

Status of FUDGE

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LLNL nuclear data management code FUDGE (For Updating Data and Generating Evaluations)

- FUDGE is designed to support GNDS
 - ENDF-6 and ENDL data files are also supported but must first be translated into GNDS. Translators are included with FUDGE
- FUDGE supports plotting, manipulating, checking for physical content, resonance reconstruction, Doppler broadening, etc.
- Also supports processing for Monte Carlo and deterministic transport
- Open source, available from <https://github.com/LLNL/fudge>
 - Latest public release was FUDGE-4.2.3 with support for GNDS-1.9
 - Next release (FUDGE-4.3) will support GNDS-2.0

Getting started with FUDGE:

- Fudge-4.2.3 (released 2018) requires Python 2.7 and numpy
 - v4.3 release forthcoming

```
>git clone https://github.com/LLNL/fudge
>cd fudge
>export PYTHONPATH=`pwd`
>make
>make check      # takes a few minutes
```

- Translating ENDF-6 file to GNDS:

```
>python fudge/site_packages/bin/endf2gnds.py n-001_H_001.endf -v
    2 [3, 4, 33] : MF=4, LTT = 1
   102 [3, 6, 33] : MF=6 : ZAP=0, LAW=2, LANG=0 : ZAP=1002, LAW=4
    1 [3, 33]
Reading resonances (MF=2 MT=151)
Reading covariances (MFs 33)
>ls *.xml
n-001_H_001.endf.gnds.xml      n-001_H_001.endf.gndsCov.xml
```

processProtare: processing Monte Carlo and/or multigroup data

```
>make merced # C++ tool used by FUDGE for generating transfer matrices
>python bin/processProtare.py n-001_H_001.endf.gnds.xml -mc -mg \
  --bdfils fudge/fudge/legacy/endf/bdfils \
  -t 300 -t 600 --temperatureUnit K -vvv
```

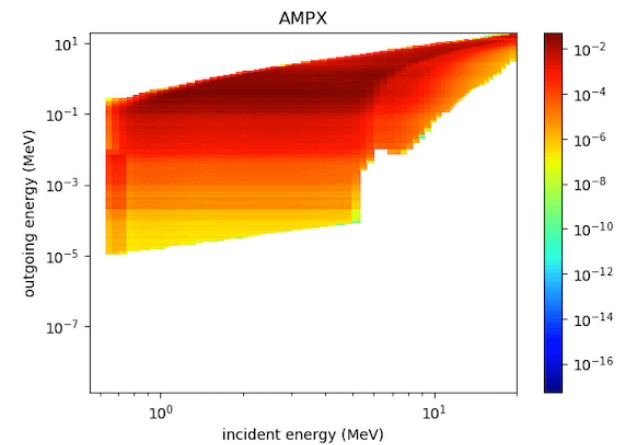
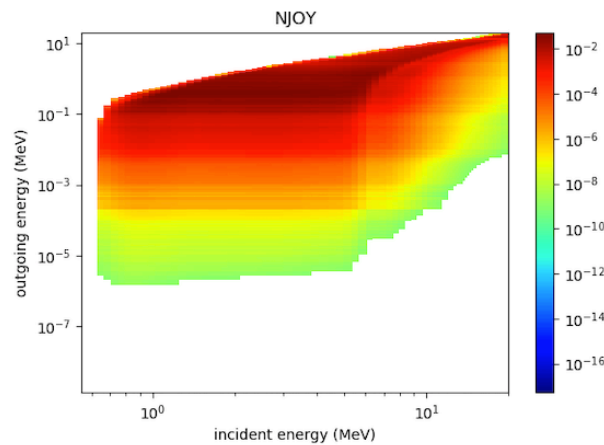
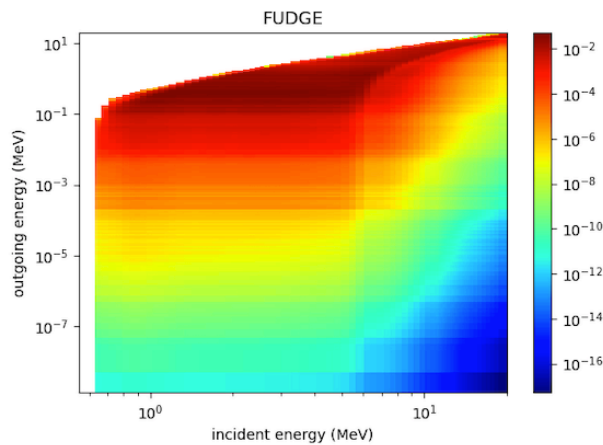
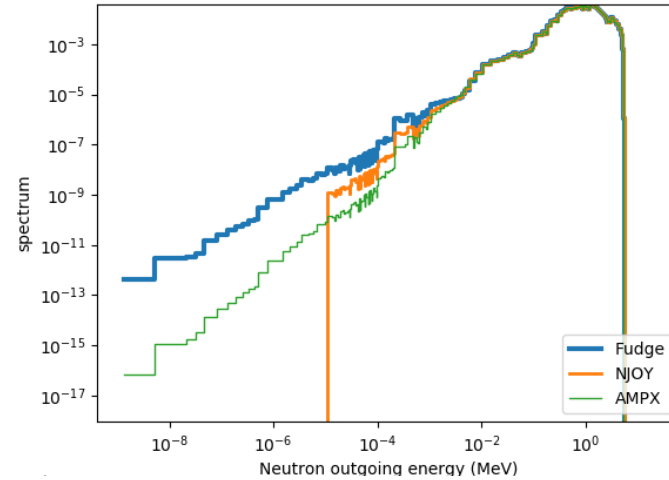
- Result contains both Monte Carlo and deterministic data at two temperatures (300 and 600 K).
- All processed data go into a new GNDS file. GNDS 'styles' help differentiate different types of processed data:

```
<reaction label="n + H1" ENDF_MT="2">
  <crossSection>
    <XYS1d label="eval">...</XYS1d>
    <XYS1d label="heated_000">...</XYS1d>
    <YS1d label="MonteCarlo_000">...</YS1d>
    <gridded1d label="MultiGroup_000">...</gridded1d>
    <XYS1d label="heated_001">...</XYS1d>
    <YS1d label="MonteCarlo_001">...</YS1d>
    <gridded1d label="MultiGroup_001">...</gridded1d>
  </crossSection>
  <outputChannel genre="twoBody">
```

Ongoing effort: compare processing results to AMPX, NJOY, PREPRO, etc.

- Different treatment of interpolation is a frequent cause of discrepancies

Grouped outgoing (n,n') spectrum (MT91)
from ENDF-VII.1 Pu239



GIDIplus: C++ library for reading and sampling processed nuclear data libraries

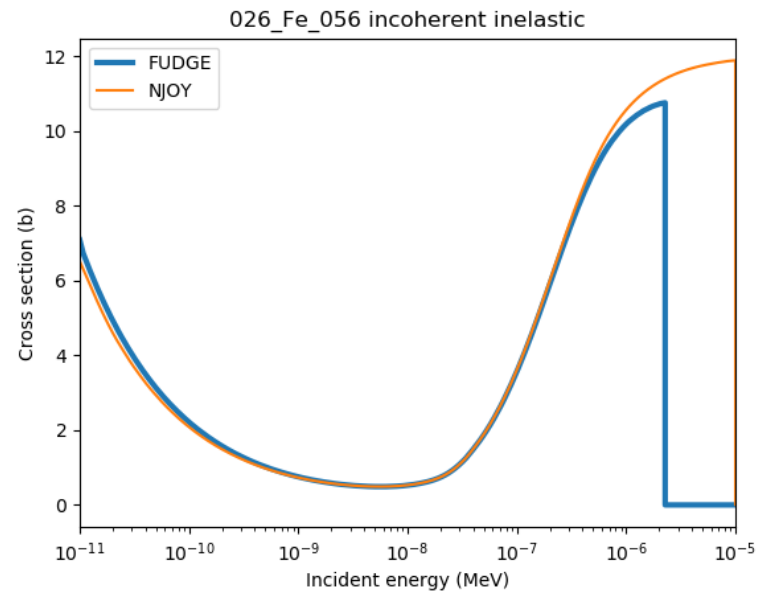
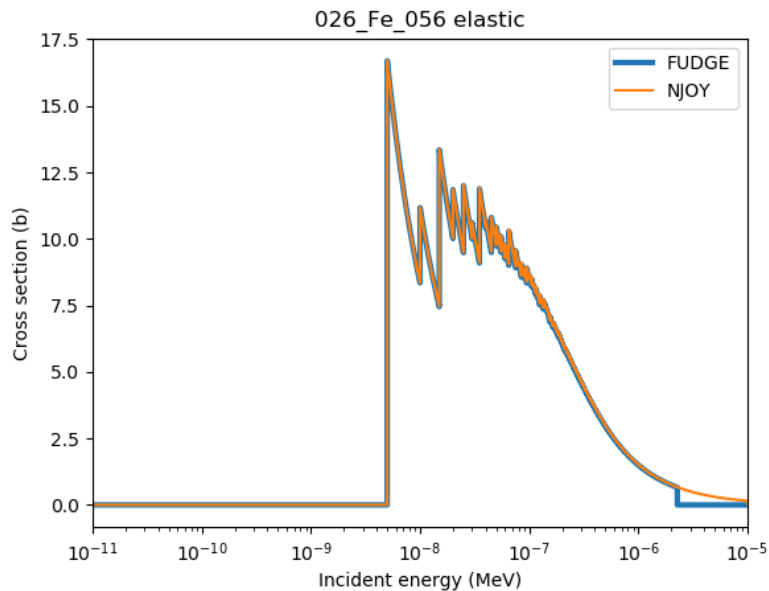
- Released as open source under MIT license
 - <https://github.com/LLNL/gidiplus>
- Latest release (v3.18.129) includes MCGIDI library for Monte Carlo sampling
- GIDIplus has been implemented in LLNL transport codes Mercury and Ardra
 - Tested extensively against older nuclear data infrastructure using broomsticks, critical assemblies, etc.

What to expect in FUDGE-4.3?

- Supports both GNDS-1.9 (current official standard) and tentative GNDS-2.0 (new standard currently under development by WPEC EG-GNDS)
- Python3 compatible
- Supports installation using either *make* or *pip install*
 - pip simplifies installation in virtual environments (conda & venv)
- LLNL development moved from SVN to gitlab
 - One main advantage: gitlab CI for testing

Some new capabilities in FUDGE-4.3:

- processProtare.py now supports TNSL evaluations
 - Recently tested using sample file from M. Zerkle (using new format proposal with both coherent and incoherent elastic scattering)
 - Release candidate can translate and process these files
 - Working to understand some differences with NJOY



Some new capabilities in FUDGE-4.3:

- `energySpectrum.py`
 - Summarizes outgoing spectrum (converting to lab frame where needed) for one incident energy. Used extensively at LLNL to check neutron and gamma spectra
- Other scripts added to help view and maintain evaluations
- Tools for managing map files
 - map files consolidate multiple GNDS files into a library (similar to `xmdir` for ACE)
- Updated plotting tools (`Gnuplot.py` to `PyQt5`)

New UQ tool 'EMU' coming soon

- Evaluations with Means and Uncertainties
 - Replaces Kiwi which only handled LLNL ENDL formatted data.
 - Main developer is Kyle Wendt.
- Uses mean and covariance data to create a realization.
- Currently a separate package from FUDGE but uses FUDGE to read/write and manipulate GNDS data.
- Plan is to independently release EMU
- Will be discussed further during covariance session later today

Summary

- FUDGE capabilities include
 - Translating older formats into GNDS
 - Translating GNDS back to ENDF-6
 - Visualizing, modifying, checking, processing GNDS data
- New version of FUDGE coming soon
 - Plan is to support GNDS-2.0 specification, but we may release sooner if v2.0 is delayed