# Background Measurement Sensitivity Goals

- Existing background knowledge [Tanaka, INGE08] suggests sensitivity of 1-100 mBq/SCM would be useful.
- Would allow probing shallow vs. deeper soil backgrounds, role of cosmic-rays, etc.
- Routinely measuring positive quantities (backgrounds) would build confidence in measurement protocols.

## Proportional Counters for OSI

- Two designs so far: 1,000 ml STP (early prototype) and 100 ml STP (recent work).
- Optimized for high pressure operation (10 Atm) and high efficiency (~80%) using only low-background materials.
- Cosmic-ray veto (active shielding) is the most important element for reaching background potential.

## Prototypical Measurement Scenario

- **Background** – With modest gamma shielding the current PNNL design exhibits a background of ~80,000 cpd, essentially all cosmic-ray induced. A very good (but achievable) 99.5% efficiency cosmic-ray veto would be of modest size and weight and would bring the background down to ~400 cpd. The cosmic-ray veto detector (e.g. plastic scintillator) would provide further information to reduce non-Poisson background variations.
- **Counter efficiency** – Monte-Carlo models (GEANT4, EGS4, and MCNP) were validated with the measured gamma and x-ray response of the PNNL design. These models predict ~80% counting efficiency for $^{37}$Ar with a 1-keV energy threshold.
- **Measurement time** – 1,000 minutes, yielding ~5 background counts per measurement.
- **Sample size** – Taken to be 1 liter of separated argon, plus necessary quench gas. This would correspond to ~270 sampled liters of soil gas (air), selecting a 40% chemical recovery and sample transfer efficiency.
- **Detection sensitivity** – The 95% CL MDA of this measurement would be 16 mBq/SCM (1,000 minute count). This reaches the range of interest for probing $^{37}$Ar backgrounds for OSI.

## PNNL 100 ml STP Proportional Counter Performance Data

- **Spectroscopic Performance vs. Pressure** (external $^{241}$Am source)
- **Energy Resolution vs. Pressure, Bias**
- **Cosmic-Ray Background Spectra**

The views expressed here do not necessarily reflect the opinion of the United States Government, the United States Department of Energy, or the Pacific Northwest National Laboratory.

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**Abstract**

On-Site Inspection (OSI) is a key component of the verification regime for the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Measurements of relevant radionuclide isotopes created by an underground test (UGT) are the most valuable sign of a Treaty violation. Argon-$^{37}$ is a desirable isotope for OSI in many ways: its near-optimum half-life of 35 days provides high specific activity and enough time for successful inspection to be done before decay limits sensitivity. Its production mechanism is via neutrons incident on ubiquitous soil calcium, $^{40}$Ca$(n,\alpha)^{37}$Ar, during an UGT. As a noble gas, $^{37}$Ar also transports well from an underground test to surface sampling locations. To provide optimum sensitivity from an $^{37}$Ar OSI inspection, backgrounds would ideally be characterized in advance. The $^{37}$Ar background is expected primarily from $(\alpha,n)$ neutrons and spontaneous fission neutrons produced in the soil, and from cosmic-ray spallation neutrons. A prototypical laboratory measurement for background characterization is outlined, along with a discussion of fixed-location laboratory analysis sensitivity and its impact on the robustness of an $^{37}$Ar OSI inspection measurement.

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