Supplementary Information for:

Unconventional and conventional quantum criticalities in $\mathbf{CeRh_{0.58}Ir_{0.42}In_5}$

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In this **Supplementary Information (SI)**, we provide additional comparison of A coefficients for $CeRhIn_5$ and $CeRh_{0.58}Ir_{0.42}In_5$ that further supports the discussion and conclusions of the main text, and a perspective on the relationship between a global model of heavy-fermion quantum criticality and other members of the family to which $CeRh_{0.58}Ir_{0.42}In_5$ belongs.

SI I. Comparison of A coefficients for $CeRhIn_5$ and $CeRh_{0.58}Ir_{0.42}In_5$

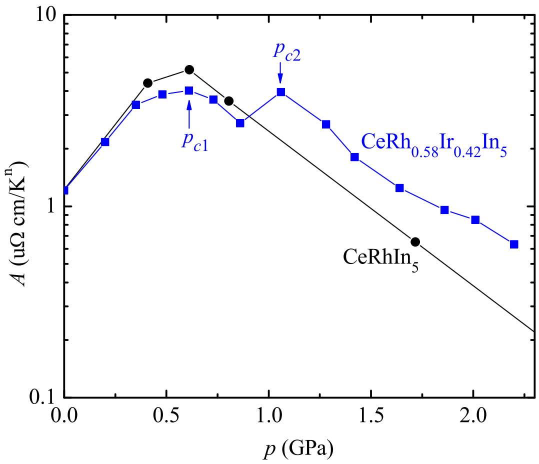

Fig. S1 Comparison of A coefficients of resistivity for $CeRhIn_5$ and $CeRh_{0.58}Ir_{0.42}In_5$ near their respective quantum critical points. Values of A for $CeRhIn_5$ are taken from Ref. [3], and the pressure axis for $CeRhIn_5$ has been shifted properly for a more direct comparison to $CeRh_{0.58}Ir_{0.42}In_5$.

In a magnetic field sufficiently large to suppress pressure-induced superconductivity in $CeRhIn_5$, experiments find evidence for a magnetic quantum-critical point at P_2=2.4 GPa that is accompanied by a change from small-to-large Fermi surface[1–3]. Figure S1 plots the pressure dependence of the A coefficient of resistivity, Eq. (1) in the main text, of $CeRhIn_5$ as a function of pressure, where the pressure axis in this case has been shifted by about -1.8 GPa. For comparison, this figure includes the A coefficient of $CeRh_{0.58}Ir_{0.42}In_5$ obtained in the present work. As shown in these plots, the evolution of $A(p)$ near the QCP for $CeRhIn_5$ is comparable to that of $CeRh_{0.58}Ir_{0.42}In_5$. In particular, the similarity in magnitude of A coefficients at their QCPs, respectively 5 and 4 $\Omega{\cdot}cm/K^n$, suggests comparably enhanced critical scattering and effective masses at their critical pressures.

SI II. Quantum criticality and the larger family

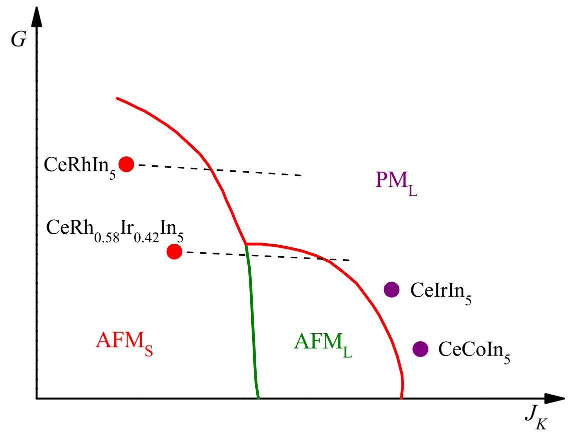

Fig. S2 CeMIn$_5$ on the global magnetic phase diagram. J_K is Kondo exchange, and G labels frustration. The abbreviations are: AFM = antiferromagnetic and PM = paramagnetic. The subscript S (or L) denotes small (or large) Fermi surface.

A theoretically proposed global model of quantum criticality in heavy-fermion materials predicts a phase diagram illustrated schematically by the solid lines in Fig. S2, where lines separate antiferromagnetic states with small (AFM$_S$) and large (AFM$_L$) Fermi surfaces and a paramagnetic state with large Fermi surface (PM$_L$). The lines have negative slope, reflecting the weakening of magnetism by both the magnetic frustration G and Kondo exchange J_K[4, 5]. Kondo-breakdown criticality occurs across the boundary between states with small and large Fermi surfaces[4]. Magnetic interactions in CeRhIn$_5$ are frustrated[6], the Kondo exchange is small and CeRhIn$_5$ crosses a Kondo-breakdown critical point as a function of pressure, leading to its placement in Fig. S2. Hybridization and hence Kondo exchange increase in the sequence CeRhIn$_5$, CeIrIn$_5$ to CeCoIn$_5$[7], with CeIrIn$_5$ and CeCoIn$_5$ being very close to a AFM$_L$ QCP at atmospheric pressure[8, 9]. Consequently, they are placed on the diagram as shown. The sequence of Kondo-breakdown and then SDW critical points in CeRh$_{0.58}$Ir$_{0.42}$In$_5$ suggests its location in this diagram. Because pressure increases Kondo exchange, CeRh$_{0.58}$Ir$_{0.42}$In$_5$ as a function of pressure should have the trajectory indicated by the dashed line. Our results on CeRh$_{0.58}$Ir$_{0.42}$In$_5$ suggest this broader perspective on quantum criticality in this larger family of materials.

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