# 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**

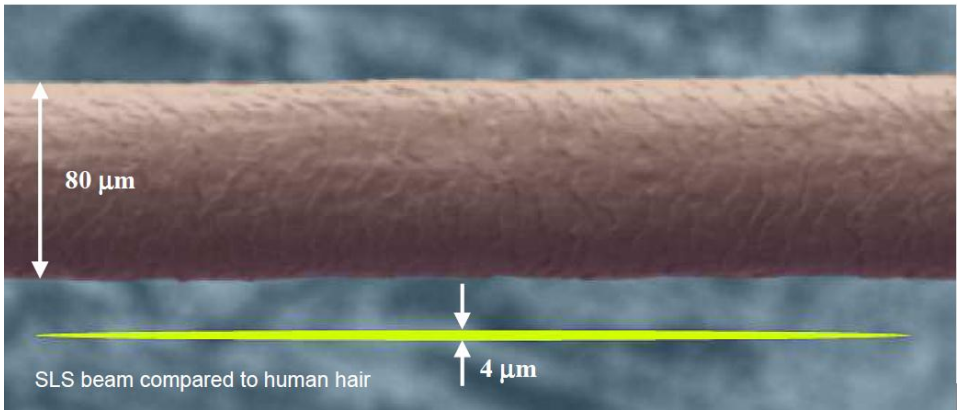
Aiba, M. (PSI) *et al*

30 May 2012

**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



# VET Methods ✓

- Prerequisite: stability and precision
  - orbit correction, feedback, top-up
- Machine preparation
  - [beam assisted] girder alignment
  - optics correction (LOCO, QV, TBT...)
  - BPM roll error measurement
- Model dependent methods
  - vertical dispersion suppression
  - betatron coupling suppression
- Model independent methods
  - Random walk, minimization of beam size

**SLS developments 2000 - 2012**

"LET" algorithm *(S. Liuzzo)*

**3 MD shifts!**

→ repeat, iterate, automate ....

# New beam size monitor

- SLS vertical emittance values
  - limitation from existing monitor ~1 pm
  - design of new monitor → 0.5 [ → 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 → 135 A !

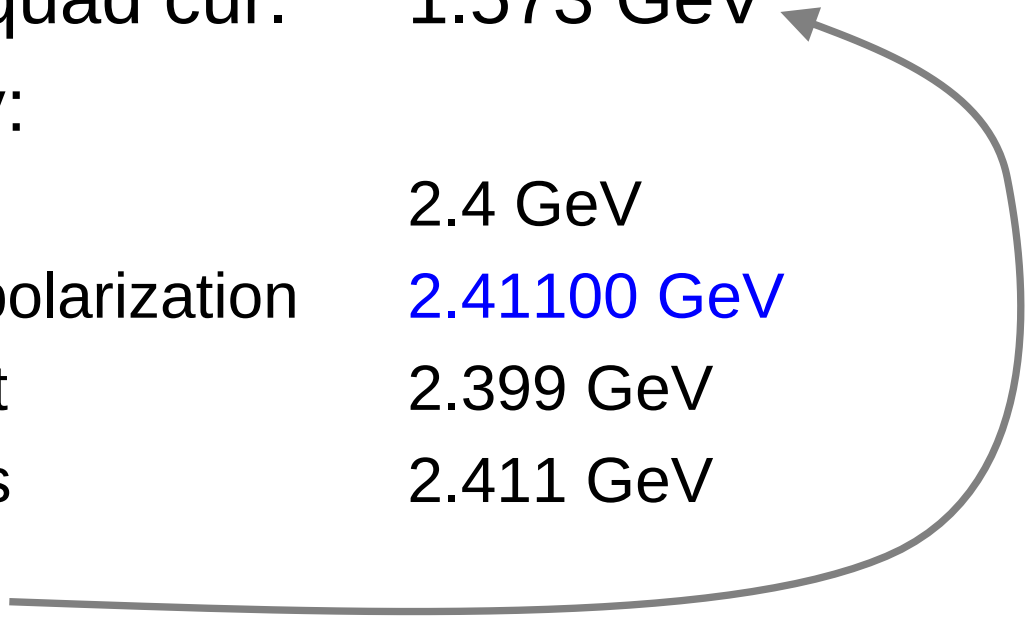
  → orbit correction difficult

  → problem to get injection/accumulation

  → not well reproducible

- Energy matching
  - booster extraction on 2.4 GeV ramp
  - energy from booster 1.617 GeV
  - energy from ring dipole cur. 1.569 GeV
  - energy from ring quad cur. 1.573 GeV
  - at nominal energy:
    - booster extraction 2.4 GeV
    - ring from spin depolarization 2.41100 GeV
    - ring dipole current 2.399 GeV
    - ring quad currents 2.411 GeV

  → believe in quads

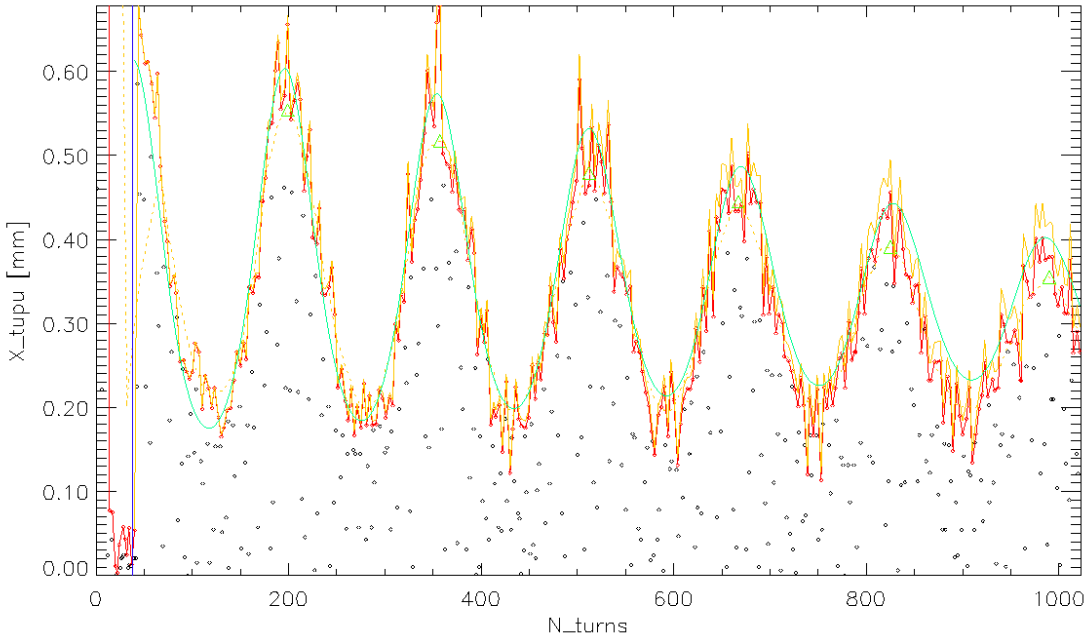


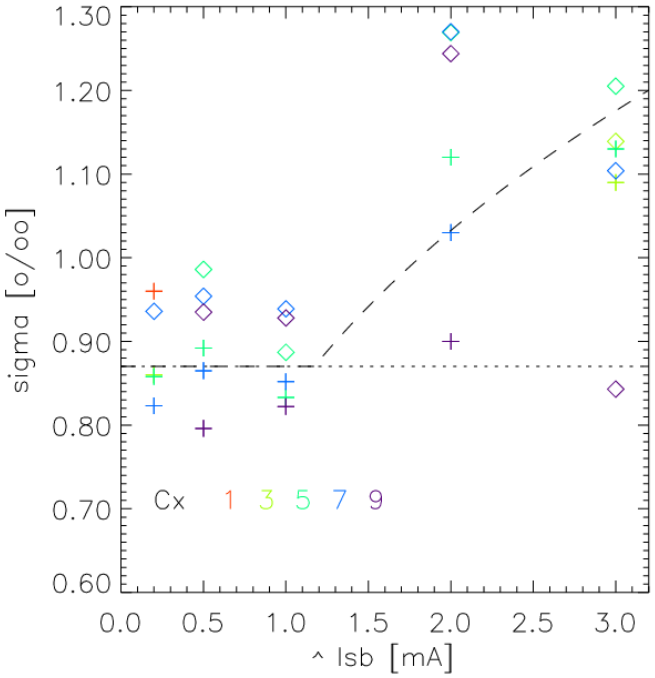
- Instabilities
  - nominal RF @ 2.4 GeV: 2.1 MV (4 x 525 kV)
  - 1.6 GeV:
    - 1 x 300..500 kV, 3 detuned → bad
    - 4 x 150...350 kV → better
  - Instabilities: long/hor/vert (mode 71, 136, ...)
  - best result (2010) for users:
    - up to 325 mA (400 bunches)
    - 4 x 320 kV and 3HC at 430 kV (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



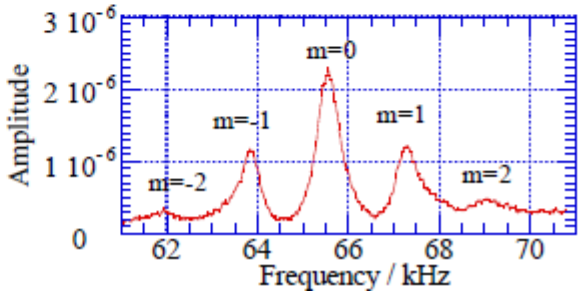
Proceedings of the 2001 Particle Accelerator Conference, Chicago

# 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*

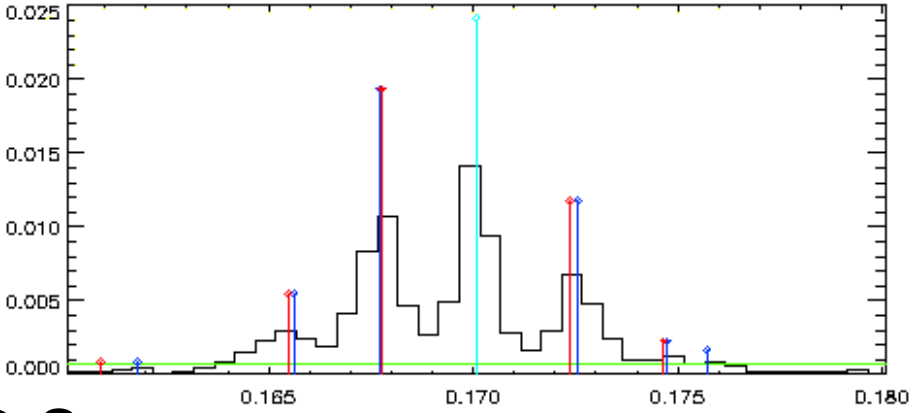
Chromaticity of a ring introduces non-harmonic betatron motion to off-momentum electrons. This motion produces synchrotron sidebands of betatron frequency in frequency response of betatron motion of a beam and reduces the main peak height. The height of these peaks depends on chromaticity and on the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

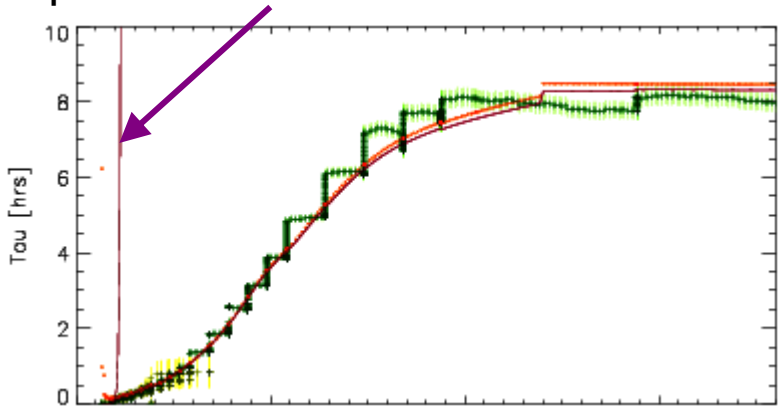
→better data using MBFB ?

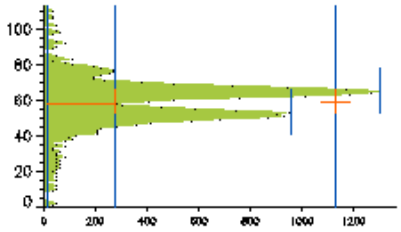


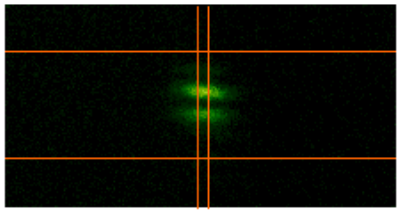
- measurement of beam size
  - at dispersive and non-dispersive location
  - using scrapers and/or pinhole arrays
  - SLS: 2 scrapers at 0 and max. dispersion
  - SLS: pinholes only at low dispersion (bend)

horizontal scraper measurement:
fit of lifetime to scraper position.

quantum lifetime → beam size

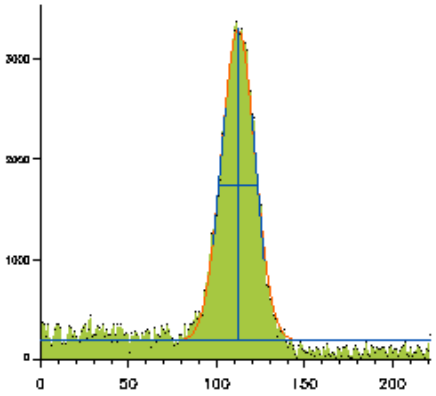


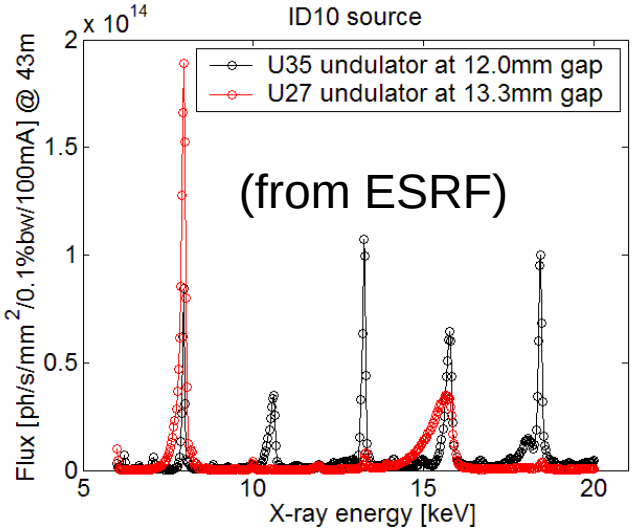
x mid = 0.112 mm
x amp = 3097.6 cts
X sig = 37.80 mic
Y sig = 10.99 mic

polarized light
monitor at 1.6 GeV
confirms ε = 2.4 nm




→ 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:**

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

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

**Formulas for synchrotron radiation from wigglers and undulators**

Werner Brefeld

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

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

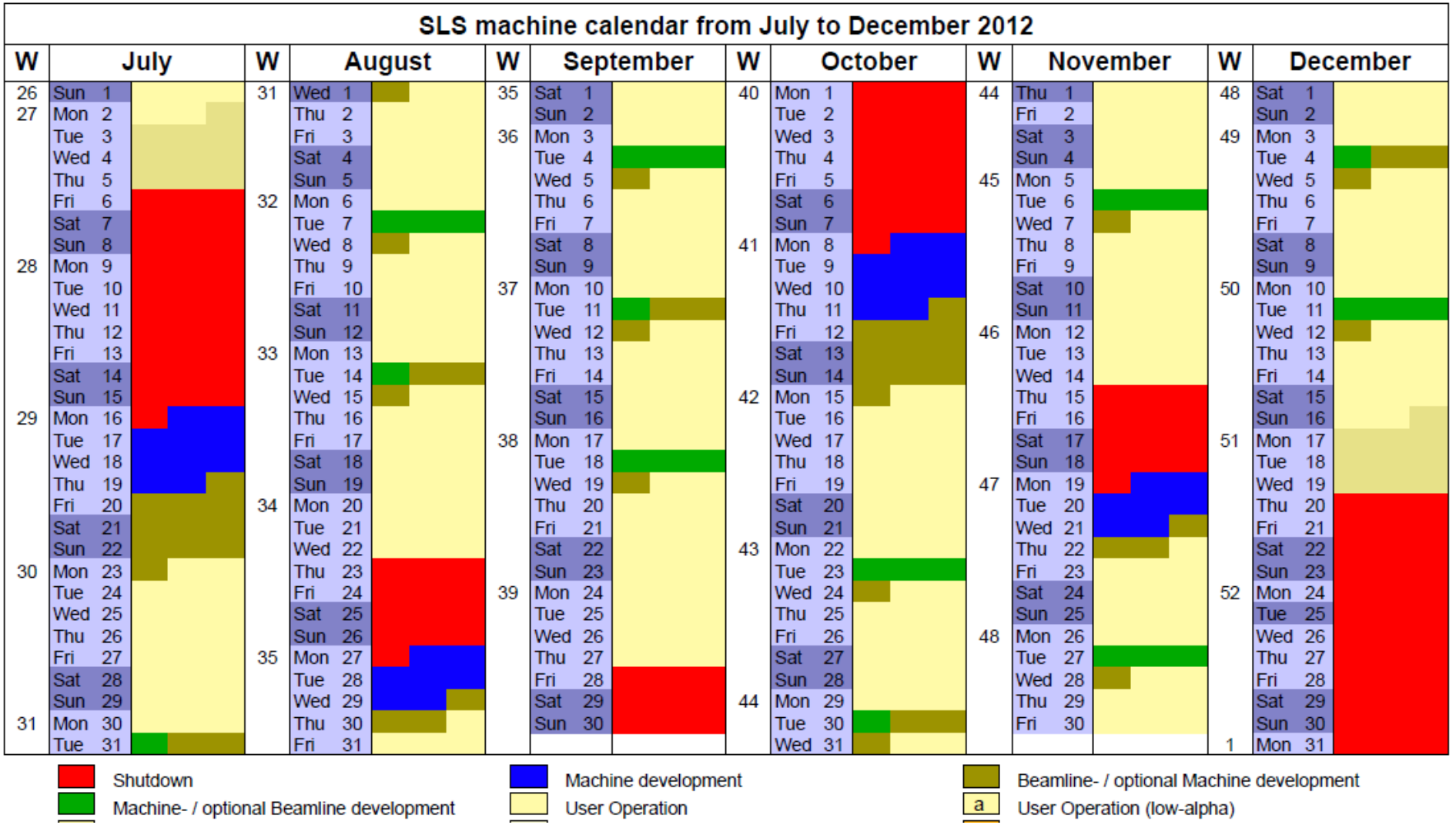
**Undulator line broadening because of the electron energy spread:**

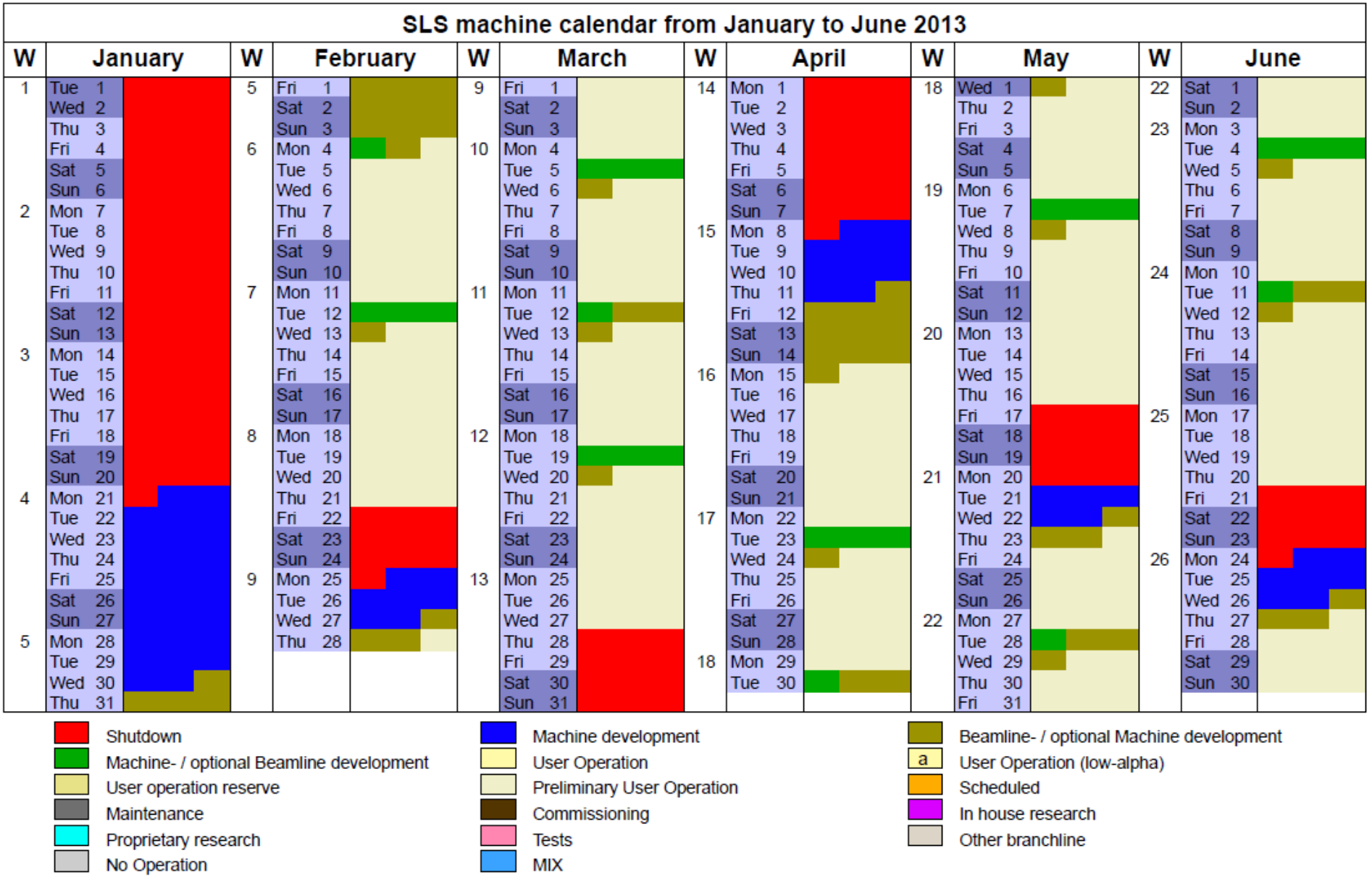
$$\frac{\Delta\lambda}{\lambda} = 2\frac{\Delta E}{E}$$

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

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

# SLS shift plan (MD = ■, ■)




SLS machine calendar from January to June 2013
W
January
February
March
April
May
June
Shutdown
Machine- / optional Beamline development
User operation reserve
Maintenance
Proprietary research
No Operation
Machine development
User Operation
Preliminary User Operation
Commissioning
Tests
MIX
Beamline- / optional Machine development
User Operation (low-alpha)
Scheduled
In house research
Other branchline