Performance of the x-ray targeted irradiation line at the IFJ PAN

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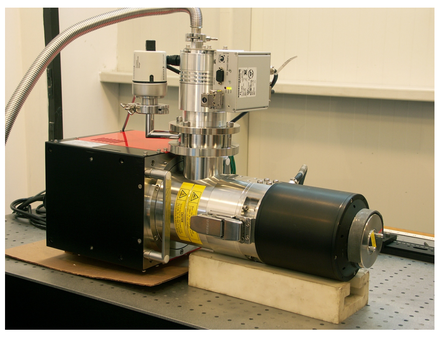
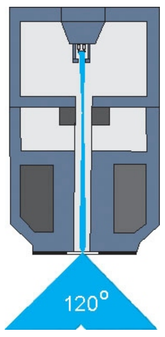
Beam focusing

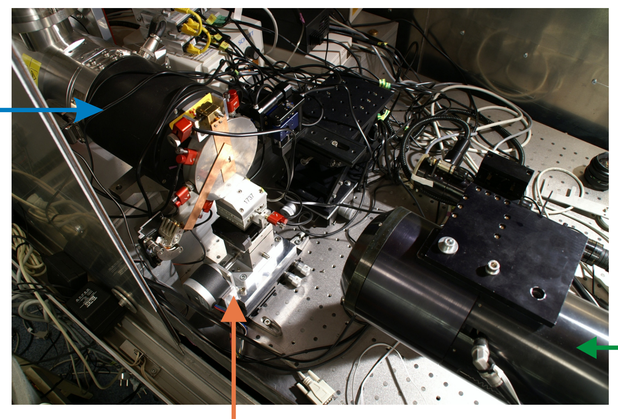
The poster shows an idea and construction details of the targeted x-ray irradiation line designed for cell irradiations. The facility is based on an open type **X-ray tube (1)** characterized by the emission spot size of 2 μm in diameter and 120 degrees cone beam. The characteristic x-ray radiation, emitted from a titanium anode is focused on the target using the Kirkpatrick-Baez **multilayer mirrors (2)**. During focusing process the image of the beam is observed on the **CCD camera (3)**.

1) X-ray tube [Hamamatsu]



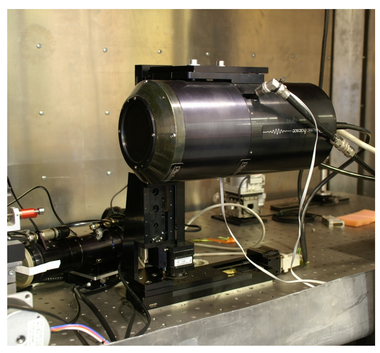


Voltage: 20kV - 160kV, tube current: 0 - 200 μA*
Target current: 0.1 μA - about 30 μA*
Target material: Titanium (Kα 4.5 keV)
* depends on the voltage



3) X-ray CCD camera [Photonic Science]

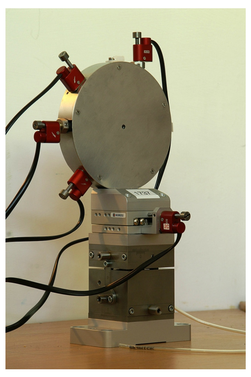
The CCD sensor is optically bonded to a tapered fibre-optic. The fibre ending has been covered with the X-ray scintillator (Gadolinium Oxysulphide doped with terbium). The thickness of the scintillator is optimized to register X-rays of energies in a range of 5 to 35 keV.

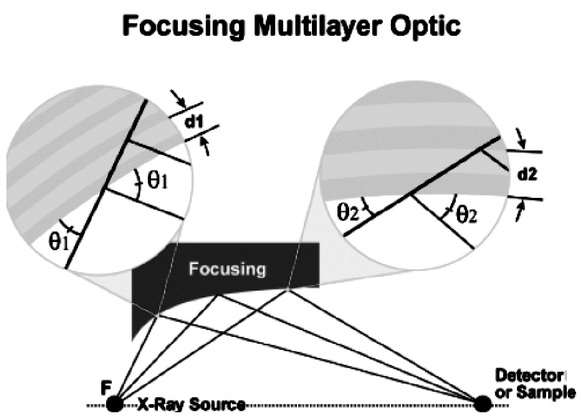


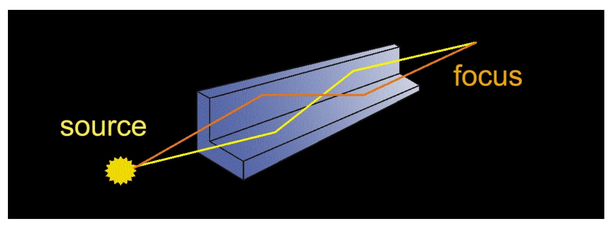
- 4008 x 2670 pixels
- 14.7 μm input pixel size
- 10 MHz frequency
- 12-bit signal accuracy
- 4096 grey levels

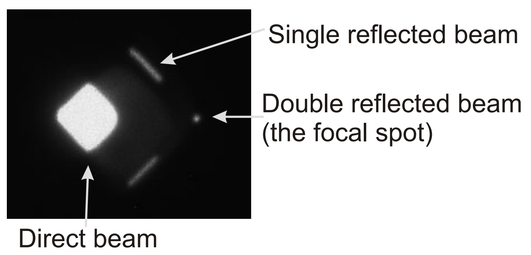
2) Multilayer mirrors [Rigaku]

The multilayer mirrors are optimized for the 4.5 keV X-ray energy (Ti Kα). The Rigaku K-B mirrors are two ellipticaly curved multilayer elements perpendiculary fixed to each other. The principle of work is based on the Bragg constructive interference. The obtained focal spot is about 10 um in diameter [1].









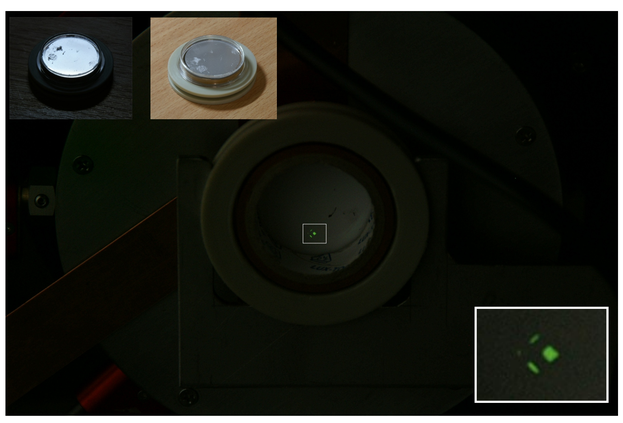
An x-ray could go through directly not touching the mirror (the direct beam), reflect from only one surface (the single reflected beam) or from both surfaces, which gives the doubly reflected beam which is the focal spot.

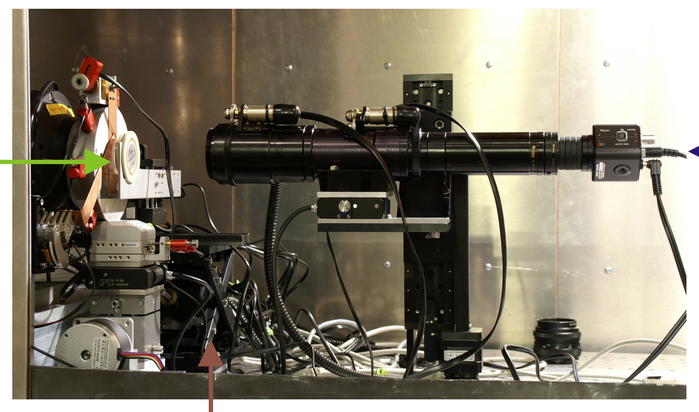
Beam alignment and irradiation

When the beam is focused, its image in the **scintillator screen (5)** is observed with the **optical microscope (4)** equipped with a CCD camera. The precise 3D **sample positioning stand (6)** and the fast **beam shutter (7)** are responsible for the sample positioning and the exact dose control. Cells are cultured and irradiated in **cell dishes (8)**. The source resolution and the focal spot size measurements were presented in our previous posters* .

5) Scintillator screen [Proxitronic]

Scintillator material: 4 micrometers of P43 phosphor on quartz substrate with 2 micrometers Al coating





4) Optical microscope [Quioptiq]

- motorized zoom and focus
- coaxial light source [Shott]
- field-of-view (zoom): 16:1
- resolution: 900 lp/mm
- camera connection [Watec]

Images of cells

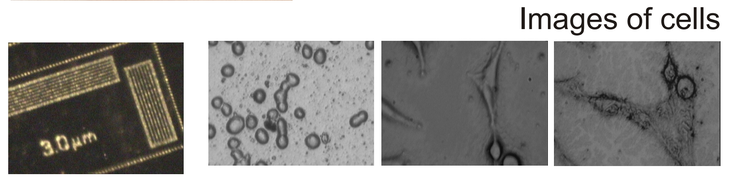
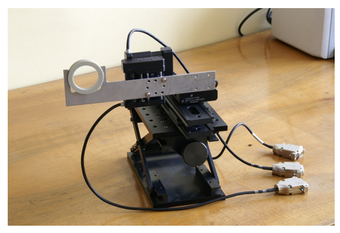


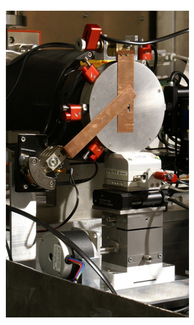
Image of calibration pattern

6) Sample positioning stand

Two precise stepper motors [Physik Instrumente] with vertically moving table [Standa]

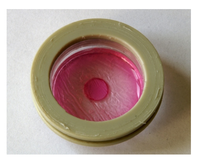


7) Beam shutter and aperture



Beam shutter is a home made element. A half milimeter copper sheet is tighten to an old computer disk head driven by USB converter.

8) Cell Petri dish [Sarstedt]



Cells are seeded and irradiated on 35 mm diameter Petri dishes with 10 mm round holes in the central part of the bottom. The bottom is covered with the 1.5 μm thick Mylar foil [Goofellow]. A population of about 10^5 cells in 4 μl medium was seeded on the central part of the Mylar foil 16–18 hours before the experiments.

*** Previous Posters**
- **X-ray focusing with multilayer elliptical mirrors,** COST MP0601 meeting in Salamanca, Spain, May 2009
- **Cells irradiation complementary lines at IFJ PAN,** COST Mp0601 meeting in Kraków, Poland, May 2010

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