Profile SFR-81

JANNUS

FRANCE

GENERAL INFORMATION

NAME OF THE FACILITY	JANNUS (Joint Accelerators for Nanoscience and Nuclear Simulation)
ACRONYM	JANNUS
MAIN PURPOSE	Materials irradiation – triple ion-beam facility
MEMBER STATE (country):	FRANCE
LOCATION (address):	CEA Paris-Saclay, B. 126 F-91191 Gif-sur-Yvette, FRANCE
OPERATOR / OWNER	CEA
CONTACT PERSON(S) (name, address, institute, function, telephone, email):	C. CABET JANNUS, B. 126 CEA Paris-Saclay F-91191 Gif-sur-Yvette CEA/DEN/ Department for Nuclear Materials Facility manager tel. +33 169 081 615 celine.cabet@cea.fr

STATUS OF THE FACILITY	In Operation
Start of operation (period):	2010's
Exact dates facility operated:	2010

MAIN RESEARCH FIELD(S)

- ☒ Zero power facility for V&V and licensing purposes
- ☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)
- ☐ Thermal-hydraulics
- ☐ Coolant chemistry
- ☒ Materials
- ☐ Systems and components
- ☐ Instrumentation & ISI&R
  + Fuel irradiation and testing

TECHNICAL DESCRIPTION

Description of the facility

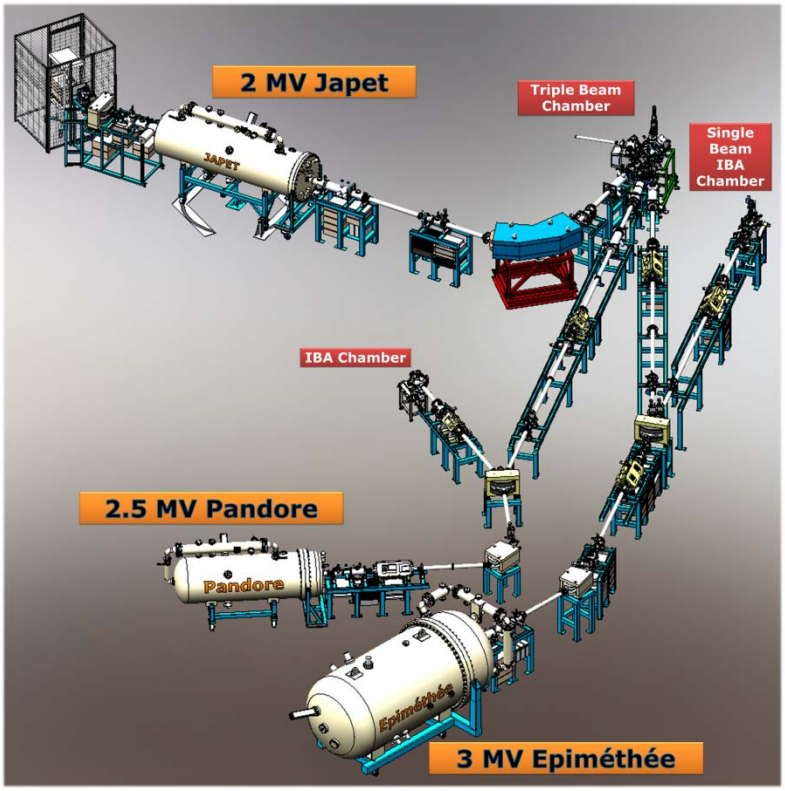
JANNuS is dedicated to the experimental simulation and fundamental knowledge of neutron damages in nuclear materials. Served by an experienced scientific staff, the JANNuS-Saclay facility consists of three electrostatic ion accelerators (respectively named Epimethee, Japet and Pandore) connected to a triple beam end-station for single-, dual- and triple beam irradiations/implantations. Two other end-stations are linked to Epimethee and Pandore for single beam ion irradiation/implantations and/or Ion Beam Analysis. These particle beams make it possible to irradiate small samples in a perfectly controlled manner, and thus to observe and quantify the evolution of their microstructure (segregation, precipitation, dissolution, change in the dislocation

network, formation of dislocation loops, cavities, bubbles, etc). Such a scientific platform has no equivalent in Europe and plays an essential role for multi-scale modelling of radiation effects in materials.

Acceptance of radioactive material

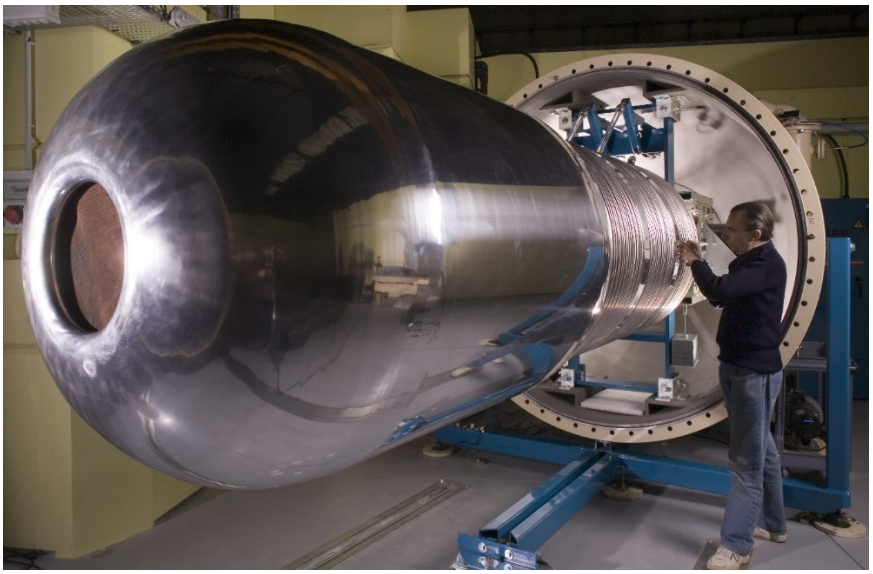
No

Scheme/diagram:



facility artistic birdview

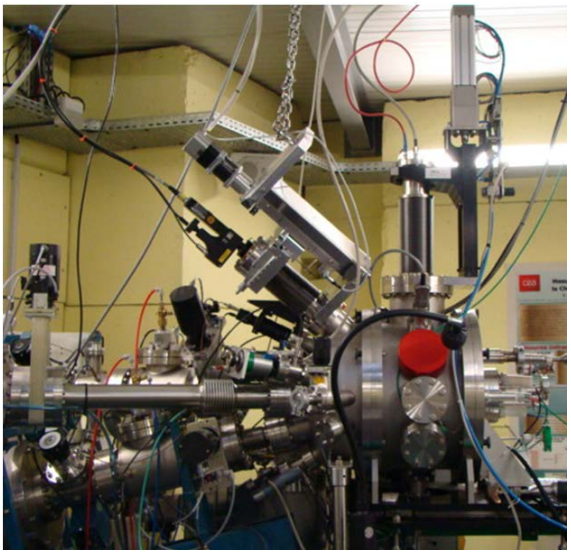
3D drawing/photo



3MV accelerator Epimethee

2MV tandem accelerator Japet

2.5MV accelerator Pandore



Triple ion beam end-station

Parameters table

Main characteristics:

Accelerator Epimethee	
Manufacturer	N.E.C. and Pantechnik
Type and voltage	Pelletron® 3 MV
Source	Electronic Cyclotron Resonance (ECR) with gasses and metals from organometallics
Beam type	Continuous beam of Ø~3mm raster scanned on 20 mm
Most frequent ions	Helium, charge: 1+, 2+ E_{min}-E_{max}: 0.5-6 MeV / Max current on target: 140 µAmp Argon, charge: 1 to 11+ E_{min}-E_{max}: 0.5-33 MeV / Max current on target: 70 µAmp Iron, charge: 1+, 3+, 5+, 9+ E_{min}-E_{max}: 0.5-27 MeV / Max current on target: 8 µAmp Krypton, charge: 4+, 8+ E_{min}-E_{max}: 0.5-24 MeV / Max current on target: 10 µAmp Xenon, charge: 3 to 12+ E_{min}-E_{max}: 0.5-36 MeV / Max current on target: 12 µAmp Tungsten, charge: 4 et 16+ E_{min}-E_{max}: 0.5-48 MeV / Max current on target: 5 µAmp ➔ Typical damage rate: 5.10^5 dpa/s to 3.10^3 dpa/s
Accelerator Pandore	
Manufacturer	N.E.C.
Type	Pelletron® 2.5 MV
Source	Radio Frequency
Beam type and size	Continuous beam of Ø~3mm raster scanned on 20 mm
Available ions	Hydrogen and deuterium, charge: 1+ E_{min}-E_{max}: 0.5-2.5 MeV / Max current on target: 2 µAmp Helium, isotopes 3 and 4, charge: 1+ E_{min}-E_{max}: 0.5-2.5 MeV / Max current on target: 9 µAmp

Accelerator Japet	
Manufacturer	N.E.C.
Type	tandem 2 MV
Source	Secondary Negative Ions by Cesium Sputtering with a solid cathode
Beam type and size	Continuous beam of Ø~3mm raster scanned on 20 mm
Most frequent ions	Hydrogen, charge: 1+ E_{min}-E_{max}: 0.5-4 MeV / Max current on target: 50 µAmp Aluminum, charge: 1 to 8+ E_{min}-E_{max}: 0.5-14 MeV / Max current on target: 3 µAmp Silicon, charge: 1 to 8+ E_{min}-E_{max}: 0.5-14 MeV / Max current on target: 18 µAmp Titanum, charge: 1 to 6+ E_{min}-E_{max}: 0.5-14 MeV / Max current on target: 2 µAmp Nickel, charge: 2 to 7+ E_{min}-E_{max}: 0.5-16 MeV / Max current on target: 5 µAmp Copper, charge: 2 to 8+ E_{min}-E_{max}: 0.5-18 MeV / Max current on target: 2 µAmp Iodin, charge: 2 to 8+ E_{min}-E_{max}: 0.5-18 MeV / Max current on target: 4 µAmp Gold, charge: 3 to 6+ E_{min}-E_{max}: 0.5-14 MeV / Max current on target: 1 µAmp
End stations	
Triple beam end-station	Experiment in single, dual and triple ion beam Heated/cooled stage with temperature: LN2 to 800°C Different sample-holders with target size of 2 cm² Temperature control: several thermocouples, IR camera Current measurement during irradiation: multipin Faraday cups Vacuum: UHV (<10^7 Torr) with cold trap On line characterization: Raman spectroscopy
Single beam end-station	Experiment with Epimethee ion beam Heated/cooled stage with temperature: LN2 to 800°C Different sample-holders with target size of 2 cm² Temperature control: several thermocouples, IR camera Current measurement during irradiation: multipin Faraday cups Vacuum: UHV (<10^7 Torr) with cold trap On line characterization: ERDA, RBS
High temperature end station	Experiment with Epimethee ion beam Heated stage with temperature up to 1200°C 1 sample of 1 cm² Temperature control: several thermocouples, bi-chromatic pyrometer Current measurement before/after: multipin Faraday cups with current monitoring during irradiation Vacuum: UHV (<10^7 Torr) with cold trap
IBA end station	RBS, NRA, PIXE/PIGE Room temperature

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

Since its commissioning and its opening as a user facility in 2008, JANNuS-Saclay has performed more than 300 experimental campaigns for various CEA and external users.

Many irradiation experiments were completed in support of the development and the fundamental knowledge of the radiation resistance of GenIV related materials.

Examples are:

- high dose irradiations of advanced austenitic steels and ODS steels for SFR cladding,
- dual beam irradiation helium and ballistic damage of SFR absorber,
- low dose irradiation with helium implantation for upper core structure of SFR,
- irradiation of SiC and SiC/SiC composite and under-beam tensile tests of SiC fiber in support of GFR cladding,
- irradiation of advanced carbides ZrC, TiC, SiC… for VHTR and GFR fuel assembly…

PLANNED EXPERIMENTS (including time schedule)

Some of the above-mentioned research programs are going on and more irradiation/implantation experimental campaigns are going to be performed on SFR cladding steels, absorber material and for structures exposed to a very low-dose.

In the near future, experiments on fuel (UO2) will be extend up to 1200°C in the newly build high-temperature end-station.

TRAINING ACTIVITIES

None

INFORMATION PROVIDED

Name	C. Cabet
Date of update	01/18, 2019

REFERENCES (*specification of availability and language*)

Provide list of references (preferably in IAEA publication format):

Y. Serruys, M.-O. Ruault, P. Trocellier et al., Multiple ion beam irradiation and implantation: JANNuS project, Nuclear Instruments and Methods in Physics Research Section B 240 (2005) 124.

Y. Serruys, P. Trocellier, S. Miro et al., JANNUS: A multi-irradiation platform for experimental validation at the scale of the atomistic modelling, Journal of Nuclear Materials 386 (2009) 967.

L. Beck, Y. Serruys, S. Miro et al., Ion irradiation and radiation effect characterization at the JANNuS-Saclay triple beam facility, Journal of Materials Research 30 (2015) 1183.

S. Miro, G. Velisa, L. Thome et al., Monitoring of the microstructure of ion-irradiated nuclear ceramics by in situ Raman spectroscopy, Journal of Raman Spectroscopy 47 (2016) 476.

S. Bouffard, EMIR: The French Accelerator Network for Material Irradiation, Nuclear Physics 26 (2016) 14

A. Gentils, C. Cabet, Investigating radiation damage in nuclear energy materials using JANNuS multiple ion beams, submitted to Nuclear Instruments and Methods in Physics Research Section B

website http://emir.in2p3.fr

Indicate if information has been included in or published as part of IAEA activities:
CRP SMoRE-II 2016-2020