Optics and Detector Testing at 1-BM

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Overall Needs for a BM Optics and Detector Testing Capability

- What is being done at present?
  - Use NSLS for topography analysis of crystal optics. Facility will close, plus travel costs in the meantime.
  - Non-optimum use of beamlines for tests via user proposals; difficult to get time, long delay between tests.
- What is our goal for the future?
  - Test optics and detectors as they are developed, with a quick fabrication-testing-analysis feedback cycle.
  - Have reproducible and optimized test setups.
  - Support optics and detectors for new scientific capabilities at APS.
  - Support optics and detectors needed for APS Upgrade.

Optics and Detector Testing at 1-BM: Specific Capabilities and Estimates of Allocated Shifts

- Topography analysis of crystals up 100 mm in diameter (crystal optics, plus industrial crystal growers)
  - White beam topography (White) - 36 shifts
  - Monochromatic beam topography (Mono) - 36 shifts
- Grating interferometry testing of wavefronts after an optic (Mono) - 27 shifts
- Detector testing - 72 shifts

– Evaluation of spectral response (Mono)
– Evaluation of point spread function (Mono)
– Evaluation of time response, count rate limits (Mono)
– Evaluation of absolute efficiency (Mono)
– Commission new detectors separately from user operations (Mono)

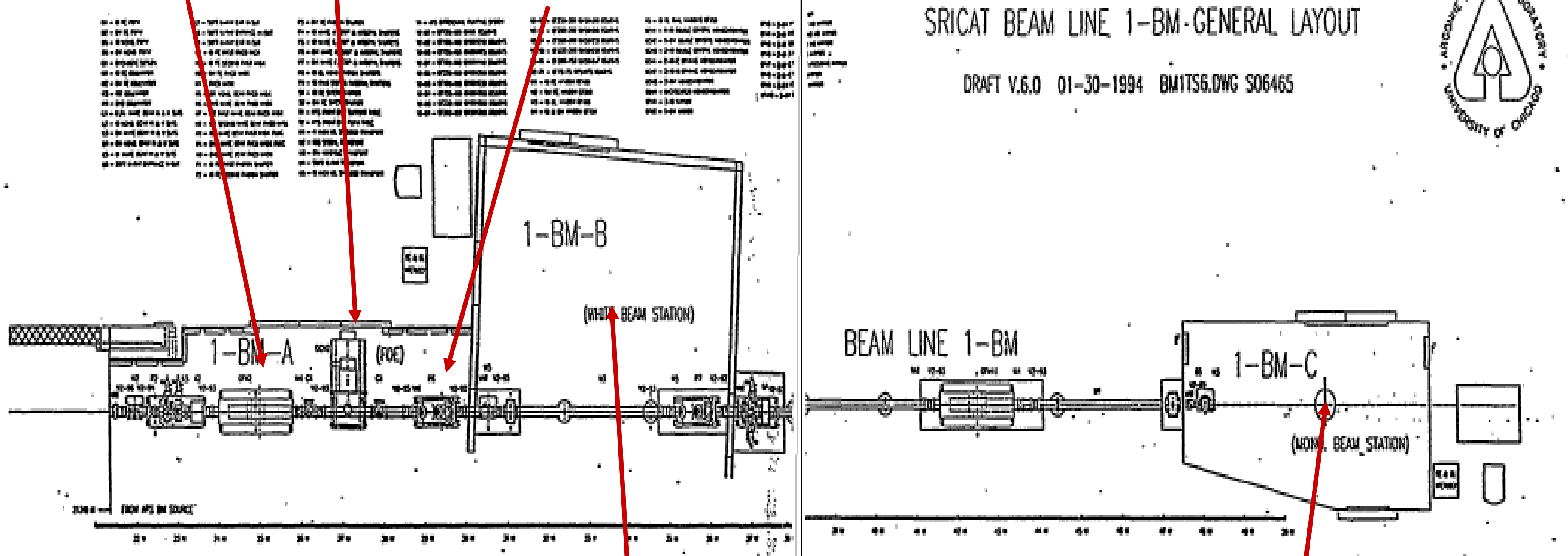
- Tests of focusing optics: KBs - 27 shifts, FZPs - 18 shifts , MLLs - 36 shifts
- General user experiments requiring flexible testing configuration – 54 shifts
- High Energy Diffraction in 1-BM-C: shift balance = 283 shifts

Proposed implementation if at 1-BM

Collimating mirror: remove, and replace with fast shutter and new Laue-Laue mono

PSL monochromator: replace sagittal focusing second crystal with a flat crystal

P6 shutter: remove riser blocks to transmit white beam



Optics and detector test hutch

Mono beam topography and high energy diffraction

Base figure from Srajer, Rodricks, Assoufid, and Mills, APS LS-35

1-BM: at present and in future

At present:

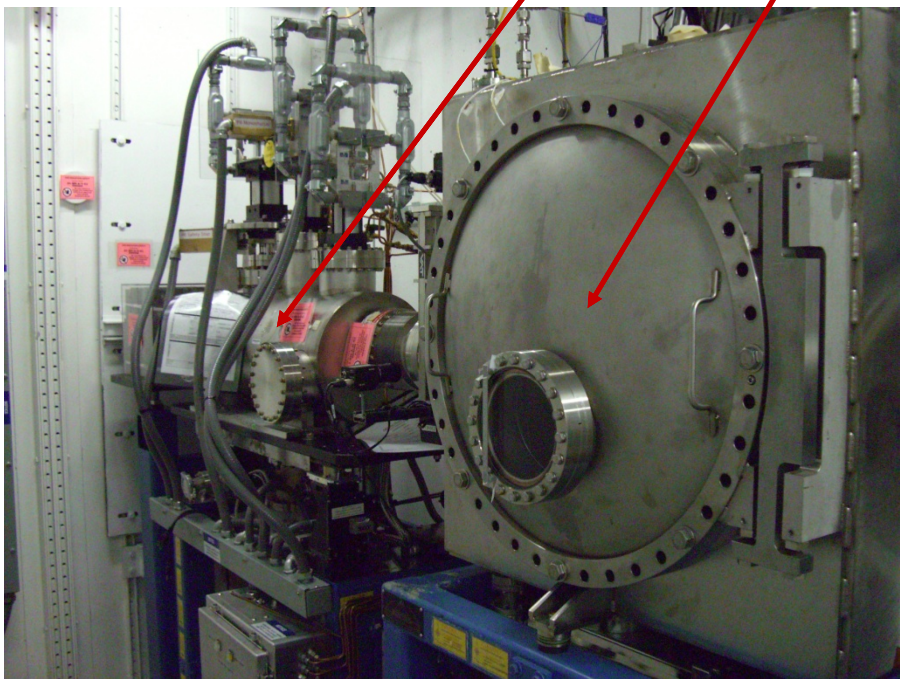
- Powder diffraction in 1-BM-C .
- PSL mono. Si(111): 3.4 – 14.4 keV; Si(004) : 7.9 – 33.2 keV
- 1-BM-B only serves as pass-through to 1-BM-C.
- P6 shutter in 1-BM-A is raised up on blocks; this precludes getting white beam into 1-BM-B.

In the future (starting in Sept 2012):

- Collimating mirror removed from 1-BM-A.
- Install flat second crystal in PSL mono.
- Install fast white beam shutter into 1-BM-A for topography exposures
- Mono beam topography to be done in 1-BM-C
- High energy diffraction program in 1-BM-C, with bent transmission Laue crystals in a new mono in 1-BM-A.

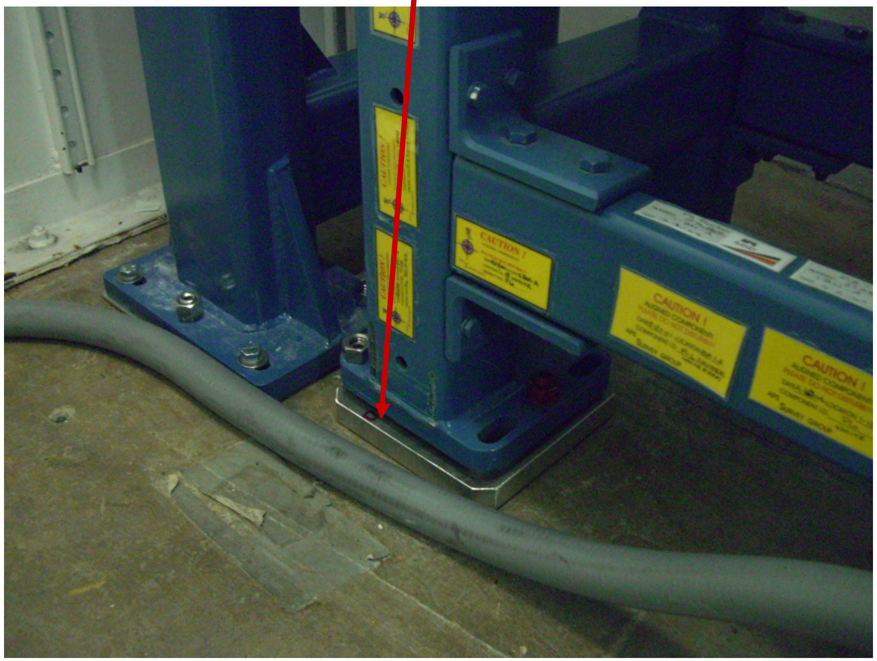
1-BM-A at present

At present: raised P6 shutter and PSL mono



Proposal: use existing PSL mono for high energy diffraction program

At present: raised-up P6 shutter

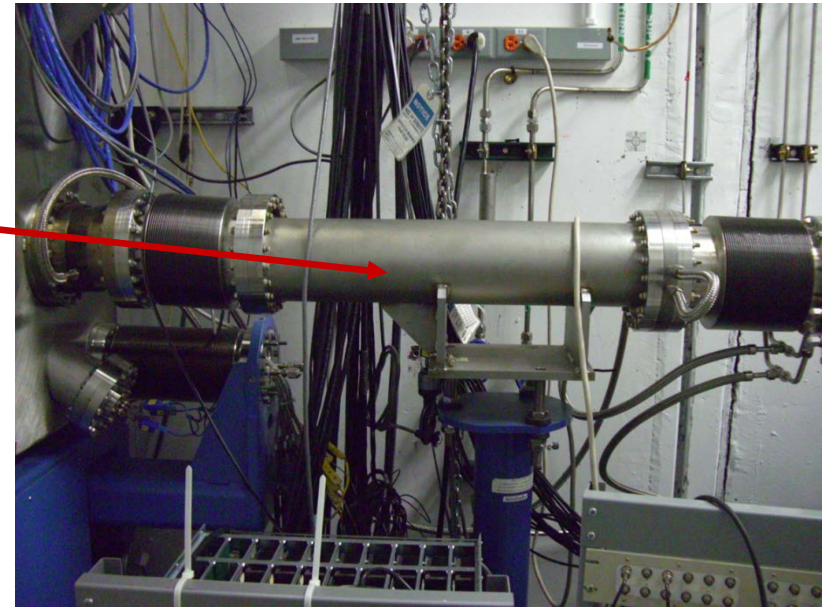


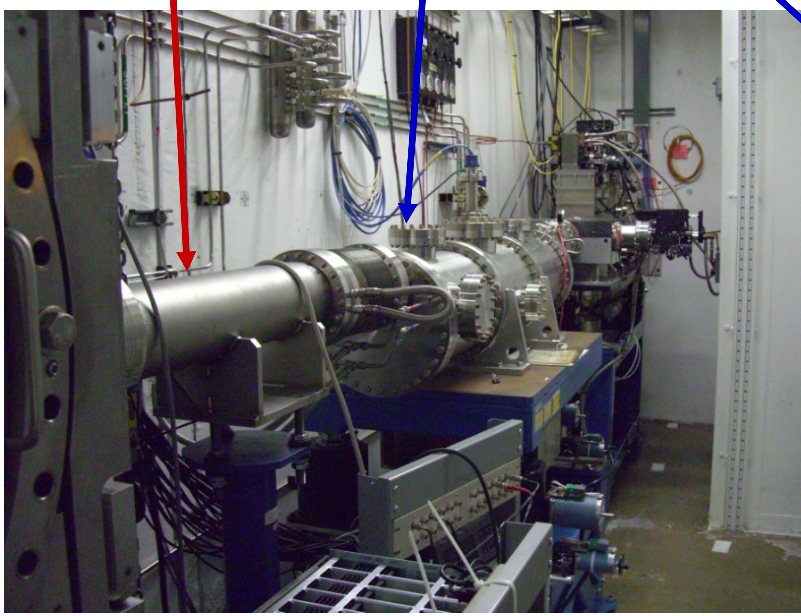
Proposal: with collimating mirror removed, the P6 shutter can be lowered to pass white and mono beams into 1-BM-B & C

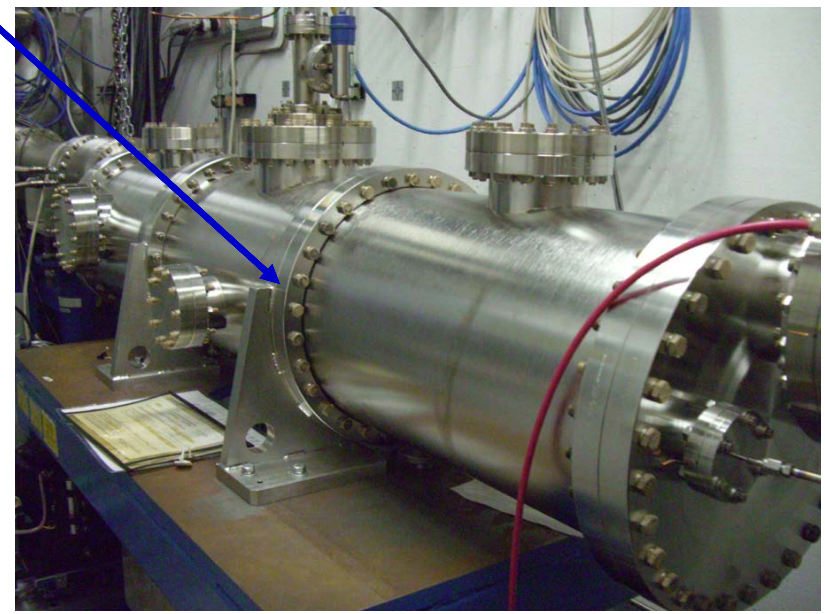
1-BM-A at present

Spool pipe & bellows:
1150 mm

collimating mirror:
1700 mm

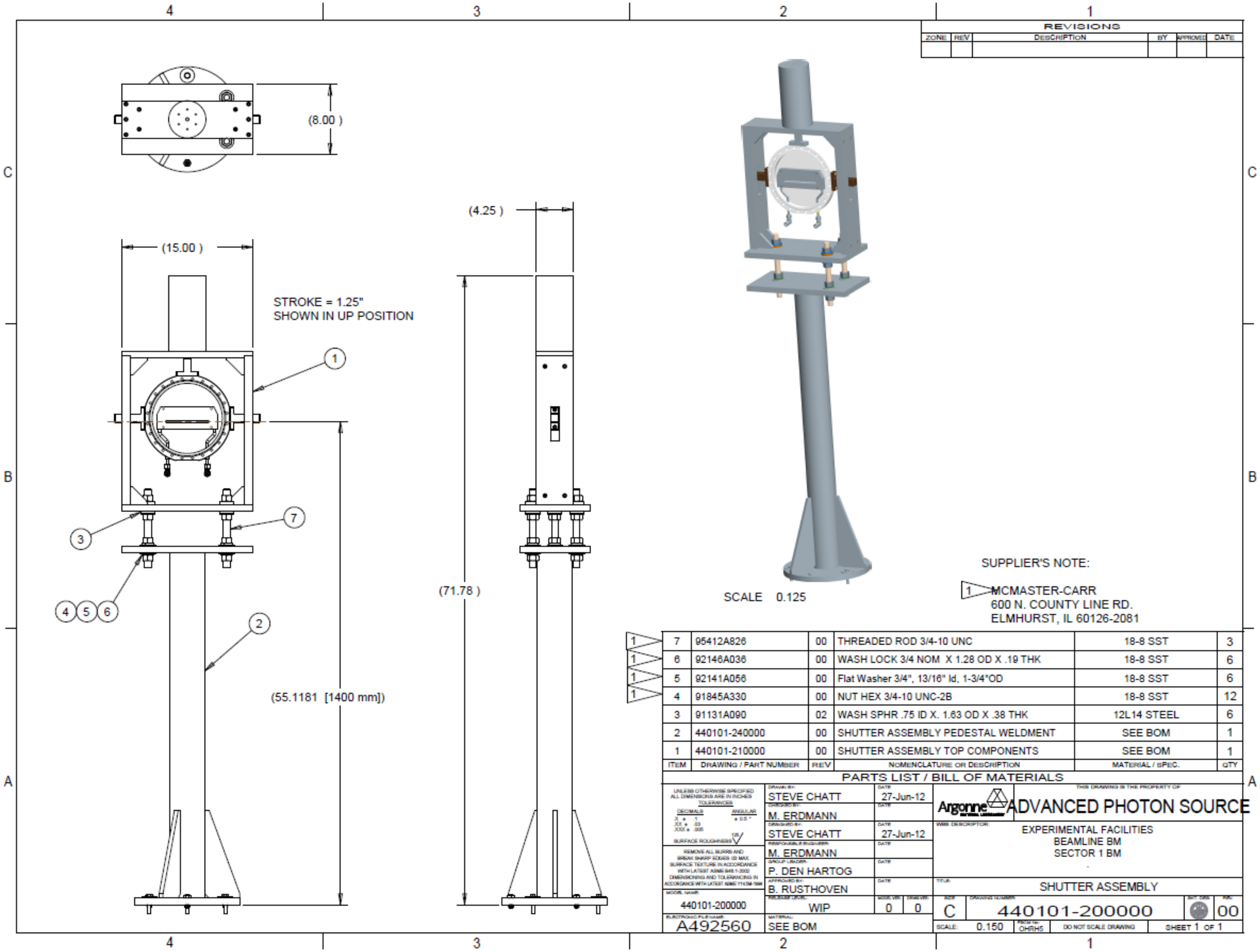






Net space available if both are removed: 1150 mm + 1700 mm = **2850 mm**

Fast Shutter to Control Topography Exposures



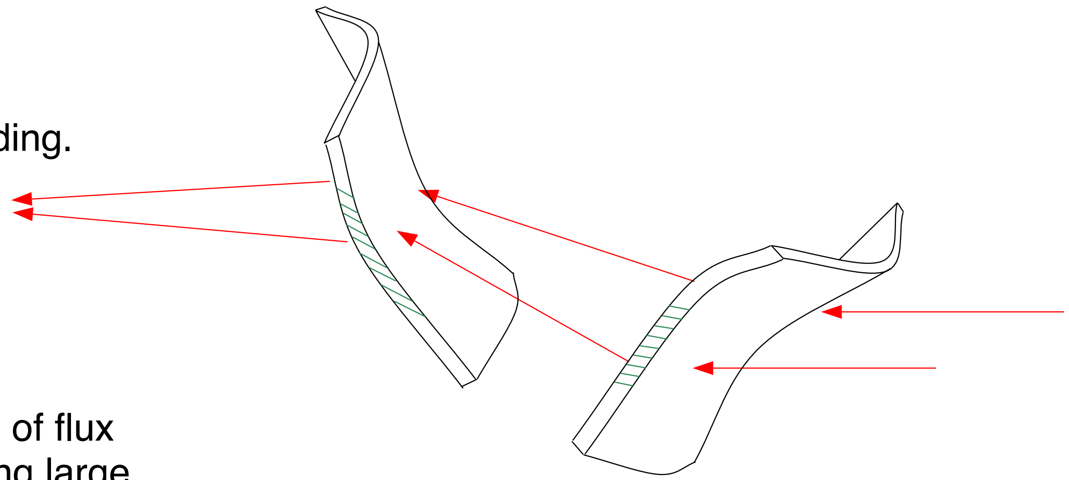
ITEM	DRAWING / PART NUMBER	REV	NOMENCLATURE OR DESCRIPTION	MATERIAL / SPEC.	QTY
7	95412A826	00	THREADED ROD 3/4-10 UNC	18-8 SST	3
6	92146A036	00	WASH LOCK 3/4 NOM X 1.28 OD X .19 THK	18-8 SST	6
5	92141A056	00	Flat Washer 3/4", 13/16" Id, 1-3/4"OD	18-8 SST	6
4	91845A330	00	NUT HEX 3/4-10 UNC-2B	18-8 SST	12
3	91131A090	02	WASH SPHR .75 ID X. 1.63 OD X .38 THK	12L14 STEEL	6
2	440101-240000	00	SHUTTER ASSEMBLY PEDESTAL WELDMENT	SEE BOM	1
1	440101-210000	00	SHUTTER ASSEMBLY TOP COMPONENTS	SEE BOM	1

PARTS LIST / BILL OF MATERIALS

Mark Erdmann, Steven Schatt

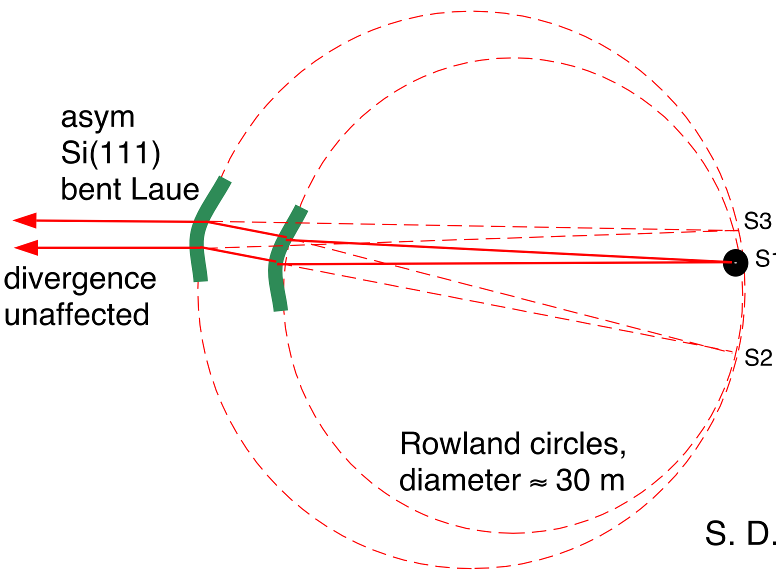
Laue Sagittal Focusing Monochromator for High Energy Diffraction

Concept by Zhong (NSLS) using anticlastic effect for simultaneous meridional (Rowland condition) bending.

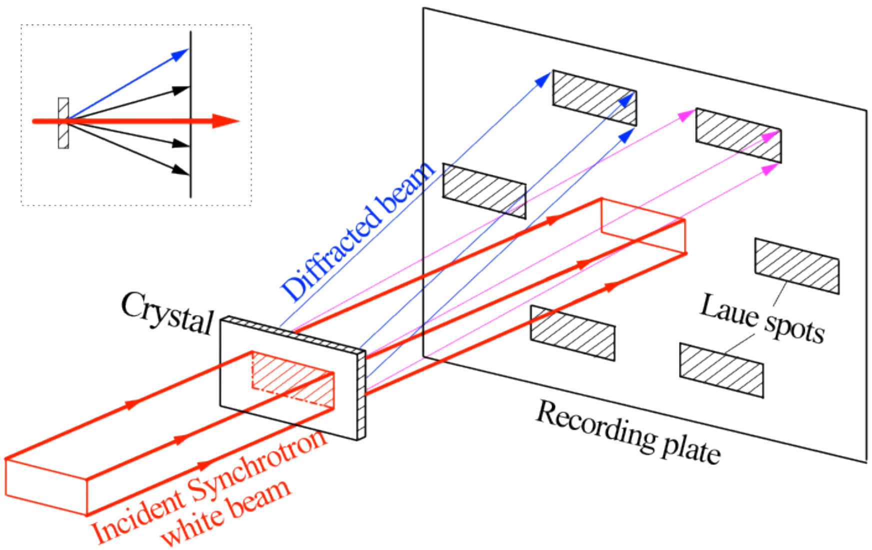


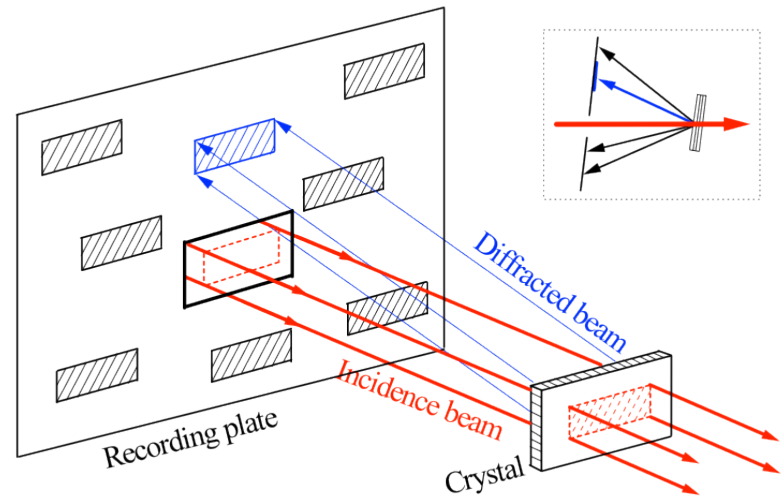
At 1-BM, could deliver up to ~ 1/10 of flux at 1-ID over 50 - 80 keV, by focusing large horizontal radiation fan.

Cryogenically cooled monochromator at 1-ID (Shastri) - meridional bending only, in nested Rowland conditions.



Synchrotron white-beam topography imaging of single crystals





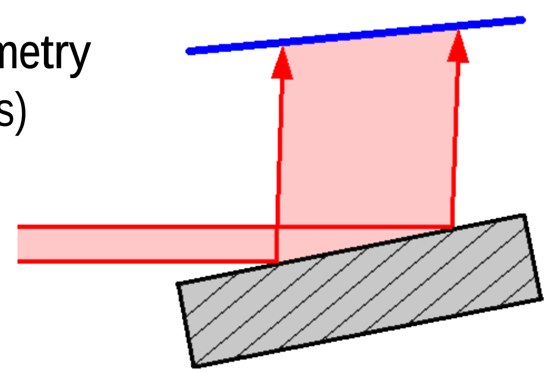
Transmission geometry

Only for thin crystals, < 0.5 mm thick

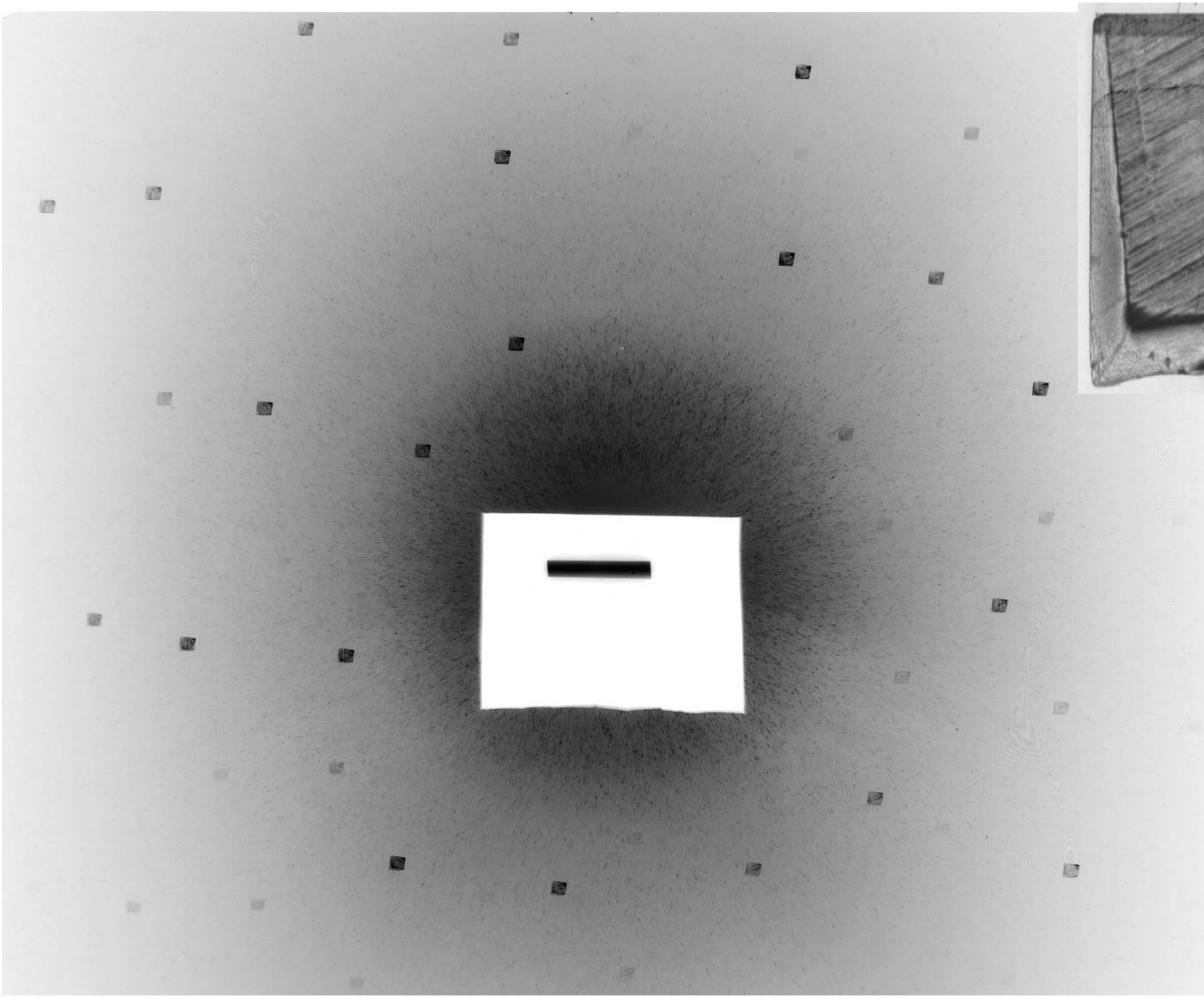
Back-reflection geometry

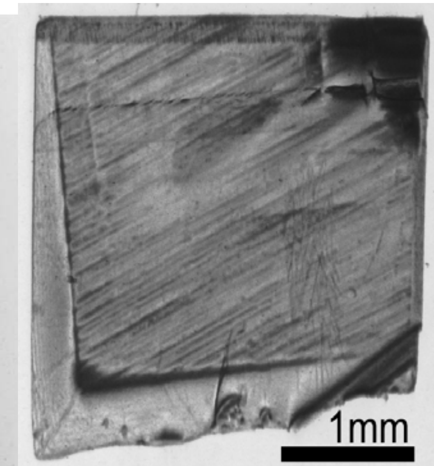
Small-incidence Bragg reflection geometry

For large-area imaging (several inches) without scanning



Industrial users at NSLS use this capability



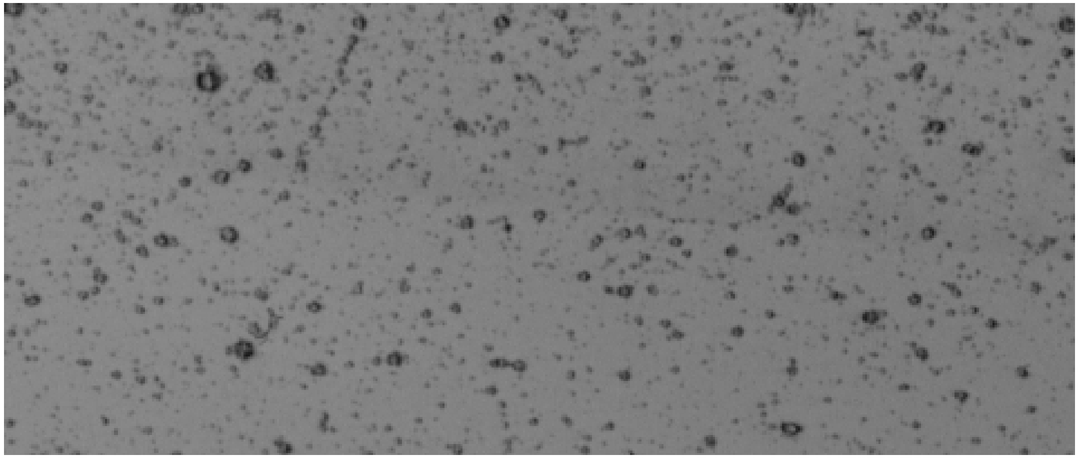


White-beam topography (NSLS X19C) of a diamond crystal bonded by Silvac

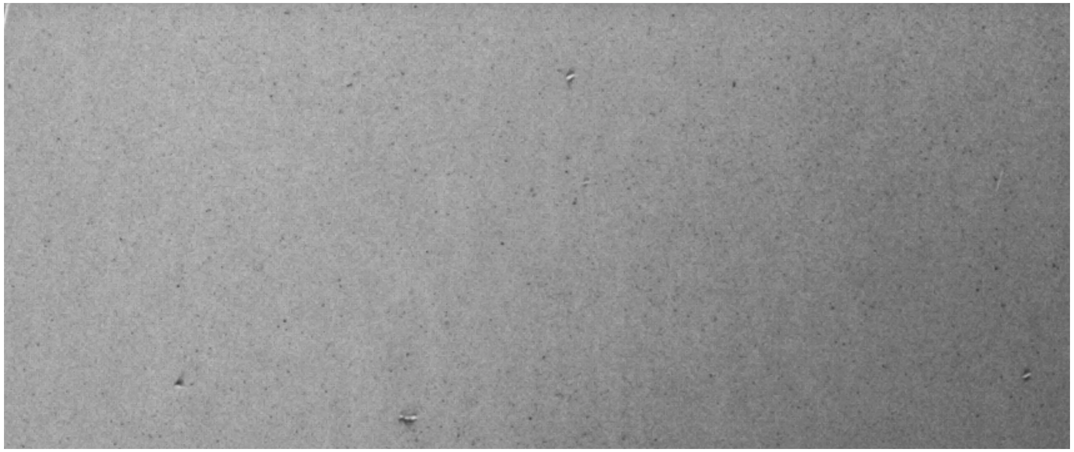
Why do we need topography?

- Characterization of Si & Ge monochromators, analyzers, and various crystal-based optical components
- Characterization of newly fabricated monos, analyzers
- Diagnostic of crystal optics components used at beamlines
- Developing advanced fabrication & polishing techniques

Routinely required by the Crystal Optics Section



White-beam topograph showing strains and damages on a polished silicon surface with roughness ~ 1 Å. Manufactured by Crystal Scientific.

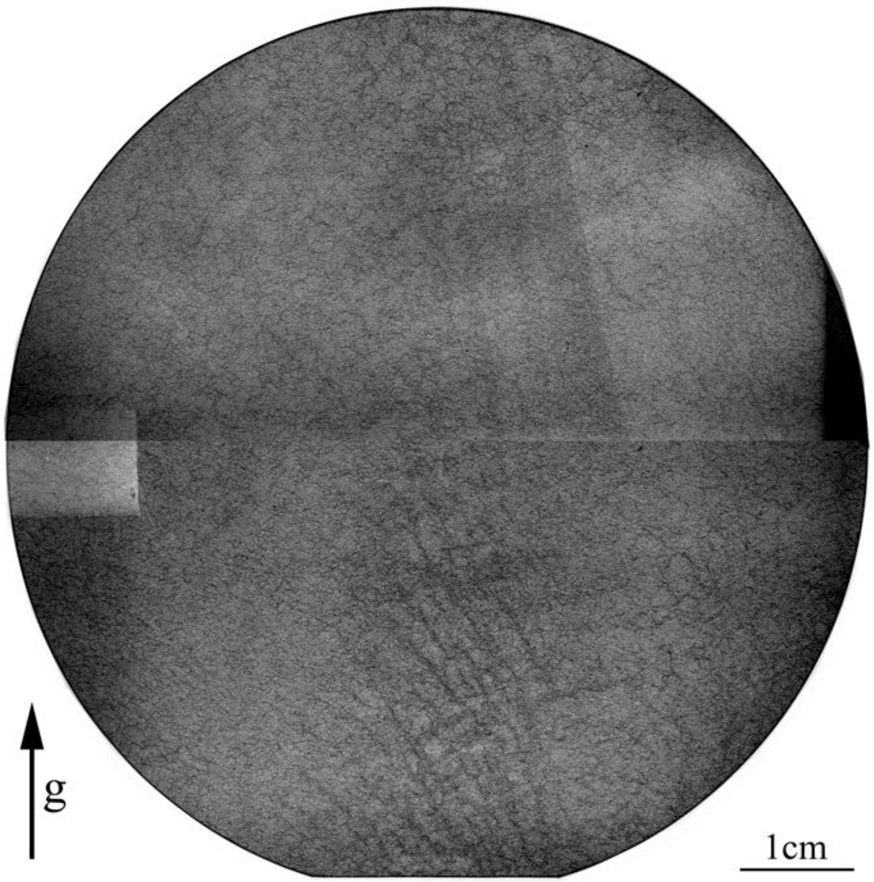


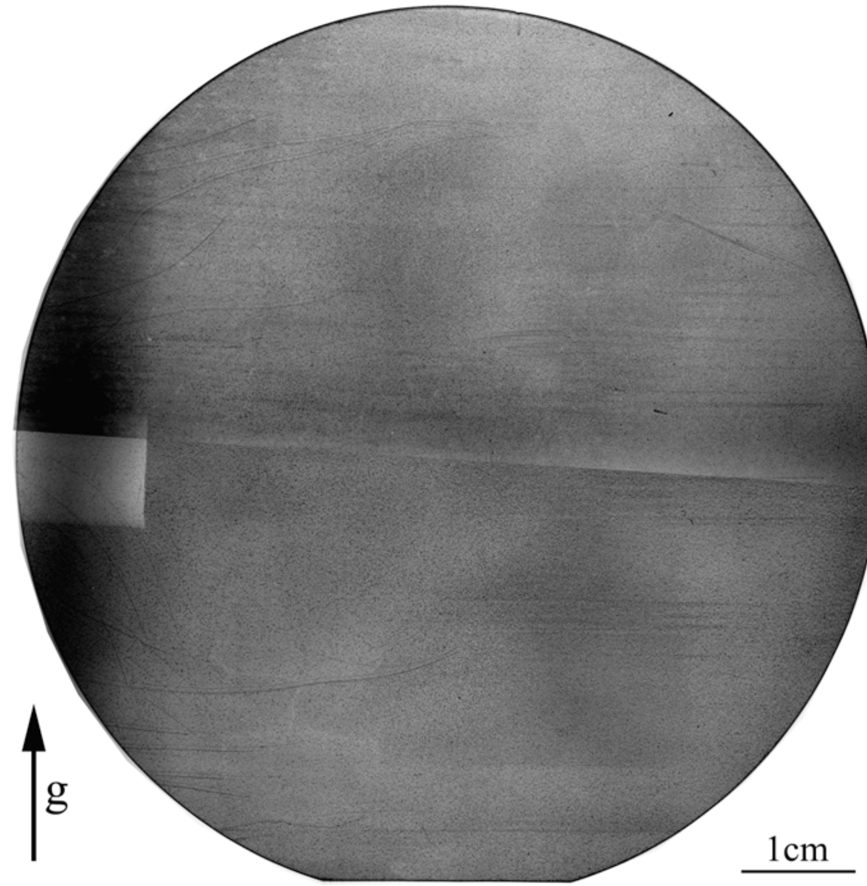
Topograph of crystal optic fabricated at APS

2. Developing RIXS analyzers with 10-20 meV resolution

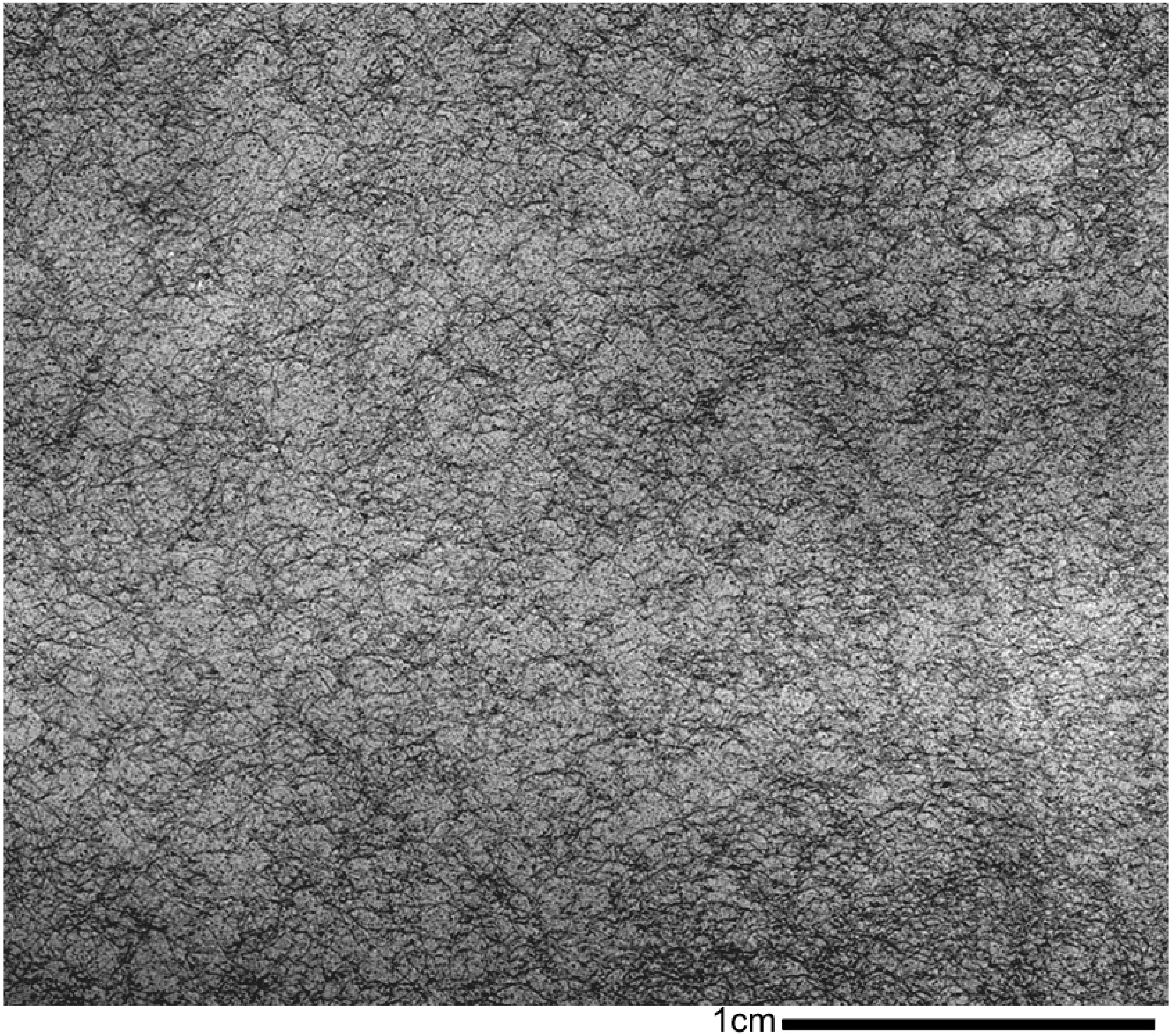
challenging, crystal characterization and screening critical!

Sapphire, quartz, LiNbO3





Full white-beam topography images of 3-inch sapphire crystals



Magnified view of dislocations in sapphire

Topography: expected interested parties and potential general users

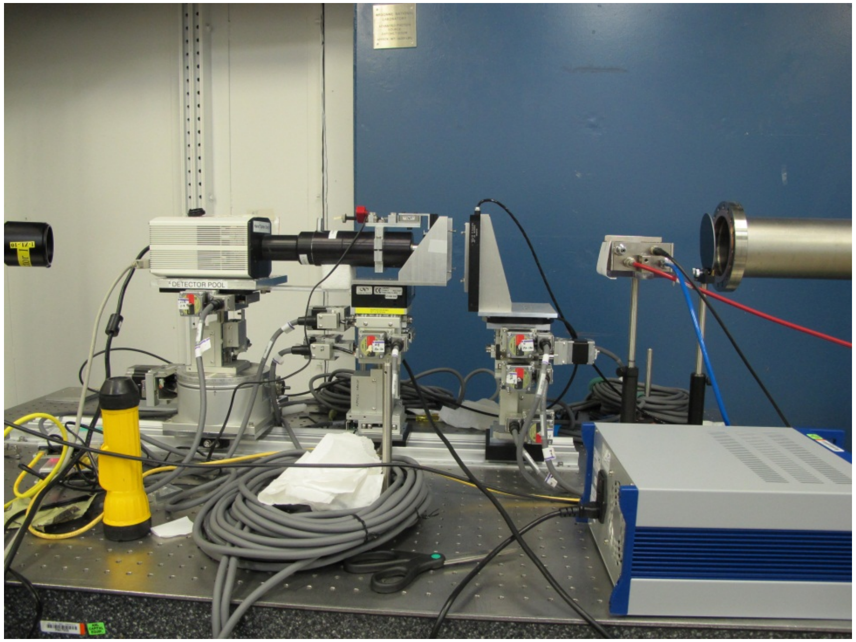
Industry

- Sain Gobain Crystals
- Cree, Inc.
- Dow Corning Corp.
- BP Solar
- Intel Corp.
- ARC Energy
- GE Research
- Hexatech, Inc.
- Fairfield Crystals
- Xtal Solar
- II-VI Inc.

Other

- Dept. of Mat. Science and Eng., Stony Brook
- Instrumentation Division, BNL
- Nasa Glenn Research Center, OH
- NIST – David Black
- Dept of Chemistry, Kansas State Univ.
- Dynamic and Energetic Materials Division, LANL
- Naval Surface Warfare Center, Indian Head Division
- Dept. Chemistry, Georgetown Univ.
- Air Force Research Laboratory
- Dept. Physics and Astronomy, Cal. Inst. of Tech.

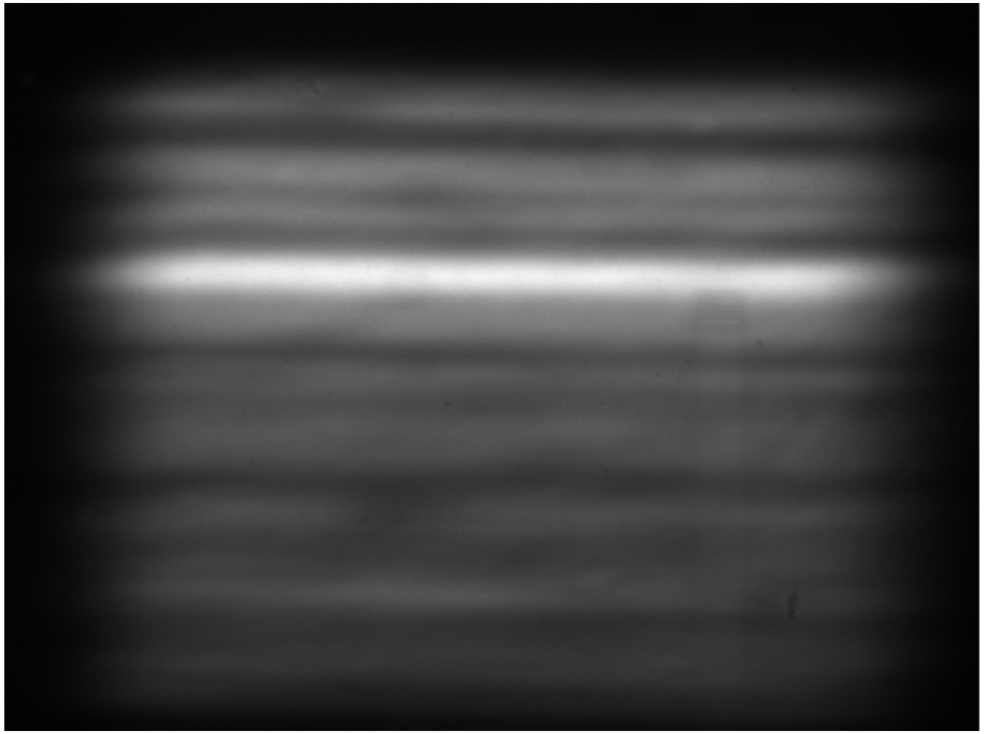
Talbot Interferometry Setup in 1-BM-B



Grating Interferometry LDRD team: L. Assoufid, S. Marathe, A. Macrander, X. Xiao,
D. Mancini, X. Xiao, F. DeCarlo, M. Wojcik , R. Divan

1-BM-B Apr2012 experiment Results

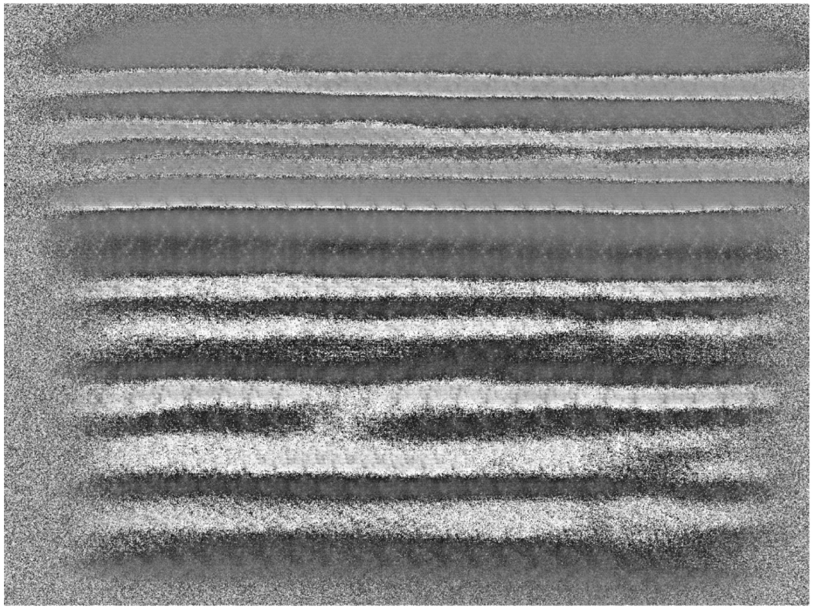
1-BM-B main beam from collimating mirror



Beam size: 700 x 700 μm^2

Phase images from the stepping scan:

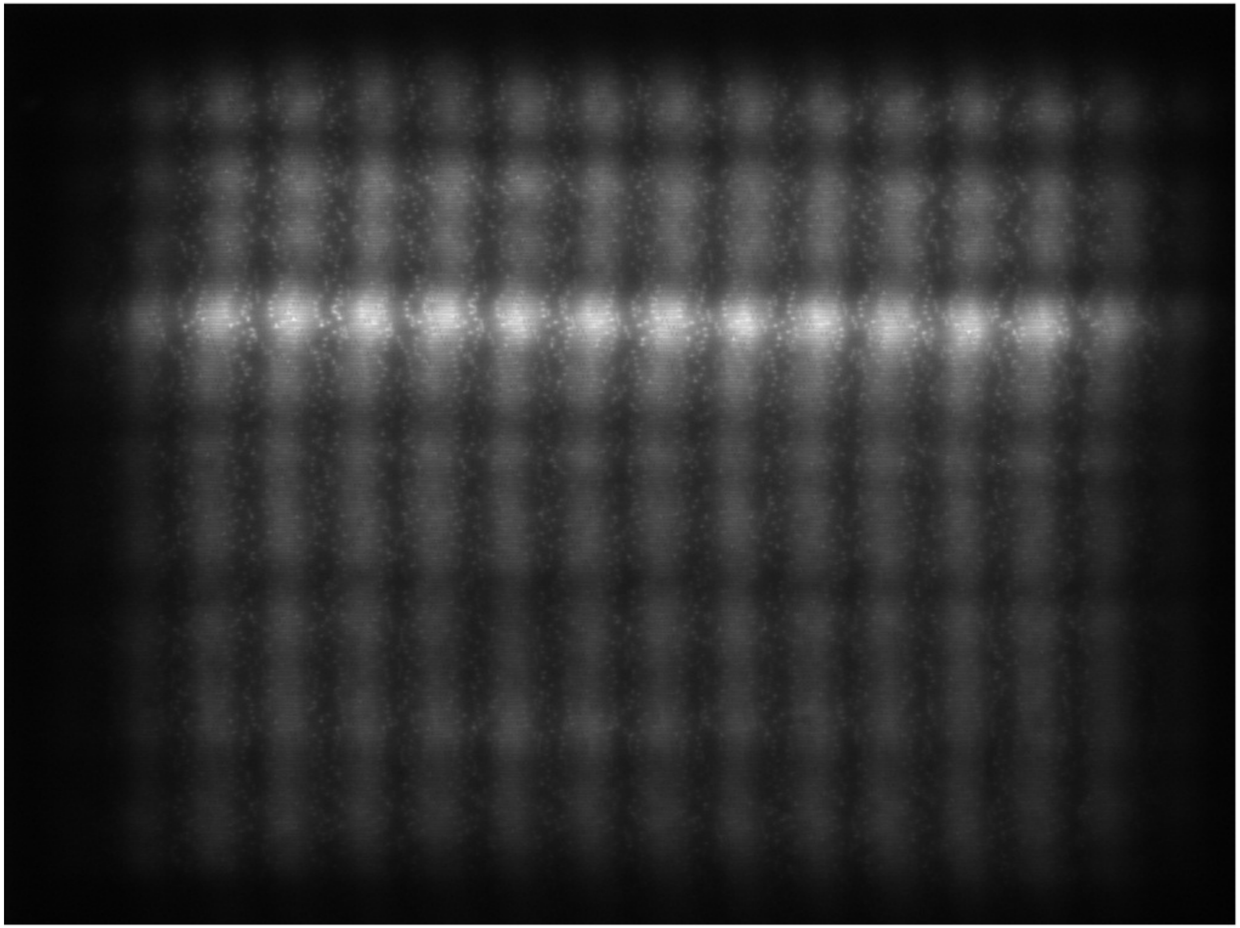
Phase image obtained from processing stepping scan



Beam size: 700 x 700 μm^2
Gratings optimized for : 18 keV, π phase shift
Grating periods : Phase grating (4.8 μm) and absorption grating (2.4 μm)
Distance between Phase grating and absorption grating: 1st Fractional Talbot , 42 mm

Interferograms obtained in Moire mode:

18keV, 1st fractional Talbot distance
Relative angle between gratings : 2.6°



Why detector testing?

- Calibration:
  - 1st level of correction for data analysis
  - Vendor-supplied calibration may not be adequate, calibration changes as detector ages, etc.
  - Underlies scientific integrity of APS
- Standard set of metrics for detector comparison
  - Determine which detector best suited for particular technique/experiment
  - Vendor specs non-standard; not always directly comparable
  - Quantitative information supporting key Detector Pool function
- Track detector performance
  - Ensure health of equipment loaned by DP
- Enable detector development
  - Micelli team's MKIDs, Ross ultrafast APDs, FastCCD
  - Fast pixel array detectors?
- If done well, will generate interest from outside APS (Nat. Sec. Tech.)

Schedule: changes in 1-BM-A to be made in upcoming shutdown

Acknowledgements

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