1st SPECIAL PV Workshop organized in the framework of ECoVEM EU project (23-24/11/2021)

The 1st edition of the SPECIAL PV workshop took place online during two half-days on November 23rd and 24th. During this event dedicated to photovoltaic (PV) cells and arrays designed for space applications, the latest research and industrial results were presented by 23 highly skilled experts of the field. The speakers were, on the one hand, from the most renowned Research institutes such as Fraunhofer ISE (Germany), CEA-INES and CNRS-C2N (France), IES-UPM (Spain), NREL and Caltech (USA), and on the other hand, from strong industrial players of Space photovoltaics applications, such as Airbus Defense and Space (The Netherlands), OneWeb (UK), DHV technology (Spain), Azur Space and STI (Germany).

INES WORKSHOP

1st SPECIAL PV Workshop

Space **P**hotovoltaics for **E**nergy **C**onversion in extra-terrestr**IAL** environment

Organized by

With the support of

23rd & 24th of November 2021

2 half days (14h-18h CET) – Online – Free of charge

SPECIAL PV WORKSHOP PROGRAM

DAY 1: Solar cells

14h00-14h35	**Introduction**
14h40-16h00	Session 1 | **High efficiency III-V solar cells**
16h10-17h50	Session 2 | **Advanced concepts for radiation hardness**

DAY 2: Solar arrays

14h00-15h20	Session 3 | **III-V solar arrays for space applications**
15h30-17h10	Session 4 | **Towards standardization of Space PV: Reliability, durability and low cost**
17h20-18h00	Session 5 | **Roundtable : Defining the R&D priorities to answer Space PV industrial challenges**

23 guest speakers and contributors:

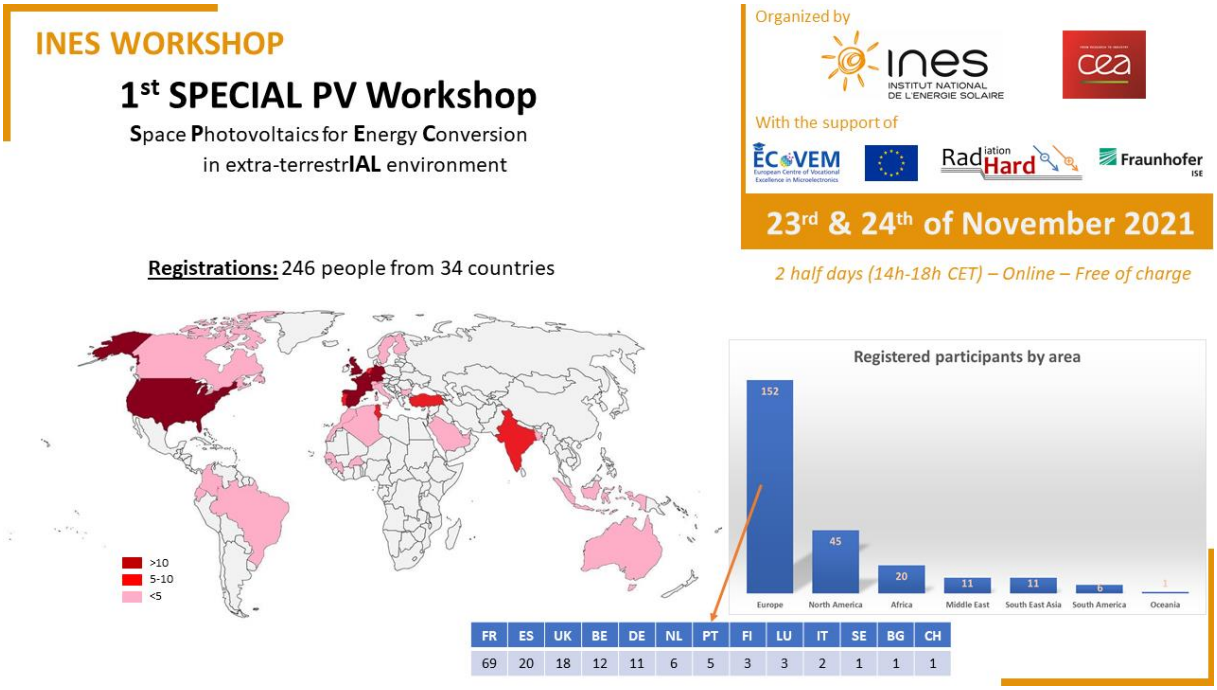
Four sessions and one round table took place virtually during two half-days, addressing the latest research topics of Space PV cell & arrays manufacturing, as well as their reliability and durability through indoor accelerated ageing tests and thermo-mechanical simulations.

This workshop, free of charge, was organized by INES-Formation & CEA-INES and was addressed to researchers, industrials, academics and students. This event was financed and promoted through the **ECoVEM European project.** As an introduction to the workshop, Professor Slavka Tzanova (TUS, Bulgaria) presented ECoVEM EU project and Business-Science-Education plan to the audience, promoting the synergies between both the education and industrial sectors by fostering the development of technological and entrepreneurial skills for the new jobs in microelectronics, including photovoltaics.

The workshop was also supported by **RadHard European project** (Grant Agreement n°EU/821876) for scientific assessment. This consortium aims to combine the most radiation hard III-V materials to form a highly efficient four-junction space solar cell via direct wafer bonding. Dr. David Lackner (Fraunhofer ISE, Germany) presented the project during the introduction of the event.

The 1st edition of the SPECIAL PV workshop was very successful as it gathered 246 people from 34 countries, mainly from EU (152 participants) and USA (42 participants). The audience was composed of general public and students, as well as highly skilled experts from academic, industry and space agencies, including influential authorities from European Space Agency (ESA), French Space Agency (CNES), European Commission HADEA and NASA. More than half of the audience was from European countries (152), the majority being from countries involved in Space PV research and development: France (69 participants), Spain (20 participants), UK (18 participants), Belgium (12 participants), and Germany (11 participants).

It was a great online event with high level presentations, cutting edge results and constructive discussions. The workshop ran smoothly without big technical issue and the time schedule was pretty well respected. The roundtable was particularly interesting and dynamic, much better than expected for such an online discussion… and it appeared it could have lasted much longer!



DAY 1: Solar cells

Introduction | SPECIAL PV Workshop

10' talks — Chairman: Jean-François Lelièvre (INES)

14h00 (CET)	David Lackner (Fraunhofer ISE)	*Introduction & RadHard European project*
14h15	Slavka Tzanova (TUS)	*ECoVEM Business-Science-Education Plan*
14h25	Romain Cariou (CEA-INES)	*Brief overview of Space PV research*

Session 1 | High efficiency III-V solar cells

15' talks + 5' Q&A — Chairman: Romain Cariou (CEA-INES)

14h40	Victor Khorenko (Azur Space)	*State-of-the-art in European industrial solar space cells: highest performance for advanced space applications*
15h00	Iván Garcia (IES-UPM)	*Space solar cells on detachable Ge virtual substrates*
15h20	David Lackner (Fraunhofer ISE)	*Flexible & high efficiency cells*
15h40	Ryan France (NREL)	*High efficiency advanced concept cell designs*

10' break

Session 2 | Advanced concepts for radiation hardness

15' talks + 5' Q&A — Chairman: David Lackner (Fraunhofer ISE)

16h10	Bruno Boizot (CEA)	*Controlling parameters like energy, dose and fluence during solar cells irradiation testing*
16h30	Antonino Alessi (LSI-Polytechnique)	*Sirius electron accelerator and solar cell test*
16h50	Andrea Cattoni (C2N-CNRS)	*Recent advances in ultrathin solar cells*
17h10	Carla Costa (CEA-INES /ONERA)	*Perovskites for space : challenges and advances*
17h30	Pilar Espinet (Caltech)	*Radiation resistant nanowire solar cells*

DAY 2: Solar arrays

Session 3 | III-V solar arrays for space applications

15' talks + 5' Q&A — Chairman: Maite Carreras (OneWeb)

14h00 (CET)	Anderson Bermudez (CEA-INES)	*Viability of solar power in various space environment*
14h20	Jean-Baptiste Charpentier(CEA-INES)	*The mechanics of PV ribbons lengthening induced by thermal cycling*
14h40	Emanuele Ferrando (STI)	*STI Solar Array product growth*
15h00	César Dominguez (IES-UPM)	*Micro-concentrator PV architectures for high-efficiency solar generators*

10' break

Session 4 | Towards standardization of Space PV: reliability, durability and low cost

15' talks + 5' Q&A — Chairman: Victor Khorenko (Azur Space)

15h30	Philippe Voarino (CEA-INES)	*Cubesat : solar array innovations trends*
15h50	Vicente Diaz (DHV technology)	*Design and qualification of PVA for constellations at DHV*
16h10	Maite Carreras (OneWeb)	*Solar arrays in the context of mega-constellations*
16h30	Julien Gaume (CEA-INES)	*Silicon low cost solar arrays*
16h50	Paul Zevenbergen (Airbus DS)	*Foldable disruptive solar array technology*

10' break

Session 5 | Roundtable: *Defining the R&D priorities to answer Space PV industrial challenges*

40' Q&A — Chairman: Carlos Algora (IES-UPM)

17h20-18h00 — Contributors: Victor Khorenko (Azur Space), Martin Kroon (Airbus DS), Loris Ibarrart (CNES), Vicente Diaz (DHV technology), Ryan France (NREL), David Lackner (Fraunhofer ISE), Romain Cariou (CEA-INES)

As highlights for day 1, dedicated to solar cells: cutting edge presentations from III-V EU/US experts showing cells diversification trends: more junction for efficiency premium, thinner cells for mass savings, but also radiation hard or even lower cost options. Insights on detailed irradiation damage mechanism in matter introduced the discussions on more disruptive potential space PV technologies: at devices levels with ultra-thin or nanowires approaches, but also with more exotic materials such as perovskites.

The second day, dedicated to solar arrays, was also full of captivating highlights. After an introduction reviewing the various constraints & opportunities for PV in Solar System, specific problematics were tackled: from interconnector thermomechanical behavior, micro-concentration systems up to development of deployment mechanisms by STI. Photovoltaics solutions for Cubesat and larger satellite constellations, like OneWeb, were talked through, with a strong focus on low cost, including terrestrial silicon. Status & challenges of innovative high power flexible solar arrays for geostationary missions were closing this session.

To conclude the workshop, a roundtable with 7 experts from industry (AZUR SPACE, Airbus DS, DHV technology) and Research institutes (CEA-INES, CNES, Fraunhofer ISE and NREL), summarized the main space PV R&D trends to address competitiveness, low cost and innovation.

The organization team give a warm thank you to all the participants for making this event live and prolific.