

CABRI CIP0-1 PRELIMINARY TEST RESULTS

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IRSN

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- Most utilities request, for economic reasons, an increase of the fuel discharge burn-up.
- MOX fuel is largely introduced
- Key points :
 - + improve clad alloys (M5, Zirlo, Duplex, MDA,...) which properties are limited by corrosion
 - + improve MOX microstructure (TU2, SBR) to minimize fission gas release

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- Determine UO₂ and MOX high burn-up fuel behaviour under RIA conditions
- Determine safety margins
- Propose new safety criteria more adapted to high burn up fuel

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- In 2000, IRSN proposed a new program under the auspices of OECD
- 12 tests planned
- 14 organisations from 11 countries have signed an agreement with IRSN

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- 2 first tests performed in the Na loop environment (reference)
 - + CIP0-1 75 GWd/t cladde d with Zirlo - 30 ms pulse width
 - + CIP0-2 75 GWd/t cladde d with M5 – 30 ms pulse width
- Both tests performed in November 2002
- CIP0-2 (M5) exhibited no clad failure

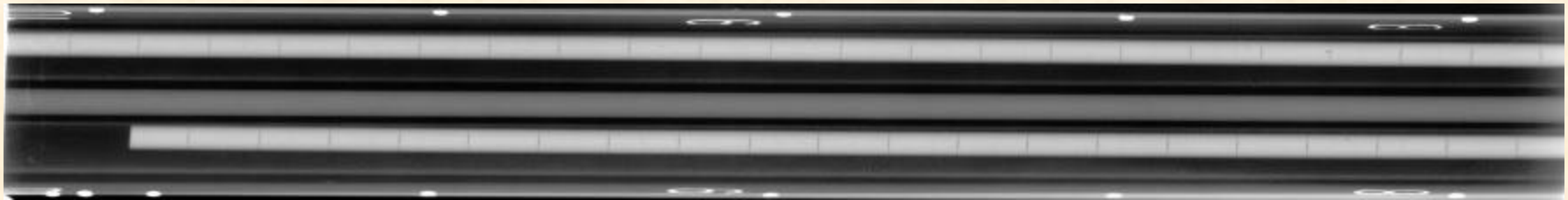
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- Irradiated in the Vandellos reactor (Spain) up to 74.8 GWd/t (pellet burn-up)
- Examined and refabricated in the Studsvik Labs (Sweden)
- Shipped to Cadarache in June 2002

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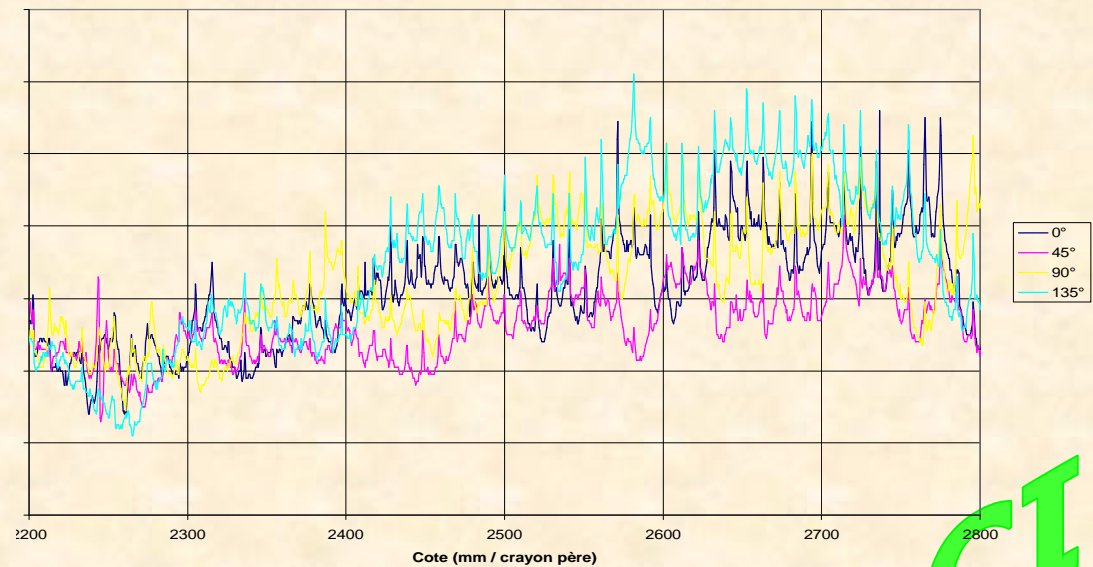
Examinations

Neutronography : hydride concentrations at pellet-pellet interface

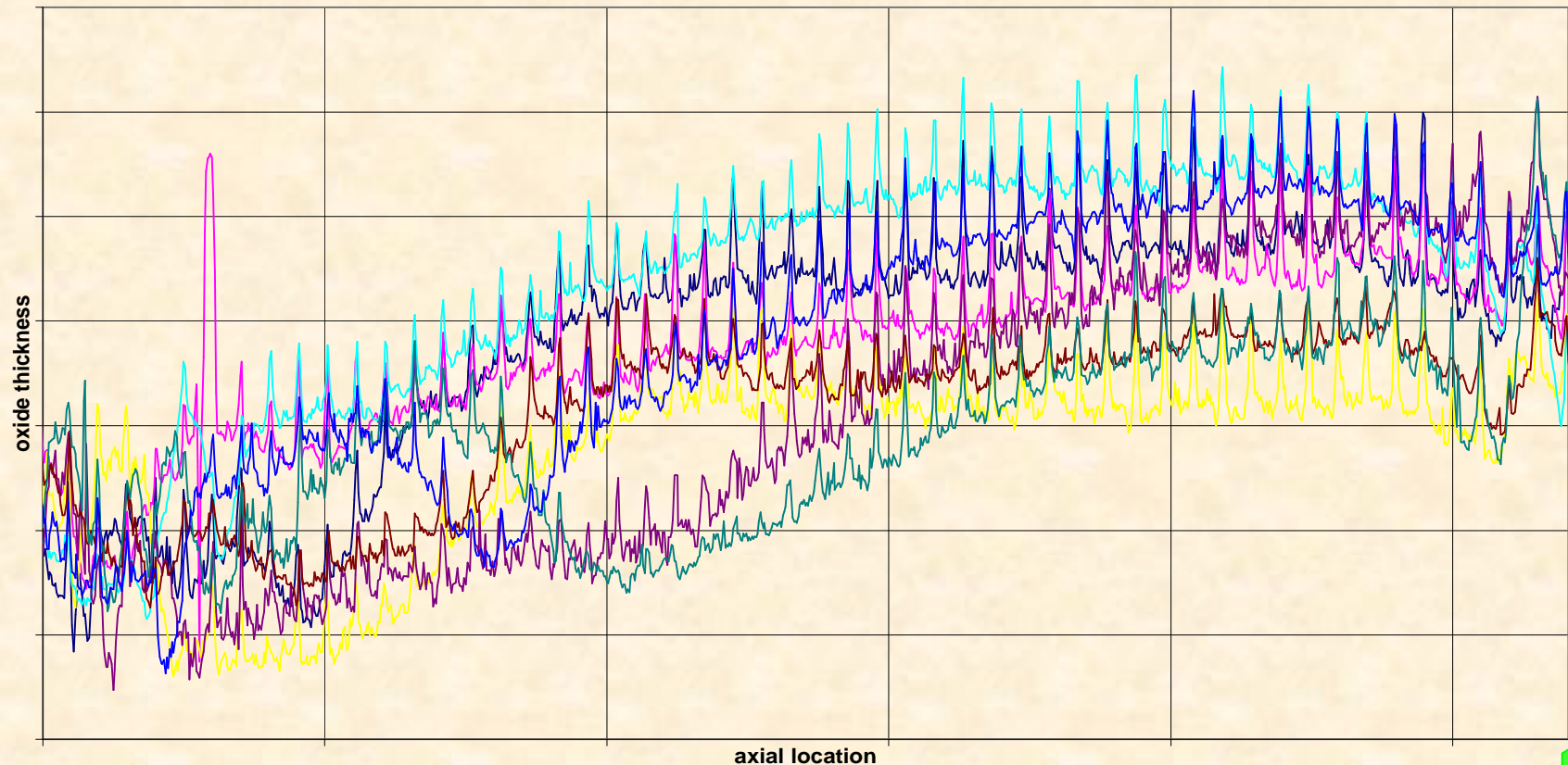


Metrology:

Typical of high burn-up fuel
(ridges, ovalization)



Important zirconia layer (75 μm average) with large axial azimuthal variations

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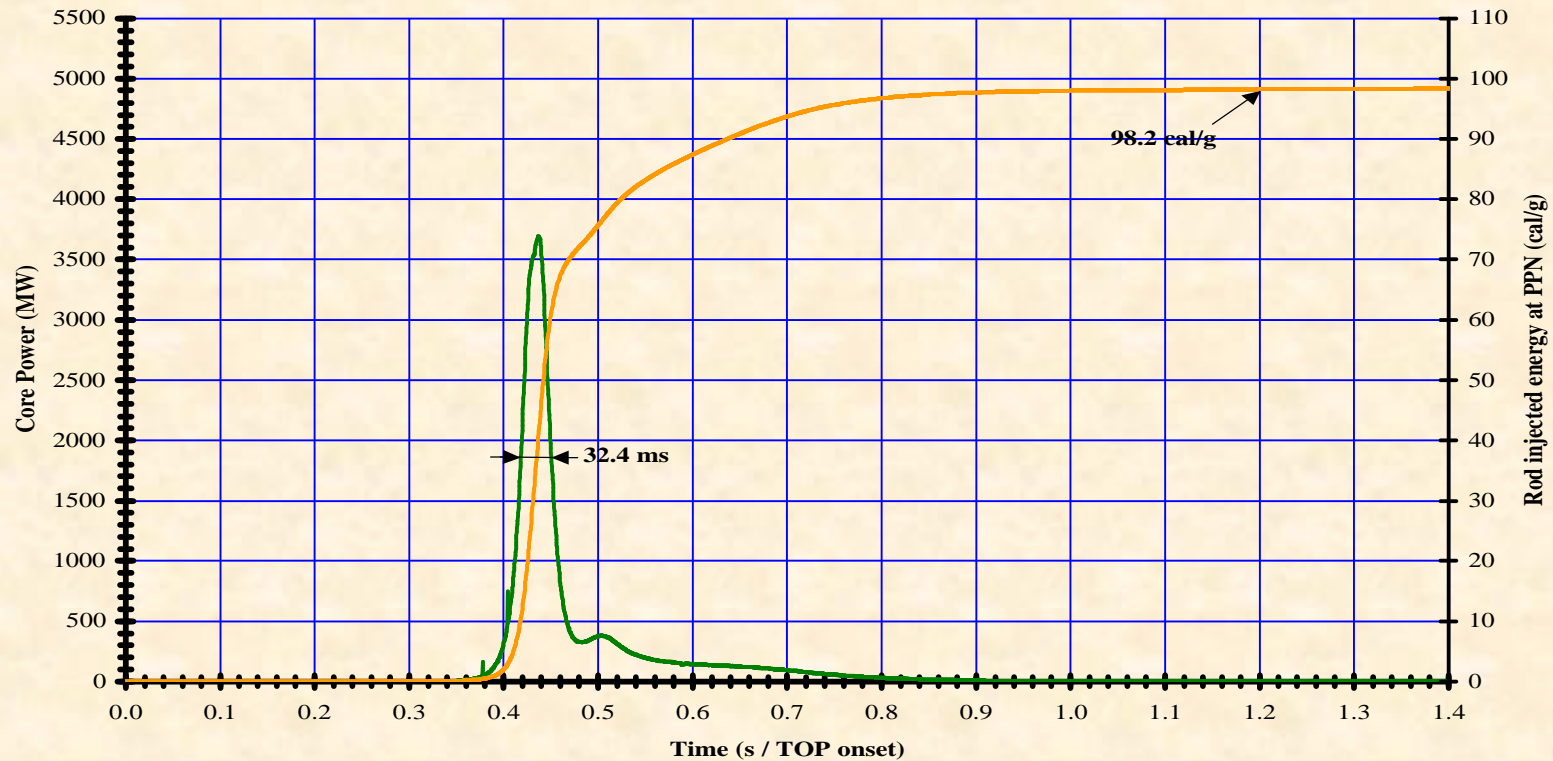
Mid-height width : 32.4 ms (30)

Total energy deposit : 98.2 cal/g (100)

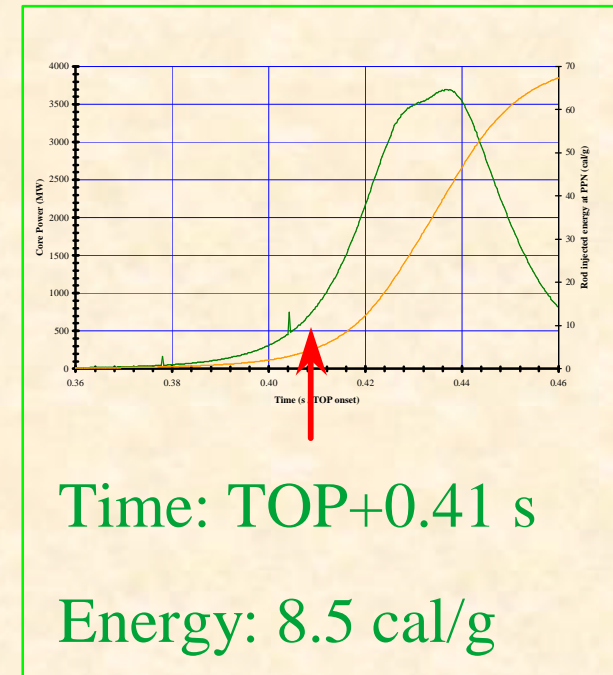
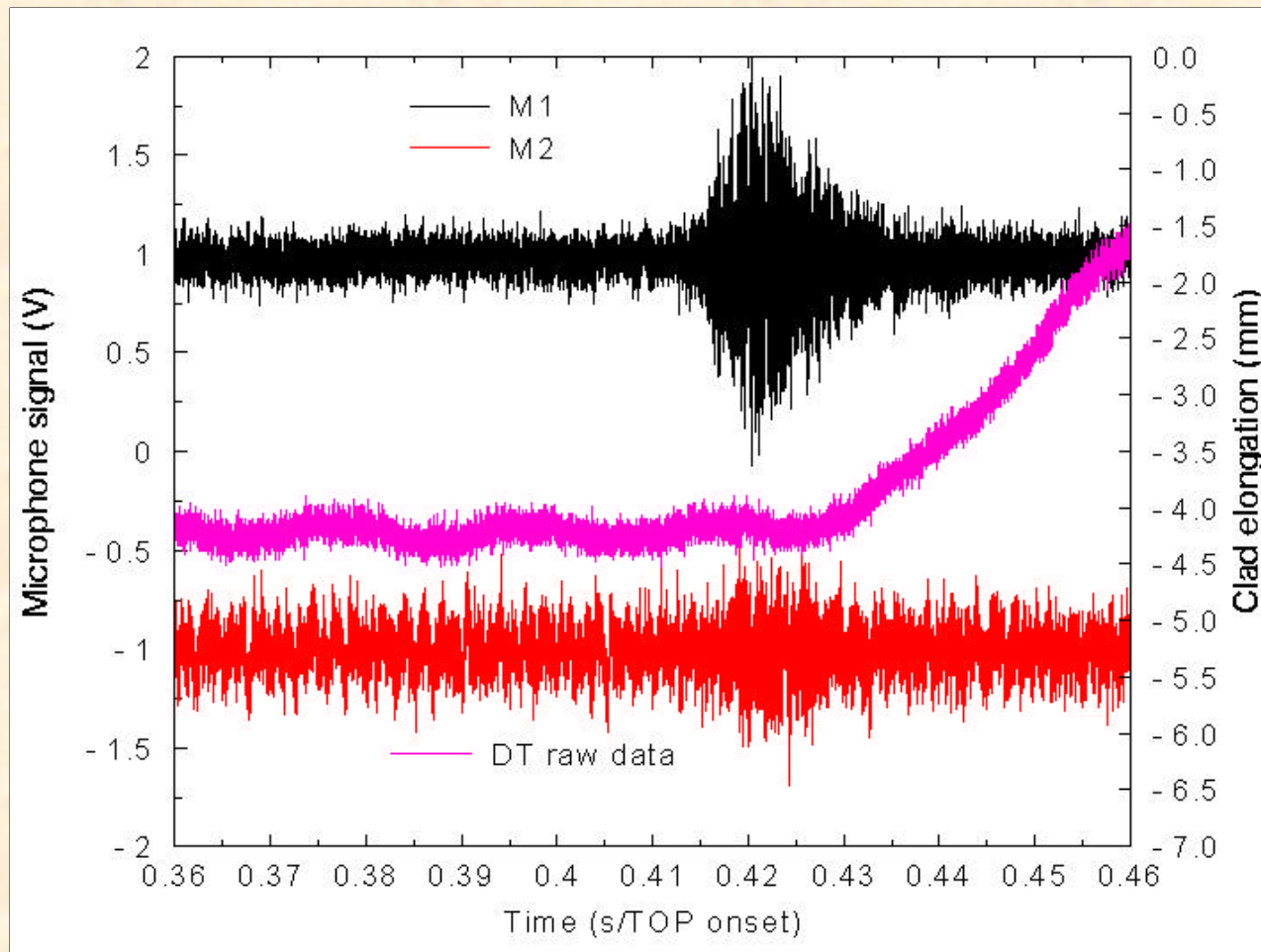
Fluid velocity : 4 m/s

Coolant temperature : 280°C

Core power : 100 kW

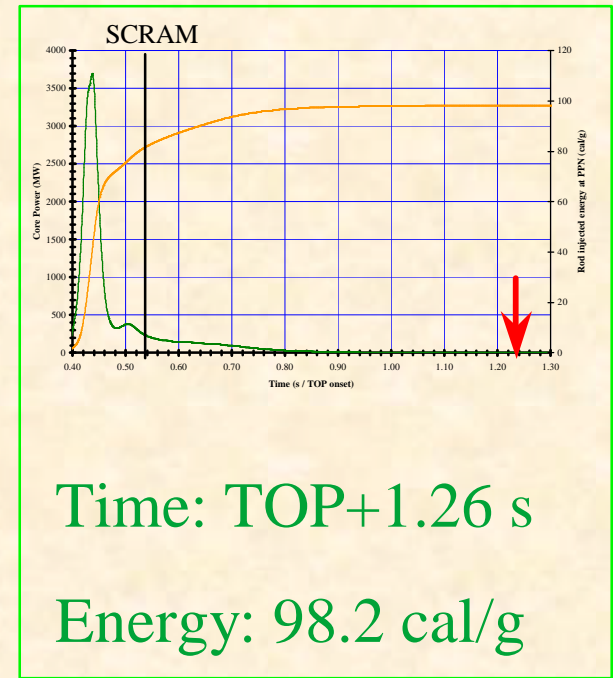
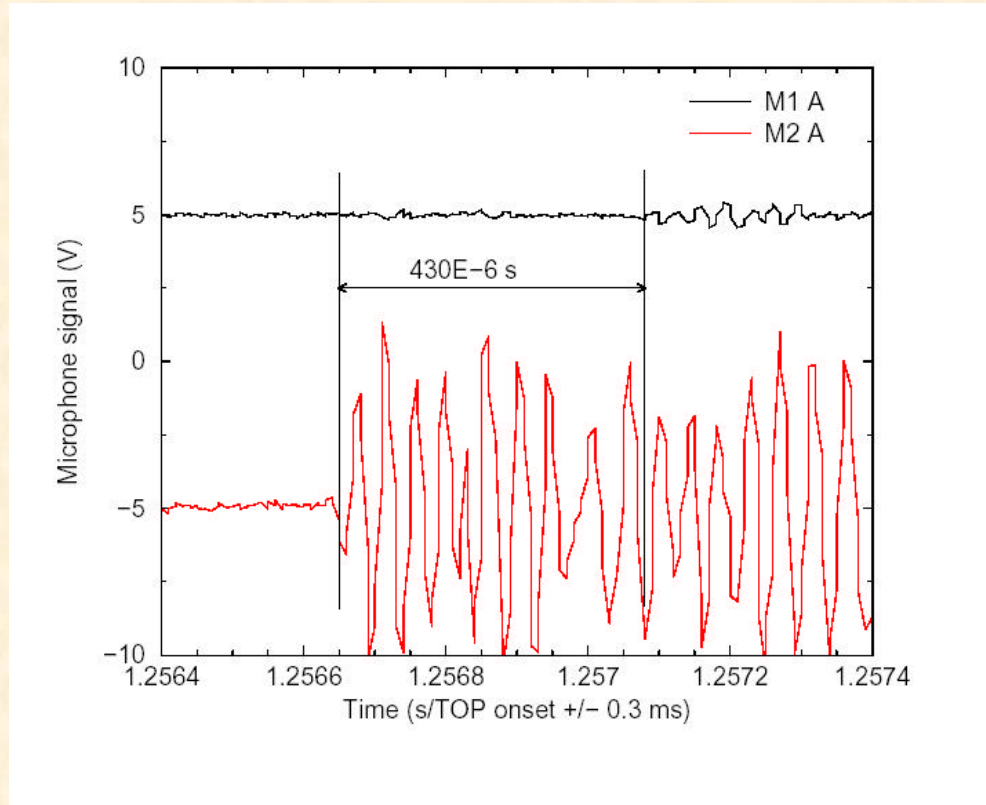


Microphone event linked with axial clad elongation



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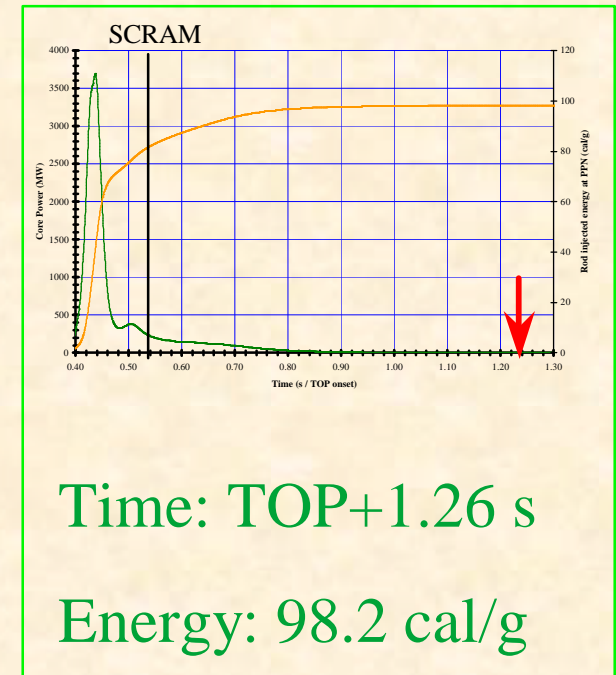
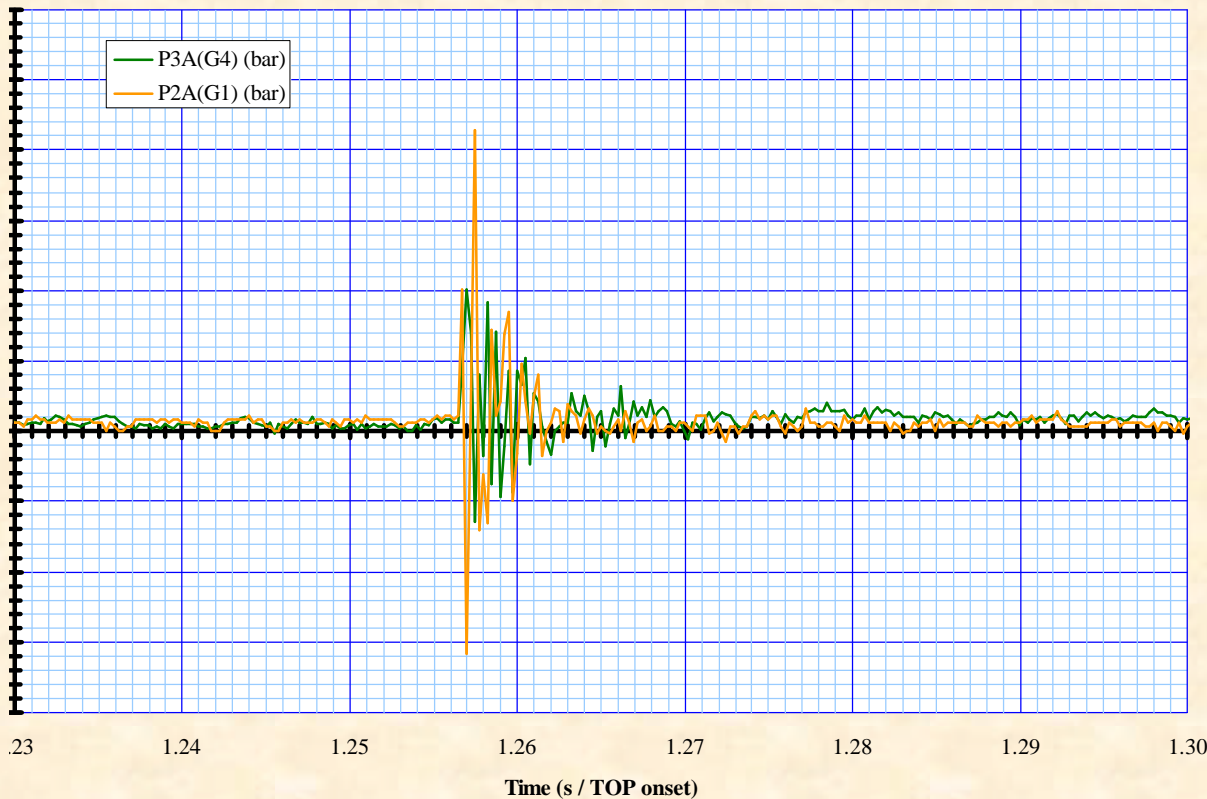
Microphone event



Location well above the tested rod !

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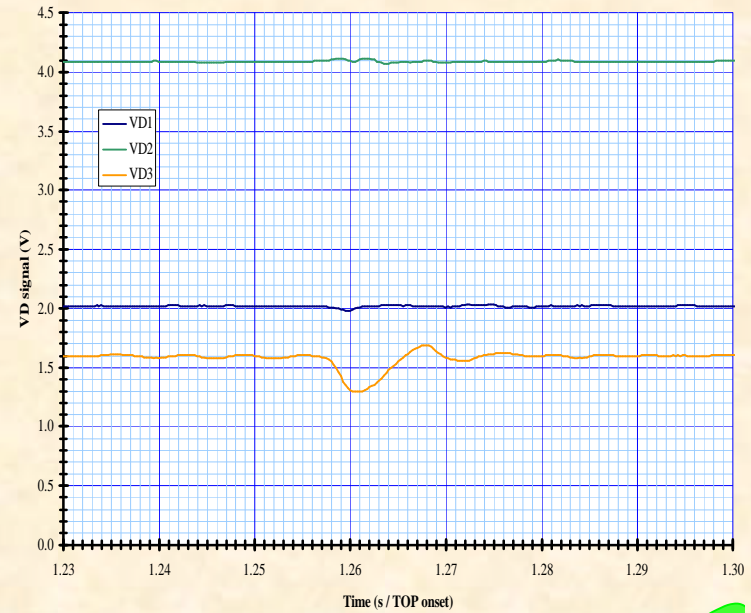
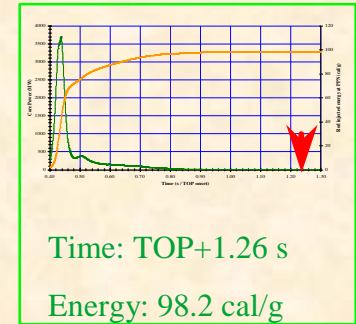
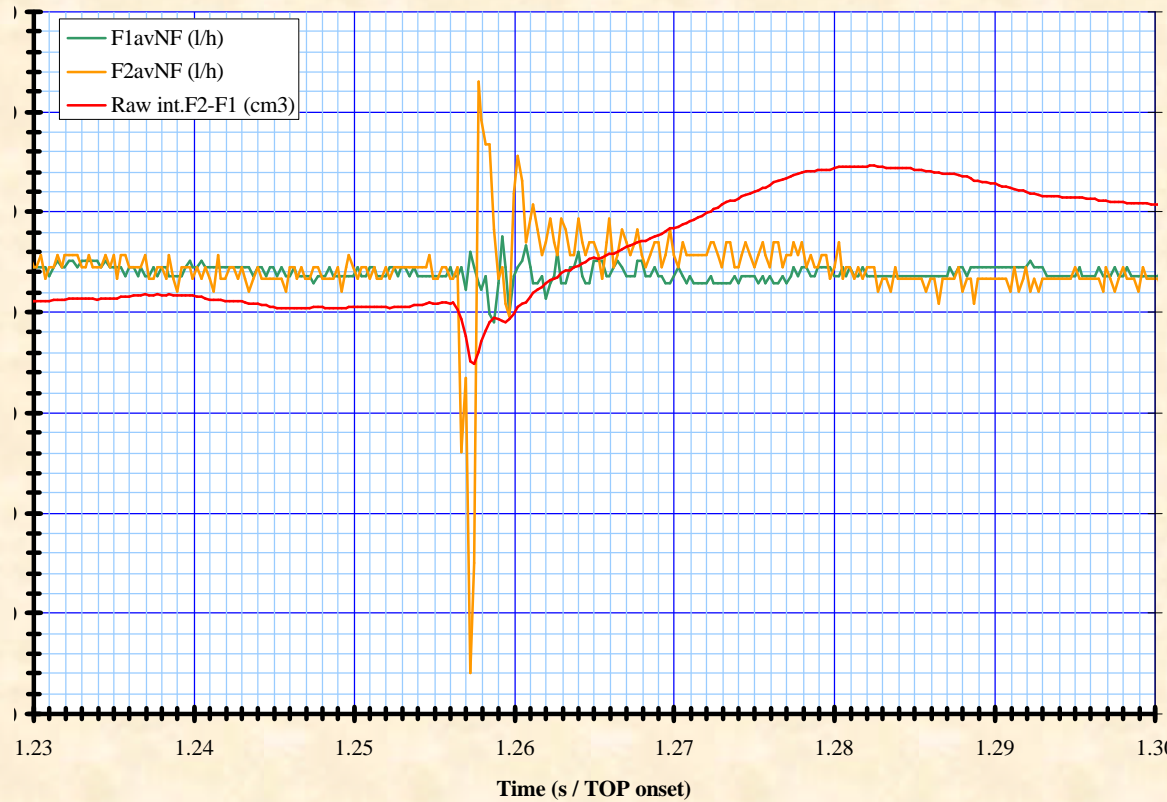
Pressure event



150 μ s before microphone event !!!

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Flow and VD event

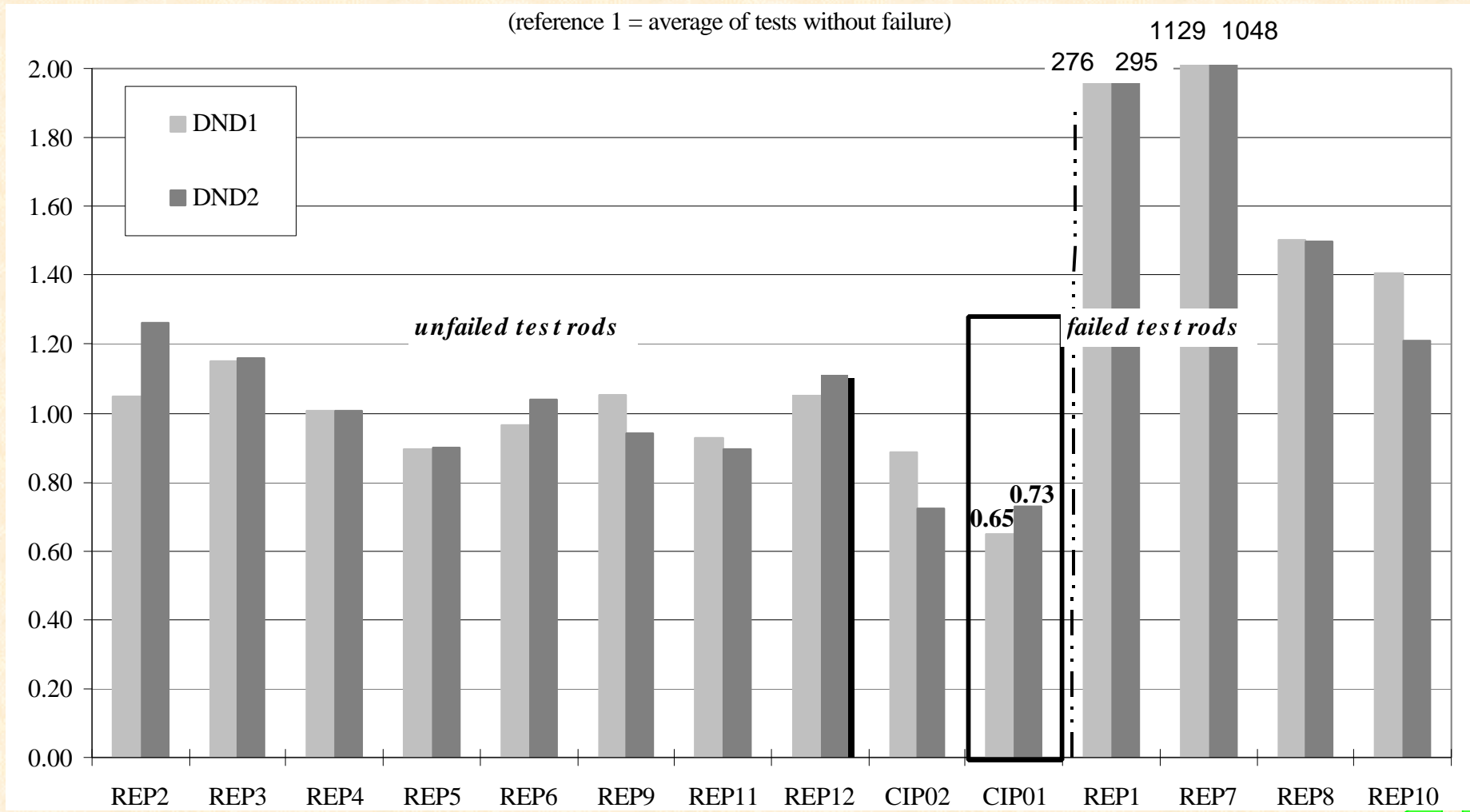


150 μ s before microphone event !!!

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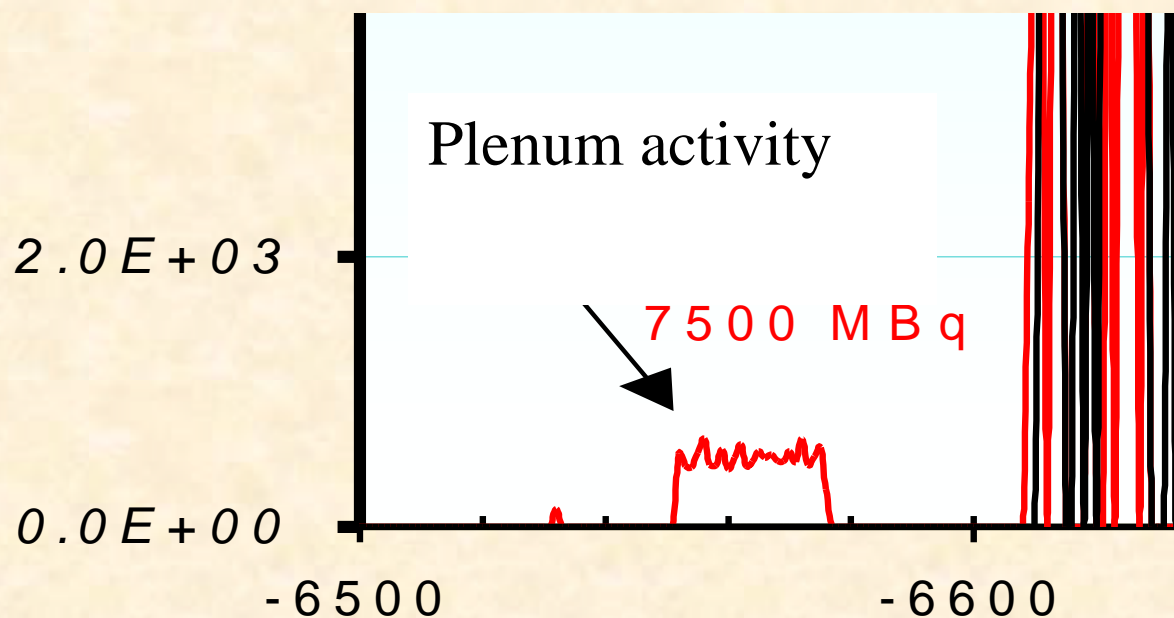
- Microphone event close to saturation on M2
- Flow, pressure and VD event
- This event could be interpreted as clad failure, but:
 - No detection on DND signals
 - No detection of ^{85}Kr on the Na cover gas after test
 - Unconsistent timing: P,Q before microphones
 - No failure seen during visual examination in hot cells
- Quantitative gamma-scanning on the upper plenum was performed

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Quantitative Gamma-scanning



Activity consistent with expected amount of FG release

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- First event = clad elongation
- Second event = most probably not a failure

The non failure will be confirmed by pin piercing in fall 2003

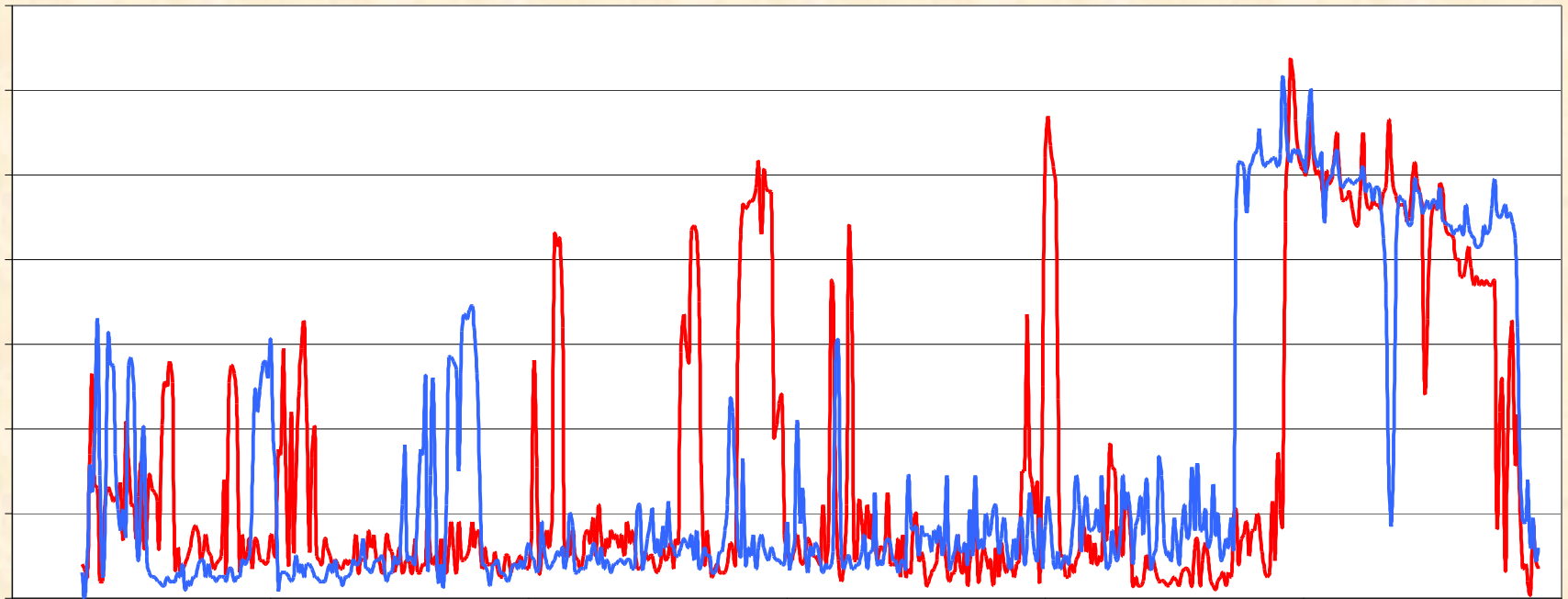
Non-destructive examinations performed :

- visual examination, profilometry
- gamma-scanning
- zirconia layer : **extended spalling**

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Zirconia measurement

extended spalling



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- Pin piercing and gas analysis in **Fall 2003**
- Destructive examinations will be performed :
axial and radial cuts at the **beginning of 2004**
- The signal analysis is undergoing (explanation of second event)

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PROMETRA Program defined within the CIP for advanced cladding materials (Zirlo, M5-6cycles)

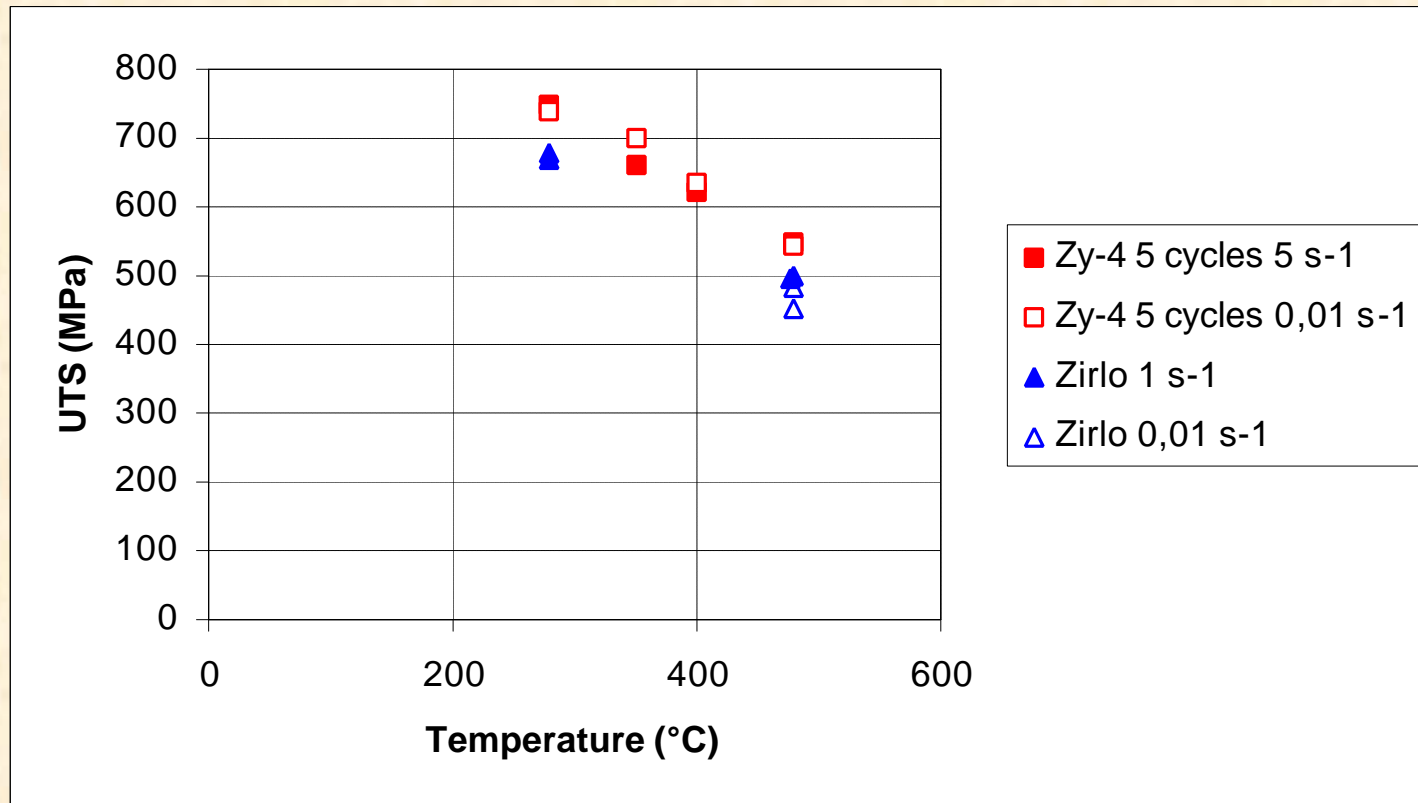
Objectives : determine the stress-strain laws and failure data

Common test matrix

- 10 hoop tensile tests (doubled) : $T = 280-800^{\circ}\text{C}$, 1 s^{-1}
 $T = 480^{\circ}\text{C}$, strain rate : 0.01 s^{-1}
- 8 Penn-State type tests (doubled) : $T = 280-800^{\circ}\text{C}$, 1 s^{-1}
- 2 burst tests $T = 280^{\circ}\text{C}$, 1 s^{-1}

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Comparison of UTS results between Zirlo and Zr4-5 cycles



Hoop tests at higher temperature finalised
Following part of the test program in 2004

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- CIP0-1 successfully performed
- Presumption of non failure – confirmation Fall 2003
- Physical origine of late event signals to be analyzed
- CIP0-1 very last test with Na loop
- 1st test (CIPQ) in the water loop foreseen in 2006

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