A quick overview of LRS

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On behalf of Prof. Andreas Pautz

Laboratory for Reactor Physics and Systems behaviour (LRS), Swiss Federal Institute of Technology in Lausanne (EPFL)
Mandate

- The primary mandate of the LRS is the **education of the next generation of nuclear engineers and scientists** through the joint Master program with ETHZ and PSI.
- The secondary mandate of the LRS is the **safe and efficient operation** of the only research reactor in Switzerland, CROCUS.
- The third mandate of the LRS is the undertaking of **cutting edge research and development** in the nuclear engineering field.

Team

- Under the supervision of Professor Andreas Pautz, a team of 4 scientists, 2 technicians, a secretary, 2 postdocs and 5 PhD students.
STUDENTS COME FROM

30 COUNTRIES

44 UNIVERSITIES

FRANCE 15%

SWITZERLAND 10%

CHINA 14%

REST OF EUROPE 31%

94% STUDENTS SATISFIED WITH THE PROGRAM

83% GRADUATES REMAIN IN THE NUCLEAR FIELD

62% GRADUATES REMAIN IN SWITZERLAND

€600 PER SEMESTER SAME LOW TUITION FOR ALL STUDENTS

For more information visit master-nuclear.ch
The CROCUS reactor

- Reactor type
  LWR with partially submerged core
  Room T (controlled) and atmospheric P
  Forced water flow (160 l.min⁻¹)

- Power
  100 W (zero-power reactor)
  i.e. maximum $2.5 \times 10^9$ cm⁻².s⁻¹
  Control: water level and/or B₄C rods
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• Core dimensions
  \(\phi\)60 cm/100 cm

• Fuel lattices
  2-zone: 336/176 rods actually
  Inner: UO\(_2\) 1.806 wt\% 1.837 cm
  Outer: U\(_{\text{met}}\) 0.947 wt\% 2.917 cm
The LOTUS irradiation platform

- Available layout
  - Cavity of 3.6 x 2.4 x 3 (h) m³
  - 2.2 m-thick concrete shielding
  - Access: lateral door and removable lid
  - PuBe (TBq) sources or SILC Co-60 beam irradiator (350 GBq)

- CAD model since 2016
The LOTUS irradiation platform

SILC: $^{60}\text{Co}$ beam irradiator
- 370 GBq $^{60}\text{Co}$ source
- Irradiator and source delivered end of 2015
- Installation in LOTUS in February 2016
- First characterisation of gamma scattering

Collaboration with CERN/Fermilab
- Study of new phenomena radiation induced on scintillators, on-going 2017

Collaboration with ETHZ
- Feasibility study for radiography imaging

Hopewell Designs G10 beam irradiator
LRS R&D activities

**CROCUUS experiments**
- VOID: Void fraction
- COLIBRI: Fuel oscillation
- Intrinsic noise experiments
- PETALE: reflector study

**Instrumentation development**
- Neutron noise station (current mode)
- Diamond detector
- Foils and TLD dosimetry
- Scintillators with fibers
- Data assimilation
- Safety analysis modelling
- OpenFOAM/GeN-Foam

**LOTUS and CARROUSEL**
- PuBe TBq & Co-60 370 GBq
- Neutron modulation

**Modelling & code development**
Diamond detector development

Co-development and testing of sCVD\textsuperscript{1} diamond detectors for gammas and thermal/fast neutrons with CIVIDEC: from accelerator toward reactor physics

- Installation and testing campaign in CROCUS in November 2015
  - sCVD\textsuperscript{1} detector was installed in the SW guide tube of the CROCUS control rod
  - E. Griesmayer (CIVIDEC) and C. Weiss (CERN) came to install/test the detector in CROCUS and teach how to use it

- Addition measurement campaigns throughout 2016-2017
  - Journal paper on the installation and testing in CROCUS submitted in 2017
  - In collaboration with CIVIDEC/CERN

\textsuperscript{1} single crystal Chemical Vapor Deposition
COLIBRI: Fuel rods oscillation experiment

Goals

Investigation of power fluctuations induced by fuel oscillations

- New experimental program in CROCUS for measuring noise induced by fuel vibration

- Status
  - 18 U_{met} rods ±3 mm radial: ±8 pcm

View of the oscillation device in-core
COLIBRI: Fuel rods oscillation experiment

Status

Investigation of power fluctuations induced by fuel oscillations

• New experimental program in CROCUS for measuring noise induced by fuel vibration

• Status
  • $18 \, U_{\text{met}}$ rods $\pm 3 \, \text{mm radial}: \pm 8 \, \text{pcm}$
  • Designed, produced and delivered
  • First test at the factory and at LRS out of core with reactors interfaces and dummy fuel rods in Jan. 2016
  • Final delivery and tests in-core with dummy fuel rods in September 2016

View of the oscillation device for in-core testing
COLIBRI: Fuel rods oscillation experiment

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  - Final delivery and tests in-core with dummy fuel rods in September 2016
  - New interfaces installed in Jan. 2017
  - End of commissioning, start of the experiments in 2018

View of the oscillation device for in-core testing
Multi-physics solver based on OpenFOAM

- GeN-Foam: Generalized Nuclear Foam
- 2D or 3D transient analysis of full core and/or primary loop
- Solves for: neutronics (diffusion/SP3), coarse/fine mesh thermal hydraulics, fuel behavior, thermal mechanics (mesh for neutronics deformed according to displacement field)
- Unstructured meshes, implicit coupling, parallel computation, adaptive time step

Fluxes, velocity and temperatures in the Argonaute reactor (Florida)
TP4 projects

Current proposals
- Effects of nuclear data uncertainties on molten salt reactor design
- Development of radiation detection experiments in the LRS nuclear facilities
- Applying the Kalman filter to transient experiments in Crocus
- Aiding in neutron noise experiments

Projets de TP4 passés
- Felix Von Rütte (printemps 2017), encadré par S. Radman et V. Lamirand : "Conception and Construction of a large Diffusion Cloud Chamber"
- Isabelle Tanseri (printemps 2017), encadré par D. Siefman et V. Lamirand : "CROCUS Concrete Activation Study by γ-ray Spectrometry and TLD Neutron Flux Measurements"
- Andrea Hoeg (printemps 2017), encadré par P. Frajtag : "Modelling and characterization of a high-purity germanium detector"
- Harrison Gavotto (automne 2016), encadré par D. Siefman et V. Lamirand : "Monte Carlo neutron transport for estimating concrete activation and neutron dosimetry with thermoluminescent dosimeters"
- Adrien Theler (printemps 2016), encadré par V. Lamirand : "Gamma characterisation of the LOTUS cavity"
- Adrien Theler (automne 2015), encadré par V. Lamirand : "Development of an experimental channel for CROCUS"
- Solange Flatt (automne 2015), supervision by M. Hursin: "Comparison of methods to solve the 1D Boltzmann Equation for neutron transport"
- Joel Carlsson (printemps 2015), supervision by M. Hursin: "Modeling of CROCUS maximum hypothetical accident with MATLAB"
- Siria Medici (automne et printemps 2014-2015), supervision by P. Frajtag and J. Damet (IRA, CHUV): First application of OSL dosimetry at CHUV
- Arnaud Azimzadeh (printemps 2015), supervision by P. Frajtag: "Gamma and Neutron irradiation study on Silicon Photomultipliers"
- Arnaud Azimzadeh (automne 2014), supervision by P. Frajtag: "Determination of irradiation conditions for the LOTUS platform by FLUKA simulations"
Current proposals... taken!

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more on [lrs.epfl.ch](http://lrs.epfl.ch)

Contact us!
Thank you for your attention!
For projects at LRS, please contact the team:

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