UPPSALA UNIVERSITET

UPPSALA
UNIVERSITET

SKC
Swedish Centre for Nuclear Technology

ANItA

SKC and ANItA-supported activities at UU - with some focus on activities at Applied Nuclear Physics

Henrik Sjöstrand
Applied nuclear physics
Department of physics and astronomy

UPPSALA UNIVERSITET

Nuclear reaction measurements

→ Supervision support for two PhD students (Ana Gomez, Lucas Filho)

Experimental activities at international facilities: JRC-Geel (Belgium) and NFS (France)

Nuclear data evaluation

→ Project support – The nuclear data evaluation pipeline

Applications

→ SKC and ANItA Projects and project support

Criticality Safety (LAICA), Fission-product diffusion, Fuel performance, Maritime applications (3S), Neutron fields and measurement techniques (NESSA), Non-destructive fuel examination, Nuclide specific measurements techniques

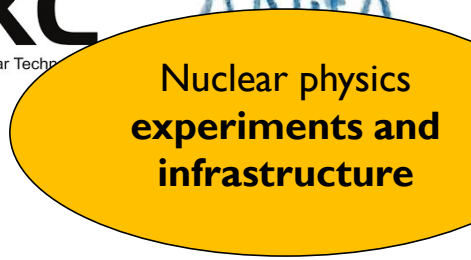
→ Postdoc and PhD student supervision support

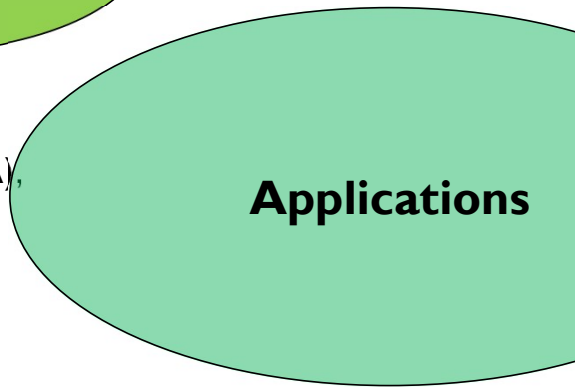
Vikram Rathore (ANItA) -> Westinghouse, Flavio Ferella (ANItA), Gustav Robertsson (SKC), Claudia Olaru (ANItA), Aurora Jahan (SKC)

Education

→ Support teaching activities in first and second cycle.

Outreach activities





UPPSALA UNIVERSITET

Bild 3

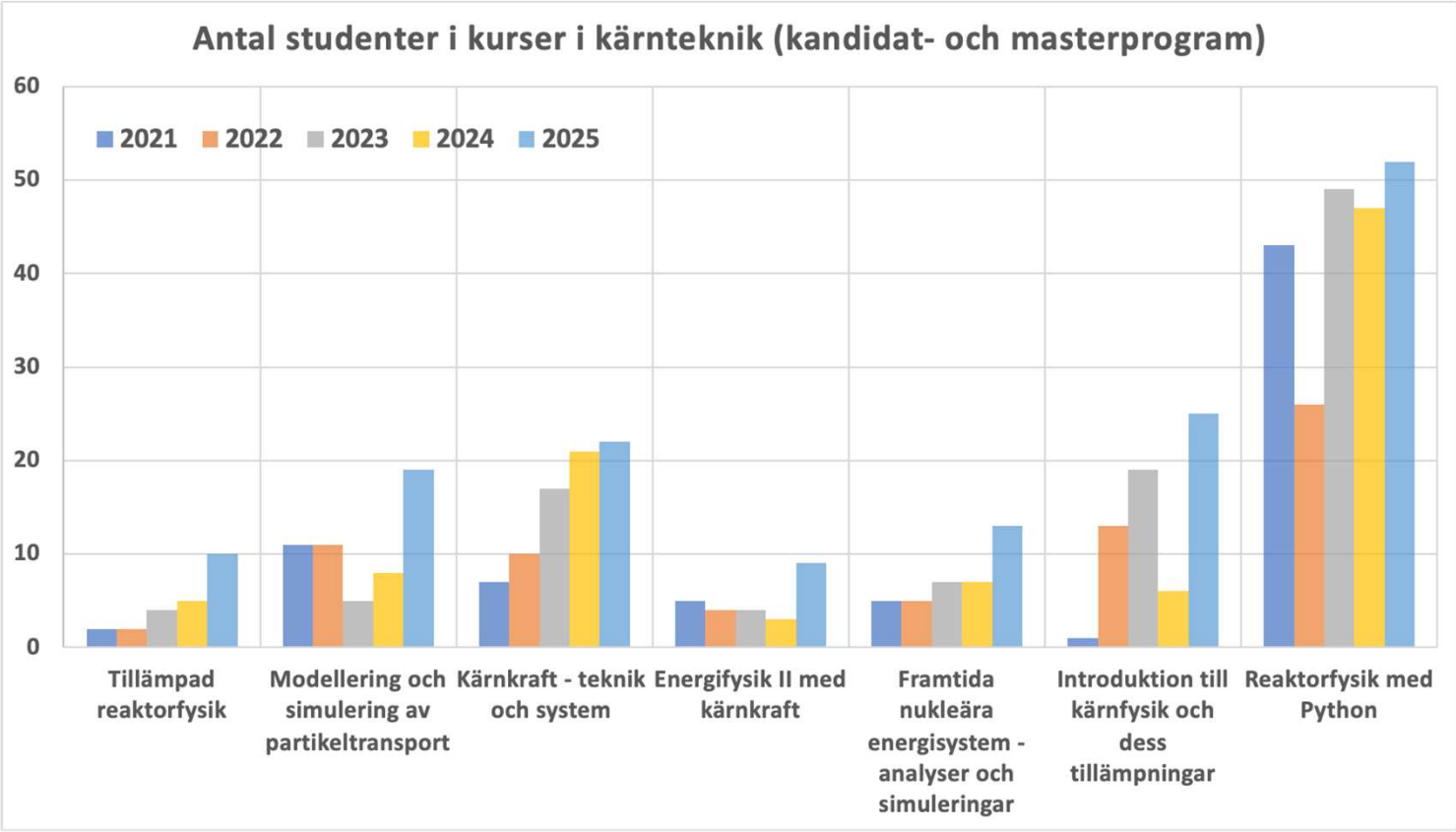
SG0 Highlights med understrykning vilka som har presentationer under symposiet (likt doktoranderna/postdocarna nedan)?

Sophie Grape; 2025-09-22T07:37:21.282

Education

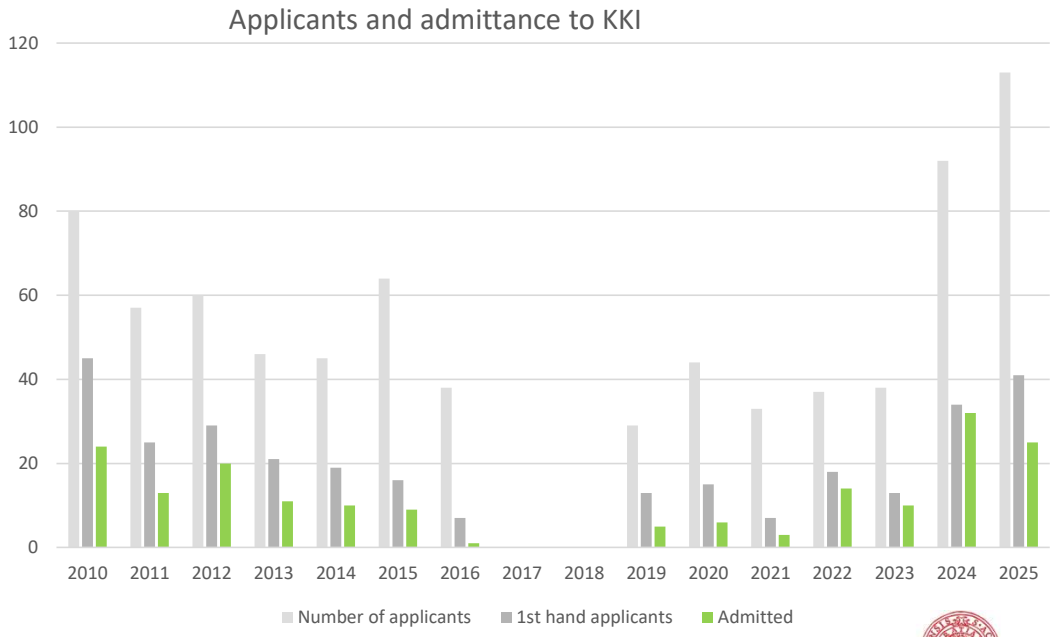
→ Support teaching activities in first and second cycle.

→ Increasing number of students in nuclear-technology courses.



Bachelor's Programme in Nuclear Engineering

Course name
• Introduction to nuclear power technology
• Reactor physics
• Nuclear thermohydraulics and steam turbine technology
• Power Engineering and three-phase systems
• Chemistry, material and fuel for reactor applications
• Nuclear power safety
• Nuclear waste and decommissioning
• Nuclear power operation
• Future nuclear energy systems
• Bachelor thesis



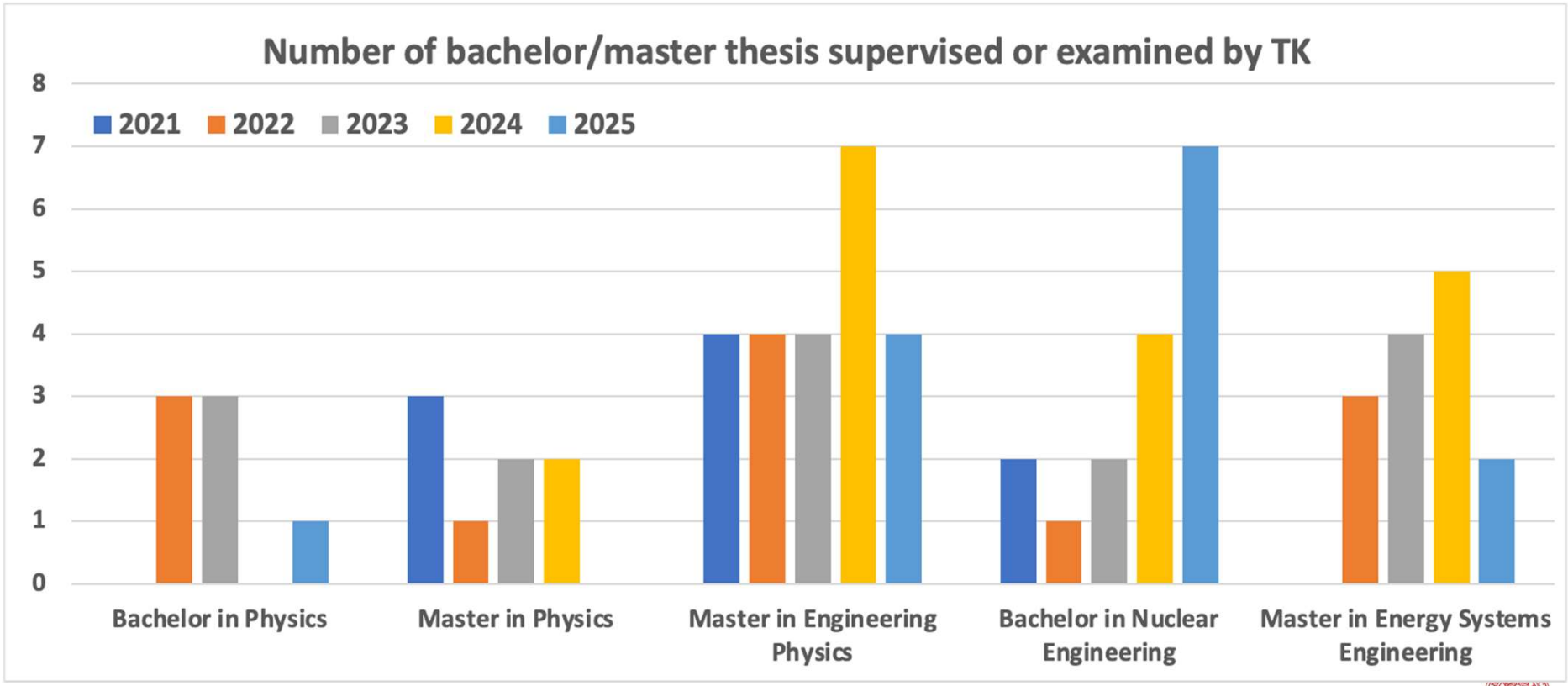
UPPSALA UNIVERSITET

Director: Cecilia Gustavsson

More nuclear engineering @ UU

- New nuclear engineering track at the Bachelor of Mechanical Engineering and Electrical Engineering program.
- Nuclear engineering track at the Master of Energy Systems Engineering program.
  - 75 credits
- Elective course in several master's programs:
  - Engineering physics, Electrical engineering, Systems in technology and Society .
- Introductory courses offered to "everyone".
- Commissioned education.

UPPSALA
UNIVERSITET



UPPSALA UNIVERSITET

Examples of Diploma thesis

- LEU+ pellets at Westinghouse Electric Sweden's fuel factory: Criticality safety analysis for the Västerås plant
- Alternative lubricants for BWR and PWR fuel rod assembly: Experimental friction testing and evaluation
- Crud in BWRs versus coolant chemistry: Linking theoretical deposition levels to measured crud amounts
- Technical obsolescence management: Evaluation of indicators at Forsmark NPP
- Radiological risk identification at a nuclear fuel factory and preparation of guidance materials for healthcare
- Integral Fuel Burnable Absorbers: A comparative study coupling depletion calculations with fuel performance
- Inverse uncertainty quantification of a TRACE model for intermediate break LOCA using DAKOTA, calibrated to BEPU benchmarks
- Methods to study hydrogen diffusion in copper: Comparison of practical techniques and simulation for waste canister materials

UPPSALA
UNIVERSITET

Examples of Diploma work

- **Alternativa smörjmedel för stavmontage av BWR och PWR: Experimentella friktionstester för utvärdering av smörjmedel**
- Kompetensförsörjning för framtida kärnkraftsprojekt i Sverige: Modellering och analys av utbildningsbehov
- Tekniskt obsolescens: Utvärdering av indikatorer vid Forsmark
- Samband mellan crud och ämneskoncentrationer i kokvattenreaktorer: Hur sambandet ser ut mellan teoretiska deponeringsnivåer och uppmätta mängder crud
- Identifiering av radiologiska risker vid en kärnbränslefabrik samt utarbetning av informationsmaterialet till sjukvården
- Challenges and Opportunities with Floating Nuclear Power Plants: A Study on Floating and Offshore NPPs
- Implementering av Små Modulära Reaktorer i Sverige: En kvalitativ studie av drivkrafter och barriärer ur ett aktörsperspektiv
- Undersökning av kärnbränslet TRISO
- Simulating radiological contamination in residential
- Utveckla metoder för att studera vätediffusion i koppar: En jämförelse av praktik och simulation
- Radionuclide Identification from Complex High-Resolution Gamma-ray Spectra
- Simulations of Neutron-Induced Light-Ion Emission using TALYS and Geant4
- Simulering av bestrålning och utbränning av vapengradigt plutonium som MOX-bränsle i lättvattenreaktor
- LEU+ Pellets in Westinghouse Electric Sweden’s nuclear fuel factory: Criticality safety analysis of the nuclear fuel factory in Västerås
- A Comparative Study of Integral Fuel Burnable Absorbers: Coupling Depletion and Fuel Performance
- Analysis of Lohengrin Ionization Chamber Test Run
- Ex-Core Neutron Monitoring in a Molten-Salt Reactor: Neutron Detection Efficiency and Shielding Requirements
- Inverse uncertainty quantification of a TRACE model for intermediate break LOCA using DAKOTA: Calibration against BEPU benchmark results

UPPSALA
UNIVERSITET

What are we missing?

- A common place for nuclear technology Diploma Works.
  - Industry, authority, and academia.
- Who: SAINT, SKC, ANItA, SSM, KTH, UU, or Chalmers.

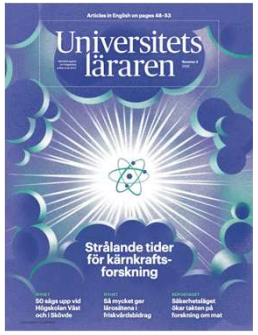
UPPSALA
UNIVERSITET

Third task activities

→ Vetenskapens värld, "Spelet om kärnkraften" del 1-3

SciFest
vetenskapsfestivalen

→ SciFest 2024, Fyrishov



Sällskapet
FÖR STUDIER AV RYSSLAND CENTRAL & ÖSTEUROPA SAMT CENTRALASIEN

FOLK OCH FORSKNING
Vetenskap & Allmänhet
PUBLIC & SCIENCE SWEDEN

sverigesradio

NyTeknik

svt

→ Several pop science texts and interviews published in different media

→ Exploring Opportunities: ANItA and INPRO Workshop on Advancing Sustainable Nuclear Energy

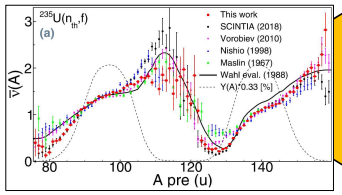
→ Several lectures and activities involving gymnasium and high school level students

Foto: Teknikåttan

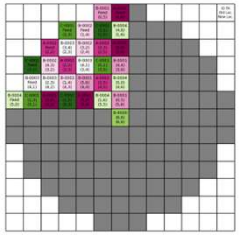
De japanska eleverna och uppsalastudenterna under lunchpausen. Foto: Mattias Lantz

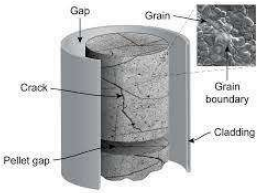
UPPSALA UNIVERSITET

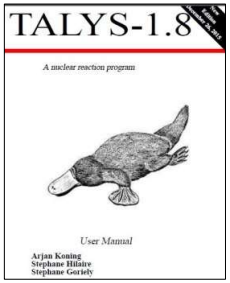
Research - ”Putting nuclear physics to work”



Nuclear physics **experiments**

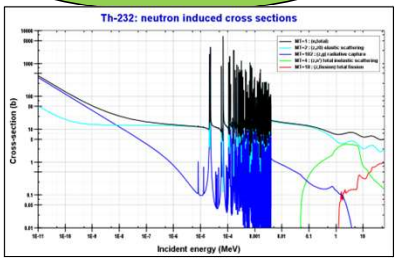






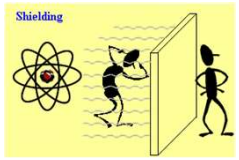
Nuclear physics **model codes**

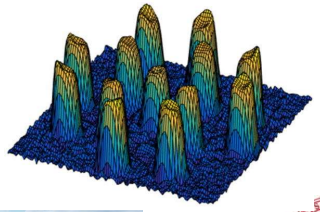
Nuclear data **evaluation**



ENDF

Applications

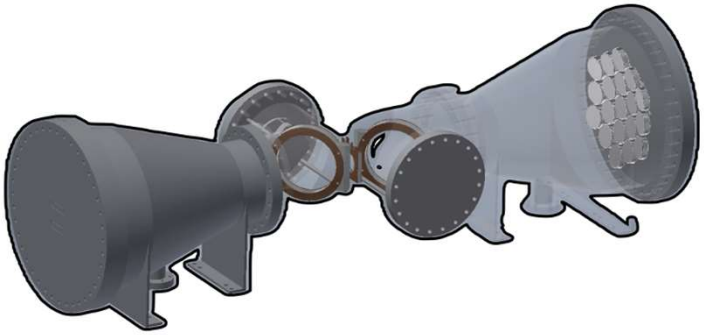


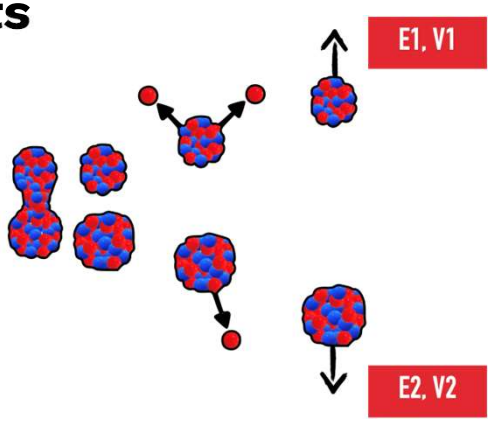


Serpent
MCNP
...

UPPSALA UNIVERSITET

Nuclear reaction measurements



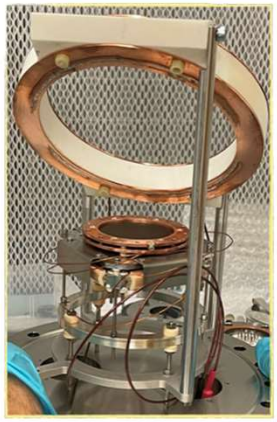


Nuclear physics **experiments**

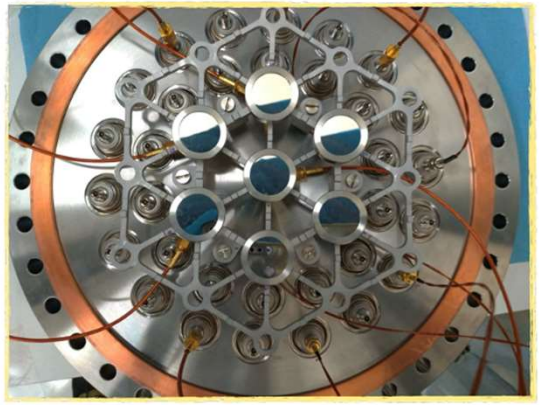
VERDI (Velocity for Direct Particle Identification)
2E-2v spectrometer – for fission observables (Presented earlier by Peter)

Published works

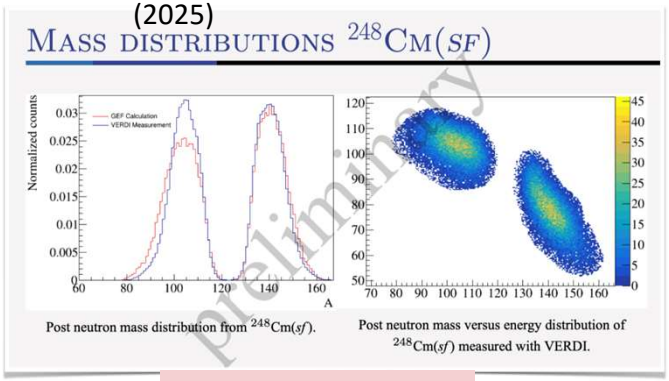
- A. M. Gómez L. et al. Recent updates in the VERDI fission-fragment spectrometer, EPJ Web of Conferences 322, 08008 (2025) CNR*24.
- A. M. Gómez L. et al. Plasma-delay studies on heavy ion detection using PIPS at the LOHENGRIN recoil separator, Eur. Phys. J. A 61:51 (2025)



Micro-channels plates



PIPS detectors

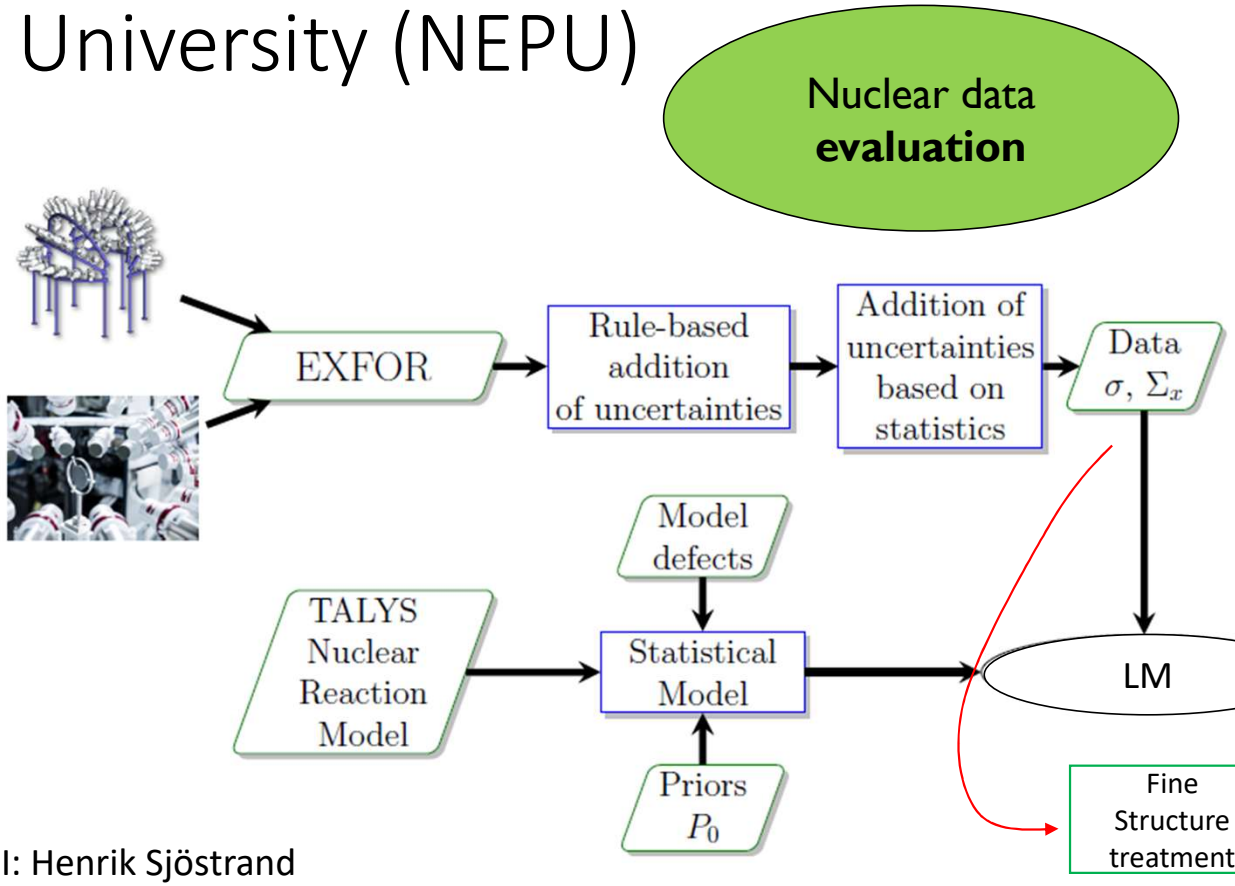


PRELIMINARY!!

SKC
Swedish Centre for Nuclear Technology

MÅSTE
GEN 4 CLEAN POWER PRODUCTION

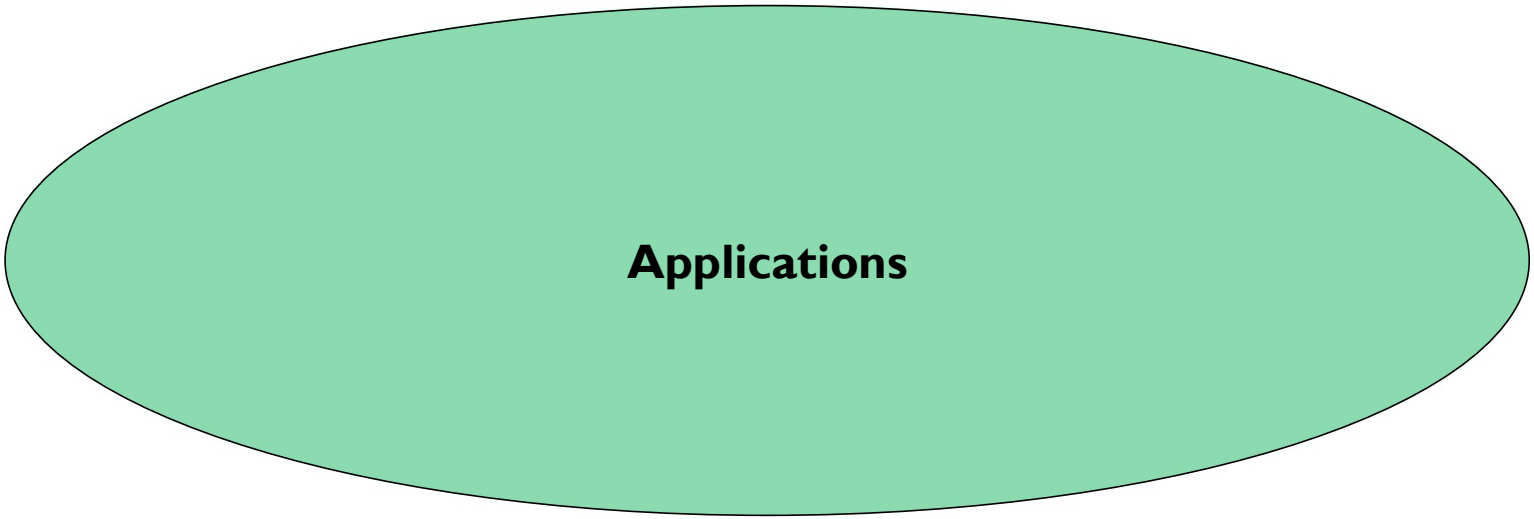
The Nuclear data Evalution Pipeline of Uppsala University (NEPU)



PI: Henrik Sjöstrand

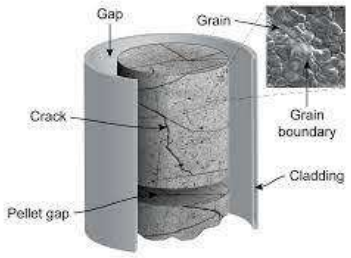
UPPSALA UNIVERSITET

Some application examples



UPPSALA
UNIVERSITET

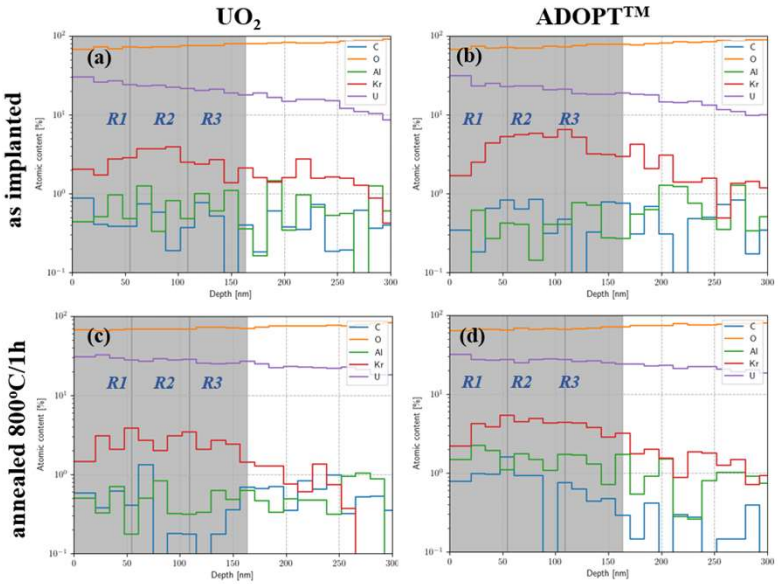
Thermal diffusion of volatile fission products



Element	Boiling temp. (ºC)
Kr	-153
Xe	-108
I	184
Cs	671
Rb	688

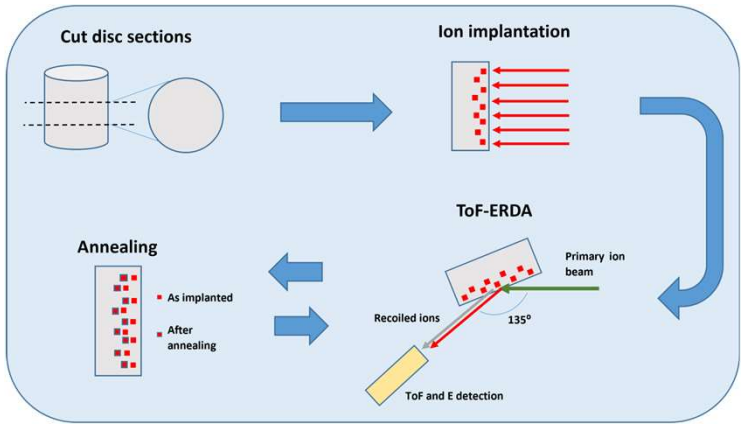
- Ion implantation, combined with ToF-ERDA, is a new methodology for studying the thermal diffusion of volatile elements in reactor fuels.
- The methodology allows for studies to be performed on unirradiated fuel, thus reducing the costs of analyses by an order of magnitude compared to traditional methods.

Observable shifts in implanted concentrated observable with annealing



Differences between fuel type observable

Process in principle:



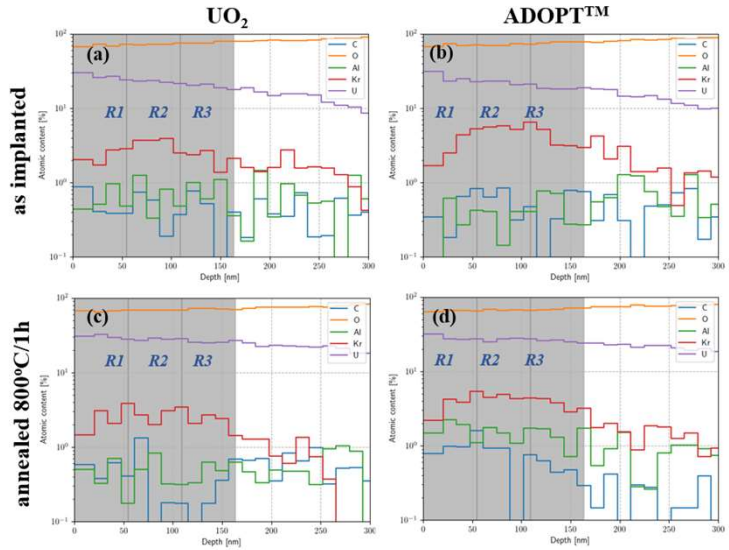
PI: **Robert Frost**, Material Physics

UPPSALA UNIVERSITET

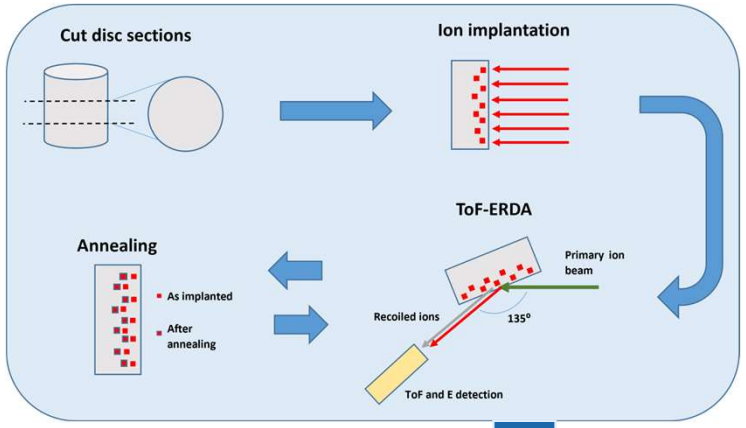
Thermal diffusion of volatile fission products

Ion implantation, combined with Time-of-Flight Elastic Recoil Detection Analysis, is used to **study the thermal diffusion of volatile elements (Xe, Kr, I, etc) in reactor fuels**.

The methodology allows for studies to be performed on unirradiated fuel, thus reducing the costs of analyses by an order of magnitude compared to traditional methods.



Process in principle:



Shift in implanted concentration is different for different fuels

PI: **Robert Frost**, Material Physics

SKC
Swedish Centre for Nuclear Technology

UPPSALA UNIVERSITET

B1: Core Design and fuel design optimization for SMR

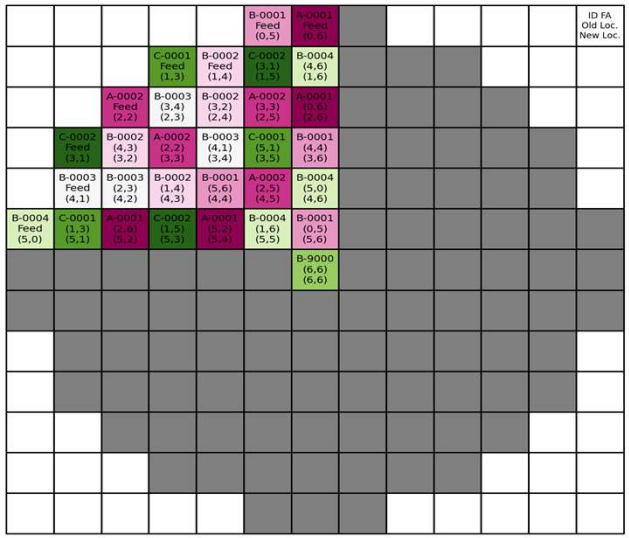
Objective:

- optimization methodologies for nuclear reactor-core loading-pattern for SMR

Methodology:

- surrogate model of loading pattern using machine learning.
- genetic search algorithm for optimization using the surogate model.

Two talks in Session B2



PI: **Jesper Kirkengard (Westinghouse)**
Main supervisor: **Andreas Solders**
PhD student: **Flavio Ferella**

Westinghouse VATTENFALL

UPPSALA UNIVERSITET

D2: Non-proliferation and nuclear safeguards in ANitA

Objective:

- **Perform proliferation resistance assessment to analyse consequences of introducing light-water SMRs in the Swedish nuclear fuel cycle.**

Methodology:

- Apply IAEA:s self-assessment methodology INPRO on selected deployment scenarios to perform a holistic analysis considering both non-technical and technical aspects (see User Requirements, or URs, below).

Status:

- Evaluate nuclear material attractiveness of existing and "new" fresh and spent fuel, considering masses and composition.
- This work complements prior efforts with the INPRO methodology to complete the analysis.
- Manuscript to be submitted for publication.

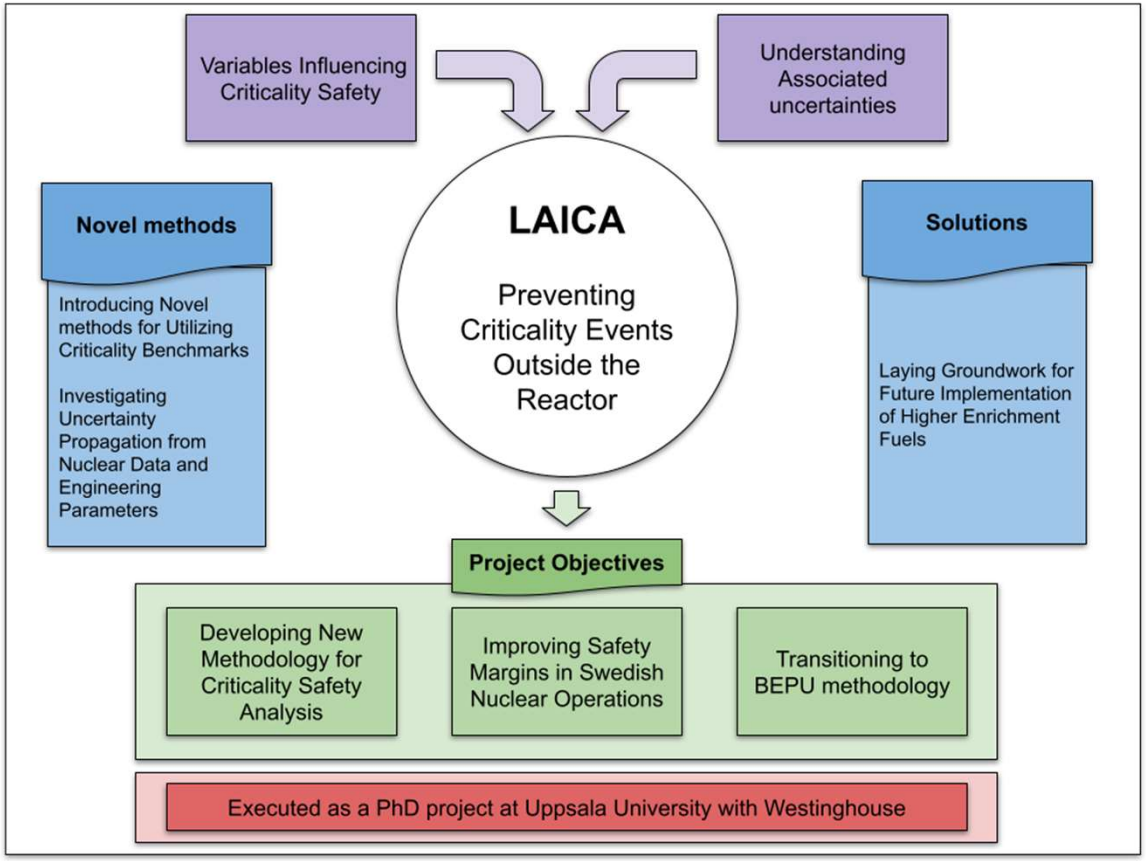
Talk in Session A3

PI: **Sophie Grape**
Main supervisor: **Sophie Grape**
PhD student: **Claudia Olaru**

UPPSALA UNIVERSITET

LAICA

Linking Academia and Industry in Criticality safety Analysis



Investigate limitations for criticality safety outside the reactor when handling uranium with higher enrichment than today.

A PhD project in collaboration with Westinghouse

Supervision now also from: Strål säkerhets myndigheten, Swedish Radiation Safety Authority

PI: **Erik Andersson Sundén**
PhD student: **Aura Jahan**

UPPSALA UNIVERSITET

Talk in Session A3

Research on maritime applications of nuclear technology

- **Interdisciplinary research project on maritime applications of nuclear energy with focus on "3S" (Safety, Security and Safeguards).** Project associated with ANItA.
- Two student projects:
  - *Challenges and Opportunities with Floating Nuclear Power Plants: A Study on Floating and Offshore NPPs*
  - *Undersökning av kärnbränslet TRISO*

Collaboration:

- Marine Technology, Mechanics and Maritime Sciences at Chalmers.
  POWERSHIP project aiming to investigate ship technology for commercial ships with SMRs, as they require changes in classification rules and standards.
- Norwegian NuProShip project on nuclear propulsion.
- Application submitted with NuProShip on establishment of "Center for Sustainable And Industrialized Nuclear Technology" (= SAINT), aiming to demonstrate the capability of retrofitting a nuclear reactor on an LNG tanker.

Talk in Session C3

PI: **Sophie Grape**

ANItA

Strål säkerhets myndigheten
Swedish Radiation Safety Authority

SKC
Swedish Centre for Nuclear Technology

UPPSALA UNIVERSITET

A Quantum Field Theory Approach to Neutron Population Fluctuations in Nuclear Reactors

Goal:

Improve the calculations of the neutron distribution during startup at Ringhals 3 and 4

Method :

Combine quantum field theory with stochastic methods to describe neutron dynamics in a reactor.
Investigate macroscopic properties emerging from a stochastic neutron field within a nuclear reactor core.

People involved:

Industrial PhD student: Jacob Persson (jacob.persson@physics.uu.se)
Supervisors @ UU: Stefano Moretti, Andreas Solders, Eliel Camargo-Molina
Supervisor at Ringhals: Anders Jonsson (Härdanalys, bränsle och safeguards)

Funding:

Vattenfall Nuclear Fuel AB (VNF) and Swedish Centre for Nuclear Technology (SKC)

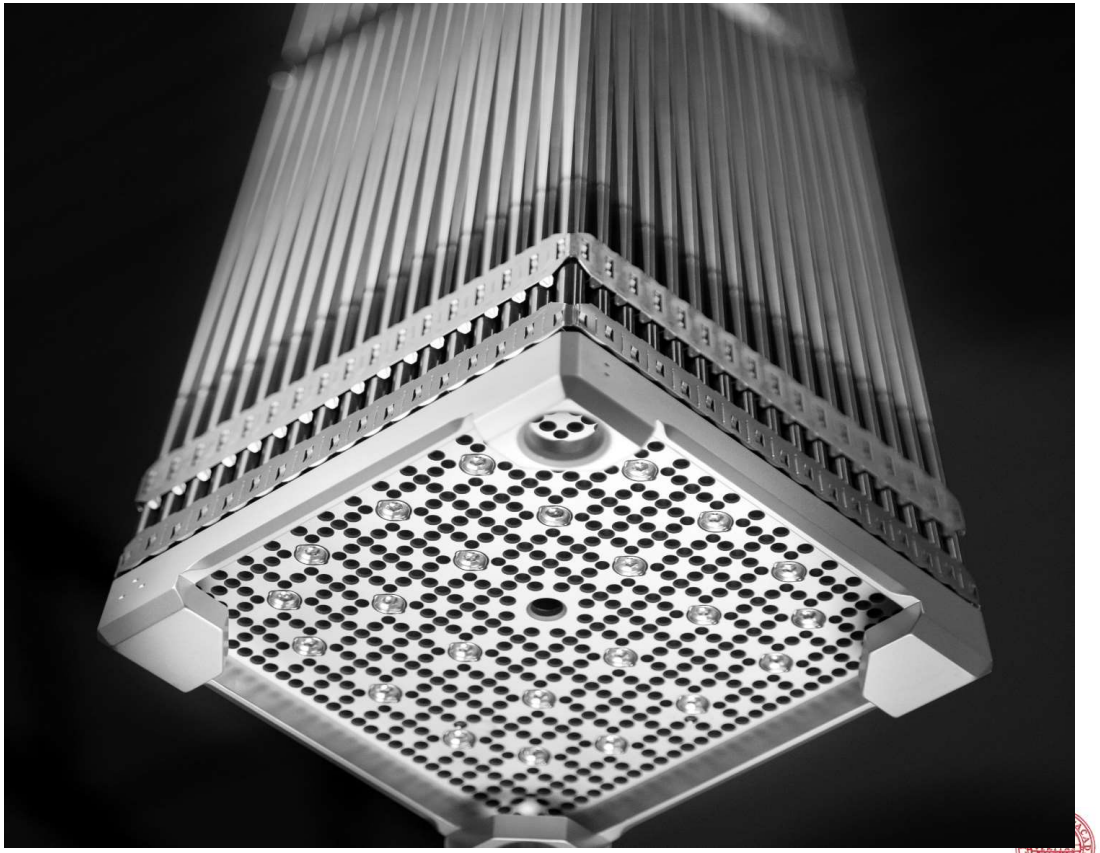
VATTENFALL

SKC
Swedish Centre for Nuclear Technology

UPPSALA UNIVERSITET

Nuclear Fuel Performance - B3

- Impact of SMR operation on fuel performance is evaluated in B3
- Methods
  - Fuel performance modelling (e.g. Transuranus)
  - Analysis of In-pile experiments and post-irradiation examination



Talk in Session B1
Peter Andersson PI
Vikram Rathore → Westinghouse

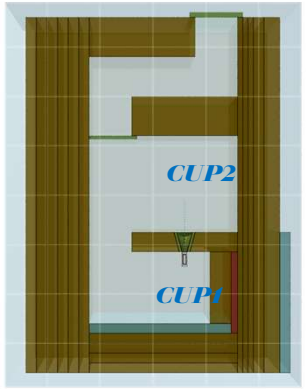
UPPSALA UNIVERSITET

NESSA – Neutron Source in uppSAla

Designed to host a high yield **14 MeV** neutron generator using the **DT reaction.**

Key Goals:

- Yield: ≥ $1 \cdot 10^{10}$ n/s in 4π.
- Flexible operation: variable neutron energies, beam sizes & flux.
- Neutron flux: up to 1.10^{9} cm^{-2} s^{-1} in close user position (CUP).



Intended Use:

- 🎓 Education & Training – easy-access campus neutron source.
- 🧪 R&D – detectors, tomography, radiation transport.
- 💻⚡ Applied Studies – electronics effects, shielding, activation.

Present Activities:

- 📢 Overview of NESSA presented at ND2025 (Madrid).
- 🔄 Relocation of 1.1 × 10^{8} n/s DT generator from Lund (Sept 2025).

🌟 **Good News!!!**

Grant received from The Swedish Energy Agency for procurement of the generator & associated support.

👥 **NESSA Team**

- Prof. **Stephan Pomp**
- Prof. **Erik Andersson Sundén**
- Prof. **Göran Ericsson**
- Dr. **Sandipan Dawn**
- … and colleagues

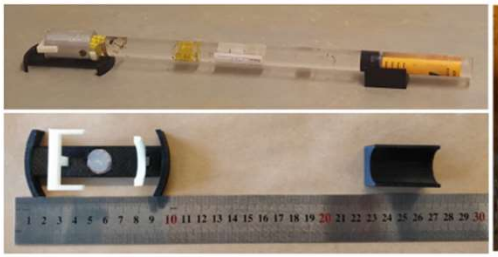
Talk in Session B2

UPPSALA UNIVERSITET

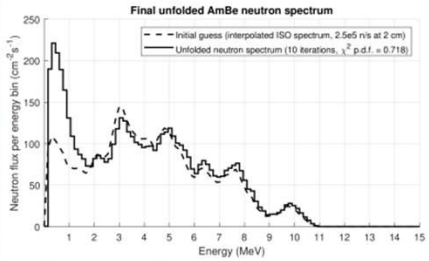
Method development for radionuclide measurements (UGGLA)

Key goals

- General gamma spectroscopy facility: **”You’ve got gamma? – We can measure it!”**
- Be a friendly **neutron activation** partner to the upcoming **NESSA** neutron facility
- **Radioecology** studies for societal concerns and environmental studies



Neutron irradiation and gamma spectroscopy



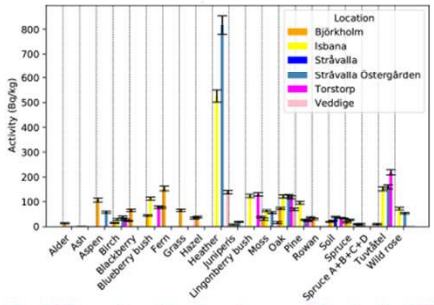
Derived AmBe neutron spectrum
Image: Elias Arnqvist

Recent/present activities

- **Neutron activation** studies (AmBe and PuC sources)
- **Radioecology**: Studies of environmental samples near Ringhals
- **Air sampling**: Basic studies for civil preparedness, radioecology and astrophysics (!)
- Method development for radioactive chain decay and buildup corrections in soil, air and water samples

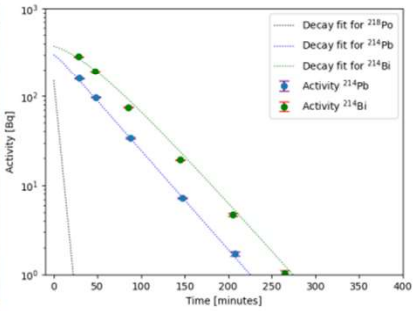
PI: Mattias Lantz

Sandipan Dawn
Cecilia Gustavsson
Erik Andersson Sundén



Cs-137 content in plants near Ringhals NPP
Image: Lucie Pratabuy Tran-Quang

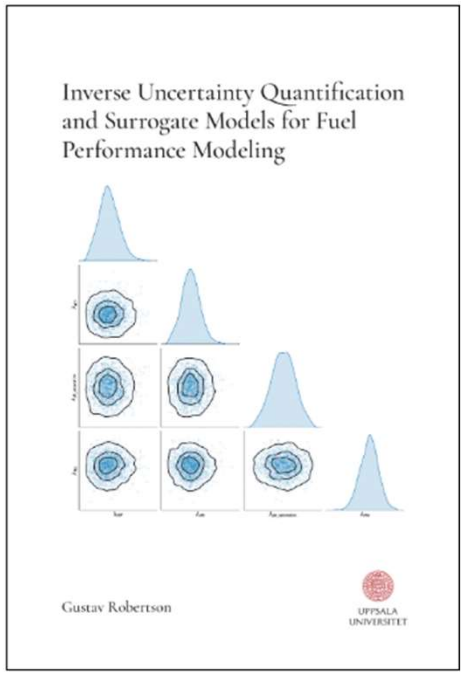
Air filter sampling of radioactive dust, sample preparation



Radon decay chain derivation
Image: Lars Jones

Inverse Uncertainty Quantification and Surrogate Models for Fuel Performance Modeling

- Successful dissertation, Gustav Robertson, 16th of May 2025.
- Winner of Sigvard Eklund Prize (together with two other winners, Filippa and Peter, from Uppsala University, this year)



APIS

SKC
Swedish Centre for Nuclear Technology

Co-funded by the European Union

UPPSALA UNIVERSITET

Winner of Euratom Nuclear Innovation Prize - Virginie Solans (PhD, Uppsala)

https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/prizes/nuclear-innovation-prize_en

UPPSALA UNIVERSITET

ANITA at UU, beyond nuclear physics.

UU involvement goes beyond the Div. of Applied nuclear physics:

C: SMR-Specific Issues Related to Reactor Safety and Safety Systems

- C3: Studies on structural materials (Materials theory)- PI - Mattias Klintenberg

E: Deployment of New Nuclear Technology in Sweden

- E1: Implementation of SMRs – serial production and project management (Civil and industrial engineering)
- E2: Licensing issues and perspectives on regulatory frameworks (Civil and industrial engineering/Department of Law)

Talk in Session C2

UPPSALA UNIVERSITET

Conclusions from Uppsala

- A record broad research portfolio.
- More application-oriented than before.
- Stronger industrial collaboration than previously.
- Research recognised with national and international awards
- Rising student interest
  - Still a challenge to find funding for smaller, specialised education programs.

Thank you!

UPPSALA UNIVERSITET