

MECHANICAL DESIGN OF NEW DUAL PINHOLE MINI-BEAM COLLIMATOR WITH MOTORIZED PITCH AND YAW ADJUSTER PROVIDES LOWER BACKGROUND FOR X-RAY CRYSTALLOGRAPHY AT GMCA@APS

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**GM/CA CAT
Argonne National Laboratory**

**With my colleagues at GM/CA CAT
Robert R. Fischetti, Naga Venugopalan, Oleg Makarov, and Sergey Stepanov**

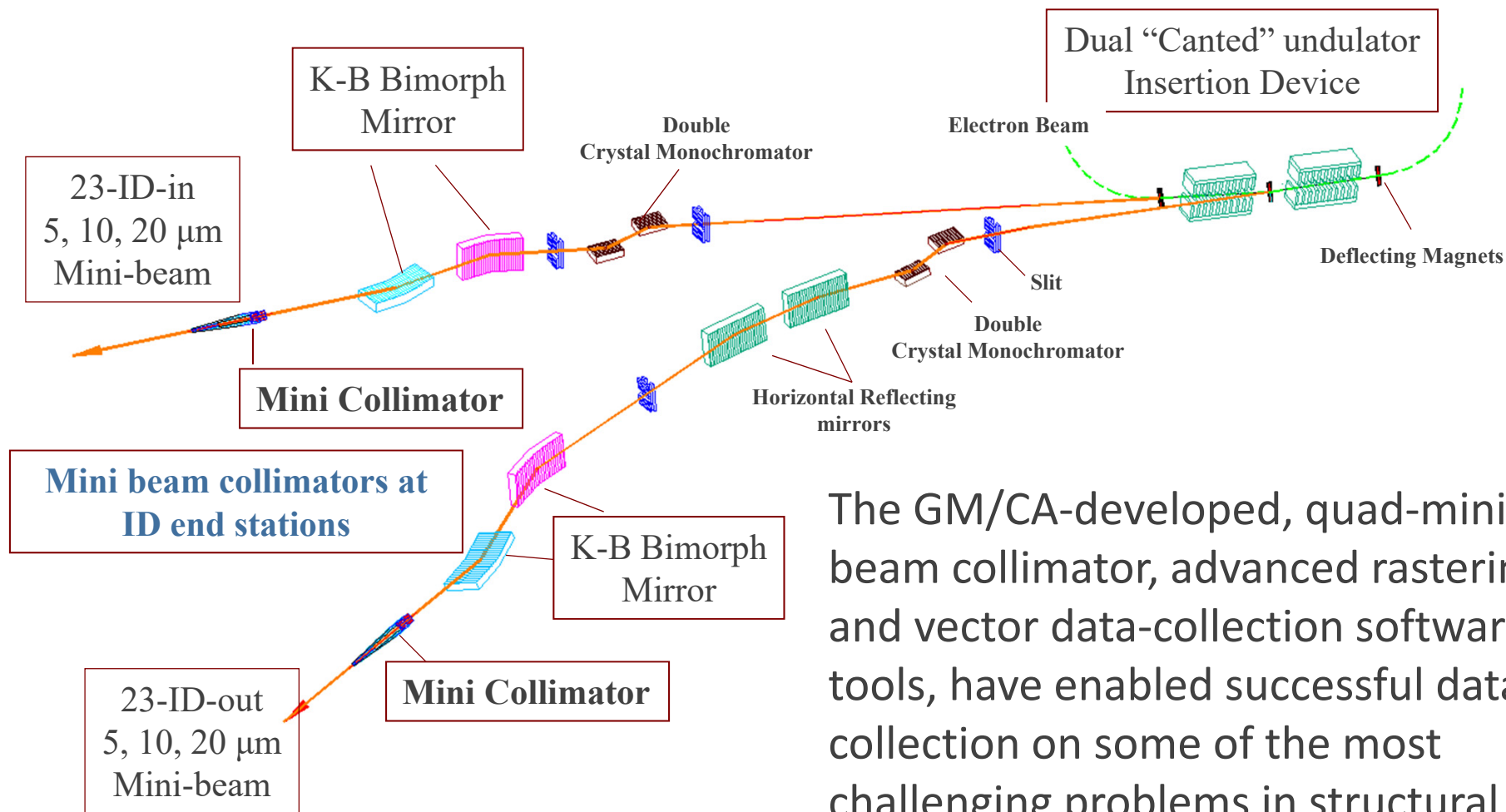
**2016 MEDSI - 9th International Conference on Mechanical Engineering Design of
Synchrotron Radiation Equipment and Instrumentation.
Barcelona Spain, September 15, 2016**

Outline

- **GMCA mini-beam, rastering and vector data-collection tool**
- **Design history of compact mini beam collimators**
- **New mini-beam collimator with small exit apertures provides lower background**
- **Collimator positioning system with motorized pitch and yaw adjuster**

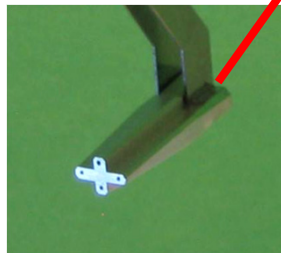
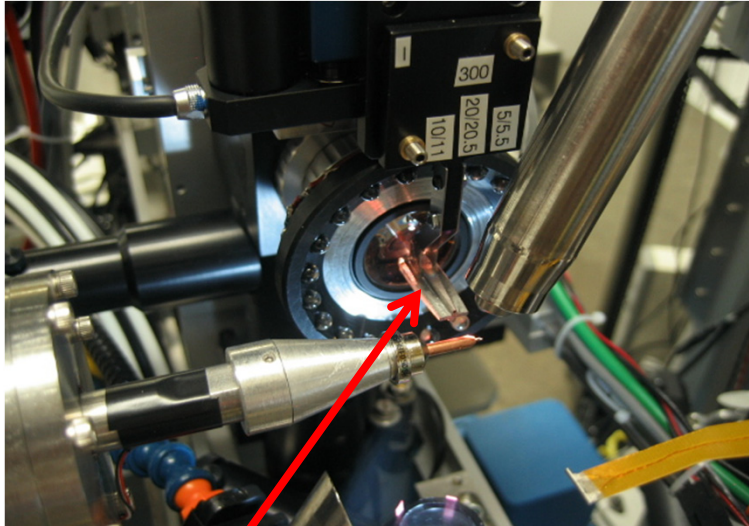


GM/CA-CAT dual canted undulator beamlines at the APS



The GM/CA-developed, quad-mini-beam collimator, advanced rastering and vector data-collection software tools, have enabled successful data collection on some of the most challenging problems in structural biology.

Original quad-mini-beam collimator



Quad mini-beam collimator: 5, 10, 20- μm beams and 300- μm scatter guard

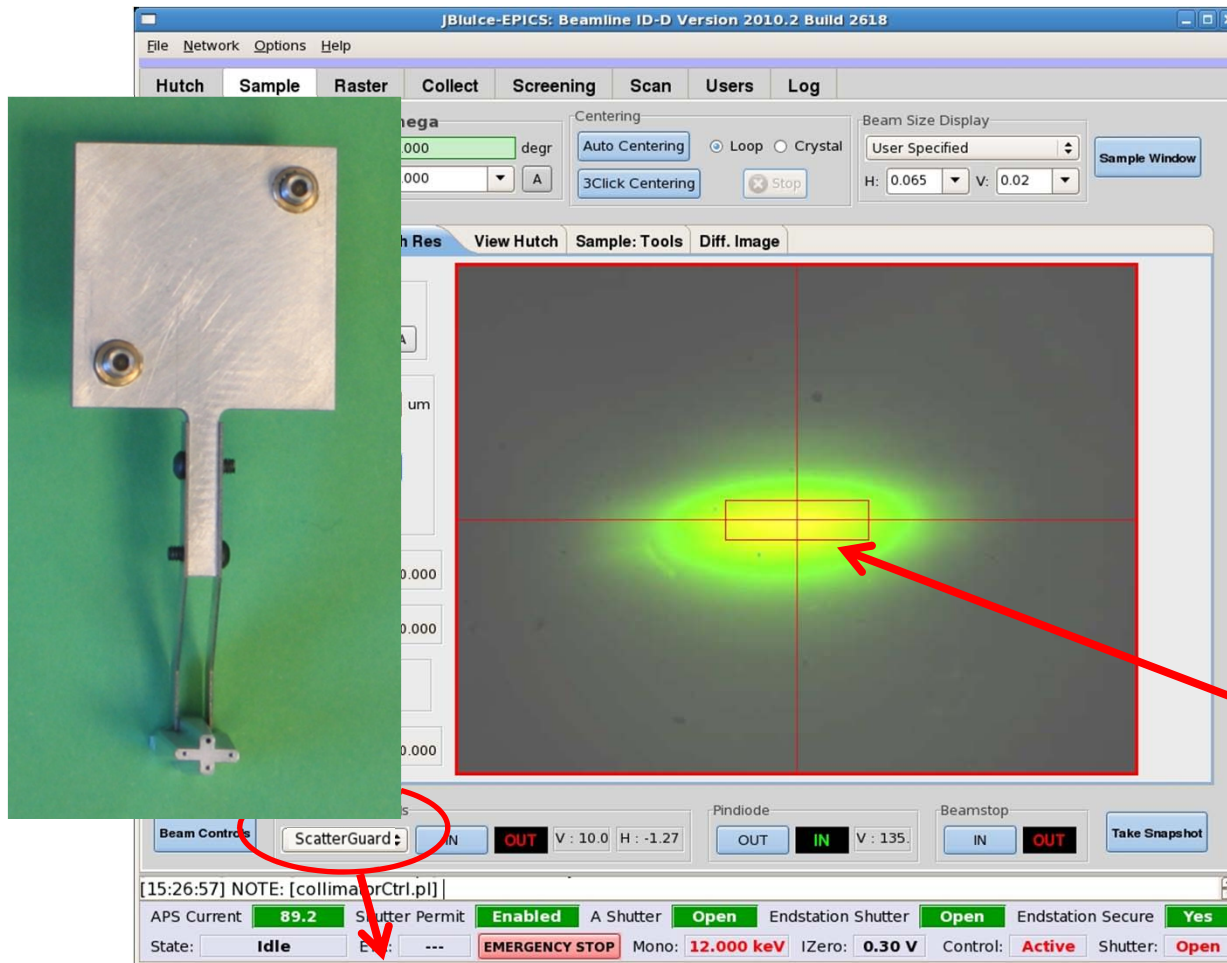
A novel hard X-Ray Quad Collimator system for micro-crystallography experiments in structural biology

Key technical advantages include highly reproducible, automated exchange between various mini-beams and the full focused beam within a **few seconds**

Mini-beam collimator enables Micro-crystallography experiments on standard beamlines



Rapid beam size selection – pioneered at GM/CA



JBlulce-EPICS GUI

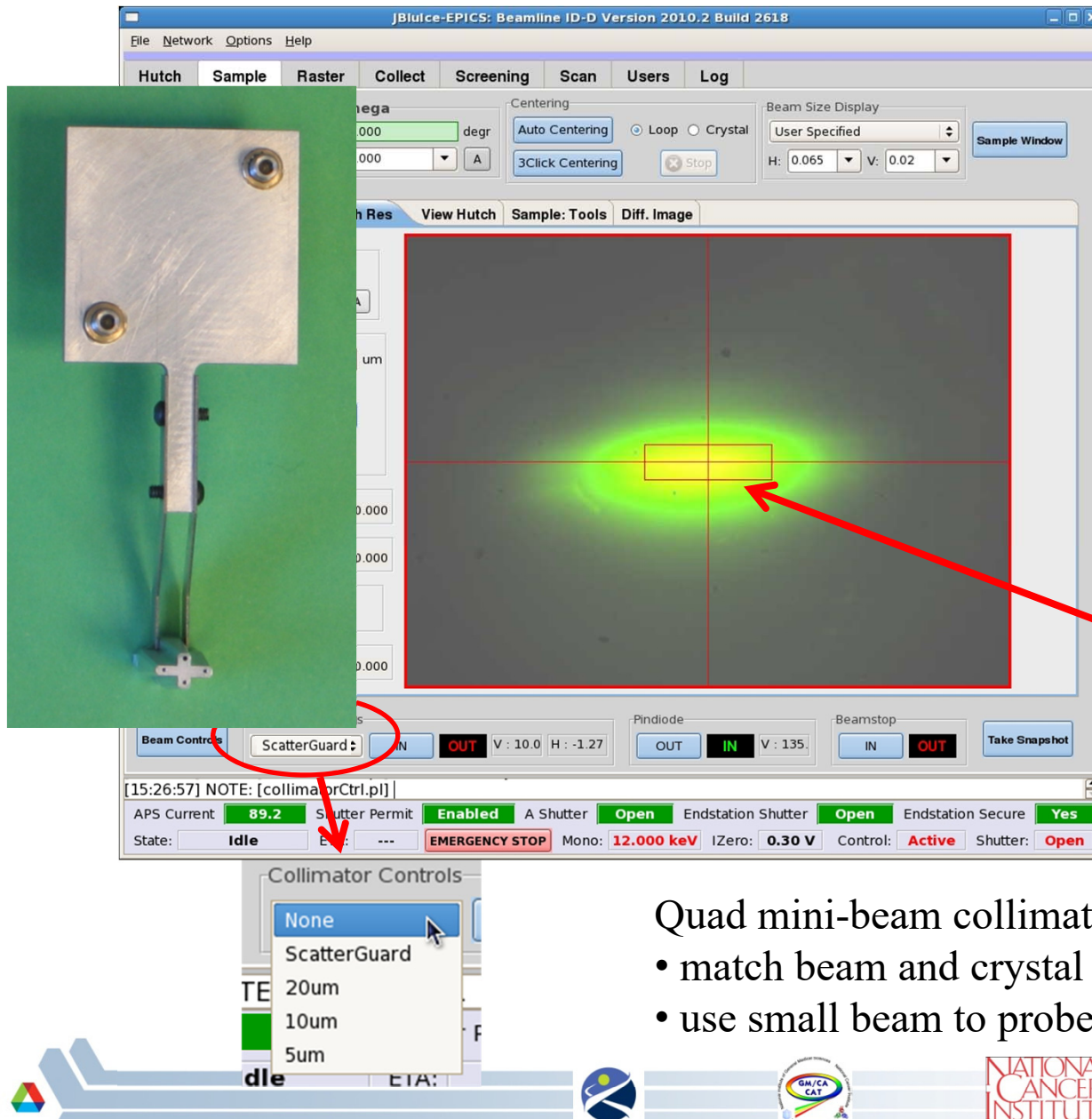
Beam size FWHM (μm)	Intensity (Ph./sec)
20 x 65	2.0×10^{13}
20 ∅	1.0×10^{12}
10 ∅	5.2×10^{11}
5 ∅	2.0×10^{11}

Image of beam at
sample position on
YAG crystal

Quad mini-beam collimator

- match beam and crystal size
- use small beam to probe large crystal

Rapid beam size selection – pioneered at GM/CA



JBlulce-EPICS GUI

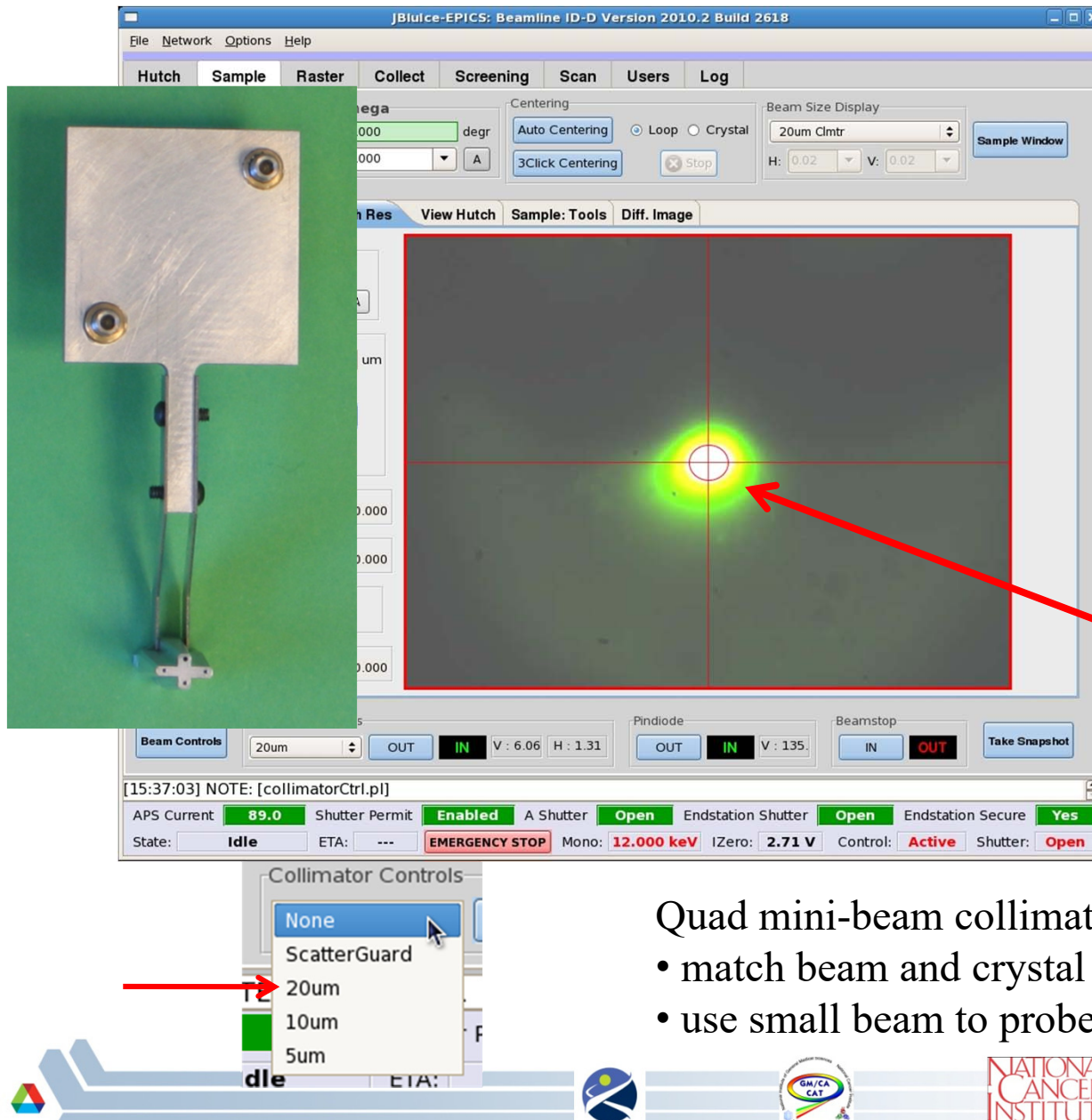
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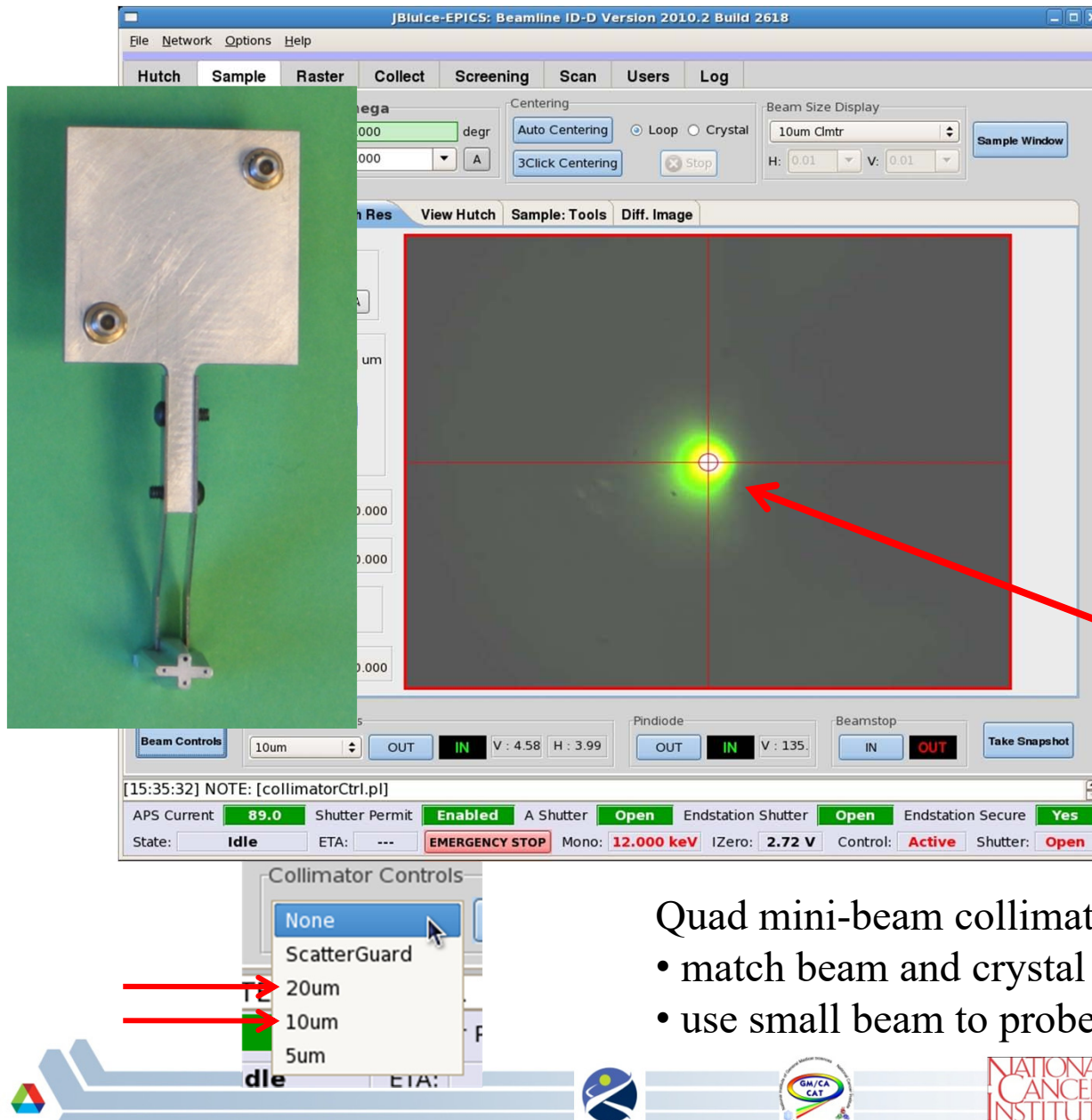
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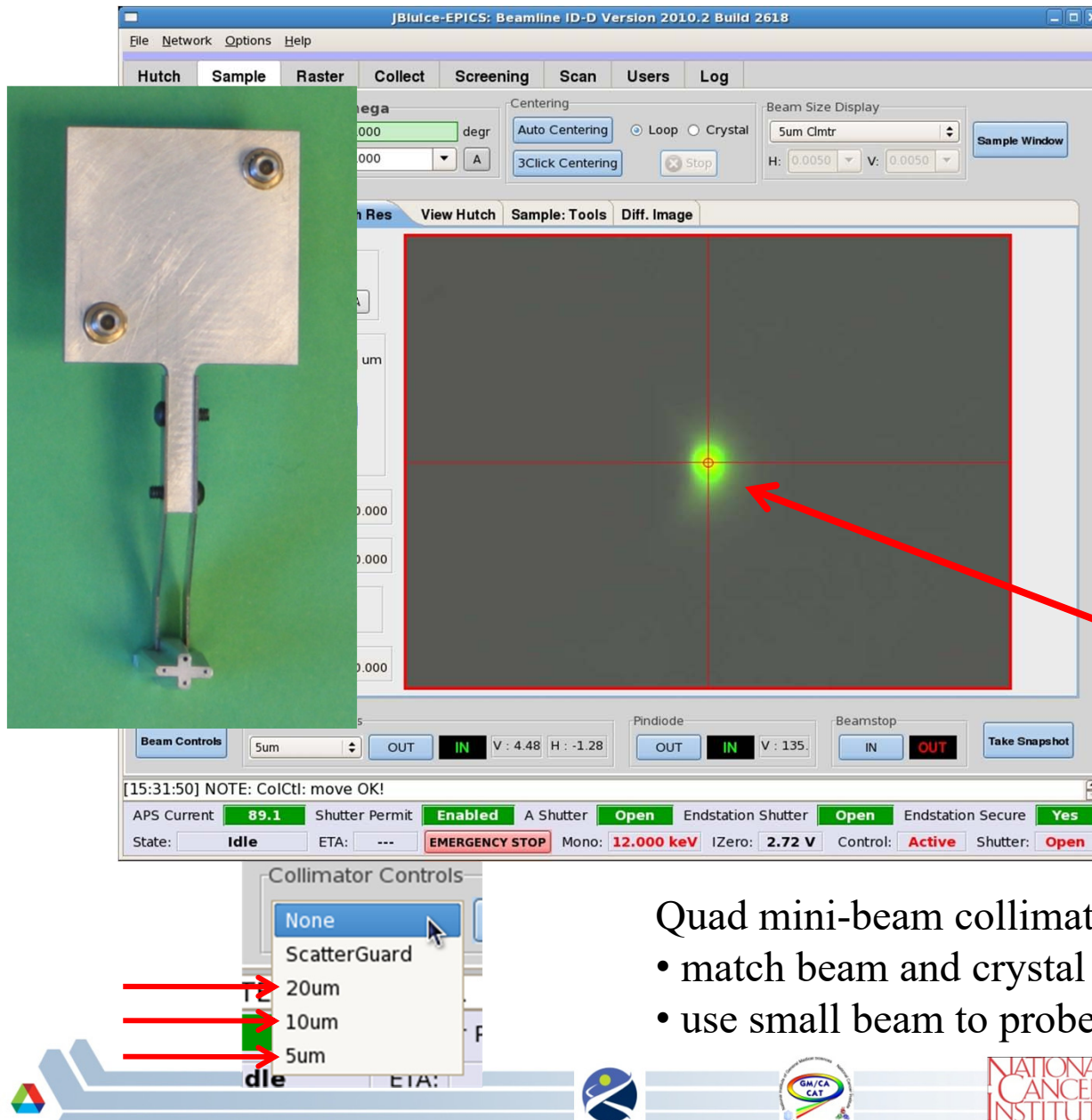
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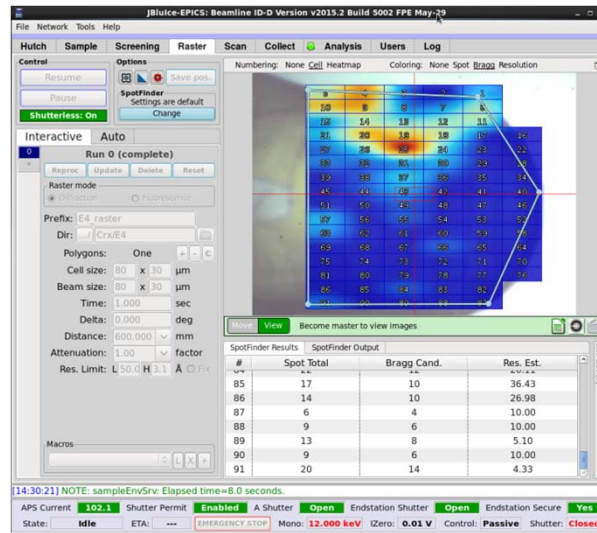
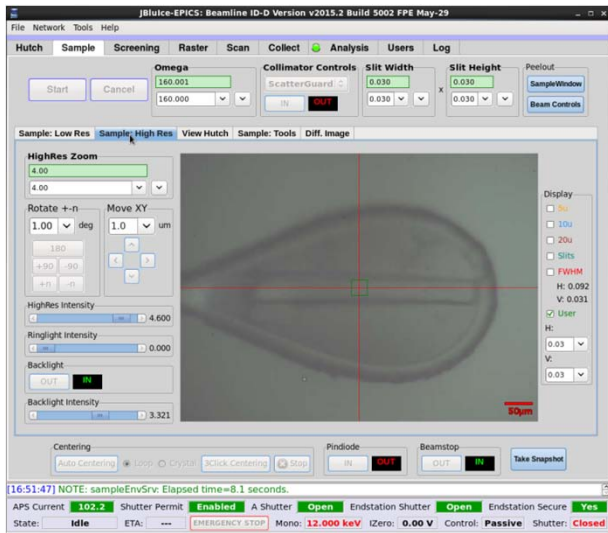
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Quad mini-beam collimator

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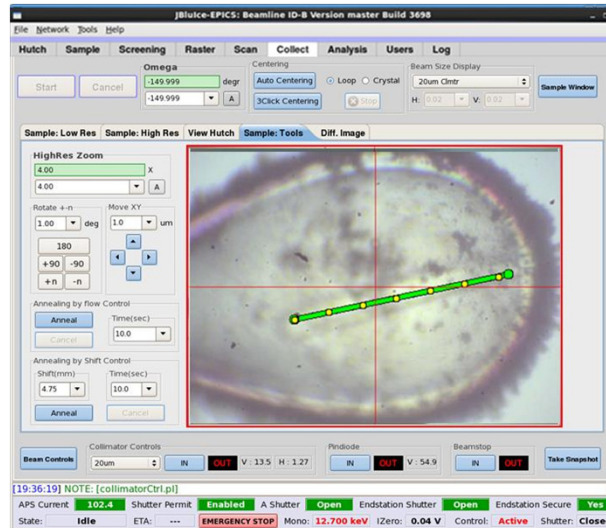
Advanced rastering and vector data-collection software tools

Rastering/mapping crystal quality

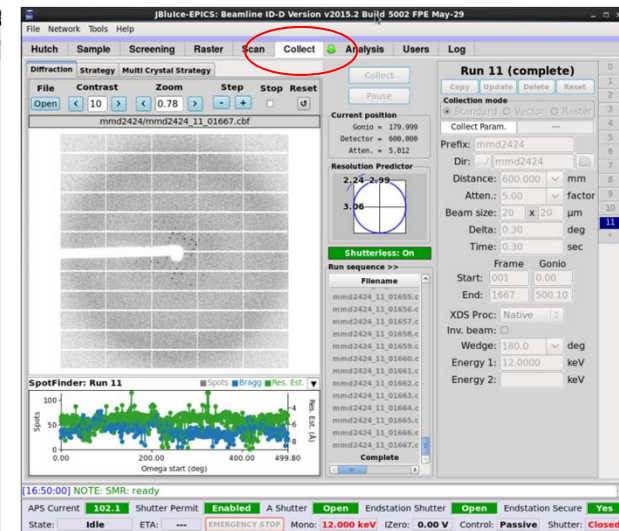


Data-collection tab

Finding/centering sample crystals



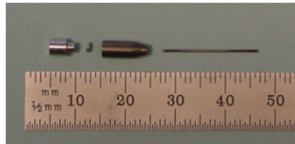
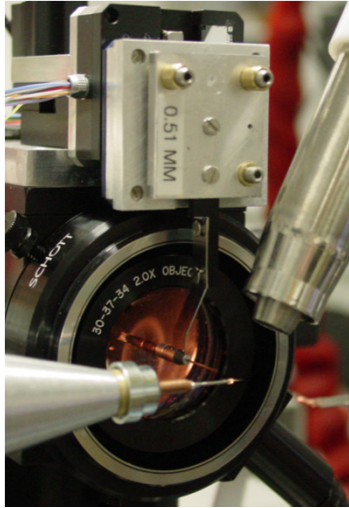
Vector data collection.



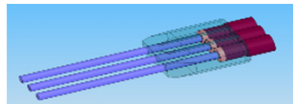
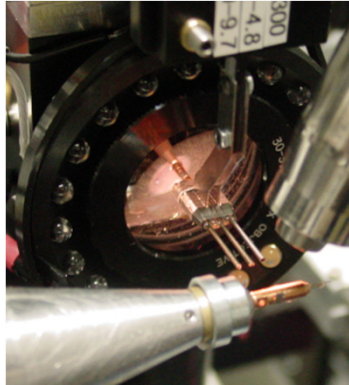
Mark, Nukri, Craig and Sergey

Design history of compact mini beam collimators

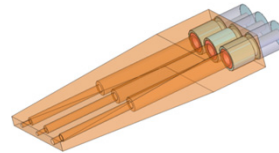
Feb 2007
single



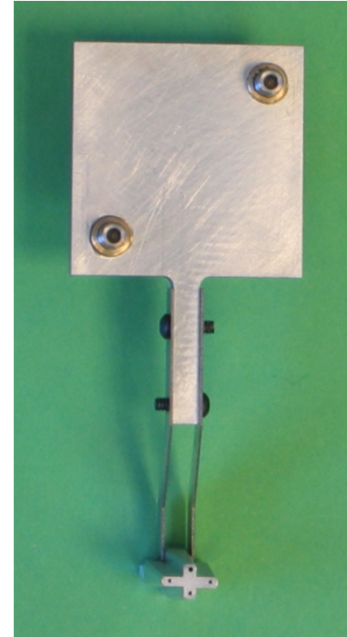
Feb 2008
dual and triple



Feb 2009
robust triple

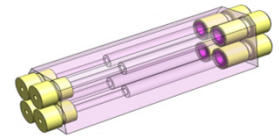
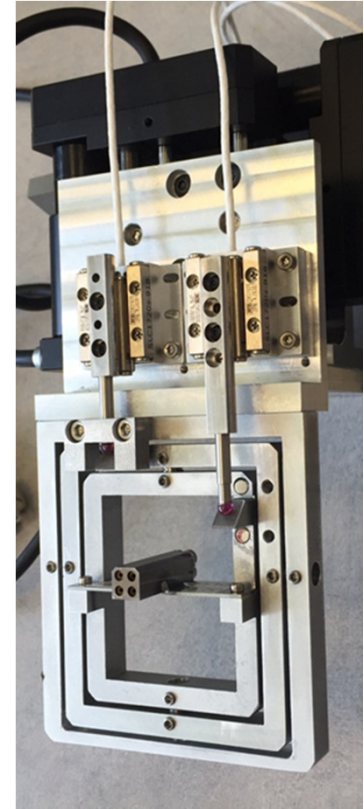


Jul 2009
quad prototype



5, 10, 20 micron
mini-beam or
scatter guard

April 2015
Dual, quad
Pitch and yaw

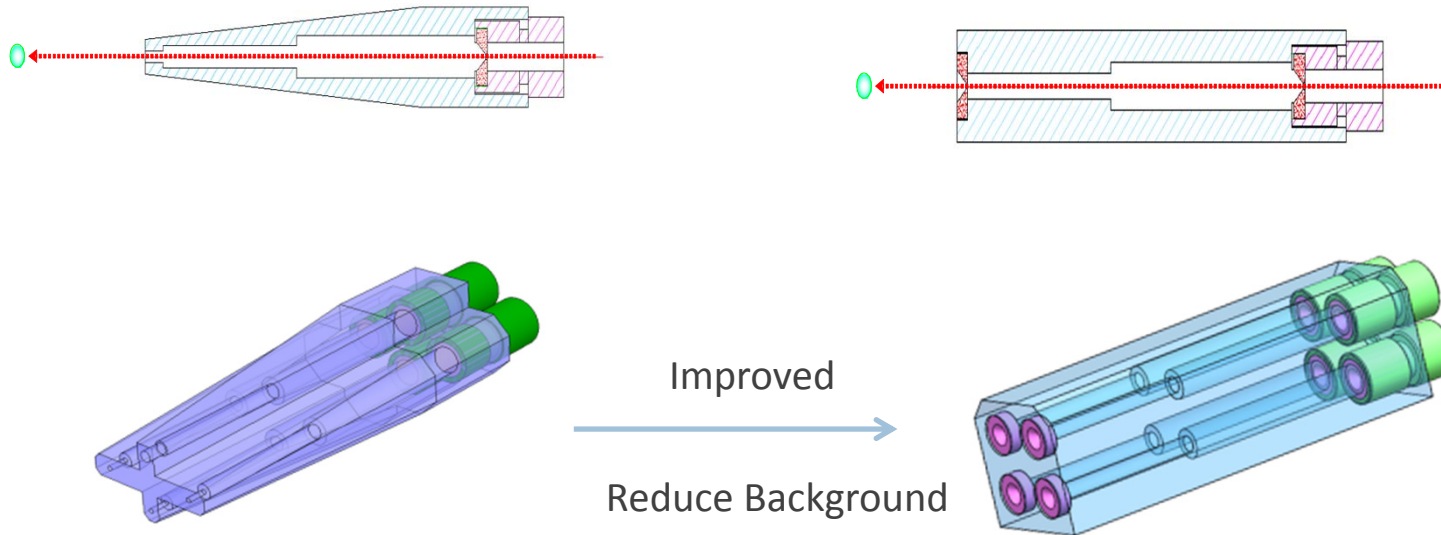


Motivation

- Provide small beam to match diffracting volume
- Stable beam
- Low background scatter
- Sample visualization



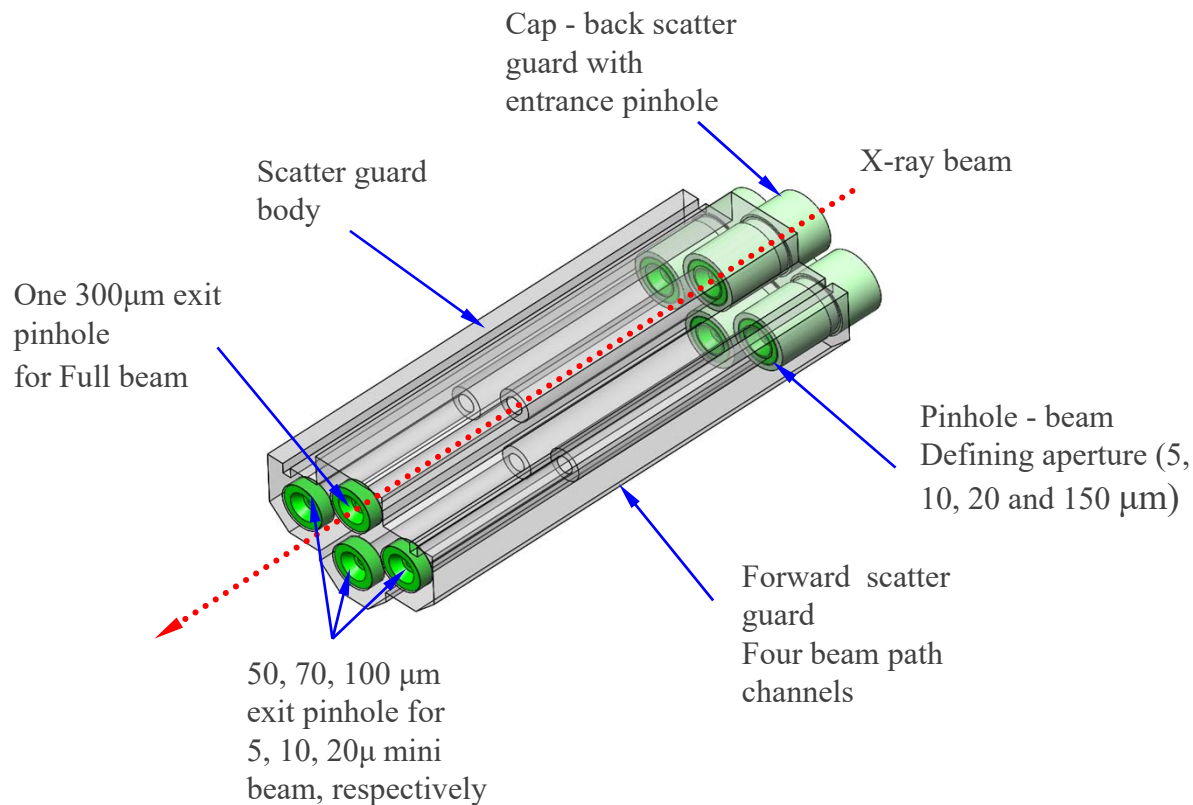
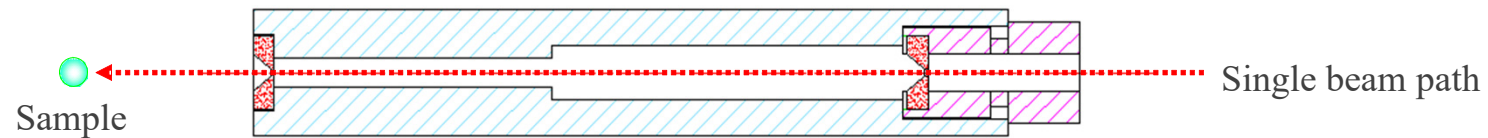
2015 developing dual-pinhole collimator with small exit apertures provides lower background



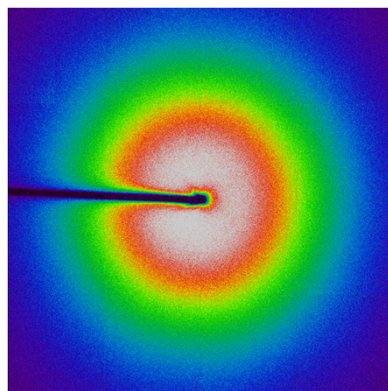
Collimator	Beam Defining pinhole (μm)	Exit Aperture (EDM) (μm)
1	5	250 EDM
2	10	250 EDM
3	20	250 EDM
4	300	600

Collimator	Beam Defining pinhole (μm)	Exit-pinhole Aperture (μm)
1	5	50
2	10	70
3	20	100
4	150	300

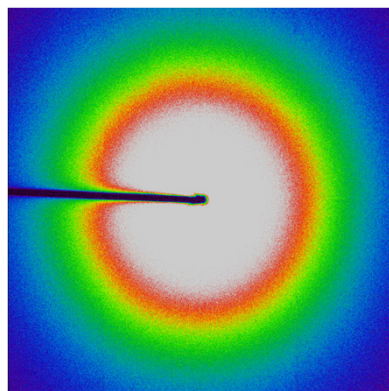
New Dual-pinhole Quad mini-beam collimator



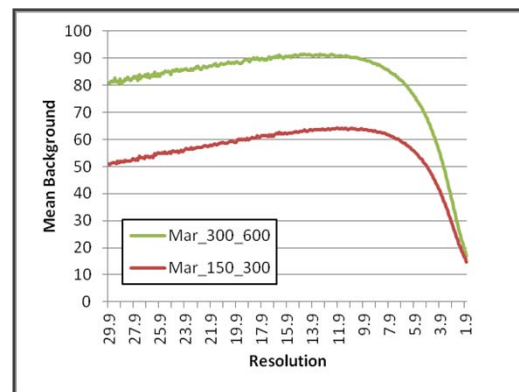
Background - Full beam: 150/300 Vs 300/600



150μm/300μm

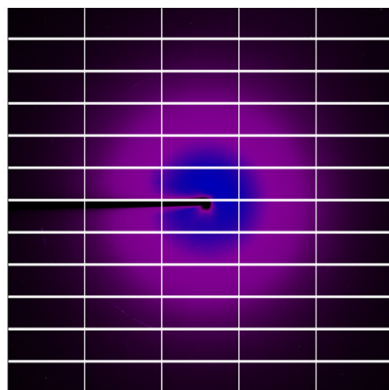


300μm/600μm

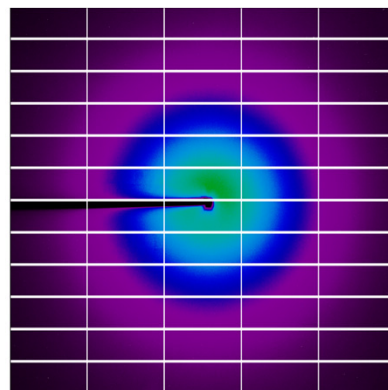


Background scattering
Decreased by 27%

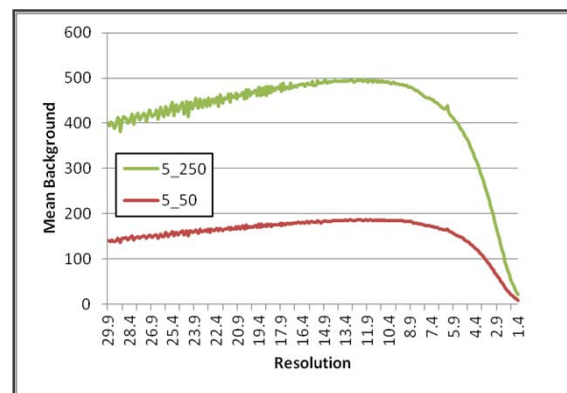
Background scatter: 5/50 Vs 5/250



5μm/50μm

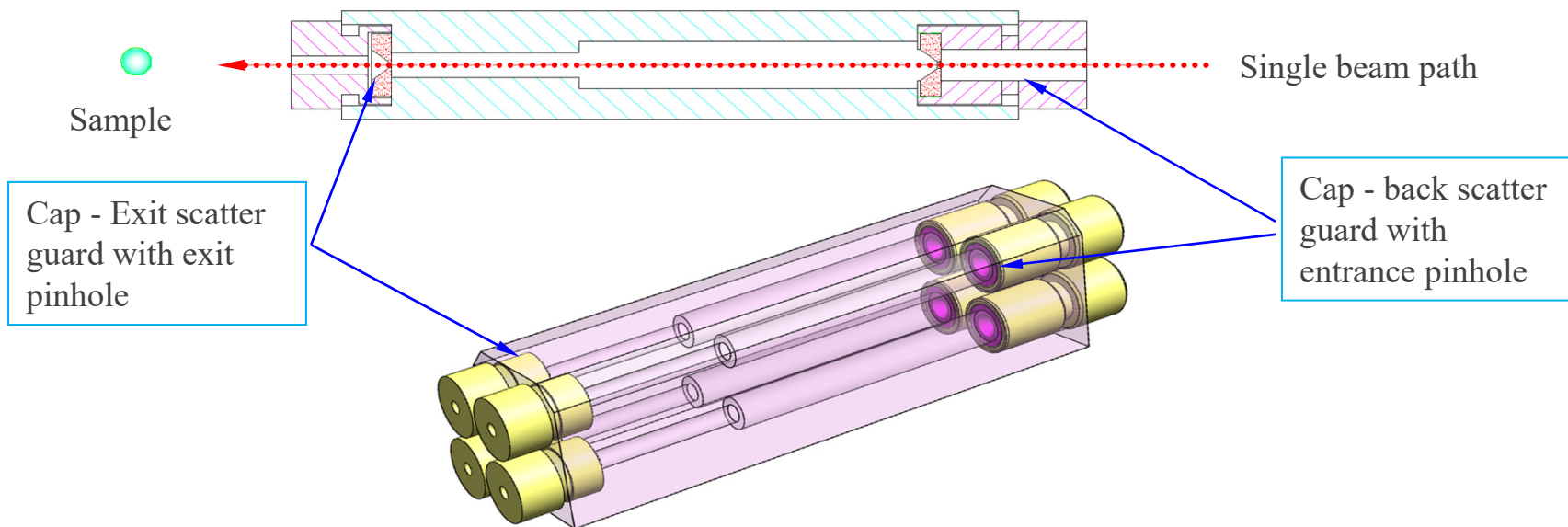
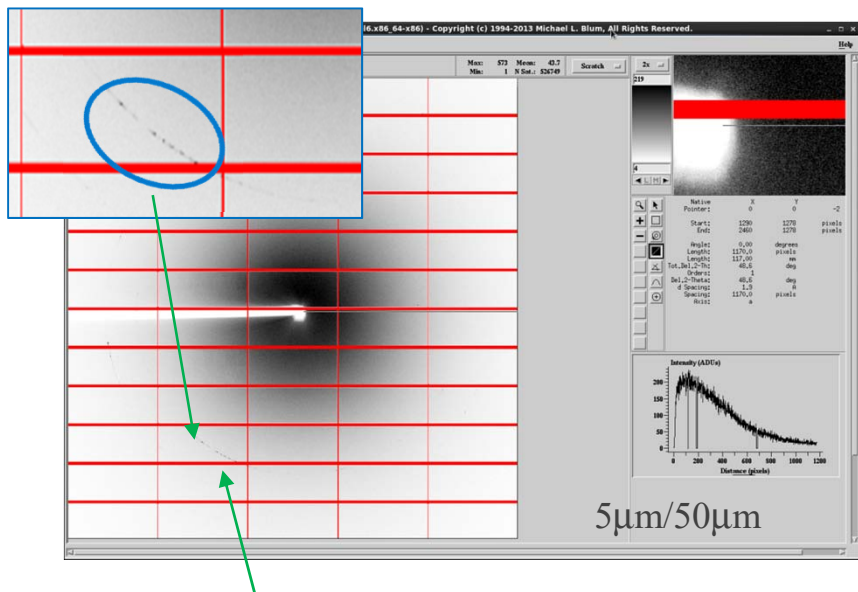


5μm/250μm

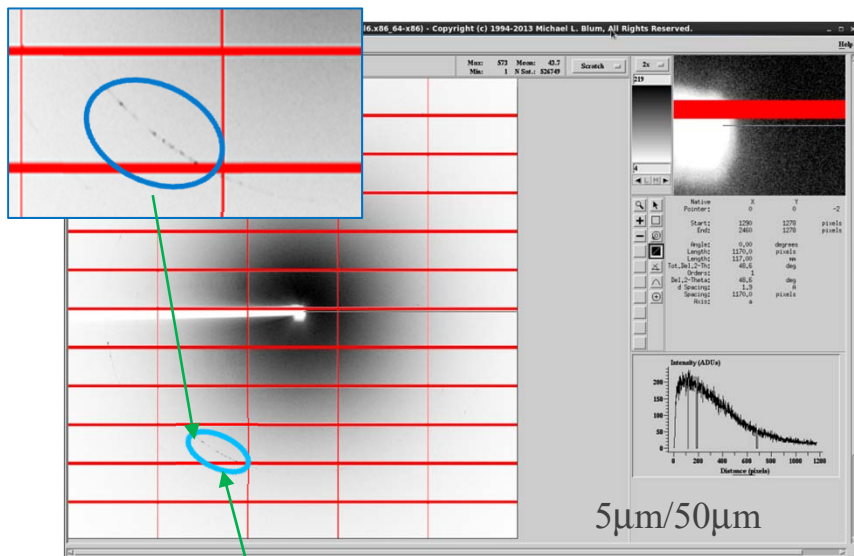


Background scattering
Decreased by 60%

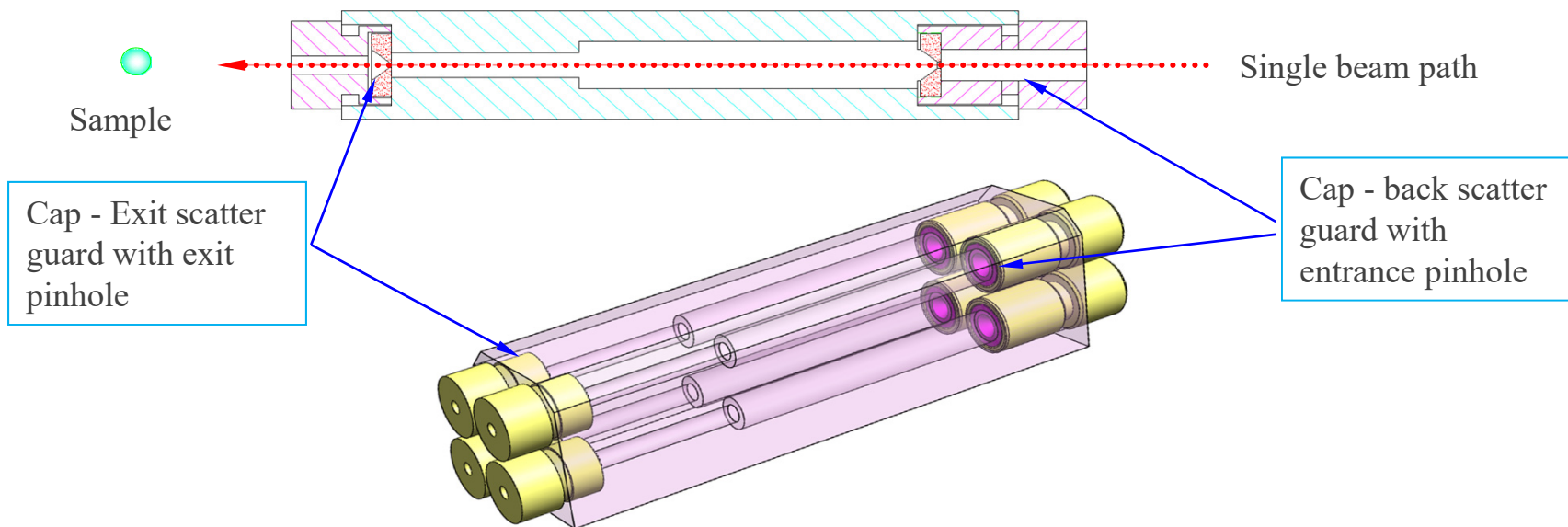
Added Exit Cap to Remove Metallic Rings



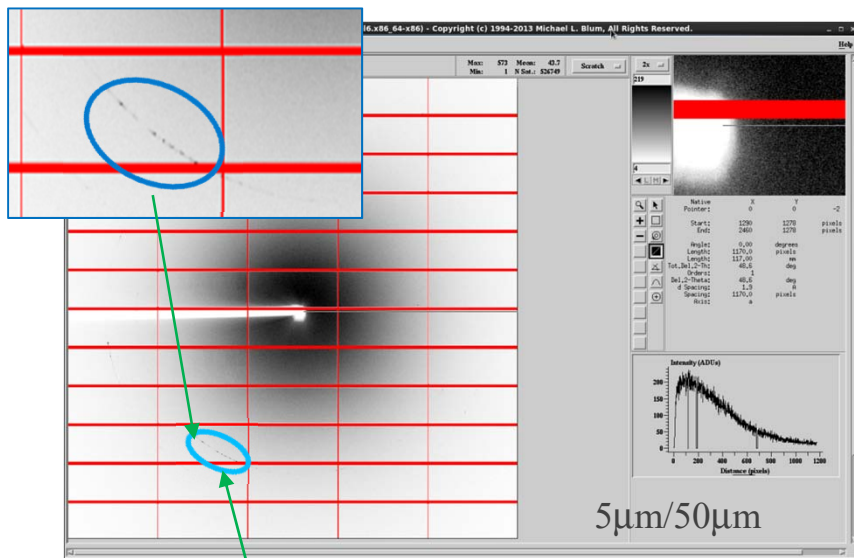
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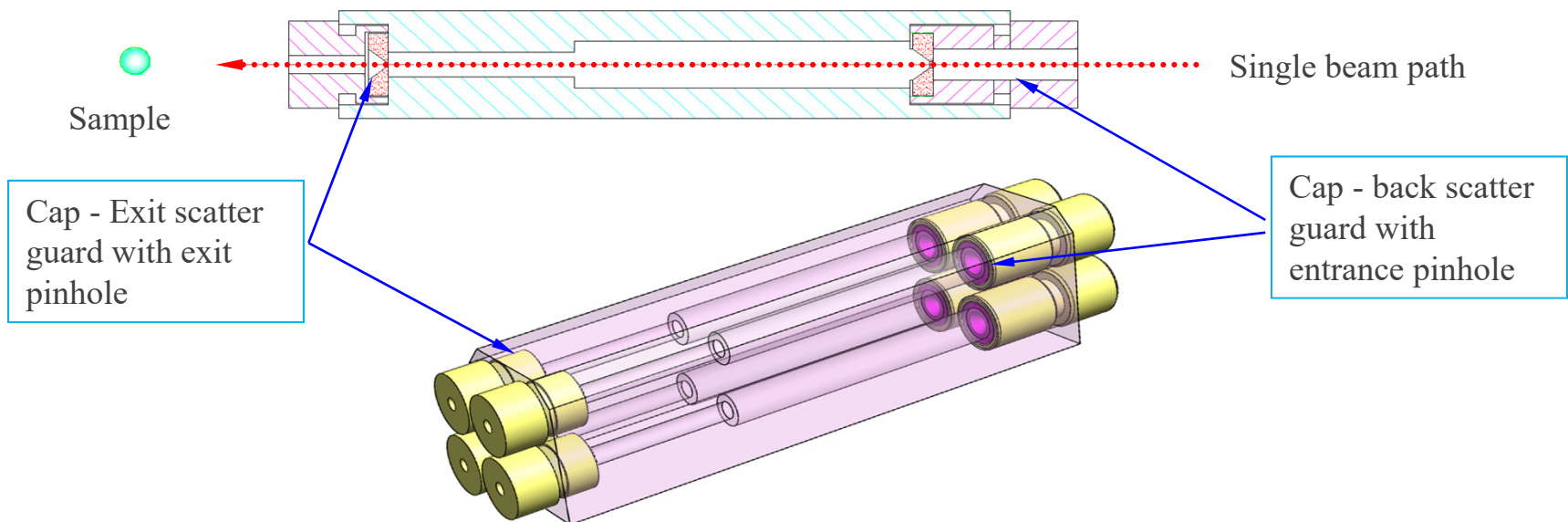
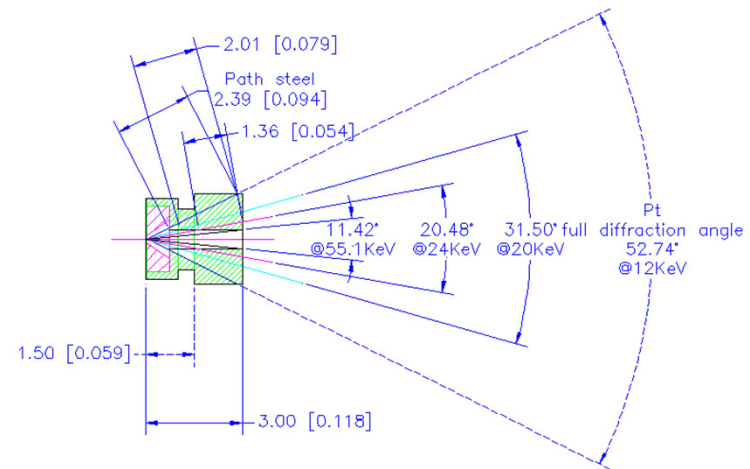
Faint metallic rings escaped exit aperture



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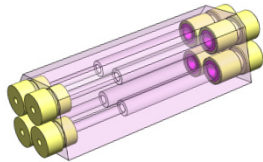


Collimator as installed at the beamline endstation

Beam direction

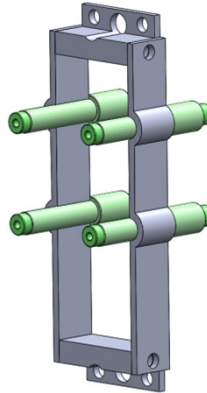


March 2015



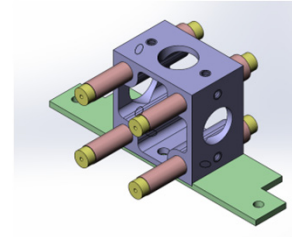
Exit scatter cap

November 2015

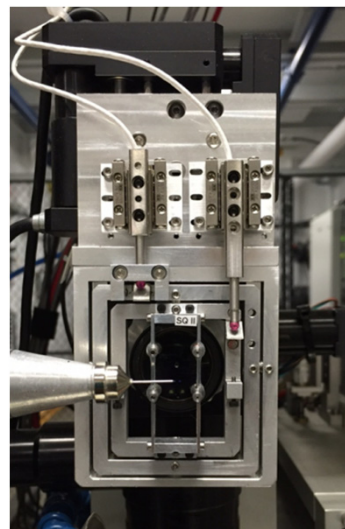
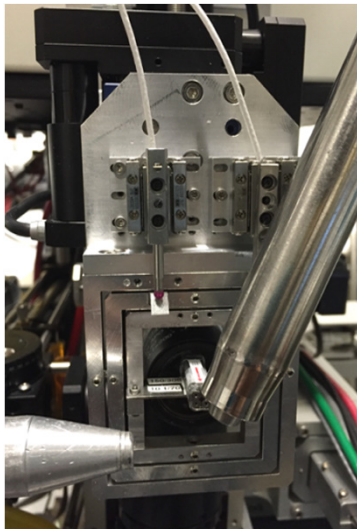


View of sample

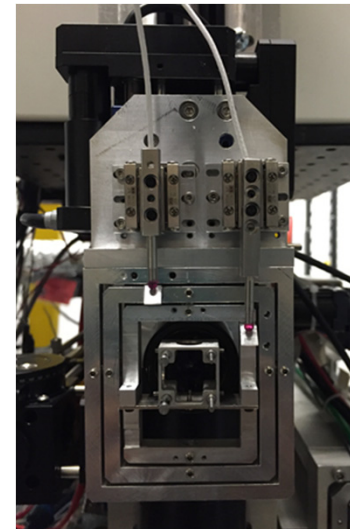
April 2016



Robust



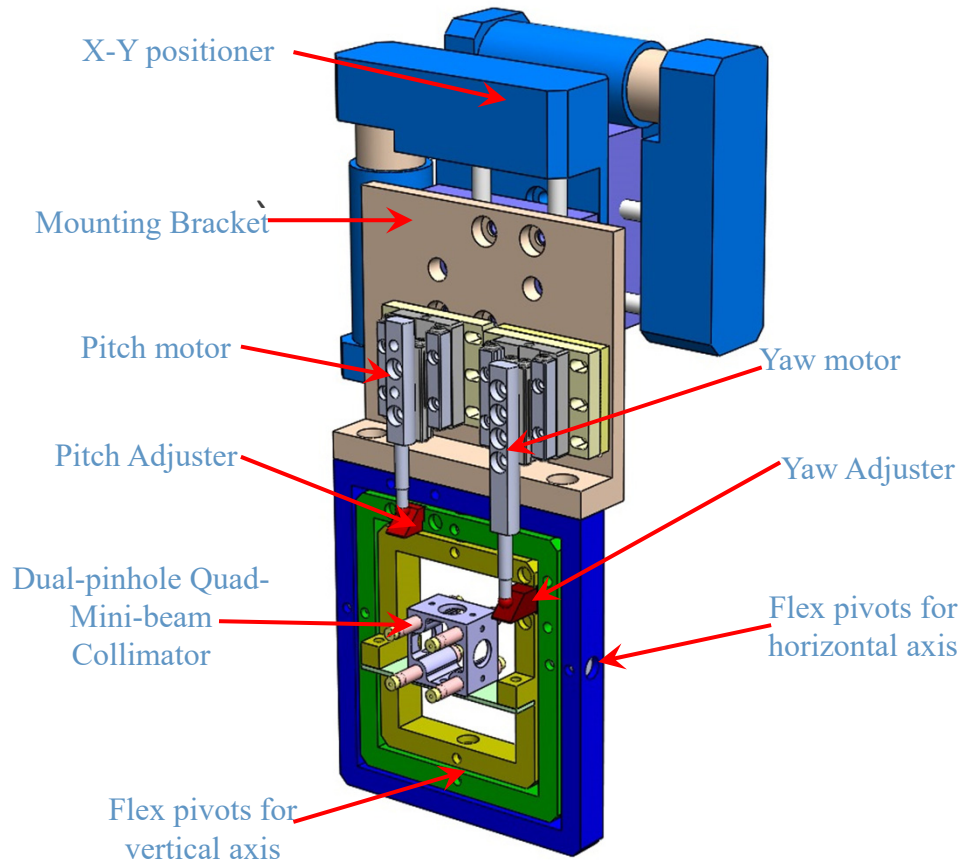
ID-D – Station



ID-B – Station



Collimator positioning system with motorized pitch and yaw adjuster

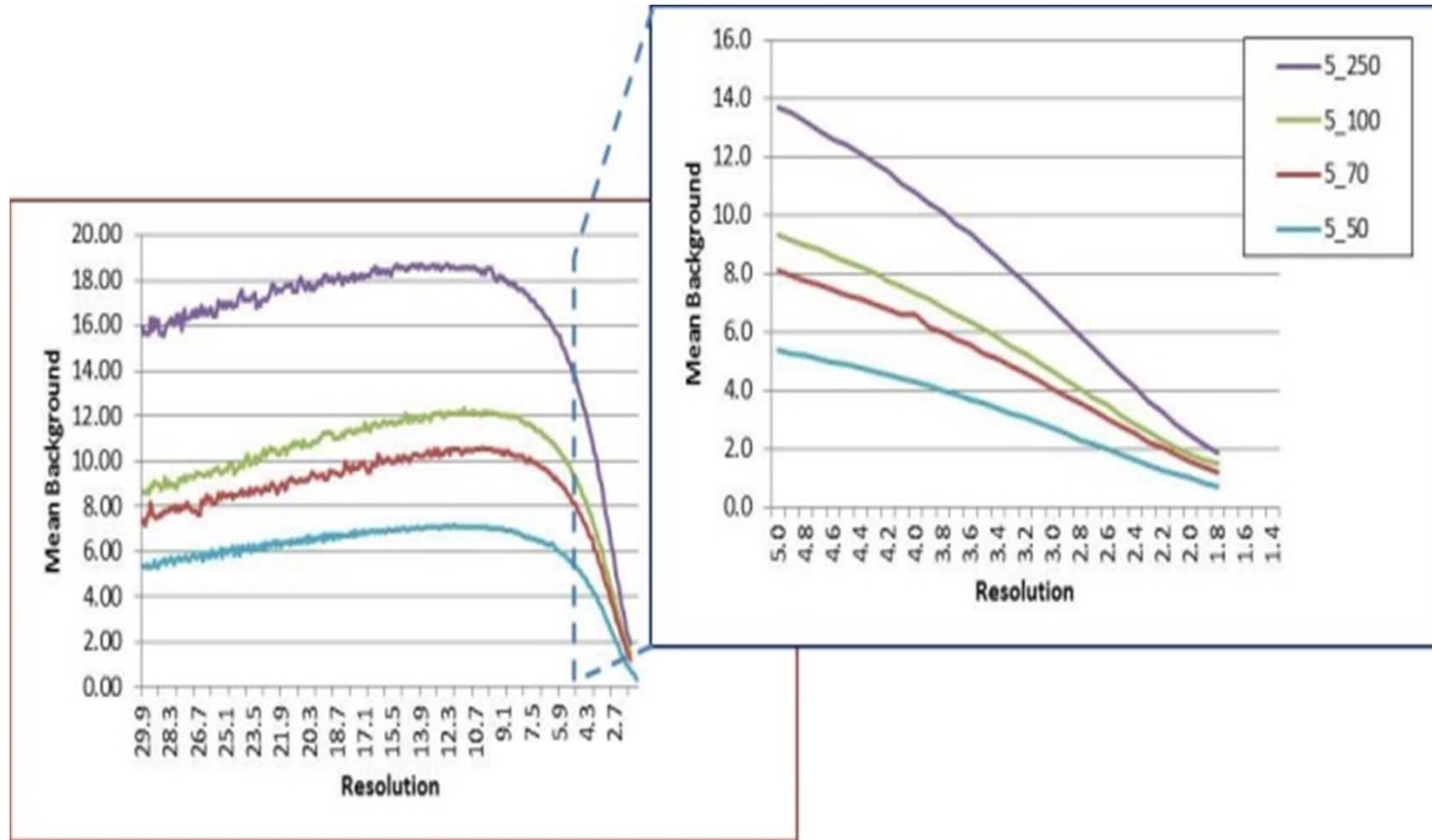


New Quad collimator Alignment

The motorized pitch and yaw motions made alignment of each beam defining/exit aperture combination relatively easy. The two translational and two angular motions were highly reproducible

Independent angular adjustments for each collimator
Translational X and Y positions and angular pitch and yaw are stored
Translational and angular positions recalled to provide desired beamsizes.

Conclusion



- Systematic reduction in background as we reduce the size of the exit aperture.
- Over all background reduced by 27% for the full beam (from 300/600 to 150/300).
- Over all background reduced by 60% for the 5mm beam (from 5/250 to 5/50).



Acknowledgements

GM/CA colleagues:



Robert R. Fischetti
Group Leader

Design



Naga Venugopalan
Crystallographer

Design, installation
and alignment



Oleg Makarov
Control Systems
Developer

Hardware and
controls



Sergey Stepanov
Control Systems Sector
Leader

Controls and
software

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Thank you for your attention!