

ING LA PALMA TECHNICAL NOTE NO. 133

Arc maps for the CuAr and CuNe lamps when used with IDS/Red+2

Version 1.0 (January 2013)

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Introduction

ING La Palma Technical Notes 70, 125 and 126 give identifications for lines produced by some of the calibration lamps and the gratings available to IDS on the Isaac Newton Telescope and to ISIS on the William Herschel Telescope. The present technical note is a compilation of arc maps for a more comprehensive range of instrument configurations available, using the low-fringing CCD RED+2.

The calibration lamp exposures were obtained from the 1st to the 5th of February 2012 using the IDS 235 mm camera with the RED+2 CCD detector. All the exposures were made with a slit width of 1.0 arcsecond. Several central wavelengths were selected for all the available gratings. No order-sorting or neutral density filter was used.

The reduction was performed using IRAF. The arc lines were identified using the IRAF task `identify`. All lines were carefully identified using the calibration data sets provided by IRAF and the ISIS lamp maps (ING technical notes 125 and 126). Appendices A, B and C show the laboratory wavelengths of the lines used.

Table 1 provides a description of the arcs obtained, and the atlas follows. On each plot, relative intensity in counts is plotted on the y axis.

Table 1: Description of the Copper-Argon and Copper-Neon arcs obtained.

- (1) *Range*: The spectral range plotted in Angstroms.
- (2) $\lambda_{central}$: The central wavelength in Angstroms.
- (3) *Lamp*: The arc lamp or lamps used.
- (4) *Exp. time*: Exposure time in seconds. In some cases two exposures were obtained, short and long and both were combined to create the plots of the spectral atlas. Note: please be aware that these exposure times refer to the lamps used in this study, and should not be taken as a standard for taking arcs as the intensity of the lamps can change over time.
- (5) *Dispersion*: Spectral dispersion in Angstroms per pixel estimated from the wavelength-pixel fit.
- (6) *Lines*: Number of spectral lines identified by the IRAF `identify` task.
- (7) *RMS*: Root mean square of the wavelength-pixel fit in Angstroms.

Range (1)	$\lambda_{central}$ (2)	Lamp (3)	Exp. time (4)	Dispersion (5)	Lines (6)	RMS (7)
R150V						
3500-10500	5500	CuAr+CuNe	3, 180	4.035	40	0.278
		CuNe	3, 180	4.035	39	0.171
		CuAr	10, 400	4.035	29	0.122
R300V						
3500-9000	5500	CuAr+CuNe	4, 30	2.058	45	0.094
		CuNe	4, 30	2.058	34	0.063
		CuAr	10, 60	2.058	39	0.091
R400B						
3250-7000	4000	CuAr+CuNe	90, 600	1.546	36	0.079
		CuNe	90, 600	1.546	39	0.083
		CuAr	1200	1.546	41	0.072
3050-9350	6000	CuAr+CuNe	8, 40	1.556	47	0.041
		CuNe	8, 40	1.556	44	0.050
		CuAr	20, 200	1.556	42	0.077
R400V						
4000-8100	5500	CuAr+CuNe	5, 30	1.554	40	0.046
		CuNe	5, 30	1.554	41	0.055
		CuAr	15, 60	1.554	31	0.052
3500-9850	6500	CuAr+CuNe	5, 30	1.559	50	0.054
		CuNe	5, 30	1.559	42	0.050
		CuAr	10, 60	1.559	44	0.078
R400R						
4000-10300	7000	CuAr+CuNe	4, 20	1.561	48	0.056
		CuNe	4, 30	1.561	44	0.061
		CuAr	10, 60	1.561	48	0.056
5000-11300	8000	CuAr+CuNe	5	1.564	44	0.077
		CuNe	5, 30	1.564	39	0.089
		CuAr	8, 40	1.564	44	0.077
R600R						
4200-8400	6200	CuAr+CuNe	3, 30	1.048	39	0.033
		CuNe	3, 30	1.048	40	0.023

		CuAr	10, 60	1.048	39	0.034
5000-9200	7000	CuAr+CuNe	3, 15	1.050	44	0.033
		CuNe	3, 30	1.050	23	0.023
		CuAr	7, 60	1.048	39	0.034
5800-10000	7800	CuAr+CuNe	3, 15	1.051	46	0.048
		CuNe	3, 30	1.051	43	0.066
		CuAr	6, 50	1.051	34	0.045
R600IR						
5500-9700	7500	CuAr+CuNe	5, 20	1.052	52	0.066
		CuNe	5, 30	1.052	48	0.059
		CuAr	10, 50	1.052	42	0.057
6500-10700	8500	CuAr+CuNe	7, 30	1.053	48	0.057
		CuNe	12, 50	1.053	46	0.044
		CuAr	8, 30	1.053	38	0.056
R632V						
3700-6500	4700	CuAr+CuNe	10, 90	0.990	28	0.044
		CuNe	10, 120	0.990	23	0.092
		CuAr	70, 140	0.990	46	0.069
3570-7540	5500	CuAr+CuNe	5, 60	0.994	42	0.034
		CuNe	5, 60	0.994	39	0.036
		CuAr	60, 120	0.994	43	0.055
4500-8500	6400	CuAr+CuNe	4, 20	0.997	47	0.026
		CuNe	4, 20	0.997	42	0.035
		CuAr	10, 120	0.997	43	0.052
R831R						
5550-8600	7000	CuAr+CuNe	3, 12	0.760	48	0.033
		CuNe	3, 12	0.760	42	0.043
		CuAr	4, 40	0.760	44	0.038
6550-9600	8000	CuAr+CuNe	5, 20	0.760	43	0.047
		CuNe	5, 30	0.760	42	0.040
		CuAr	5, 20	0.760	34	0.039
7500-10600	9000	CuAr+CuNe	5, 20	0.756	42	0.050
		CuNe	20, 120	0.756	40	0.047
		CuAr	5, 90	0.756	22	0.061
R900V						
2700-5500	4000	CuAr+CuNe	420	0.700	56	0.039
		CuNe	600	0.700	39	0.054
		CuAr	600	0.700	53	0.039
3700-6500	5000	CuAr+CuNe	5, 120	0.702	43	0.043
		CuNe	5, 500	0.702	42	0.041
		CuAr	360	0.702	67	0.049
5150-8000	6500	CuAr+CuNe	3, 15	0.703	46	0.028
		CuNe	3, 15	0.703	40	0.028
		CuAr	20, 180	0.703	39	0.038
R1200U						
2480-4630	3500	CuAr+CuNe	180	0.527	39	0.042
		CuNe	180	0.527	30	0.046

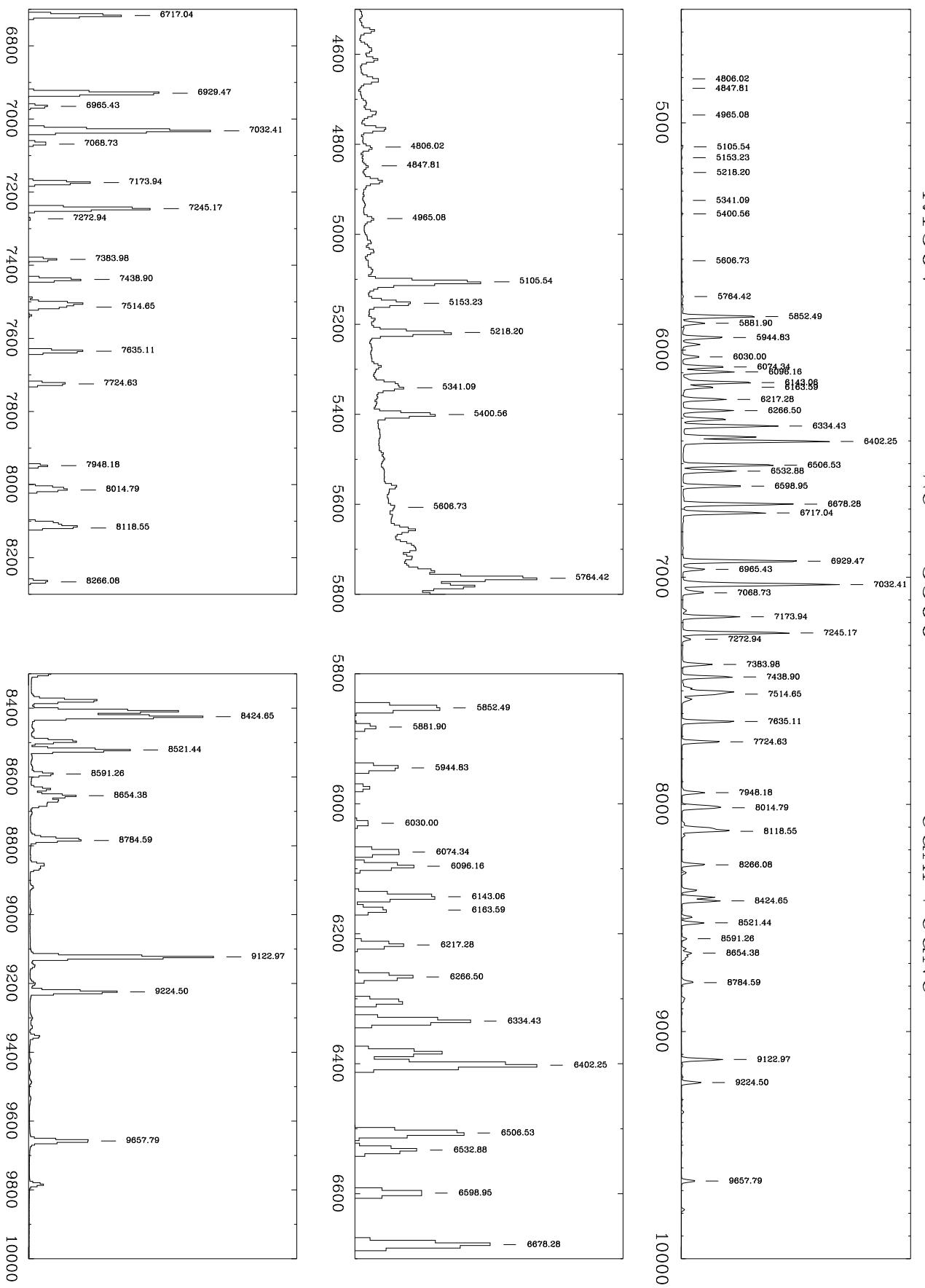
		CuAr	180	0.527	39	0.049
2990-5120	4000	CuAr+CuNe	180	0.527	49	0.050
		CuNe	180	0.527	40	0.073
		CuAr	180	0.527	52	0.038
3490-5620	4500	CuAr+CuNe	180	0.528	50	0.031
		CuNe	180	0.528	41	0.051
		CuAr	180	0.528	47	0.024
R1200B						
2480-4630	3500	CuAr+CuNe	180	0.527	46	0.038
		CuNe	180	0.527	32	0.049
		CuAr	180	0.527	46	0.048
2990-5120	4000	CuAr+CuNe	180	0.528	44	0.030
		CuAr	180	0.528	47	0.045
3490-5620	4500	CuAr+CuNe	180	0.528	40	0.020
		CuNe	180	0.528	44	0.020
		CuAr	180	0.528	44	0.021
R1200Y (R1200V)						
4470-6600	5500	CuAr+CuNe	5, 60	0.526	44	0.032
		CuNe	5, 60	0.526	41	0.027
		CuAr	300	0.526	45	0.050
5000-7120	6000	CuAr+CuNe	5, 30	0.526	42	0.035
		CuNe	5, 30	0.526	34	0.018
		CuAr	300	0.526	44	0.032
5500-7600	6500	CuAr+CuNe	5	0.524	35	0.017
		CuNe	5	0.524	28	0.047
		CuAr	30, 200	0.524	46	0.027
6000-8100	7000	CuAr+CuNe	3	0.521	34	0.048
		CuNe	3	0.521	22	0.049
		CuAr	30, 200	0.521	41	0.033
R1200R						
5470-7605	6500	CuAr+CuNe	3, 20	0.524	37	0.025
		CuNe	3, 20	0.524	32	0.049
		CuAr	15, 120	0.524	46	0.041
5975-8095	7000	CuAr+CuNe	3, 15	0.521	43	0.042
		CuNe	3, 15	0.521	24	0.049
		CuAr	6, 40	0.521	41	0.035
6470-8580	7500	CuAr+CuNe	3, 20	0.518	39	0.023
		CuNe	3, 20	0.518	28	0.048
		CuAr	6, 40	0.518	37	0.038
6980-9070	8000	CuAr+CuNe	7	0.513	42	0.051
		CuNe	12, 30	0.513	44	0.035
		CuAr	7	0.513	25	0.049
H1800V						
3320-4740	4000	CuAr+CuNe	1800	0.351	47	0.028
		CuNe	1800	0.351	30	0.065
		CuAr	1800	0.351	47	0.022
3820-5240	4500	CuAr+CuNe	1200	0.349	45	0.024

		CuNe	1800	0.349	30	0.042
		CuAr	1800	0.349	46	0.025
4330-5720	5000	CuAr+CuNe	600	0.345	44	0.021
		CuNe	600	0.345	46	0.017
		CuAr	600	0.345	42	0.015
4820-6210	5500	CuAr+CuNe	10, 600	0.341	40	0.031
		CuNe	10, 600	0.341	42	0.032
		CuAr	600	0.341	46	0.032
5330-6700	6000	CuAr+CuNe	5, 30	0.336	41	0.026
		CuNe	5, 30	0.336	37	0.029
		CuAr	600	0.336	45	0.016
H2400B						
3000-4050	3500	CuAr+CuNe	600	0.261	38	0.025
3500-4530	4000	CuAr+CuNe	500	0.257	40	0.018
		CuAr	500	0.257	46	0.018
4000-5020	4500	CuAr+CuNe	500	0.252	38	0.014
		CuAr	400	0.252	45	0.021

R150V

$\lambda_C = 5500$

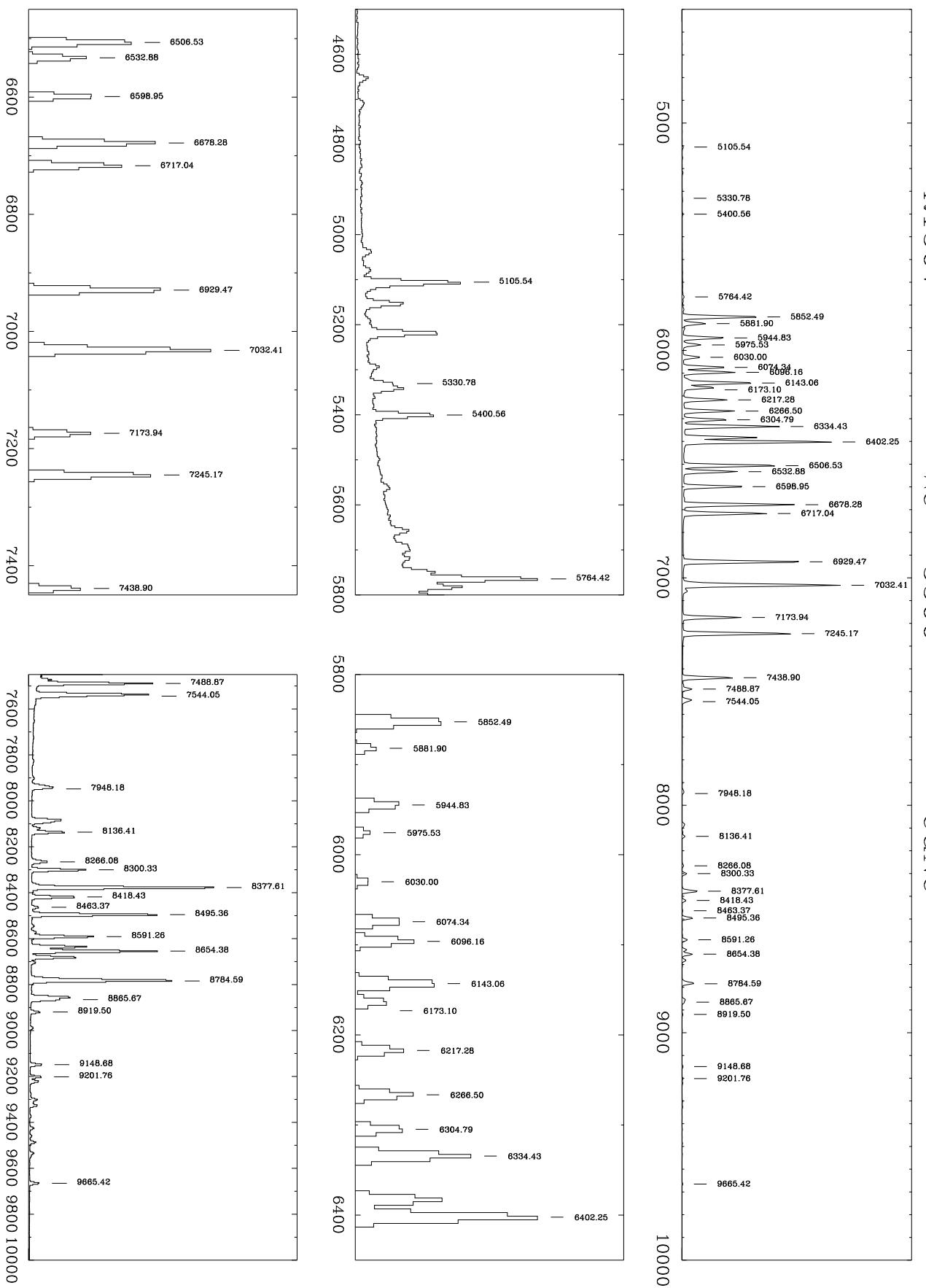
CuAr + CuNe



R150V

$\lambda_C = 5500$

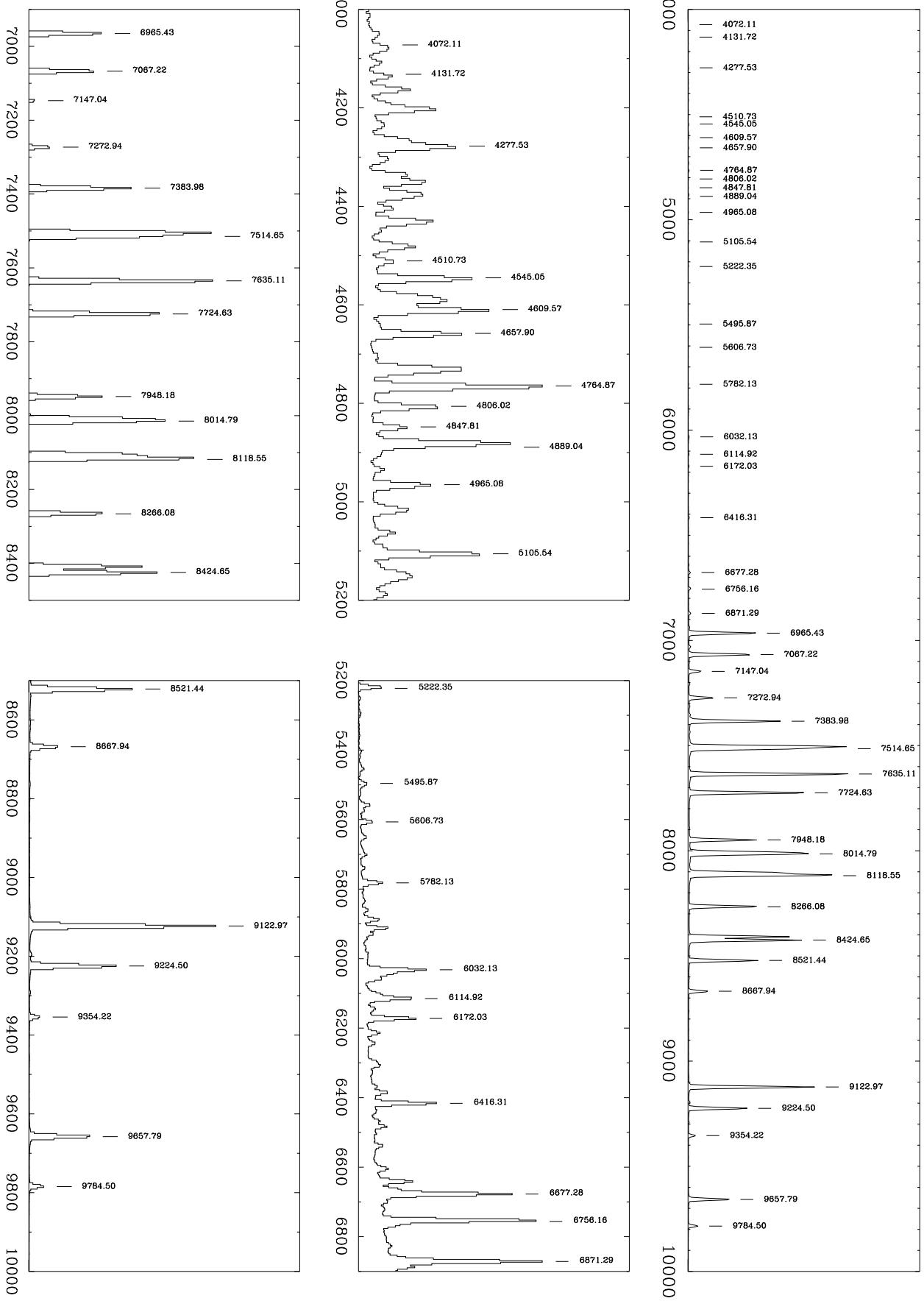
CuNe



R150V

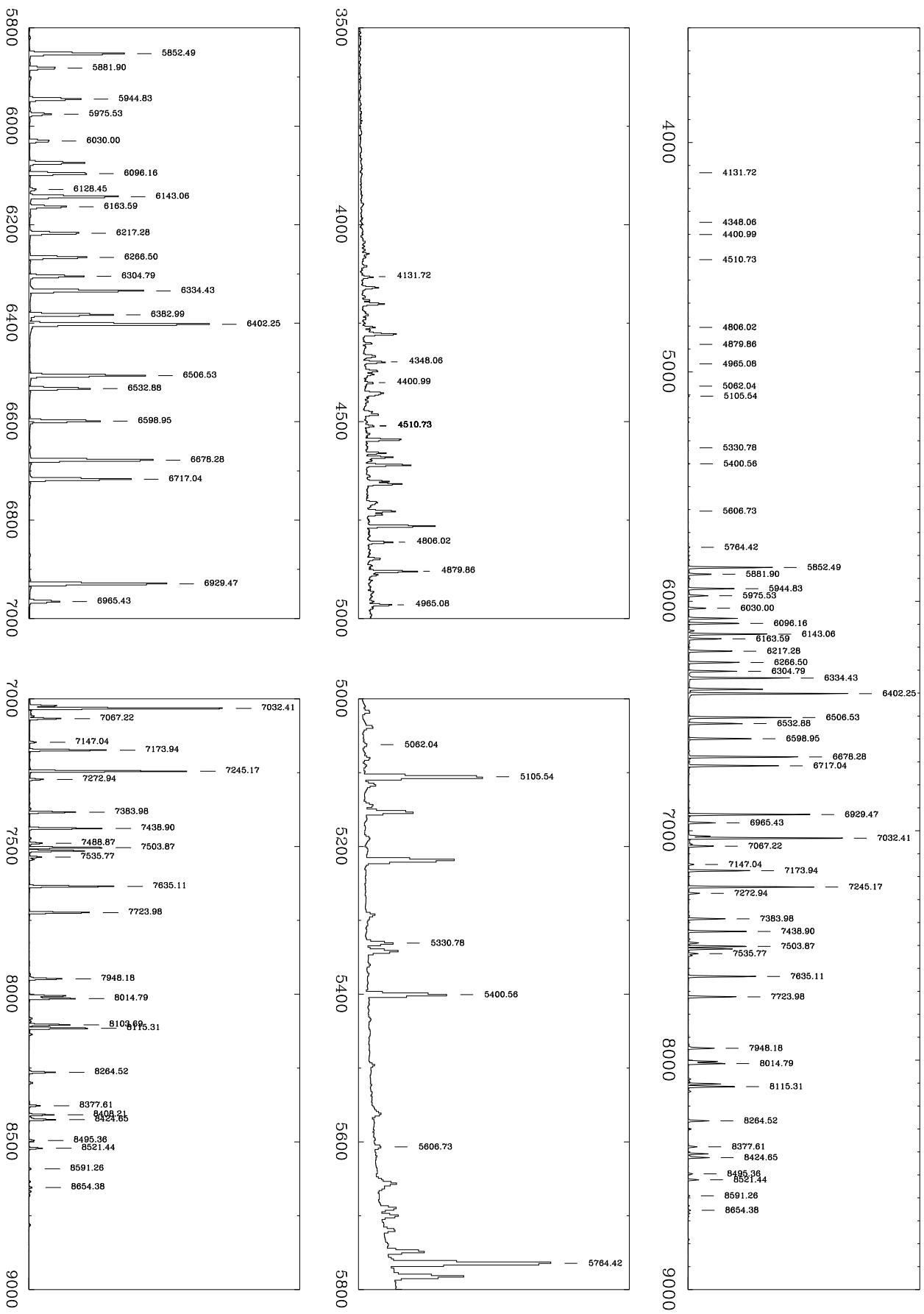
$\lambda_C = 5500$

C_{uAr}



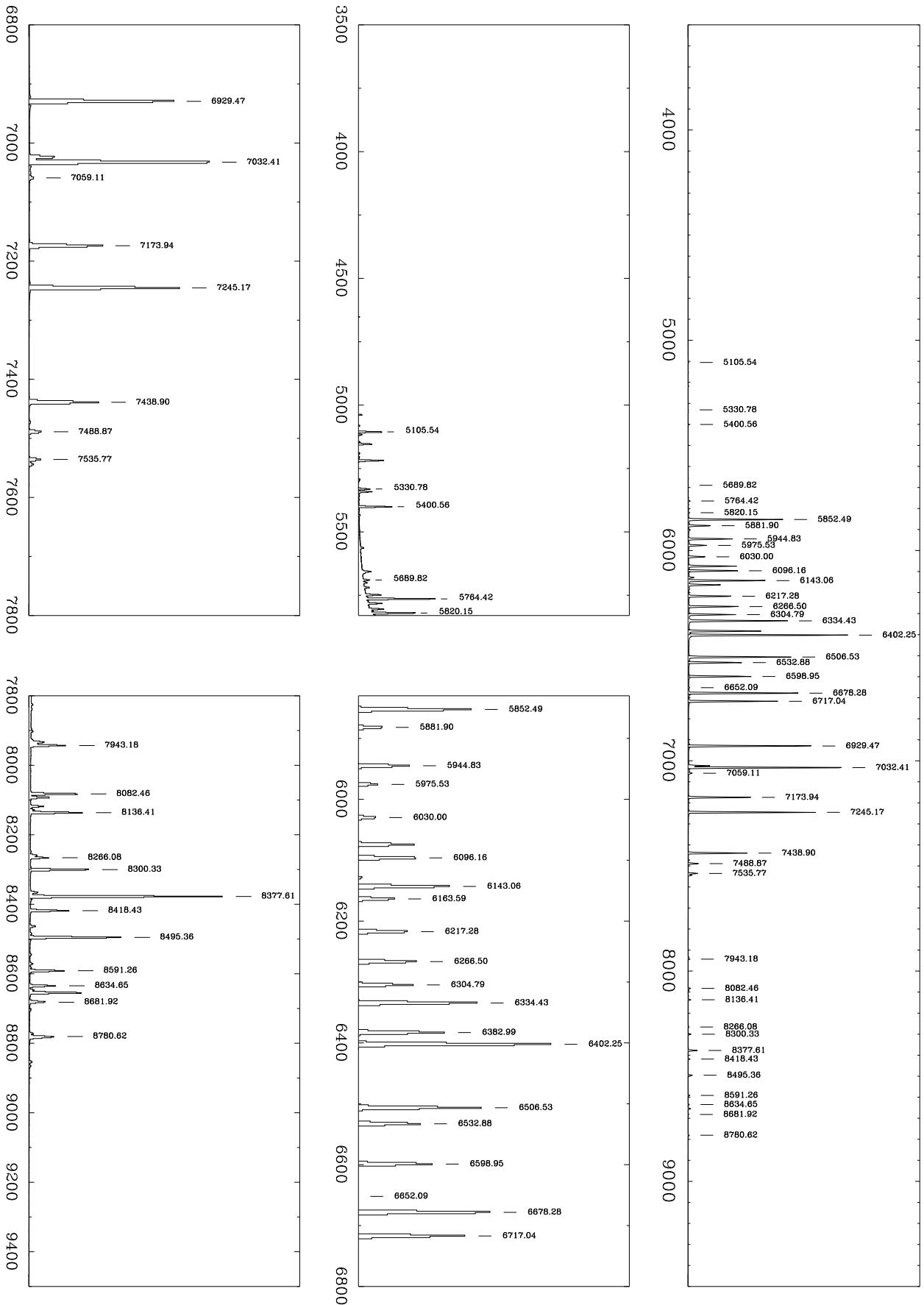
R300V $\lambda_C = 5500$

CuAr + CuNe



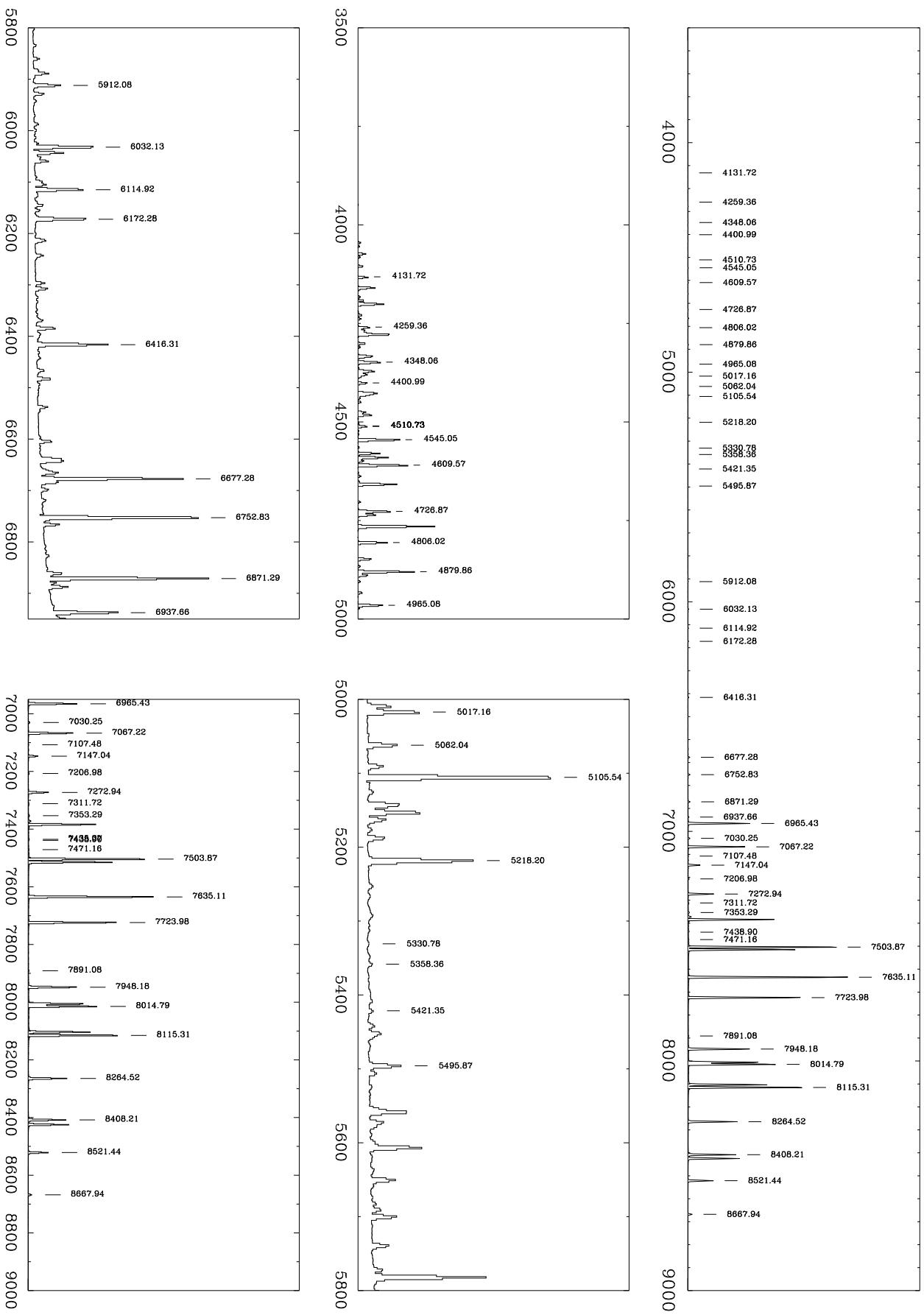
R300V $\lambda_C = 5500$

CuNe



R300V $\lambda_C = 5500$

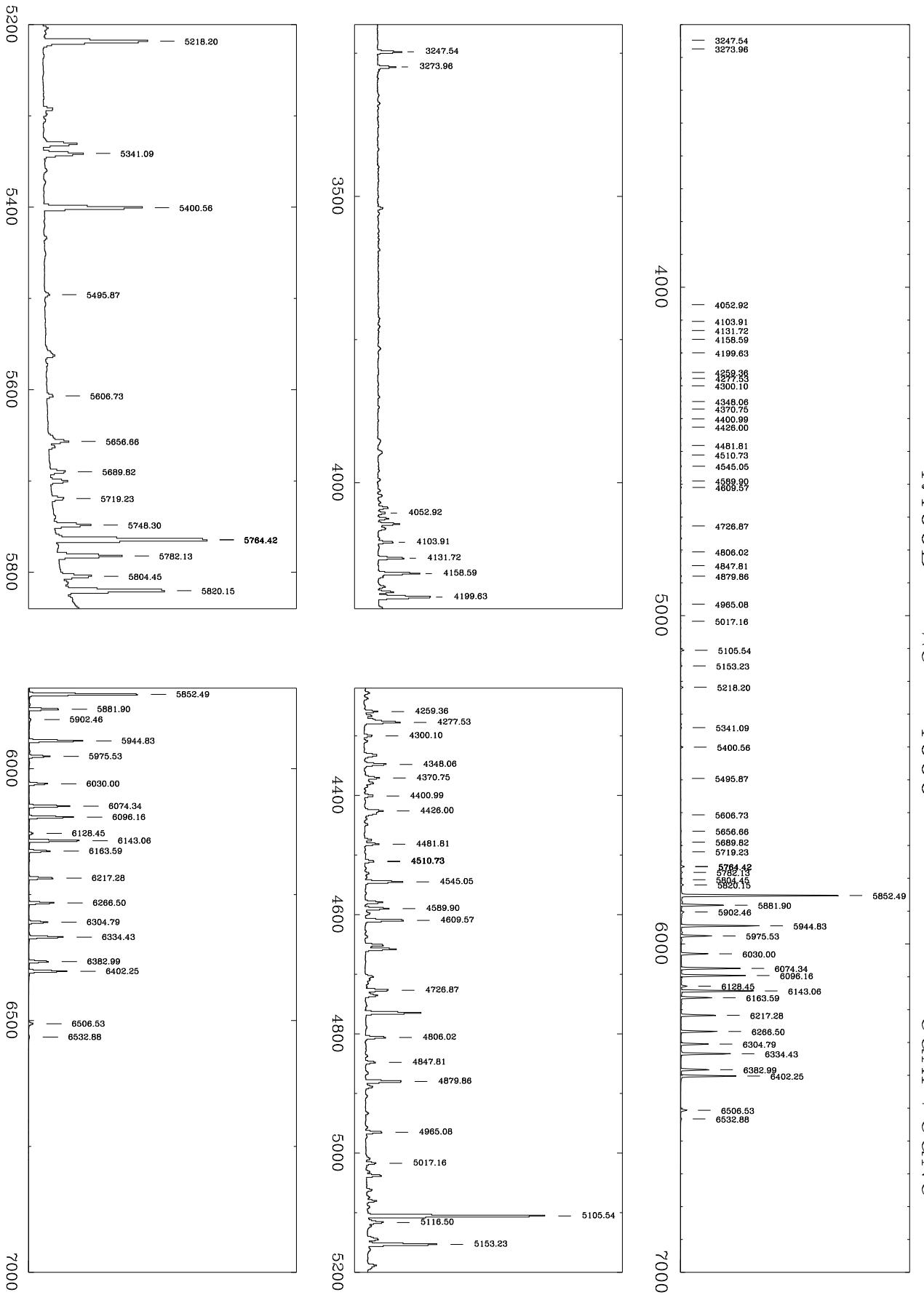
CuAr



R400B

$\lambda_C = 4000$

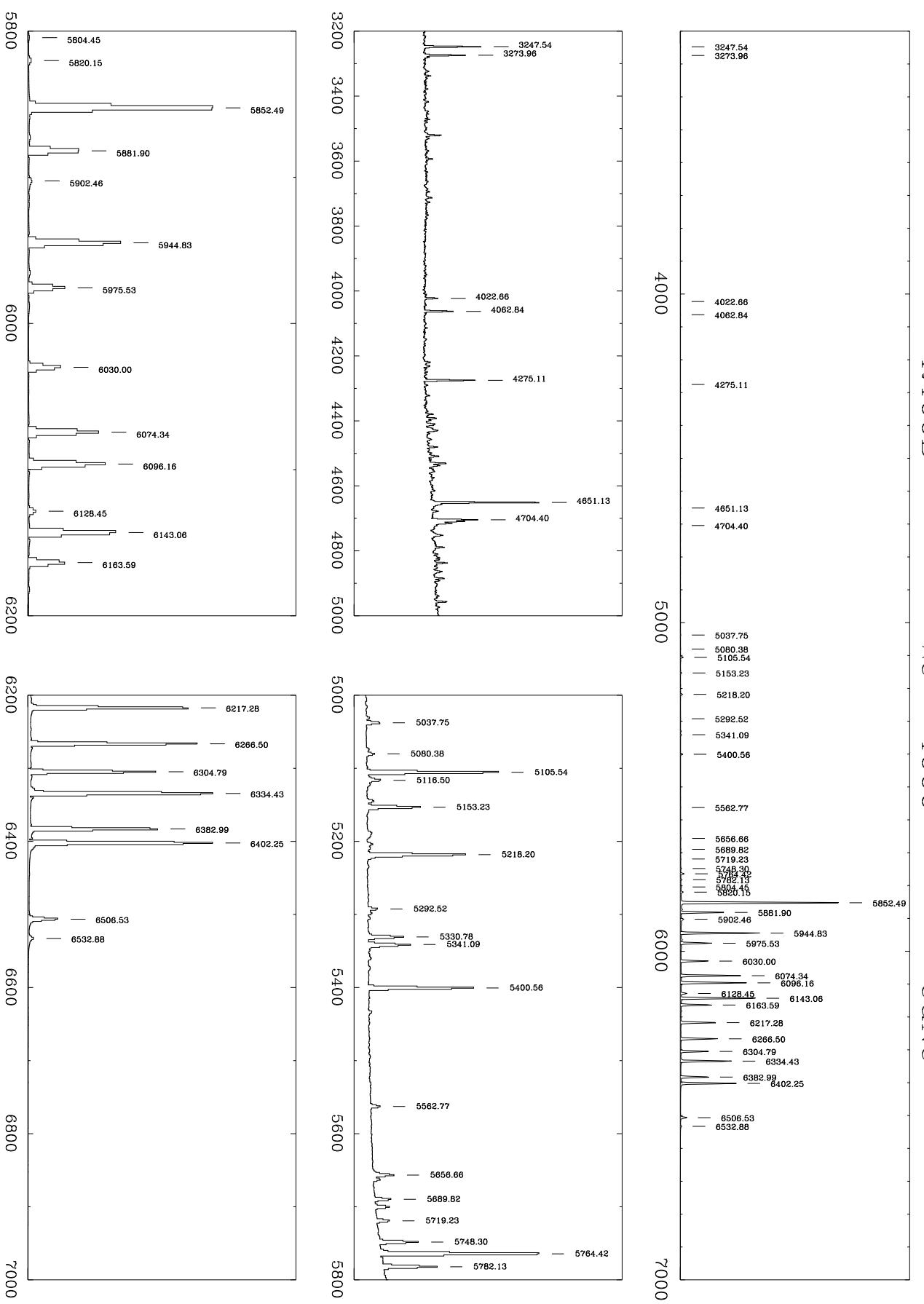
CuAr + CuNe



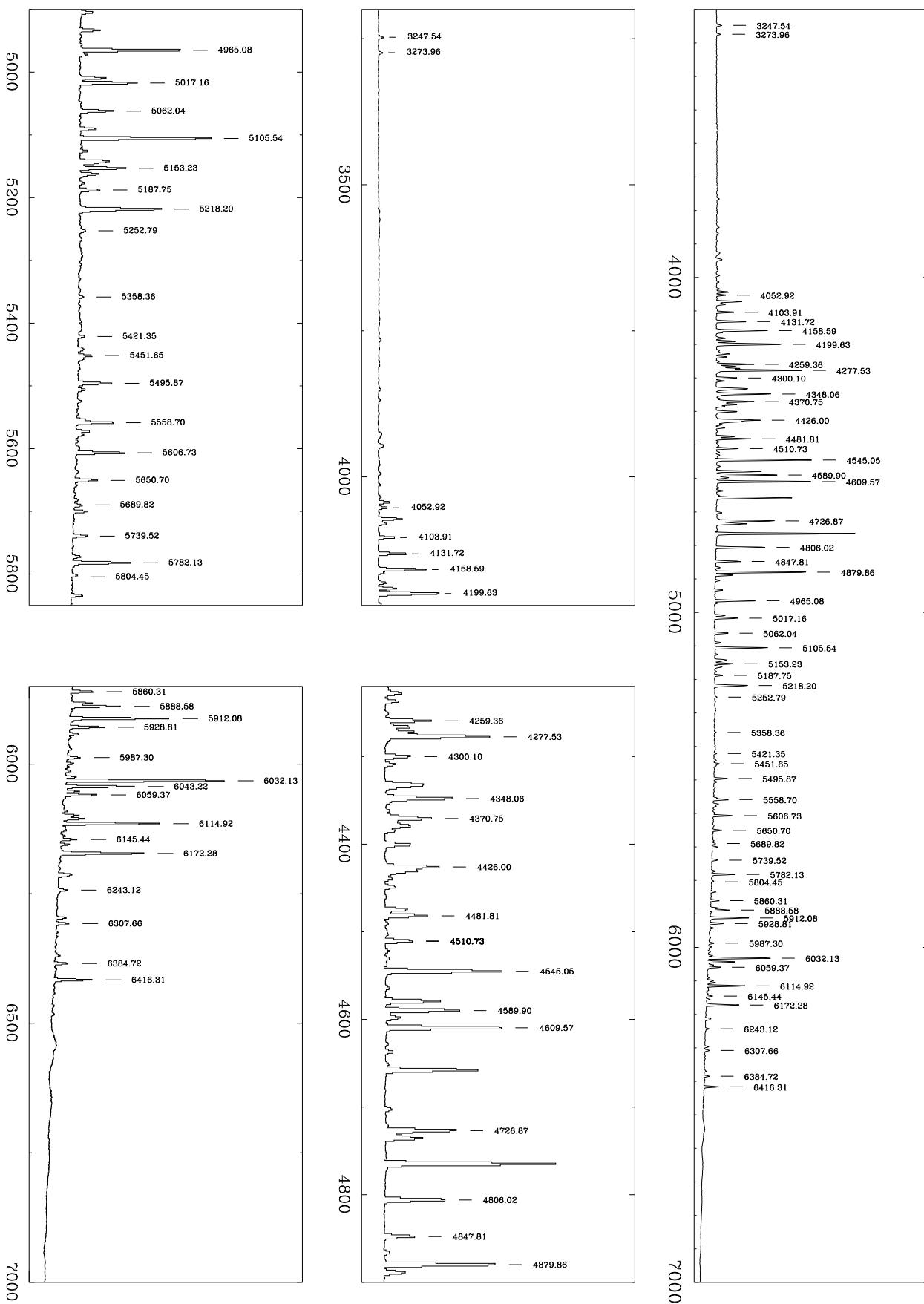
R400B

$\lambda C = 4000$

CuNe



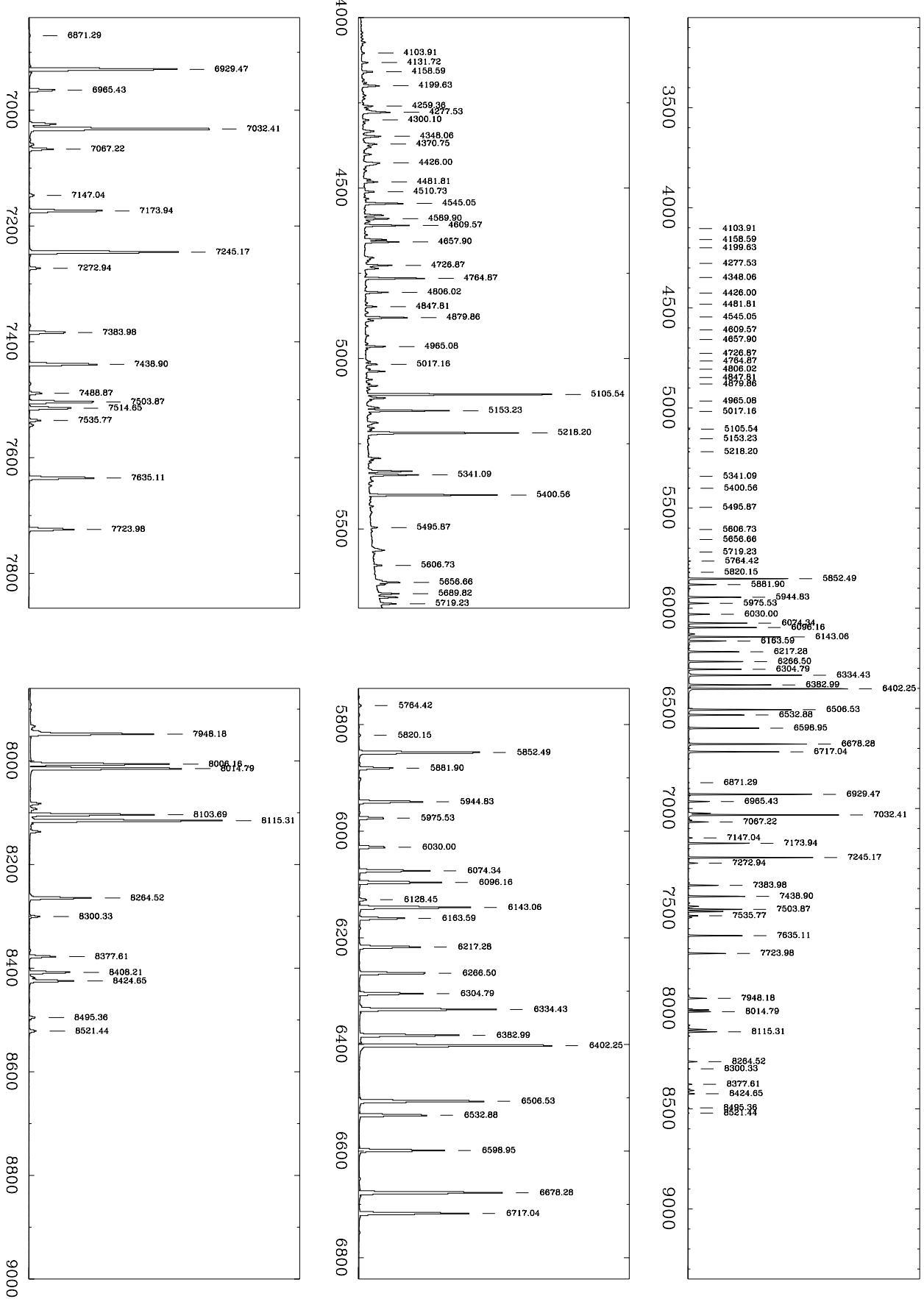
R400B $\lambda_C = 4000$ CuAr



R400B

$\lambda_C = 6000$

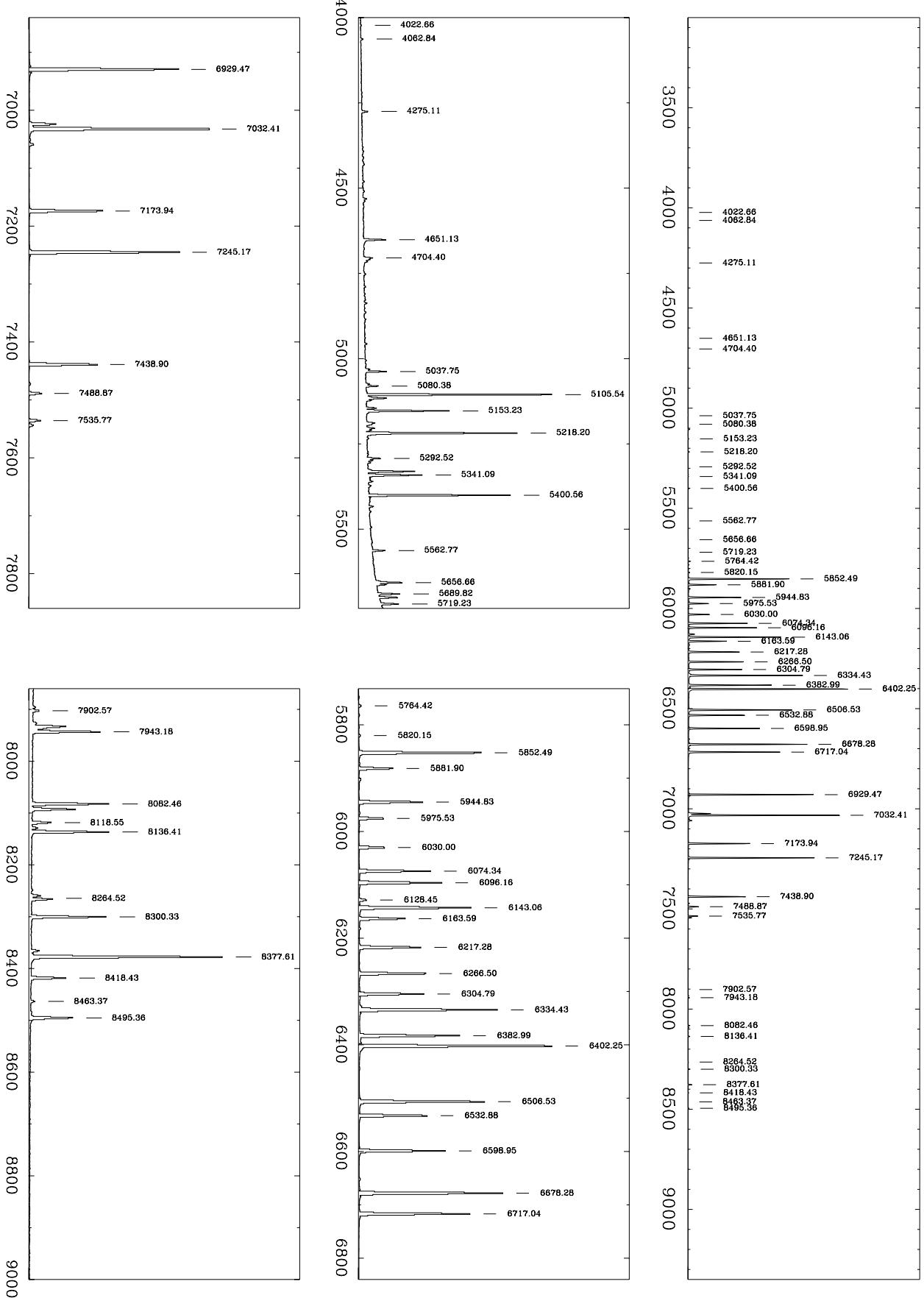
CuAr + CuNe



R400B

$\lambda_C = 6000$

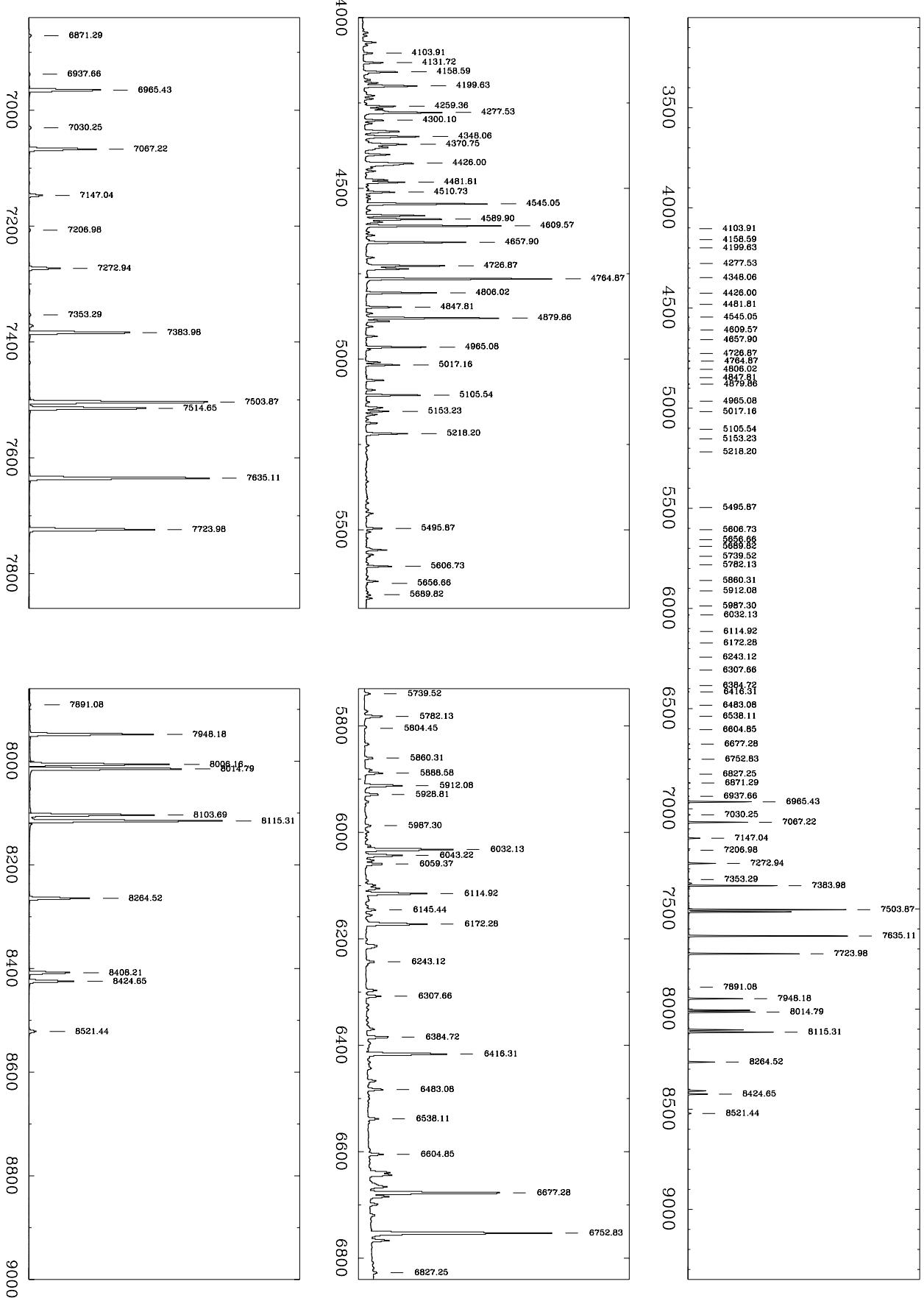
CuNe



R400B

$\lambda_C = 6000$

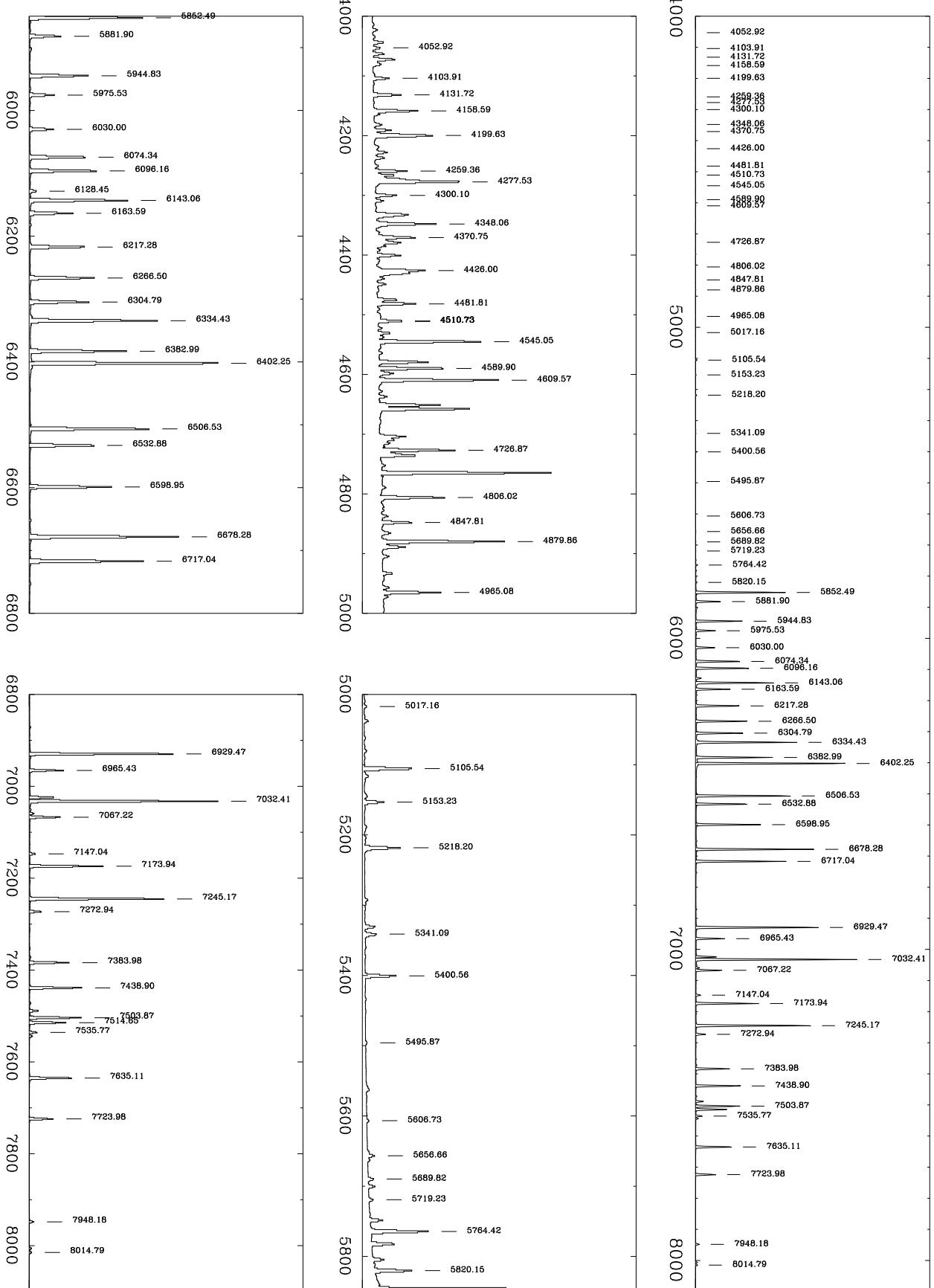
CuAr



R400V

$\lambda_C = 5500$

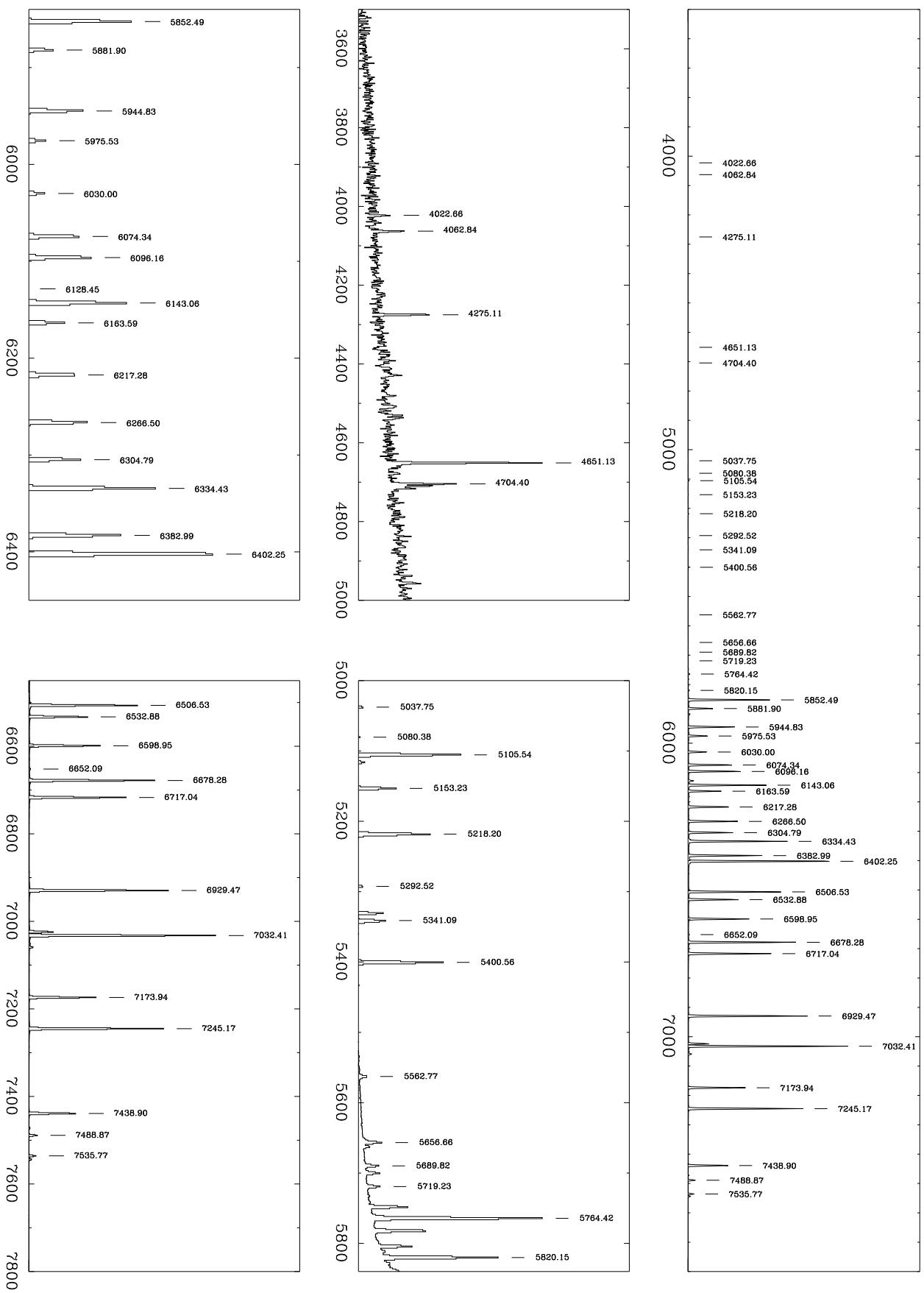
CuAr + CuNe



R400V

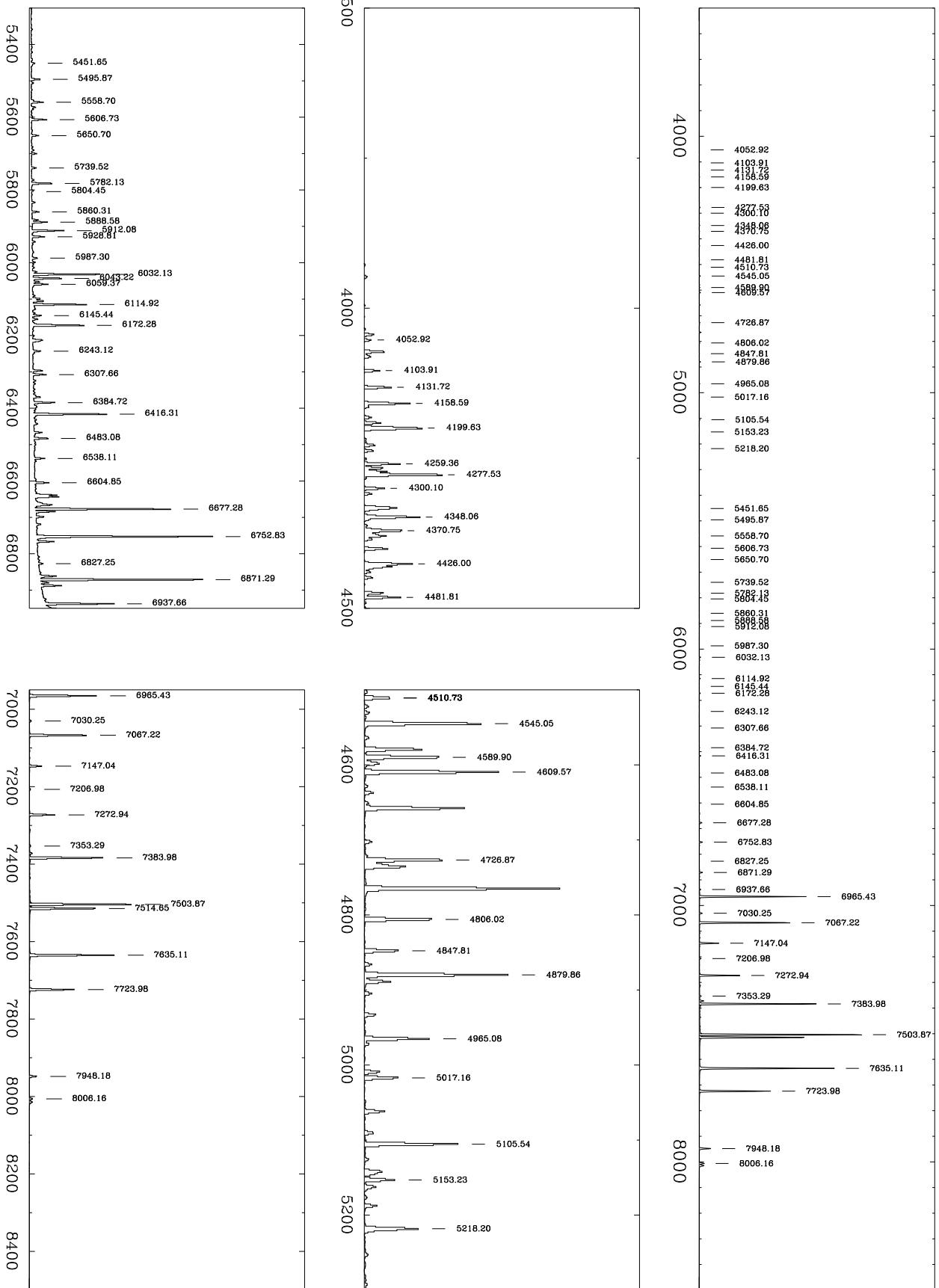
$\lambda C = 5500$

CuNe



R400V $\lambda_C = 5500$

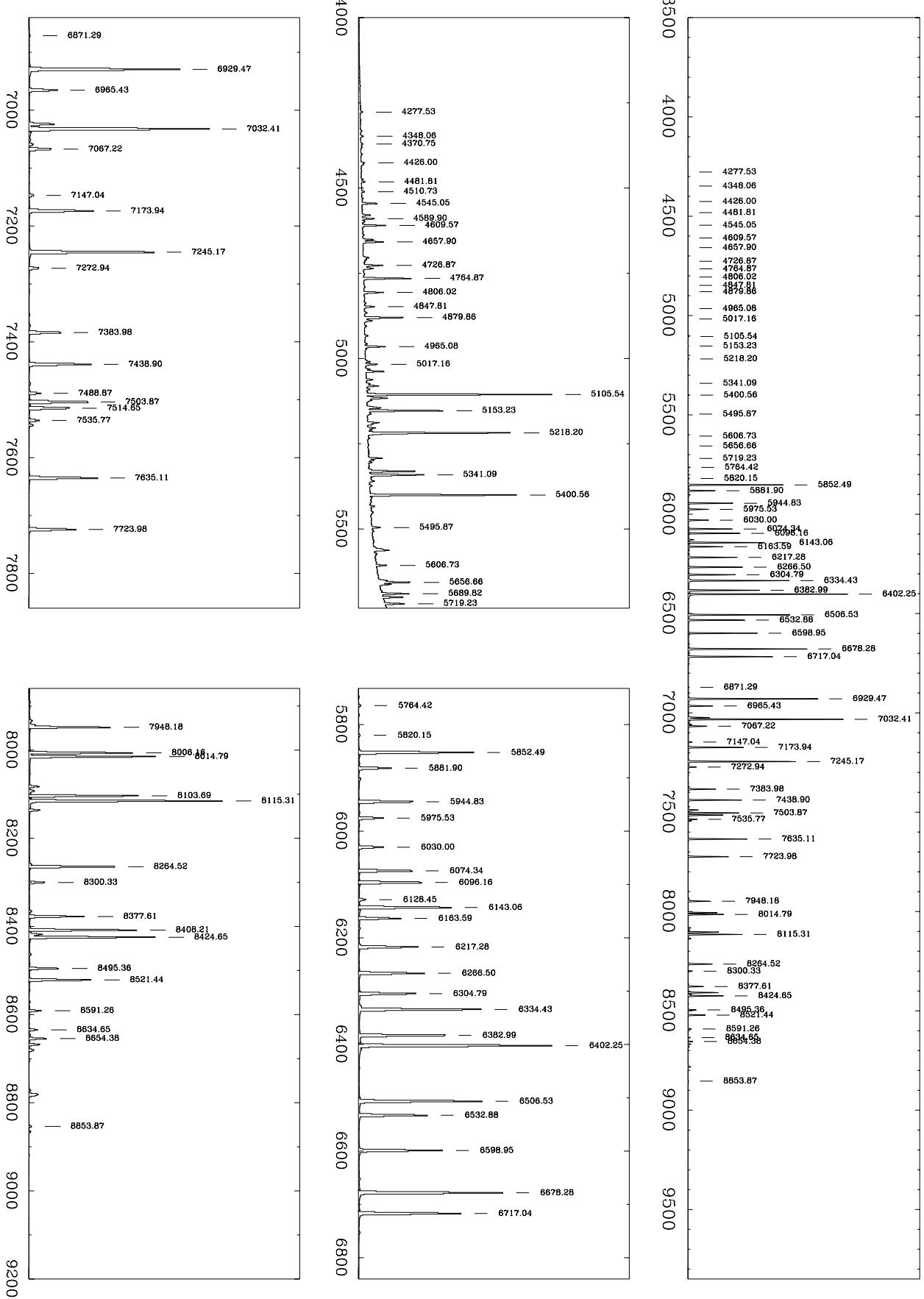
CuAr



R400V

$\lambda_C = 6500$

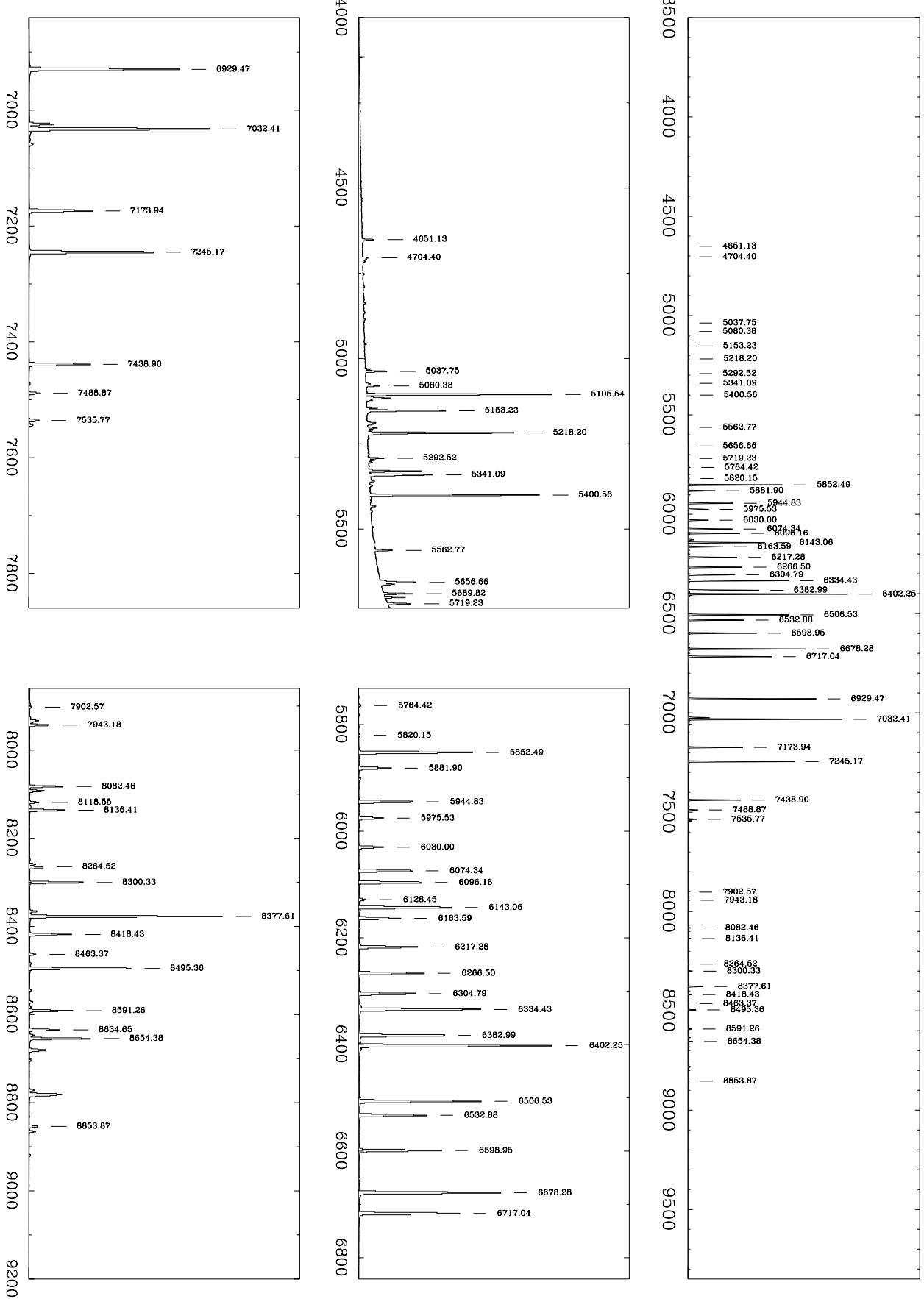
CuAr + CuNe



R400V

$\lambda_C = 6500$

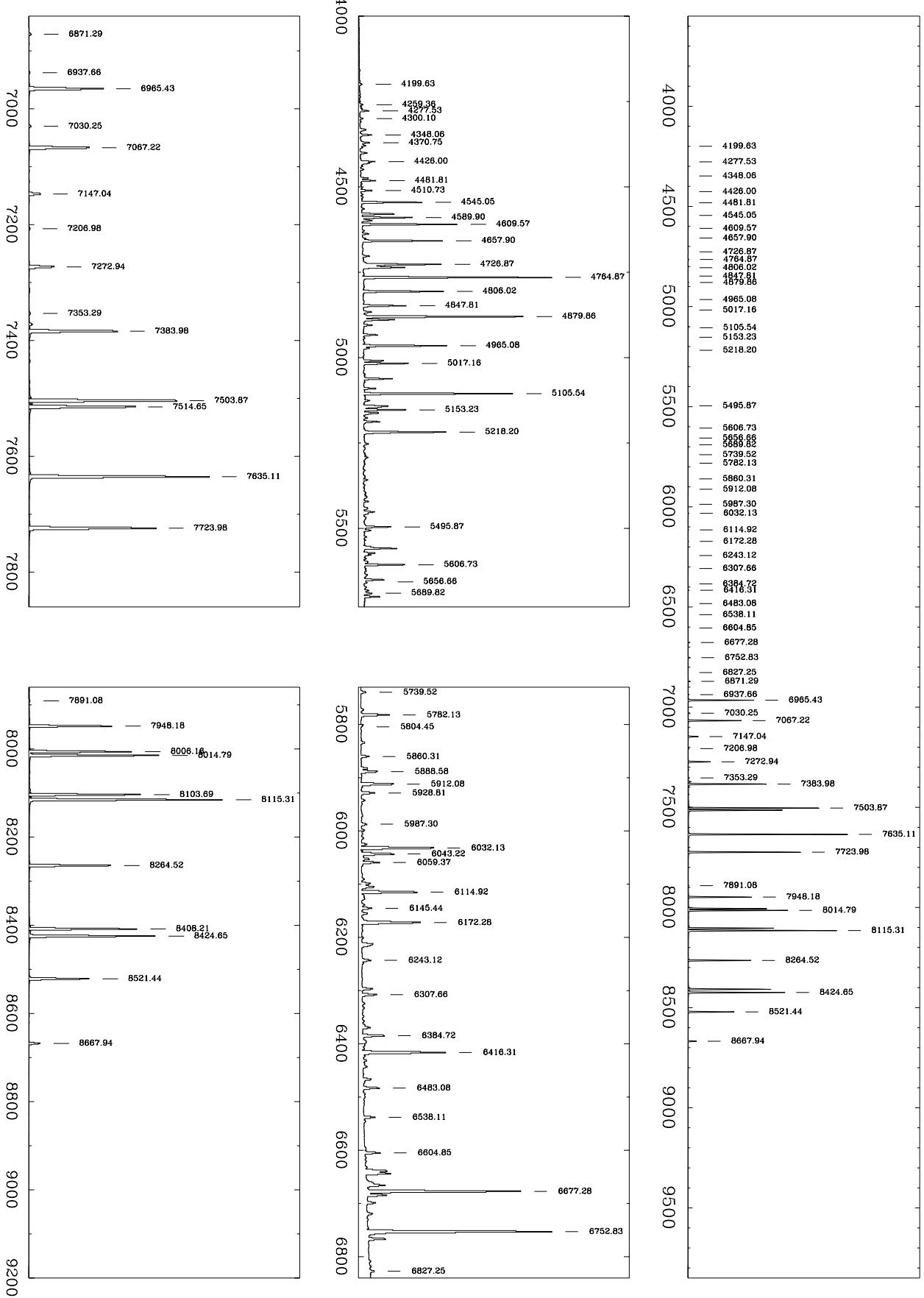
CuNe



R400V

$\lambda C = 6500$

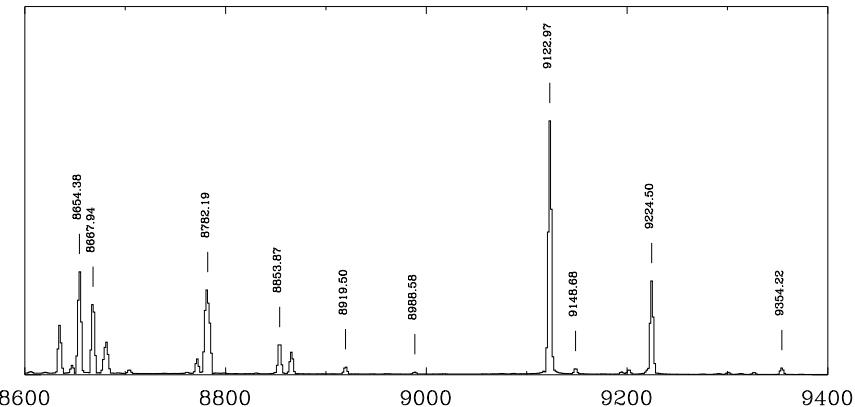
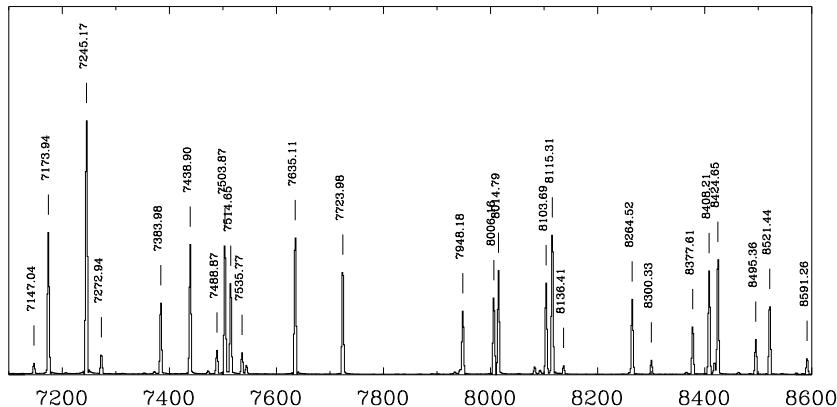
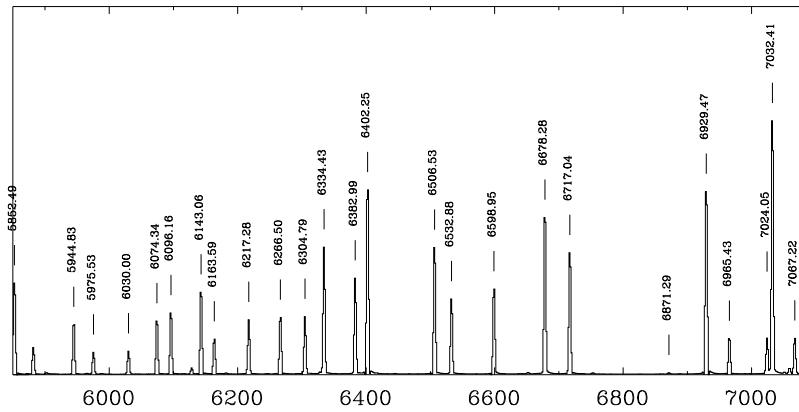
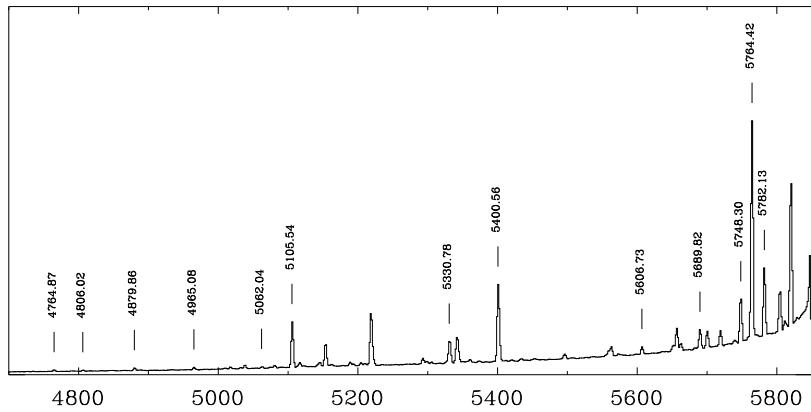
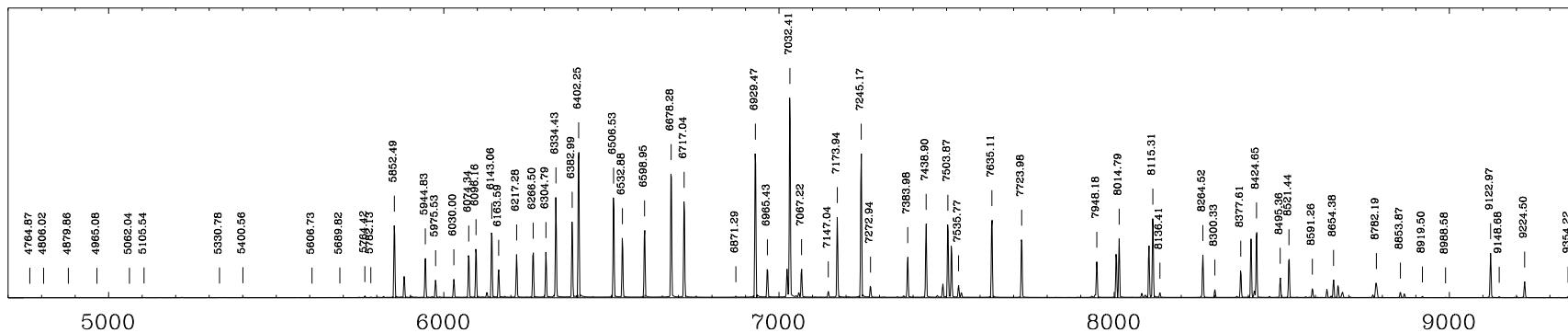
CuAr



R400R

 $\lambda_C = 7000$

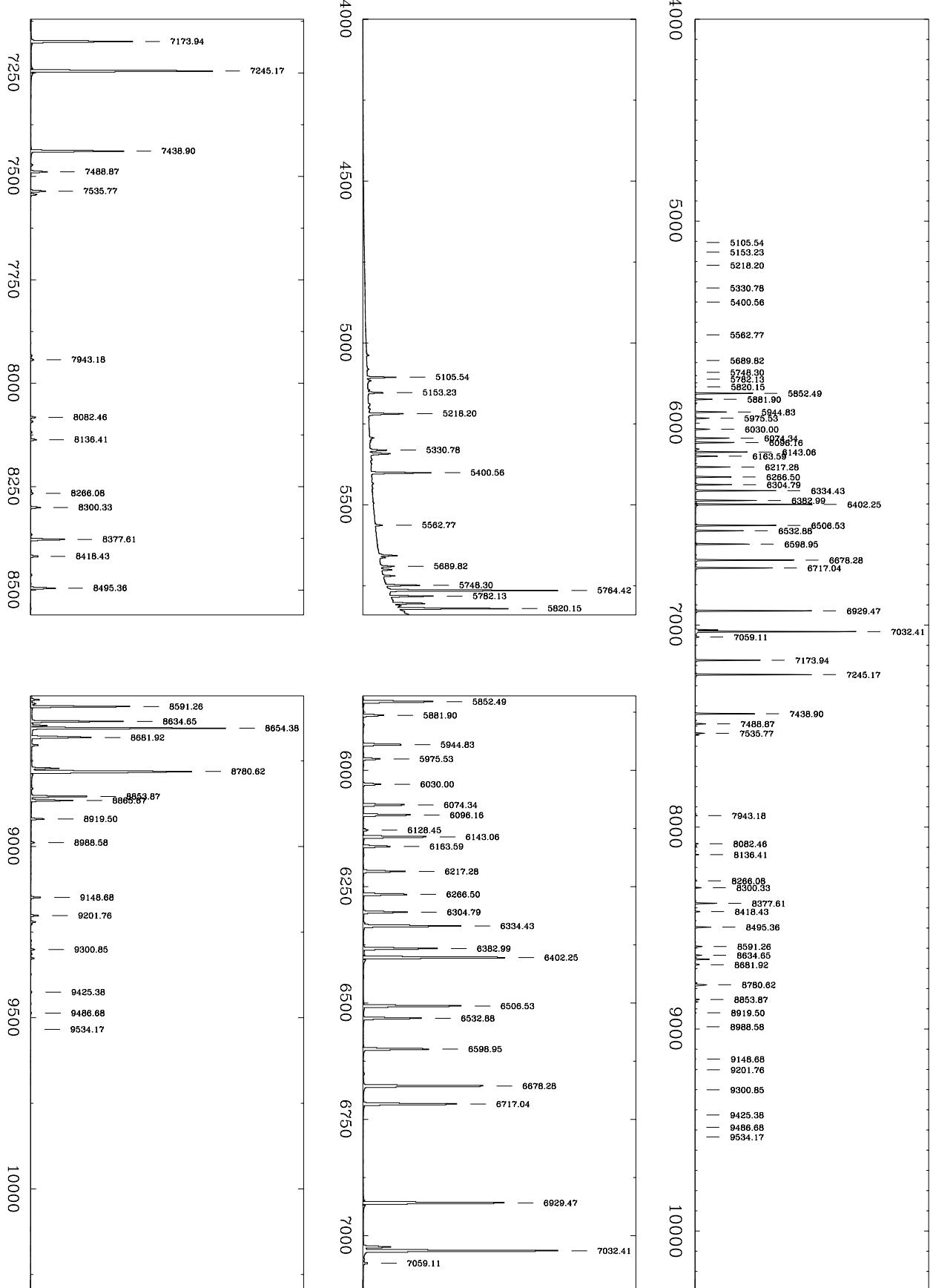
CuAr+CuNe



R400R

$\lambda_C = \gamma 000$

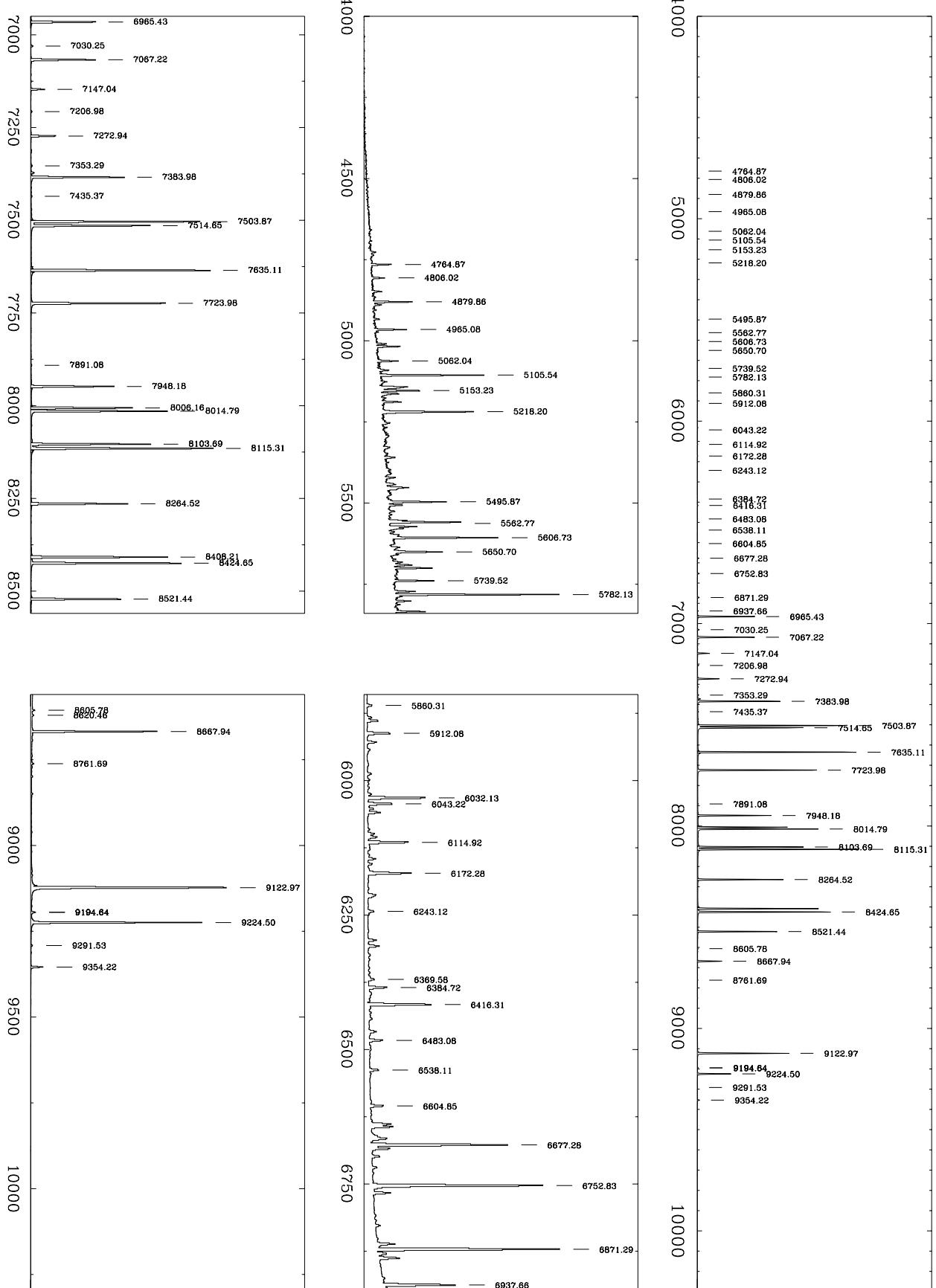
CuNe



R400R

$\lambda_C = 7000$

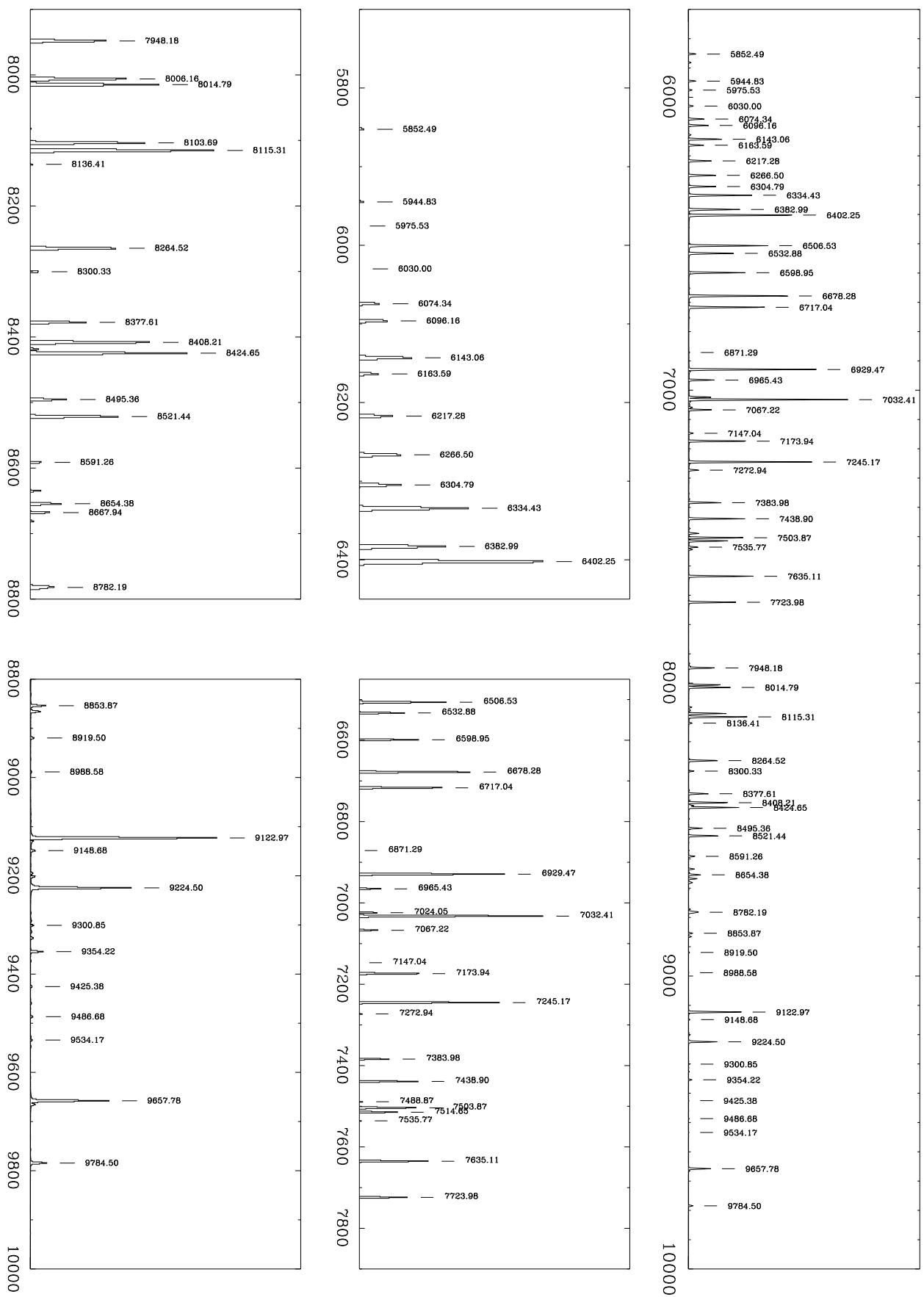
CuAr



R400R

$\lambda_C = 8000$

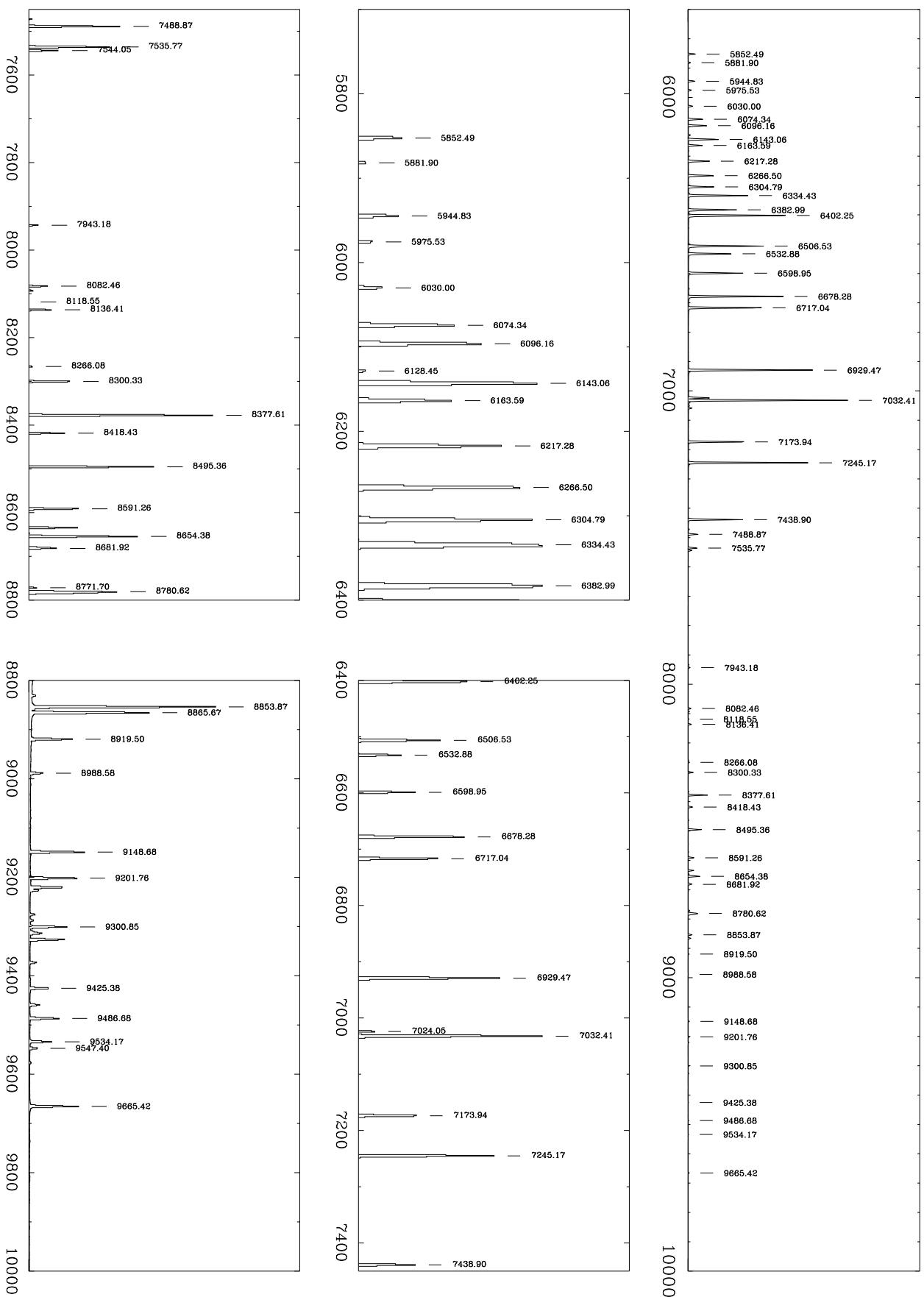
CuAr+CuNe



R400R

$\lambda_c = 8000$

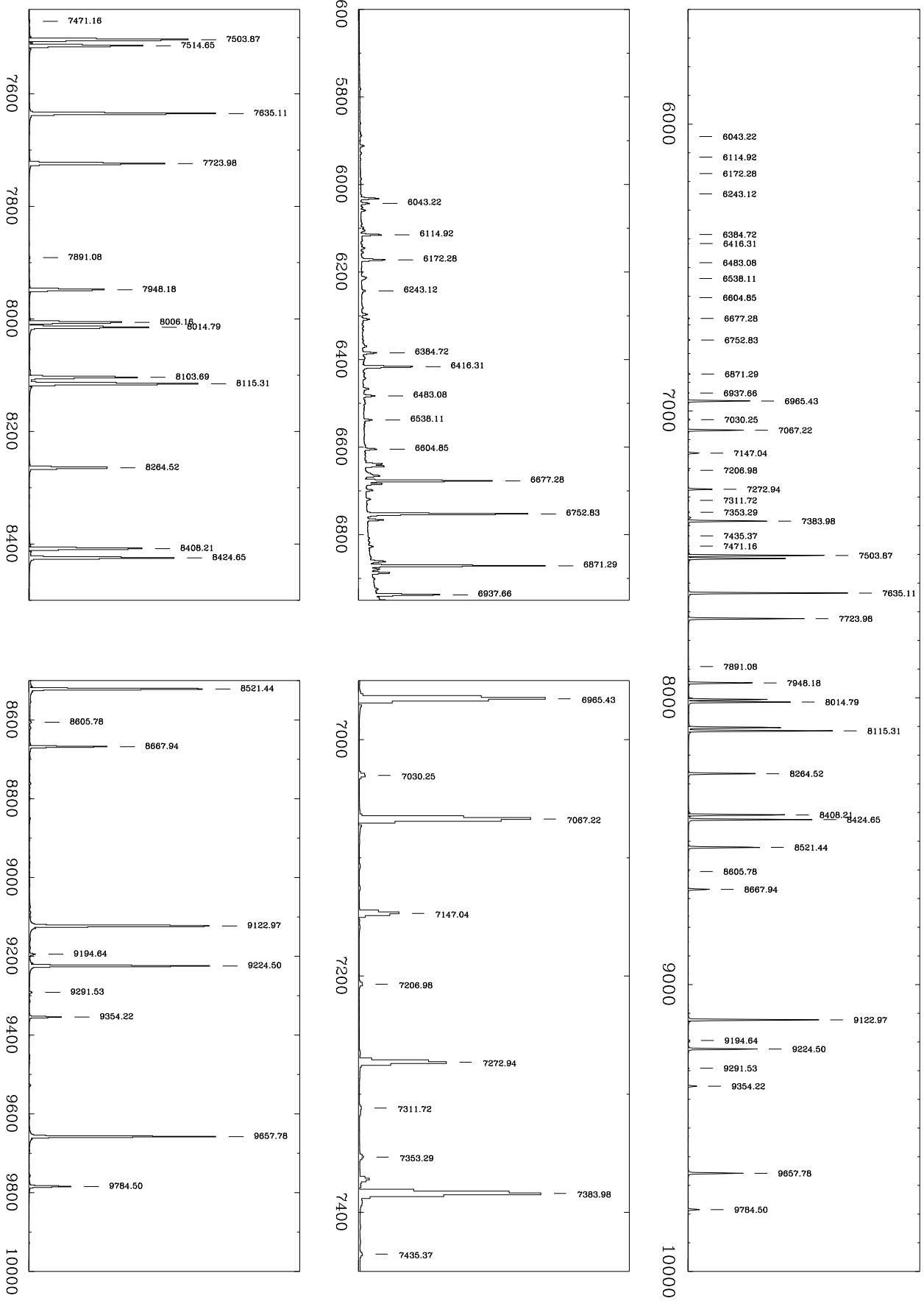
CuNe



R400R

$\lambda_C = 8000$

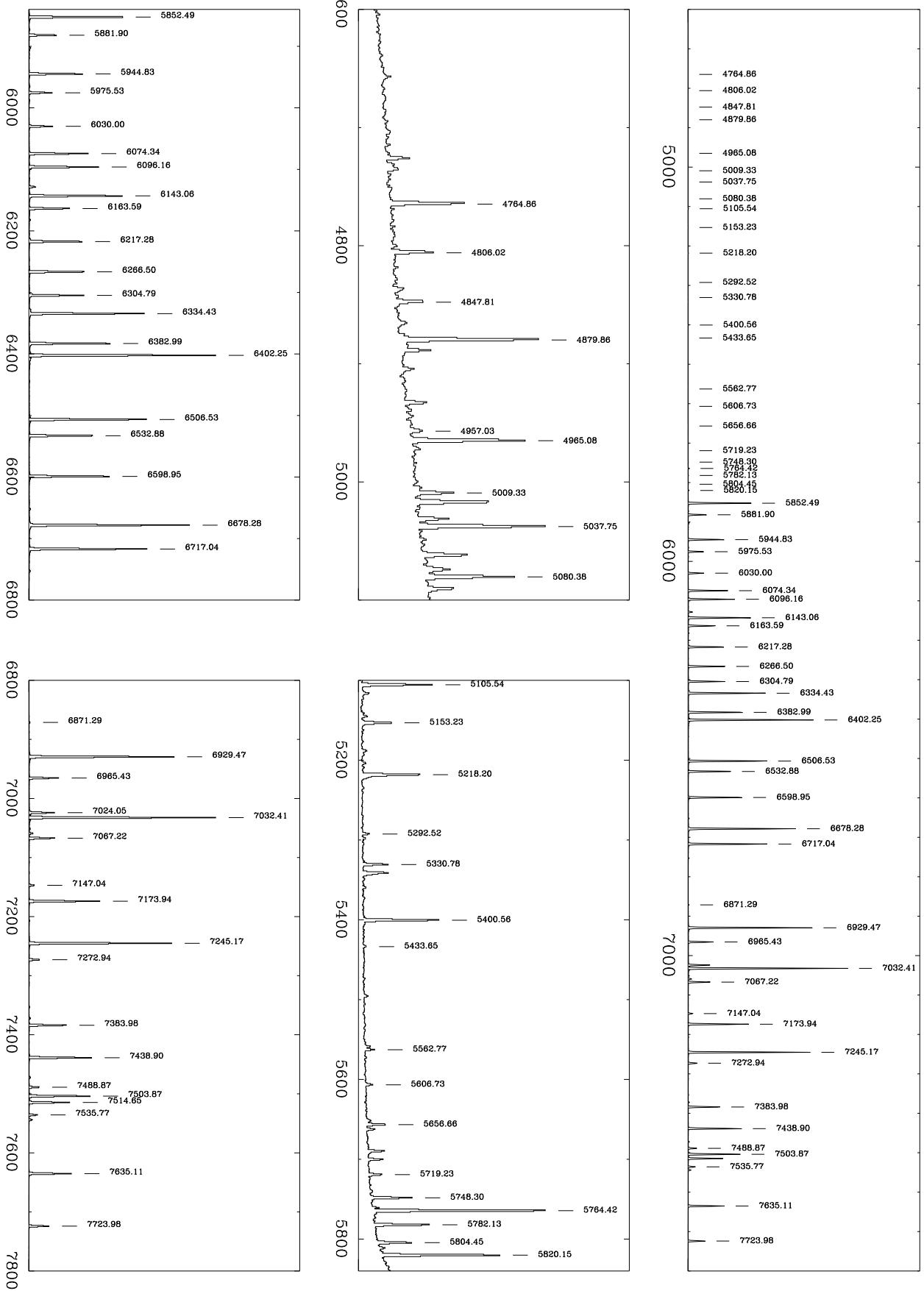
CuAr



R600R

$\lambda_C = 6200$

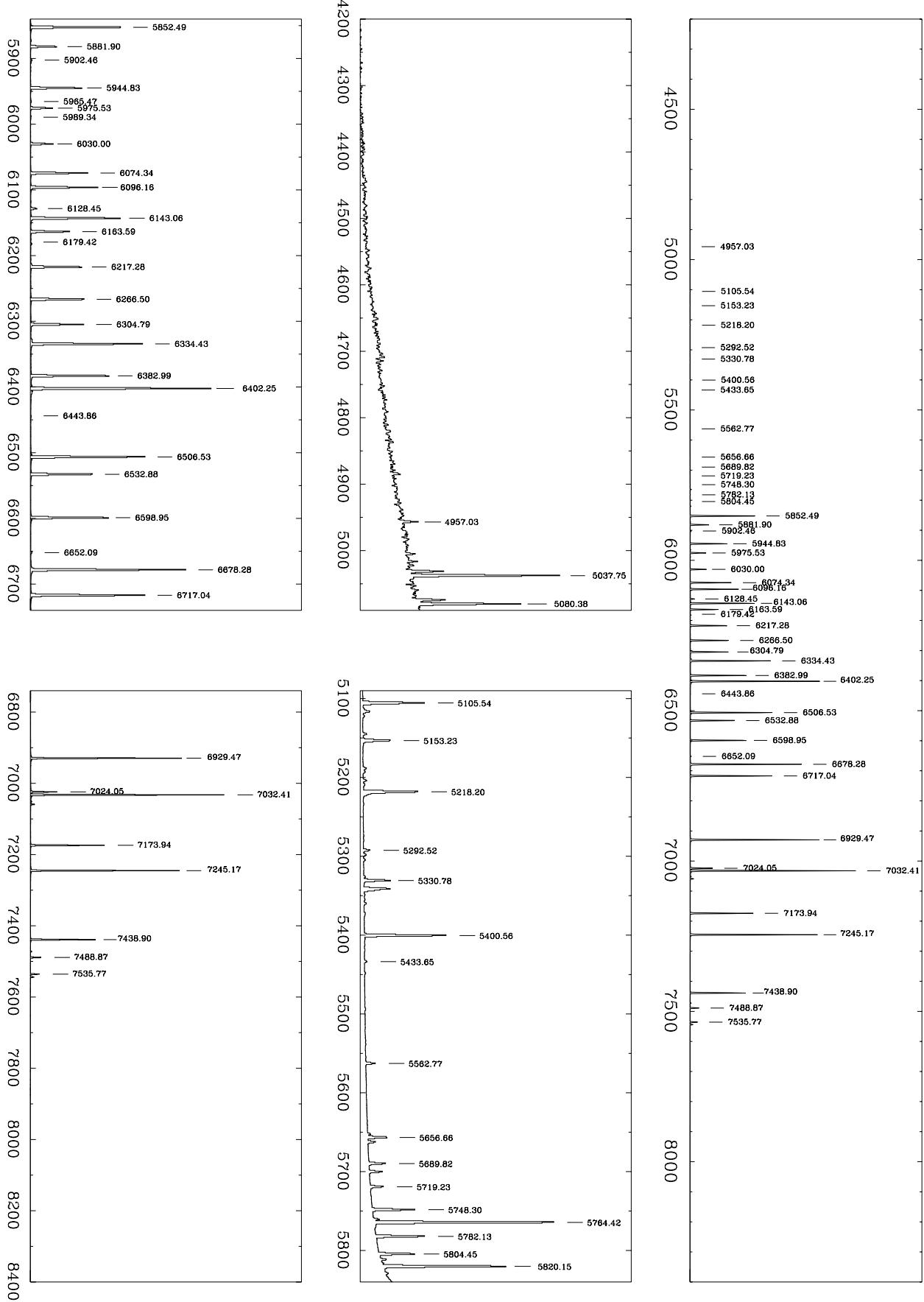
CuAr + CuNe

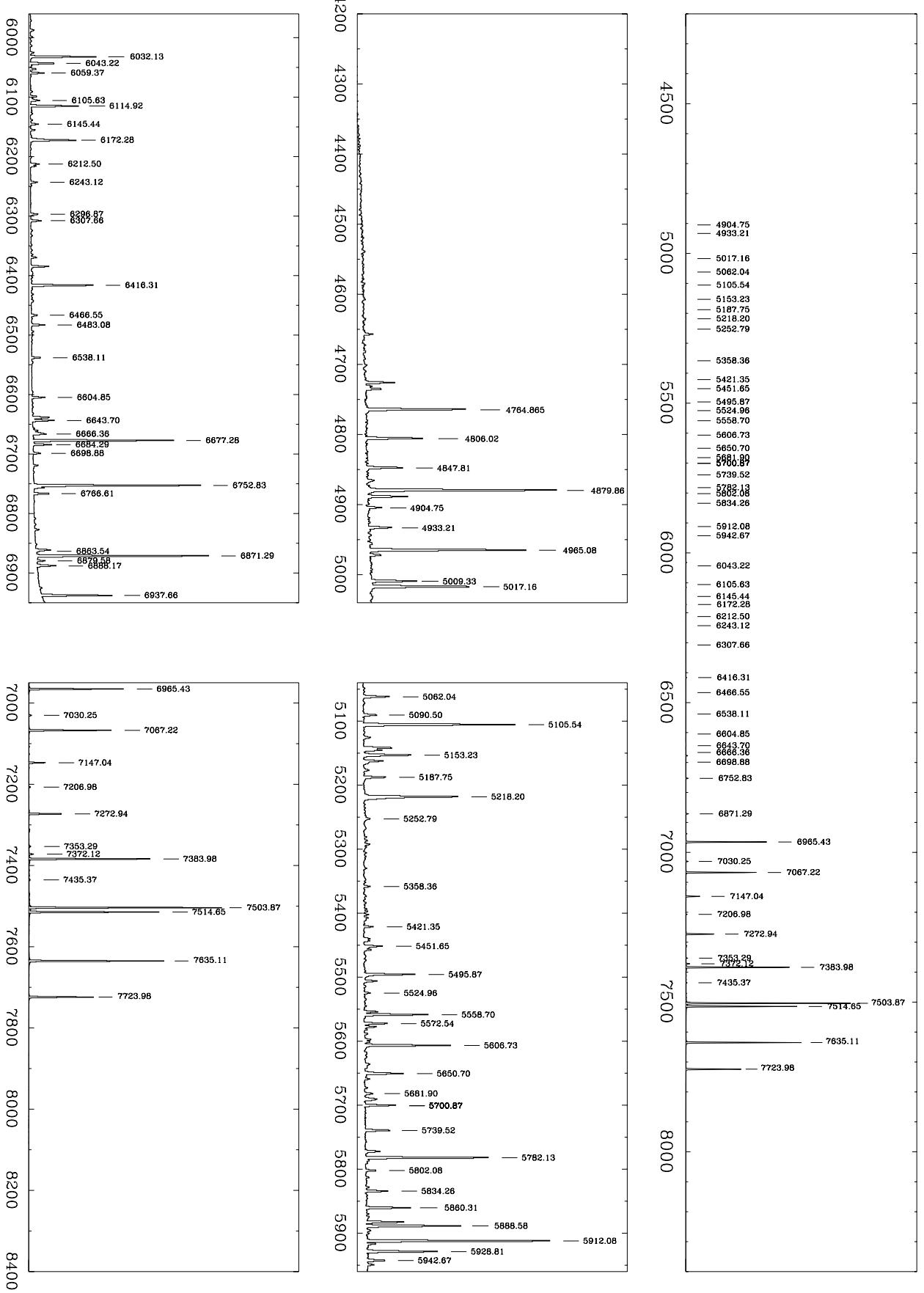


R600R

$\lambda_C = 6200$

CuNe

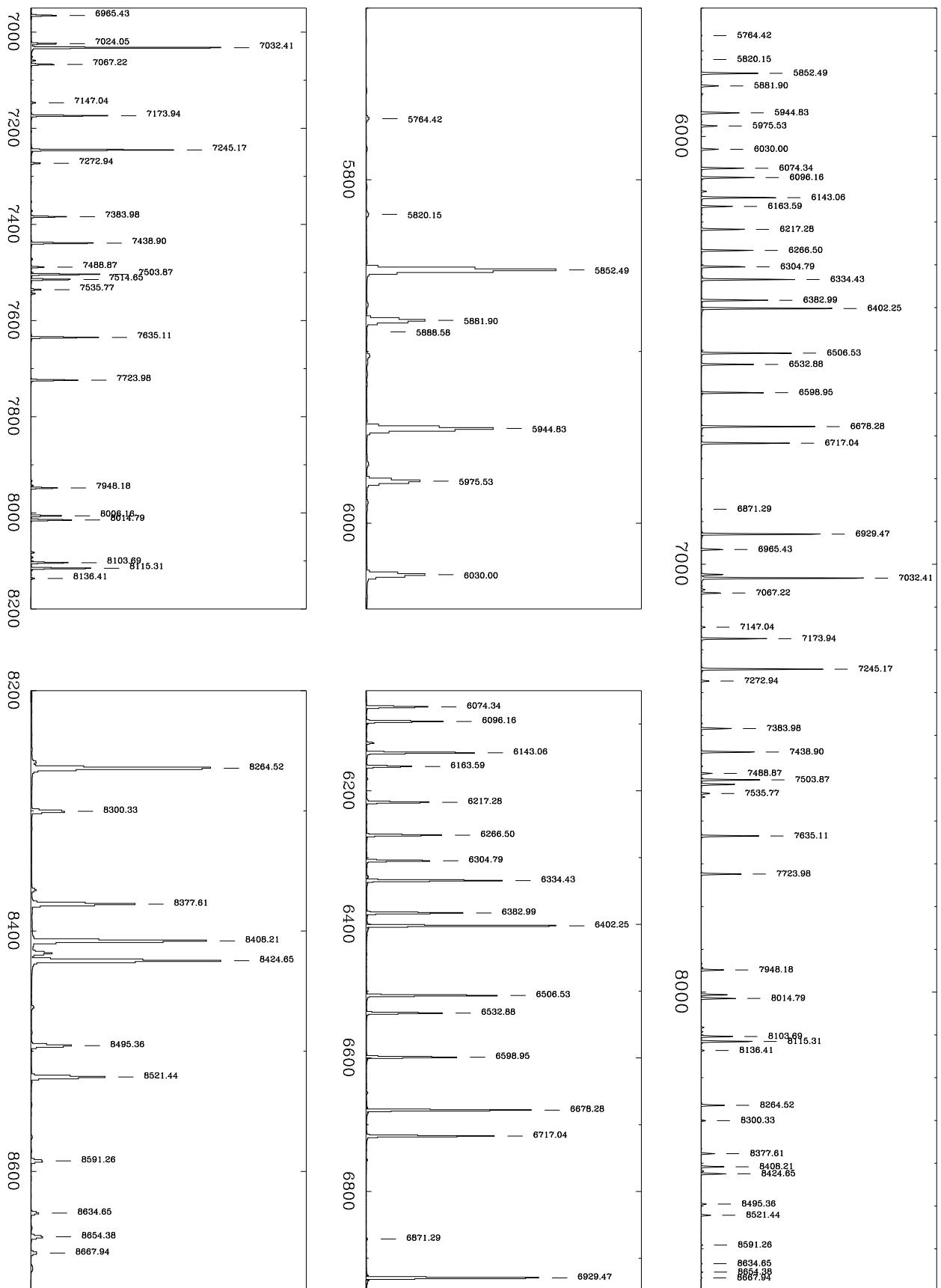




R600R

$\lambda_C = \gamma_{000}$

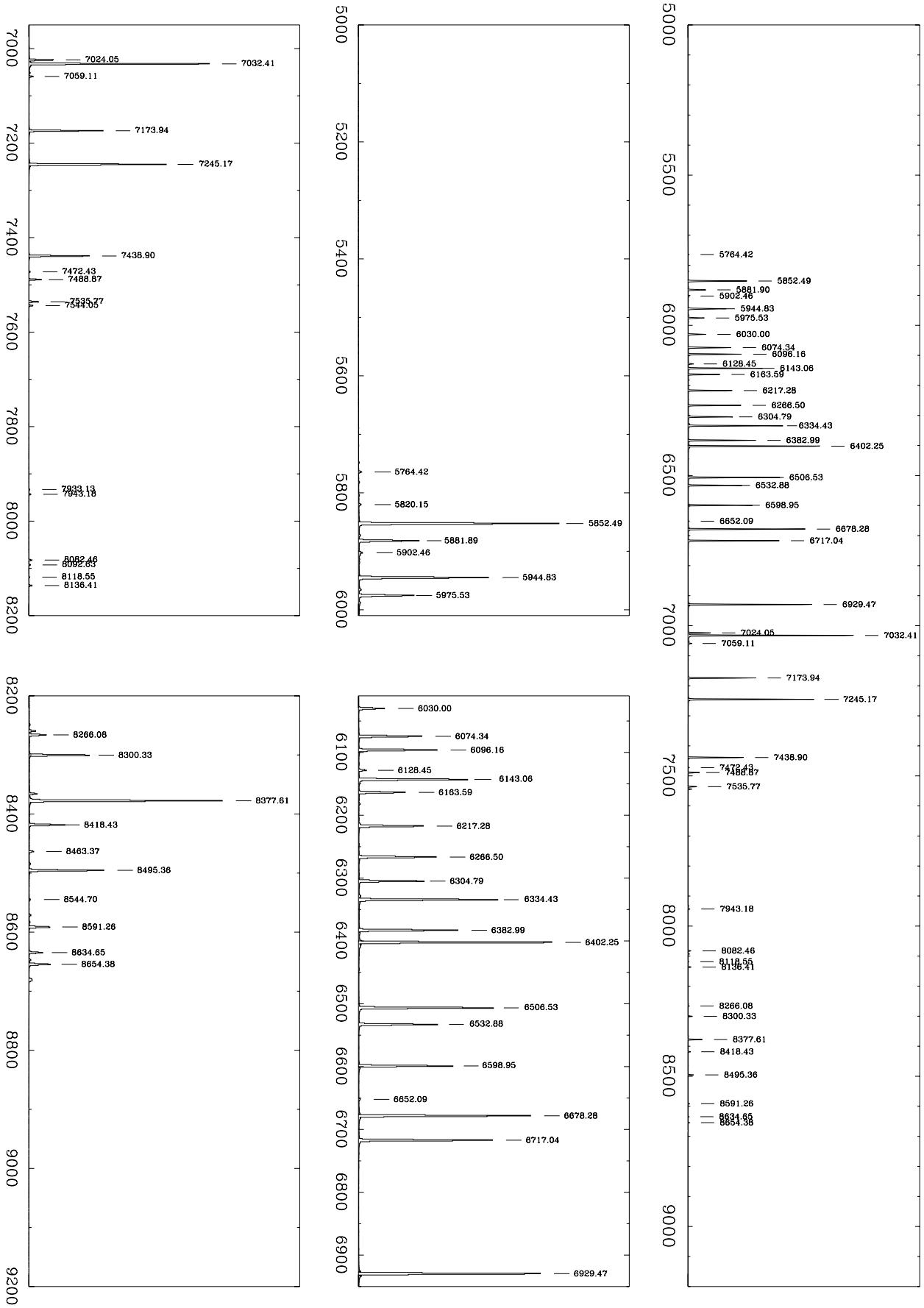
CuAr+CuNe



R600R

$\lambda_C = 7000$

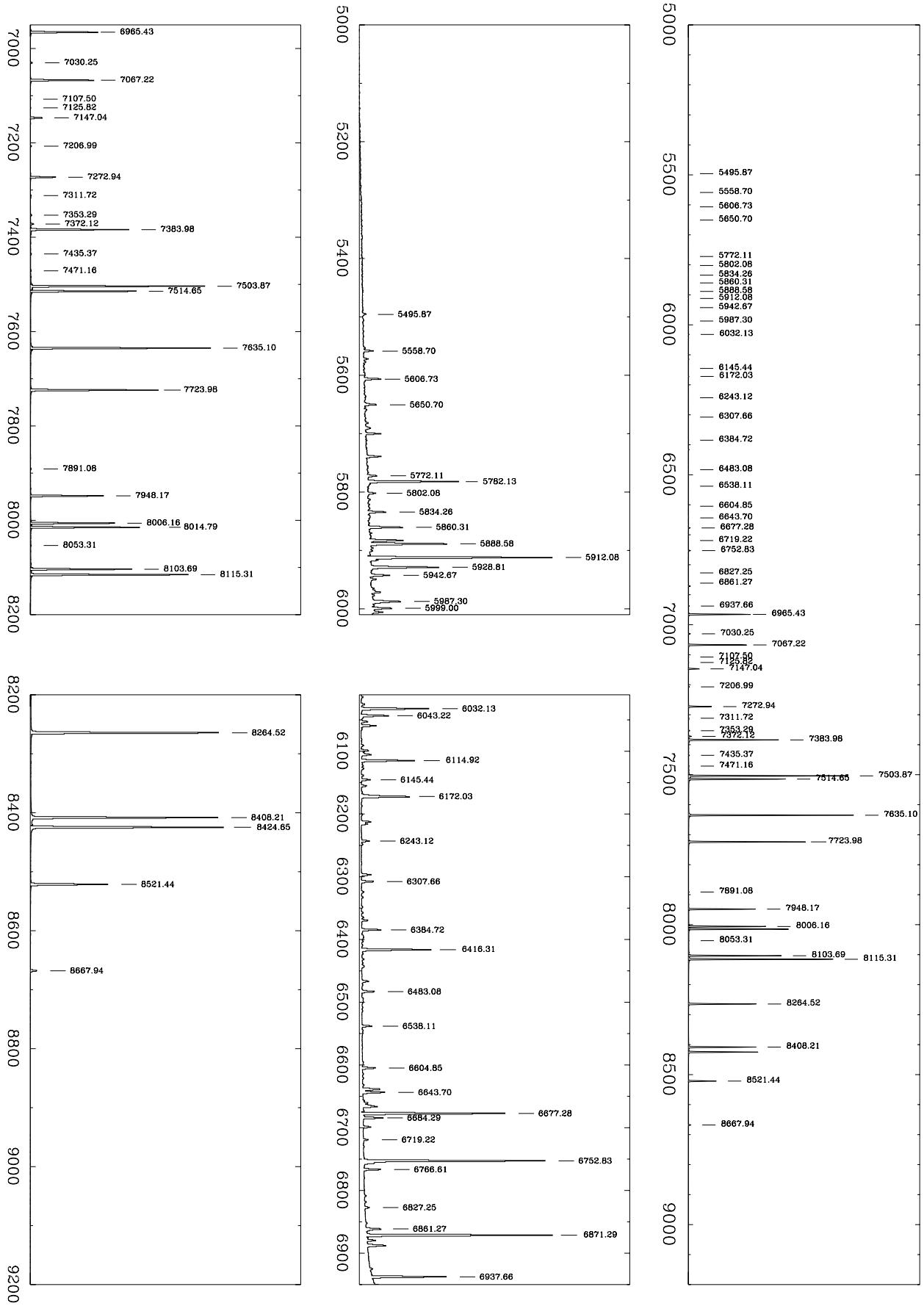
CuNe

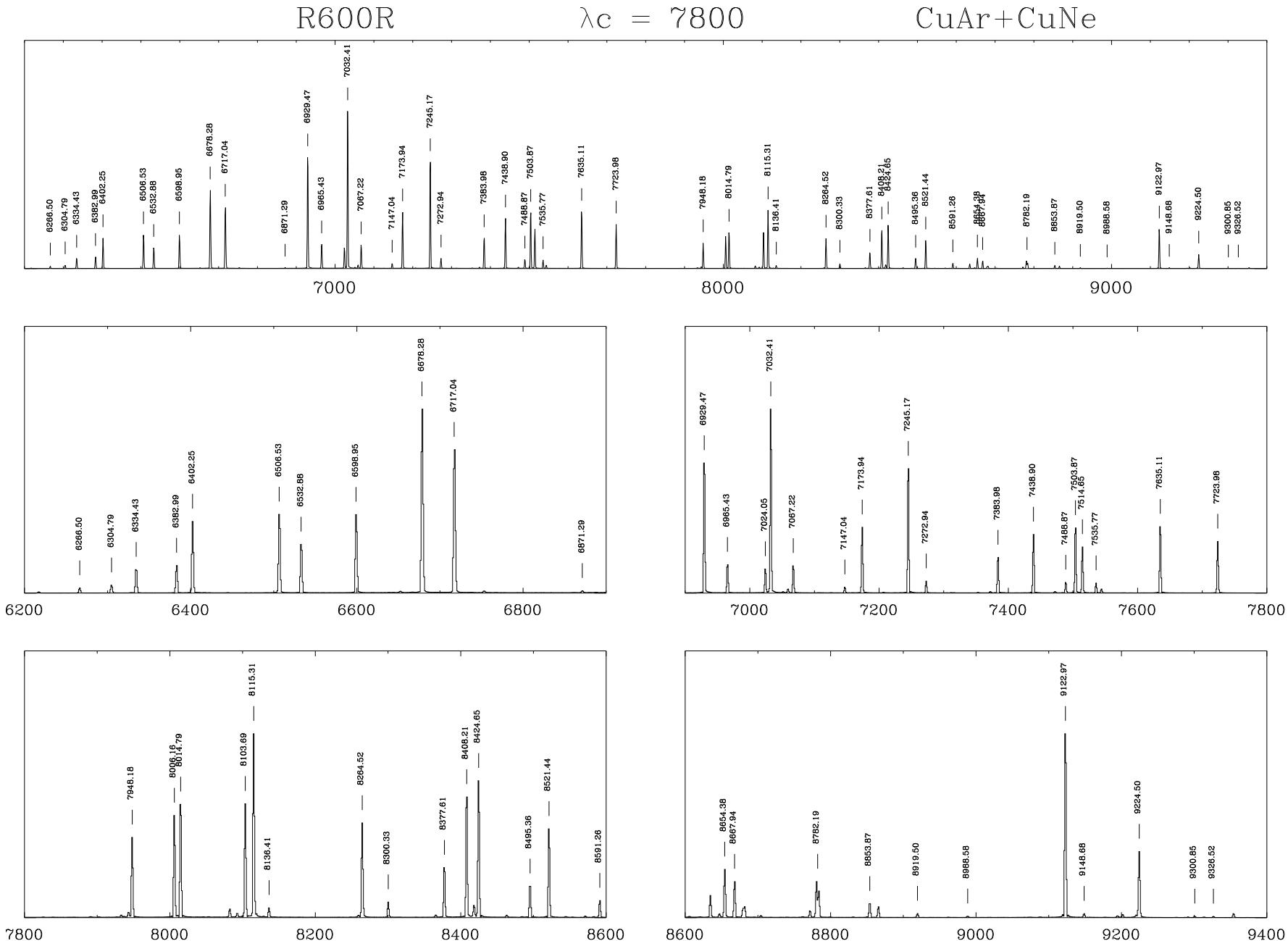


R600R

$\lambda_C = 7000$

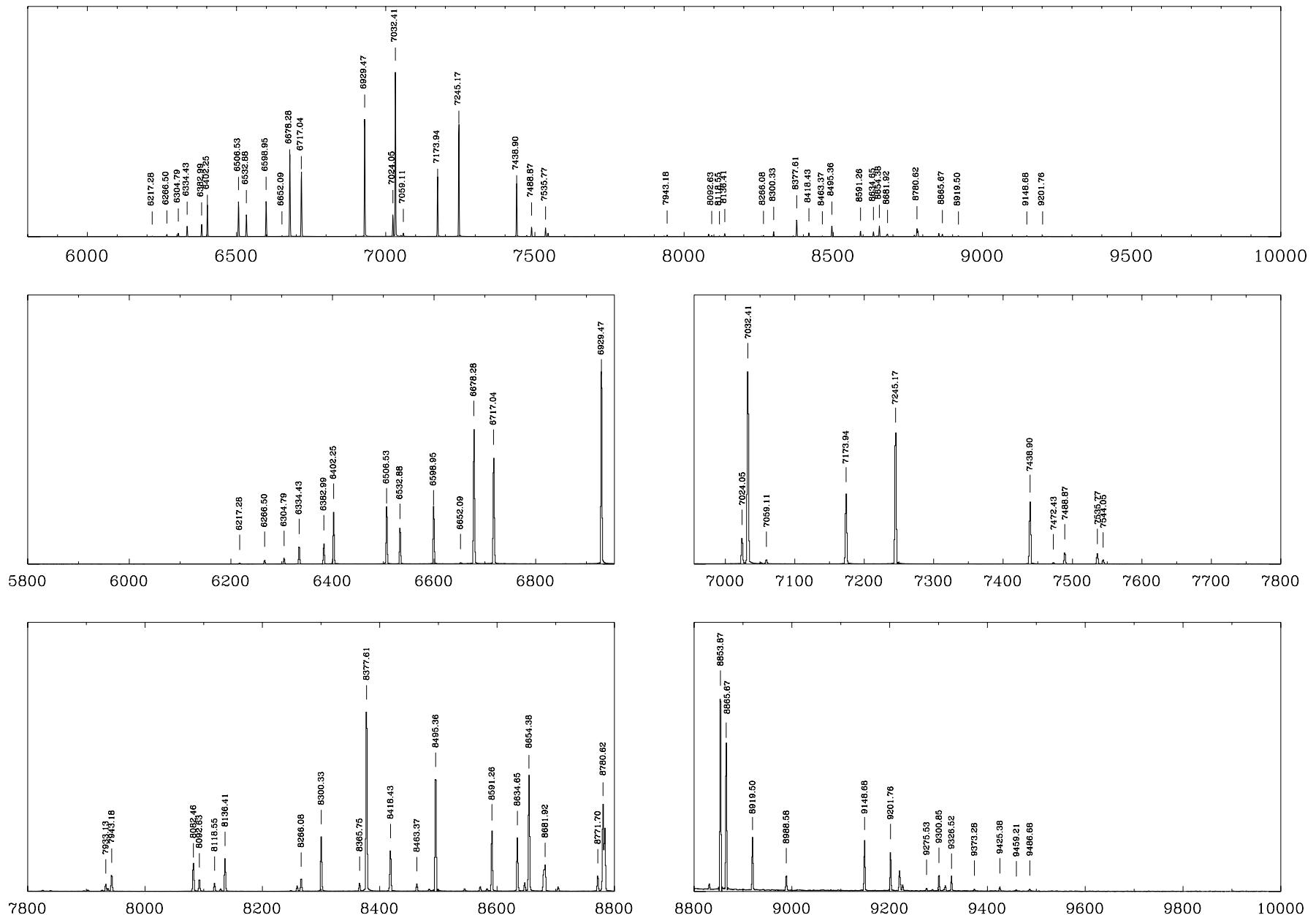
CuAr





R600R $\lambda_C = 7800$

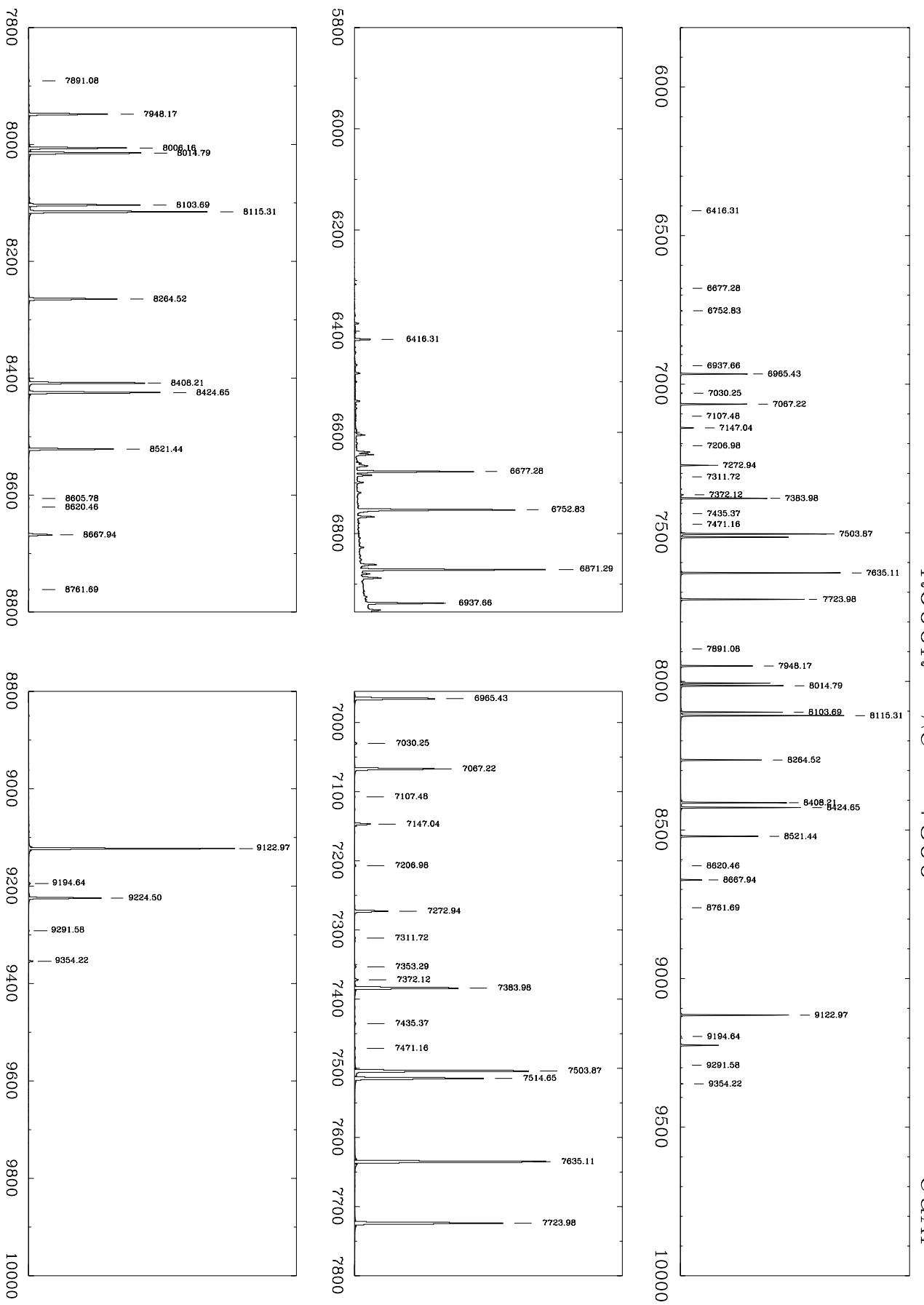
CuNe



R600R

$\lambda C = \gamma 800$

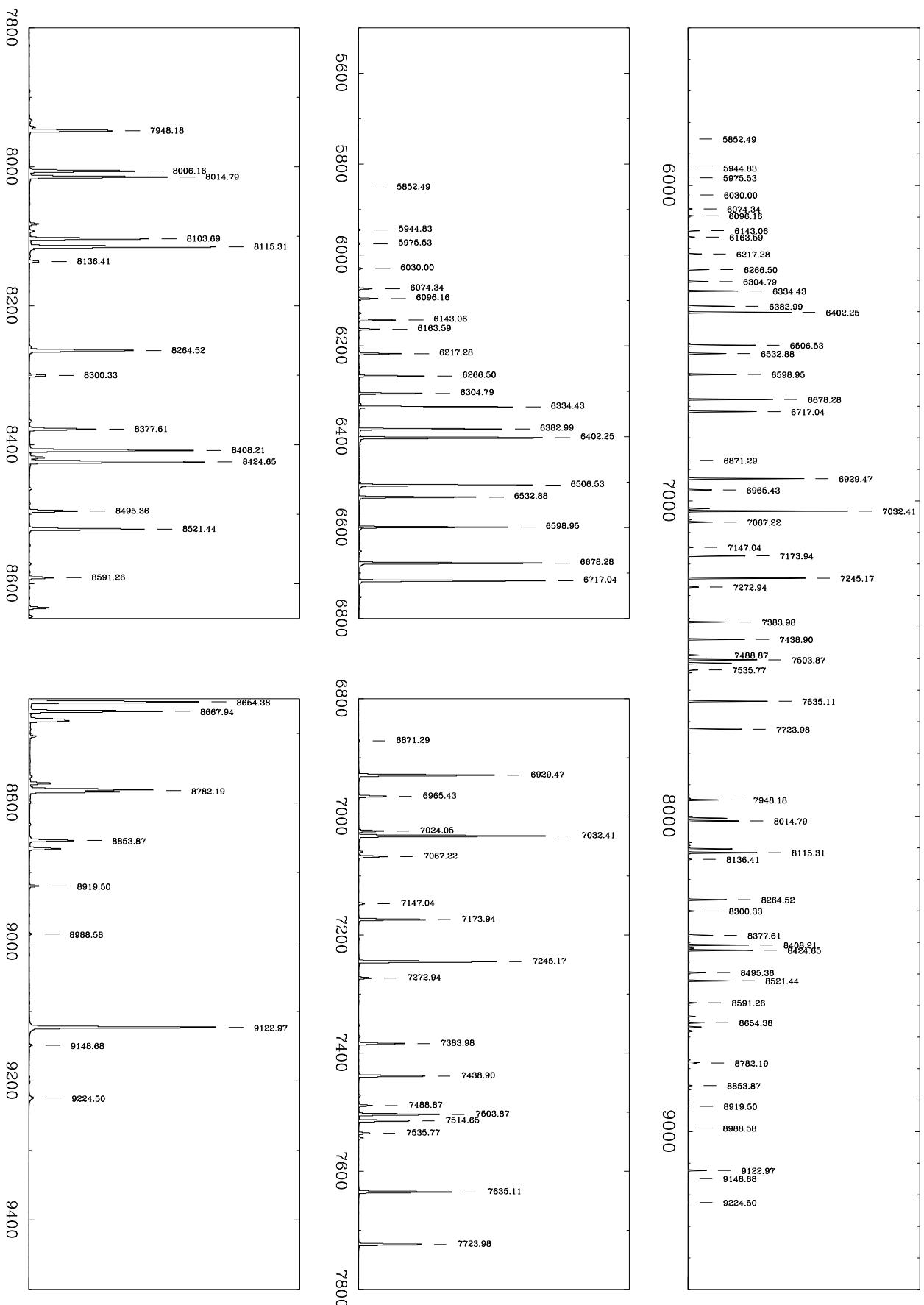
CuAr



R600IR

$\lambda_C = \gamma 500$

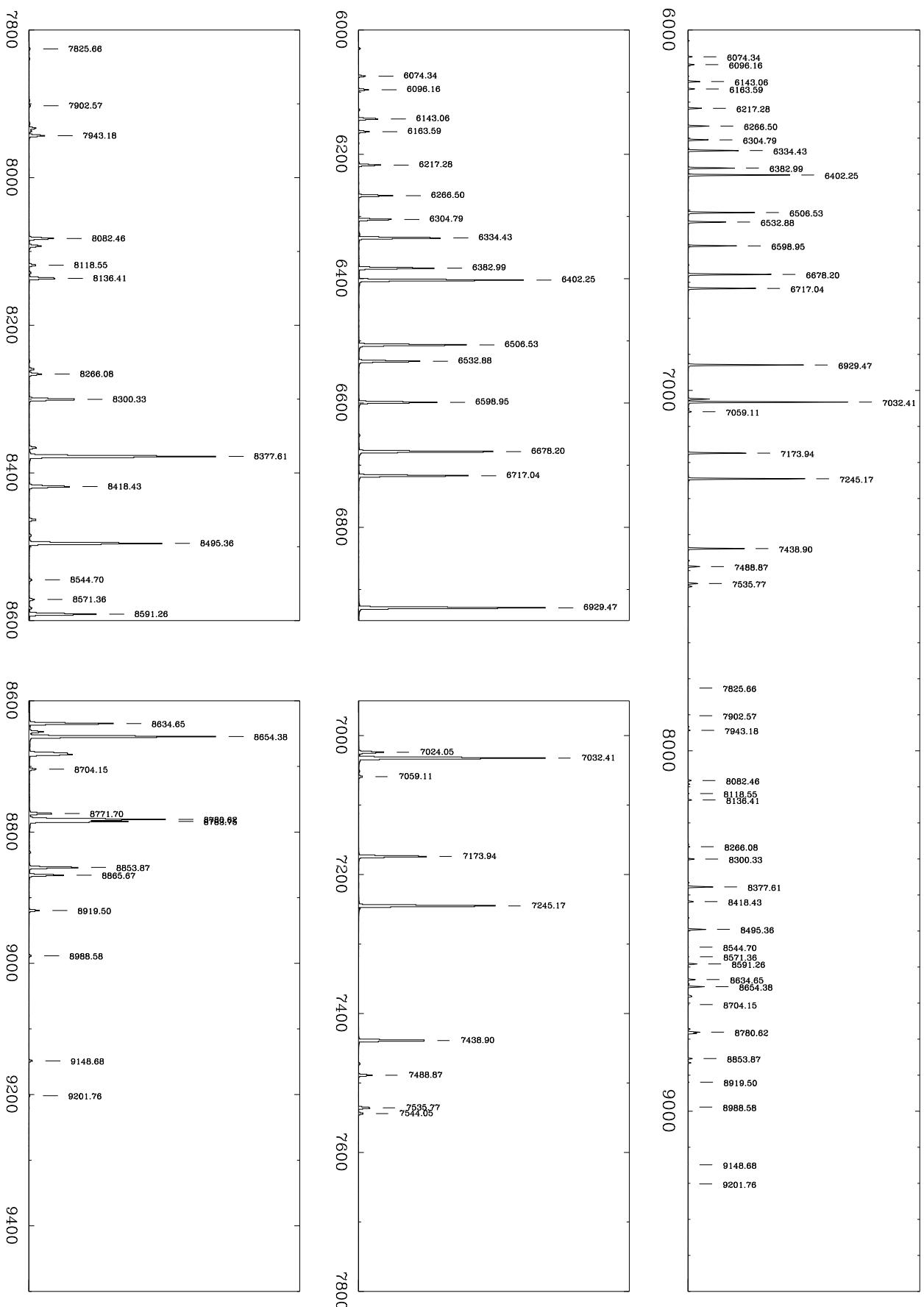
CuAr + CuNe



R600IR

$\lambda_C = \gamma 500$

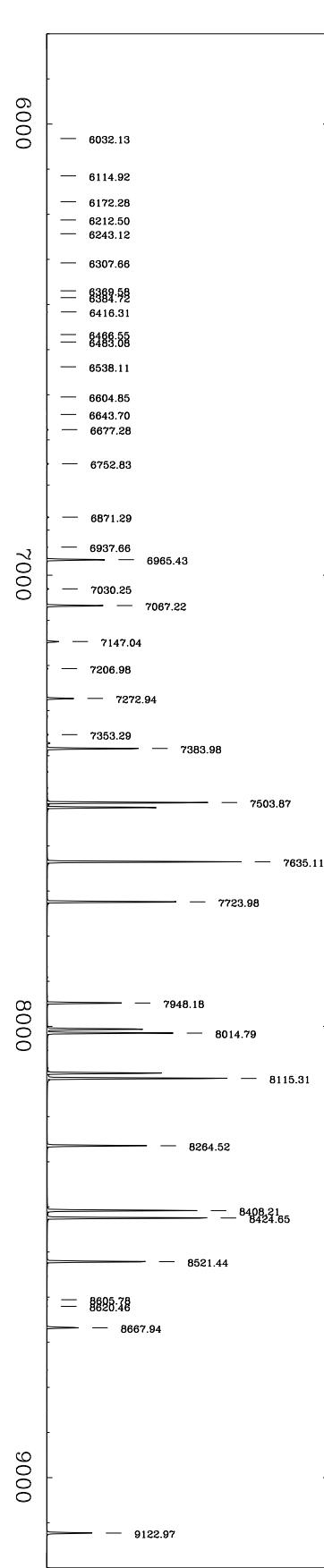
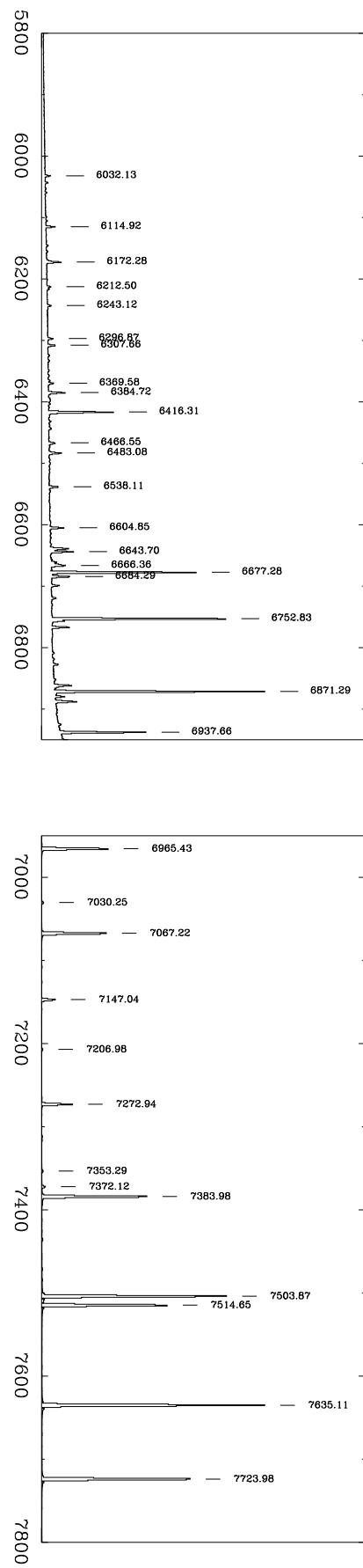
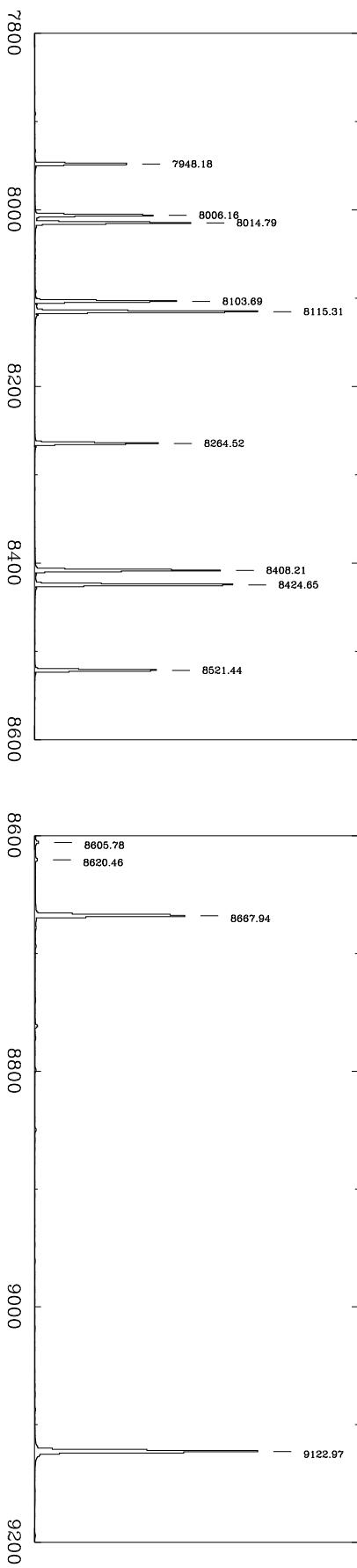
CuNe



R600IR

$\lambda_C = \gamma 500$

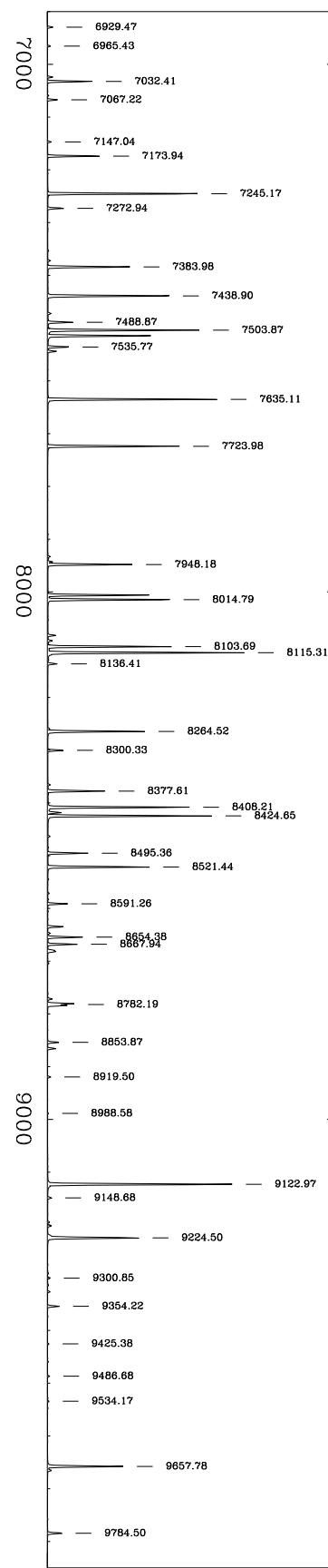
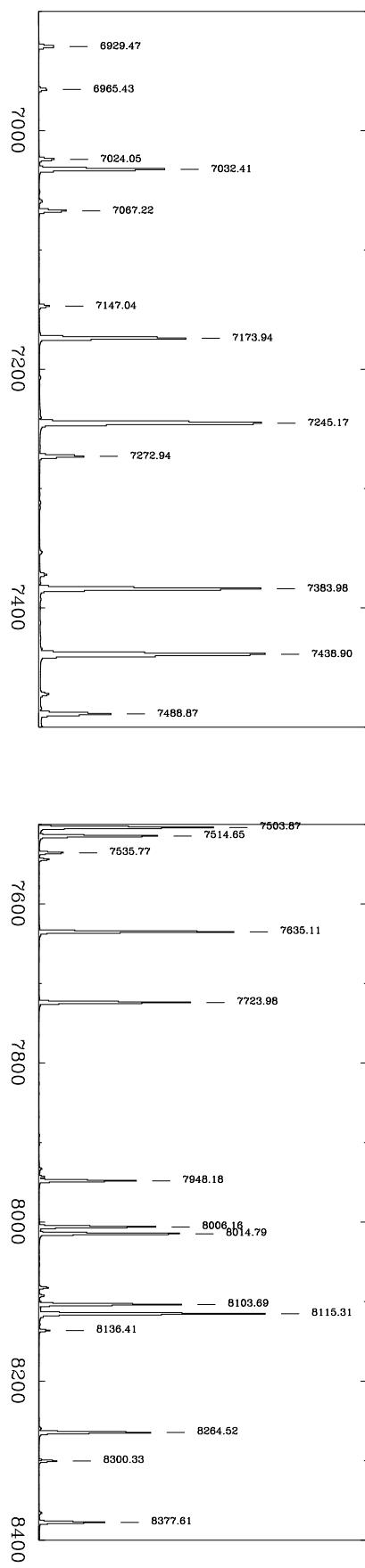
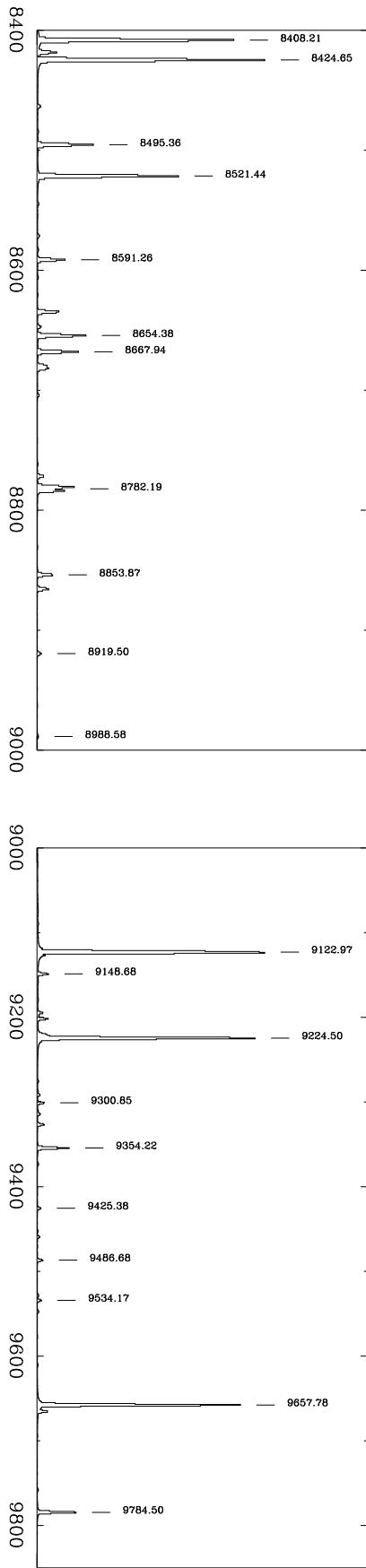
CuAr



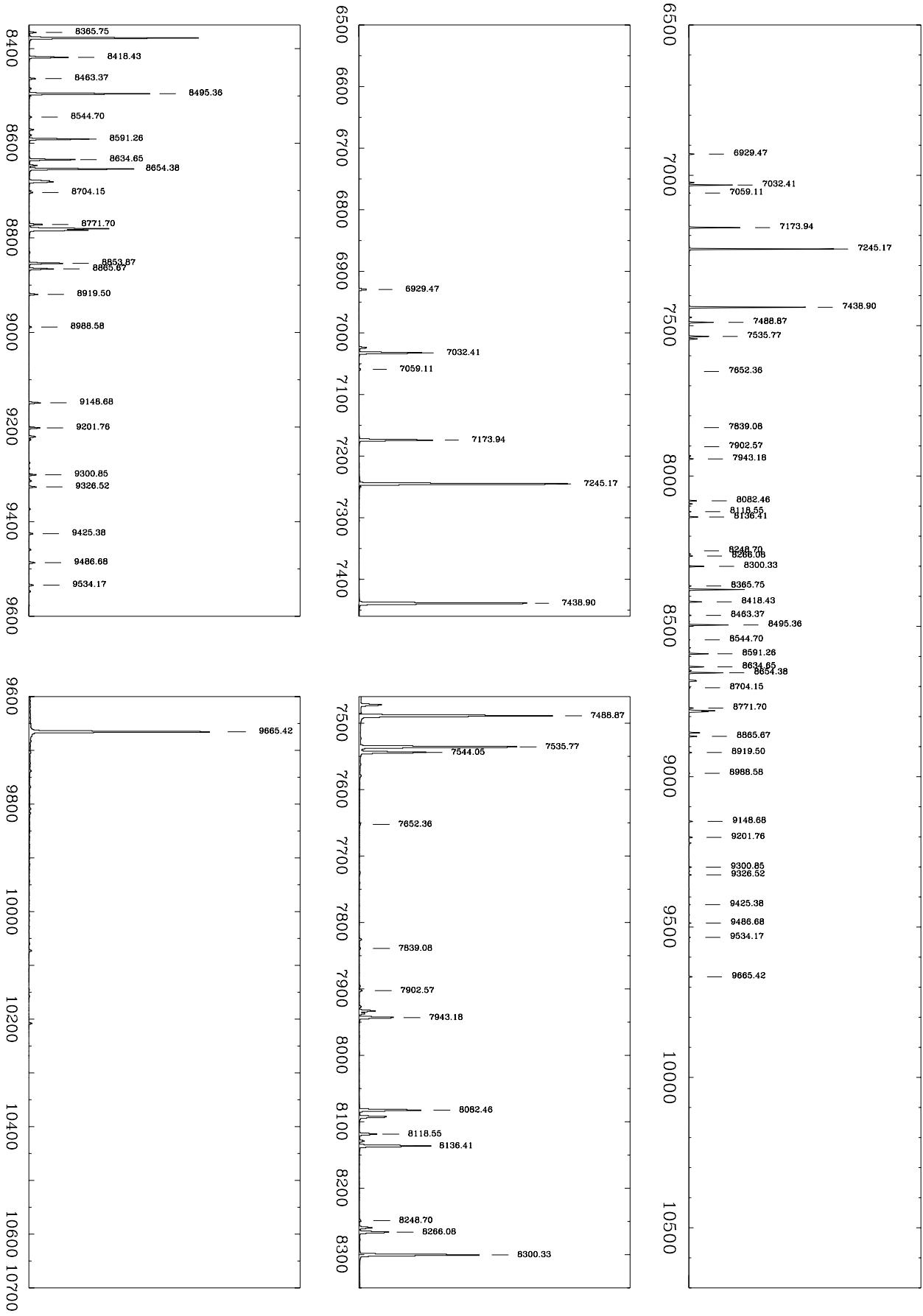
R600IR

$\lambda_C = 8500$

CuAr + CuNe



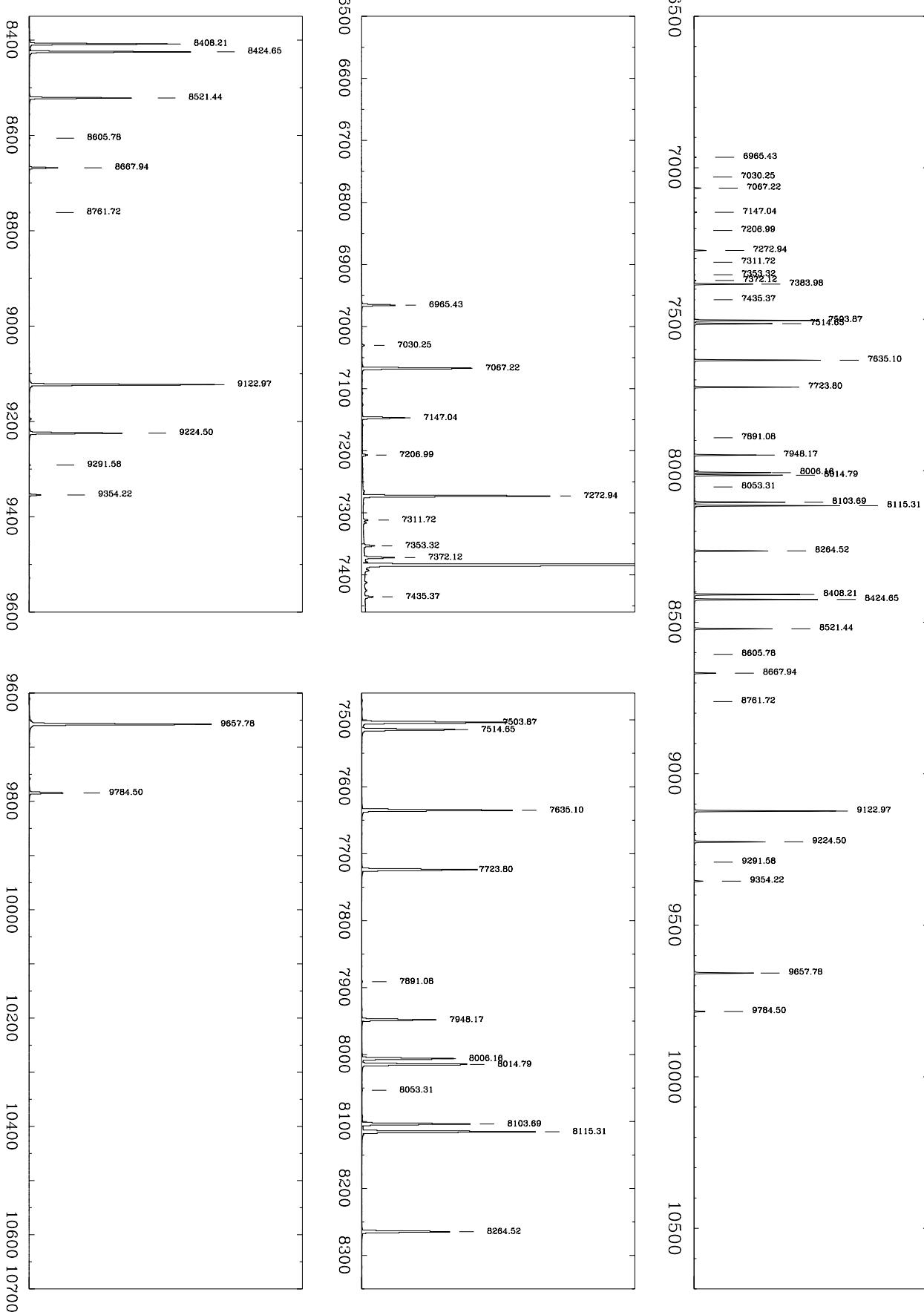
R600IR $\lambda_c = 8500$ CuNe



R600IR

$\lambda_c = 8500$

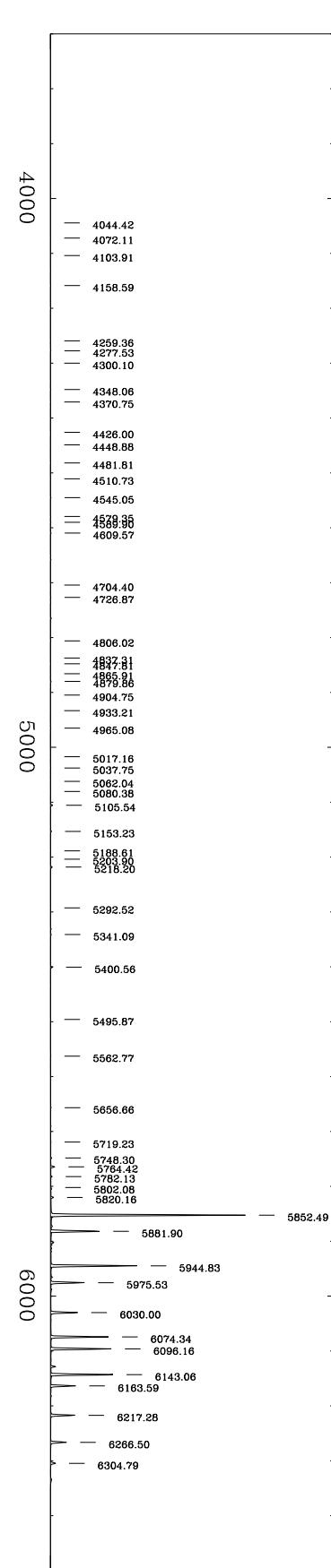
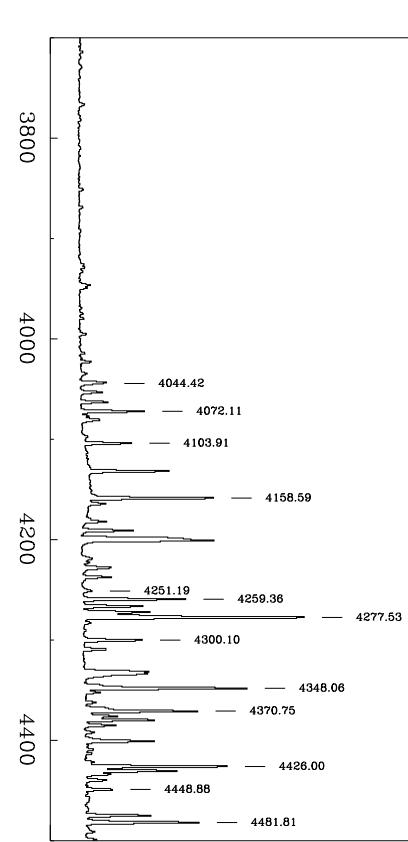
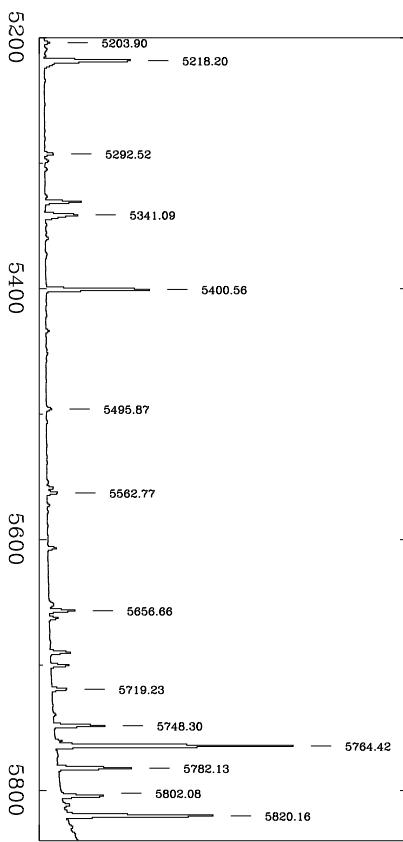
CuAr



R632V

$\lambda_C = 4700$

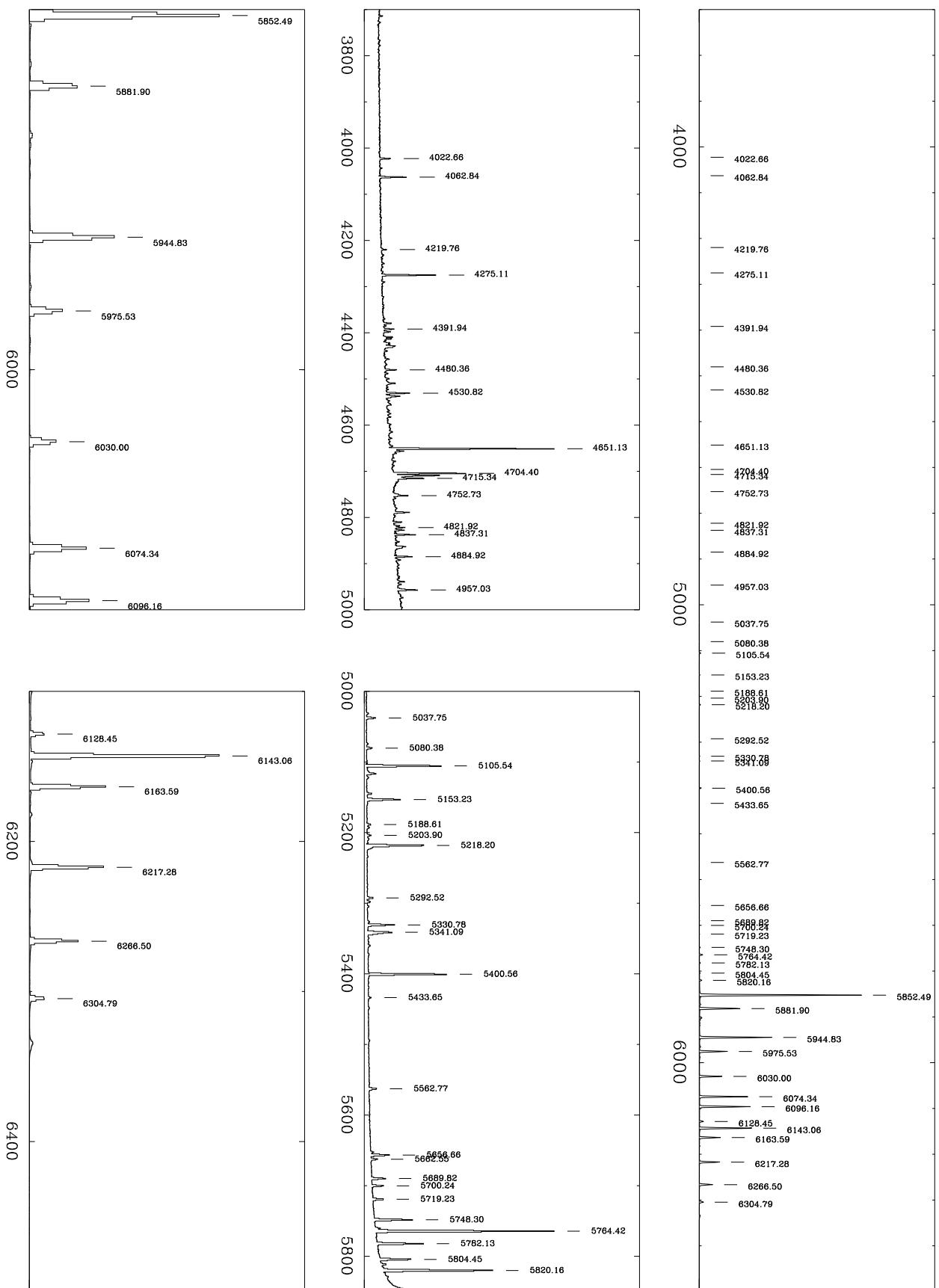
CuAr+CuNe



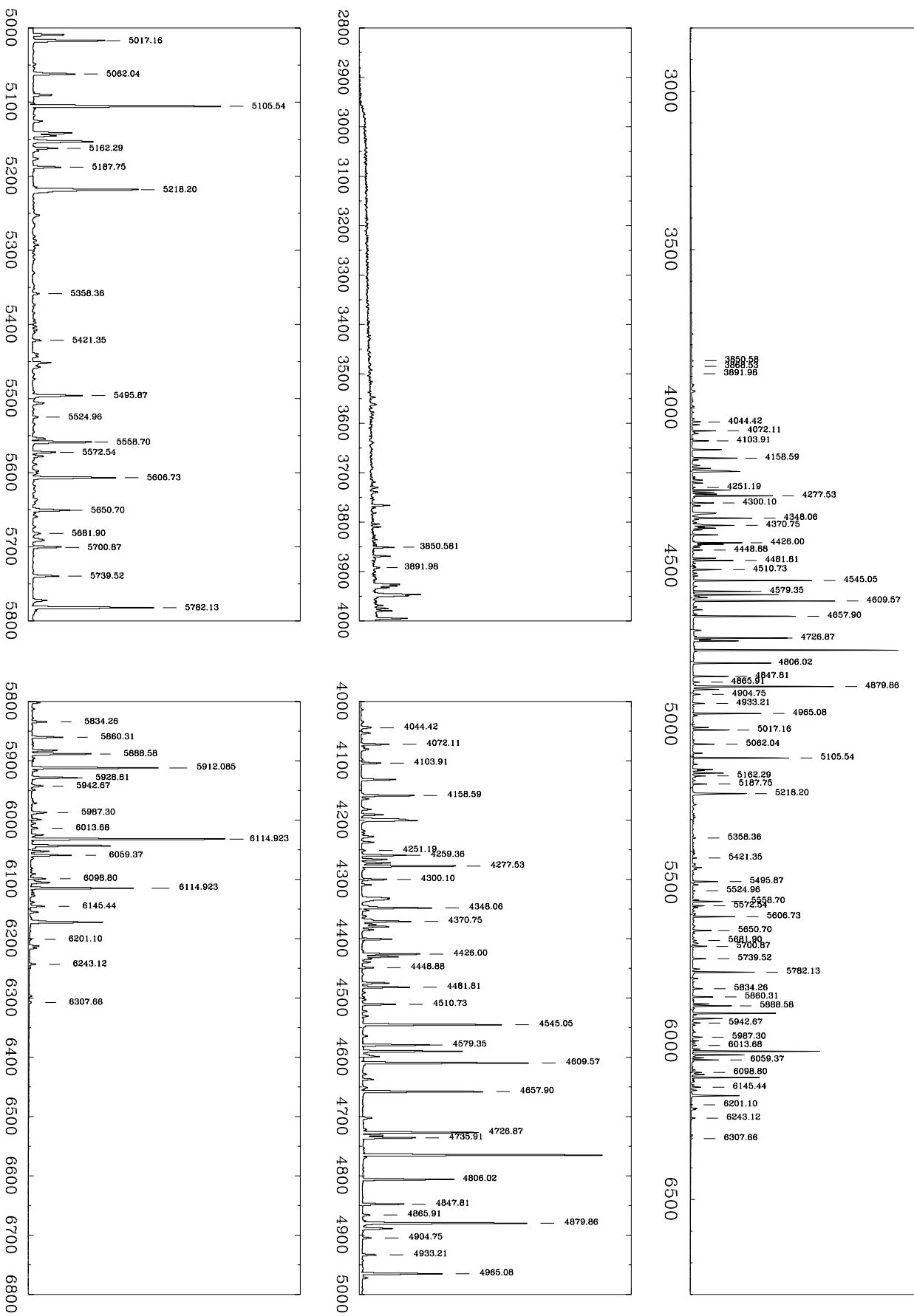
R632V

$\lambda_C = 4700$

CuNe

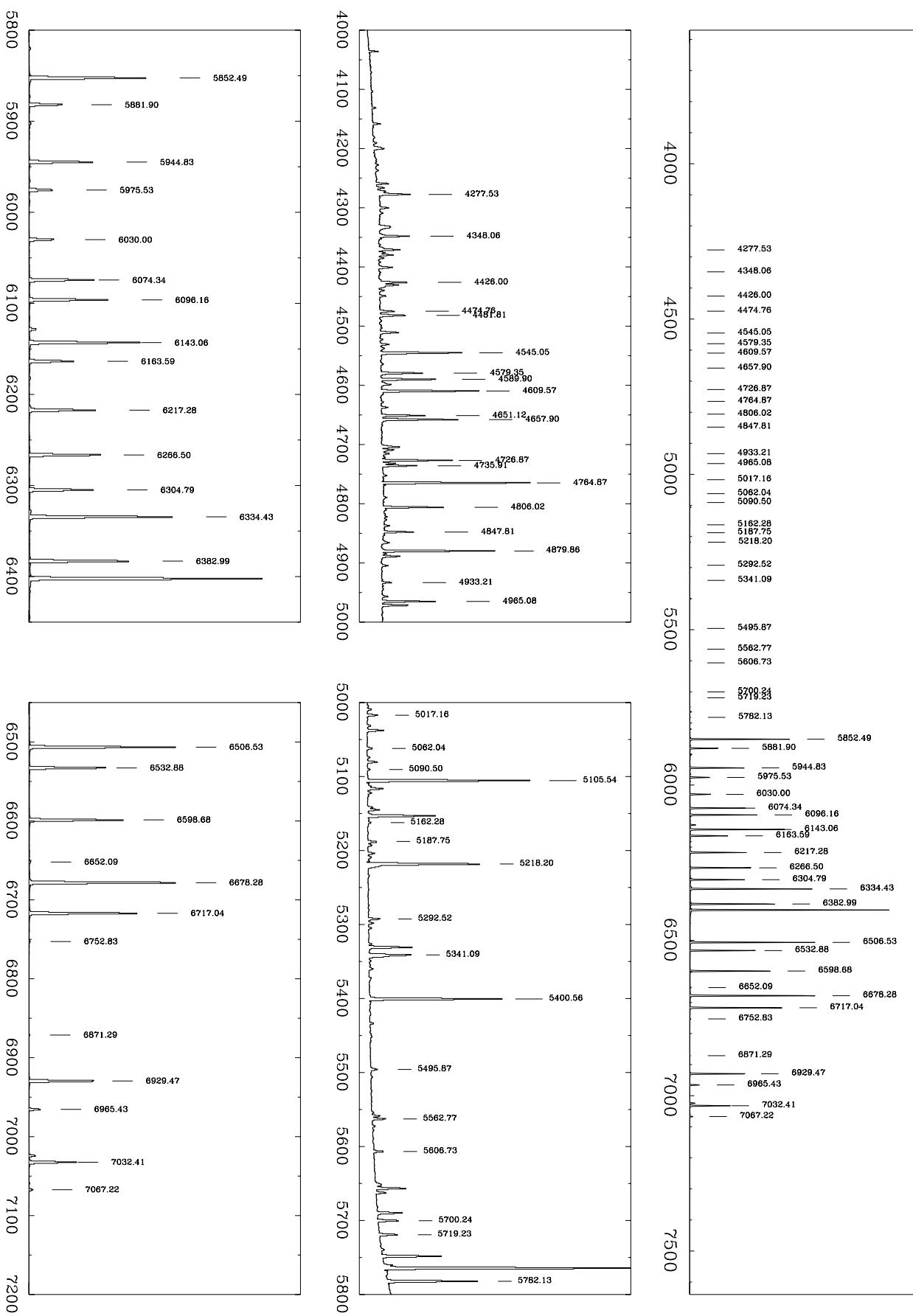


R632V $\lambda_C = 4700$ CuAr



R632V $\lambda_C = 5500$

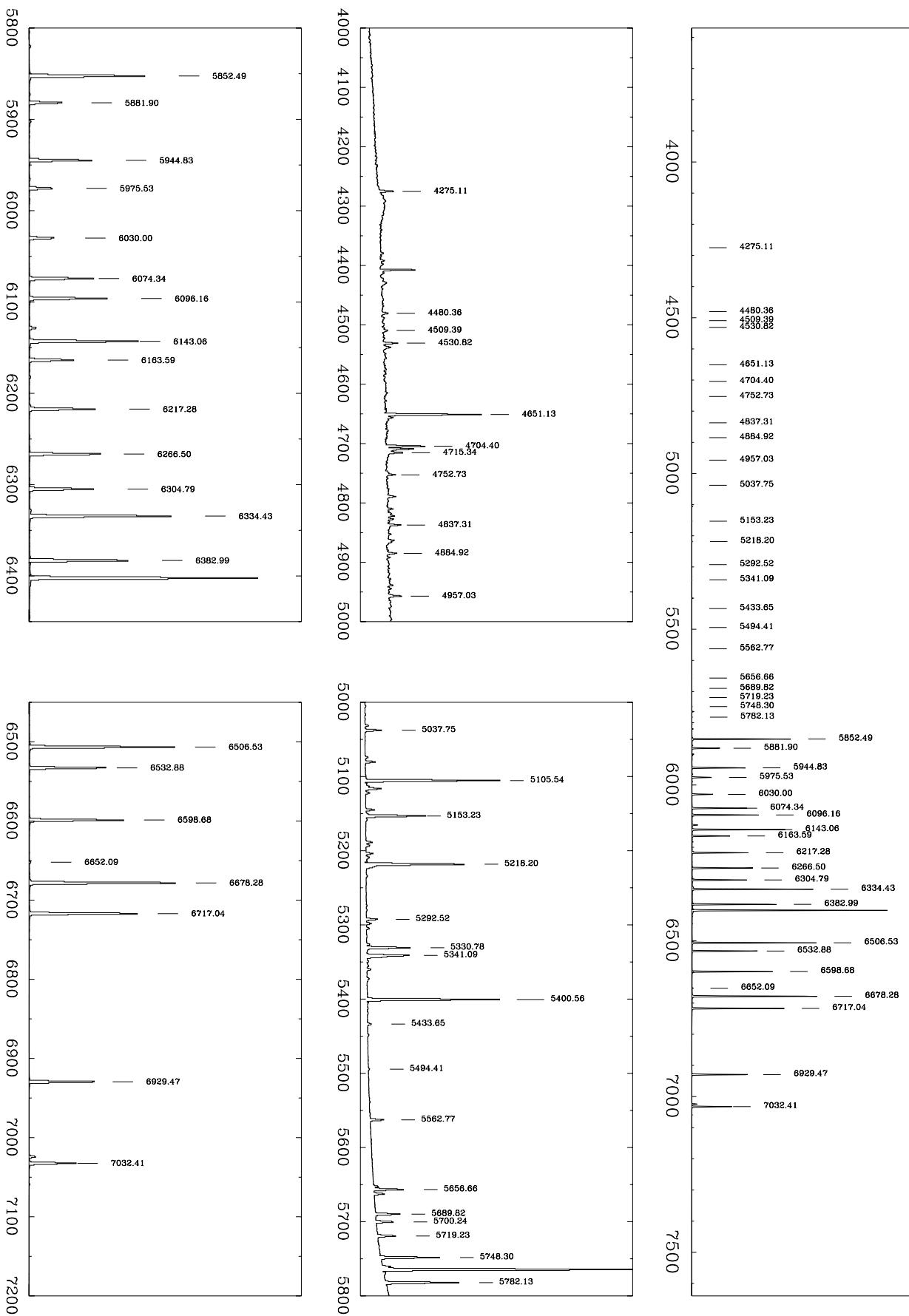
CuAr + CuNe



R632V

$\lambda_C = 5500$

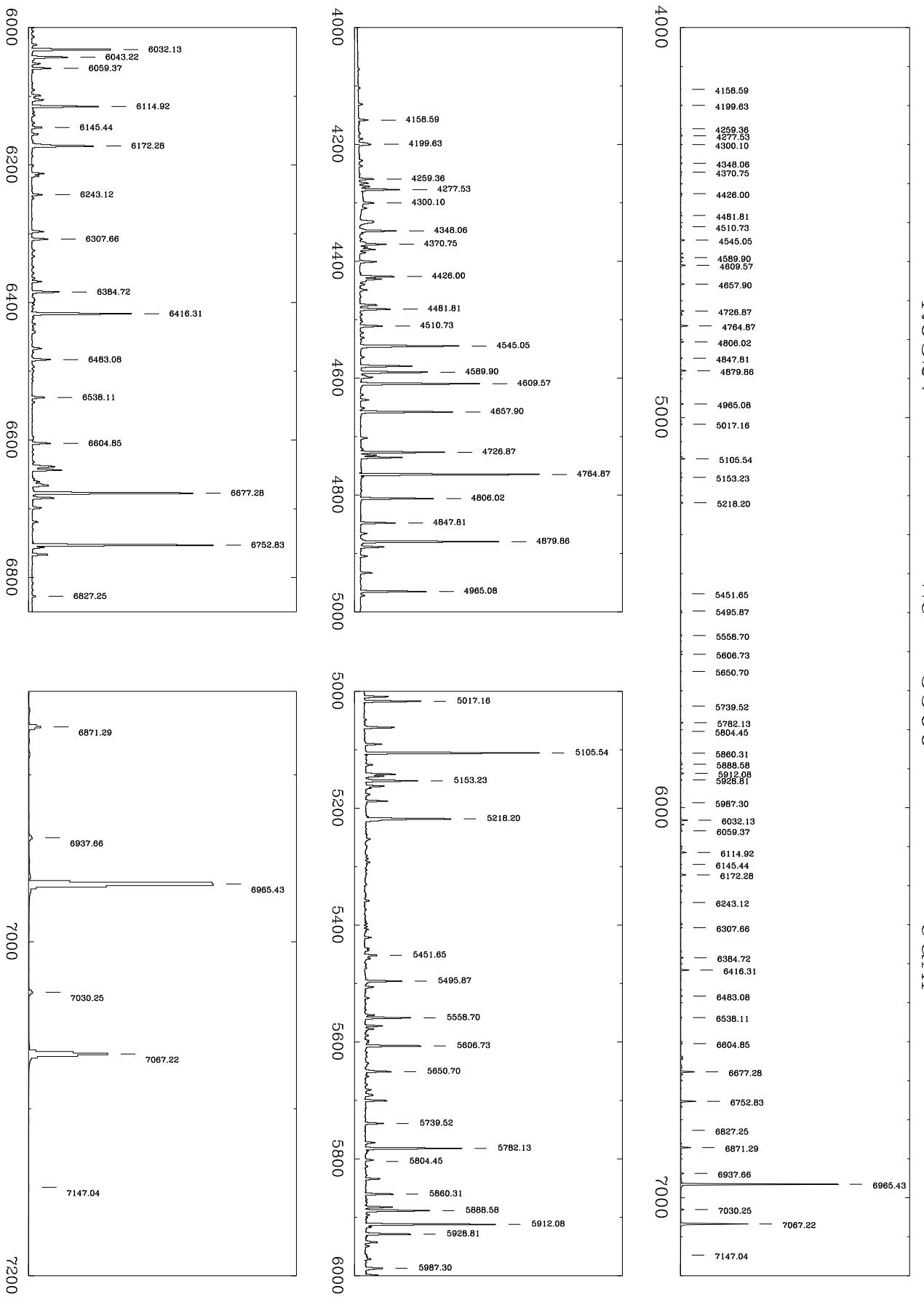
CuNe



R632V

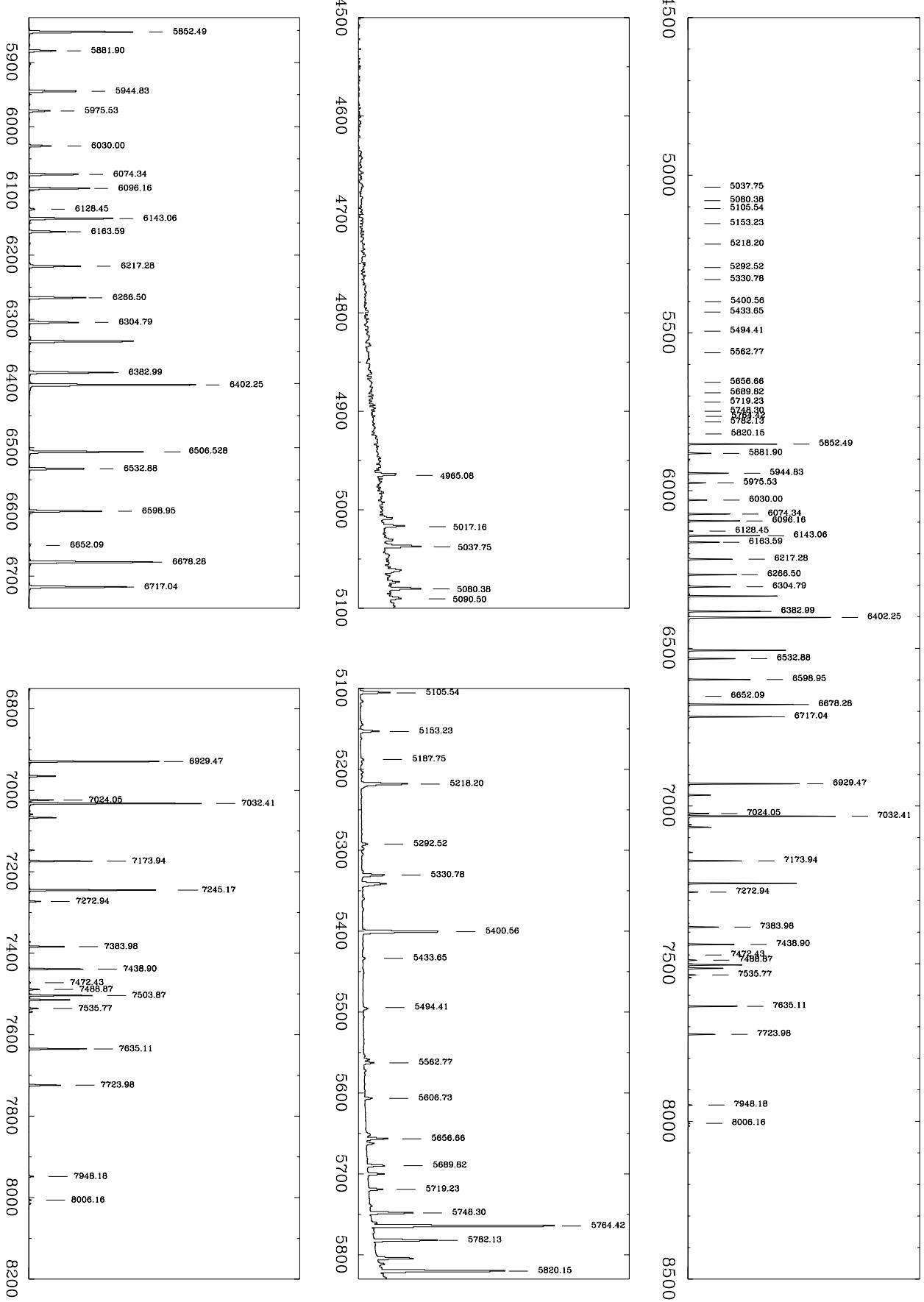
$\lambda_C = 5500$

Cuar



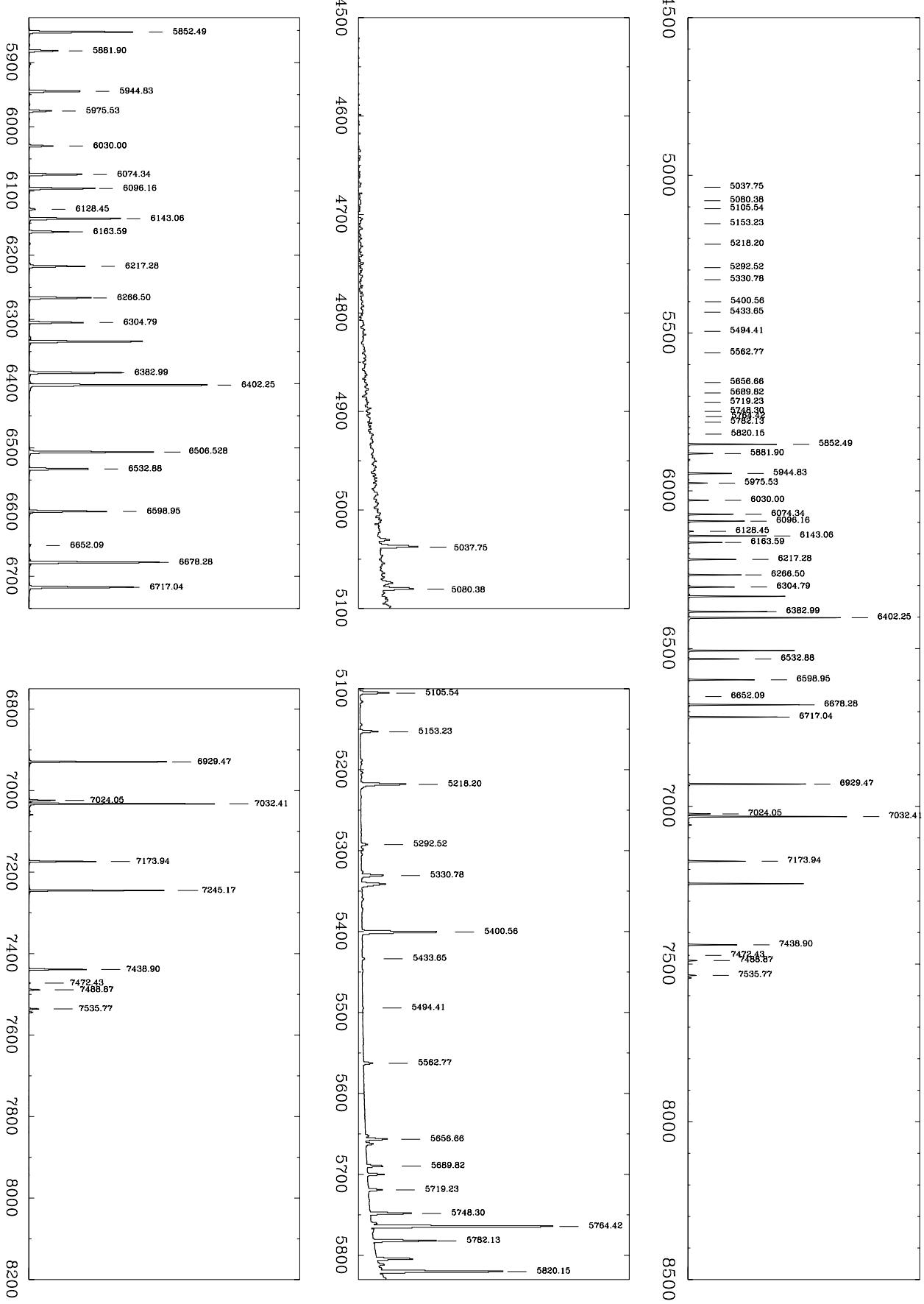
R632V $\lambda_C = 6400$

CuAr+CuNe



R632V $\lambda_C = 6400$

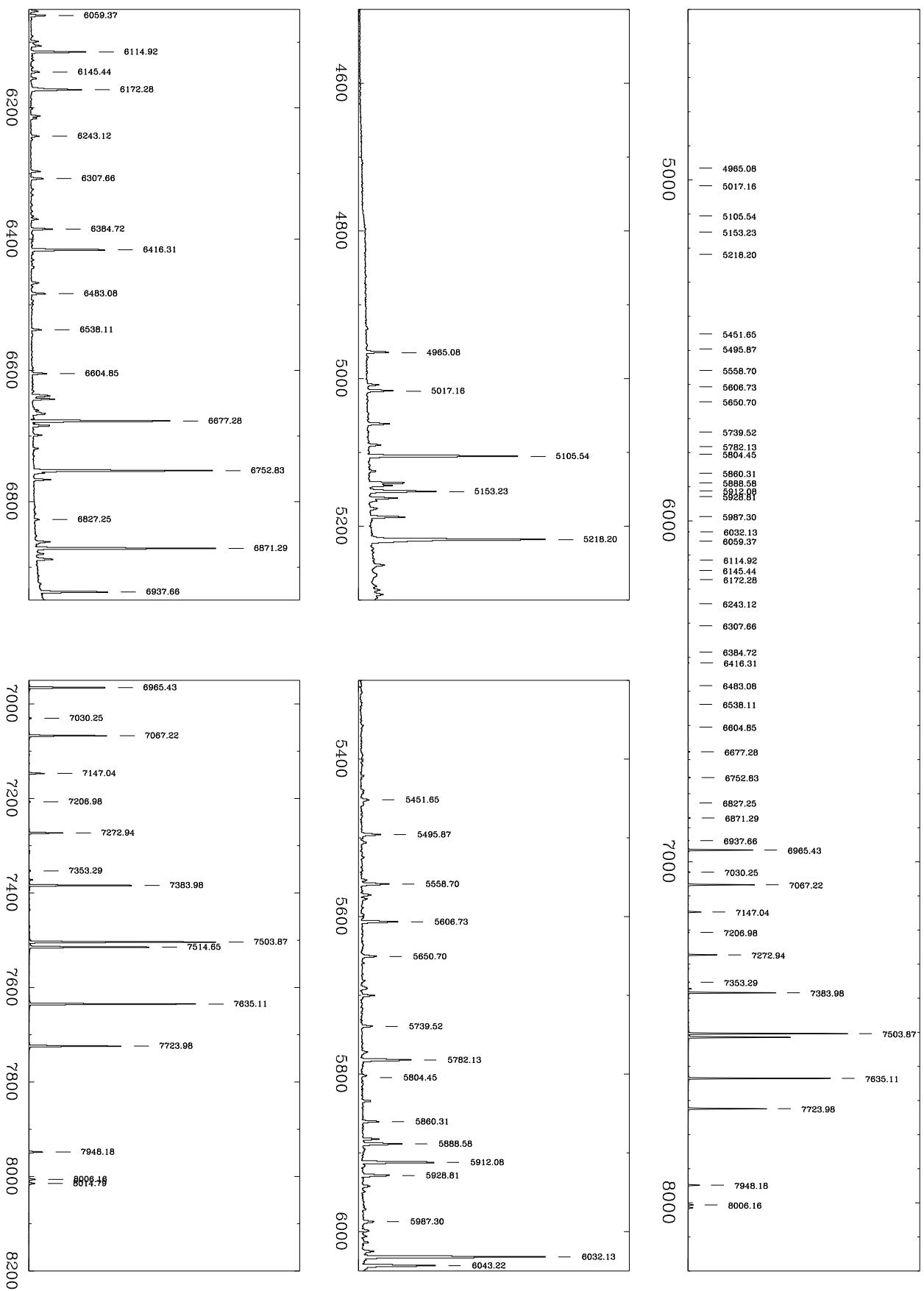
CuNe



R632V

$\lambda_C = 6400$

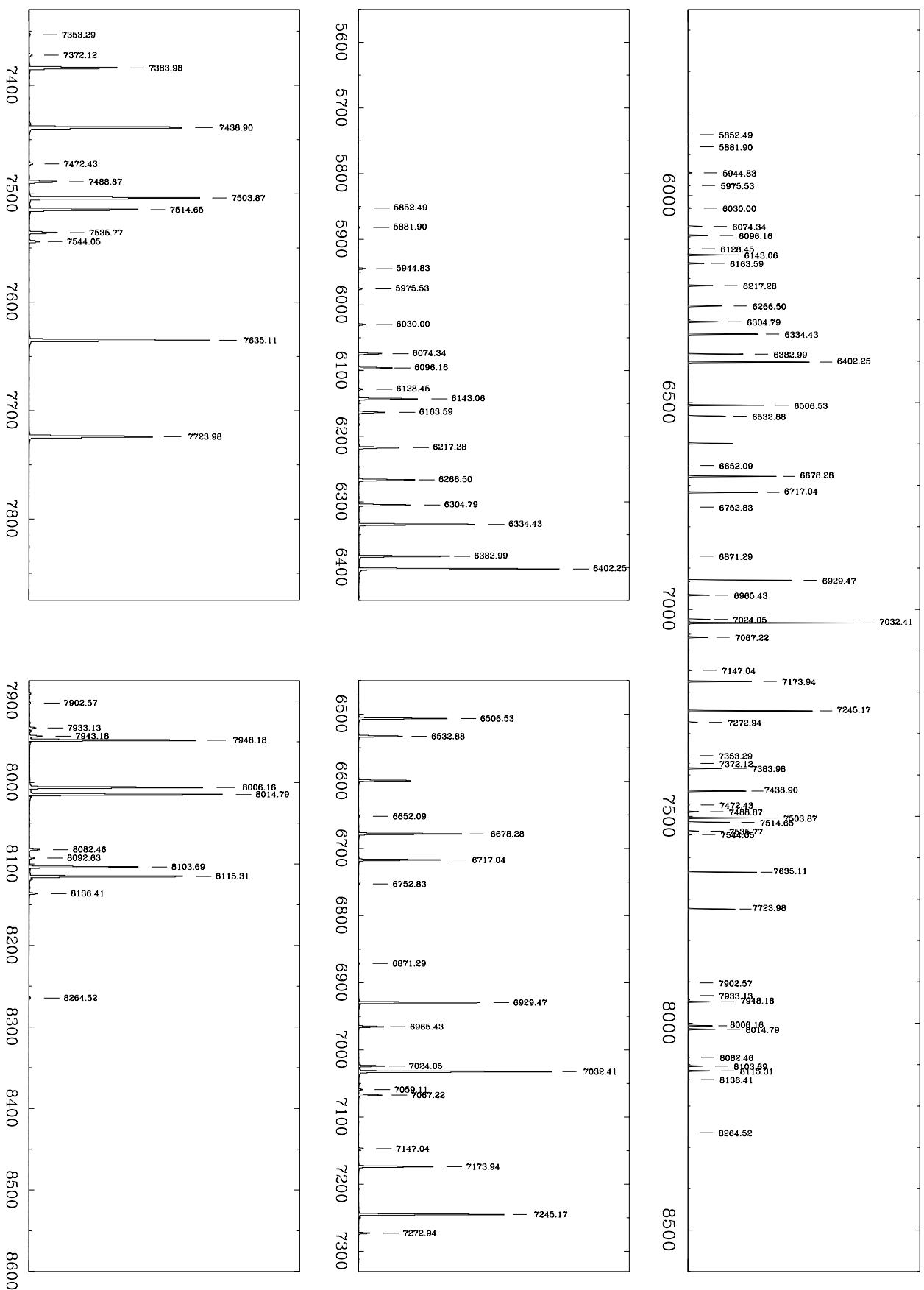
CuAr



R831R

$\lambda_C = 7000$

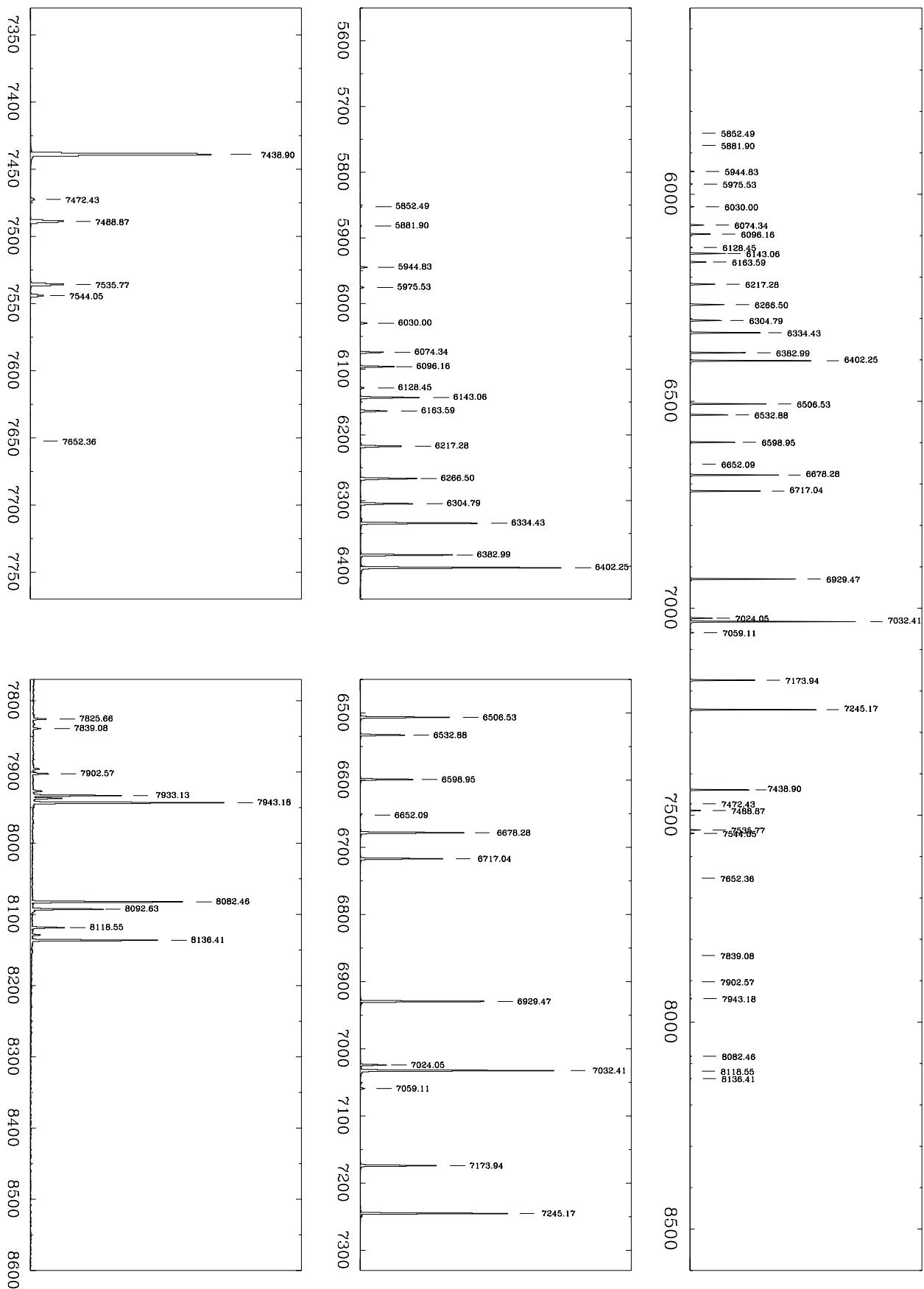
CuAr + CuNe



R831R

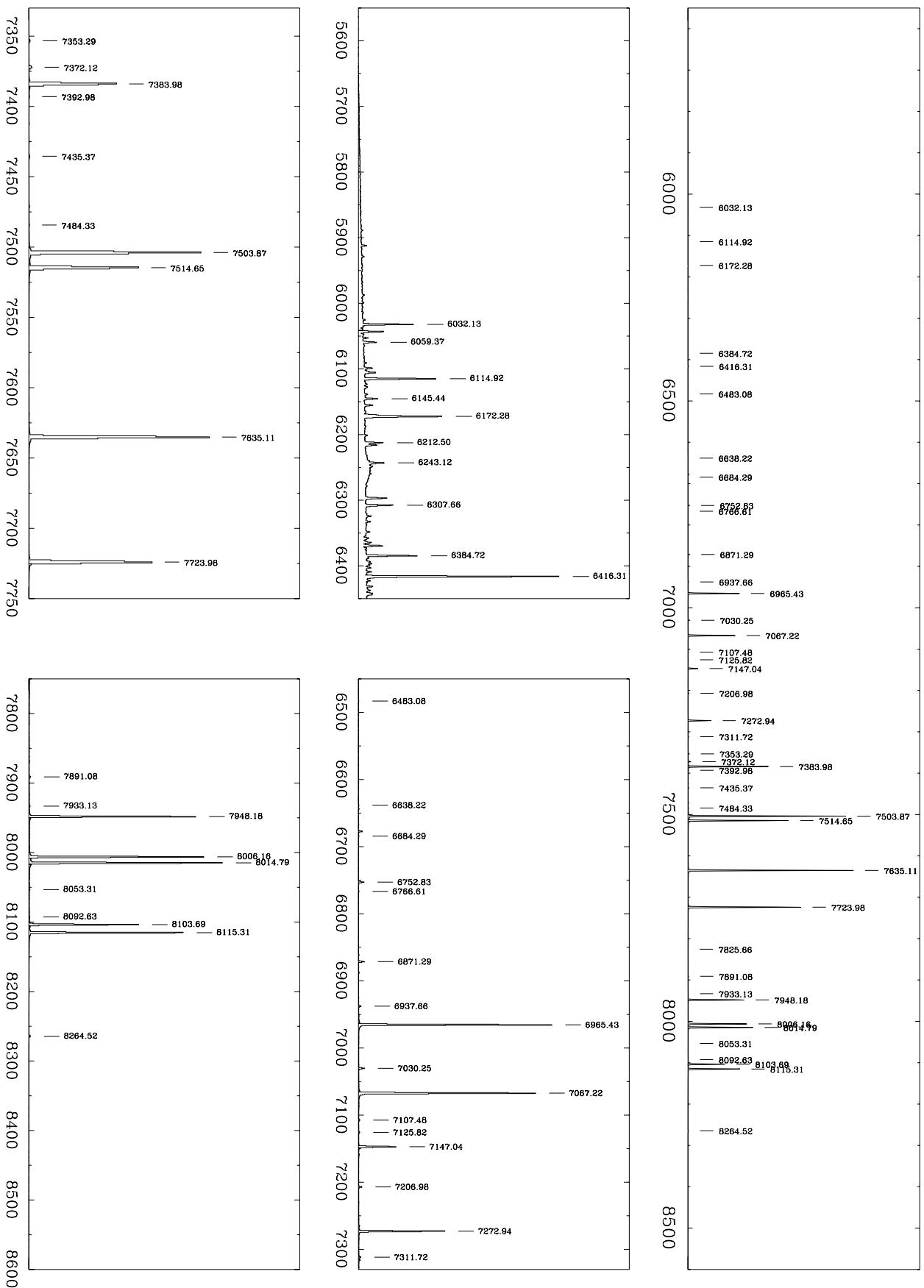
$\lambda_C = 7000$

CuNe



R831R $\lambda_C = 7000$

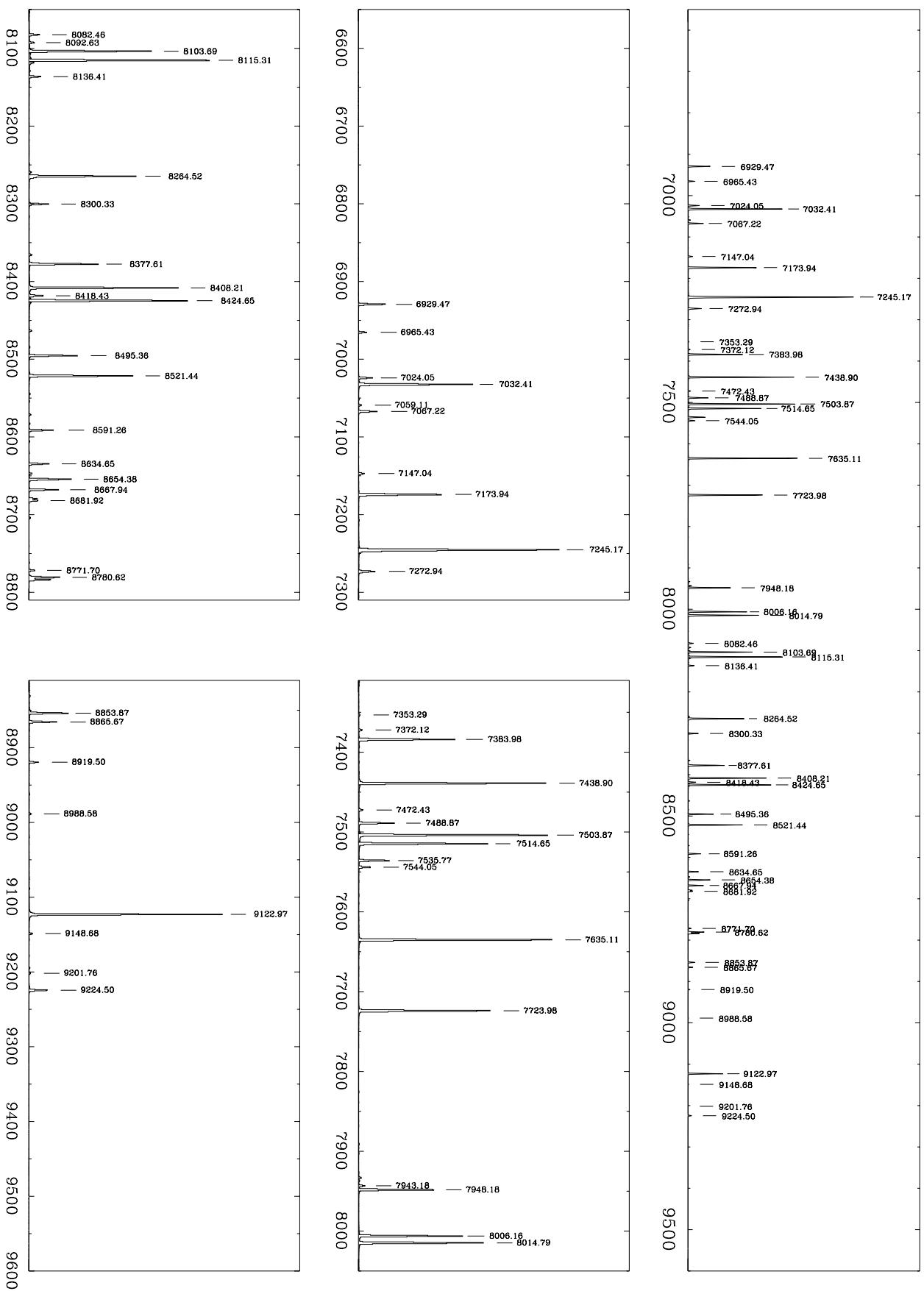
CuAr



R831R

$\lambda_C = 8000$

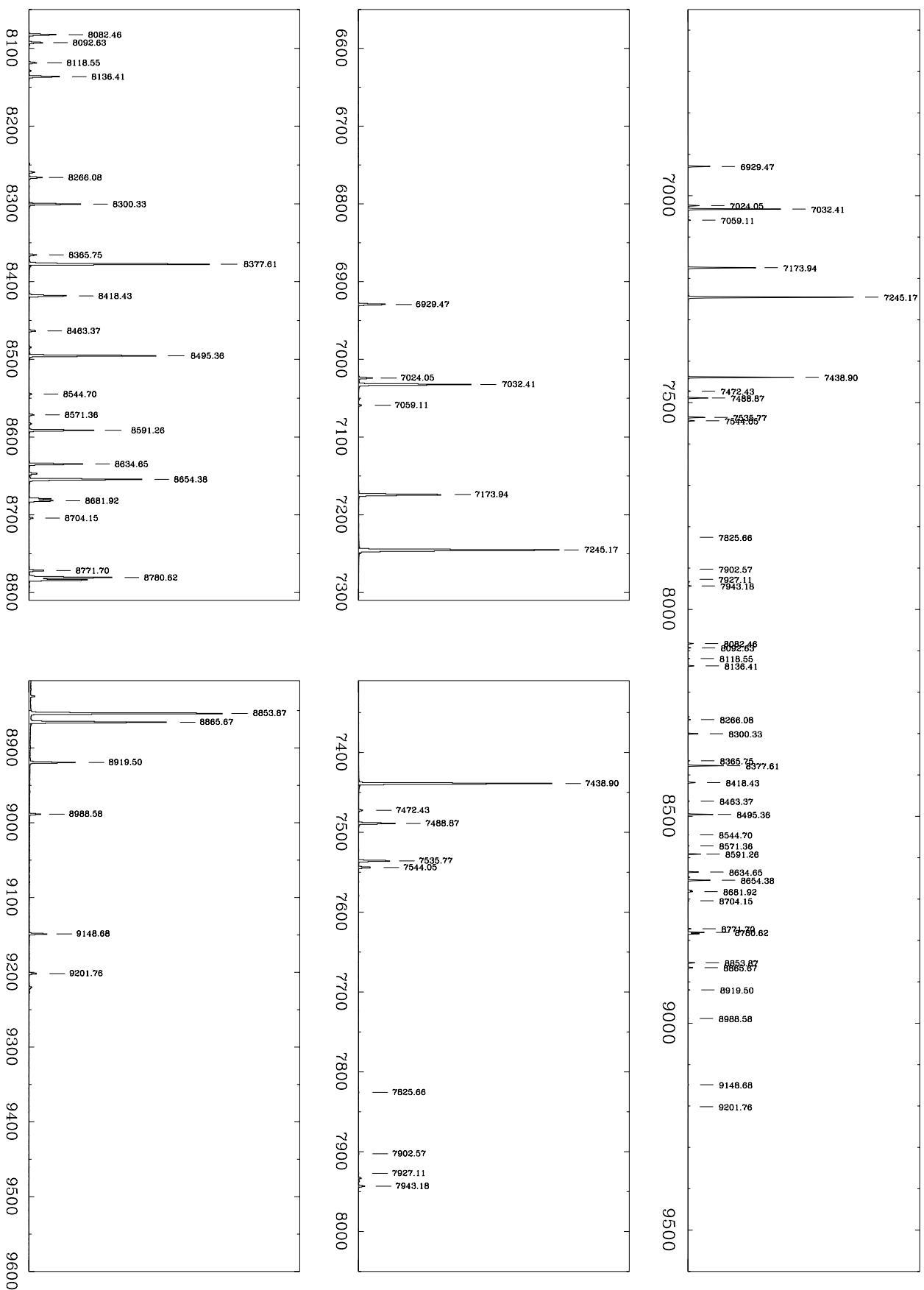
CuAr + CuNe



R831R

$\lambda_C = 8000$

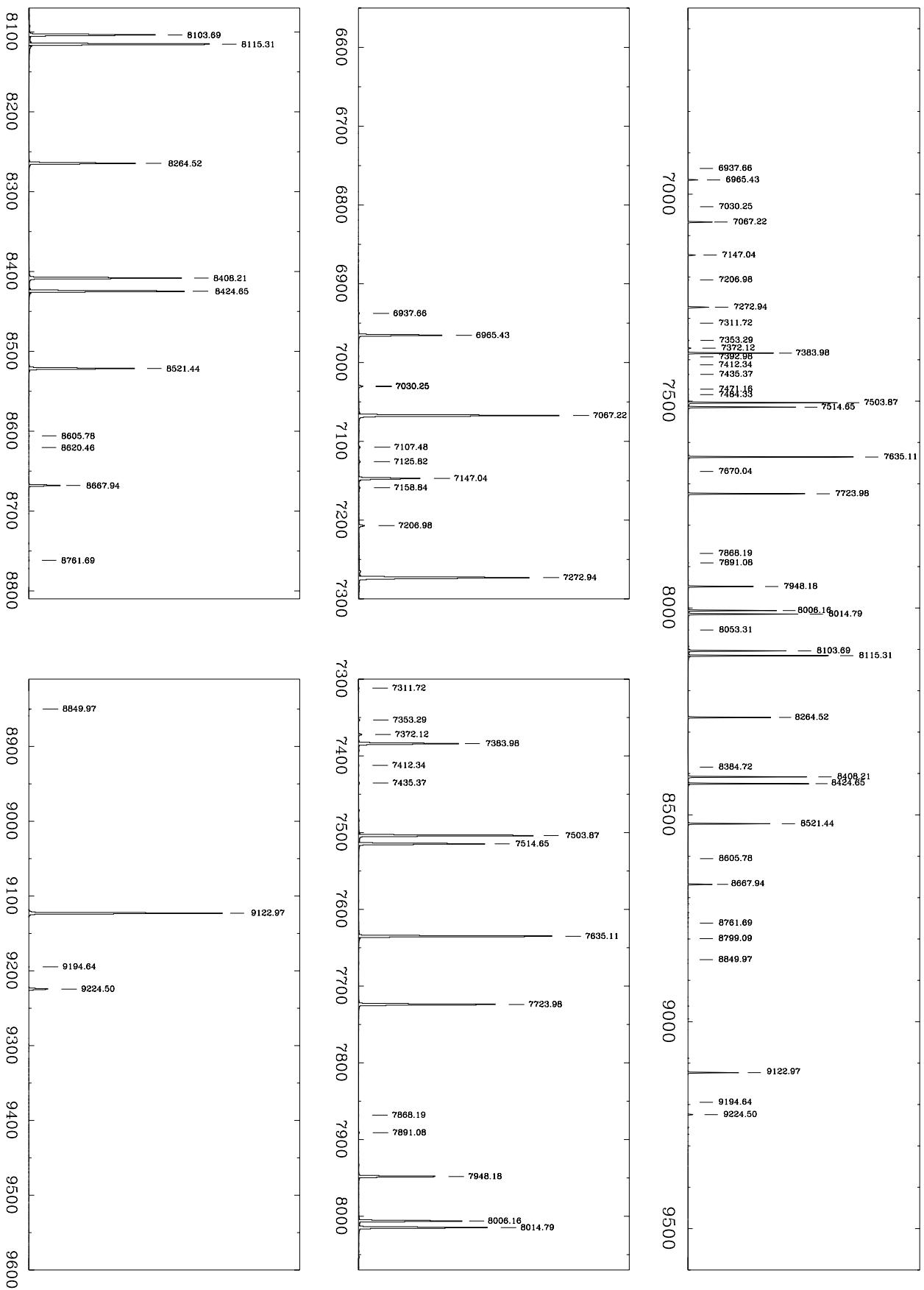
CuNe



R831R

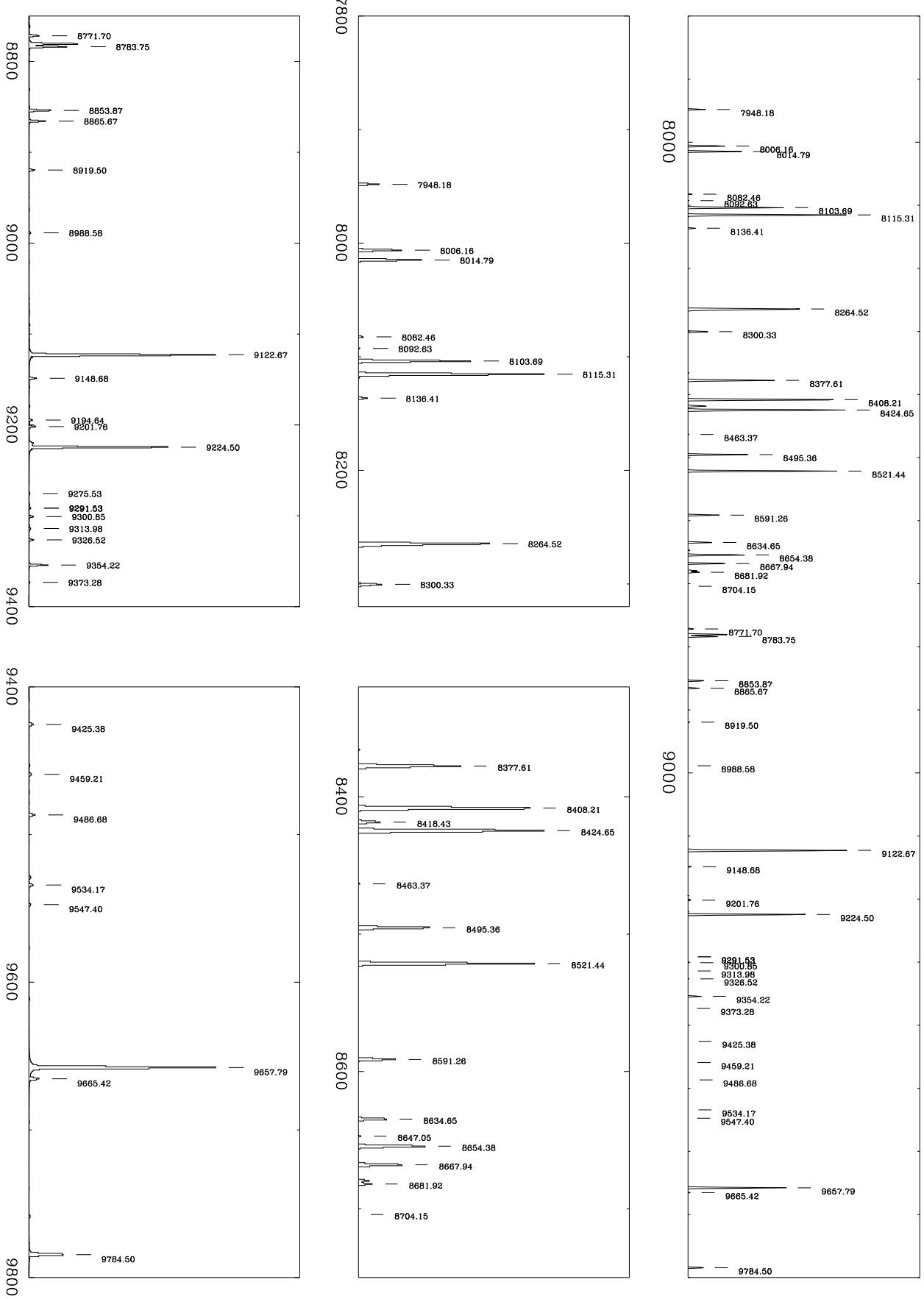
$\lambda_C = 8000$

CuAr

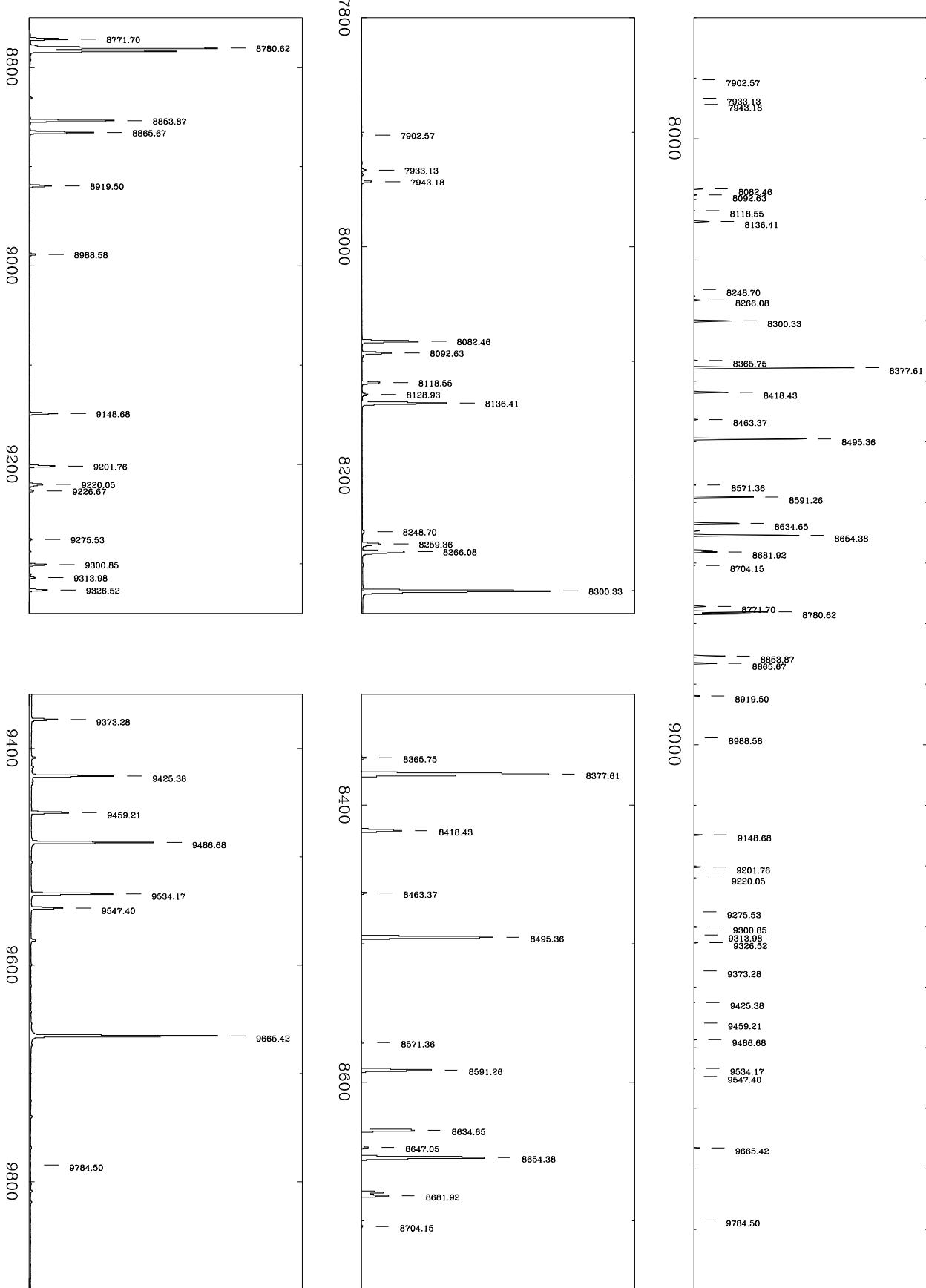


R831R $\lambda_C = 9000$

CuAr+CuNe



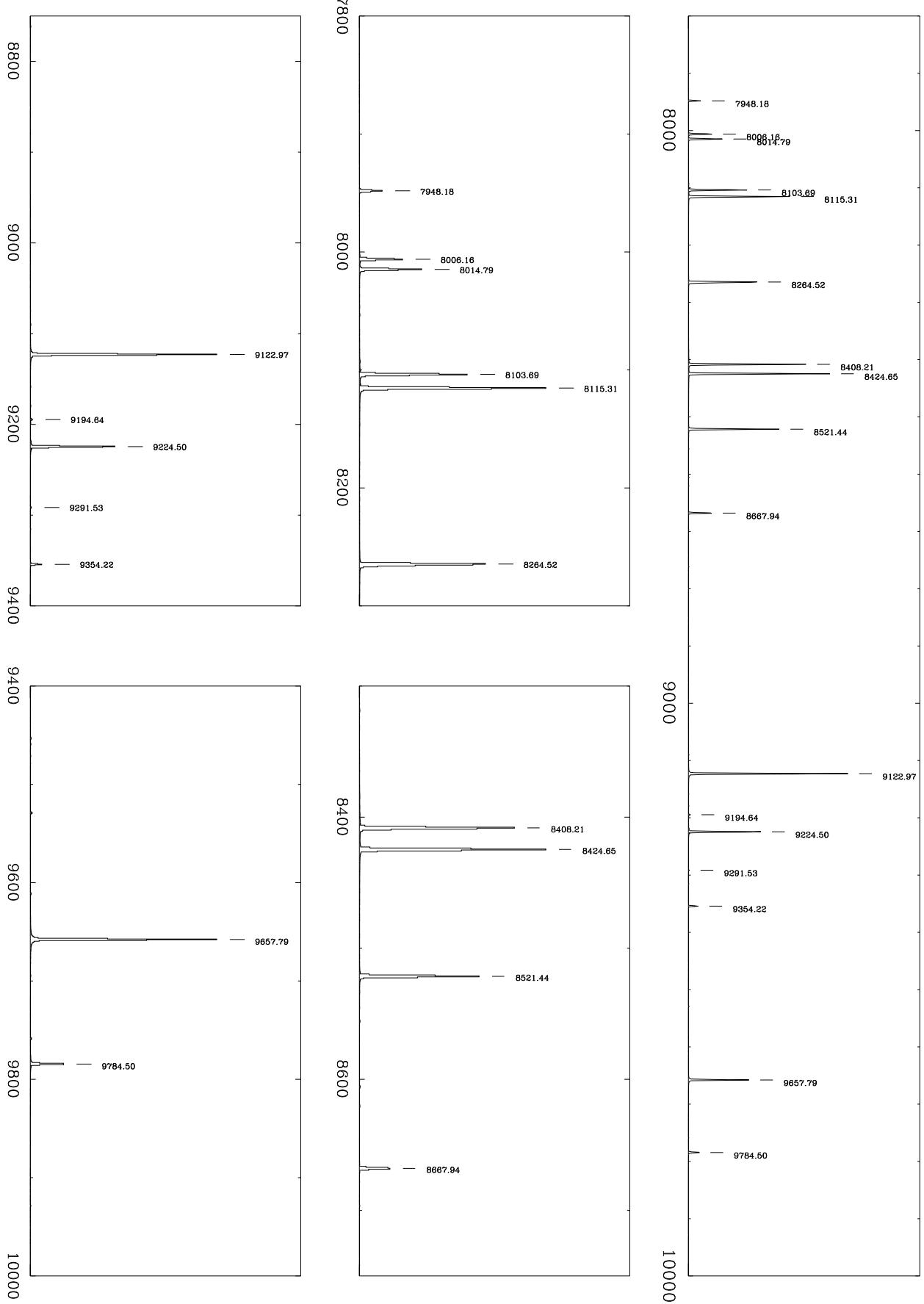
R831R $\lambda_C = 9000$ CuN_e



R831R

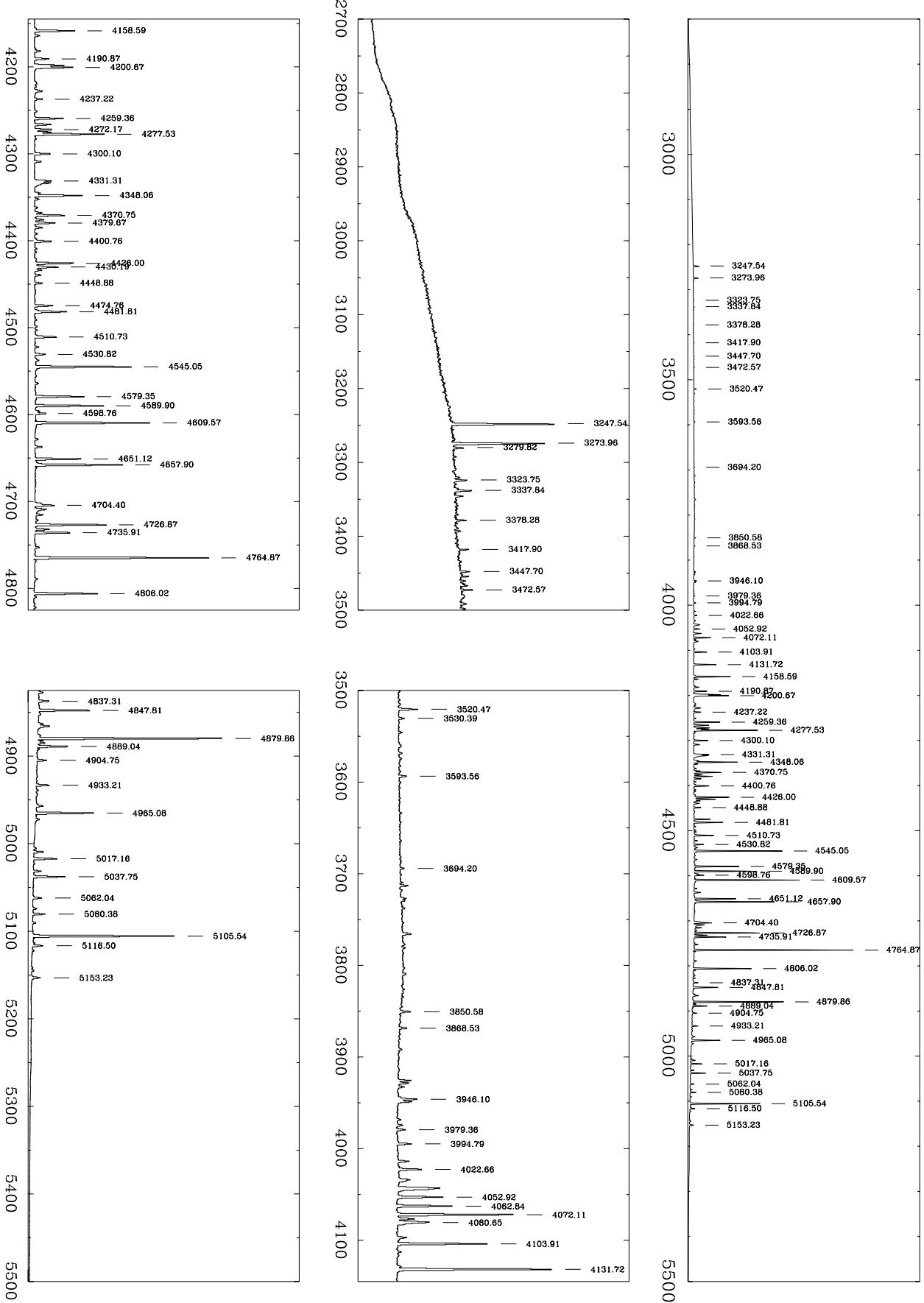
$\lambda_C = 9000$

CuAr



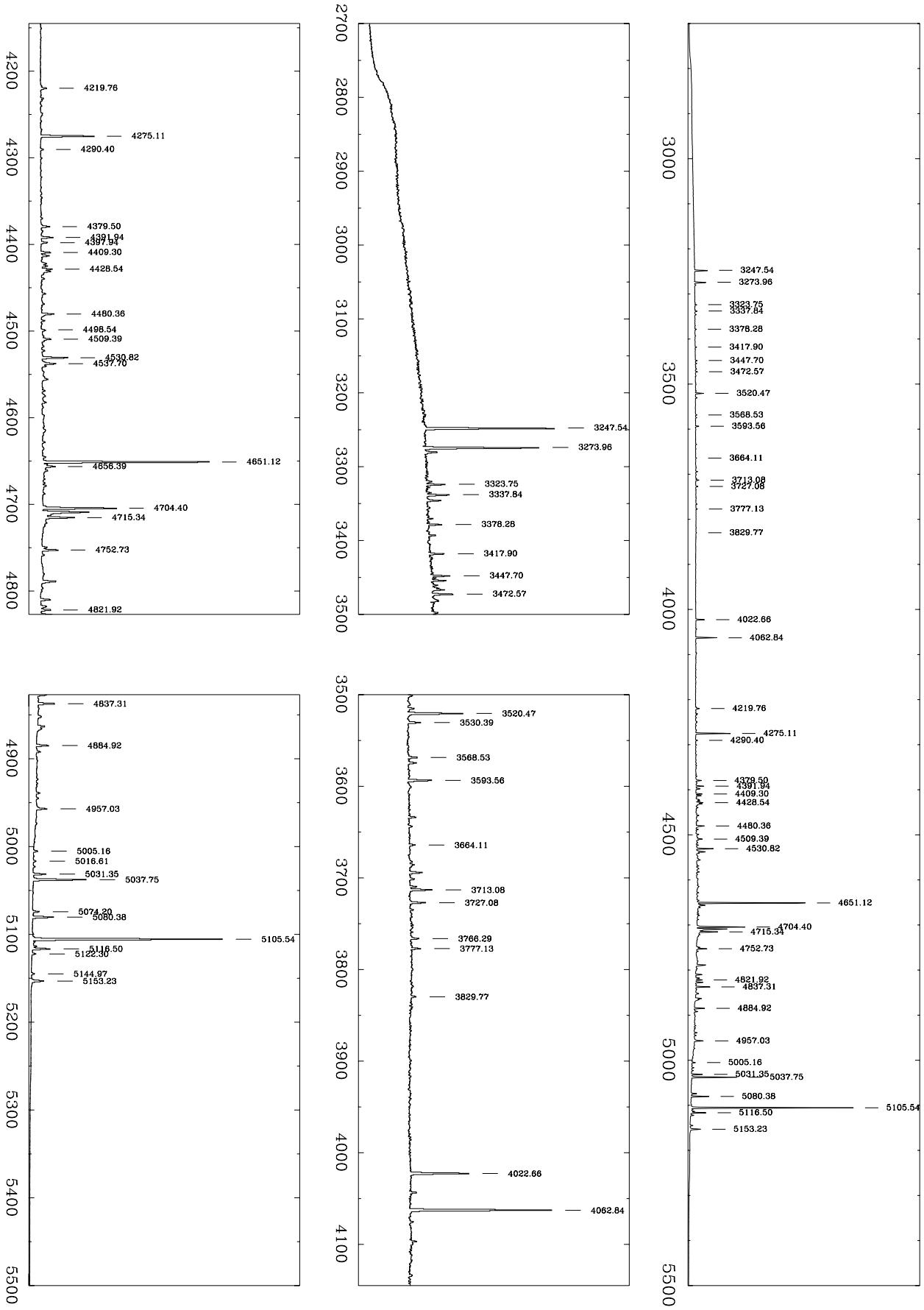
R900V $\lambda_C = 4000$

CuAr + CuNe



R900V $\lambda_c = 4000$

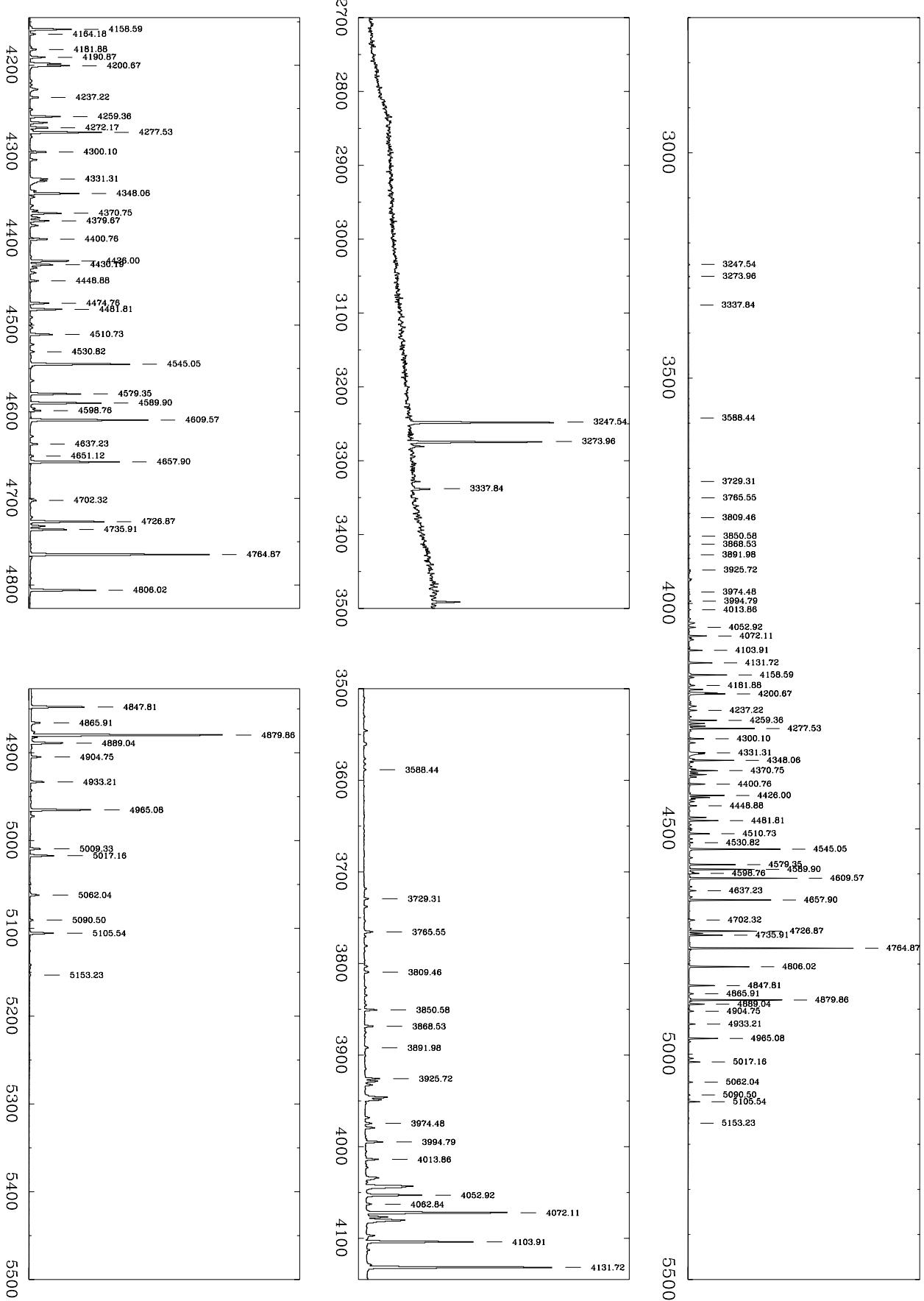
CuNe



R900V

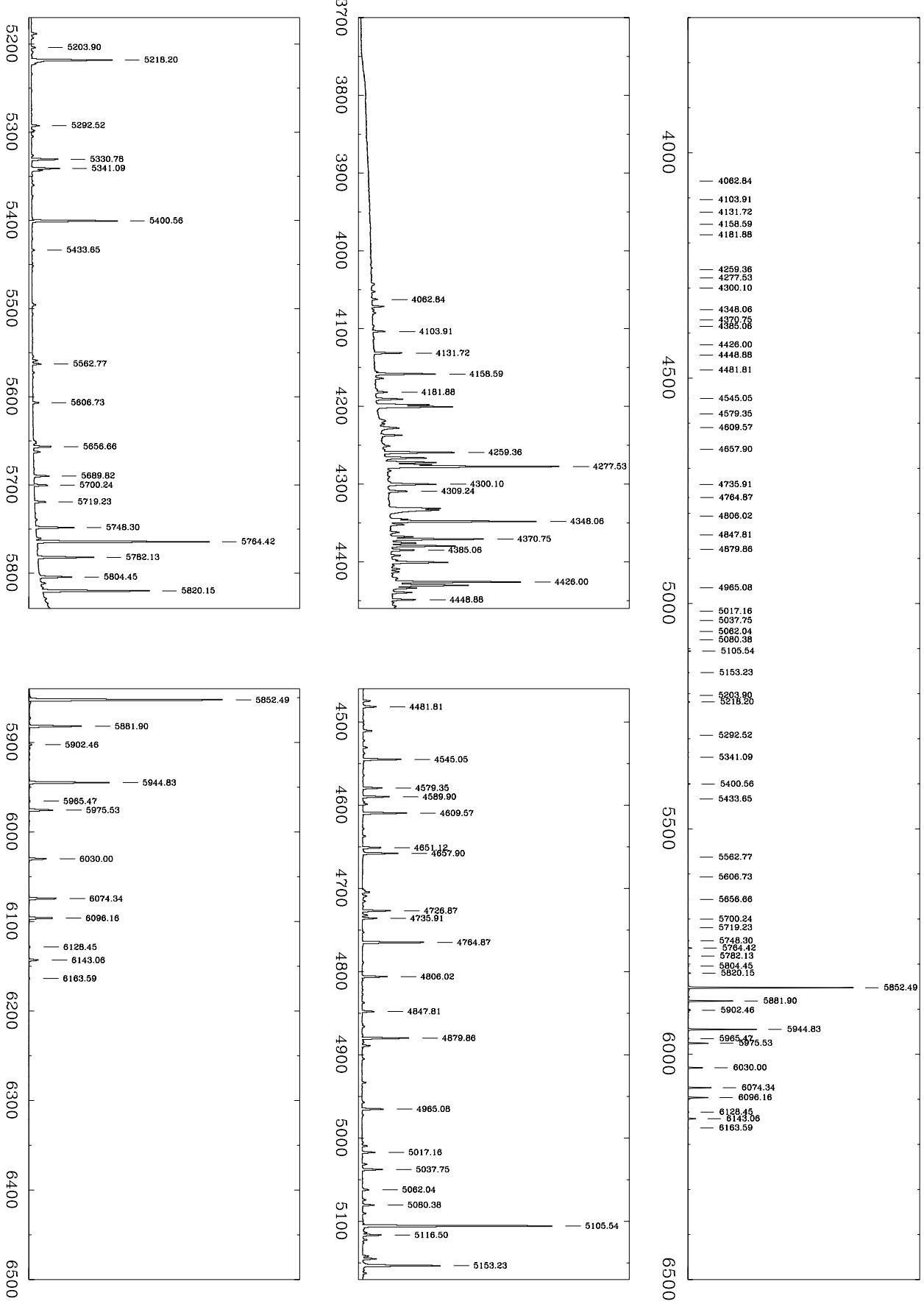
$\lambda C = 4000$

CuAr



R900V $\lambda_C = 5000$

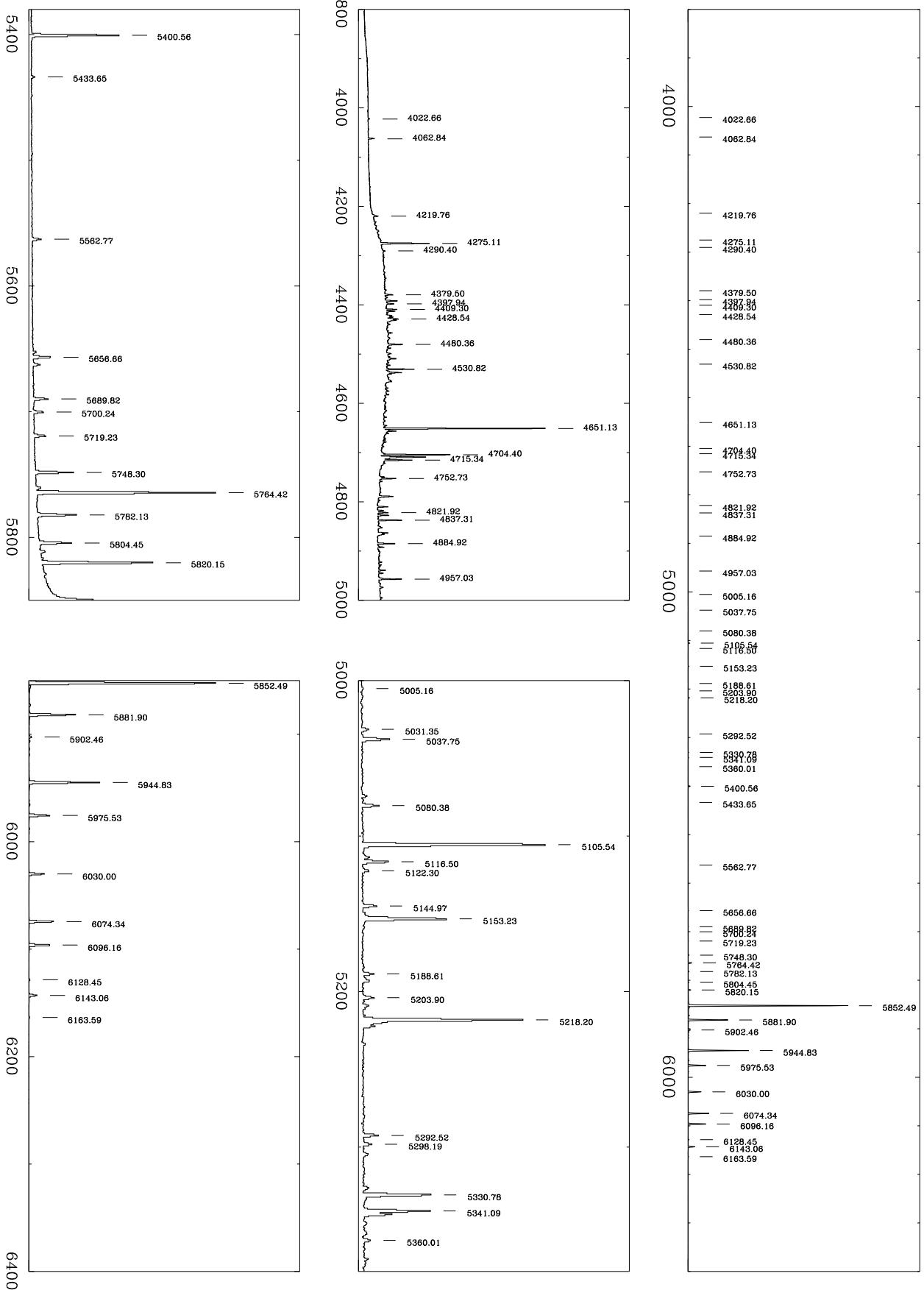
CuAr + CuNe



R900W

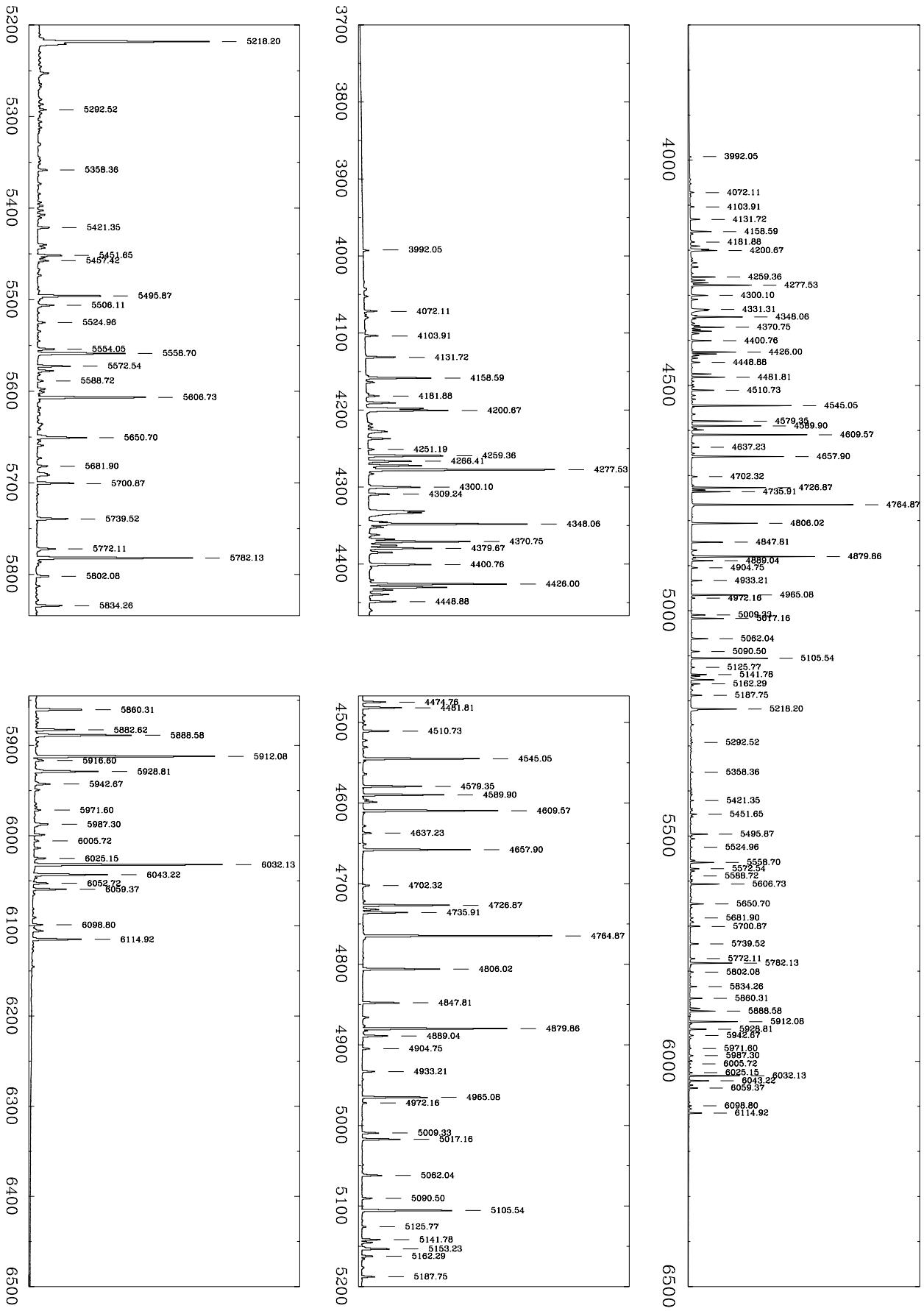
$\lambda C = 5000$

CuNe



R900V $\lambda_C = 5000$

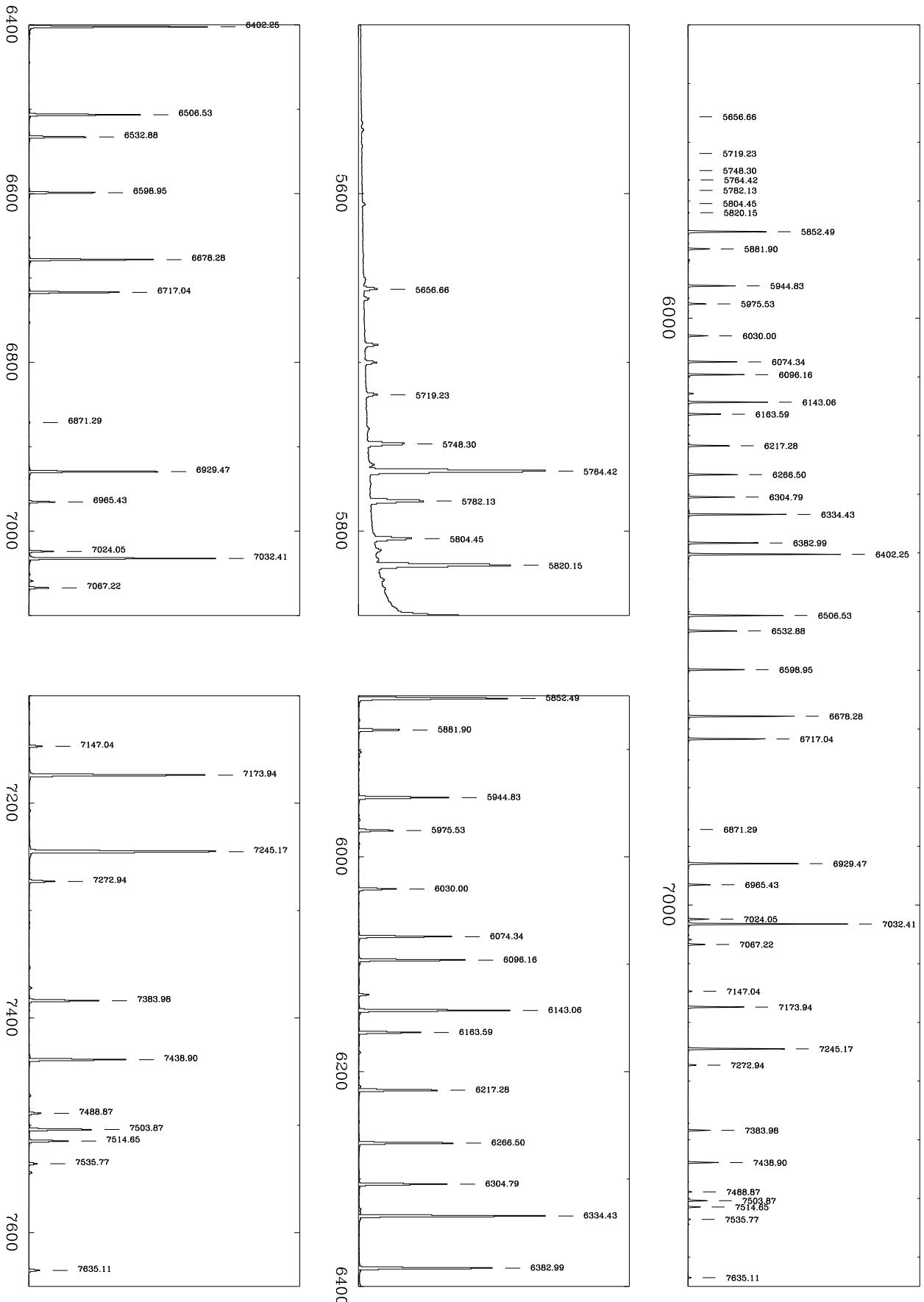
CuAr



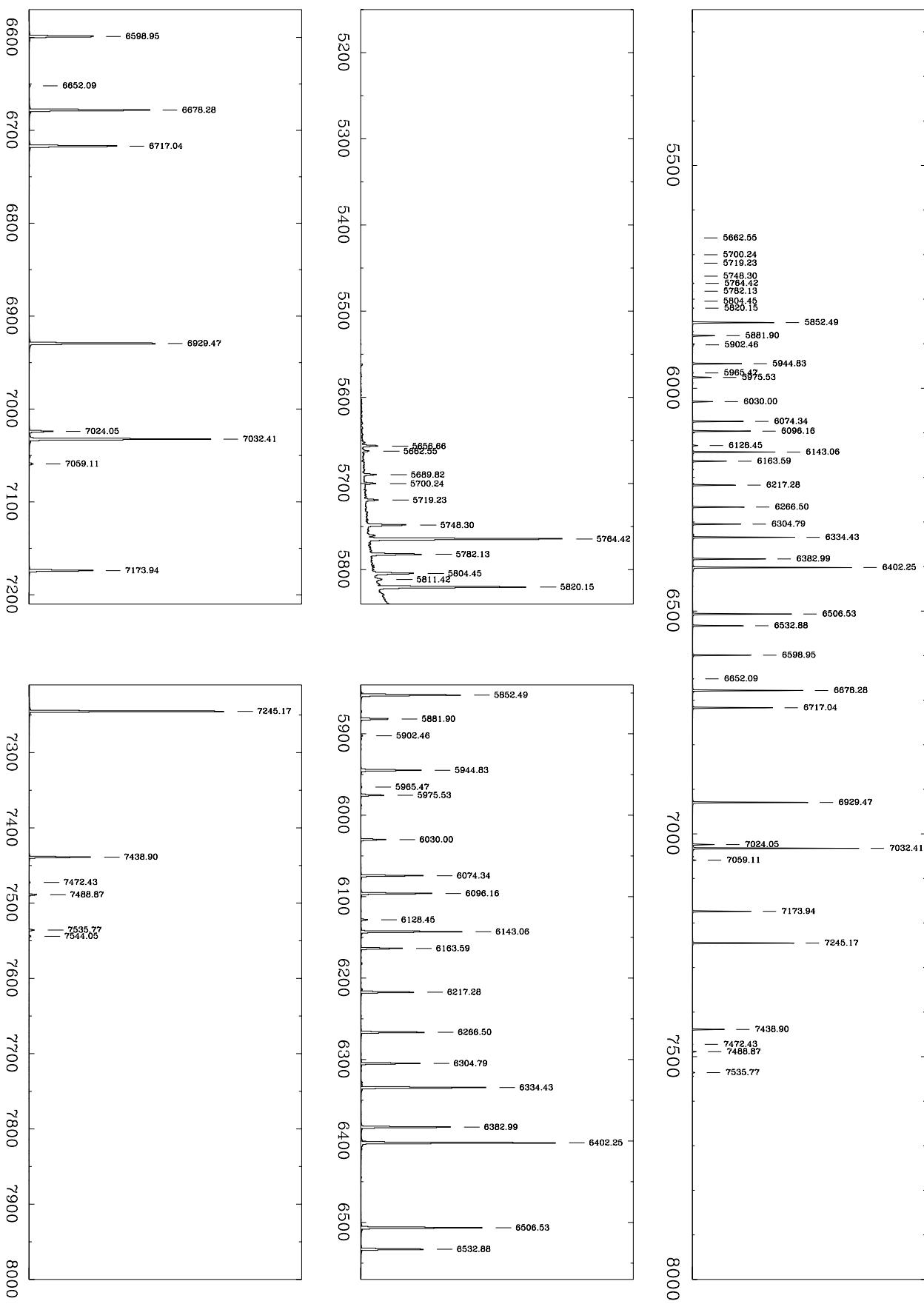
R900V

$\lambda_C = 6500$

CuAr + CuNe



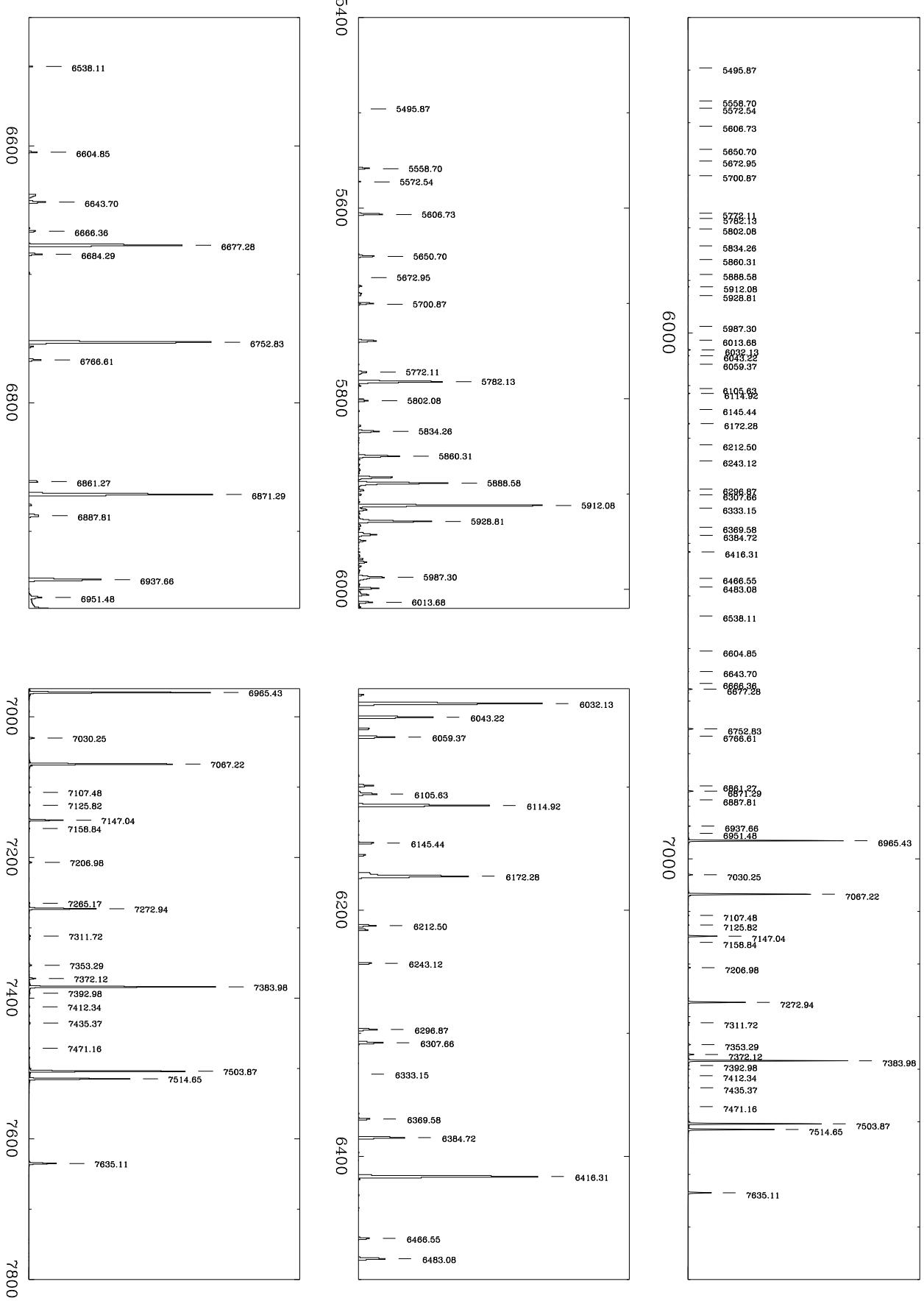
R900V $\lambda_C = 6500$ CuNe



R900V

$\lambda_C = 6500$

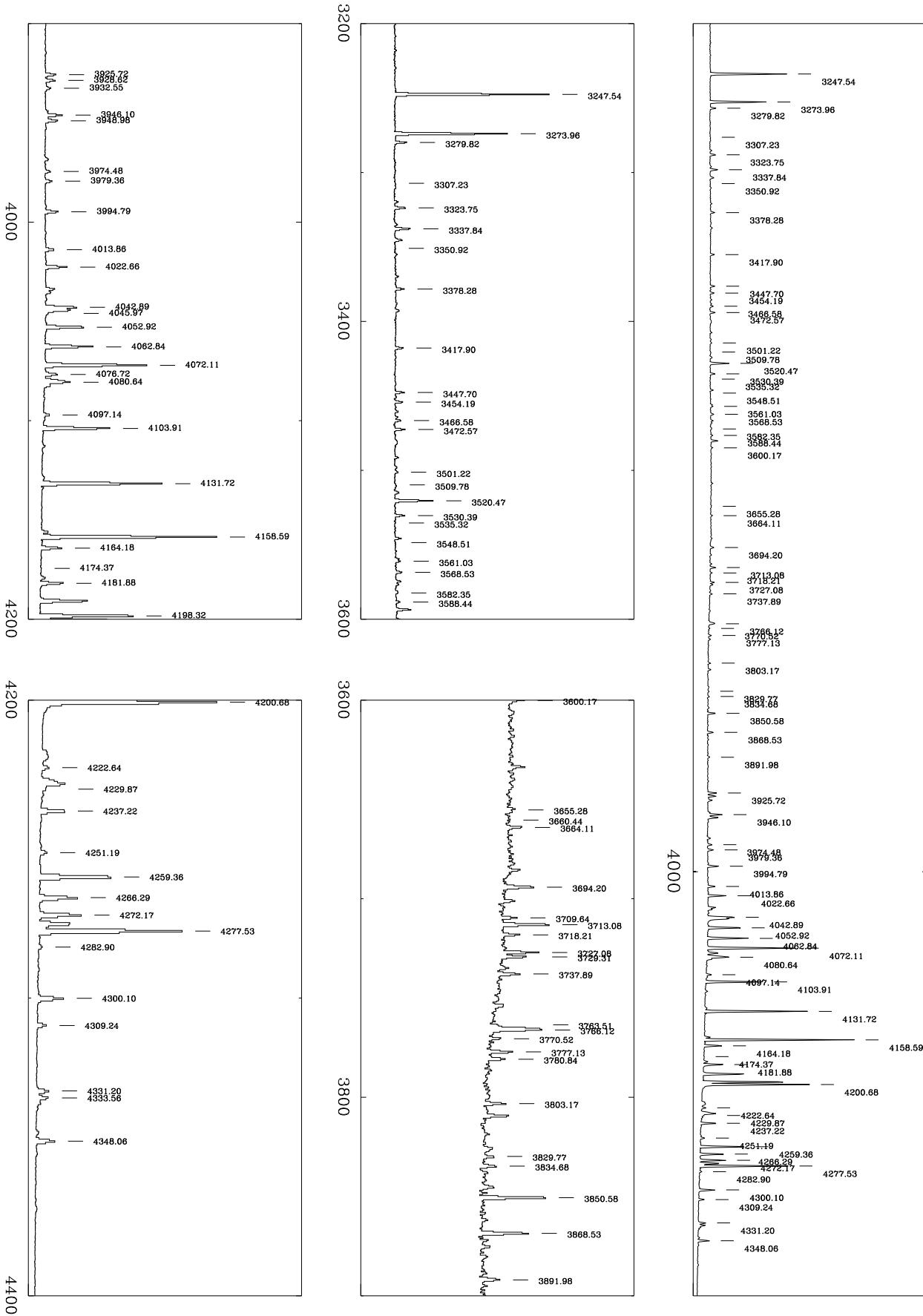
CuAr



R1200U

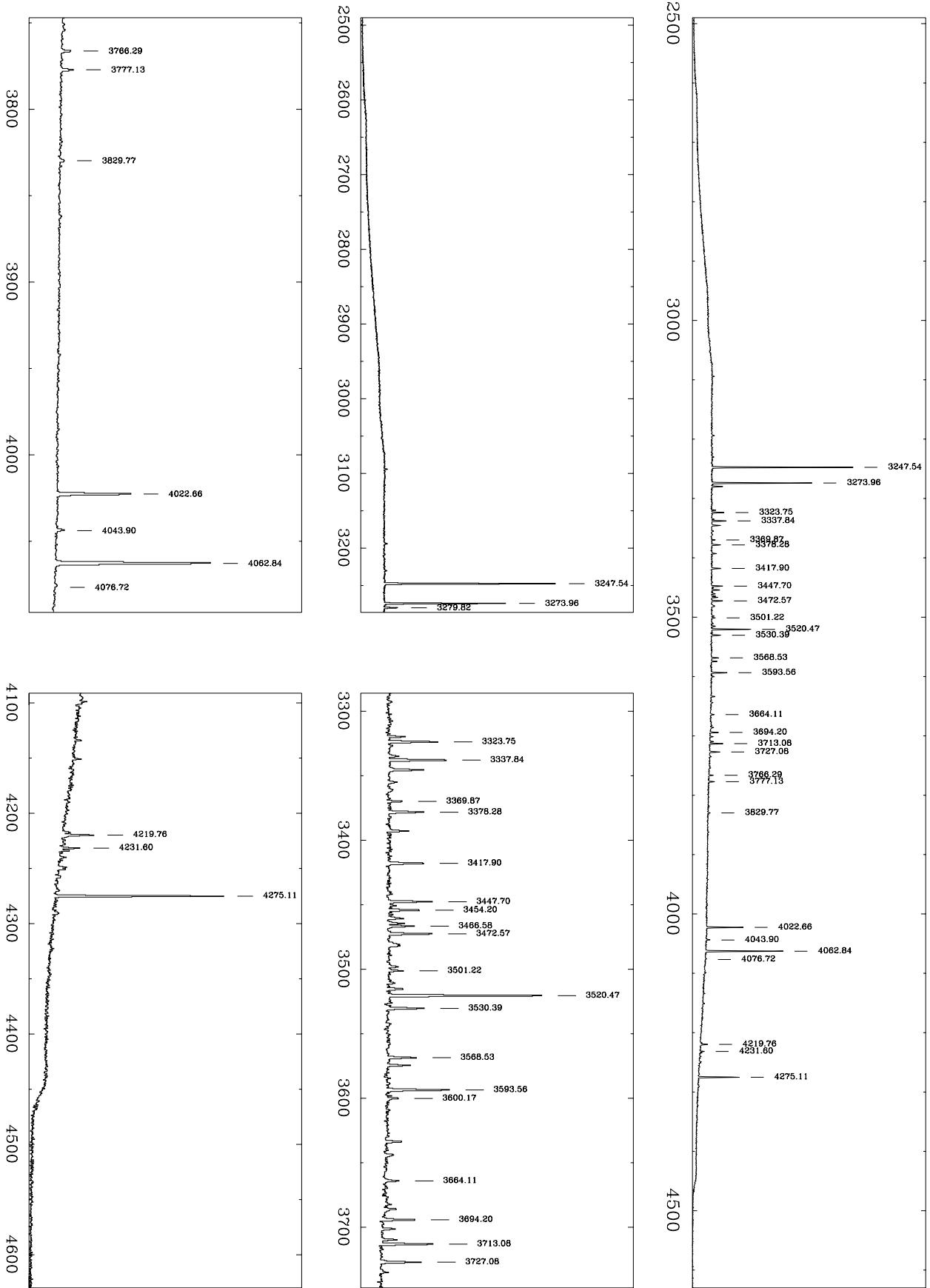
$\lambda_C = 3500$

CuAr+CuNe



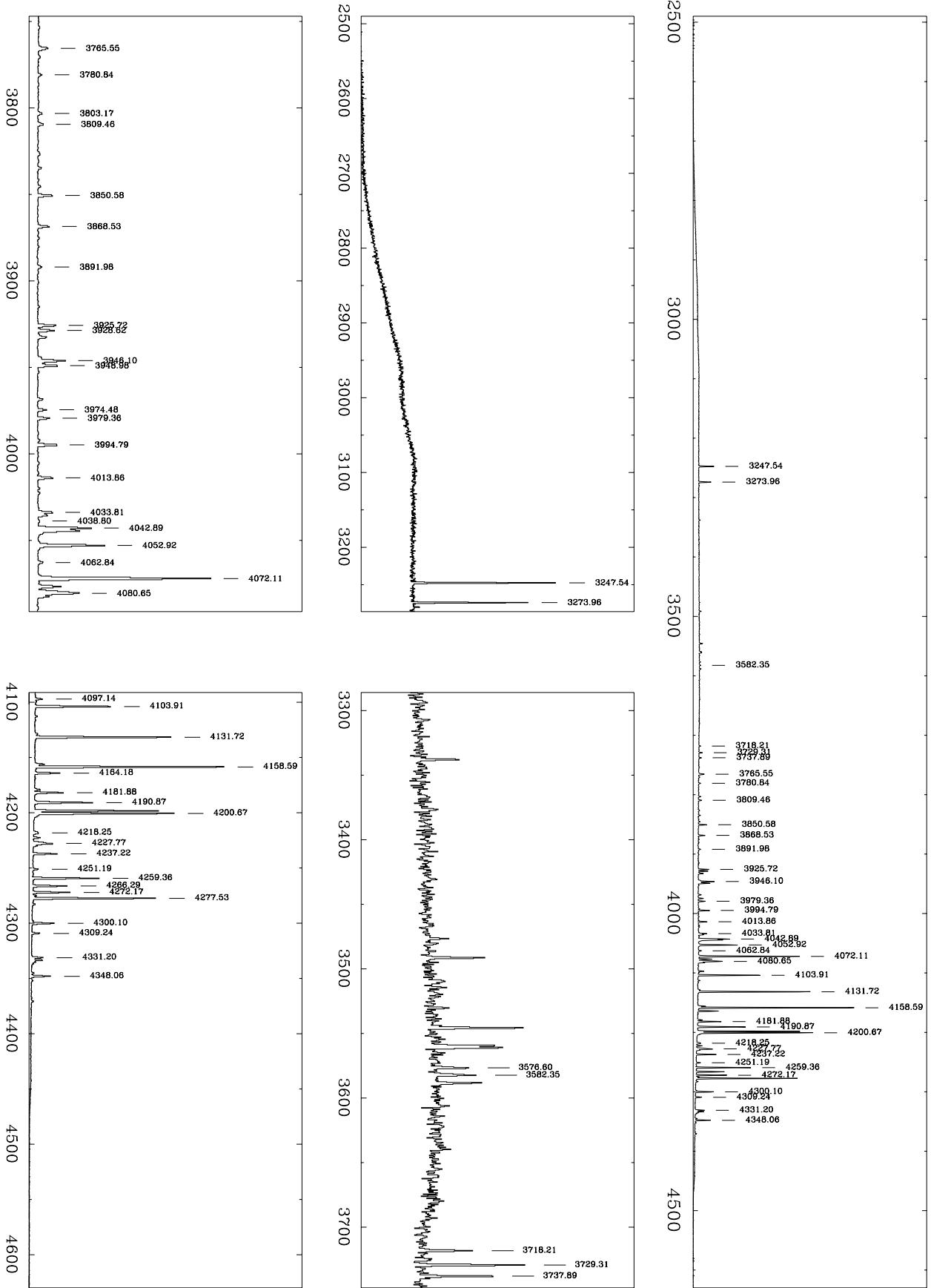
R1200U $\lambda C = 3500$

CuNe



R1200U $\lambda C = 3500$

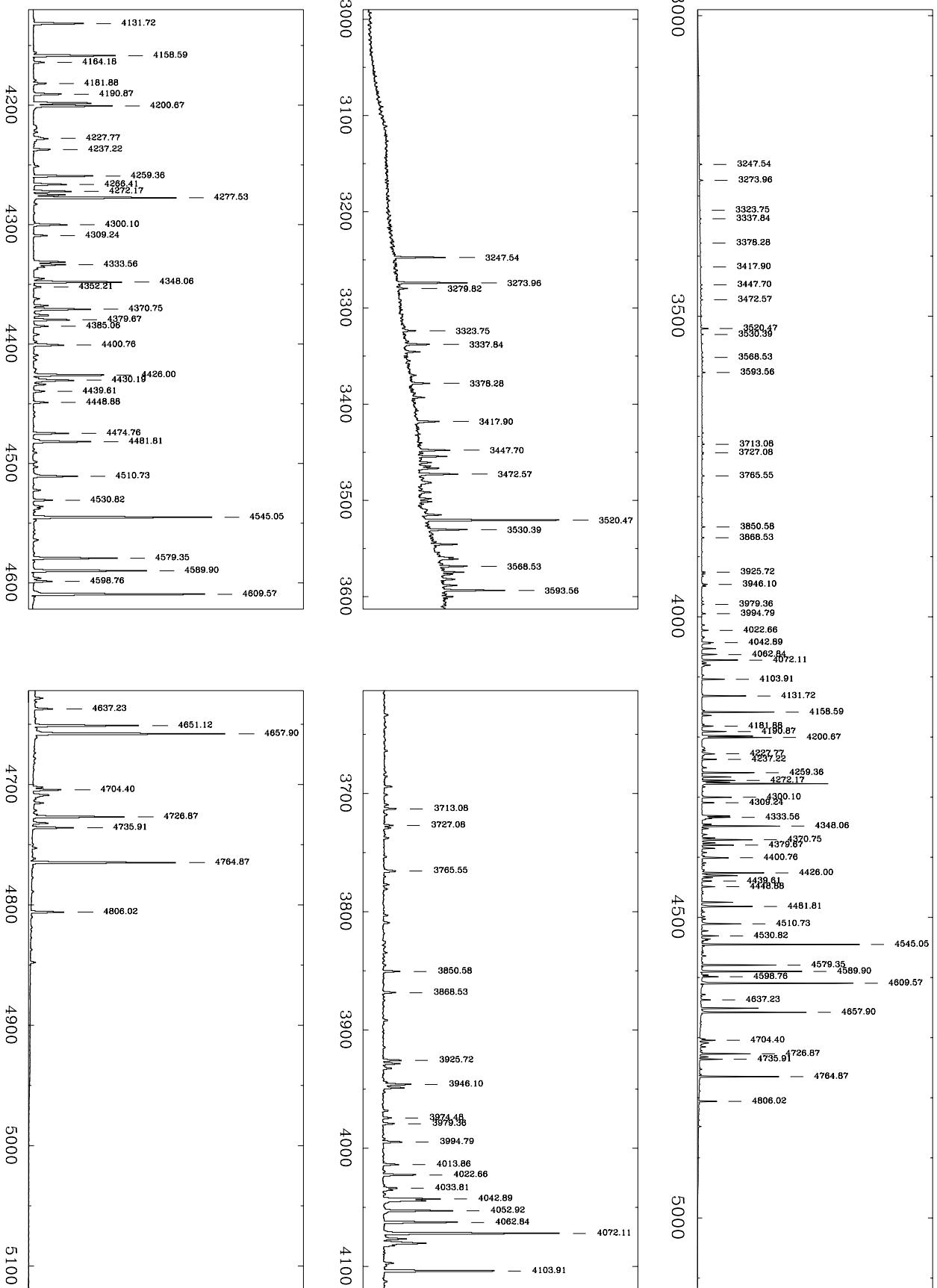
CuAr



R1200U

$\lambda_C = 4000$

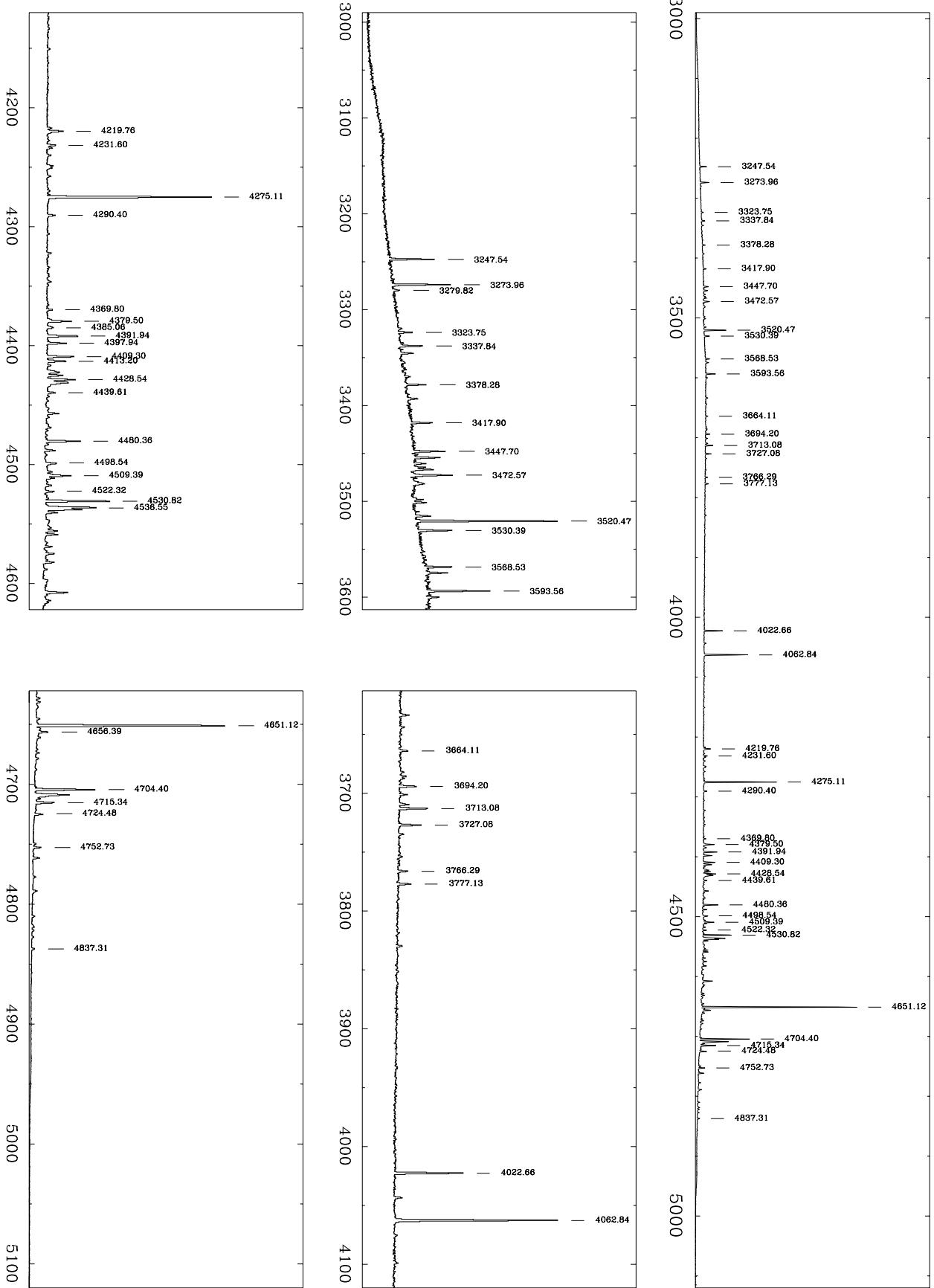
CuAr + CuNe



R1200U

$\lambda_C = 4000$

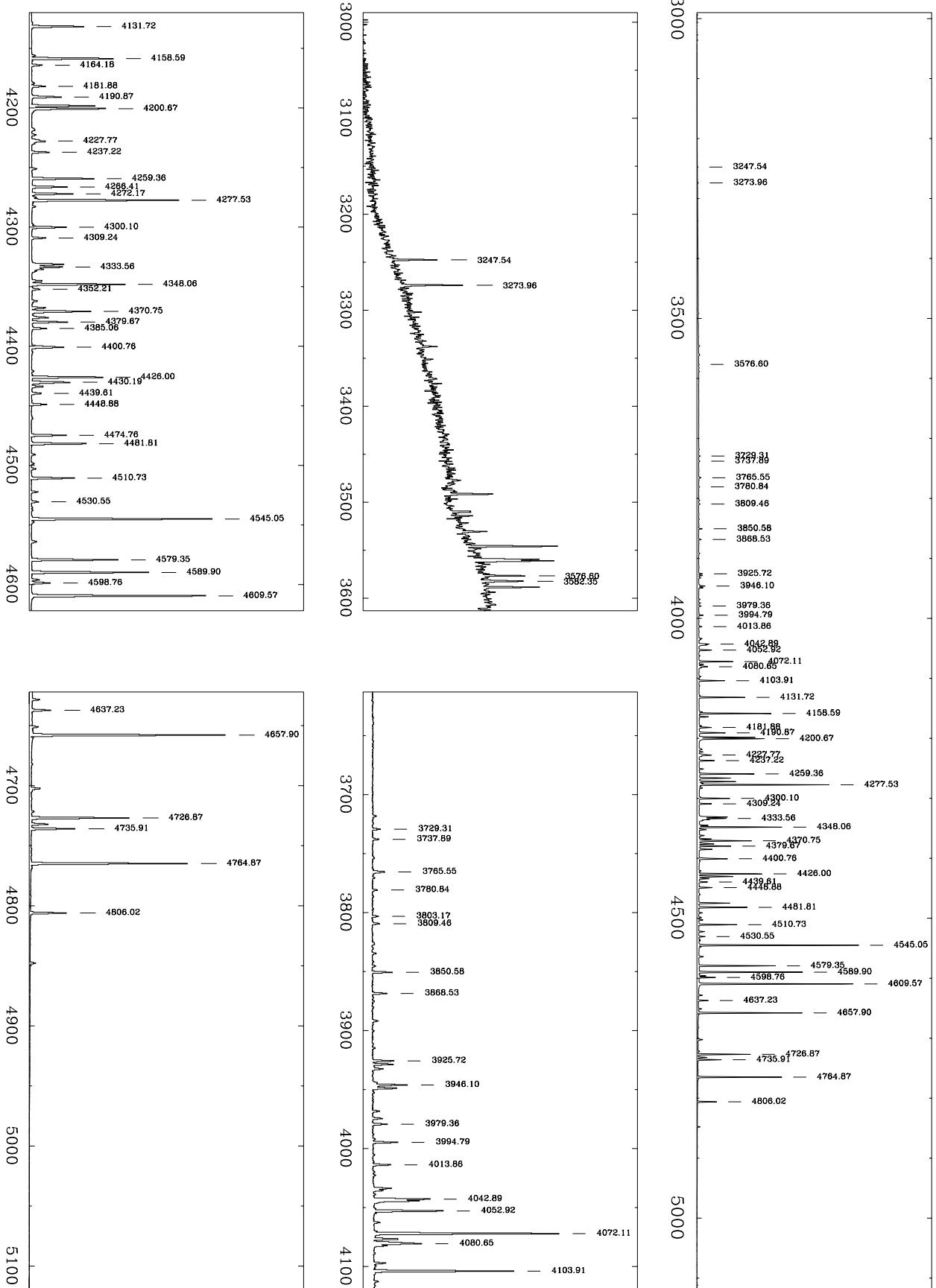
CuNe



R1200U

$\lambda_C = 4000$

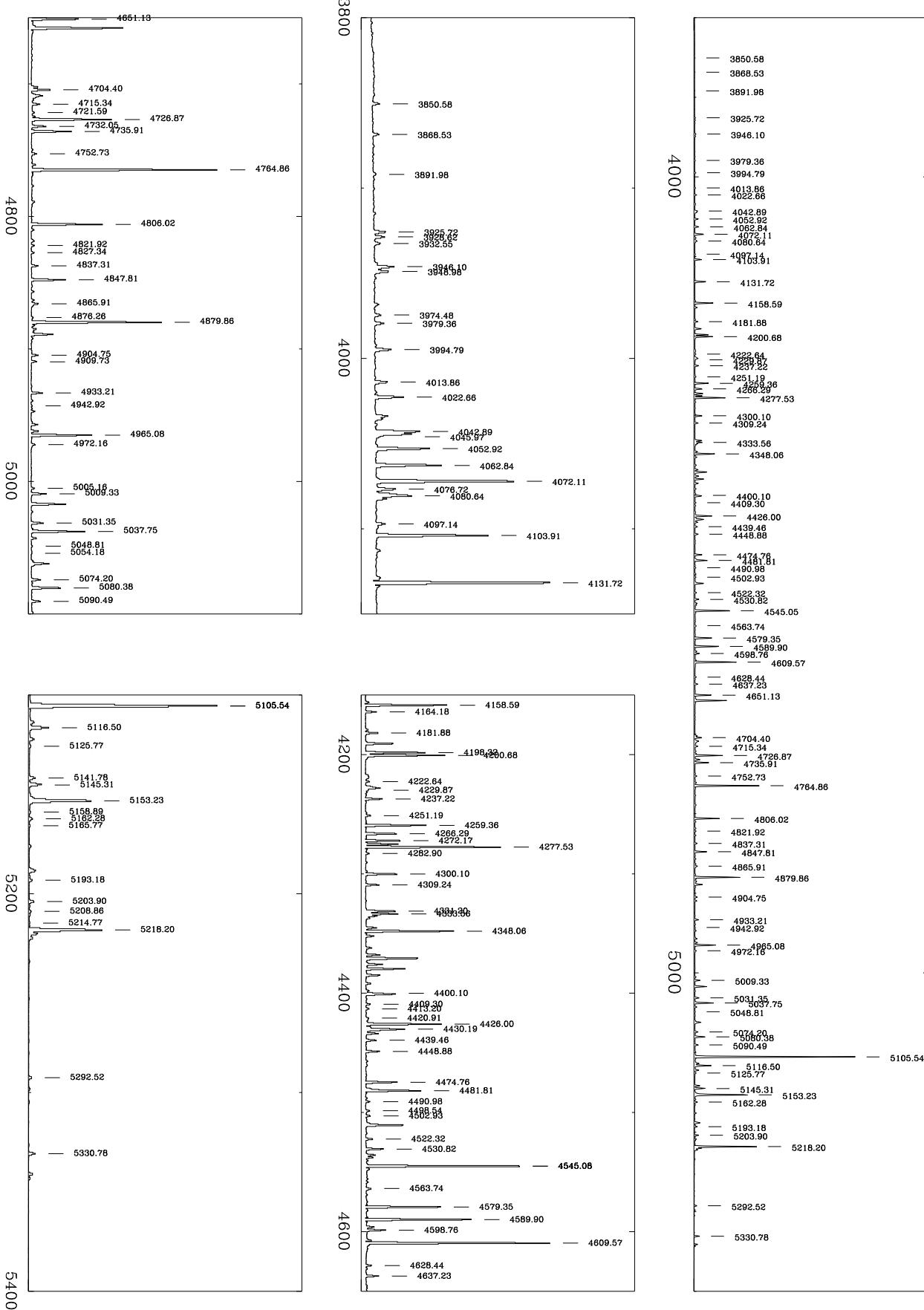
CuAr



R1200U

$\lambda_C = 4500$

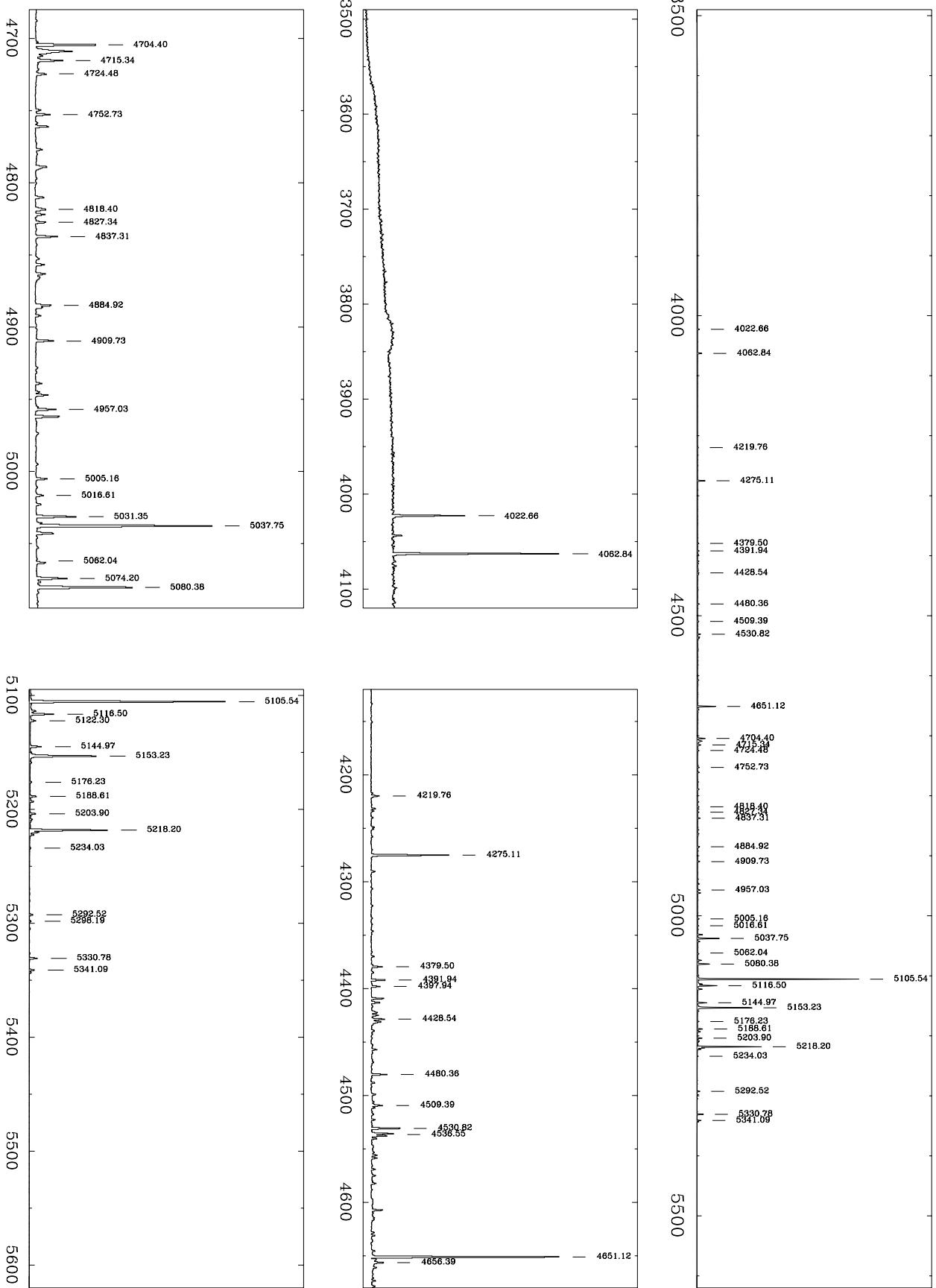
CuAr+CuNe



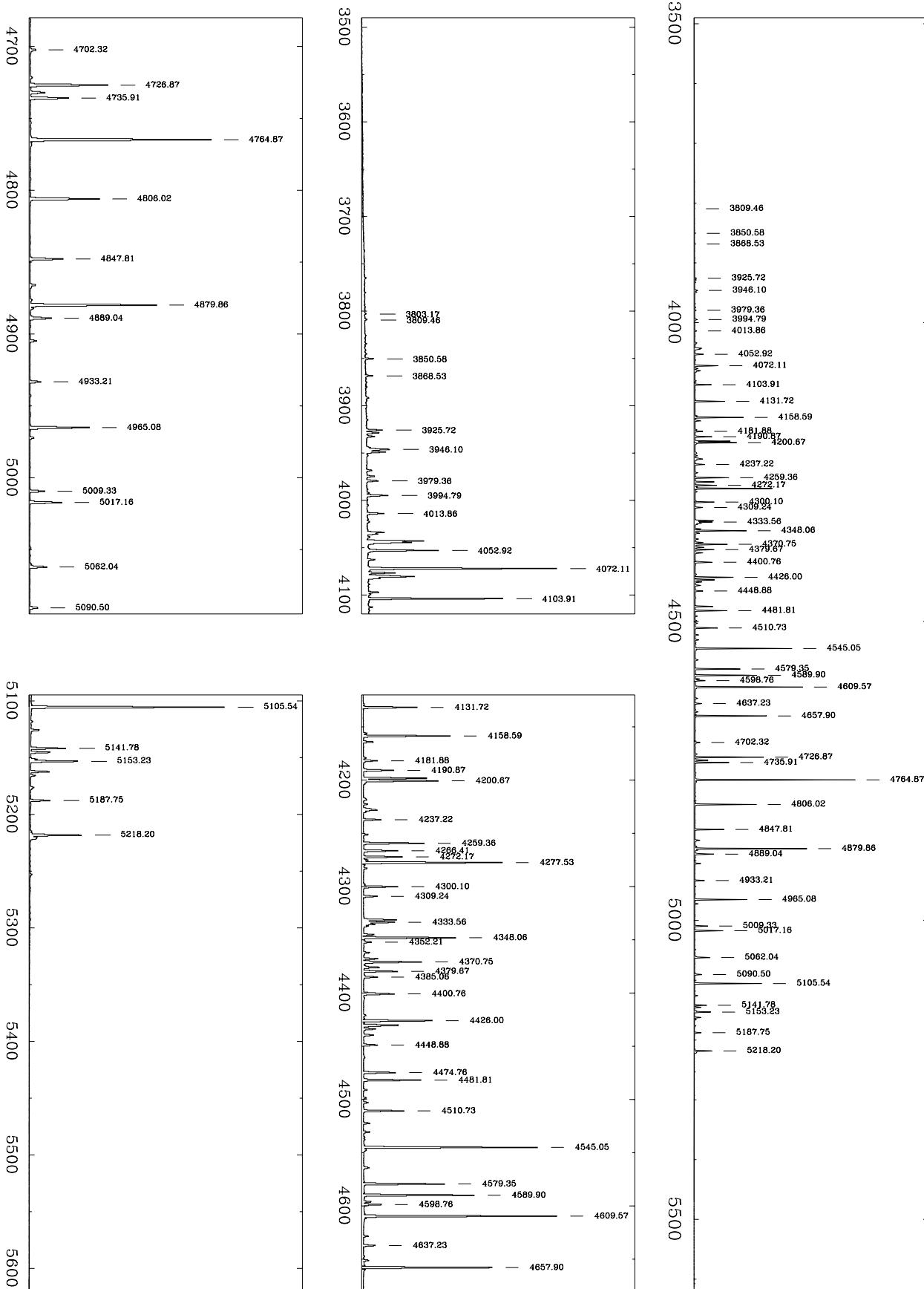
R1200U

$\lambda_C = 4500$

CuNe



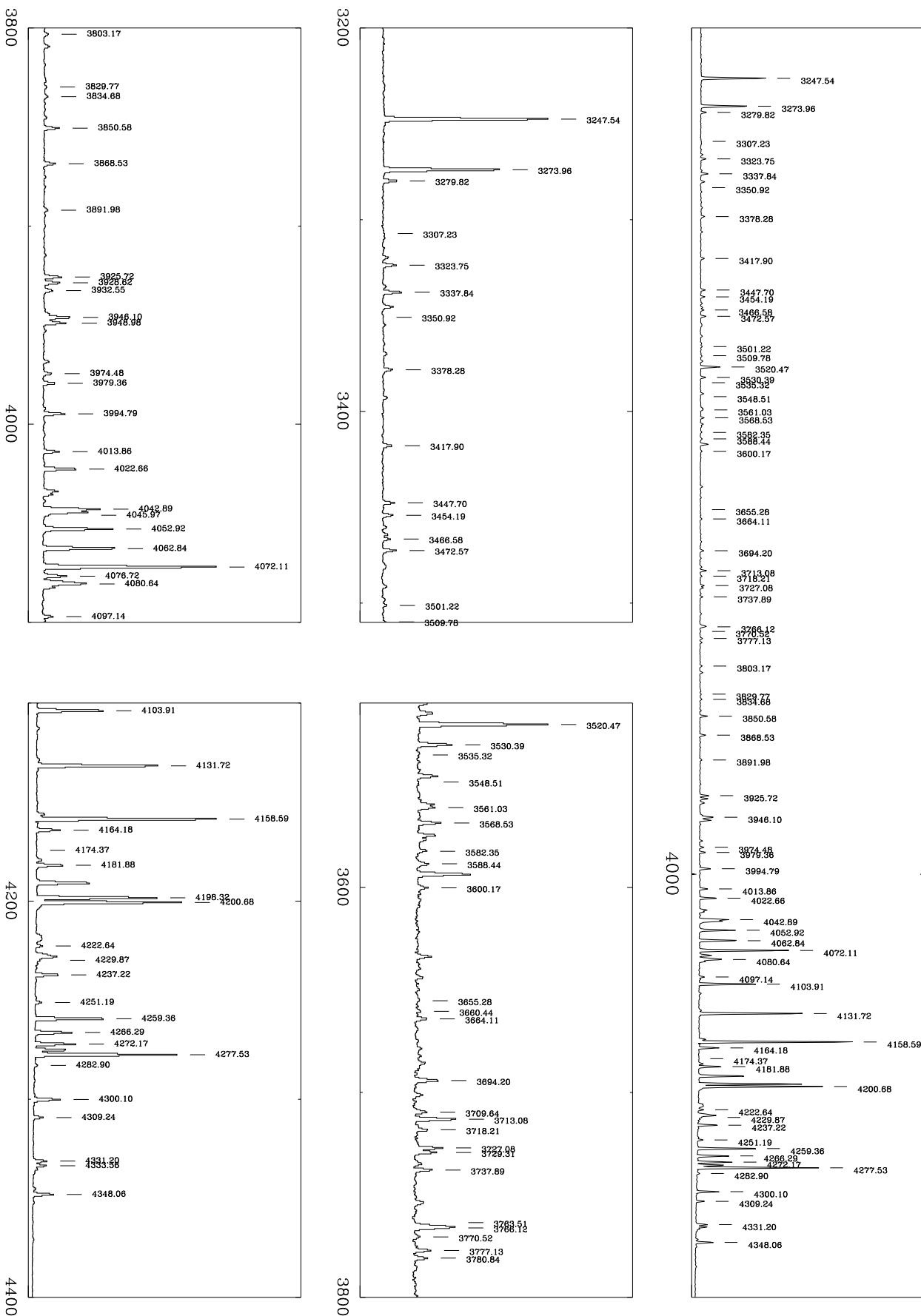
R1200U $\lambda_C = 4500$ CuAr



R1200B

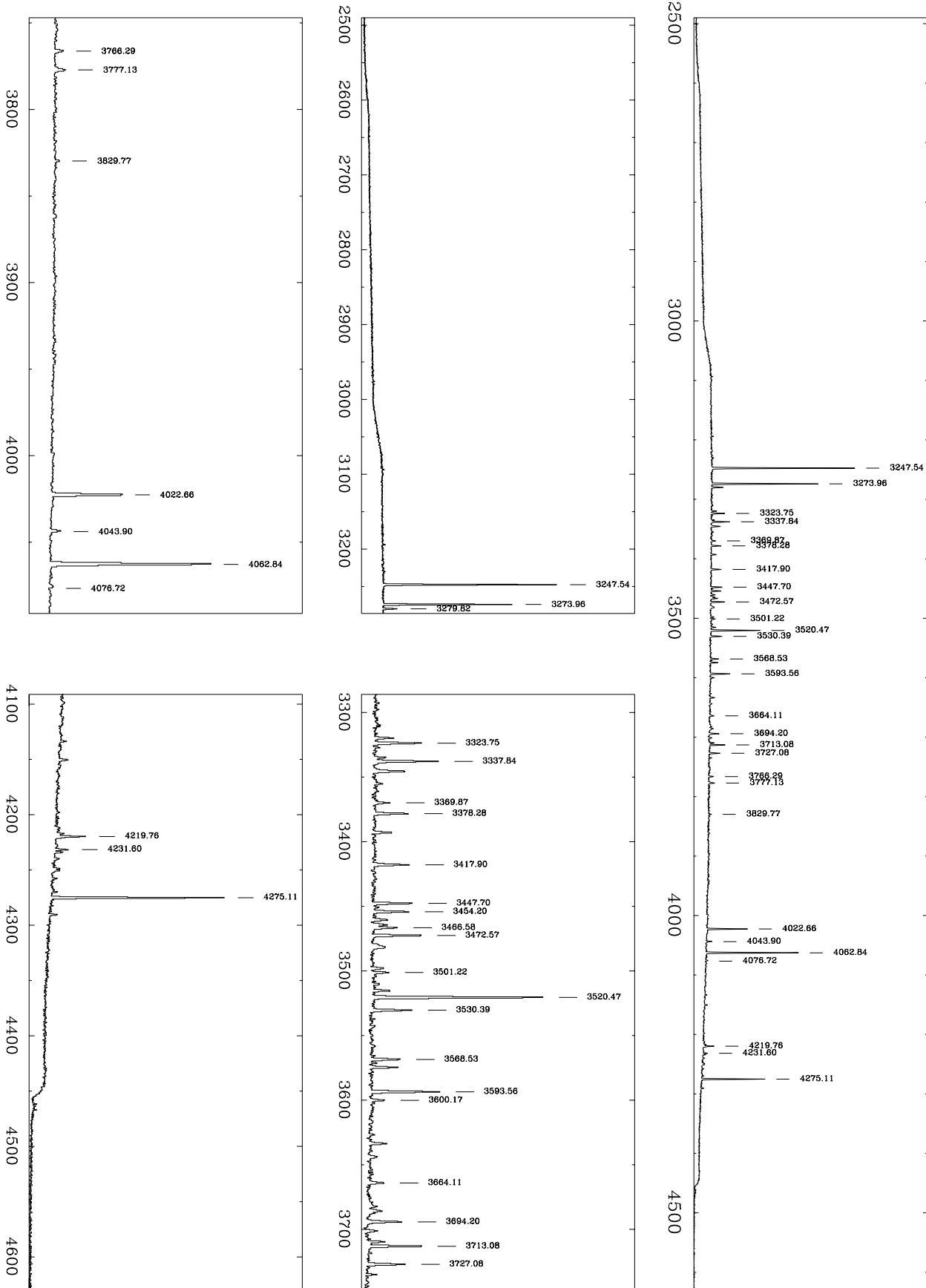
$\lambda_C = 3500$

CuAr + CuNe



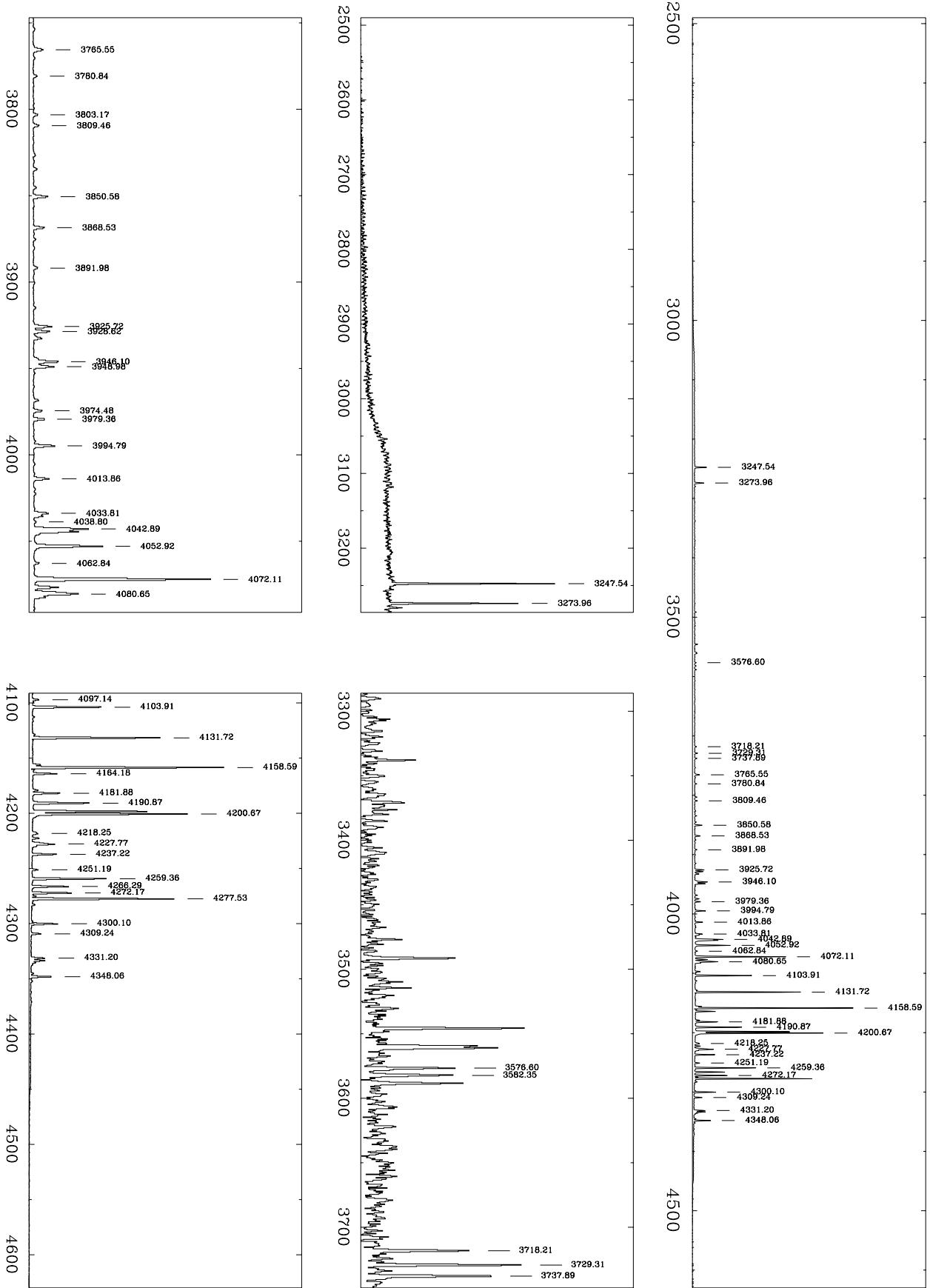
R1200B $\lambda_C = 3500$

CuNe



R1200B $\lambda_C = 3500$

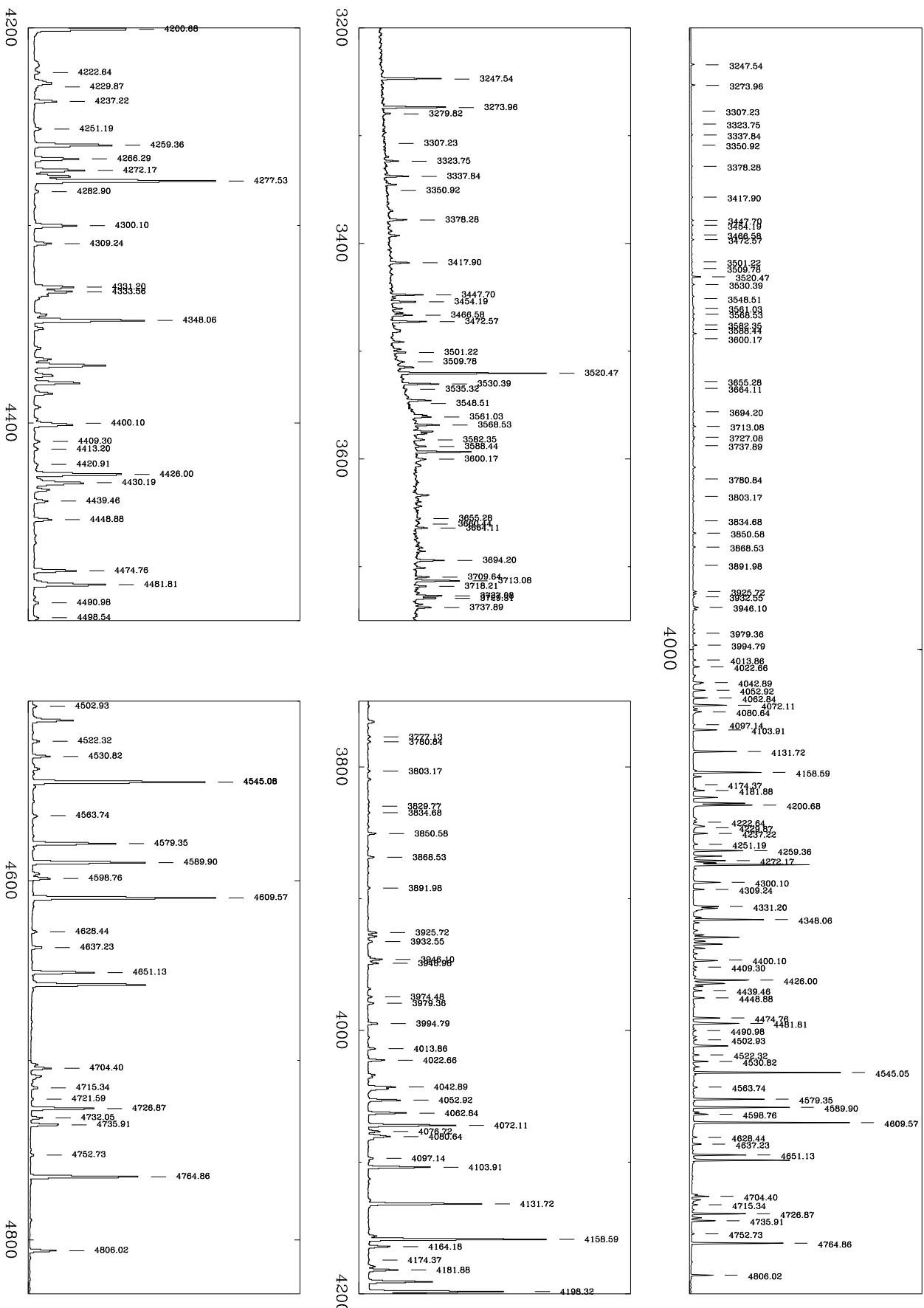
CuAr



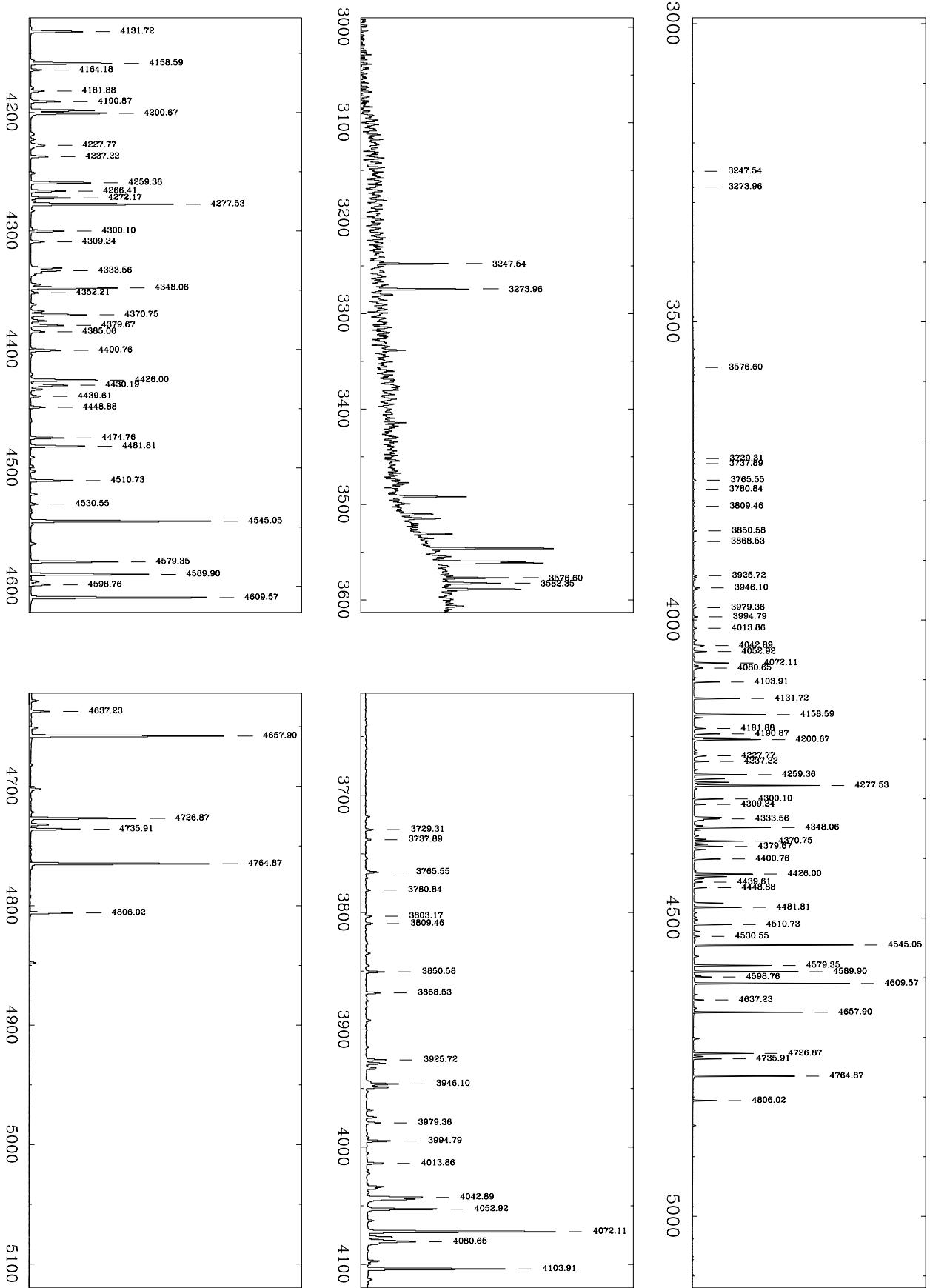
R1200B

$\lambda_C = 4000$

CuAr + CuN_E



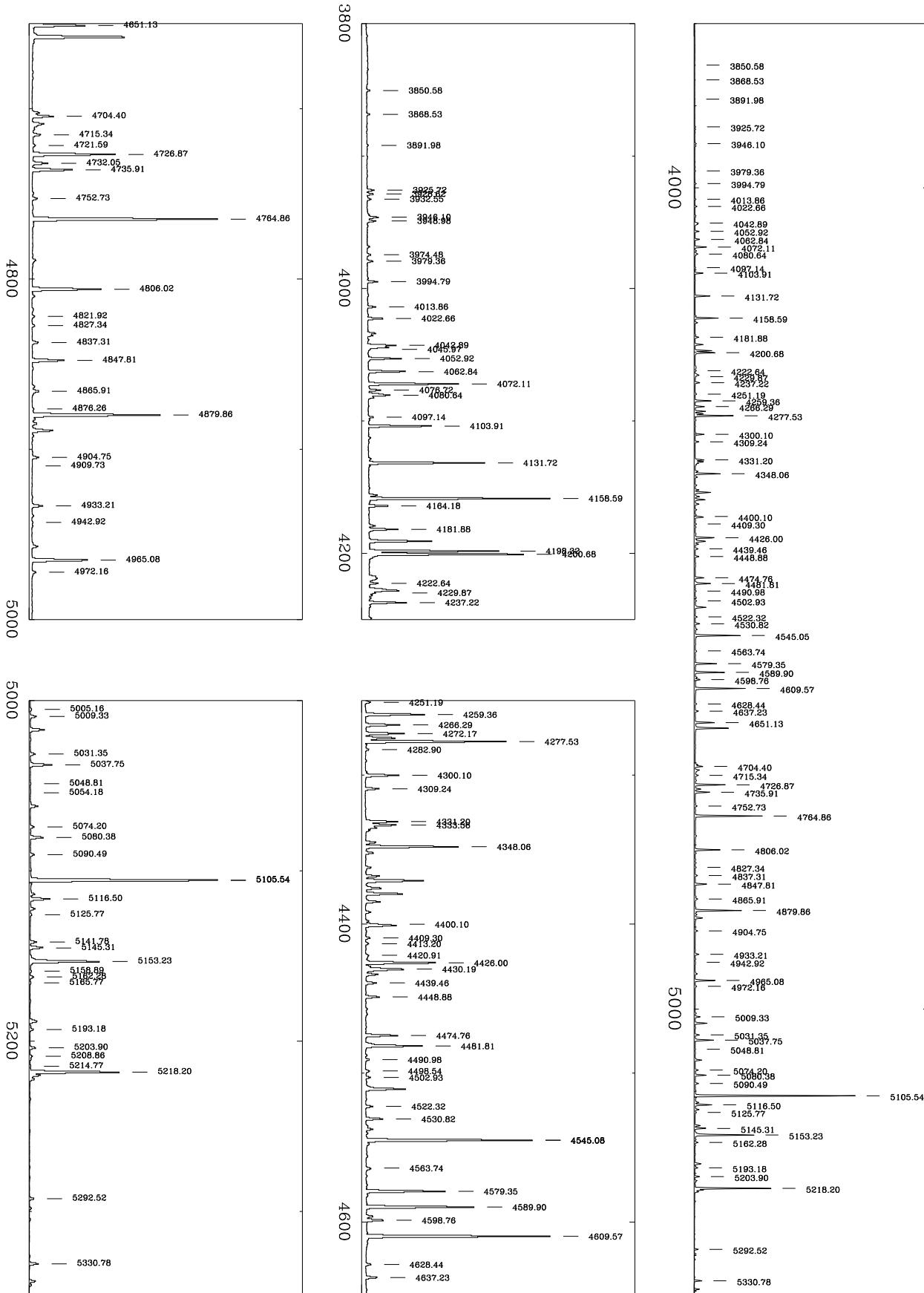
R1200B $\lambda_C = 4000$ CuAr



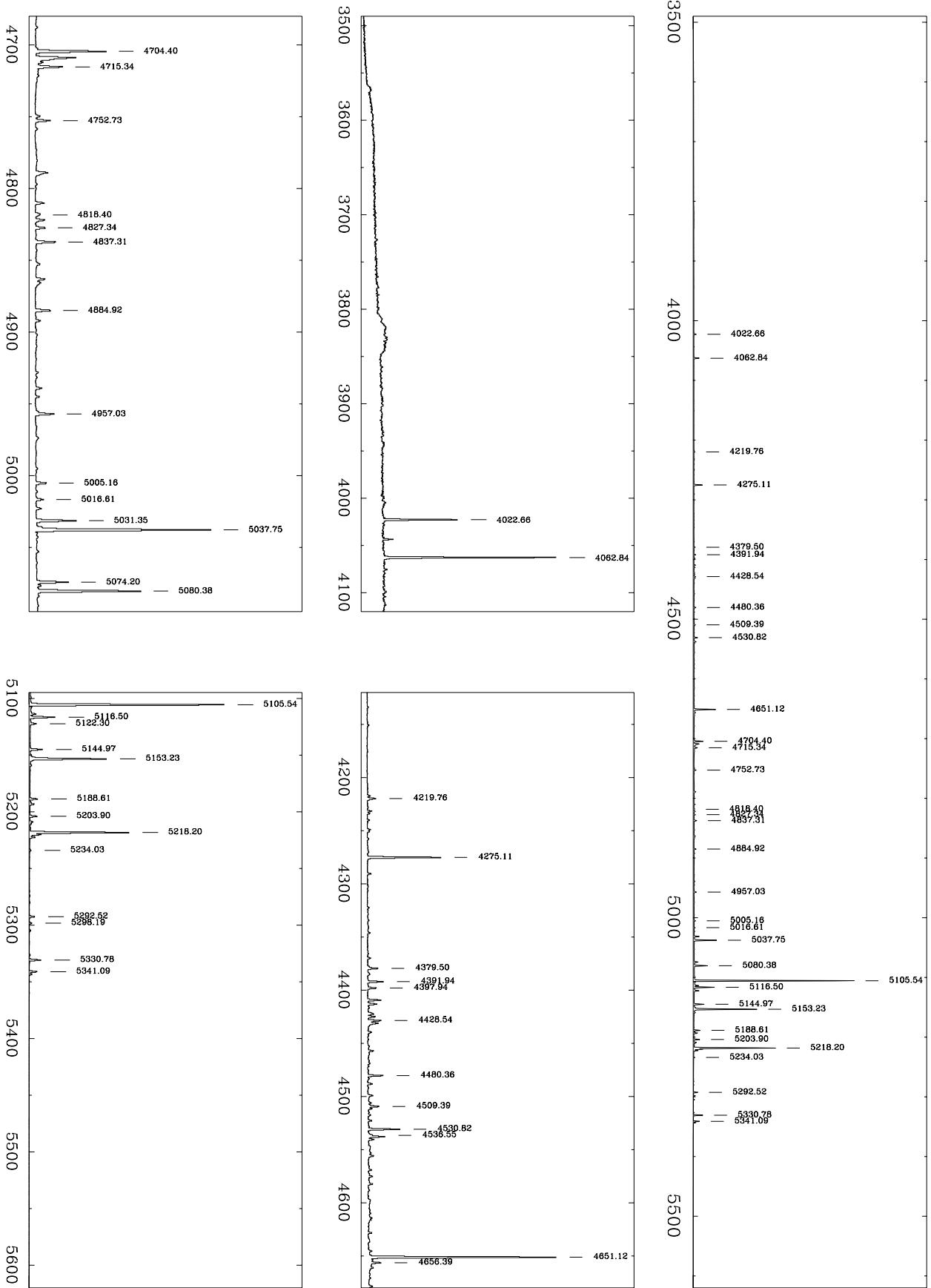
R1200B

$\lambda_C = 4500$

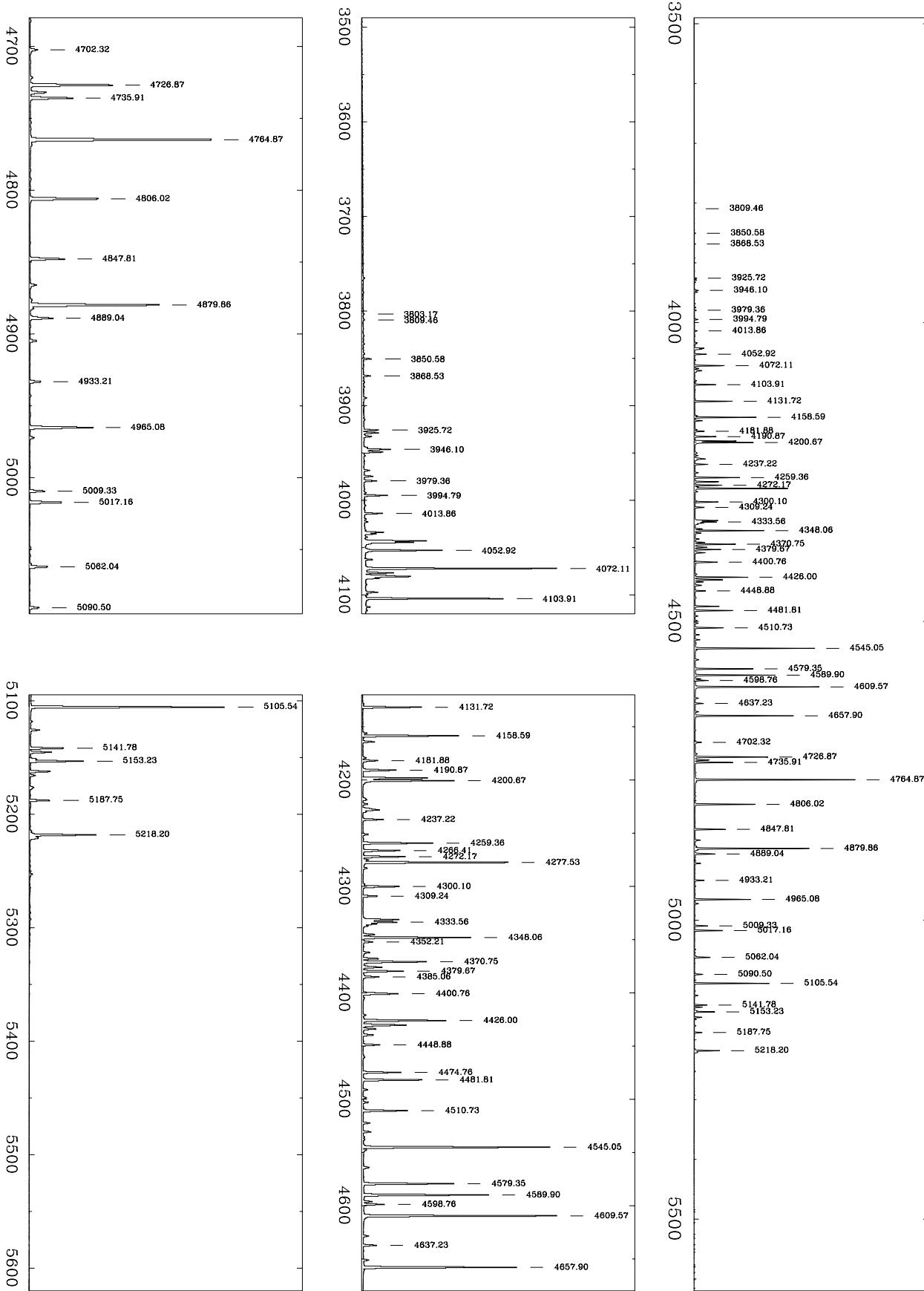
CuAr + CuNe



R1200B $\lambda_C = 4500$ CuNe



R1200B $\lambda C = 4500$ CuAr



R1200V

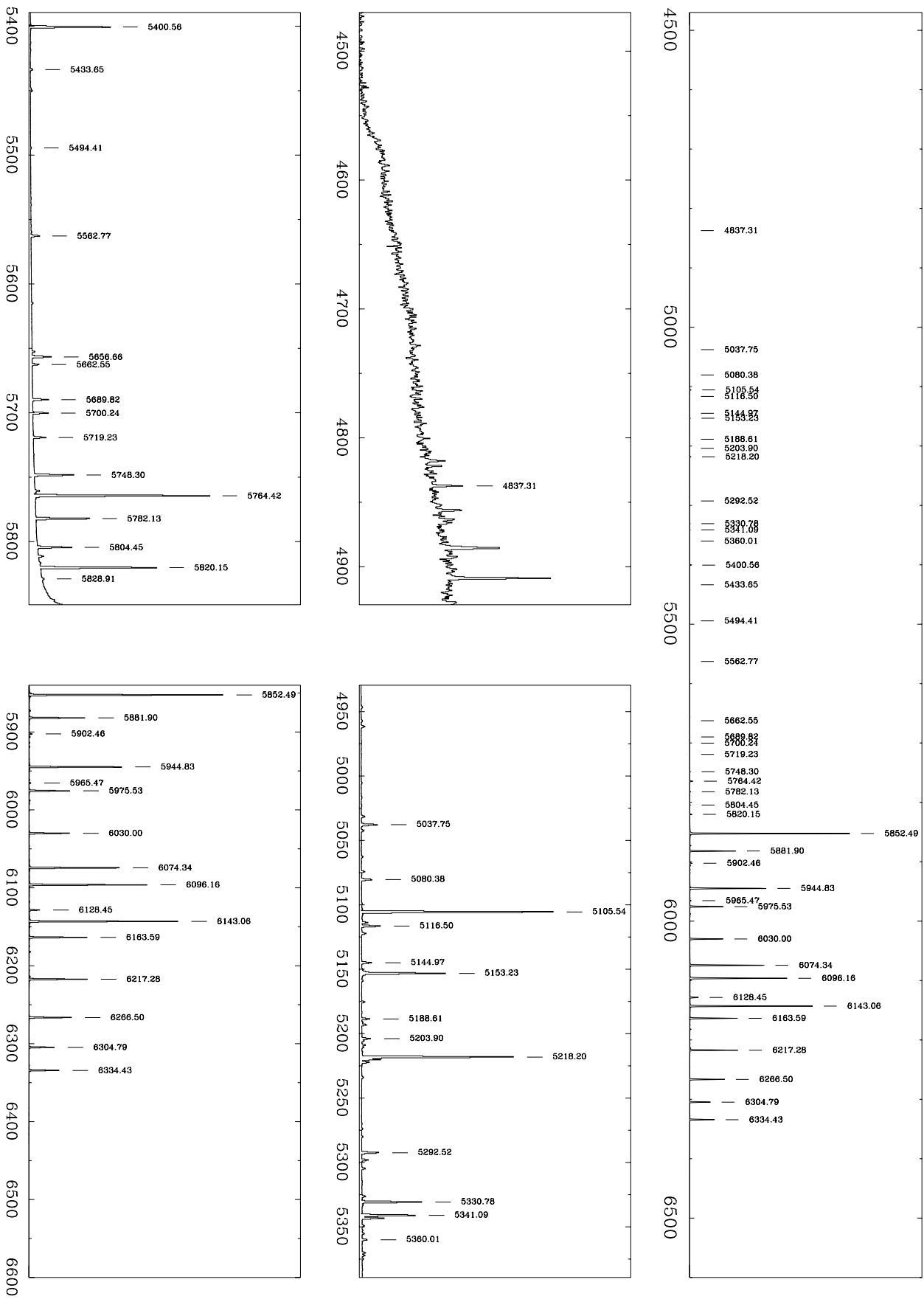
$\lambda_C = 5500$

CuAr + CuNe



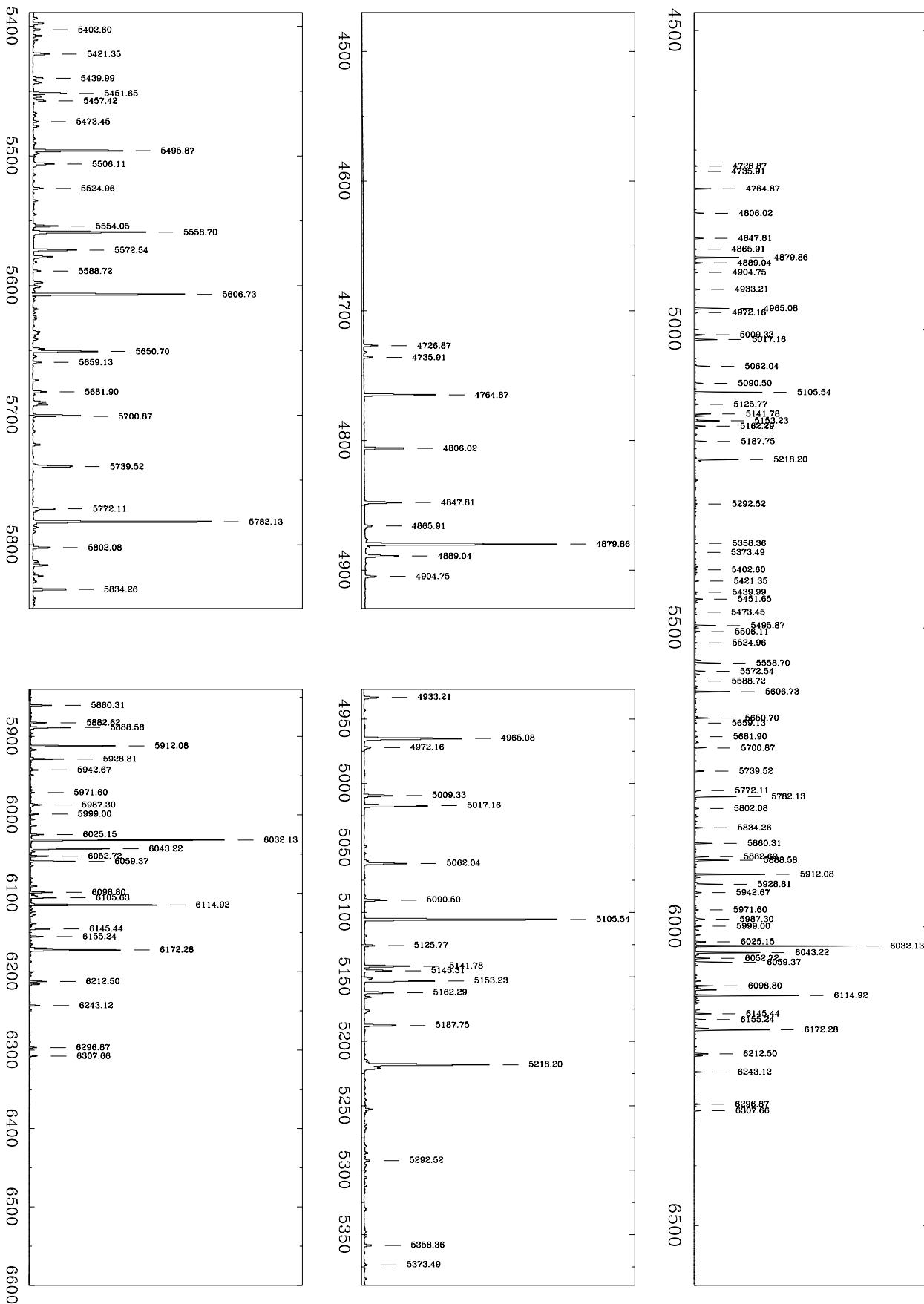
R1200V $\lambda_c = 5500$

CuNe



R1200V $\lambda_C = 5500$

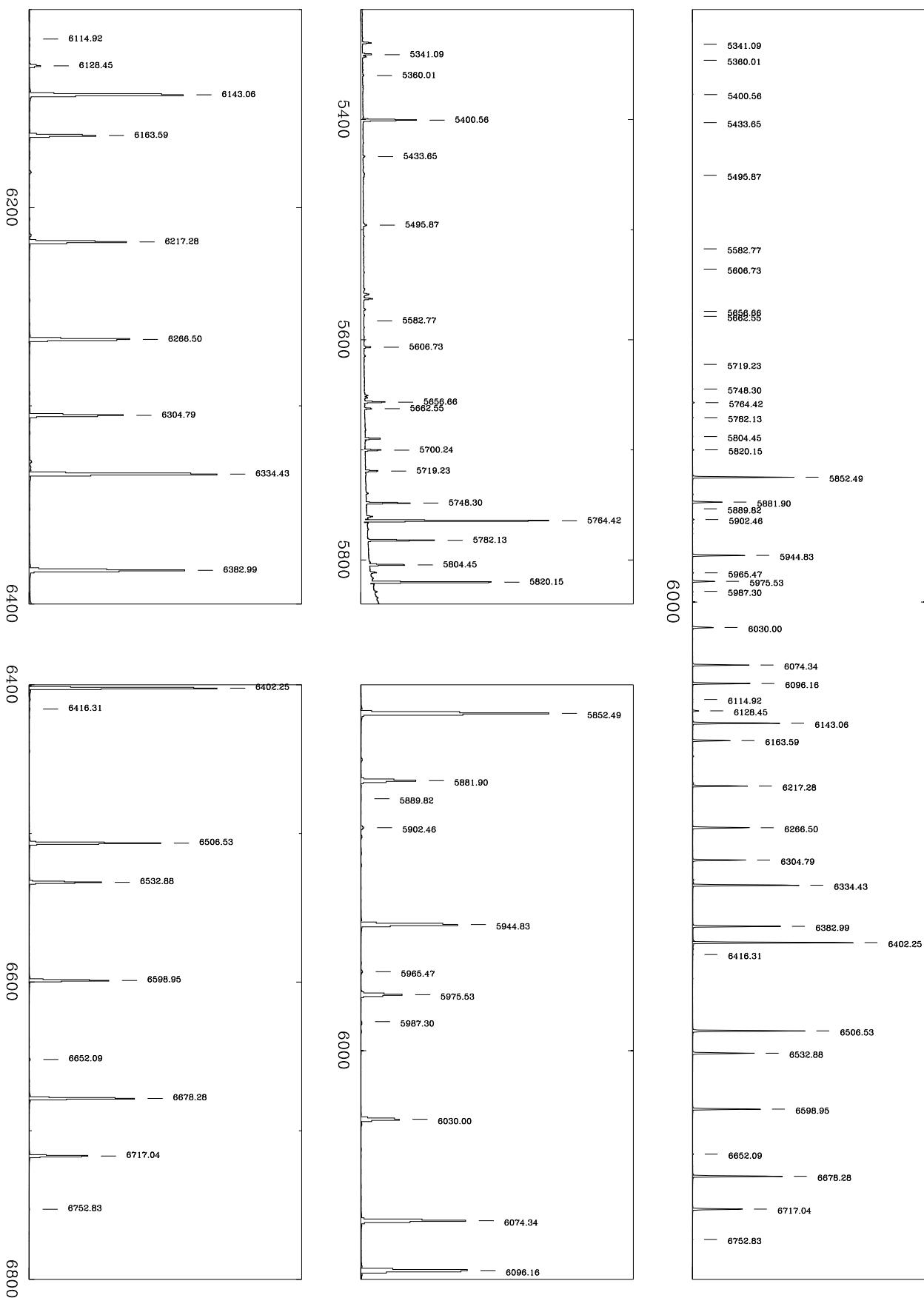
CuAr



R1200V

$\lambda_C = 6000$

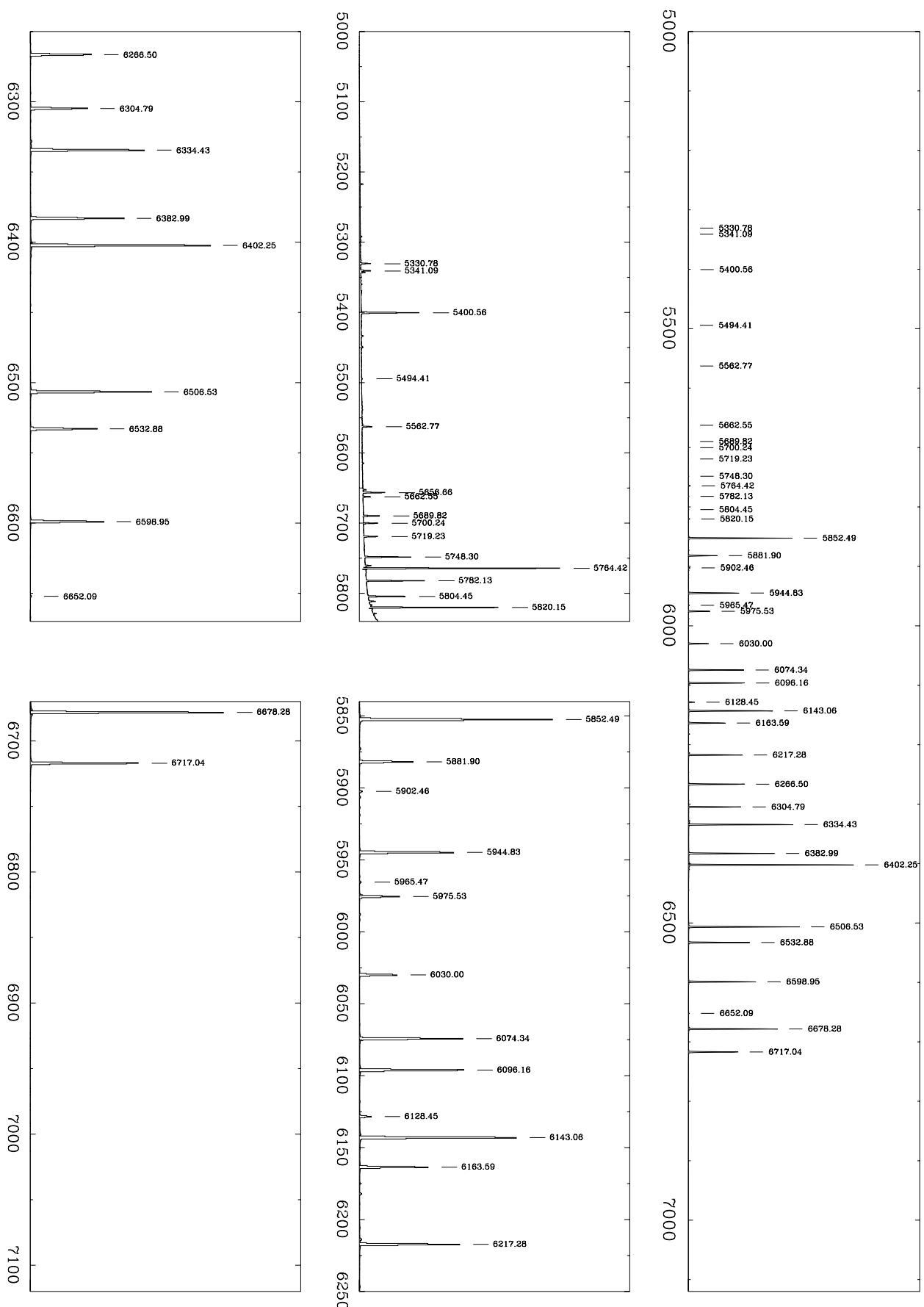
CuAr+CuNe



R1200V

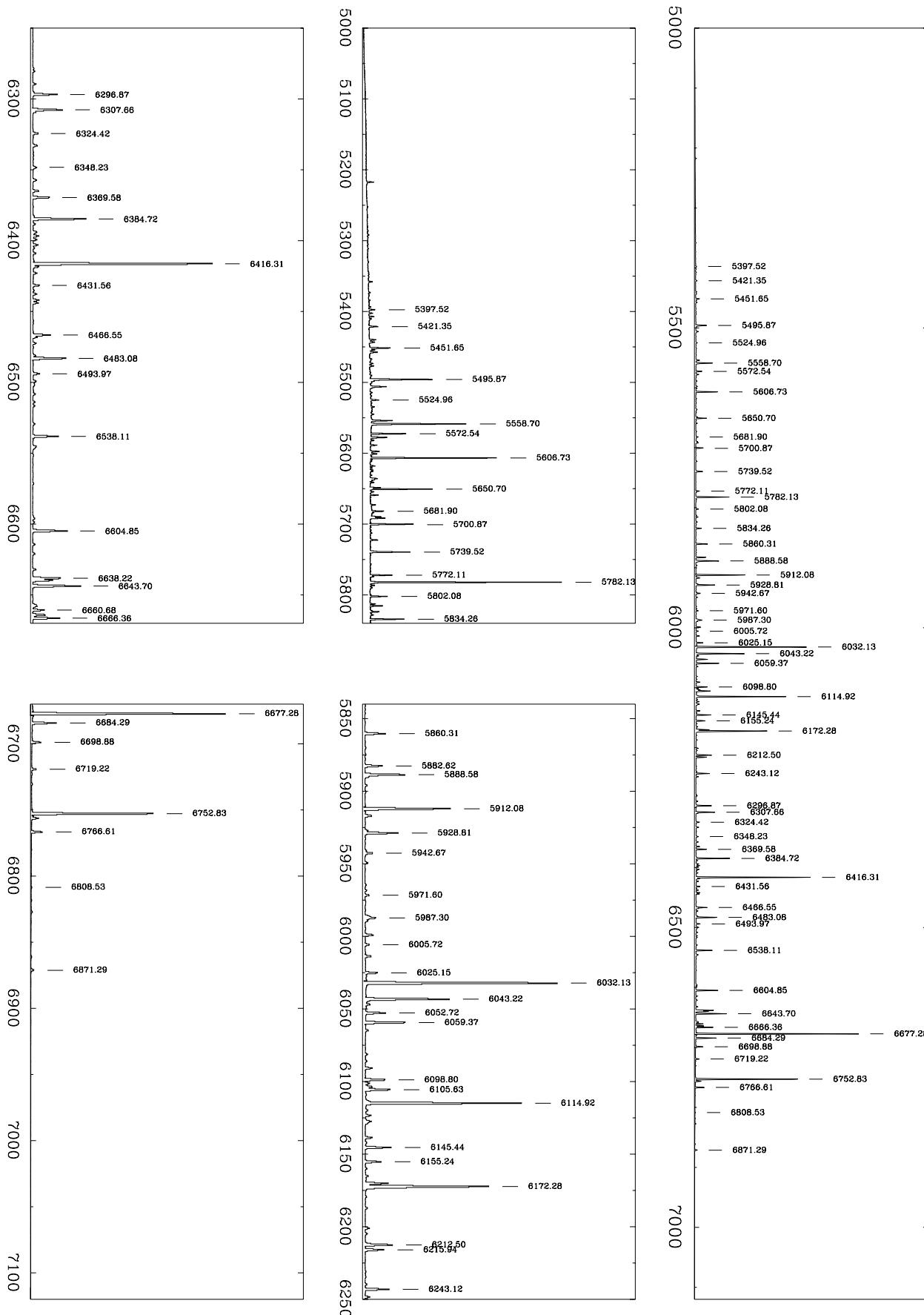
$\lambda C = 6000$

CuNe



R1200V $\lambda_C = 6000$

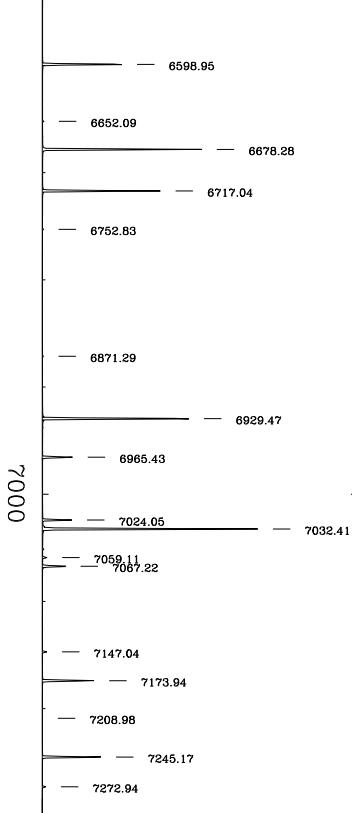
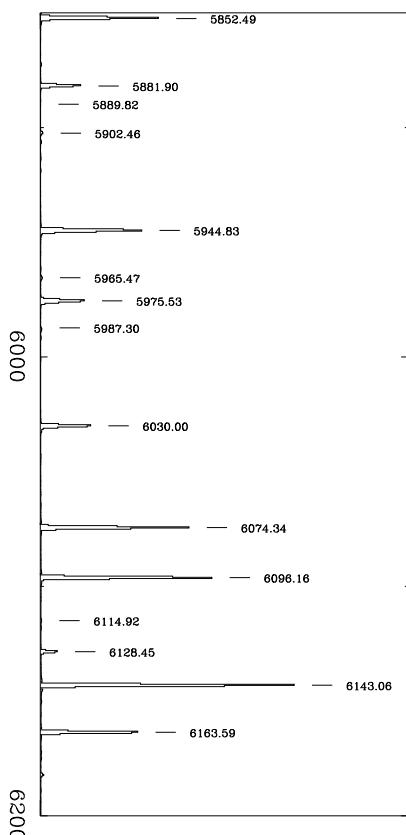
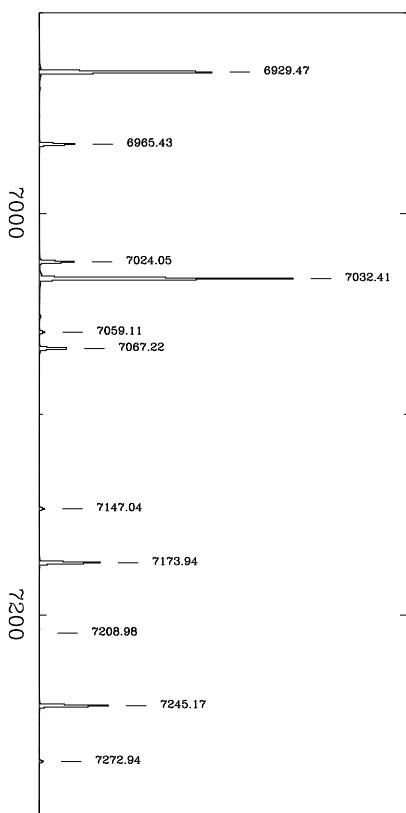
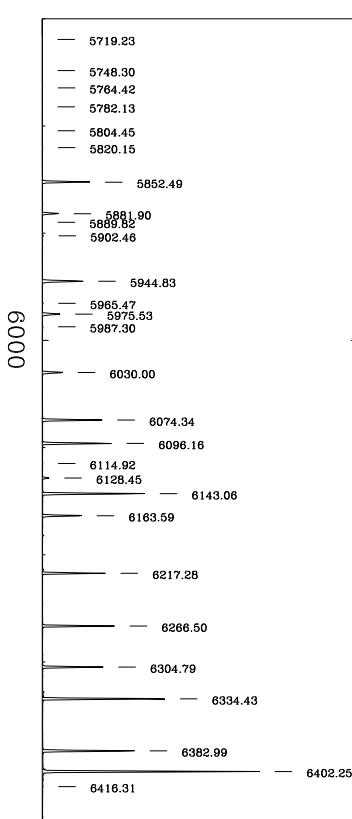
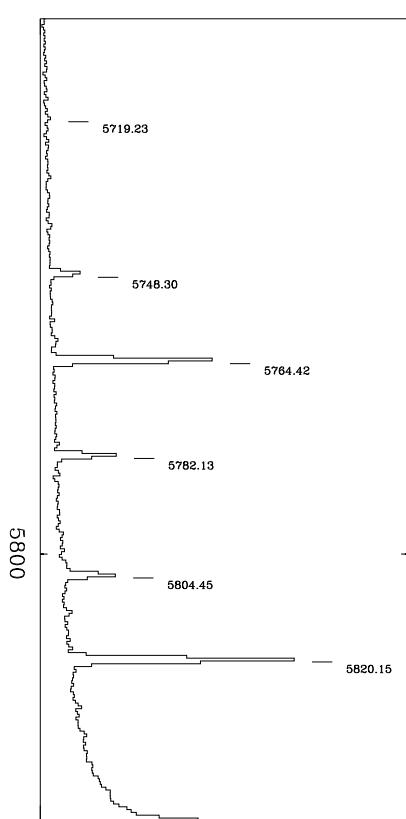
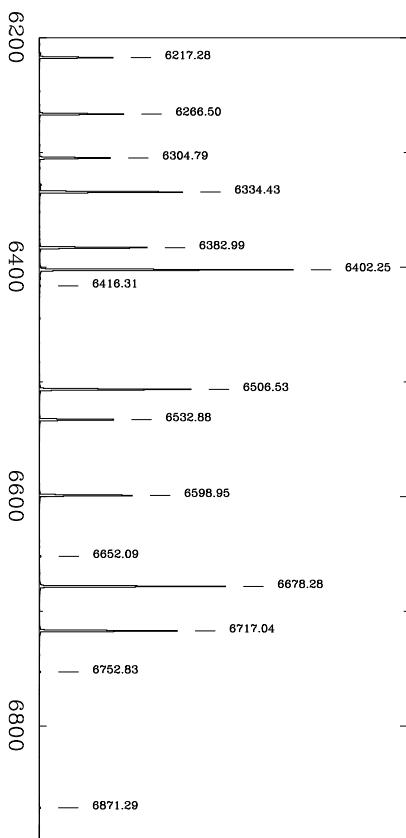
CuAr



R1200V

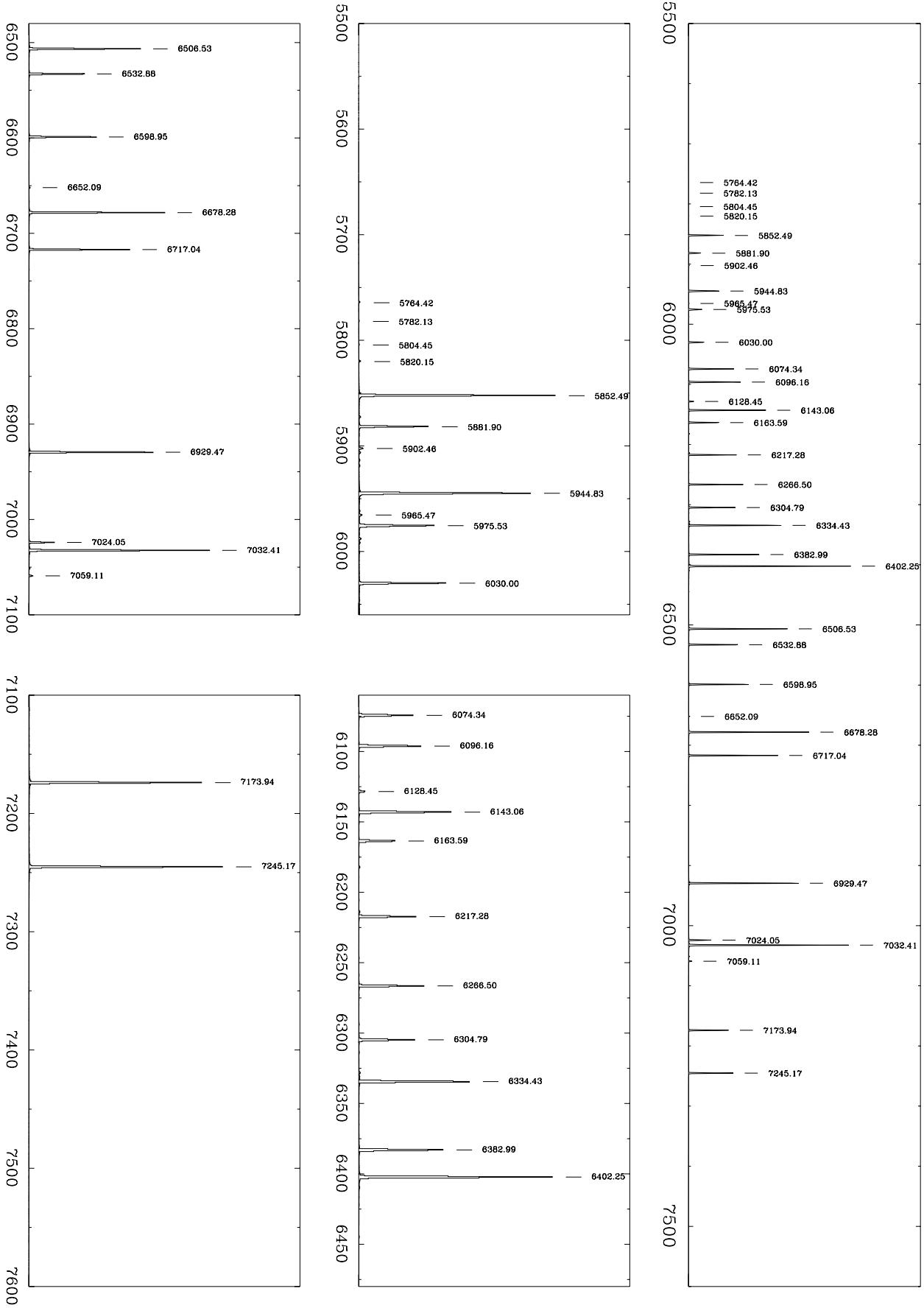
$\lambda_C = 6500$

CuAr + CuNe



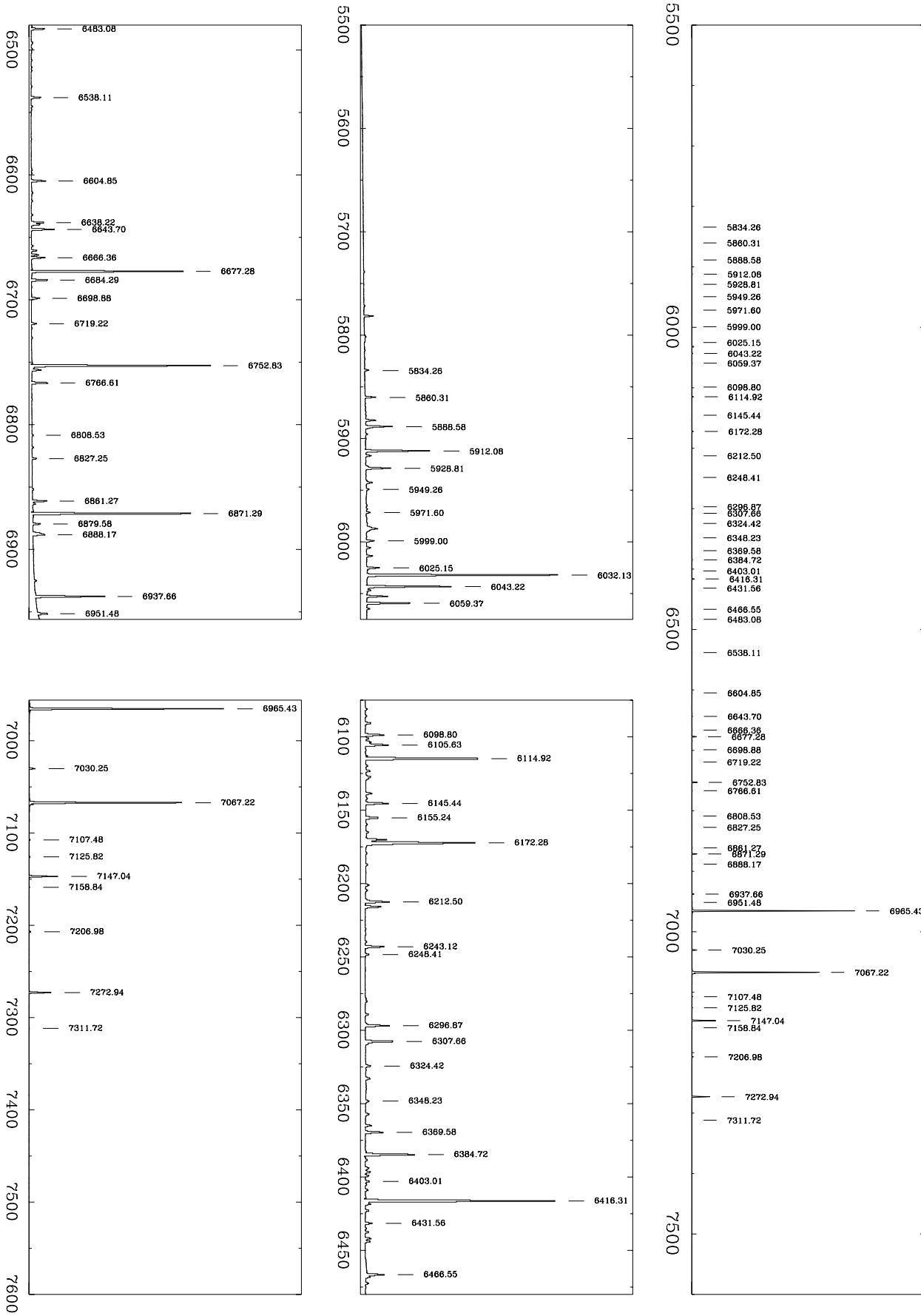
R_{1200V} λ_C = 6500

CuNe



R1200V $\lambda_C = 6500$

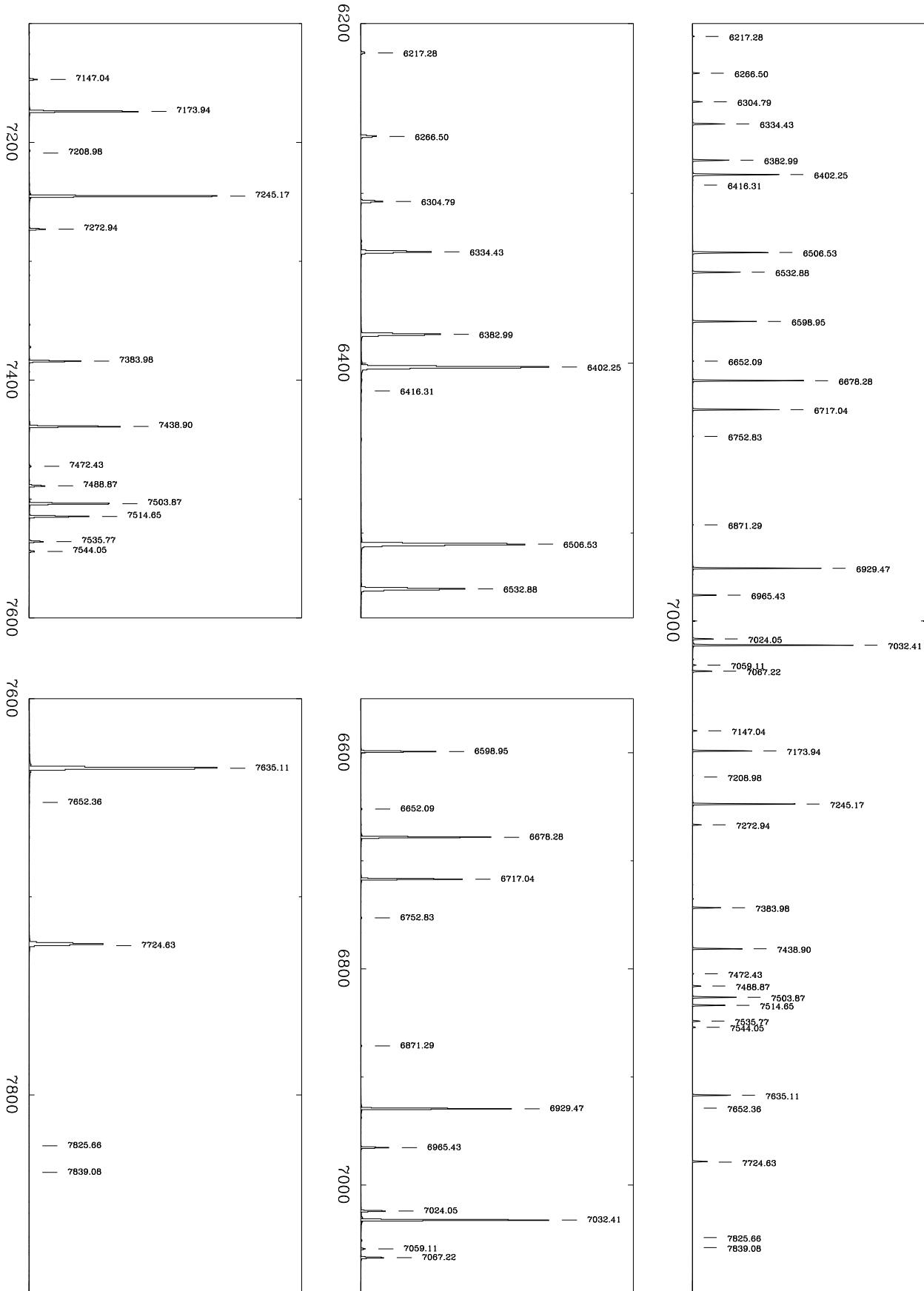
CuAr



R1200V

$\lambda_C = 7000$

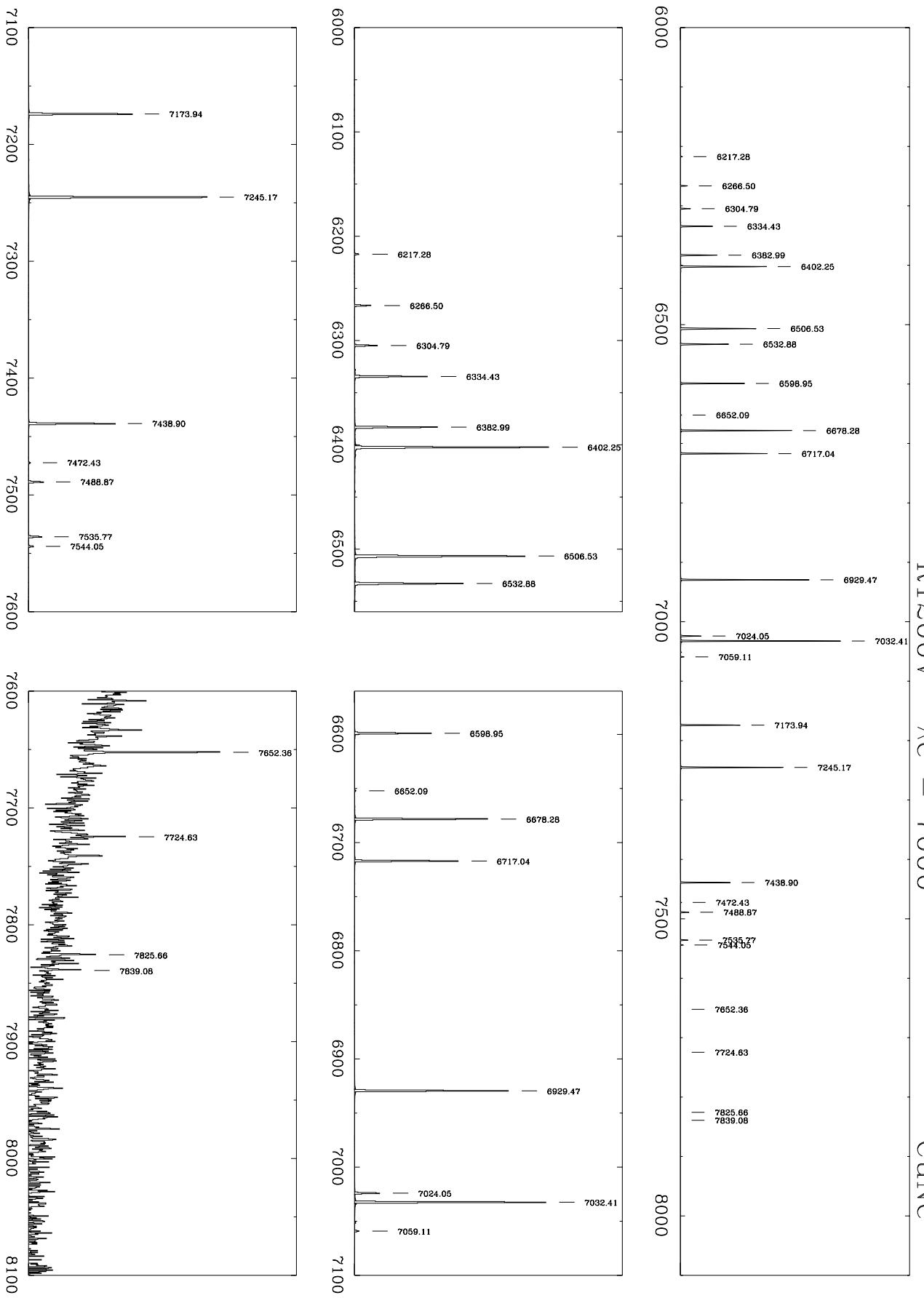
CuAr + CuNe



R1200V

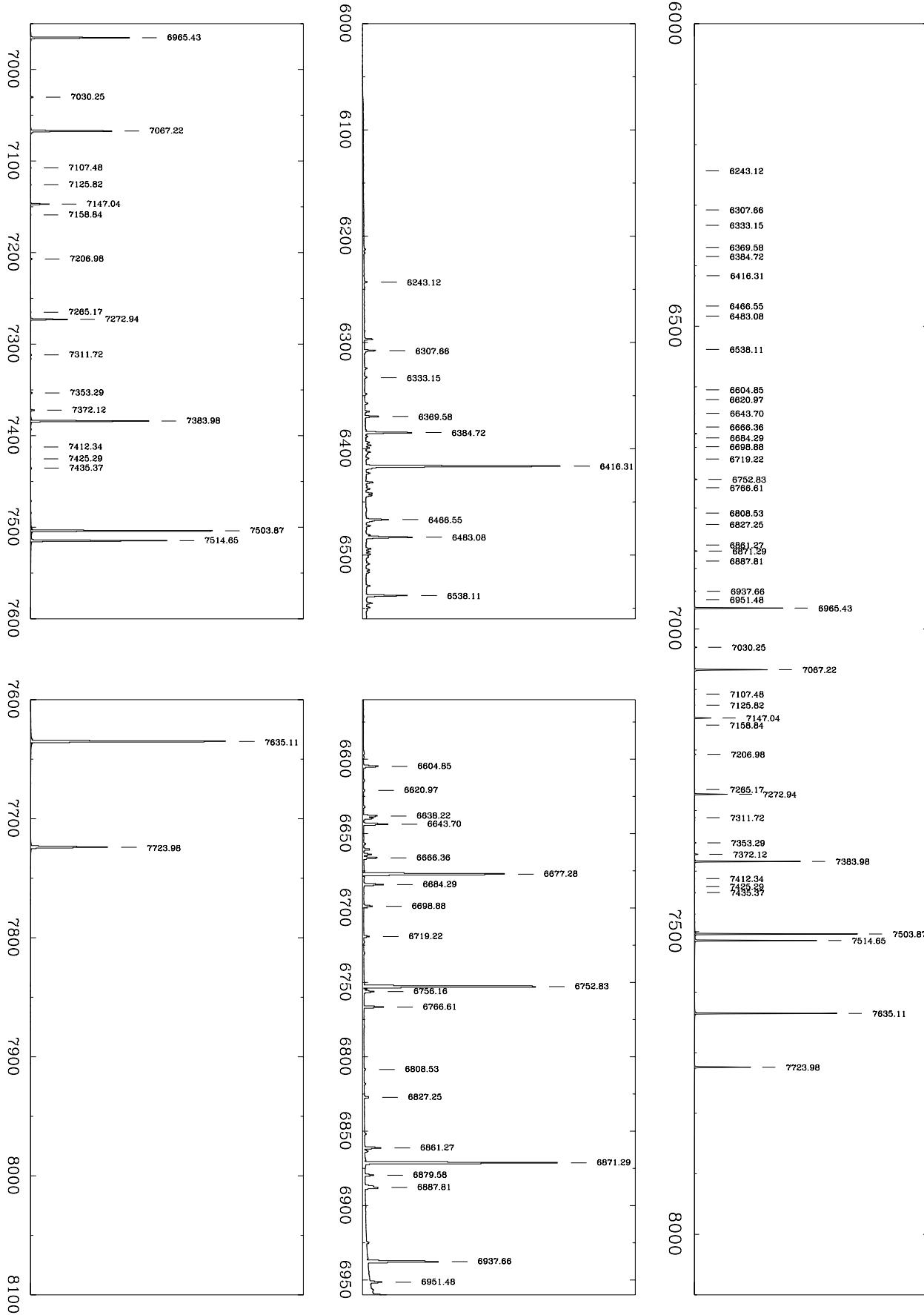
$\lambda_C = 7000$

CuNe



R1200V $\lambda_C = 7000$

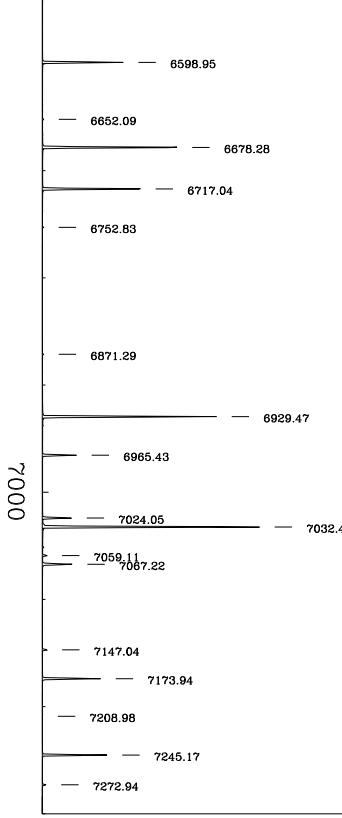
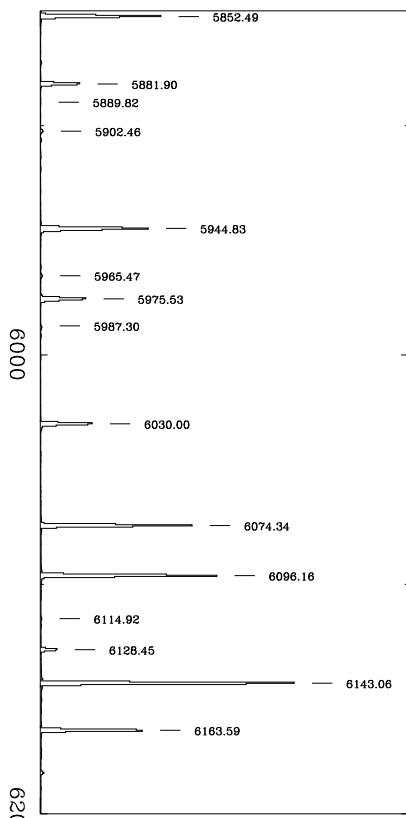
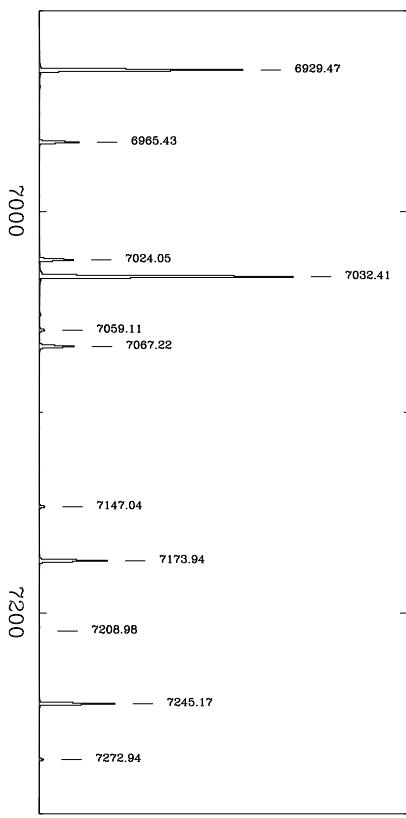
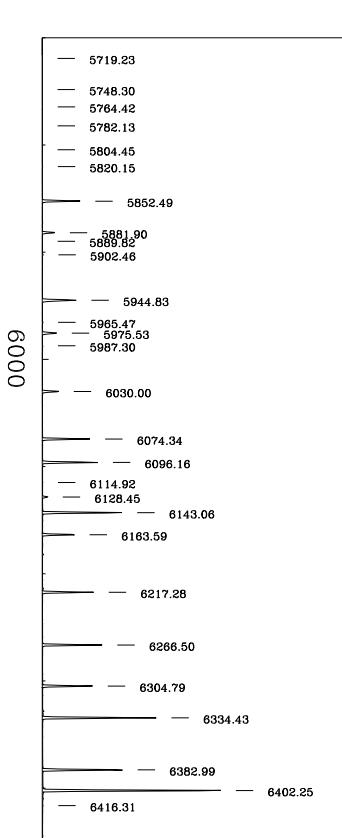
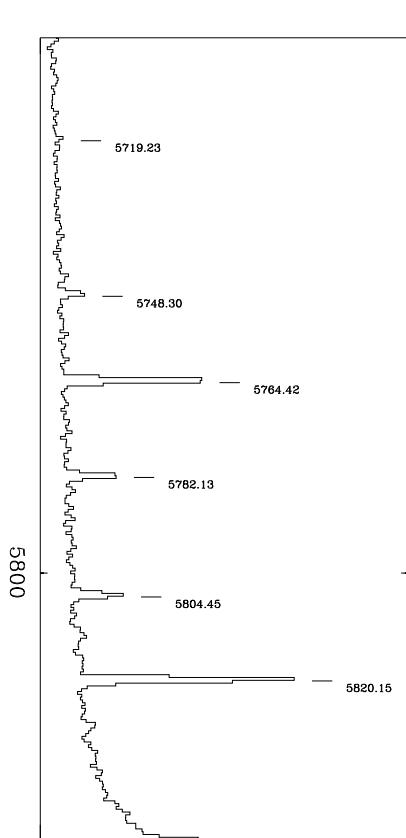
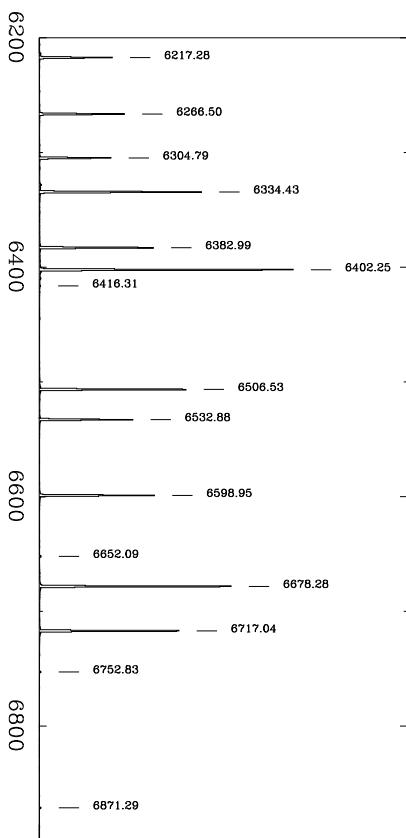
CuAr



R1200R

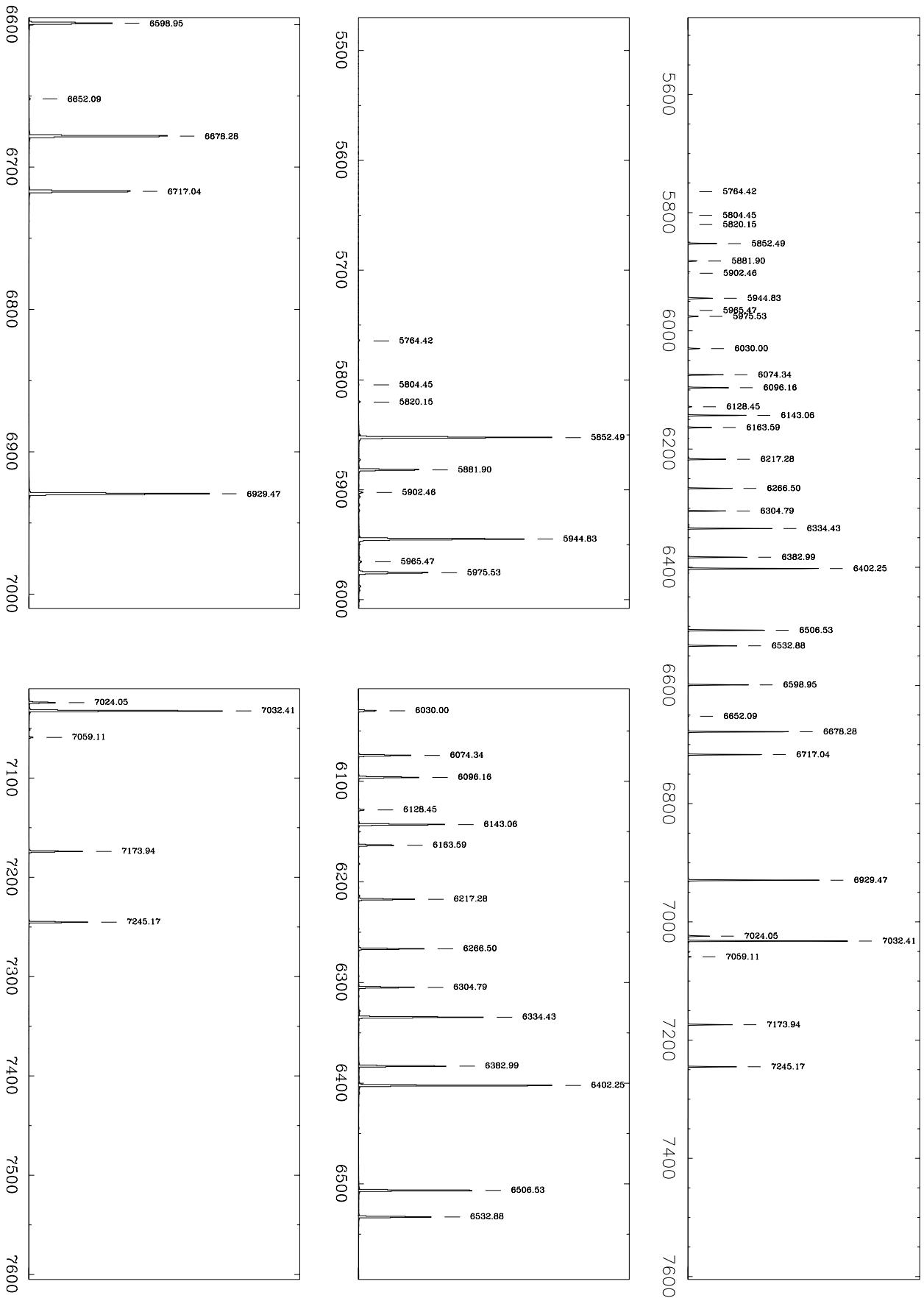
$\lambda_C = 6500$

CuAr+CuNe



R1200R $\lambda_C = 6500$

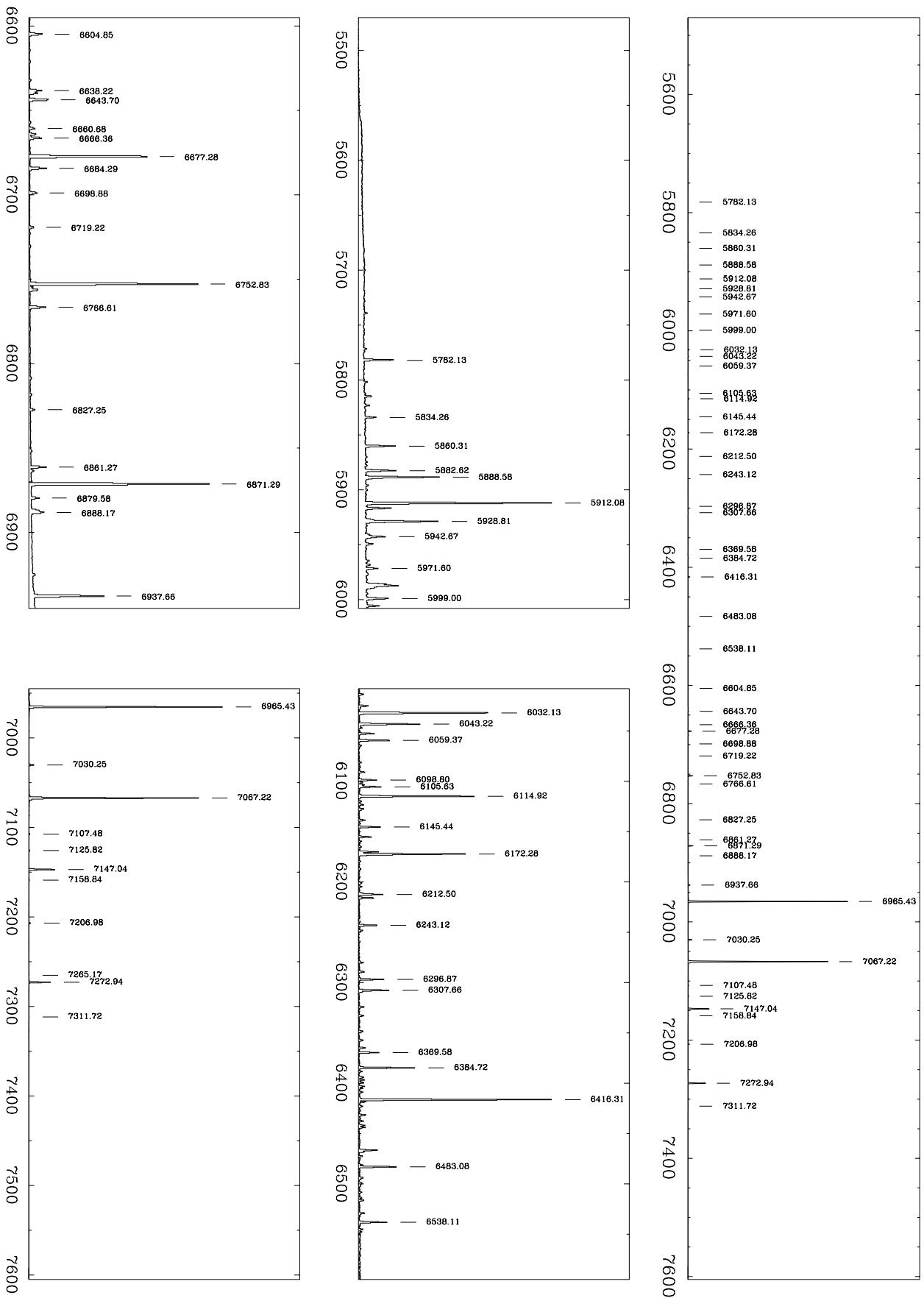
CuNe



R1200R

$\lambda_c = 6500$

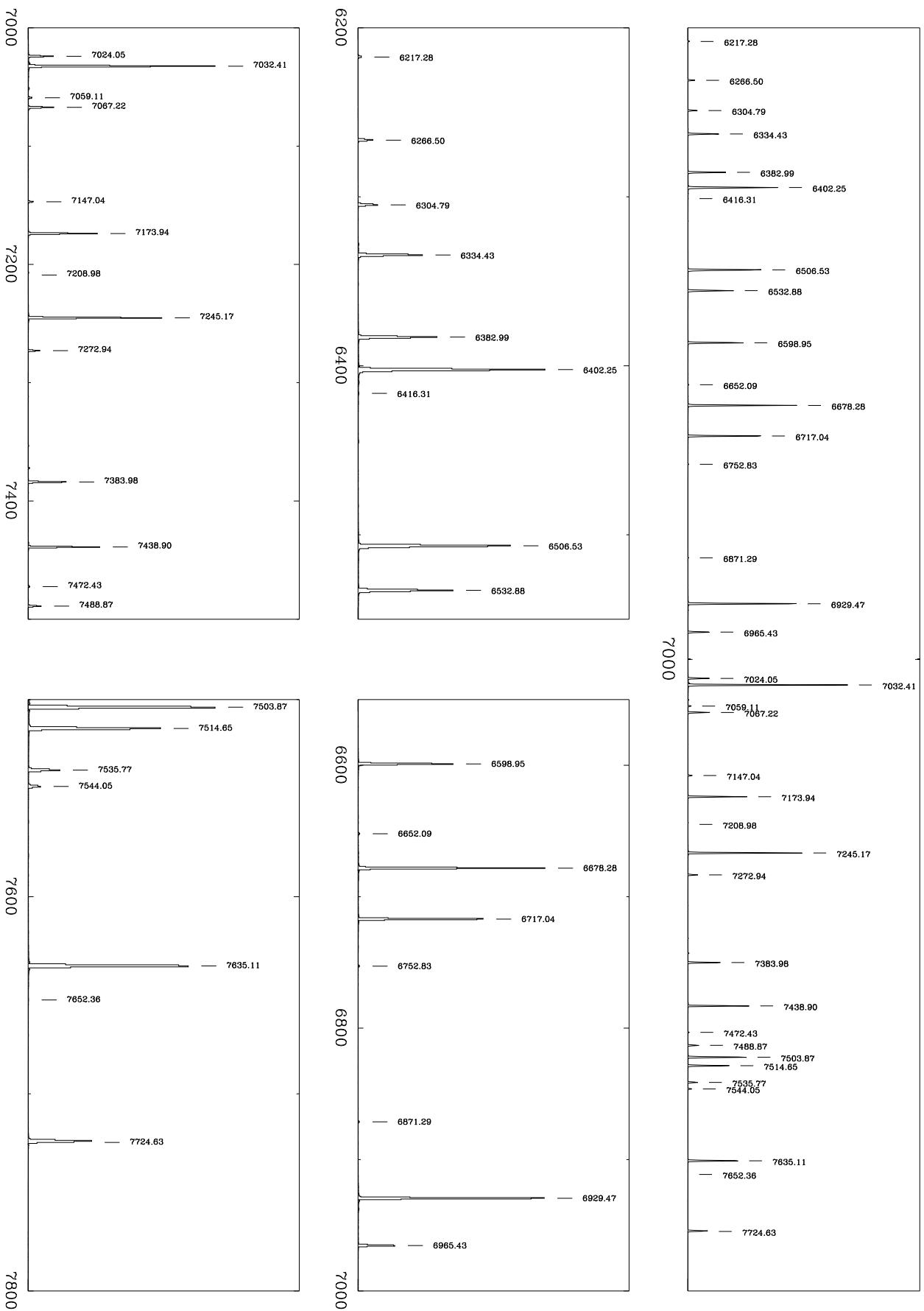
CuAr



R1200R

$\lambda_C = \gamma_{000}$

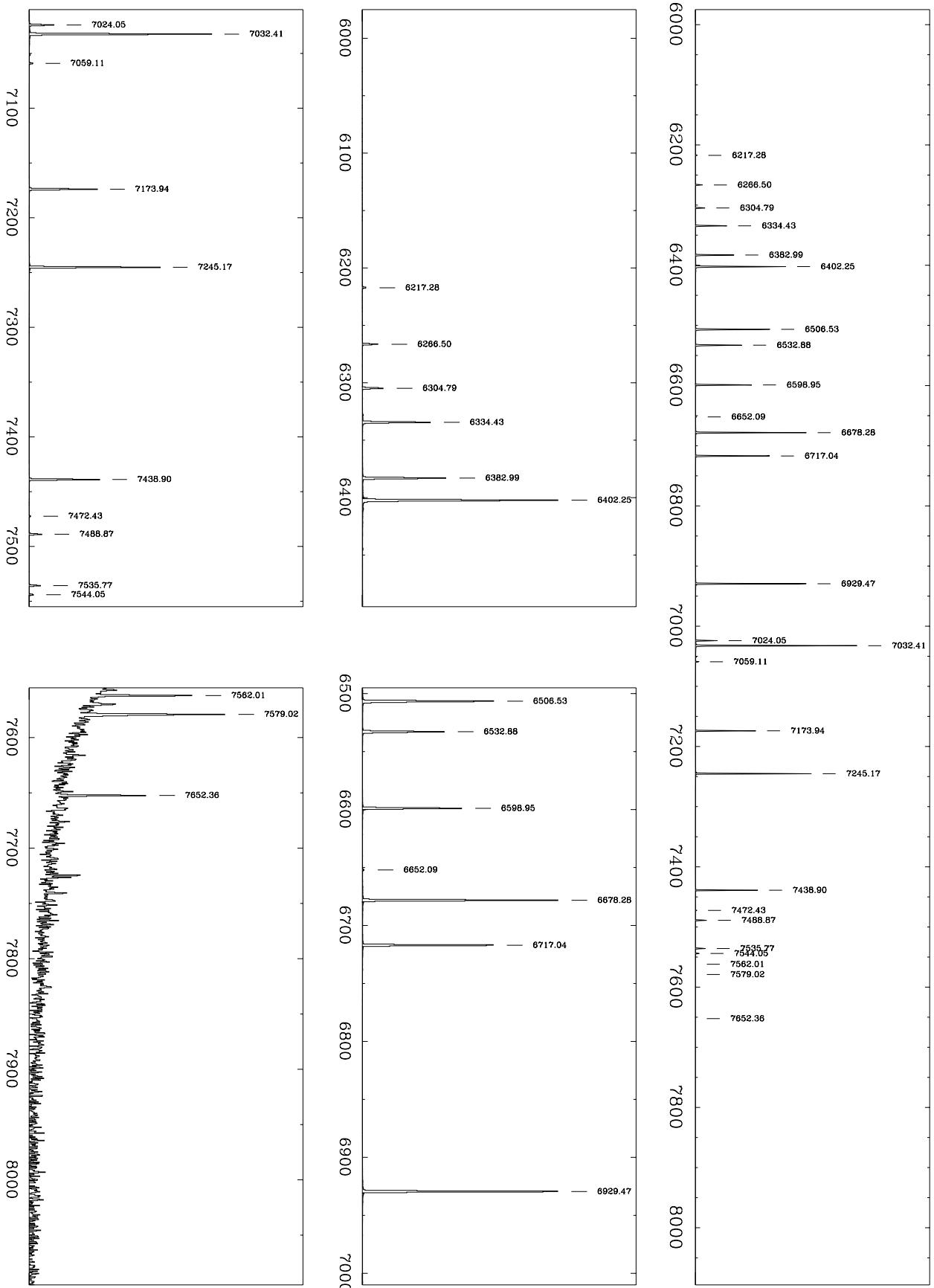
CuAr + CuNe



R1200R

$\lambda_c = 7000$

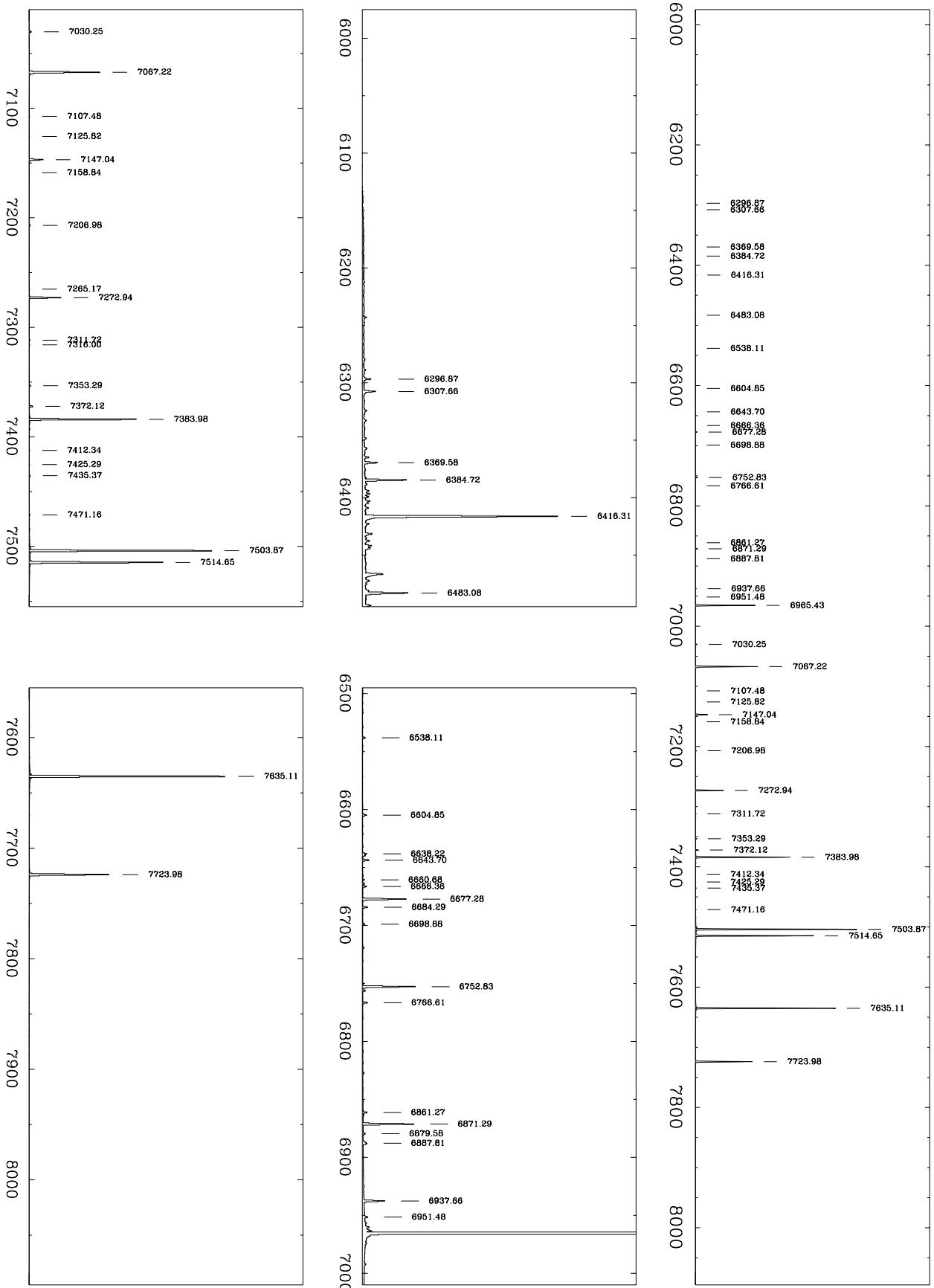
CuNe



R1200R

$\lambda_c = 7000$

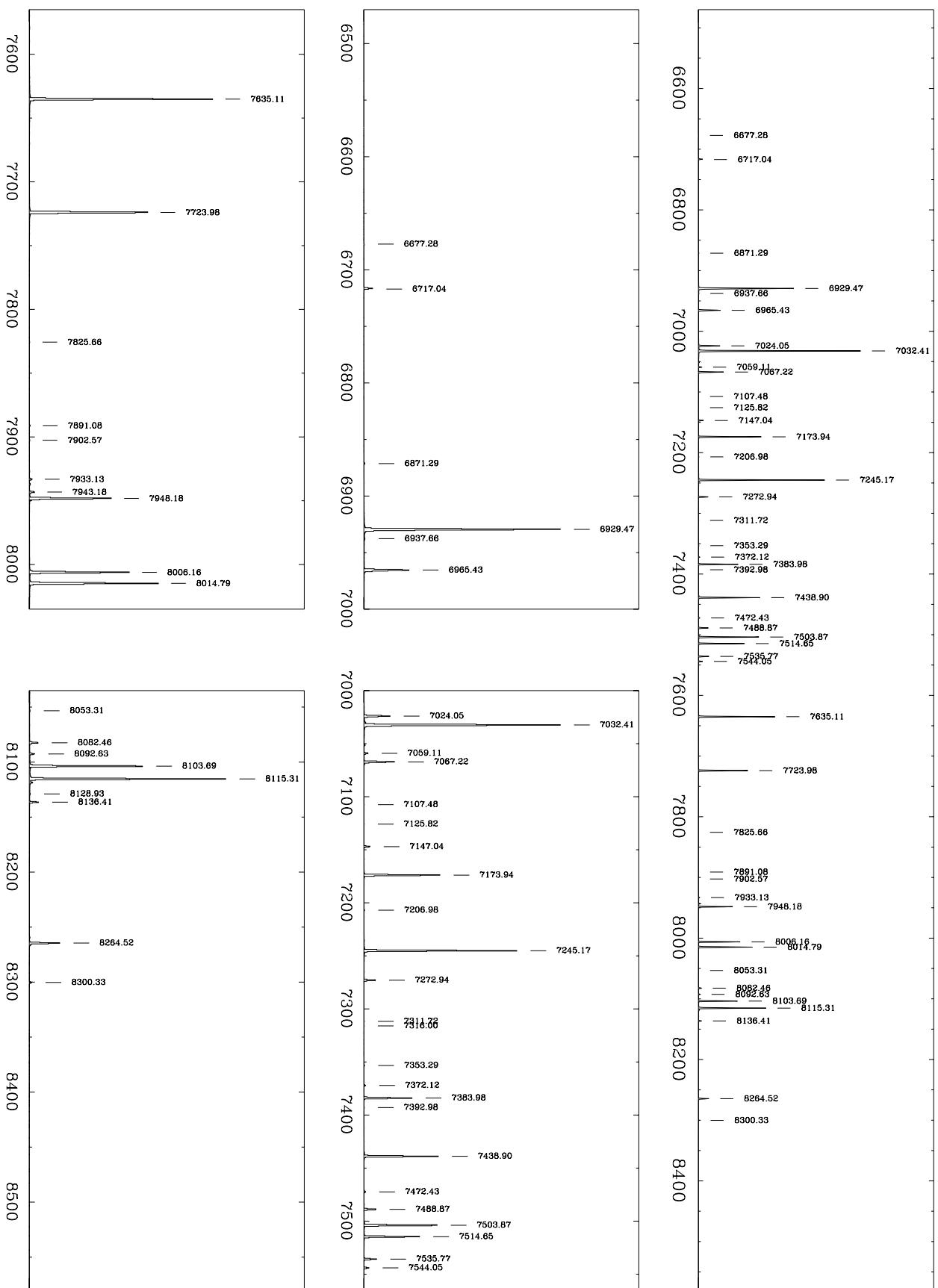
CuAr



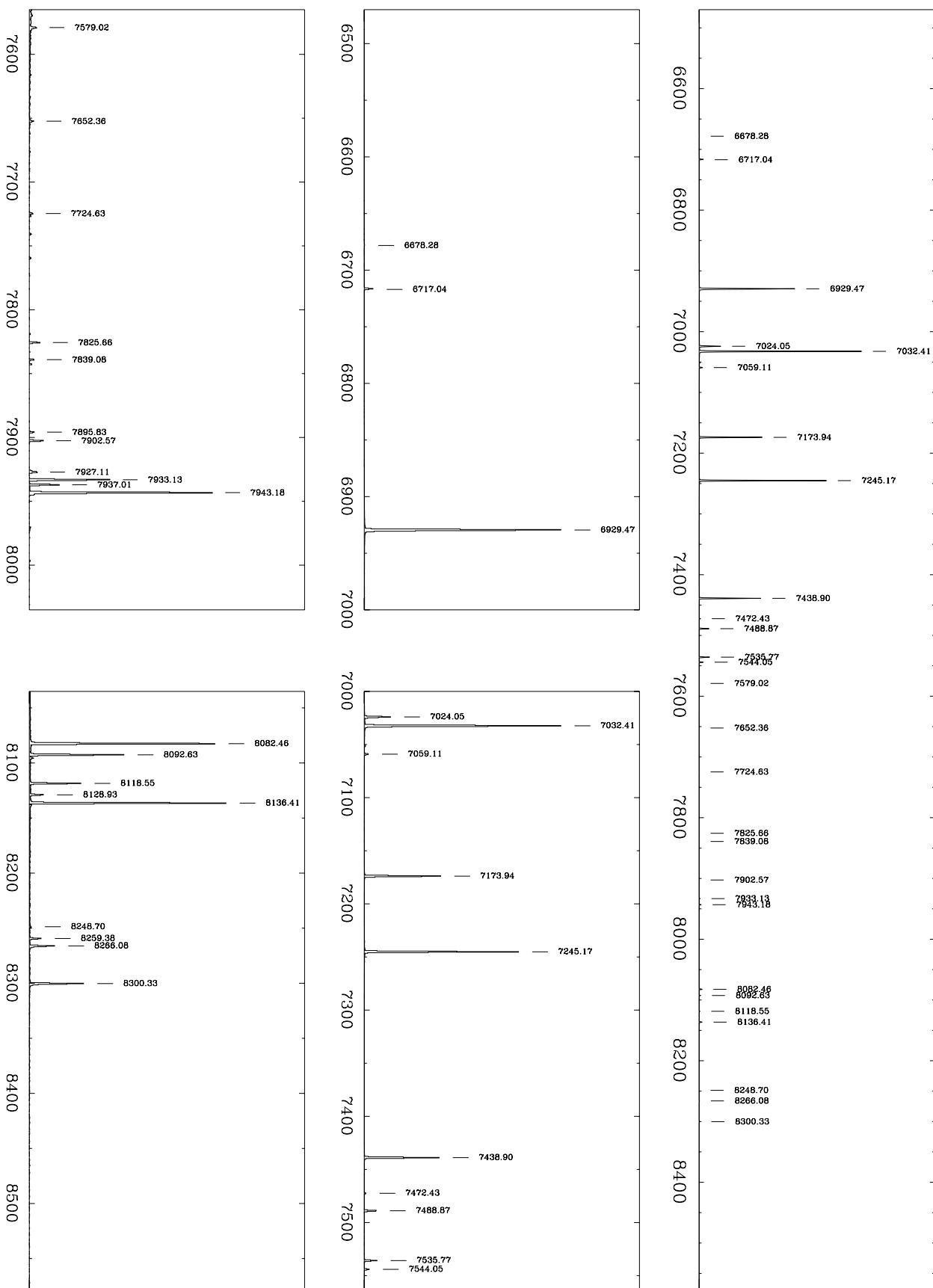
R1200R

$\lambda_C = 7500$

CuAr + CuNe



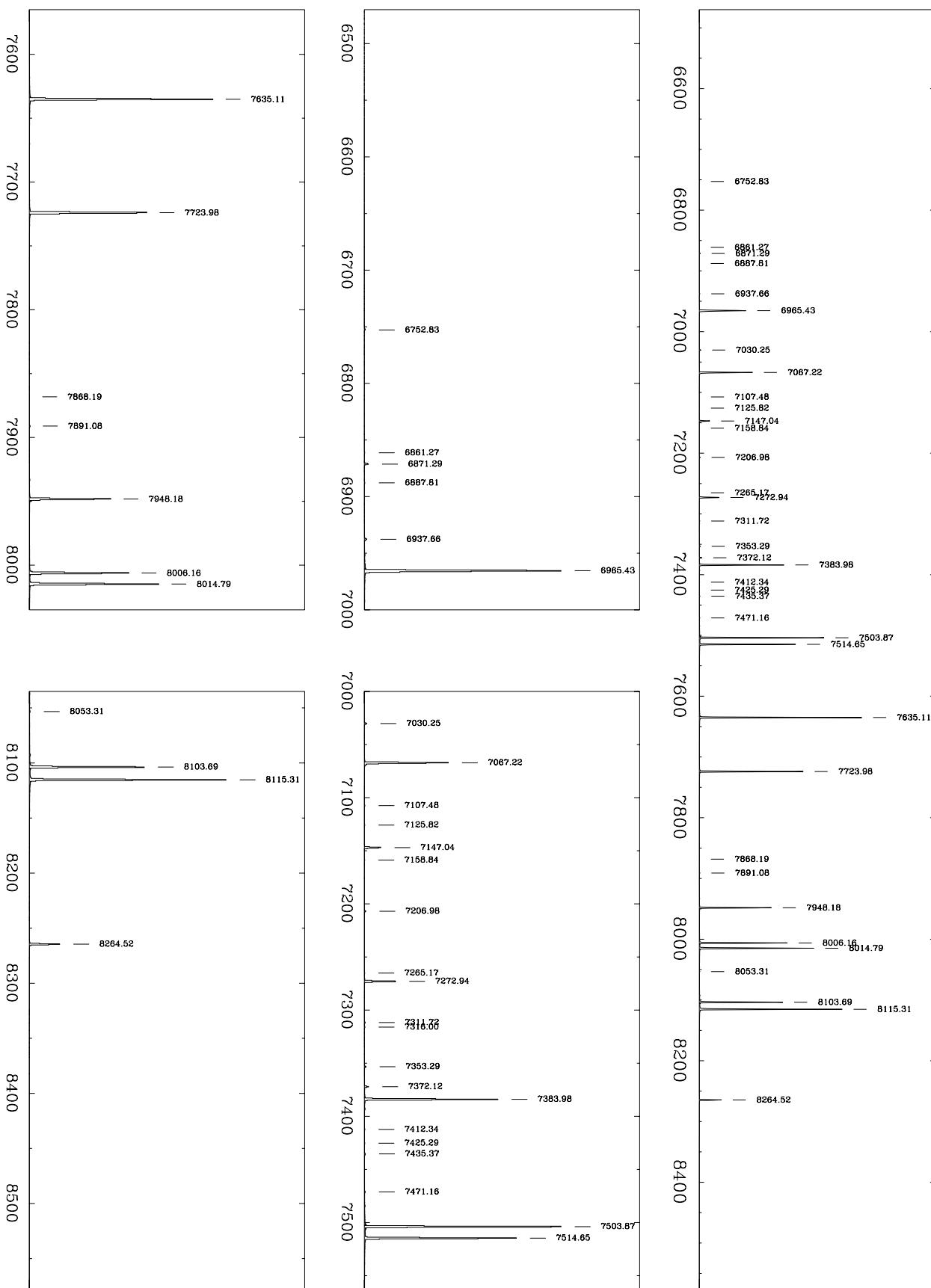
R1200R $\lambda_C = \gamma 500$ CuNe



R1200R

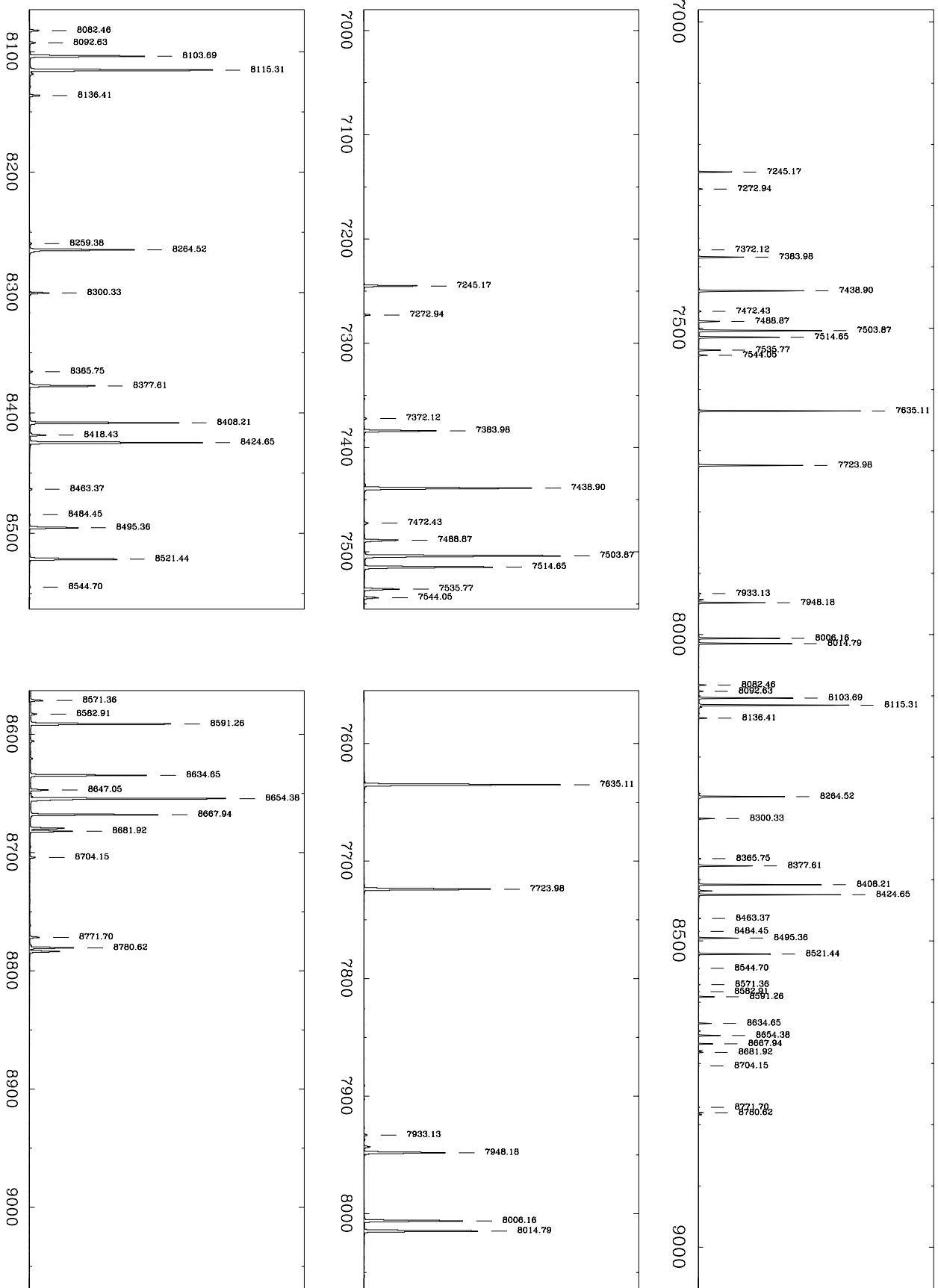
$\lambda_C = \gamma 500$

CuAr

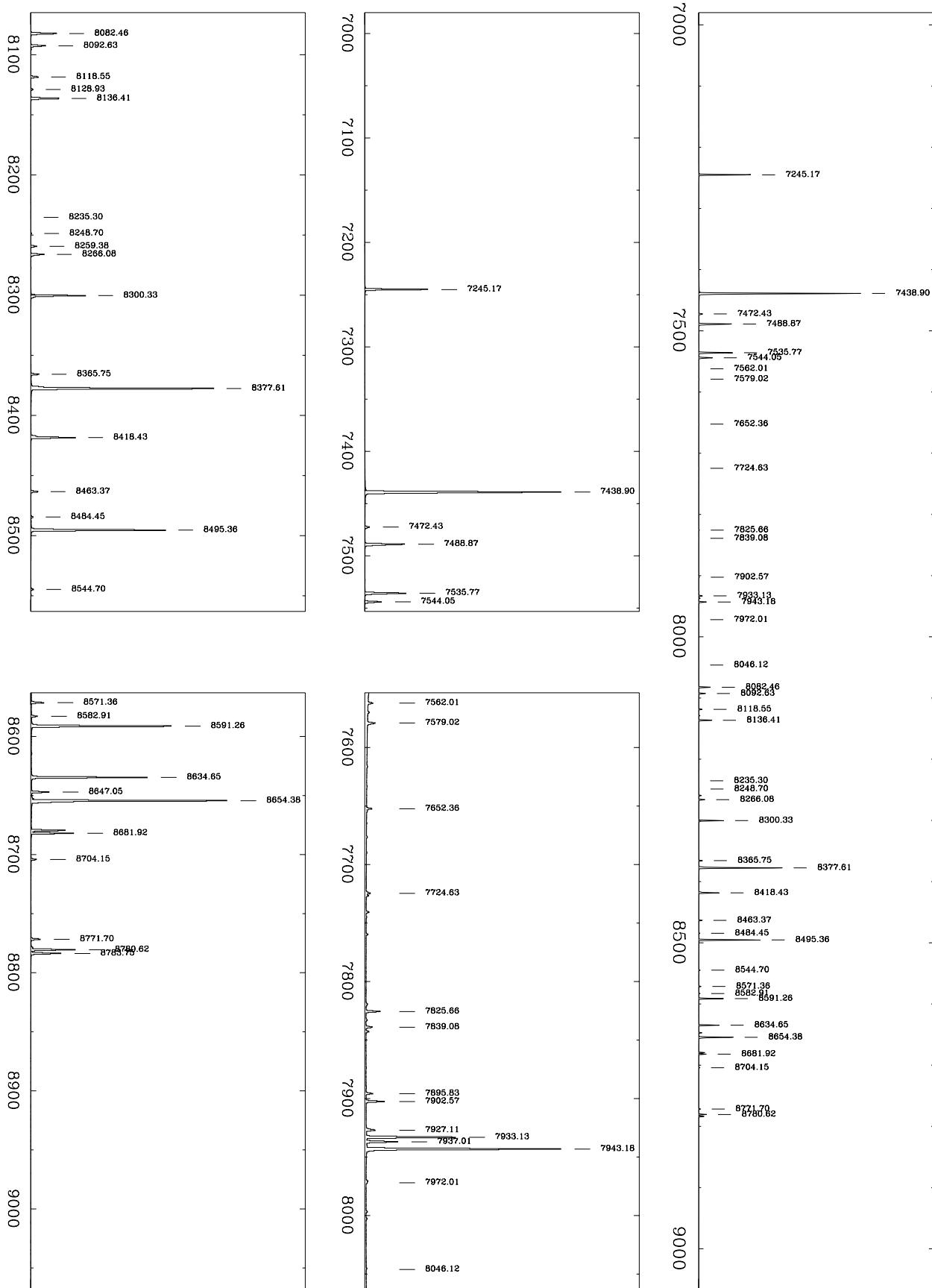


R1200R $\lambda C = 8000$

CuAr + CuNe

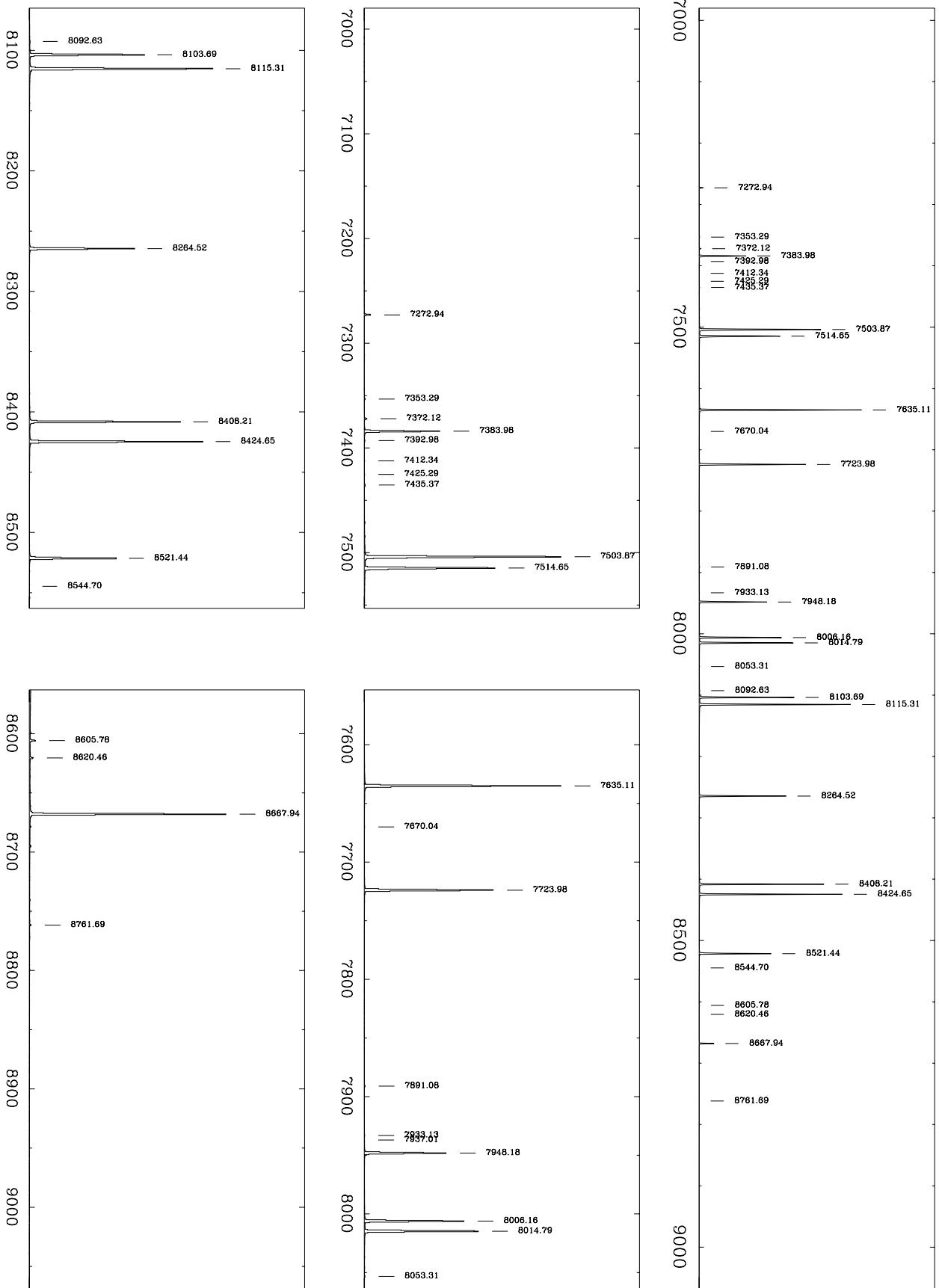


R1200R $\lambda C = 8000$ CuNe



R1200R $\lambda C = 8000$

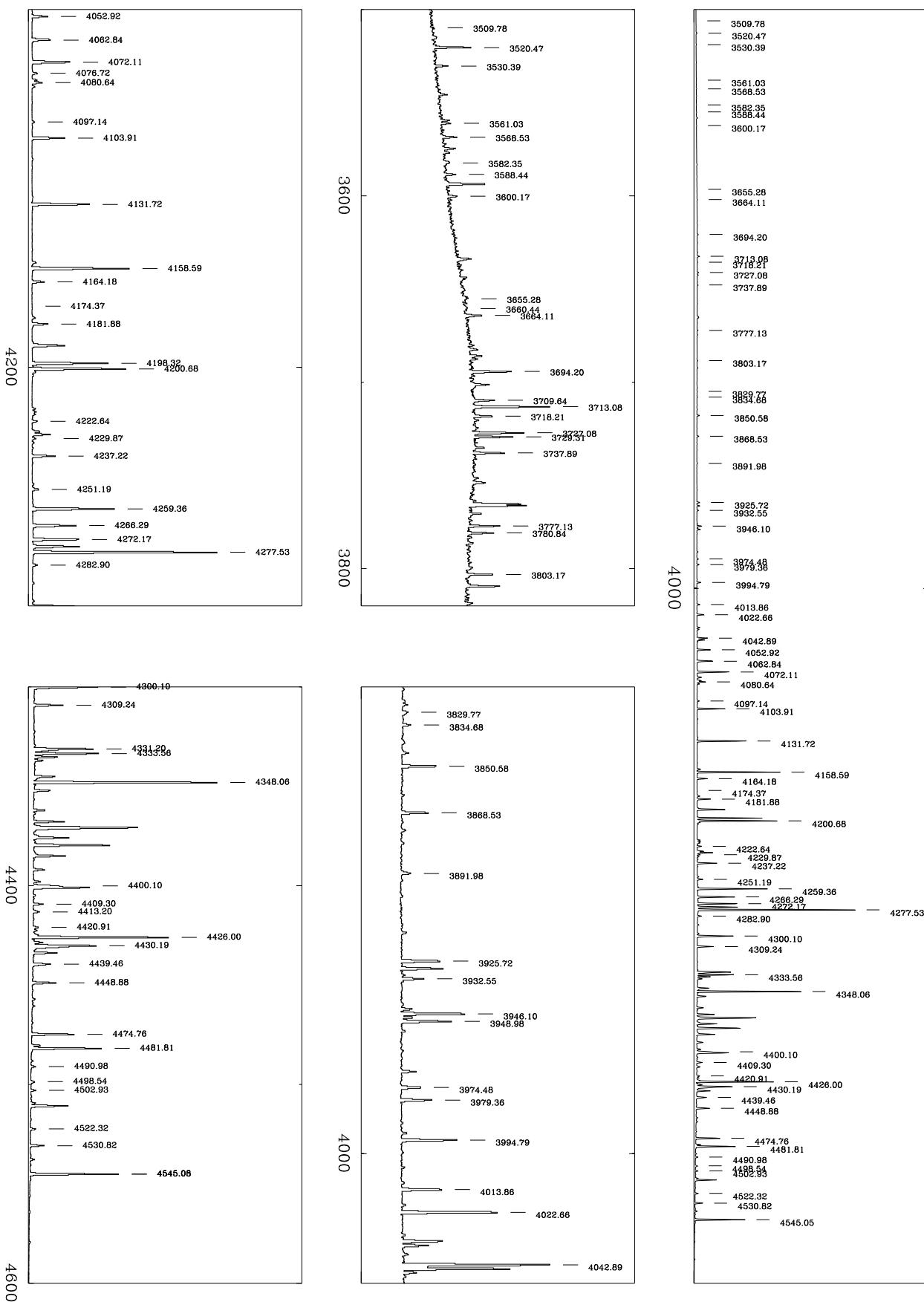
CuAr



H1800W

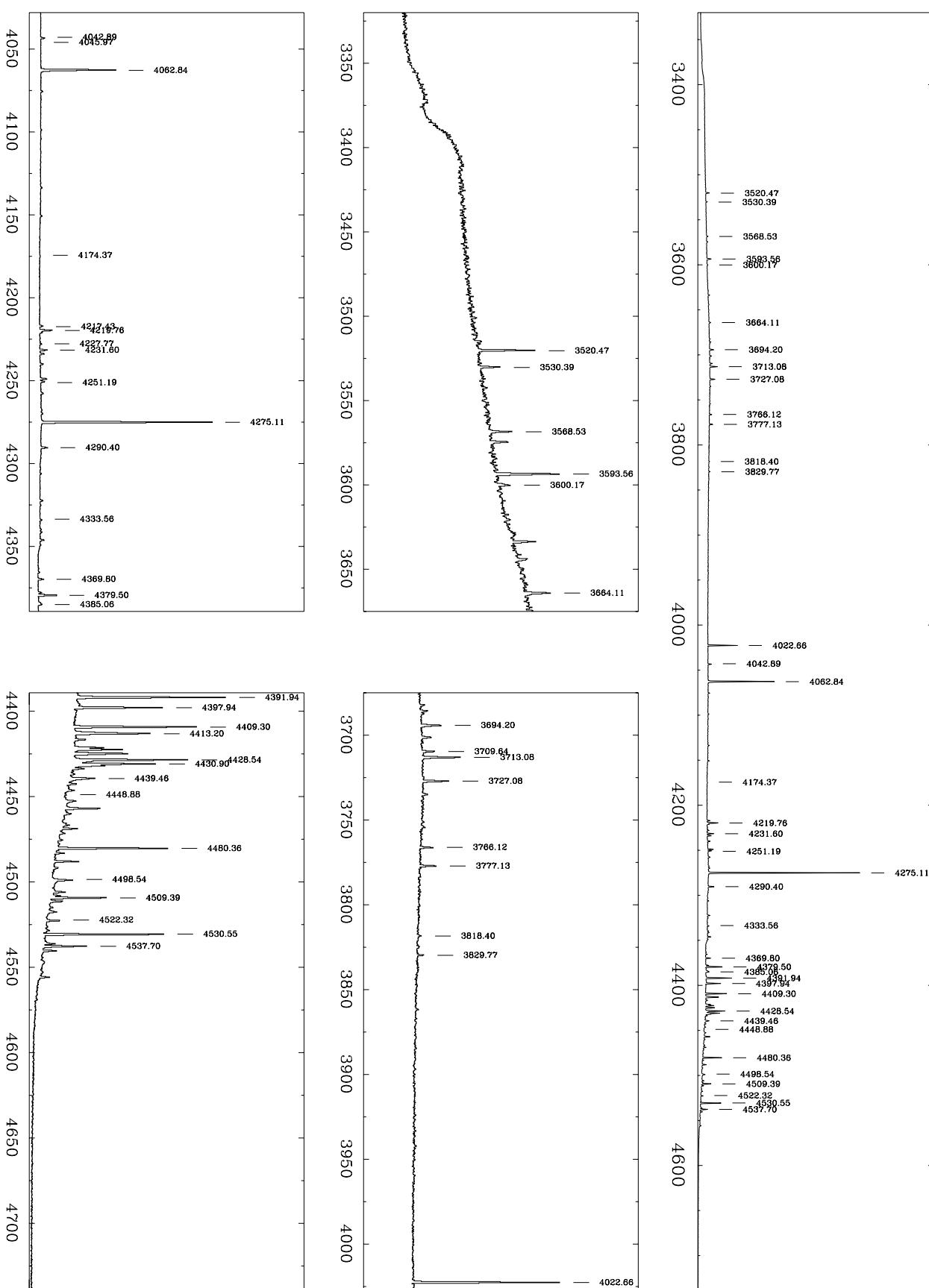
$\lambda_C = 4000$

CuAr+CuNe



H1 800V $\lambda_C = 4000$

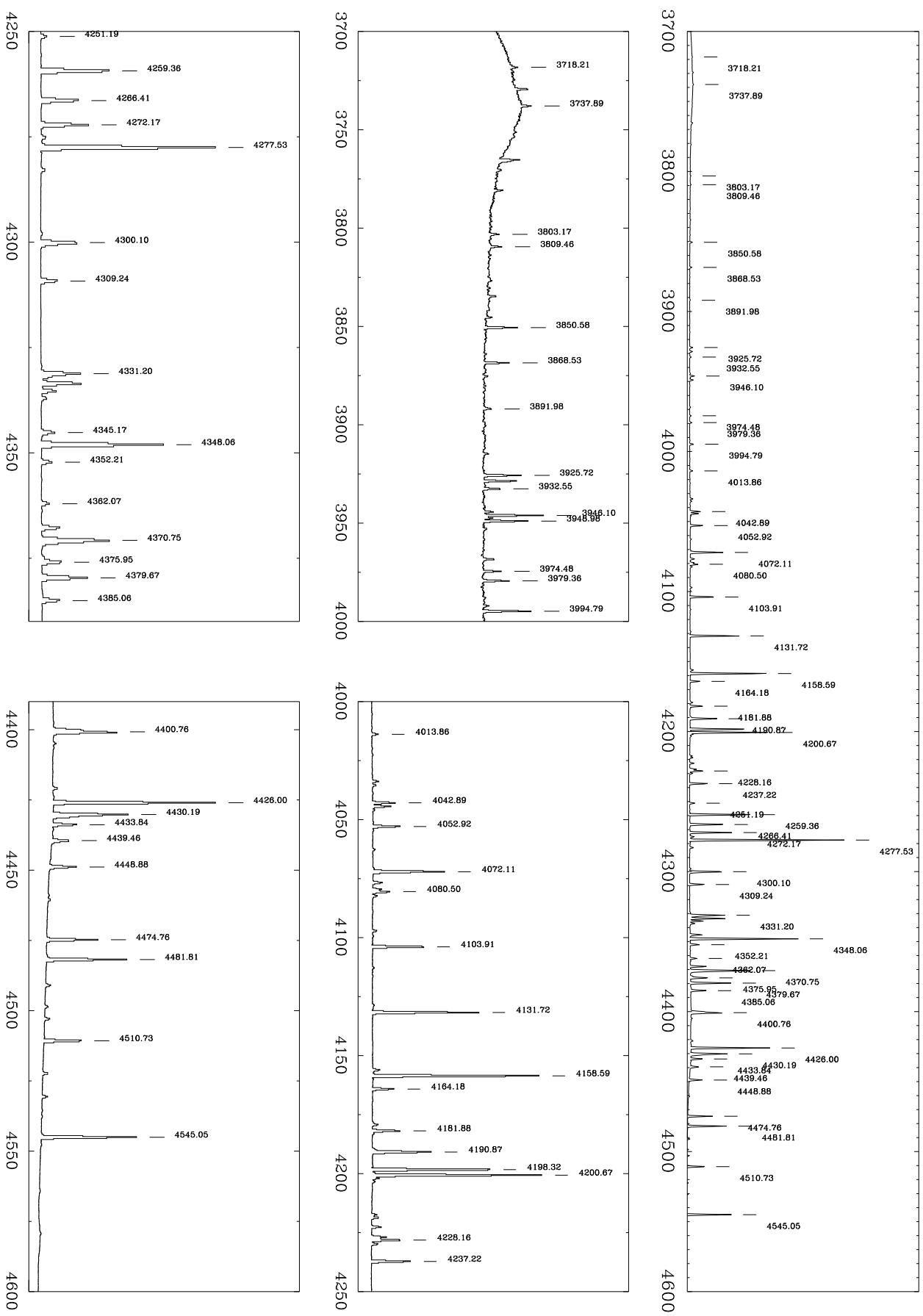
CuNe



H1800V

$\lambda_C = 4000$

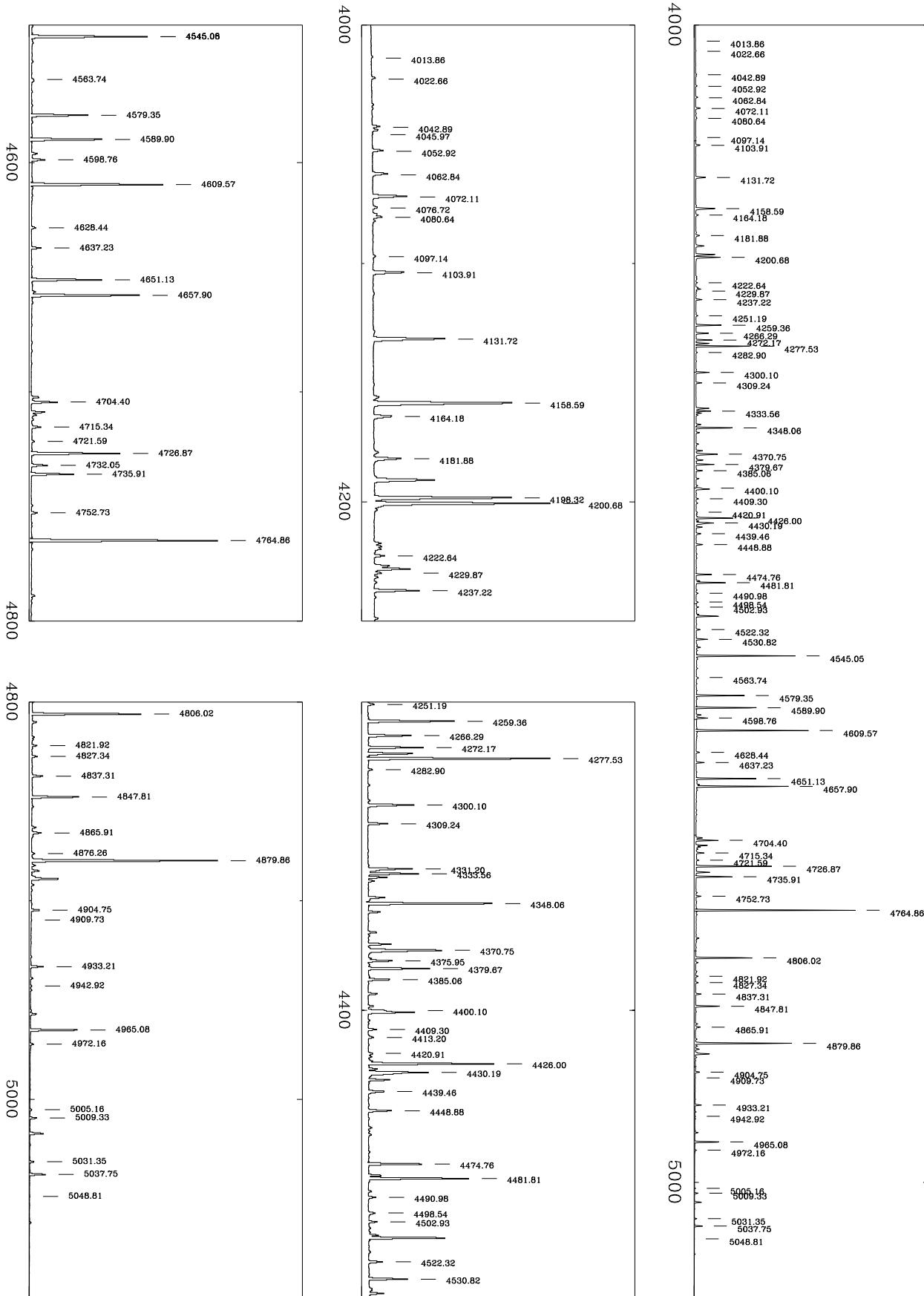
CuAr



H1800W

$\lambda_C = 4500$

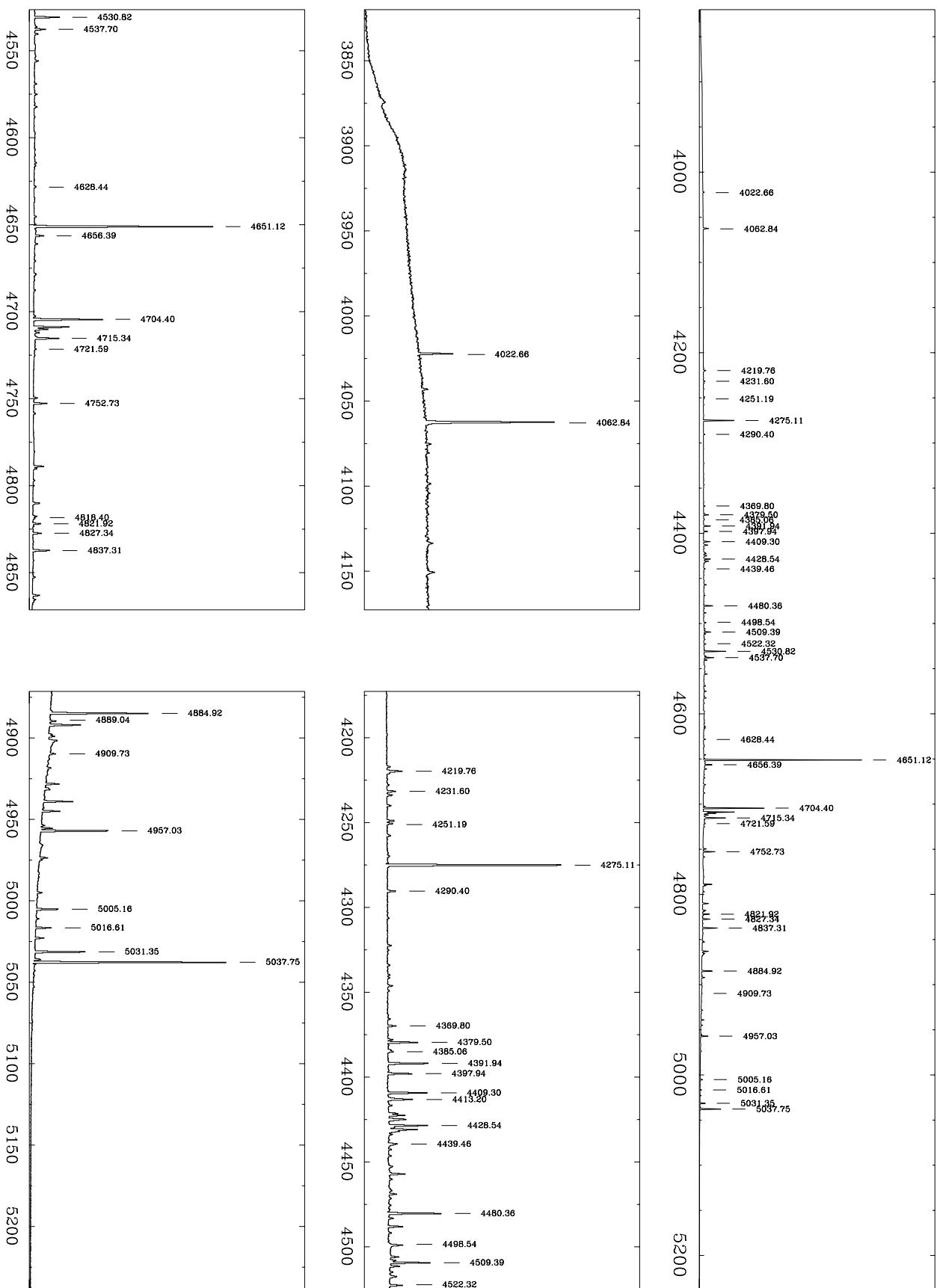
CuAr+CuNe



H1 800V

$\lambda_C = 4500$

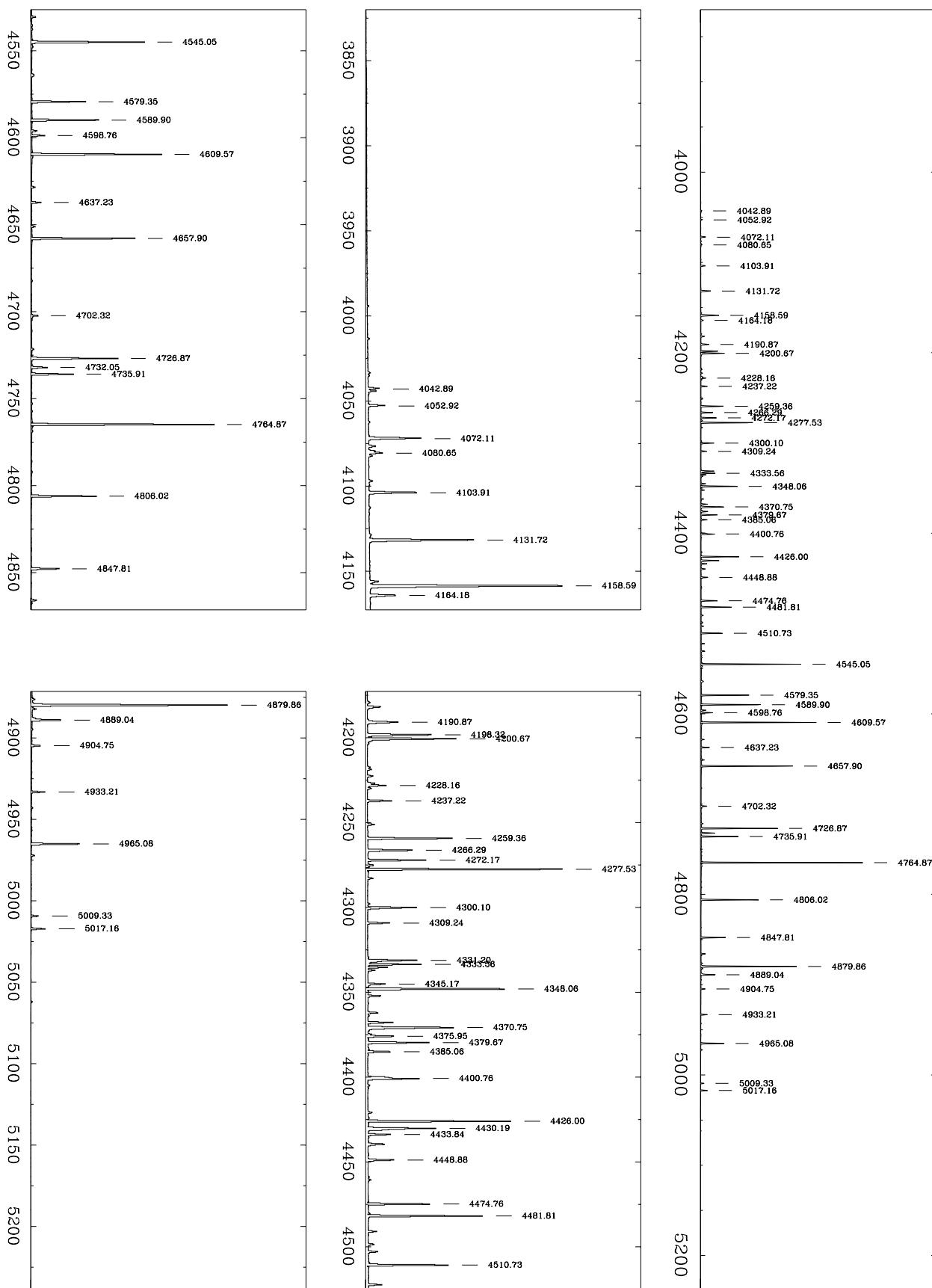
CuNe



H1 800V

$\lambda_C = 4500$

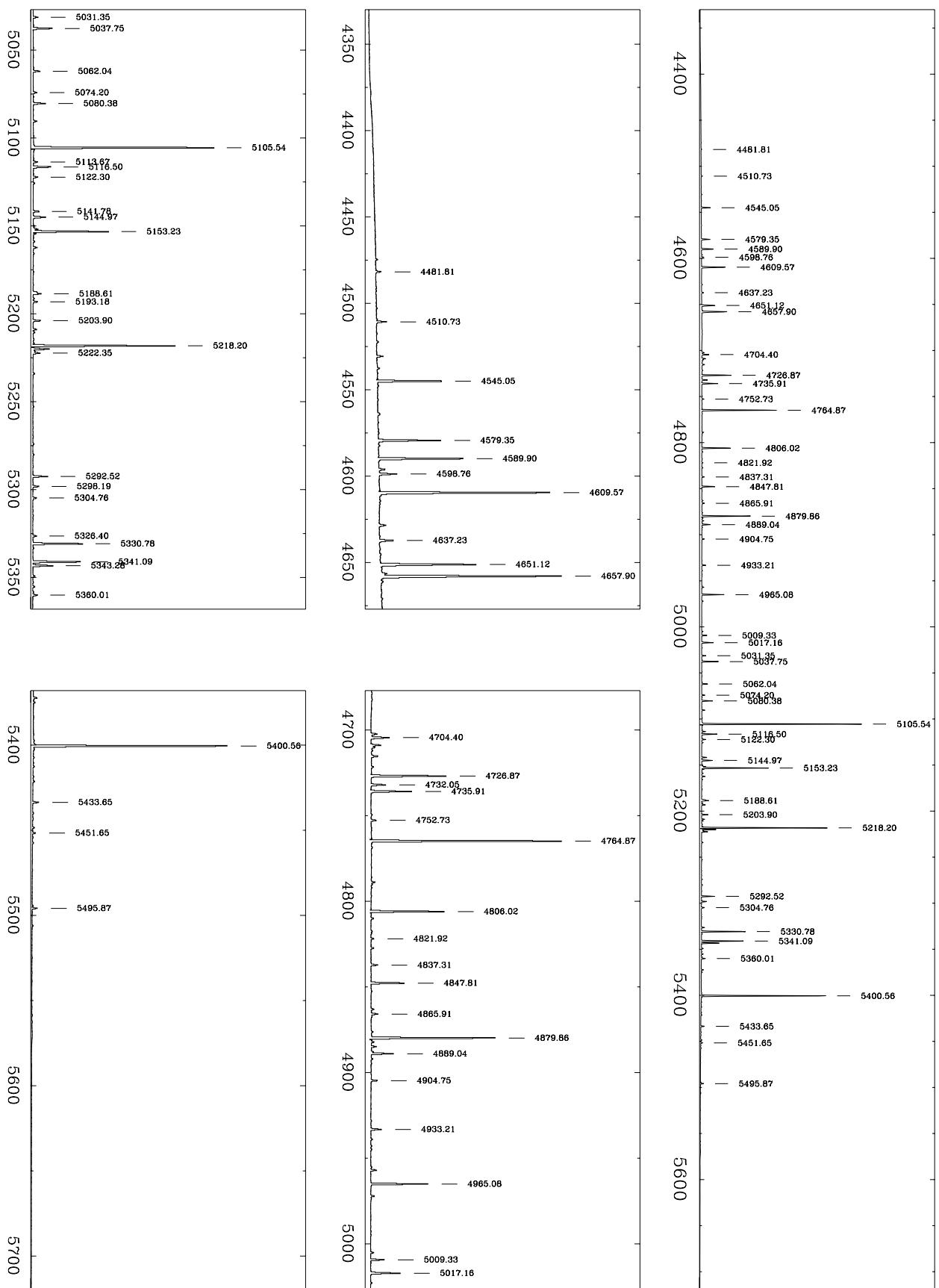
CuAr

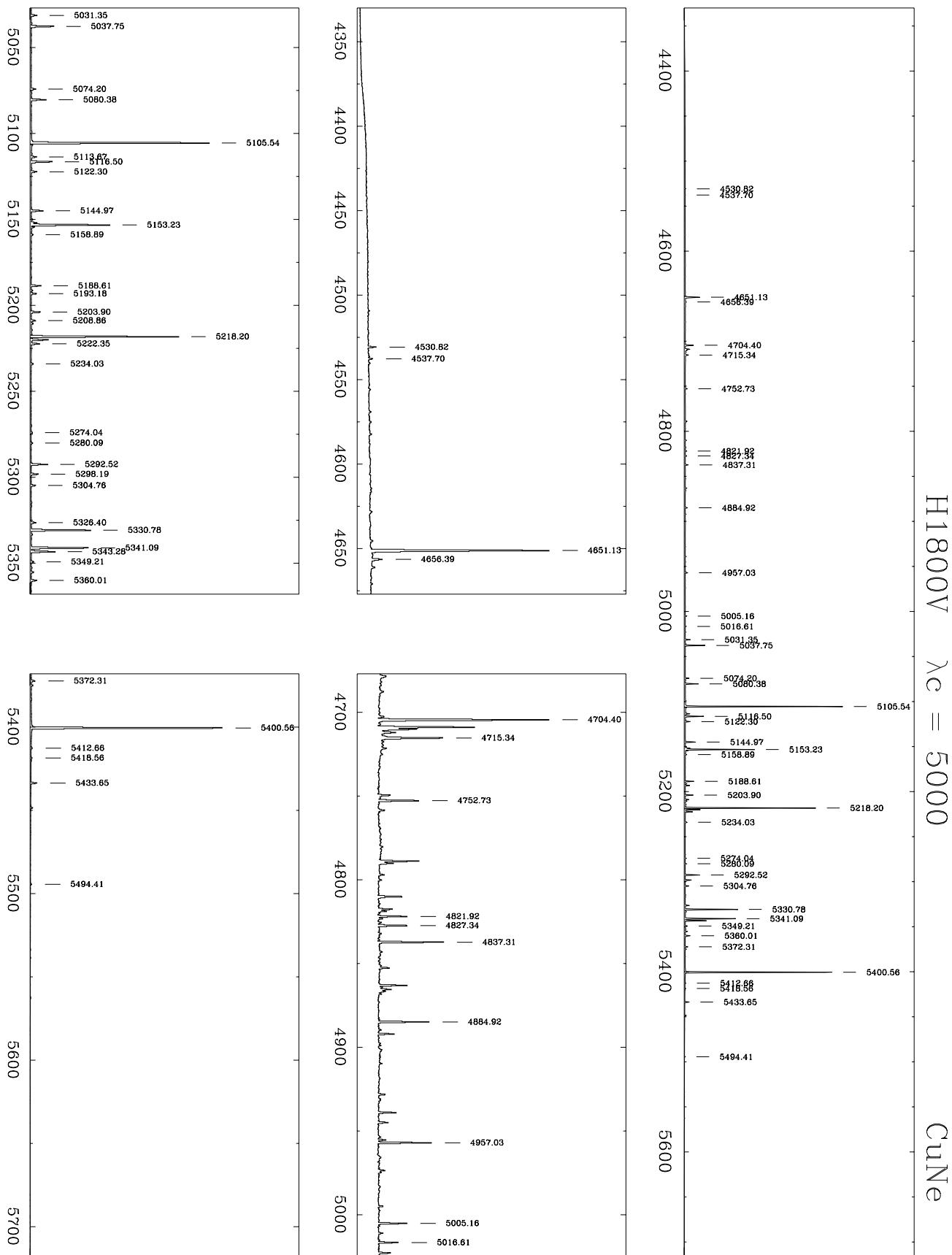


H1800V

$\lambda_C = 5000$

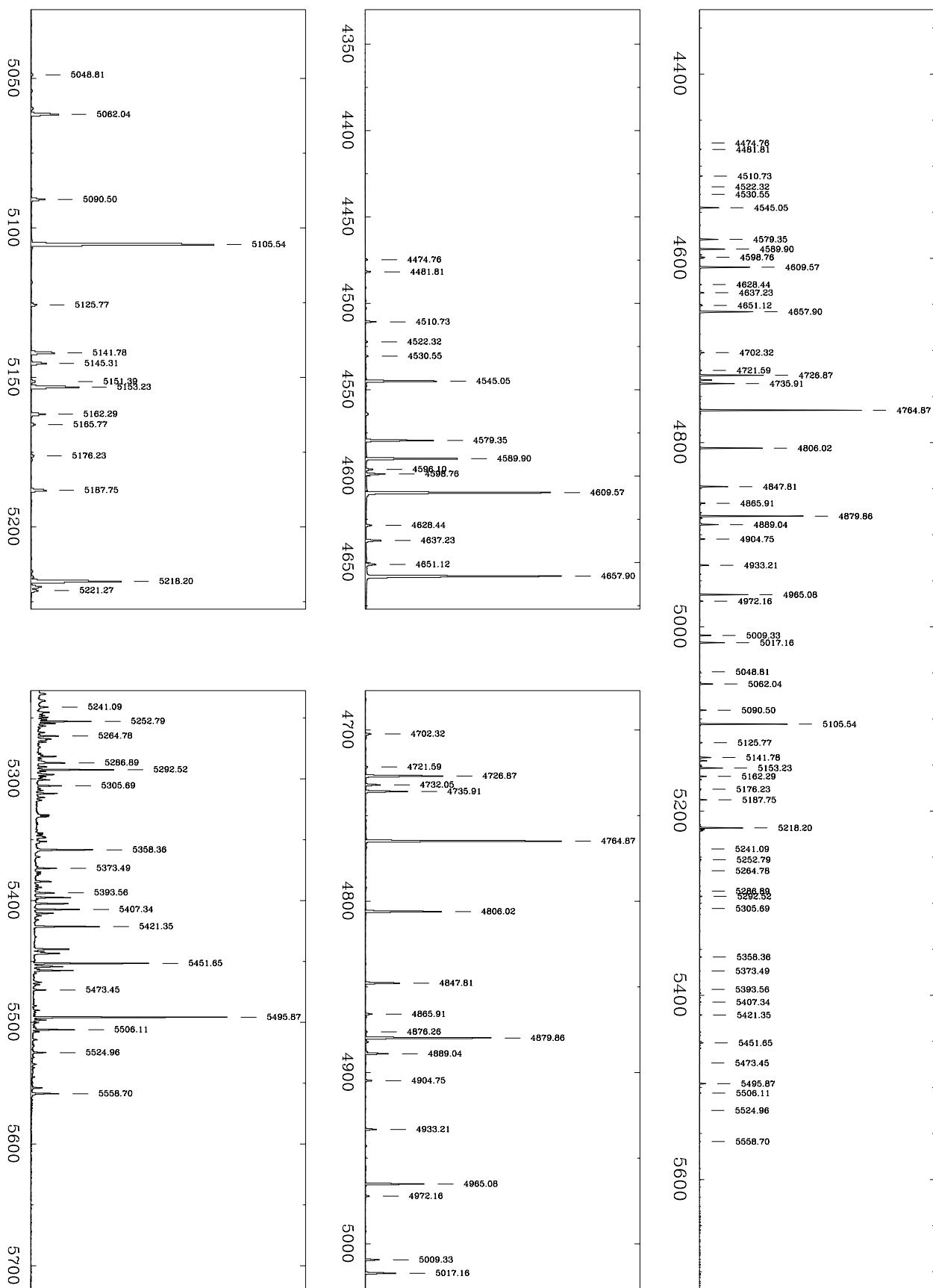
CuAr+CuNe





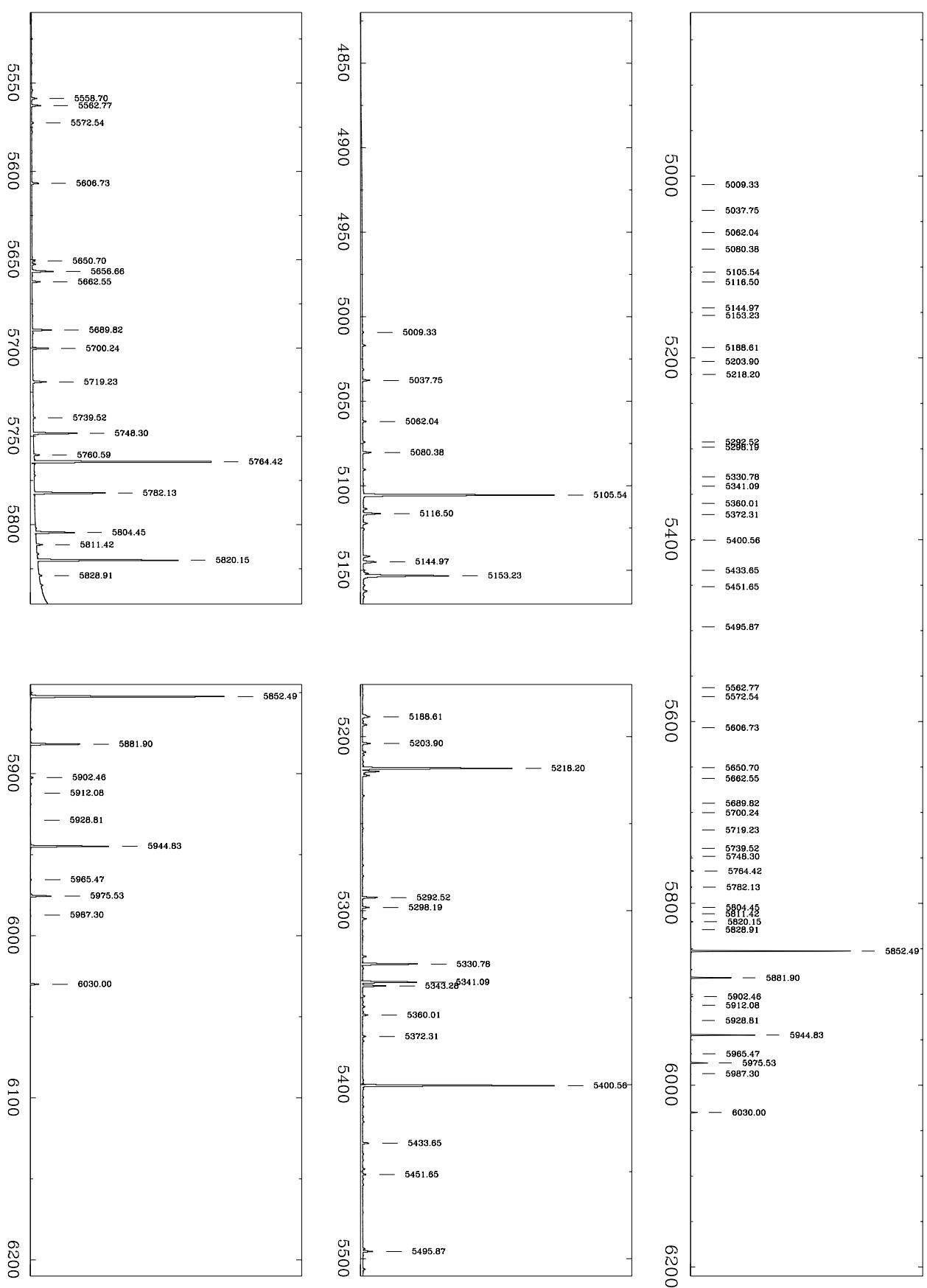
H1800V $\lambda_C = 5000$

CuAr



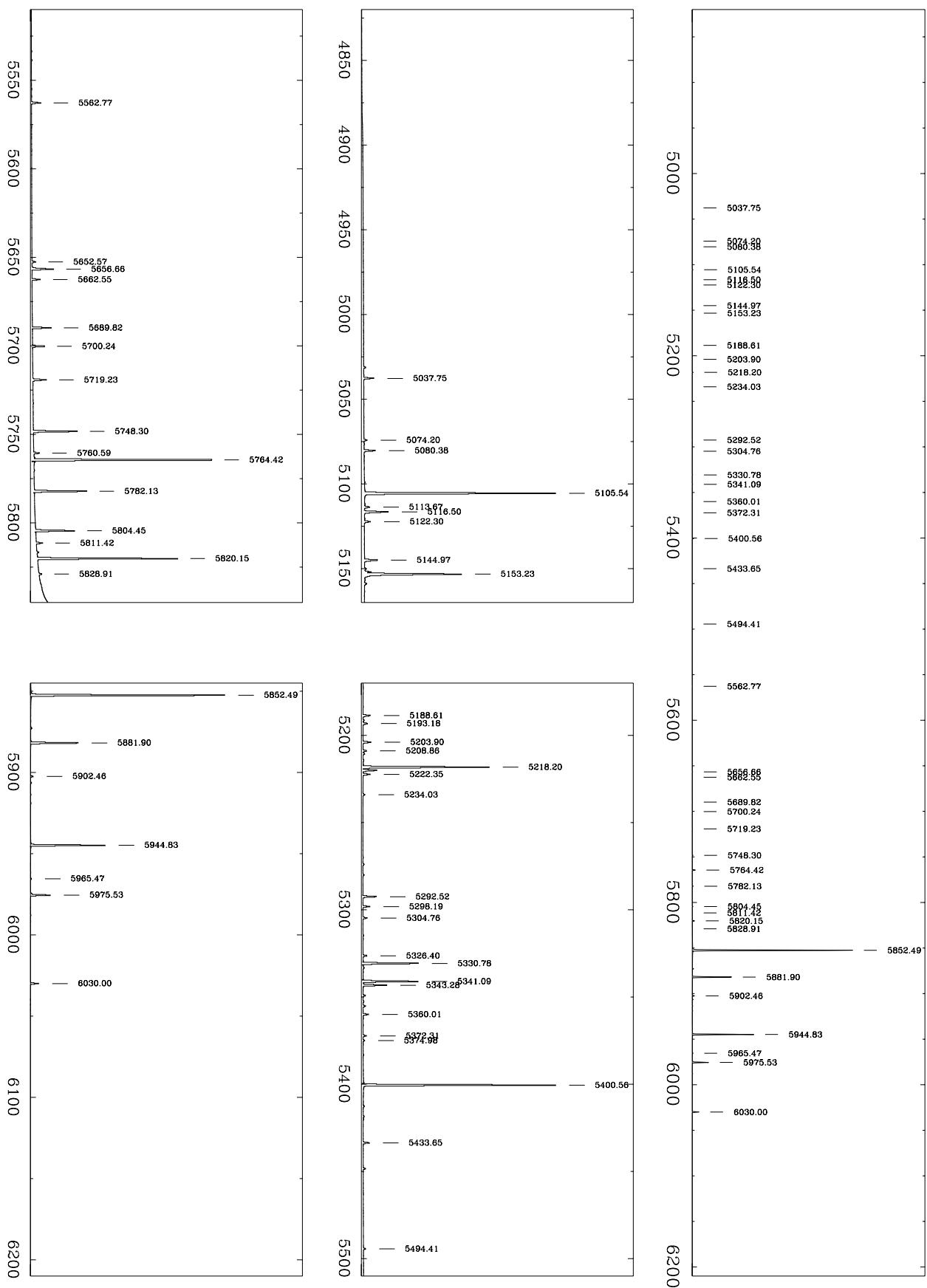
H1800V $\lambda_C = 5500$

CuAr+CuNe



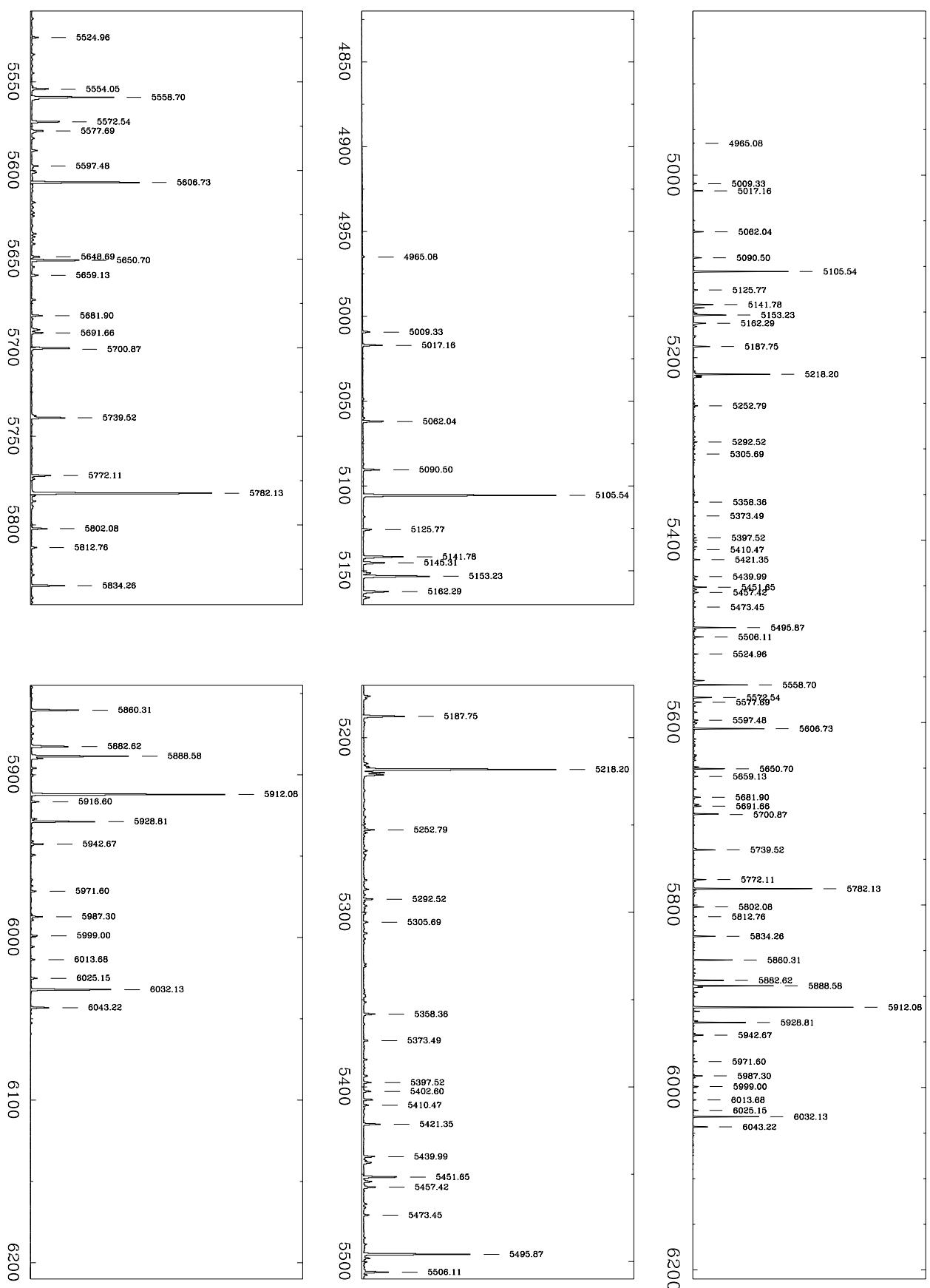
H1 800V $\lambda_C = 5500$

CuNe



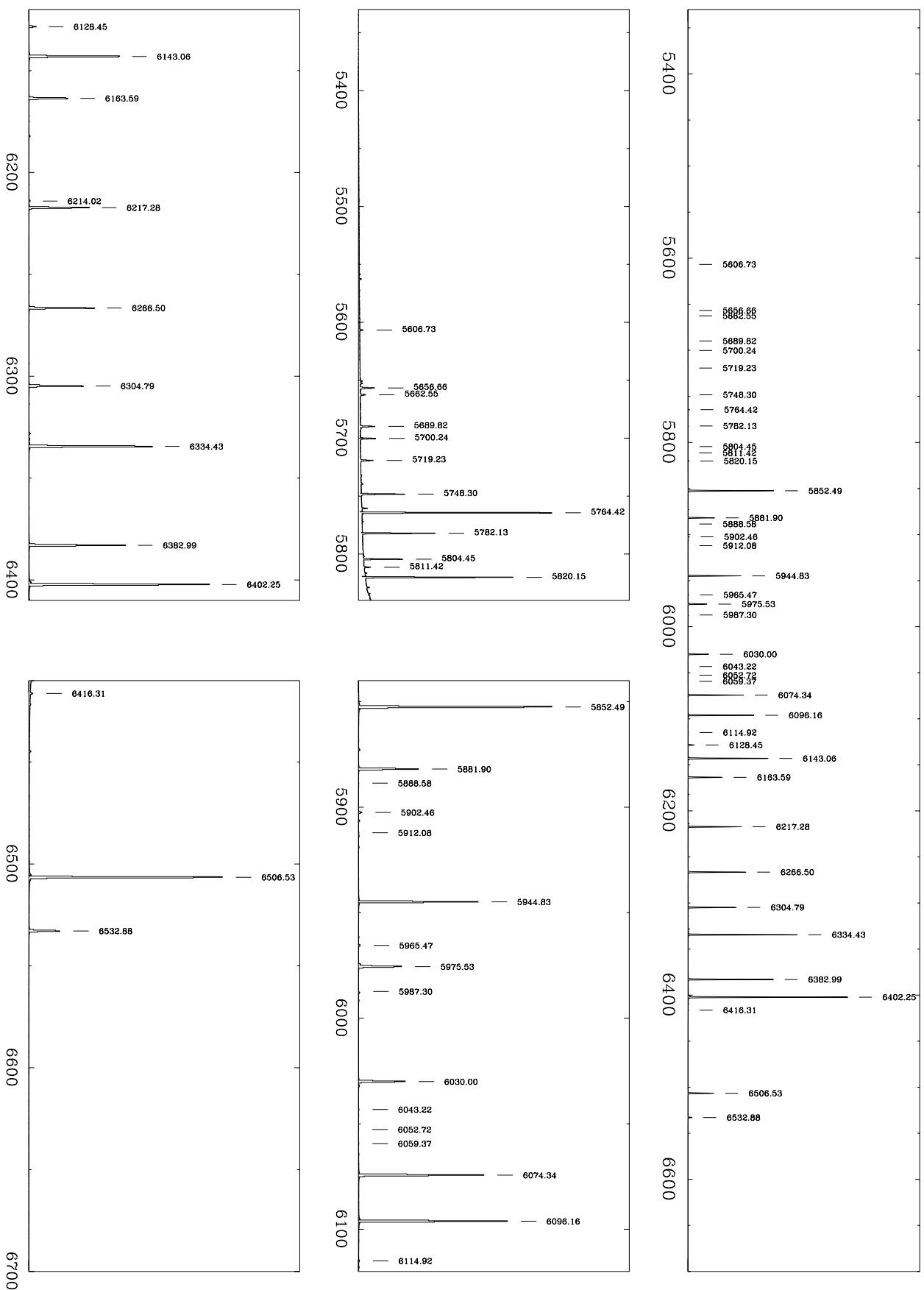
H1800V $\lambda_C = 5500$

CuAr



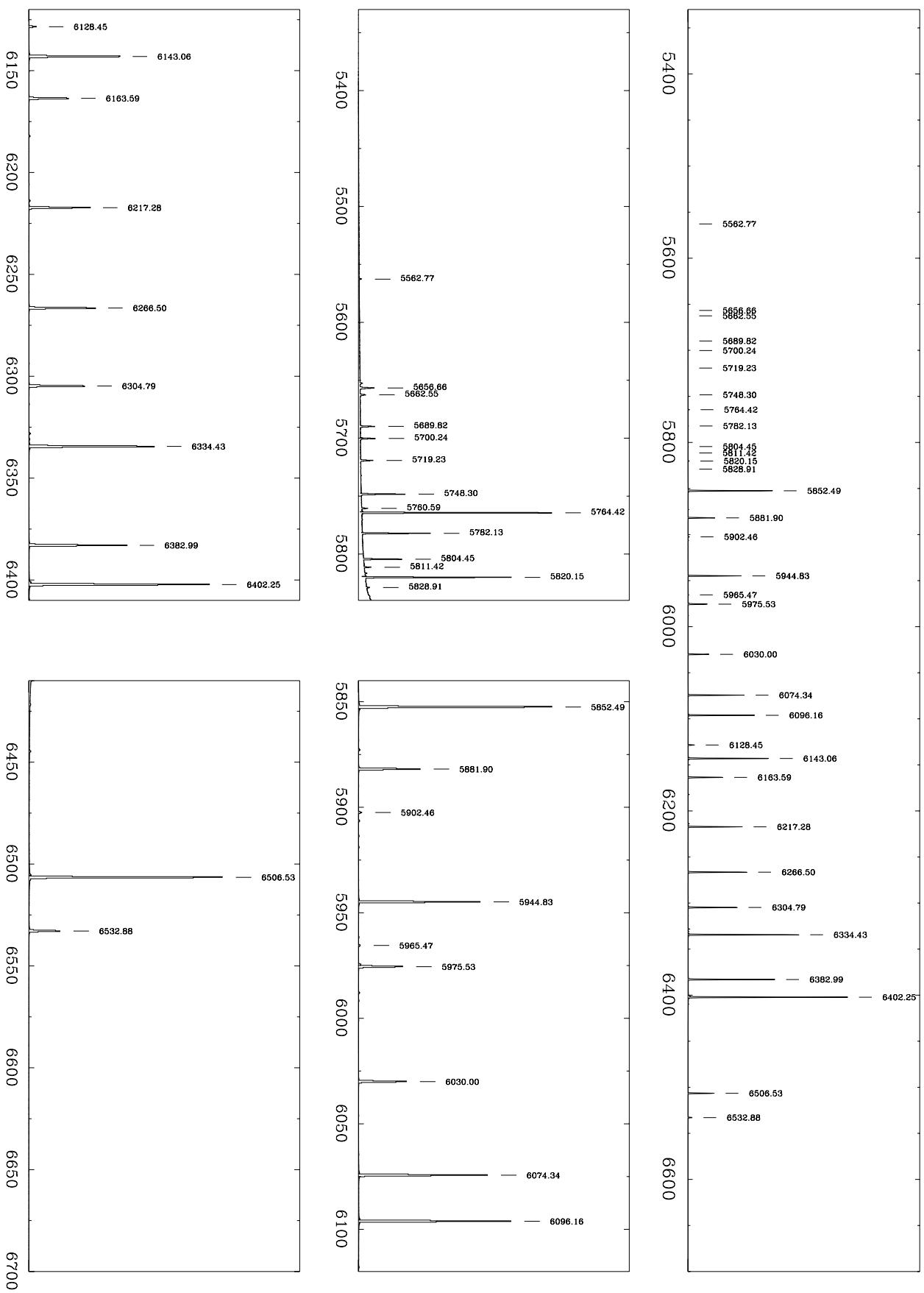
H1800V $\lambda_C = 6000$

CuAr+CuNe

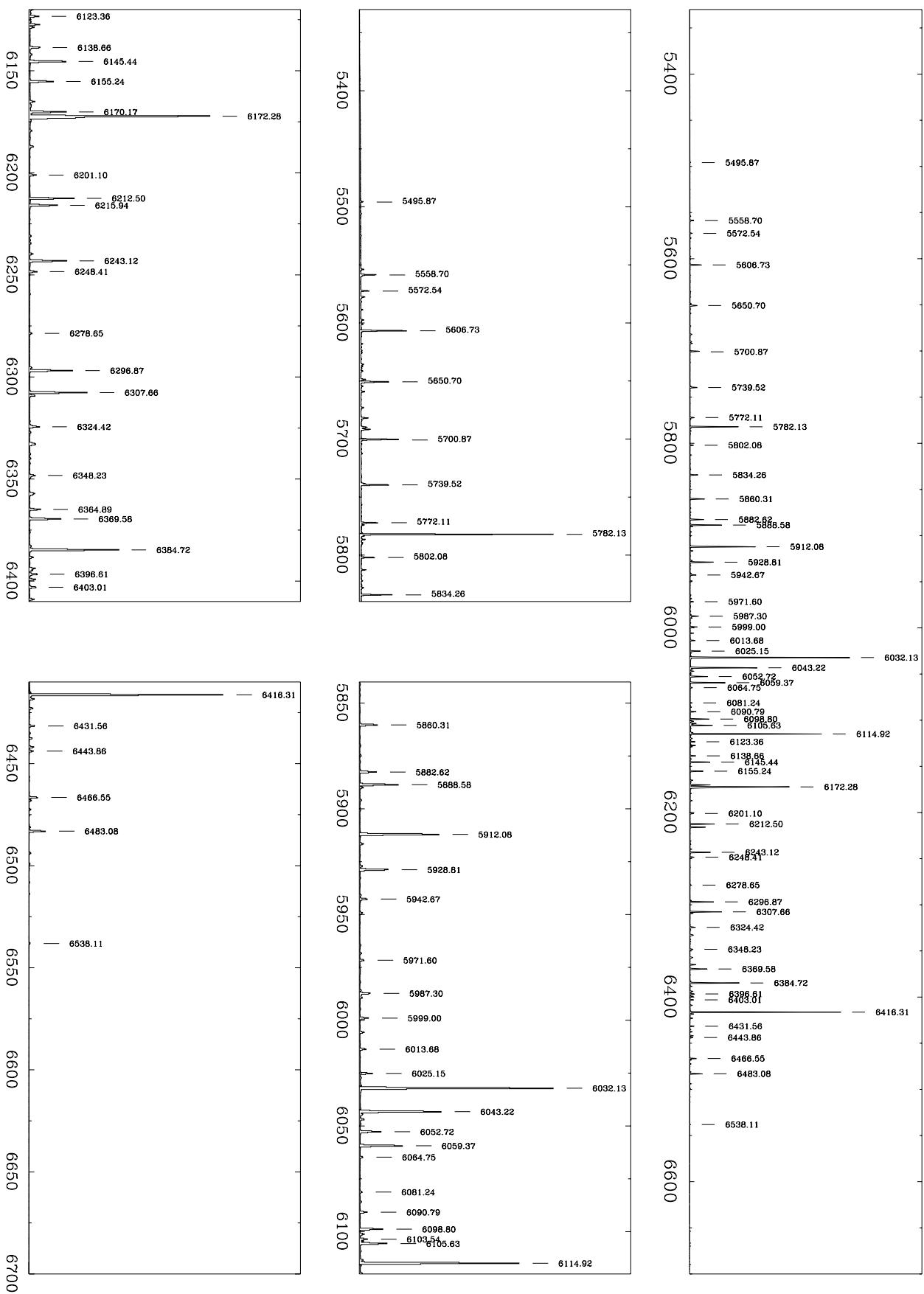


H1800V $\lambda_C = 6000$

CuNe



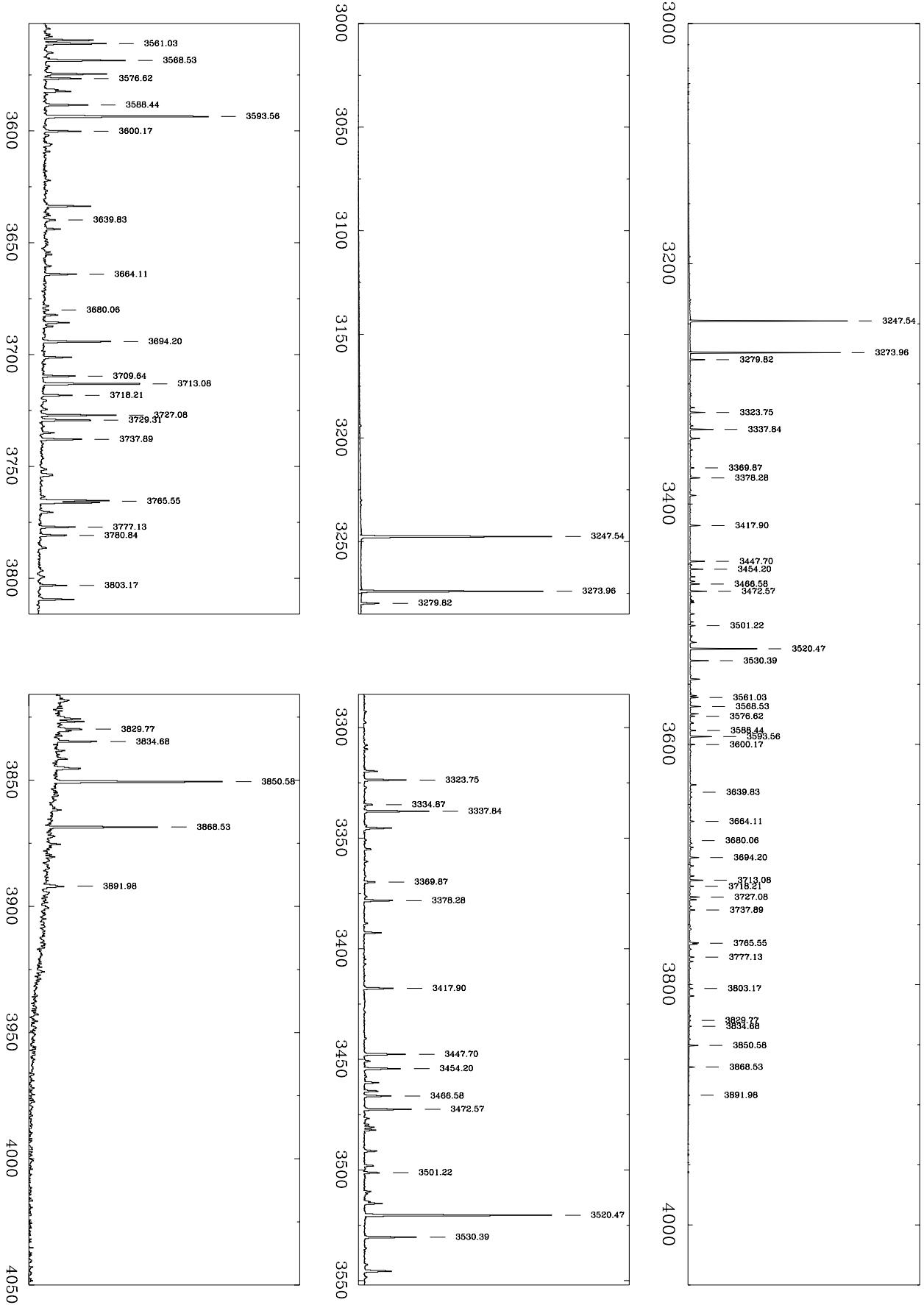
H1800V $\lambda_C = 6000$ CuAr



H2400B

$\lambda_c = 3500$

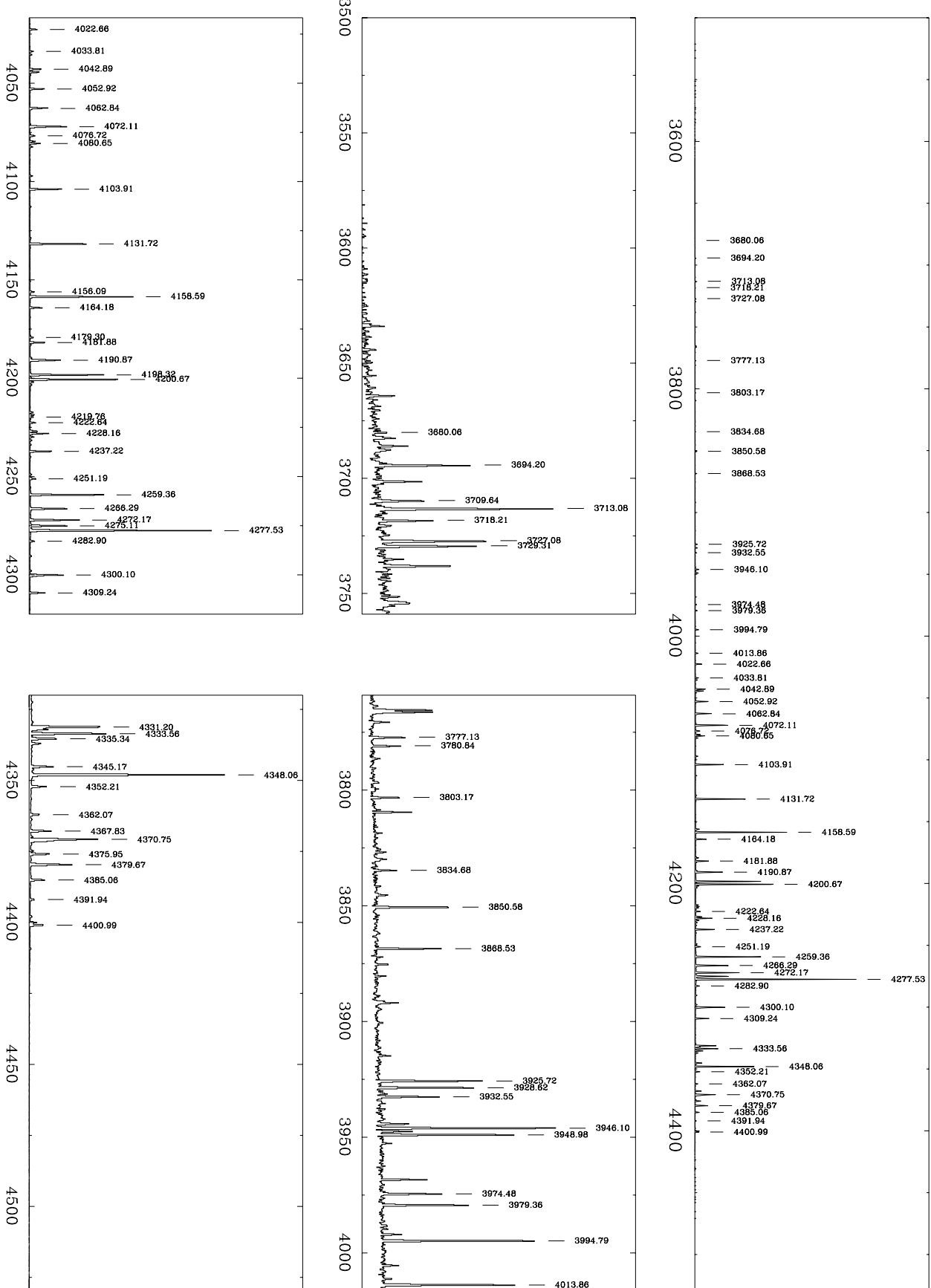
CuAr + CuNe



H2400B

$\lambda_c = 4000$

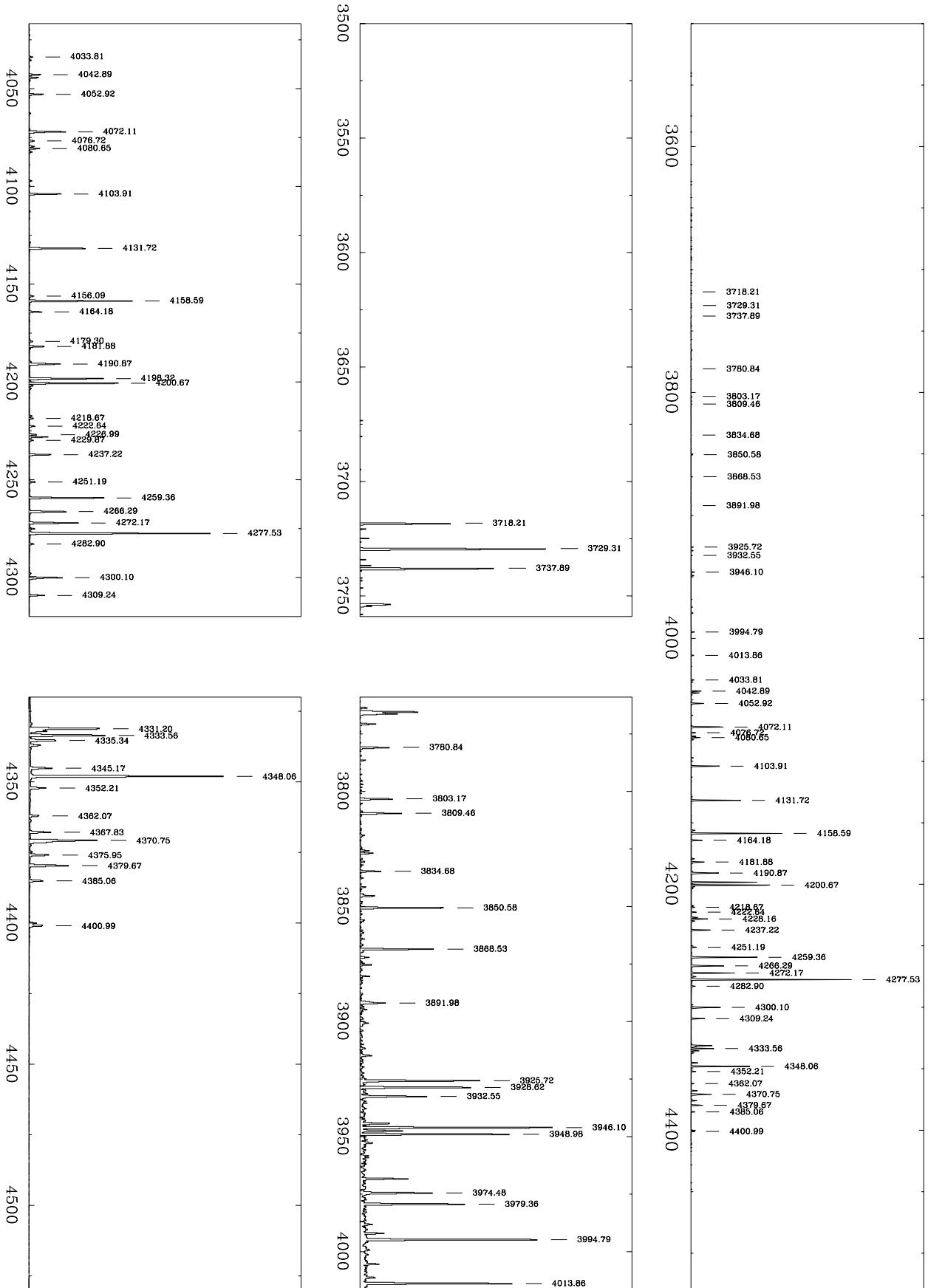
CuAr + CuNe



H2400B

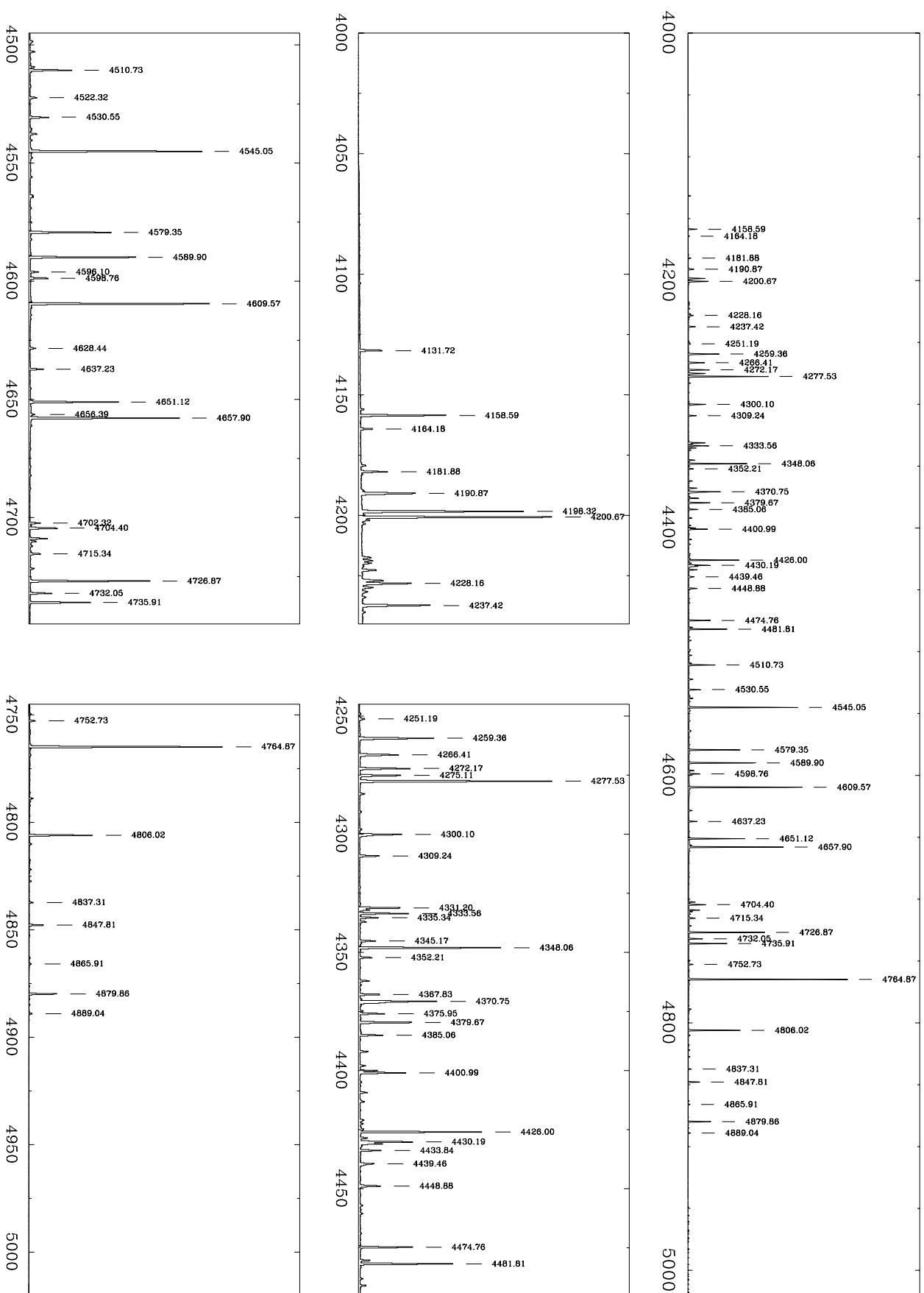
$\lambda_c = 4000$

CuAr

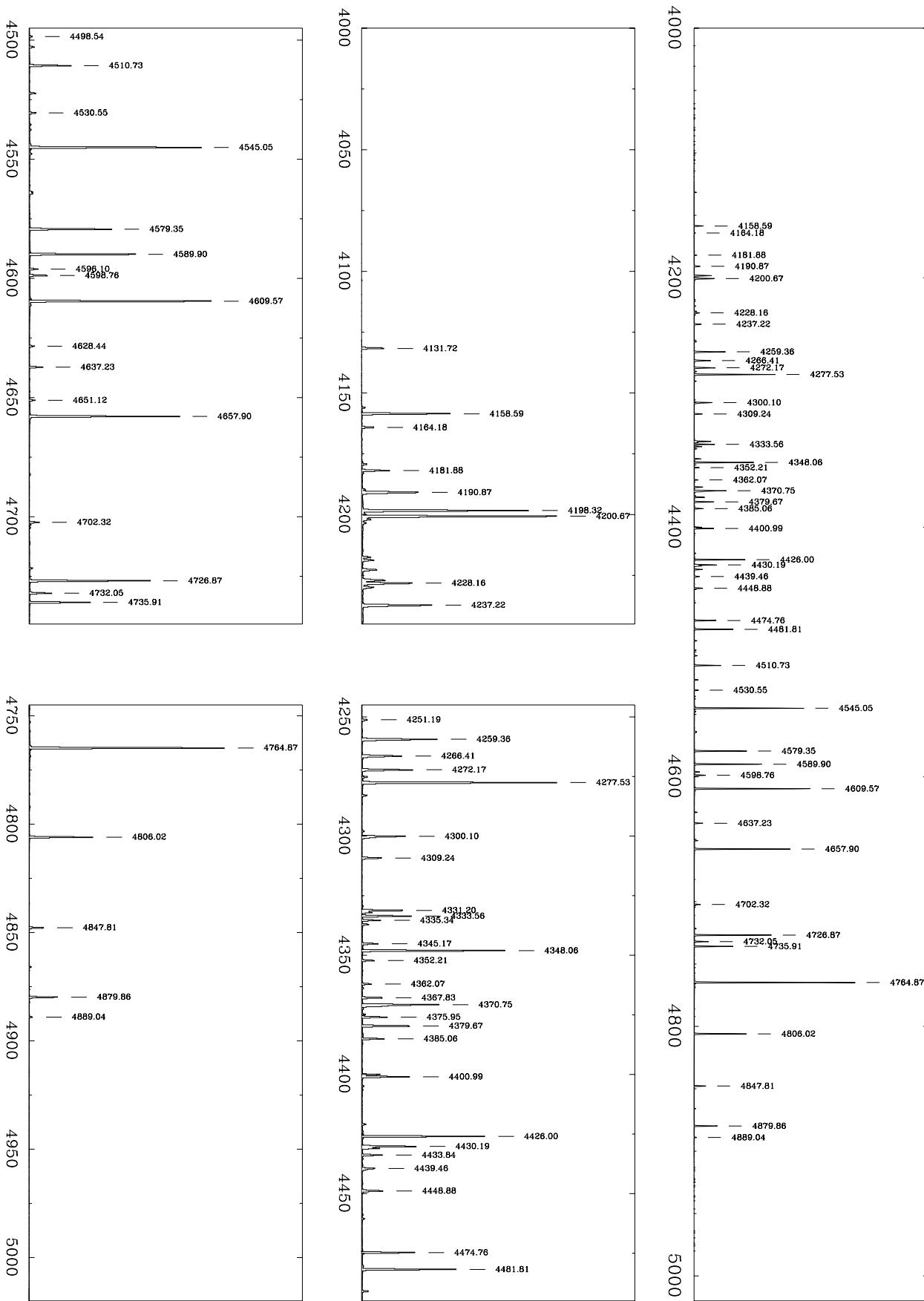


H₂400B $\lambda_C = 4500$

CuAr + CuNe



H₂400B $\lambda_C = 4500$ CuAr



Appendix A. Copper-Argon and Copper-Neon spectral lines used for wavelength calibration in the low-resolution spectra.

3247.540	5105.541	6143.063	7723.98
3273.962	5116.503	6145.441	7891.075
3447.703	5141.783	6155.239	7943.180
3520.472	5153.235	6163.594	7948.176
3713.08	5162.285	6172.03	8006.157
3777.13	5187.746	6214.02	8014.786
3947.53	5218.202	6217.281	8053.309
4022.66	5221.07	6243.120	8082.458
4043.90	5253.13	6266.495	8103.693
4072.11	5330.778	6296.872	8115.311
4103.912	5341.091	6304.789	8136.406
4131.724	5373.494	6307.657	8264.523
4158.591	5400.5619	6334.428	8266.08
4181.884	5421.352	6369.575	8300.326
4190.87	5451.652	6382.991	8377.607
4198.317	5495.874	6384.717	8408.210
4259.362	5506.113	6402.247	8418.427
4275.11	5524.957	6416.307	8424.648
4277.528	5558.702	6506.528	8495.360
4300.101	5572.541	6532.882	8521.442
4331.31	5606.733	6598.953	8591.258
4348.064	5650.704	6677.282	8605.776
4370.753	5681.900	6678.277	8634.648
4427.05	5689.910	6684.293	8654.383
4474.759	5739.520	6717.043	8667.944
4481.811	5748.299	6752.834	8761.686
4510.733	5764.418	6871.289	8849.970
4530.82	5772.114	6929.468	8853.866
4545.052	5802.080	6937.664	8865.670
4579.350	5834.263	6965.430	8919.500
4589.899	5852.4878	7030.252	9075.395
4609.567	5860.310	7032.413	9122.967
4651.13	5881.8950	7067.218	9148.680
4657.901	5882.624	7107.478	9194.639
4702.316	5888.584	7125.820	9224.499
4704.395	5912.085	7147.042	9291.531
4726.868	5928.813	7173.939	9300.850
4735.906	5944.834	7206.980	9326.520
4764.865	5975.534	7245.167	9354.220
4806.021	5987.302	7272.936	9425.380
4847.810	5998.999	7311.716	9657.786
4879.864	6025.150	7353.293	9665.424
4884.915	6030.000	7372.118	9784.503
4889.042	6032.127	7383.981	
4933.209	6043.223	7435.368	
4965.08	6052.723	7438.899	
5009.334	6059.373	7471.164	
5017.163	6074.338	7488.872	
5037.7505	6096.163	7503.869	
5062.037	6098.803	7514.652	
5080.383	6105.635	7535.775	
5090.495	6114.923	7635.106	

Appendix B. Copper-Argon and Copper-Neon spectral lines used for wavelength calibration in the high-resolution spectra.

3088.19995	3766.119	4228.158	4545.08008	5090.495
3093.40186	3766.29	4229.870	4563.743	5105.541
3169.69995	3770.52002	4231.60	4579.350	5105.541
3181.10010	3777.13	4237.220	4589.899	5113.675
3247.54004	3780.840	4251.185	4596.097	5116.503
3273.96191	3803.17	4259.362	4598.763	5118.202
3279.82007	3829.77	4266.286	4609.567	5125.765
3307.22827	3834.679	4272.169	4628.441	5141.783
3323.75000	3850.581	4277.528	4637.233	5145.308
3334.87	3868.528	4282.898	4651.130	5151.391
3337.84009	3891.980	4290.40	4656.3923	5153.235
3350.92432	3925.719	4300.101	4657.901	5153.235
3376.43579	3928.623	4309.239	4702.316	5158.89
3378.28003	3932.547	4331.200	4704.395	5162.285
3417.90356	3946.097	4333.561	4715.344	5165.773
3447.70288	3947.505	4335.338	4721.59082	5176.229
3454.18994	3948.979	4345.168	4726.868	5177.540
3466.58008	3974.477	4348.064	4732.053	5187.746
3472.57104	3979.356	4352.205	4735.906	5188.612
3476.74731	3992.054	4362.066	4752.7313	5193.18
3501.217	3994.792	4367.832	4764.865	5203.895
3509.77856	4013.857	4370.753	4806.021	5208.863
3520.472	4022.66	4375.954	4821.924	5214.774
3520.50000	4033.809	4379.50	4827.34	5218.202
3530.38989	4035.460	4379.667	4837.312	5221.271
3535.31958	4038.804	4385.057	4847.810	5222.351
3548.51440	4042.894	4391.94	4865.911	5234.028
3554.30591	4044.418	4397.94	4876.261	5241.091
3556.90405	4045.965	4400.097	4879.864	5252.788
3559.50806	4052.921	4400.986	4884.915	5254.465
3561.03052	4062.84	4409.30	4888.261	5264.782
3568.53	4079.574	4413.20	4889.042	5274.04
3582.35449	4080.645	4420.912	4904.752	5280.09
3588.44067	4082.387	4426.001	4909.726	5286.887
3600.16919	4097.140	4428.54	4933.209	5292.517
3622.13745	4103.912	4430.189	4942.92139	5298.190
3639.83301	4112.815	4430.90	4956.750	5304.756
3655.27832	4128.640	4433.838	4957.033	5305.688
3660.43701	4131.724	4439.461	4965.080	5317.726
3664.11	4156.086	4448.879	4972.160	5326.396
3678.27002	4158.591	4474.759	5005.160	5329.698
3680.06079	4164.180	4480.36	5009.334	5330.77734
3694.20	4174.37	4481.811	5016.61	5330.778
3709.64	4179.297	4490.982	5017.163	5341.08984
3713.08	4181.884	4498.538	5031.3484	5343.284
3718.207	4198.317	4502.927	5037.7505	5345.81
3720.42651	4200.675	4509.39	5048.813	5347.412
3727.08	4217.431	4510.733	5054.178	5349.21
3729.30859	4218.665	4522.323	5060.079	5352.67
3737.889	4219.76	4530.82	5062.037	5358.363
3763.50537	4222.637	4536.552	5074.200	5360.012
3765.270	4226.988	4545.052	5080.383	5372.31

5373.494	5689.81641	6025.150	6304.7892	6678.277
5374.975	5689.91	6029.9971	6307.657	6684.293
5387.37	5691.661	6032.127	6309.160	6698.875
5393.560	5700.24	6043.223	6313.692	6698.876
5393.971	5700.873	6044.468	6324.416	6717.0428
5397.516	5712.48	6046.898	6328.165	6719.218
5400.56152	5719.225	6052.723	6333.146	6722.890
5402.605	5738.387	6059.373	6334.4279	6752.834
5407.344	5739.520	6064.751	6348.232	6754.30
5410.473	5748.29834	6074.3377	6364.894	6756.163
5412.66	5760.59	6081.243	6369.575	6766.612
5418.56	5764.41895	6085.880	6382.9914	6779.933
5421.352	5772.114	6090.785	6384.717	6808.531
5433.65	5774.009	6096.16309	6393.797	6818.291
5439.989	5782.130	6098.803	6394.729	6827.249
5442.248	5783.536	6101.162	6396.610	6851.884
5443.24	5786.555	6103.539	6399.207	6861.269
5451.652	5789.474	6104.590	6402.246	6863.535
5454.307	5802.080	6105.635	6403.013	6871.289
5457.416	5804.449	6113.466	6408.904	6879.582
5467.161	5811.42	6114.92334	6416.307	6887.088
5473.452	5812.760	6118.027	6418.370	6888.174
5490.119	5820.15576	6119.657	6422.897	6929.468
5494.41	5828.91	6123.362	6431.555	6937.664
5495.874	5834.263	6127.416	6437.600	6951.478
5506.113	5843.778	6128.44971	6441.900	6960.250
5524.957	5852.48779	6128.723	6443.860	6965.431
5528.93	5860.310	6138.656	6444.712	6992.213
5534.45	5870.454	6142.05	6466.553	7024.051
5540.90	5881.89502	6143.06250	6468.048	7030.251
5554.050	5882.624	6143.063	6472.429	7032.4127
5558.702	5888.584	6145.441	6481.145	7051.294
5572.541	5902.464	6150.384	6483.083	7059.109
5577.685	5912.085	6155.239	6493.969	7067.218
5581.871	5916.599	6163.5939	6499.106	7068.734
5588.720	5927.126	6165.123	6506.5279	7086.704
5597.476	5928.813	6170.174	6513.846	7107.478
5601.122	5940.855	6172.278	6532.8824	7112.2
5606.733	5942.669	6173.096	6538.112	7125.820
5618.010	5944.83398	6179.419	6594.66	7147.042
5620.913	5949.258	6182.146	6596.114	7158.839
5623.778	5964.472	6187.135	6598.678	7173.939
5625.678	5965.474	6201.100	6598.9529	7206.980
5637.32	5968.320	6212.503	6604.853	7245.167
5639.14	5971.601	6215.938	6620.967	7265.172
5641.375	5975.534	6217.2813	6632.084	7270.664
5648.686	5975.53418	6230.922	6638.221	7272.936
5650.704	5981.924	6239.712	6639.740	7304.82
5652.57	5985.914	6243.120	6643.698	7311.716
5654.457	5987.302	6248.406	6652.092	7316.005
5656.659	5989.339	6266.495	6656.939	7353.293
5659.127	5994.66	6278.645	6660.676	7372.118
5662.547	5998.999	6293.745	6664.051	7383.981
5672.952	6005.724	6295.446	6666.359	7392.980
5681.900	6013.678	6296.872	6677.282	7412.337

7425.294	7839.08	8248.681	8667.9442	8986.615
7435.368	7861.91	8248.70	8678.408	8988.58
7438.899	7868.195	8259.379	8679.491	9008.455
7471.164	7891.075	8259.380	8679.492	9017.596
7471.168	7895.83	8264.5225	8681.920	9057.23
7472.439	7902.57	8266.076	8681.922	9066.77
7484.24	7927.11	8277.60	8704.113	9073.34
7484.327	7933.13	8300.326	8704.15	9075.395
7488.872	7937.01	8365.746	8736.63	9122.9674
7500.656	7943.180	8377.607	8761.686	9148.68
7503.869	7943.181	8384.724	8761.691	9194.639
7510.408	7948.176	8408.210	8771.70	9198.61
7514.652	7972.01	8424.6475	8771.860	9201.76
7535.775	8006.157	8463.357	8771.885	9219.003
7544.046	8014.786	8484.444	8780.622	9220.05
7544.046	8046.117	8484.45	8783.755	9221.59
7562.01	8053.308	8495.36	8784.59	9354.220
7579.02	8053.309	8503.46	8799.088	9373.28
7589.32	8082.458	8521.4422	8840.82	9402.69
7618.33	8092.634	8544.695	8849.97	9425.38
7628.86	8095.55	8544.70	8853.867	9459.09
7635.106	8103.693	8571.353	8865.67	9459.21
7652.36	8115.311	8571.360	8865.755	9486.680
7670.04	8118.549	8582.91	8874.84	9534.17
7704.81	8118.550	8591.259	8905.658	9547.40
7723.7611	8128.908	8605.776	8919.50	9657.786
7724.63	8128.93	8620.460	8931.326	9665.424
7798.55	8136.406	8634.648	8962.147	9784.503
7814.33	8178.96	8647.05	8962.19	
7825.66	8235.30	8654.383	8970.98	

Appendix C. Laboratory spectral lines.

The Copper-Neon and Copper-Argon laboratory lines extracted from the ING technical notes no. 70, 125 and 126 and partially used to make the lists in Appendices A and B.

Line (Å)	Symbol	Line (Å)	Symbol	Line (Å)	Symbol	Line (Å)	Symbol
3088.19995		3729.309	ArII	3925.719	ArII	4231.60	NeII
3093.40186		3737.889	ArII	3928.623	ArII	4237.220	ArII
3169.69995		3765.270	ArII	3932.547	ArII	4251.185	ArI
3181.10010		3766.119	ArII	3946.097	ArII	4259.362	ArI
3247.54004		3780.840	ArII	3947.505	ArI	4266.286	ArI
3273.96191		3803.172	ArII	3948.979	ArI	4272.169	ArI
3279.82007		3834.679	ArI	3974.477	ArII	4277.528	ArII
3307.22827		3850.581	ArII	3979.356	ArII	4282.898	ArII
3323.75000	NeII	3868.528	ArII	3992.054	ArII	4290.40	NeII
3334.87	NeII	3891.980	ArII	3994.792	ArII	4300.101	ArI
3337.84009	ArII	3925.719	ArII	4013.857	ArII	4309.239	ArII
3350.92432	ArI	3928.623	ArII	4033.809	ArII	4331.200	ArII
3376.43579		3932.547	ArII	4035.460	ArII	4333.561	ArI
3378.28003	NeI	3946.097	ArII	4038.804	ArII	4335.338	ArI
3417.90356	ArII; NeI	3947.505	ArI	4042.894	ArII	4345.168	ArI
3447.70288	ArII; NeI	3948.979	ArI	4044.418	ArI	4348.064	ArII
3454.18994	NeI	3974.477	ArII	4045.965	ArI	4352.205	ArII
3466.58008	ArII	3979.356	ArII	4052.921	ArII	4362.066	ArII
3472.57104	NeI	3992.054	ArII	4072.11	ArII	4367.832	ArII
3476.74731	ArII	3994.792	ArII	4076.72	ArII	4370.753	ArII
3501.217	NeI	4013.857	ArII	4079.574	ArII	4375.954	ArII
3509.77856	NeI	4033.809	ArII	4080.645	ArII	4379.50	NeII
3520.472	NeI	4035.460	ArII	4082.387	ArII	4379.667	ArII
3520.50000	ArII	4038.804	ArII	4097.140	ArII	4385.057	ArII
3530.38989		4042.894	ArII	4103.912	ArII	4391.94	NeII
3535.31958	NeI	4044.418	ArI	4112.815	ArII	4397.94	NeII
3548.51440	ArII	4045.965	ArI	4128.640	ArII	4400.097	ArII
3554.30591	ArII	4052.921	ArII	4131.724	ArII	4400.986	ArII
3556.90405	ArII	4072.11	ArII	4156.086	ArII	4409.30	NeII
3559.50806	NeI	4076.72	ArII	4158.591	ArI	4413.20	NeII
3561.03052	ArII	4079.574	ArII	4164.180	ArI	4420.912	ArII
3568.53	NeI	4080.645	ArII	4174.37	NeI	4426.001	ArII
3582.35449		4082.387	ArII	4179.297	ArII	4428.54	NeII
3588.44067		4097.140	ArII	4181.884	ArI	4430.189	ArII
3600.16919	ArII	4103.912	ArII	4190.87	ArI	4430.90	NeII
3622.13745		3737.889	ArII	4198.317	ArI	4433.838	ArII
3639.83301		3765.270	ArII	4200.675	ArI	4439.461	ArII
3655.27832	ArII	3766.119	ArII	4217.431	ArII	4448.879	ArII
3660.43701		3780.840	ArII	4218.665	ArII	4474.759	ArII
3664.11	NeII	3803.172	ArII	4219.76	NeII	4480.36	
3678.27002	ArI	3834.679	ArI	4222.637	ArII	4481.811	ArII
3680.06079	NeI	3850.581	ArII	4226.988	ArII	4490.982	ArII
3694.20	NeII	3868.528	ArII	4228.158	ArII	4498.538	ArII
3718.207	ArII	3891.980	ArII	4229.870	ArII	4502.927	ArII

Line (Å)	Symbol						
4509.39		5037.7505	NeI	5347.412	ArI	5641.375	ArI
4510.733	ArI	5048.813	ArI	5349.21	NeI	5648.686	ArI
4522.323	ArI	5054.178	ArI	5352.67		5650.704	ArI
4530.82		5060.079	ArI	5358.363	ArII	5652.57	NeI
4536.552	ArII	5062.037	ArII	5360.012	NeI	5654.457	ArII
4545.052	ArII	5074.200	NeI	5372.31	NeI	5656.659	NeI
4545.08008		5080.383	NeI	5373.494	ArI	5659.127	ArI
4563.743	ArII	5090.495	ArII	5374.975	NeI	5662.547	NeI
4579.350	ArII	5105.541		5387.37	ArI	5672.952	ArII
4589.899	ArII	5113.675	NeI	5393.560	ArII	5681.900	ArI
4596.097	ArI	5116.503	NeI	5393.971	ArI	5689.81641	NeI
4598.763	ArII	5118.202	ArI	5397.516	ArII	5689.91	ArI
4609.567	ArII	5125.765	ArII	5400.56152	NeI	5691.661	ArII
4628.441	ArI	5141.783	ArII	5402.605	ArII	5700.24	
4637.233	ArII	5145.308	ArII	5407.344	ArII	5700.873	ArI
4651.130		5151.391	ArI	5410.473	ArI	5712.48	ArI
4656.3923	NeI	5153.235		5412.66	NeI	5719.225	NeI
4657.901	ArII	5158.89	NeI	5418.56	NeI	5738.387	ArI
4702.316	ArI	5162.285	ArI	5421.352	ArI	5739.520	ArI
4704.395	NeI	5165.773	ArII	5433.65	NeI	5748.29834	NeI
4715.344	NeI	5176.229	ArII	5439.989	ArI	5760.59	NeI
4721.59082		5177.540	ArI	5442.248	ArI	5764.41895	NeI
4726.868	ArII	5187.746	ArI	5443.24	ArI	5772.114	ArI
4732.053	ArII	5188.612	NeI	5451.652	ArI	5774.009	ArI
4735.906	ArII	5193.18	NeI	5454.307	ArII	5782.130	
4752.7313	NeI	5203.895	NeI	5457.416	ArI	5783.536	ArI
4764.865	ArII	5208.863	NeI	5467.161	ArI	5786.555	ArII
4806.021	ArII	5214.774	ArI	5473.452	ArI	5789.474	ArI
4821.924	NeI	5218.202		5490.119	ArI	5802.080	ArI
4827.34	NeI	5221.271	ArI	5494.41	NeI	5804.449	NeI
4837.312	NeI	5222.351	NeI	5495.874	ArI	5811.42	NeI
4847.810	ArII	5234.028	NeI	5506.113	ArI	5812.760	ArII
4865.911	ArII	5241.091	ArI	5524.957	ArI	5820.15576	NeI
4876.261	ArI	5252.788	ArI	5528.93	ArI	5828.91	NeI
4879.864	ArII	5254.465	ArI	5534.45	ArI	5834.263	ArI
4884.915	NeI	5264.782	ArII	5540.90	ArI	5843.778	ArII
4888.261	ArII	5274.04	NeI	5554.050	ArII	5852.48779	NeI
4889.042	ArII	5280.09	NeI	5558.702	ArI	5860.310	ArI
4904.752	ArII	5286.887	ArII	5572.541	ArI	5870.454	ArII
4909.726		5292.517		5577.685	ArII	5881.89502	NeI
4933.209	ArII	5298.190	NeI	5581.871	ArI	5882.624	ArI
4942.92139		5304.756	NeI	5588.720	ArI	5888.584	ArI
4956.750	ArI	5305.688	ArII	5597.476	ArI	5902.464	NeI
4957.033	NeI	5317.726	ArI	5601.122	ArI	5912.085	ArI
4965.080	ArII	5326.396	NeI	5606.733	ArI	5916.599	ArI
4972.160	ArII	5329.698	ArII	5618.010	ArII	5927.126	ArI
5005.160	NeI	5330.77734		5620.913	ArI	5928.813	ArI
5009.334	ArII	5330.778	NeI	5623.778	ArII	5940.855	ArI
5016.61		5341.08984		5625.678	ArII	5942.669	ArI
5017.163	ArII	5343.284	NeI	5637.32	ArI	5944.83398	NeI
5031.3484	NeI	5345.81	ArI	5639.14	ArI	5949.258	ArI

Line (Å)	Symbol	Line (Å)	Symbol	Line (Å)	Symbol	Line (Å)	Symbol
5964.472	ArI	6187.135	ArII	6513.846	NeI	7032.4127	NeI
5965.474	NeI	6212.503	ArI	6532.8824	ArI	7051.294	
5968.320	ArI	6215.938	ArI	6538.112	NeI	7059.109	NeI
5971.601	ArI	6217.2813	NeI	6594.66	ArI	7067.218	ArI
5975.534	NeI; ArI	6230.922	ArI	6596.114	ArI	7068.734	ArI
5981.924	ArI	6239.712	ArII	6598.678	ArI	7086.704	ArI
5985.914	ArII	6243.120	ArII	6598.9529	ArI	7107.478	ArI
5987.302	ArI	6248.406	ArI	6604.853	NeI	7112.2	
5989.339	ArI	6266.495	NeI	6620.967	ArI	7125.820	ArI
5994.66	ArI	6278.645	ArI	6632.084	ArII	7147.042	ArI
5998.999	ArI	6293.745		6638.221	ArI	7158.839	ArI
6005.724	ArI	6295.446	ArII	6639.740	ArII	7173.939	NeI
6013.678	ArI	6296.872	ArI	6643.698	ArII	7206.980	ArI
6025.150	ArI	6304.7892	NeI	6652.092	ArII	7245.167	NeI
6029.9971	NeI	6307.657	ArI	6656.939	NeI	7265.172	ArI
6032.127	ArI; NeI	6309.160	ArI	6660.676	ArI	7270.664	ArI
6043.223	ArI	6313.692		6664.051	ArI	7272.936	ArI
6044.468	ArII	6324.416	ArII	6666.359	ArI	7304.82	
6046.898	ArII	6328.165		6677.282	ArII	7311.716	ArI
6052.723	ArI	6333.146	ArII	6678.277	ArI	7316.005	ArI
6059.373	ArI; NeI	6334.4279	NeI	6684.293	NeI	7353.293	ArI
6064.751	ArI	6348.232	ArII	6698.875	ArII	7372.118	ArI
6074.3377	NeI	6364.894	ArI	6698.876	NeI	7383.981	ArI
6081.243	ArI	6369.575	ArI	6717.0428	ArI	7392.980	ArI
6085.880	ArI	6382.9914	NeI	6719.218	NeI	7412.337	ArI
6090.785	ArI	6384.717	ArI	6722.890	ArI	7425.294	ArI
6096.16309		6393.797	ArII	6752.834	ArI	7435.368	ArI
6098.803	ArI	6394.729	ArII	6754.30	ArI	7438.899	NeI
6101.162	ArI	6396.610	ArII	6756.163	ArI	7471.164	ArI
6103.539	ArII	6399.207	ArII	6766.612	ArI	7471.168	
6104.590	ArI	6402.246	NeI	6779.933	ArI	7472.439	NeI
6105.635	ArI	6403.013	ArII	6808.531	ArI	7484.24	
6113.466	ArI	6408.904	ArII	6818.291	ArI	7484.327	ArI
6114.92334	NeI; ArII	6416.307	ArI	6827.249	ArI	7488.872	NeI
6118.027	NeI	6418.370	ArII	6851.884	ArI	7500.656	ArI
6119.657	ArI	6422.897	ArII	6861.269	ArII	7503.869	ArI
6123.362	ArII	6431.555	ArI	6863.535	ArII	7510.408	ArI
6127.416	ArI	6437.600		6871.289	ArI	7514.652	ArI
6128.44971	NeI	6441.900	ArII	6879.582	ArI	7535.775	NeI
6128.723	ArI	6443.860	ArII	6887.088	ArI	7544.046	NeI
6138.656	ArII	6444.712	ArII	6888.174	ArI	7562.01	
6142.05	ArI	6466.553		6929.468	NeI	7579.02	
6143.063	NeI	6468.048	ArI	6937.664	ArI	7589.32	
6145.441	ArI	6472.429	ArII	6951.478	ArI	7618.33	ArI
6150.384		6481.145	ArII	6960.250	ArI	7628.86	ArI
6155.239	ArI/NeI	6483.083	ArII	6965.431	ArI	7635.106	ArI
6173.096	ArI	6493.969	ArII; NeI	6992.213	ArI	7652.36	
6179.419	ArI	6499.106	ArI	7024.051	NeI	7670.04	ArI
6182.146		6506.5279	ArI	7030.251	ArI	7704.81	

Line (Å)	Symbol	Line (Å)	Symbol	Line (Å)	Symbol
7723.7611		8484.45	NeI	9066.77	
7724.63	NeI	8495.36	NeI	9073.34	ArI
7798.55	ArI	8503.46		9075.395	ArI
7814.33	ArI	8521.4422	ArI	9122.9674	ArI
7825.66		8544.695		9148.68	NeI
7839.08	NeI	8544.70	NeI	9194.639	ArI
7861.91	ArI	8571.353		9198.61	ArI
7868.195	ArI	8571.360	NeI	9201.76	NeI
7891.075	ArI	8582.91	NeI	9219.003	ArII
7895.83		8591.259	NeI	9220.05	NeI
7902.57		8605.776	ArI	9221.59	NeI
7927.11	NeI	8620.460	ArI	9224.499	ArI
7933.13		8634.648	NeI	9226.67	NeI
7937.01	NeI	8647.05	NeI	9275.53	NeI
7943.180	NeI	8654.383	ArI;NeI	9291.531	ArI
7943.181		8667.9442	ArI	9300.85	NeI
7948.176	ArI	8678.408	ArI	9310.58	NeI
7972.01		8679.491	NeI	9326.52	NeI
8006.157	ArI	8679.492		9354.220	ArI
8014.786	ArI	8681.920	NeI	9373.28	NeI
8046.117	ArI	8681.922		9402.69	ArI
8053.308		8704.113		9425.38	NeI
8053.309	ArI	8704.15	NeI	9459.09	ArI
8082.458	NeI	8736.63	ArI	9459.21	NeI
8092.634		8761.686	ArI	9486.680	NeI
8095.55		8761.691		9534.17	NeI
8103.693	ArI	8771.70	NeI	9547.40	NeI
8115.311	ArI	8771.860	ArII	9657.786	ArI
8118.549		8771.885		9665.424	NeI
8118.550	NeI	8780.622	NeI	9784.503	ArI
8128.908		8783.755	NeI		
8128.93	NeI	8784.59	ArI		
8136.406	NeI	8799.088	ArI		
8178.96		8840.82	ArI		
8235.30		8849.97	ArI		
8248.681		8853.867	NeI		
8248.70	NeI	8865.67	NeI		
8259.379		8865.755			
8259.380	NeI	8874.84	ArI		
8264.5225	ArI	8905.658	ArII		
8266.076	NeI	8919.50	NeI		
8277.60		8931.326	ArII		
8300.326	NeI	8962.147	ArI		
8365.746	NeI	8962.19			
8377.607	NeI	8970.98			
8384.724	ArI	8986.615	ArII		
8408.210	ArI	8988.58			
8418.427	NeI	9008.455	ArII		
8424.6475	ArI				
8463.357	NeI	9017.596	ArII		
8484.444	ArI	9057.23	ArI		

Appendix D. Atlas plotting code.

This appendix gives the IDL code for plotting the arc spectra with the labels and ticks on some identified lines. The inputs are two files, one containing the wavelengths and the fluxes, and another one with the wavelengths of the lines to be marked. The output is a formatted pdf file showing five plots: one covers the entire spectrum and the other four zoom in four splits, in order to facilitate the line identification.

```
;*****  
; all.pro procedure  
; January 2013  
; Authors: Hassan Fathivavsari, Javier Mendez and Liam Hardy  
;*****  
; It requires files *_XXXX_c*.txt, and ticksall_* in the  
; same directory  
;*****  
; *_XXXX_c*.txt is the 1-D ascii file containing two columns:  
; wavelength and flux.  
;*****  
; ticksall_* contains all the lines to mark. Example:  
; 5100 5100 5100  
; 5105.54 5105.54 5105.54  
; 5330.78 5330.78 5330.78  
; 5400.56 5400.56 5400.56  
; 5500 5500 5500  
; The 3 columns can be generated from a one-single column file  
; with the following procedure:  
;  
; pro file,filename1,2 =enw + '_' + arc + '.txt'  
; n=(filename1)  
; readcol,1,ame2  
; for i=do begin  
; if (varl[i] GT min) AND (varl[i] LT max) then begin  
; printf,i],rmat=F7.2)'  
; endif  
; endfor  
; close,/all  
; end  
;  
;*****  
; Execute as follows:  
; IDL>  
all,'R900V','6500','cuarcune','CuAr+CuNe','low','high','low','low','high',3500  
,5800,6600,8500,10500,5000  
;*****  
  
pro all,gra,cenw,arc,arc2,exp1,exp2,exp3,exp4,exp5,x1,x2,x3,x4,x5,xmargin  
set_plot,'ps'  
  
device,filename=gra + '_' + cenw + '_' + arc +  
.ps',/color,bits_per_pixel=8,/landscape  
loadct, 39  
!p.multi=[0,1,3]  
  
ticksfile='ticksall_-' + gra + '_' + cenw + '_' + arc + '.txt'  
maximum = fltarr(5)  
mm = fltarr(9)  
  
filename_H=gra + '_' + cenw + '_' + arc + '_' + exp2 + '.txt'  
n=file_lines(filename_H)  
data_H=fltarr(2,n)  
get_lun,lun  
openr,lun,filename_H  
readf,lun,data_H
```

```

free_lun,lun
wave_H=data_H(0,*)
flux_H=data_H(1,*)

filename_exp1=gra + '_' + cenw + '_' + arc + '_' + exp1 + '.txt'
n=file_lines(filename_exp1)
data_exp1=fltarr(2,n)
get_lun,lun
openr,lun,filename_exp1
readf,lun,data_exp1
free_lun,lun
wave_exp1=data_exp1(0,*)
flux_exp1=data_exp1(1,*)

filename_exp2=gra + '_' + cenw + '_' + arc + '_' + exp2 + '.txt'
n=file_lines(filename_exp2)
data_exp2=fltarr(2,n)
get_lun,lun
openr,lun,filename_exp2
readf,lun,data_exp2
free_lun,lun
wave_exp2=data_exp2(0,*)
flux_exp2=data_exp2(1,*)

filename_exp3=gra + '_' + cenw + '_' + arc + '_' + exp3 + '.txt'
n=file_lines(filename_exp3)
data_exp3=fltarr(2,n)
get_lun,lun
openr,lun,filename_exp3
readf,lun,data_exp3
free_lun,lun
wave_exp3=data_exp3(0,*)
flux_exp3=data_exp3(1,*)

filename_exp4=gra + '_' + cenw + '_' + arc + '_' + exp4 + '.txt'
n=file_lines(filename_exp4)
data_exp4=fltarr(2,n)
get_lun,lun
openr,lun,filename_exp4
readf,lun,data_exp4
free_lun,lun
wave_exp4=data_exp4(0,*)
flux_exp4=data_exp4(1,*)

filename_exp5=gra + '_' + cenw + '_' + arc + '_' + exp5 + '.txt'
n=file_lines(filename_exp5)
data_exp5=fltarr(2,n)
get_lun,lun
openr,lun,filename_exp5
readf,lun,data_exp5
free_lun,lun
wave_exp5=data_exp5(0,*)
flux_exp5=data_exp5(1,*)

;*****
;***** X-Range Definition *****
;*****

xran=[fix(x1),fix(x2),fix(x3),fix(x4),fix(x5)]

x0b = xran(0)
x0e = xran(4)
x1b = xran(0)
x1e = xran(1)
x2b = xran(1)
x2e = xran(2)

```

```

x3b = xran(2)
x3e = xran(3)
x4b = xran(3)
x4e = xran(4)

;***** MAX Code *****
;***** MAX Code *****
;***** MAX Code *****

readcol, filename_exp1, var1,var2, f='(d,d)'
max=0

for i=value_locate(wave_exp1, x0b),value_locate(wave_exp1, x4e) do begin
if var2(i) gt max then max = var2(i)
endfor

maximum(0) = max

!Y.MARGIN=[4,6]
labels = [ ' ', ' ', ' ', ' ', ' ']

plot, wave_exp1, flux_exp1 , xrange=[x0b, x0e],/xstyle , yrange=[0, $ 
max+0.45*max],/ystyle , xtickinterval=1000 , ytickinterval = 30000000 ,$ 
yticks=0 , thick = 0.65 , xticklen = 0.02 , yticklen=0.01 ,xcharsize=1.7 ,$ 
y tickname=labels ; , x tickname=labelsx

xyouts,xmargin,max+0.53*max, gra + ' !6!6!4k!3!6c = ' + cenw + ' $ 
' + arc2 + ' ' , charsize=1.5, charthick=0.8 ,/data

;***** Ticks Mark *****
;***** Ticks Mark *****

readcol, ticksfile, var1, var2, var3

t = var3
n = n_elements(var3)

dx = x0e - x0b
xx = 0.003666141 * dx

buffer = fltarr(2)
ticks = fltarr(n)

m = 0

for k=1,n-1 do begin
buffer(0) = t(k-1)
buffer(1) = t(k)

msb0 = value_locate(wave_exp1, buffer(0)) - 0
msb1 = value_locate(wave_exp1, buffer(1)) - 0

for j = 0, 6 do begin
mm(j) = flux_exp1(msb0 -4 + j)
endfor
mm0 = max(mm)

for j = 0, 6 do begin
mm(j) = flux_exp1(msb1 -4 + j)
endfor

mm1 = max(mm)

IF buffer(1) LT (buffer(0)+xx) THEN BEGIN

```

```

IF mm1 GT mm0 THEN ticks(m) = buffer(1) ELSE ticks(m) = buffer(0)
m = m + 1
ENDIF ELSE BEGIN
ticks(m) = buffer(0)
m = m + 1
ENDELSE
endfor
print, ticks

;***** This Removes the Too Close Wavelengths *****
;t = ticks
n = n_elements(t)
m = 0
ticks2 = fltarr(n)
dx = x0e - x0b
xx = 0.003666141 * dx

for k = 1,n-1 do begin
IF ( t(k) GE (t(k-1)+xx) ) THEN BEGIN
ticks2(m) = t(k)
m = m + 1
ENDIF
endfor

t = ticks2

for i=0,m-1 do begin
msb = value_locate(wave_exp1, t(i)) -0
for j = 0, 8 do begin
mm(j) = flux_exp1(msb - 4 + j)
endfor
y = max(mm)
plots, [t(i),t(i)], [y + 0.07*max, y+ 3*0.05*max], thick=0.8
xyouts,t(i)+5,y+1.5*0.09*max,t(i) , charsize=0.4, alignment=0.2 ,
orientation=90, charthick=0.8 ,/data
endfor

;***** WINDOW For No. "" 1 "" *****
!p.multi=[4,2,3]
labels = [ ' ', ' ', ' ', ' ', ' ' ]
!Y.MARGIN=[4,2]

;***** MAX Code *****
;***** readcol, filename_exp2, var1,var2, f='(d,d)'
max=0
for i=value_locate(wave_exp2, xlb),value_locate(wave_exp2, xle) do begin
if var2(i) gt max then max = var2(i)
endfor

maximum(1) = max

```

```

plot, wave_exp2, flux_exp2 , psym= 10 , xrange=[xlb, xle],/xstyle, yrangle=[0,$
max+0.45*max],/ystyle , xtickinterval=200 , ytickinterval = 30000000 ,$  

yticks=0 , thick = 0.65 , xticklen = 0.02 , xminor=2 ,xcharsize=1.5 , $  

y tickname=labels

;***** Ticks Mark *****  

readcol, ticksfile, var1,var2,var3;, f='(d,d,d)'  

t = var3  

n=n_elements(var3)  

for i=1,n-2 do begin  

msb = value_locate(wave_exp2, t(i)) -0  

for j = 0, 8 do begin  

mm(j) = flux_exp2(msb -4 + j)  

endfor  

y = max(mm)  

IF (t(i) gt xlb) AND (t(i) lt xle) AND (t(i) ne 10) THEN BEGIN  

plots, [t(i),t(i)], [y + 0.07*max, y+ 3*0.05*max], thick=0.8  

xyouts,t(i)+2,y+1.5*0.09*max,t(i) , charsize=0.4, alignment=0.2 , $  

orientation=90, charthick=0.8 ,/data  

endif  

endfor  

;***** WINDOW For No. "" 2 "" *****  

!p.multi=[3,2,3]  

labels = [ ' ', ' ', ' ', ' ', ' ' ]  

;***** MAX Code *****  

;*****  

;*****  

readcol, filename_exp3, var1,var2, f='(d,d)'  

max=0  

for i=value_locate(wave_exp3, x2b),value_locate(wave_exp3, x2e) do begin  

if var2(i) gt max then max = var2(i)  

endfor  

maximum(2) = max  

plot, wave_exp3, flux_exp3 , psym= 10 , xrange=[x2b, x2e],/xstyle, yrangle=[0, $  

max+0.45*max],/ystyle , xtickinterval=200 , ytickinterval = 30000000 ,$  

yticks=0 , thick = 0.65 , xticklen = 0.02 , xminor=2 ,xcharsize=1.5 , $  

y tickname=labels

;***** Ticks Mark *****  

readcol, ticksfile, var1,var2,var3;, f='(d,d,d)'  

t = var3  

n=n_elements(var3)  

for i=1,n-2 do begin  

msb = value_locate(wave_exp3, t(i)) -0  

for j = 0, 8 do begin  

mm(j) = flux_exp3(msb -4 + j)  

endfor  

y = max(mm)  

IF (t(i) gt x2b) AND (t(i) lt x2e) THEN BEGIN  

plots, [t(i),t(i)], [y + 0.07*max, y+ 3*0.05*max], thick=0.8  

xyouts,t(i)+2,y+1.5*0.09*max,t(i) , charsize=0.4, alignment=0.2, $  

orientation=90, charthick=0.8 ,/data  

endif

```

```

endfor

;***** WINDOW For No. "" 3 ""

!p.multi=[2,2,3]
labels = [ ' ', ' ', ' ', ' ', ' ']

;*****
;***** MAX Code *****
;*****

readcol, filename_exp4, var1,var2, f='(d,d)'
max=0
for i=value_locate(wave_exp4, x3b),value_locate(wave_exp4, x3e) do begin
if var2(i) gt max then max = var2(i)
endfor
maximum(3) = max

plot, wave_exp4, flux_exp4, psym= 10, xrange=[x3b, x3e],/xstyle , yrange=[0, $ max+0.45*max],/ystyle , xtickinterval=200 , ytickinterval = 30000000 ,$ yticks=0 , thick = 0.65 , xticklen = 0.02 , xminor=2 ,xcharsize=1.5 , $ ytickname=labels ; , xtickname = labelsx

;***** Ticks Mark *****

readcol, ticksfile, var1,var2,var3;, f='(d,d,d)'

t = var3

n=n_elements(var3)

for i=1,n-2 do begin

msb = value_locate(wave_exp4, t(i)) -0

for j = 0, 8 do begin
mm(j) = flux_exp4(msb -4 + j)
endfor

y = max(mm)

IF (t(i) gt x3b) AND (t(i) lt x3e) THEN BEGIN

plots, [t(i),t(i)], [y + 0.07*max, y+ 3*0.05*max], thick=0.8
xyouts,t(i)+1,y+1.5*0.09*max,t(i) , charsize=0.4, alignment=0.2 ,$ orientation=90, charthick=0.8 ,/data

endif

endfor

;***** WINDOW For No. "" 4 ""

!p.multi=[1,2,3]
labels = [ ' ', ' ', ' ', ' ', ' ']

;*****
;***** MAX Code *****
;*****



readcol, filename_exp5, var1,var2, f='(d,d)'
max=0
for i=value_locate(wave_exp5, x4b),value_locate(wave_exp5, x4e) do begin
if var2(i) gt max then max = var2(i)
endfor

```

```

maximum(4) = max

plot, wave_exp5, flux_exp5 , psym= 10, xrange=[x4b, x4e],/xstyle, yrange=[0, $ 
max+0.45*max],/ystyle , xtickinterval=200 , ytickinterval = 30000000 ,$ 
yticks=0 , thick = 0.65 , xticklen = 0.02 , xminor=2 ,xcharsize=1.5, $ 
y tickname=labels , x tickname=labelsx

;***** Ticks Mark *****

readcol, ticksfile, var1,var2,var3;, f='(d,d,d)'

t = var3

n=n_elements(var3)

for i=1,n-2 do begin

msb = value_locate(wave_exp5, t(i)) -0

for j = 0, 8 do begin
mm(j) = flux_exp5(msb -4 + j)
endfor

y = max(mm)

IF (t(i) gt x4b) AND (t(i) lt x4e) THEN BEGIN

plots, [t(i),t(i)], [y + 0.07*max, y+ 3*0.05*max], thick=0.8

xyouts,t(i)+1,y+1.5*0.09*max,t(i) , charsize=0.4, alignment=0.2 ,
orientation=90, charthick=0.8 ,/data

endif

endfor

device, /close

spawn, 'rm -f out.pdf'
spawn, 'rm -f out2.pdf'
spawn, 'rm -f ' + gra + '_' + cenw + '_' + arc + '.pdf'

spawn, 'ps2pdf13 ' + gra + '_' + cenw + '_' + arc + '.ps out.pdf'

spawn, 'pdftk out.pdf cat 1-endW output out2.pdf'

spawn, 'acroread out2.pdf &'

spawn, 'pdftk out.pdf cat 1-endN output ' + gra + '_' + cenw + '_' + arc +
'.pdf'

print,'Output saved to ' + gra + '_' + cenw + '_' + arc + '.pdf'

end

```

Appendix E. Calibration observing script.

This appendix gives the c-shell code for a script which will take calibration frames (arcs/flats) with IDS. A choice of lamp configuration is required, as well as short/long exposure times. The script can be called with the lamp and exposure time choices in the same line, as `source calib_ids.csh CUAR 5 120', or if the variables are missing, the user will be prompted for the values. The previous/nominal values are offered at the prompt.

```
# Script for taking arcs with IDS
#
# Version 1.0 (August 2012)
#
# Author: Liam Hardy

set noclobber

set startup = "This script requires 3 input parameters, and should be
called as 'calib_ids.csh lamp exp1 exp2'. Enter 'none' as the 3rd
parameter if you wish to only take one exposure. The script assumes
the CCD, grating, slit and filter wheels are already set-up as
required. For flats, enter the exposure time as exp1, and the number
of exposures required as exp2."
#echo $startup

if ($?LAMP == 0) then
    setenv LAMP CuAr+CuNe
endif
if ($?EXP1 == 0) then
    setenv EXP1 5
endif
if ($?EXP2 == 0) then
    setenv EXP2 60
endif

echo -----
-----
switch ($#argv)
case 0:
echo 'Please choose a lamp configuration from CUAR, CUNE, CUAR+CUNE,
or W ('$LAMP '):'
set temp1 = $<
if ($temp1 == '') then
    set lamp = $LAMP
else
    set lamp = $temp1
endif
echo 'Please choose the short exposure time ('$EXP1 'seconds):'
set temp1 = $<
if ($temp1 == '') then
    set exp1 = $EXP1
else
    set exp1 = $temp1
endif
echo 'Please choose the long exposure time or the number of flats
requested if taking flats. ('$EXP2 'seconds):'
set temp1 = $<
if ($temp1 == '') then
    set exp2 = $EXP2
else
    set exp2 = $temp1
endif
breaksw
```

```

case 1:
set lamp = $1
echo 'You have chosen' $lamp
echo 'Please choose the short exposure time ('$EXP1 'seconds):'
set temp1 = $<
if ($temp1 == '') then
    set exp1 = $EXP1
else
    set exp1 = $temp1
endif
echo 'Please choose the long exposure time or the number of flats
requested if taking flats. ('$EXP2 'seconds):'
set temp1 = $<
if ($temp1 == '') then
    set exp2 = $EXP2
else
    set exp2 = $temp1
endif
breaksw

case 2:
set lamp = $1
set exp1 = $2
echo 'You have chosen the following lamp(s):' $lamp 'with a short
exposure time of' $exp1
echo 'Please choose the long exposure time or the number of flats
requested if taking flats. ('$EXP2 'seconds):'
set temp1 = $<
if ($temp1 == '') then
    set exp2 = $EXP2
else
    set exp2 = $temp1
endif
breaksw

case 3:
set lamp = $1
set exp1 = $2
set exp2 = $3
breaksw

default:
echo "Error!" $startup
exit

endsw

echo "Lamp = " $lamp
echo "Short exposure time= " $exp1
echo "Long exposure time (/number of flats) = " $exp2
echo "Is this correct? (y/n)"
if ($< == 'y') then
    echo "Starting arc process..."
else
    echo "Goodbye!"
    setenv LAMP $lamp
    setenv EXP1 $exp1
    setenv EXP2 $exp2
    exit
endif

compmirror in #insert mirror for calibration lamps

switch ( $lamp ) #start switch statement for each lamp config
case '[Cc] [Uu] [Aa] [Rr]':
#echo 'CuAr';
complamps CuAr

```

```

arc $exp1
if ($exp2 == 'none' || $exp2 == 'None' || $exp2 == 'NONE') then
    breaksw;
endif
arc $exp2
breaksw;

case '[Cc] [Uu] [Nn] [Ee]' :
#echo 'CuNe';
complamps CuNe
arc $exp1
if ($exp2 == 'none' || $exp2 == 'None' || $exp2 == 'NONE') then
    breaksw;
endif
arc $exp2
breaksw;

case '[Cc] [Uu] [Aa] [Rr] + [Cc] [Uu] [Nn] [Ee]' :
#echo 'CuAr+CuNe';
complamps CuAr+CuNe
arc $exp1
if ($exp2 == 'none' || $exp2 == 'None' || $exp2 == 'NONE') then
    breaksw;
endif
arc $exp2
breaksw;

case '[Cc] [Uu] [Nn] [Ee] + [Cc] [Uu] [Aa] [Rr]' :
#echo 'CuAr+CuNe';
complamps CuAr+CuNe
arc $exp1
if ($exp2 == 'none' || $exp2 == 'None' || $exp2 == 'NONE') then
    breaksw;
endif
arc $exp2
breaksw;

case '[Ww]' :
#echo 'W';
complamps W
multflat $exp2 $exp1
breaksw;

default:
echo "Error\! Unknown lamp configuration"
echo $startup
exit 2
endsw #end lamp config switch

complamps off #switch off lamps
compmirror out #return to viewing sky

setenv LAMP $lamp
setenv EXP1 $exp1
setenv EXP2 $exp2

beep

```