Operating Instructions for R2D1, the VLPC Single Cassette Cryostat

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1 Overview

This is a brief summary of instructions for
a) cooling the VLPC's down to operating temperature, and
b) VLPC operation itself, including the verification of proper functioning by checking the noise level using the QPA02 amplifier boards.
c) Temperature calibration data for cassette 26 are also included.

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2 Description of the VLPC Cryo Rack

From top to bottom:

- *Flow Controller Command Module* for R2D1 annular flow, with LCD display and flow setting (command) and flow readout (flow) selector switch (right).
- VLPC cryo *Cassette In(t)erface Chassis*; includes *preamp power supplies* for four QPA02 preamp boards (left side, dip switches with green indicator lamps), cassette slot (= preamp board) *card B - card C* temperature sensor selector switch (middle), and four *VLPC bias voltage* LEMO interface plugs (right side).
- Anafaze Temperature Controller.
- VLPC *Bias Supply*, with internal/external reference voltage selector switch (top left), internal reference dial (left), bias trip indicator lights (middle), and reset button (right). Channels 2 - 5 are wired to preamp (or SVX) card auxiliary cable connectors A to D.

- VLPC cryo control screen.
- VLPC cryo control computer.

3 Cooldown Instructions

Detailed cryogenics instructions are in the cryo folder (labelled *'Cryogenic Procedures for the VLPC Single Cassette Cryostat'*). Instructions for the use of the Anafaze temperature controller are in the VLPC cryo log book (labelled *'VLPC Cryogenic Operations Log'*), on page 3. This text is just a brief summary.

- Connect a 500 liter dewar to the R2D1 cryostat with a transfer line. Please call Bob Barger (x2820) or Stefan Grünendahl (x8760) if you are not 100% sure about how to do this.
- Pressurize the dewar to 8 psi. This can be done by using the heater built into most of the storage dewars. Alternatively, the external helium gas supply can be used. Again, if in doubt, call Bob or me.
- Meanwhile, pump and purge the cassette space.
- Make sure that auxiliary connector A is plugged into a board (either QPA02 or SVX) in cassette slot A (top, right hand side), and at least one of connector B or C into a board in the corresponding slot. (The sensor selector switch on the interface chassis (above the cryo control computer screen) has to be set to the corresponding slot.)
- Start the cryo control program ANA-EV, using job setup R2D1.
- Log the beginning of the cooldown in the *VLPC Cryogenic Operations Log*.
- Edit loop 3, the cryostat temperature loop, and change the loop operation from manual to automatic. This opens the R2D1 liquid helium inlet valve, and thus starts the cooldown. The standard set point for 6.5 K VLPC operation is 380 Ohm.
- The flow controller should be set to 1.85 (liter/minute), and read (once helium is flowing) accordingly about 1.87. For faster cool down, the annular flow can be increased (to the maximum possible, 3.8).
- Similarly, for faster cool down the bypass valve (labelled *vent*), bottom left on the cryo control panel, can be opened to bypass the main exhaust flow meter.
- Loop 1, the cassette temperature loop, should already be set to automatic operation, at about 521 Ohm = 6.5 K. A table showing the correspondence between temperature and resistance can be found in chapter 6 of this manual.
- As the cassette temperature approaches the set point, the bypass valve should be closed, and the annular flow set to the default value.

Cooling down takes about 30 to 45 minutes. After reaching the operating temperature, cassette temperature stabilization may take another 10 to 15 minutes. Cryostat temperature oscillations will probably not die out, and will also be reflected in slight VLPC temperature variations. The *cassette temperature* (loop 3) fluctuations should be of order 10 millikelvin (1 Ohm = 10 millikelvin for a sensor at 6.5 Kelvin = 500 Ohm), and less than 100 millikelvin (= 10 Ohm at 500 Ohm). Steady state helium exhaust flow ideally should be around 70 scfm (standard cubic feet per minute), more typically around 100 scfm.

4 VLPC Operation

Once the VLPC's are at operating temperature, the following steps will power them up:

- Select *internal reference* for the VLPC bias power supply (black rack mounted unit above cryo computer, top left hand side toggle switch, up position).
- Using the left 10-turn potentiometer, set the *bias voltage*; reasonable values are between 6 and 7 Volt.
- *Bias trips* are indicated by red LED's on the power supply front panel separately for each of the four 32 channel cassette slots (=preamp boards), and can be *reset* by pressing the red reset button (top right on the VLPC bias power supply front panel).

5 Verifying VLPC Operation with a QPA02 Board

To check VLPC operation with a QPA02 preamplifier board:

- On the interface chassis, switch power on for the particular QPA02 board position being used (A – D).
- Connect a scope probe to one of the QPA02 board output connector pins, and look for a VLPC single photoelectron signal of about 50 mV amplitude and 10 ns width. The pins most easily accessible (long outside leads) carry a signal of negative polarity. The single photoelectron band should be clearly separated and distinguishable from the preamplifier noise.
- If no single PE band is visible, one of the following may be the reason:
  - The VLPC bias tripped. Reset it, dial a lower voltage if necessary.
  - The VLPC gain is insufficient, or the dark count rate is too low. Dial a higher bias voltage.
  - The VLPC temperature is too low; in this case rising the bias voltage might not lead to an observable single PE noise signal. Select a higher temperature. 6.5 K should be fine.
  - You picked a dead VLPC channel. (Cassette 26 has six of those.) Attach the probe to a different VLPC channel.

6 Resistance vs. Temperature Calibration Data for VLPC Cassette 26

Column ‘B1’ contains the resistance data (in Ohm) for the temperature sensor read out via slot ‘B’ in the 128 channel cassette 26. The first column shows the temperature in Kelvin.

940214	-B1	-B2	-B3	-B4	-B5	-B6
293.477	100.31	101.47	100.71	99.75	101.33	101.35
77.828	118.39	122.85	118.54	114.98	123.28	123.04
56.171	129.75	135.22	129.84	125.86	135.31	135.06
51.195	133.65	139.28	133.62	129.47	139.46	139.14
46.159	138.34	144.37	138.18	133.98	144.34	143.96
41.037	144.11	150.62	144.06	139.61	150.54	149.99
36.125	151.43	158.35	151.24	146.61	157.84	157.30
31.045	160.91	168.48	160.62	155.84	167.65	167.00
30.524	162.16	169.84	161.84	157.02	168.85	168.17
29.991	163.62	171.37	163.29	158.37	170.32	169.62
29.442	164.72	172.59	164.49	159.50	171.42	170.63
28.939	166.08	173.88	165.58	160.82	172.81	172.02
28.394	167.51	175.45	166.97	162.07	174.15	173.45
27.788	169.13	177.29	168.73	163.63	175.88	175.07
27.192	170.73	178.93	170.25	165.26	177.42	176.63
26.640	172.42	180.79	172.08	167.03	179.34	178.51
25.394	176.39	184.90	175.80	170.66	183.21	182.42
24.708	178.65	187.41	178.14	172.96	185.60	184.60
24.139	180.82	189.55	180.21	174.98	187.60	186.68
23.602	182.88	191.90	182.31	177.08	189.83	188.73
23.096	184.91	193.98	184.23	179.01	191.72	190.74
22.637	186.68	195.88	185.98	180.73	193.59	192.54
22.179	188.69	197.96	187.83	182.58	195.54	194.39
21.723	190.89	200.34	190.08	184.72	197.76	196.61
21.205	193.34	202.96	192.41	187.14	200.25	198.89
20.657	196.06	205.76	195.06	189.84	202.91	201.79
20.106	199.06	209.13	198.14	192.72	205.91	204.59
19.572	202.13	212.21	201.10	195.70	208.92	207.62
19.068	205.04	215.36	203.96	198.43	211.90	210.47
18.576	208.46	218.77	207.13	201.58	215.24	213.67
18.076	211.79	222.55	210.49	204.92	218.43	216.99
17.495	215.93	226.88	214.60	209.04	222.65	221.08
17.004	219.74	230.80	218.48	212.74	226.41	224.71
16.530	223.78	234.93	222.08	216.34	230.20	228.34
16.058	227.92	239.44	226.26	220.48	234.27	232.51
15.605	232.03	243.86	230.36	224.52	238.37	236.48
15.069	237.55	249.82	235.59	229.88	243.74	241.76
14.646	242.19	254.58	240.22	234.37	248.34	246.24

14.133	248.39	261.13	246.28	240.23	254.27	252.06
13.494	256.15	269.30	253.61	247.76	261.83	259.56
13.039	263.07	276.75	260.56	254.59	268.66	265.93
12.583	270.53	284.46	267.69	261.74	275.76	273.03
12.127	278.25	292.51	275.20	269.14	283.19	280.31
11.607	288.35	303.32	284.99	278.95	292.78	289.81
11.070	299.67	315.31	295.99	289.75	303.81	300.43
10.572	312.10	328.19	308.06	301.78	315.46	311.78
10.095	324.77	341.67	320.33	314.05	327.79	323.84
9.573	341.16	359.07	336.27	330.02	343.34	338.97
9.154	356.05	374.56	350.50	344.20	357.29	352.68
8.628	377.74	397.60	371.34	365.27	377.71	372.44
8.456	385.62	405.85	379.06	372.86	385.21	379.70
8.371	389.94	410.19	383.07	377.02	389.21	383.44
8.277	394.18	414.84	387.25	381.08	393.20	387.47
8.177	399.09	420.02	391.99	386.02	397.76	391.85
8.071	404.72	425.82	397.22	391.25	403.08	397.10
7.962	410.37	431.85	402.55	396.79	408.28	402.28
7.857	416.53	438.36	408.58	402.76	414.07	407.89
7.749	423.09	445.35	415.01	409.08	420.13	413.72
7.636	430.25	452.76	421.84	415.95	426.75	420.22
7.523	437.59	460.62	428.96	423.16	433.68	426.82
7.403	445.67	468.85	436.50	430.84	441.10	433.93
7.283	453.94	477.75	444.58	438.92	448.74	441.47
7.162	462.83	487.15	453.17	447.47	457.04	449.49
7.036	472.00	496.79	461.95	456.27	465.47	457.69
6.917	481.83	507.21	471.45	465.80	474.55	466.34
6.802	492.21	518.08	481.33	475.77	484.08	475.65
6.684	502.72	529.15	491.37	485.92	493.64	485.13
6.567	513.99	541.12	502.23	497.03	504.10	495.11
6.448	525.52	553.38	513.15	508.14	514.64	505.48
6.329	538.62	567.07	525.73	520.59	526.56	516.84
6.207	551.41	580.66	538.11	533.13	538.41	528.33
6.048	571.52	601.89	557.32	552.50	556.78	546.03
5.938	585.73	616.74	570.78	566.15	569.43	558.35
5.833	600.29	632.20	584.71	580.13	582.61	571.13
5.727	615.23	647.97	599.00	594.70	596.45	584.42
5.624	631.24	664.83	614.22	610.09	610.80	598.23
5.522	646.98	681.42	629.39	625.38	624.84	611.95
5.420	664.74	700.28	646.13	642.55	640.98	627.41
5.321	683.42	719.89	663.80	660.52	657.74	643.48
5.216	703.56	741.25	683.22	680.09	675.72	660.98
5.114	724.58	763.53	703.24	700.28	694.80	679.23
5.006	747.98	788.17	725.33	722.90	715.65	699.26
4.903	773.07	814.69	749.22	747.22	737.92	720.95

4.797	800.28	843.53	775.32	773.56	762.34	744.23
4.686	830.96	875.95	804.26	803.33	789.51	770.37
4.570	865.22	912.27	836.99	836.41	820.04	799.70
4.254	977.61	1030.99	943.29	944.96	918.79	894.54
4.138	1026.18	1082.46	989.24	991.89	961.22	935.14
3.849	1171.47	1236.55	1126.50	1132.33	1087.68	1056.30
2.597	3123.00	3315.58	2960.10	3029.39	2734.71	2624.98
2.083	5829.75	6210.27	5453.54	5630.04	4916.87	4674.17
1.984	6703.84	7141.41	6253.39	6504.82	5610.49	5330.71
1.922	7344.56	7827.63	6819.74	7126.56	6107.40	5775.76
1.813	8962.68	9597.06	8319.42	8671.28	7368.14	6948.94
1.527	16448.03	17603.83	15075.34	15939.68	13037.05	12192.88
1.257	35402.08	38089.56	31960.00	34167.36	26708.60	24891.80