Centro Nacional de Aceleradores

Irradiation facilities at CNA for aerospace applications

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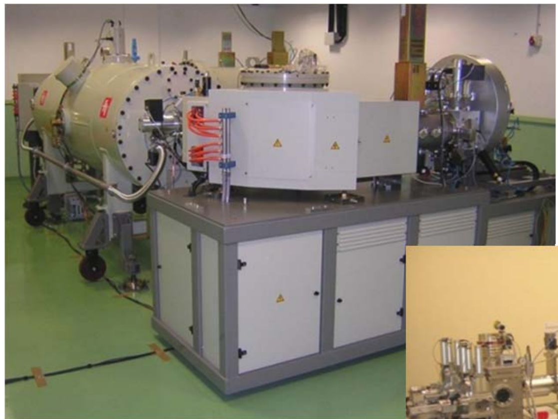
CNA – MAIN EQUIPMENTS

Spanish ICTS (singular scientific and technological infraestructure) Interdisciplinary research

3 MV Tandem accelerator

18/9 Cyclotron accelerator

Co-60 Gamma-irradiator



1 MV Tandem AMS

MICADAS

PET / CT SCANNERS

Radiopharmacy

Accelerated tests / Irradiation tests

Space and other hostile environments

- **The nature of the radiation, energy, flux and fluence of the beam determine the type of test, which in turn will depend on the structure, design and use of the device**

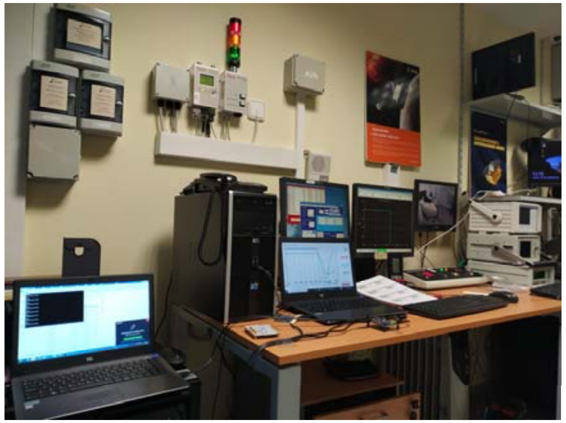
- The parameters used in the tests will be determined by the flight conditions and service of the spacecraft or equipment (usually 10-30 years exposure real-time)

- Radiation effects important to consider for instrument and spacecraft design fall roughly into three categories: degradation from Total Ionizing Dose (TID), degradation from Total Non Ionizing Dose (TNID), or Displacement Damage Dose (DDD), and Single Event Effects (SEE).

Irradiation capabilities at the CNA

PHOTONS

Low E-IONS & NEUTRONS



RadLab Gamma irradiation tests with Co-60

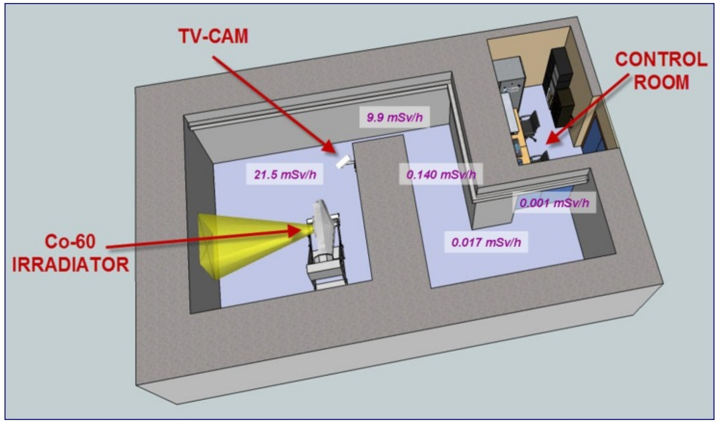
RadLab

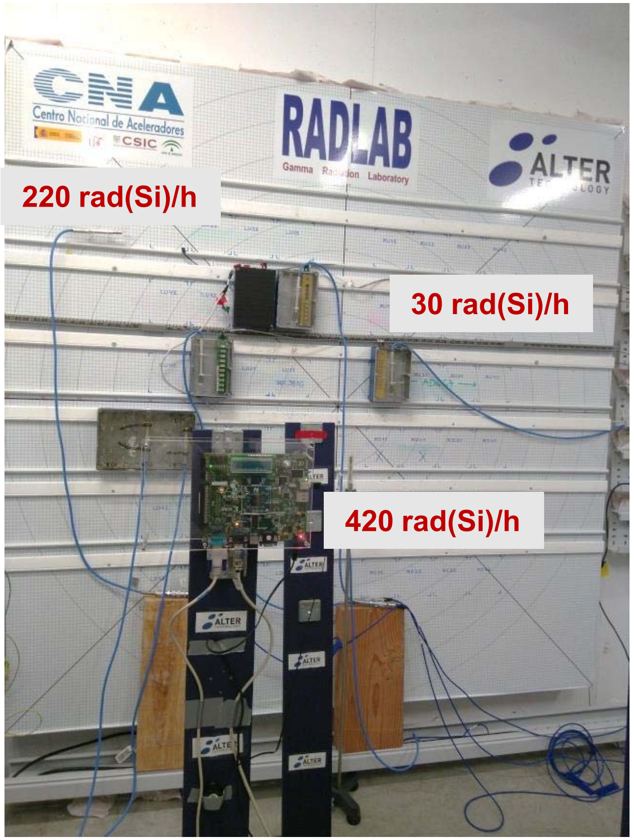
^{60}Co Irradiator system (Gammabeam ® X200, Best Theratronics)

- **Photons energies** 1,17 and 1,33 MeV (**1,25 MeV** average)
- **Activity** 117 TBq (May 2022)

Dose rate range

~14 **rad(Si)/h**
to 14 **krad(Si)/h**
u ≤ 4%



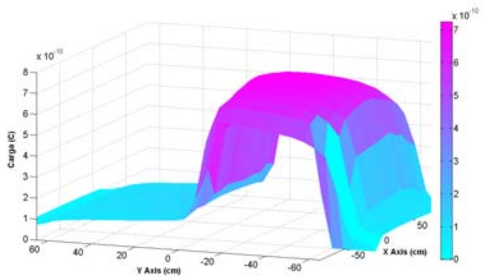


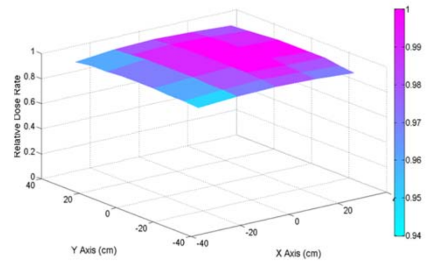
Remote access & staff support

Dynamic study can be checked by user
Step measurements in collaboration

Square flat radiation fields.

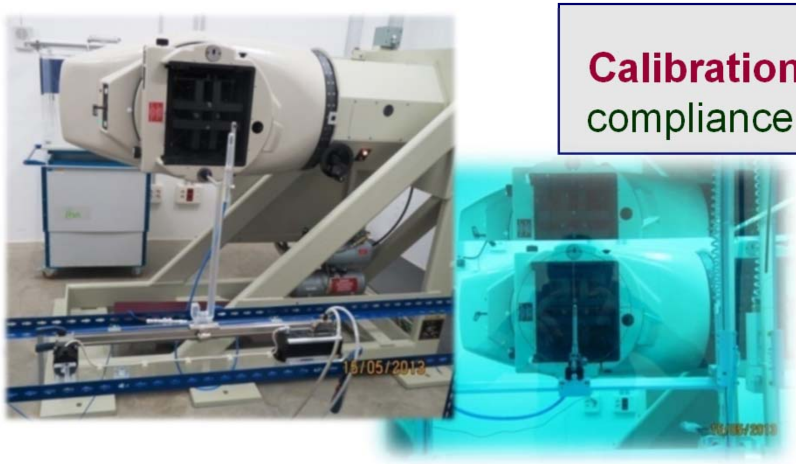
Areas from about 110 cm x 110 cm meet standards homogeneity requirement, although dose rate nonuniformity ≤ 1% is also available for a wide range of field size.





Attenuation System allows to obtain different dose rates, over several irradiation field areas, to carry out independent tests, under different dose rate conditions, simultaneously.

ALTER TECHNOLOGY TÜV Nord S.A.U. / CNA Project RADLAB (IPT-2011-1603-370000), Spanish MICIIN, Subprograma INNPACTO



Calibration and certification by **SSDL PTW-Freiburg**.
compliance with TRS-398 and TRS-469 IAEA protocols.

RadLab

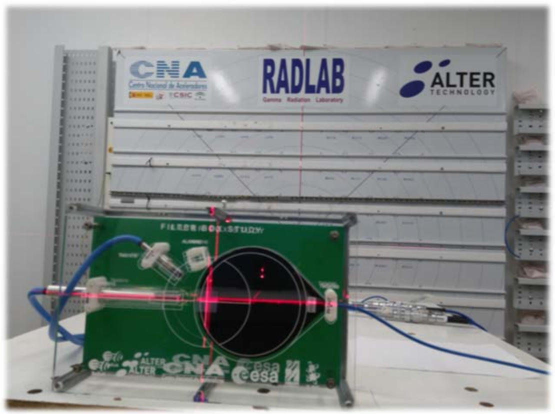
Alter Technology agreement

ESCC 22900 and MIL-STD-883/750 test methods 1019
(ISO17025; DLA Lab suitability)

Dosimetry Intercomparison exercises

- **Based on ionization chamber; ESA/ESTEC, CNA-ALTER/RadLab and UCL/CRC (2013)**
- **Based on the study of the filterbox with european, american and russian institutions (2018-2021)**
- **Based on allanine dosimetry with ESA/ESTEC; SL & TRAD (2020-2021)**

PTW THE DOSIMETRY COMPANY CERN UMASS LOWELL esa SEIBERSDORF LABORATORIES TRAD Tests & radiations



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ALTER TECHNOLOGY

Novelty

Current activity In the frame of PRECEDER Project

Prediction of the behavior for electronic devices under radiation applying "machine learning"

Objective: to be included in VIRTUAL-LAB
https://www.altertechnology-group.com/en/news/news-details/article/virtual-lab/

Irradiation tests with LEP, HI and n

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3 MV Tandem Pelletron (NEC):

- Available quasi-monoenergetic (FWHM 0.2 - 0.03 %) ion beams
- $^1H^+$ [LET(Si) ~0.2 - 0.05 MeV-cm^2/mg / Range ~7-300 microns]
- Heavier ions (Range in Si, máximum in the order of tens of microns)
- Neutrons up to 9 MeV by nuclear reaction using >5MeV deuteron as primary beam

- Energy range from ~600 keV to several MeV
  (E=(1+q)V; p.e. 600 keV to 6 MeV for H^+)
- Different ion beam sises
  - Irradiation beam line (usually 1cm^2)
  - Microprobe (beam resolution ~ µm)
- Maximum irradiated área (scanning systems):
  Irradiation beam line, 16x20 cm^2 (for mE/q^2=18)
  Vacuum Microprobe line, 2.5x2.5 mm^2 (for mE/q^2=3)

- Vacuum system (P ~ 10^{-6} mbar)
- Several opto-electrical feedthroughs

Compact 18/9 Cyclotron (IBA):

- Available quasi-monoenergetic (FWHM 1 – 3 %) $^1H^+$ 18 MeV and $^2H^+$ 9 MeV
- Lower energies are available by using foils degraders (usually $^1H^+$ 16-10 MeV)
- H [LET(Si) ~0.02 - 0.04 MeV-cm^2/mg / Range ~700-2000 microns]

- External beam line. (Possibility to couple vacuum chamber)
- Maximum achievable >90% uniform irradiated area at 10 MeV (Ø 3.5 cm)

Irradiated area uniformity better than 10%

Fluence u ~ 10-20%

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LEP Space Applications

Proton Irradiation Test on Solar Cells cables and shielding materials

Usual requirement T<40ºC on the samples; easy reached with prompt flux <1E13 p/cm^2

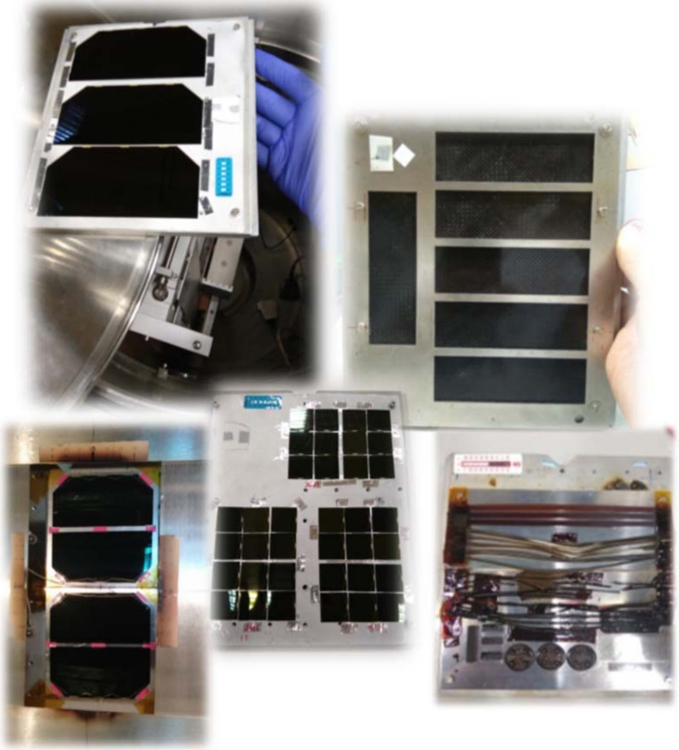
CESI | AIRBUS DEFENCE & SPACE | INTA | ARTE | QIOPTIQ Photonics for Innovation An Excelitas Technologies Company | TRAD Tests & radiations

SPASOLAB

1MeV Proton Energy

2MeV Proton Energy

10MeV Proton Energy



$2x10^{10}$ p^+cm^{-2} Fluence

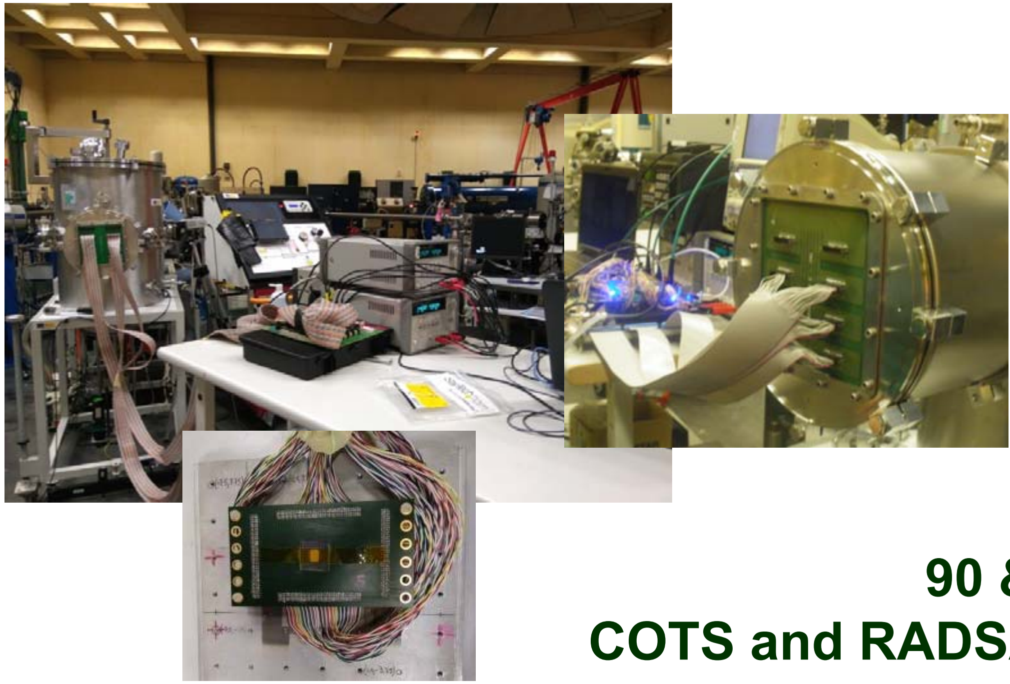
$3x10^{11}$ p^+cm^{-2} Fluence

$5x10^{12}$ p^+cm^{-2} Fluence

$5x10^{15}$ p^+cm^{-2} Fluence

LEP Applications; Space, Radiation monitors

Low energy proton direct ionization testing on FPGAs
Single Event Effects (SEE) cross sections



SRAM <65 nm

0.6 – 5.5 MeV

MFlux 2E7 – 2E9 p/cm^2s
PFlux 8E8 – 3E10 p/cm^2s
Tilts (15º/30º/45º/60º)
Fluence 4E8 – 8E11 p/cm^2

Tests & radiations

90 & 65 nm
COTS and RADSAGA SRAMs (ESR15)

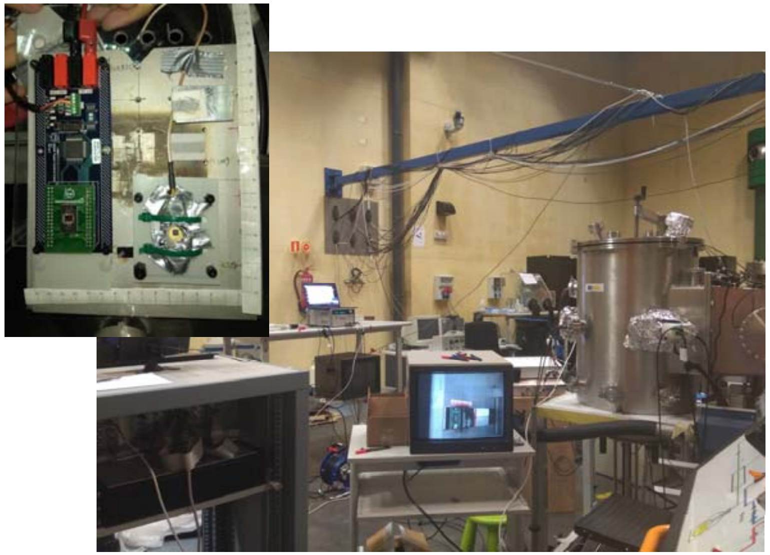
0.5 – 5.9 MeV

E steps <50 keV

MFlux 3E4 – 4E8 p/cm^2s
PFlux 5E7 – 1.3E11 p/cm^2s

Complementary Si diode system (by ChipIR)
MFlux 1.5E2 – 5E5 p/cm^2s

Fluence 1.1E6 – 1.2E11 p/cm^2



Acknowledgements

To the users and collaborators from public institutions and private companies

Your requirements are our improvements !!!