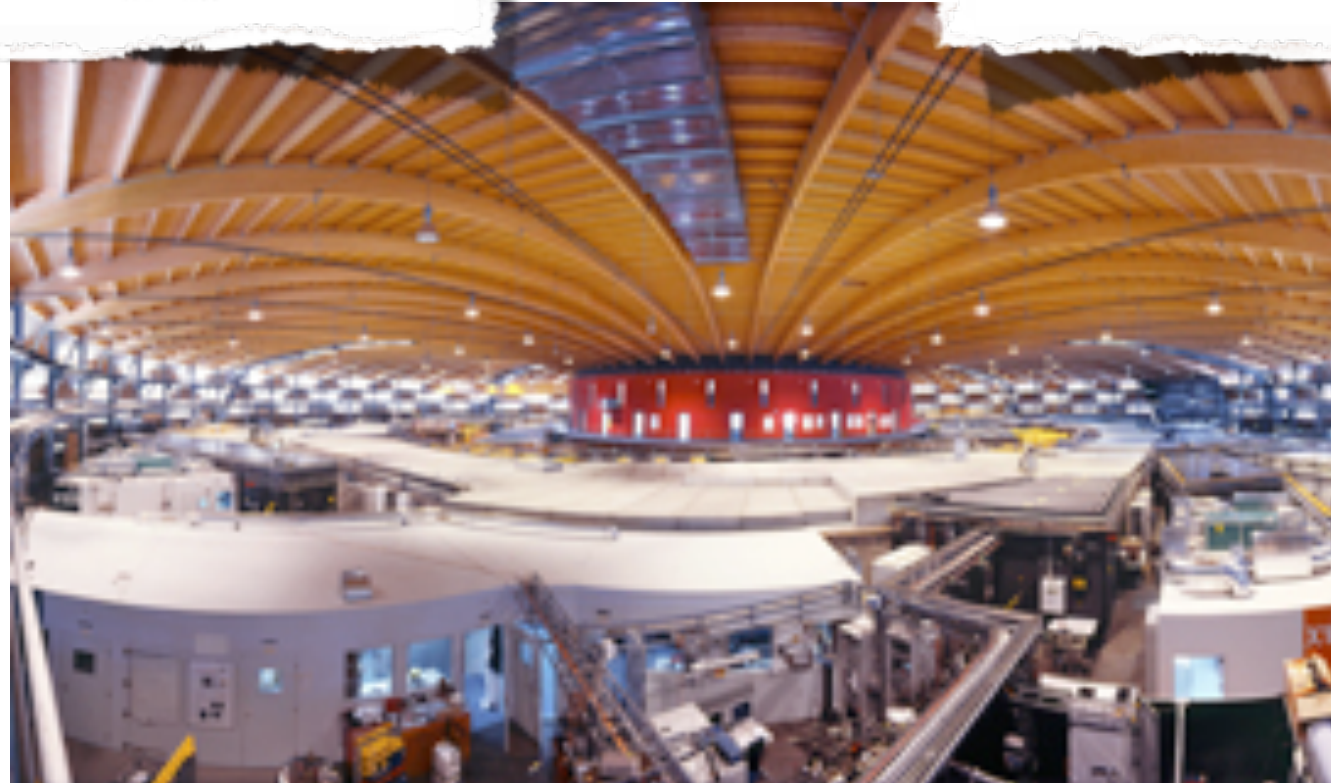
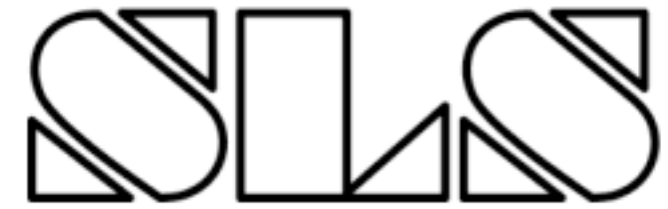


PAUL SCHERRER INSTITUT



SWISS LIGHT SOURCE



SLS Status Report/2009

Natalia Prado de Abreu

XVIIth european synchrotron radiation light source workshop 2009

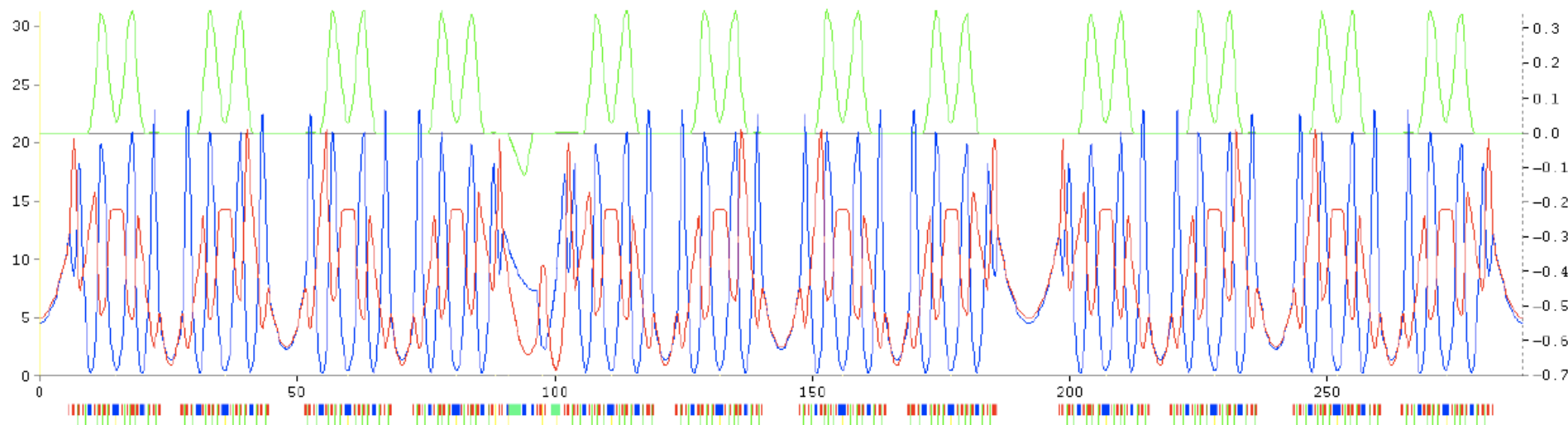
26th and 27th November, Hamburg, Germany

Outline

- Overview of the SLS;
- This year improvements:
 - Multipoles, Coupling and Optics correction
[Michael Böge, “*Emittance Control at the SLS*”. 26th Nov. at 17:50],
 - New Filling Modes and
 - Low Alpha Operation; 
- Closing Remarks.

Current Status: **In operation since 2001**

- Availability: Jan-Nov 2009 : 98,7% (from 2002-08 : 96%)
- 2.4 GeV, 288 m circumference, 12 TBA
- Emittances: $\epsilon_x=5.0-6.9$ nm rad and $\epsilon_y=3-10$ pm rad
- Current 400 ± 1 mA (top-up), lifetime 5-10 hours
- 480 bunches (500 MHz RF)
- Filling mode: 390 x~1mA + 1x5mA



Optics (β_x β_y η) in standard user operation mode at working point 20.43 / 8.74

Multipole Correctors, Coupling & Optics Correction (1)

- All 120 sextupoles in SLS were delivered with H&V correctors coils → make skew quadrupoles and auxiliary sextupoles. 24 skew quads for **betatron coupling** correction, 12 skew quads for **vertical dispersion** correction and 12 aux. sextupoles for **resonance suppression**.

Dispersive and non-dispersive
Skew quads

$$h_{00101} \Rightarrow Q_y \Rightarrow \eta_y$$

$$h_{10100} \Rightarrow Q_x + Q_y$$

$$h_{10010} \Rightarrow Q_x - Q_y$$

Sextupoles

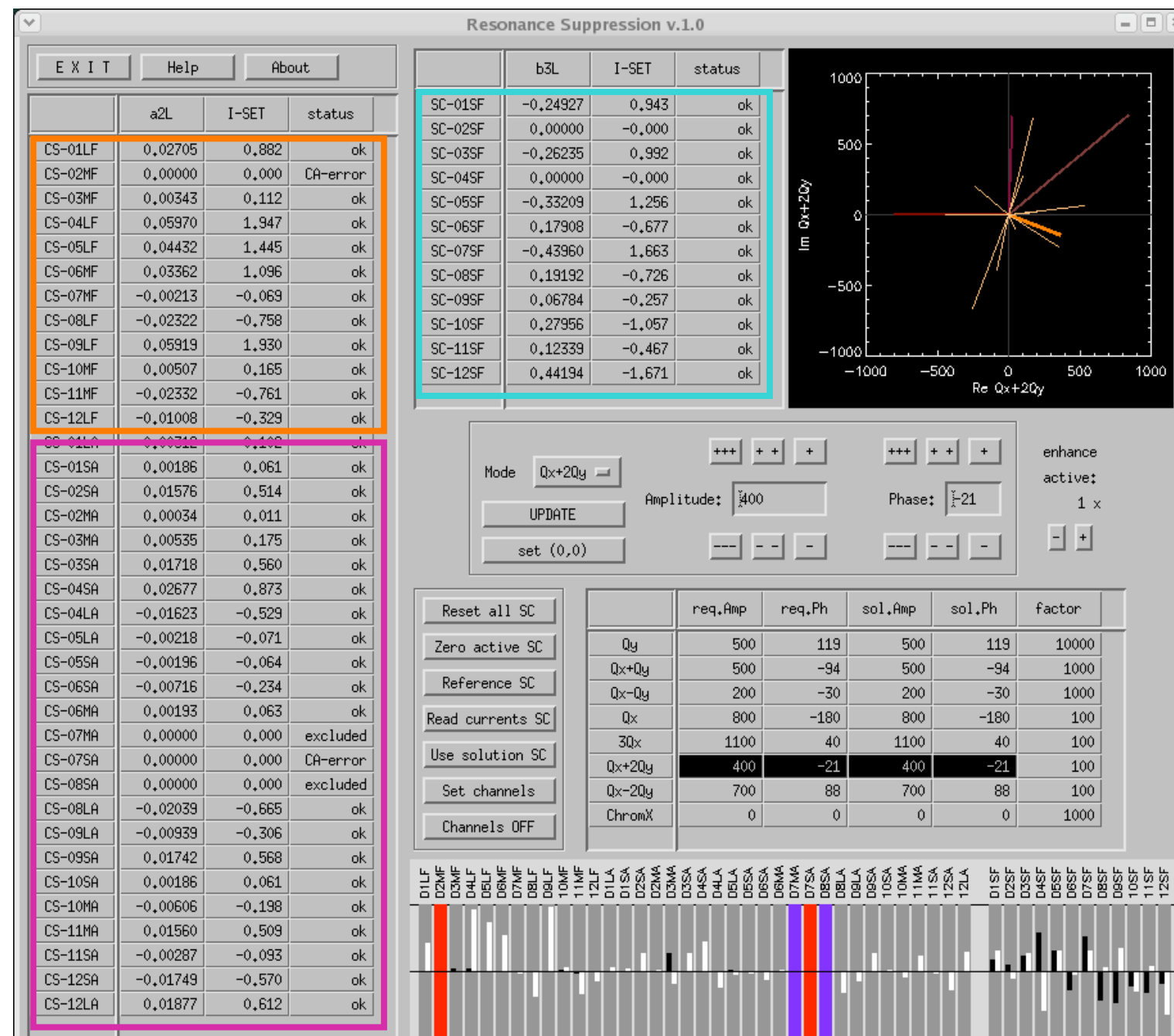
$$h_{21000} \Rightarrow Q_x$$

$$h_{30000} \Rightarrow 3Q_x$$

$$h_{10200} \Rightarrow Q_x + 2Q_y$$

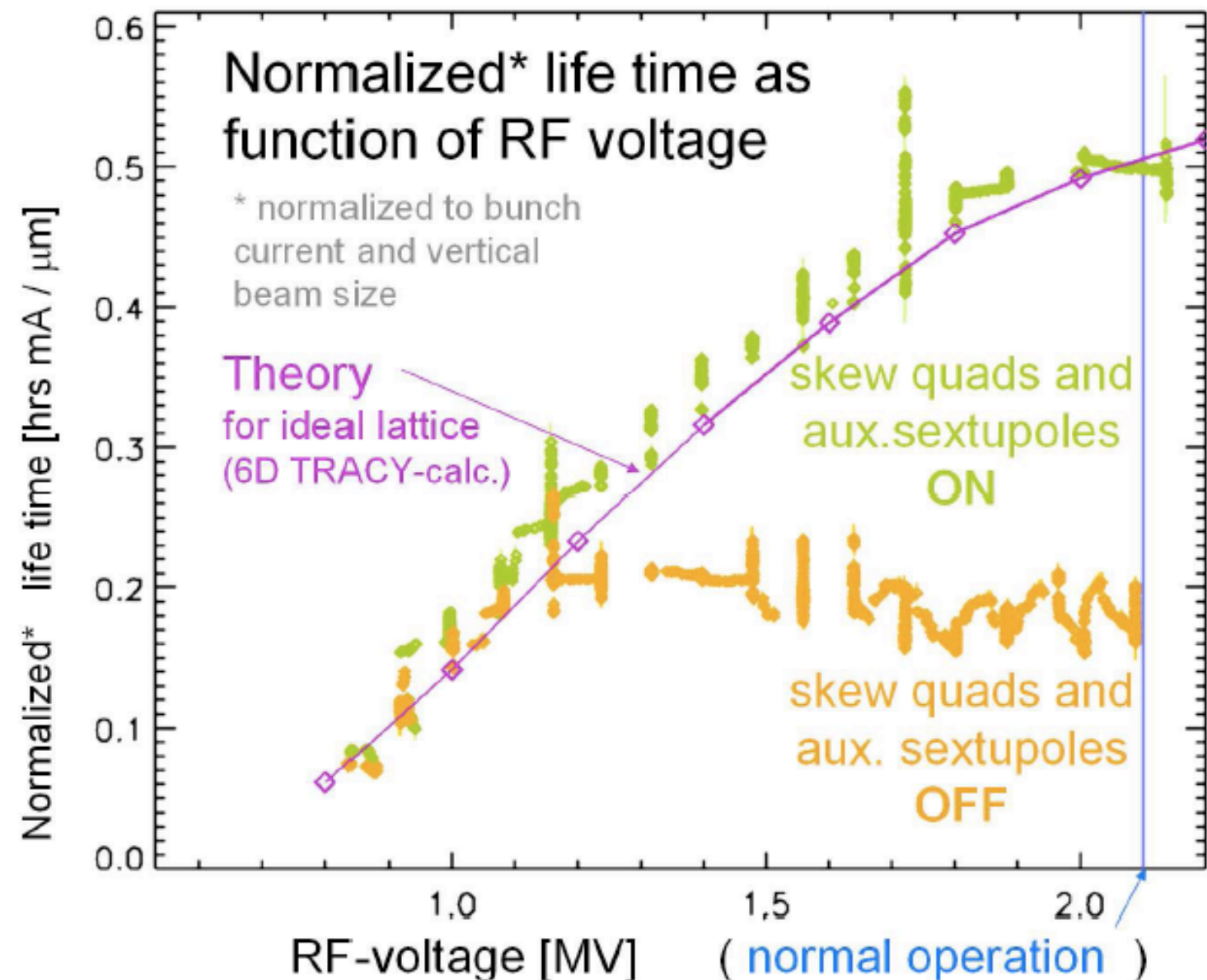
$$h_{10020} \Rightarrow Q_x - 2Q_y$$

the σ_v/τ operator tool



Multipole Correctors, Coupling & Optics Correction (2)

- Symmetrization of sextupole patterns. Nonlinear optics correction → beam lifetime
- coupling correction (achieved 0.05% coupling with an emittance of 2.8 pm) and
- resonance tuning (restored the 3% energy acceptance → Touschek Lifetime)
- Lifetime in agreement with theory
- The optimization tool still empirical → in the future we plan to use Bartolini's method for optimization.



Ref.: M. Böge et al., *Correction of imperfections in the SLS storage ring*, PAC'09

New Filling Modes

Ref.: N. Abreu et al., *New filling patterns for SLS FEMTO*
SLS-TME-TA-2009-0317

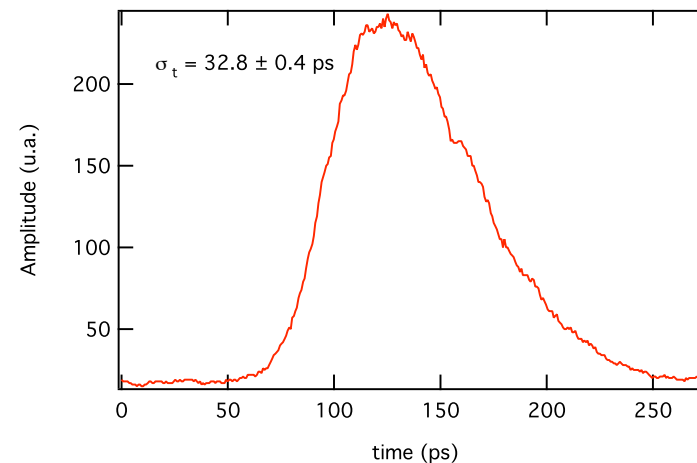
- Filling pattern feedback allows the use of any filling, however not every filling is stable;

- Stable operating modes:

- Hybrid 5 (400 mA)

- Comb 60 (240 mA)

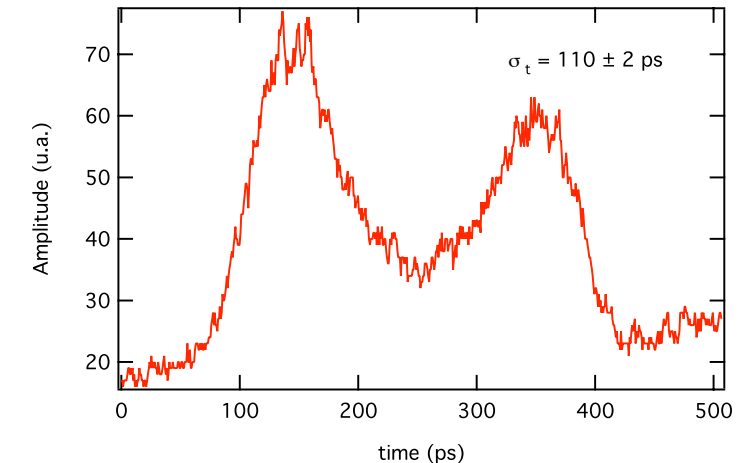
FEMTO
upgrade?



5x(36+camshaft)

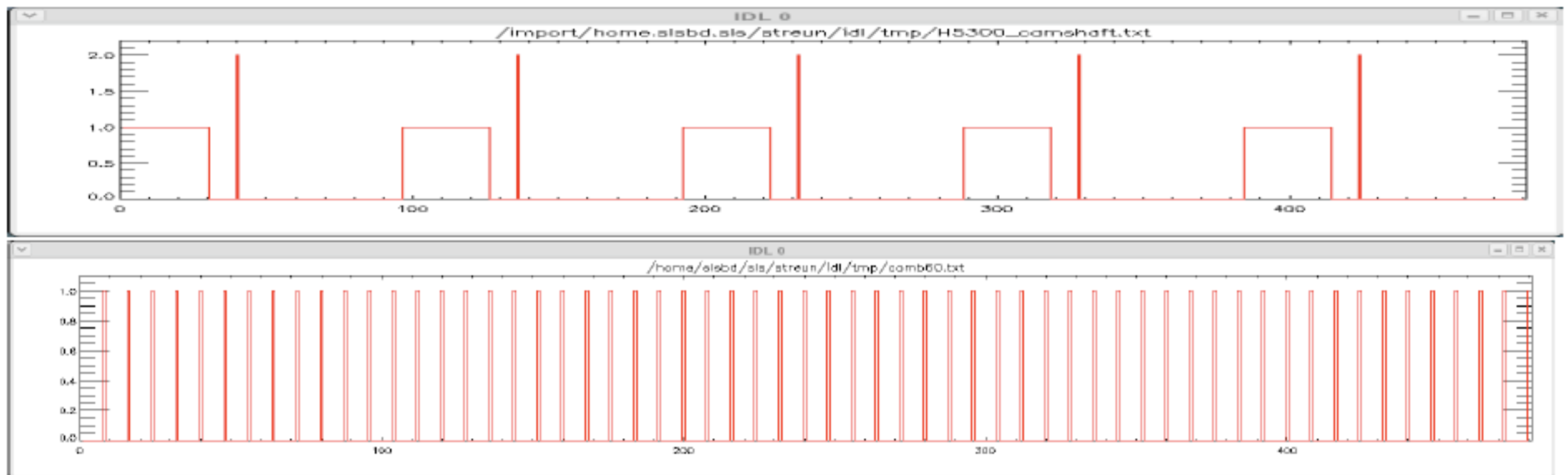
stable

Streak camera measurement
of the "camshaft" bunch



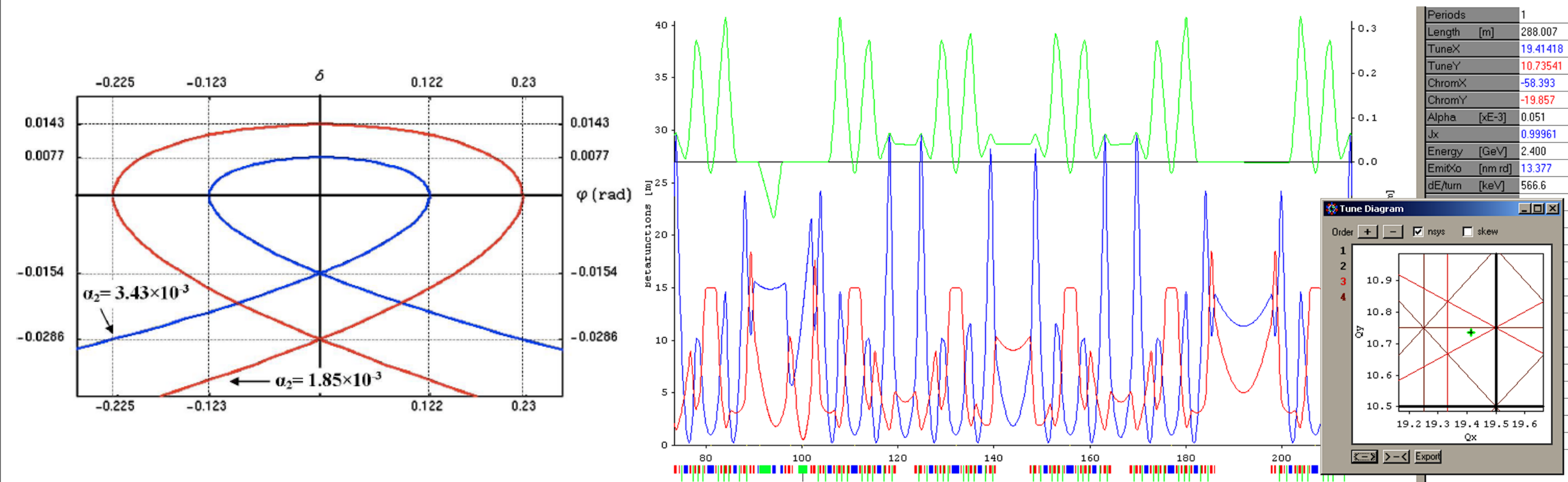
5x(60+camshaft)

unstable

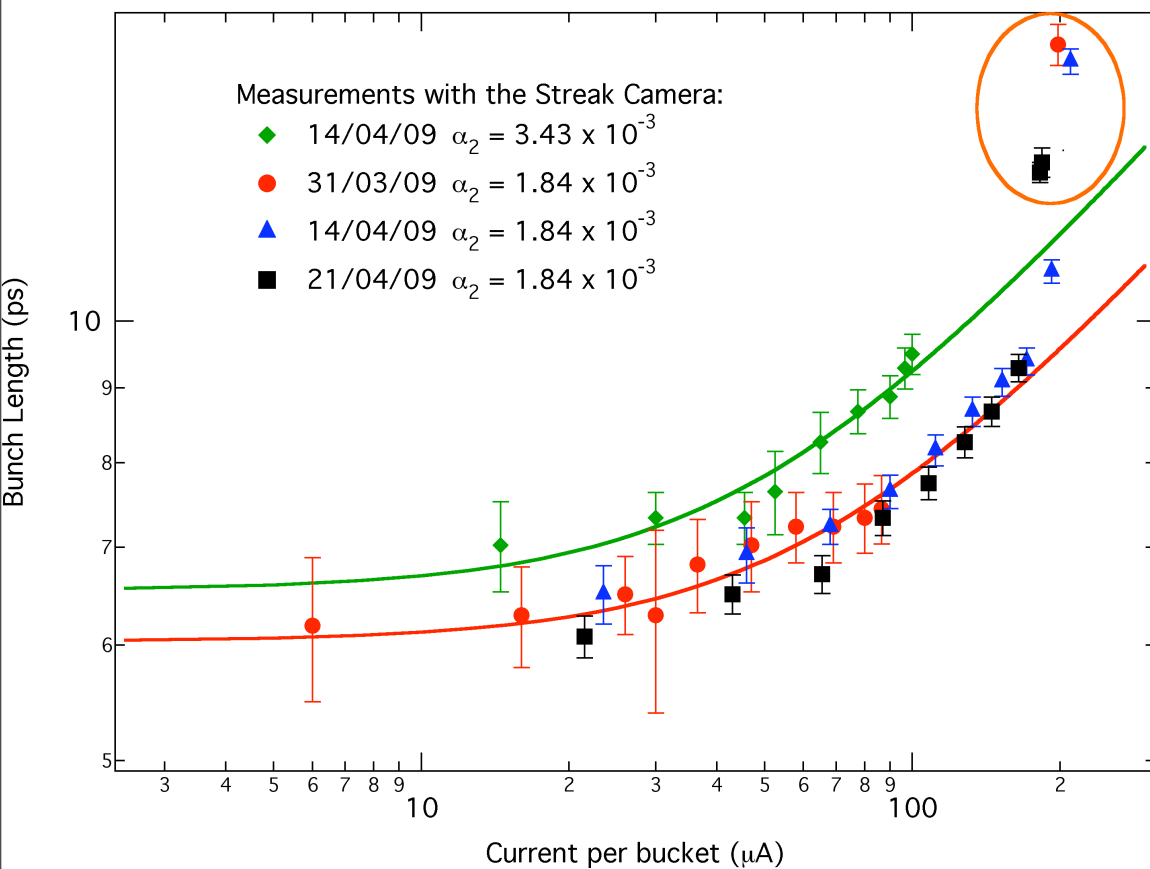


Low-alpha Operation (1)

- Operation with < 8 ps bunches for time resolved experiments;
- Total current: 50 mA (0.12 mA/bunch), top-up mode
- $\alpha_1 = 6 \times 10^{-4} \rightarrow 4 \times 10^{-5}$ (we can operate with two different values of α_2)
- we have the fast orbit feedback running normally (after some adjustments to the software to include non linear response)



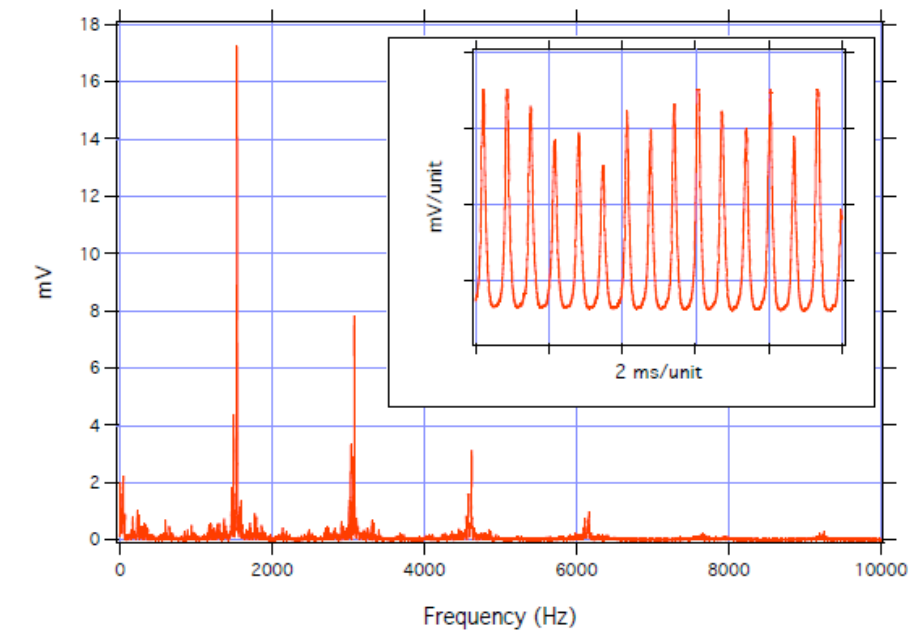
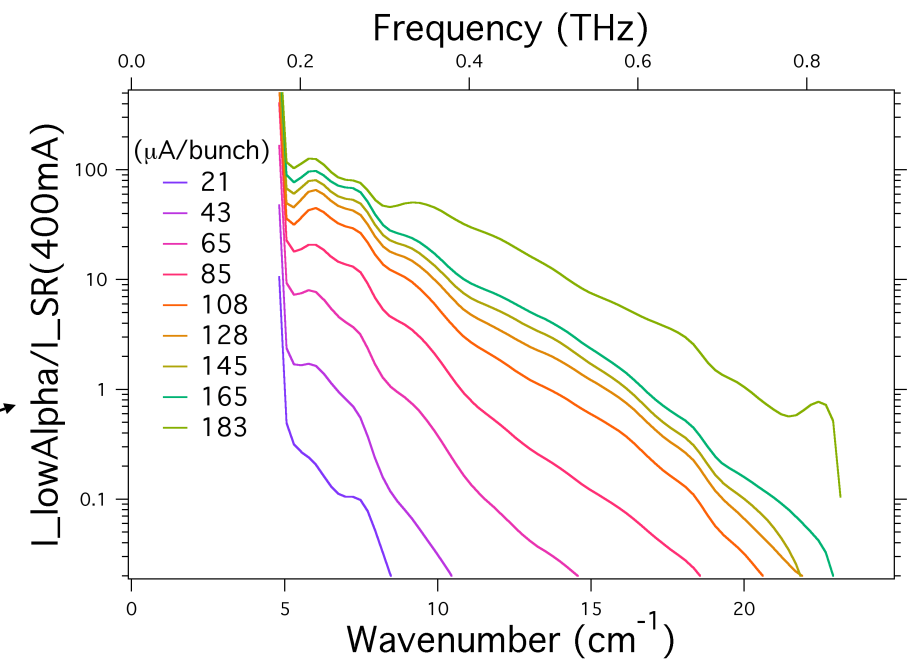
Low-alpha Operation (2)



bunch length
vs. current and
 $\sigma \sim I^{3/8}$ fit

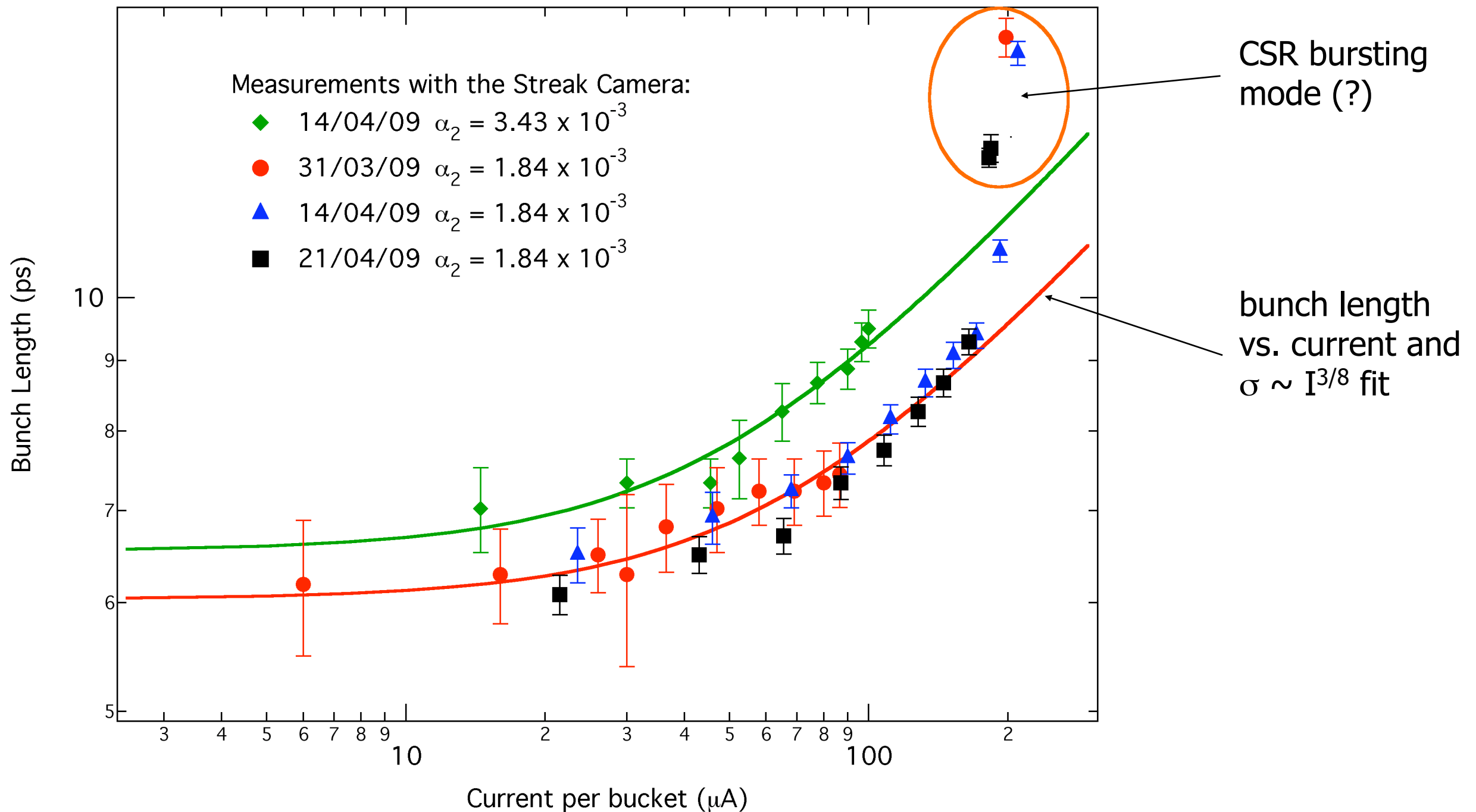
C THz spectra
for different
currents
(H. Sigg, F. Müller)

CTHz bursts
at 1.6 kHz
(= sync. freq.)
for 0.18 mA
bunch current



→ Low-alpha operation scheduled for 2010: 2×7 shifts

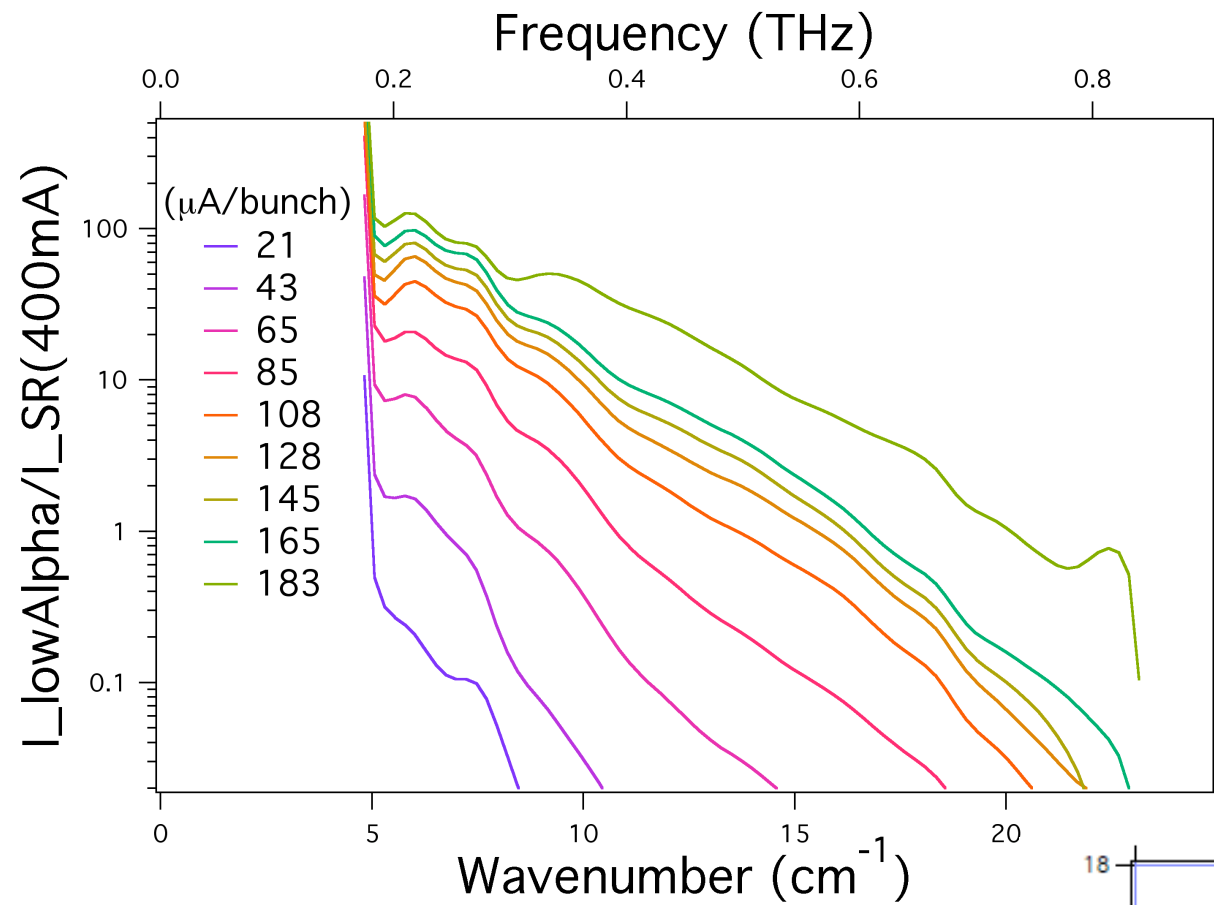
Low-alpha Operation (2)



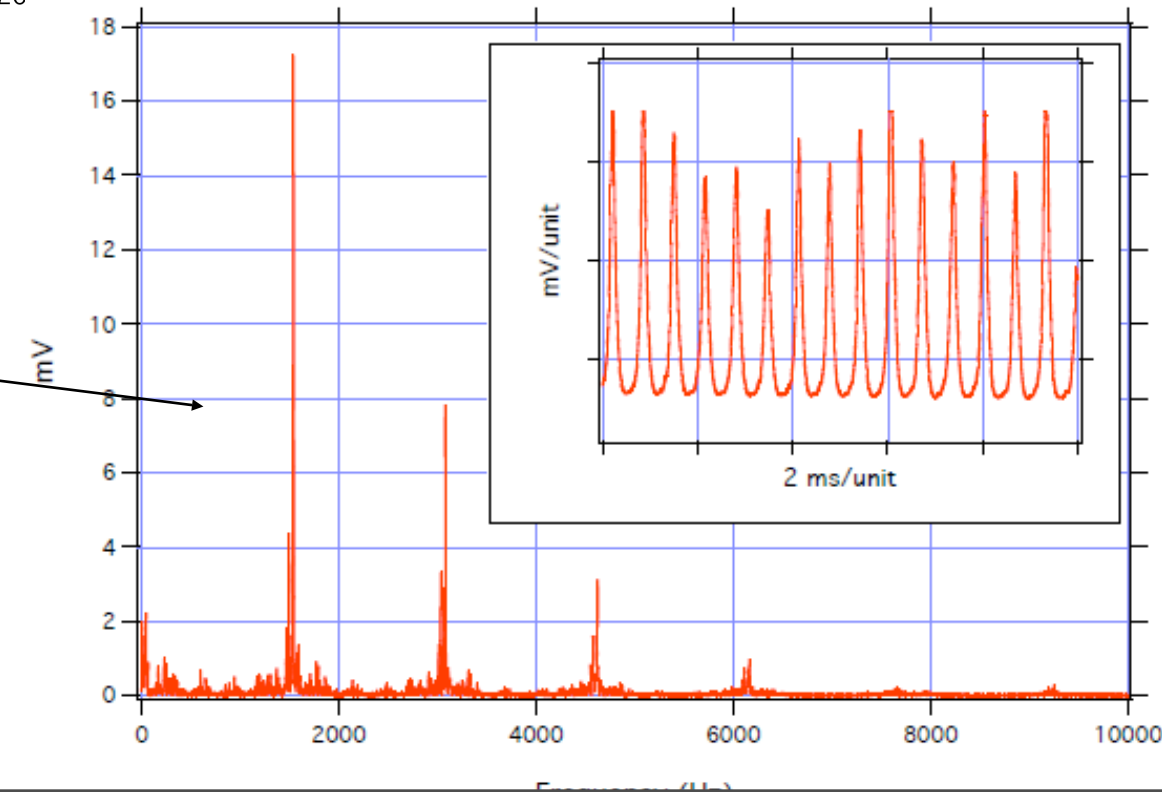
→ Low-alpha operation scheduled for 2010: 2×7 shifts

Low-alpha Operation (2)

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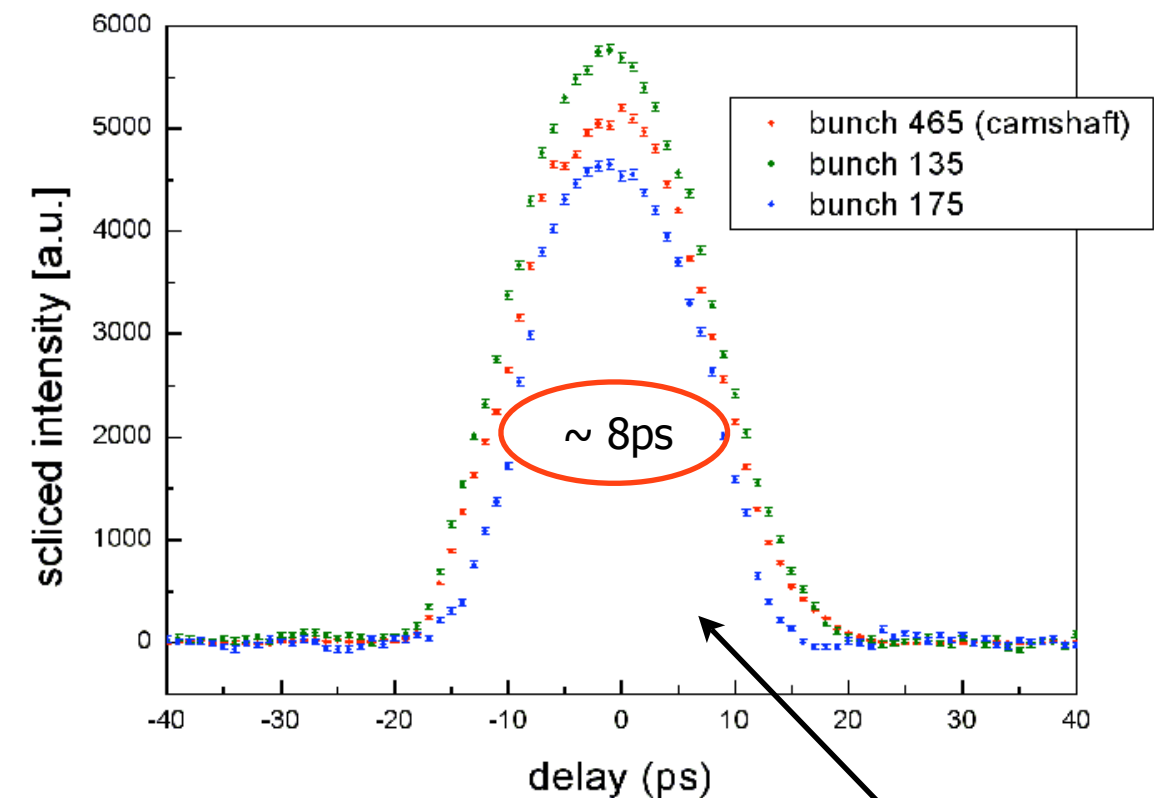
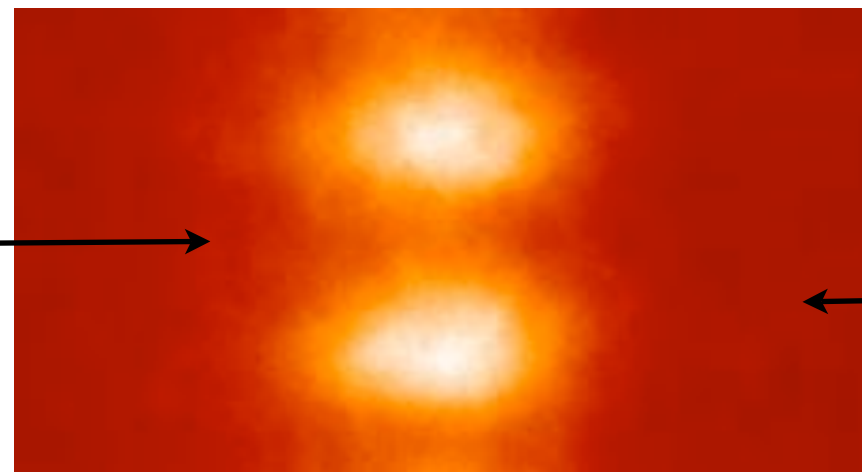
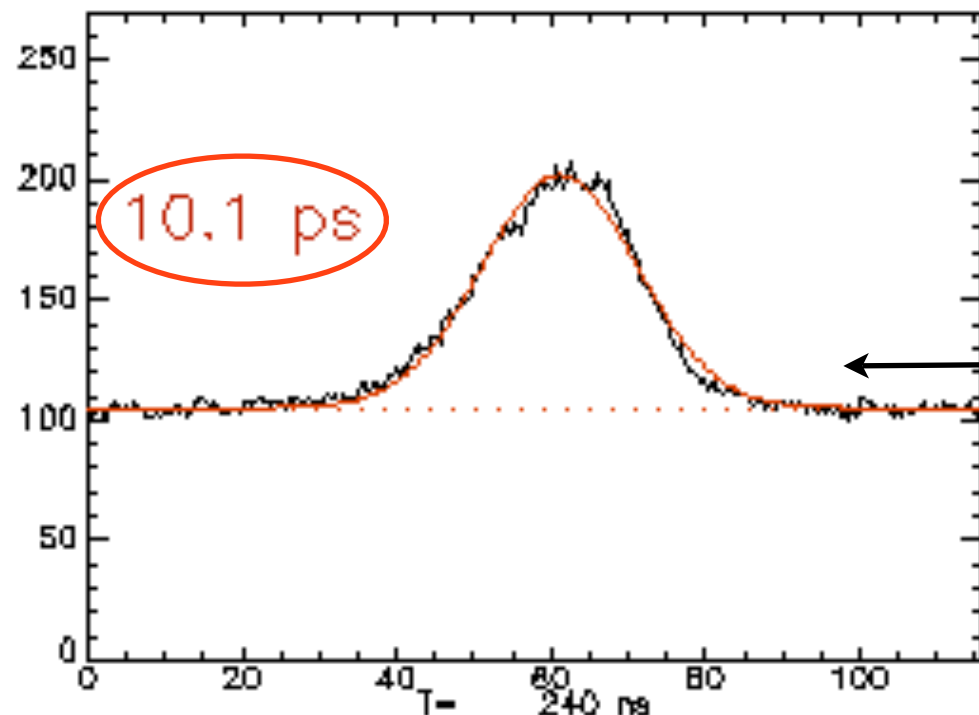


CTHz bursts
at 1.6 kHz
(= sync. freq.)
for 0.18 mA
bunch current



Low-alpha Operation (3)

- Beamline tests: 27/Set and 17/Nov 2009
- Filling: 50 mA (390 + 1 camshaft with the same intensity as the other bunches)
- Lifetime: 4.2 hrs @ 50 mA
- Working point: $Q_x=19.42$ and $Q_y=10.73$



Sliced intensity for
3 different bunches
(Paul Beaud)

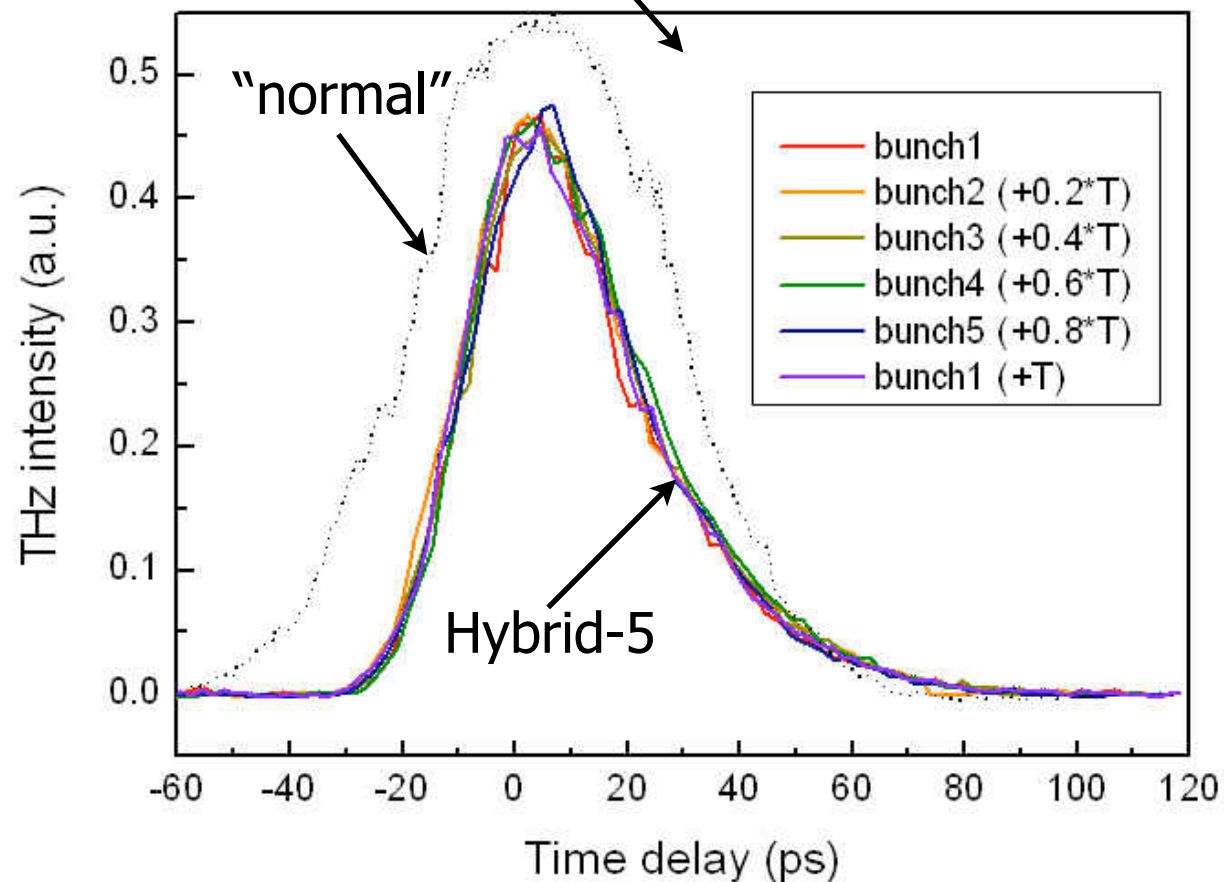
Longitudinal profile
measured with the
streak camera
(Helge Brands)

Closing Remarks

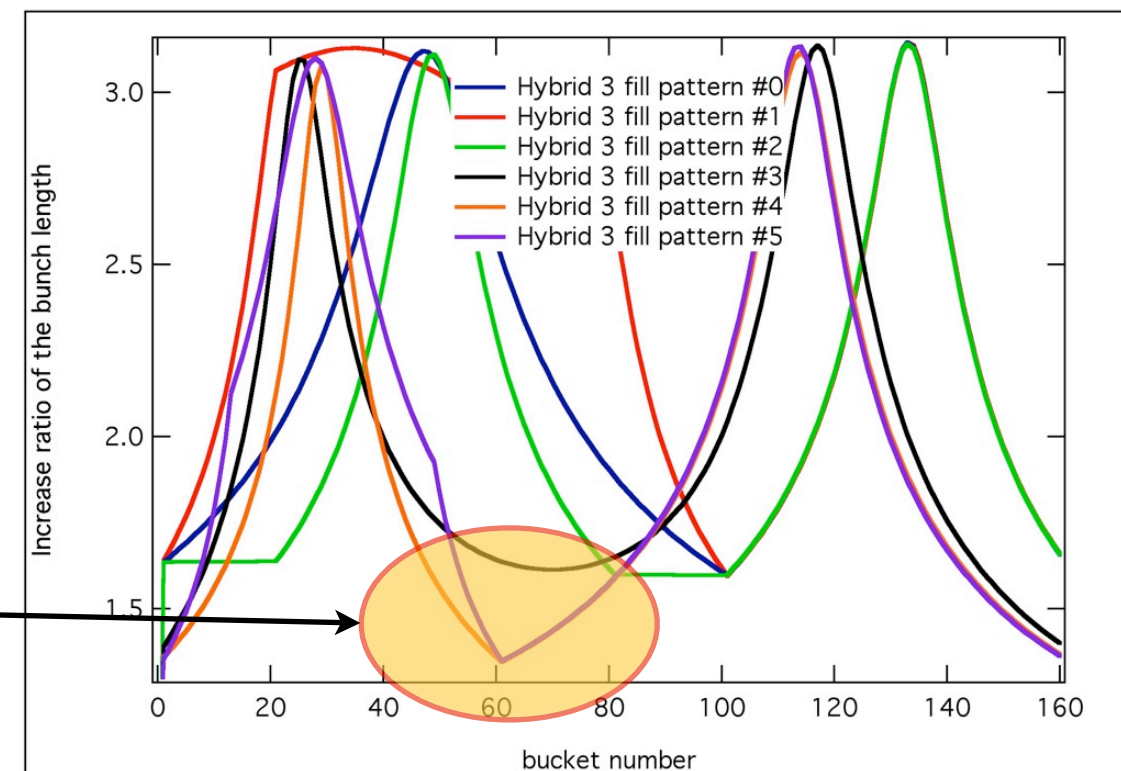
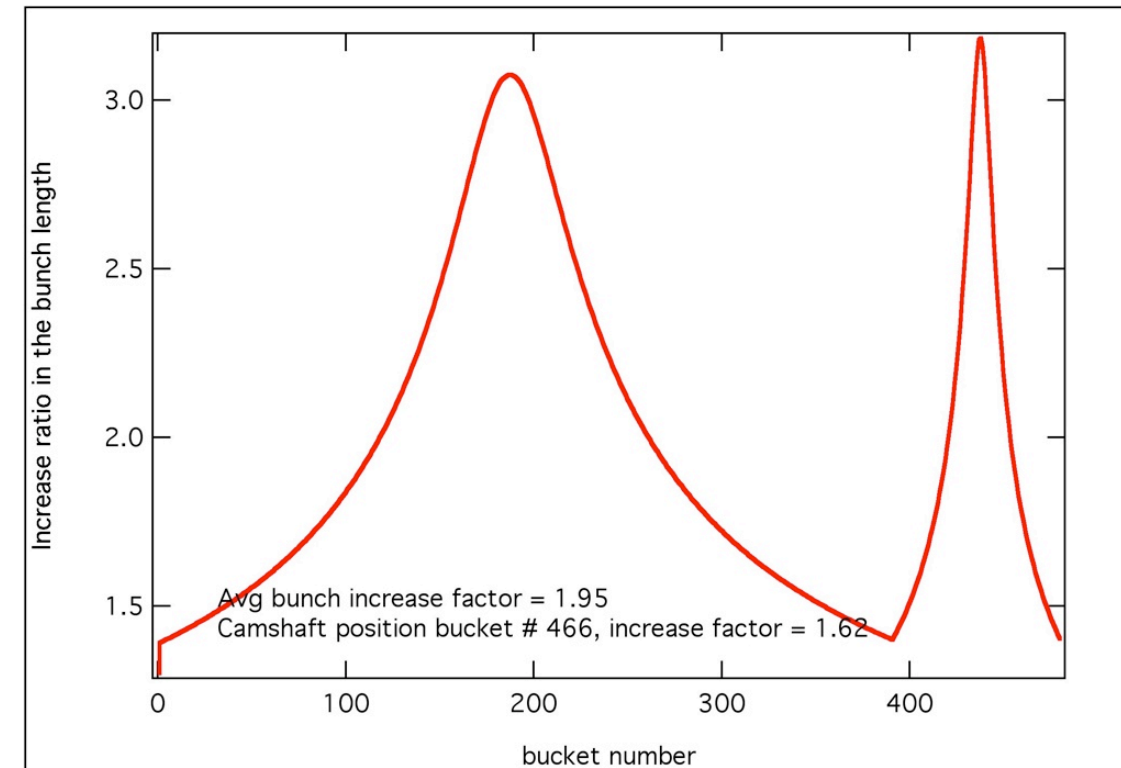
- Coupling suppression using 36 skew quads and 73 BPMs achieved a vertical emittance of 2.8 pm, just a factor 5 above the natural limit, corresponding to 0.05% emittance coupling.
- Resonance tuning using 36 skew quads and 12 auxiliary sextupoles restored the 3% energy acceptance and the calculated Touschek lifetime of the ideal lattice.
- New stable filling modes are possible for the SLS (according to user's demands).
- SLS is operating in low α mode, with 2 x 7 user's shifts scheduled for 2010.

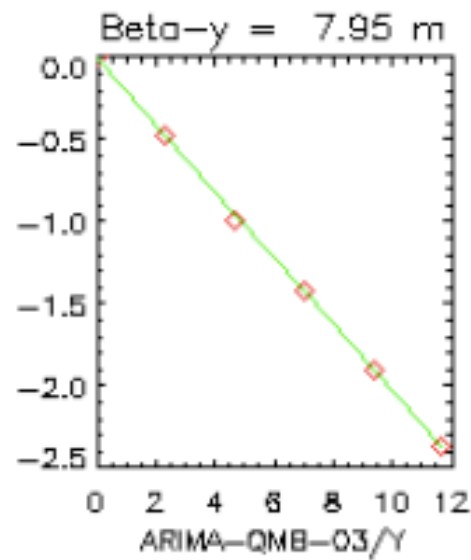
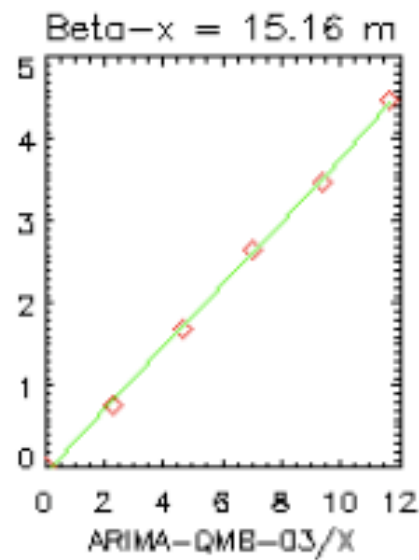
New Filling Modes: Instabilities (2)

Comparison of the THZ sliced scan for the "normal" camshaft and for the Hybrid-5 mode

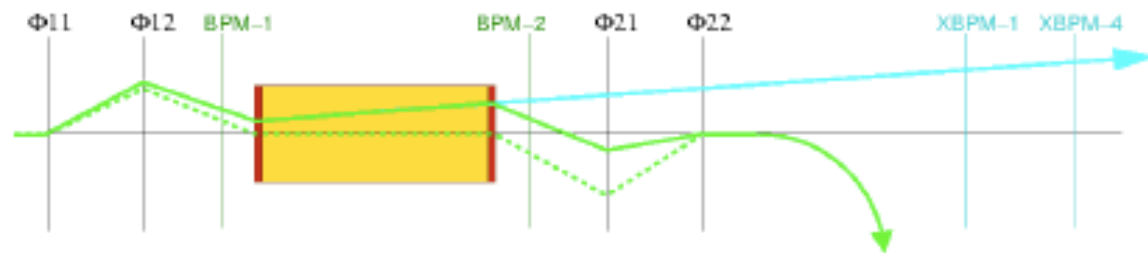


It is possible to have shorter bunches if you increase the phase transient in the 3HC

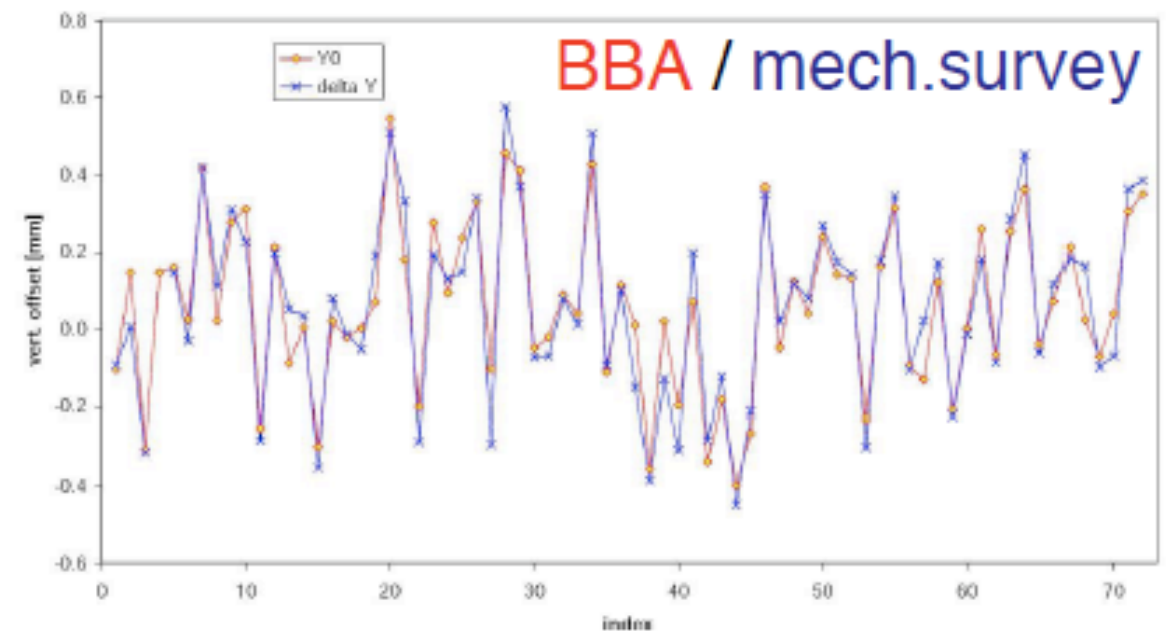




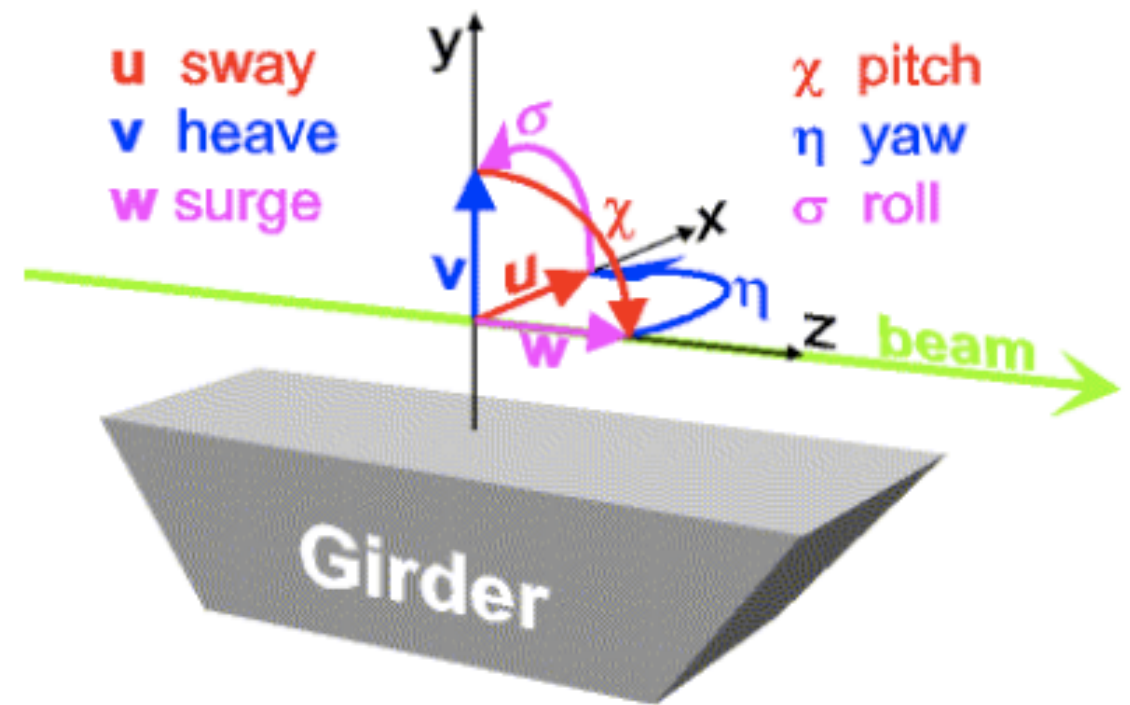
Beta function measurement:
tune change from quad variation
→ calculation of **current corrections**
(SLS has individual quad PS !)



Feed forward corrections for IDs:
orbit and, for Femto modulator, tune



BPM calibration (Beam based alignment)



Girder dynamic realignment

Multipole Correctors, Coupling
& Optics Correction (3)