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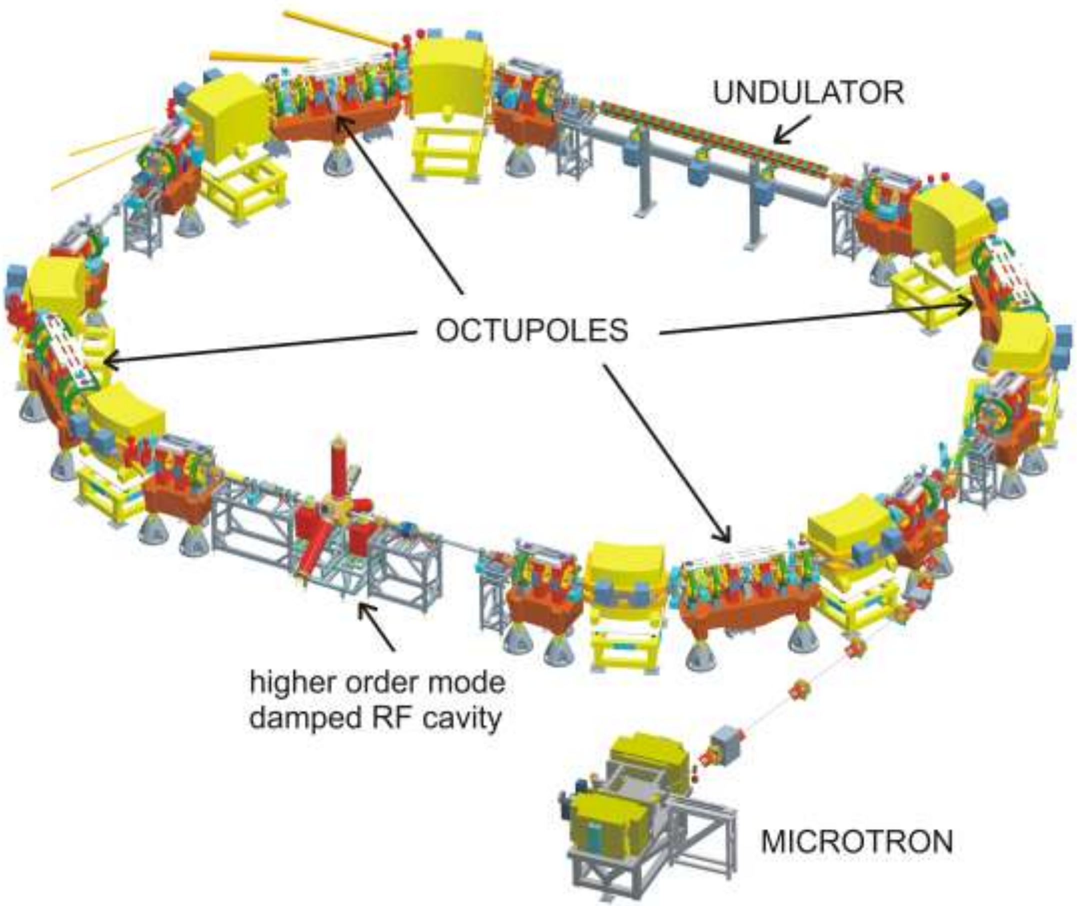
Recent Work at the Metrology Light Source

Jörg Feikes for the MLS Team

The MLS ring



- **Circumference = 48 m**
- **Injection E = 105 MeV**
- **operational E = 105 - 629 MeV**
- **I_e = 1 pA (=1e-) - 200 mA**
- **|α| = 5x10-5 – 7x10-2**

first ring optimized for low alpha operation by use of octupoles

- **Qx / Qy = 3.18 / 2.23**
- **ε_{design} = 100 nmrad** @600 MeV

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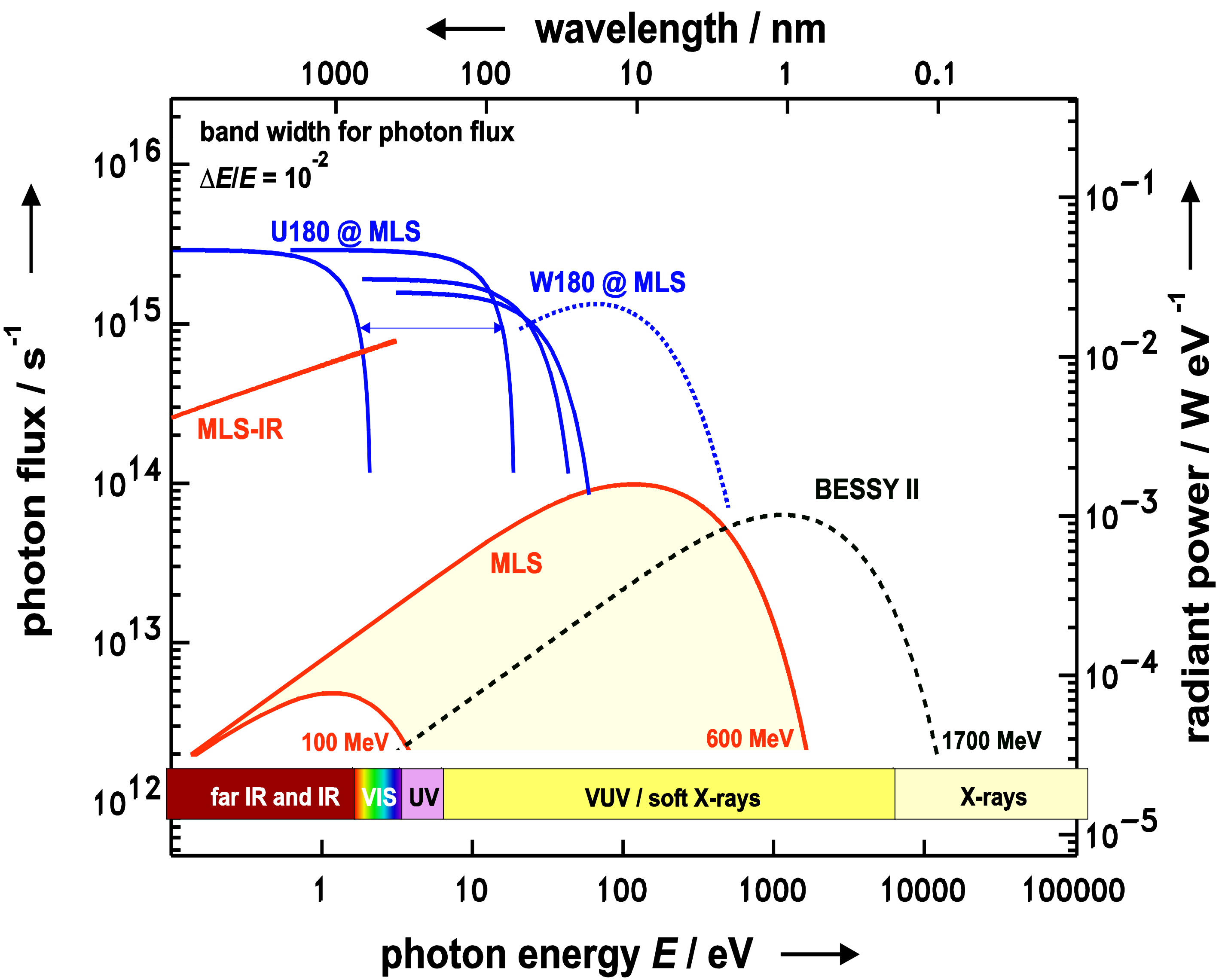

MLS Operation

until 2011 user operation: Mo-Fr 8h–20h
envisaged 2012: Mo-Fr 7h-23h + “dawn special“ (= no operator)

typical for MLS operation are varying user conditions

- **beam current : 1e (1pA) – 200 mA**
- **beam energy : 105 MeV – 629 MeV**
- **momentum compaction factor: 0.033 - 0.00005**

Distribution of user time 2010

	absolut / d	relativ / %
user time	147	100
standard user mode	67,5	46
special modes	79,5	54
within special low α	39,5	27

working groups	absolut / d	relativ / %
Synchrotronstrahlungsquellen	24	16
EUV-Radiometrie	6	4
UV- und VUV-Radiometrie	58,5	40
IR-Spektrometrie	58,5	40

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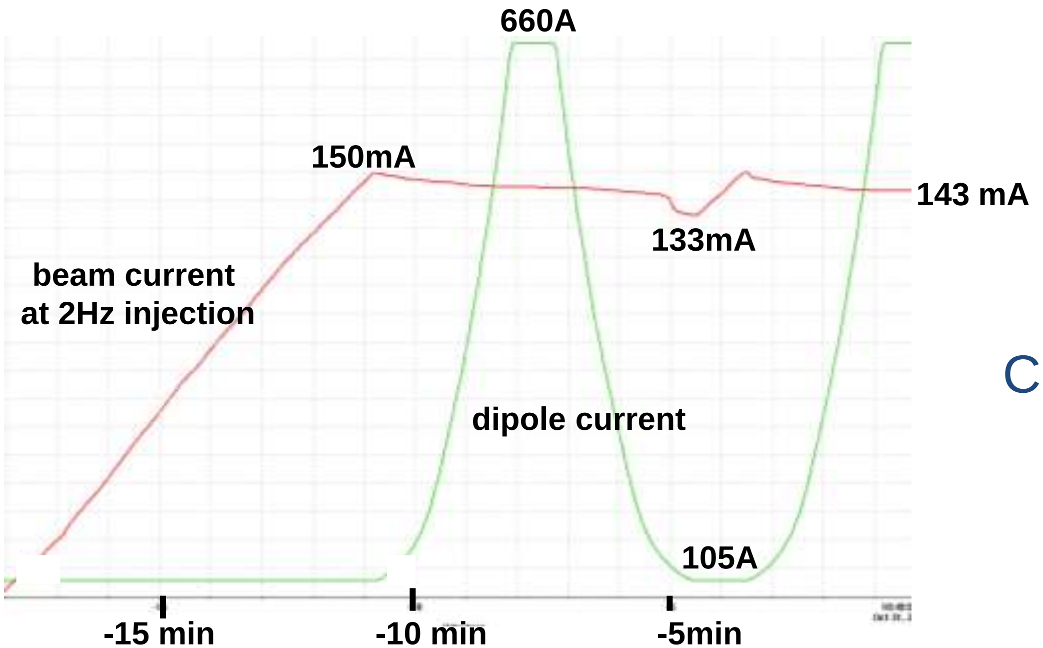

Current conserving refill cycle

beam current remains stored during complete ramp cycle ->

- advantage: reduced activation

- draw back: magnets are not degaussed ->

strong hysteresis -> errors in handling of magnets = serious impact !

state changes are complex. Errors are likely and potentially serious -> operation done by

automated state machine = „Operation Master“ (MLS Talk@ ESLS2010)

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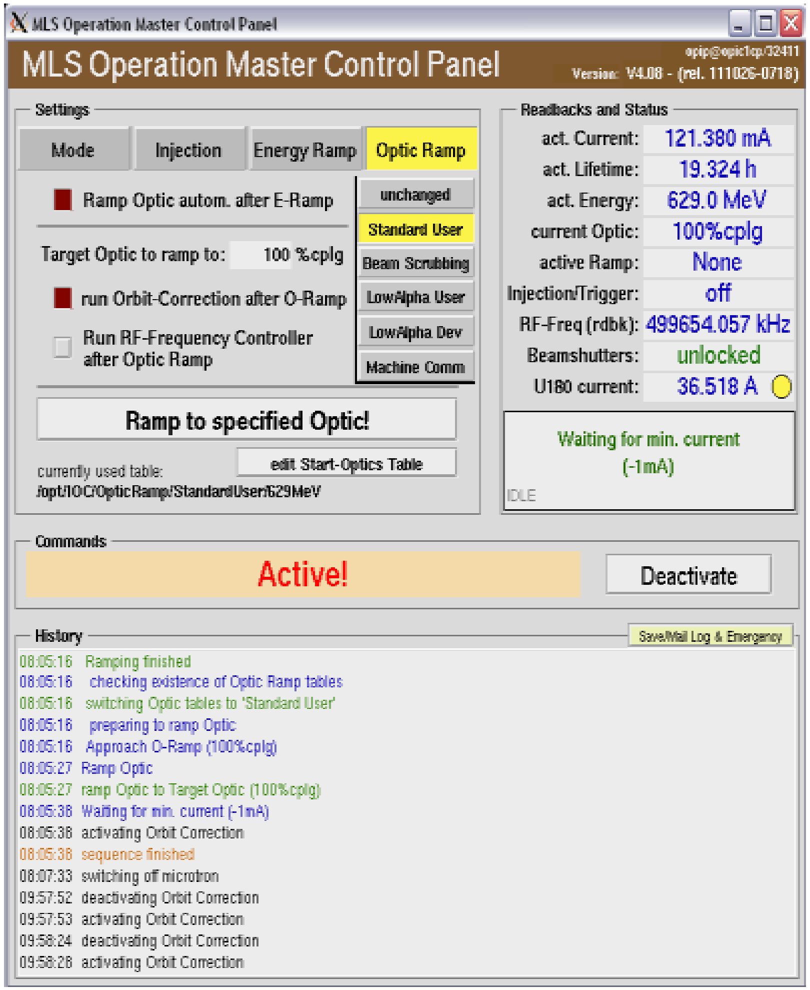
Expanding the Operation Master (T. Birke, PAC09, Vanvcouver)



operator selects desired machine state

- **beam current** and **energy**
- **operating modes:**
- **standard User Mode** + vertical beam size
- **Low Alpha Mode** + value of **alpha**
- **Beam scrubbing Mode** + **current limits**

push „**GO**“ -Button

Operation Master performs transition

- analyzes actual machine state, checks that all sub-systems are ready
- transition to ramp state
- ramps down to injection energy
- switch on systems for injection
- injects up to desired current and ramps up to desired energy
- switches off sub-systems not needed
- performs transition to desired user modes
- configures and starts sub-systems for user run

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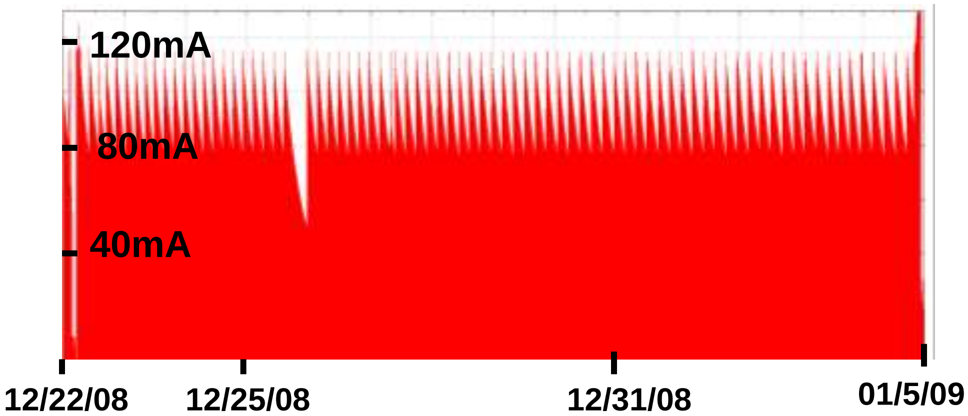
Expanding the Operation Master

concept of Operation Master stretches far beyond concept of „automated operation" *)

-> Next step: including permanent beam-based check of target properties (beam size, orbit, stability …)

***) automated operation Dez08-Jan09:**



2 weeks of unmaned operation

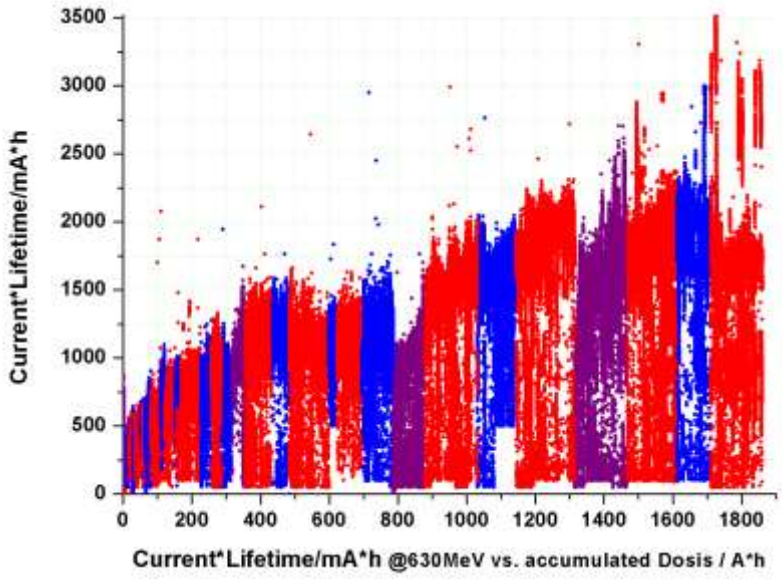
an early application of the state machine concept

see MLS Talk@ ESLS2010

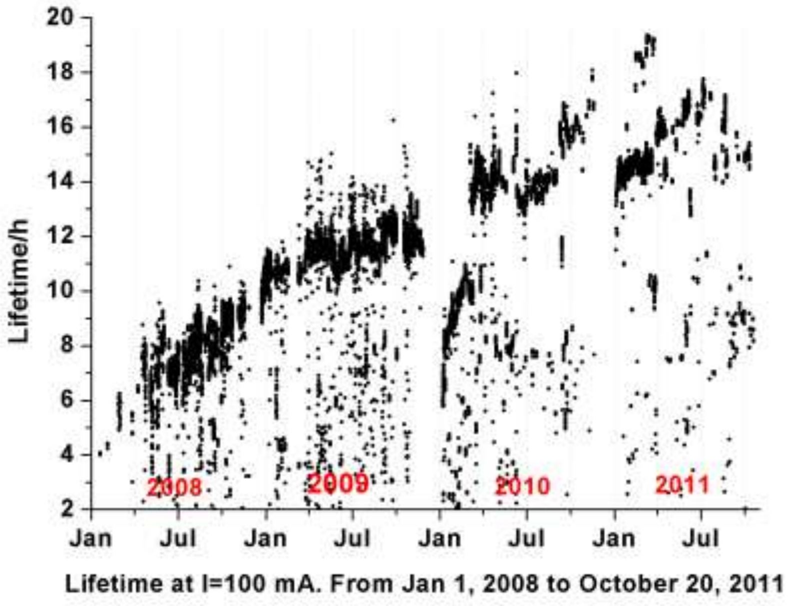
Vacuum conditions

Continous Beam scrubbing still very important to recover from openings of vacuum system. Still improving Lifetime with accumulated dosis

current*Lifetime vs accumulated dosis



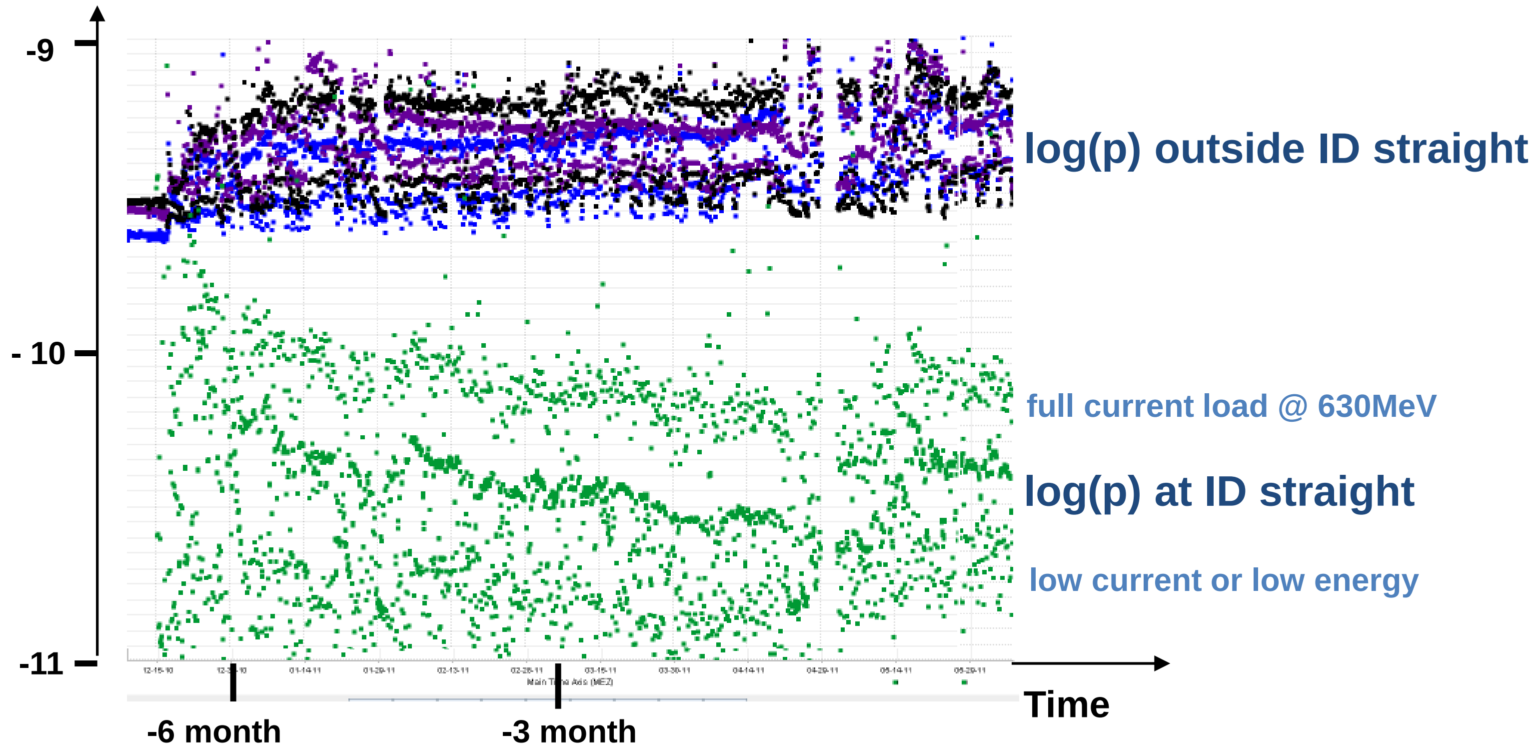
Lifetime@100mA in user operation



Vacuum conditions II

December 2010 installation of a new ID NEG chamber
(first NEG chamber at HZB) -> promising behaviour !

Pressure values measured after NEG installation **12/15/10- 6/1/11**



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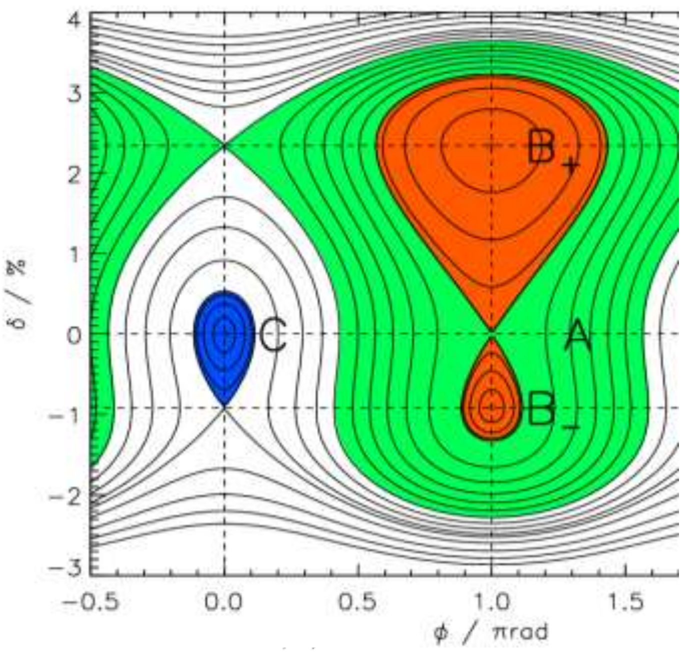
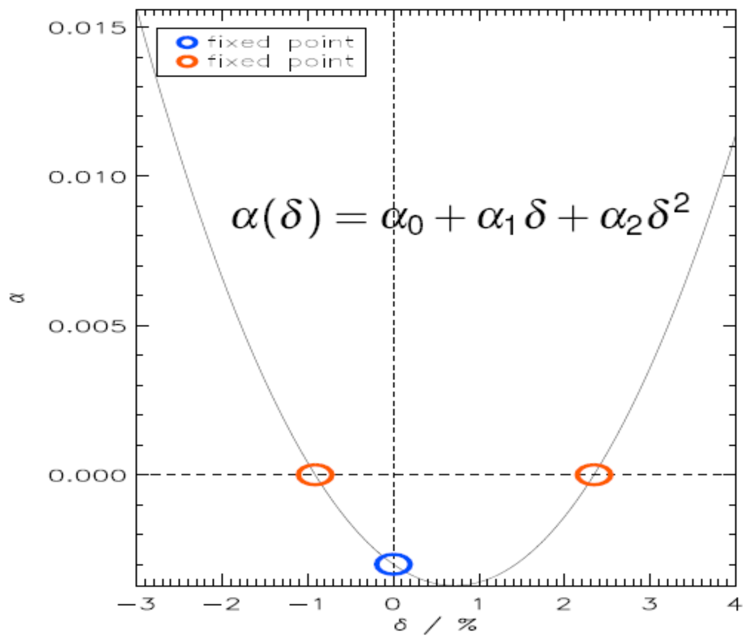
Low Alpha Operation - Nonlinear Buckets

(M. Ries, IPAC 2011, San Sebastian)

adjusted with octupole

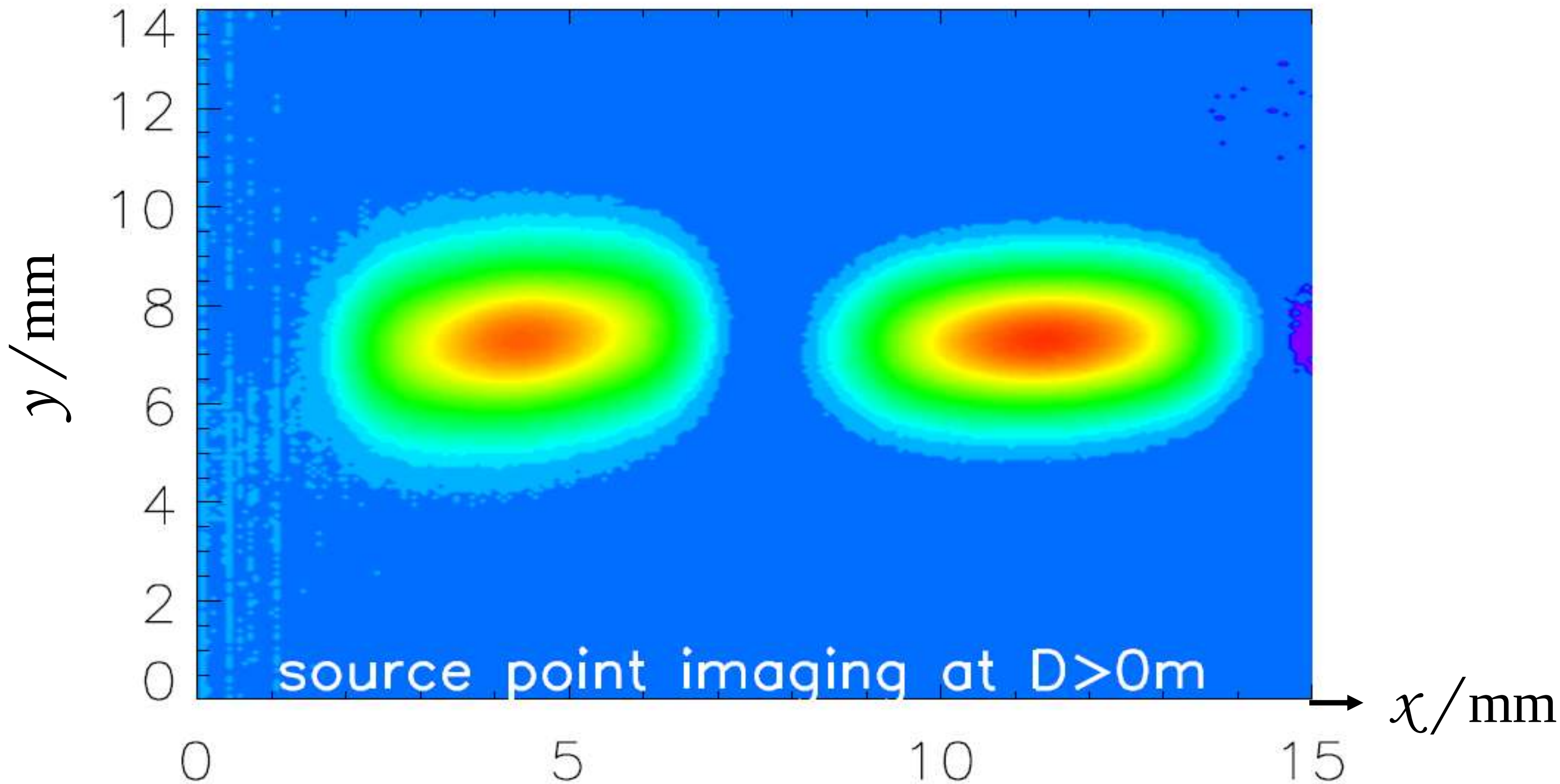
$$\mathcal{H}(\phi,\delta) = 2\pi q f_{\text{rev}} \left(\frac{\alpha_0}{2} + \frac{\alpha_1}{3}\,\delta + \frac{\alpha_2}{4}\,\delta^2 \ldots \right) \delta^2 + \frac{eU_0 f_{\text{rev}}}{\beta^2 E_0} \cos(\phi)$$



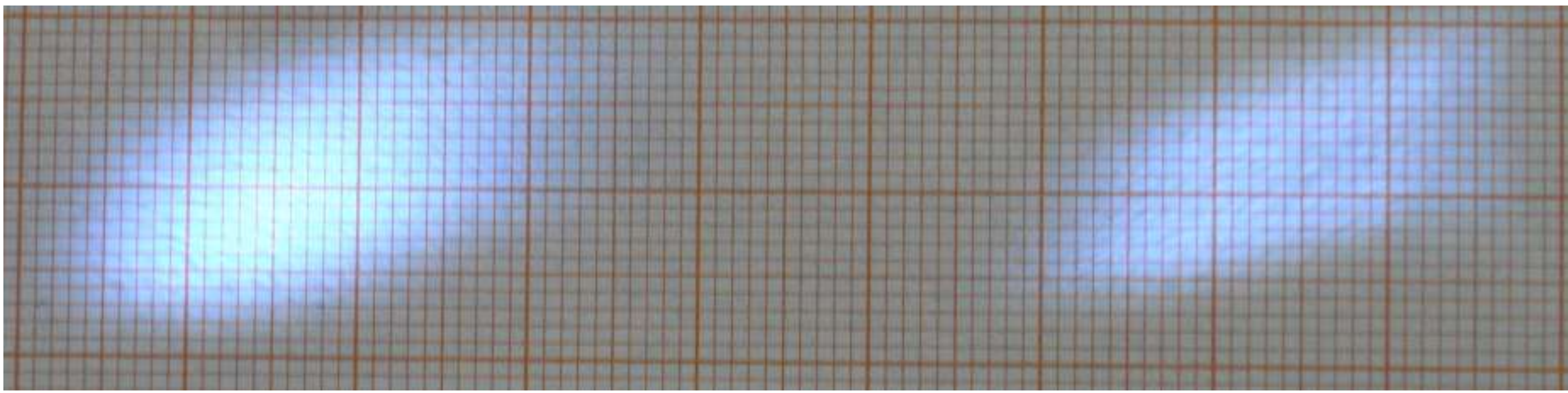


$E = 629$ MeV, $I = 170$ mA, $\tau = 10$ h

Double beam operation

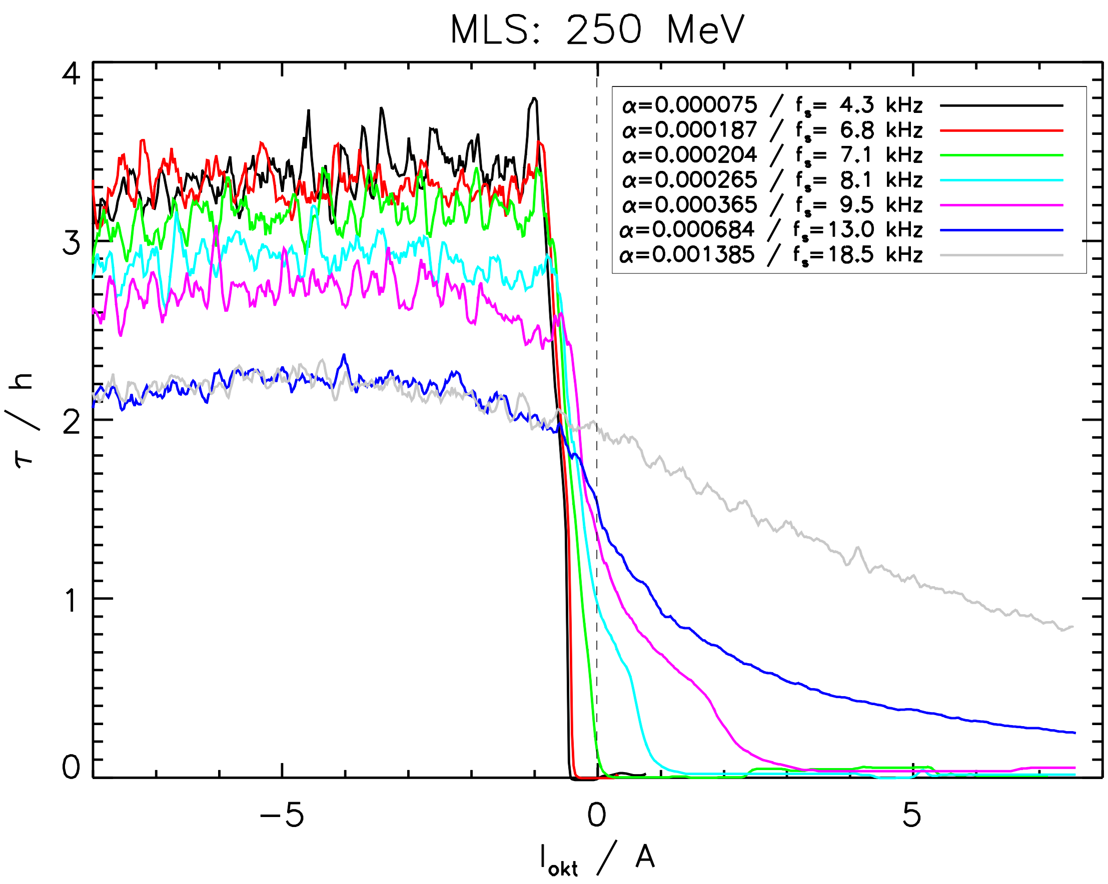


Double Beam: well seperated source points at experiment(s)



5 cm

Importance of octupoles at low alpha: lifetime vs. octupole current



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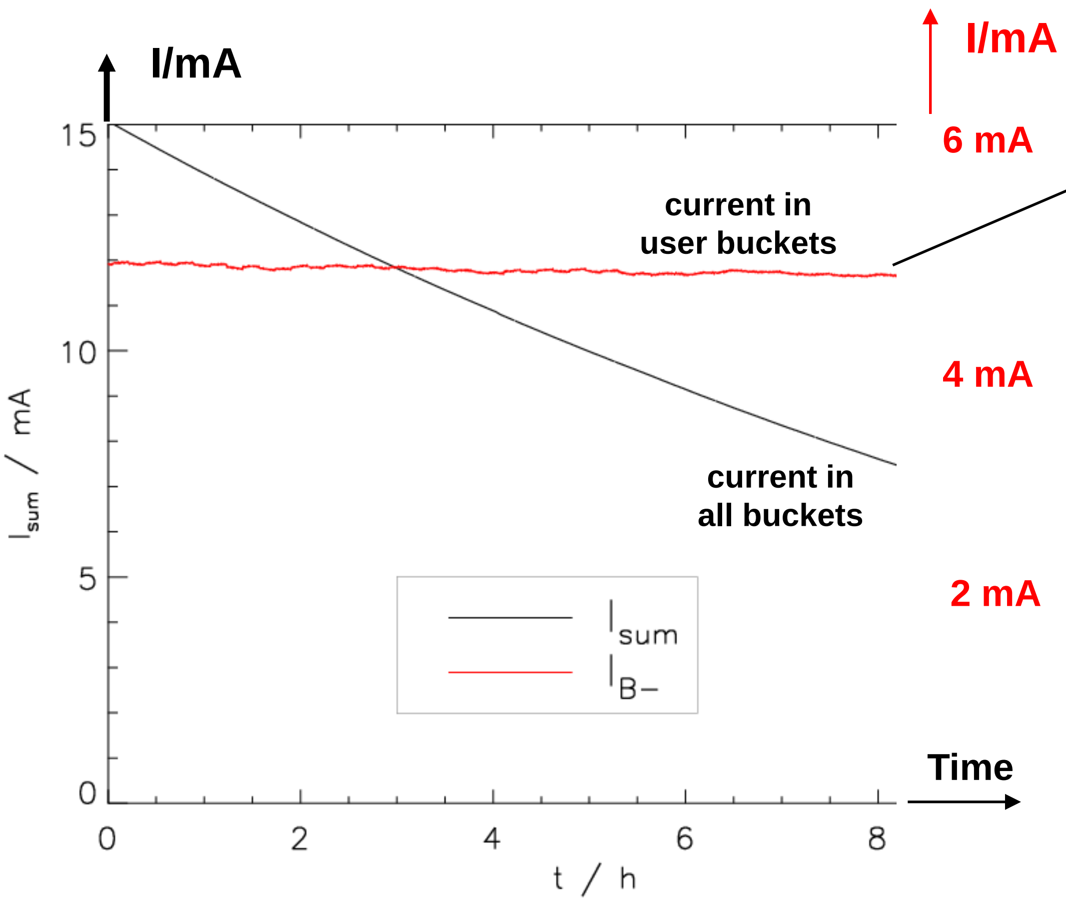
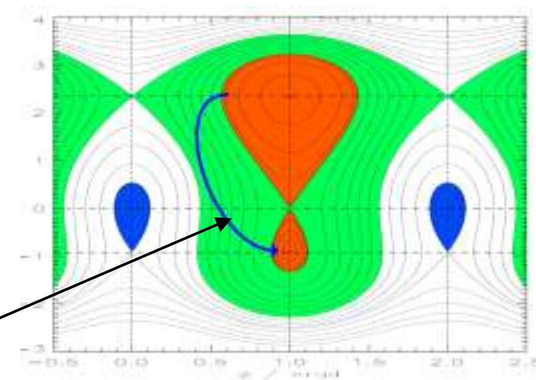
Demonstration of a constant flux mode using „lifetime feedback“ on double beam





by adjusting the diffusion rate from reservoir to user buckets

beam lifetime ≈ ∞ (nearly)

was achieved for over 10h

User requirements at the MLS

2011 moderate requirements on beam conditions
- beam unstable in standard user mode
- „large“ vertical beam size

2012: new EUV reflectometry BL and scanning new field optical microscope with new challenging demands

beam size requirement horiz. < 250 µm, vert. < 200 µm
stability -> max 10% of beam size at time scale 1s – 1h
lifetime -> at least 4h at high current (>140 mA)

conflicting demands: small vertical beam vs good lifetime vs beam stability

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user demands on lifetime, source size and stability

20h@ 1000µm

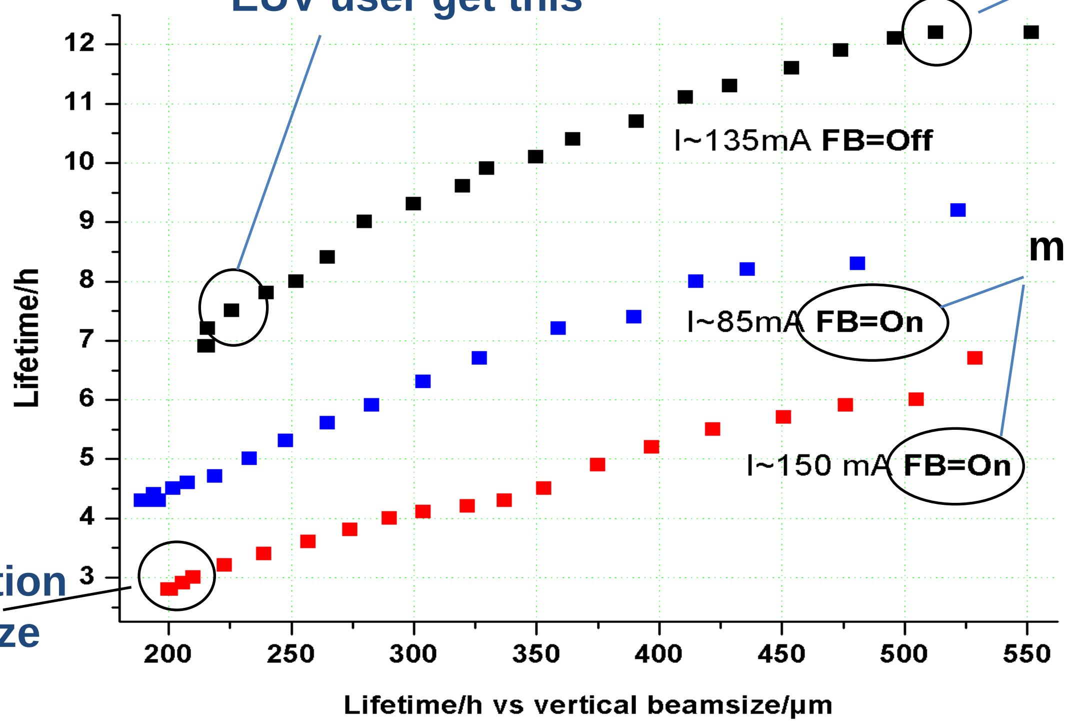
one User gets this

most other users get this

EUV user get this

multi bunch feedback

EUV specification vert. beam size

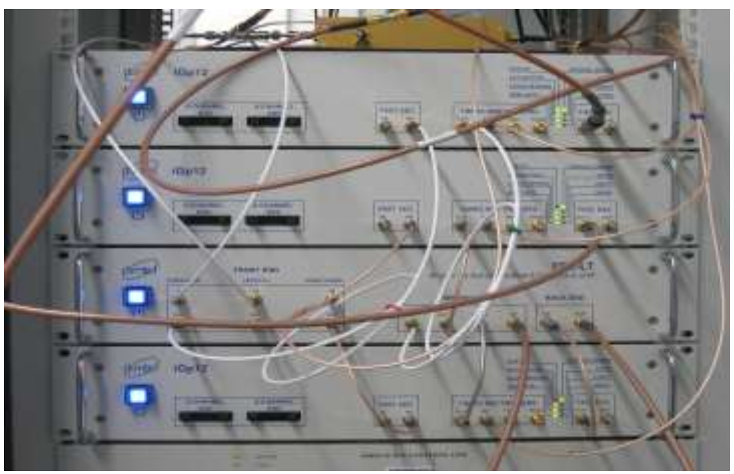


suggested solution **Landau Cavity**

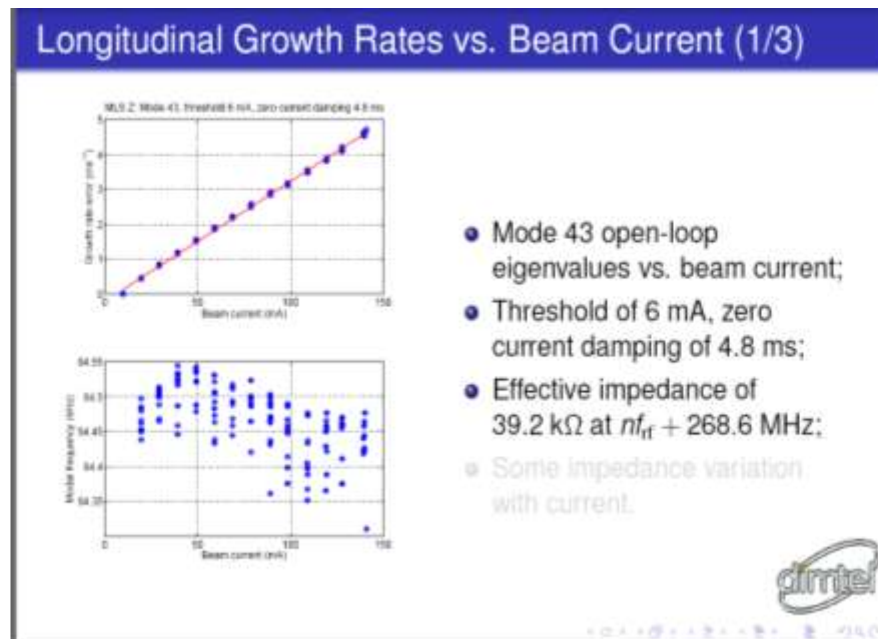
MLS Multi Bunch Feedback

- effectively damping coherent instabilities in all planes
- bunch cleaning -> variable fill patterns can now be offered to our users
- diagnosis of beam instabilities and ion effects

Long. + Transv DIMTEL MB- FB systems

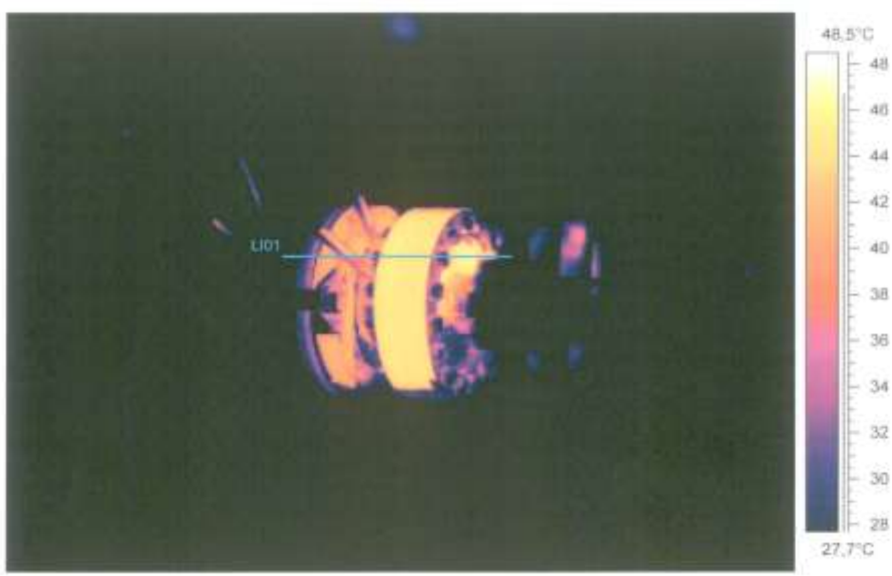


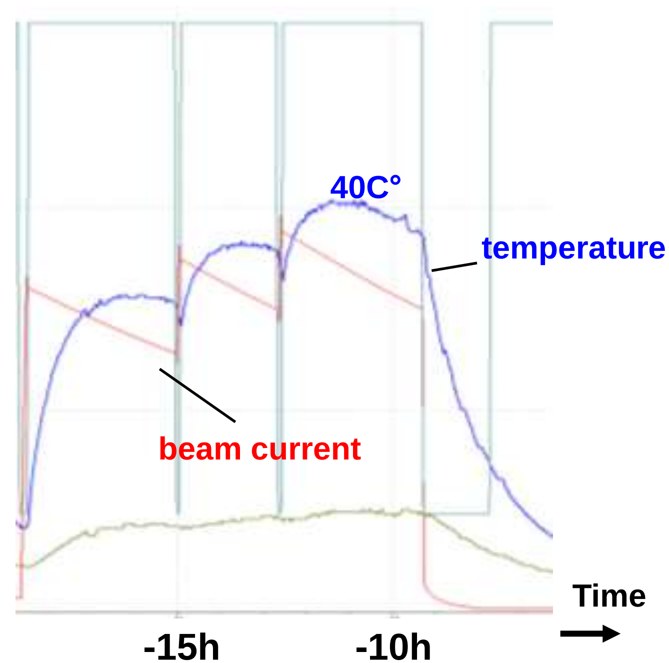
10/27/11 long. Impedance measurement
D. Teytelman



MLS parasitic impedance

thermo scan in search for **parasitic impedances** –> **<u>result:</u>** a **flange** heats up
temperature rise depends on **beam current and bunch length** (shorter bunch -> hotter flange)
Characterizing parameters (instability growth rates, current thresholds etc) were measured and will be measured again after **changing the flange in Shut Down December 2011**.

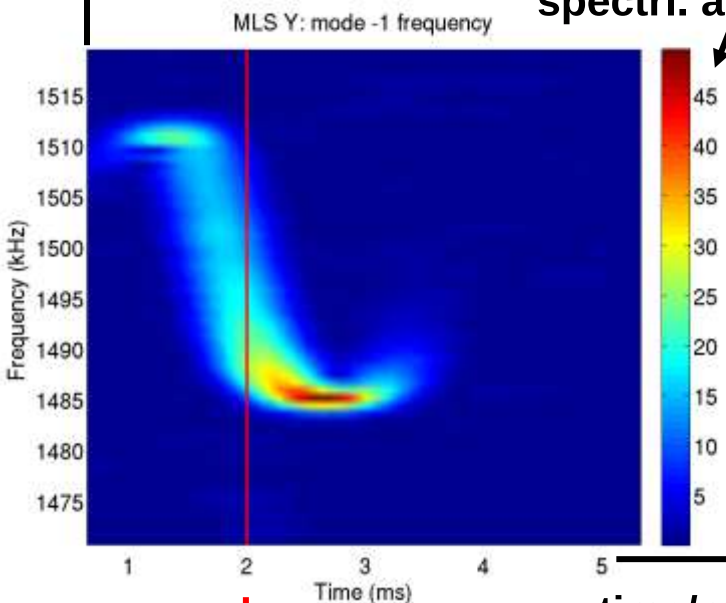




Example for Ion/Feedback Interaction

mode frequency/kHz

spectrl. ampl./db



time/ms

FB Off | FB On

atypical behaviour during Growth/Damp Measurement

- **large Tuneshift of mode -1 @ amplitudes 12 -21 µm damps back to nominal tunes with purely reactive FB**
- **perfectly damping FB excites beam up to beam loss if osc. amplitudes exceeds values some 10 µm during meas.**

Our model for the mechanism behind:

-osc. beam excites ion cloud around it
-> FB sensor detects sum signal of beam + ion cloud
-> FB phase shifted by „wrong“ ion cloud phase
- >FB not longer reactive -> FB phase detuned
->stronger oscillations -> detuning enhanced
-> beam loss

Outlook: next steps

- better quantitative understanding of **ion-**related **phenomena**
- identifying **dominant impedances**
- better understanding of the accumulation process
- use of **LOCO model** (Talk of P. Schmid)**: design** and **apply new optic features**
  using individual quadrupole power supplies installed end of 2010
  - adjusting long-trans coupling at cavity
  - dispersion at injection point
  - transparency of ID
- Quantifying the impact of the different collective mechanisms (intra beam scattering, Touschek, beam gas/beam ion) on beam lifetime and emittance
- trying alternative emittance lattices
- reducing **current losses on the energy ramp** (appeared in 2011)