

A new V&V philosophy for fusion nuclear data libraries

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²*University of Bologna, Bologna, Italy*

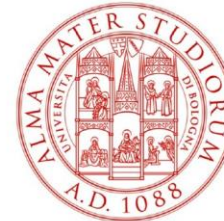
³*Fusion For Energy, Barcelona, Spain*



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ENERGY**

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JADE

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- The Sphere Leakage benchmark
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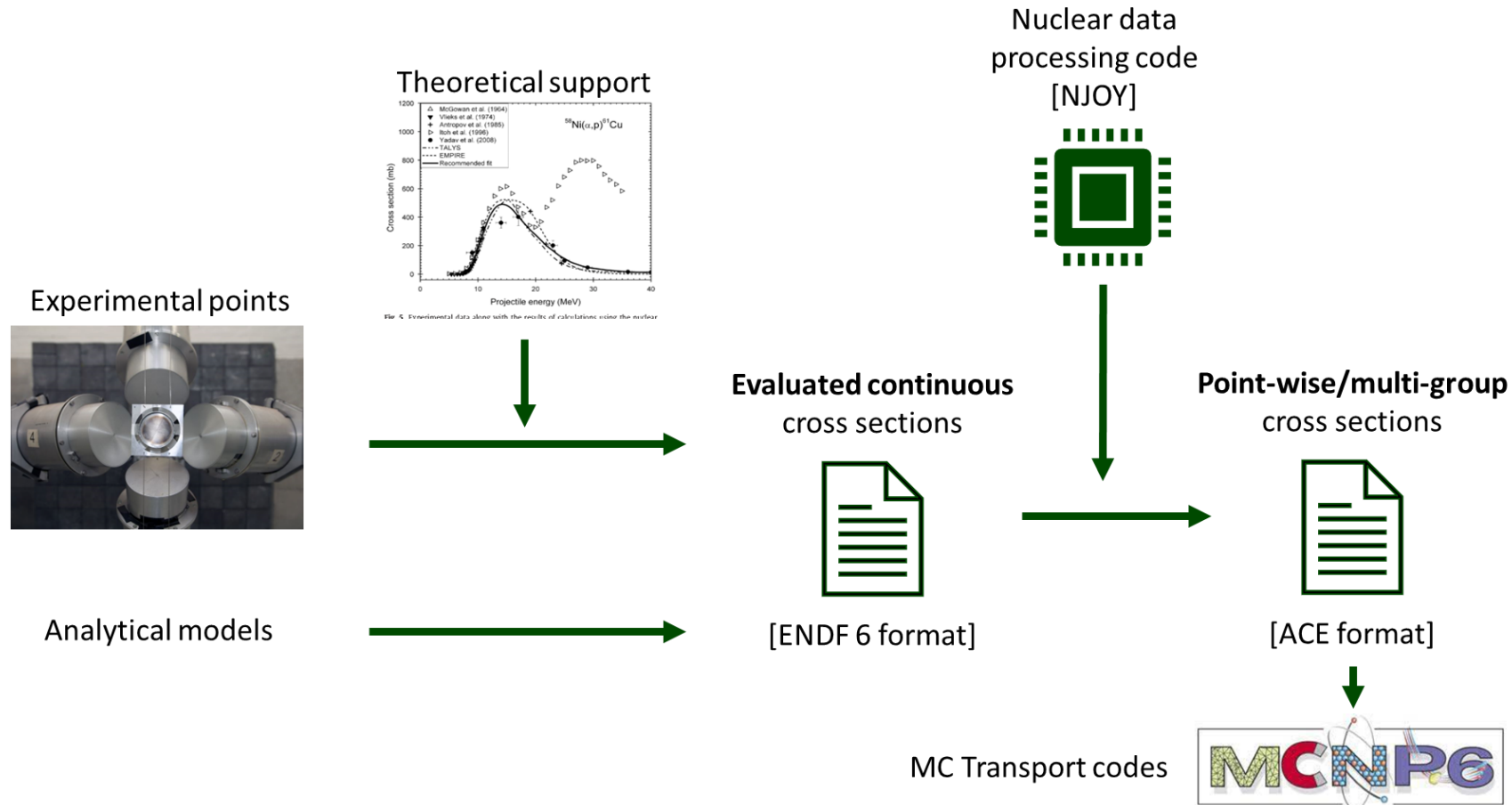
- Our wish list
- Machine Learning
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JADE

Nuclear data libraries and their V&V



The nuclear data libraries production chain

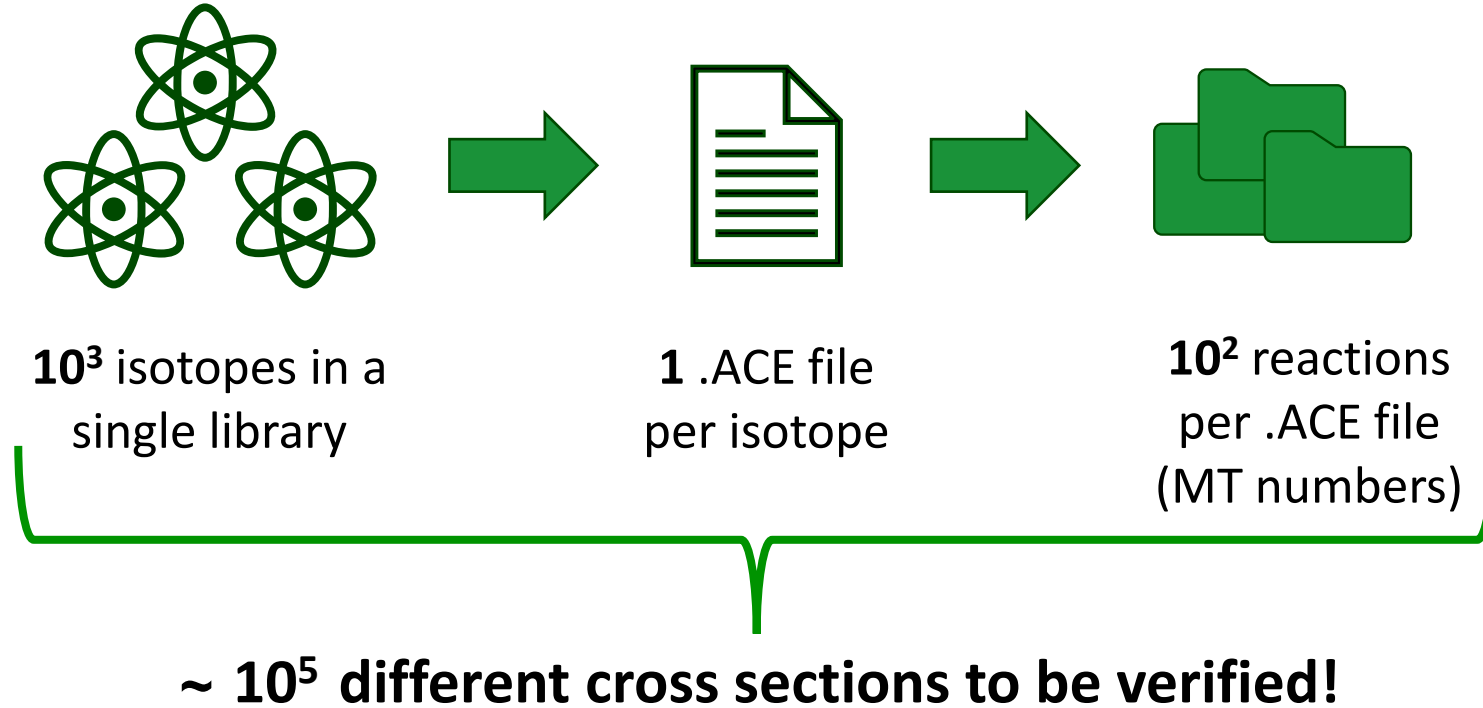


It is a complex procedure that require extensive Verification and Validation (V&V)

Nuclear data libraries and their V&V



The need for automation and standardization



Heavy automation is a necessity, which, at the same time, is an opportunity for standardization



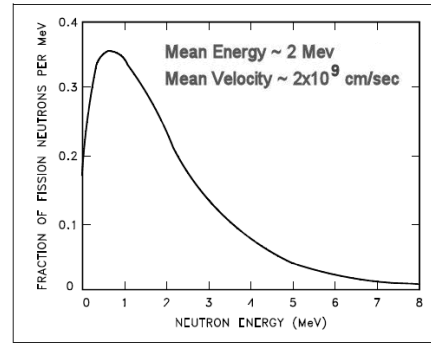
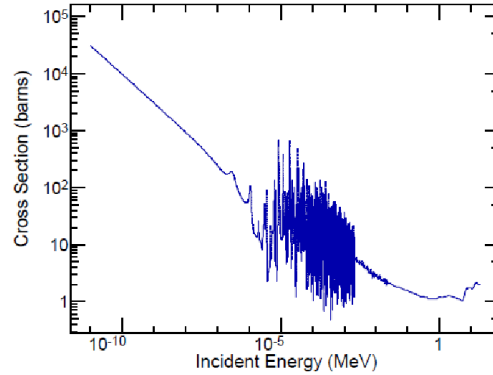
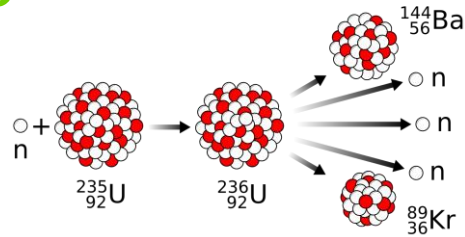
Nuclear data libraries and their V&V



The fission bias

Energy range

Different materials and cross sections

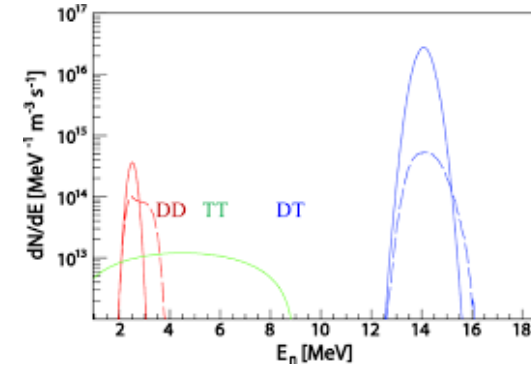
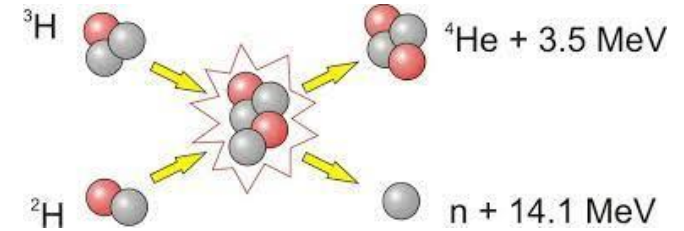


Prompt Fission Neutron Energy Spectrum for Thermal Fission of Uranium-235

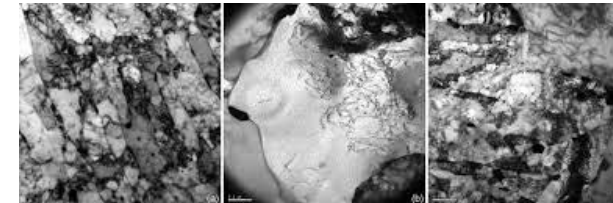


- Fission rate
- Fission products

Vs

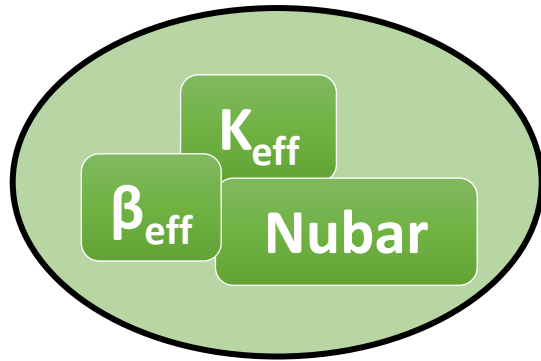
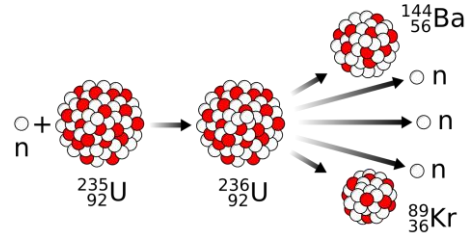


EUROFER 97



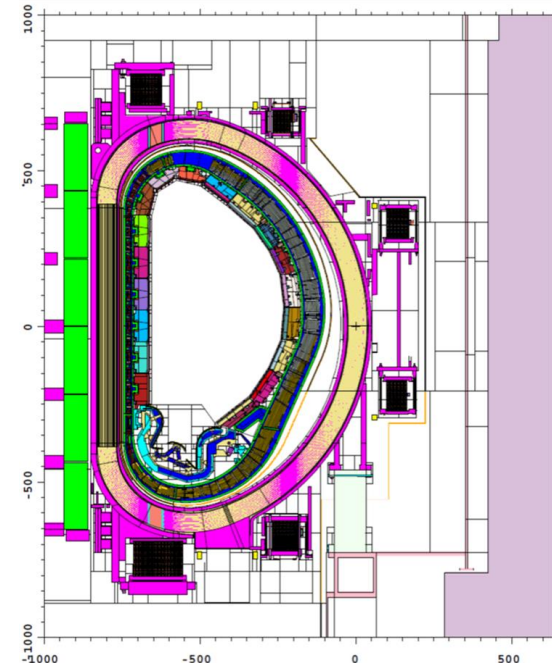
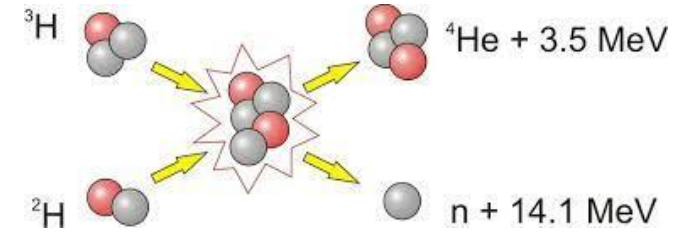
- Fusion rate
- Tritium production
- Heating on superconductive magnets
- Activation issues

The fission bias



Integral parameters representative of the entire system that simplifies the V&V process

Vs



Vast amount of tallies and energy/spatial discretization

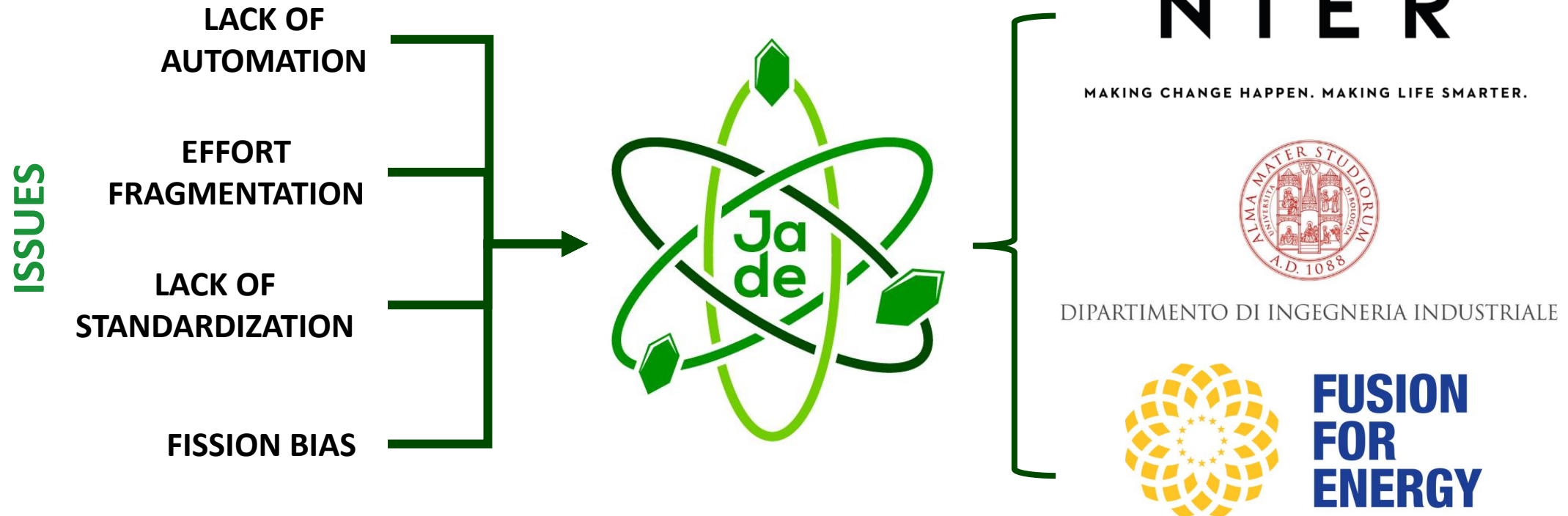
- complex geometries that need to be fully modelled
- different regions with different needs
- a detailed spatial distribution of tallies is needed

What is JADE?



JADE

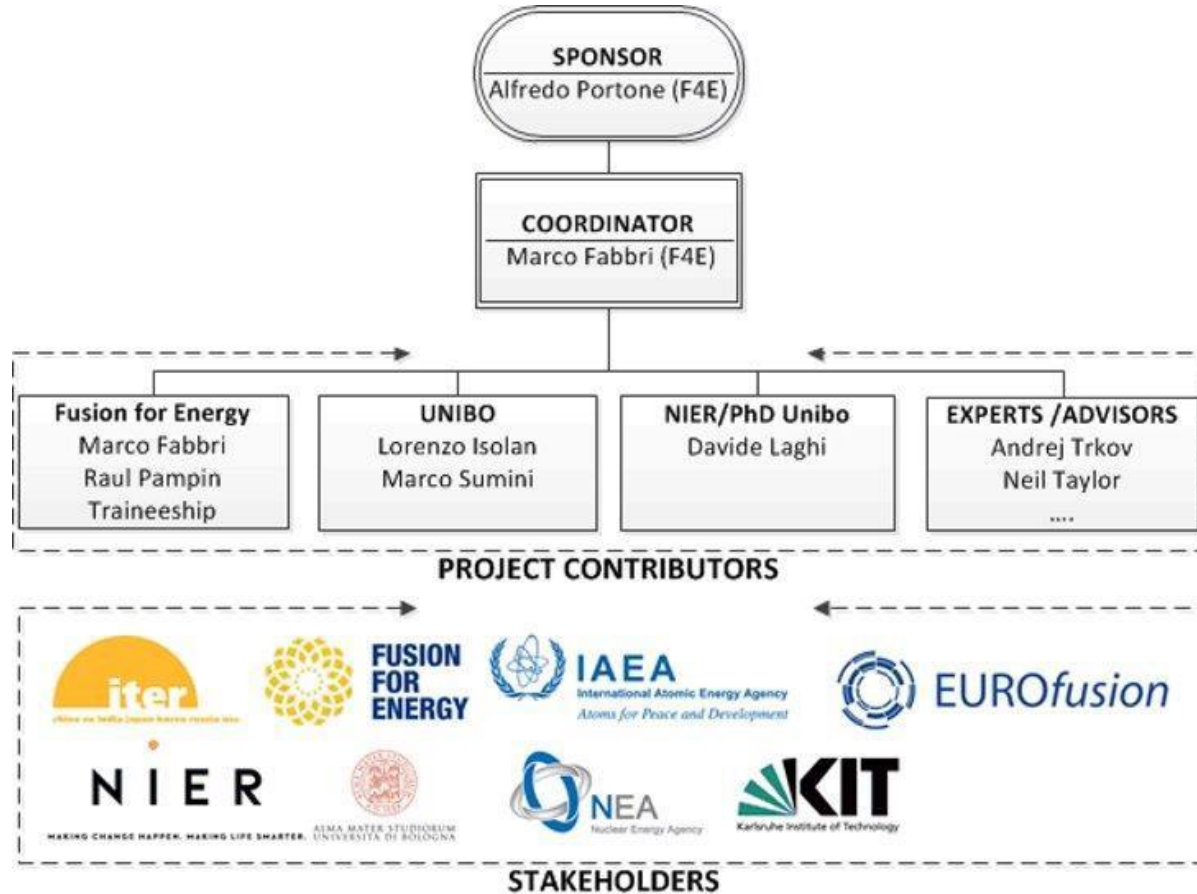
JADE is a python based software that aims to establish itself as a corner stone for a complete and extensive **automated and standardized V&V procedure** for nuclear data libraries, with a special focus towards fusion applications.



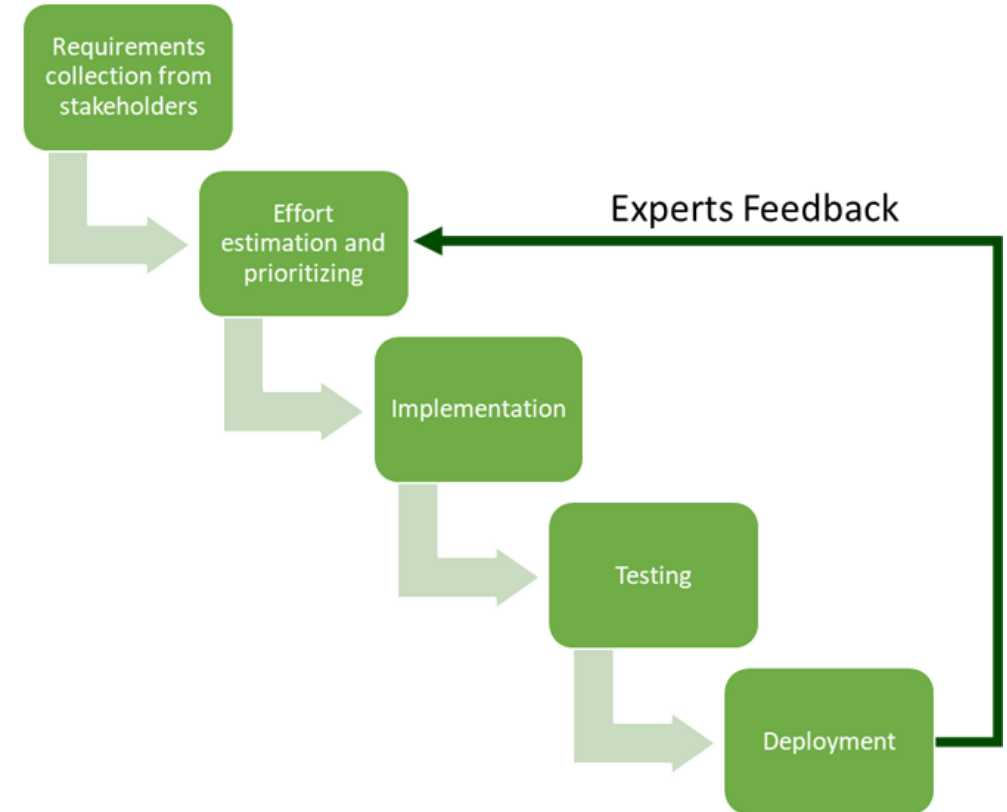
What is JADE?



The organization of the project



Waterfall approach

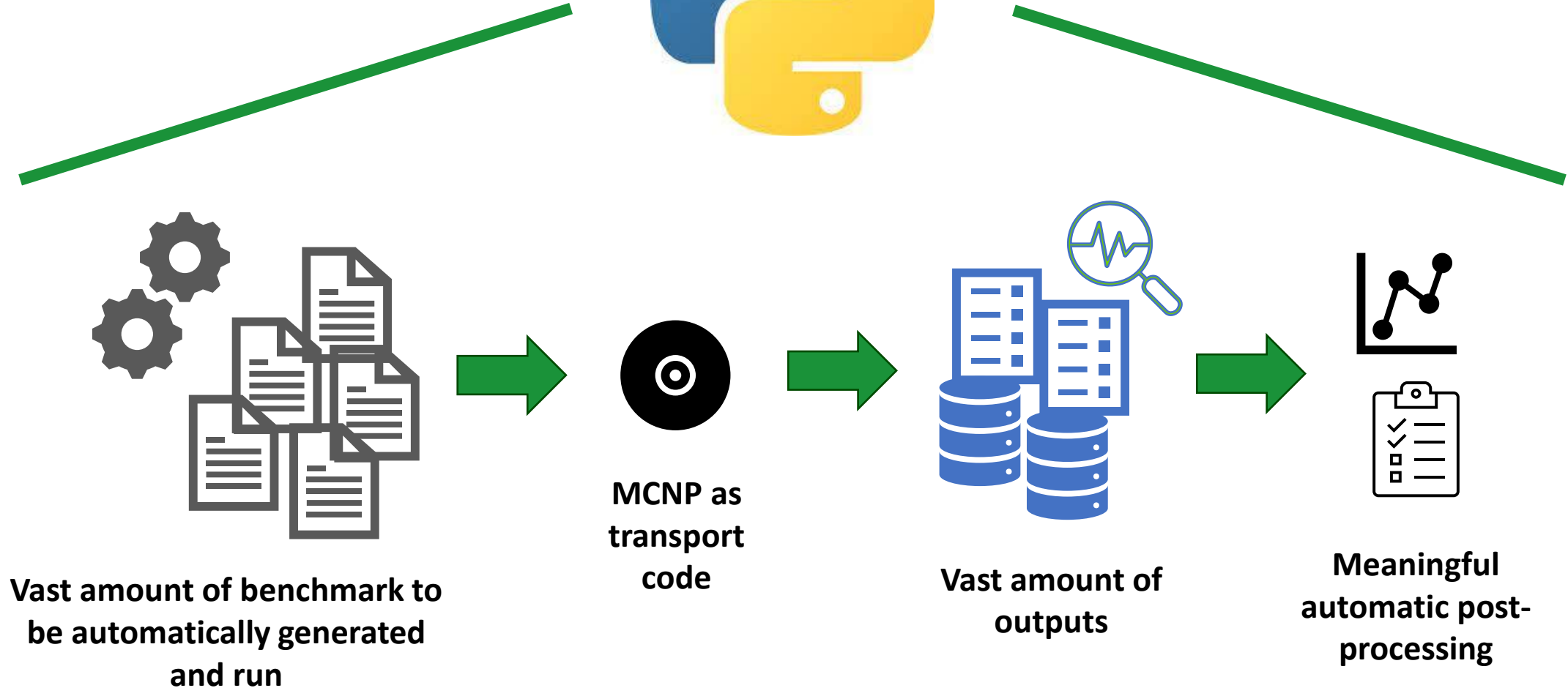
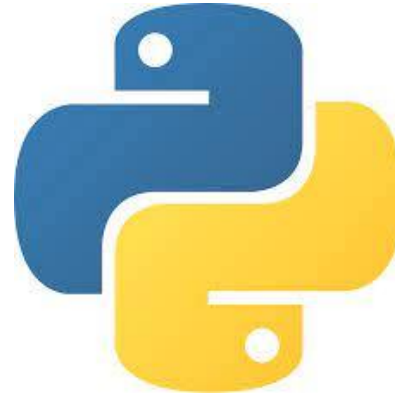


Implemented by means of a stage approach and > 1.5 ppy of total effort

What is JADE?



JADE needs



What is JADE?

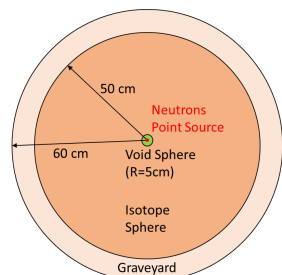


Benchmarks suite

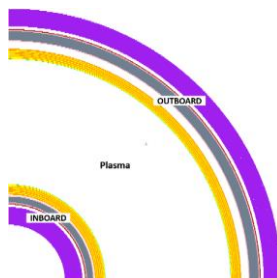
COMPUTATIONAL

TRANSPORT

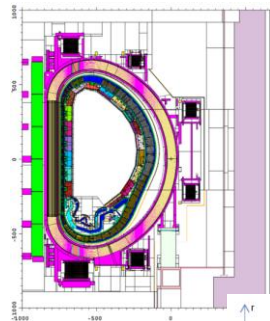
Sphere Leakage



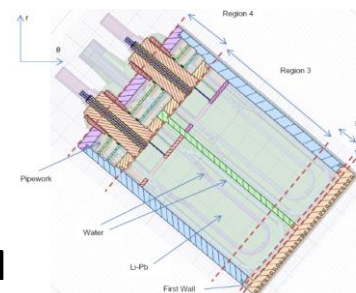
ITER 1D



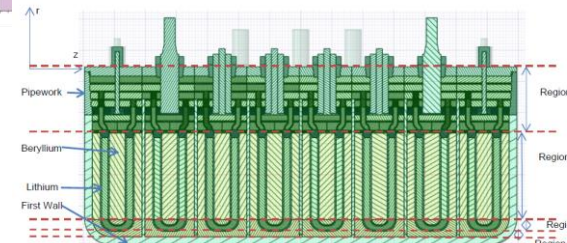
C-model



WCLL TBM

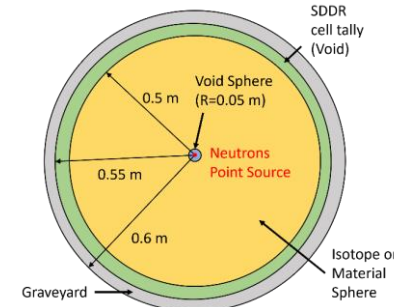


HCPB TBM

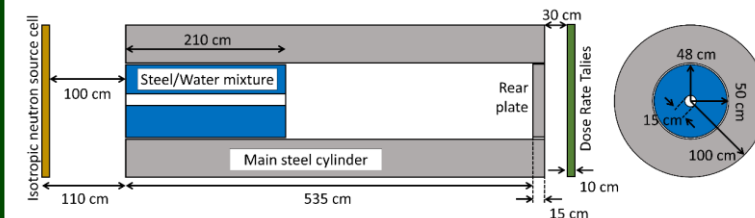


ACTIVATION

SPHERE SDDR

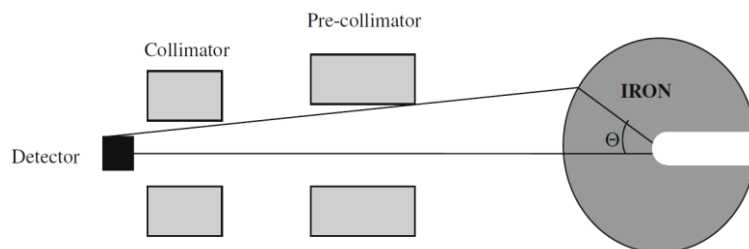


ITER CYL SDDR

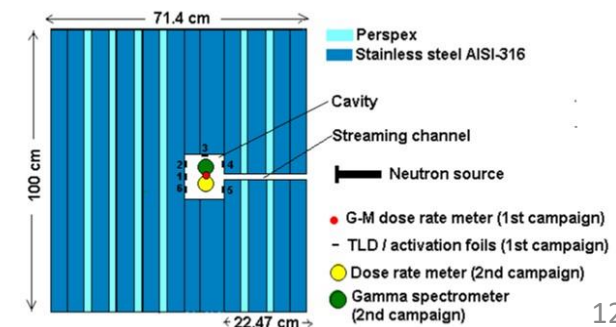


EXPERIMENTAL

OKTAVIAN

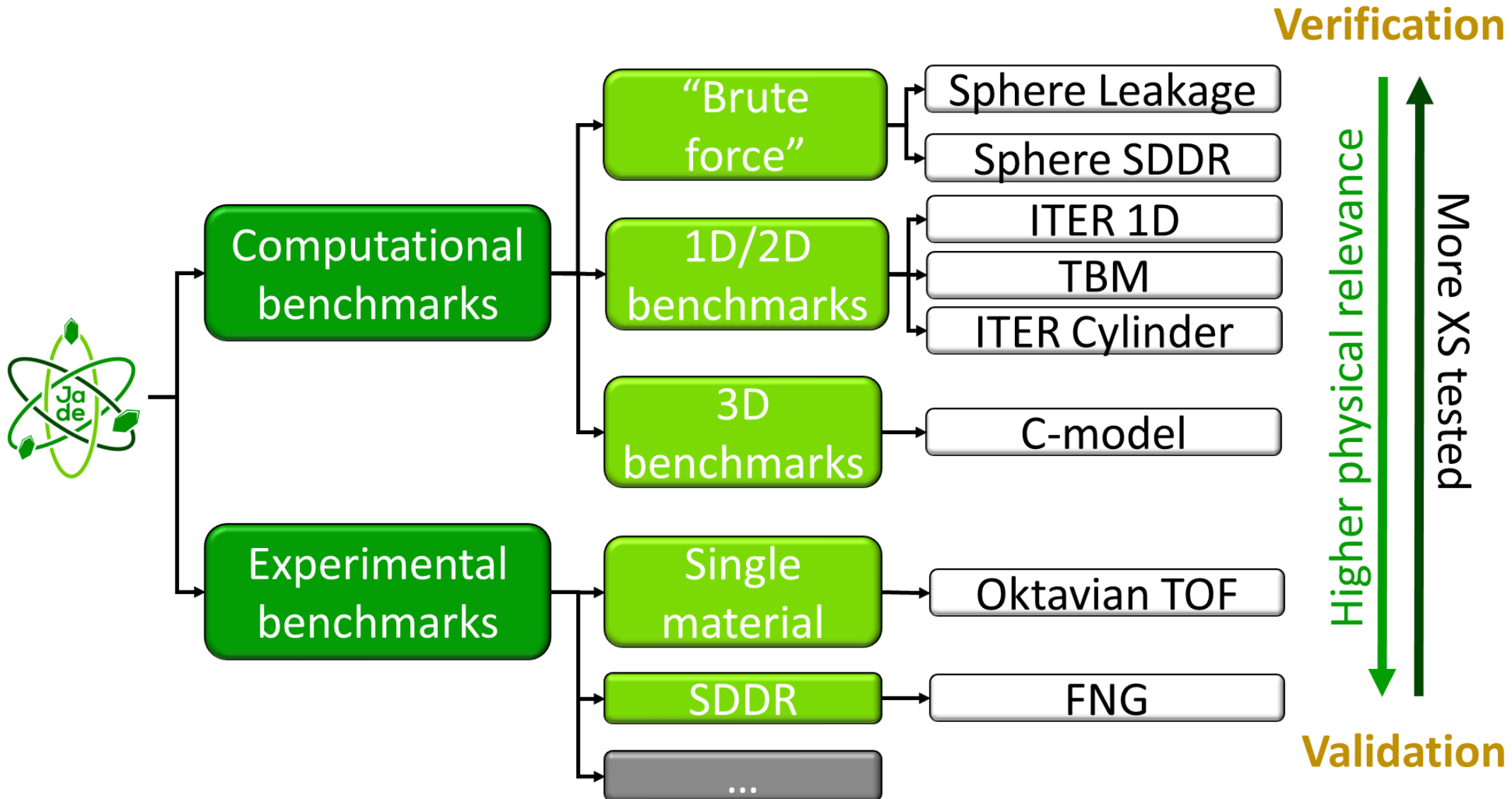


FNG SDDR



What is JADE

Benchmarks suite



The Sphere Leakage benchmark



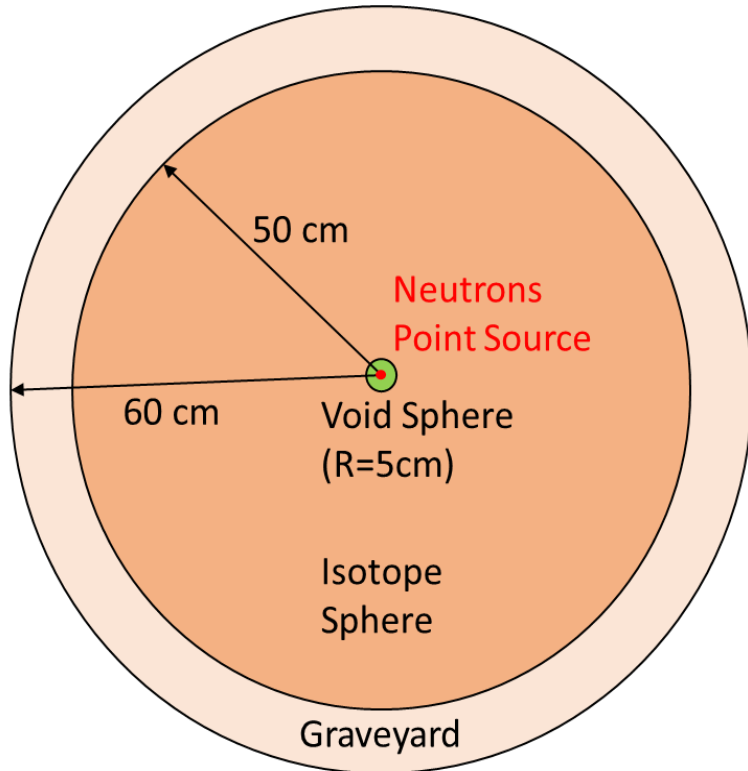
Benchmark description

A uniform 0-14 MeV neutron point source is inserted at the center of a sphere composed entirely by a single isotope or a typical ITER material.

All isotopes provided by the nuclear data library under assessment are singularly tested.

Tallied quantities:

- Neutron and photon leakage flux (energy binned);
- Neutron and photon heating inside the sphere;
- Tritium and Helium production inside the sphere;
- DPA.



The Sphere Leakage benchmark

Excel formatted tables



Salvataggio automatico Sphere_comparison_30c_Vs_31c.xlsx Davide Laghi

File Home Inserisci Layout di pagina Formule Dati Revisione Visualizza Guida

Calibri 11 Testo a capo Testo Normale Neutrale Valore non V... Valore valido Calcolo Cella collegata

Passed

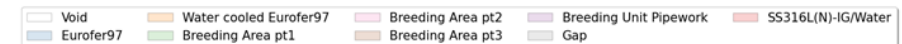
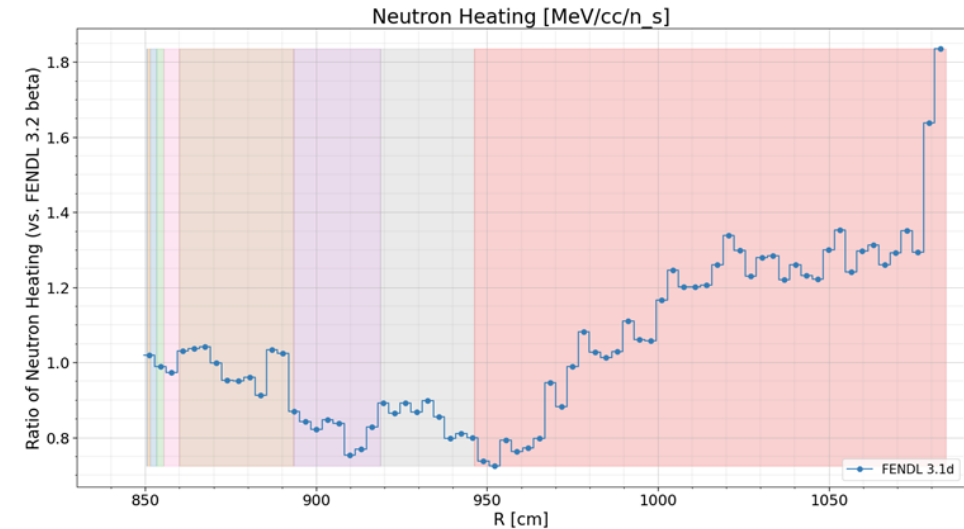
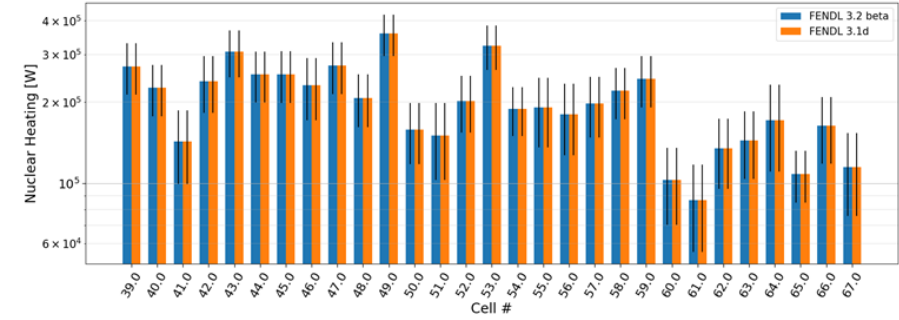
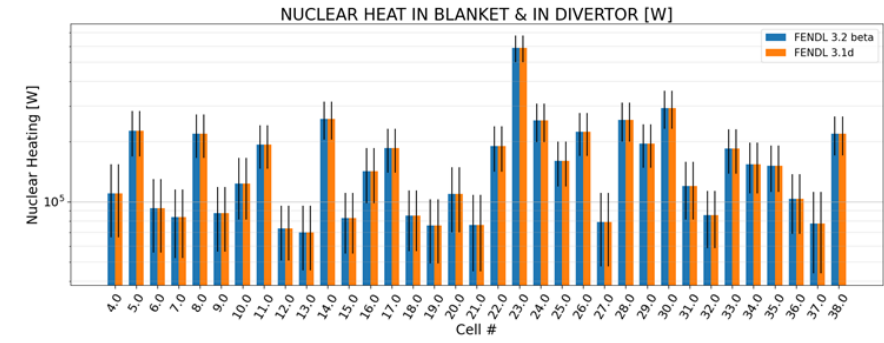
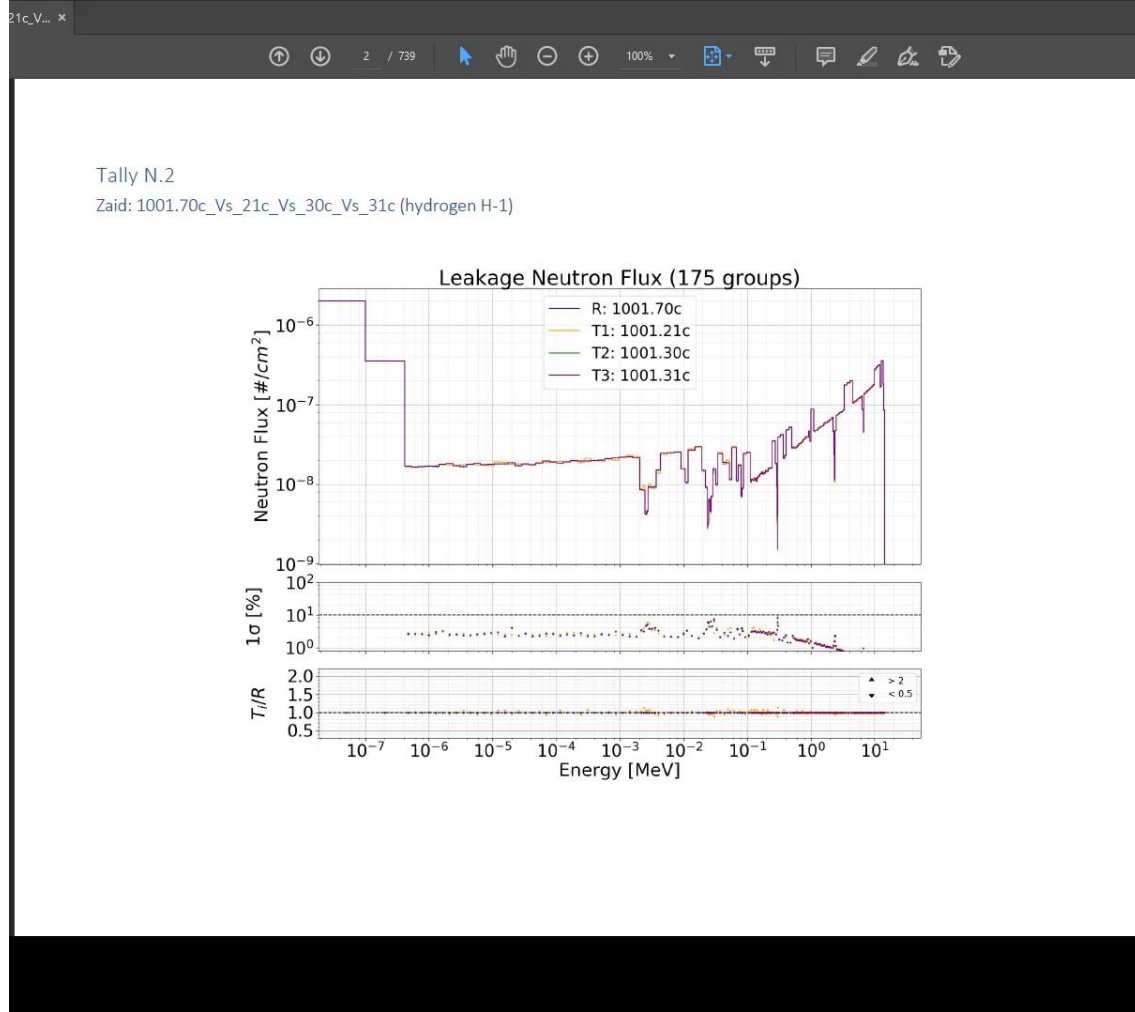
LIBRARY:		31c											
SPHERE LEAKAGE TEST RESULTS RECAP: STATISTICAL CHECKS													
ZAID		TALLY											
Zaid	Zaid Name	Neutron Flux at the external surface in Vitamin-J 175 energy groups [2]	Neutron heating with F4+FM multiplier [4]	Neutron heating F6 [6]	Neutron Flux at the external surface in course energy groups [12]	He ppm production [14]	T production [24]	DPA production [34]	Gamma flux at the external surface [22]	Gamma flux at the external surface [FINE@FISPACT MANUAL 24 Group Structure] [32]	Gamma heating with F4+FM multiplier [44]	Gamma heating F6 [46]	
1001	H-1	Passed	Passed	Passed	Passed	All zeros	All zeros	Passed	Missed	Missed	Passed	Passed	
1002	H-2	Missed	Passed	Passed	Missed	All zeros	Passed	Passed	Passed	Passed	Passed	Passed	
1003	H-3	Passed	Passed	Passed	Passed	All zeros	All zeros	Passed	All zeros	All zeros	All zeros	All zeros	
2003	He-3	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	
2004	He-4	Passed	Passed	Passed	Passed	All zeros	All zeros	Passed	All zeros	All zeros	All zeros	All zeros	
3006	Li-6	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	
3007	Li-7	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Missed	Missed	Missed	Missed	
4009	Be-9	Missed	Passed	Passed	Missed	Passed	Passed	Passed	Missed	Missed	Passed	Passed	
5010	B-10	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	
5011	B-11	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Missed	Missed	Passed	Passed	
6012	C-12	Passed	Passed	Passed	Passed	Passed	All zeros	Passed	Passed	Passed	Passed	Passed	
6013	C-13	Missed	Passed	Passed	Missed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	
7014	N-14	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	
7015	N-15	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	
8016	O-16	Passed	Passed	Passed	Passed	Passed	All zeros	Passed	Passed	Passed	Passed	Passed	
8017	O-17	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	
8018	O-18	Passed	Passed	Passed	Passed	Passed	All zeros	Passed	Passed	Passed	Passed	Passed	
9019	F-19	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Missed	Missed	Missed	Missed	
11023	Na-23	Passed	Passed	Passed	Passed	Passed	All zeros	Passed	Passed	Passed	Passed	Passed	
12024	Mg-24	Passed	Passed	Passed	Passed	Passed	All zeros	Missed	Passed	Passed	Passed	Passed	
12025	Mg-25	Passed	Passed	Passed	Passed	Passed	All zeros	Passed	Passed	Passed	Passed	Passed	
12026	Mg-26	Passed	Passed	Passed	Passed	Passed	All zeros	Passed	Missed	Missed	Passed	Passed	
13027	Al-27	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Missed	Missed	Passed	Passed	
14028	Si-28	Passed	Passed	Passed	Passed	Passed	All zeros	Passed	Passed	Passed	Passed	Passed	

Statistical Checks (2) Errors (2) Values (2) Statistical Checks Errors Values Comparison

Pronto Impostazioni di visualizzazione 85%

The Sphere Leakage benchmark

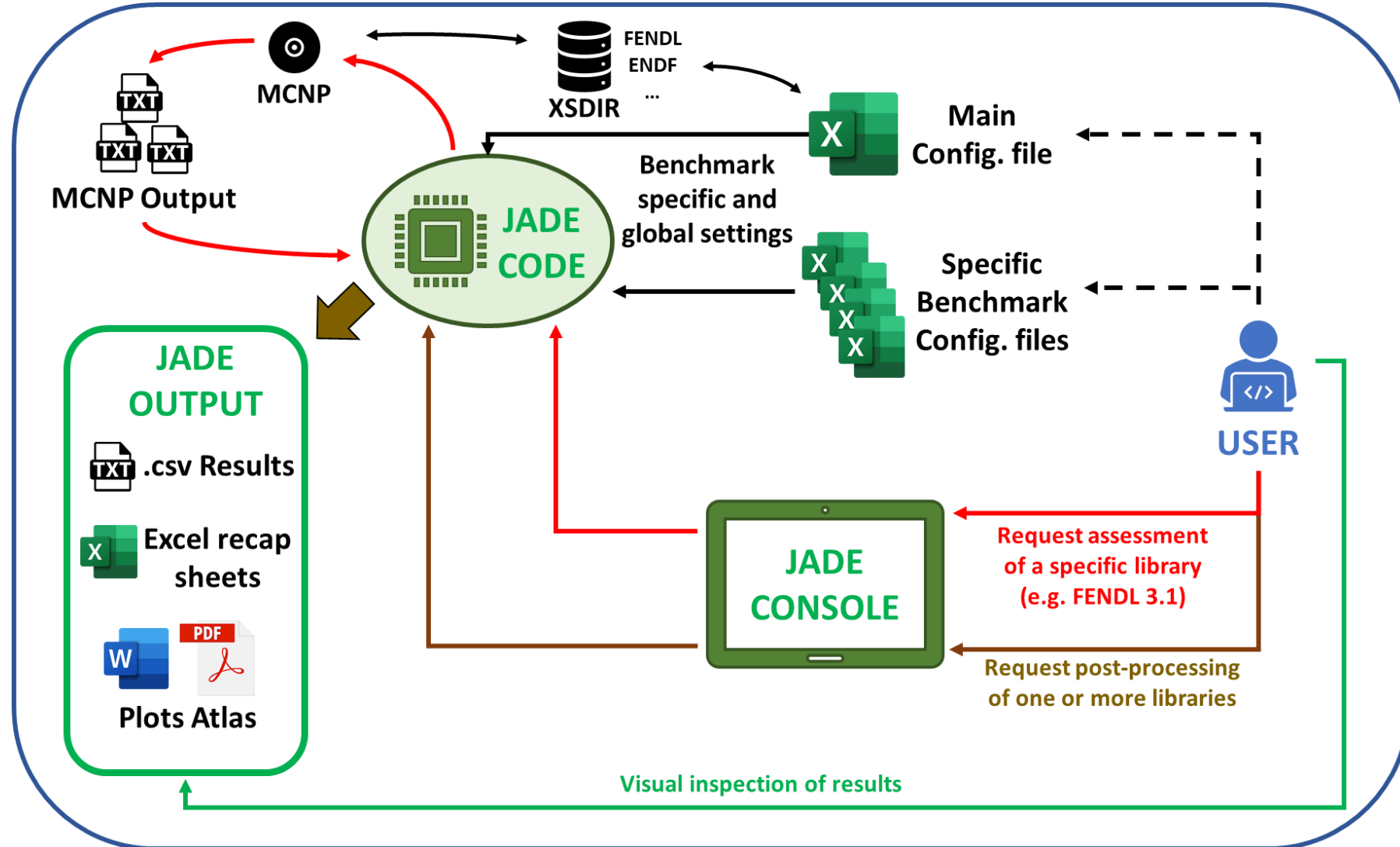
Plot atlas



JADE architecture and development



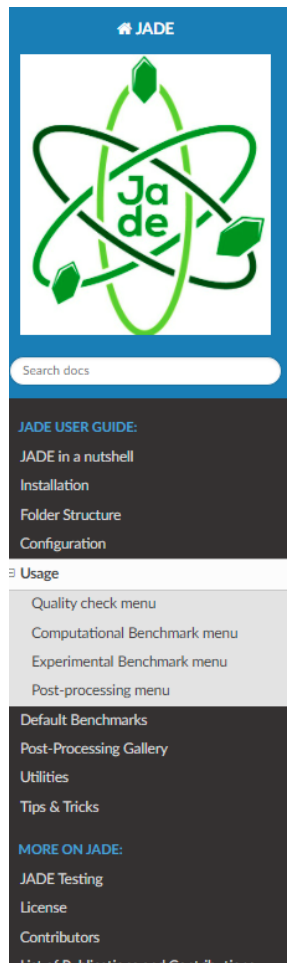
General scheme



JADE Architecture and development



Open source



```
Compare Libraries (compare)
* Compare Vs Experiments (compexp)
* Back to main menu (back)
* Exit (exit)

Enter action:
```

The following options are available in the post-processing menu:

- `printlib` print all libraries that were tested and that are available for post-processing;
- `pp` post-process a single library;
- `compare` compare different libraries results on computational benchmarks;
- `compexp` compare different libraries results on experimental benchmarks;
- `back` go back to the main menu;
- `exit` exit the application.

For the `pp`, `compare` and `compexp` the selection of the libraries will be directly prompt to video. The selection of the libraries is done indicating their correspondent suffix specified in the xsdir file (e.g. `31c`). When comparing more than one library, the suffixes should be separated by a '-' (e.g. `31c-32c`). The first library that is indicated is always considered as the *reference library* for the post-processing. There may be a limitation on the number of libraries that can be compared at once depending on the post-processing settings.

Only one library at the time can be post-processed with the `pp` option. Nevertheless, when a comparison is requested that includes libraries that were not singularly post-processed, an automatic `pp` operation is conducted on them.

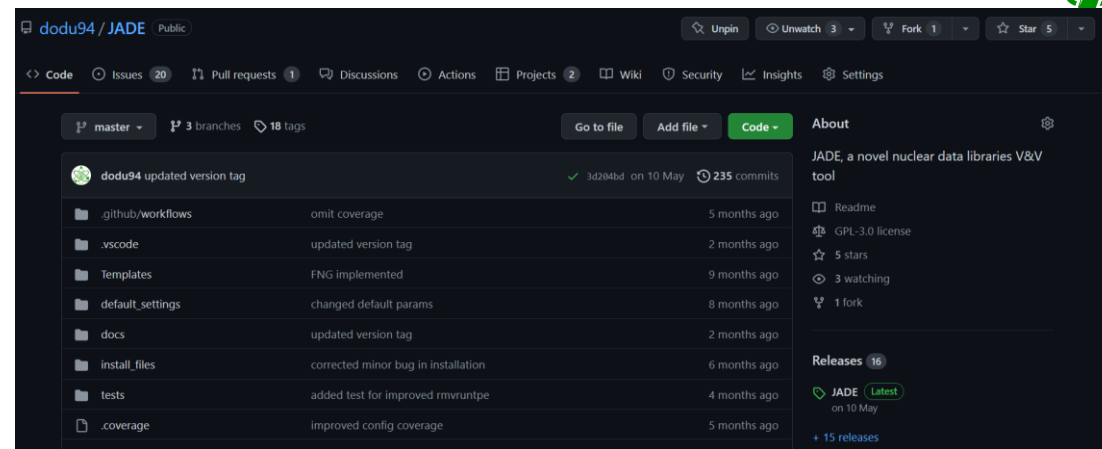
Warning

Please note that `printlib` will simply show all libraries for which at least one benchmark has been run.

Warning

Please note that part of the single post-processing of the libraries is used in the comparisons. Also, JADE does not perform any checks on the consistency between the two. This responsibility is left to the user. The following is an example of incorrect usage that can lead to erroneous results:

1. a first assessment is run;
2. single post-processing is completed;
3. some configuration settings are changed and the assessment is re-run;
4. a comparison is requested.

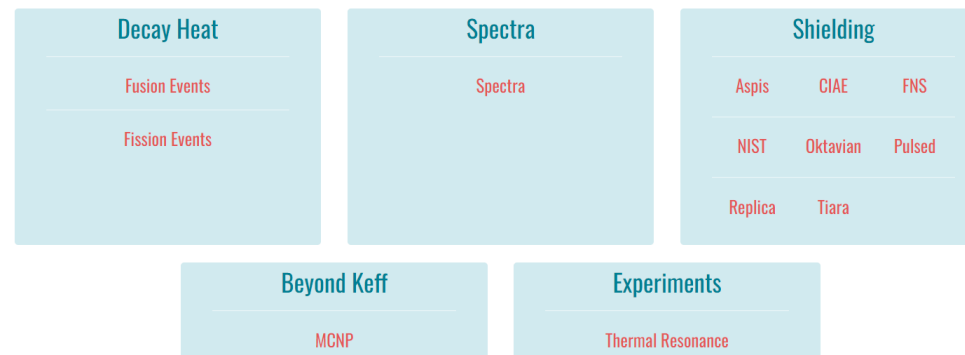


GitHub: <https://github.com/dodu94/JADE>



Compilation of Nuclear Data Experiments for Radiation Characterisation (CoNDERC)

The purpose of the CoNDERC project is to transfer into technology the experimental integral radiation information that can be used as part of the Validation and Verification processes of nuclear model and code systems, and to provide various schema to perform the V&V. Under the auspices of the IAEA Nuclear Data Section, individuals and institutions are assembling several of databases and code infrastructures based on their own V&V activities mainly associated with inventory, activation-transmutation, source term and radiation shielding R&D.



CoNDERC: <https://nds.iaea.org/conderc/>

ReadTheDocs: <https://jade-a-nuclear-data-libraries-vv-tool.readthedocs.io/en/latest/>



Automatic testing with pytest and coverage

```
(base) C:\Users\d.laghi\Documents\GitHub\JADE\Code\tests>pytest
===== test session starts =====
platform win32 -- Python 3.8.5, pytest-6.1.1, py-1.9.0, pluggy-0.13.1
rootdir: C:\Users\d.laghi\Documents\GitHub\JADE\Code\tests
collected 29 items

inputfile_test.py ... [ 10%]
libmanager_test.py ..... [ 24%]
matreader_test.py ..... [ 44%]
output_test.py . [ 48%]
parsersD1S_test.py ..... [ 93%]
sphereoutput_test.py .. [100%]

===== warnings summary =====
..\..\..\..\Anaconda3\lib\site-packages\pyreadline\py3k_compat.py:8
C:\Users\d.laghi\Anaconda3\lib\site-packages\pyreadline\py3k_compat.py:8: DeprecationWarning: Using or importing the ABCs from 'collections' instead of from 'collections.abc' is deprecated since Python 3.3, and in 3.9 it will stop working
    return isinstance(x, collections.Callable)

..\..\..\..\Anaconda3\lib\site-packages\win32\lib\pywintypes.py:2
C:\Users\d.laghi\Anaconda3\lib\site-packages\win32\lib\pywintypes.py:2: DeprecationWarning: the imp module is deprecated in favour of importlib; see the module's documentation for alternative uses
    import imp, sys, os

..\..\..\..\Anaconda3\lib\site-packages\docx\section.py:7
C:\Users\d.laghi\Anaconda3\lib\site-packages\docx\section.py:7: DeprecationWarning: Using or importing the ABCs from 'collections' instead of from 'collections.abc' is deprecated since Python 3.3, and in 3.9 it will stop working
    from collections import Sequence

..\..\..\..\Anaconda3\lib\site-packages\xlrd\xlsx.py:266
..\..\..\..\Anaconda3\lib\site-packages\xlrd\xlsx.py:266
C:\Users\d.laghi\Anaconda3\lib\site-packages\xlrd\xlsx.py:266: DeprecationWarning: This method will be removed in future versions. Use 'tree.iter()' or 'list(tree.iter_r())' instead.
    for elem in self.tree.iter() if Element_has_iter else self.tree.getiterator():

..\..\..\..\Anaconda3\lib\site-packages\xlrd\xlsx.py:312
C:\Users\d.laghi\Anaconda3\lib\site-packages\xlrd\xlsx.py:312: DeprecationWarning: This method will be removed in future versions. Use 'tree.iter()' or 'list(tree.iter_r())' instead.
    for elem in self.tree.iter() if Element_has_iter else self.tree.getiterator():

matreader_test.py::TestMatCardList::test_translation
..\libmanager.py:162: UserWarning: The Deafult library 81c was used for zaid 1001
    warnings.warn(MSG_DEFLIB.format(self.defaultlib, zaid))

-- Docs: https://docs.pytest.org/en/stable/warnings.html
===== 29 passed, 7 warnings in 2.83s =====
```

- Help the stability of the code
- Increase trust on JADE results
- Sets a minimum quality standard for future contributors to the code
- Speed up introduction of new features (faster verification)

JADE architecture and development



Continuous Integration (CI)

GitHub Actions workflow for JADE. The workflow 'Update .gitattributes build #29' is shown as successful. The job 'build' is expanded to show steps:

- Set up job
- Run actions/checkout@v2
- Set up Python
- Install dependencies
- Testing
- Post Set up Python
- Post Run actions/checkout@v2
- Complete job

ReadTheDocs website for JADE. The page title is "JADE, a nuclear data libraries V&V tool". It features navigation buttons for "Panoramica", "Download", "Cerca", "Compilazioni", "Versioni", and "Amministrazione". Below, the "Compilazioni Recenti" section shows a list of recent builds for the "latest" version, with timestamps ranging from 1 day to 3 weeks ago.

Versione di Compilazione:	latest
Passato versione latest (html)	2 settimane, 1 giorno fa
Passato versione latest (html)	2 settimane, 1 giorno fa
Passato versione latest (html)	3 settimane, 1 giorno fa
Passato versione latest (html)	3 settimane, 1 giorno fa
Passato versione latest (html)	3 settimane, 1 giorno fa
Passato versione latest (html)	3 settimane, 1 giorno fa

At each push on the main JADE branch:

- JADE is installed in a cloud Windows environment and the automatic testing is run (handled by GitHub)
- The documentation is rebuilt by ReadTheDocs and adjourned



12k

Lines of code



9

**Implemented
benchmarks**



2

**Published
papers**

D. Laghi et al, 2020, “JADE, a new software tool for nuclear fusion data libraries Verification & Validation”, *Fusion Engineering and Design*, **161** 112075. DOI: <https://doi.org/10.1016/j.fusengdes.2020.112075>

D. Laghi et al, “Application of JADE V&V capabilities to the new FENDL v3.2 Beta release”, *Nuclear Fusion*, **61** 11. DOI: <http://iopscience.iop.org/article/10.1088/1741-4326/ac121a>



>10⁶

**CPU simulation
hours worth of data
that has been post-
processed**

Looking
ahead

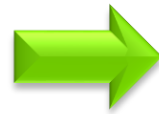
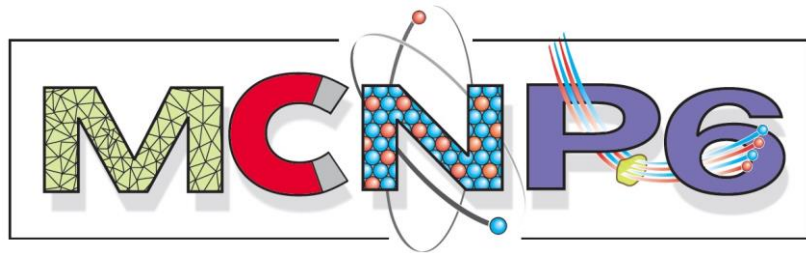
Next foreseeable steps



Expansion of the benchmarks suite



CoNDERC & SINBAD



Machine learning: a possible mid-term future



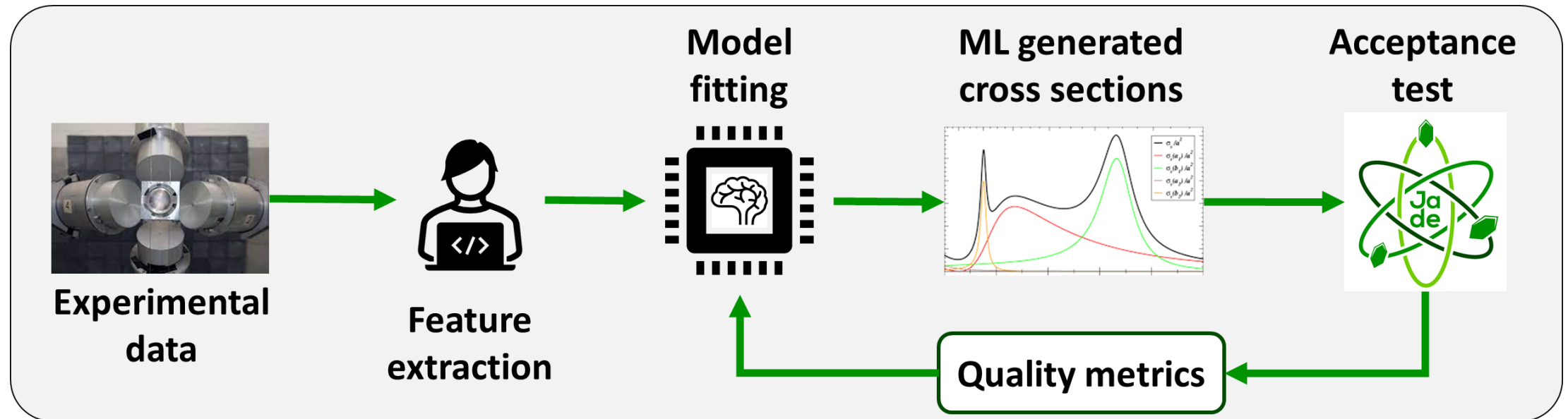
Monte Carlo codes like OpenMC are currently porting their code to GPU solvers



Simulation time could decrease by a few order of magnitudes!



Leveraging the open source automation of benchmarks running and definition of acceptance test, ML algorithm could be introduced to support the libraries evaluation process



An example of application is **NucML**¹: <https://pedrojrv.github.io/nucml/index.html>

¹Pedro Jr. Vicente-Valdez, Massimiliano Fratoni (UC Berkely, USA)

What it will be great to have



- A comprehensive, unified, user-friendly, open-source, ready to be used database of experiment (e.g., Conderc+SINBAD GitHub).
- A platform to provide feedback and record exchanges (e.g., GitHub).
- A collection of computational benchmark to use (e.g., 1D ITER).
- A standardized way to share and collect the different executed benchmarks in a common database (e.g., CONDERC) trying to avoid duplication.
- A closer collaboration with the different parties with periodic exchange (i.e., CCFE).
- Guidelines for the V&V of (fusion) libraries with clear acceptance criteria (e.g., C/E TBR : [0.95, 1.05]).



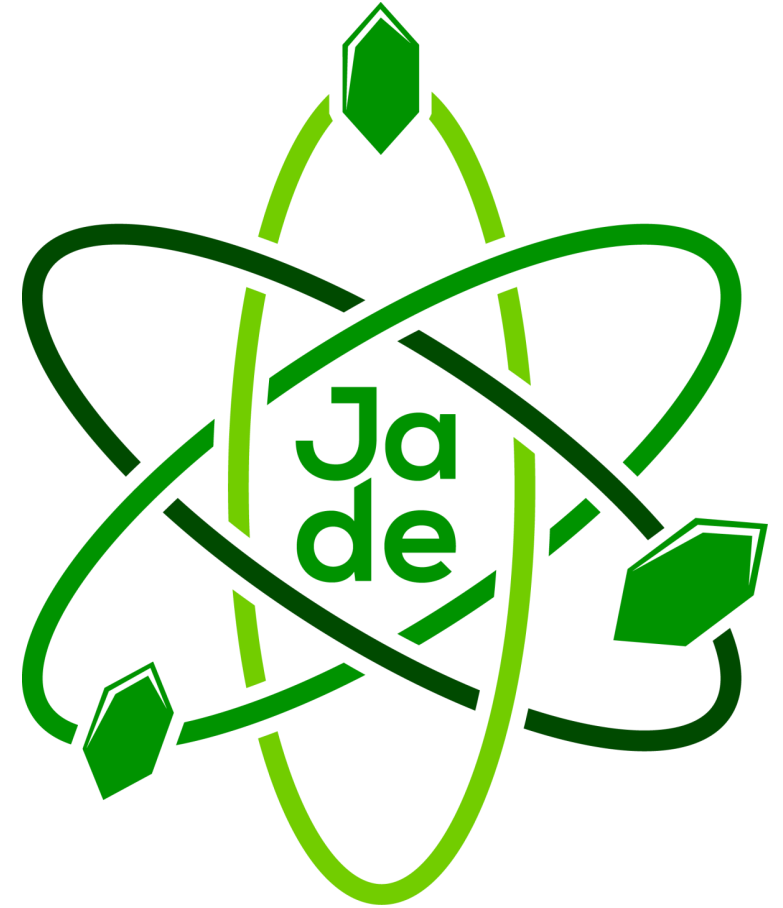
- JADE improves the standardization and the automation level in the field of nuclear data V&V (especially regarding fusion application).
- JADE is a consolidated open-source tool built for the community by the community. If you are interested on collaborating do not hesitate to contact us. Let's join forces.
- V&V on many libraries has been already performed by JADE(i.e., FENDL3.1d, FENDL3.2, JEFF-3.3., JEFF-4.0T1). Few inconsistencies and discrepancies were spotted and reported. More work is planned.
- We sincerely appreciate the effort put in place by NEA, IAEA, SINBAD to modernize the experimental database and the collaboration with the different parties to continue the development of JADE.

GitHub: <https://github.com/dodu94/JADE>

READ THE DOCS: <https://readthedocs.org/>

Any Questions?

Thank you for your kind attention!



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MAKING CHANGE HAPPEN. MAKING LIFE SMARTER.



DIPARTIMENTO DI INGEGNERIA INDUSTRIALE



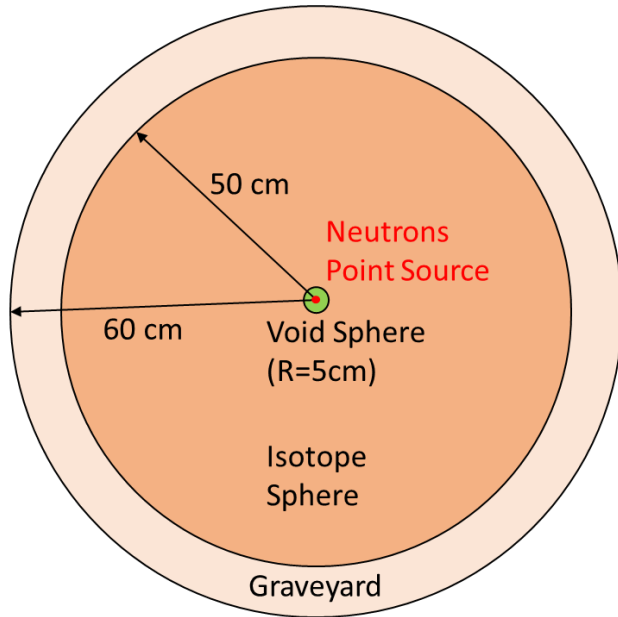
**FUSION
FOR
ENERGY**

Backup
slides

JADE application to production cases



Proof of concept



Tested libraries:

- FENDL v2.1
- FENDL v3.0
- FENDL v3.1d
- ENDF VII.1

LIBRARY:		31c								
SPHERE LEAKAGE TEST RESULTS RECAP: VALUES										
ZAID		TALLY								
Zaid	Zaid Name	Neutron Flux at the external surface in Vitamin-175 energy groups	He ppm production	T production	DPA production	Gamma flux at the external surface [FINE@FISPACT MANUAL 24 Group Structure]	Neutron Heating comparison [F4 vs F6]	Gamma Heating comparison [F4 vs F6]	Notes	
41093	Nb-93	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
42092	Mo-92	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	69.37%	0.00%		
42094	Mo-94	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	326.48%	0.00%		
42095	Mo-95	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	270.14%	0.00%		
42096	Mo-96	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	399.40%	0.00%		
42097	Mo-97	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	228.12%	0.00%		
42098	Mo-98	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	206.98%	0.00%		
42100	Mo-100	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	389.98%	0.00%		
45103	Rh-103	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	145.85%	0.00%		
47107	Ag-107	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
47109	Ag-109	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
48106	Cd-106	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
48108	Cd-108	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	355.40%	0.00%		
48110	Cd-110	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	323.99%	0.00%		
48111	Cd-111	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
48112	Cd-112	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	261.28%	0.00%		
48113	Cd-113	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	182.22%	0.00%		
48114	Cd-114	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	255.50%	0.00%		
48116	Cd-116	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value = 0 for all bins	215.38%	0.00%		
50112	Sn-112	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
50114	Sn-114	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
50115	Sn-115	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		
50116	Sn-116	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	Value > 0 for all bins	0.00%	0.00%		

LEGEND	
	> 5 %
	1 % ≤ 5 %
	0.5 % ≤ 1 %
	< 0.5 %

Known errors in the FENDL v3.1d were re-spotted by JADE consistency checks

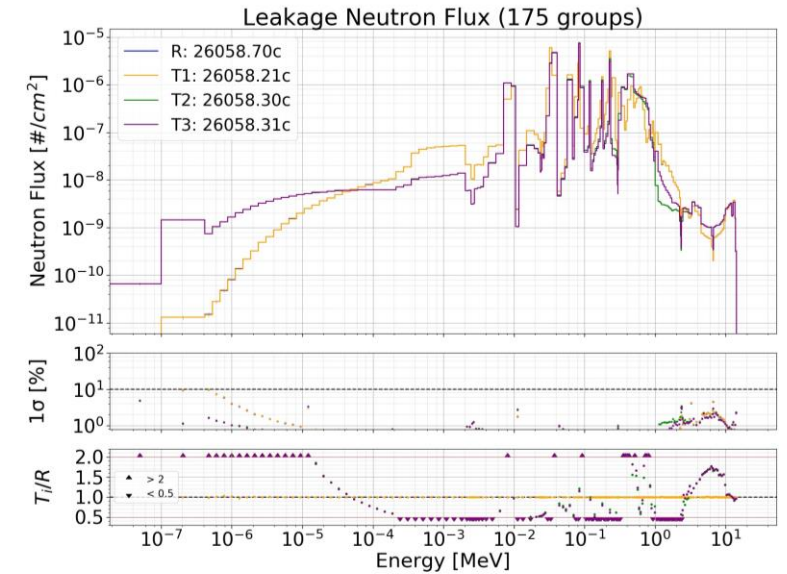
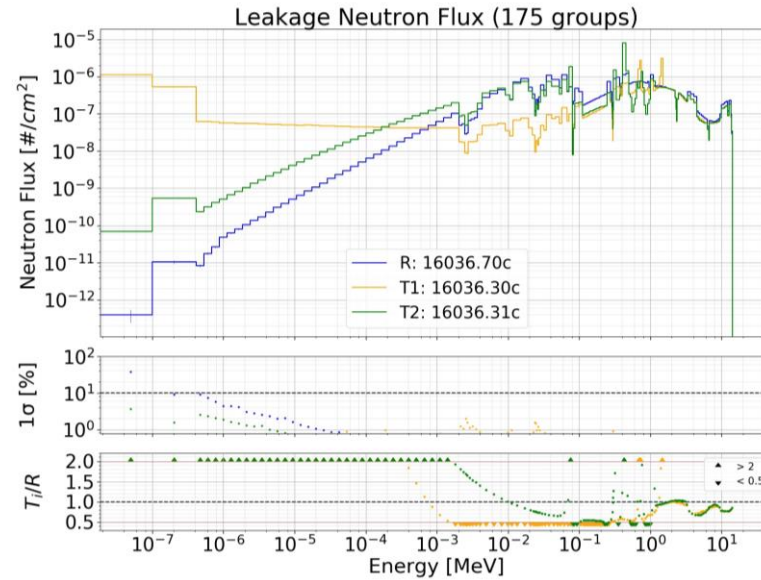
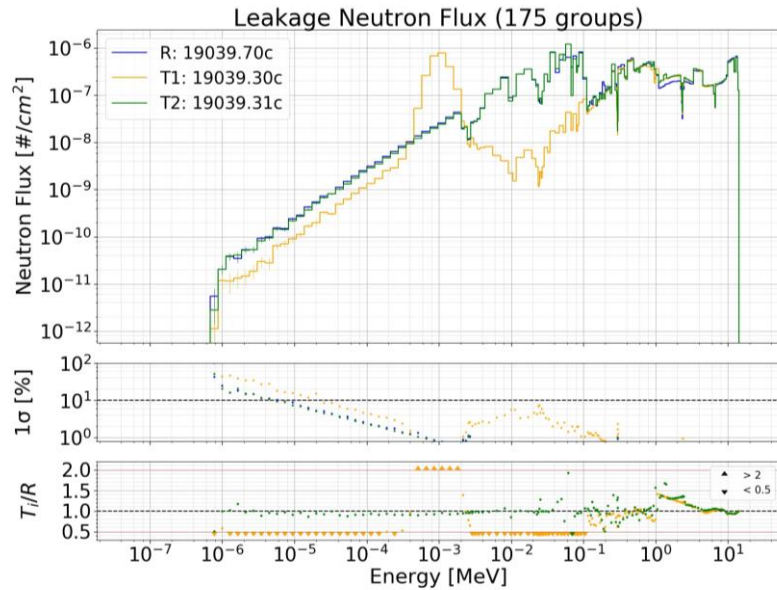
Paper:

D. Laghi, M. Fabbri, L. Isolan, R. Pampin, M. Sumini, A. Portone and A. Trkov, 2020, "JADE, a new software tool for nuclear fusion data libraries Verification & Validation", *Fusion Engineering and Design*, **161** 112075. DOI: <https://doi.org/10.1016/j.fusengdes.2020.112075>

JADE application to production cases



Proof of concept



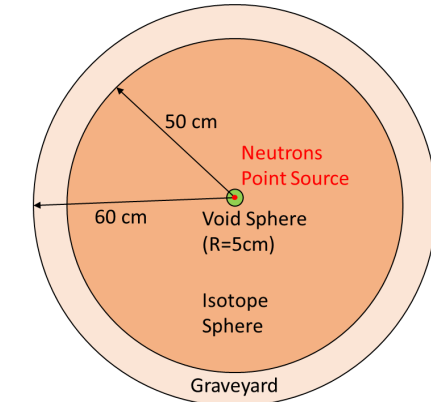
Some examples where the leakage neutron flux results differed significantly among the tested libraries.



FENDL v3.2 release (BETA)

SPHERE LEAKAGE COMPARISON RECAP

ZAID		TALLIES				
		T production	He ppm production	DPA production	Neutron heating F6	Gamma heating F6
M901	Polyethylene, Non-borated		-0.01%	0.01%	0.02%	0.02%
M900	Natural silicon		0.00%	0.00%	0.00%	0.00%
M101	SS316L(N)-IG	0.57%	4.18%	79.12%	98.41%	2.38%
M203	Boron carbide (B4C)	9.68%	0.79%	100.00%	100.00%	-0.01%
M200	Ordinary concrete	1.52%	10.47%	87.15%	97.53%	-8.15%
M400	Water	0.57%	16.37%	-2.82%	6.00%	-3.24%



Important differences in key neutron related quantities were spotted for typical ITER materials when comparing the old and new release of FENDL libraries

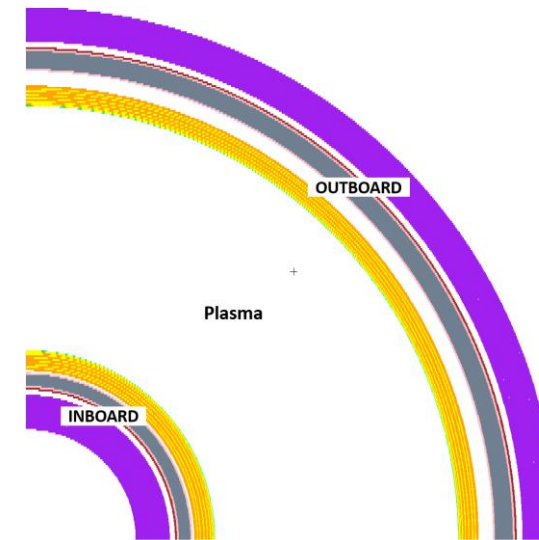
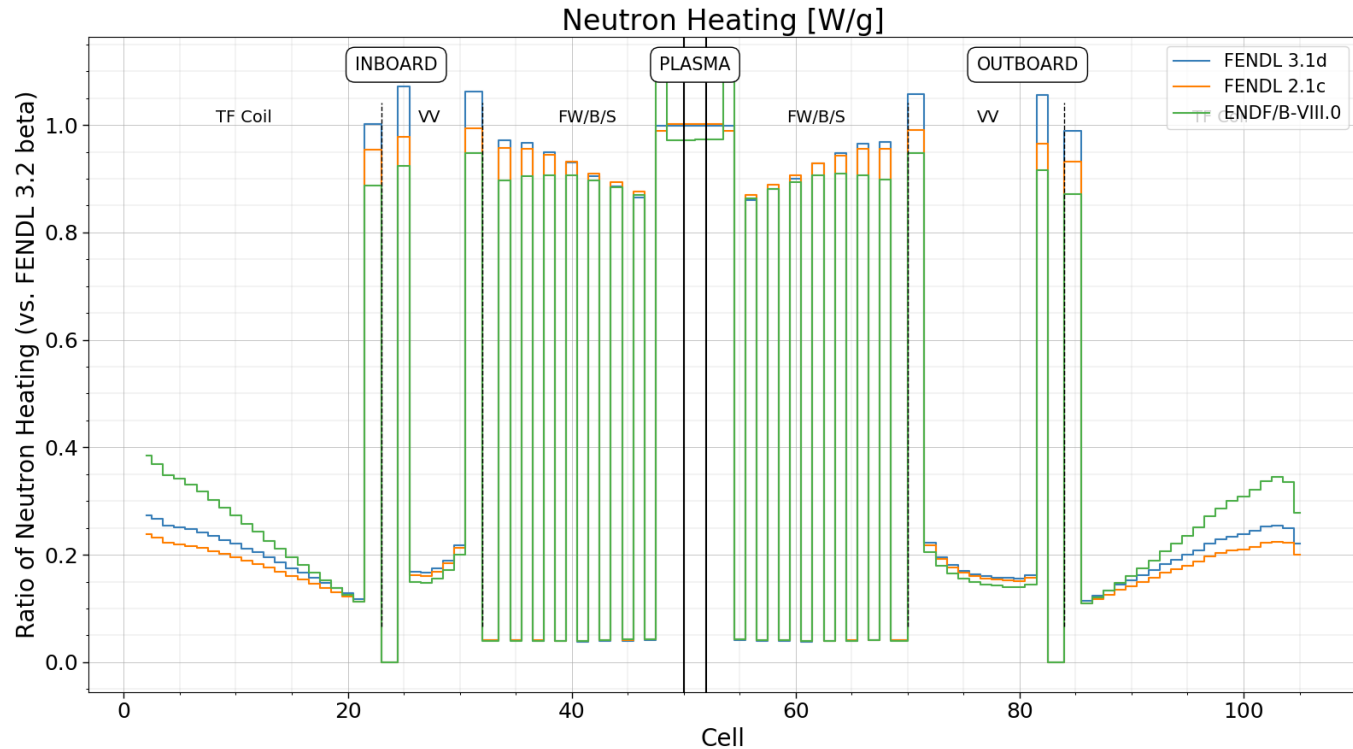
Paper:

D. Laghi, M. Fabbri, L. Isolan, M. Sumini, G. Schnabel and A. Trkov, 2021, "Application of JADE V&V capabilities to the new FENDL v3.2 Beta release", *Nuclear Fusion*, **61** 11. DOI: <http://iopscience.iop.org/article/10.1088/1741-4326/ac121a>

JADE application to production cases



FENDL v3.2 release (BETA)

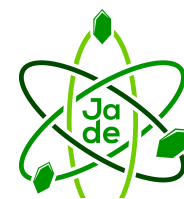


Effect of the higher neutron heating in the steel layers of the ITER 1D model

SPHERE LEAKAGE COMPARISON RECAP						
ZAID		TALLIES				
		T production	He ppm production	DPA production	Neutron heating F6	Gamma heating F6
5010	B-10	5.17%	0.49%	100.00%	100.00%	-0.50%

B-10 accounts only for 0.00036 % (in mass) of SS316L(N)-IG and at the same time SS316L(N)-IG is composed by 45 different isotopes. Without systematic and automated testing it would have been more difficult to track the origin of the issue.

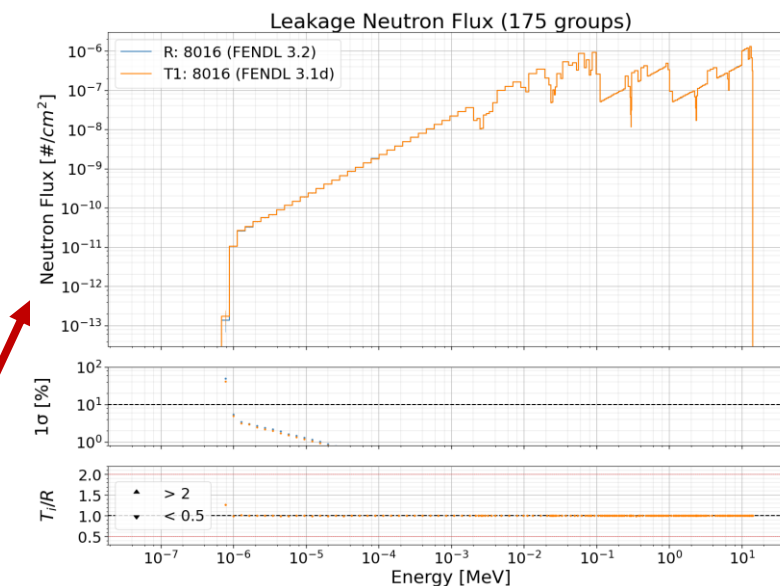
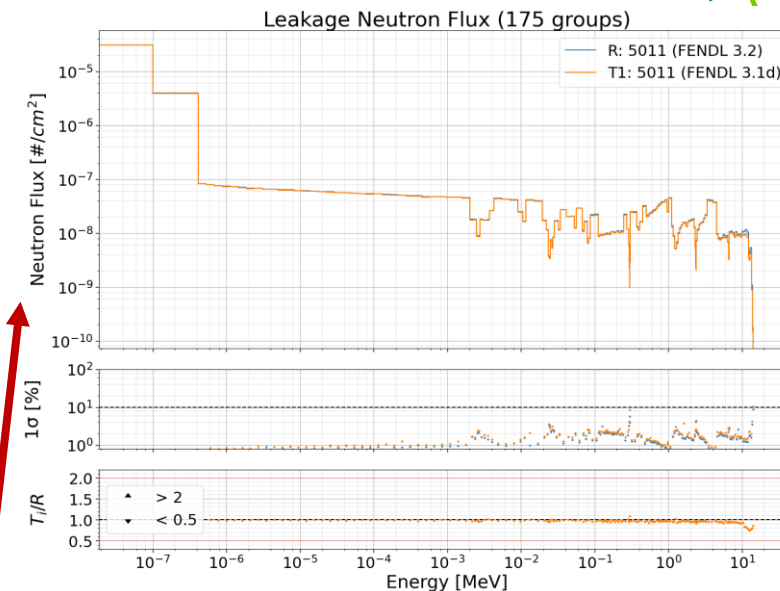
JADE application to production cases



FENDL v3.2 official release

ZAID		TALLIES				
Zaid N.	Symbol	T production	He ppm production	DPA production	Neutron heating F6	Gamma heating F6
M101	SS316L(N)-IG	8.59%	0.57%	0.15%	-8.67%	3.92%
M200	Ordinary Concrete	-0.27%	3.09%	-0.42%	10.15%	-2.53%
M203	Boron Carbide	13.13%	0.80%	-0.09%	-1.28%	0.95%
M400	Water	1.10%	16.19%	-1.86%	6.52%	-2.35%
M900	Natural Silicon		0.00%	0.00%	0.00%	0.00%
M901	Polyethylene, non-borated		0.00%	0.01%	0.02%	0.01%

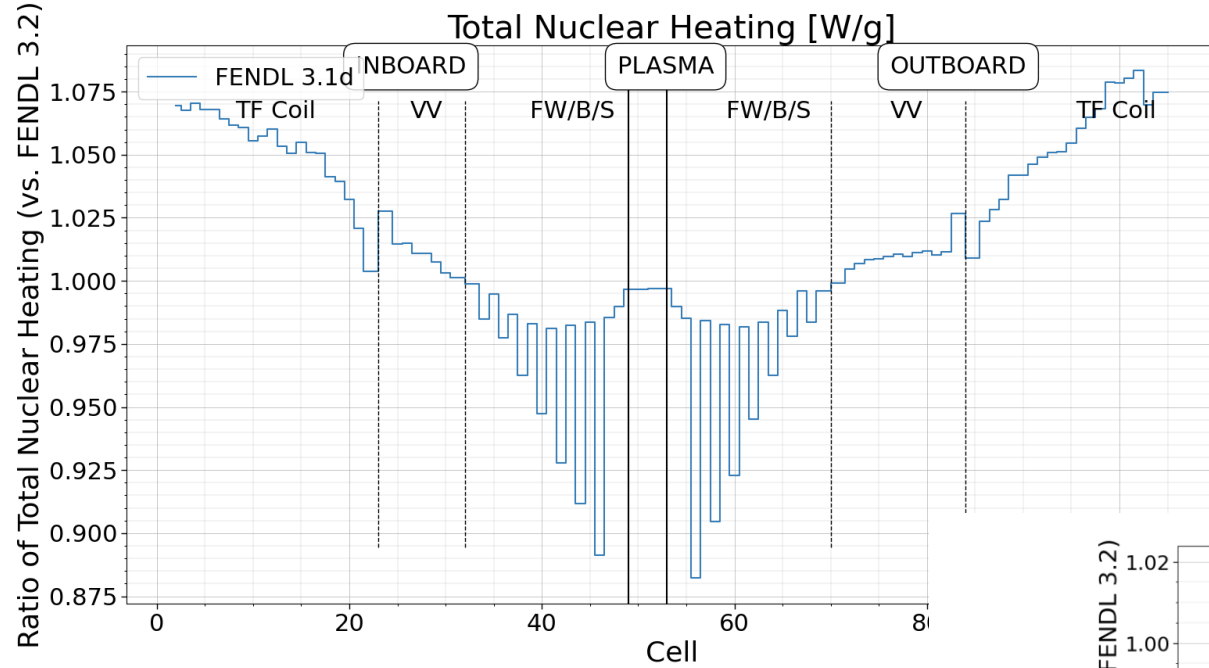
ZAID		TALLIES				
Zaid N.	Symbol	T production	He ppm production	DPA production	Neutron heating F6	Gamma heating F6
3007	Li-7	-0.01%	-0.01%	0.00%	-0.01%	-0.01%
4009	Be-9	0.04%	0.04%	0.02%	0.03%	-0.03%
5010	B-10	5.17%	0.49%	-2.55%	-6.53%	-0.50%
5011	B-11	39.56%	16.60%	0.24%	0.60%	1.46%
6012	C-12		-0.09%	0.04%	0.01%	-0.04%
6013	C-13	0.03%	-0.04%	0.02%	0.01%	-0.04%
7014	N-14	0.00%	0.00%	0.00%	0.00%	-0.01%
7015	N-15	0.00%	0.00%	0.00%	Identical	-0.01%
8016	O-16		17.63%	-3.09%	32.79%	-20.20%
8017	O-17	0.00%	0.00%	Identical	0.00%	-0.05%
8018	O-18		-91.74%	-35.81%	-12.19%	-47.58%



JADE application to production cases



FENDL v3.2 official release (Water/O-16)



Difference in neutron heating are clearly visible in water both in ITER1D and HCPB TBM benchmarks.

IAEA nuclear data section is considering for the O-16 cross section to either to:

- Switch to ENDFVIII.0 evaluation;
- Correct NJOY processing routine for KERMA data

