Recent Developments at Diamond Light Source

Richard P. Walker, on behalf of the Diamond Machine Team

1. **Introduction**
2. **Top-up**
3. **Low-alpha**
4. **Low gap ID operation**
5. **Other ID developments**
6. **Beam stability**

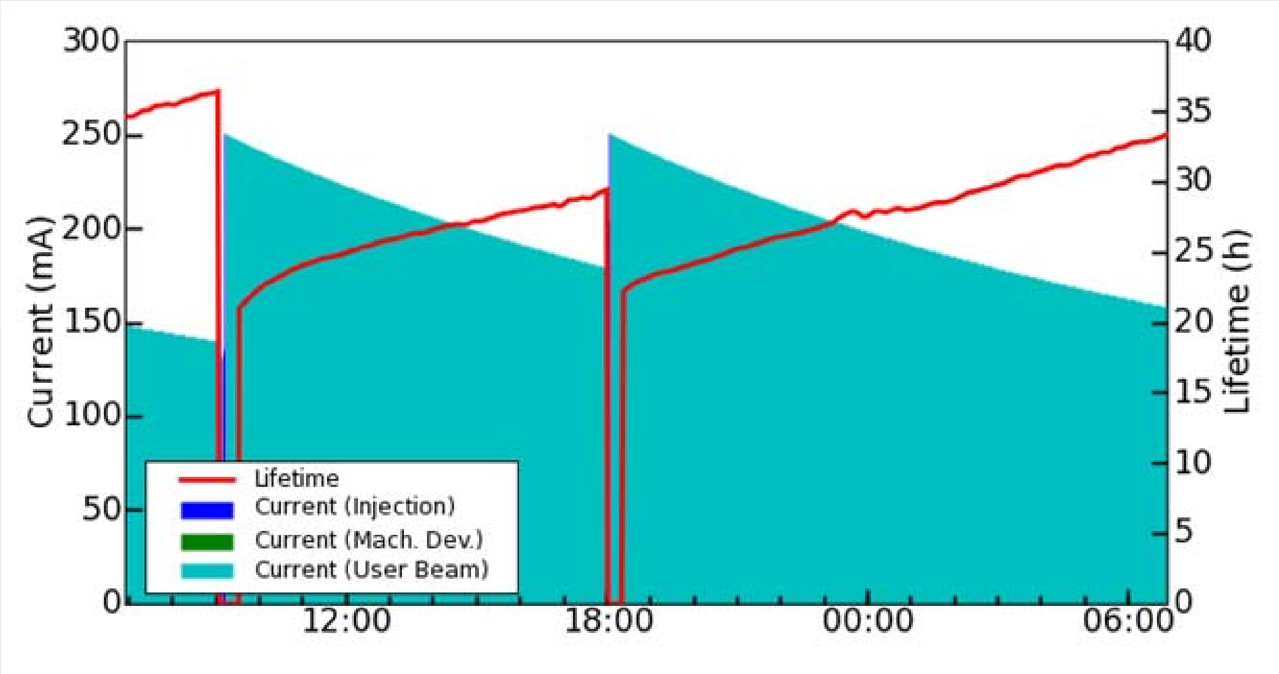
Diamond Main Parameters

Circumference	**561.6 m**	
Energy	**3 GeV**	
Current	**300 mA**	***(250 mA user mode)***
Lifetime	**20 h**	
Emittance		
- horizontal	**2.7 nm**	
- vertical	**2.7–50 pm**	***(27 pm user mode)***
Min. ID gap	**5-7 mm**	

Top-Up

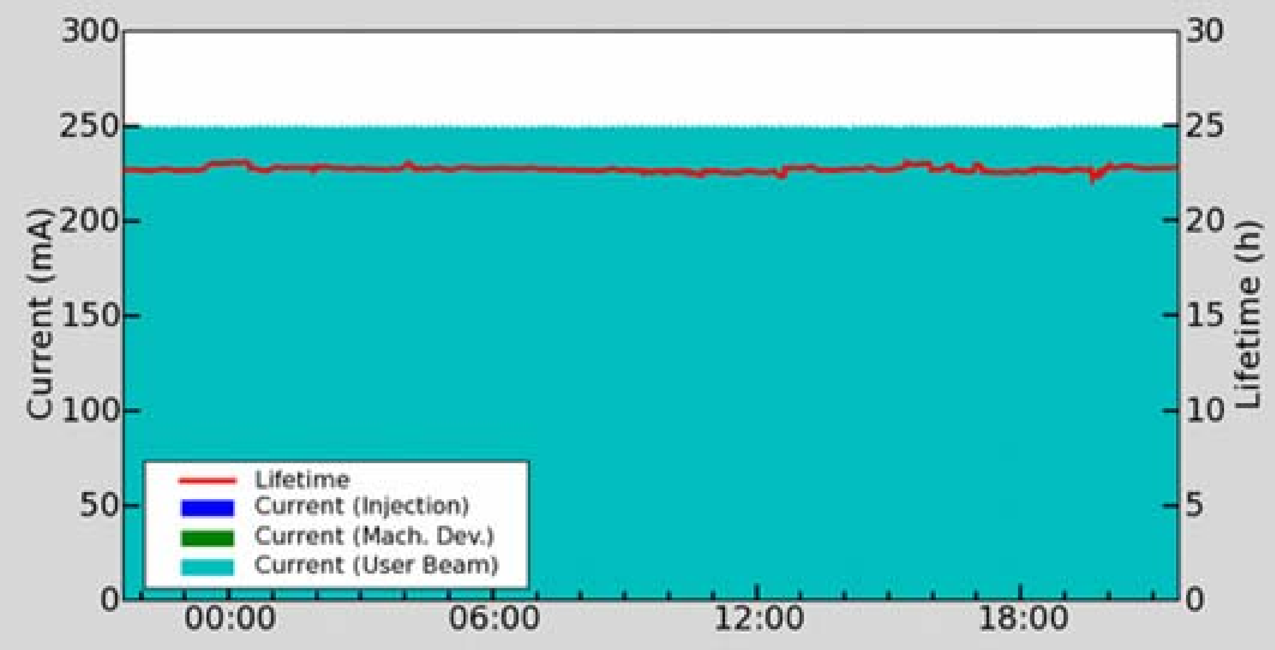
Before Oct. 28th 2008:

“decay mode”

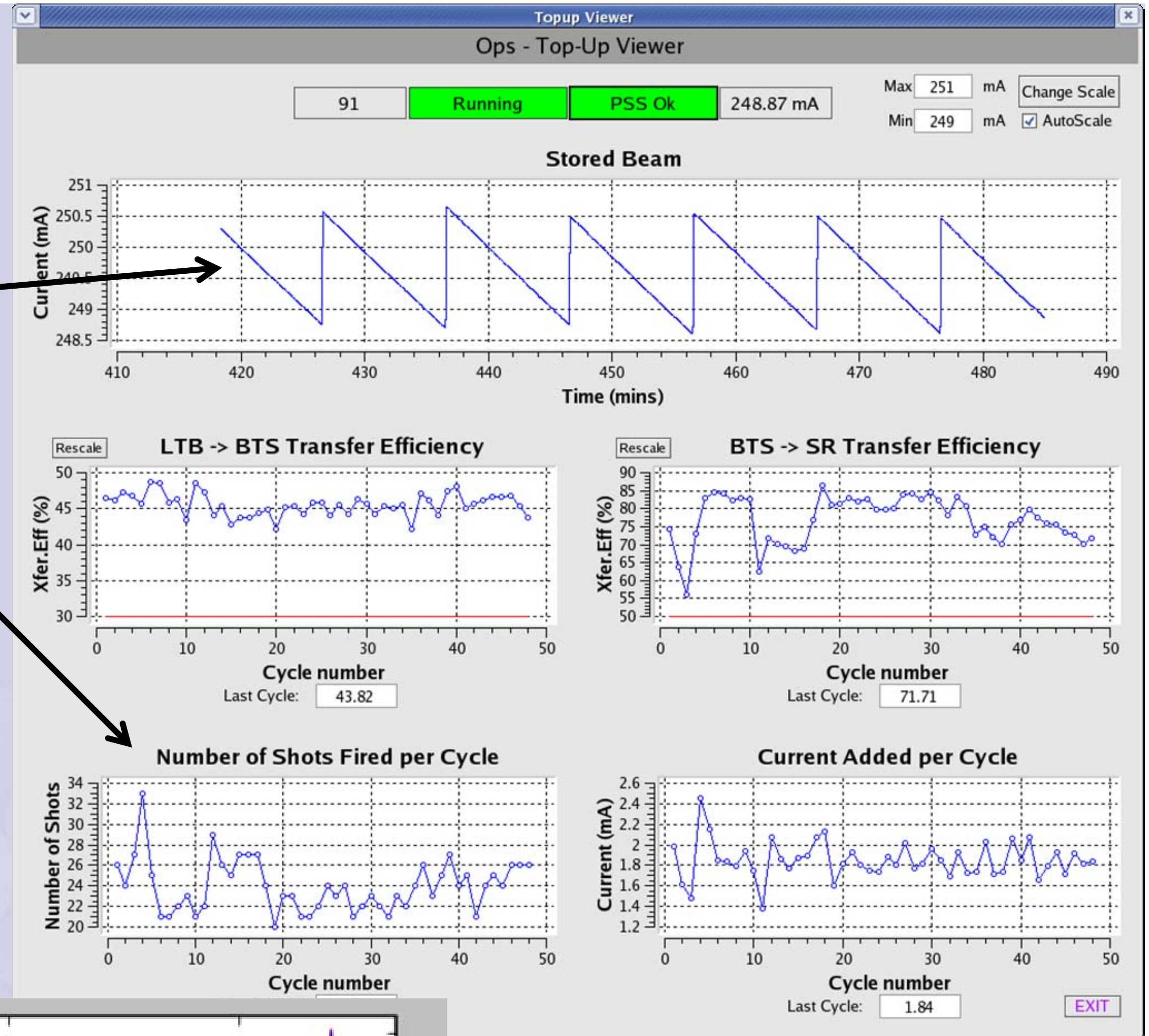


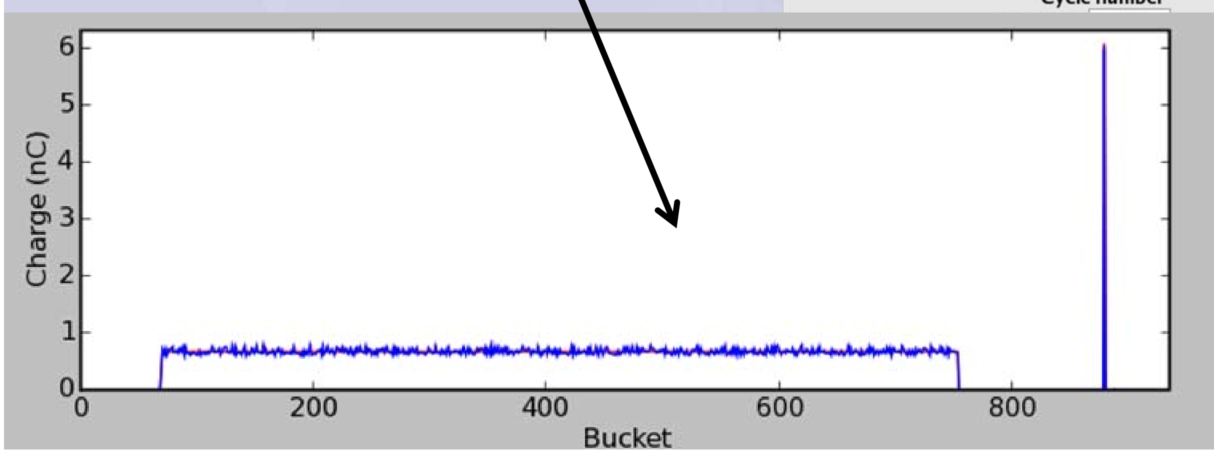
Since Oct. 28th 2008:

“top-up mode”



- **Injection regularly every 10 minutes**
- **20-30 single bunch shots, at 5 Hz**
- **Arbitrary fill pattern can be set-up and maintained, e.g. “hybrid mode”**





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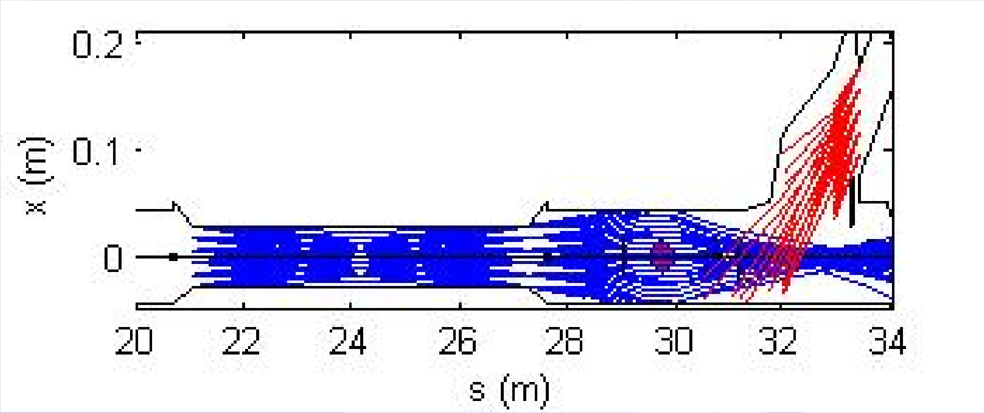
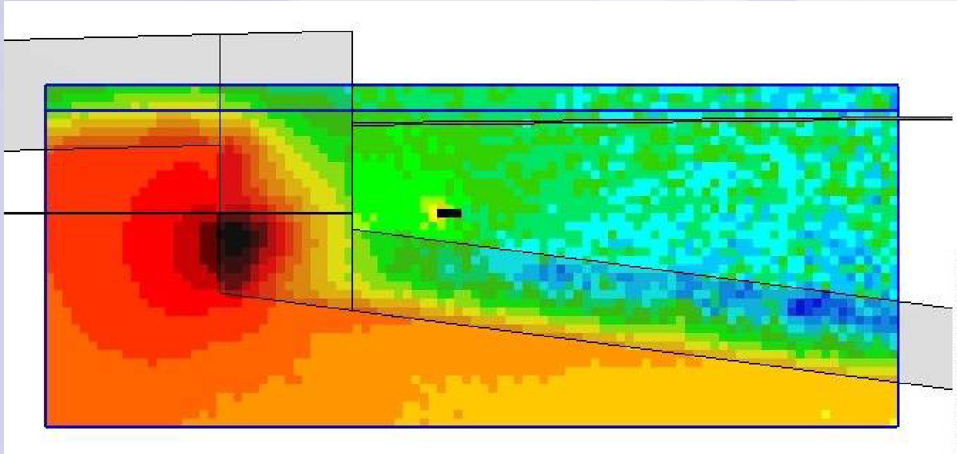
Top-Up Safety Studies

Tracking simulations



Radiation dose calculations and measurements



Walker et al., EPAC’08, p. 2121

Martin et al., EPAC’08, p. 2085

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Top-Up Safety

1) PSS integrity hardware interlocks:

- stored beam > 50 mA
- BTS dipoles and SR dipole currents within +/- 1% of nominal
- tested at the start of each Run

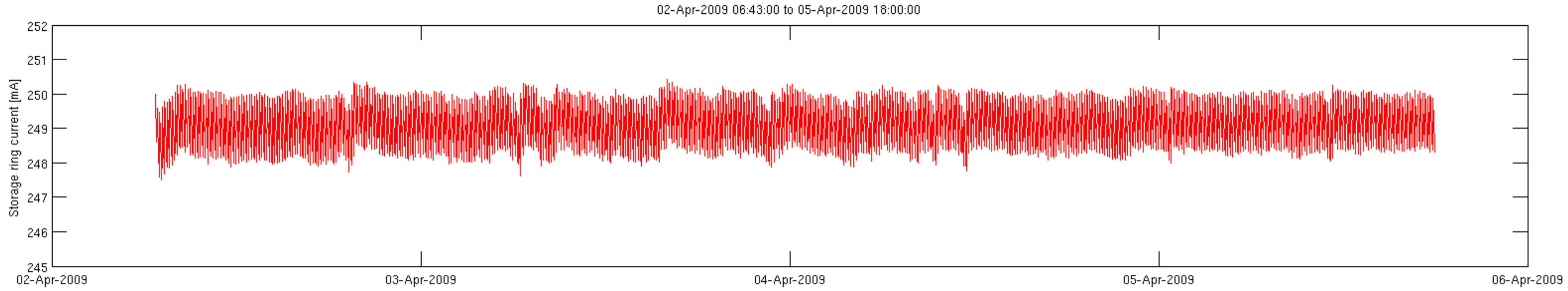
2) Software checks in the top-up control program:

- injection efficiency > 50%
- stored beam lifetime > 10 h
- various other checks to assure that machine is set up correctly

3) Beamline radiation monitors (γ+n)

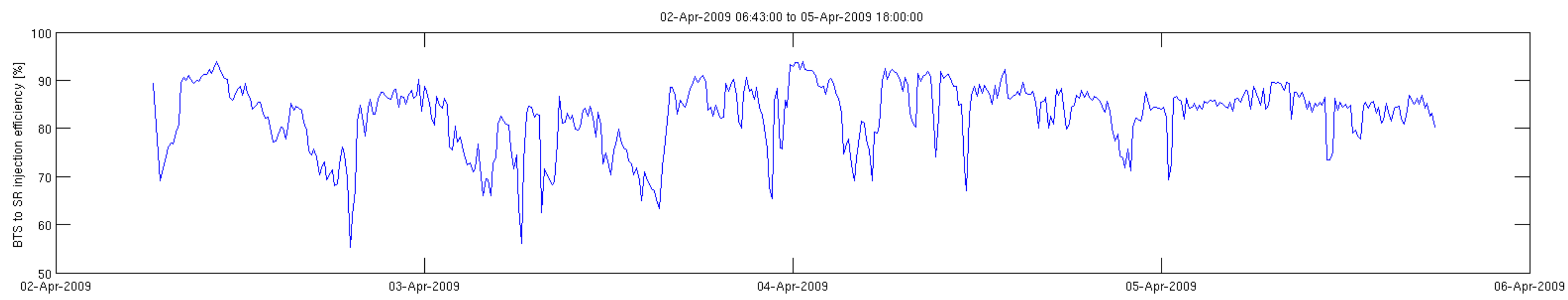
- trip on instantaneous or 4 h integrated dose

❖ 2nd-5th April 2009: 83 h of uninterrupted top-up:



Total current stability = 1.16%,

of which lifetime accounted for 0.83% (10 min / 20 h – *at that time*)



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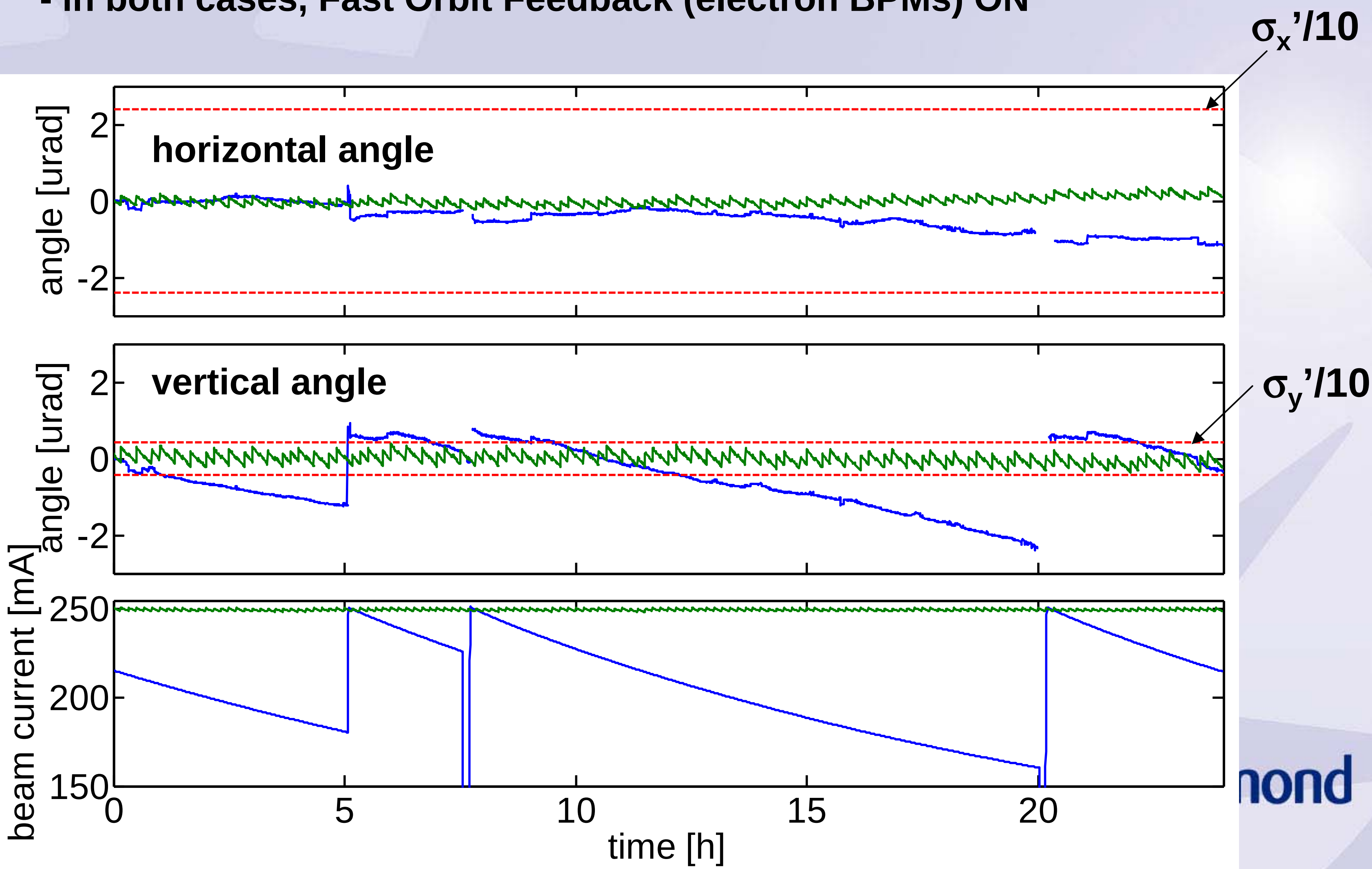
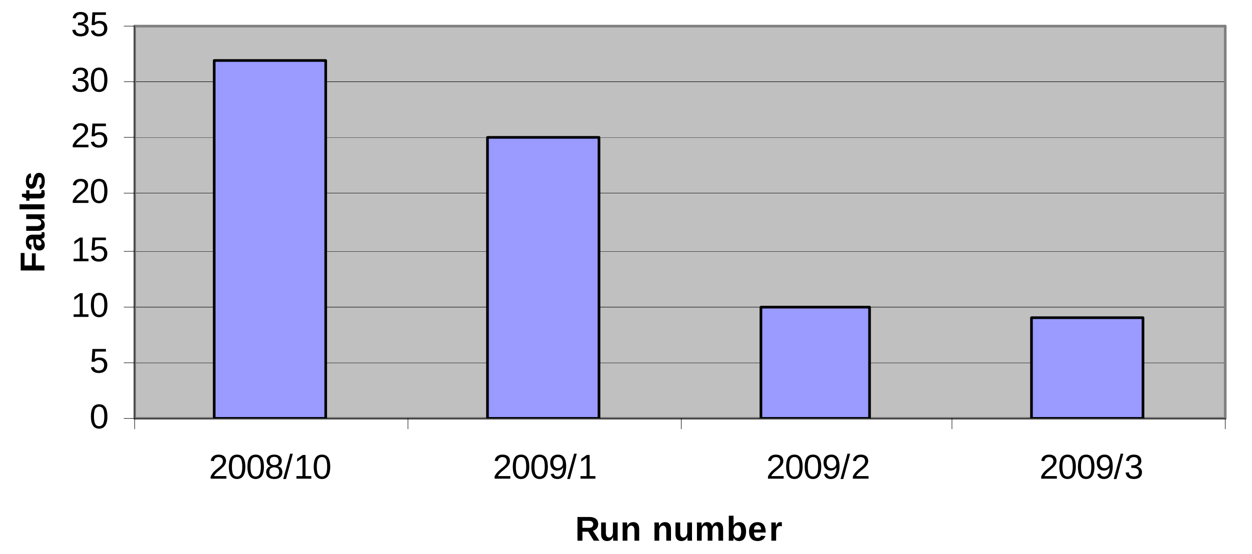
Improvement in Orbit Stability in Top-Up

- measured using one of the photon BPMs (fixed ID gap)
- in both cases, Fast Orbit Feedback (electron BPMs) ON



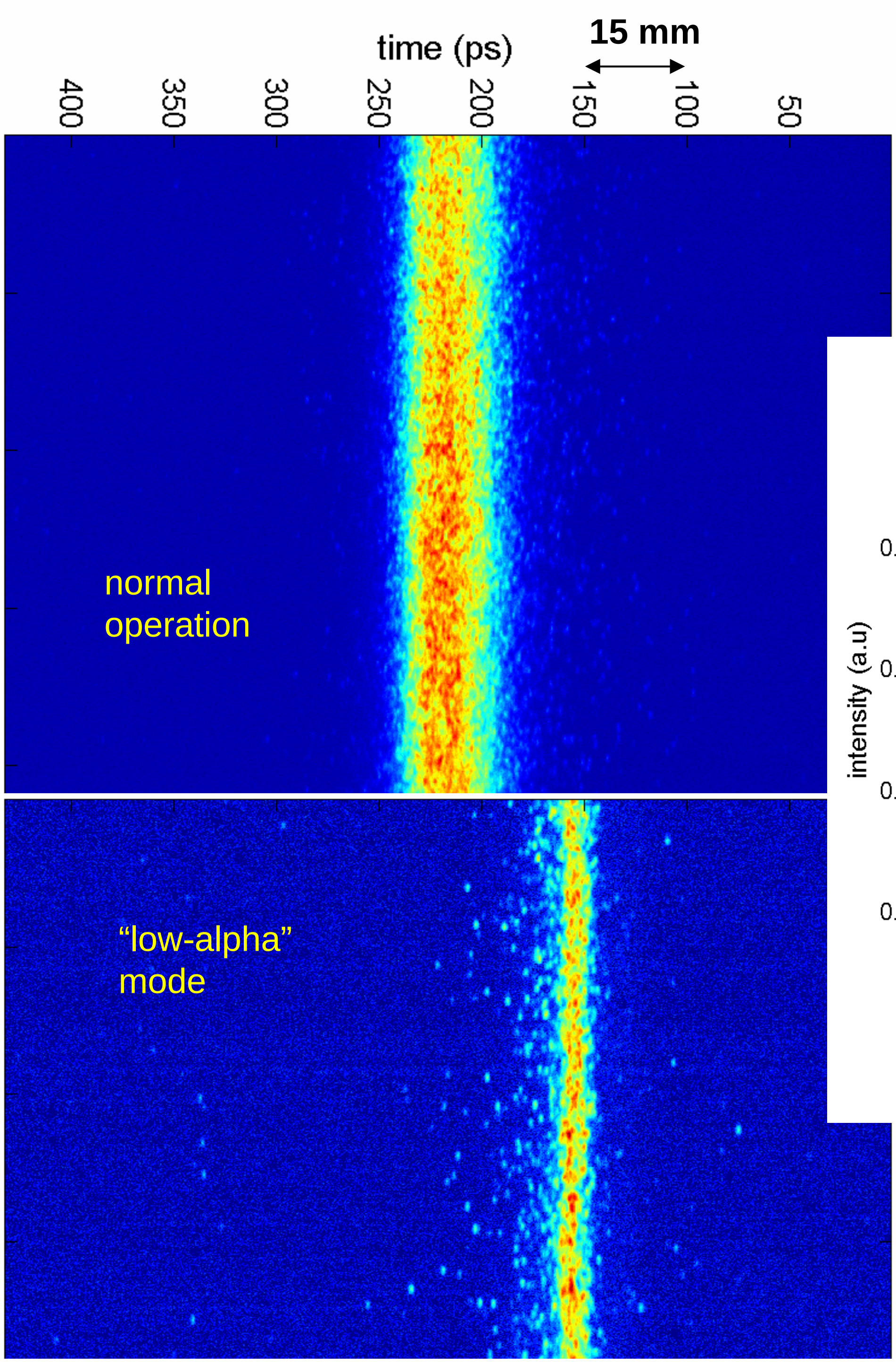
Top-Up Reliability

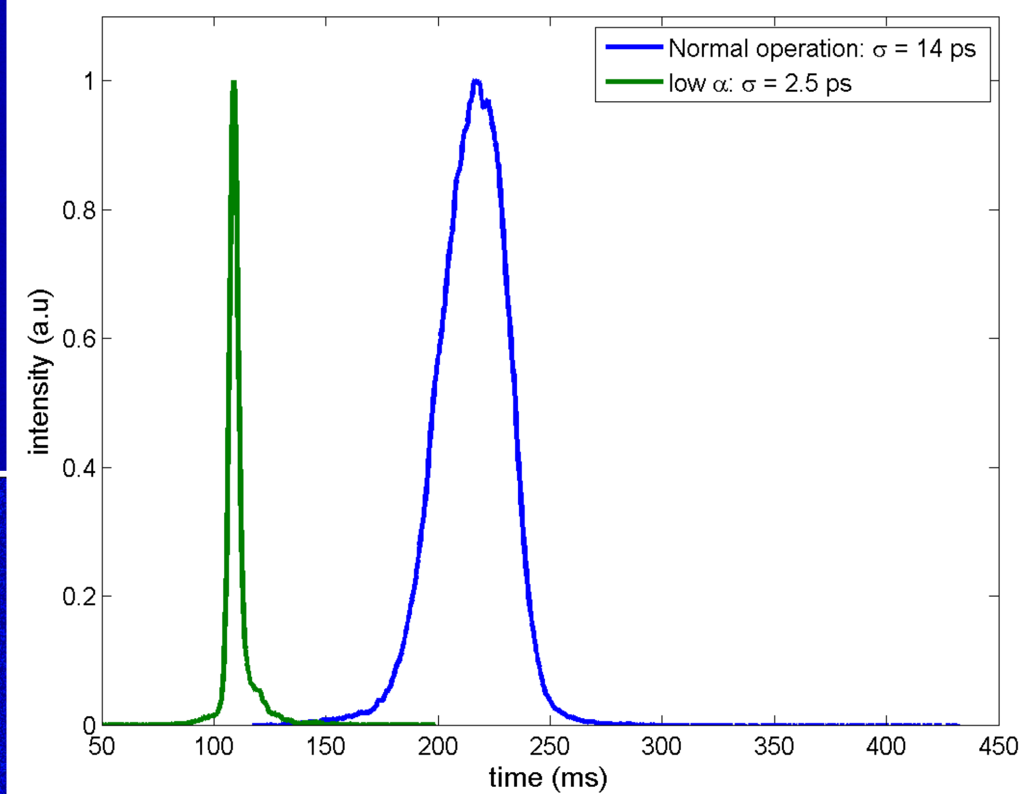


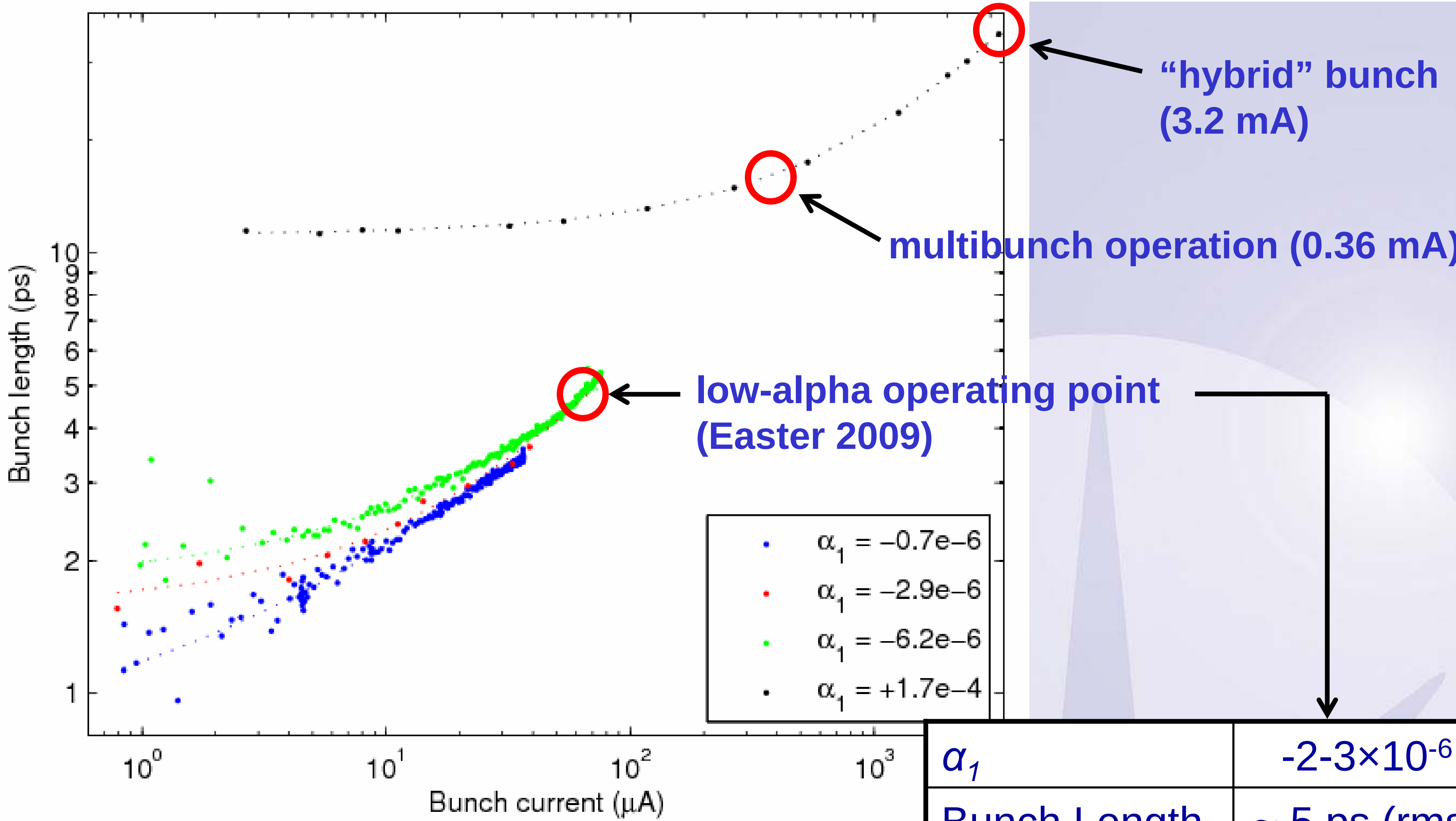
Number of occasions top-up has failed (i.e. missed cycles, usually 1-4, but without beam loss)

Fault	Run 9-08	Run 1-09	Run 2-09	Run 3-09
Linac	4	14	5	3
Booster	9	1	1	1
Linac to Booster transfer efficiency	2	5	0	3
Booster to Storage Ring transfer efficiency	7	1	2	1
Communication errors	4	2	2	1
Others	6	2	0	0
TOTAL	32	25	10	9

“Low-alpha” mode



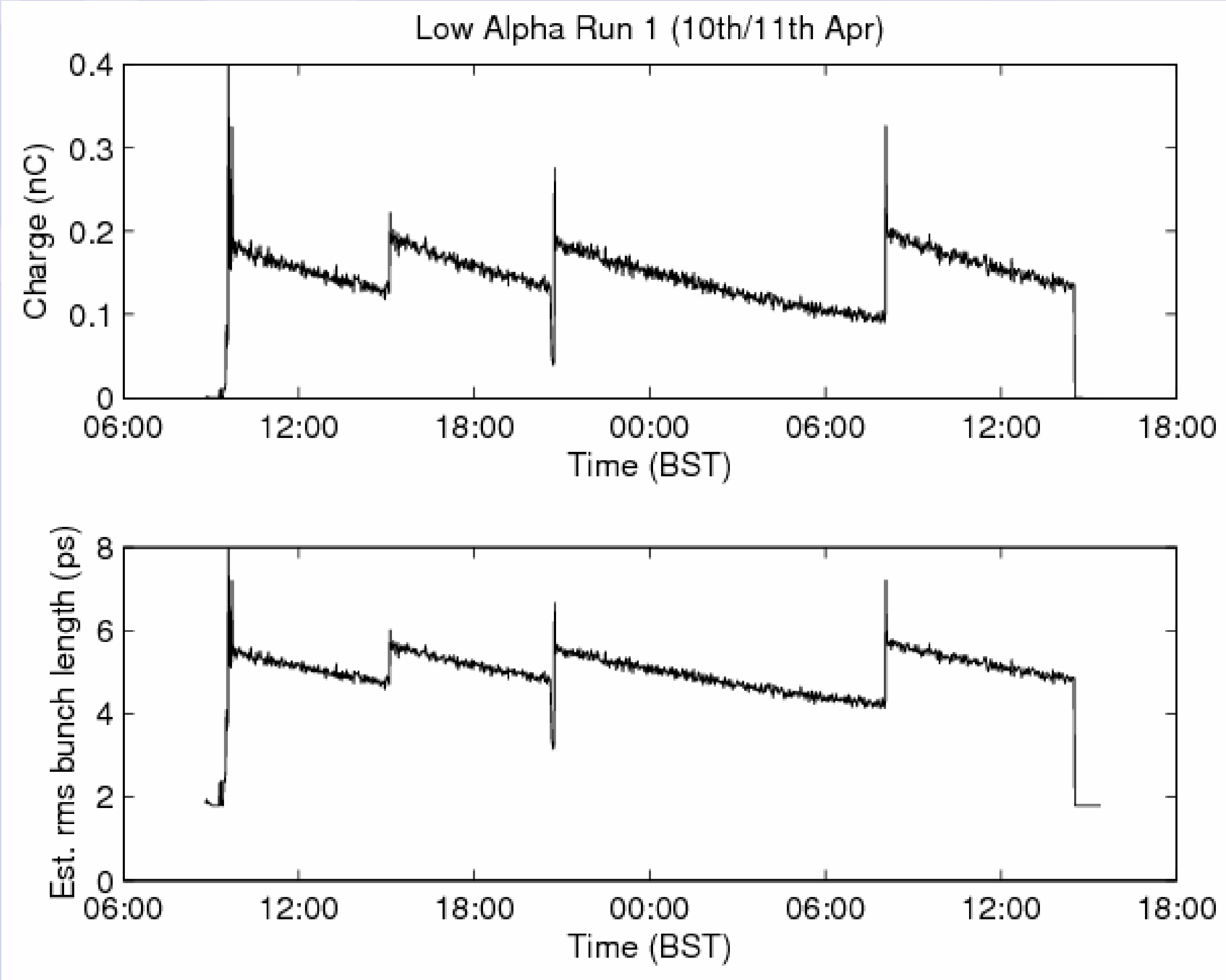




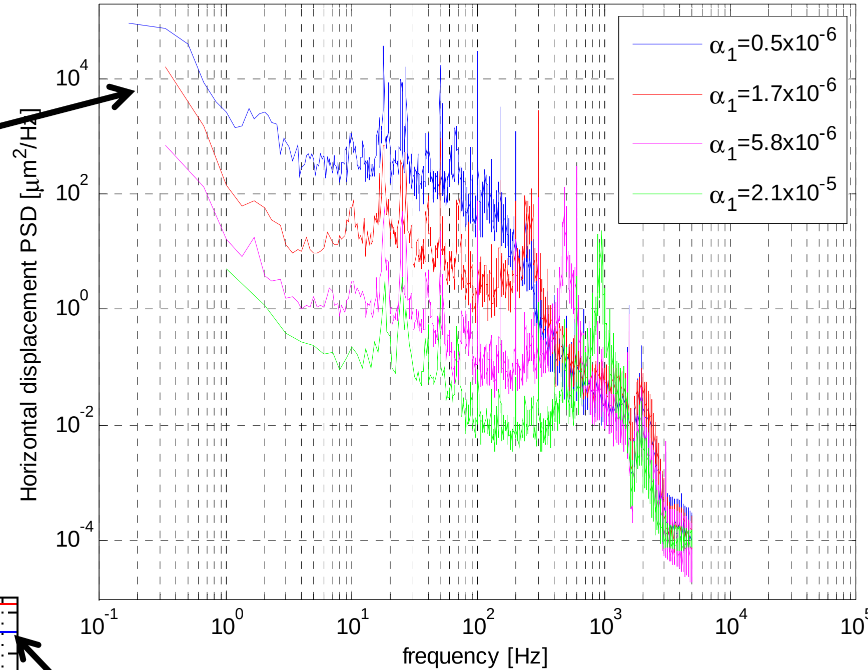
α_1	$-2\text{-}3\times10^{-6}$
Bunch Length	~ 5 ps (rms)
Bunch Current	~ 80 μA
Lifetime	~ 12 h
Emittance	~ 30 nm.rad
Coupling	< 0.1%

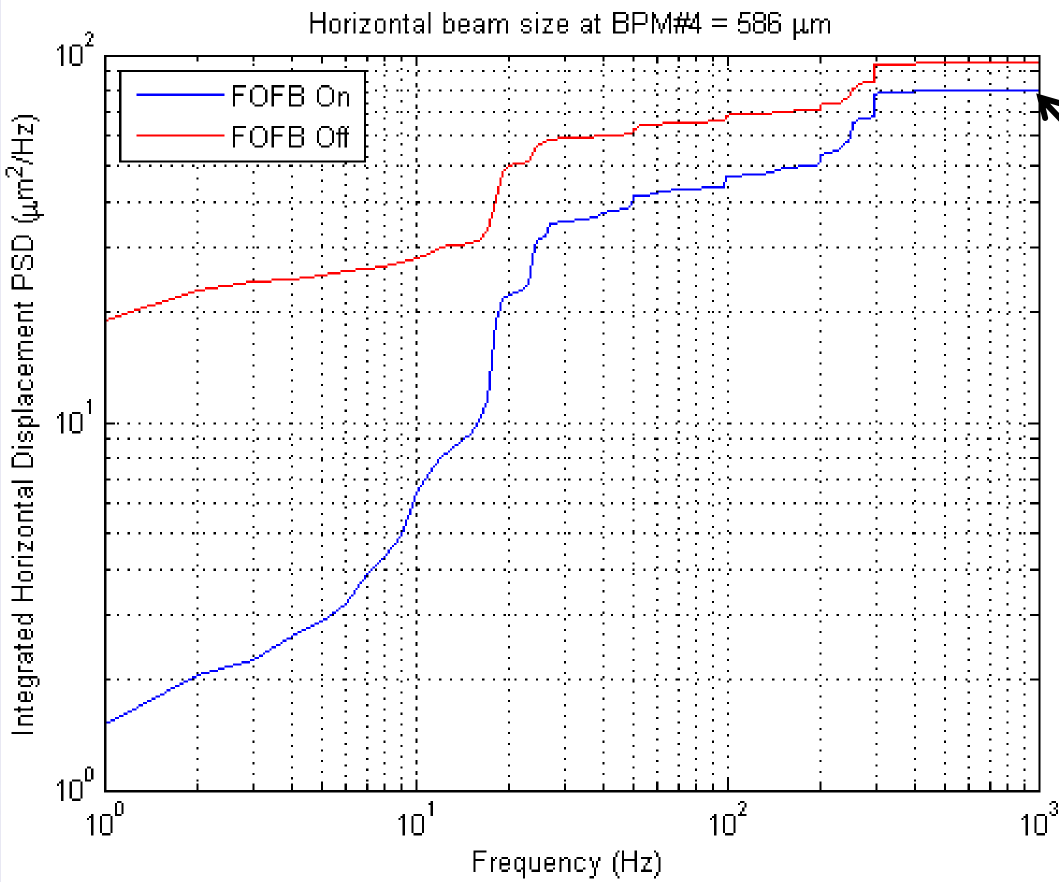
See: TH6PFP032, I. Martin et al.

Part of a period of scheduled low-alpha operation April 10th-14th



Horizontal orbit motion increases as alpha decreases, especially at low frequencies, due to ~ μm circumference changes





13% σ_x

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“Low-gap” in-vac. ID Operation

- Diamond has 10 in-vacuum undulators.
- Strong pressure from some beamlines to reduce minimum operating gap from 7 mm (original specification) to 5 mm (“future target”).
- Campaign of measurements to understand and minimise effects on lifetime, injection efficiency and beam losses is ongoing, meanwhile:

  - 4 devices allowed to operate at 5 mm
  - 1 device allowed to operate at 6 mm (as requested)
  - 1 device undergoing tests to determine requirements

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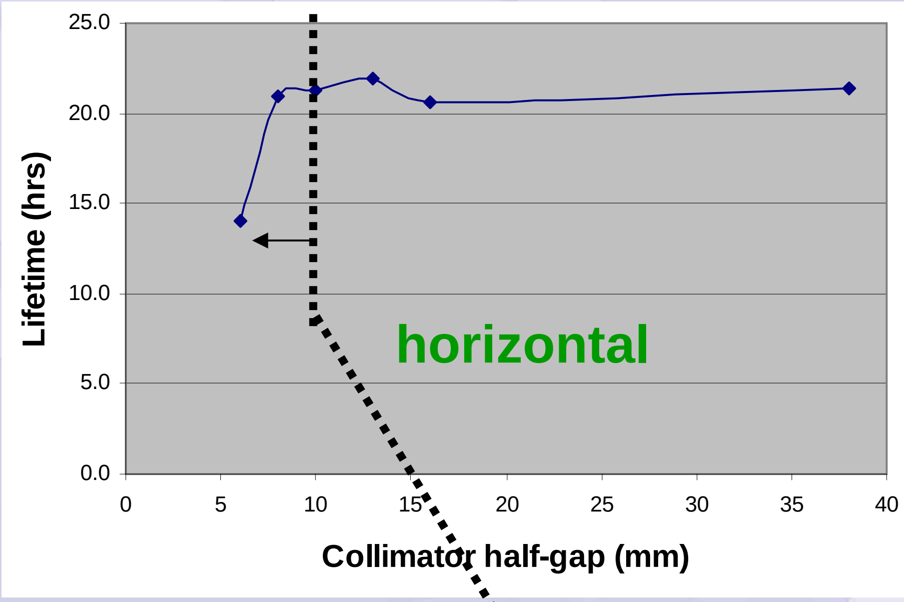
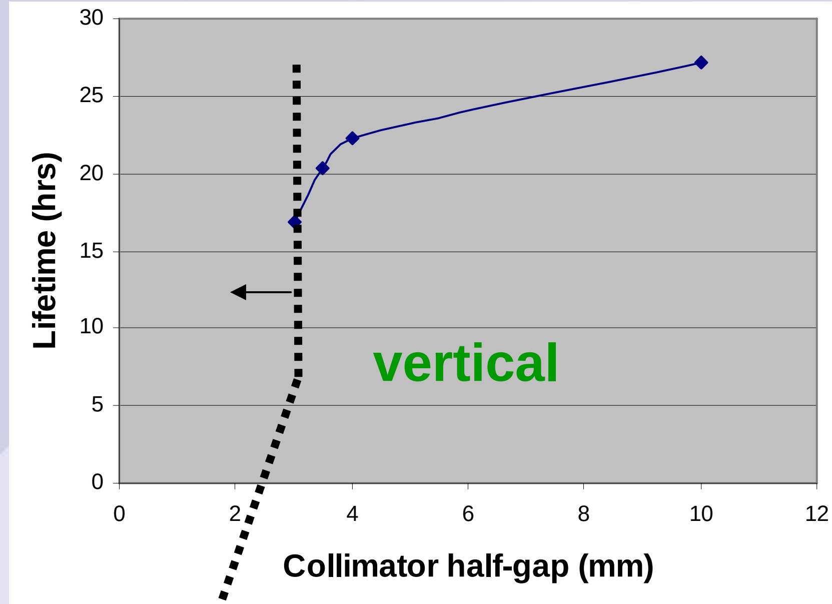
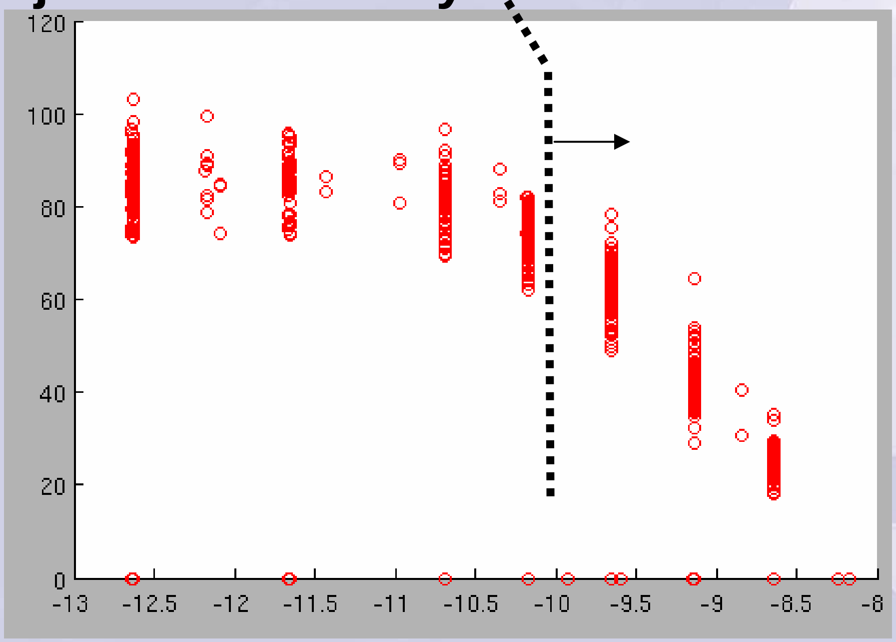
Collimator settings

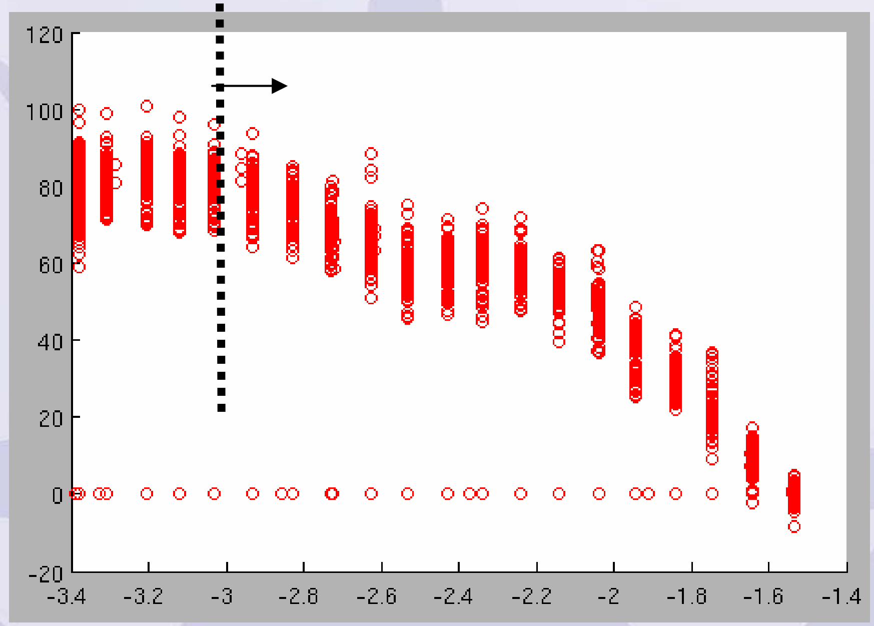
Lifetime:





Injection efficiency:



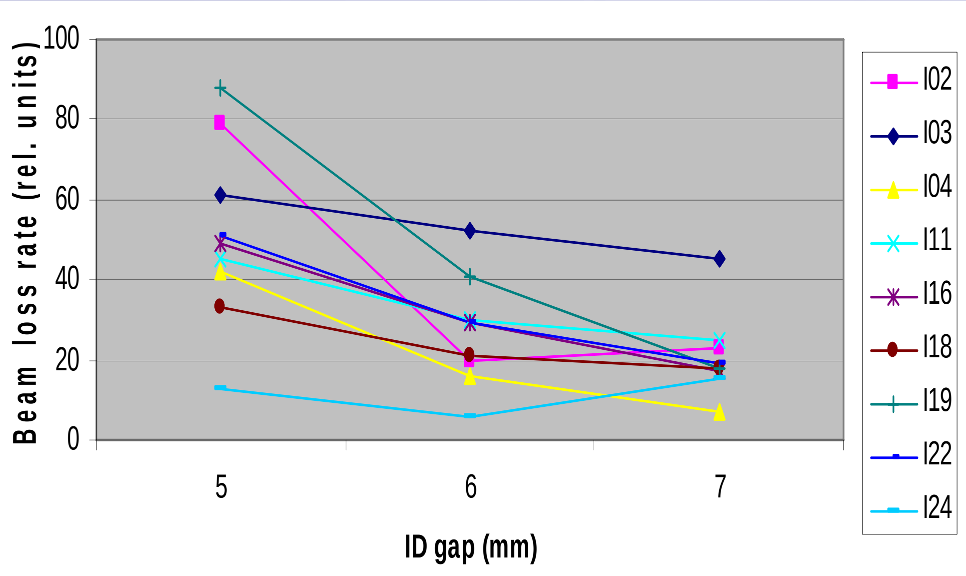


Closing IDs to 5 mm

Stored beam:

- lifetime: no effect from individual IDs, but all together ~ 10 % loss in lifetime

- beam losses: increase, variable from ID to ID …



Injection:

- injection efficiency: most IDs have no effect. One device reduces injection efficiency from 80% to 67% between 6 mm and 5 mm

- beam losses: very strange ! - can increase (x2-x3) in one straight when closing ID in another straight, even if injection efficiency unchanged - but generally less contribution to the integrated dose than from stored beam

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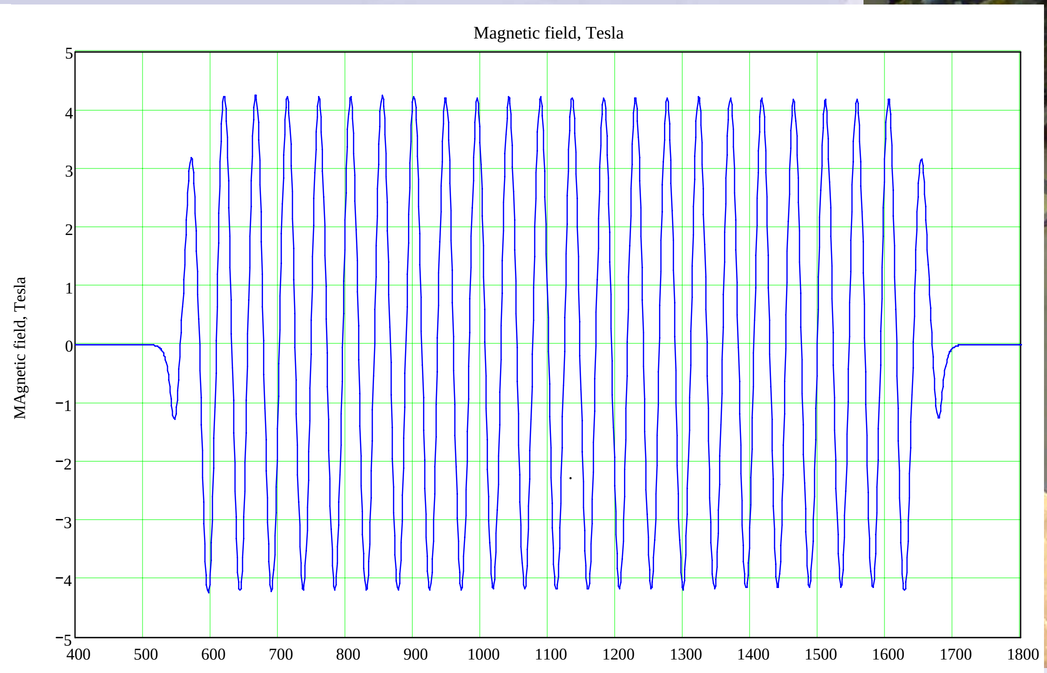
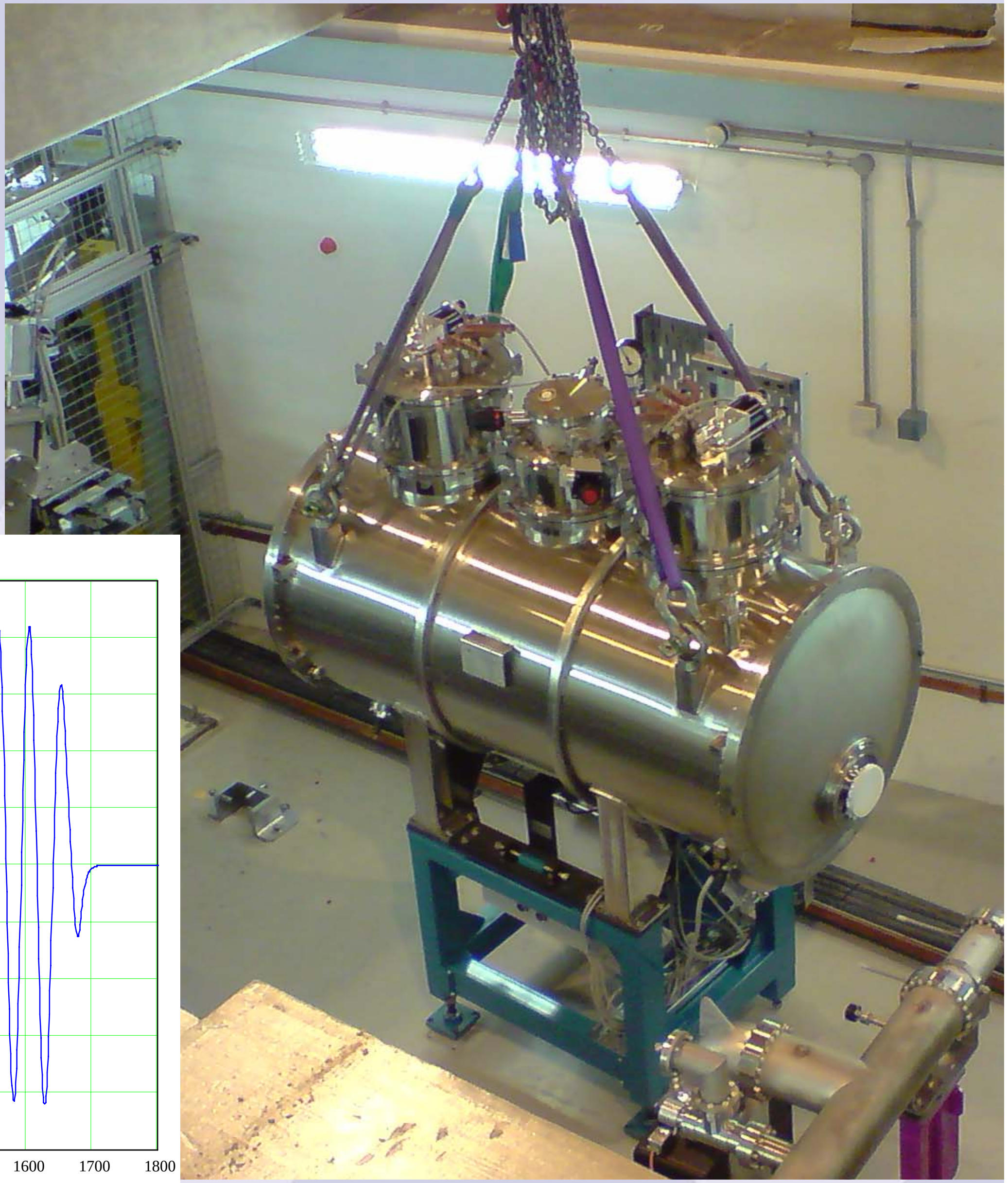
Insertion Device Developments

- **Second superconducting multipole wiggler (BINP) installed March '09**

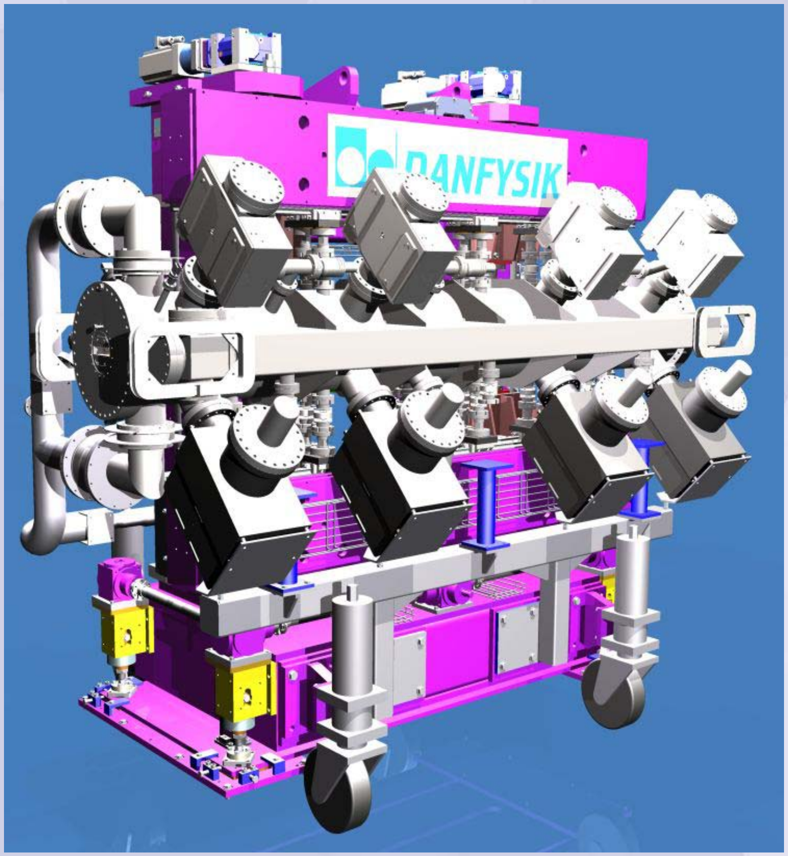
  4.2 T, 48 mm period,
  45 full poles

  Under commissioning with beam





- **Cryo-cooled Undulator under construction (Danfysik)**



- **Period length 17.7mm**
- **113 periods**
- **K-value 1.7 (@ 5mm gap)**
- **Minimum gap 4 mm**
- **Total length 2486 mm**
- **Working temperature 120K – 150K**
- **Cooling system: Standard monochromator cryo-cooler**
- **Delivery Oct. 2009**

(picture courtesy of Danfysik)

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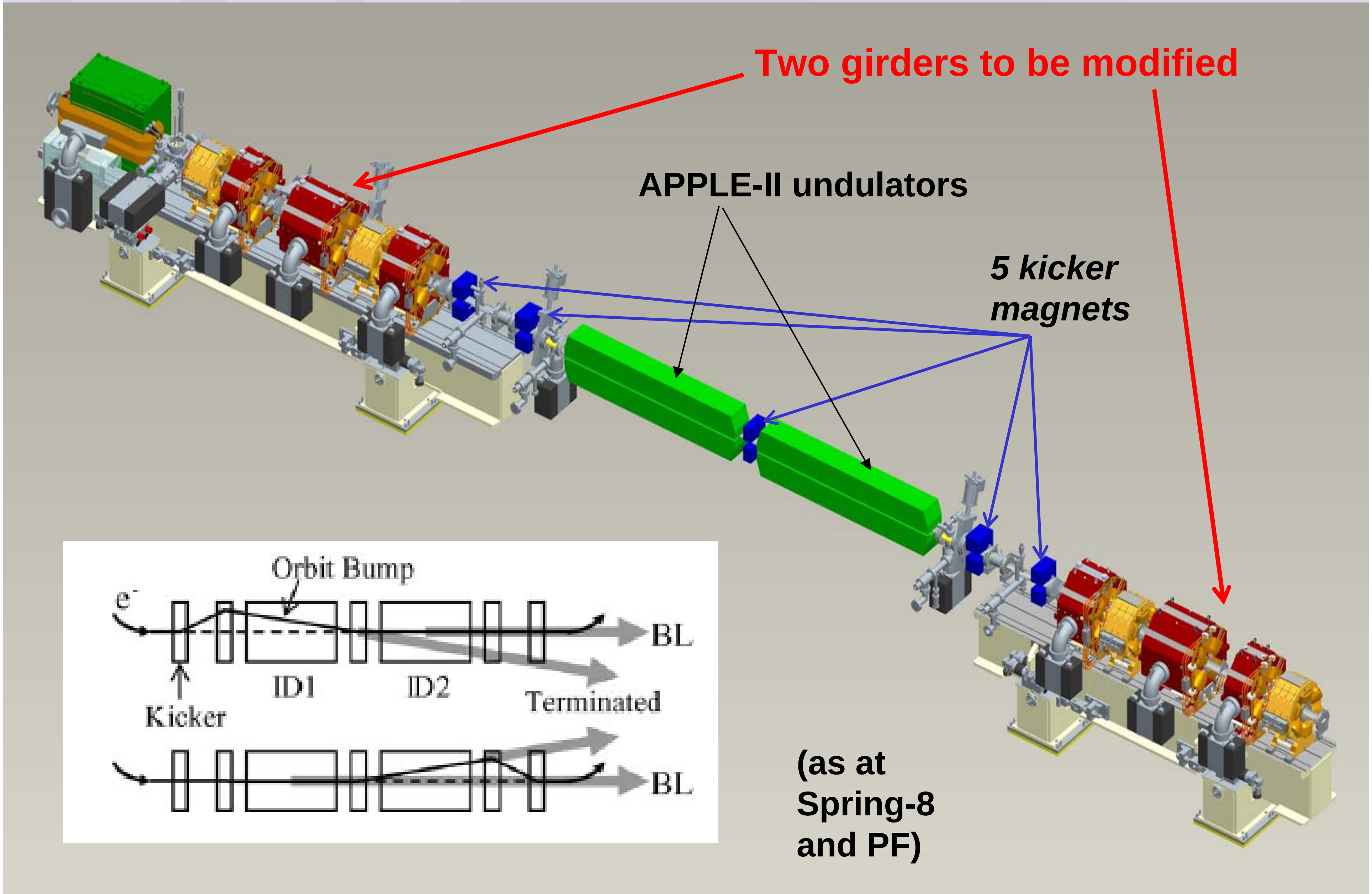
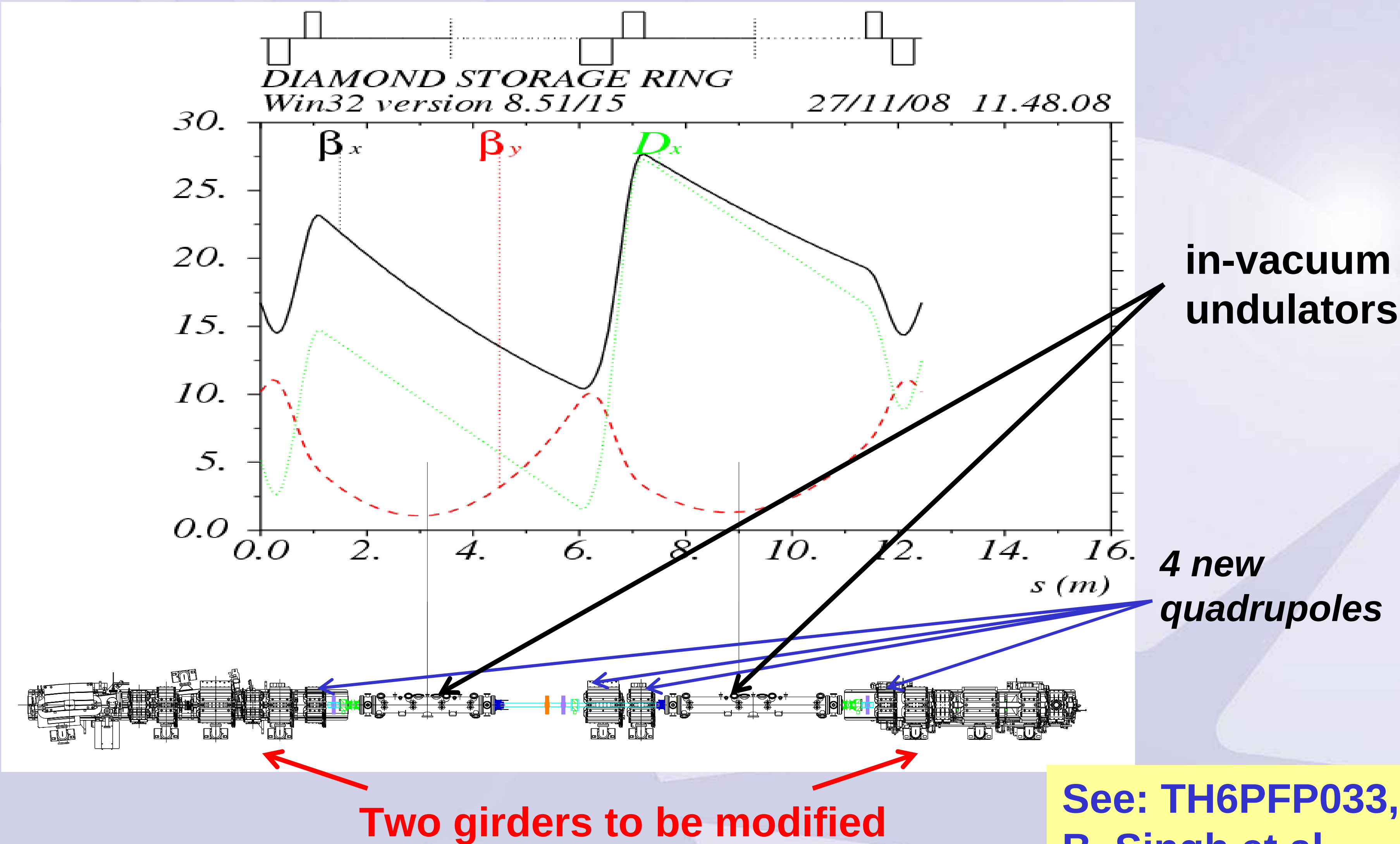
I10: Fast Polarisation Switching Scheme

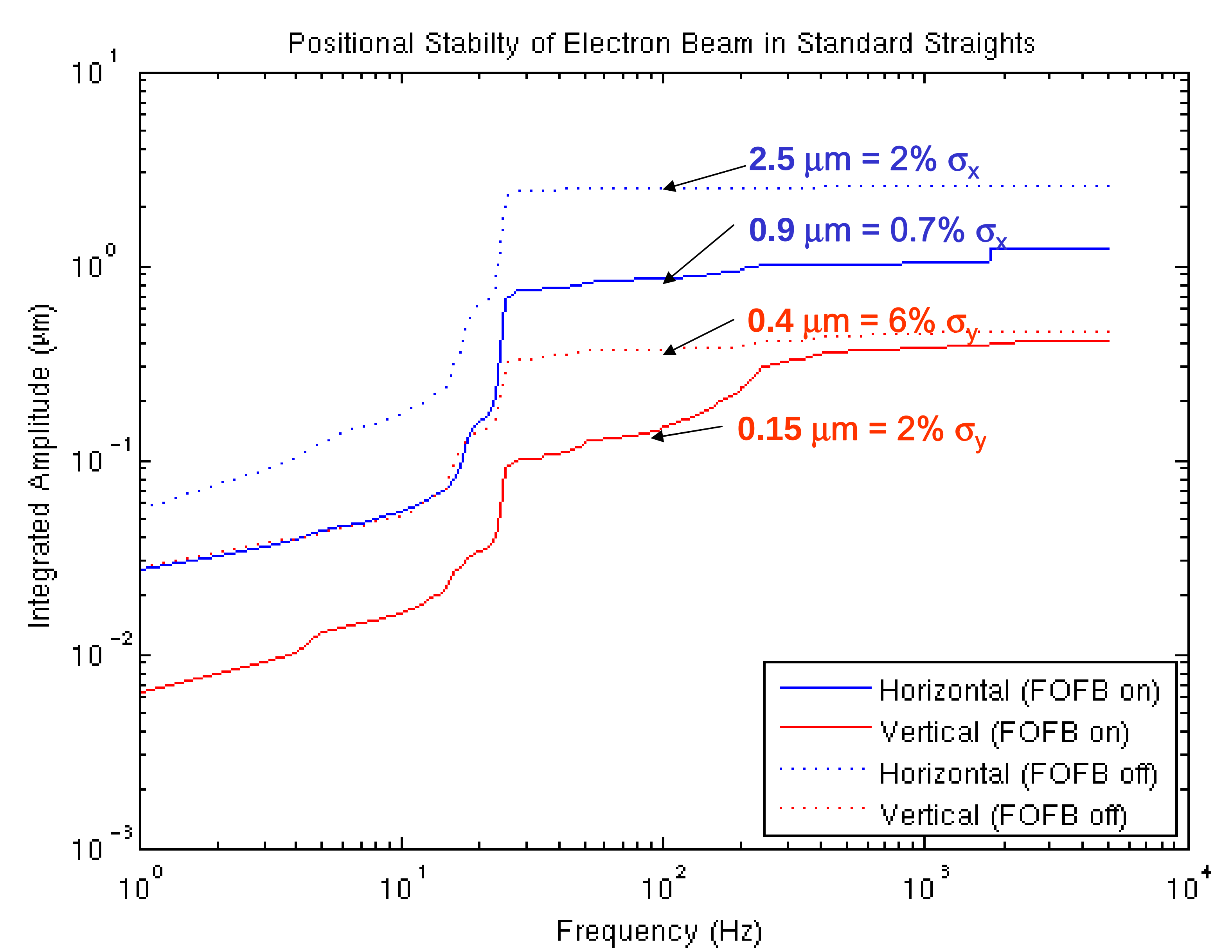


I13: "Double mini-beta" and Horizontally Focusing Optics



See: TH6PFP033, B. Singh et al.

Beam Stability



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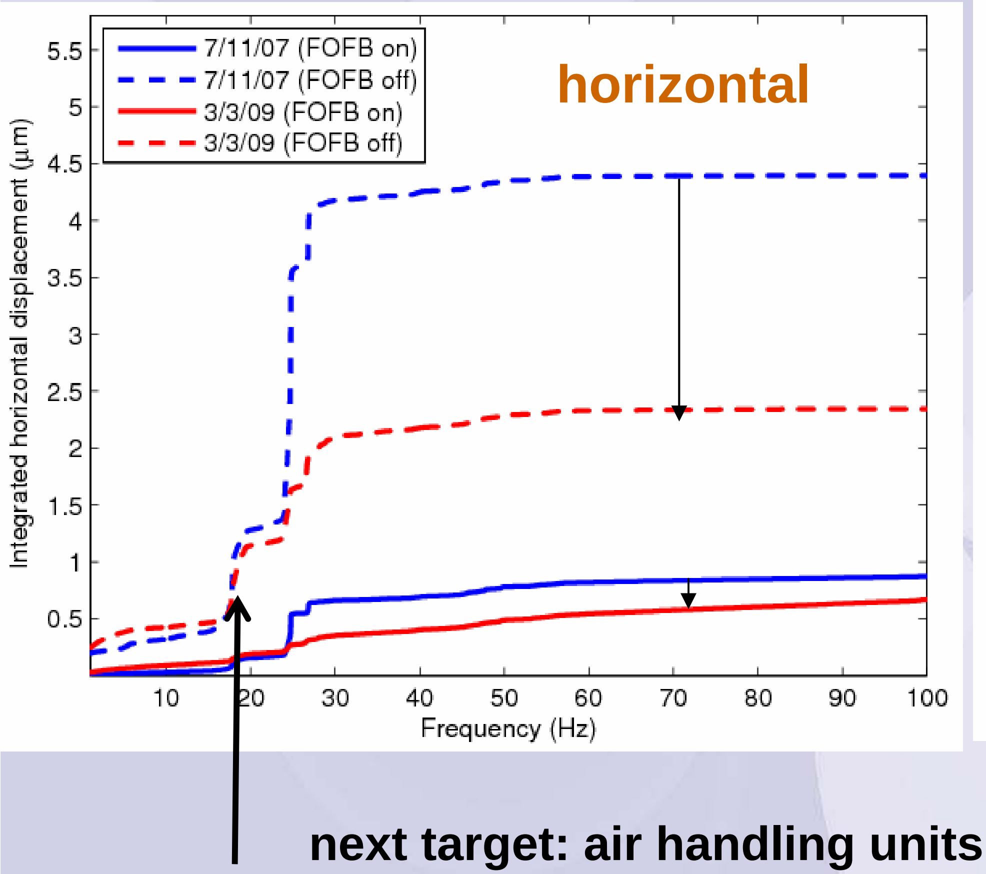
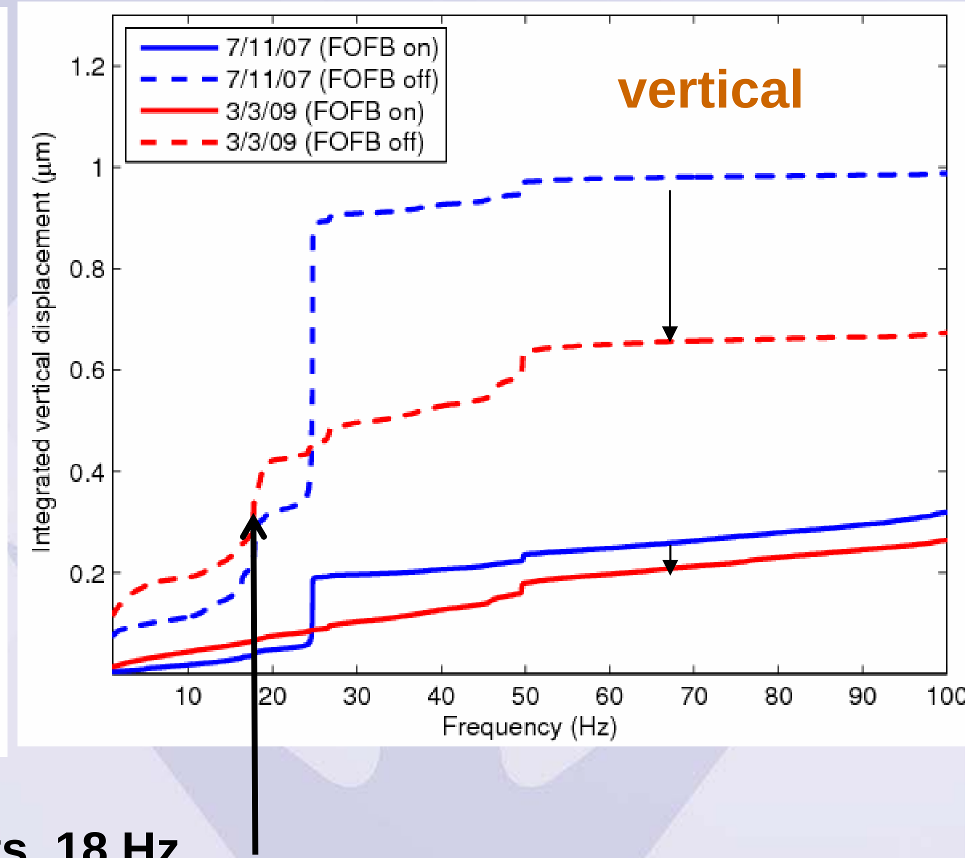
Elimination of vibrations at 24.9 Hz after fixing water cooling pump mountings





next target: air handling units, 18 Hz

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Thanks to the Diamond Machine Team

Thanks for Your Attention

PAC, Vancouver, May 4-8th 2009

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