# Earth AntineutRino Tomography (EARTH)

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Stichting (Foundation) EARTH

Neutrino Geoscience 2010, Gran Sasso, Italy
October 2010

# 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: $^{3}He/^{4}He$, $^{129}Xe$ and $^{136}Xe/Xe$

# 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)

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# Detector development

- Directly via reaction $\overline{\nu_e} + p \rightarrow e^{+} + n.$

- Indirectly via change of count rate of β decay following Jenkins et al. interpretation of count rate oscillations in $\beta^-$ decay due to changes in solar neutrino flux.
- If true a similar effect has to be present for $\beta^+$ decay.

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# 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!

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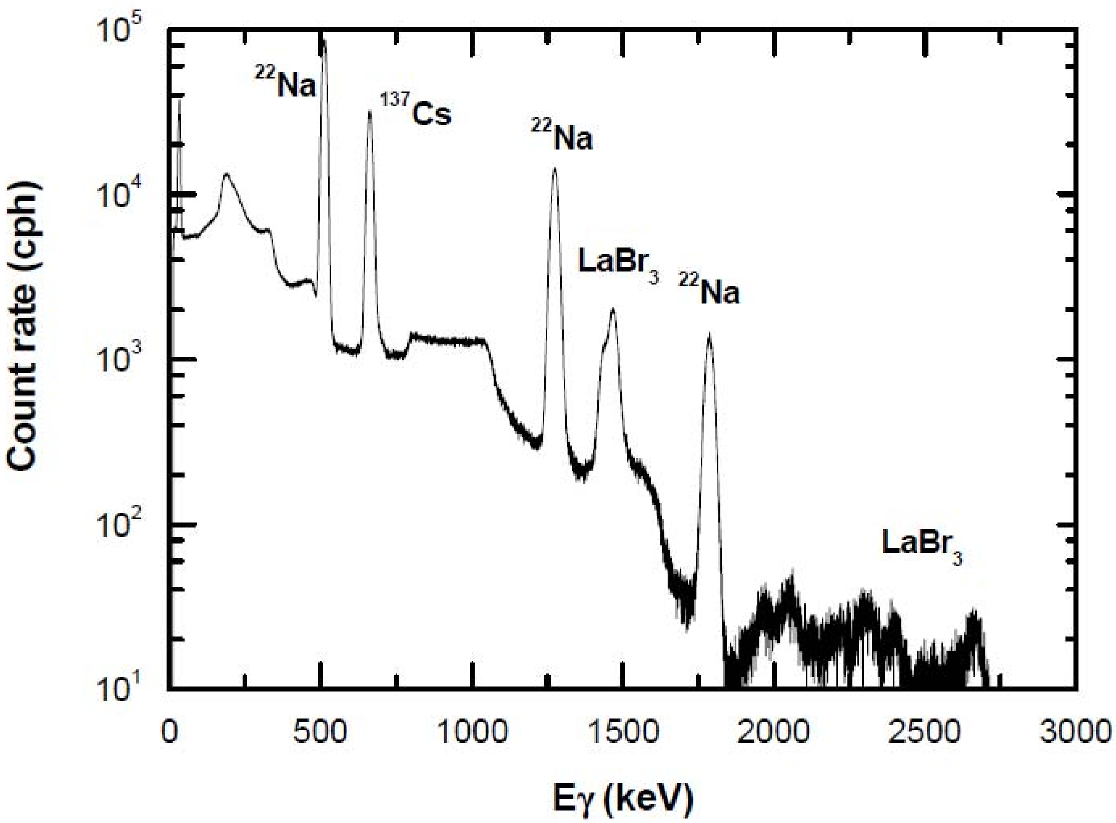
# Reactor monitoring

- 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 $^{6}Li$.
- Ranges: n (5-10 cm); $e^+$ (1-2 mm) and α (few micron).
- Monte Carlo simulations indicate reasonable direction sensitivity.

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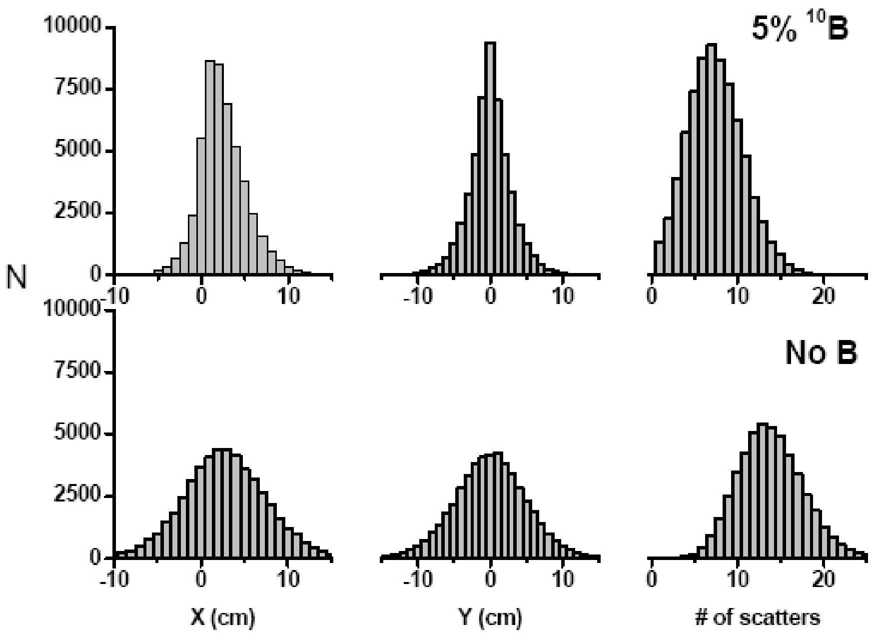
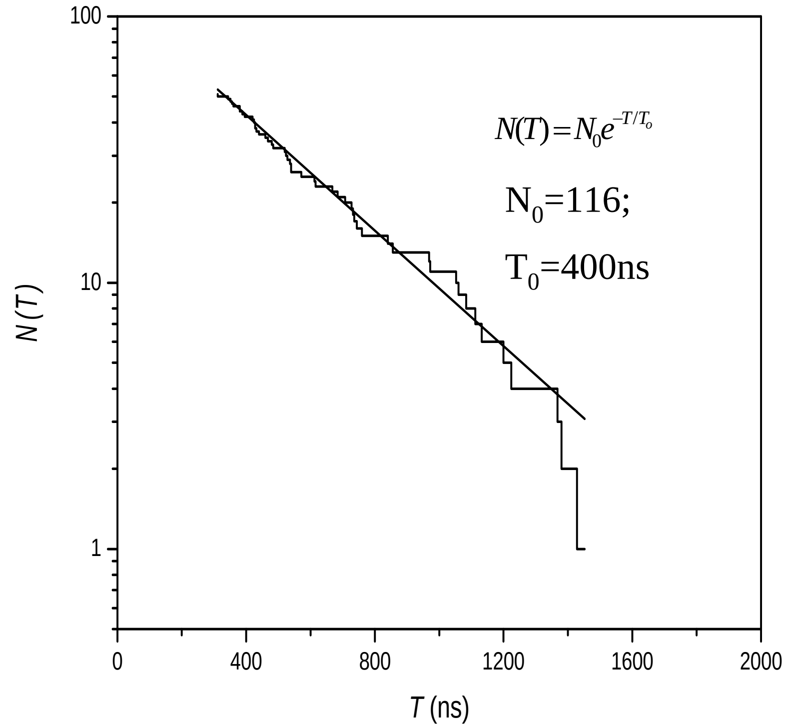
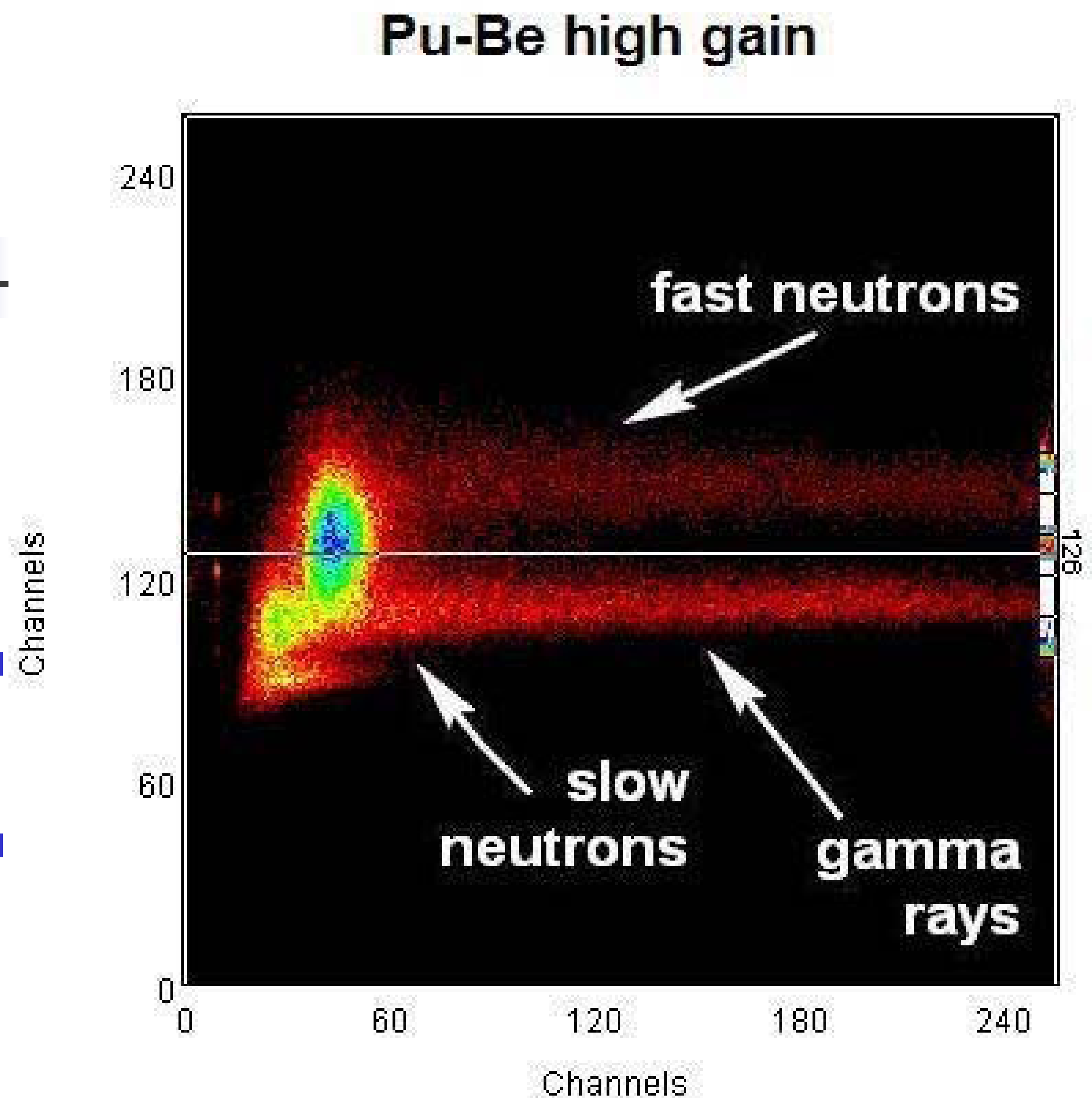
# Earlier results




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


Pu-Be high gain
fast neutrons
slow neutrons
gamma rays
Channels
Channels
126
0
60
120
180
240
0
60
120
180
240

eV).

# Development in collaboration with INCAS[3], Univ. Groningen, industry

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

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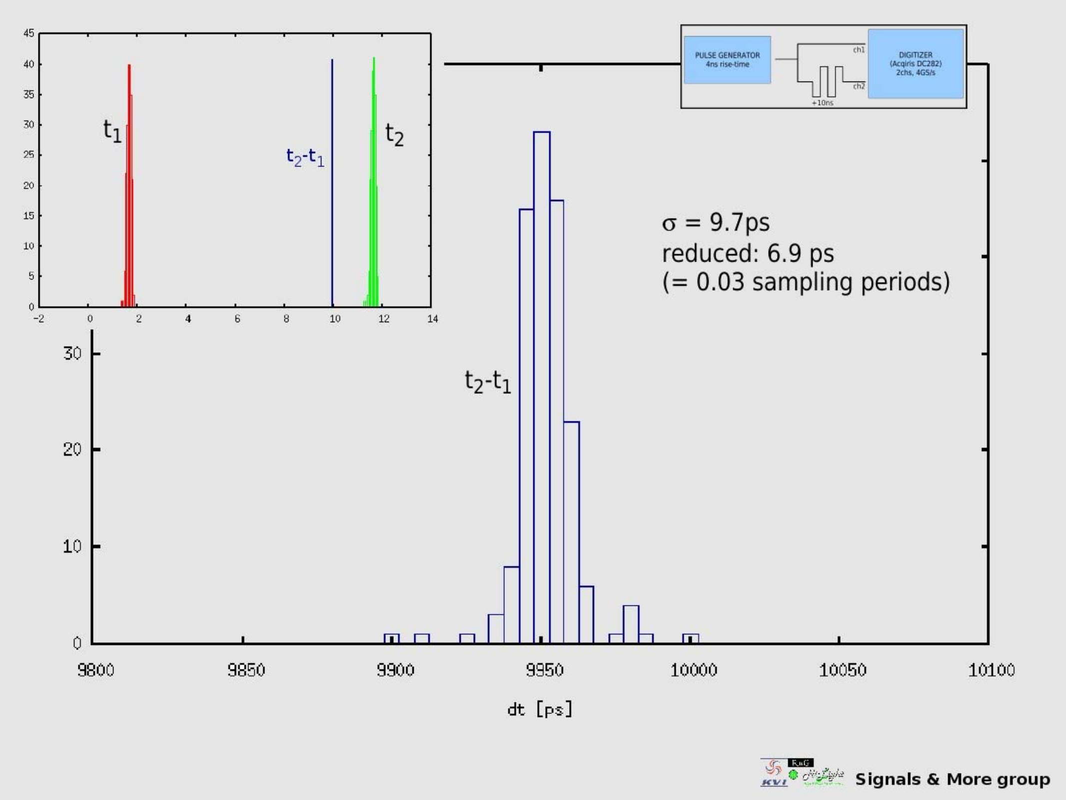
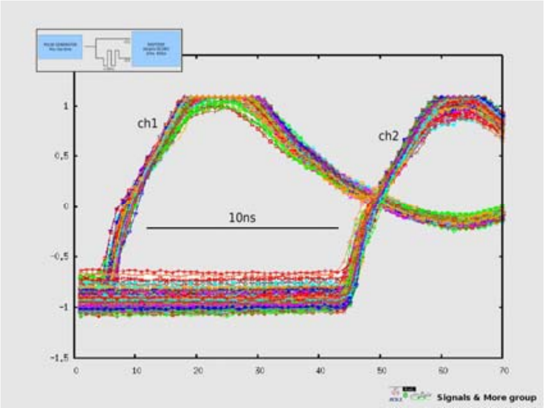
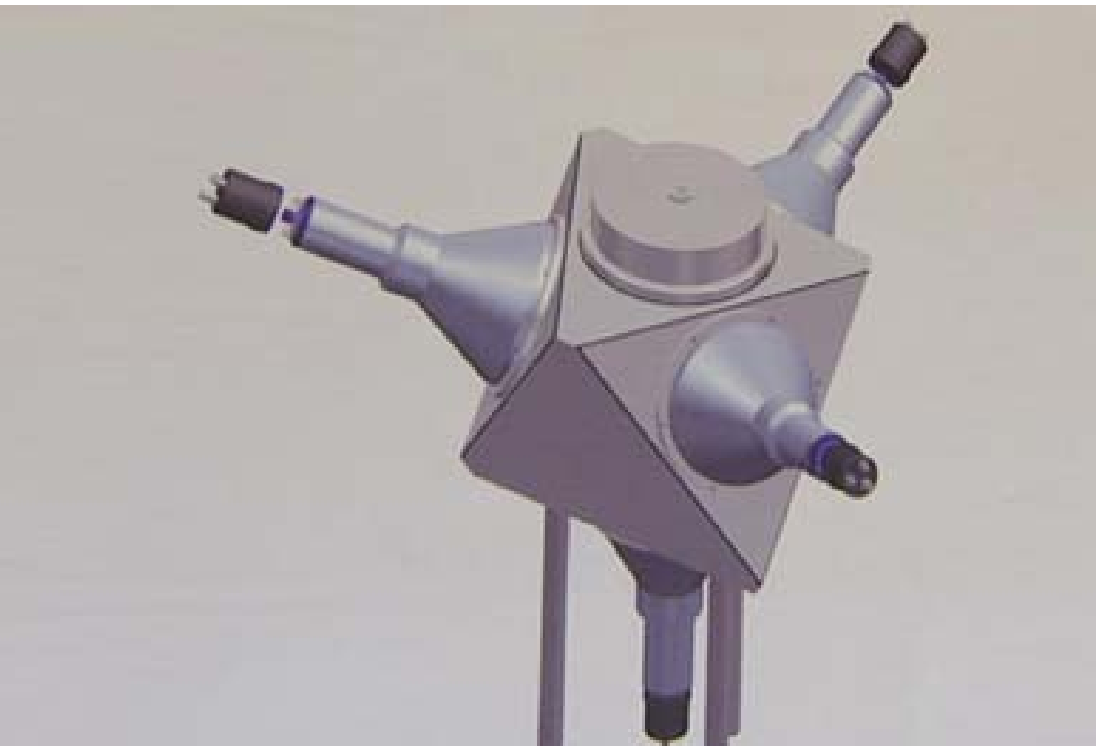
# Triangulation ?




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

**Expected suppression factor: $10^{10}$-$10^{14}$**

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# 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.