HHL Monochromator, Absorbers and XBPM Testing at 29-ID: Status and Future Plans

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Dan Burke
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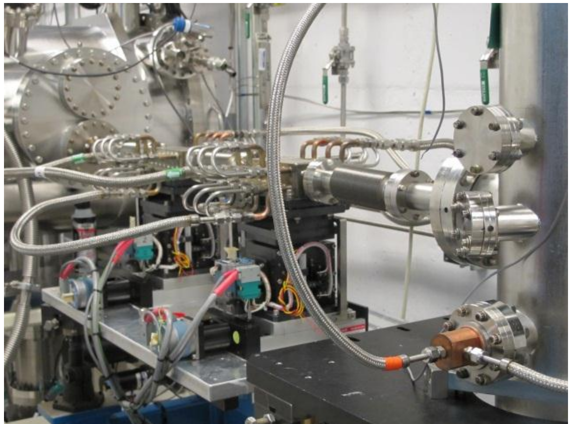
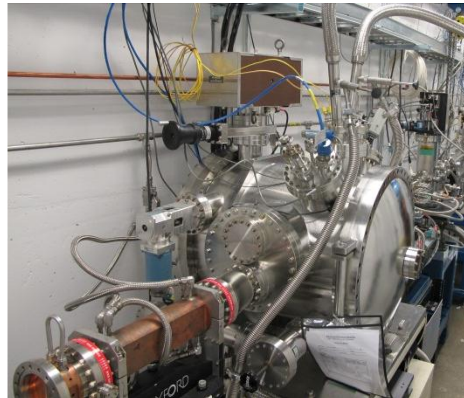
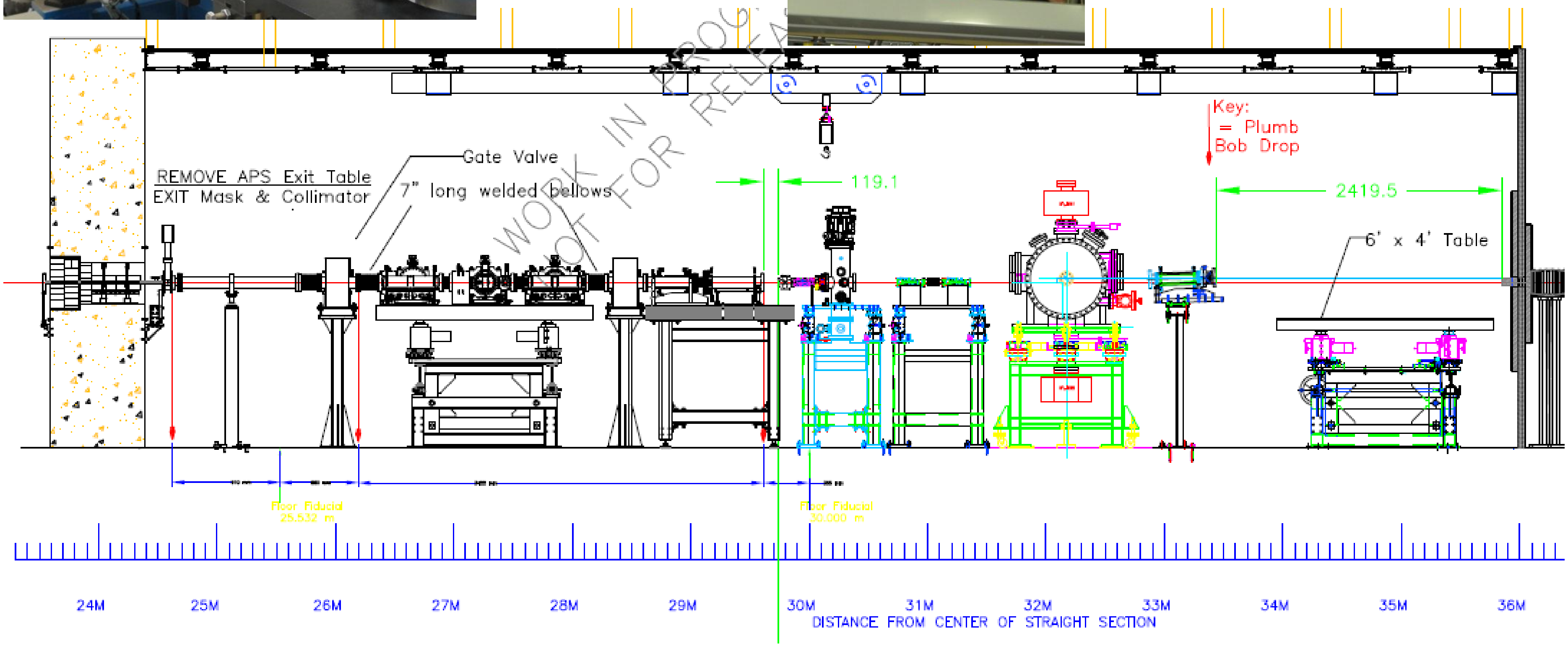
Outline

- Introduction
- Thermal Fatigue of GlidCop® 29-ID-A Test Program
  - Motivations, Progress and Future Plans
- High Heat Load Monochromator Testing
  - Motivations, Progress and Future Plans
- Grazing-Incidence Insertion Device X-ray Beam Position Monitor (GRID-XBPM) Testing
  - Motivations, Progress and Future Plans
- Summary

29-ID-A Layout







Thermal Fatigue of GlidCop® 29-ID-A Test Program Progress

Motivations

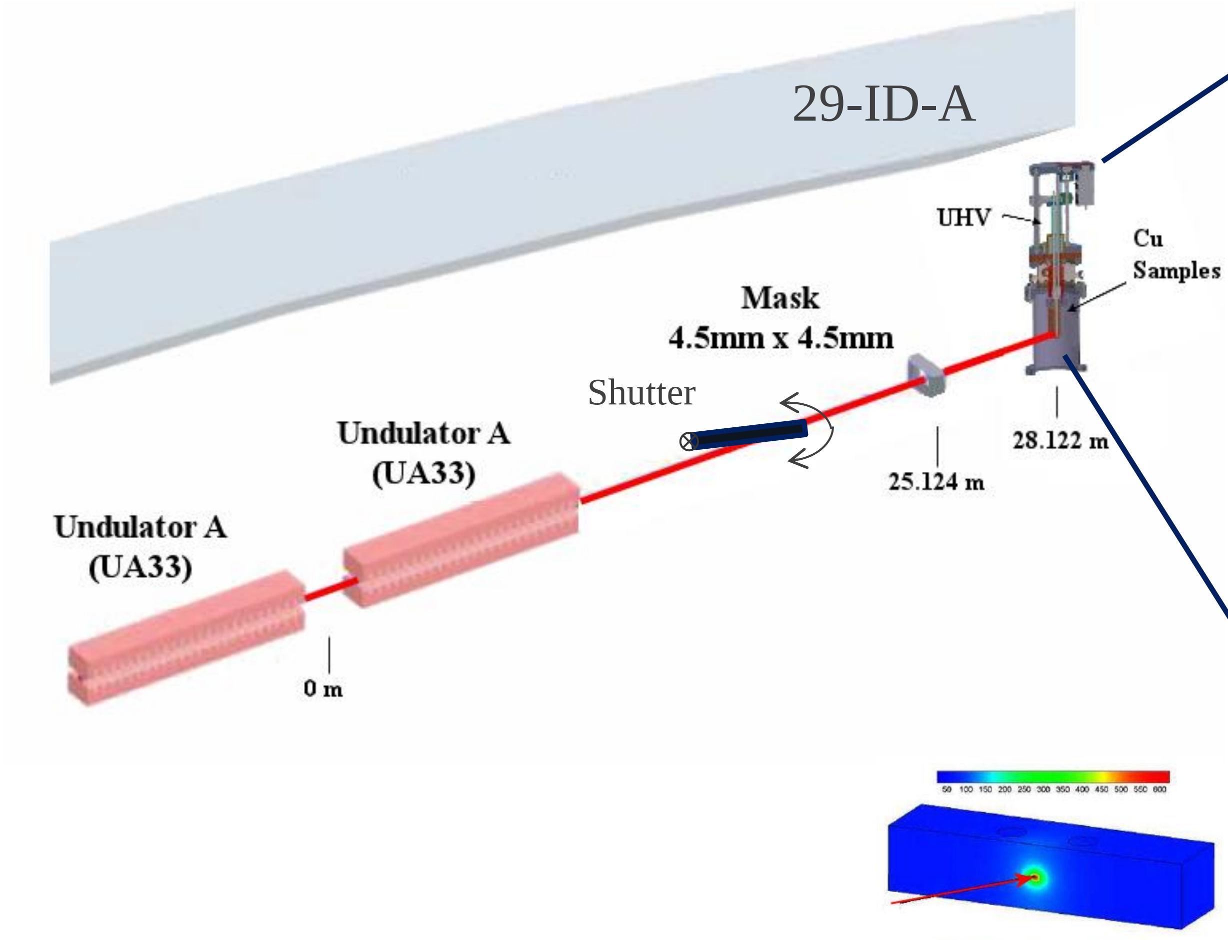
- Currently use conservative design criteria for establishing the maximum thermal load acceptable for beam-intercepting components (shutters, masks, stops):
  - Maximum temperature on GlidCop < 300°C to prevent material creep
  - Maximum temperature on the cooling wall < water boiling temperature
  - Maximum stress < 23°C yield strength (400 MPa) for photon shutters

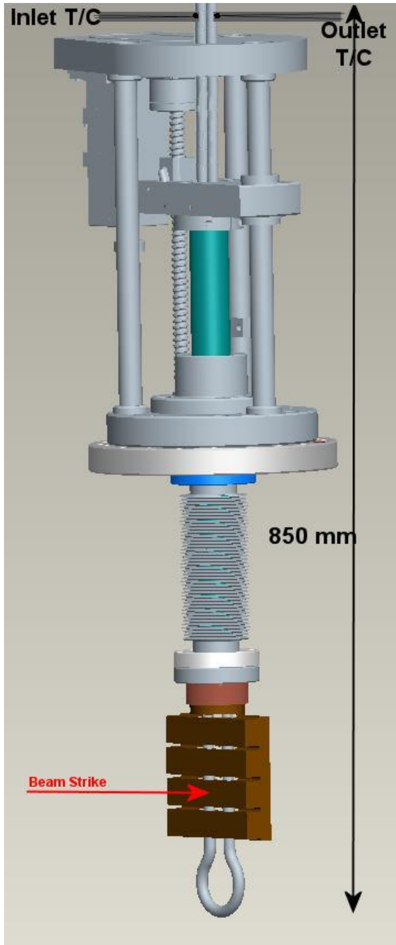
Question: At higher current operation, are we approaching a range where a new phenomena, thermal fatigue becomes a problem?

Team (LDRD Project):

- J. Collins, B. Brajuskovic, P. Den Hartog, A.Khounsary, G. Navrotski, J. Nudell

Thermal Fatigue of GlidCop®: Experimental Set-up

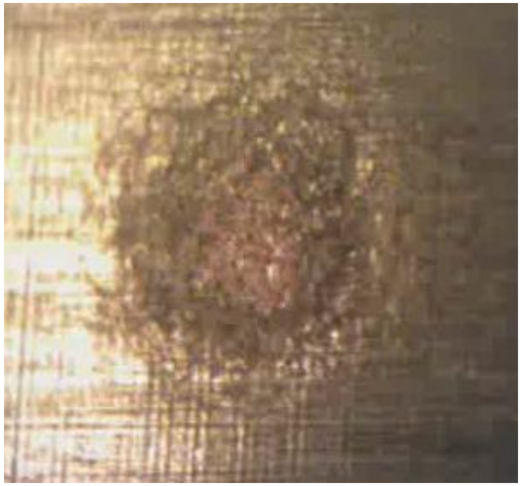




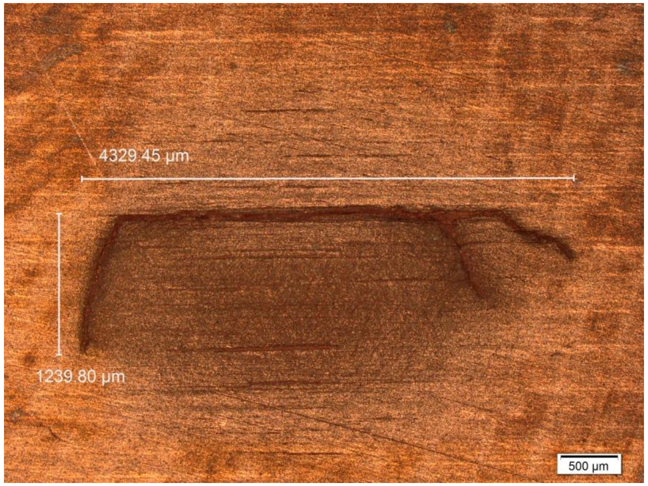
Absorber Failure: Crack Morphologies

High Power / Temperature Regime

- Exfoliation



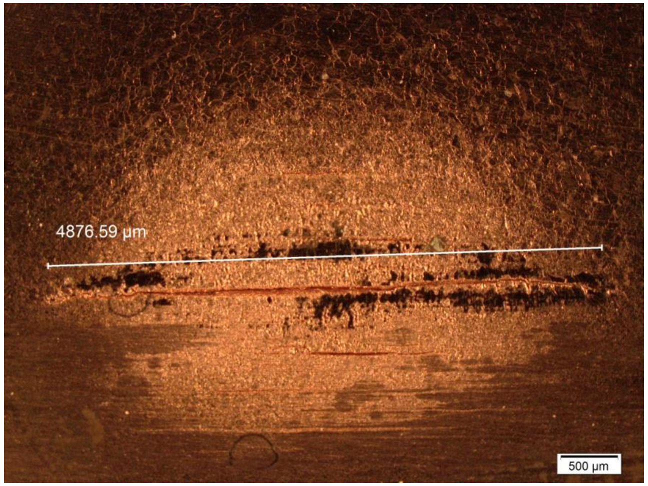
Branching



Medium Power / Temperature Regime

- Branching

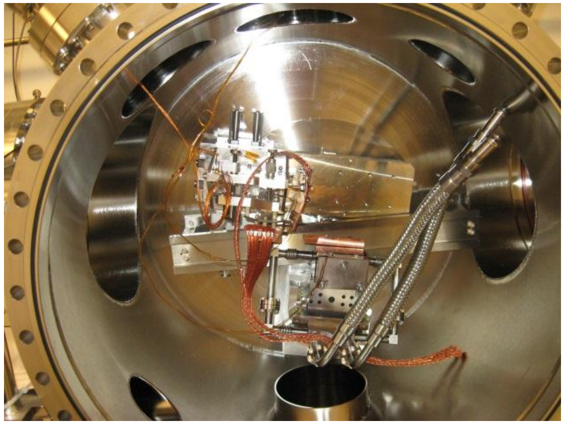
Linear



Thermal Fatigue of GlidCop®: Future Plans

- Develop a "Zero Crack Initiation" limit for thermal fatigue
- Understand and quantify the crack initiation and growth morphologies of GlidCop-Al15®
- Validate ANSYS model for this material

HHL Monochromator Test in 29-ID



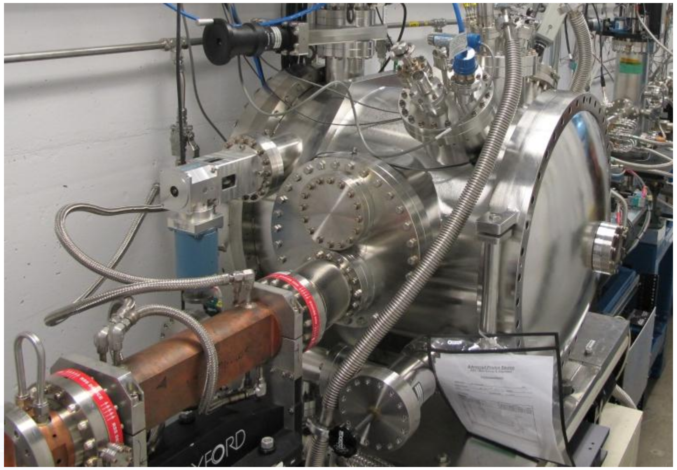
Motivations

- Follow on past work (W-K Lee, P. Fernandez, D. Mills), J. Synchrotron Rad . (2000) **17** 12-17)
- Determine the limits of the internally and side-cooled monochromators using two undulators in tandem
- Validate finite element modeling with ANSYS

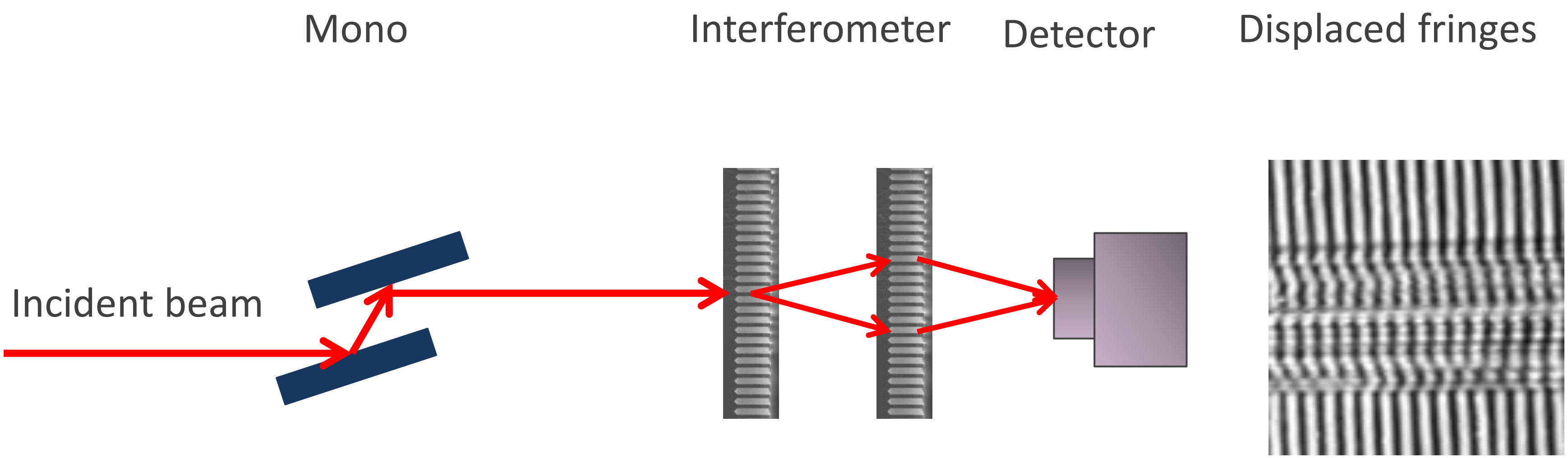
Team:

“High-Heat-Load Hard-Xray Monochromators”, Strategic LDRD 2012-199-NO., A. Macrander, L. Assoufid, G. Navrotski, X. Huang, E. Dufresne, and M. Ramanathan.

Naresh Kajula (postdoc)



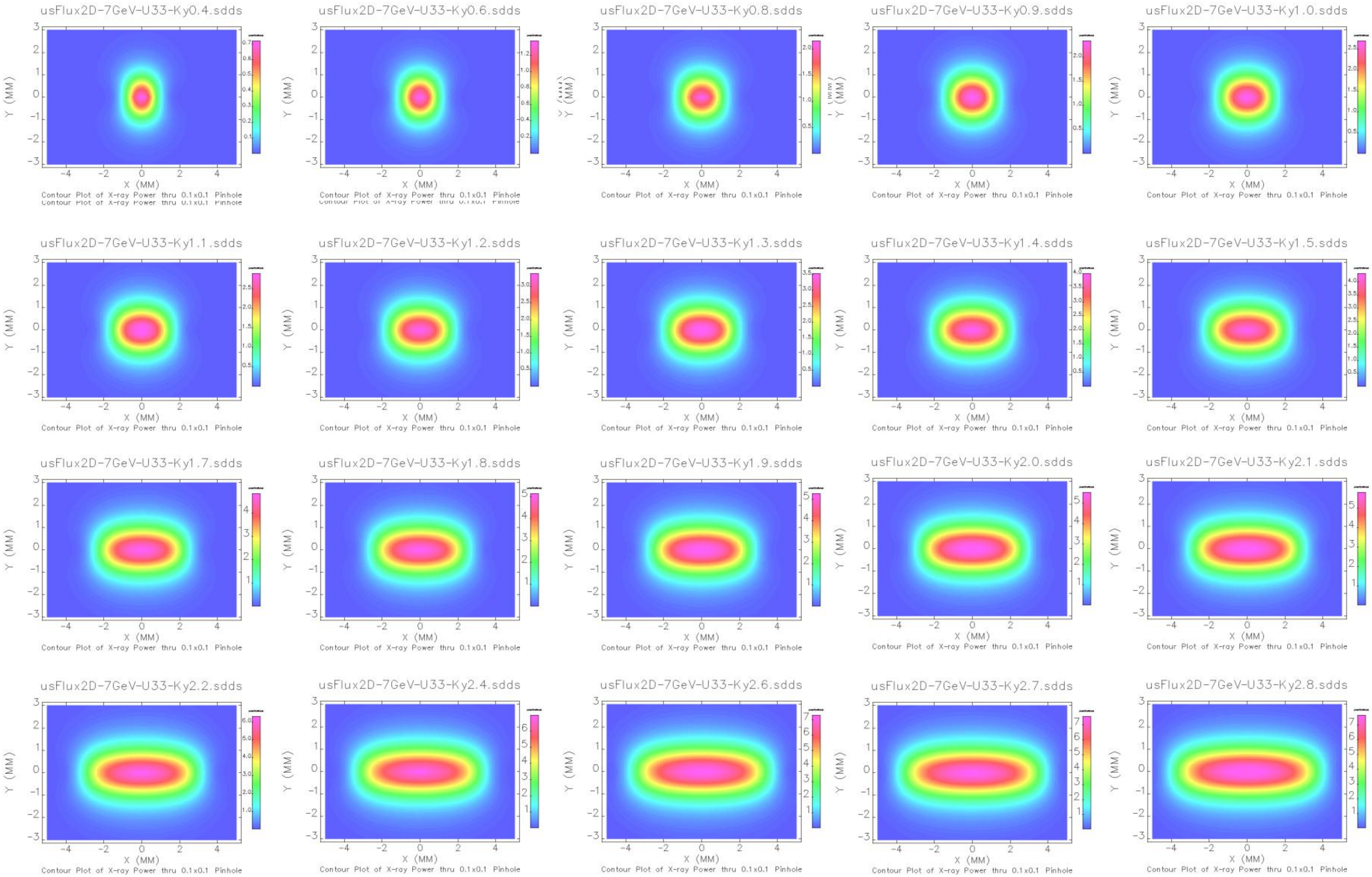
Beam Wavefront Characterization Using Talbot Interferometry



$$\alpha = \frac{\lambda}{2\pi}\frac{\partial\varphi}{\partial x}$$

Strategic LDRD 2011-170-NO- L. Assoufid, S. Marathe, D. Mancini, X. Xiao, A. Macrander, A. Sandy, F. DeCarlo, R. Divan, K. Fezza, and W-K. Lee.

Power Distribution U33 vs. Gap



HHL Monochromator Test in 29-ID: Staus & Future Plans

- **Status**
  - The monochromator is installed and aligned. First Bragg beam was observed.
  - Testing the cryo-pump and cooling lines and vacuum leak checking are in progress.
  - Plan to start HHL tests next week
- **Plan**
  - Energy: 8 keV
  - Various power loads and slits
  - Test on both the thin web and bulk parts
  - Wavefront characterization
  - Change to a side cooled crystal

GRID-XBPM* Test in 29-ID

(*Grazing-Incidence Insertion Device X-ray Beam Position Monitor)

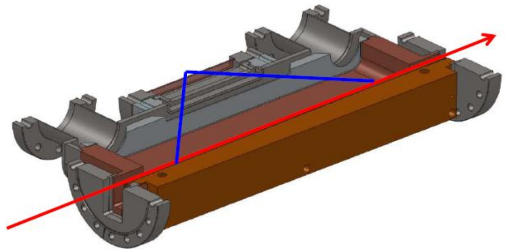
Motivations

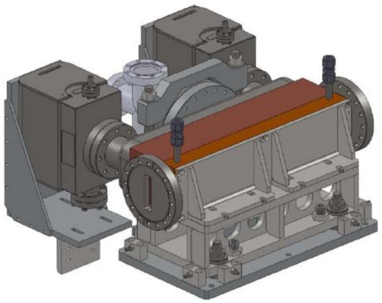
- High heat load front end XBPM-1 concept for APS-U
- Canted undulator front end XBPM-1 concept for APS-U
- Test both configurations at 29-ID-A with full power density

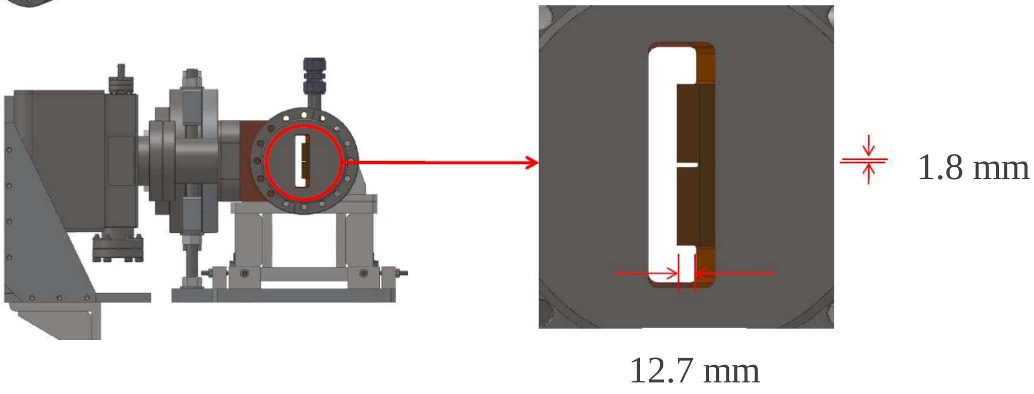
Team:

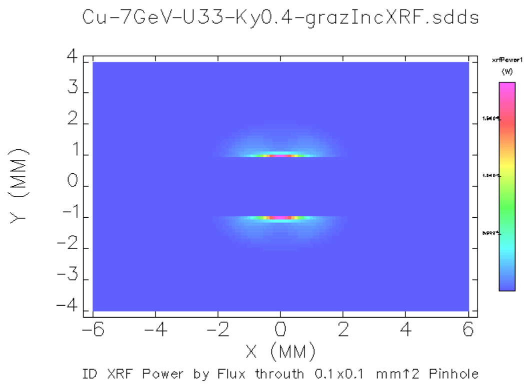
- Bingxin Yang, Glenn Decker and Soon Kong Lee, Den Hartog, and K. W. Schlax (Ref.: Proceedings of 2011 PAC, New York)

High heat load front end XBPM-1 concept for APS-U

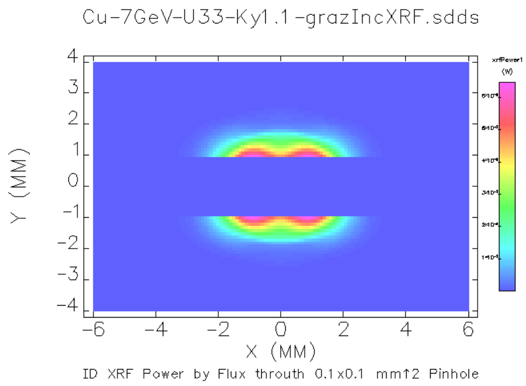




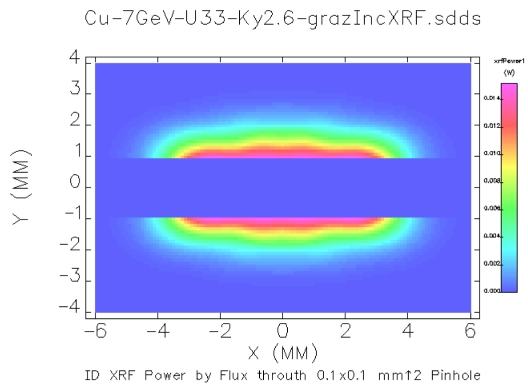




K = 0.4



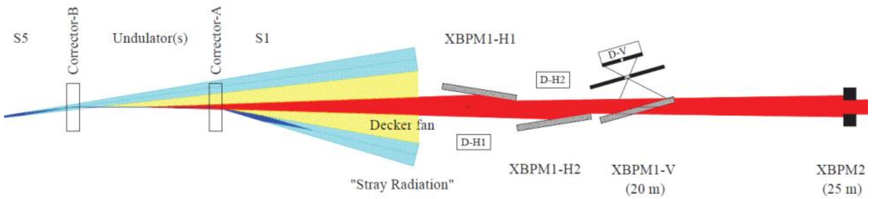
K = 1.1



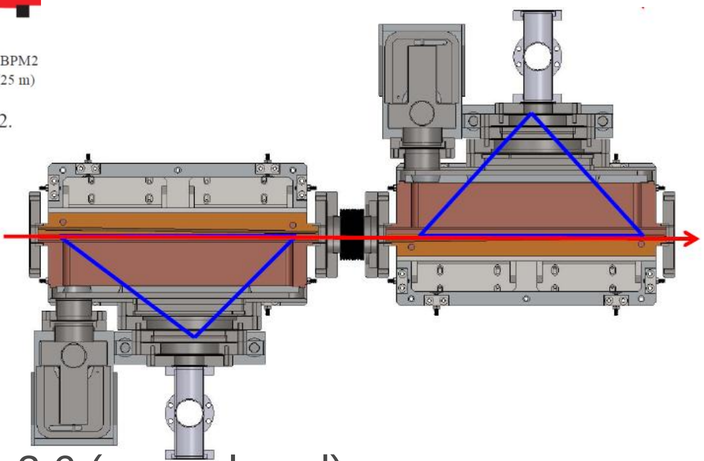
K = 2.6

Canted undulator front end XBPM-1 concept for APS-U

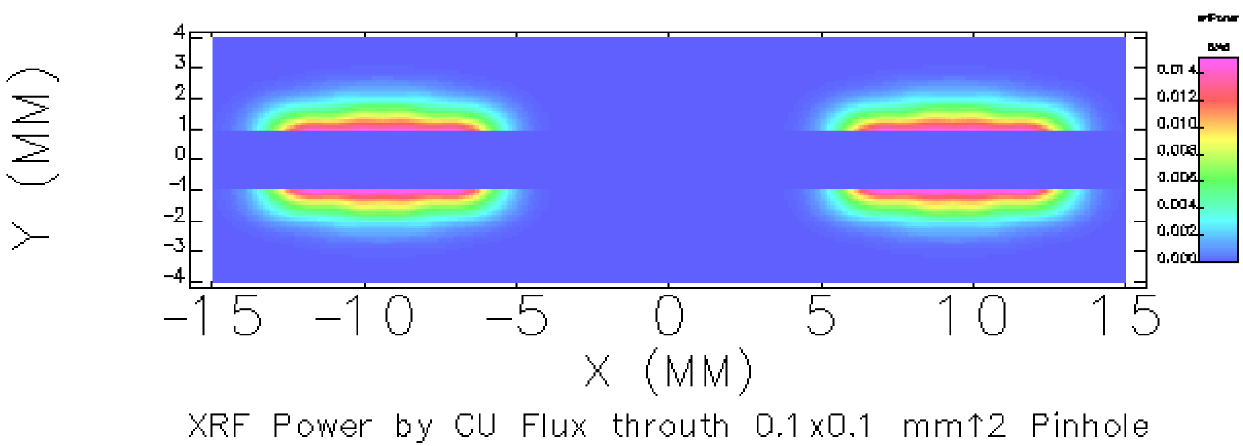
XBPM Absorber Arrangement (side view)



igure 1: Top view of the undulator and XBPM showing the main design idea of GRID-XBPM and XBPM2.



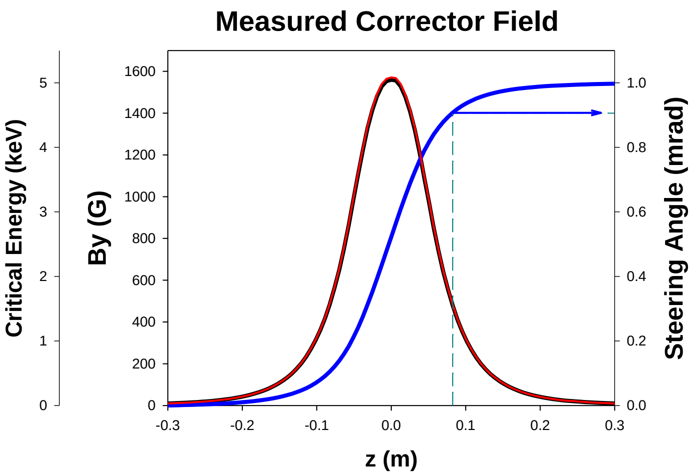
Intercepted pattern for Ky1 = Ky2 = 2.6 (gaps closed)



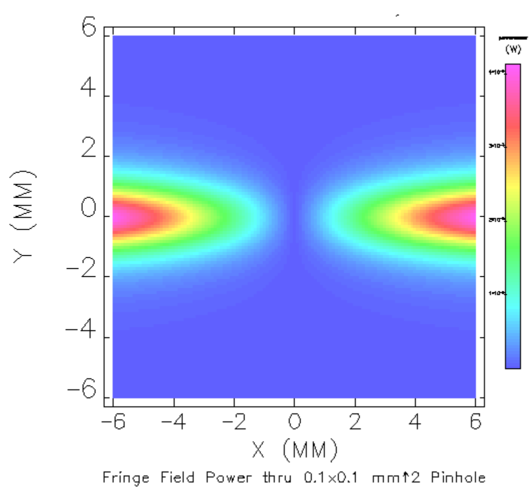
Hard x-ray BPM: lower signal background

One step further: hard x-ray BPM.

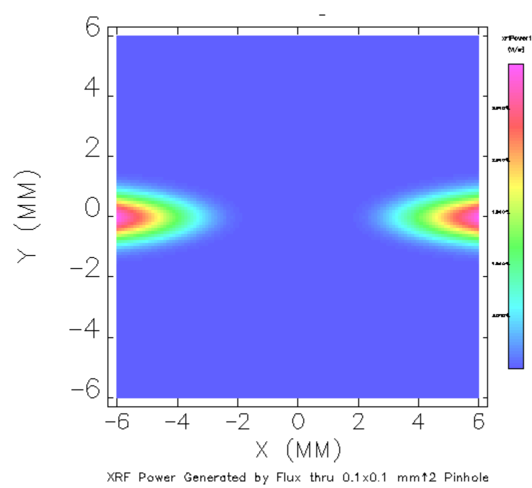
- Correctors have soft magnetic edges, generating mostly soft x-rays.
- A Cu-K XRF detector is insensitive to low-energy x-ray photons (< 9 keV).



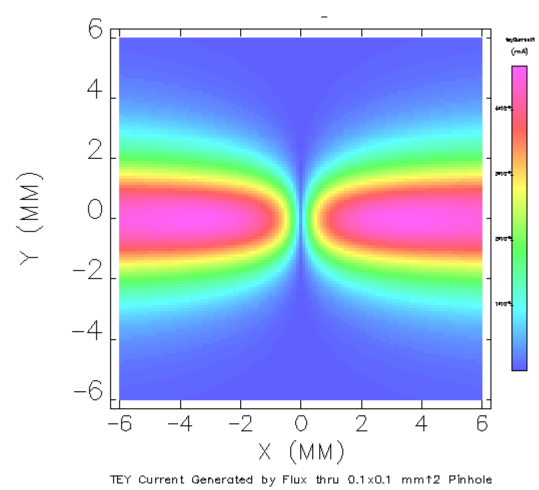
Comparison of 2-D intensity distribution
of BM radiation from corrector magnets: XRF map @ 20 m has a clean center



(A) Power



(B) X-ray fluorescence



(C) Total Electron Yield

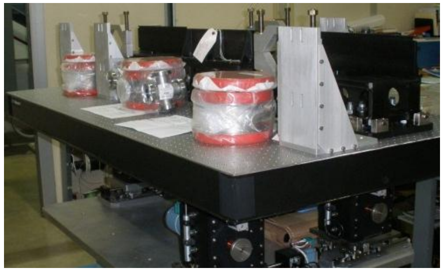
Test both configurations at 29-ID with full power density

Plan

- Assemble test table in November ➔ December / January
- Test XBPM from November to December ➔ February / March

Status

- 70% parts received
- Brazing components fabrication encountered difficulties
- Start assembly in November.



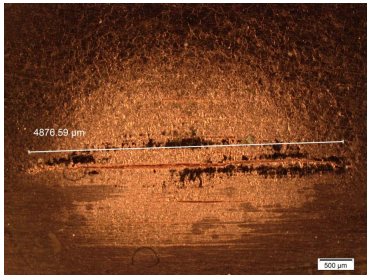
(1) Mount both configurations on one motorized table
(2) Test one piece GRID-XBPM up to max beam size available
(3) Test two-piece GRID-XBPM in horizontal configuration
(4) Study thermal, mechanical, detector, electrical issues, …

Summary

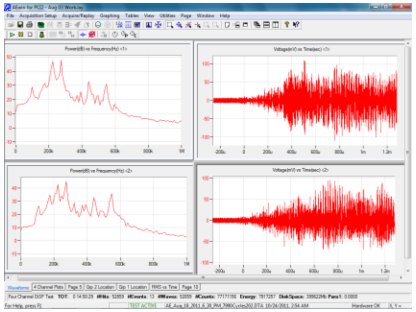
- Performed a series of thermal cycling of GlidCop tests at high power load:
  - Goals:
    - Thermal fatigue experiments to develop a “Zero Crack Initiation” limit for thermal fatigue
    - Understand and quantify the crack initiation and growth morphologies of GlidCop-Al15®
    - Validate ANSYS model for this material
- Test monochromator at 150 mA using two undulators in tandem
  - Monochromator installed
  - Test will begin next week
- Develop and test new XBPM concepts for high power load
    - Test will begin November
- 29-ID available until mid March 2012

EXTRAS

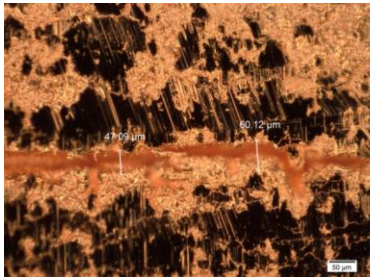
Thermal Fatigue of GlidCop® :Test Status



- **In-situ**
  - Cyclic thermal fatigue to 10,000 cycles
    - Thermal fatigue is a statistical process
    - Running as many specimens as possible in the time available
    - Variables: Total Power/Power Density & Surface Preparation
  - Video
  - Acoustic emission

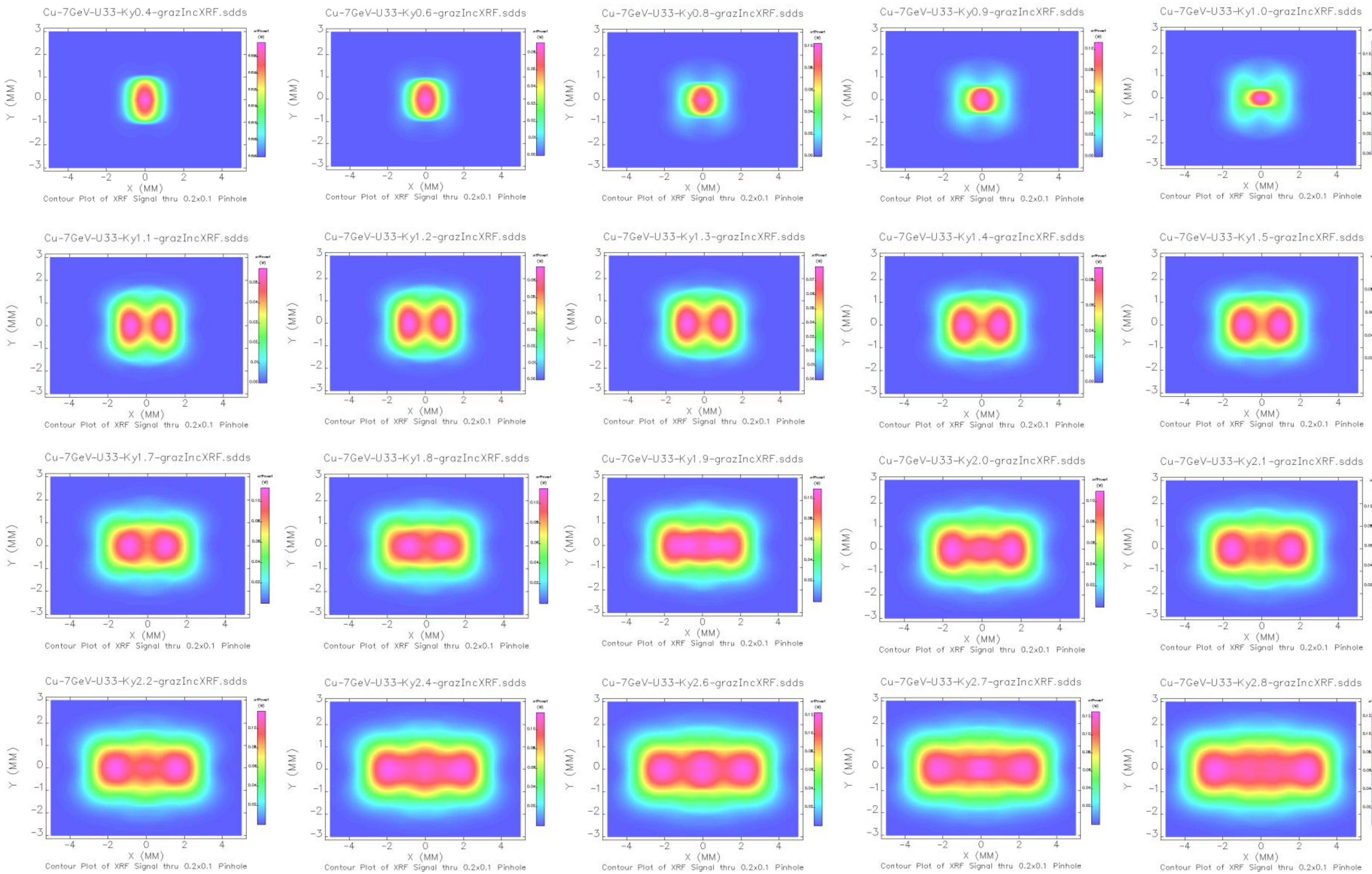


- **Post-mortem**
  - Fractography (surface crack characterization)
  - Metallography (cross-sections and analysis of crack growth)
  - Crack Morphology (surface / depth) aspect ratios



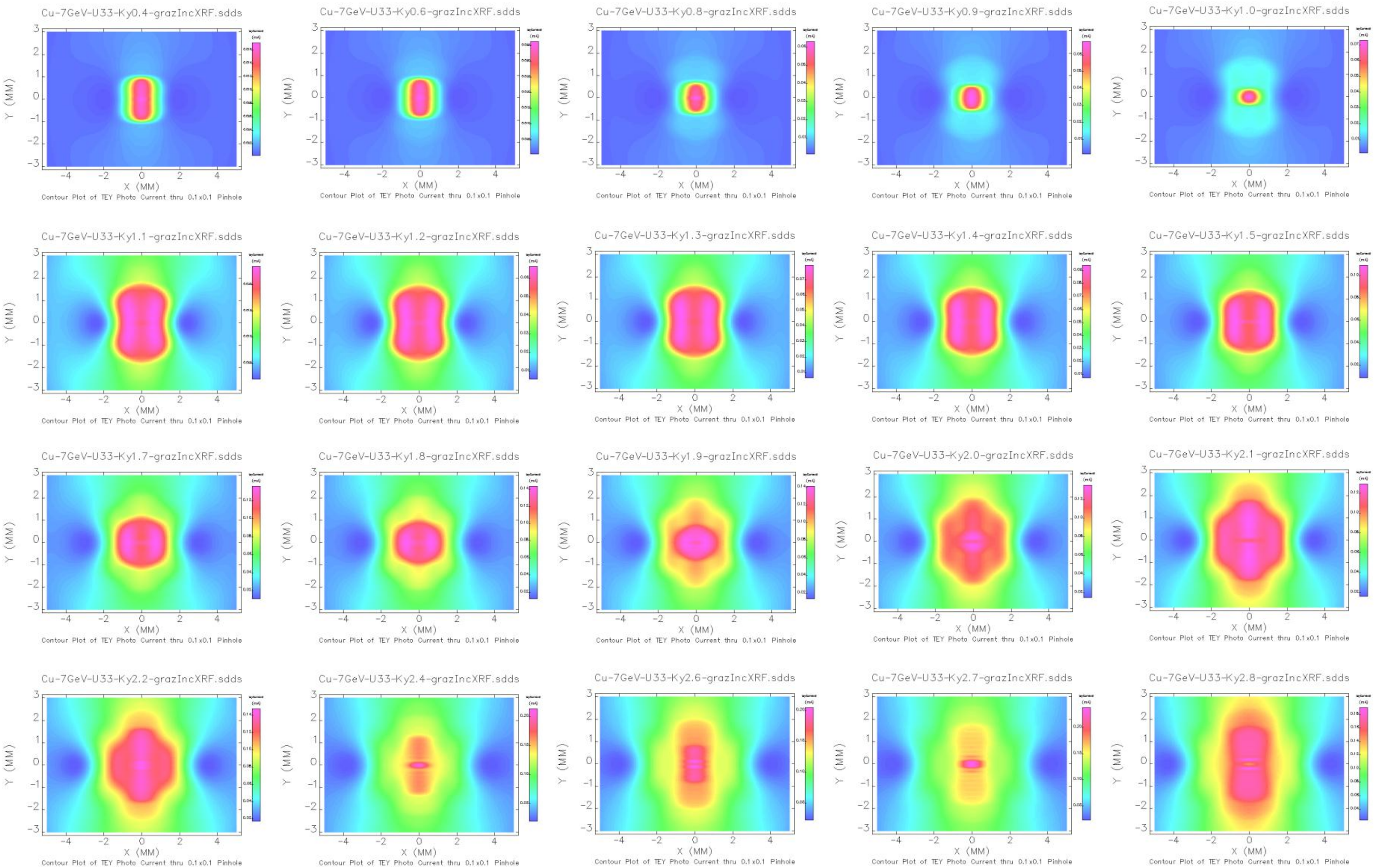
X-Ray Fluorescence Intensity Distribution, U33

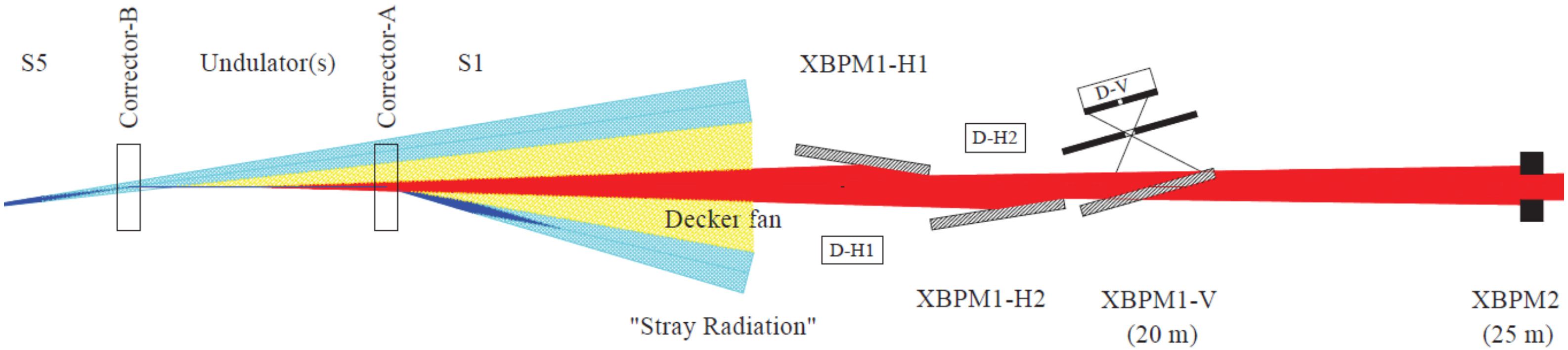
$E_1(K=\mathbf{1.07}\ ) = 2E_1(K=\mathbf{2.07})\ ) = 3E_1(K=\mathbf{2.73}) = 8.98$ keV (Cu-K)



Photoemission Total Electron Yield Current Distribution Undulator U33

$E_1(K=\mathbf{1.07}\ ) = 2E_1(K=\mathbf{2.07})\ ) = 3E_1(K=\mathbf{2.73}) = 8.98$ keV (Cu-K)





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