New VTT Hot Cells in Operation

Wade Karlsen, VTT
+ 12 others

VTT Centre for Nuclear Safety

The VTT Centre for Nuclear Safety is a new green field site project:

- 1/2014: Ground breaking
- 6/2016: Laboratory-wing ready for move-in
- 8/2017: Hot cell installation completed
- 4/2018: IAEA baseline swipe tests
- 5/2018: License for hot cell operation granted from STUK

- Handling and testing of hot structural materials.
- Metallography, dimensioning, marking, hardness, and imaging tools.
- Analytical electron microscopy to nano-scale.
- Measurements of gamma, beta and alpha.
- Chemical analyses across periodic table
  - from H and He to isotopes of actinides,
  - down to parts-per-trillion resolutions.
- Aerosol, iodine and bentonite laboratories.

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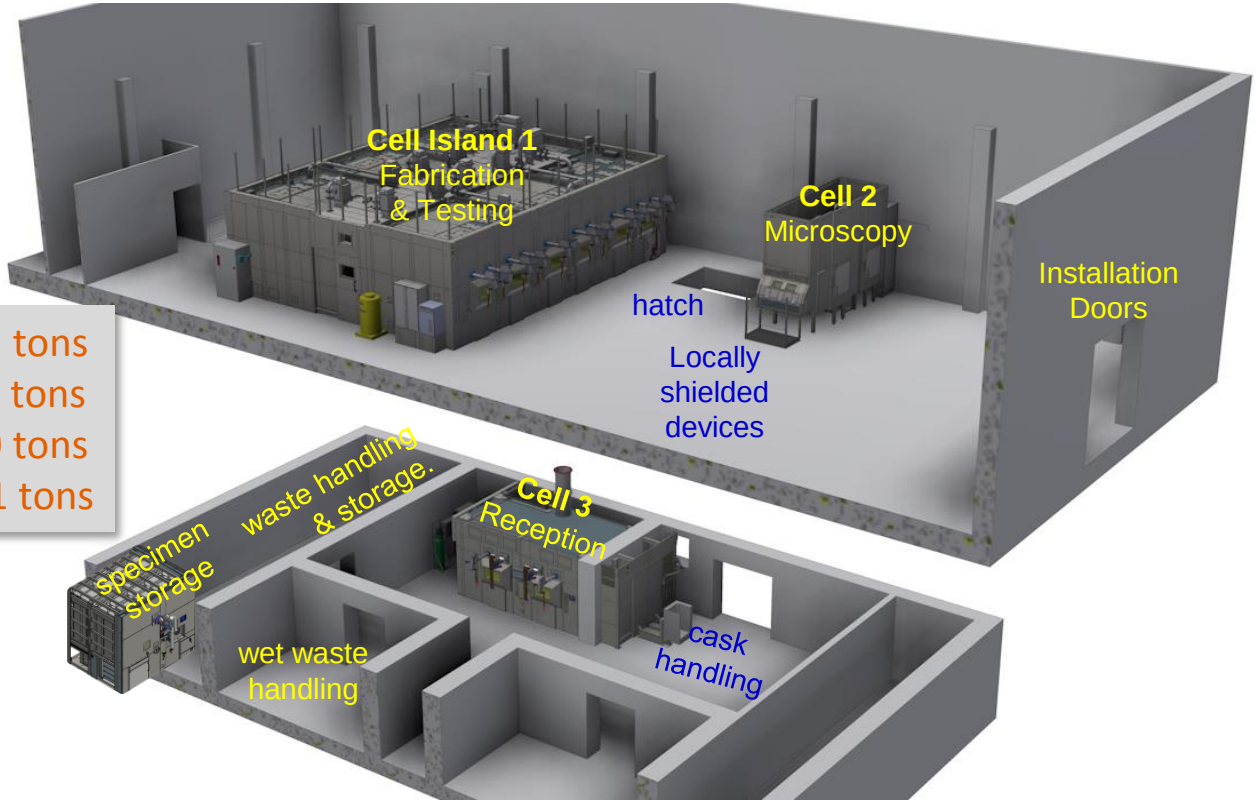
Radiological laboratory hot cell area

Hot Cell group 1: ~662 tons
Hot Cell group 2: ~42 tons
Hot Cell group 3: ~160 tons
Specimen storage: ~51 tons



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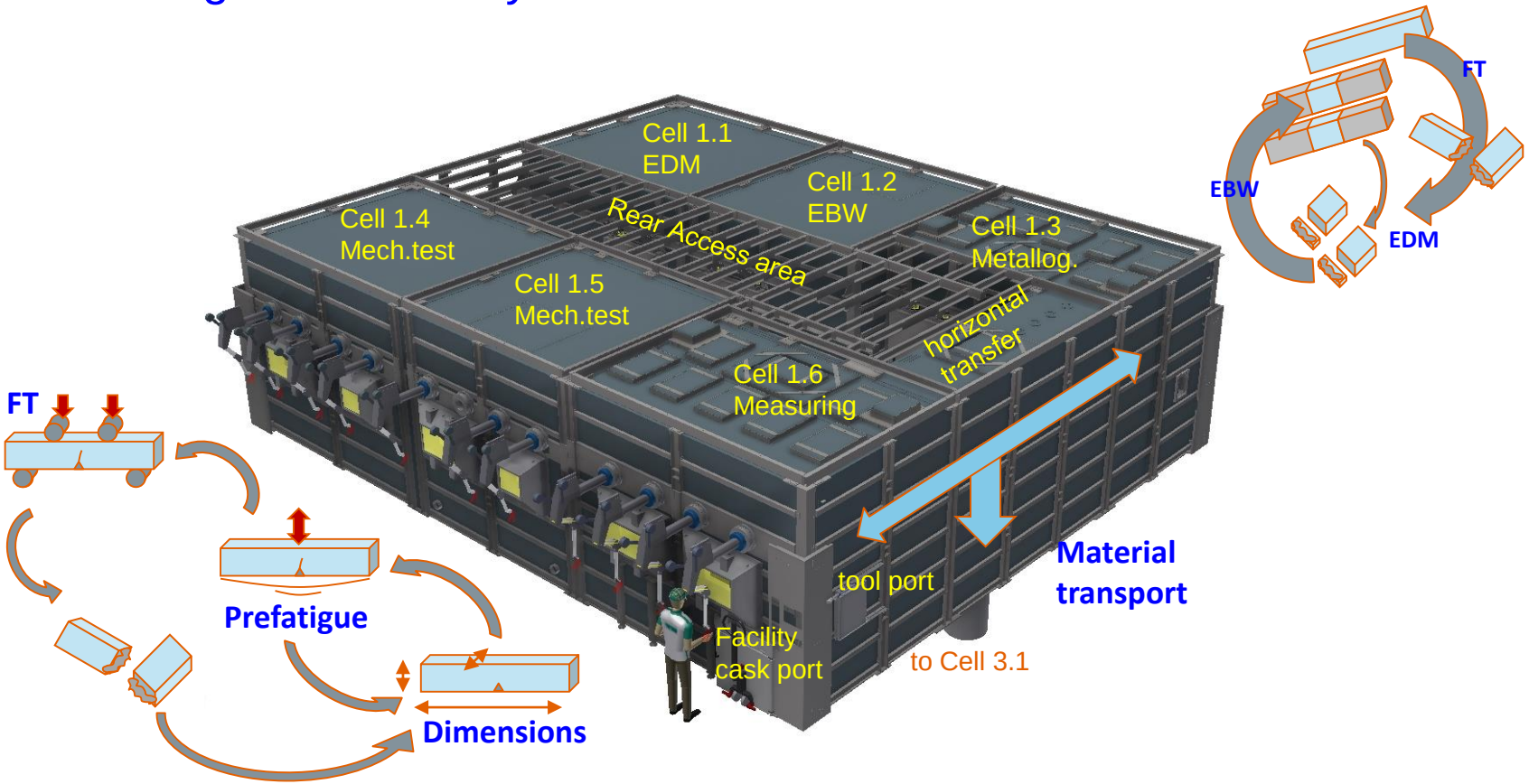
Radiological laboratory hot cell area



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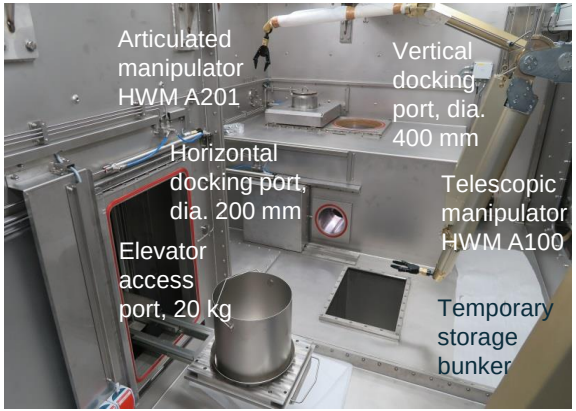
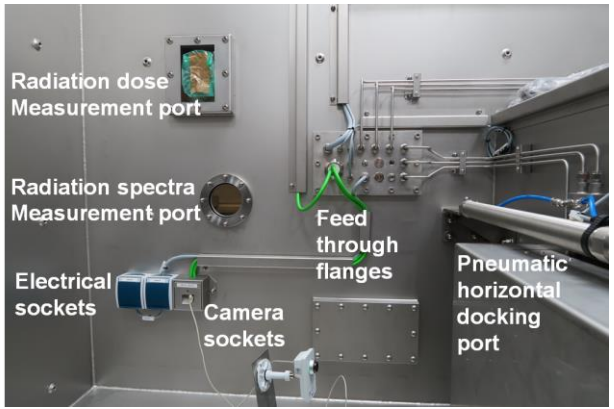
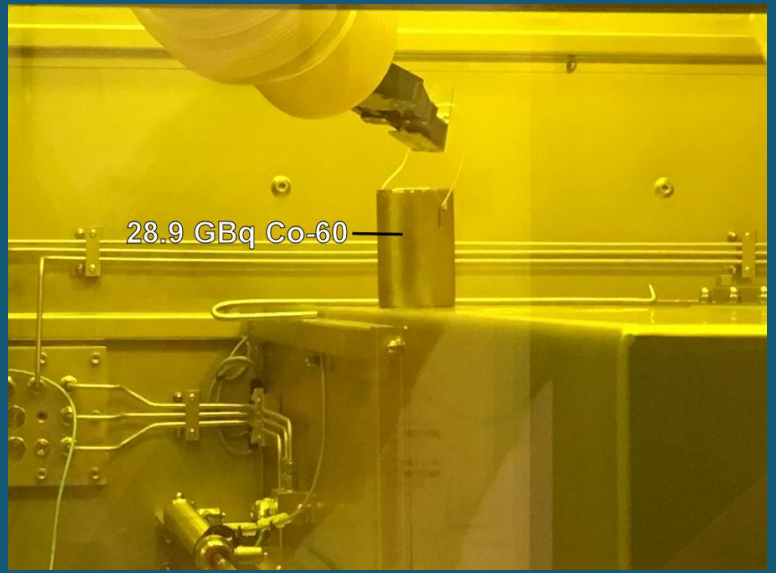
Radiological laboratory hot cell area



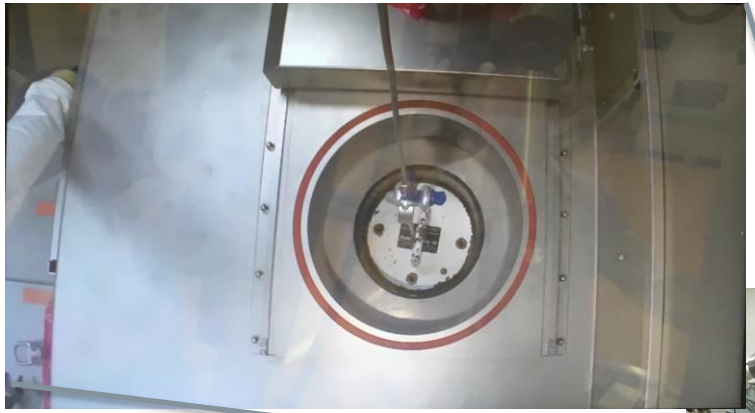


Logistics for hot material transport and storage



Transport reception cell

For unloading horizontal and vertical casks



Task	Purpose
Safely dock casks of various size, horizontally (Ø 200mm port) or vertically (Ø 400mm port).	Enable reception of diverse research materials from various different partners.

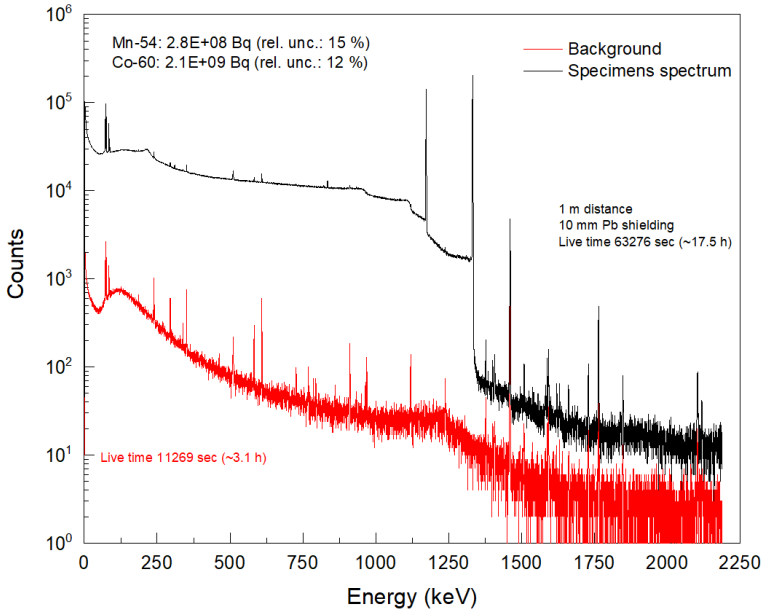
Reception cell in-cell gamma spectrometry

For confirmation or determination of source term

- First hot transport was unloaded into reception cell in mid-2018.
- Since then several transports have been received in the CNS.
- Deployment of in-cell gamma spectrometry has been tested.

Main activities, pr.1/1-2019

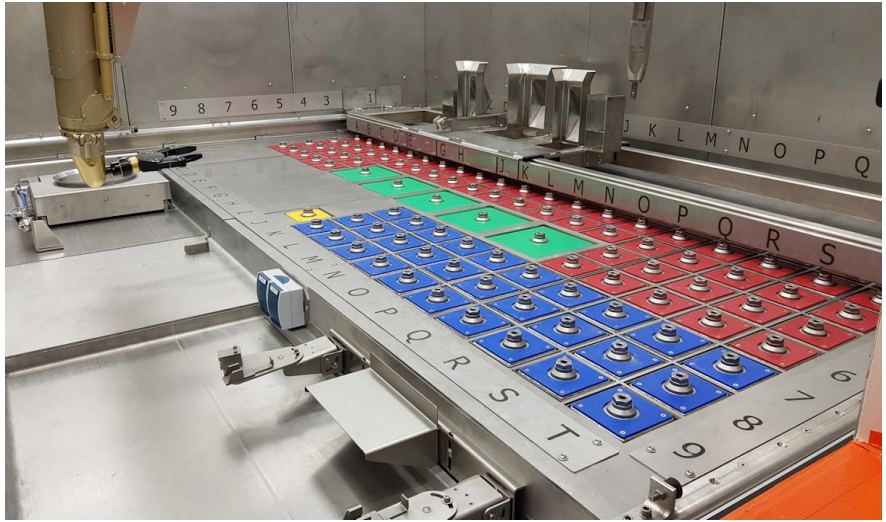
Nuclide	Activity[Bq]	A2[Bq]	Fraction of A2
Co-58	5.3E+07	1.0E+12	5.3E-05
Co-60	8.5E+09	4.0E+11	2.1E-02
Cr-51	1.4E+07	3.0E+13	4.6E-07
Fe-55	9.0E+09	4.0E+13	2.3E-04
Fe-59	4.8E+06	9.0E+11	5.3E-06
Mn-54	1.9E+08	1.0E+12	1.9E-04
Nb-93m	5.1E+06	3.0E+13	1.7E-07
Ni-59	6.7E+05	unlimited	
Ni-63	6.2E+08	3.0E+13	2.1E-05
Total [Bq]=	**1.8E+10**	**Tot. A2=**	**2.2E-02**



Employment of specimen storage cell

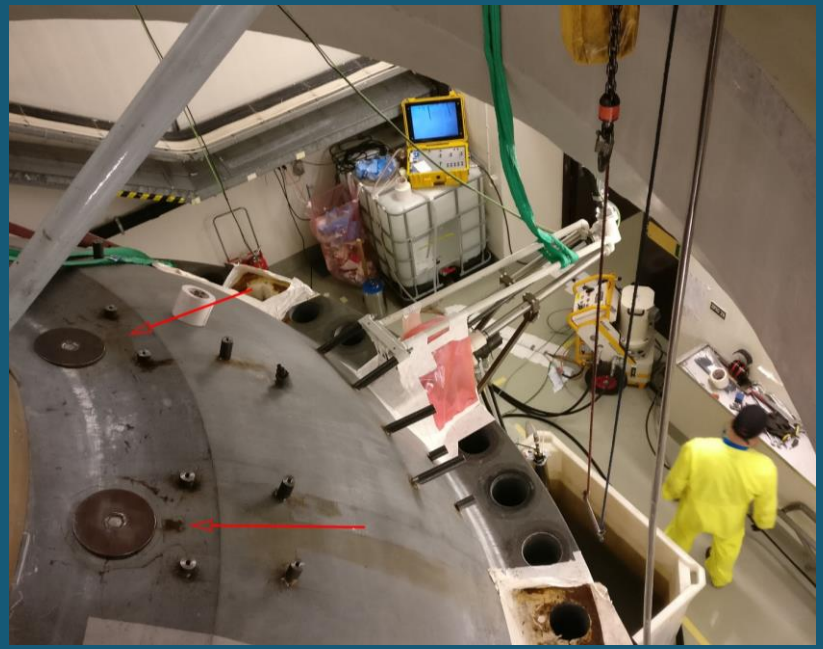
For safe and orderly interim storage of hot test materials

- Indexed locations; documentation recorded in electronic database.
- Storage cell commissioned in mid-2019.
- Already contains newest research materials.
- Archive RPV materials from old facilities now being transferred.



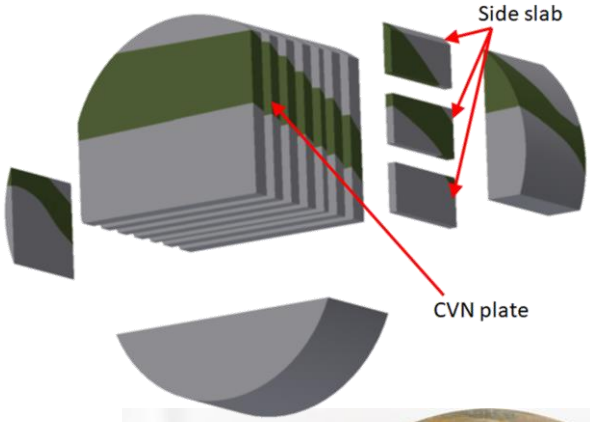
RPV trepan study

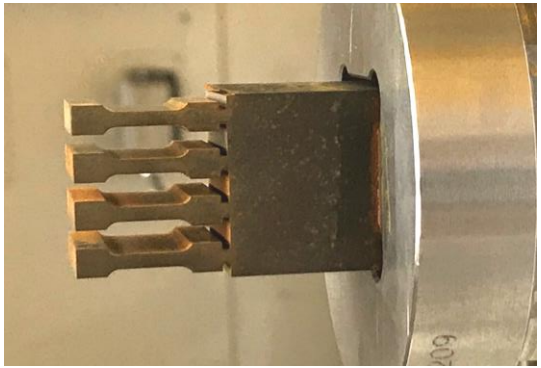
SAFIR 2022 BRUTE and BREDA Barsebäck R&D arena



Employment of in-cell EDM

For slicing trepan, for specimen fabrication

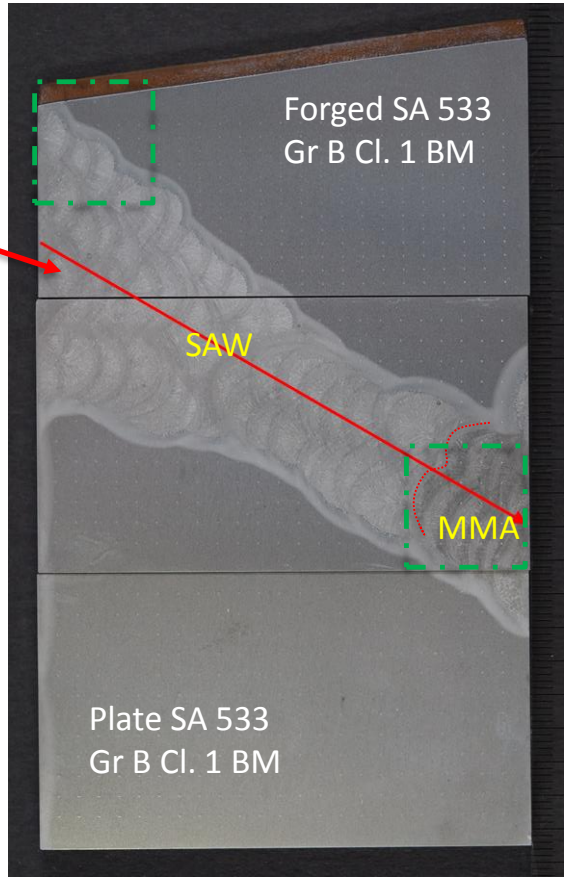


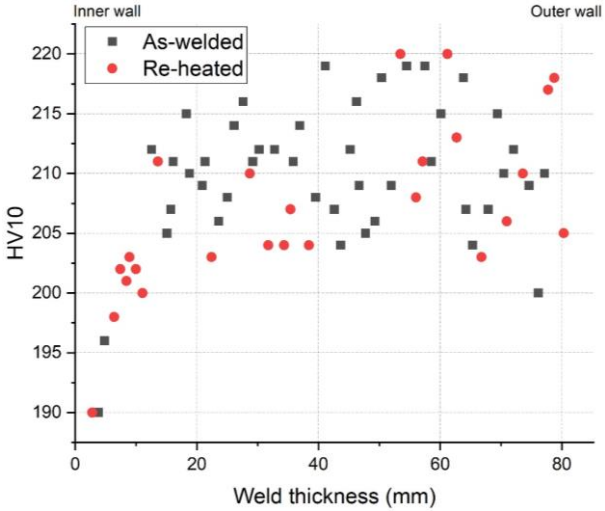


Microhardness testing of macro-section

To correlate local hardness and microstructure variation.

Temperature gradient due to stainless steel cladding

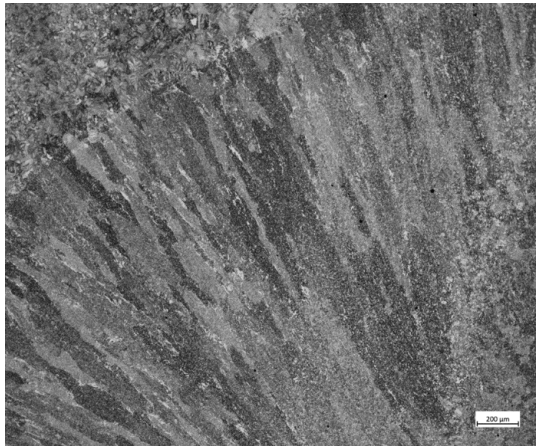


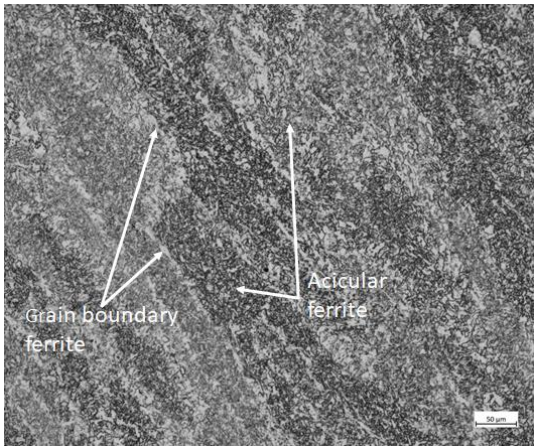


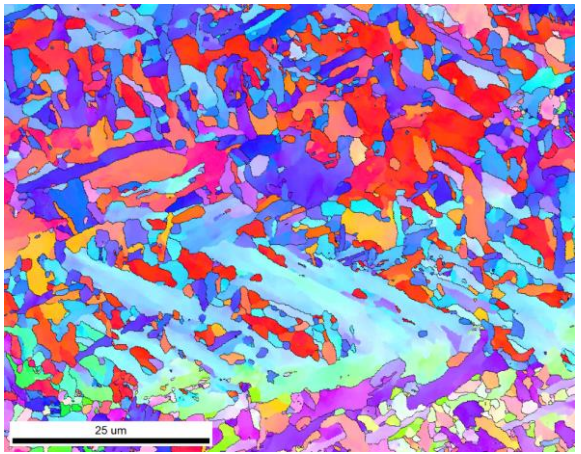
- Average hardness of both as-welded and re-heated 210 HV10
- Range < 20 HV units
- Values typical for SAW welds in LAS

Metallography of cross sections

To identify microstructural features.



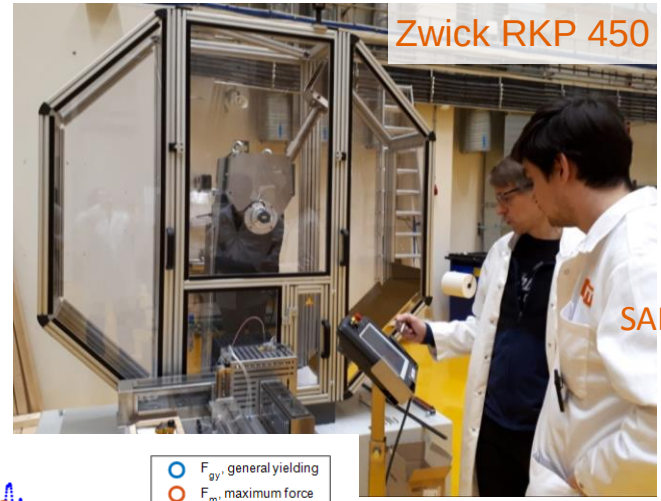




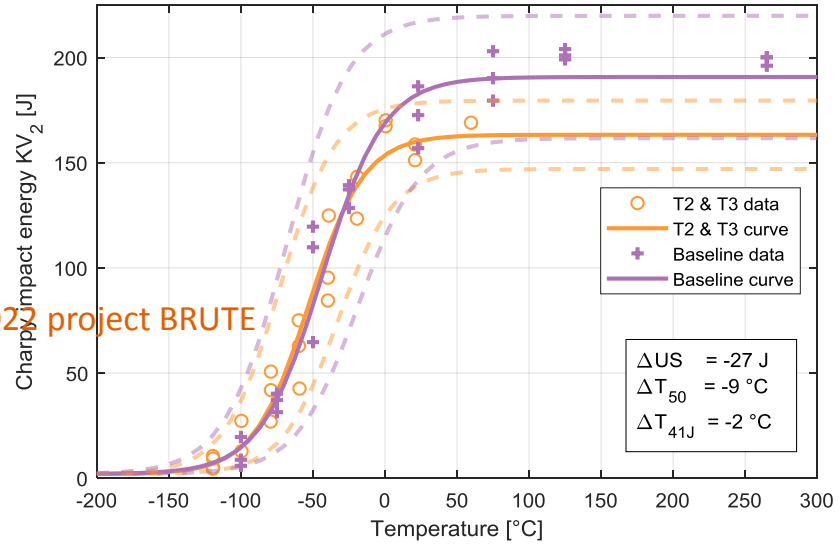
- The microstructure of both weld types is typical for high quality weld
- Different phases can be distinguished using EBSD

Mechanical testing with instrumented impact

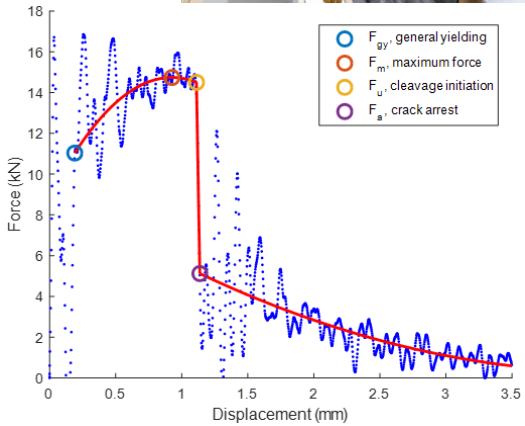
To evaluate toughness over temperature, to determine DBTT.



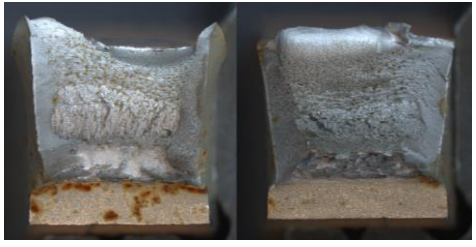
SAFIR 2022 project BRUTE



Transition curve determined for W28 weld metal

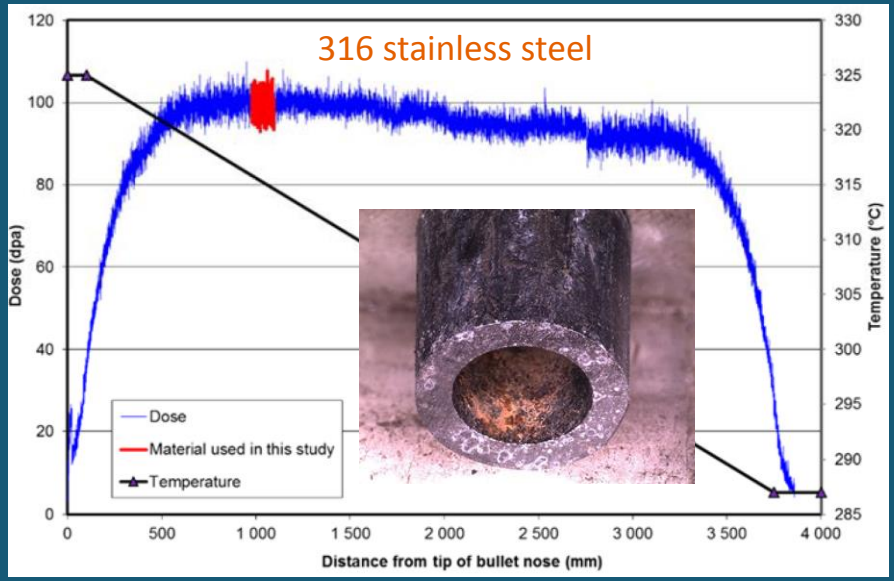


Lateral expansion and shear fracture appearance correlated directly with impact energy, with a very good fit



Autoclave testing of high dpa FTT

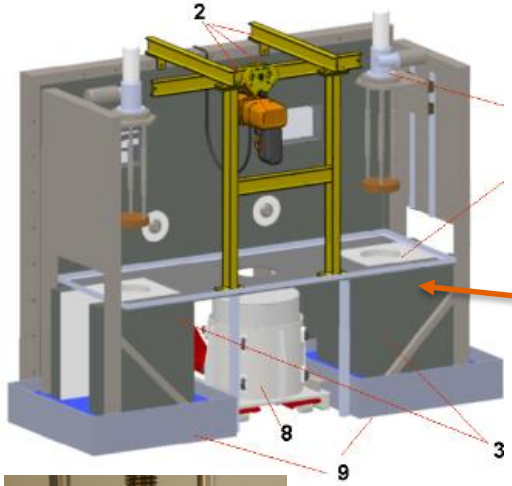
EU SOTERIA and Vattenfall AB

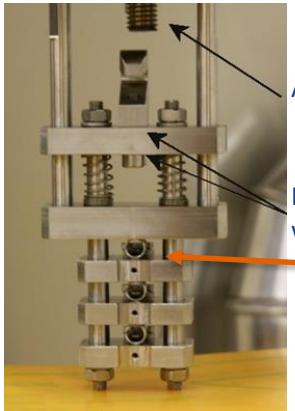


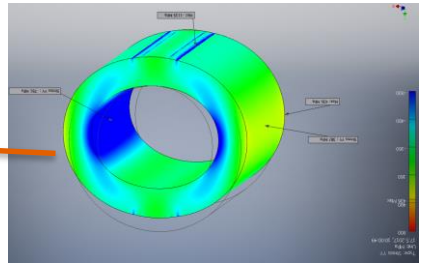
FTT	Dose, dpa	Length, mm	Co-60, GBq	Specific Co-60, GBq/g	@ 10 cm, mSv/hr
FTT-1	65	10	0,6	0,3	14
FTT-2	100	10	3,4	1,7	77

Locally shielded autoclave with recirculating water loop

Primary circuit simulation for corrosion and stress corrosion cracking

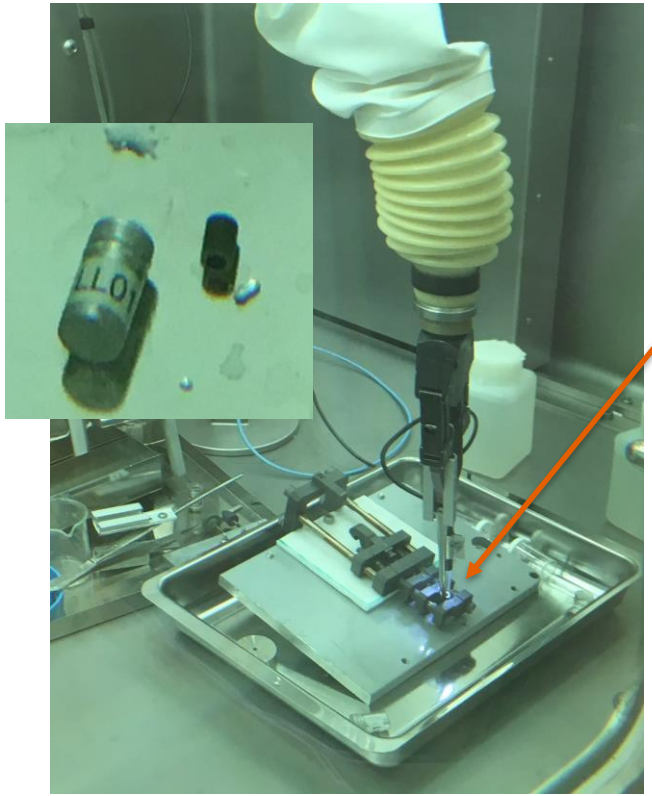


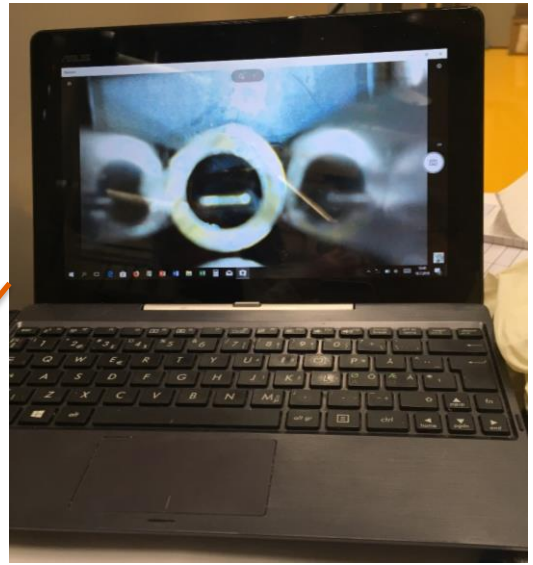




In-cell o-ring specimen loading

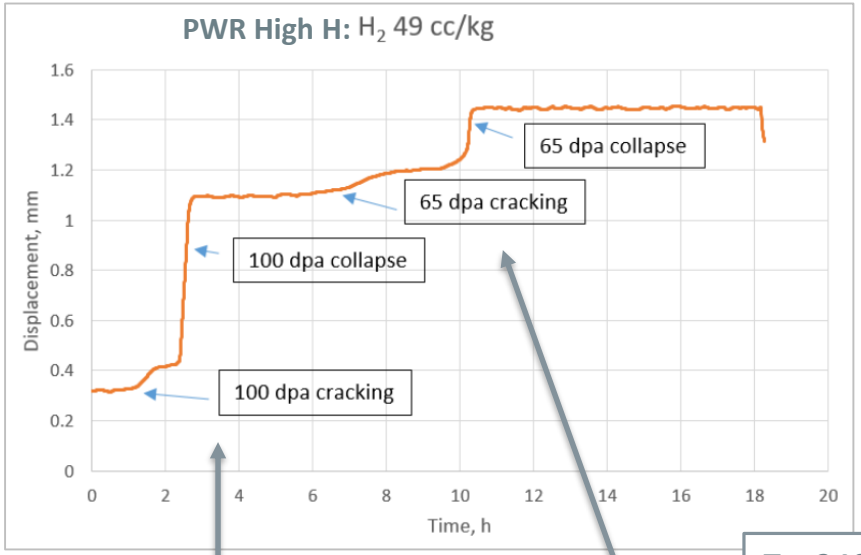
Primary circuit simulation for corrosion and stress corrosion cracking

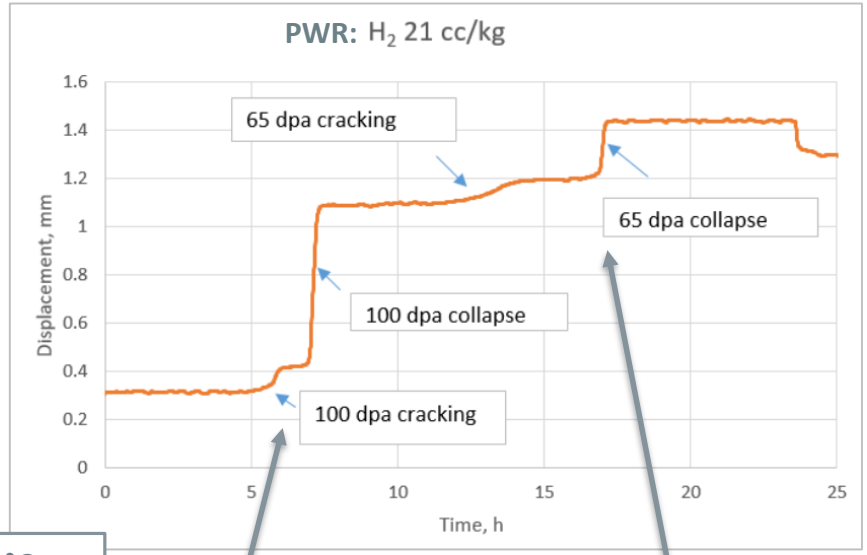


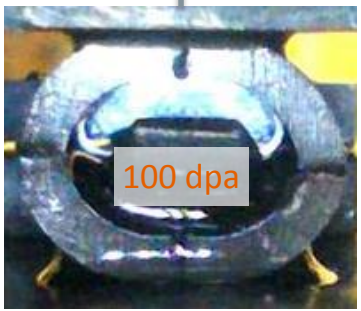


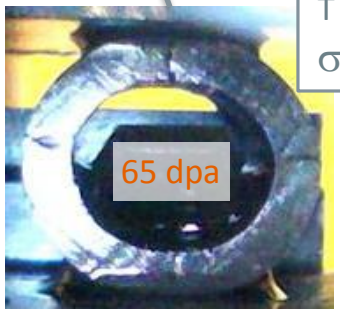
Locally shielded autoclave with recirculating water loop

Primary circuit simulation for corrosion and stress corrosion cracking



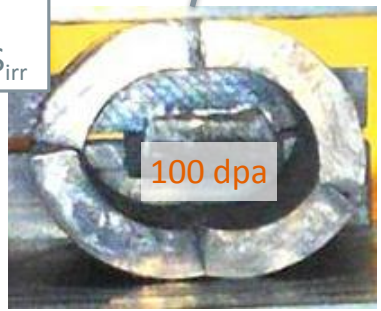






T = 340°C

σ = 75% YS_{irr}



Analytical TEM of high dpa FTT

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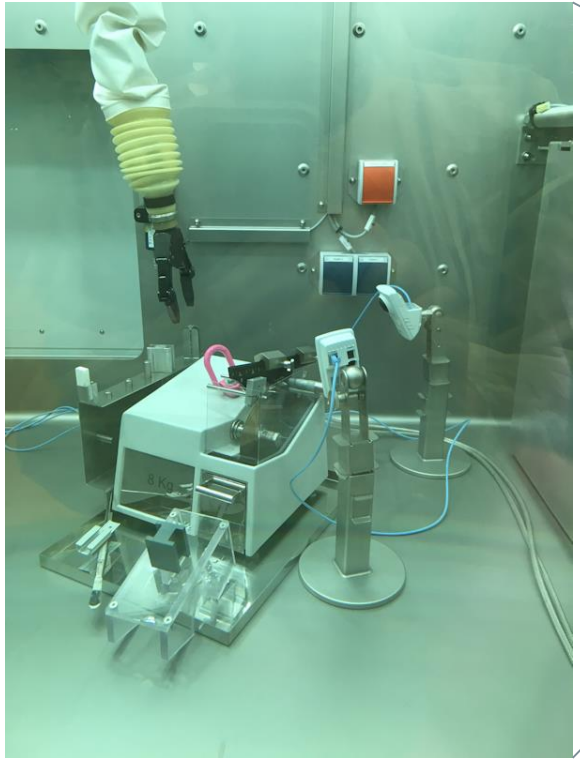
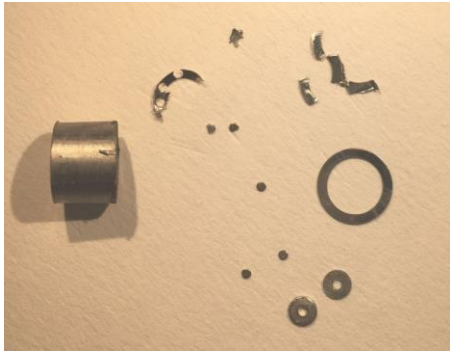
In-cell specimen preparation

For microstructural examinations

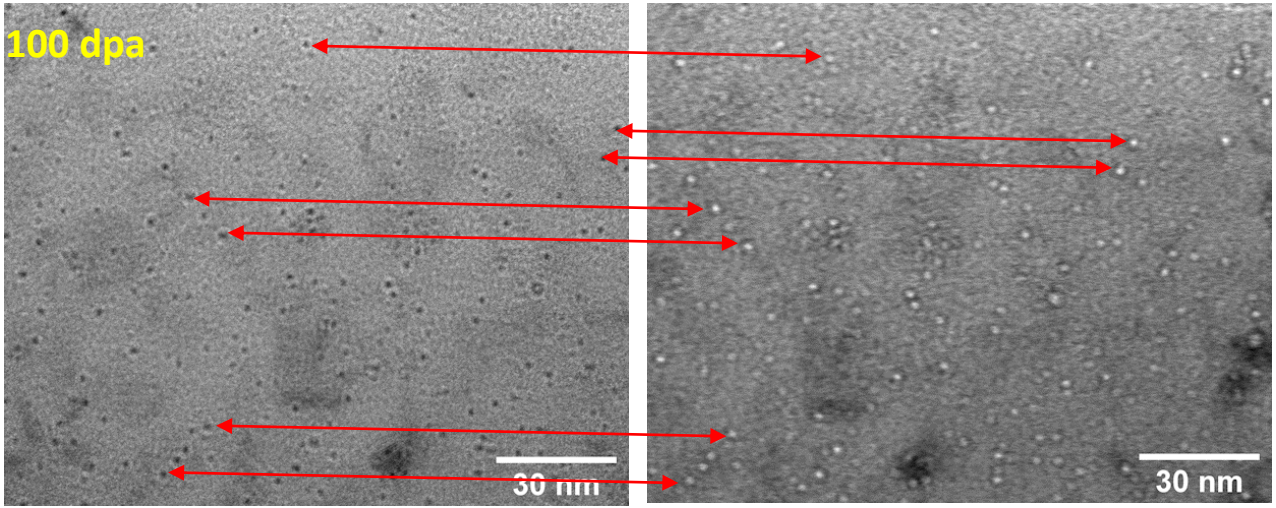




Analytical transmission electron microscopy

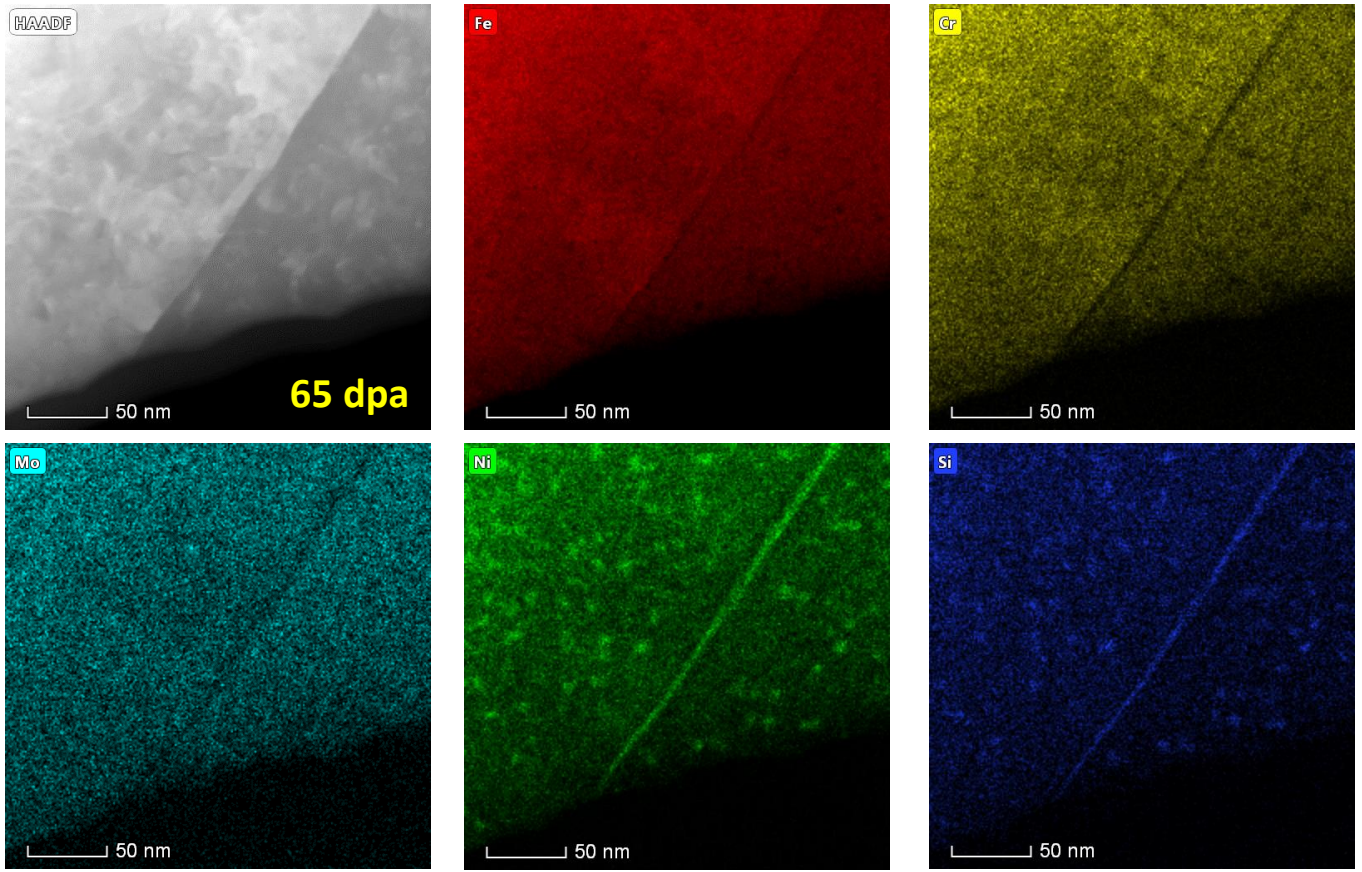
For irradiation-induced microstructure at nanoscale resolution

- Under- and over-focused images reveal population of cavities, on the order of about 1-2 nm diameter.



Analytical transmission electron microscopy

For elemental distribution down to nanoscale resolution



Summary

- The new hot cells installed in VTT's new Centre for Nuclear Safety radiological research and testing facility are being taken into use.
- RPV trepans are being cut into specimens for mechanical testing and microstructural characterization by in-cell EDM.
- RPV materials are being mechanically tested with in-cell and locally-shielded devices.
- The microhardness profiles and microstructures of RPV macro sections are being characterized.
- Highly irradiated stainless steel flux thimble tube materials are being tested in simulated PWR conditions with shielded autoclaves.
- Specimens have been prepared from highly irradiated stainless steel FTT materials and examined by analytical electron microscopy to nanometer scale.

Put the new hot cells to work for **your** materials characterization needs as well!

Acknowledgements

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  - Finnish Nuclear Waste Management Fund, VYR
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Thank you for your attention!