Advanced Fuel and Fuel Cycles S&T

Rosaura Ham-Su, Fuel Development

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Outline

Advanced Fuel and Fuel Cycles

- Canadian Nuclear Laboratories
- Fuel S&T Drivers
- Advanced Fuel and Fuel Cycles S&T
- Summary

CNL

Four sites:

Chalk River

Whiteshell

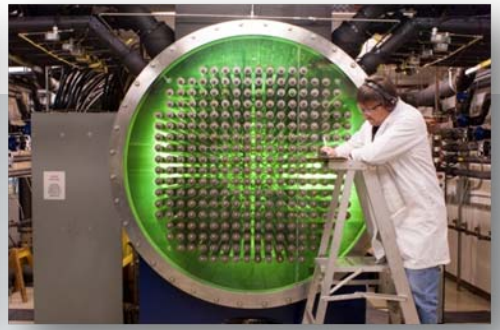
Ottawa

Port Hope

S&T Facilities

Fuel Fabrication

Thermalhydraulics

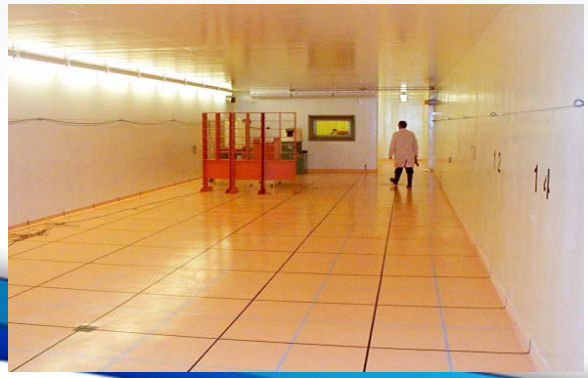


Surface Science

Hot Cells

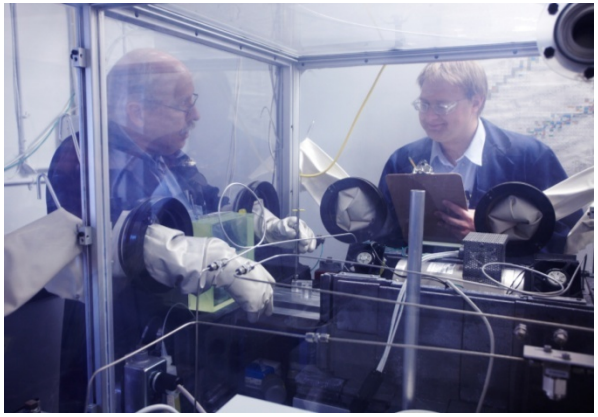
NRU

BRF



ZED-2





Fuel S&T

nuclear fuel S&T, including fuel cycles, fabrication, testing, and post irradiation examination

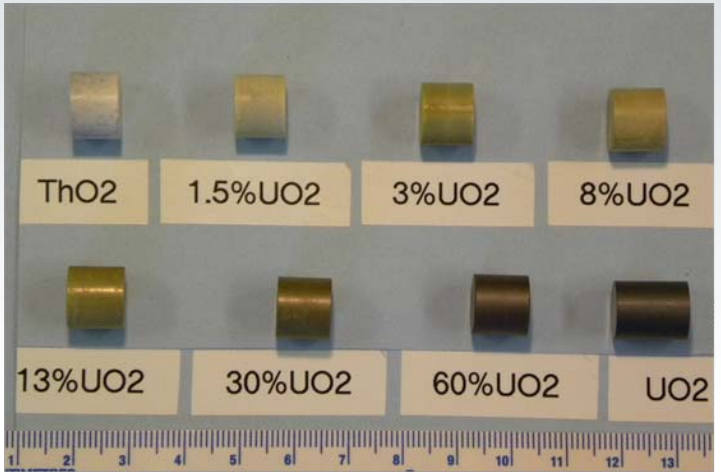
Advanced Fuel and Fuel Cycles

Advanced Fuel and Fuel Cycles are aimed at sustainability

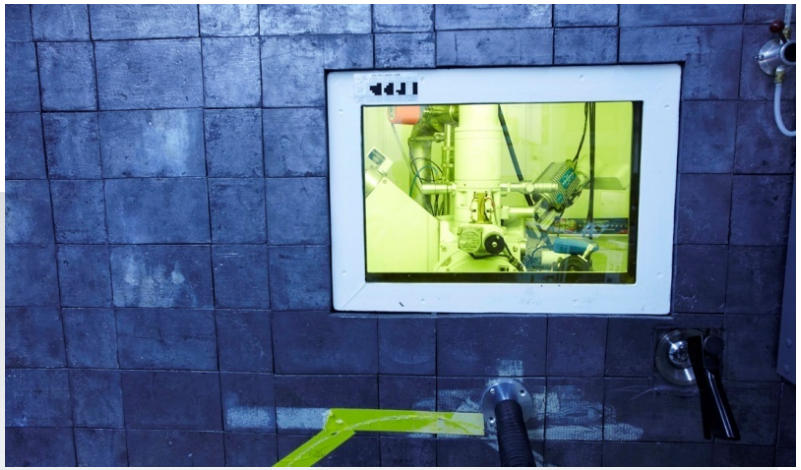
for both, power reactors and research reactors

Power reactors: Gen III and Gen IV, small reactors

Reference fuel for SCWR Thoria/13% Plutonia

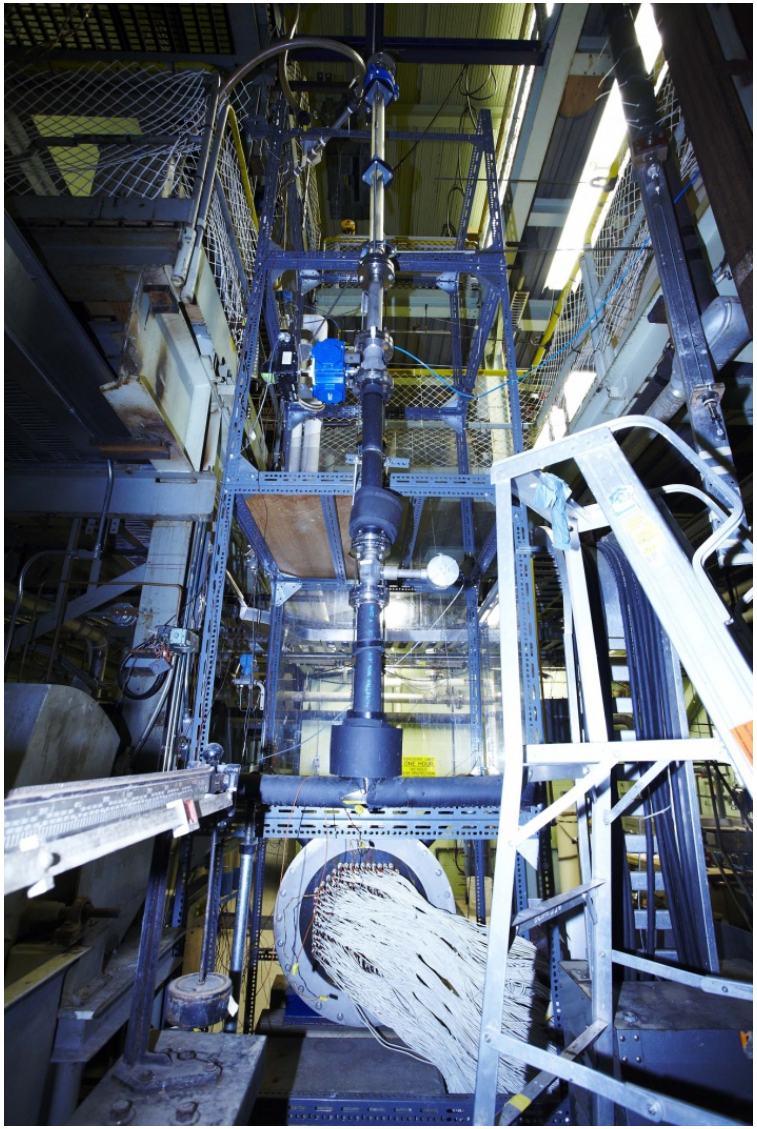


Sustainability



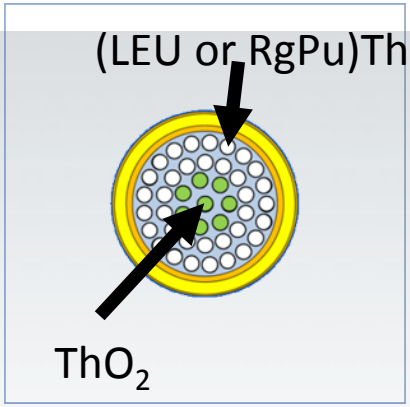
- Expand limits of resources
  - Reduce, reuse, recycle
  - Alternative fuels cycles (thoria)
- Increase safety and reliability
- Decrease environmental impact
  - Reduce waste
  - Manage spent fuel cycle
- Develop proliferation-resistant fuel and fuel cycles

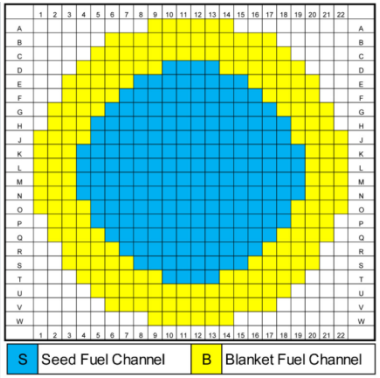
Areas of Interest

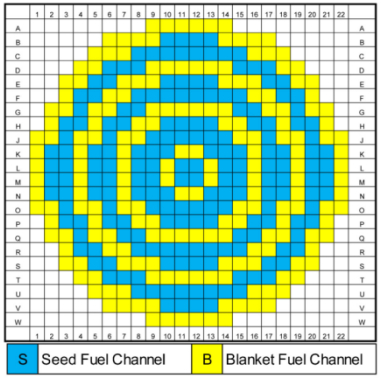


Advanced Nuclear Fuel and Fuel Cycles

Core optimization

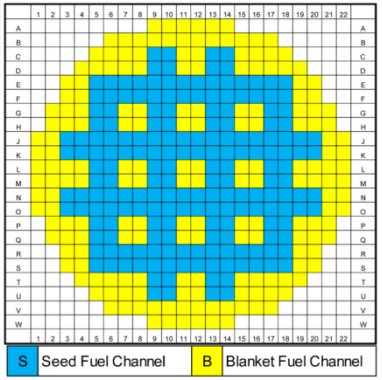


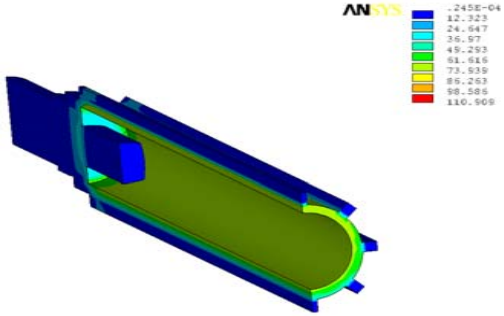




- "seed" and "blanket" fuel bundles can be used to breed U-233
- concepts yield fissile utilization competitive with natural uranium
- cores can be optimized for either power or U-233 production
- all concepts can be implemented in the same, conventional HWR core

B.P. Bromley and B. Hyland, Nuclear Technology, Vol. 186, pp. 317-339, 2014.



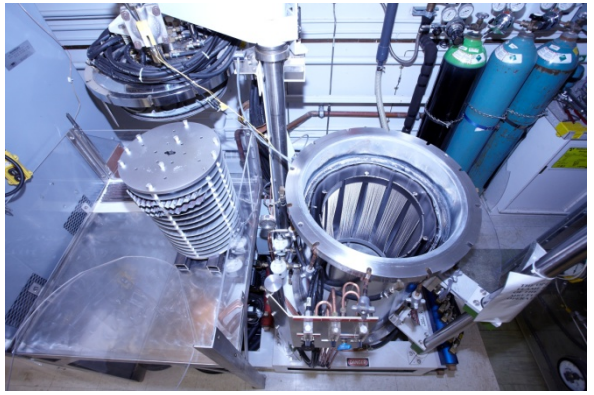


Fuel Fabrication

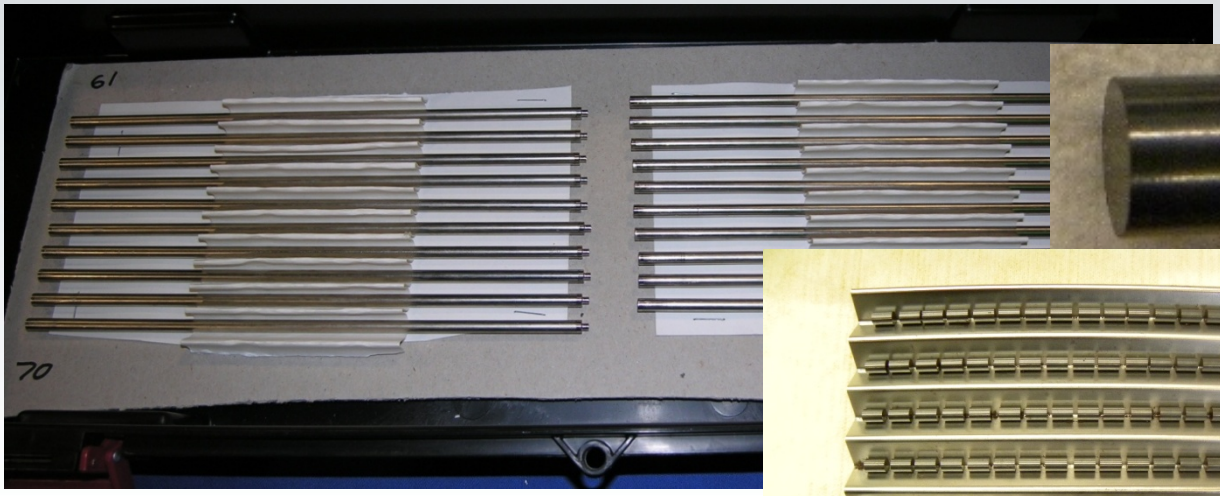
Metallic fuel

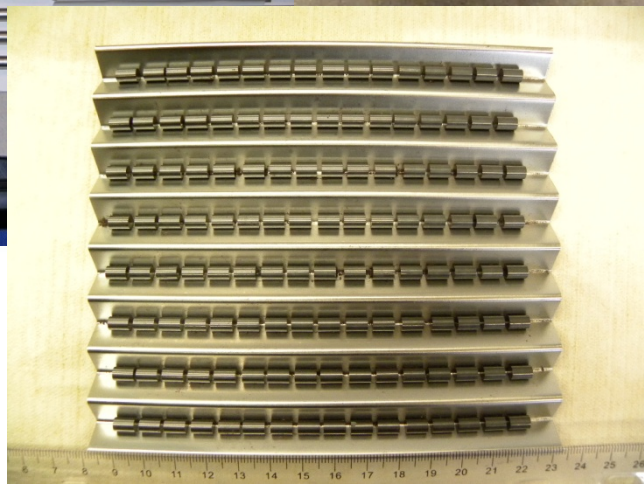
Proliferation resistant,
Recyclable fuel
For Research Reactors

Fuel Fabrication



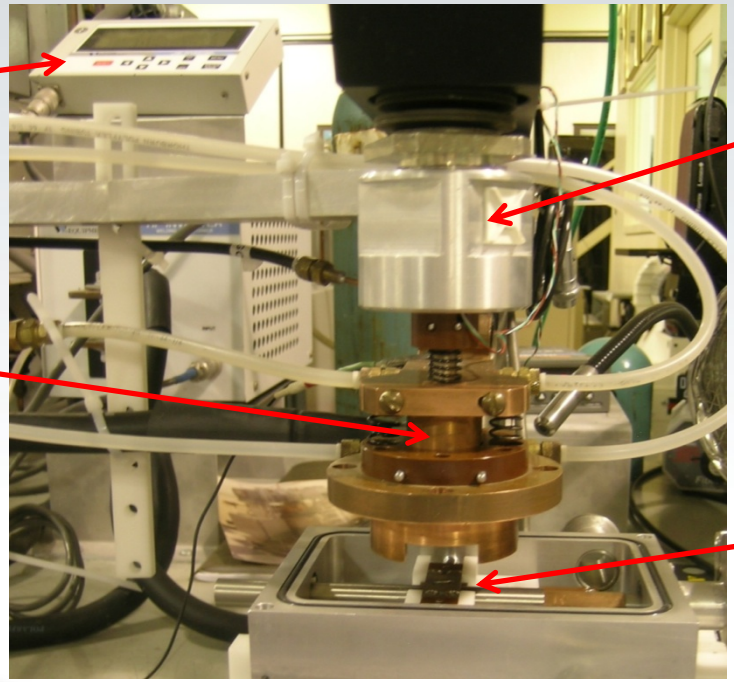
Ceramic fuel





Fuel Fabrication

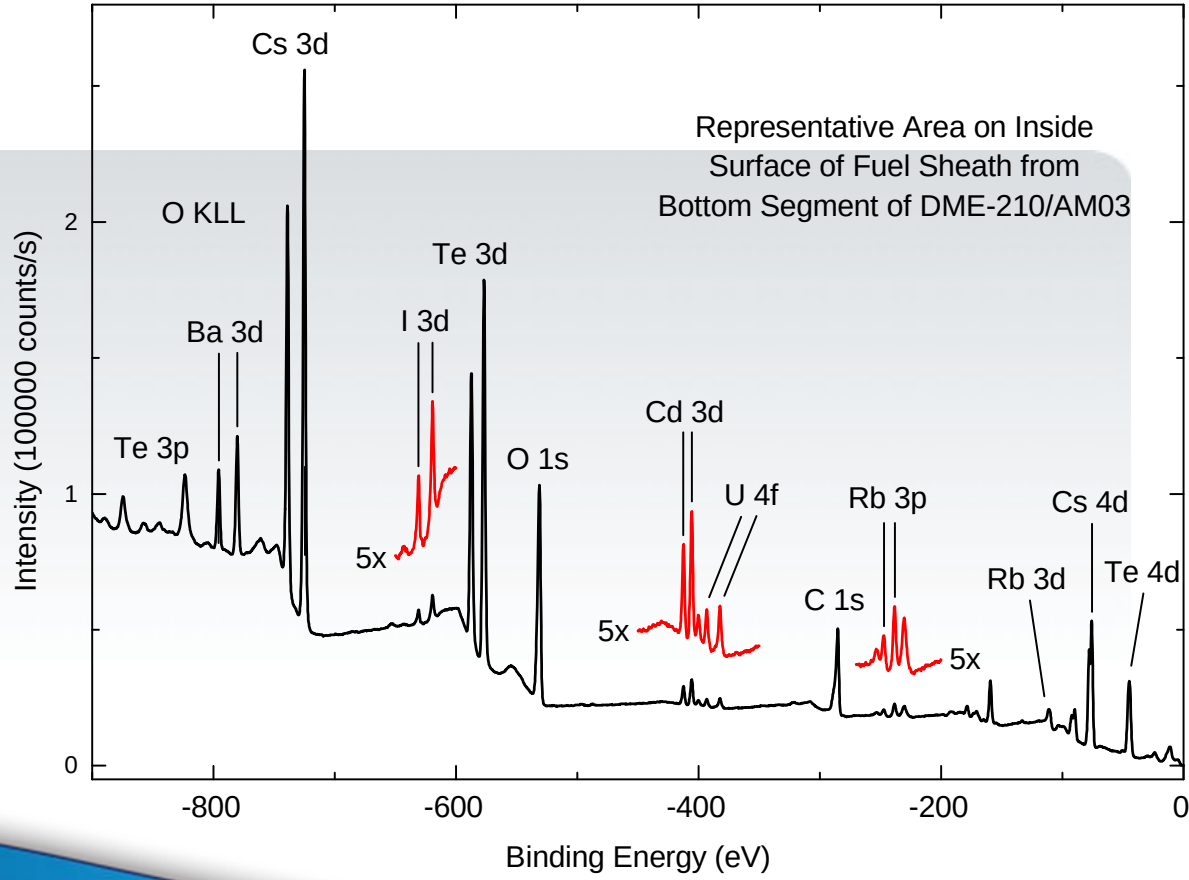
Development of joining techniques
High precision machining
Welding and brazing



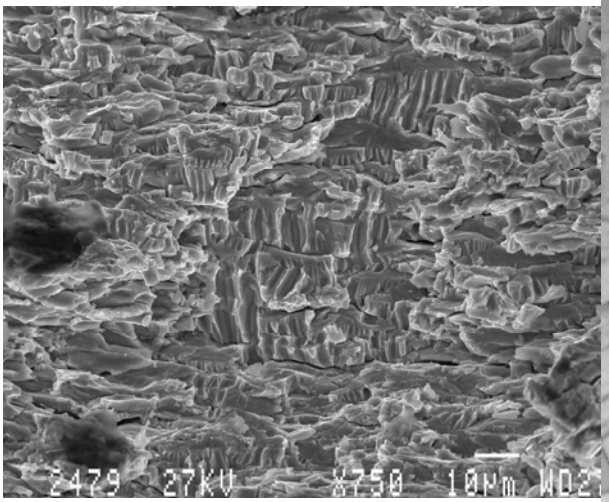
High frequency welding

Fuel Characterization

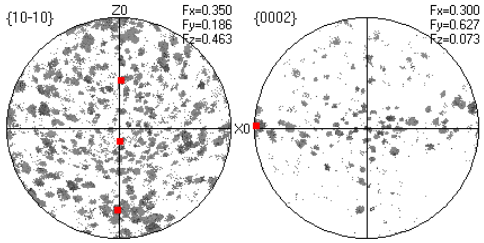
X-Ray photoelectron spectroscopy analysis of fuel sheath from experimental fuel

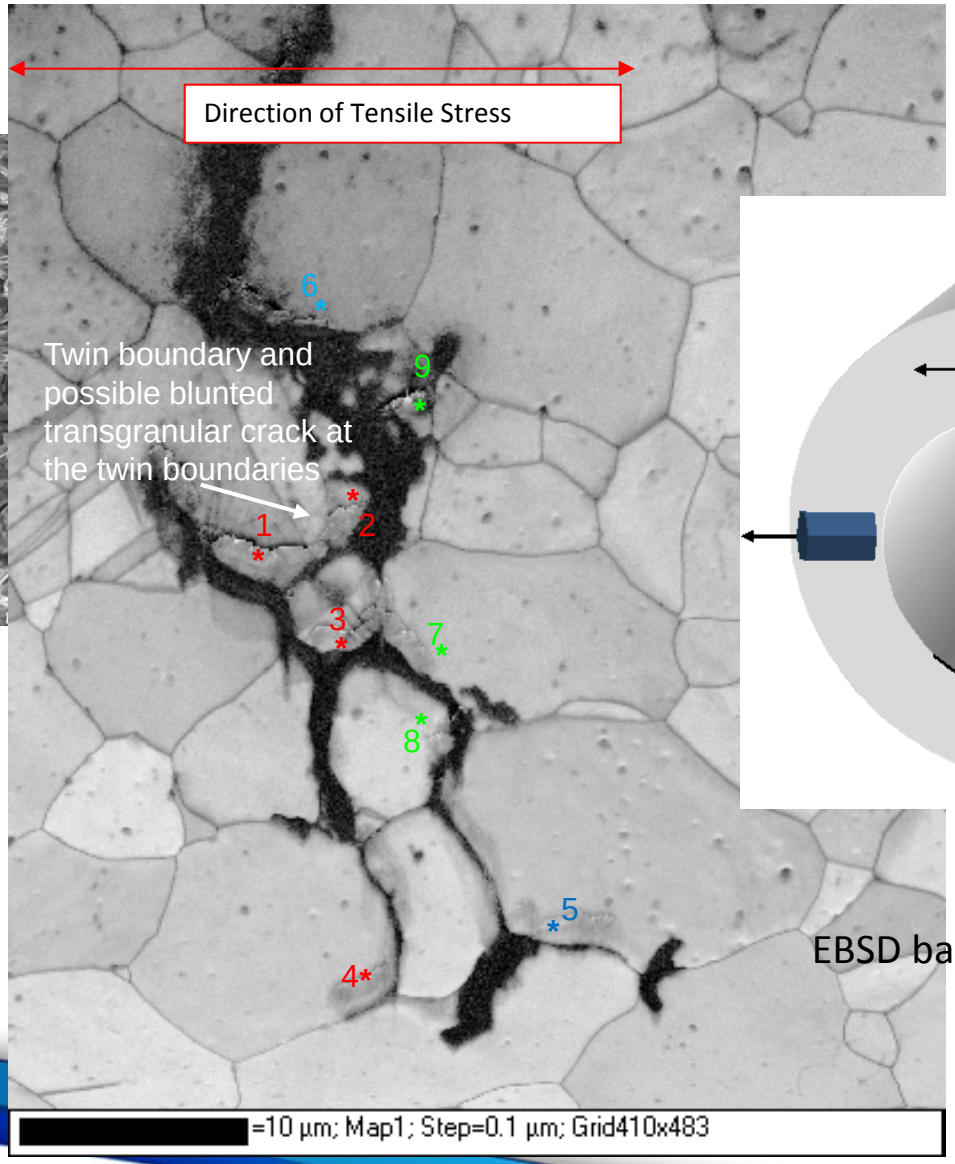


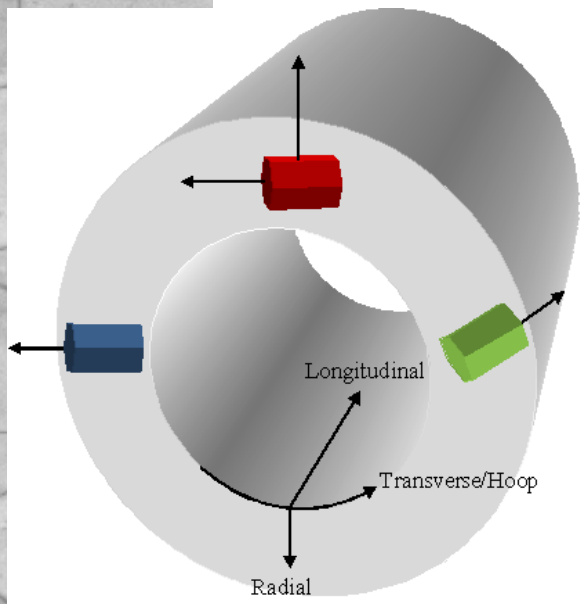
EBSD



Pole figure Region 1





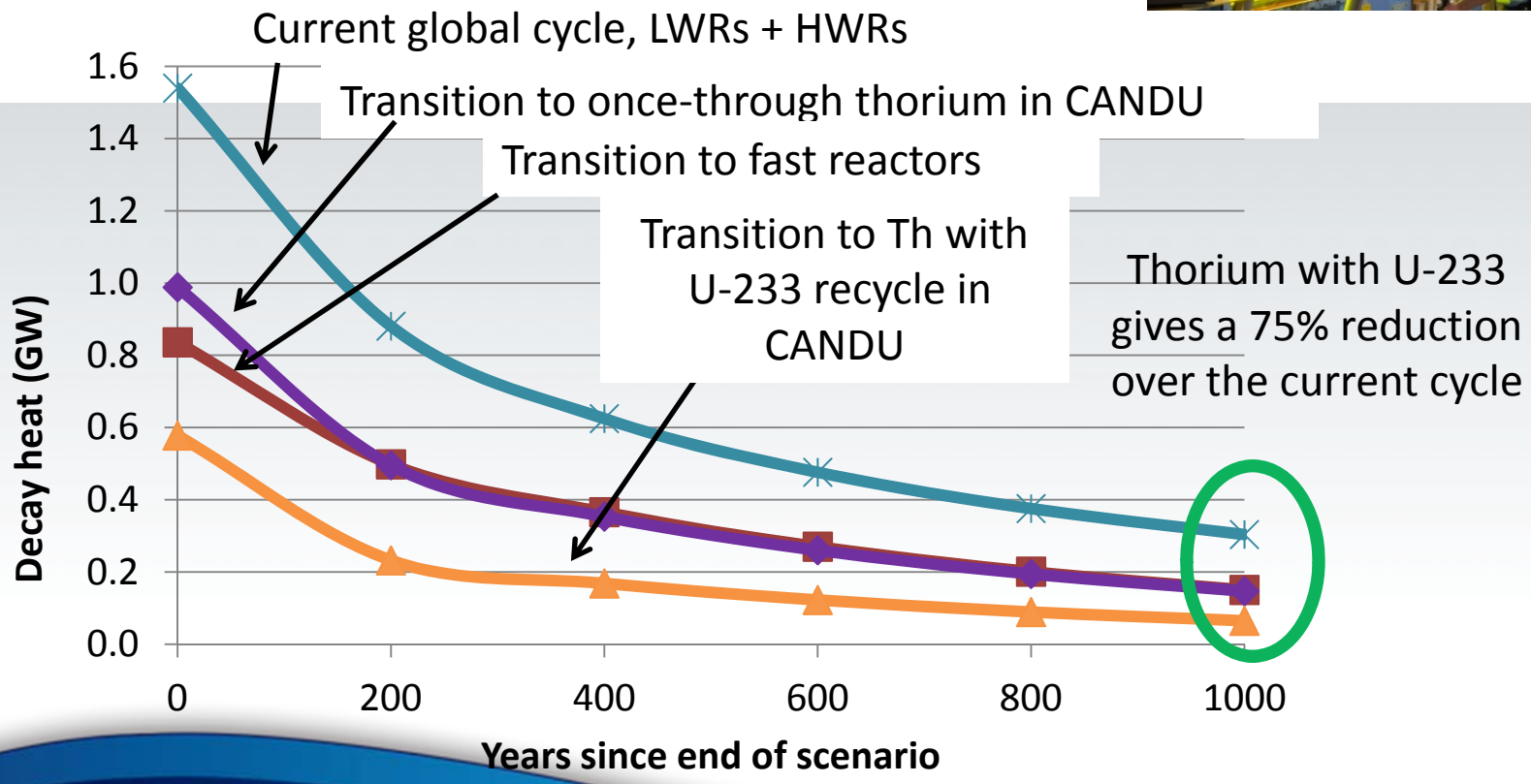


EBSD band contrast map

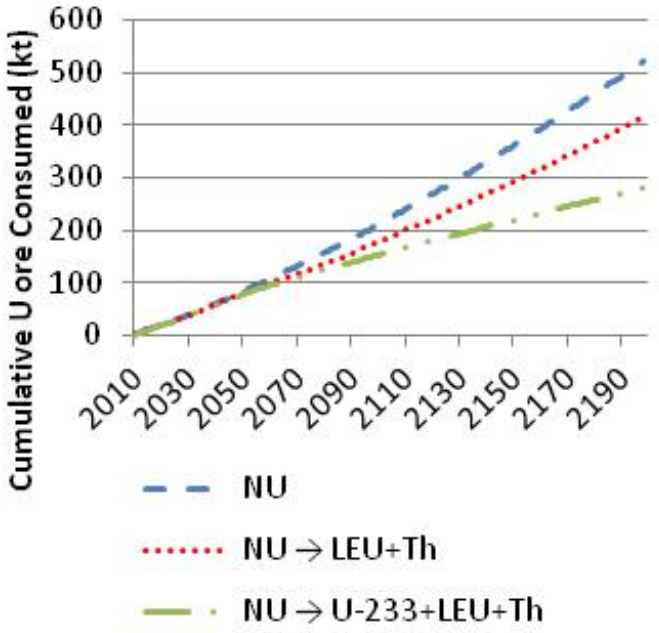
Glove box facilities

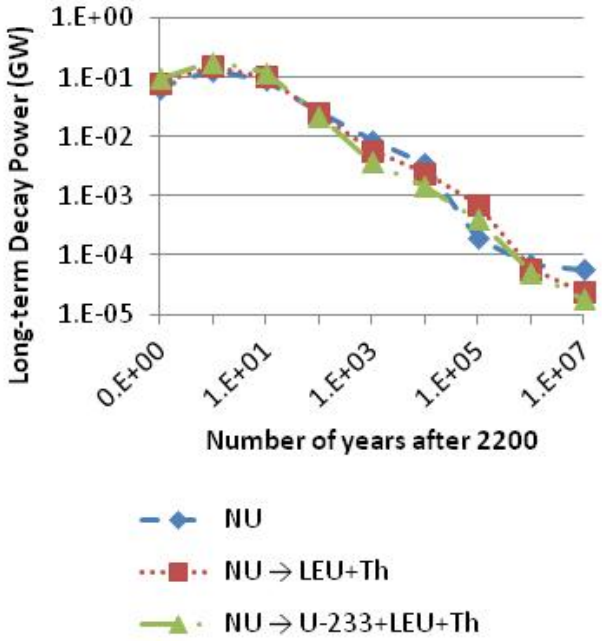
Actinides

Fuel Cycles

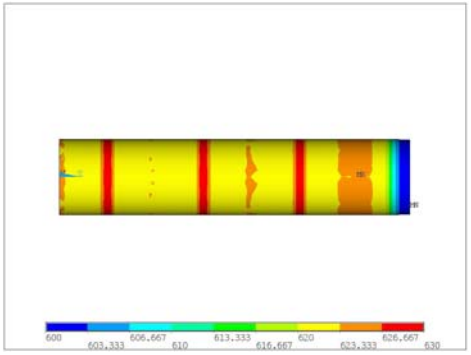

Current global cycle, LWRs + HWRs
Transition to once-through thorium in CANDU
Transition to fast reactors
Transition to Th with U-233 recycle in CANDU
Thorium with U-233 gives a 75% reduction over the current cycle
Decay heat (GW)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
Years since end of scenario

Fuel Cycles


Cumulative U ore Consumed (kt)
600
500
400
300
200
100
0
2010
2030
2050
2070
2090
2110
2130
2150
2170
2190
NU
NU → LEU+Th
NU → U-233+LEU+Th


Long-term Decay Power (GW)
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
0.E+00
1.E+01
1.E+03
1.E+05
1.E+07
Number of years after 2200
NU
NU → LEU+Th
NU → U-233+LEU+Th

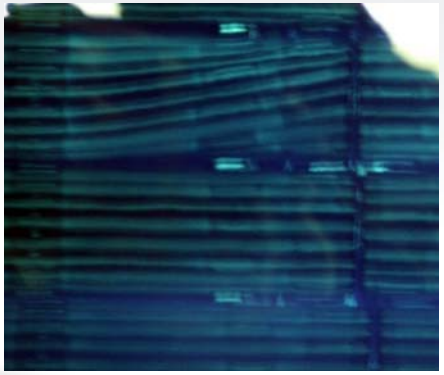
Testing and Post Irradiation Examination

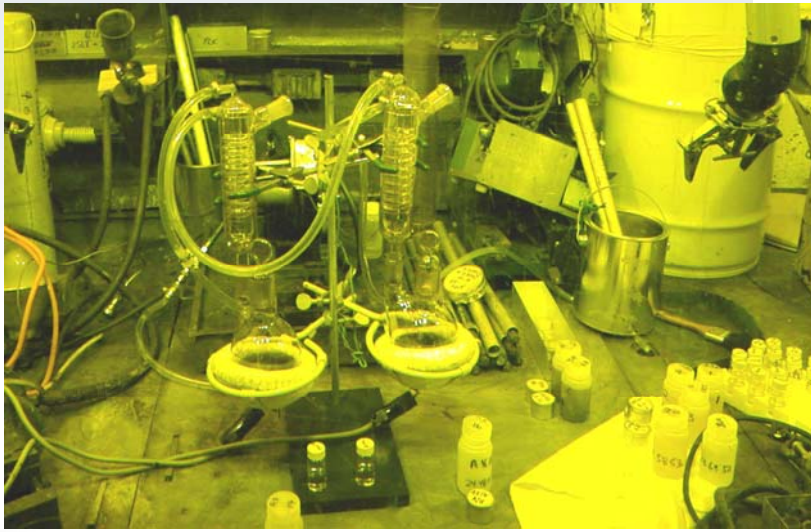


Fuel testing

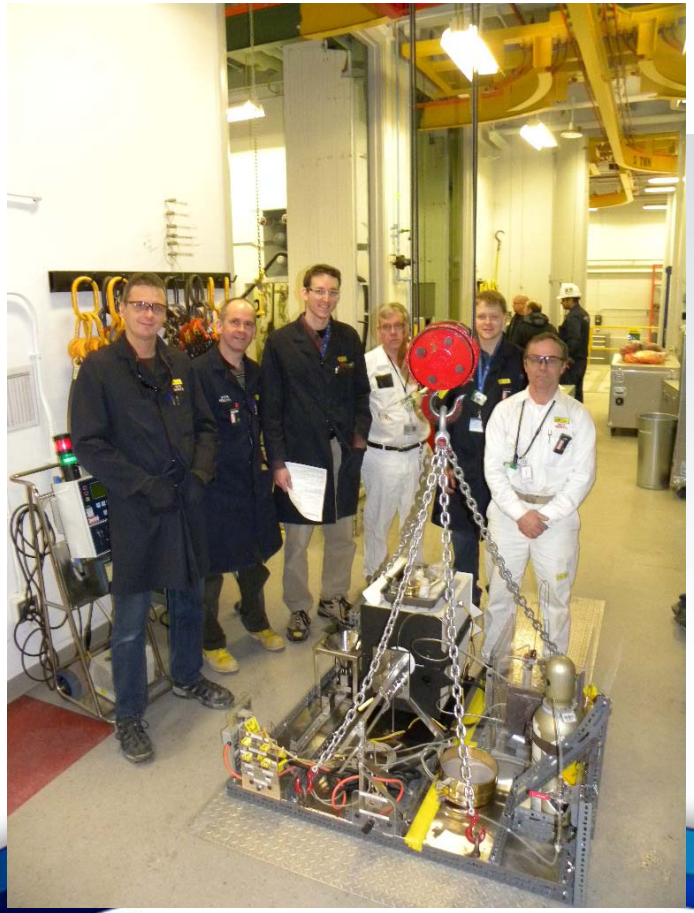
Evaluation of fuel performance

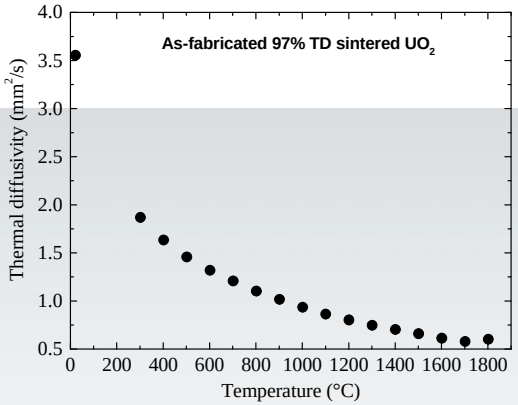
Failure investigations

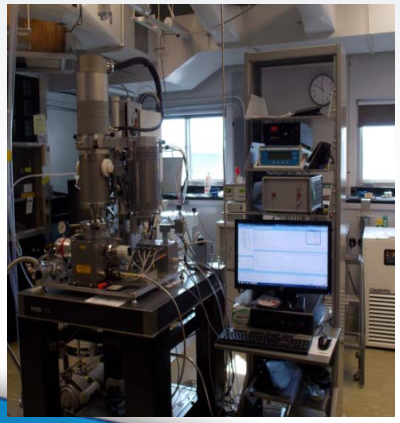


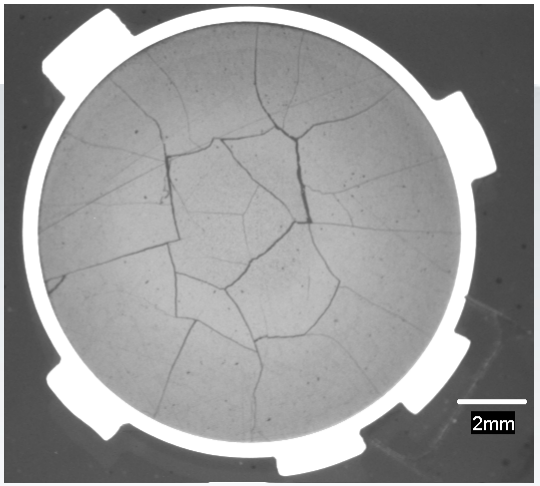


Testing and Post Irradiation Examination



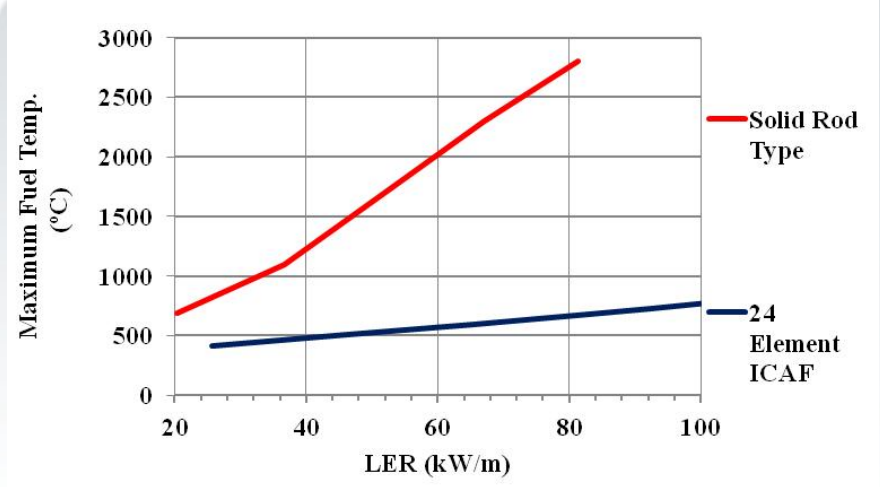






- PWR fuel with 670 MWh/kgU
- 0.8 wt.% U-235 in U; 0.9 wt.% Pu in HE
- Tested to additional burnup of 517 MWh/kgHE (NRU)

ICAF



Comparison of fuel temperatures versus power rating for ICAF and solid rod fuel

Advanced Fuel and Fuel Cycles

What is next

- Support Candu
- Thoria Roadmap
- Small Reactors

Summary

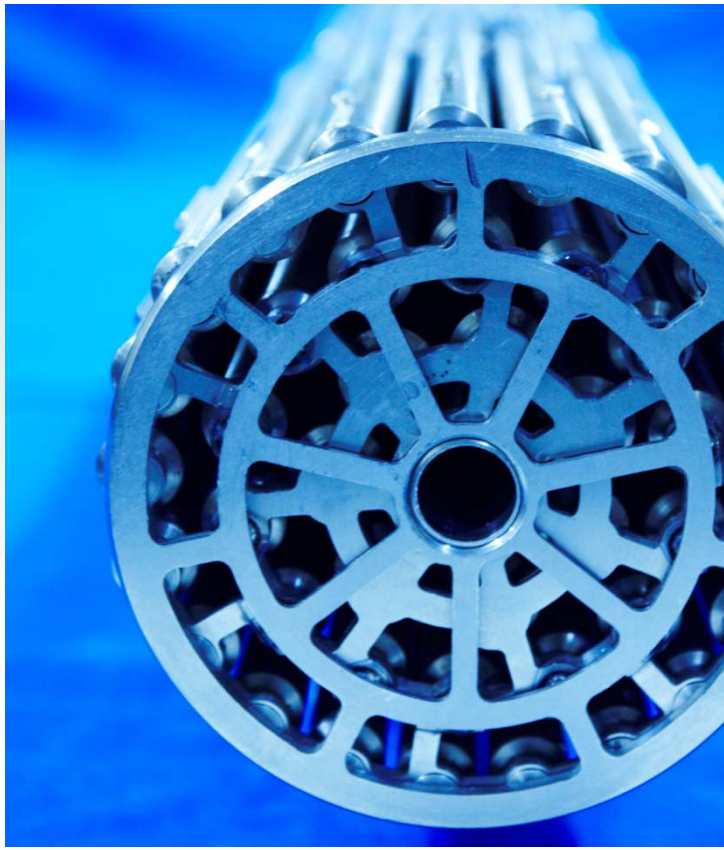
Advanced Fuel and Fuel Cycles

CNL

Fuel S&T driver: sustainability

Areas of interest

rosaura.ham-su@cnl.ca

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