

2.8 mm (B) and -6.2 mm (C) from bregma. The temperature distribution in these three slices was calculated using [eq. \[1\]](#). The average temperature was  $36.4 \pm 0.3$  °C,  $36.5 \pm 0.2$  °C and  $36.3 \pm 0.3$  °C, respectively. The presence of a temperature gradient of  $\sim 0.3$  °C across cortex was demonstrated by measuring the average temperatures in the upper (UC), middle (MC) and lower (LC) cortical layers, indicated by the three red boxes in (A). Moreover, significantly higher temperatures ( $>0.5$  °C compared to cortex) were measured in corpus callosum (CC, red oval in (A)), hippocampus (HC, red oval in (B)) and superior colliculus (SC, red oval in (C)). [R1.6] The location of the surface coil relative to the animal brain is also indicated. [R2.2]

**Supplementary Figure 1.** *Dependence of  $-CH_3$  resonance intensity corresponding to encoding index  $(n_x, n_y, n_z)$  in the  $k$ -space, on the distance  $R$  to the center of  $k$ -space.* The intensities in voxels corresponding to large  $R$  values have negligible contribution to the total signal. The cutoff value of  $R_0 = 14$  (indicated by the arrow) represents the minimum distance  $R$  in  $k$ -space for which the corresponding signal intensity has a negligible contribution to the total SNR.

**Supplementary Figure 2.** *Statistics of temperature distribution in rat brain.* The number of voxels at various temperatures (incremented by 0.1 °C) was plotted to show the temperature distribution in the rat brain around an average value of  $36.4 \pm 0.6$  °C. As expected, the temperatures span a relatively narrow range, with 85% of the values between 36 and 37 °C.