Canted Undulator Upgrade for GeoSoilEnviroCARS (Sector 13) at the Advanced Photon Source

A White Paper Prepared (June 2008) by:

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Submitted to:

Department of Energy - Office of Science
N. Woodward, Director, Geosciences Program
J. M. Gibson, Director, Advanced Photon Source

National Aeronautics and Space Administration – Science Mission Directorate
D. Lindstrom, Director, Sample Return Laboratory Instrument and Data Analysis Program
National Science Foundation – Directorate for Geosciences
D. Lambert, Director, Instrumentation and Facilities Program

White Paper Summary:

GSECARS is a heavily oversubscribed, multi-user, synchrotron radiation research facility dedicated to earth, environmental and planetary science.

This upgrade will expand the available undulator beam time and provide new sector capabilities, thereby greatly enhancing the science conducted at the sector.

The scientific impact:

A unique sub-micron microprobe will be available in a dedicated enclosure for detailed speciation and compositional research on light (as low as sulfur) and heavy elements in systems of geochemical, environmental and cosmochemical significance.

An optimized high energy insertion device will advance the quality of surface and high pressure diffraction measurements.

The doubling of undulator beam time will open up the capabilities of GSECARS to more investigators than currently possible.

Because of the wide-ranging science program at GSECARS, cost-sharing is proposed involving programs at NSF, DOE and NASA

The motivation for a canted undulator upgrade:

Provide additional capacity for experiments that require insertion device radiation.

Adding a second, independent undulator in a canted geometry Provide new analytical capabilities.

Customizing an undulator to extend the available beam energy down to 2.3 keV allowing for the first time the possibility of near-simultaneous, low and high energy analyses.

Employ a secondary focus geometry to provide size tunable sub-micron spatial resolution.

History:

March 2005 SAC Review

"The SRP would like to encourage GSECARS to apply for canted undulators. These would significantly increase their capabilities and help meet the demand for beam time. We suggest that their chances of success in acquiring canted undulators will be improved if they approach funding agencies at the same time that they approach APS management."

2006 GSECARS NSF and DOE Renewal

A detailed canted upgrade plan was developed with the plan to seek additional funding.

December 2006 a Letter of Intent Submitted to the APS Scientific Advisory Committee

January 2007 SAC Meeting and Letter from Murray Gibson

"Dear Steve,
The SAC recommended that I strongly encourage you to seek funding for your beamline upgrade; when you have obtained funding for that purpose, the APS will give high priority to providing and installing a second undulator in Sector 13–depending, of course, on other commitments and budget constraints at the time."

January 2008 an attempt to secure a University of Chicago slot for an NSF MRI proposal failed

June 2008 White Paper Submitted to DOE, NASA and NSF to share the beamline side of the upgrade

Three equal cost sharing proposal were subsequently prepared and submitted.

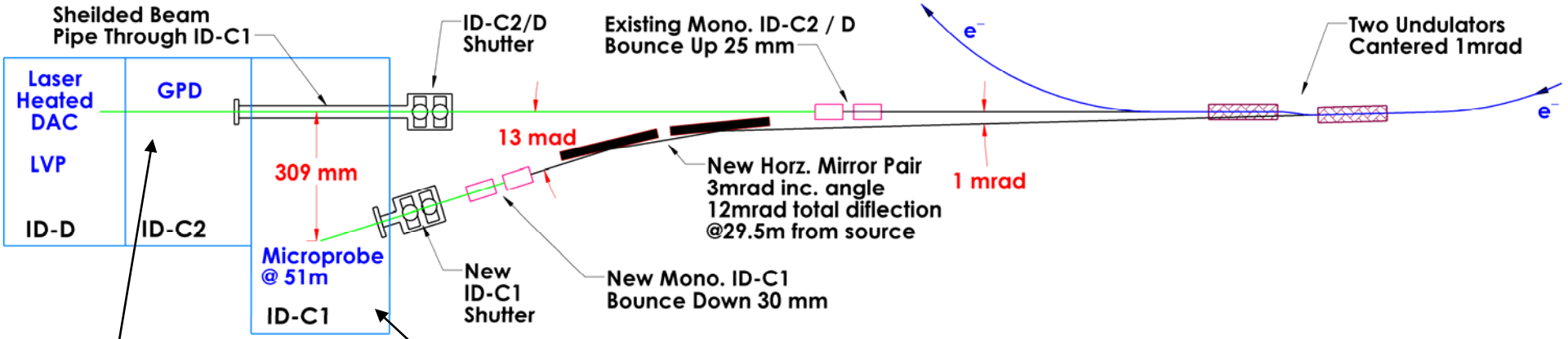
October 2008 NASA Funding Recommended

December 2008 NSF Funding Recommended (ARRA)

July 2009 DOE Single Investigator and Small Group Research " (SISGR) program was been selected for funding

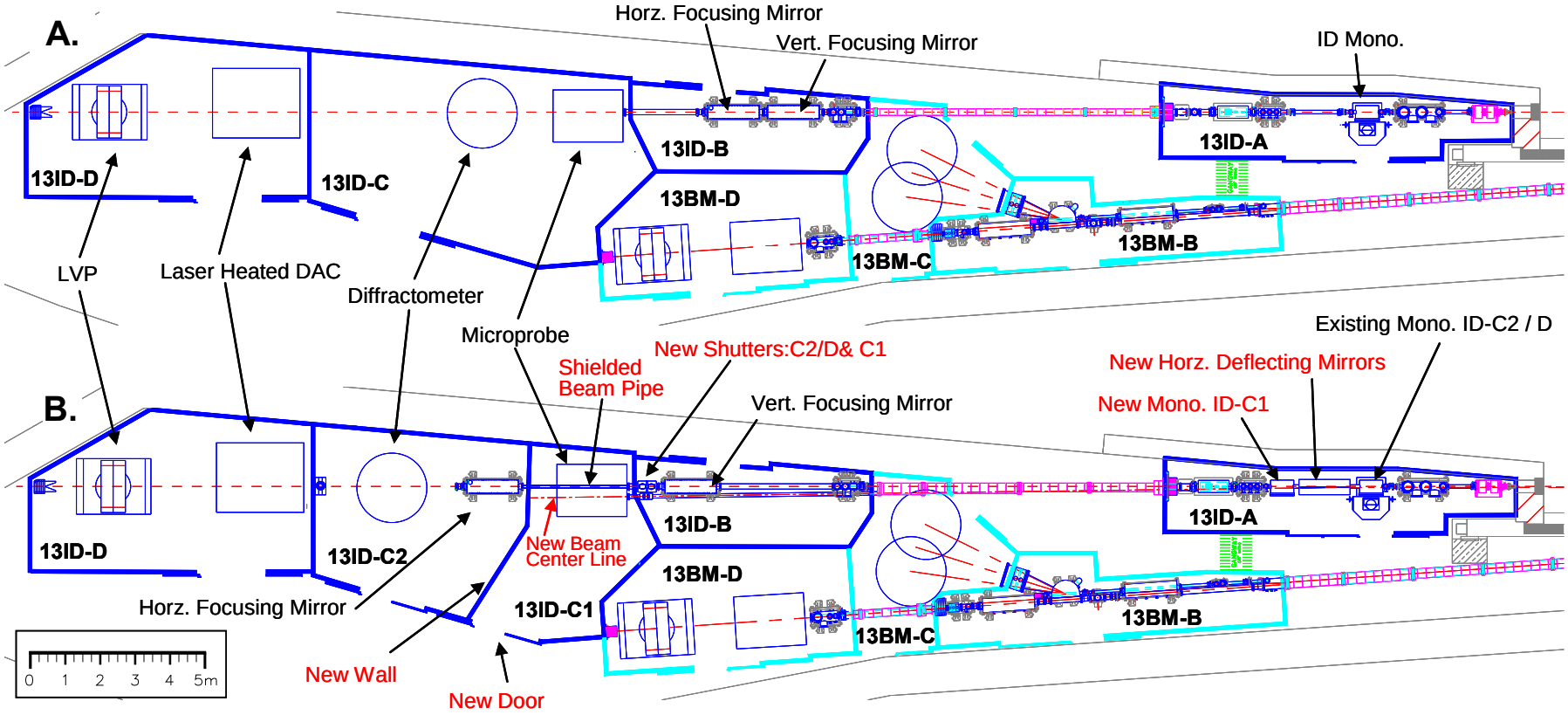
July 2009 GSECARS Front End Canted upgrade funded through the APS request for stimulus funding (ARRA)

August 3rd 2009 First meeting to finalize Undulators and Front end details.

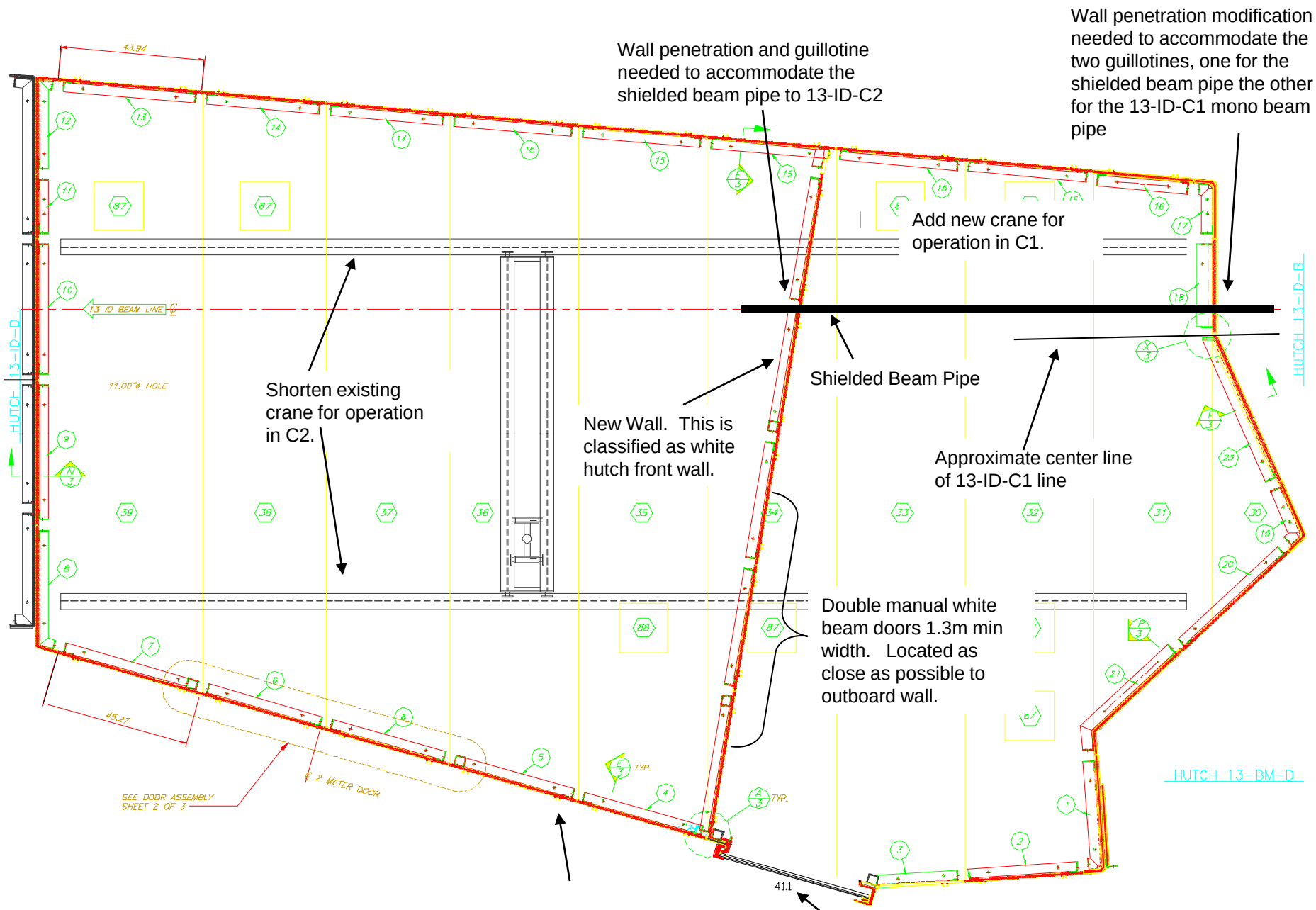


Double Focused Submicron
2.3 – 24 keV

Double Focused 15 x 40 micron
5 – 45 keV



- **Dedicated Microprobe** → **12 Weeks**
- **Time shared between diffraction, DAC and LVP** → **One additional week each**


Wall penetration and guillotine needed to accommodate the shielded beam pipe to 13-ID-C2
Wall penetration modification needed to accommodate the two guillotines, one for the shielded beam pipe the other for the 13-ID-C1 mono beam pipe
Add new crane for operation in C1.
Shorten existing crane for operation in C2.
New Wall. This is classified as white hutch front wall.
Shielded Beam Pipe
Approximate center line of 13-ID-C1 line
Double manual white beam doors 1.3m min width. Located as close as possible to outboard wall.
PSS box mounts here off of a false wall that allows sliding doors to pass behind
New pneumatic door shown 41.1" Wide. This could be as narrower as allowed since it will only be used for people access. Note this is white beam door.
43.94
45.27
41.1
HUTCH 13-ID-D
HUTCH 13-ID-B
HUTCH 13-BM-D
13 ID BEAM LINE
11.00"ø HOLE
SEE DOOR ASSEMBLY SHEET 2 OF 3
4' 2 METER DOOR
TYP.

Source Vertical

$\Sigma_V = 8.87\,\mu m$

$fwhm_V = 20.8\,\mu m$

$\Sigma'_V = 5.9\,\mu rad$

Small KB Mirror Vertical

$L = 0.260m$

$\theta = 3mrad$

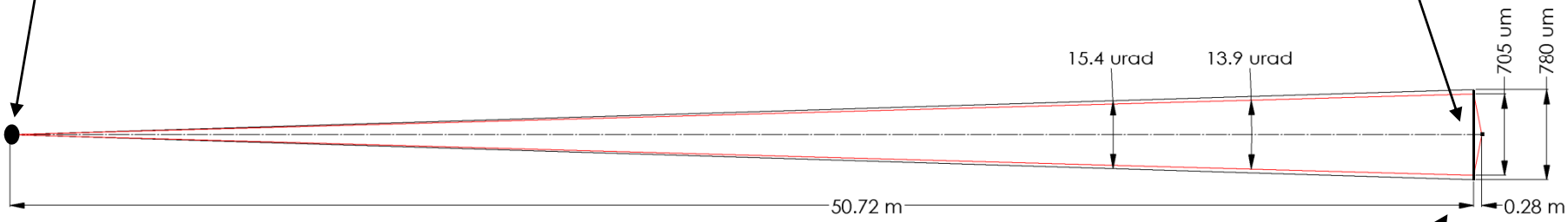
$OA = 780\mu m$

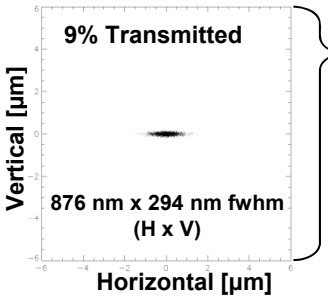
$E_c^{Rh} = 20keV$

$DeMag = 182$

$RMS_E = 0.20\mu rad$

$D = 2.5$





Focal Point @ 51.0m

$fwhm_V = 290nm$

$fwhm'_V = 2.5mrad$

$fwhm_H = 876nm$

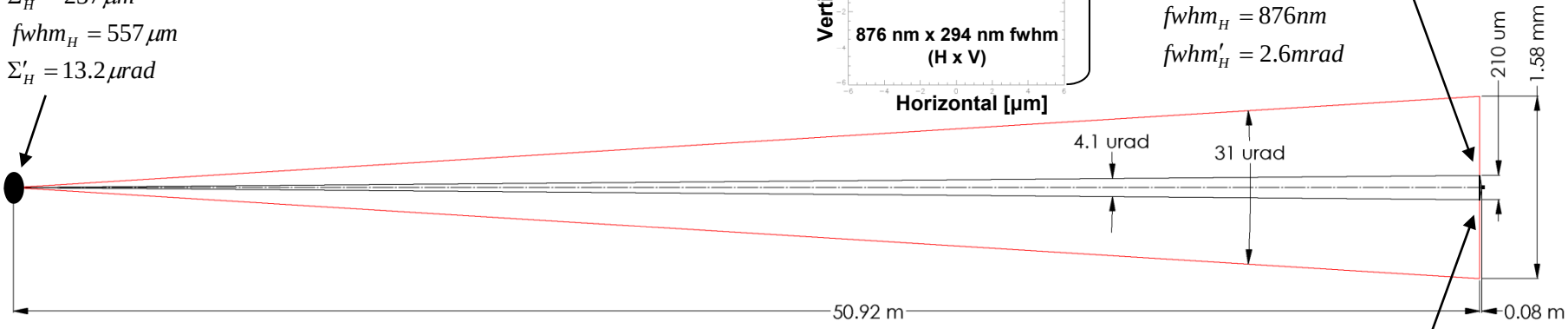
$fwhm'_H = 2.6mrad$

Source Horizontal

$\Sigma_H = 237\,\mu m$

$fwhm_H = 557\,\mu m$

$\Sigma'_H = 13.2\,\mu rad$



Small KB Mirror Horizontal

$L = 0.070m$

$\theta = 3mrad$

$OA = 210\mu m$

$E_c^{Rh} = 20keV$

$DeMag = 636$

$RMS_E = 0.25\mu rad$

$D = 1.0$

Source Horizontal

$\Sigma_H = 237\,\mu m$

$fwhm_H = 557\,\mu m$

$\Sigma'_H = 13.2\,\mu rad$

Horizontal Mirror

$L = 0.5m$ $\quad E_c^{Rh} = 20keV$

$\theta = 3mrad$ $\quad E_c^{Si} = 12keV$

$OA = 1.5mm$

$DeMag = 1.55$

$RMS_E = 1\mu rad$

$D = 1.03$

Secondary Source and Aperture (SSA)

$\Sigma_{H1} = 145\,\mu m$

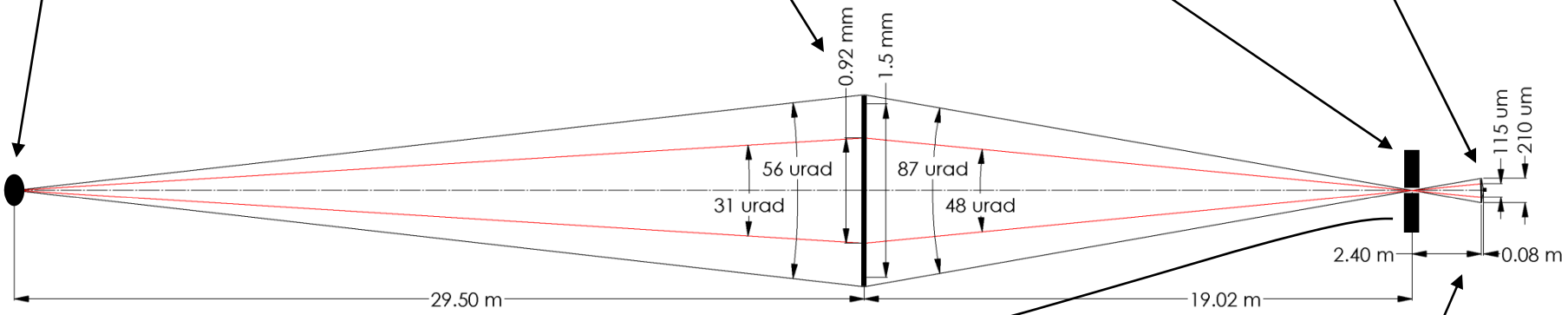
$FWHM_{H1} = 341\,\mu m$

Small KB Mirror Horizontal

$L = 0.070m$ $\quad E_c^{Rh} = 20keV$

$\theta = 3mrad$ $\quad DeMag = 30$

$OA = 210\mu m$ $\quad RMS_E = 0.25\mu rad$

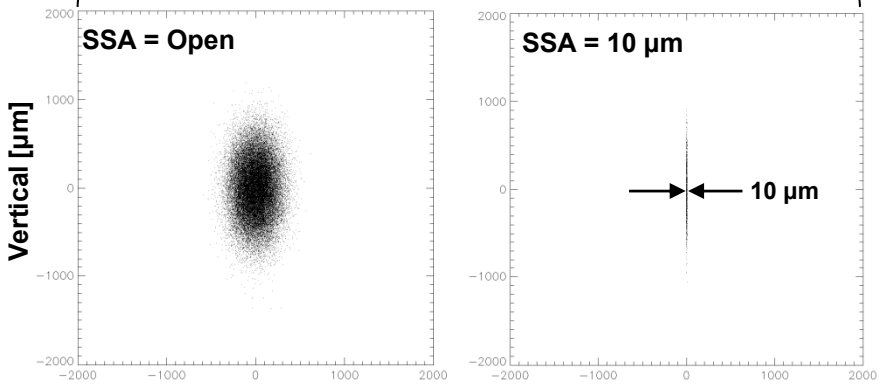


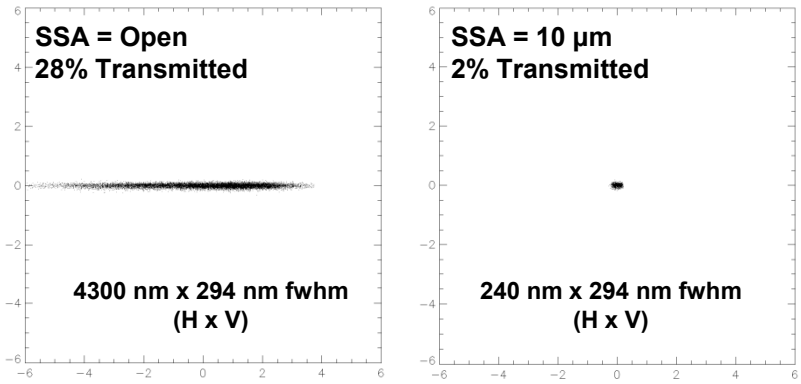
Focal Point @ 51.0m

$fwhm_H = 0.24 - 4.3\,\mu m$

$fwhm'_H = 1.4mrad$

Secondary Source





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On The Selection of Canted Undulator Period Lengths for The GSECARS Beamlines

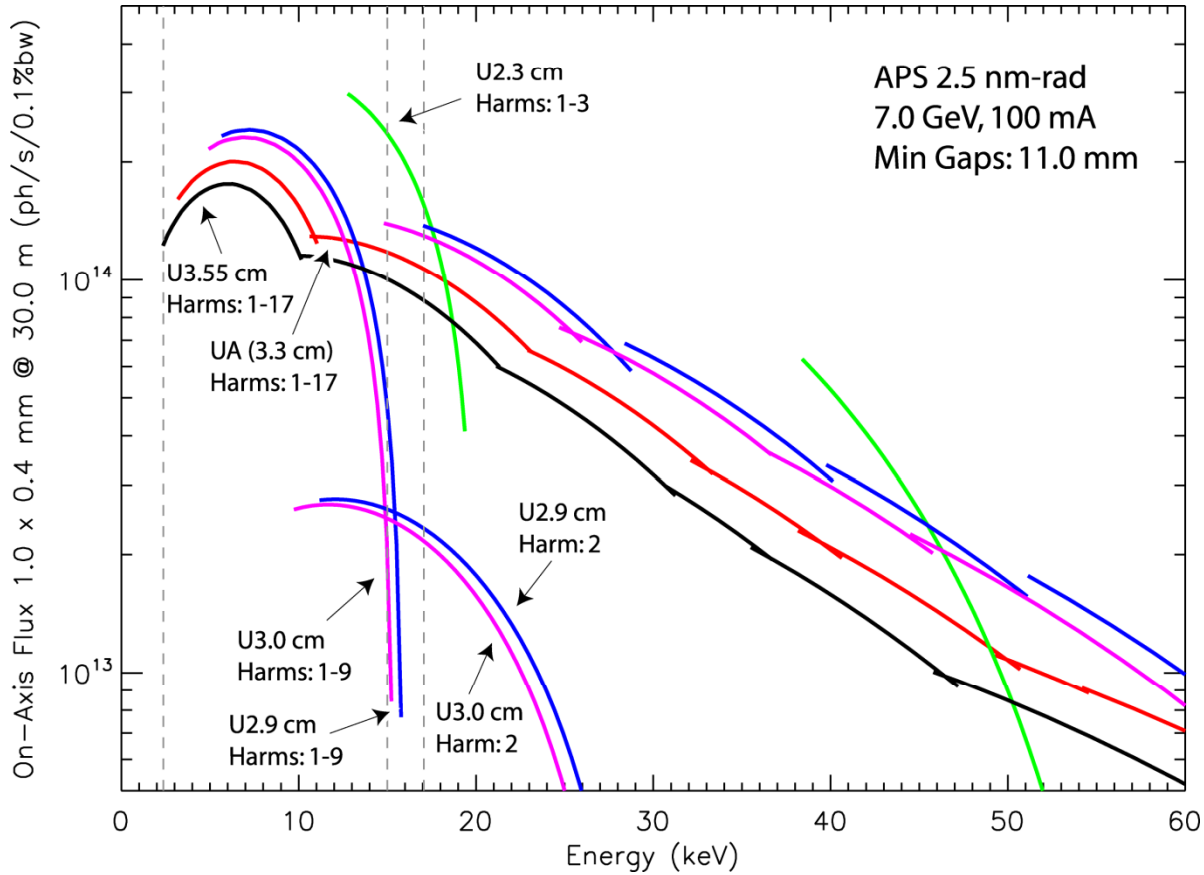
August 19, 2009: Added flux tuning curves for two aperture sizes. Changed the energies of the vertical markers of the flux tuning curve slides to become 100 eV less than the S K-edge and U L3-edge.

August 3, 2009: Added tuning curves of second harmonics for U2.9 cm and U3.0 cm.

July 24, 2009: Initial release.

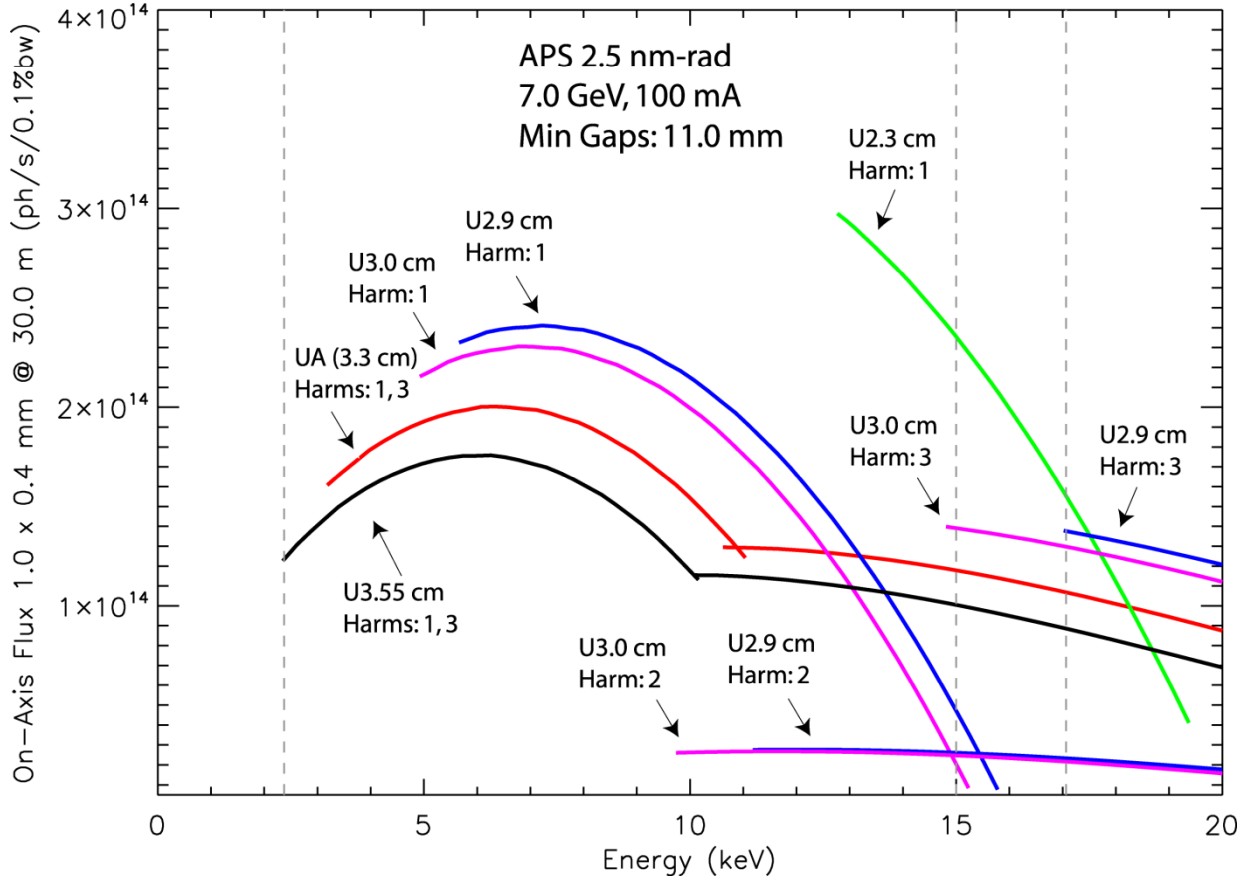
To Y. Jaski from R. Dejus

On-axis flux tuning curves of different period lengths 2.3 cm, 2.9 cm, 3.0 cm, 3.55 cm vs. UA (3.3 cm), aperture: 1.0 (h) x 0.4 (v) mm @ 30 m



- Flux tuning curves for odd harmonics and second harmonics for select planar permanent magnet hybrid 2.1-m-long undulators of different period lengths for 11.0 min. gaps. Reductions due to magnetic field error were applied (estimated from one measured undulator A at the APS).
- The first harmonic min. energies are (with emittance taken into account): 12.77 keV (2.3 cm), 5.66 keV (2.9 cm), 4.92 keV (3.0 cm), 3.18 keV (3.3 cm), and 2.35 keV (3.55 cm). Vertical dashed lines are at 2.372 keV, 15.000 keV, and 17.066 keV.

On-axis flux tuning curves close-up view of previous slide, aperture: 1.0 (h) x 0.4 (v) mm @ 30 m



- Close-up view of previous slide using a linear y-scale for energies up to 20 keV.
- The third harmonic min. energies are (with emittance taken into account): 17.02 keV (2.9 cm) and 14.81 keV (3.0 cm). The first harmonic energies were listed on the previous slide. Vertical dashed lines are at 2.372 keV, 15.000 keV, and 17.066 keV.