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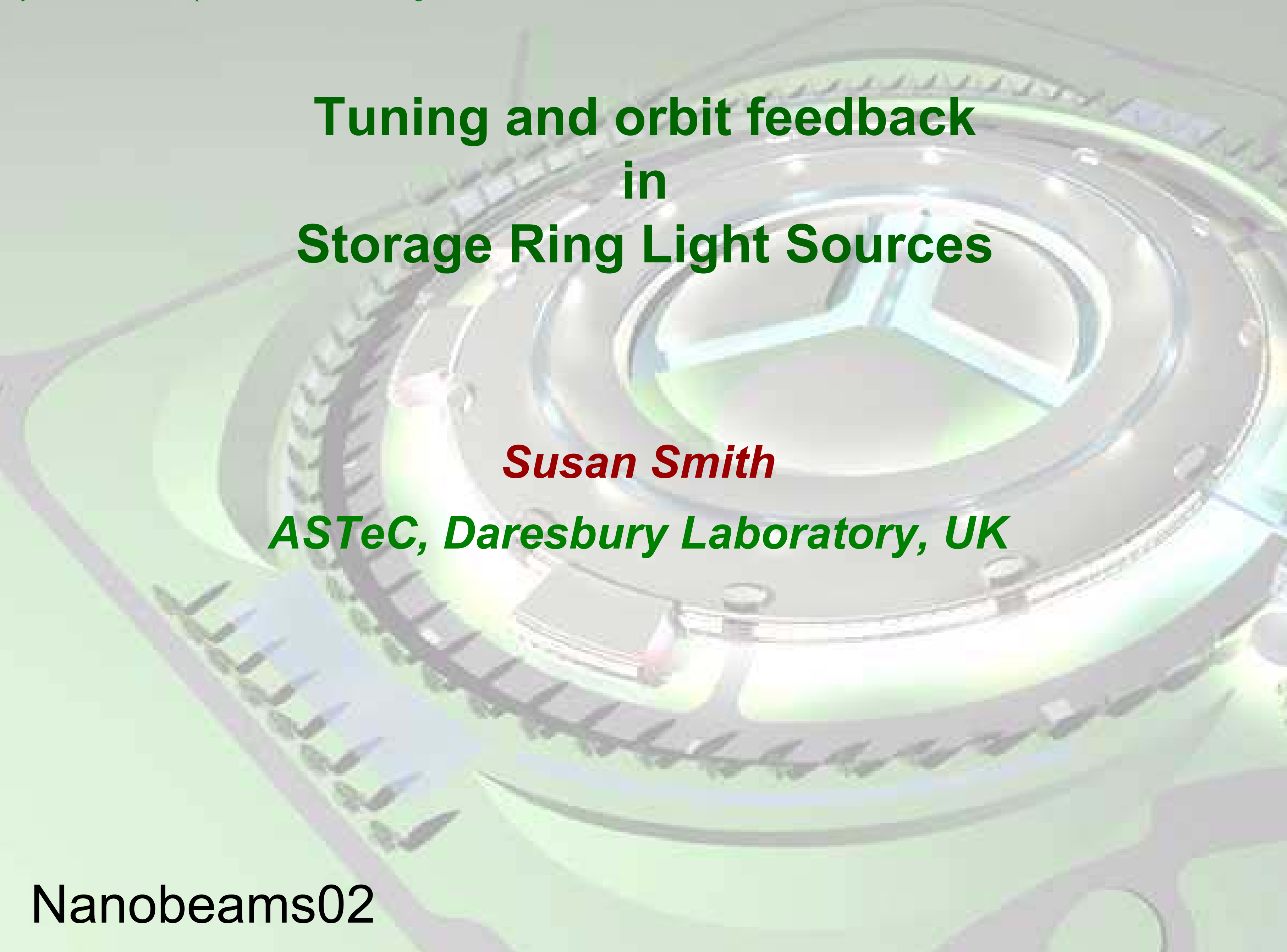

Tuning and orbit feedback in Storage Ring Light Sources

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ASTeC, Daresbury Laboratory, UK

Nanobeams02

Content

- **Tuning**
  - » **Quality factors**
  - » **My idea of tuning**
- **Orbit control and feedback**
  - » **Local correction**
  - » **Global correction**
  - » **Fast global correction**

Quality factors

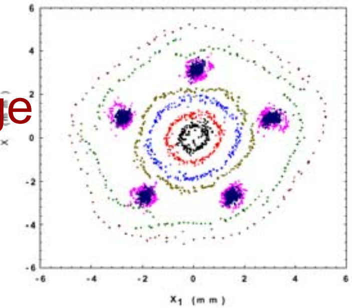
- Beam current
  - » Single bunch and multibunch instabilities
  - » Ion effects
  - » Beam heating
  - » Stability
- Lifetime
  - » Vacuum
  - » Aperture
  - » Dynamic aperture
  - » Momentum aperture
- Vertical and horizontal beamsizes and divergence (emittance and coupling)
  - » Instabilities
  - » Magnet errors
  - » Orbit errors
- Injection rate
  - » Nonlinear dynamics

Tuning

- Strive to set the machine to the model (which has random errors etc.)
  - » Set tunes and desired chromaticity etc.
  - » Correct the orbit, dispersion and coupling
- Refinement and correction of machine or model
  - » Beam based alignment
  - » “Experimental calibration” e.g. LOCO, Linear Optics from Closed Orbits (:- response matrix measurement and fitting of model)
- Measure and understand the nonlinear dynamics particular important because of the large momentum aperture required for Touschek lifetime

Nonlinear measurement/optimisation

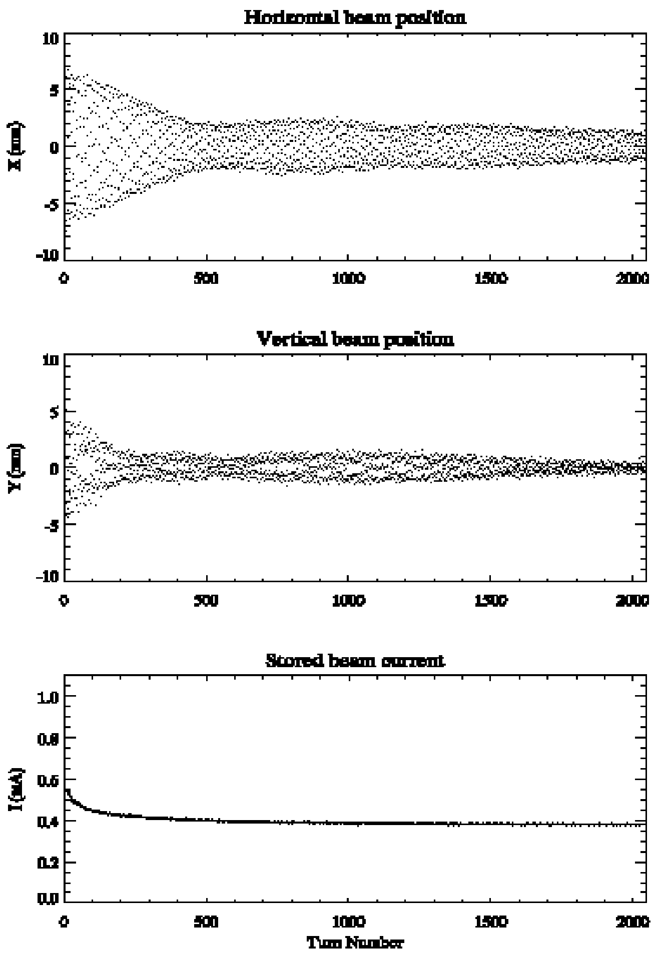
- Tracking
  - » Turn by turn tracking using fast BPMs and digital storage
    - Tuneshift with amplitude
    - “Phase space”
    - Measured frequency maps



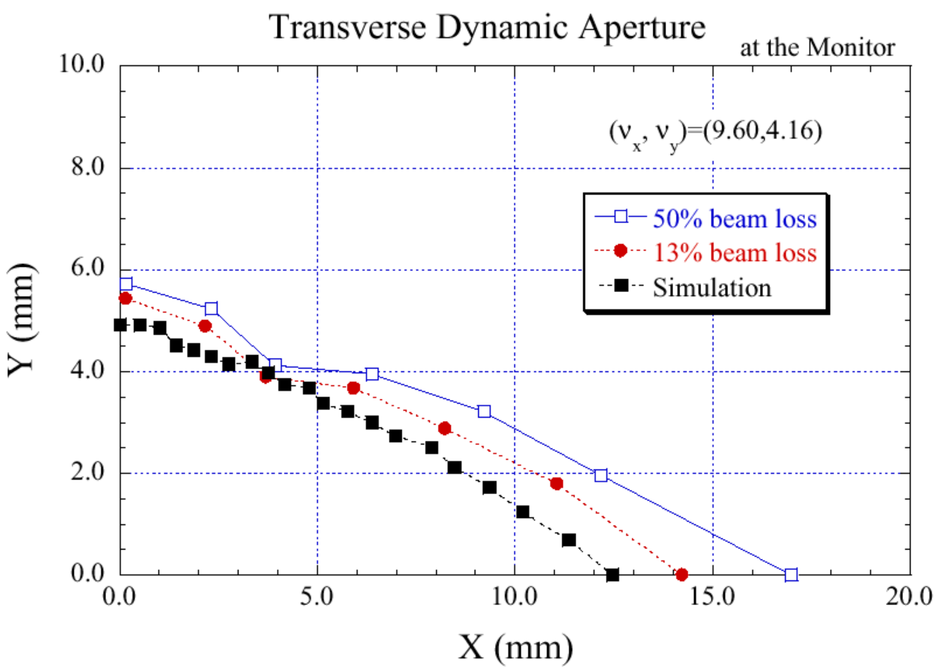
SSRC T.S. Ueng PAC’01

- Dynamic aperture measurements
  - » Lifetime and injection studies
  - » Kick experiments
- Momentum aperture
  - » Lifetime measurements
- Tuneshifts with momentum

Dynamic aperture measurements



Kick then measure on fast position monitors and loss rates



Photon Factory EPAC'00 **Y.Kobayashi and K. Haga**

Tuneshift with momentum

Change RF frequency and follow off energy orbit

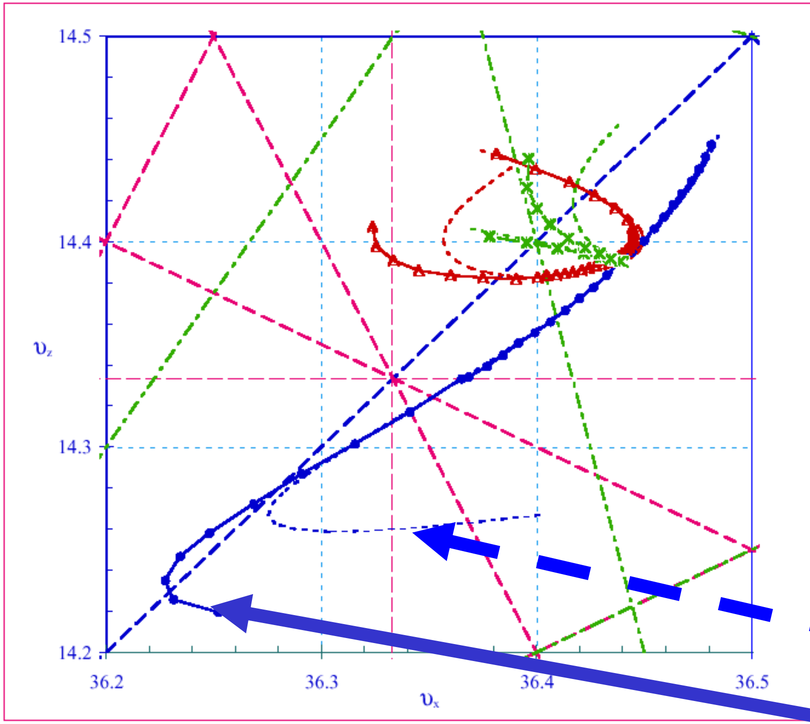


Figure 6: Measured and predicted (dashed) tune paths

- Thin sextupoles an issue
- Checked multipole contribution
- Fitted sextupole strengths to data

Predicted

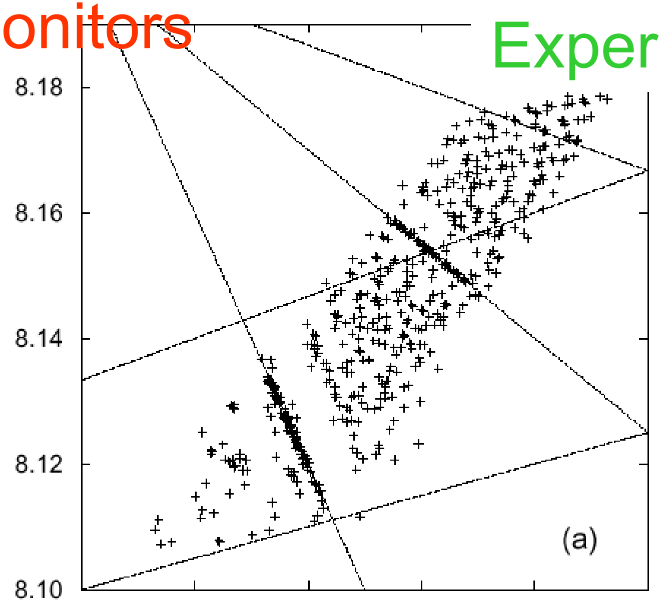
Measured

PAC 2001 **A. Ropert, L. Farvacque,**

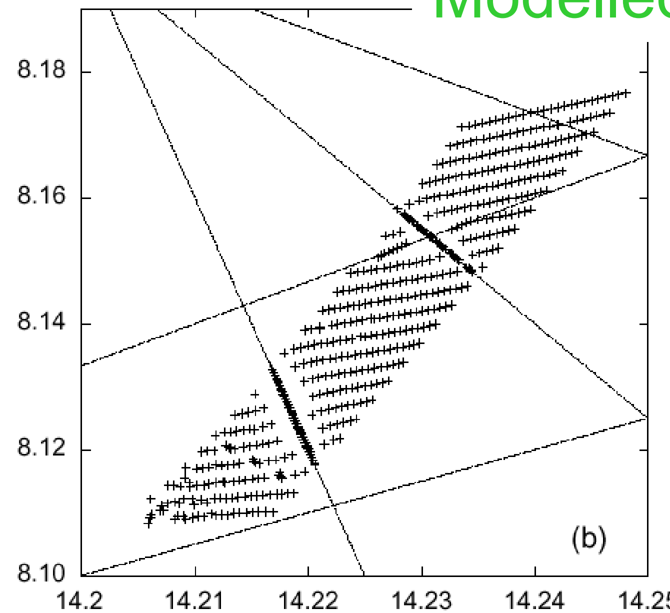
Frequency map

Kick then measure on fast position monitors

Experimental



Modelled

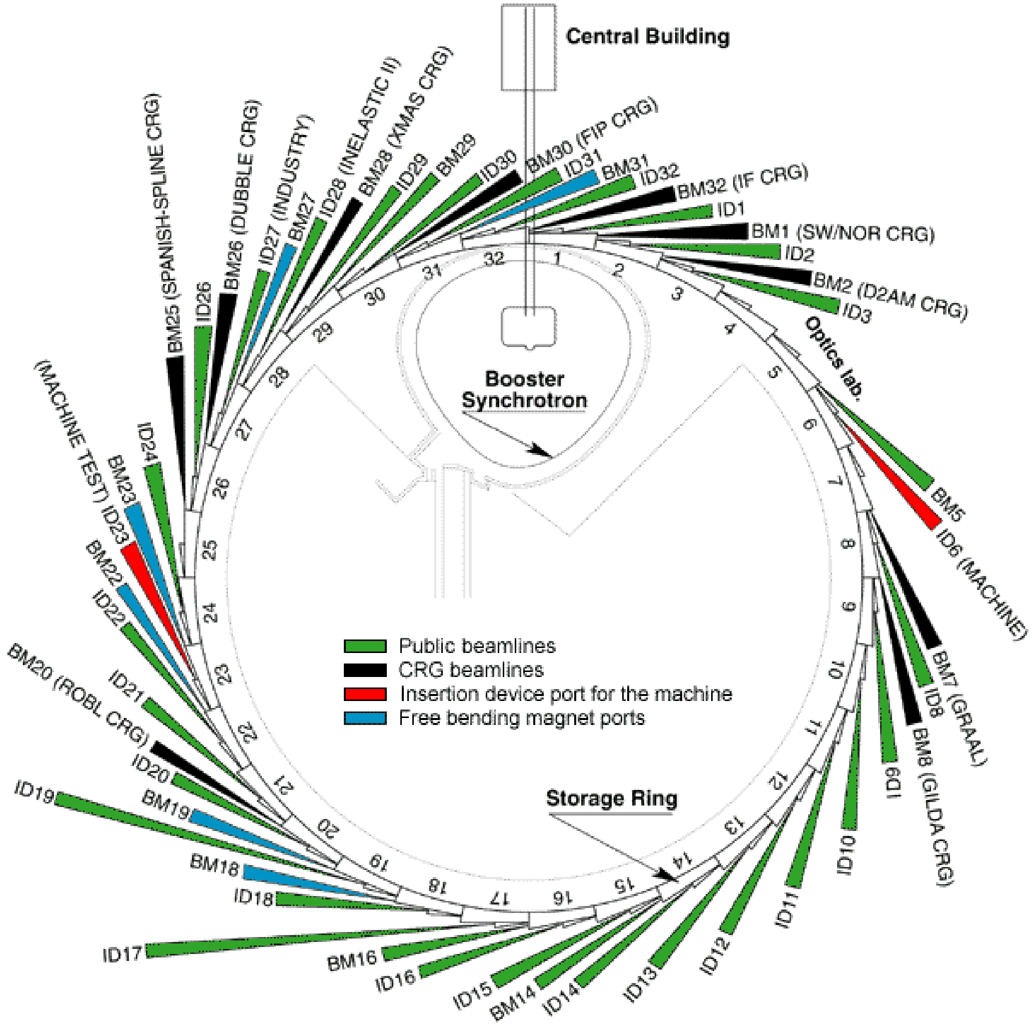


Frequency maps for ALS with a calibrated lattice (I.e. adjusted to match measured response matrix,**LOCO**)

Un-allowed resonances appear.

ALS EPAC'00 C. Steier, D. Robin

Orbit Feedback In SR Sources

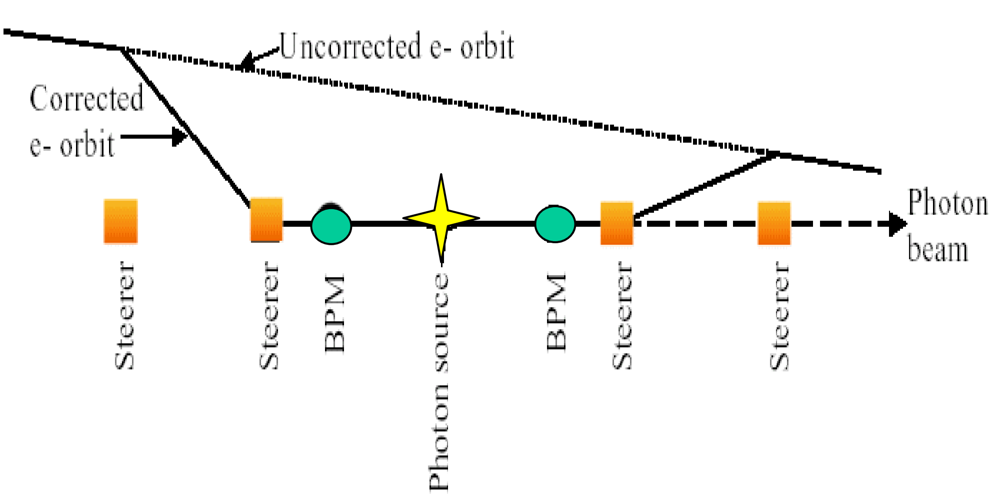


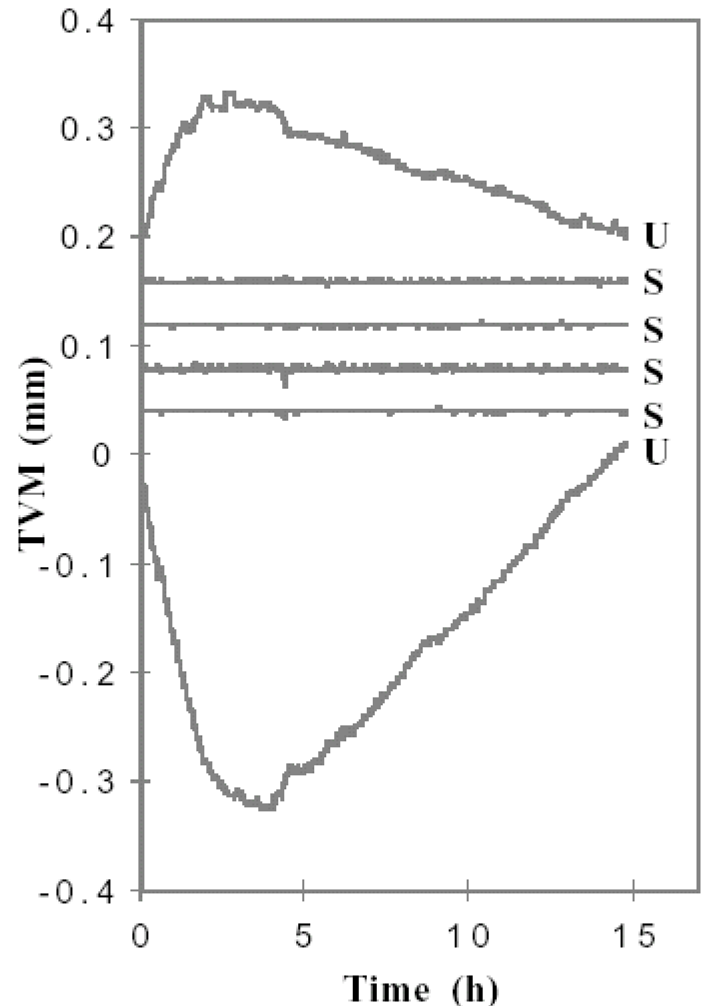
Orbit Feedback In SR Sources

- Low emittance <10nmrad and small coupling <1%
- Users require stability to 5-10% in position and angle
- Vertical stability of ~1 micron for high performance 3rd generation machines
- Stability period msec to hours
- Electron jitter increase the effective beam sizes and degrades the brightness of the photon beam
- Slow orbit drifts leads to frequent realignment of the optics

Local Steering

3 or 4 magnet bump, using 1 or two position monitors can be either electron or photon monitors





SRS slow local feedback

Global Steering

- Single corrector results in an oscillating change at the correctors
- Orbit shift O from steering magnets = R x M in matrix form
- Global correction the matrix R is "inverted" to find the correctors for any desired orbit changed.
- Non square matrix, poorly positioned correctors or magnets, errors in matrix measurements means that this is often ill conditioned..
- Singular value decomposition (SVD) $\underline{R}=\underline{UWV^T}$ is now a popular and robust method to exclude singular values…
  - » More monitors than correctors minimises monitor errors.
  - » More correctors than monitors minimises the corrector strengths used.
  - » Also used is MICADO and Harmonic correction.

SRS

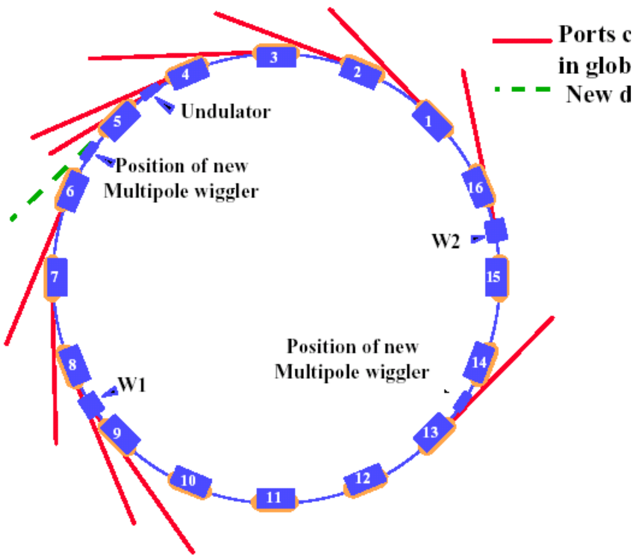


Figure 2: Distribution of TVMs around t

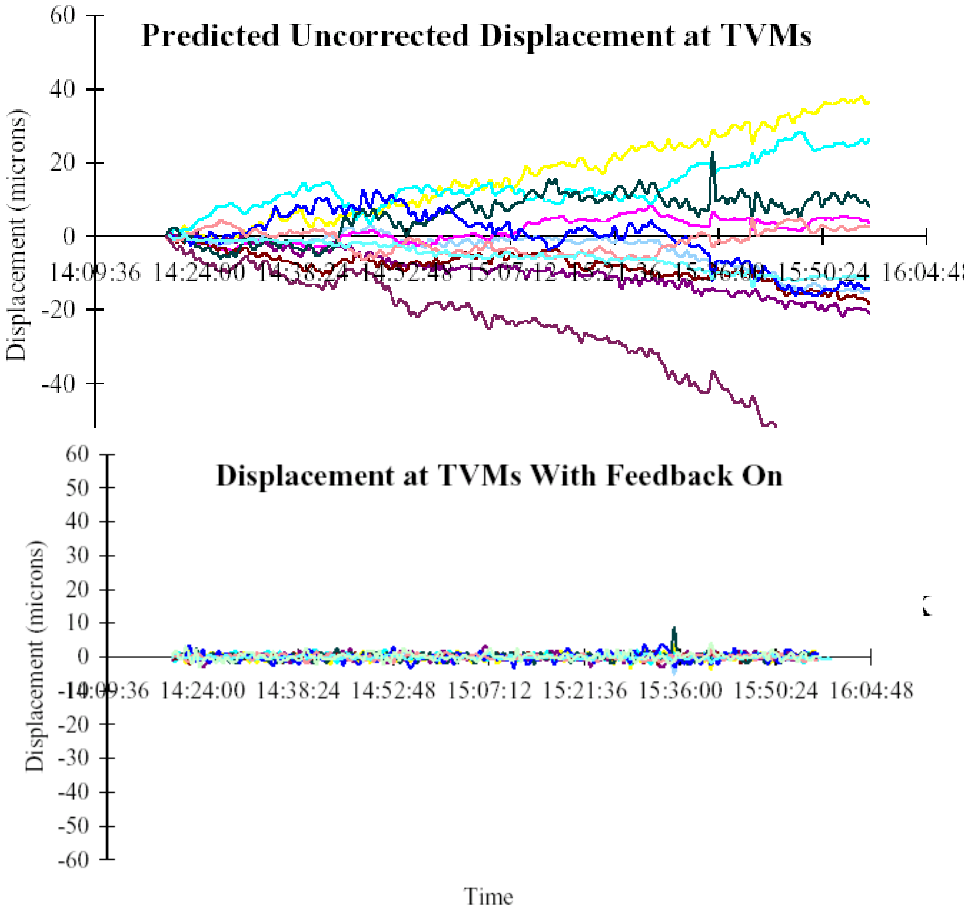
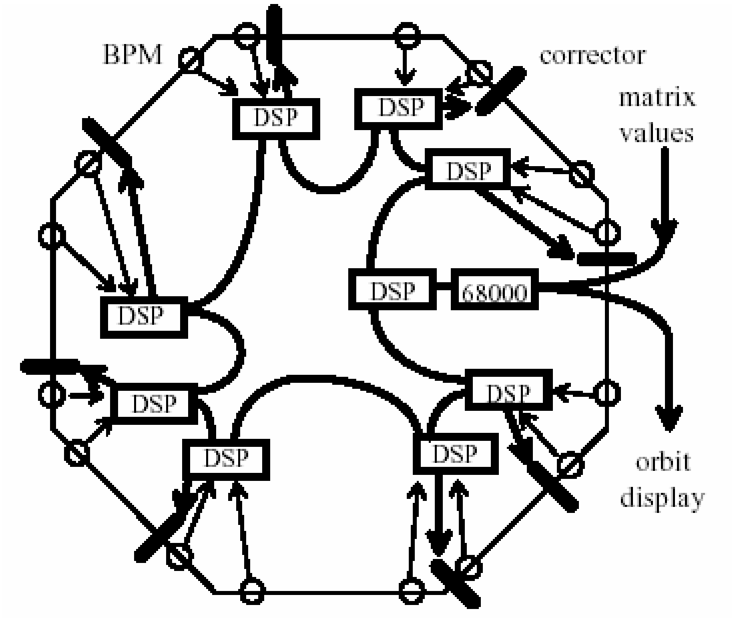


Figure 3: Operation of global vertical feedback on the photon beam monitors during a user beam.

Fast global correction



Up to ~200 Hz Bandwidth

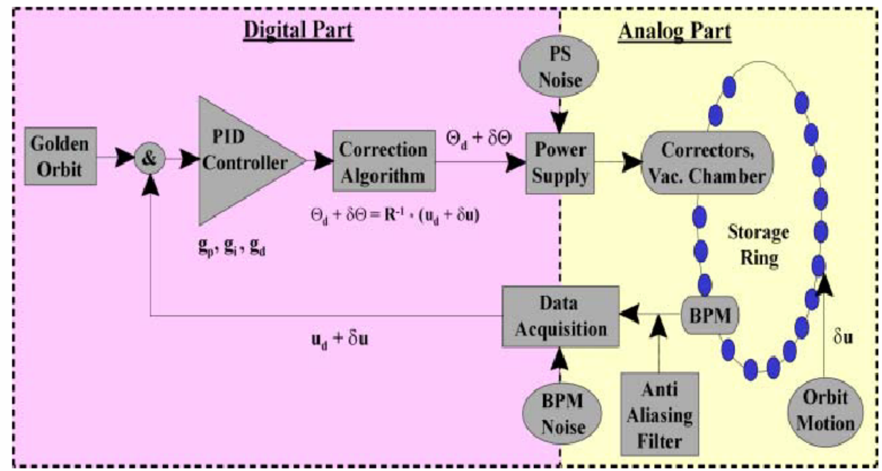


Figure 2: Block diagram of global orbit feedback.

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Super-ACO Fast Digital Feedback System

L.Cassinari PAC 99

APS

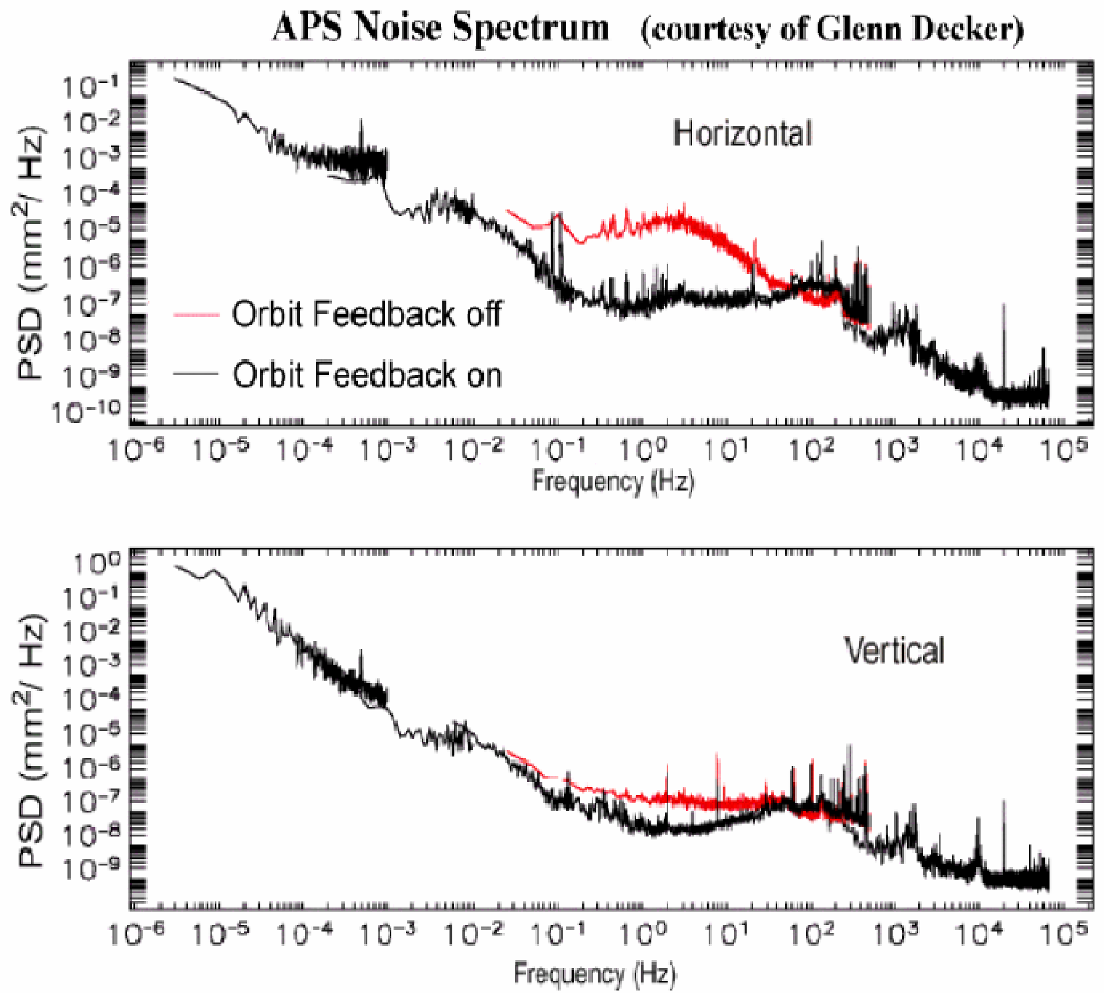

Figure 1: Power spectral density of noise sources at APS.

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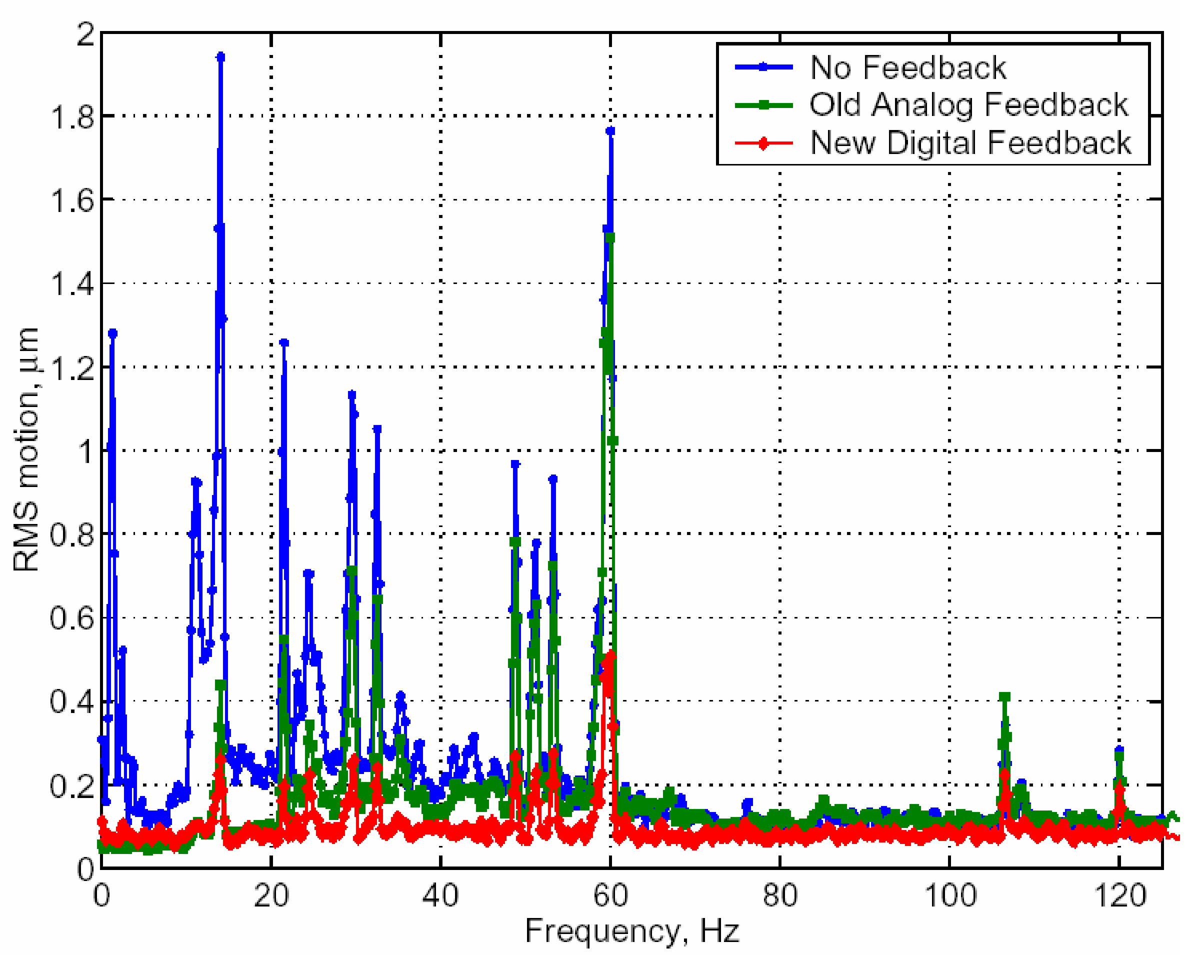
NSLS

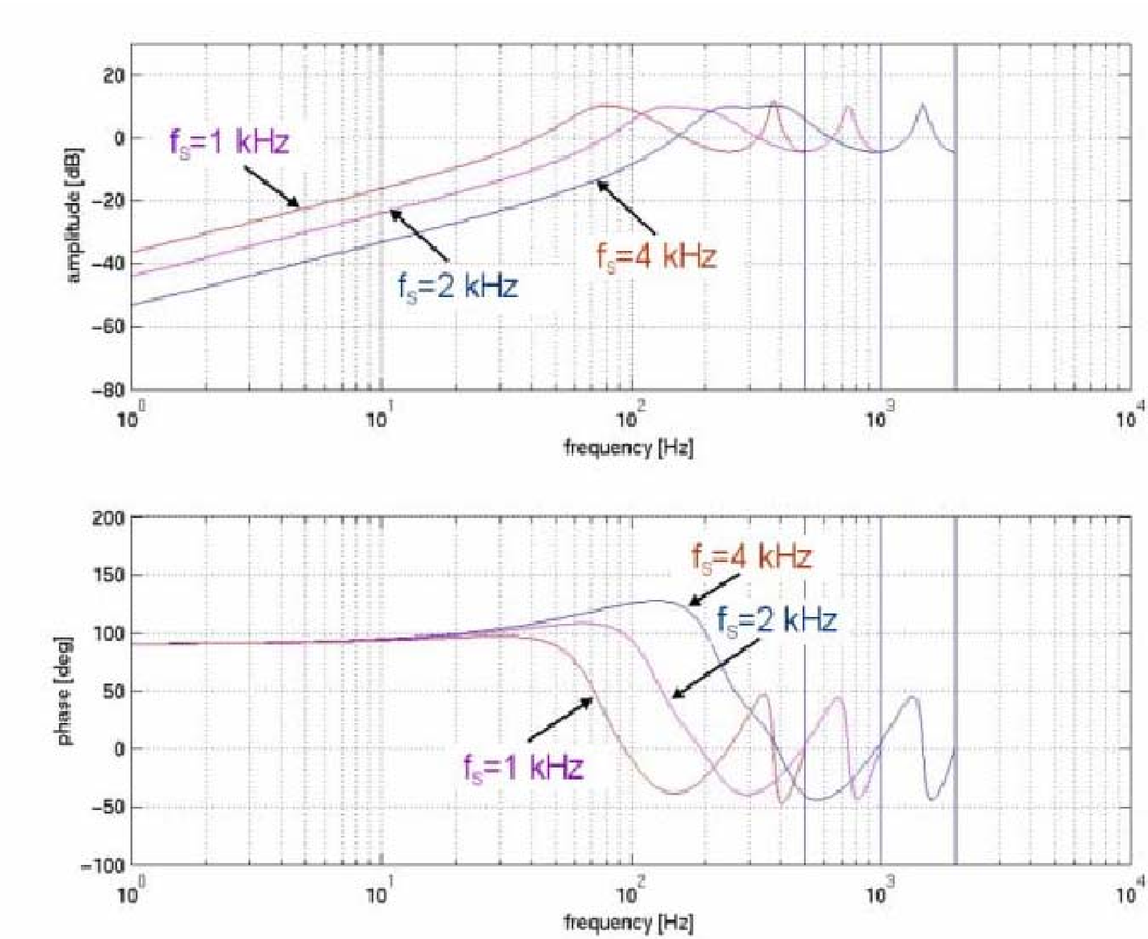


No Feedback
Old Analog Feedback
New Digital Feedback
RMS motion, µm
Frequency, Hz
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
20
40
60
80
100
120

Some Issues

- eBPM movements
  - » Decouple eBPM vacuum chambers
  - » SVD filtering of non-beam movements
  - » Measure the motion and compensate
- pBPMs Dipole contamination of undulator radiation
  - » Move the orbit (APS)
  - » Energy sensitive photon monitors (ELETTRA)
- eBPM Intensity/Fill pattern dependence
- BPM and Steering magnet resolution

BPM Sampling Frequency



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Dependency of closed position feedback loop on BPM sampling rate

Position Feedback Worldwide

Table 1: Position feedbacks in SR sources worldwide

SR facility	FB type	Monitors	max. BW	Stability
ALS*	G	rf-BPMs	< 100 Hz	< 1 μm
APS	G and L	rf & p-BPMs	< 30 Hz < 50 Hz *	< 2 μm < 1 μm *
NSLS	G	rf-BPMs	< 200 Hz	0.5 μm
SPEAR 3*	G	rf-BPMs	< 200 Hz	< 1 μm
BESSY *	L	rf and p-BPMs	< 100 Hz	< 1 μm
DELTA	G	rf-BPMs	< 1 Hz	< 5 μm
ELETTRA *	L	rf-BPMs	< 20 Hz	< 0.2 μm
ESRF	G	rf-BPMs	100 Hz	0.6 μm
MAX-lab	G	rf-BPMs	1 Hz	< 3 μm
SLS *	G	rf & p-BPMs	100 Hz	< 0.5 μm
SRS	~~L~~ G	p-BPMs	0.03 Hz	1 μm
SUPER-ACO	G	Rf-BPMs	< 150 Hz	< 5 μm
DIAMOND *	G	rf-BPMs	100 Hz	< 1 μm
SOLEIL *	G	rf and p-BPMs	100 Hz	0.2 μm
KEK-PF	G	rf-BPMs	3 Hz	< 5 μm
SPRING-8	G	rf-BPMs	< 0.01 Hz 200 Hz *	< 3 μm < 1 μm *

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