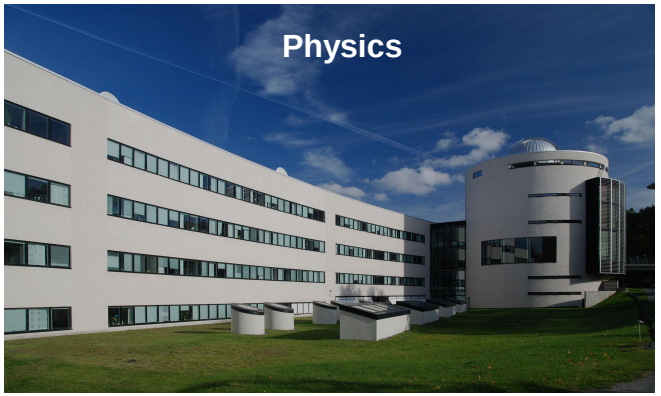
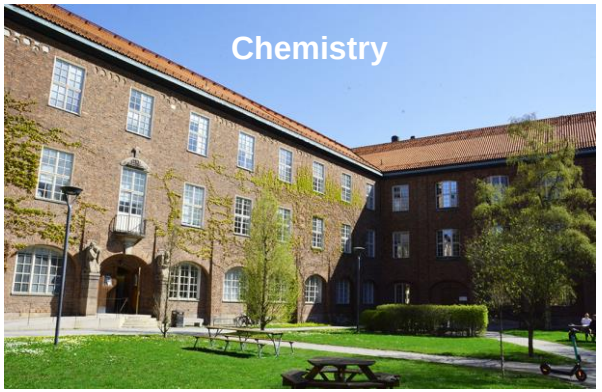
Nuclear energy research at KTH





Nuclear energy research at KTH:

Staff and activities at

- SCI - Physics
  - Nuclear Science and Engineering (65)
- CBH - Chemistry
  - Applied Physical Chemistry (7)
- CBH - Chemical Engineering (5)
- SCI - Engineering Mechanics
  - Solid Mechanics (6)
- ITM – Materials Science and Engineering (7)

Research centres

- Swedish Nuclear Technology centre (SKC) – Industry + authority funded
- SUNRISE centre – SSF + industry funded
- ANItA centre (hosted @UU) – Energy Agency + industry + academia funded

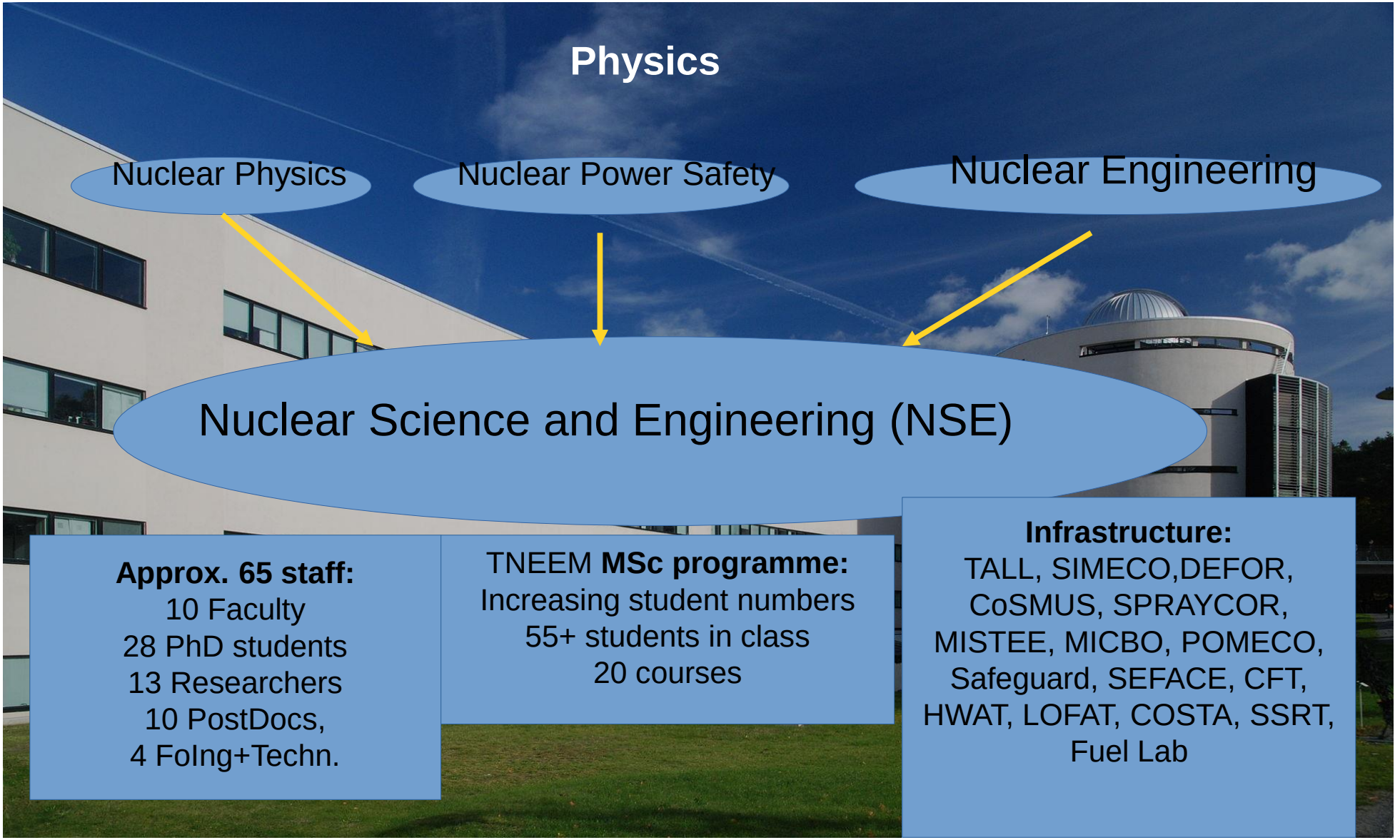
Research funding

- SSF
- SSM
- VR
- Euratom
- SKC
- Energy Agency
- SKB
- Vinnova
- ...

Some large projects:

- SUNRISE (60 Mkr) – Centre on lead fast reactor development
- Solstice (99 Mkr) – Electrical lead-cooled reactor prototype
- NuMaP (42 Mkr) – Nuclear Materials Platform
- ANItA (75 Mkr) – Small Modular Reactor cross cutting project
- MÅSTE (50 Mkr) – Gen-IV research and development

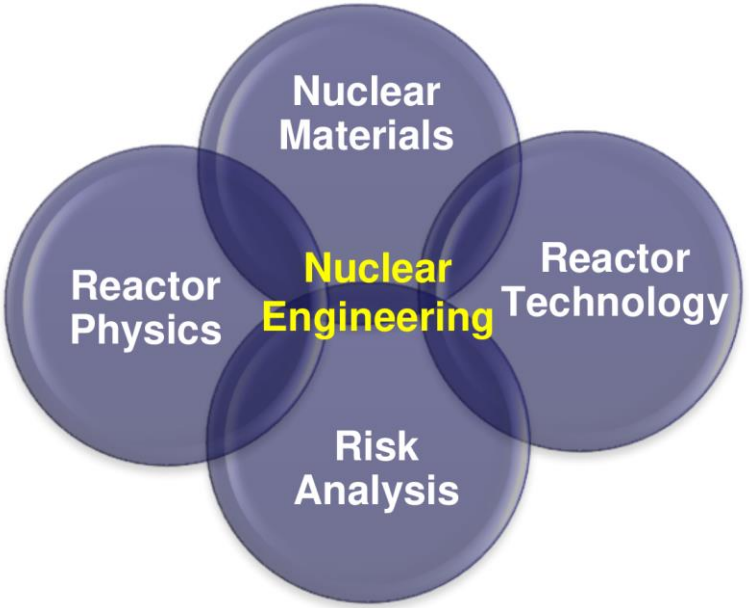
Three nuclear research divisions were merged into one in 2024:



NSE: Nuclear Engin. Research

- **Main pillars of nuclear engineering**
  - **Physics + Materials + Technology + Risk Analysis**
  - Interdisciplinary collaboration
    - to create large scale impactful projects

Subfields:

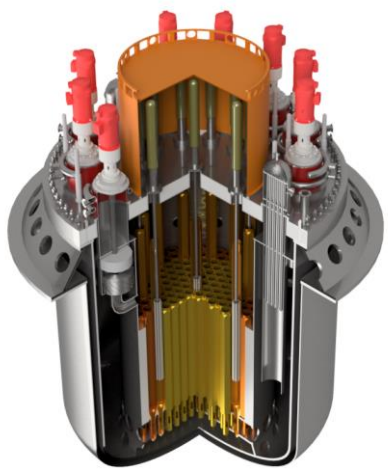


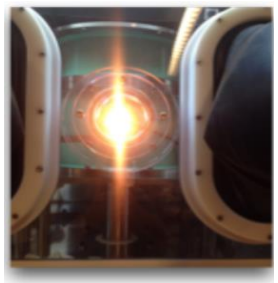
- Sustainable Nuclear Ener
  - Generation IV reactors
  - Nuclear materials and fu
  - Nuclear climate solution
  - Reactor physics
  - Monte Carlo methods
- Thermo-hydraulics
  - Multiphase flow and CFI
  - Supercritical heat transfe
  - Containment phenomena
- Risk and uncertainty analysis
  - Integrated deterministic and probabilistic safety analysis (IDPSA)
  - Code validation with uncertainty quantification and application
  - Severe accident phenomena and Risk Oriented Accident Analysis Methodologies

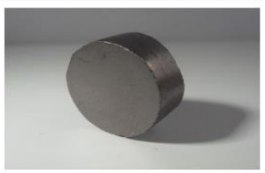
Sustainable Nuclear Energy

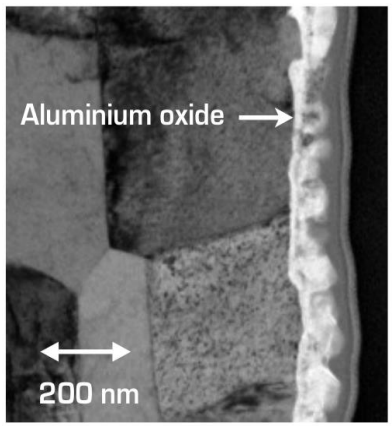
- SUNRISE centre funded by SSF with 50 MSEK (2021-2026)
- **Goals:** Meet the sustainable energy challenge of UN Agenda 2030
- **Objectives:** Design a lead-cooled research reactor

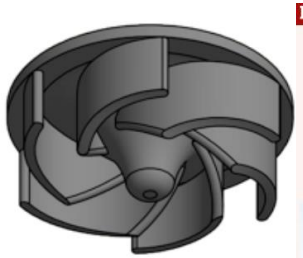
- In SUNRISE, we work on reactor design and safety analysis, materials development, high-temperature HLM exposure experiments, fuel development, materials degradation and more. Mid-term stage of centre just passed.
- Very strong academic group with significant industrial support.
- **Solstice** project approved in 2021 (99 MSEK funding from Energimyndigheten) – to construct an electrically heated experiment facility









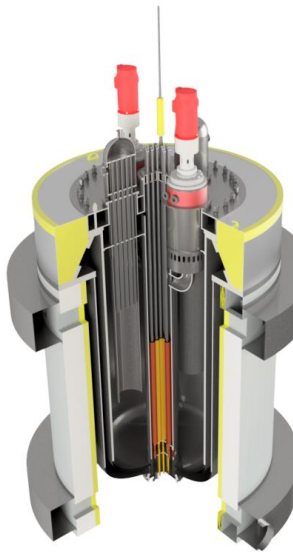


sverigesradio

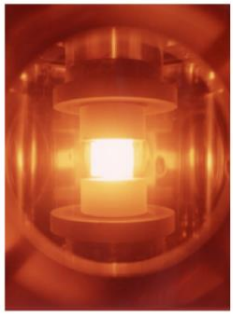
Kalmar

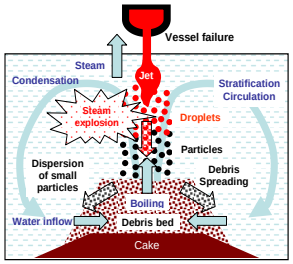

Dagens industri START BÖRS MARKNADSNYTT BEVAKNINGAR
En framtid för svensk kärnkraft
LEDARE. Fjärde generationens reaktorer ska utnyttja kärnbränslet uran nästan hundra gånger mer effektivt. Det gör kärnkraften till ett hållbart energislag.
Ledare: Lotta Engzell-Larsson

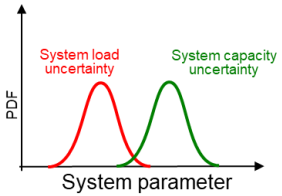

NyTeknik
PREMIUM
Wallenius: ”Första steget mot blykylda reaktorer inom 15 år”
2020-06-05 13:58 Av: Linda Nohrstedt 26 kommentarer
Smält bly kyler svensk reaktor



Euratom projects







- OperaHPC
  - Development of HPC tools for advanced nuclear fuels
- ASSAS
  - Artificial intelligence for the Simulation of Severe Accidents
- SASPAM
  - Safety Analysis of SMR with Passive Mitigation strategies
- FREDMANS (*Chalmers coord*)
  - Fuel Recycle and Experimentally Demonstrated Manufacturing of Advanced Nuclear Solutions for Safety
- CONNECT-NM
- Nuclear materials EU partnership

NSE: Nuclear Power Safety Research

✓ ~20 active research projects.
✓ High supports from SSM, industry (NPPs) and EU.
✓ Strong experimental infrastructure located in two laboratories.

Sub-fields

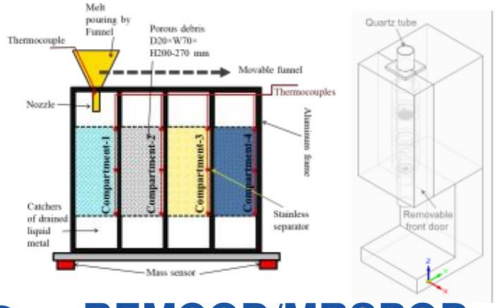
- Accident phenomena in light water reactors (PWRs and BWRs)
  - ✓ Thermal-hydraulics (including the coupling with neutron-kinetics);
  - ✓ Severe accident phenomena: reactor core degradation and relocation, fuel coolant interactions, debris formation, steam explosion, debris re-melting, melt penetration, melt pool convection and heat transfer, reactor pressure vessel failure, melt spreading, etc.
- Safety analysis of nuclear power plants, including best estimate plus uncertainty (BEPU) analyses of design basis accidents and severe accidents.
- Development and assessment of severe accident management strategies/measures.
- Safety of future nuclear power including Generation IV or small modular reactor (SMR) technologies.

NSE: Nuclear Power Safety Research

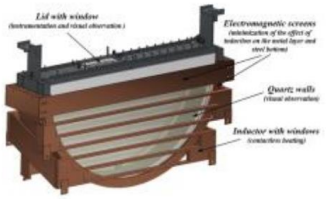
- NPS was one of the major players in the EU large project IVMR for severe accident research.
- NPS is participating in most OECD/NEA projects for the Fukushima accident.
- NPS has developed well-known test facilities, some of them became a part of the virtual integrated laboratory of the EU SAFEST project, together with the large facilities at CEA in France and at KIT in Germany, among others.

TALL/TALL-3D

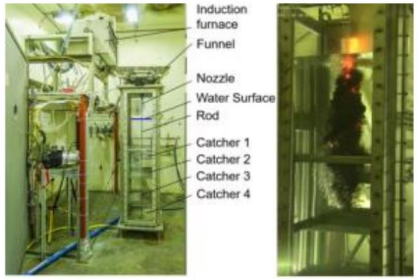
PULiMS/SES



REMCOD/MRSPOD

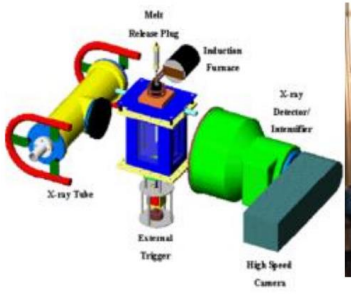


SIMECO-2

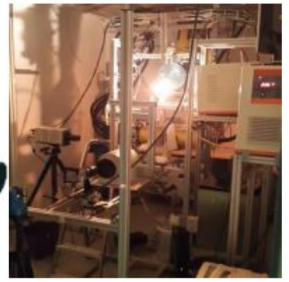


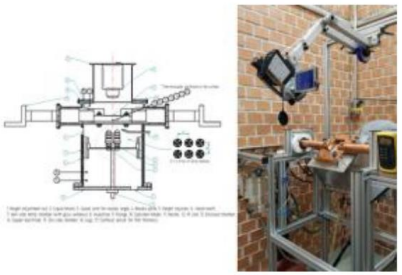
DEFOR

Containment

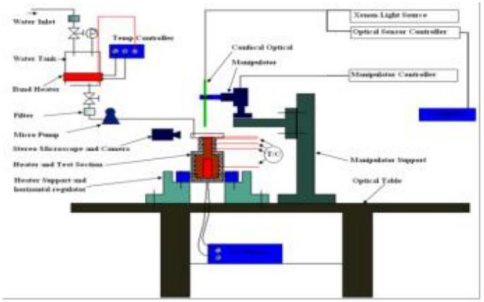


MISTEE



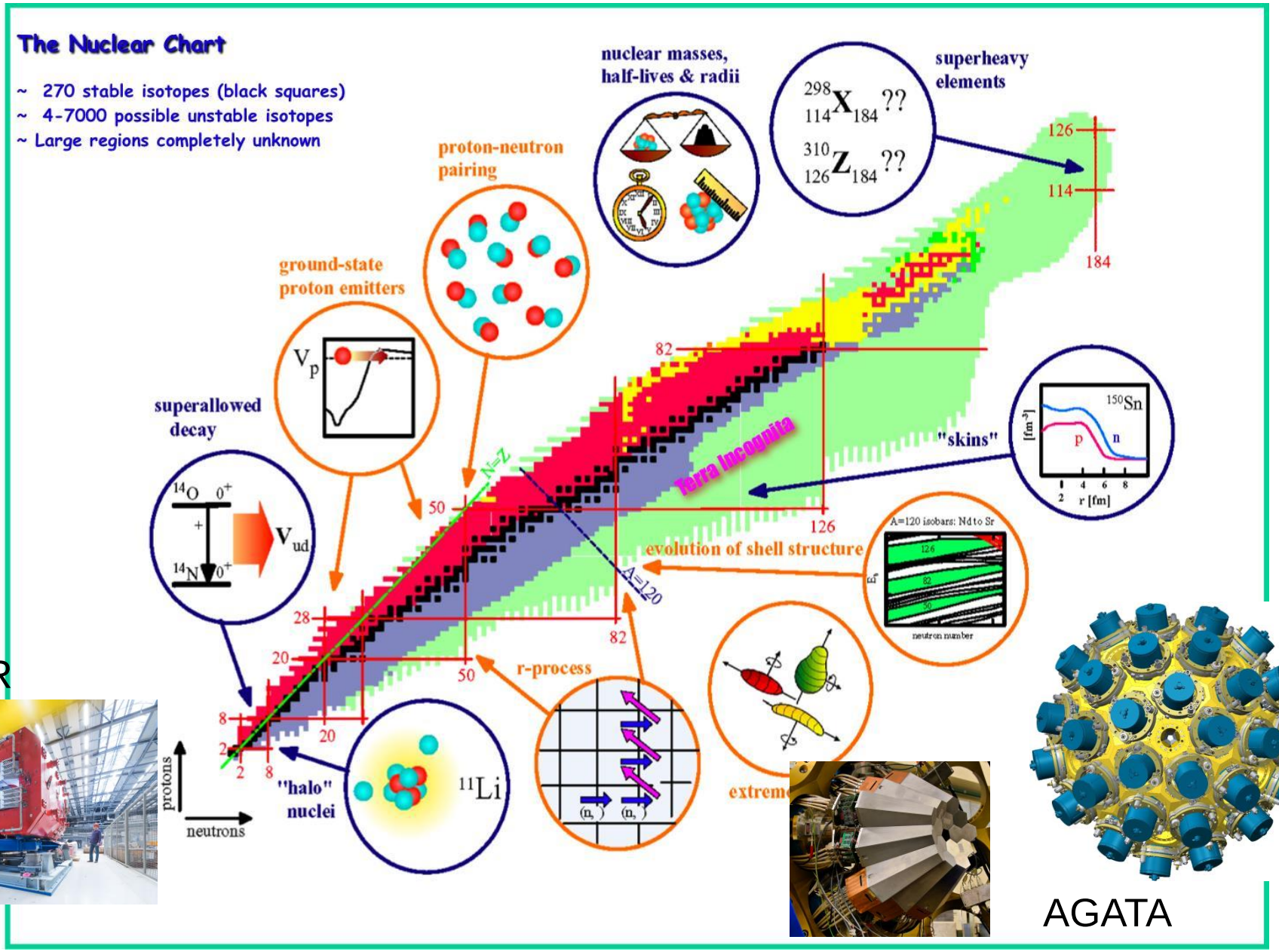


SPAYCOR

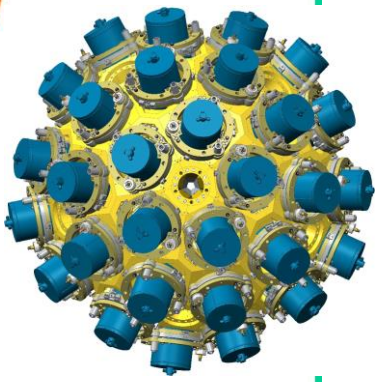


MICBO

NSE: Nuclear Physics, Fundamental Research



FAIR



AGATA

NSE: Applied Nuclear Physics Research:

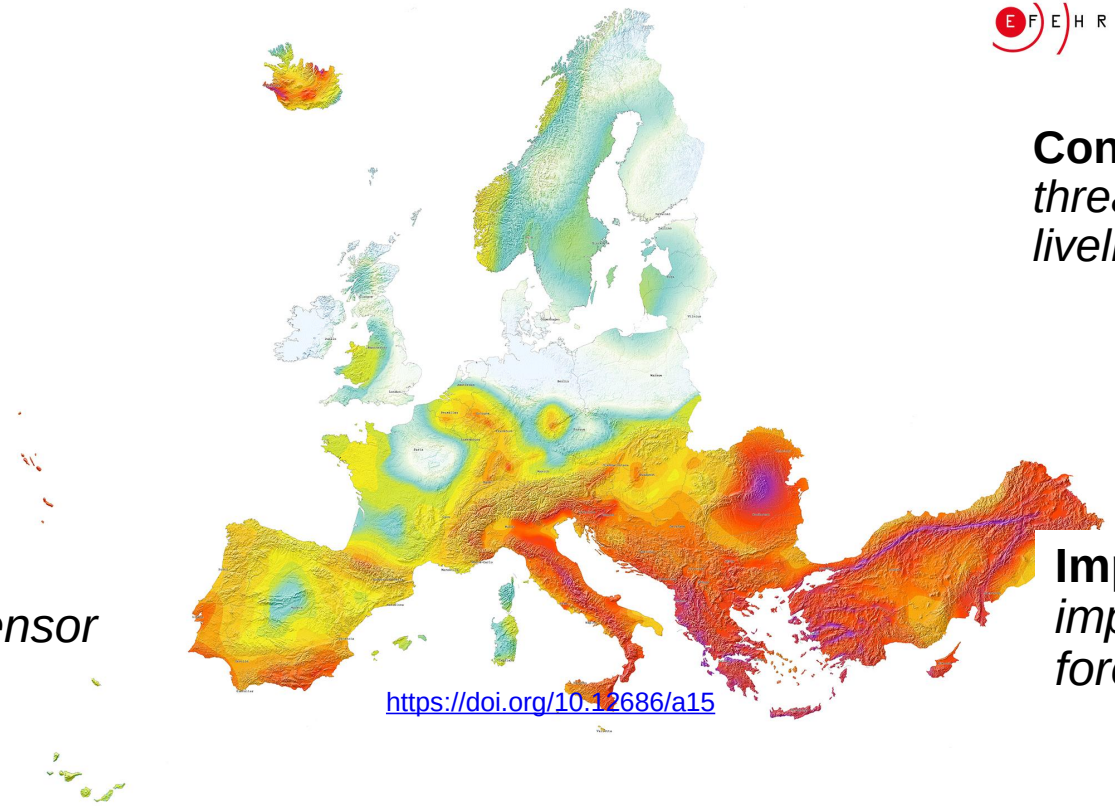
ArtEmis

Awareness and resilience through European multi sensor system

A Euratom Horizon Europe research project

In a nutshell
radon based earthquake forecasting

Context
threat to our lifes and livelihood



https://doi.org/10.12686/a15

Objectives
develop a large sensor radon network

Impact
improved earth-quake fore-casting methods

Project Coordinator: KTH
Main Contact Person: Ayşe Ataç Nyberg, aanyber@kth.se

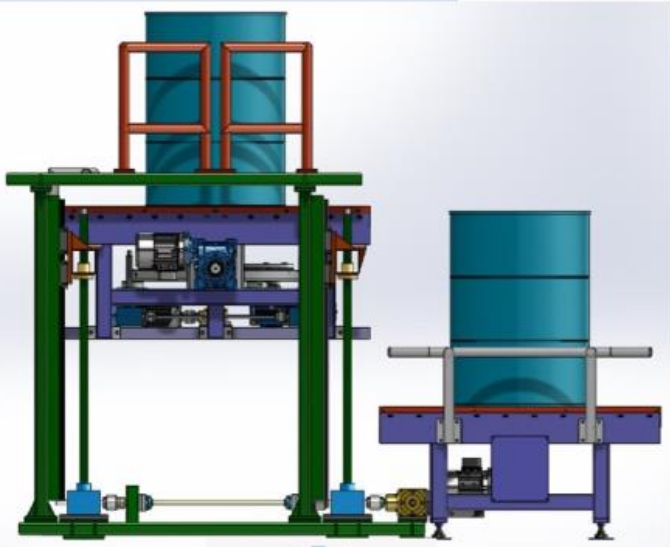
2022 - 2026

KTH/NSE:
Applied Nuclear Physics Research:

Neutron-Gamma Emission Tomography for radioactive waste characterization

Bo Cederwall[1], Sarabjot Kaur[1*], Vivian Peters[1,2], Anders Puranen[2], Ihor Tavrovskyi, Jana Vasiljevic[1], K. Axell[3]

[1]KTH Nuclear Physics Division [2]SVAFO AB, Studsvik Sweden [3]SSM * from 10/2022



VINNOVA SVAFO FORMAS Strål säkerhets myndigheten Swedish Radiation Safety Authority

Swedish Foundation for Strategic Research

Nuclear Chemistry

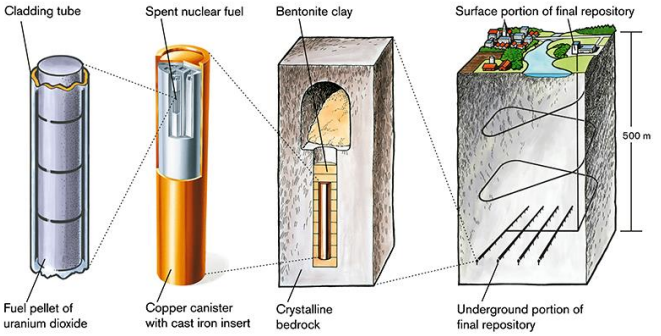
Staff:
1 Professor
5 PhD-students (4 at KTH and 1 shared with Chalmers)
3 Postdocs
Currently recruiting 1 postdoc and 2 PhD-students

Core activities:
Radiation chemistry/Interfacial radiation chemistry

Teaching:

- MSc-level:
  - Nuclear Chemistry, Photo-, Radiation- and Radical Chemistry
- PhD-level:
  - Radiation chemistry, Radiochemistry, Radiation synthesis of nanoparticles

Nuclear Chemistry



Research projects

- Stability of nuclear fuel materials in aqueous systems (e.g., geological repository)– Funding: SKB + Euratom
- Reactor chemistry and radiation induced corrosion of reactor materials – Funding: SKC + EM
- Corium dissolution: SKC + Euratom
- CRUD-chemistry: SSM
- Radiation processing of proteins (RADOV) : Euratom
- Radiation effects on nuclear fuel reprocessing materials: EM
- Radiation-induced corrosion of cladding materials: EM

RADOV

eurad 2
European Partnership
on Radioactive Waste Management

SOCRATES

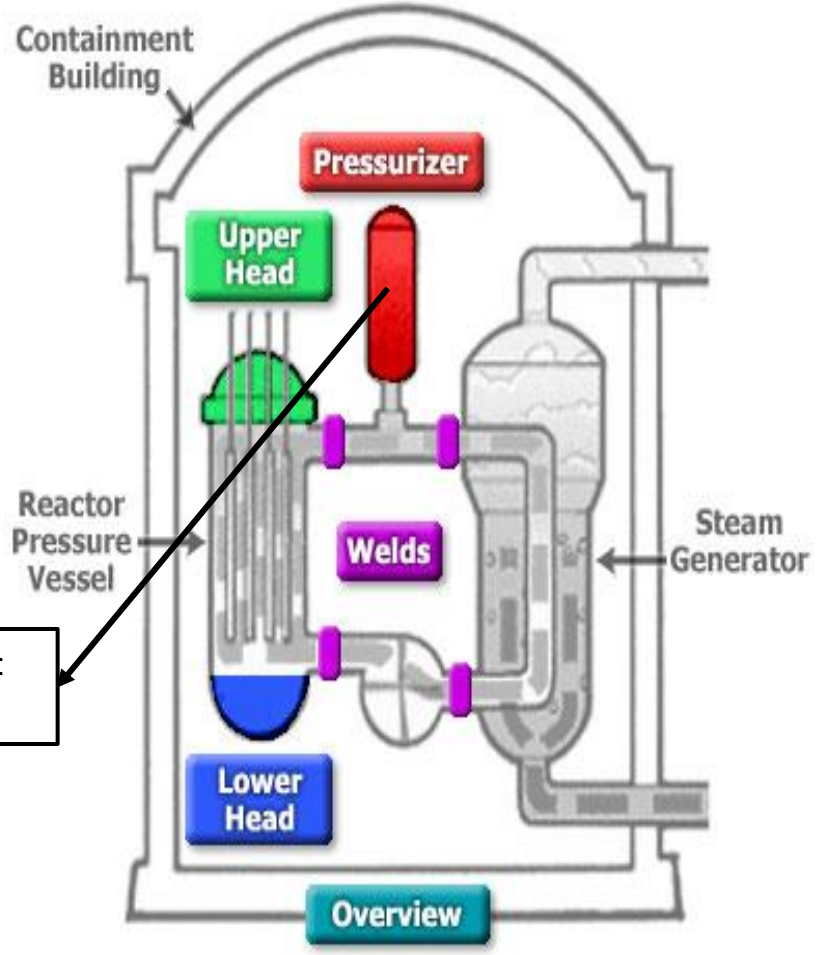
Solid Mechanics

www.hallf.kth.se/en

Prediction of crack initiation and propagation in aged material

Shuyue Wang (PhD student), Jonas Faleskog (supervisor), Pål Efsing (Co-supervisor)

- Good life properties at low Ductile-to-Brittle Transition Temperature (DBTT).
- DBTT increases with ageing
  - changes material properties
- Characterize how fracture toughness is affected by ageing above DBTT:
  - numerical modelling
  - experiments
  - micro-mechanical studies



Ringhals 2 – Pressurizer: thermally aged material.

Wang S, Faleskog J. *European Journal of Mechanics / A Solids.*, 2023
https://doi.org/10.1016/j.euromechsol.2023.105056

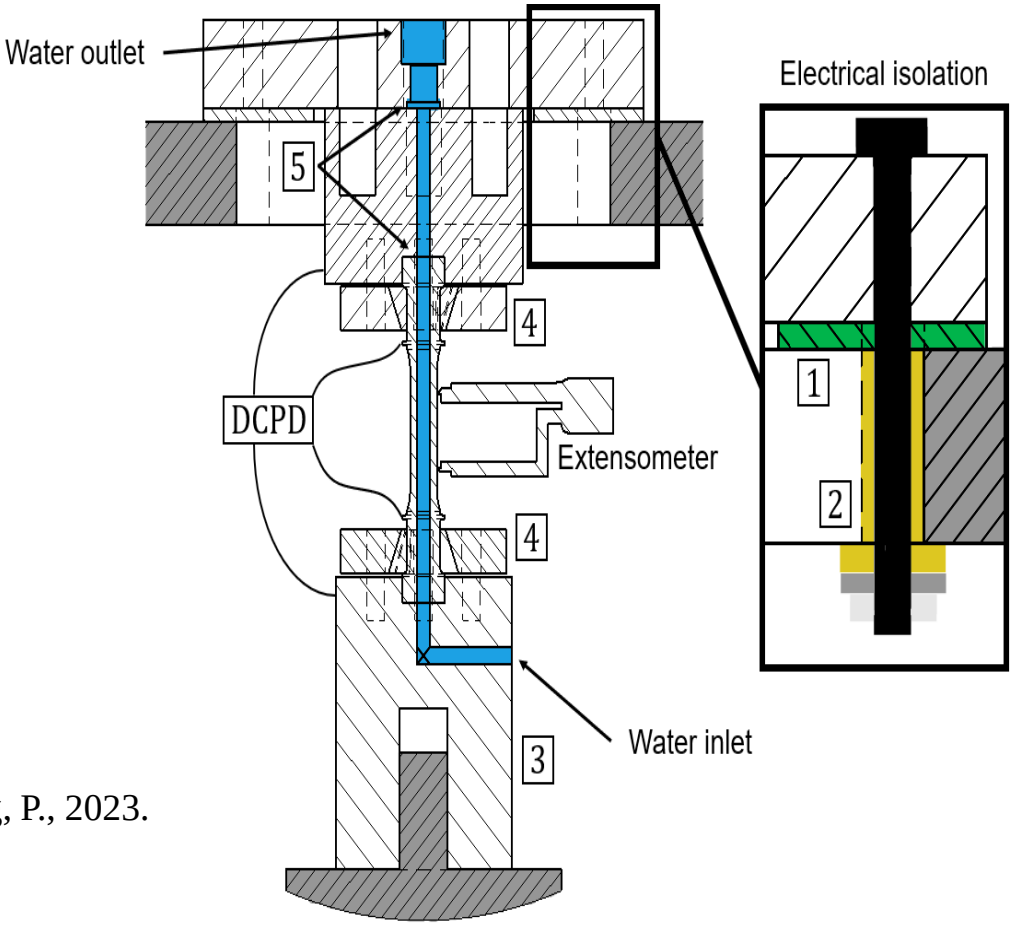
Solid Mechanics

Corrosion fatigue in LWR water environment at cyclic thermal and mechanical loads

Mustafa Subasic (PhD student)
Pål Efsing, Carl Dahlberg, Mattias Thuvander & Jean Smith

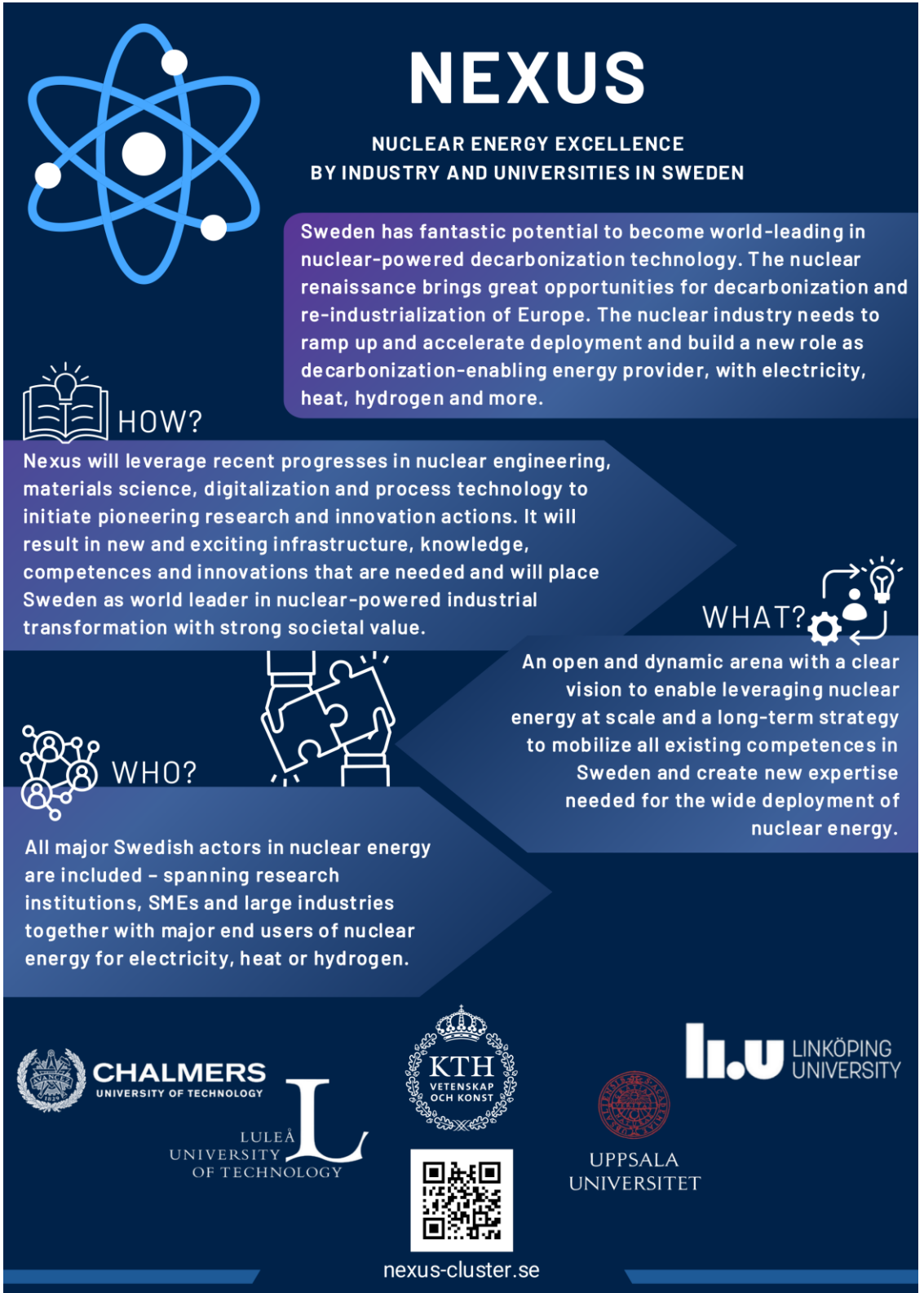
Corrosion fatigue in the piping system of the nuclear reactor. The project consists of:

- Mechanical characterization and cyclic plasticity modelling of 304L stainless steel at RT and 300 °C.
- Corrosion fatigue tests with hollow specimens in BWR & PWR water environments.
- Mechanical-electrochemical coupled crystal plasticity model to predict corrosion fatigue crack initiation.



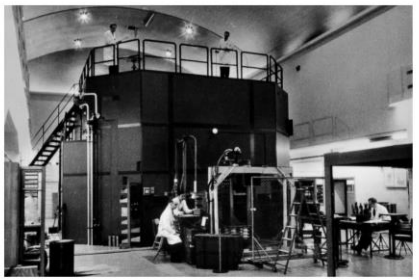
Subasic, M., Alfredsson, B., Dahlberg, C.F.O., Öberg, M., Efsing, P., 2023. Exp. Mech. https://doi.org/10.1007/s11340-023-00992-5

- **National collaboration!**
- Nexus Vision project:
  - Application submitted to Vinnova for the Excellence cluster planning call – Sep 4 2025
- The Nexus vision project will assemble all nuclear universities and attract the industry to form an excellence cluster application in 2026
- Application team:
  - Pär Olsson, Christophe Duwig (KTH), Christian Ekberg Teodora Retegan Vollmer (Chalmers), Henrik Sjöstrand, Sophie Grape (UU), Jens Hardell, Marta-Lena Antti (LTU), Magnus Odén (LiU)



Nuclear energy research at KTH
Long tradition - bright future!

1954:
R1 Reactor
@KTH



- The nuclear energy research field/activites at KTH has recently been **growing significantly**
- 2024: New merged division **Nuclear Science and Engineering** was formed (60+ staff).
- Growing staff numbers (juniors/PhD) at KTH (but **constant number of senior staff**).
- **Large collaboration projects** across several universities is a key aspect

- Major changes from **significant levels of funding** from SSF
  - SAFETY (Mat-2016 project) (36 MSEK, 9@KTH)
  - SUNRISE (Arc-2019 centre) (50 MSEK, 30@KTH)

- **Change in Energimyndigheten (EM) regulation and funding policy** (from 2020)
  - Anita competence centre (25/75 MSEK, 8@KTH)
  - Solstice project (99/267 MSEK)
  - Several SSM and EM PhD and postdoc projects (ca 40 MSEK)
  - NuMaP (Nuclear Materials Platform) (40/42 MSEK, 17@KTH)
  - MÅSTE (Multidisciplinära åtaganden för Gen-IV forskning) (50 MSEK, 6@KTH)
  - BAMSE (Industrial led project – fuel and materials for LFR) (37 MSEK, 3@KTH)
  - Infrastructure projects: SPG-MSR (Molten Salt Reactor test bed) - 1.8 MSEK; FEATHER (Feasibility for LFR thermohydraulics) – 3 MSEK

- **Government pro-active and enhancing relevant budgets** – important for all of us

- **Further support and expansion of educational program will be crucial**