PEPR SCIAM

Fission Yield Evaluations : from thermal point to fast neutron energy range

A.Regonesi, N. Teixeira-Rua, G. Kessedjian, A. Chebboubi, S. M. Cheikh, O. Serot, D. Bernard, O. Litaize

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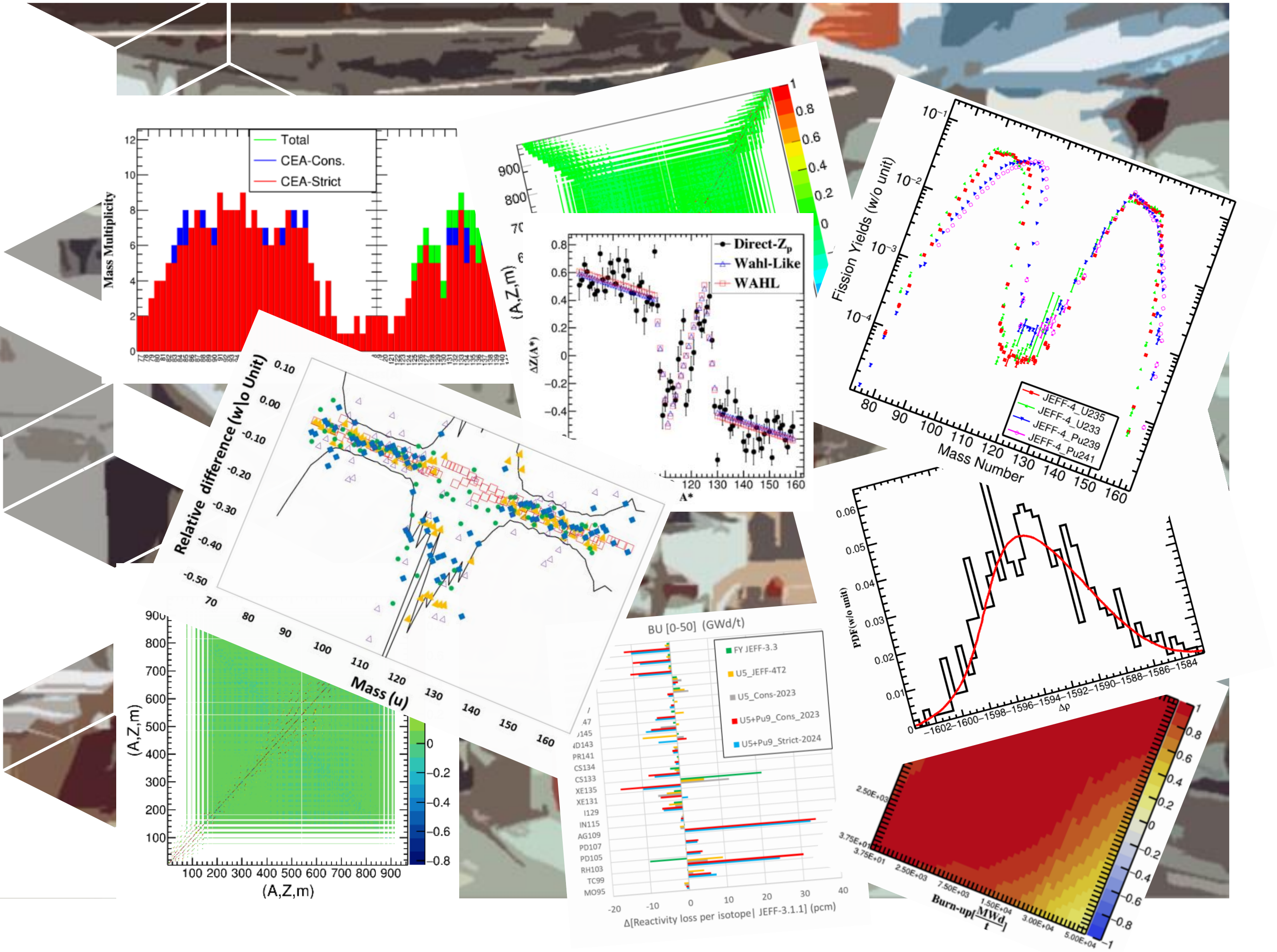
9 june 2026
PEPR SCIAM



Context: methodology of FY Evaluation for thermal neutron induced fission

Theoretically

$$Y(A^*, Z, E^*, J^\pi) = Y(A^*) \cdot P(Z|A*, E^*) \cdot P(E_K|A^*, Z) \cdot P(E^*, J^\pi|A^*, Z, E^*)$$

Pre-neutron Mass, charge, excitation energy

↕

$\boxed{\text{Fission models}}$

↔

Experimentally

$$Y(A, Z, E_K, I) = Y(A) \cdot P(Z|A, E_K) \cdot P(E_k|A, Z) \cdot P(m|A, Z, E_K)$$

Mass | Charge | Kinetic Energy | Isomeric

↔

Application

$Y(A, Z, m)$ *Independent Yields*

↓

$C(A, Z, m)$ *Cumulative Yields*

↓

$C(A)$ *Chain Yields*

↕

Fuel Cycle applications
- Reactivity losses (BU)
- PIE (BU) : Post-Irradiated Experiment
- CFE
- Decay Heat

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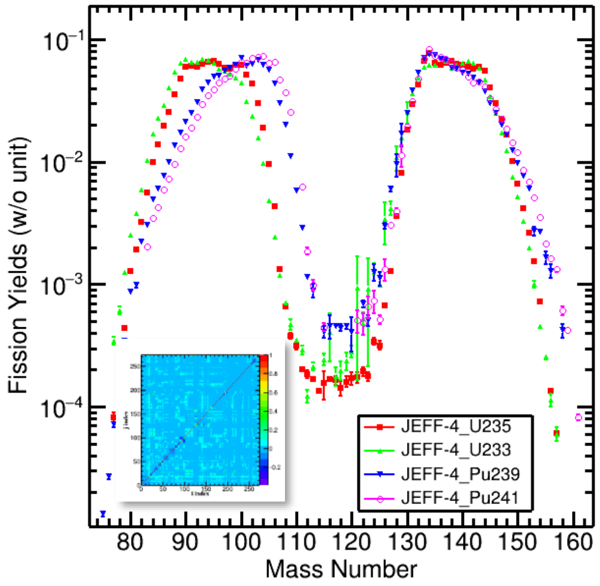
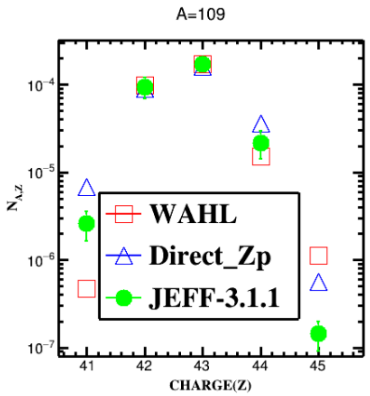
Mass Charge Kinetic Energy Isomeric





$\leftrightarrow$

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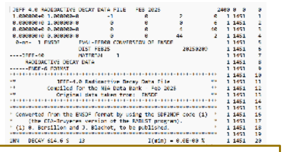

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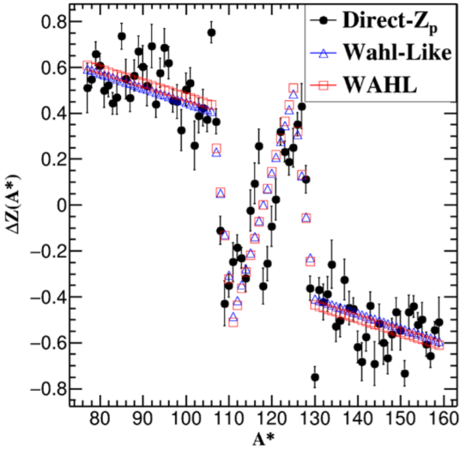
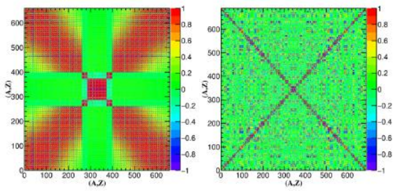
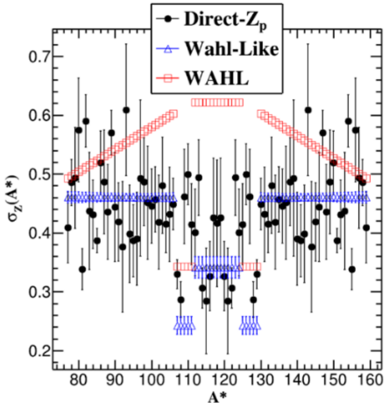
Pre-neutron Mass, charge, excitation energy

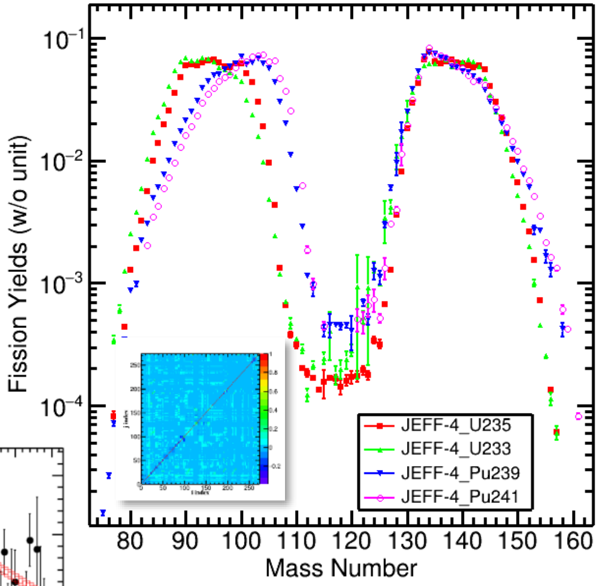
Mass Charge Kinetic Energy Isomeric

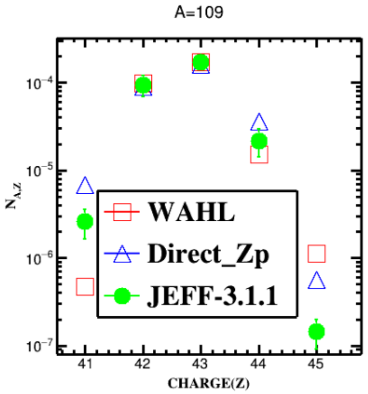
Fission models

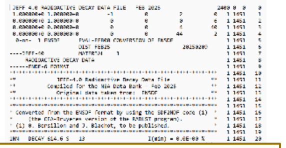












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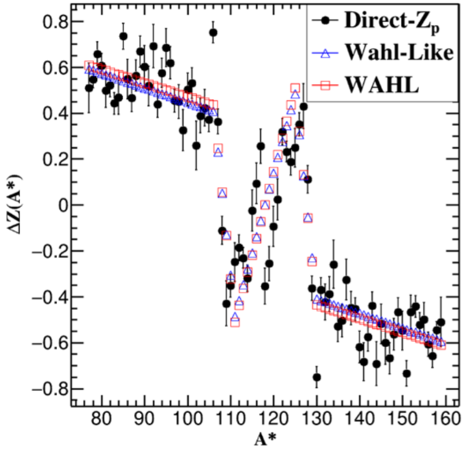

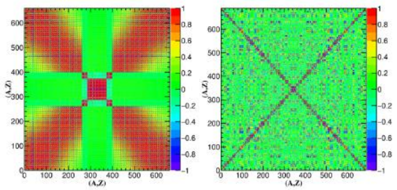

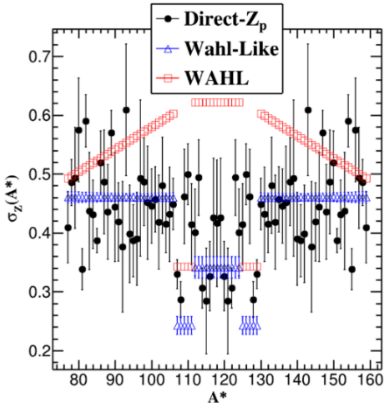

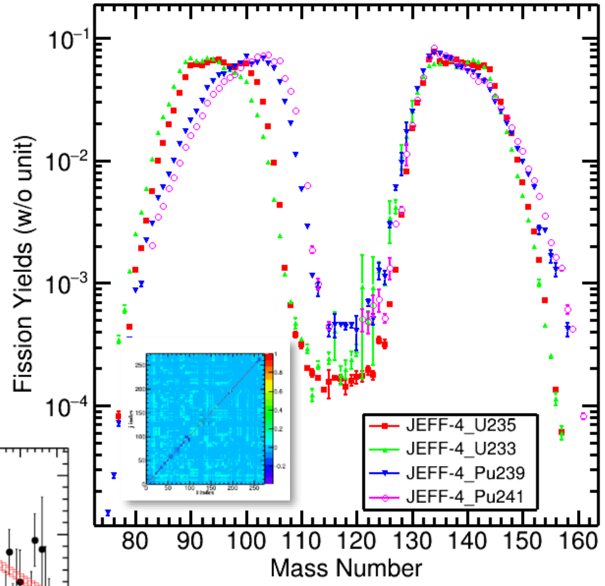

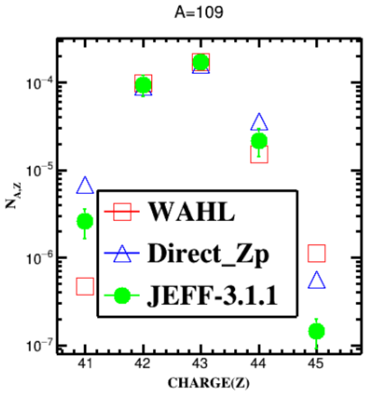

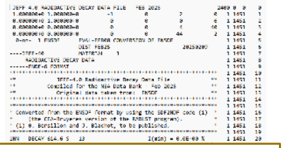

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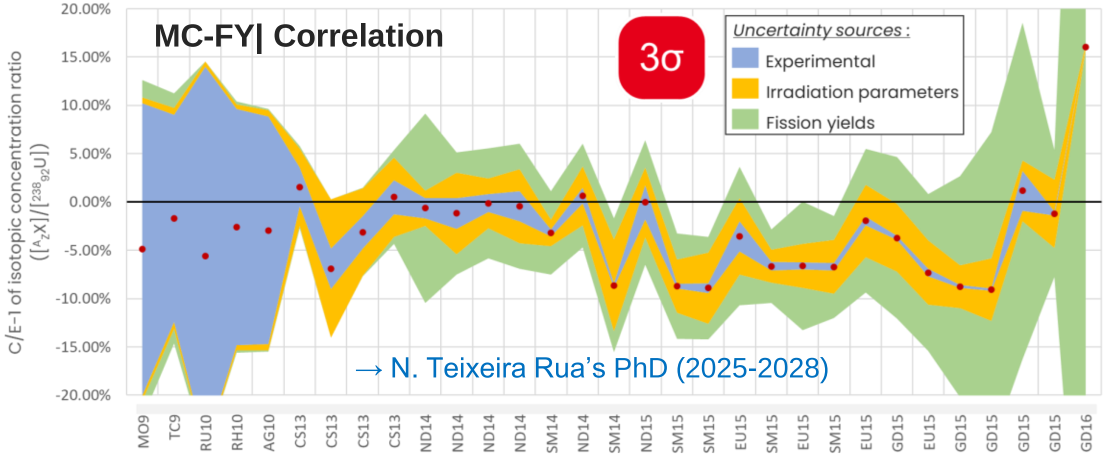

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$(nt_h,, f) \Longrightarrow$ | $Y(A^*|nt_h) \cdot P(Z|A^*, n_{th})$ → $P(\nu|A^*, n_{th})$ → $Y(A, Z|nth)$ → $C(A, Z, m|nt_h)$

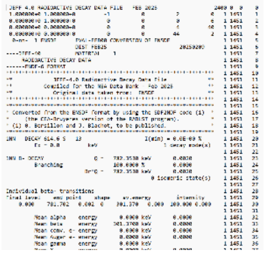
« 2E » & « 2E-2V » Pheno. Models (Brosa-like)

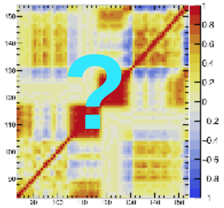
Pheno. Models (Wahl-like)

Pheno. Models (FIFRELIN, GEF, CGMF, FREYA)

Major experimental data

$(nf_{ast}, f) \Longrightarrow$ | $Y(A^*|nf_{ast}) \cdot P(Z|A^*, E_n)$ → $P(\nu|A^*, E_n)$ → $Y(A, Z|En)$ → $C(A|E_n)$





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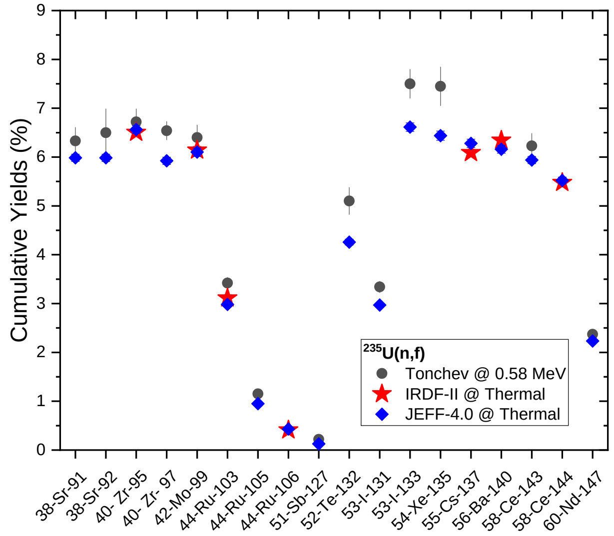
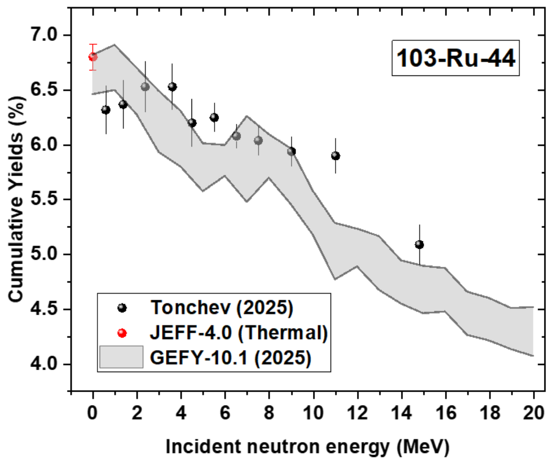
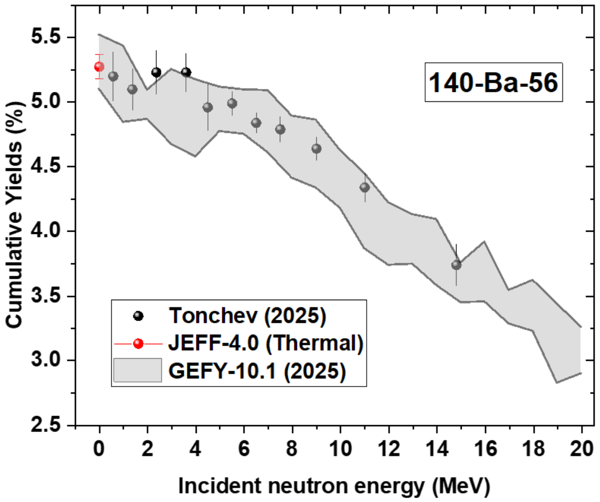
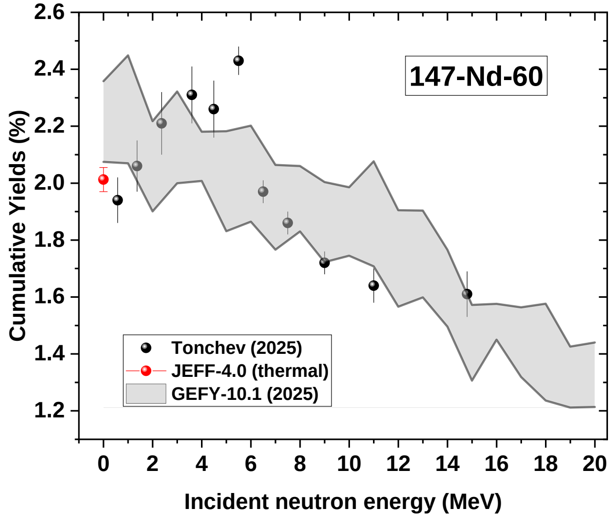
O. Serot, JEFDOC_2550 / APRENDE (Avril 2026)

A. Tonchev et al., Nuclear Data Sheets 202, 12 (2025)









Pre-neutron mass yields : Limit of resolution ; e.g. $^{235}U(n_{th},f)$ $Y(A^*)$

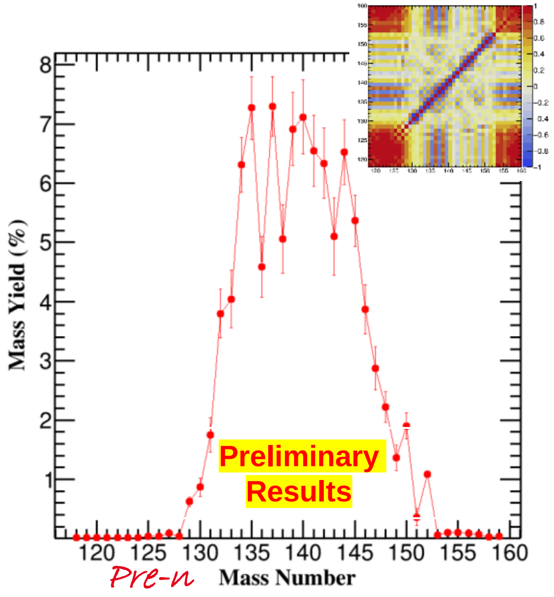
→ A. Regonesi et al. ND2025
→ A. Regonesi's PhD (2024-2027)

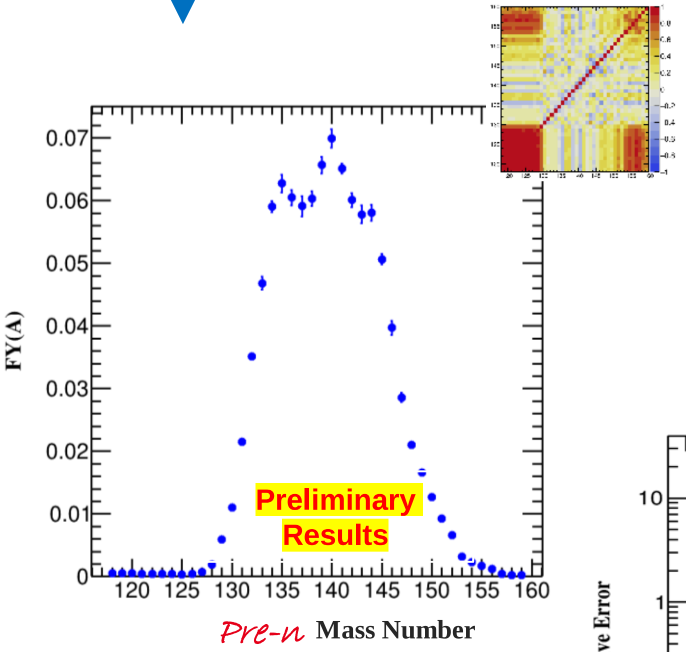
Zero Resolution

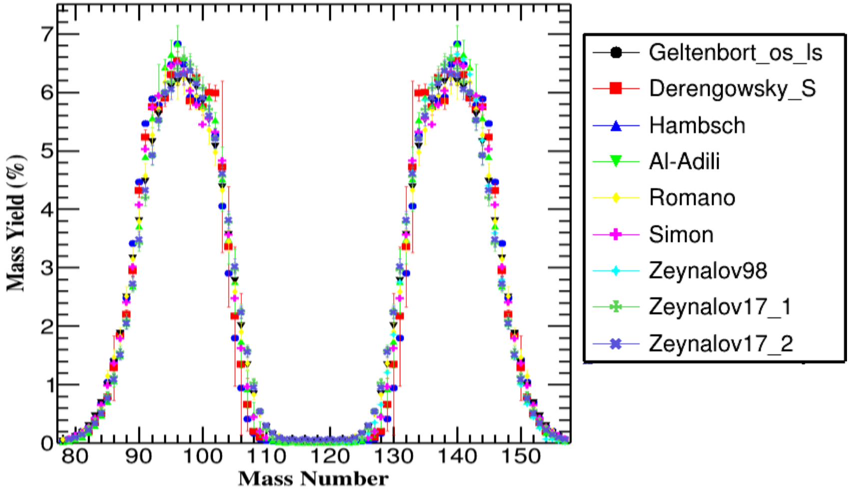
Y(A*) Exp. Limit

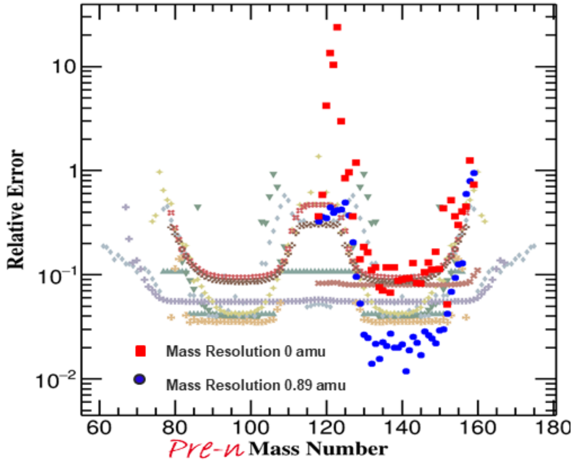
0	(1)	(2)	(3)	(6)	(7)	(9)	(4)	(5)	(8)
0	2.09	2.31	2.59	3.67	4.07	5.09	5.65	5.75	5.86

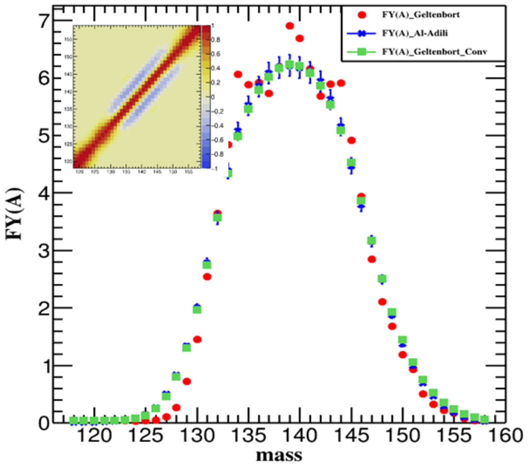
FWHM Mass Resolution (amu)









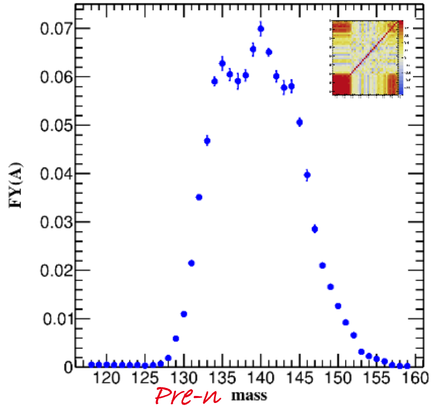


Prompt Neutron emission per mass : e.g. $^{235}U(n_{th},f)$ $\nu(A^*)$

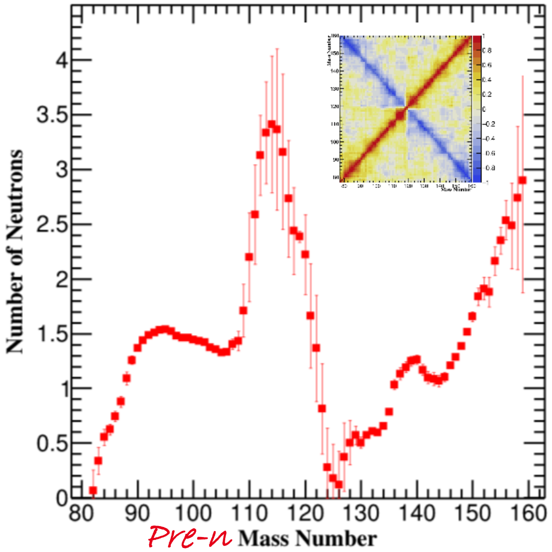
→ A. Regonesi's PhD (2024-2027)

Res Zero

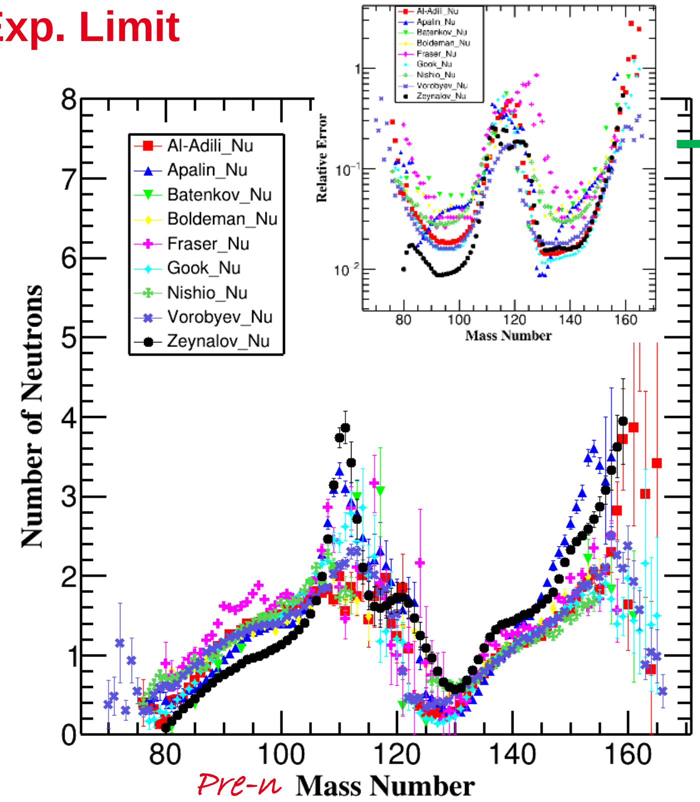
	(1)	(2)	(3)	(6)	(7)	(9)	(4)	(5)	(8)	FWHM Mass Resolution
	2.09	2.31	2.59	3.67	4.07	5.09	5.65	5.75	5.86	(amu)



Y(A*) Eval Exp. Limit



Terrel's $\nu(A^*)$ | Y(A*) Exp. Limit



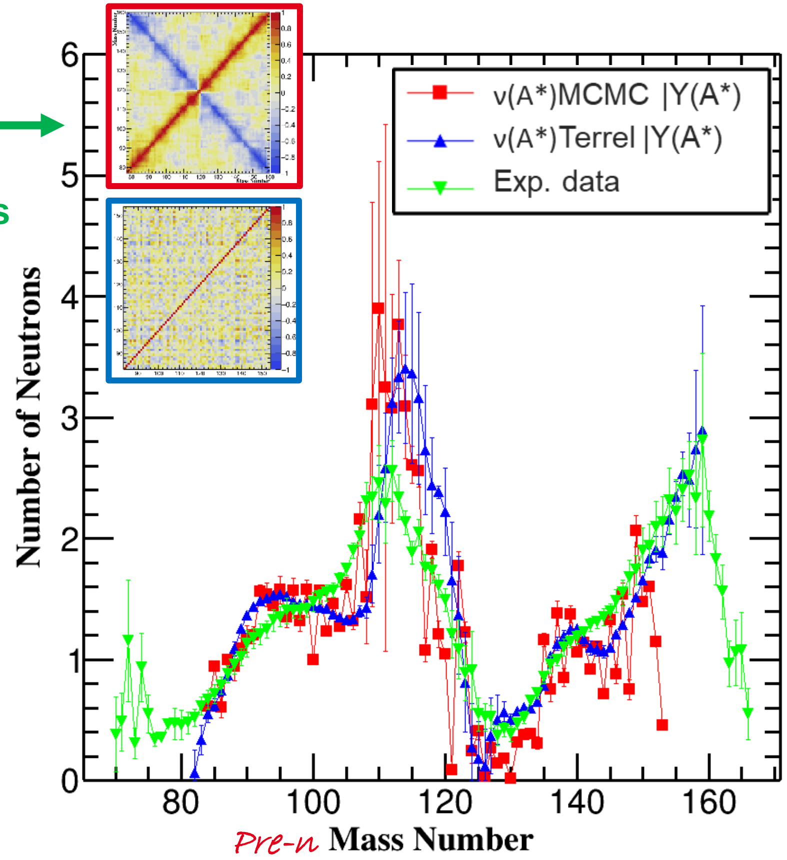
Exp. Evaluation (Student PDF)

$\nu(A^*)$ Effective mass resolution

$$Y(A) = \sum_{\substack{\nu \\ A^*=A+\nu}} Y(A^*)\, P(\nu|A^*)$$

MCMC Evaluation

$\nu(A^*)$ Evaluation Ref. mass resolution → (4) Al Adili et al.



→ Important Biases

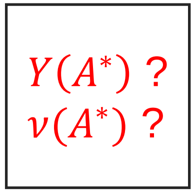
Prompt Neutron emission per mass : e.g. $^{235}U(n_{th},f)$ $\nu(A^*)$

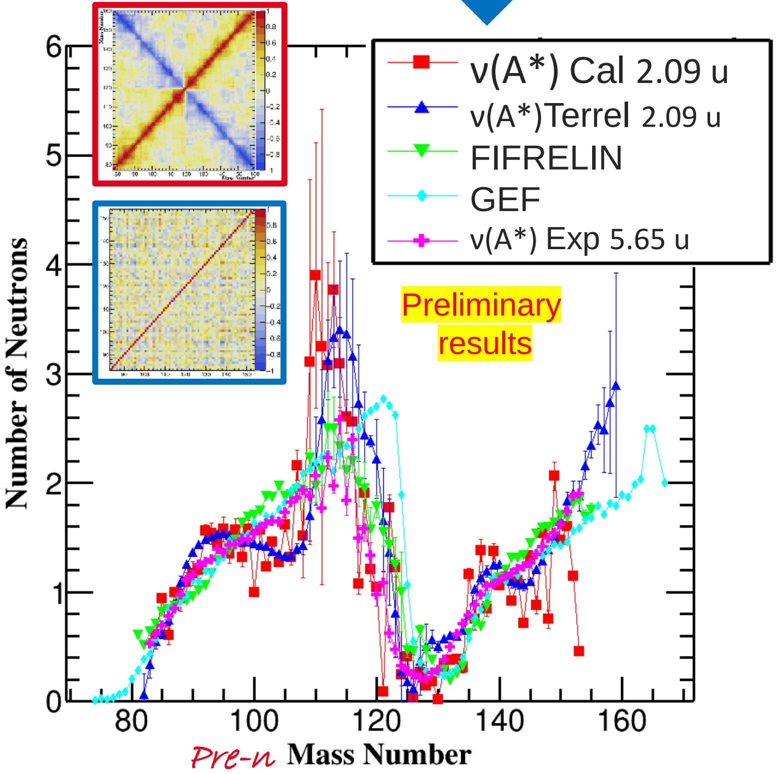
→ A. Regonesi's PhD (2024-2027)

$Y(A)$
Resolved

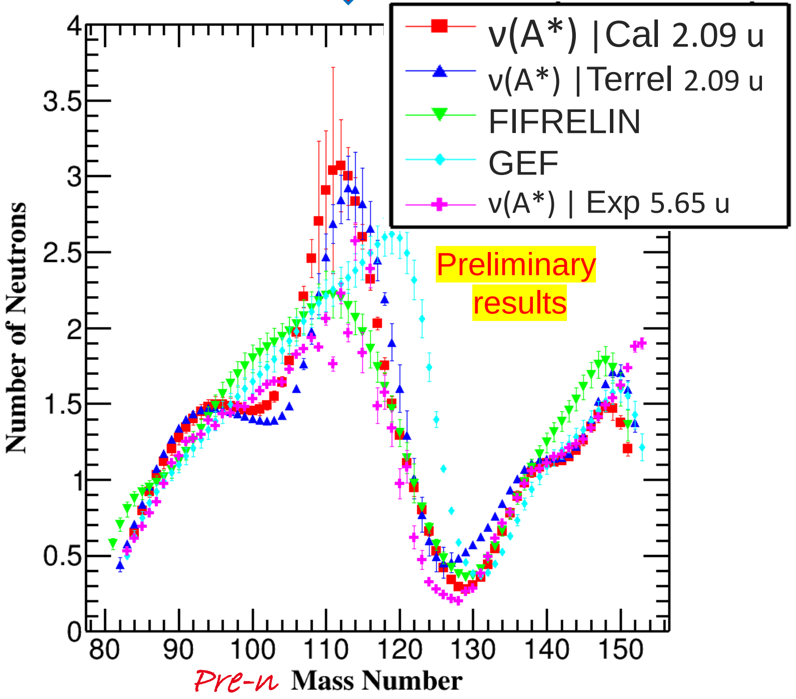
$Y(A^*)$
Best Exp.
Resolution 2.09 u

$\{Y,\nu\}$ (A^*)
Best Exp.
Resolution

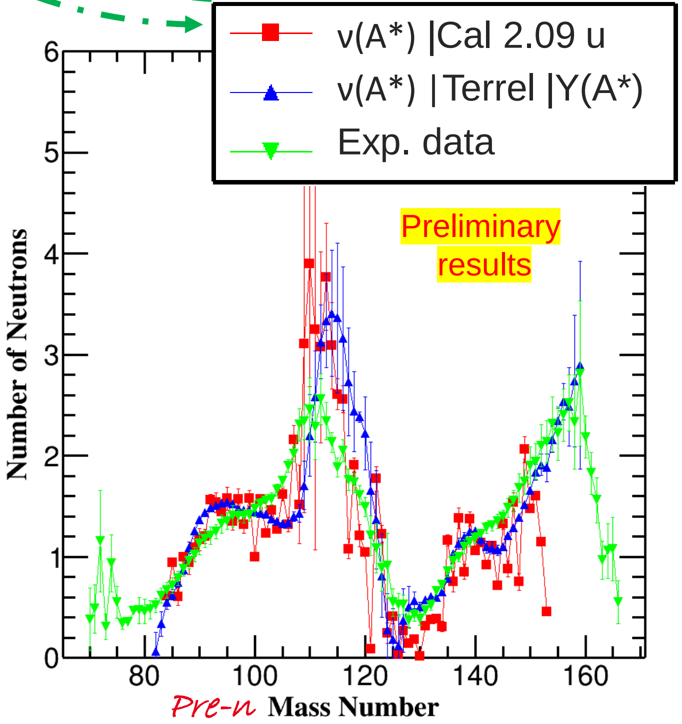




Terrel's $\nu(A^*)$ | Y(A*) Exp. Limit (2.09 u)



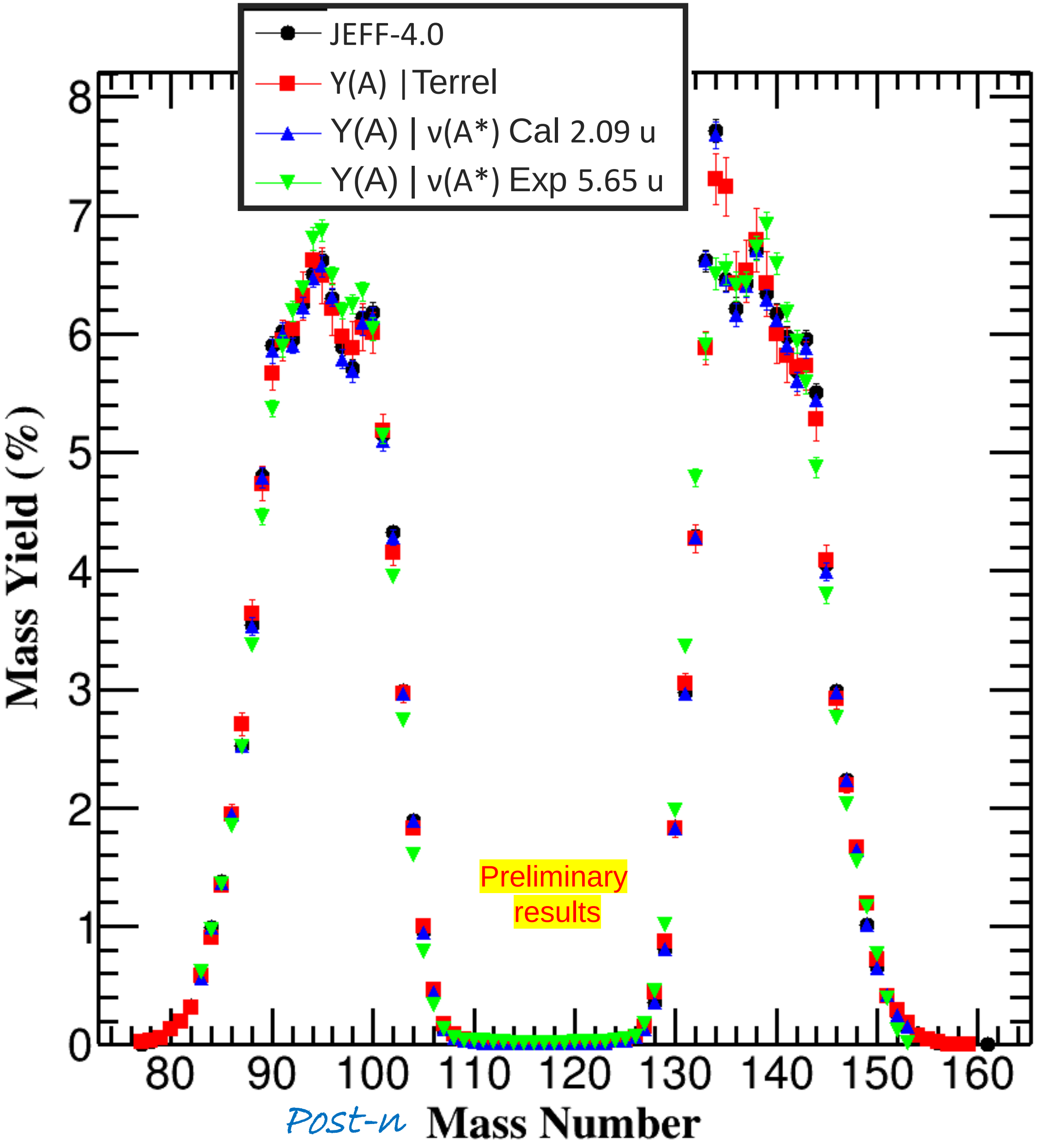
$\nu(A^*)$ Evaluation
FWHM 5.65 u



$\nu(A^*)$ Effective mass resolution

Post-neutron mass yields : consistency test e.g. $^{235}U(n_{th},f)\ \ Y(A)$

→ A. Regonesi's PhD (2024-2027)



$\nu(A^*|$TERRELL) → Pvalue ≈ 0

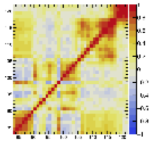
$\nu(A^*|$ Exp 5.65 u) → Pvalue ≈ 0

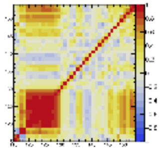
$\nu(A^*|$ Cal 2.09 u) → { L → Pvalue = 22.6% ; H → Pvalue = 7.2% }

$\nu(A^*|$ Cal 2.09 u)

L $\sigma_{gauss} = 1.08\ \pm 0.043$

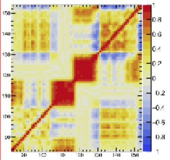
H $\sigma_{gauss} = 0.76\ \pm 0.01$





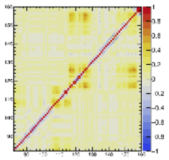
$\nu(A^*|$ Exp 5.65 u)

$\sigma_{gauss} = 0.91\ \pm 0.06$

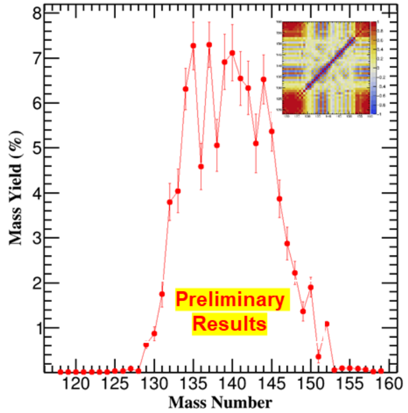


$\nu(A^*|$TERRELL)

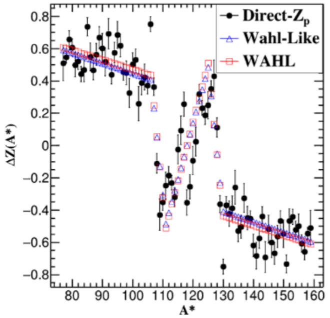
$\sigma_{gauss} = 0.57\ \pm 0.055$

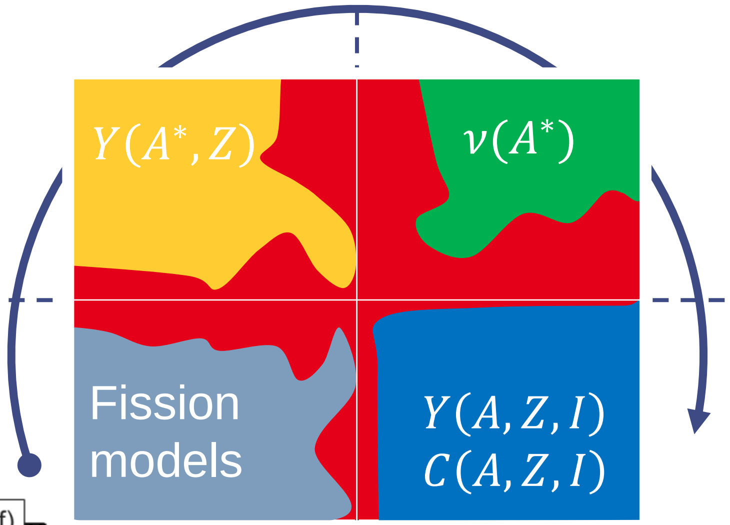


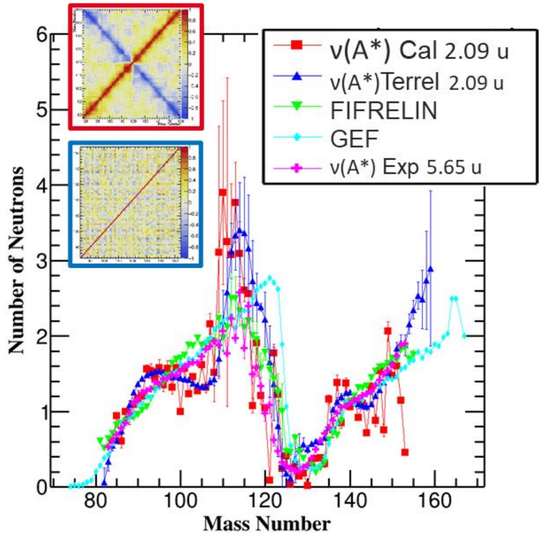
Conclusion & perspectives

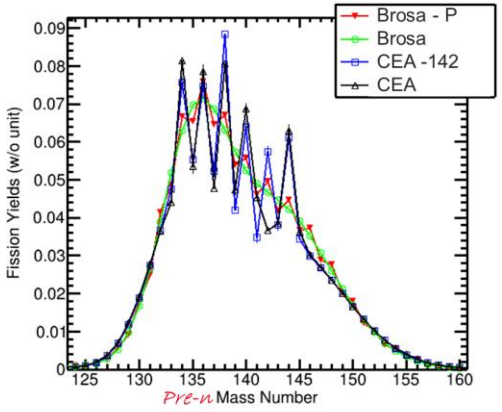


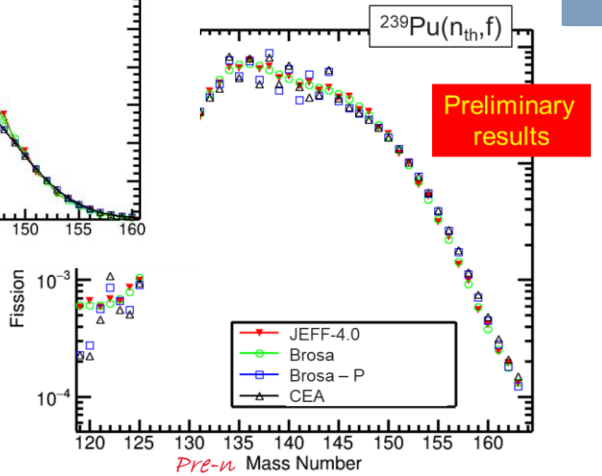
1st - unblurring
2nd - Biases
3rd - Accuracy











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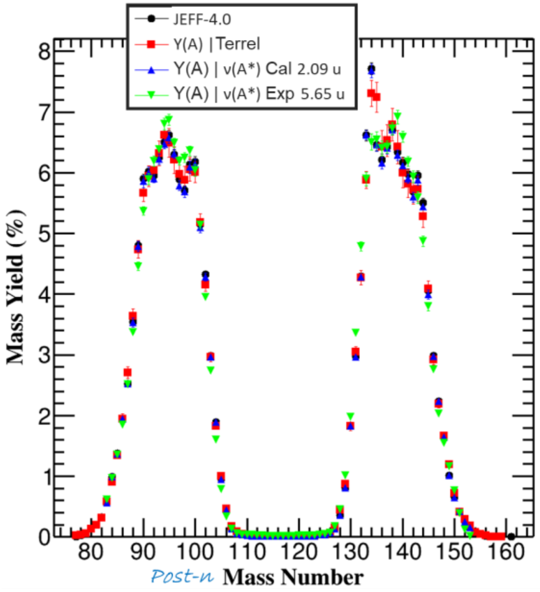

Conclusion & perspectives → P(ND)²-3

- 2018-2025 : independent & cumulative FY evaluation → **JEFF-4.0** with ***correlation matrix*** for the first time around the world

→ based on EXFOR database
→ S-M. Cheikh's PhD (2020-2023)

◘ Program for the next ½ Decade :

- Develop methodology of Evaluation from pre-n observables

  Adjust phenomenological models considering :

  - correlation matrices at all steps to propagate uncertainties
  - default model to estimate the biases
  - statistical tests to validate the uncertainty and the biases

→ based on EXFOR database
→ A. Regonesi's PhD (2024-2027)

- Complete the (n_{th},f) FY evaluations : from P(Z|A) to PIE

→ based on EXFOR database
→ N. Teixeira Rua's PhD (2026-2029)

- Adjusted fission model parameters in order to interpreted fast neutron energy range data [0; 6 MeV] & Evaluation as a function of incident neutron energy

→ PhD thesis subject (2027-2030)

- **Threats/risks :** manpower alongside the experimental program

→Towards JEFF-4.1 ???

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Thank you for your attention

jefdoc-1902
jefdoc-1982
jefdoc-2007
jefdoc-2038
jefdoc-2056
jefdoc-2027
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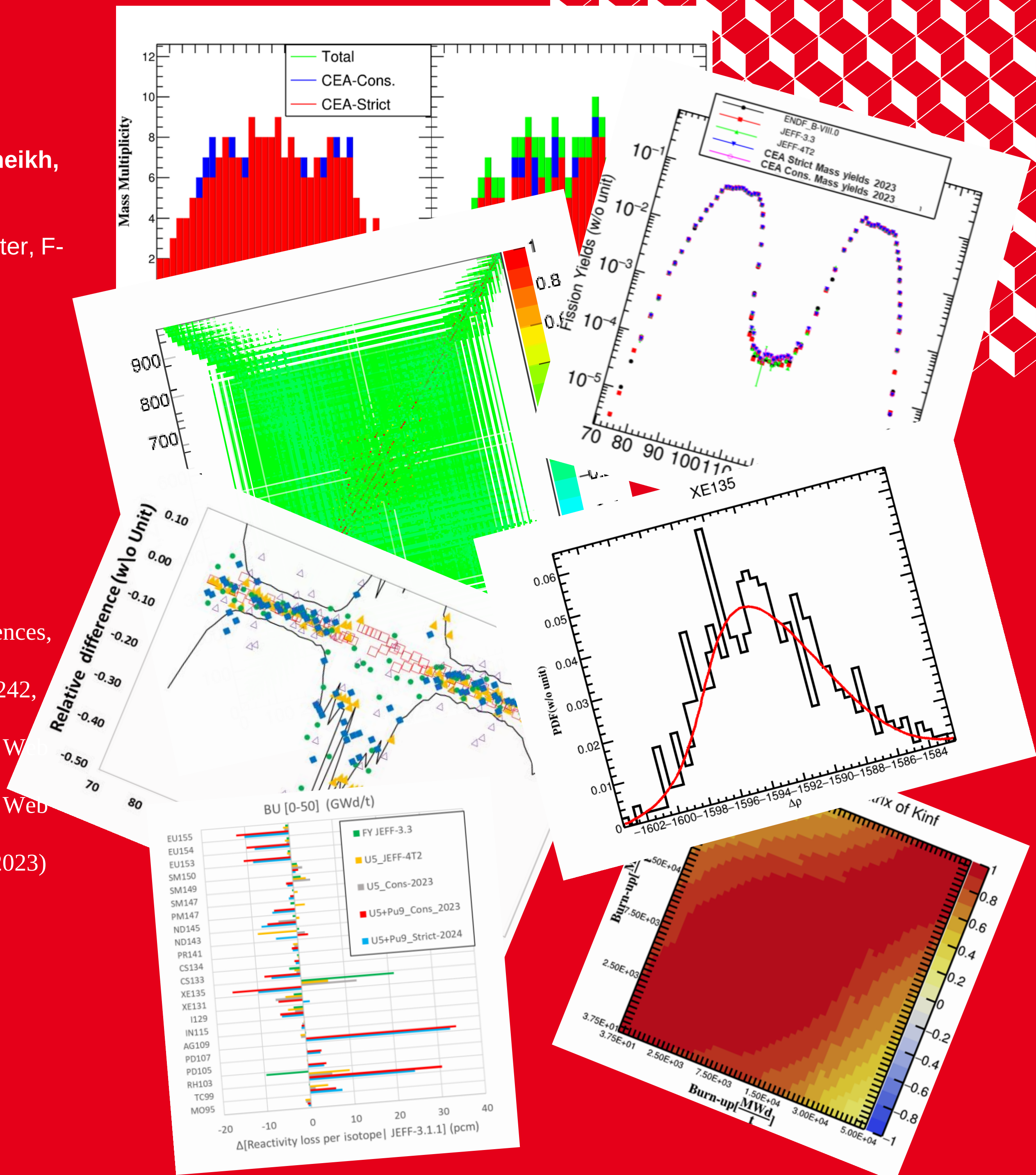
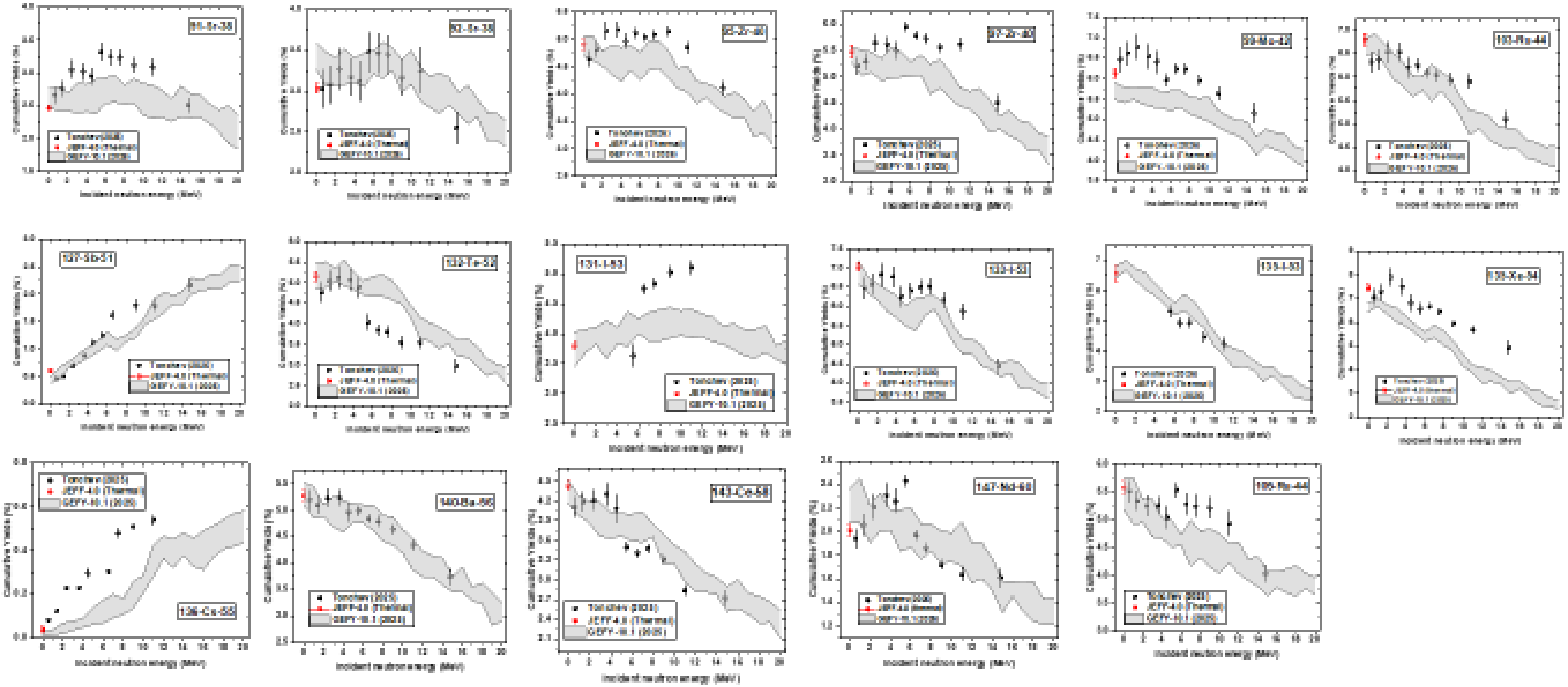
- JEFF-4.0 Fission yields evaluations, on going



Overview of the 17 Cumulative Fission Products yields measured by Tonchev



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Context: methodology of FY Evaluation for fast neutron induced fission

$(nt_h,, f) \Longrightarrow$ | $Y(A^*|nt_h) \cdot P(Z|A^*, n_{th})$ → $P(\nu|A^*, n_{th})$ → $Y(A, Z|nth)$ → $C(A, Z, m|nt_h)$

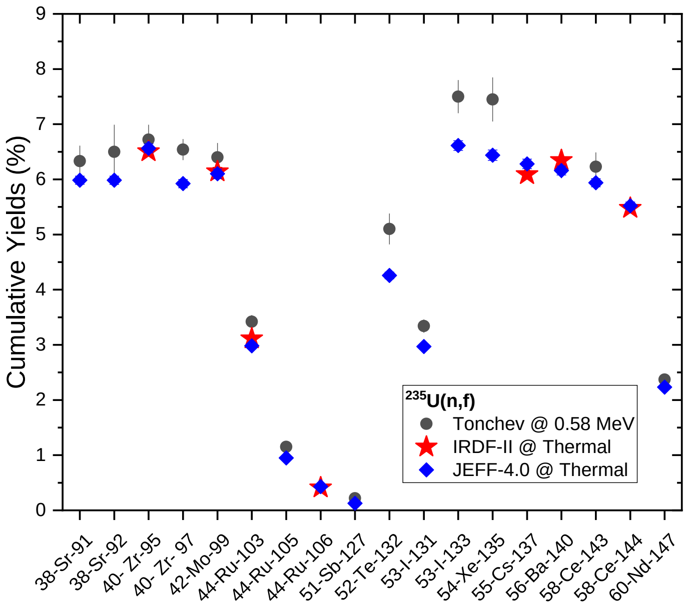
« 2E » & « 2E-2V » Pheno. Models (Brosa-like)

Pheno. Models (Wahl-like)

Pheno. Models (FIFRELIN, GEF, CGMF, FREYA)

Major experimental data

$(nf_{ast}, f) \Longrightarrow$ | $Y(A^*|nf_{ast}) \cdot P(Z|A^*, E_n)$ → $P(\nu|A^*, E_n)$ → $Y(A, Z|En)$ → $C(A|E_n)$



A. Tonchev et al., Nuclear Data Sheets 202, 12 (2025)