ESRF	**Experiment title:** Surface Magnetism Studied via Nuclear Resonant Scattering at the 6.2 keV Resonance of ^{181}Ta	**Experiment number:** SI 509
Beamline: ID18	**Date of Experiment:** from: 7. 12. 1999 to: 17. 12. 1999	**Date of Report:** 28. 2. 2000
Shifts: 21	**Local contact(s):** A. I. Chumakov, R. Rüffer	*Received at ESRF:*

Names and affiliations of applicants (*indicates experimentalists):

R. Röhlsberger*, V. Senz*, K. W. Quast*, J. Bansmann,
K. H. Meiwes-Broer, E. Burkel

Fachbereich Physik der Universität Rostock
Universitätsplatz 3, 18051 Rostock, Germany

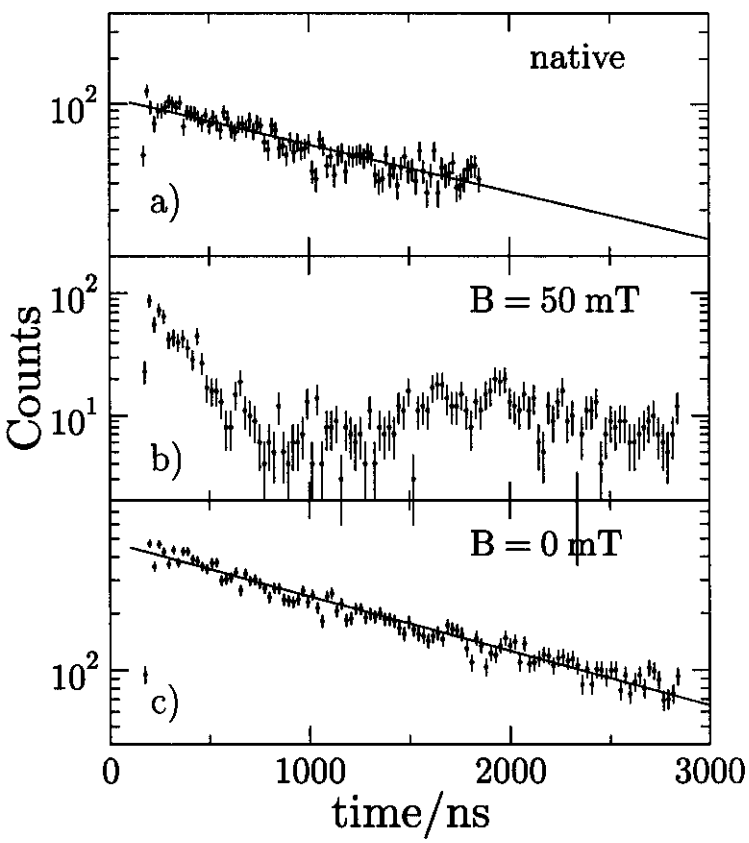
Report:

The aim of this experiment was to study the magnetism of deposited thin films or clusters on Ta single crystals by employing the 6.2 keV nuclear resonance of ^{181}Ta ($\Gamma_0 = 6.7 \times 10^{-11}$eV) as a very sensitive probe. The magnetic field of the deposits that reaches into the Ta leads to quantum beats in the time spectrum of the nuclear decay. The analysis of the beat pattern then allows to determine the magnitude and the orientation of the magnetic fields. This approach may open the possibility to investigate the magnetism of compounds consisting of non-Mössbauer isotopes by using a Mössbauer isotope as a probe. The range of possible applications in the field of surface magnetism and the magnetism of small particles could then be considerably extended.

The experiment performed here, however, suffered from a dramatic increase in the surface roughness of the Ta crystals in the annealing process that was performed during the sample preparation. The roughness led to considerable damping of the reflected amplitude so that no resonant signal could be observed in grazing incidence reflection. Instead, we switched to the Ta(110) Bragg reflection where a resonant signal could be observed. The experimental data are shown in fig. 1. The Ta surface was coated with a few monolayer thick film of Fe. Fig. 1a shows the time dependence of the nuclear decay of the sample in the native state. Fig. 1b displays the time spectrum of the decay where only the $\Delta m = 0$ transitions are excited via an external magnetic field of B = 50 mT perpendicular to the scattering plane.

The data in fig. 1c were taken with the external field removed.
The nuclear decay in figs. 1a and 1c can be described as an exponential decay with a lifetime of $\tau = 1.5$ ns. Taking the coherent enhancement in the Bragg scattering geometry into account, one obtains a linewidth of the Ta resonance of appr. $3\,\Gamma_0$. This is significantly below the smallest value observed so far [1], indicating a very good crystalline quality of the Ta in the bulk.
However, these datasets do not indicate any magnetic hyperfine interaction at the Ta nuclei. The modulation of the time spectrum in fig. 1b is mainly caused by the external magnetic field of B = 50 mT. Even though the data evaluation is not completed yet, it is very likely that the data in fig. 1b can be explained without a magnetic field generated by the Fe film at the sites of the Ta nuclei. This is reasonable since the decay length of the Fe magnetic field into the Ta is much smaller than the penetration depth of the x-rays into the crystal. This ratio can be significantly improved in grazing incidence geometry. For such an experiment, however, the surface quality of the Ta crystals has to be much better. We are very optimistic that this can be achieved in a subsequent experiment.

Fig.1
Time spectra of the Ta(110) reflection. See the text for explanation.



We greatfully acknowledge the support of K. Geske and E. Gerdau (University of Hamburg) in setting up the detector electronics in this experiment.

References

[1] A. I. Chumakov et al. Phys. Rev. Lett. 75, 549 (1995).