Introduction and History
The On Site Inspection (OSI) component of the CTBT Verification Regime has come into sharp focus as the next major research and development effort needed by the larger nuclear monitoring community. There has been significant progress over the past decade to address field noble gas analysis equipment for Ar-37. This poster aims to lay out a workable scientific plan needed to maximize samples acquired, measured and confidence of explosion detection, while minimizing staff time and amount of equipment required. Topics discussed in this poster are as follows:

- Individual sampling stations from shallow boreholes to achieve an Ar and Xe background plus any host duplicate requirements, sample counts times, collection efficiencies, and error budget requirements.
- Impactors, sample mixing can provide rapid radioxenon/radioargon screening and then narrowing down to the samples of highest interest. The poster will conclude with a best methods approach that is derived from the aforementioned topics and suggest a well-reasoned concept of operations for noble gas sampling that will satisfy detection needs and may satisfy OSI operational limitations.

Ar-37 Backgrounds In Soil

The graph shows the measured concentrations from subsurface sampling at various depths and locations. The measurements were made at the University of Berne, Physics Institute, Climate and Environmental Physics department. This graph clearly indicates the need for several local samples that are away from any suspected underground test to determine the Ar-37 background. Experience with the radioxenon sampling stations has also indicated that ambient backgrounds from nuclear reactors and medical isotope production facilities can be quite high. Therefore measuring subsurface radioxenon concentrations may be important to establish baselines.

<table>
<thead>
<tr>
<th>Sample Size (liters)</th>
<th>Tank size (liters)</th>
<th>Stable Ar</th>
<th>Stable Xe</th>
<th>Stable Xe (cc)</th>
<th>Stable Ar (cc)</th>
<th>Xenon MDC (mbq/SCM)</th>
<th>Argon MDC (mbq/SCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1</td>
<td>0.00174</td>
<td>0.0086</td>
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<td>2</td>
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<td>0.0424</td>
<td>0.0424</td>
<td>0.0212</td>
<td>930</td>
<td>460</td>
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<td>2.12</td>
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<td>3800</td>
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</tbody>
</table>

Sample Size and Minimum-Detection Efficiency (MDC)
The following assumptions are made for the MDC’s listed in the table below. The rows highlighted in red indicate the best sample size to achieve measurements at or close to background levels for Ar-37.

- Nuclear detector type
  - Beta-Gamma for Xenon
  - Proportional counter for Ar

- Count time = 1000 minutes
- Nuclear detection efficiency of 80% for Argon and 50% for Xeon
- 95% confidence level
- Less than 2 mBq background rate

Russian Soil Sampling Exercise
In 1989, a Russian team box ground samples at Semipalatinsk and were able to measure both Xe-133 (3.24 day half-life) and Xe-135 (11.9 day half-life). They performed these measurements by drilling several holes 0-12 meters deep and collecting 600 to 1000 liters of air. What was remarkable was the detection of these two isotopes at times greater than 180-days at concentrations of 0.8 and 2.6 Bq/m3 for Xe-133 and 3.2 and 16.0 Bq/m3 for Xe-135 at a distance greater than 100 m from the actual underground nuclear explosion (UNE).1


Sample Scenarios
The need for both background samples and potential UNE samples will require a robust sampling scheme. The ability to drift a shallow well (20-200 m deep) quickly will most likely require a truck with a core parameterer, a modest collection compressed gas, and many sampling tanks. At each sampling site a total of these three samples should be taken simultaneously. One of the samples will be used in a wide-area site survey to establish which of the sampling sites has elevated radio argon and xenon levels. The remaining two samples will provide the high sensitivity samples used to confirm an elevated sample site. The wide-area site survey will also provide the necessary background measurements to baseline the naturally occurring levels of radio argon and xenon. It is expected that one or two teams can collect samples at 4 to 12 sites per day in this way.

Sample Processing
A wide-area site survey would consist of samples from four different sites processed through one leg of a folded argon-xenon system (FAXIS) for a total of 16 sites surveyed. Total volume processed would be four times nominal sample volume. An elevated level in one of the legs would then lead to further analysis of the four sites represented by the samples on that leg. A high-sensitivity survey would consist of samples from the four sites identified earlier during the wide-area site survey. This survey would achieve an eight-fold increase in sensitivity over the wide-area survey. As with the wide-area site survey one of the FAXIS legs should need much higher than the other three. Subsequent sampling can focus on this one site with the potential of multiple sampling locations at that site.