IRPhEP Pilot Evaluation KRITZ-2:19

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Presentation Outline

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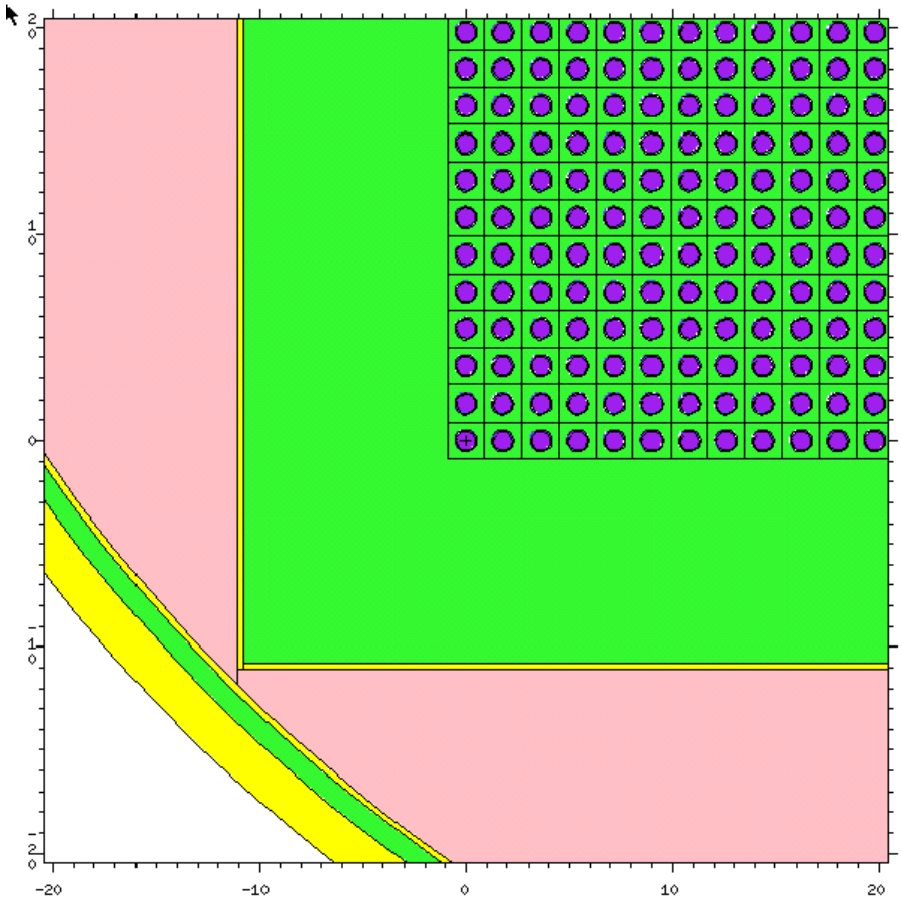
    - Cell k-inf
    - Cell reaction rates
- Summary



Introduction

- **At ORNL the initial work on analysis of KRITZ experiments was performed in the frame of reactor-based plutonium disposition program**
- **In 2000 KRITZ was accepted as international benchmark exercise by the *OECD/NEA Task Force on Reactor-based Plutonium Disposition (TFRPD)* and *Working Party on the Physics of Plutonium and Innovative Fuel Cycles (WPPR)***
- **August 2000- first draft**
- **Aug.- Sept 2000- reformatted according to ICSBEP requirements**

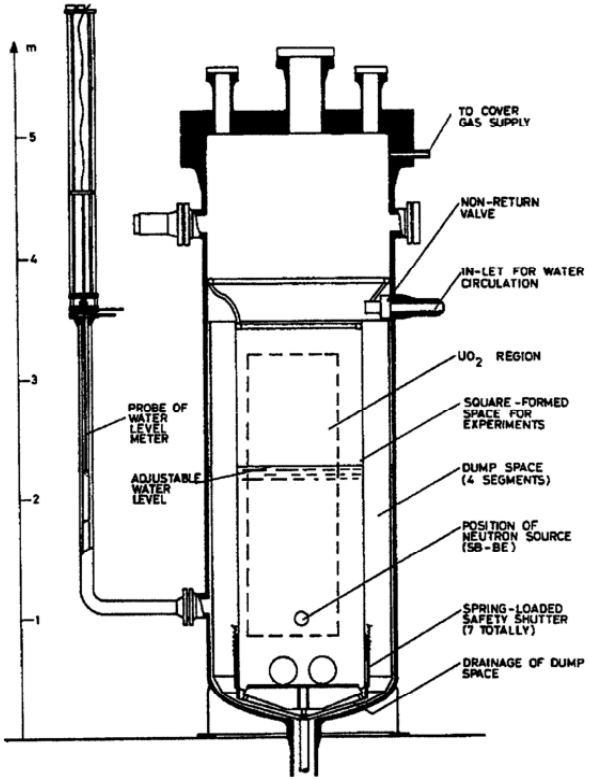
Introduction (Continued)

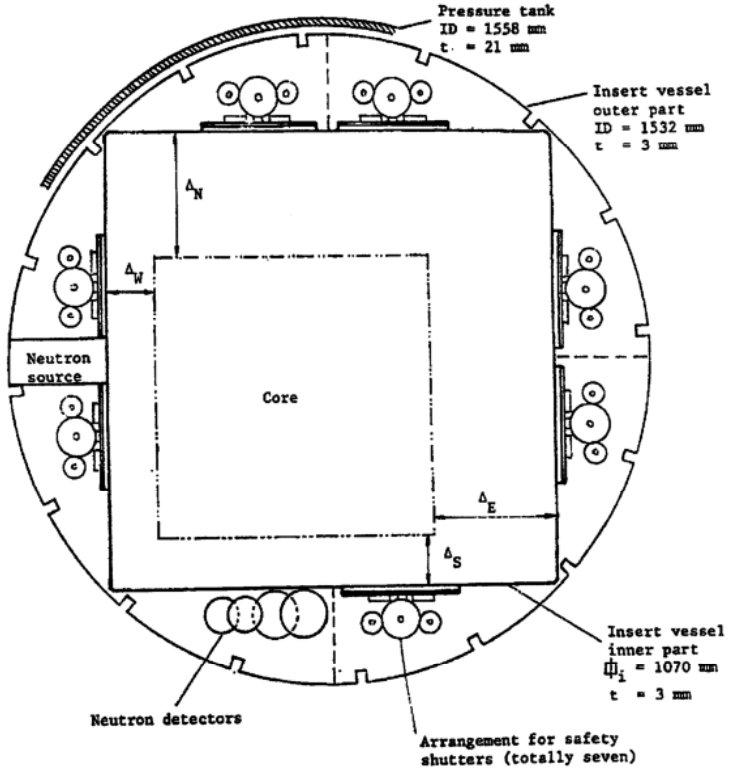
- Oct. 2000- draft specifications distributed to the participants
- Jan. 2001- preliminary results obtained
- May 2001- draft of KRITZ 2:19 in IRPhEP format
- Oct. 2001- March 2002- final results from the participants received
- April 2002- preparation of final report on benchmark results started
- April 2002- Rev.1 of KRITZ 2:19 for IRPhEP

Characteristics of KRITZ-2 Benchmark

- **Experiments performed at Studsvik, Sweden, during the early 1970**
- **Basis for the benchmark: the report *"Data and Results for KRITZ Experiments on Regular H_2O/Fuel Pin Lattices at Temperatures up to 245°C,"* by Erik Johansson**
- **Critical experiments:**
  - **UO_2 cores: KRITZ-2:1, KRITZ-2:13, and KRITZ-1**
  - **PuO_2UO_2 core: KRITZ-2:19**
  - **criticality attained at room and elevated temperatures**

KRITZ reactor (Characteristics continued)





Critical Configurations (Characteristics continued)

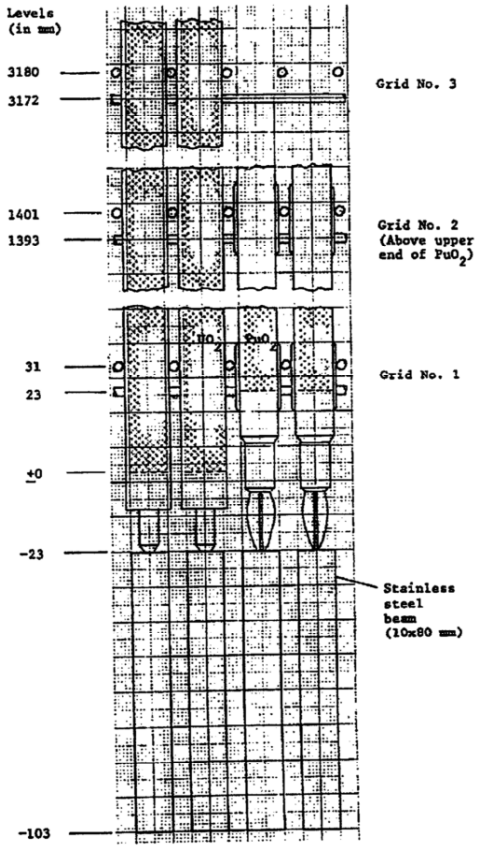
Core	Fuel	Rod Pitch (mm)	No. of rods	Temp, deg. C	Boron, ppm	H_w, mm
KRITZ 2:1	UO_2, 1.86 wt% U235	18.0	44×44	19.7 248.5	217.9 26.2	652.8 1055.
KRITZ 2:13		14.85	40×40	22.1 243.0	451.9 280.1	961.7 1109.
KRITZ 2:19	UO_2PuO_2, 1.50wt% PuO_2 in fuel, 91.41 at% Pu239	16.35	25×24	21.1 235.9	4.8 5.2	665.6 1042.

Status

- **Compilation:**
  - **Practically completed**
  - **Formatted according to IRPhE requirements; includes "Status Table", and Summary**
  - **Reviewed by participants of benchmark exercise**
- **Evaluation:**
  - **Completed**
  - **Reviewed by participants of benchmark exercise**

Experience from Benchmark Preparation

- **Limited source of information (only relatively short report available)**
- **While no significant omissions or inconsistencies were found, some details were not provided**
  - **Geometry:**
    - **Fuel rod bottom-end plug not described**
    - **Short tubes attached to fuel rods not described**

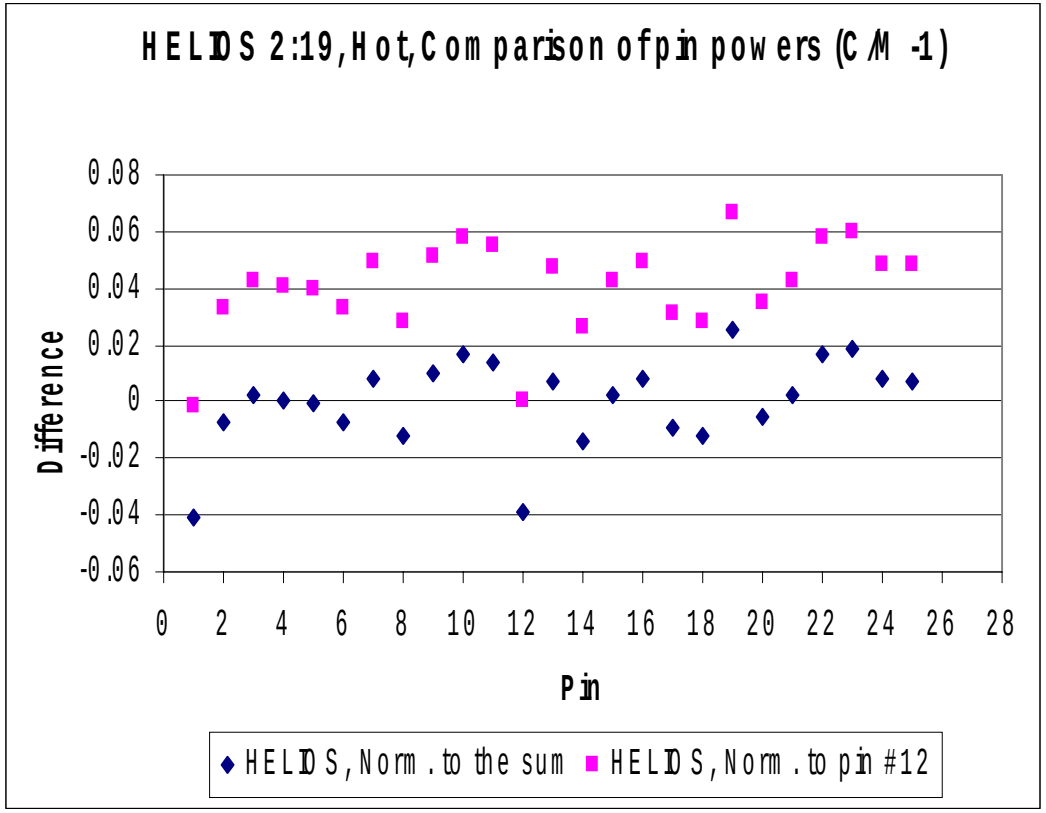


Experience from Benchmark Preparation
(Continued)

- **Material data:**
  - **Chemical composition of Zircaloy-2 and stainless steel not given**
  - **Pu isotopic composition was determined ~10 years before the experiments. It is not known if Am stripping was performed before experiments; probably it was not.**
- **Thermal expansion coefficients not provided**
  - **Change in density of vibrocompacted PuO_2/UO_2 treated approximately**
  - **Values from literature for steel and Zircaloy-2**
- **Measured axial distributions**
  - **The axial distributions obtained from the gamma scanning of the fuel rods and the measurements of the activation profiles of the copper rods are not provided**
  - **A direct evaluation of the extrapolation lengths is therefore not possible**
- **Uncertainty of k_{eff} was estimated to be ±80 pcm (1 F) ; however, complete uncertainty analysis was not performed**

Experience from Benchmark Preparation
(Continued)

– **Fission Rate Distributions**
  - **It was indicated that for two of the measured fuel rods, the relative powers have uncertainties significantly greater than 1%.**
  - **The differences between the calculations and the measurements for these two rods were found significantly greater than the average deviation for all rods.**



- **If the calculated fuel rod fission rates are normalized to the sum of measurements, the effect of excluding the "erroneous" measurements is negligible. Consequently the two rods with larger uncertainties were retained in the benchmark.**

Further Work

- **Sensitivity analysis to determine the effects of:**
  - **uncertainty of water level**
  - **grain size of PuO_2**
  - **omission of spacer grid**
  - **content of Am-241**
  - **uncertainty of axial buckling**
  - **uncertainty of boron concentration (considered negligible)**
  - **uncertainty of temperature (deemed negligible)**

- **Recalculate the atom concentrations with nuclear constants listed in IRPhE experimental format specifications (changes should be negligible).**

Inter-comparison Exercise

- **Participants**
  - **Russian Research Center "Kurchatov Institute," Russia**
  - **Korea Atomic Energy Research Institute (KAERI), Korea**
  - **Korea Atomic Energy Research Institute (KAERI), Korea, and OECD/NEA, France**
  - **Gesellschaft fuer Anlagen- und Reaktorsicherheit (GRS) mbH, and University of Stuttgart, IKE, Germany**
  - **SCK•CEN, Mol, Belgium**
  - **Oak Ridge National Laboratory, USA**

Inter-comparison Exercise

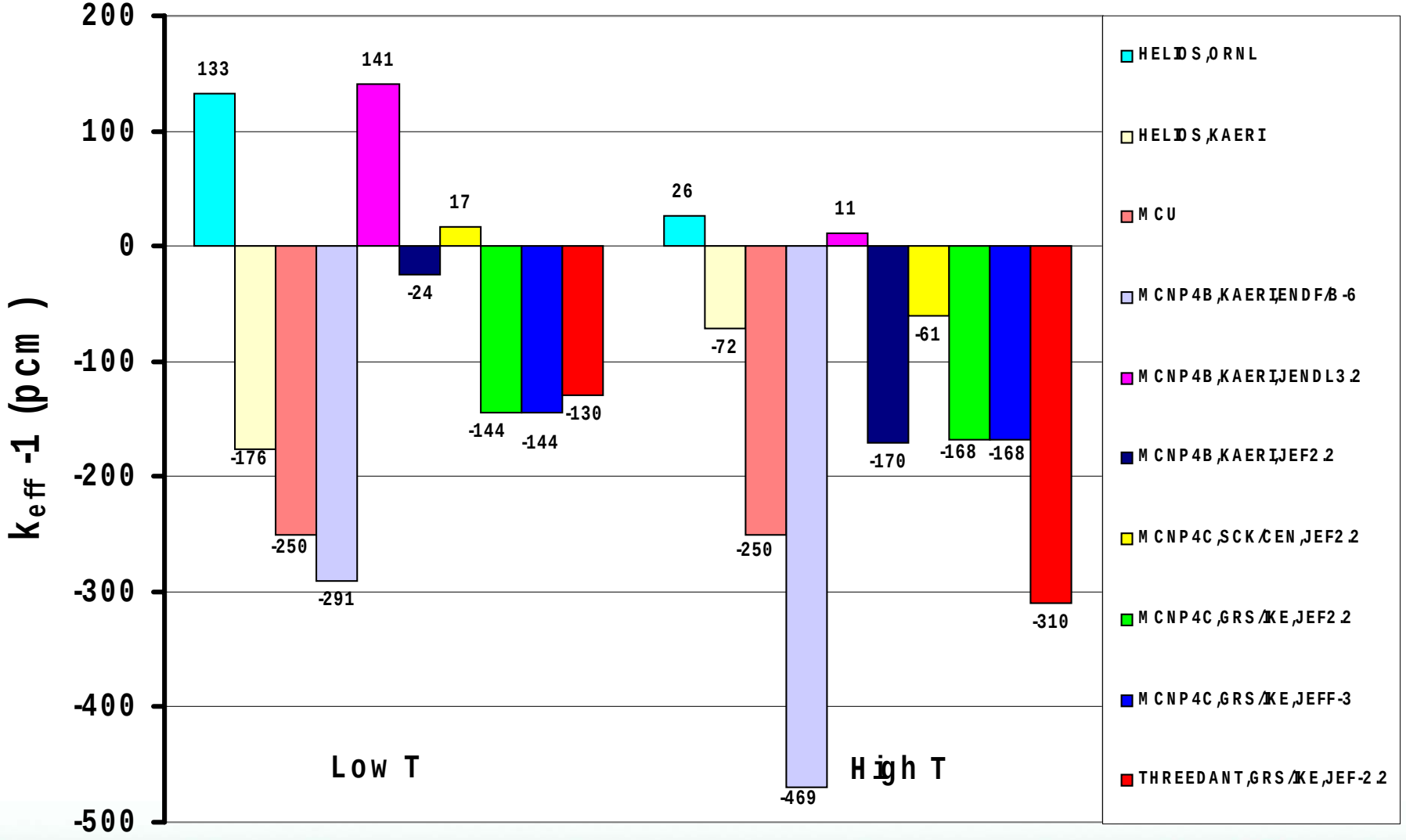
Codes Used:

- MCU, (KI)
- HELIOS 1.6, (KAERI)
- MCNP-4B, (KAERI+OECD/NEA, ORNL)
- MCNP-4C, (SCK•CEN, GRS+IKE)
- HELIOS 1.5, (ORNL)
- THREEDANT, (GRS+IKE)

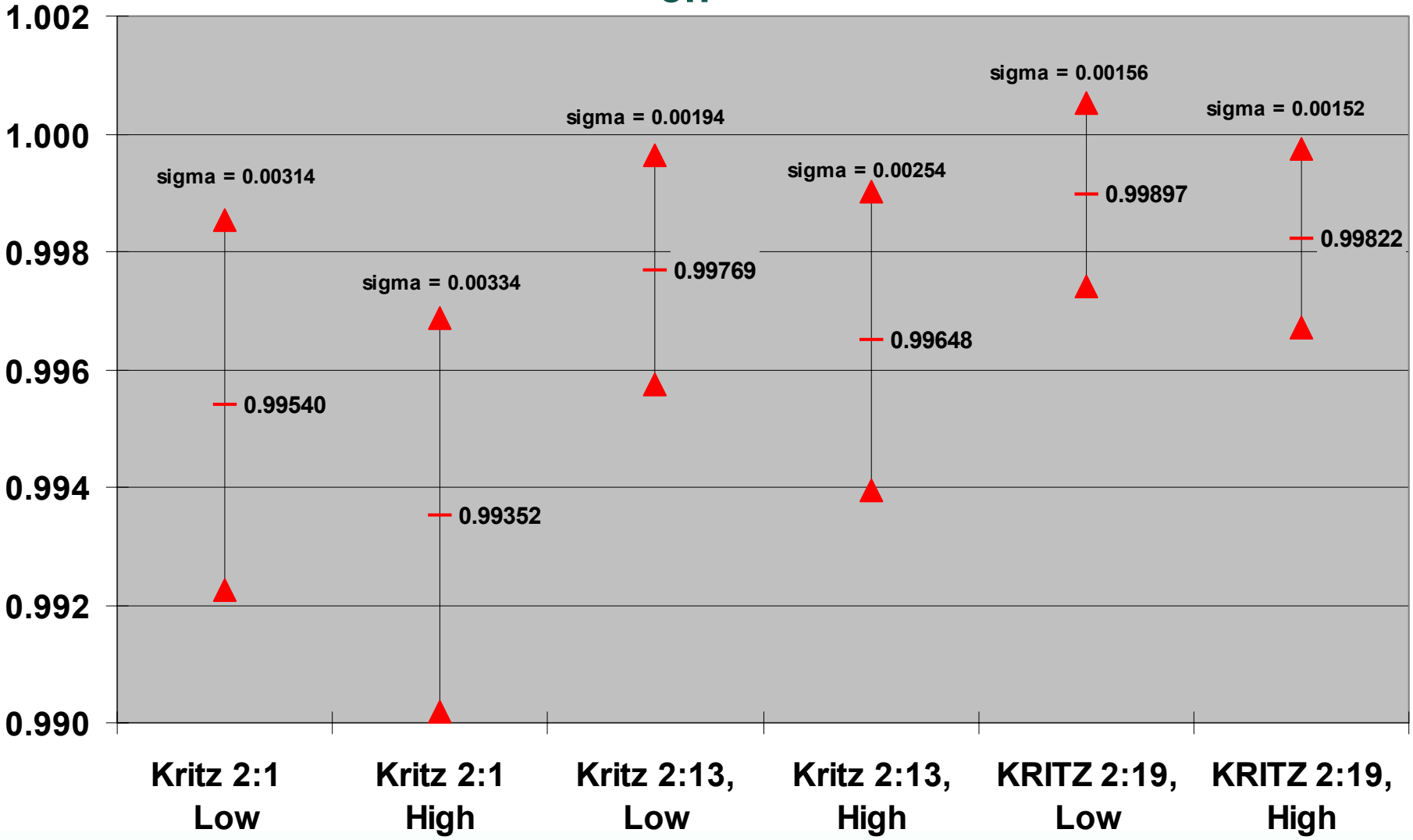
Results

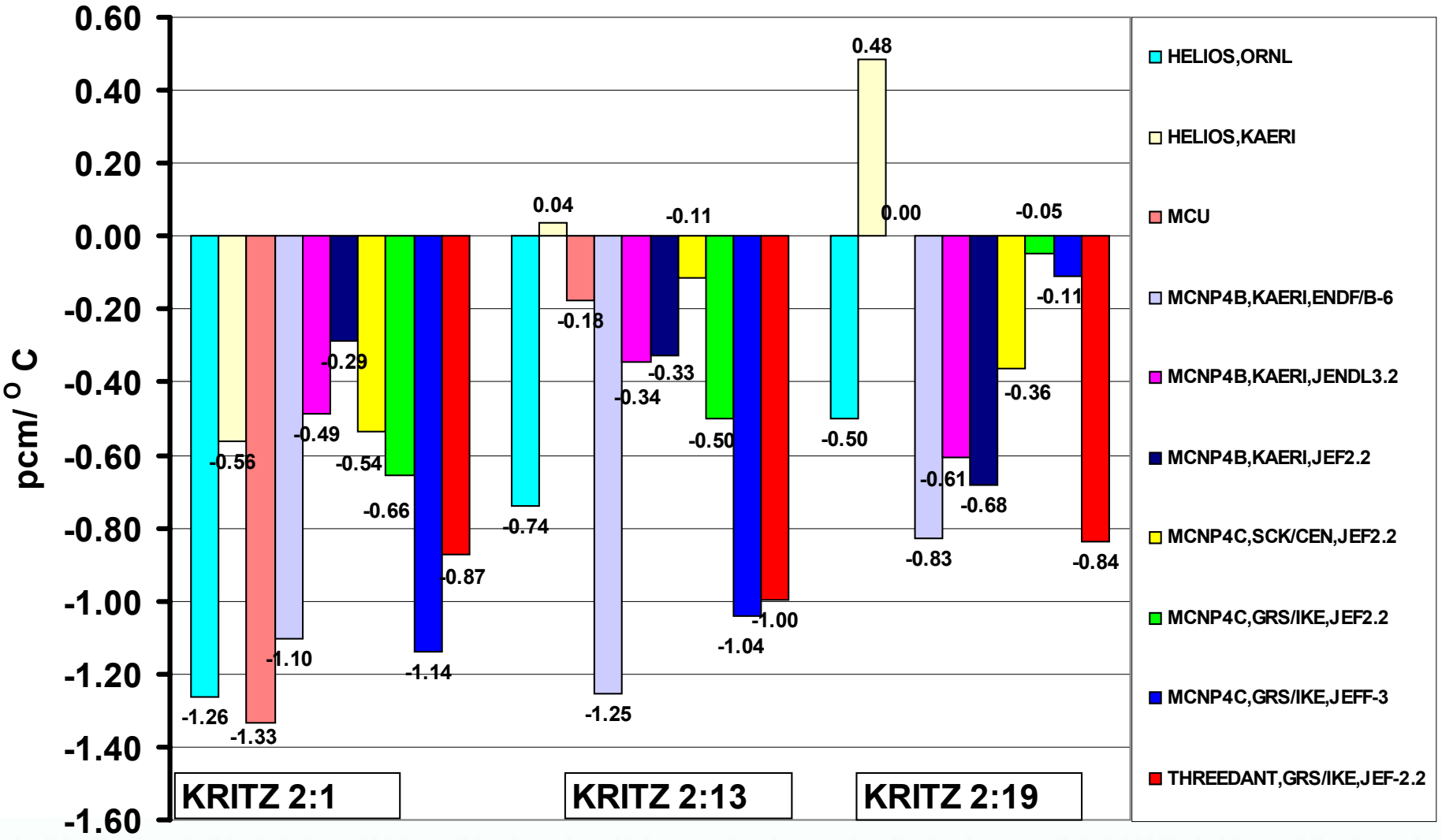
- **Core**
  - **k_{eff}**
  - **pin powers for selected pins**
- **Cell**
  - **k_{inf}**
  - **selected reaction rates in fuel**

k_{eff} Comparison KRITZ 2:19

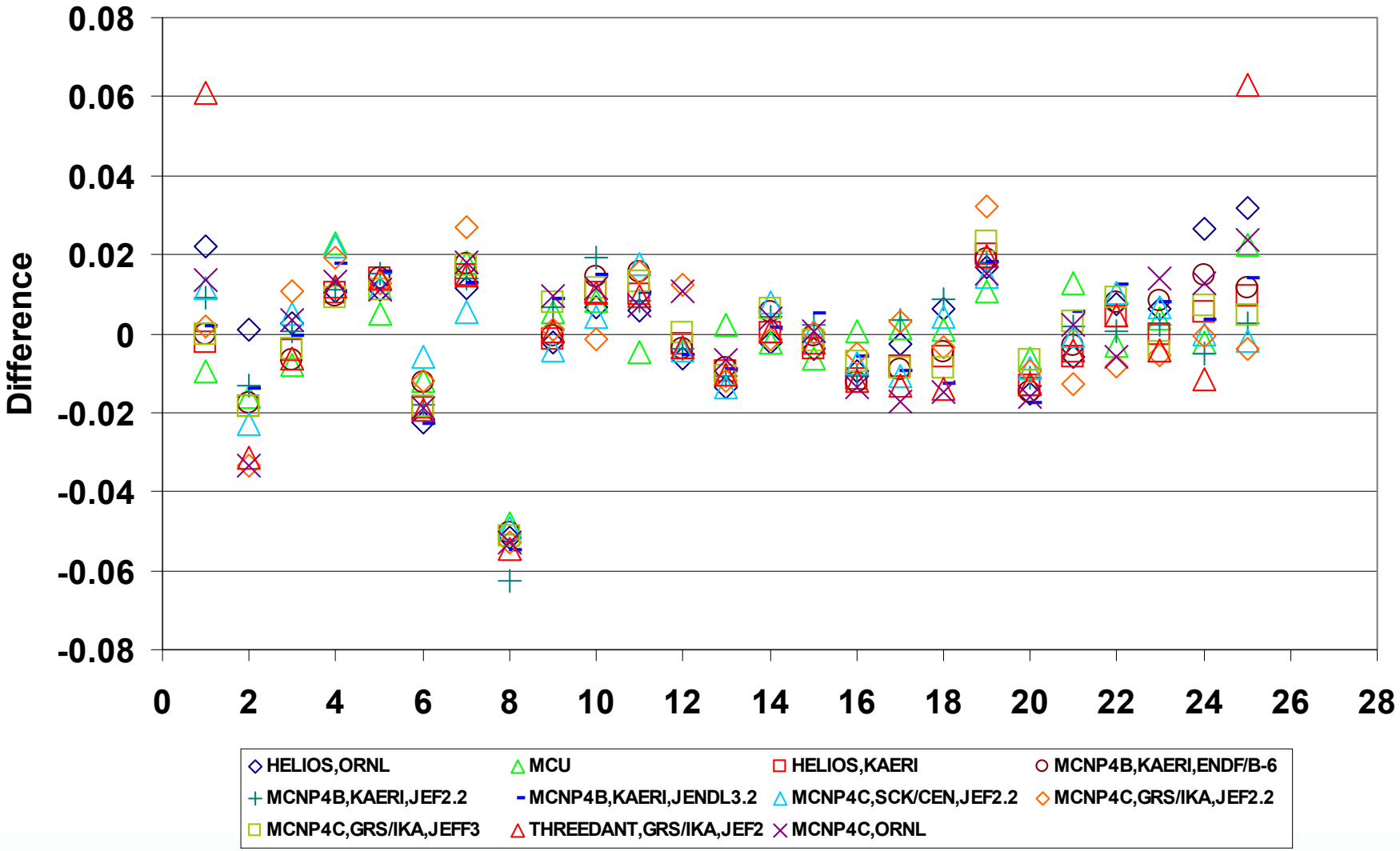


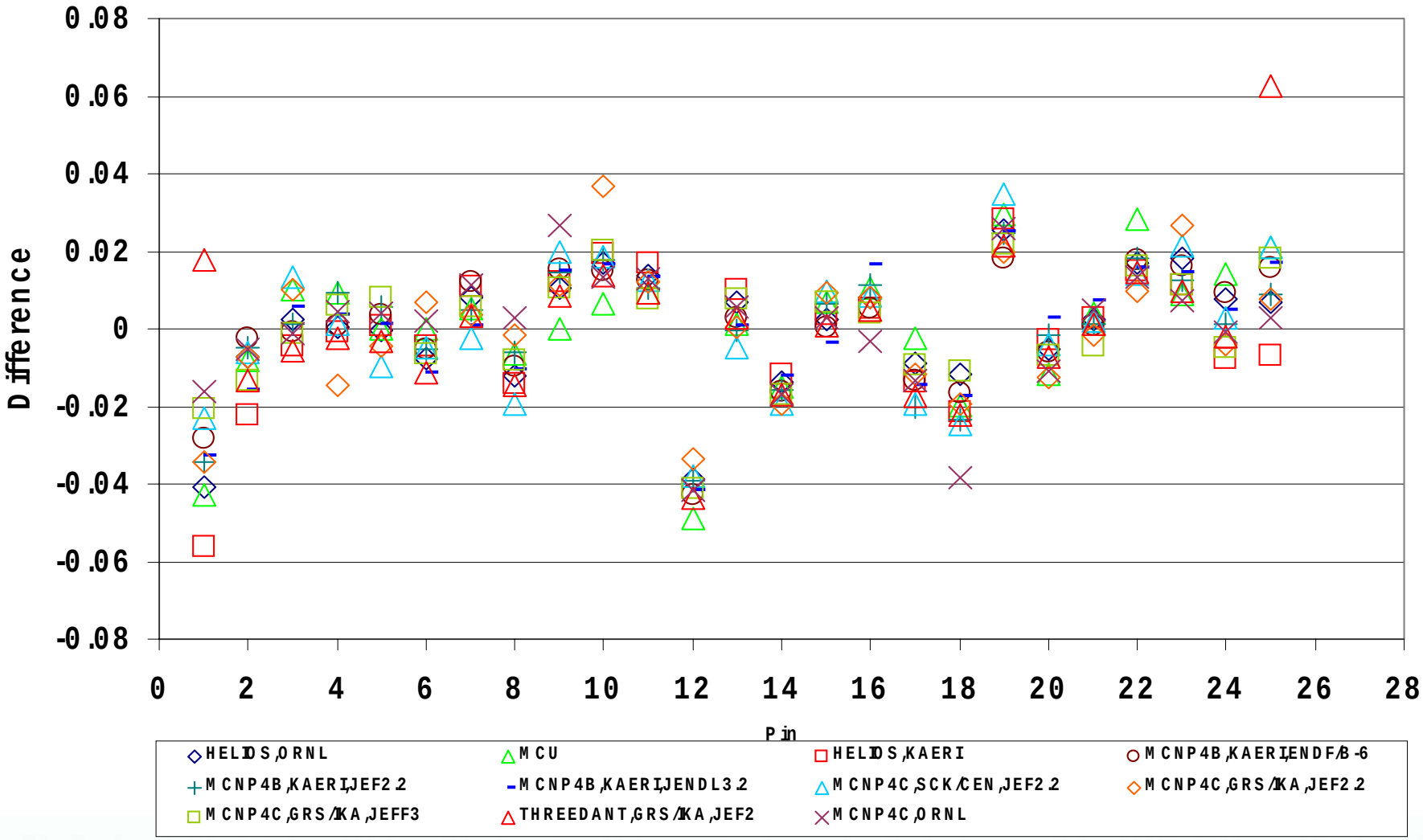
KRITZ Benchmark k_{eff} Summary



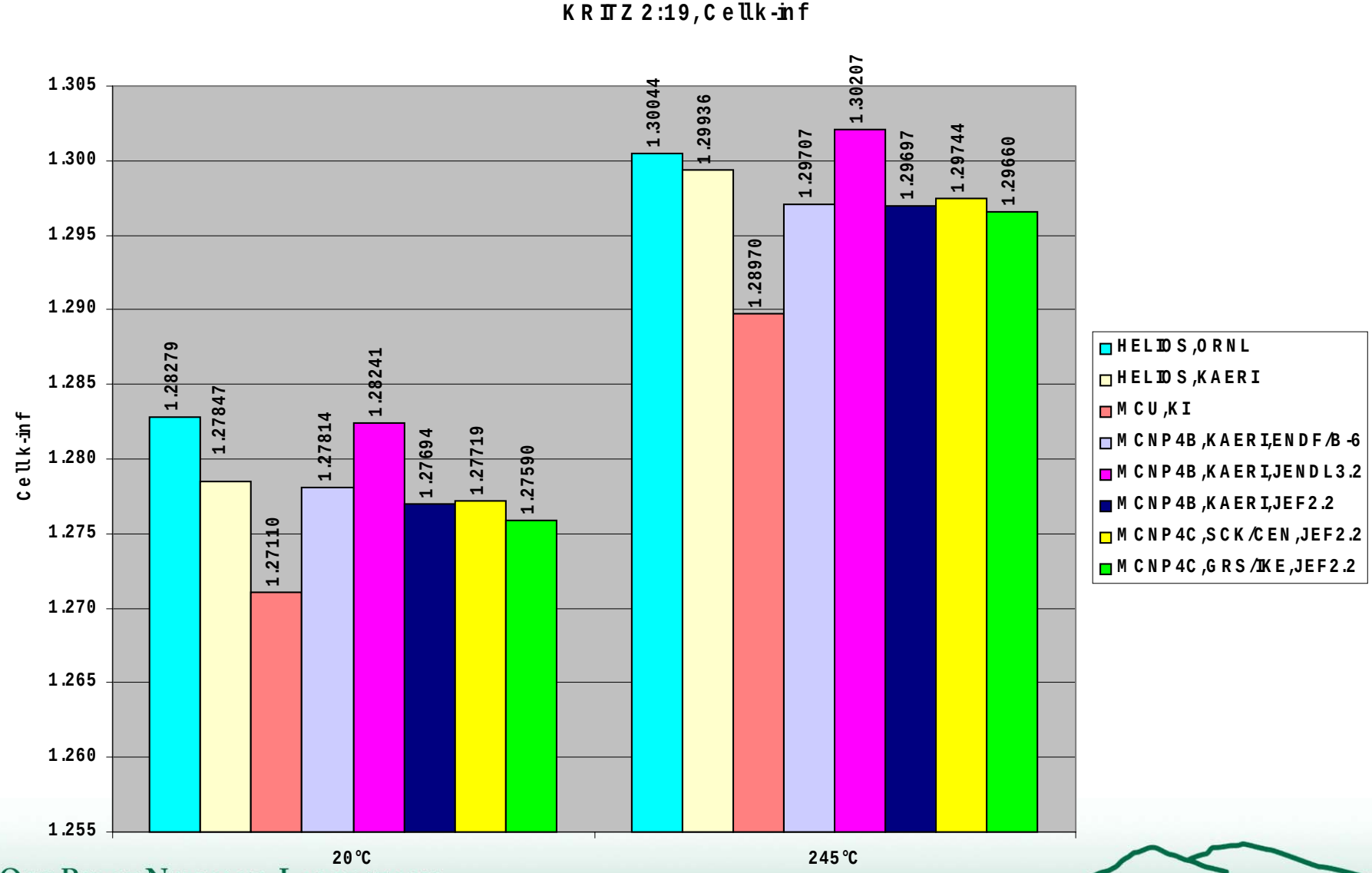

(keff(Hot) - keff(Cold)) / (Thot-Tcold)
pcm/ o C
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
-1.26
-0.56
-1.33
-1.10
-0.49
-0.29
-0.54
-0.66
-1.14
-0.87
0.04
-0.74
-0.18
-1.25
-0.34
-0.33
-0.11
-0.50
-1.04
-1.00
0.48
-0.50
0.00
-0.83
-0.61
-0.68
-0.05
-0.36
-0.11
-0.84
KRITZ 2:1
KRITZ 2:13
KRITZ 2:19
HELIOS,ORNL
HELIOS,KAERI
MCU
MCNP4B,KAERI,ENDF/B-6
MCNP4B,KAERI,JENDL3.2
MCNP4B,KAERI,JEF2.2
MCNP4C,SCK/CEN,JEF2.2
MCNP4C,GRS/IKE,JEF2.2
MCNP4C,GRS/IKE,JEFF-3
THREEDANT,GRS/IKE,JEF-2.2

HELIOS 2:19, Cold, Comparison of pin powers (C/M -1)

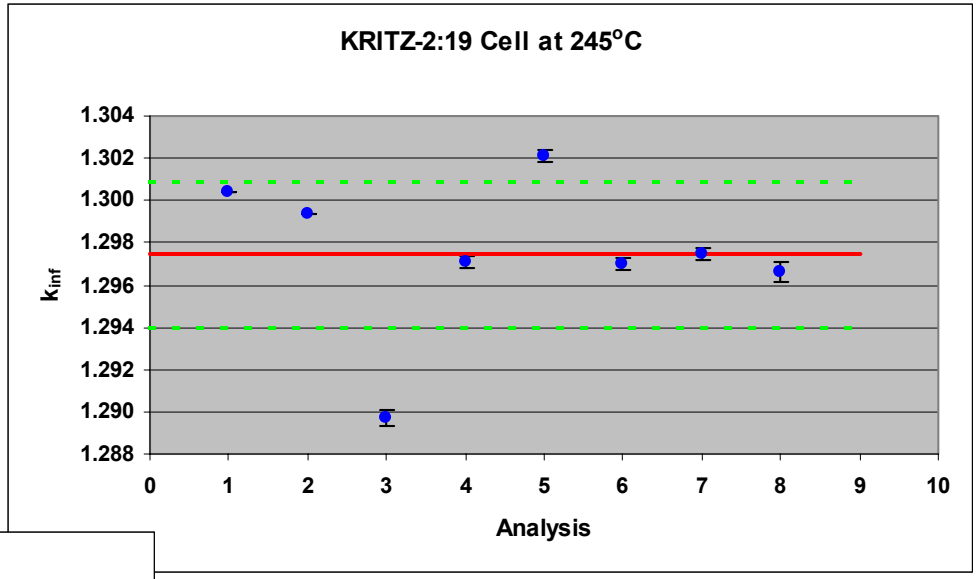


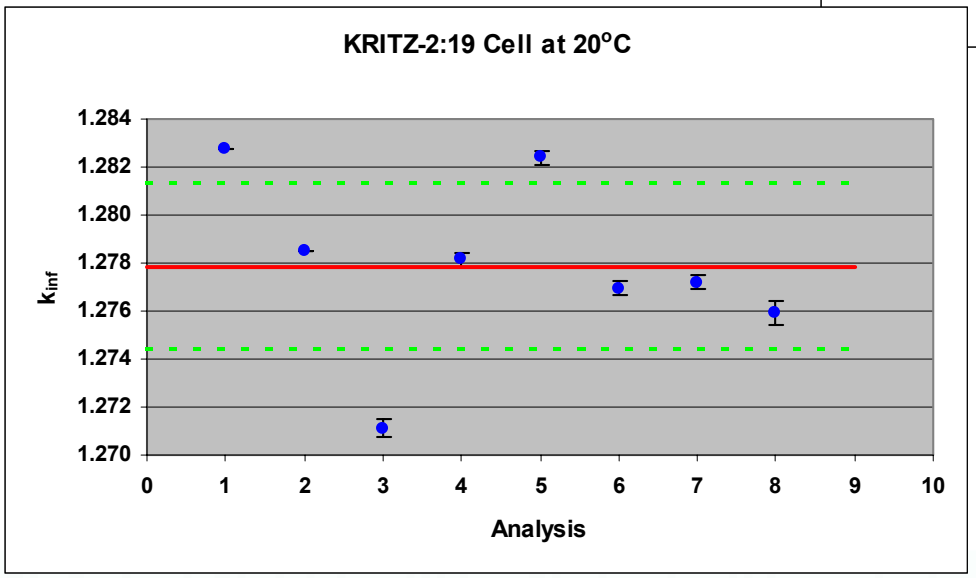

HELIOS 2:19, Hot, Comparison of pin powers (C/M -1)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Difference
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Pin
HELIOS, ORNL
MCU
HELIOS, KAERI
MCNP4B, KAERI, ENDF/B-6
MCNP4B, KAERI, JEF2.2
MCNP4B, KAERI, JENDL3.2
MCNP4C, SCK/CEN, JEF2.2
MCNP4C, GRS/IKA, JEF2.2
MCNP4C, GRS/IKA, JEFF3
THREEDANT, GRS/IKA, JEF2
MCNP4C, ORNL

KRITZ-2:19 Cell k_{inf}

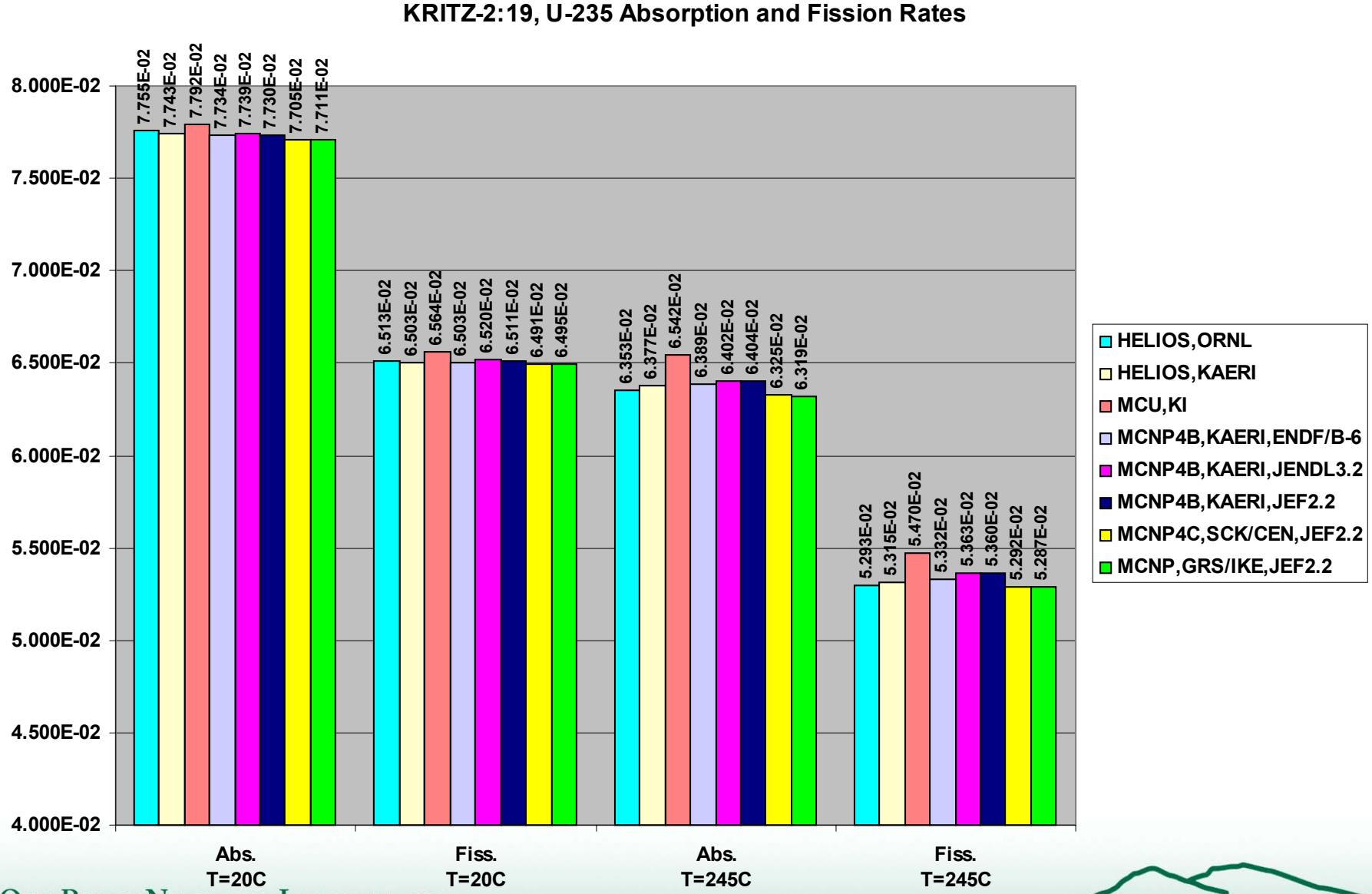


KRITZ-2:19 Cell k_{inf}

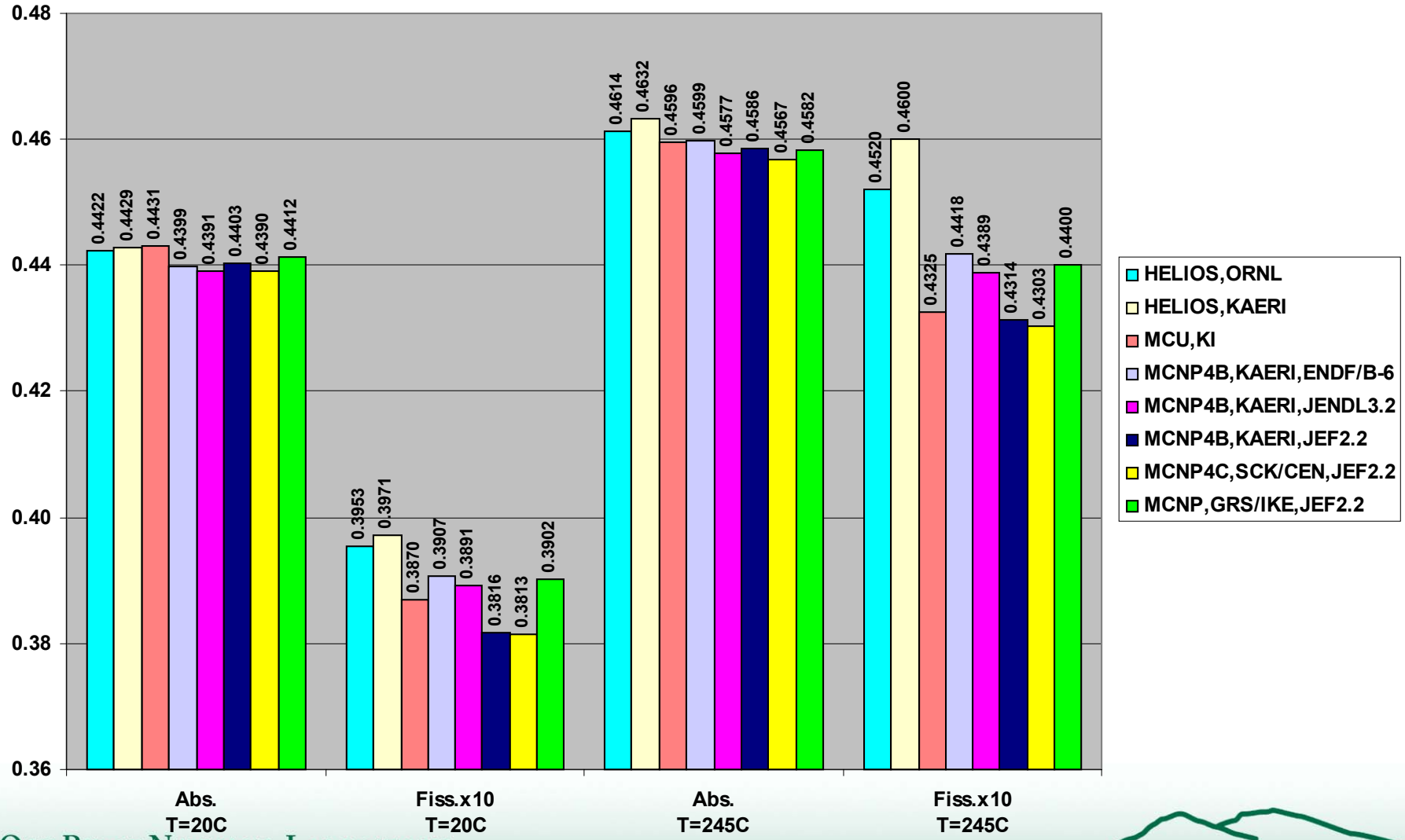




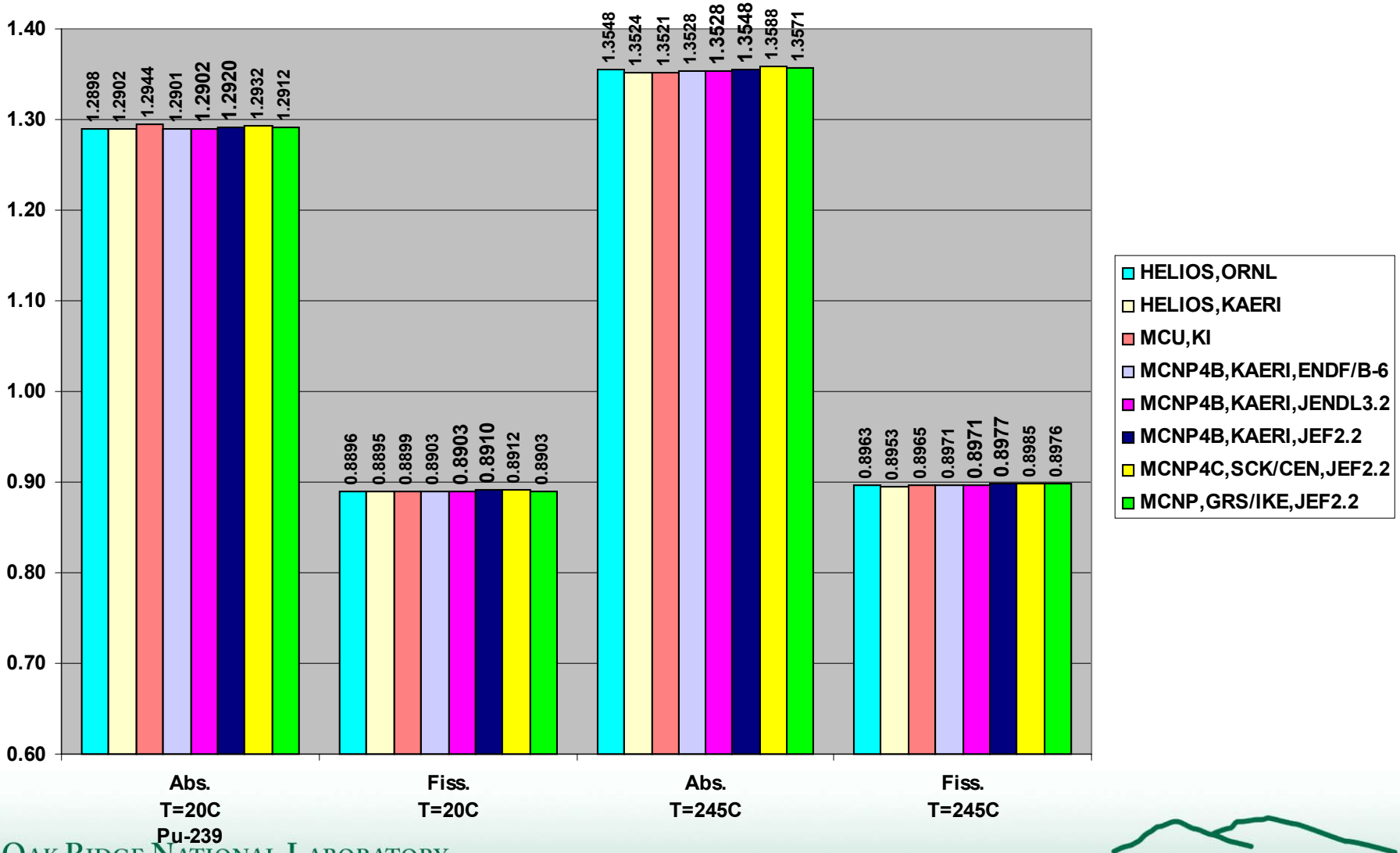
KRITZ-2:19 U-235 reaction rates



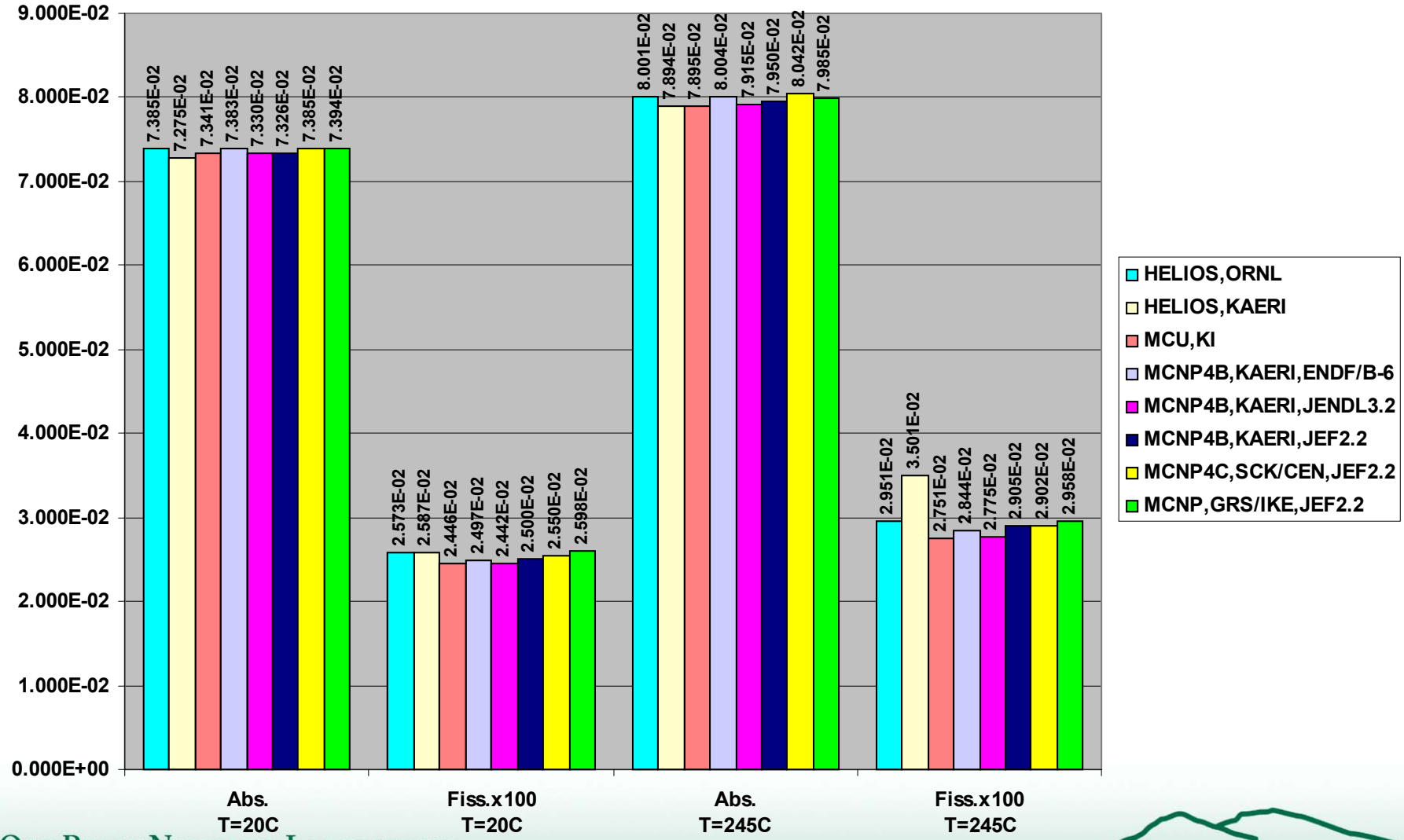
KRITZ-2:19 U-238 reaction rates



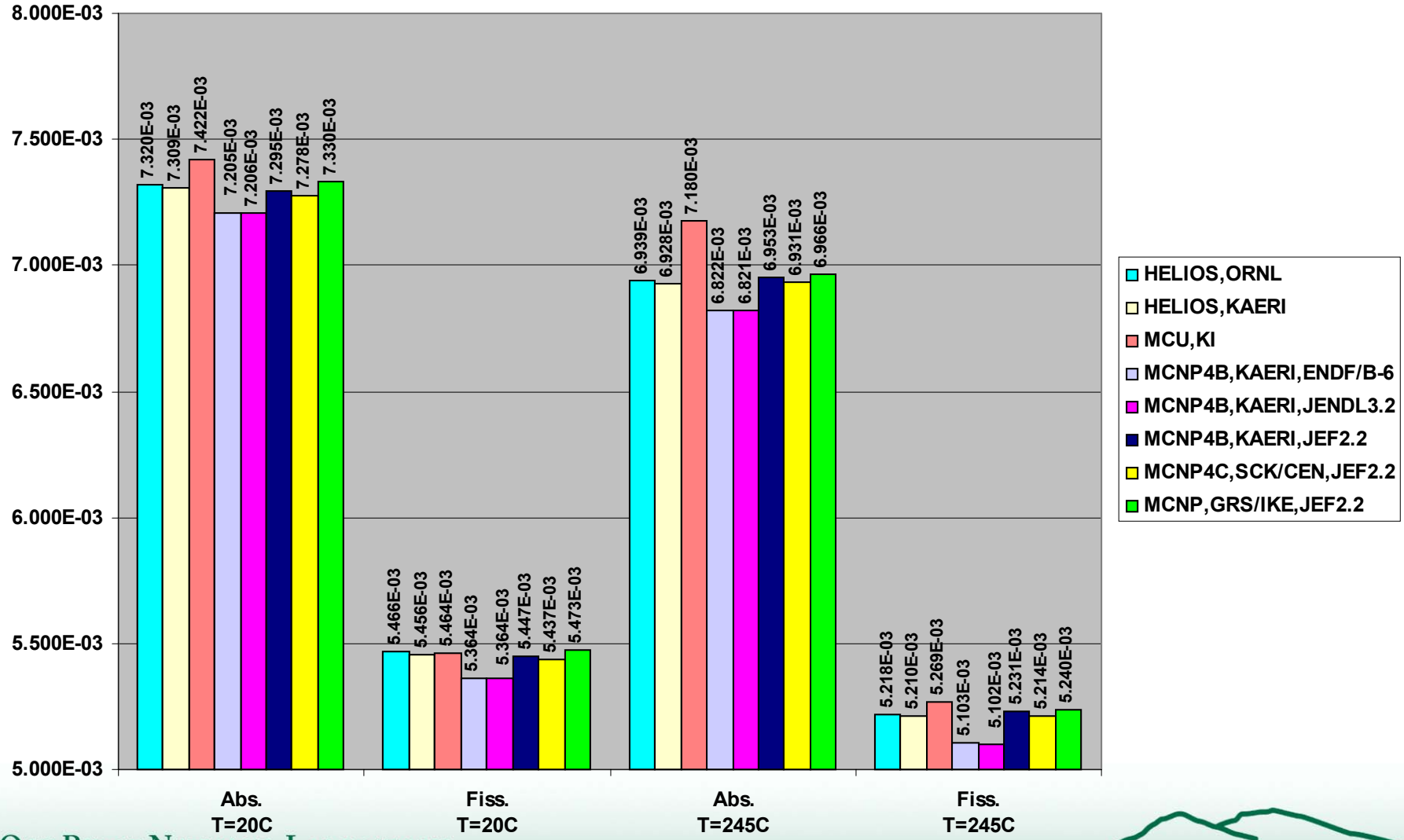
KRITZ-2:19 Pu-239 reaction rates



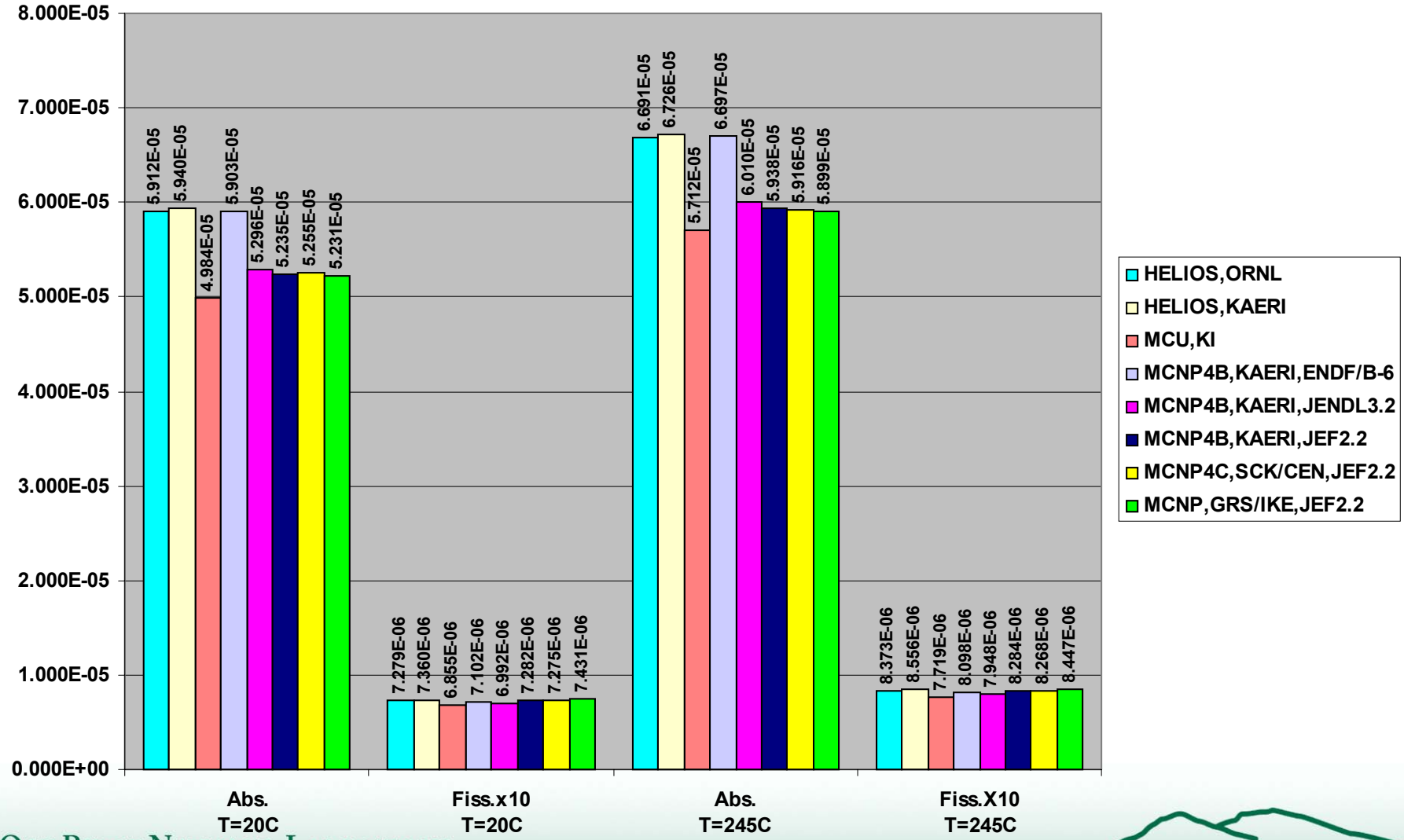
KRITZ-2:19 Pu-240 reaction rates



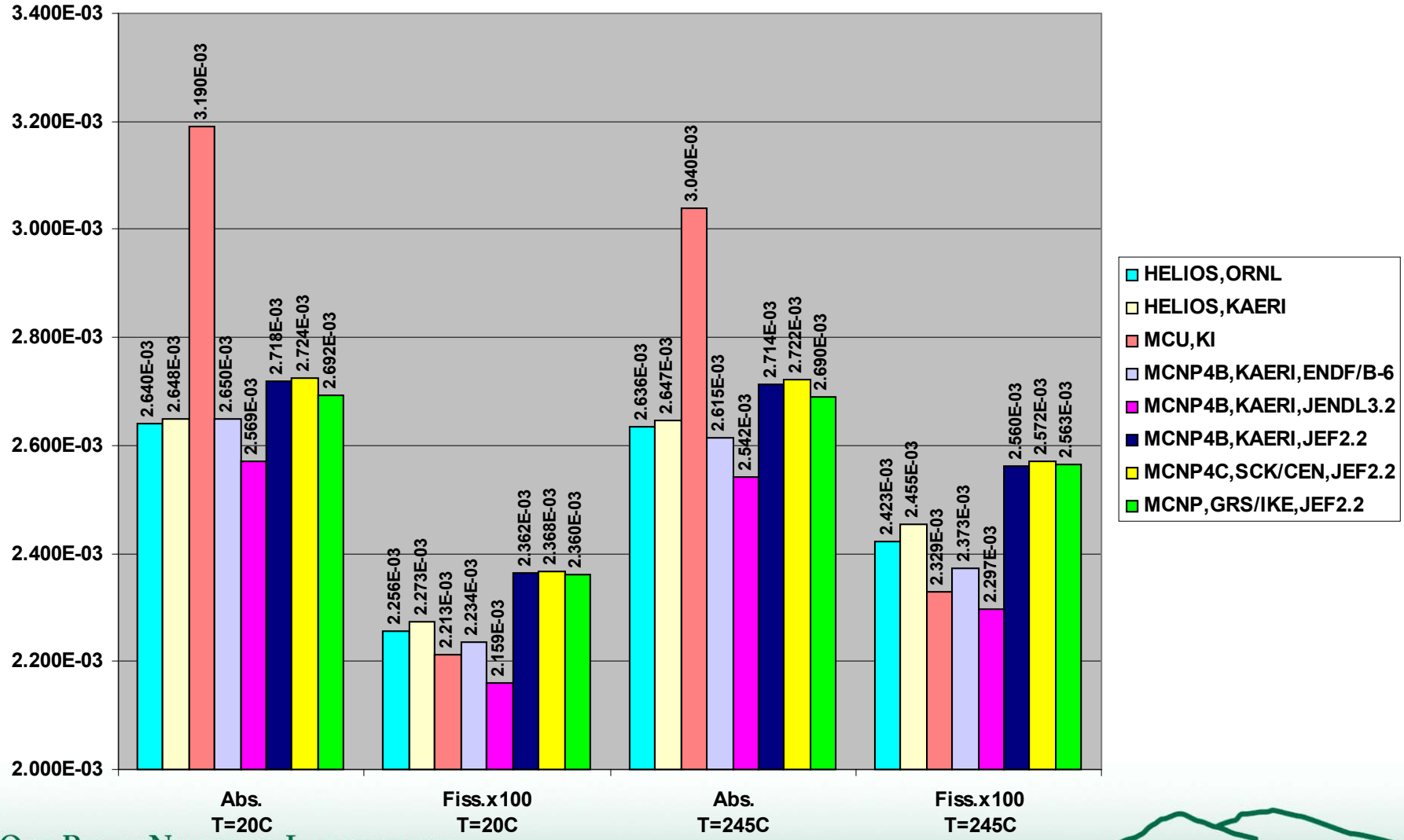
KRITZ-2:19 Pu-241 reaction rates



KRITZ-2:19 Pu-242 reaction rates



KRITZ-2:19 Am-241 reaction rates



Summary

KRITZ-2:19 benchmark for IRPhEP

- Compilation practically completed
  - Reviewed by participants of benchmark exercise
- Evaluation practically completed
  - Reviewed by participants of benchmark exercise

Inter-comparison exercise

- Participants submitted final results
- Evaluation of results in progress
- Report in preparation