Advanced Antineutrino Estimation

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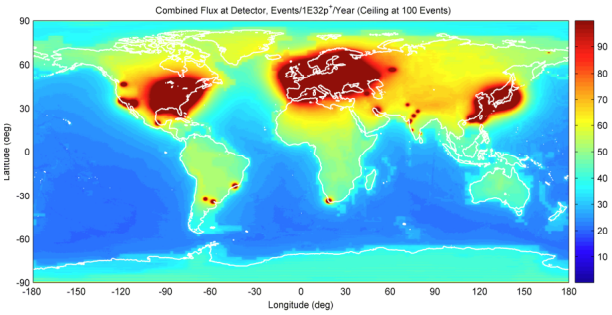
Geoneutrinos are emitted via Uranium and Thorium decay within the Earth's crust and mantle, and, when observed by current antineutrino detectors can provide great insights into the inner geological workings of the Earth. Unfortunately though, these valuable geoneutrino measurements are nearly always obscured today within larger datasets populated by various types of unwanted background. Common approaches to this statistical quandary, such as trying to identify and filter out geoneutrinos from the background, are largely unsatisfactory and suboptimal. In this paper we attempt to combat this problem three ways.

First we introduce a novel mixture-distribution Bayesian estimator capable of operating in extremely low Signal to Background Ratio (SBR) environments. We show how, under real world conditions, an antineutrino signal obscured 100 times over by background (0.01 SBR) can still yield great quantities of information about a source if a moderate understanding of the obscuring background is available.

Secondly, we show how exploitation of the energy and direction vector of individual antineutrino measurements can offer far more information than that available by counts only. We show that crust-geoneutrinos can be segregated statistically from mantle-geoneutrinos in this manner.

Thirdly, we demonstrate the use of Cramer-Rao Lower Bounds for optimal detector placement. We evaluate the entire surface of the Earth and find the best spots to place a detector to study geoneutrinos and theta$_{12}$ oscillations.



Lastly we model the entire Earth, and combine all the above methods into a large Monte Carlo simulation showing how four oceangoing antineutrino detectors, strategically placed around the world, can reduce geoneutrino flux uncertainty by 50%, and antineutrino theta$_{12}$ oscillation uncertainty by 80% within just 1 year.

Ge/Si variations in the deep sea deduced from microanalyses of giant spicules of the sponge *Monorhaphis chuni*

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The exceptional longevity of the deep-sea sponge *Monorhaphis chuni* and the stability of their giant spicules provide the potential that they can be used as paleoenvironmental archives spanning the last 13 ka. To track secular variations of the geochemically similar elements Si and Ge [1] in the East and South China Sea, we used femtosecond-LA–MC-ICP-MS at GFZ and LA-ICP-MS at MPI for the high-resolution *in-situ* determination of Si isotope ratios and Ge and other trace element concentrations, respectively, in cross sections of giant spicules.

Significant variations in Si isotope ratios (δ^{30}Si: from -1.9 to -3.7 ‰) and Ge concentrations (0.21-0.29 μg g^{-1}) were observed in the largest spicule collected so far (SCS-4, 2.7 m long) from a depth of 2100 m. No obvious trend in Si isotope variability could be identified in smaller and presumably younger spicules. To convert the Si isotope and Ge data into respective seawater concentrations, we used the inverse relationship of Si(OH)$_4$ in seawater and δ^{30}Si in the sponge [2] as well as the linear relationship between Ge/Si in the sponge and the Ge concentration in the seawater [3]. Present-day Ge/Si is uniform and about 0.7 μmol mol^{-1}. In contrast, there are significant changes of Ge/Si in the time interval corresponding to the Younger Dryas event 11 – 13 ka BP, where Ge/Si is about 0.55 μmol mol^{-1}. A high value of 0.8 μmol mol^{-1} was observed at the Holocene optimum around 6 ka BP. The Ge/Si pattern compares well with the results of previous studies on diatomaceous opal obtained from South Atlantic cores [4] and supports the idea of secular changes of whole ocean Ge/Si.

[1] Froelich and Andreae (1981) *Science* **213**, 205-207. [2] Hendry *et al*. (2010) *EPSL* **292**, 290-300. [3] Ellwood *et al*. (2006) *EPSL* **243**, 749-759. [4] Mortlock *et al*. (1991) *Nature* **220**, 220-223.

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