IRSN WORK IN SUPPORT TO NCSP: FY2021 AND PLAN FOR FUTURE

Sophie PIGNET

Head of neutronics and criticality safety department , IRSN

sophie.pignet@irsn.fr

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# Highlights on FY2021 work

FY2021: Integral experiments

WORK FOCUS MAINLY ON TWO IER AT SNL, DESIGN LEADED BY IRSN

*COVID IMPACT: NO IRSN PARTICIPATION TO THE MUSIC EXPERIMENT (IER 488) AND NO DOSIMETRY EXERCISE*

IER 305 – Mo experiments
- Technical specifications report for Mo sleeves published
- Deal completed with the PLANSEE company following French rules for public bodies purchases
  Specific contract between IRSN and SNL has been signed to transfer sleeves property to SNL
- Delivery of the 400 sleeves at Sandia in two batches in October and November
- Controls performed by Gary Harms => sleeves are consistent with specifications
  → **Experiments scheduled in FY2022, with IRSN participation**
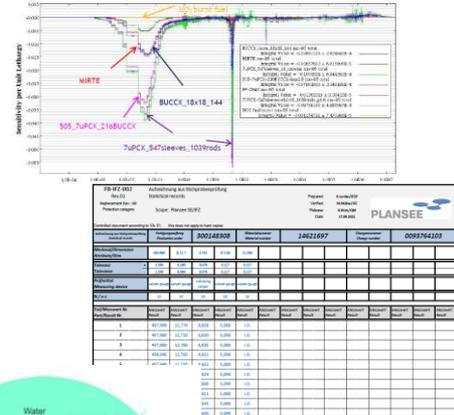
IER 306 – Rh experiments
- CED2 report completed and sent to Gary Harms for review
  → **comments from ORNL received, waiting for other reviewers**
- Design study concluded to a prohibited cost due to huge increase of Rhodium costs
  → **Project in stand by**
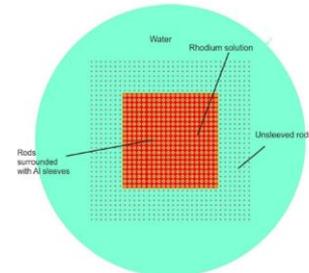
FY2021: Analytical methods

NO COVID IMPACT



- **Update of the Slide Rule**
  - Important work performed which allowed to understand the inconsistency between LLNL, ORNL and IRSN results
  - Specific presentation from Johann HERTH

- **Intercomparison study on k_{eff}**
  - Extension of the comparison between codes and libraries to U233 and MIX series
    - Addition of 131 U233 cases and 21 MIX cases for MORET code
  - Extension of the intercomparison scope with benchmarks from SINBAD and TSL comparisons
  - Writing of a first draft by IRSN with k_{eff} results by the end of 2022

- **Intercomparison study on bias assessment**
  - Selection of five application cases (benchmarks from ICSBEP) by IRSN, LANL and ORNL
    - Comparison of k_{eff} calculated by Monte Carlo codes
    - Use of the MACSENS tool (GLLSM) for determination of bias and associated uncertainties and comparison with TSURFER and WHISPER results
  - Paper submitted to NCSD 2022 conference
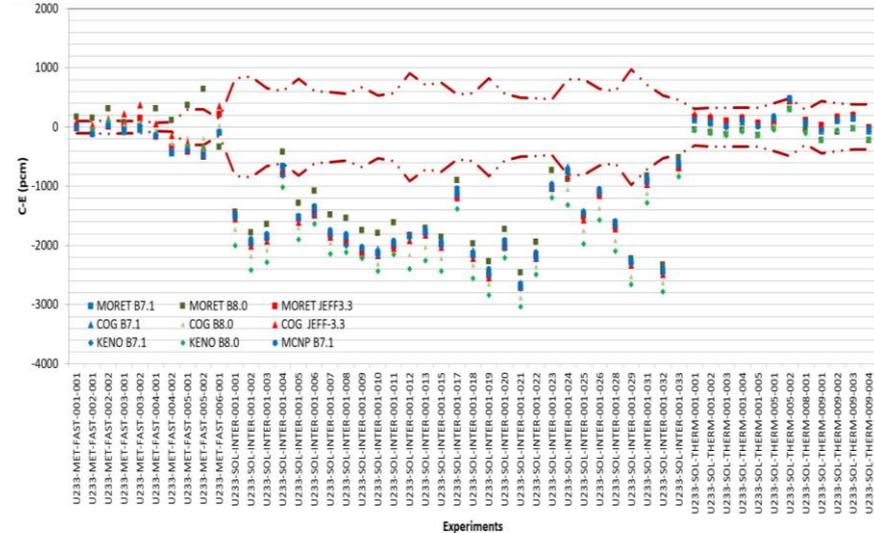
FY2021: Nuclear data evaluations

NO COVID IMPACT

▌ ^{19}F (RRR): RRR up to 1 MeV fitting of two inelastic channels – new (n, n') experimental data still needed

▌ ^{233}U (RRR and URR): RRR extended to 2 keV; URR from 2 keV to 40 keV
- Benchmark testing on ICSBEP benchmarks

▌ ^{239}Pu (URR): work under way

▌ ^{103}Rh (RRR): (URR carried out as NNL/IRSN) – task completed; ANS paper: **Testing of a New** ^{103}**Rh Resolved Resonance Evaluation**
- Benchmark testing on French IE MIRTE experiment with rhodium nitrate solution

▌ ^{155}Gd and ^{157}Gd (RRR):
- Benchmark testing on PST-034 ICSBEP experiment

▌ ^{54}Fe (RRR): Collaboration with RPI (see Sukhjinder Singh presentation)

▌ ^{208}Pb (RRR): Collaboration with RPI and BNL (see Peter Brainpresentation)

▌ ^{95}Mo (RRR): Collaboration with LANL: RRR extended to 8 keV;
- Benchmark testing on MIRTE experiments with Mo screen, future validation on IER 305 when available

▌ Hf evaluation (RRR and URR): Several meetings held between IRSN, ORNL, NNL/RPI. Issue: enriched samples are needed to improve existing evaluations
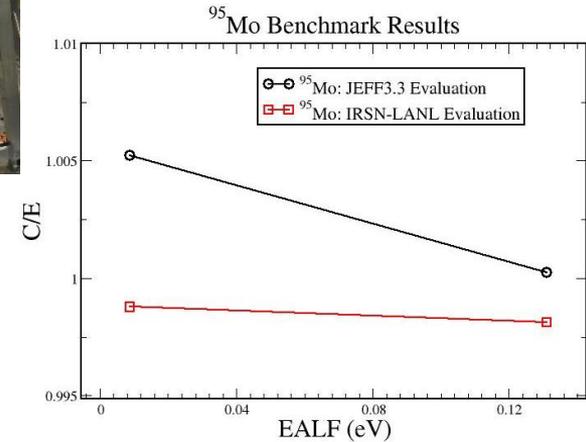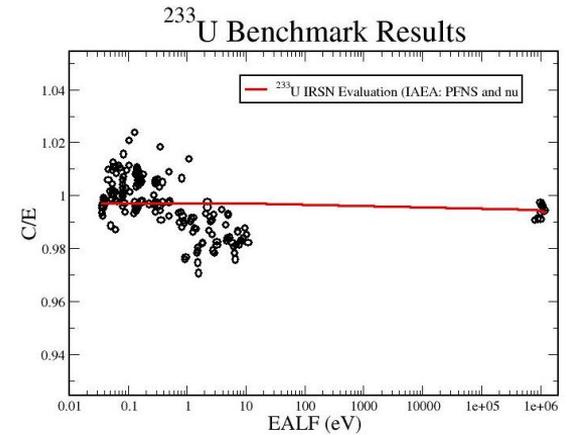
FY2021: Publications

FRENCH MIRTE 2 EXPERIMENTS PUBLISHED AT ICSBEP

Publication in Nature Communication physics
- *Patchy nuclear chain reaction*; E. Dumonteil, R. Bahran, T. Cutler, B. Dechenaux, T. Grove, J. Hutchinson, G. MacKenzie, A. McSpaden, W. Monange, M. Nelson, N. Thompson, A. Zoia
- Validation of theoric principles and MORET 6 simulations with RCF experiments

Participation to ANS summer and winter meetings
- *Assessment of Hafnium Nuclear Data for Criticality Safety Applications*; V. Dumont, N. Leclaire, I. Duhamel and L. Leal
- *Direct Calculation of Doubles Counting Rate for Neutron Multiplicity Methods*; W. Monange
- *Similarity of the PMM-2 critical experiments and criticality safety cases based on the k_{eff} sensitivity analysis*; M. Brovchenko
- *Testing of a New 103Rh Resolved Resonance Evaluation*; Luiz Leal, Nicolas Leclaire, Devin Barry, Amanda Lewis, Peter Schillebeeckx, Stefan Kopecky, and Cristian Mihailescu

Publication of MIRTE benchmarks in the ICSBEP Handbook
- LEU-COMP-THERM-106

NCSD 2022
- 8 full papers submitted

FY 2022 challenges

FY2022 challenges

IRSN PARTICIPATION TO INTEGRAL EXPERIMENTS COME BACK

Integral experiments participation

- Participation to **IER 305** at SNL

- Participation to **IER 518** « High Multiplication Subcritical Experiments » at SNL with IRSN detectors

- Participation to **IER 538** Intercomparison of criticality dosimetry around GODIVA with IRSN NAD for irradiation

NCSP benchmark modeling

- Validation of MORET 6 on **MUSIC** experiments

Analytical method

- Delivery of a draft of the **intercomparison** report on k_{eff}

- NCSD paper on **bias assessment** methodologies with LANL and ORNL

Nuclear Data

- Perform data measurements in the absence of enriched samples (Hf, Mo…)

- Delivery of complete evaluation including uncertainties for practical applications
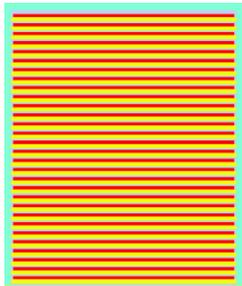
FY2022 challenges

DETAILED TEX MOX DESIGN

TEX-MOX with Polyethylene moderator – Intermediate spectrum	
Total number of fuel layers	30
Moderator thickness (cm)	0.36-0.39
Aluminum plate thickness (cm)	0.8245
Square fuel layer dimension (cm)	46.5846
Height/Width ratio of the fissile stack	1.21
Estimated decay power (W)	680
Intermediate fission rate (%)	49.45

▌ Ongoing work to optimize design by taking into account **issue on polyethylene temperature**
- **Support from IRSN engineering team** to improve the design
- Minimization of experimental uncertainties (vertical gaps, positioning)
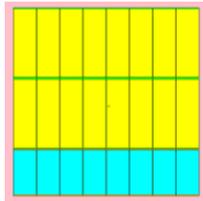
▌ Issue :
- PUMN fuels plates (~28% Pu) shipped at NCERC recently -> specific heat and radiative issues
- Preliminary design Polyethylene moderator particularly interesting for nuclear data covariance reduction (see ANS Winter meeting Transactions)
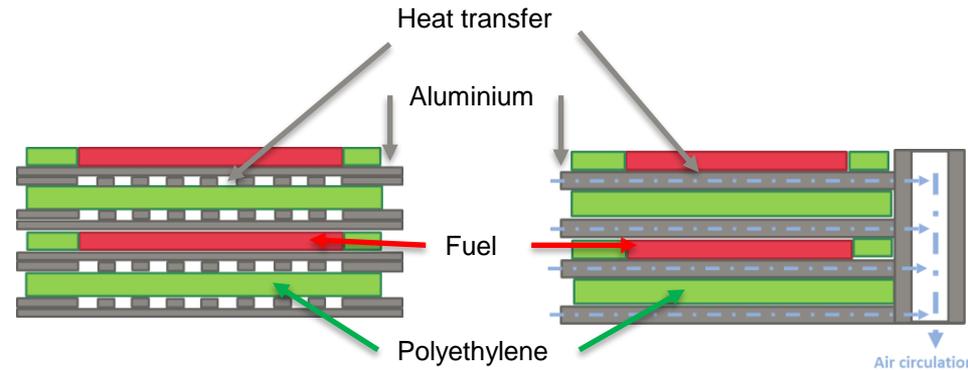- But, polyethylene material has bad thermal conductivity

Fuel assembly with PE layers

PUMN fuel plates

Heat transfer

Aluminium

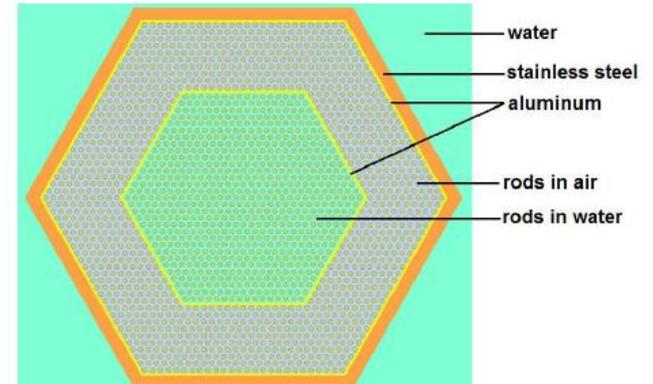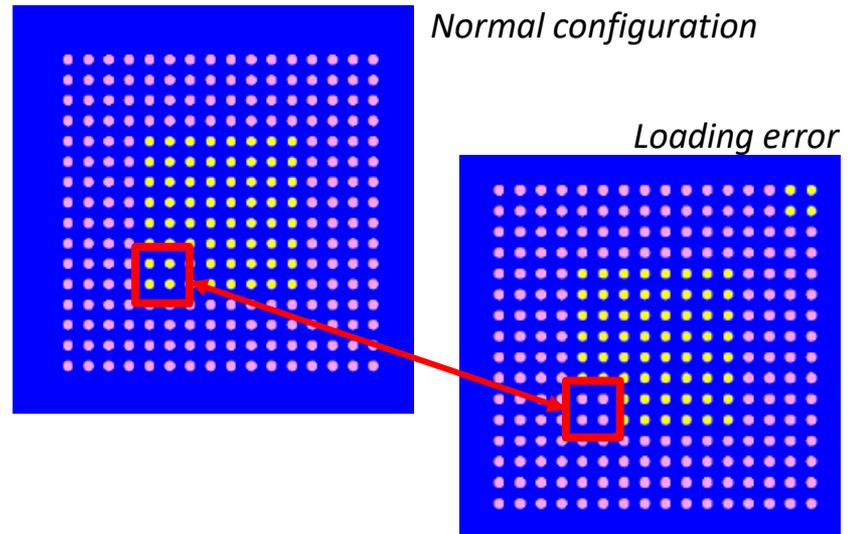Fuel

Polyethylene

Air circulation

Planning for the future

Future Activities Investigations

INNOVATIVE EXPERIMENTS AT SNL

▐ **FY 2021**: Two feasibility studies on new experimental designs (new opportunity for collaboration)

▐ **Detection of loading error with neutron noise**
- Difficulties to detect an error given the fuel rods similarity
- Need to reduce measurement uncertainties by extending measurement time
- Further studies are needed prior proposing new NCSP tasks

▐ **Validation of stainless steel as reflector**
- Five configurations studied with close similarity to the MIRTE experiments (no addition information)
- Optimization needed to increase the sensitivities in the epithermal energy range
- Sensibilities increased with the reflector thickness (design challenges)

Normal configuration

Loading error

water
stainless steel
aluminum
rods in air
rods in water

Future Activities Investigations

fissile material   metal

resin

water

LOW TEMPERATURE EXPERIMENTS

IRSN has interest on validation of nuclear data at low temperatures

Identification of materials of interest at low temperature
- Criticality calculations performed at -20°c and -40°c for realistic transport configurations
- First results highlighted an impact of polymer materials

Many discussions with LLNL on their proposed TEX low temperatures experiments
- IRSN started to work on the LLNL design
- Work to be done in 2022: investigate the possibility to **add industrial transport materials** to the LLNL design

- Air
- Natural iron
- Water
- Water
- Stainless steel
- Borated aluminum
- Water
- Aluminum
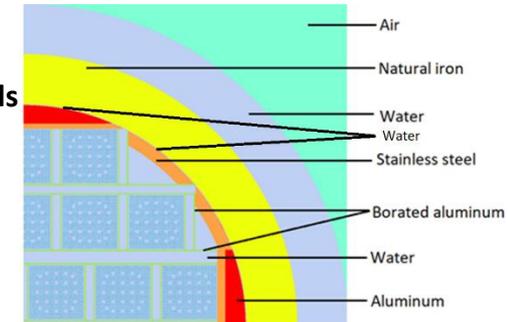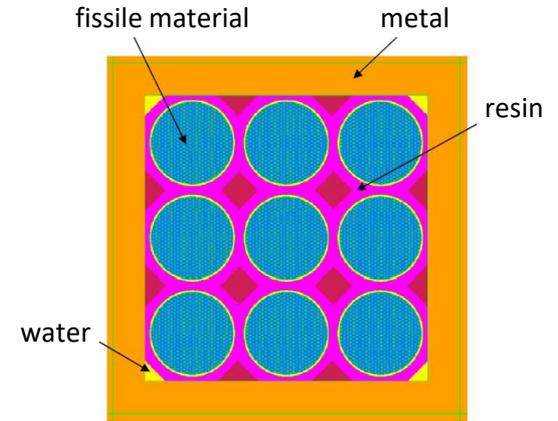
CONCLUSION

▌ **IRSN and NCSP collaboration has been very fruitful**. Despite the sanitary conditions (CV19), the work has been performed regularly by video conference. Monthly basis meeting with LLNL and LANL; Specifics meetings with ORNL and SNL when needed.
  - MANY THANKS to US colleagues for their availability !!!
  - We are looking forward to continuing our collaboration and hopefully with face-to-face meetings in the near future.

▌ After two years without any IRSN participation to experiments, we, at IRSN, are looking forward to fully **participating in the three proposed integral experiments scheduled in 2022**

▌ We are working on new important and interesting projects mainly : **TEX-MOX and TEX-low temperatures**

▌ Analytical method and Nuclear data are very valuable portions of the collaboration:
  - Efficient frame for **benchmarking between codes and methods**
  - Efficient frame to get **new evaluations for important isotopes** for nuclear criticality safety.

IRSN

Thank you !