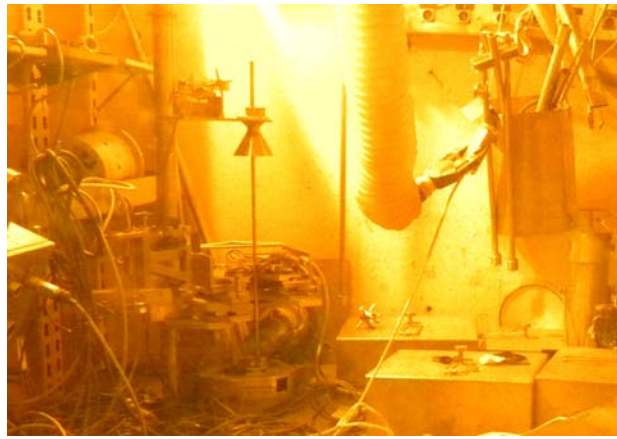
DE LA RECHERCHE À L'INDUSTRIE

The contribution of the bench VENDAUM in LECA-STAR (Cadarache) for Non-Destructive Examinations

L. LOUBET

Place Vendôme (Paris)



Banc Vendaum (Cadarache)

Idaho Falls 23 -26 sept 2013

Summary

1 : Non-Destructive Examinations on irradiated fuel rods

- Interest of the Non Destructive Examinations on fuel
- NDE at LEGEND Laboratory in LECA STAR

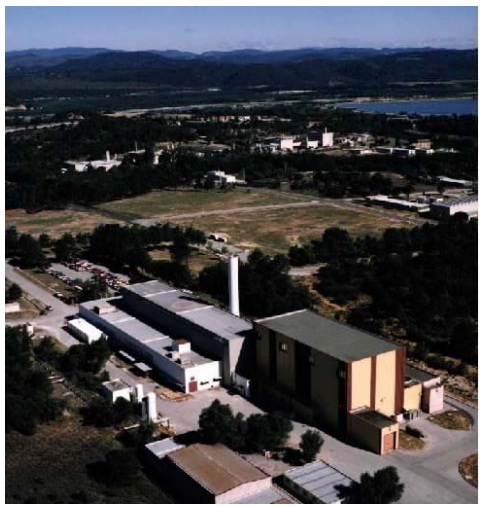
2: NDE on VENDAUM bench in LECA

- Characteristics of the bench
  - position in the hot cell
  - design
  - modularity
- Overview of the potential of VENDAUM from some results

Conclusion and prospects

Improvement and characterization of nuclear fuel

LECA-STAR Facility in Cadarache



Post irradiation examinations in hot cells:

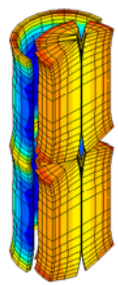
- **<u>Non Destructives</u>**
- Drilling, cuttings
- Destructives

REQUEST
Government, EDF, AREVA, IRSN

Actual and future PWR's,
Metal test reactors and nuclear powered navy ships,
Future concepts,
Imterim storage

COMPREHENSION OF THE MECHANISMS COMPUTERIZED SIMULATION

QUALIFICATION FOLDERS



FUEL CONCEPTION

Mécanical, Thermal, Materials
Micro-structures,
Physics and Chemistry

LECA-STAR VERDON LARC

EXPERIMENTAL DEVICES

POST IRRADIATION EXAMINATIONS

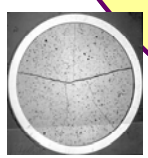
ANALYTICAL EXPERIMENTS

CHEMICAL ANALYSES

LEFCA – LBF LARC

FABRICATION CARACTERIZATION

CHEMICAL ANALYSES



IN-PILE TESTS

PWR's, OSIRIS, CABRI, PHENIX, RJH, HFR, BR2, ATR …

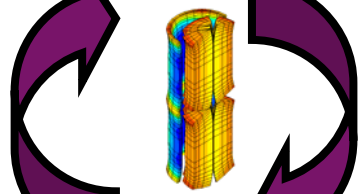
NDE in LECA STAR

Arrival of the irradiated elements

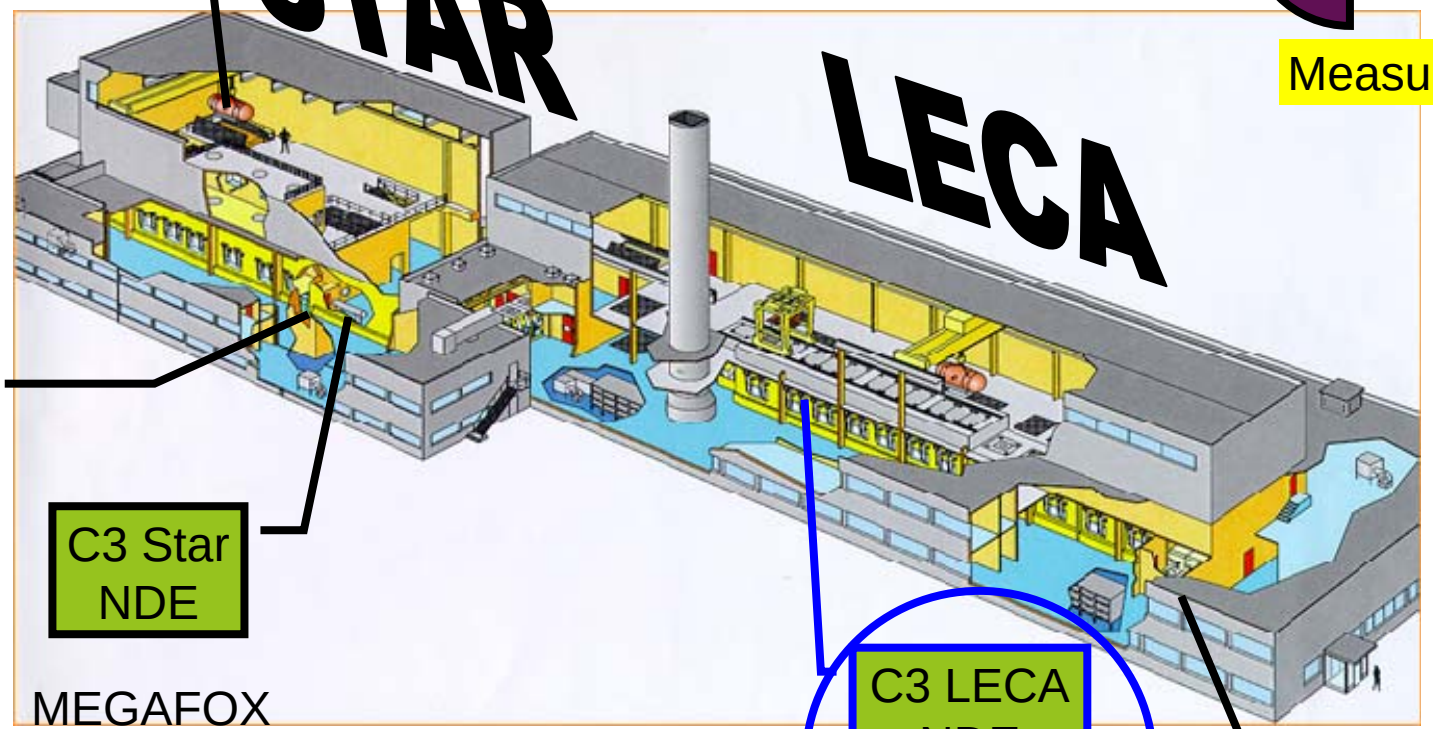
Irradiated objects

➔ Hot cells

Simulation



Measurement



C2 Star Drilling, cuttings

C3 Star NDE

MEGAFOX

Bench

C3 LECA NDE

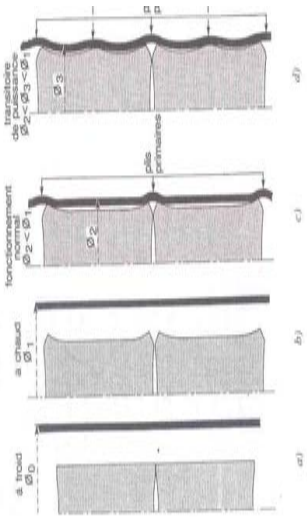
VENDAUM

Bench…

DE

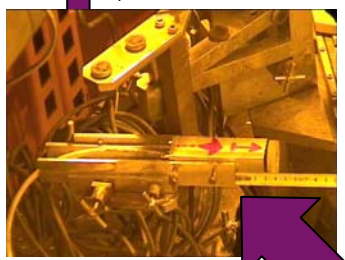
Non Destructive Examinations in hot cells

irradiated



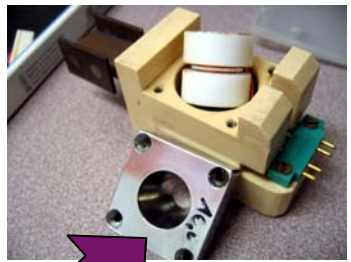
fabricated

Cladding aspects camera



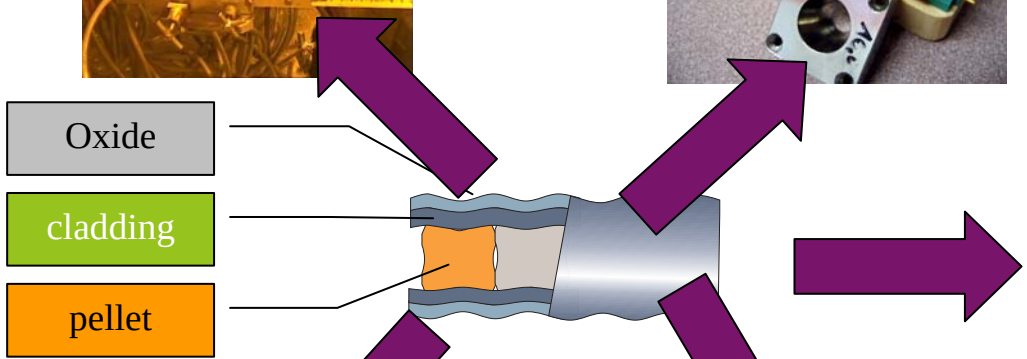
Cladding defects, health

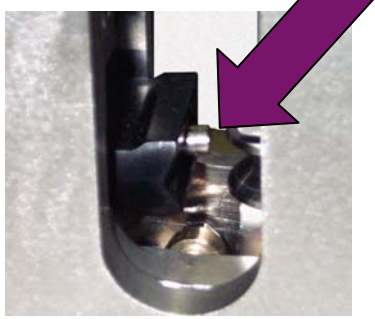
Eddy currents sensor



Fuel column

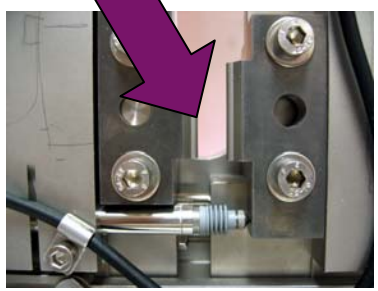
Gamma detector





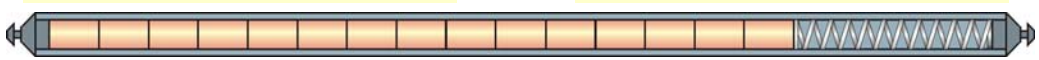
Oxide thickness sensor

External corrosion



LVDT sensor

Diameter measurement

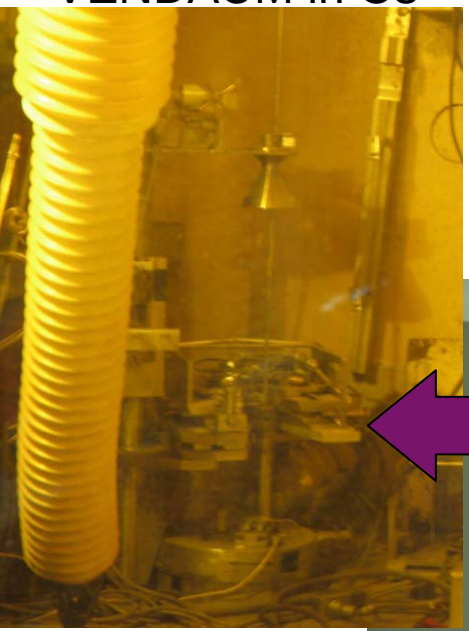


2: NDE on VENDAUM bench in LECA

- Characteristics of the bench
  - position in the hot cell
  - design
  - modularity
- Overview of the potential of VENDAUM from some results

Cellule 3 at LECA

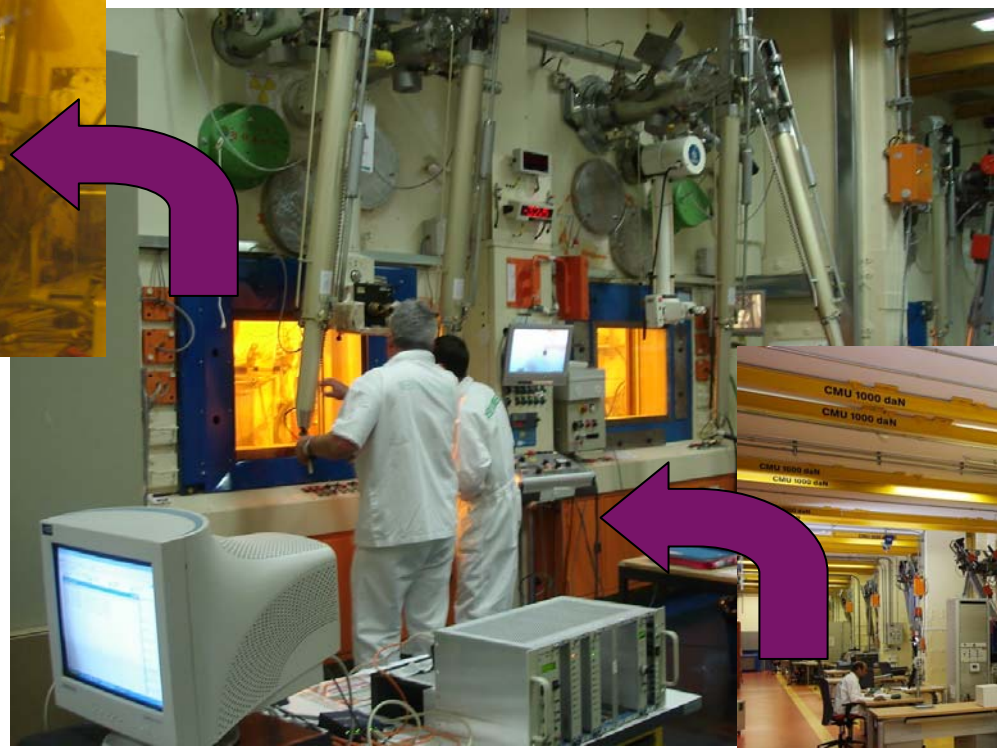
VENDAUM in C3



12 hot cells in LECA

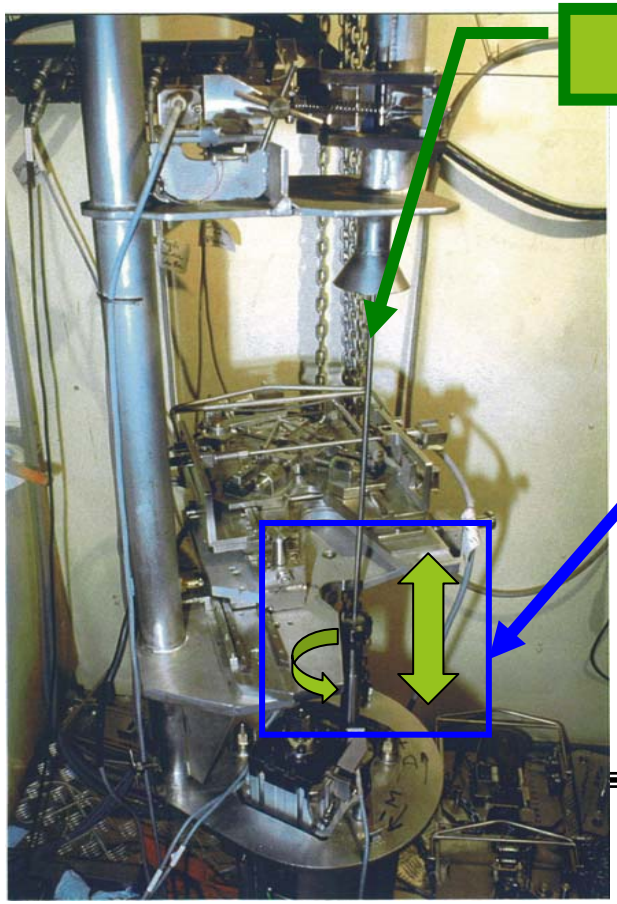
NDE, preparation of samples, DE, waste, storage…

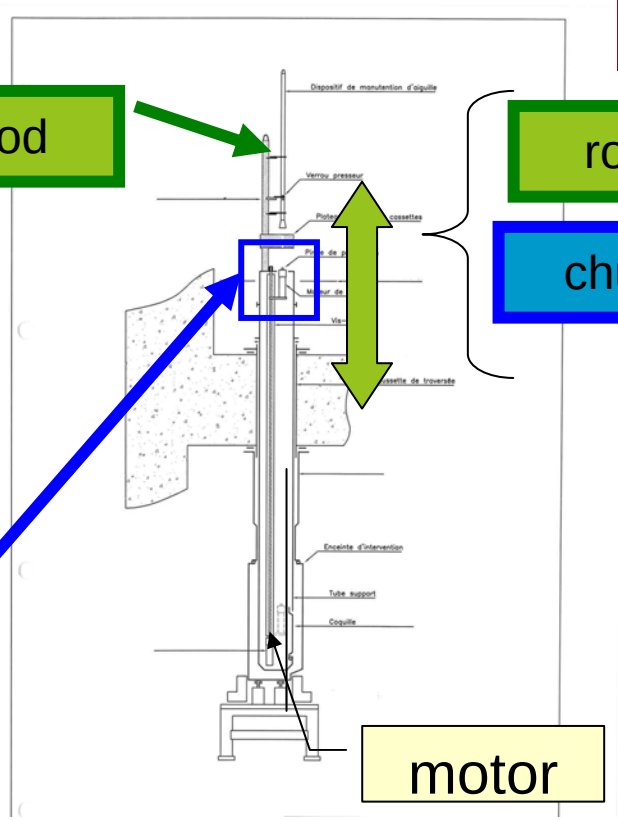
Front area of C3 in LECA

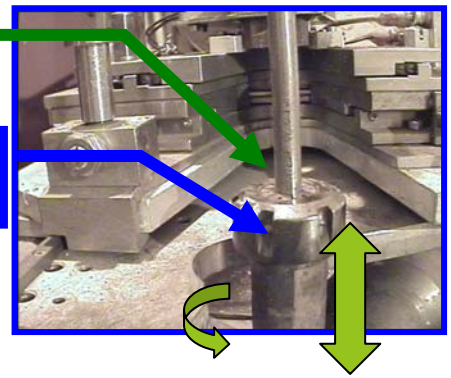


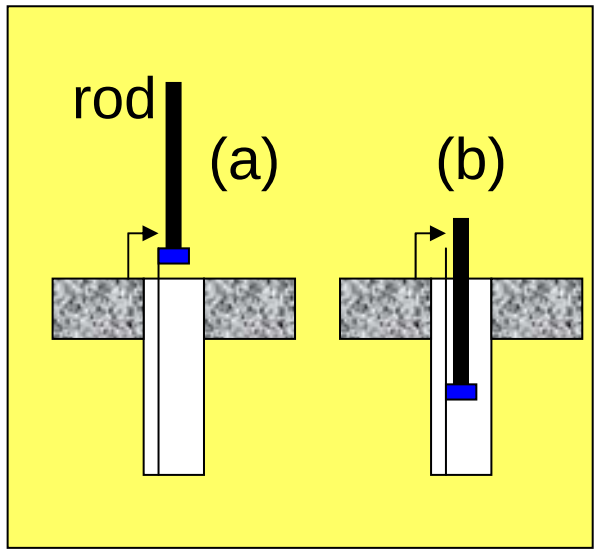
Front area in LECA

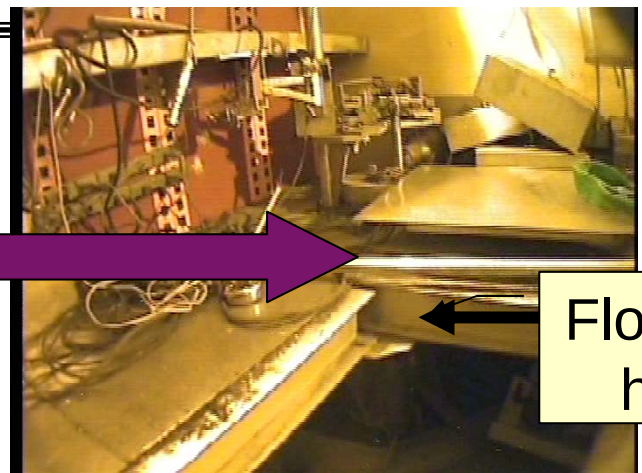
VENDAUM BENCH : moving the rod in a vertical direction









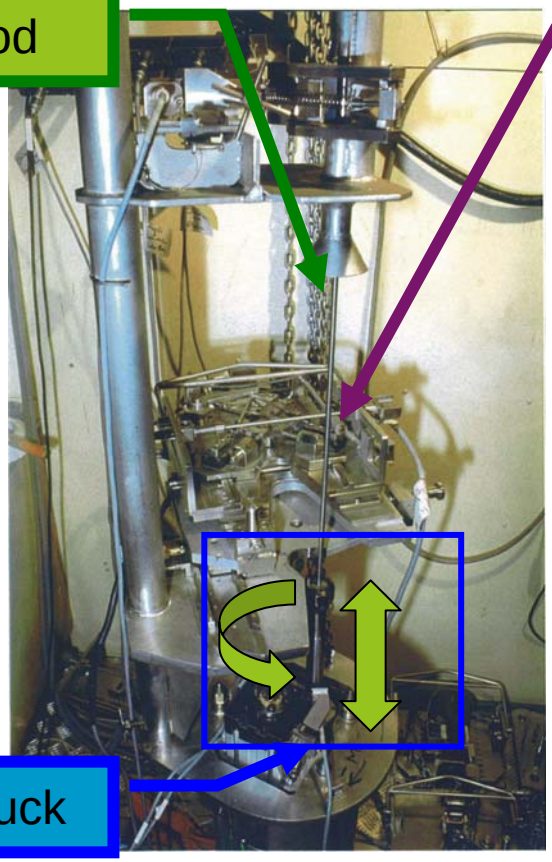


Thanks to dedicated area under the hot cell a 2.7 m* rod can be scanned from its bottom (a) to its top (b)

* 106 inches

VENDAUM BENCH : modular

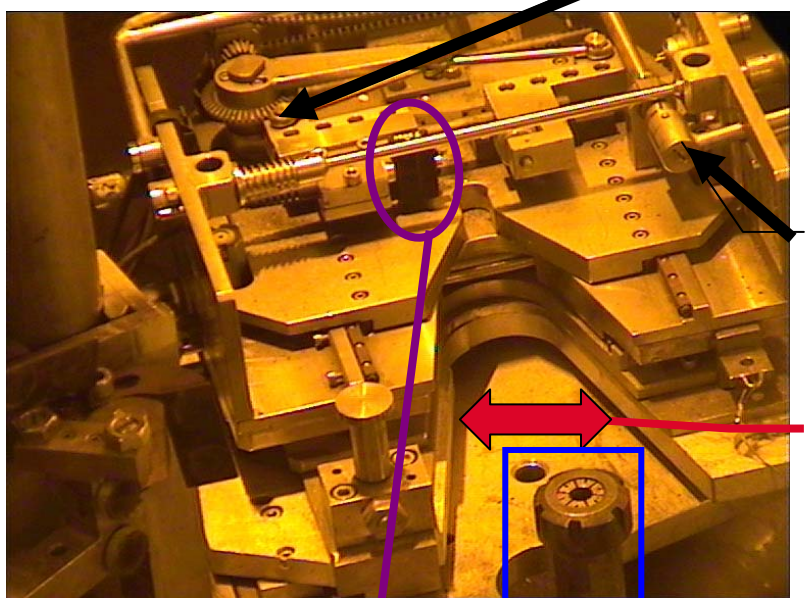
rod



chuck

Measurement cartridge

- 1 for visual
- 1 for diameter
- 1 for oxide thickness
- 1 for health…



Mechanical set up

Design for tele operation

Acceptance up to Φ 4cm*

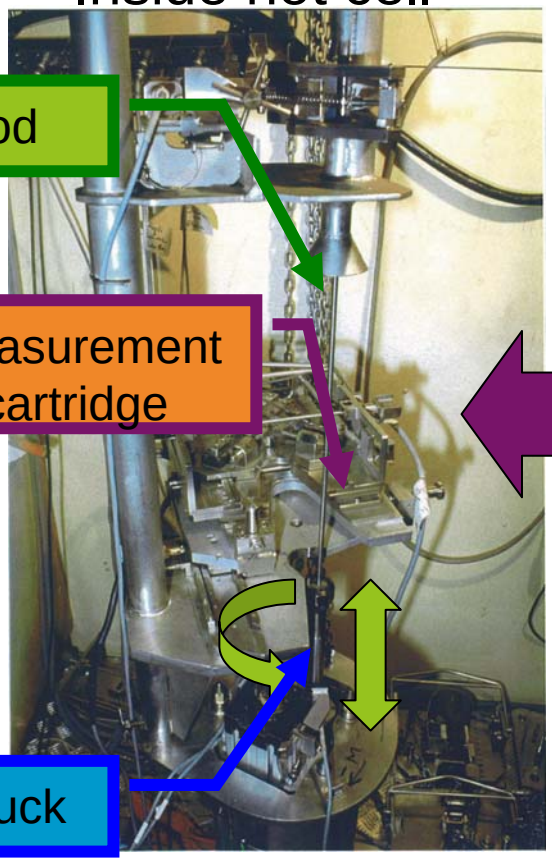
Motionless sensor

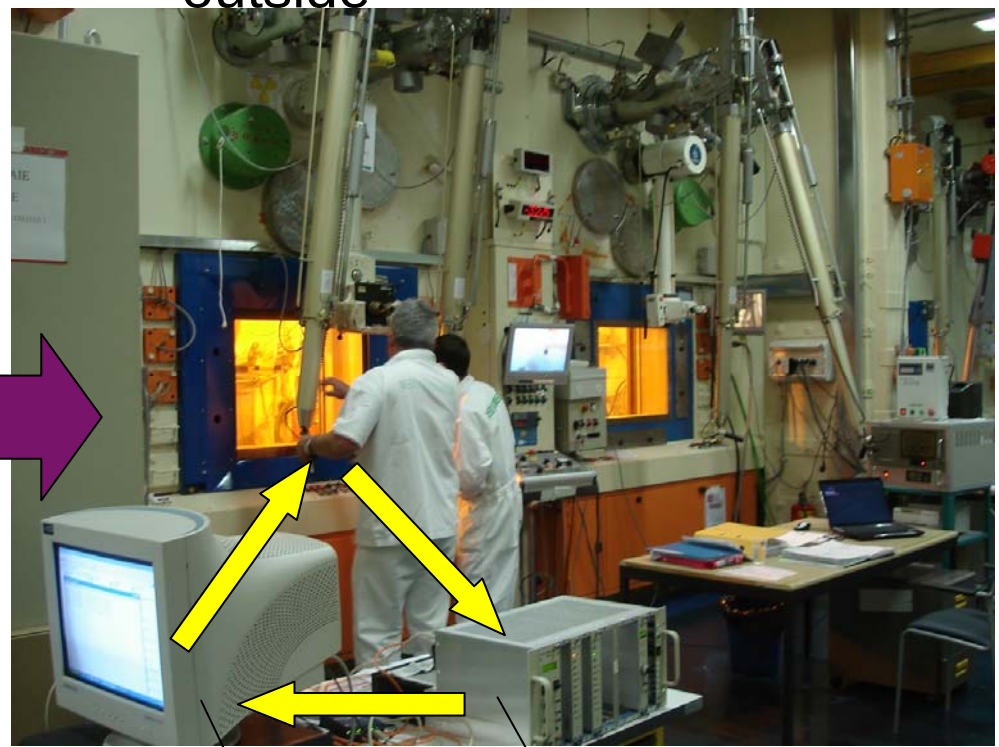
* 1.57 inch

VENDAUM BENCH : automatic

Inside hot cell

outside



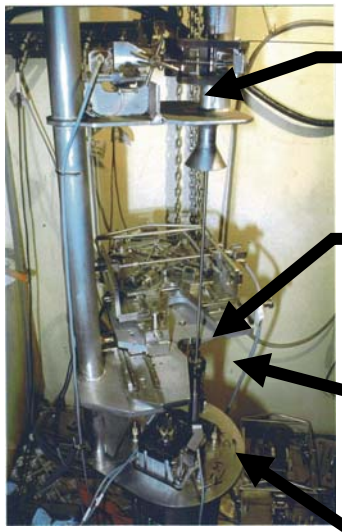


Motionless sensors

Moving objects

(L<2.7 m ; Φ< 4 cm)

Measurement on VENDAUM



Measurement cartridge

rod

chuck

motors

3

2

1

Measure at this position

Displacement of the rod

asking for a position (z, Θ) on the rod

command control computer

saving the data

acquisition

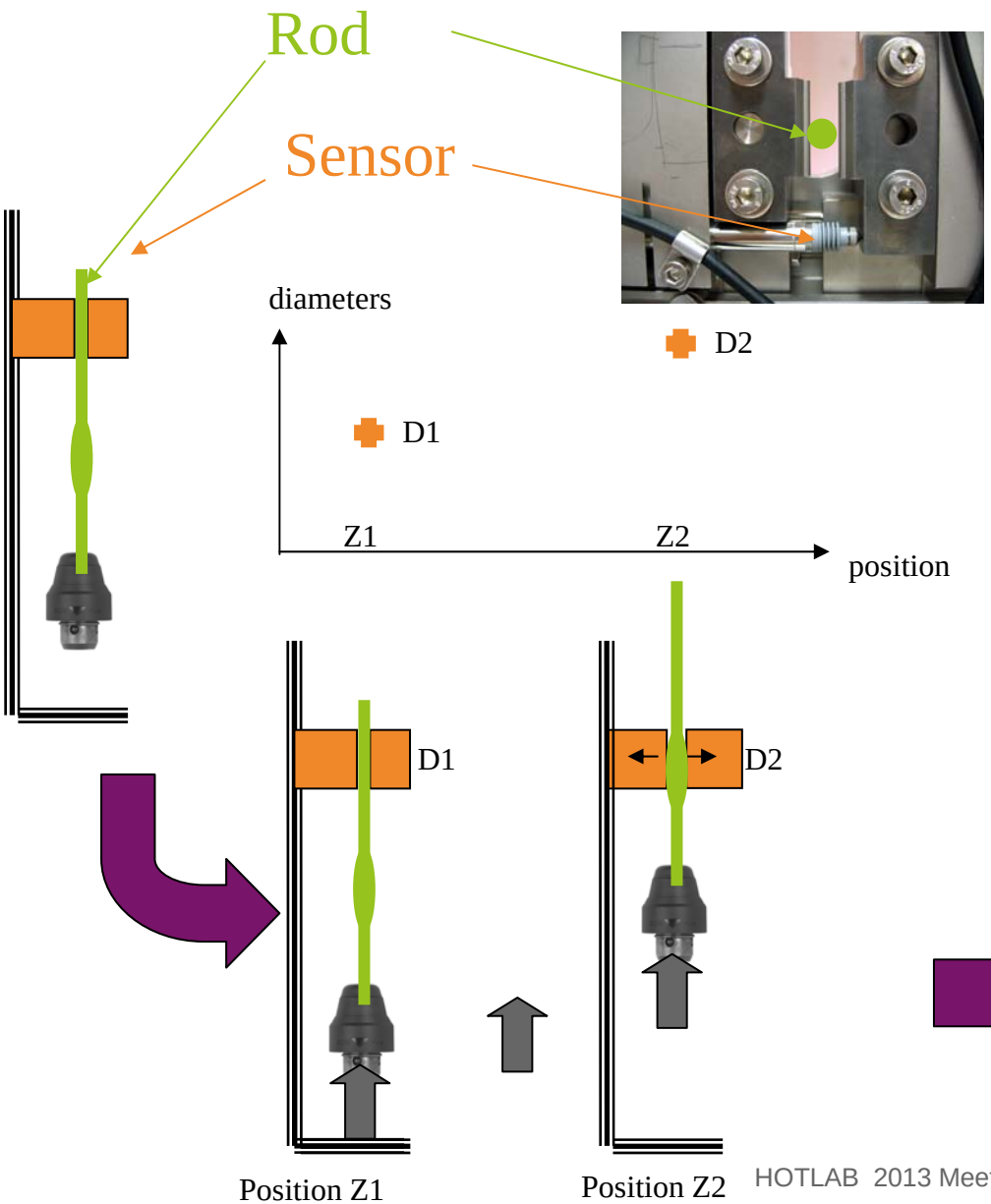
4

For each method, a standard is used in cell to certify our results

Focus on cable

Focus on SBM

Example of diameters Measurements



Changes in diameters

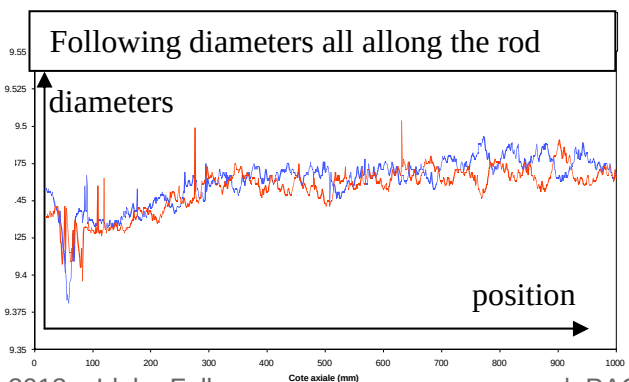
↔

changes of the sensor

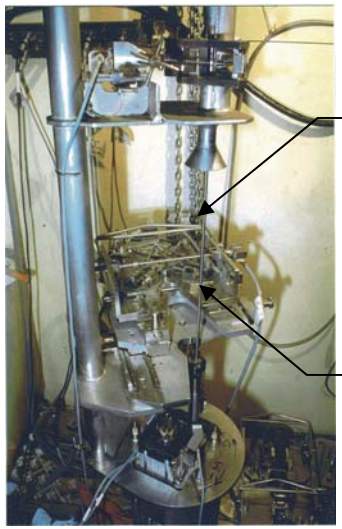
1 point / 0.5 mm

0°, 45°, 90°, 135°

Position	: Measure
Z1	: D1 (mm)
Z2	: D2 (mm)…



Characteristics of VENDAUM



rod

Measurement cartridge

Command Control

Acquisition block

Vertical

Examinations

Non

Destructives

AUtomatic

Modular

on irradiated rods

(L<2.7 m ; Φ< 4 cm)

Diameters, video, oxide thickness, cladding, F column

Precise positioning

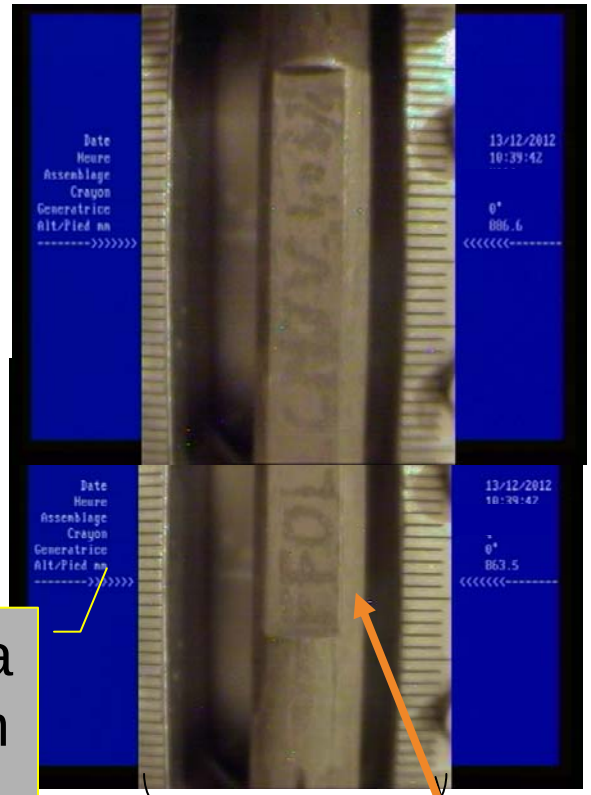
comparisons

2: NDE on VENDAUM bench in LECA

- Characteristics of the bench
  - position in the hot cell
  - design
  - modularity
- Overview of the potential of VENDAUM from some results

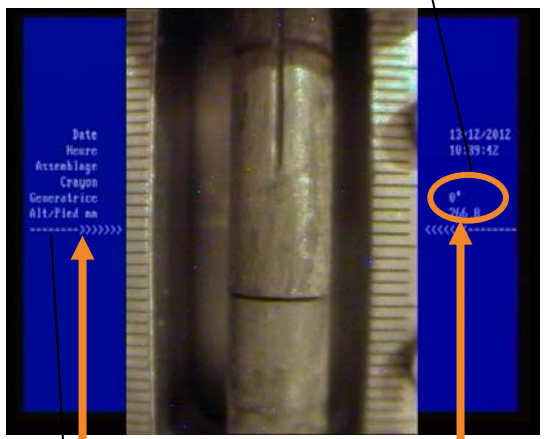
Overview of the VENDAUM's potential : positionning

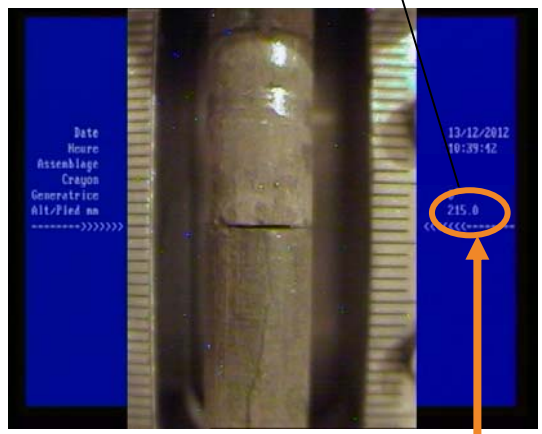
Visual examinations



0°

215 mm





Precise and reproducible positioning in z and theta

Data from cc

Photo of the rod

Reception of objects in hot cell Identification, nuclear inventory

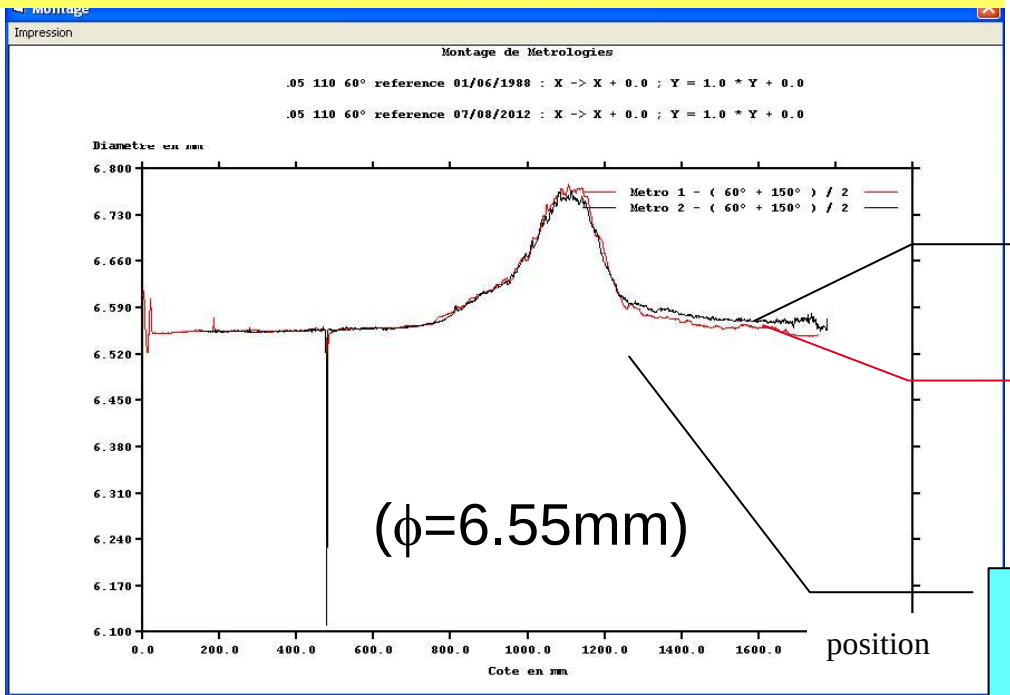
Detection and localization of defects

Overview of the VENDAUM's potential : reproductibility

With its characteristics, VENDAUM was first dedicated to NDE on fast reactors pins (Phenix)

It has conserved all its capacities in the subject, recently reactivate for transmutations new studies for example

Diameter measurements on Phenix's pin



2012

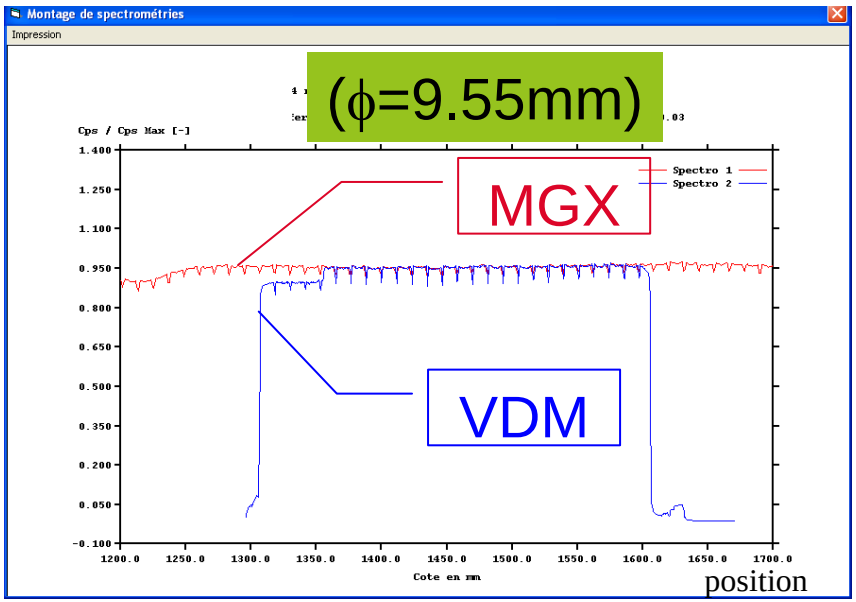
1988

Same results :
(+) positioning, saving

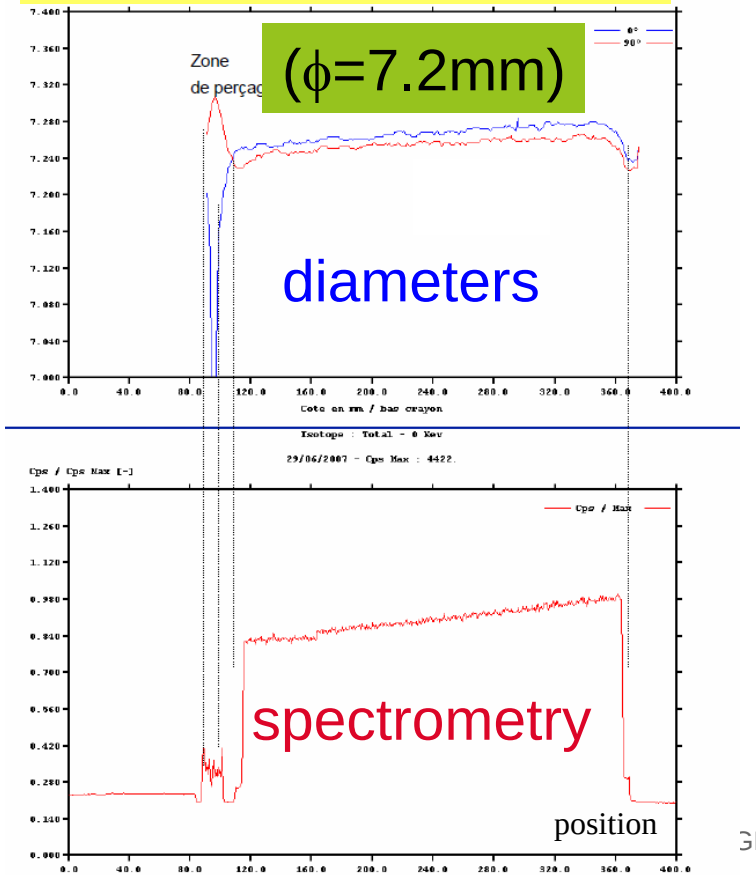
Overview of the VENDAUM's potential : large acceptance

With its characteristics, VENDAUM accepts a large scale of irradiated rods,

NDE on part of PWR rod



NDE on rod from foreign reactor

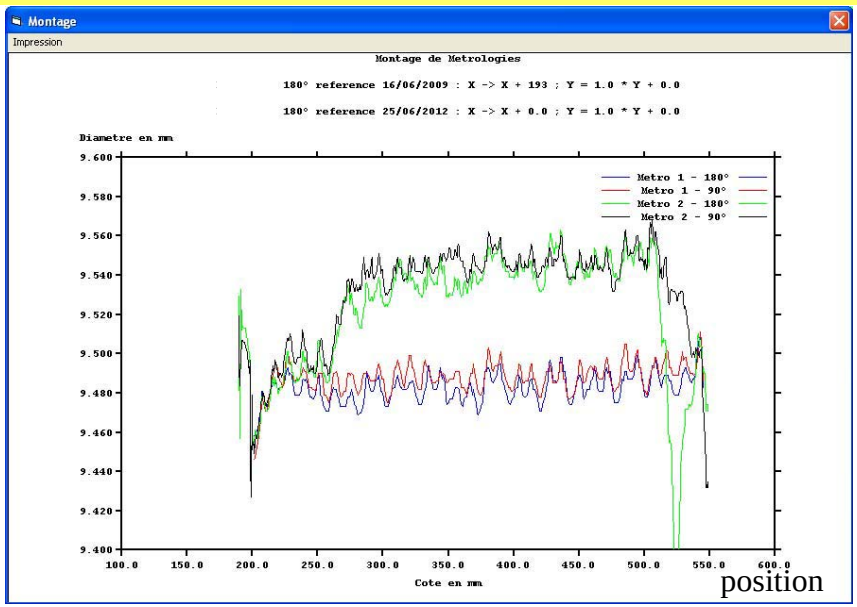


Rods from
6.55 mm (or less) …to 40 mm

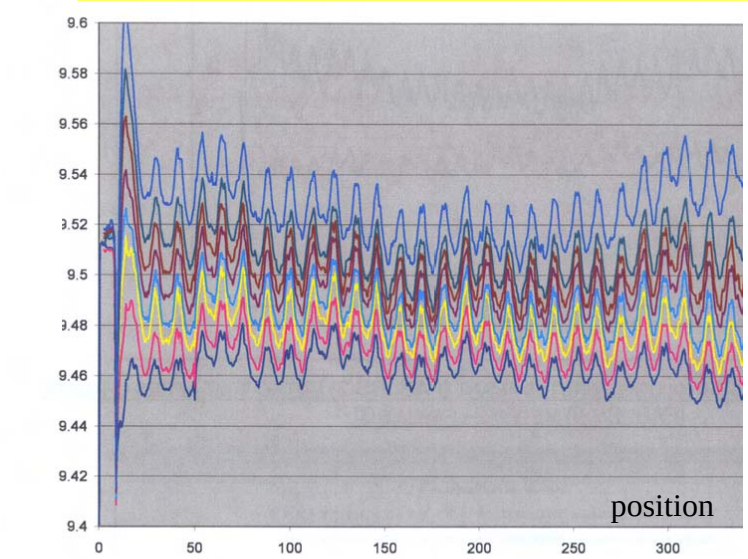
Overview of the VENDAUM's potential : comparisons

Thanks to its reproducible positioning, VENDAUM allows the comparison of NDE on the same object but also the following of evolution of an object during tests

Changes of diameter after tests



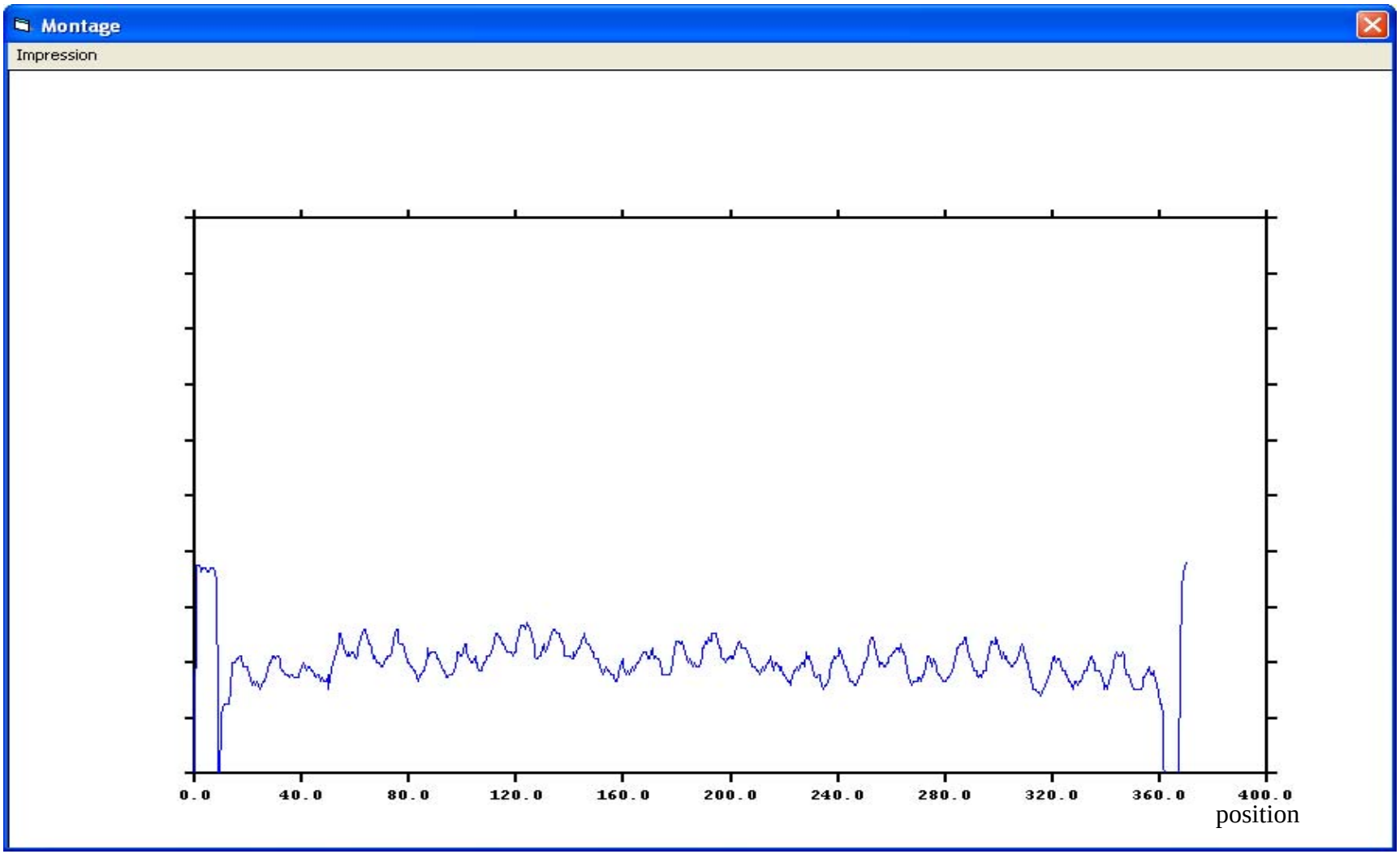
Changes of diameter after several heatings



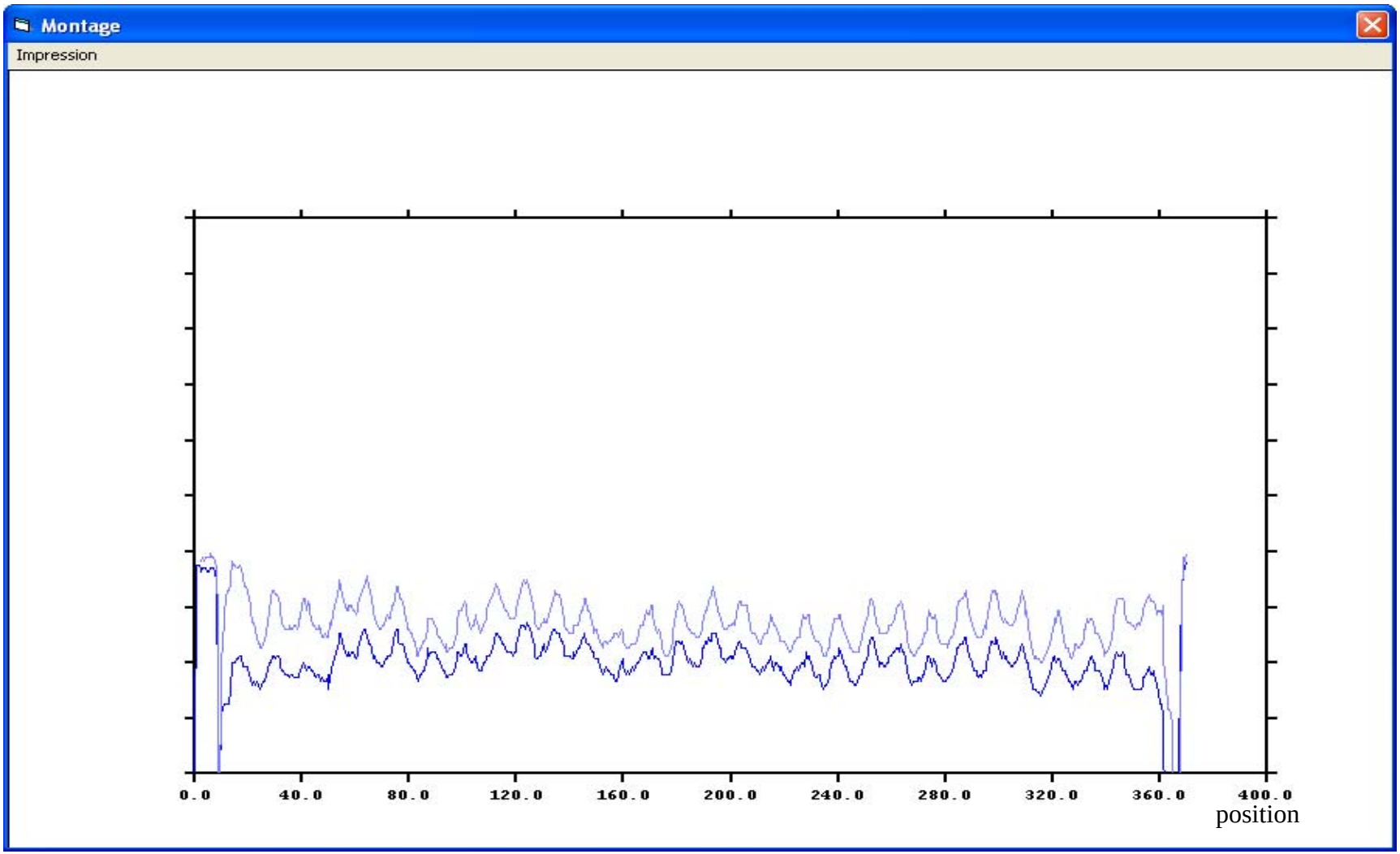
Studies on incidental situations

Studies on storage conditions

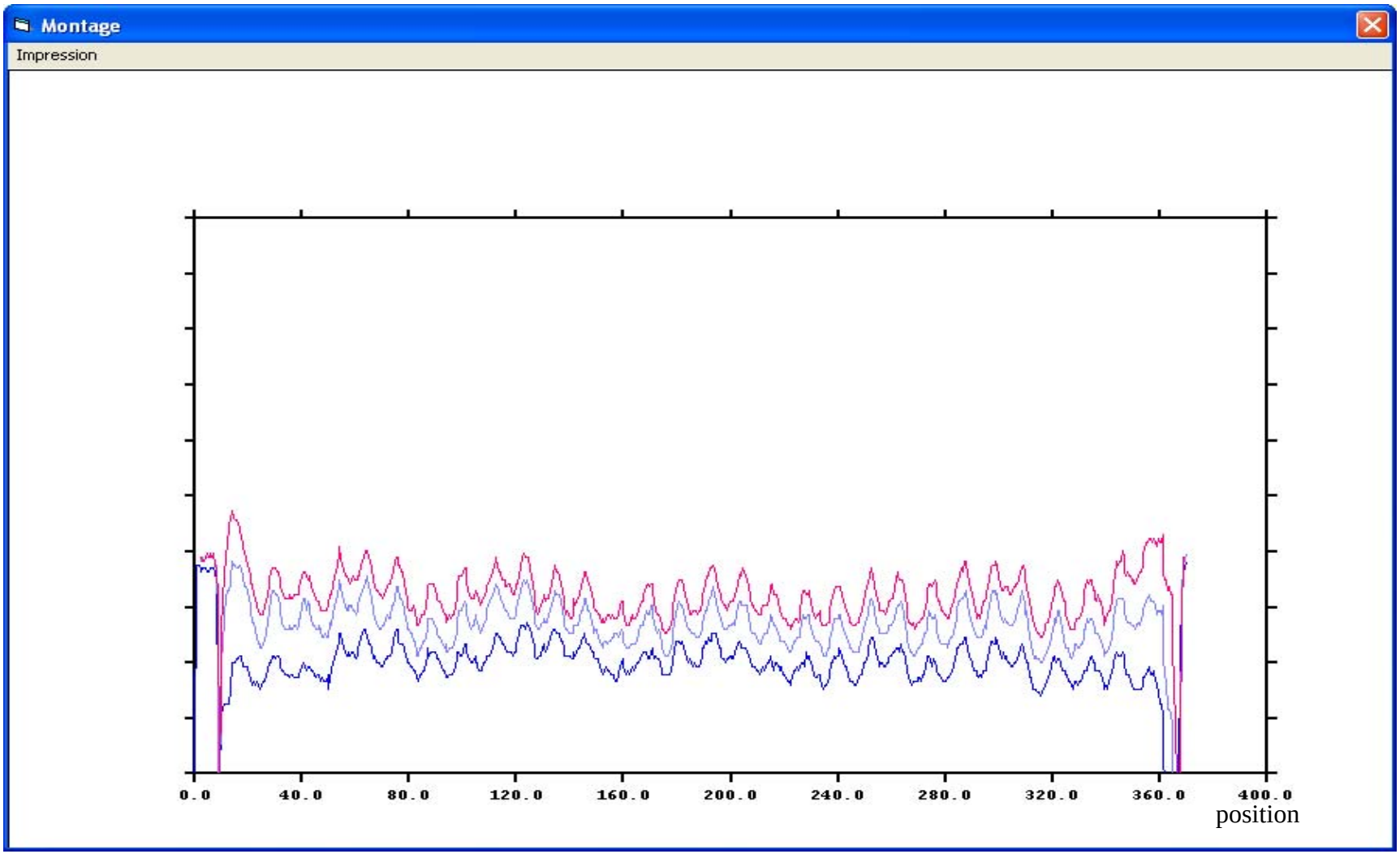
Step 0 : initial diameter measurement



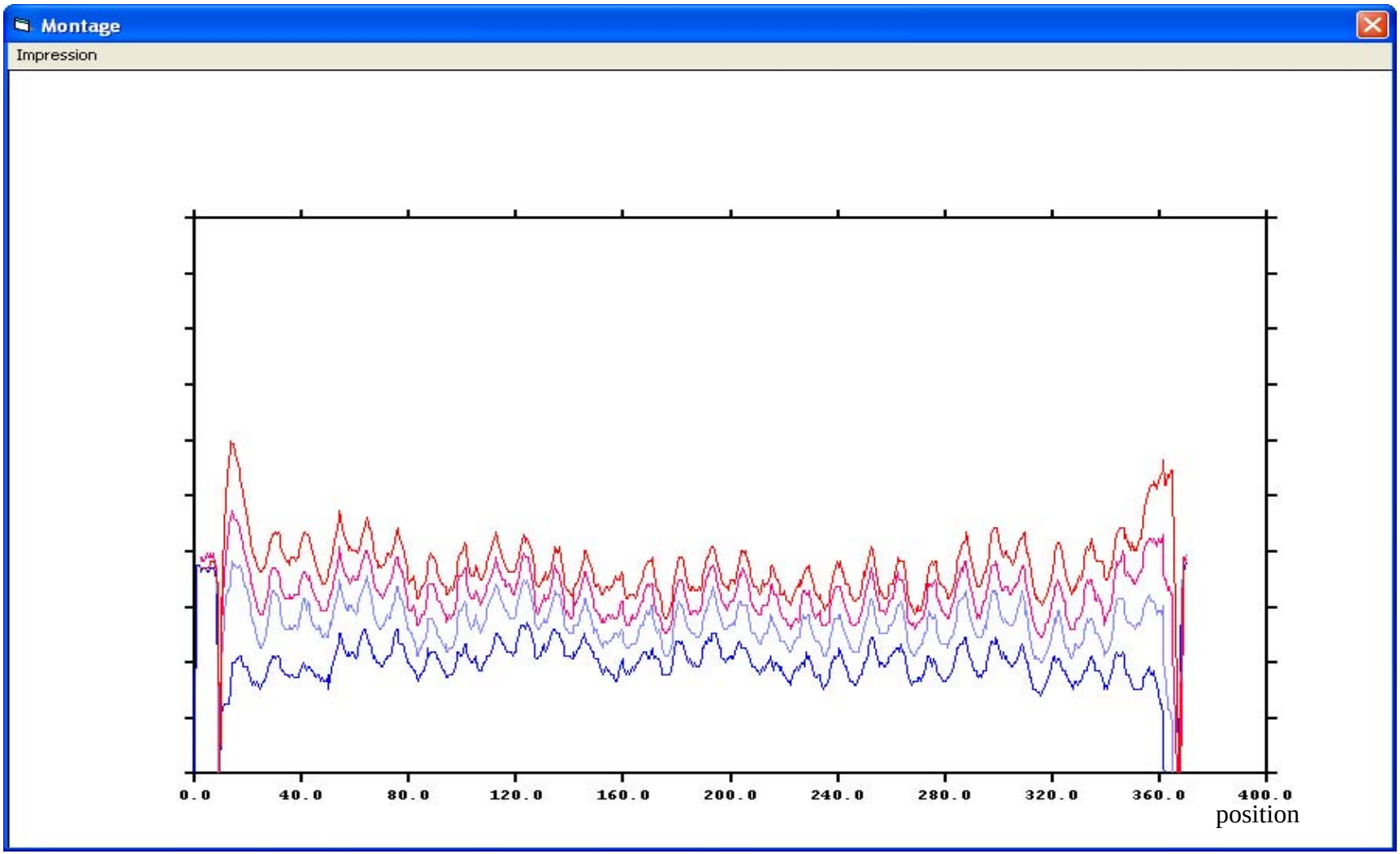
Step 1 : diameter measurement after one heating



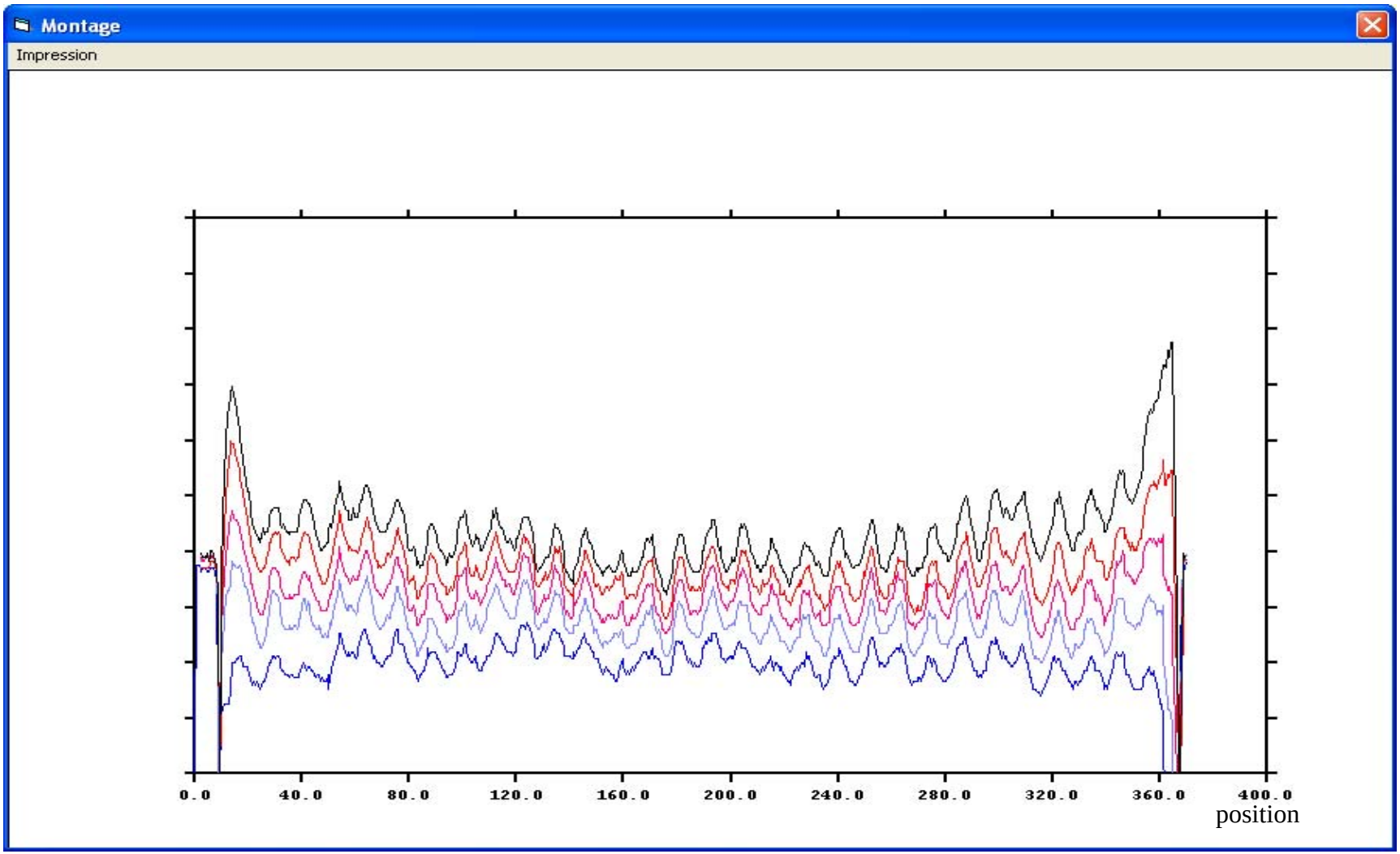
Step 2 : diameter measurement after two heatings



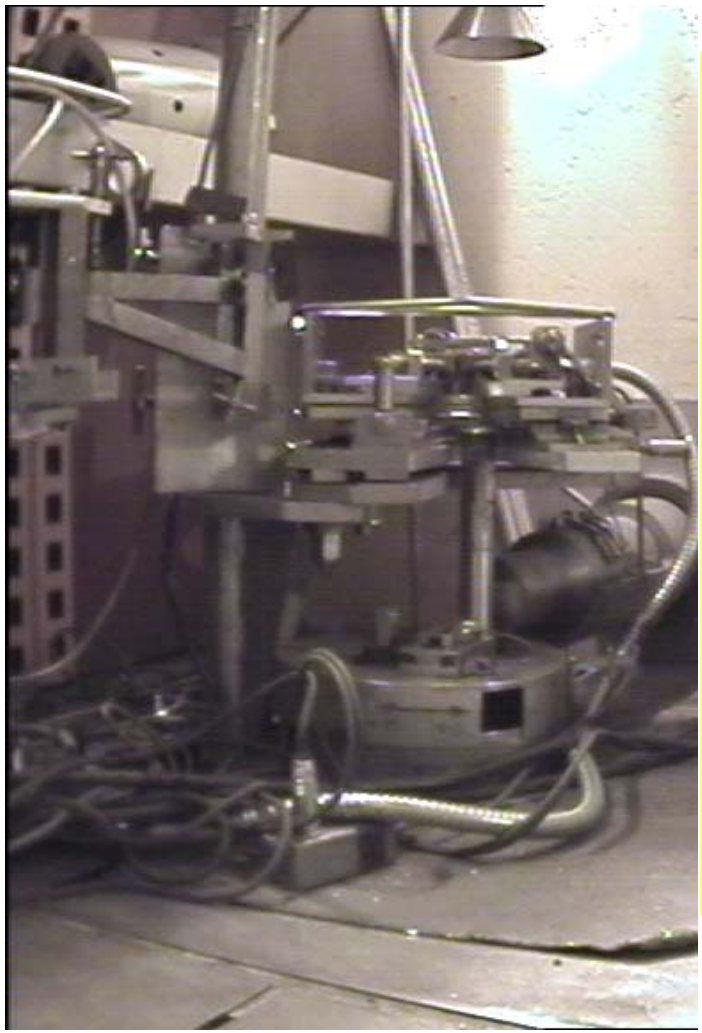
Step 3 : diameter measurement after three heatings



Step 4 : diameter measurement after four heatings



Conlusions and prospects



VENDAUM has many assets and answers already to a broad pallet of needs (L<2.7m ϕ<4cm).

The diversity of the examined objects and of measurement conditions is a motivating aspect of the use of this bench.

Innovating evolutions, such as metrology without contact by ombroscopy, confocal microscopy, will soon be set on our bench to meet new specificities.

Example of real visual exam

Thank you for your attention

Contribution : LEGEND's team

with special thanks

to Thierry and Franck

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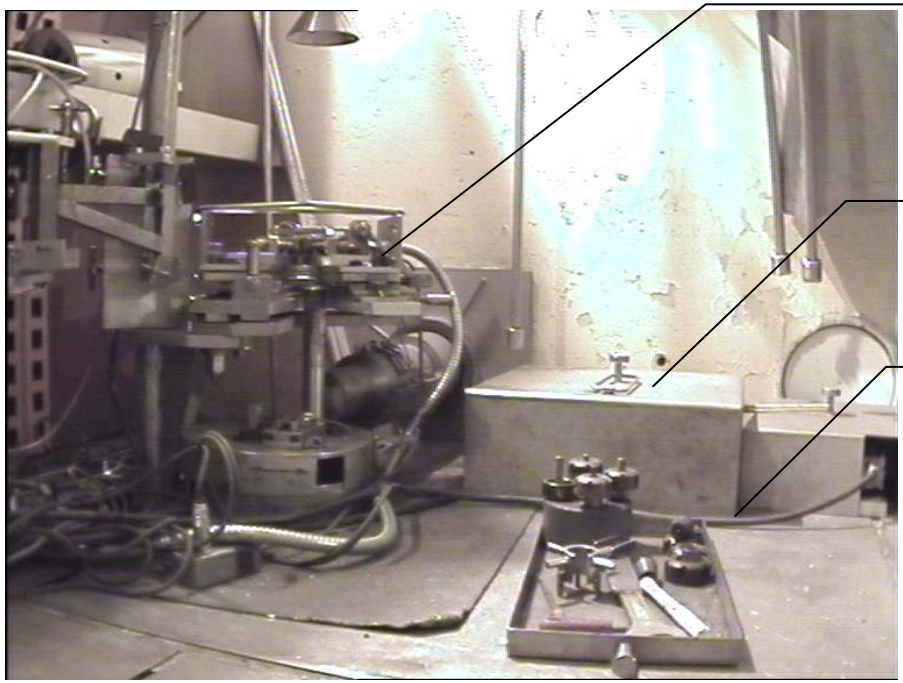
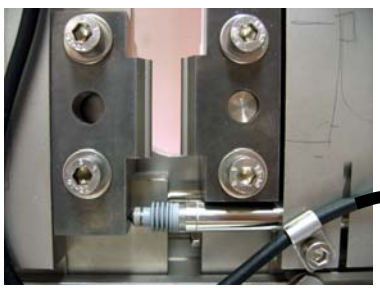
Additional information on VENDAUM



cartridges

Protection box

cables



Bio protection

wall

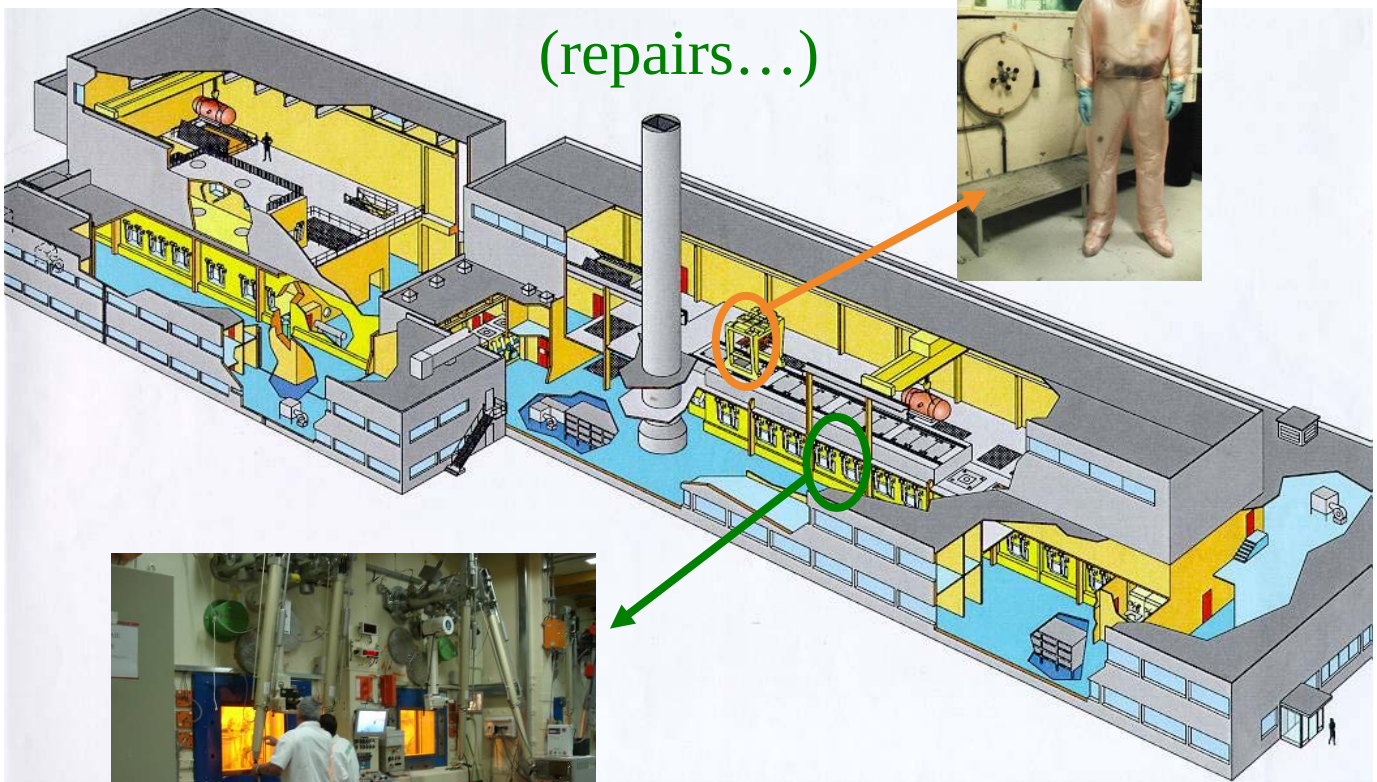
In hot cell

outside

Sometimes

Upper cell

(repairs…)



Level 0 :

measurement in hot cells