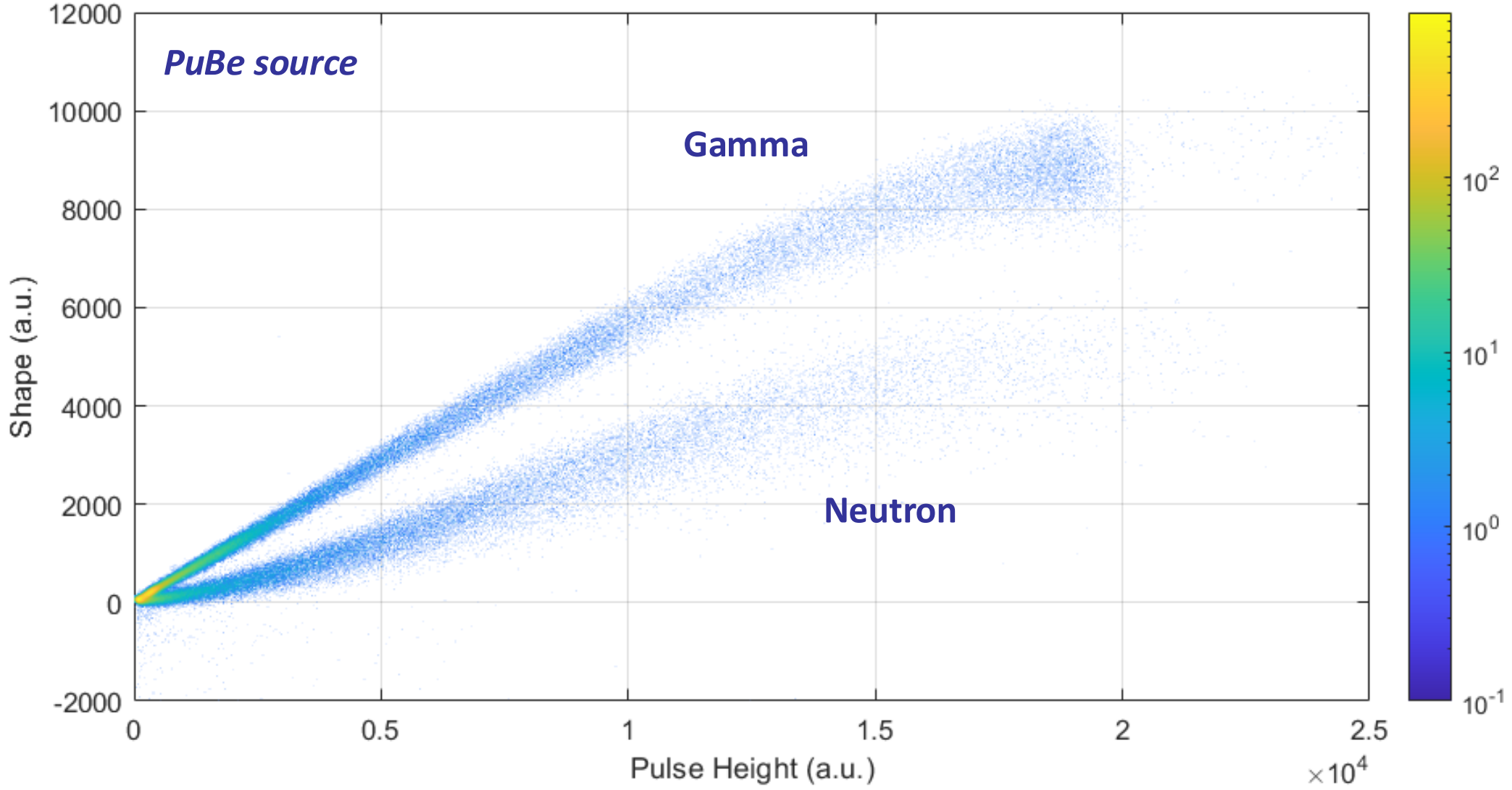


Neutron detector inside lower veto shield



Completed CANS detector module

Initial Data from CANS Demonstration Model



Planned Characterization/Calibration Facilities

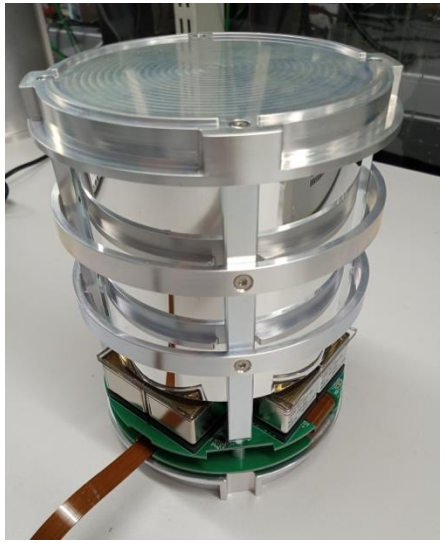
Facility	Beam Types	Purpose for CANS	Beam Energies
BTI	Neutron generators 2.5 and 14.1 MeV	Calibration of the main neutron detector	2.5 MeV 14.1 MeV
PTB	Monoenergetic neutrons 0.024 – 19 MeV	Calibration of the main neutron detector	0.565 MeV 1.2 MeV 2.5 MeV 5.0 MeV 14.8 MeV 19.0 MeV
iThemba LABS	Quasi-monoenergetic neutrons 35 – 200 MeV	Calibration of the main neutron detector	66 MeV 100 MeV 150 MeV 200 MeV
LLUMC	Protons 70 – 250 MeV	Veto shield testing Irradiation of electronic parts	TBD

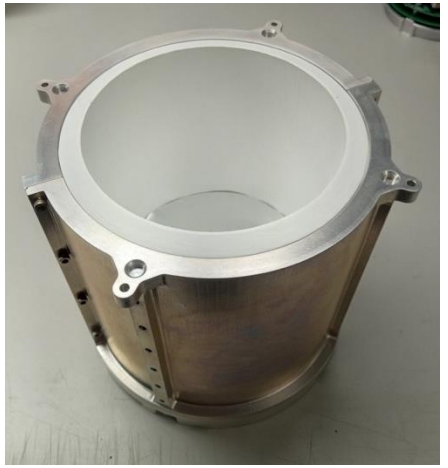
Alternative Characterization/Calibration Facilities

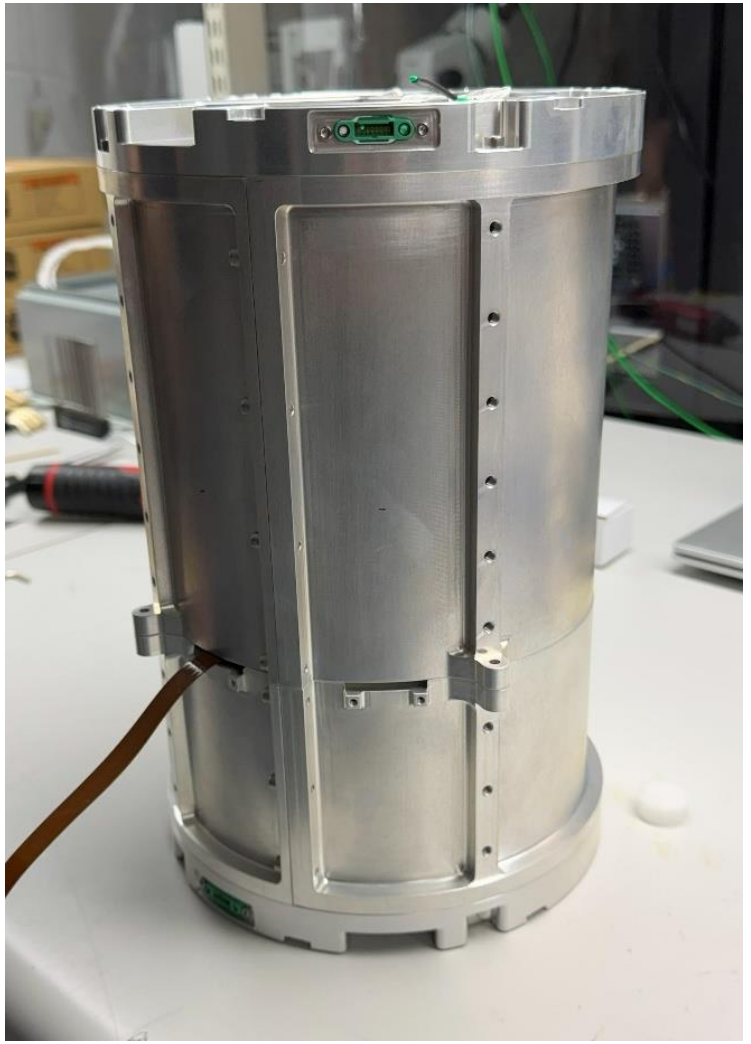
Facility	Beam Types	Purpose for CANS	Beam Energies
LANSCE	Broad-energy neutrons up to 600 MeV Mixed fields	Calibration of the main neutron detector	N/A
NSRL	Protons and charged particles 50 – 1500 MeV	Veto shield testing Irradiation of electronic parts	TBD

CANS Summary and Status

- Characterization of the CANS DM has started and will continue at BTI in September 2026
- Once the BTI measurements are completed, the DM will be taken to accelerator facilities, beginning with PTB
- Meanwhile, design of the EM is nearing completion and will be presented at the PDR in October 2026
- The EM will be fabricated and tested starting in early 2027
- Following EM testing, the PFM will be built, tested, and delivered for flight
- Launch to the ISS is expected in 2028







This project is undertaken with the financial support of the Canadian Space Agency



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