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Characterization of samples from laboratory erosion and dust experiments – plans and capabilities

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EUROfusion

Vetenskapsrådet

Task description & deliverables

Eurofusion PWIE SP-B.1

Task description:

Perform ion-beam analyses for samples from dust studies and laboratory experiments (VR - jointly with ENEA and ÖAW)

Deliverable – D6:

RBS, ERDA and MEIS/LEIS characterization of selected samples from laboratory erosion and dust experiments

The Tandem Laboratory @ UU

An overview of the experimental infrastructure

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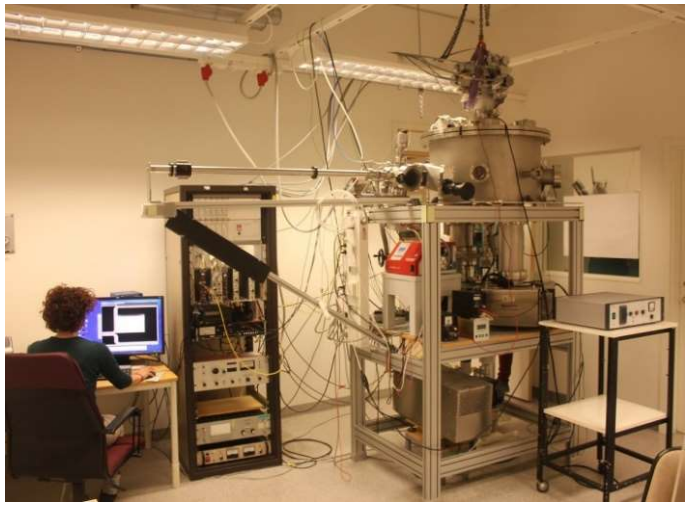
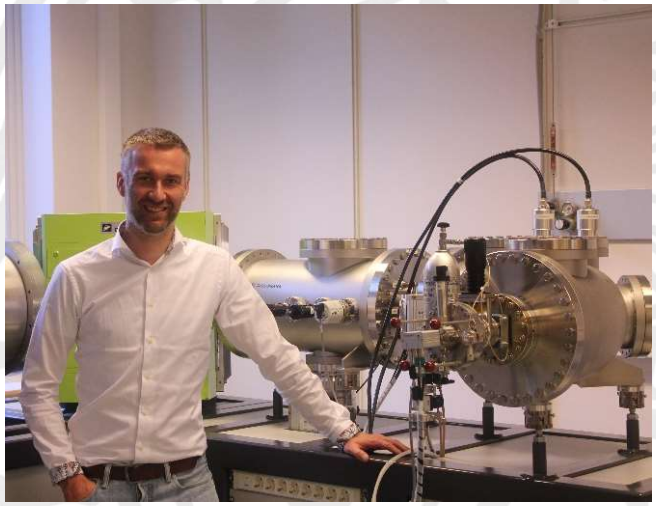
4 accelerators, 9 ion sources, 11 beam lines:

Tandem accelerator NEC 5 MV Pelletron (‘01)	IBA, IBMM, AMS
Linear 350 kV Danfysik accelerator (’03 &’15)	IBA, IBMM
MICADAS, 170 kV, ETH (‘14).	AMS
Dedicated clean-room for sample preparation	AMS, IBA, IBMM
Low-Energy Ion Scattering set-up (’18)	IBA, IBMM
Low-Energy Ion Implanter (under construction)	IBMM





The Tandem Laboratory @ UU

Equipment for IBA & IBMM – accessible for users

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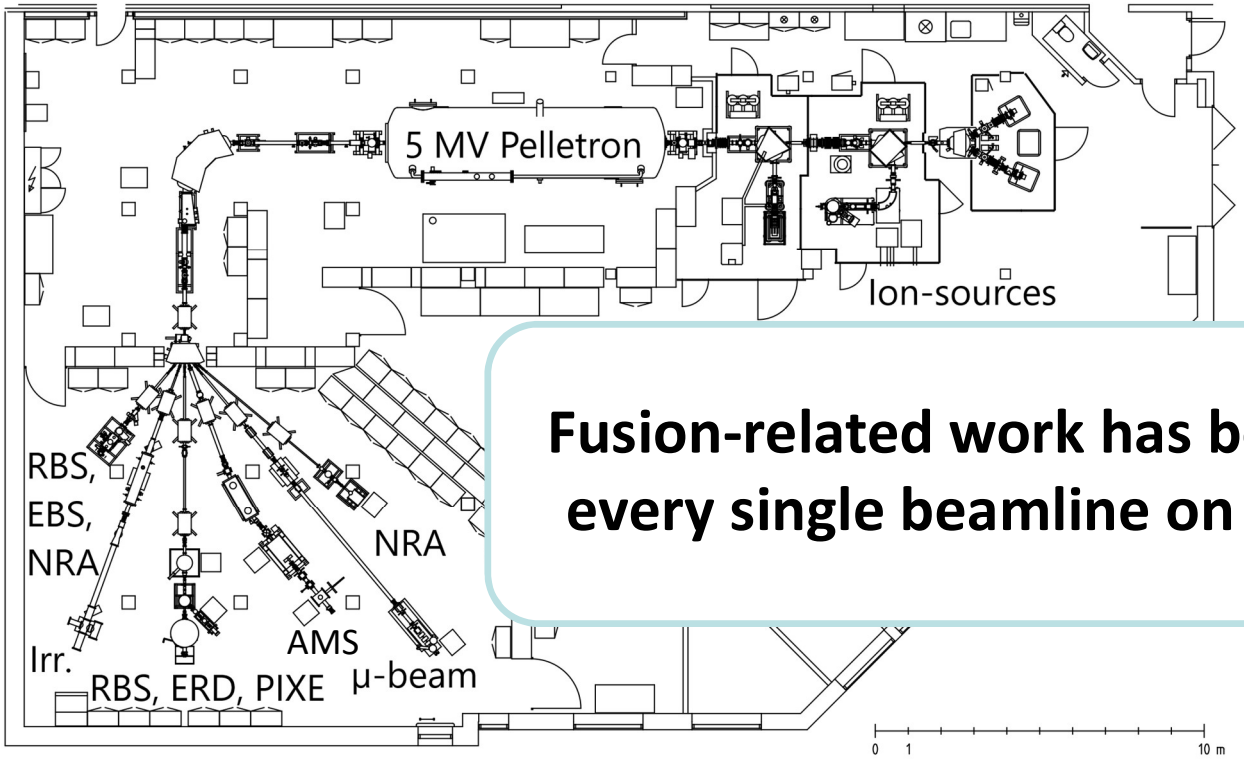
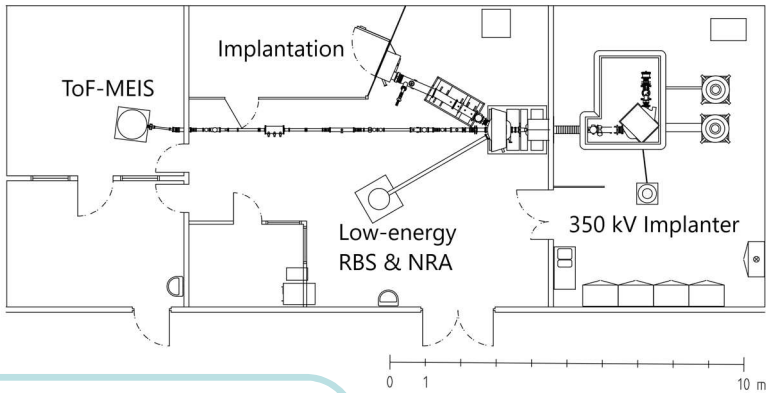
5 MV 15-SDH2 pelletron accelerator



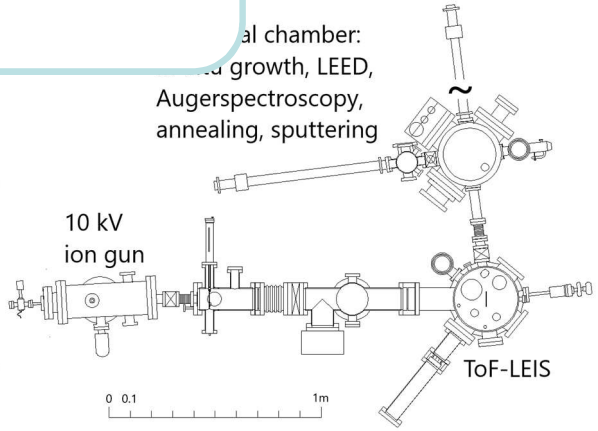
Fusion-related work has been done on every single beamline on all systems.

2 gas & 2 sputter ion sources – beams of H, D, ^{3}He, ^{4}He, C, N, O, Cu, Br, I, Au, …

350 kV Danfysik implanter



geable sources:
sputter
EIS system



5 MV Pelletron, Uppsala University

All standard tools available

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Chamber for NRA & RBS

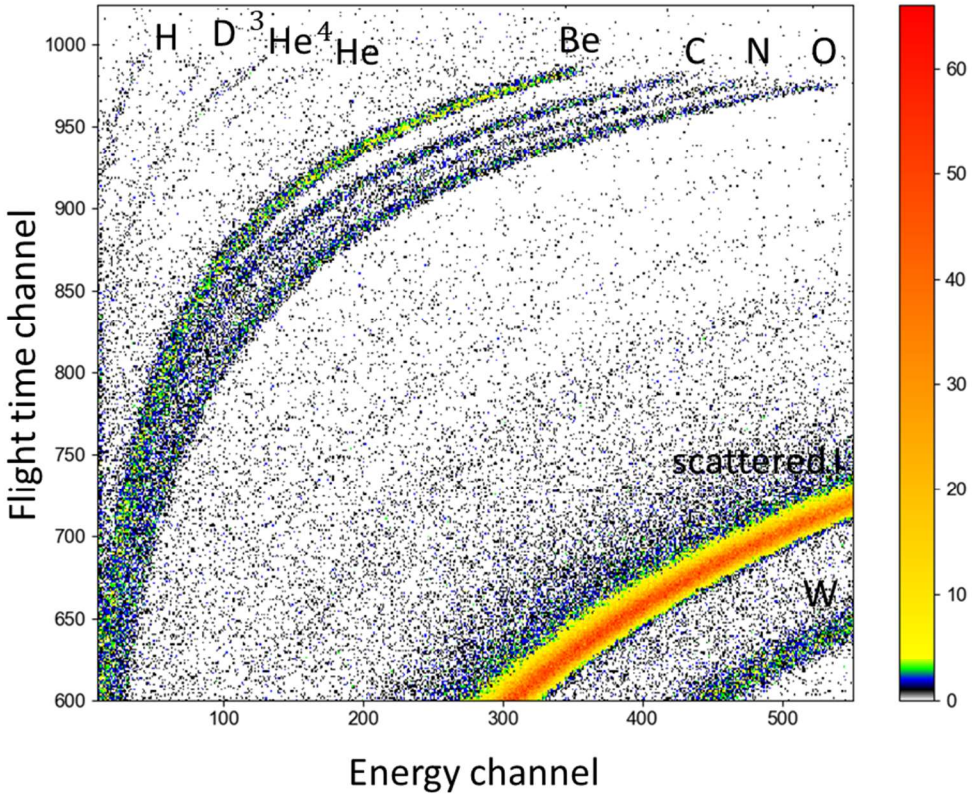
PIXE & μ-beam

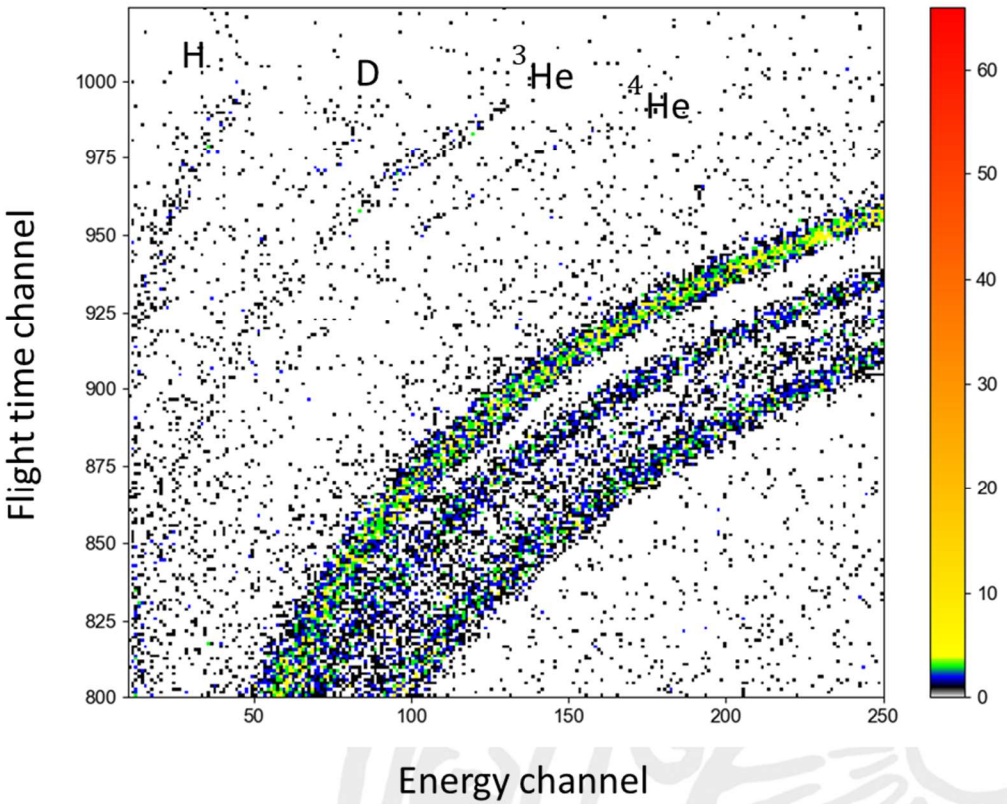
2x RBS, PIXE and ToF-ERDA

Irradiation

Example: low-Z characterization

W 124 – lamellae C 23, toroidal gap side, ILW1+3



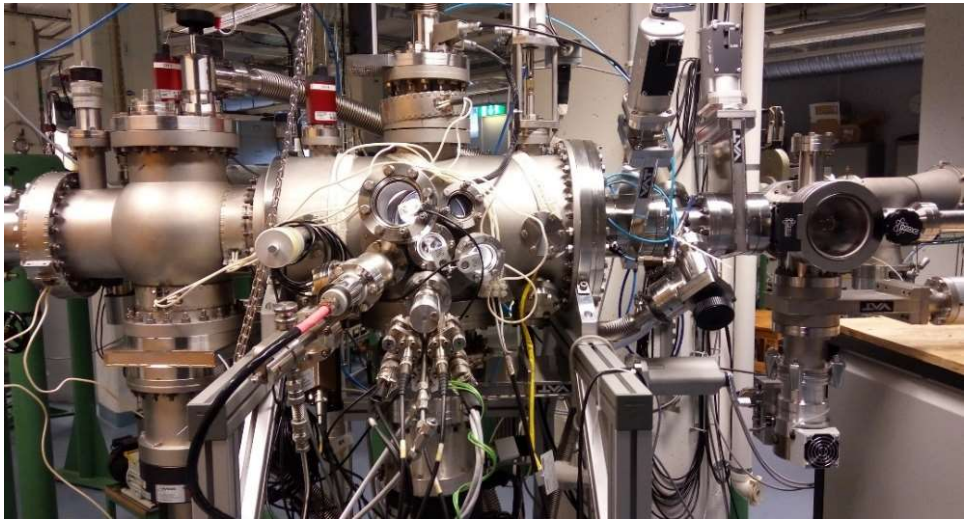


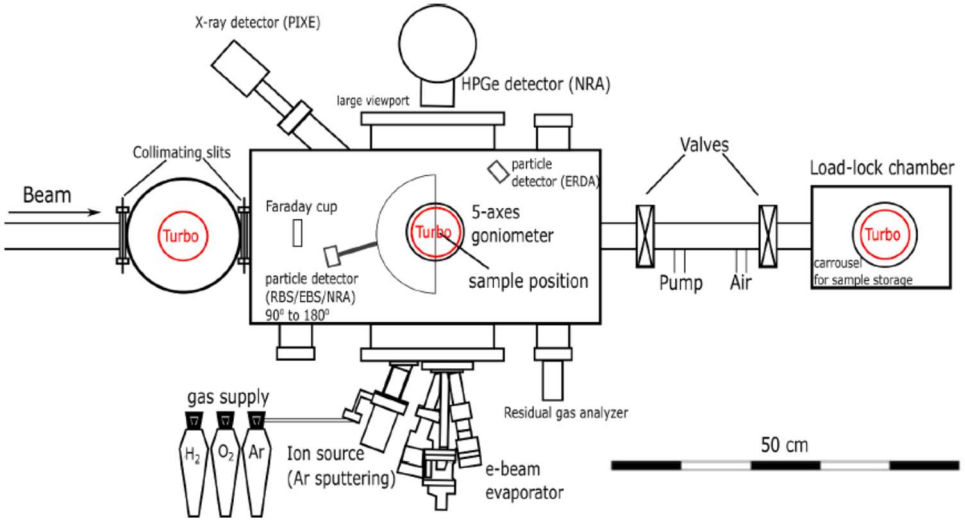
ToF-ERDA for multi-element analysis – can be complemented by NRA

Recent developments…

5 MV Pelletron, Uppsala University

In-situ target modification & IBA characterization





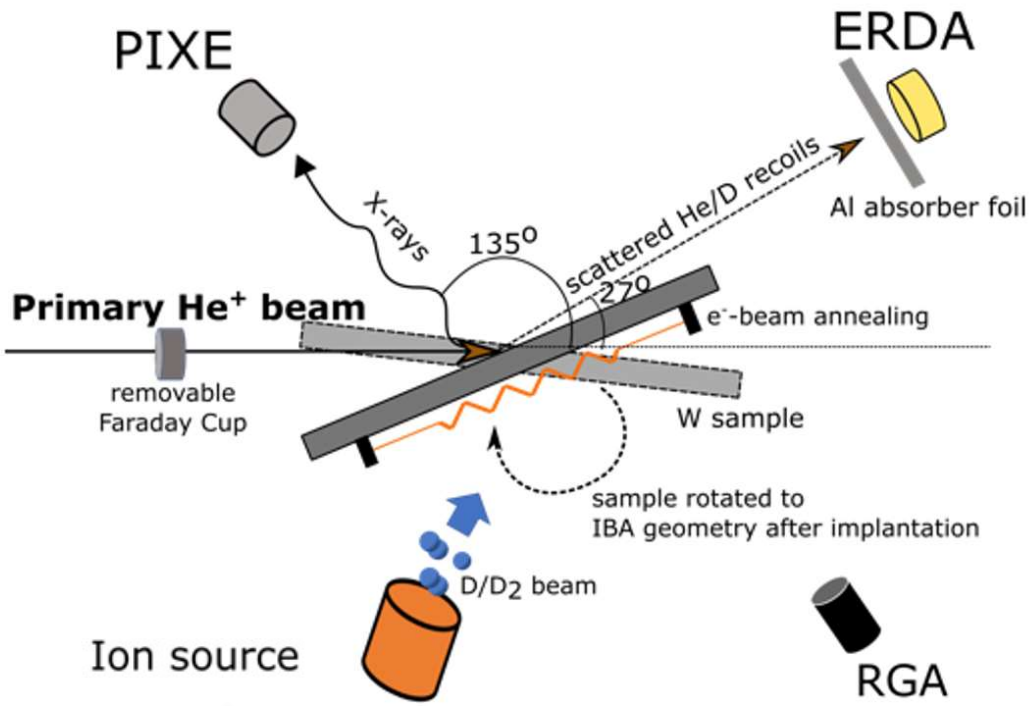
- **UHV-chamber at T6 @ 5MV tandem**
- **Accessible for light and heavy ions**
- **Beam energies from 2 – 50 MeV**
- **Multi-method capabilities**

	RBS/EBS	NRA*	PIGE	ERDA	PIXE	Evaporation	Annealing	Sputtering	Implantation
RBS/EBS									
NRA									
PIGE									
ERDA									
PIXE									
Evaporation									
Annealing									
Sputtering									
Implantation									

K. Kantre et al., Nucl. Instr. Meth. B (2020)

In-situ IBA for fusion-related research

H-implantation and retention



- **Combined *in-situ* D-implantation IBA & TDS experiments**
  - **Implantation to >10^{22}m^{-2} and annealing to >1000 °C**

In-situ IBA for fusion-related research

Surface segregation and D-retention in EUROFER

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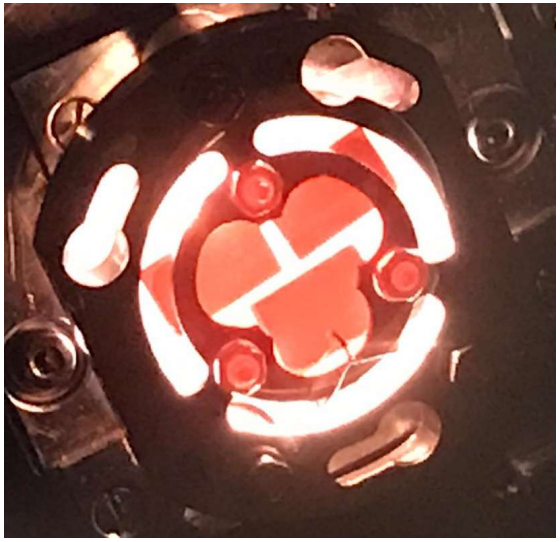
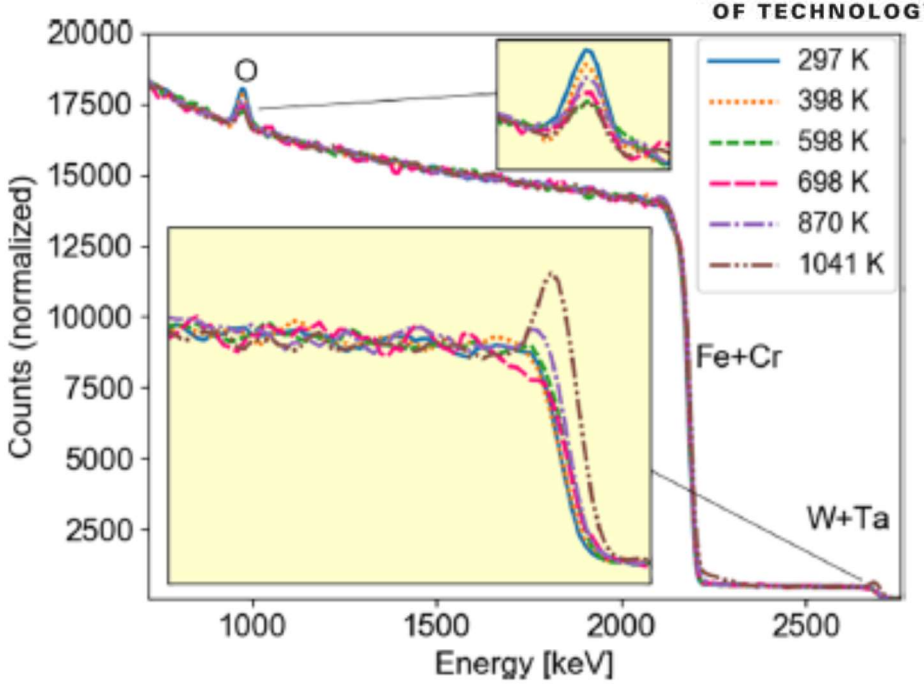




- *In-situ* analysis using RBS

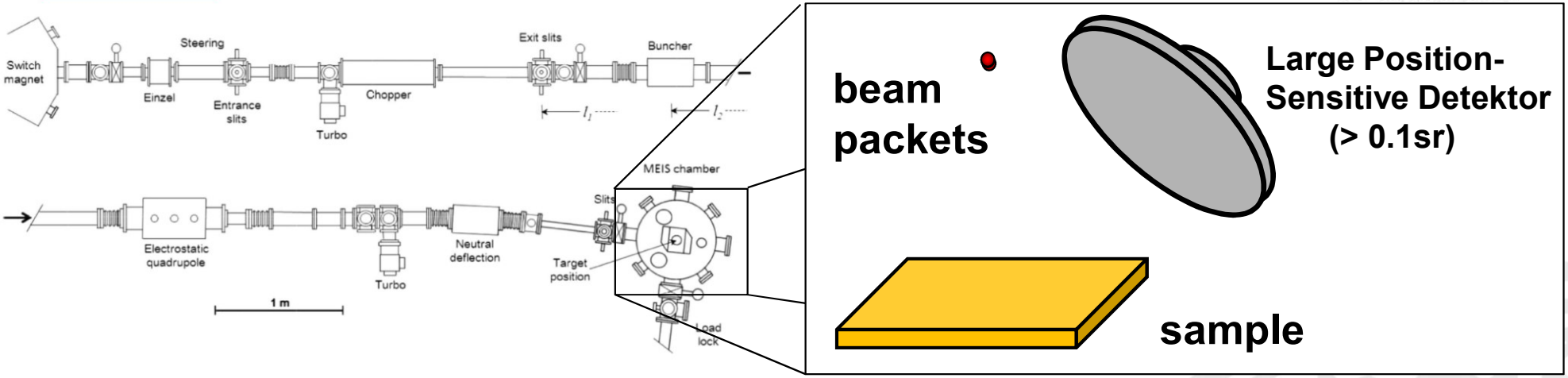
Ström et al., Nucl. Mat. Eng. (2021)

Questions adressed:

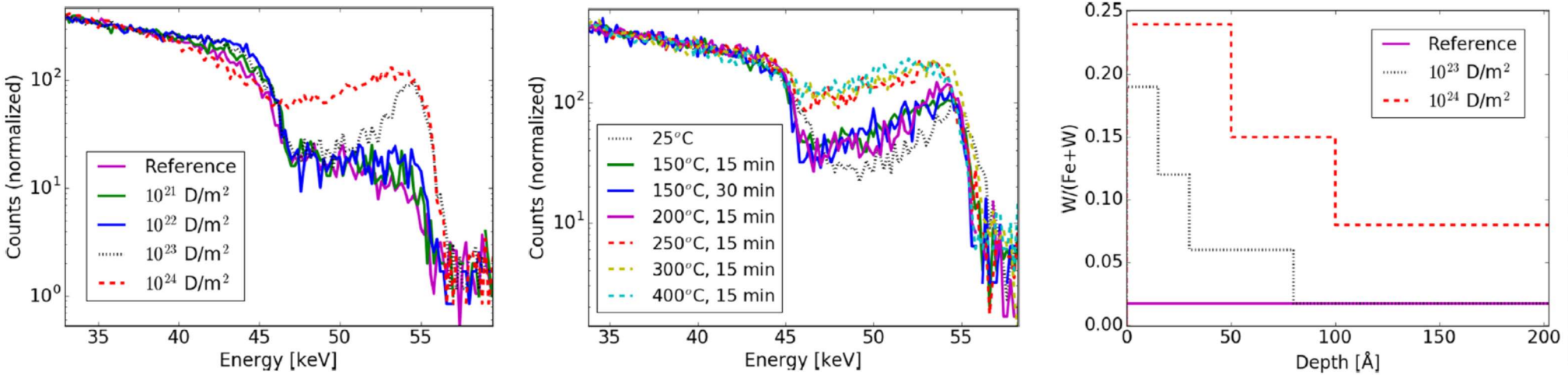
- **How much and at which temperature seggregates W to the surface?**
- **How much of a hysteresis is observed in heating/cooling cycles?**
- **What happens if surface is preenriched with tungsten?**

The Uppsala ToF-MEIS system

A versatile tool for HR-depth profiling



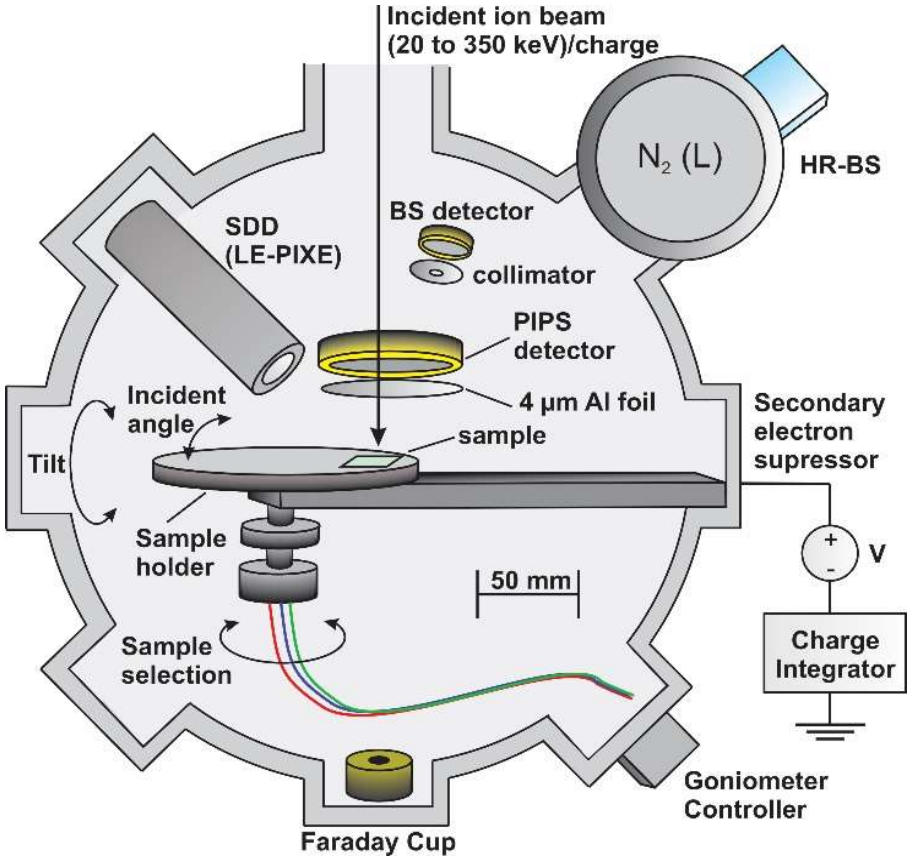
M. Linnarsson et al., Rev. Sci. Instr. (2012)



Ström et al., Nucl. Mat. Eng. (2017)

New beam line at the implanter

Low-energy HR-RBS and NRA



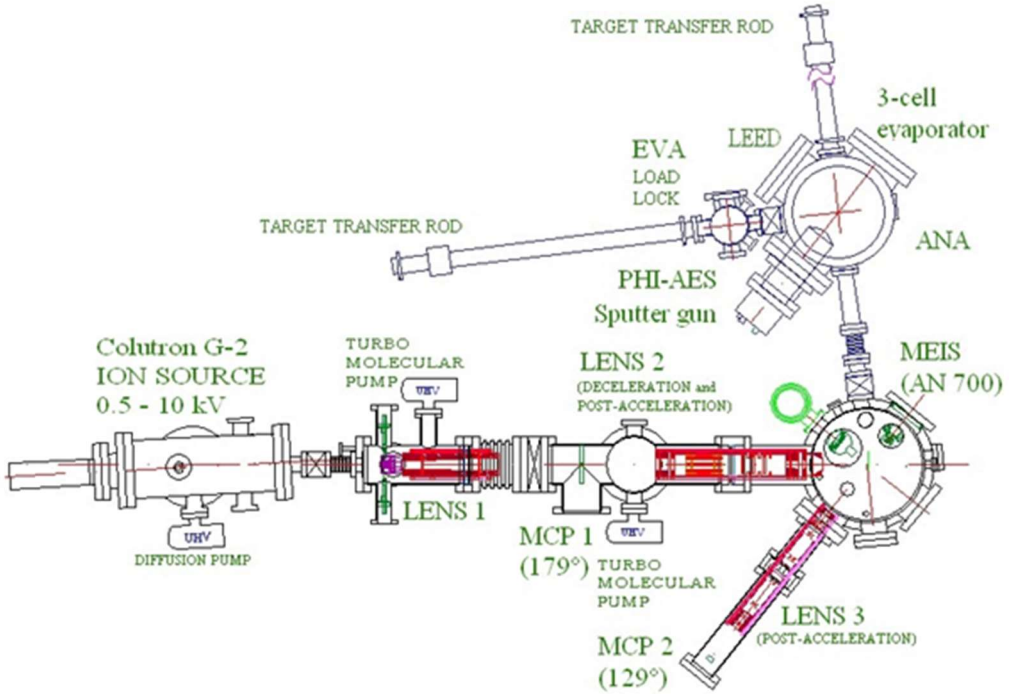
S.A. Correa et al., NimB (2020)

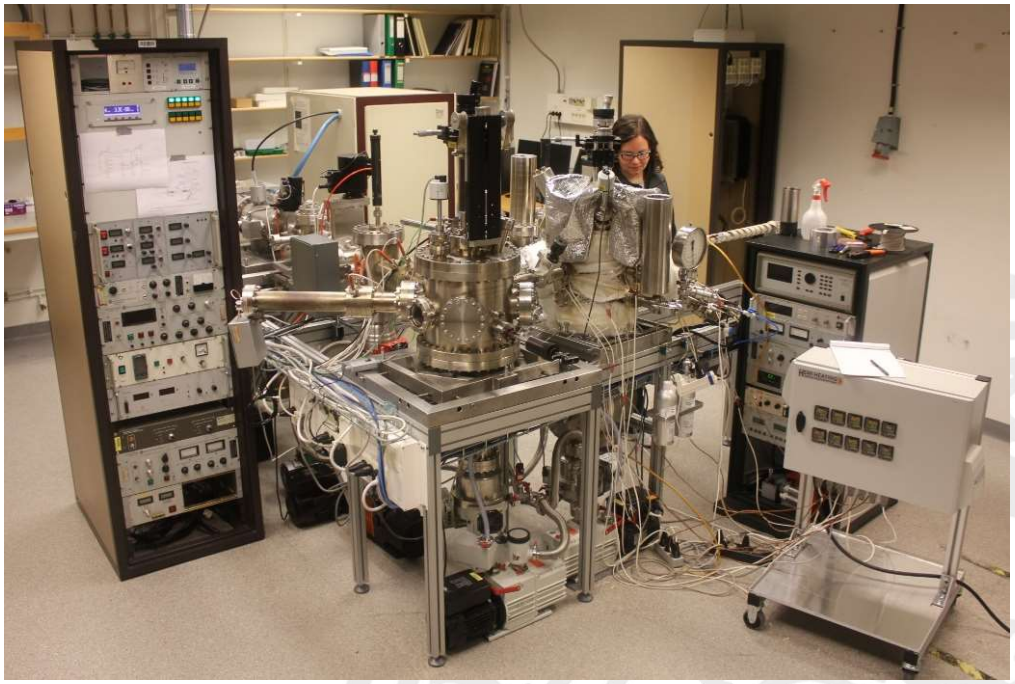
Methods available:

- **HR-RBS**
- **LE-PIXE**
- **NRA for ^{18}O, ^{11}B**

The Uppsala ToF-LEIS system

Surface analysis & in-situ growth and modification



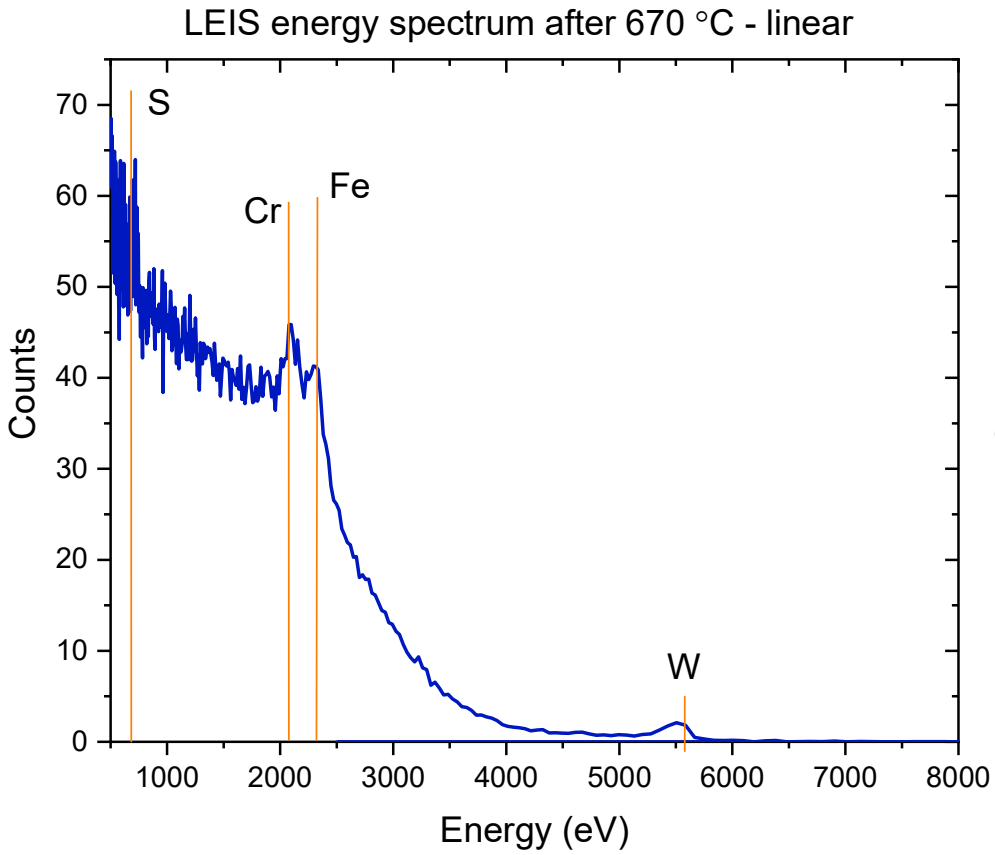


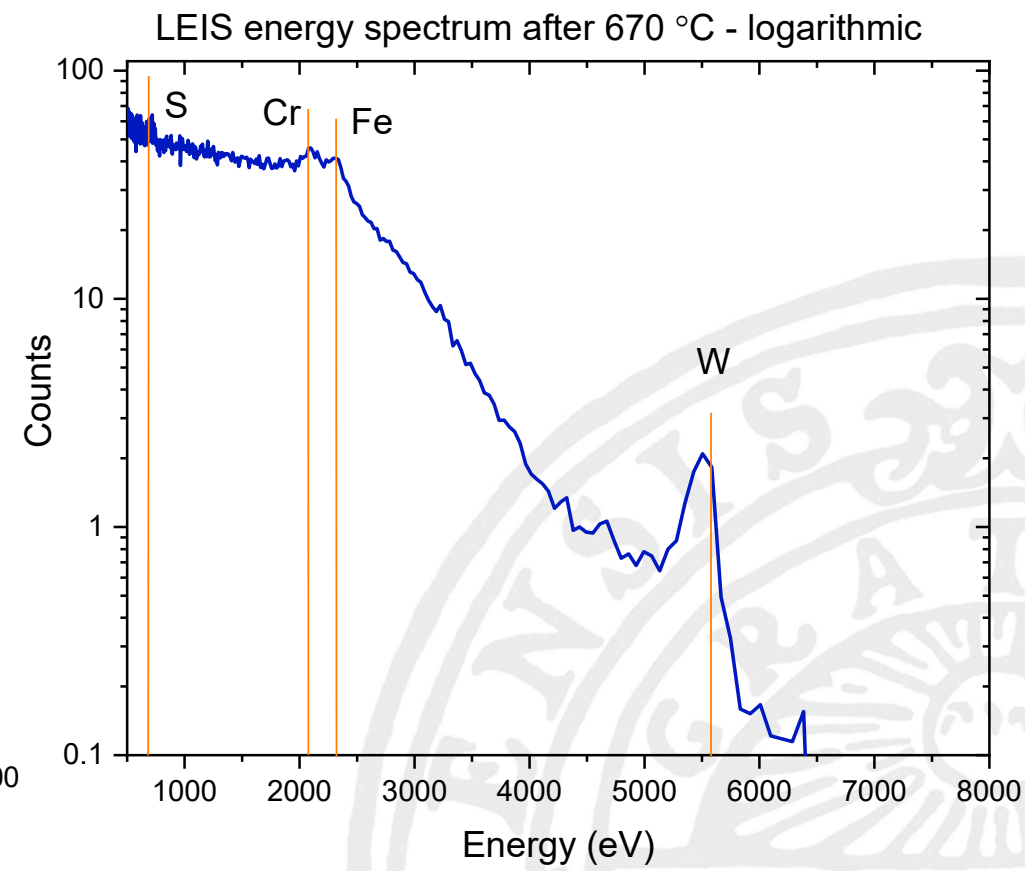
S.N. Markin et al., Vacuum 73 (2004)
S.N. Markin, PhD Thesis JKU Linz (2008)

- **Ideal tool for studying surfaces**
- **Neutrals permit subsurface profiling**
- ***In-situ* annealing**
- **LEES, AES, sputtering, evaporation**

Surface segregation of W in Eurofer

8 keV Ne: annealed EUROFER





- **Annealing leads to W-seggregation – temperature dependence can be studied**
- **Also surface-seggregation of Cr and S can be observed**

Project plan

Characterize samples as they arrive

- **ToF-HIERDA for overall assessment of sample composition**
- **NRA (with and without μ-beam) for light species characterization**
- **MEIS & LEIS for HR-characterization**

With ÖAW: first pre-characterization of W and W-redeposited layers

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Thank you!