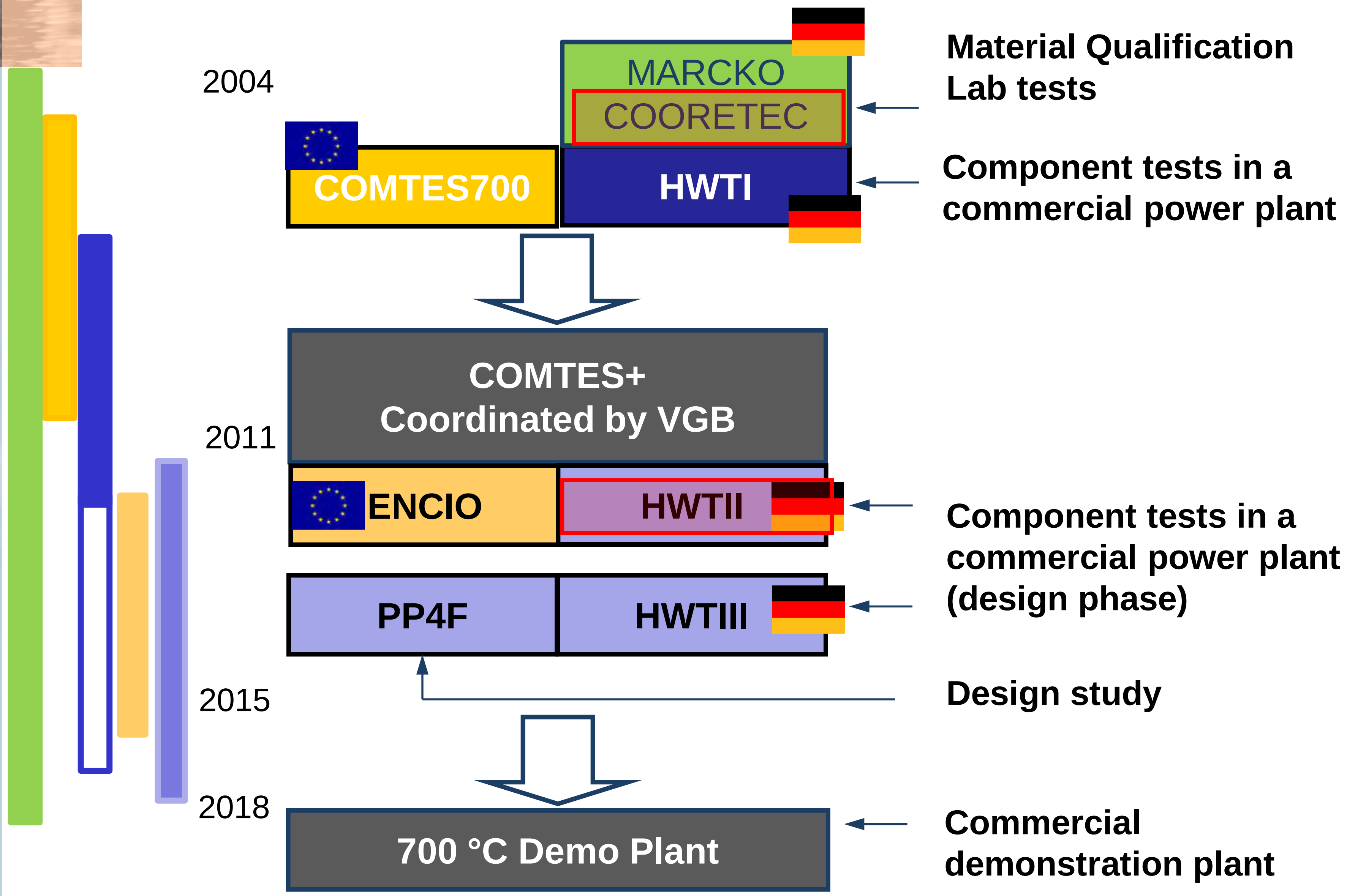
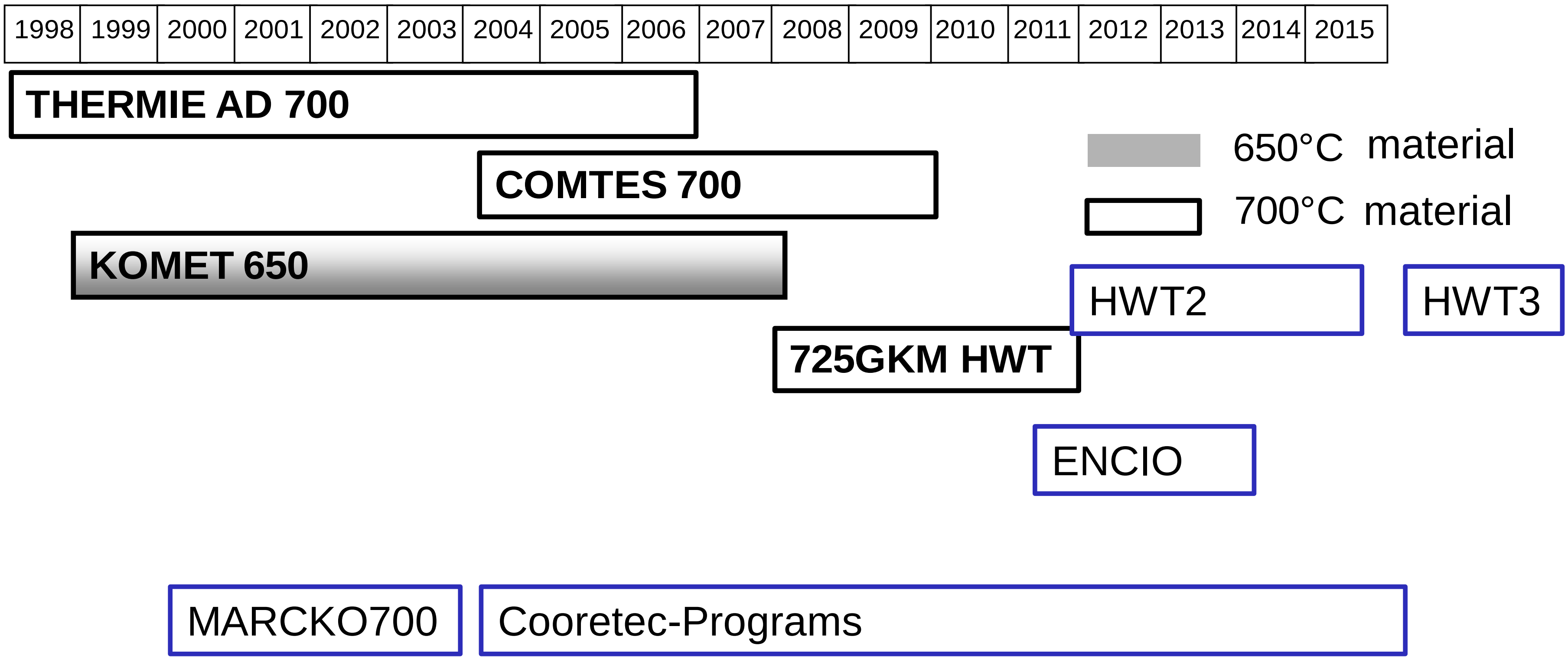
MPA Universität Stuttgart

Research on high efficient and flexible plants



Research Framework: Material Qualification Programs and Field Tests



002 606px

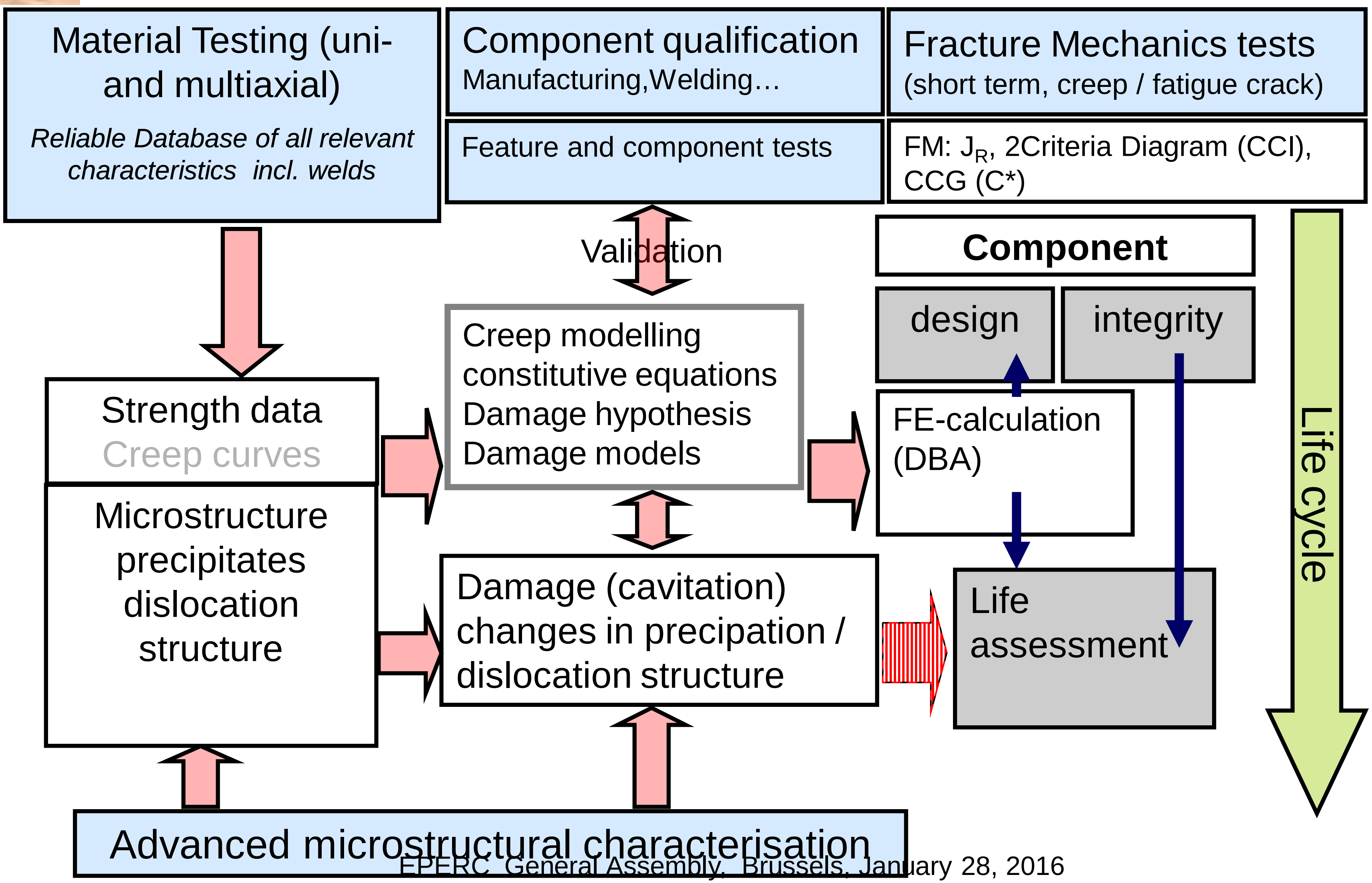
Research Framework: Marcko / COORETEC projects

Boiler application		Status
MARCK0 700	Material qualification for the 700/720 °C power plant	Finished
DE-1	Fireside corrosion and steam side oxidation behavior of materials for 700°C power plant	Finished
DE-2	Characterization of superheater materials after cold deformation	Finished
FDBR02	Qualification of pipes with longitudinal welds made of Alloy 617	Ongoing
DE-4	Characterization of strength and deformation of pipes and forgings made of Ni-based alloys	Finished 06/2013
725HWT (1) Phase 2	Investigation of the long term service behavior of tubes for the future high-efficiency power plant	Finished Ongoing
HWT 2	Investigation of the long term service behavior pipes, bends and headers under static and cyclic loading	Ongoing
Turbine application		
DT-3	Qualification of dissimilar welds between 10%Cr-steels and Ni-based alloys	Finished
DT-4	Procedures and Fracture mechanics approaches for life assessment of components operating in high temperature regime	Finished
WK2	Advanced material concepts for forged and cast turbine components	Ongoing
Turbine and pipe work application		
TD-1	Optimization of non-destructive testing methods for thick walled components made of Ni-base alloys	Finished

002 606px

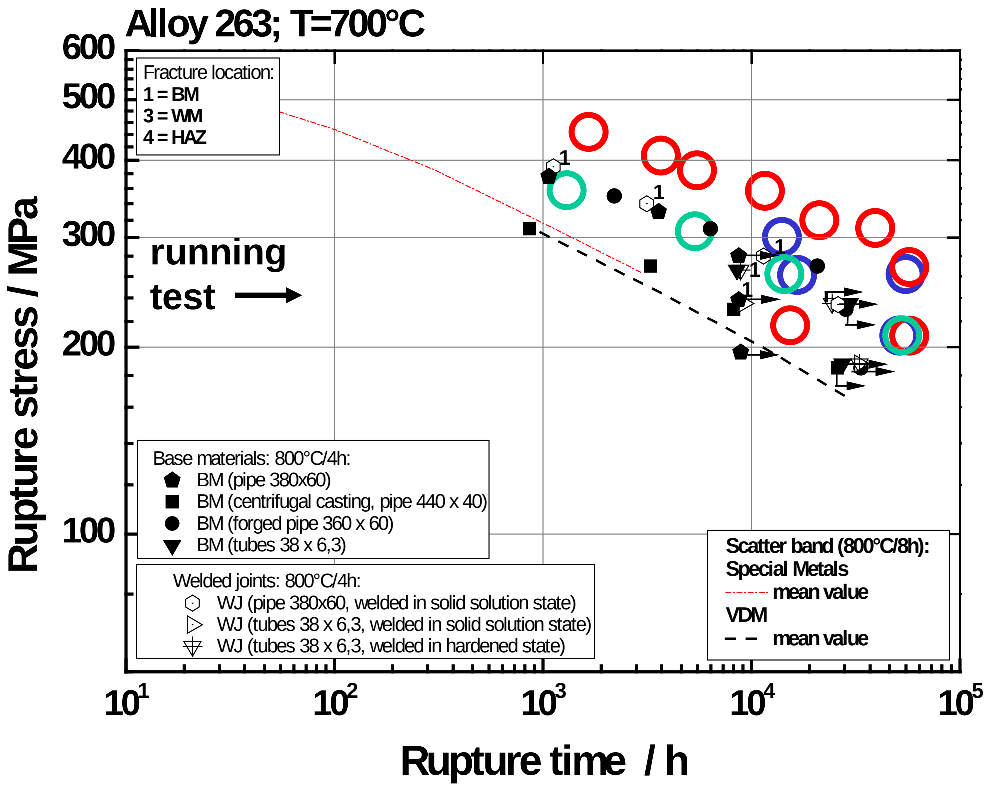
What is needed?

- **Research on materials for components**



Creep rupture of Alloy 263

- Creep resistance the most important property
- Alloy 263: excellent creep rupture behaviour
- Welded joints: similar behaviour as base material



Tube
Higher values than specification of manufacturer, many tests are still running

Pipes
Forged & seamless pipes: similar rupture behavior, highest values of all components

Centrifugal cast pipe
Lowest creep rupture properties compared to another components

Numerical analysis

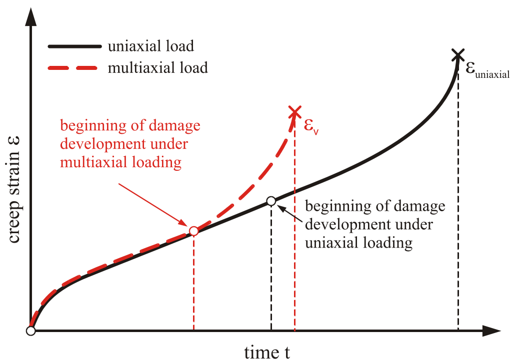
- **Development of material models to describe creep and creep-fatigue behaviour**
- **Modified Graham-Walles creep law:**

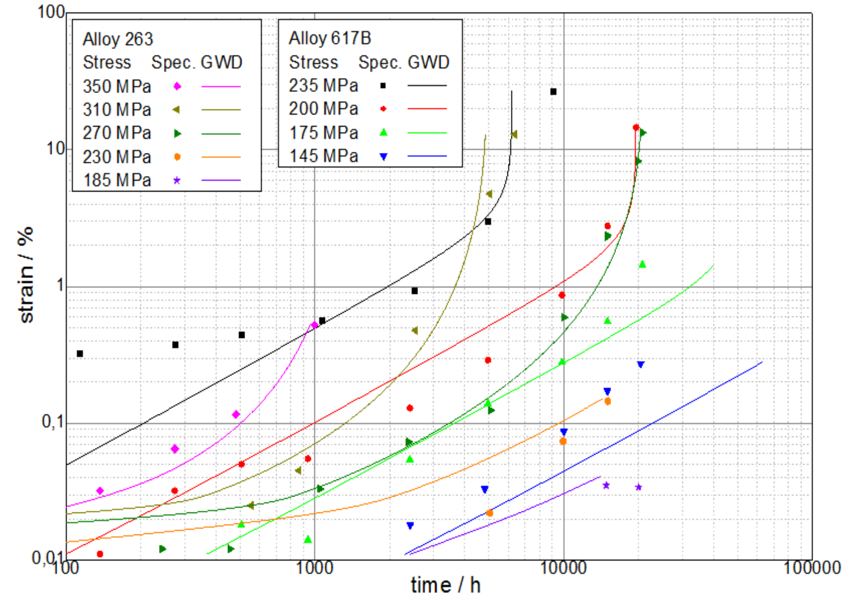
$$\frac{d\varepsilon}{dt} = 10^{A1}\cdot\left[\frac{\sigma}{1-D}\right]^{n1}\cdot\varepsilon^{m1} + 10^{A2}\cdot\left[\frac{\sigma}{1-D}\right]^{n2}\cdot\varepsilon^{m2}$$

$$\frac{dD}{dt} = 10^{AD1}\cdot\left[\left(\frac{\sqrt{3}}{q}\right)^{\alpha}\cdot\sigma\right]^{nD1}\cdot\varepsilon^{mD1} + 10^{AD2}\cdot\left[\left(\frac{\sqrt{3}}{q}\right)^{\alpha}\cdot\sigma\right]^{nD2}\cdot\varepsilon^{mD2}$$

with

$$q = \frac{1}{\sqrt{3}}\cdot\frac{\sigma_{Mises}}{\sigma_{Hydro}}$$



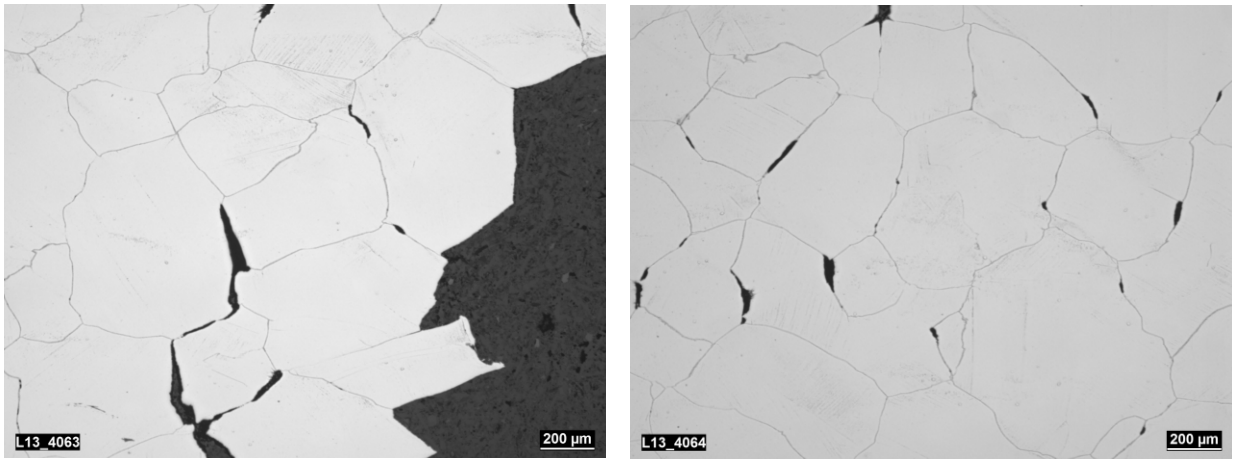


- **Norton and Garofalo type creep equations**
- **Constitutive equation based on Chaboche, Nouailhas, Ohno and Wang for creep-fatigue**

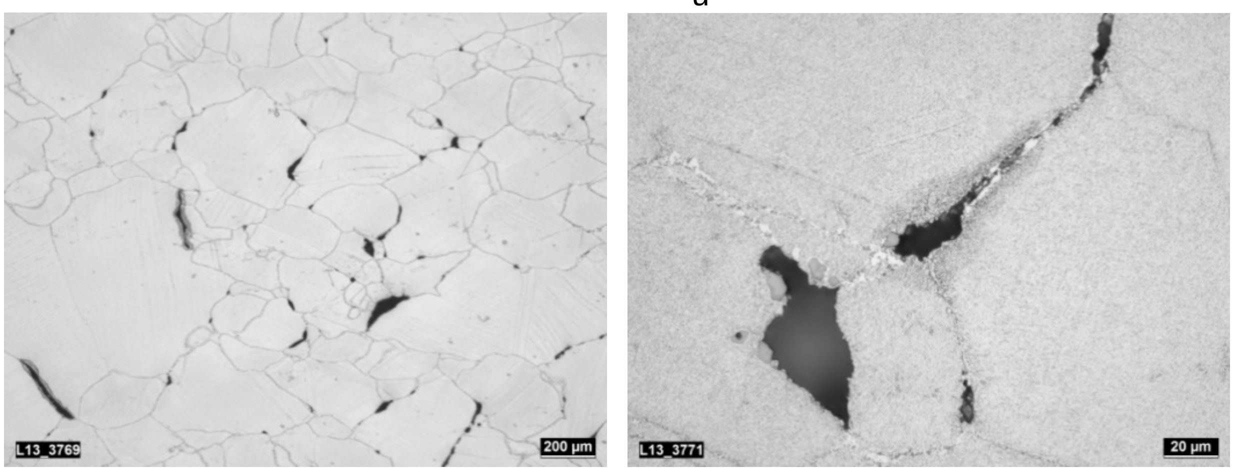
Advanced Design by Analysis – Tools available

Damage after creep, Alloy 617 (OM)

- **Creep damage behaviour at 700 °C (cross section of the creep specimens)**



T=700 °C, 200 MPa, tu=19.600 h, A_u=15 %, 167 / 303 HV10



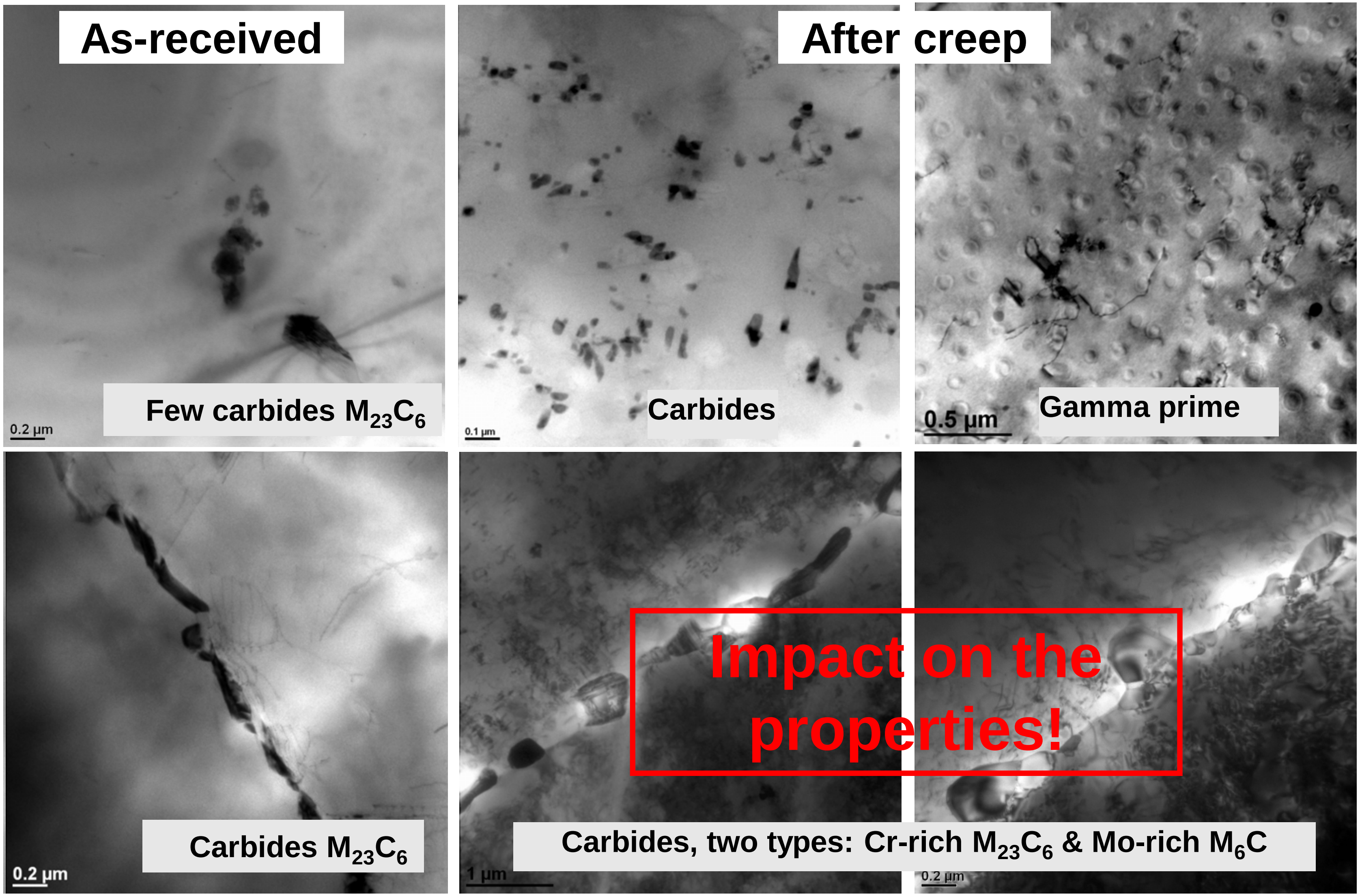
T=700 °C, 164 MPa, tu=45.000 h, A_u=22 %, 168/296 HV10

- Creep damage due to the separation of grain boundaries (micro cracks) in the investigated stress and temperature range
- Only limited creep void formation
- Important for the inspections and remain life time assessment

Microstructure of Alloy 617 (TEM)

Grain

Grain Boundary



Characterisation by thin metal foils & EDS & SADP