Testing materials and devices under ionizing radiation for terrestrial applications and space missions

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Tested materials, components, devices:

- different doped glasses
- scintillating materials
- optical materials for mid-IR: CaF_2, BaF_2, ZnSe, sapphire (windows & optical fibers)
- visible and near-IR detectors
- mid-IR detectors
- semiconductor lasers
- optical fibers (UV-vis, near-IR, plastic, optical amplifiers)
- optical fiber sensors (FBGs, LPGs)

Purpose of the tests:

- radiation induced material changes
- reliability of components/ devices (nuclear installations, nuclear waste repositories, satellites & space missions)
- radiation dosimetry/ monitoring/ radiation field mapping

Irradiation conditions (off-line & on-line):

- gamma ray
- X ray
- electron, proton, deuteron beams
- alpha particles
- neutron from Cyclotron accelerator and nuclear research reactor

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Additional infrastructure of interest

- optical radiometer (200 nm – 35 μm, emission, transmission, reflection spectroscopy, detectors & sources characterization)
- tunable ns laser (from 245 nm to 1.7 μm)
- tunable ps laser (400 nm – 820 nm @ 65-70 ps & 10 nm)
- THz spectroscopy (transmission, reflection, tomography)
- facility for shocks and vibrations measurements

Experiment background (1)

- **Extensive use of solar panels in space applications:**

- Low Earth Orbit (LEO) mission (800 km)
- Medium Earth Orbit (MEO) mission (20,000 km)
- Geostationary Earth Orbit (GEO) mission (35,870 km)
- inter planetary missions (JUICE - JUpiter ICy moons Explorer)

- **Radiation fields:**

- protons and electrons trapped in the Van Allen belts
- heavy ions trapped in the magnetosphere
- cosmic ray protons and heavy ions
- protons and heavy ions from solar flares

Experiment background (2)

ESA's interest towards the effects of radiation on electronic and optoelectronic components included in instrumentation employed in space missions is proved by the fact that, starting from 2000, ESA has regulations on this issues and subcontracted research programs on "radiation effects for future technologies and missions":

- C. S Dyer and G. R Hopkinson, *Space radiation effects for future technologies and missions*, Report QINETIQ/KI/SPACE/TR010690/1.1, ESA contract 14968/00/NL/EC
- European Cooperation for Space Standardization (ECSS), *Space engineering: Space environment*, ECSS-E-10-04A, Noordwijk (2000)

Experiment background (3)

- **Over 30 years of research in radiation effects on:**

- X rays, gamma rays, proton, electron
- various solar cells (some examples): GaAs/Ge; Si; CdSe(In)/p-Si; CuInGaSe2;GaAs; a-Si:H; InGaP/GaAs/Ge; $InAs_xP_{1-x}$ / In P; AlInGaP; $Al_{0.14}Ga_{0.86}N$; AlInGaP; InGaAs; $Cu(In,Ga)Se_2$; InGaP; InGaAsP; InP; InP/Si,etc.

- **Organic solar cells > novelty:**

- C.G Kouhestani, BS Thesis, The University of New Mexico, December 2014
- Ionizing radiation induced parametric variations in P3HT:PCBM organic photovoltaic cells, *J. Vacuum Sci. & Techn.*, B 33, 032403 (2015); doi: 10.1116/1.4917008

Experiment background (4)

- El-Nahass, M. M. & Hassanien, A. M., Gamma radiation-induced changes on the optical properties of dibenzthiopheno-perylene-N,N '-dicyclohexylimide thin films, *Radiat. Phys. Chem.*, **97,** pp. 178-183
- Cook, P. L. et al., Radiation damage in biomimetic dye molecules for solar cells, *J. Chem. Phys.*, **131** (21), Article Number: 214702
- Uslu, H. et al. The effect of gamma irradiation on electrical and dielectric properties of organic-based Schottky barrier diodes (SBDs) at room temperature, *Radiat. Phys. Chem.*, **81**(4) pp.362-369
- Binda, M . et al., Organic based photodetectors Suitability for X- and Gamma-rays sensing application, *Nucl. Instrum. Meth. A*, **624** (2) pp. 443-448
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- Ankit Kumar et al. Origin of Radiation-Induced Degradation in Polymer Solar Cells, *Adv. Funct. Mater.,* 2010, **20**, 2729–2736
- P. Zygmanski et al., Low-cost flexible thin-film detector for medical dosimetry applications, J. Appl. Clinical Medical Phys, **15**, (2) 2014

Experiment goals

- Start the investigations on possible use of organic solar cells for space missions
- Identification of devices provides and testing laboratories
- Identification of suitable materials/ technologies
- Development of appropriate testing procedure
- Development of alternative technologies for reliability issues
- Generation of new knowledge > IPR issues (patents, publications)
- Identification of would-be beneficiaries
- Defining new partnerships for common projects
- Localization of future funding schemes (national, H2020, ESA)

Steps to follow (1)

- Call for expression of interest to participate as:
  - device manufacturers
  - testing laboratories

Deadline:…..

- Defining the materials/ technologies to focus on, types of irradiations, characteristics to be evaluated

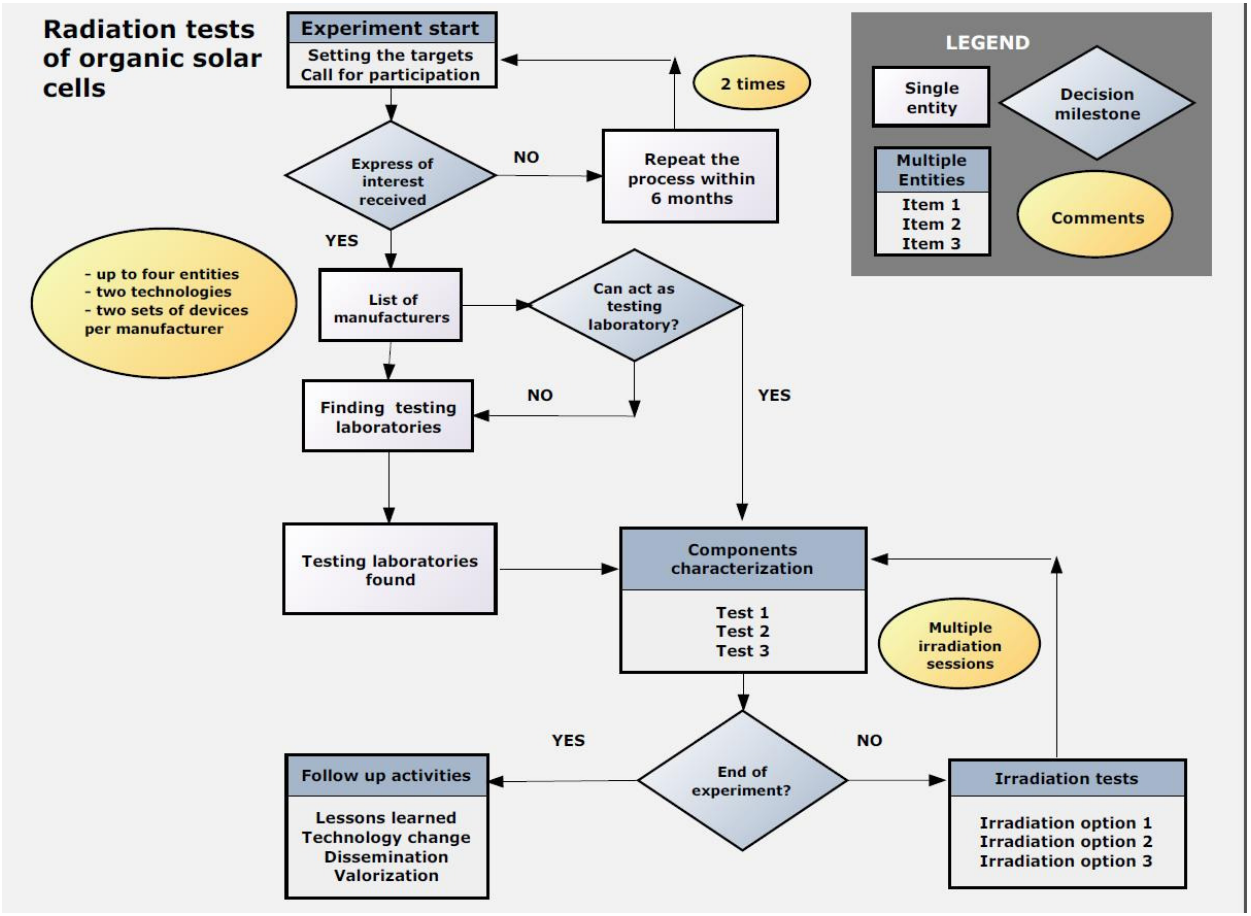
Deadline:….

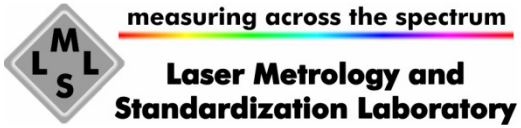
- Testing campaign

Deadline: ……

- Dissemination campaign (i.e. publications, conference papers)
- Valorization campaign (i.e. project proposals, interaction with industry)

Steps to follow (2)





Laboratory expertise in the field

- European Fusion Program: evaluation of optical fibers and optoelectronic components degradation (semiconductor lasers, photodetectors, Peltier elements) under irradiation

- National research project “Advanced Photonics Systems for Process Control”– APhoS

- National research project “Sensor systems for secure Operation of Critical Installations” – SOCI

- National project “Evaluation of Components for Space Applications” - ECSA

- EU FP7 TRIPOD project "Training & Research Involving Polymer Optical Devices"

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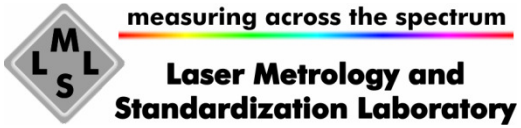
International collaborations

- COST Action TD1001: Novel and Reliable Optical Fibre Sensor Systems for Future Security and Safety Applications (OFSeSa)
- COST Action IC1101: Optical Wireless Communications - An Emerging Technology
- COST Action TD1205: Innovative methods in radiotherapy and radiosurgery using synchrotron radiation
- COST Action TD1401: Fast advanced Scintillator Timing (FAST)
- COST Action MP1401: Advanced fibre laser and coherent source as tools for society, manufacturing and life science
- COST Action MP1307 - Stable Next Generation Photovoltaics
- Collaboration with University of Limerick (Ireland)
- Collaboration with University of Palermo (Italy)
- Collaboration with Aston University (United Kingdom)
- Collaboration with Jena Institute of Photonic Technology (Germany)
- Collaboration with National Radioactive Waste Management Agency (France)
- iXFIber (France)
- European Synchrotron Radiation Facility (France)
- University of Naples "Parthenope" (Italy)
- University of New South Wales (Australia)
- Federal Institute for Materials Research and Testing - BAM (Germany)
- Beijing University of Posts and Telecommunications (China)
- Shanghai University (China)
- Polish Centre for Photonics and Fibre Optics (Poland)



National partners

- National Institute for Laser, Plasma and Radiation Physics
  - Accelerators Laboratory – INFLPR
  - X-ray Microtomography Laboratory – INFLPR
- "Horia Hulubei" National Institute of Physics and Nuclear Engineering:
  - TANDEM Department
  - Cyclotron Accelerator Department
  - IRASM
  - Radioactive Waste Treatment Laboratory
- Romanian Authority for Nucleas Activities - Nuclear Research Branch in Pitesti
- National Institute of Materials Physics
- Apel Laser SRL

Publications & patents

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- D. Sporea, Adelina Sporea, C. Oproiu, “Effects of hydrogen loading on optical attenuation of gamma-irradiated UV fibers,” *J. Nuclear Mat.*, vol. 423, Issue 1, pp. 142-148, 2012
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Publications & patents

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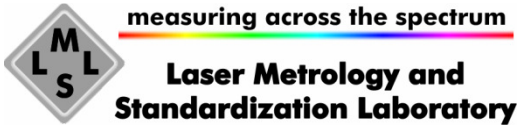

Thank you for your attention

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