ESRF	**Experiment title:** Structural distortions at the boundary between antiferromagnetism and superconductivity in $NaFe_{1-x}M_xAs$ (M = Co, Ni)	**Experiment number**: HS-4136
Beamline: ID31	**Date of experiment**: from: 12/6/2010 to: 15/6/2010	**Date of report**: 23/03/2010
Shifts: 9	**Local contact(s)**: Caroline Curfs, Adrian Hill	*Received at ESRF:*

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Report:

We investigated the evolution of the crystal structures of NaFeAs and $NaFe_{1-x}Co_xAs$ with temperature and composition. Our previous measurements [1] had revealed that in the transition from itinerant antiferromagnetism ($x = 0$) to bulk superconductivity ($x = 0.025$) there was a region in which there is competition between antiferromagnetism and superconductivity. Measurements on the analogous system $BaFe_{2-x}Co_xAs_2$ showed that the orthorhombic distortion which accompanies antiferromagnetic ordering is suppressed in the superconducting state (i.e. below T_c the distortion decreases) for a narrow range of compositions in this mixed region. These experiment were to probe whether similar behaviour was displayed by the doped NaFeAs system.

The results show the following:
For a very limited range of compositions $NaFe_{1-x}Co_xAs$ with $0.015 \leq x \leq 0.02$ there is clear evidence that the size of the orthorhombic structural distortion decreases below the superconducting T_c as shown in the figure. The determination of this behaviour required the extremely high resolution of ID31. The results suggest, in line with other evidence (NMR, Mössbauer, etc..) that each Fe ion in the structure is participating in both magnetic order and superconductivity. This is presumably enabled by the multiband nature of the region around the Fermi surface which is dominated by Fe-based orbitals.

[Note: HS-4136 was initially denied beamtime, but after the proposal had been resubmitted as HS-4264, HS-4136 was awarded beamtime. The behaviour of the samples was such that the two experimental sessions were in fact required to investigate these materials in detail.]

This work is being prepared for publication as a follow-up to reference [1].

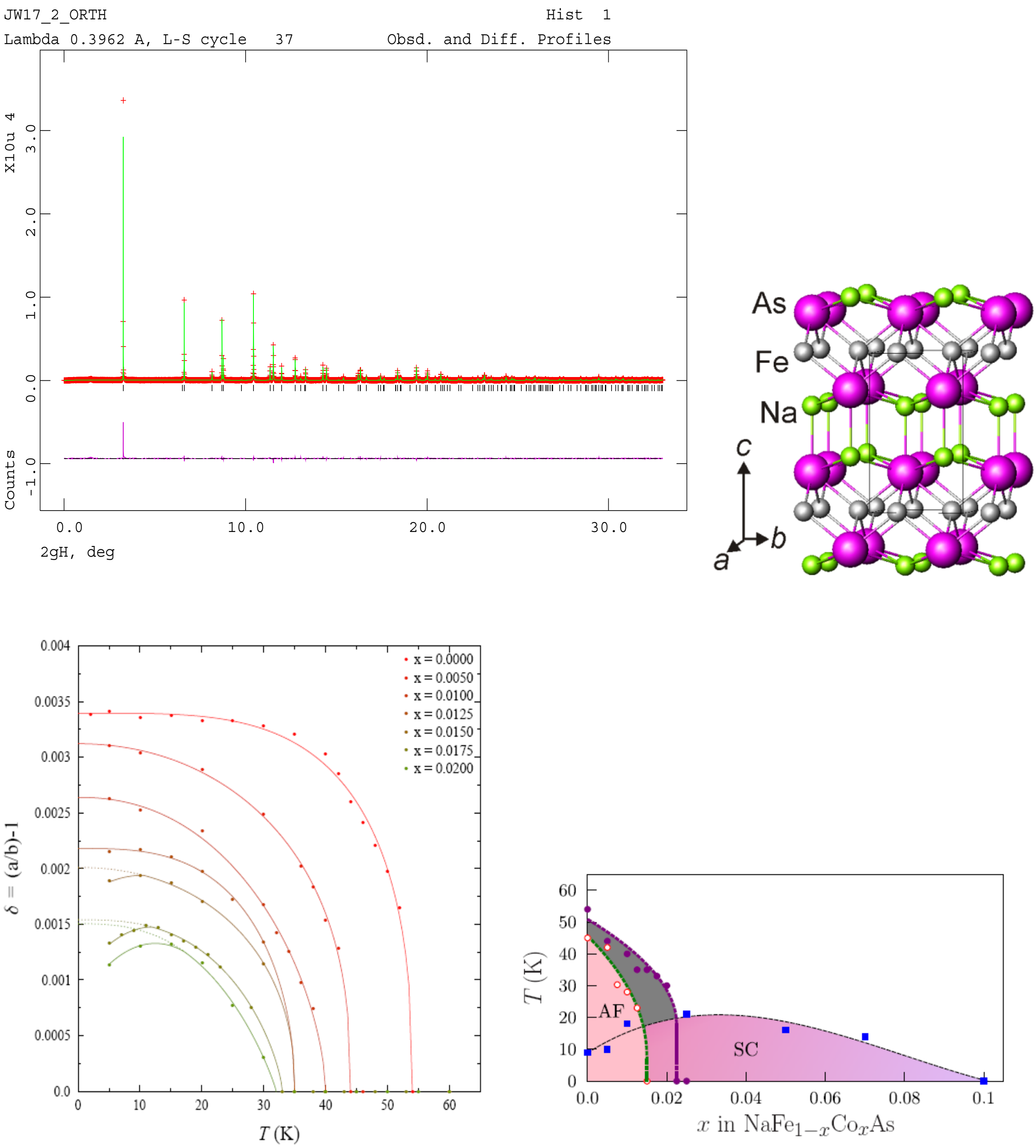

Figure 1. Refinement against ID31 data of the sample with $x = 0.02$ at 5 K. The behaviour of the orthorhombic distortion with temperature for a range of samples measured in this experiment showing the suppression of the distortion. The phase diagram for the $NaFe_{1-x}Co_xAs$ system showing the evolution with composition of the antiferromagnetic ordering temperature (open circles), the orthorhombic distortion temperature (closed cicles) and the superconducting T_c (closed squares)

[1] Parker, D. R.; Smith, M. J. P.; Lancaster, T.; Steele, A. J.; Franke, I.; Baker, P. J.; Pratt, F. L.; Pitcher, M. J.; Blundell, S. J.; Clarke, S. J. *Phys. Rev. Lett.* **2010**, *104*, 057007.