Support to MSR technology

SNETP Forum, 2-4 February 2021

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Nuclear. For life.

Contents

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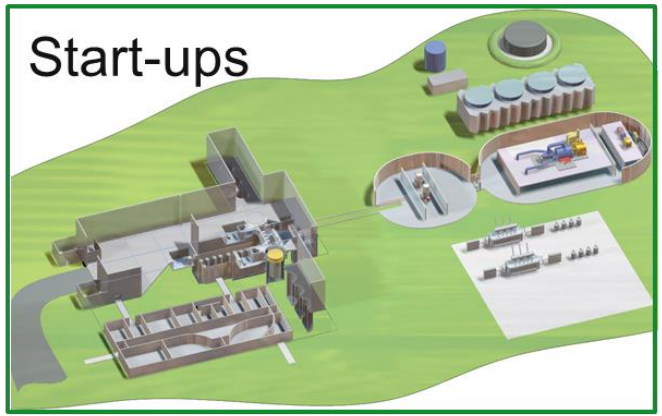
Investors

Utilities (?)

Start-ups



Regulator(s)

‘’Sites” for Demonstrator

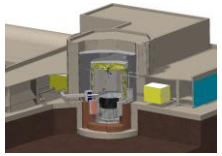
R&D organizations (Data for qualification)

- Material qualification
- Safety analysis / accident scenarios
- Salt processing

Suppliers

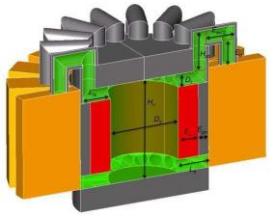
Many International MSR developers

UJV Group
TECHNOLOGY | INNOVATION | PEOPLE

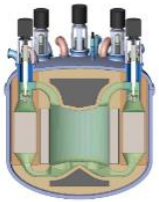


moltex
clean energy

ThorCon



cnrs



TerraPower
Southern Company

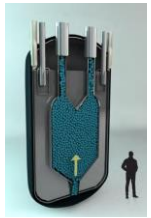
TMSR

Flibe
ENERGY

SEABORG

copenhagen
atomics

TERRESTRIAL
ENERGY



Kairos Power

MANY MSR INITIATIVES, BUT…

1. **Some seem to promise all the benefits of using thorium…**
   But this is complicated due to online fission product management

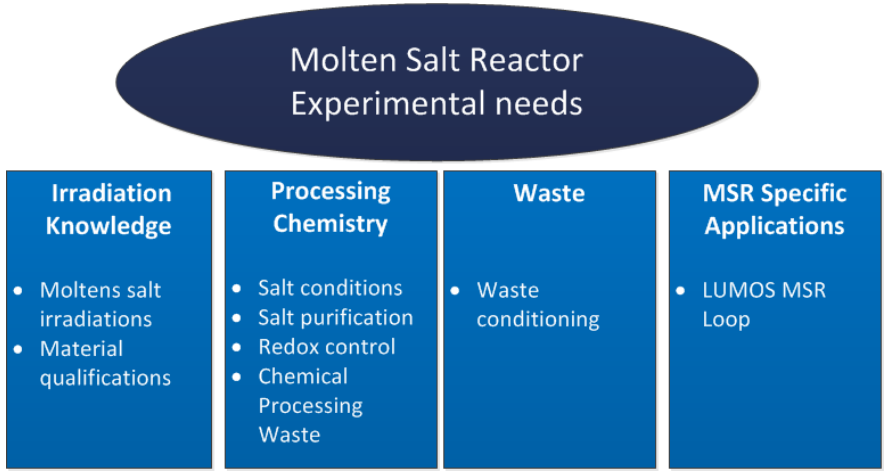
2. **Fast track reactors have a modular approach based on MSRE design**
   But performance is not necessarily much better than existing solid fuel reactors
   MSRE was a test reactor, not a first of a kind power system,
   and new waste issues are created (what do to with the salt?)

3. **Fast spectrum molten salt reactors can close the U-Pu cycle**
   But require proof and perhaps more development than thermal MSRs
   and MSR promised safety is not guaranteed

Few of them currently invest significantly in the experimental effort needed for design, safety evaluation, code and system validation, and licensing

Molten Salt reactor challenges

- MSRs are complex, and difficulties are multidisciplinary
- Technological challenges need to be solved for a safe and economic MSR.
- Time-consuming and costly experiments are required, to tackle these challenges and provide a basis to license MSR designs



Program overview

- Sponsored by the Dutch Ministry of Economic Affairs as part of a broader Nuclear Energy R&D program.
- In collaborations with JRC, TU Delft and CV Rez, which provide complementary competences
- Program objective: provide meaningful contribution to MSR technology development.
  - Obtain operational experience
  - Improve safety
  - Support materials development
  - Tackle waste issues
  - Integral Demonstration

Ministry of Economic Affairs of the Netherlands

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TU Delft Technische Universiteit Delft

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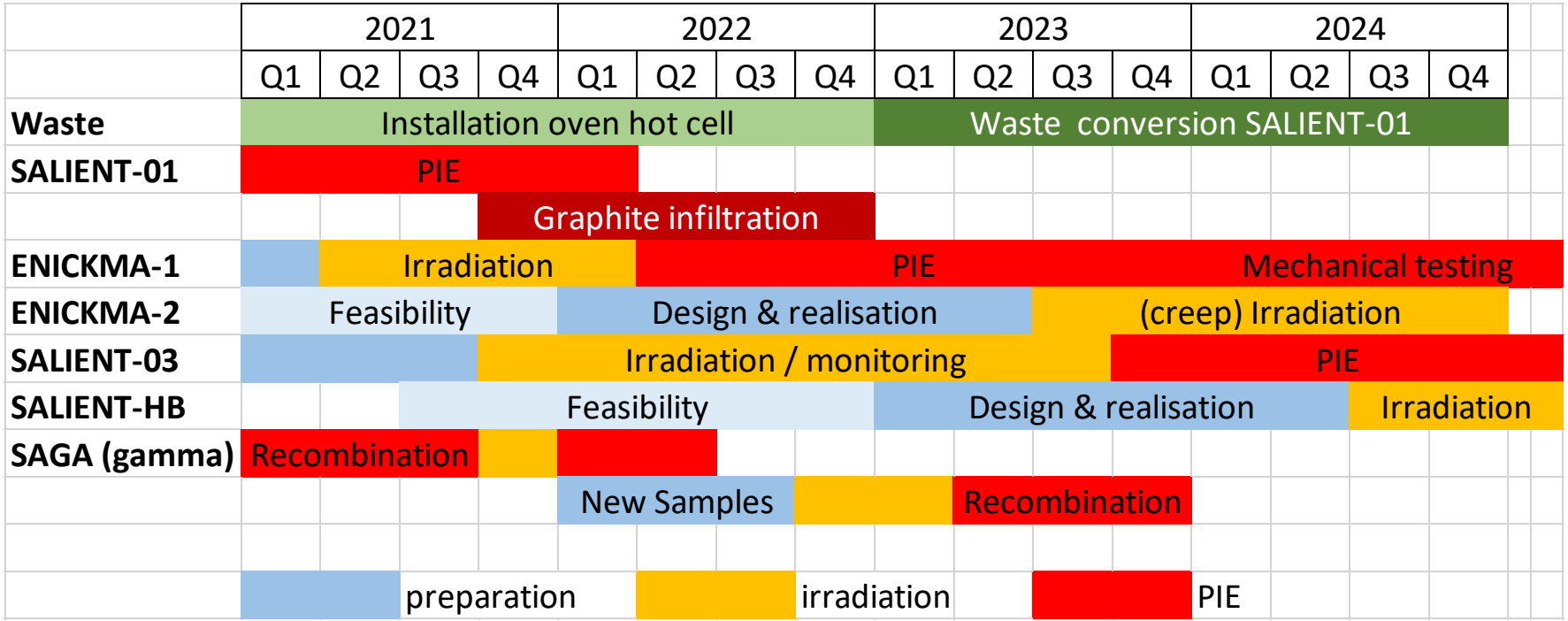
Current Program and Timeline

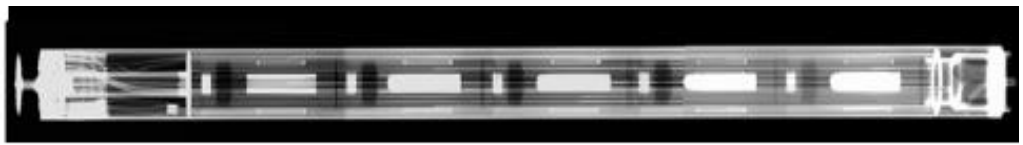


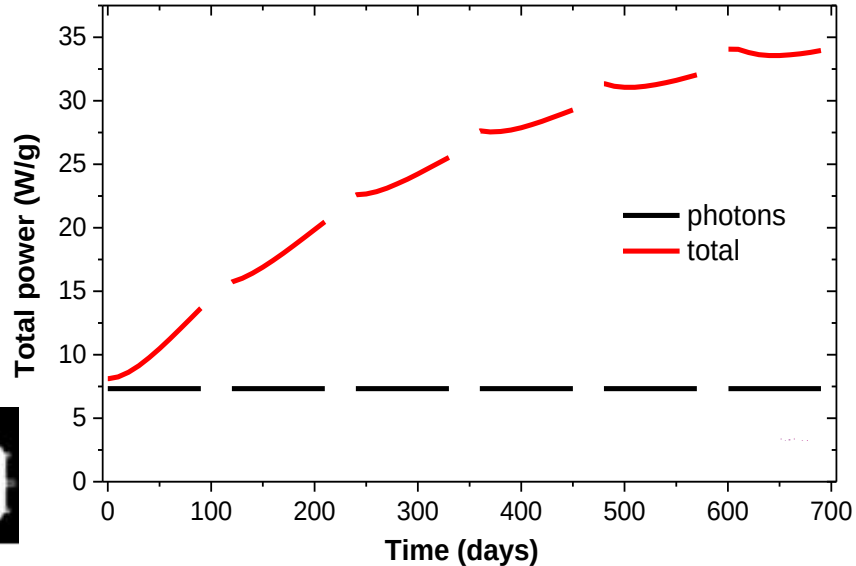
- **Focus on irradiation technology**
- **Focus on generic topics (not specific for certain concepts)**
- **Ambitious program with limited funding, program open for partnering**

SALIENT-01

Scope:

- Irradiation of 78LiF-22ThF_4 salt samples in graphite crucibles
- Determination of fission gas release
- Study noble metal deposition
- Extensive electron microscopy (SEM/WDS) to explore post-irradiation condition of the samples



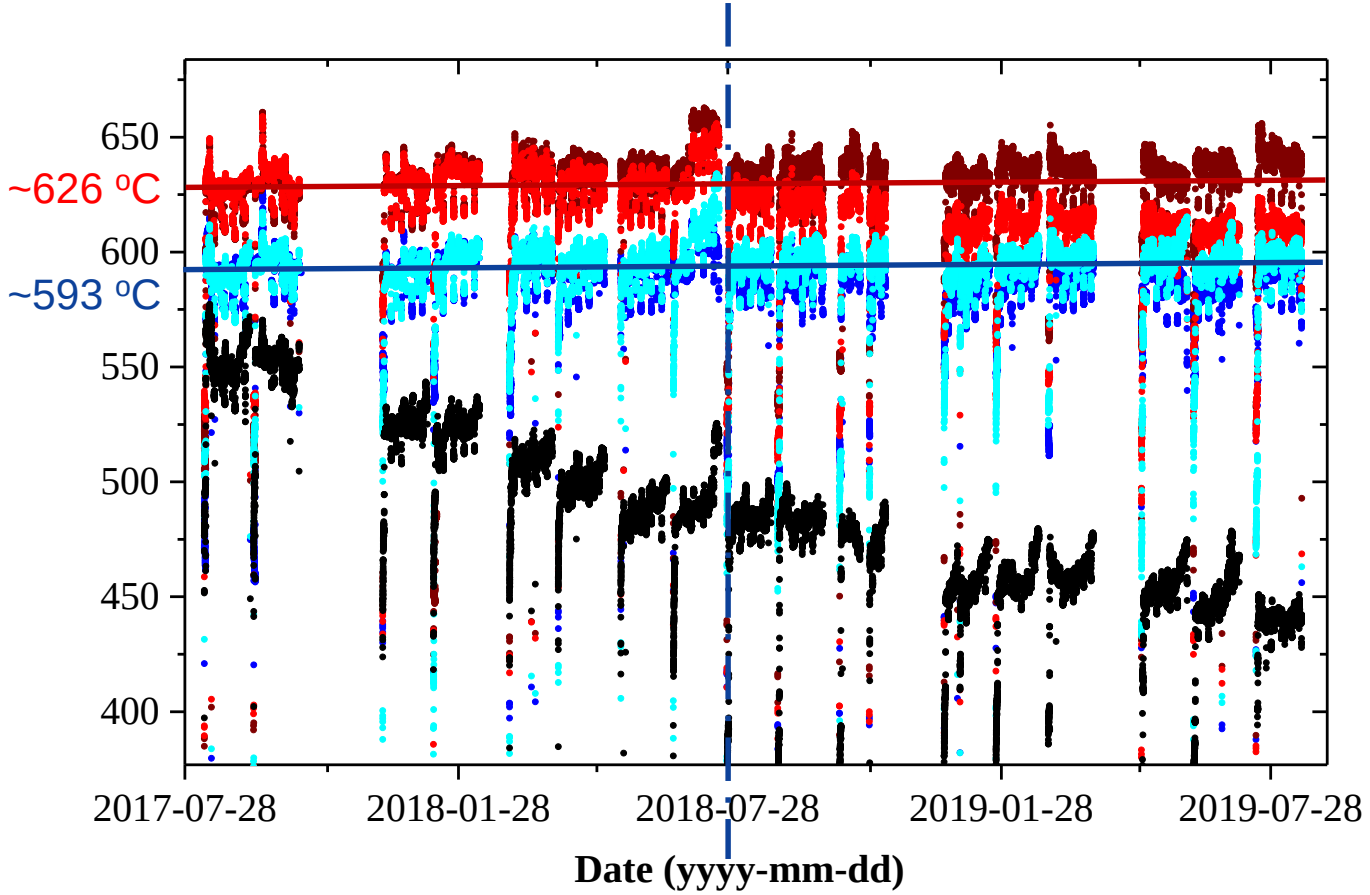


Irradiation (August 2017 – August 2019)

Measured graphite wall temperatures over 508 full power days.

Active temperature regulation of the salt-bearing capsules.

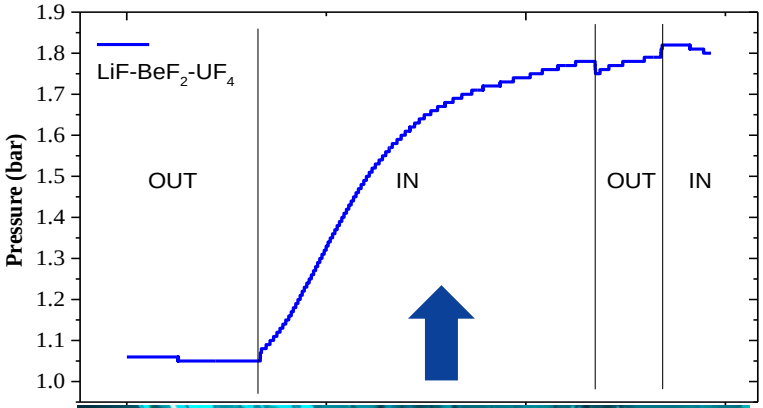
SALIENT-01 was moved to a lower-flux position following cycle 8.

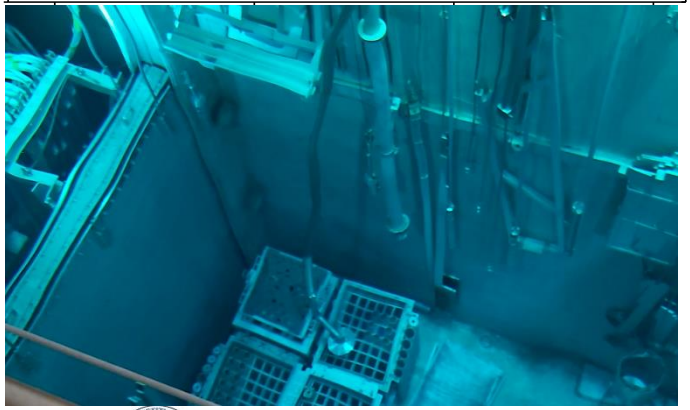


Next Steps (H2020 SAMOSAFER)

1. Plenum gas analysis - DONE
2. Transfer of SALIENT-01 to a smaller cell containing inert atmosphere
3. Removal of the 1st containment to recover the samples and activation monitoring sets
4. Preparation of small samples for transport to JRC Karlsruhe (→ Knudsen Cell Analysis)
5. Preparation of samples for in-cell microscopy (Light Microscopy and SEM/EDS/WDS)

The SAGA facility for quantifying radiolytic gas production





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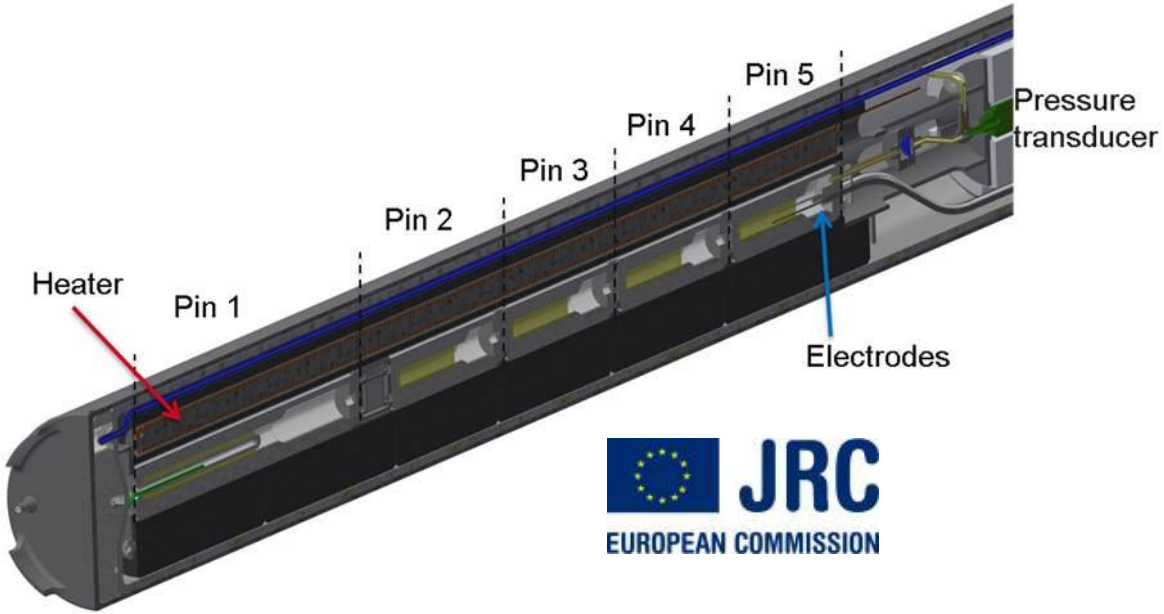
Irradiation tests in preparation

- ENICKMA: Helium embrittlement in nickel-based alloys (Hastelloy N, Hastelloy 242, MONICR) and ASTRID steel (316 L(N)) at 650-730 ºC.

- SALIENT-03: Molten salt corrosion of Hastelloy N and fission product behavior.



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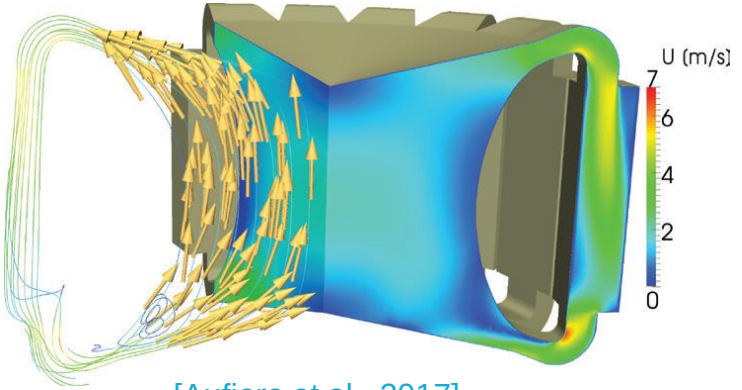
Modelling & Simulation Support

GeN-Foam

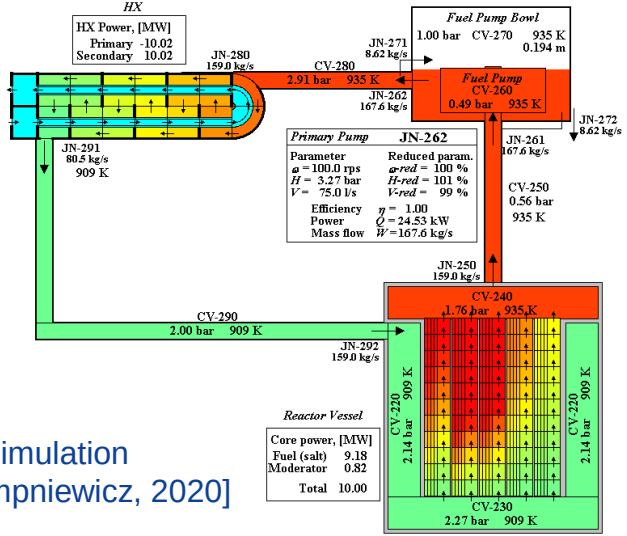
- 3D advanced multi-physics solver development based on open-source software [Fiorina et al., 2015]
  - 3D thermal-hydraulics CFD sub-solver
  - Displacement based thermal-mechanics sub-solver
  - Multi-group neutron diffusion sub-solver
  - Finite-difference sub-scale fuel model



[Aufiero et al., 2017]

1D fast running SPECTRA system code

- Specific MSR features:
  - delayed neutron precursor drift
  - fission product transport in (fueled) molten salt reactors
  - noble gas and noble metal behavior
  - noble metal extraction
  - chromium leaching and deposition



MSRE simulation
[Roelofs & Stempniewicz, 2020]

Acknowledgements

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