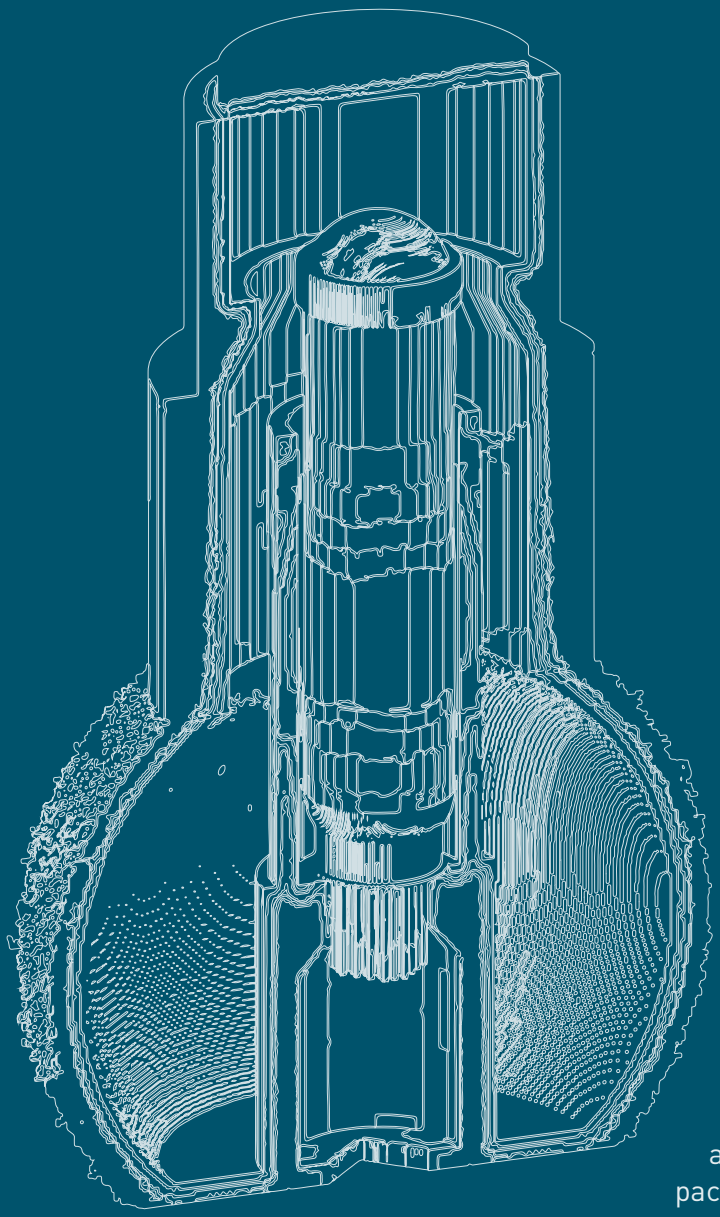
AMAC

Nagra's Advanced Methodology for Activation Characterization

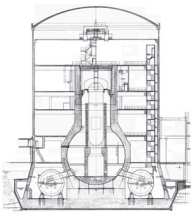


Over the last 15 years Nagra in Switzerland has developed a methodology (AMAC) to characterize the activation of NPP components and building structures caused by neutron irradiation. AMAC has been successfully applied and validated for the determination of the radioactive waste volumes and activity classifications in the context of NPP decommission planning. AMAC delivers a detailed three-dimensional neutron flux and activation distribution mapping and inventories for reactor building structures, RPV and internals, as well as segmentation strategies and optimized packaging concepts.

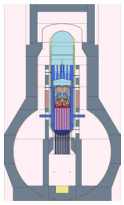
nagra.

AMAC Code Sequence

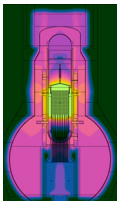
Overview of steps for an NPP project as well as the sequence of nuclear and in-house codes being used.



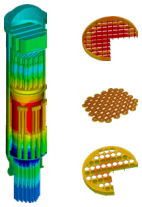
Obtain NPP Technical Data



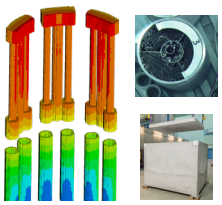
Build MCNP Model of NPP



Flux Distribution



Activation Calculations
(for each component)



Decommissioning Planning
(segmentation, packaging)

MCNP

Neutron flux distribution and spectrum, reaction rates

Detailed 3D NPP models optimized for component activation and neutron streaming effects

ADVANTG

Hybrid variance reduction

Massive increase in computational efficiency (orders of magnitude)
Oak Ridge National Lab/ USA and NAGRA collaboration

ORIGEN (SCALE) & LAVA

Activation sequence
Automated material assignment, efficient cross-code API calls, highly resolved component-wise activation inventories (>100 nuclides)

AMAC: Optimization and Automatization of Code Interactions

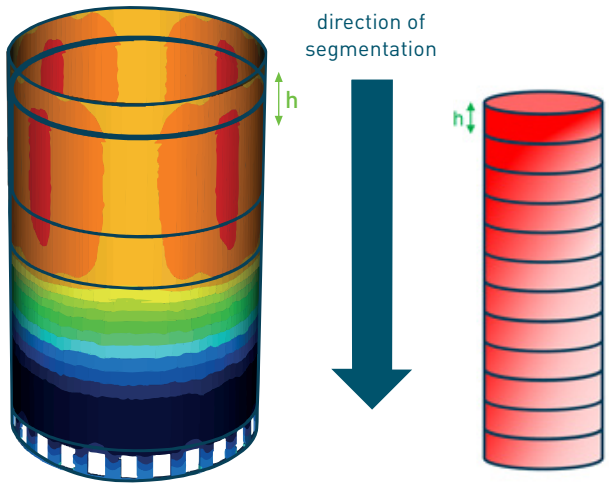
AMAC Data Tools

Activation data management and analysis for segmentation support and optimization

ALGOPACK

Algorithmic packaging optimization

ALGOPACK Packaging Optimization

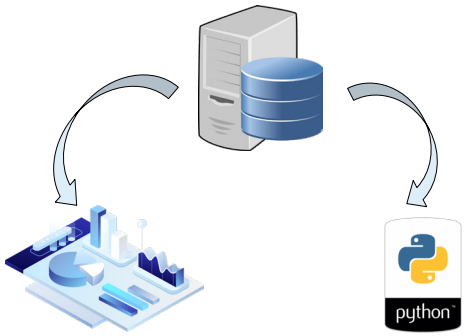


In AMAC, every component is described with 10^5–10^7 voxels, each with its own full nuclide vector (~250 nuclides). These results are input to a waste packaging optimization module, ALGOPACK, which automatically determines the optimal selection of waste containers, taking advantage of the detailed activity distribution available. For each waste container, ALGOPACK considers the activity distribution inside, as well as all other applicable limits (usable volume limitations, maximum loading mass, dose rate limits).

AMAC Data Tools

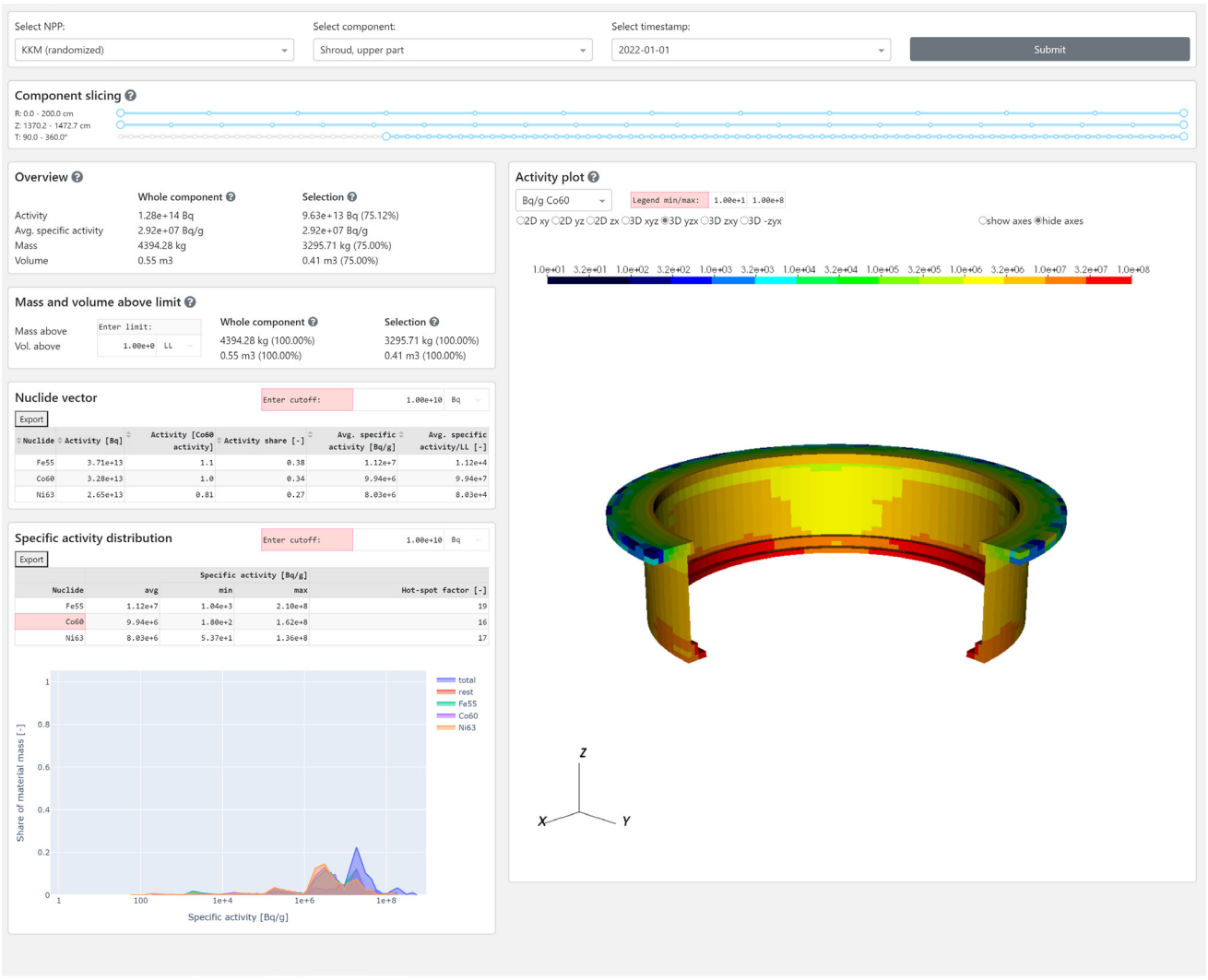
AMAC produces large amounts (~100 GB for a single NPP) of complex data. In order to effectively analyze this data and gain valuable insights, Nagra developed several specialized software tools.

- All AMAC data are collected and organized in AMAC-Database.
- Remote access to the data is provided by AMAC-DataServer.
- Custom Python API is provided for efficient retrieval of data from the database.
- User-friendly AMAC-Dashboard makes basic analysis tasks quick, simple, and reproducible.

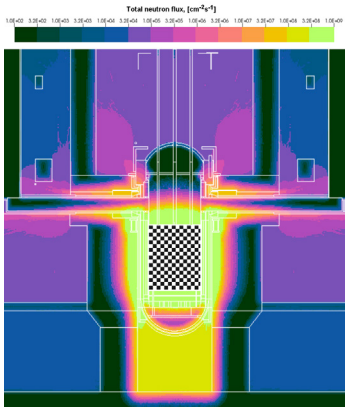


AMAC-Dashboard

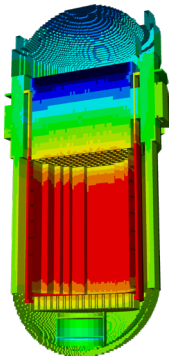
API for custom analyses



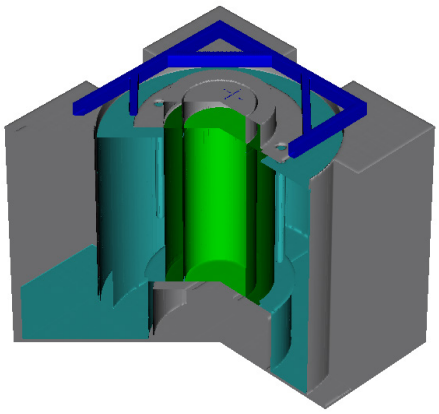
AMAC Application Examples



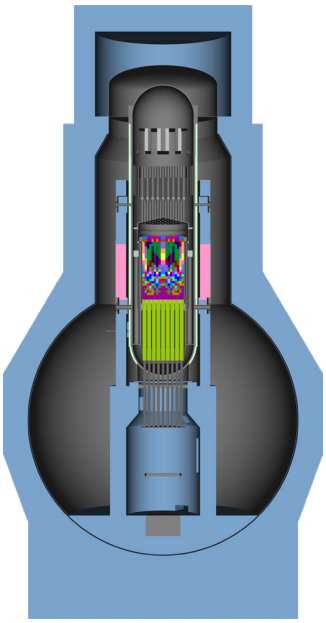
Beznau PWR
neutron flux distribution



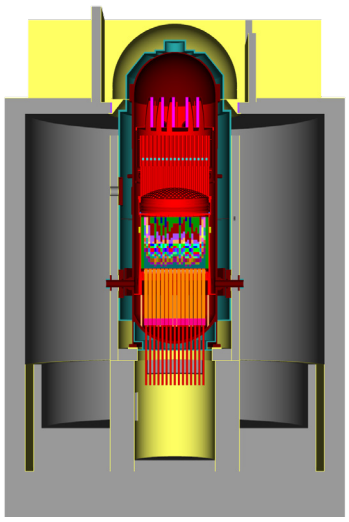
Gösgen PWR
RPV & internals activation



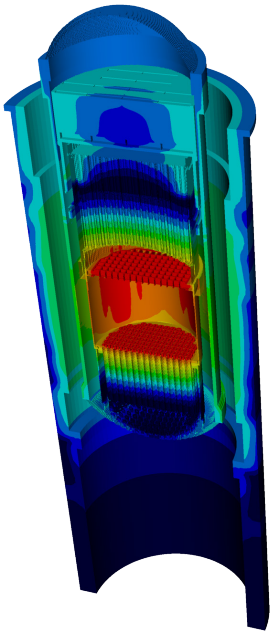
CROCUS research reactor
MCNP model



Mühleberg BWR
MCNP model



Leibstadt BWR
MCNP model



Gundremmingen BWR
RPV & bioshield activation

Additional applications not shown here : Basel research reactor, illustration of methodology for Kori-1

COMPONENT-WISE 3D ACTIVATON ATLAS

OVER 90 % REDUCTION IN RADIOLOGICAL SAMPLING NEEDS

OPTIMAL BASIS FOR SEGMENTATION AND PACKAGING STRATEGIES

DECOMMISSIONING COST REDUCTION

FACILITATING INTERACTION WITH THE REGULATOR

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