REWARD
Wide Area Radiation Surveillance with Semiconductor Detectors

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http://www.reward-p [illegible] eu/ [illegible] ortium.html

Introduction

- The REWARD idea
- Radiation detectors:

  Gamma and Neutron systems
- Status

The REWARD Partners: Industry

- XIE GmbH is a SME from Freiburg, Germany
- S&C is a SME from Barcelona, Spain
- Vitrociset is a large Italian Company
- Edisoft is a large Portuguese Company

The REWARD Partners: Academia

- CSIC is the Spanish Research Council of Scientific Investigations
- University in Freiburg, Germany
- ITN is the Portuguese Nuclear and Technological Institute in Lisbon

The REWARD Partners: End Users

- Civil Protection of the Region of Campania, Italy

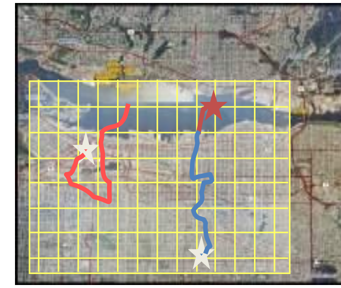
  (We also work with the Rome Fire Brigade)

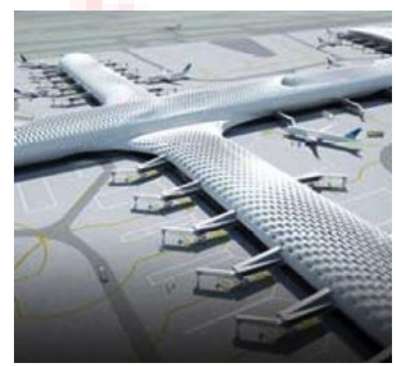
- Spanish Civil Protection from Catalunya

- Spanish “Guardia Civil” from Catalunya

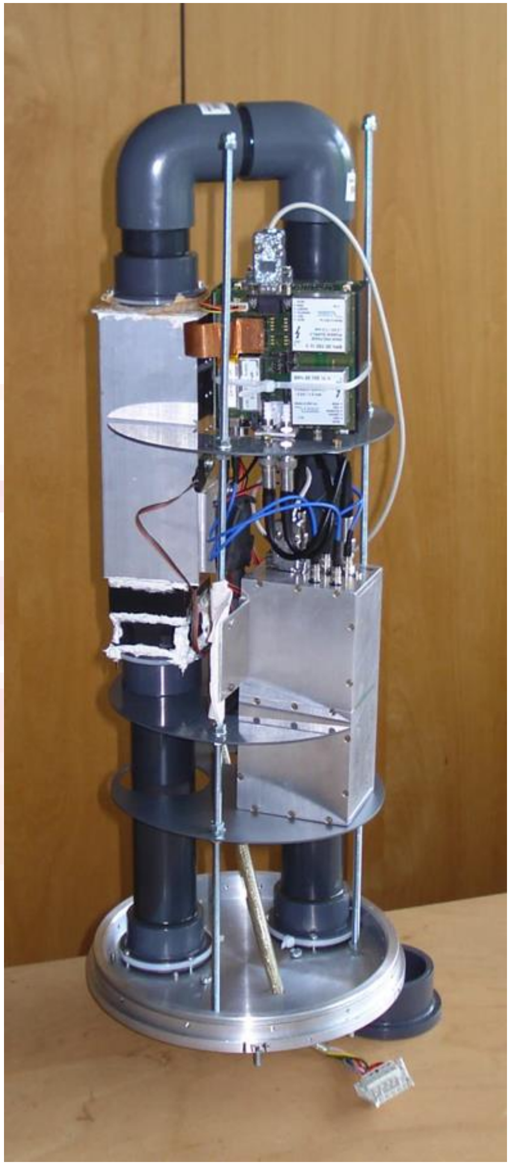
The REWARD Concept

- Radiation monitoring network: small autonomous mobile units mounted on cars
- Semiconductor sensors for gamma and neutron detection
- (Cd,Zn)Te (CZT) gamma sensor for precise energy measurement (isotope ID)
- Si detector with converter for thermal neutrons
- Geolocation from GPS receiver
- Secure communications unit
  - Choice of TETRA, GSM (UMTS, …)
- Data get send to and processed in Central Control Room in real time
- Goals: Obtain radiation map (background mapping), discover potential radioactive threats

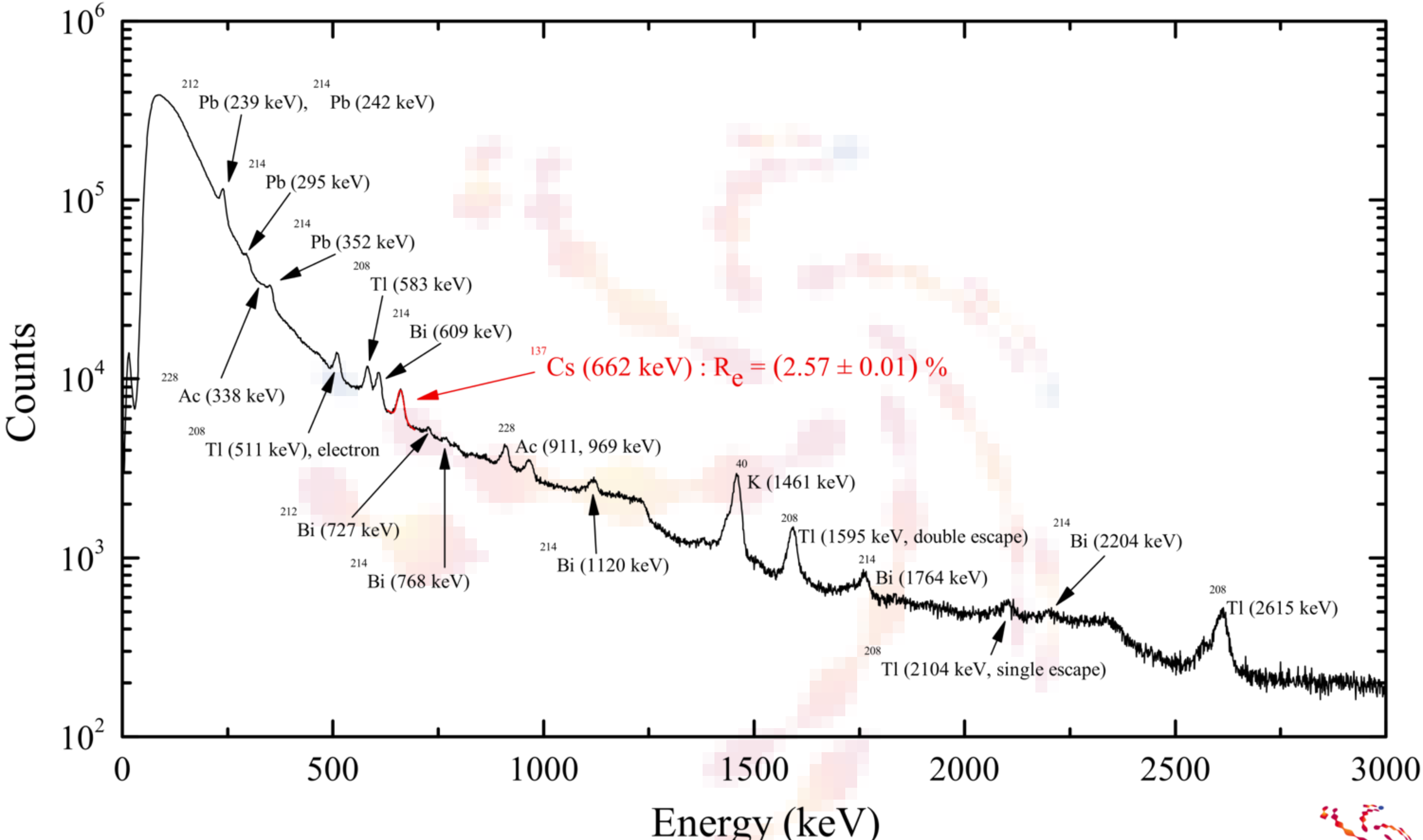




- Decade of CZT expertise in Freiburg Materials Research Centre (FMF) and spin-off company X-Ray Imaging Europe (XIE)
- CZT System designed for autonomous long-term gamma spectroscopy
- Joint Project with Federal Ministry of Radiation Protection (German "*BFS*")
- BFS operates a nationwide network of radiation monitors
- CZT Unit placed on top of Black Forest Mountain near Freiburg
- Successful data taking for many months

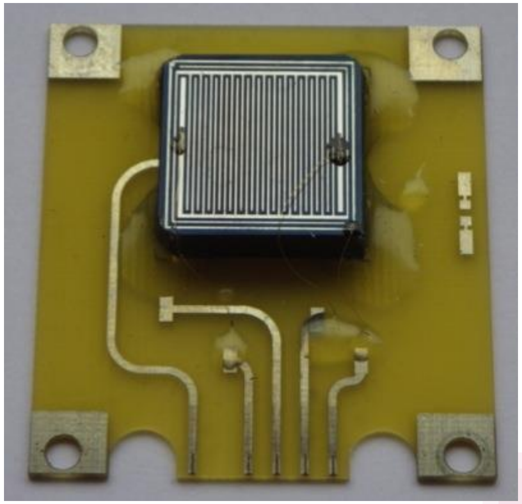


Long-Term Spectrum from BFS CZT Prototype

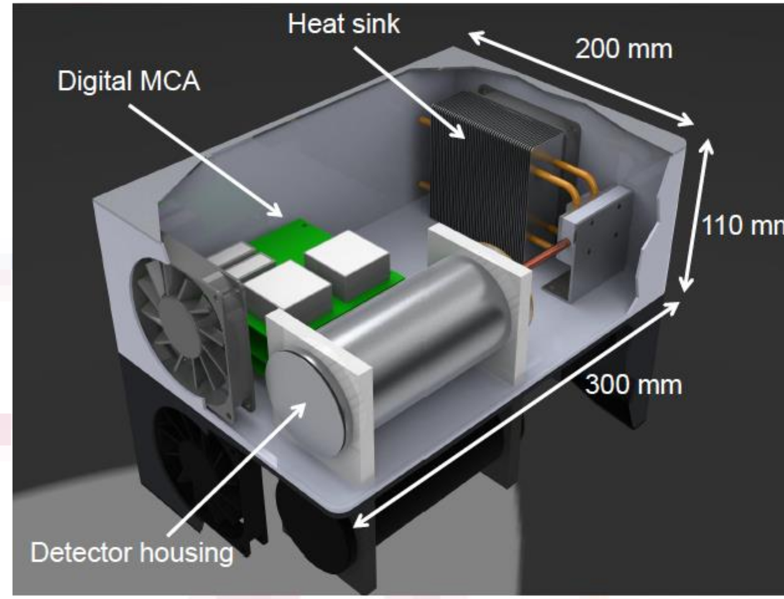


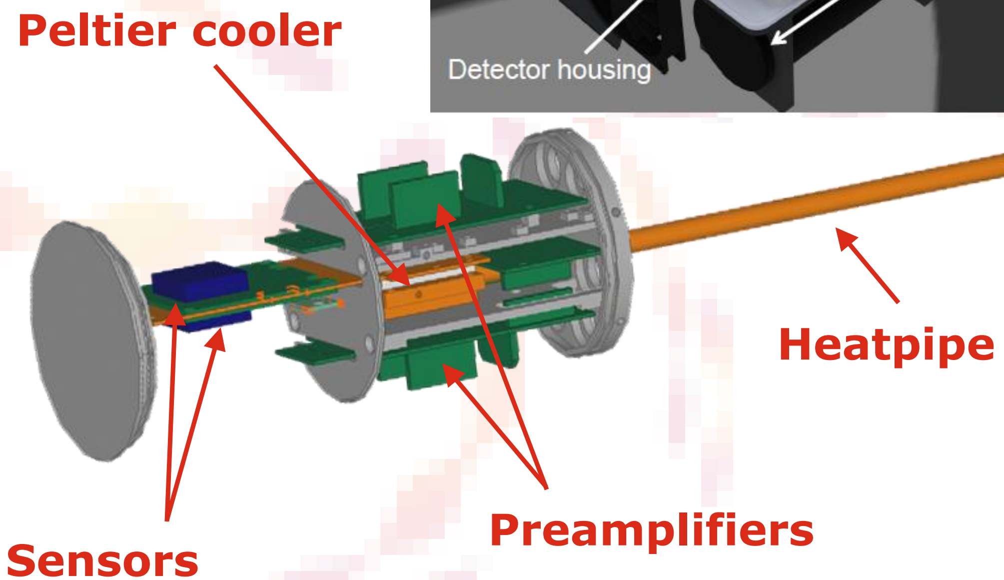
Initial Prototype Gamma Detector System

The core:
Coplanar Grid detector



- (Cd,Zn)Te sensor on PCB biasing board
- Similar to BFS system
- Coplanar Grid anode structure (removal of hole current contribution)

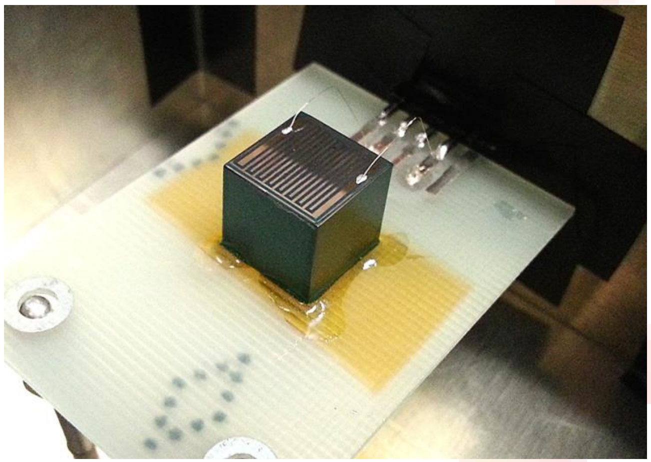




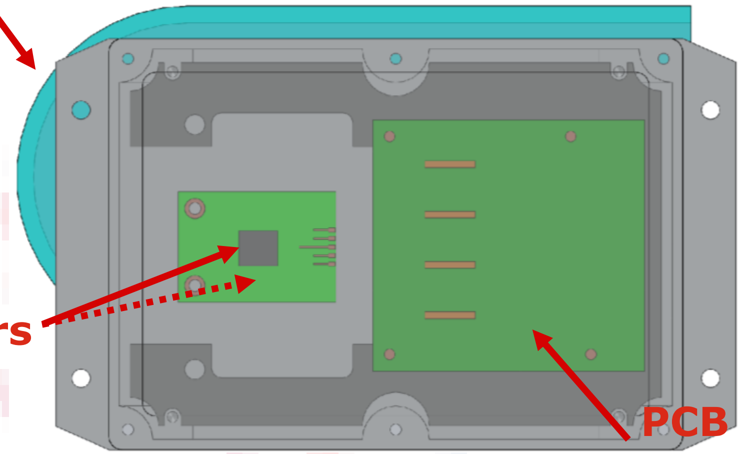
- Two (Cd,Zn)Te sensors (19 x 19 x 5 mm^3) in coincidence
- FE Read Out Electronics (shielded) and cooling nearby

2nd Prototype: Gamma Detection System

Coplanar GRID detector

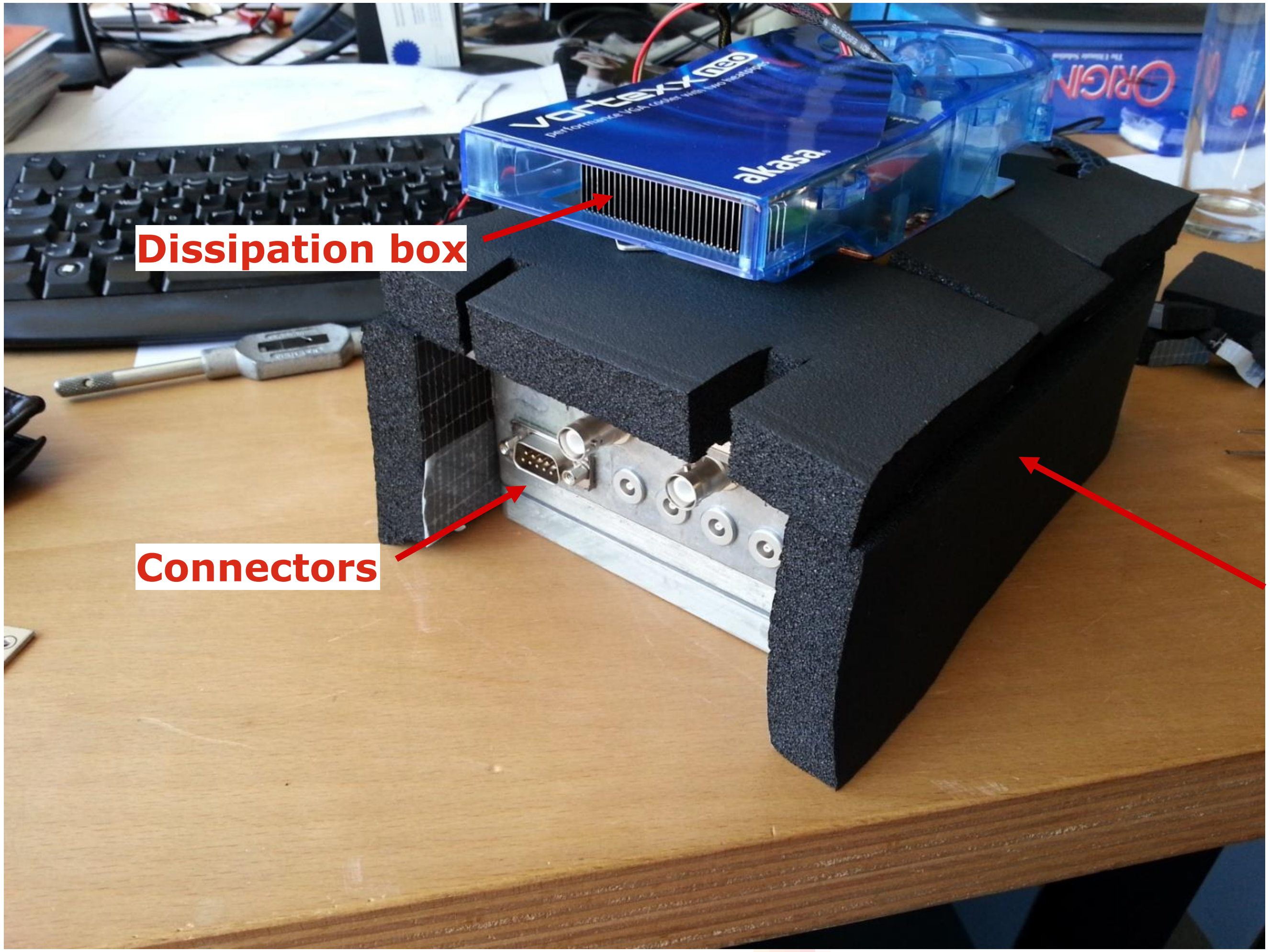


Picture of one (Cd,Zn)Te sensor on the PCB biasing board

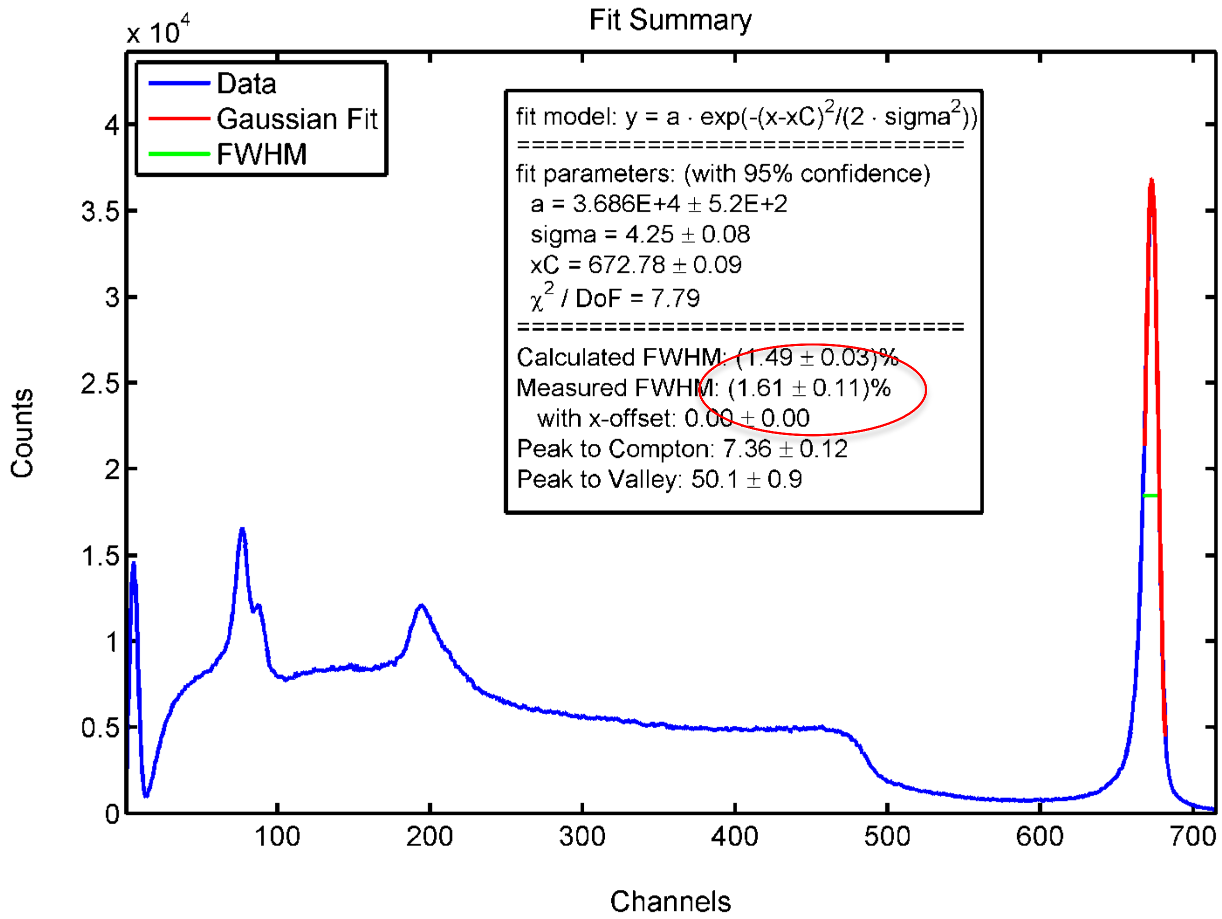


- 2x (Cd,Zn)Te sensors **(10 x 10 x 10 mm)** in coincidence
- MCA up to 4 MeV (1 keV energy binning)
- Temperature stabilization: 20˚C with Peltier cooling
- Ideal biasing voltages have to be determined for each detector
- One prototype built, currently testing

2nd Prototype: Gamma Detection System



Cs-137 Energy Spectrum, measured with a 1 cm³ CZT CPG at Room Temperature



Energy resolution:
1.6%

Implementation of the Gamma Detector in Geant4

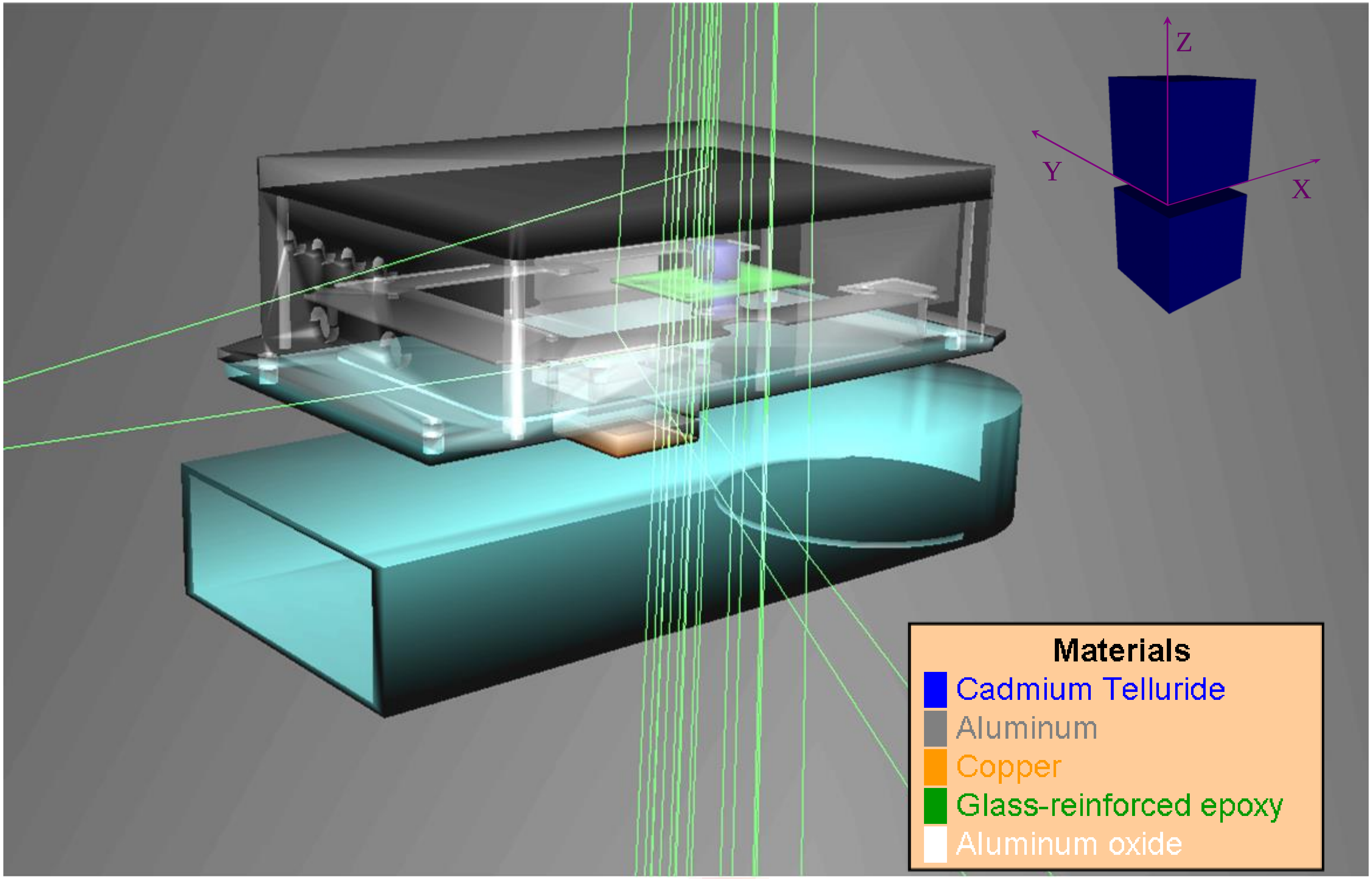
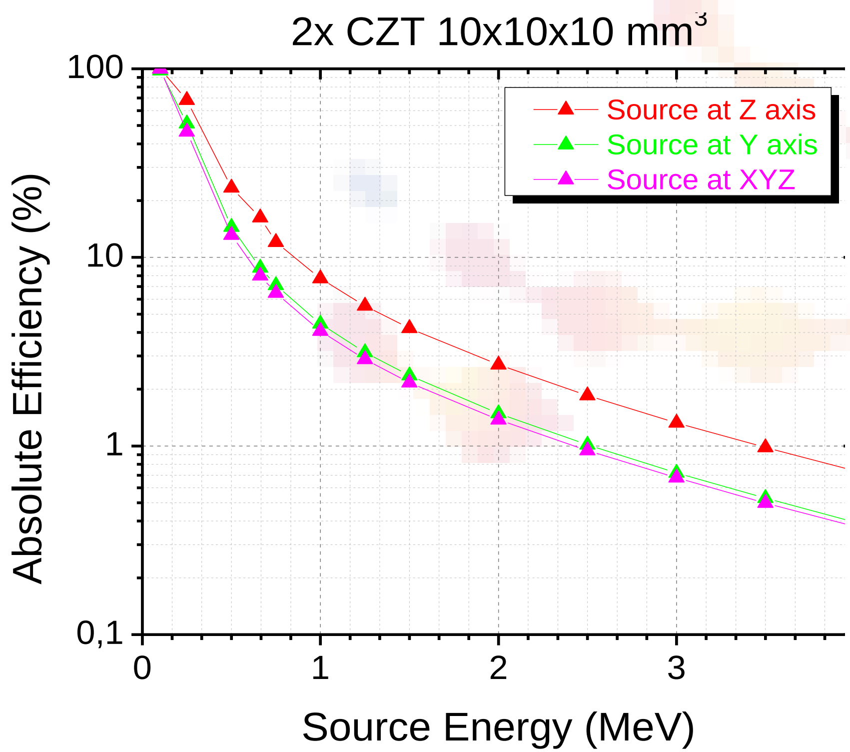
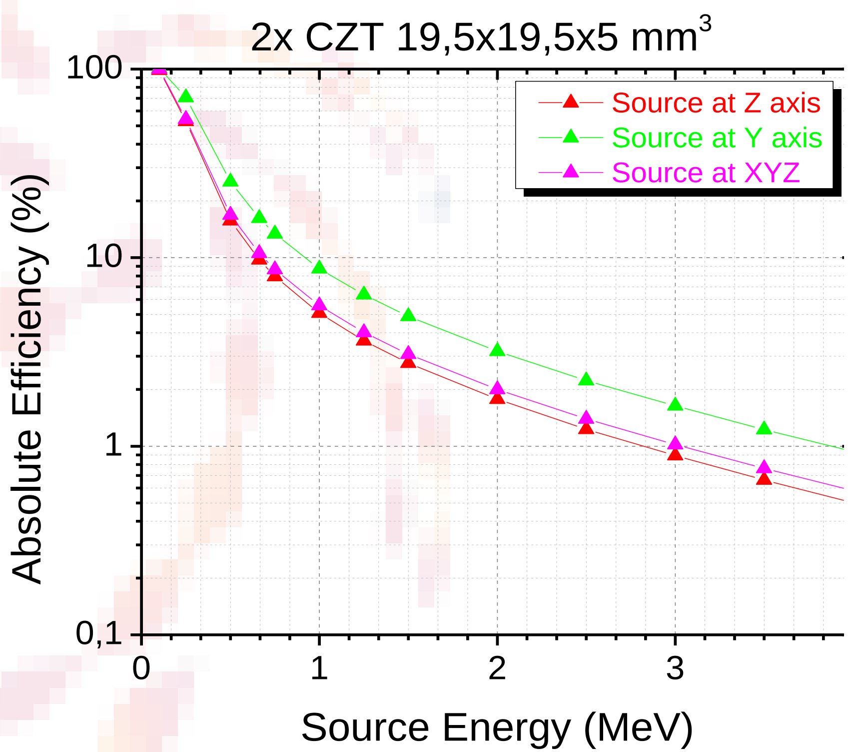


Photo Peak Detection Efficiency

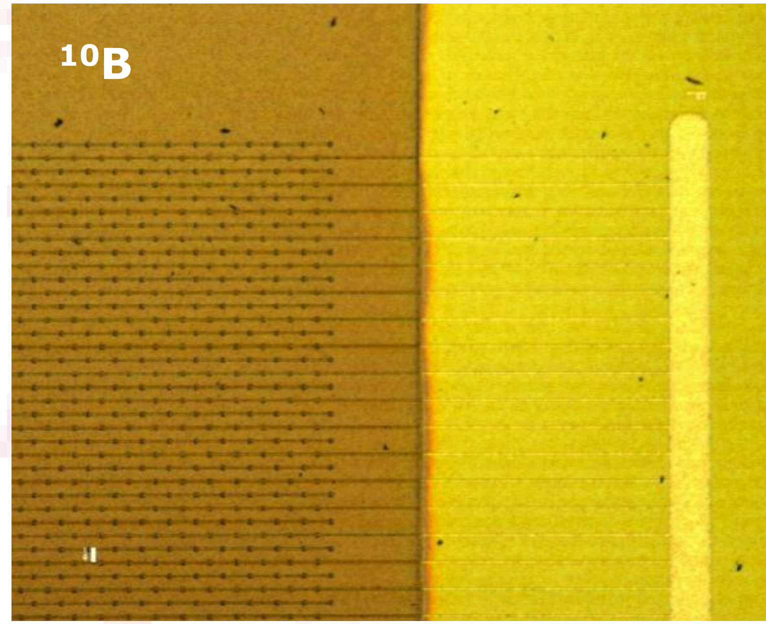
Determination of photo peak detection efficiency for two CZT sensors working in coincidence for different incident angles of mono-energetic gamma rays



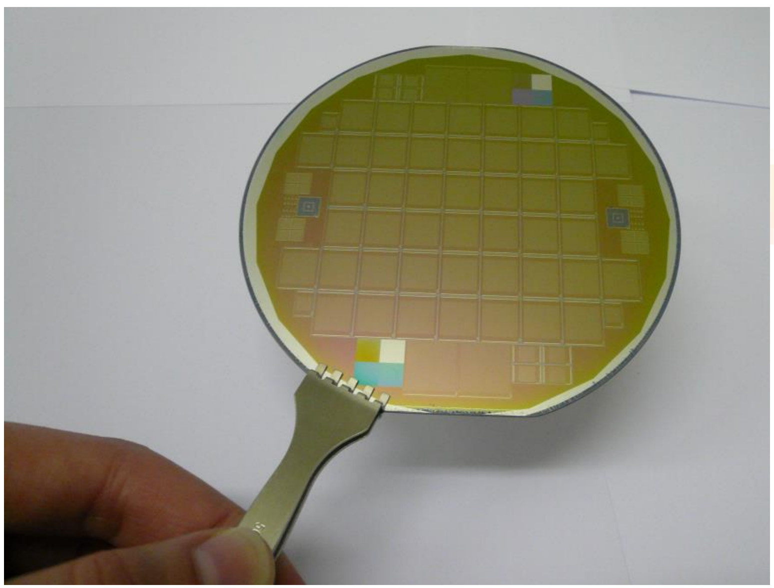


Neutron Detector System (CNM Barcelona)

- Neutron detection based on thin silicon sensor and ^{10}B converter layer for slow neutrons
- Reduced thickness to reduce gamma rates
- Si sensor in novel 3D-type layout to increase area and hence efficiency

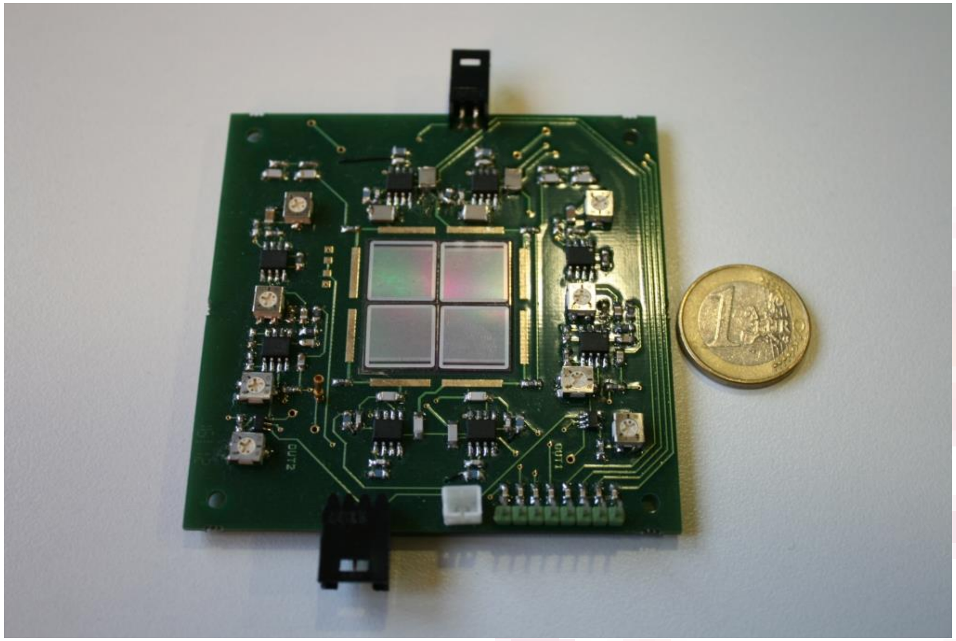


Prototype sensor with ^{10}B layer



Silicon wafer with sensors at CNM

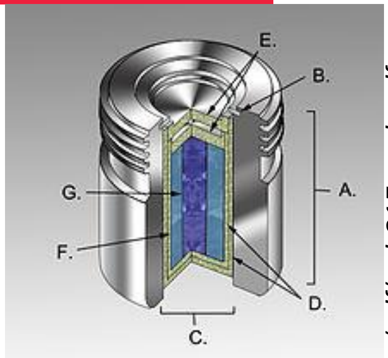
Neutron Detector System (CNM Barcelona)



- Neutron detector board with 4 silicon sensors and electronic components
- Several boards used simultaneously to increase efficiency

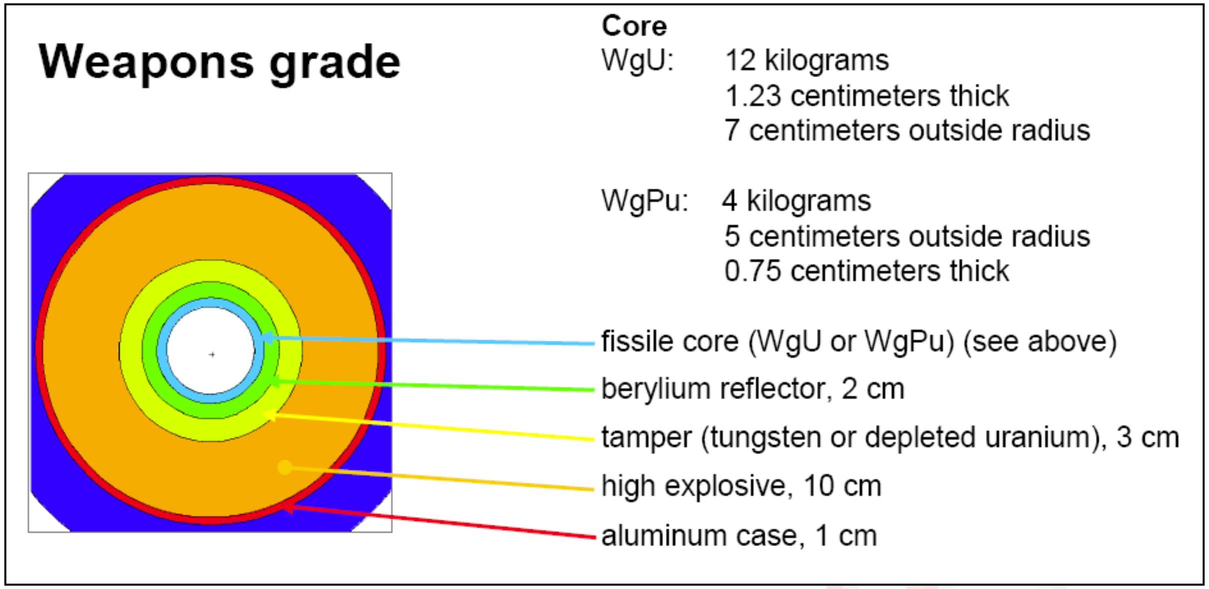
- First prototype of neutron detector module
- 4 boards (no sensors mounted)
- Central PE block serves as moderator to increase rate of slow neutrons

- **„Goiania Incident“ used as one reference scenario**
- Radiotherapy ^{137}Cs source stolen from abandoned hospital in Brazil 1987
- Opened, handled and ^{137}Cs powder touched by several people (who were unaware of any risks)
- Nuclear hazard recognised as such after 16 days
- 4 fast deaths, 249 people significantly contaminated, enormous clean-up operation
- Goiania Model source: 5.1 x 10^{13} Bq of ^{137}Cs behind a shield of Pb, Cu, W, steel



Images from IAEA Report *www-pub.iaea.org/mtcd/publications/pdf/pub815_web.pdf*

Reference Test Case: Nuclear Warhead

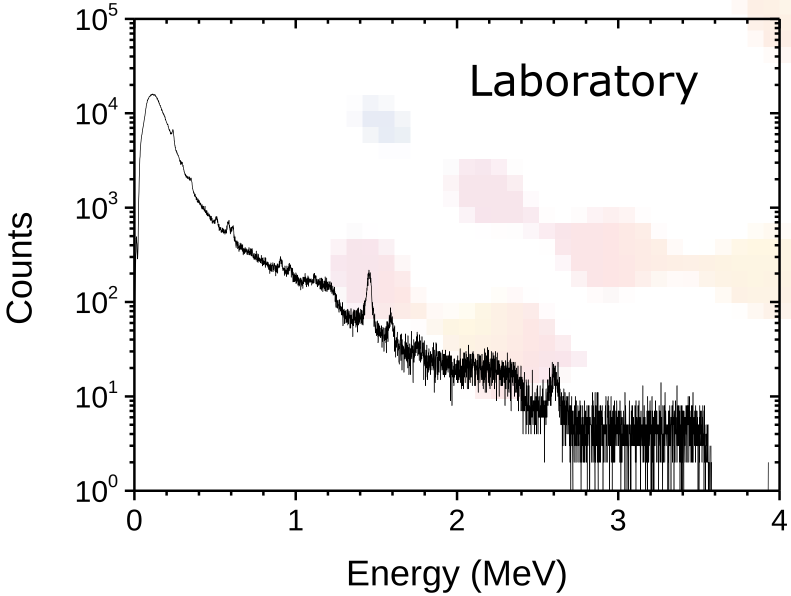


- **Nuclear Warhead scenarios from non-classified sources**
  - Fetter, S. et al. “Detecting Nuclear Warheads”. Science & Global Security, 1990, Volume 1, pp.225-302.
- Based on typical weapons grade Uranium or Plutonium cores
- Surrounded by tamper and shielding

Background Experimental Measurements

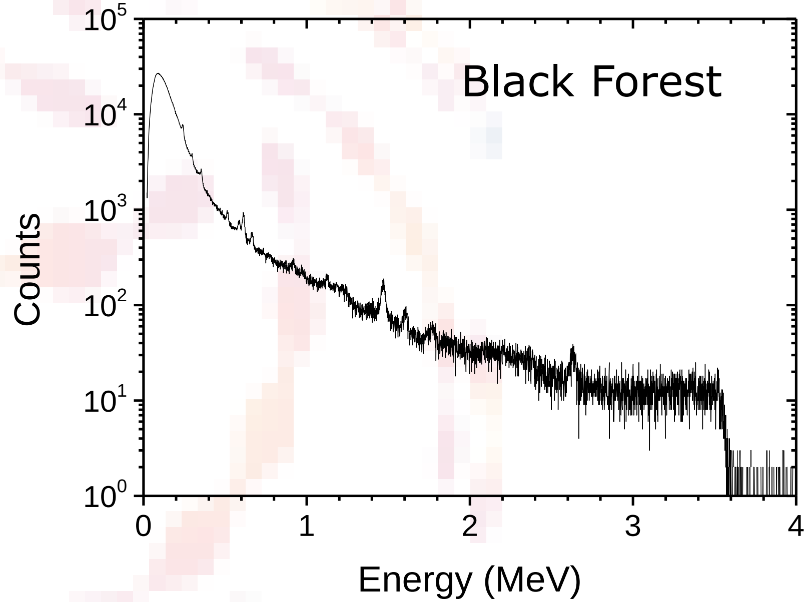
Spectrum (Lab conditions)

Measuring time: 140 hours



Spectrum from the Black Forest

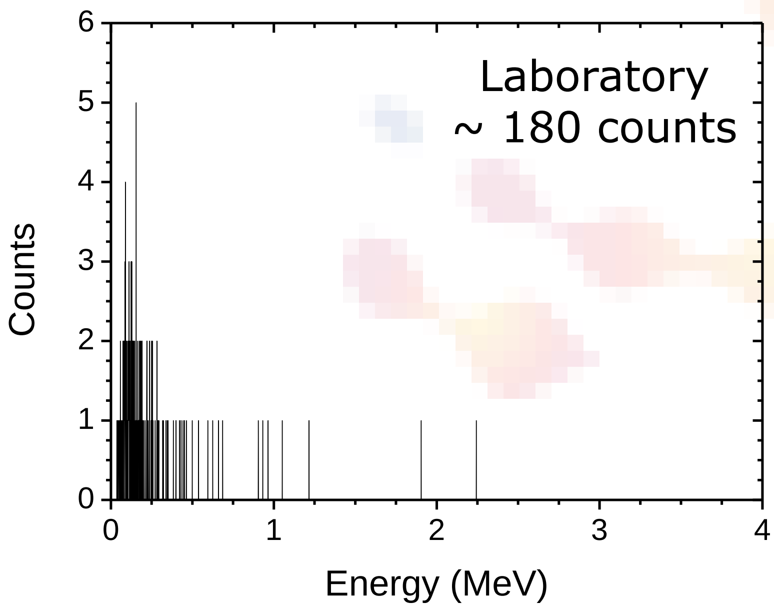
Measuring time: 196 hours



Background Experimental Measurements

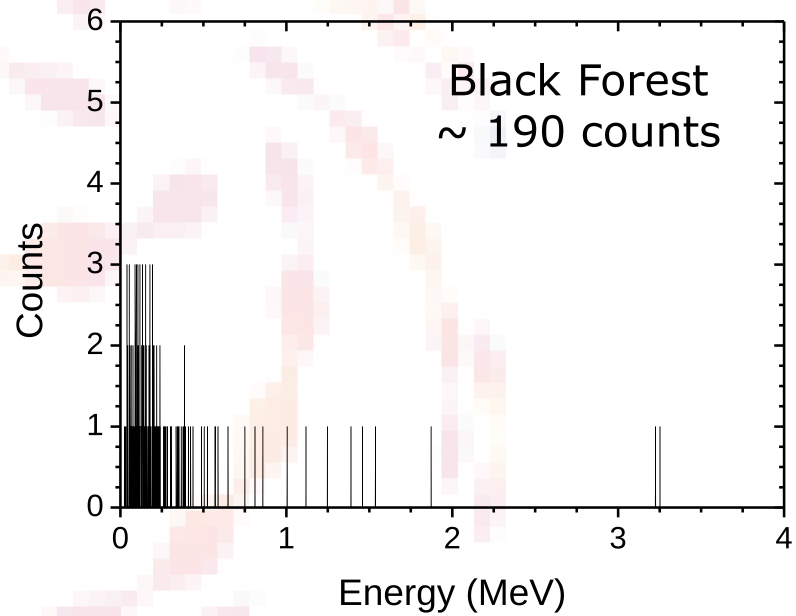
Spectrum (Lab conditions)

Sampling time: 30 seconds

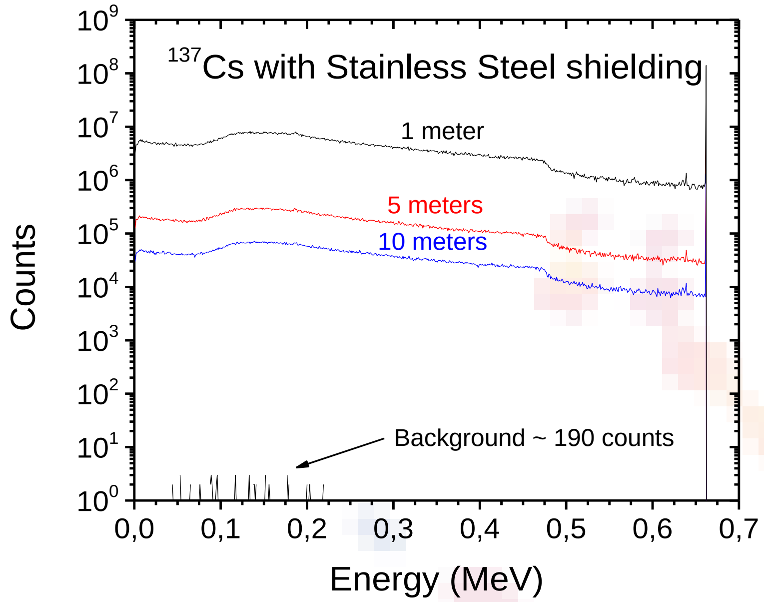


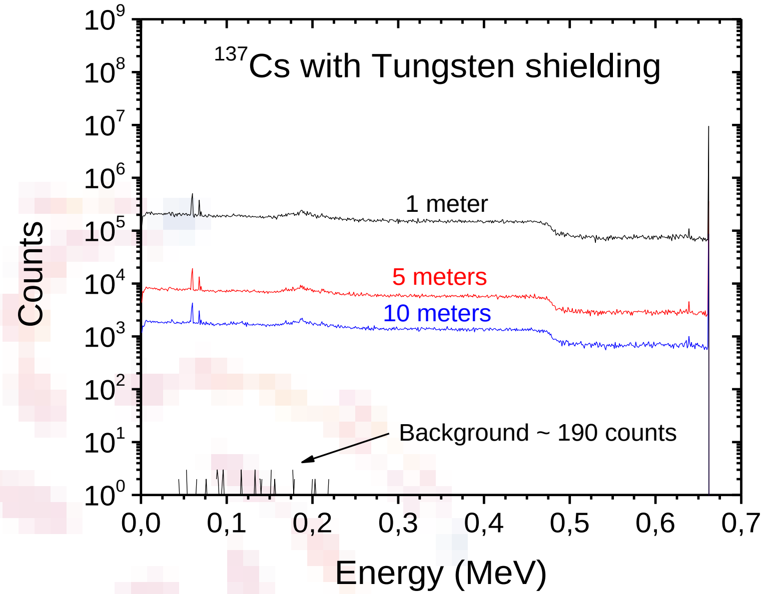
Spectrum from the Black Forest

Sampling time: 30 seconds



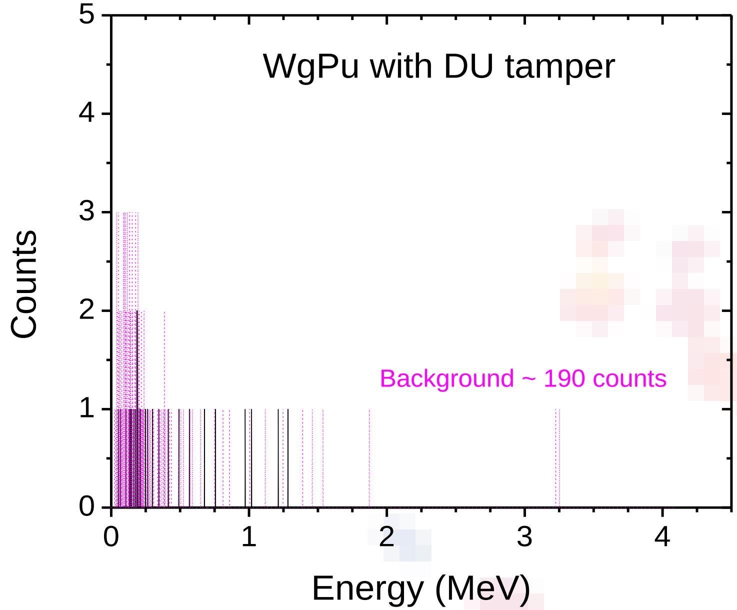
Expected System Performance: ^{137}Cs

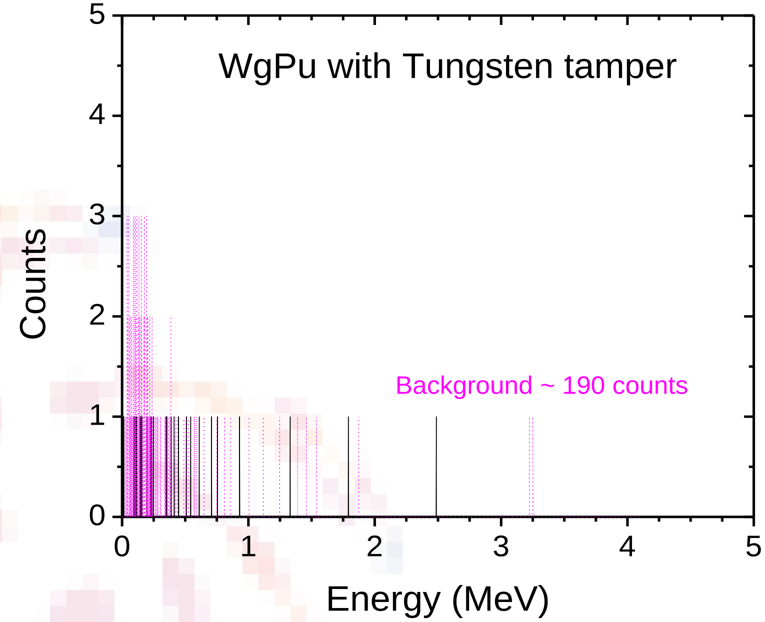




- Simulated spectra for Goiania type scenario
- CZT System 1 (5, 10) m away from source, running for 30s
- Can very easily see signal and discriminate against background, and identify the ^{137}Cs from the 662keV line

Expected System Performance: Nuclear Warhead





- Simulated spectra for weapons grade Plutonium scenario
- CZT System 1 m away from source, running for 30s
- Difficult to see signal above background
- Situation even worse for weapons grade Uranium

Conclusions & Outlook

- Novel silicon sensors, (Cd,Zn)Te CPG sensors plus IT and communication technology fused to create radiation detection and monitoring network
- First prototype put together this summer
- Commercialisation possible (and desired!)
- System well suited to e.g. Goainia scenario.
- Nuclear warheads more difficult to detect - would need extra info from neutron system
- Many other use feasible case:
    - Monitoring after Fukushima-type incident
    - Background mapping

Advertisement: Freiburg is looking to recruit

- PhD student to work on Si detectors (ATLAS Tracker Upgrade)

Contact Ulrich.Parzefall@cern.ch for details and/or informal enquiries