UNIVERSITY OF SASKATCHEWAN

A Vertical Phase Space Beam Position and Emittance Monitor for Synchrotron Radiation

Nazanin Samadi

IBIC18 , Sep 2018

Light exploring life
BMIT

Canadian Light Source
Centre canadien de rayonnement synchrotron

Where is The Beam?

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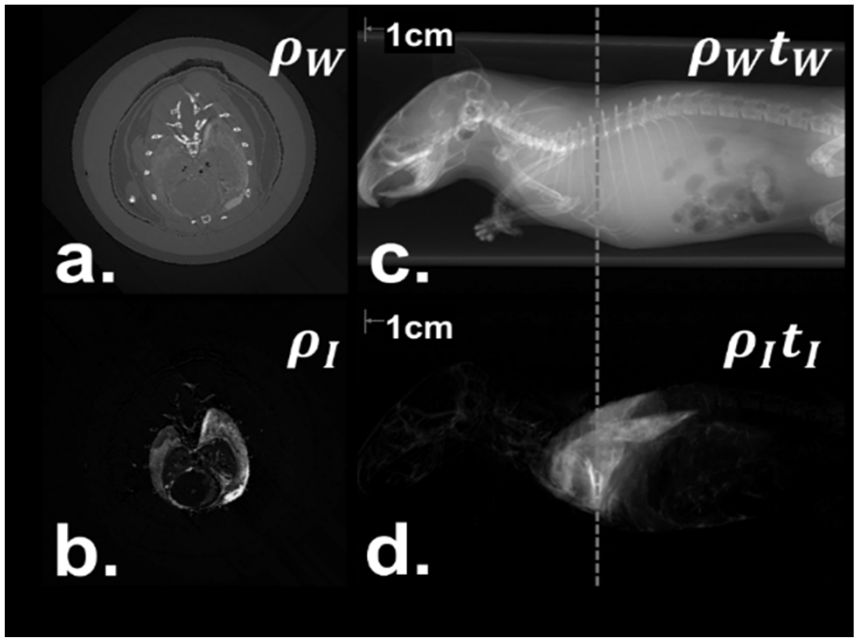
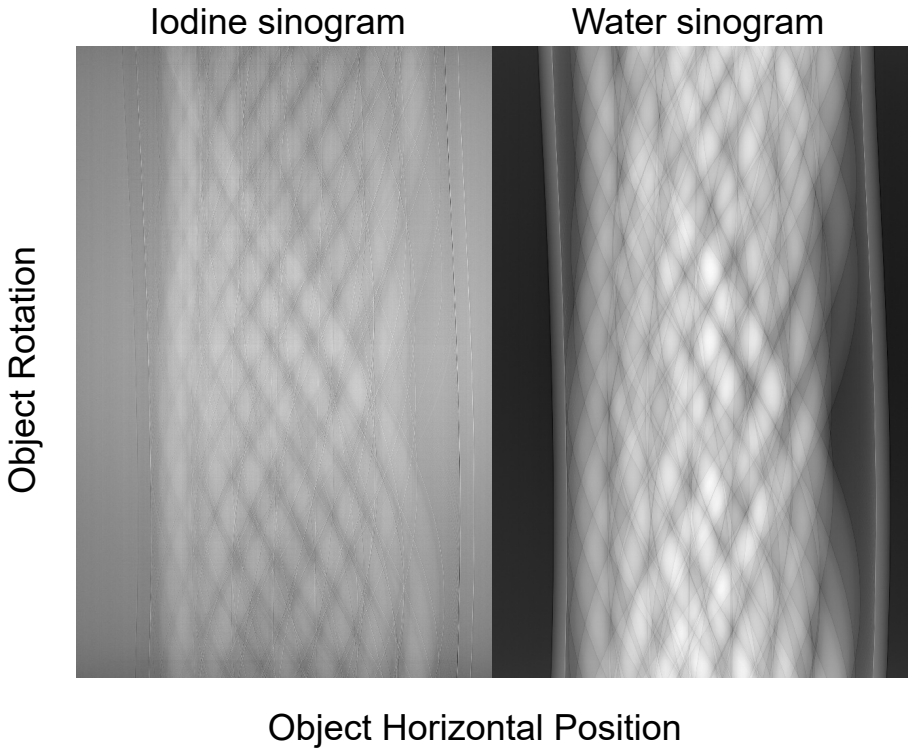
Why Did I Care?

- Biomedical Imaging and Therapy Beamline
  - Bend Magnet Source
    - 15-40 KeV
  - Super Conducting Wiggler
    - 25-150 KeV

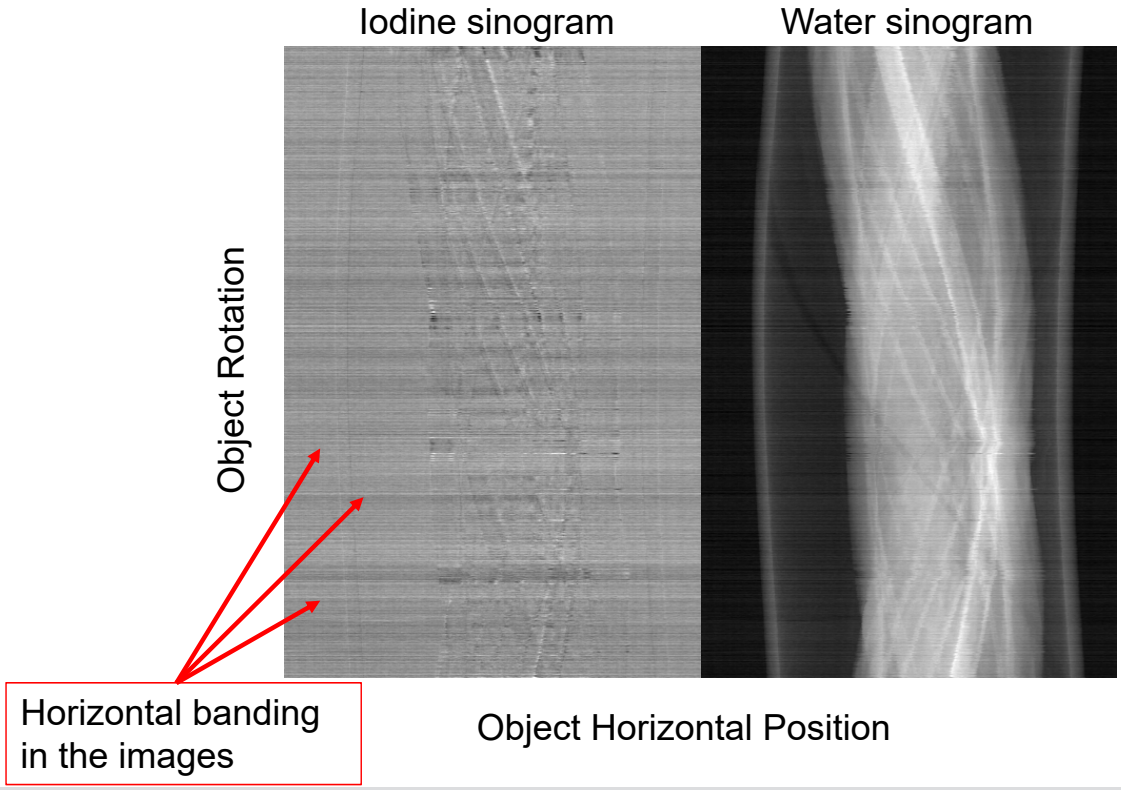


Y. Zhu, N. Samadi, *et al.*, "Spectral K-edge subtraction imaging," *Physics in Medicine and Biology,* vol. 59, pp. 2485-2503, 2014.

What Happens When the Beam Doesn't Moves?

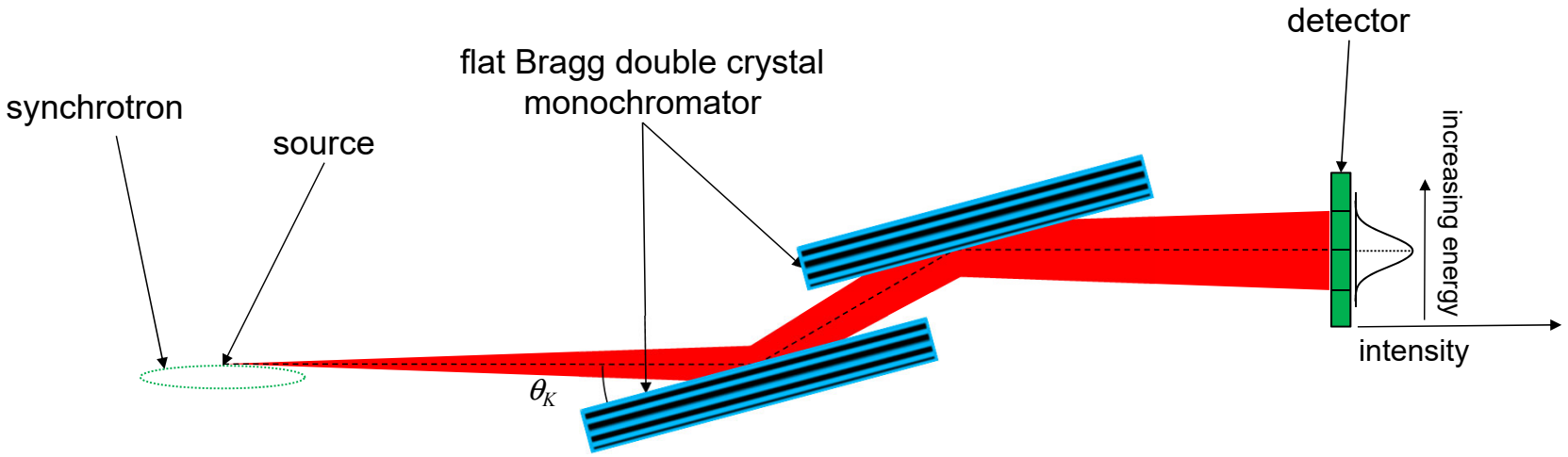


What Happens When the Beam Moves?

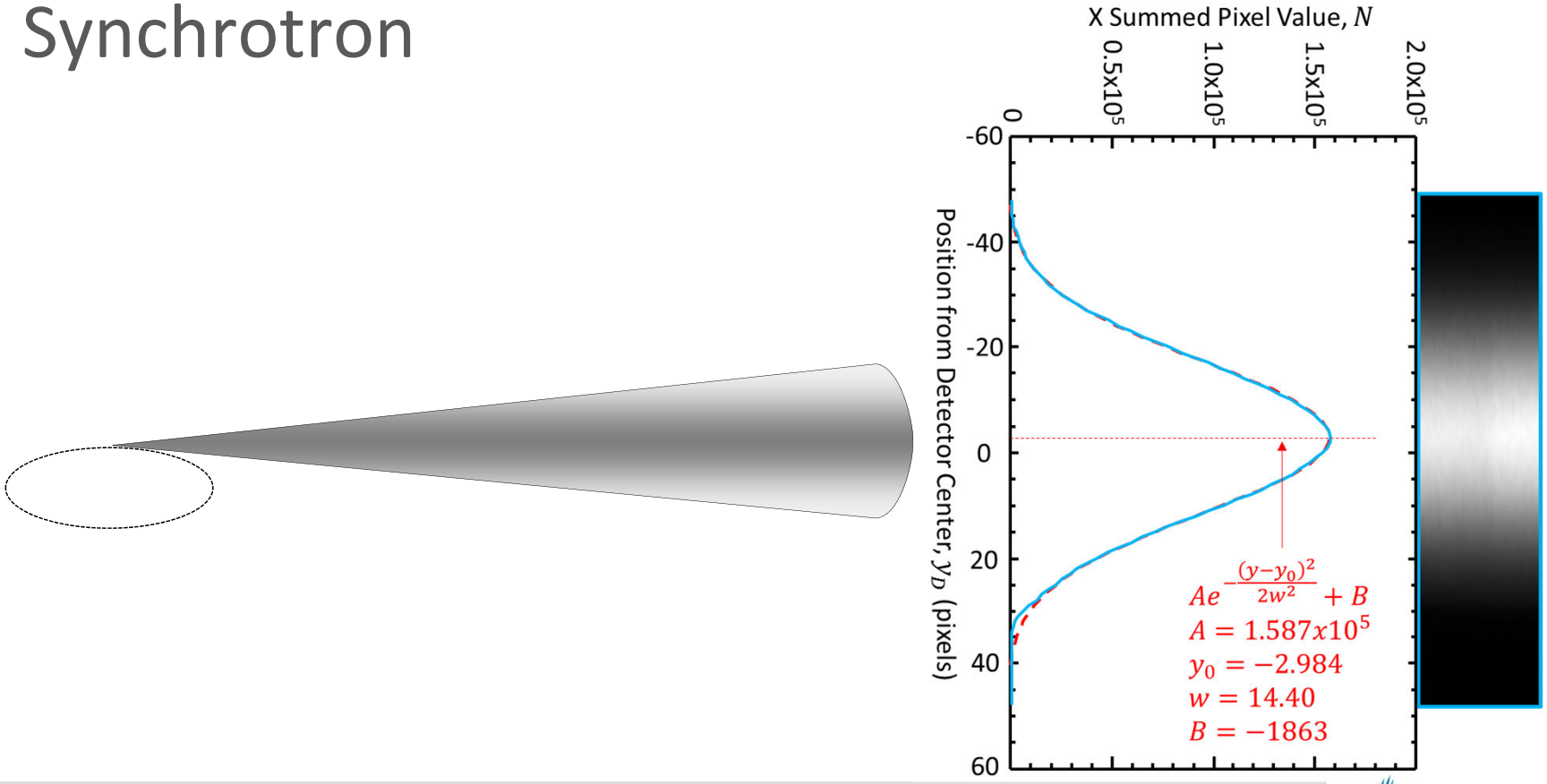


What Can Cause a Beam Motion in the Data?

- Biomedical Imaging and Therapy Beamline



Synchrotron

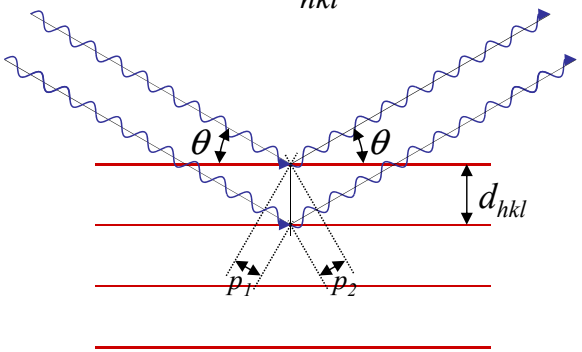


Diffraction

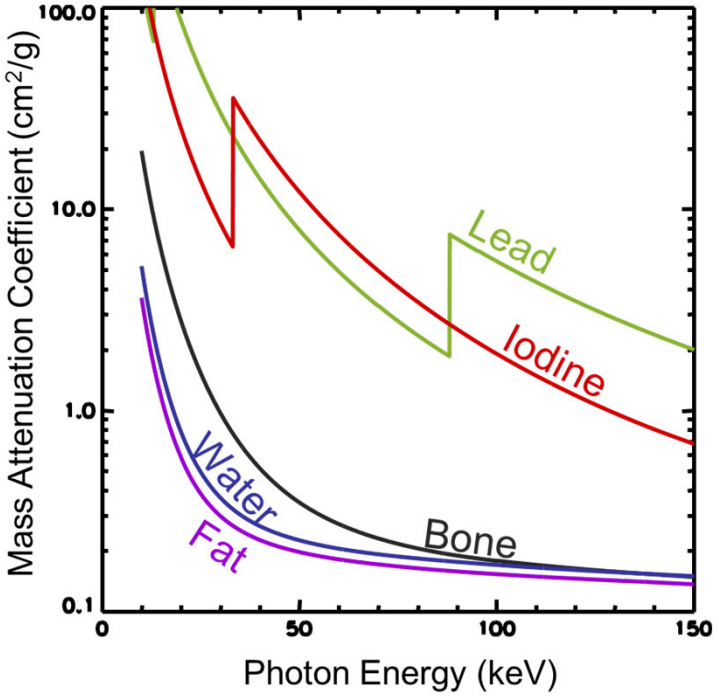
- Bragg's Law
  - An angle – energy relationship (dispersion)

$$n\lambda = p_1 + p_2$$

$$\lambda = 2d_{hkl}\sin\theta$$

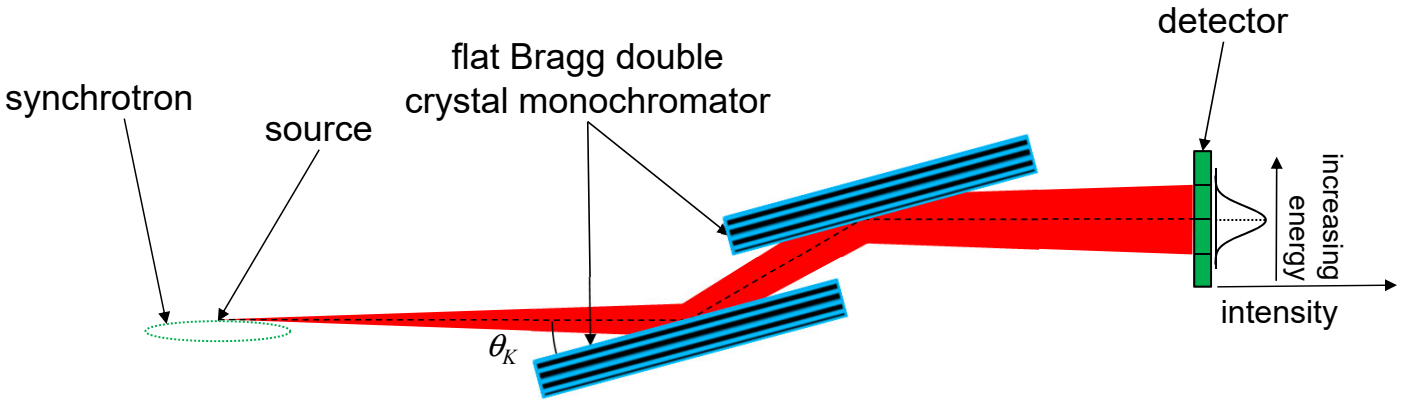


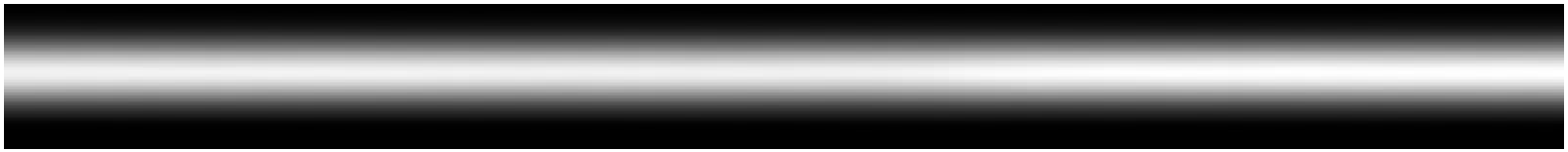
K-edge Absorption



Introduction – Double Crystal Monochromator

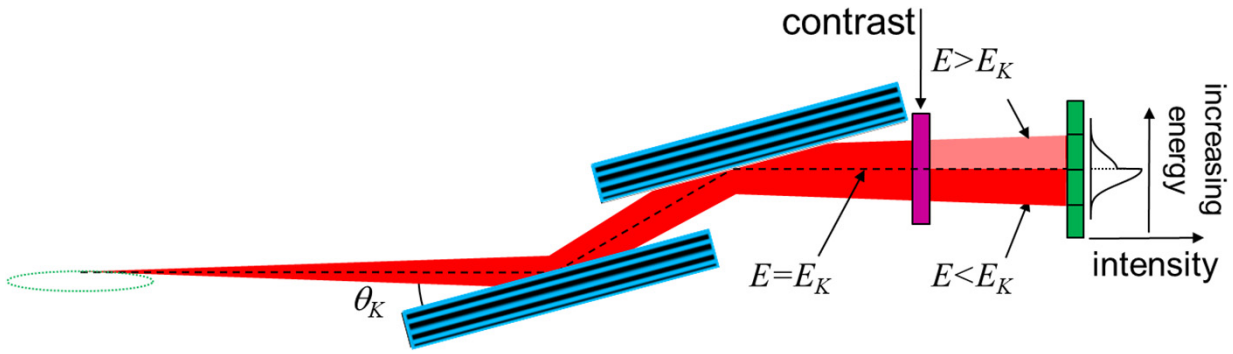
- Double Crystal Monochromator (DCM), Creates a nearly monochromatic beam

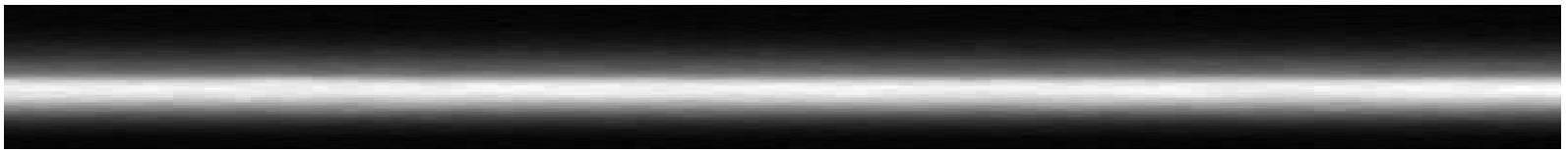




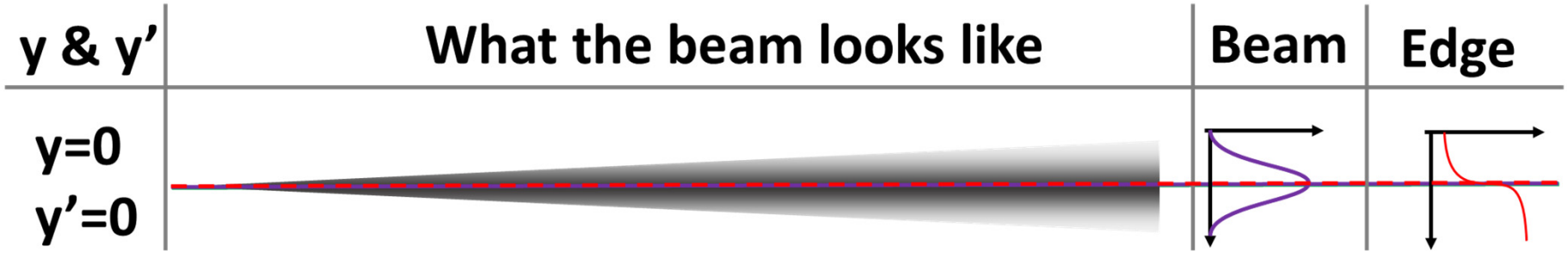
Introduction – DCM @ K-edge Absorption

- Some of the beam above and some of the beam below the edge energy

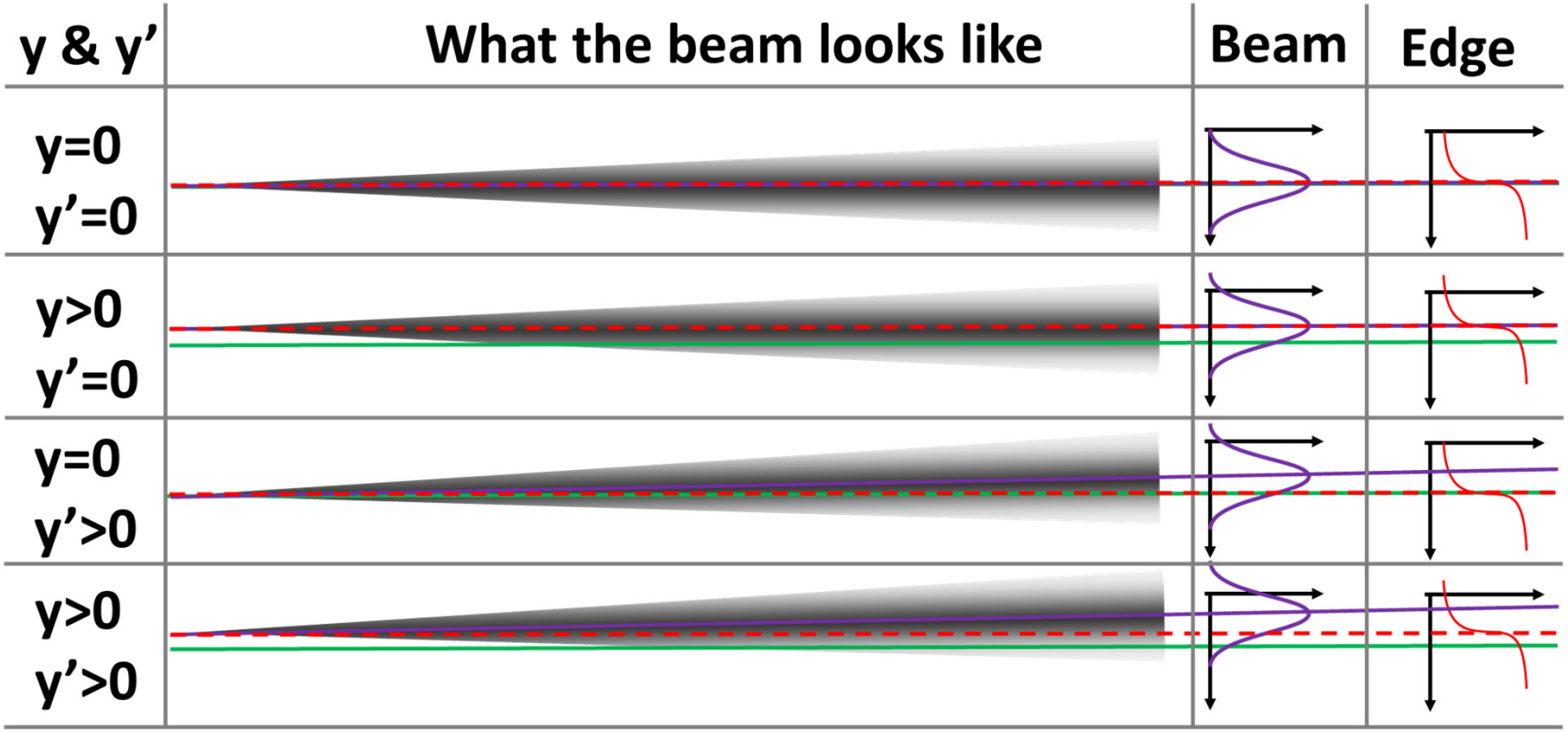




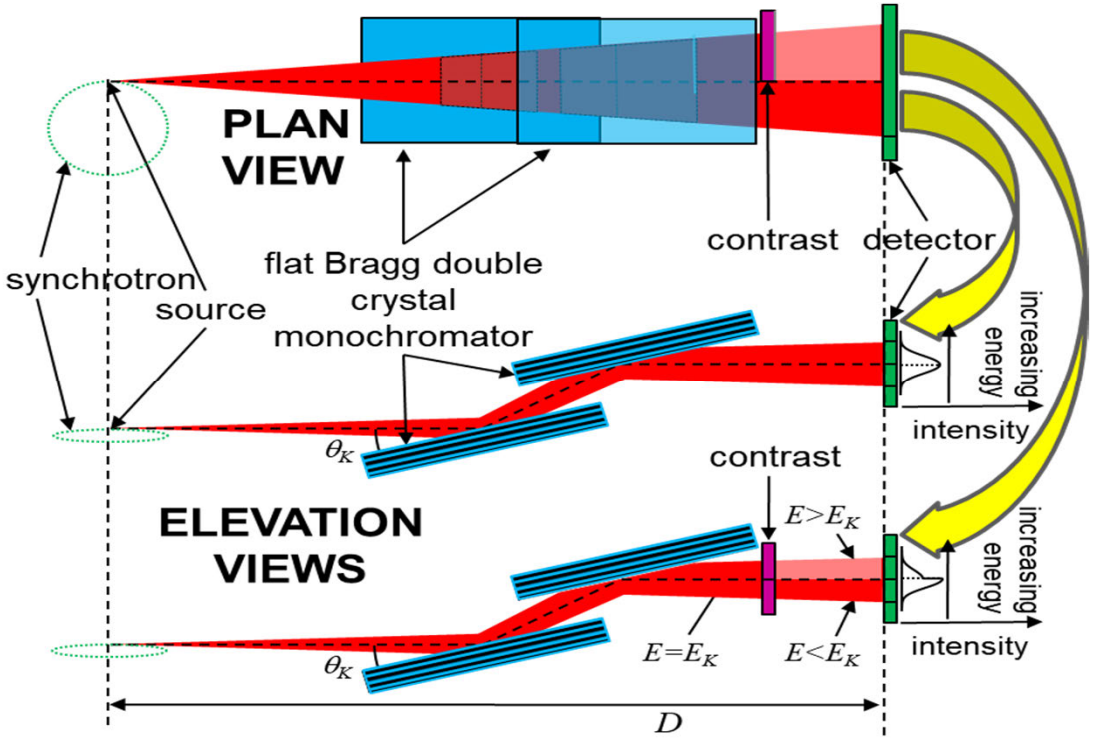
What the Beam Looks Like?



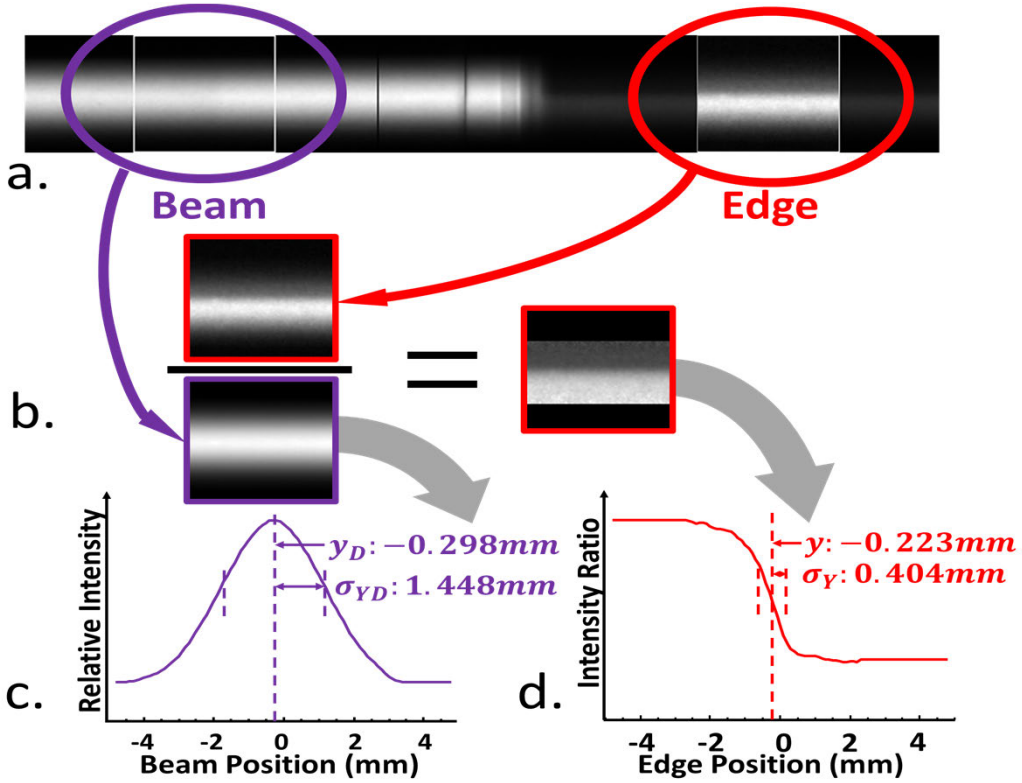
What Happens When the Beam Moves?



Layout of the System



Extracting Information



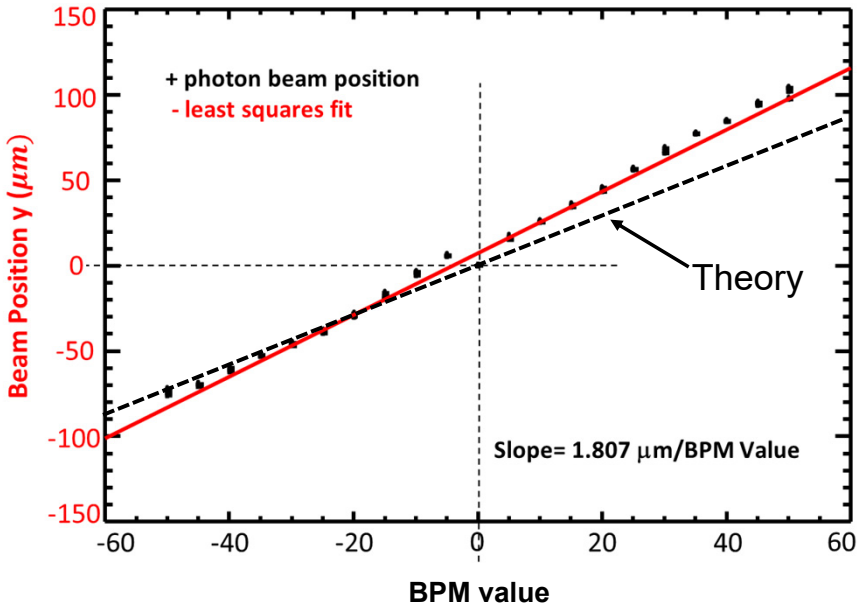
The System

- Beam Side – no filter
  - $y_d = y + Dy'$
- Edge Side – contrast filter
  - $y_c = y$

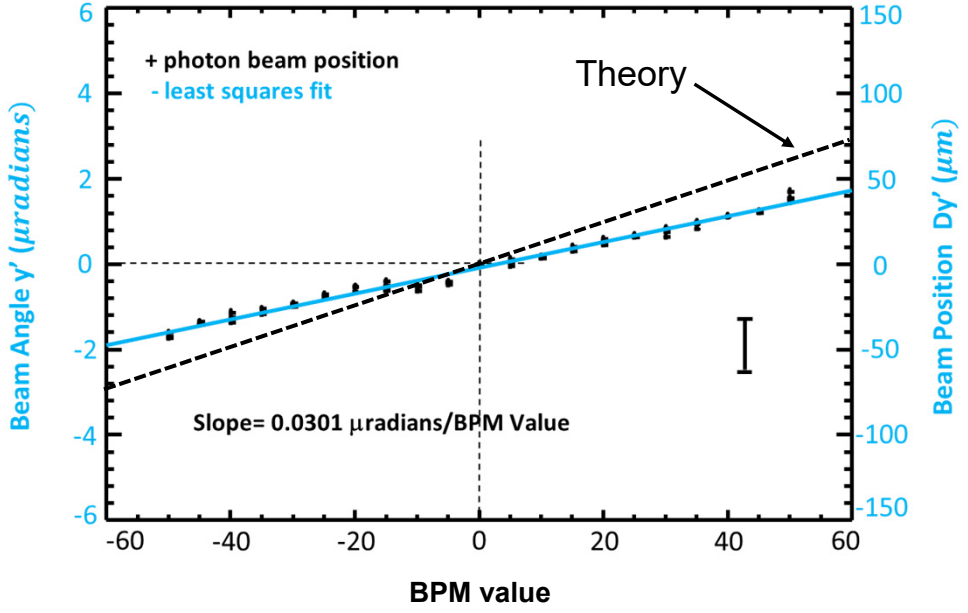
$$y = y_c \quad \& \quad y' = \frac{y_d - y_c}{D}$$

Moving the Electron Beam **Position** (mostly)

Position

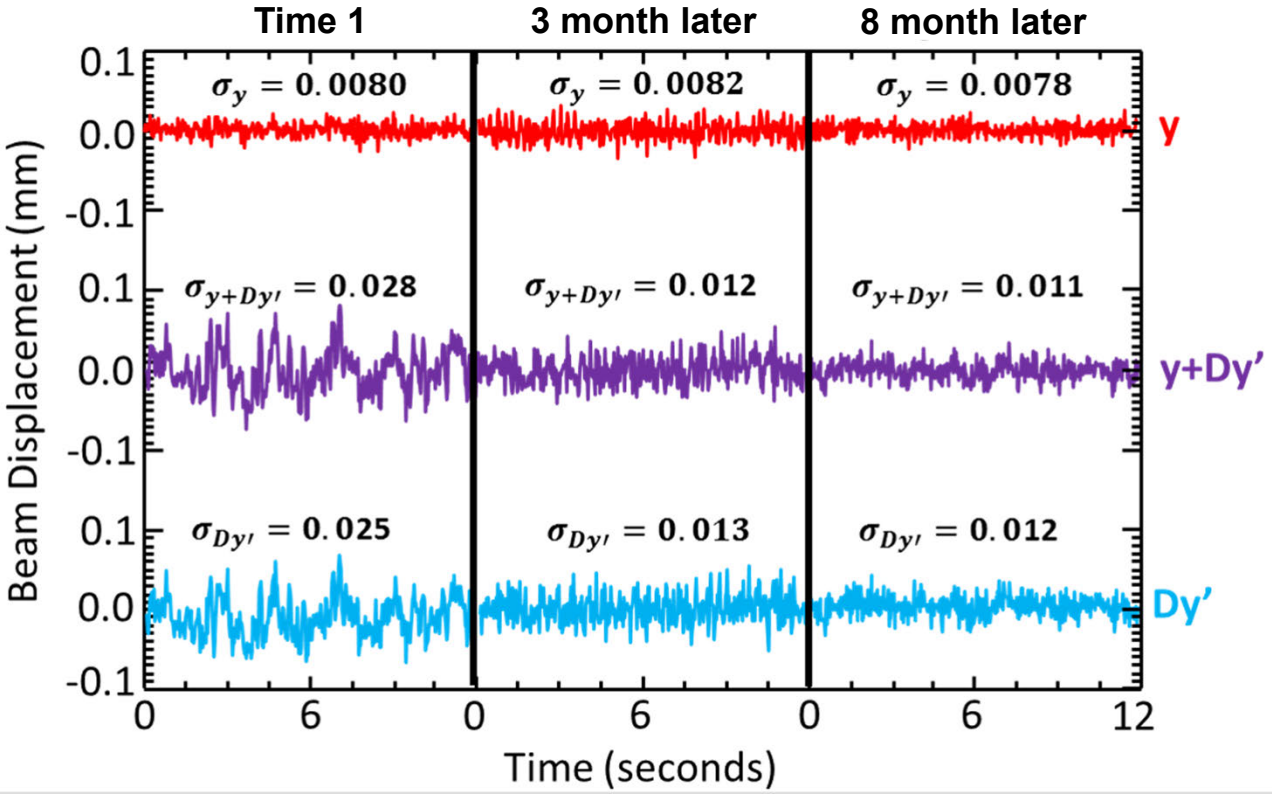


Angle



N. Samadi, *et al.*, "A phase-space beam position monitor for synchrotron radiation," *J Synchrotron Radiat,* vol. 22, pp. 946-55, Jul 2015.

Normal Operations Measurements



- Measurements made while the beam stability was improved

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What Are We Going to Do With It?

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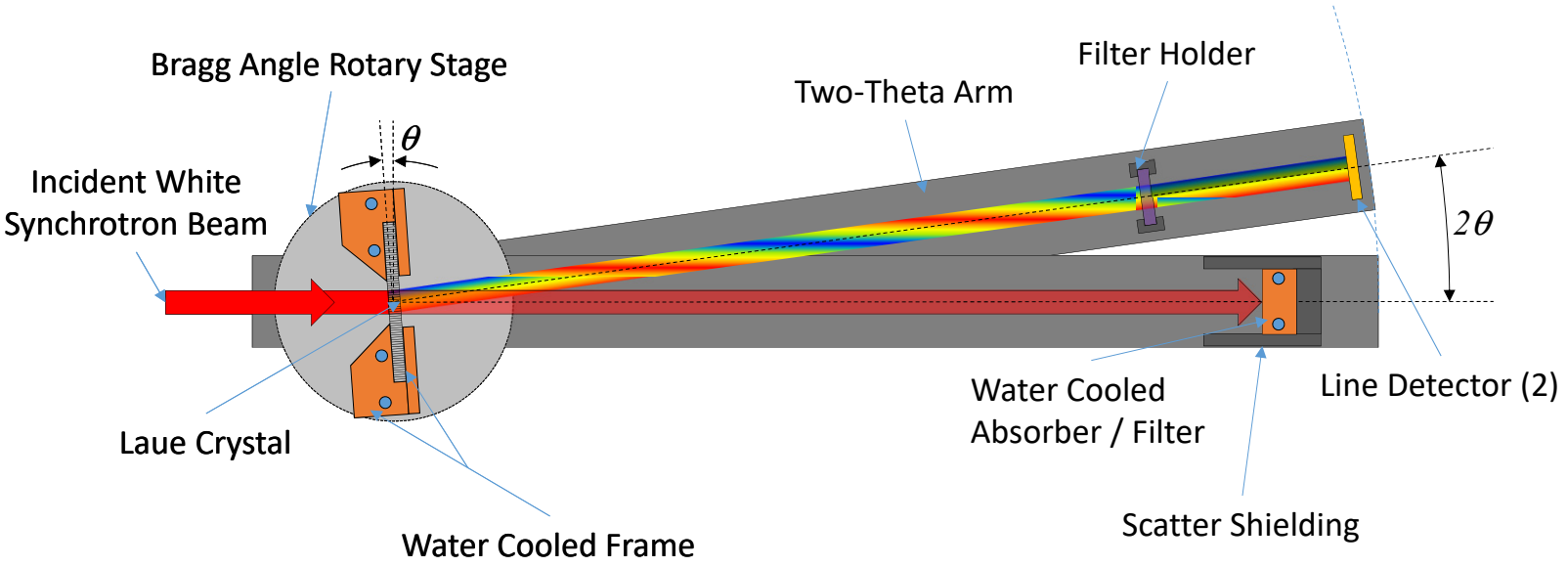
- As a BPM system, as a monitor and/or a feedback element
  - We have a design in mind and some test of it

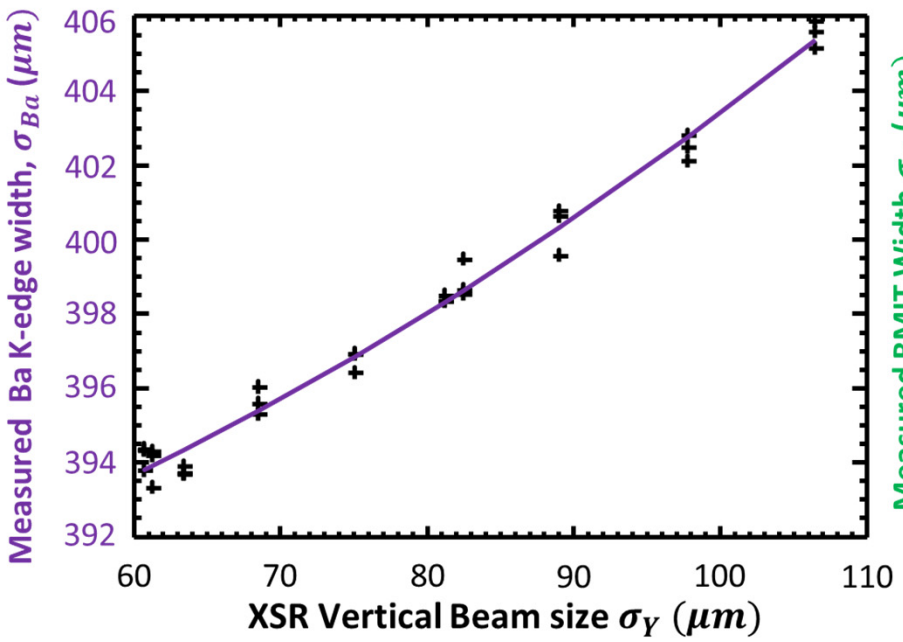
Laue ps-BPM Initial Design

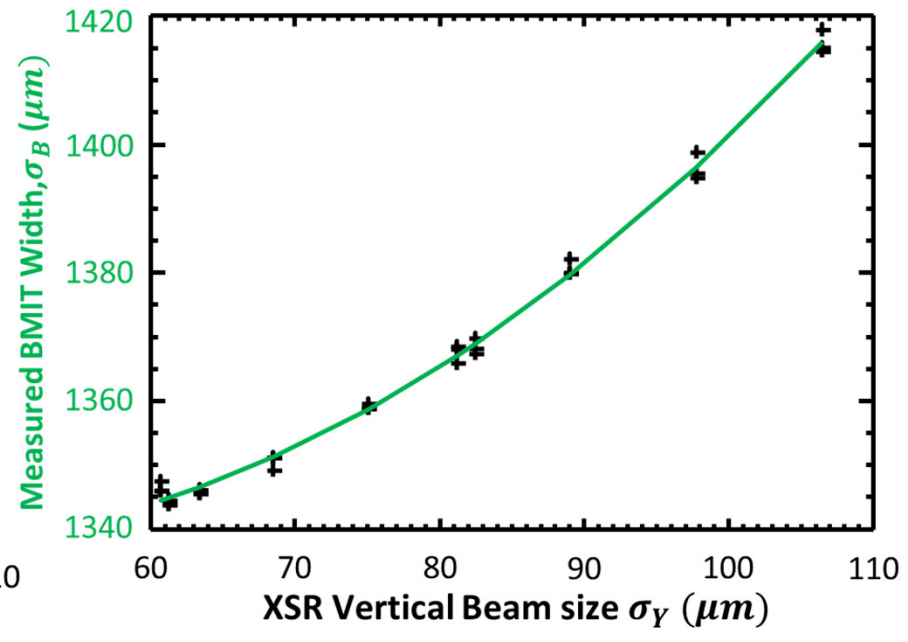


What are we Going to do with it?

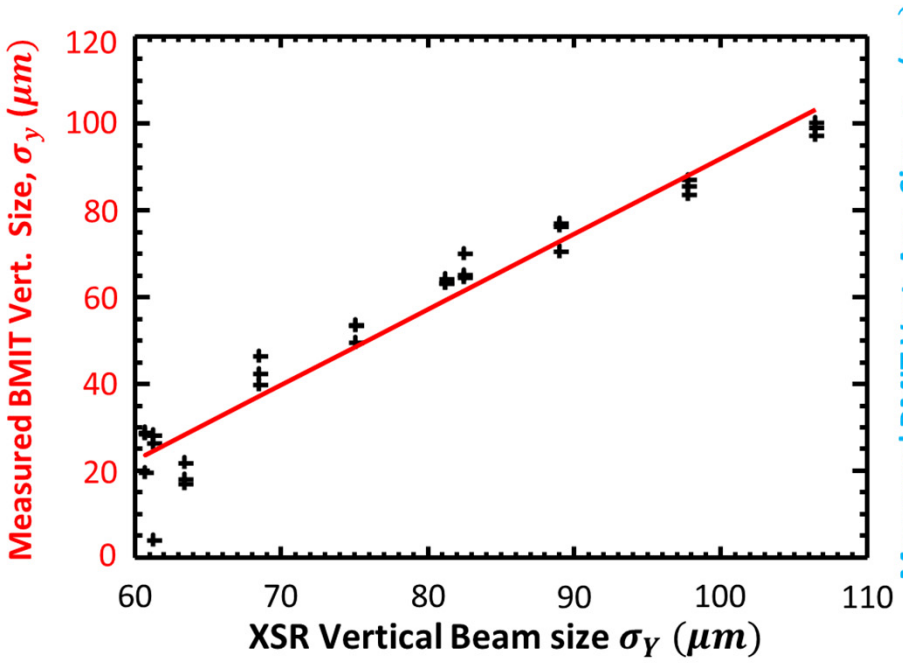
- As a BPM system as a monitor and/or a feedback element
  - We have a design in mind and some test of it
- As a way to measure the vertical emittance
  - Data has been taken and now being modeled

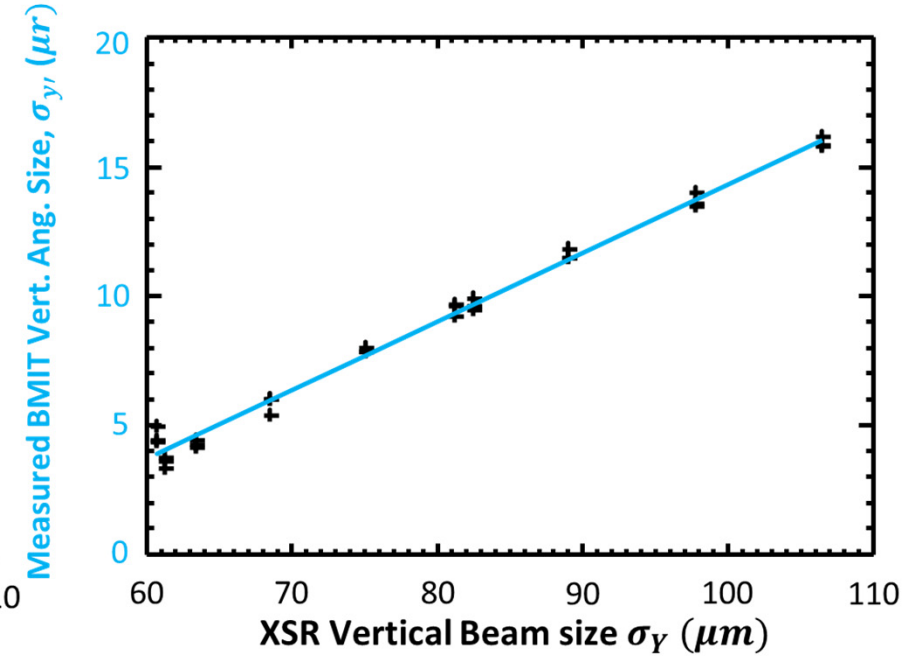
Changing the Electron Beam Size (mostly)





Changing the Electron beam Size (mostly)





What are we Going to do with it?

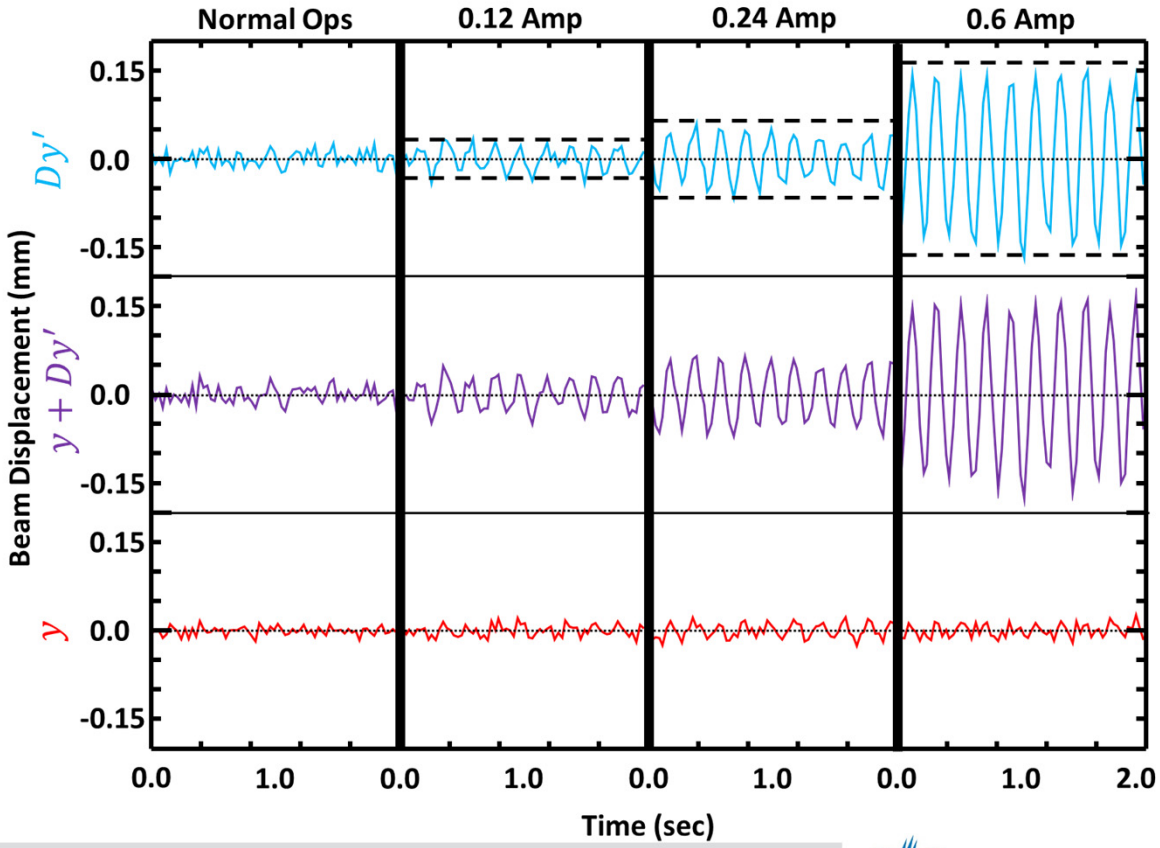
- As a BPM system as a monitor and/or a feedback element
  - We have a design in mind and some test of it
- As a way to measure the vertical emittance
  - Data has been taken and now being modeled
- As a way to correct experimental data
  - The rest of the talk …

Steps Towards Correcting Experimental Data

- The beam was no longer unstable, so we fixed that!
- A known frequency beam perturbation was used in the ring
- Measurements were made with ps-BPM system and imaging data

Results

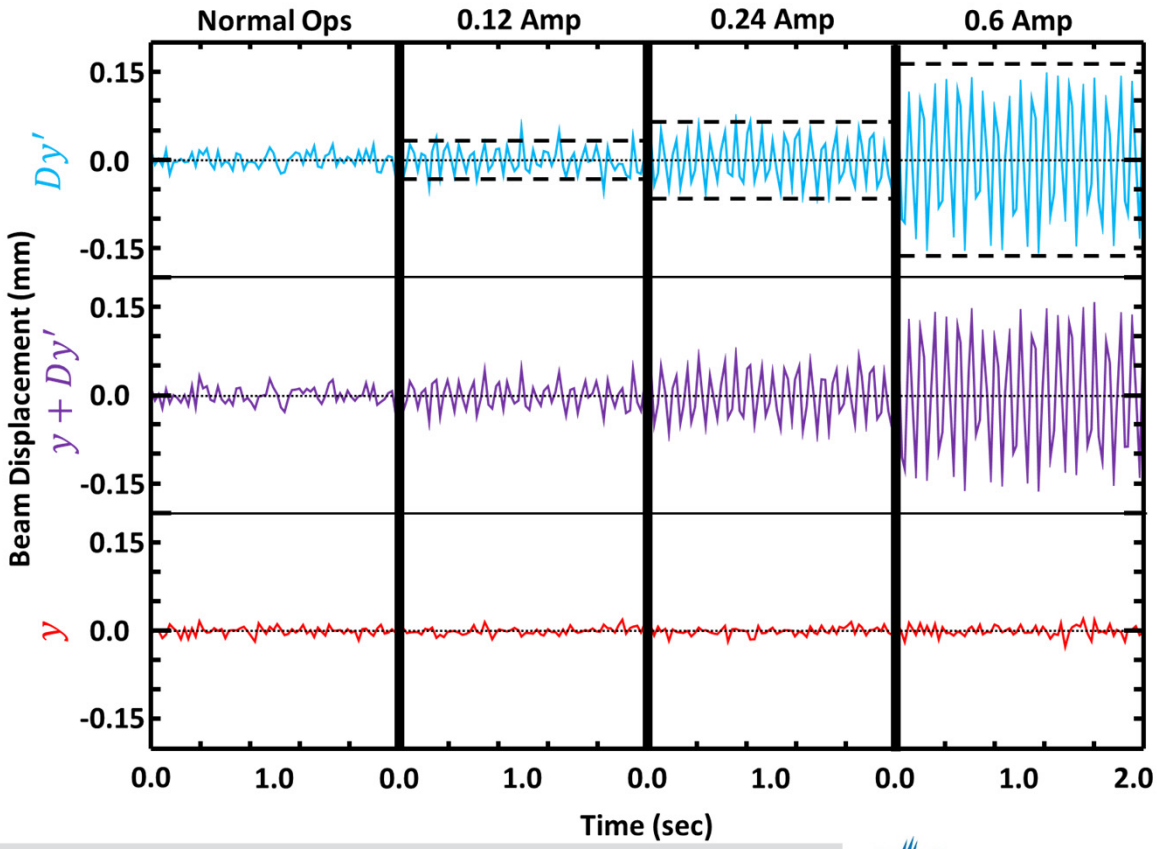
- Measurements made while a beam motion with 5 Hz frequency and different amplitudes was put in the ring



The Dashed line show the predicted value based on a machine optics simulation

Results

- Measurements made while a beam motion with 10 Hz frequency and different amplitudes was put in the ring



The Dashed line show the predicted value based on a machine optics simulation

Conclusion – Why Should ~~We~~ I All Care?

- Beamline
  - BPM
  - Correcting Experimental Data
- Machine
  - BPM
  - Control and Feedback System
  - Emittance Measurements
- Papers
- And a PhD!

Reference

research papers

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A phase-space beam position monitor for synchrotron radiation

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The stability of the photon beam position on synchrotron beamlines is critical for most if not all synchrotron radiation experiments. The position of the beam at the experiment or optical element location is set by the position and angle of the electron beam source as it traverses the magnetic field of the bend-magnet or insertion device. Thus an ideal photon beam monitor would be able to simultaneously measure the photon beam's position and angle, and thus infer

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Thank you!

Questions?