

Nuclear Safety and Security: the Role of Canada's Nuclear Laboratories

Rosaura Ham-Su

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2011 Global, Japan



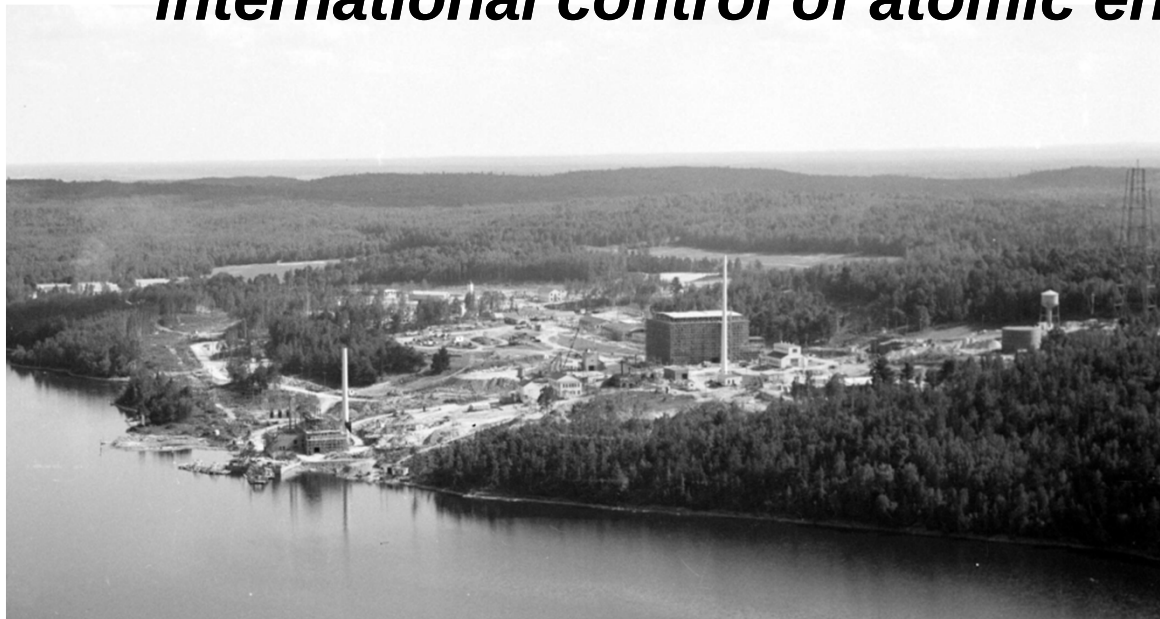
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Outline

- **A**tom**E**nergy of **C**anada **L**imited, AECL Nuclear Laboratories
- AECL's role in Safety and Security
- Safety and Security Program
 - Description and capabilities
 - S&T Program
- Summary

The Nuclear Laboratories

- Established as a Crown Corporation (AECL) in 1952
 - *“For the control and supervision of the development, application and use of atomic energy and to enable Canada to participate effectively in measures of international control of atomic energy ...”*



Nuclear Laboratories

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- **A nuclear laboratory producing and applying science & technology for the benefit of Canadians and the world**

Nuclear Laboratories

- We work for the public good

Nuclear Laboratories



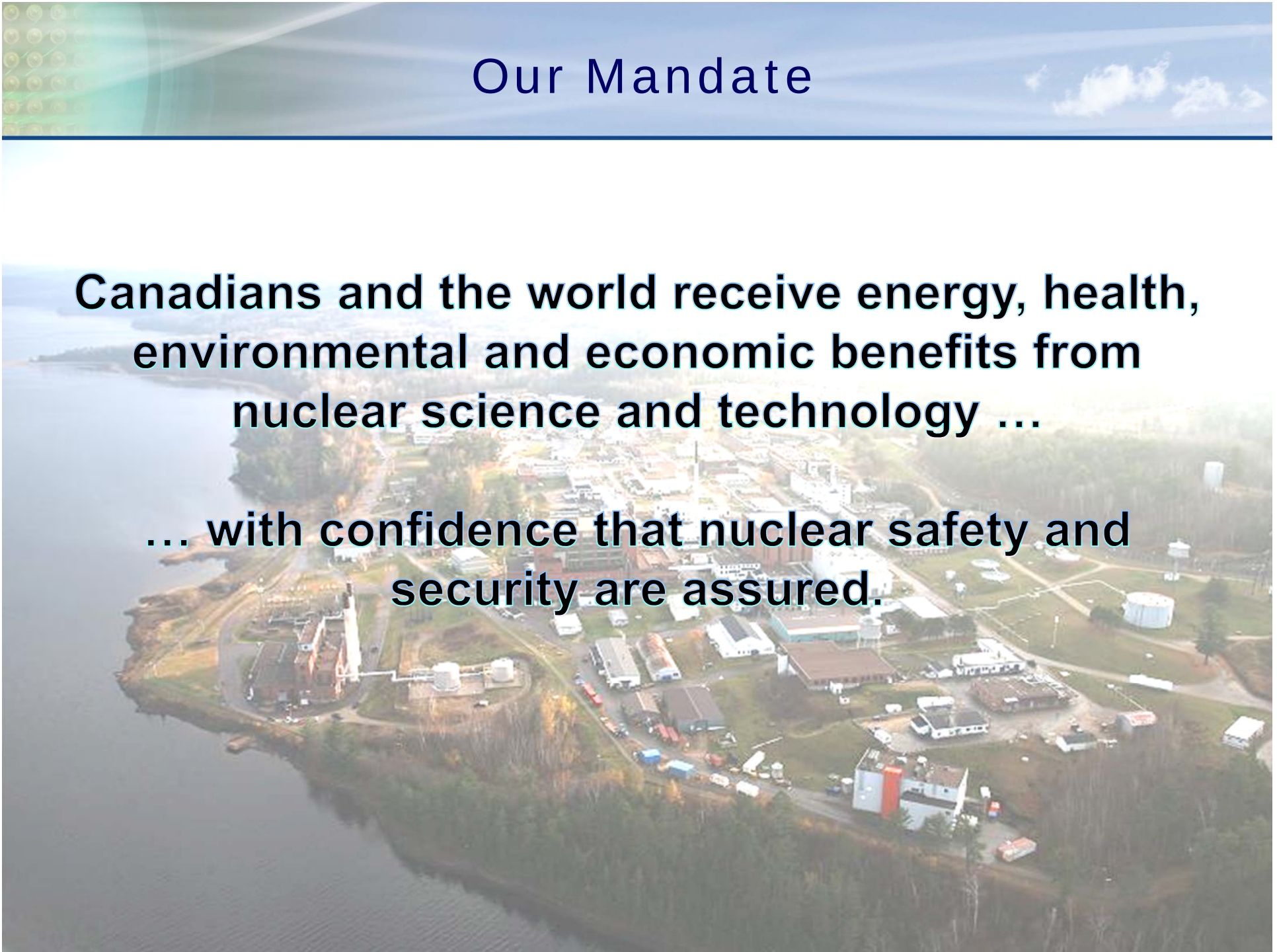
Our Mandate



Our Mandate

**Canadians and the world receive energy, health,
environmental and economic benefits from
nuclear science and technology ...**

**... with confidence that nuclear safety and
security are assured.**



Strength in People & Facilities



Sites:

Chalk River - HQ

Whiteshell

Ottawa

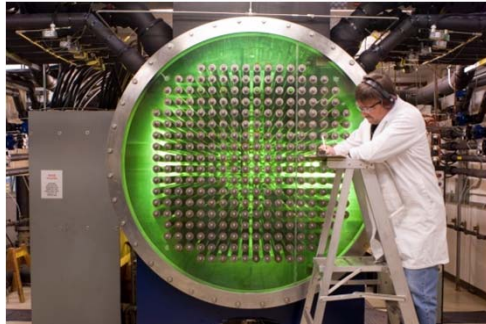
Port Hope



- **3000+ people**
- **Specialized Facilities**
- **Unique capabilities – strong interactions between groups facilitated by proximity**

Unique S&T Facilities

Fuel Fabrication Thermalhydraulics



Surface Science



Hot Cells



NRU



BRF



ZED-2



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Nuclear Laboratories

Program Activities

Nuclear Industry Capability	Nuclear Safety and Security	Clean, Safe Energy
Health, Isotopes and Radiation	Nuclear Environmental Stewardship	Nuclear Innovation Networks

Supporting / Enabling Program Activities

Mission-Ready Science & Technology Infrastructure	Internal Services
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- Protection, mitigation, risk assessment tools and emergency response capability should an incident occur.
- Access to technical expertise for response forces, regulators and other government agencies, so that decisions taken to protect Canadians are risk informed

Safety and Security Program

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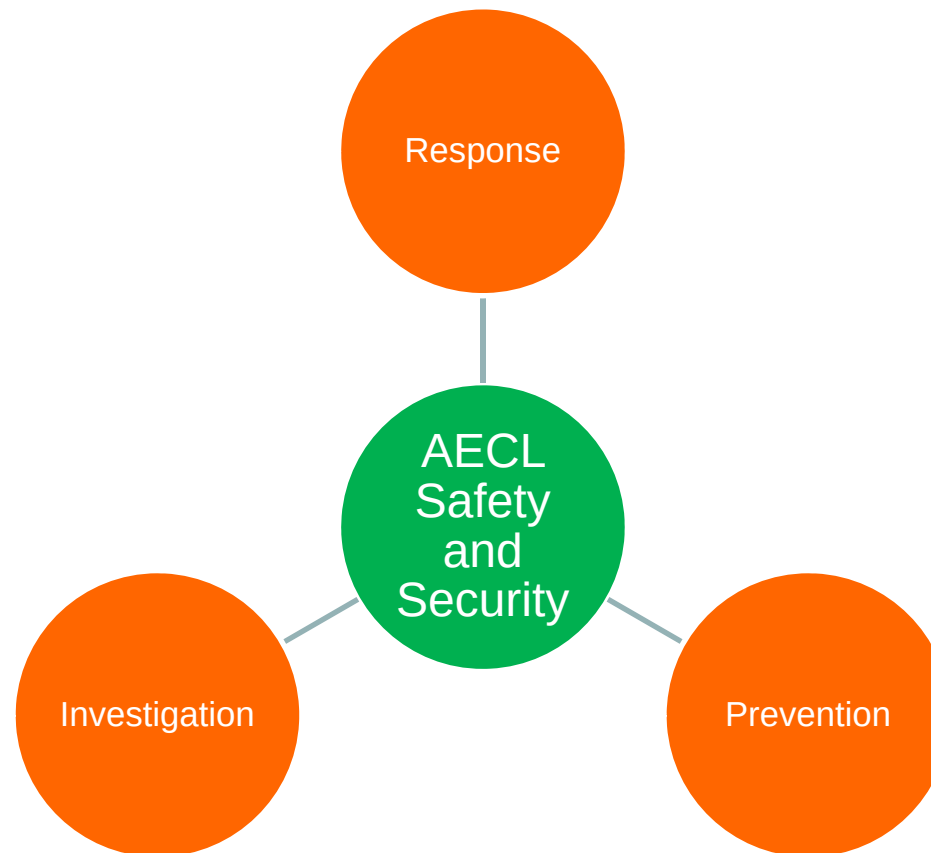
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- Prototype Safety Analyses Codes

Safety and Security Services



Prevention

- Reactor Safety S&T
- Dosimetry services
- Physical protection
- Safeguards & non-proliferation
- Risk assessment
- Security of radioactive sources
- Security of nuclear waste
- Transportation
- Error prevention
- Cause analysis
- Human performance



Investigation

- Nuclear forensics
- Analytical laboratory services
- Proliferation Resistance and Physical Protection (PR&PP) assessment
- Safeguards by Design (SBD) consultant services
- Information exchange



Response

- RN rapid emergency response
- Radiation detection
- Reception of nuclear materials
- Analytical laboratory services
- Environmental analysis
- Accident assessment
- Policy support (Gov't of Canada)
- Health of population

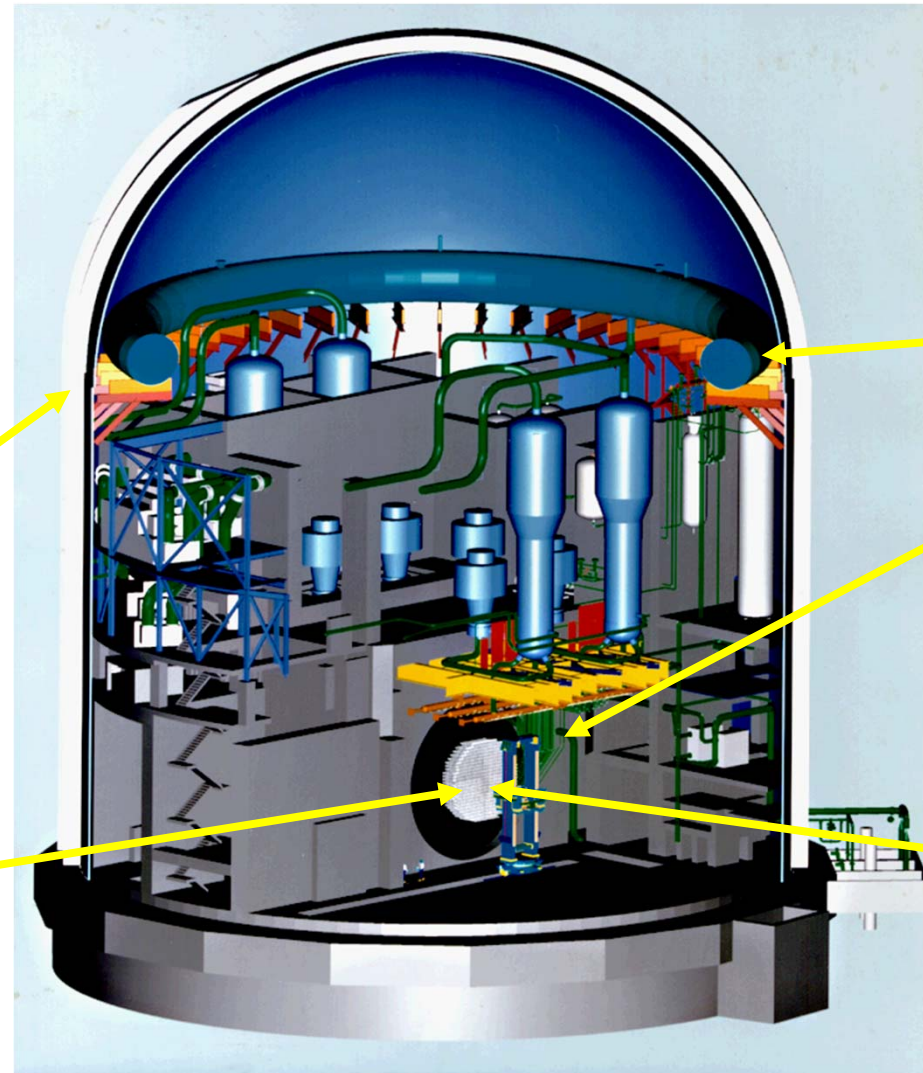


Nuclear Safety S&T

Methodology
Development

Containment
Behaviour

Fuel Channel
Behaviour



Passive
Features

Thermalhydraulics

Fuel and Fission
Product
Behaviour

Nuclear Safety Technology - S&T

- Understand, prevent and mitigate risks associated with nuclear operations and activities
- Advance the knowledge base for informed standards and regulation
- Enhance national and global nuclear security
- Help ensure the successful maintenance and safety of our CANDU industry

Nuclear Safety Technology - S&T Activities

- **Current Safety Code Suite – Development and Validation**

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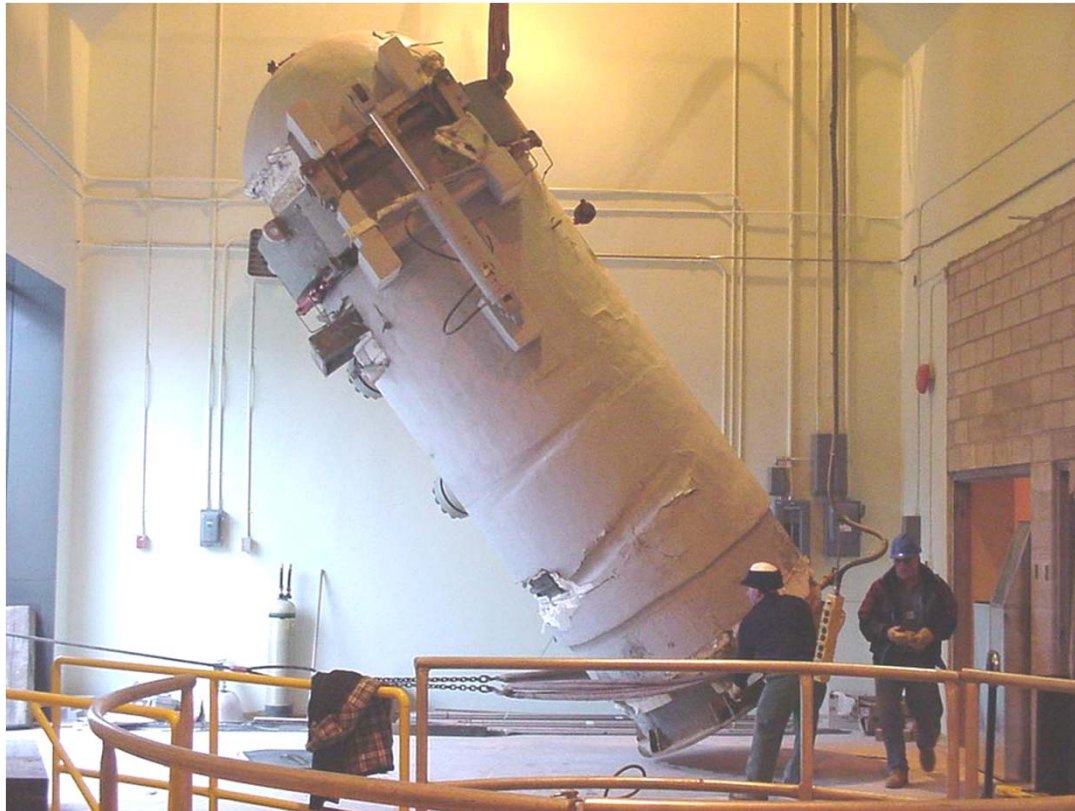
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- **Fuel Safety Margins - Quantification of Fuel Failure and Fission Product Release**

Severe Accident Research

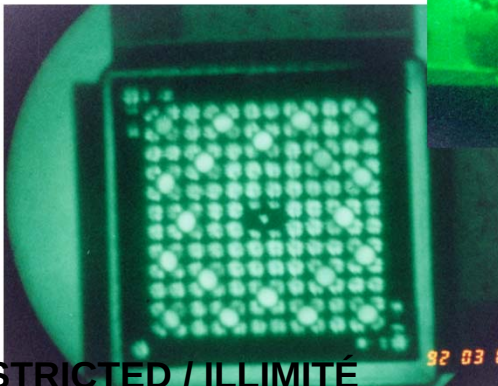
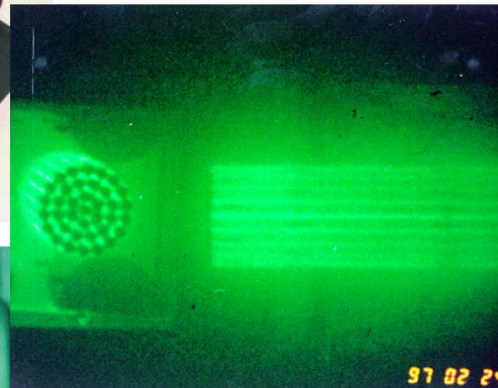
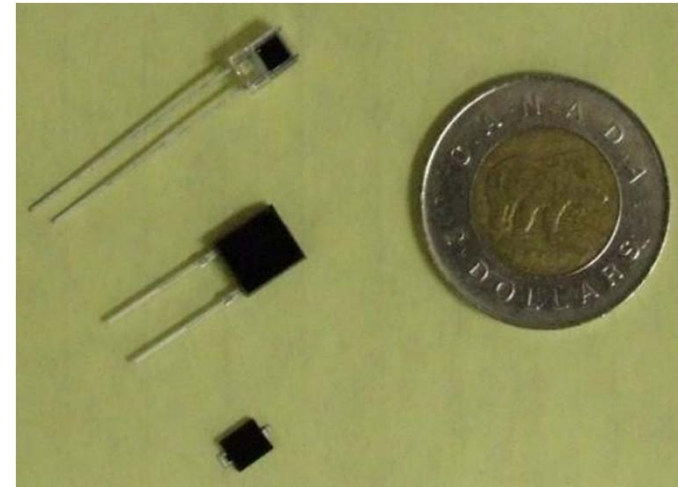
Molten Fuel Moderator Interaction Experiments to Satisfy Regulatory Concerns



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Technology development

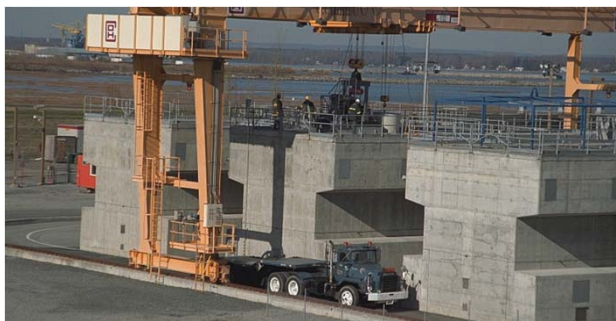
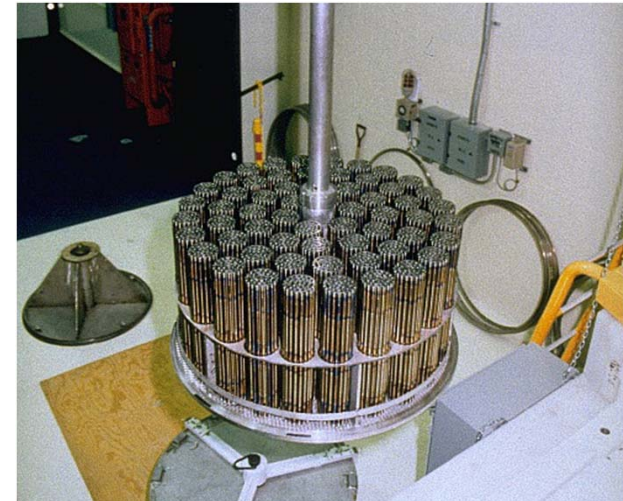
- Cerenkov Viewing Device (CVD)
- Muon Tomography
- Anti-neutrino Detector
- Solid-state radiation detectors (incl. neutron)
- Direct production of He-3 from PHWRs



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Non-proliferation & Safeguards support

- Advanced safeguards instrumentation development
 - digital CVD, micro radiation detectors, anti-neutrino monitoring, muon tomography of transport containers
- Safeguards by Design
 - new reactor designs, SF management, advanced fuel cycles



Loss of Coolant Accident Experiments

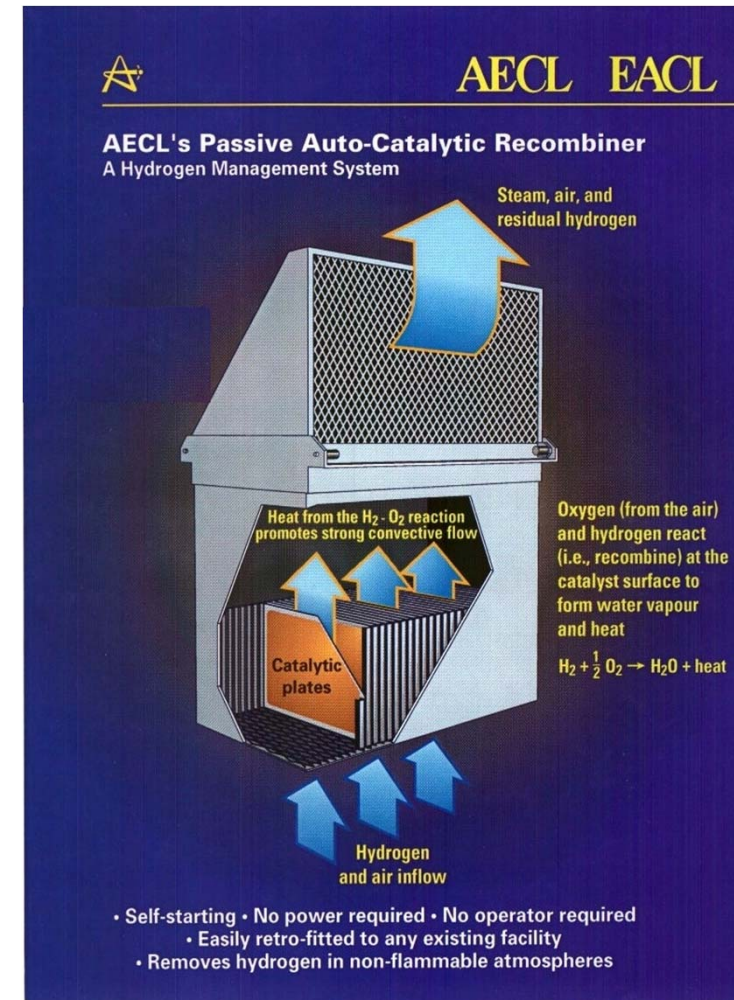


RD-14M Facility at Whiteshell Laboratories

- Full-elevation thermalhydraulic facility – for CANDU heat transport system
- Used for large LOCA analyses for CANDU reactors

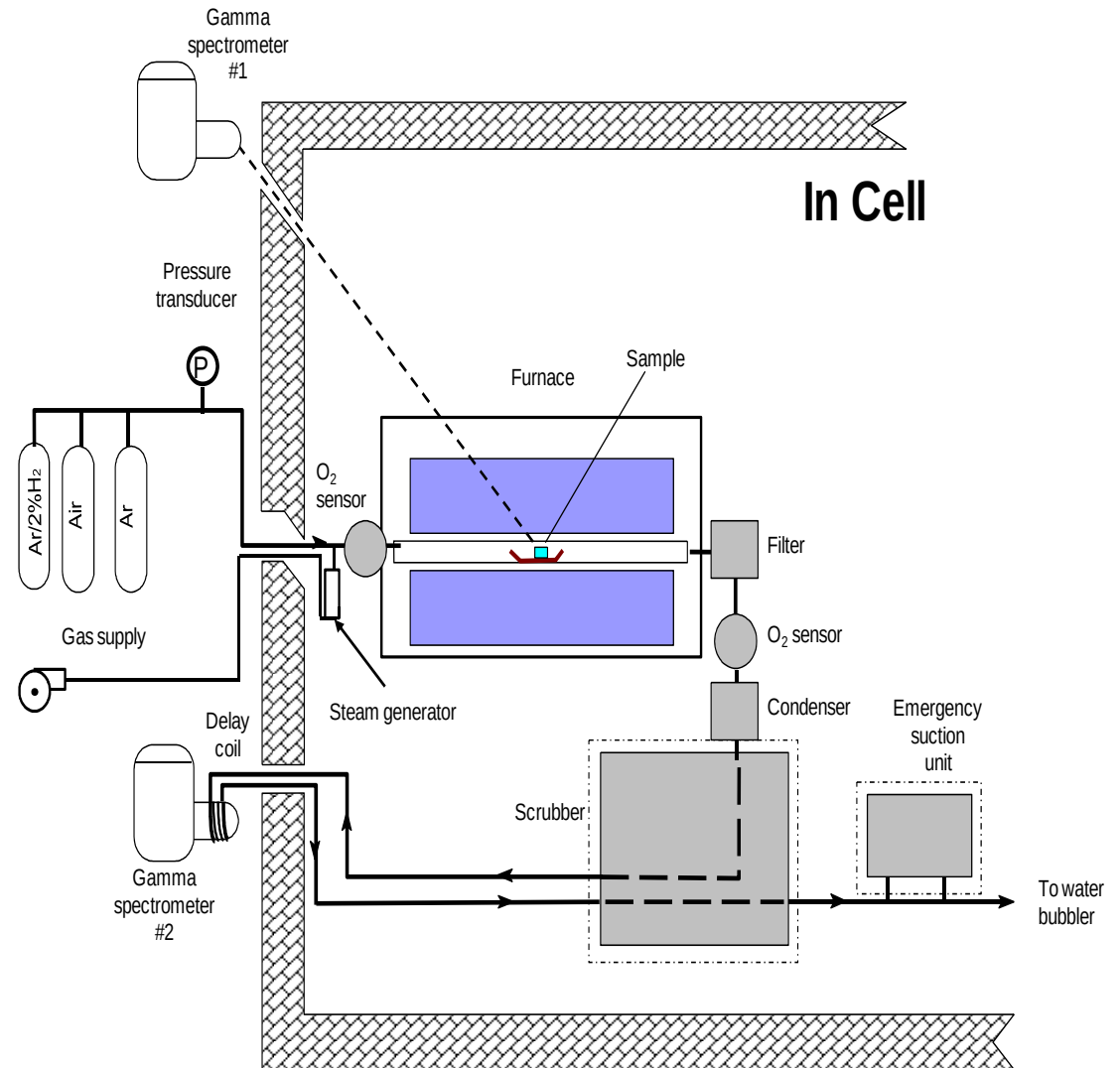
Hydrogen Hazard Mitigation

- Passive Autocatalytic Recombiners (PARs) for hydrogen mitigation in nuclear reactor containment - reduce risk of hydrogen combustion/deflagration under severe accident conditions
- Built on AECL catalyst technology development for D₂O production
- Numerous installations world-wide – CANDU and PWR
 - Finland, France, Ukraine, Korea
 - Canadian CANDU stations
- R&D continues on PAR improvements



Hot-Cell Fission Product Release Experiments

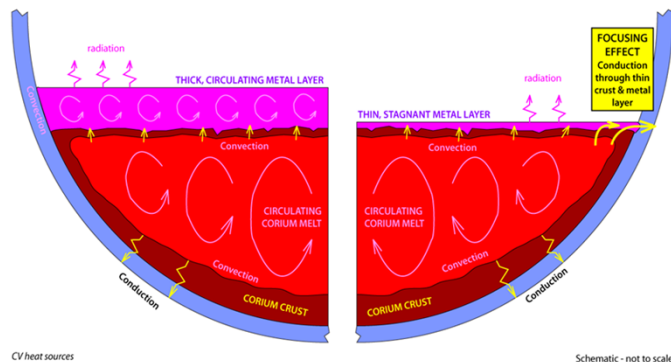
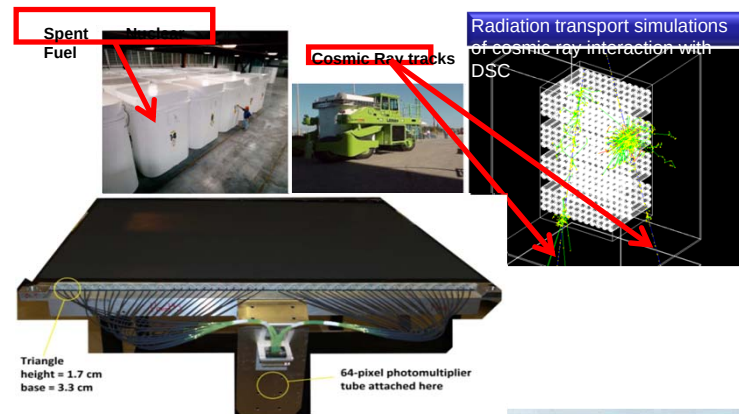
- Measure FP release from various fuels as a function of environment
- Emphasis changes in light of Fukushima events,
 - Release from UO_2 fuel in air-steam mixtures
 - Leaching of fission products from fuel samples and deposits using water and saline solutions



Summary

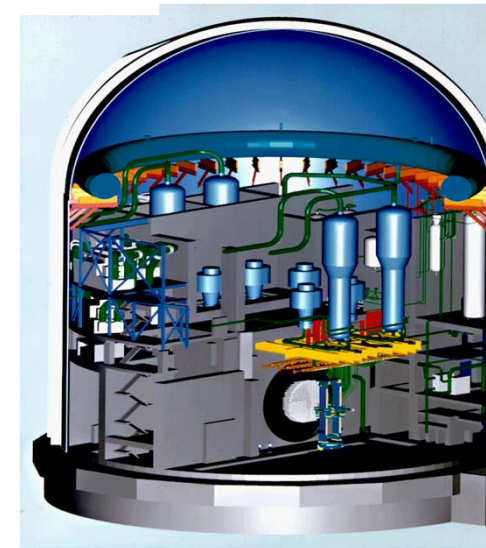
Nuclear Safety and Security Program:

Projects and services that ensure the safety of Canadian nuclear facilities, their employees and the Canadian public



CV heat sources

Schematic - not to scale



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Contact:

Rosaura Ham-Su, Fuel Development Branch Manager,
Sustainable Energy Technologies SA Lead

hamsur@aecl.ca

Joanne Ball, Reactor Safety Division Director,
Safety and Security Program Lead

ballj@aecl.ca





 **AECL EACL**



Nuclear Laboratories Program Activities

Nuclear Industry Capability

- CANDU Inc. Support
- CANDU Owners Group R&D
- CANDU Industry R&D

Clean, Safe Energy

- Generation IV
- Tritium and Fusion Technologies
- Hydrogen Technology
- Sustainable Energy Technologies
- Materials Science and Chemistry
- Small Reactors

Nuclear Environmental Stewardship

- AECL Nuclear Legacy Liabilities
- Whiteshell Decommissioning
- Port Hope Area Initiative
- Historic Wastes
- Nuclear Environmental Technology
- Nuclear Waste Services

Nuclear Safety and Security

- Non-proliferation & Counter-terrorism
- Nuclear Security and Emergency Response
- Nuclear Materials Handling
- Nuclear Oversight
- Nuclear Safety Technology

Health, Isotopes and Radiation

- Isotope Production
- Isotope Reliability
- Legacy Obligations
- Radiation Biology and Health

Nuclear Innovation Networks

- NRC Canadian Neutron Beam Centre
- AECL Innovation Networks

Analytical capabilities

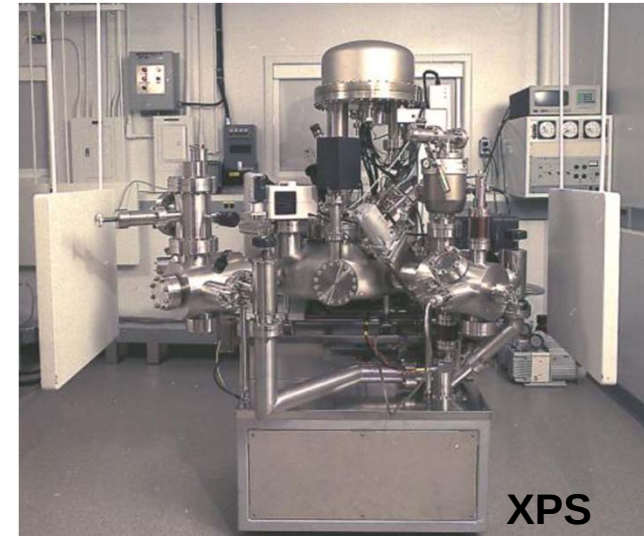
- **U/Pu analysis and isotopic measurements for personnel bioassay, environmental and fuel burnup measurements, using:**
 - TIMS (Thermal Ionization Mass Spectrometry)
 - ICP-MS (Inductively Coupled Plasma – Mass Spectrometry)
 - Radiochemical analysis – alpha, beta and gamma spectrometry
 - Chemical separations – HPLC (High Performance Liquid Chromatography), Ion Chromatography, etc.
- **RN rapid emergency response:**
 - LSC (Liquid Scintillation Counters) – low background, with alpha/beta discrimination
 - nasal swab LSC screening
 - rapid radiochemical separation (U, Ra-226, Sr-90, actinides for rapid bioassay)



Analytical capabilities

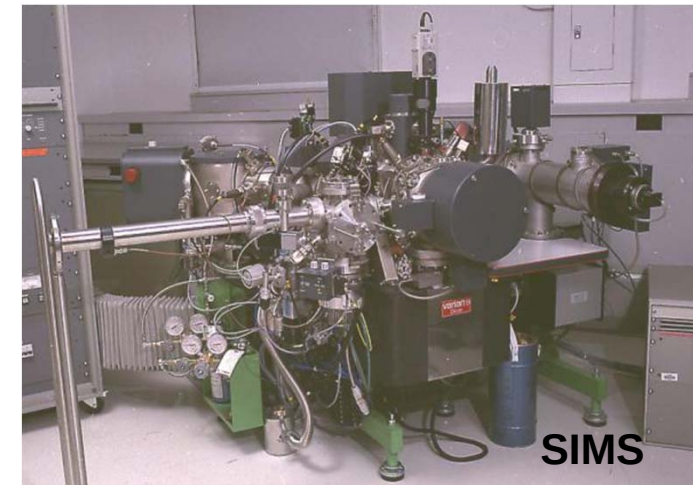
- **Surface science analysis:**

- Scanning Electron Microscopy (SEM) with detection systems for Energy Dispersive Spectrometer (EDS), Wavelength Dispersive Spectrometer (WDS) and Electron Back Scattered Diffraction (EBSD).
- Scanning Auger Microscopy (SAM)
- Secondary Ion Mass Spectrometry (SIMS)
- X-ray Photoelectron Spectroscopy (XPS)
- SIMS, XPS configured for highly radioactive samples



- **Nuclear Forensics:**

- Post-incident analysis, and pre-incident deterrence
- Relevant AECL capabilities:
 - signature model development
 - analysis against signature models
 - laboratory analysis, irradiated fuel analysis
 - fuel cycle physics analysis
 - training



Simulation capabilities

- Radiation transport
- Detector response
- Reactor physics, fuel cycle analysis

