SEABORG

Using Serpent to design the CMSR

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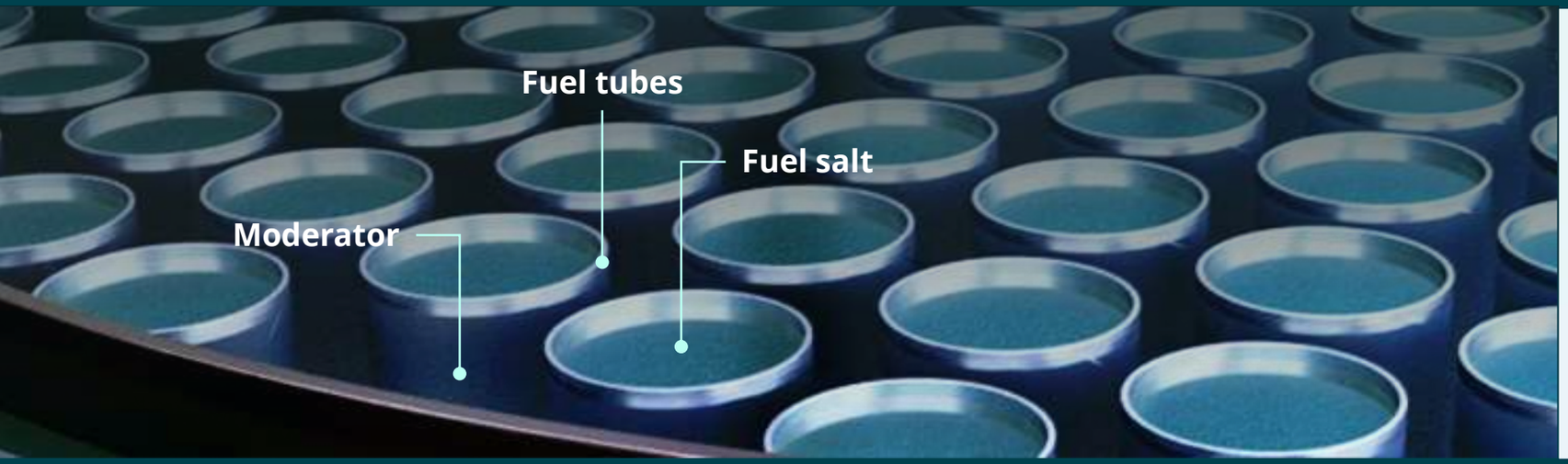
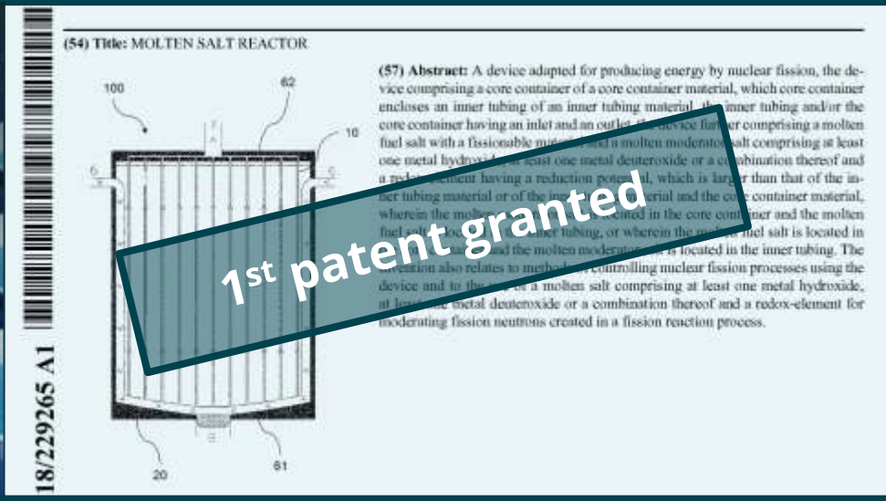
Seaborg in a Nutshell

- Founded in **2015**
- Privately held and privately funded
- **100+ employees from 20+ countries**
- HQ and laboratories in Copenhagen, Denmark
- Business office in South Korea & Singapore
- **Partnerships** with shipyards, nuclear players, academia, and heavy industry

CMSR

Uranium-fluoride salt fuelled




(54) Title: MOLTEN SALT REACTOR

(57) Abstract: A device adapted for producing energy by nuclear fission, the device comprising a core container of a core container material, which core container encloses an inner tubing of an inner tubing material, the inner tubing and/or the core container having an inlet and an outlet, the device further comprising a molten fuel salt with a fissionable material, a molten moderator salt comprising at least one metal hydroxide, at least one metal deuteroxide or a combination thereof and a redox-element having a reduction potential, which is larger than that of the inner tubing material or of the inner tubing material and the core container material, wherein the molten fuel salt is contained in the core container and the molten fuel salt is located in the inner tubing, or wherein the molten fuel salt is located in the core container and the molten moderator salt is located in the inner tubing. The invention also relates to methods for controlling nuclear fission processes using the device and to the use of a molten salt comprising at least one metal hydroxide, at least one metal deuteroxide or a combination thereof and a redox-element for moderating fission neutrons created in a fission reaction process.

18/229265 A1

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1st patent granted

NaOH
(sodium hydroxide)

No radiation damage.

Liquid from 318°C to 1388°C; excellent chemical stability; low viscosity; decent heat capacity; very affordable.

Efficient moderator with **10 times** the slowing-down power of graphite, and about 1/2 that of water.

Experience and knowledge exist from **use in other industries**.

CMSR core

- Fuel salt flows from core to heat exchanger.
- Secondary salt transports heat to steam generators.

Seaborg
Power barge

Turnkey Floating Power Plant

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Designed and built by

SAMSUNG

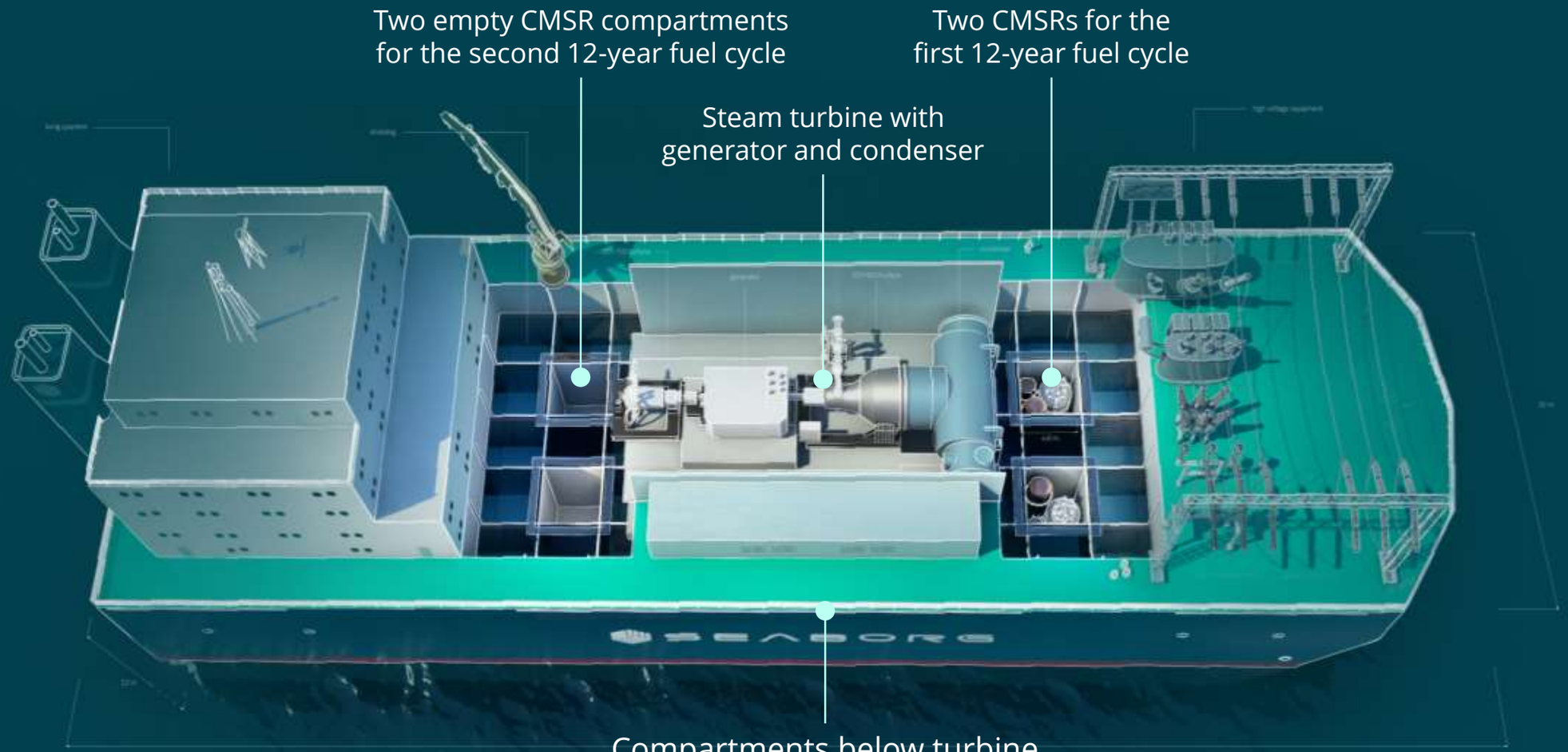
SAMSUNG HEAVY INDUSTRIES

Standardized modular design

- **3 years** from order to grid
- Fully commissioned **at Samsung shipyard**
- **Flexible deployment**

	Length [m]	Net electrical output [MWe]
2x CMSR	98	200
4x CMSR	160	400
6x CMSR	223	600
8x CMSR	286	800

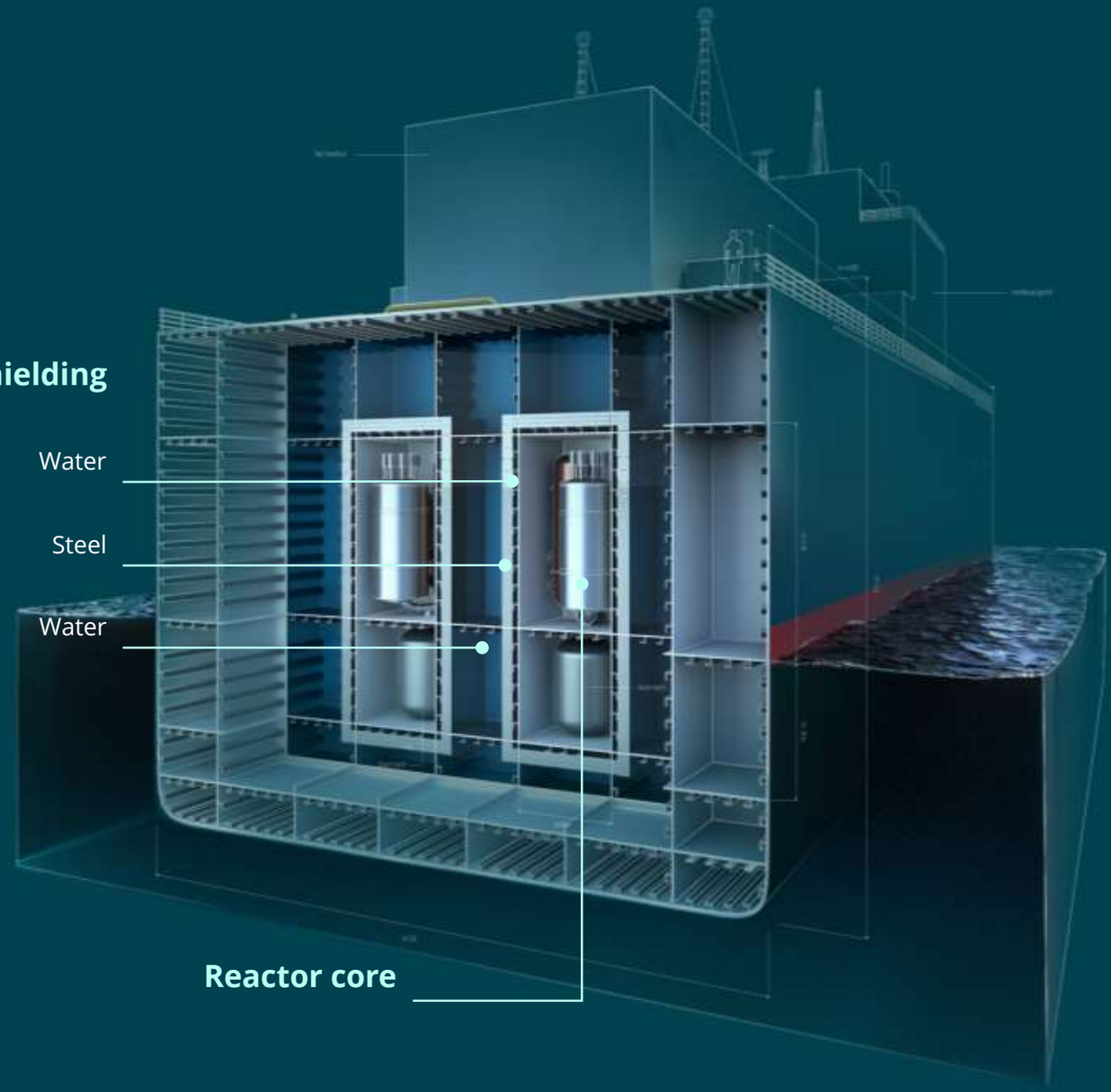
Inside the Power Barge



REACTOR ARRANGEMENT

The power barge is constructed so only the reactor unit and the steel shielding of the reactor is activated.

- Only the CMSR and shielding materials needs nuclear decommissioning.
- The power barge is recycled as any normal ship.
- Hull designed with a complete double hull to protect shielding tanks and systems.



MOLTEN SALT ACTIVATION

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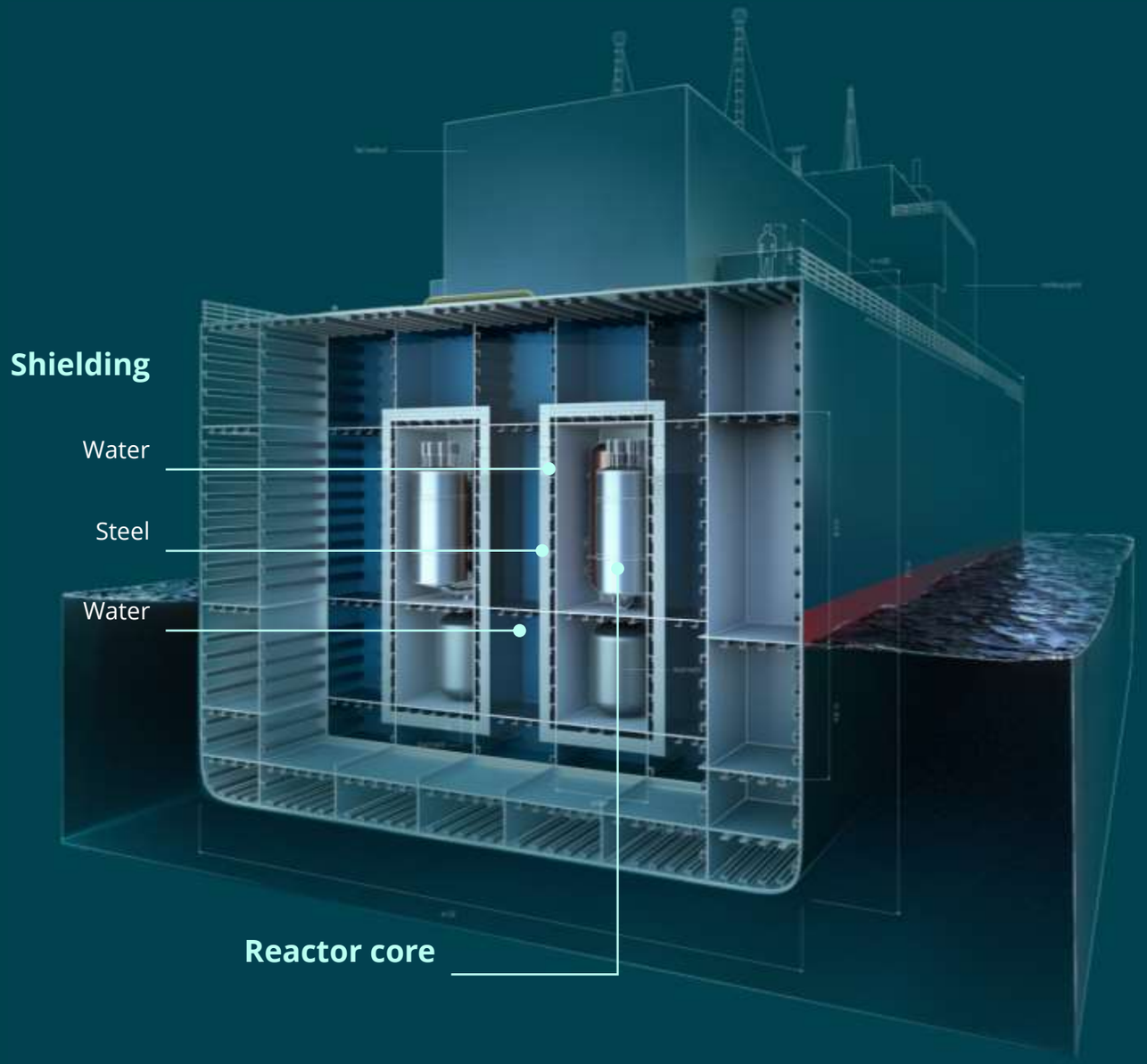
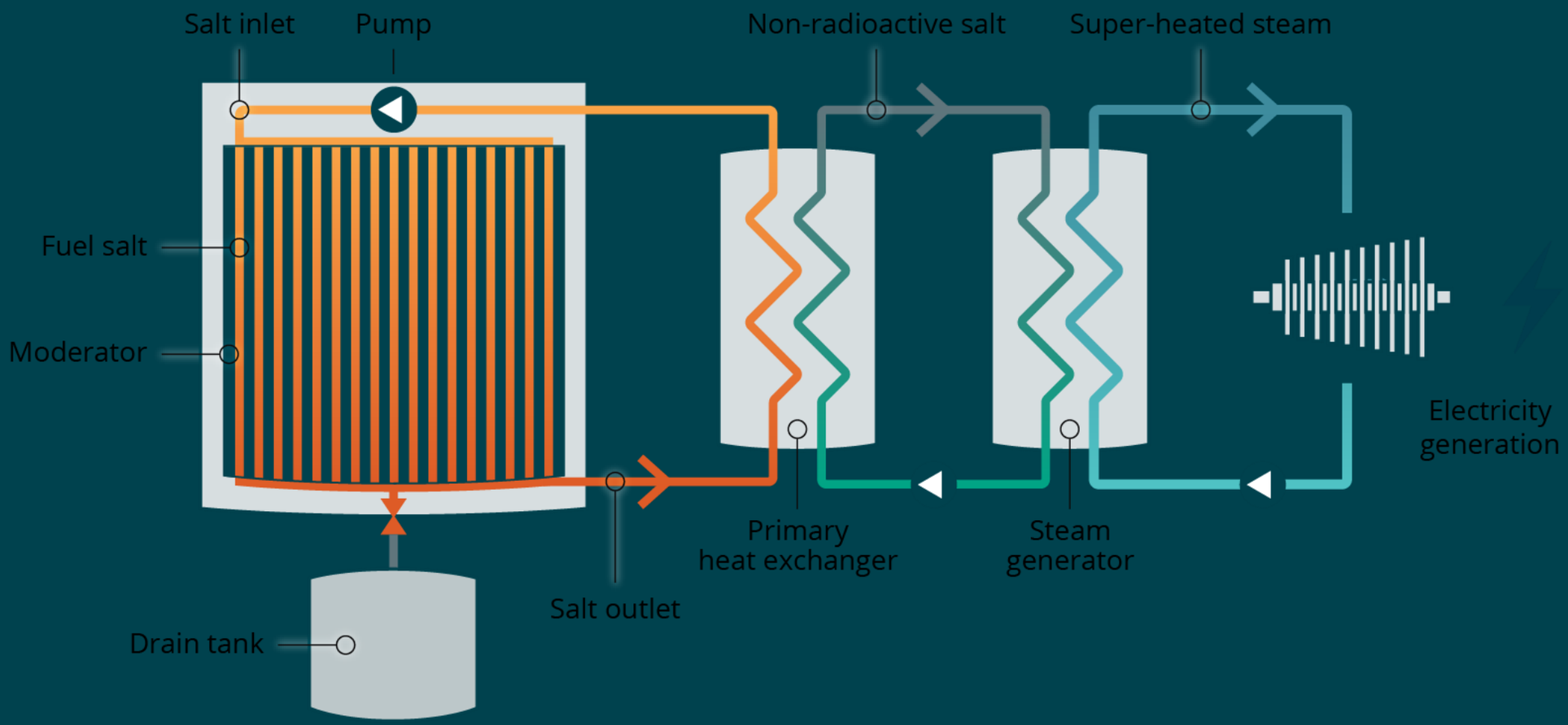
A problem specific to MSRs is moving fuel

Core shielding is same issue as in a LWR

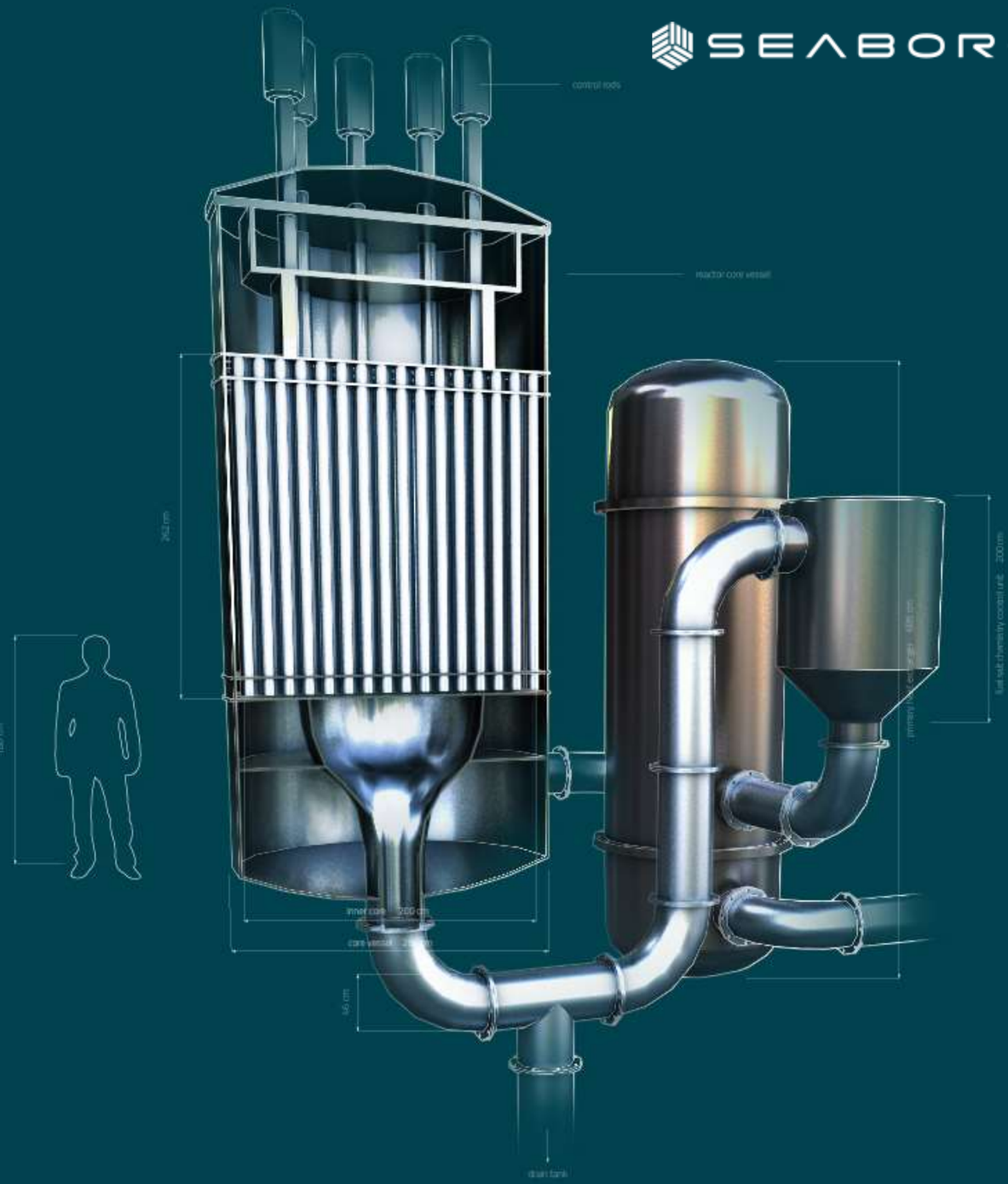


But activated salt moves out of the core…



Simulated in Serpent 2.1.32 with a combination of

- Burn steps
- Decay steps
- Activation steps



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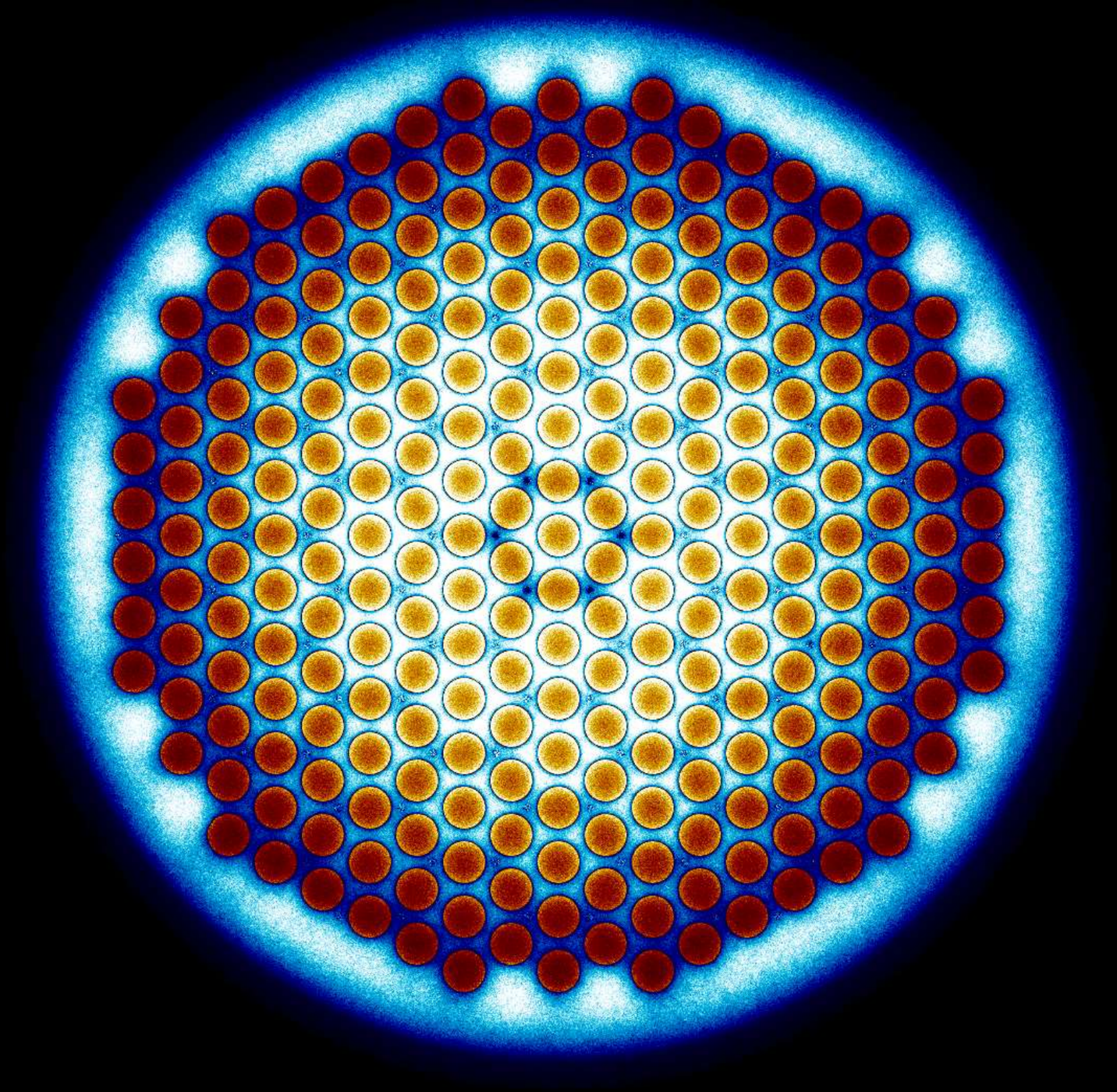
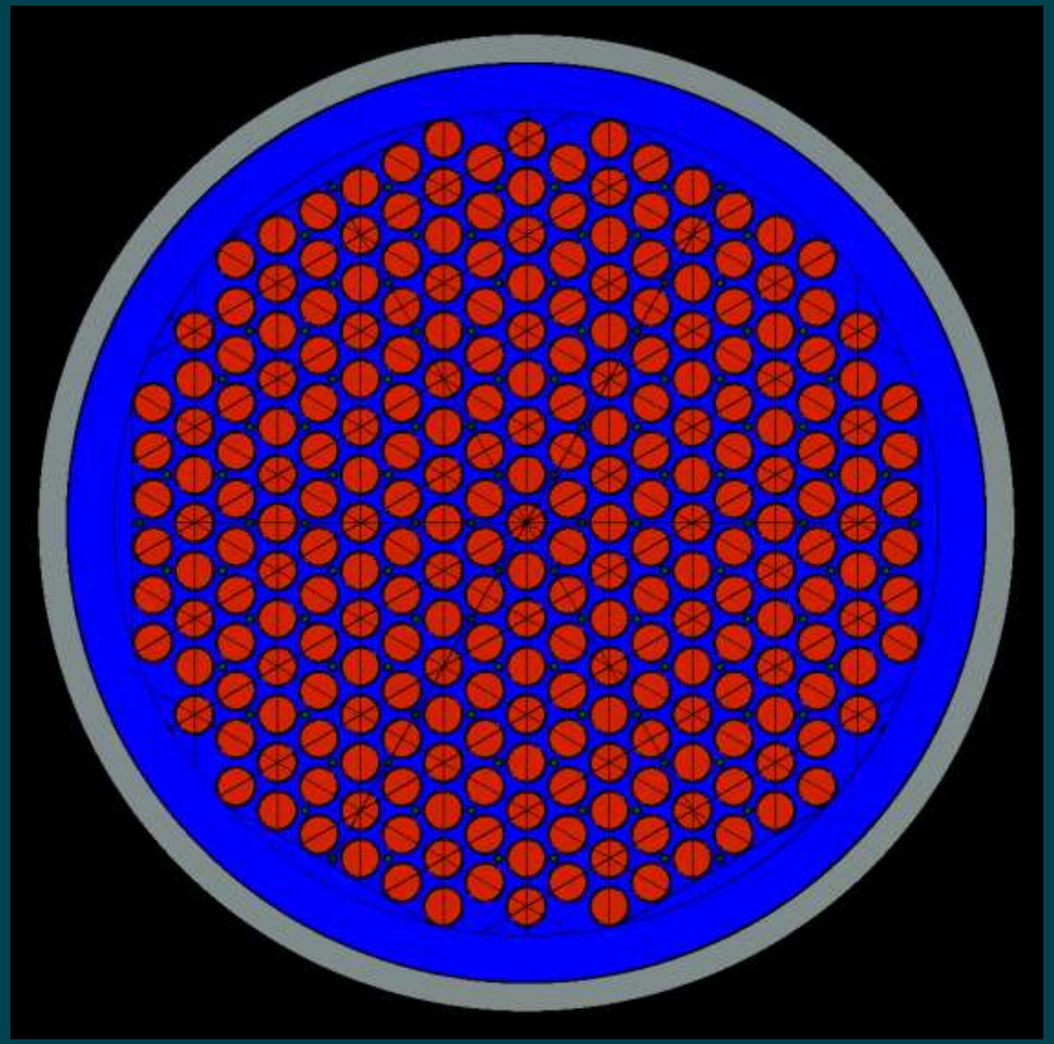
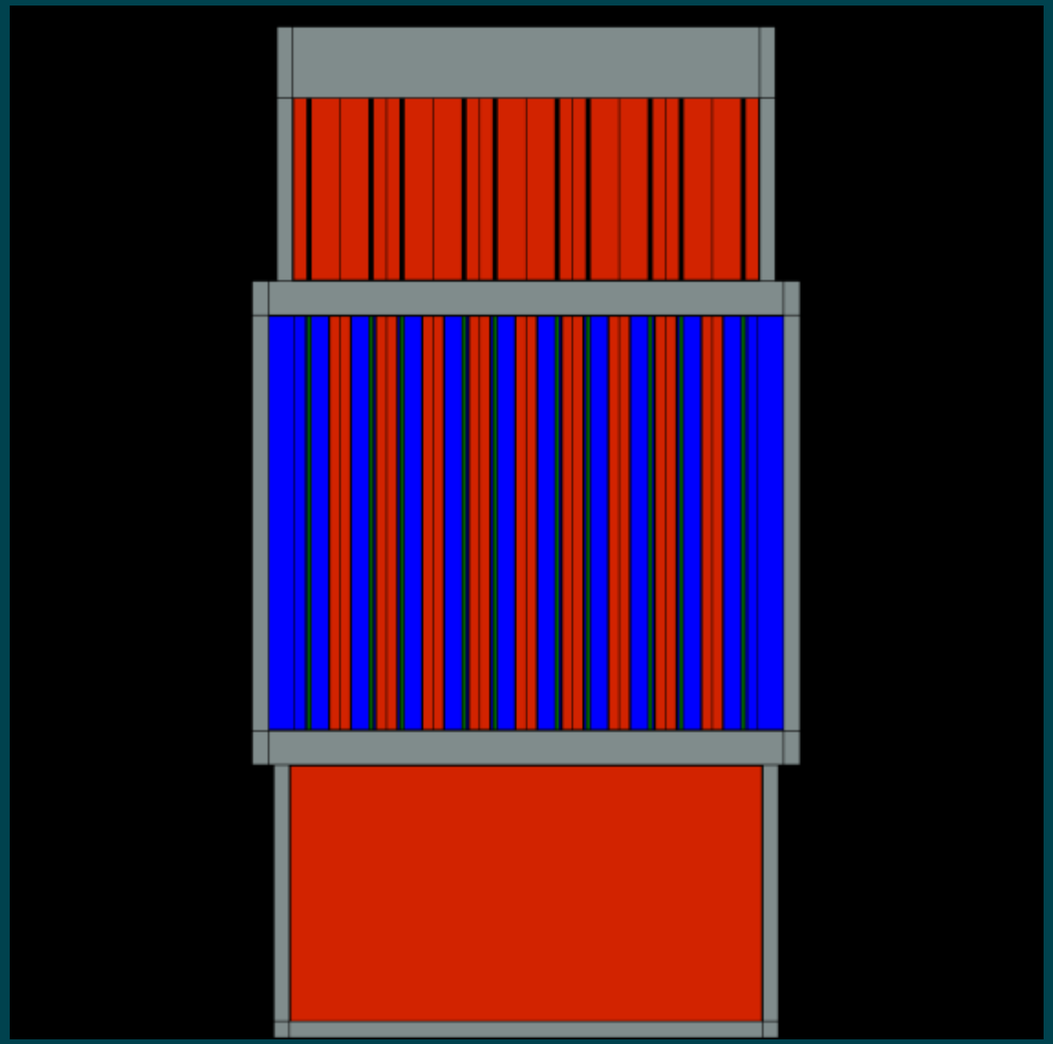
Core



Core

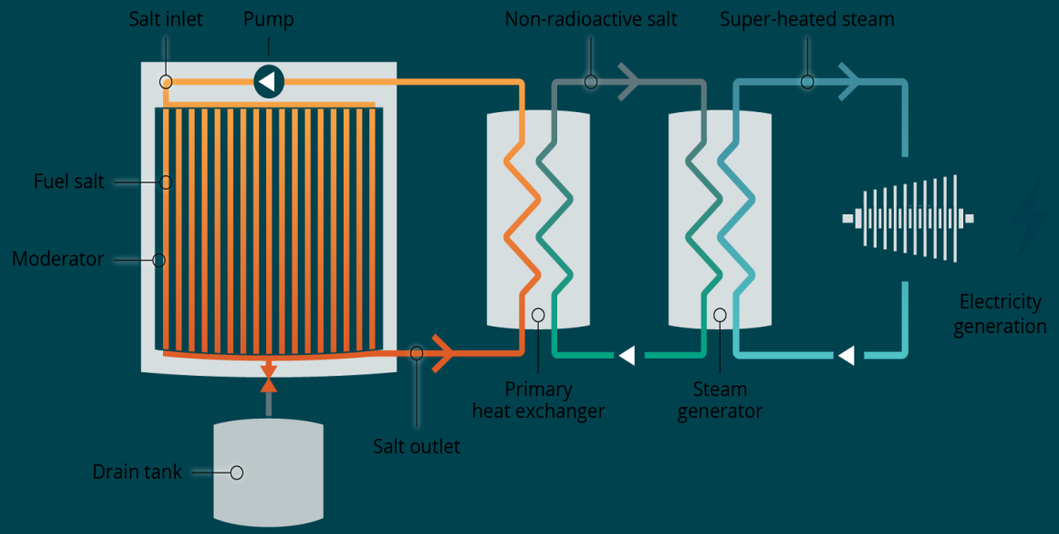




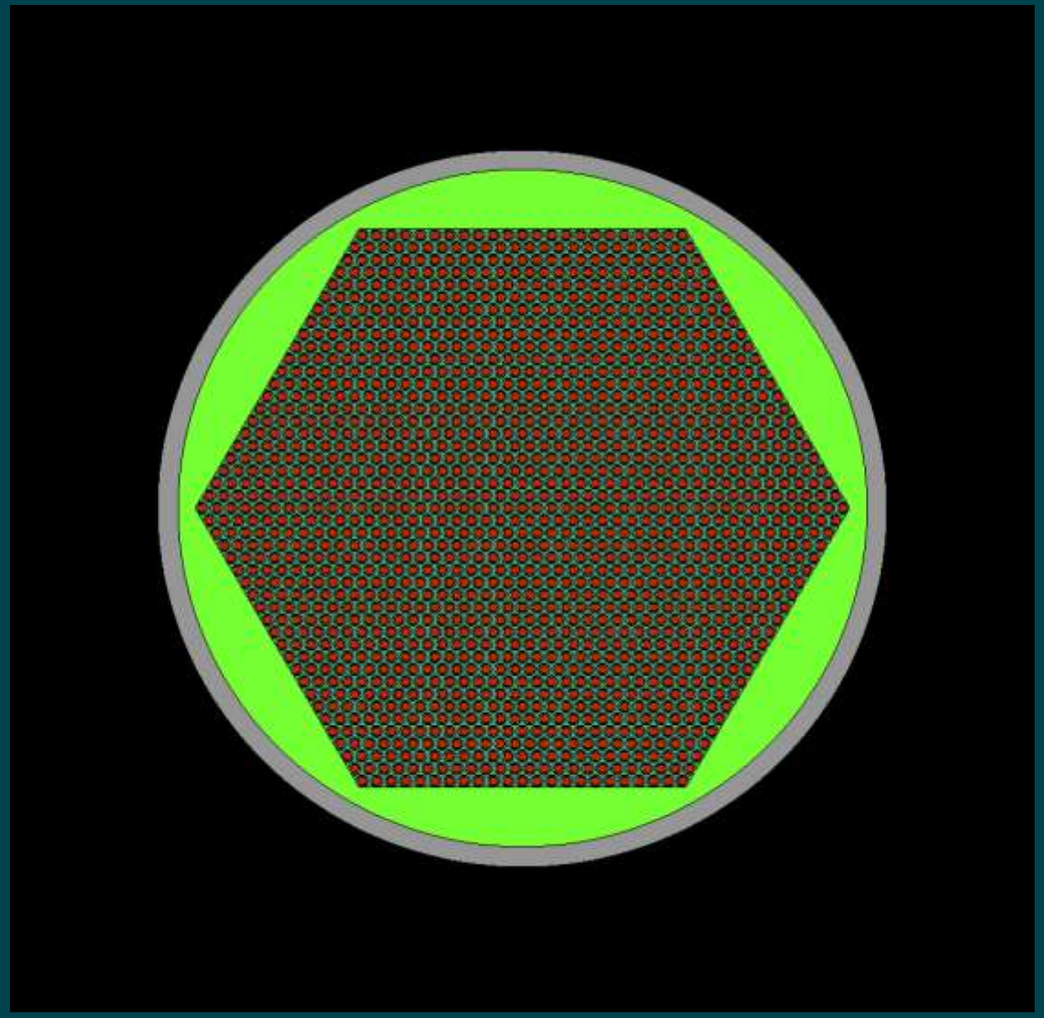
Core

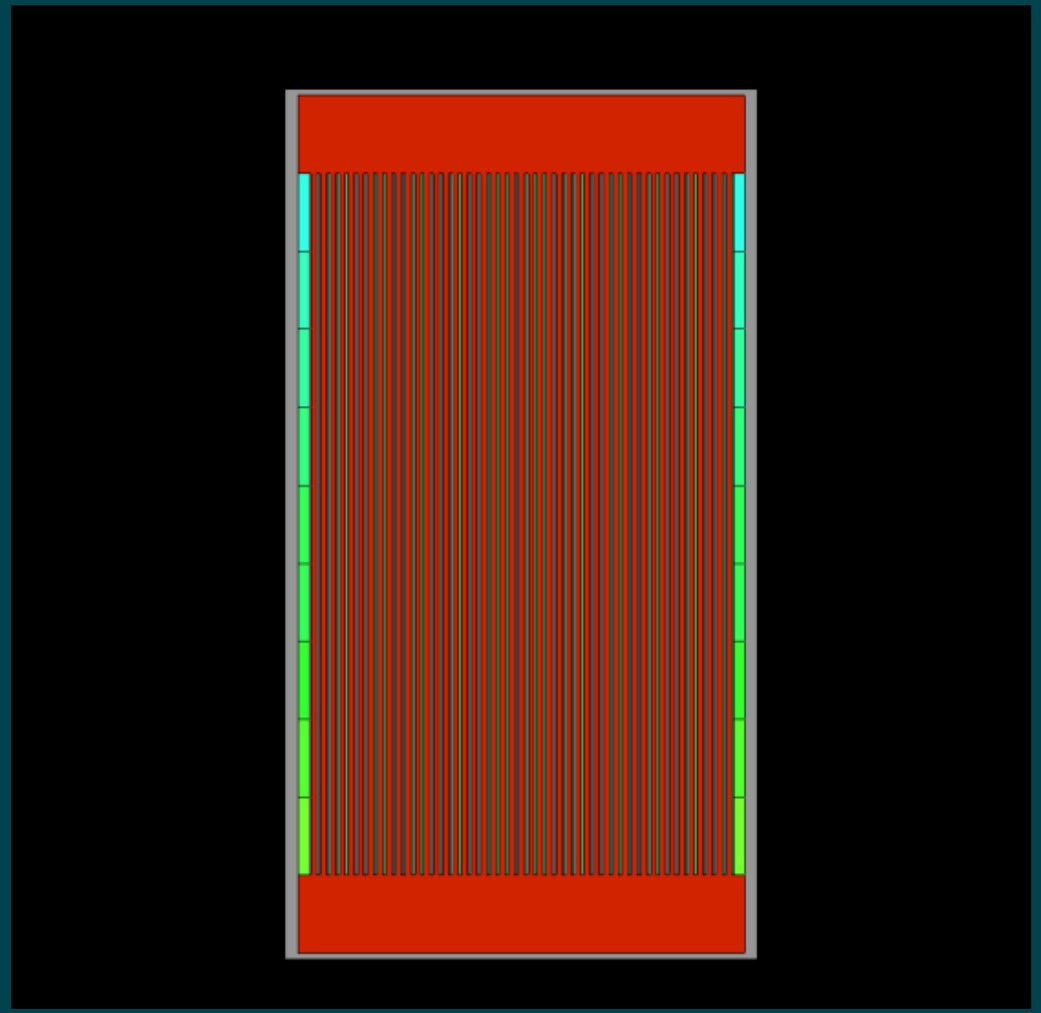
- Burn fuel
- Decay fuel
- Output

- dep daystep 4383
- dep decstep *flowtime*
- set rfw 1



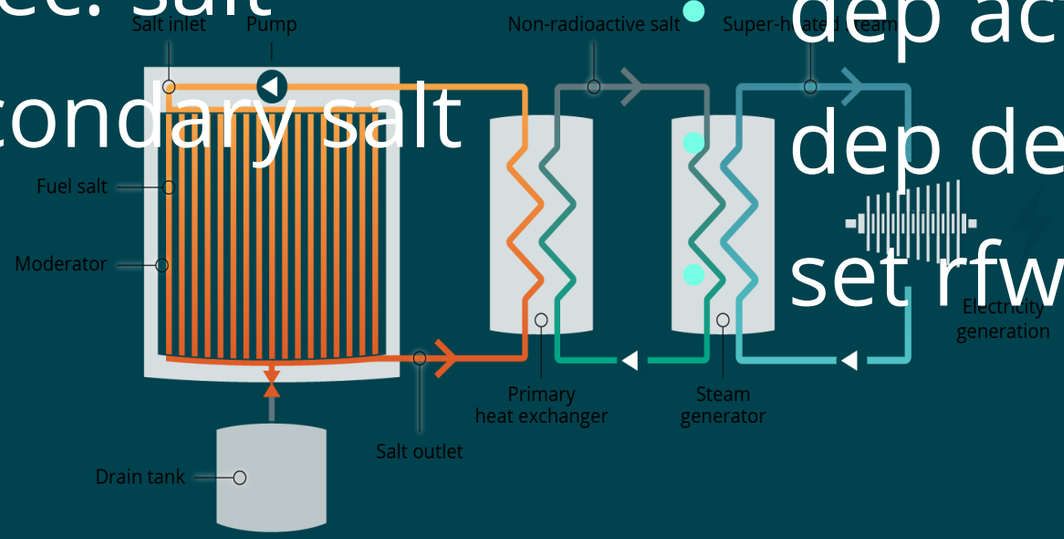
Primary heat exchanger





Primary Heat Exchanger

- Load activated fuel
- Get subcritical fissions
- Activate sec. salt
- Decay secondary salt
- Output

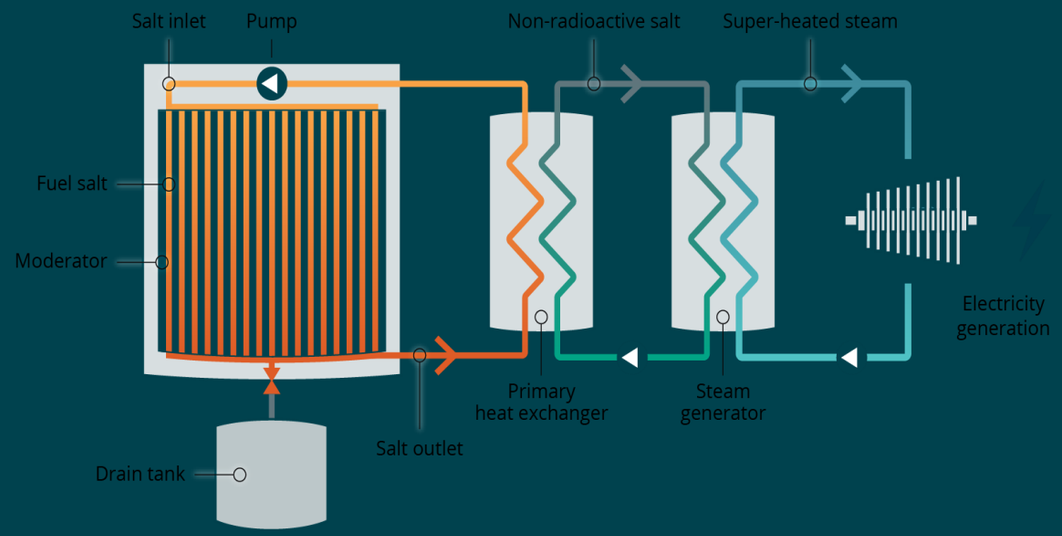


- set rfr “core.wrk”
- src source n sg “fuel” 1
- dep daystep 1e-20
- dep actstep xxx
- dep decstep flowtime
- set rfw 1

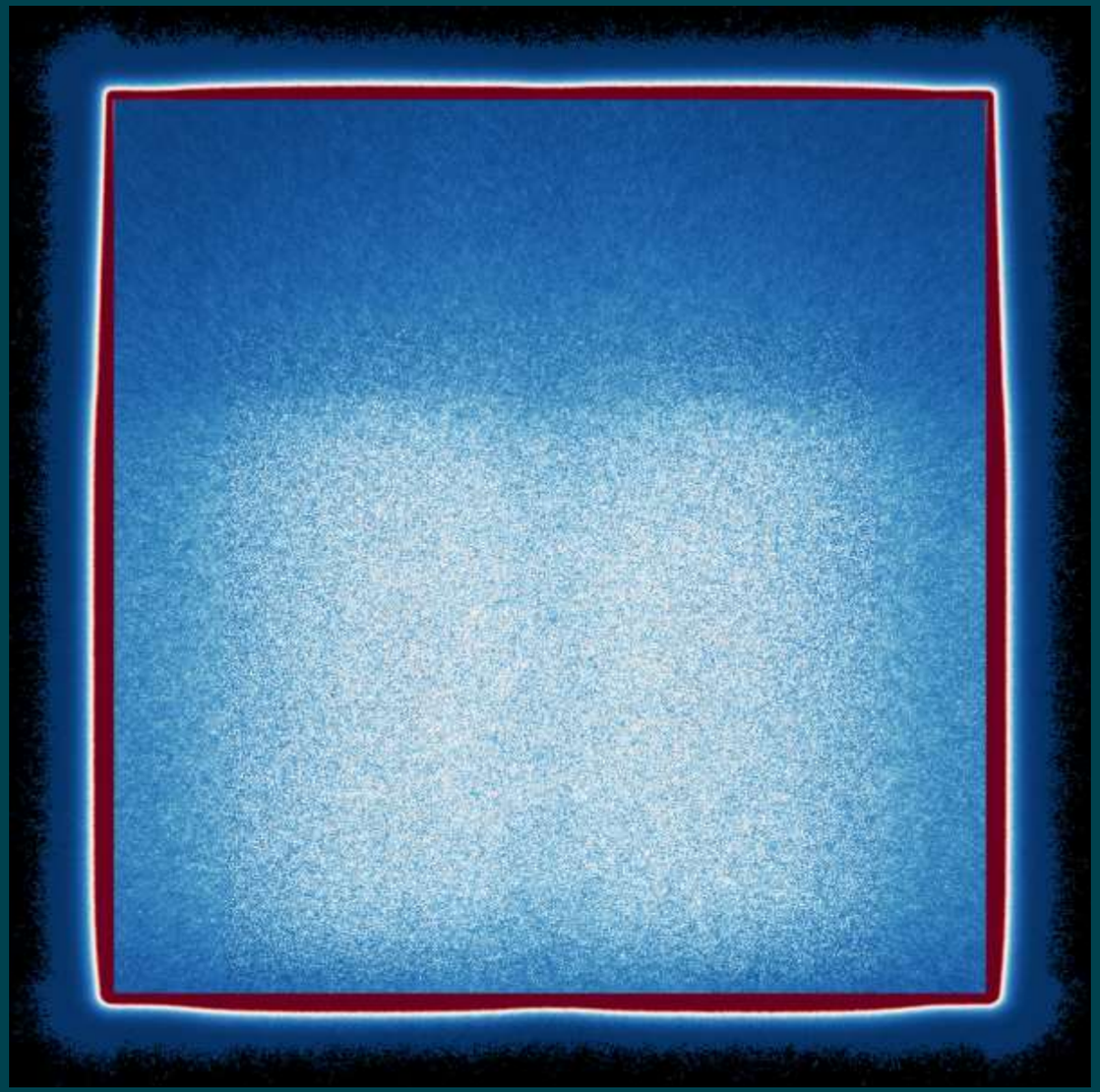
Secondary circuit

- Load activated secondary salt
- Quantify radiation

- set rfr “PHX.wrk”
- src source p sg “sec” 1
- det …..

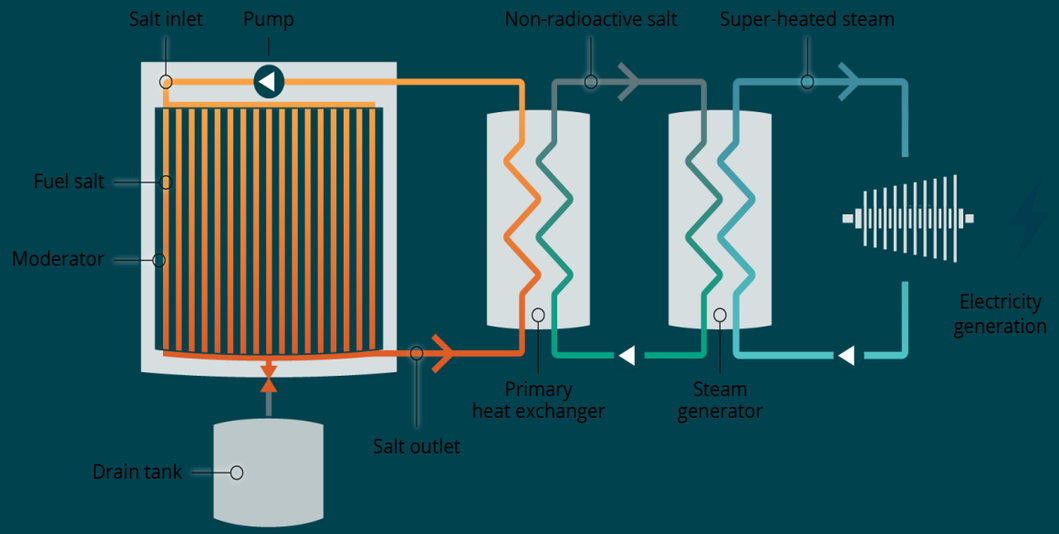


Secondary circuit



To-do

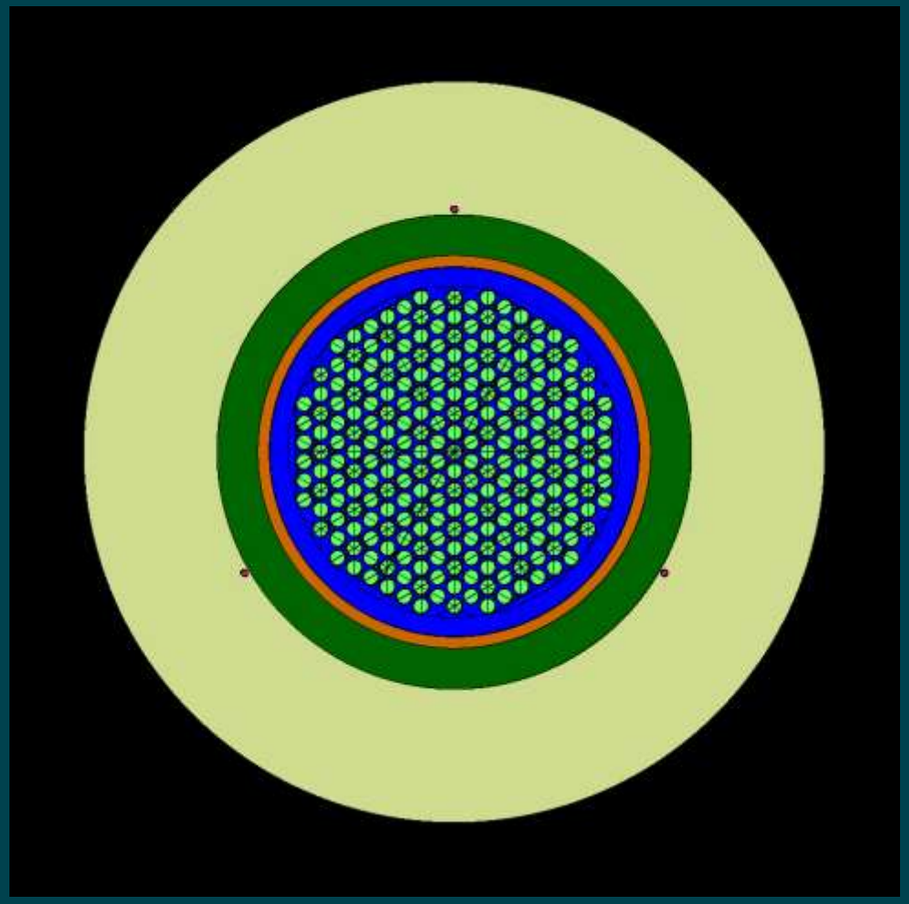
- How to model changed β_{eff} due to moving precursors?

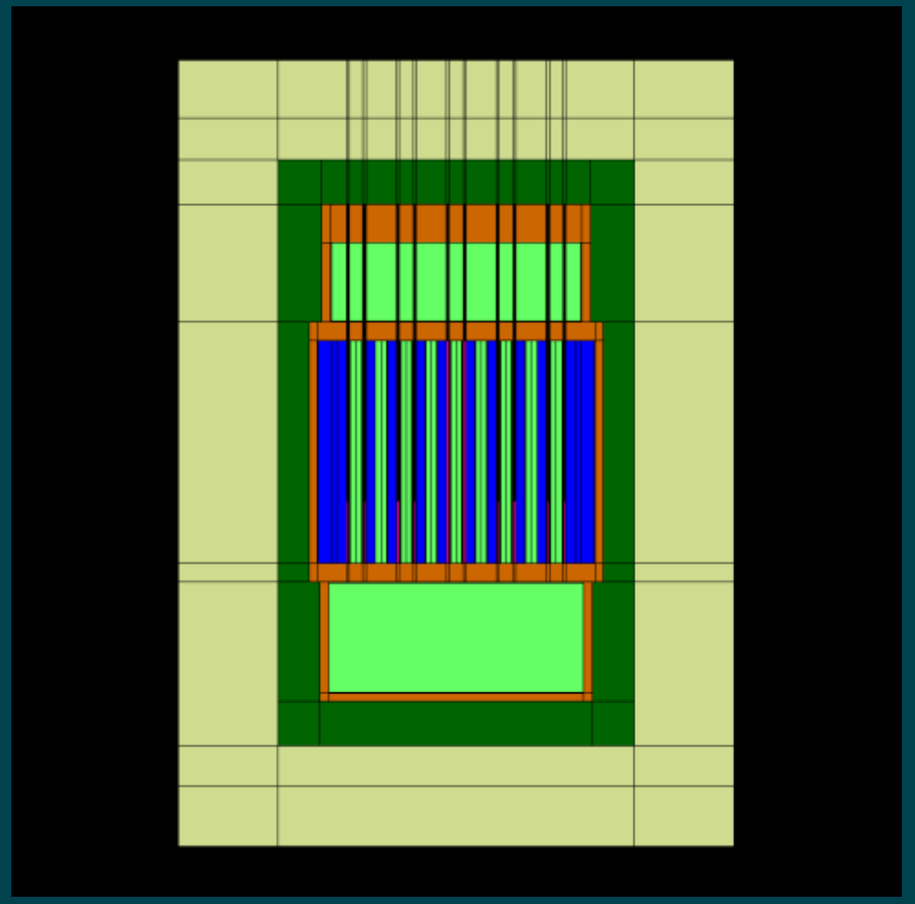


USING VR TO FOCUS ON DET

By Dr. Elter

Neutronic instrumentation layout



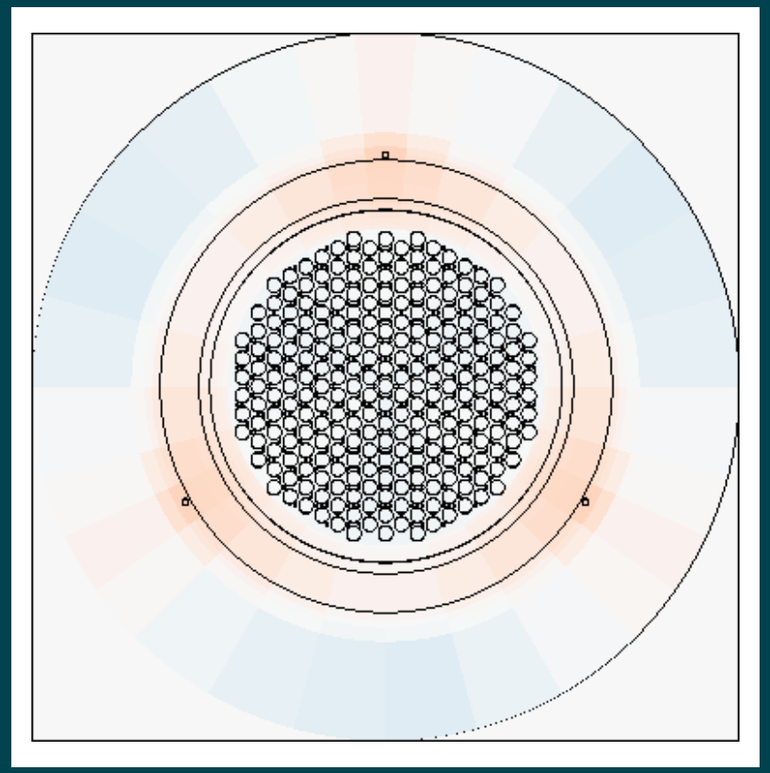


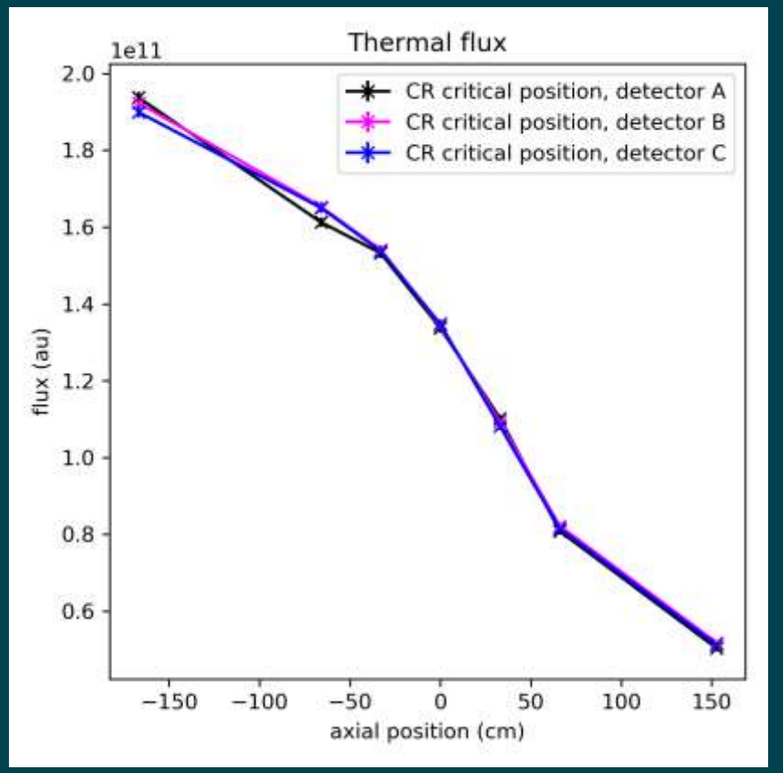
Incore neutron detection might be difficult (temperature)
Excore detectors to indicate power and axial power profile
Following 120deg symmetry, placed at 6 axial locations

Methodology and some results

Serpent wiki solution

1. ‘set csw’ to get criticality source
2. Run external source with WW (optimized for 3 locations)





WISHLIST FOR SERPENT

Wishlist for Serpent

- Units on all numbers in output files.

  E.g., instead of:

```
3.65707E-08 3.88506E-08 4.11987E-08 % Ba137
5.35509E-07 5.53664E-07 5.71884E-07 % Ba138
3.71932E-08 3.74877E-08 3.74737E-08 % Ba140
0.00000E+00 7.67972E-13 1.54581E-12 % La138
```

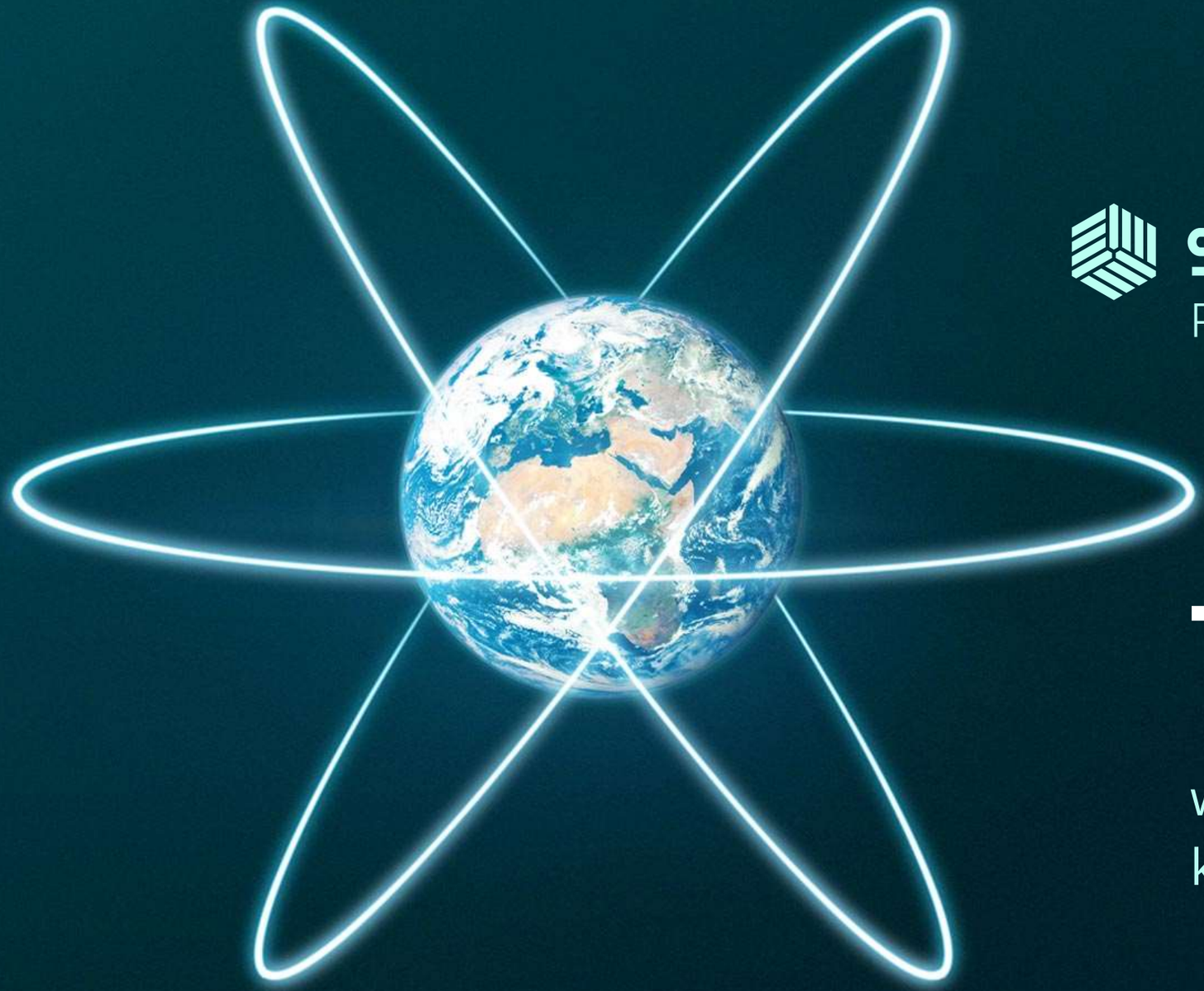
  This:

```
3.65707E-08 3.88506E-08 4.11987E-08 % Ba137 ADENS [b^-1 * cm^-1]
5.35509E-07 5.53664E-07 5.71884E-07 % Ba138 ADENS [b^-1 * cm^-1]
3.71932E-08 3.74877E-08 3.74737E-08 % Ba140 ADENS [b^-1 * cm^-1]
0.00000E+00 7.67972E-13 1.54581E-12 % La138 ADENS [b^-1 * cm^-1]
```

- Error bars on depletion results.
- $\alpha \rightarrow n$ reactions for radiation protection.

Wishlist from my colleagues

- The equivalent of MCNP F5 tallies.
- Easy access to VTK or SILO format.
- Fix the pin universes with mflow bug.



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Rethinking nuclear

Thank you!

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