1 MeV electron irradiation test during the conception of new radiation resistant solar cells

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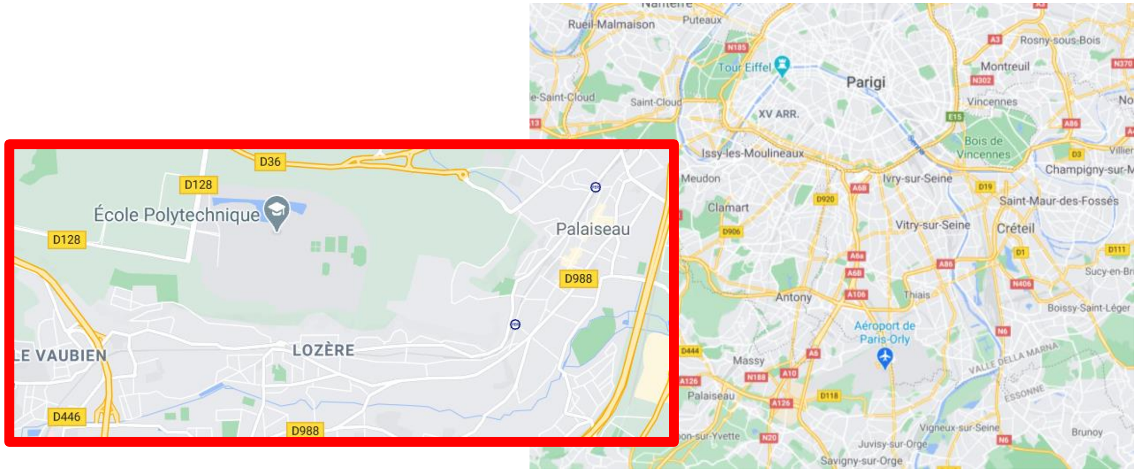
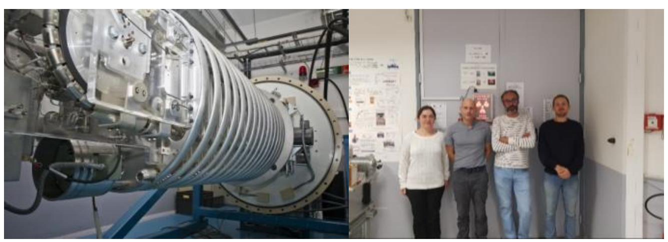
SIRIUS

Système d’**IR**radiation pour l’**I**nnovation et les **U**tilisations **S**cientifiques

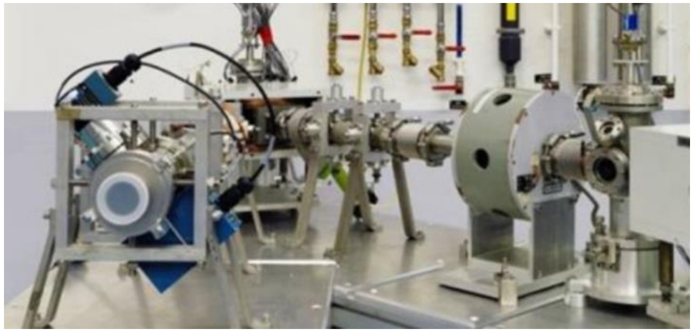




Réseau national d’accélérateurs pour l’irradiation et l’analyse des molécules et matériaux

Beamline Manager: Antonino Alessi
Technical Manager: Olivier Cavani
Beamline Scientist : Romain Grasset
Support Developments: Audrey Courpron

SIRIUS



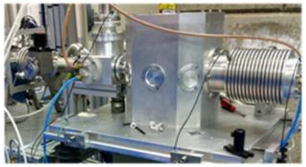
ACCELERATOR

The important particularity of SIRIUS :

- The NEC Pelletron accelerator
- Adjustable energy (150 keV - 2.5 MeV) and current (10 nA - 50 µA).
- The accelerator is equipped with several irradiation set-ups.
- Two beamlines.

Two Beam-lines operating in vacuum 5×10^{-8} mbars avoiding energy and current degradation

CIRANO



- Current beam : < 40 µA
- 300 K < T < 600 K
- Sample : Ø 28 mm
- Atmosphere (Air, Vacuum, Helium, Argon)
- Water-cooled sample holder
- Optical aperture for *in situ* UV-VIS absorption

GRANDE SURFACE

- Current beam : < 50 µA
- 100 K < T < 300 K
- Sample : 180x130 mm2
- AM0 solar simulator for solar cells
- *In-situ* electrical measurements

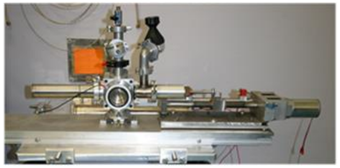
CRYO 1

- Current beam : < 10 µA
- T = 20 K
- Sample : Ø 8 mm
- Cooling power > 25 W
- *In situ* electrical measurements

CRYO 2

- Current beam : < 5 µA
- 4 K < T < 300 K
- Sample : Ø 5 mm
- *In situ* resistivity and Hall effect
- EPR under development

IRRAPLAST



- Current beam : ~ few µA
- T = 300 K
- Atmosphere (Air, Helium, Argon)
- Translation along one axis (15 cm)

Application fields:

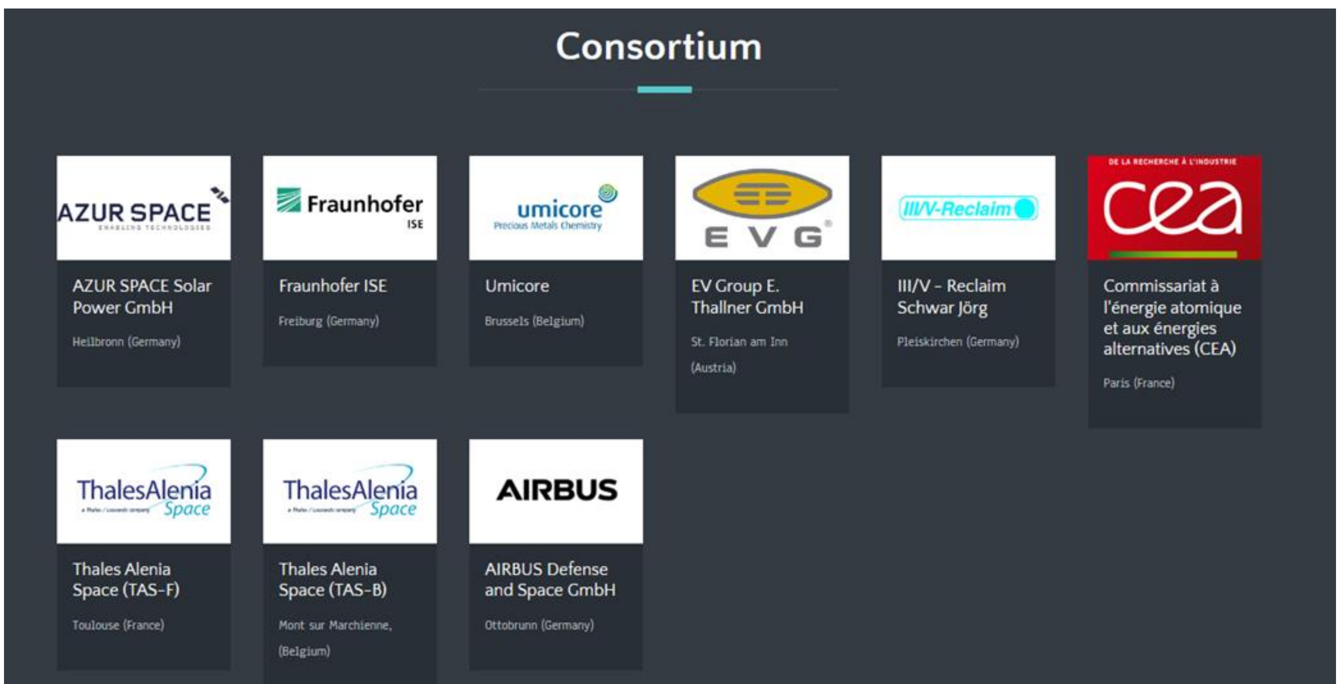
Glasses
Polymers
Semiconductors
Ceramics
Metal
Superconductors
Nuclear fuel
Solid state physics
Solar cell
Cements
others

RADHARD

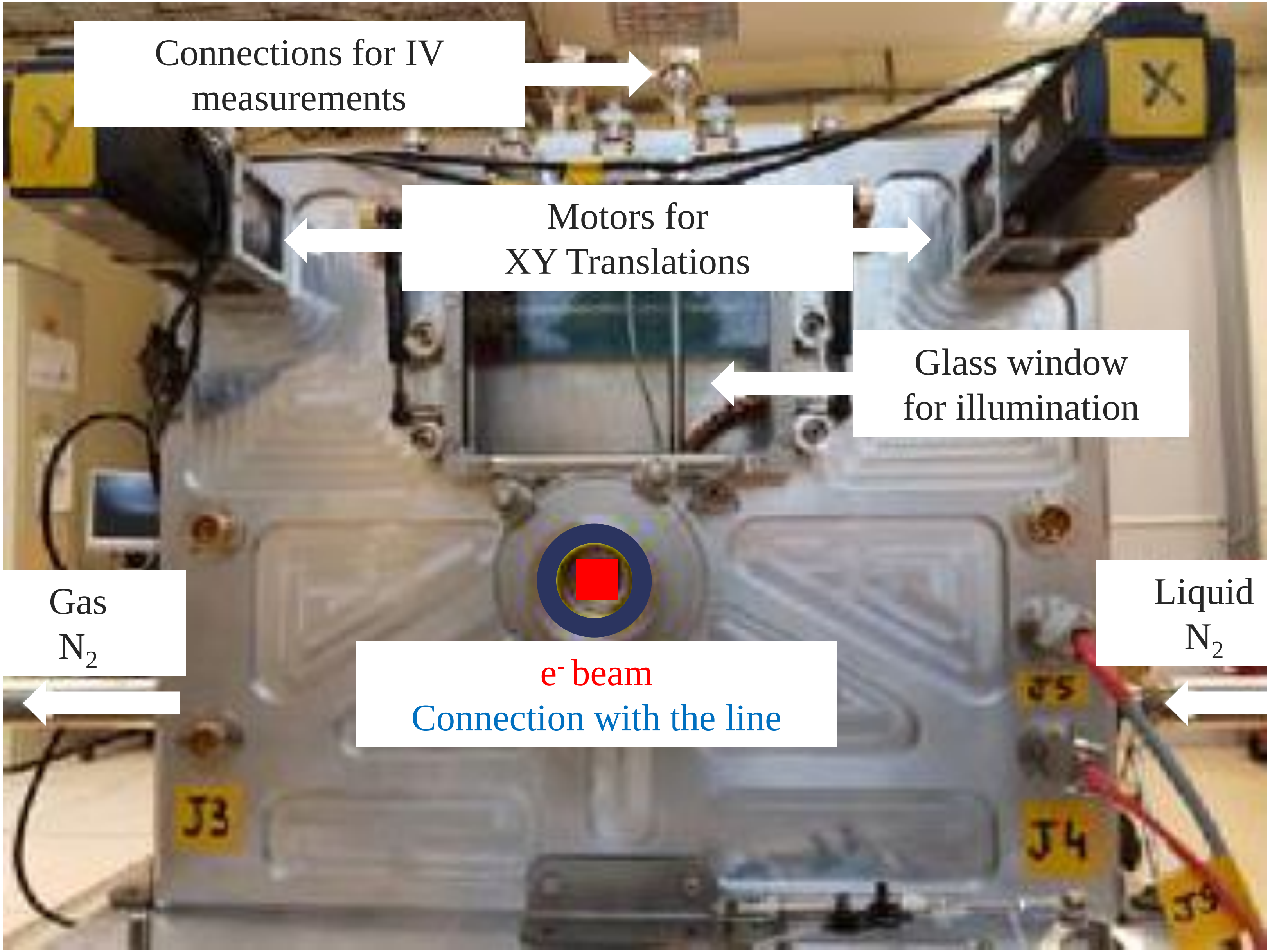
Orbit raising leads to an increase of the radiation dose for satellites
Increased solar power generation needed (to power ion thrusters)

i) 4-j solar cell with beginning-of-life efficiency >35% under AM0 condition
ii) High efficiency (possibly>31%) after 10^{15} ecm^{-2} 1MeV electron irradiation
iii) Competitive cost of the product

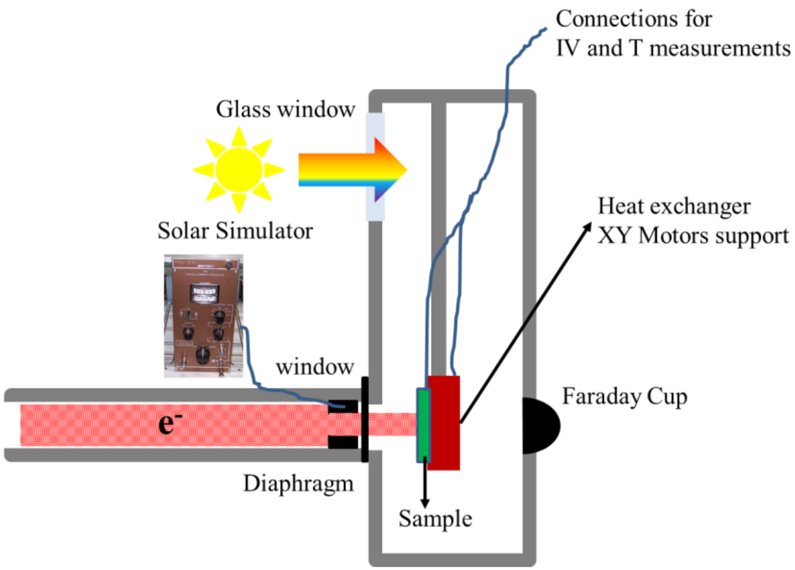
https://radhard.org/

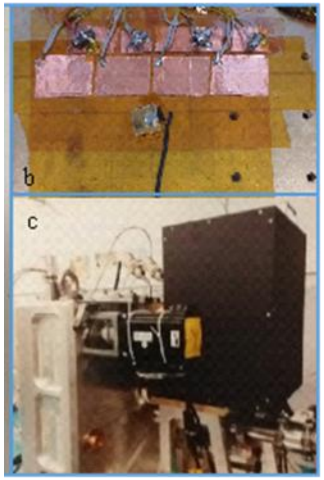


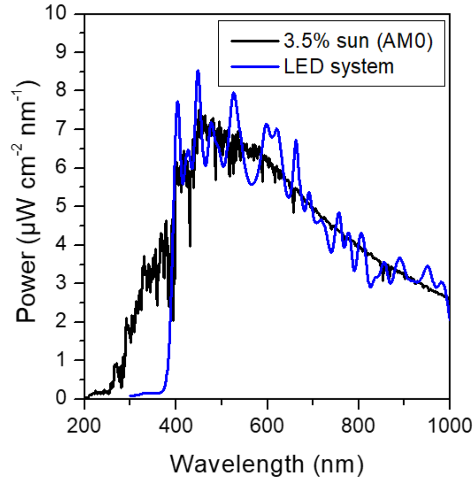
Grande Surface

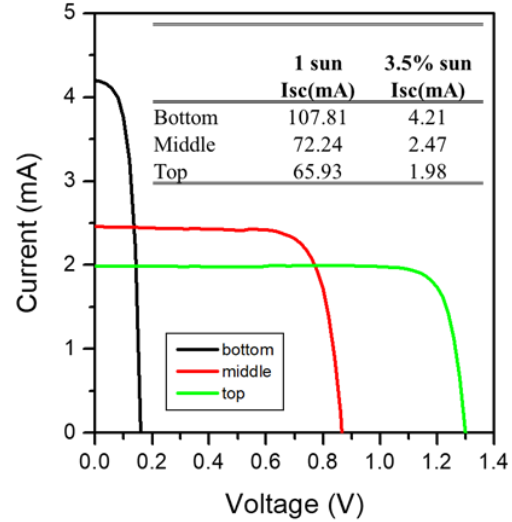


Grande Surface









43 LEDs

Via software, the voltage can be varied to adjust the intensity of five groups of LEDs.

The voltage of the single LED must be adjusted by the hardware.

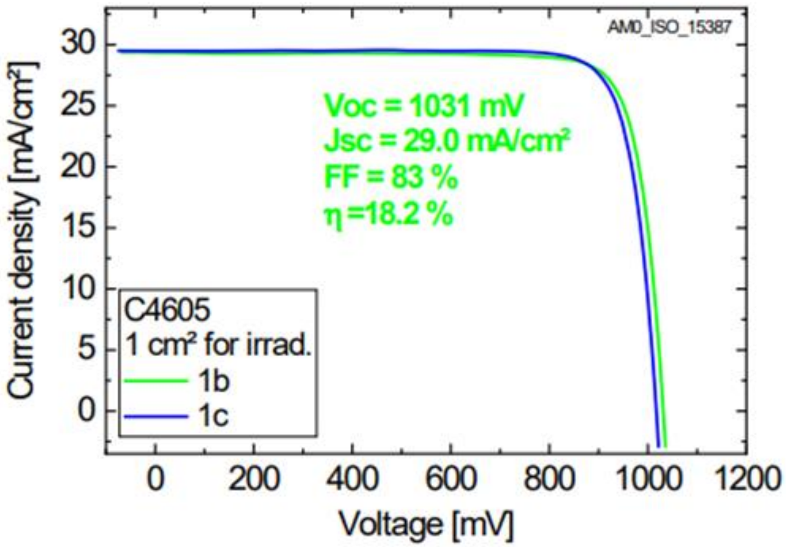
Additional light sources can be coupled.

Before irradiation

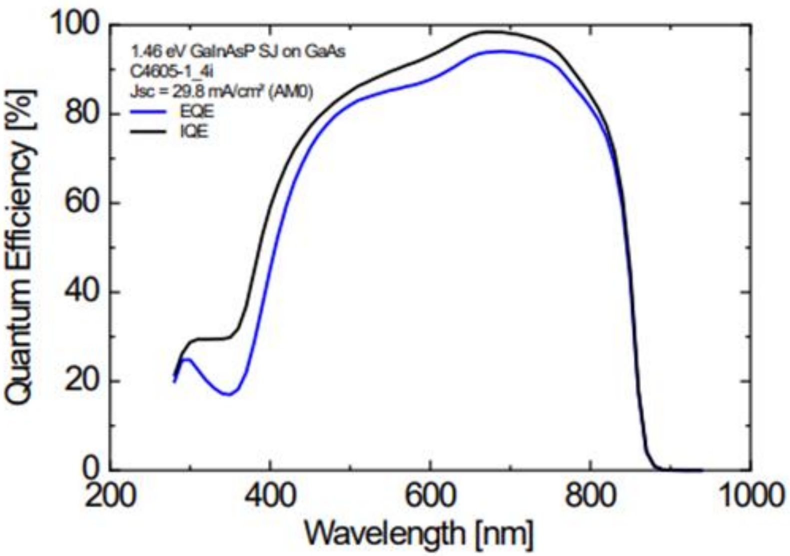
Single junction GaInAsP cells with a bandgap of 1.46 eV

GaInAsP solar cell was grown on top of a metamorphic buffer on a GaAs wafer

IV characteristics



QE measurement*



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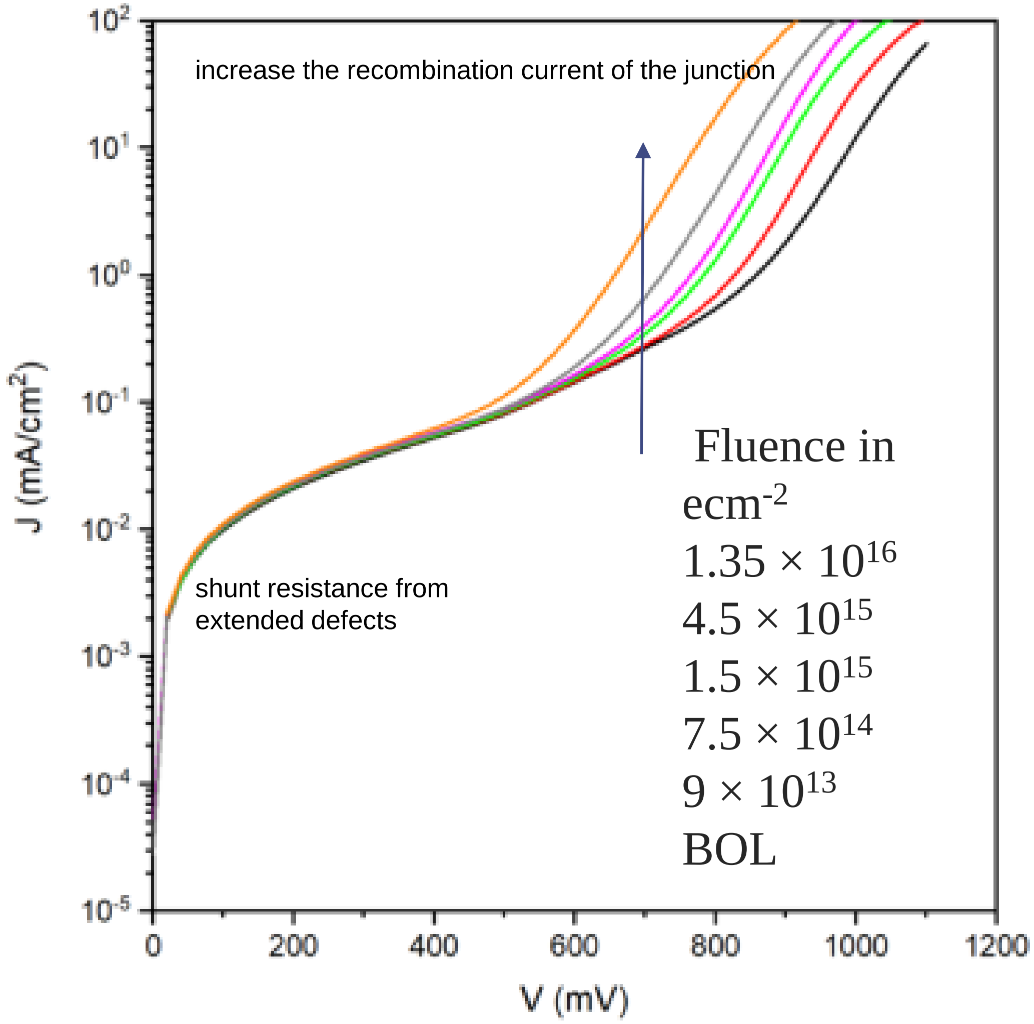
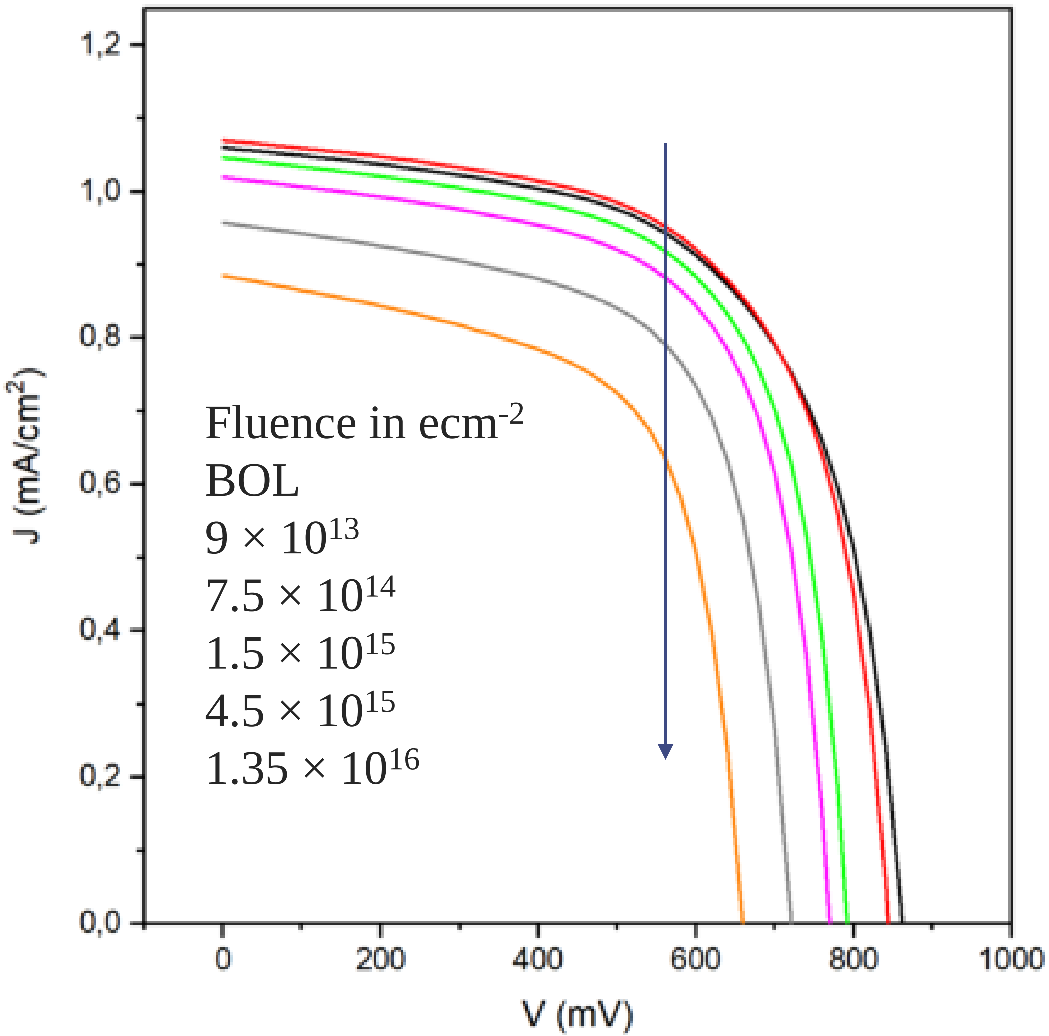
Radiation effects



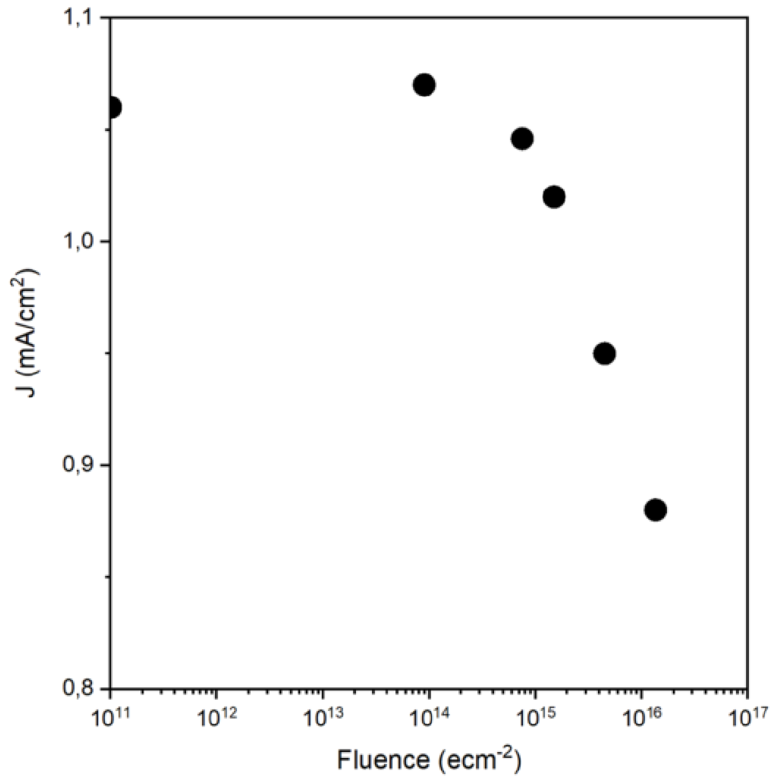
Radiation effects

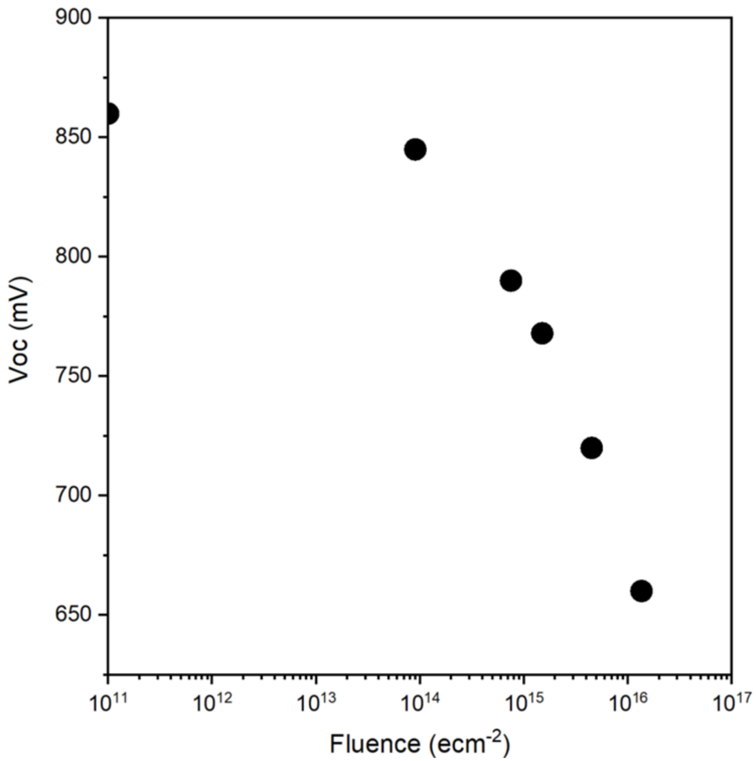
In situ under low illumination



Radiation effects

In situ under low illumination





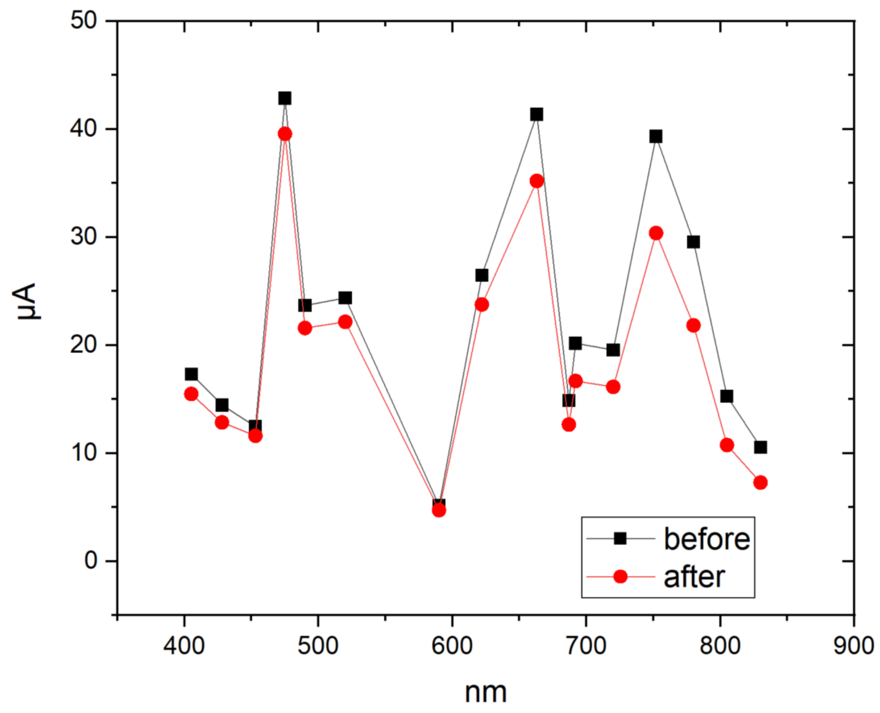
The efficiency of the cell changes from 11% to 7.3 % under low illumination as a consequence of the electron irradiation up to about 1.35 × 10^{16} ecm^{-2}

Possible annealing effect when operated under AM0 at 60°C
(typical operation condition in GEO Orbits)

Radiation effects

the solar cell was illuminated with one LED at a time and we measured the generated current

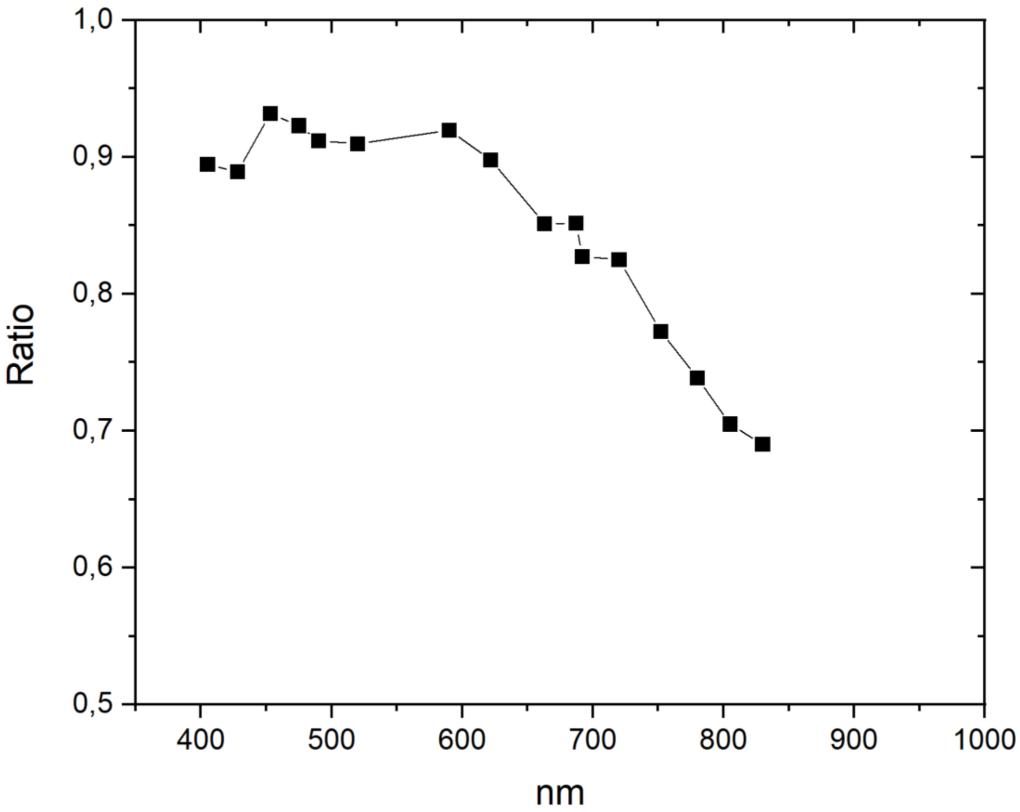
The experiment has be performed before and after irradiation at the maximum fluence



The generated current decreases at any investigated wavelength

Radiation effects

Ratio between the current measured after and before irradiation as a function of the illumination wavelength



The decrease of the generated current is larger at high wavelengths

Effect due to the radiation induced reduction of the diffusion length that affects more the electrons generated by photons of high wavelengths

Questions