

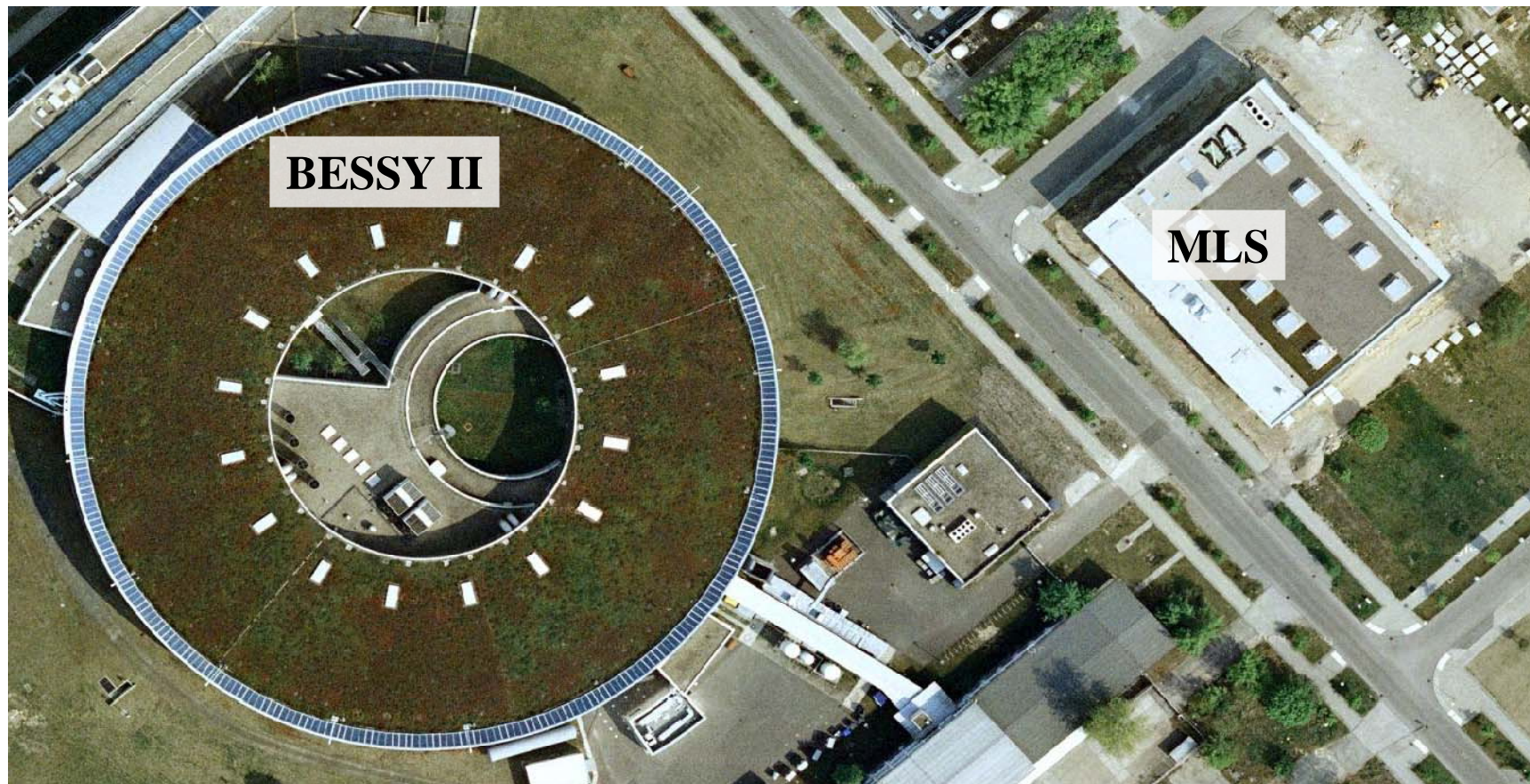
# Something New from the Metrology Light Source (MLS)

associated workgroups:

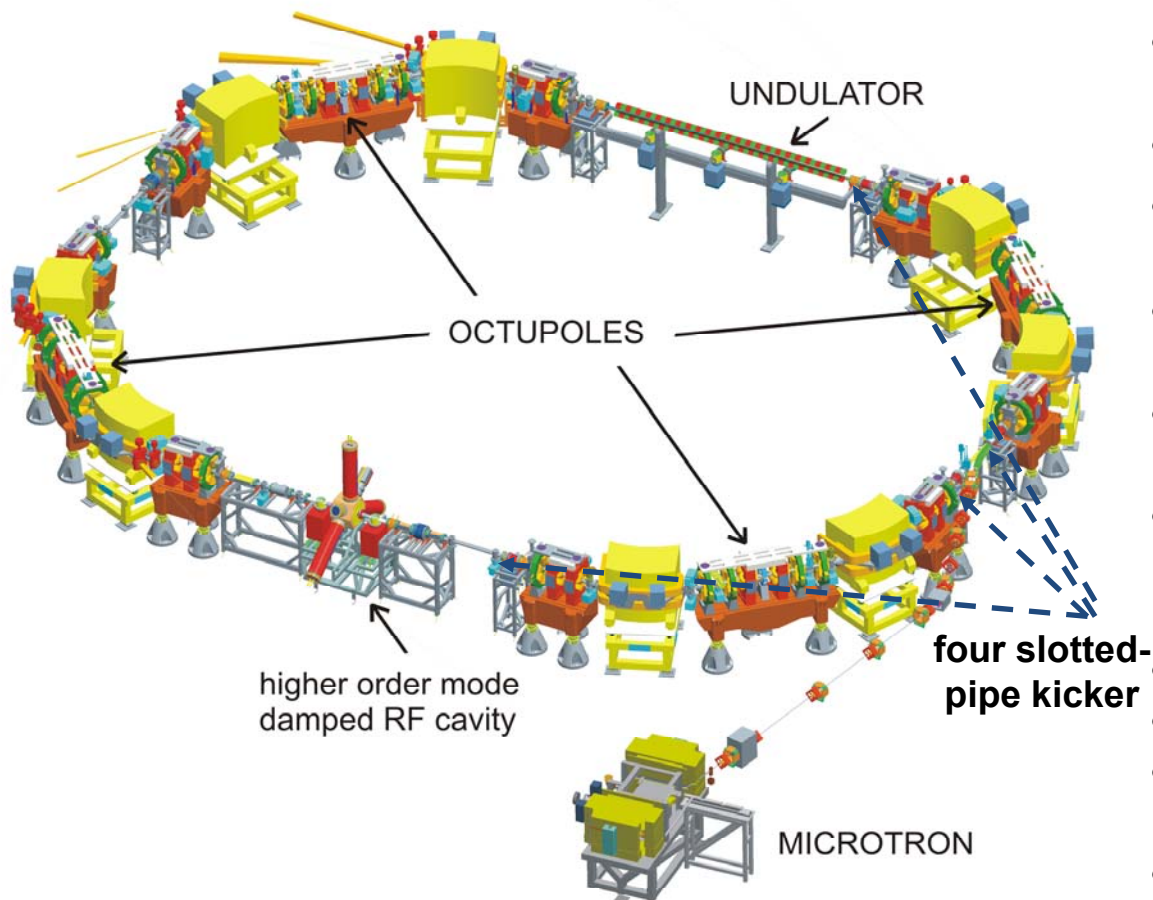
**HZB: J. Feikes, M. Ries, P. Schmid,  
G. Wüstefeld**

**PTB: A. Hoehl, R. Klein, R. Müller,  
A. Serdyukov, G. Ulm**

## Birds view of BESSY II site



## The MLS ring

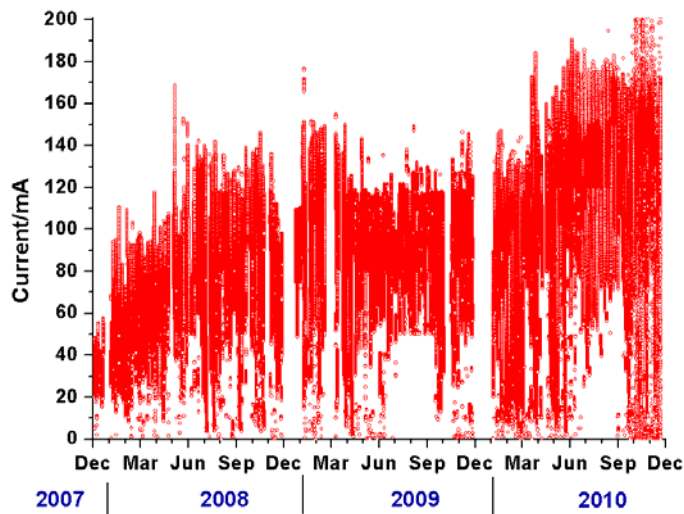


- $2\pi R = 48 \text{ m}$
- $R_{\text{bend}} = 1.528 \text{ m}$
- Injection  $E = 105 \text{ MeV}$
- operational  $E = 105 - 629 \text{ MeV}$
- $I_e = 1 \text{ pA (=1e-)} - 200 \text{ mA}$
- $t_{\text{damp}} = 5 \text{ s}$  at injection
- $|\alpha| = 1 \times 10^{-5} - 7 \times 10^{-2}$   
(Talk of Markus Ries)
- $f_{\text{RF}} = 500 \text{ MHz}$
- $V_{\text{RF}} = 50 - 500 \text{ kV}$
- $h = 80 = 500 \text{ MHz} / 6.25 \text{ MHz}$
- $Q_x / Q_y = 3.18 / 2.23$

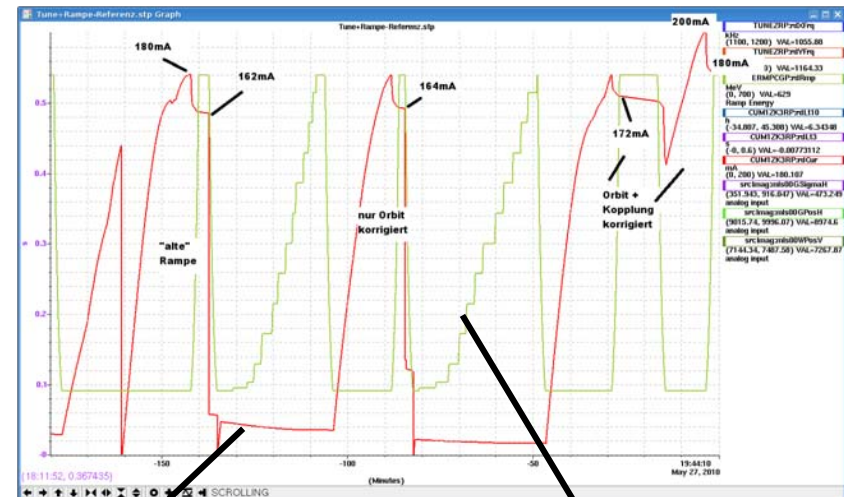
## Since June 2010 User Operation with Currents up to 200 mA (Design value)

- electr. isolation of Septum from transfer line allows improved new accumulation scheme at a 2 Hz rate (x10)
- adjustment of transv.+ long. tunes, chromaticity, coupling on ramp  
-> **only 15% ramp losses at currents around 200 mA**

### beam currents in user operation



### optimizing ramp tables

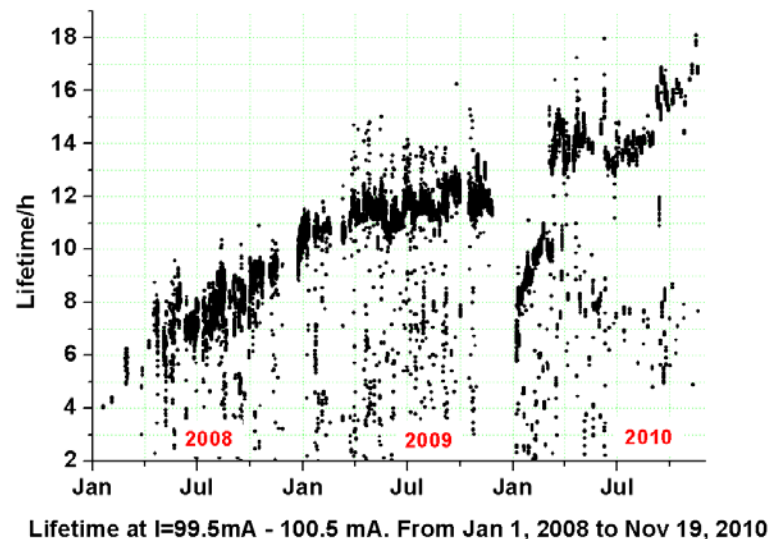
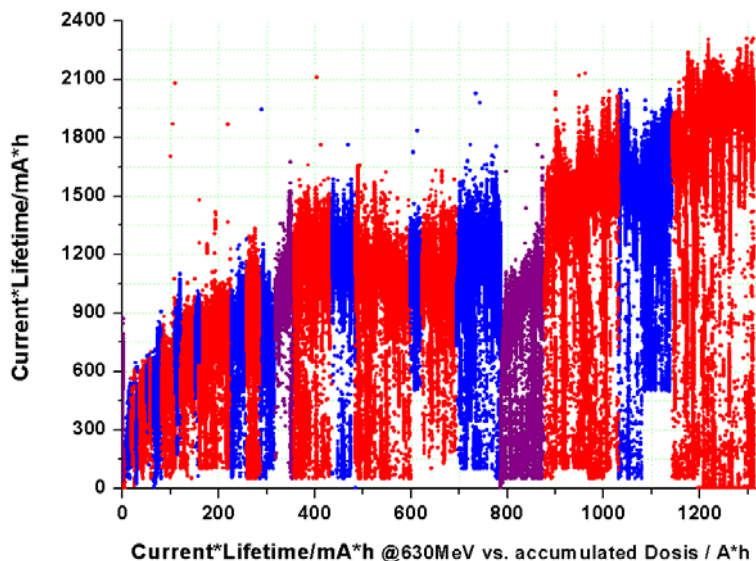


beam current

beam energy

## Vacuum and lifetime

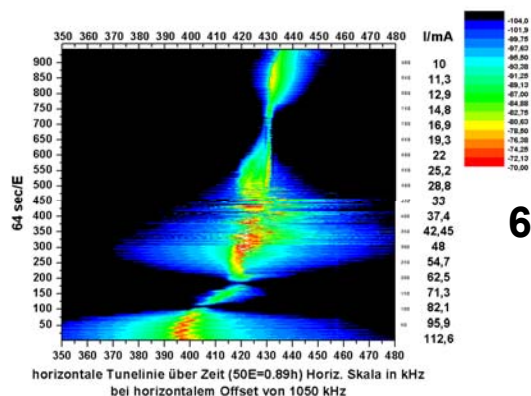
- continuous beam scrubbing -> better vacuum -> improved machine handling



## MLS – basic operation conditions established !

after 3 years Commissioning at a complex machine

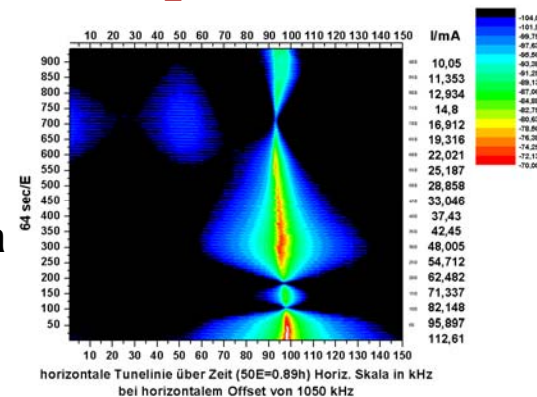
$f_x$  vs.  $I_{\text{Beam}}$



Example:

630 MeV beam spectra  
vs beam current  
-> a lot of dynamics

$f_z$  vs.  $I_{\text{Beam}}$

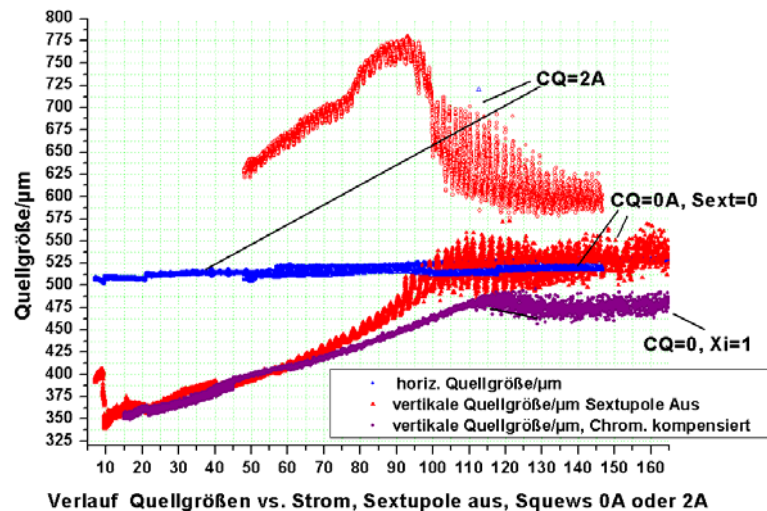


- low injection energy (105 MeV) – damping time some seconds
- many ion related problems
- strong impact of hysteresis on handling
- **successful development to dedicated THz source** (Markus Ries Talk)

**up to now moderate user requirements on beam conditions**  
(at currents > 80 mA beam is highly unstable in all spatial directions)

## 2011: new reflectometry BL with challenging demands

**beam size requirement** horiz. < 250  $\mu\text{m}$ , vert. < 200  $\mu\text{m}$  (1 sigma)  
**stability** -> max 10% of beam size at time scale 1s – 1h



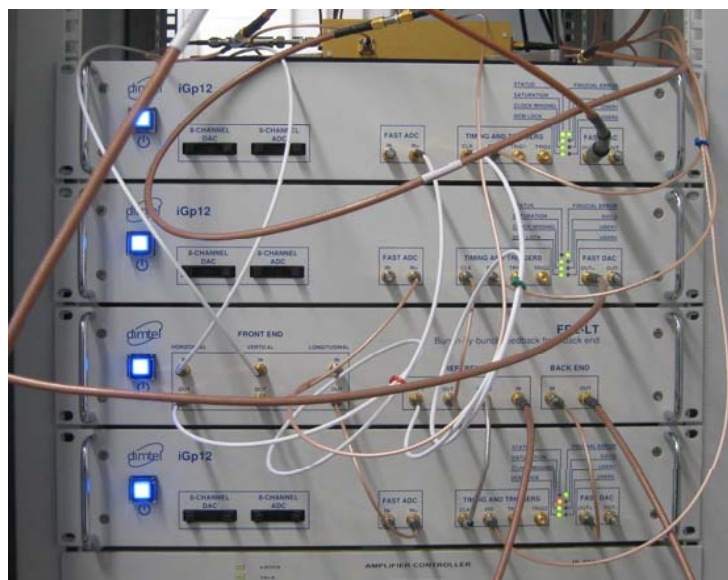
**systematic investigations of user files**

- coupling
- tunes
- chromaticity
- ....

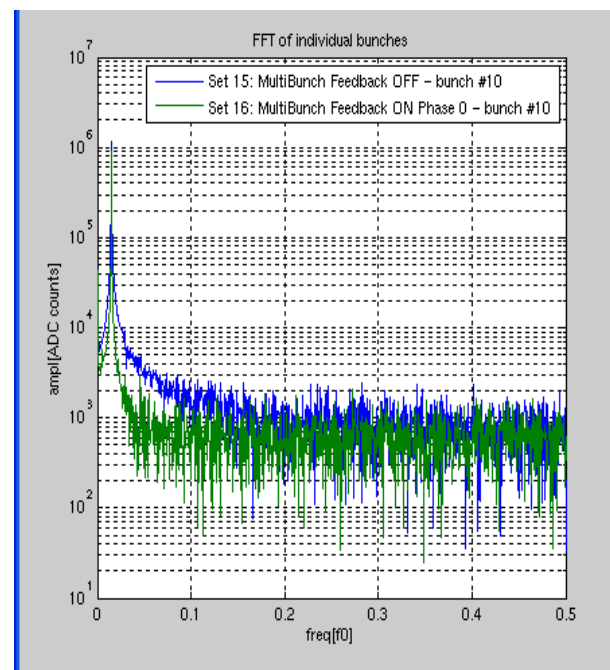
**Example:**  
**vert. beam size vs beam current vs coupling**

strong **Multi Bunch Instabilities** at  $I > 80$  mA ->  
 Reflectometry BL needs stable beam at highest currents  
**Multi Bunch Feedback in all spatial directions desired**

-> **Test of available systems at MLS**



**Dimtel (=Dmitry Teytelman)**

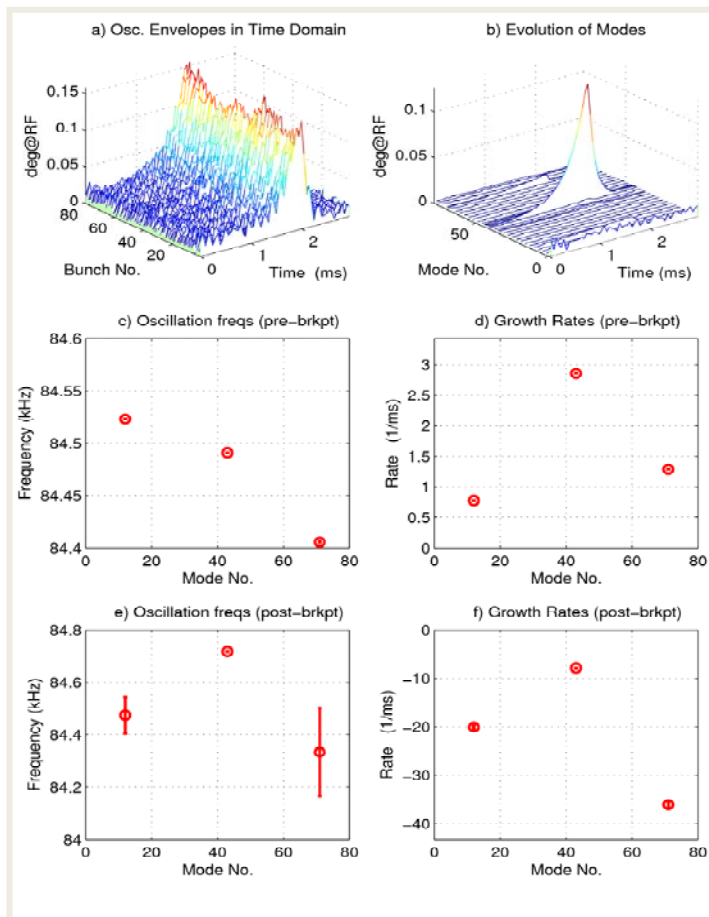


**Libera**

long. spectrum with FB on/off  
 (P. Tavares, Nigel Smale, Karlsruhe)

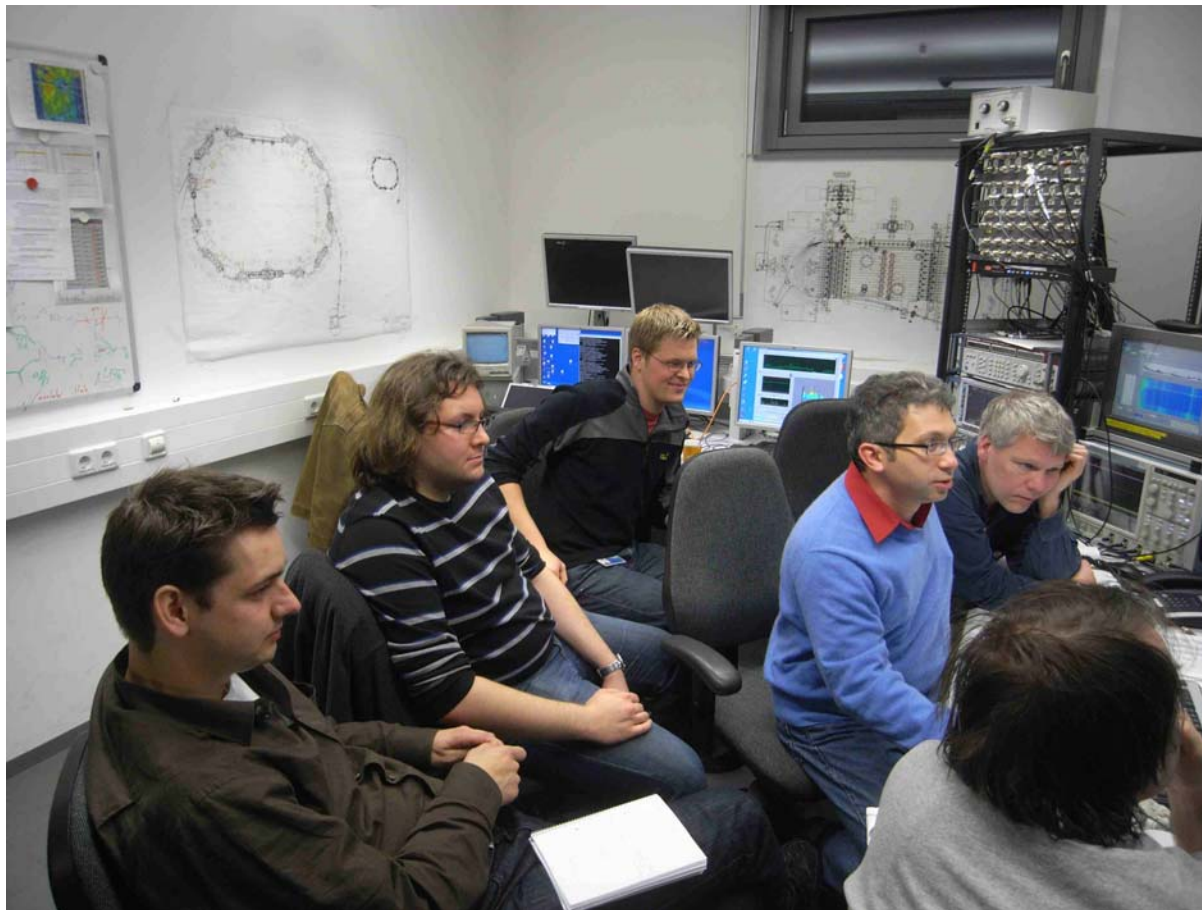


## Feedback für MLS ordered at Dimtel and successfully commissioned at MLS Nov 15 – Nov 19 (2010) by Dmitry



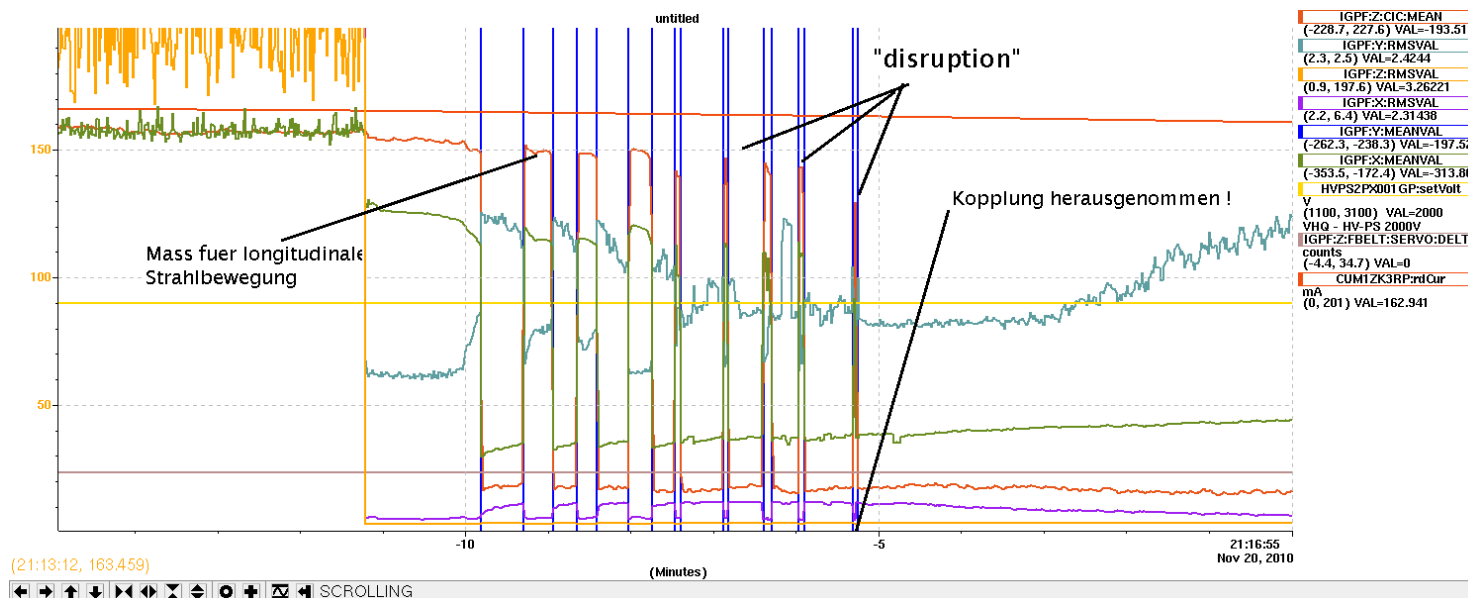
- Open-loop growth at 86 mA shows modes 43, 71, and 12
- Very fast feedback damping
- Resistive - minimal tune shift
- Average damped transversal oscillation amplitude is about **5  $\mu\text{m}$** .
- Average oscillation amplitude is **14.4 milli-degrees (80 fs)**
- neither **accumulation nor energy ramp** is achieved so far with active FB

## FB Tutorial in the MLS Controll Room



## Future investigation of intensity dependent instabilities using powerful DIMTEL Analysis Tools

A first FB related example for complex behaviour:  
**longitudinal phase jumps every 10 seconds due to **Ion-FB interaction****



## Operational issues

- User operation from **Mo-Fr 7 h–20 h**. Performed by BESSYII staff

- typical for MLS operation are widely varying user conditions

- **beam current** : 1e (1pA) – 200 mA
- **beam energy** : 105 MeV – 629 MeV
- **momentum compaction factor**: 0.033 -> 0.00001

Often changes of user settings decided at a short term

**As changes of user states are complex and blunder is easy  
operation is done by a  
automatically working state machine = „Operation Master“**

MLS Operation Master Control Panel <@opic1cp>

Version: V3.03 - (rel. 091204-1239)

Settings

Mode: Injection Energy Ramp Optic Ramp

Minimum Current: 50 mA

Maximum Current: 130 mA

Aux. Current (if Inj. timed out): 30 mA

Force Injection Now!

Readbacks and Status

act. Current: 0.027 mA

act. Lifetime: -5.254 h

act. Energy: 105.0 MeV

Ramp-State: Stop

Ramp-Tables: Up

Synchr.-Freq.: nan kHz

Injection/Trigger: on

RF-Freq (rdbk): 499684.000 kHz

Beamshutters: unlocked

Inactive

Commands

Inactive Activate

History

12:39:46 -- restarting --

12:39:54 all PVs (re-)connected!

12:39:54 Starting Engine

12:39:54 MLS Operation Master V3.03 - (rel. 091204-1239) started!

12:39:54 Engine is inactive

12:39:54 Inactive

07:23:25 7 PVs not connected!

07:23:25 PAHRP:setVoltCav disconnected

07:23:25 PSEK1RP:stoCur.PROC disconnected

07:23:25 PAHRP:panel.stKeyRf disconnected

07:23:25 PAHRP:cntrl.cmdReset disconnected

07:23:25 PSEK1RP:setCur disconnected

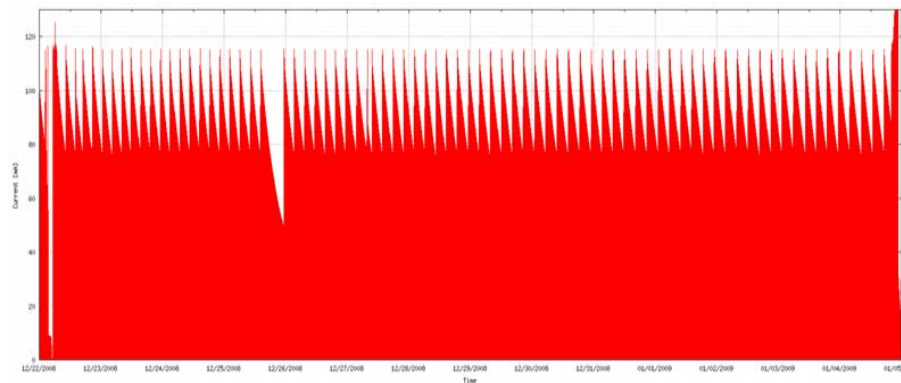
07:23:25 PAHRP:cntrl.cmdOff disconnected

07:23:25 PSEK1RP:rciCur.PROC disconnected

07:24:37 all PVs (re-)connected!

defining the desired operating parameters  
**-> Activate!**

Very good experience  
with automated operation !



Dez08-Jan09:2 weeks of unmaned operation

## Some developments at MLS

- **mode free Cavity** (E. Weihreter, F. Marhauser et. al.)  
 Prototyp reached **38 kW** (planned **80 kW**). Design was modified in house and a modified Cavity ordered -> higher voltage desired
- **500 MHz IOT successfully commissioned** (H.G. Hoberg, A. Heugel, et.)
- **hardware capable to do fast orbit correction** (T. Schneegans, G.Schindhelm) is in use since beginning of operation and working reliable
- design, construction and reliable operation of four **slotted pipe kickers**
- **use of octupoles not** only to adjust 2d order long. chromaticity (M. Ries talk) but also to stabilize the beam at higher currents
- adapting **MatLab ToolKit** to needs of MLS control and measurement (D. Engel, P. Schmid)

## Next steps in MLS evolution

- Dec 2010 installation of a **NEG coated Undulator chamber**
- establishing **high current, high quality beam** for needs of new sensitive reflectometry Beam Line users ([how to operate MB Feedback ?](#))
- in Dec 2010 **PS upgrade**. Each Quadrupole will be powered individually  
 Motivation:
  - indiv. control of **dispersion in Cavity and injection** (10Hz injection ?)
  - **symmetrisation** of optics with undulator powered
  - flexible adjustment of **optical functions in source point**
- **further investigation of the observed bunch lengths** (streak camera)



**The End**



## example for sub-routine : change to Low Alpha Optics

**Optic Ramp**

**Approch Ramp**

Target Optic: 3.50 kHz

Number of Steps: 100

/opt/IOC/OpticRamp/LowAlpha/629MeV

Go Idle

**Drive Ramp**

Target Optic: 3.50 kHz

Ramp Speed: 10 %/s

Ramp Rate: 0.10 s

Ramp Command & State: Stop Go

Ramp Optic: 3.50 kHz

Old Optic: 3.50 kHz

Ramp Time: 10.10 s

/opt/IOC/OpticRamp/LowAlpha/629MeV

Reload All Tables

Master Clock: Enabled Disabled

synchrotron frequency

	5	10	16	30	60	86
Q1P1RP:setCur	49.4754	49.3670	49.2870	48.1164	45.7239	41.3
Q1P2RP:setCur	49.4754	49.3670	49.2870	48.1164	45.7239	41.3
Q2PKRP:setCur	71.1339	71.1339	71.1339	71.1339	71.1339	71.1
Q2PL2RP:setCur	66.1310	65.7531	65.6919	65.8352	66.2730	67.7
Q2PL4RP:setCur	66.1310	65.7531	65.6919	65.8352	66.2730	67.7
Q3PKRP:setCur	77.7273	77.7273	77.7273	77.7273	77.7273	77.7
Q3PL2RP:setCur	76.7377	76.5339	76.5674	77.2474	78.8968	83.2
Q3PL4RP:setCur	76.7377	76.5339	76.5674	77.2474	78.8968	83.2
CQS1P1L2RP:setCur	-0.3181	-0.3181	-0.3181	-0.3181	-0.3181	-0.3
CQS1P2L2RP:setCur	-0.0500	-0.0500	-0.0500	-0.0500	-0.0500	-0.0
CQS1P1L4RP:setCur	0.0000	0.0001	0.0001	0.0001	0.0001	0.0
CQS1P2L4RP:setCur	0.0865	0.0865	0.0865	0.0865	0.0865	0.0
OPRP:setCur	-6.0000	-6.0000	-6.0000	-3.5294	-3.0000	-3.0

Devices

## MLS control room



## Wie wird gerammt. „Energy Ramp“

synchrones Fahren aller Geräte mit „Energy Ramp“

Table-Set Editor - /opt/IOC/EnergyRamp/static/up <@opic10c>

File Edit Window Help

Open... Save Save as... Revert Undo Redo Calculate... Auto edit... Zoom Exit

Comment:

	100	105	110	120	150	200	250	350	400	450	550	600	629
Q1P1RP:setCur	6.2770	6.5600	6.8807	7.5221	9.4432	12.8241	16.2050	22.6622	25.9220	29.1818	35.7052	39.2207	41.3673
Q1P2RP:setCur	6.2770	6.5600	6.8807	7.5221	9.4432	12.8241	16.2050	22.6622	25.9220	29.1818	35.7052	39.2207	41.3673
Q2PKRP:setCur	10.7483	11.2500	11.7994	12.8982	16.1946	22.0123	27.8300	38.9440	44.5540	50.1639	61.3904	67.4402	71.1344
Q2PL2RP:setCur	10.1328	10.5896	11.1374	12.1628	15.2783	20.9155	26.5527	37.2366	42.6341	48.0315	58.6509	64.1437	67.3258
Q2LARP:setCur	10.1328	10.5896	11.1374	12.1628	15.2783	20.9155	26.5527	37.2366	42.6341	48.0315	58.6509	64.1437	67.3258
Q3PKRP:setCur	11.7992	12.3500	12.9498	14.1494	17.7482	24.1091	30.4700	42.5845	48.7090	54.8335	67.0898	73.6947	77.2728
Q3PL2RP:setCur	12.2361	12.7928	13.4689	14.7707	18.7217	25.8538	32.9859	46.1121	52.9681	59.8242	72.5402	78.9944	82.6024
Q3LARP:setCur	12.2361	12.7928	13.4689	14.7707	18.7217	25.8538	32.9859	46.1121	52.9681	59.8242	72.5402	78.9944	82.6024
CQS1P1L2RP:setCur	-0.2102	-0.3200	-0.3250	-0.3600	-0.3857	-0.5103	-0.6350	-0.1022	-0.0844	-0.0666	-0.0310	-0.0117	0.0000
CQS1P2L2RP:setCur	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0009	-0.0012	-0.0015	-0.0071	-0.0337	-0.0500
CQS1P1LARP:setCur	0.1529	0.2257	0.2400	0.2400	0.3810	0.5080	0.6350	0.0860	0.0711	0.0561	0.0261	0.0099	0.0000
CQS1P2LARP:setCur	0.0860	0.0600	0.0700	0.0750	0.0800	0.1200	0.1200	0.2463	1.1232	2.0000	2.0000	2.0000	2.0000
OPRP:setCur	-1.0900	-1.5000	-2.0000	-3.0000	-4.5000	-5.0000	-4.5000	-3.0000	-2.0000	-1.3000	-1.3000	-1.3000	-1.3000
S1P1RP:setCur	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	4.5000	0.0000	0.5600	7.0000	7.0000
S1P2RP:setCur	5.0114	5.7100	6.2000	7.2000	8.8000	12.9000	17.0000	23.8600	24.4300	25.0000	25.0000	25.0000	25.0000
S2P1RP:setCur	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	4.0000	8.0000	6.0000	6.0000	0.0000
S2P2RP:setCur	5.8446	6.6000	7.1000	8.1000	9.7000	14.5000	19.3000	27.6000	27.3750	27.1500	30.0000	30.8276	36.0000
S3P1RP:setCur	0.0300	0.0800	0.0750	0.0400	0.1000	0.5092	0.9184	1.9773	2.5537	3.1300	4.8448	4.9138	5.0000
S3P2RP:setCur	-0.1400	-0.0800	-0.0750	-0.0400	-0.1000	-0.5091	-0.9182	-1.9706	-2.5047	-3.0388	-4.8448	-4.9138	-5.0000
VS2P1K1RP:setCur	0.0623	0.0641	0.0739	0.0832	0.1131	0.1671	0.2229	0.3303	0.3688	0.4175	0.5001	0.5478	0.5614
VS2P2K1RP:setCur	0.0311	0.0345	0.0396	0.0450	0.0627	0.0933	0.1264	0.1945	0.2090	0.2528	0.3041	0.3317	0.3364
VS2P1L2RP:setCur	0.0566	0.0843	0.0876	0.0996	0.1370	0.2040	0.2730	0.3861	0.4388	0.4960	0.5947	0.6415	0.6559
VS2P2L2RP:setCur	-0.0034	-0.0227	-0.0245	-0.0269	-0.0327	-0.0425	-0.0523	-0.0762	-0.0862	-0.1034	-0.1031	-0.1248	-0.1634
VS2P1K3RP:setCur	0.0080	-0.0053	-0.0057	-0.0078	-0.0122	-0.0173	-0.0206	-0.0269	-0.0330	-0.0390	-0.0912	-0.1095	-0.0734
VS2P2K3RP:setCur	0.0993	-0.0198	-0.0209	-0.0231	-0.0292	-0.0396	-0.0497	-0.0724	-0.0879	-0.1000	-0.1030	-0.0966	-0.1528
VS2P1L4RP:setCur	-0.1451	0.0455	0.0482	0.0514	0.0630	0.0840	0.1052	0.1528	0.1842	0.2028	0.2258	0.2247	0.2562
VS2P2L4RP:setCur	0.0360	0.0735	0.0751	0.0823	0.1077	0.1547	0.2035	0.2995	0.3243	0.3541	0.4320	0.4663	0.4881
VS3P1K1RP:setCur	0.0209	0.0309	0.0271	0.0313	0.0456	0.0710	0.0983	0.1560	0.1716	0.2046	0.2518	0.2687	0.2771
VS3P2K1RP:setCur	0.0259	0.0185	0.0170	0.0244	0.0471	0.0883	0.1265	0.1925	0.2348	0.2556	0.3064	0.3337	0.3556
VS3P1L2RP:setCur	0.0233	-0.0158	-0.0146	-0.0084	0.0125	0.0489	0.0821	0.1463	0.1785	0.2034	0.2606	0.2841	0.2949
VS3P2L2RP:setCur	-0.0065	0.0101	0.0084	0.0135	0.0306	0.0600	0.0857	0.1293	0.1480	0.1677	0.1795	0.1963	0.2187
VS3P1K3RP:setCur	-0.0199	-0.0120	-0.0181	-0.0210	-0.0281	-0.0354	-0.0422	-0.0561	-0.0704	-0.0743	-0.0613	-0.0653	-0.1296
VS3P2K3RP:setCur	0.0219	0.0353	0.0357	0.0438	0.0697	0.1163	0.1607	0.2371	0.2809	0.3133	0.3529	0.3623	0.4311
VS3P1L4RP:setCur	0.0072	-0.1215	-0.1278	-0.1347	-0.1548	-0.1876	-0.2168	-0.2702	-0.3017	-0.3248	-0.3717	-0.3874	-0.4252
VS3P2L4RP:setCur	-0.0741	-0.1118	-0.1111	-0.1106	-0.1073	-0.0966	-0.0852	-0.0682	-0.0646	-0.0546	-0.0534	-0.0539	-0.0531
HS1P1K1RP:setCur	-0.1188	-0.0988	-0.1043	-0.0968	-0.0809	-0.0834	-0.1160	-0.1988	-0.3152	-0.4096	-0.6991	-0.9470	-1.0925
HS1P2K1RP:setCur	-0.1321	-0.1493	-0.1432	-0.1326	-0.1071	-0.1175	-0.1677	-0.2778	-0.3431	-0.4096	-0.5799	-0.7699	-0.9590
HS1P1K3RP:setCur	0.0670	0.0877	0.0752	0.0726	0.0826	0.1367	0.1728	0.2194	0.2033	0.1770	0.0094	-0.1571	-0.2359
HS1P2K3RP:setCur	-0.0301	0.0261	0.2103	0.1910	0.1540	0.1899	0.2685	0.4281	0.4719	0.5276	0.4448	0.2591	0.1493
HS3P1K1RP:setCur	0.0336	0.0384	0.0276	0.0662	-0.0388	-0.0599	-0.0645	-0.1321	-0.1304	-0.2036	-0.3698	-0.5145	-0.6548
HS3P2K1RP:setCur	-0.1242	-0.1195	-0.1118	-0.0845	-0.0200	0.0405	0.0638	0.1426	0.1239	0.1859	0.2241	0.2240	0.2474
HS3P1L2RP:setCur	0.0424	0.0093	0.0016	-0.0005	0.0064	0.0261	0.0497	0.1154	0.1254	0.1565	0.1640	0.1142	0.0623

Energie-  
stützpunkte

/opt/OPI/MLS-Controls/links/PROI

### Energy Ramp

**Approach Ramp**

Target Energy  MeV

Number of Steps

Up Down

Go Idle

---

**Drive Ramp**

Target Energy  MeV

Ramp Speed  MeV/s

Ramp Acceleration Time  s

Relative Ramp Speed  %/s

Ramp Rate  s

Ramp Mode  Fixed  Relative

Ramp Command & State

Ramp Energy  MeV

Old Energy  MeV

Actual Ramp Speed  MeV/s

Ramp Time  s

Up Down

Directory /opt/IOC/EnergyRamp/static/up

Devices

Ramp-Tabelle