# Simulation SMR-NuScale with PARCS code

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UPM

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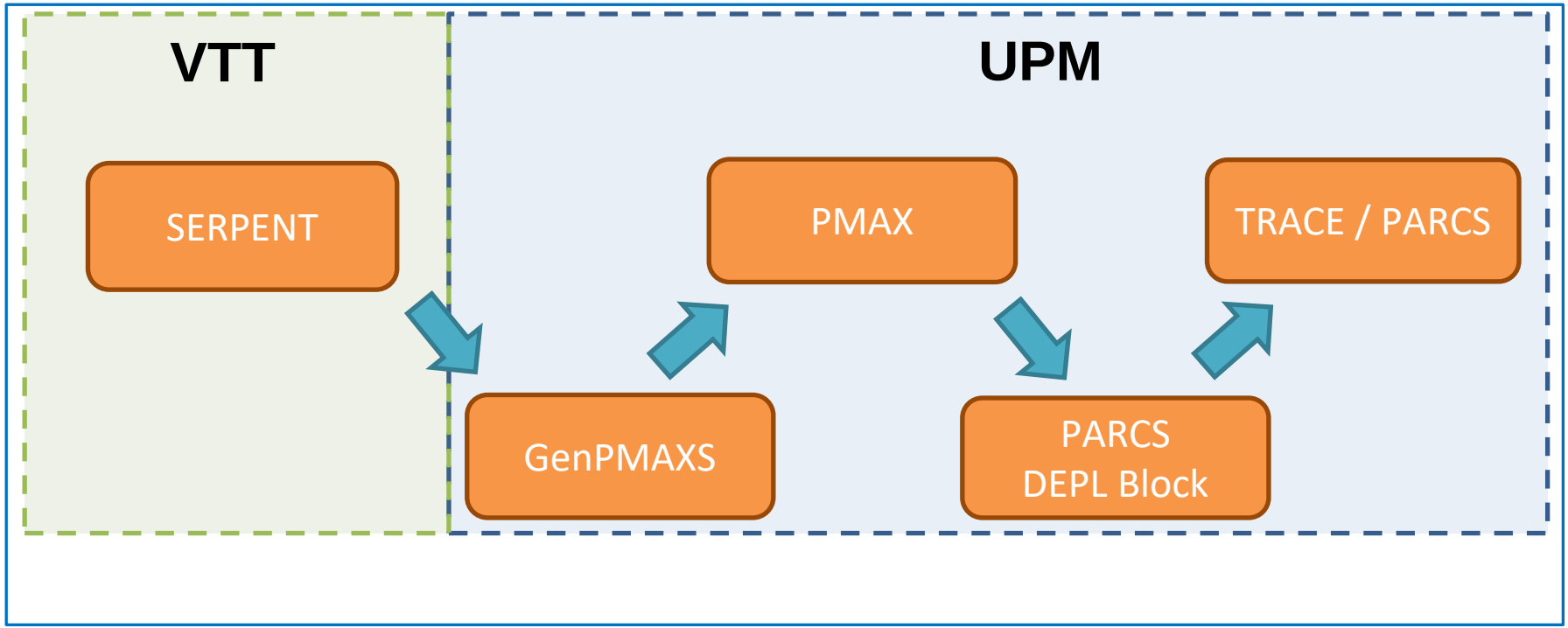
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945063.

# Outline

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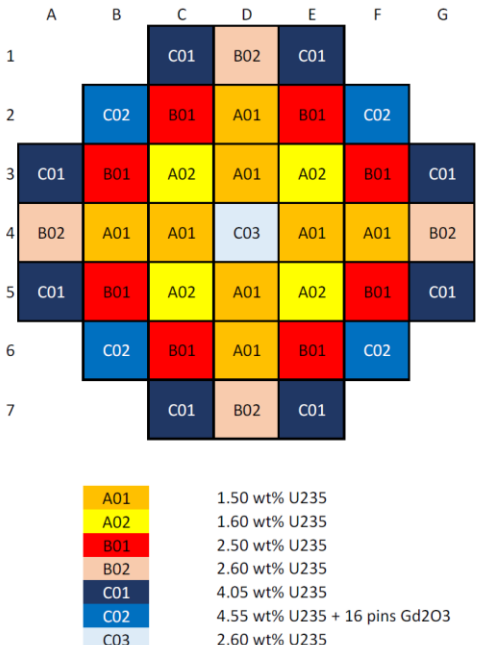
# NuScale Core




| | |
|---|---|
| Core thermal output | 160MWth |
| System pressure | 1850 psia |
| Inlet temperature | 258.3 ºC |
| Core average temperature | 283.9 ºC |
| Fuel assemblies | 37 (17x17) |
| Diameter active core | 150.57 cm |

| | |
|---|---|
| Partial CRs | AgInCd (30.48cm) + B4C (157.48 cm) |
| Fuel rod pitch (cold) | 1.2598 cm |
| Fuel assembly pitch | 21.5036 cm |
| Active height | 200 cm |

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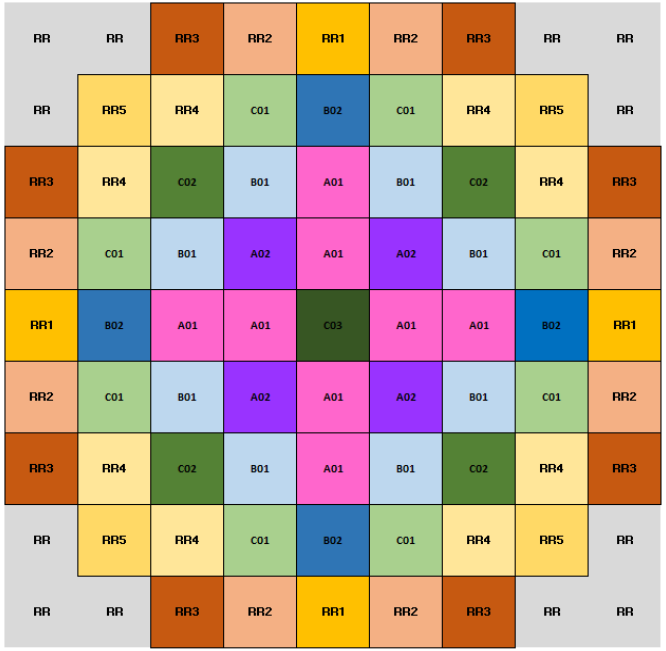
- The XS have been provided by VTT.
- Fresh fuel (at zero burnup) is considered.
- Four energy groups.
- ENDF/B-VII.1. library has been used.

| STATE VARIABLES | BRANCHING |
|---|---|
| DM (g/cm$^3$) | 0.9, 0.8, 0.7, 0.6, 0.5, 0.3 |
| PM (ppm) | 0, 1000, 2000 |
| TF (K) | 900 |

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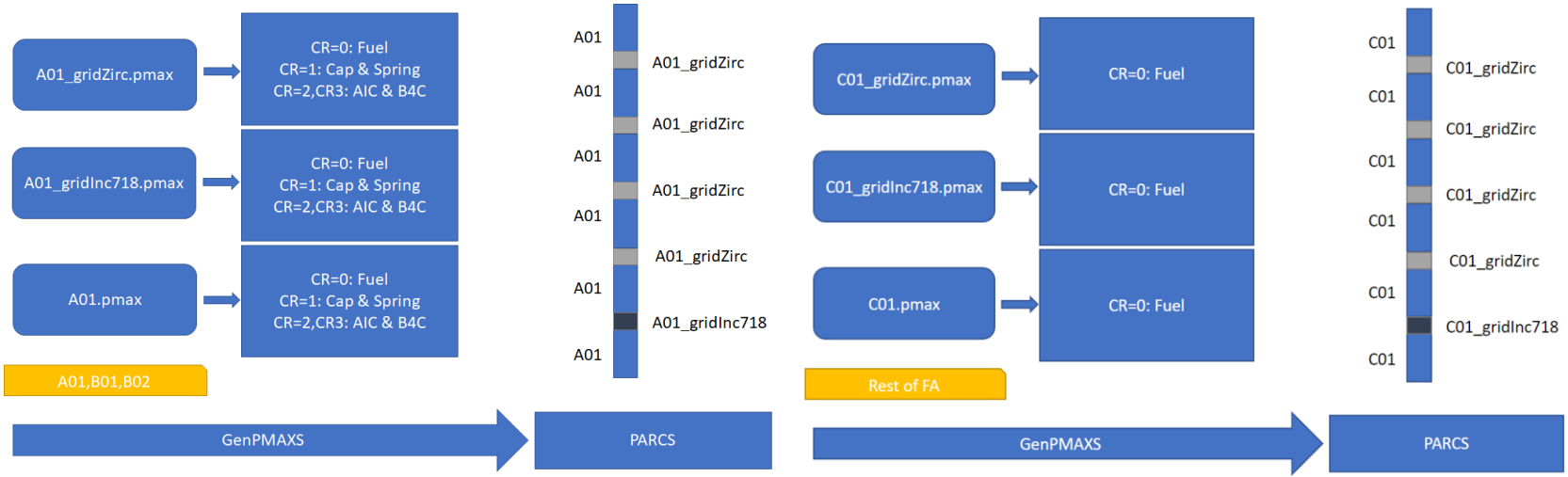
# GenPMAXS

GenPMAXS allows to treat CRs with different absorber materials.
CR, TF, PC and DC state variables are allowed.

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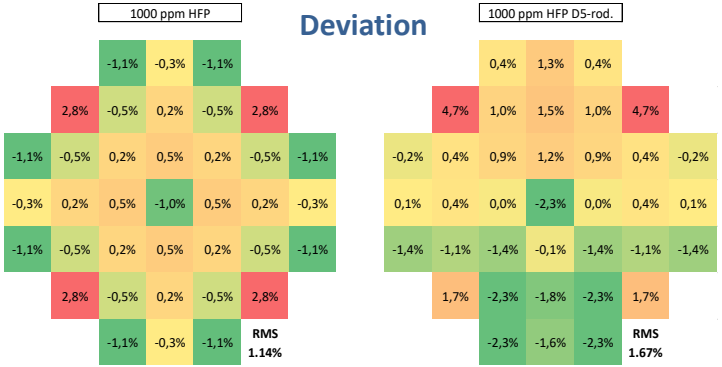
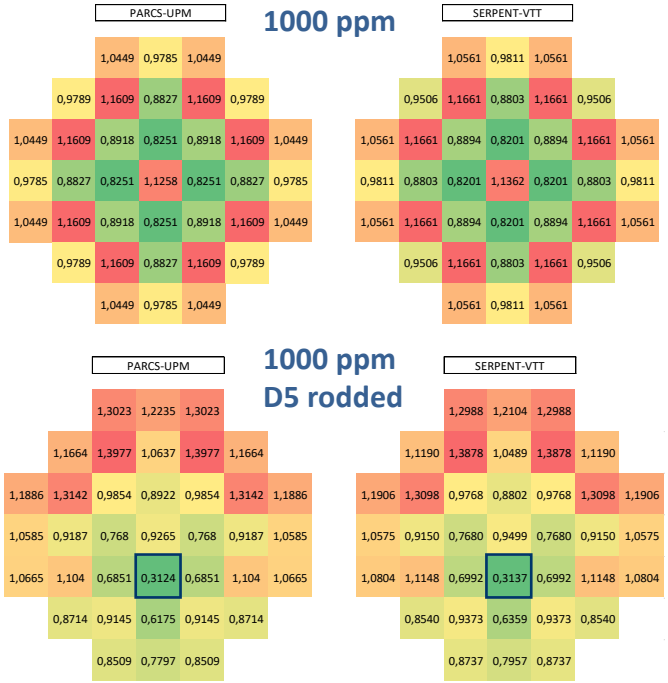
# SERPENT vs. PARCS Benchmark. Radial Power Distribution at BOC

| Keff (HFP) | PARCS | SERPENT |
|---|---|---|
| 1000 ppm | 1.02845 | 1.02762 |
| 1000 ppm, D5 rodded | 1.02223 | 1.02207 |




NEMMG has been employed.

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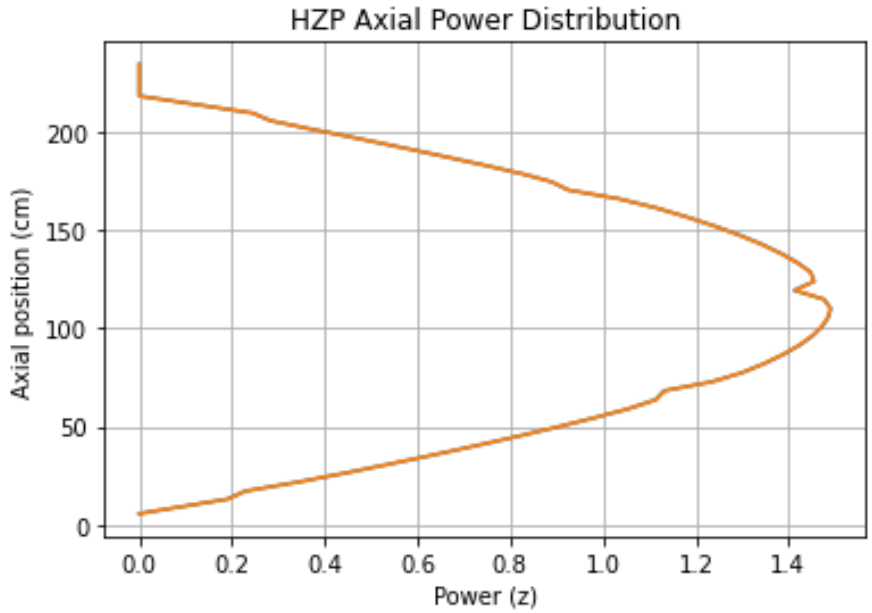
# Axial Power Distribution at BOC

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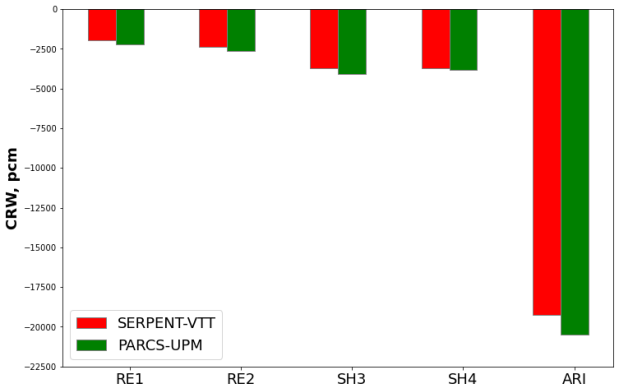
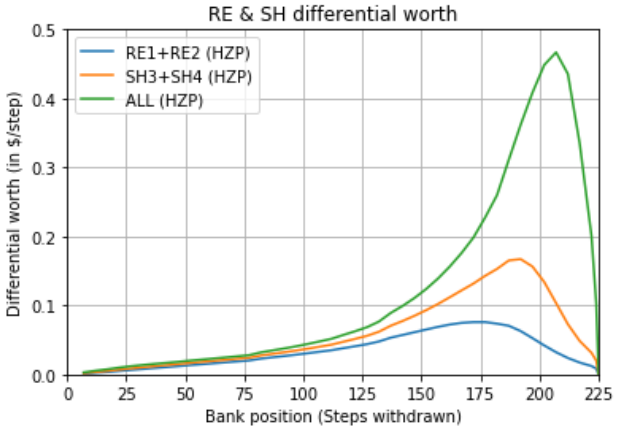
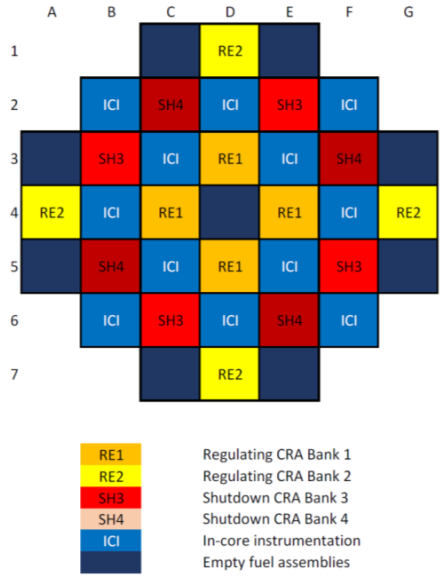
# Control Rod Worth

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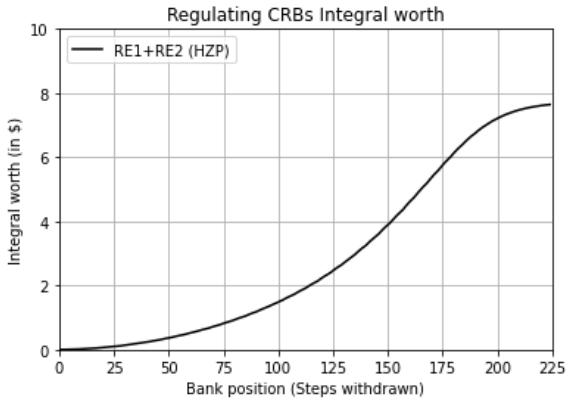
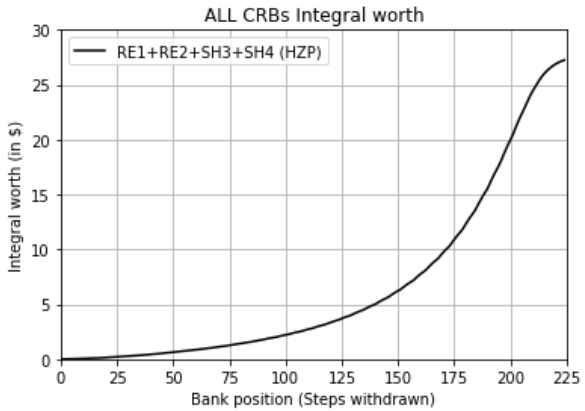
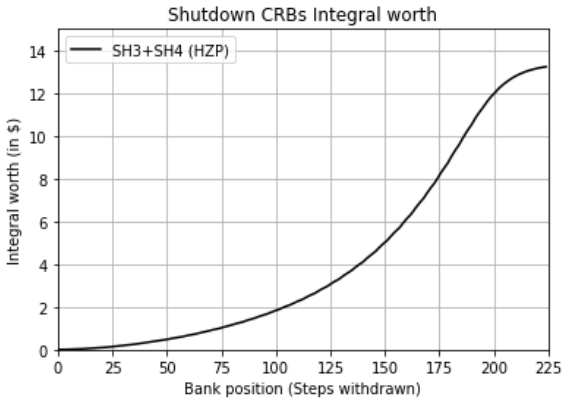
# Integral CRs Worth

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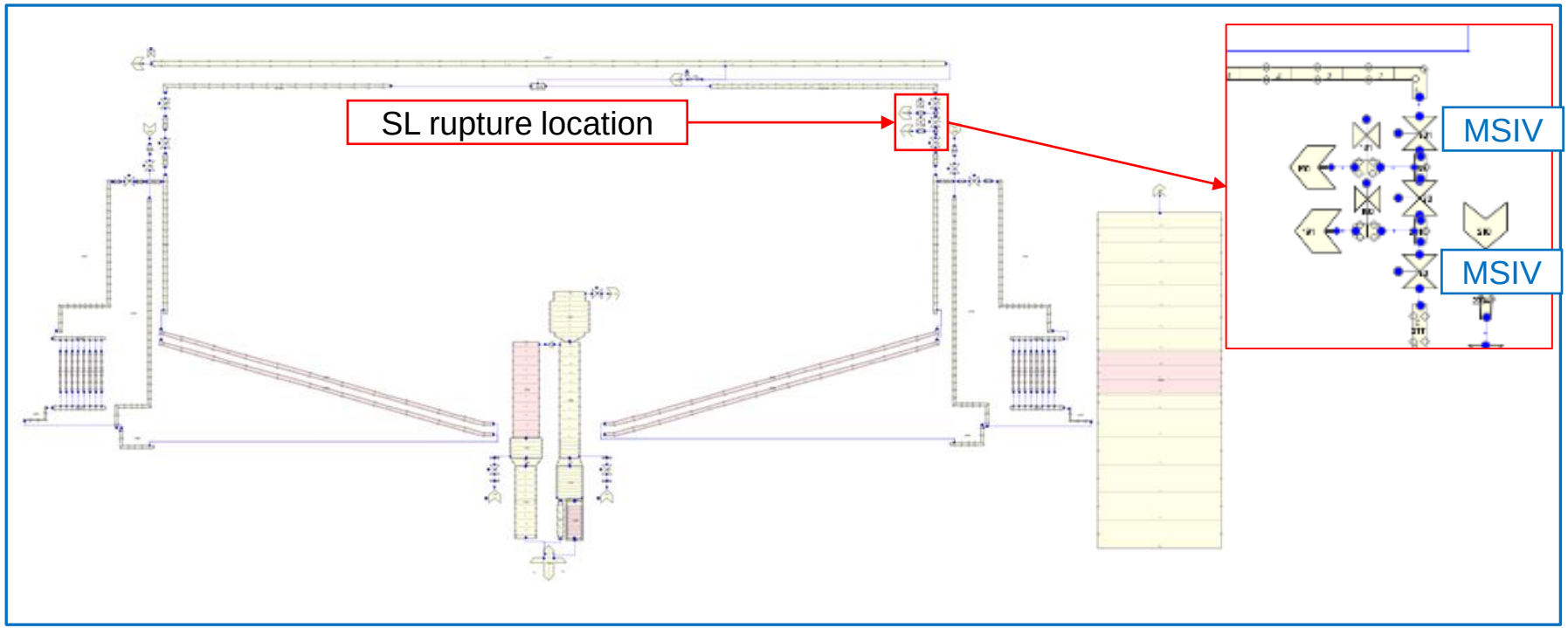
# TRACE 1D model. Steam Line Break. Nodalization scheme

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# TRACE 1D model. Steam Line Break. **McSAFER hypotheses**

## Initial conditions:

| Parameter | Nominal Value | DEGB-SL |
|---|---|---|
| **Core Power (MWt)** | 160 | **100% (IC fixed)** |
| **Rupture Location** | - | **SL between the primary and secondary MSIVs** |
| **PZR Pressure (MPa)** | 12.755 | 12.755 |
| **Pressurizer Level (%)** | 60 | 60 |
| **RCS Flow rate (kg/s)** | 544.29 | **535 (IC fixed)** |
| **RCS Avg. Temp. (K)** | 558.15 | 563.71 |
| **SG Pressure (MPa)** | 3.447 | 3.689 |
| **Core exposure** | | Burn-up = 0.0 |

## Hypotheses McSAFER:

- Initial power level is assumed to be 100 % RTP at BOC condition along with high RCS temperature and SG pressure.
- The Low Steam Pressure Trip signal is credited.
- The High Core Power Trip signal is credited (125%).
- It is assumed that normal AC power is available.
- The failure of the **primary MSIV** associated with the impacted SG train is assumed.
- The FW flow is allowed to be increased in 0.181 kg/s for every 0.00689 MPa decrease in SG pressure.

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# TRACE-1D/PARCS-3D model. Steady-State Power Distribution

## Radial Power Distribution

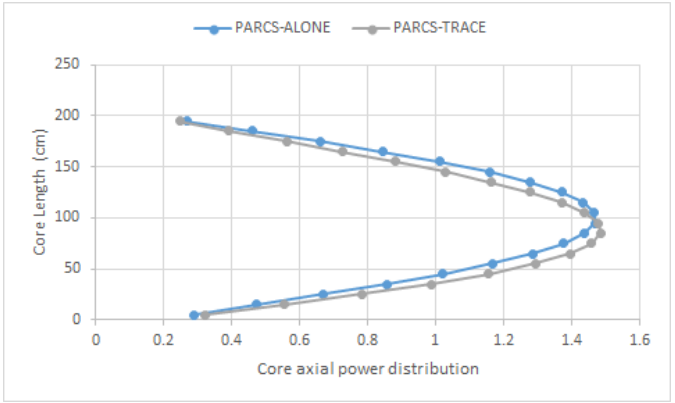
| | | | | | | |
|---|---|---|---|---|---|---|
| | | 1.0692 | 0.9871 | 1.0692 | | |
| | 1.0032 | 1.1596 | 0.8695 | 1.1596 | 1.0032 | |
| 1.0692 | 1.1596 | 0.8681 | 0.7936 | 0.8681 | 1.1596 | 1.0692 |
| 0.9871 | 0.8695 | 0.7936 | 1.0831 | 0.7936 | 0.8695 | 0.9871 |
| 1.0692 | 1.1596 | 0.8681 | 0.7936 | 0.8681 | 1.1596 | 1.0692 |
| | 1.0032 | 1.1596 | 0.8695 | 1.1596 | 1.0032 | |
| | | 1.0692 | 0.9871 | 1.0692 | | |

UPM/PARCS ALONE

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 1.0468 | 0.9818 | 1.0468 | | |
| | 0.9792 | 1.1592 | 0.8816 | 1.1592 | 0.9792 | |
| 1.0468 | 1.1592 | 0.8894 | 0.8249 | 0.8894 | 1.1592 | 1.0468 |
| 0.9818 | 0.8816 | 0.8249 | 1.1247 | 0.8249 | 0.8816 | 0.9818 |
| 1.0468 | 1.1592 | 0.8894 | 0.8249 | 0.8894 | 1.1592 | 1.0468 |
| | 0.9792 | 1.1592 | 0.8816 | 1.1592 | 0.9792 | |
| | | 1.0468 | 0.9818 | 1.0468 | | |

UPM/PARCS-TRACE

## Axial Power Distribution

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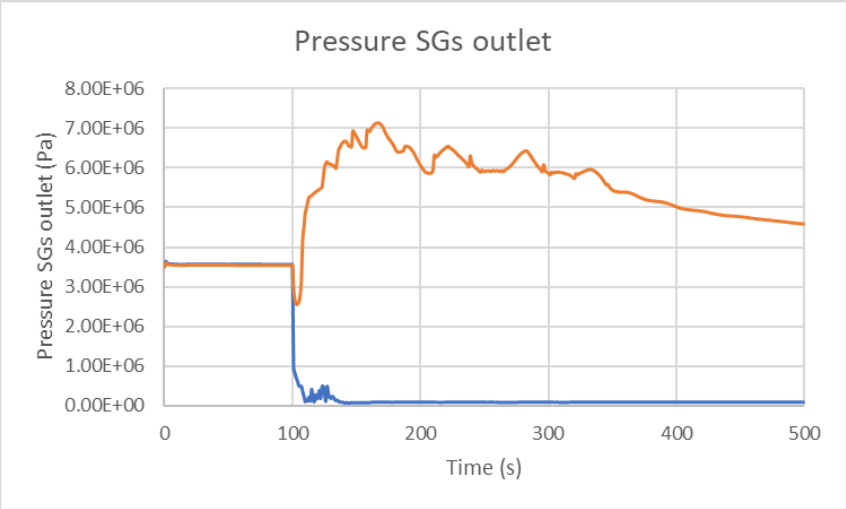
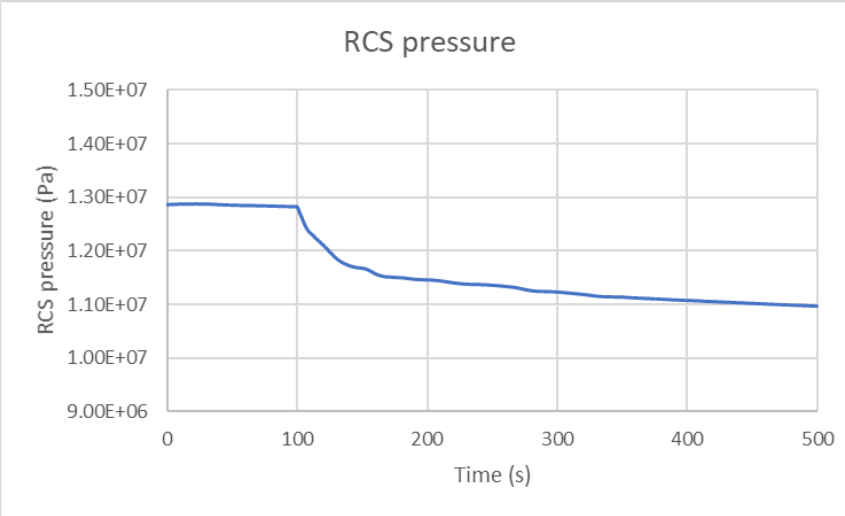
# TRACE-1D/PARCS-3D model. Steam Line Break

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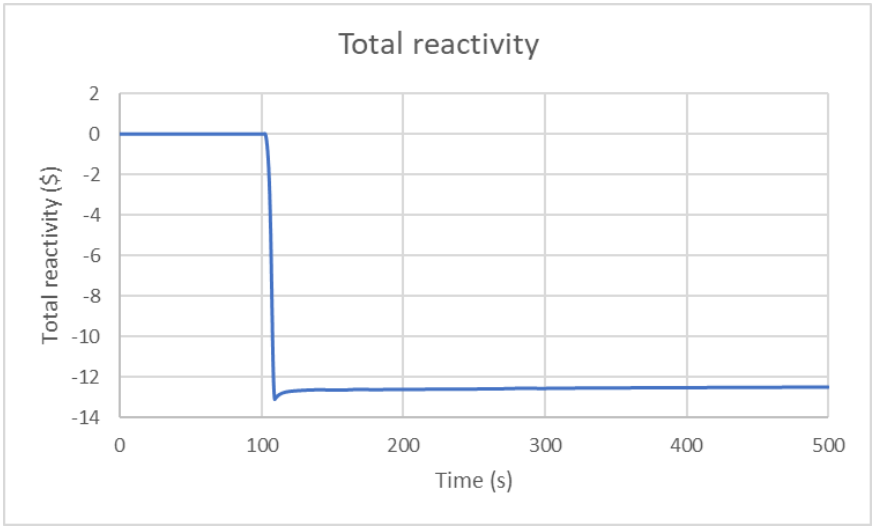
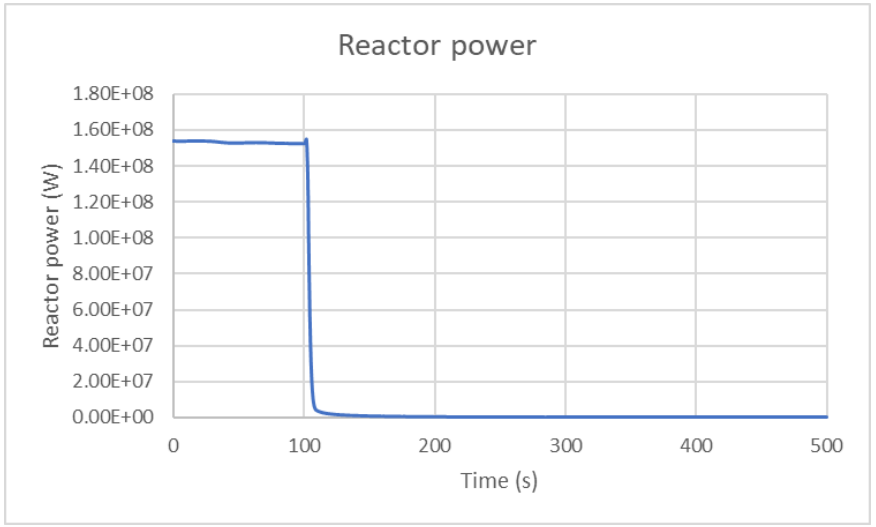
# TRACE-1D/PARCS-3D model. Steam Line Break

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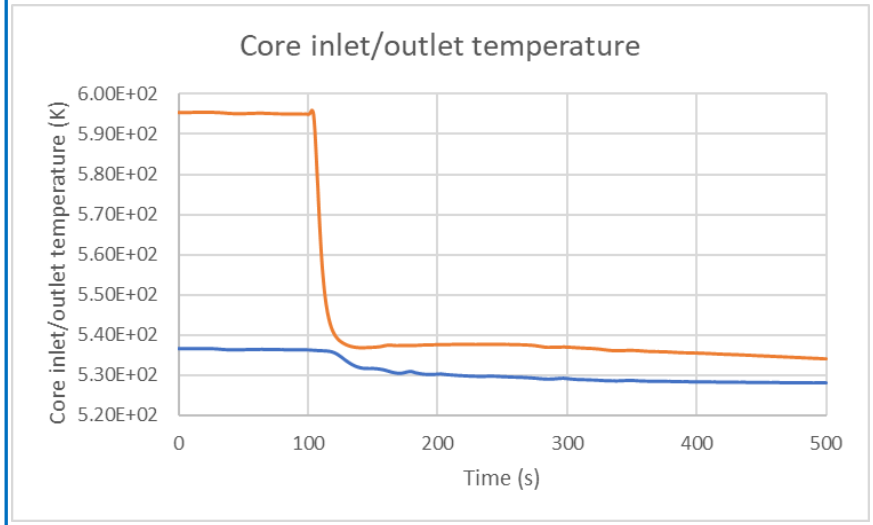
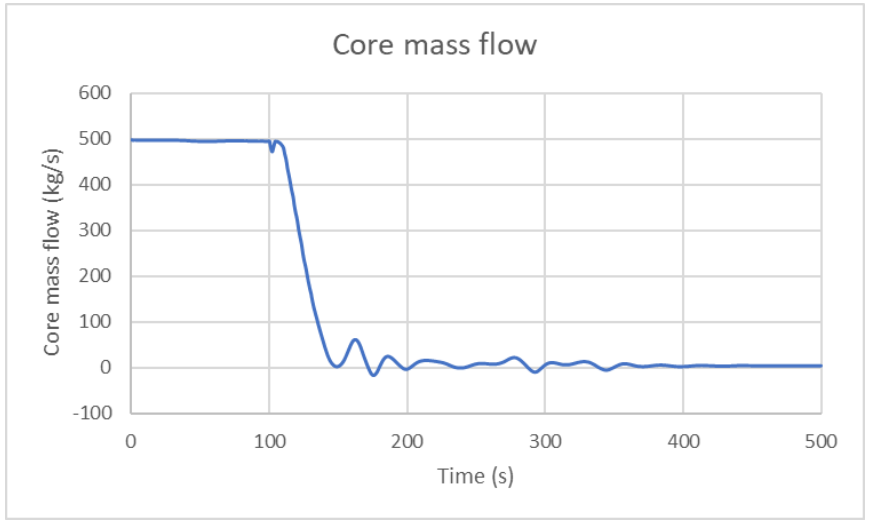
# TRACE-1D/PARCS-3D model. Steam Line Break

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# TRACE-1D/PARCS-3D model. Steam Line Break

| Parameter | Nominal Value |
|---|---|
| Steam Line Break [s] | 100 |
| Low Steam Pressure setpoint [s] | 103 |
| SCRAM setpoint [-] | Low Steam Pressure setpoint |
| SCRAM signal [s] | 103 |

Different numerical methods and convergence criteria are being tested:

- NEMG (4G),
- Hybrid (4G),
- FDM (2G).

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# CONCLUSIONS

- It has been obtained a NuScale representative model in PARCS. The model has then been validated with the results obtained from VTT's neutronic model.
- A Steam Break Line transient has been successfully simulated by coupling the core PARCS model with a TH plant model from TRACE code.
- PARCS is a suitable tool for the development of models for non-conventional reactors, such as NuScale.

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# ACKNOWLEGEMENTS

Special thanks to VTT for providing the SERPENT Cross Sections  used to perform the models.

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