Supplementary Information

Pb Isotope Ratio and Trace Element Analysis Using VUV-TOF Mass Spectrometry: Applications to NIST 610/612 and Zircon FC1

Yixuan Li, Haoyu Shi, Peng Wang and Yuxiang Mo*

[a]Department of Physics and State Key Laboratory of Low-Dimensional Quantum Physics, Tsinghua University, Beijing 100084, China

*Email: ymo@mail.tsinghua.edu.cn

Table S1. Signal intensities for trace elements in NIST 610 and relative signal ratios between elements of NIST 610 and 612 measured by VUV-TOF mass spectrometry.

Element	Signal (mV/pulse)	Measured Ratio 610/612	Recognized ratio[23-25] 610/612	Recognized Concentration for 610 (μg/g)[23-25]
Li	43	11.9	11.7	464
Be	6	12.5	11.6	469
B	1	5.9	9.9	332
P	10	5.2	9.0	342
K	380		7.1	488
V	16	3.0	11.3	442
Cr	13	4.7	11.5	415
Mn	15	7.1	11.9	419
Co	235	6.4	12.0	375
Ni	20		11.8	438
Cu	470	9.5	11.8	422
Zn	54		11.8	447
Ga	677	7.3	11.8	444
Ge	621	6.1	10.0	433
As	318	6.2	8.8	330
Se	50	3.2		111
Rb	2881	7.8	13.4	435
Sr	620	8.1	6.6	480
Y	100	22.3	11.8	440
Nb	105	15.1	11.9	374
Mo	150	8.2	11.5	364
Ag	50		10.9	235
In	800	6.4	13.2	424
Sn	750	7.0	13.1	391
Sb	640	8.8	9.6	346
Te	80	3.0		
Cs	2470	5.1	8.9	429
Ba	500	10.0	11.7	424
La	96	11.1	12.2	448
Ce	83	12.5	11.9	463
Pr	110	13.4	12.0	433
Nd	135	15.9	12.1	456

Sm	280	20.2	12.0	485
Eu	234	14.4	12.6	480
Gd	250		12.2	437
Tb	56	16.6	11.8	444
Dy	95	11.6	12.3	420
Ho	40	28.5	11.7	446
Er	50	22.3	11.8	440
Tm	44	14.4	11.7	431
Yb	90	12.3	11.7	467
Lu	50	13.0	11.9	431
Hf	10		11.6	419
Ta	10	14.9	11.9	366
W	20	9.4	13.2	426
Re	3	5.0	7.5	137
Au	2	2.6	4.9	22.7
Tl	6	3.7	6.3	62
Pb	510	7.0	12.1	409
Bi	318	7.8	12.7	326
Th	20	13.0	11.8	448
U	60	12.5	12.3	453

Table S2. Ratios of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ of NIST 610 measured at different sessions. σ is the weighted uncertainty. The experiments were all performed in 2024.

Date-Session	$^{207}Pb/^{206}Pb$	2σ	Ref. value	$^{208}Pb/^{206}Pb$	2σ	Ref. value
0313-1	0.9133	0.0056	0.9098(2)	2.1625	0.0111	2.1690(8)
0512-1	0.9104	0.0075		2.1728	0.0149	
0514-1	0.9024	0.0092		2.1632	0.0130	
0514-2	0.9067	0.0082		2.1619	0.0164	
0514-3	0.9071	0.0056		2.1522	0.0110	
0514-4	0.9097	0.0058		2.1482	0.0115	
0515-1	0.9129	0.0077		2.1729	0.0153	
0515-2	0.9160	0.0074		2.1691	0.0147	
0520-1	0.9164	0.0069		2.1777	0.0136	
All	0.9104	0.0020		2.1645	0.0041	

[a]Relative accuracy=100 x (Measured value-Ref. vaule)/(Ref. value)

Table S3. Ratios of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ of NIST 612 measured at different sessions. σ is the weighted uncertainty. The experiments were performed in 2024.

Date-Session	$^{207}Pb/^{206}Pb$	2σ	Ref. Ratio	$^{208}Pb/^{206}Pb$	2σ	Ref. Ratio
0520-1	0.9102	0.0154	0.9073(4)	2.1875	0.0309	2.1645(9)
0527-1	0.9086	0.0110		2.1676	0.0217	
0603-1	0.9147	0.0146		2.1590	0.0285	
0604-1	0.8983	0.0135		2.1718	0.0271	
0605-1	0.9039	0.0179		2.1642	0.0355	
0701-1	0.9004	0.0148		2.1427	0.0263	
0701-2	0.9052	0.0143		2.1392	0.0261	
All	0.9059	0.0050		2.1617	0.0099	

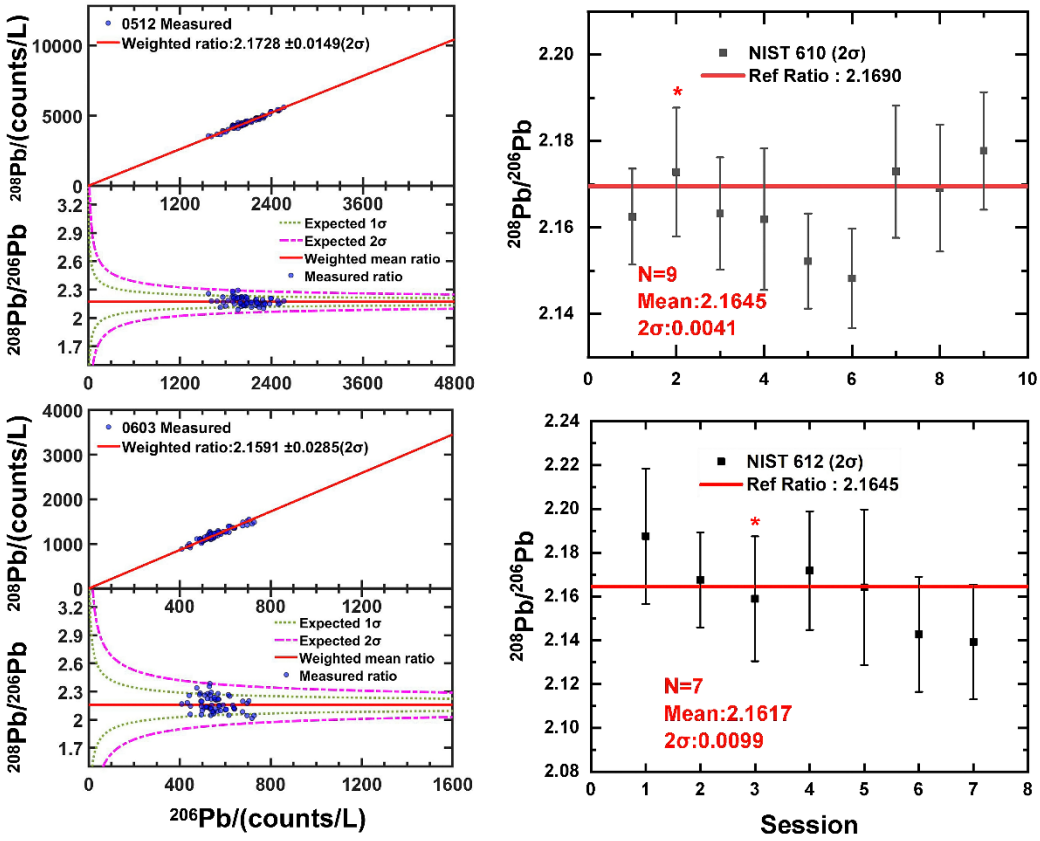
Table S4. Ratios of $^{207}Pb/^{206}Pb$ of zircon FC1 measured at different sessions. σ is the weighted uncertainty. The experiments were performed in 2024.

FC1					
Date-Session	$^{207}Pb/^{206}Pb$	2σ	$^{207}Pb/^{206}Pb$ Age (Ma)	2σ (Ma)	Ref Ratio (Age)
0609-1	0.0756	0.00085	1081	44	0.07615(2) (1099.0(6) Ma)
0620-1	0.0764	0.00076	1102	39	
0620-2	0.07674	0.00084	1111	43	
0622-1	0.07591	0.00123	1089	64	
0624-1	0.07671	0.00078	1110	40	
0624-2	0.07725	0.00075	1124	38	
0628-1	0.07614	0.00083	1095	43	
0628-2	0.0765	0.00081	1104	42	
0705-1	0.07546	0.00071	1077	37	
0711-1	0.07595	0.00092	1090	48	
0711-2	0.07588	0.00101	1088	52	
0718-1	0.07591	0.00096	1089	50	
0719-1	0.07697	0.00082	1117	42	
0722-1	0.07626	0.00073	1098	38	
0725-1	0.07678	0.00091	1112	47	
0730-1	0.0756	0.00085	1066	52	
All	0.07622	0.00020	1097	5.5	

Table S5. Variation of $^{207}Pb/^{206}Pb$ ratios with integration ranges. The first two rows (corresponding to Figures S2(a) and S(2b) show ratios within 1σ, while the third and fourth rows (corresponding to Figures S(2c) and S(2d)) show ratios within 2σ from that of the fifth row. The ranges of the fifth row used in the main text were selected because they have the shortest background ranges.

^{206}Pb mass range	^{207}Pb mass range	$^{207}Pb/^{206}Pb$	Deviation from 0.07626	2σ	Figure number
205.73~206.93	206.83~207.43	0.07664	0.00038	0.00074	Figure S2(a)
205.73~206.63	206.83~207.36	0.07588	-0.00038	0.00073	Figure S2(b)
205.73~207.04	206.83~207.43	0.07701	0.00075	0.00074	Figure S2(c)
205.73~206.63	206.83~207.31	0.07553	-0.00073	0.00073	Figure S2(d)
205.73–206.63	206.83–207.43	0.07626	0.0	0.00073	Figure 7 in the main text

Figure S1. Measurement of $^{208}Pb/^{206}Pb$ ratios for NIST 610, and NIST 612. The left column consists of three panels, each representing a typical measurement. In each panel, the upper and lower figures show the variation of the ^{208}Pb signals and the $^{208}Pb/^{206}Pb$ ratios as a function of ^{206}Pb signal intensities, respectively. Each data point corresponds to a summation of data from one layer or 60 laser pulses (see main text). Signal intensities are expressed as counts derived from measured analog signals (see main text).The red solid lines indicate the weighted average ratios. The right column displays the $^{208}Pb/^{206}Pb$ratios obtained from multiple measurement sessions. Points labeled with "*" in the right panels correspond to example measurements from the left column.



Figures S2(a)-(d). Variations in $^{207}Pb/^{206}Pb$ ratios as a function of integration ranges. The specific ranges and corresponding values are detailed in Table S5. More details can be found in caption of Figure 8 in the main text.