# CSX Interference and Path Forward

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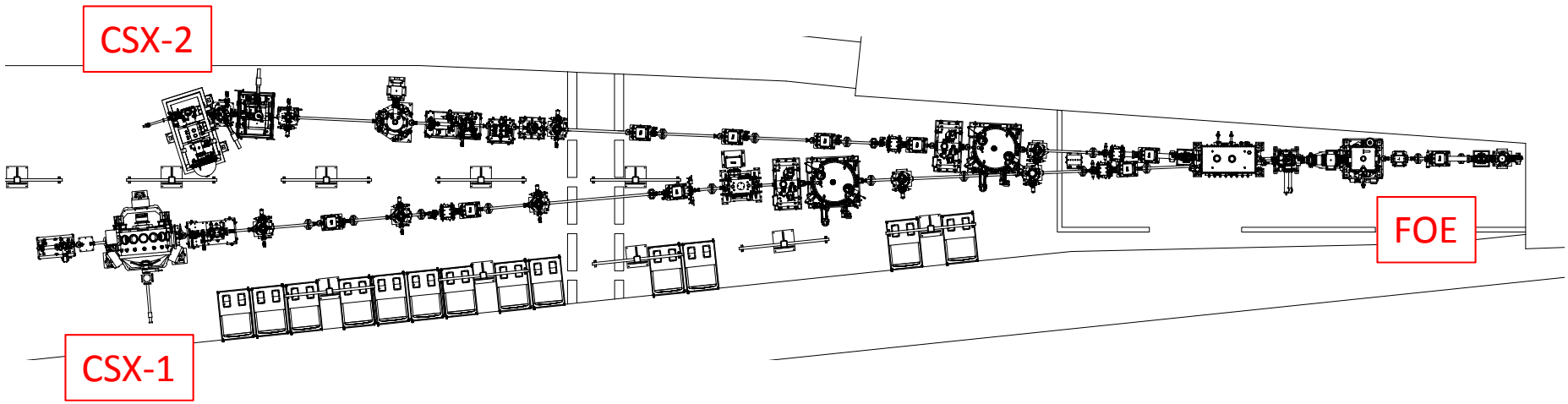
Soft X-ray Scattering and Spectroscopy Program Manager

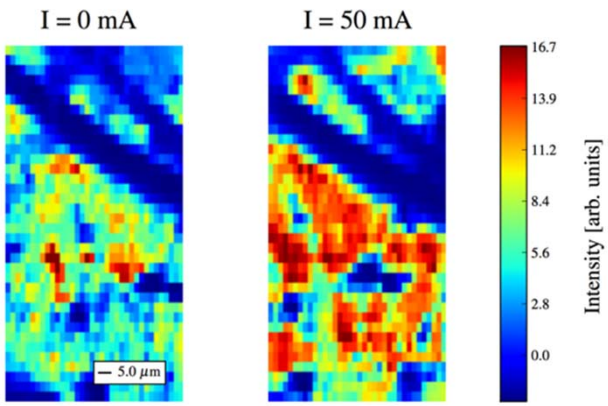
# CSX Design Parameters

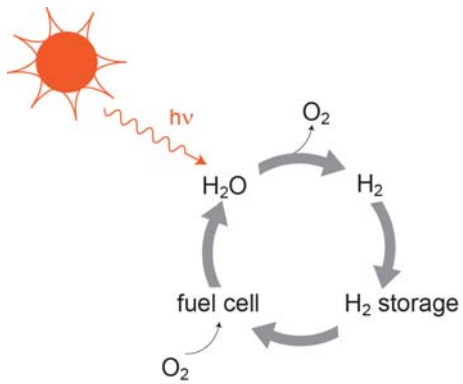



- 2 EPUs canted at an angle of 0.16 mrad.
- Energy Range 250 eV to 2 keV
- $\Delta E$ = 0.05 eV @ 500 eV
- Variable polarization through EPU
- Flux 1 x $10^{13}$ Ph.$s^{-1}$ @ 500 eV

# CSX-1 / CSX-2 Details

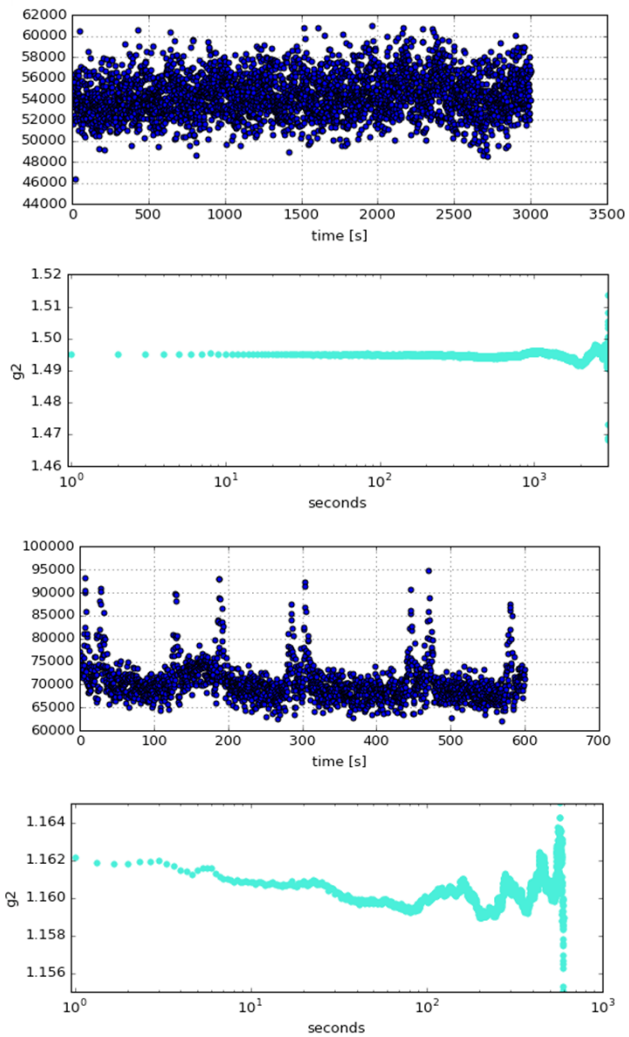
- CSX-1 has the world's highest coherent flux in the soft x-ray region.
  - Program centers on XPCS and CDI from quantum materials.
  - Addresses such questions as how electronic textures define the properties of quantum materials.
- CSX-2 Program now contains:
  - Ambient Pressure XPS (Partner with BNL-CFN)
  - In-Operando X-ray XAS (Partner with BNL-Chemistry).
  - Understanding mechanisms and dynamics of catalytic reactions
  - Design and controlled synthesis of novel catalytic materials



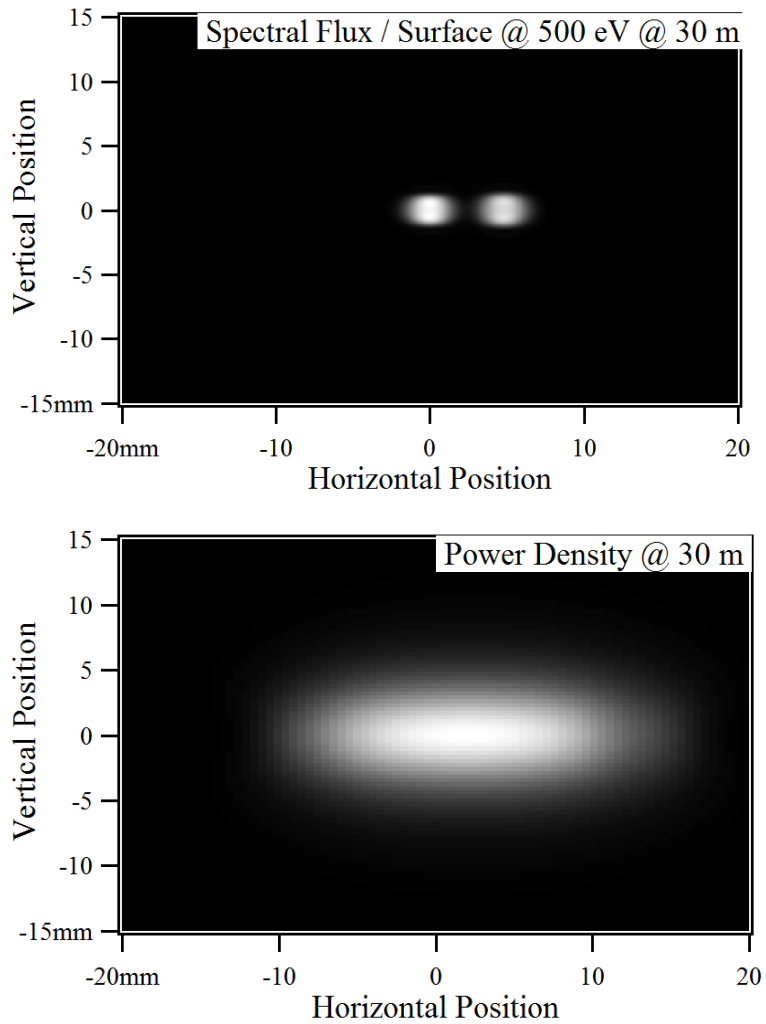



# Interference observed at CSX-1

- Interference is noticed mostly at CSX-1 due to sensitivity of XPCS to small perturbations.
- Biggest effect is change of CSX-1 energy caused by:
  - Beam motion
  - Heat load changes on the CSX-1 monochromator.
  - At energy contamination.
- Both cause a changing photon energy which causes intensity and background changes in data.
- As CSX-2 does spectroscopy, gap is in constant motion.
- Impact on the CSX-1 program is that it is not possible to run experimental data collection while CSX-2 operates for either XPCS (glitches) or soft x-ray diffraction experiments (changing background)

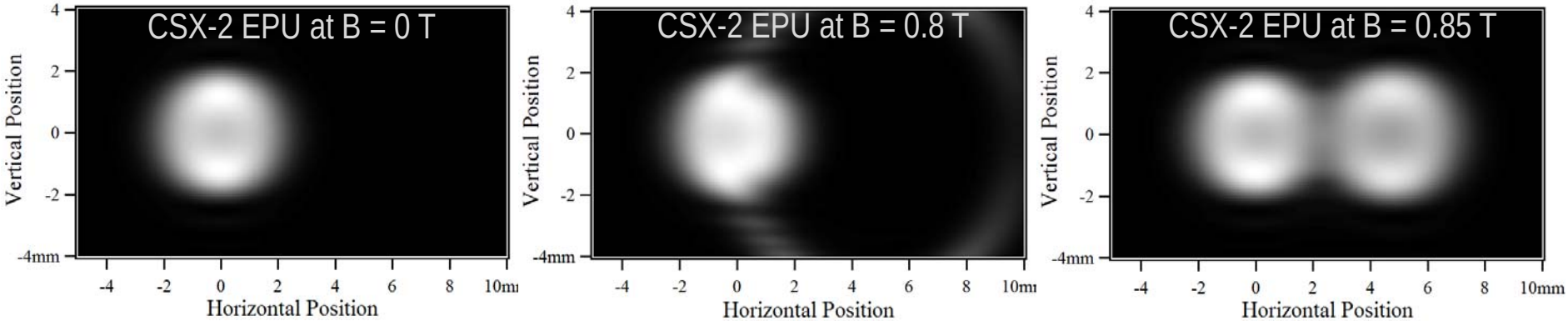


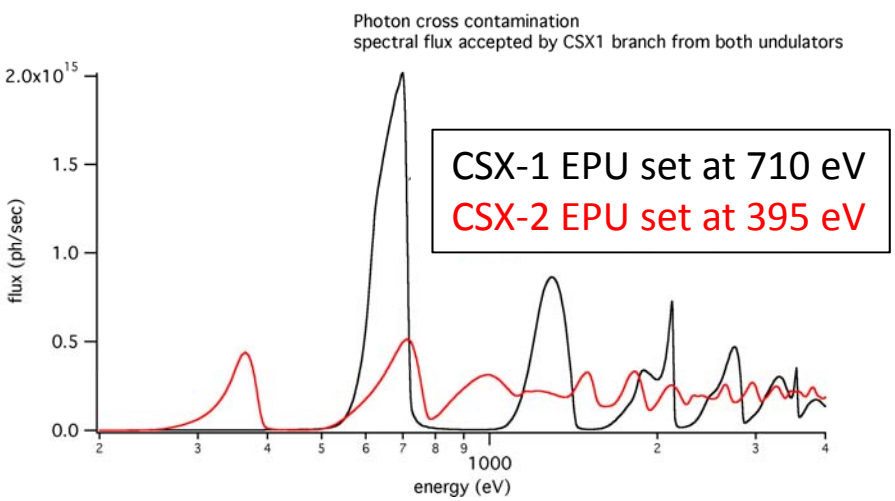
# CSX Interference Problem 2




- Second effect is due to heat load and overlap of modes of the undulator.
- At minimum gap of either undulator the horizontal extent of the power spectrum is far greater than the canting angle causing severe cross contamination.
- While the monochromator removes this, it is still subjected to a varying heat load.

# CSX Interference Problem 2



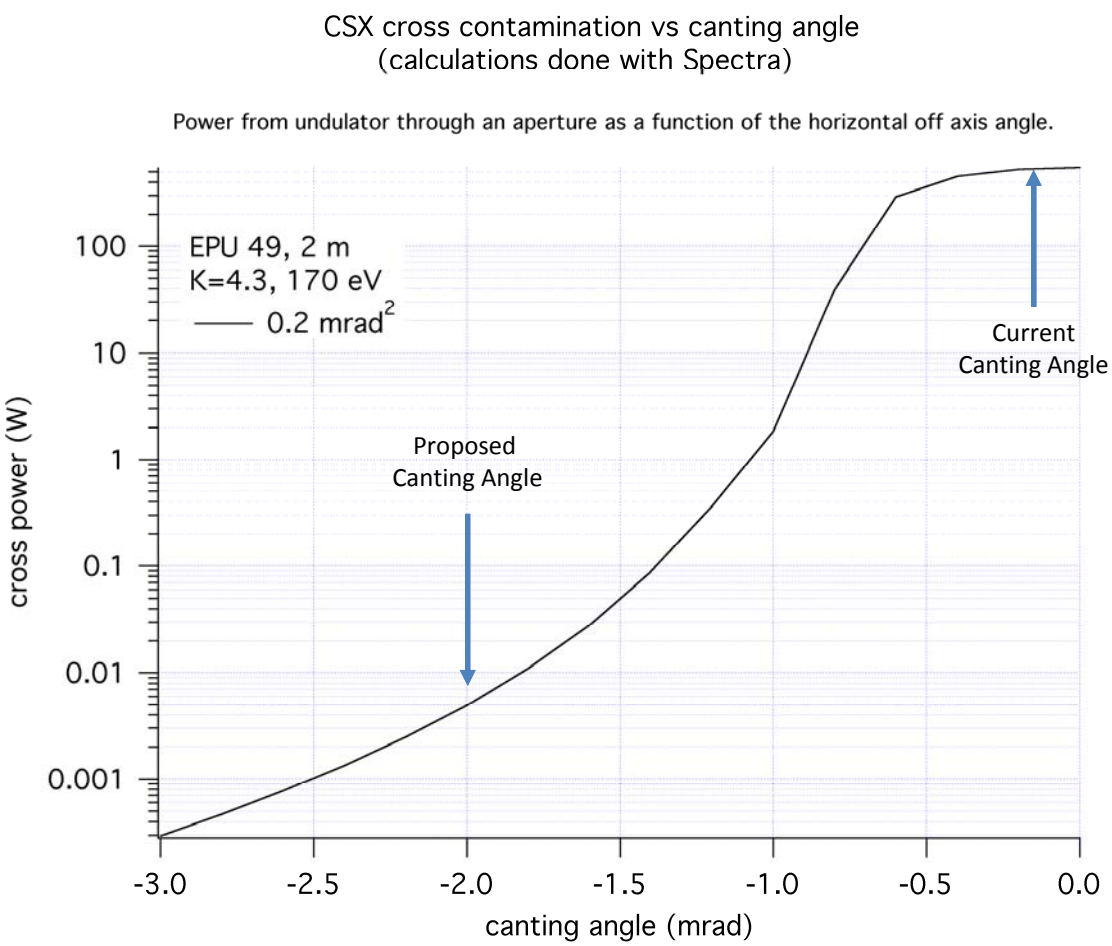




- A second effect is seen due to at-energy photons cross contaminating even when gap settings are not identical due to extent of EM modes from the undulator.

# Solutions to Cross Talk

- To address crosstalk there are a number of possibilities:
- Run CSX-1 and CSX-2 in a time shifting **shared mode**, running only one branch at a time with "parasitic" mode for the other branch (current mode)
  - Impact on CSX-1: cannot get an increase in the possible flux of ~3.5 for a photon-hungry technique.
- Install phasing magnet into straight section of CSX and run with no parasitic mode, but run experiments at CSX-1 with a ~3.5 increase in flux (**split mode**)
  - Would increase photon flux at CSX-1 which is needed by most experiments.
  - Would stop "parasitic mode" use, which is currently only used by CSX-2.
- **Recant** the CSX beamline in order to stop interference.
  - Would permanently hold CSX-1 at present flux (no x3.5 increase).
  - Would allow simultaneous operation of CSX-1 and CSX-2 concurrently increasing available beam time on both beamlines.

# Possible Cross-talk Solution - Canting




- *Recant* the beamline to increase the canting angle sufficiently to avoid crosstalk.
- Angle of 2.0 mrad gives 5 order of magnitude decrease in power contamination.
- 2 mrad is the maximum that can be achieved and still be practical from engineering standpoint

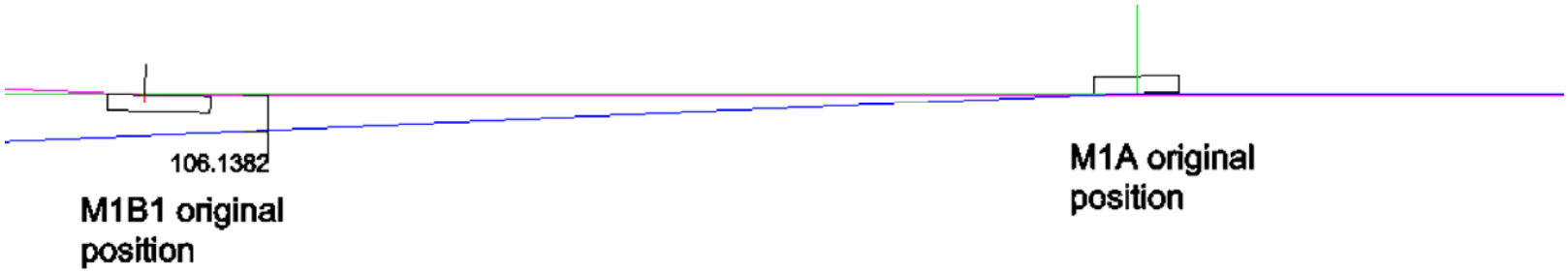
# 2 mrad canting solution

- Straight section would be changed; Replace undulator vessels to be identical to the 2 mrad canted beamline SST.
- Permanent canting magnets would be installed (identical to SST) to setup straight section.
- BPMs would be installed to increase from 3 to 4 BPMs
  - Would increase FOFB sensitivity and provide more stability under gap changes
- Front End changes are minimal and mostly would be due to increased acceptance for GB.

# 2 mrad canting solution.

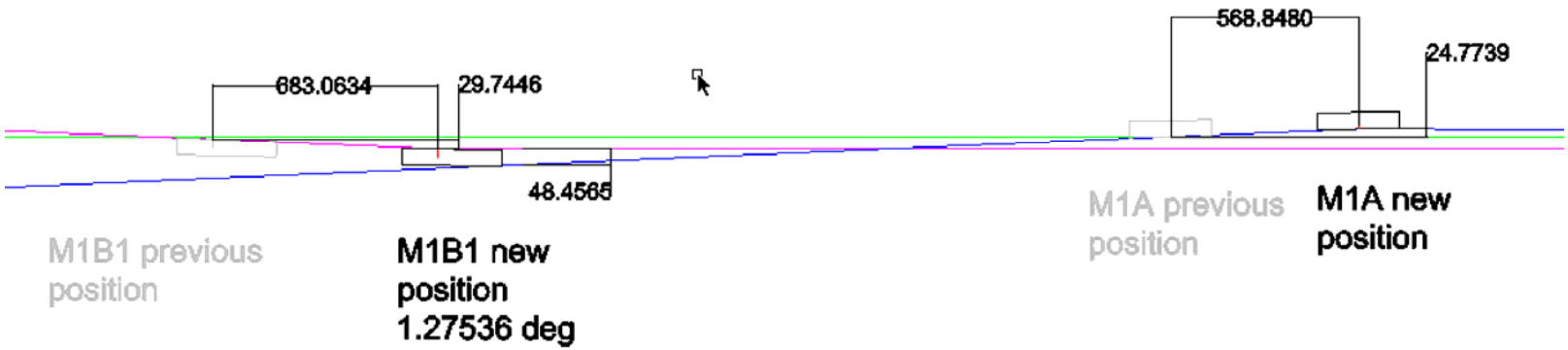
CSX1 undulator canted 0.08 mrad inboard

CSX2 undulator canted 0.08 mrad outboard




CSX1 undulator canted 1.0 mrad inboard

CSX2 undulator canted 1.0 mrad outboard



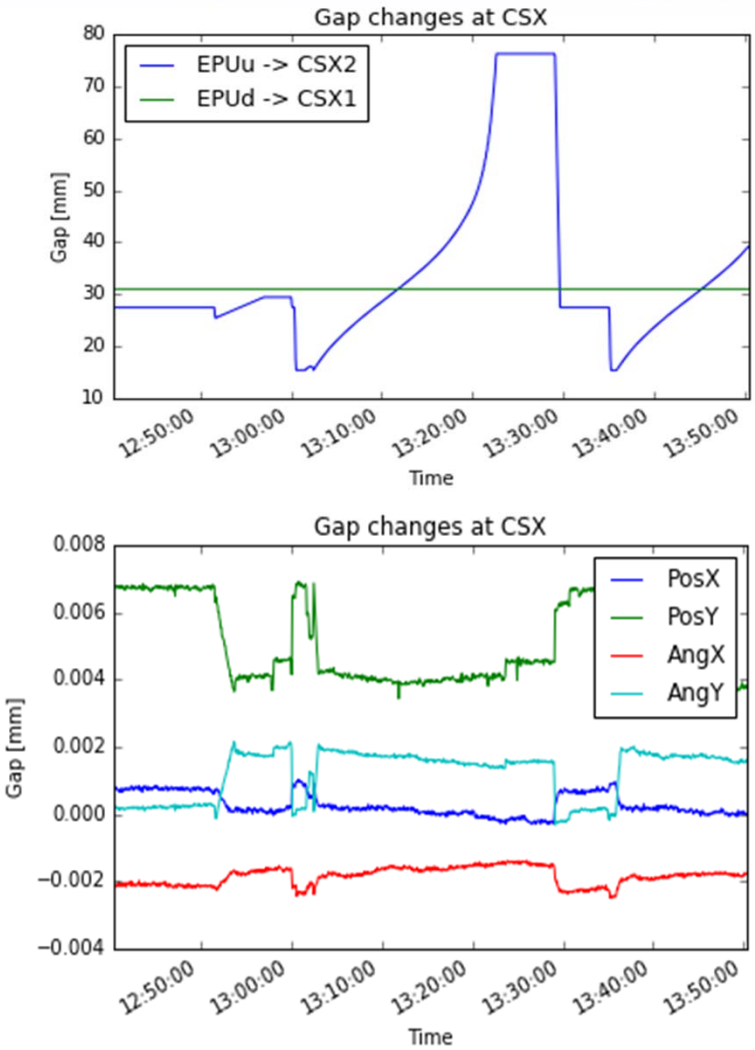
# Conclusions

- CSX-1 and CSX-2 interference effects have been identified
  - At-energy contamination from extended spectra from EPU
  - Heatload of monochrometer changing abruptly.
- CSX could be run in a **split mode or shared mode** with the potential for installing the phasing magnet ($100k capital cost).
  - This would have a large positive impact on the CSX-1 program over the current situation as the majority of experiments are flux limited and some have failed or were marginal.
  - CSX-2 program would lose potential for parasitic beamtime if phasing and essentially a single undulator is used.
  - This option provides for end station reconfiguration in the context of the future needs for soft x-rays at NSLS-II. For example, the STXM program could be jump started using parasitic beam at CSX-2 or CSX-1.
  - A hybrid of the **split mode** and **shared mode** could be developed.
- CSX Could be "**recanted**" to an angle of 2.0 mrad. This would:
  - Remove the possible gain for CSX-1 in flux of 3.5.
  - Allow the CSX-1 and CSX-2 science programs to run 100%.

# Work Plan and Impacts

- Work would be completed using 2 shutdowns and the CSX beamlines being down for 1 cycle.
- First shutdown would:
  - Move EPUs out, remove straight section and replace.
  - Do necessary FE work and LOTO safety shutters.
  - Start CSX FOE Changes.
- After shutdown machine would return to service and CSX FOE work would continue.
- During second shutdown:
  - EPUs would be but back into place.
  - Canting magnets would be installed.
  - Work in CSX FOE would be completed
  - IRR Completed to authorize the start of commissioning of FE and beamlines.

# CSX Interference Problem 1




- Initial interference was caused by beam motion in the straight section when moving the other beamlines gap.
- This causes step changes in intensity and energy in the CSX-1 endstation.
- Due to the work of the Beam Stability Task Force, CSX team and AD this has been largely resolved by improving both the undulator feed forward tables and fast orbit feedback.