Status of LLNL's support for GNDS: from evaluated nuclear data to transport codes

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LLNL Codes from A to Z

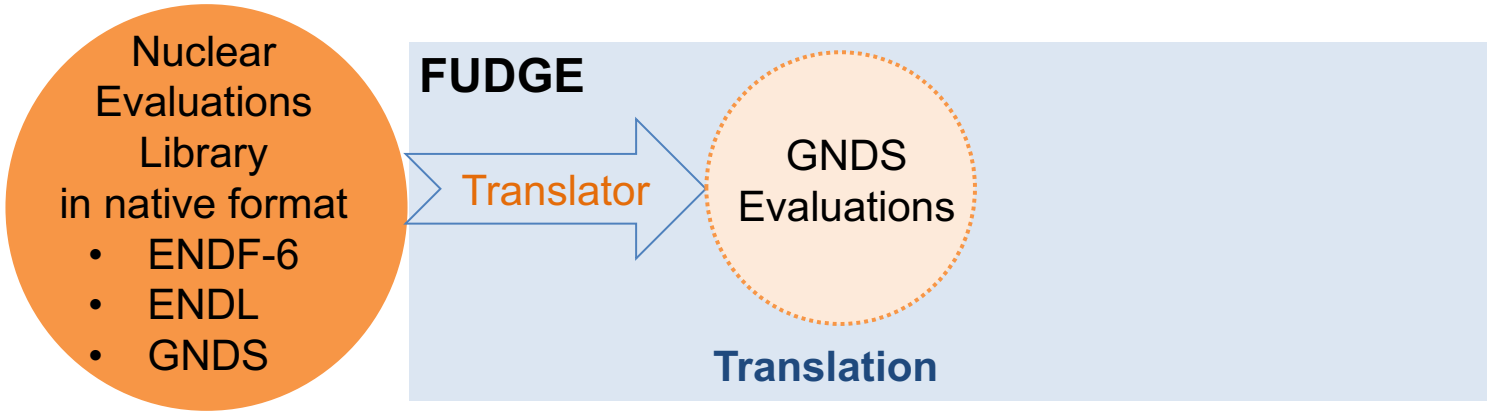
- FUDGE
  - Python based GNDS infrastructure toolkit
- GIDI
  - C++ reader for transport codes
- MCGIDI
  - C++ sampler for Monte Carlo transport codes
- Mercury
  - Monte Carlo transport code
- Ardra
  - Sn transport code
- V&V suite

GNDS: from evaluated nuclear data to transport simulations

Nuclear Evaluations Library in native format

- ENDF-6
- ENDL
- GNDS

GNDS: from evaluated nuclear data to transport simulations



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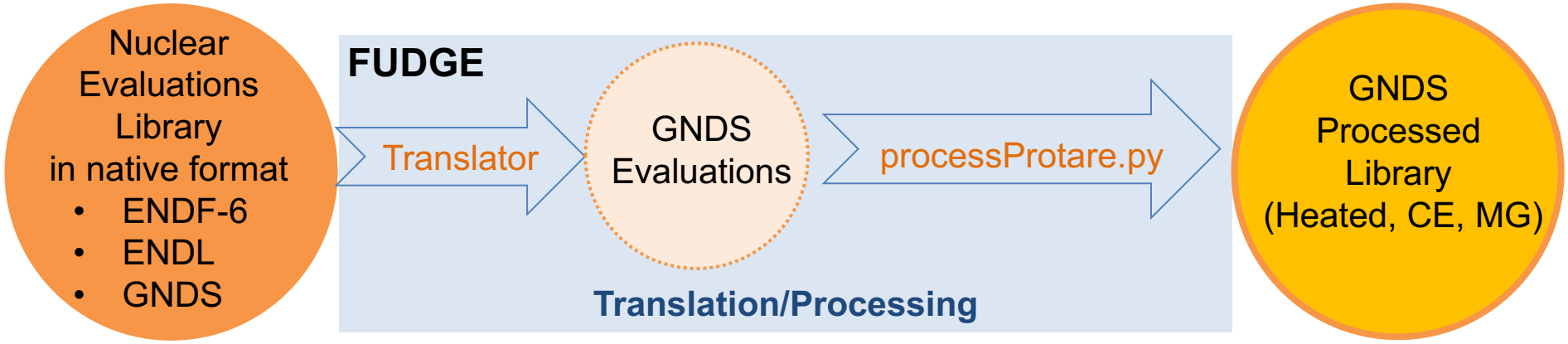

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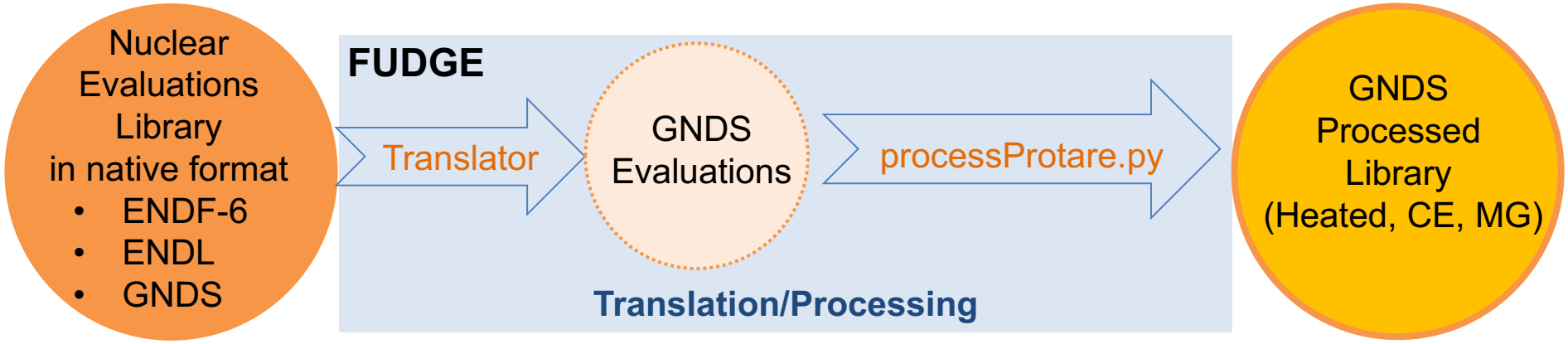
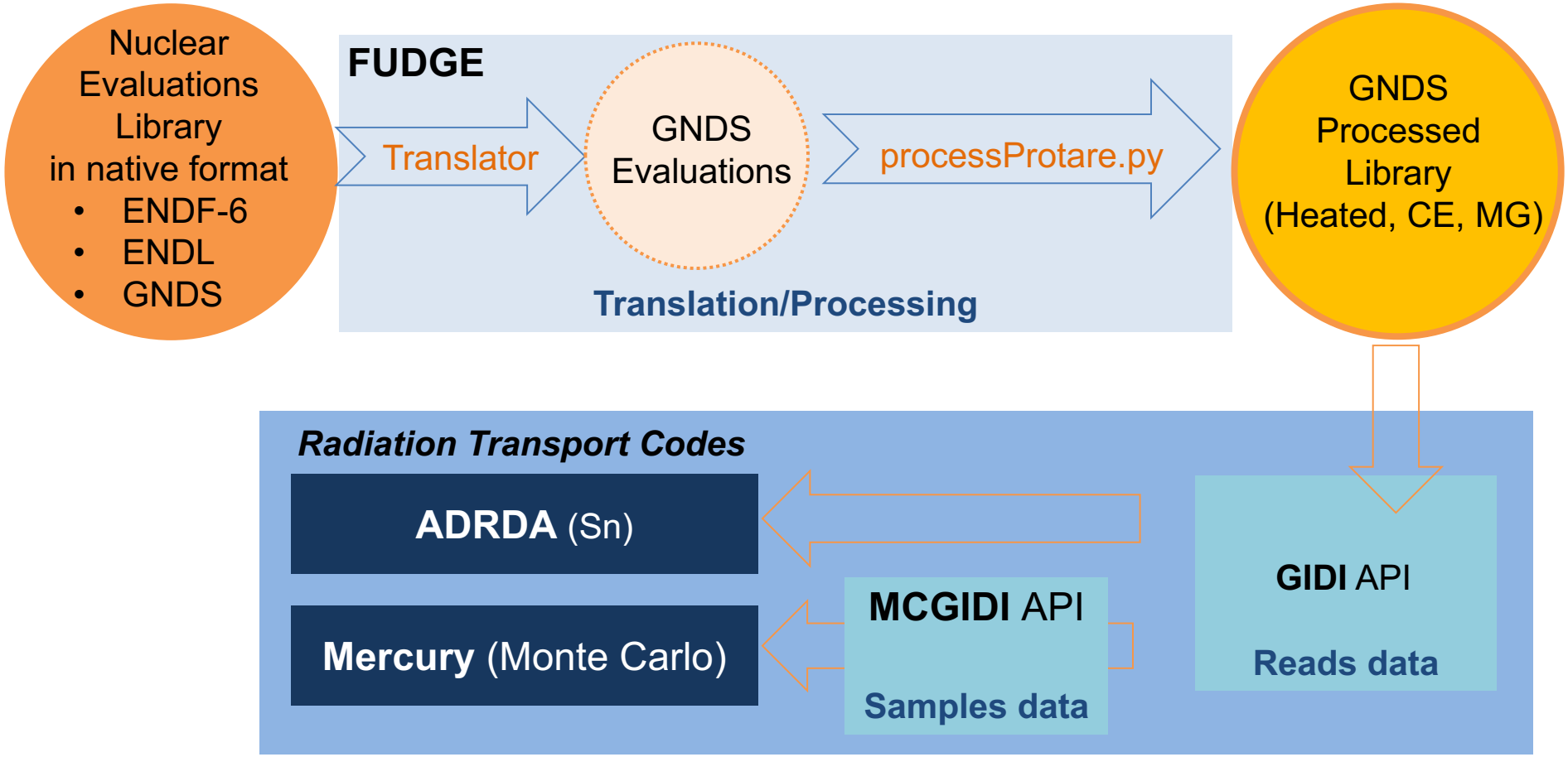


Radiation Transport Codes

ADRDA (Sn)

Mercury (Monte Carlo)

GNDS: from evaluated nuclear data to transport simulations



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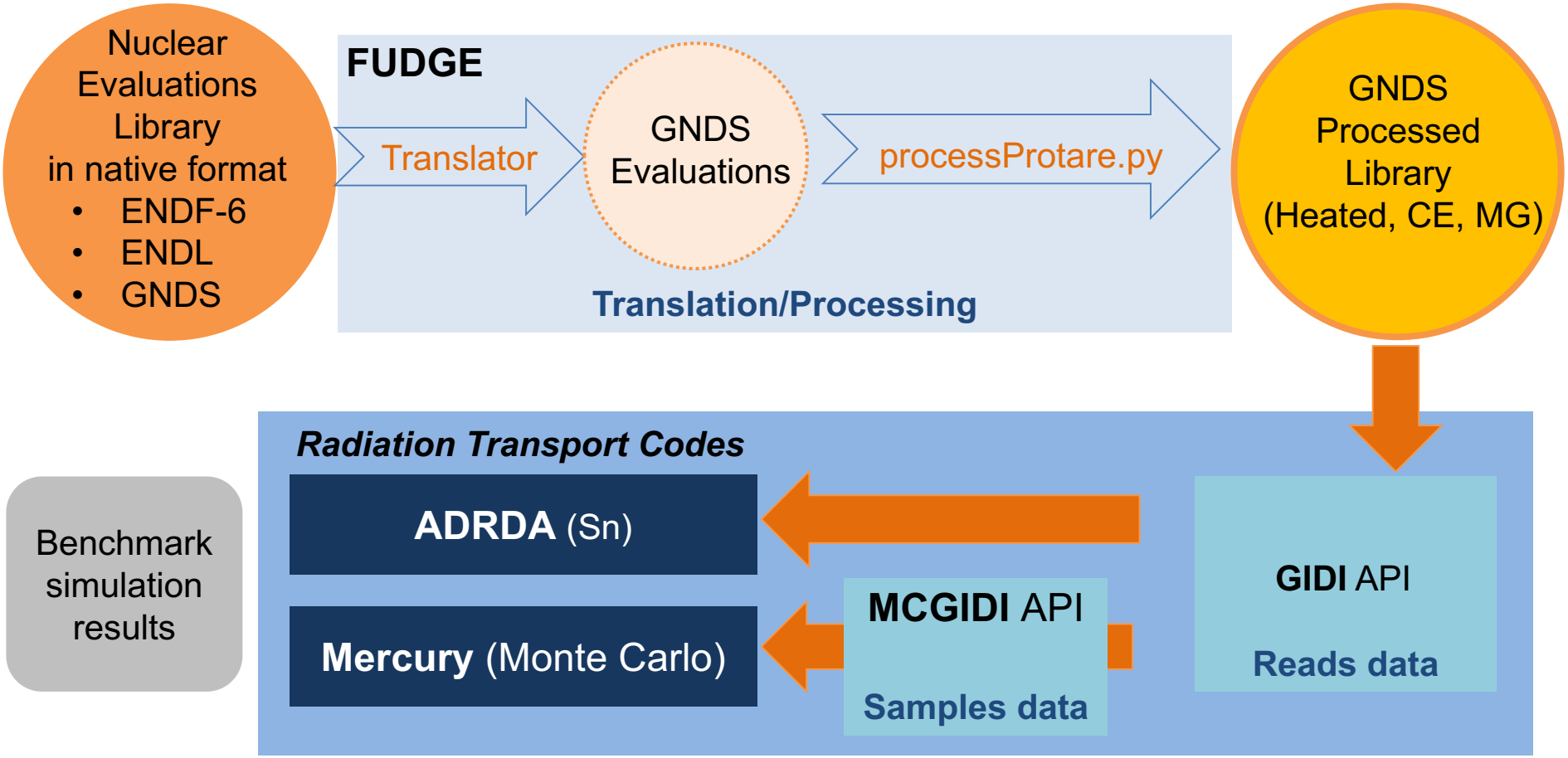
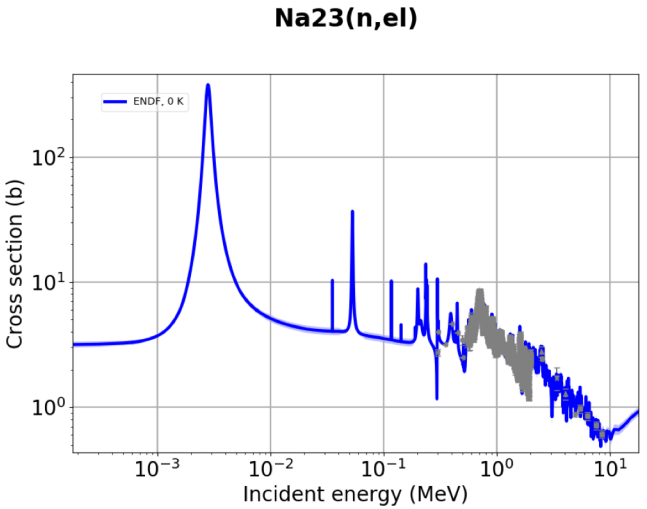
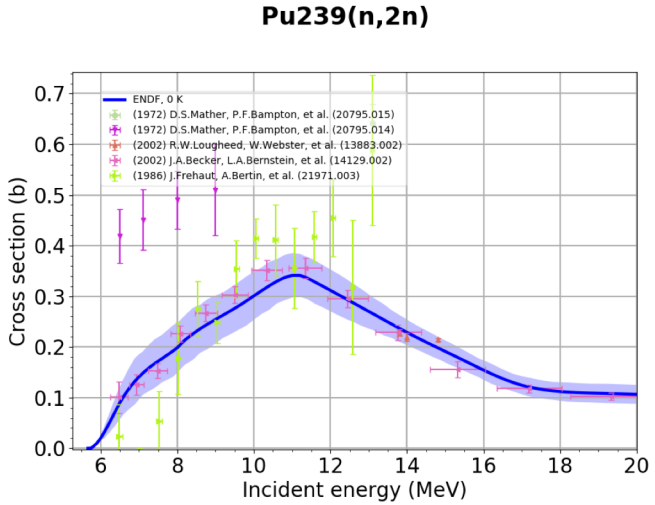


FUDGE: For Updating Data and Generating Evaluation

- FUDGE toolkit
  - Python 2.7 with extension in C and C++ to handle computationally expensive tasks
  - Translate LLNL ENDL and ENDF-6 to GNDS, and GNDS to ENDF-6
  - Manage, manipulate, view, check and process GNDS data
- Processing:
  - Converts units
  - Reconstructs cross sections and angular data for resonance parameters
  - Heats cross section
  - Creates cdf from pdf for Monte Carlo sampling
  - Calculated energy data
  - Puts cross sections on a common grid for Monte Carlo
  - Multi-groups data (with upscatter for Sn transport)
- **Open source**: released under BSD license





- Download fudge via **http://www.nndc.bnl.gov/endf/codes/FUDGE/index.html**

Status of Translation/Processing of ENDF to GNDS

- **Translation** of the following ENDF sub-libraries
  - Note that the definition for nfy and sfy is not finalized in GNDS

neutrons	protons	deuterons	tritons
helium3s	gammas	photoat	standards
electrons	decay	atomic_relax	thermal_scatt
nfy	*sfy*	alphas	

- FUDGE handles all properly formatted ENDF-6 formatted files
  - In ENDF/B-VII.1, VIII.0
  - *Except* for new data format for fission in ENDF/B-VIII.0

- **Processing** of the following ENDF sub-libraries

neutrons	protons	deuterons	tritons
gammas	helium3s	photoat	alphas

TO DO LIST (partial)
- Thermal scattering laws
- URR probability tables

GIDI & MCGIDI: General Interaction Data Interface

- GIDI version 3
  - C++ API to read GNDS files for transport codes
  - Can get data at any level in GNDS structure
  - Multi-group collapsing
    - For vectors and matrices
    - Transport correction
  - Calculates multi-group energy deposition
  - Complete for neutrons, photons and charged particles

- MCGIDI version 3: Monte Carlo GIDI
  - C++ API to store and sample for Monte Carlo transport codes
  - Uses GIDI to read data, then puts it into better form for optimal MC sampling
  - Handles point-wise cross sections and pdf/cdf distributions
  - Supports moving objects to GPUs
  - Will sample a reaction for a protare and outgoing distribution

- Currently working on:
  - point-wise energy deposition
  - multi-group and fixed-grid support for cross sections, deposition energy, etc.
  - photo-atomic

- **Open Source:** will be released *soon* under BSD license

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GNDS is in production now

Ardra (Sn)
GIDI/MCGIDI
version 3

GIDI
MCGIDI
C++
Open source

- **Data QA in ADVANCE**
  - **Plotting**
  - **Rigorous tests**
  - **Since ENDF/B-VII.1 (2011)**

GEANT4
A SIMULATION TOOLKIT

G4LND collision kernel
GIDI/MCGIDI version2
Written in C

- **Data Visualization on NNDC and IAEA websites**

slide based on slide from D. Brown

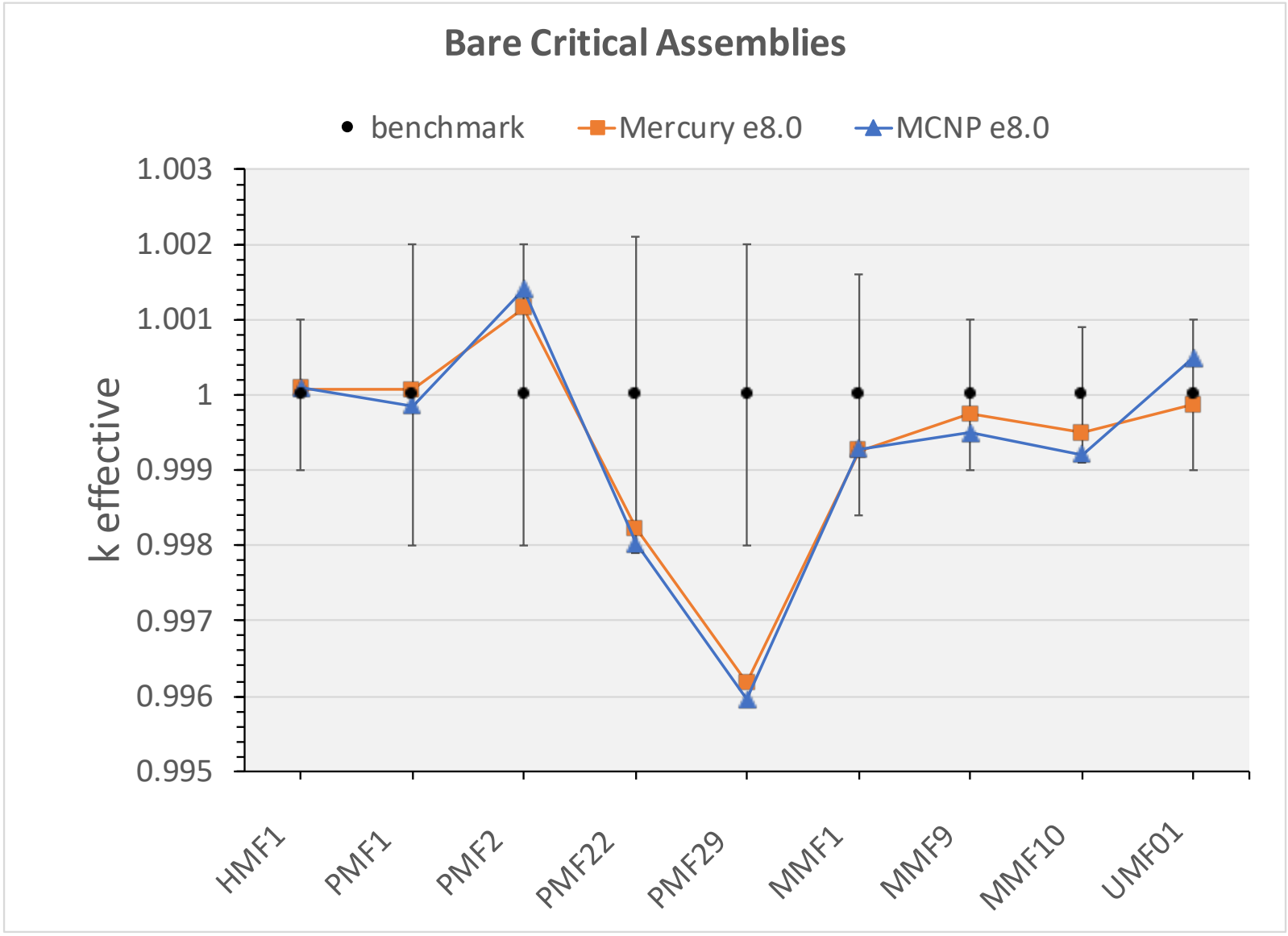
Testing ENDF/B libraries in GNDS format

- Two ENDF libraries were translated and processed with FUDGE into GNDS format
  - ENDF/B-VII.1
  - ENDF/B-VIII.0

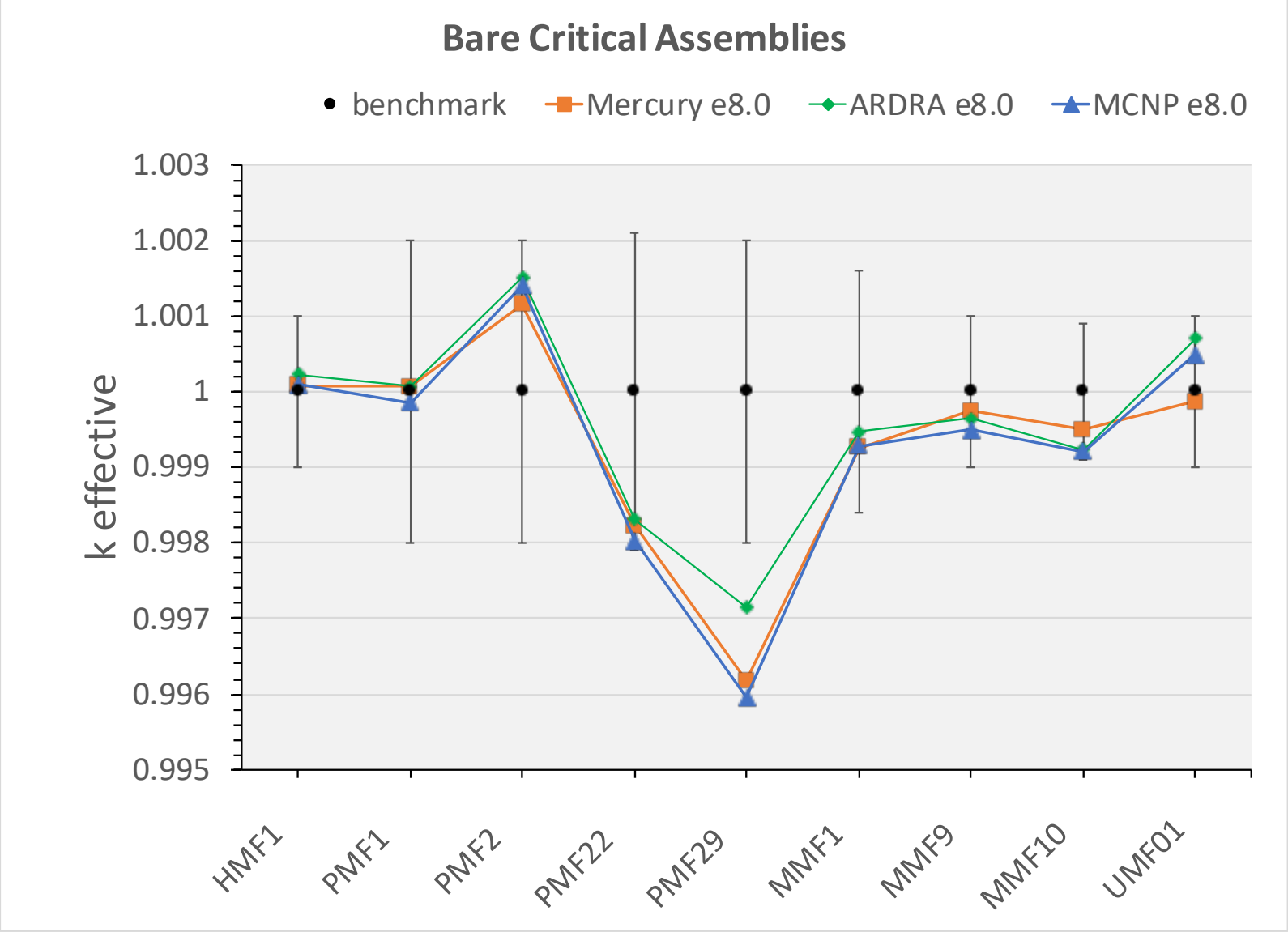
Code	Code Type	Run mode	Data Format/API	Benchmark tests	Cross-sections
Mercury	Monte Carlo	Batch	GNDS/ GIDI/ MCGIDI	Criticality: 123 fast assemblies Reaction ratios: 3 assemblies	Continuous Energy
Ardra	Deterministic Sn	Interactive	GNDS/ GIDI	Criticality:79 assemblies	Multigroup: 230 groups

- Results were compared to MCNP6 - ENDF/B-VII.1 and VIII.0 results (2017)

Bare assemblies: Godiva, Jezebel, Jezebel240,…



Adding Ardra results



Conclusion

- Processing with FUDGE is significantly faster compared to previous tools
- LLNL implemented the GNDS format for evaluated and processed nuclear data
  - FUDGE toolkit
  - GIDI/MCGIDI APIs now in ARDRA and Mercury transport codes
- Tested on ENDF/B-VIII.0 and VII.1 libraries in ENDF-6 format
  - Translation and processing
  - Verification and Validation using LLNL V&V test suite
    - Fast criticality benchmarks (123 Mercury cases, 79 Ardra cases)
    - Reaction ratios (3 Mercury cases)
    - Pulsed spheres coming soon
- Comparison with MCNP6 results published in ENDF/B-VIII.0 release paper

Future work

- Complete GNDS specifications
  - WPEC meeting in Paris, May 2018

- FUDGE Processing
  - Neutron thermal scattering laws
  - Unresolved resonance probability tables
  - Multi-band (Sn)
  - GNDS to ACE, NDI, etc.

- GIDI / MCGIDI
  - Neutron thermal scattering laws
  - Unresolved resonance probability tables
  - Longer term: investigate On-the-fly heating and multi-grouping by GIDI (GPUs)

- CODES: ARDRA & Mercury
  - Multi-band

- Kiwi -> FUDGE Creating realizations for Uncertainty Quantification

Useful links

- GNDS
  - **https://www.oecd-nea.org/science/wpec/sg38/**
- FUDGE
  - **http://www.nndc.bnl.gov/endf/codes/FUDGE/index.html**
- GIDI/MCGIDI
  - Coming soon
- ENDF/B-VIII.0
  - ENDF-6: **http://www.nndc.bnl.gov/endf/b8.0/download.html**
  - GNDS: **http://www.nndc.bnl.gov/endf/b8.0/gndsfiles.html**