FMX's year since first light

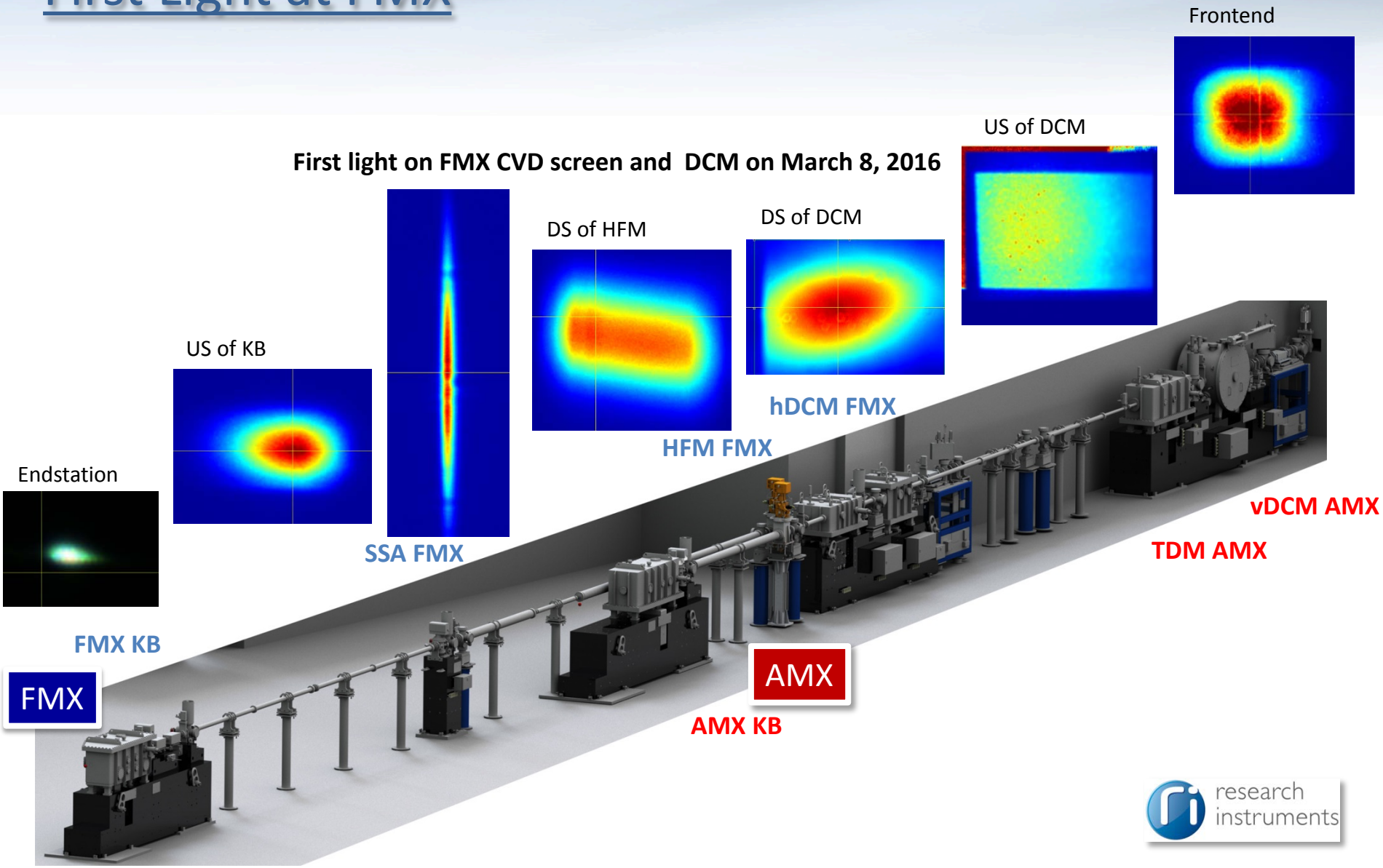
Martin Fuchs

LSBR Advisory Meeting

March 28, 2017

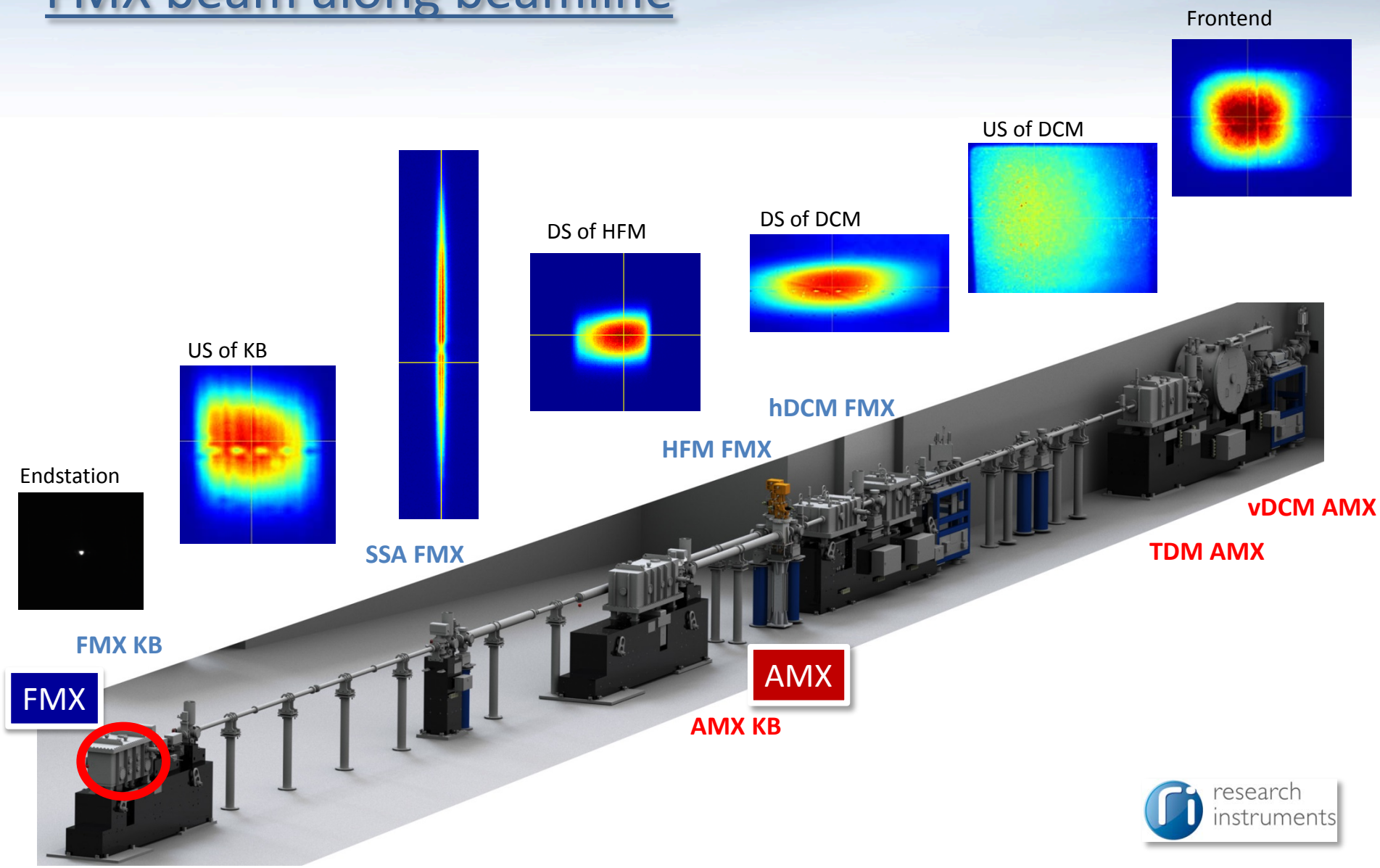
First Light at FMX

First light on FMX CVD screen and DCM on March 8, 2016



research instruments

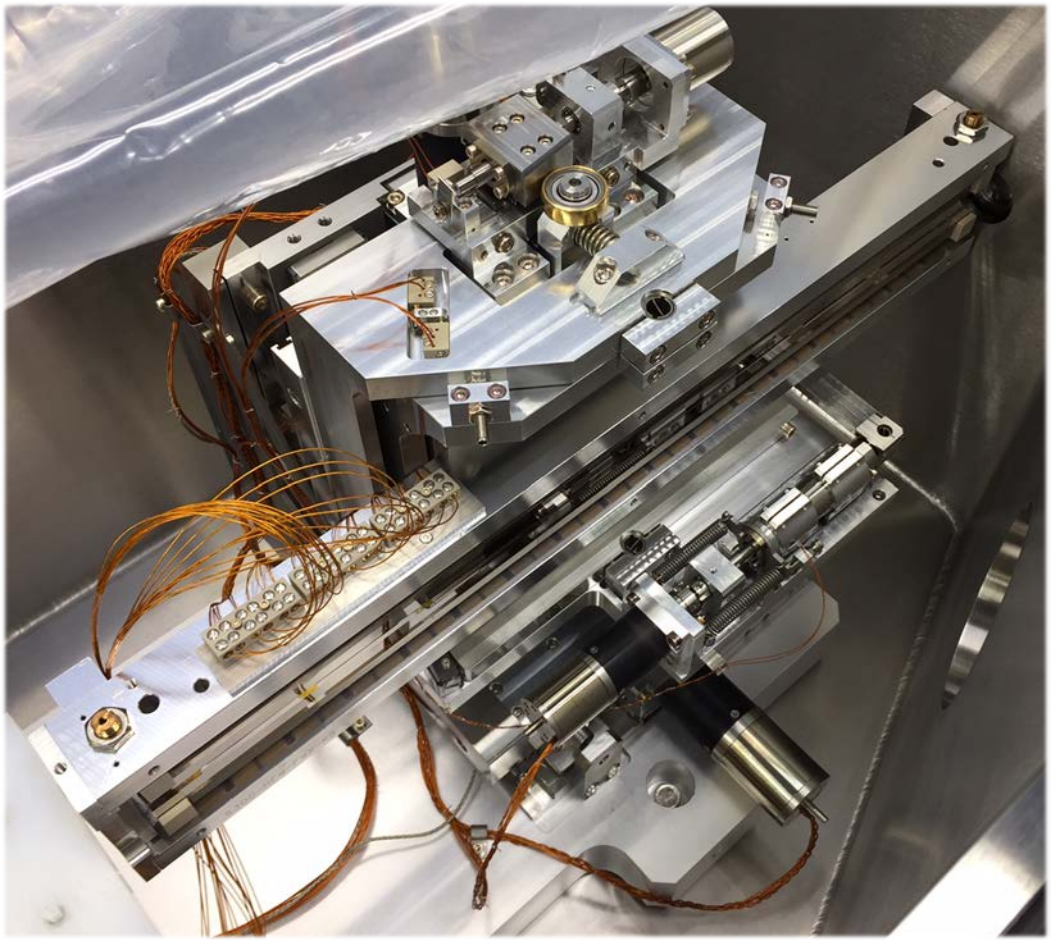
FMX beam along beamline



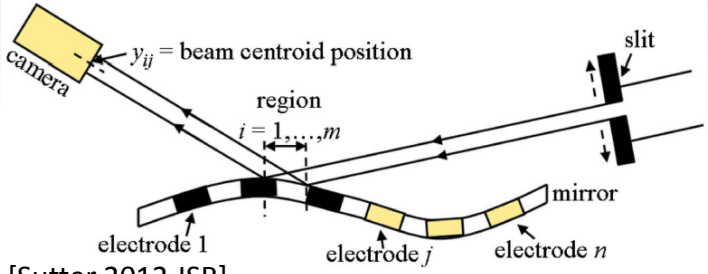
research instruments

FMX horizontal focusing KB mirror installation

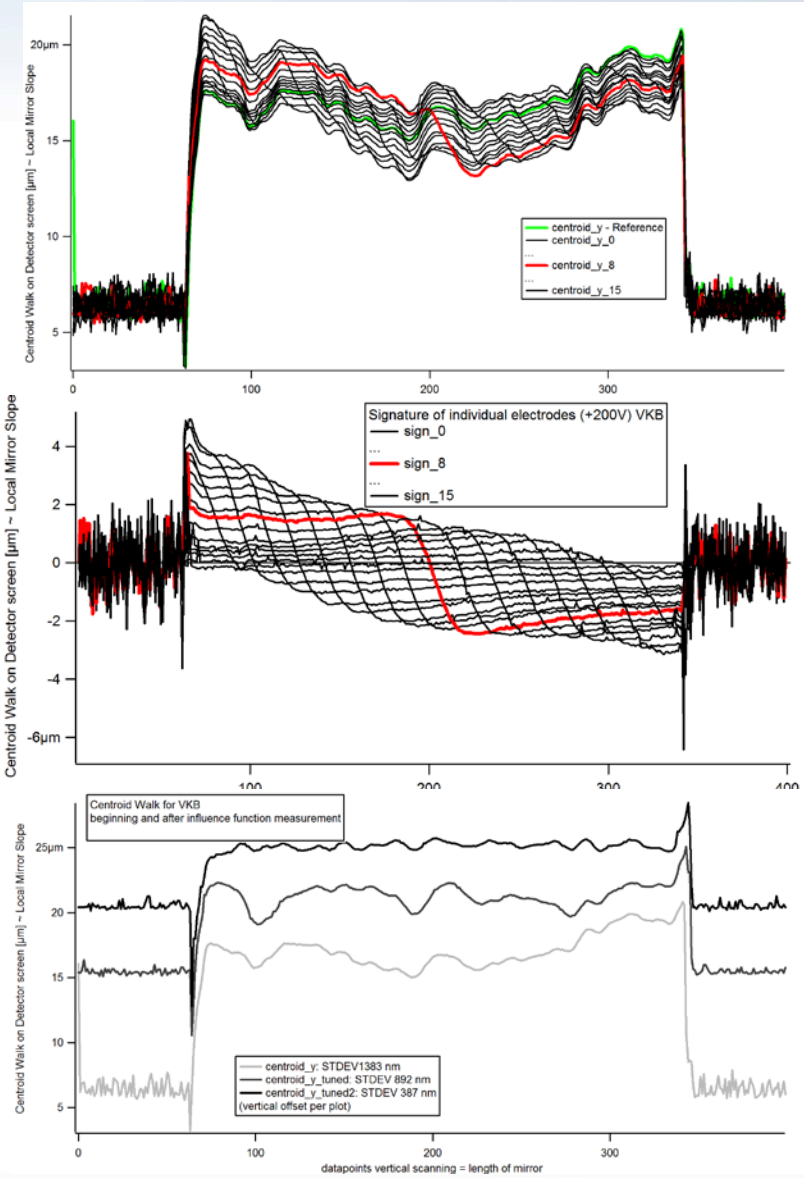
- January 2017: Secondary horizontal focusing stage completes FMX photon delivery system



Mirror commissioning:In-situ metrology



[Sutter 2012 JSR]

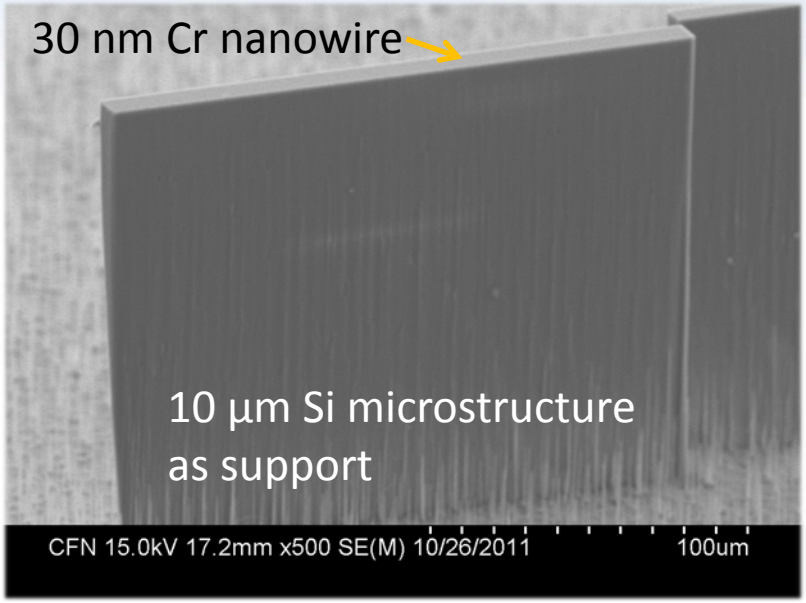


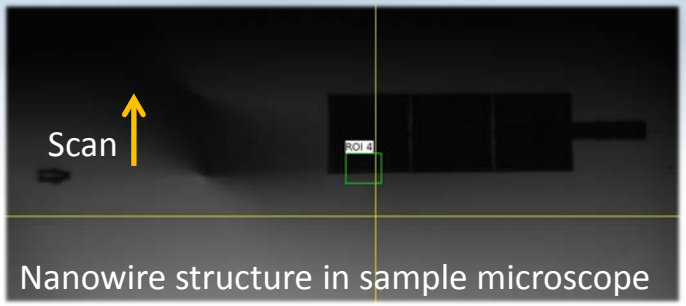
- 16-actuator bimorph piezo bender (SESO)
- Pencil beam scanning for in-situ slope measurement
- Fast fly scan implementation: 1-2 min / scan
  - Influence functions for each electrode
  - Convergence after 3 iterations
  - Recover LTP metrology results
- Top hat beams next

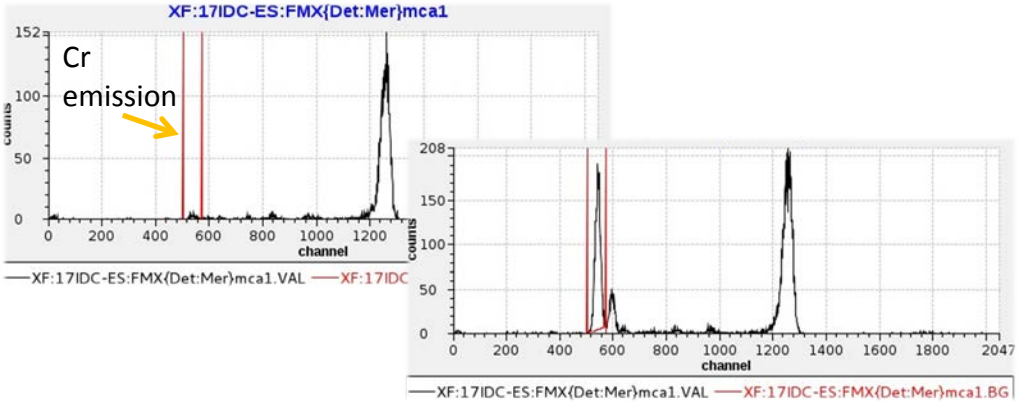
➢ Lei Huang, Mourad Idir

Huang, L.; Xue, J. & Idir, M. “Controlling X-ray deformable mirrors during inspection” *J. Synchrotron Rad.*, **2016**, *23*, 1348-1356

Mirror commissioning



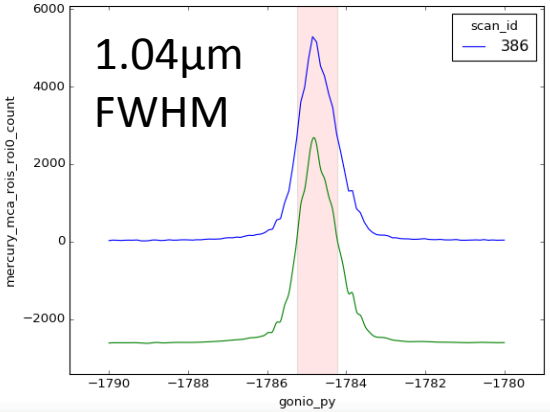




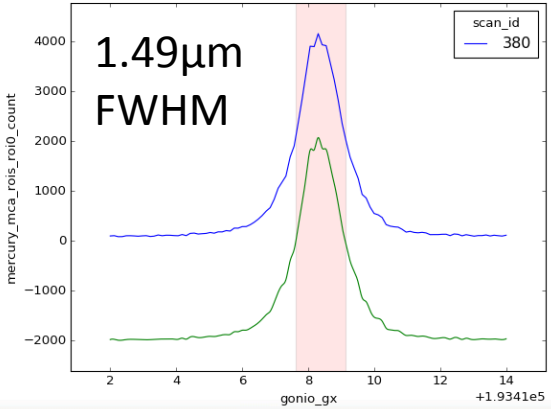
➢ Kenneth Evans-Lutterodt

- Beam size by Cr nano-wire scan with fluorescence detection
- Bluesky scan of Cr fluorescence ROI counts

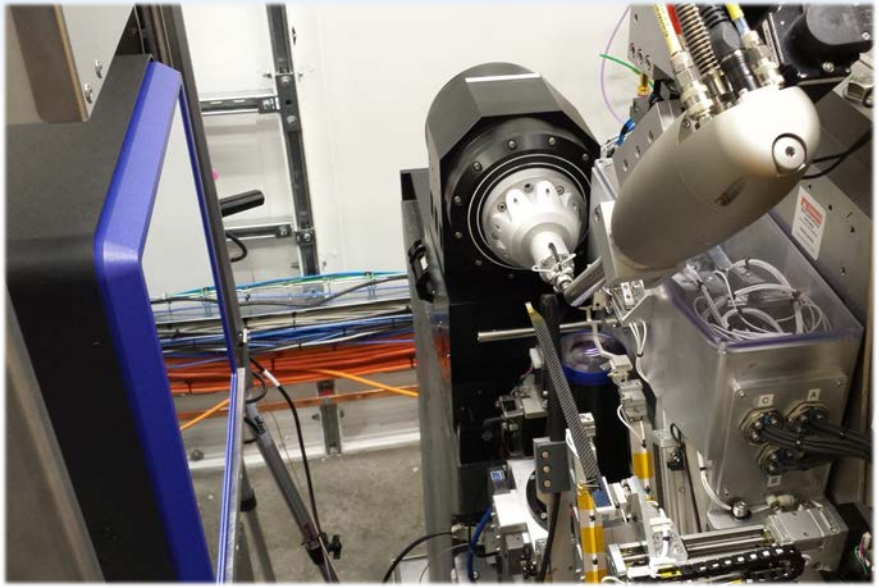
Vertical focus

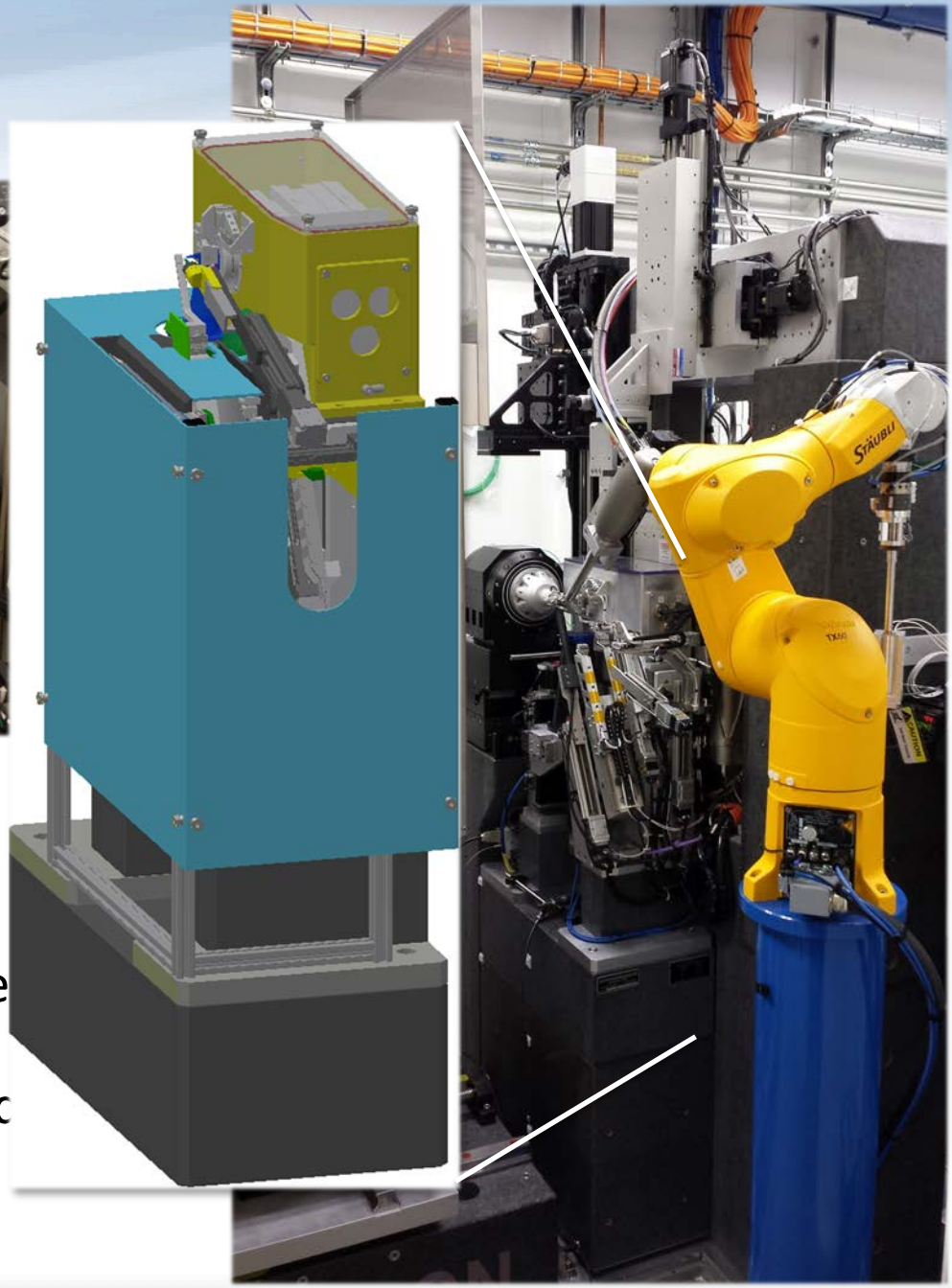


Horizontal focus



FMX Endstation

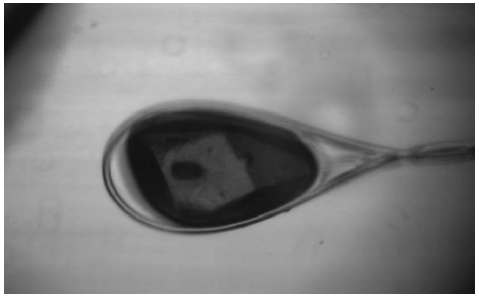


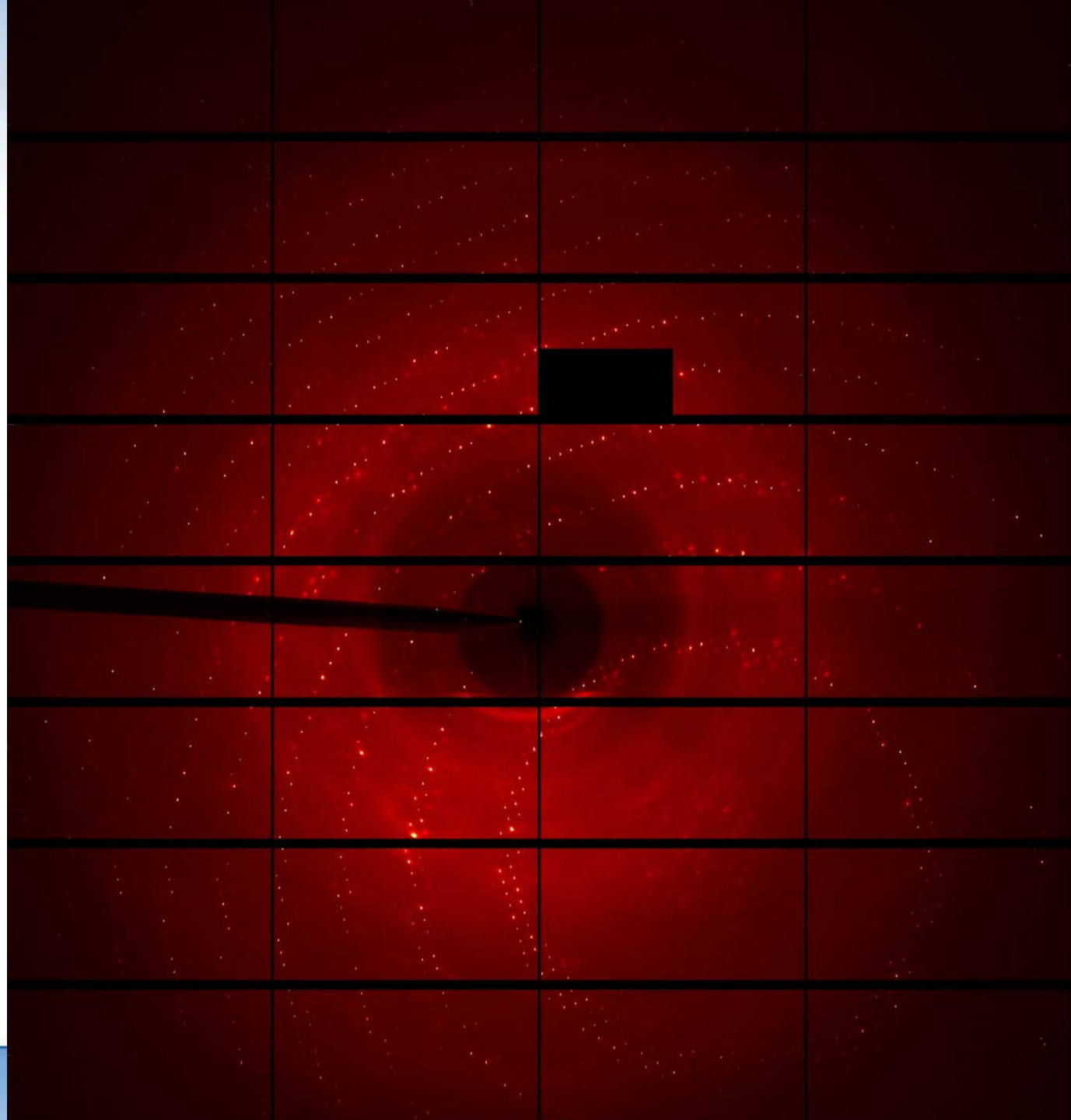


- 190 mm along beam
- 500 nm SOC gonio (uncorrected)
- Eiger 16M detector
- Beam conditioning unit 5/6 device
- TBD: inline diode/scintillator, XRF detector integration, cover, second gonio

FMX 2016-07-15

- Lysozyme
- Room temp





FMX technical commissioning

- Flux at 12.7 keV = 3×10^{12} ph/s (KPP, as designed)
- Beam size
  - Using 1st horizontal focusing mirror for missing H-KB
  - 10×100 µm (V×H)
  - 10×25 µm using slits
- All anomalous scatterer edges and reference energies mapped up to 25 keV
- Rastering and vector data collection
- Beam stability monitoring with machine group (horizontal angle!)

FMX modes 2017-03-05

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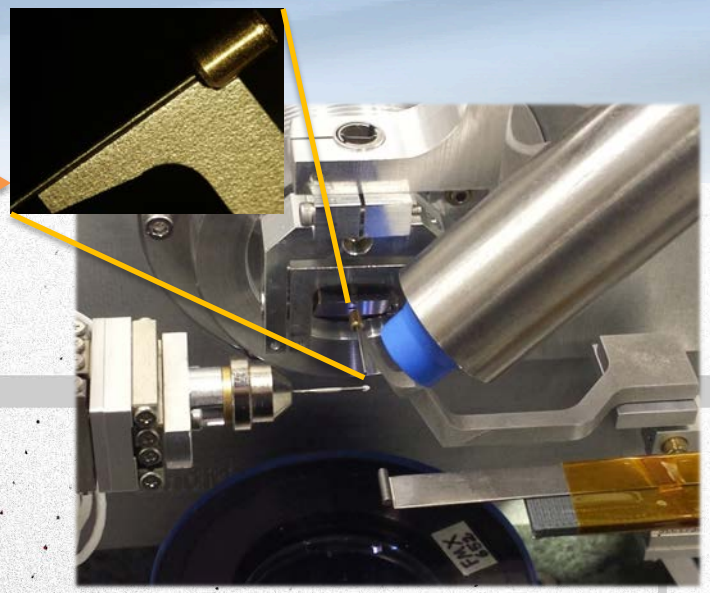
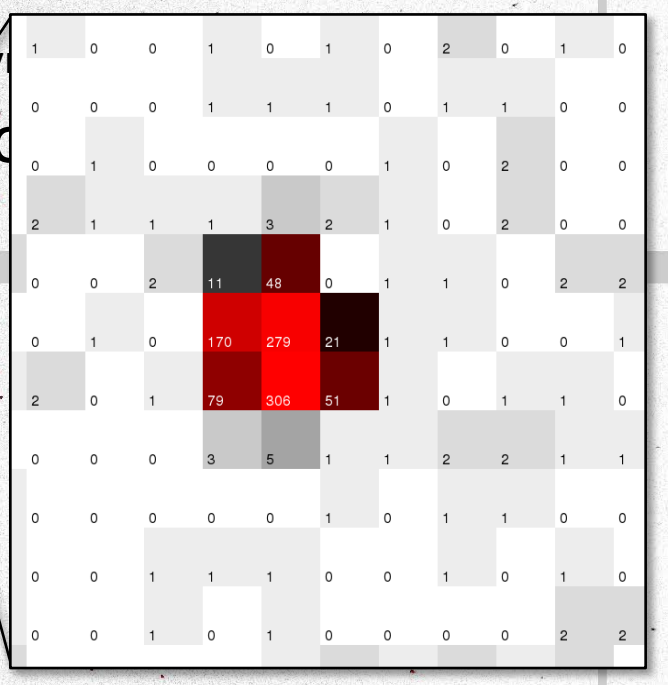
Energy (eV)

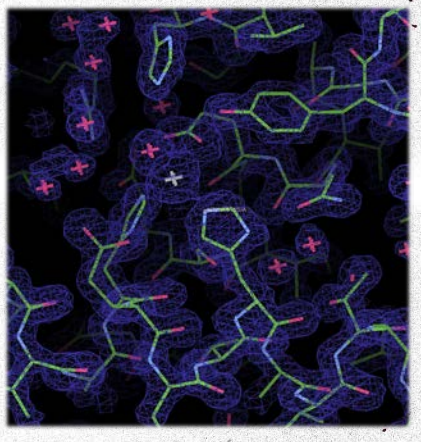
	A	B	C	D	E	F	G
1	Energy (eV)	5000	6000	6539	7110	7200	7500
2	Wavelength (A)	2.4797	2.0664	1.8961	1.7438	1.722	1.6531
3	Scatterer			Mn	Fe		
4							
5	IVU gap (mm)	6.905	7.865	8.39	8.967	9.062	9.367
6							
7	DCM bragg (deg)	23.294	19.241	17.601	16.147	15.938	15.286
8	DCM gap (mm)	16.331	15.887	15.737	15.616	15.6	15.55
9	DCM roll (mrad)				0.438	0.416	
10	DCM 2nd xtal pitch	1.311	1.311	1.311	1.311	1.321	1.315
11							
12	HFM pitch				-2.547	-2.555	
13	HFM X				0.97	1.37	
14	HFM Y (mm)	0	0		0	0	
15							
16	V KB X (um)				4500	4500	
17	V KB Y (um)				-446	-445	
18	V KB pitch (urad)				-2516	-2524.5	
19							
20	H KB X (um)				320	240	
21	H KB Y (um)				7000	7000	
22	H KB pitch (urad)				-2520	-2510	
23	H KB roll (urad)				0	0	

FMX technical commissioning

- Beam collimation to minimize background
- Test crystal data collections
  - Lysozyme at 100 K
    - R_{meas} = 3.9%; resolution < 1.4 Å; $I/\sigma I_{asy}$
  - Thermolysin at 100 K, Zn anomalo
    - Following slides







FMX scientific commissioning in cycle 2016-02 and -03

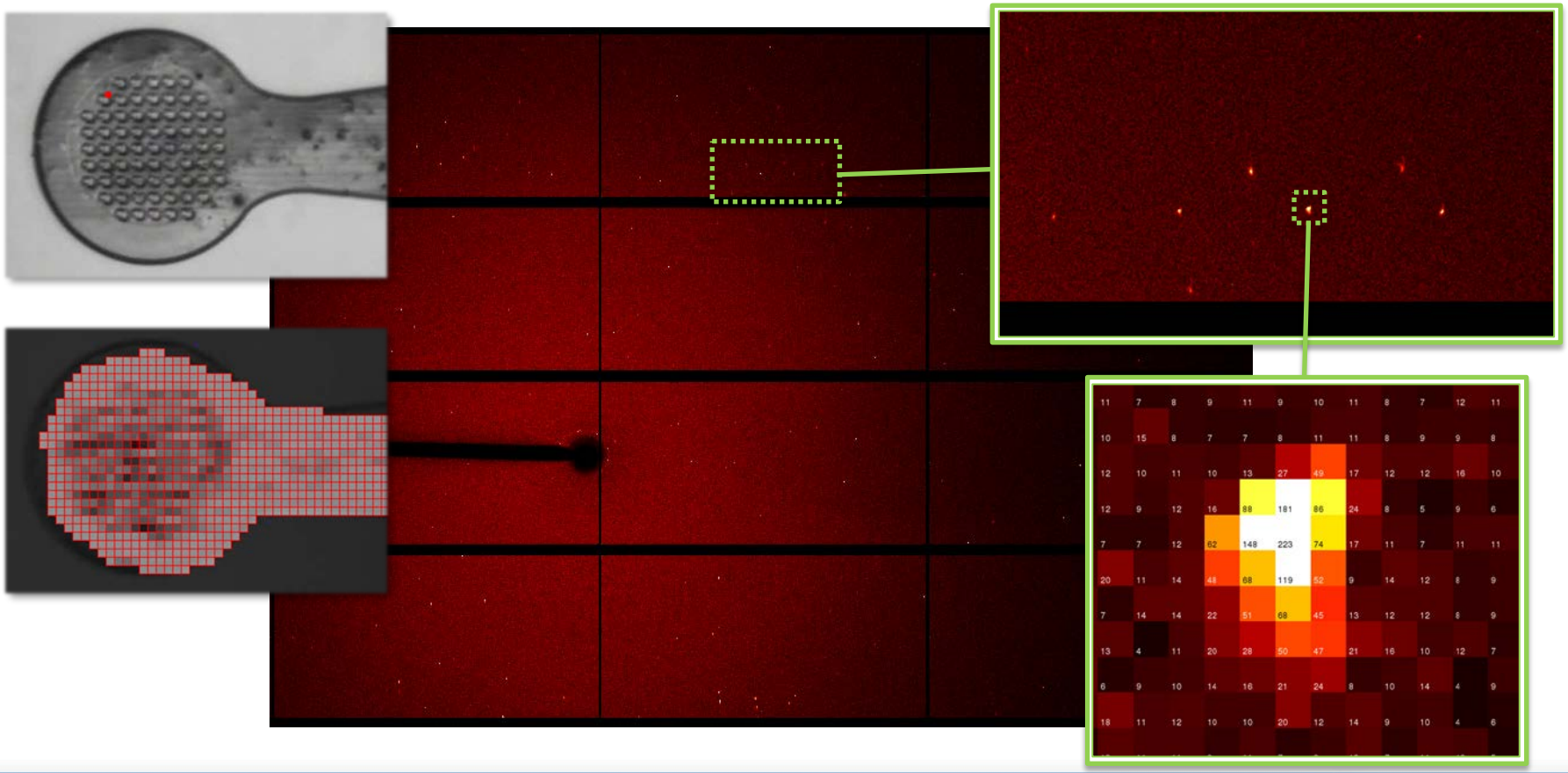
- Data collection with 13 external user groups
- Wide variety of sample properties
  - Crystal size
  - Unit cell
  - Diffraction power
- Early feedback on software features
- Comparison to data collected elsewhere

Lomakin, Steitz (Yale) – Human Ribosome (2016-08-25)

FMX scientific commissioning in cycle 2016-03

Q. Liu (BNL Biology Dept)

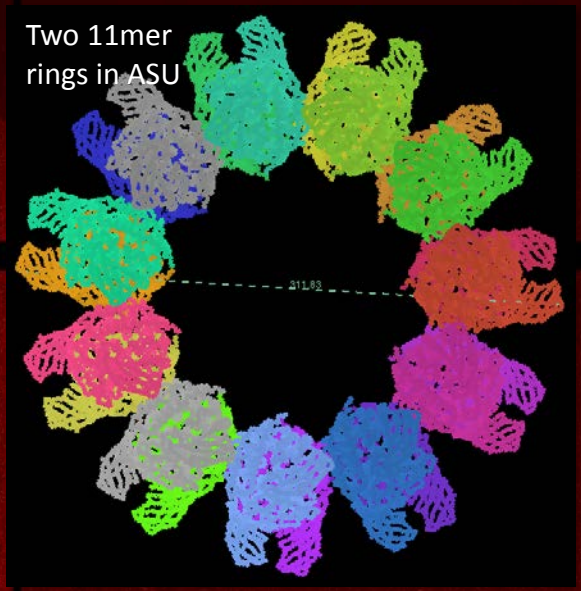
- Developing raster data collection
- Serial microcrystallography of 1-5 µm size Thaumatin crystals

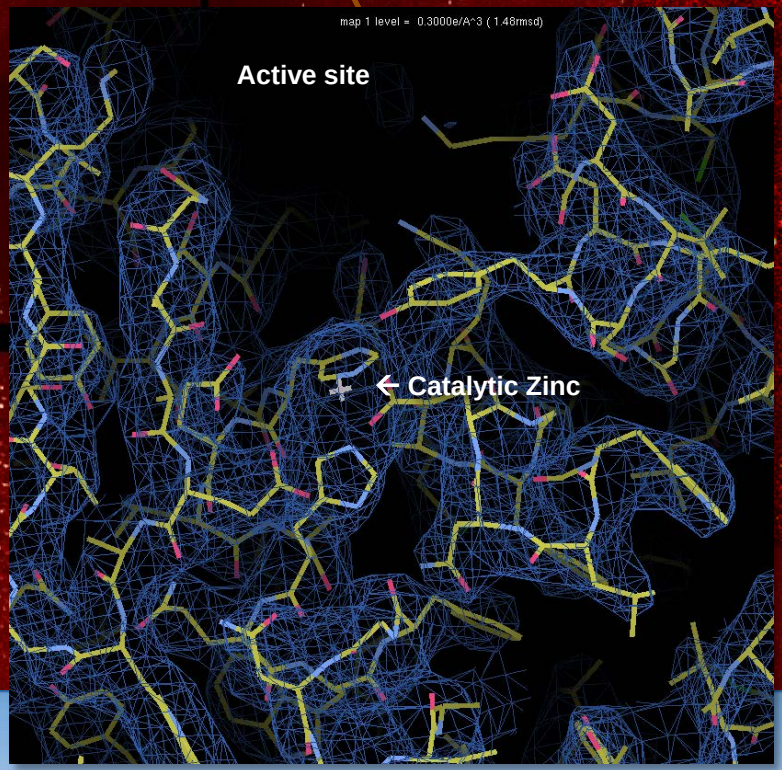


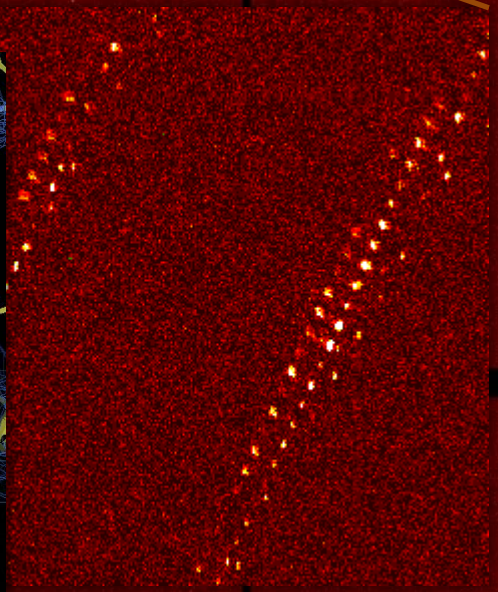
FMX scientific commissioning in cycle 2016-03

Maben, Stern (U Massachusetts Medical School)

- Endoplasmic-reticulum associated aminopeptidase 1 (ERAP1) Involved in immune system function
- Very large unit cell 585 × 545 × 125 Å^3
- Full separation of 2 large axes
- Resolution 3.25 Å



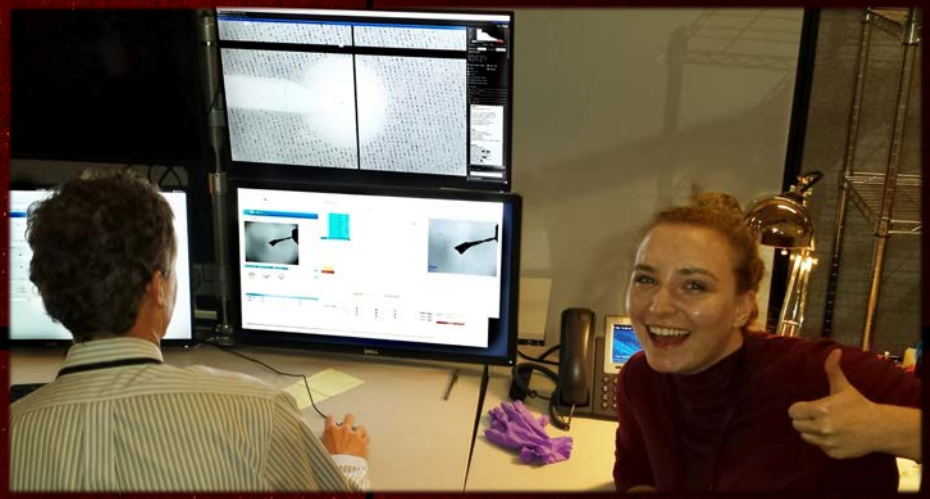


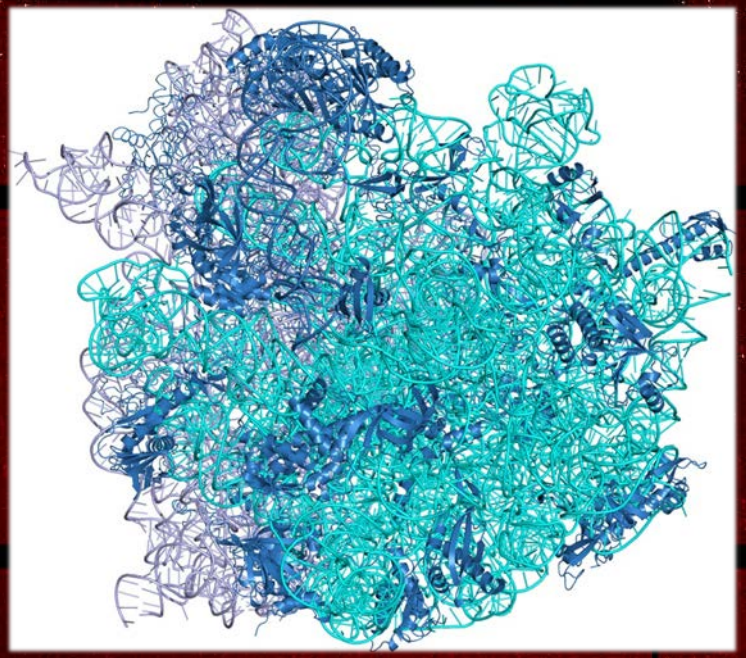


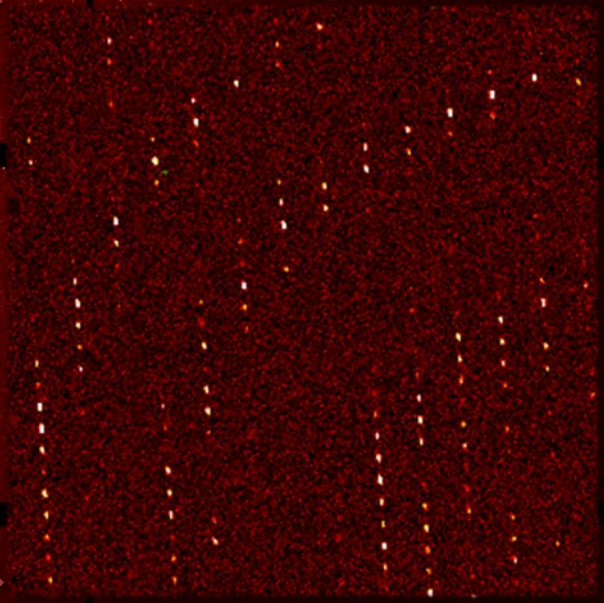
FMX scientific commissioning in cycle 2016-03

G. Jogl (Brown U)

- Wild-type 70S ribosomes from *Thermus thermophilus*
- Unit cell 620 × 450 × 210 Å^3
- Resolution ~3.1 Å







Installation of the FMX sample mounting robot

Clockwise: Dileep Bhogadi, Nicolas Guichard, Kun Qian, Edwin Lazo

- 6-axis robotic sample changer
- 384 sample LN_2 dewar
- Integration with experimental station
- Integrated testing warm, then cold

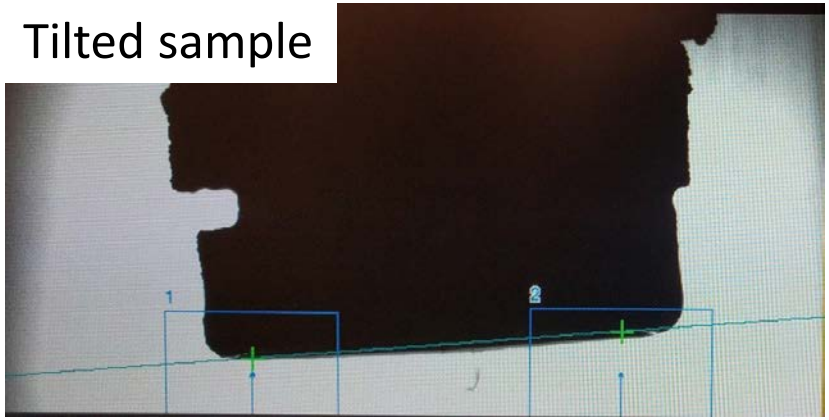
Bruno Martins, Edwin Lazo, Stu Myers, Kun Qian

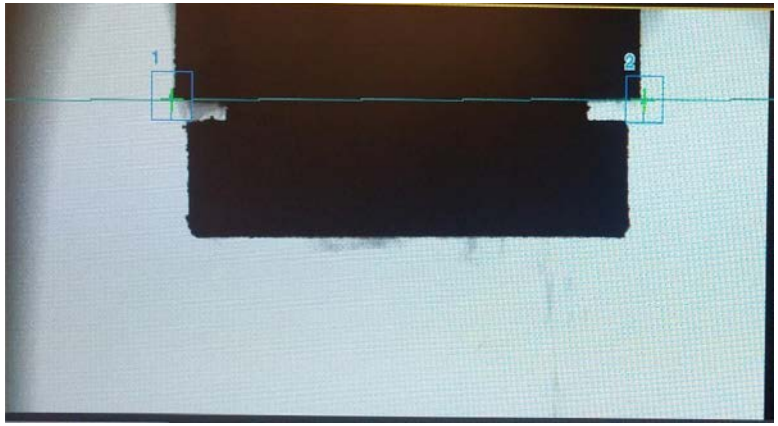
Sample diagnostics

Machine vision

Images taken and analyzed by machine vision, a point on the robot's trajectory.

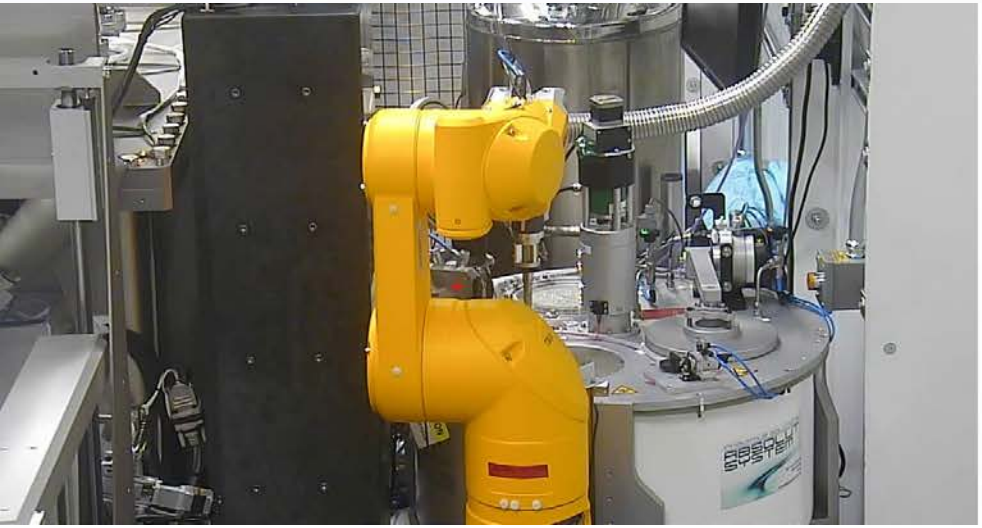
Tilted sample





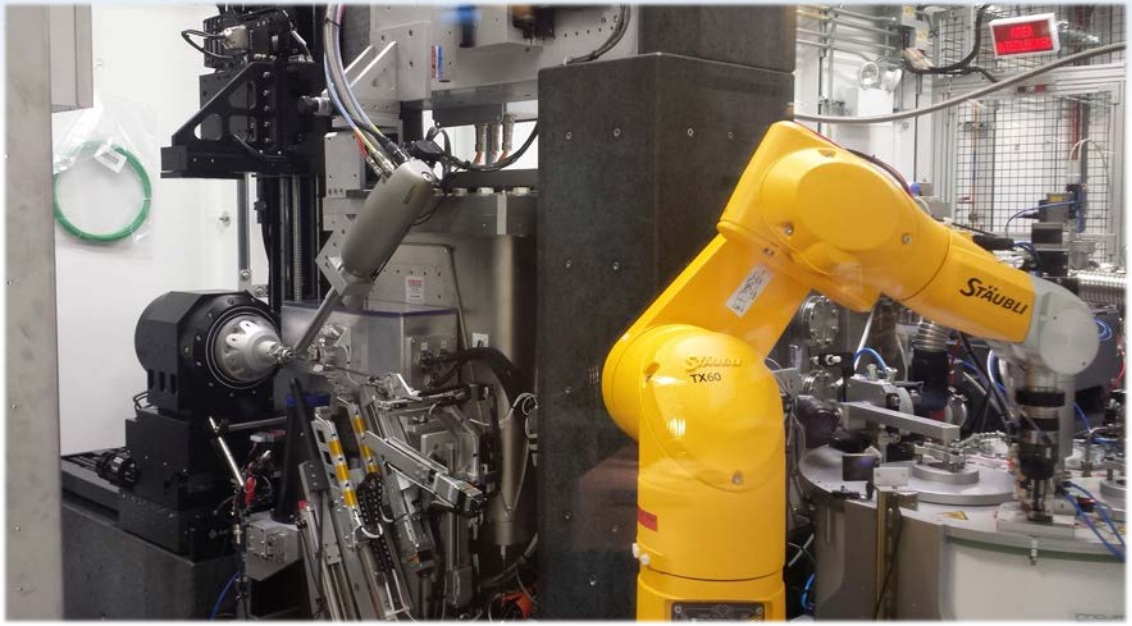
Left- Tool that detects sample position. In this case the sample is tilted.
Right- Tool that checks gripper position.

FMX sample mounting robot

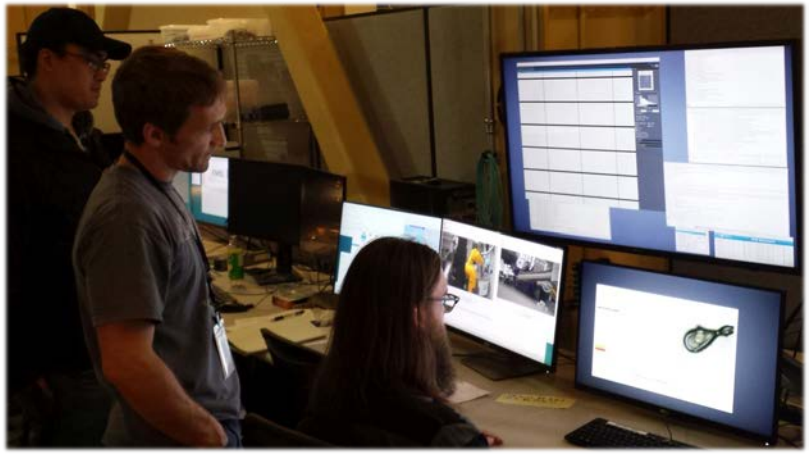


- Current sample exchange time = 51s
- Diagnostics
  - Machine vision for “sample-in-gripper” check
  - Force-torque sensor for collision detection/prevention
  - Continuous temperature monitoring (< 100 K)

First users with the FMX sample robot



- 2017-03-01
- Jochen Zimmer (University of Virginia)
- Mechanism of bacterial cellulose biosynthesis



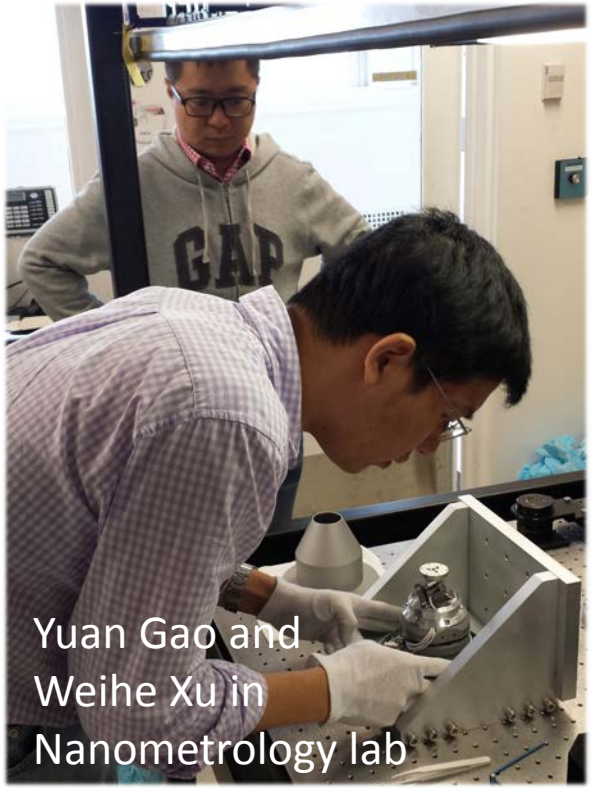
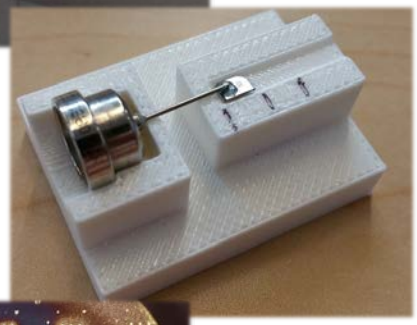
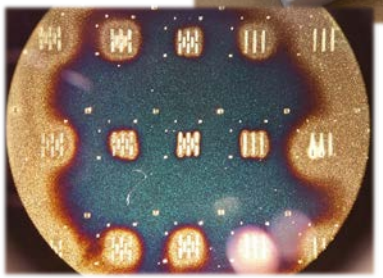
Serial Micro-crystallography

LDRD FY16 *"Serial Micro-crystallography at Full Flux"*

Martin Fuchs and Evgeny Nazaretski (Co-PI)

- Coarse/fine 3D piezo scanner rastering stage
- Micro-structured Si sample holder (CFN)

Physik Instrumente


Yuan Gao and Weihe Xu in Nanometrology lab