to the axial trap period (40 times shorter) the density distribution in the axial direction reflects the in-trap axial density distribution. The potential energy per particle, in units of E_F, is then $V = \frac{3}{NE_F}\frac{1}{2}m\omega_z^2\langle z^2\rangle$, where $\langle z^2\rangle$ is the mean squared width of the cloud in the axial direction and we have assumed that the total potential energy is distributed equally over the three axes.

To measure the release energy $T + I$ we turn off the trap suddenly and let the cloud expand for $t = 16$ ms (with interactions) before imaging along one of the radial directions; this is similar to measurements reported in Ref. [26]. The total release energy is the sum of the release energy in the two radial directions and the release energy in the axial direction. For the radial direction, the release energy per particle, in units of E_F, is simply $T_r + I_r = \frac{2}{NE_F}\frac{1}{2}m\frac{\langle y^2\rangle}{t^2}$ where t is the expansion time and $\langle y^2\rangle$ is the mean squared width of the expanded cloud in the radial direction. For the axial direction, the expansion is slower and the expanded cloud may not be much larger than the in-trap density distribution. This is especially true near the Feshbach resonance where the cloud expands hydrodynamically [27]. Accounting for this, the axial release energy is $T_z + I_z = \frac{1}{NE_F}\frac{1}{2}m\frac{\langle z^2\rangle - z_0^2}{t^2}$, where z_0^2 is mean squared axial width of the in-trap density distribution. We extract the mean squared cloud widths from surface fits to the images, where we fit to a finite temperature Fermi Dirac distribution while minimizing the difference in energy between the raw data and the fit. Rather than being theoretically motivated, we simply find empirically that this functional form fits well to our images. To eliminate systematic error due to uncertainty in the trap frequencies and imaging magnification, we measure the release energy and potential energy of a very weakly interacting Fermi gas at $\frac{T}{T_F} = 0.11$, where $T + I$ and V for an ideal Fermi gas is $0.40E_F$. We then use the ratio of $0.40E_F$ to our measured values as a multiplicative correction factor that we apply to all of the data. This correction is within 5% of unity. For the point with $\frac{1}{k_F a} > 0$ we take into account the binding energy of the molecules in our tabulation of the release energy $T + I$ by adding $-1/(k_F a)^2$. We show our data for the V and $T + I$ versus $(k_F a)^{-1}$ in the inset of Fig. 3.

We can now test the predicted universal relations connecting the $1/k^4$ tail of the momentum distribution with the thermodynamics of the trapped Fermi gas. We first consider the adiabatic sweep theorem [1],

$$2\pi \frac{dE}{d(-1/(k_F a))} = C, \tag{2}$$

which relates the contact C to the change in the total energy of the system when the