^{208}Pb(^{36}S,^{35}Pγ) 2008Wi09,2015Ch56,2019Gr08

2008Wi09,2010WiZZ: A 230-MeV ^{36}S beam was produced by the Argonne Tandem Linac Accelerator System (ATLAS) with an intensity of 1.5 pnA on a 0.5 mg/cm^2 ^{208}Pb target and an intensity of 0.3 pnA on a 44 mg/cm^2 ^{208}Pb target. In the thin-target run, binary transfer products were detected using a heavy-ion parallel-plate avalanche counter (PPAC) array (CHICO) (Time resolution ≈0.7ns). The polar angle covered was 12°to 85° with respect to the beam. γ rays were detected by Gammasphere consisting of 101 HPGe detectors with FWHM=2-10 keV at Eγ=1 MeV. Event-by-event Doppler shift correction was applied. In the thick-target run, binary transfer products were stopped in the target. γ rays were detected by Gammasphere consisting of 95 HPGe detectors with FWHM=2-3 keV at Eγ=1 MeV. Measured Eγ, Iγ, $\gamma\gamma$-coin. Deduced levels. Comparisons with shell-model calculations. Branching-ratio limits were reported for predicted transitions to the $2\hbar\omega$ bandheads in ^{35}P and ^{34}Si. An e-mail reply from Mathis Wiedeking in April, 2010 (2010WiZZ) provides relative γ-ray intensities, supplementing 2008Wi09.

2015Ch56: A 215-MeV ^{36}S beam was produced using the combination of XTU tandem Van de Graaff accelerator and ALPI superconducting linear accelerator at the INFN Legnaro National Laboratory. The target was 300−μg/cm^2 99.7% enriched ^{208}Pb on a 20 μg/cm^2 carbon backing. Projectile-like fragments produced in multinucleon binary grazing reactions were separated and identified by the PRISMA spectrometer. γ rays were detected using the CLARA array of 22 EUROBALL escape-suppressed HPGe clover detectors. Doppler corrections of γ-ray energies were performed event by event. Measured Eγ, Iγ, (^{35}P)γ-coin, and $\gamma\gamma$-coin. 2015Ch56 also revisited the $\gamma\gamma\gamma$-coin of ^{36}S+^{176}Yb deep-inelastic data by J. Ollier Ph.D. thesis, University of Paisley (2004) to strengthen the evidence for γ-ray placements (see Ref. [39] in 2015Ch56). Deduced levels, J, π. Comparisons with shell-model calculations.

2019Gr08: A 225-MeV ^{36}S beam was provided by Tandem-ALPI accelerator complex at the INFN Legnaro National Laboratory. The target was 1 mg/cm^2 99.7% enriched ^{208}Pb with 1 mg/cm^2 Nb backing and mounted onto the Cologne differential plunger. Projectile-like fragments produced in binary grazing reactions were separated and identified by the PRISMA spectrometer. γ rays were detected using the AGATA demonstrator array of five triple cluster modules of 36-fold segmented Ge crystals covering backward angles from 135° to 175°. Doppler corrections of γ-ray energies were performed event by event. Measured Eγ, (^{35}P)γ-coin, and level lifetimes using the differential recoil-distance method (DRDM). Comparison with shell-model calculations.

^{35}P Levels

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	Comments
0	1/2$^+$		
2386.7 *7*	3/2$^+$	<0.69 ps	T$_{1/2}$: estimated mean lifetime τ<1 ps (2019Gr08).
3860.8 *7*	5/2$^+$	<0.69 ps	T$_{1/2}$: estimated mean lifetime τ<1 ps (2019Gr08).
4102.1 *7*	(7/2$^-$)	>69 ps	J$^\pi$: 7/2$^-$ proposed by 2019Gr08 based on comparisons with shell-model calculations. T$_{1/2}$: estimated mean lifetime τ>100 ps (2019Gr08).
4381.9 *10*	(5/2$^-$)		
4494.2 *8*	(7/2$^-$)	2.29 ps *49*	J$^\pi$: 7/2$^-$ proposed by 2019Gr08 based on comparisons with shell-model calculations. T$_{1/2}$: measured mean lifetime τ=3.3 ps *7* (2019Gr08).
4767.1 *10*	(9/2$^-$)		J$^\pi$: 9/2$^-$ proposed by 2019Gr08 based on comparisons with shell-model calculations.
4869.0 *8*	(5/2$^-$,7/2$^-$)		
4962.1 *12*	(9/2$^-$)		J$^\pi$: 9/2$^-$ proposed by 2019Gr08 based on comparisons with shell-model calculations.
5089.8 *11*	(11/2$^-$)		J$^\pi$: 11/2$^-$ proposed by 2019Gr08 based on comparisons with shell-model calculations.
5488.2 *10*			
5560.1 *12*	(5/2$^-$)		
6222.4 *11*	(7/2$^-$,9/2,11/2$^-$)		

† From a least-squares fit to γ-ray energies.
‡ From the Adopted Levels.
# From differential recoil-distance method (DRDM) (2019Gr08).

^{208}Pb(^{36}S,^{35}Pγ) 2008Wi09,2015Ch56,2019Gr08 (continued)

γ(^{35}P)

E_γ	I_γ	E_i(level)	J^π_i	E_f	J^π_f	Mult.‡	Comments
128 *1*	10 *5*	5089.8	(11/2⁻)	4962.1	(9/2⁻)		E_γ: weighted average of 128 *1* (2008Wi09) and 127 *1* (2015Ch56). I_γ: unweighted average of 14 *2* (2008Wi09) and 5.2 *6* (2015Ch56).
241 *1*	61 *4*	4102.1	(7/2⁻)	3860.8	5/2⁺	[E1]	E_γ: From 2008Wi09 and 2015Ch56. I_γ: From 2008Wi09. Other: 32.6 *9* (2015Ch56).
273 *1*	12.8 *8*	4767.1	(9/2⁻)	4494.2	(7/2⁻)		E_γ: From 2008Wi09 and 2015Ch56. I_γ: weighted average of 12 *2* (2008Wi09) and 12.9 *8* (2015Ch56).
322 *1*	20 *7*	5089.8	(11/2⁻)	4767.1	(9/2⁻)		E_γ: weighted average of 321 *1* (2008Wi09) and 323 *1* (2015Ch56). I_γ: unweighted average of 27 *3* (2008Wi09) and 12.9 *8* (2015Ch56).
374† *1*	3† *1*	4869.0	(5/2⁻,7/2⁻)	4494.2	(7/2⁻)		
392 *1*	30 *5*	4494.2	(7/2⁻)	4102.1	(7/2⁻)		E_γ: weighted average of 391 *1* (2008Wi09) and 392 *1* (2015Ch56). I_γ: unweighted average of 35 *3* (2008Wi09) and 24.9 *11* (2015Ch56).
468 *2*	16.2 *12*	4962.1	(9/2⁻)	4494.2	(7/2⁻)		E_γ: unweighted average of 466 *1* (2008Wi09) and 469 *1* (2015Ch56). I_γ: weighted average of 14 *2* (2008Wi09) and 16.8 *11* (2015Ch56).
487† *1*	<2†	4869.0	(5/2⁻,7/2⁻)	4381.9	(5/2⁻)		I_γ: 1 *1* from 2008Wi09.
633 *1*	8.2 *22*	4494.2	(7/2⁻)	3860.8	5/2⁺		E_γ: weighted average of 632 *1* (2008Wi09) and 633 *1* (2015Ch56). I_γ: unweighted average of 6 *1* (2008Wi09) and 10.4 *9* (2015Ch56).
664 *1*	32 *15*	4767.1	(9/2⁻)	4102.1	(7/2⁻)		E_γ: weighted average of 663 *1* (2008Wi09) and 665 *1* (2015Ch56). I_γ: unweighted average of 47 *4* (2008Wi09) and 17.8 *10* (2015Ch56).
767† *1*	5† *1*	4869.0	(5/2⁻,7/2⁻)	4102.1	(7/2⁻)		
859 *3*	10.7 *14*	4962.1	(9/2⁻)	4102.1	(7/2⁻)		E_γ: unweighted average of 856 *1* (2008Wi09) and 861 *1* (2015Ch56). I_γ: weighted average of 13 *2* (2008Wi09) and 9.8 *12* (2015Ch56).
993† *1*	5† *1*	5488.2		4494.2	(7/2⁻)		
1009† *1*	<1†	4869.0	(5/2⁻,7/2⁻)	3860.8	5/2⁺		
1132† *1*	<1†	6222.4	(7/2⁻,9/2,11/2⁻)	5089.8	(11/2⁻)		
1260† *1*	4† *1*	6222.4	(7/2⁻,9/2,11/2⁻)	4962.1	(9/2⁻)		
ˣ1353 *1*	9.2 *11*						E_γ,I_γ: From 2015Ch56.
1387† *1*	3† *1*	5488.2		4102.1	(7/2⁻)		
1458† *1*	7† *2*	5560.1	(5/2⁻)	4102.1	(7/2⁻)		
1474 *1*	15.9 *14*	3860.8	5/2⁺	2386.7	3/2⁺	[M1,E2]	E_γ: weighted average of 1473 *1* (2008Wi09) and 1474 *1* (2015Ch56). I_γ: weighted average of 15 *2* (2008Wi09) and 16.4 *14* (2015Ch56).
ˣ1592 *1*	7.7 *10*						E_γ,I_γ: From 2015Ch56.
1715† *1*	4† *1*	4102.1	(7/2⁻)	2386.7	3/2⁺	[M2,E3]	
1729† *1*	4† *1*	6222.4	(7/2⁻,9/2,11/2⁻)	4494.2	(7/2⁻)		
1995 *1*	8 *6*	4381.9	(5/2⁻)	2386.7	3/2⁺		E_γ: weighted average of 1995 *1* (2008Wi09) and 1994 *1* (2015Ch56).

Continued on next page (footnotes at end of table)

^{208}Pb(^{36}S,^{35}Pγ) 2008Wi09,2015Ch56,2019Gr08 (continued)

γ(^{35}P) (continued)

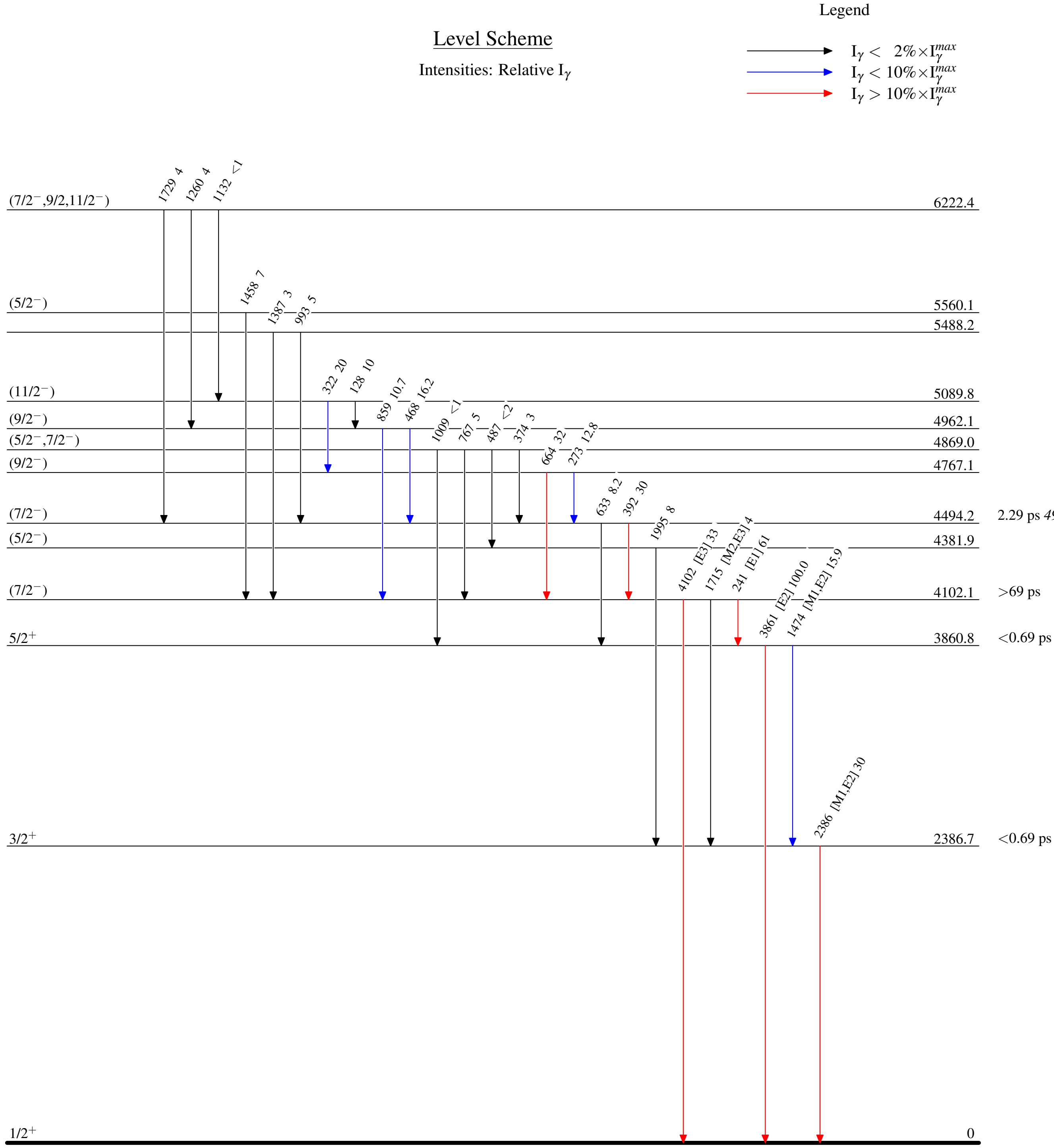
E_γ	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.‡	Comments
							I_γ: unweighted average of 2 *1* (2008Wi09) and 14.2 *11* (2015Ch56).
2386 *1*	30 *4*	2386.7	3/2$^+$	0	1/2$^+$	[M1,E2]	E_γ: From 2008Wi09 and 2015Ch56. I_γ: From 2008Wi09. Other: 99.2 *28* (2015Ch56). Shell-model calculations indidate a small occupancy of the proton $1d_{3/2}$ orbit in the ground state of ^{36}S.
3861 *1*	100.0 *32*	3860.8	5/2$^+$	0	1/2$^+$	[E2]	E_γ: weighted average of 3861 *1* (2008Wi09) and 3860 *1* (2015Ch56). I_γ: From 2015Ch56. Other: 100 (2008Wi09).
4102† *1*	33† *5*	4102.1	(7/2$^-$)	0	1/2$^+$	[E3]	E_γ: other: 4101 (2015Ch56).

† From 2008Wi09.
‡ From 2019Gr08-shell model calculations.
^{x} γ ray not placed in level scheme.

$^{208}Pb(^{36}S,^{35}P\gamma)$ 2008Wi09,2015Ch56,2019Gr08

Level Scheme

Intensities: Relative I_γ



$^{35}_{15}P_{20}$