ENDF/B-VII.0 Validation Testing Using Selected ^{235}U Thermal Solution Benchmarks

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Presented at the November 6, 2007
Cross Section Evaluation Working Group (CSEWG)
Data Testing Subcommittee Meeting
held at
Brookhaven National Laboratory

Introduction

- Bettis has performed continuous energy Monte Carlo (RCP01) eigenvalue calculations for a variety of ICSBEP ^{235}U fueled thermal solution benchmarks with ENDF/B-VI.8 and ENDF/B-VII.0 cross sections.
- RCP01 eigenvalues are calculated based on 50 million neutron histories in ten independent 5 million history jobs.
  - For RCP01, the 95% eigenvalue confidence interval is determined from the variance in the ten independent eigenvalue estimates and is typically less than 0.0005 Δk (i.e., roughly the size of the plot symbol in subsequent graphs).
- Calculated eigenvalues and subsequent correlations are based upon RCP01 results.
- A majority of these calculations use models derived from the ICSBEP Handbook

^{235}U Solution Benchmarks Analyzed

- HEU-SOL-THERM
  - 9 HEU evaluations, 31 critical configurations that appear in the 2004 edition of the ICSBEP Handbook plus two ORNL experiments (L5, L6).
    - 4 evaluations (8 critical configurations) include a H_2O reflector.
- LEU-SOL-THERM
  - 9 LEU evaluations, 39 critical configurations
    - 4 evaluations (19 critical configurations) include a H_2O reflector.
- Total
  - 72 critical configurations
  - 27 critical configurations include a H_2O reflector

HST Benchmarks

Benchmark Name	Benchmark Model k_{eff} (1σ)	ENDF/B-VI.8 k_{eff} (95% CI)	ENDF/B-VII.0 k_{eff} (95% CI)
HST1.1	1.0004(60)	0.99938(30)	0.99717(41)
HST1.2	1.0021(72)	0.99664(35)	0.99515(29)
HST1.3	1.0003(35)	1.00226(18)	1.00027(26)
HST1.4	1.0008(53)	0.99839(44)	0.99663(42)
HST1.5	1.0001(49)	0.99985(30)	0.99740(15)
HST1.6	1.0002(49)	1.00321(34)	1.00076(26)
HST1.7	1.0008(40)	0.99832(39)	0.99635(24)
HST1.8	0.9998(38)	0.99875(30)	0.99647(41)
HST1.9	1.0008(54)	0.99425(32)	0.99265(17)
HST1.10	0.9993(54)	0.99343(17)	0.99101(33)
HST-9.1	0.9990(43)	1.00028(20)	1.00131(25)
HST-9.2	1.0000(39)	1.00063(36)	1.00174(23)
HST-9.3	1.0000(36)	1.00029(26)	1.00117(20)
HST-9.4	0.9986(35)	0.99490(32)	0.99549(34)
HST10.1	1.0000(39)	1.00041(19)	1.00055(26)
HST11.1	1.0000(23)	1.00473(21)	1.00417(23)
HST11.2	1.0000(23)	1.00089(25)	1.00025(33)
HST12.1	0.9999(58)	1.00084(19)	1.00037(13)
HST13.1	1.0012(26)	0.99877(16)	0.99765(16)
HST32.1	1.0015(26)	0.99831(14)	0.99864(12)

$\sigma < |\Delta k| \leq 2\sigma$

$|\Delta k| > 2\sigma$

HST Benchmarks (Cont'd)

Benchmark Name	Benchmark Model k_{eff} (1σ)	ENDF/B-VI.8 k_{eff} (95% CI)	ENDF/B-VII.0 k_{eff} (95% CI)
HST42.1	0.9957(39)	0.99639(17)	0.99585(14)
HST42.2	0.9965(36)	0.99608(15)	0.99572(17)
HST42.3	0.9994(28)	0.99993(12)	1.00006(10)
HST42.4	1.0000(34)	1.00119(13)	1.00154(11)
HST42.5	1.0000(34)	0.99892(10)	0.99949(09)
HST42.6	1.0000(37)	0.99919(10)	0.99978(08)
HST42.7	1.0000(36)	1.00004(04)	1.00070(07)
HST42.8	1.0000(35)	1.00058(11)	1.00145(11)
HST43.1	0.9986(31)	0.99564(29)	0.99366(29)
HST43.2	0.9995(26)	1.00615(21)	1.00437(14)
HST43.3	0.9990(25)	1.00122(20)	1.00006(19)
L5	1.0000	1.00233(31)	1.00110(32)
L6	1.0000	1.00176(29)	1.00091(43)

$\sigma < |\Delta k| \leq 2\sigma$

$|\Delta k| > 2\sigma$

LST Benchmarks

Benchmark Name	Benchmark Model k_{eff} (1σ)	ENDF/B-VI.8 k_{eff} (95% CI)	ENDF/B-VII.0 k_{eff} (95% CI)
LST1	0.9991(29)	1.00939(26)	1.01121(23)
LST2.1	1.0038(40)	0.99771(23)	0.99487(25)
LST2.2	1.0024(37)	0.99396(14)	0.99204(12)
LST3.3	0.9995(42)	0.99900(26)	0.99945(26)
LST3.6	0.9999(49)	0.99700(17)	0.99749(10)
LST3.9	0.9996(52)	0.99603(17)	0.99723(14)
LST4.1	0.9994(08)	0.99883(24)	0.99988(13)
LST4.2	0.9999(09)	1.00007(29)	1.00061(10)
LST4.3	0.9999(09)	0.99813(25)	0.99852(20)
LST4.4	0.9999(10)	1.00043(18)	1.00089(18)
LST4.5	0.9999(10)	1.00024(19)	1.00090(17)
LST4.6	0.9994(11)	0.99928(13)	1.00066(16)
LST4.7	0.9996(11)	0.99960(11)	1.00066(17)
LST7.1	0.9961(09)	0.99365(20)	0.99743(27)
LST7.2	0.9973(09)	0.99606(23)	0.99881(21)
LST7.3	0.9985(10)	0.99493(22)	0.99649(18)
LST7.4	0.9988(11)	0.99682(12)	0.99815(15)
LST7.5	0.9983(11)	0.99609(16)	0.99801(22)

$\sigma < |\Delta k| \leq 2\sigma$

$|\Delta k| > 2\sigma$

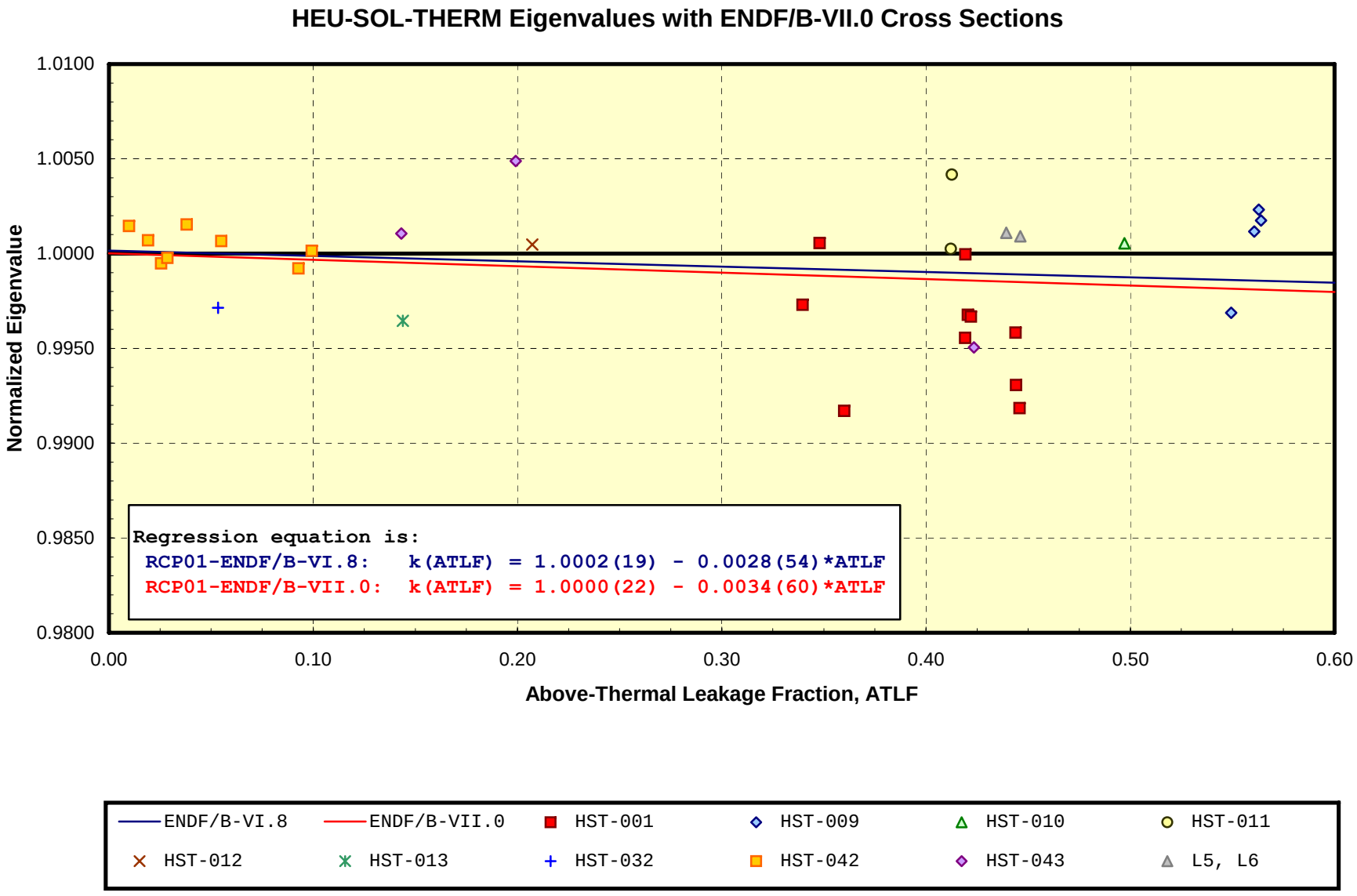
LST Benchmarks (Cont'd)

Benchmark Name	Benchmark Model k_{eff} (1σ)	ENDF/B-VI.8 k_{eff} (95% CI)	ENDF/B-VII.0 k_{eff} (95% CI)
LST16.1	0.9996(13)	1.00382(17)	1.00440(30)
LST16.2	0.9999(13)	1.00393(22)	1.00409(26)
LST16.3	0.9994(14)	1.00383(20)	1.00415(15)
LST16.4	0.9996(14)	1.00304(19)	1.00354(26)
LST16.5	0.9995(14)	1.00263(12)	1.00312(18)
LST16.6	0.9992(15)	1.00102(26)	1.00176(20)
LST16.7	0.9994(15)	1.00228(25)	1.00291(20)
LST17.1	0.9981(13)	0.99366(21)	0.99553(19)
LST17.2	0.9986(13)	0.99491(23)	0.99634(15)
LST17.3	0.9989(14)	0.99666(18)	0.99737(21)
LST17.4	0.9992(14)	0.99831(14)	0.99894(19)
LST17.5	0.9987(15)	0.99907(20)	1.00029(22)
LST17.6	0.9996(15)	0.99960(22)	0.99992(24)
LST20.1	0.9995(10)	0.99844(18)	0.99926(14)
LST20.2	0.9996(10)	0.99811(20)	0.99868(20)
LST20.3	0.9997(12)	0.99738(09)	0.99826(13)
LST20.4	0.9998(12)	0.99838(18)	0.99922(16)
LST21.1	0.9983(09)	0.99673(21)	0.99832(27)
LST21.2	0.9985(10)	0.99696(12)	0.99869(17)
LST21.3	0.9989(11)	0.99608(22)	0.99753(17)
LST21.4	0.9993(12)	0.99788(11)	0.99917(14)

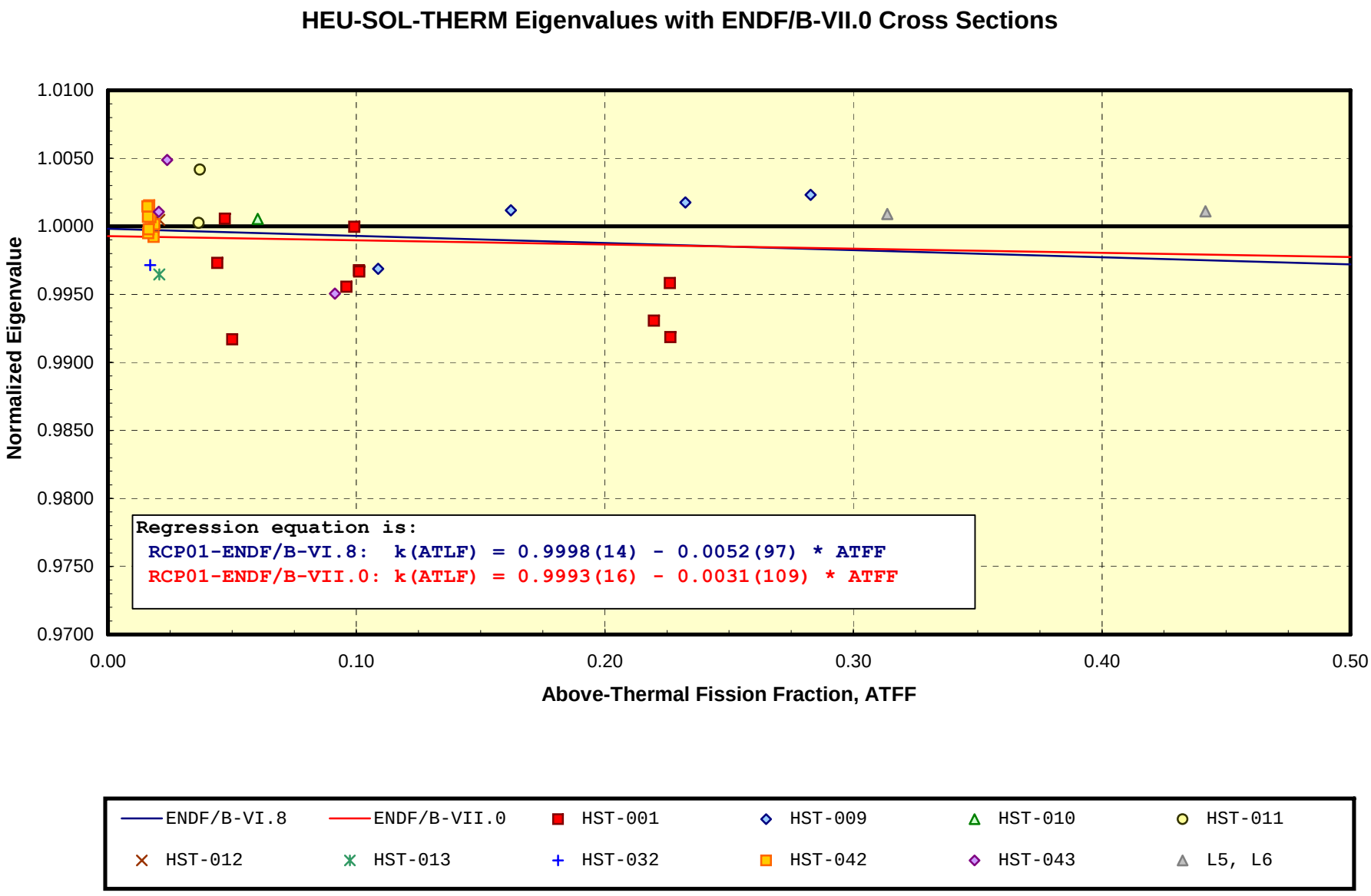
$\sigma < |\Delta k| \leq 2\sigma$

$|\Delta k| > 2\sigma$

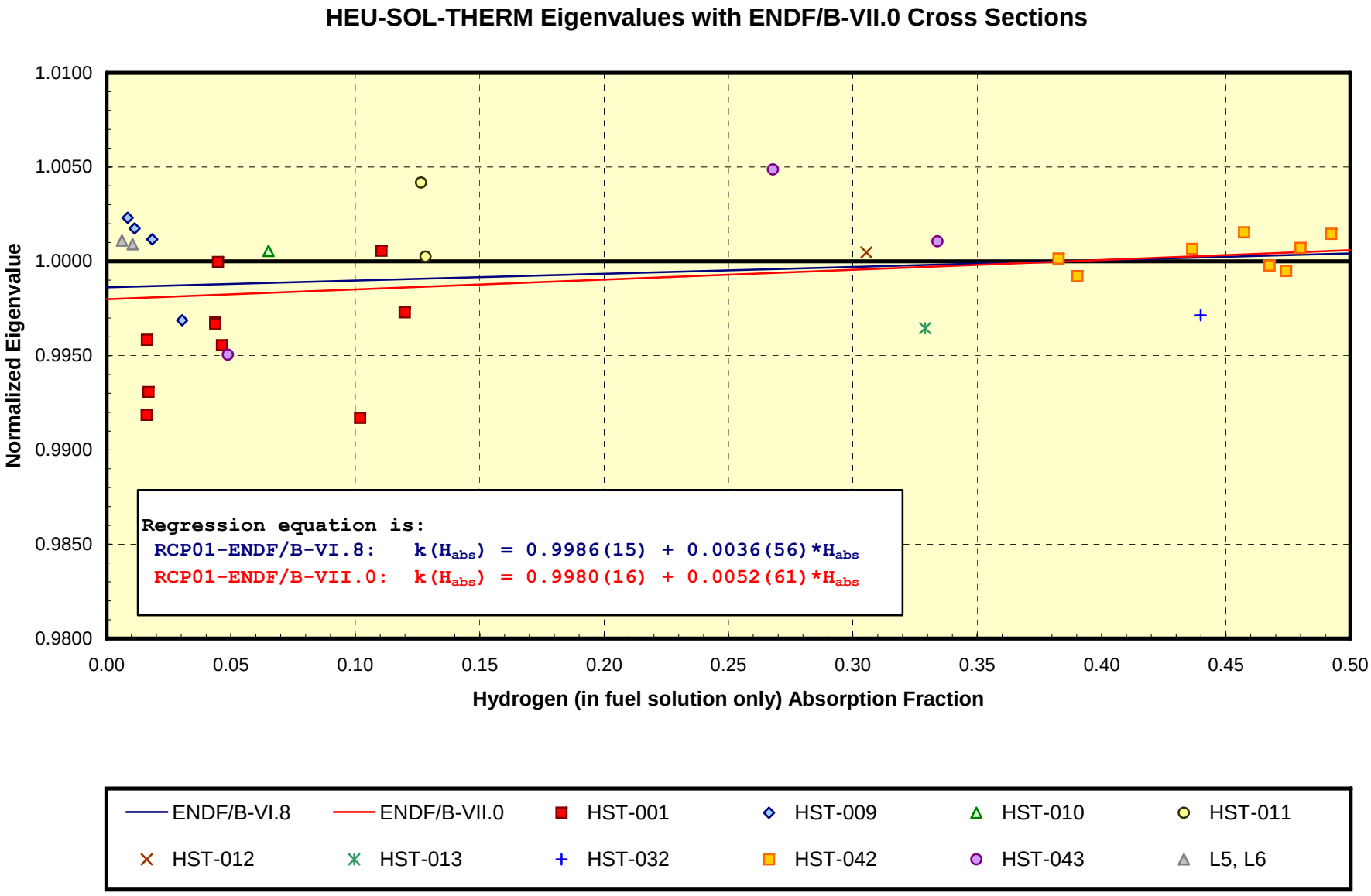
Trend vs. ATLF for HST Benchmarks



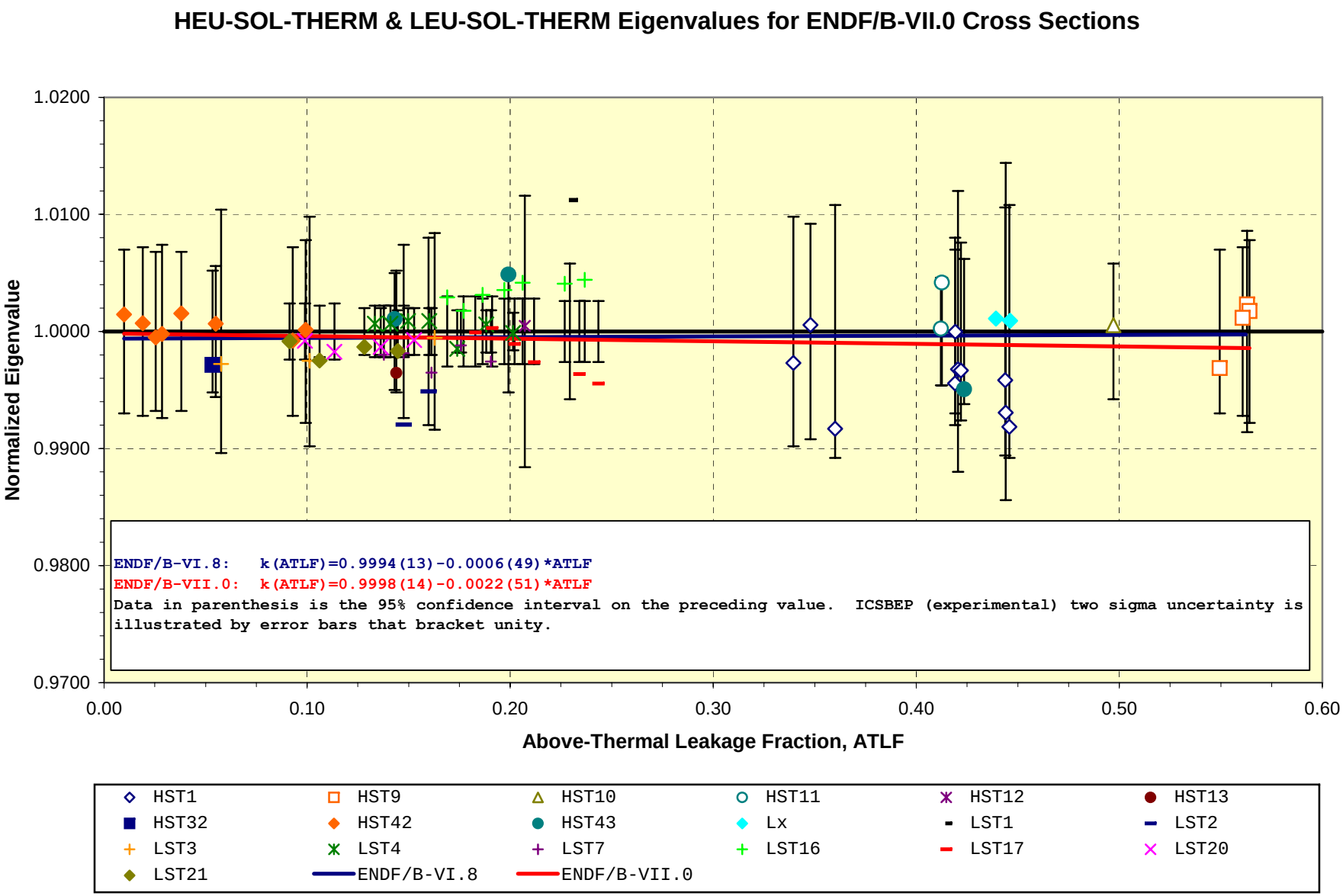
Trend vs. ATFF for HST Benchmarks



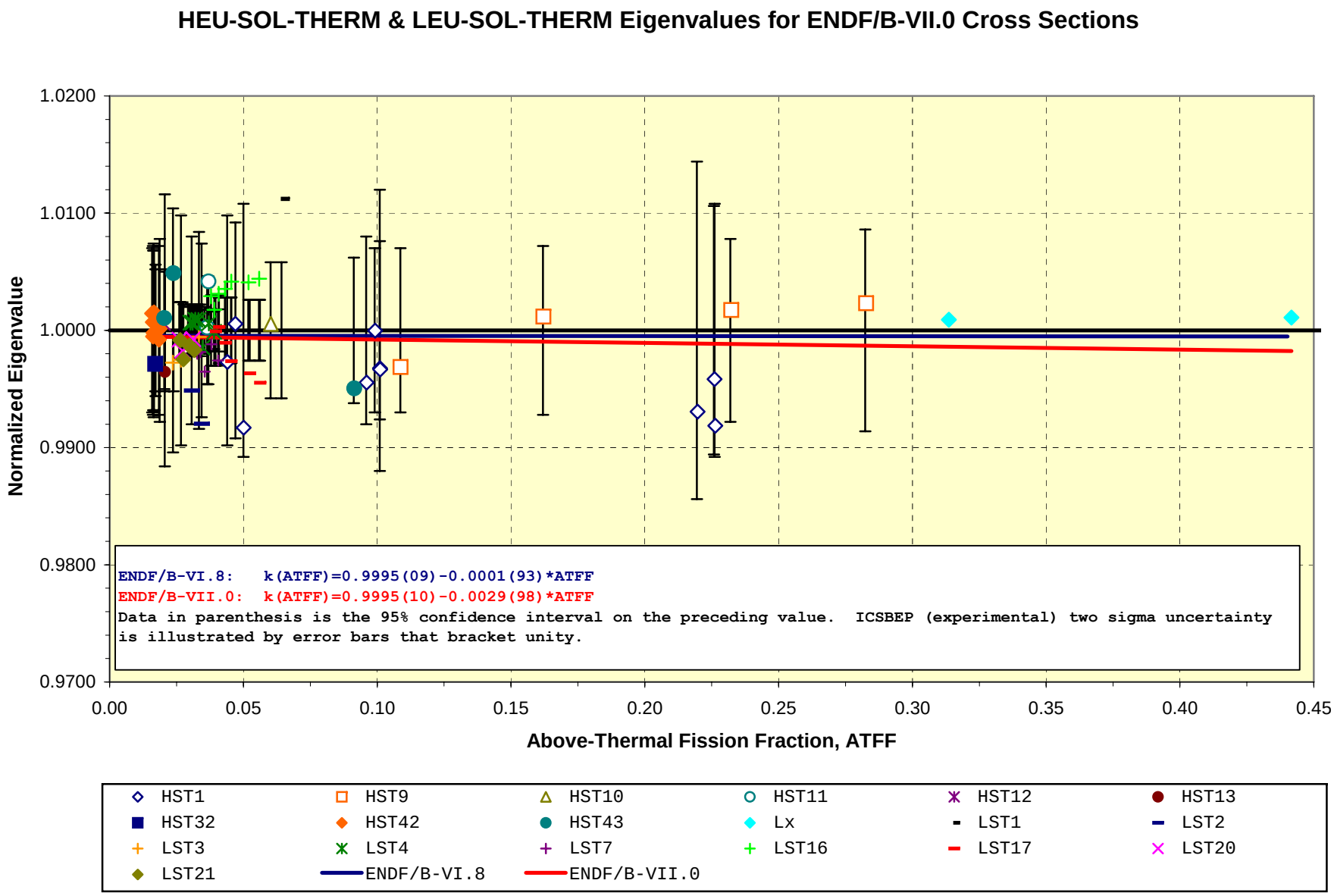
Trend vs. Hydrogen Absorption in the Solution for HST Benchmarks



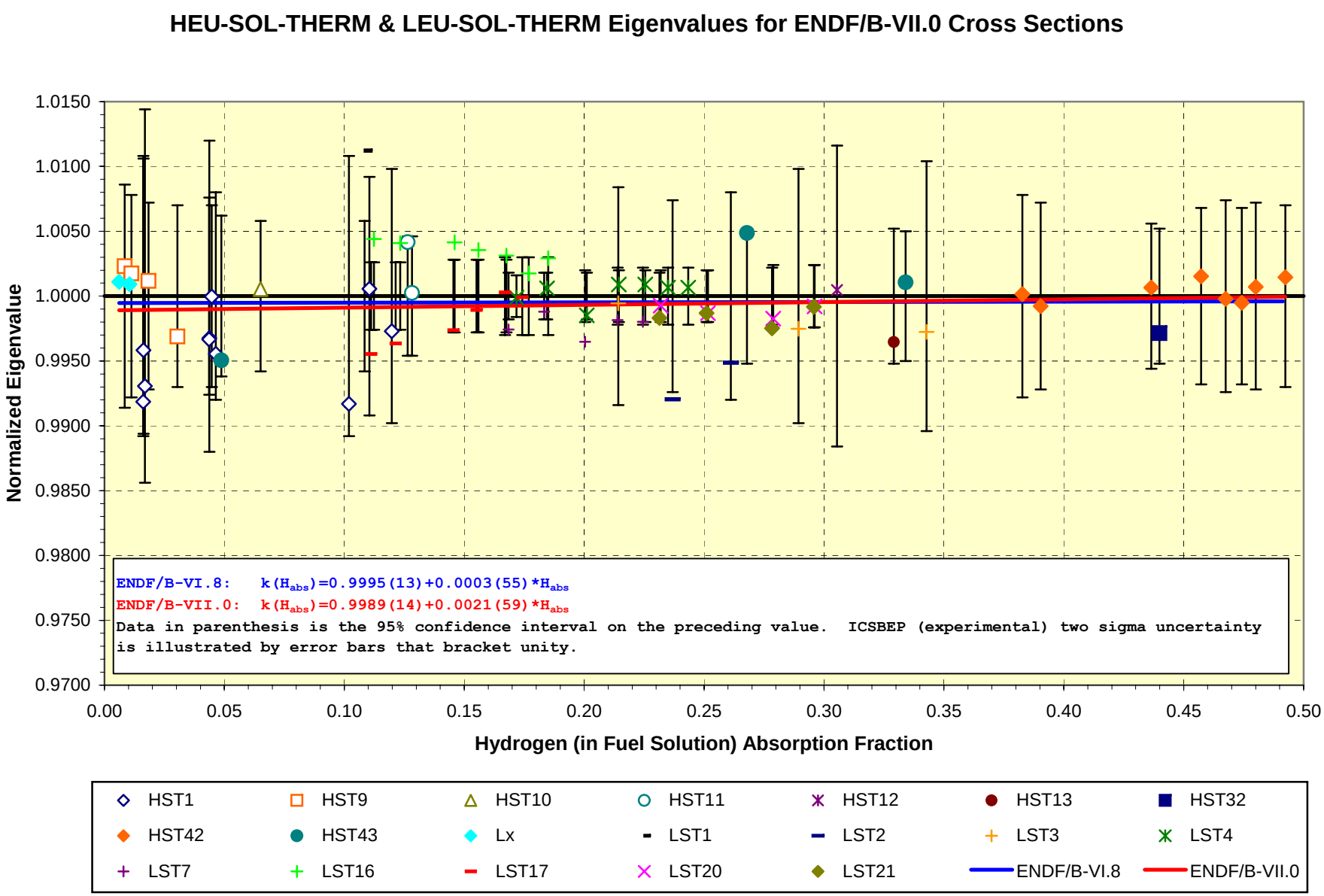
Trend vs. ATLF for HST + LST Benchmarks



Trend vs. ATFF for HST + LST Benchmarks



Trend vs. Hydrogen Absorption in the Solution for HST + LST Benchmarks



Summary and Conclusions

- ATLF
  - k(ATLF) = 0.9994(13) – 0.0006(49)*ATLF ENDF/B-VI.8
  - k(ATLF) = 0.9998(14) – 0.0022(51)*ATLF ENDF/B-VII.0
- ATFF
  - k(ATFF) = 0.9995(09) – 0.0001(93)*ATFF ENDF/B-VI.8
  - k(ATFF) = 0.9995(10) – 0.0029(98)*ATFF ENDF/B-VII.0
- H_{abs}
  - $k(H_{abs}) = 0.9995(13) + 0.0003(55)* H_{abs}$ ENDF/B-VI.8
  - $k(H_{abs}) = 0.9989(14) – 0.0021(59)* H_{abs}$ ENDF/B-VII.0

- Observing some reduction in performance with respect to trend with ATLF, ATFF, H_{abs} for HST+LST Benchmarks using ENDF/B-VII.0.
  - Within statistics
  - Behavior not observed in sensitivity analyses performed during ENDF/B-VII beta testing.