Beamline Stability

Michael Borland for Glenn Decker

- Evolution of beam stabilization systems

- Performance of present beam stabilization systems

  i) AC beam stability

  ii) Long term drift
    Bending magnet source points
    Insertion device source points

- Vision for the future

Advanced Photon Source

Accelerator stabilization efforts have undergone a continuing process of evolution

- Particle beam position monitoring - approx. 3 meters from source point

  i) Original broadband radio-frequency (rf) beam position monitor electronics. (1995 to present)

  ii) Addition of 140 channels of narrowband rf bpm electronics at ID source points. (May 1998 - December 2003)

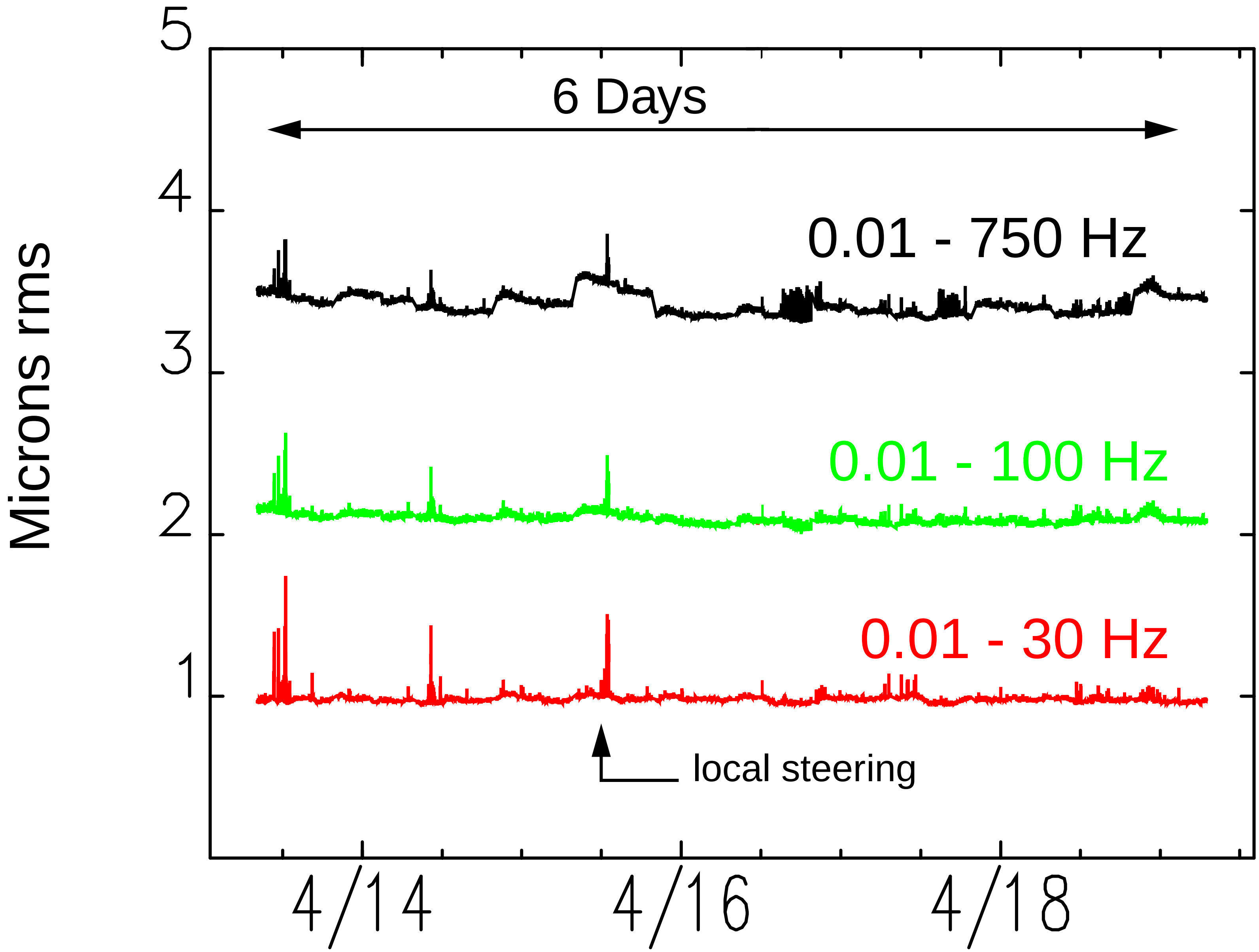
- Photon beam position monitoring - 11 to 20 meters from source point

    i) Upgrade of bending magnet and insertion device photon beam position monitoring electronics. (Dec. 1999 - Feb. 2002)
    20 sectors of BM monitoring are actively in use for orbit correction

    ii) Decker distortions
    Phys. Rev. ST Accel. Beams **2**, 112801 (1999)
    (September 1997 - present)
    31 sectors (all operational beamlines) to be completed by October, 2004

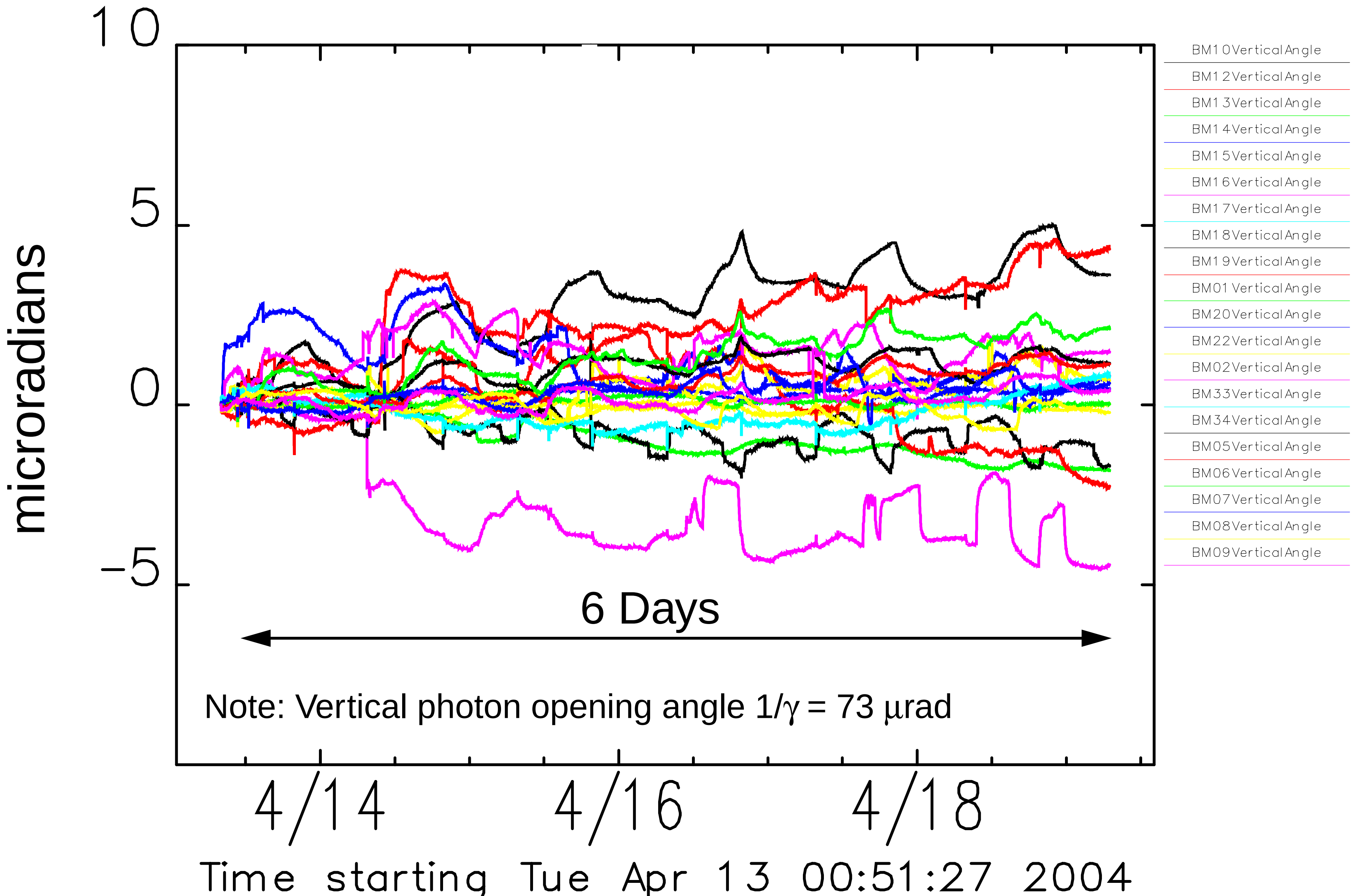
    iii) Algorithm developments to compensate ID photon bpm gap-dependent systematic errors using feedforward
    (1999 - present)
    15 sectors of ID photon bpm's presently in use for orbit correction

Peak Vertical RMS Beam Motion

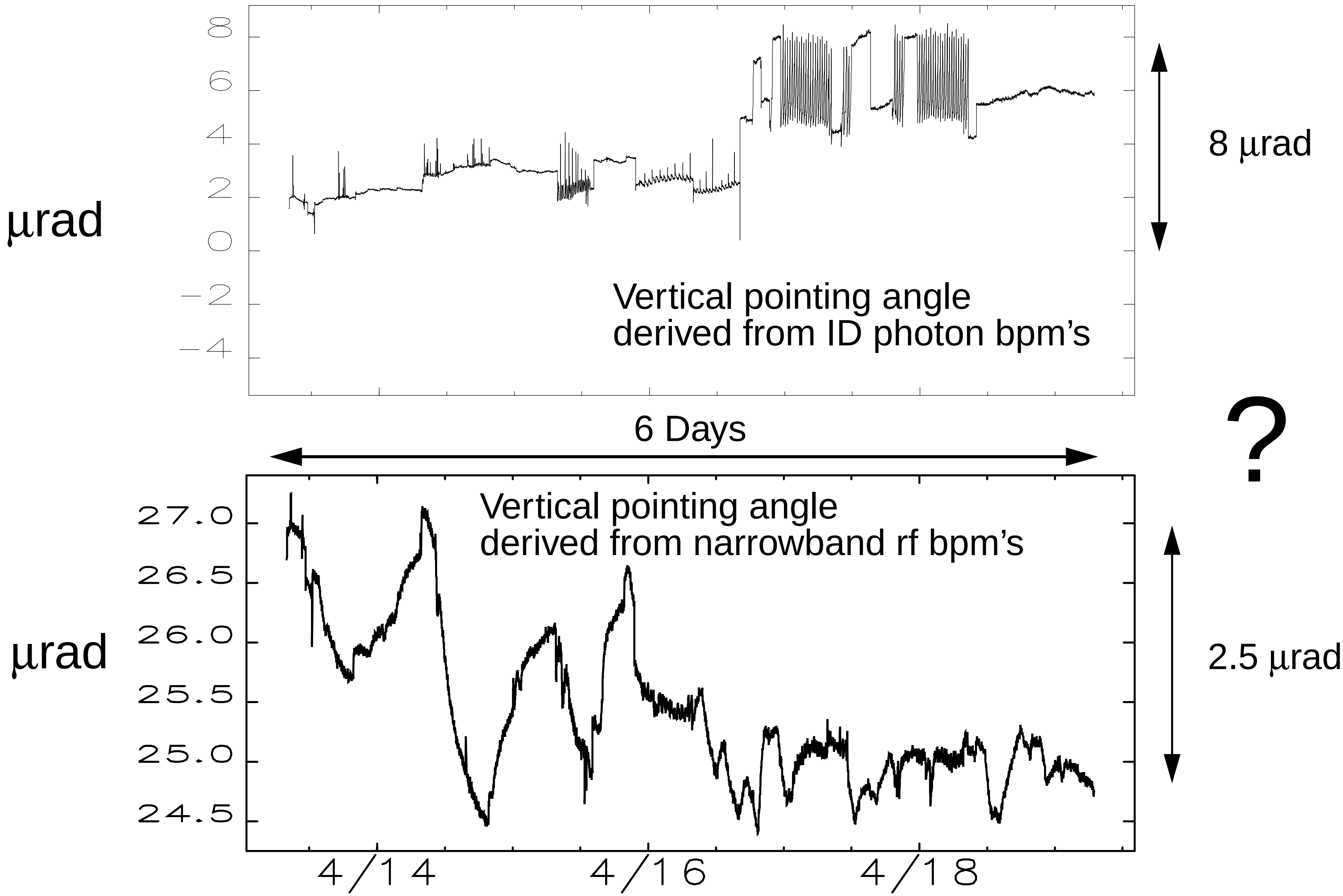


Note: Vertical electron beam size = 13 μm rms

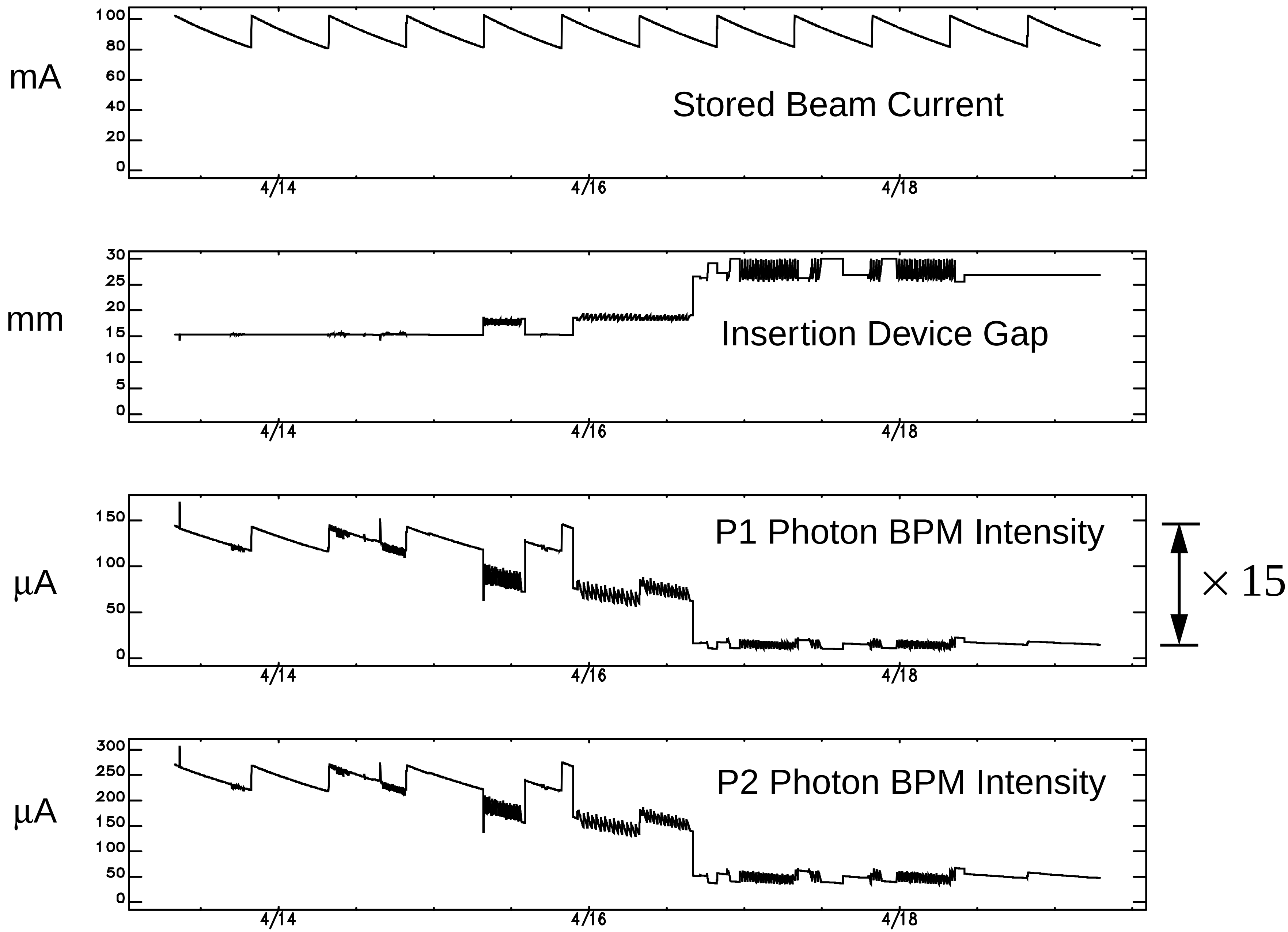
Vertical pointing stability derived from BM photon BPMs



Advanced Photon Source

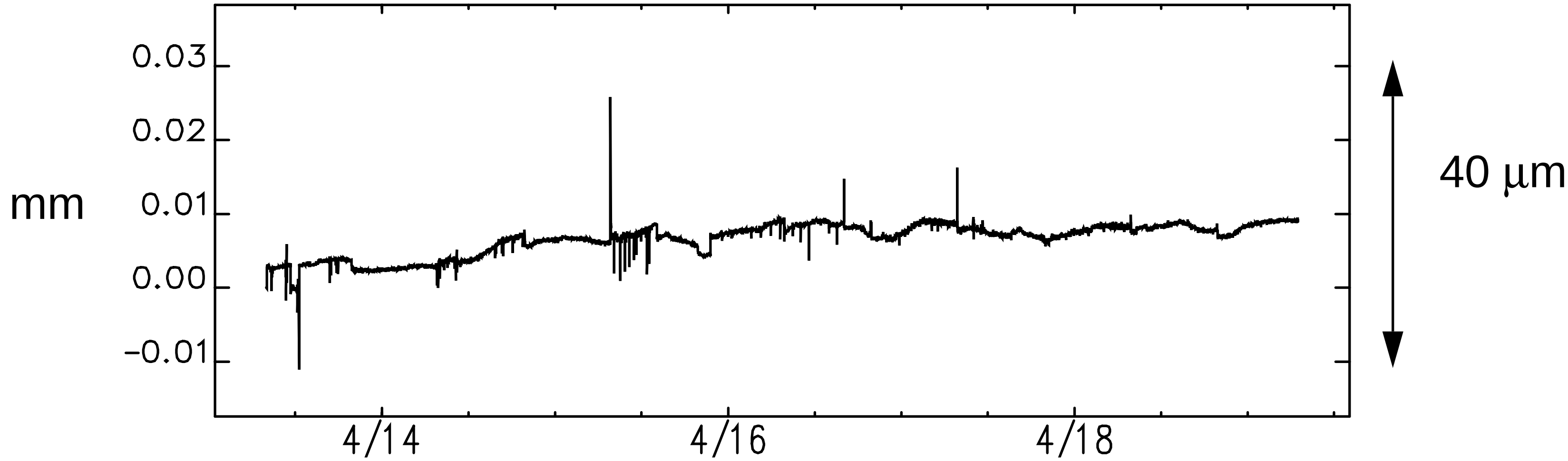


Note: Vertical photon opening angle $\frac{1}{\gamma\sqrt{N}}$ ~ 10 µrad

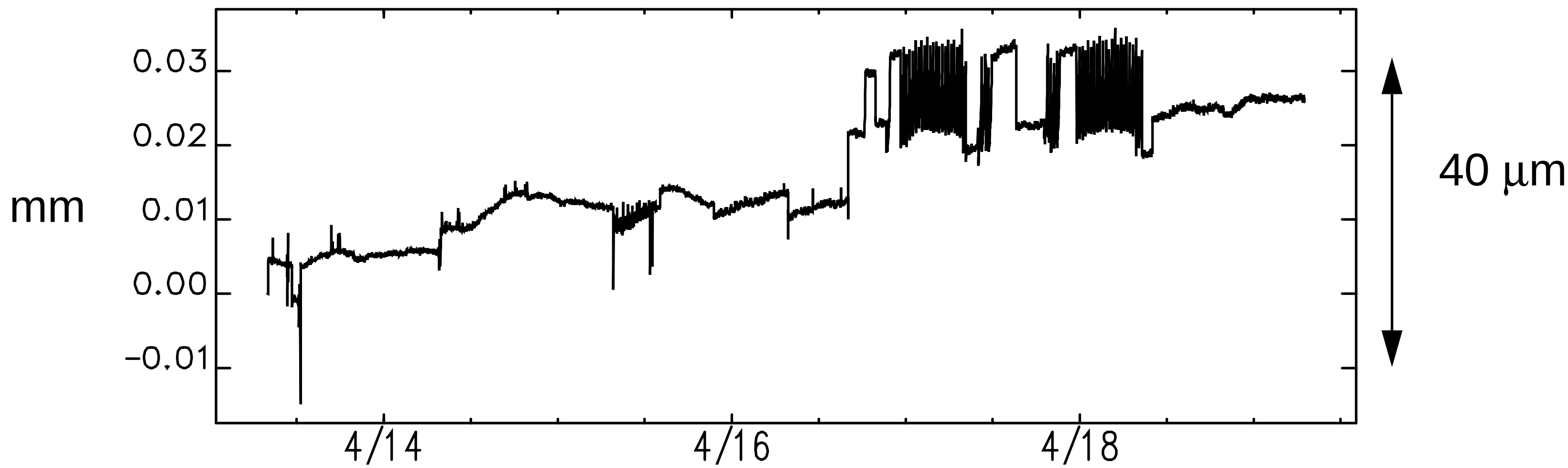


Advanced Photon Source

Upstream photon bpm readback*;
in use by orbit control algorithm



Downstream photon bpm readback*;
*_not_* in use by orbit control algorithm



* : After gap feedforward correction

Performance Summary

- Steady state AC beam stability is good

  - Except while steering is being performed
  - Inclusion of photon bpm's in real-time feedback will give significant improvement

- Long term (> 48 hours) drift performance

  Generally good vertically for BM source points

  Horizontal positioning at BM source points relies on aging broadband rf bpm system

  Probably pretty good for ID source points

    i) Systematic error correction uncertainties are on the scale of 10's of microns at a distance 16 meters downstream of the source

    ii) Local steering was performed 87 times during run 2004-1; approx. once per day.

This is about as good as it's going to get with existing in-tunnel hardware, but it probably isn't good enough for many APS user groups.

A simple, widely distributed survey of beamline personnel (summer 2002) asked 5 questions:

1. Are you satisfied with the stability of the x-ray beam arriving at your sample?
   ID: *Yes= 2, No = 16, Undecided=1;* BM: *Yes=3, No = 1*

2. Do you use any feedback to stabilize your beam?
   ID: *Yes = 10, No = 9;* BM: *Yes=2, No = 2*

3. Have you determined at your beamline the relative contributions to the beam instability from the source and from the beamline optics?
   ID: *Yes = 8, No = 11;* BM: *Yes = 3, No = 1*

4. Is there a class of experiments that is made difficult by the present level of stability on your beamline?
   ID: *Yes = 15, No=2, Undecided = 2;* BM: *Yes=2, No=2*

5. If APS will help with diagnostics of beam stability, will you use such a service?
   ID: *Yes=16, No = 0, Undecided = 3;* BM: *Yes=4, No=0*

APS Vision

(or at least Glenn's vision)

1. Local steering requests should never be needed. There should never be any uncertainty regarding the position of the white beam as it strikes the first optic, at the level of fractions of a microradian.

2. Every beamline that can benefit from feedback downstream of the first optic (e.g. using monochromatic beam position monitoring) should have it. Alignment of x-rays on the sample should require a mouse click only (maybe two).

3. This should come to pass no later than three or four years from now.

Implementation

1. An insertion device “gold standard” white beam position monitor is needed, located as far downstream of the source point as practicable.

   i) Investigations of all presently available technologies will be conducted. Both destructive and non-destructive monitoring will be considered.

   ii) One, or at most two, will be selected, prototyped, and tested using an existing unused photon beam position monitor vacuum housing located in the beamline front end, inside the accelerator enclosure. This takes advantage of existing hardware and controls associated with mechanical translation stages.

   iii) A facility-wide implementation plan will be developed and executed.

2. Monochromatic and/or pink beam position monitoring and control.

   i) “Primum non nocere” - First, do no harm.

   ii) Standardized diagnostics, data acquisition and controls will be developed

   ii) Global implementation will be made possible, tailored to individual beamline requirements.

Summary

- As the APS enters the present mature phase of operation, the elimination of disruptions associated with photon beam alignment questions is imperative.
- The APS has a large experience base associated with large-scale diagnostic systems, data acquisition, processing and control, in addition to many other disciplines.
- Glenn Decker has volunteered a significant fraction of his time over the next few years to this cause, for what its worth.

GD