SOTERIA FINAL WORKSHOP

WRAP-UP

27TH JUNE 2019

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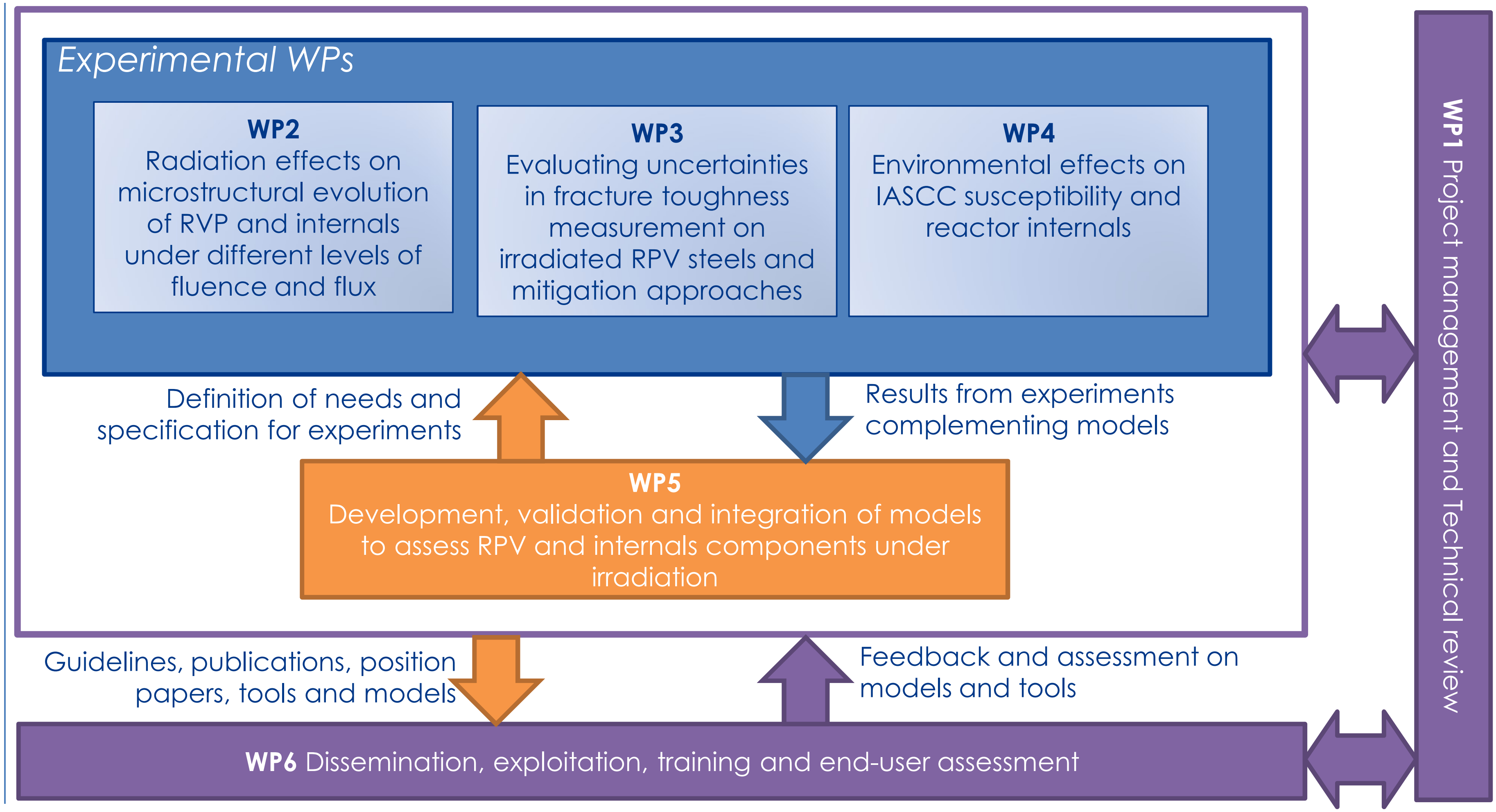
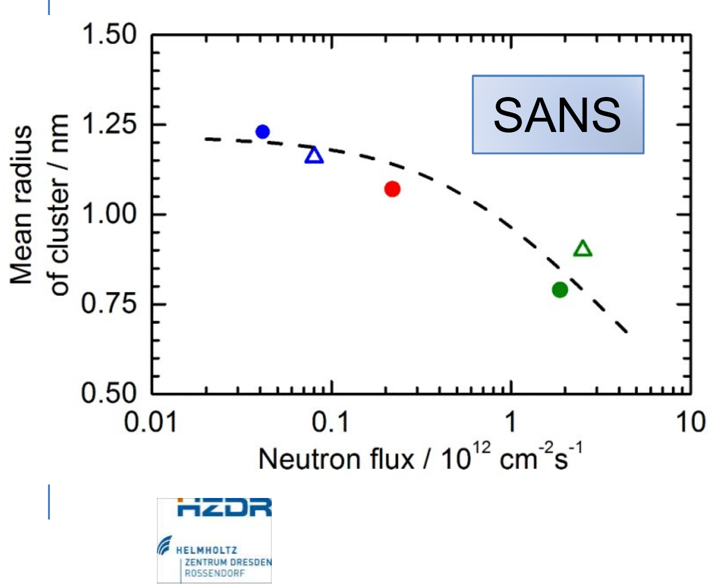
SOTERIA Work Packages

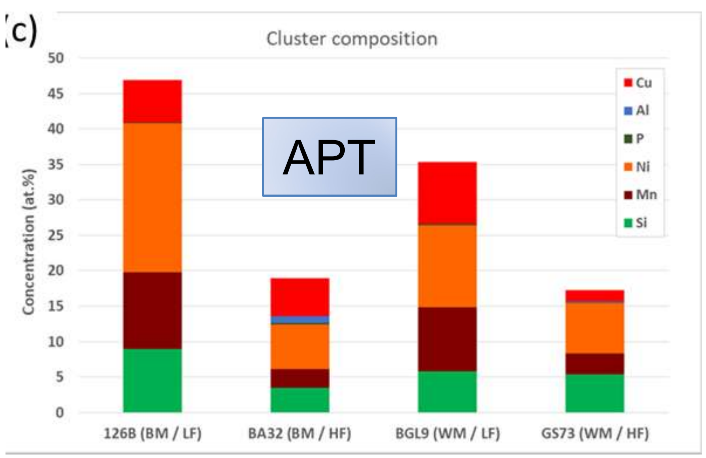


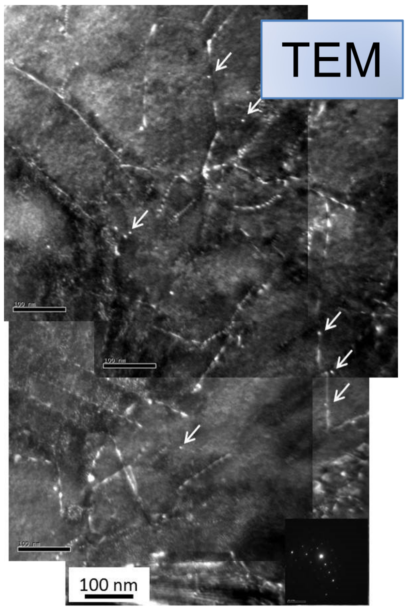
WP2 – Highlights

- T2.1: Flux effects on RPV and internals
  - T2.1.1: Flux effects on RPV materials,
    - **Base mat ANP-3 and ANP-10** Fluence: about $3x10^{19}$ cm^{-2}
      Flux: 0.04 and $1.88x10^{12}$ $cm^{-2}s^{-1}$
    - **Welds ANP-6 and VFAB-1** Fluence: about $5.7x10^{19}$ cm^{-2}
      Flux: 0.08 and $2.51x10^{12}$ $cm^{-2}s^{-1}$

Deliverabe 2.1







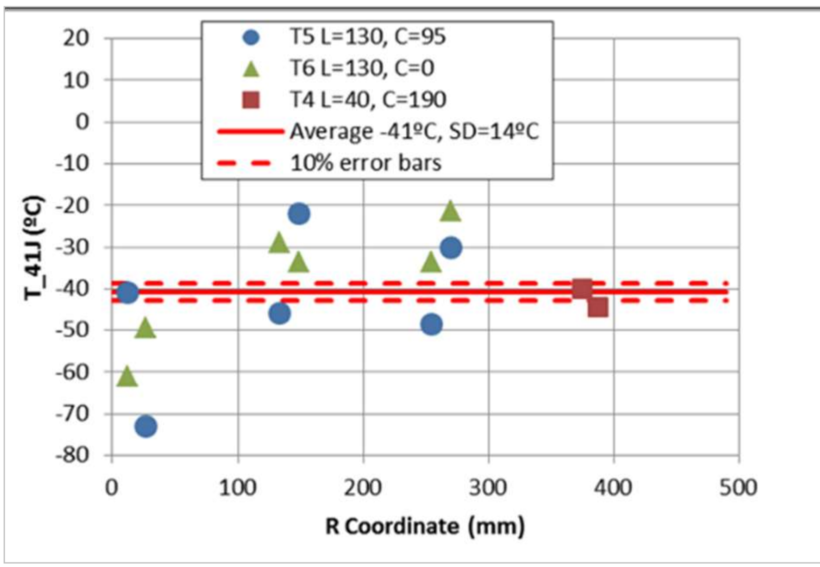
WP2: further highlights

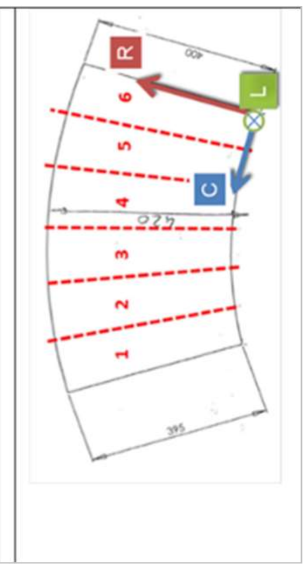
Effect of neutron flux on the radiation-induced damage of RPV materials

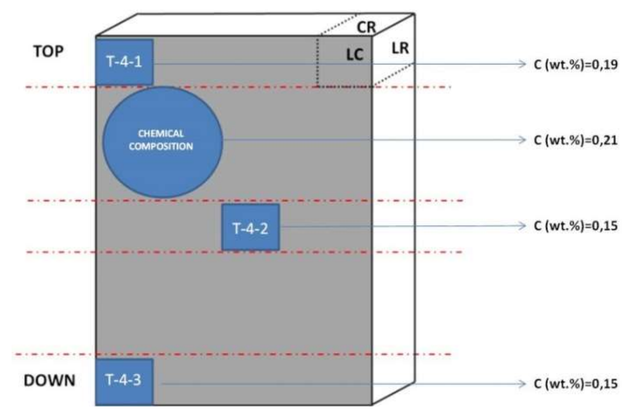
- The **weld** materials have a **higher susceptibilities** than the base materials in terms of volume fraction of the defect clusters (×2 fluence means ×5 higher volume fraction).
- The vacancy concentrations and solute cluster sizes are higher for the high-flux than for the respective low-flux irradiation conditions. **The same conclusion applies to both base and weld materials**.
- The evolution of the clusters with the neutron flux can be described using a **unique** deterministic growth model.

WP3 – Highlights

- *Main technical highlights & related added value:*
  - *The effect of materials heterogeneities on mechanical properties at initial and post-irradiated state has been shown*
    - *Clear effect of the removal position of the specimens in both BM and WM for various industrial alloys*
    - *Inhomogeneities in terms of composition, microstructure and mechanical properties are significant → data scattering that persist after irradiation, including in LTO conditions*







WP3: further highlights

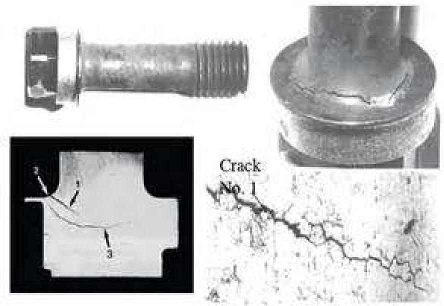
- Initial material heterogeneities… (for WP5 models)
  - Material microstructure:
    - Chemical composition of the **solid solution** (which determines the friction stress) – APT
    - Average **dislocation density** (forest hardening) – TEM
    - **Grain size** distribution and hierarchy (Hall-Petch effect) – TEM, EBSD
  - Second-phase inclusions:
    - **Carbides** (mechanical response, fracture models) – ATP, TEM
    - Approximation in the established **IASCC thresholds**
  - Irradiation defect dispersions:
    - Size, number density, dose dependent, irradiation-temperature dependence (physical models) – APT, TEM, SANS

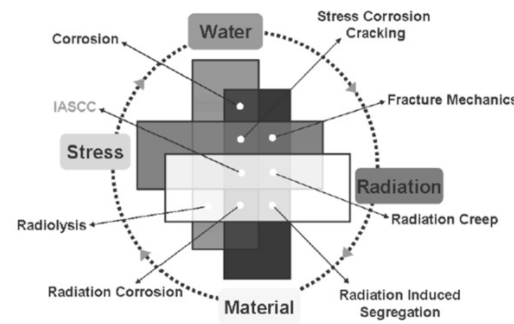
Effects of irradiation on SCC

Irradiation damage (magnitude & type)
Environment (He, H_2 etc)

Surface finish
Cold work

Loading (magnitude and type, e.g. constant load or SSRT)



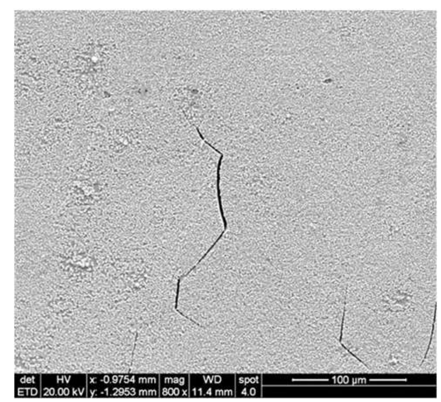


Empirical relationships

IASCC (quantity, type, magnitude)

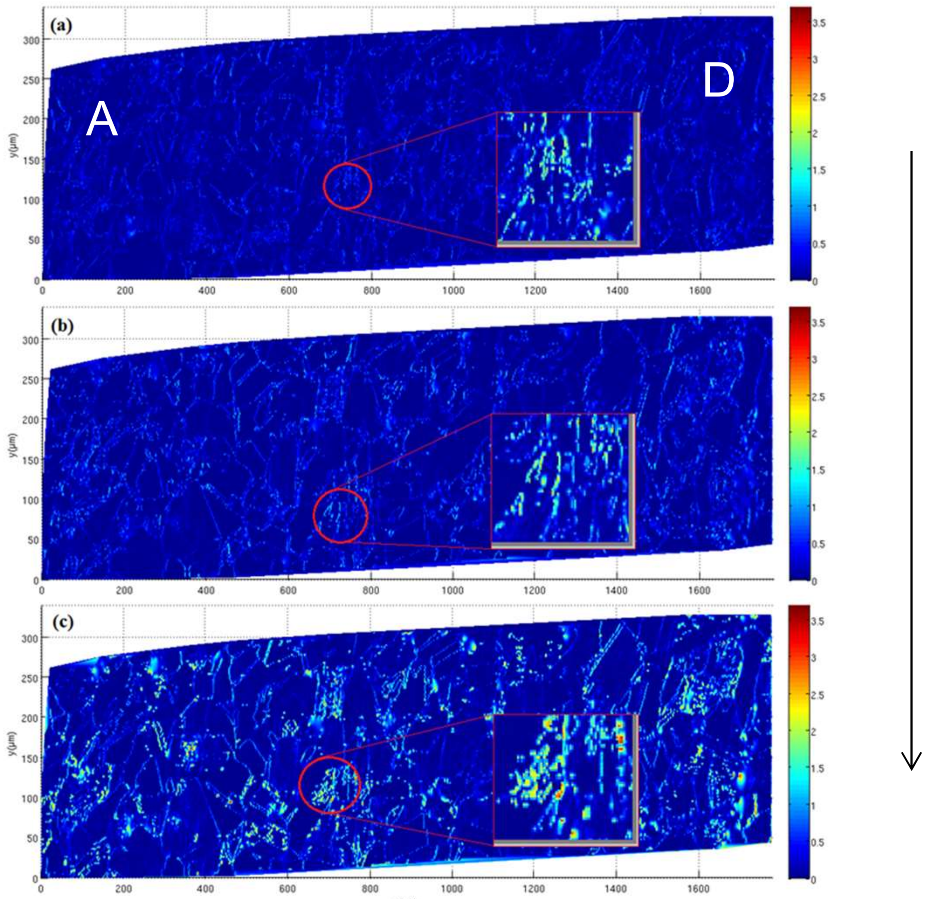
Understanding

Material characterisation
Transport properties
Oxide properties

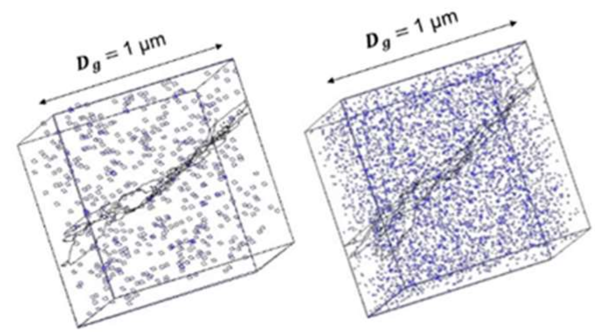


p+ 5 dpa, PWR/300°C, SSRT

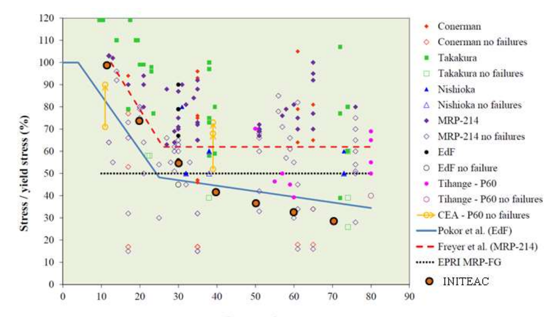
WP4 – Highlights (II/II)



Model : dose-dependent flow localization (high [He] at GB no intergranular crack initiation!)



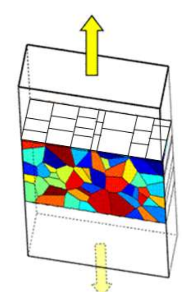
Effect of rising dose on GB loading

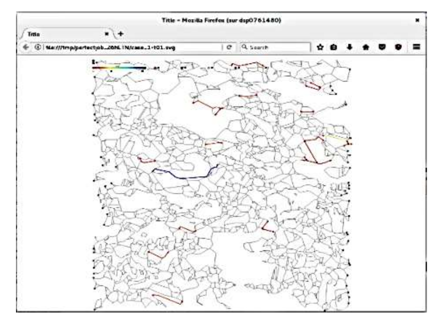


dose-dependent non-cracking stress level identification

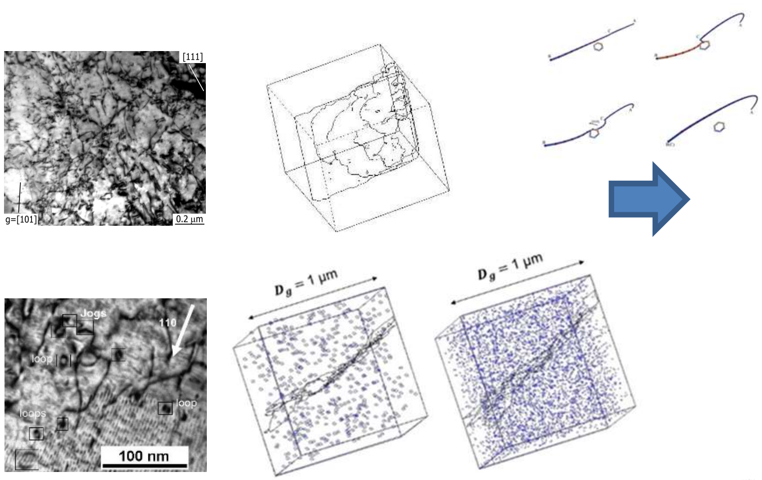
WP5 – Highlights (I/II)

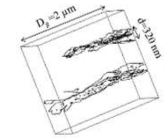
- *Main technical highlights & related added value:*
- T5.1
  - OKMC model applied to industrially relevant steels up to RPV-relevant fluence.
- T5.2
  - Crystal plasticity law identified for RPV and internals for unirradiated and irradiated materials.
- T5.3
  - Contribution of intergranular fracture and heterogeneities of carbide distribution to cleavage for outlier justification.
- T5.4
  - Integration of INITEAC into the platform.



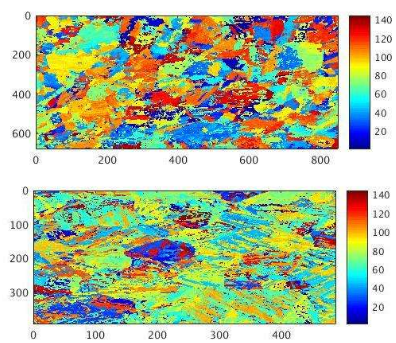


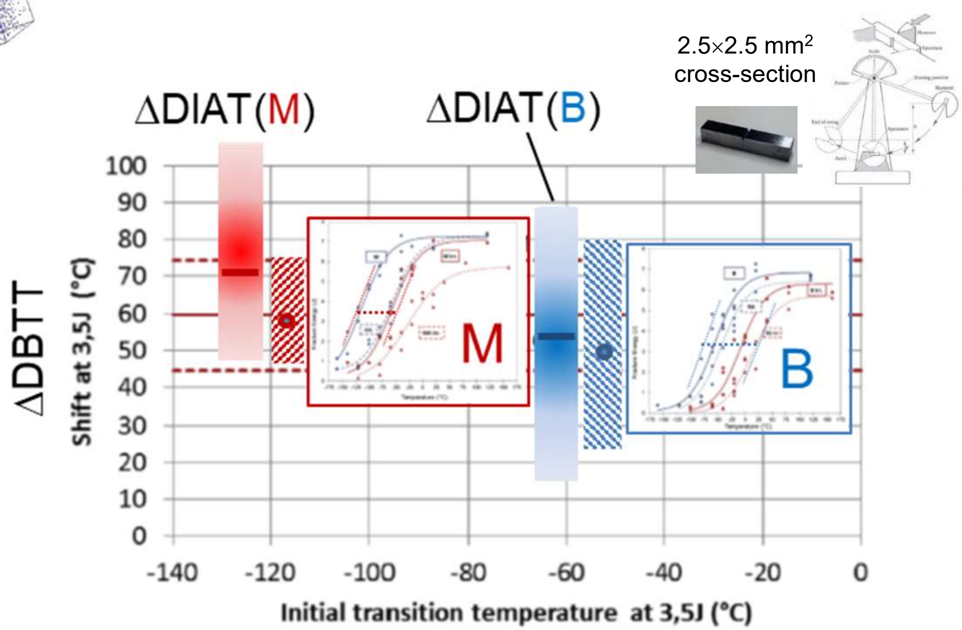
WP5 – Highlights (II/II) – T5.3





$$\Delta\text{DIAT} = \Delta T_{max}\left(1 - exp\left(-\frac{D}{\lambda}\right)\right)\left(1 - exp(-d^2 DN)\right)$$





☞ DIAT: estimation de la fragilisation induite par l'irradiation / mesures non-destructives

THANKS FOR YOUR ATTENTION