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Technik und Umwelt

Wissenschaftliche Berichte
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Februar 1998

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Forschungszentrum Karlsruhe GmbH, Karlsruhe
1998

Als Manuskript gedruckt

Forschungszentrum Karlsruhe GmbH
Postfach 3640, 76021 Karlsruhe

Mitglied der Hermann von Helmholtz-Gemeinschaft
Deutscher Forschungszentren (HGF)

ISSN 0947-8620

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To investigate the dependence of the local texture of parts of an YBaCuO specimen on the distance of the seed crystal from the position of the part of the specimen, a very good textured YBaCuO specimen was cut into 9 rectangular pieces and into 12 boundary pieces of the cylindric original specimen. From the individual parts of the YBaCuO specimen the texture was measured by neutron diffraction at the Geesthacht reactor with an equal area raster. The grid width was 1° up to 10° deviation from the cylinder axis of the original YBaCuO cylinder and 2° from 10° deviation until 20° deviation. From the sum of the counted neutrons on small circles on the pole sphere the individual values of the distributions of the angular deviations of the c-axes of the crystalline domains from the cylinder axis have been calculated. The mean deviation of the c-axes from the axis of the original cylinder increases from the inner part with the seed crystal to the boundary parts of the cylindric YBaCuO specimen.

Die ordnende Wirkung eines Saat-Kristalles auf die Textur einer massiven YBaCuO-Probe

Um die Abhängigkeit der lokalen Textur von Teilen einer zylindrischen YBaCuO-Probe vom Abstand zum Saatkristall zu untersuchen, wurde eine sehr gut texturierte YBaCuO-Probe in 9 rechteckige und in 12 Randstücke zerschnitten. Von den einzelnen Teilen der YBaCuO-Probe wurden die Texturen mit Hilfe der Neutronen-Beugung am Reaktor in Geesthacht gemessen und zwar mit einem „equal-area"-Raster. Die Maschenweite betrug 1° bis zu einer Achsabweichung der Zylinderachse der originären YBaCuO-Probe von 10° und von 10° Achsabweichung bis zu 20° Achsabweichung betrug die Maschenweite 2°. Aus der Summe der gezählten Neutronen auf Kleinkreisen der Polkugel wurden die einzelnen Werte der Verteilung der Achsabweichungen der c-Achsen der kristallinen Domänen von der Zylinderachse berechnet. Die mittlere Achsabweichung der c-Achsen der kristallinen Domänen von der Zylinderachse der unzerschnittenen YBaCuO-Probe wächst vom inneren Stück mit dem Saatkristall zu den Randstücken der zylindrischen Probe hin an.

As can be seen in Fig. 1, a cylindrical YBaCuO specimen of 43 mm diameter and 15 mm height was cut into nine rectangular pieces and twelve edge pieces for examination of the local texture of these parts.

One aspect under study was the range of the ordering effect of the central seed crystal. Measurements of the texture of the pieces of the specimen indicated that the sum total of the full width at half maximum of the distribution of axial deviations of the c-axes of the crystal domains from the cylinder axis of the YBaCuO specimen and the axial deviation of the center of mass of the distribution increase continuously towards the edge of the specimen. This sum total was produced because there may be narrow distributions with large distances of the center of mass as well as broader distributions with short distances of the center of mass from the cylinder axis. In most cases, however, both values - the width of distribution and the distance of the center of mass - increased towards the edge of the specimen in roughly the same way. The ordering effect of the seed crystal thus decreases towards the edge of the specimen.

The other factor to be studied was whether, with the same global texture of the bulk specimen, a special local texture is able to change the potential maximum current carrying capacity of the superconductor [1]. A decisive factor in this respect is the way in which the distribution of orientations of the c-axes of the crystalline domains is tilted completely relative to the cylinder axis of the specimen. The axis of distribution may be tilted solely in the direction of the cylinder axis in such a way that the cylinder axis and the axis of distribution are situated in the same plane. In this case, the effect reducing the current carrying capacity is extremely slight, as the distribution axis is always normal to the direction of the superconducting currents flowing in concentric circles about the cylinder axis, if these currents are induced by an approaching permanent magnet.

If the axis of distribution of the c-axes of the domains is no longer normal to the direction of the superconducting currents, the influence of the tilt of the distribution axis of the c-axis distribution from the normal to the direction of the superconducting currents is more pronounced than in the case in which the axis of distribution is in the same plane as the cylinder axis [2]. This second case was to be studied by cutting the specimen and subsequently measuring the texture of the pieces. However, it is apparent from the texture measurements conducted that the latter effect does not occur in the specimen under study. Hence, interest was focused mainly upon the range of the ordering effect of the seed crystal implanted into the recrystallizing YBaCuO melt [3].

After the pole spheres had been scanned with a raster of 1.5° in χ and 2° in φ on great circles in the range of $70° < \chi < 90°$ of the pieces of specimen M39 under study, this raster was found to be too coarse. With a raster that coarse, one measurement of the central region of the pole spheres of $70° < \chi < 90°$ took approximately 70 minutes.

For subsequent measurements with a finer raster it was sufficient to apply that fine raster in the ranges of $80° < \chi < 90°$ and $90° < \chi < 100°$. While a 1° raster was used to measure in the central region, a 2° raster was sufficient for the $70° < \chi < 80°$ and $100° < \chi < 110°$ regions. This kept the the number of measuring points to be addressed within reasonable limits. Now it was possible, by measuring the distributions at $\chi < 90°$ and at $\chi > 90°$, to eliminate by averaging any bias arising from the intensity of the neutron beam not being constant over the vertical beam divergence. This condition simulates a misalignment of the incident beam of 0.25° and, at $2\,\theta = 34°$, causes apparent misalignment of the scattering vector of 0.45°.

The inequality of the intensity distribution of the neutron beam over the vertical divergence is due to flaws in the Cu (111) single-crystal monochromator. At an expense of approx. DM 10,000 for a new Cu (111) single-crystal monochromator it is possible, however, to eliminate this apparent misalignment of the scattering vector. If, after installation of a new monochromator, measurements at $\chi < 90°$ and at $\chi > 90°$ result in identical mirror image distributions, the necessary measuring time can be reduced by half if measurements are performed only at $\chi < 90°$ or at $\chi > 90°$. Moreover, a new monochromator allows the neutron beam to be focused horizontally upon the center of the specimen by an arrangement of Cu (111) single crystals on a circular arc of approx. 6 m radius [4].

As no new Cu (111) single-crystal monochromator was available at short notice, the apparent misalignment of the scattering vector of 0,45° had to be put up with initially. Measuring the texture of a piece of the specimen with the measuring raster shown in Fig. 2 took approximately three hours. As a consequence, it was not possible to measure all pieces of the M39 specimen. The pieces measured were the center piece, No.5, with the seed crystal; piece 2i between the center piece, No. 5, and the edge piece, No. 2 (see Fig. 1); the edge piece, No. 2; the adjacent piece, No. 3; and the edge pieces, No. 3a and 1a.

The values of the neutrons counted as obtained from the measurement raster (see Fig. 2) were used to plot sections through the pole spheres. In the absence of any apparent misalignment of the scattering vector, these sections must be mirror images if the value of $\varphi + \pi$ is set instead of the value of φ. The mean value obtained from the asymmetry of the centers of the intensity distributions was the value of apparent misalignment of the scattering vector of 0.45°. For the rest, the sections through the orientation distributions showed the narrowness of the full widths at half maximum of the sections through the distributions.

Summing up the measured counting rates at identical axis deviations from the cylinder axis of the uncut specimen results in the values of the distributions of the deviations of the c-axes of the crystalline domains from the cylinder axis of the YBaCuO specimen [3]. These distributions of the sums of counting rates on small circles about the pole axis clearly indicate a right-left asymmetry caused by the apparent misalignment of the scattering vector.

In order to obtain a measure of the quality of the texture, the sum total was produced of the full width at half maximum (FWHM) of the new distribution and the distance of the center of full width at half maximum from the $\chi = 90°$direction ($\Delta\chi$). Despite all differences in distributions, this sum total, ($\Delta\chi$ + FWHM), is a tangible dimension increasing continuously from the center piece, No. 5, with the seed crystal to the edge piece, No. 3a and, in this way, clearly indicating the decreasing ordering effect of the seed crystal from the center to the edge of the specimen.

The mean value of $\Delta\chi$ + FWHM was produced in two ways: In one way, the value shown above was obtained from the distributions of $\chi < 90°$ and for $\chi > 90°$, and the mean was produced from the two values. In the other case, means were produced for each of the measured values, $|\chi - \pi/2|$, which represent the values of the averaged distribution. From this distribution of mean values of the sums total of the measured values, a different value was obtained for $\Delta\chi$ + FWHM. These mean values obtained in two ways do not differ from each other in the center piece, No. 5, and differ by only 0.05° in the edge piece, No. 2. In the adjacent piece, No. 3 (see Fig. 1), the deviation is 0.15° throughout.

Fig. 3a shows the sections through the pole sphere of the center piece, No. 5, while Fig. 3b shows the summation of the measured values on small circles about the direction of $\chi = 90°$. This applies correspondingly to piece No. 2i (Fig. 4a and Fig. 4b), the edge piece, No. 2 (Fig. 5a and Fig. 5b), the edge piece, No. 1a (Fig. 6a and Fig. 6b), the edge piece, No. 3a (Fig. 7a and Fig. 7b), and piece No. 3 (Fig. 8a and Fig. 8b). Figure 9, finally, provides an overview of all results, i.e. averaging of the right and left distributions from Fig. 3b to Fig. 8b.

Further measurements to be performed with a new Cu (111) single-crystal monochromator are to provide information about the range of the ordering effect of the seed crystal in the depth of the superconducting YBaCuO material along the cylinder axis of the cylindrical specimens.

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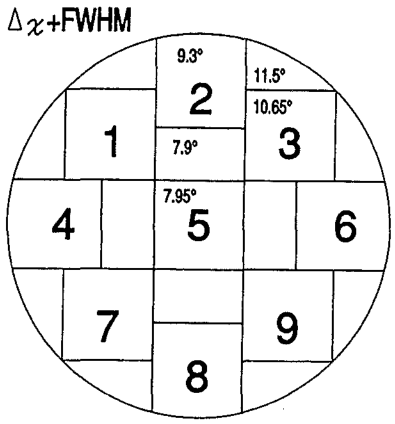

Fig. 1: YBaCuO cylinder with cut lines and numbers of the pieces. The values of degrees represent the sum of $\Delta\chi$ + FWHM of the distributions in Fig. 9.

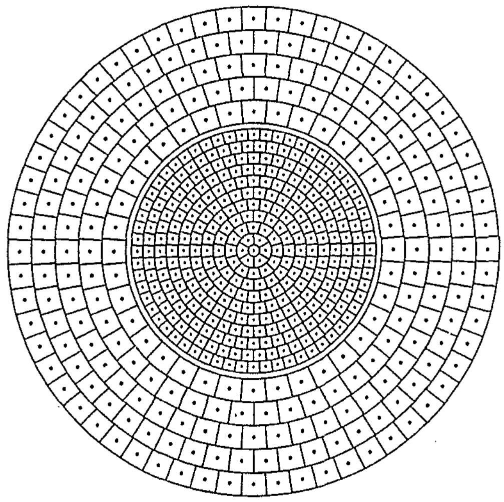

Fig. 2: Equal area raster for measuring of orientation distributions of the c-axes of the crystalline domains of the different pieces of specimen M 39. For a deviation of the c-axes from the cylinder axis = 10° the grid width was 1° and from 10° until 20° deviation the grid witdth was 2°.

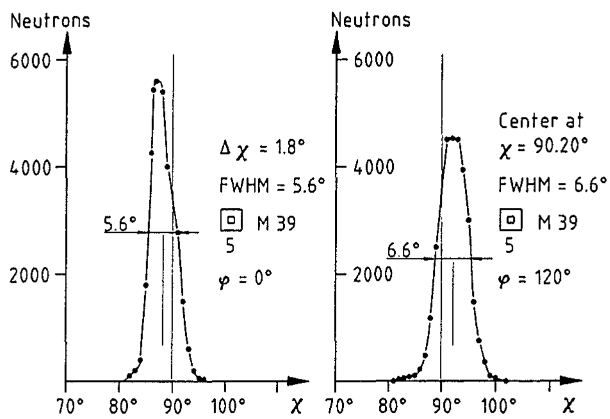

Fig. 3a: Cuts though the pole sphere of the central piece number 5 at the values φ = 0° and φ = 120°. At 2° polar distance 30° in φ correspond to 1° on a big circle of the pole sphere.

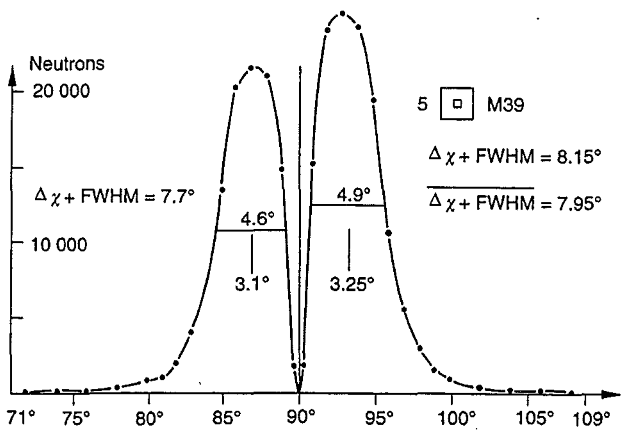

Fig. 3b: Sums of the (005) reflection intensities on small circles of the pole sphere around the cylinder axis of the YBaCuO cylinder. The variation of χ was in the limits $70° < \chi < 110°$. The simulated misalignment of the scattering vector = 0.45°.

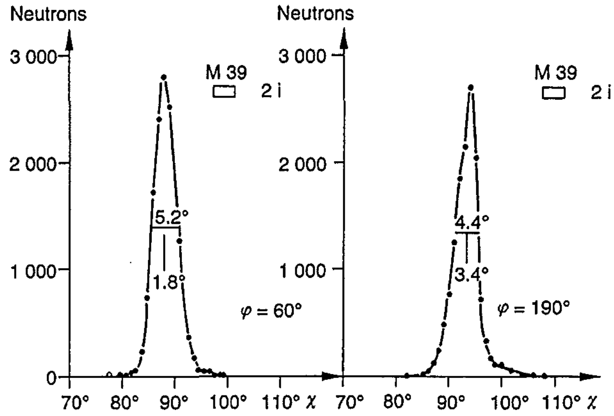

Fig. 4a: Cuts through the pole sphere of piece number 2i between piece number 5 and boundary piece number 2. The cuts were performed at φ = 60° and at φ = 190°.

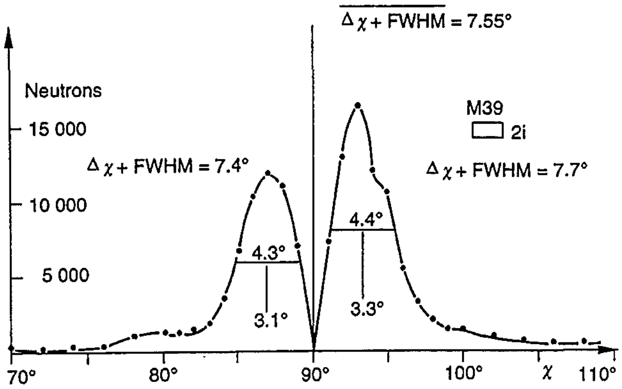

Fig. 4b: Sums of the (005) reflection intensities on small circles around the cylinder axis for piece number 2i. By calculating the mean values the simulated misalignment of the scattering vector was eliminated. This simulated and apparent misalignment was caused by a non-constant intensity over the vertical divergence of the neutron beam.

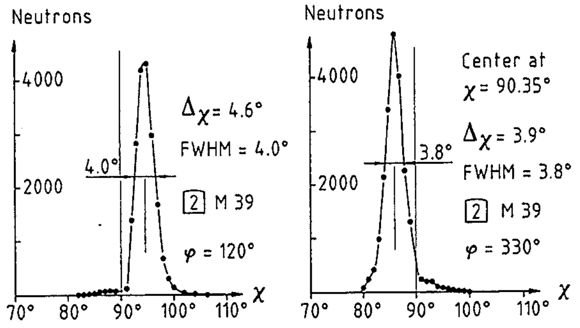

Fig. 5a: Cuts through the pole sphere of the boundary piece number 2 at φ = 120° and φ = 330°.

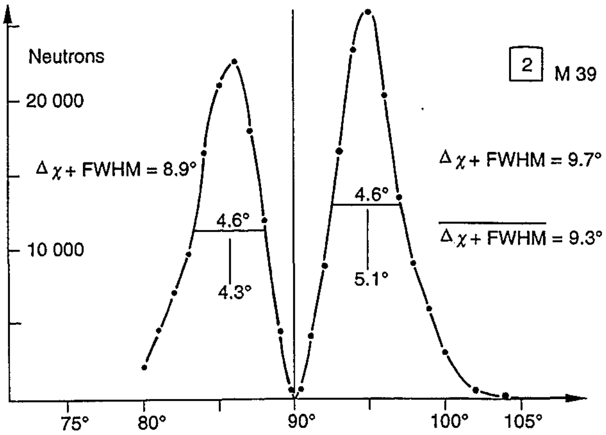

Fig. 5b: Sums of the (005) reflection intensities on small circles around the cylinder axis of the cylindric YBaCuO specimen M 39. The mean values Δχ + FWHM produced in different ways differ only by 0.05°.

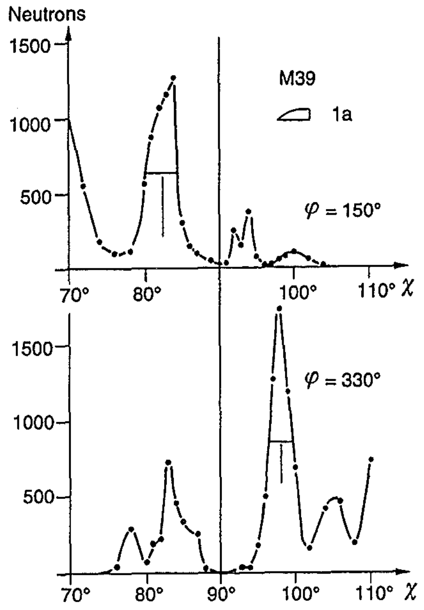

Fig. 6a: Cuts through the pole sphere of the boundary piece number 1a at φ = 150° and φ = 330°.

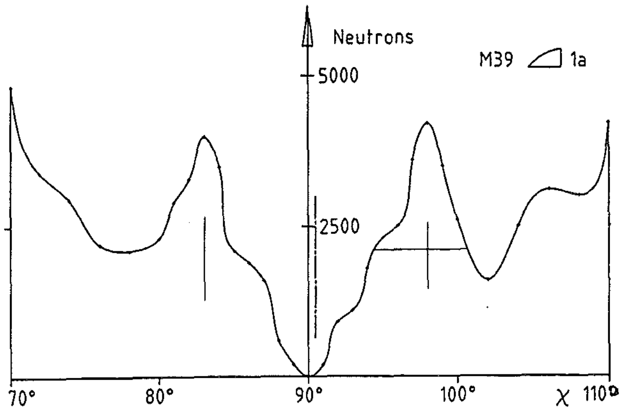

Fig. 6b: Sums of the (005) reflection intensities on small circles of the pole sphere around the cylinder axis of the YBaCuO specimen M 39. Only by summations of the reflection intensity values on small circles of the pole sphere the distribution of the angular deviations of the c-axes from the cylinder axis becomes pronounced.

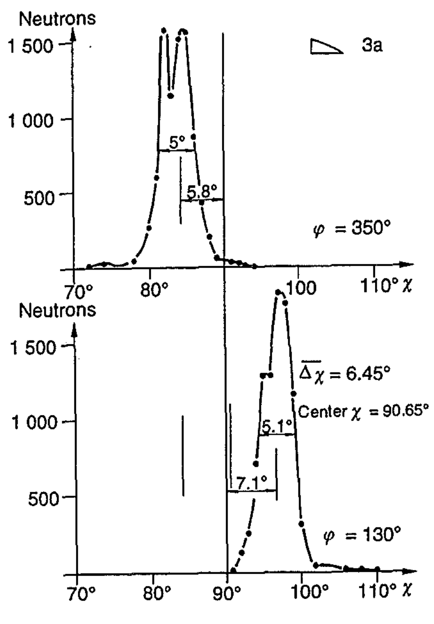

Fig. 7a: Cuts through the pole sphere of the boundary piece number 3a of specimen M 39. This boundary piece has still a clean texture.

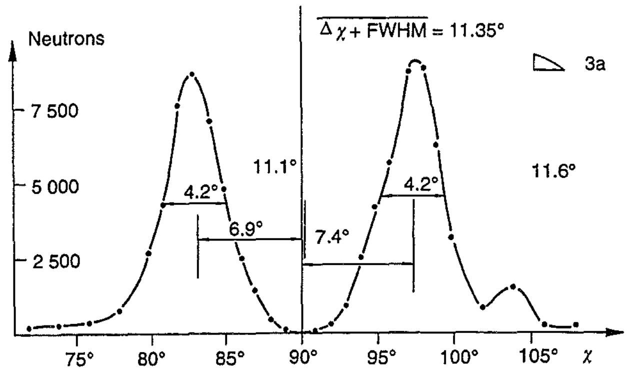

Fig. 7b: Distribution of angular deviations of the c-axes from the cylinder axis for piece number 3a. In contrast to the boundary piece number 1a, the boundary piece number 3a shows a value for $\Delta\chi$ + FWHM = 11.35°. This texture is still clean.

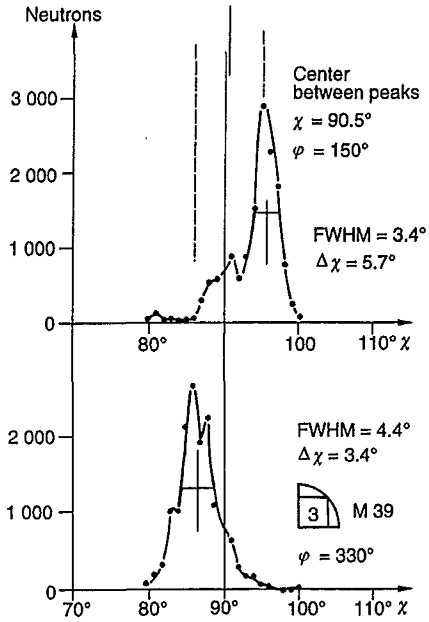

Fig. 8a: Cuts through the pole sphere of piece number 3, neighbour of the boundary piece number 3a. The medium between distribution maxima has the value χ = 90.5°. That means that the simulated misalignment of the scattering vector is 0.5°.

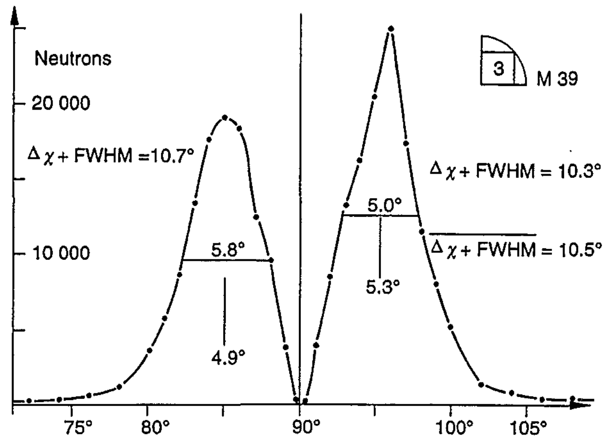

Fig. 8b: Sums of the (005) reflection intensities on small circles of the pole sphere of piece number 3 of specimen M 39. The difference of the different mean value calculations for the value $\Delta\chi$ + FWHM is only 0.15° (see Fig. 9).

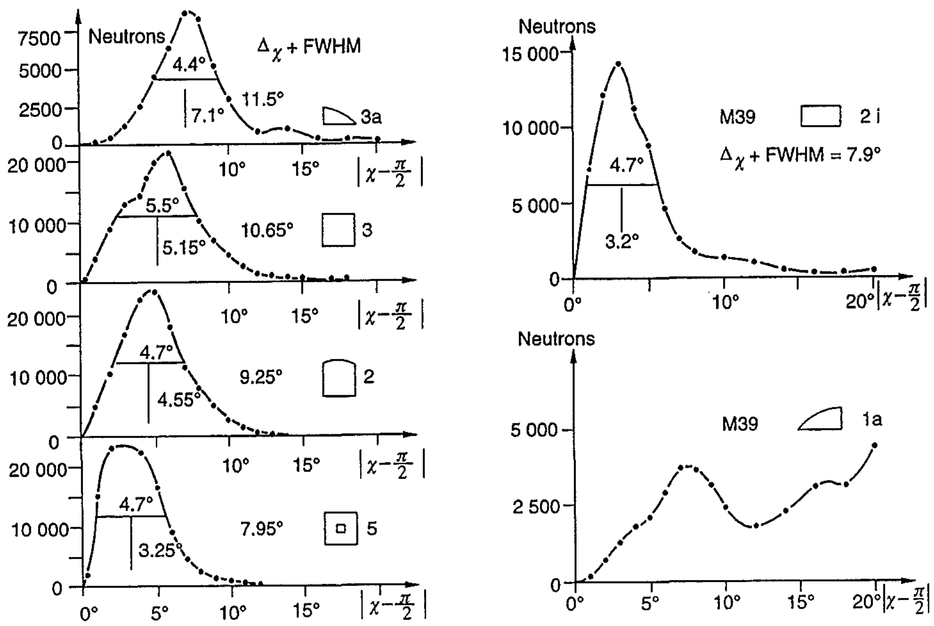

Fig. 9: From the distribution for $\chi < 90°$ and $\chi > 90°$ for each value $|\chi - \pi/2|$ the mean value was calculated. The simulated and apparant misalignment of the scattering vector was eliminated by this procedure. The value $\Delta\chi$ + FWHM increases from piece 5 at center to piece 3a at the boundary.