

Earth Antineutrino Tomography (EARTH)

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Stichting (Foundation) EARTH

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Science and Technology Programme



- Geoscience
(Wim van Westrenen, VU University Amsterdam)
 1. Georeactors in CMB
 2. Georeactor excursion for Moon formation (Seifritz)
 3. Moons at other planets
- Detector development
(Ricky Smit et al., iThemba LABS)
 1. Compact and direction sensitive antineutrino detectors



Geoscience

- Feasibility study of Georeactors in the CMB. (South African Journal of Science, 2008, **104**, 111-118)
 1. U & Th concentrated in Ca-perovskite leads to 12 ppm U&Th in ancient CMB.
 2. Requires an additional concentration by an order of magnitude for reactor start and maintenance.
 3. Not unlikely.
 4. Indicators: $^3\text{He}/^4\text{He}$, ^{129}Xe and $^{136}\text{Xe}/\text{Xe}$



Moon formation

- Excursion by a georeactor in the CMB.
 1. Explains why geochemically Moon and Earth's mantle are so similar in element and isotopic composition. (in revision for PEPI; preprint ArXiv 1001.4243).
 2. Supported by reactor-physics calculations. (in prep. for Kerntechnik).
 3. How about moons at other planets? (Venus, in preparation for Icarus)



Detector development

- Directly via reaction $\bar{\nu}_e + p \rightarrow e^+ + n$.
- Indirectly via change of count rate of β decay following Jenkins et al. interpretation of count rate oscillations in β^- decay due to changes in solar neutrino flux.
- If true a similar effect has to be present for β^+ decay.



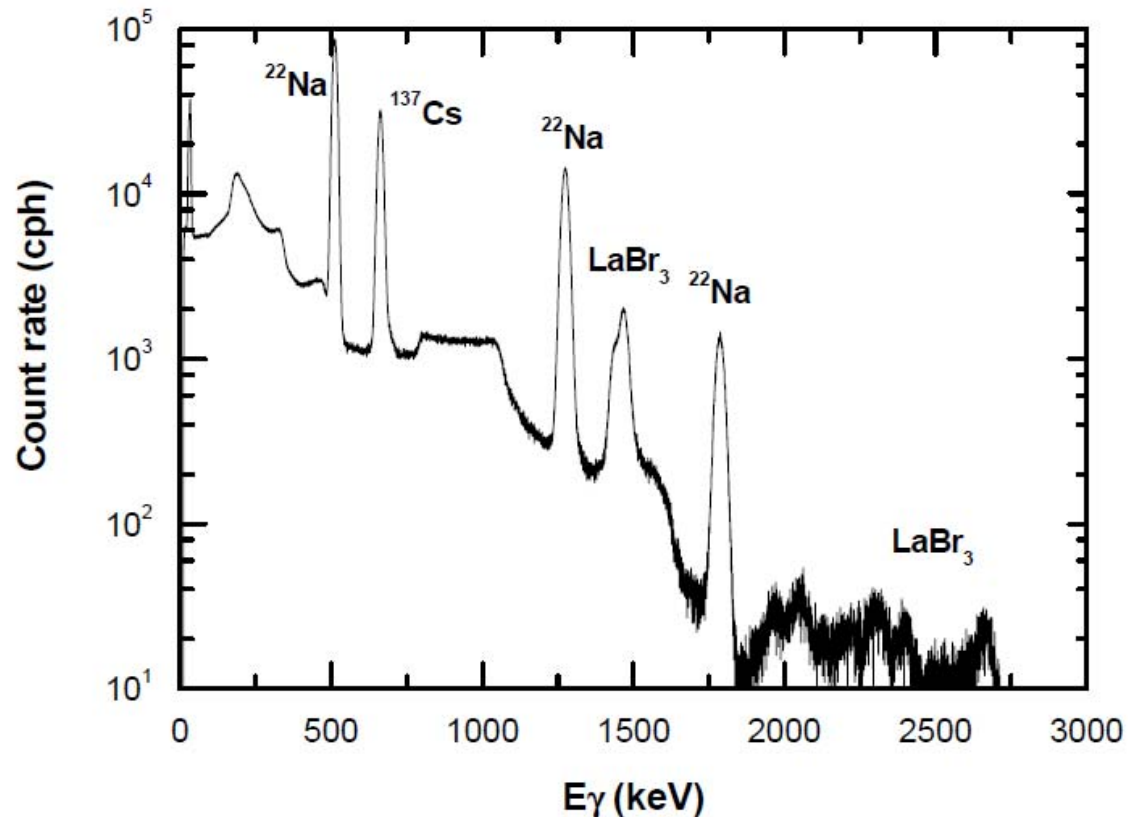
Geo-LOFAR

- Combine γ -ray detectors with LOFAR to obtain geoneutrino (U,Th &K) antenna?
- Experiment at Delft reactor reduces effect by two orders of magnitude (ARI in press;doi:10.1016/j.apradiso.2010.08.002 .
- Not too promising!



Reactor monitoring

- But present upper limit allows for reactor monitoring.
- Test at large reactor in preparation.

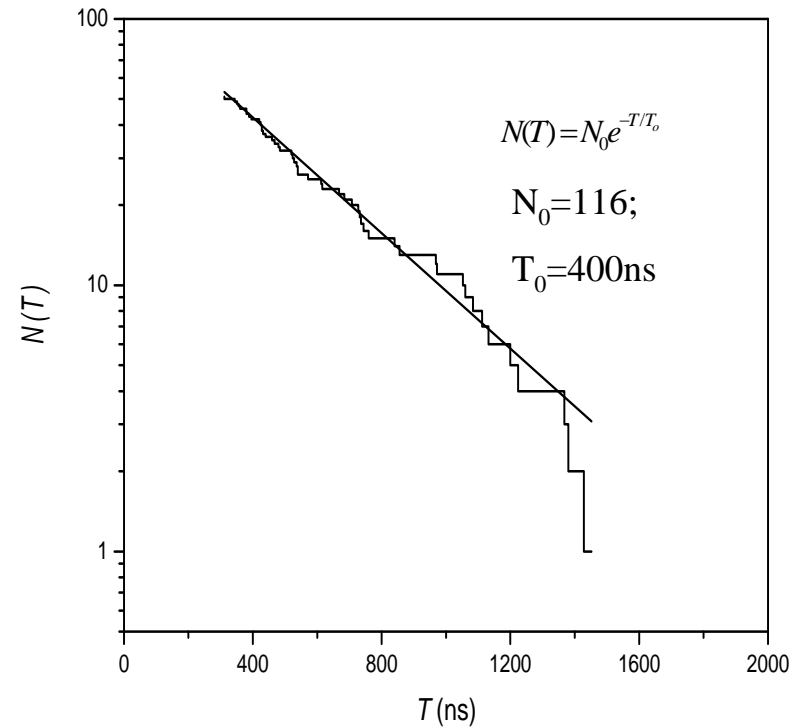
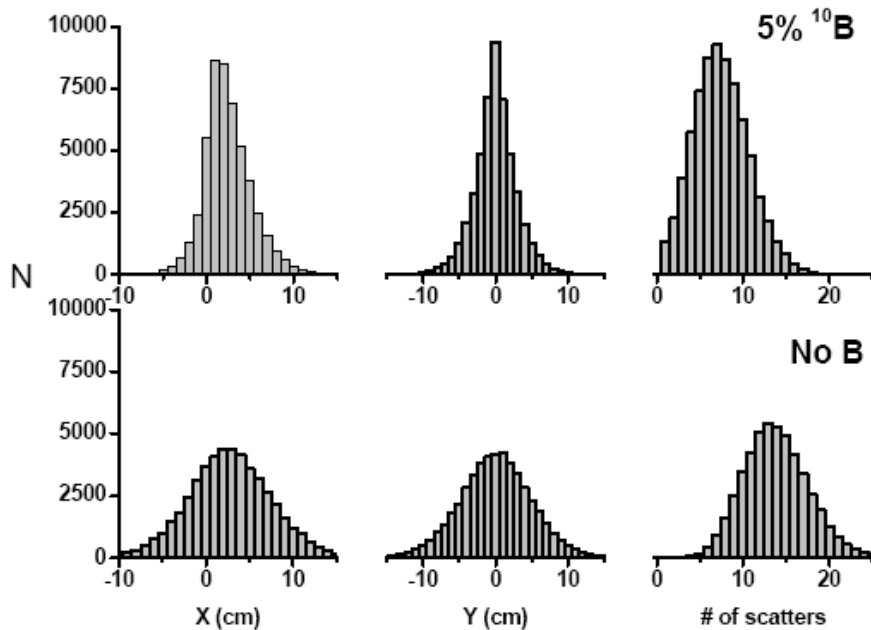




Direct antineutrino detection

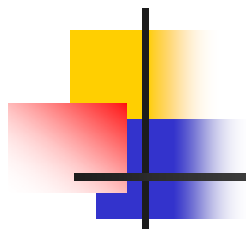
- Antineutrino signal defined by slowdown signal of positron and of α -particle produced in n-capture by ^{10}B or ^6Li .
- Ranges: n (5-10 cm); e^+ (1-2 mm) and α (few micron).
- Monte Carlo simulations indicate reasonable direction sensitivity.

Earlier results

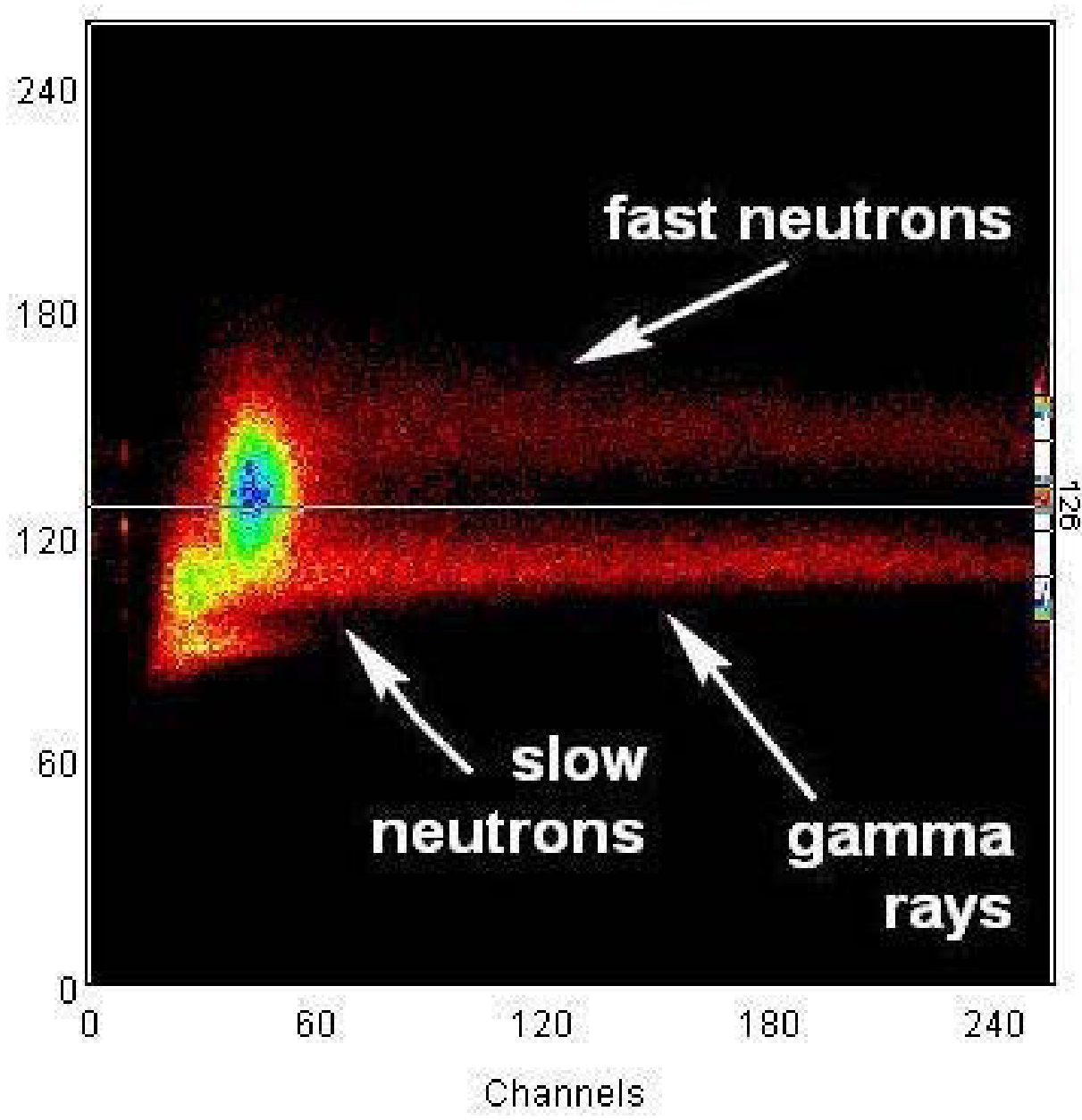


Earth, Moon, and Planets (2006) 99:193–206
DOI 10.1007/s11038-006-9104-8

Pu-Be high gain



Channels



(eV).

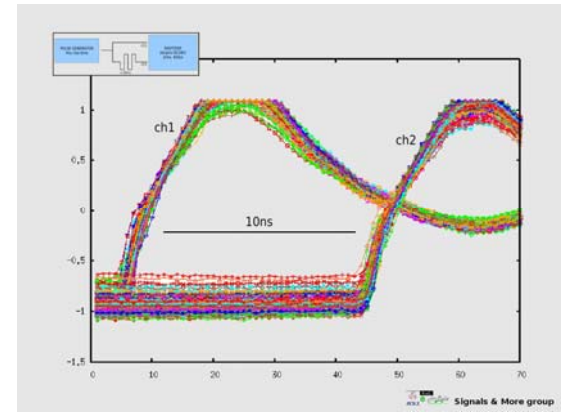
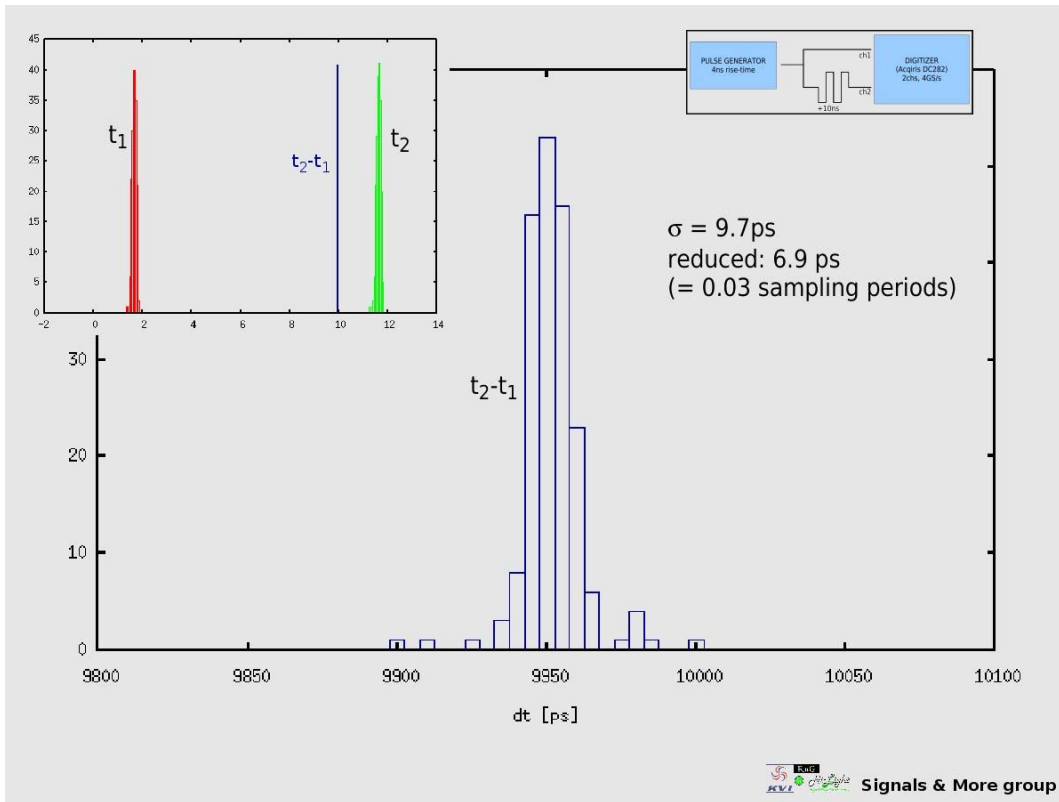




Development in collaboration with INCAS³, Univ. Groningen, industry

- Starting: new borated materials with PSD and less quenching.
- Planning: new photon detectors.

Triangulation ?



H.J. Wörtche & M. Vencelj

Larger compact detector (GiZA)



- Suitable for tests at a nuclear power plant. Volume 36 litres.
- Equipped with state of the art scintillation material and photon detection.
- Status:
 1. Light transport simulated,
 2. Mechanical design completed.
 3. Acquiring finances and access permission



Background suppression

- Delayed coincidences ($\sim 10^6$);
- Position requirements (~ 10);
- Pulse shape ($\sim 10^{1-2}$);
- Constant magnitude α -puls ($\sim 10^{1-2}$);
- (Anti-)coincidences ($\sim 10^{2-3}$);

Expected suppression factor: 10^{10-14}



Programme at power plant

- Check various background reduction techniques (hardware/software). First under laboratory conditions, then at the reactor.
- Characterize antineutrino events.
- Design and build proto-type detector.
- Test it.



Conclusions

- EARTH programme focusses on geoscience and detector development.
- Addresses georeactors in the CMB, Moon formation.
- Investigates possibility of compact, direction sensitive antineutrino detectors, has started development of new scintillation materials.
- Working towards next generation compact, direction sensitive antineutrino detectors for science and technology.

