#### Master slave topology based, remotely operated, precision X-ray beam profiler and placement system for high pressure physics experiment at Indus-2 beam line

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## Aim

- To measure Angle Dispersive X-Ray Diffraction (ADXRD) at High pressure. It is extremely important to determine the structural properties of materials under extreme condition.
- Beamline BL-12 of Indus-2, for its wider utilization, is being upgraded to perform high pressure experiments in the ADXRD geometry.
- Use DAC to generate high pressure (~10<sup>6</sup> bar).
- To align repeatedly and mount precisely the Diamond Anvil Cell (DAC) for the experiments.

#### Challenges

- X-Rays being an ionizing radiations, exposure to the user needs to be strictly avoided
- To locate precisely ~100  $\mu$  wide incoming X-ray beam in 10,000 x 10,000  $\mu^2$  (10 x 10 mm²) area
- After locating the beam, placement of the DAC (300  $\mu$  opening) at the centre of the beam with accuracy of ~2.5  $\mu$
- The alignment needs to be carried out in a shielded environment using a remote controlled system

#### Development

- A remotely operated precision beam locator cum placement system Lakshya based on a master slave topology has been developed
- Instrument uses all indigenous and low cost components i.e. XY motorized translation stage (TS), its driver, controller, Plastic serial link and software have been developed in-house at RRCAT
- Ta (tantalum) orifice is made by drilling a 100 micron hole in a 400  $\mu$  thick Ta sheet, Its thickness ensures complete absorption of the highest photon energy from the beamline (25 keV)

#### **Experimental Setup**



Schematic of the high pressure experiment setup

#### Experimental Setup cont..

- DAC is mounted on a two axes translation stage (TS) with X-ray sensitive detector placed behind it
- TS motion in a plane perpendicular to the X-Ray beam
- Software guides the DAC to scan selected region
- The detector, gives the X-Ray intensity through the DAC as a function of X & Y position
- Data is presented in image format
- Optimum position of the DAC is determined as the co-ordinates where the transmission of X-Rays through the DAC is the maximum

Lakshya, लक्ष्य Master software



- ADXRD beam line (BL-12) is used by various external researchers also, may not be software conversant
- GUI based robust software have been developed, which is self explanatory and has self guiding capability. Extended error handling incorporated
- Elaborate Image Processing software **TRILOCHAN** is a part of Lakshya to carry further measurements

## Lakshya, Scanning ...

#### Rough scan

- Scans 10,000 x 10,000  $\mu^2$  with selectable resolution (10 to 100  $\mu$ ). Which provides the tentative X-ray beam position in 2-D format
- Takes ~ only 5 to 6 minutes for a rough scan at a scanning resolution of 25  $\mu$

#### • Fine scan

- The area is selected from rough scanned image. Scanning with programmable resolution from 2.5 to 10  $\mu$  in steps of 2.5  $\mu$
- Provides accurate 2-D map of X-ray beam

#### Lakshya, SW Features

- After scanning, the DAC / detector can be placed on desired position
- Mouse movement provides beam intensity at cursor position
- DAC placement location is picked by a mouse click from scanned x-ray beam image (No range exceed message)
- After placement of DAC at the desired location as a feedback, it provides the X-ray beam intensity

#### Lakshya, SW features cont..

- Intensity profile measurement in horizontal, vertical direction
- Direct Measurements of beam size
- Selectable pseudo color shades & schemes
- Low pass filter in X, Y or XY direction for noise reduction
- Median filtering for removing isolated noise with minimum blurring
- On-line color stretching provides full-scale color resolution
- Viewing 3-D image at different viewing angle

#### Lakshya, Rough Scan



Rough scan @ 100 micron. Image shows SRS beam clearly. The defined ROI is further fine scanned to know exact position of beam.

#### Lakshya Fine Scanning



Fine scanning in progress.

#### Embedded Trilochan in Lakshya







# Color shades and pseudo color

Beam in 256 pseudo colors.



## **Removing Noise**

- Removes isolated noise without blurring
- Data rearranged, No new value generated

#### Image with isolated noise



#### 3x3 median filtered



### 3D View of X-ray Beam using Lakshya



#### **FWHM Measurements**



# Rough Scan

S. No.	Fixed Scan Size	Resolution	Image Size	Scan Time
1	10000 µ x 10000 µ	2.5 µ	4000 x 4000	16000 S
2	"	5 µ	2000 x 2000	4000 S
3	"	10 µ	1000 x 1000	2500 S
4	"	25 µ	400 x 400	400 S
5	"	50 µ	200 x 200	100 S
6	"	100 µ	100 x 100	25 S

- From Master : aSC + No. of data in line (4) + No. of lines (4) + Direction (1) + ADC S/N (1) ;
- Reply from slave : [= Line no. (4), No. of data points
  (4) + dd,dd,dd,.....dd + Checksum (6) + FSOVR]
- All reply from  $\mu$ C is received as an EVENT

# Fine scan

From Master : aFC + Start position (4) + End position (4) + No. of data in line(4) + No. of lines (4) + Direction (1) + ADC S/N (1) ;

Reply from slave : [= Line no. (4), No. of data points (4) + dd,dd,dd,....dd + checksum (6) + FSOVR]

# Go to X,Y

From Master : aXY + X Position (4) + Y Position (4) ;

Reply from slave : [= X Position Y Position, MOVED]

#### All in one type 80c552 based CPU card 16 Ch TTL Digital inputs / outputs 8 Ch analog inputs (10 bit), 16K EPROM, 32K RAM



~ 150 such CPU Cards are being used in various DAE Units

#### **Motor Driver**





Universal Stepper motor controller, can be used with any CPU for 4 - 8 wires motor

#### Compact, Optical RS-232 link



High speed data transfer (57,600 baud rate) optical serial link is used. No bit error observed even in a Giga bits of transmission. Developed at RRCAT, being used since 1994.



DAC mounted on an automated X-Y scanner controlled through Lakshya

#### Results : XRD Pattern of LaB<sub>6</sub> as a function of pressure



Measurements carried out on developed setup, using NIST standard LaB6 powder as a function of pressure. Au powder was used for the calibration of the pressure inside the cell.

# **Thank You**

