Accident Tolerant Fuel- Canada

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OECD/NEA Meeting

Boise, Idaho, 2016 September

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

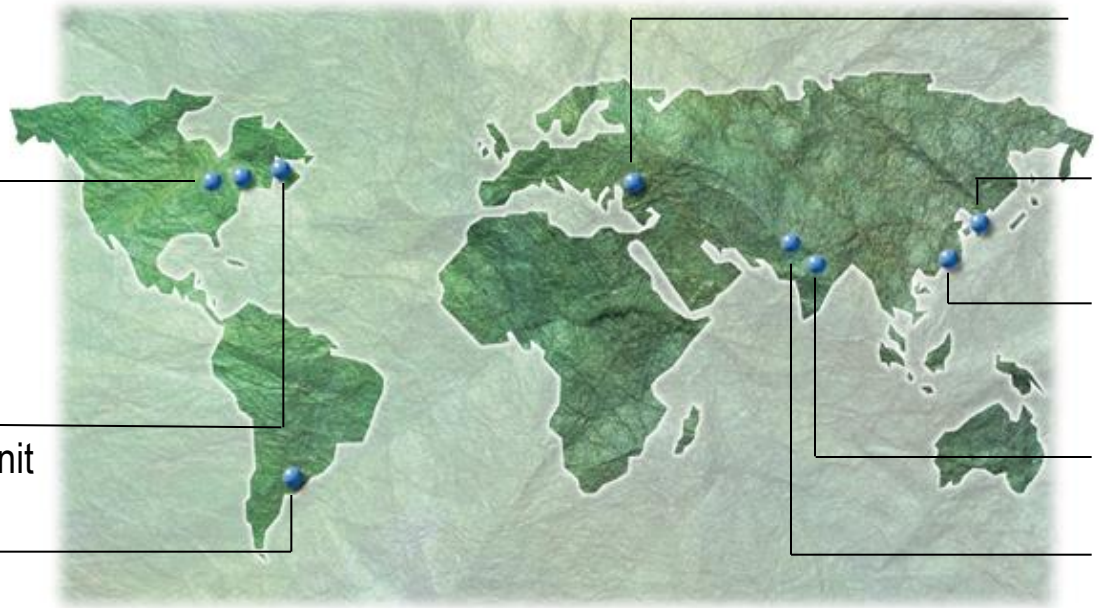
- Pressurized Heavy Water Reactors
- Canadian Nuclear Laboratories
- Fuel Science and Technology: ATF

31 CANDU reactors in operation around the world and 16 in India based on pressure tube design

Ontario, Canada
Darlington 4 units
Pickering 6 units
Bruce 8 units

New Brunswick, Canada
Point Lepreau 1 unit

Argentina
Embalse 1 unit



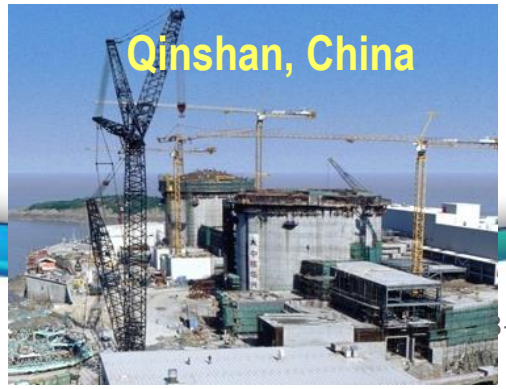
Romania
Cernavoda 2 units

Republic of Korea
Wolsong 4 units

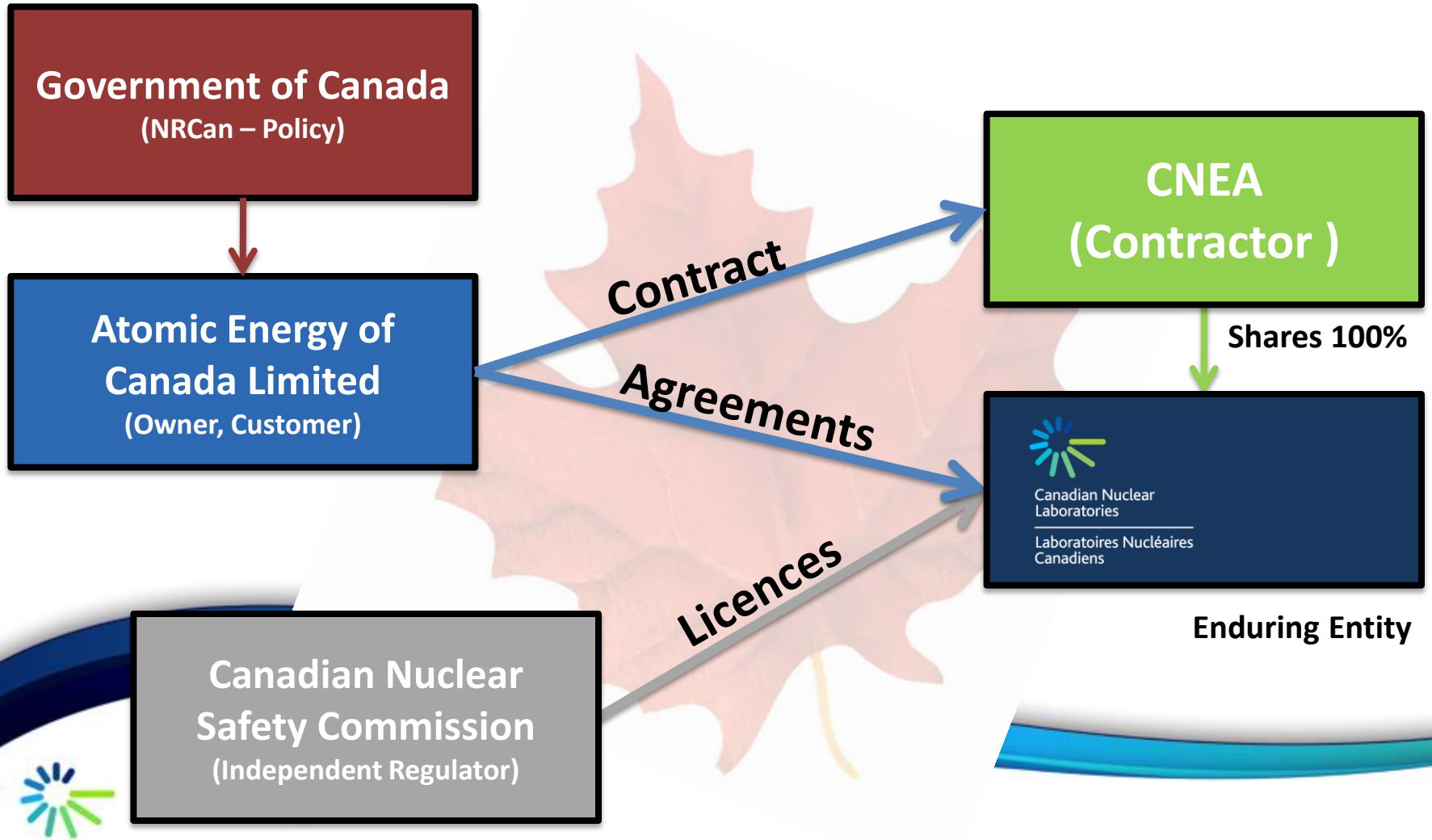
China
Qinshan 2 units

India
2 CANDU units +
16 HWR units

Pakistan
KANUPP 1 unit



Canadian Nuclear Laboratories since 2015 September



CNL

Chalk River Laboratories

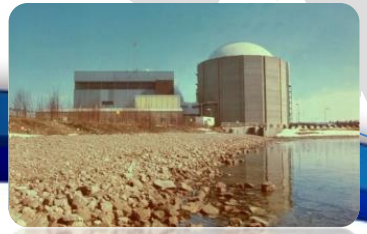
NPD

LaPrade

Gentilly 1

Glace Bay

Whiteshell Laboratories



Douglas Point

Port Hope / Granby

Manitoba

Ontario

Quebec

New Brunswick

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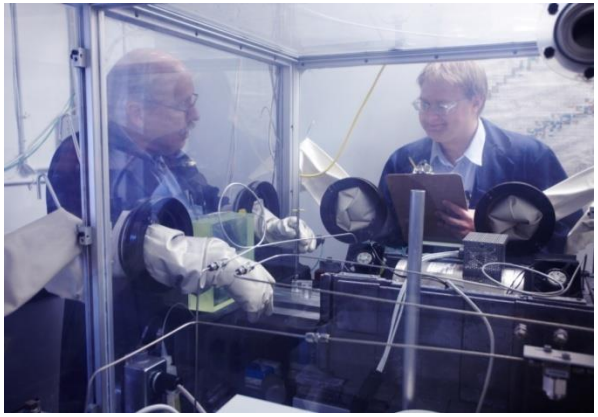
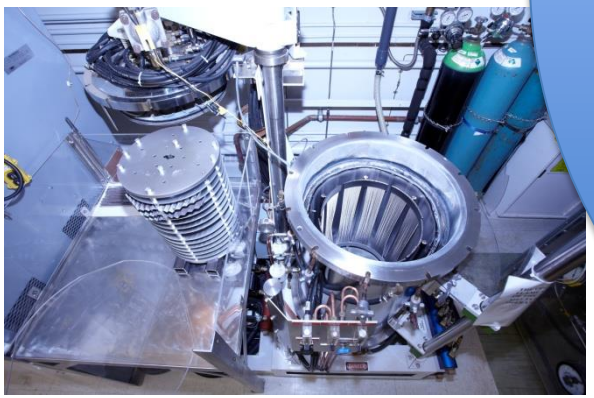
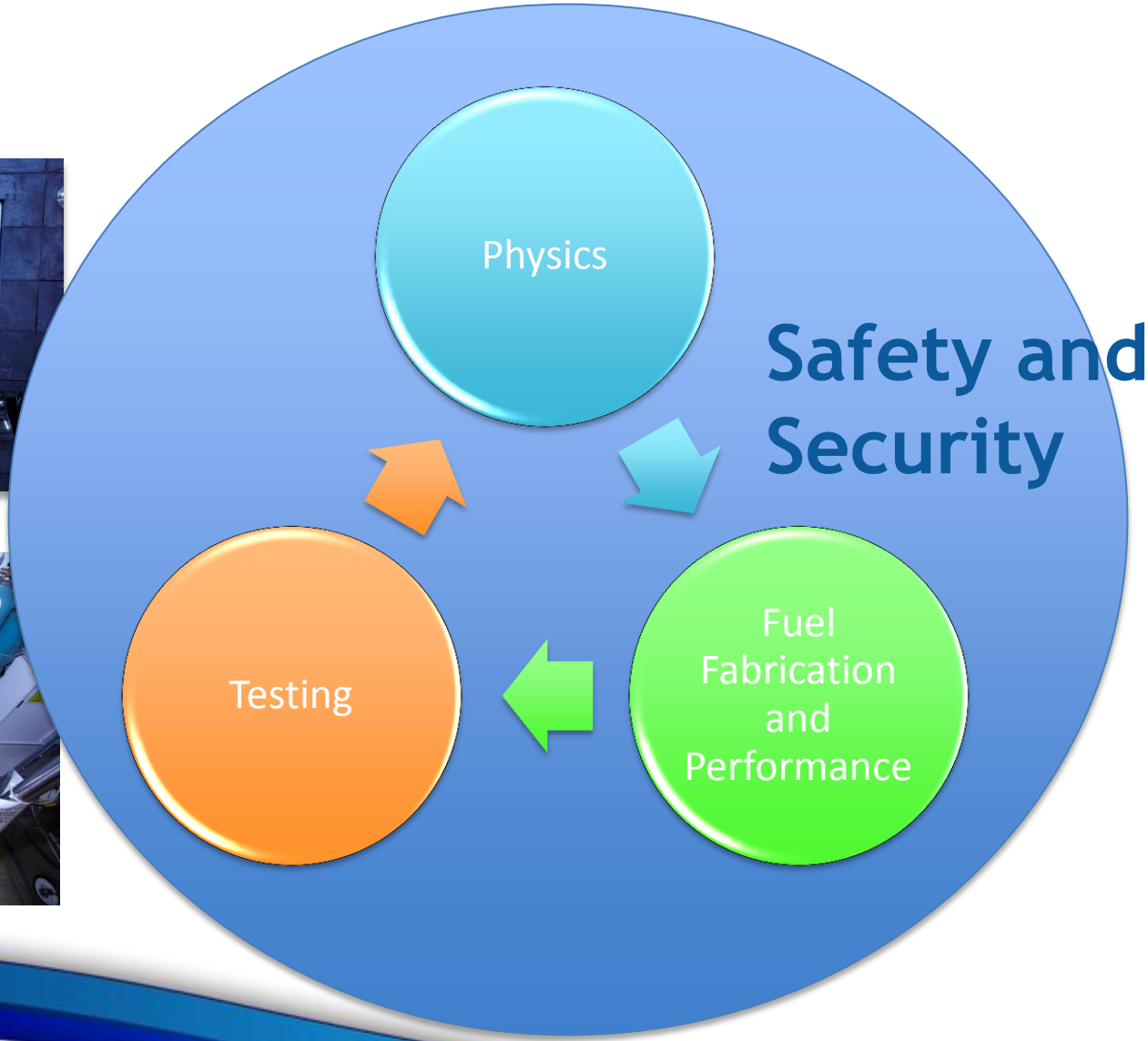


Fuel S&T

nuclear fuel S&T includes: fuel cycles, spent fuel management, fabrication, testing, modelling, and post irradiation examination




Physics
Fuel Fabrication and Performance
Testing
Safety and Security

Accident Tolerant Fuel

Project initiated in April 2016

- Water reactors are the workforce of nuclear power in Canada for the foreseeable future
- Short, medium and long term efforts
- What changes in the fuel can be implemented in the short term?
  - Manufacturing
  - Operations of CANDU reactors
  - Recyclable
  - Waste - DGR

Accident Tolerant Fuel: start

Cladding

- Reduce H, increase softening T (e.g. steels, SiC) - CANMET
- Manufacturing and assembly
- Pellet-cladding interaction and environmentally assisted cracking
- Coatings
- Hydriding

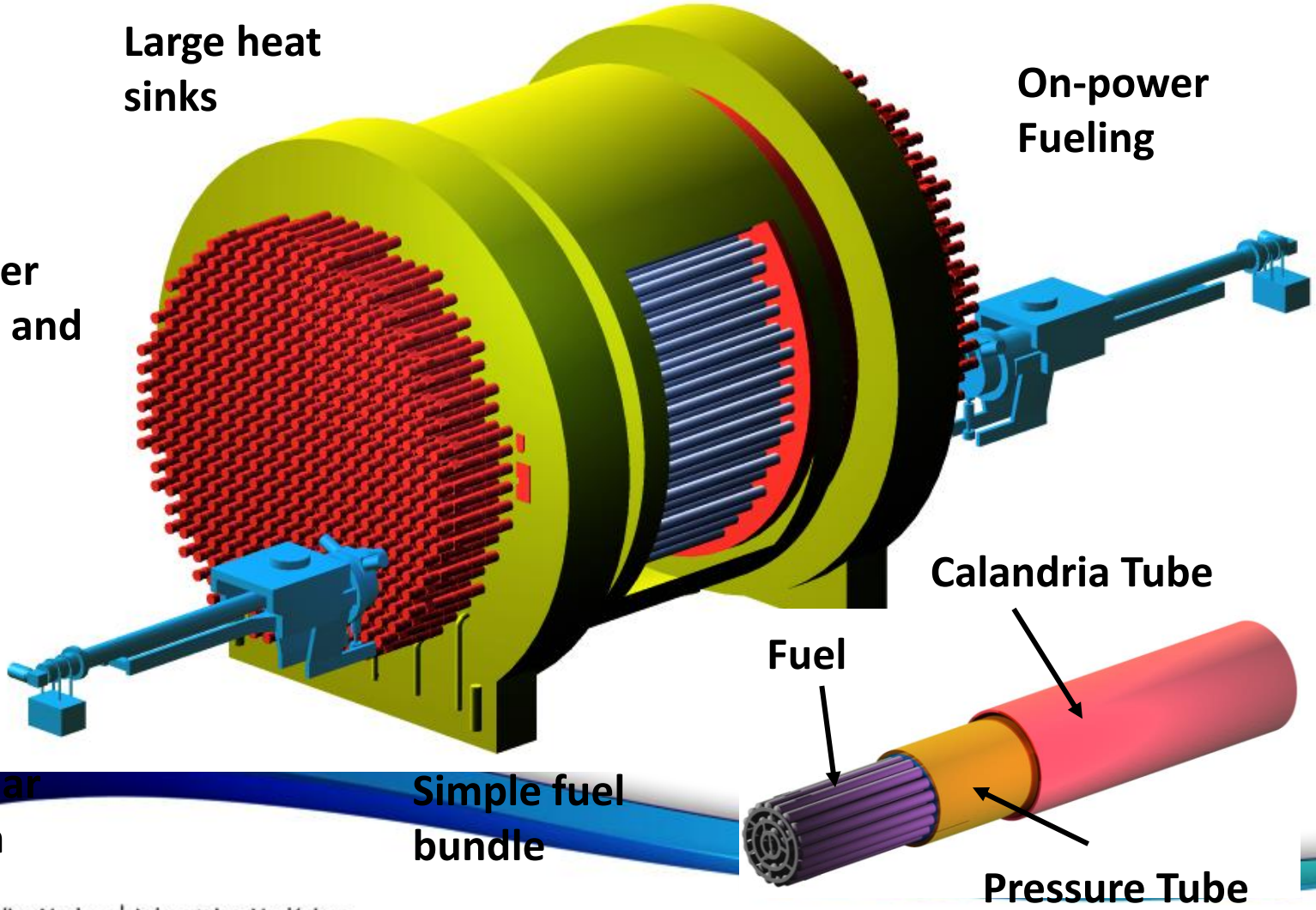
Cooler Fuel

- Required for advanced fuel cycles
- Increase thermal conductivity (graphite discs or additives embedded in matrix, thoria)
- Design changes - ICAF

Systems check

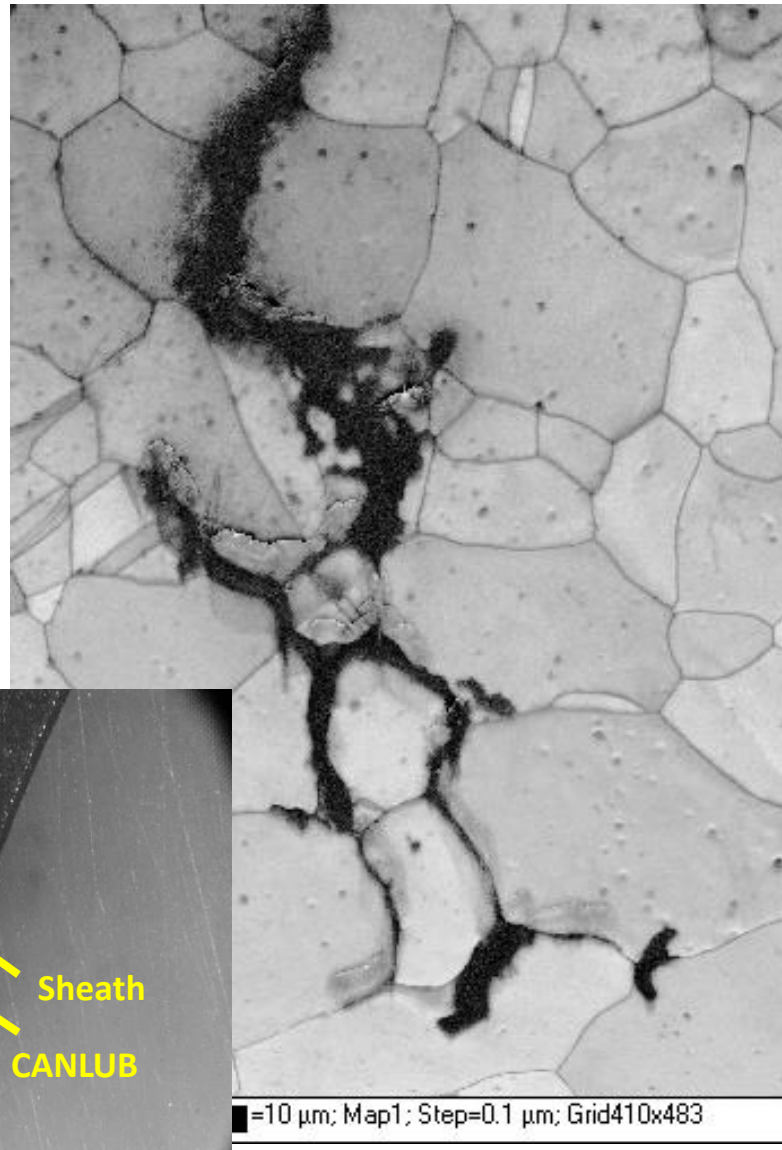
- Thermal hydraulics
- Physics
- Waste Management
- Short-term – is it realistic?
- Medium or long term

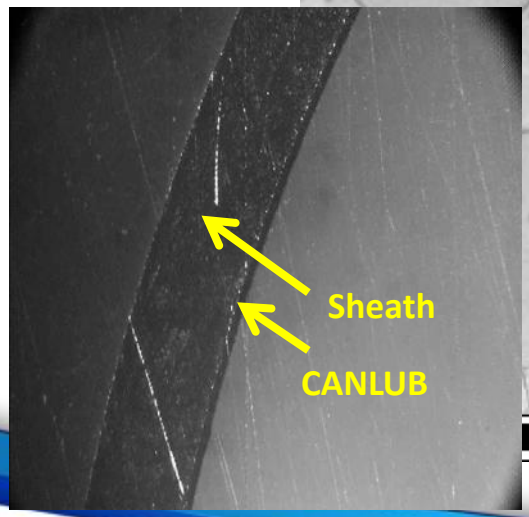
CANDU Reactor Core



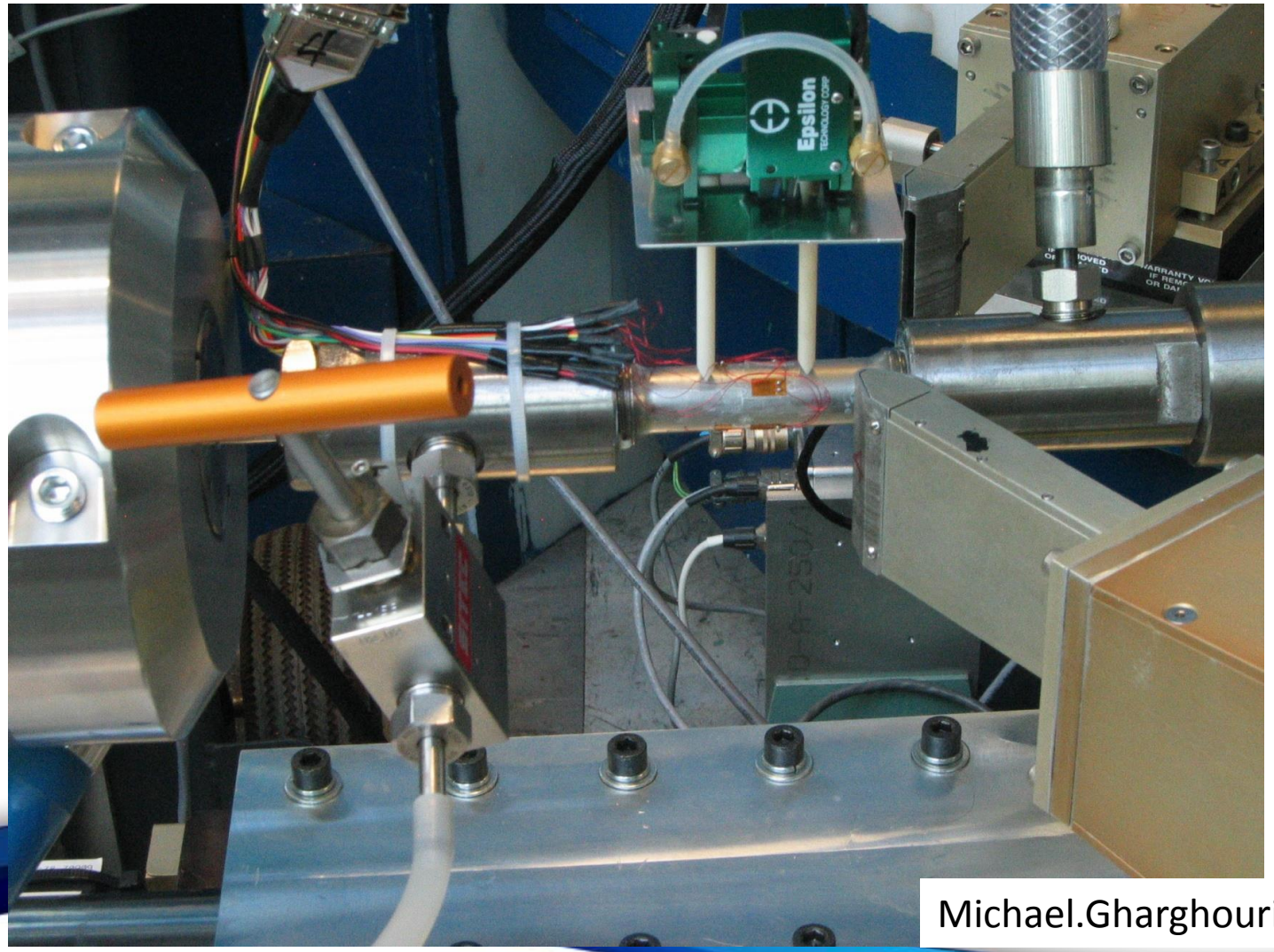
CANDU

- Thin Zircaloy-4 sheath collapses onto the fuel upon reactor entry
- Sheath follows pellet shape
- On-power refuelling – PCI (SCC)
- SCC is strain rate dependent
- Biaxial deformation behaviour





BIAXIAL DEFORMATION OF ZIRCONIUM ALLOYS



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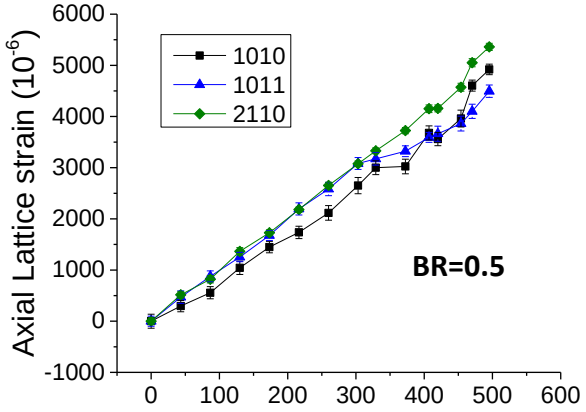

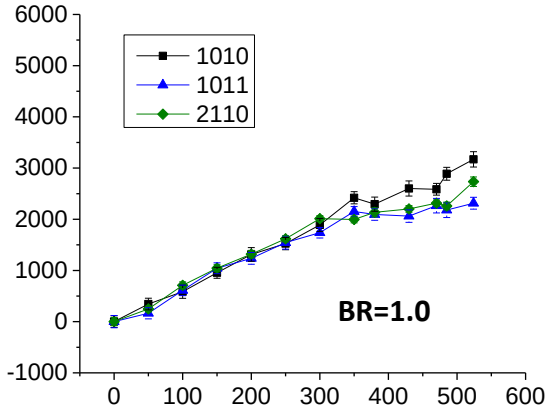

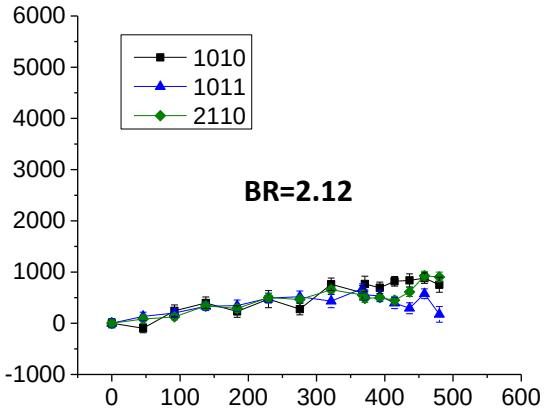

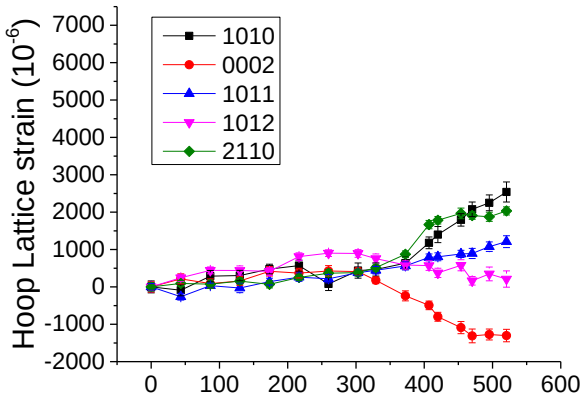

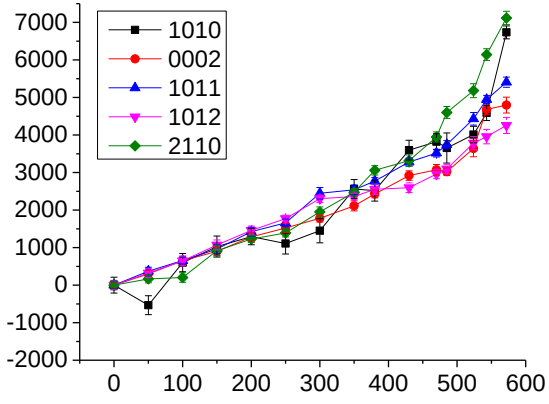

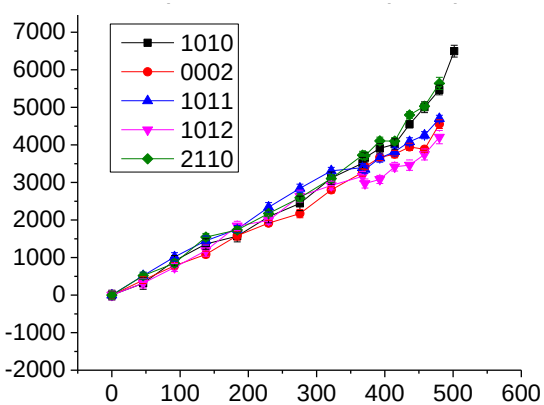

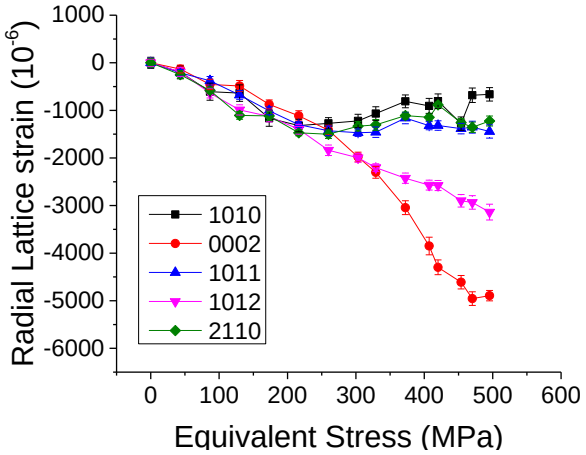

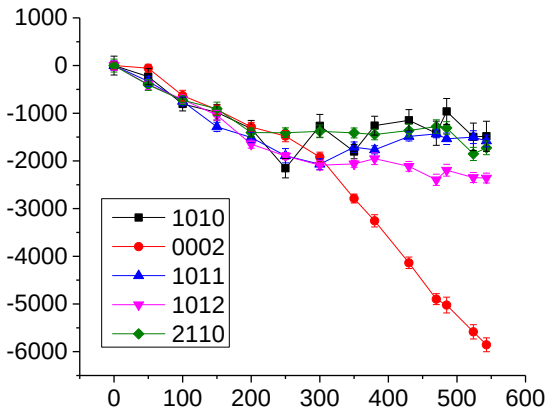

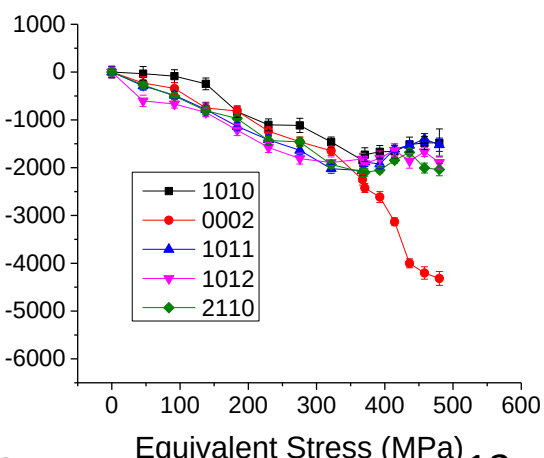

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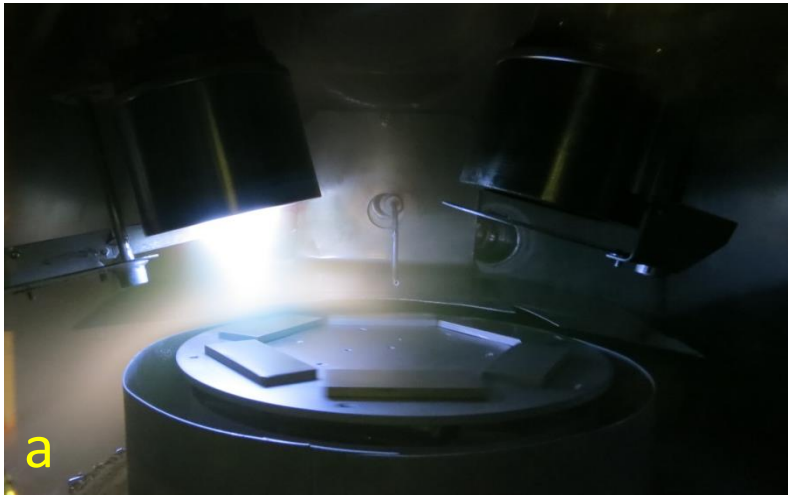
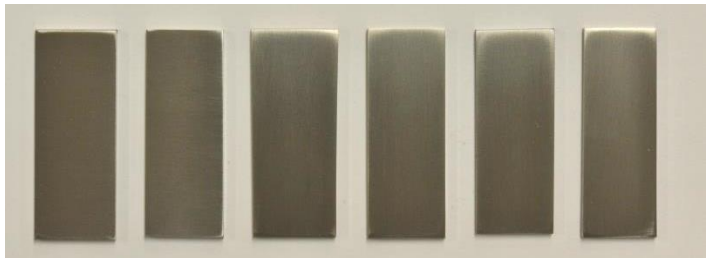
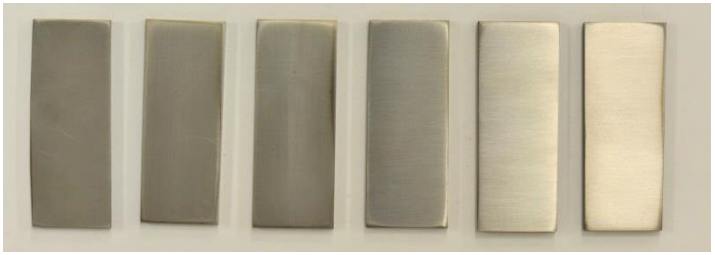
UNRESTRICTED / ILLIMITÉ

ATF R&D - Coatings to improve oxidation-resistance of zirconium alloys

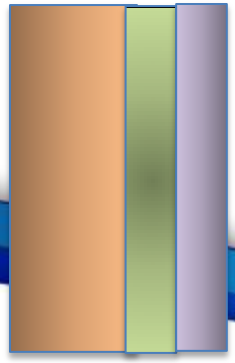



b


c


d

a: Close view of sputtering process
b: Zirconium plates in as-received condition
c: Single-layer coating
d: Double-layer coating



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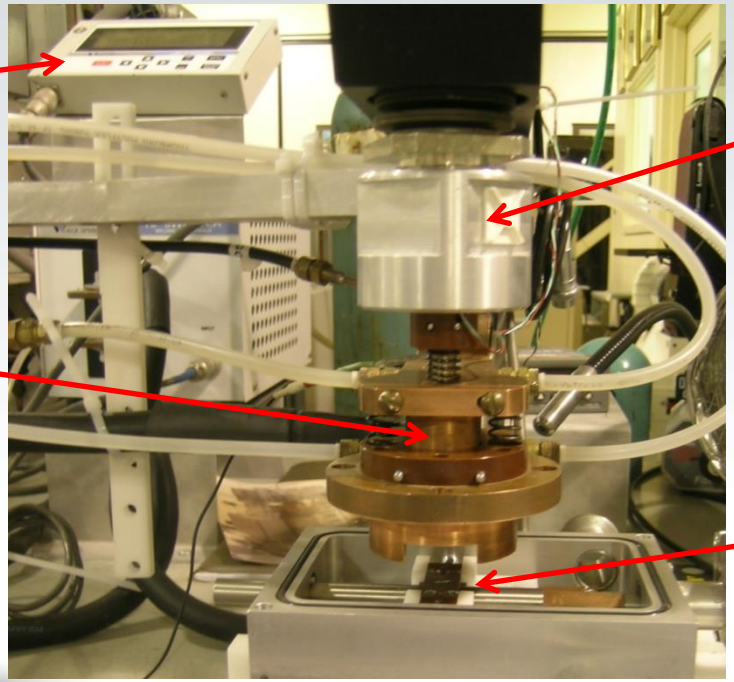
Joining and manufacturability

Development of joining techniques Welding and brazing



High frequency welding

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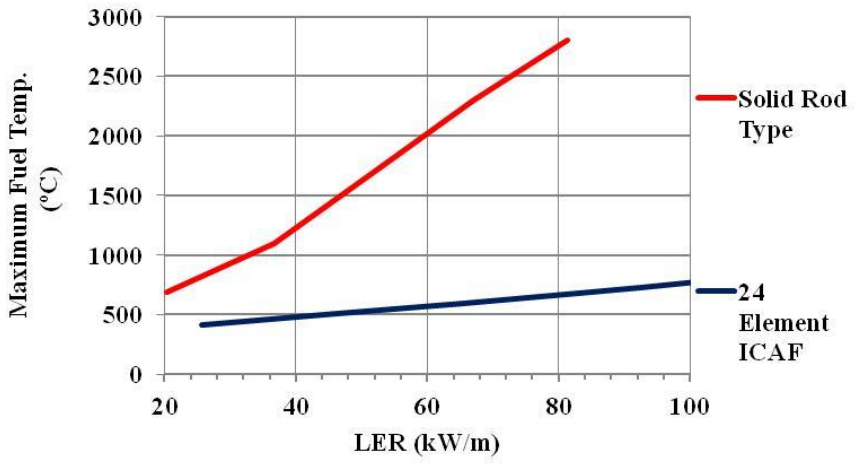
Medium to long term efforts: Design changes



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

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Accident Tolerant Fuel

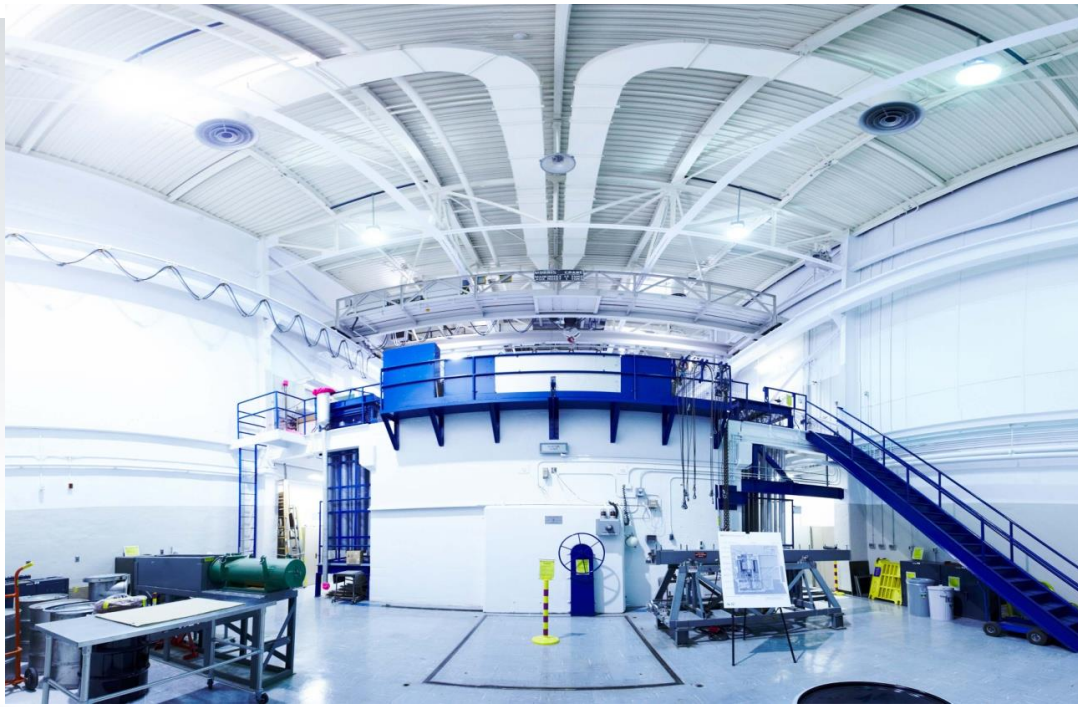
Shor term: work focusing on coatings; heavy involvement from utilities and fabricators is required

Medium and long term efforts are being defined now: universities, government laboratories, reactor vendors, etc. are or will be expected to be involved

Thanks!

Accident Tolerant Fuel

- Coatings in the short term
- Medium and long term efforts are now being defined.



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