May 2, 2008 Updated "one-pager" to DEDC

(Submitted on May 6, 2008)

GROUP NAME: Geoneutrino Radiometric Analysis for Geosciences

SCIENCE

Abstract

Neutrino detection is a rapidly developing field of research in particle physics. There are three technologies for detecting neutrinos including antineutrinos. Large scale detectors (meaning kiloton or more) were designed and built to study neutrinos from the Sun. Recently 1 ton detector was also tested for detecting the antineutrinos from a power reactor. Cherenkov detectors were built to study the directionality of neutrinos being detected. New generation of neutrino detectors are being proposed with increase detection efficiency. In this context the 1 ton detector is very competitive and mobile for certain applications in geosciences.

Our goal is to develop a radiometric method using antineutrinos from the Earth for in-situ determination of the heat producing elements (HPE) in regions inaccessible to conventional sampling techniques. We also want to investigate correlations with HPE in different geothermal regions, using DUSEL facilities at Lead, SD.

The cost of building large detectors is in the range of few hundred millions dollars. The 1 ton detector can be built for under 10 million dollars. A fully tested and used detector is available for immediate research and development purposes.

OBJECTIVES

Employ a cubic meter size mobile antineutrino detector

1. Develop a radiometric method
   using antineutrinos from the Earth
   for in-situ determination of HPE to demonstrate
   proof-of-concept.
2. Optimize the antineutrino radiometric method
   to determine HPE in regions inaccessible
   to conventional sampling methods

3. Apply the method to investigate correlations with HPE in different geothermal regions. ??? (pending discussions).
4. Interface with high temperature geochemistry knowledge base regarding fractionation of HPE in Earth's interior. ??? (pending agreements)
5. Refine the BSE model. ???(pending agreements)

APRROACH – LIST SUB PROPOSAL TOPICS

For Objective 1: (Principals and Tentative collaborators)
----

1. Investigate solid angle dependence (PI, PJ, RP, GIL)
2. Investigate backgrounds and interferences (PI, PJ, GIL)
3. Geoscience design goals for instrumentation (PI, WG, FF?, BM?)
3. Investigate Proof-of-concept (POC) (PI, PJ, RP, GIL)
4. Test the POC and draw conclusions (PI,PJ, GIL, RP, WG, FF?)
5. Optimize and iterate item 2 and 3 for depth sensitivity (PI, RP, WG, FF?, BM?)

For Objective 2: (Principals and Tentative collaborators)
----

1. Investigate calibration of the method for HPE (PI, RP, GIL, PJ)
2. Investigate precision of the method (PI, PJ, GIL, RP)
3. Investigate accuracy of the method (PI, PJ, GIL, WG)

How the list is amalgamated into a program to address the objectives

Our Working Paradigm: Give us the tools of the trade, and we have a worked out methodology to achieve the science objectives.

Our program is based on the above paradigm. We have listed above the series of investigations and experiments, needed to be done to achieve the science objectives. They are listed in the order in which they are needed for a logical progression of steps to achieve the science goals.

As can be seen from the steps listed for objectives 1 and

2, to do the whole Earth assay of the primary Heat Producing Elements (HPE) we need instruments capable of in-situ measurements as opposed to grab sampling or time consuming and expensive drill core sampling methods.

THE TIME LINES AND BENCH MARKS

1. **1st half year 1: Objective - Project start up**
   low radioactivity site selection
   shielding design
   system components acquisition
   site preparation
   personnel recruitment

2. **2nd half year 1: Objective - Assemble Test Equipment**
   Training of personnel and team members
   Assembly of primary test systems
   Calibration of primary systems
   Preliminary test runs above and below ground
   Quality control tests, Quality Assurance tests
   Evidence evaluation for proof of sensitivity

3. **1st half year 2: Objective - Determination of sensitivity**
   Negotiations for Field deployment 1
   Field deployment at a uranium mine site
   Evaluation of data, Quality control tests
   Science analysis and observations 1

4. **2nd half year 2: Objective –**
   Validation at known locations
   Negotiations for Field deployment 2
   Field deployments at selected Heatflow sites
   Evaluation of data, Quality control tests
   Science analysis and observations 2

5. **1st half year 3: Objective - Quality assurance tests**
   Negotiations for Field deployment 3
   Field deployments at a deep oceanic site
   Evaluation of data, Quality control tests
   Science analysis and observations 3

6. **2nd half year 3: Deep Earth Assay design**

- synergy with Physics working Groups
Evaluation of science and sensitivity
of the investigation from Observations 1,2,3
Science analysis and plans for year 4
Funding proposals for years 4 and 5

7. Years 4 and 5: Discussions in progress for the design of antineutrino detectors with the required detection sensitivity to assay core of the Earth for heat producing elements.

EXPECTED RESULTS:

1. Well tested instrumentation and methodology for geoneutrino radiometric analysis of heat producing elements into the deep interior of the Earth.

2. Synergy with particle physics groups is expected to produce radiometric analysis to the center of the Earth.

BRIEF DESCRIPTION OF FIRST SUITE OF EXPERIMENTS

Potential Initial Suite of Experiments (ISEs):

1. Surface background characterization.
2. Underground background characterization.
3. Proof of Concept of geoneutrino radiometric analysis for geosciences.
4. Feasibility study for geothermal exploration.

1. Name of the experiment:
Surface background characterization

What does characterization involve?
Observation of the influences of local geology on the background recorded by 1 m^3 detector.

Step 1. Borrow the 1 m^3 detector and learn to operate it.

Step 2. Collect existing data from at various locations.

Step 3. Collect supplementary data at locations with dramatically different local geology.

Step 4. Identify trends in the surface background.

2. Name of the experiment:
Underground background characterization

What does this characterization involve?
Observation of the interference from cosmic rays and its variation with depth, and also with local geology.

Step 1. Collect data with 1 m^3 detector, preferably at 5 depths or more, to determine cosmic ray related contributions quantitatively for the assay of HPE in the Earth.

Step 2. Collect data with 1 m^3 detector, preferably at 3 depths or More, to determine contributions quantitatively to study the influence of local geology for the assay of HPE in the Earth.

Step 3. Identify the interferences from cosmic rays in the measured radiometric data from geoneutrinos.
Step 4. Identify the influences of the local geological parameters on the measured radiometric data from geoneutrinos.

Step 5. Analyze all data from experiments 1 and 2 to separate the geoneutrino data from the deep interior of the Earth from cosmic ray influences and local geology**.**

3. Name of the experiment:
Proof of Concept of geoneutrino radiometric analysis for Geosciences

What does POC involve?
Detection a local uranium mine with a given precision.

Step 1. Collect surface data with the 1 m^3 detector at a known mine with proven reserves of uranium.
Step 2. Analyze the data to determine the uranium in the mine based on the first two experiments.

Step 3. Compare the measured uranium value in the mine with the estimated reserve.
Step 4. Draw conclusions about the theory and experiment for the radiometric methodology using geoneutrinos from deep interior of the Earth.

4. Name of the experiment:
Feasibility study for geothermal exploration.

What does this involve?
Establishing correlation of a Heat flow studies with geoneutrino data
Please comment here
Please provide your steps, ….input –(WG)

Step 1. Collect surface data with the 1 m^3 detector at known geothermal fields with a wide range of heat flow data.

Step 2. Analyze the data to determine the correlation between the known heat flow data and the measured geoneutrino data based on the first two experiments.

Step 3. Evaluate the geoneutrino method for geothermal exploration.

DEVELOPMENT NEEDS PRIOR TO CONDUCTING EXPERIMENTS AT HOMESTAKE

Infrastructure engineering and design:
Radon-free air supply
Liquid nitrogen supply
Clean room systems and protocols for entry into the Radiometric Analysis labs

Laboratory experiments, theoretical analyses:
Custom designed electronics and software
Monte Carlo simulation capability with MCNP for solid angle determinations, for shielding design

COST ESTIMATES

S-4 proposal cost ?? what is the scope of S-4 RFP??

ISE Project cost ?? what has to be included ??

Tasks required to refine cost estimate

SCHEDULE

Estimated time required
Sequence of tasks
(start with S-4 activities) ??? Help needed with scope ??

FACILITIES REQUIRED TO SUCCESSFULLY CONDUCT EXPERIMENT

Space
Access
Power
Equipment
Communications
Services
Special materials

POINT OF CONTACT

for issues regarding facilities
ILA pila@mit.edu

E & O

1. Geoneutrino studies for uranium exploration,
2. Geothermal heat sources,
3. Models of the composition of earth,
4. Geoneutrinos as cutting edge tool to study Earth's interior

APRROACH – LIST SUB PROPOSAL TOPICS
(Principals and Tentative collaborators)
(PI, PJ, WG, MR, AS, Local Entrepreneurs, Local Talent)

1. Geoneutrino studies for uranium exploration
Intended audience: entrepreneurs
Give an informal talk informing them of the concepts
and opportunities with the new technology
Intended result:
Make the audience knowledgeable about the new technology

2. Geothermal heat sources
Concept:
Intended audience: general public.
Contact the communities and inform them about the heat
sources and concepts of energy.

3. Models of the composition of the Earth
Concept:
Intended audience: grades K – 12, general public
Intended result:
Provoke interest about Earth's components and composition

4. Geoneutrinos as cutting edge tool to study Earth's interior
Intended audience: grades K – 12, general public
Intended result:
Provoke interest about one of the tools that can be used to study the Earth's interior

RISK IDENTIFICATION AND MANAGEMENT

Potential problems
that could affect successful outcome
Potential problems
that could affect other experiments or facility

INTERESTED PRINICPALS AND COLLABORATORS

Will Gosnold	Heatflow spokesperson
Bill McDonough	Bulk Silicate Earth spokesperson
Fred Frey	Geochemistry spokesperson
Glenn I Lykken	Cosmic-rays and shielding spokesperson
Ronald Pevey	Sampling and shielding spokesperson
Ila	Radiometric method spokesperson
Jagam	Instrumentation consultant
Meredith Redlin	Community groups contact person (to be confirmed)
Abigail Semple	High school students out reach (to be confirmed)

POST-MEETING

After the meeting, the WGLs are asked to update the one-page (or larger) documents which have evolved during the meeting and file these online (May 2).

And then act as the coordinator to transform these documents into compelling proposals to design and to develop collections of individual experiments in response to the S-4 call. The anticipated due date for these proposals is June 30th, 2008