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## IRSN Irradiation facilities

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# NUTECH-2020

Warsaw, 4-7 October 2020

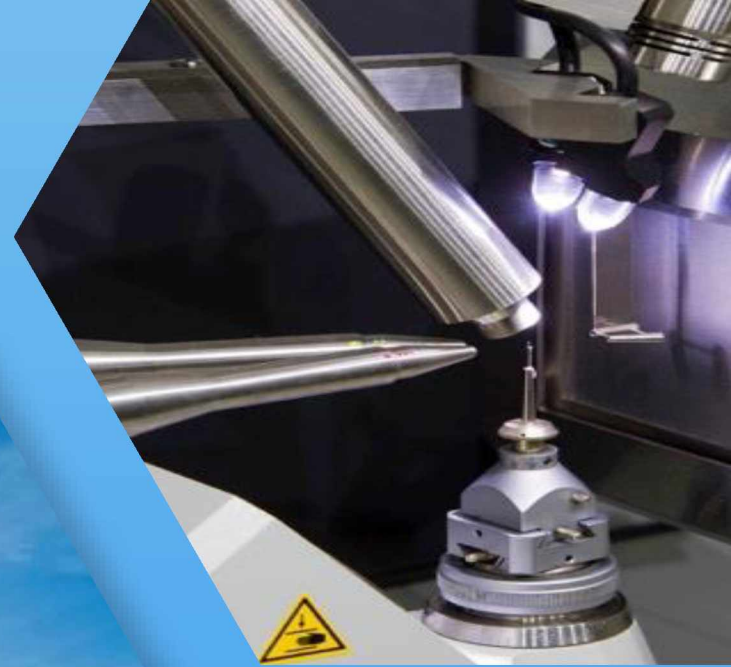
International Conference on Development and  
Applications of Nuclear Technologies



IRSN J.Colombani

## IRSN irradiation facilities

Irradiation skills and knowledge in the  
fields of medicine, environment and  
nuclear industry



# IRSN irradiation facilities overview

IRSN : Institut de Radioprotection et de Sûreté Nucléaire

Public expert in France on nuclear and radiation risks

↳ contributes to public policy of protection against ionizing radiation

in the fields of:

- Nuclear safety
- Human protection
- Environmental protection

▶ *EPICUR*  $\gamma$  ( $^{60}\text{Co}$ )

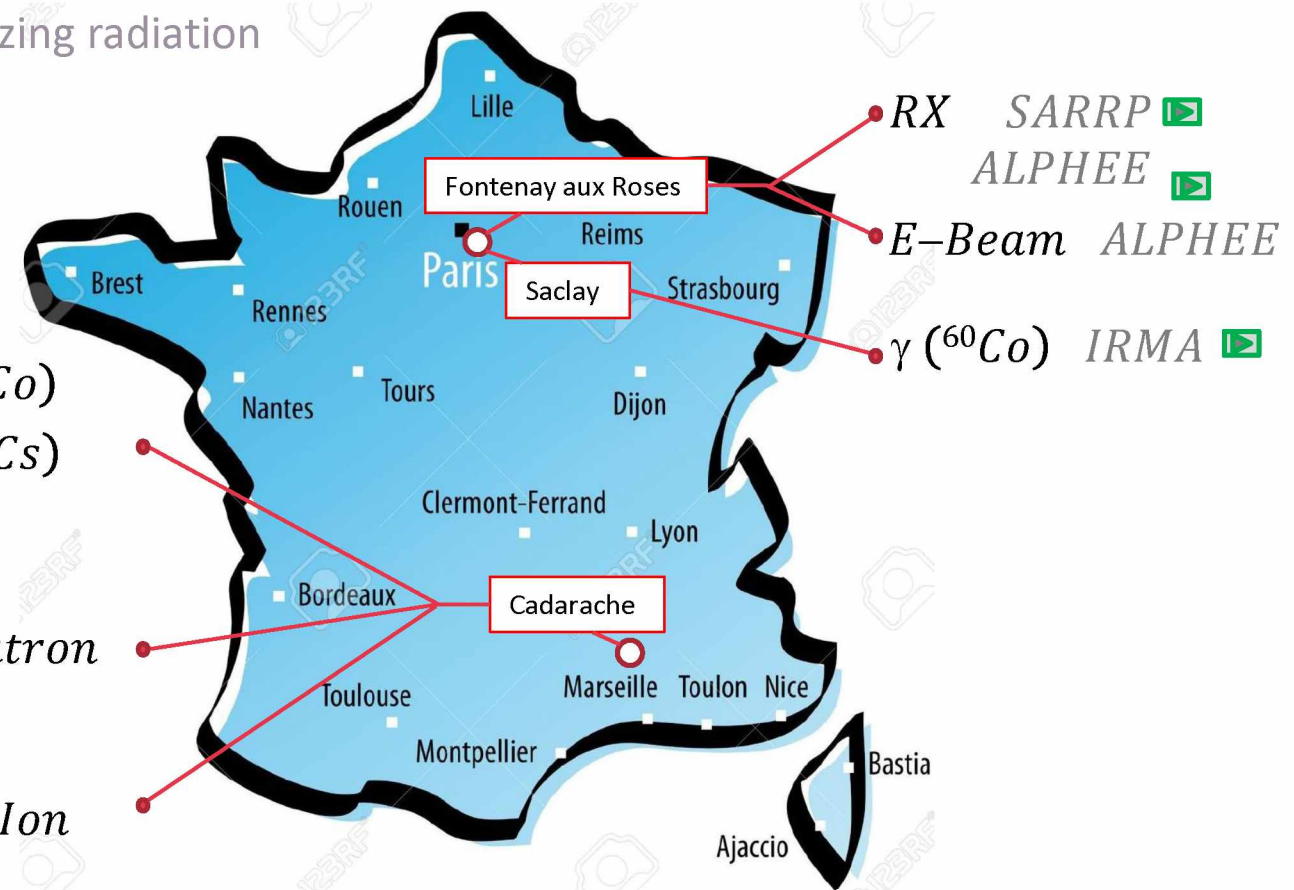
▶ *MICADO*  $\gamma$  ( $^{137}\text{Cs}$ )

▶ *VAN GOGH*

▶ *AMANDE* Neutron

▶ *CARAT*

▶ *MIRCOCM* Ion





# Main technical features of the IRSN irradiation facilities

Facilities	Radiation	Source	Activity / Energy	Dose rate	Sample size	Irradiation specifications			
						Pressure	Temperature	Relative Humidity	Atmosphere
EPICUR	Gamma	$^{60}\text{Co}$	555 TBq max	several kGy/h	several cm <sup>2</sup>	1,2 to 5 bars	20 to 140°C	0 to 100% (controlled RH)	Air, O <sub>2</sub> , He...
IRMA	Gamma	$^{60}\text{Co}$	1450 TBq max	5 μGy/h to 20 kGy/h	until 1m <sup>2</sup>	1 bar	Ambient	Ambient	Air
MICADO	Gamma	$^{137}\text{Cs}$	444 GBq max	5 μGy/h to 100 mGy/h	> 1m <sup>3</sup>	1 bar	Ambient	Ambient	Air
ALPHEE	Ebeam	Accelerator	4, 6, 8, 10 and 12 MeV	0,6 to 2 Gy/min	30cm <sup>2</sup> at 1m from the source	1 bar	21°C	Ambient	Air
	RX	Accelerator	4, 10 and 18 MV	0,6 to 5 Gy/min	30cm <sup>2</sup> at 1m from the source	1 bar	21°C	Ambient	Air
SARRP	RX	Micro Irradiator	30 – 225 kV	few cGy/mn	several mm <sup>2</sup> to cm <sup>2</sup>	1 bar	21°C	Ambient	Air
MIRCOM	Ions	Accelerator	protons : 1 to 4 MeV	from 1 to a few thousand particles /s	from a few μm to mm in diameter	1 bar	20°C à 37 °C	Ambient (30 to 60 %)	Air
			alpha particles: 1 to 6 MeV						
			heavier ions : 3to 8-10 MeV						
AMANDE	Neutrons	Accelerator	2 keV to 20 MeV	up to 10 mSv/h at 1 m distance	depending on the distance (solid angle <5° recommended)	1 bar	20 °C	Ambient (30 to 60 %)	Air
CARAT	Neutrons	Accelerator	de 0 to 3 MeV	3 MeV : 0 - 50 mSv/h at 1 m distance	up to a few tens of cm radius	1 bar	20 - 25 °C	Ambient (20 à 60 %)	Air
				Thermal neutron fiels : 0 - 100 μSv/h					
				Realistic neutron fields : 0 - 1 mSv/h					
VAN GOGH	Neutrons	Source	Average energy	1 m away from the source (01/01/2020)	up to a few tens of cm radius	1 bar	20 - 25 °C	Ambient (20 to 60 %)	Air
		Am-Be	4,4 MeV	400 μSv/h					
		$^{252}\text{Cf}$	2,3 MeV	4 mSv/h					
		$^{252}\text{Cf}$ (moderate by D <sub>2</sub> O)	2,1 MeV	1 mSv/h					



# Skills & expertise, projects & collaborations and significant publications

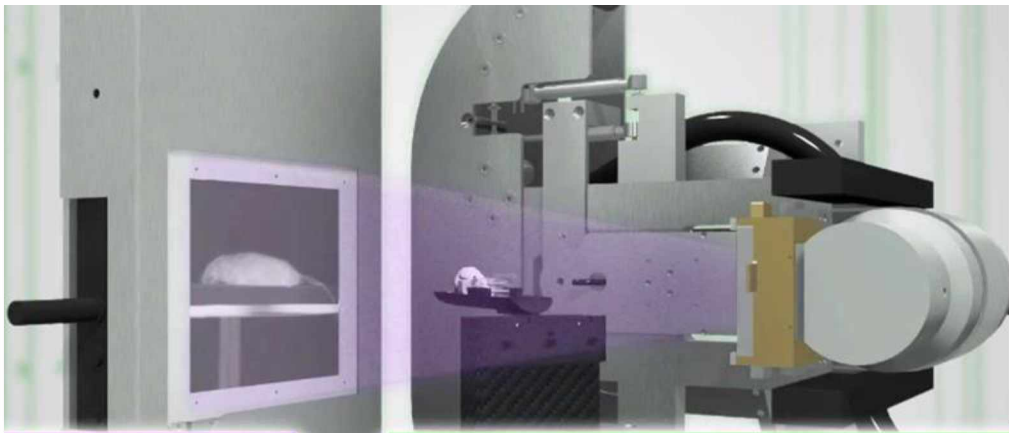
Facilities	Radiation	Associated experimental means	Skills and expertise	Projects and Collaborations	Internet link	Publications
EPICUR	Gamma	Medium and Near Infrared	Iodine behavior under radiation	H2020 (TeaM Cables project); OECD (STEM1&2 projects)	<a href="https://www.irsn.fr/EN/Research/Scientific-organisations/Research-programmes/SOURCE-TERME/EPICUR/Pages/EPICUR-Experimental-programme-of-iodine-chemistry-under-radiation-https://www.irsn.fr/EN/prestations_et_ formations/prestations/installations-nucleaires-et-industrielles/pages/evaluer_comportement_materiaux_equipements_sous_irradiation.aspx#t.X2u0uKd">https://www.irsn.fr/EN/Research/Scientific-organisations/Research-programmes/SOURCE-TERME/EPICUR/Pages/EPICUR-Experimental-programme-of-iodine-chemistry-under-radiation-https://www.irsn.fr/EN/prestations_et_ formations/prestations/installations-nucleaires-et-industrielles/pages/evaluer_comportement_materiaux_equipements_sous_irradiation.aspx#t.X2u0uKd</a>	J. Colombani et al, Analytica Chimica Acta 960 (2017) 53-62
		Time Induction Oxidation				A. Sidi et al, Radiation Physics and Chemistry 142 (2018) 14-22
		Elongation at Break	Ageing of polymers and other compounds			L. Bosland et al, Annals of Nuclear Energy 140 (2020) 107241
		Scanning Electron Microscopy				J. Colombani et al, Polymer Degradation and Stability 153 (2018) 130-144
IRMA	Gamma	Scanning Electron Microscopy	Irradiation of materials	ANDRA, CEA	<a href="https://www.irsn.fr/EN/Research/Scientific-organisations/Research-programmes/SOURCE-TERME/EPICUR/Pages/EPICUR-Experimental-programme-of-iodine-chemistry-under-radiation-https://www.irsn.fr/EN/prestations_et_ formations/prestations/installations-nucleaires-et-industrielles/pages/evaluer_comportement_materiaux_equipements_sous_irradiation.aspx#t.X2u0uKd">https://www.irsn.fr/EN/Research/Scientific-organisations/Research-programmes/SOURCE-TERME/EPICUR/Pages/EPICUR-Experimental-programme-of-iodine-chemistry-under-radiation-https://www.irsn.fr/EN/prestations_et_ formations/prestations/installations-nucleaires-et-industrielles/pages/evaluer_comportement_materiaux_equipements_sous_irradiation.aspx#t.X2u0uKd</a>	
			Study of radiation/matter interactions			
MICADO	Gamma	Fish housing and invertebrate breeding platforms	Study of the effects of radiation on living organisms	CEA, Sterling University	<a href="https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/MICADO-Lab/Pages/MICADO-Lab-experimental-platform.aspx">https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/MICADO-Lab/Pages/MICADO-Lab-experimental-platform.aspx</a>	N. Guirandy et al, Environmental Toxicology and Chemistry 38(11) (2019) 2556-2567
		Biological analysis platform				M. Kuzmic et al, Free Radical Biology and Medicine 134 (2019) 657-665
		Dosimetry platform				S. Murat El Houdigui et al, Scientific reports 9(1) (2019) 20241
ALPHEE	Ebeam				<a href="https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/ALPHEE-accelerator/Pages/default.aspx">https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/ALPHEE-accelerator/Pages/default.aspx</a>	S. Murat El Houdigui et al, International Journal of Molecular Sciences 21(11) (2020) 1014
	RX	Semiflex ionization Chamber	Radiobiology Irradiation of dosimeters			
SARRP	RX	Semiflex Ionization Chamber	Radiobiology	IGR, CEA	<a href="https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/SARRP/Pages/default.aspx">https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/SARRP/Pages/default.aspx</a>	A. Bertho et al, International journal of radiation oncology, biology, physics 107(3) (2020) 548-
		Soft X-Ray Chamber	Stereotactic irradiation of small animals			N. Tang et al, International Journal of Molecular Sciences 20(24) (2019) 6204
MIRCOM	Ions	Passivated Implanted Planar Silicon Detector	Radiobiology	CEA, CNRS, Aix-Marseille University, PTB	<a href="https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/MIRCOM/Pages/default.aspx">https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/MIRCOM/Pages/default.aspx</a>	M. Dos Santos et al, International Journal of Radiation Biology 94(6) (2018) 597-606
		Epifluorescence microscope	Study of the effects of radiation on cells			A. Freneau et al, International Journal of Radiation Biology 94(12) (2018)1075-1084
		Particle detectors				
AMANDE	Neutrons	Neutron detectors	Instrument calibration Metrology	European metrology institutes	<a href="https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/Amade/Pages/Amade-facility.aspx">https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/Amade/Pages/Amade-facility.aspx</a>	V. Gressier V et al, Nuclear Instruments and Methods in Physics Research A 505(1-2) (2003) 370-
		Photon detectors				V. Gressier et al, Radiation Protection Dosimetry 110(1-4) (2004) 49-52
CARAT	Neutrons	Neutron detectors	Instrument calibration Metrology	European metrology institutes	<a href="https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/CARAT/Pages/default.aspx">https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/CARAT/Pages/default.aspx</a>	M. A. Cagnet et al, Metrologia 47 (2010) 377-386
		Photon detectors				V. Gressier et al, Metrologia 51 (2014) 531
						V. Lacoste et al, Radiation Protection Dosimetry 110(1-4) (2004) 123-127
VAN GOGH	Neutrons	Neutron detectors	Instrument calibration Metrology	European metrology institutes	<a href="https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/VAN_GOGH/Pages/default.aspx">https://www.irsn.fr/EN/Research/Scientific-tools/experimental-facilities-means/VAN_GOGH/Pages/default.aspx</a>	V. Gressier et al, Radiation Protection Dosimetry 110(1-4) (2004) 523-527
		Photon detectors				V. Lacoste et al, Radiation Protection Dosimetry 125(1-4) (2007) 185-188
						V. Lacoste, Radiation Protection Dosimetry 126(1-4) (2007) 58-63
						V. Gressier et al, Radioprotection 41 (2006) 11-32
						N. Magalotti et al Radiation Protection and Dosimetry 125(1-4) (2007) 69-72
						F. Langner et al, Radiation Protection Dosimetry 126(1-4) (2007) 145-150



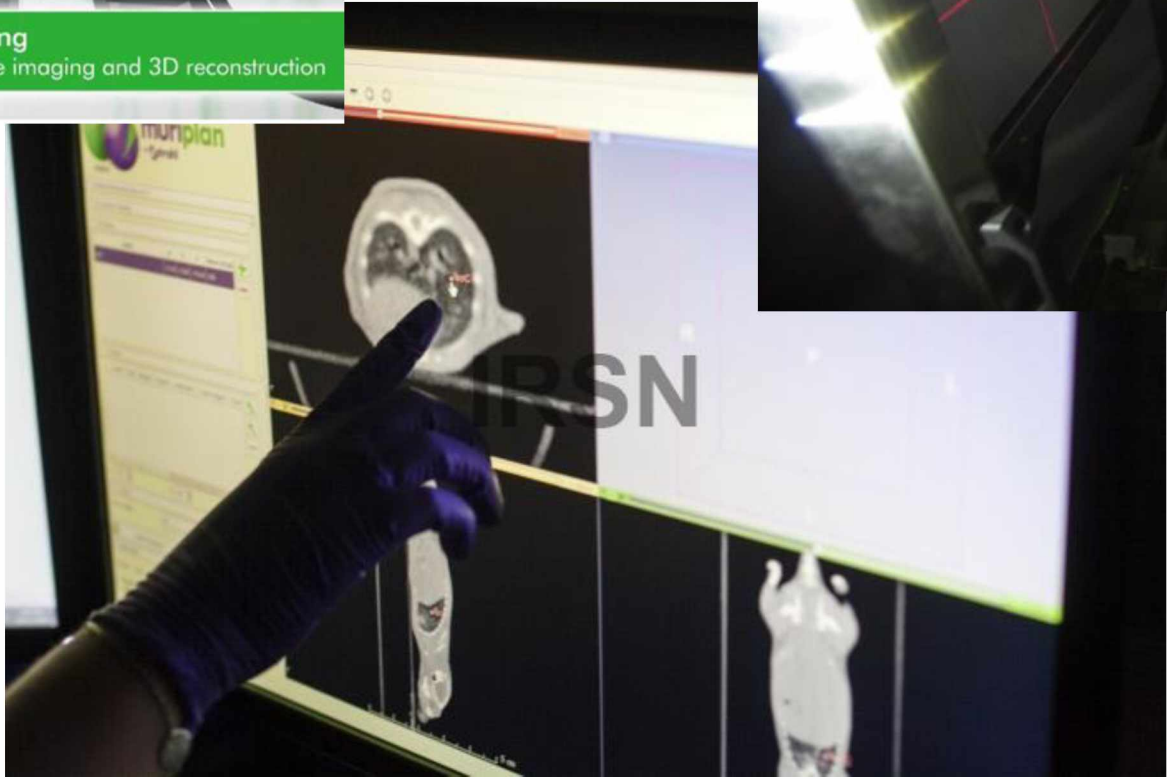
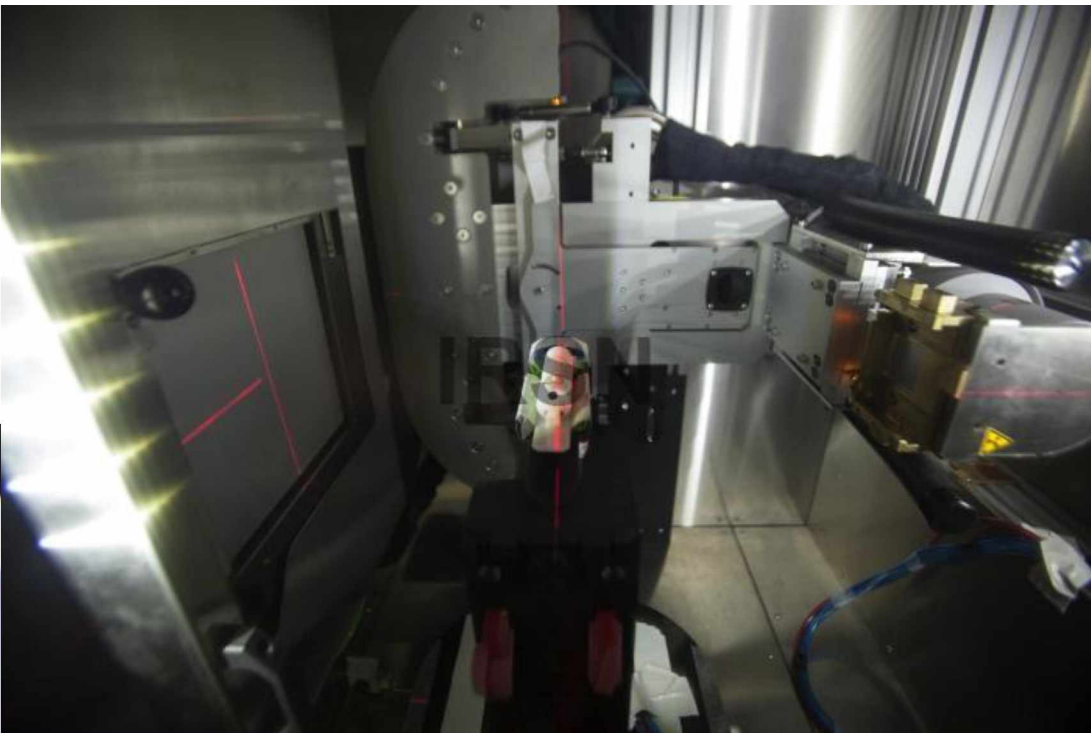
THANK YOU FOR  
YOUR ATTENTION!



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On Board CT Imaging  
High resolution, low dose imaging and 3D reconstruction

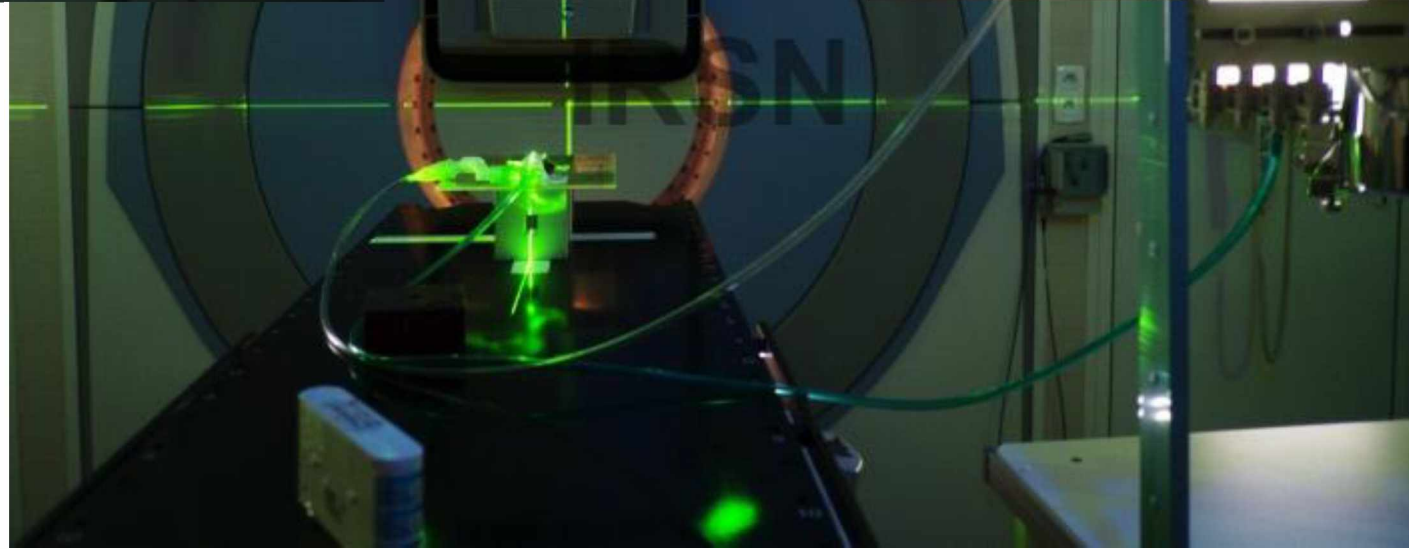
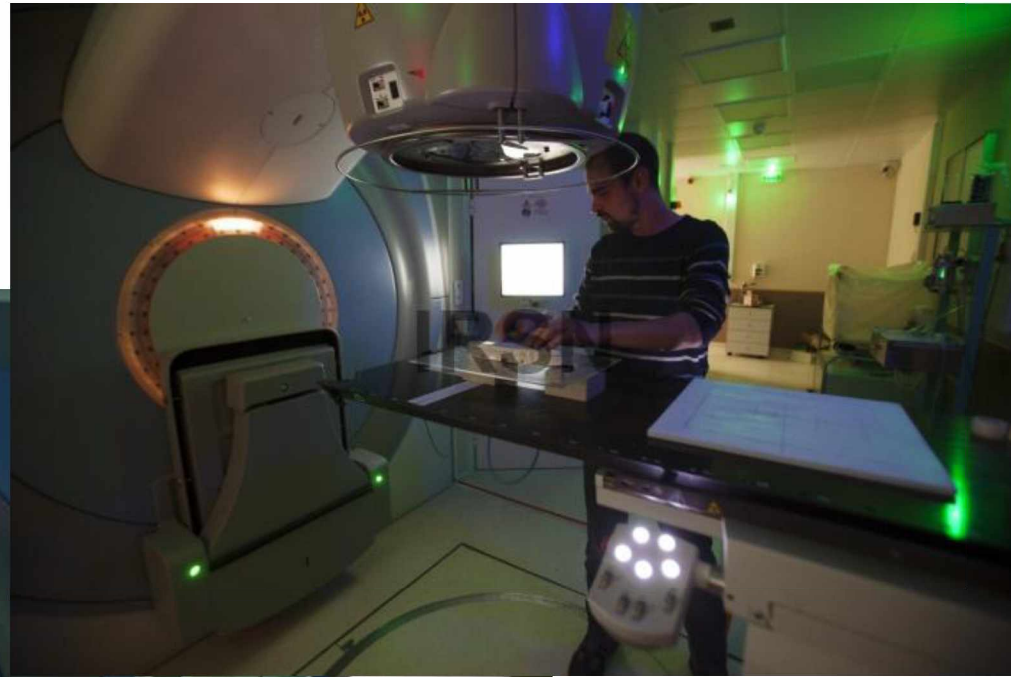


# SARRP irradiator

Small Animal Radiation Research Platform





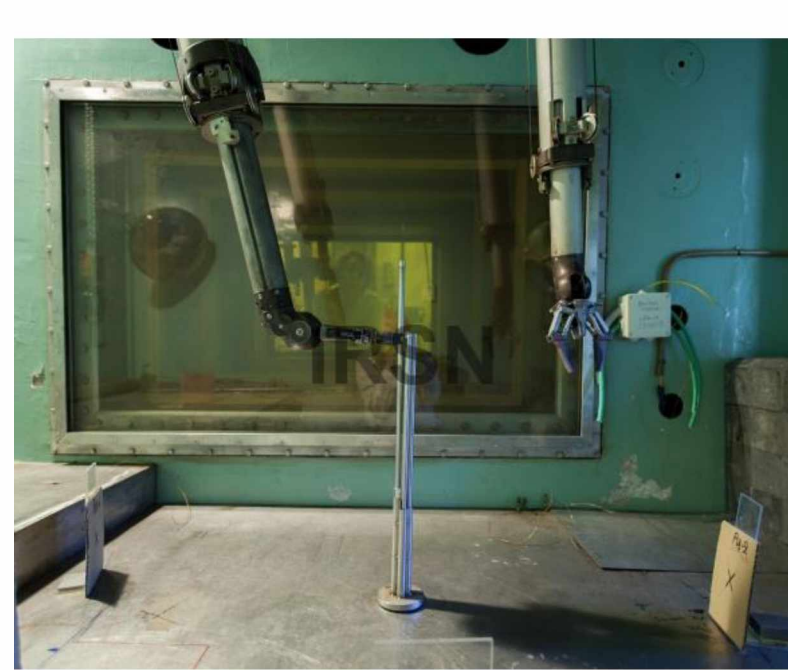


# ALPHEE accelerator

Accélérateur Linéaire pour la  
Production de photons et d'Electrons







# IRMA irradiator

IRradiation **MA**tériaux

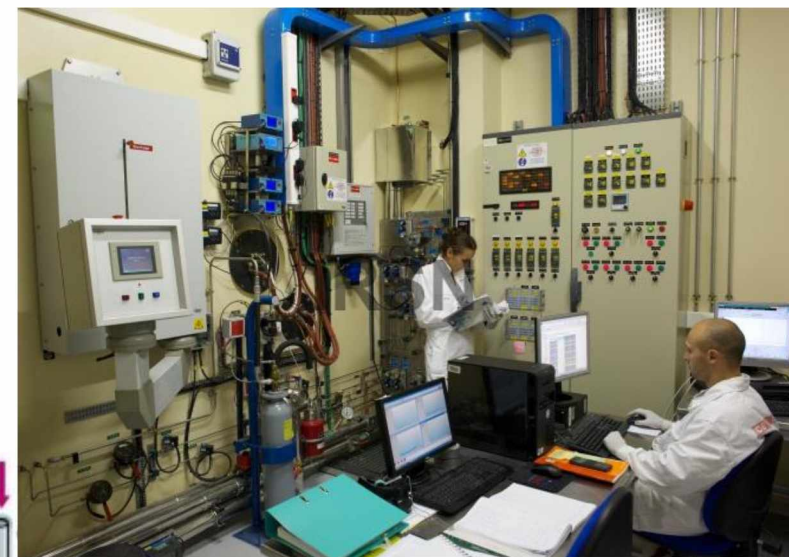
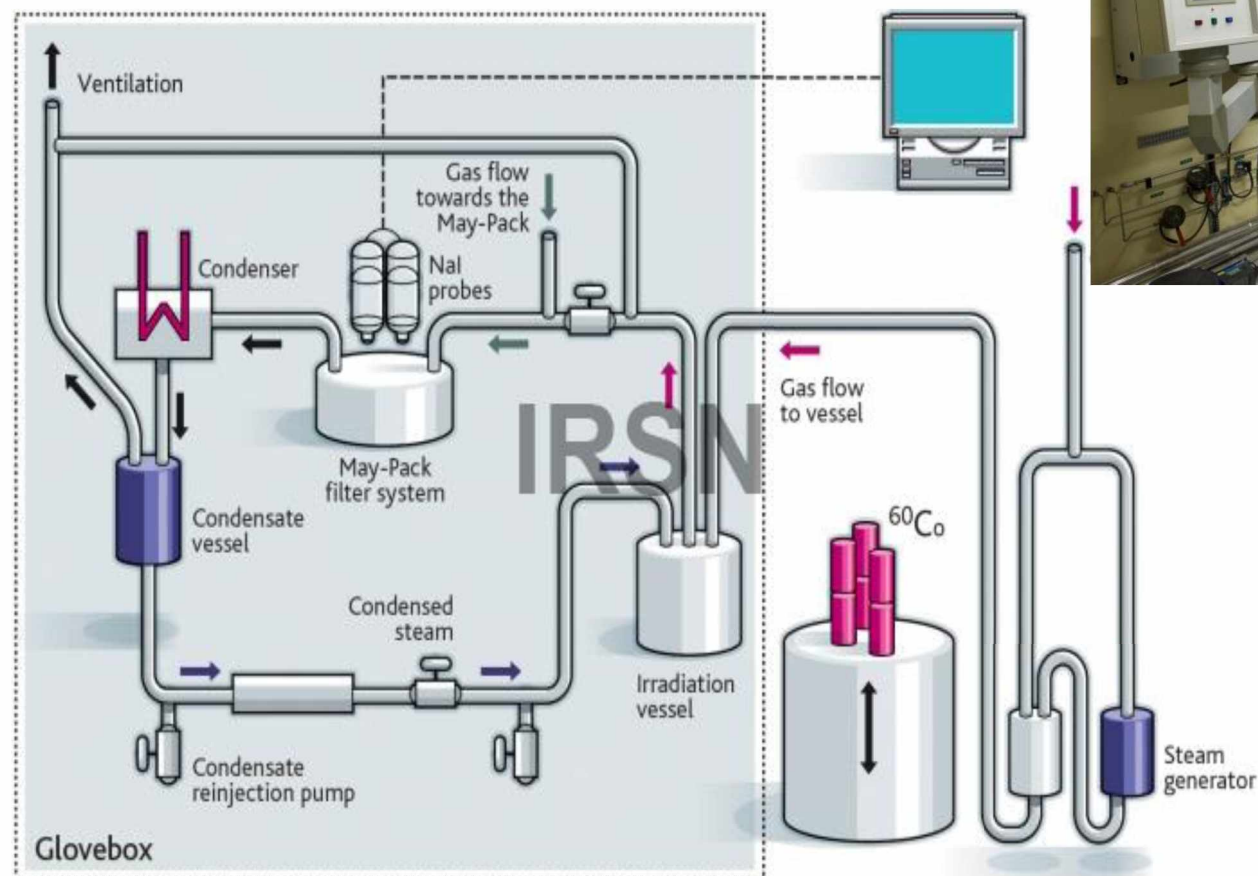




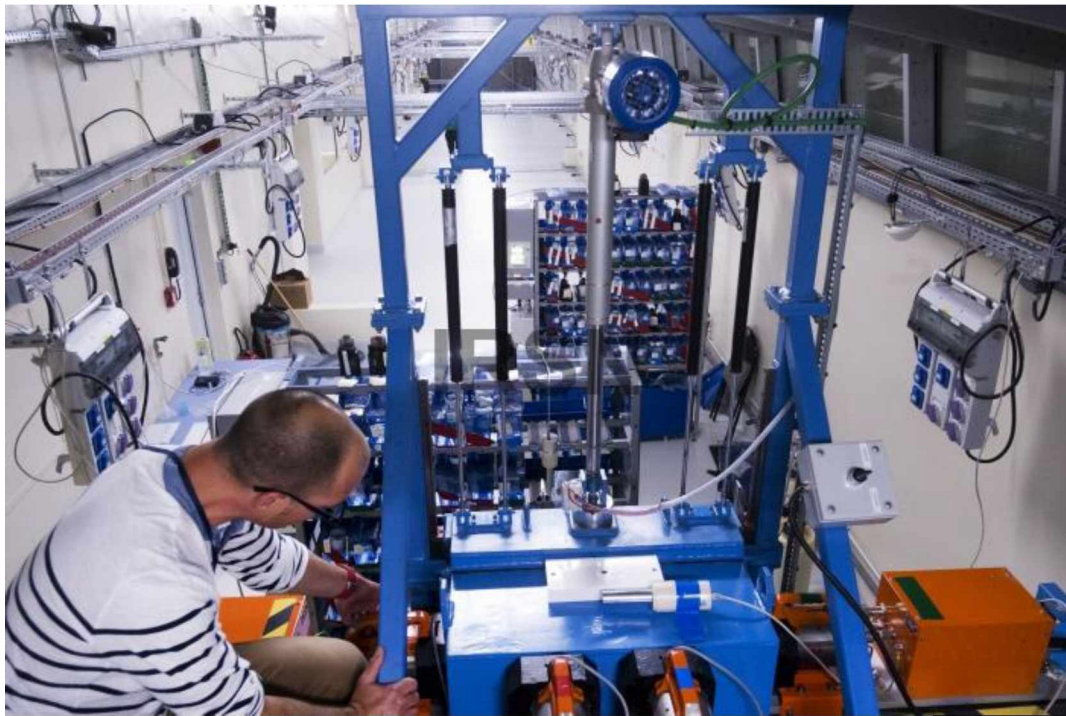


# EPICUR irradiator

Experimental Program of Iodine  
Chemistry Under Radiation







## MICADO LAB

Moyen d'Irradiation Chronique pour  
l'Acquisition de relations **DO**se-effet en  
**LAB**oratoire







# VAN GOGH Irradiator

Irradiator with 2 radioactive neutron sources (Am-Be and Cf)







## AMANDE facility

Accelerator for Metrology And Neutron applications in external Dosimetry





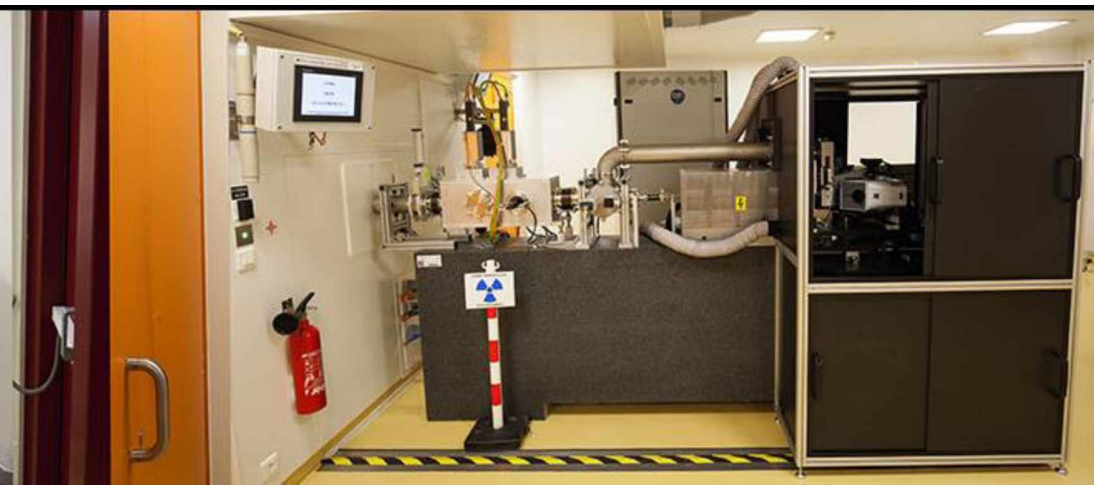


## CARAT platform

ChAmps de Référence Associés au T400







## MIRCOM platform

Ion **M**icrobeam for the **R**adiobiology of intra- and intercellular **C**OMmunications

