



- FUNDAMENTAL PHYSICS
- SPACE SCIENCES AND TECHNOLOGY
- FUSION DIAGNOSTICS AND TECHNOLOGY
- RESEARCH REACTORS AND PARTICLE ACCELERATORS
- NUCLEAR POWER REACTORS MONITORING AND CONTROL
- SEVERE ACCIDENT MONITORING
- NUCLEAR FUEL CYCLE, SAFEGUARDS AND HOMELAND SECURITY
- DECOMMISSIONING, DISMANTLING AND REMOTE HANDLING
- ENVIRONMENTAL AND MEDICAL SCIENCES
- EDUCATION, TRAINING AND OUTREACH
- CURRENT TRENDS IN DEVELOPMENT OF RADIATION DETECTORS

# Feedback of the WORKSHOP session

**Workshops organization chair: Christelle REYNARD-CARETTE**

Aix Marseille Univ, Université de Toulon, CNRS, IM2NP, Marseille, France  
 Aix Marseille Univ, Faculté des Sciences, Filière Instrumentation, Marseille, France  
 Aix Marseille Univ, CNRS, CEA, ISFIN, Marseille, France

[christelle.carette@univ-amu.fr](mailto:christelle.carette@univ-amu.fr)

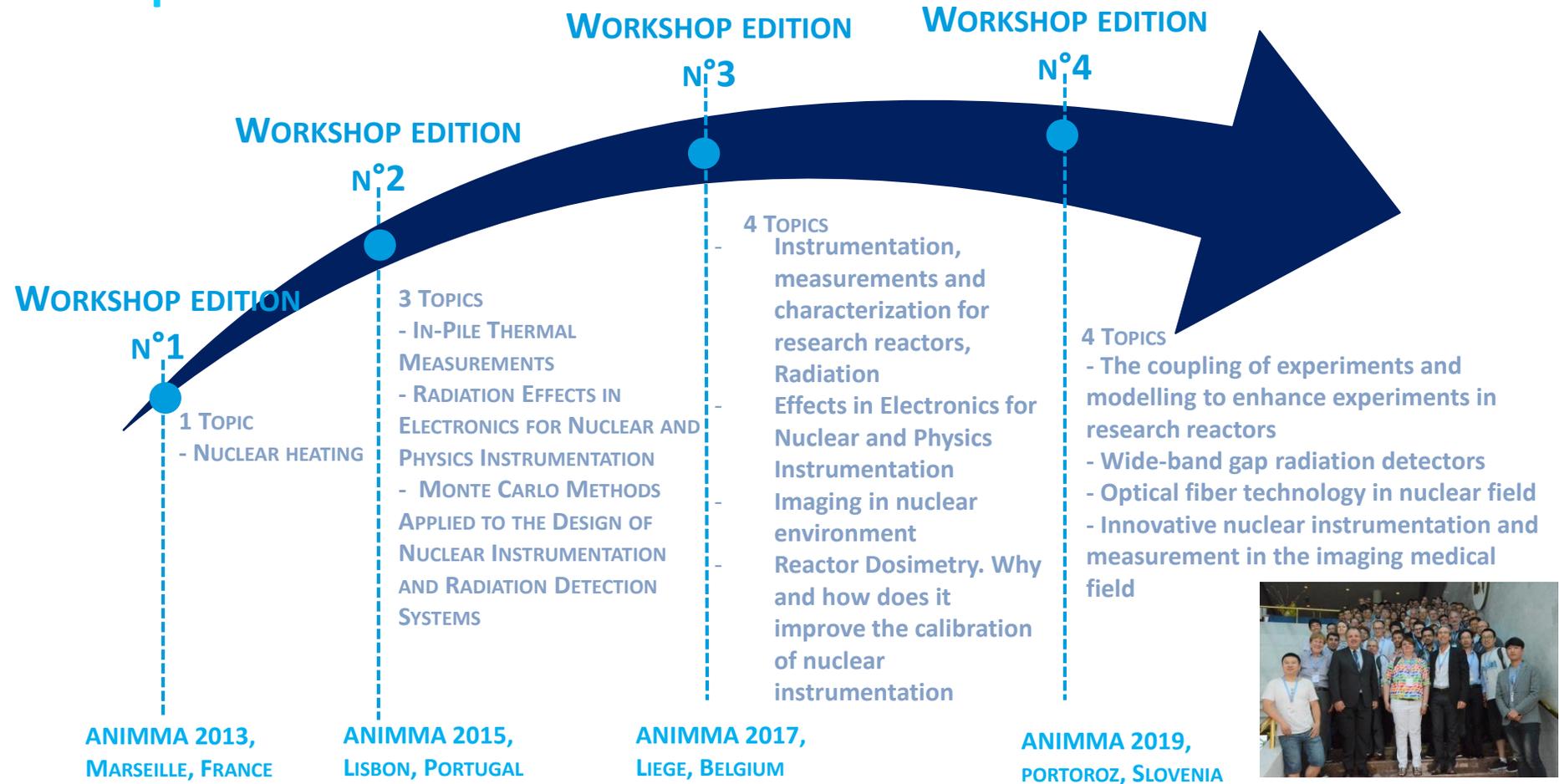




# A bit of history

## □ Workshop session created in 2013

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# Session 2021

- ½-day workshop (instead of 1-day)
- 3 topics addressed



With the very precious help of



**ANIMMA Local Organizing Committee Chair: Rastislav HODAK** (Institute of Experimental and Applied Physics, CTU, Czech Republic, [rastislav.hodak@utef.cvu.cz](mailto:rastislav.hodak@utef.cvu.cz))

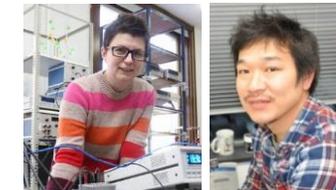
- **Workshop #1: Nuclear instrumentation and measurement for major research facilities in the fields of fusion and fission**

**Workshop conveners:** **Christelle REYNARD-CARETTE** (Aix-Marseille University, IM2NP UMR7334, ISFIN institute, [christelle.carette@univ-amu.fr](mailto:christelle.carette@univ-amu.fr)) and **Gordon KOHSE** (MIT, NRL, USA, [kohse@mit.edu](mailto:kohse@mit.edu))



- **Workshop#2: Crystalline Materials for Radiation Detection**

**Workshop conveners:** **Ivana CAPAN** (Rudjer Boskovic Institute, Croatia, [capan@irb.hr](mailto:capan@irb.hr)) and **Takahiro MAKINO**, National Institutes for Quantum and Radiological Science and Technology (QST), Japan, [makino.takahiro@qst.go.jp](mailto:makino.takahiro@qst.go.jp))



- **Workshop#3: Prospective technologies for the future of Nuclear medicine**

**Workshop conveners:** **Patrick LE DÛ** (Retired from CEA Saclay and IEEE NPSS, [patrickledu@me.com](mailto:patrickledu@me.com)), **Christian BOHM** (University of Stockholm, Sweden, [bohm@fysik.su.se](mailto:bohm@fysik.su.se)), **Cinzia DA VIA** (University of Manchester, UK, [cinzia.davia@manchester.ac.uk](mailto:cinzia.davia@manchester.ac.uk)), **Masaharu NOMACHI** (Osaka University, Japan, [nomachi@rcnp.osaka-u.ac.jp](mailto:nomachi@rcnp.osaka-u.ac.jp))





## Session 2021

- ½-day workshop (instead of 1-day)
- 3 topics addressed
- 19 talks

FUNDAMENTAL PHYSICS  
 SPACE SCIENCES AND TECHNOLOGY  
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 SEVERE ACCIDENT MONITORING  
 NUCLEAR FUEL CYCLE, SAFEGUARDS AND HOMELAND SECURITY  
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 ENVIRONMENTAL AND MEDICAL SCIENCES  
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 CURRENT TRENDS IN DEVELOPMENT OF RADIATION DETECTORS

The collage contains 19 posters, organized into three main workshop categories as indicated by the legend on the right:

- Workshop#1 (Light Blue):**
  - Neutron Detection using Silicon Carbide-based Sensors: 3D Thermal Numerical Simulations and Instrumentation
  - Measurement of nuclear absorbed dose rate by calorimeter: from present work focused on a future irradiation campaign in the MIT's reactor to key challenges
  - Sensor Technologies for the European TBM Program in ITER and DEMO Relevancy Aspects
  - Contributions to the development of nuclear instrumentation for the EU test blanket modules for ITER
- Workshop#2 (Dark Blue):**
  - Proposal and Development of Novel Neutron Detector using Boron Gallium Nitride
  - MIT Nuclear Reactor Laboratory: Instrumentation requirements, development, and opportunities in a new, large volume, irradiation position at the MITR research reactor
  - Radiation defects in the silicon sublattice of 4H-SiC: Electronic structure and annealing behavior
  - Conversion pathways of primary defects by annealing in proton-irradiated n-type 4H-SiC
- Workshop#3 (Medium Blue):**
  - Whole gamma imaging: a new concept of PET combined with Compton imaging
  - Picosecond Timing Resolution for PET
  - State-of-the-art Small Animal PET and Beyond
  - AI in nuclear imaging: Status, opportunities, pitfalls and challenges
  - Total-Body PET imaging: current status and a novel design approach with DOI and TOF capabilities
  - Compton and PET

- Workshop#1
- Workshop#2
- Workshop#3

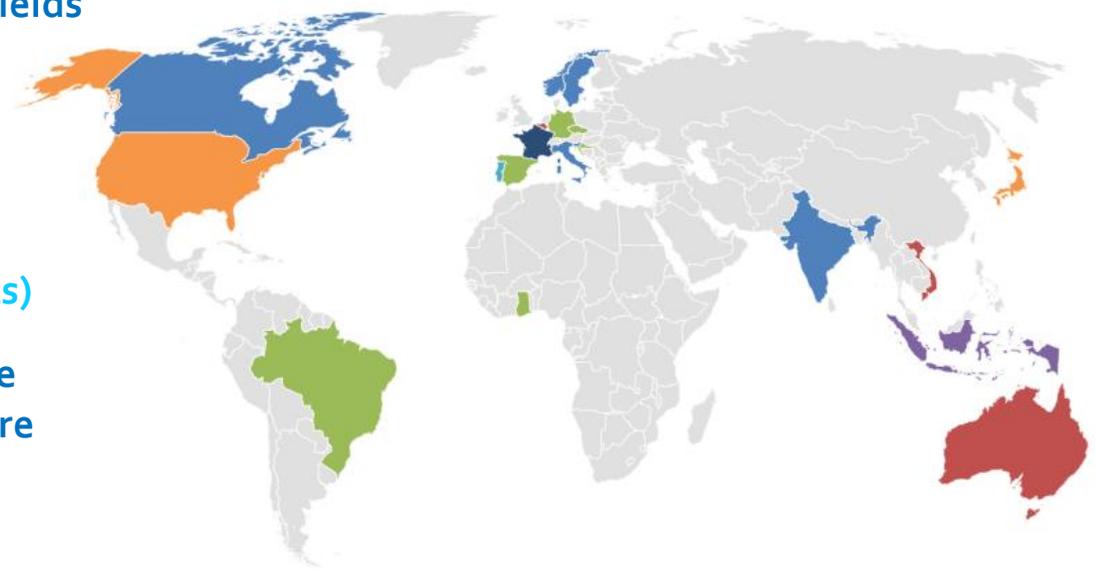


# Session 2021

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- ½-day workshop
- 3 Workshop topics
- 19 talks
- 90 participants
  - from 22 countries
  - including 19 speakers and 8 conveners

- **Workshop #1: Nuclear instrumentation and measurement for major research facilities in the fields of fusion and fission (40 participants)**
- **Workshop#2: Crystalline Materials for Radiation Detection (16 participants)**
- **Workshop#3: Prospective technologies for the future of Nuclear medicine (39 participants)**



CANADA
INDIA
ITALY
NORWAY
SLOVENIA
SWEDEN
AUSTRALIA
BELGIUM
VIETNAM
BRAZIL
CROATIA
CZECH REPUBLIC
ENGLAND
GERMANY
GHANA
SPAIN
INDONESIA
PORTUGAL
SWITZERLAND
JAPAN
USA
FRANCE

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# Thank you to the

Conveners

Speakers

Attendees

Local support



# Program

- **Workshop #1: Nuclear instrumentation and measurement for major research facilities in the fields of fusion and fission**

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 CURRENT TRENDS IN DEVELOPMENT OF RADIATION DETECTORS

Title	First name and last name of the speaker and coauthors	Speaker affiliation and email address	
14:00 – 14:30	Introduction	<b>C. Reynard-Carette</b> <b>G. Kohse</b>	Aix-Marseille Université, IM2NP UMR7334, France <a href="mailto:christelle.carette@univ-amu.fr">christelle.carette@univ-amu.fr</a> MIT, NRL, USA <a href="mailto:kohse@mit.edu">kohse@mit.edu</a>
14:30 – 15:00	Recent improvements in instrumentation for French experimental nuclear reactors	<b>C. Destouches</b> , A. Lyoussi	CEA, DES/IRENE/DER/SPESI, France <a href="mailto:christophe.destouches@cea.fr">christophe.destouches@cea.fr</a>
15:00 – 15:30	Measurement of nuclear absorbed dose rate by calorimeter: from present work focused on a future irradiation campaign in the MIT's reactor to key challenges.	<b>A. Volte</b> , M. Carette, A. Lyoussi, G. Kohse, C. Reynard-Carette	Aix-Marseille Université, IM2NP UMR7334, France <a href="mailto:adrien.volte@univ-amu.fr">adrien.volte@univ-amu.fr</a>
15:30 – 16:00	Sensor Technologies for the European TBM Program in ITER and DEMO Relevancy Aspects	<b>I. Ricapito</b>	F4E at ITER Organization, France <a href="mailto:Italo.Ricapito@f4e.europa.eu">Italo.Ricapito@f4e.europa.eu</a> <a href="mailto:Italo.Ricapito@iter.org">Italo.Ricapito@iter.org</a>
16:00 – 16:15	Coffee Break		
16:15 – 16:45	Contributions to the development of nuclear instrumentation for the EU test blanket modules for ITER	<b>A. Klix</b> , P. Raj, M. Angelone, D. Szalkai, L. Ottaviani, B. Eugene Ghidersa, K. Tian	Karlsruhe Institute of Technology, Germany <a href="mailto:axel.klix@kit.edu">axel.klix@kit.edu</a>
16:45 – 17:15	Neutron Detection using Silicon-Carbide- and Diamond-based Sensors: 3D Thermal Simulations and Instrumentation	<b>L. Ottaviani</b> , O. Palais, V. Valero, C. Reynard-Carette, A. Klix, C. Destouches, A. Lyoussi	Aix-Marseille Université, IM2NP UMR7334, France <a href="mailto:Laurent.ottaviani@univ-amu.fr">Laurent.ottaviani@univ-amu.fr</a>
17:15 – 17:45	Instrumentation requirements and development for a new, large volume, irradiation position at the MITR research reactor, with applications for advanced reactor and fusion reactor development	<b>G. Kohse</b>	MIT, NRL, USA <a href="mailto:kohse@mit.edu">kohse@mit.edu</a>



# Program

## ○ Workshop#2: Crystalline Materials for Radiation Detection

FUNDAMENTAL PHYSICS  
SPACE SCIENCES AND TECHNOLOGY  
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RESEARCH REACTORS AND PARTICLE ACCELERATORS  
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SEVERE ACCIDENT MONITORING  
NUCLEAR FUEL CYCLE, SAFEGUARDS AND HOMELAND SECURITY  
DECOMMISSIONING, DISMANTLING AND REMOTE HANDLING  
ENVIRONMENTAL AND MEDICAL SCIENCES  
EDUCATION, TRAINING AND OUTREACH  
CURRENT TRENDS IN DEVELOPMENT OF RADIATION DETECTORS

Title	First name and last name of the speaker and coauthors	Speaker affiliation and email address	
14:00 – 14:30	Radiation defects in the silicon sublattice of 4H-SiC: electronic structure and annealing behavior	<b>José Coutinho</b>	University of Aveiro, Portugal <a href="mailto:jose.coutinho@ua.pt">jose.coutinho@ua.pt</a>
14:30 – 15:00	Silicon-Carbide- and Diamond-based Neutron Sensors: Detection Stability under Irradiation	<b>Laurent Ottaviani</b> , O. Palais, V. Valero, C. Reynard-Carette, A. Klix, C. Destouches, A. Lyoussi	Aix-Marseille Univ, France <a href="mailto:laurent.ottaviani@univ-amu.fr">laurent.ottaviani@univ-amu.fr</a>
15:00 – 15:30	Conversion pathways of primary defects by annealing in proton-irradiated n-type 4H-SiC	<b>Robert Karsthof</b> , M. Etzelmüller Bathen, A. Galeckas, L. Vines	University of Oslo, Norway <a href="mailto:r.m.karsthof@smn.uio.no">r.m.karsthof@smn.uio.no</a>
15:30 – 16:00	Silicon carbide neutron detectors: sensitivity, energy selectivity and new converting materials – overview of research activities in the scope of the E-SiCure and E-SiCure2 projects	<b>Vladimir Radulović</b> , I. Capan, T. Makino, J. Coutinho, L. Snoj	Jozef Stefan Institute, Slovenia <a href="mailto:vladimir.radulovic@ijs.si">vladimir.radulovic@ijs.si</a>
16:00 – 16:15	Coffee Break		
16:15 – 16:45	Proposal and Development of Novel Neutron Detector using Boron Gallium Nitride	<b>Takayuki Nakano</b> , T. Aoki	Shizuoka University, Japan <a href="mailto:nakano.takayuki@shizuoka.ac.jp">nakano.takayuki@shizuoka.ac.jp</a>
16:45 – 17:15	Crystalline Solid State Quantum Sensors for Space Applications – Magnetometers and other Sensing Applications leveraging Radiation Defects	<b>Hannes Kraus</b>	NASA JPL, USA <a href="mailto:hannes.kraus@jpl.nasa.gov">hannes.kraus@jpl.nasa.gov</a>
17:15 – 17:45	Closing remarks	<b>Takahiro Makino</b>  <b>Ivana Capan</b>	QST, Japan <a href="mailto:makino.takahiro@qst.go.jp">makino.takahiro@qst.go.jp</a> RBI, Croatia <a href="mailto:capan@irb.hr">capan@irb.hr</a>



# Program

## Workshop#3: Forum on prospective technologies for the future PET imaging

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 RESEARCH REACTORS AND PARTICLE ACCELERATORS  
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 EDUCATION, TRAINING AND OUTREACH  
 CURRENT TRENDS IN DEVELOPMENT OF RADIATION DETECTORS

	Title	First name and last name of the speaker and coauthors	Speaker affiliation and email address
14:00 – 14:30	Part1: Introduction and presentation of the forum (10 min)  Part2: Whole gamma imaging: a new concept of PET combined with Compton imaging	<b>Patrick Le Du</b>  <b>Taiga Yamaya</b>	Retired from CEA Saclay and IEEE NPSS, France <a href="mailto:patrickledu@me.com">patrickledu@me.com</a>  National Institutes for Quantum and Radiological Science and Technology (QST), Japan <a href="mailto:yamaya.taiga@qst.go.jp">yamaya.taiga@qst.go.jp</a>
14:30 – 15:00	Picosecond timing resolution with scintillators	<b>Paul Lecoq</b>	Instituto de Instrumentación para Imagen Molecular (I3M), Valencia, Spain; Multiwave Metacrystal S.A., Geneva, Switzerland; CERN, Switzerland <a href="mailto:Paul.Lecoq@cern.ch">Paul.Lecoq@cern.ch</a>
15:00 – 15:30	State-of-the-art Small Animal PET and Beyond	<b>Roger Lecomte</b>	Sherbrooke University Québec, Canada <a href="mailto:roger.lecomte@usherbrooke.ca">roger.lecomte@usherbrooke.ca</a>
15:30 – 16:00	Compton and PET state f of the art	<b>Gabriela Llosa</b>	IFIC - Instituto de Física Corpuscular Parc Científic de la Universitat de València, Spain <a href="mailto:gabriela.llosa@ific.uv.es">gabriela.llosa@ific.uv.es</a>
16:00 – 16:15	Coffee Break		
16:15 – 16:45	Total-Body PET imaging: current status and a novel design approach with DOI and TOF capabilities	<b>Antonio Gonzalez</b>	IFIC University of Valencia, Spain <a href="mailto:agonzalez@i3m.upv.es">agonzalez@i3m.upv.es</a>
16:45 – 17:15	AI in nuclear imaging: opportunities, pitfalls and challenges	<b>Mitra SAFAVI-NAEINI</b>	ANSTO, Australia <a href="mailto:mitras@ansto.gov.au">mitras@ansto.gov.au</a>
17:15 – 17:45	Novel Time-of flight Positron Emission Tomography Systems Under Construction at Stanford	<b>Craig Levin</b>	Stanford University, USA <a href="mailto:cslevin@stanford.edu">cslevin@stanford.edu</a>
17:45 – 18:15	Round Table		

**ANIMMA 2021**  
Prague, Czech Republic  
June 21-25, 2021

**Workshops #1**  
Recent improvements in instrumentation for French experimental nuclear reactors

Christelle Destouches, Abdellah Lelouch

**Neutron Detection using Silicon Carbide-based Sensors 3D Thermal Numerical Simulations and Instrumentation**

L. Ottaviani, V. Valero, O. Palais, C. Reynard-Carette, A. Klix, C. Destouches, A. Lyoussi

Workshop # Nuclear instrumentation and measurement for major research facilities in the field of fusion and fission - June, 21<sup>st</sup> 2021

**Measurement of nuclear absorbed dose rate by calorimeter: from present work focused on a future irradiation campaign in the MIT's reactor to key challenges**

Oral presentation, Workshops #1: Nuclear instrumentation and measurement for major research facilities in the fields of fusion and fission, 2021/06/21

A. VOLTE, M. CARETTE, A. LYOUSSEF, G. KOHSEI, C. REYNARD-CARETTE

**MIT NUCLEAR REACTOR LABORATORY**  
an MIT Interdepartmental Center

**Instrumentation requirements, development, and opportunities in a new, large volume, irradiation position at the MITR research reactor**

ANIMMA 2021 Workshop - Nuclear instrumentation and measurement for major research facilities in the fields of fusion and fission  
Gordan Kohse, Managing Director for Operations  
June 20, 2021

**SENSOR TECHNOLOGIES FOR THE EUROPEAN TBM PROGRAM IN ITER AND DEMO RELEVANCE ASPECTS**

L. Bogaard, B. Beldi, ITER Delivery - TBM Program, Fusion for Energy

**KIT**

**Contributions to the development of nuclear instrumentation for the EU test blanket modules for ITER**

Julia Klix, Marijana Angjelinac, Džalid Čindrić, Laurent Ottaviani, Pierrick Rog, Dora Székely

**Proposal and Development of Novel Neutron Detector using Boron Gallium Nitride**

Takayuki Nakano and Toru Aoki  
R. I. E. Shizuoka University, Hamamatsu, Japan

**Jet Propulsion Laboratory**  
California Institute of Technology

**Crystalline Solid State Quantum Sensors for Space Applications - Magnetometers using Radiation Defects and other Sensors**

Dr. Hermes Klingenberg, h.klingenberg@jpl.nasa.gov

**Silicon Carbide and Diamond-based Neutron Sensors: Detection Stability under Irradiation**

L. Ottaviani, O. Palais, V. Valero, C. Reynard-Carette, A. Klix, C. Destouches, A. Lyoussi

Workshop # Crystalline Materials for Radiation Detection - June, 21<sup>st</sup> 2021

**Radiation defects in the silicon sublattice of 4H-SiC**  
Electronic structure and annealing behavior

Presented by: José Coutinho (University of Aveiro, Portugal)

In collaboration with E-SiCure project partners: Ivana Čapan, Vladimir Radulović, Luka Šnoj and Takahiro Makino

**Conversion pathways of primary defects by annealing in proton-irradiated n-type 4H-SiC**

Workshop no. 2: Crystalline Materials for Radiation Detection  
Robert Karstoft, Marianne E. Bathen, Augustinas Galeckas, Marius J. Engel, Lesse Vines

Center for Material Research and NanoTechnology, University of Oslo, Norway

**Silicon carbide neutron detectors: sensitivity, energy selectivity and new converting materials - overview of research activities in the scope of the E-SiCure and E-SiCure2 projects**

Vladimir Radulović et al.  
Jozef Stefan Institute, Ljubljana, Slovenia

ANIMMA 2021, June 21-25, Prague, Czech Republic  
Workshop on Crystalline Materials for Radiation Detection

Prague, Czech Republic

**Whole gamma imaging: a new concept of PET combined with Compton imaging**

Taiga Yamaya  
National Institutes for Quantum and Radiological Science and Technology (QST, Former NIRS)

**Picosecond Timing Resolution for PET**

P. LECOQ  
Instituto de Instrumentación para Imagen Molecular (I3M), Valencia, Spain  
Muhawar Metcalyst S.A., Geneva, Switzerland  
CEIN, Switzerland

**State-of-the-art Small Animal PET and Beyond**

Roger Lecomte, Ph.D.

CIMS Centre of imaging moléculaire de  
3IT Institut Interdisciplinaire d'Innovation technologique  
UNIVERSITÉ DE SHERBROOKE Department of Nuclear

**AI in nuclear imaging**  
Status, opportunities, pitfalls and challenges

Dr Mitra Safavi-Naeini  
Principal Physicist - ANSTO

Science, Ingenuity, Sustainability.

**Novel Time-of-Flight Positron Emission Tomography Systems Under Construction at Stanford**

Craig S. Levin, Ph.D.  
Professor of Radiology, Physics, Electrical Engineering, and Bioengineering, Molecular Imaging Program at Stanford

**Total-Body PET imaging: current status and a novel design approach with DOI and TOF capabilities**

Institute for Instrumentation in Molecular Imaging, I3M

**Compton and PET**

Gabriela Llošá Lácer  
Instituto de Física Corpuscular (IFIC) CSIC/UV  
IRIS group. <http://ific.uv.es/iris>  
Gabriela.llosa@ific.uv.es

ANIMMA 2021  
Prospective technologies for the future PET imaging workshop.  
June 21, 2021

- Workshop#1
- Workshop#2
- Workshop#3