Supplementary Information: Transport near a quantum critical point in 
BaFe$_2$(As$_{1-x}$P$_x$)$_2$

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I. SUPPLEMENTARY INFORMATION

A. Raw magneto-transport data

In Figure 1 we illustrate the raw MR data (normalised to their room temperature resistance) for compositions shown in Figure 1 of the main text. Deviations from quadratic magnetic field dependence are particularly apparent in the optimally doped samples, though these diminish at sufficiently high temperature. At sufficiently high field all curves appear linear in $B^2$, and it is over this range that the curves are fit. This causes an over-estimate in the zero-field resistance by an amount $\delta R$, which we discuss in the main text and in Supplementary Information I B.

FIG. 1. Identical data set to that shown in Figure 1 of the main text except the data has not been offset and higher temperatures are also shown.

B. The temperature dependence of the offset resistance $\delta R$

In Figure 2 we show the offset resistance $\delta R \equiv (\rho_{\text{exptl}} - \rho_{\text{fit}})|_{0,T}$ normalized to the room temperature resistance for comparison with Figure 2 of the main text. The offset is in general more than 10× smaller than the value $\rho_{0,T}$. In the range in $T$ at which we have data at $B = 0$, there is a weak positive $T$ dependence $\delta R$. If this trend continues at $T < T_c$ the transport will decrease faster than we determine, and will cause our determination of $n$ to be larger than it actually is. This would cause the divergence in $2A$ to occur more rapidly than shown in Figure 3 (c). However, the correspondence of $A$ with $m^*$ (assuming the Kadowaki-Woods ratio holds) suggests that the effect of $\delta R$ is small.

FIG. 2. Dependence of the offset resistance for $T > T_c$ between the real resistivity at $B = 0$ and the resistivity extrapolated using $\rho(B) = \rho_{0,T} + AB^2$ shown for dopings (a) $x = 0.31$, (b) $x = 0.34$, (c) $x = 0.37$.

C. Magnetoresistance of underdoped samples

If the analysis used to understand the data in Figure 1 and 2 of the main text is applied to optimally doped samples (where $T_N$ is very near $T_c$), the zero field intercept of the MR again falls smoothly on the zero-field transport curve and exhibits the characteristics of a AFM transition occurring at $T < T_c(B = 0)$, as shown in Figure 3. This makes the analysis of the power law complex at these dopings because the zero-field transport curve will flatten at low temperature around the AFM transition, which in turn will appear to increase the power law $n$ and lower the
FIG. 3. The resistivity curve of two samples with optimal $T_c$ where (a) has $T_N \sim 42$K while (b) has $T_N \leq T_c$. In the former the data extrapolated from the MR below $T_c$ appears to peak, as the AFM transition is crossed. In (b) the zero field intercept of the MR data flattens out.

value 2A. If $T_N > 0$K the above analysis will not be able to distinguish between the intrinsic quasiparticle scattering and the effect of magnetic order on the zero-field resistivity. However, we observe the normal-state cusp in $d\rho/dT$ to drop with a shallower slope either side of $x = 0.34$, where it is steepest, independent of our low temperature analysis (Figure 3 (a)). If this cusp is interpreted as a cross-over in temperature across the critical fluctuation cut-off frequency $\omega_c$, it would only be expected to behave this way if $x_c > 0.31$. 