Supported by EU Horizon 2020

EuPRAXIA

European Network for Novel Accelerators

EuroNNAc 2

Pilot Applications of Electron Plasma Accelerators (PAEPA)

supported by EU via EuCARD2

The Cockcroft Institute of Accelerator Science and Technology

Universität Hamburg

SCAPA

University of Strathclyde Glasgow

Terrestrial reproduction of space radiation using Plasma Wakefield Accelerators

Panagiotis Delinikolas, Andrew Beaton, Grace Manahan, Bernhard Hidding *et al.*

Department of Physics, University of Strathclyde, UK

Space radiation

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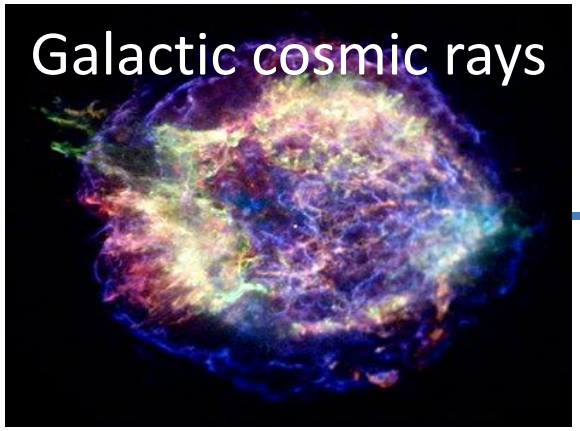
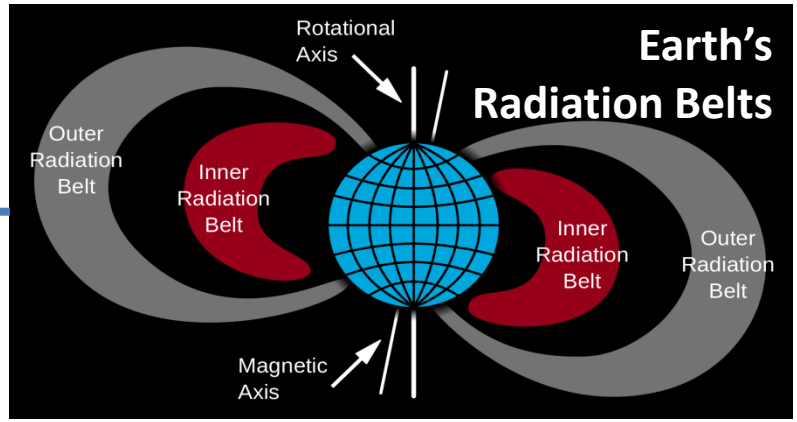
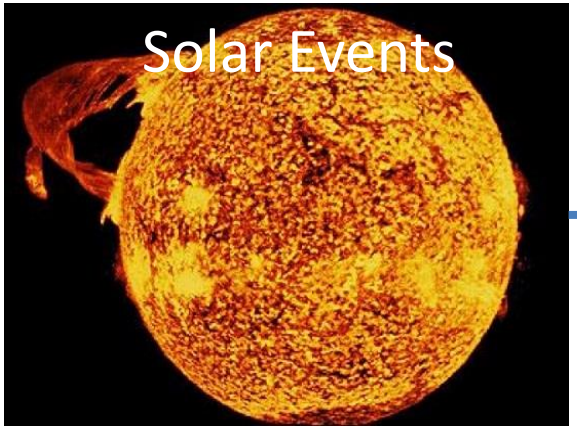


- 98% Hadrons (87% p, 12% alpha, 1% heavy)
- 2% Leptons (electrons, positrons)
- Small fraction of photons



- Broadband Electron Fluxes
- Broadband Proton Fluxes



- Mostly low energy protons and electrons
- Rarely higher-energies
- Some heavy ions

Van Allen Radiation Belts

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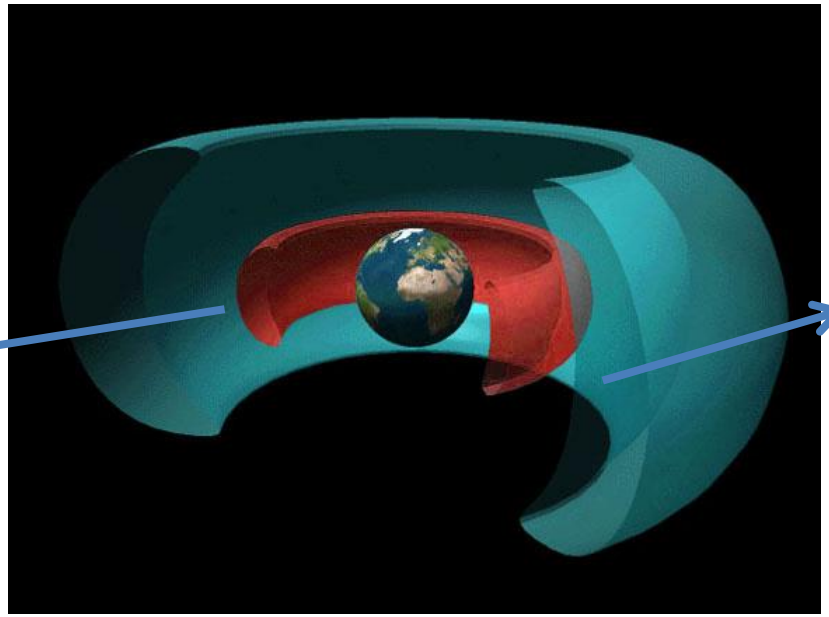
Inner Belt: 1,000-6,000km
Lower boundary can go down to 200km (ISS at 400km) depending on solar activity and the South Atlantic Anomaly.

Electrons Dominant Broadband Spectrum of several hundreds of KeV

Protons ~100MeV



Outer Belt: 13,000-60,000km

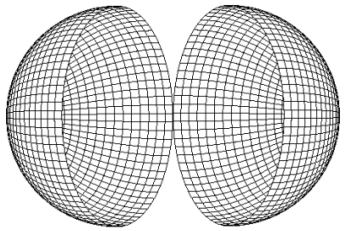
Electrons Broadband Spectrum of the hundreds of KeV to tens of MeV

Protons Dominant ~100MeV

So why these belts are so important?

High fluxes of combined galactic, solar and trapped particles affecting spacecraft electronics and crews.

Terrestrial reproduction for dosimetry and testing is crucial both for electronic testing and crew dosimetry before missions!



Particle dose in water within the Belt Region after certain Al thickness (SPENVIS)

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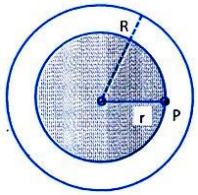
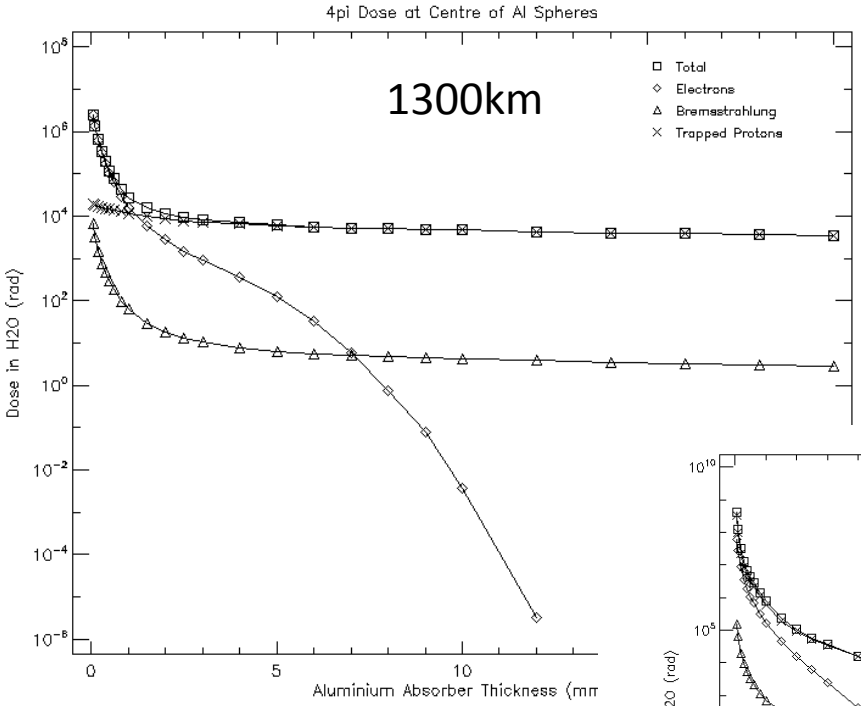
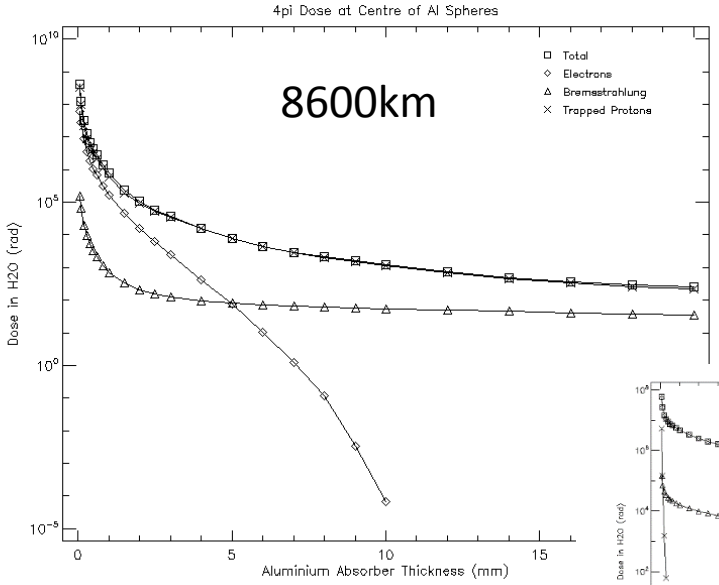
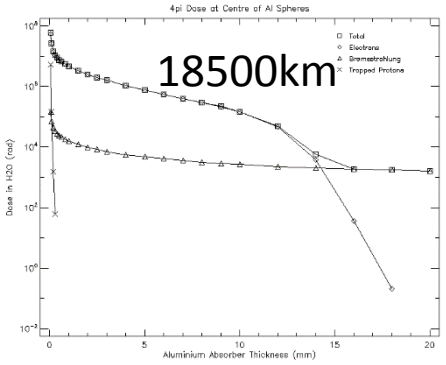




More electrons that should be seriously considered for inter-planetary missions



More protons near the Low Earth orbits (ISS, satellites etc)



Can conventional Linacs produce such space radiation spectra?

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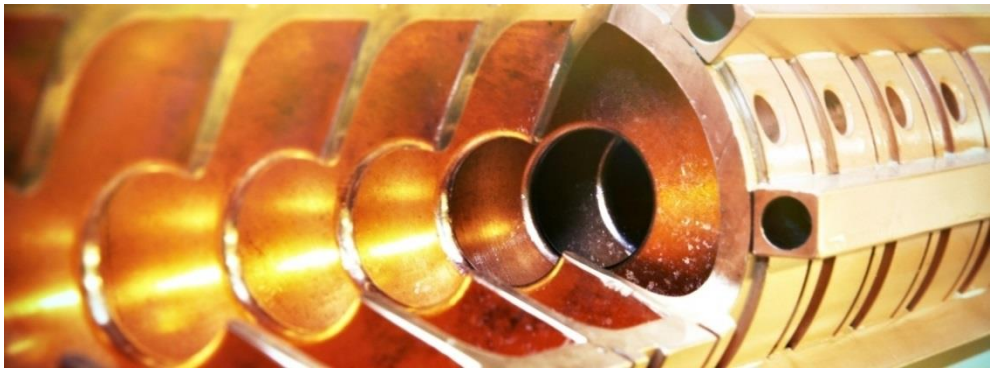
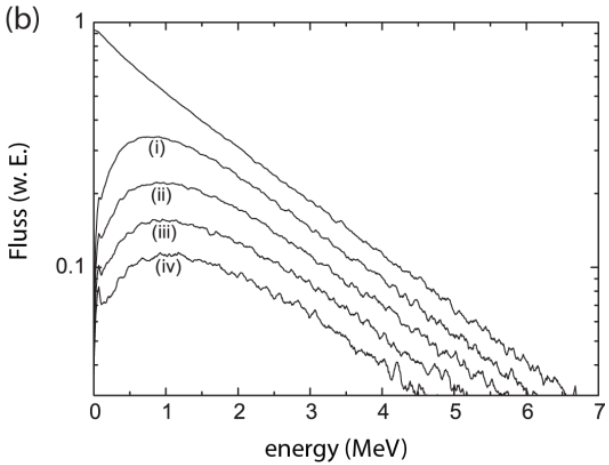
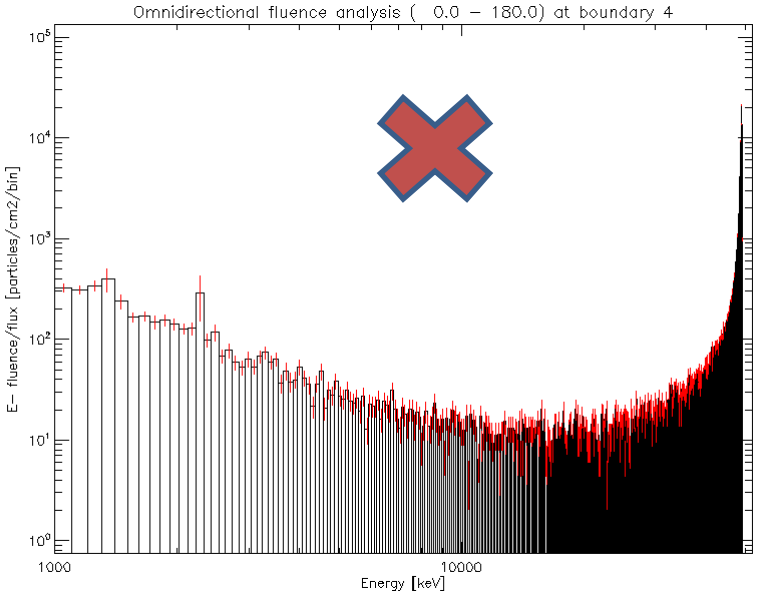


Spectrum of the produced beams from Linear Accelerators are very confined and electron bunches are rather monoenergetic.

The shape of the spectrum even after passing through a 2mm shield remains “unnatural” and certainly not space radiation like.

Broadband space radiation





Electron spectrum reproduction mechanisms based on Plasma Acceleration

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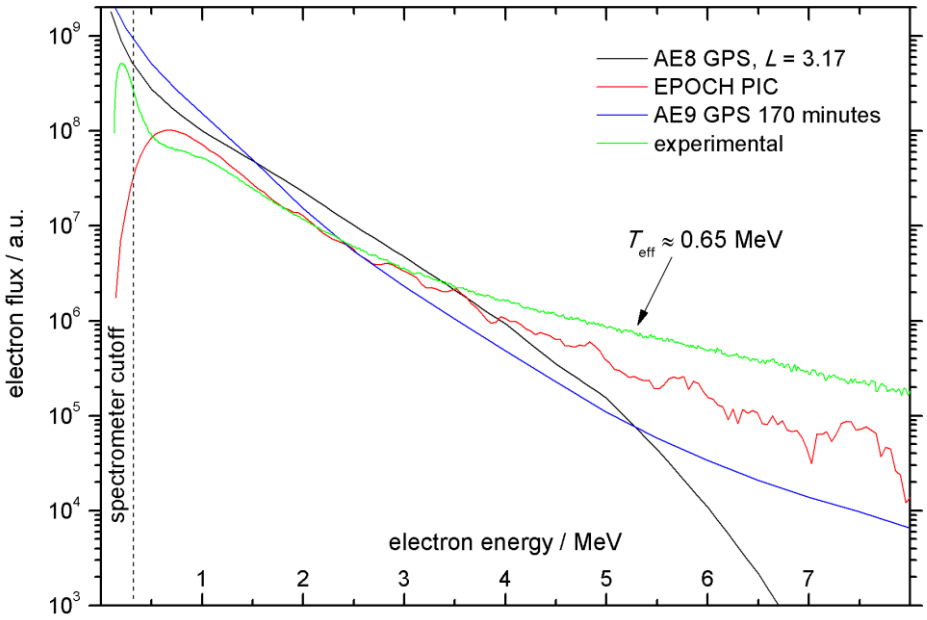
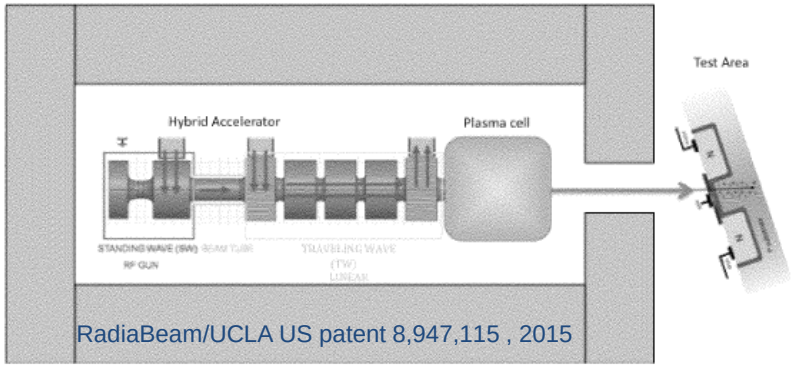
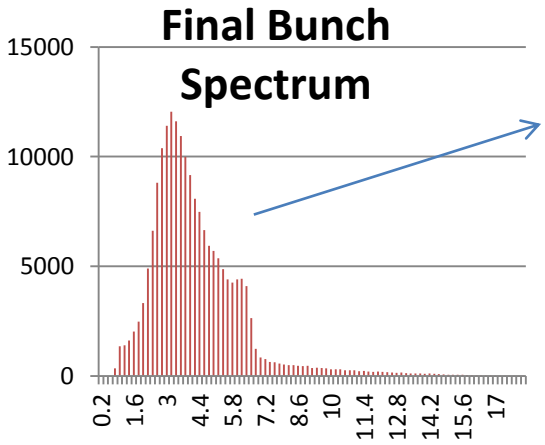
Laser Plasma Acceleration in Underdense targets



Hybrid Linac+PWFA





Tuneable by changing driver and plasma parameters (Vsim PIC)

Proton spectrum reproduction mechanism based on Plasma Acceleration

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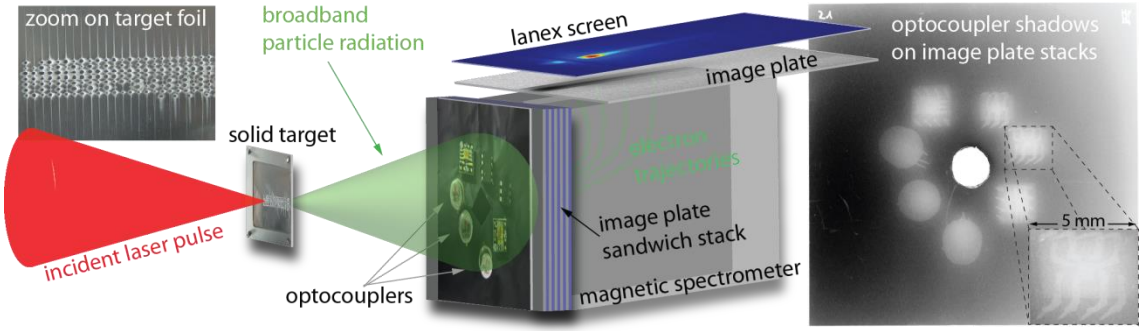
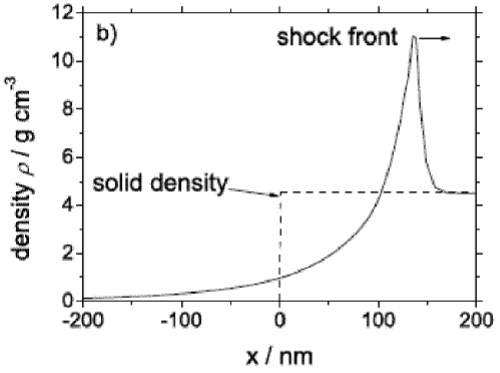
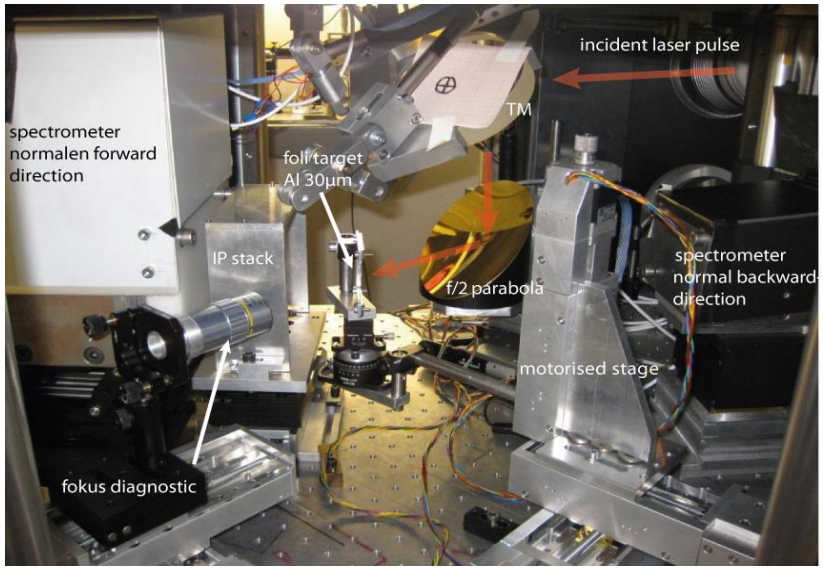
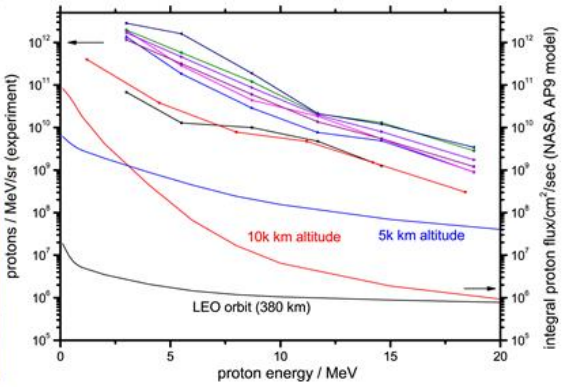
Laser-Solid Interaction









European Synergies

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HORIZON 2020

European Commission

The EU Framework Programme for Research and Innovation

CALL: FET-OPEN – NOVEL IDEAS FOR RADICALLY NEW TECHNOLOGIES

NPL

The Cockcroft Institute of Accelerator Science and Technology

New collaborations encouraged and **VERY VERY WELCOME**

Feel free to contact me:
Panagiotis.Delinikolas@strath.ac.uk

European Synergies
FET-Open Dlines

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Topic: FETOPEN-01-2016-2017: FET-Open research and innovation actions — Open
Publication date: 14 October 2015

Types of action: RIA Research and Innovation action
DeadlineModel: multiple cut-off
Opening date: 08 December 2015
Cut-off dates: 11 May 2016 17:00:00; 17 January 2017 17:00:00; 27 September 2017 17:00:00

Time Zone : (Brussels time)

Topic: FETOPEN-02-2016: FET-Open Coordination and Support Actions — Closed
Publication date: 14 October 2015

Types of action: CSA Coordination and support action
DeadlineModel: single-stage
Opening date: 08 December 2015
Deadline: 11 May 2016 17:00:00

Time Zone : (Brussels time)

Topic: FETOPEN-03-2017: FET-Open Coordination and Support Actions — Open
Publication date: 14 October 2015

Types of action: CSA Coordination and support action
DeadlineModel: single-stage
Opening date: 20 September 2016
Deadline: 17 January 2017 17:00:00

Time Zone : (Brussels time)

Topic: FETOPEN-04-2016-2017: FET Innovation Launchpad — Open
Publication date: 14 October 2015

Types of action: CSA Coordination and support action
DeadlineModel: multiple cut-off
Opening date: 01 March 2016
Cut-off dates: 29 September 2016 17:00:00; 27 September 2017 17:00:00

Time Zone : (Brussels time)

ESA support

Final Report (180 pages): Study of Space Radiation Effects with Laser-Plasma-Accelerators, European Space Agency (ESA) Network Partnering Contract No. 4000102854, B. Hidding, O. Karger, T. Königstein, G. Pretzler, J. B. Rosenzweig, (2014)

Final Report: Laser-Plasma-Accelerator's Potential to Radically Transform Space Radiation Testing, European Space Agency (ESA) General Studies Programme (GSP) activity, Contract No. GSP-SOW-10-xx16 // RFQ 3-13258/11/NL/AF, 2014

Jupiter belts are inhabited by broadband electrons with energies up to 150 MeV, reachable by both the laser –underdense and the electron driven wakefield acceleration methods.

Eupraxia Scope

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A **radiation testing network** can be realized within the Eupraxia community and is extremely important both for **Space radiobiology** and **electronics testing**. We would be more than happy to coordinate this attempt!

Since the generation of the broadband energy is much easier than the monoenergetic beams, **early applications of the Eupraxia facility** for space radiation reproduction are possible.

University of Strathclyde Glasgow

Thank you

Panagiotis Delinikolas
MSc Med.Phys, PhD Student, UoS

Literature

University of Strathclyde Glasgow

- B. Hidding, T. Königstein, O. Willi, G. Pretzler. Method for testing the radiation hardness of electronic devices with particle and photon beams generated by laser-plasma-interaction.German Patent AZ 10 2010 010 716.6, March 2010. Filed on March 8, 2011 as extended United States patent in collaboration with RadiaBeam Technologies, Santa Monica, Method for testing electronic components, Serial No. 13/042,738

- Laser-plasma-accelerators -- A novel, versatile tool for space radiation studies, B. Hidding, T. Königstein, O. Willi, J.B. Rosenzweig, K. Nakajima, and G. Pretzler. Nucl. Instr. Meth. A, Vol. 636, 1, 2011.

- Design and applications of an X-band hybrid photoinjector, J.B. Rosenzweig, A. Valloni, D. Alesini, G. Andonian, N. Bernard, L. Faillace, L. Ficcadenti, A. Fukusawa, B. Hidding, M. Migliorati, A. Mostacci, P. Musumeci, B. O'Shea, L. Palumbo, B. Spataro and A. Yakub, Nuclear Instruments and Methods in Physics A, 657, 1, pp. 107-113, 2011.

- Design considerations for the use of laser-plasma accelerators for advanced space radiation studies, T Königstein, O. Karger, G. Pretzler, J. B. Rosenzweig, B. Hidding, Journal of Plasma Physics, Volume 78 / Special Issue 04 / August 2012, pp 383-391

- ESA NPI project “Study of Space Radiation Effects with Laser-Plasma-Accelerators” final report, 2014

- ESA GSP project “Laser-Plasma-Accelerator’s Potential to Radically Transform Space Radiation Testing”, 2014

- Proof-of-concept Ti:Sapphire laser experiment results submitted