LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

encontro CIÊNCIA '22

From Particle Physics to Health & to Space

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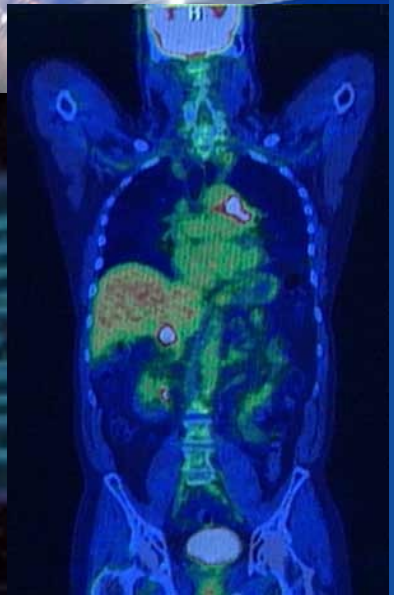
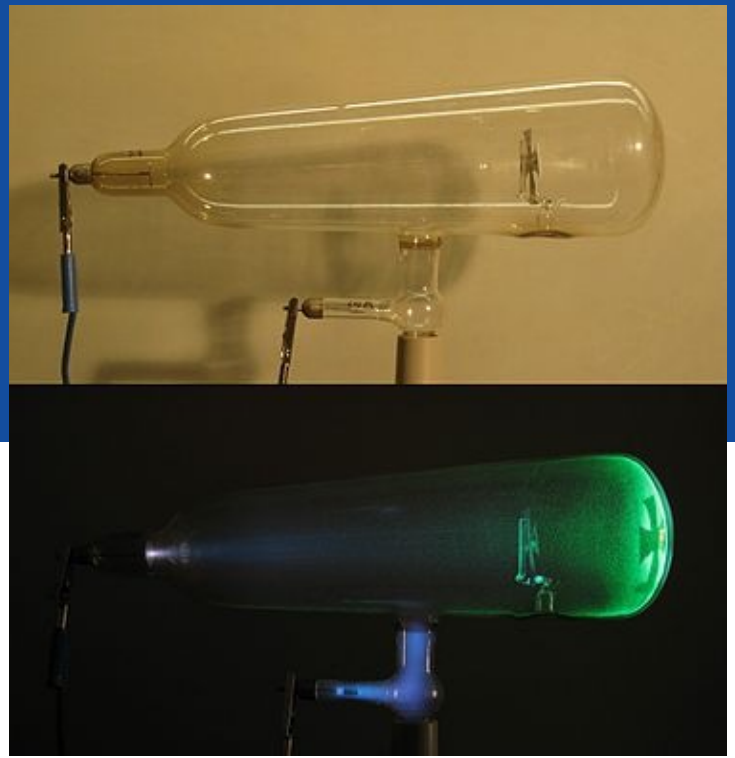
Particles physics technologies

- Radiation interaction with matter
- Detectors and Instrumentation
- Beam lines and accelerators
- Software development
  - Detector simulation
  - System control
  - Data analysis
  - Image reconstruction



HEALTH

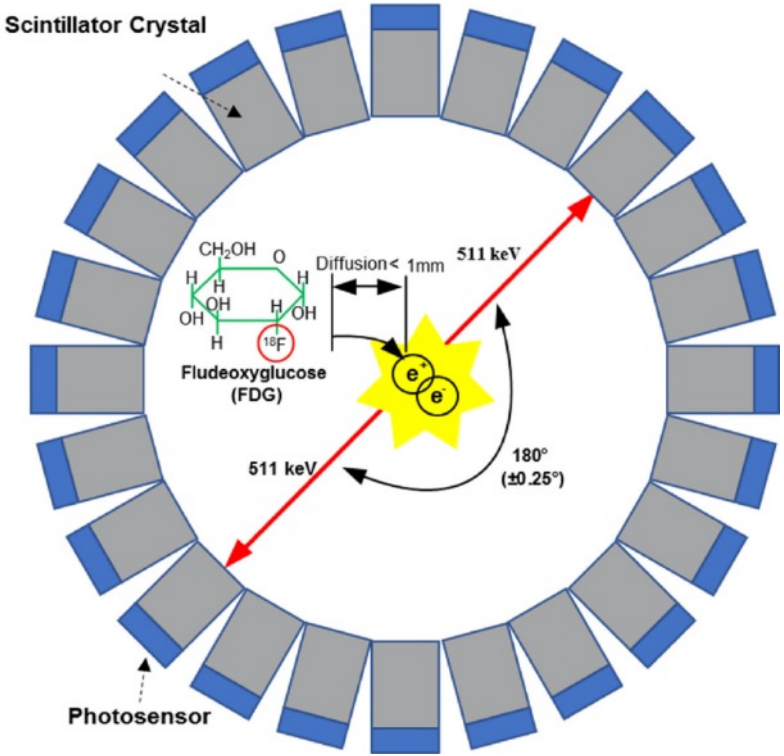


The first “Medical application of particles

Roentgen 1895

1st x-ray photograph
Bertha´s hand

Exposure time:
15 minutes



Positron Emission Tomography

RPC based PET imaging

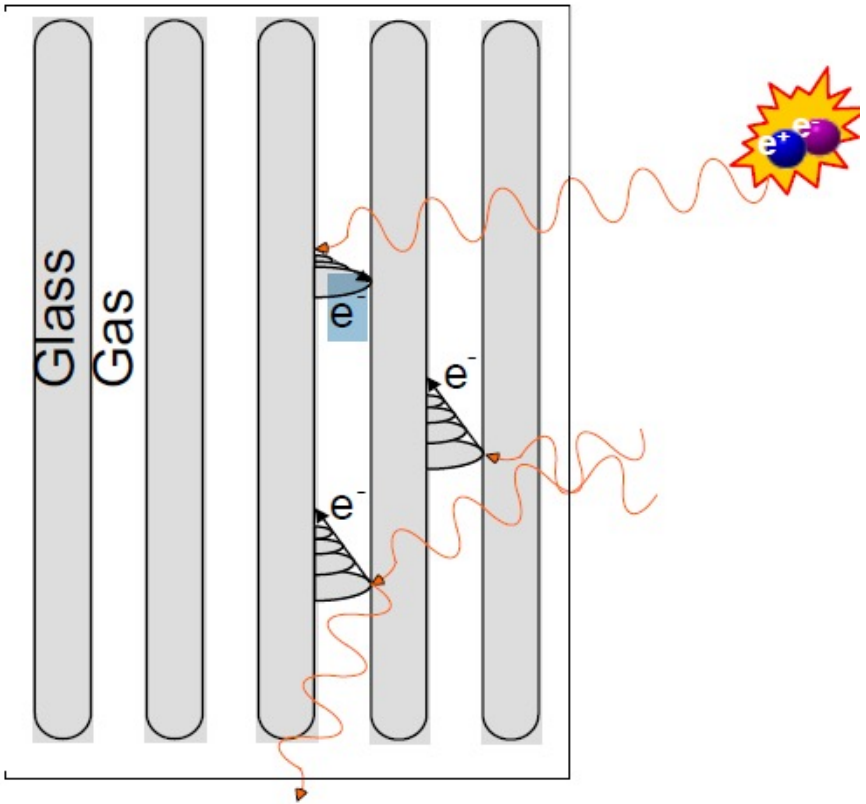
RPC: resistive plate chambers
Converter plane principle

Use the electrode plates as a γ converter, taking advantage of the natural layered construction of the RPCs.

Time resolution for 511 keV photons:
- 90 ps σ for 1 photon
- e- 300 ps FWHM for the photon pair

Phys. Med. Biol.66(2021)065016 (https://doi.org/10.1088/1361-6560/abe558)

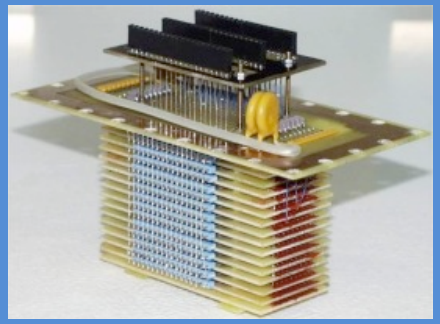
Resistive plate chambers

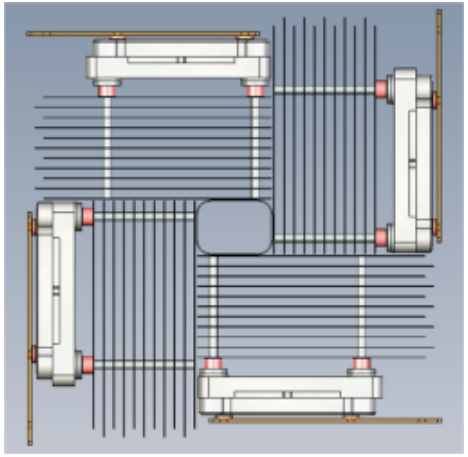


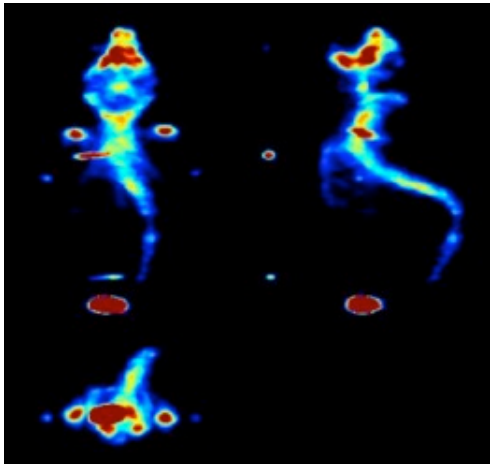
RPC based PET imaging

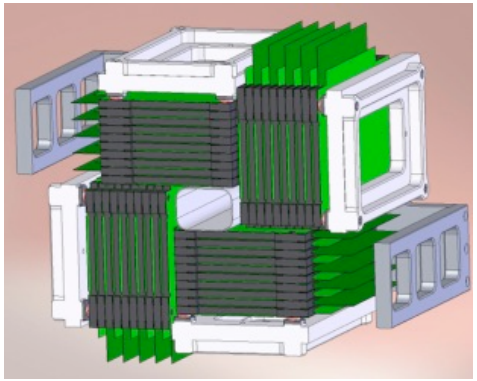
Small animal PET

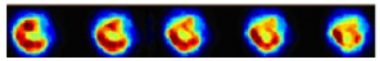
- Hundred of mice examined for biology research
- > three years of routine use



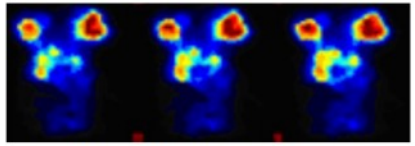




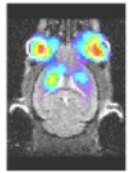




Live heart transaxial section with ^{18}FDG



Harderian glands and left striatum with ^{11}C-raclopride



Co-registration with MRI

Phys. Med. Biol.66(2021)065016 (https://doi.org/10.1088/1361-6560/abe558)

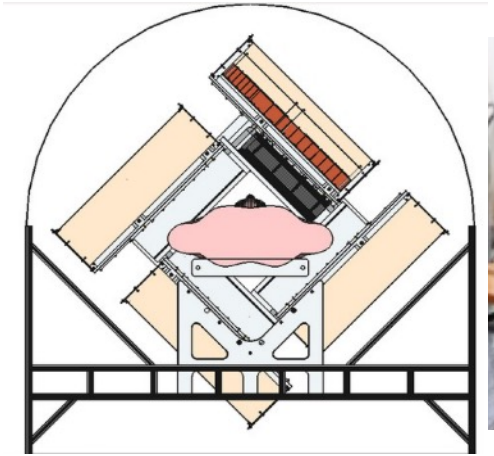
RPC based PET imaging

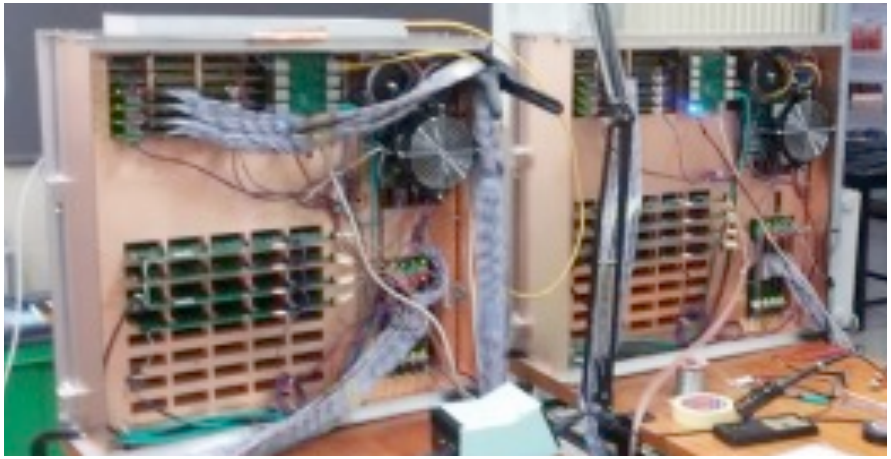
Human brain PET

Diagnosis and investigation of diseases of the central nervous system by allowing to resolve small brain structures

Construction of a tomograph for Human brain imaging with the requirements:

- Spatial precision ~ 1 mm
- Timing precision < 300 ps
- Solid angle coverage > 50%
- Sensitivity of the order of 0.1 %

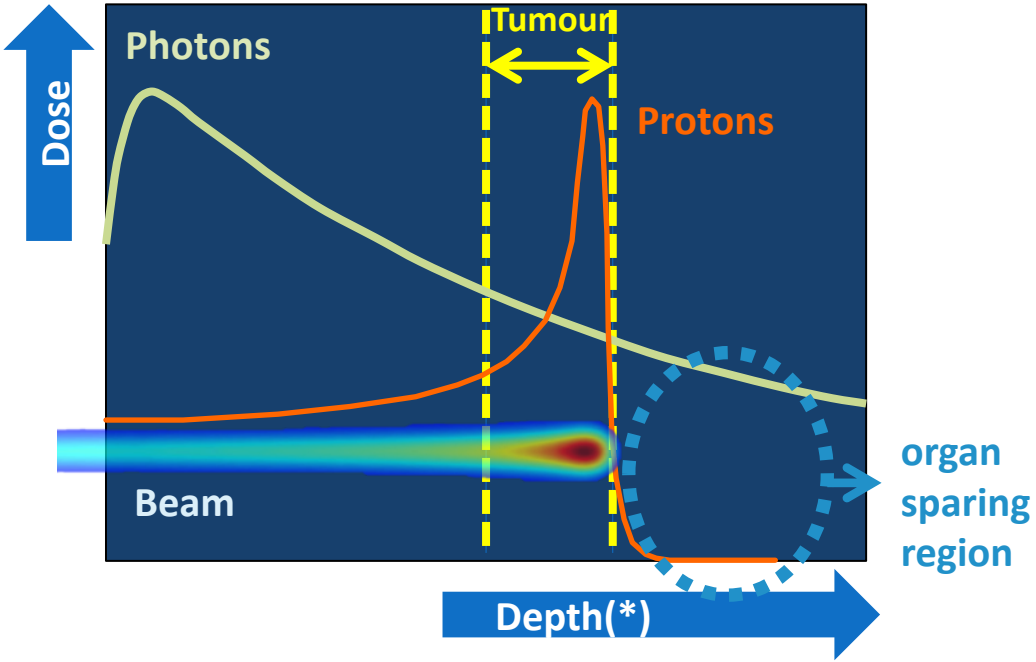




Charged Particle Radiotherapy

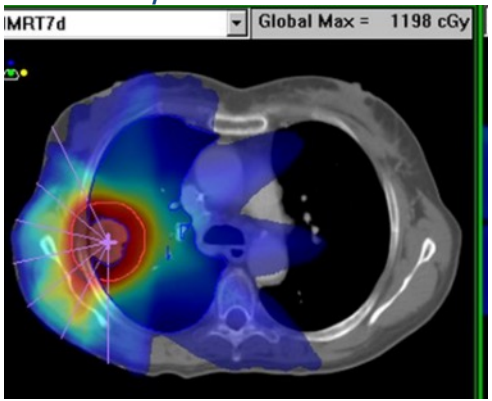
Reduction of side effects in cancer treatment and potentially increase of the doses delivered to tumours through **ultra-precise dose delivery**

Charged Particle Therapy

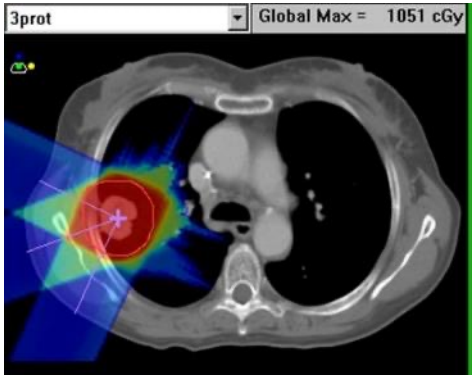


(*) Penetration depth is a function of the particle energy!

Intensity Modulated RadioTherapy

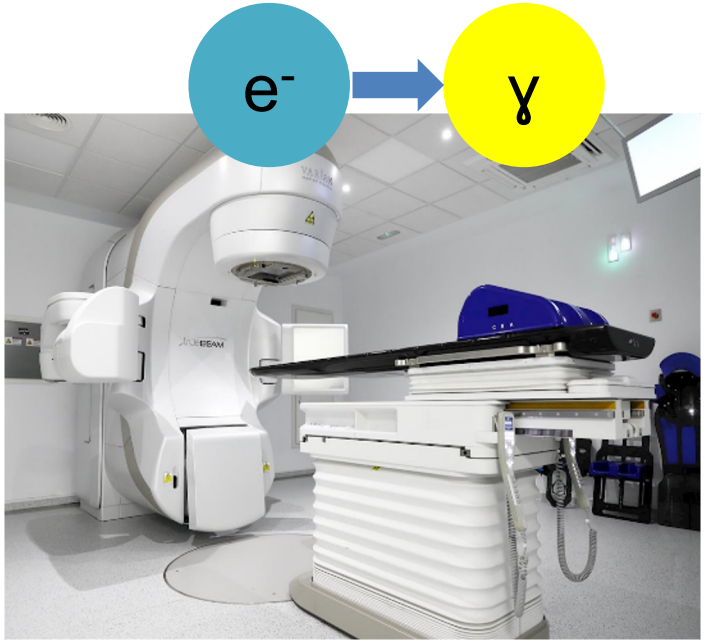


Proton therapy



Accelerators

How do we generate high-energy protons or ions?



LINAC - Linear accelerator

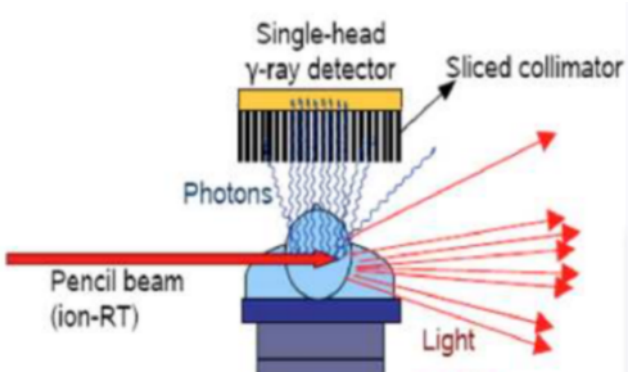
"Circular" accelerator - Cyclotron or Synchrotron

O- PGI

Orthogonal Prompt-Gamma Imaging for Proton Therapy

Objective: Real-time range monitoring

Development of an imaging system capable of detecting Bragg peak location in real-time through detection of a prompt gamma signal which “stops” at beam range.



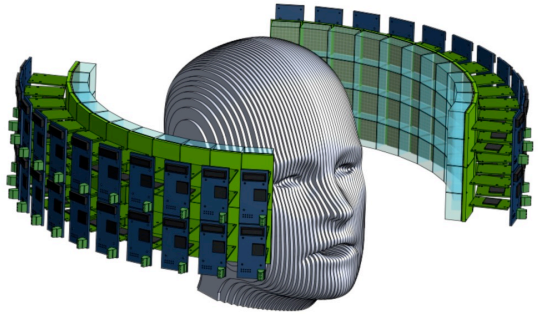
FCT: CERN/FIS-TEC/0017/2021 & CERN/FIS-TEC/0019/2019

TPPT

TOF-PET for Proton Therapy

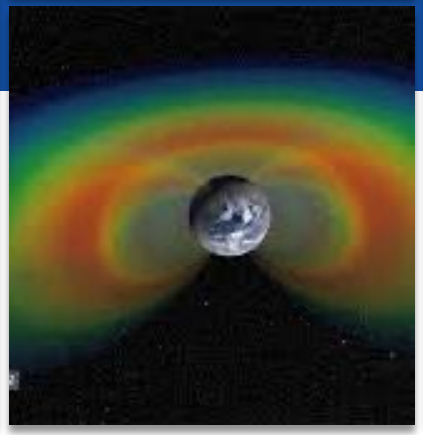
Objective: Real-time information of beam location & intensity

Use Monte-Carlo Simulation & experimental data in conjunction to optimize PET scanner detector response to β+ emitters produced by tissue activation.



UT-Austin Project 45904 (SI-47-2019-05) - PetSys, ICNAS (UC), CTN(IST) & LIP

SPACE



In Space, accelerators are larger and detectors are … smaller

Radiation Monitors

- S/C Radiation Housekeeping
- Alert and Safeguarding
- Support to platform and Payload
- Future Mission Preparation and Provision of scientific data

Particle detectors in Space

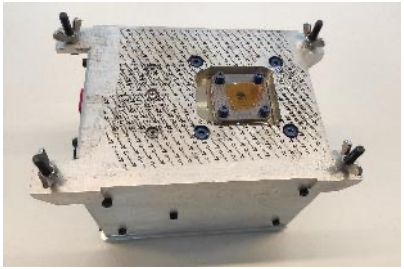
- Mass ~1 kg O(10k€/kg)
- Power ~1 Watt
- Volume ~ 1 ltr

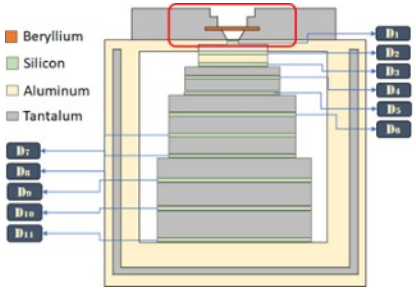
The radiation environment in the solar system: from Mercury to Jupiter

To Mercury – BepiColombo Mission (2018)
BERM – BEpiColombo Radiation Monitor

Measurement
- electron, proton and ion spectra

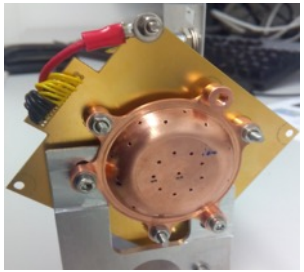
Earth radiation belts measurements in 2021
Now near Mercury

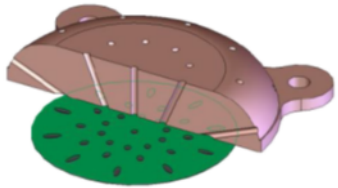




To Jupiter – ESA JUICE Mission (2023)
RADEM – RADiation hard Electron Monitor

Measurement
- electron and proton spectra
- ion LET
- electron directionality

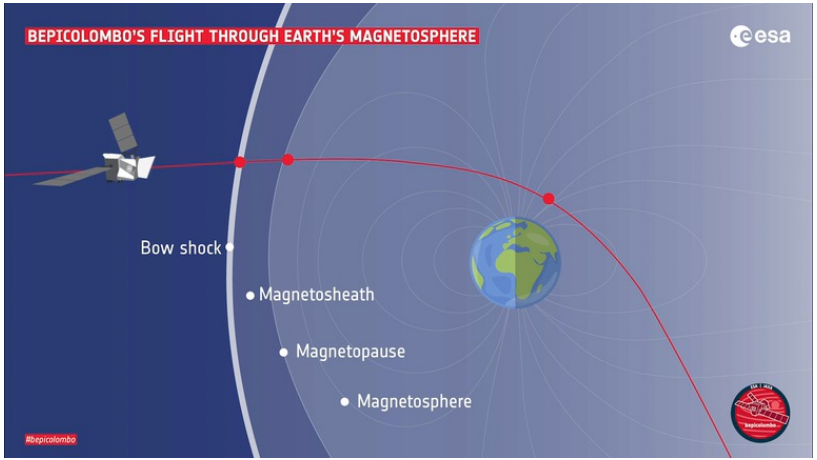




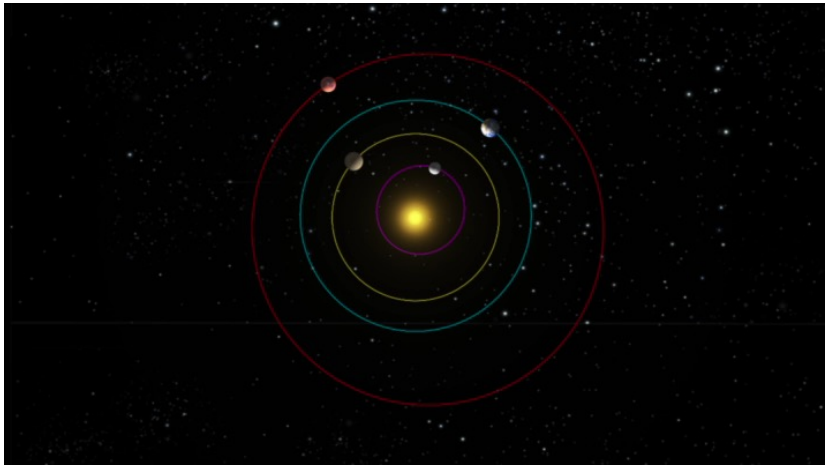
ESA Contract No. 4000137865/22/ES/JD - Expert support to BERM (BepiColombo Environment Radiation Monitor) & RADEM units on board BepiColombo and JUICE spacecraft (LIP,SE2S)
ESA Contact No. 4000110643/13/NL/HB - RADEM Proto-Flight Model (EFACEC, PSI, IDEAS, LIP)

The radiation environment in the solar system: from Mercury to Jupiter

To Mercury – BepiColombo Mission (2018)
BERM – BepiColombo Radiation Monitor



To Jupiter – ESA Juice Mission (2023)
RADEM – RADiation hard Electron Monitor



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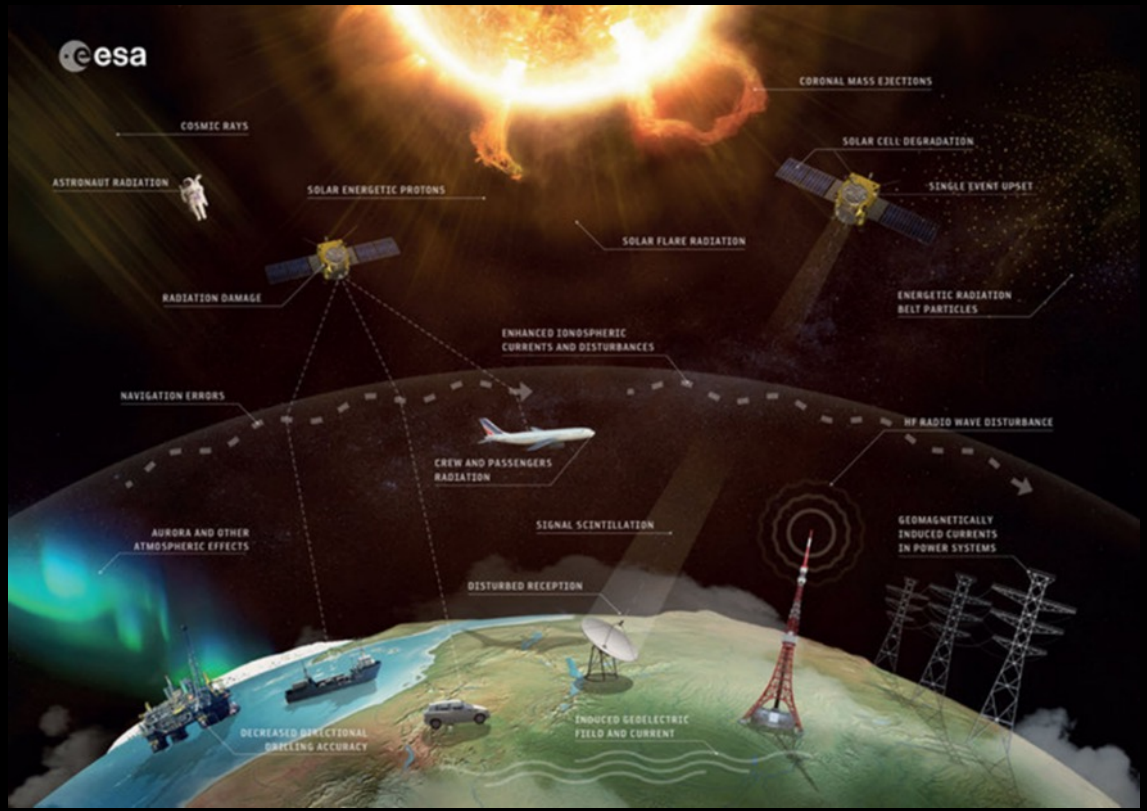
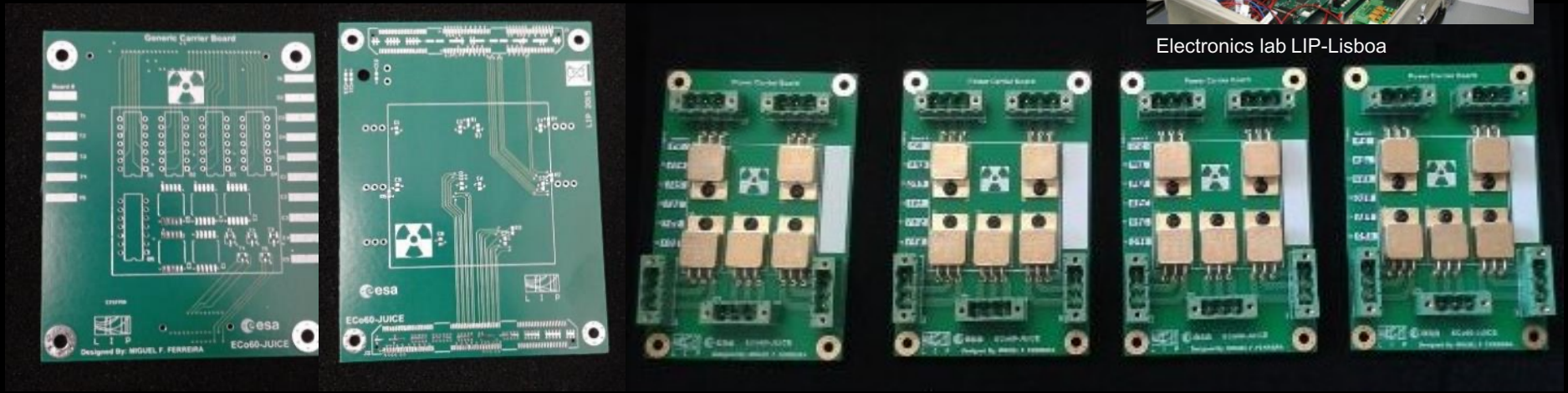
SPACE Radiation Environment and Effects



Test, Characterization and Radiation Hardness Assurance of EEE components

- Electronics
- Instrumentation
- Beam-lines

Electronics lab LIP-Lisboa



From Particle Physics to Health & to Space

Particle and accelerator physics are often best known for the large-scale physics experiments performed at world-famous physics laboratories like CERN or Fermilab.

At these institutes, extremely high-energy accelerators are used to reconstruct, amongst other things, the conditions at the very beginning of our universe.

In addition to all the fundamental knowledge of nature, R&D in High Energy Physics has contributed to society with important spin-offs, applications, and multidisciplinary solutions in different fields such as Health and Space!

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