



# **Radiation tests under controlled temperature and vacuum conditions: why and how**

**ALTER TECHNOLOGY TÜV NORD**  
**Innovation Department**

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# INDEX

- Why:
  - Motivation for radiation tests under controlled temperature
- How:
  - Liquid Nitrogen Proposed setup
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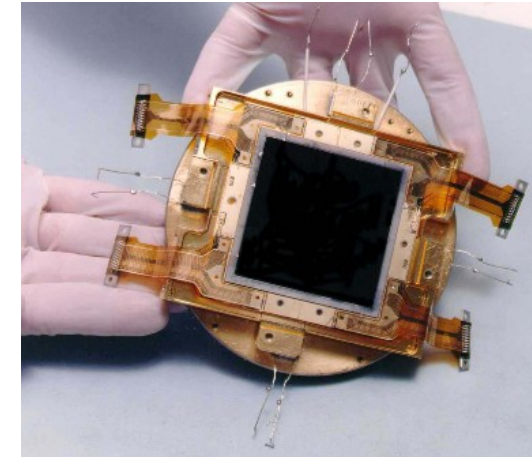
# Why Low Temperature Radiation

- Some future missions could lead to the necessity of low temperature electronics.
  - To save power that is used to keep electronics warm
  - Supporting electronics for cold sensors
- Annealing recovery is reduced at low operating temperatures
- Working environmental conditions. For example:
  - Detectors for space telescopes
  - Mars Temp: 140K aprox
  - Lunar South Pole Temp: 40K
  - Jupiter Moons. Ej. Titan:
    - Temp: 75K to 125K
    - 5Krad/month at 10cm depth

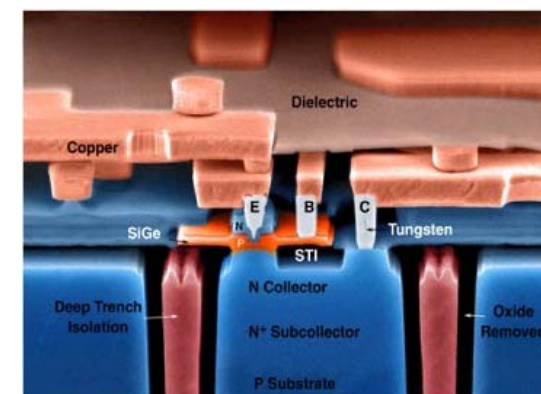


# Low Temperature Electronics

- Performance of standard electronics can be improved by cooling.
- Astronomy detectors and associated electronics.
- Si long channel FETs and p-MOSFETS for cryogenic temperature operation.
- SiGe HBT (Heterojunction Bipolar Transistors) have higher gain when the temperature drops. It can operate at very low temperature without heat.



E2v CCD Sensor



After Dr. John D. Cressler  
(Georgia Institute of Technology)

# Why Low Temperature Radiation



The screenshot shows the CESAR website with a blue and purple gradient header. The main content area features a grid of astronomical images and a list of publications. The left sidebar contains navigation links for Home, Project Overview, Consortium, Work Packages, Public Documents, and Relevant Links. The bottom of the page features the European Union flag and the text 'SEVENTH FRAMEWORK PROGRAMME'.

**CESAR**  
Cryogenic Electronics  
for Space Applications and Research

Home

Project Overview  
Elementary Components  
Complex Circuits  
Applications

Consortium  
CEA  
IMEC  
Konkoly Obs.  
CNRS  
UNIPA  
Imperial College

Work Packages  
WP1: Management  
WP2: Elementary Components Development  
WP3: Complex Circuits Development  
WP4: X-Ray microcalorimeter  
WP5: Infrared & Magnetometry  
WP6: Dissemination

Public Documents  
Document 1  
Document 2

Relevant Links  
Publications  
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SEVENTH FRAMEWORK PROGRAMME

CESAR: Cryogenic Electronics for Space Applications and Research

Observations from space provide real benefits in many scientific fields, like astrophysics. They allow to significantly improve the spectral information compared to ground-based observations.

To carry out these observations, many laboratories are developing new generation ultra-sensitive sensors. The space environment is a major challenge for the development of cryogenic electronics associated with these sensors.

The CESAR project explores new solutions in this area.

The CESAR project funded by the European Union is a collaborative project under the Seventh Framework Program (FP7).  
COORDINATOR : Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), France  
EU FP7 Contract no : 263455  
Duration : 36 months

LATEST CESAR PUBLICATIONS

- Q. Dong et al, "The role of the gate geometry for cryogenic HEMTs: towards an input voltage noise below 0.5 nV/Hz<sup>1/2</sup> at 1 kHz and 4.2K", J Low Temp Phys, 167, 626-631 (2012)
- Y.X. Liang et al, "Input noise voltage below 1 nV/Hz<sup>1/2</sup> at 1 kHz in the HEMTs at 4.2 K", J Low Temp Phys, 167, 632-637 (2012)
- Y. X. Liang et al, "Insight into low frequency noise induced by gate leakage current in AlGaAs/GaAs high electron mobility transistors at 4.2K", Appl. Phys. Lett. 99, 113505 (2011)

More ...

## ACTIVE RESEARCH FIELD

### CRYOGENIC ELECTRONICS FOR SPACE APPLICATIONS

Evaluation of Ge based FETs working at 4K.

Development of very low noise SiGe based bipolar transistors.

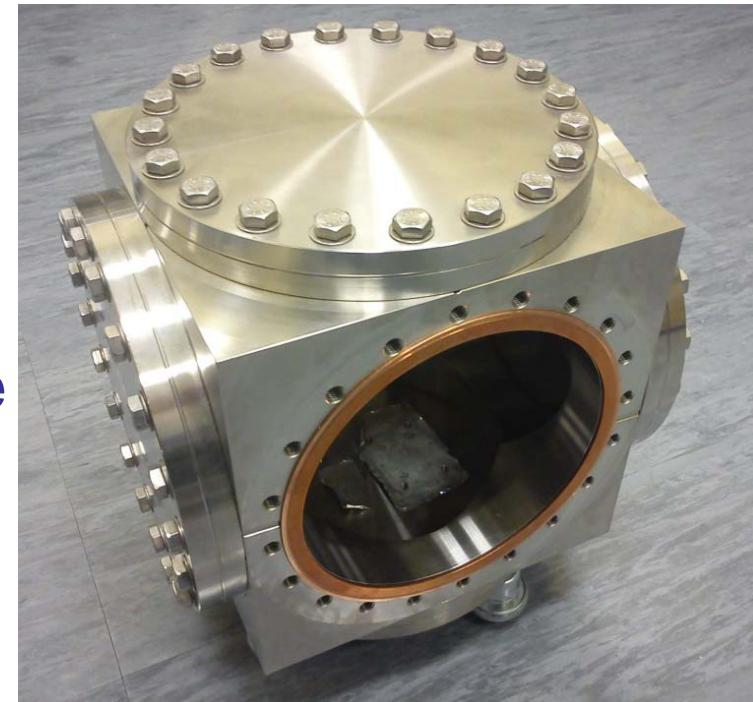
Development of AsGa HEMTs.

Radiation hardness



# Controlled Atmosphere

- Vacuum (Optionally)
  - Some sensors operate in vacuum
  - To prevent water condensation
- Metal sealing: wide temperature range and no outgassing
- Capability of simulation of other planetary atmospheres
  - Ej. Mars: 8mbar of CO<sub>2</sub>



Vacuum Chamber

## Proposed Setup for Radiation tests under controlled temperature and vacuum

Liquid  
Nitrogen  
Deposit

Turbo  
Pump  
System



Climatic  
Chamber

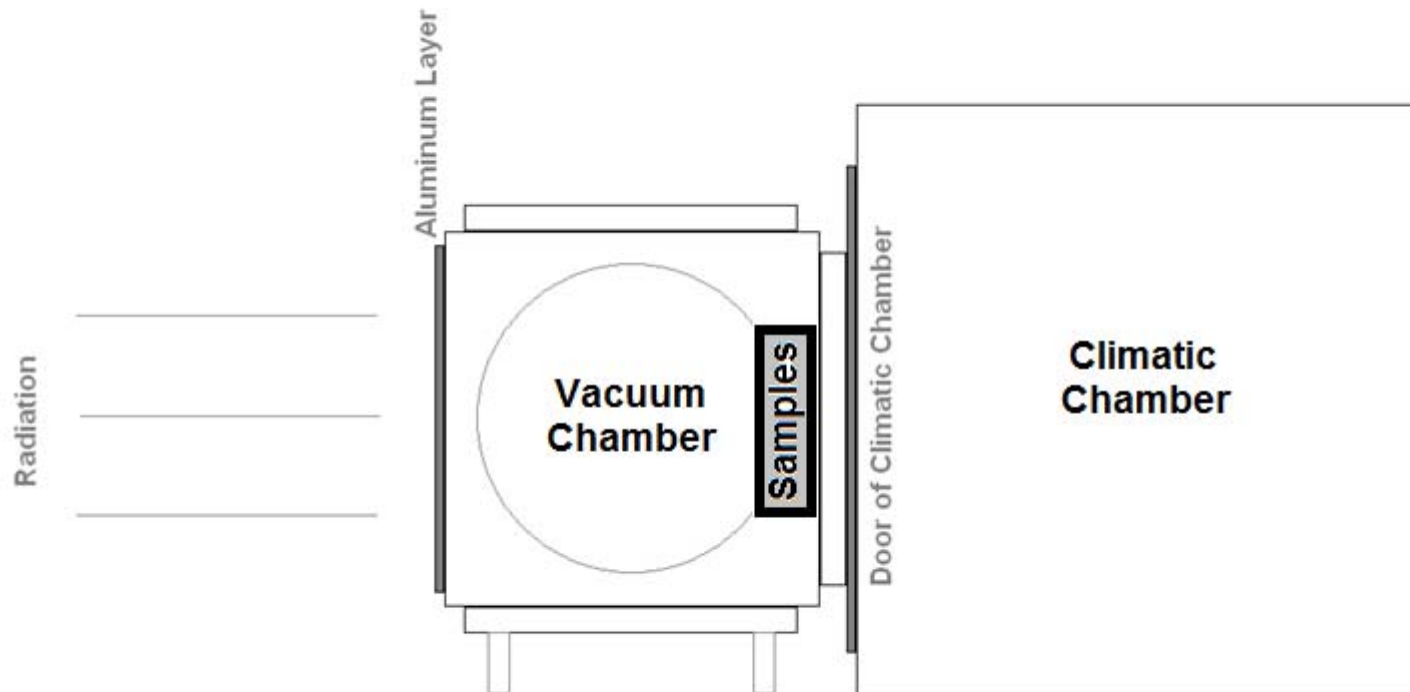
Radiation

Vacuum  
Chamber

Feed-  
throughs

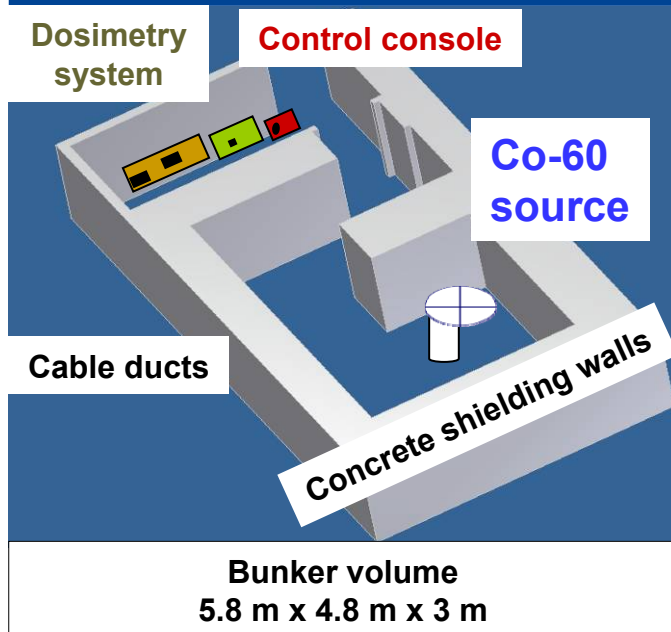
## Proposed Setup for Radiation tests under controlled temperature and vacuum

- Radiation cross the front tap (steel or aluminium)
- Temperature controlled on the samples with PID control loop and thermocouples in direct contact with the DUT.
- Feed-through for electrical, optical, thermocouples, etc.



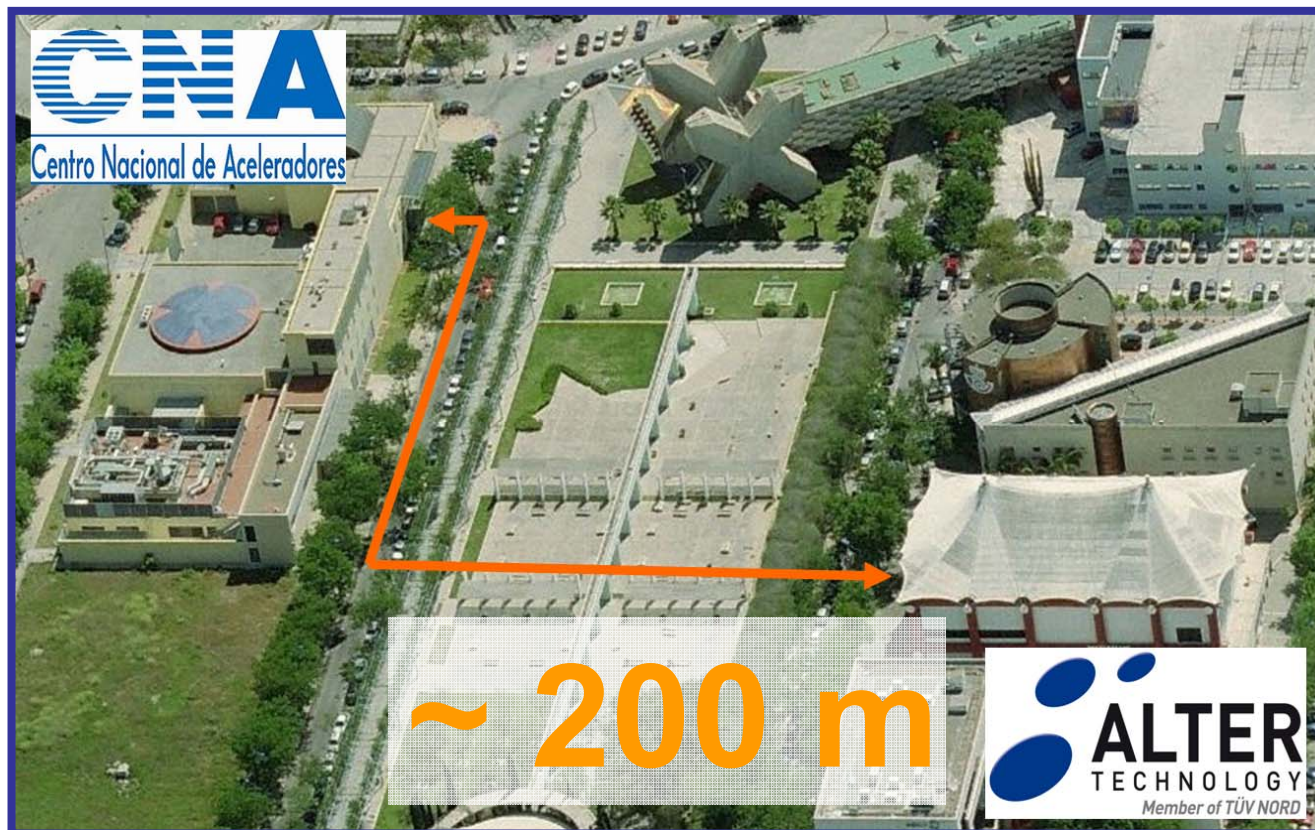


# RADLAB Facilities outline



1. Co60 nominal activity 444 TBq (12 kCi)
2. Range of dose rate :  
0.36 - 360 Gy/h // 36rad(Si)/h to  
36krad(Si)/hr.
3. Dose rate uncertainty  $\leq 10\%$
4. Maximum radiation field non-uniformity of  
10% in a wide surface
5. Gamma-ray dose rate calibrated to  $\leq 5\%$ .
6. Dosimetry traceable to international  
standards and patterns.
7. Environmental conditions (temperature,  
humidity) controlled and monitored.
8. Different field size and dose rate can be  
achieved by attenuation. i.e. 1 m of  
distance: 120 Gy/h (200 rad/min), min 5x5  
cm<sup>2</sup> and max 43x43 cm<sup>2</sup>

## RADLAB outline ALTER – CNA.



**Due to the short distance between both facilities, the tandem ALTER / CNA provides an ideal frame to offer a comprehensive radiation laboratory to characterize, validate and test all EEE component types under gamma radiation.**

The work presented is under the developments of an ALTER Internal Innovation Project that is not completed yet.

## **Already performed:**

- Temperature and Vacuum Setup
- Development of LabView PID loop program for the temperature control at the samples site
- Verification of the thermal stability in the samples area within the vacuum chamber
- Verification of feasibility at radiation facilities.

## **To be done:**

- Dosimeter analysis with the shielding of the front cover including uniformity characterization
- Actual Tests (foreseen for next months)

## Proposed Setup for Radiation tests under controlled temperature and vacuum

### FOR LOWER TEMPERATURES (under evaluation)

- Liquid Helium close loop cryostats
- Cavity big enough for components
- Temperatures down to some K or even less.
- Vacuum Feed-throughs for in-situ measurements



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# Conclusions

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- Some future missions will lead to the necessity of low temperature electronics.
- Some components have to work at low temperature to improve their performances (i.e. sensors).
- Annealing effects are reduced at low operating temperatures.
- No real knowledge of possible influence of actual operating conditions on radiation degradation.
- ALTER TECHNOLOGY is prepared to perform radiation test at temperatures down to liquid nitrogen (-190°C) and up to more than 200°C and is studying the setups needed for lower temperature testing.



**THANK YOU FOR YOUR ATTENTION**



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