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A Record in Backscattering Energy Resolution — First Tests on IN16B with GaAs 200

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Since late 2013, we have been developing a prototype setup using the GaAs 200 reflection for neutron backscattering spectrometer to bring about a significant increase in energy resolution. Here, we report on first test measurements conducted during the first reactor cycle in 2017 on IN16B.

Background

The energy resolution in neutron backscattering can be enhanced by using the GaAs 200 Bragg reflection instead of the currently utilised Si 111, taking advantage of its narrower intrinsic line width. This improvement poses severe constraints on manufacturing tolerances, in particular on angular misalignment of the 4x4 mm^2 crystals as well as temperature stability, homogeneity and the temperature gradient, which needs to be called upon to compensate for gravity effects. Further, temperature scans of the monochromator have been employed in this setup for an energy scan. We have devised a manufacturing technique and built a prototype monochromator and analyser in the geometry of a user instrument, albeit covering only approximately 1% of the crystal surface of a fully equipped spectrometer.

Resolution

The resolution function shown in Fig. 1 was obtained using a Ø8 mm wooden ball as strongly elastically scattering sample. The measurement is compared to the resolutions of the two available standard conditions of IN16B. The measured GaAs resolution line width of (76.5 ± 3.3) neV FWHM presents a world record for a standard backscattering configuration.

Benchmark inelastic spectrum: Hyperfine splitting in Cobalt

Cobalt shows hyperfine splitting at room temperature which can be spectroscopically observed as three Delta peaks (one elastic, two inelastic) of equal intensity convolved with the resolution function of the instrument. In spite of its low scattering cross section and high absorption, Co was chosen because it had previously been used as a benchmark (IN10/IN16/IN16B). Fig. 2 shows the Cobalt spectrum recorded during 5 days with the GaAs prototype, compared with measurements from IN16B in two standard resolution configurations.

Outlook

After these extremely encouraging first test results with a reduced analyser surface we see potential in improving the temperature homogeneity and the crystal orientation, which should lead to a further improvement of the energy resolution. The feasibility of a standard spectrometer with 100 times higher count rate due to a larger analyser surface is already proven with our first tests.

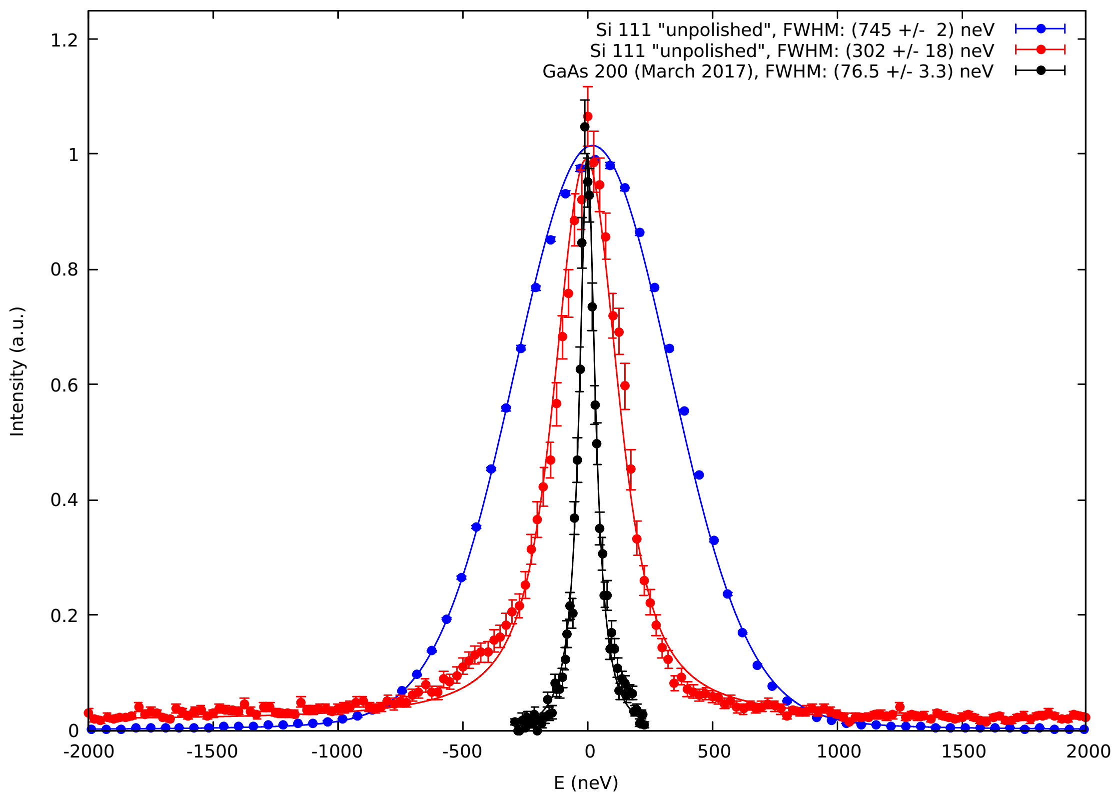

Figure 1: Comparison of the resolution functions of the two standard Si 111 configurations and GaAs 200. Slight asymmetry towards positive energy transfers in GaAs resolution may result from misalignment of the crystals; This will be under further investigation.

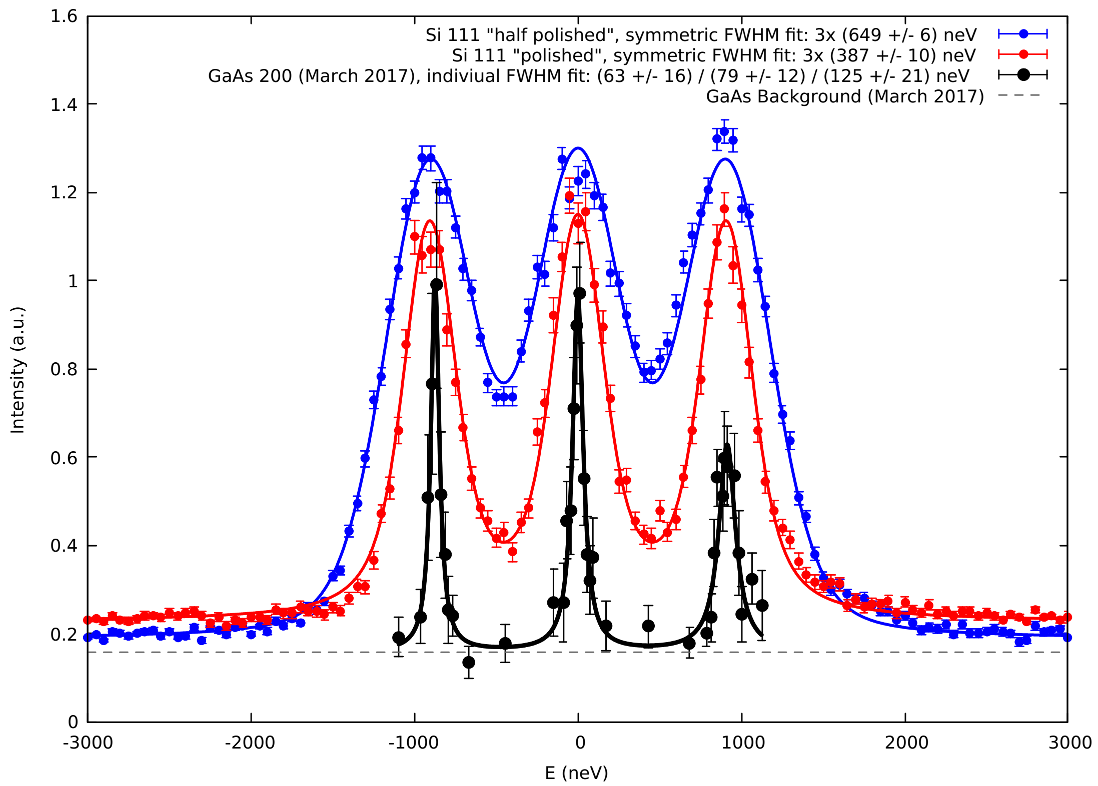

Figure 2: Hyperfine splitting in Cobalt. Comparison between GaAs 200 and two Si 111 measurements from IN16B (scaled to GaAs background). Si 111 curves: Triple symmetric Voigt profile fit. GaAs 200: Triple individual Lorentz fit. While the line widths of the left and central peak are close to expectation it is unclear at present whether the line profile of the right peak suffers from uncertainties in temperature measurements and/or inhomogeneity of the temperature gradient. Further investigation will follow.