Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

<table>
<tr><td>ESRF</td><td>Experiment title:
Detecting the superconducting gap in V_3Si</td><td>Experiment number:
HE-802</td></tr>
<tr><td>Beamline:
ID16</td><td>Date of experiment:
from:4.5.00, 7.a.m. to:16.5.00, 7 a.m.</td><td rowspan="2">Date of report:
30.8.00
Received at ESRF:</td></tr>
<tr><td>Shifts:
30</td><td>Local contact(s):
A. Shukla</td></tr>
<tr><td colspan="3">Names and affiliations of applicants (* indicates experimentalists): A. Shukla, A. Manuel, F. Sette.</td></tr>
</table>

Report:

In this proposal we aimed to measure electronic excitations across the gap in a low temperature, BCS-like superconductor, V_3Si as a pioneering experiment of its kind. This is a well-characterized compound of the A15 (or β-tungsten) structure, with relatively low Z elements and correspondingly low density. The T_c of V_3Si is 17K giving a BCS value for 2Δ well below T_c to be 5.2 meV ($2\Delta=3.5\ k_BT_c$. A sample of 90 microns thickness and 17K T_c was prepared to optimize the signal strength at the Si 999 setting of 17.8 keV of the spectrometer. To reach temperatures well below T_c we used for the first time the pulsed tube cryostat recently acquired by ID16, which performed well, giving regular access to 3K at the sample.

However it was soon evident that the signal from phonons far overweighed that from any electronic excitations, so the decision was taken to steady the phonon energy loss spectra and detect any anomalies associated with the lattice dynamics, that is both the martensitic transition occuring at ~ 21K and the superconducting transition at ~ 17K. There are some good reasons to measure phononic excitations in V3Si with x-rays: Firstly, due to the presence of Vanadium, this is a very difficult sample to measure with neutrons. Secondly we were able to measure spectra with large energy losses (> 50 meV), thus measuring the acoustic and optical phonons in one go and with the same resolution, this being again difficult for neutrons for kinematical reasons. Since earlier acoustic and neutron measurments had determined phonon softening in the [110] branch with $[1\bar{1}0]$ polarization, we decided to measure the same branch and in particular the [1.2 0.8 0] point which seemed to show the biggest softening in the earlier measurements. Another reason for concentrating on this point was to search for an eventual ‘gap mode’, a sharp mode that has been detected in a BCS like superconductor (YNi_2B_2C) below Tc, and at a wave vector corresponding to a Fermi surface nesting vector. V3Si seemed to be an ideal candidate for detecting such a ‘gap mode’.

The measurement startegy was then to position the sample and spectrometer in a way so that the analyser no. 3 measured purely transverse phonons at the [1.2 0.8 0] point while the other analysers measured a mix of acoustic and longitudinal modes at other points across the BZ.
Two runs of measurements were performed. In the first run energy loss spectra were taken at different temperatures (300K, 80K, 40K, 19K which is below the martensitic transition but above the superconducting transition, and 3K which is well below the superconducting transition). Though softening for low energy acoustic phonons was clearly observed, the most spectacular effect here was the dramatic increase in incoherent elastic scattering as the temperature dropped till the martensitic transition, and then stabilisation of this scattering intensity below the martensitic transition. Indeed the elastic intensity at low temperatures was of the order of that observed for disordered systems, indicating that a lot of starin was introduced in the sample by the structural dynamics involved with this transition. Figure (1) shows the evolution of this intensity with temperature.

Following this, it was decided to heat the sample up rapidly to room temperature and then cool down to 19K. On heating, the elastic intensity all but disappeared, as expected form a single crystalline sample, and there was not much increase in this intensity upon rapid cooling. Phonon energy loss spectra measured at 300K, 19K and 3K from this run are shown for analyser no.2 ([0.67 1.06 0]) and analyser 3([1.2 0.8 0]) in figures 2 and 3. The softening for the acoustic phonons below 20 meV is clearly visible in figure(2) which compares the spectra at 300k and 19K. Figure 3 compares spectra at 19K and 3K. Statistics are limited due to the low temperature and the fact that we are in a low order BZ, but there are some differences above and below T_c around 15 meV and 22 meV. Whether this is due to the appearance of predicted soft optical modes or otherwise is a point that remains to be clarified with further measurements. Finally we did not observe any gap mode around 5 meV, below T_c.

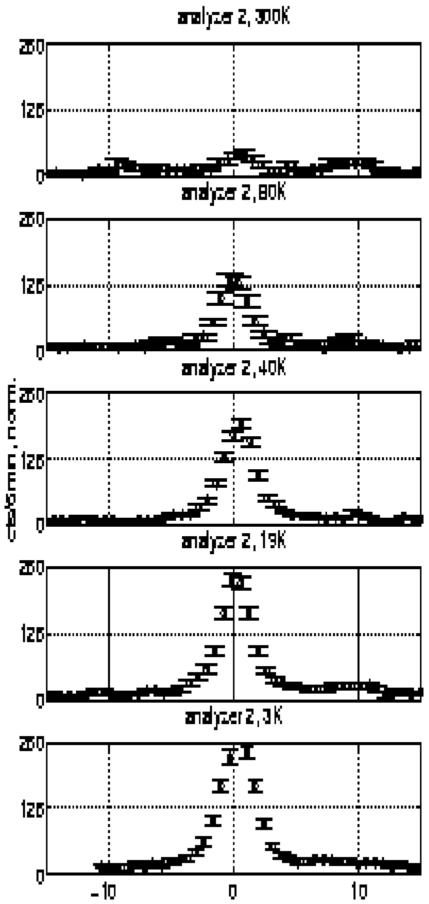

Figure 1

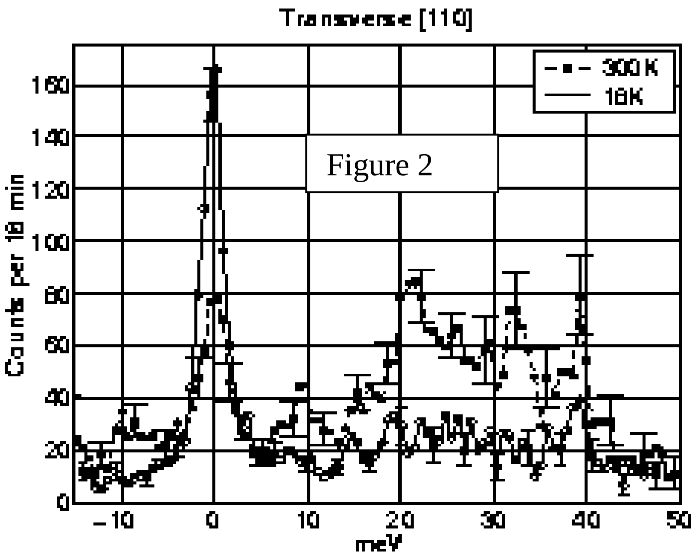

Figure 2

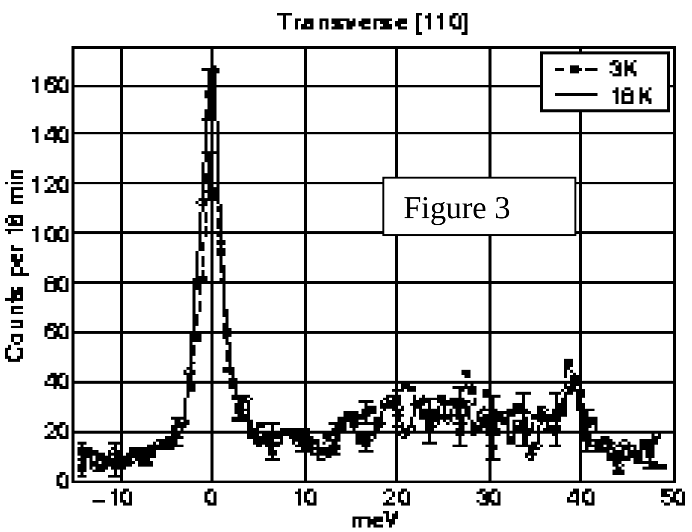

Figure 3