E614 Beam Note #2

Stability of M13 Magnet Power Supplies

Glen Marshall
2 June 2000

This note contains a presentation and rudimentary analysis of some M13 magnet power supply stability tests which were carried out overnight May 3rd and 4th, 2000, beginning at about 5 pm, and lasting over 16 hours.

With assistance from Dave Ottewell (M13 coordinator and CHAOS beam line expert) and Erwin Klassen (Controls Hardware), Brian Evans (Electronics) installed an HP/Agilent 34970A Data Acquisition and Switch unit to monitor the power supply voltage signals which are normally used to monitor magnet currents by the TRIUMF Central Control System. The HP device (see http://literature.hp.com/litweb/pdf/5965-5290EN.pdf) is essentially a DVM in a mainframe which reads various inputs on installable switch modules, all under software (proprietary or custom, via RS232 or GPIB) control. It was at TRIUMF on loan from HP for assessment regarding its suitability for use in E614 slow signal monitoring.

All M13 beam line magnet power supplies were monitored except for the first bending magnet, B1, which was off for safety reasons due to maintenance which was taking place on a nearby slit box. Two consecutive maintenance days allowed us to have control of the elements for the overnight period. Currents were set to values calculated to deliver a beam of surface muons. The control signal (D to A converter output, or DAC) which is used to set the current in Q1 was also monitored. In addition, temperatures were measured by thermocouples inside the cabinet of one of the supplies (ext), internal to the HP unit (int 1), and in air near the HP unit (ambient).

Table 1 summarizes some properties of the power supplies and magnets. It shows maximum load capacities of the power supplies, the present control voltage conversion factors, and the nominal activation values for magnetic fields (pole tip field for quadrupoles). The control voltage conversions may change when DC current transformers (DCCTs) are installed on all elements.

Table 2 lists the DAC and current settings used in these stability tests, except for B1 which was off as previously noted. The values were derived from scaling the nominal DAC settings to 29.5 MeV/c. The last column is the percentage of full current of the power supplies. Stability specifications are typically only for the range of 10%-100% of maximum current, so the test was run outside of these values for some magnets. No changes were made to the power supplies for these tests. Often it is possible to improve stability by changing transformer taps so that the regulation voltage is closer to the best operating range. It is also expected that the results might improve if the DAC conversions were adjusted so that higher numbers corresponded to the required currents.

Table 3 summarizes the stability measurements of the power supply monitor voltages in terms of mean, standard deviation (σ), and fractional maximum and minimum deviations from the mean (considering the deviation as a signed number).

The figures show the measurements as a function of elapsed time in hours. A power failure caused the laptop recording the data to crash part way through the test, but the HP device continued to record data at fifteen second intervals. Some data were lost, resulting in a gap in all of the measurements.

Figure 1 is for the bending magnets, B1 and B2; recall that B1 was off so that this graph is not very meaningful. Figure 2 is for the first three quadrupoles. The top graph is the Q1 DAC voltage while the other three are the current monitor voltages. Figure 3 is for the last four quadrupoles. Dashed lines have been superimposed on the data at deviations from the mean of $\pm 10^{-4}$; dotted lines correspond to $\pm 10^{-3}$.

Finally, Fig. 4 shows the variations in temperatures recorded by the three probes. Due to the limited time for the measurement, it is not clear whether there is a correlation between temperature and power supply stability or output. This will require further testing over several days, which will only be possible following the conclusion of CHAOS running in M13, scheduled for late July 2000.

If we expect nominal performance such that dipole power supplies should have a stability within $\pm 10^{-4}$ and that quadrupole supplies should be within $\pm 10^{-3}$, not all elements are satisfactory under the conditions of this test. In particular, B2 is a factor of nearly three worse, while Q5 and Q6 have significantly greater deviations. Further measurements will be necessary to determine whether hardware changes will bring the deviations within these nominal values. The HP unit is quite useful for gathering this information and should also perform quite well in the tasks of online monitoring of E614 experimental parameters.

	Rating (kW)	Current (A)	Voltage (V)	Control (A at 10V)	Activation B(G)/I(A)
B1	100	750	133	1500	21.67
B2	100	750	133	1500	28.54
Q1	35	1000	35	2000	6.66
Q2	25	500	50	1000	15.2
Q3	30	750	40	1500	15.2
Q4	50	500	100	1000	15.2
Q5	30	750	40	1500	15.2
Q6	25	500	50	1000	15.2
Q7	25	500	50	1000	15.2

Table 1: Summary of power supply and magnet specifications. See text for details.

	DAC	Current (A)	% of max A
B1	2707	41.3	5.5
B2	3070	34.3	4.6
Q1	675	165.2	16.5
Q2	8027	60.8	12.2
Q3	722	131.3	17.5
Q4	822	98.8	19.8
Q5	722	123.9	16.5
Q6	343	42.4	8.5
Q7	292	34.3	6.9

Table 2: Magnet settings scaled to surface muon values, as used for these stability tests (except B1 was off). Current settings are only nominal, and may not agree precisely with the actual values.

	mean (V)	σ (V)	$\frac{\max-\text{mean}}{\text{mean}}$	$\frac{\min-\text{mean}}{\text{mean}}$
B1	-1.0827×10^{-6}	1.59×10^{-7}	N/A	N/A
B2	0.22935	1.98×10^{-5}	2.7×10^{-3}	2.1×10^{-3}
Q1	0.82473	2.78×10^{-5}	9.58×10^{-5}	-8.38×10^{-5}
Q2	0.60605	1.46×10^{-5}	7.89×10^{-5}	-7.30×10^{-5}
Q3	0.87332	3.55×10^{-5}	1.12×10^{-4}	-1.29×10^{-4}
Q4	1.0030	8.07×10^{-5}	2.91×10^{-4}	-1.59×10^{-4}
Q5	0.76262	1.31×10^{-3}	5.04×10^{-3}	-8.03×10^{-3}
Q6	0.43418	8.04×10^{-4}	3.21×10^{-3}	-6.41×10^{-3}
Q7	0.33233	8.53×10^{-5}	8.29×10^{-4}	-4.96×10^{-4}

Table 3: Summary of magnet power supply stability measurements.

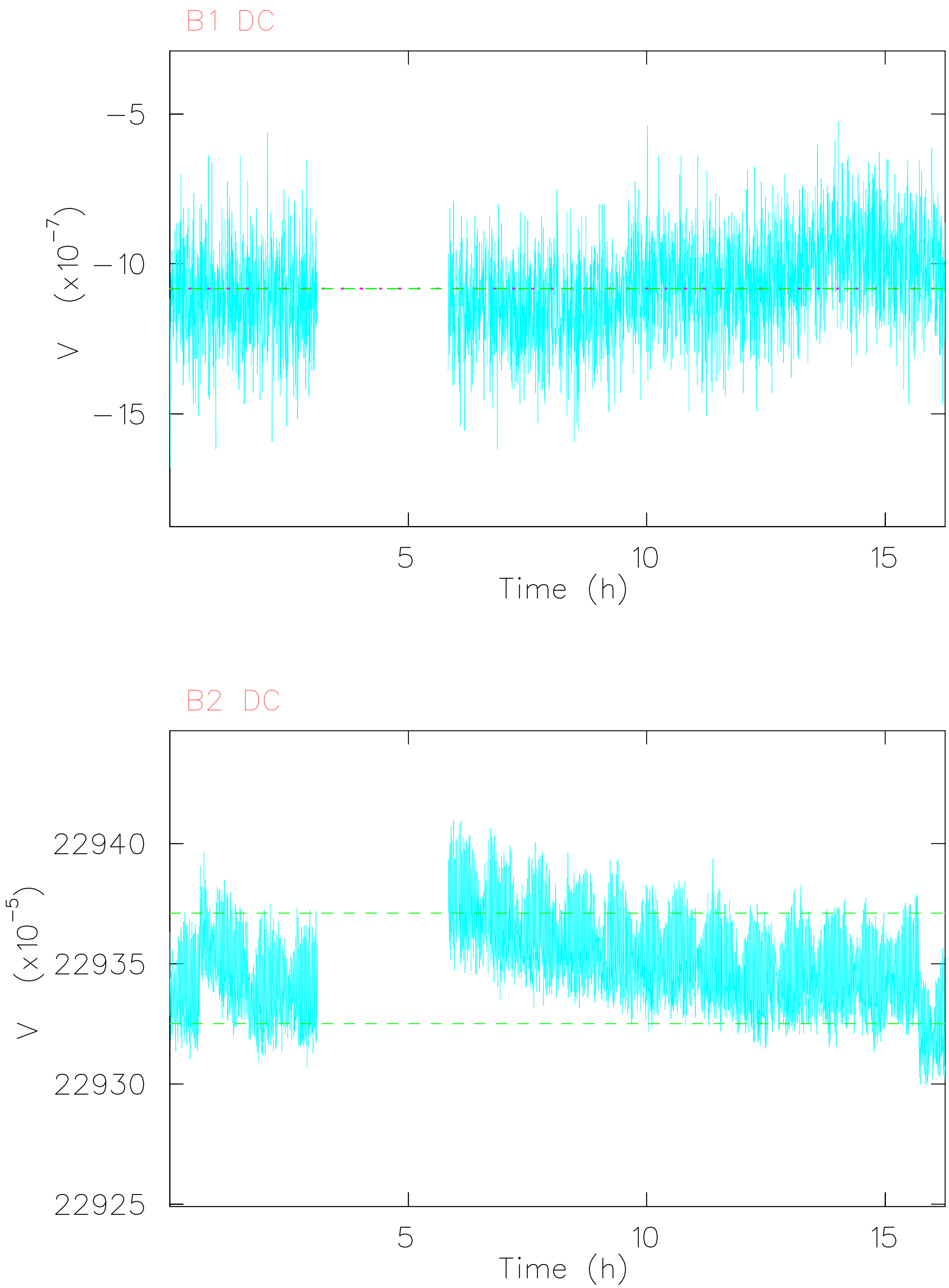

Figure 1: Bending magnet current monitor voltages. Note that B1 was off.

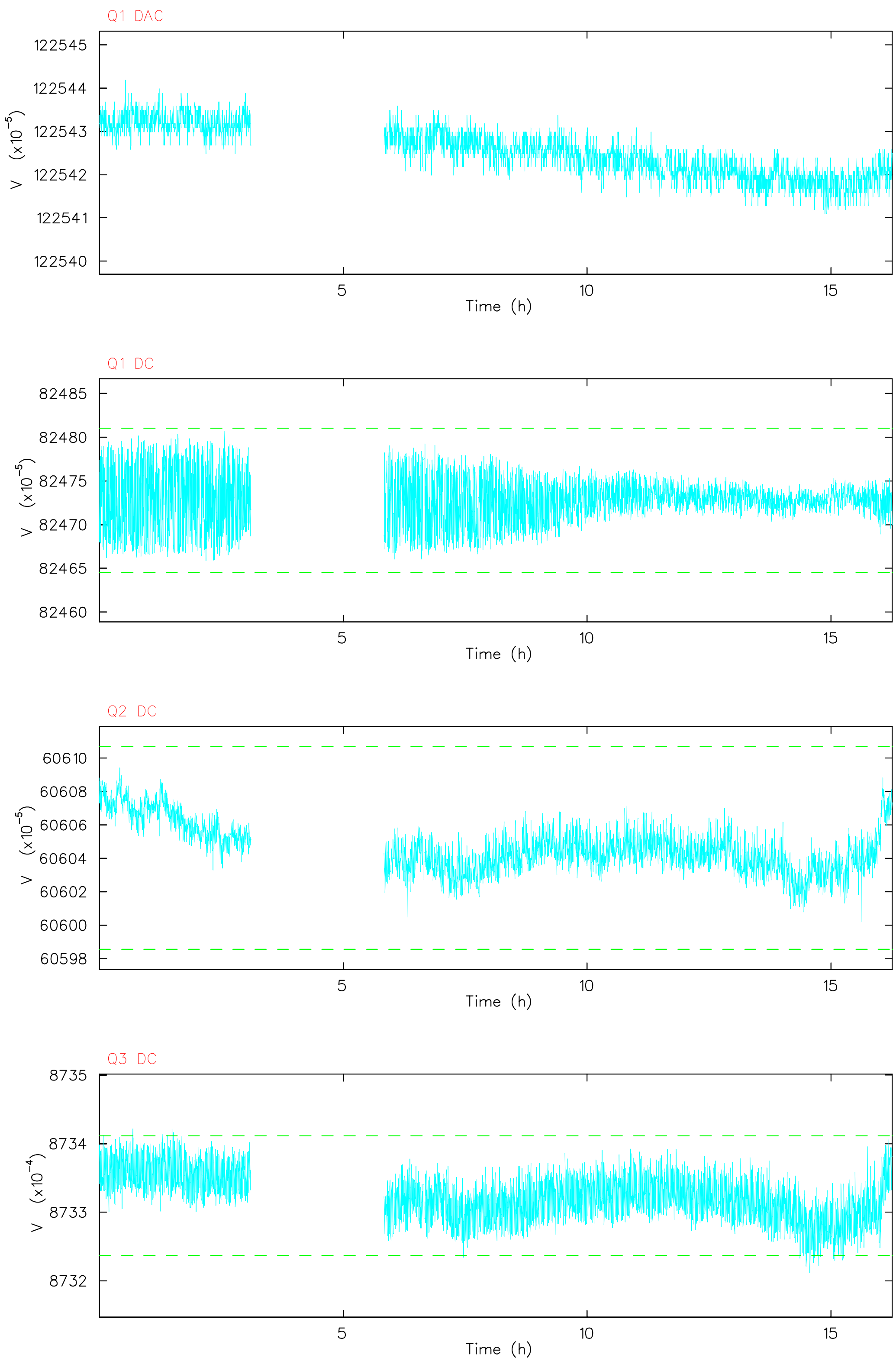

Figure 2: DAC voltage for Q1 power supply, and current monitor voltages for quadrupoles Q1-Q3.

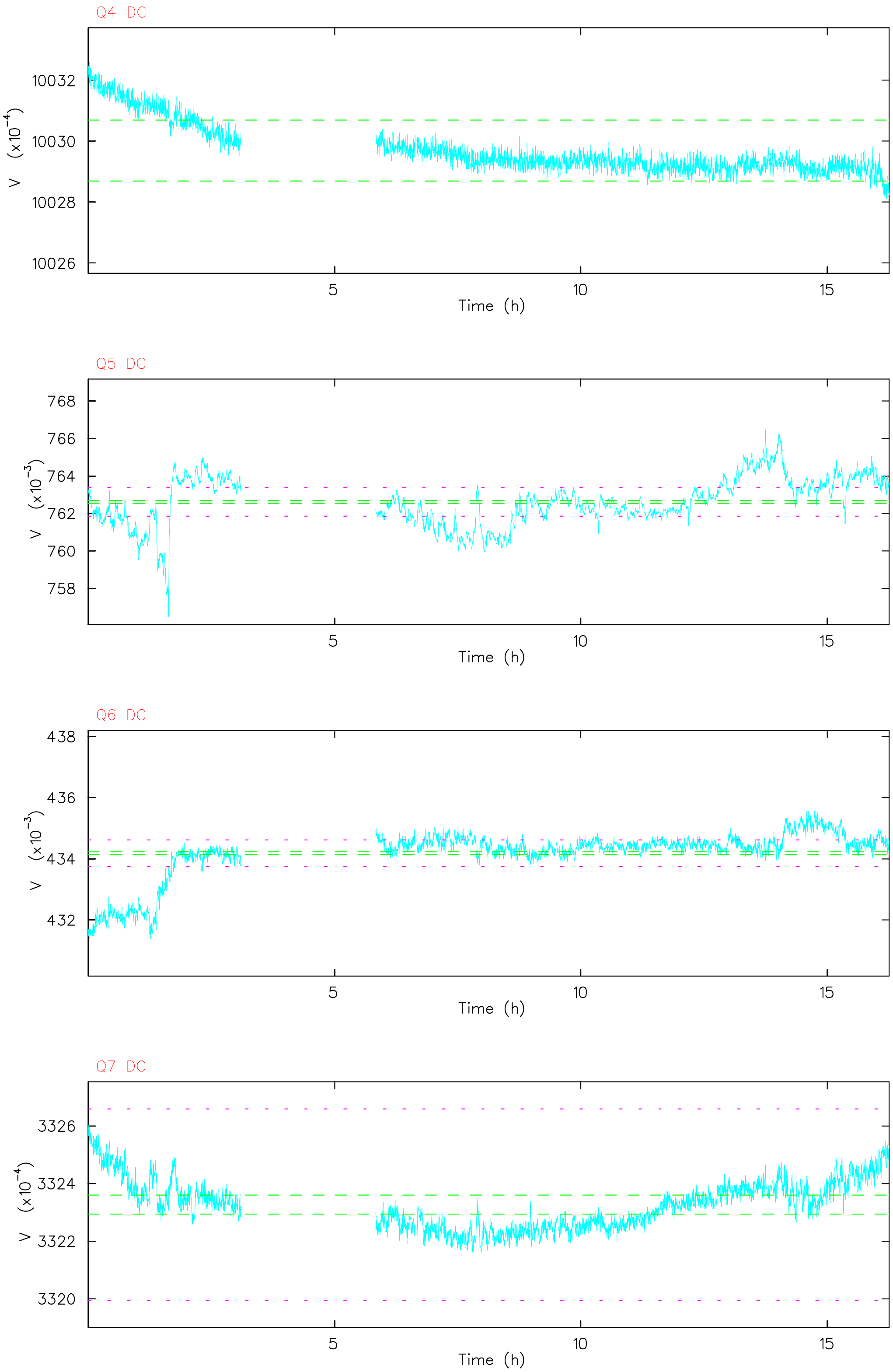

Figure 3: Current monitor voltages for quadrupoles Q4-Q7.

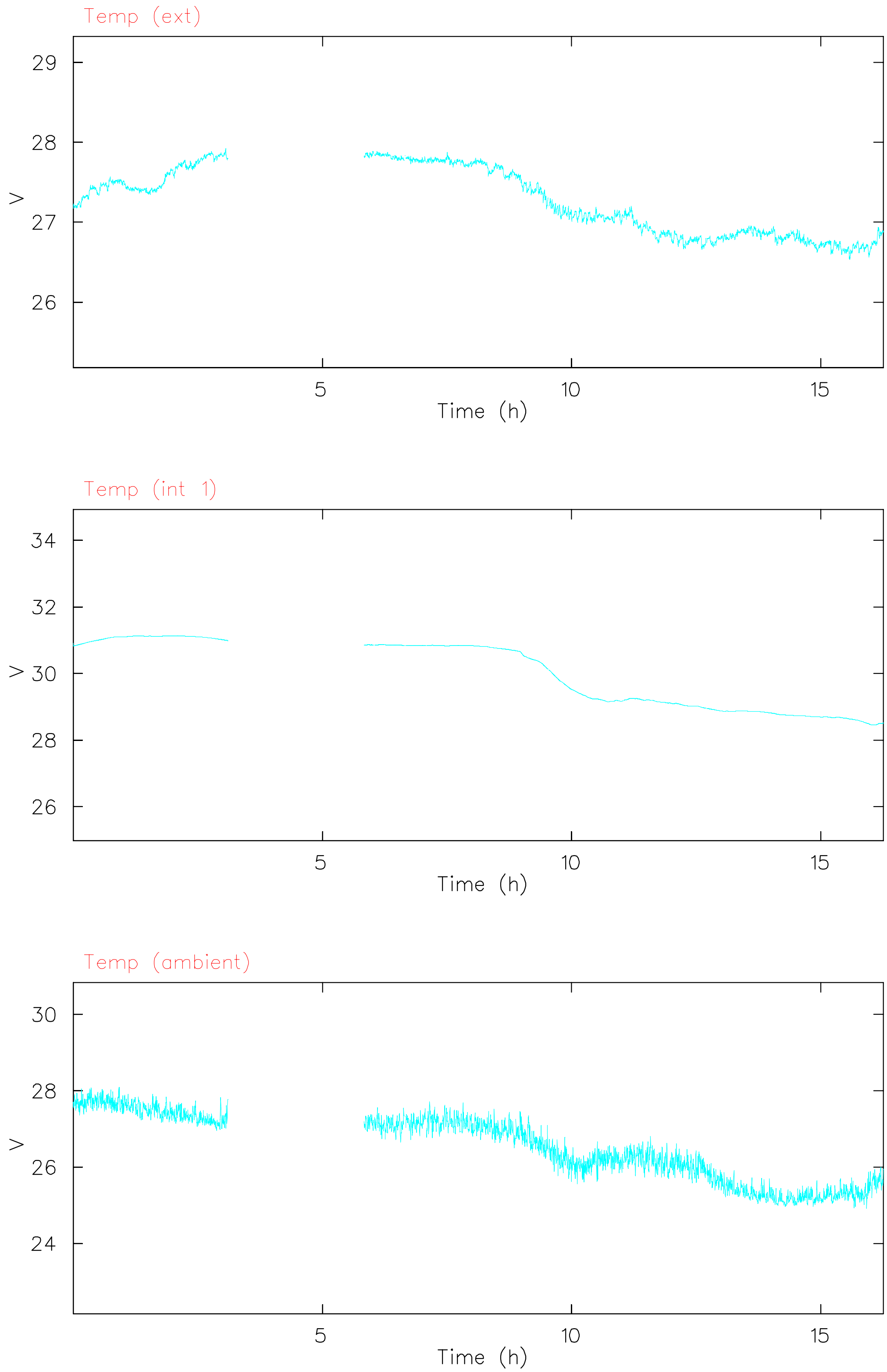

Figure 4: Temperature measurements inside a quadrupole power supply cabinet (ext), inside the case of the HP measurement unit (int 1), and in air near the unit (ambient).