Status of Metrology Light Source

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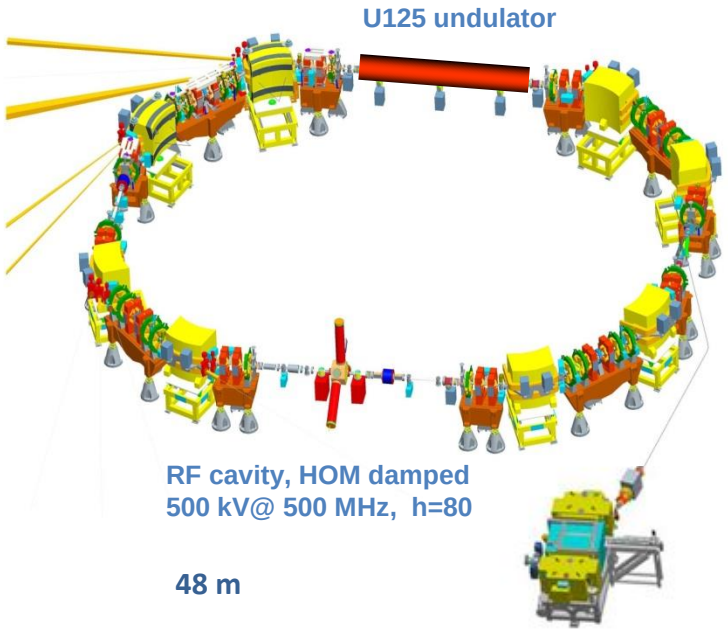
OUTLINE

- The Metrology Light Source(MLS)
- Problems in operations
- On-going studies
- Summary

THE METROLOGY LIGHT SOURCE(MLS)

HZB Helmholtz Zentrum Berlin



Owned by PTB
Run by HZB

Circumference	**48 m**
Revolution frequency	**f_{rev} = 6.25 MHz, T_{rev} = 160 ns**
Injection Energy	**105 MeV**
Operational Energy	**50 MeV to 630 MeV**
Beam Current	**1 pA (1e-) to 200 mA**
Momentum Compaction Factor	**-0.05 < α < 0.05**
Emittances at 630 MeV	**25 nmrad** (low emittance) **100 nmrad** (standard user)
Typical lifetimes in different operation modes	Standard **6h @150mA, 80h @1pA (1 e-)** Low emit. **2h @150mA** Low Alpha **10h @150mA**

PTB

HZB Helmholtz Zentrum Berlin

❖ **Severe operational problems throughout 2017 limited user conditions**

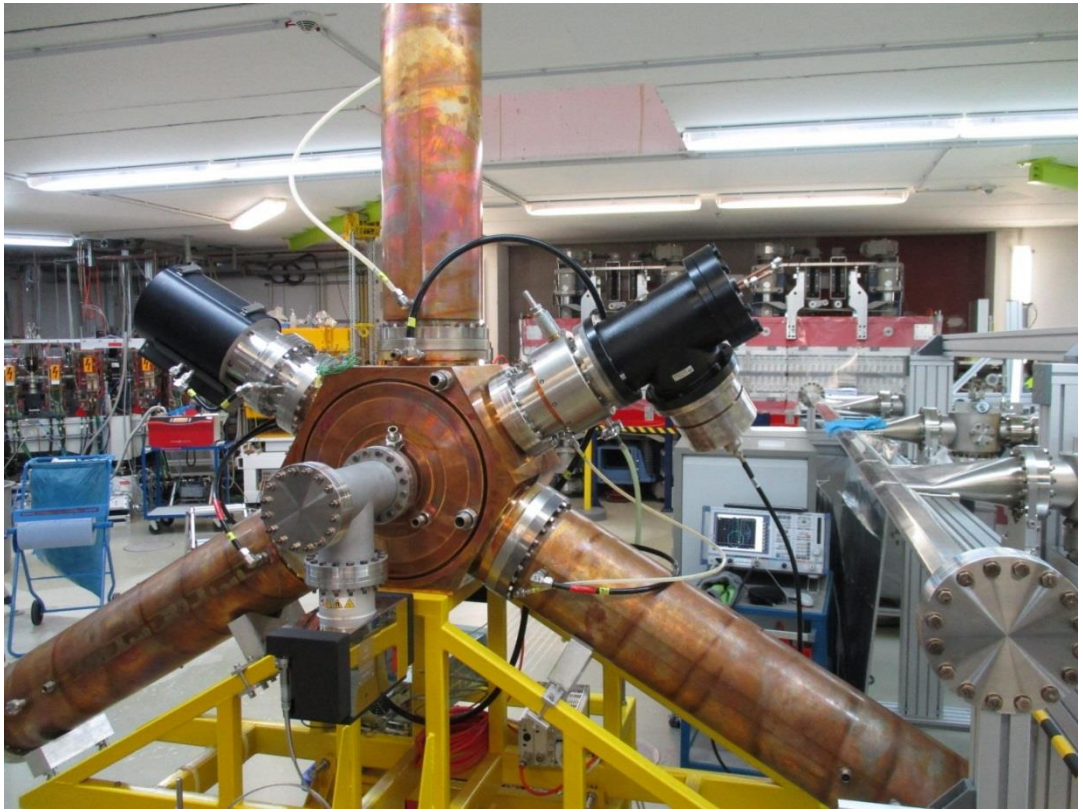
- vacuum leak inside cavity
  - ➢ for periods no beam available for users
- energy ramping difficulties due to unsynchronized data allocation
  - ➢ reduced beam current throughout 2017
  - ➢ longer energy ramping time needed -> more loss of user time
- No user time statistics of the avaibility.

  All machine problems resulting user time limitations are discussed and coordinated directly and in time with MLS users

PTB

November 2016 during MLS shut down RF-Cavity was replaced

- modified spare cavity allows more power (45kW->80kW)
- the **vacuum leak** showed up soon afterwards
- **several attempts of leak search failed**



VACUUM LEAK OF THE MLS CAVITY

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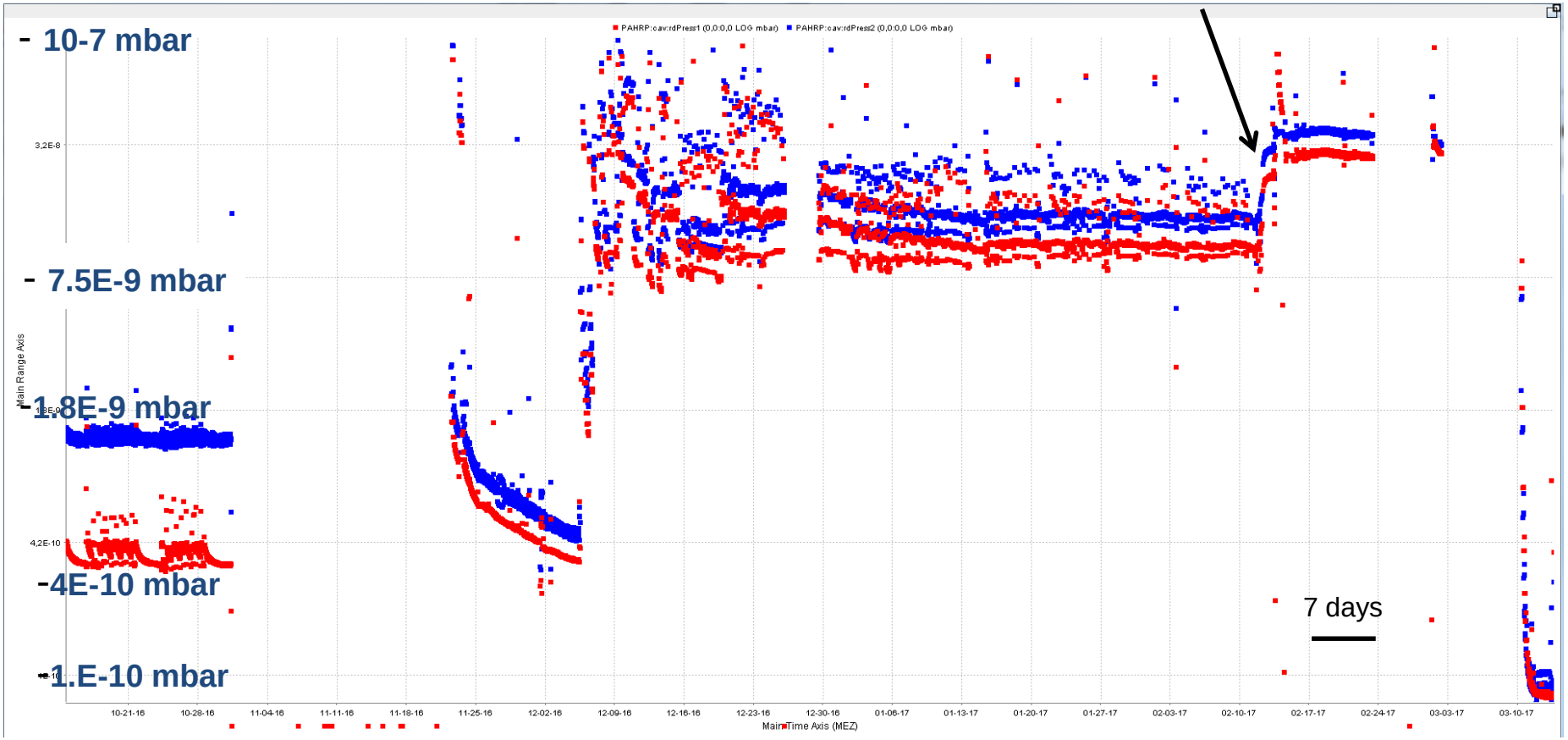
User Run Oct16 | **Shut Down Cav replaced** | **Cav-Heating** | **Conditioning** | **user operation at reduced op-conditions** | **leak opens further** | **leak search** | **leak glued and cav cond.**



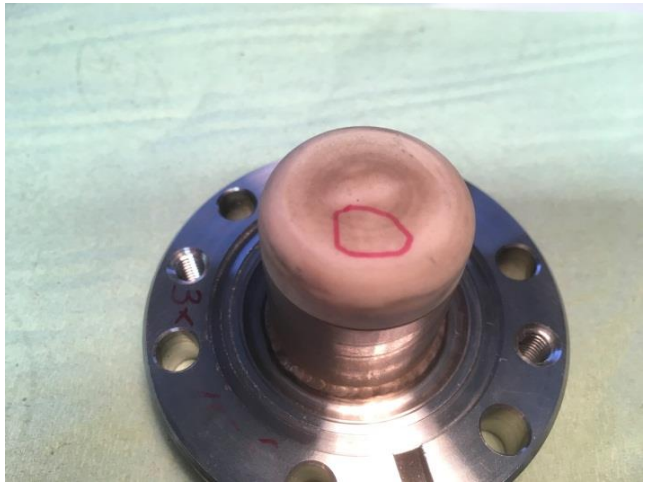
Oct 16 — March 17

Pressure inside Cavity vs Time (y log-scale)

PTB

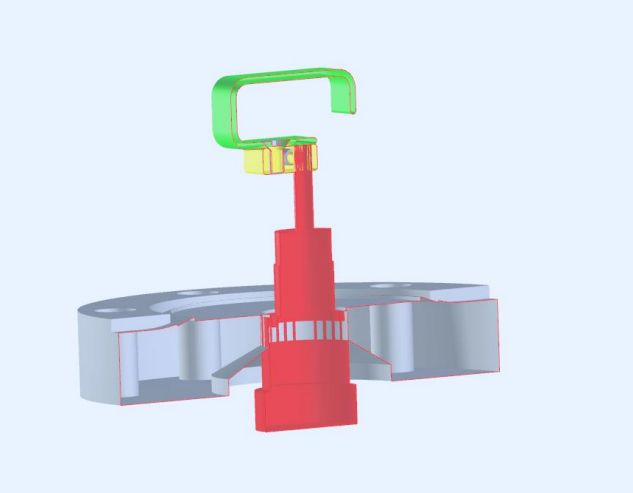
VACUUM LEAK OF THE MLS CAVITY: REASON

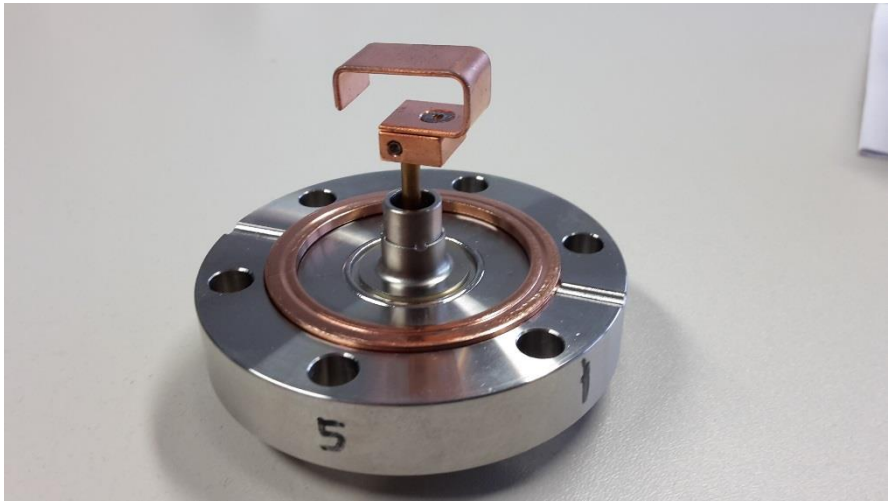
- Leak found **inside ceramic box holding the diagnostic coupling antenna**
  30 minutes before giving up the search and deciding of changing back to previous Cavity
- ceramic inside antenna holder was broken -> ~40-year-old device ->
  oxidation of the old copper antenna leads to heating up on the ceramic surface



- antenna box was **enclosed to atmosphere** -> Helium of the leak detector cannot easily enter
- vacuum deteriotation by enclosed gas volume inside antenna holder box

- Glueing the leak could only be a temporary solution for user operation
- A new in-vacuum antenna (ALBA design) was built and installed in May 2017



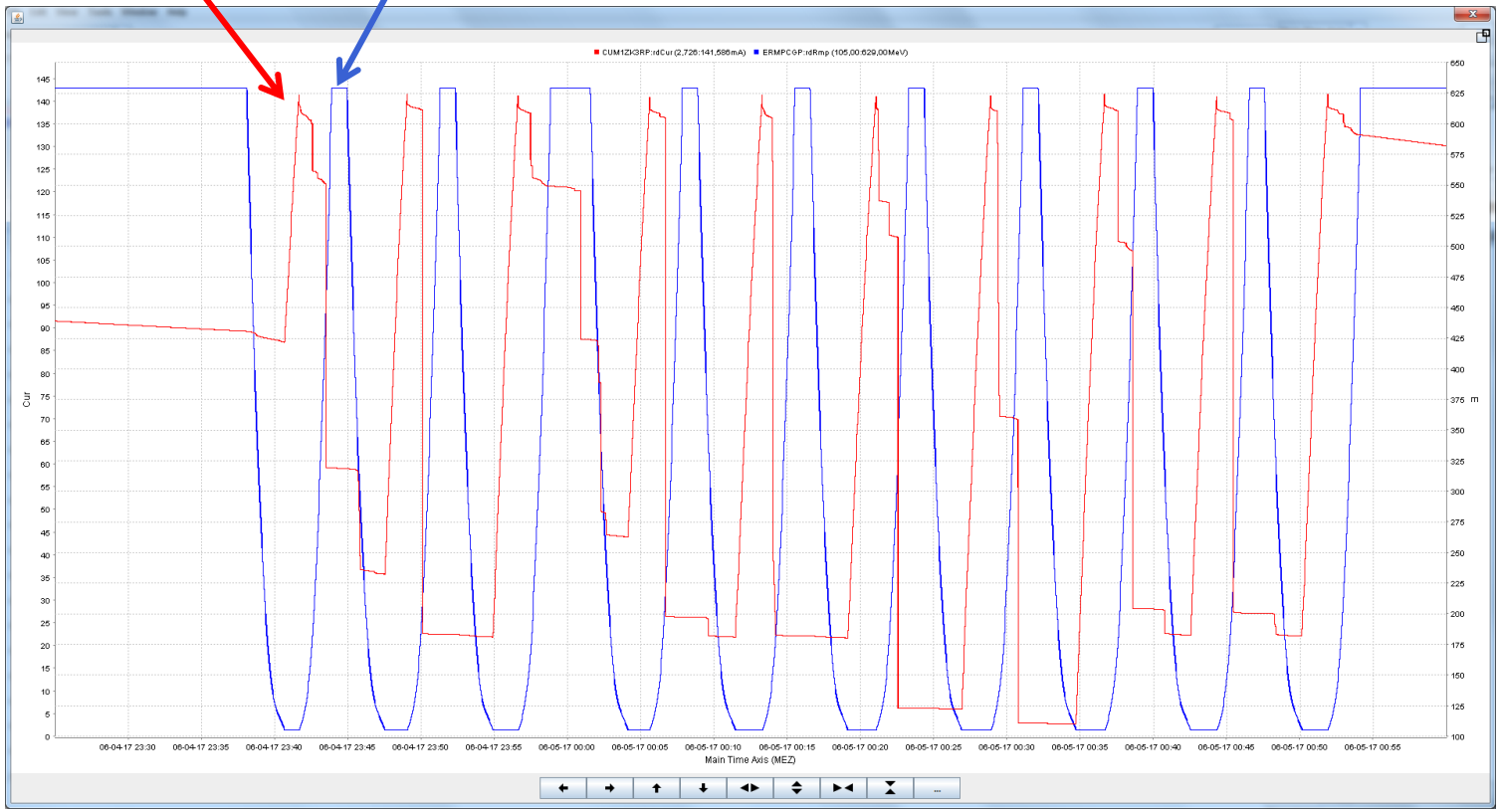


- Vacuum lifetime increased to **80h** compared to **30h** before cavity replacement
  - showing that the former antenna holder must already had a leak in last years
  - the same problem found at BESSY II (in the talk of M. Ries)

After vacuum recovered frequent **beam losses in energy ramp** became a severe problem，and this was masked by the bad vacuum conditions before

beam current

beam energy



for **1 ½ h** trying to ramp up with140 mA beam current

- It was found the synchronisation of the set values delivery via EPICS to the power supplies was disturbed
  - after changes and updates of the control system
  - increased data trafic in the EPICS channels

- **A new conceptional design of the EPICS data delivery for MLS is needed** (ongoing)

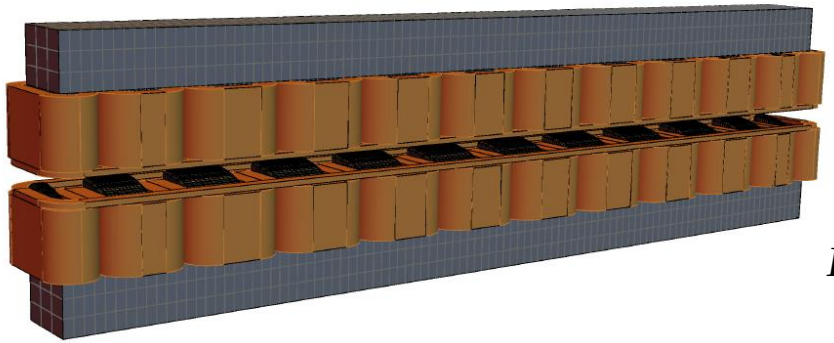
- so far ramping capability was recovered by some provisional measures

  - increasd ramping time from 4 to 5 ½ minutes (was 90 seconds in 2007)
  - reduced data traffic by suppressing less important data transfer during energy ramp
  - reduced maximum accumulated current from 200 mA to 180 mA

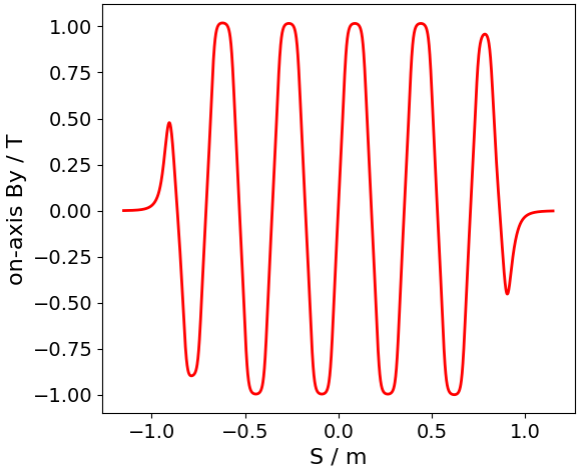
- **Developing a new negative low alpha user state**
  - single bunch bursting current threshold increased by a **factor of 40** in new negative α state compared to formerly used low alpha optics (with positive alpha)
  - stable power emission in multi-bunch operation doubled in new neg. alpha optics

- MLS will serve as a testbed for the **Steady-State MicroBunching** (SSMB) scheme proposed by A. Chao and D. Ratner in 2014 (details in *SLAC PUB 16115*).

- Subjects to consider for further studies:
  - how to achieve high peak current without bursting at very low alpha ($\alpha \sim 10^{-5}$) ?
  - optimum values of higher order components of momentum compaction function ?

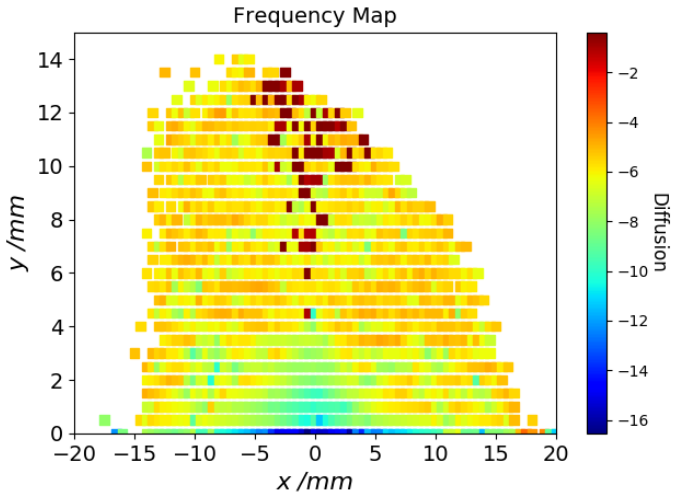


$$D = \frac{I_4}{I_2}$$



$$\varepsilon_x = C_q \gamma^2 \frac{I_5}{I_2} \frac{1}{1-D} = \varepsilon_{x,0} \cdot \frac{1}{1-D} \qquad \sigma_x = \sqrt{\varepsilon_x \beta_x + \sigma_\delta^2 \eta_x^2}$$

$$\sigma_\delta^2 = C_q \gamma^2 \frac{I_3}{I_2} \frac{1}{2+D} = \sigma_{\delta,0}^2 \cdot \frac{2}{2+D} \qquad \sigma_z = \frac{\alpha \sigma_\delta C}{2\pi \nu_s}$$

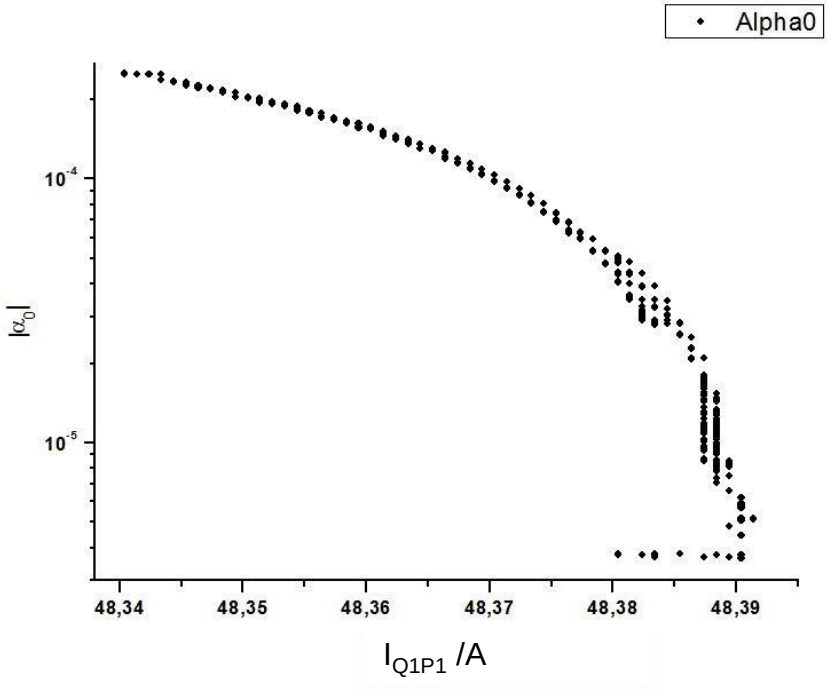


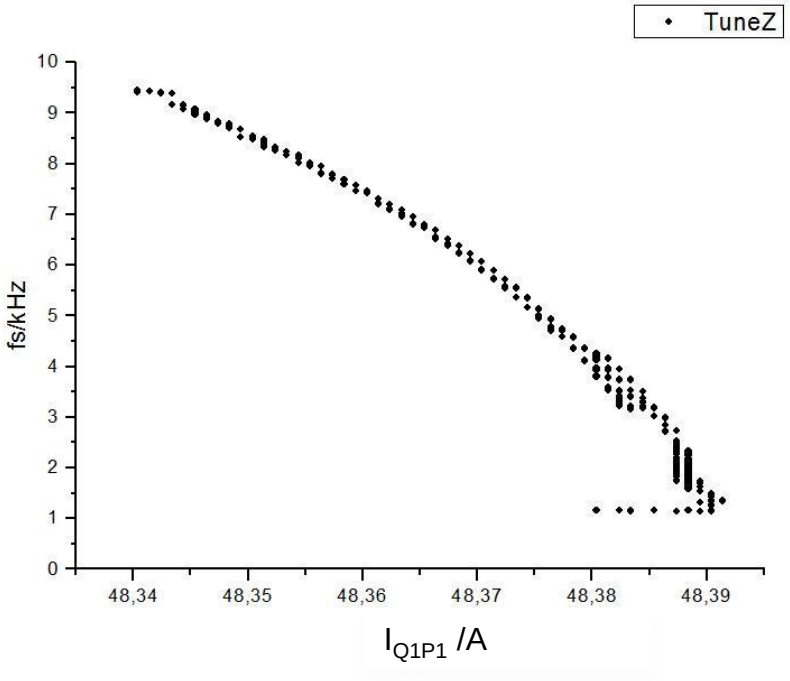
1. Manipulating hor. and long. damping -> make D negative
2. To keep σ_x and increase σ_s in operation for longer lifetime
3. Final calculations on-going: nonlinear dynamics
4. Manufacture will start in 2018

SUMMARY

- MLS is very flexible in operation modes and machine studies
- MLS and BESSY II benefited from the new antenna after the vacuum leak
- Studies of negative low alpha mode are very exciting and will go further
- Robinson wiggler is planned to be installed in 2019

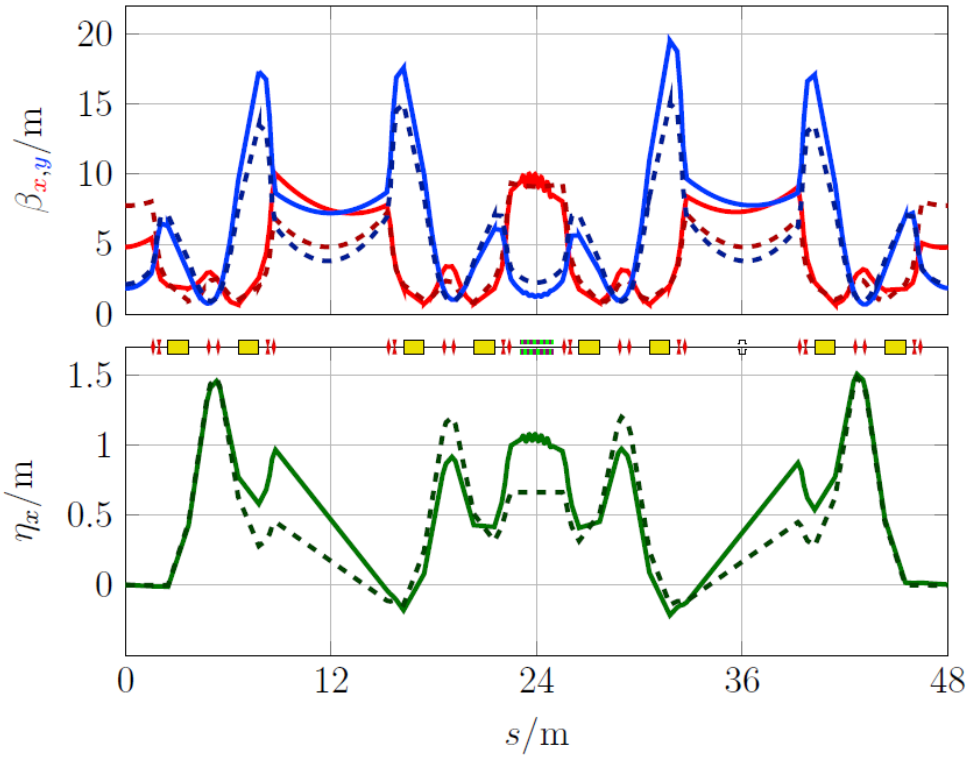
Thanks for your attention!


Alpha0
10^{-4}
10^{-5}
$|\alpha_0|$
48,34
48,35
48,36
48,37
48,38
48,39
I_{Q1P1} /A


TuneZ
10
9
8
7
6
5
4
3
2
1
0
fs/kHz
48,34
48,35
48,36
48,37
48,38
48,39
I_{Q1P1} /A

$$I_2 = \oint \frac{1}{\rho^2} ds$$

$$I_4 = \oint \frac{\eta_x}{\rho}\left(\frac{1}{\rho^2} + 2k_1\right) ds = \oint \left(\frac{\eta_x}{\rho^3} + \frac{2}{(B\rho)^2}\eta_x B_y \frac{\partial B_y}{\partial x}\right) ds$$



Optics w/o RW
in T. Tydecks PhD thesis