

Symposium at Tsinghua University:

Application of Germanium detector in

Fundamental research

Highlights of Germanium Detector technology

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Specialty Detectors & Dedicated Solutions
March 25th.2011

"What the Specialty Detector development and Manufacturing Team can offer to demanding Scientist World Wide"



Agenda

- A little bit of history : major breakthroughs in Germanium detector technology
- Germanium detector technology and innovations
 - The material
 - Innovating larger efficiencies
 - The diode process
 - Introducing new features with segmentation and new passivations
 - The cryostat
 - New packaging with Encapsulation
 - Ultra low background materials
 - Low noise electronics
 - · Propriatary input stages and Fets
- Large efficiency setups
 - Clovers
 - Encapsulation
- Our contribution to dark matter experiments
 - Point contact detectors
 - Segmented detectors



CANBERRA

START of the Company LASCO(Fr) and CANBERRA (US)

1968 Ge and Si detectors

ENERTEC SCHLUMBERGER

1974 Acquisition by Schlumberger

1978: first Hp(Ge)

1987: first point Contact &

Segmented detectors

1992: first new detector technologies:

1964: first Ge(Li)

encapsulation and Clovers

INTERTECHNIQUE

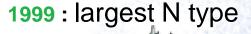
1987 Instrumentation and Nuclear Systems Dept

EURISYS MESURES

1993 set up by COGEMA

2001 CANBERRA EURISYS

new brand after the acquisition of Canberra by COGEMA-**AREVA**

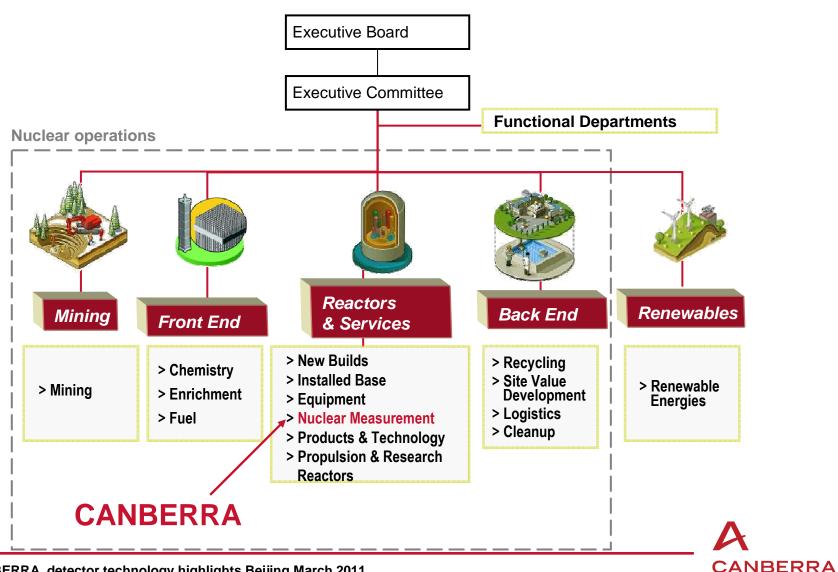




CANBERRA France

CANBERRA

CANBERRA, BU Nuclear Measurements in the AREVA Group



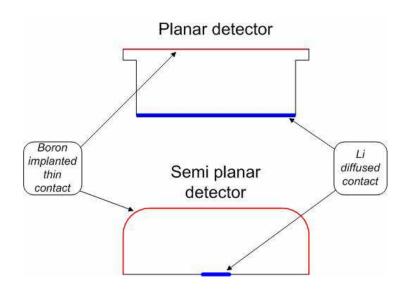
Agenda

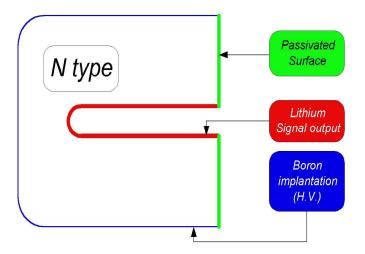
- ► A little bit of history : major breakthroughs in Germanium detector technology
- Germanium detector technology and innovations
 - The material
 - Innovating clovers
 - **♦** The diode process
 - segmentation
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- Our contribution to dark matter exp
 - Point contact
 - segmented



Germanium detector technology

▶ Principle









Germanium detector technology



Germanium material

- High purity :10 ¹⁰cm⁻³ impurities
- Excellent cristallography
- Need for Large volume

But:

- Hard and fragile
- Need for Violent Chemical etch
- Diffusion of impurities (Temperature)
- Operation at liquid Nitrogen temperature

Current sizes and challenges at CANBERRA

- ->P type :dia 100mm length 100
- ->N type : dia 80mm length 90/dia 70 length 140mm
- Germanium 76



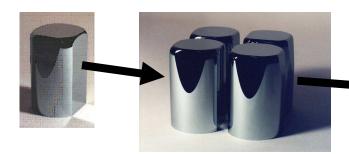




CANBERRA's Innovative Products: CLOVER Detectors: a solution to increase efficiency

► Highlights:

- Large Efficiency HPGe Arrays of N types detectors.
- CANBERRA Clovers for nuclear physics experiments (tracking) or large efficiency.
- More than 200 detectors delivered world wide.
- 4 crystals in one cryostat.
- With or without segmentation.
- Up to 12kg of HPGe material in one cryostat.
- LN2 free cooling available on request.





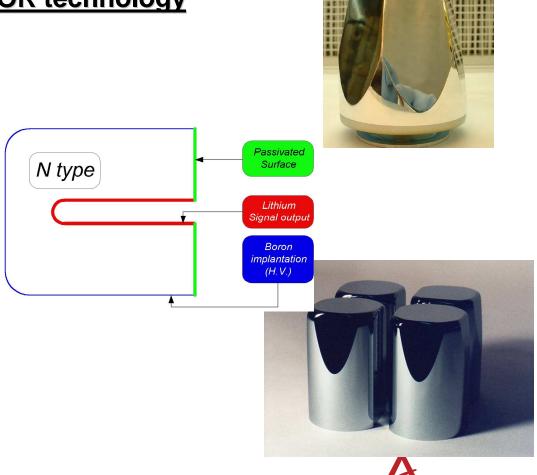


In each clover detector.



Germanium detector technology

- Process : SINGLE DETECTOR technology
- Machining and shaping
 - lapping sawing drilling
- N type contact :
 - Lithium diffusion
 - Thin window alternative
- P type contact :
 - Boron implantation
 - Thin window alternative
- PASSIVATION



CANBERRA

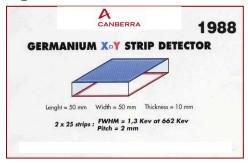
Germanium detector technology: segmentation a unique technology introduced 1987

BORON SEGMENTATION PROCESS

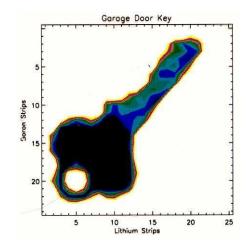
	STEPS:	
1 2	1. Lithium diffusion	
<u> </u>	2. Photoresist deposit	
	3. Photoresist exposure	
	4. Implantation	
	5. Resist removal	
	6. Aluminium deposit	
	7. Photoresist exposure	on
	8. Development of metallization	
	9. Passivation.	no grooves
Technology High lights:		no loss of material no dead zone reliability

CANBERRA's Innovative Products: segmented Detectors for position information

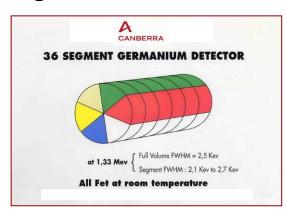
segmented Planar Ge detectors







segmented Coaxial Ge Detectors





Segmentation = innovative imaging or tracking features since 1987.

- Applications
 - Imaging
 - Compton camera
 - Doppler correction
 - Polarization measurement
 - Tracking





Clean room

- Environmental control
- Equipment characterization and performance follow up
- Equipment redundancy
- Material and critical component sourcing

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Process control

- Process description
- Skilled /hand made operations
- Surface characterization
- IS0 9001 quality management

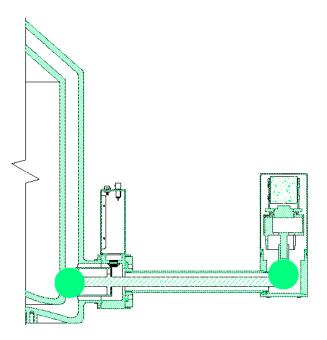
high yield and delivery control challenge



Germanium detector technology

Cryostats

- Operation at Liquid Nitrogen temperature
- Vacuum enclosure
- 1. with minimum absorption
- 2. With clean vacuum 10⁻⁶ mbar
- 3. With best temperature cycling performance
- 4. With best mechanical vibration decoupling
- 5. With lowest material contribution to spectrum background



high performance and reliability



CANBERRA HPGe Detector cryostats

Any cryostat is available LN2 or electrical cooled



SeGA- MSU



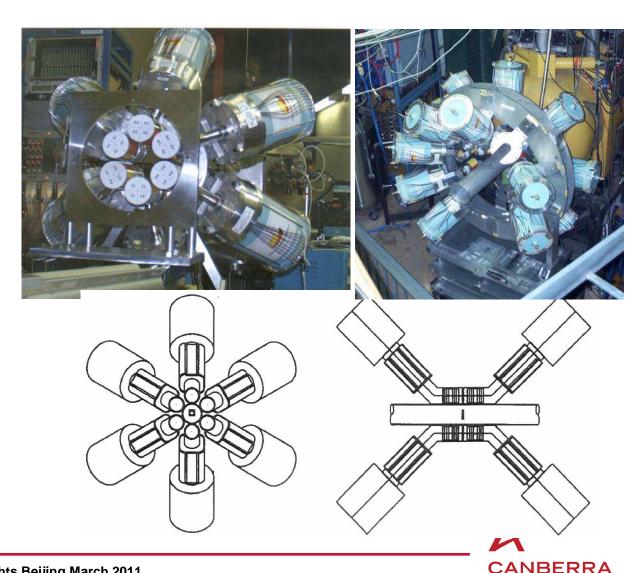
hammer2 X 70 X 90
With large BGO veto detector



CANBERRA's Segmented Coaxial HPGe Detectors

 SeGA detector cryostat: versatile configuration as a 4π gamma box and Doppler correction.





Germanium detector technology: cryostats



100% coax

► Alternatives to LN2 cooling

Cryogenerators: pulse tube cooler 10y

MTBF

UHV packaging





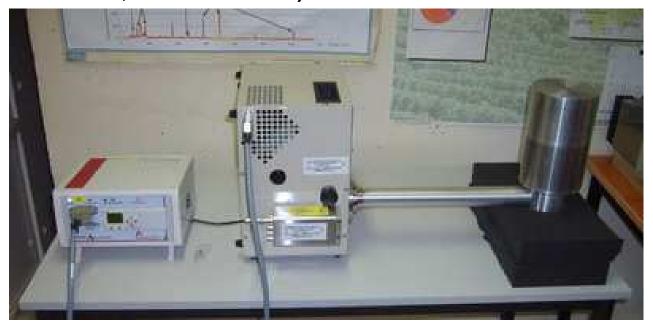


15% coax; pipe dia:3"



ULB detectors with ultimate ultra low background material specifications

- ► CANBERRA ULB BEGe detectors (CP5 cooler):
- ► Performances of a custom designed BEGe5030 detector
 - Less than 0.09 counts per min :10mn for 1 ct !
 (Measured at Modane Underground Lab, 4500mwe
 15-1500keV,850eV @ 122keV)





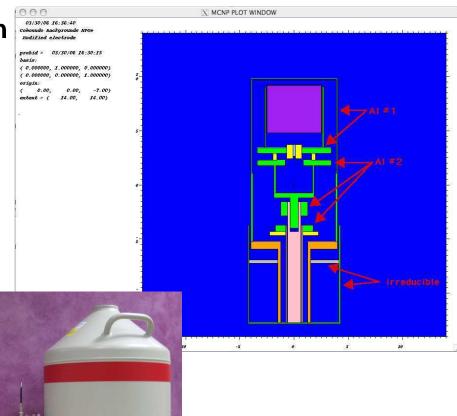
ULB detectors with ultimate specifications



► CANBERRA is collaborating with customers on theoretical responses:

 Collaboration with customers for detector characterization through MCNP or Geant4 modeling.

 Permanent search of new detector hardware for ultimate ULB performances as required for Underground Labs.



CANBERRA



CANBERRA's Encapsulated HPGe detectors: a unique vacuum enclosure

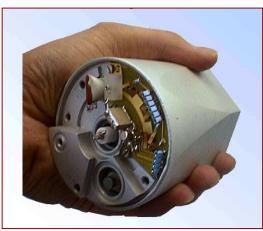
▶ Highlights:

- Reliability
- Easy mounting/exchange
- Compact assembly
- Wide range of shapes
- On-site annealing without pumping



- Nuclear Physics :
 - Euroball Cluster- Miniball Rising
 - Greta / Agata
- Space :
 - Integral (ESA)
 - Mars (NASA)
- Airborne
- Industrial: rough motion applications





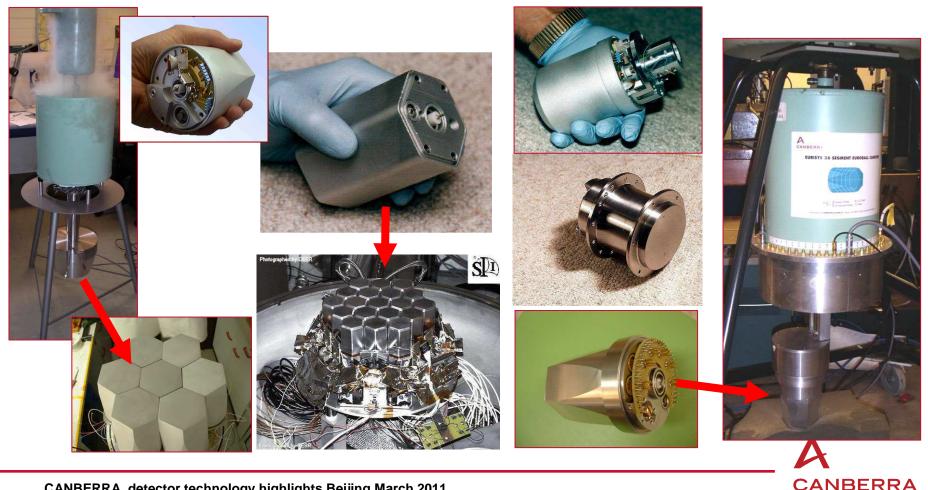
More than 290 capsules delivered in many countries

Encapsulation = only solution to address close packing arrays or rough motion application.



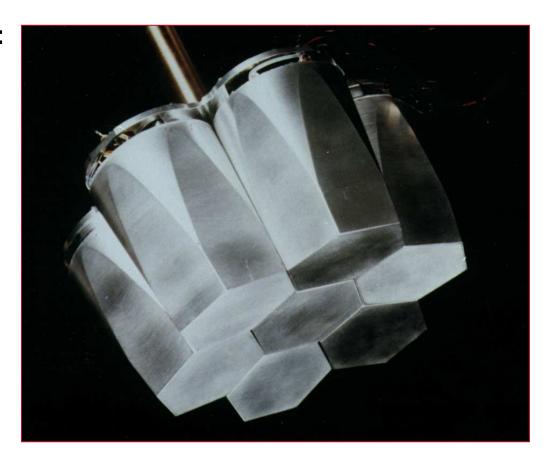
CANBERRA's Encapsulated HPGe detectors

▶ Different encapsulated HPGe detectors:



CANBERRA's Encapsulated HPGe detectors

- Euroball cluster detector: first 7 capsule array detector.
 - Unsegmented 300cc N type detectors.
 - Total efficiency at1.33MeV: 7x 55% x 1.4 =539%
 - More than 150 units delivered for EUROBALL and all STILL in operation.





CANBERRA's Innovative Products: Encapsulated Detectors

► Highlights :

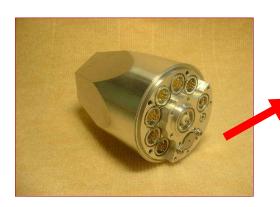
 Large Efficiency HPGe Arrays of encapsulated N types detectors for nuclear physic experiments (GRETA or AGATA among others).

Efficient solutions to build close 4 Pl arrays.

More than 250 deliveries world wide.

 Up to 4 segmented crystals in one cryostat with 148 channels.

Up to 10kg of HPGe material in one cryostat.





CANBERRA's Innovative Products: Rough Motion Detectors

► Highlights :

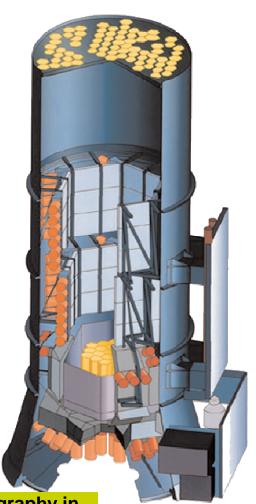
- CANBERRA detectors for space applications or airborne gear.
- Close efficient array solutions available.
- LN2 free cooling.
- Vibration specifications: up to 50G.

High reliability.





19 capsule telescope accurate for gamma cartography in galaxies (study of supernovae, black holes,...).

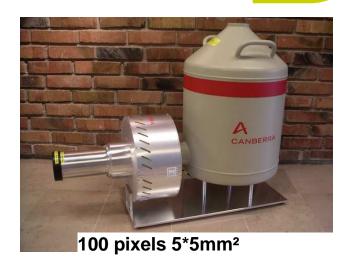


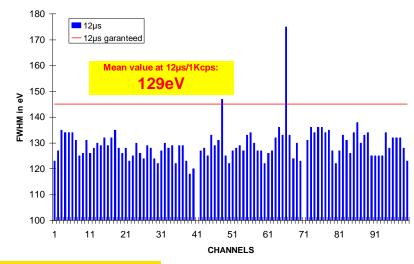
Germanium detector technology

Low noise electronics

- Selected FET
- Optimized temperature
- Grounding/RFI shielding
- Dense and compact cabling
- Add.considerations: Feedtroughs HV,ULB materials, density, temperature excursion

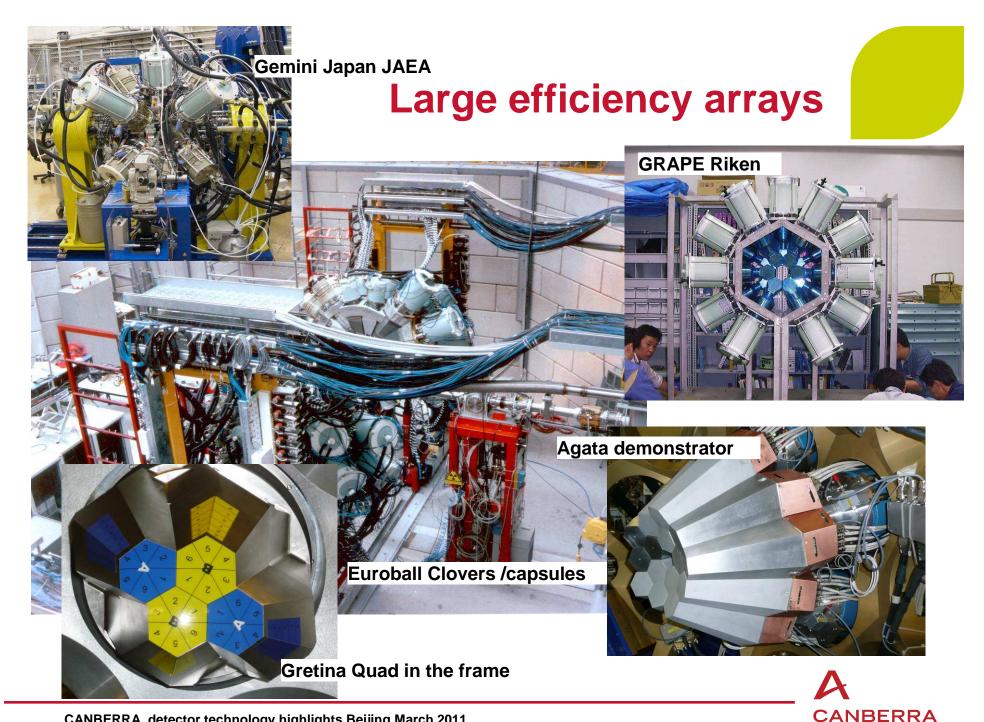






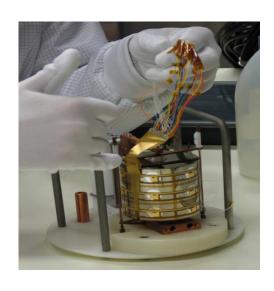




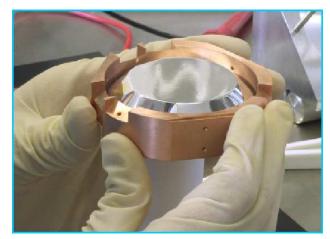


CANBERRA'S contribution to Dark matter search





Gerda 18
segments &Point
contacts
Cryostat less
operation



Edelweiss bolometer



Texono point contact detector

Heritage of mature technologies and huge expertise





- ► Major issues with Germanium detectors for Dark Matter experiments
 - Material selection / reduction : substrates ,components, cabling
 - Noise level: embedded Fets, ASICs?
 - Improved signal shapes for PSA: minimize distance
 - Volume
 - Other ideas?

Thank you

