# Vertical emittance minimization update and low energy set-up

Andreas Streun, SLS, PSI

# ✓ Vertical emittance minimization ✓ presentation Wednesday 12:05 ✓ TIARA-REP-WP6-2012-008, specification of emittance knobs, May 2012

### TIARA-REP-WP6-2012-008



Test Infrastructure and Accelerator Research Area

### **Status Report**

# **Specification of emittance knobs**

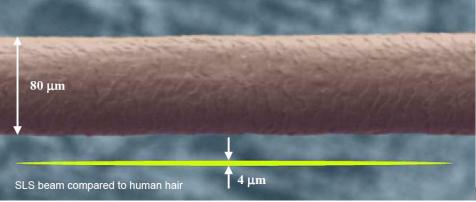
Aiba, M. (PSI) et al

Reaching 1 pm vertical emittance at the Swiss Light Source storage ring

Andreas Streun (PSI)

TIARA mid-term meeting, CIEMAT, Madrid, June 12-14, 2012





30 May 2012



•	Prerequisite: stability and precision	SLS developments 2000 - 2012			
	<ul> <li>orbit correction, feedback, top-up</li> </ul>				
•	Machine preparation				
	<ul> <li>– [beam assisted] girder alignment</li> </ul>				
	<ul> <li>optics correction (LOCO, QV, TBT)</li> </ul>				
	<ul> <li>BPM roll error measurement</li> </ul>		"LET"		
•	Model dependent methods		algorithm		
	<ul> <li>vertical dispersion suppression</li> </ul>		(S. Liuzzo)		
	<ul> <li>betatron coupling suppression</li> </ul>		3 MD shifts!		
•	Model independent methods				
	<ul> <li>Random walk, minimization of beam size</li> </ul>	)			

 $\rightarrow$  repeat, iterate, automate ....

# New beam size monitor

- SLS vertical emittance values
  - limitation from existing monitor ~1 pm
  - design of new monitor  $\rightarrow 0.5 [ \rightarrow 0.3 ]$  pm
  - quantum limit 0.2 pm
- Budget & Time schedule
  - WP6 hardware budget 215 k€
  - design ~finished: TIARA report due June'12
  - installation: July'12 & Dec.'12 Jan.'13
  - commissioning: Jan. Mar. [?] '13
  - measurements: Jan. June '13

# SLS low energy operation

- 1.6 GeV instead of 2.4 GeV
- Ring setup problem
  - 3 normal conducting super bends, 3 T
  - fully saturated center pole, I = 500 A
  - center pole at 1.6 GeV:  $I \rightarrow 135 A!$
  - $\rightarrow$  orbit correction difficult
  - $\rightarrow$  problem to get injection/accumulation
  - $\rightarrow$  not well reproducible

- Energy matching
  - booster extraction on 2.4 GeV ramp
  - energy from booster
  - energy from ring dipole cur.
  - energy from ring quad cur.
  - at nominal energy:
    - booster extraction
    - ring from spin depolarization
    - ring dipole current
    - ring quad currents
  - $\rightarrow$  believe in quads .

1.617 GeV 1.569 GeV

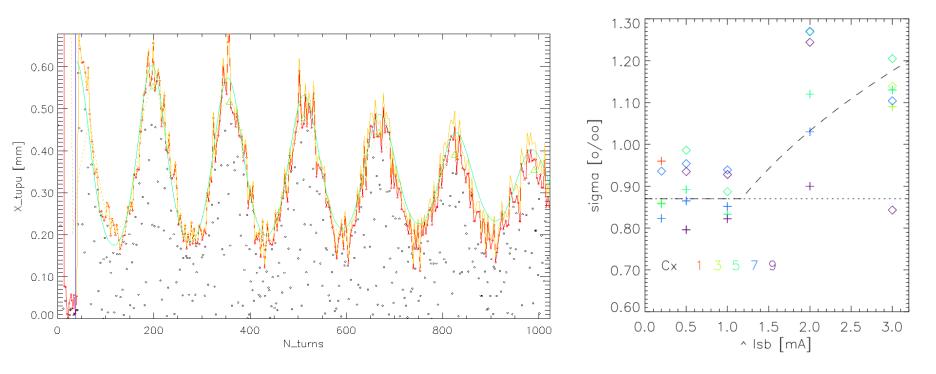
```
1.573 GeV
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```
2.4 GeV
2.41100 GeV
2.399 GeV
2.411 GeV
```

- Instabilities
  - nominal RF @ 2.4 GeV: 2.1 MV (4 x 525 kV)
  - 1.6 GeV:
    - 1 x 300..500 kV, 3 detuned  $\rightarrow$  bad
    - 4 x 150...350 kV → better
  - Instabilities: long/hor/vert (mode 71, 136, ...)
  - best result (2010) for users:
    - up to 325 mA (400 bunches)
    - 4 x 320 kV and 3HC at 430 kV (1/3  $V_{tot}$ )
  - recent (May'12) for IBS:
    - few mA (1 or 3 bunches): 4 x (100..500 kV)
    - 40 mA in aperiodic filling of 80 bunches

# Energy spread measurements essential for analysis of IBS data

- Decoherence signal <x(t)>
  - fragile fit, many parameters
  - problem of BPM turn mixing

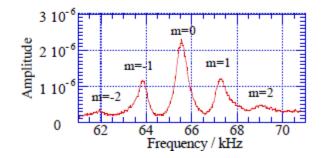


# CHROMATICITY FOR ENERGY SPREAD MEASUREMENT AND FOR CURE OF TRANSVERSE MULTI-BUNCH INSTABILITY IN THE SPRING-8 STORAGE RING

T. Nakamura, K. Soutome, M. Takao, S. Takano T. Ohshima, M. Masaki, S. Sasaki, M. Shoji, K. Tsumaki, JASRI/SPring-8, Mikazuki-cho, Hyogo, JAPAN

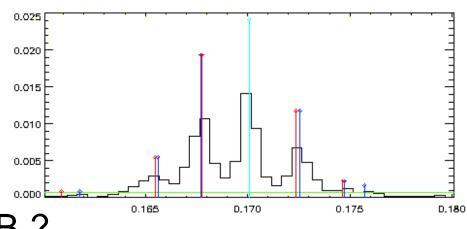
### Abstract

Chromaticity of a ring introduces non-harmonic betatron motion to off-momentum electrons. This motion produces synchrotron sidebands of betatron frequency in frequency response of betatron motion of a beam and reduces the main peak height. The height of these peaks depends on chromaticity and on the energy spread of the beam and we measured energy spread of the SPring-8



- Sideband heights (FFT of decoherence signal)
  - unequal ±m peaks due to res.wall impedance
  - →refined model
    - including impedance ?

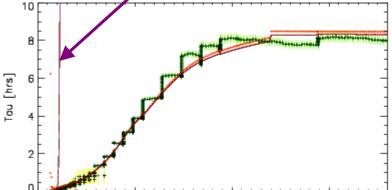
→better data using MBFB ?

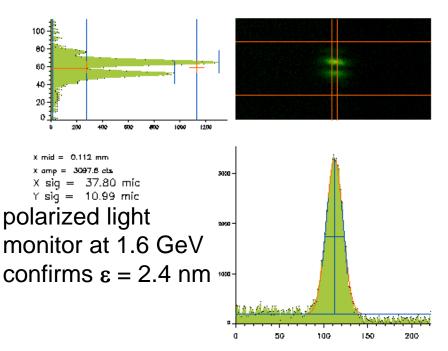


- measurement of beam size
  - at dispersive and non-dispersive location
  - using scrapers and/or pinhole arrays
  - SLS: 2 scrapers at 0 and max. dispersion
  - SLS: pinholes only at low dispersion (bend)

horizontal scraper measurement: fit of lifetime to scraper position.

quantum lifetime  $\rightarrow$  beam size





 $\rightarrow$  to be explored...

undulator line width

Undulator line width for the  $N^{th}$  harmonics and for n periods:

$$\frac{\Delta\lambda}{\lambda} = \frac{1}{n \cdot N}$$
(Example :  $\Delta\lambda/\lambda = 0.26\%$ ;  $n = 128$ ;  $N = 3$ )

### Undulator line broadening because of the electron beam divergence:

$$\frac{\Delta\lambda}{\lambda} = \frac{(\gamma \cdot \sigma_r')^2}{1 + \frac{k^2}{2}}$$

 $(Example: \Delta \lambda / \lambda = 8.8\%; E = 4.5 GeV; \sigma'_r = 51 \mu rad; k = 1.61)$ 

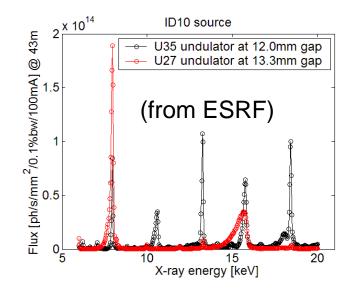
Undulator line broadening because of the acceptance angle  $\theta$ :

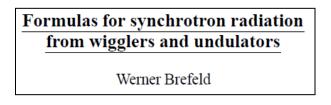
$$\frac{\Delta\lambda}{\lambda} = \frac{(\gamma \cdot \theta)^2}{1 + \frac{k^2}{2}}$$

Undulator line broadening because of the electron energy spread:

$$\frac{\Delta\lambda}{\lambda} = 2\frac{\Delta E}{E}$$

 $(Example: \Delta\lambda/\lambda = 0.22\%; \Delta E/E = 0.11\%)$ 





→ beamline 11M (the 1.6 GeV user) was asked...

# SLS shift plan (MD = ■,■)

SLS machine calendar from July to December 2012											
W	July	W	August	W	September	W	October	W	November	W	December
26 27 28	Sun 1 Mon 2 Tue 3 Wed 4 Thu 5 Fri 6 Sat 7 Sun 8 Mon 9	31 32	Wed 1 Thu 2 Fri 3 Sat 4 Sun 5 Mon 6 Tue 7 Wed 8 Thu 9	35 36	Sat 1 Sun 2 Mon 3 Tue 4 Wed 5 Thu 6 Fri 7 Sat 8 Sun 9	40	Mon 1 Tue 2 Wed 3 Thu 4 Fri 5 Sat 6 Sun 7 Mon 8 Tue 9	44 45	Thu 1 Fri 2 Sat 3 Sun 4 Mon 5 Tue 6 Wed 7 Thu 8 Fri 9	48 49	Sat 1 Sun 2 Mon 3 Tue 4 Wed 5 Thu 6 Fri 7 Sat 8 Sun 9
29	Tue 10 Wed 11 Thu 12 Fri 13 Sat 14 Sun 15 Mon 16 Tue 17	33	Fri 10 Sat 11 Sun 12 Mon 13 Tue 14 Wed 15 Thu 16 Fri 17	37	Mon 10 Tue 11 Wed 12 Thu 13 Fri 14 Sat 15 Sun 16 Mon 17	42	Wed         10           Thu         11           Fri         12           Sat         13           Sun         14           Mon         15           Tue         16           Wed         17	46	Sat 10 Sun 11 Mon 12 Tue 13 Wed 14 Thu 15 Fri 16 Sat 17	50	Mon 10 Tue 11 Wed 12 Thu 13 Fri 14 Sat 15 Sun 16 Mon 17
30	Wed         18           Thu         19           Fri         20           Sat         21           Sun         22           Mon         23           Tue         24           Wed         25	34	Sat         18           Sun         19           Mon         20           Tue         21           Wed         22           Thu         23           Fri         24           Sat         25	39	Tue       18         Wed       19         Thu       20         Fri       21         Sat       22         Sun       23         Mon       24         Tue       25	43	Thu 18 Fri 19 Sat 20 Sun 21 Mon 22 Tue 23 Wed 24 Thu 25	47	Sun         18           Mon         19           Tue         20           Wed         21           Thu         22           Fri         23           Sat         24           Sun         25	52	Tue       18         Wed       19         Thu       20         Fri       21         Sat       22         Sun       23         Mon       24         Tue       25
31	Thu 26 Fri 27 Sat 28 Sun 29 Mon 30 Tue 31 Shutdown	35	Sun 26 Mon 27 Tue 28 Wed 29 Thu 30 Fri 31		Wed 26 Thu 27 Fri 28 Sat 29 Sun 30 Machine developme User Operation	44 nt	Fri         26           Sat         27           Sun         28           Mon         29           Tue         30           Wed         31	48 a	Mon 26 Tue 27 Wed 28 Thu 29 Fri 30 Beamline- / optional Ma User Operation (low-alp		Wed 26 Thu 27 Fri 28 Sat 29 Sun 30 Mon 31 e development

SLS machine calendar from January to June 2013											
W	January	W	February	W	March	W	April	W	Мау	W	June
1	Tue 1 Wed 2 Thu 3 Fri 4 Sat 5 Sun 6 Mon 7 Tue 8 Wed 9 Thu 10	6	Fri 1 Sat 2 Sun 3 Mon 4 Tue 5 Wed 6 Thu 7 Fri 8 Sat 9 Sun 10	9	Fri       1         Sat       2         Sun       3         Mon       4         Tue       5         Wed       6         Thu       7         Fri       8         Sat       9         Sun       10		Mon 1 Tue 2 Wed 3 Thu 4 Fri 5 Sat 6 Sun 7 Mon 8 Tue 9 Wed 10		Wed         1           Thu         2           Fri         3           Sat         4           Sun         5           Mon         6           Tue         7           Wed         8           Thu         9           Fri         10	22 23 24	Sat       1         Sun       2         Mon       3         Tue       4         Wed       5         Thu       6         Fri       7         Sat       8         Sun       9         Mon       10
3	Fri       11         Sat       12         Sun       13         Mon       14         Tue       15         Wed       16         Thu       17         Fri       18		Sun         10           Mon         11           Tue         12           Wed         13           Thu         14           Fri         15           Sat         16           Sun         17           Mon         18	11	Sun         IO           Mon         11           Tue         12           Wed         13           Thu         14           Fri         15           Sat         16           Sun         17           Mon         18	16	Thu         11           Fri         12           Sat         13           Sun         14           Mon         15           Tue         16           Wed         17           Thu         18	20	Sat         11           Sun         12           Mon         13           Tue         14           Wed         15           Thu         16           Fri         17           Sat         18	24	Tue 11 Wed 12 Thu 13 Fri 14 Sat 15 Sun 16 Mon 17 Tue 18
4	Sat         19           Sun         20           Mon         21           Tue         22           Wed         23           Thu         24           Fri         25           Sat         26           Sun         27	9	Tue 19 Wed 20 Thu 21 Fri 22 Sat 23 Sun 24 Mon 25 Tue 26	13	Tue 19 Wed 20 Thu 21 Fri 22 Sat 23 Sun 24 Mon 25 Tue 26	17	Fri       19         Sat       20         Sun       21         Mon       22         Tue       23         Wed       24         Thu       25         Fri       26         Sat       27		Sun 19 Mon 20 Tue 21 Wed 22 Thu 23 Fri 24 Sat 25 Sun 26 Mon 27	26	Wed         19           Thu         20           Fri         21           Sat         22           Sun         23           Mon         24           Tue         25           Wed         26
5	Sun 27 Mon 28 Tue 29 Wed 30 Thu 31		Wed 27 Thu 28		Wed         27           Thu         28           Fri         29           Sat         30           Sun         31	18	Sat 27 Sun 28 Mon 29 Tue 30	22	Mon 27 Tue 28 Wed 29 Thu 30 Fri 31		Thu         27           Fri         28           Sat         29           Sun         30
Shutdown Machine- / optional Beamline development User operation reserve Maintenance Proprietary research No Operation					Machine development       Beamline- / optional Machine development         User Operation       User Operation (low-alpha)         Preliminary User Operation       Scheduled         Commissioning       In house research         Tests       Other branchline         MIX       Hit Scheduled					edevelopment	