Diamond detector for a portable α-particle spectrometer

$\succ$ 1^{st} ADAMAS workshop $\prec$

GSI Darmstadt, 16^{th}-18^{st}-December-2012

Jose Dueñas[1], Alejandro Martín[2] & Julián de la Torre[2]

Dpto. Física Aplicada Universidad de [1]Huelva & [2]Extremadura

Universidad de Huelva

Outline

1. Motivation.
   - Identification of alpha-particle emitting nuclides.
   - A portable alpha spectrometer
2. Diamonds for Nuclear Spectroscopy.
   - Thin sample of 50μm.
   - Energy resolution.
3. Continuous Air Monitoring Detector form CANBERRA
   - Si detector with special entrance window.
   - Designed for working in harsh environment.
4. Comparison between detectors
   - Working in air
   - and with incident light.

Motivation

The need

- Illegal transport of radioactive material is becoming a problem.
- Rapid methods to identify possible radioactive materials are needed.
- Rather difficult to achieve for alpha particle due to its short range.

What's in the market

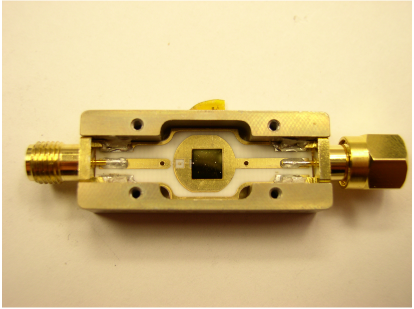
- No-portable stations, auxiliary equipment, some need a NIM crate.
- Main manufactures: ORTEC & CANBERRA.
- Quite costly piece of equipment.

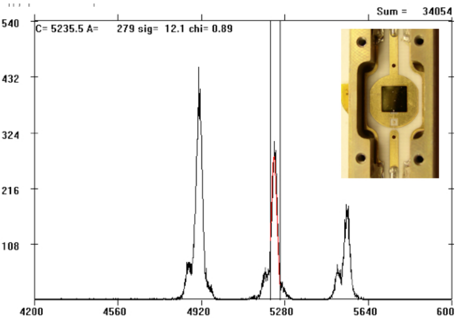
Requirements

- Relatively small dimensions and weight.
- Able to work in air and with light background.
- Low energy consumption.

Single crystal Diamond Detector (Sc-DD)

Sc-DD 50 μm properties



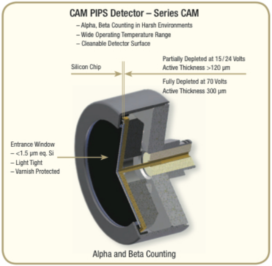


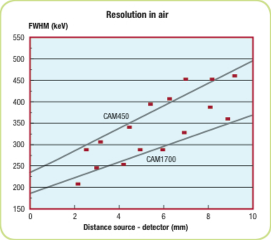
- ▷**Type**: Single crystal ▷**Thickness**: 50 μm ▷**Size**: $4.5mm \times 4.5mm$
- ▷**Contact**: DLC/Pt/Al (3/16/200 nm) ▷**Capacitance**: 24 pF (GSI)
- **Energy resolution** 29 keV (at GSI) for 50 V bias.
- Manufactured by Diamond Detector LTD (2011)

Continuous Air Monitoring Detector form CANBERRA

CAM properties

MODEL		CAM450
Active Area (mm²)		450
Junction Area (mm²)*		531
Active Diameter (mm)		23.9
Thickness (min/max)		120/325 µm
Bias (min/max)		+10/90 V
Bias (typical)		+24/70 V
Si-Resistivity (min)		3000 Ohm • cm
Operation Temp. (min/max)		-30/+50 °C
Storage Temp. (max)		+100 °C
Alpha Resolution at 15-24 V (FWHM – in keV)	in vacuum	38
Alpha Resolution at 70 V (FWHM – in keV)	in vacuum	34
Alpha Background (counts/day)		
Beta Resolution at 70 V (FWHM)		17
Beta Threshold at 70 V		51

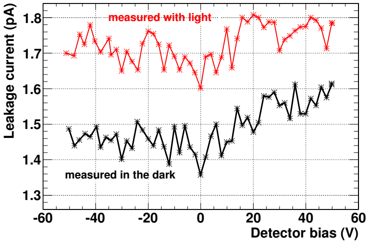




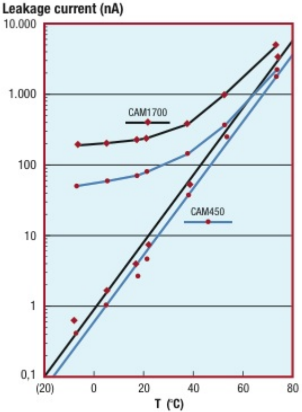
Leakage current with incident light

Sc-DD Leakage current measurement

- Measurements with light on/off.
- at 20 °C and 55 % RH.
- Keithly 6517B Electrometer.
- Light has minimum effect on leakage current.

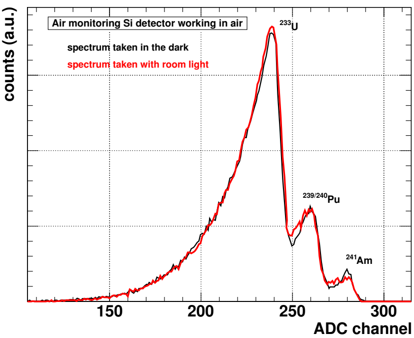


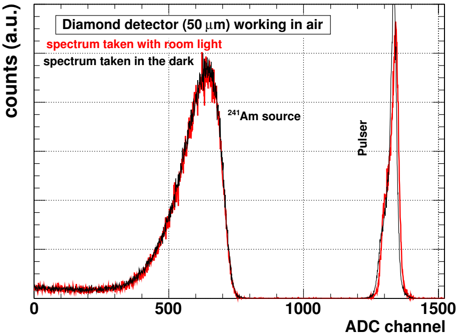
- CAM specs from Canberra.



Energy resolution in air

Exposing detectors to room light





- Spectra taken at Extremadura (left) and Huelva (right) Universities.
- α-source distance 1 cm. Bias: 24 V (CAM), 50 V (Sc-DD).
- Both detectors are able to detect the alpha emissions in air.

Energy resolution in air

CAM vs Sc-DD

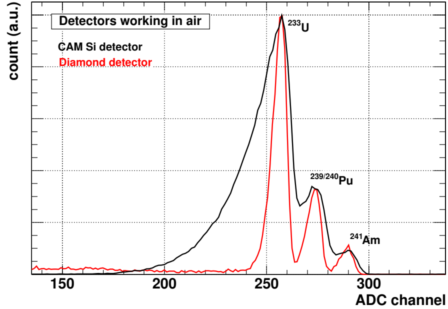


Table: Energy resolution (keV).

	CAM	Sc-DD
Vacuum	130	70
Air	299	120

- Both detectors plugged in to the same electronic chain.
- Total exposure time 10 minutes.

Conclusion & future work

Conclusions

- Thin diamond detector can definitely be used for α & β ID.
- Don't need special entrance window (work in open air with light).
- Harsh environments are not an issue.
- Main drawback may be the size, which will affect the absolute efficiency (greater area gets more hits).

Future work

- Increase the size using a "good" thin Pc-DD (Ø 25 mm).
- Design a proper housing for this application.
- Integrate the electronics as much as possible.