

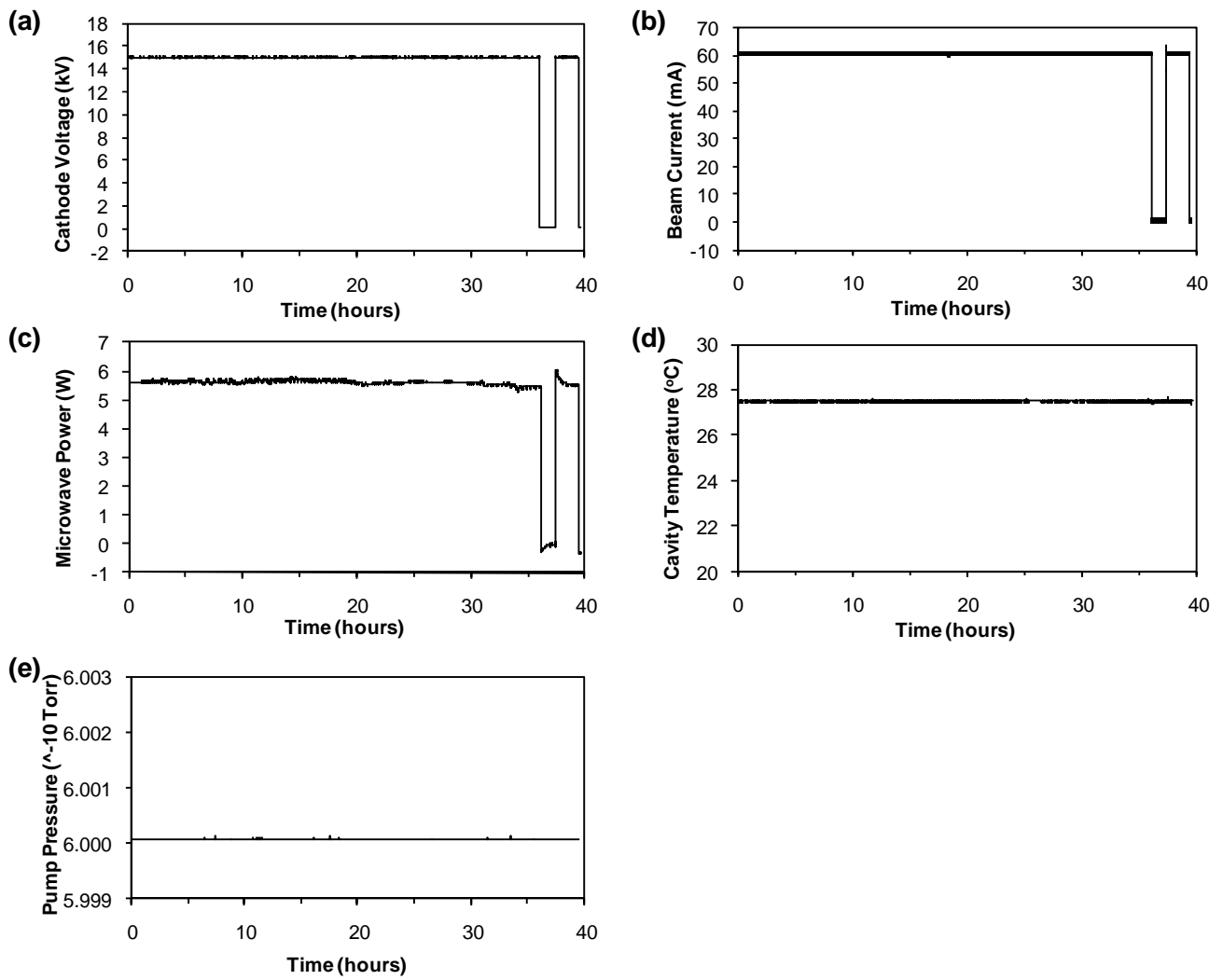
Solid-State Dynamic Nuclear Polarization at 263 GHz: Spectrometer Design and Experimental Results

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Supplementary Data

Stable gyrotron operation is illustrated in Supplementary Figure 1. The plots show the logged values recorded by the gyrotron control system software once per second. The cathode voltage, in panel (a) was set at 15 kV and is stable to within ± 24 V (5.8 V standard deviation). The electron beam current panel (b) is stabilized with a PI controller which compares the measured value to the set point and adjusts the filament heater as needed. The electron beam current in panel (b) is stable to within ± 0.5 mA (0.09 mA standard deviation on 60.52 mA average). With constant cathode voltage and stabilized electron beam current, the output power is constant as shown in panel (c). The noise level is due to fluctuations in the calorimeter reading and is also observed when the gyrotron is off. Power measurements using the detector diode produced similar noise level. The PI controller utilizes the electron beam current as input rather than microwave power since the output power is proportional to the electron beam current with all other parameters fixed (Figure 3a) and it offers fast response time and lower measurement noise.

The cavity coolant temperature also has a PI controller for constant output frequency and is stable to within ± 0.1 °C of the 27.5 °C set point, panel (d). The gyrotron frequency, which was not measured during this experiment, has always been stable to within the measurement resolution of 1 MHz in previous frequency measurements. Therefore, after approximately 3 months of operation the frequency measurement assembly was removed from the directional coupler and replaced with an absorbing load. The VacIon pump pressure remained at extremely low pressure of 6×10^{-10} Torr during the entire run. We have seen absolutely no signs of any limitation on duration of gyrotron operation, including experimental DNP runs of up to 12 days.



Supplementary Figure 1. Gyrotron parameter values during extended experiment run consisting of 36 hours gyrotron on, followed by 80 minutes gyrotron off, 2 hours gyrotron back on and off again: (a) cathode voltage, (b) electron beam current, (c) power measurement from laser calorimeter reading calibrated with water load, (d) cavity coolant temperature, and (e) tube vacuum.