Radiation Effects Research in Finland

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

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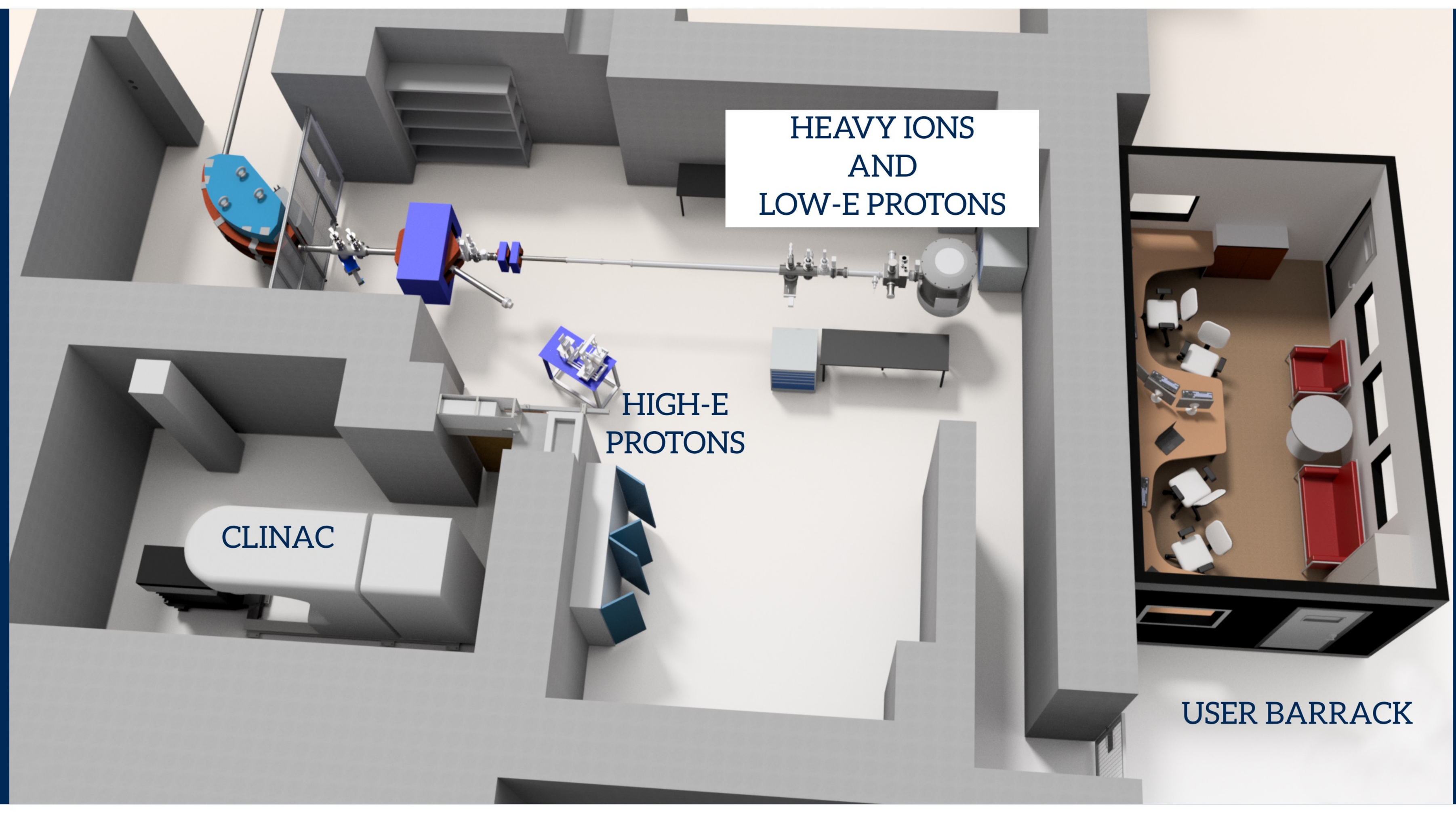
Introduction

In order to assure the reliability of a satellite mission, one important consideration is the inevitable presence of the radiation field in the satellite operating environment. The radiation effects, induced by (1) high energy heavy-ions, (2) protons and (3) electrons, as well as (4) high energy gammas from various sources in the solar system, can dramatically interfere the operation of space systems. In worst cases, the radiation can result in the loss of the whole mission. Radiation effects can be studied by using particle accelerators and other artificial radiation sources already on ground level before launch. The Accelerator Laboratory in the University of Jyväskylä hosts the RADiation Effects Facility, RADEF, that provides energetic particle beams, which are frequently used for radiation hardness assurance testing for the needs of various space projects. Among others, in RADEF's years of operation, electronic devices used practically in each ESA's space missions (e.g. BebiColombo, JUICE etc.) designed during that period, have been tested at this facility.

RADiation Effects Facility - RADEF

RADEF is specialized in applied research regarding radiation effects on electronic devices and systems, as well as related materials. RADEF officially became an ESA supported European Component Irradiation Facility (ECIF) in 2005. Since then irradiation tests have been carried out not only for ESA and the European space industry, but also for other world leading space organizations, companies and universities (e.g. NASA, JAXA, CNES). The contract with ESA was again extended for five years in 2018. The facility offers wide variety of different sorts of radiation types from gammas and electrons to protons and heavy ions for research. For these, the RADEF group utilizes the LINAC electron accelerator, and combination of JYFL's ECR ion sources and K-130 cyclotron.



Heavy Ion Beams

16.3 MeV/u	**LET [MeV cm^2/mg]**	**Range [µm]**
O	1.5	481
Ne	2.3	360
Ar	7.2	264
Fe	13.3	214
Kr	24.5	185
Xe	48.5	157

* Fast ion change
* Practical flux maximum: 5x10^5 ions/cm^2/s
* Irradiation area: max. dia. 5 cm in vacuum, 3 cm in air
* "Old" 9.3 MeV/u cocktail: N, Ne, Ar, Fe, Kr, Xe

Protons

High Energy
* up to 55 MeV
* Fast energy changes using degraders
* Maximum flux 3x10^8 p/cm^2/s
* Beam diameter 10 cm
* Irradiation in air

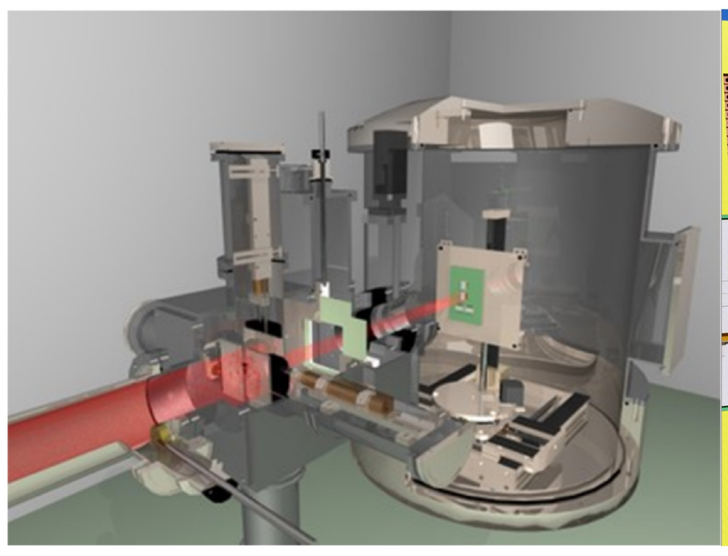
Low Energy
* 0.4–8 MeV (freely adjustable)
* Energy resolution 30 keV (FWHM)
* Beam diameter max. 5 cm
* Irradiation in vacuum

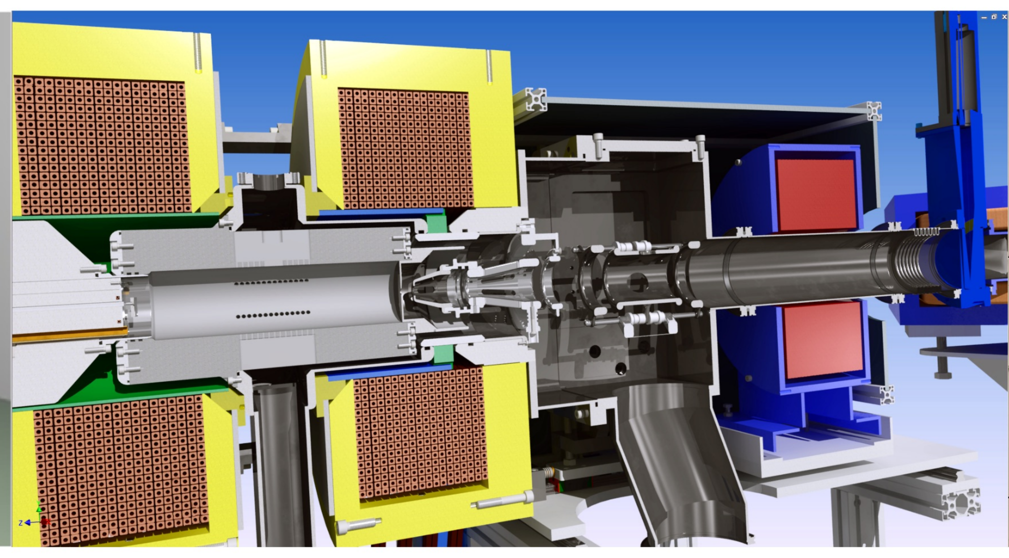
Electrons and Gammas

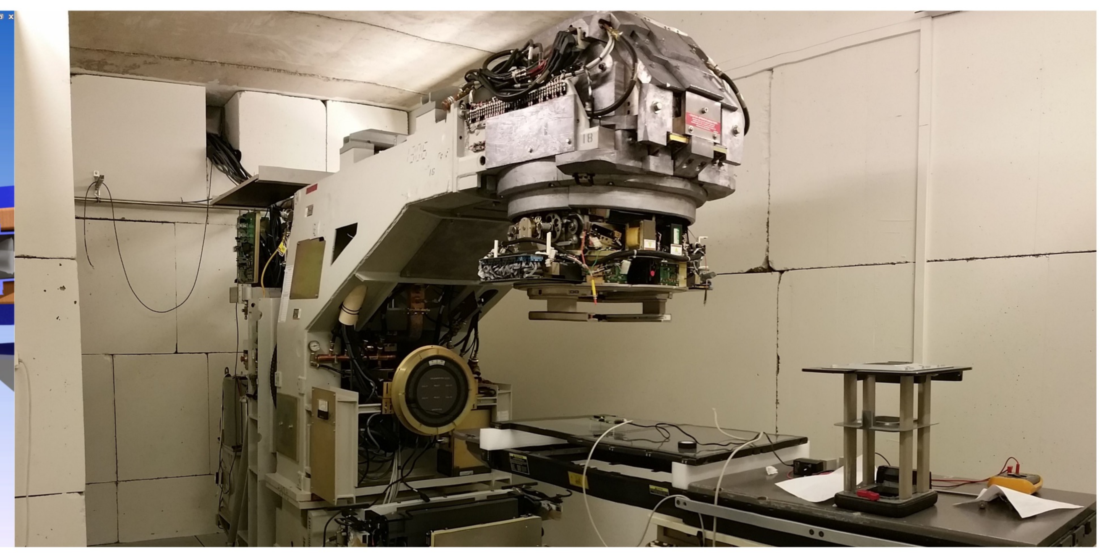
* Recommisioned radiotherapy accelerator
* Beam size 30 x 30 cm max
* Pulsed beam

Electrons
* Energies 6, 9, 12, 16 and 20 MeV
* Dose rate 100–1000 rad(H_2O)/min

Gamma-rays
* Bremsstrahlung spectrum
* Terminal voltages 6 MV and 15 MV
* Dose rate 100–600 rad(H_20)/min







Future in Radiation Effects Reseach

With the dramatic increase in commercial satellite activities (cubesats, megaconstellations, etc.) worldwide it is foreseen to increase need for studies of radiation effects in satellite electronics. The higher demand is already showing up as increased beam time requested at RADEF by various companies, such as Thales Alenia Space, Airbus, and Boeing. Also, both the EU and ESA has expressed their concerns about the radiation related risks in the overall systems reliability due to increased use of commercial electronics in space. Additionally, recent studies have shown that due to the decreasing technological node size, radiation can cause issues also in ground level applications. In order to address these future challenges, RADEF in collaboration with CERN and other European institutes formed a consortium for an EU MSCA ITN project RADSAGA (*https://radsaga.web.cern.ch/*) that will educate PhDs for European industry needs. Also the University of Jyväskylä and its Accelerator Laboratory is planning to build a new cyclotron for higher particle energy beams, which in turn will make RADEF the leading test facility in Europe, and competing side-by-side with international facilities, such as the Texas A&M in the US.

RADSAGA

www.jyu.fi/accelerator/radef

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