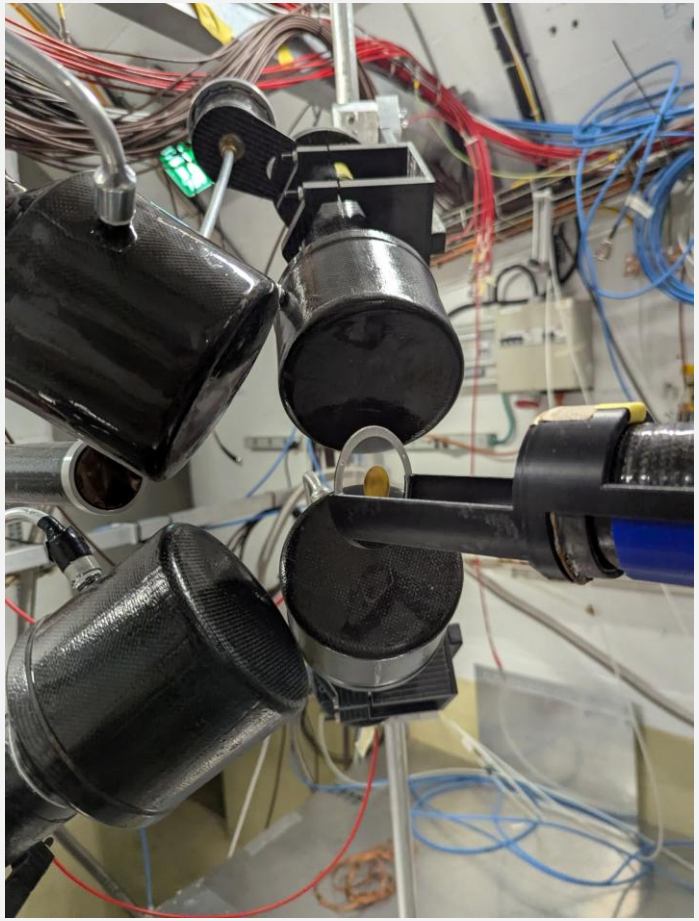
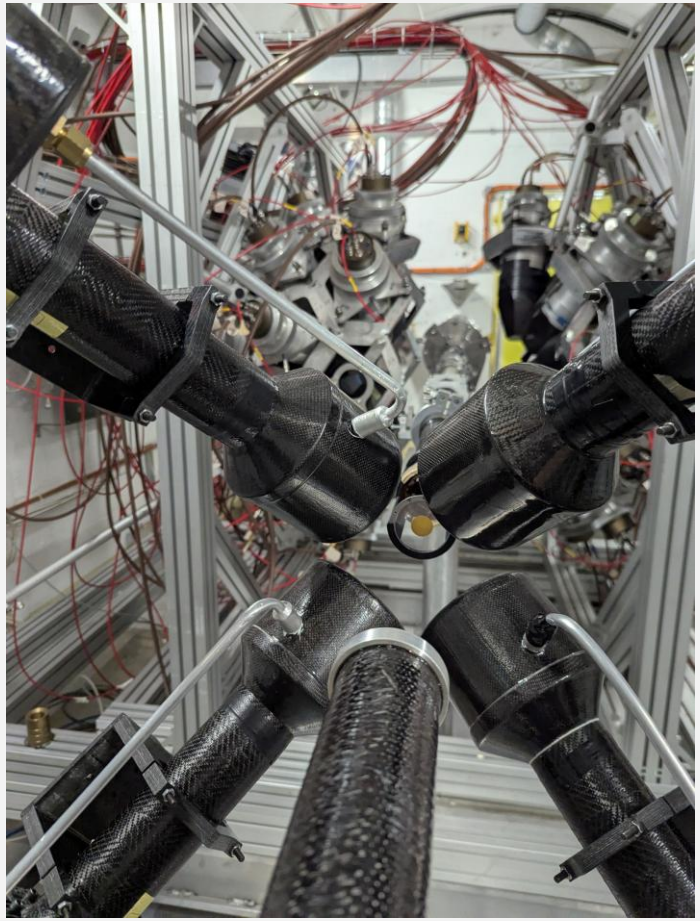
New Mo(n,γ) at EAR1 and EAR2

Importance of molybdenum

- Fission product in nuclear power plants;
- Transport casks, irradiated fuel storage;
- Research reactors and Accident Tolerant Fuels;
- Structural material in fusion reactors;
- Stellar nucleosynthesis;
- Production of ^{99}Tc.

Setup



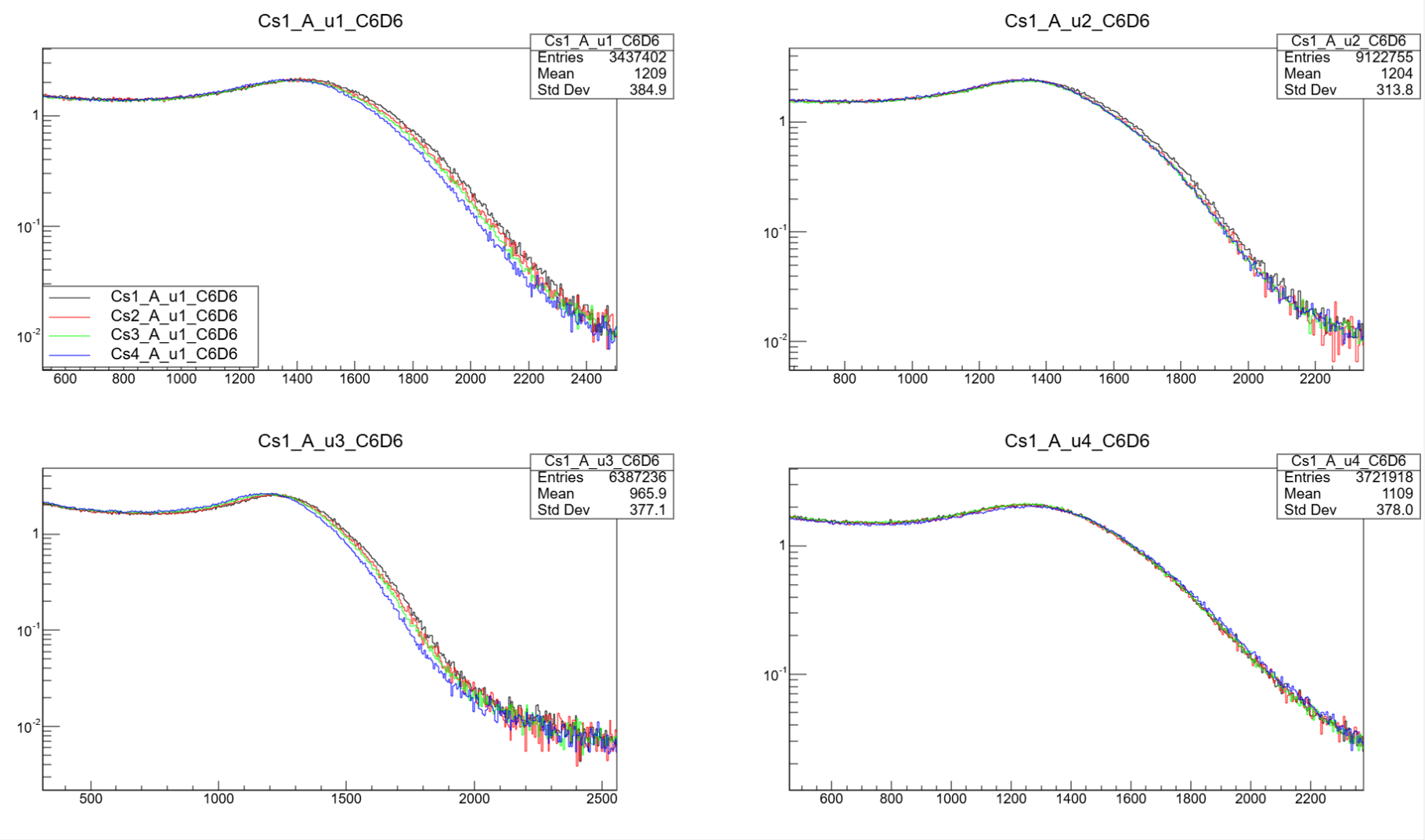


- 4 L6D6 @ 9cm and 135° from sample center;
- 3 new PMT, 1 old PMT;
- Carbon fiber pipes in front and back, using 3D printed sample holder

Sample preparation at n_TOF

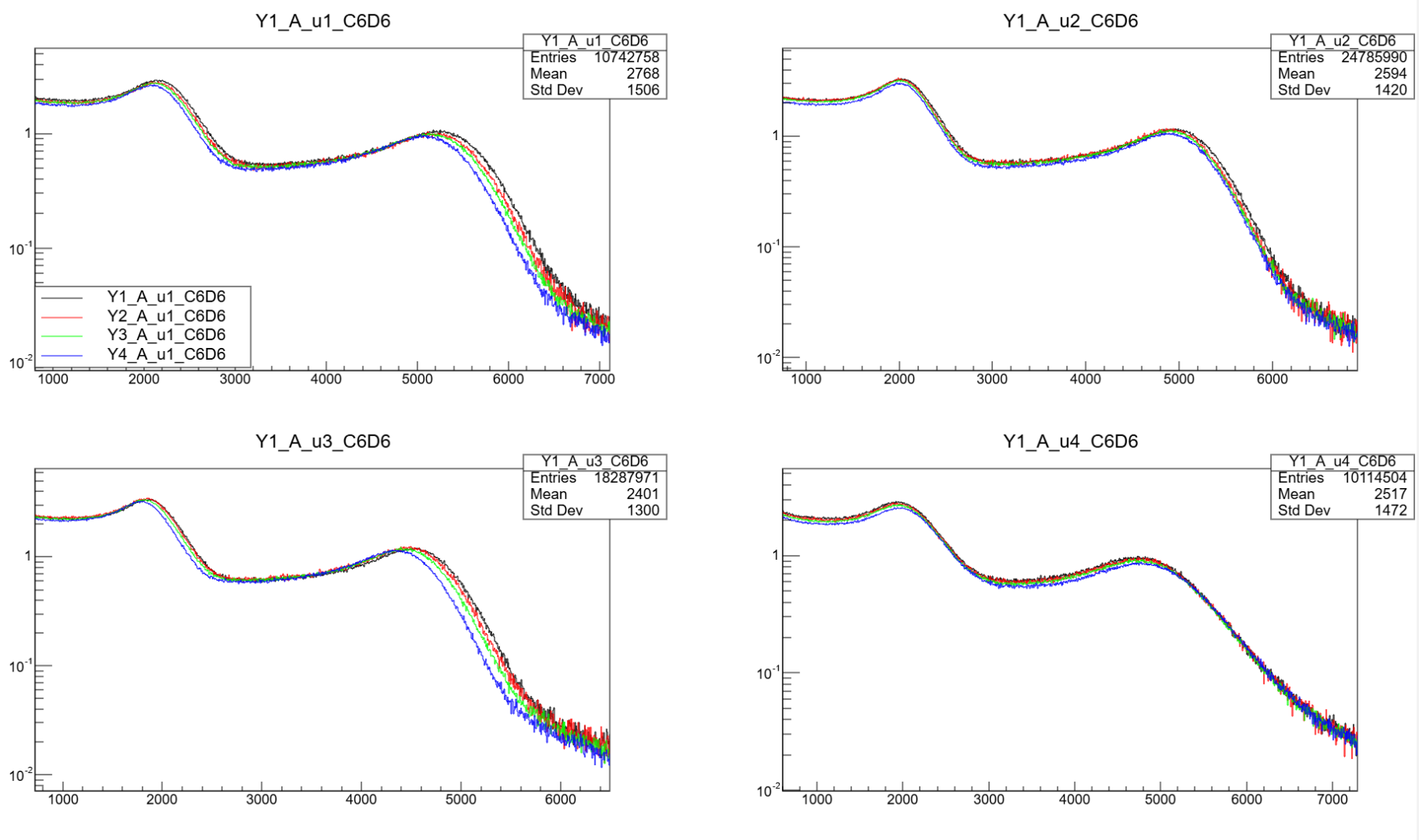
- Metallic powder of ^{nat}Mo with grain size like previous enriched samples;
- Sample prepared using 2g of material in a 2cm diameter disk;
- Preparation performed locally at n_TOF using hydraulic press;
- Minimal amount of material loss during preparation (<0,1%);
- Self sustaining samples, no sign of instability.

Gain stability



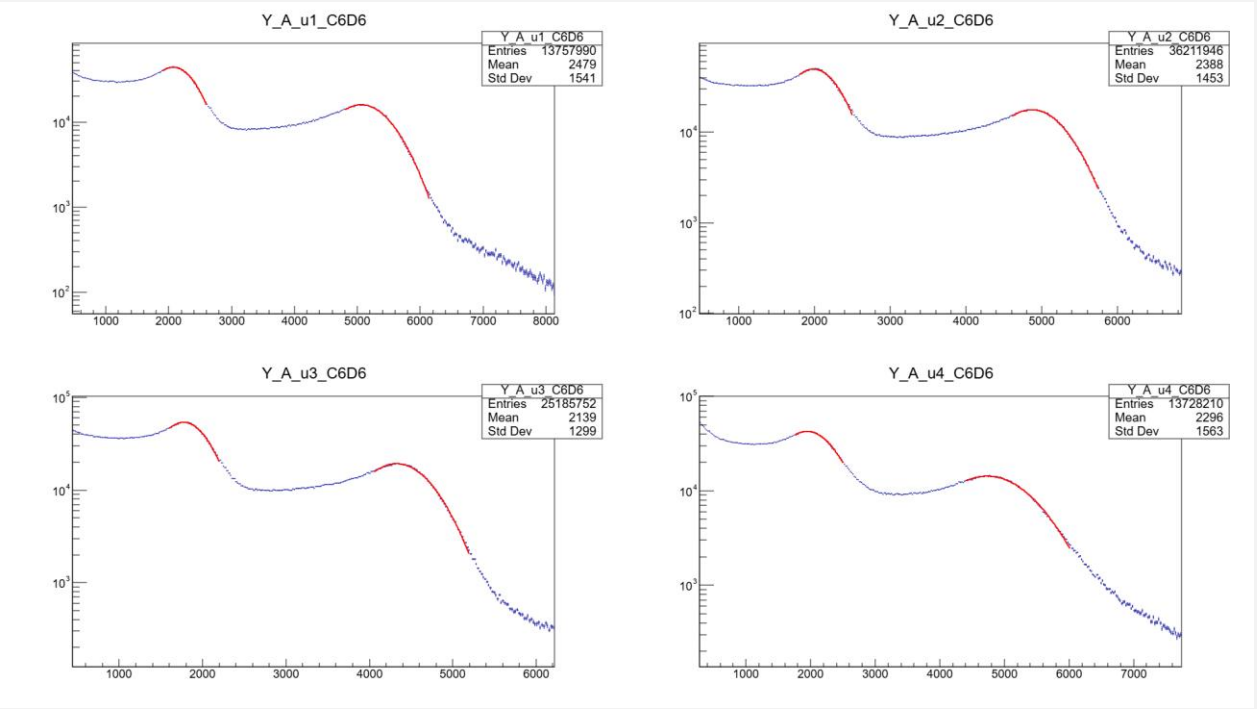
- Small gain shift observed in C6D6 1 and 3 (3%)
- Negligible differences in C6D6 2 and 4 (~1%)

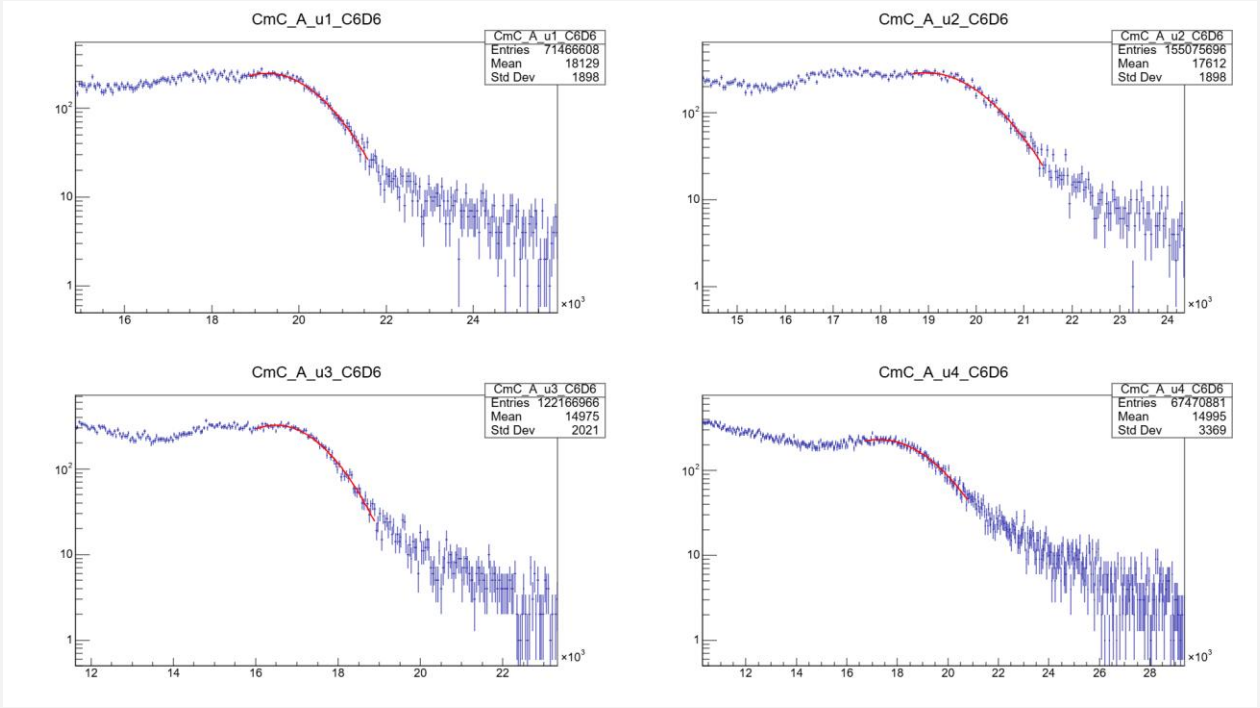
Gain stability



- Small gain shift observed in C6D6 1 and 3 (3%)
- Negligible differences in C6D6 2 and 4 (~1%)

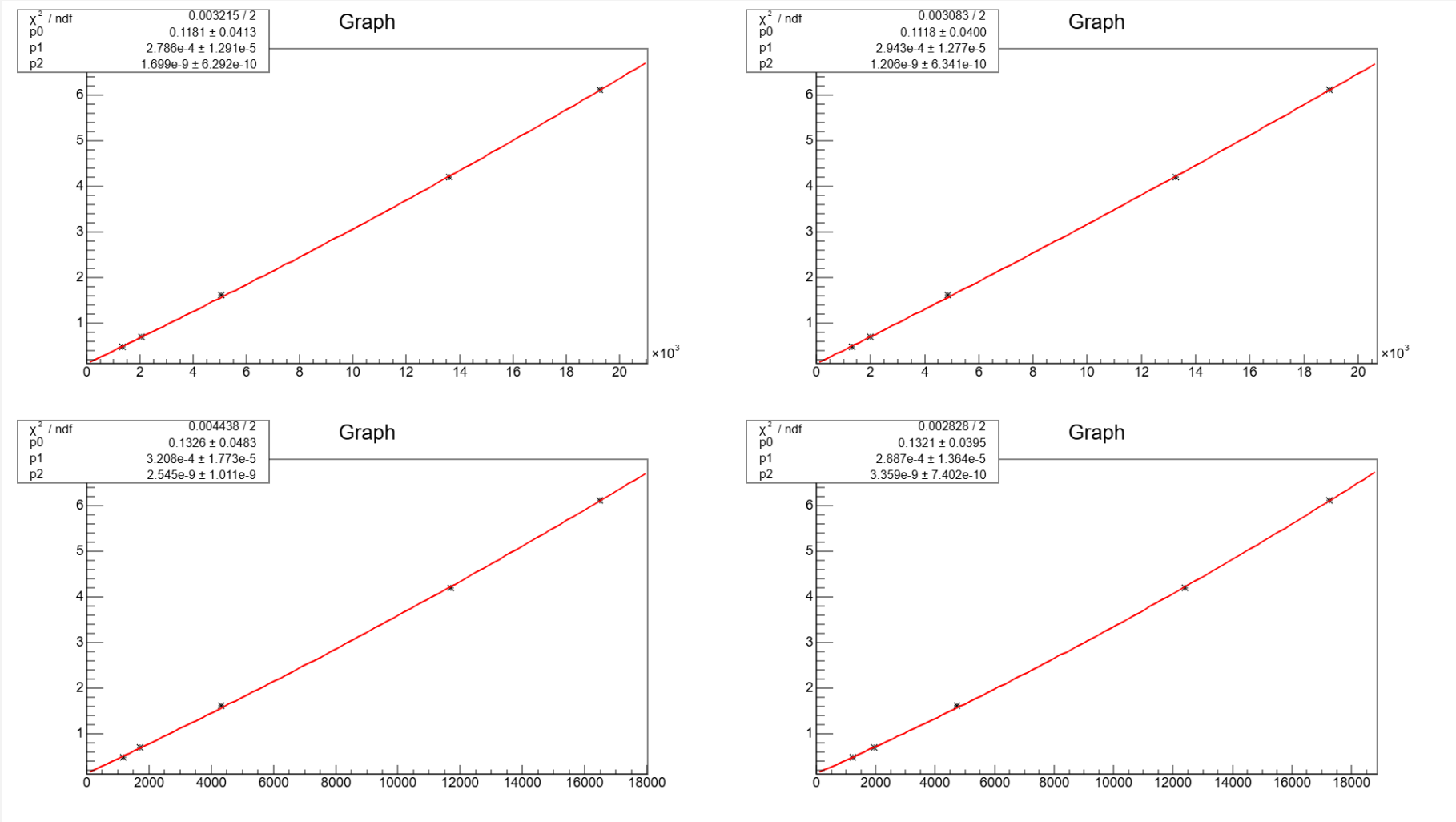
Calibrations



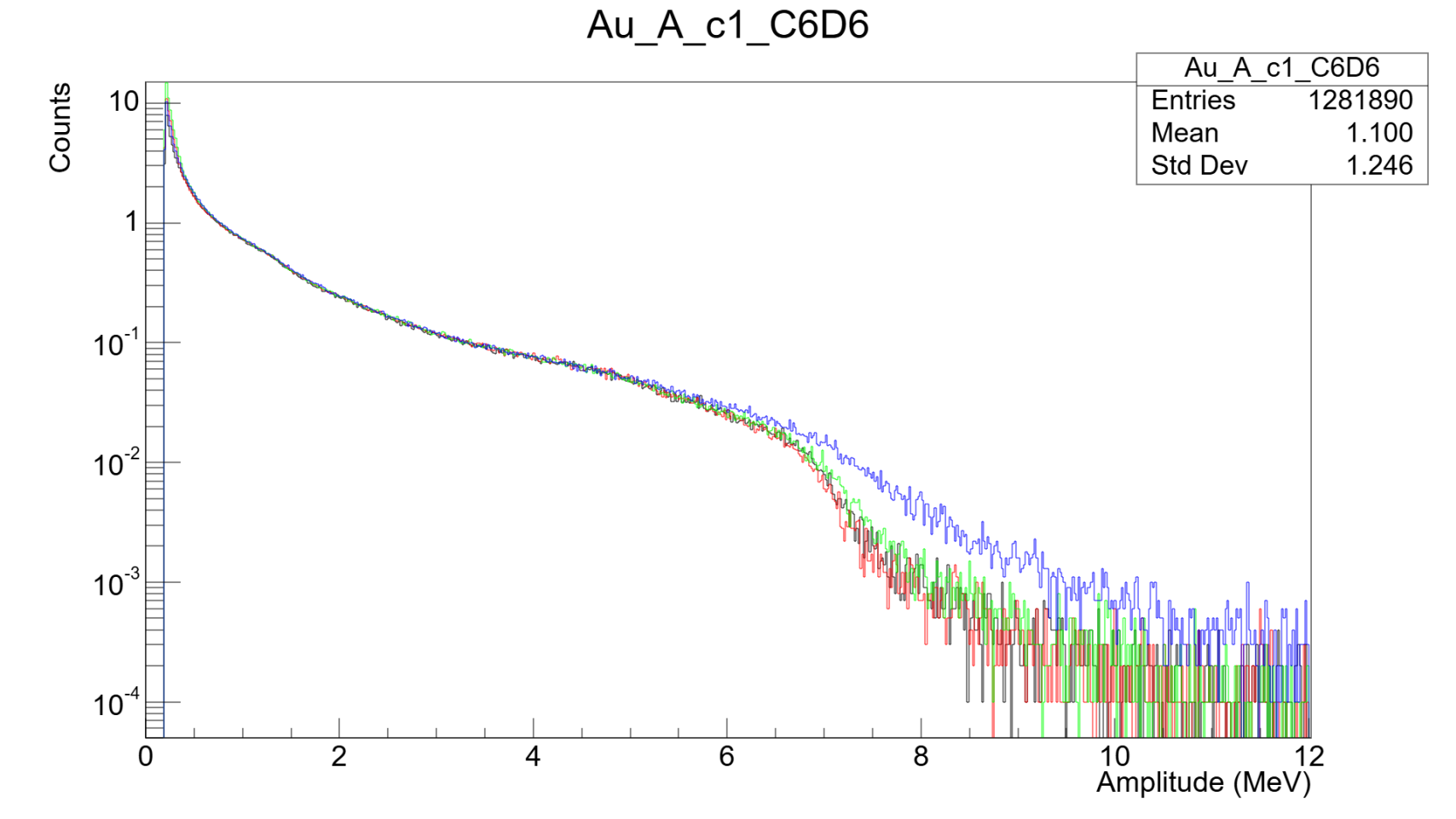


Calibrations

- Preliminary calibrations performed using Cs, Y, AmBe and CmC sources;
- Quadratic calibration;
- Very small deviation from linear (~1e-9)



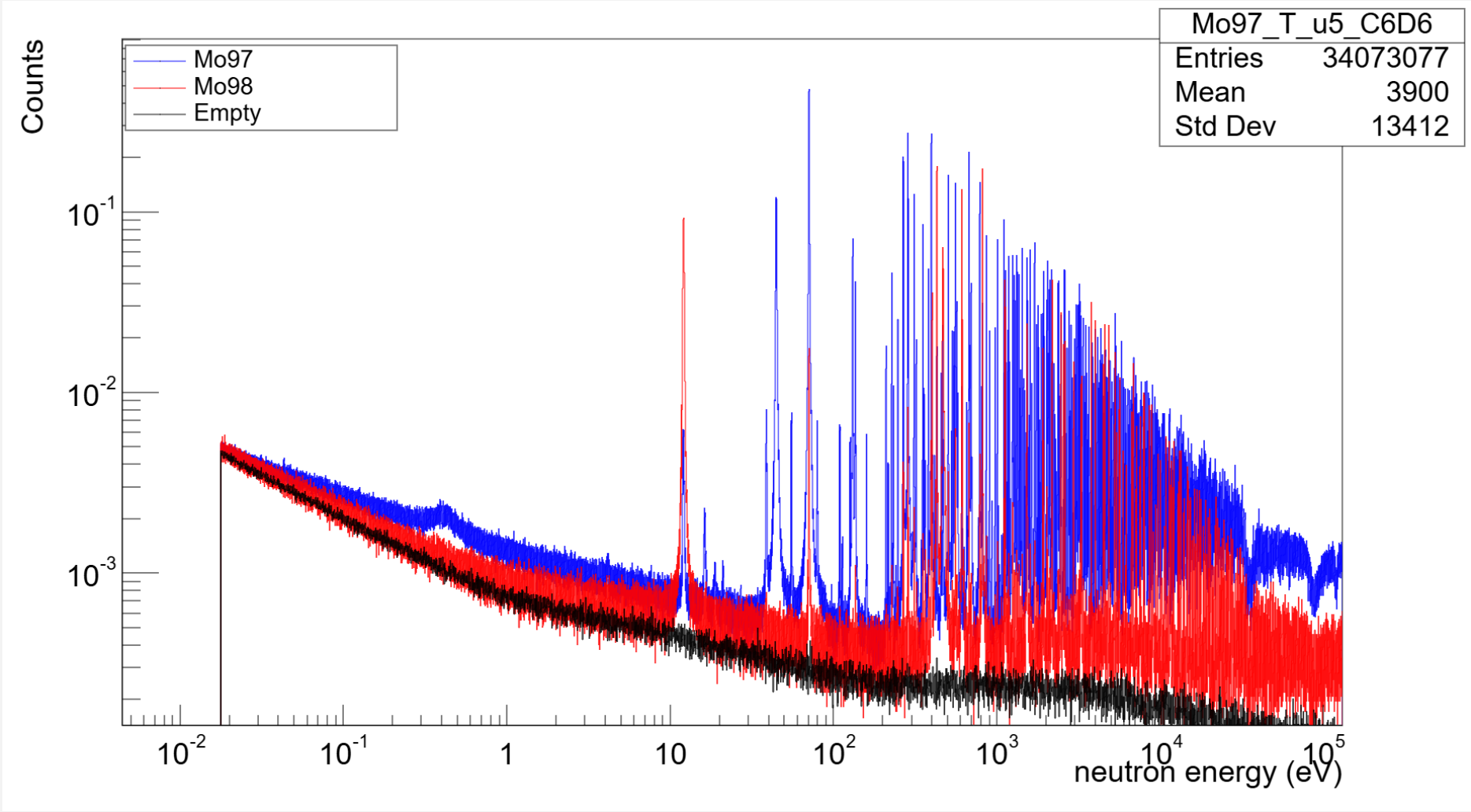
Au cascade



- Gold cascade with preliminary calibration;
- Good agreement of new PMT detectors (1,2,3), detector 4 shows worse resolution

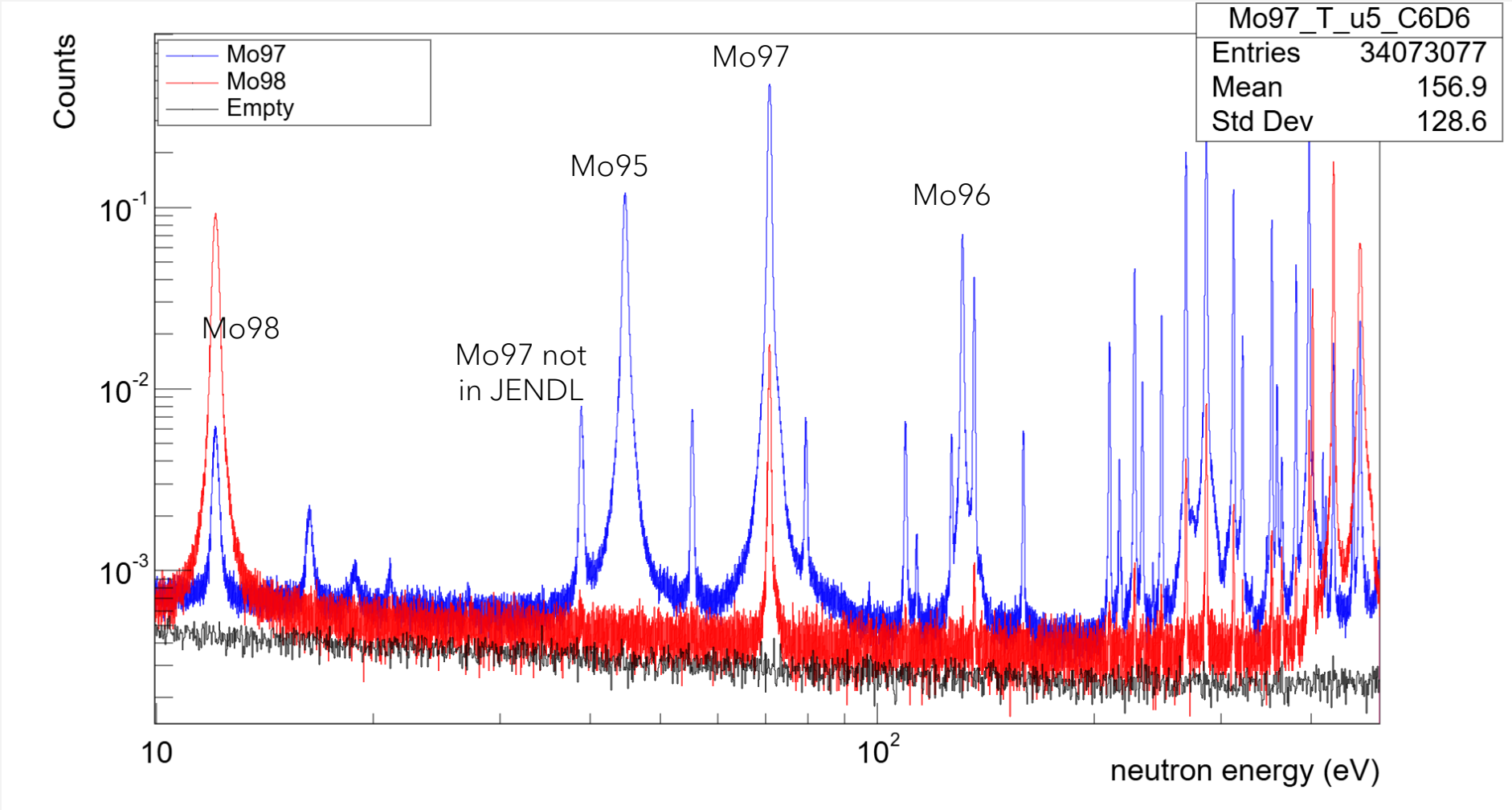
Mo97 and Mo98

- Spectra obtained with Mo97 and Mo98 samples compared with Empty



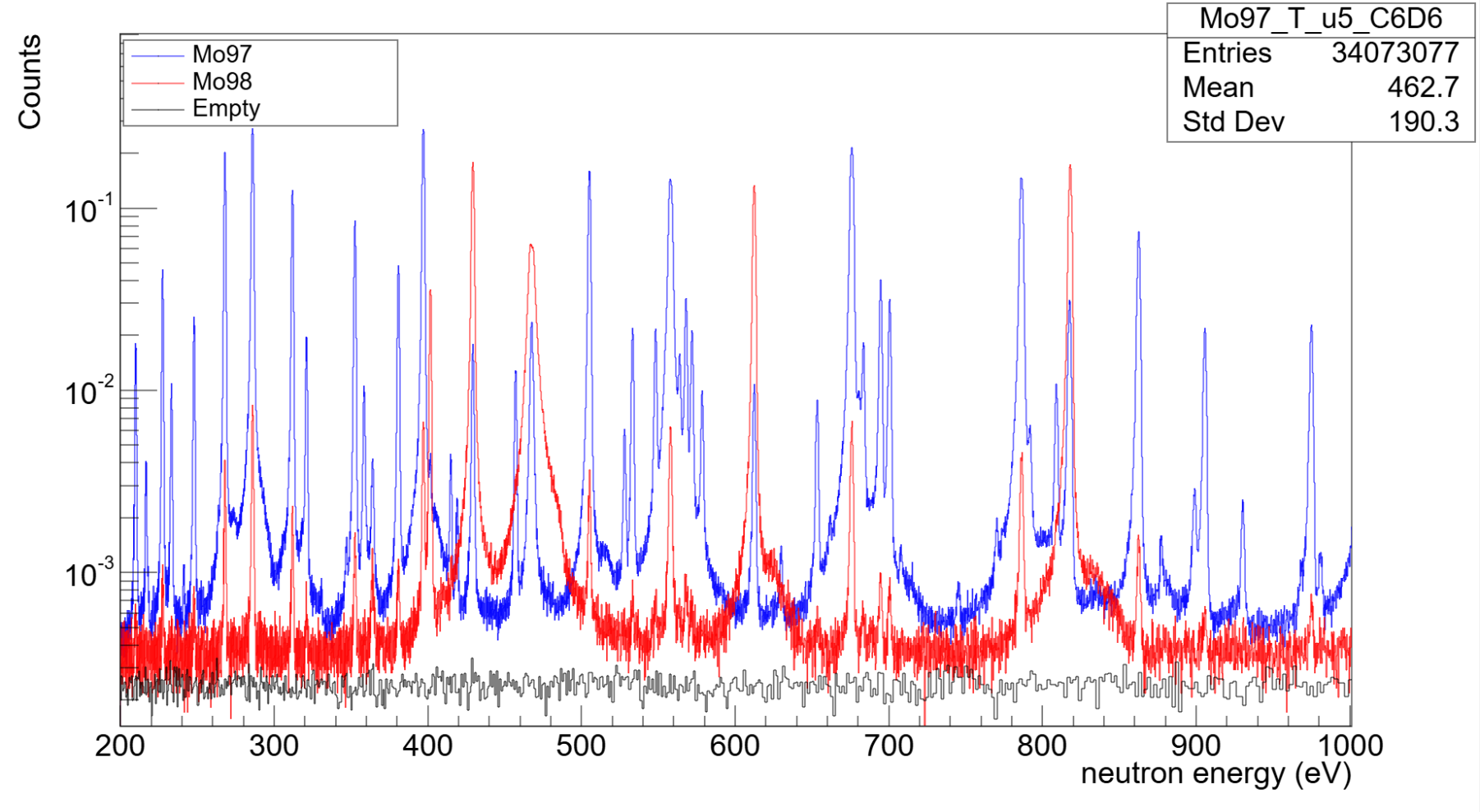
Mo97 and Mo98

- Spectra obtained with Mo97 and Mo98 samples compared with Empty;
- Presence of contamination from other isotopes in Mo97 sample

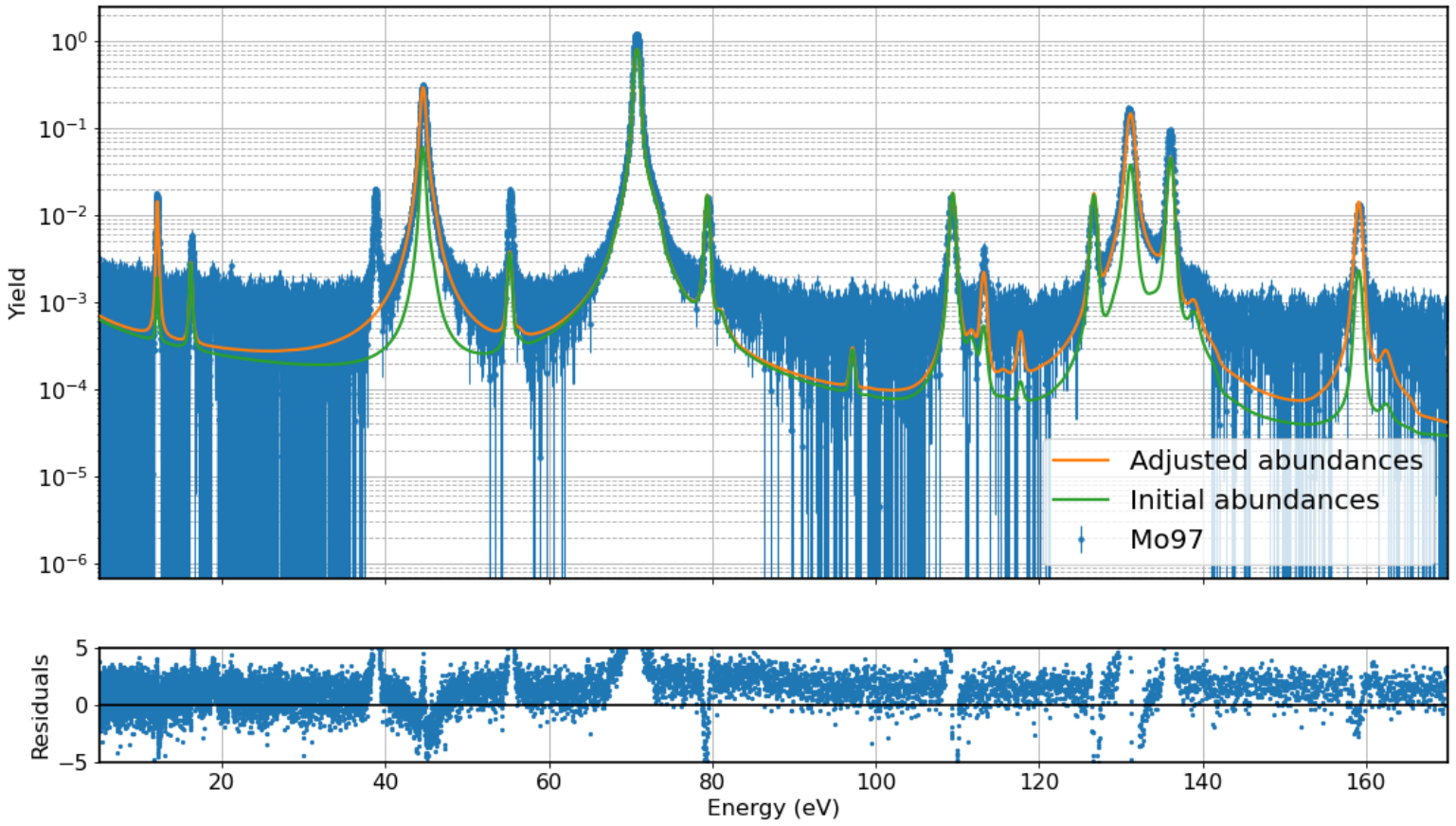


Mo97 and Mo98

- Spectra obtained with Mo97 and Mo98 samples compared with Empty;
- Presence of contamination from other isotopes in Mo97 sample



Mo97 contaminants

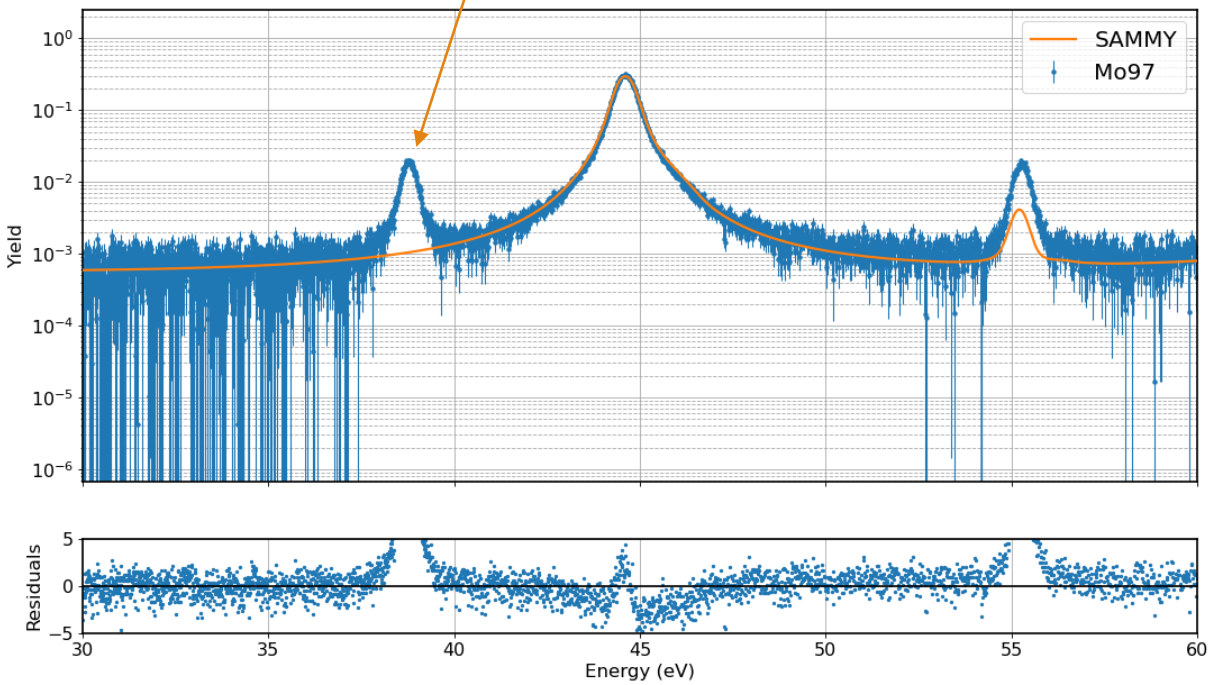


- Preliminary evaluation of contaminants level in Mo97 sample;
- Higher presence of other isotopes respect to declared amount;
- Preliminary estimate of real contaminants abundance with SAMMY

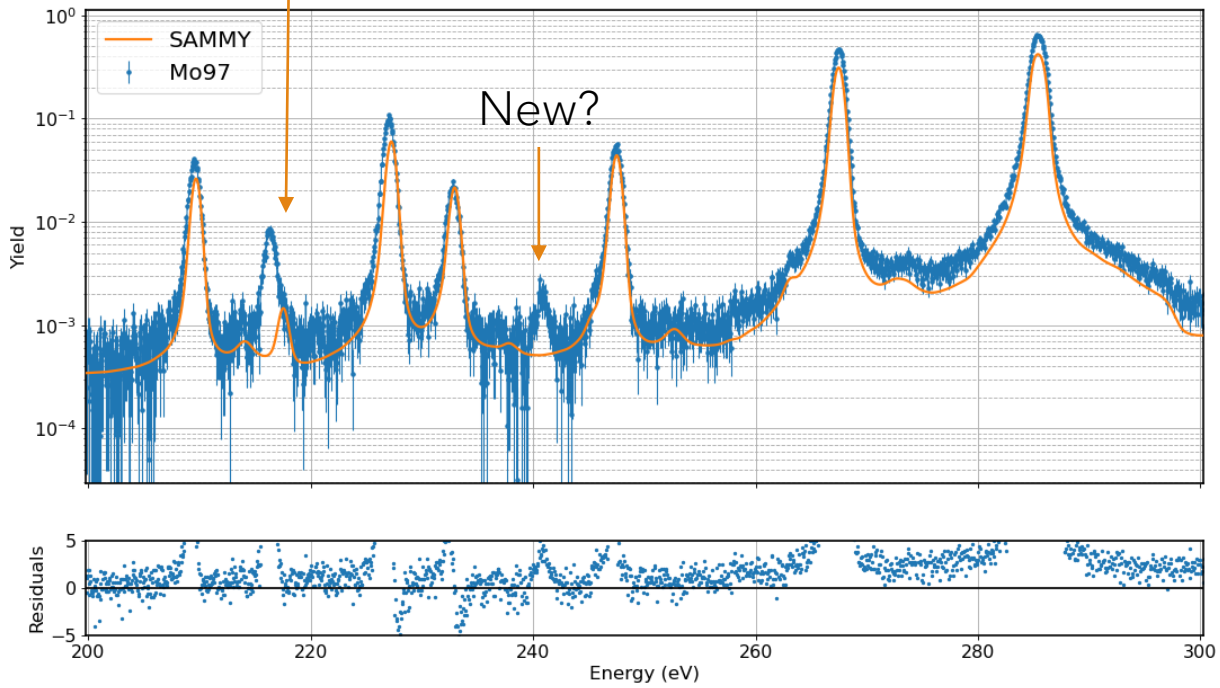
Isotope	Mo95	Mo96	Mo98
Declared	0,28%	0,55%	0,56%
Fitted	1,75%	2,85%	5,0%

Mo97 resonances

Observed at DANCE [1]



Observed at DANCE [1]



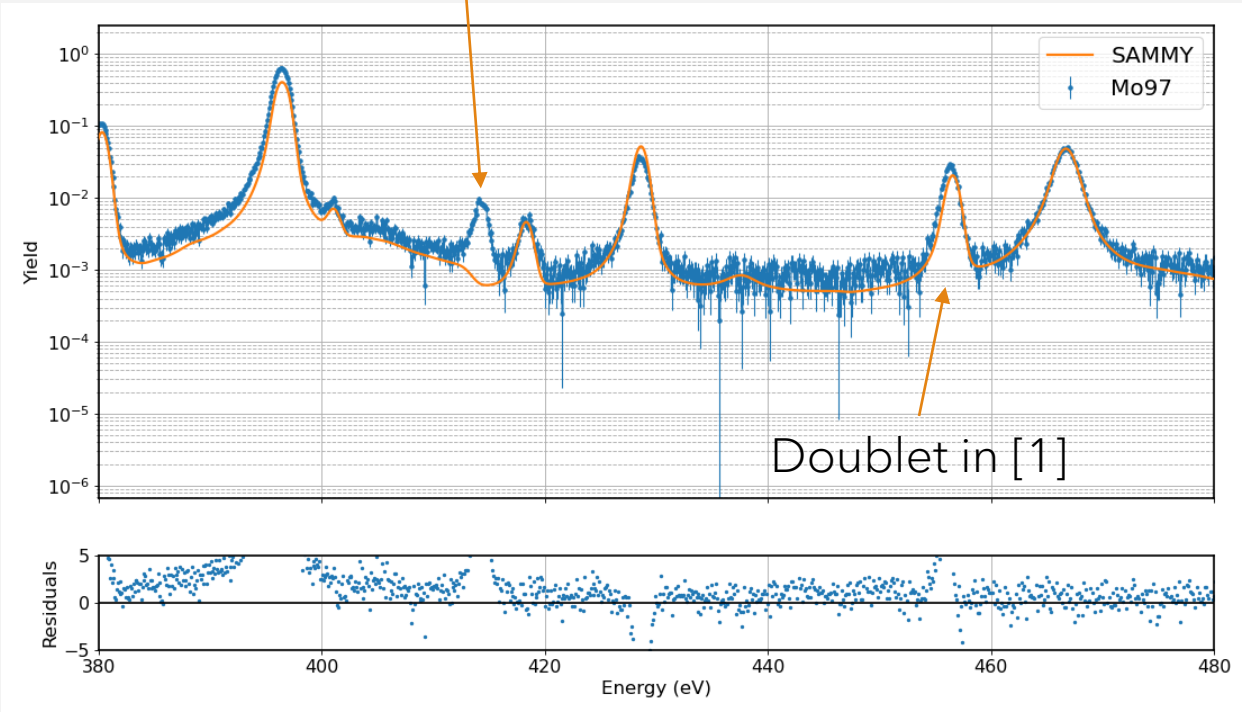
[1] Walker et al., PRC 92,014324 (2015)

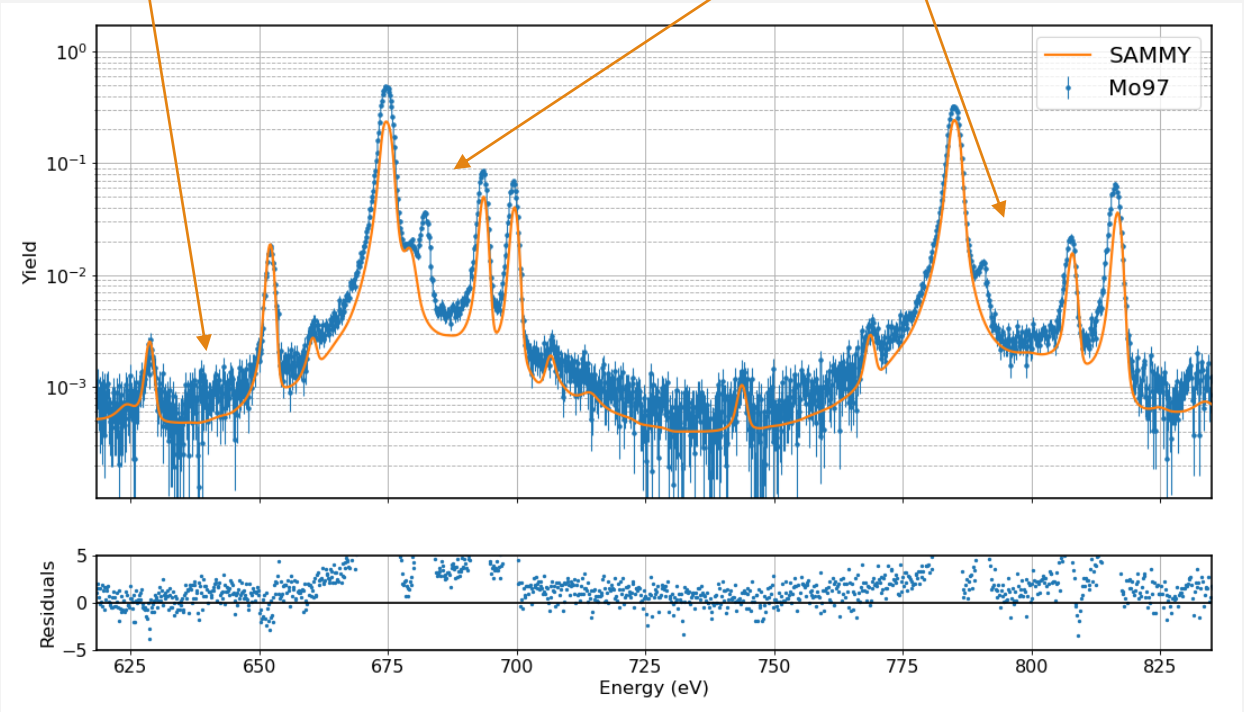
Mo97 resonances

Observed at DANCE [1]

Missing resonance reported in [1]

New?

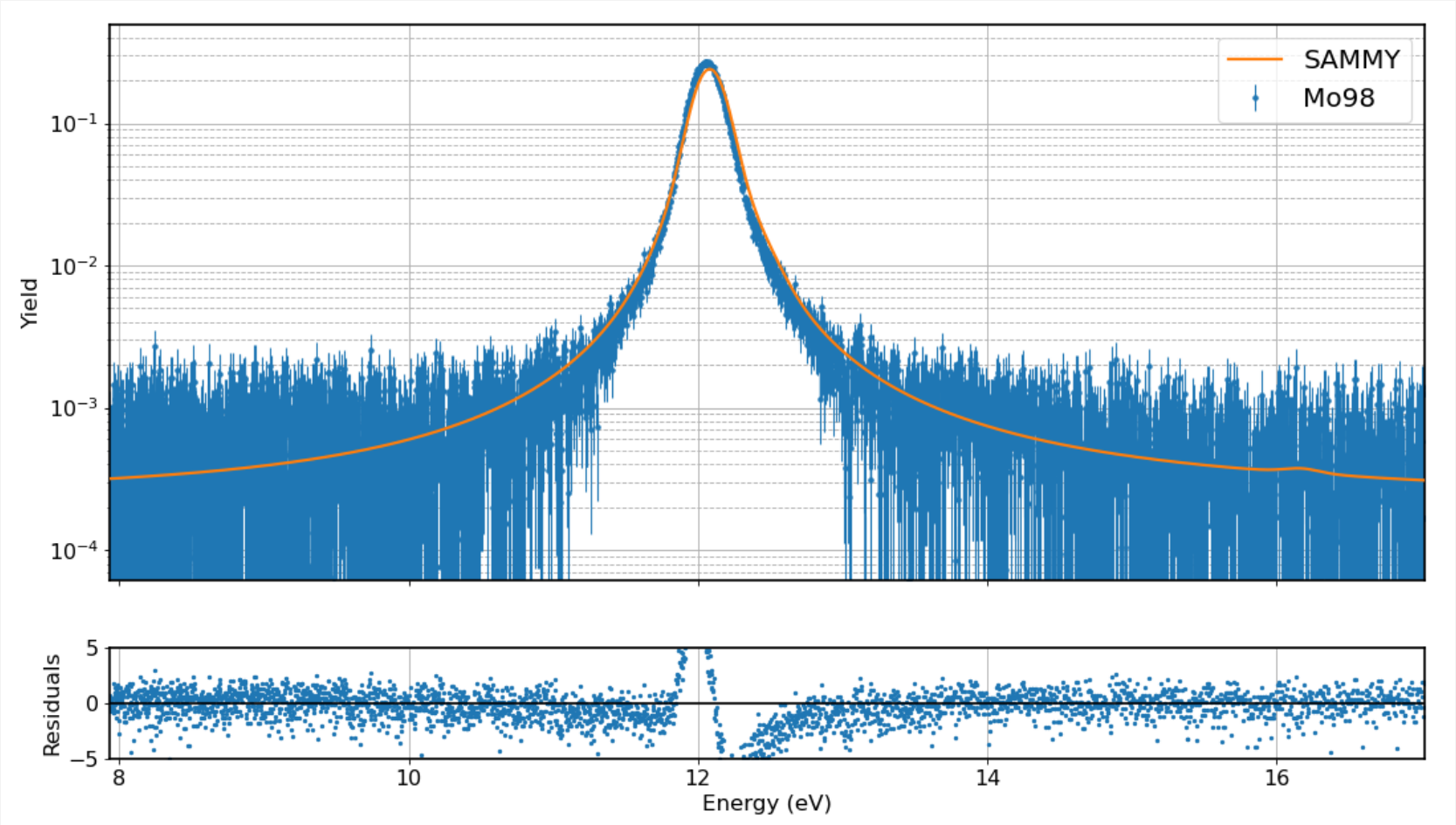




[1] Walker et al., PRC 92,014324 (2015)

Mo98 resonances

- Mo98 well reproduced with starting parameters;
- Small contamination of Mo97, compatible with declared by provider



Mo98 resonances

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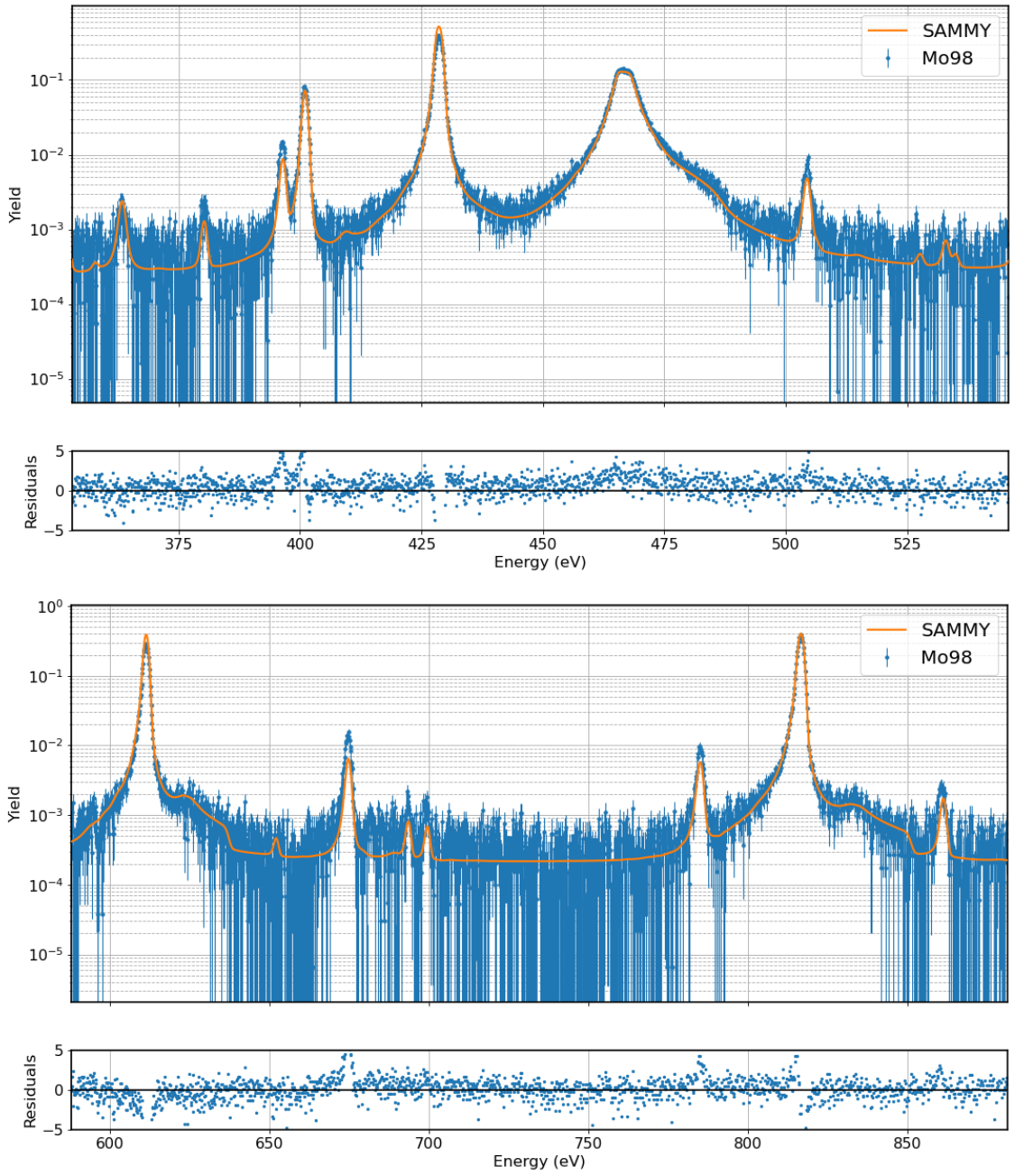
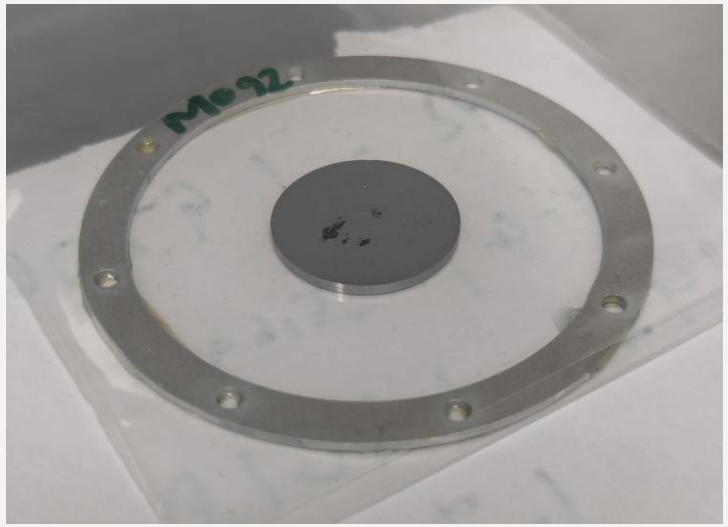
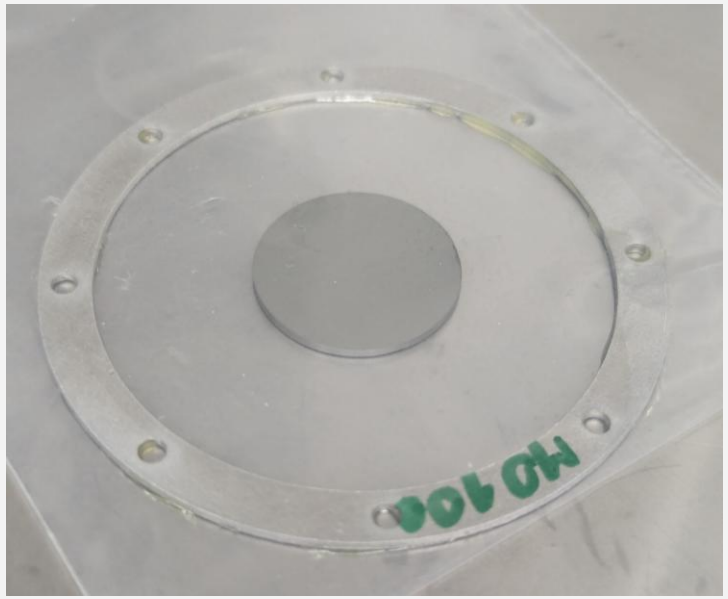


Mo92 and Mo100 in EAR2





- Sample prepared using 2g of material in a 2cm diameter disk;
- Preparation performed locally at n_TOF using hydraulic press;
- Mo92 shipped to Frankfurt University for processing with cryomill;
- Self sustaining samples, no sign of instability;
- Measurement currently ongoing.

Conclusions

EAR1:

- Analysis of Mo94,95,96 still ongoing;
- NEW measurements performed with Mo97,98;
- Higher level of contaminants in Mo97, good agreement for Mo98.

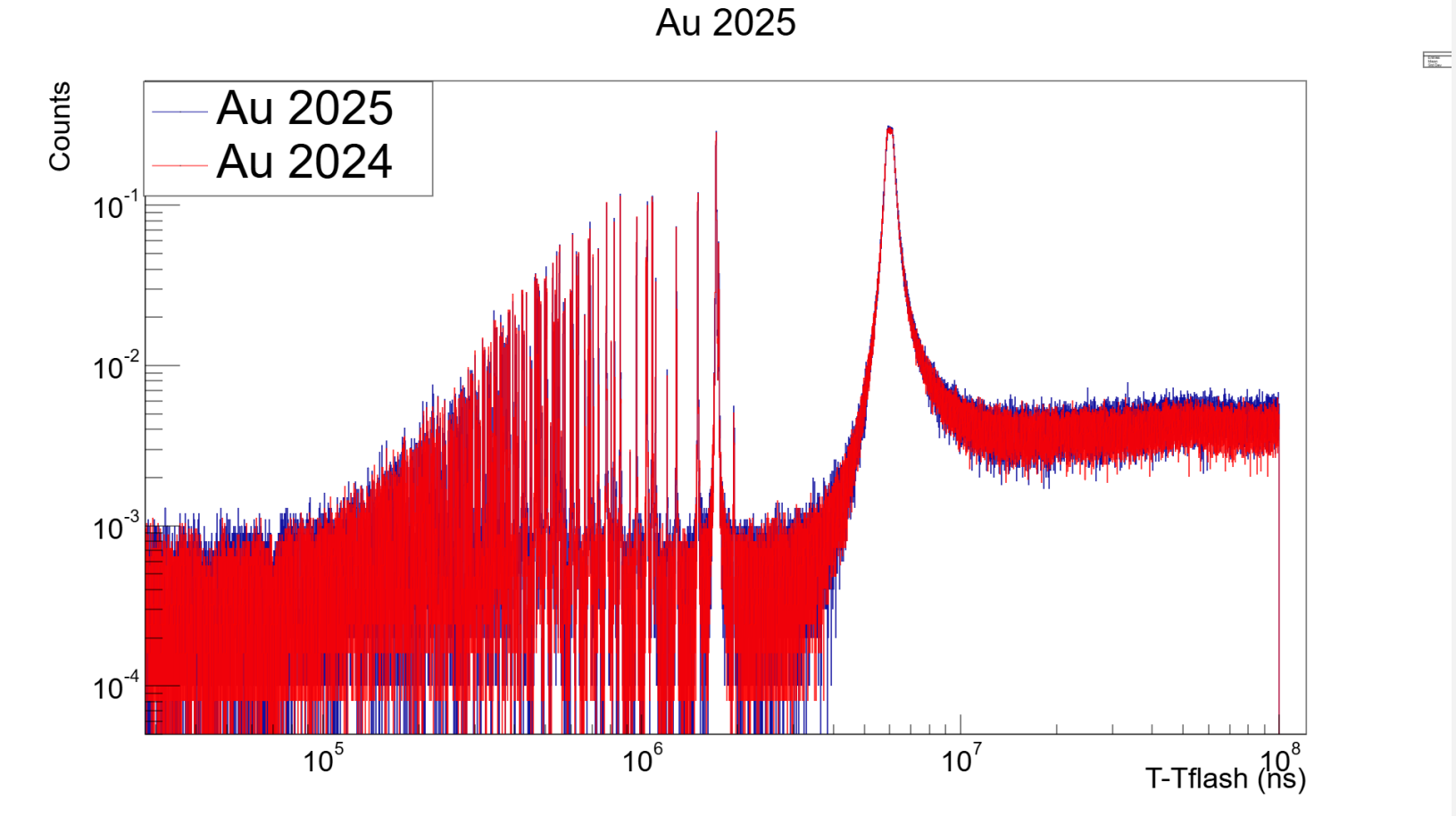
EAR2:

- Mo92 and Mo100 pressed samples prepared at n_TOF;
- Measurement currently ongoing in EAR2 using 9 sTED detectors.

Thank you for your attention

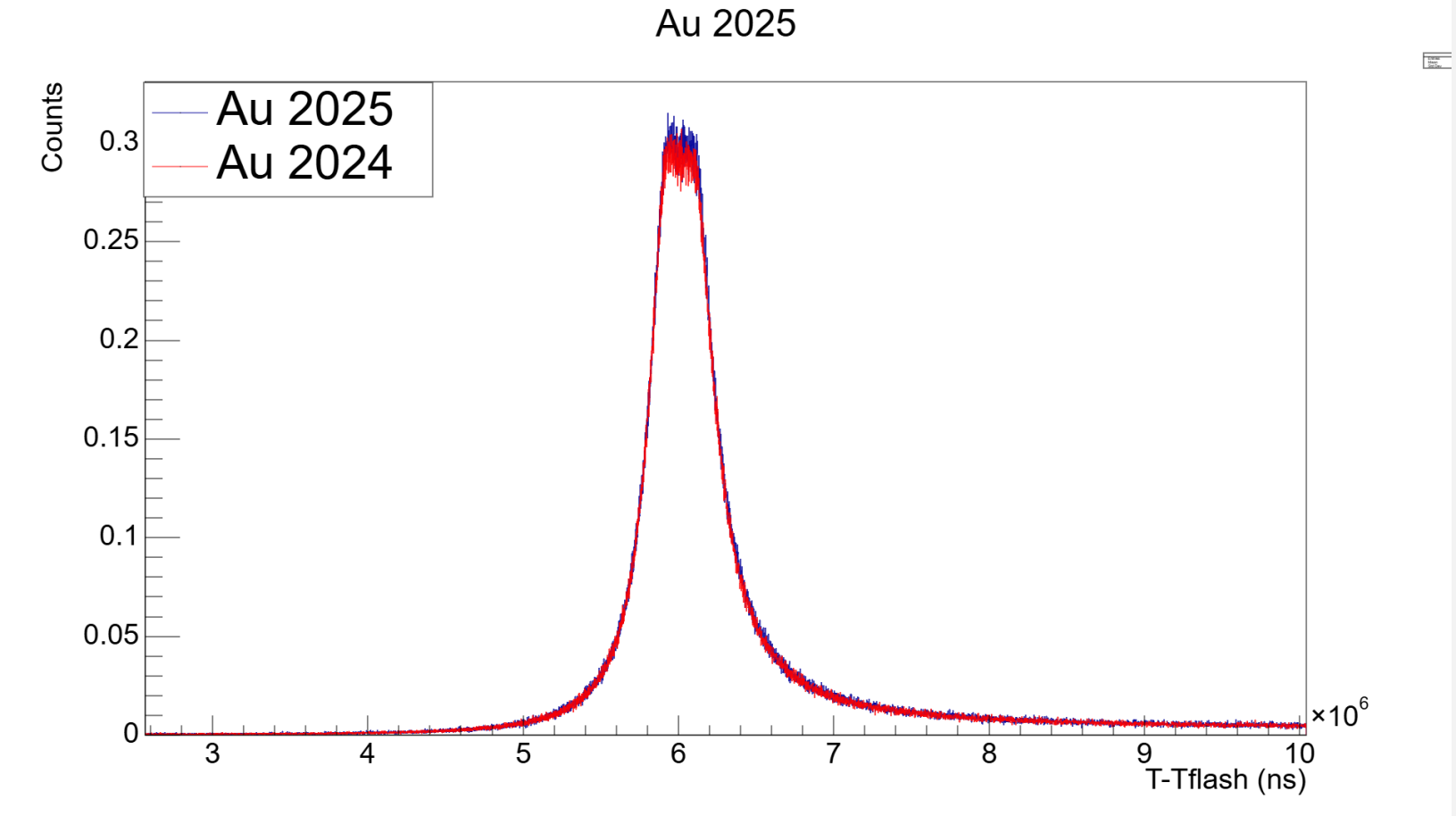
backup

Au comparison



Comparison of Au 20mm sample with measurements of 2024

Au comparison



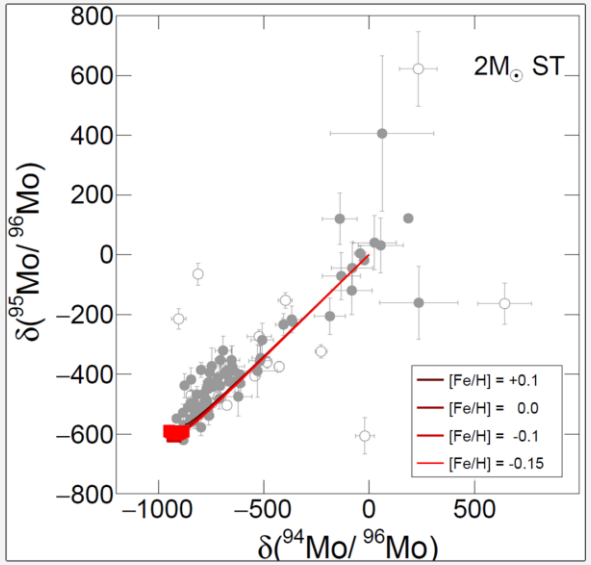
Comparison of Au 20mm sample with measurements of 2024

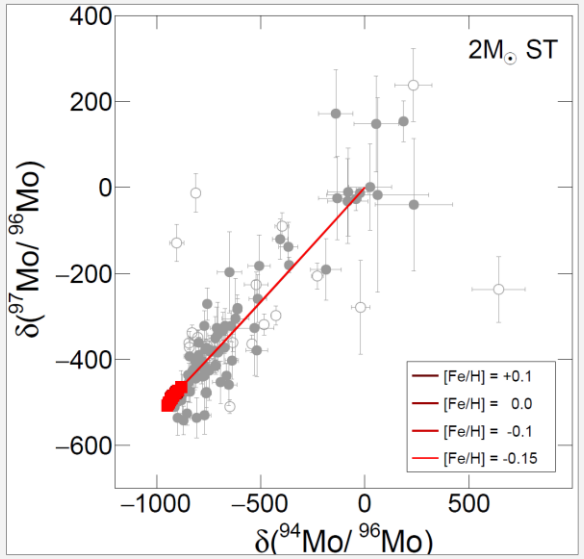
	DAY	00 - 04	04 - 08	08 - 12	12 - 16	16 - 20	20 - 24	Proton/day
Tue	1				SETUP	SETUP	Au	6.64E+16
Wed	2	Au	Au	Cal	Mo97	Mo97	Mo97	1.13E+17
Thu	3	Mo97	Mo97	Mo97	Mo97	Mo97	Mo97	1.46E+17
Fri	4	Mo97	Mo97	Mo97	Mo97	Mo97	Mo97	1.55E+17
Sat	5	Mo97	Mo97	Mo97	Mo97	Mo97	Mo97	1.61E+17
Sun	6	Mo97	Mo97	Mo97	Mo97	Mo97	Mo97	1.39E+17
Mon	7	Mo97	Mo97	Empty	Empty	Empty	Empty	1.59E+17
Tue	8	Empty	Empty	Empty	Empty	Empty	Empty (Al)	1.41E+17
Wed	9	Empty (Al)	Empty (Al)	Cal	Cal	Au	C	9.35E+16
Thu	10	C	C	C	C	C	C	1.68E+17
Fri	11	C	C	C (Al)	C (Al)	C (Al)	Mo97	1.47E+17
Sat	12	Mo97	Mo97	Mo97	Mo97	Mo97	Mo97	1.74E+17
Sun	13	Mo97	Mo97	Mo97	Mo97	Mo97	Mo97	1.85E+17
Mon	14	Mo97	Mo97	Mo97	Mo97	Mo97	Mo97 (Al)	1.56E+17
Tue	15	Mo97 (Al)	Mo97 (Al)	Cal	Cal	Pb	Pb	4.54E+16
Wed	16	Pb	Pb	Pb	Pb	Pb	Pb	1.64E+17
Thu	17	Pb (Al)	Pb (Al)	Pb (Al)	Au	Mo98	Mo98	1.72E+17
Fri	18	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	1.62E+17
Sat	19	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	1.48E+17
Sun	20	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	1.72E+17
Mon	21	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	1.72E+17
Tue	22	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	3.45E+16
Wed	23	Mo98	Mo98	Cal	Cal	Mo98	Mo98	0.00E+00
Thu	24	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	0.00E+00
Fri	25	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	0.00E+00
Sat	26	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	0.00E+00
Sun	27	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	0.00E+00
Mon	28	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	0.00E+00
Tue	29	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	0.00E+00
Wed	30	Mo98	Mo98	Mo98	Mo98	Mo98	Mo98	0.00E+00
Thu	1	Mo98	Mo98	Mo98	Mo98	Mo98	Sr87	0.00E+00
Fri	2	Sr87	Sr87	Sr87	Sr87	Sr87	Sr87	0.00E+00
Sat	3	Sr87	Sr87	Sr87	Sr87	Sr87	Sr87	0.00E+00
Sun	4	Sr87	Sr87	Sr87	Sr87	Sr87	Sr87	0.00E+00
Mon	5	Sr87	Sr87	Sr87	Sr87	Sr-nat	Sr-nat	0.00E+00
Tue	6	Sr-nat	Sr-nat	Sr-nat	Sr-nat	empty capsule	empty capsule	0.00E+00
Wed	7	empty capsule	empty capsule	Cal	Cal	empty empty	empty empty	0.00E+00
Thu	8	empty empty	empty empty	Sr87	Sr87	Sr87	Sr87	0.00E+00
Fri	9	Sr87	Sr87	Sr87	Sr87	Sr87	Sr87	0.00E+00

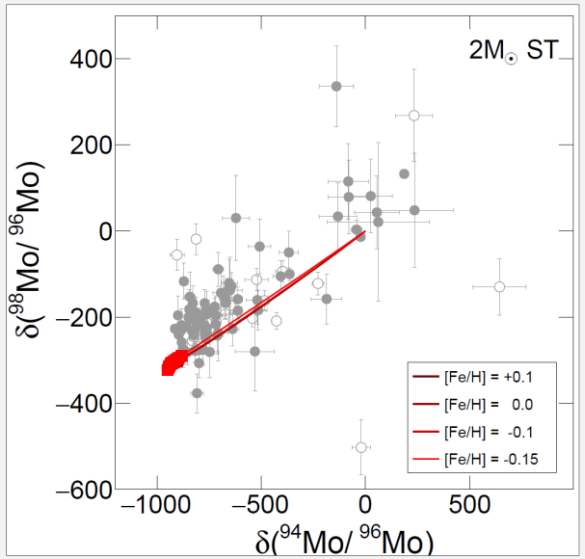
%		ID material setup	This Plan	Measured	Expected
115.30	Mo97	7208	9.40E+17	1.08E+18	1.00E+18
45.47	Mo98	7207	1.66E+18	7.55E+17	1.70E+18
114.79	Au	7212	1.00E+17	1.15E+17	1.00E+17
110.57	Empty	7271	1.80E+17	1.99E+17	1.80E+17
137.09	C	7213	1.80E+17	2.47E+17	1.80E+17
128.42	Pb	7267	1.60E+17	2.05E+17	1.80E+17
223.92	Mo97 (Al)	7269	6.00E+16	1.34E+17	6.00E+16
140.72	Empty (Al)	7272	6.00E+16	8.44E+16	6.00E+16
138.54	C (Al)	7270	6.00E+16	8.31E+16	6.00E+16
181.04	Pb (Al)	7268	6.00E+16	1.09E+17	6.00E+16
	Total		3.46E+18	3.02E+18	3.58E+18

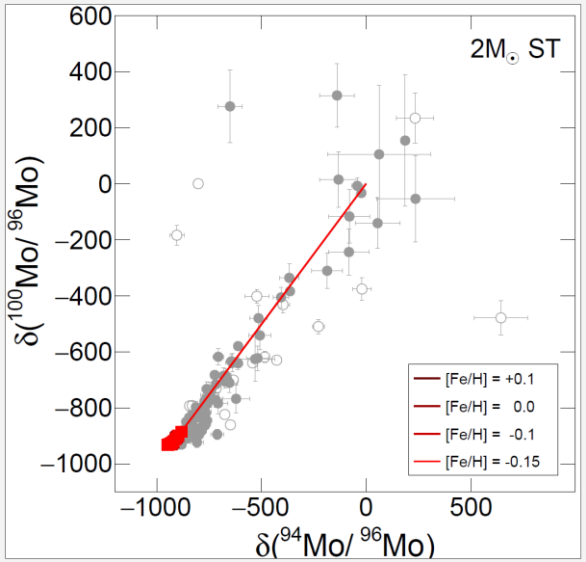
done (%)	sample	ID material setup	ID sample	target #p (x 1e10)	measured #p (x 1e10)	(2e16 p / 4 h)
0.00	**Sr87**		2729	168	0	
0.00	**Sr87 (Al)**		2729	12	0	
0.00	**Sr-nat**		2730	12	0	
0.00	**empty capsule**		2733	8	0	
0.00	**empty empty**			8	0	
0.00	**In**		374	8	0	
0.00	**Au**		689	2	0	
0.00	**Ag**		183	4	0	
0.00	**Ir**		370	4	0	
0.00	**total**			**226**	**0**	

Presolar grain composition









- Comparison of SiC grains composition versus stellar model (FRANEC) using delta notation:

$$\delta\left(\frac{^{95}Mo}{^{96}Mo}\right) = 10^3 \times \left[\left(\frac{^{95}Mo}{^{96}Mo}\right) \Big/ \left(\frac{^{95}Mo}{^{96}Mo}\right)_{\odot} - 1\right]$$

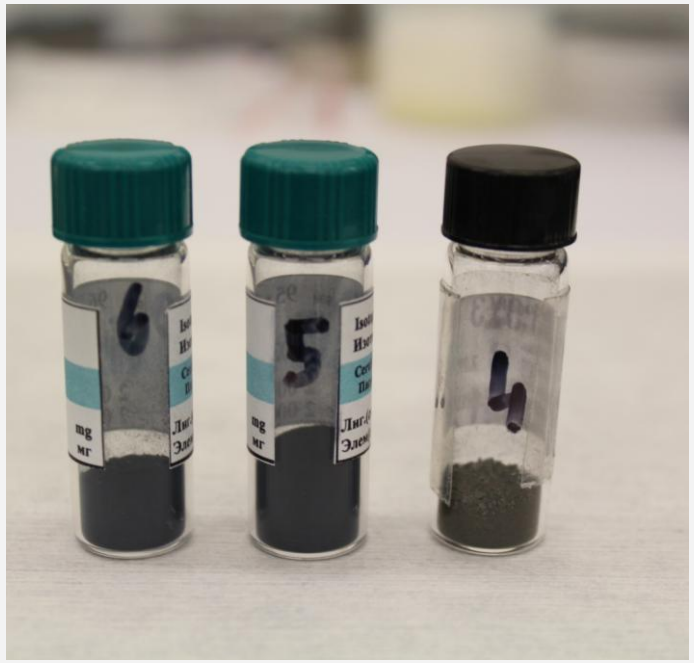
- MACS from KADoNiS v1.0 database,
- Slight discrepancies between model and isotopic composition,
- Possible overestimation of MACS in KADoNiS.

S. Palmerini et al., ApJ 921 7 (2021)

Enriched pellets preparation

To avoid the background coming from aluminum capsule three pressed pellets were prepared using enriched powder:

- Pellets prepared at JRC-Geel;
- Self sustaining pellets of ~ 2g;
- Additional ^{nat}Mo samples prepared using powder with different grain sizes;



^{nat}Mo abundances

Isotope	Abundance
^{92}Mo	14.84%
^{94}Mo	9.25%
^{95}Mo	15.92%
^{96}Mo	16.68%
^{97}Mo	9.55%
^{98}Mo	24.13%
^{100}Mo	9.63%

Libraries sources

Isotope	JENDL-3.3	JENDL-4	ENDF-B/VIII	JEFF-3.3
^{92}Mo	Wasson, Weigmann, Musgrove	Wasson, Weigmann, Musgrove	Mughabghab	JENDL-4
^{94}Mo	Weigmann, Musgrove	Weigmann, Musgrove, Wang	JENDL-3.3	JENDL-4
^{95}Mo	Weigmann, Shwe	Weigmann, Shwe, Wang	Mughabghab	Mughabghab
^{96}Mo	Weigmann, Musgrove	Weigmann, Musgrove, Wang	JENDL-3.3	JENDL-4
^{97}Mo	Weigmann, Shwe	Weigmann, Shwe, Wang	JENDL-3.3	JENDL-4
^{98}Mo	Weigmann, Musgrove, Chrien	Weigmann, Musgrove, Chrien, Babich, Wang	JENDL-3.3	JENDL-4
^{100}Mo	Weigmann, Musgrove, Weigmann	Weigmann, Musgrove, Weigmann, Wang	JENDL-3.3	JENDL-4