ESRF	**Experiment title:** High energy x-ray diffraction on curved crystals for gamma-ray astronomy	**Experiment number**: MI - 1070
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Shifts: 12	**Local contact(s)**: Veijo Honkimaki	*Received at ESRF:*

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Report:

In the field of high energy gamma-ray astronomy there is an increasing interest in exploring the range of gamma-ray energies between 100 keV and 1 MeV. In order to efficiently collect and focus gamma-rays in this energy range through Bragg diffraction, the use of "Laue lenses", made of several oriented single crystals, is considered [1-4]. To achieve the maximum efficiency each crystal should have a reflectivity range close to the geometrical resolution of the lens, which is of the order of several tens of arcseconds. In particular, in the framework of our project "LAUE – Una lente per raggi gamma" (supported by the Italian Space Agency) we consider different crystals with reflectivity of about 30 arcseconds.

For this purpose perfect crystals proved to be inefficient because of the very narrow angular diffraction range for high energetic gamma-rays. In order to improve the collection efficiency, mosaic crystals with mosaic spread matched to the resolution limit may then be used. An alternative option to increase the diffraction angular range with respect to the mosaic crystal case is based on curved crystals [5,6].

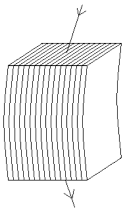
Owing to this, we consider both mosaic and bent crystals to be used as optical elements in our Laue lens. In particular:

- mosaic crystals: GaAs, Cu, CdTe, and CdZnTe crystals;
- bent crystals: we propose an "artificial mosaic" Si or GaAs optical element made of curved single crystals where the lattice curvature was obtained by introducing a compressive stress on one of the crystal surfaces.

The analysed samples were:

- one Cu mosaic crystal (200) oriented (15x15x6 mm^3) grown at ILL [7];
- two CdTe mosaic crystals grown at IMEM-CNR, one (111) and the other (100) oriented;
- three GaAs mosaic crystals (100) oriented (thickness from 1.6 to 5 mm) grown at IMEM-CNR;
- one stack of 15 curved Si single crystals (100) oriented (about 0.75 mm thick);
- one stack of 12 curved GaAs single crystals (100) oriented (about 0.5 mm thick);
- one stack of 11 GaAs single crystals (100) oriented (0.5 mm thick).

The measurements were performed in different positions on each sample and at x-ray energies ranging between 200 and 500 keV. A monochromatic beam from the synchrotron is obtained by two parallel Ge 711 monochromators bent on the Rowland circle to get a sharp monochromaticity between about 120 and 700 keV with a fixed exit. A 1x1 mm^2 beam size was selected by slits. Rocking curves in Laue geometry were collected in both diffraction and transmission by means of Si-diode detectors. Another detector allowed to monitor the incident beam. In particular, the collected rocking curves were those related to 200 reflections in the case of Cu sample, 220 for GaAs and CdTe crystals, and 400 for the stacks (with the beam entering the stack from its "side", see figure).



The diffracting plane curvature in the curved crystals was previously checked for each single crystal by means of high resolution x-ray diffraction (8 keV) at IMEM-CNR.

The main aims of the experiment were to verify 1) the efficiency of mosaic and "artificial mosaic" (the stack) crystals and 2) the alignment of single tesserae inside each stack.

The experiment has been globally successful and allowed us to draw some conclusions:

- Cu mosaic crystal has peak FWHM between 30 and 150 arcseconds, decreasing with the increase of energy from 8 to 500 keV (Fig. 1);
- CdTe mosaic crystals present low angle grain boundaries that are not compatible with the required crystal uniformity;
- GaAs mosaic crystals present mosaicity values too low (up to 20-25 arcseconds, Fig. 1); on the other hand, the diffraction efficiency of these samples reaches values near 50% (Fig. 2);
- the diffraction efficiency of a curved GaAs tessera of the stack is close to 100% (Fig. 3);
- unfortunately, we find the tesserae of the stacks are slightly misaligned with respect to each other.

Thus, we can conclude that curved crystals are good candidates as optic elements of a Laue lens, even if both the curvature and the alignment of the tesserae in the stack should be further controlled and improved.
Probably other sessions will be necessary to study in depth some mechanisms (as the FWHM decrease with energy increasing) and future developments of curved crystals.
Some results obtained in this experiment will be published in a scientific journal [8-9].

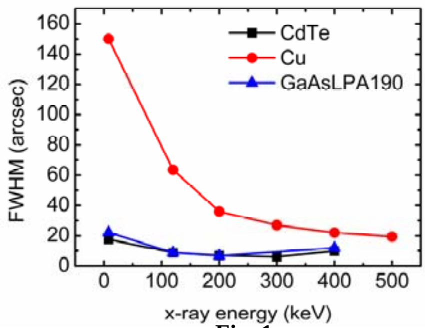


Fig. 1

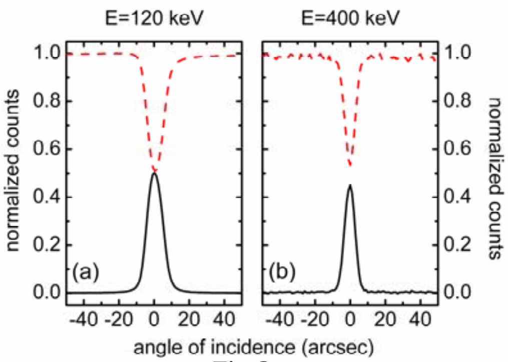


Fig. 2

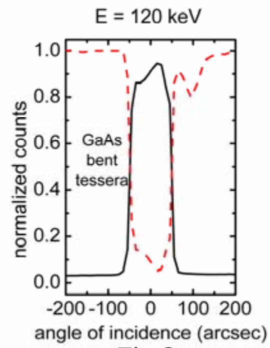


Fig. 3

Fig. 1: FWHM measured by x-ray diffraction for CdTe (black squares), Cu (red dots), and GaAs (blue triangles) samples at 8 keV (reflection Bragg geometry) and 120, 200, 300, 400, 500 keV (transmission Laue geometry). **Figs. 2 and 3:** rocking curves collected in diffraction (black solid curves) and in transmission (red dashed curves), normalized by the intensity of the transmitted beam when no diffraction occurs, on a GaAs crystal (Fig. 2) and a GaAs bent tessera (Fig. 3).

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