

EAR2 neutron flux evaluation for n_TOF-Phase4

n_TOF Collaboration meeting

Valencia

22.11.2023, CERN

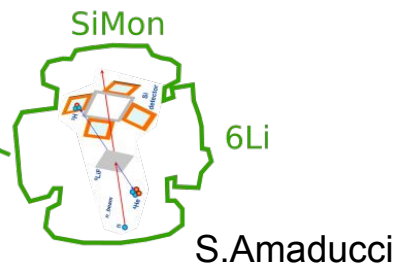
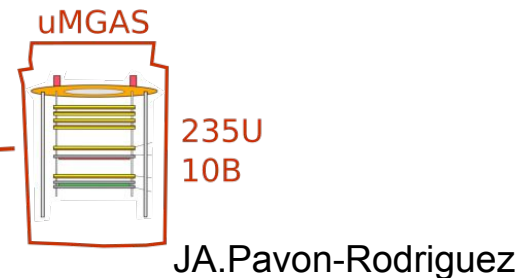
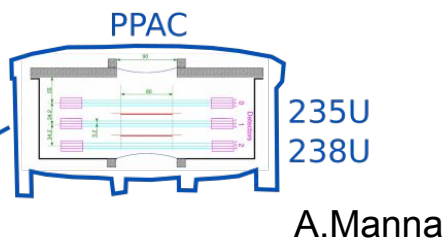
J.A. Pavón-Rodríguez, S.Amaducci, A. Manna, M. Bacak, F. García-Infantes, N. Kyritsis,
E. Musacchio, N. Patronis, M. Sabaté-Gilarte, M.E. Stamati



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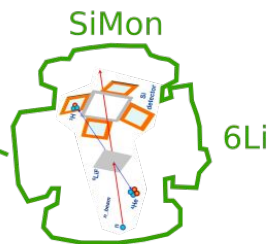
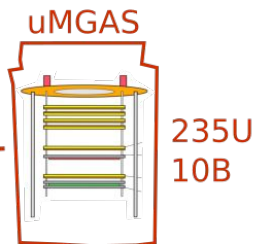
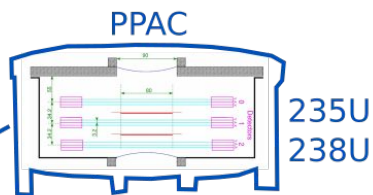
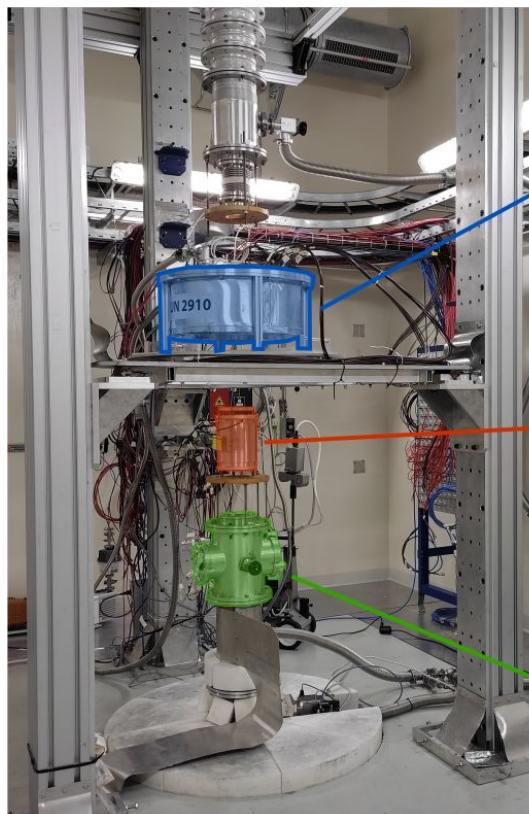
Experimental Setup EAR2



The setup to measure the neutron flux consisted of solid state detectors (SiMon) and gas detectors (uMGAS, PPAC), employing (n, charged-particles) and (n,f) reactions on samples considered as standard.

Detector	Sample	Mass ($\mu\text{g}/\text{cm}^2$)
SiMon	${}^6\text{Li}(n,\alpha)t$	$78.8\pm(2\%)$
uMGAS	${}^{10}\text{B}(n,\alpha){}^7\text{Li}$ ${}^{235}\text{U}(n,f)$	$4.9\pm(20\%)$ $117.6\pm(0.4\%)$
PPAC	${}^{238}\text{U}(n,f)$ ${}^{235}\text{U}(n,f)$	not characterised $280\pm(<1\%)$

Experimental Setup EAR2

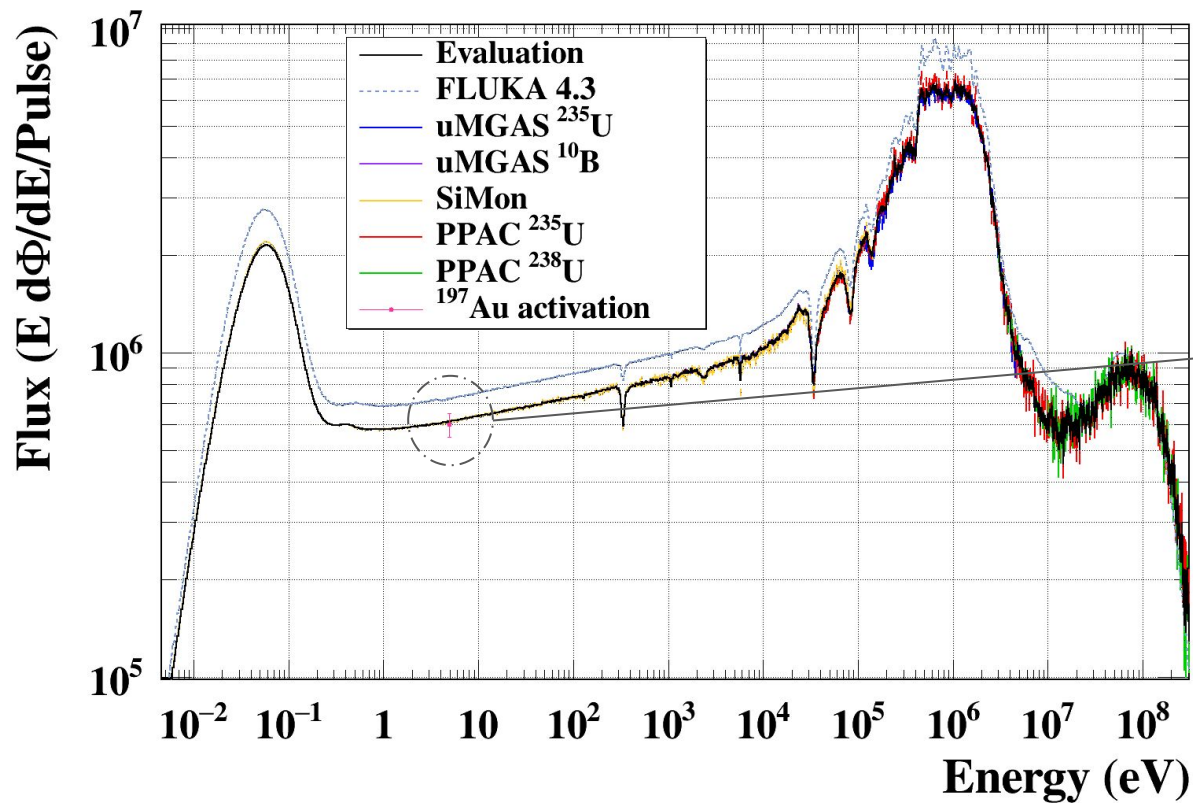


Samples used for each energy range of the final evaluation:

Energy range [eV]	SiMon	uMGAS		PPAC	
	⁶ Li	¹⁰ B	²³⁵ U	²³⁵ U	²³⁸ U
$1 \times 10^{-3} - 3 \times 10^4$	✓	✓	✗	✗	✗
$3 \times 10^4 - 2 \times 10^5$	✓	✗	✓	✓	✗
$2 \times 10^5 - 3 \times 10^6$	✗	✗	✓	✓	✗
$3 \times 10^6 - 5 \times 10^6$	✗	✗	✓	✓	✓
$5 \times 10^6 - 2 \times 10^8$	✗	✗	✗	✓	✓

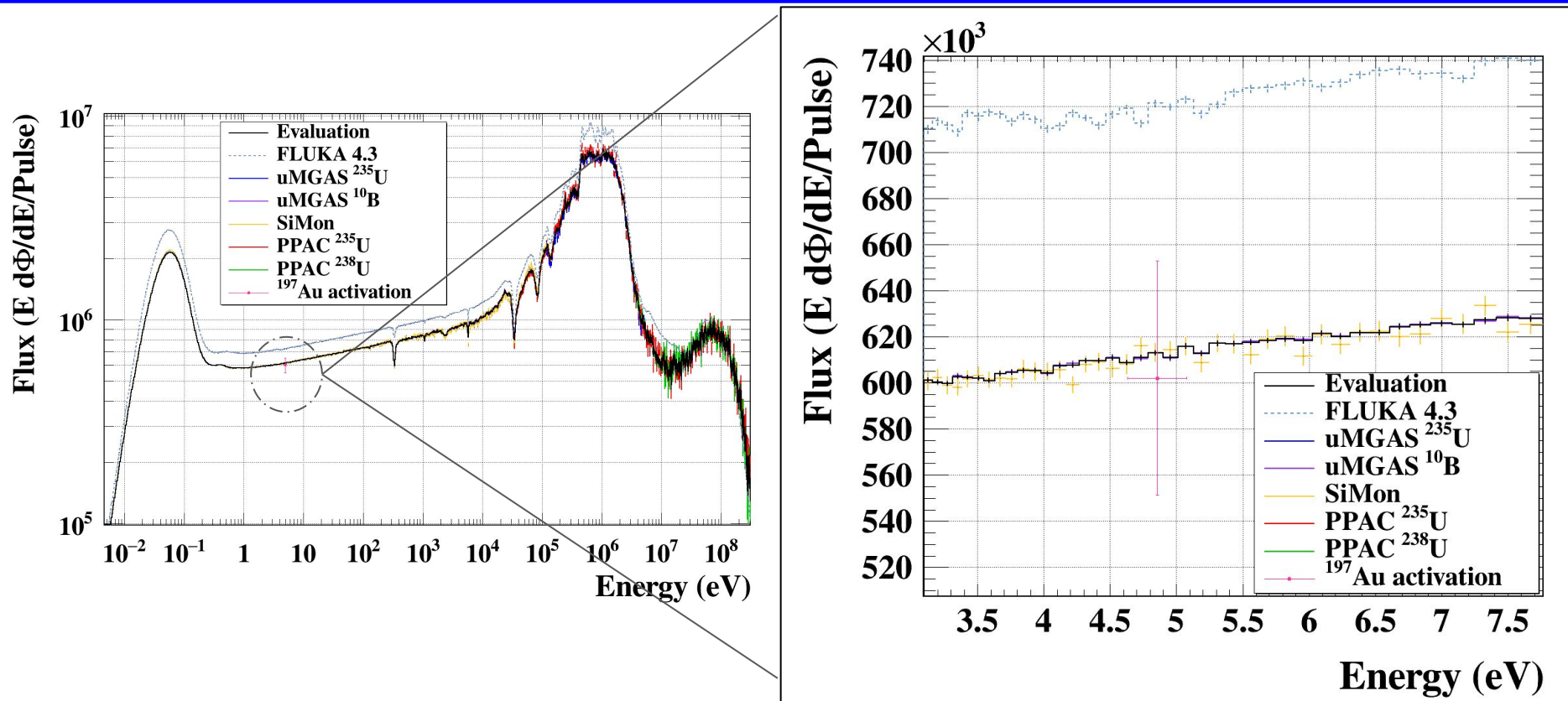
All data sets have been normalised to the integral of PPAC ²³⁵U data between 7.8 eV and 11 eV.

EAR2 evaluated flux and gold activation

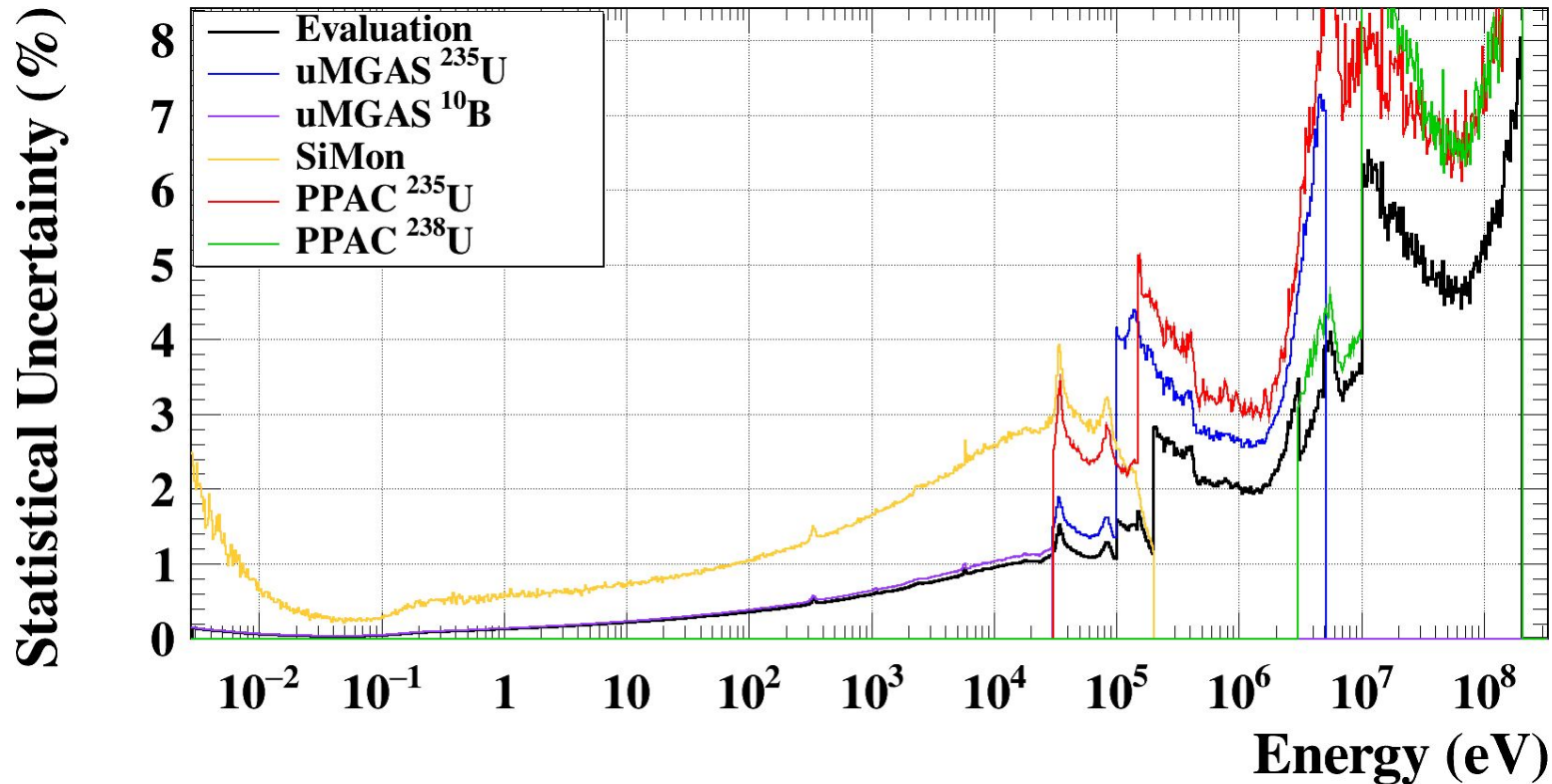


Gold activation matches the evaluated flux within uncertainties

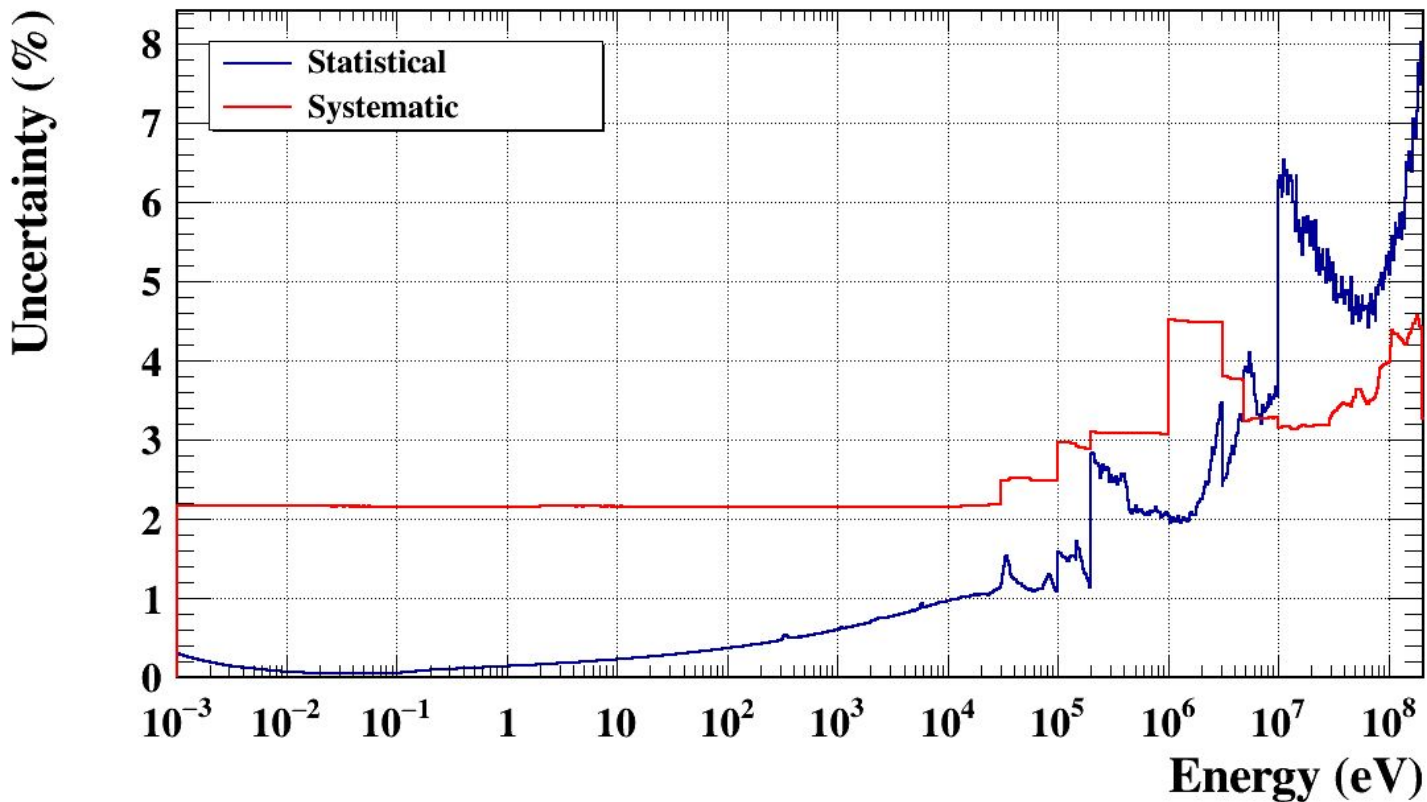
EAR2 evaluated flux and gold activation



Statistical uncertainties in 100 BPD



Flux uncertainties in 100 BPD



Summary

- Flux evaluation:
 - all energy ranges rely at least on two or more detectors/samples.
 - in agreement in $\sim 2\% < 100$ keV and $5\text{-}7\% > 150$ keV.
 - final rootfile with the version presented will be available on CERN lxplus/EOS
 - A paper about EAR2 commissioning is under preparation at the moment

Thank you for your attention!

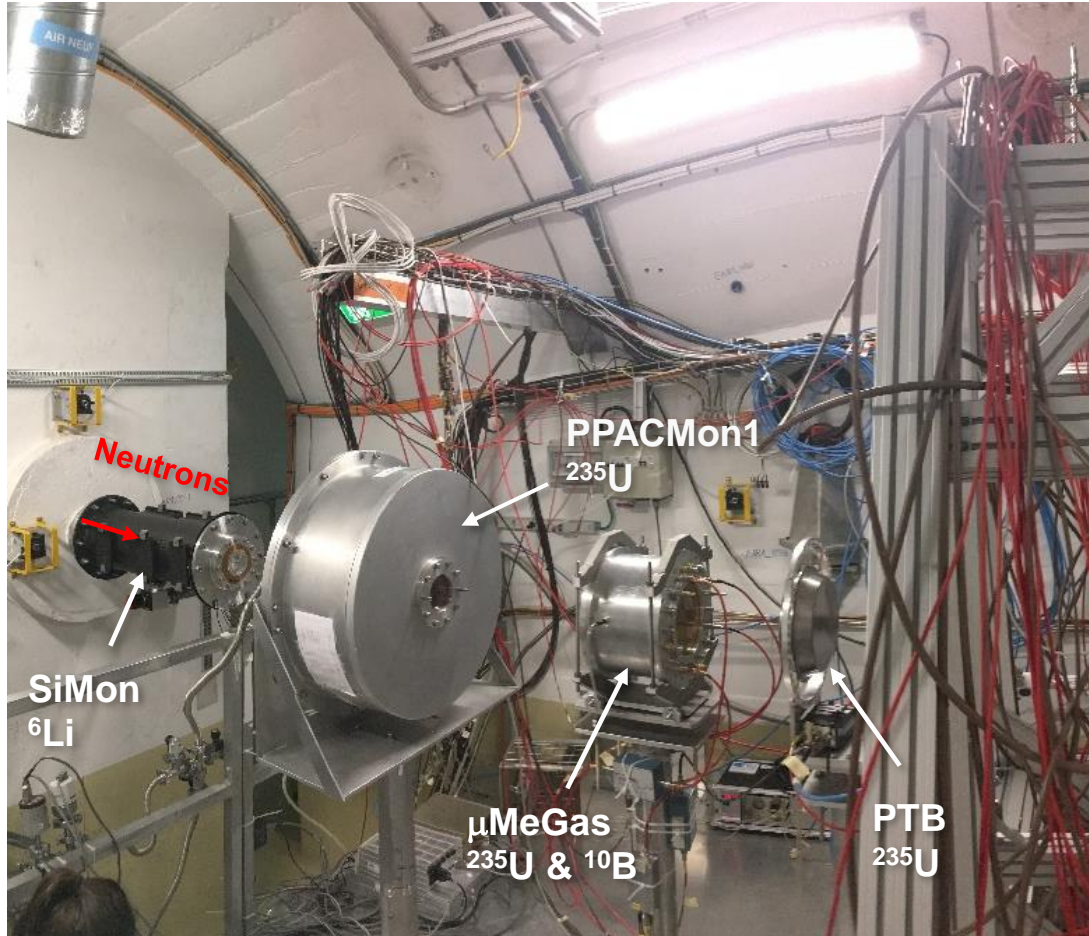




Status of the Phase-4 EAR1 flux evaluation

S. Amaducci, M. Bacak, F. Garcia-Infantes, N. Kyritsis, A. Manna, E. Musacchio, N. Patronis, J. Pavon-Rodriguez, M. Sabate-Gilarte, M. E. Stamati, R. Zarrella

Flux setup



+ Gold foil activation

	Reaction(s)	Mass ($\mu\text{g}/\text{cm}^2$)	Energy Rol (eV)
SiMon	${}^6\text{Li}(n,\alpha){}^3\text{H}$	600 (95% ${}^6\text{LiF}$) ($\pm 20\%$)	$25 \cdot 10^{-3} - 10^6$
PPACMon1	$2x {}^{235}\text{U}(n,f)$	278.5 ($\pm 1\%$) 298.4 ($\pm 1\%$)	$25 \cdot 10^{-3}$ $0.15 \cdot 10^6 - 10^9$
μMeGas	${}^{10}\text{B}(n,\alpha){}^7\text{Li}$	24.5 (80% ${}^{10}\text{B}_4\text{C}$) ($\pm 20\%$)	$25 \cdot 10^{-3} - 10^6$
	${}^{235}\text{U}(n,f)$	281.4 ($\pm 1.1 \mu\text{g}/\text{cm}^2$)	$25 \cdot 10^{-3}$ $0.15 \cdot 10^6 - 10^9$
PTB	$10x {}^{235}\text{U}(n,f)$	$10x 444.3 (\pm 1\%)$	$25 \cdot 10^{-3}$ $0.15 \cdot 10^6 - 10^9$
Gold	$2x {}^{197}\text{Au}(n,\gamma)$	50 μm (upstream) 100 μm (downstream)	4.9

Redone with 2x 100 μm
in April 2023

Status of the detectors' analyses

	SiMon	PPACMon1	μ MeGas	PTB	Gold
PSA	✓	✓	✓	✓	n/a
Gain drifts	✓	n/a	✓	✓	n/a
Pile-Up	✓	✓	✓	✓	n/a
Efficiency	✓	✓	✓	✓	✓
HE / anisotr.	n/a	✓	✓	✓	n/a
Transmission	n/a	✓	✓	✓	✓

All data sets fully analysed

Scaling & evaluation ranges

Detectors considered absolute:

- PPAC1
- PTB
- MGAS U5

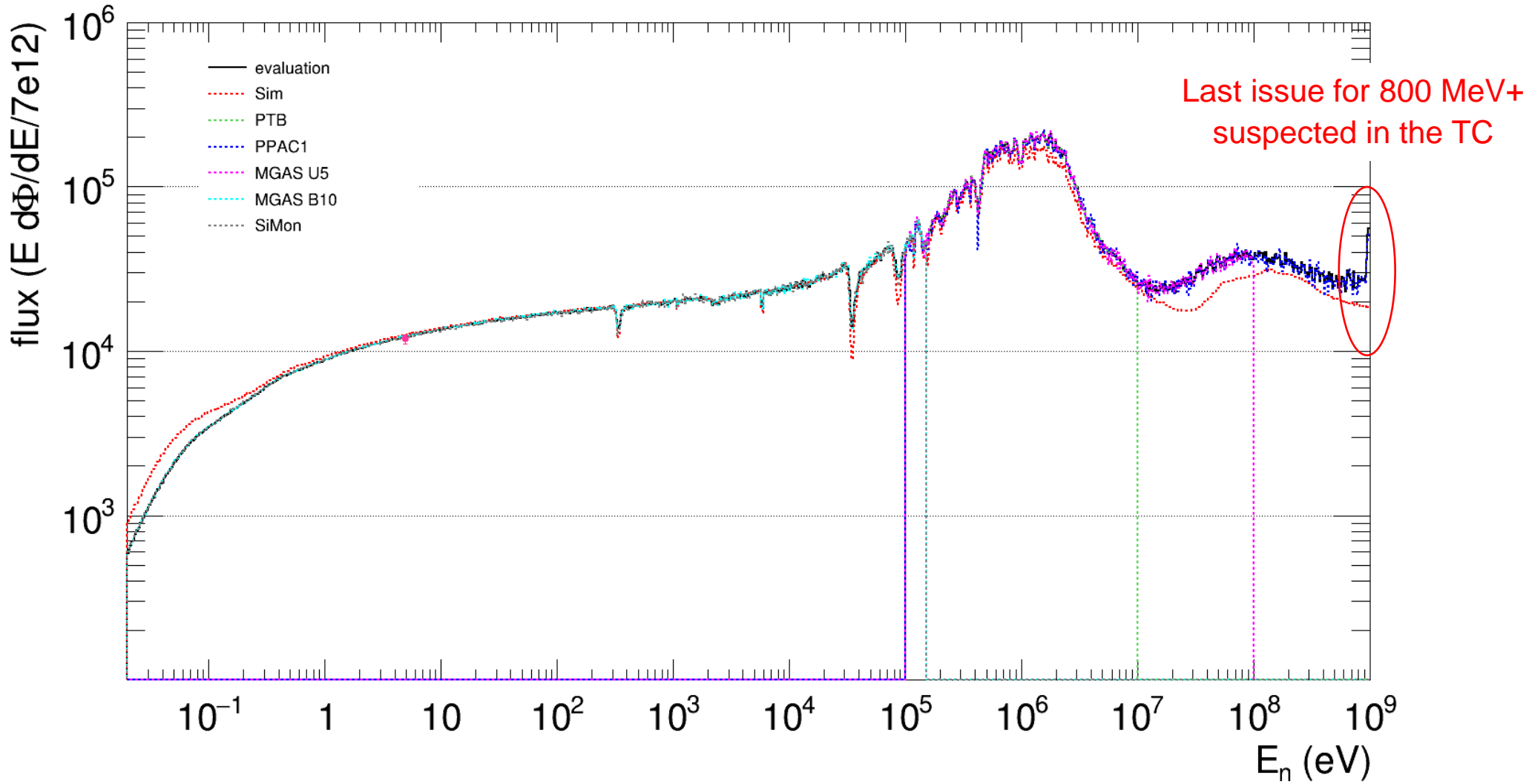
Detectors scaled:

- MGAS B10 scaled to PTB from 0.05 to 0.2 eV
- SiMon scaled to PTB from 0.05 to 0.2 eV

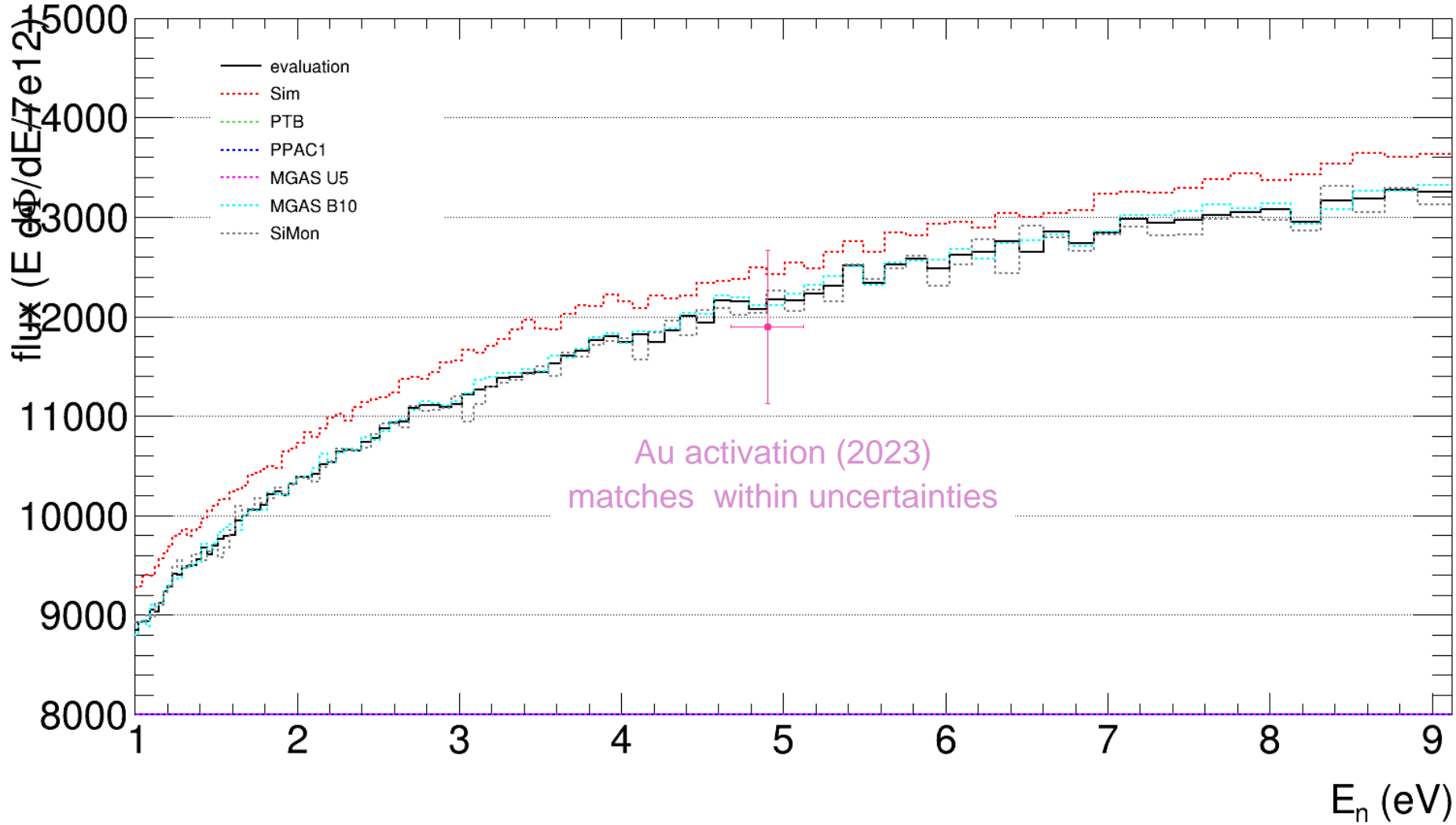
All those detectors agree very well in the low energy range (flat ratios at 1) → **transmission correction**

	0.02 eV – 150 keV	100 keV – 20 MeV	20 MeV – 100 MeV	100 MeV – 1 GeV
PPAC1	not standard	x	x	x
PPAC2	discarded due to broken sample – difficult for efficiency calc.			
PTB	for scaling	x	different trend wrt MGAS U5 (and PPAC)	
MGAS U5	not standard	x	x	
MGAS B10	x (scaled at 0.05-0.2)	up to 150 keV		
SiMon	x (scaled at 0.05-0.2)	up to 150 keV		

Flux per detector



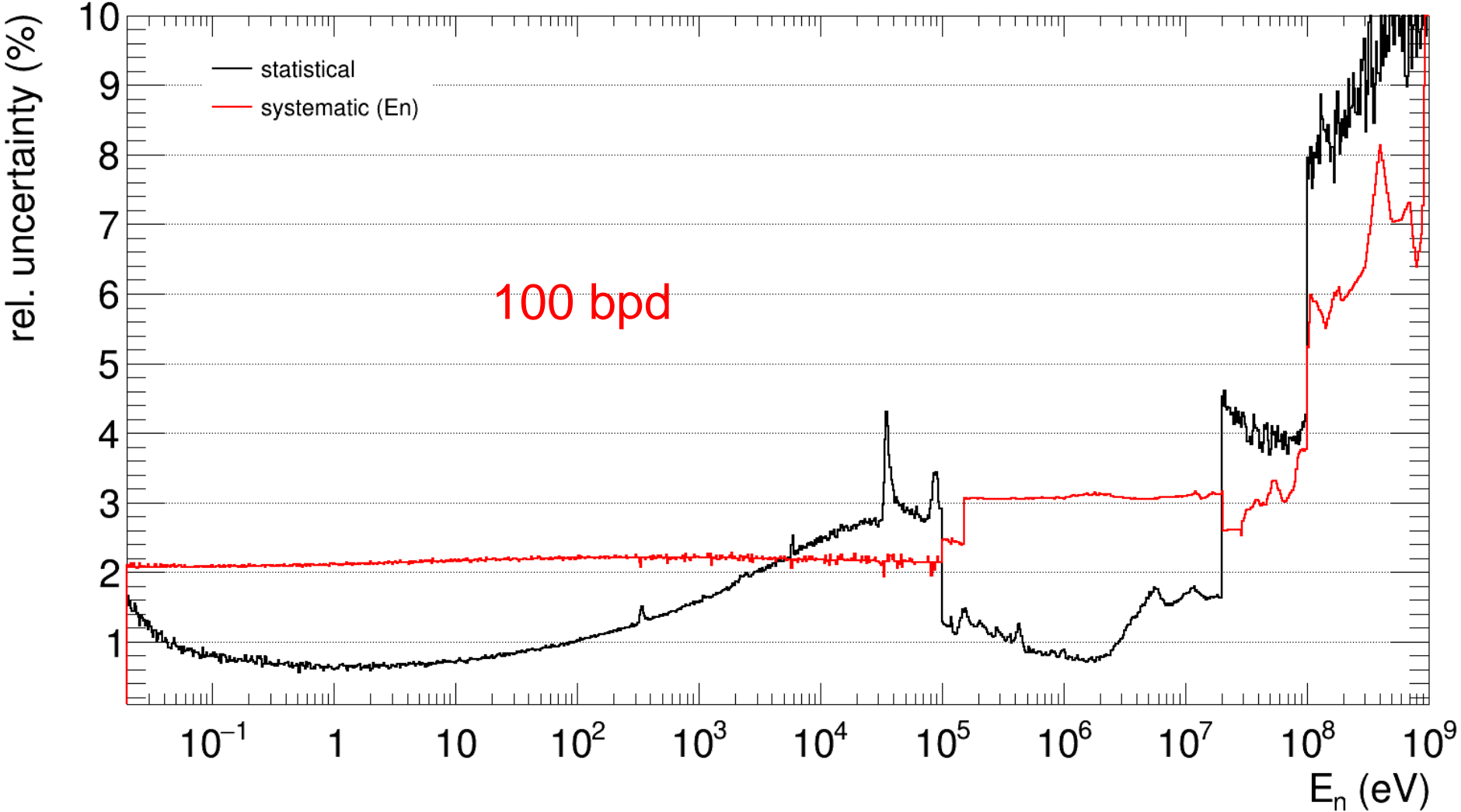
Flux per detector



Systematic uncertainty estimation

- „Energy dependent“ includes:
 - Cuts
 - Angular distribution
 - Dead time
 - High energy (boost and inelastic)
 - A 2% uncertainty in every detector flux from the FLUKA simulations
- **Does not include „flat efficiency“ and mass („scaling“)**
- **Merging based on quadratic summing and merging of different detectors by stat. err. weighing**

Uncertainties (100 bpd)



Summary & Outlook

- **Since May 2023:**

- Detector analyses finished
- Tune evaluation ranges
- Sys. uncertainties
- Au activation analysis & merge/normalization

- **Evaluation performed:**

- < 100 keV agreement within 2%
- > 100 keV agreement within 5%
- Final version of evaluated flux including sys. uncertainty histogram in preparation

latest version (as 05/2023) for use: /eos/experiment/ntof/2021_Commissioning/flux/EAR1/evalFlux_prelim.root

- **To-Do list:**

- 800 MeV+ issue
- EAR1 commissioning paper in preparation

Reminder: low energy region in EAR1 is not trustworthy → change of boron concentration in moderator with time (see F. Garcia-Infantes' talk)

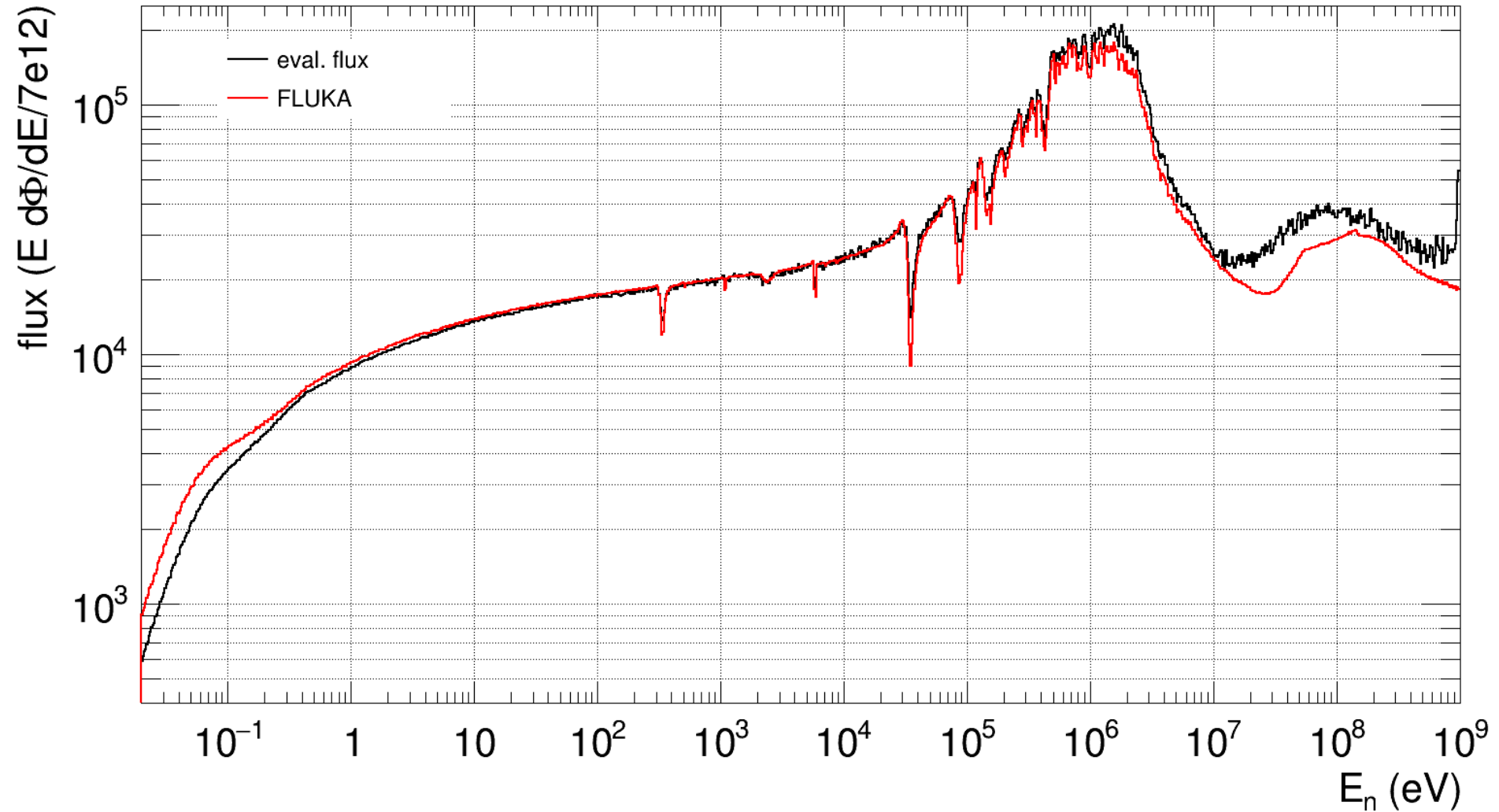


Thanks!

Michael Bacak
michael.bacak@cern.ch



Comparison with simulations



Comparison with simulations – ratio

