
CANBERRA

Instrumentation and methods :
Stakes and perspectives for the fuel cycle

H. TOUBON
Development Director, European R&D coordinator
CANBERRA France

N. MENAA
R&D Project Manager
CANBERRA France

CANBERRA

Table of content

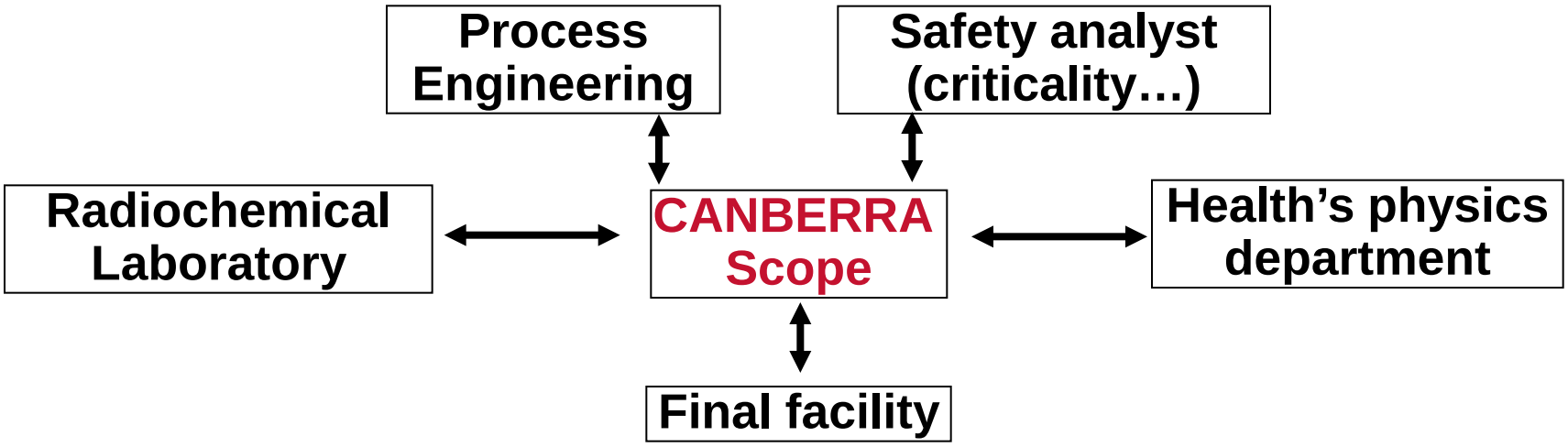
CANBERRA

1. Main stakes and applications in the nuclear fuel cycle

CANBERRA

Use of nuclear measurement

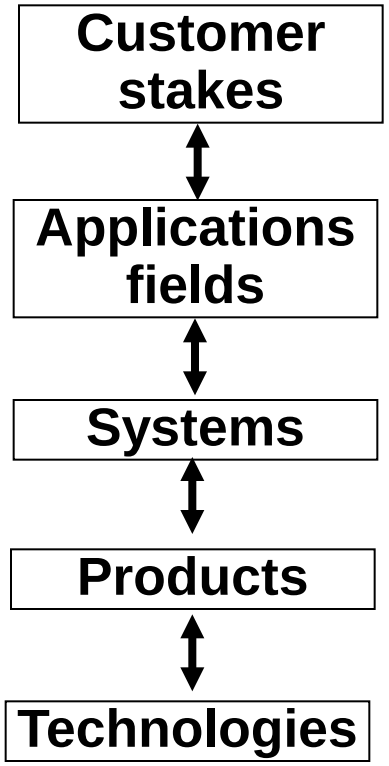
- **Domains of application of nuclear measurements**
  - **Fundamental Research**
  - **Medicine**
  - **Cultural applications**
  - **Agribusiness**
  - **Nuclear industrial application**



CANBERRA

Main customer stakes

- In support of working operations for
  - Mass evaluation statement
  - Nuclear control of the process
- Safety risk
  - Environmental impact
  - Health's physics
  - Criticality
  - Decay heat
- Waste characterization
  - From very low level to very high level waste



CANBERRA

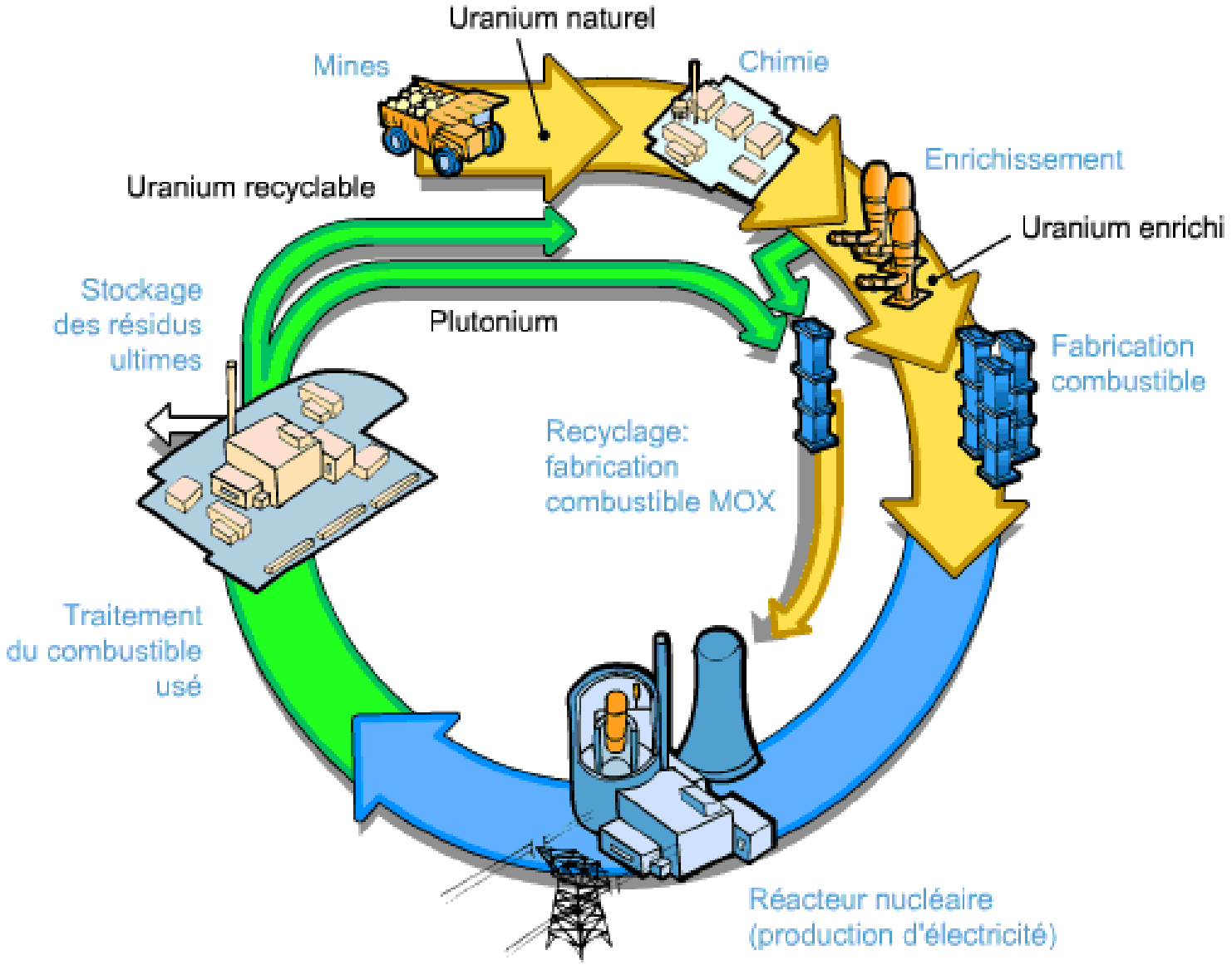
The main current applications for nuclear measurement

- **Process and waste**
  - **Nuclear control of process**
    - From safety-criticality constraints to follow up process
  - **Radiation monitoring systems**
    - For NPP or fuel cycle facilities
  - **Waste assay**
    - From low level to high level waste activity systems
  - **Safeguards applications**

- **Radiochemistry Laboratories**
  - **Process control sampling and analysis**
  - **Environmental analysis**
  - **Medical analysis**

- **Health's physics controls**
  - **Dosimetry**
  - **Portable measurements**
  - **Air and environmental monitoring**
  - **Fixed portal monitor for access control areas**

CANBERRA


Uranium naturel
Mines
Chimie
Enrichissement
Uranium recyclable
Uranium enrichi
Stockage
des résidus
ultimes
Plutonium
Fabrication
combustible
Recyclage:
fabrication
combustible MOX
Traitement
du combustible
usé
Réacteur nucléaire
(production d'électricité)

CANBERRA

2. Front end fuel cycle
Mining, conversion, enrichment

CANBERRA

Front End fuel cycle

Mining

Main activities

- in Niger, Canada, Kazakhstan
- From 1% to 20% of U per ton

Product :

- Yellow cake, concentrate at 80% of U3O8

Main needs

- Radiochemistry Labs
- Exploration for low grade uranium
- Borehole technologies
- Process measurement in the factory

CANBERRA

Front End fuel cycle

Conversion

Main activities

- COMURHEX Malvesi : From Yellow cake to pure UF_4
- COMURHEX Pierrelatte : From UF_4 to UF_6

Comurhex

- Dissolution by HNO3 then TBP and NH3
- concentrate → UO2(NO3)2 → UO3 → UO2

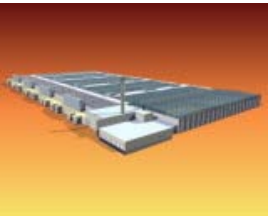
Sur Pierrelatte

- Hydrofluoration par HF : UO2 → UF4
- Fluoration par F2 : UF4 → UF6 pur
- Cristallisation de l'hexafluorure (cristaux incolores

Main needs

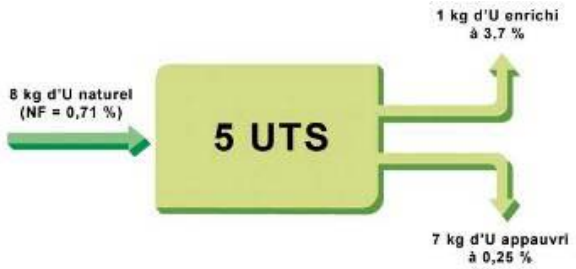
- Area monitoring
- Health's physics
- On line monitoring with simple measurements

Front End fuel cycle



Enrichment

- **Objective : From 0,7 % to 4-5 % in U 235**
- **Possibility of isotopic separation by**
  - Mass difference
    - Gaseous diffusion through a barrier : EURODIF
    - Gazeous ultracentrifugation : GBII
  - Difference of electromagnetic energy absorption
  - molecular or atomic selective ionization



Main needs

- UF6 enrichment measurement
- Labs analysis
- Area monitoring
- Criticality monitor
- Safeguards

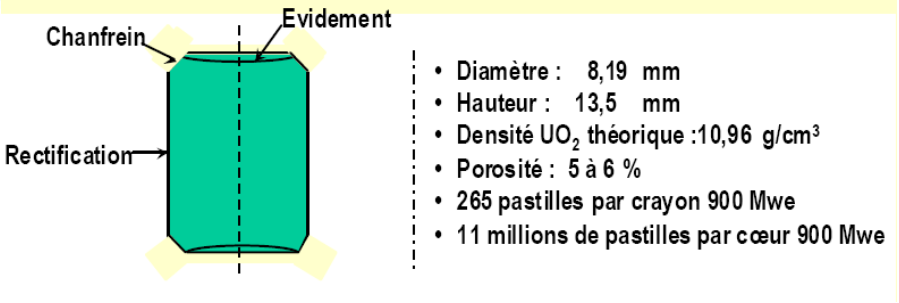
CANBERRA

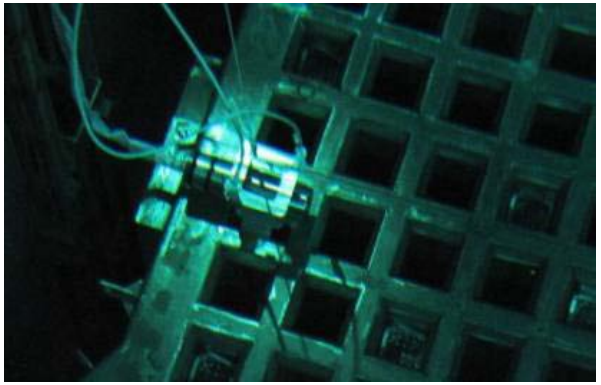
3. Fuels and Reactors

CANBERRA

Reactor and fuel fabrication

- **Fuel fabrication**
  - Area monitoring
  - Enrichment measurement
  - Safeguards
  - Criticality monitor
- **Reactor (current and future types)**
  - In core and excore controls
  - Radiation Monitoring Systems
  - Radiochemistry labs
  - Burn-up measurement
  - Safeguards





CANBERRA

4. Back-end

La Hague Process

Irradiated fuel

Fuel ponds

Nitric acid HNO_3

Dissolution

U, Pu, FP, minor actinides solution

Fuel hulls and end pieces

Extraction

FP + minor actinides vitrification

Compaction facility

U + Pu solution

CSD-V container

CSD-C container

Extraction

Pu solution

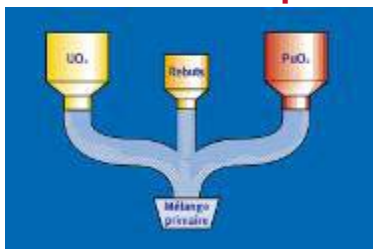
Uranyle nitrate solution

PuO_2 powder

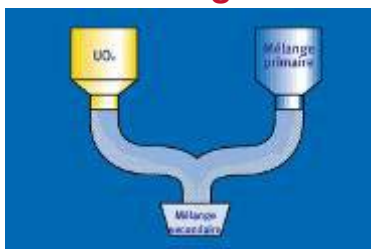
CANBERRA

MOX process at MELOX plant

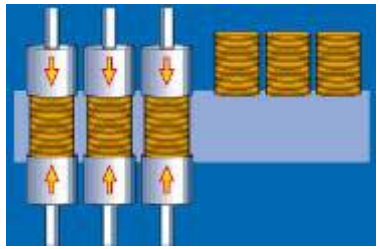
- **MOX : depleted UO_2 (from EURODIF) + PuO_2 (from La Hague)**
  - **Correct proportioning of Pu grade and isotopic composition**
  - **All the process is performed in glove box !**



1 *Preparation of powder mixtures*

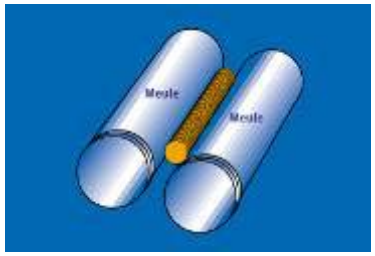


2 *Preparation of powder mixtures*

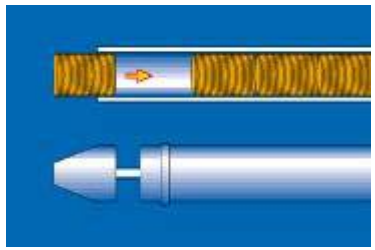


3 *Pressing or pelletizing*

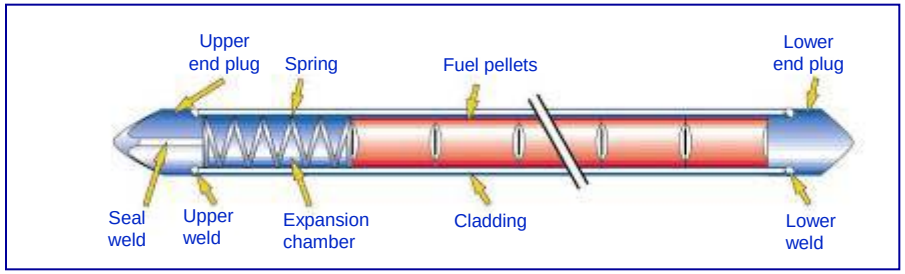
4 *Sintering*



5 *Grinding*



6 *Rod cladding*

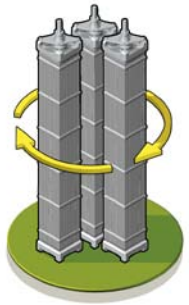


Light water type fuel rod

7 *Assemblies fabrication*

CANBERRA

Back end fuel cycle



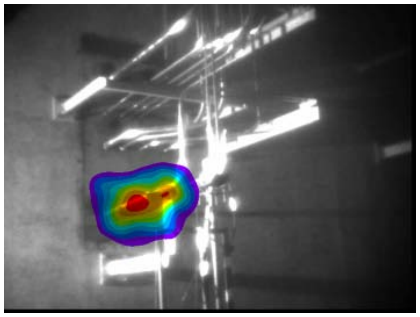
- **Reprocessing**
  - **Labs**
  - **Health's physics**
  - **Area monitoring**
  - **More integrated systems for**
    - Process, Safety-criticality and Safeguards controls
  - **Decrease labs analysis via on line measurements**
  - **New waste characterization methodologies**
    - mainly for alpha and very low activity waste
- **MOX fuel fabrication**
  - **Health's physics**
    - Hands and finger operational dosimetry
  - **On line Measurement in glove box**
    - Hold up measurement
  - **Air monitoring**
  - **Waste characterization**

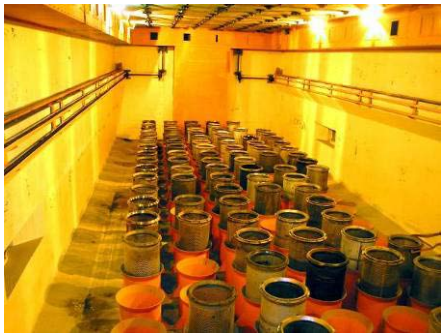
CANBERRA

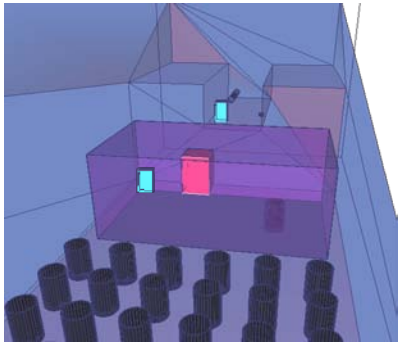
Nuclear measurements : Future needs

Maintenance, services, and D&D

- **Equipment and maintenance**
  - **Pipe & valves monitoring**
  - **Waste characterization**
- **Services and D&D**
  - **Investigation to define dismantling scenarios**
  - **Follow up of decontamination**
  - **Good waste package categorization**







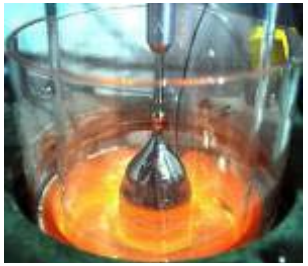
CANBERRA

5. Which strategic orientation for nuclear measurement in the future

CANBERRA

Need for innovation at all steps of detection chain

- **Detectors**
  - Germanium growth and Silicium technologies
  - New types of scintillators (LaBr…)
  - New gaseous and plastics detectors
  - New cryogenic techniques
  - Electrical fields and nuclear modeling



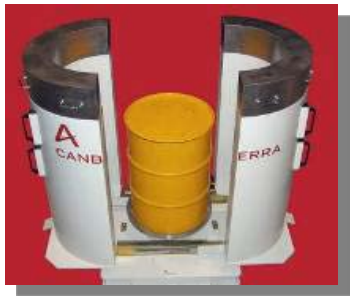
- **New integrated probes**
  - Small integrated electronics
  - Directly connected to PC
  - Embedded intelligence

- **New electronics**
  - Digital electronics
  - High count rate
  - Introduction of ASIC
  - Use of standard building blocks

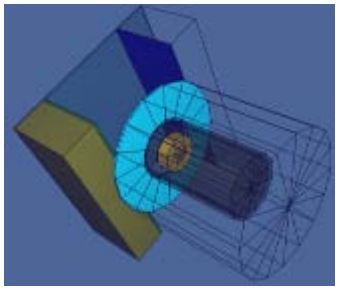
CANBERRA

Need for innovation at all steps of detection chain

- **Software and network**
  - Real time data acquisition
  - Algorithms
  - Network protocols
  - Common supervisory



- **Optimization of systems**
  - Nuclear modeling tools
  - Combined measurement techniques
  - Optimization of mechanics



- **Portable integrated systems**
  - Portable systems with embedded modeling
  - Imaging systems

CANBERRA

Conclusions

- **The nuclear measurement systems used to characterize radioactive materials are extremely varied.**
- **The solutions adopted largely depend on:**
  - the purpose of nuclear measurement stations,
  - the environment (radioactive environment, available room),
  - the assumptions that can be made about the process (deduction of correlations between the variables measured and those to be characterized).
- **Consequently, the solutions adopted for a project may vary:**
  - from the simplest detector,
  - to the most highly complex measurement and interpretation system.
- **Nuclear measurements are closely in link with**
  - **R&D institute**
  - **Nuclear safety staff**
  - **Radiochemical laboratories**
  - **Health's physics departments**
  - **Engineering companies**