DOE Workshop on Nuclear Physics and Related Computational Science R&D for Advanced Fuel Cycles

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Nuclear Data Working Group

Integral Validation and Quality Assurance

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Integral Validation and Quality Assurance

- International Handbook of Evaluated Criticality Safety Benchmark Experiments [NEA/NSC/DOC(95)03].
  - Primary data source for criticality benchmark testing of cross section data files.
    - Various fissile system categories (HEU, IEU, LEU, Pu, ^{233}U, MIXed (e.g., Pu-U) and SPECial (e.g., ^{237}Np)).
    - Various material specifications (METal, COMPound (e.g. UO_2), SOLution).
    - Various spectral specifications (FAST, INTERmediate, THERMal).
  - New and/or revised benchmark evaluations are reviewed and approved by the International Criticality Safety Benchmark Evaluation Project (ICSBEP).
    - Updated editions of the Handbook have been published in their entirety annually since 1995.
    - The 2005 edition includes 416 evaluations that specify 3649 critical, near critical or subcritical configurations.

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- ENDF/B neutron cross section libraries have received extensive criticality testing with ICSBEP benchmarks.
  - Data testing results have been reported at regular Cross Section Evaluation Working Group (CSEWG) meetings for a variety of continuous energy Monte Carlo programs, including
    - MCNP, versions 4 and 5 (LANL and Europe);
    - RCP01 (Bechtel Bettis (Naval Reactors));
    - RACER (KAPL (Naval Reactors));
    - KENO/CENTRM/SCALE (ORNL);
    - VIM (Argonne);
    - COG, TART (LLNL);
    - Tripoli (France).

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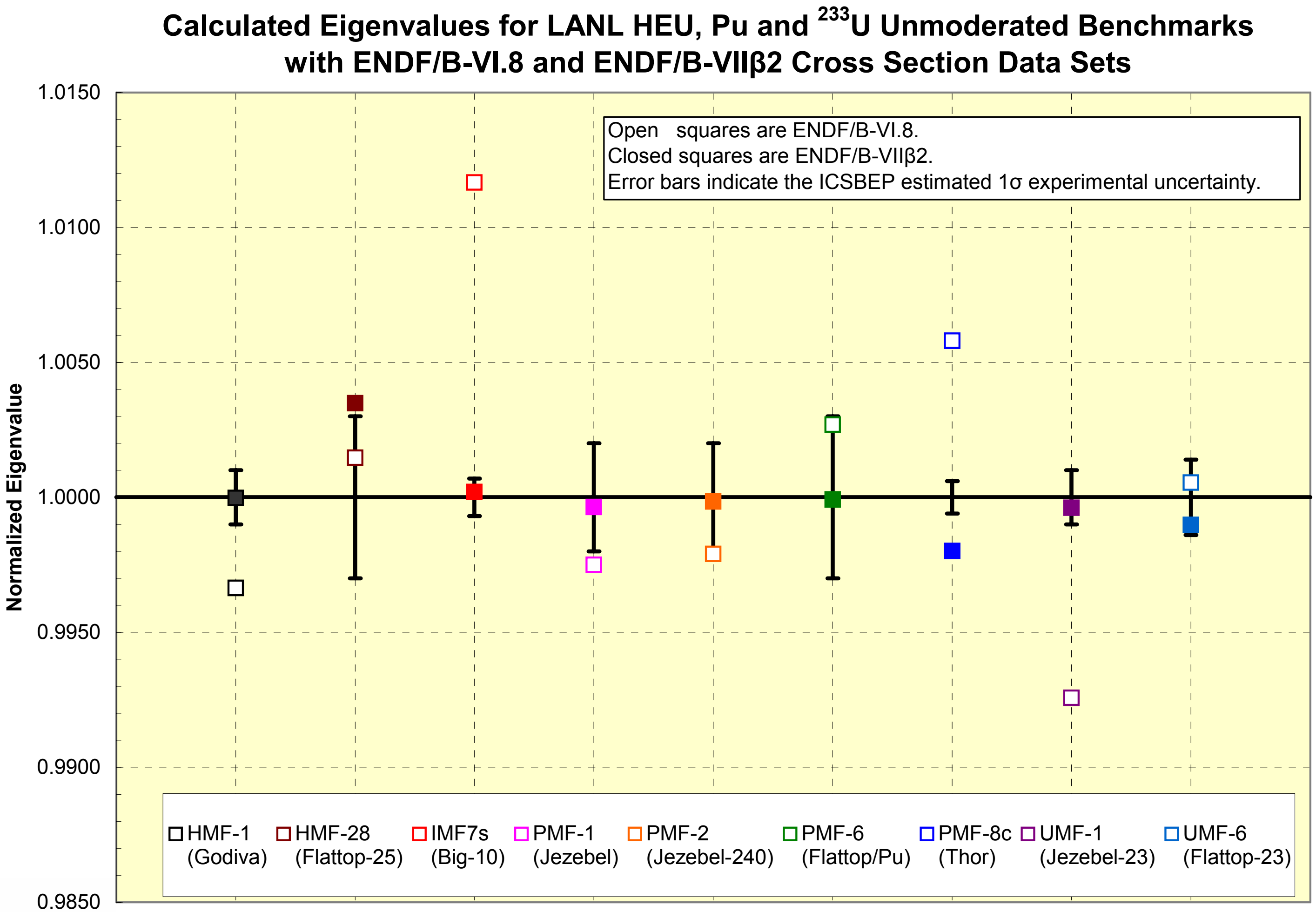

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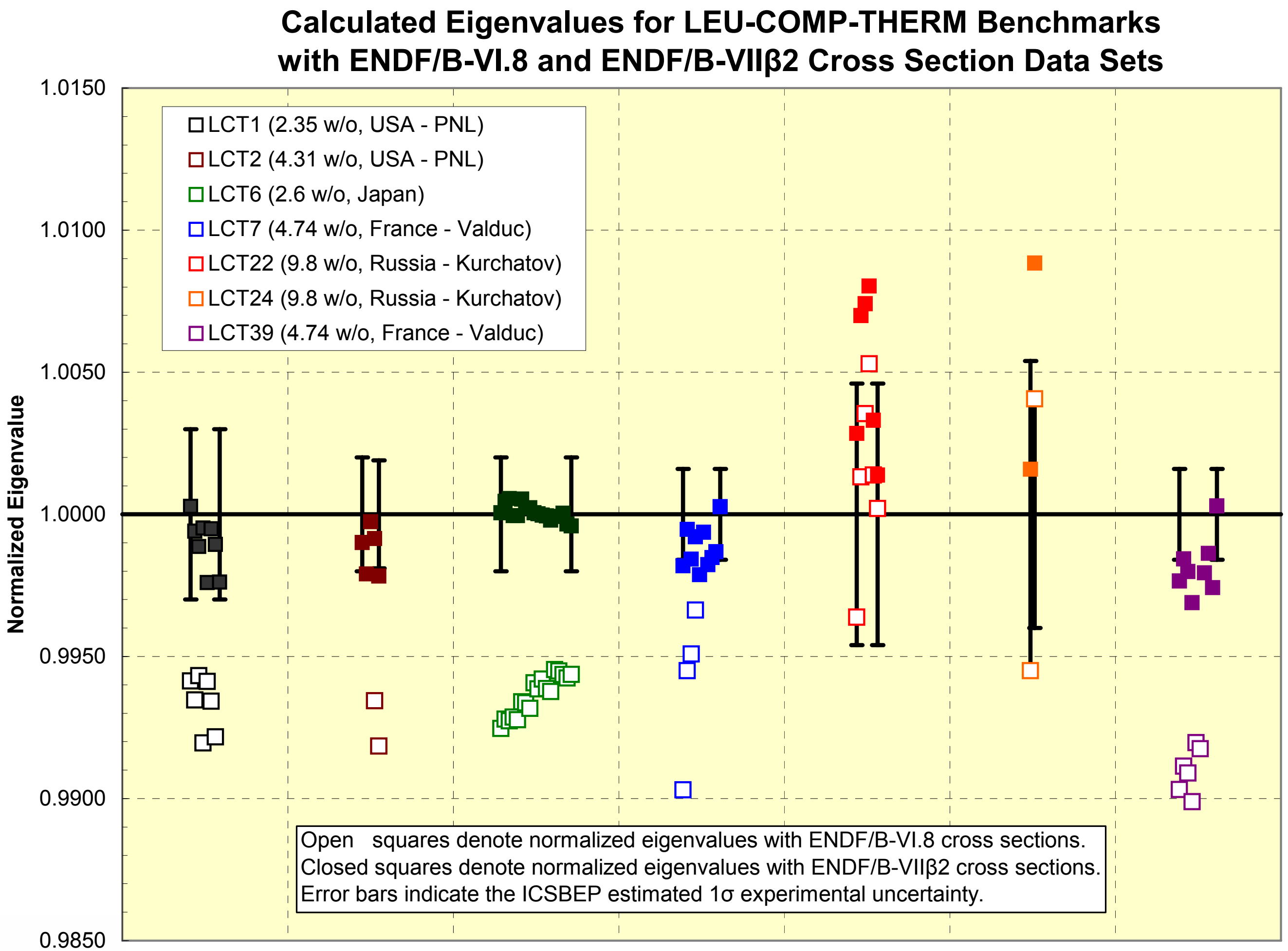

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- Comparisons with LANL and Europe (Petten) for ENDF/B-VIIβ2.
  - NJOY/MCNP used (independently) at both institutions.
  - 216 ICSBEP benchmarks in common.
    - Petten/LANL eigenvalue ratio varies from 0.9964 to 1.0036.
    - 2/3^{rds} of these ratios fall between 0.9990 and 1.0010.
- Comparisons with LANL and Europe (France) for ENDF/B-VIIβ2.
  - NJOY/MCNP used at LANL; NJOY(CALENDF)/Tripoli use at Cadarache.
  - 42 ICSBEP benchmarks in common.
    - Tripoli/MCNP ratio varies from 0.9996 to 1.0010.
    - Common benchmarks include HEU-MET-FAST, IEU-MET-FAST, PU-MET-FAST, HEU-SOL-THERM and LEU-COMP-THERM.
- Comparison with LANL (MCNP) and Naval Reactors (RCP01/RACER).
  - Excellent agreement in calculated eigenvalues has been observed for many years (mostly HEU-SOL-THERM).

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- Future benchmark calculations need to include important reactor design parameters other than the critical eigenvalue
  - depletion inventories;
  - reaction rates;
  - reactivity coefficients.
- An important new source of such benchmark data will be the International Handbook of Evaluated Reactor Physics Benchmark Experiments [NEA/NSC/DOC(2006)1].
  - First published in March, 2006.
- Significant computing resources are required to perform such calculations with Monte Carlo codes.
  - Tens of thousands of CPU hours may be needed to perform a single continuous energy Monte Carlo lifetime calculation for a given design.
  - A design iteration may require dozens of lifetime calculations.

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- Conclusion
  - The excellent agreement observed from an extensive comparison of calculated eigenvalues for a wide range of ICSBEP benchmarks, using independently derived model input decks (when the codes are the same), independent codes and “independent” processing of basic cross section data files provides a high degree of assurance that today’s data processing and continuous energy Monte Carlo codes can be used to accurately calculate a wide variety of fissile systems.