INTERACTIVE SESSION II : RPV EMBRITTLEMENT COMPUTING A DUCTILE-TO-BRITTLE TRANSITION TEMPERATURE TK7/T0.9 VIA CHARPY TEST

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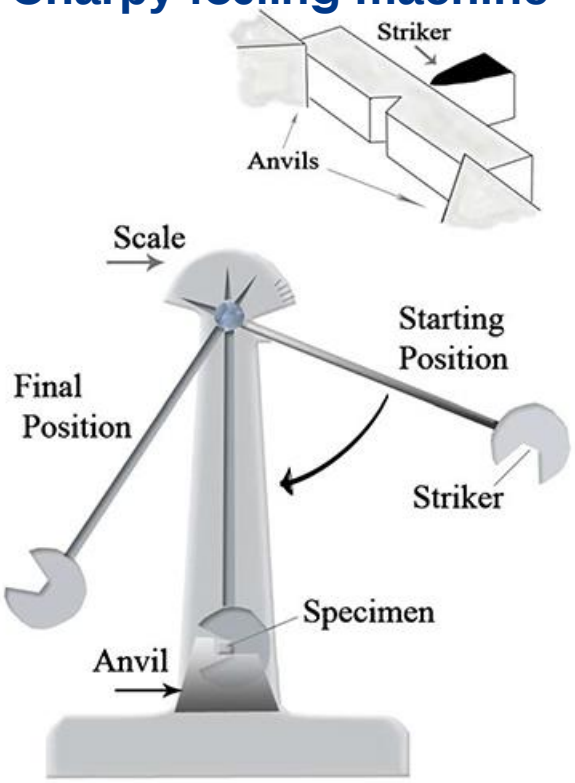
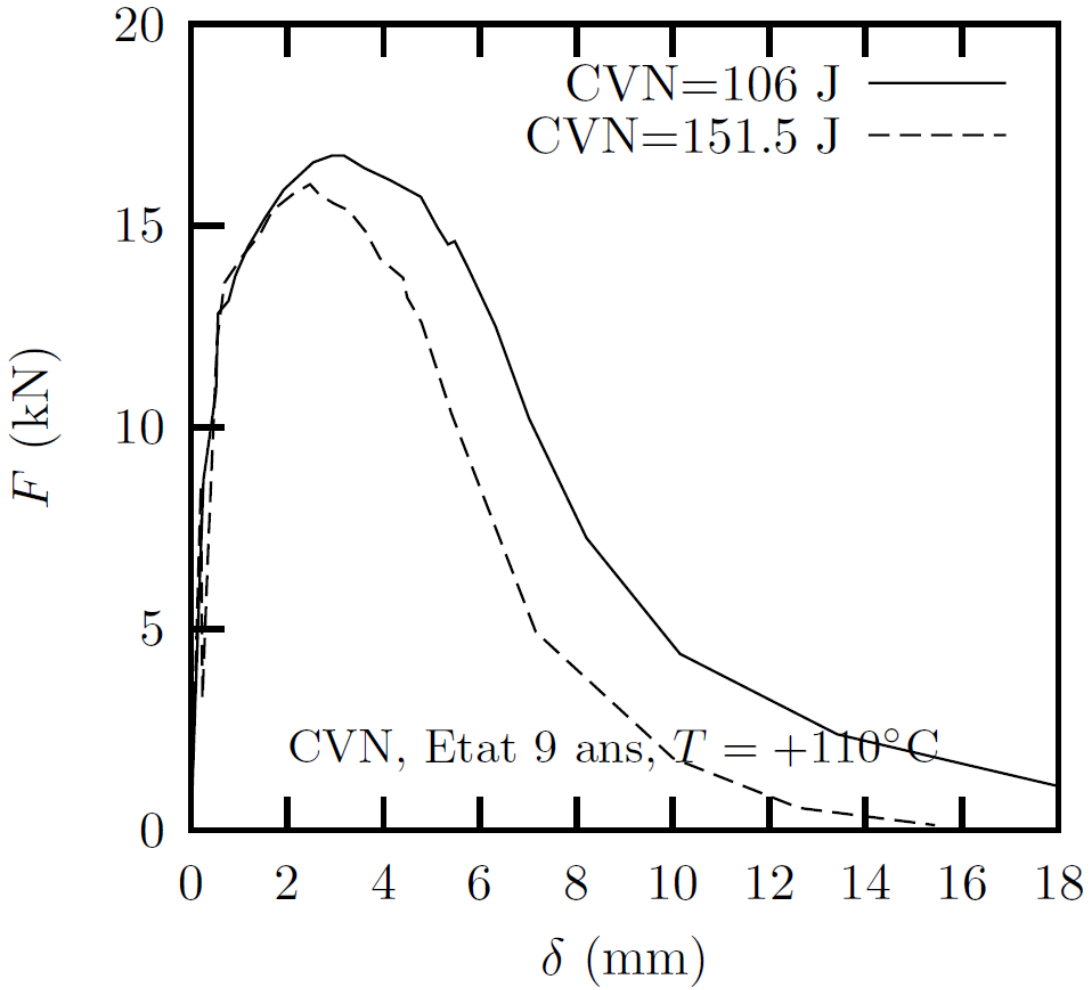
Charpy: classical dynamic test

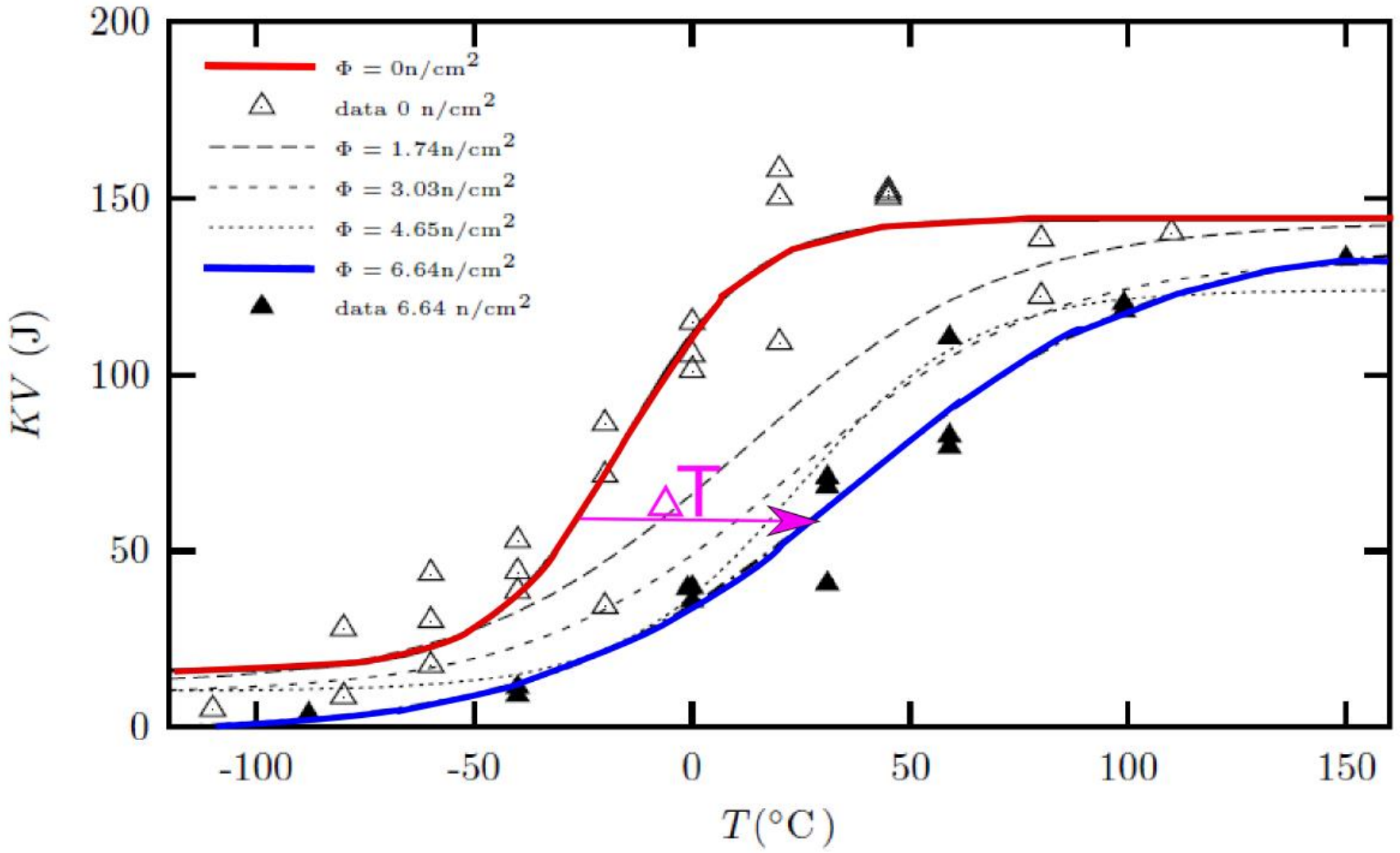
Charpy testing machine



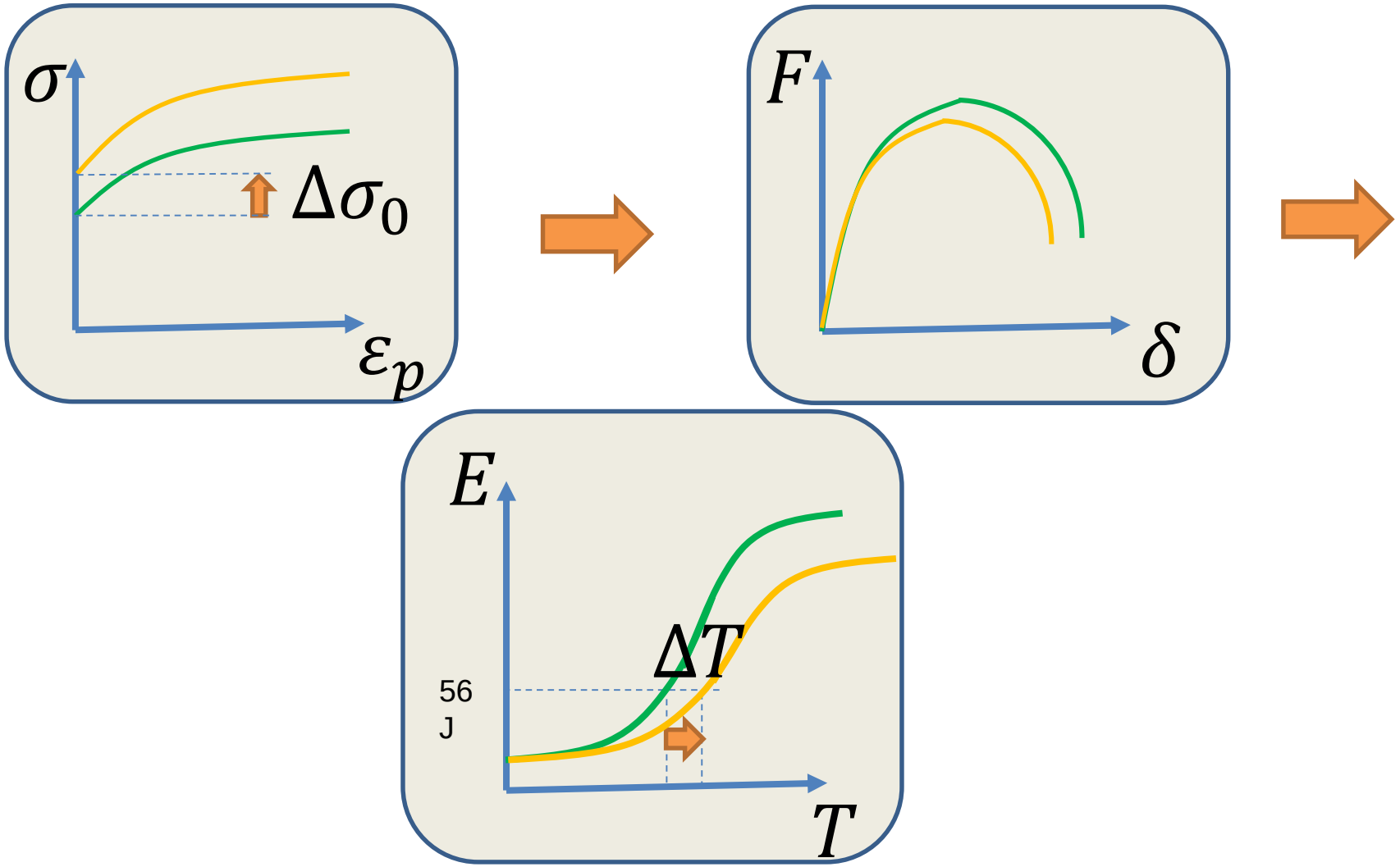


Charpy instrumented curve

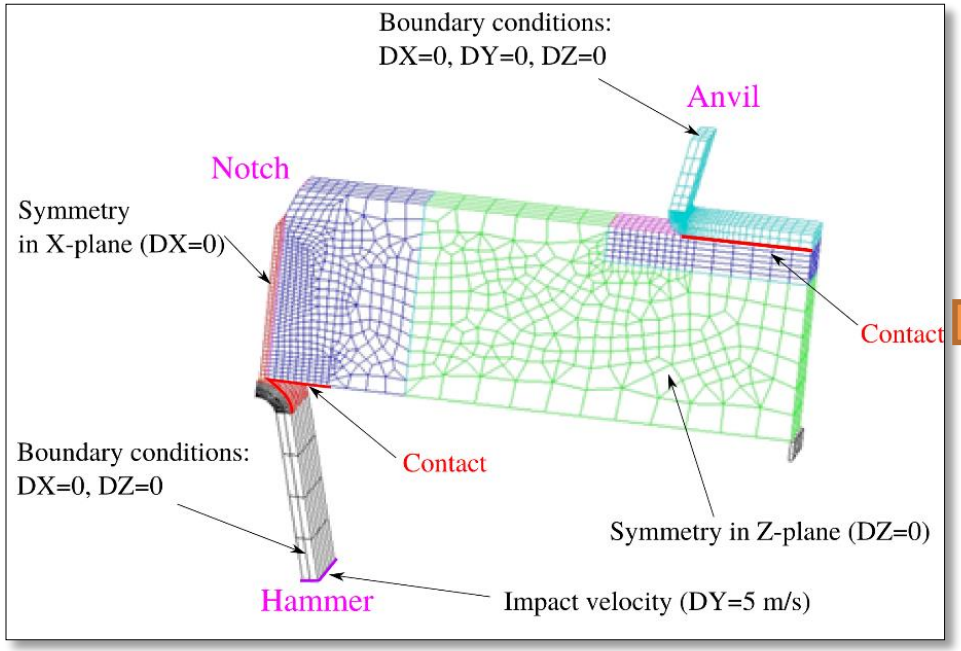
ISP: DBTT shift for irradiated material



Exercise Objective



Possibilities with the platform

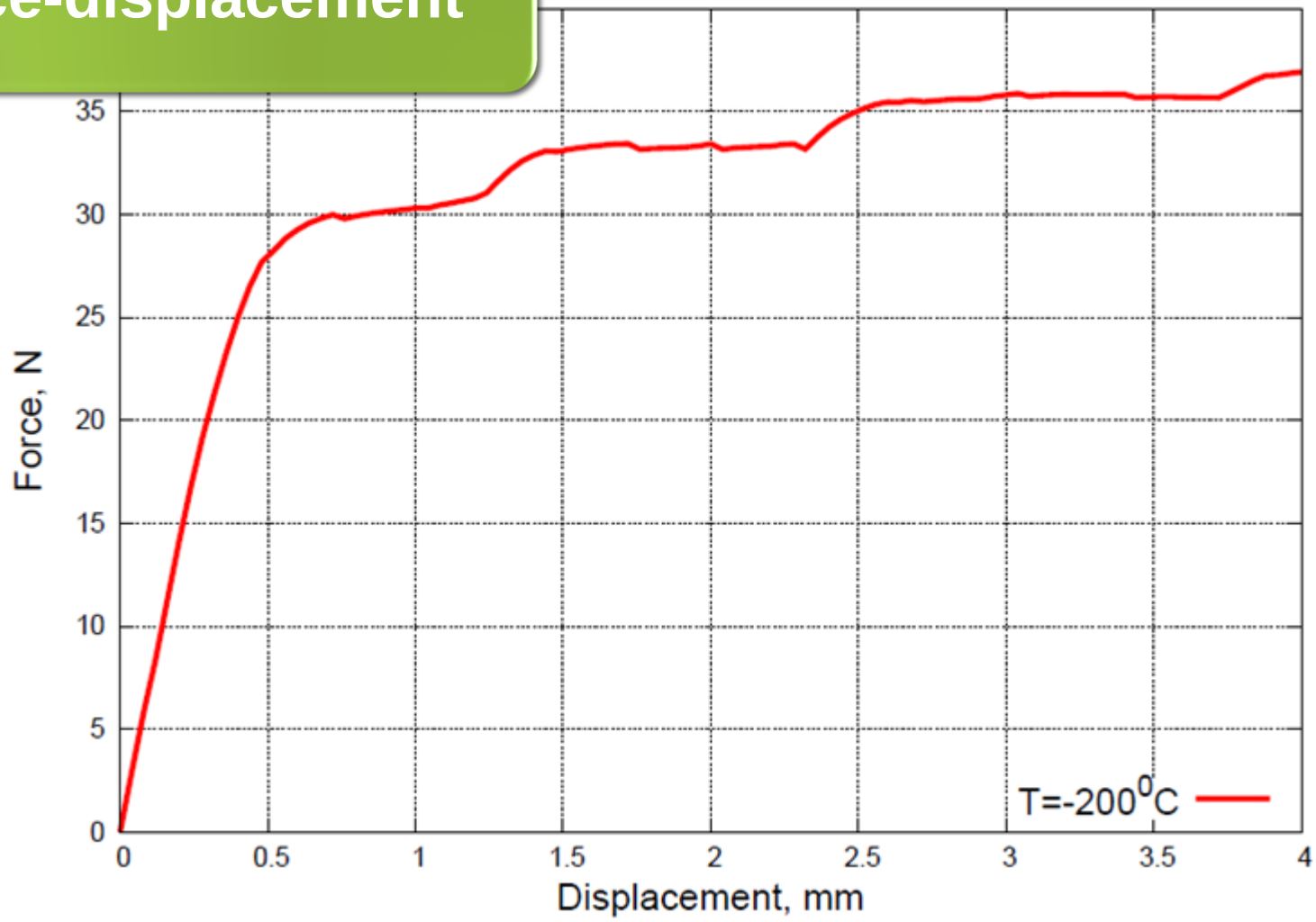


Elasto-viscoplastic model with damage (Rousselier model)

Beremin model in post-processing

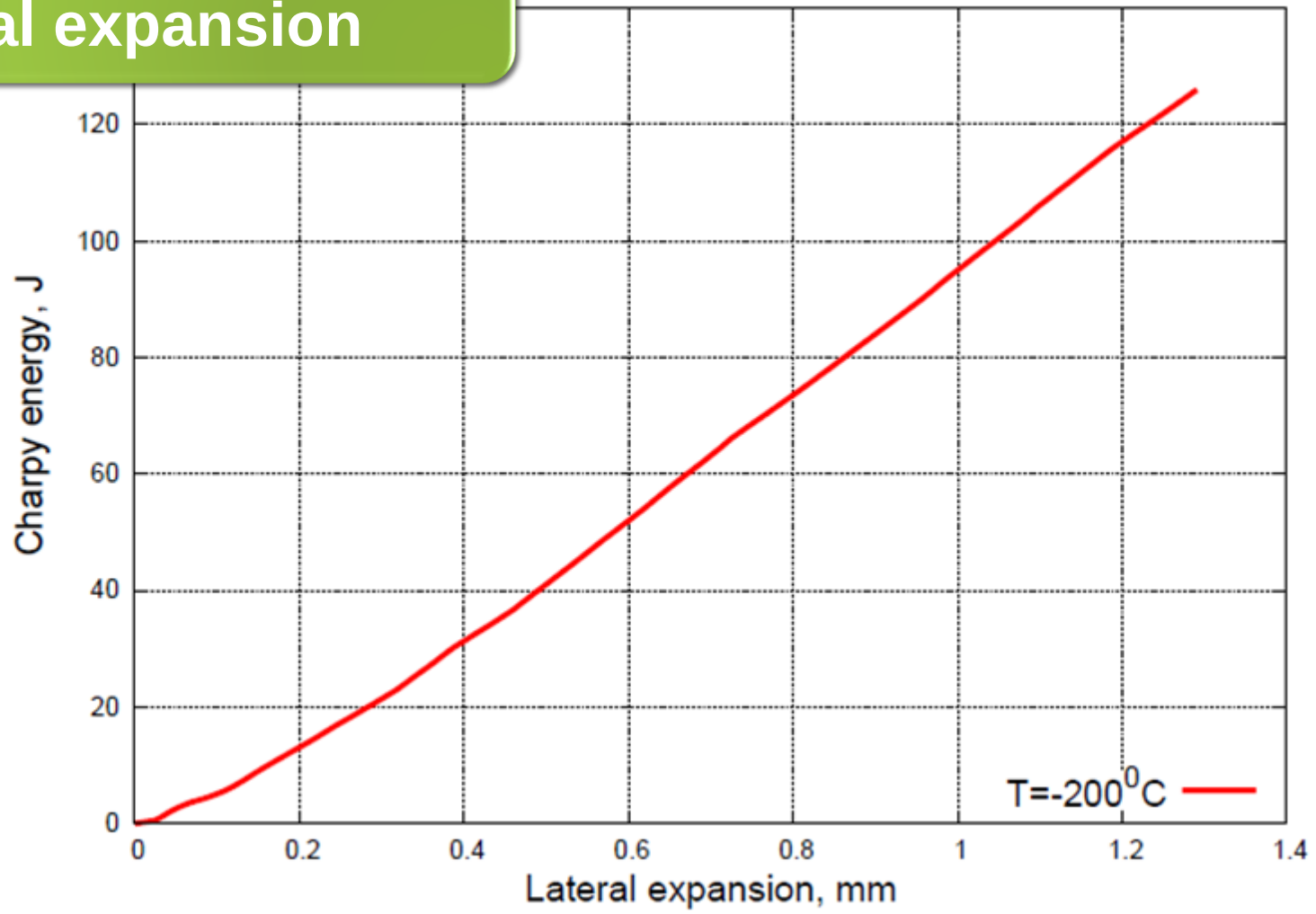
Simulations results

Force-displacement

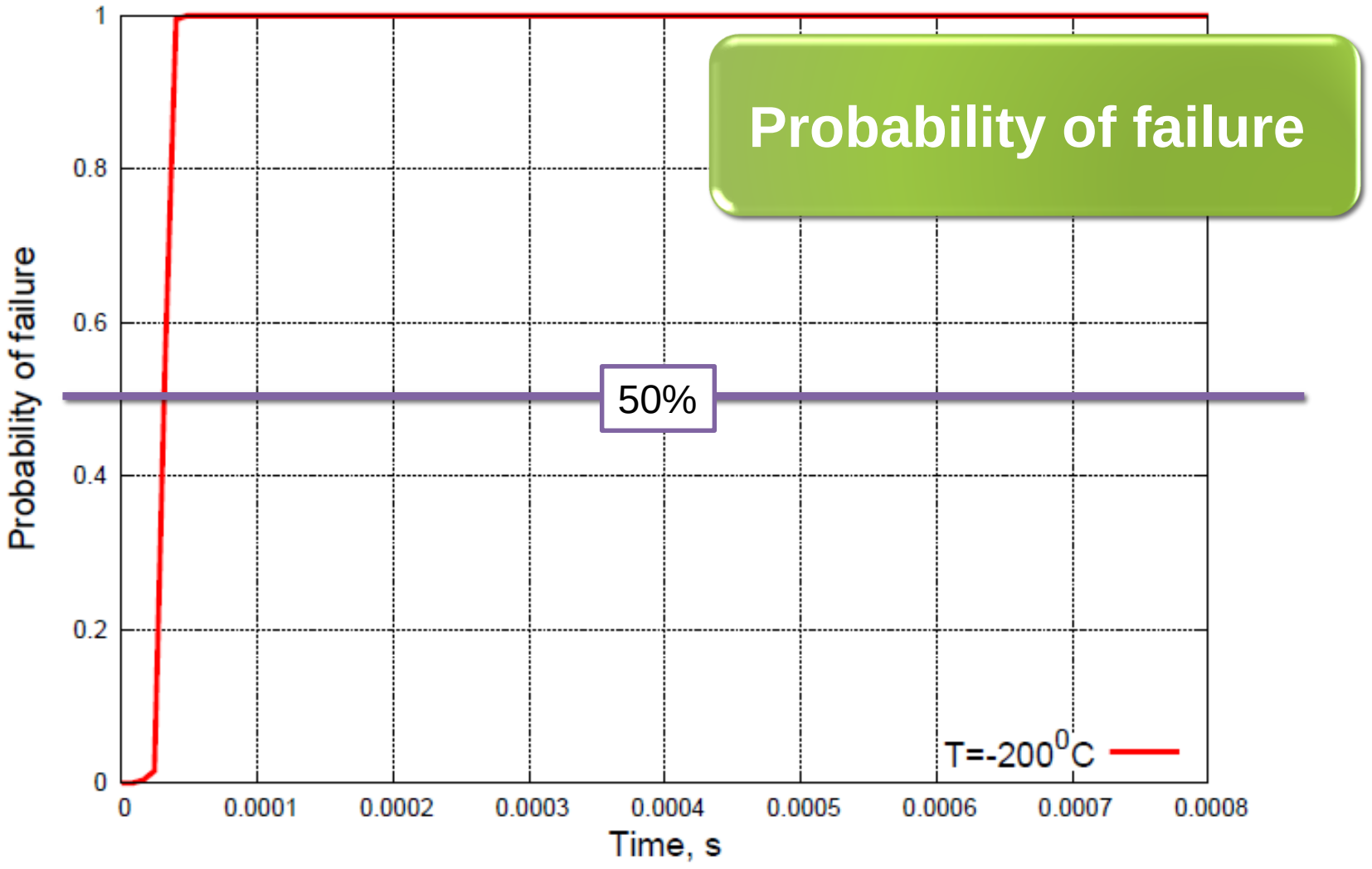


Simulations results

Charpy energy and lateral expansion



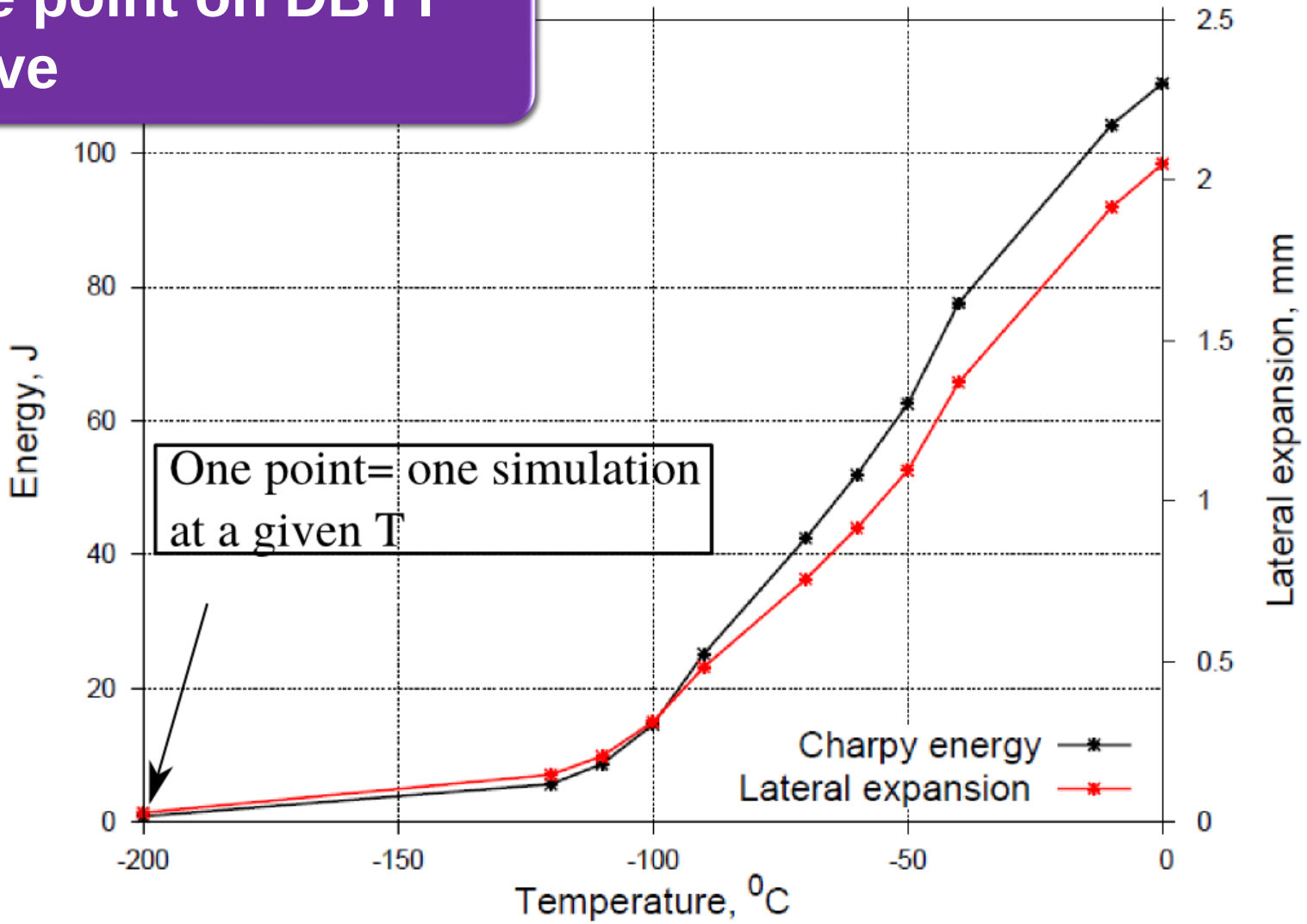
Simulations results



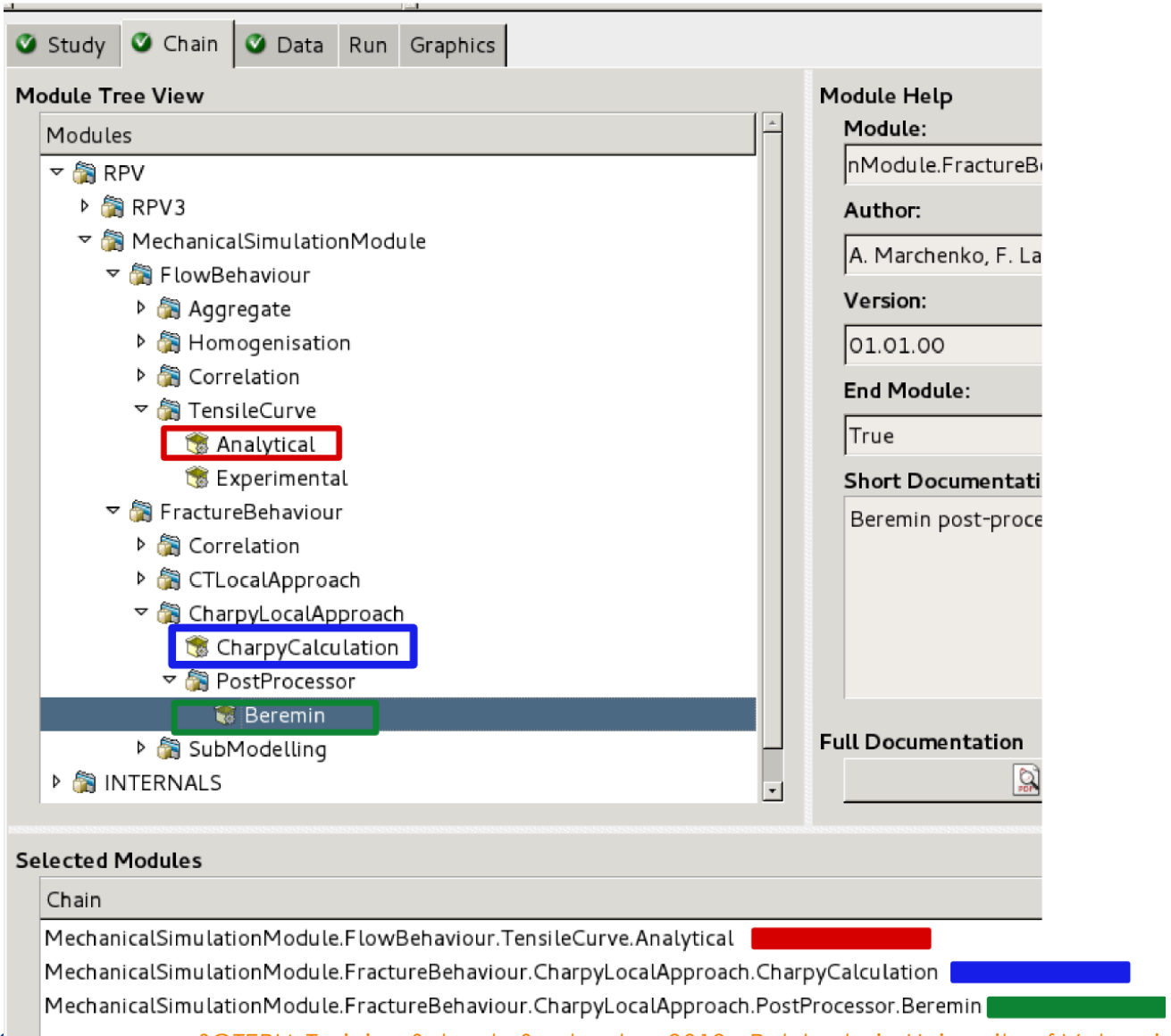
Probability of failure

Simulations results

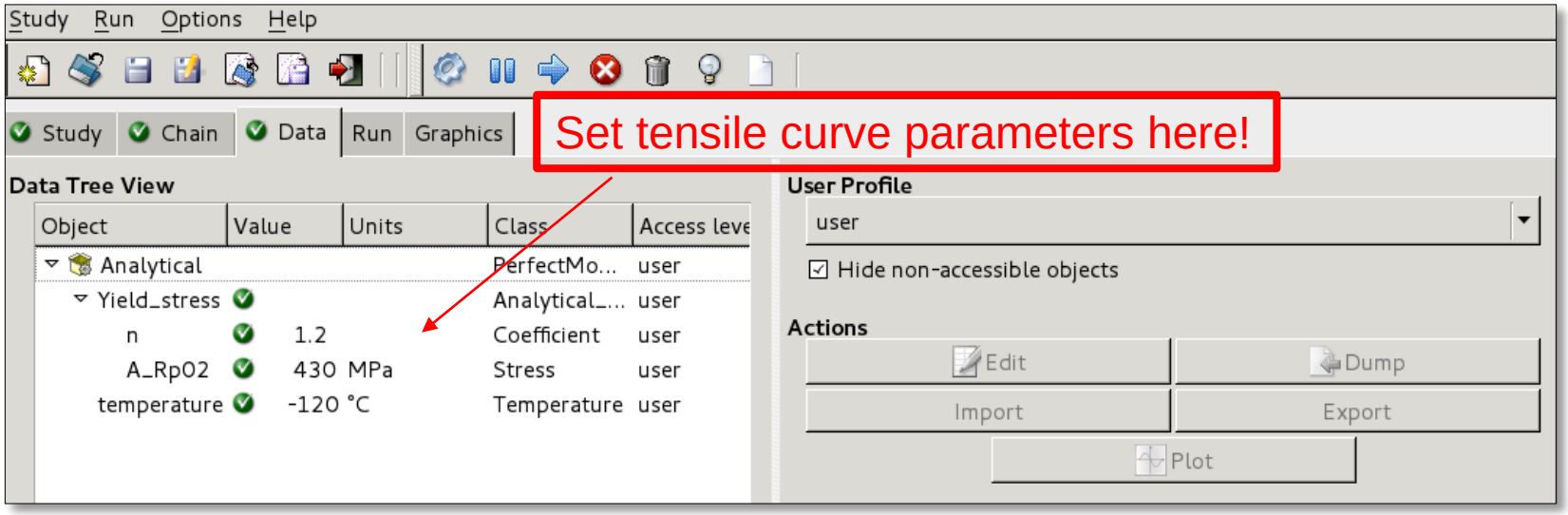
One point on DBTT curve



Modules chaining



Materials definition



- **Yield stress:** $\sigma_{Y0}(T) \approx R_{p0.2}(T) = \boldsymbol{a_{Rp0.2}} + b_{Rp0.2} * e^{-cT}$
- **Flow stress:** $R(p) = \sigma_{Y0}(T) + \boldsymbol{n} * \left[Q_1(T)(1 - e^{-b_1(T)p}) + Q_2(1 - e^{-b_2(T)p})\right]$

Fitted from $R_{p0.2}$ and R_m by

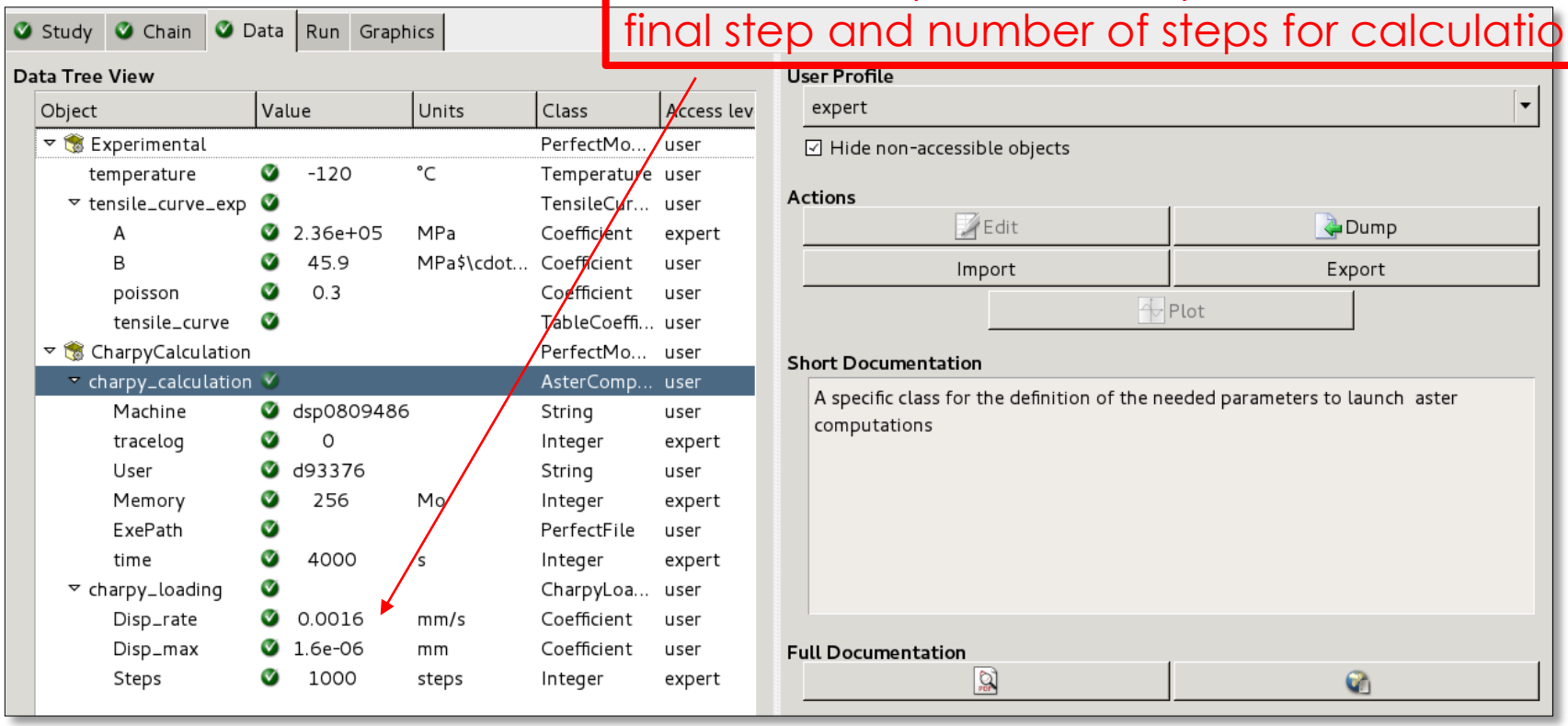
[S. Renevey, 1997, thesis]

[B. Tanguy, 2001, thesis]

determined for **H1BQ12 (16MND5)**

Charpy calculation

Set here the speed of the pendulum, final step and number of steps for calculation



- **Viscoplasticity :**

$$\dot{p} = \left(\frac{\sigma_{eq} - R(p)}{K(T)} \right)^{N(T)}$$

! Is fixed and included into Charpy calculation module

Beremin post-processing

Set here the Beremin model parameters

Beremin				PerfectMo...	user
beremin	✓			Beremin	user
V0	✓	0.000125	nm³	Volume	user
quantile	✓			TableCoeffi...	user
m	✓	20		Coefficient	user
sigma_u	✓	2647	MPa	Stress	user
beremin_calculation	✓			AsterComp...	user
Machine	✓	dsp0809486		String	user
tracelog	✓	0		Integer	expert
User	✓	d93376		String	user
Memory	✓	256	Mo	Integer	expert
ExePath	✓			PerfectFile	user
time	✓	1000	s	Integer	expert

- **Beremin model**

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

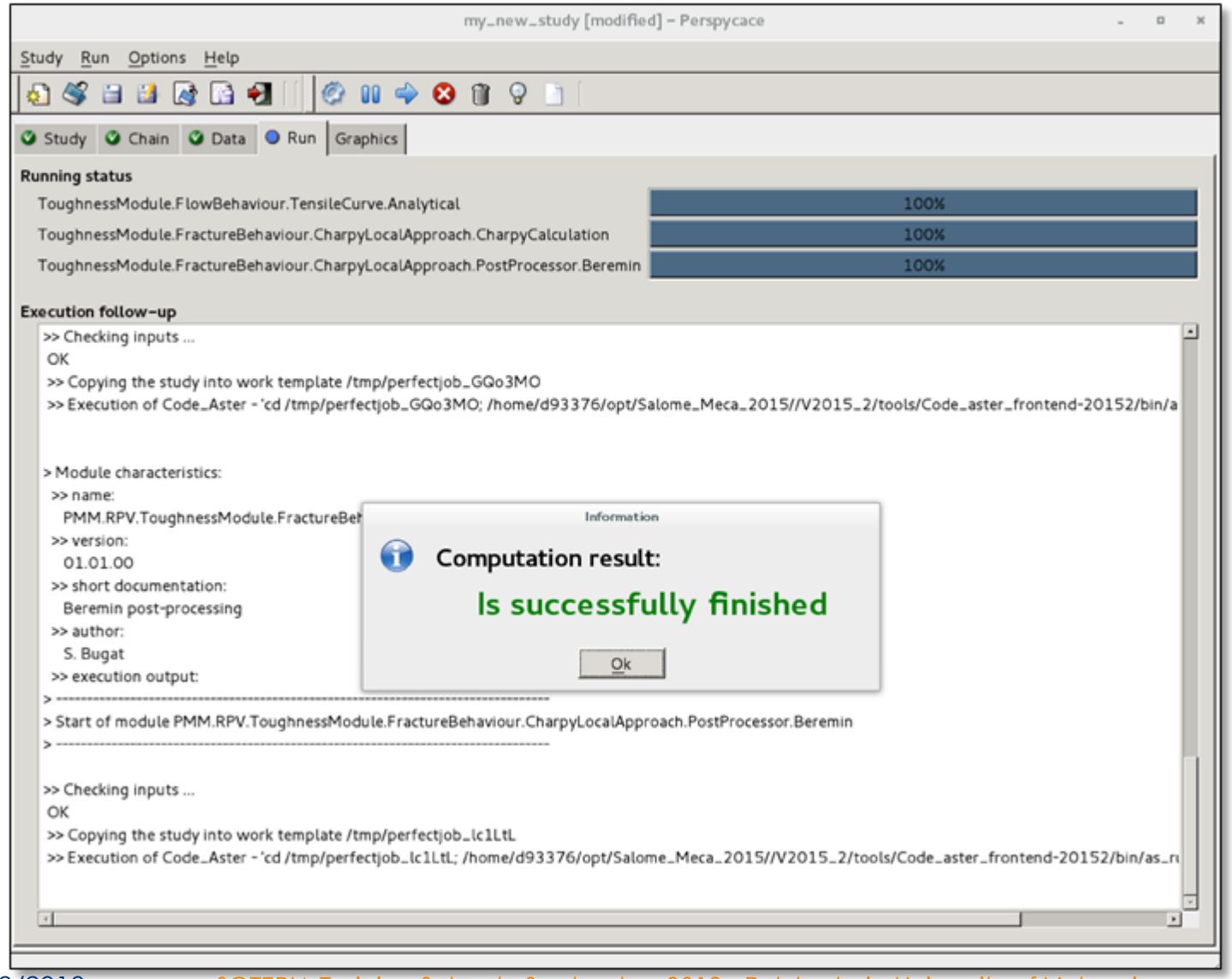
$$\sigma_w = \left[\int_0^{V_p} \tilde{\sigma}_{Ip}^m \frac{dV}{V_0}\right]^{1/m}$$

$$\sigma_u = a_{\sigma u} + b_{\sigma u} * e^{0.025T}$$

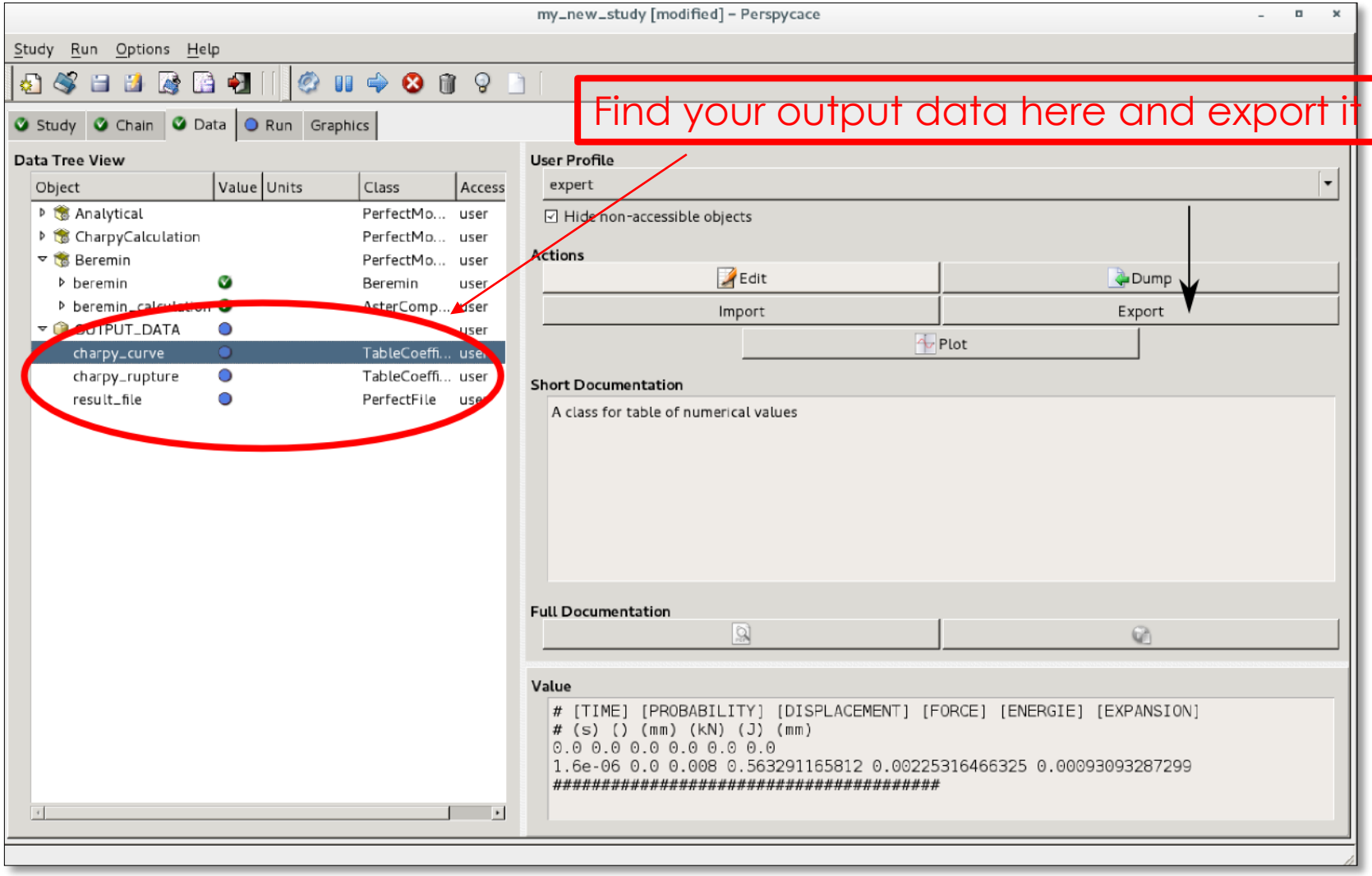
σ_u - the normalizing stress
σ_w - the Weibull stress
m - the Weibull shape factor ($m = 20$)
P_R - probability to failure
V_0 - the elementary volume element
$\tilde{\sigma}_{Ip}(t) = \max \sigma_{Ip}(t')$ – effective failure stress

$a_{\sigma u}$ $b_{\sigma u}$ reference values

Execution procedure



Output data

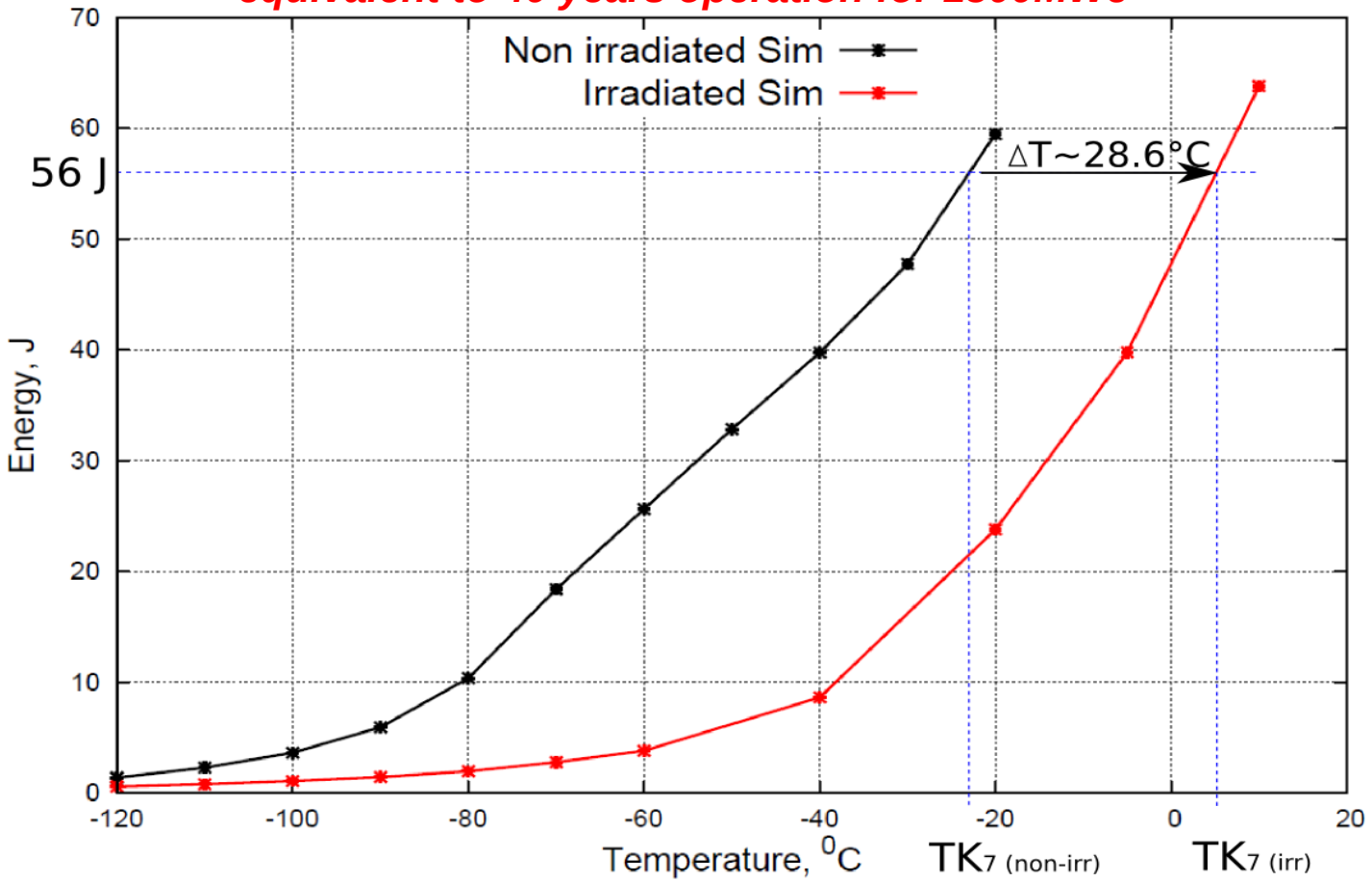

my_new_study [modified] – Perspycace
Study Run Options Help
Study Chain Data Run Graphics
Find your output data here and export it
Data Tree View
Object Value Units Class Access
Analytical PerfectMo... user
CharpyCalculation PerfectMo... user
Beremin PerfectMo... user
beremin Beremin user
OUTPUT_DATA user
charpy_curve TableCoeffi... user
charpy_rupture TableCoeffi... user
result_file PerfectFile user
User Profile
expert
Hide non-accessible objects
Actions
Edit
Dump
Import
Export
Plot
Short Documentation
A class for table of numerical values
Full Documentation
Value
[TIME] [PROBABILITY] [DISPLACEMENT] [FORCE] [ENERGIE] [EXPANSION]
(s) () (mm) (kN) (J) (mm)
0.0 0.0 0.0 0.0 0.0 0.0
1.6e-06 0.0 0.008 0.563291165812 0.00225316466325 0.00093093287299
##

Final goal

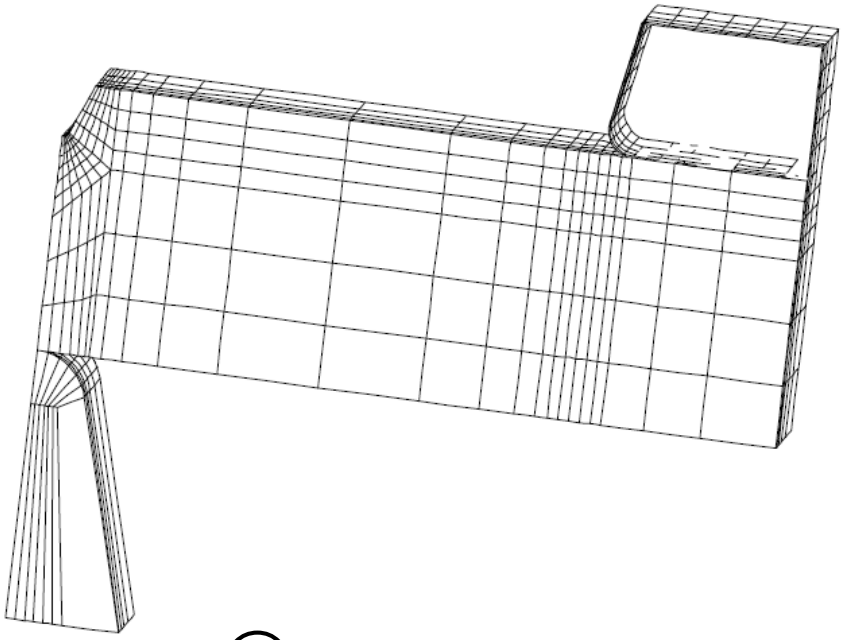
Estimation of the temperature shift due to irradiation

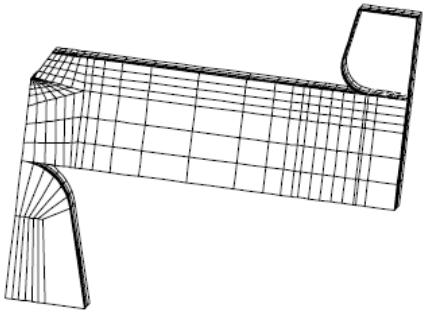
$$\phi = 4,3 \cdot 10^{19} n/cm^2$$

equivalent to 40 years operation for 1300MWe



Mini and sub-sized Charpy





- Validated micro-mechanical model
- Good prediction of the irradiation effect

- Transferability problem (Constraint effect)
- Empirical correlations only
- Absence of experimental data
- Parameters for local approach models