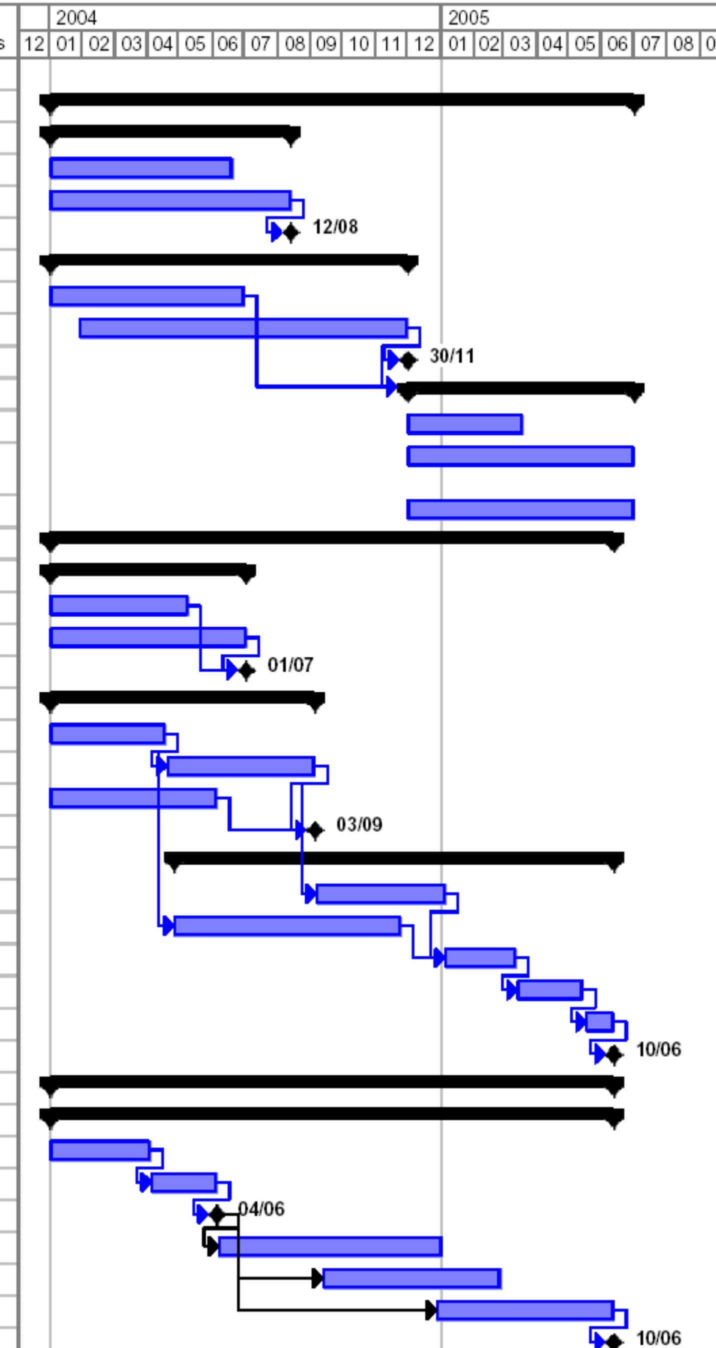
TESLA Collaboration Meeting

WP 6 Task Contents:

- SQUID scanning (W. Singer)
- Application of magnetometry to electrochemisrty (E.P.)

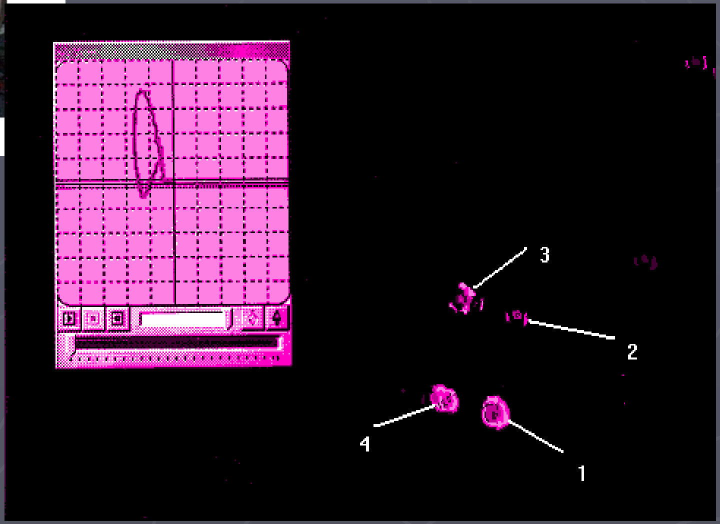
Desy-Zeuthen January 21-23, 2004

Task Name	Milestones	Deliverables
WP 6 Materials analysis		
6.1 SQUID scanning		
6.1.1 Produce calibration defects		
6.1.1.1 Production of surface defects		
6.1.1.2 Production of bulk defects		
6.1.1.3 Calibration defects finished	**Report**	
6.1.2 Design components of SQUID scanner		
6.1.2.1 Design of the scanning table and support		
6.1.2.2 Design of the SQUID cooling system		
6.1.2.3 Design Scanner finished	**Design report**	
6.1.3 Construction of scanning apparatus		
6.1.3.1 Fabrication of the SQUID		
6.1.3.2 Fabrication and purchase of components for SQUID scanner		
6.1.3.3 Software for the SQUID scanner		
6.2 Flux gate magnetometry		
6.2.1 Produce calibration defects		
6.2.1.1 Production of surface defects		
6.2.1.2 Production of bulk defects		
6.2.1.3 Calibration defects finished	**Report**	
6.2.2 Design components of flux gate head		
6.2.2.1 Design electronics		
6.2.2.2 Design of flux gate head		
6.2.2.3 Design of operations software		
MS 6.2.2.4 Design flux gate head finished	**Design report**	
6.2.3 Fabrication of flux gate detector		
6.2.3.1 Fabrication of flux gate head		
6.2.3.2 Fabrication of mechanics		
6.2.3.3 Implementation of software		
6.2.3.4 commissioning of flux gate detector		
6.2.3.5 Calibration of flux gate detector		
6.2.3.6 Flux gate detector operational	**Report, Start operation**	
6.3 DC field emission studies of Nb samples		
6.3.1 Quality control scans		
6.3.1.1 Modification of Scanning apparatus		
6.3.1.2 Calibration of Scanning apparatus		
6.3.1.3 Start scanning activity	**Start operation**	
6.3.1.4 BCP and HPR samples		
6.3.1.5 EP and HPR samples		
6.3.1.6 BCP/EP and DIC samples		
6.3.1.7 First report on BCP/EP and DIC surface	**Report**	

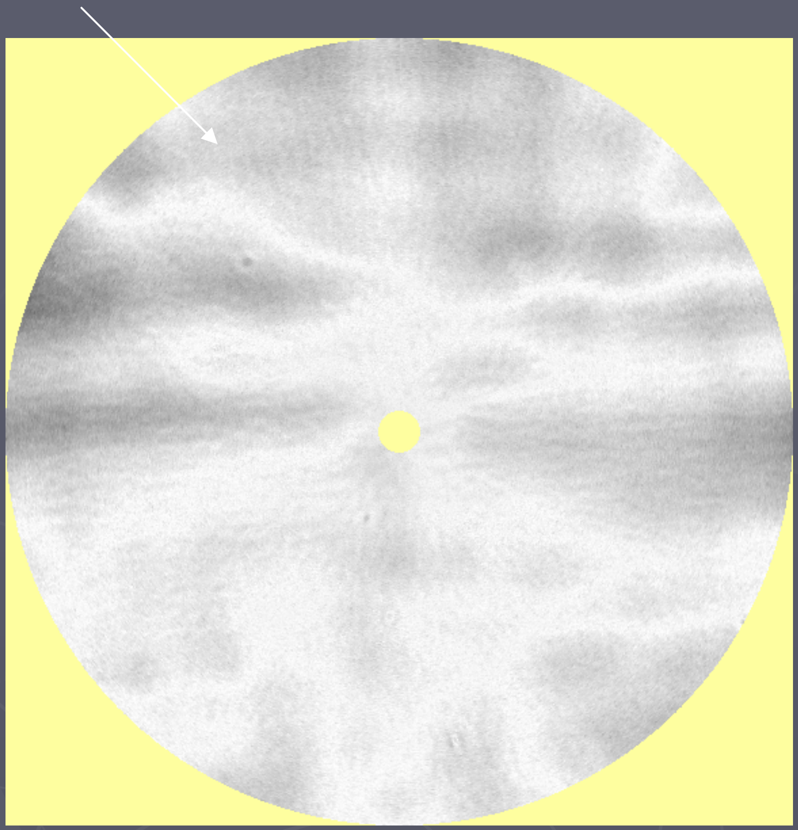


Example of small iron particles, probably imbedded during rolling, detected in Nb sheet by eddy current

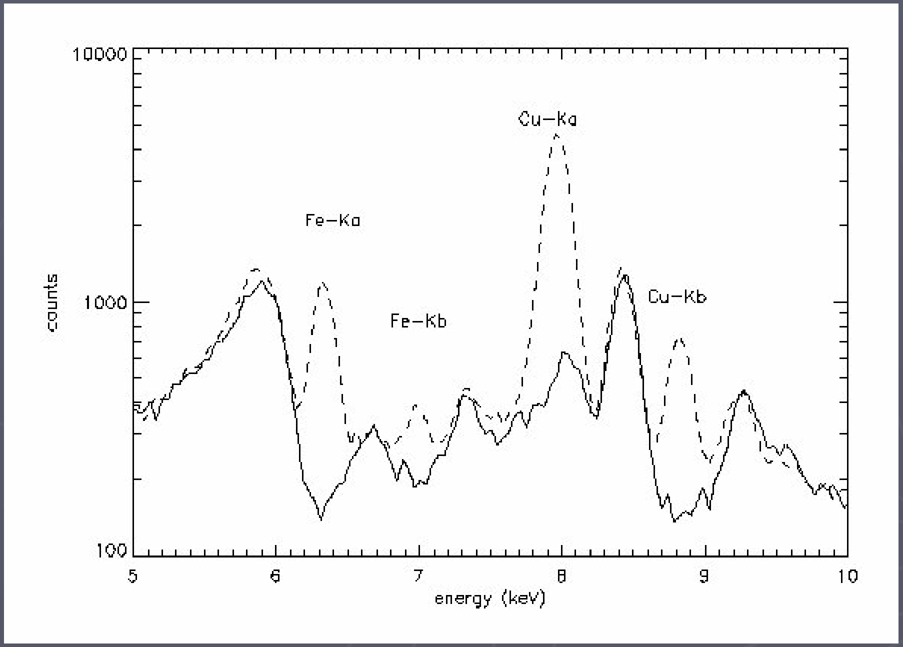
Eddy current scanning apparatus for niobium discs. 100% Nb sheets for TTF scanned and sorted out



The spot was identified as an inclusion of foreign material. Cu and Fe signal has been observed in the SURFA spectrum in the spot area.



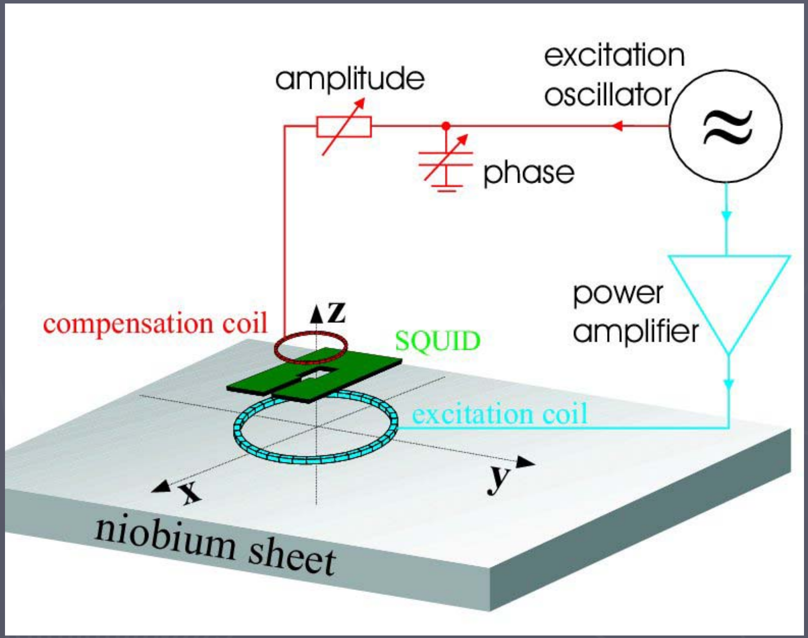
Example of the Nb sheet eddy current scanning test. Arrow indicates the suspicious spot.



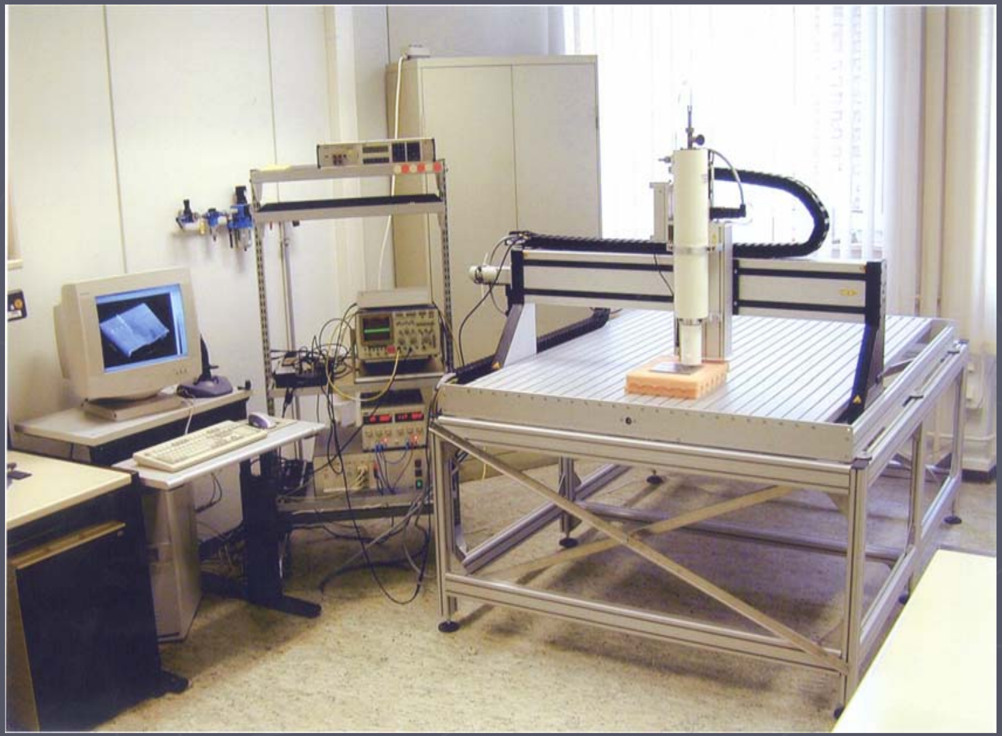
SURFA (Synchrotron Radiation Fluorescence Analysis). Spectrum of K-lines at the spot area (dashed line) in comparison with spot free area (full line).

The ratio signal/noise is low. More sensitive system is desirable

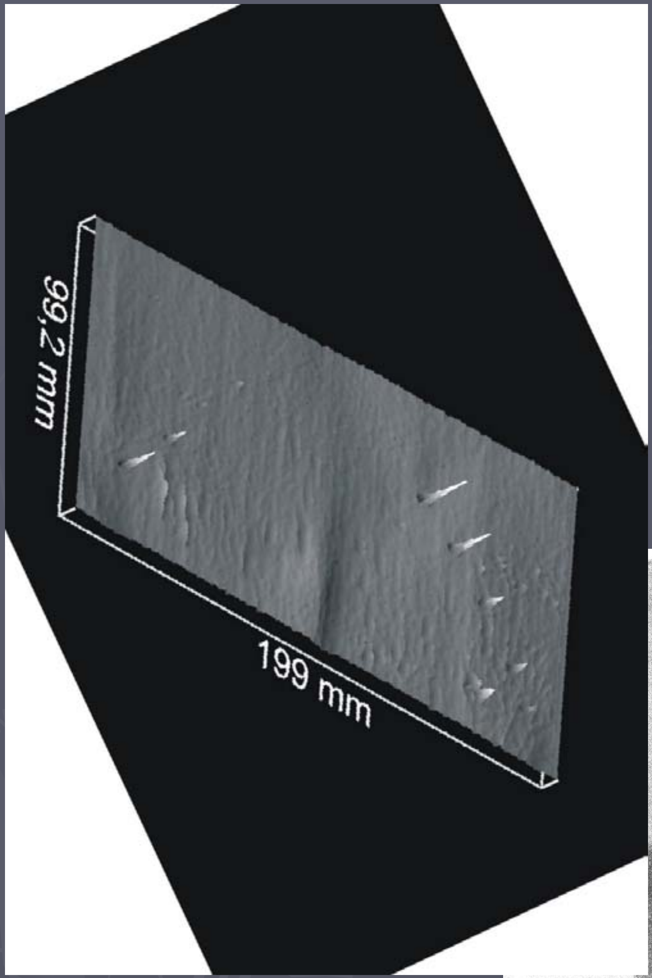
Aim: SQUID system for eddy current testing of niobium sheets



An excitation coil produces eddy currents in the sample, whose magnetic field is detected by the SQUID. A compensation coil close to the SQUID cancels the excitation field at the SQUID.

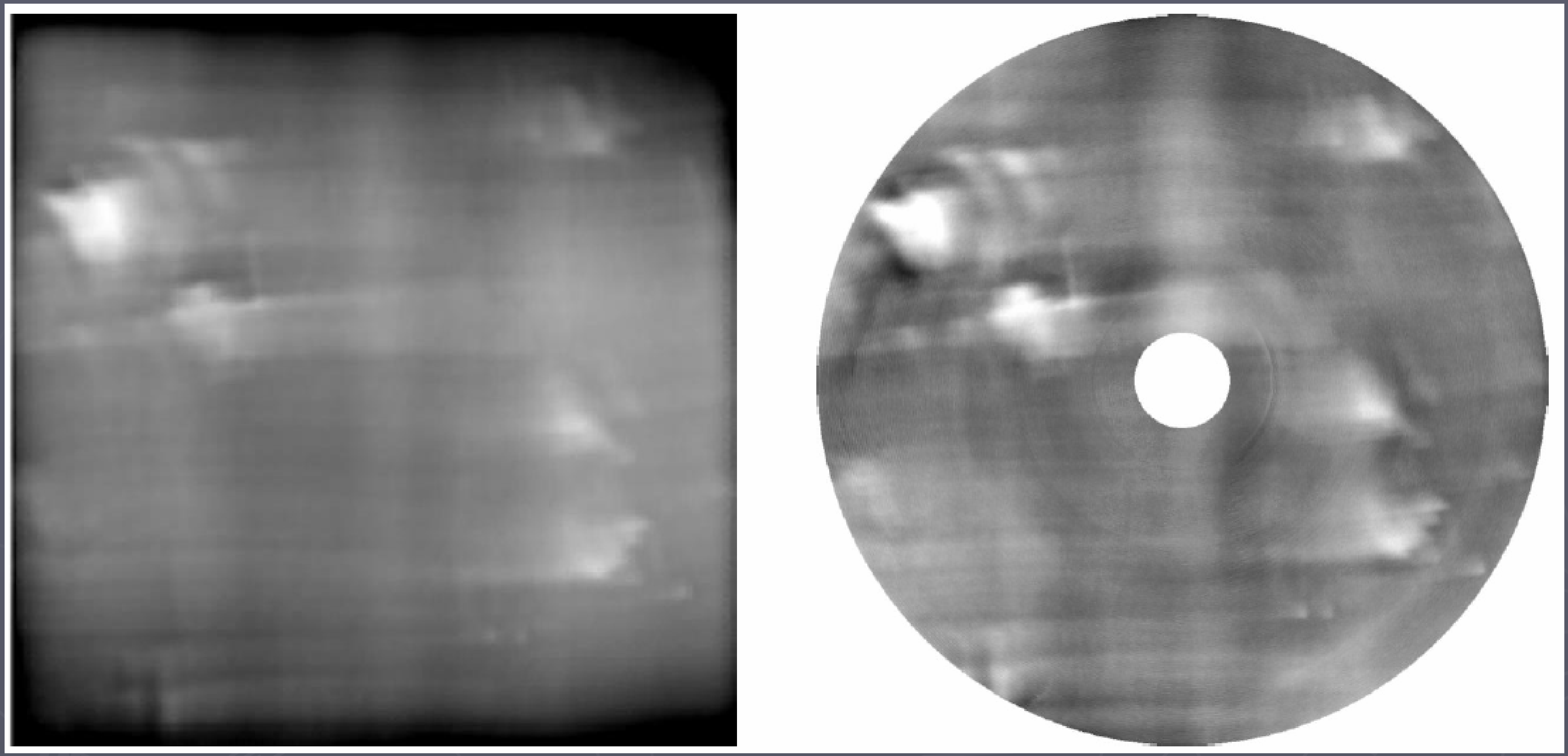


SQUID-based scanning system developed at company WSK and University Gießen (Germany)



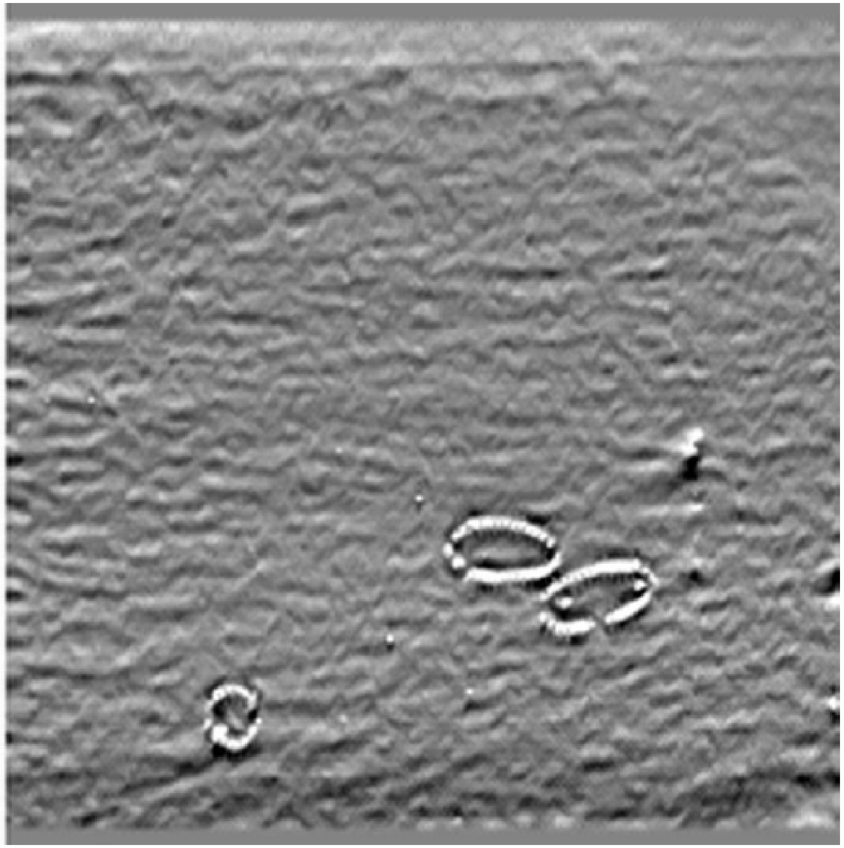
Two-dimensional distribution of the eddy-current field above a test sample containing a number of surface flaws (tantalum inclusions of size 0,1-0,05 mm close to surface) , measured with SQUID system. Eddy current frequency 110 kHz, diameter of the excitation coil 3 mm.

Same sample, however, measured by the conventional eddy current system
SQUID system promise to be more sensitive



Scan of sheet 41 with SQUID sensor system (left). Scanning line density is 1 line/mm, excitation frequency 33 kHz.
Scan of sheet 41 with DESY eddy current system (right). Scanning line density ca. 5 lines/mm, excitation frequency 170 kHz.

Scanning time of 5 min for the sheet 265x265mm by SQUID system is realistic



Scan of sheet 9 with SQUID sensor system and excitation frequency 90kHz (left). The three ellipses shown are pen markings for scratches (within the ellipses) on the BACK of the sheet. Some more dots are visible.

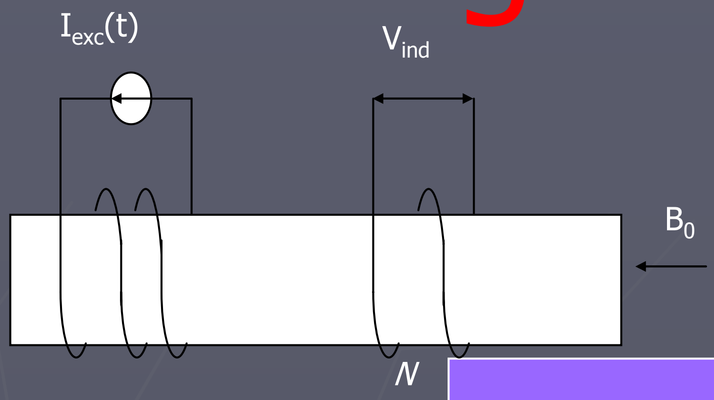
Scan of sheet 9 with DESY eddy current system and excitation frequency 170 kHz (right). None of the scratches is visible on the back of the sheet.

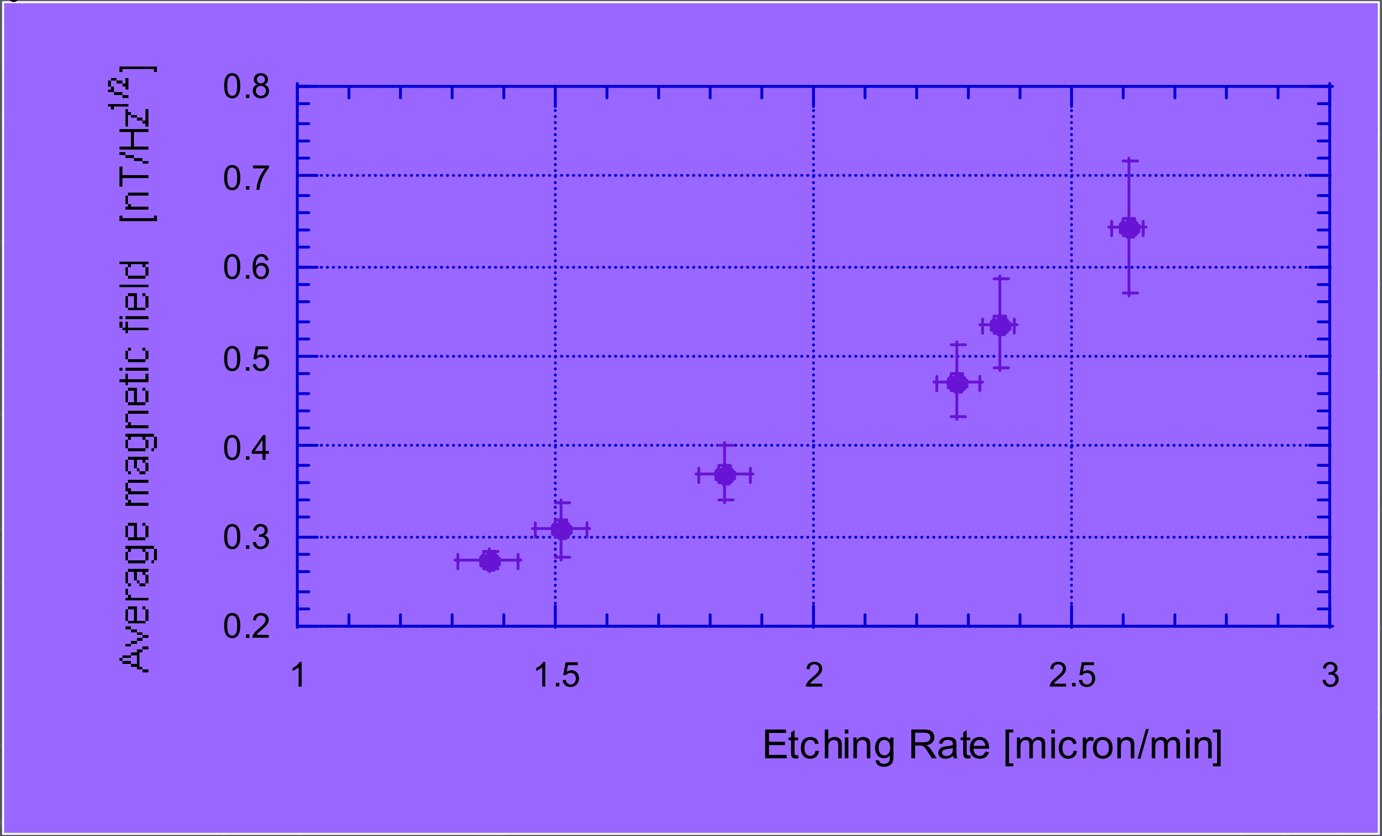
Task: Creating in cooperation with WSK a SQUID scanning system for Nb sheets of 265x265 mm (prototype for XFEL)

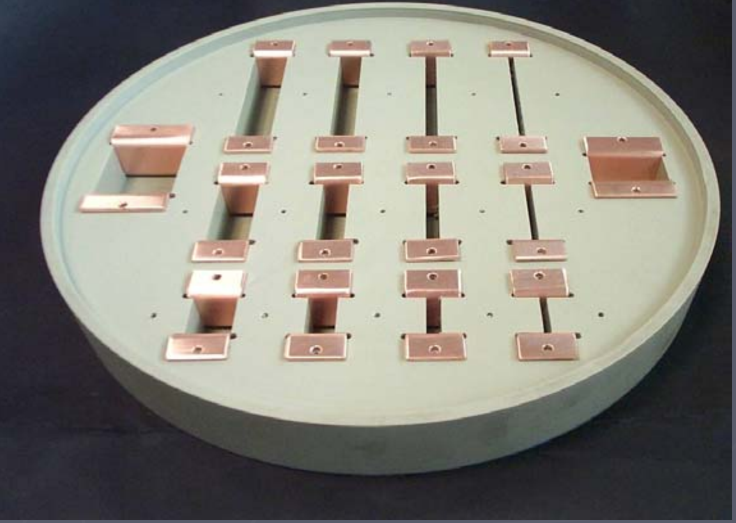
Specification for SQUID scanning system should include:

- rotating table
- high signal/noise ratio
- compensation of lift off effect
- rather fast scanning (5-10 min/sheet)
- vacuum holder of the sheet, keeping it flat

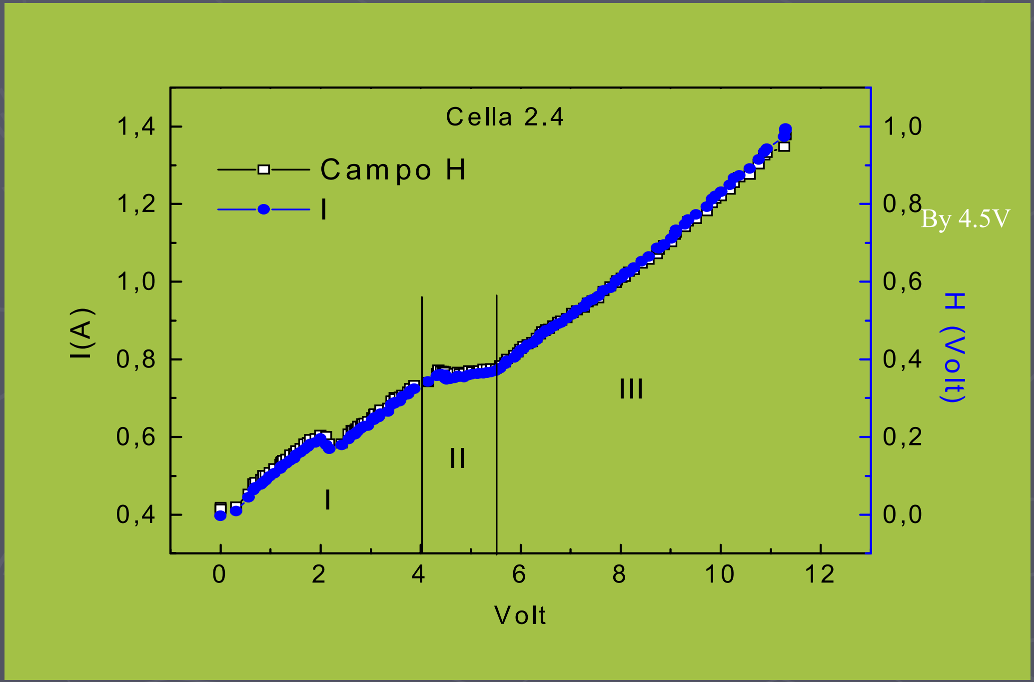
Flux gate Magnetometry

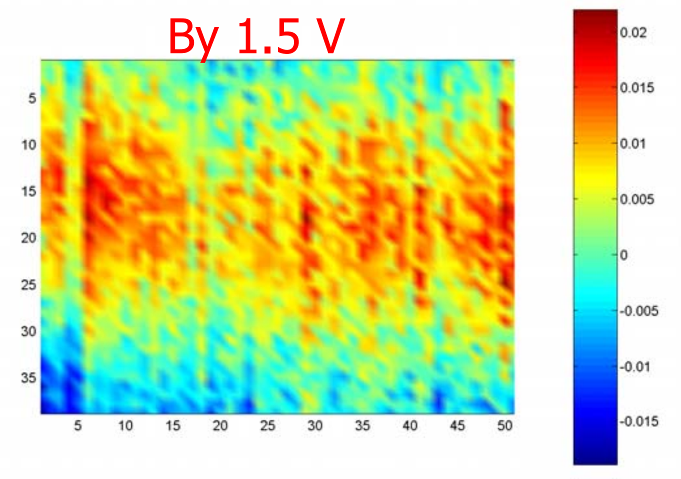


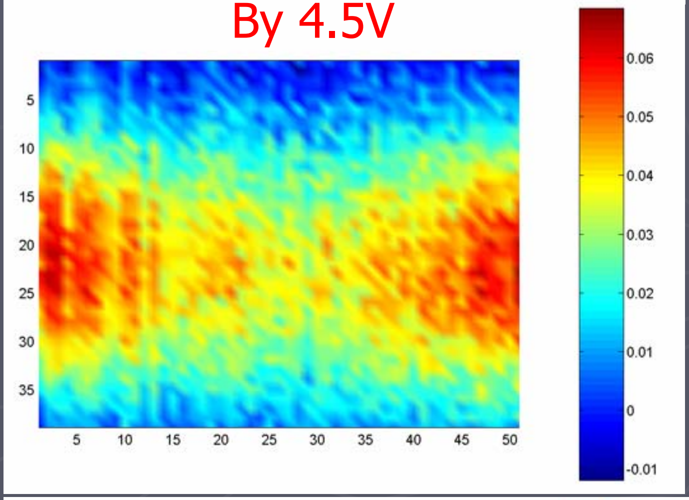


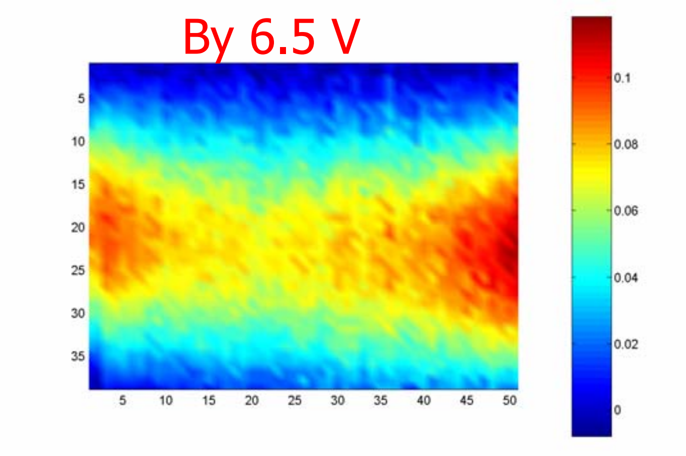


Investigation of Distance and Area role on EP polarization curve









Inverting the Biot-Savart law

$$\mathbf{B}(\mathbf{r}) = \frac{\mu_0}{4\pi}\int \frac{\mathbf{J}(\mathbf{r}')\wedge(\mathbf{r}-\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|} d^3 r'$$

assuming the continuity equation and the condition $J_z = 0$,

it is possible to deduce the current density induced by the magnetic field

$$\mu_0 \mathbf{H}_{ind} \cdot \hat{\mathbf{i}} = \mu_0 H_x(x,y,z) =$$
$$= \frac{\mu_0}{4\pi}\iiint \frac{J_y(x',y',z')\cdot(z-z') - J_z(x',y',z')\cdot(y-y')}{\sqrt{\left[(x-x')^2+(y-y')^2+(z-z')^2\right]^3}} dx'dy'dz'$$

$$\mu_0 \mathbf{H}_{ind} \cdot \hat{\mathbf{j}} = \mu_0 H_y(x,y,z) =$$
$$= \frac{\mu_0}{4\pi}\iiint \frac{J_z(x',y',z')\cdot(x-x') - J_x(x',y',z')\cdot(z-z')}{\sqrt{\left[(x-x')^2+(y-y')^2+(z-z')^2\right]^3}} dx'dy'dz'$$

$$\mu_0 \mathbf{H}_{ind} \cdot \hat{\mathbf{k}} = \mu_0 H_z(x,y,z) =$$
$$= \frac{\mu_0}{4\pi}\iiint \frac{J_x(x',y',z')\cdot(y-y') - J_y(x',y',z')\cdot(x-x')}{\sqrt{\left[(x-x')^2+(y-y')^2+(z-z')^2\right]^3}} dx'dy'dz'$$

Two goals:

- Studying the cathode shape
- To engineer an eventual industrial device