Evaluation on light-nuclei for JENDL-5

- from R-matrix works with AMUR -

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Nuclear data center

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Overview of light-nuclei in JENDL-5

JENDL-5 was released in December 2021

https://wwwndc.jaea.go.jp/index.html

Japanese Evaluated Nuclear Data Library

➢ Status of neutron data on light nuclei

- H-1 from ENDF/B-VIII.0
- AMUR resonance analysis
  - C-12, C-13, N-15, O-16, F-19, Na-23
- New data
  - H-3 (ENDF/B-VIII.0)
  - New evaluation including stable and unstable nuclei:
    - Be-7, 10, C-11, 12, 13, 14, O-17,18, Ne-20-22, Na-22,24, Mg-28, Al-26, Si-31,32
  - Elemental data (Carbon) are separated to isotopic data (C-12, 13)

Current status of AMUR

😢 Unfortunately, no fundamental progresses since 2018 …

1. **R-matrix (Wigner & Eisenbud + Reich-Moore)**
2. **Kalman filtering method for parameter search, estimation of Cov.**
3. **Simulation of experimental condition (resolution, temperature, …)**
4. Object oriented framework (C++/ROOT), with multi-threads
5. Interface to EXFOR (C4/C5)

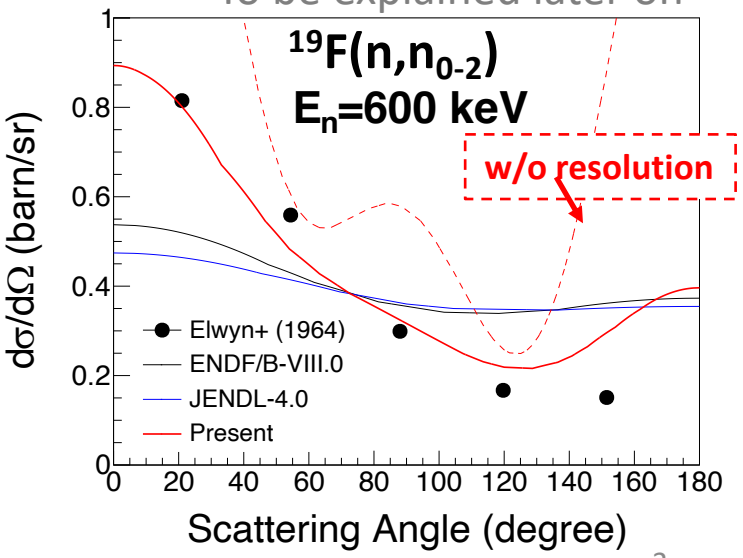
😀 **One technical progress**

Angular distribution is calculated with experimental energy resolution

analyze measured $\frac{d\sigma}{d\Omega}(\theta)$ data more realistically

(need many cpu cores …)

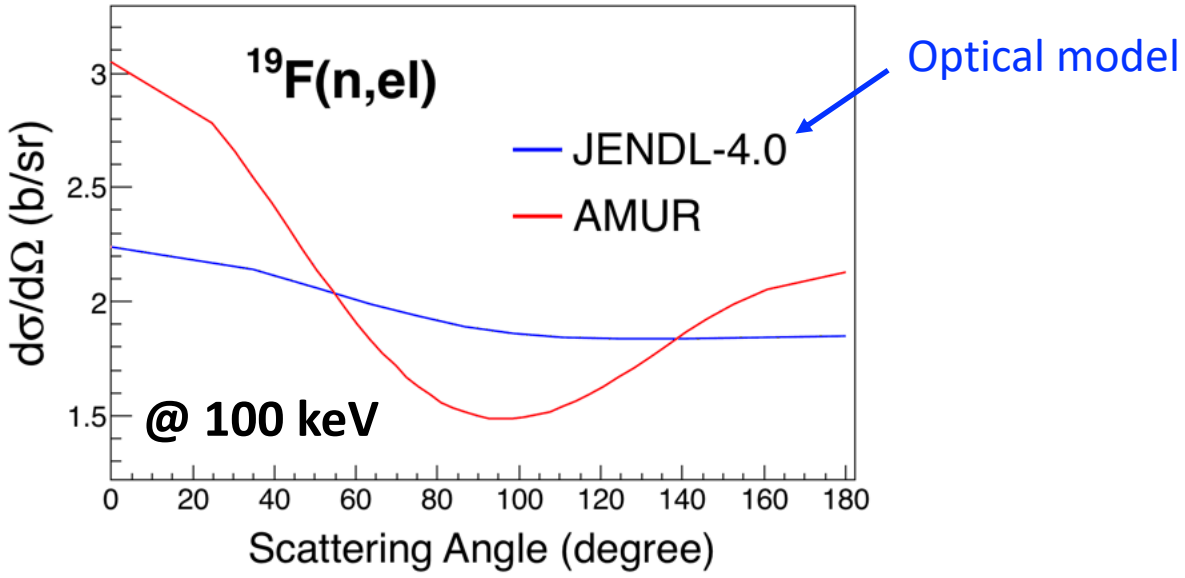
To be explained later on



Analysis of n + ^{19}F (E_n<1 MeV)

➢ Motivations

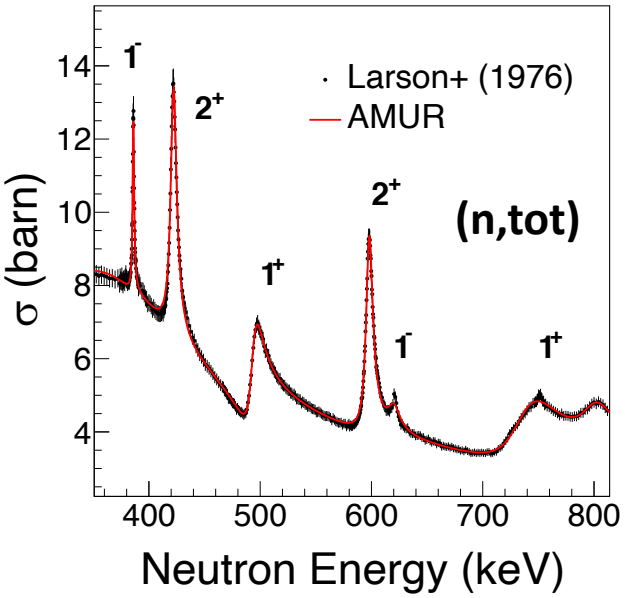
- LiF-BeF_2 is a candidate for moderator/coolant in the molten-salt reactors (MSR)
- R-matrix results are very different from the optical model estimation
  (How affect on the neutronics calculation ?)

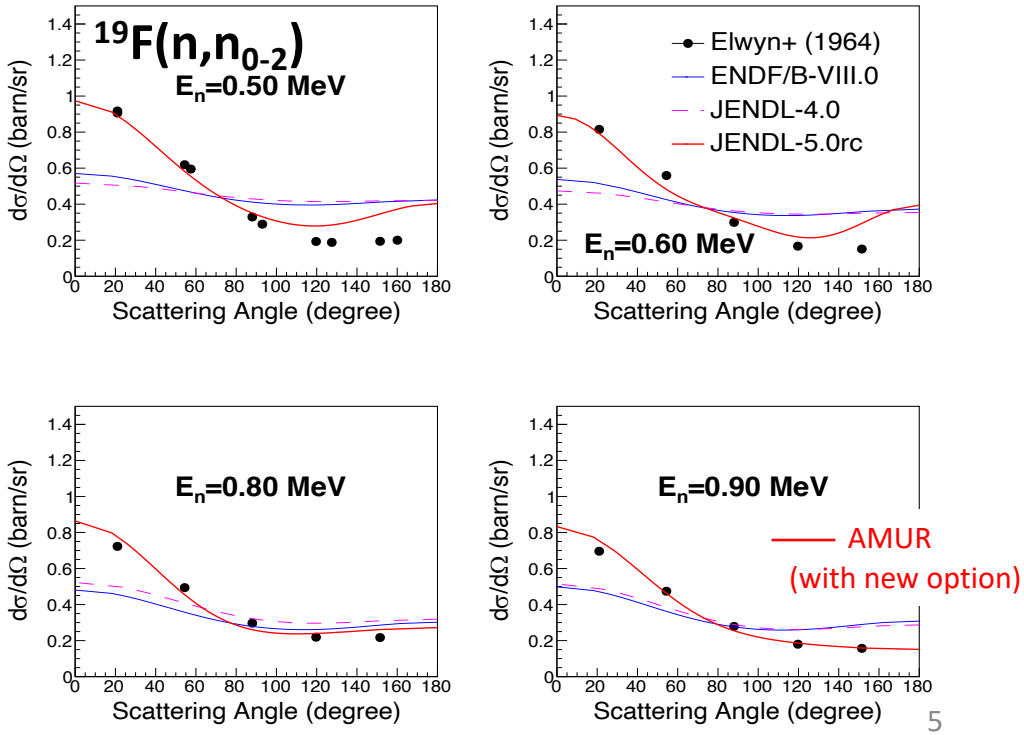


Analysis of n + ^{19}F (E_n<1 MeV)

^{19}F	(n,tot)	Larson+	(1976)	0.005 – 1.0 MeV
	(n,n_1)	Lashuk+	(1994)	0.1 – 1.0 MeV
	(n,n_2)	Lashuk+	(1994)	0.3 – 1.0 MeV
	$(n,n_{1,2})$	Broder+	(1969)	0.23 – 1.0 MeV
	(n,n_{0-2})	Elwyn+	(1964)	0.2 – 1.0 MeV
	(n,γ)	Gabbard+	(1959)	0.016 – 1.0 MeV
	(n,γ)	Egorov+	(2005)	0.0280 eV

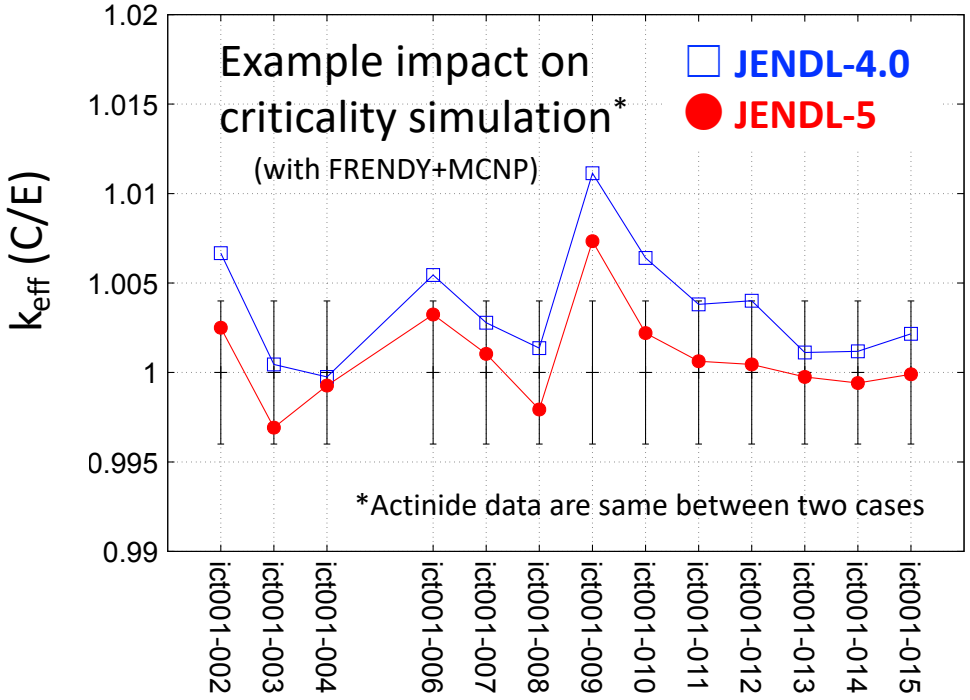
← DA, FWHM=100 (keV)





Impact of new ^{19}F evaluation

- □ **JENDL-4.0**
  - **SIG : BW + eye-guide fit to measurements, e.g., to Larson-1979**
  - **DA : Optical model calculation**
- ● **JENDL-5**
  - **SIG : = JENDL-4.0**
  - **DA : MF=4,MT=2,51,52 of JENDL-4.0 replaced with R-matrix results (En < 1 MeV)**

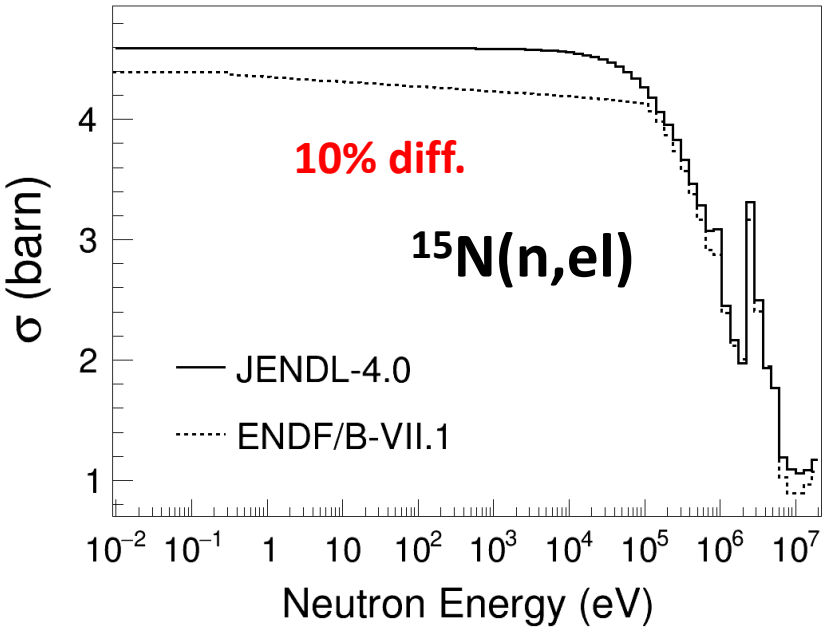


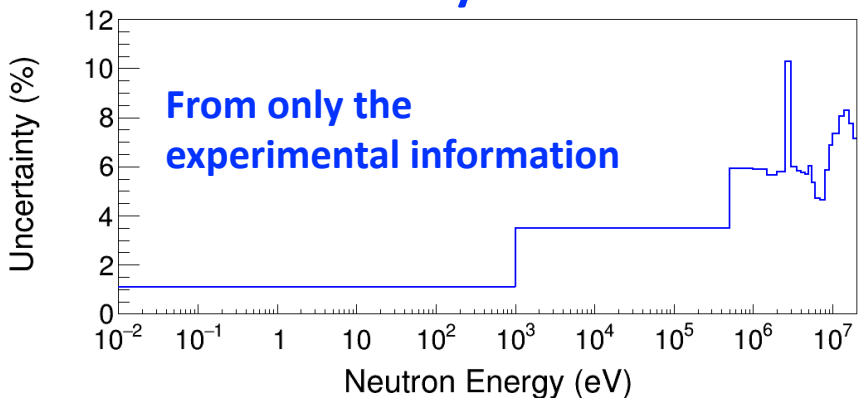
n + ^{15}N

➢ Motivation :

- Nitride fuel is assumed in the design of ADS
- Natural abundance : ^{14}N (99.63%)、 ^{15}N (0.37%)
- ^{15}N is a first candidate because ^{14}C is produced by ^{14}N(n,p)^{14}C

➢ Status of data in libraries:



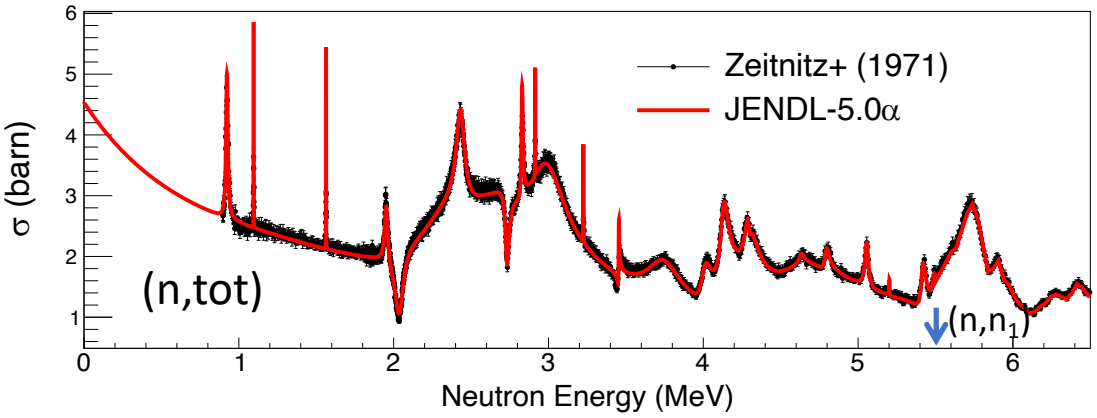


n + ^{15}N

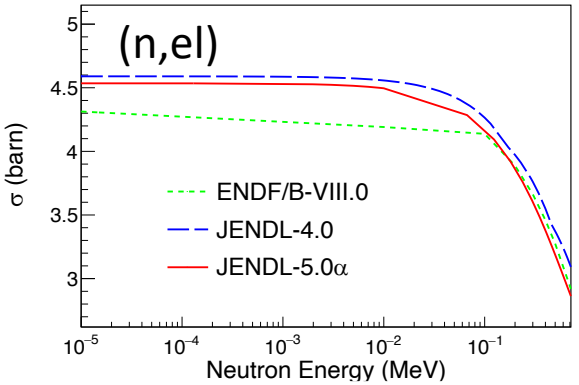
R-matrix fits by AMUR (En<5.5 MeV) :

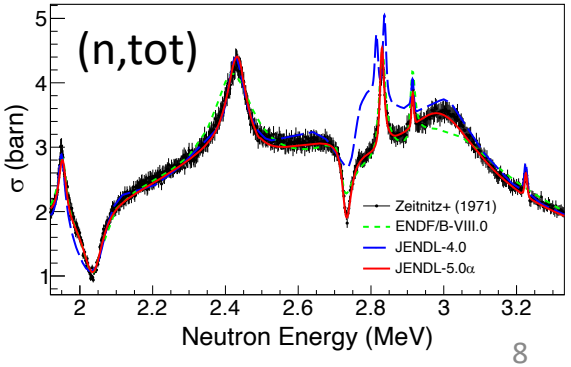
- Mughabghab+ (2006)
  σ_{el} = 4.59 ±0.05 (barn)
- Zeitnitz+ (1971)
  σ_{tot}, TOF, 0.9 – 32 MeV, KIC
- Sikkema+ (1962)
  $(d\sigma/d\Omega)_{el}$, 1.9 – 3.5 MeV, CCW

J^p of ^{16}N* is based on ENSDF

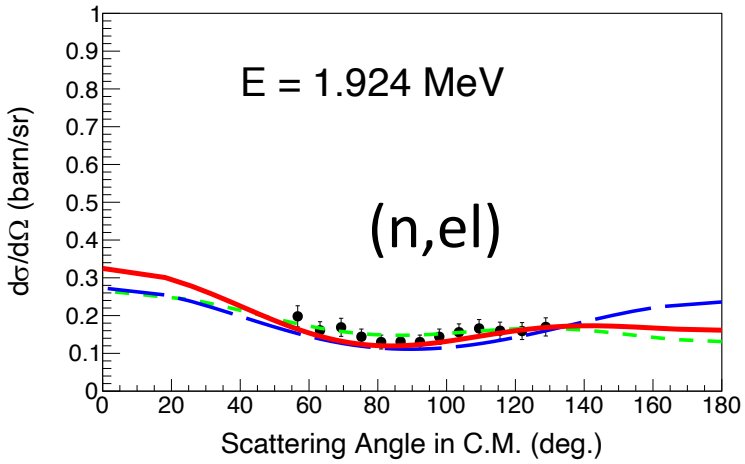


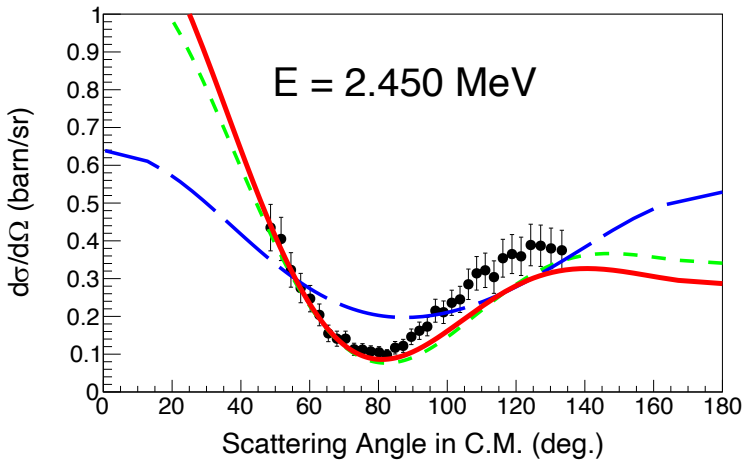
normalization：1.01266 ± 0.264 %

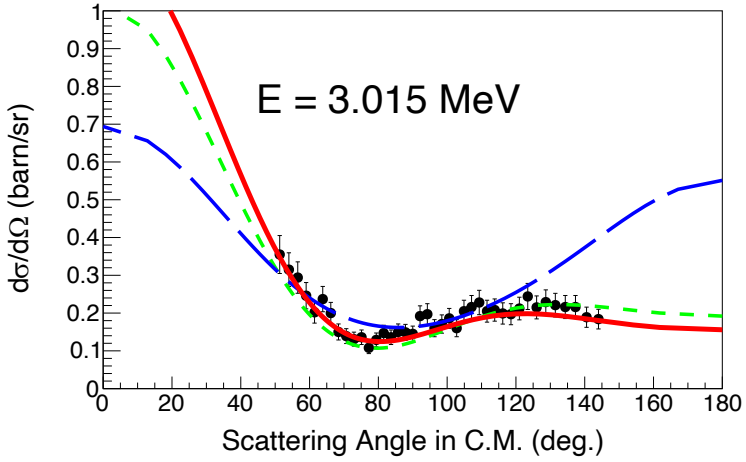


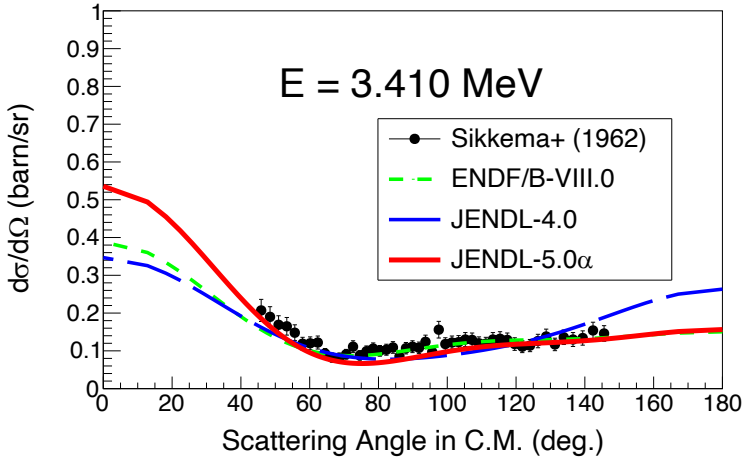


n + ^{15}N





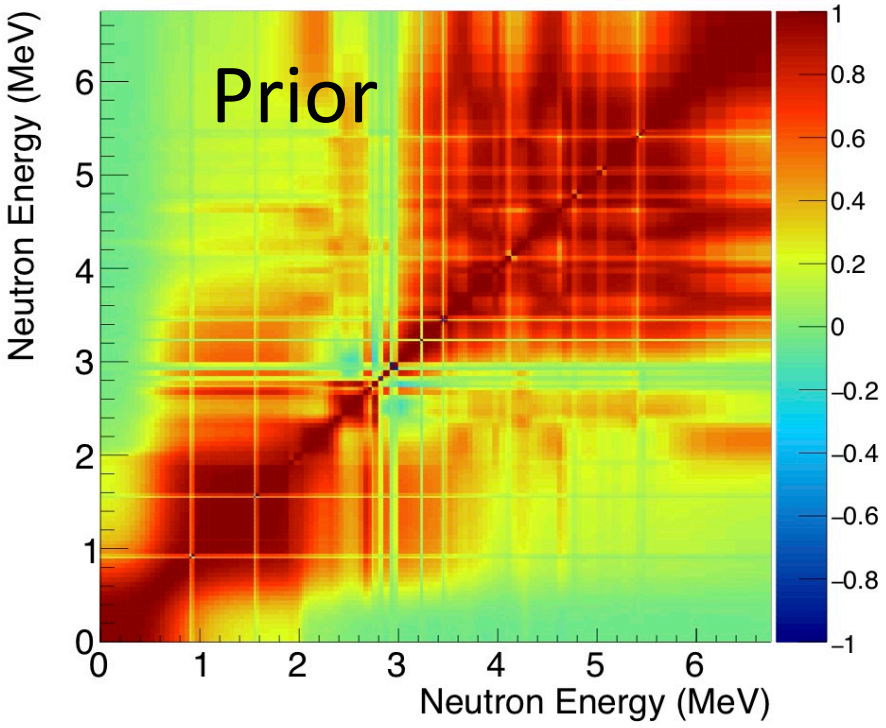


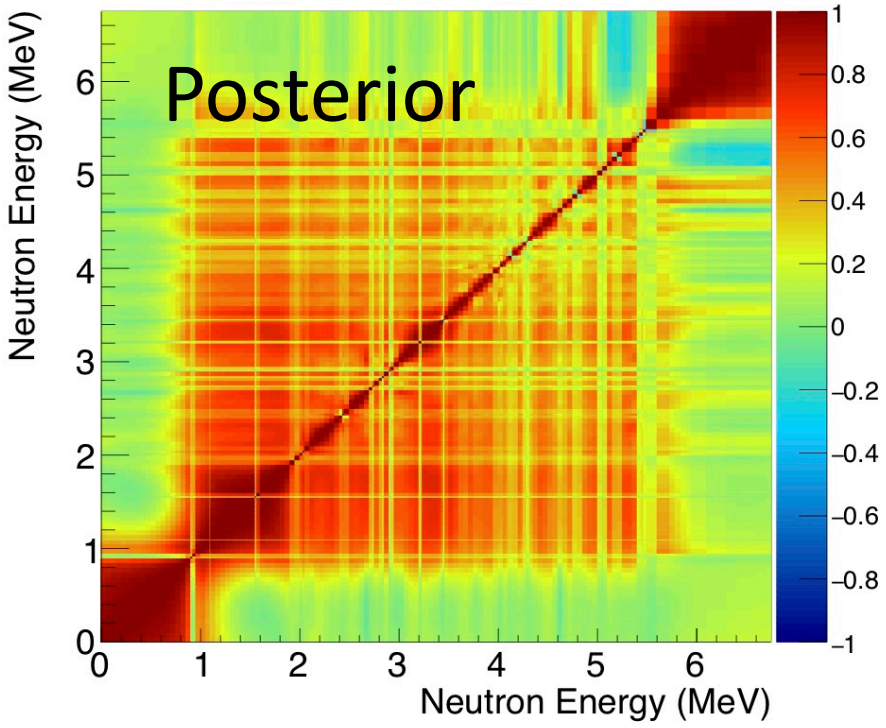


normalization：1.16892 ± 0.357 %

n + ^{15}N, Covariance

Correlation matrix, (MF,MT)=(33,2)



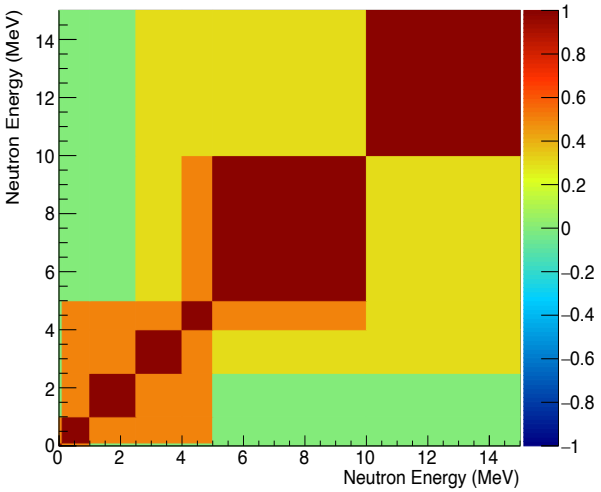


You can see ~unitarity limit !

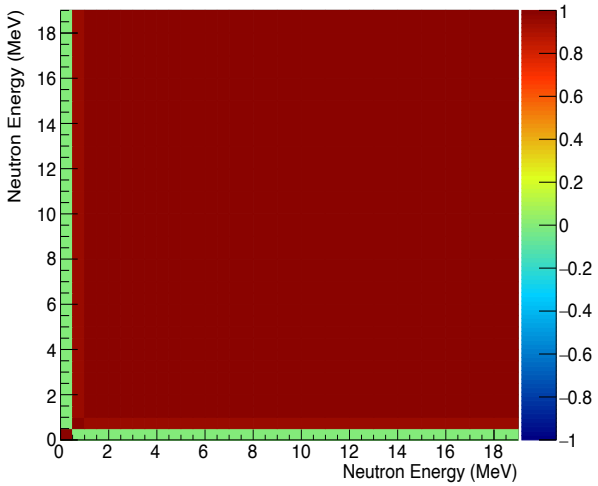
(note that n,γ cross-sections are tiny)

n + ^{15}N, Covariance

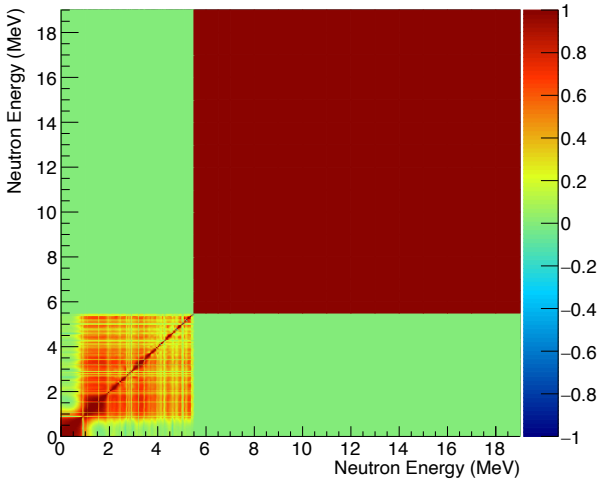
ENDF/B-VIII.0



JENDL-4.0



JENDL-5.0alpha



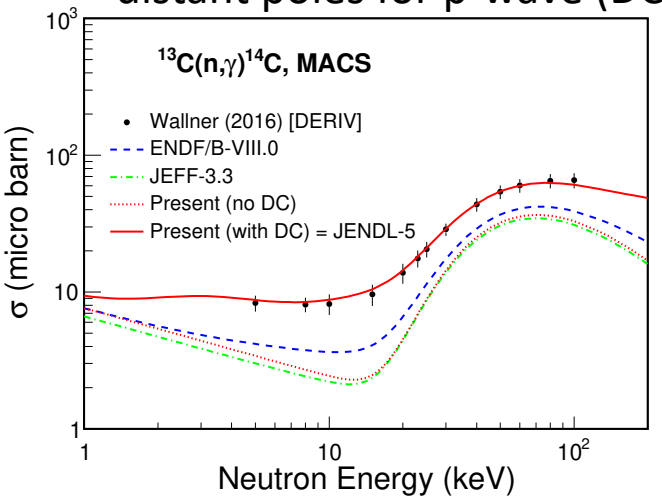
Present work

Others (overview)

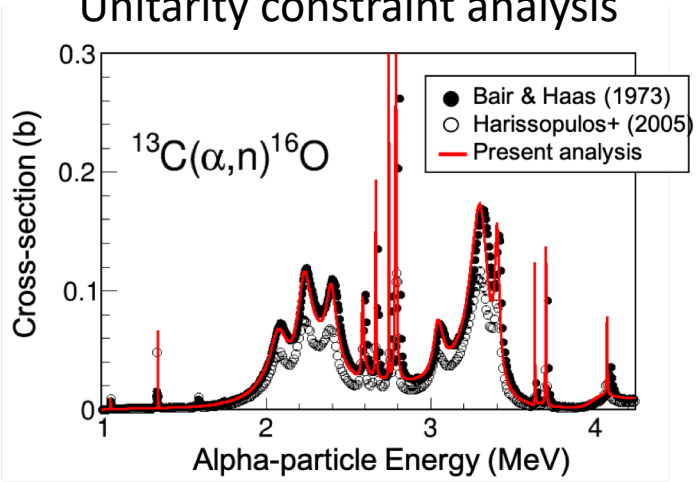
	^{12}C	^{13}C	^{15}N	^{16}O	^{19}F
E_n	< 4.4 MeV	< 10 MeV	< 5.5 MeV	< 5.5 MeV	< 1 MeV
Diff. from JENDL-4.0	Almost same as in ^{nat}C in J-4.0	new	(n,n_0)	(n,a) 30%↑	$(n,n_{0,1,2})$ DA
Cov. ?		○	○	○	
Non-resonant region	J-4.0 (^{nat}C)	New (CCONE)	J-4.0	J-4.0	J-4.0

≒ CIELO

with Reich-Moore
+ distant poles for p-wave (DC)



Unitarity constraint analysis

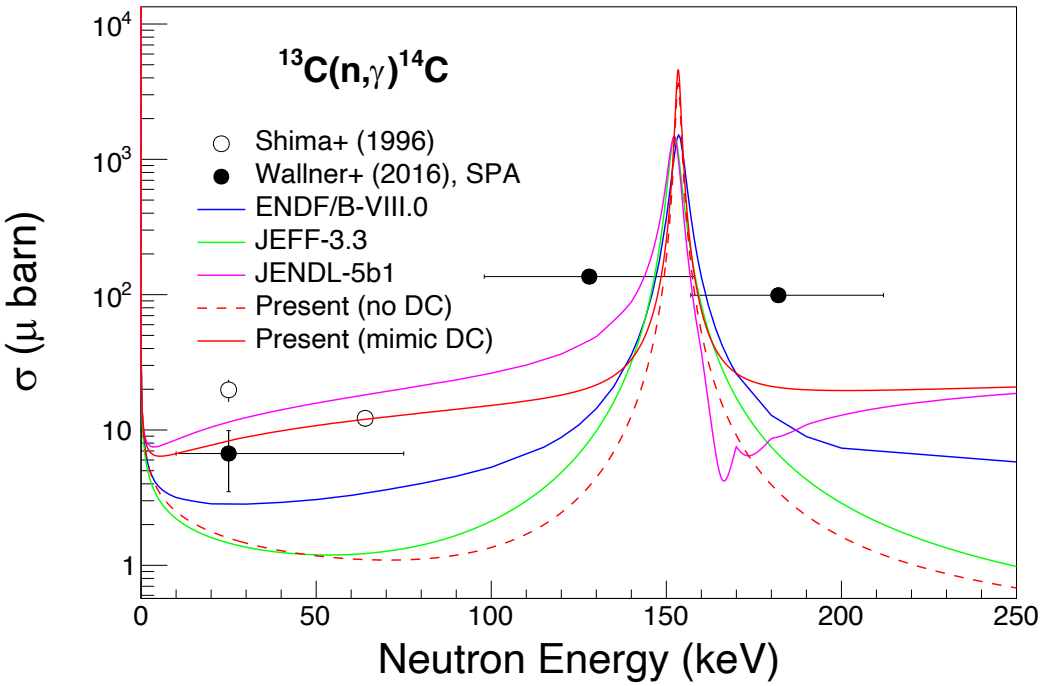


Consistent with G.Hale & M.Paris

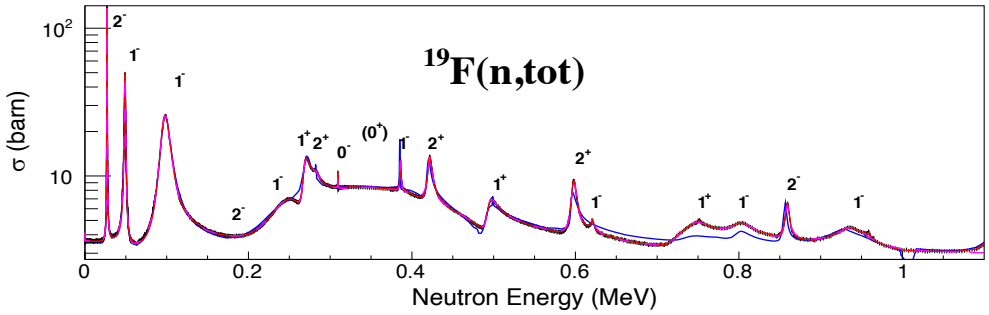
Summary

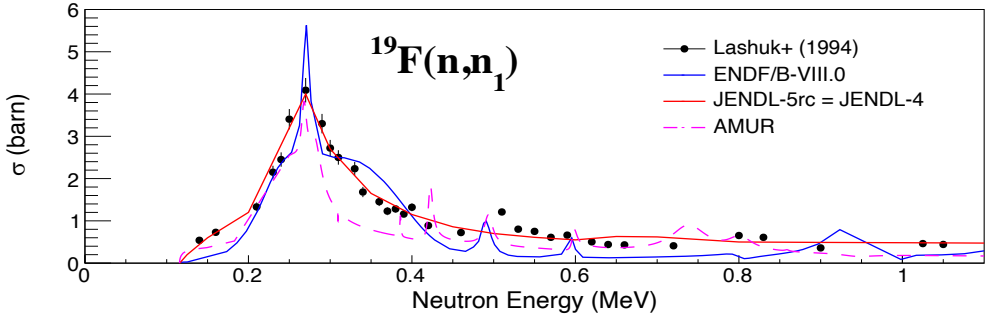
- JENDL-5 was released in December 2021
- Update of angular distribution in RRR shows a impact on neutronics simulation (^{19}F)
- Covariance matrices from AMUR were compile in J-5 as mu as I can.
- Unitarity constraint result of AMUR is comipled in J-5 for ^{16}O and ^{15}N.

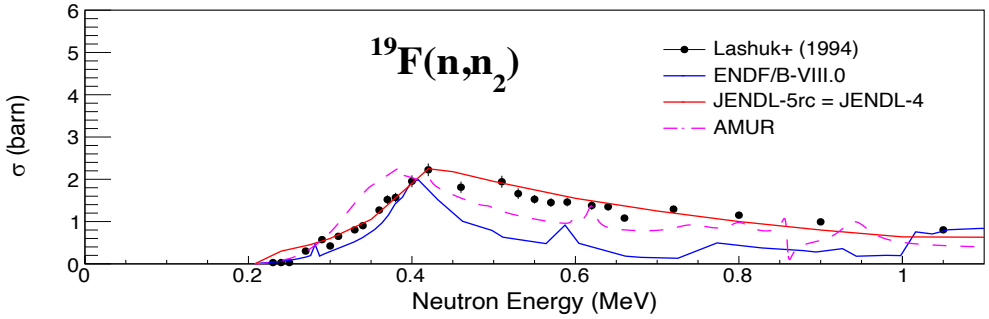
backups


$^{13}C(n,\gamma)^{14}C$
Shima+ (1996)
Wallner+ (2016), SPA
ENDF/B-VIII.0
JEFF-3.3
JENDL-5b1
Present (no DC)
Present (mimic DC)
σ (μ barn)
Neutron Energy (keV)
10^4
10^3
10^2
10
1
0
50
100
150
200
250

backups







Now I'm looking into Lashuk+ (1994)

Impact by revision of n+^{19}F data