SNO+ | Using ^{60}Co as a high precision calibration device

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on behalf of the SNO+ Collaboration
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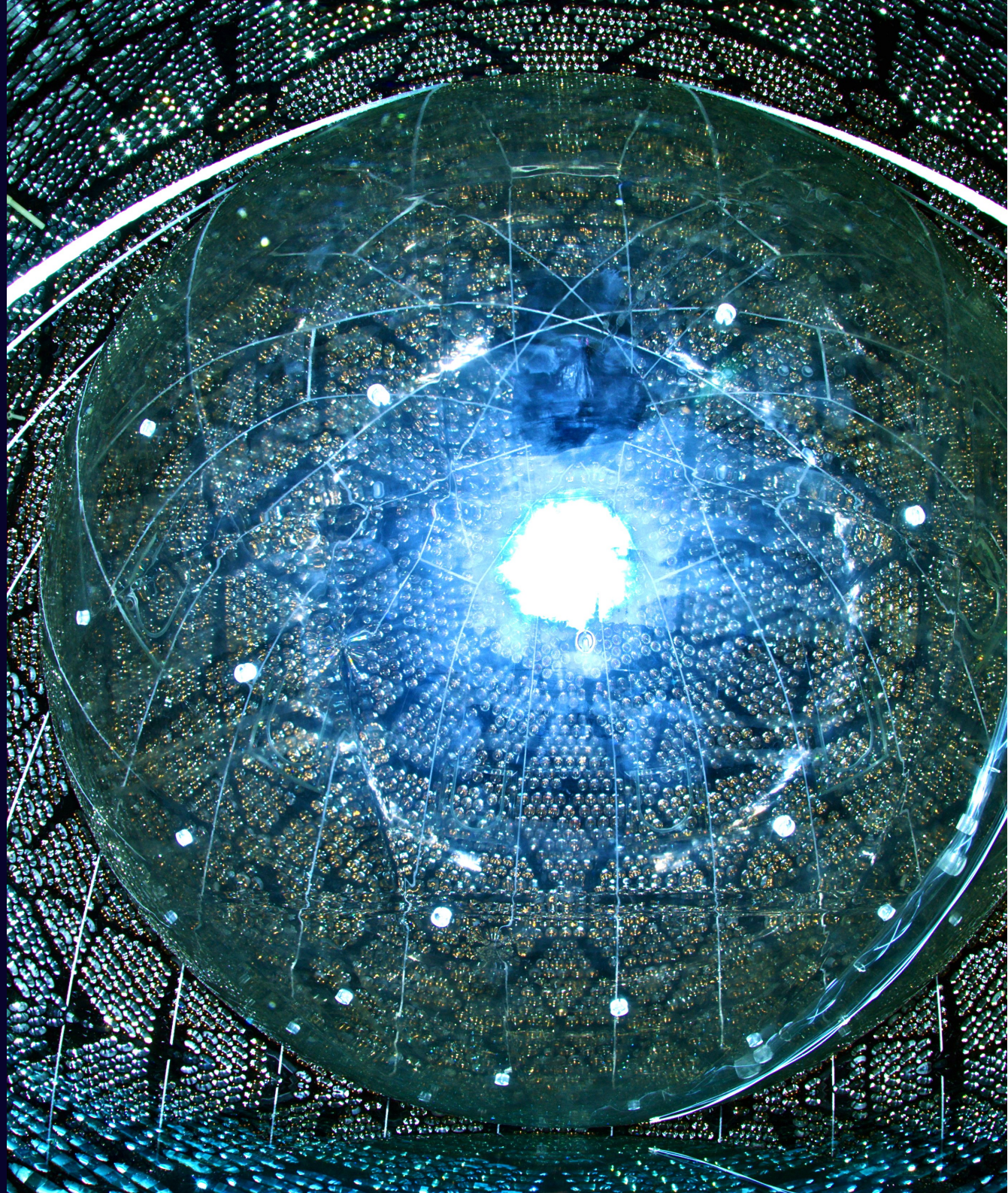
SNO+ will be one of the **world's largest** liquid scintillator particle detectors

- 12 m diameter acrylic vessel
- Filled with 780 t liquid scintillator
- Buoyed by 7000 t ultra-pure water
- Viewed by nearly 9500 PMTs

All **6800 ft** underground



See talk by A. Hallin in Session M1-6

As its main physics goal

SNO+

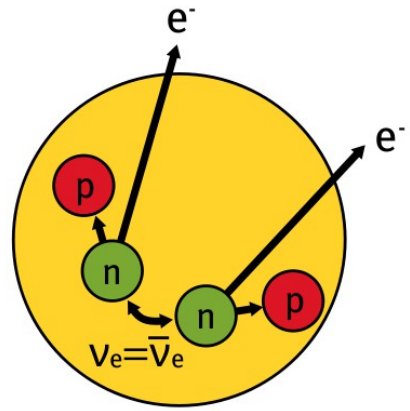
will be searching for
neutrinoless double beta decay

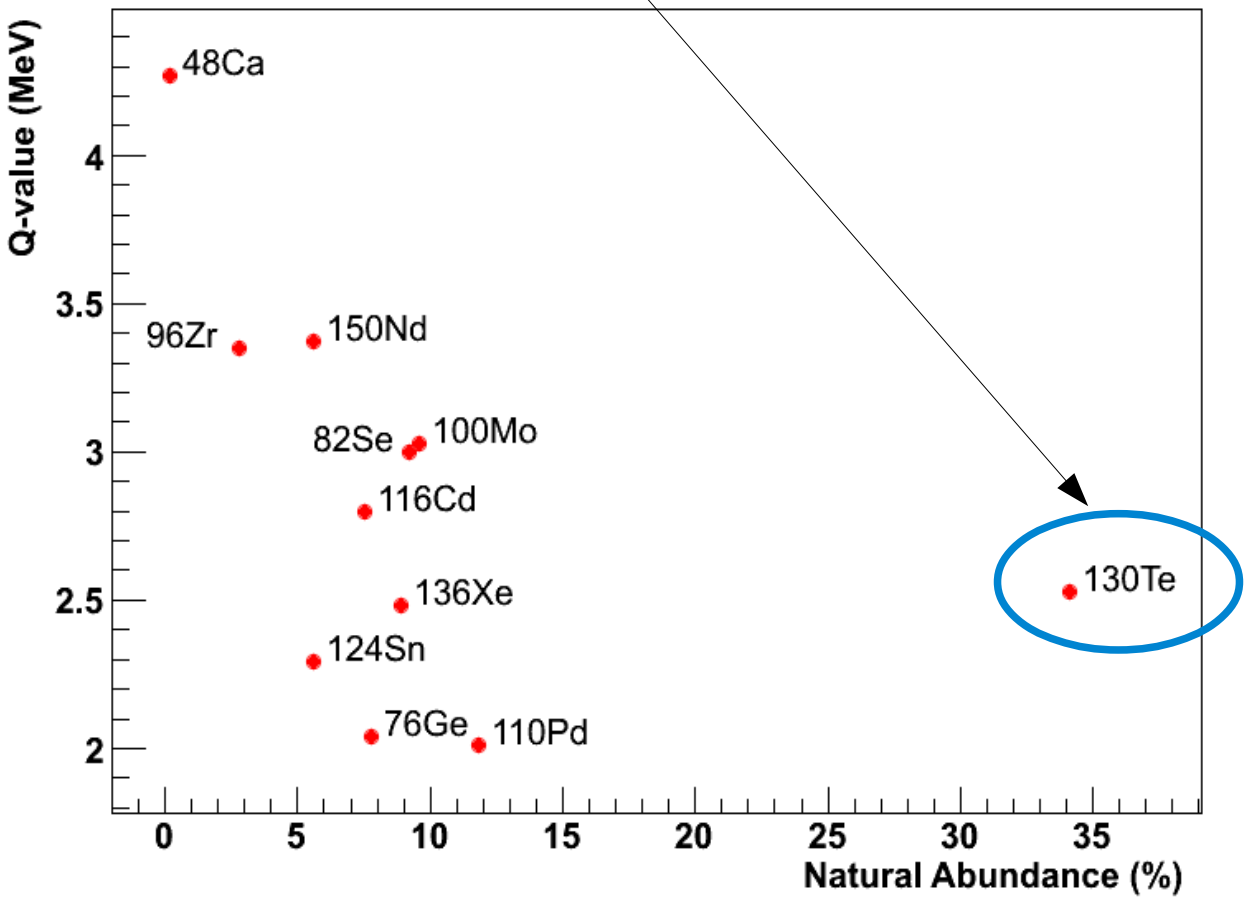
(see talk by S. Bilenky in Session M1-6)

Add 0.3%–0.5% (>2.3 t) of natural Te, or

800 kg ^{130}Te

into the SNO+ liquid scintillator





A large active mass means a high number of statistics (many decays)

Spectral fitting helps compensate for limited inherent energy resolution of liquid scintillators

A high 34.1% natural abundance and 2.53 MeV Q-value make ^{130}Te an excellent choice

Light yield nearing
10,000 photons/MeV

4.5% energy resolution
at the ^{130}Te Q-value

Attenuation length ~20 m

Potential α/β discrimination

Environmentally safe

Chemically **compatible**
with acrylic (i.e. SNO+)

Stable over time for ^{nat}Te
levels of up to 3%

(solvent) (fluor) (isotope)

Linear alkylbenzene (**LAB**) + 2 g/L 2,5-diphenyloxazole (**PPO**) + ^{nat}**Te**

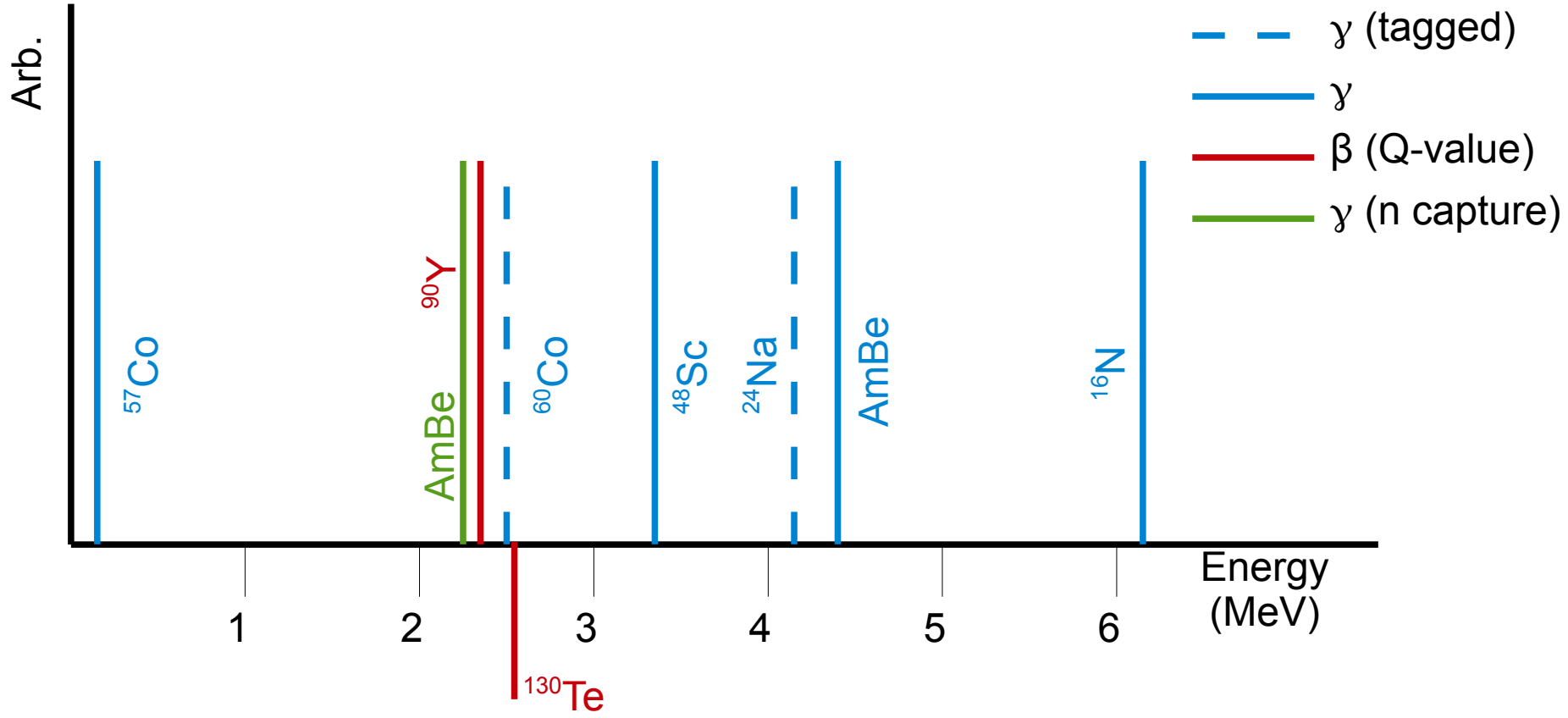
(+ surfactant + water + wavelength shifter)

A suite of **calibration sources** are being designed to help understand the response of the LAB scintillator cocktail

Radioactive sources will characterize the **energy scale** and **resolution** to different particles over a range of energies

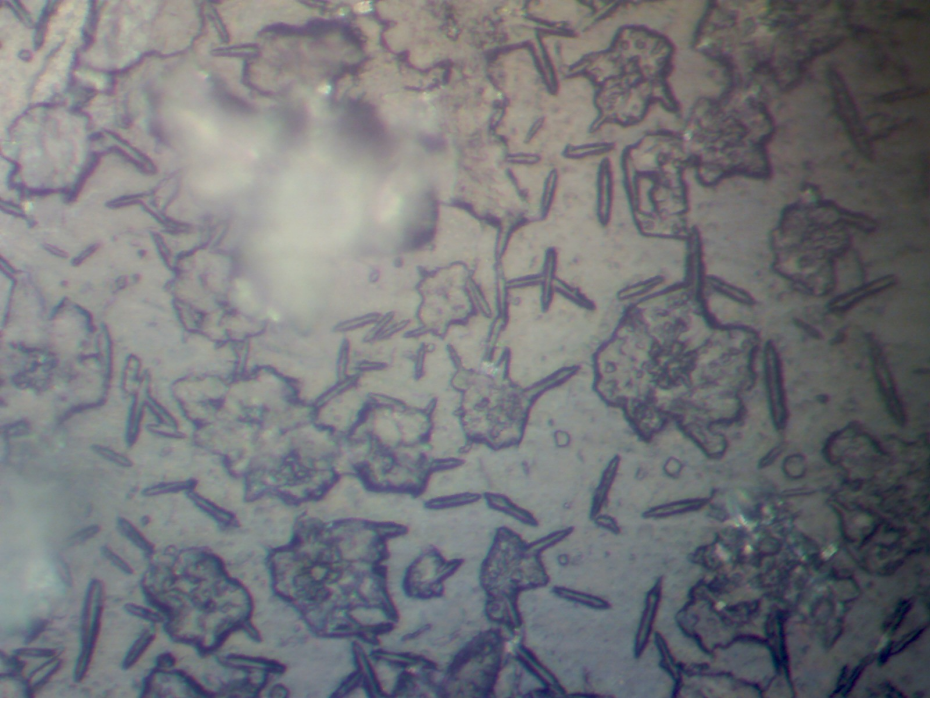
Optical calibration sources (LED/Laser fibres, diffuse laser source, Čerenkov source) to measure scintillator scattering and absorption, and PMT response
(see talk by K. Singh in session M1-6)

Major upgrades to calibration hardware, as well



The ^{60}Co source is designed as a

tagged source



The ^{60}Co source is designed as a

tagged source

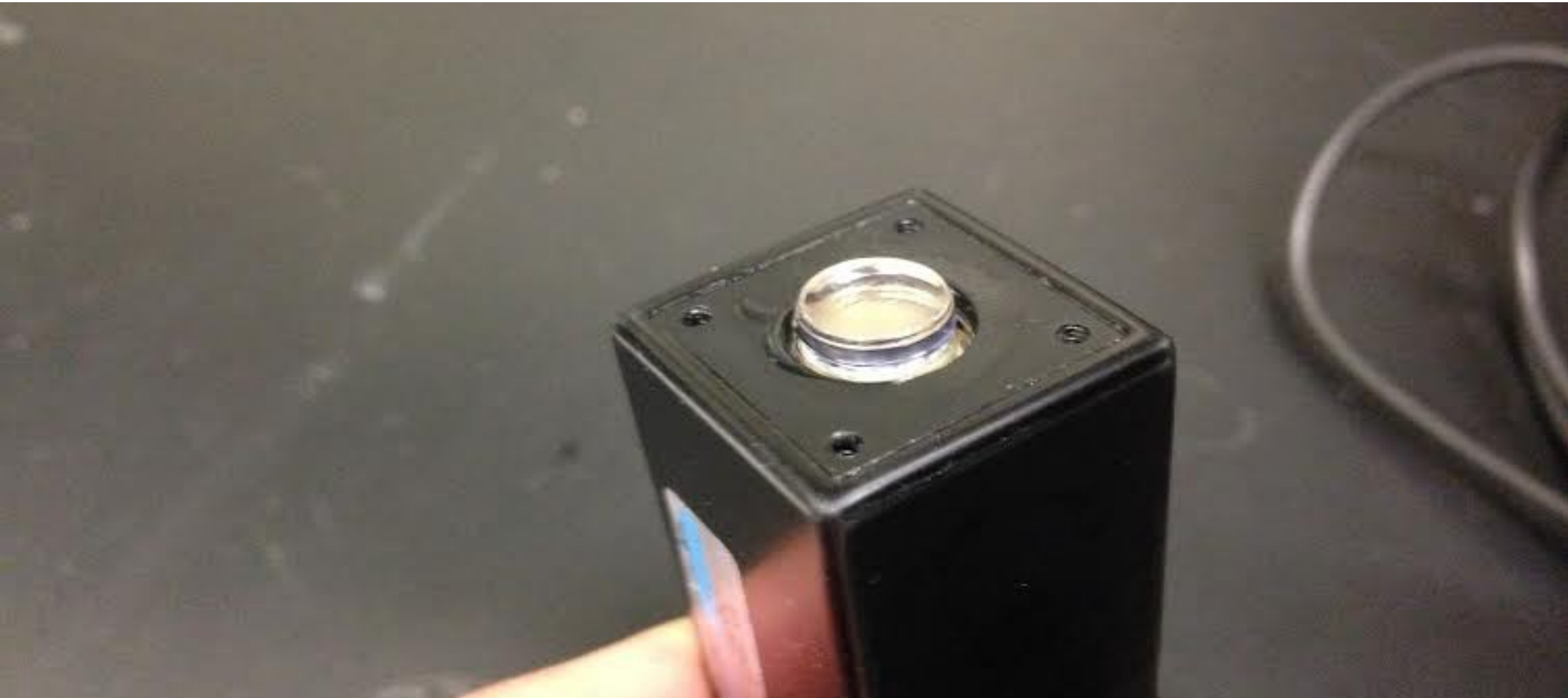
$^{60}CoCl_2$ is deposited on and embedded between small disks of

plastic scintillator

The ^{60}Co source is designed as a

tagged source

This is coupled to a small **PMT** that picks up scintillation in the plastic caused from the β released in ^{60}Co decay, while the two γ rays escape the source



The ^{60}Co source is designed as a

tagged source

The PMT is wrapped in a reflective layer, then soldered *in situ* into a

leak-tight

copper enclosure, then

The ^{60}Co source is designed as a

tagged source

Encapsulated

in a secondary plastic enclosure, for redundancy in preventing release of radioactive contamination into SNO+

The ^{60}Co source is designed as a

tagged source

Each step of the process undergoes

rigourous

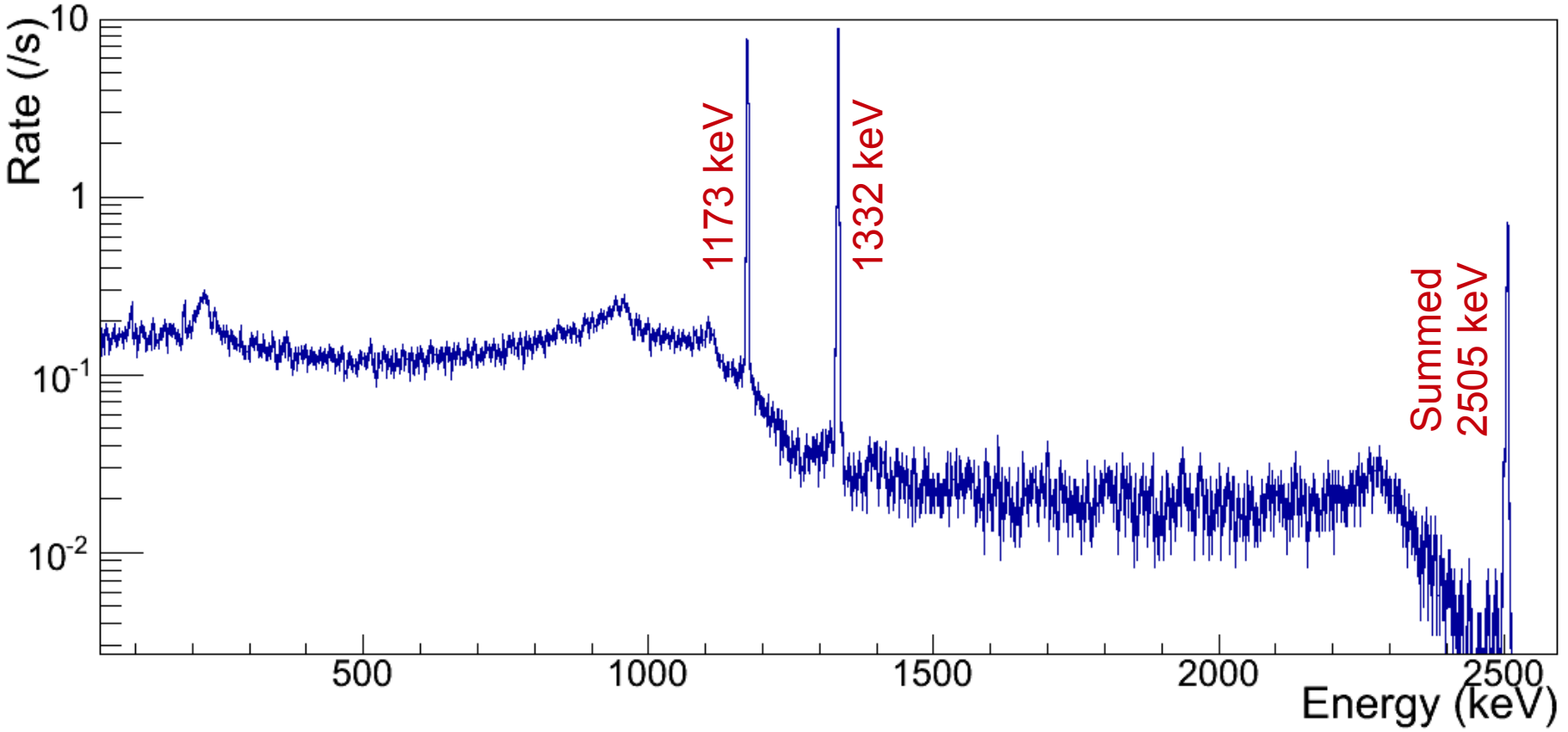
testing to ensure quality control

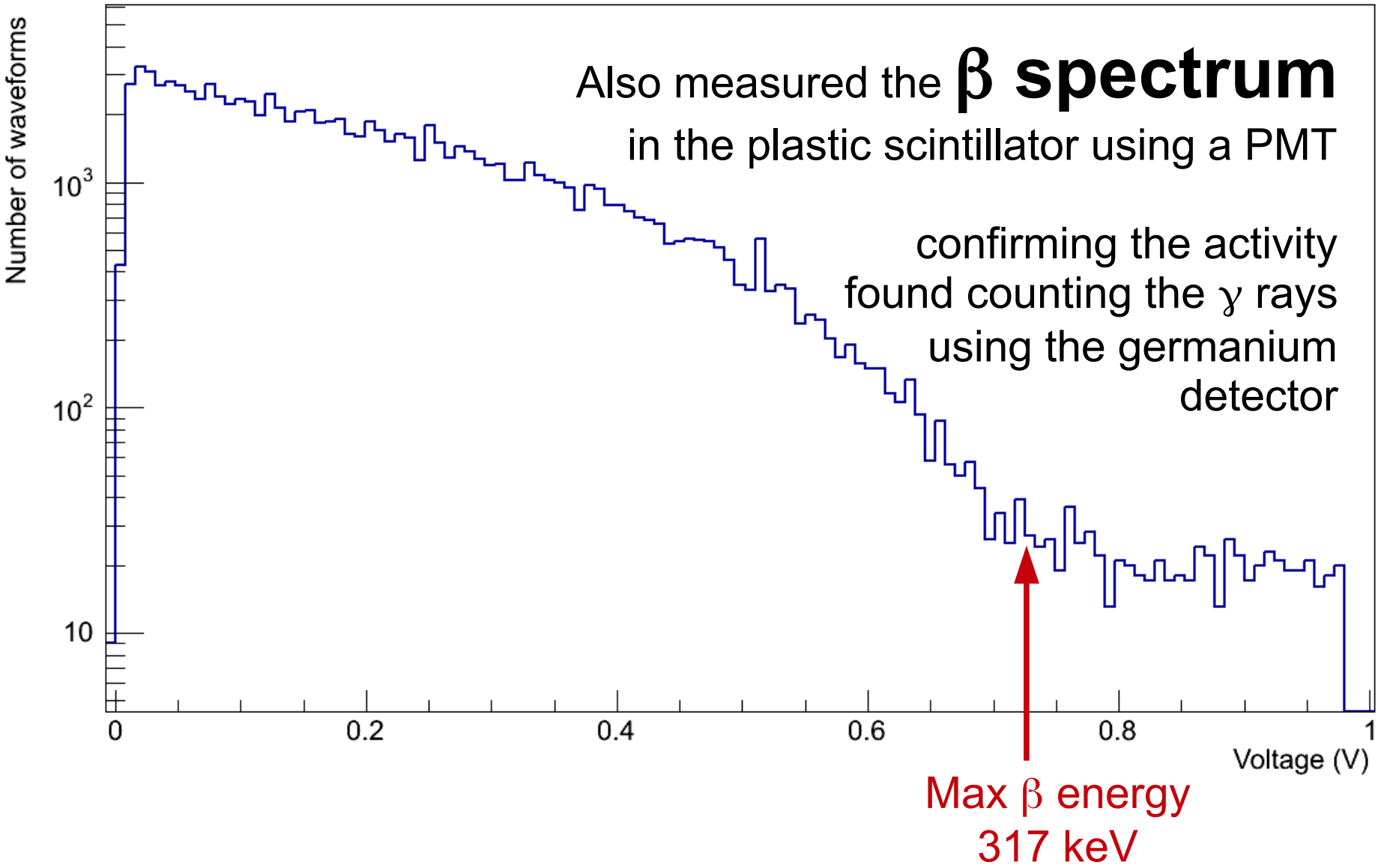
The source activity has been

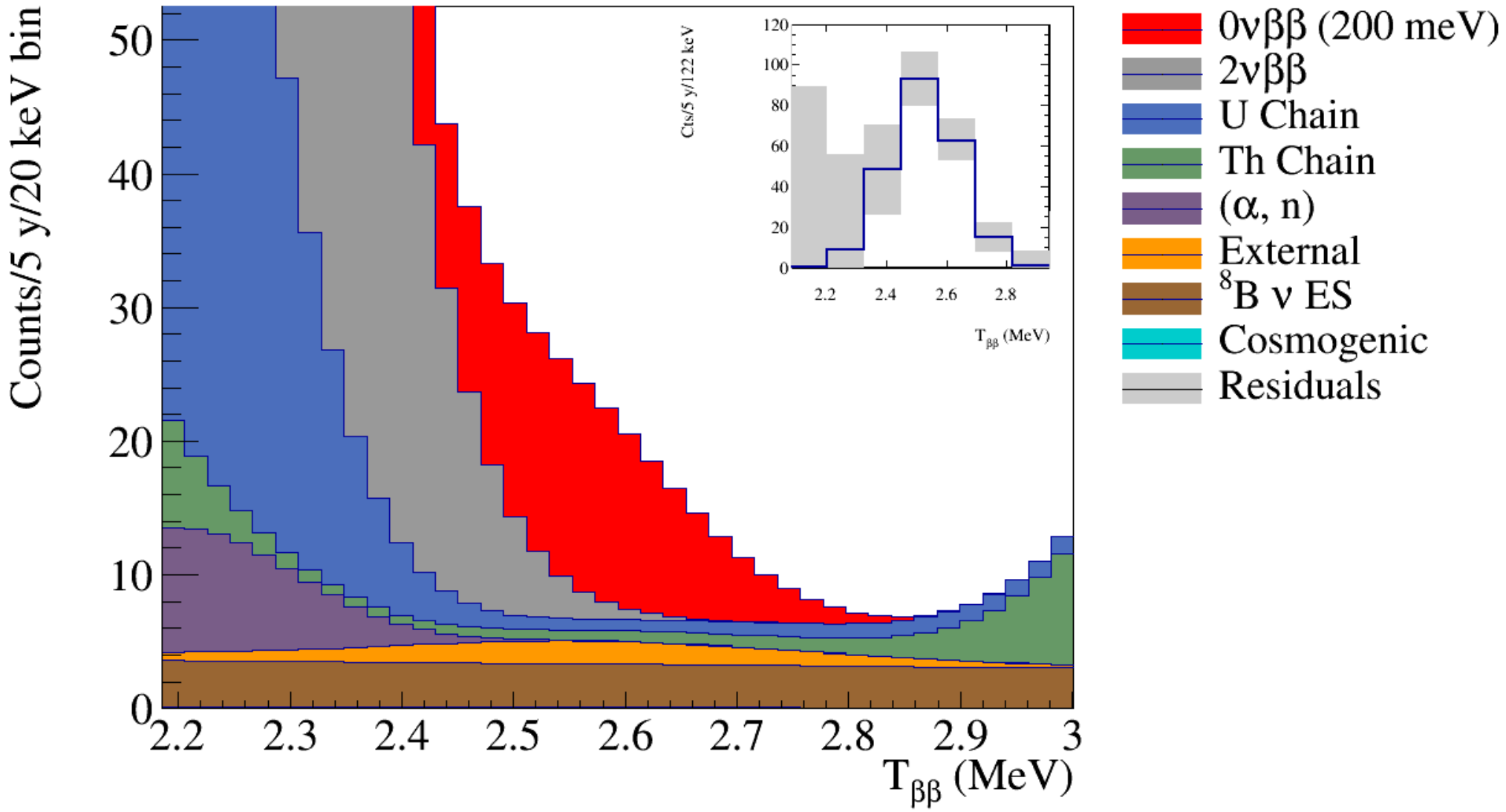
precisely measured

using a high purity germanium detector

This low-rate source has an activity of 225 ± 8 Bq




Also measured the β spectrum
in the plastic scintillator using a PMT
confirming the activity
found counting the γ rays
using the germanium
detector
Number of waveforms
10³
10²
10
0
0.2
0.4
0.6
0.8
1
Voltage (V)
Max β energy
317 keV

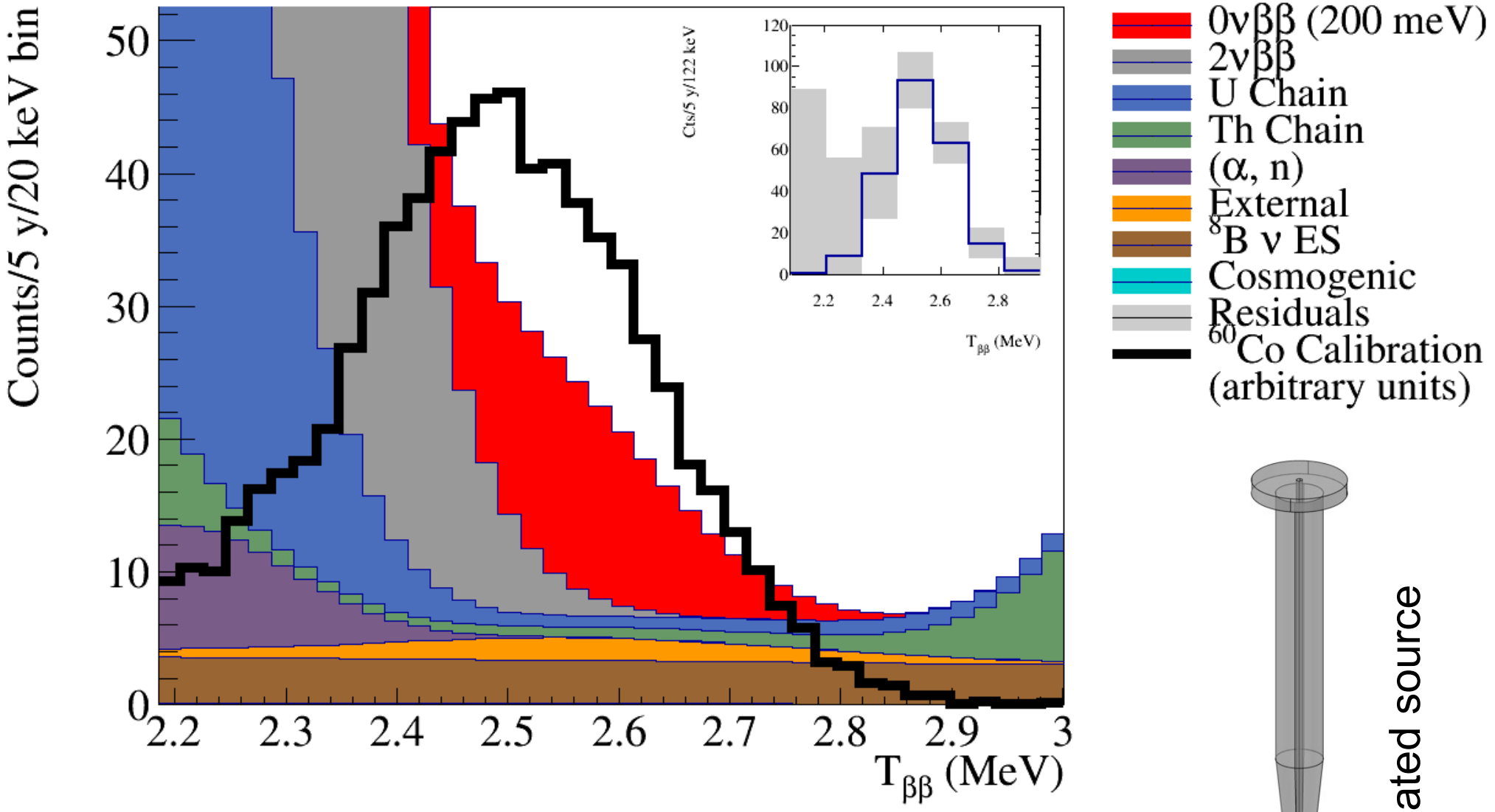


This is a Monte Carlo representation of

what SNO+ expects

to observe with 5 years of data,
assuming various background constraints

See talk by A. Hallin in Session M1-6

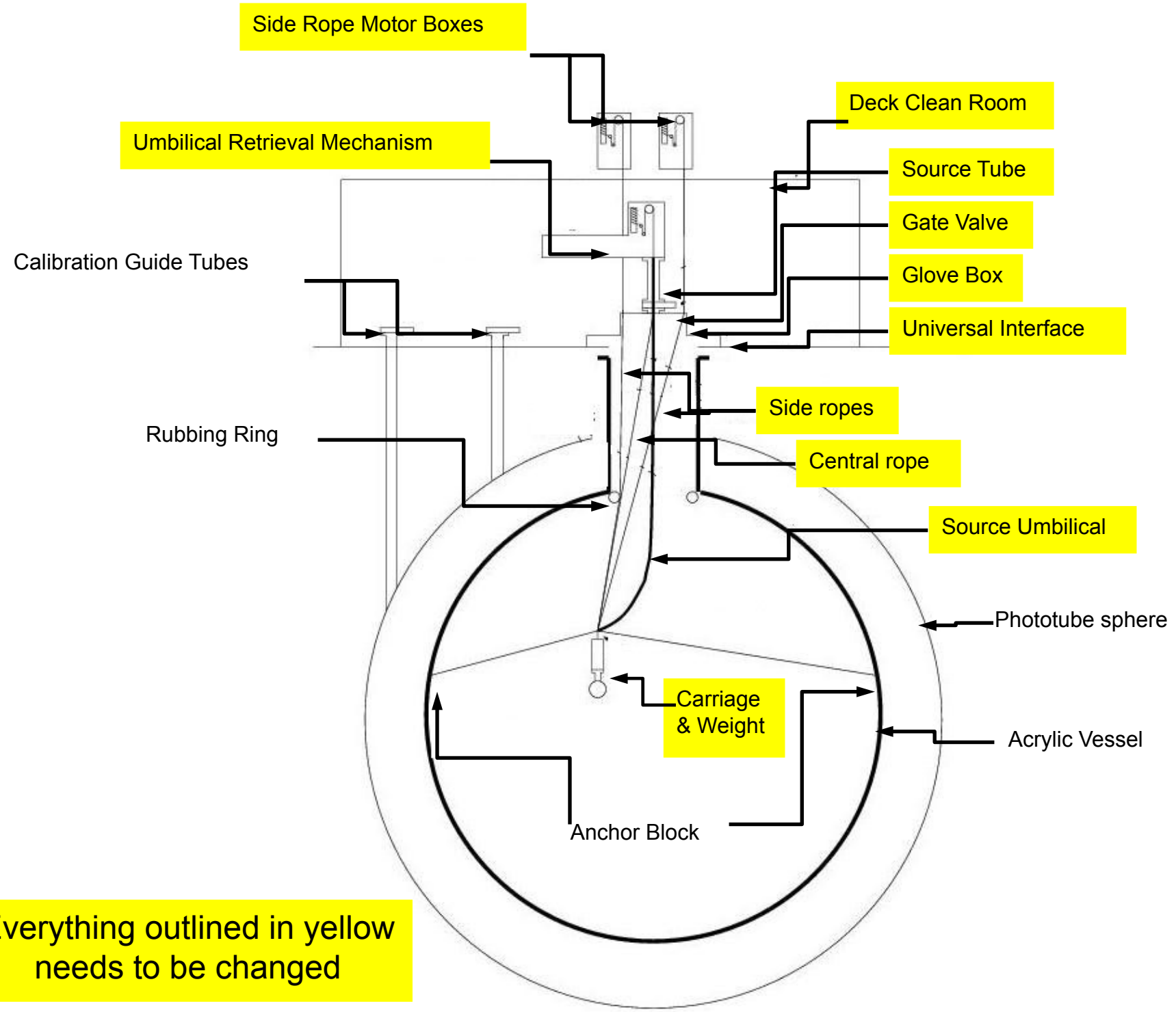


Simulated source

The ^{60}Co calibration source

will help set the energy scale and
aid in understanding the shape of the expected
4.5% energy resolution at 2.5 MeV

THANKS


Side Rope Motor Boxes
Deck Clean Room
Umbilical Retrieval Mechanism
Source Tube
Gate Valve
Calibration Guide Tubes
Glove Box
Universal Interface
Side ropes
Rubbing Ring
Central rope
Source Umbilical
Phototube sphere
Carriage
& Weight
Acrylic Vessel
Anchor Block
Everything outlined in yellow
needs to be changed