γ-ray spectrometry practices in the deep ocean

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Outline

- Study/Criteria
- KATERINA-Deep detection system
- Pressure tests and selection materials
- Simulations (MCNP-CP)
- Methodology (Quantification and MDA)
- Results (γ spectrum and MDA)
- Conclusions

Study / Criteria (in situ detection)

Detection crystal selection

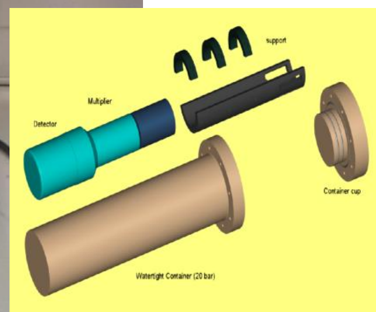
- ✓ Low consumption
- ✓ Low cost
- ✓ High efficiency
- ✓ Without cooling

Enclosure material selection (housing)

- ✓ Minimum absorption of gamma rays
- ✓ Robustness
- ✓ Tolerant for deep sea deployment
- ✓ Easy to manage (appropriate dimensions, light weight)

KATERINA-Deep System

Patent INT.CL: G01T 7/00 [Commercialised]



Specifications

- Crystal: 3x3" NaI
- **Consumption: <1 W**
- Resolution at 662keV: < 6.5 %
- Variable energy range
- Adjustable spectroscopy and HV
- Operating temperature: 0^0-50^0C
- Output voltage stability
- Autonomy (without PC connect)
- Continuous monitoring in autonomy mode
- Adjustable amplifier gain, PZC, BLR and shaping time
- Option for real time (software independent)

Pressure test and on going work

- Upgrade towards integration in deep sea observatories (up to 4500 m)
- Project RADIOSCOPIO: Research and development of an in-situ underwater gamma-ray spectrometer for low-level radioactivity measurements Bilateral R&T Greece-China collaboration 2012-2014 [Funded by the Hellenic General Secretariat for R & T]
- Project LEVECO (task: monitoring gases in mud volcanoes)

Crystal and housing material

Detection crystal selection:

minimum dimensions of the crystal NaI: 3x3 inches

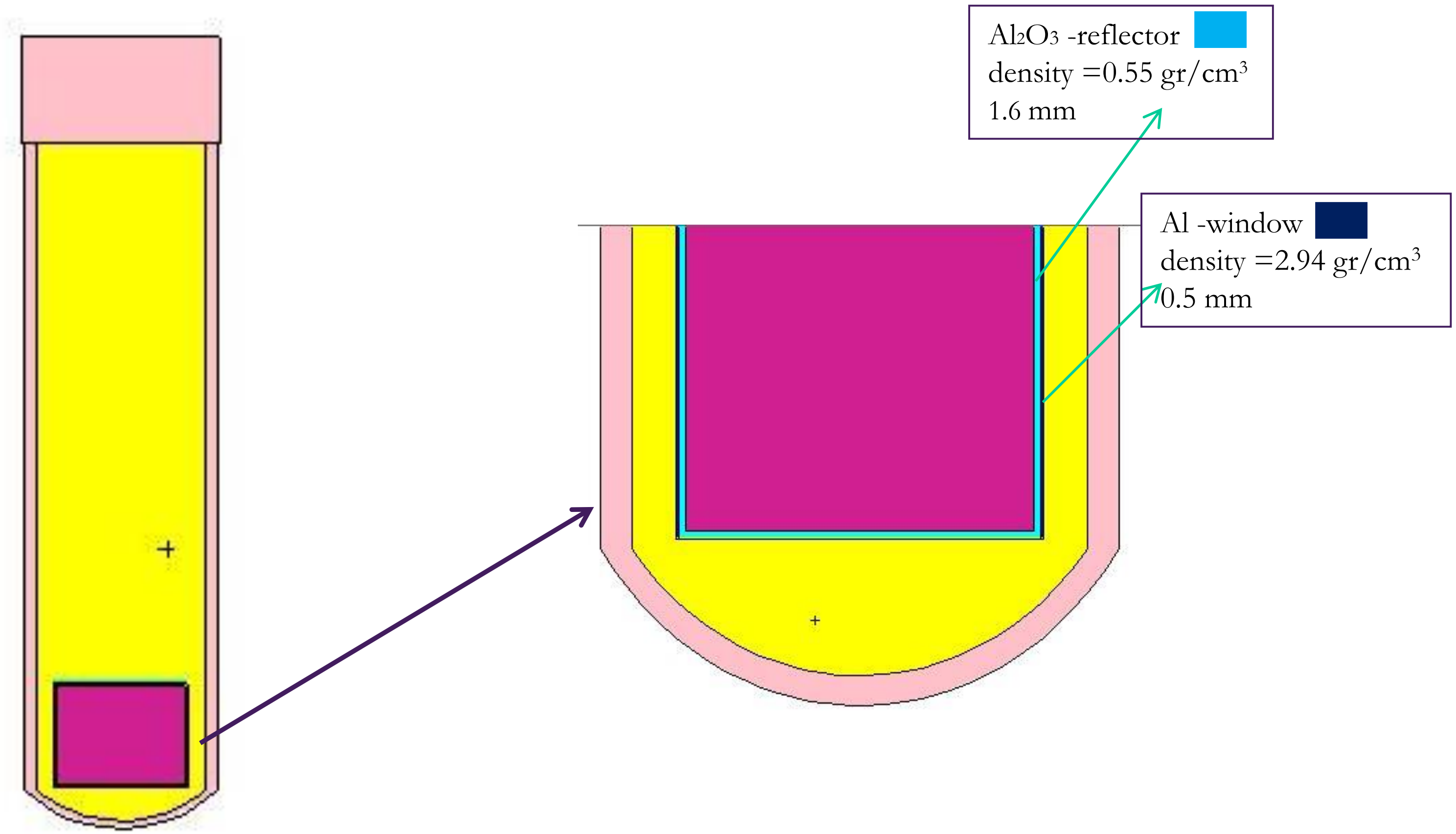
Enclosure material selection (housing):

Candidate materials: Stainless Steel, Borosilicate Glass, Carbon Fiber, Aluminium, Titanium

Comments: Al is not tolerant for deployments at 4500m, Ti is not cost-effective

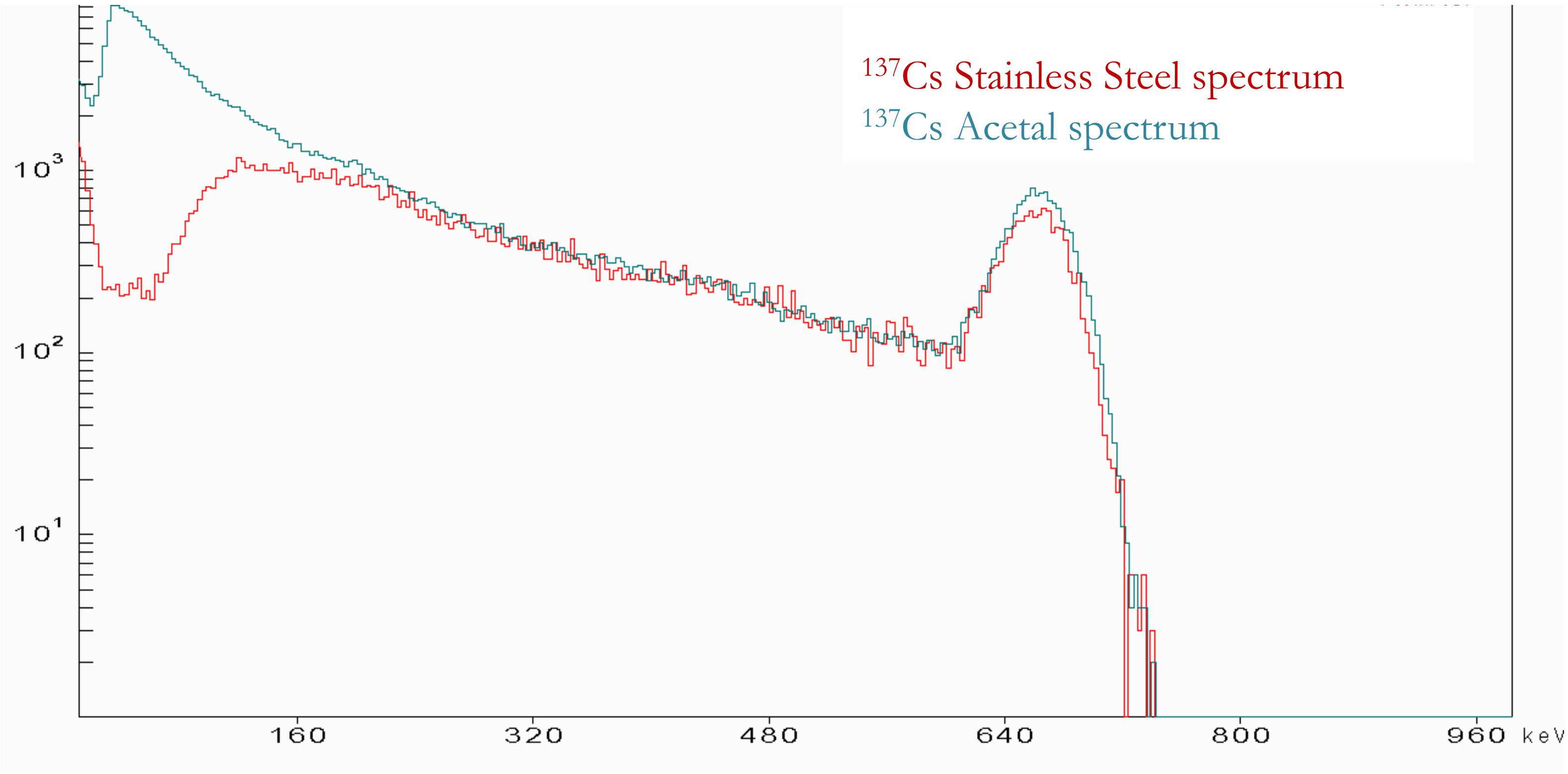
Selected material: Stainless Steel, Borosilicate Glass, Carbon Fiber

Stainless steel configuration (up to 4500 m depth)

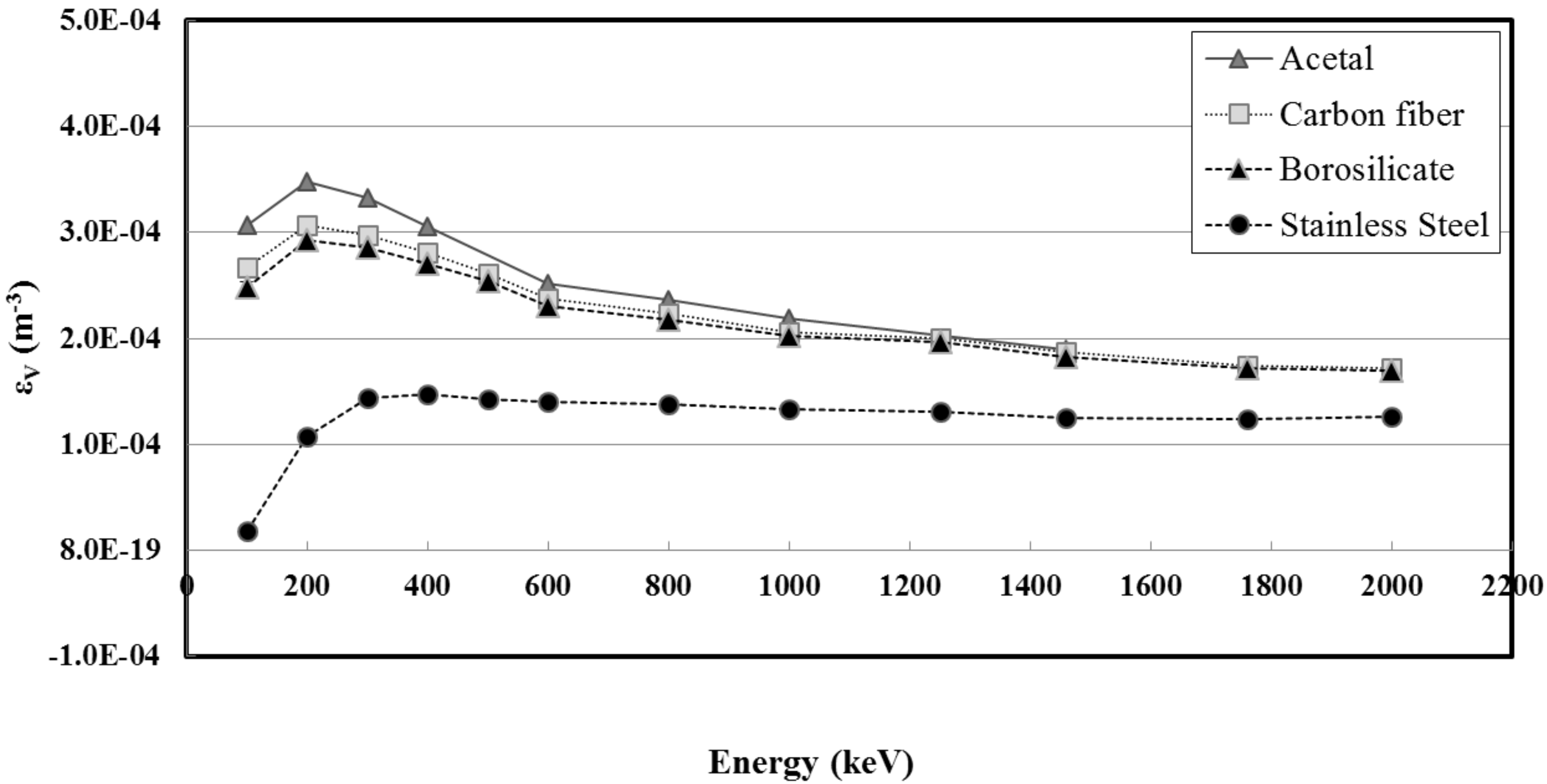


Threshold energy of the deep system

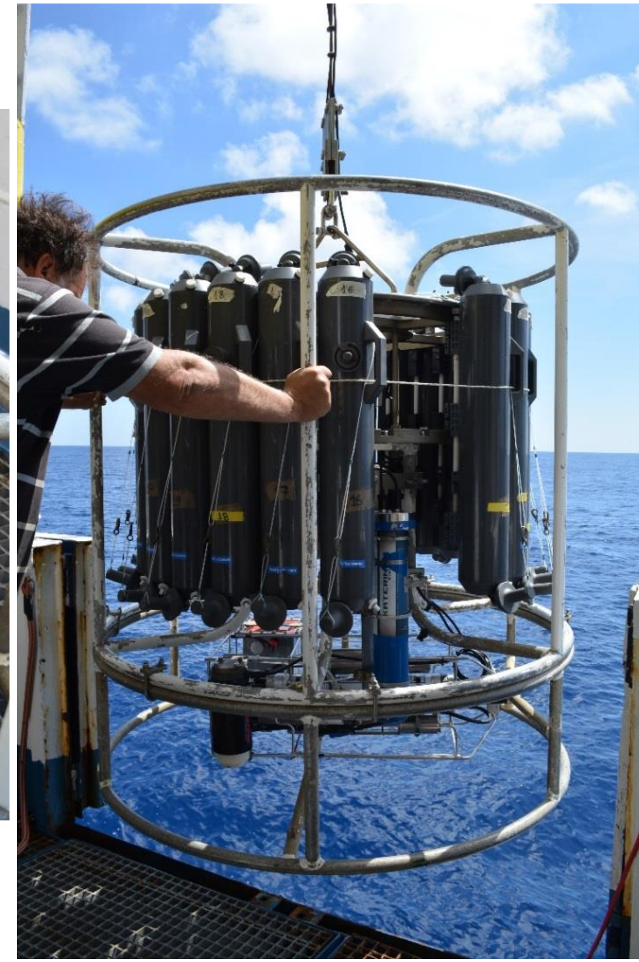
^{137}Cs normalized simulation spectra



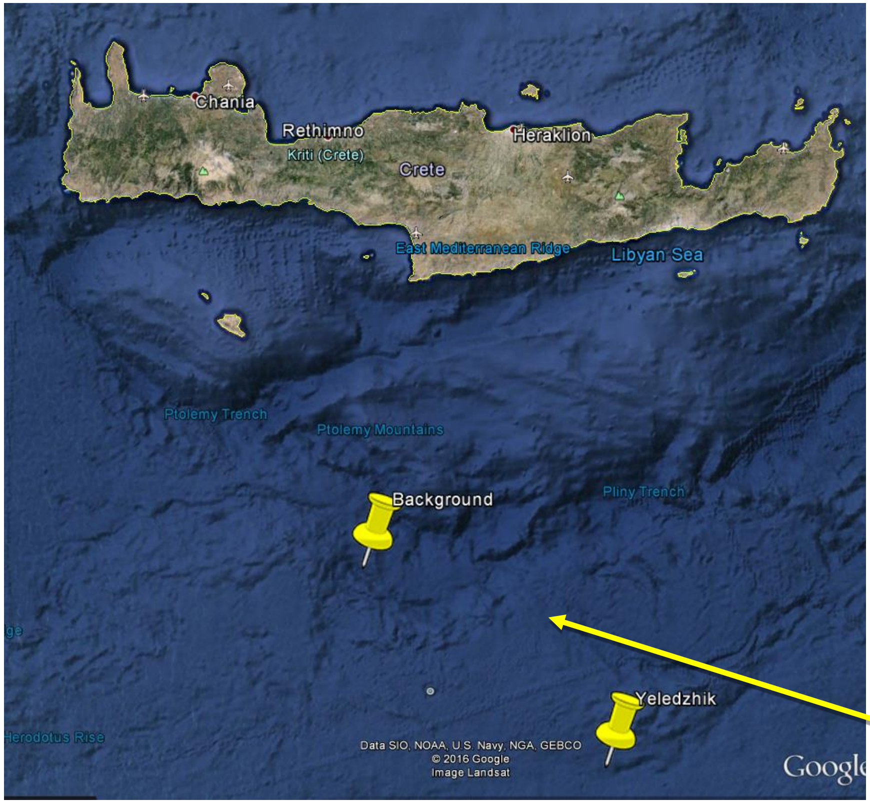
FEPE comparison of housing materials



Deployments (deep sea)



Study area

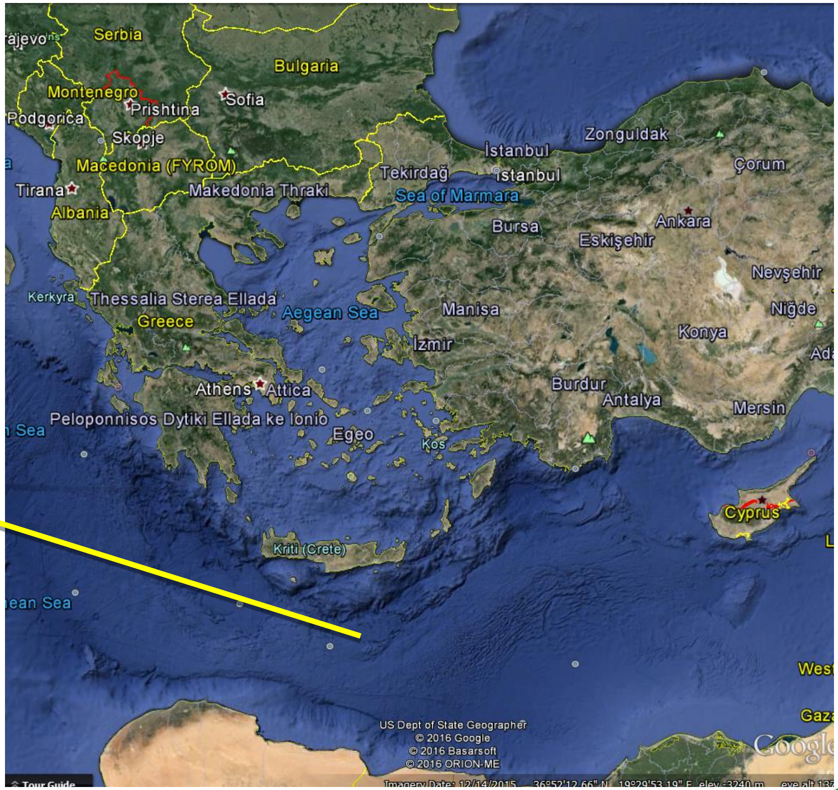


Background station

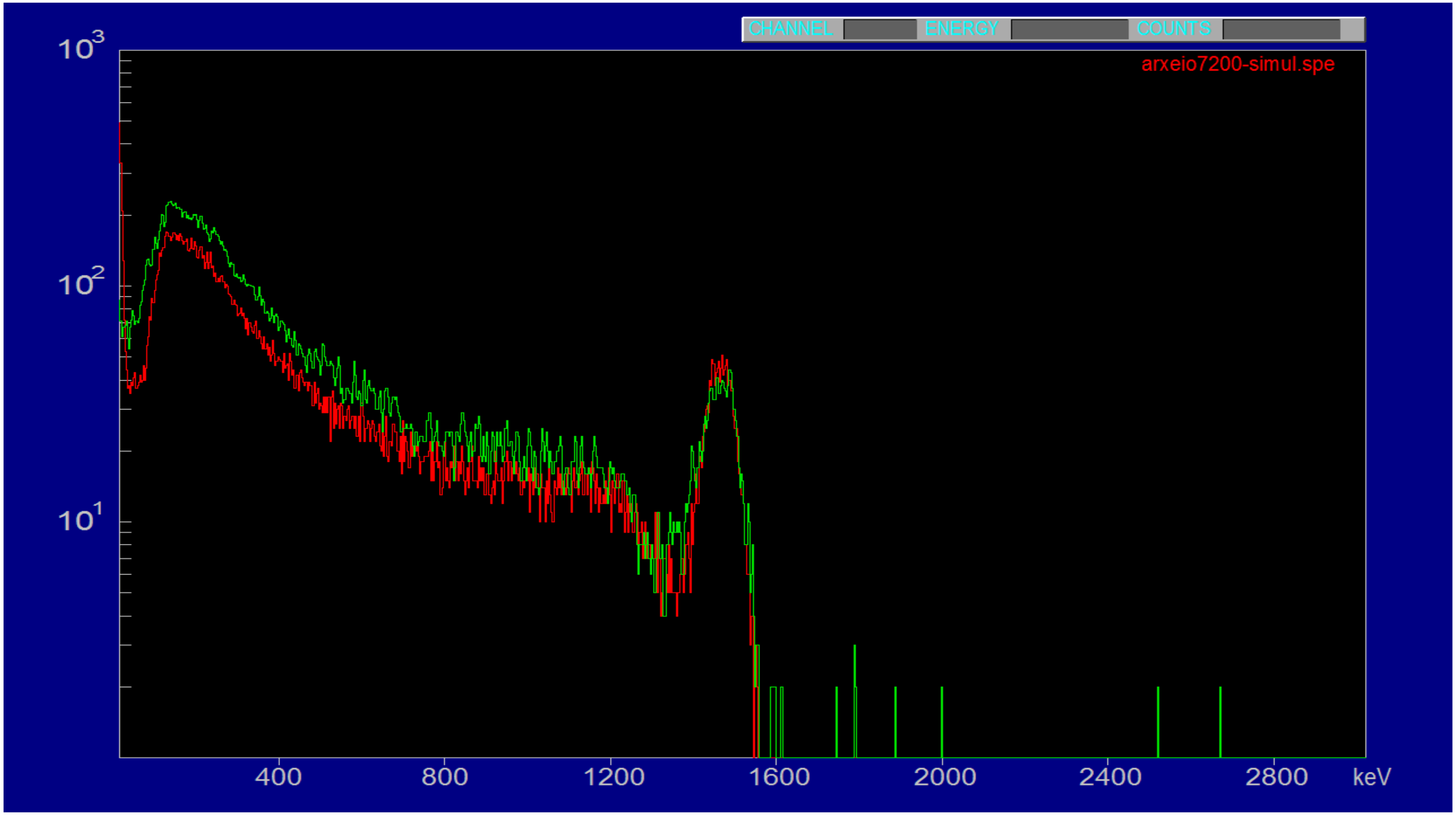
Background measurement, Depth: 2070 m

YELEDZHIK station

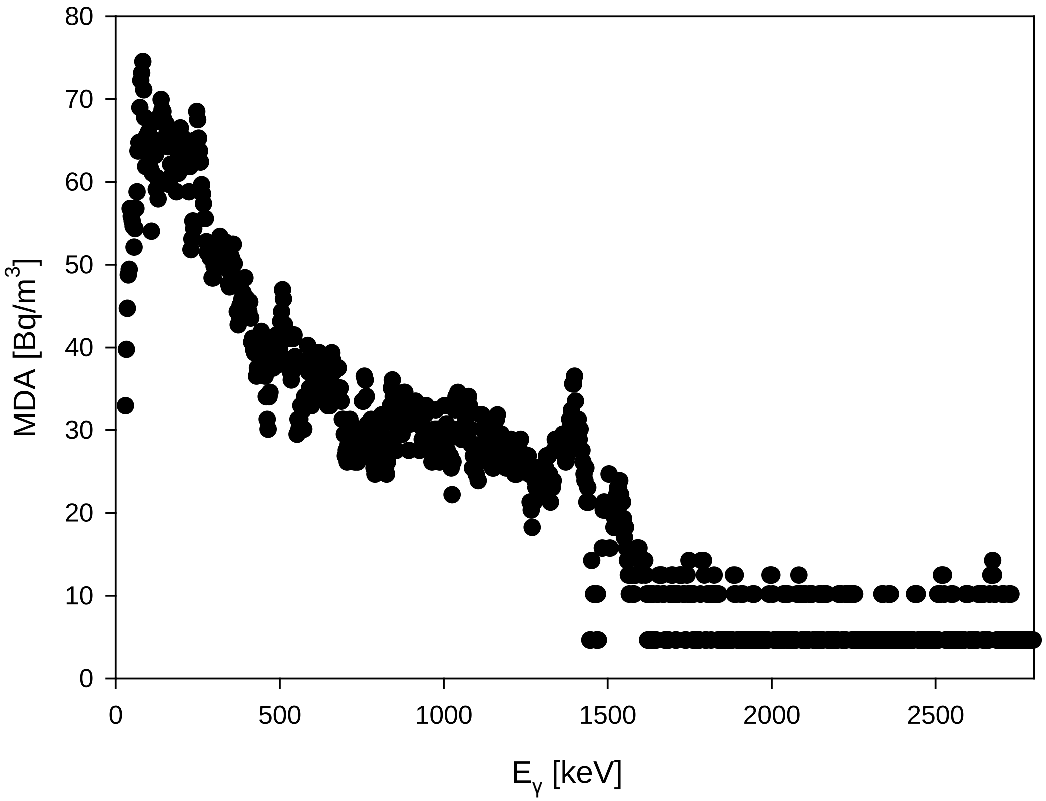
Gas emission of mud volcano, Depth : 1685m



γ-ray spectra (~ 2070 m) experimental & simulation



MDA calculation (after ^{40}K subtraction)



$$MDA = \frac{L_D}{e * V * I_g * T}$$

Conclusions

- Stainless Steel is a robust enclosure material for high pressures (> 450 atm).
- Deep sea is the optimum environment for radioactive gas monitoring at volcanic areas. A background γ spectrum is recorded for 2 hours at 2070 m depth.
- The MDA of the system is very low (~ 3 Bq/m^3 for thoron progenies, ~ 5 Bq/m^3 for radon progenies).
- The MDA of the system is drastically reduced for the low gamma-ray emitters after subtraction of ^{40}K contribution.

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