Upgrading of the LEFCA experimental facility for the study of next generation nuclear fuels

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Outline

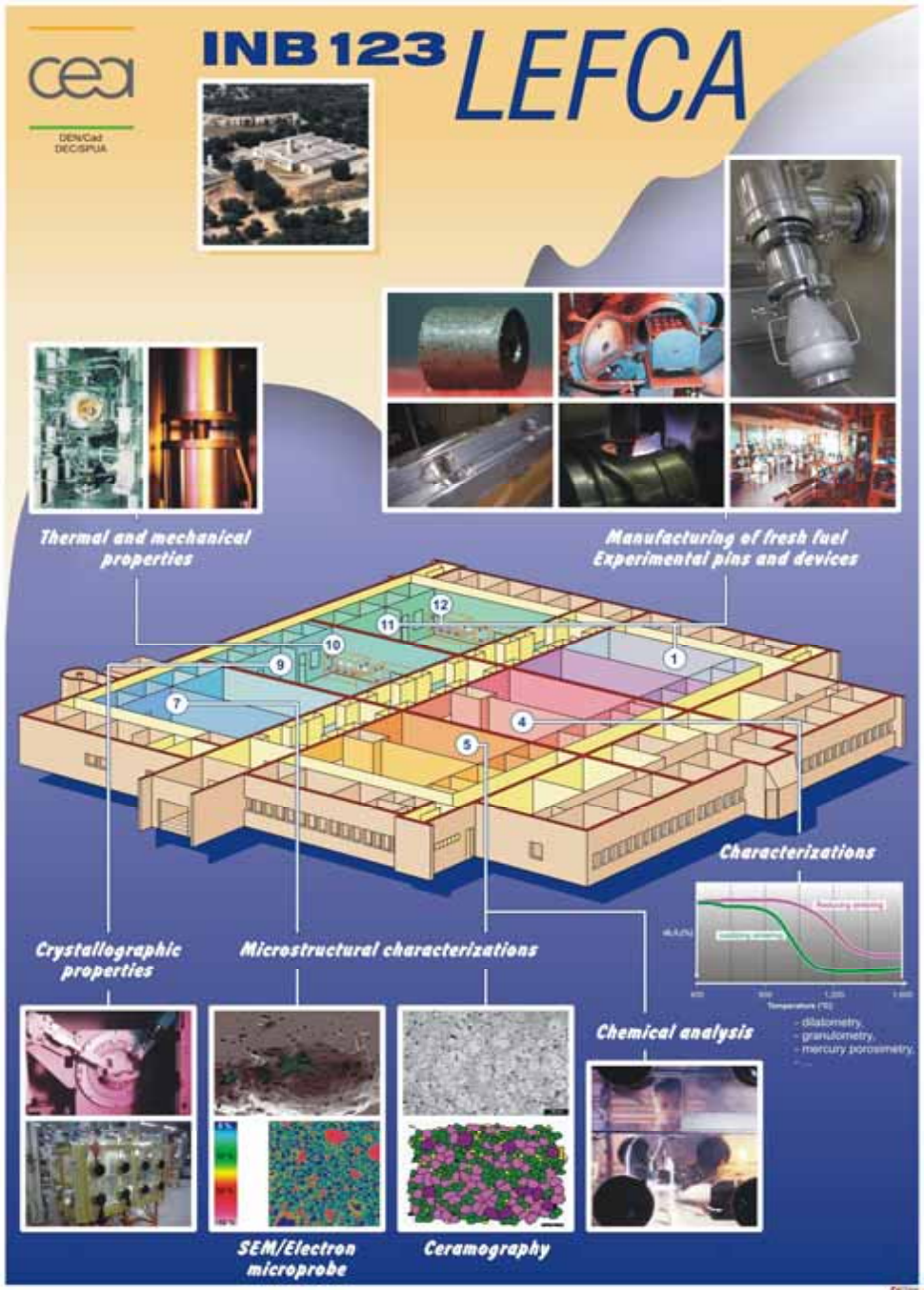
- LEFCA presentation
- Upgrading :
  - Dismantling of old gloveboxes
  - Improvements related to nuclear safety
  - New equipments dedicated to programs
- Future prospects
- Plutonium school
- Economic aspects
- Conclusion

LEFCA presentation : the building

LEFCA presentation

Laboratoire d'Études et de Fabrications expérimentales de Combustibles nucléaires Avancés

- **13 cells with 80 glove boxes handling α fuels**
- **facility built in 1981;**
- **1984 : Start up with plutonium material**
- **2003 : last safety re-assessment ;**
- **~ 50 employees in operation.**



Main research and development topics

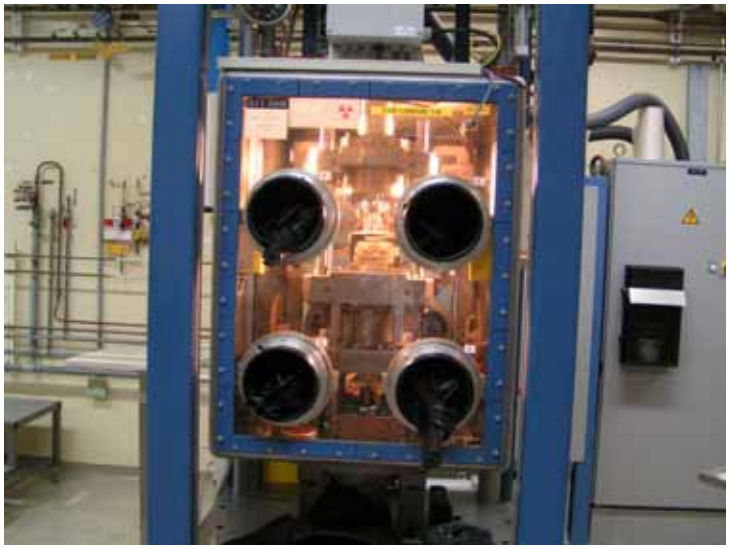
- LWR MOX fuels;
- FBR MOX fuels;
- Future reactor fuels (generations III and IV);
- Transmutation targets;
- Fuel and actinides fabrication process;
- Material (fuel, ceramics, actinides,…) studies and characterizations;
- Experimental rods manufacturing for irradiation experiments;
- Treatment and conditioning of nuclear materials.

Fabrication and control capabilities

- Powder management : grinding mills, mixers, press, sieves;
- Pellet fabrication : press, grinding machine;
- Thermal treatment :
  - two sintering furnaces (great capacity) and oxidizing furnaces;
  - Metallic furnace;
  - oxidizing furnaces.
- Experimental rod manufacturing (length < 4 m) : cladding, pressurisation unit, TIG welding and seal welding;
- Control fabrication : dimensional control, MOX dissolution test, X radiography, optical microscopy, TIG welding tightness test; ISO 9001 ;
- 100% Am materials synthesis on small quantities (<10 mg)

Fabrication and control capabilities

Example of gloveboxes for fuel fabrication



Fabrication and control capabilities

Shielding gloveboxe dedicated to
100% Am materials synthesis

Properties measurements and characterization

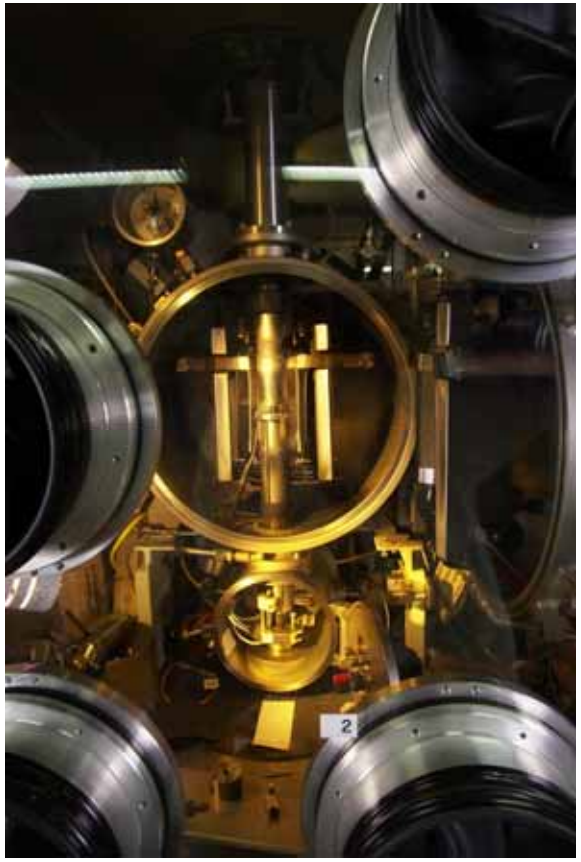
- Ceramic observation : optical microscopy, ceramography
- Micro structural characterization :
  - X-rays diffraction for phase identification
  - electron probe micro analysis;
  - scanning electron microscopy;
- Thermo mechanical properties;
- Thermal properties :
  - Differential scanning calorimeter (Cp, T<1100°C);
  - Drop calorimeter (Cp, T>1100°C);
  - Laser flash on PROTEE device (thermal diffusivity, 400°C< T<2500°C).

Properties measurements and characterization

- U, Pu content : coulometry, spectrophotometry
- Pu homogeneity : alpha auto radiography
- Kinetics, thermodynamics : TDA, TGA
- Granulometry : laser granulometer
- Specific surface : BET
- Density and porosity : hydrostatic density
- O/M measurements : dedicated furnace
- Thermal dilatation : dilatometer, 1650 °C (Ar/H_2)
- Fusion temperature : PROTEE device.

Properties measurements and characterization

Thermo mechanical properties



HT range (1800°C) and controlled atmosphere

Creep tests : uniaxial constant compressive load (100 kN)

Hardening tests : constraint strain rate (10-20 µm/min)

Properties measurements and characterization

- Micro structural characterization :
  - Electron probe micro analysis;
  - Gloveboxes for decontamination of the samples.

Dismantling of old gloveboxes

- Objectives :
  - Reduce exploitation costs;
  - Create free surface for new research and development programs;
  - Reduce the cost of seismic strengthening.
- Phase 1 (2004-2005) : dismantling of 10 gloveboxes
- Phase 2 (2007-2009) : dismantling of 32 gloveboxes
- LEFCA does not have a decontamination and dismantling glovebox area.
  - Special procedures;
  - Total decontamination of the gloveboxes (time consuming);
  - Keeping in mind the cost of the waste.

Improvements related to nuclear safety

- 2003 Permanent Group with Nuclear Safety Authority : 114 safety engagements;
- Main objectives :
  - Fire protection improvements;
  - Confinement improvements;
  - Seismic strengthening : works needed on the three barriers of the facility : gloveboxes, cells and building;
  - Improvement of reliability on electricity supply systems and ventilation controls systems;
  - Improvement of nuclear material management;
- Works : from 2005 to 2010.

Fire protection works (2008)

Works on the second barrier

- New 27 doors and 12 windows with 2 hours fire resistance;
- Works on pipes, cables trays which penetrate fire separation.

Confinement improvement works (2008)

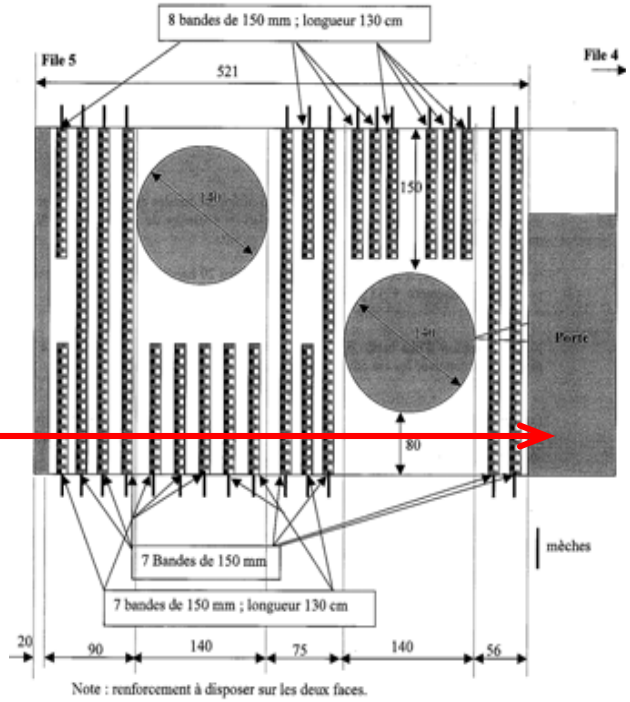
- Confinement improvement after a seism;
  - windows replaced by walls;
  - new windows more resistant (left photo);
- New doors (right photo) and new seals on existing structure.

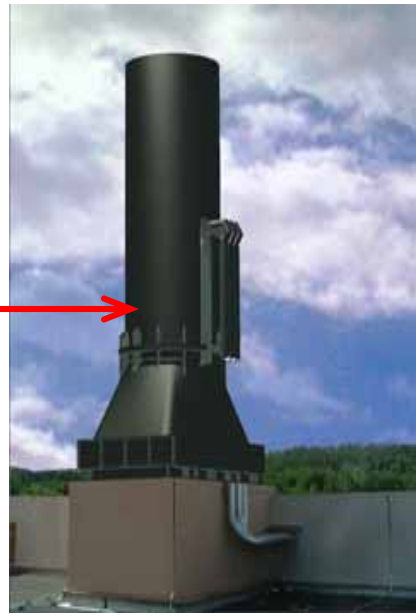
Seismic strengthening : works on the first barrier (2006)

- Fixing of gloveboxes
- Fixing of internal and external missiles in case of seism.

Seismic strengthening : works on the third barrier (2009)

- Nuclear safety authority agreement in July 2007 for the use of carbon fibre





- New ventilation shaft on the building

New equipments (2005 –2008)

- Carbides, nitrides :
  - Inert gas in tight gloveboxes;
  - Nearly 30 gloveboxes “C,N” authorized;
  - Purification system
- Measurements of the impurities :
  - New analysers (C, S, O, N)
  - New gas analysis system applied to TGA/TDA
- High temperature (new materials) :
  - High temperature furnace used for carbothermy, sintering and brazing (SiC)
  - High temperature dilatometer (2200°C Ar)
  - High temperature X-rays diffraction (2000°C)

New equipments (2005 –2008)

- Innovative process : equipments and gloveboxes with blend of organics and actinides.
- More precise measurements :
  - New scanning system of electron probe micro analysis;
  - New detector of scanning electron microscope;
  - New optical microscopy including new gloveboxe dedicated to carbide and nitride.
  - Visible Ultraviolet spectrometry for Am content
  - New gamma spectrometer to improve nuclear material measurements.
- Treatment and conditioning of nuclear materials :
  - Oxidizing furnaces for stabilization of pyrophoric materials;

New equipments (2007- 2008)

- X-rays diffraction (room temperature);
- High temperature X-rays diffraction (in gloveboxe by the end of 2008).

New equipments (2005-2008)

Cell 3 : toward the next generation

2003 : before dismantling

2004–2005 : refurbishment

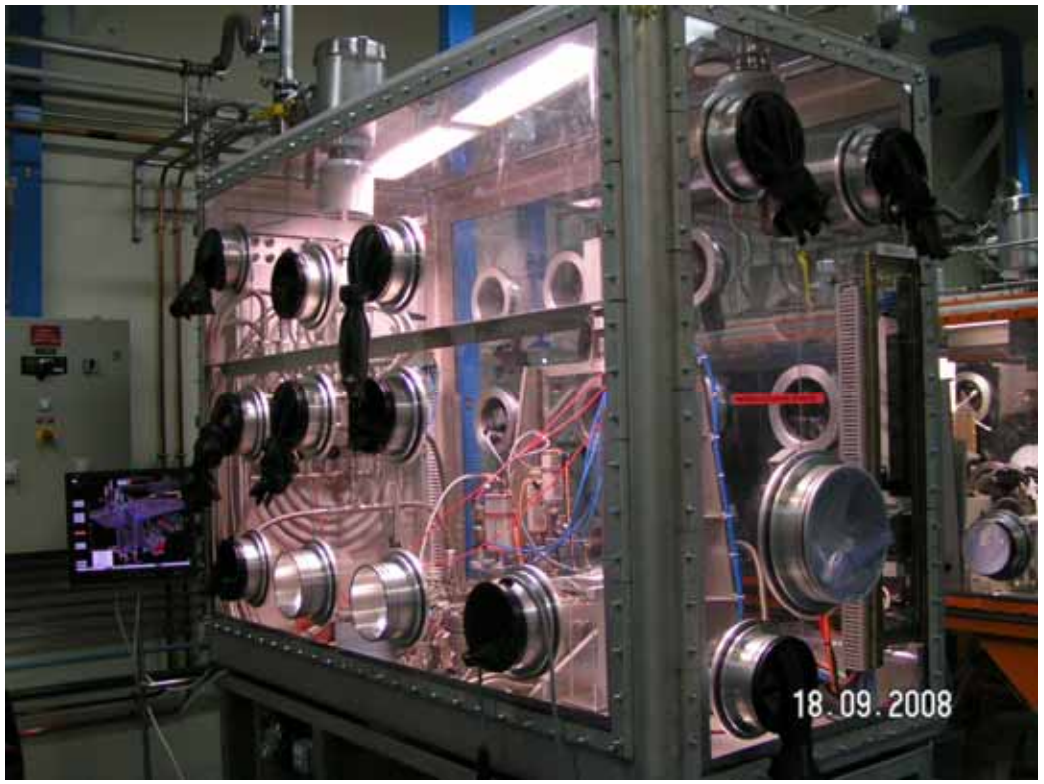
- TITANS : Technical Implements to Test Actinides for Nuclear Systems

New equipments (2005-2008)

- TITANS : carbide and nitride chain

New equipments (2005-2008)

- TITANS



- High Temperature furnace (above)
- O/N analyser (left)

Future prospects on new equipments

- Carbides, nitrides :
  - More gloveboxes “C, N” authorized;
  - Heavier batches authorized;
  - Purification system applied to other gloveboxes and a better control of the monitoring of the oxygen content.
- Measurements of the impurities :
  - Gas analysis system applied to other equipments
  - C/M measurements
- High temperature :
  - High temperature mass spectrometry;
  - High frequency furnace (2400°C).

Future prospects on new equipments

- New kind of measurements :
  - New small scanning electron microscope in order to install it in gloveboxe :
    - ✓ avoid the decontamination of the samples;
    - ✓ make possible measurements on powder ;
  - New gamma spectrometer for Am measurement.
- Treatment of nuclear materials :
  - Uranyl nitrate treatment glovebox (2009)
  - gloveboxes devoted to solid exotic nuclear materials management;
  - New test area for transport cask;
- Fabrication cells :
  - New organisation to reduce nuclear materials transfers.
  - Prepare free area for new programs.

Plutonium school

- Our team is involved in teaching;
- Formations based on :
  - conferences on nuclear physics and plutonium aspects as properties, metallurgy, chemistry, biological and medical;
  - conferences on risks as contamination, irradiation and criticality;
  - conferences on laws about waste and facility management, safety and security;
  - Practical works in LEFCA facility and Pu school on both active and inactive gloveboxes.
  - Visits on plants and reactors
- Teachers : mostly CEA and AREVA NC employees.

Economic aspects

- Since 2005, many efforts have been made to reduce the effective costs of the facility.
  - Several projects :
    - Improvement of radioactive waste management
    - Improvement of the reliability of the facility with works on electricity supplies and on ventilation control
    - Reduction of gas consumption and other goods;
    - Use of planning for all activities (facility, works, experiments)
    - ISO 14001 certification : calories back system from the exhaust air flow of the facility.
  - From 2006 to 2007 : 13 % cost reduction

Conclusion

- Since 1984, LEFCA facility has studied and produced innovative nuclear fuels.
- For the last four years, many realizations were achieved with a laboratory still at work.
- Other improvements will be implemented in the next years.
- All these works made possible to obtain a facility ready for :
  - the next decade in terms of facility management (nuclear safety, environment and quality);
  - our experimental activities on innovative fuels of generation III and generation IV
- Plutonium school will play a central role to transfer knowledge to the next generation research workers

Thank you
for your attention

Fuel studies department