USING ARUCO CODES FOR BEAM SPOT ANALYSIS WITH A CAMERA AT AN UNKNOWN POSITION

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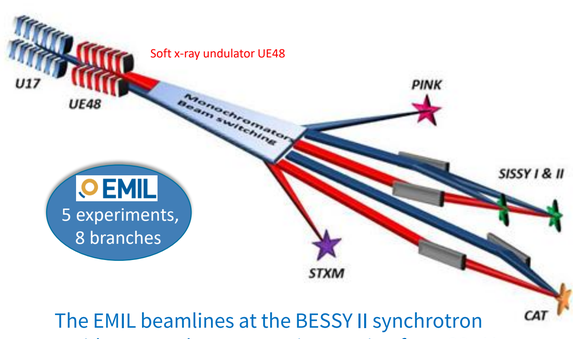
Challenges in Measuring the Size and Shape of an X-ray Beam Spot

The size and shape of an X-ray beam is an important parameter in the design of sample cells and for verification of beamline setup.

Motivation

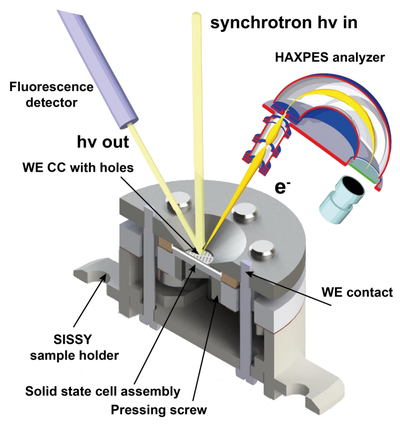
Hard x-ray undulator U17
(cryogenic in-vacuum undulator)



The EMIL beamlines at the BESSY II synchrotron provides x-ray photon energies ranging from 80 eV up to 10000 eV [1]

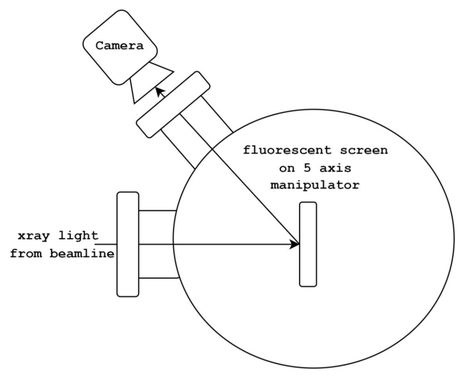
- Hard and soft X-rays can be focused at a single point
- At SISSY-1 interaction point theoretical beam size:
  - Soft beam 44 μm x 7 μm (100 μm exit slit, 80eV).
  - Hard beam 93 μm x 5 μm (2 KeV, Si 111).
- Characterization of X-ray spot at the interaction point is important for design of sample cells and verification of beamline setup.

Sample Cell with Narrow Openings



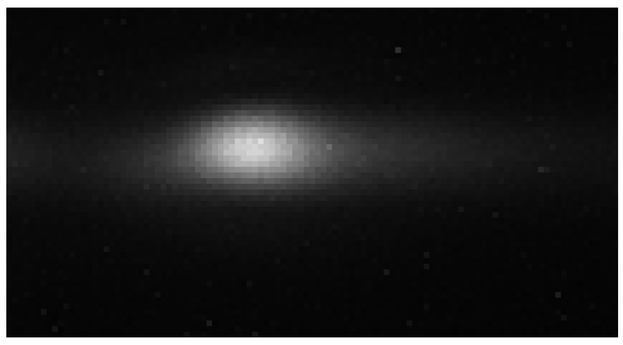
X-ray light must be threaded through small openings in the sample cell. Knowing how big the beam is helps with designing these cells. It's also useful for planning measurement pattens when measuring at multiple sample locations.

Endstation Chamber



We can put a fluorescent screen in the endstation chamber. It will make a bright spot where the X-ray hits it. The screen is moved around the chamber to find the focus so the position of the camera relative to the screen is not fixed.

Resulting Warped Image

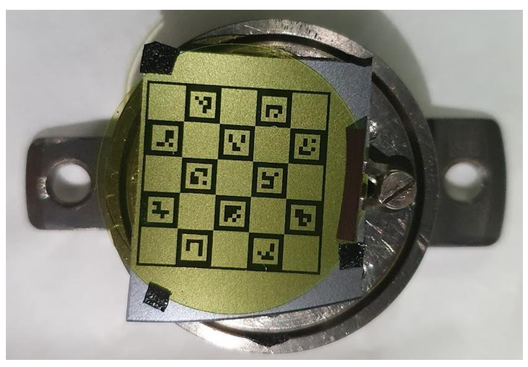


However, the position of camera relative to the screen causes unwanted perspective in the image.

There is no reference, so it's not possible to say how big each pixel is and so we cannot measure the beam.

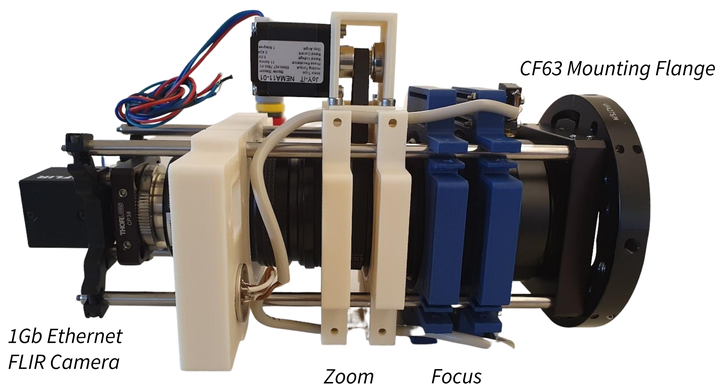
Creating a Reference Screen & Building an Imaging System

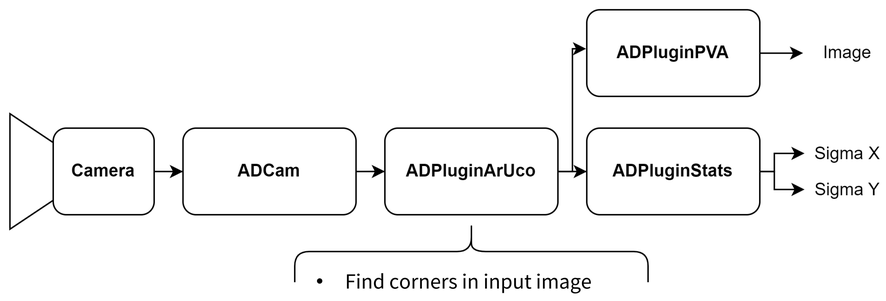
YAG:Ce 200 μm Thick Crystal. TiO2 ChArUco Board Printed with UV Lithography



ChArUco board provides reference points that can be easily found by a computer vision system to sub pixel accuracy [2]. The screen get's mounted to a sample holder.

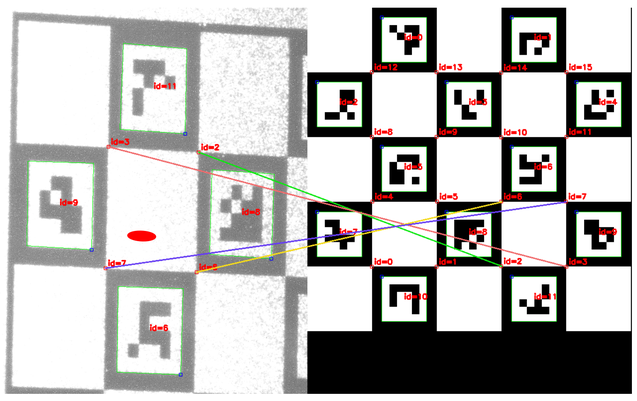
Lens with Zoom and Focus Controlled with EPICS Motor Record





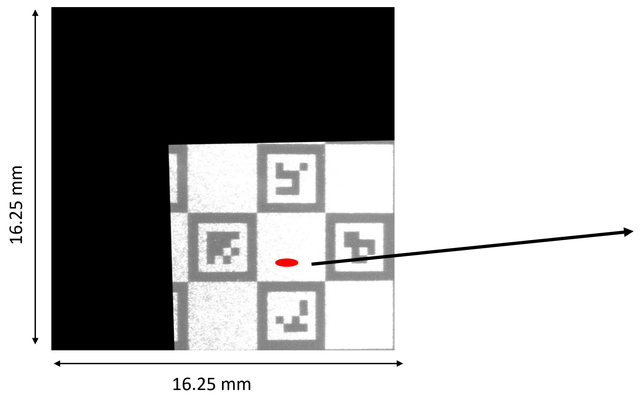
Removing Perspective & Measuring Beam in Real Time with OpenCV & AreaDetector

Determine Homography Between Input Image and Reference



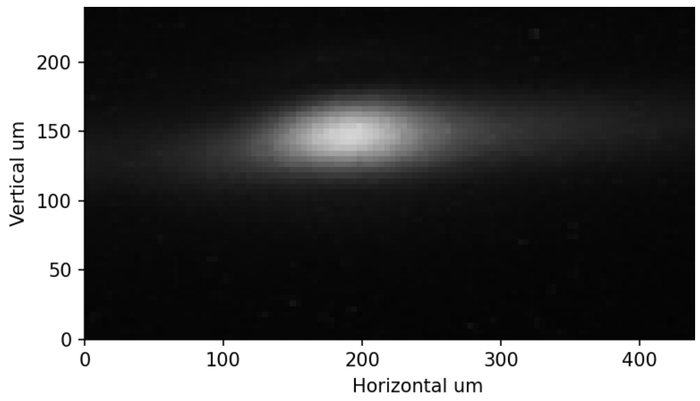
Red spot represents beam spot. In practice it is too small to see. In future versions the ChArUco board should be made more dense, giving more available corners when zoomed in.

Use Homography to Remove Perspective



Now we know the size of every pixel in the image. It's as if the camera is pointing directly at the reference screen

X-ray Beam Spot in Image is also Corrected



This processing takes less that 0.1ms for a 1024 x1024 image

CONCLUSIONS

This study has shown that it is possible to accurately measure the size and shape of an X-ray beam even when the screen is not directly facing the camera. A ChArUco board printed on a fluorescent YAG:Ce crystal provides the necessary reference points which can be easily located in real time with sub-pixel accuracy by an AreaDetector Plugin using OpenCV.

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[3] *ADPluginArUcoUnwarp*, https://github.com/whs92/adpluginarucounwarp

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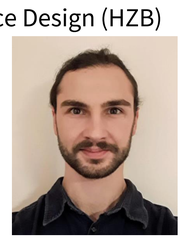

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