Materials Research for LTO

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SNETP Forum 2021, February 2-4, 2021, TS1

European Commission

Nuclear: Energy and Technologies

- Fruitful on-line meeting between Commissioner Mariya Gabriel (Innovation, Research, Culture, Education and Youth) with SNETP and FORATOM
- Nuclear Energy a role to play to achieve de-carbonisation target in Europe

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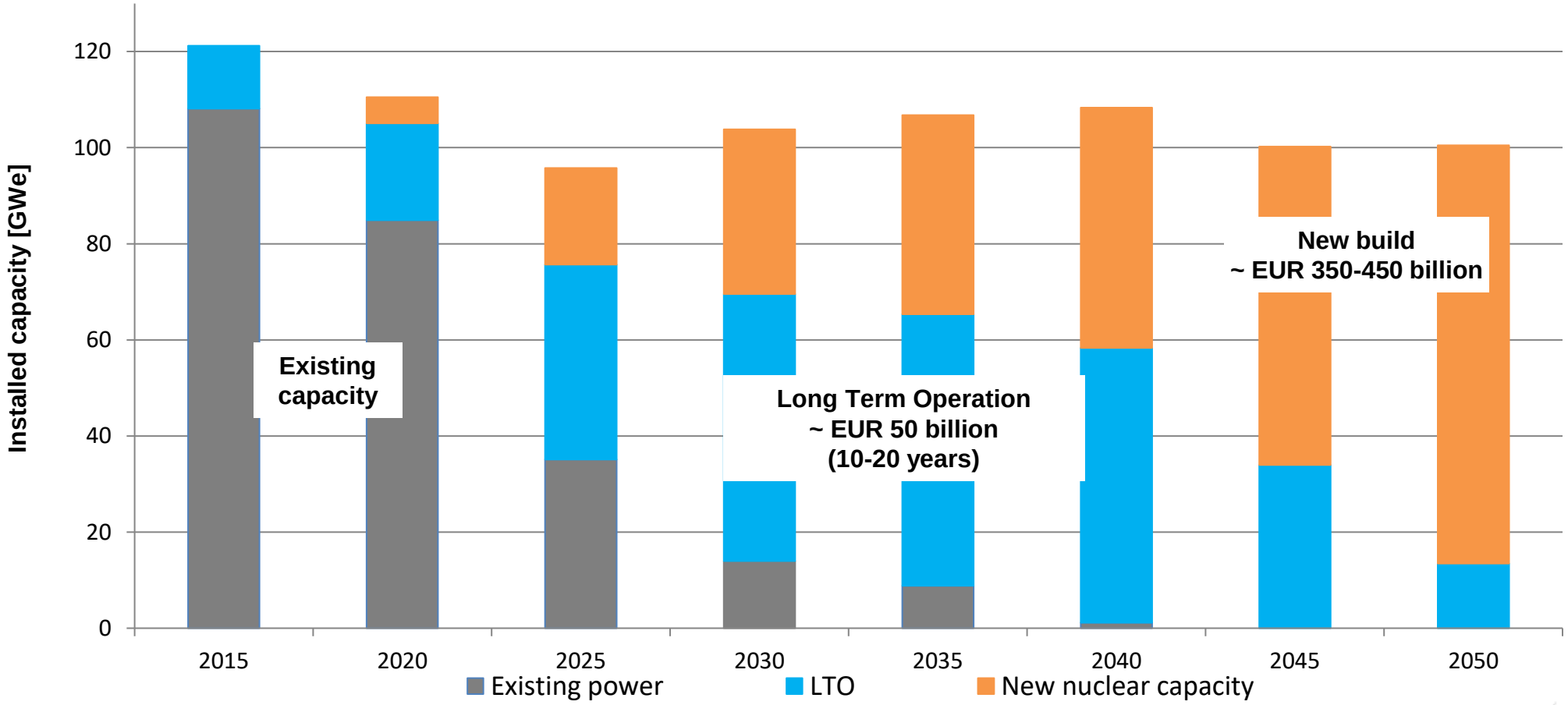
Expected nuclear capacity towards 2050 [GWe]

Nuclear generation electric capacity at EU level is predicted to decline up to 2025, and then increase to about 100 GWe by 2050 as a consequence of new build and LTO



Source: Nuclear Illustrative Programme, Communication from the European Commission, COM(2017) 237 final of 12 May 2017 [https://ec.europa.eu/energy/sites/ener/files/documents/nuclear_illustrative_programme_pinc_-_may_2017_en.pdf]

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Synopsis

- Activities on LTO at JRC
- From macro to micro testing
- A proposal for RadLab at JRC
- Conclusions

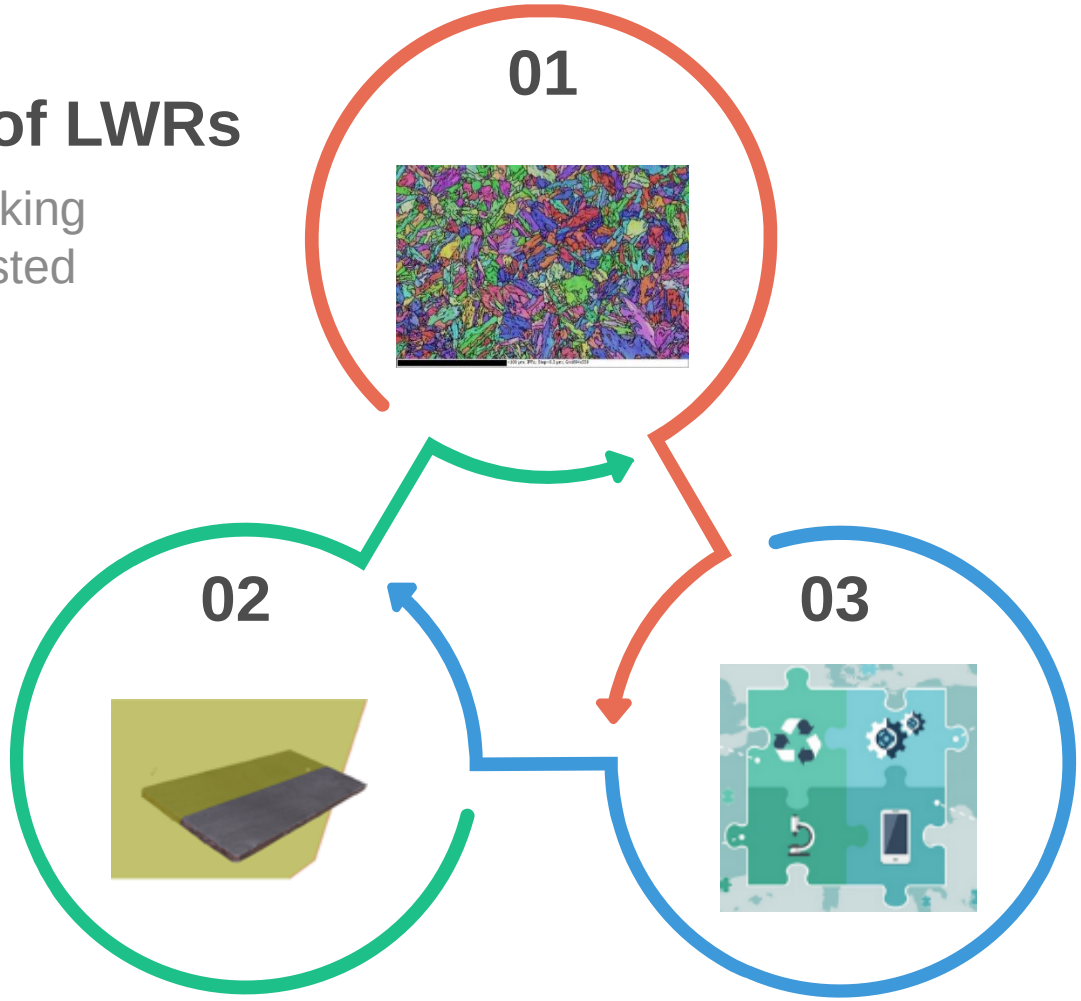
JRC activities on LTO

01. Aging of LWRs

- Stress Corrosion Cracking
- Environmanetal Assissted Fatigue
- RPV Embrittlement

02. LWR innovations

- Additive Manfacturing
- Sub-sized speciments / miniature testing methods.



03. Harmonisation and Standardisation

- Nuclear codes and standards
- Nuclear Supply Chain
- European Network for Inspection and Qualification
- Aging Management Programmes (e.g. IAEA IGALL)

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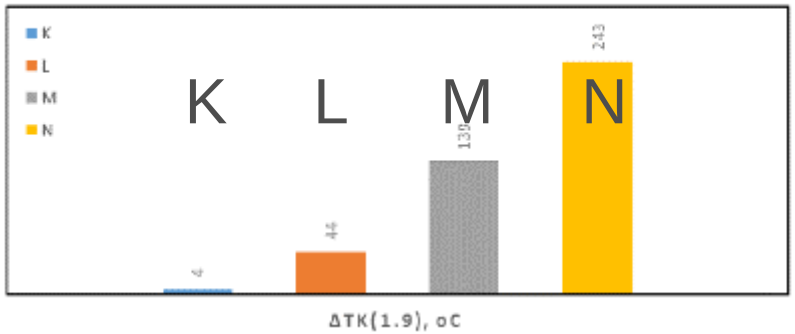
R&D to study RPV Embrittlement: an example from the STRUMAT-LTO project

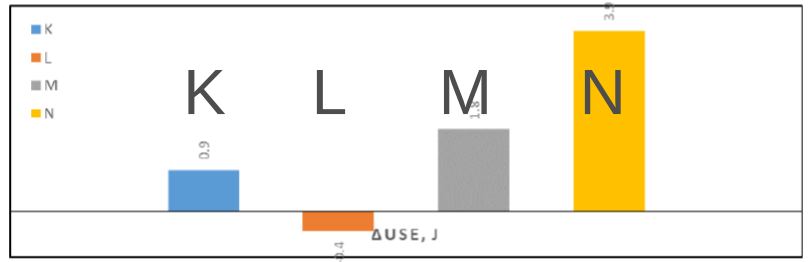
- Charpy impact tests on unirradiated (JRC) and irradiated (NRG) KLST specimens of 4 model steels based on PWR RPV steels
- LYRA-10 irradiation campaign

[m%]	K (blu)	L (orange)	M (grey)	N (yellow)
Mn	0.78	0.77	0.74	1.27
Ni	0.58	0.96	1.90	1.97

Δ DBTT Shift



Δ Upper Shelf Energy



Alloy N shows largest DBTT shift & drop in Upper Shelf Energy confirming deleterious role of Mn in high Ni RPV steels at high fluences (1-1.2E+24 n/m2).

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Need for Sub-Sized Specimen / Miniature Testing: RPV Surveillance Programmes

RPV surveillance programmes (number of specimens) designed to cover original reactor design life → With LTO possible shortage of specimens → “Re-use” of specimens needed !

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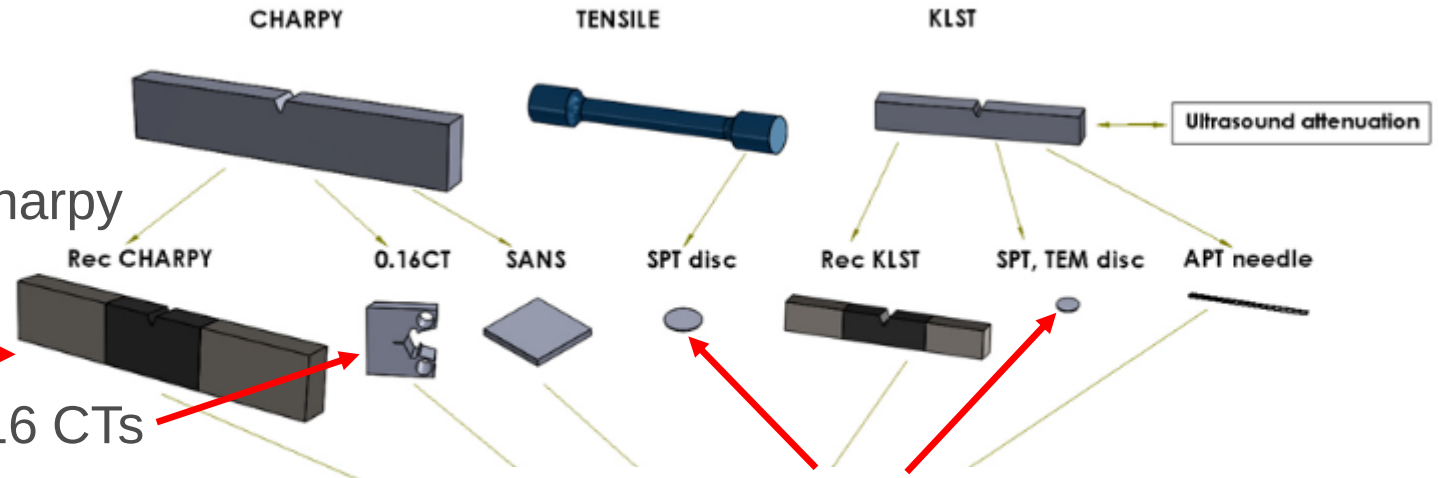
Re-use of tested Charpy specimens via

- reconstitution
- machining to 0.16 CTs



Small punch test (SPT) useful alternative / complementary method

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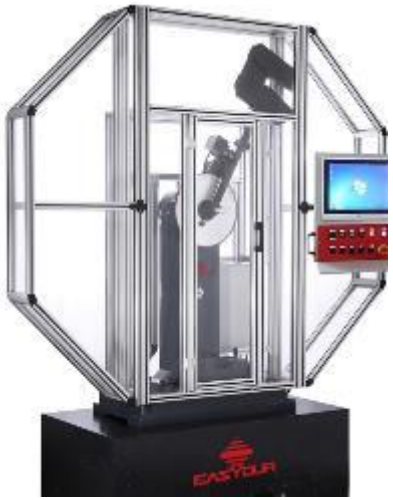
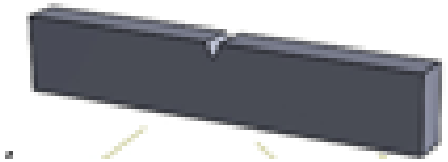
From macro to subsize: testing methods, specimens and data evaluation

Charpy Hammer (300 J)



Charpy



Charpy Hammer (50 J)

KLST (mini-charpy)

Small Punch Test

Disc

Conversion of KLST to full size charpy data

DBTT/USE from SP data

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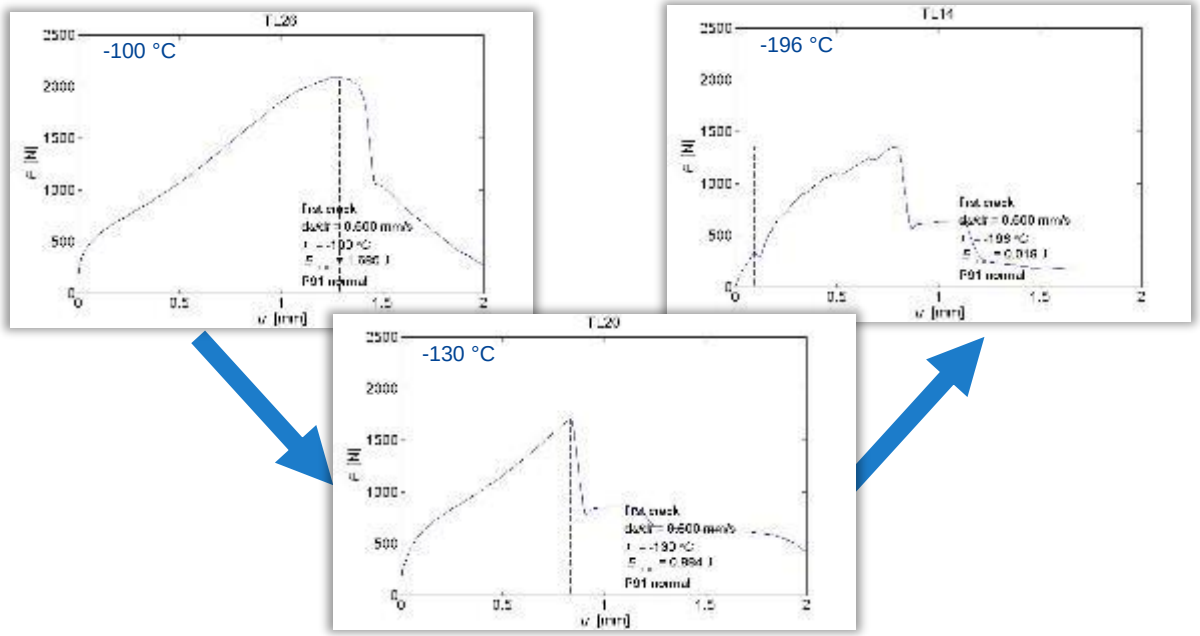
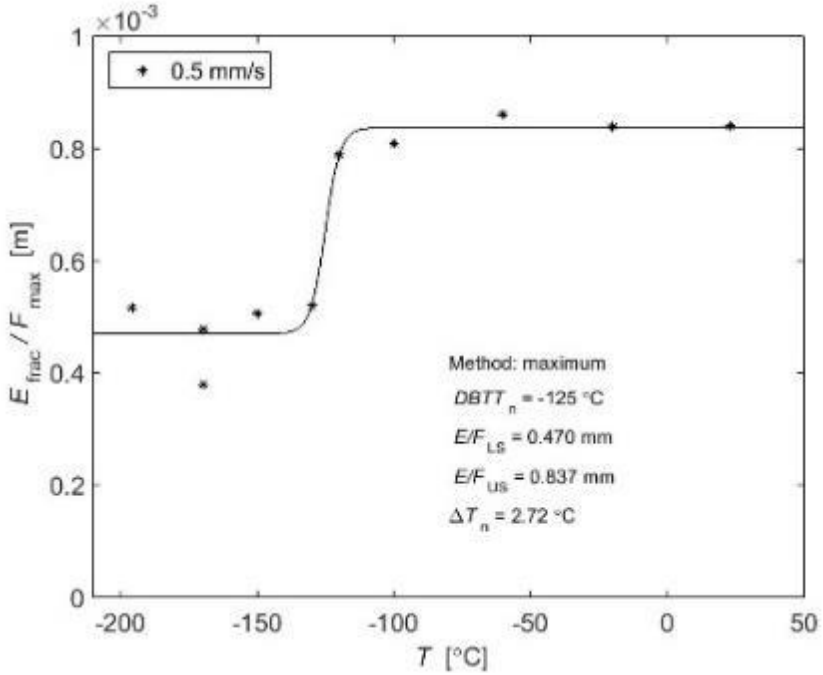
The DBTT/USE from SP data





Further field of development: Use of AI for SP data handling

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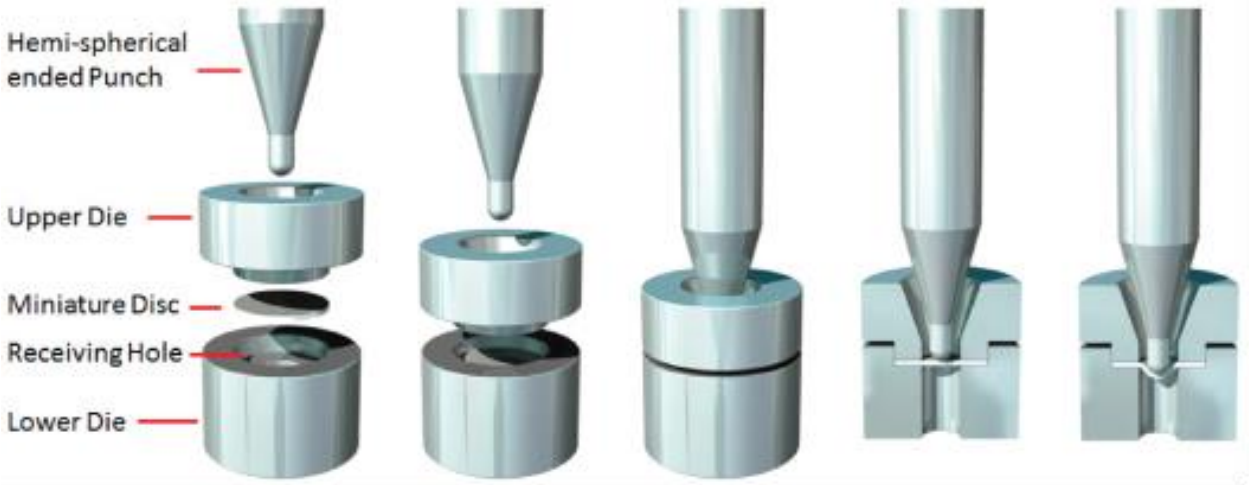
The last step: standardisation (Small Punch Test)

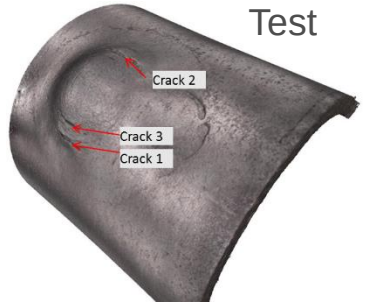
R&D, Method validation — 2005 -

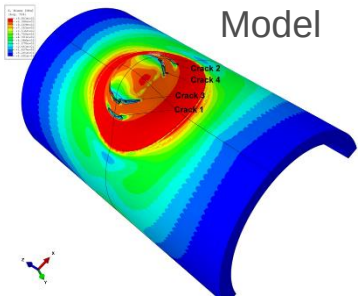
Code-of-Practice — 2007

Draft Standard — 2018

European Standard — 2020







SPT **a screening test for material properties** is now standardised test (ISO 10371) and allows in principle determination of tensile properties, DBTTs, FT properties and creep properties of any alloy.

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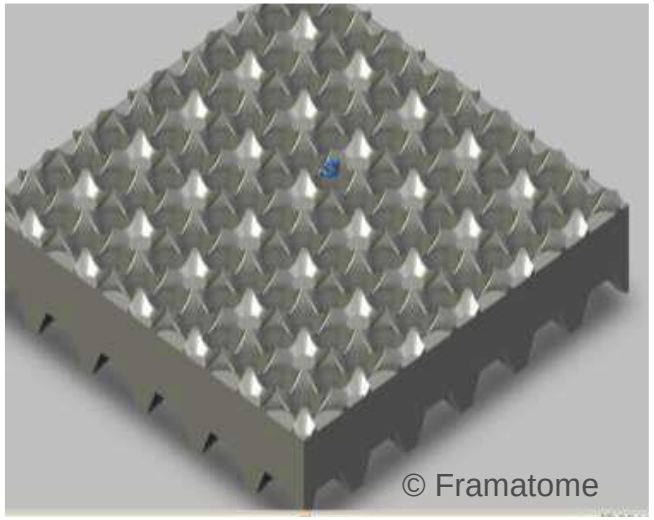
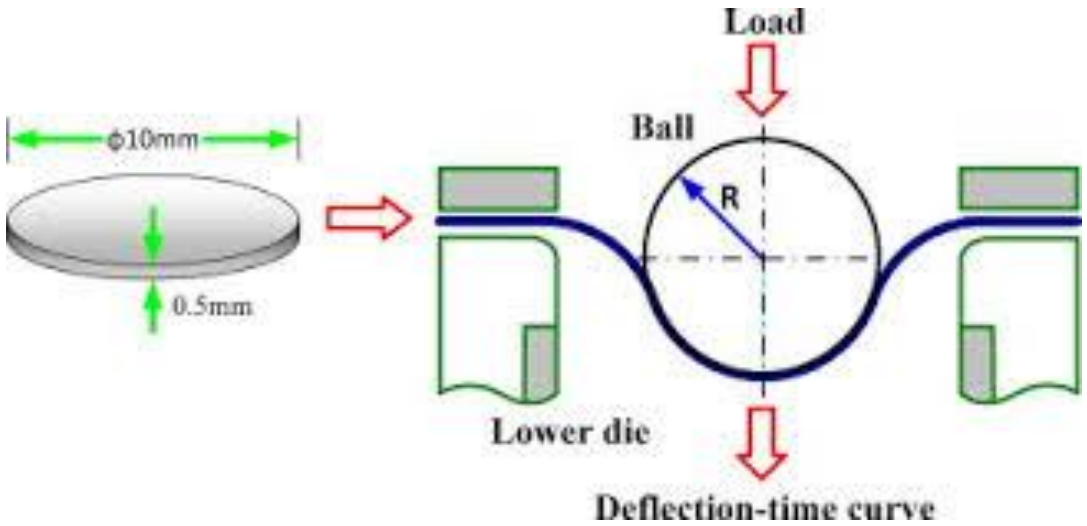
Screening of new manufacturing technologies with SPT

Development of a qualification methodology for additively manufactured (AM) components in nuclear facilities (NUCOBAM Project)



One of two components in scope: Debris filter

SPT on AM 316L planned to determine creep properties



SPT beneficial if amount of available test material limited.

SNETP Sustainable Nuclear Energy Technology Platform

NUGENIA Nuclear Generation II&III Alliance

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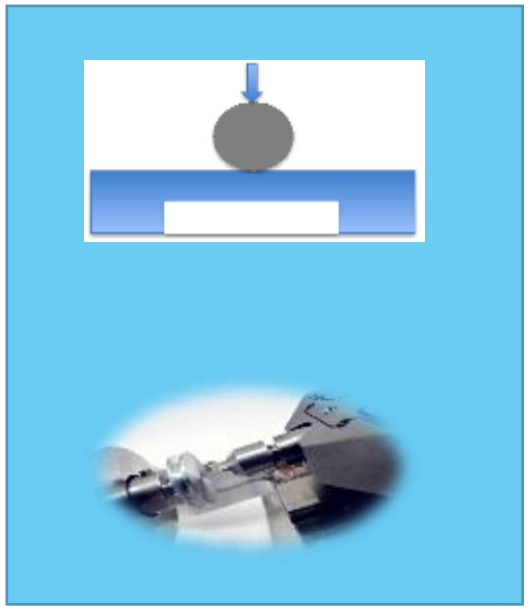
Further potential in „going smaller“

- Mini SPT

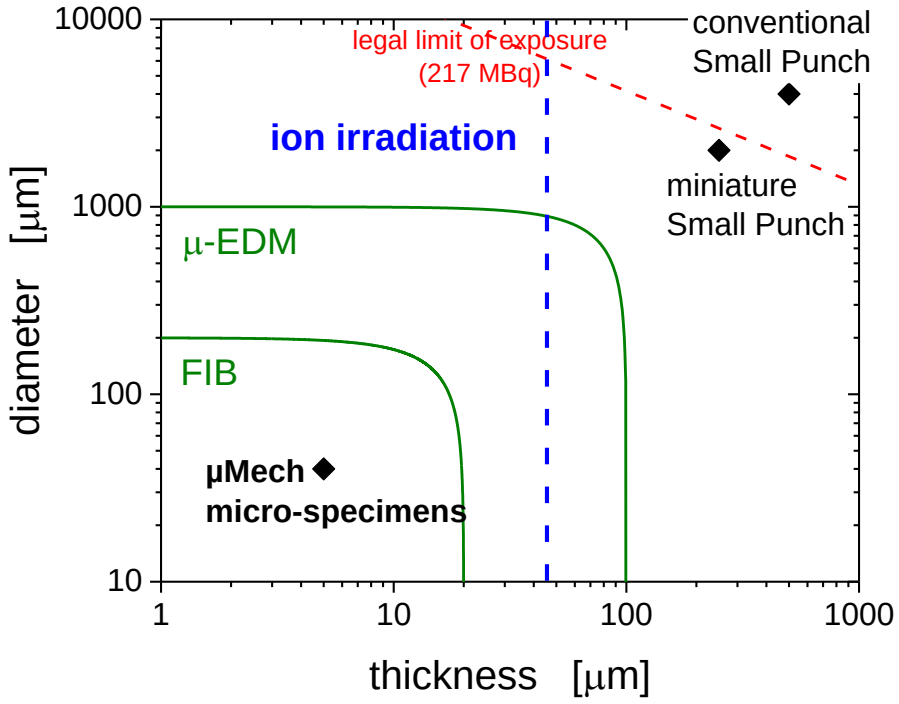
Mini SPT specimen
(⌀ = 3, t = 0.25)

- Micro SPT



Metallic membranes

- From macro to micro



The limit is the sky (the atom)

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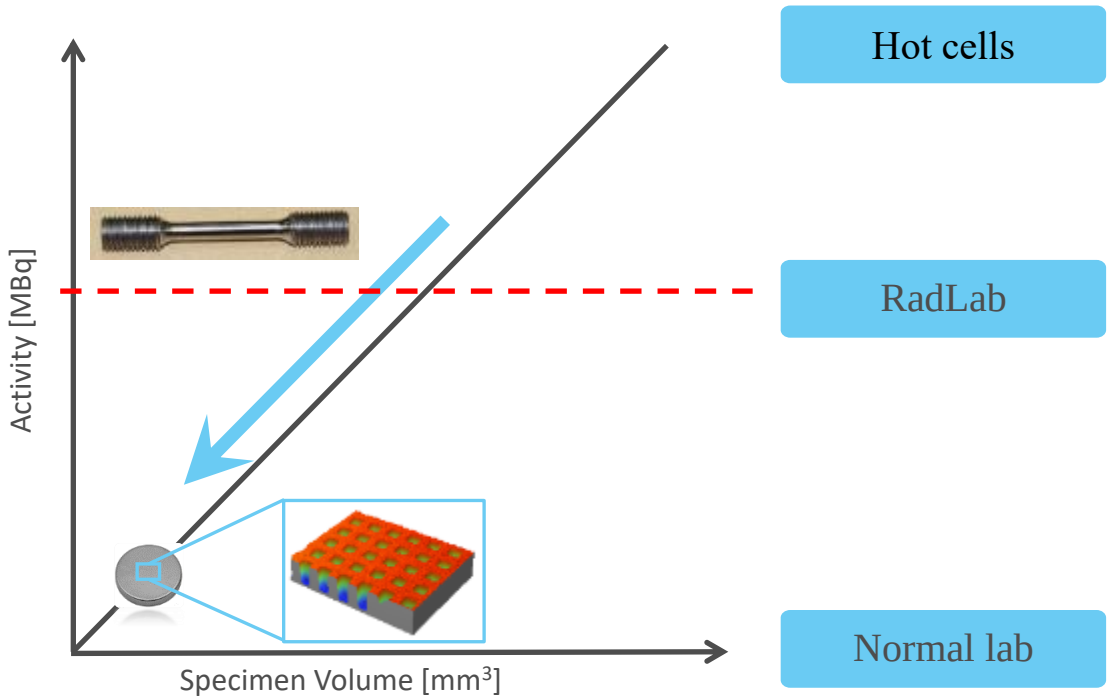
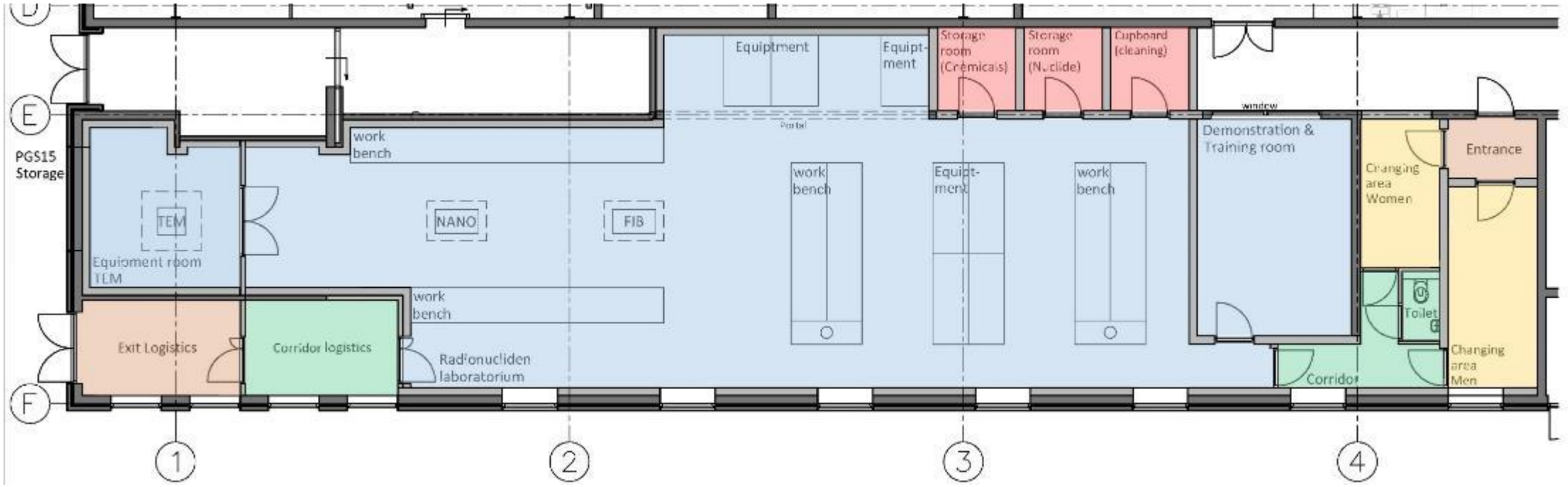
Testing of irradiated samples: the idea to have a dedicated infrastructure at JRC



MOTIVATIONS

- Investigate combined effects
- Validation of miniaturised testing methods on irradiated specimens.
- Extending Harmonisation and standardisation to irradiated materials
- Support design-by-analysis and accelerated testing
- Data for physical modelling at relevant scale.
- Include non-power applications
- Reduce, overall, nuclear waste
- ….

Radiological Laboratory in Petten: could become an important “open access” infrastructure for EU



- Nuclear Safety Applications
- Micro-characterization and Nuclear Science Applications
- Demonstration for safety culture and hands-on training

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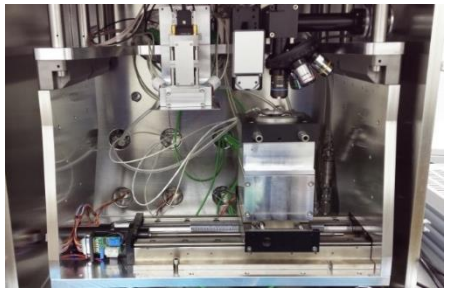
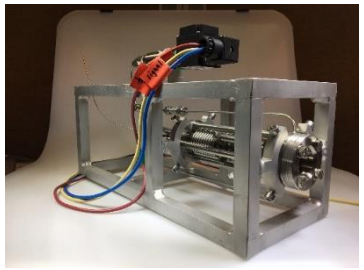
Potential equipments for the RadLab



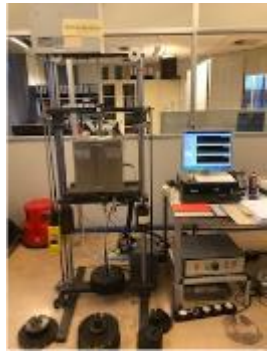
High T Nano-indentation



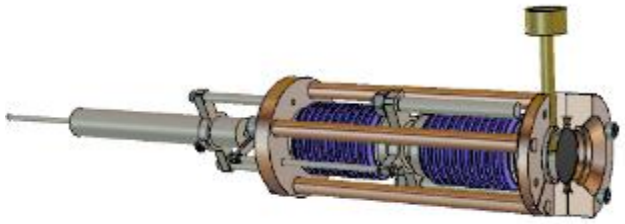
Design and construction of MTR test rigs

Nano-particles generator

plasma FIB-SEM

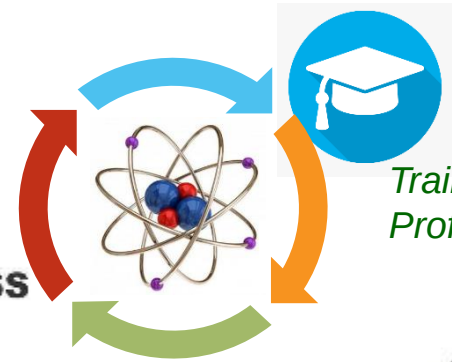


Small Punch Test



Membrane bulge testing

OPEN ACCESS



Training and Professional development

TEM

Micro-pillar compression

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Conclusions

- Nuclear energy to play a role in achieving EU de-carbonisation target
- LTO is an important part of short- medium-term nuclear energy strategy
- Materials testing from macro to micro will be more and more important for LTO, screening of new materials, delivering data for model validation etc.
- Miniaturised testing need harmonisation and standardisation on non-irradiated and irradiated materials
- JRC contributes to assessment of non-irradiated materials at macro- and micro-mechanical scale and could contribute on irradiated materials with the RadLab
- RadLab: 

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Thank you

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