Training School, 3 - 7 September 2018
Polytechnic University of Valencia (Spain)

SOTERIA

INTERACTIVE SESSION III : RPV EMBRITTLEMENT COMPUTING A DUCTILE-BRITTLE TRANSITION TEMPERATURE T_0 USING A LOCAL APPROACH TO FRACTURE

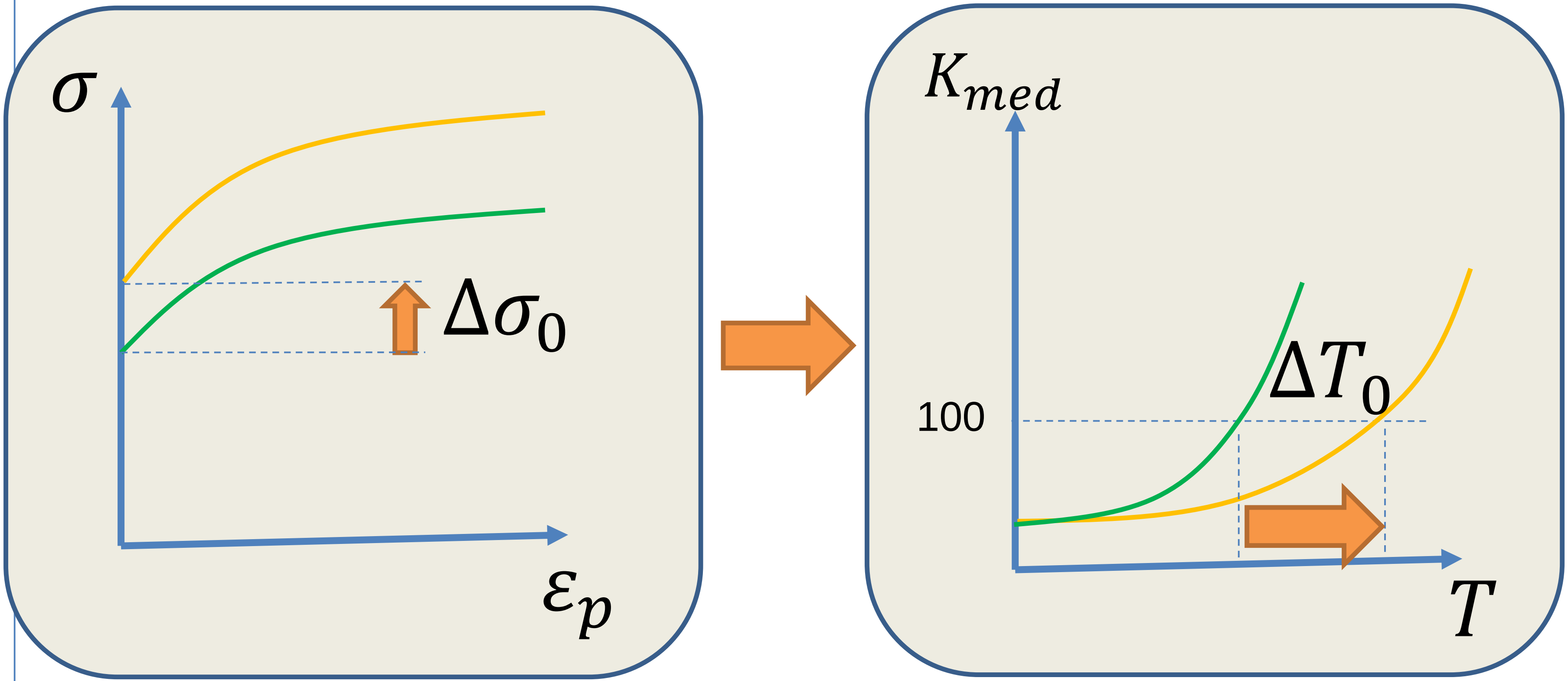
A. Marchenko
P. James

edf

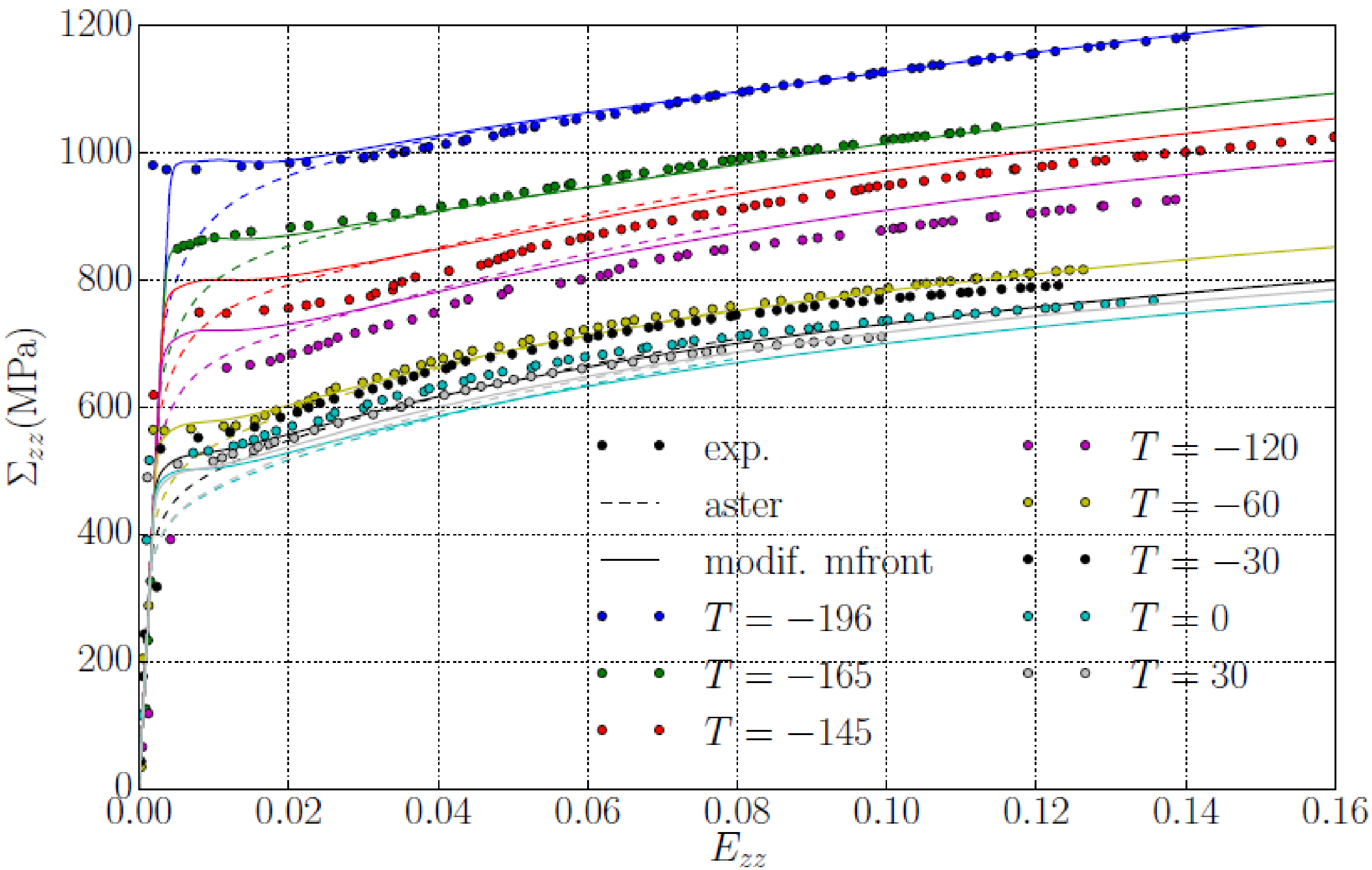
wood.

This project received funding under the Euratom research and training programme 2014-2018 under grant agreement N° 661913

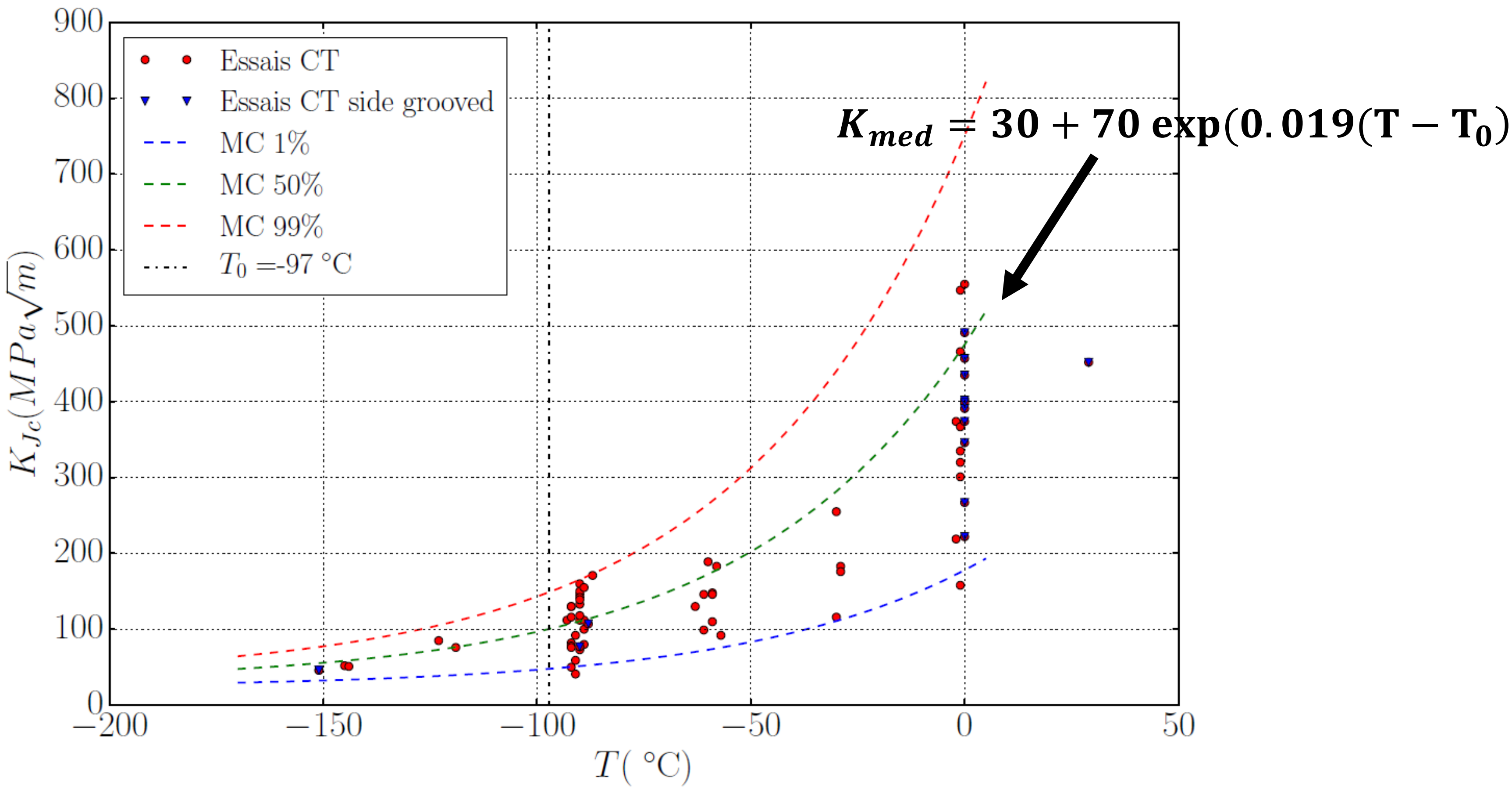
Exercise Objective



H1BQ12 Steel tensile properties



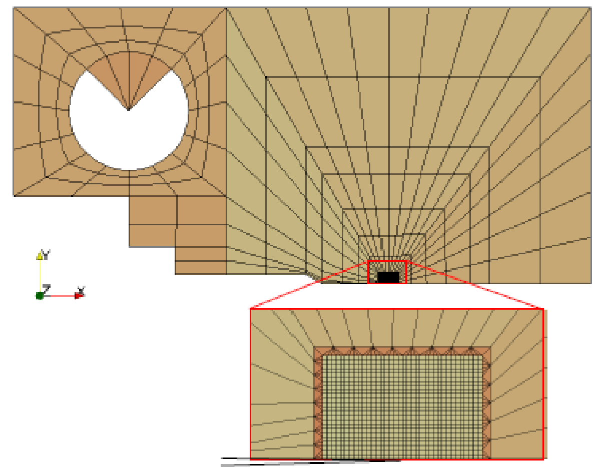
H1BQ12 Steel fracture properties



Master Curve

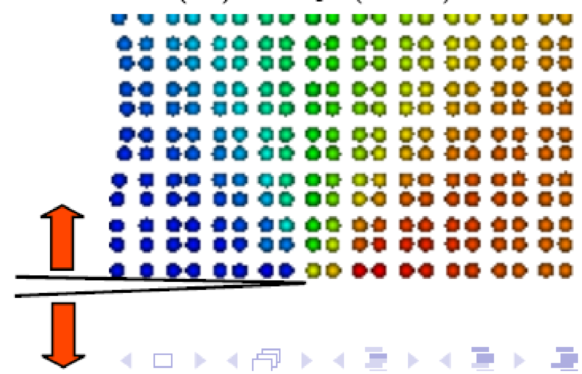
$$P_f(K_{Jc} \leq K) = 1 - \exp\left[-\frac{B}{B_0}\left(\frac{K - K_{min}}{K_{med} - K_{min}}\right)^4\right]$$

CT Calculation with the platform



- To circumvent the limitations of the Master Curve approach, the local approach to failure proposes a chaining of a plastic calculation and a failure post-treatment
- The plastic calculation proposed in the platform is available in the RPV Toughness Module as "CTCalculation"
- It is a 2D calculation using Code_Aster as solver
- possible chainings with homogenized crystal plasticity law to benefit from lower scale plastic models

$$\sigma_I(x) = f(K_J)$$

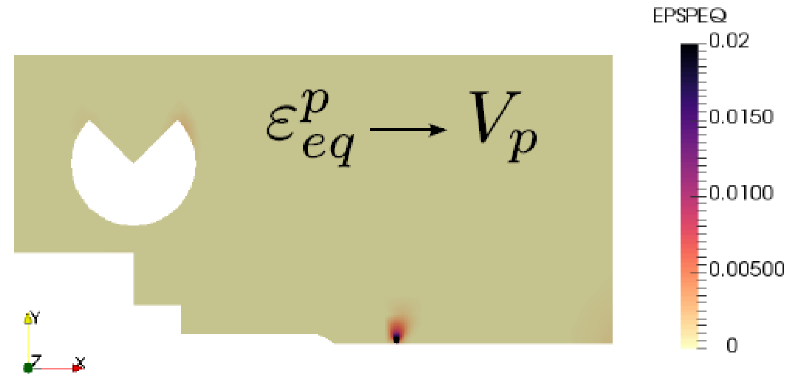


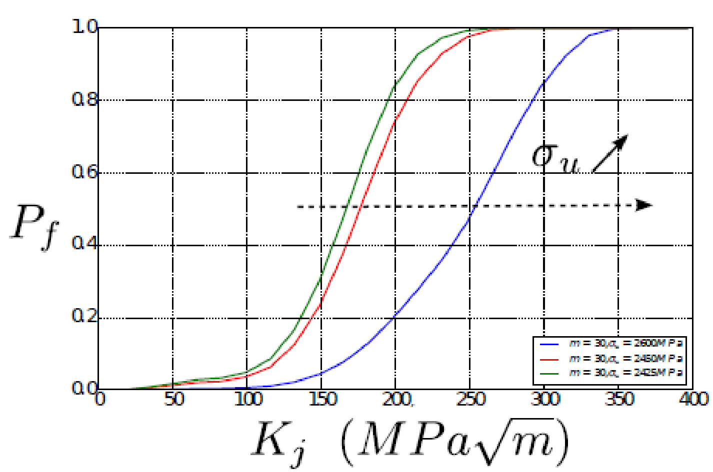
Beremin model

- $\forall K_j(t_i)$
  - fitting a Weibull stress σ_W on the plastic Volume V_p using the σ_I field
  - Compute the failure probability P_f

$$\sigma_W = \left(\int_{V_p} {\sigma_I}^m \frac{dV}{V_0} \right)^{m^{-1}}$$

$$P_f = 1 - \exp\left[- \left(\frac{\sigma_W}{\sigma_u} \right)^m \right]$$

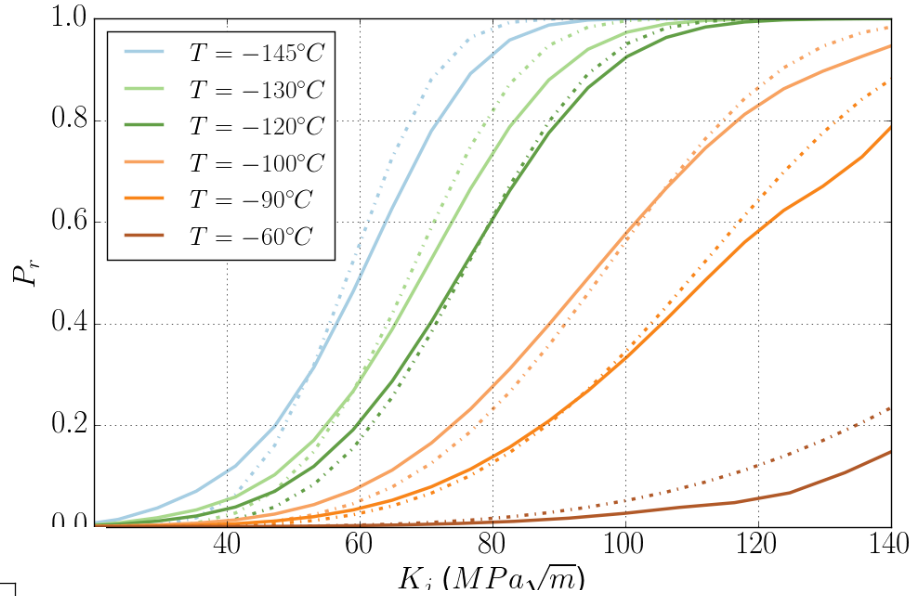


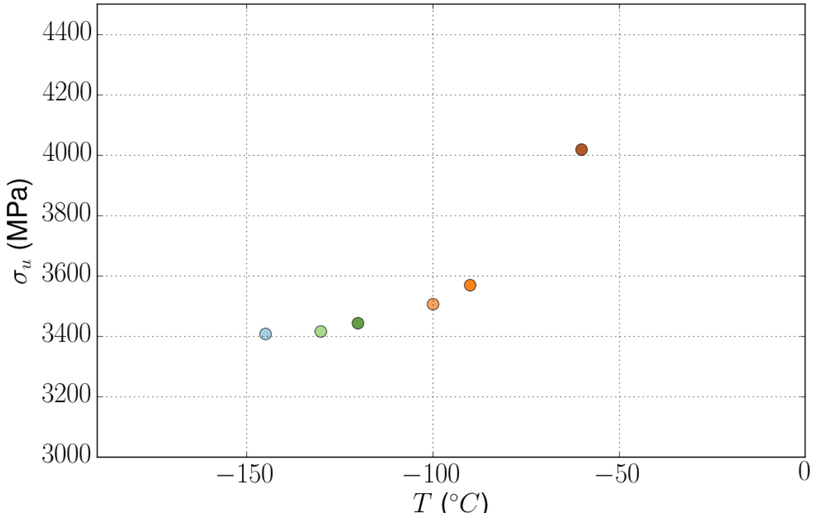


- Beremin parameters : m, σ_u, V_0

Correlation Beremin – Master Curve

Solid Line = Beremin
Dashed Line = Master Curve





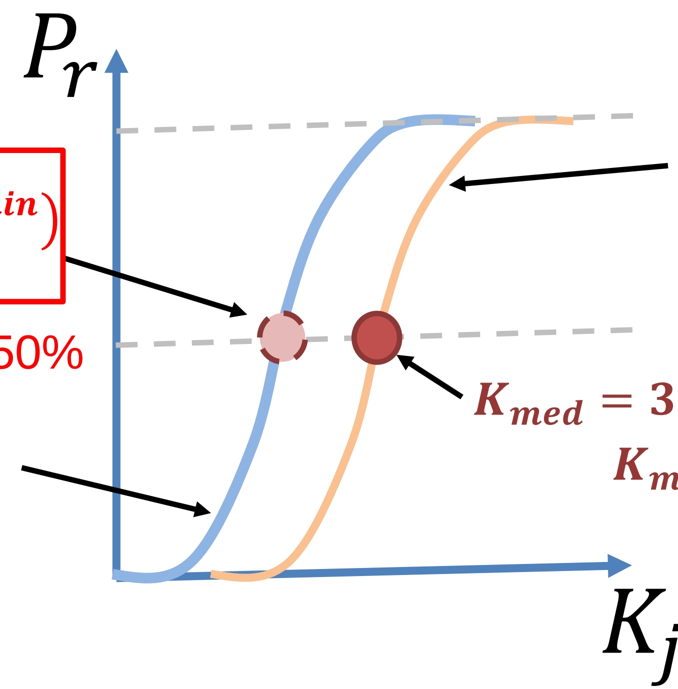
$$\sigma_u = A + B\ exp(C\ T)$$

A (MPa)	B (MPa)	C
3267	961	0.025

Fitting T_0 with MasterCurve

$$T_0^{optimal} = f^{-1}(K_{med}^{beremin})$$

Output of the platform : Beremin failure probability



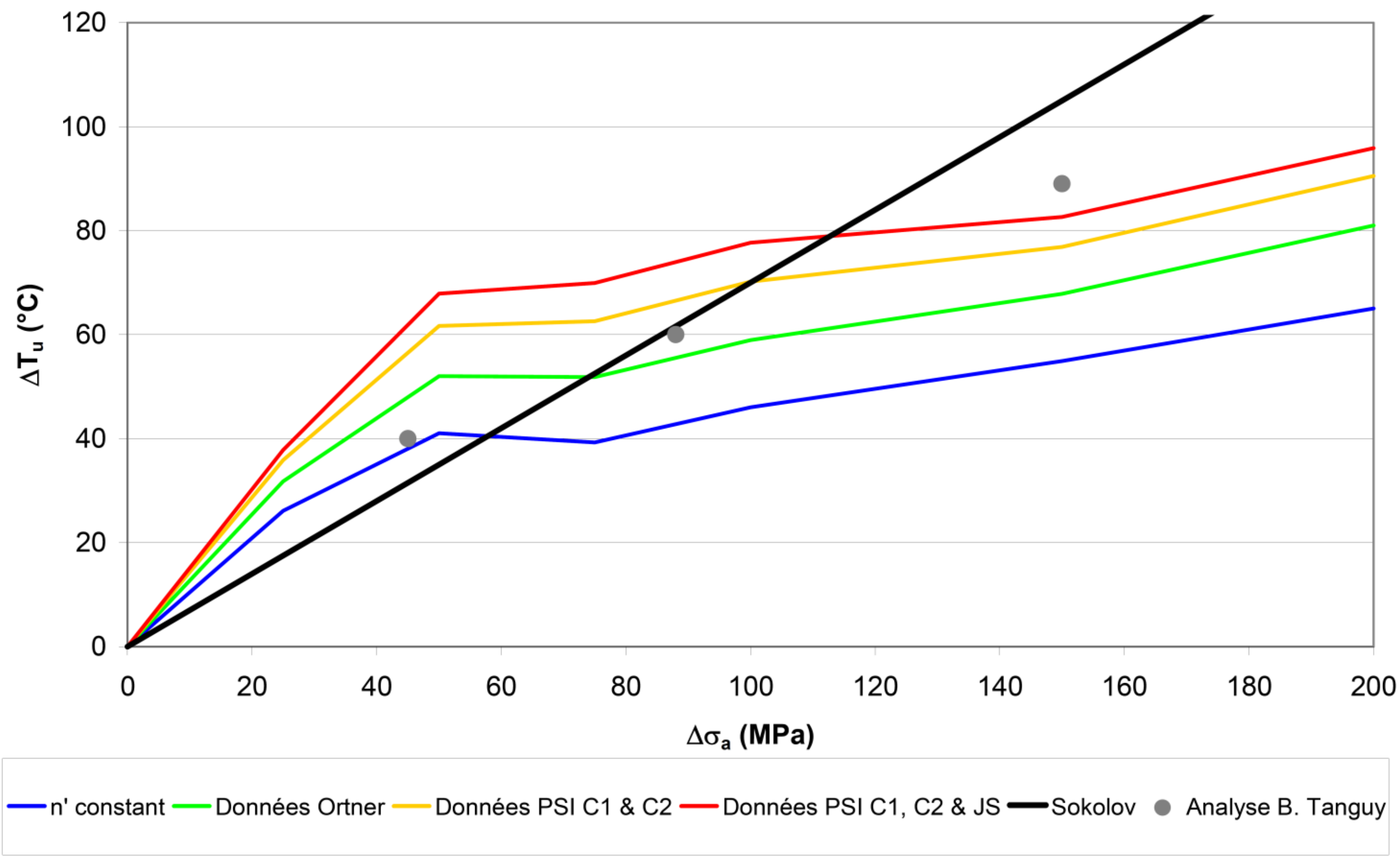
Example of **Master Curve** isothermal probability (random T_0)

$$K_{med} = 30 + 70\exp(0.019(T - T_0))$$

$$K_{med} = f(T_0)$$

$$P_f(K_{Jc} \leq K) = 1 - \exp\left[-\frac{B}{B_0}\left(\frac{K - K_{min}}{K_{med} - K_{min}}\right)^4\right]$$

Irradiation effect on fracture



$\sigma_u = A + B\, exp(C\,(T - \Delta T_u)),\qquad \Delta T_u = \Delta T_0,\qquad \boxed{\Delta T_0 = \alpha \Delta \sigma_0, \quad with \quad \alpha = 0.7}$

B.Tanguy, A. Parrot

Sokolov relation

Modules chaining