

Student Outreach & Internship Programme

EPFL, 19.11.2024

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nagra.

Introduction: Who are we?

- We are the **Swiss National Cooperative for the Disposal of Radioactive Waste** ↔ **Nagra**
- Established in 1972 by **NPP operators & Swiss government**
- Around **130 employees**:
mainly scientists and engineers
- Financed by the waste producers:
Nuclear Power Plants: 92%
Swiss government: 8%
- Cost contained in electricity price:
approx. 1 €-Cent per kWh



Introduction: What is our goal?

**Safety and
Engineering Feasibility
highest priority**

Site Selection

- Process and responsibilities
- Criteria (safety, environmental impact, socio-economic issues)

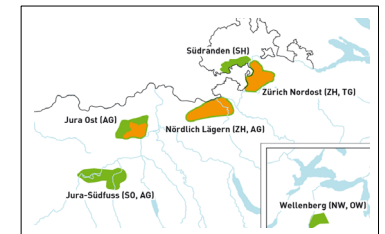
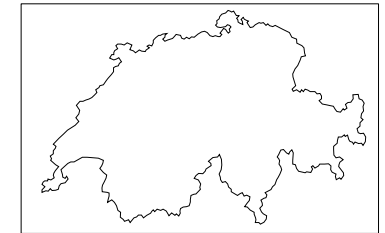
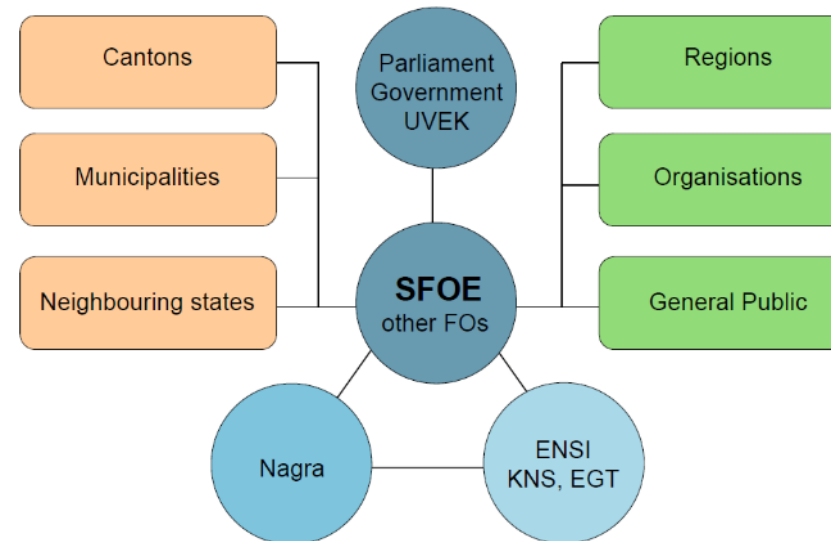
1. Properties of host rock and geologic environment

2. Long-term stability

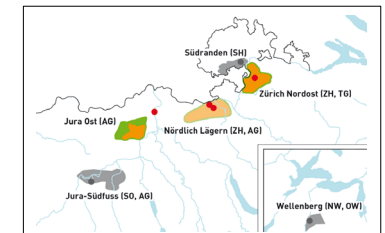
3. Reliability of geological information

4. Suitability for construction

Actors in the site selection process



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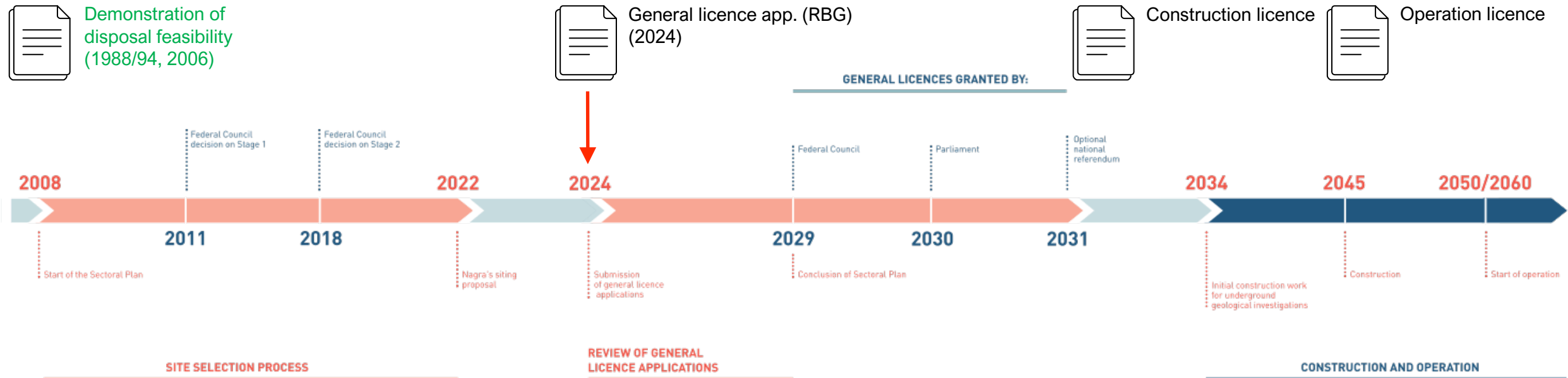


«General Site
Application»
(Today!)

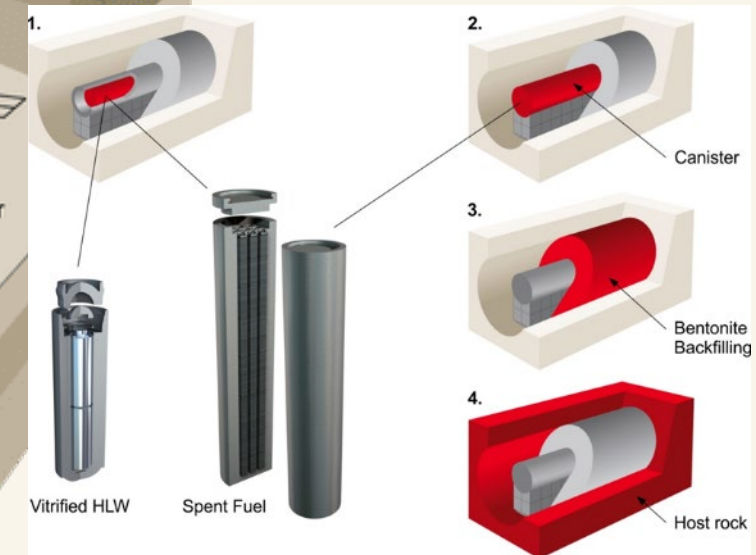
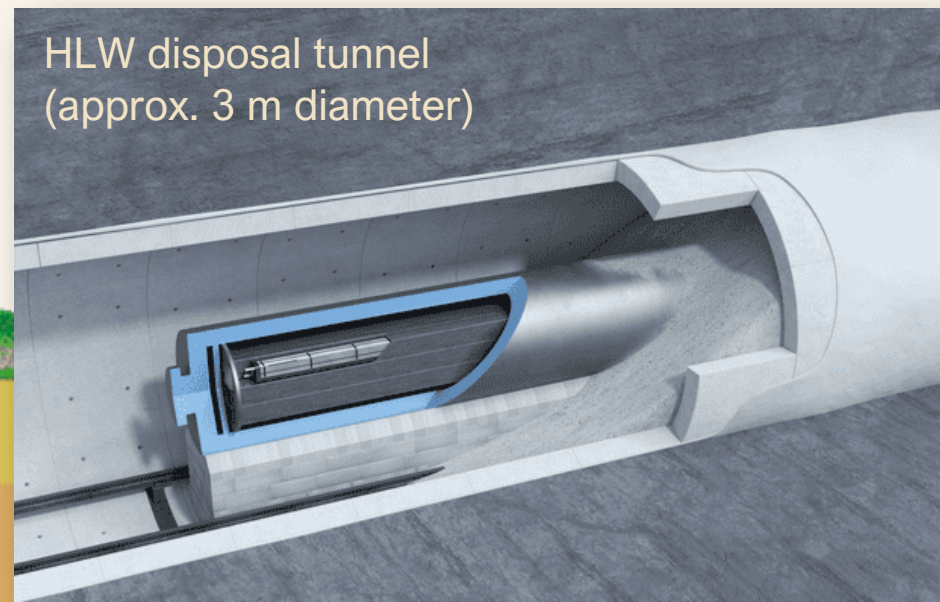
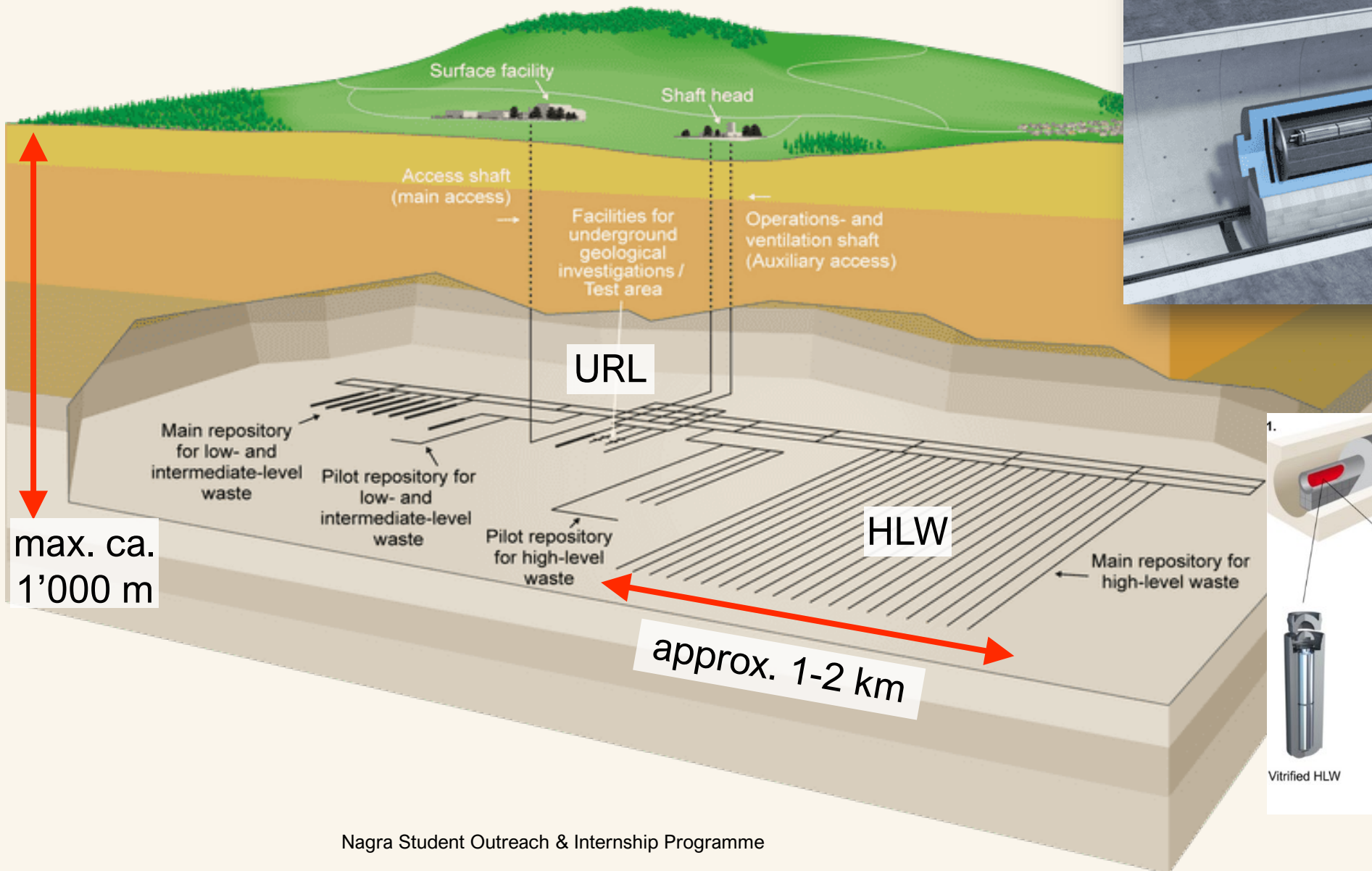
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Radioactive waste disposal – Status in Switzerland

- Nagra's → design, optimization, and safety analyses of the planned deep geological repository DGR
- In 2022, Nagra proposed a site for the repository
- General license application (RBG) to be submitted today!

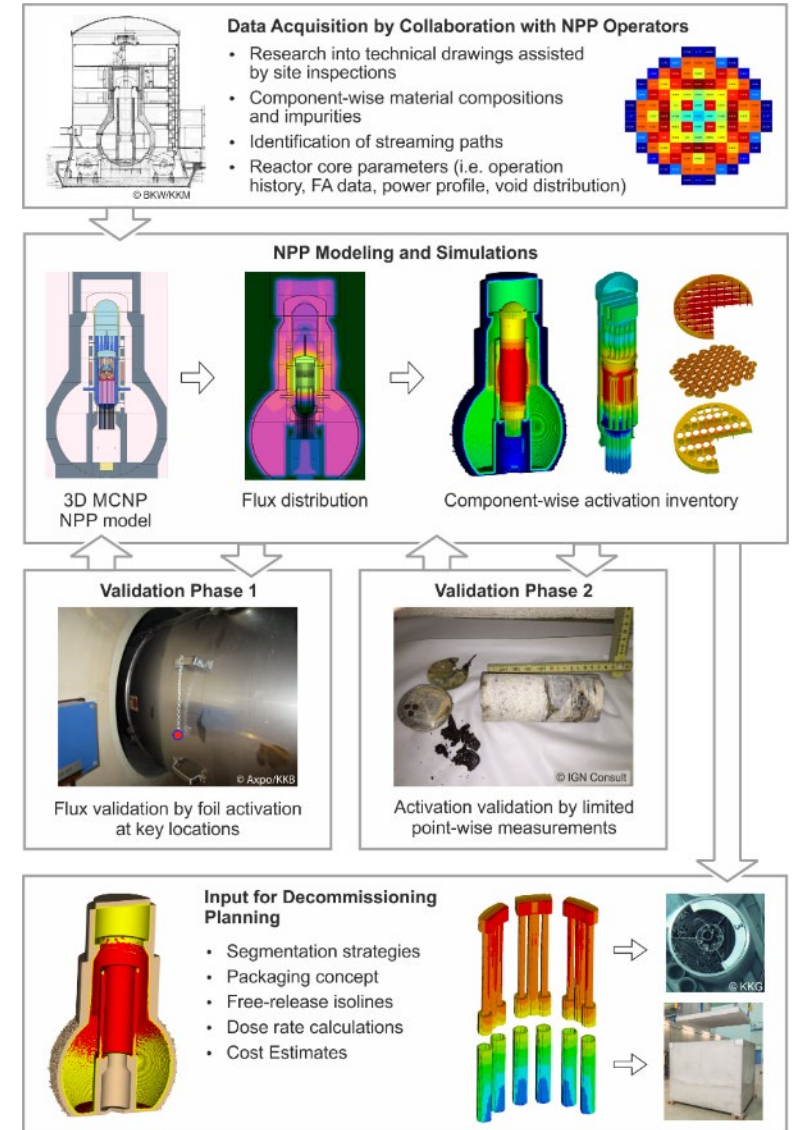


Context: Final Disposal Concept



Student outreach & internship programme

- Internship topics at Nagra → at the **interface between research & industrial application**
- Nagra interns **actively contribute** to Nagra's RD&D, optimisation, technical and safety assessment work by:
 - Carrying out calculations for characterising the Swiss nuclear waste inventory
 - Further developing & optimising packaging concepts
 - Implementing safety case evaluations of the final disposal concept, e.g. criticality safety, etc.
 - Developing **new computational methods** such as AMAC (Advanced Methodology for Activation Characterization)
 - etc.
- **Many thanks to all our interns:**
your contribution is highly appreciated!



Student outreach & internship programme: Retrospective

- Programme started in 2009 – initiated by Prof. Prasser
- 55 students from 24 countries completed their internship at Nagra



Europe:
Spain
France
Lithuania
Poland
Slovakia
Greece
Czech Republic
Italy
Switzerland
Germany
Ukraine
Croatia
Serbia
Austria
Cyprus
Estonia
UK

Outside Europe:
China
India
Lebanon
Singapore
Egypt
USA
Mexico

Student outreach & internship programme: A success story I

- Outcome:
 - More than 30 scientific papers published & conference contributions

Volmert B., Tamaseviciute E. et al: MCNP Neutron Streaming Investigations from the Reactor Core to Regions Outside the RPV for a Swiss PWR; Proceedings of 12th International Conference on Radiation Shielding (ICRS-12), Nara, Japan, September 2-7, (2012).

Pantelias M.; Lierse von Gostomski Ch.; Krumpholz U.; Volmert B.; Artinger R.; Filss M.: Reactor pressure vessel activation - RPV sample analysis and Monte Carlo Simulations; Proc. of KONTEC, Dresden, Germany, April 6-8, (2011).

Schlömer L.; Philippen P.W.; Volmert B.; Pantelias M.: Aktivierungsrechnungen für Komponenten eines Druckwasserreaktors; Jahrestagung Kerntechnik JTK, May 17-19, Berlin (2011).

Volmert B., Pantelias M., Neukaeter E. and Schloemer L.: Activation Inventory Calculations for the Swiss Decommissioning Study using MCNP and GRSATIV2; Proceedings of Joint International Conference on Supercomputing in Nuclear Applications and Monte Carlo (SNA+MC2010), Tokyo, Japan, October 17-21, (2010).

Volmert B.; Scolaro A.; Scheit T.; Fasold W.: Activation Analysis, Validation and Component-wise Packaging Concept for the Decommissioning Planning of the NPP Gundremmingen; Annual Meeting on Nuclear Technology, May 29-30, Berlin, Germany, (2018).

Bykov V.; Mosher S.; Volmert B.; et al: Nagra Activation Analysis for the Optimization of NPP Decommissioning and Component Segmentation Strategy; Proceedings PHYSOR 2018, Cancun, Mexico, April 22-26, (2018).

Vlassopoulos, E.; Bykov V.; Siefman D.; Volmert B.; Pantelias M.: Neutron Streaming Investigations with Classic and Hybrid Monte Carlo Variance Reduction Methods for the AGN-211-P Re-search Reactor in Basel; Proceedings PHYSOR 2016, Sun Valley, Idaho, USA, May 1-5, (2016).

Bykov V.; Volmert B.; Pautz A.: Enhancement and Validation of BWR MCNP Activation Simulations for Swiss Decommissioning Planning; Proceedings of ANS Student Conference, College Station, Texas, USA, April 9-11, (2015).

Pantelias M.; Volmert B.: Activation Neutronics for a Swiss Pressurized Water Reactor; Nuclear Technology, 192, 3, dx.doi.org/10.13182/NT15-13, (2015).

Pantelias M.; Bykov V.; Volmert B.: Activation Neutronics for a Swiss PWR and BWR; American Nuclear Society Annual Meeting, San Antonio, TX, USA, June 7-11, (2015) – Award by the American Nuclear Society.

(List by no means exhaustive)

Student outreach & internship programme: A success story II

- Outcome:
 - More than 30 scientific papers published & conference contributions
 - 12 MSc.-Theses completed

MSc Thesis:

Hadjigeorgiou, M. [2022]: Sensitivity Studies on the Structural Response of a PWR Spent Fuel Sub-Assembly using Finite Element Modelling; Master Thesis, EPFL, Lausanne.

Bellotti, M. [2020]: Towards beam modelling for static structural analysis of spent nuclear fuel rods"; EPFL, Lausanne.

Tomic G. [2019]: Validation of the Nagra Advanced Methodology for Activation Characterization for the Leibstadt NPP including Waste Packaging Concept for activated RPV, Internals and Building Structures ; EPFL, Lausanne.

Pisano, P. [2018]: Validation of the Nagra Activation Calculation Methodology for the Beznau NPP and Development of an Activated Materials Packaging Concept; EPFL, Lausanne.

Scolaro, A. [2016]: Implementation of the Nagra Activation Calculation Methodology for the Gundremmingen Nuclear Power Plant; Master Thesis, EPFL, Lausanne.

Vlassopoulos E. [2015]: Development of an Optimization Code for the Logistics of Spent Fuel Assembly Loading into Final Disposal Canisters; Master Thesis; EPFL, Lausanne.

Bykov V. [2014]: Enhancement and validation of the NPP Mühleberg MCNP activation simulations for Swiss Decommissioning Planning. Master Thesis. ETH, Zürich.

Yan Y. [2013]: An MCNP generic sample activation model for validation of the Nagra NPP activation methodology; Master Thesis; EPFL, Lausanne.

Zvoncek P. [2012]: Comparison and suitability analysis of codes for NPP ex-core activation calculations; Master Thesis; ETH, Zürich.

Tamaseviciute E. [2011]: Neutron streaming investigation outside the RPV of the Gösgen Nuclear Power Plant with the Monte Carlo Method; Master Thesis; ETH, Zürich.

Pantelias Garcés M. [2010]: Monte Carlo Simulation for reactor pressure vessel activation analysis; Master Thesis; ETH, Zürich.

Student outreach & internship programme: A success story III

- Outcome:
 - More than 30 scientific papers published & conference contributions
 - 12 MSc.-Theses completed
 - 4 PhD-Theses completed

PhD Theses:

Shama, A. [2021]: Data-Driven Predictive Models: Computational Bias in Characterization of Spent Nuclear Fuel, PhD thesis, EPFL, Lausanne.

Vlassopoulos, E. [2021]: Structural performance and mechanical properties investigation of spent nuclear fuel rods under static and dynamic bending loads; PhD thesis, EPFL, Lausanne.

Bykov V. [2019]: High-Fidelity Determination of Nuclide Inventories for Radioactive Waste Disposal; Diss. EPFL No. 8960, Lausanne.

Pantelias Garcés M. [2013]: Activation Neutronics for the Swiss Nuclear Power Plants; Diss. No 21623. ETH, Zürich.

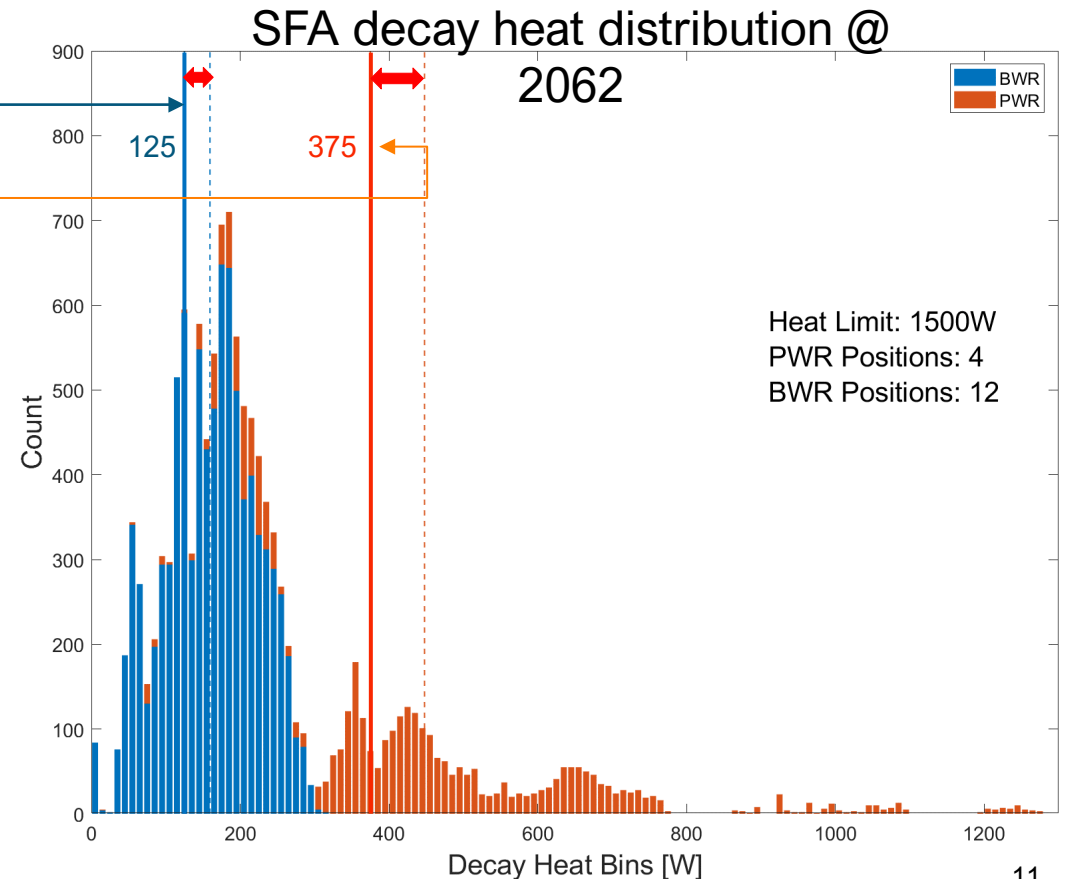
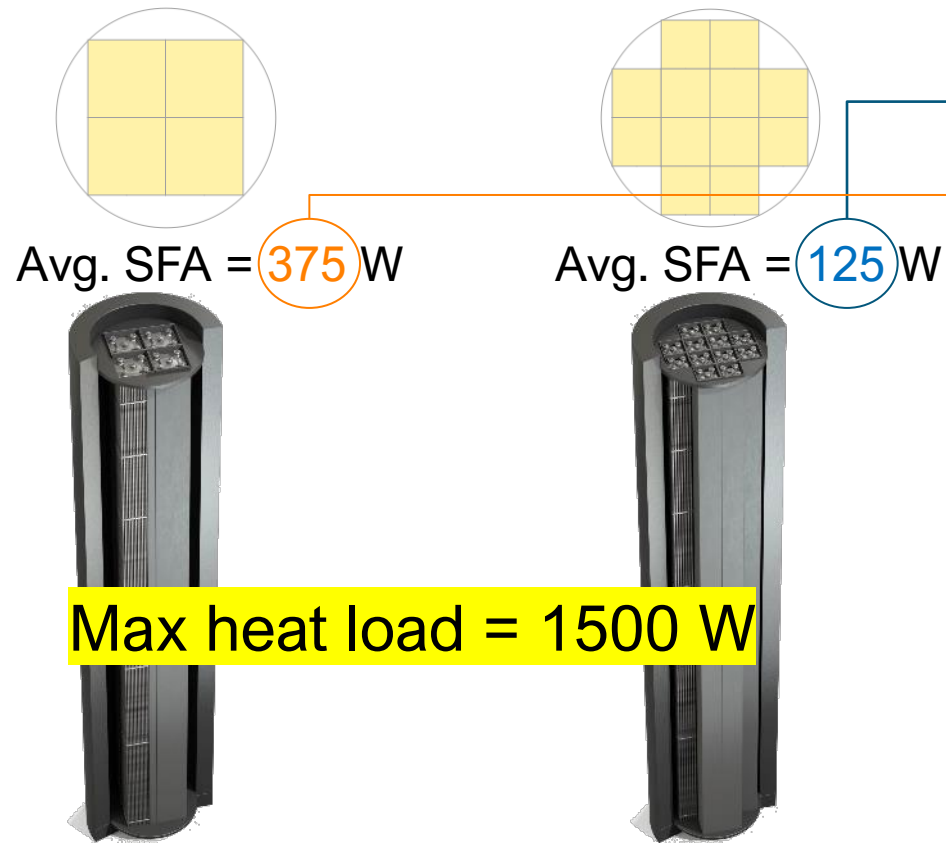
Example: Loading optimization of SNF in final disposal canisters

Why is optimization required?

- Minimize number of ELBs required for disposal of about 12'500 irradiated fuel assemblies
- Given the disposal **constraints** it's **not** possible to “easily” load the SFA into a **min** number of ELBs

4 PWR SFAs

12 BWR SFAs



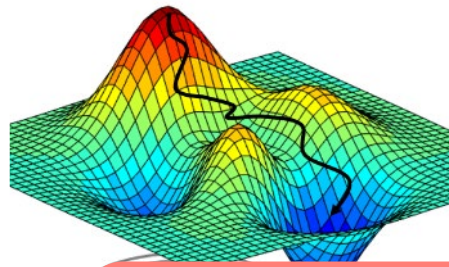
Example: Loading optimization of SNF in final disposal canisters II

- There is no analytical solution and all SFA combinations for given ELBs cannot be computed (CPU time “explodes”)
- **Numerical** solutions using global optimization algorithms provide **high quality results**
- **SIMAN** – Nagra’s **logistics optimization tool** for ELB loading



Input data

- SNF/TLB database
- Decay heat calculations
- BEVA characteristics



Optimization algorithm

- Minimize # of ELBs



Results

- # of ELBs
- Detailed loading plan
- More...

Example: Criticality safety for geological disposal

- Criticality Safety:

“It has to be ensured through adequate measures that, neither in the operational phase nor after the closure of a geological repository, can a state of nuclear criticality occur.”

[ENSI Regulatory Guideline G03]

4 PWR SFAs



12 BWR SFAs

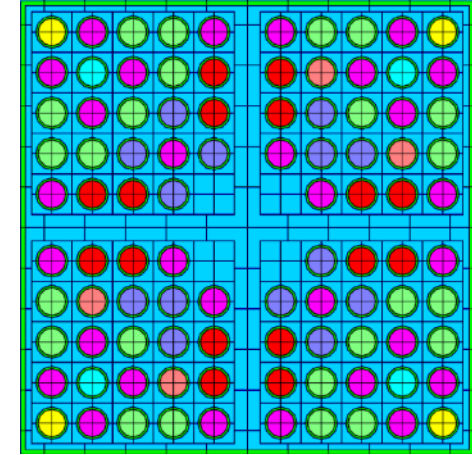


- General approach:

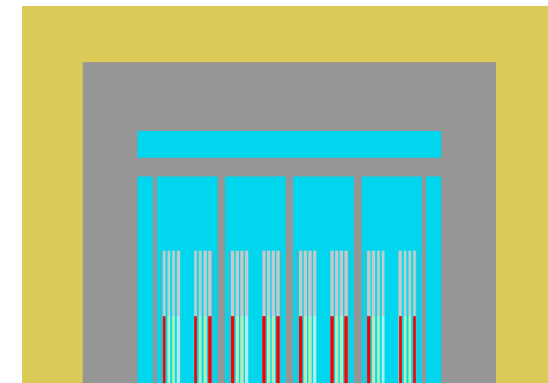
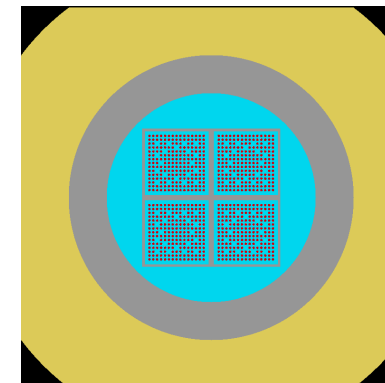
- Formulate conservative but realistic scenarios $\Rightarrow$ compute k_{eff} & evaluate w.r.t. upper criticality safety limit

Example: Criticality safety for geological disposal II

- What you could be working on:
 - Setting up computational models for various configurations of the final disposal canister (with different fuel assembly types, materials, etc.)
 - Calculating k_{eff} , for different canister configurations using Monte Carlo code like SCALE, MCNP, etc.
 - Studying & evaluating different sources of uncertainty in criticality calculations.
 - Look into how to evaluate potential consequences of postulated criticality excursions.



KENO-VI models of a BWR fuel assembly (above) and PWR final disposal canisters



Scope and other potential internship topics

Waste characterisation & packaging optimisation

- What kind of waste do you have? How much? → Volume
- How radioactive is it? What is the half-life? → Activity (t)
- How much heat does it produce? → Decay Heat
- Is it critical (now or later)? → Criticality Analyses
- How is it transported over time (nuclides/packages)? → Safety Analyses / Logistic Optimisation

Disposal concept & safety case relevant assessments

- Developing tools for the optimisation of the final disposal container design
- Modelling work & methodology development: nuclide transport, long-term criticality safety assessments, etc.

Projects in support of & collaboration with waste producers

- Shielding Calculations → Dose Rates
- Decommissioning Planning → Segmentation planning, Packaging Concepts, Dose Rates

What an internship at Nagra looks like

- Typical duration: 3 months (e.g. July – September)
However, different time frames may also be possible – depending on availability of topics & time resources.
- Typical workload: 100% full time — i.e. 8.5 h/day x 5 days/week
Other preferences may be accommodated.
- **Internship is paid**
- Nagra takes care of the work permit application
- MSc Thesis projects may be possible – discussion during the internship
- Each intern gets assigned a technical coordinator
- Wherever feasible **Nagra interns are encouraged to:**
 - Publish scientific papers & participate in industry events and conferences
 - Get involved in experimental activities



HAA-ELB design optimisation experiments in Mellingen

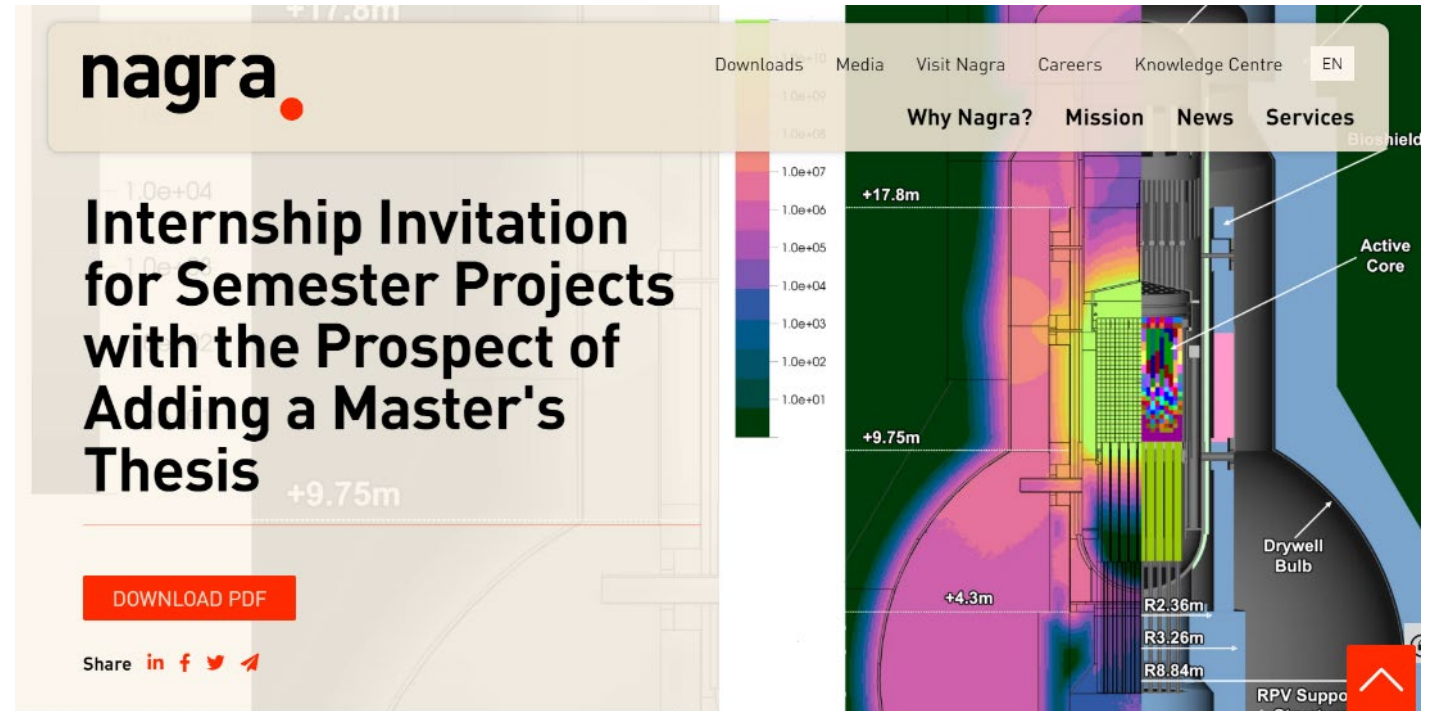
WATCH THIS SPACE!

All internship projects available on [our homepage](#).

Review periods can also be found on homepage: applications sent before these dates are reviewed in the next available review period.

Application deadlines for summer internship:

- 17.02.2024 (interviews early March) – preferred
- 14.04.2024 (interviews early May)





Contact us:

For questions concerning the programme:

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For applications:

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thank you
for your attention

nagra●