Christoph Steier

A. Biocca, S. Jacobson, L. Nadolski,

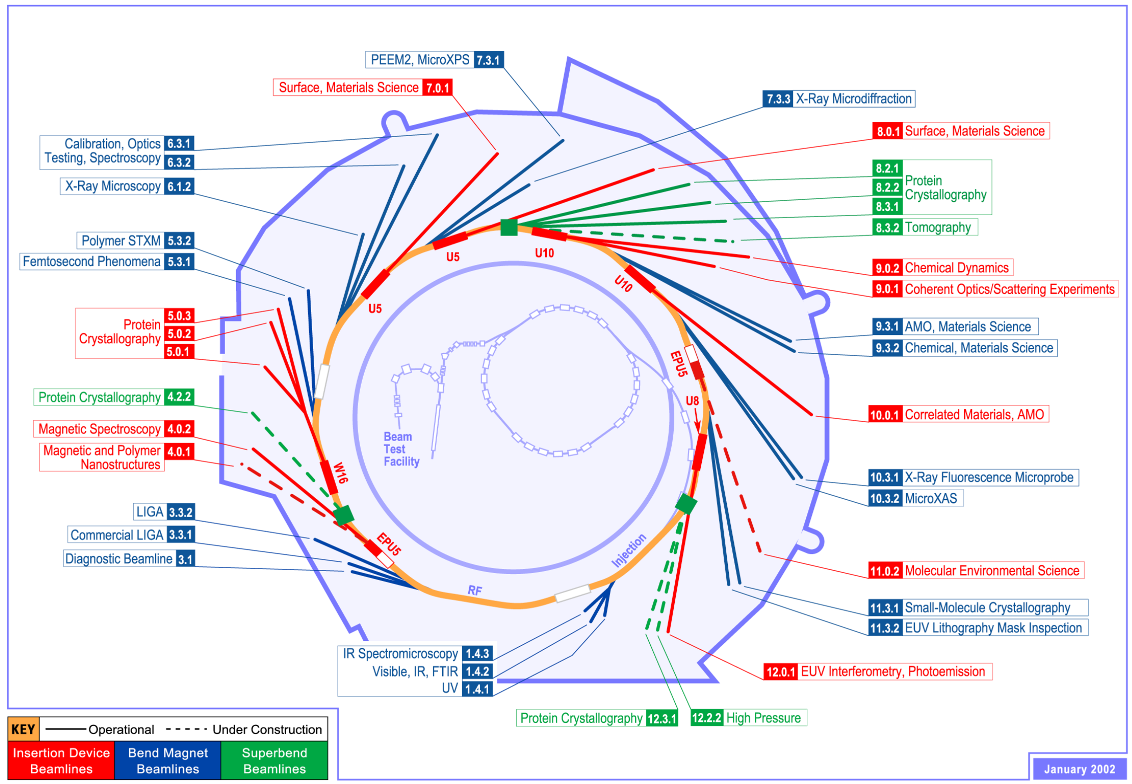
G. Portmann, T. Scarvie

ALS Accelerator Physics Group

- The Advanced Light Source
- Orbit Stability: Long term
- Recent slow feedback upgrades
- Example: RF frequency feedback
- Summary/future slow feedback development

ALS Parameters:

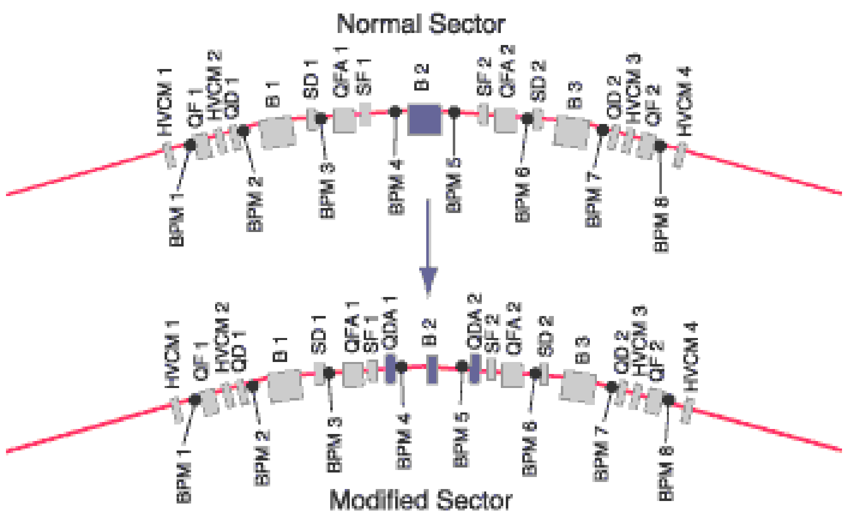
Nominal Energy	1.5-1.9 GeV
Circumference	196.8 m
RF frequency	499.642 MHz
Harmonic number	328
Beam current	400 mA multibunch 65 mA two-bunch
Nat. emittance	6.3 nm at 1.9 GeV
Emittance Coupling	Typical about 2%
Nat. energy spread	0.097%
Refill period	3 times daily multibunch, 12 times daily, two-bunch

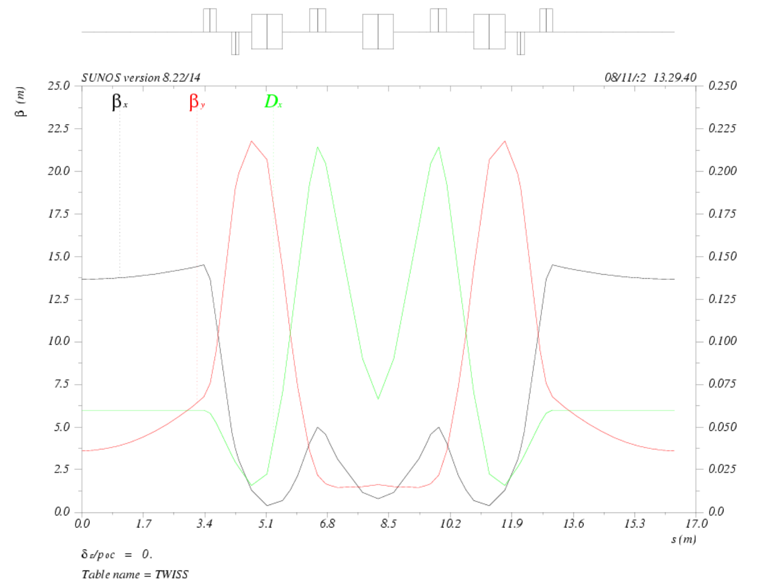


1/10 Electron Beam Size ⇒

Beam Location	Horizontal	Vertical
Straight Section	30 μm	2.3 μm
Bend Magnet #2	10.3 μm	1.3 μm

ALS Lattice

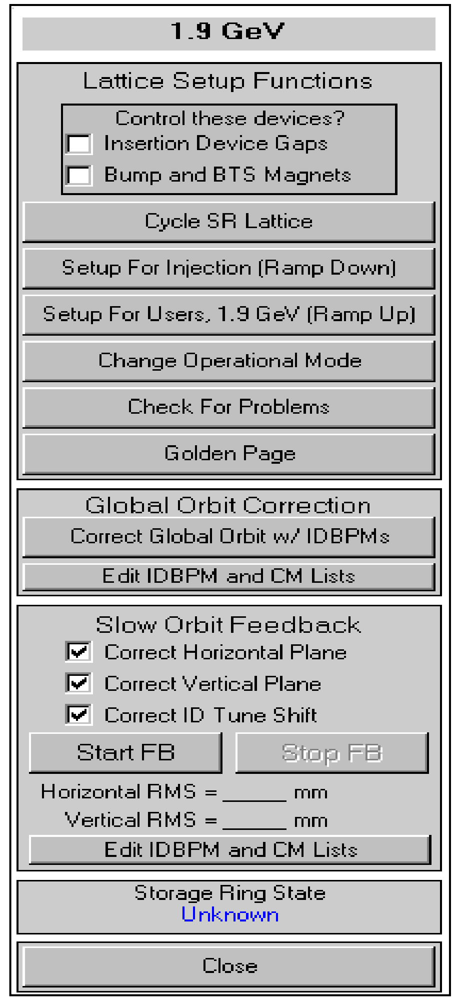




- 12 nearly identical arcs – TBA; aluminum vacuum chamber
- 96 + 40 beam position monitors (about 4 of stable type per arc)
- 8 horizontal, 6 vertical corrector magnets per arc
- 18 individual skew quadrupoles
- beam based alignment capability in all quadrupoles (either individual power supplies or shunts)
- 22 corrector magnets in each plane on especially thin vacuum chamber pieces

Software used for slow orbit feedback

- All ALS high level controls accelerator physics routines are implememted in Matlab
- Orbit feedback is controlled using a GUI which allows to ramp for injection, do single orbit corrections, standardize the lattice, etc.
- Matlab includes all Matrix manipulation tools necessary and has proven to be very reliable
- Code is very flexible (algorithm development is simple and can if urgent need arises even be done during user operation)
- Compiled version (does not need Matlab license) exists



Achieved orbit stability at ALS

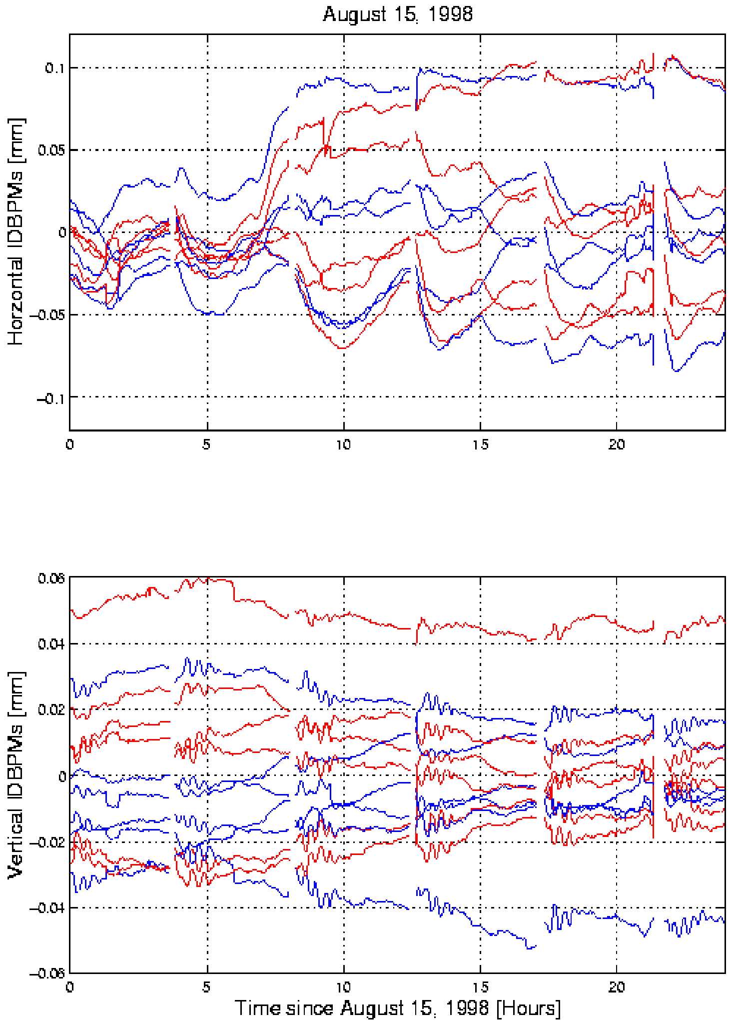
Frequency	Magnitude	Dominant Cause
1 hour – 2 weeks	±3 µm Horizontal ±5 µm Vertical	1. BPM chamber motion 2. BPM electronics drift and systematic errors 3. Limited number of BPMs/correctors
Minutes	< 1 µm	1. BPM noise and beam vibration (aliasing) 2. Corrector resolution (digitization)
.2 to 300 Hz	3 µm Horizontal 1 µm Vertical	1. Ground vibrations 2. Cooling water vibrations 3. Power supply ripple 4. Feed forward errors

Beam Stability in straight sections w/ Orbit Feedback and w/ Insertion Device Feed-Forward

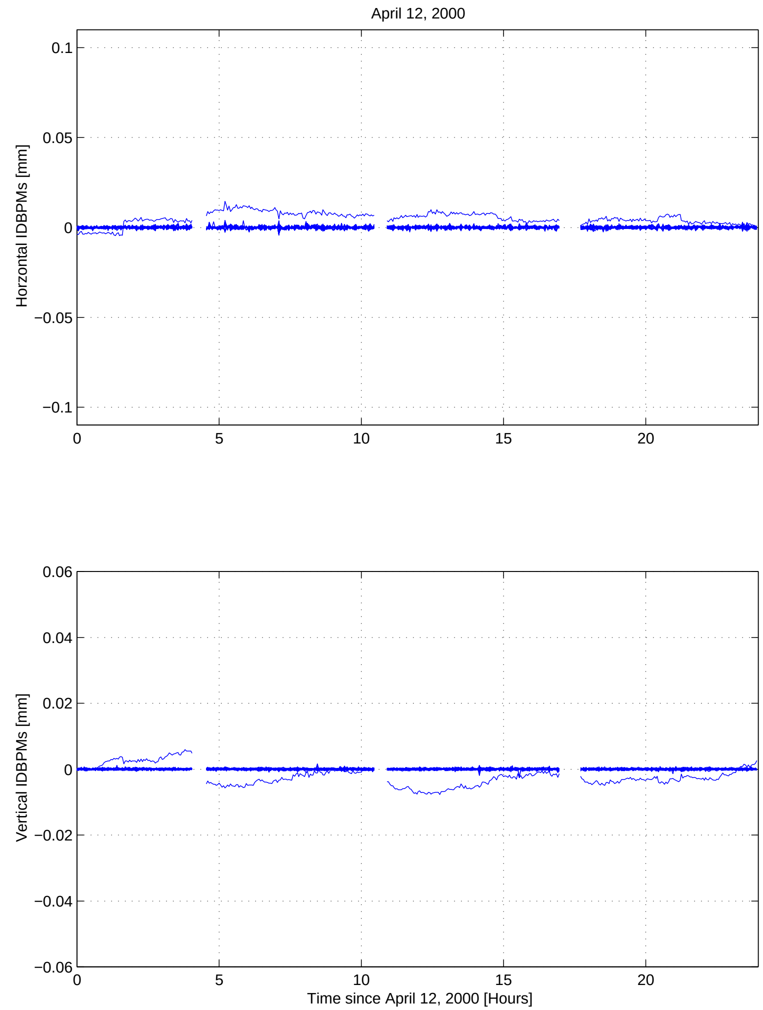
- Improve long term stability with measurement of physical BPM location (relative to ground plate)

DAILY ORBIT VARIATIONS WITH AND WITHOUT SLOW ORBIT FEEDBACK

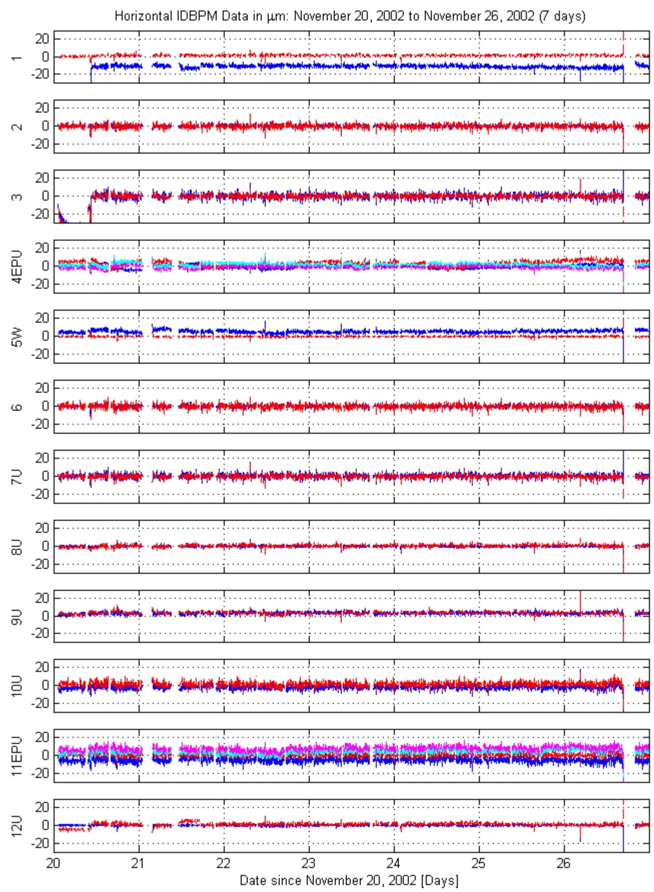
August 15, 1998: w/ ID Compensation
w/o Orbit Correction
w/o Slow Orbit Feedback

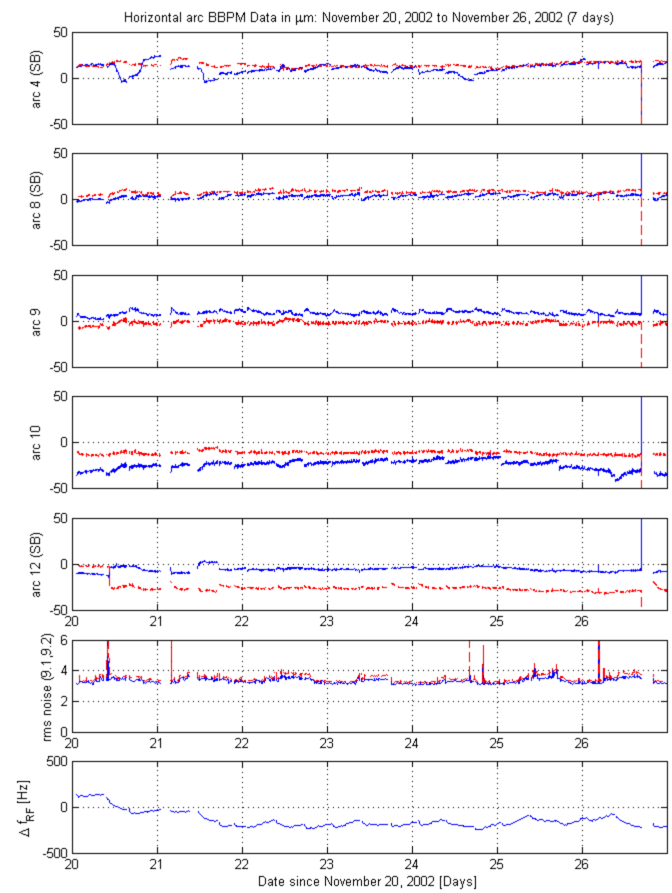


April 12, 2000: w/ ID Compensation
w/ Orbit Correction
w/ Slow Orbit Feedback



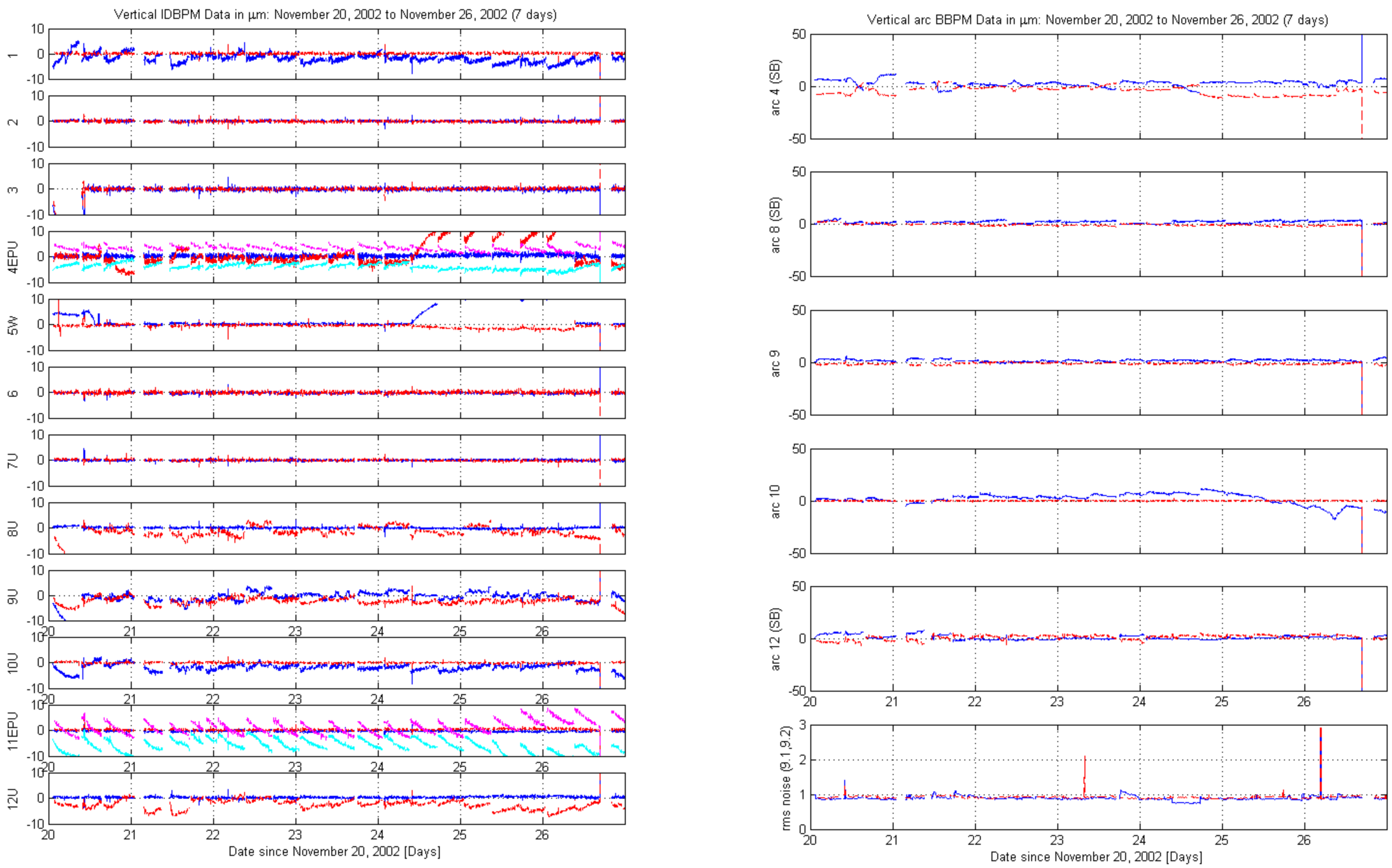
Orbit feedback performance over 1 week





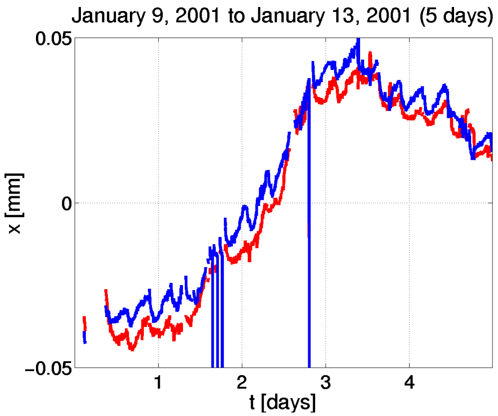
- ❖ Slow orbit feedback is performing very well in horizontal plane
- ❖ Typically better than 1/50 of beam size (system is underconstrained!)

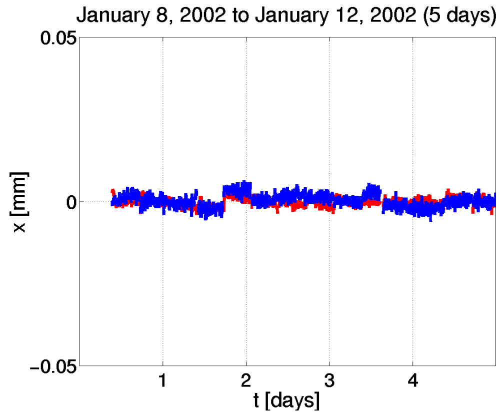
Orbit feedback performance over 1 week II

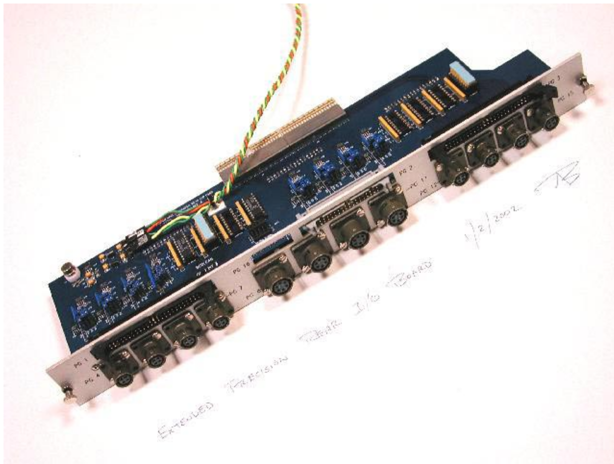


- ❖ Slow orbit feedback is performing well in vertical plane
- ❖ Some BPMs clearly are problematic (thermal behaviour + drift)
- ❖ Again system is underconstrained

Recent Upgrades





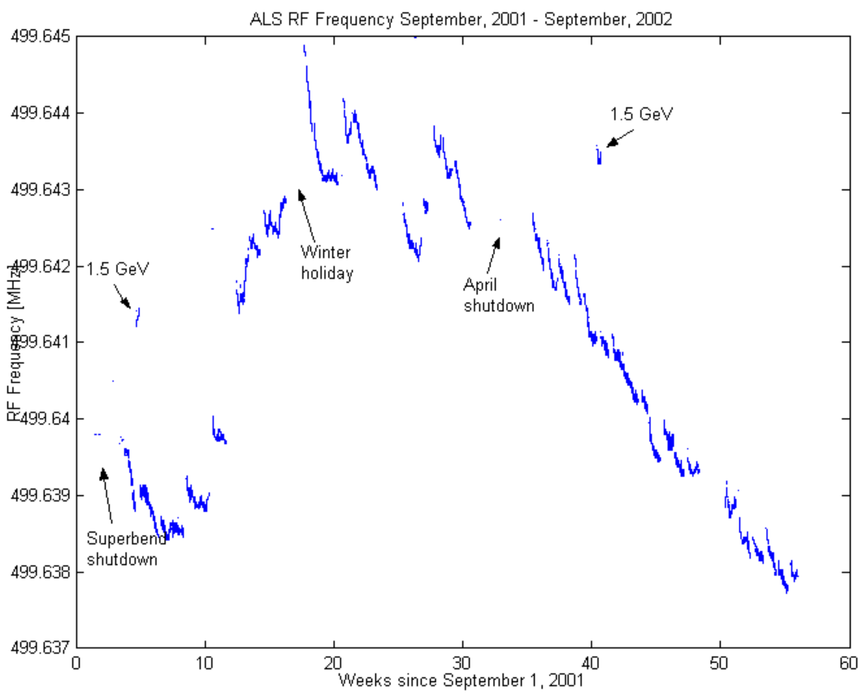


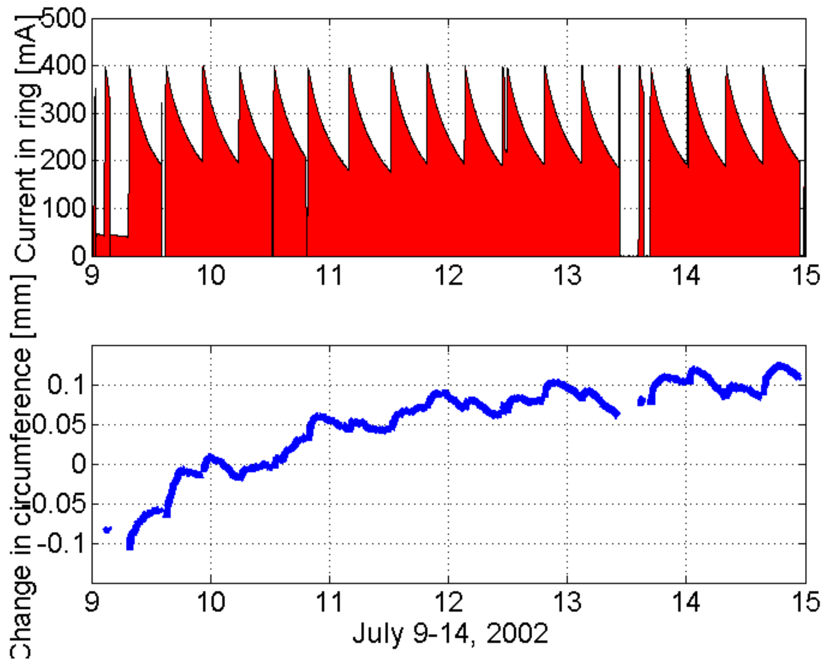
- RF-frequency feedback (significantly improved horizontal orbit stability in arcs, and the beam energy stability)
- 20 Bit D/A converters

Two staged 16 Bit DACs, analog summing junction, low pass filter for coarse DAC, feedback only uses fine DAC

- No digitization noise from SVD – mid term orbit stability now typically submicron
- Subsequent installation of additional stable BPMs inside all arcs (only 6 arcs and all straights are equipped so far) in response to a direct user request
- Inclusion of additional corrector magnets
- Reduction of aliasing problems with multiplexing noise of new Bergoz BPMs

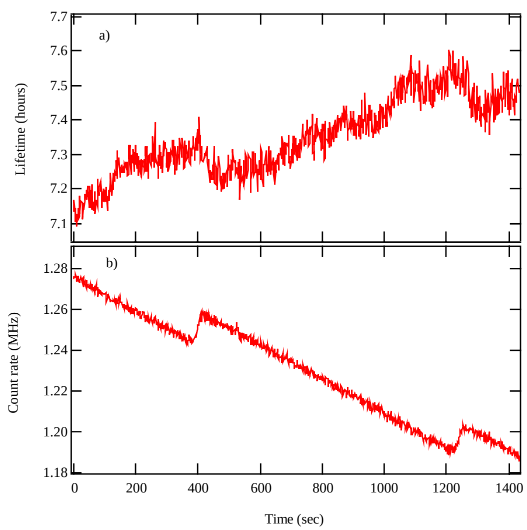
RF-Frequency Feedback

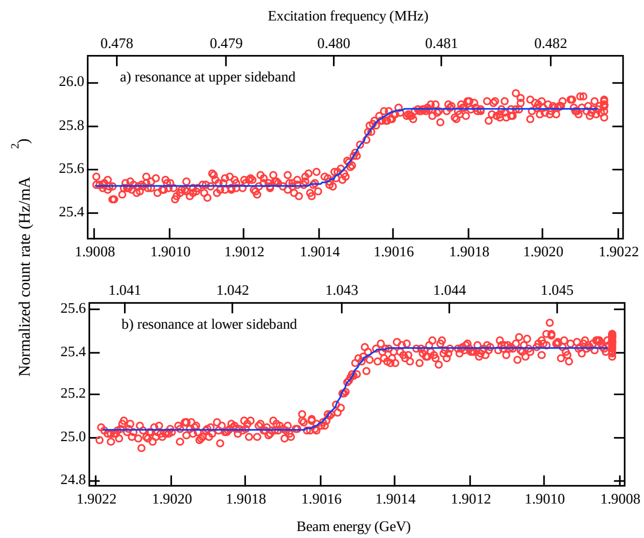


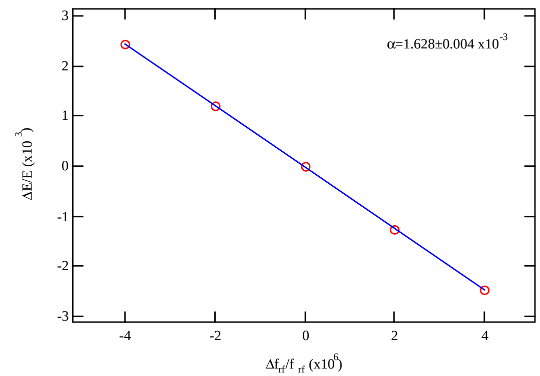


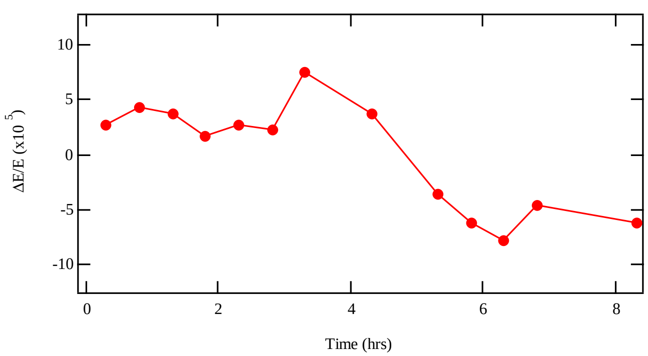
- Largest long term effect is rain season (plus outside temperature)
- Short term the fill cycle has a strong effect (heating), but insertion device gap changes are equally important and in an FFT also tidal effects show up

Energy calibration (resonant depolarization)









- High precision measurement of beam energy is relatively simple at low energy light sources like ALS
- Allows some conclusions about long term orbit/magnet/ground plate stability
- Verified the RF-frequency feedback at ALS

Summary

- *The slow orbit stability at the ALS is constantly being improved*
- *Main improvement comes from slow orbit feedback*
- *Most user requirements are fulfilled right now, but experiments get more advanced*
- *To get below 1/10 of a beamsize in the the vertical plane, position monitoring of BPMs or even better thermal stability is necessary*
- *Higher DAC resolution improved stability on s to min timescale significantly*
- *Continue to upgrade more BPMs to stable electronics and buttons*
- *BPM performance is crucial and currently we have to chase a lot of intermittent problems – we will work on better automated diagnostic*