Experimental validation of the Resolution Function @ EAR2

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on behalf of the Resolution Function -WG

n_TOF Collaboration Meeting, Edinburgh, 13-14 Dec 2022

RF @ EAR2: Outline

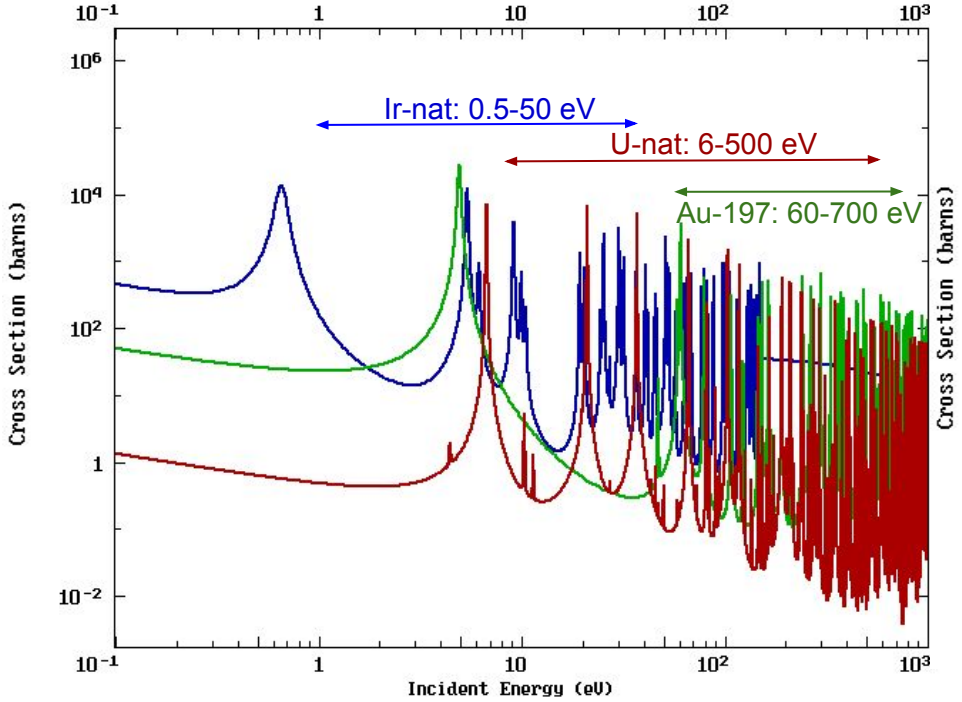
- **Review of status of last meetings**

Links:
Nov ‘21 (JLM)
May ‘22 (ND2022, JAP)

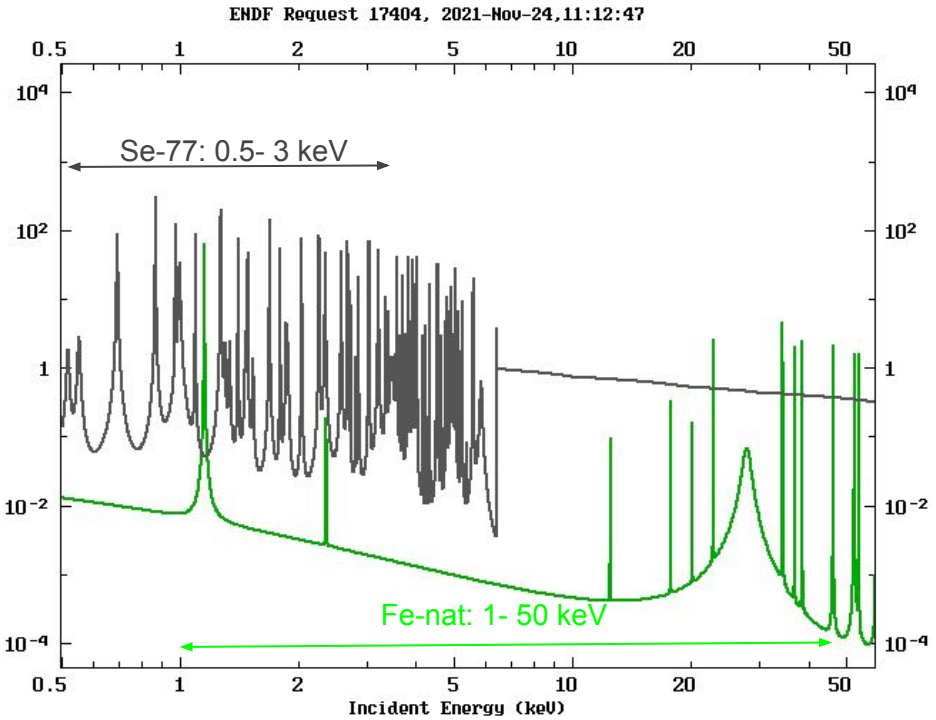
- Recent progress in the data analysis
- RF from FLUKA simulations & transport code
- Analysis with SAMMY
- Results of the validation

Data for the RF @ EAR2: 500 meV - 30 keV

Setup #1: Detectors at 30 cm



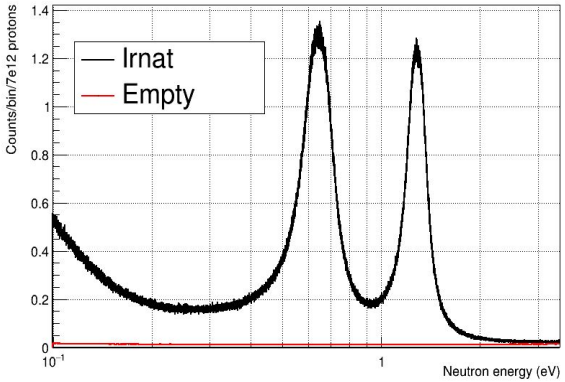
Setup #2: Detectors at 15 cm

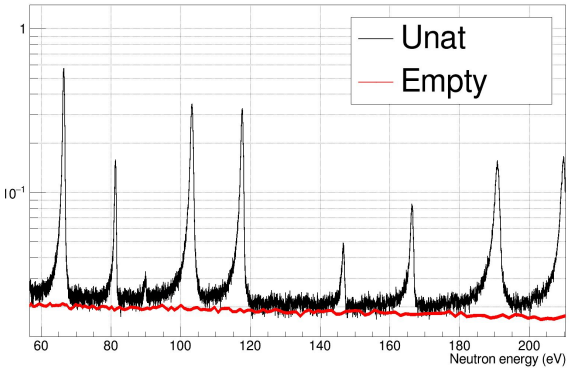


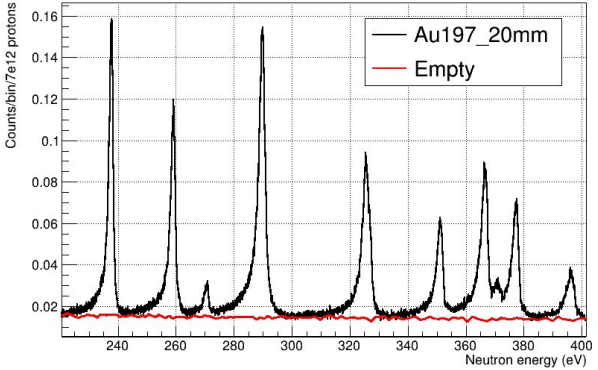
Data for the RF @ EAR2: Setup #1

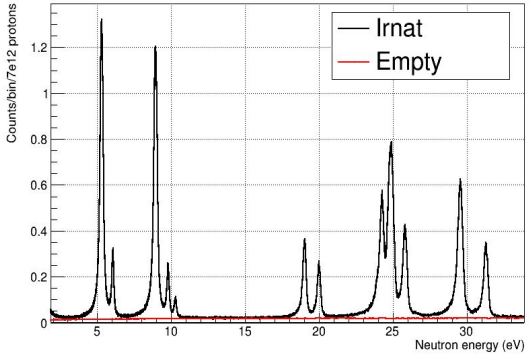
SETUP #1: detectors at 30 cm

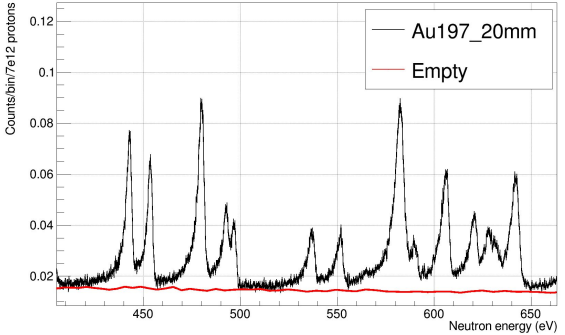
Validation of RF up to 60-600 eV









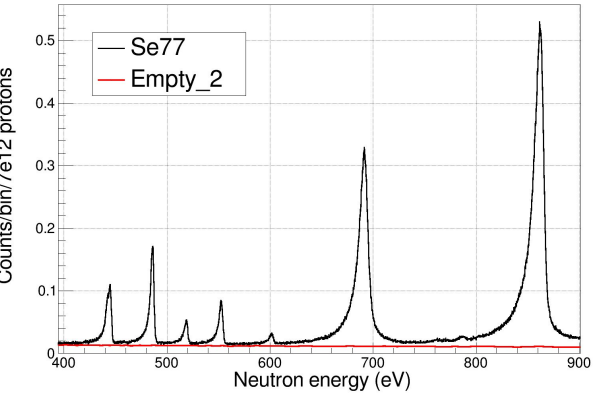


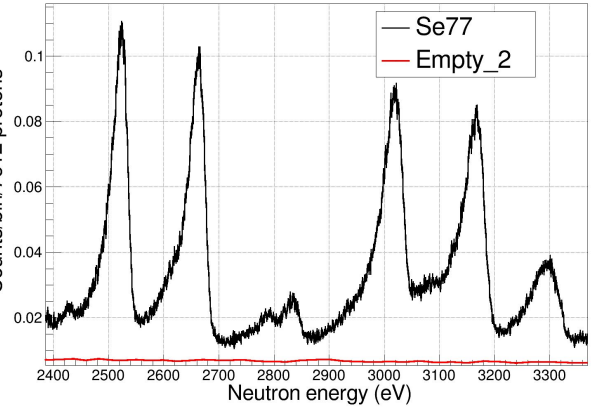
Data for the RF @ EAR2: Setup #2

SETUP #2: detectors at 15 cm

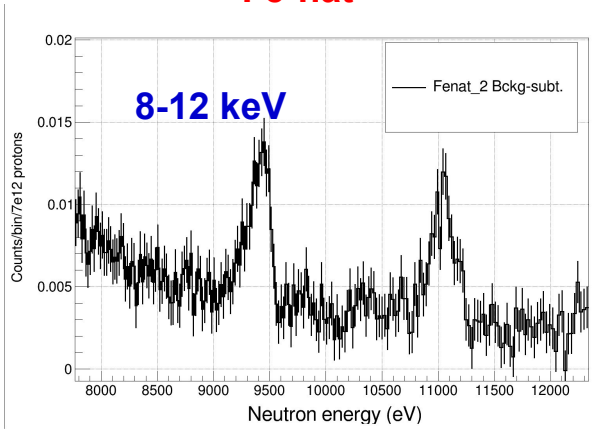
Validation of RF >500 eV

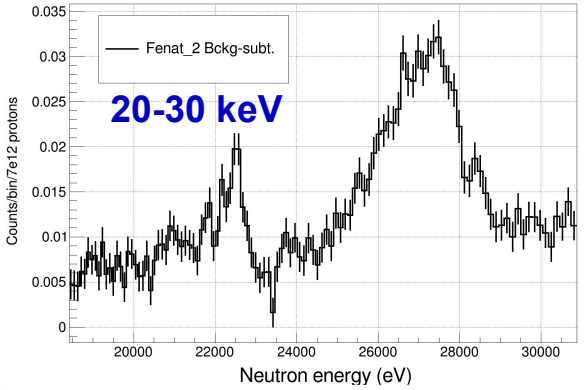
Se-77





Fe-nat

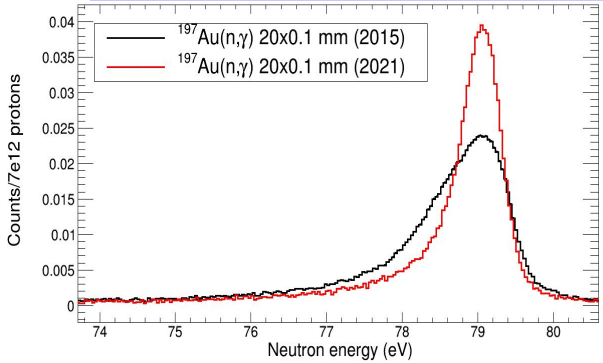


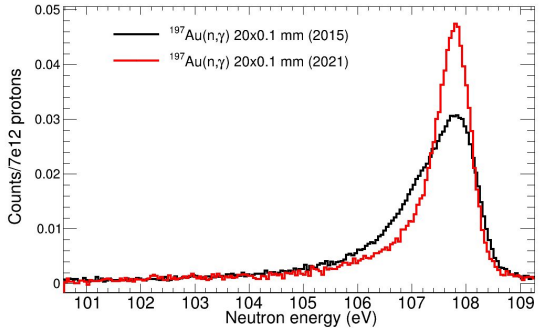


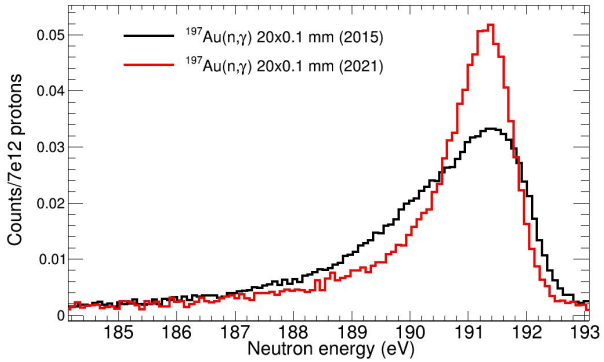
SBR and statistics were limited for Fe-nat

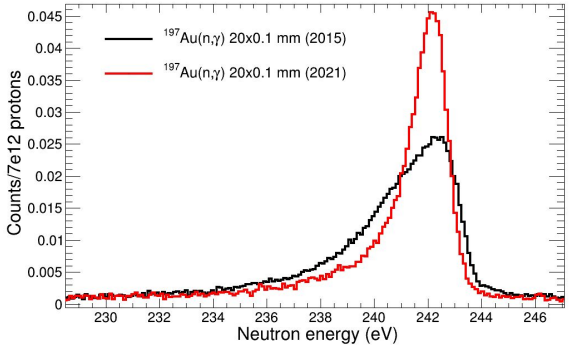
RF @ EAR2: 2015 vs 2021

Same Au-20mmx0.1mm sample (ID = 170)









Normalized to the area of each resonance to compare the shape

Despite the non-final analysis, **the improvement in terms of RF seems clear in different energy ranges**

RF @ EAR2: Status @ last meeting

- (n,g) measurements at EAR2 → RRR in the energy range from 0.5eV to 30 keV.
- Two different setups :
  - Ensure the correct performance of the detectors in terms of C. rates.
  - Sufficient S/B ratio for the samples with resonances in the keV range.
- Up to now: Preliminary analysis & PSA parameters improvement.
- (n,g) data ready to validate the RF in a wide energy range.
- Comparison 2015: RF improved & (now) no significant shape change with small samples.
- Additional: Preliminary confirmed 2-3mm shift of the center of the beam for low energies.

- Final analysis and yield extraction: Preliminary flux shape is required (already available but not yet done)
- FLUKA + MNCP (**now FLUKA v.4.3**) simulations have been improved and massive production are launched
- After simulations are ready: Validation (Time depends on the level of agreement)
  - Direct comparison Exp data vs (n,g) TOF yield from transport code
  - Numerical RF to SAMMY

RF @ EAR2: Outline

- Review of status of last meeting
- **Recent progress in the data analysis**
- RF from FLUKA simulations & transport code
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RF @ EAR2: Progress in data analysis / quality

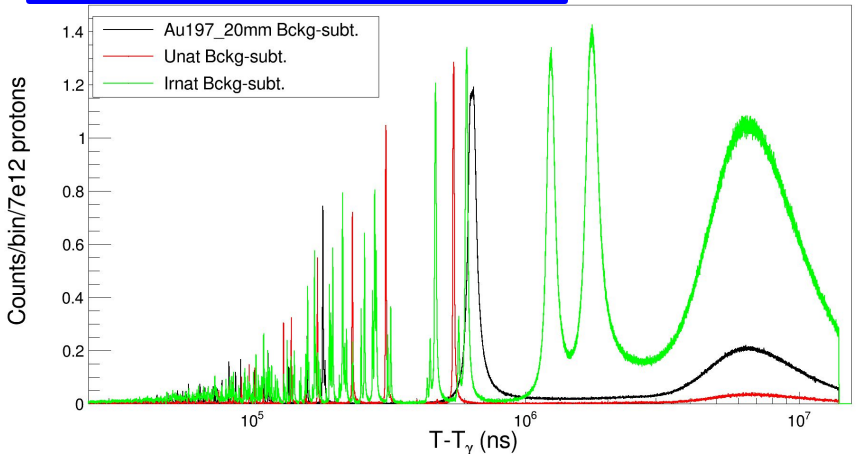
- **Final analysis and yield extraction with preliminary flux shape**

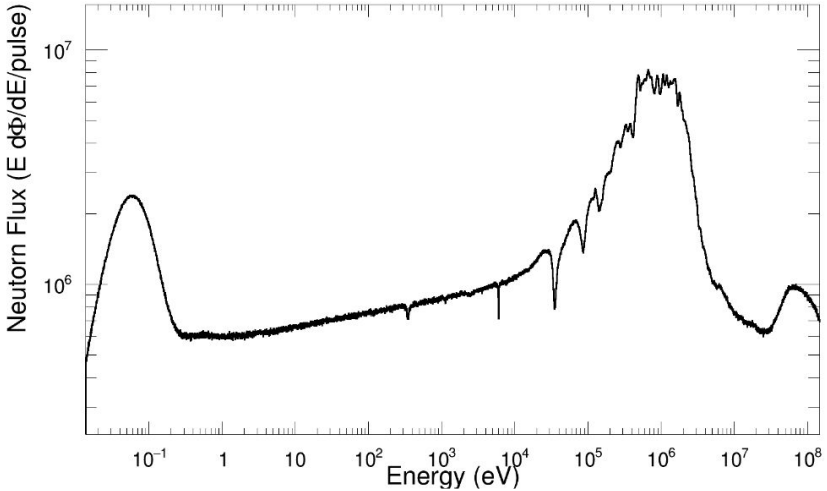
Divide by

Background-subtracted unweighted Counts vs TOF

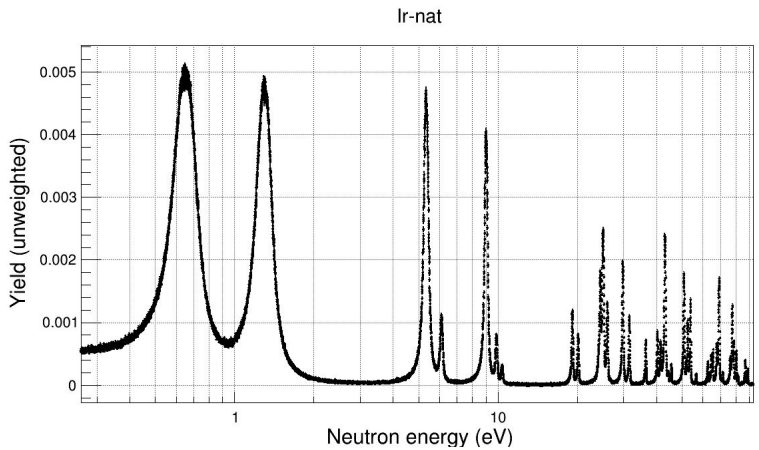
\+ T2E conversion (fixed L_0 = 19.51 m)

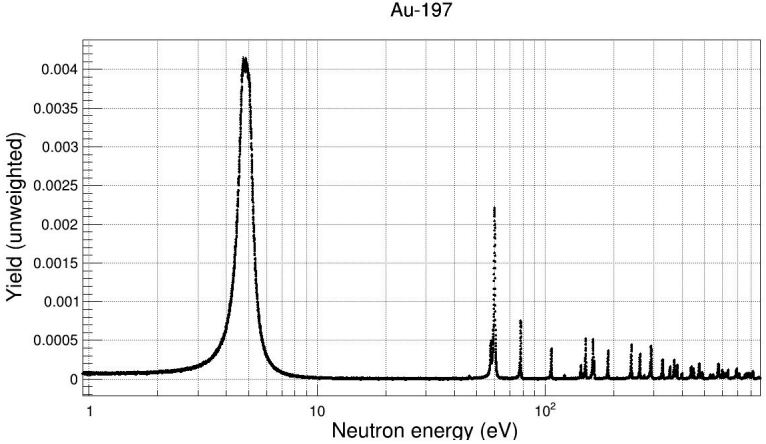
Preliminary Flux shape EAR2

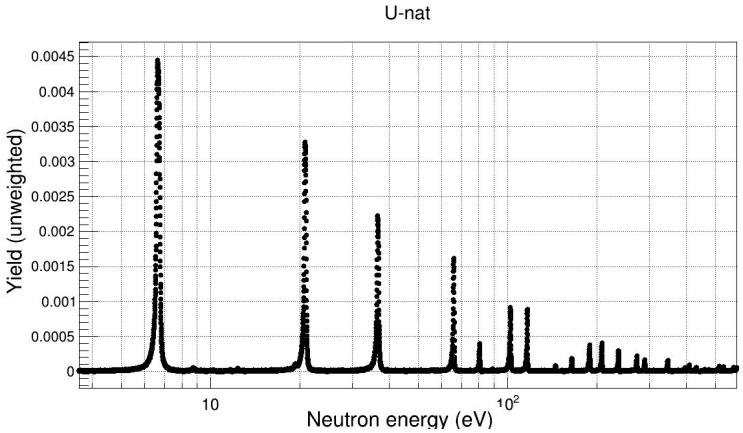


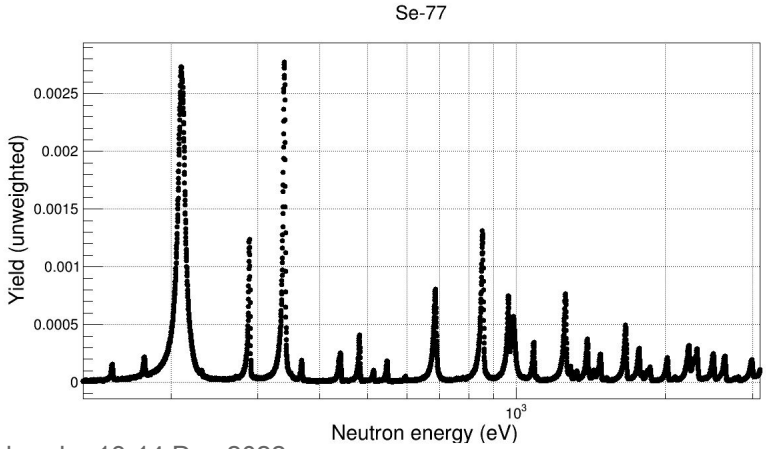


RF @ EAR2: Progress in data analysis / quality









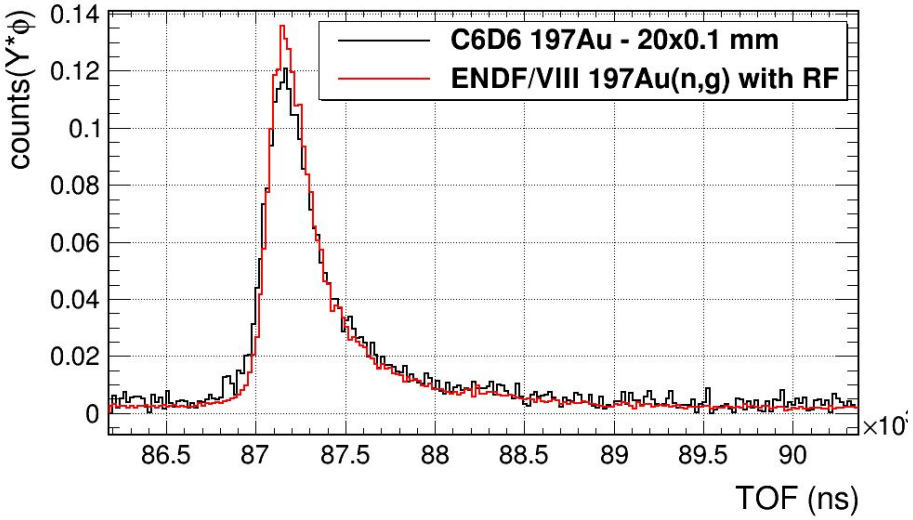
RF @ EAR2: Outline

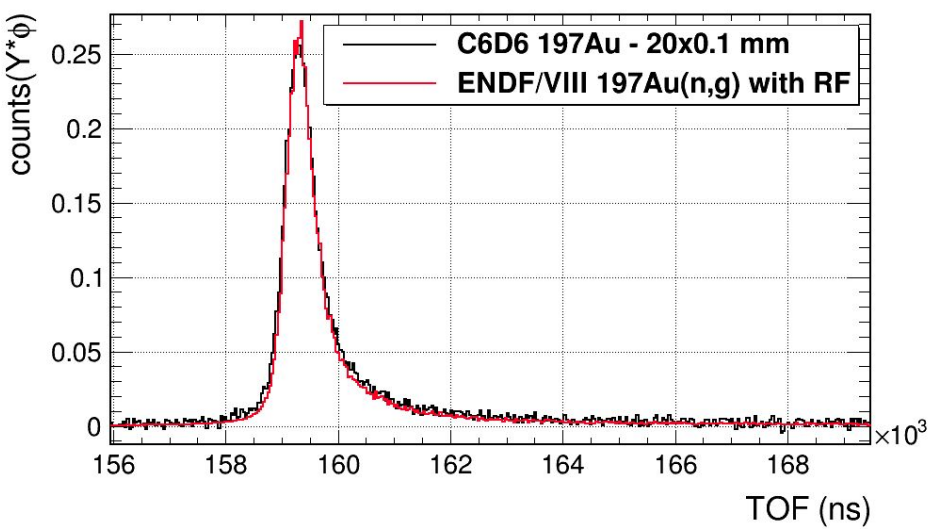
- Review of status of last meeting
- Recent progress in the data analysis
- **RF from FLUKA simulations & transport code**
- Analysis with SAMMY
- Results of the validation

RF @ EAR2: Experiment vs Transport code

Background subtracted c. rates vs TOF vs FLUKA simulations + T. Code

- Extract the flightpath for the RF
- first validation of the RF vs experimental data





Geometrical flightpath (TC) = 19.81 m +
preliminary validation of the RF → good agreement between data & calculation in shape and the tail

RF @ EAR2: Outline

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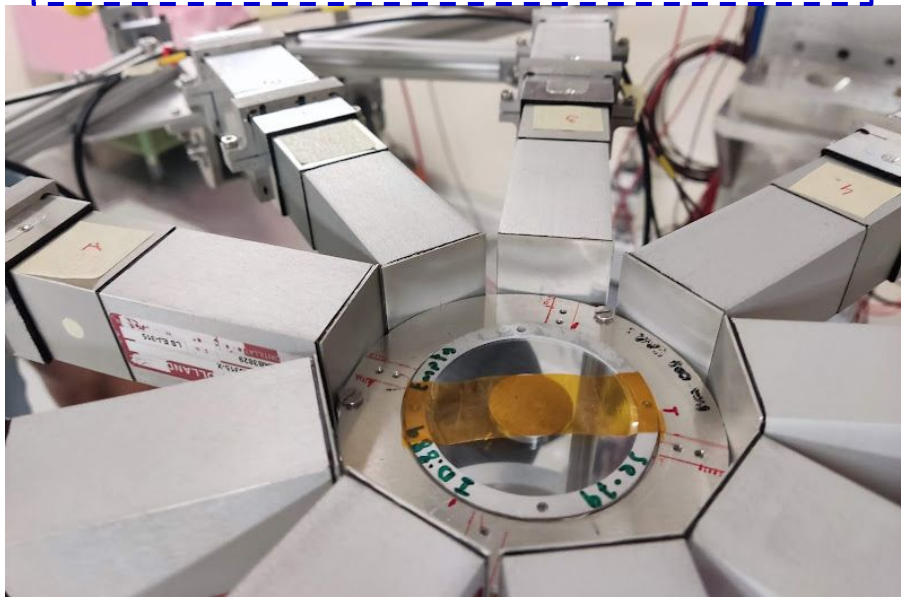
RF @ EAR2: Progress in data analysis / quality

- **Fe-nat re-measured in 2022 with STEDs for higher SBR**

- Same setup than Nb-94,Se-79 campaigns
- 9 sTEDs @ 4.5 cm
- 2 C6D6 @ 17 cm
- 1 LaCl3 @ 9 cm

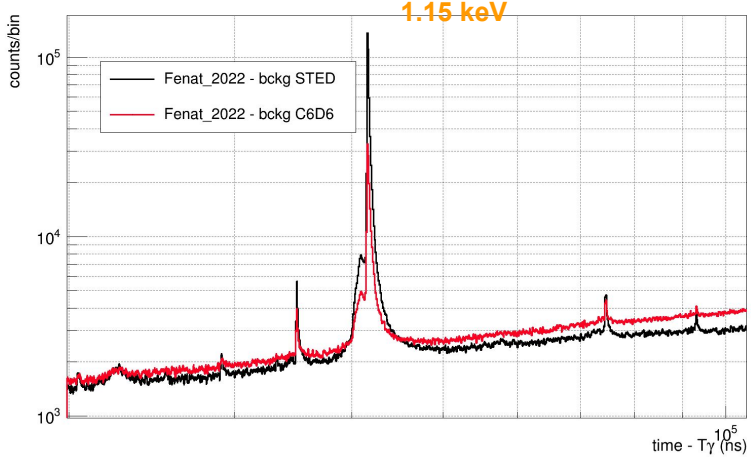
2022 RF Fe-nat measurement :
20 x 2 mm sample mounted on ^{79}Se empty
(2021: 20 x 1 mm)

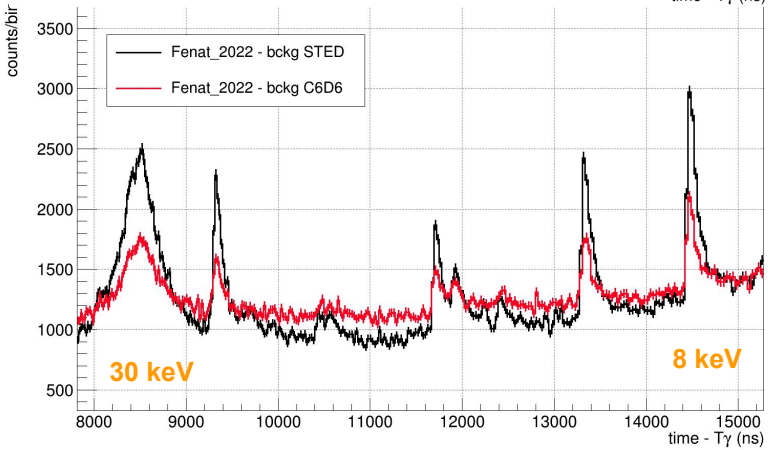


Setup with enhanced efficiency and SBR to improve the quality of the Fe-nat data for the RF @ 10-100 keV

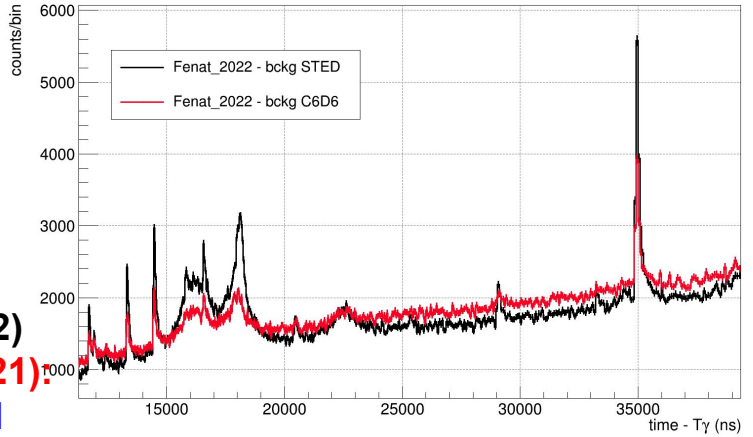
RF @ EAR2: Progress in data analysis / quality

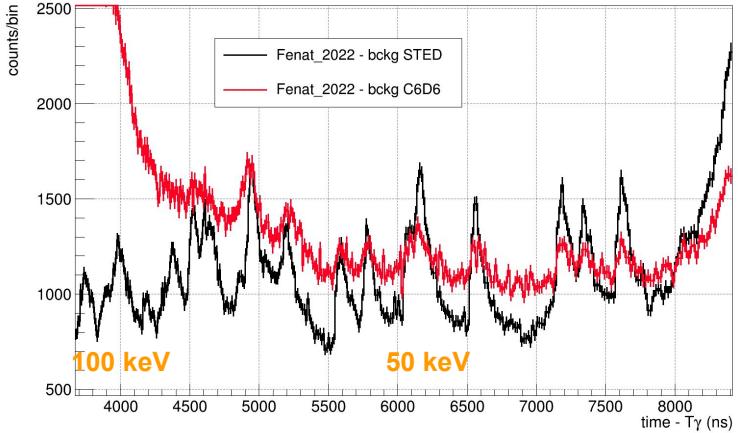
- **Fe-nat re-measured in 2022 with STEDs for higher SBR:**





STED (2022) vs C6D6 (2021): Enhanced SBR!





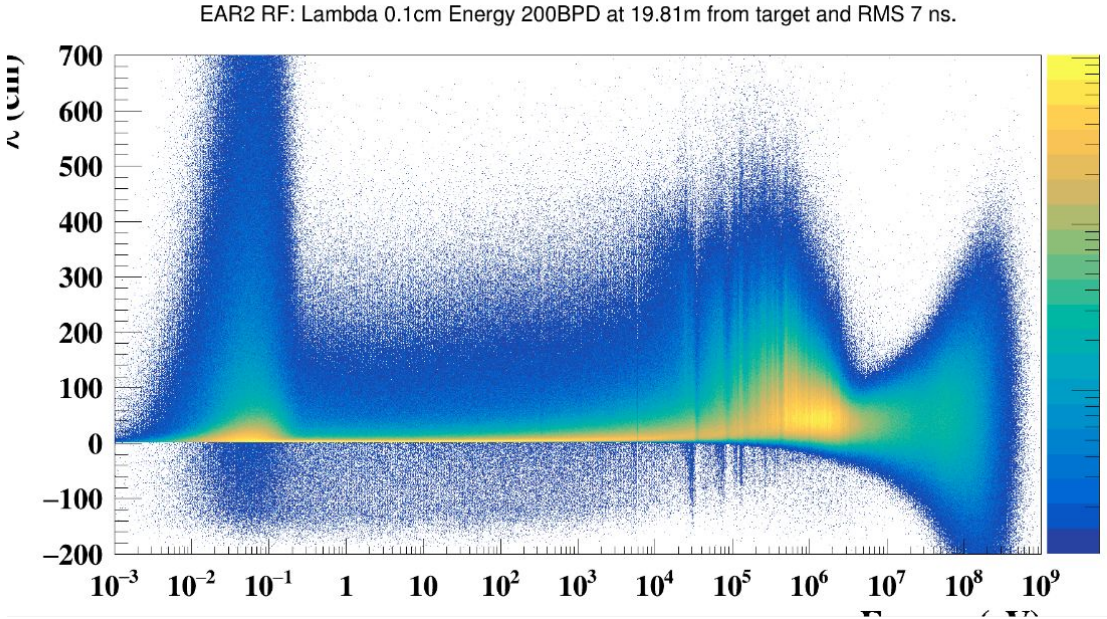
RF @ EAR2: Analysis with SAMMY

1) Prepared input files and data files in SAMMY format:
JEFF-3.3 (+ N. Sosnin et al. for ^{77}Se)

RF WORK DIRECTORY:
/eos/experiment/ntof/2021_Commissioning/RF/

2) **RF (lambda vs E_n) @ 19.81 m (TC)**→ SAMMY (**RF2Sammy**, F. Gunsing)

3) Calculation with SAMMY with **Final RF (200 bpd En, 0.1 cm bin_L)** + Data from RF campaign (2500 bpd)



/eos/experiment/ntof/2021_Commissioning/RF/RF2sammyFolder/EAR2_RF_FLUKAv4.3_all_statistics.root

RF @ EAR2: Analysis with SAMMY

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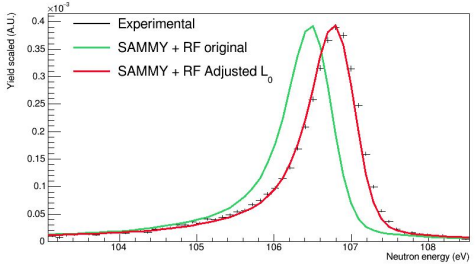
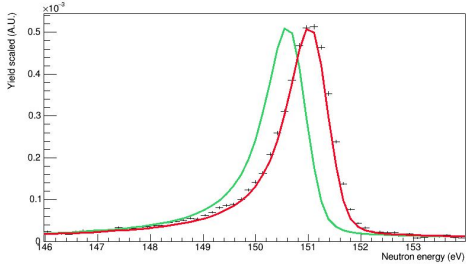
/eos/experiment/ntof/2021_Commissioning/RF/

3) Calculation with SAMMY with Final RF (200 bpd En, 0.1 cm bin_L) + Data from RF campaign (2500 bpd)

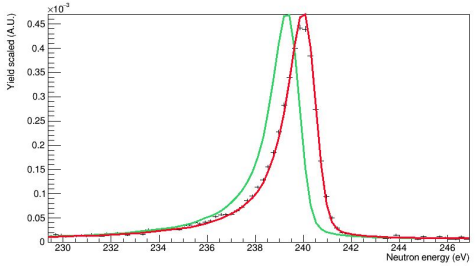
4) **Adjust with SAMMY L_0**:
   a) L_0 initial (used for t2e) = 19.51 m
   b) L_0 fitted with SAMMY

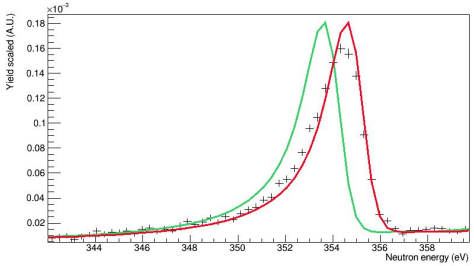
Adjusted L_0 : 19.484 eV





Need to fit down to mm!





RF @ EAR2: Analysis with SAMMY

1) Prepared input files and data files in SAMMY format

RF WORK DIRECTORY:
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2) RF (lambda vs E_n) → SAMMY (RF2Sammy, F. Gunsing)

3) Calculation with SAMMY with Final RF (200 bpd En, 0.1 cm bin_L) + Data from RF campaign (2500 bpd)

4) Adjust with SAMMY L_0:
   a) L_0 initial (used for t2e) = 19.51 m
   b) L_0 fitted with SAMMY

Adjusted L_0 : 19.484 eV

Initial L0			
19.51			
Min Energy Fit	**Max Energy Fit**	**Factor Lo**	**Adjusted L0**
100.000	1000.000	0.99868	19.484
100.000 eV	600.000	0.99862	19.483
200	600.000	0.99871	19.485

5) **Redone the t2e calibration** with the adjusted L_0

6) **Check with SAMMY → Multiplicative factor of L_0 =1**
   a) Multiplication factor fitted with SAMMY

Fitted L_0 value agrees within 2mm for various ranges

Adjusted L0			
19.484			
Min Energy Fit	**Max Energy Fit**	**Factor Lo**	**Adjusted L0**
100.000 eV	1000.000	1.0000	19.484
100.000	600.000	1.0000	19.483
200	600.000	1.0000	19.485

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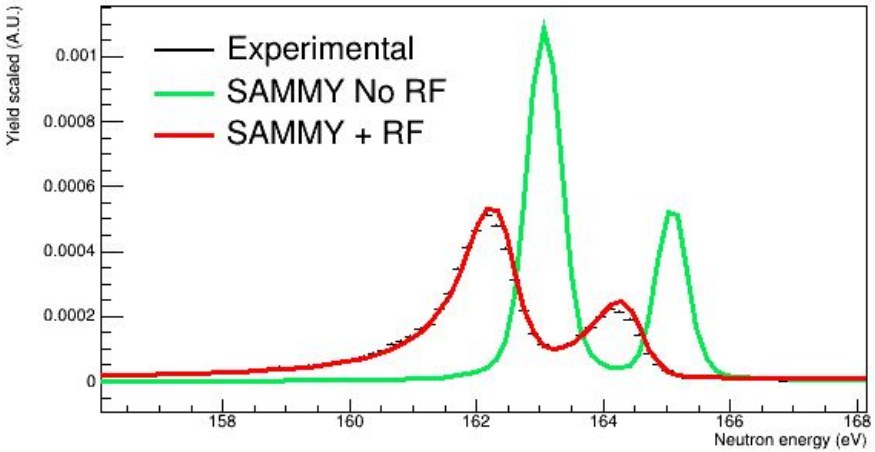
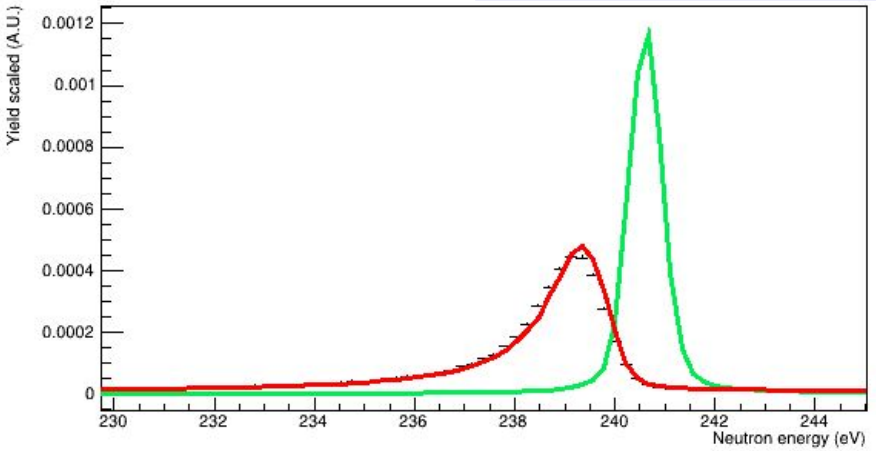
RF @ EAR2: Impact of the RF in SAMMY

^{197}Au (n,g): SAMMY **with** vs **without** RF compared to the experimental data (L_0 adjusted = 19.484 m)

Impact of the RF:
- Broadening
- Shifting energy



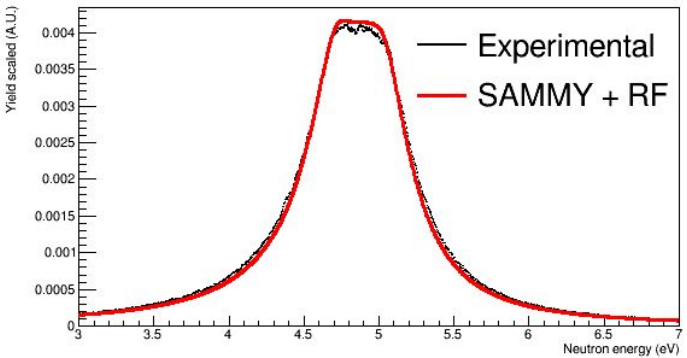


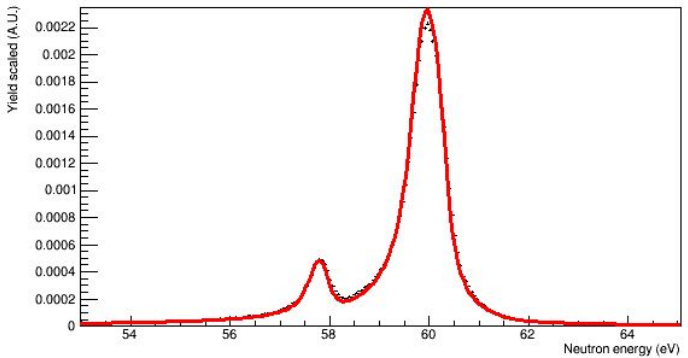
SAMMY recompiled to avoid shifting the RF to lambda mean = 0

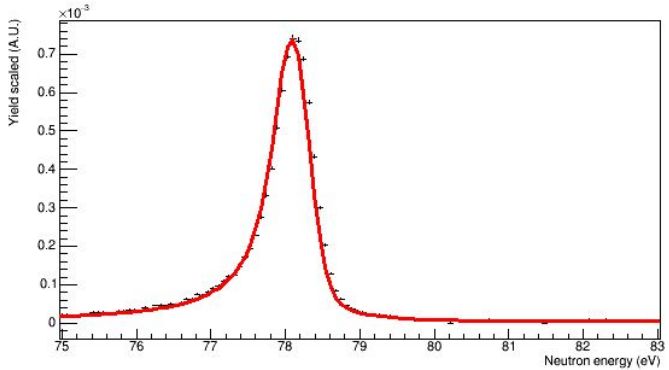
comment line 265 of sammy/src/udr/mudr3.f
Udt_E(J,Nud) = Udt_E(J,Nud) – Ct

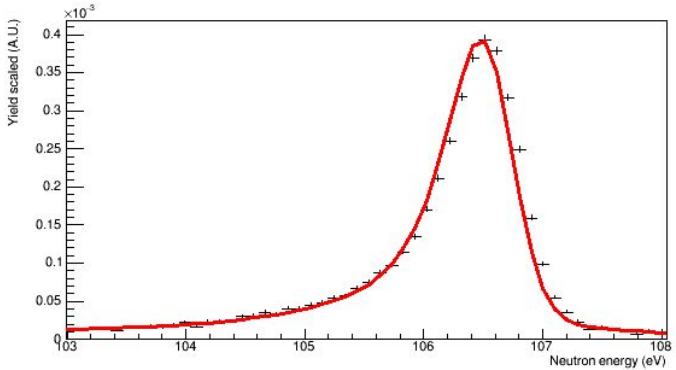
RF @ EAR2: Validation with SAMMY

^{197}Au (n,g): yield normalized between 100 and 250 eV, L_0 =19.484m (adjusted), RF not shifted by SAMMY









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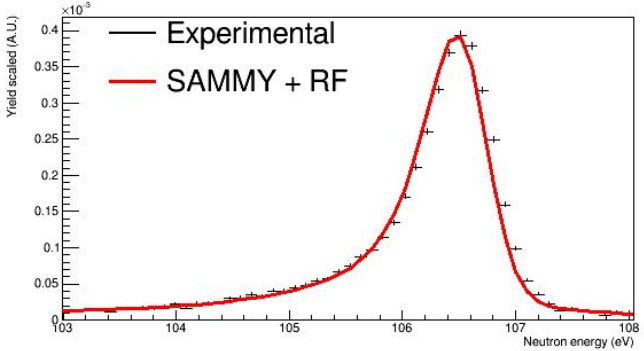
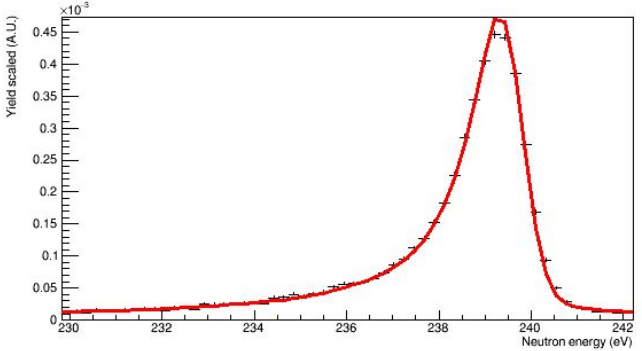
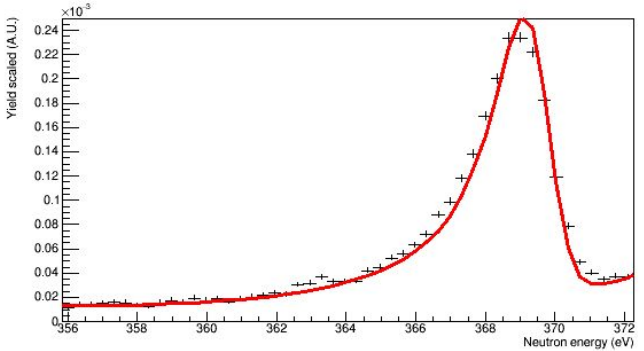
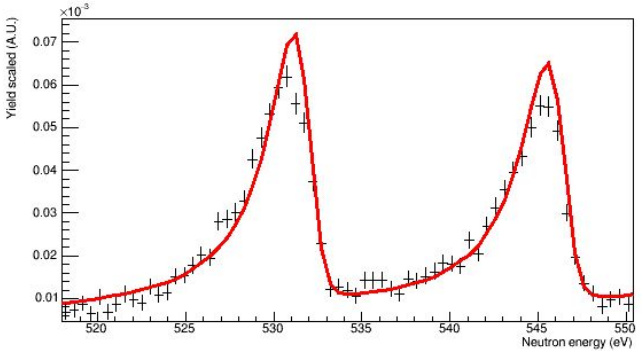


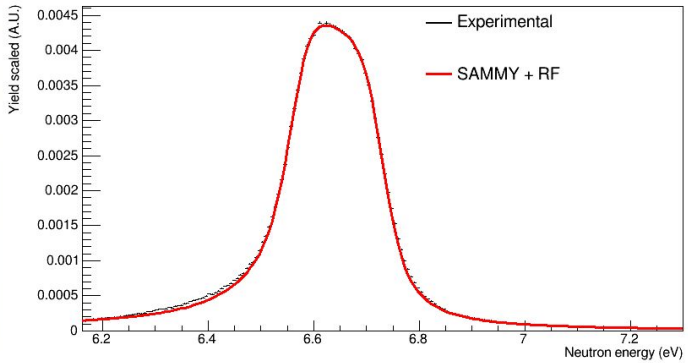


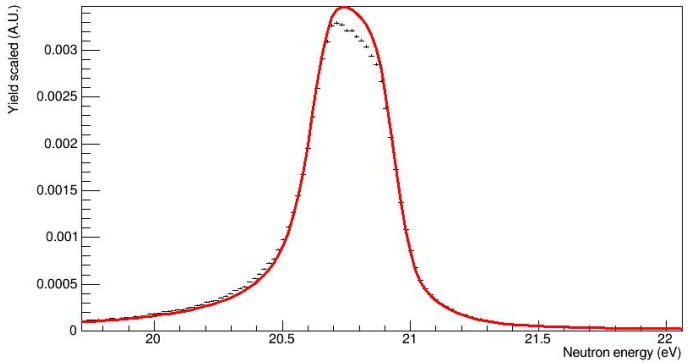


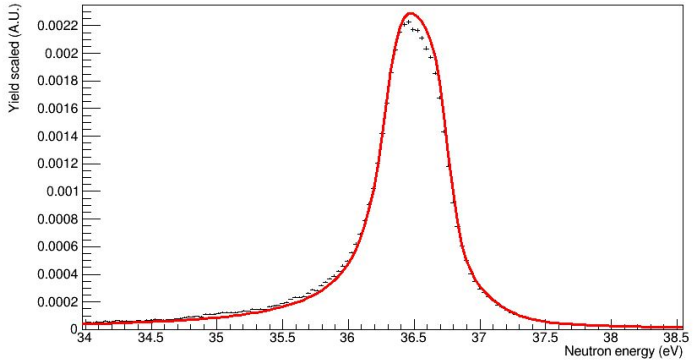


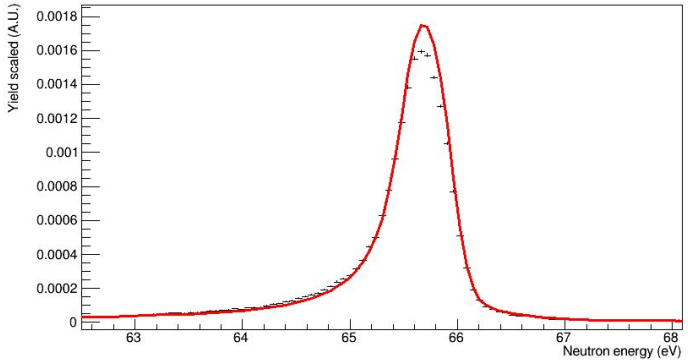
RF @ EAR2: Validation with SAMMY

^{238}U (n,g): yield normalized between 5 and 100 eV, L_0 =19.484m (adjusted with Au), RF not shifted by SAMMY









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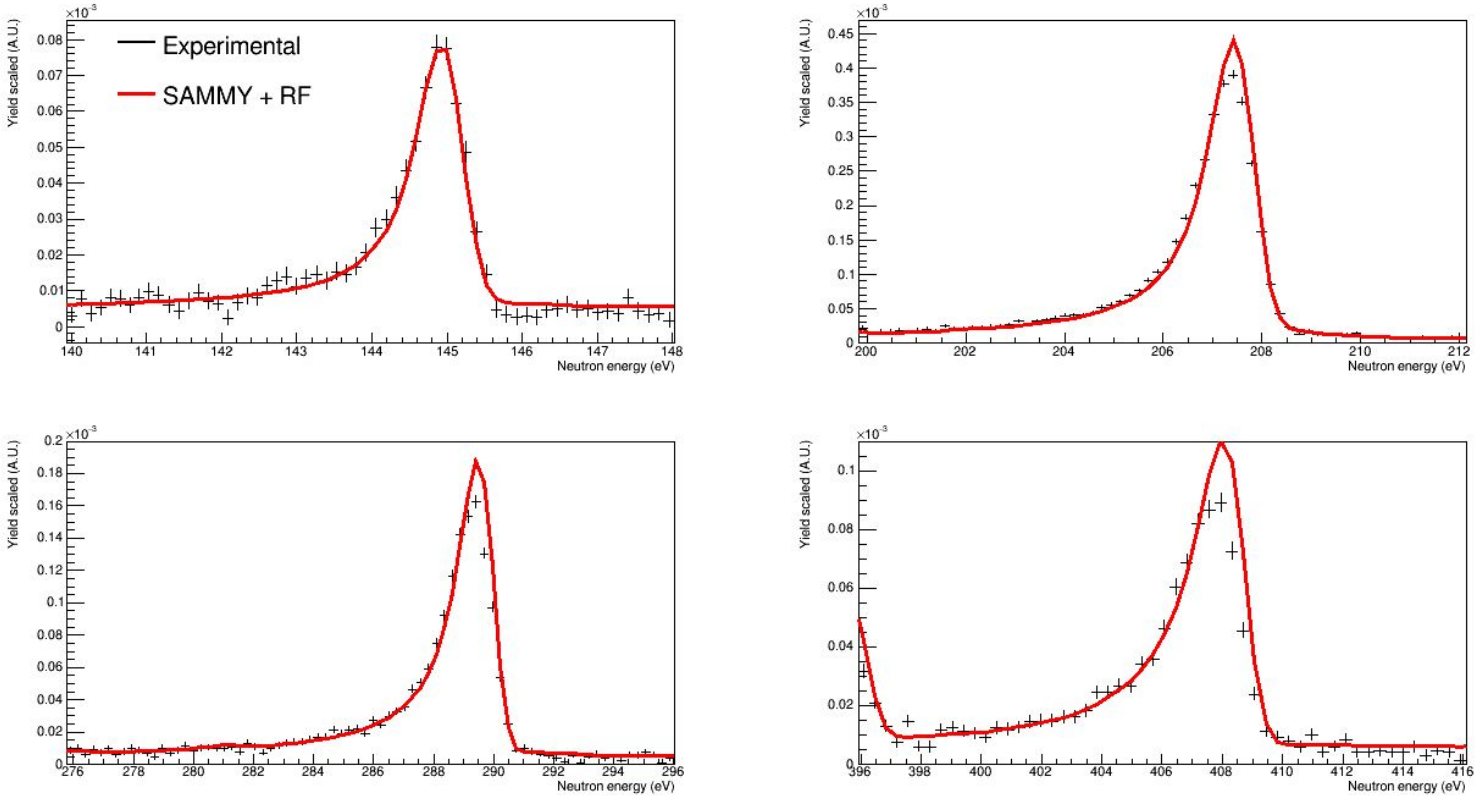

RF @ EAR2: Validation with SAMMY

Validation with ^{197}Au(n,g) and ^{238}U(n,g) up to 600 eV:

- Energy shift of resonances is **fairly** reproduced → Deviation SAMMY+RF vs experiment equivalent to **ΔL~mm**
- Shape of the resonance tails (RF) good reproduced.
- In large resonances and at higher energies → overestimation of peak counts in the calculation
  - RF does reproduce the shape?
  - Non-corrected dead time? → Check & correct with STED data ^{79}Se campaign (parasitic bunches) (2022)

RF @ EAR2: Summary & outlook

- **Summary:**
- Data from few eV up to several tenths of keV. Data quality improved in 2022 with a new measurement of Fe-nat with STEDs.

- FLUKA simulations + Transport → Adjusting the flightpath to extract the RF @ sample position → 19.81 m

- Final RF of EAR2 with full statistics is now available.

- First validation with SAMMY: L_0 = 19.48 m adjusted in the energy range 1-200 eV
- Results for ^{197}Au and ^{nat}: good/fair agreement in the shape up to 500 eV but energy shift is not fully reproduced.

- **Next steps:**
- Understand the small deviation in the resonance energy after adjusting L_0 → RF or methodology with SAMMY?

- Complete the validation with ^{nat}Ir, ^{77}Se and ^{nat}Fe: narrow and isolated resonances <10eV and > 1keV.

- Check if experimental effects such as **dead time** can have an influence to reproduce shape around the maximum. The data of STEDs of 2022 & parasitic bunches will be useful for this purpose.

- Calculate the RF for different small misalignments and check the possible impact in the agreement.

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THANK YOU FOR YOUR ATTENTION!

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