REVIEW AND SUMMARY OF INELASTIC NEUTRON SCATTERING (INS) SYSTEM FOR Carbon Analysis in Soil

Project Number FWP-AACH-139

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Developing the Technologies and Building the Infrastructure for CO_2 Storage

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Presentation Outline

- **General comments.**
- **Physical basis for the project.**
- **Inelastic Neutron Scattering (INS) system; Alpha, Beta prototypes.**
- **INS Characteristics**
  - **Sample size**
  - **static and scanning capabilities**
  - **Applicable in a variety of soil types**
  - **Multi-elemental spectral analysis**
- **Results.**
- **Summary.**

Benefit to the Program

INS Program Goal:

Hypothesis: **increase in soil CO_2 seepage decreases soil organic carbon.**

Goal: **to develop new technology to facilitates monitoring cumulative effects of low level CO_2 leaks; over open fields spanning geological reservoirs.**

Objective: **to contribute to the CSP's effort to ensure reservoir's integrity, to assure human health and safety, and minimize impact on the environment.**

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Benefit to the Program

Project benefits:

- The project develops a mobile INS technology to non-destructively monitor changes in the organic soil carbon levels over large areas due to CO_2 seepage.
- This technology provides unique time and space integration of the cumulative CO_2 impact in contrast to conventional point measurements.
- INS, once demonstrated, will enhance the capabilities of monitoring reservoir integrity and early detection of risk to humans or possible impact on the environment.

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Project Overview –

Goal & Objectives

The individual goals of the overall objective entail:

- **Development of pulsed nuclear spectroscopy electronics for gated multiple detector system.**
- **Design rugged mobile field system.**
- **Data analysis software.**

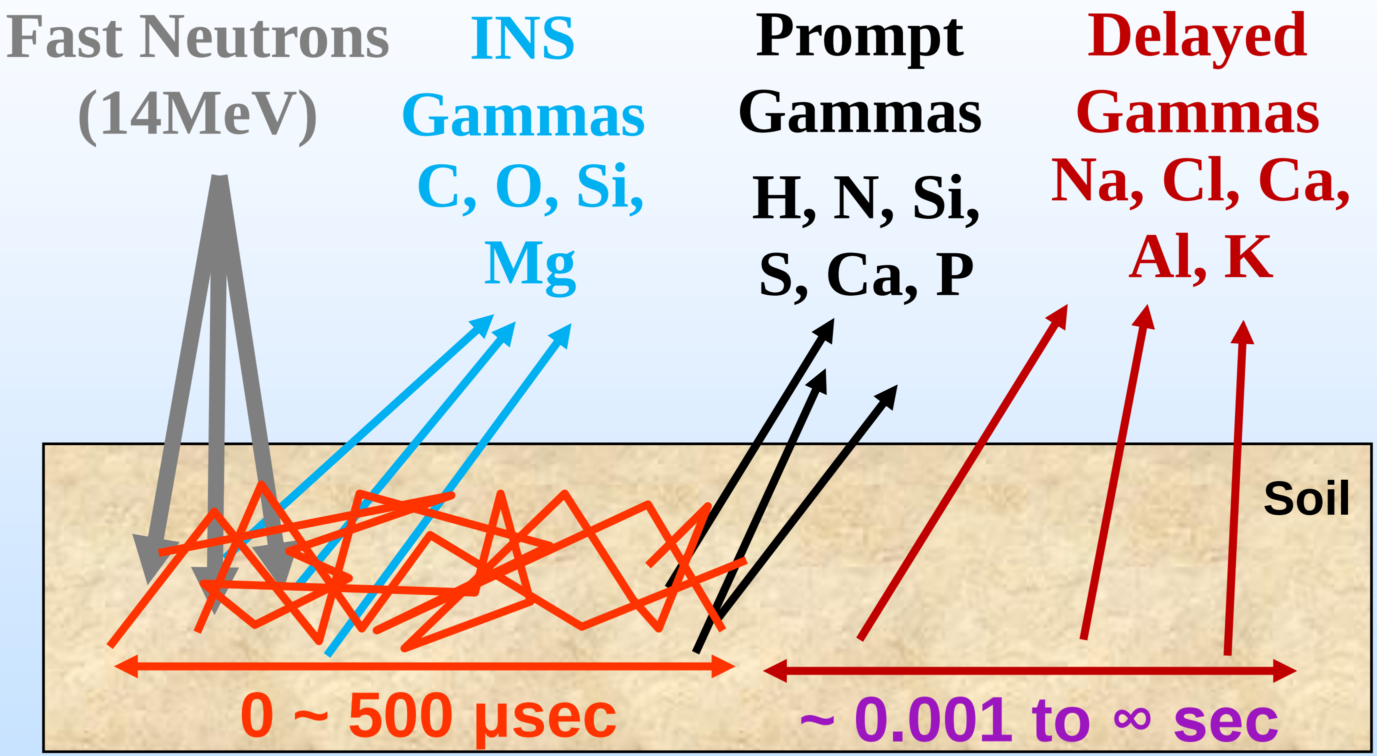
These objectives relate directly to the sensitivity and minimum detection limit required for accomplishing the project goal.

Project Overview – Success Criteria

Success was determined by comparing the soil carbon content determined by the INS system to the chemical analysis of small soil samples by dry combustion.

Technical Status

Physical Basis

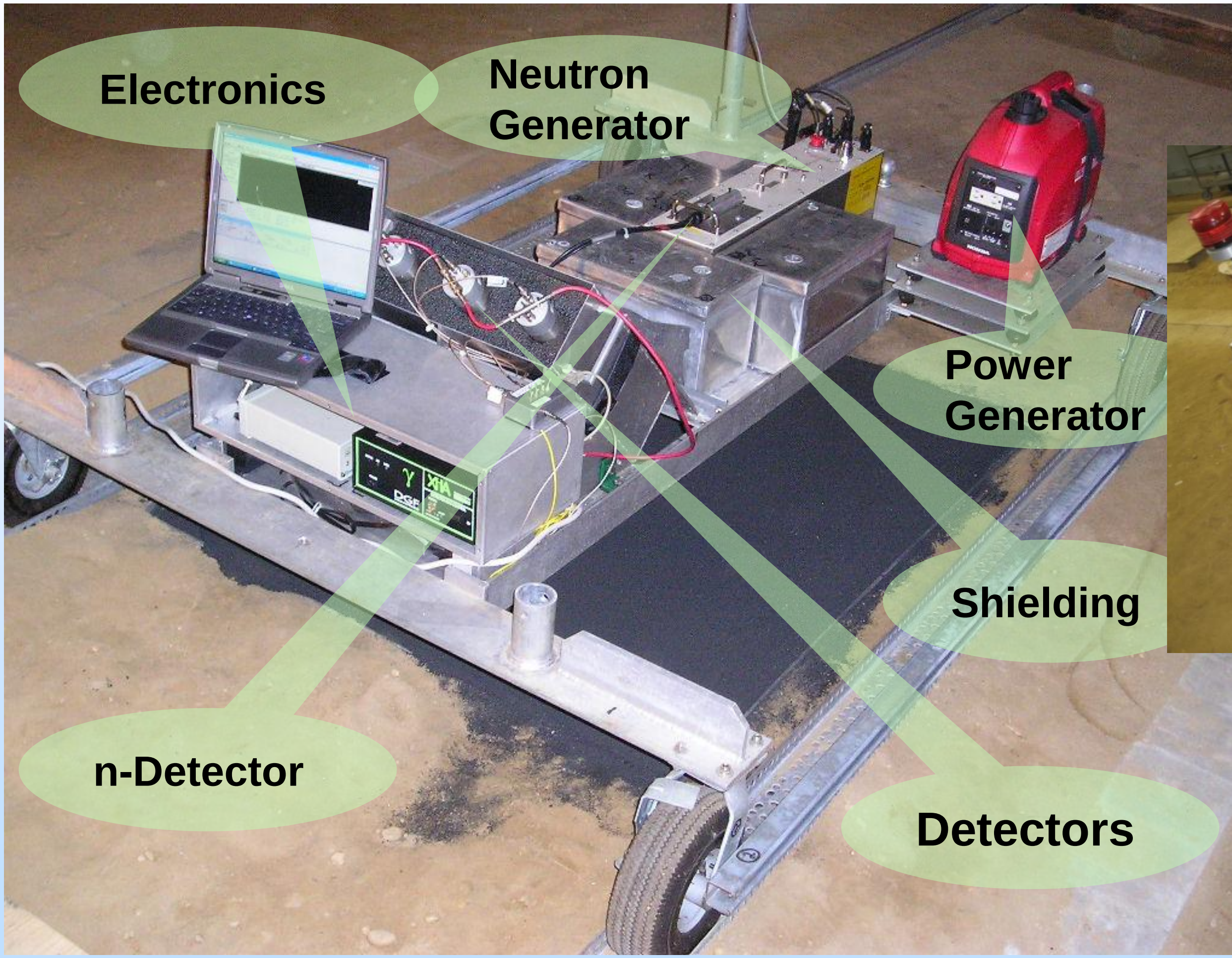


Neutrons Thermalize via Elastic Scatterings and Thermal Neutron Captures

Delayed Activation Following Neutron Capture

Technical Status

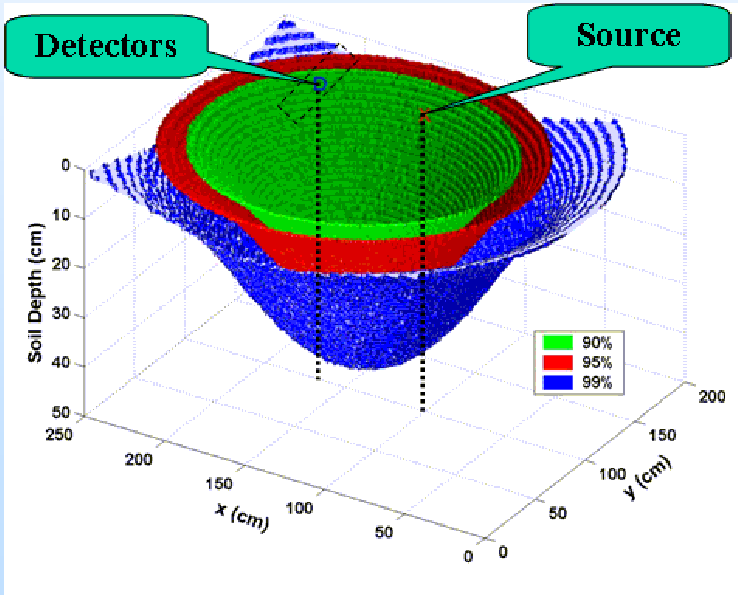
Alpha, Beta Prototypes



Technical Status

INS Key Characteristics

INS uniquely samples large volumes with large footprints (MCNP simulations)

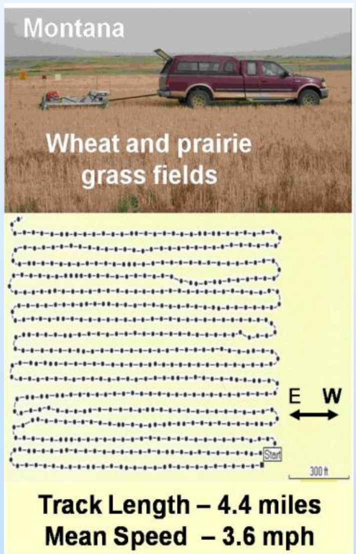


% of Total Response	Depth (cm)	Footprint (m^2)	Volume (m^3)	Mass (kg)
90	25	2.400	0.233	325.66
95	31	3.345	0.373	522.18
99	44	7.069	0.789	1105.29

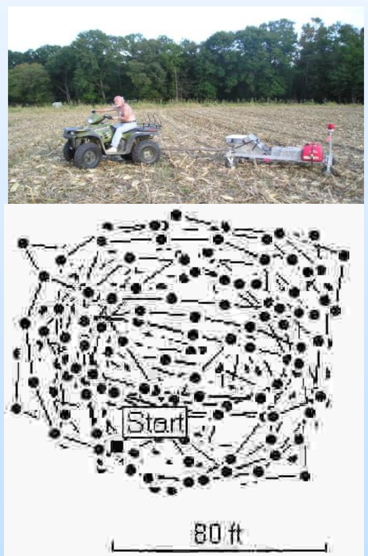
Technical Status

INS Key Characteristics

INS unique scanning capabilities and operation over a variety of field types



Montana Wheat Fields



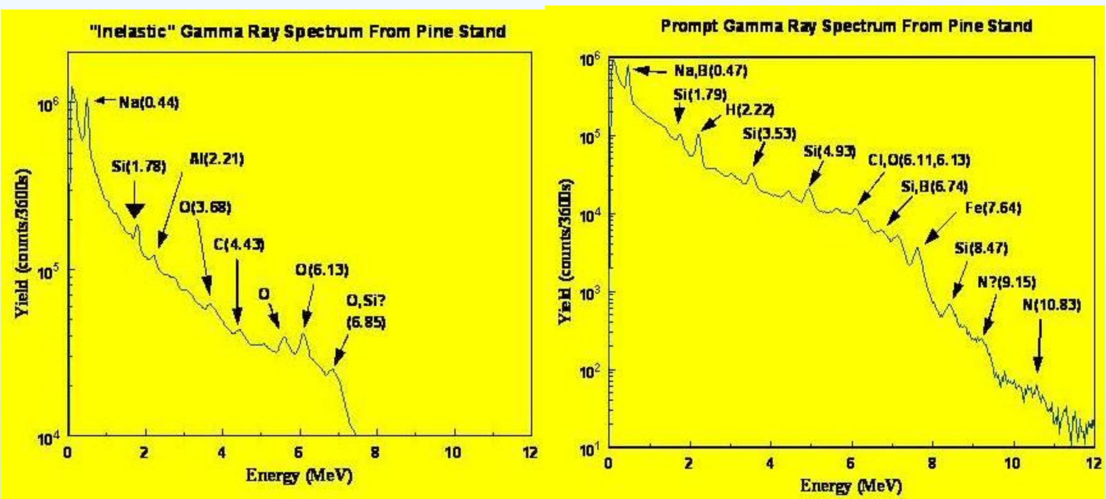
Beltsville, MD Corn Fields

Wheeler, PA Abandoned Mine Field

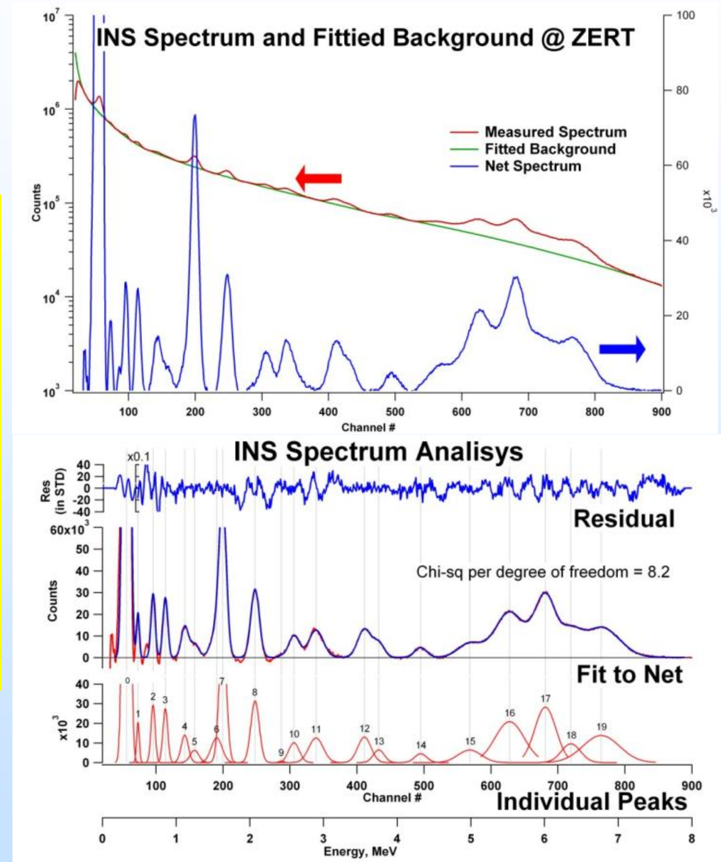
Bartlett, NH Forest

Technical Status
INS Key Characteristics

Spectral Analysis



INS and TNC Gamma Ray Spectra



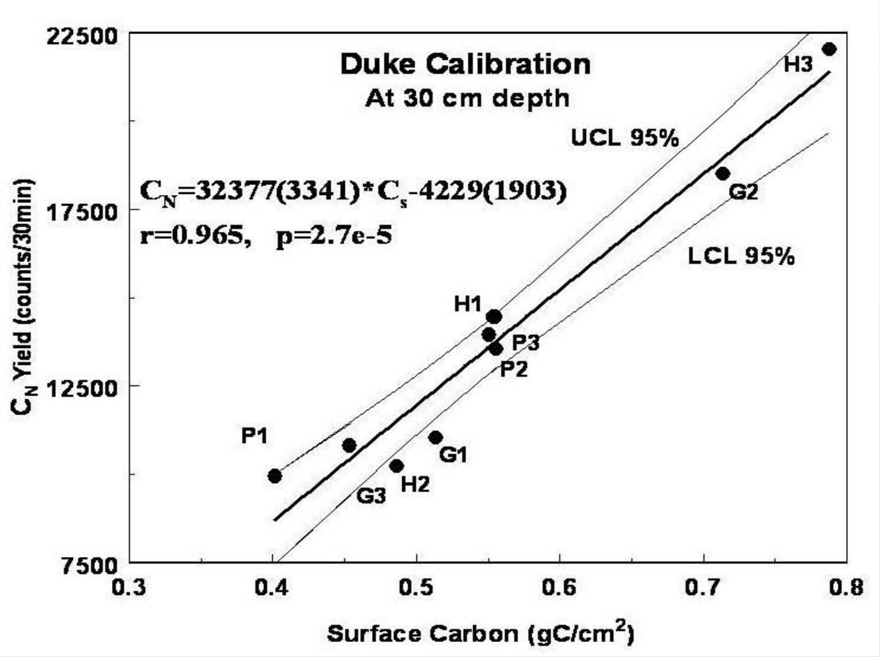
Segmented Least Squares analysis is superior to the trapezoidal method in resolving multiple- and overlapping-peaks.

Technical Status

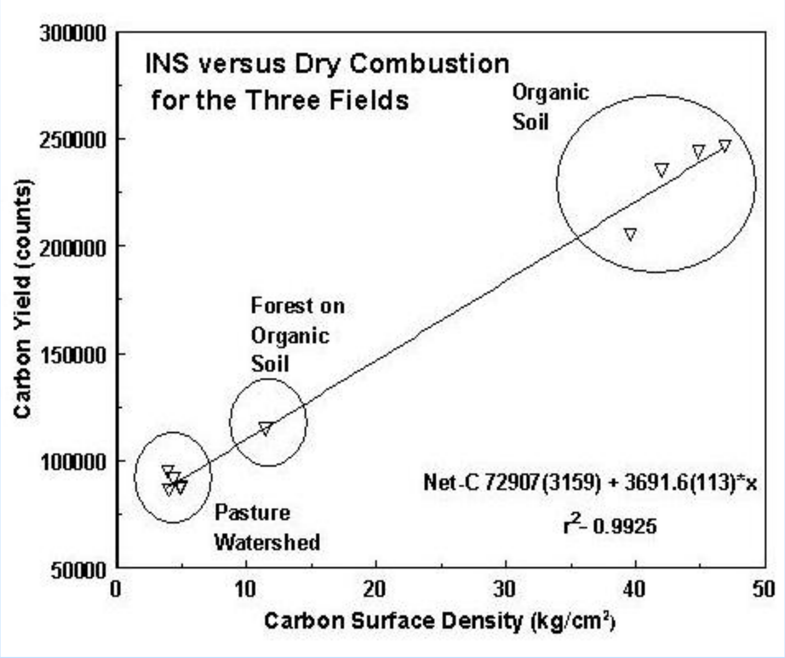
INS Key Characteristics

Correlation with Chemical Analysis

INS Calibration of a Grass Field (G), Hard Wood Forest (H), and Pine Forest (P) in Duke Forest.



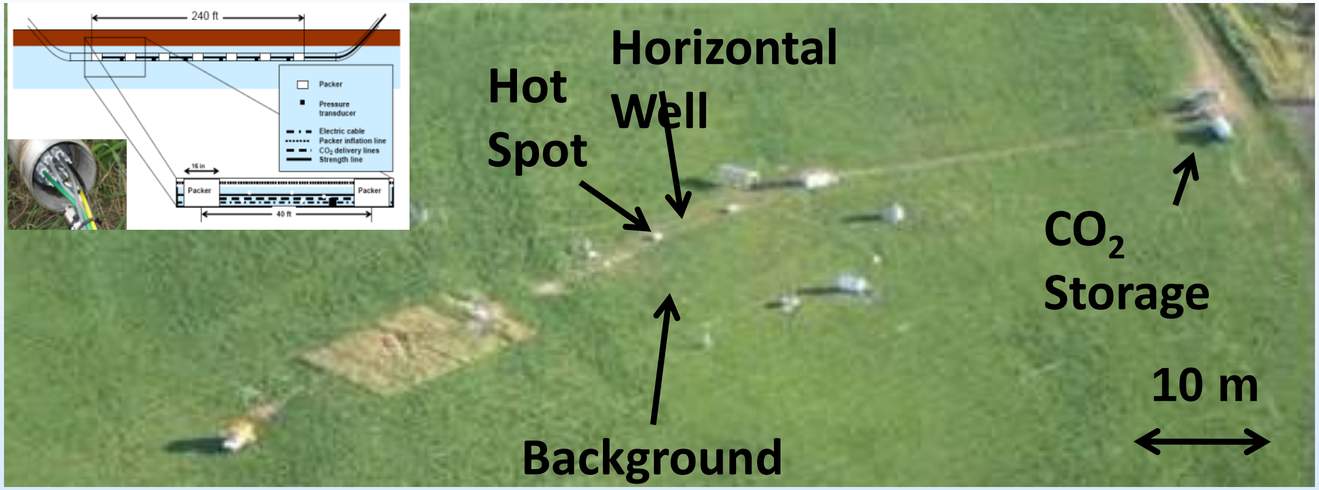
Joint INS Calibration of a Pasture Field, Mixed Forest, and an Organic Field.

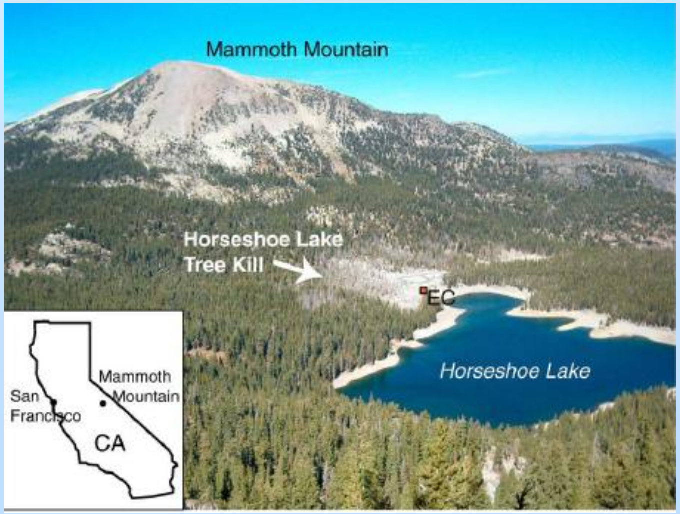


Technical Status

Results

ZERT- CO_2 Leak test facility





Technical Status

Results

ZERT- CO_2 Leak test facility

Relative change in the leak are :
Δ % = (1-HS/B) %- Percent difference between background and hot spot

	Si	O	C
2008 During Injection			
Δ %	2.3	-2.2	-14.0
2009 Pre-injection			
Δ %	3.7	-2.3	-1.9
2009 Post-injection			
Δ %	3.7	-1.2	-6.9

Accomplishments to Date

- Demonstrated the proportionality of the INS response to soil organic carbon content.

- Confirmed that underground CO_2 leaks impact negatively the soil organic carbon content in the root zone.

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Summary

- **Key Finding:** **INS is a viable technology to measure underground CO_2 seepage. Measurement of cumulative effect over large areas offers higher sensitivity for detecting low level leakages in undefined locations than point measurement in time and space.**

- **Lessons Learned:** **Sensitivity of the INS system can be further improved by increasing the number of detector; whereas the minimum detection change can be improved as square root of the counting time.**

Summary

- **Future Plans (if funded):**

  - **Improve spectral analysis**
  - **Identify the lowest detectable CO_2 leak that will provide an early alarm.**
  - **Run field experiments on a geological sequestration site.**
  - **Set an integrated platform with other modalities to provide long term comprehensive site monitoring.**

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Thanks for the Attention

Cheers