Impact of ENDF/B-VII.0 for AECL

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AECL – Chalk River Laboratories
CSEWG annual meeting - BNL
2007 November 6-8

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AECL ENDF/B-VII.0 implementation status

- ***Kudos*** **to: Ramon Arcilla & NNDC, LANL & RSICC for processing & distributing ENDF/B-VII.0 as MCNP-useable ACE-format files**
  - Provides a standard reference library data set & facilitated early testing
- **Early testing of ENDF/B-VII.0 against ZED-2 D_2O/air-cooled Natural Uranium (NU) critical experiments indicated** (see ND-2007 paper)
  - Systematic increase in MCNP k_{eff} by ~4.3 mk, improving agreement with measurement (except for ZEEP NU metal lattices); mainly due to ^{238}U changes
  - Small (0.4 mk), consistent reduction of MCNP D_2O Coolant Void Reactivity (CVR) calculation bias when Thermal Scattering Law (TSL; $S(\alpha,\beta)$) data for O&U in UO_2 available with ENDF/B-VII.0 are used
- **Additional comparisons against AECL critical measurements exemplify the benefits of ENDF/B-VII.0 & are considered further here** (summary submitted to PHYSOR-2008)
  - ZED-2: H_2O/air-cooled Slightly Enriched Uranium (SEU; 0.95 wt% ^{235}U)/ Recovered Uranium (RU; 0.96 wt% ^{235}U)
  - MAPLE (Multipurpose Applied Physics Lattice Experiment): initial startup commissioning measurements
- **Current AECL ENDF/B-VII.0 implementation status**
  - Recommend early adoption of ENDF/B-VII.0 for all AECL applications: CANDU; ACR (Advanced CANDU Reactor); MAPLE; ZED-2; NRU (50-year old National Research Universal)
  - ***But*** **still need LEAPR input files or input specifications from LANL for TSL libraries: H in H_2O; D in D_2O; O & U in UO_2; & Al to be able to generate multi-temperature data libraries with NJOY at the temperatures needed for specific applications & for accident analyses**

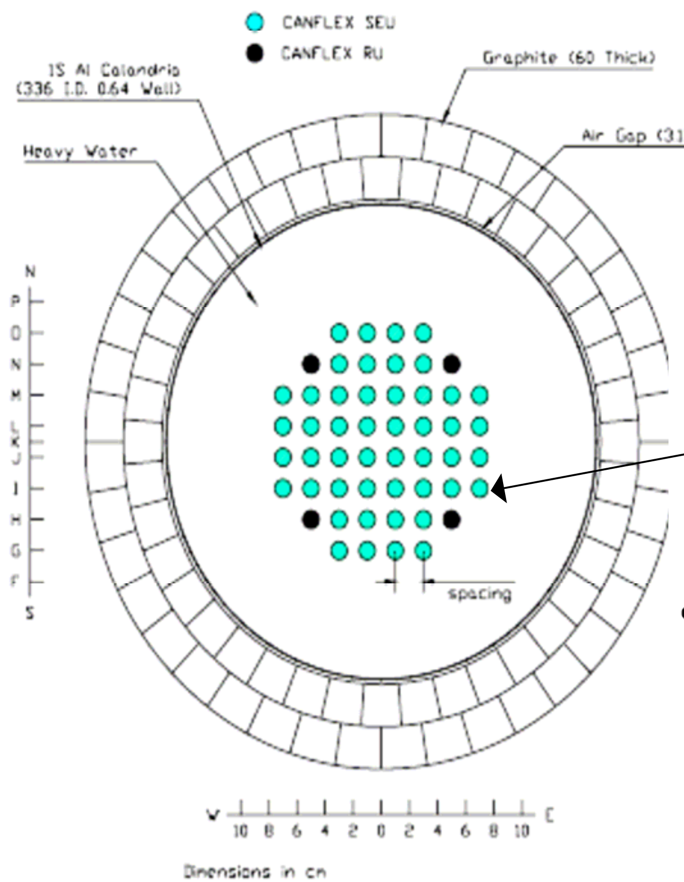
Zero Energy Deuterium (ZED-2)

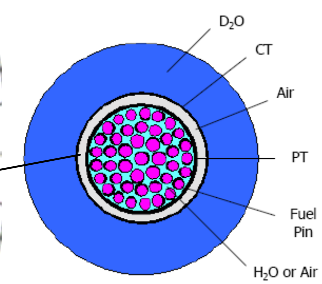
- Large D_2O-moderated fuel lattice
- Cylindrical aluminum tank with 336 cm ID and 334 cm deep
- Surrounded by graphite reflector, 60 cm radially and 90 cm bottom
- Fuel rods and/or channels are suspended from steel beams at top of calandria at various spacings:
  - 28.6 cm for CANDU
  - 24.0 cm for ACR-1000
- Criticality achieved by adjusting moderator level within ± 0.2 cm
- Fuel channel consists of calandria tube, pressure tube, fuel assembly and coolant (D_2O, H_2O or air).

ZED-2, Chalk River Labs

SEU/RU Flux-Map Experiments

- 52 fuel channels arranged in a square lattice with a spacing of 20 cm or 24 cm.
- Channel consists of five 43-pin fuel assemblies surrounded by CANDU-sized aluminum PT/CT:
  - 48 channels use 0.95% SEU
  - 4 channels use 0.96% RU (recovered uranium)
- H_2O or air (void) coolant.
- D_2O moderator height adjusted to achieve criticality.
- Cu and In-Al foil activation measurements performed axially and radially.

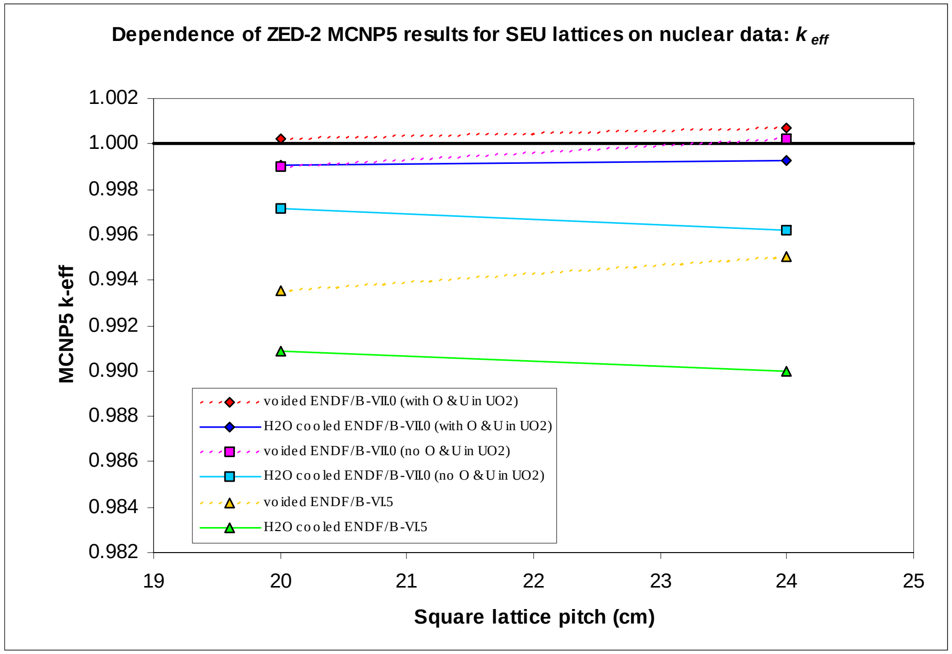


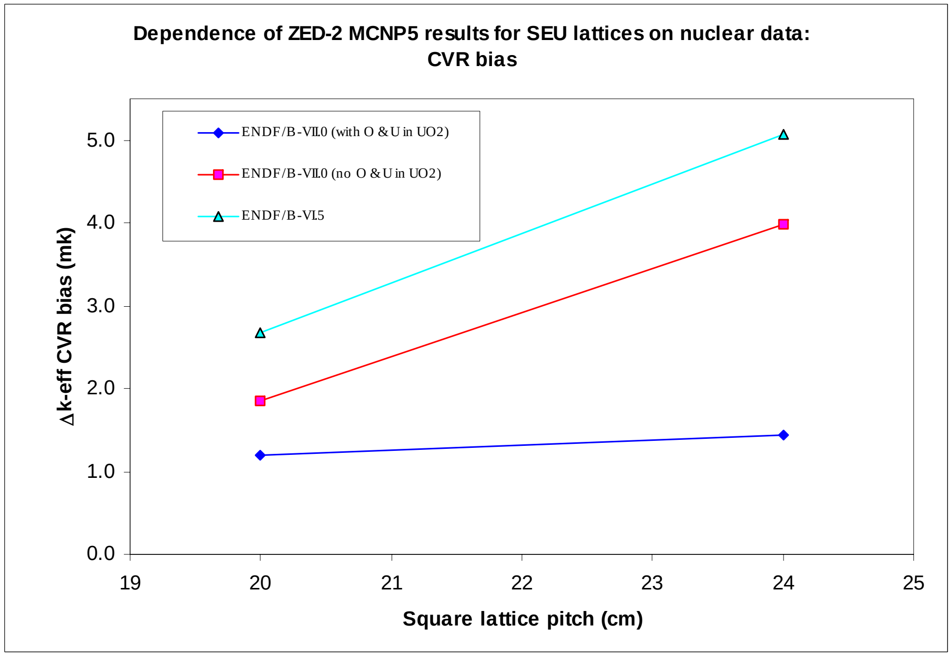


CANFLEX-SEU Fuel Assembly WIMS9A Model

ZED-2 SEU/RU H_2O/air-cooled critical measurements

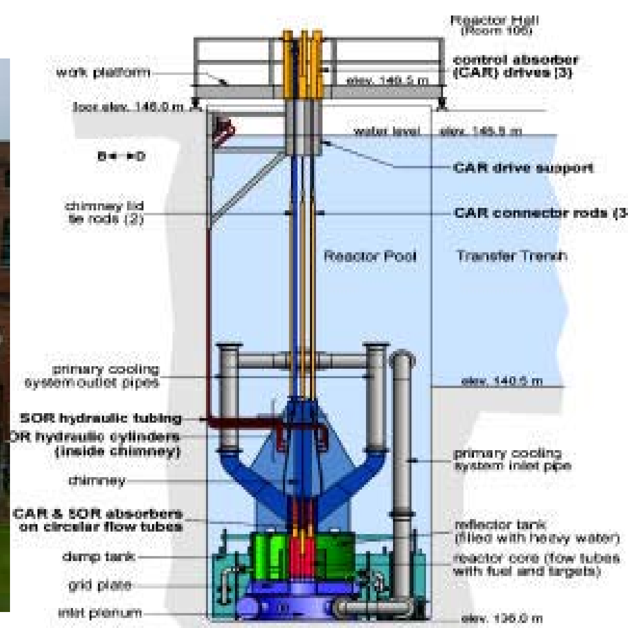
- **Dramatic improvement in both k_{eff} & CVR bias when ENDF/B-VII.0 used with TSL data for O&U in UO_2**



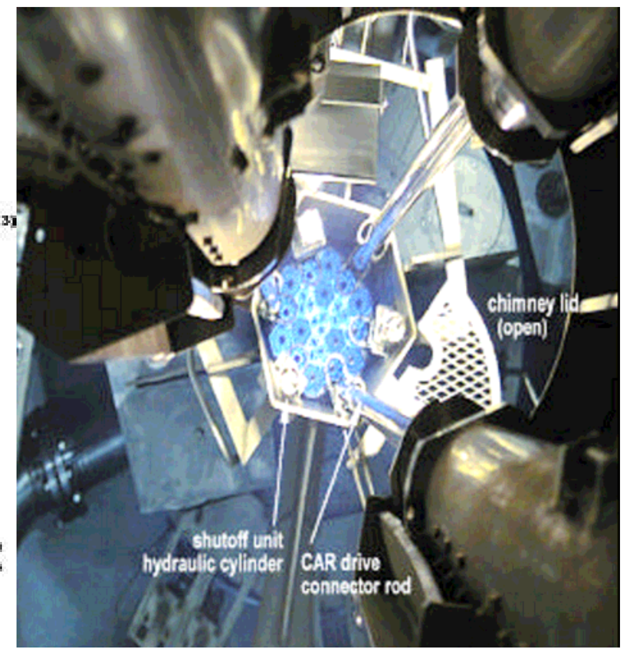


MAPLE dedicated isotope production reactors

- Two 10-MW_t MAPLE reactors to replace NRU mainly for fission-product ^{99}Mo production
- Complex, compact initial start-up core consisting of HEU (93.0 wt% ^{235}U) UO_2 target fuel assemblies, 36-element & 18-element LEU (19.75 wt% ^{235}U) driver fuel assemblies & 36-el. DU (Depleted Uranium) assemblies

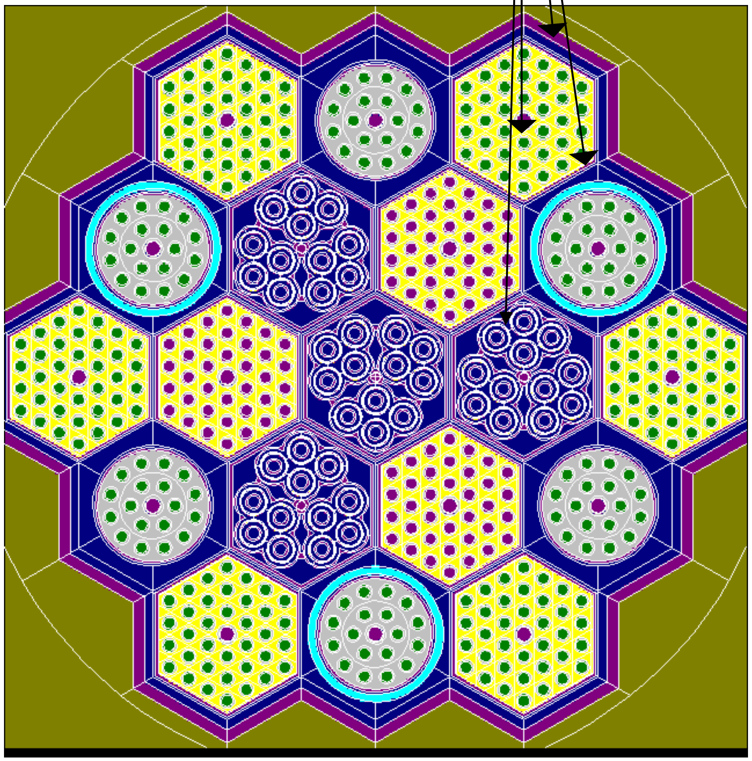


MAPLE Reactor



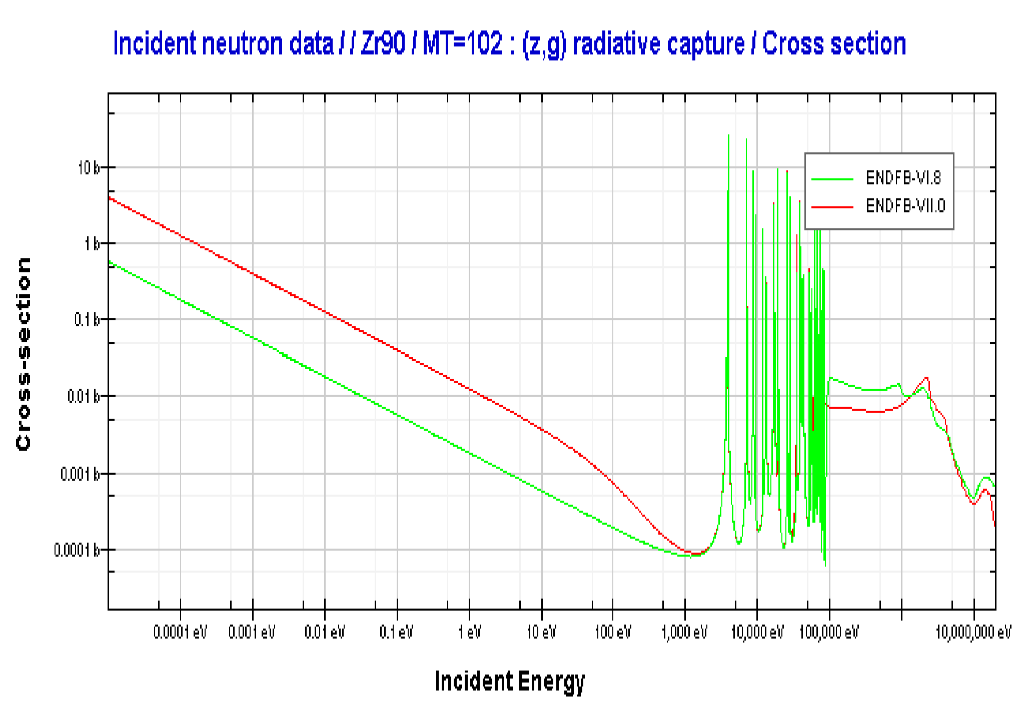
MAPLE 30°C isothermal critical results

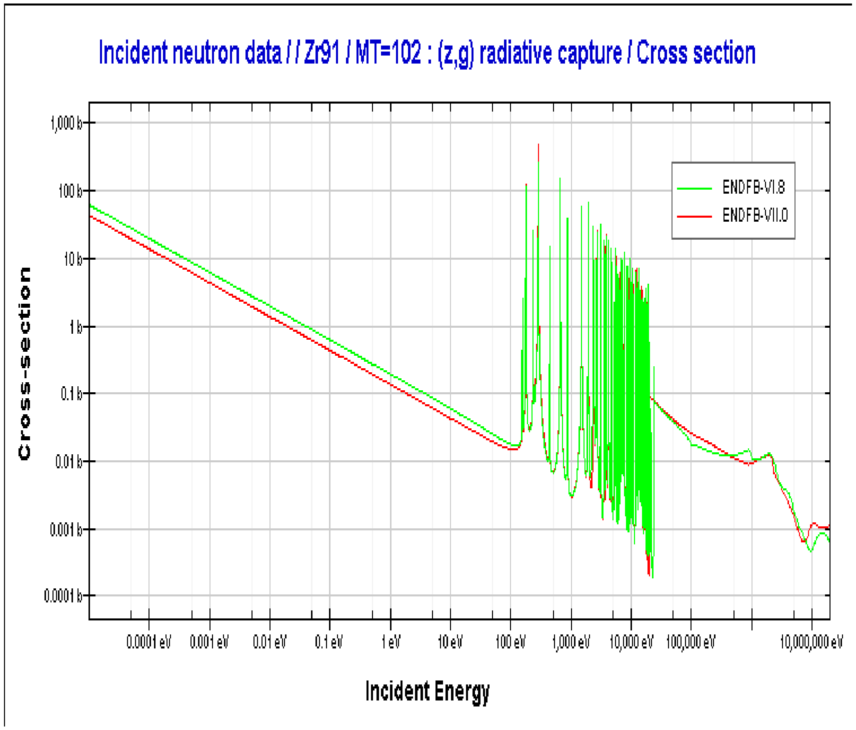
- MCNP5 k_{eff} within ~1 mk using ENDF/B-VII.0
- ~7% of total n captures occur in Zr (zirc-4: core-reflector boundary; hex flow tubes; central support rods; HEU clad & structures)
- Reactivity impacts of major changes to ^{90}Zr (51.5% abundance) & ^{91}Zr (11.2% abundance) capture cross sections tend to cancel out



Changes to Zr thermal captures

- Huge increase in ^{90}Zr capture cross section, but low net reactivity impact due to opposing change to ^{91}Zr capture cross section
- Less incentive to develop Zr materials enriched in ^{90}Zr





MAPLE MCNP5 results for 30°C isothermal core

Case	Particle weight loss to ^{90}Zr captures	Particle weight loss to ^{91}Zr captures	Calculated k_{eff}	Δk_{eff} (mk)
ENDF/B-VII.0 reference	8.81E-03	2.15E-02	1.000725 ± 0.000037	-
ENDF/B-VI.5	2.06E-03	2.94E-02	0.997460 ± 0.000050	-3.26 ± 0.06
ENDF/B-VII.0 with ^{90}Zr from ENDF/B-VI.5	2.07E-03	2.18E-02	1.002985 ± 0.000053	2.26 ± 0.06
ENDF/B-VII.0 with ^{91}Zr from ENDF/B-VI.5	8.68E-03	2.87E-02	0.997451 ± 0.000100	-3.27 ± 0.06

Other nuclear data items of potential interest

- 3-way collaboration (IRMM-GELINA, ORNL, AECL) to address new (n,d) energy-angle elastic scattering evaluation
  - AECL to fund additional nuclear theory calculations incorporating: alternate nuclear potential models, magnetic interaction & 3-body forces
- New RPI measurements for Gd, did not make it into ENDF/B-VII.0
  - Qualitative agreement with ZED-2 measurements; may confirm changes
- Some ZED-2 In (Indium) flux-scan measurements appear to show small systematic discrepancies relative to MCNP simulations; need to simulate with ENDF/B-VII.0

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