Status of Elettra, top-up and other upgrades

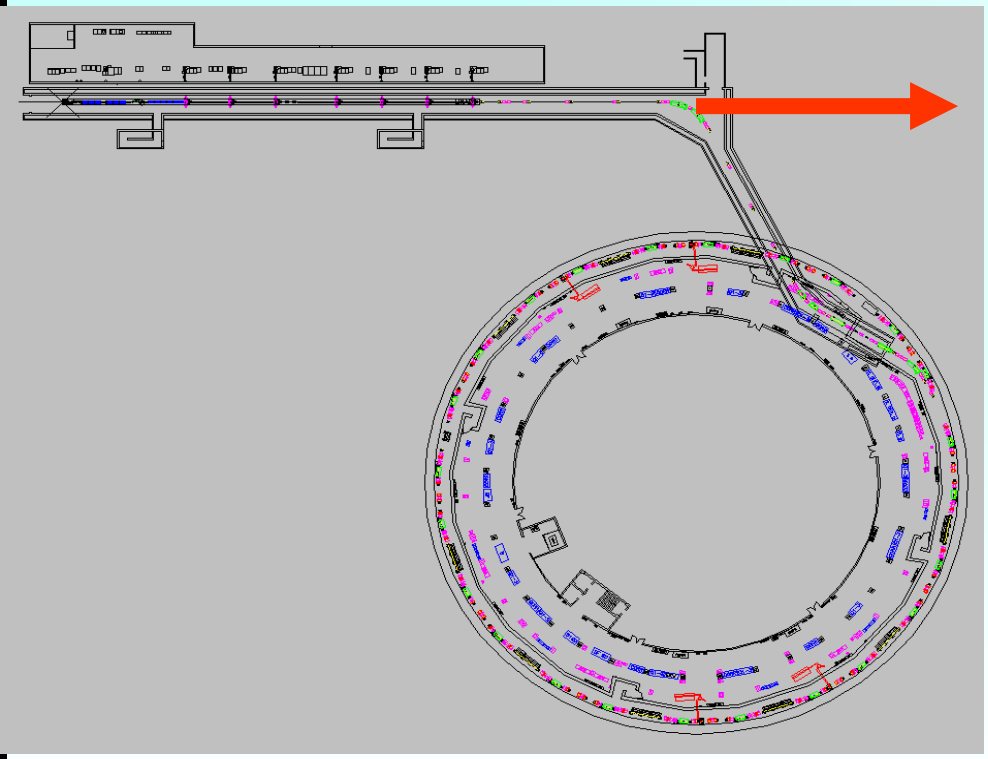
Emanuel Karantzoulis

ESLS XVIII Workshop

ELETTRA / Trieste, Italy / 2010 November 25-26

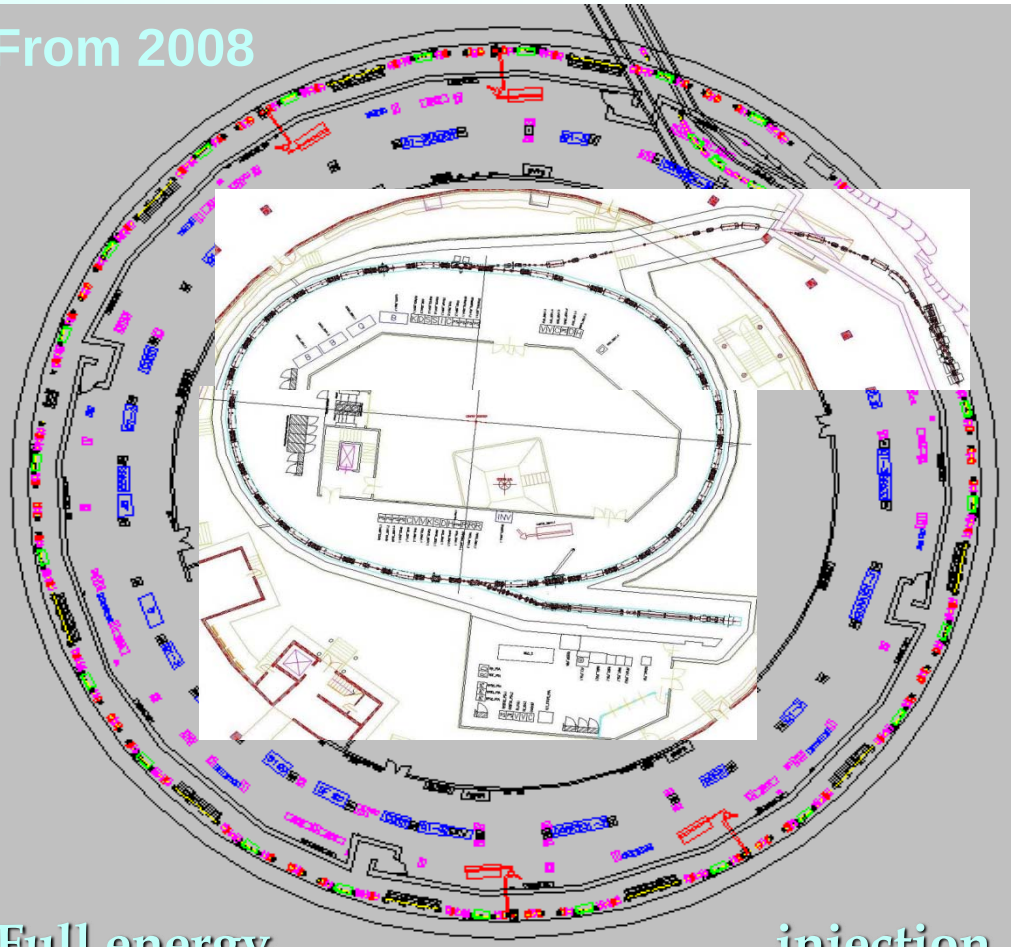
Past and Present Configurations

1994- 2007



No full energy injection

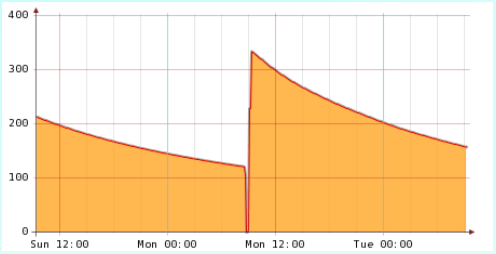
From 2008



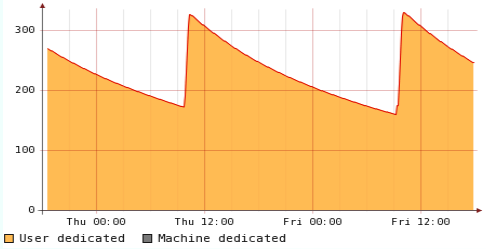
Full energy injection

2008 and 2010: transition years

1994 - 2007 Elettra ramping



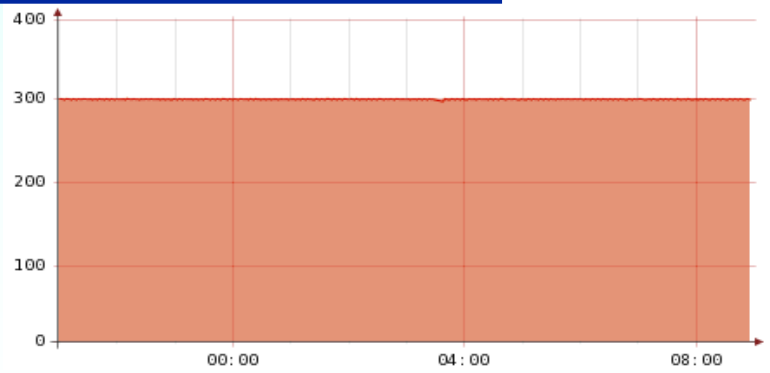
Since 2008 Full energy injection

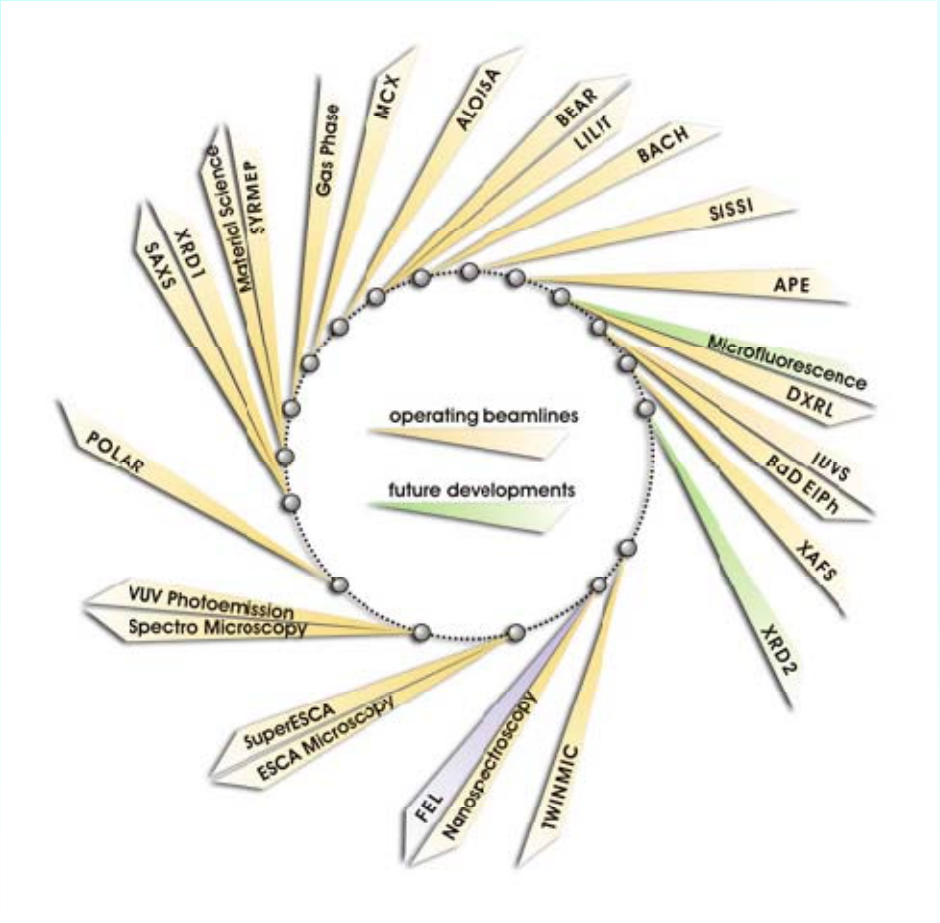


Decay mode, 2 GeV (340mA) and 2.4 GeV (140) – SRFEL at 1 GeV.

Since May 2010 Elettra in top-up

Top-up at 2 GeV (300mA)
&
2.4 GeV (150 mA)





26 beam lines

of which major upgrades

XRD1

SuperESCA

SR-FEL *(2 GeV , currently 1.8 GeV and 130 nm)*

2 under construction

Microflurescence

XRD2

Modes of operation

- 2 GeV multibunch / hybrid / very small demand for single bunch
- 2.4 GeV multibunch / hybrid
- 1-1.8 GeV SR-FEL single, 4-bunch
- 0.8-1.0 GeV 4 bunch, CSR also for pump-probe experiments

5000 hours/year for users. For 2011 total 6560 hours

11 ID sections with PM wiggler, PM undulators: planar, APPLE II , canted, short; electromagnetic (circular polarization) and a superconducting wiggler. Also many bending beam lines including one for Mammography and one IR (THz)

Allow the users to change gaps but not beam position/angle (we set it).

How operate

- 24 hours per day 7 days a week for periods from 4 to 8 weeks with 1 to 2 weeks shutdown
- Group of 14 operators , shift in pair , 3 shifts per day
- Elettra runs as a project (ODAC) that enters vertically to the matrixed structure of ST. Uses 104 persons for 28.8 man years, has 28 task leaders corresponding to the subsystems while 19 of them have dedicated budget; for 2010 the budget for functioning of the complex was 620 k€

Elettra's "new" injector

- 2005 project funded
- 2007 autumn connection with SR
- 2008 Finished on time (3 March 2008 for user shifts already programmed since 2007) and within budget

- Difficulties with the booster main PSs
- Stability
- Reproducibility

100 MeV pre-injector

Performs well, still margin for improvement especially on the klystron discharges (almost one per day and many false)

- Spare gun and modulator constructed (redundancy)
- Effort on water/ambient temp stability

Linac made of a thermionic gun, cathode Th306 Thales, a 500 MHz pre bunching cavity, an S-band 3 GHz bunching structure and two LIL (CERN) 5 m accelerating sections of about 50 MeV each providing thus ≥10 MeV /m

The sections are powered by a 3 GHz 45 MW pulsed Thales 2132A S–band klystron using a MDK modulator

Booster

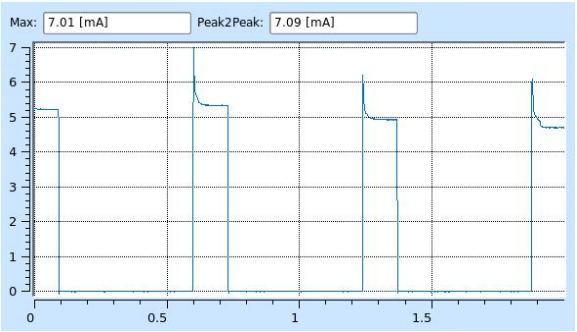
Faced problems mainly due to big PSs (also their controls); hard work of about 1 year, main problems fixed

Acceptable operations established. Booster operates at full cycle (2.5 GeV) and up to 3 Hz

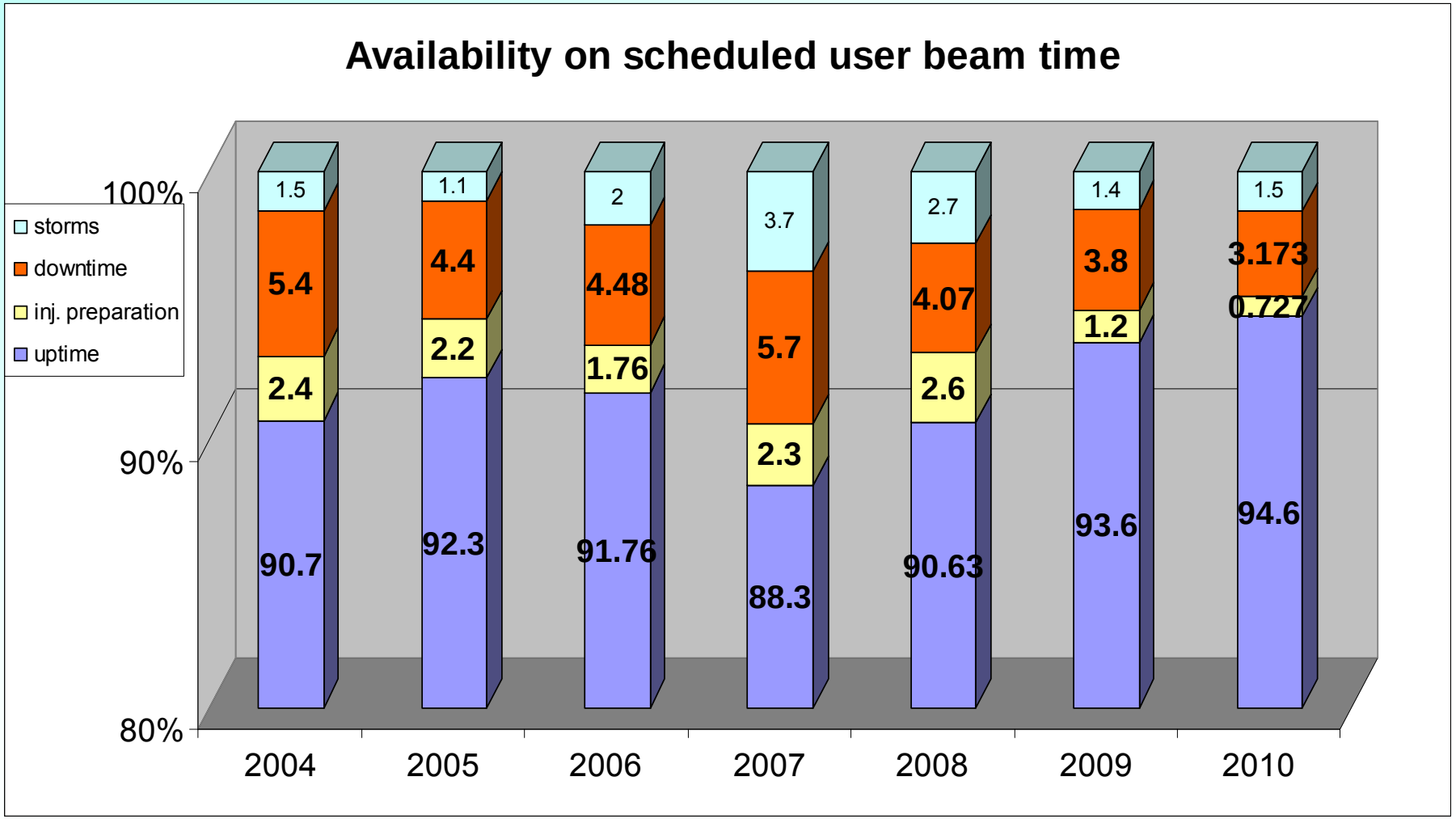
Full energy injection to Elettra at any energy and any filling (multibunch , single bunch ,few bunch) up to 2.4 Hz rep. rate with efficiencies up to 100%

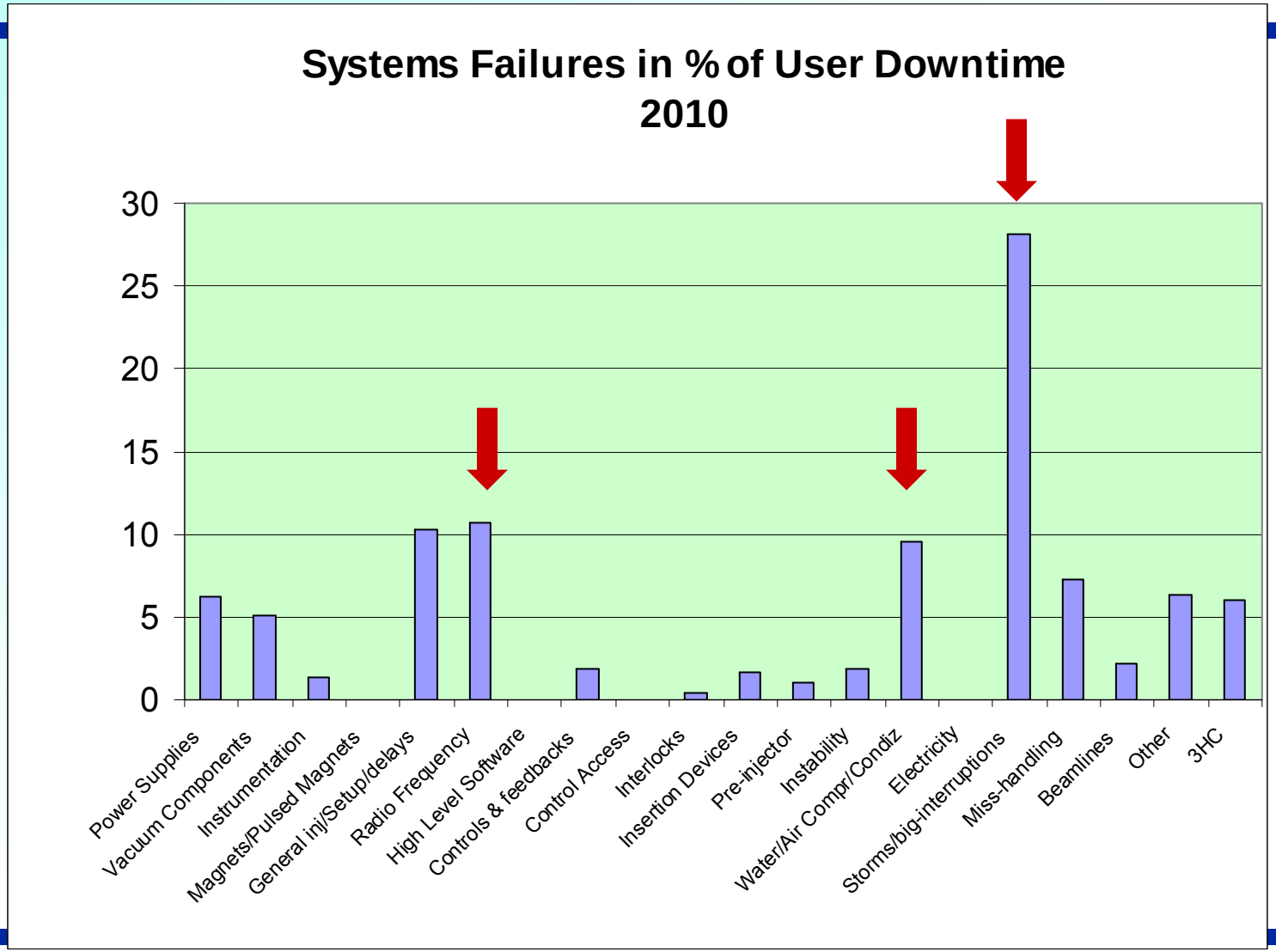
RF system taken from Elettra (RF9) 500 MHz 60 kW (TV klystron) and a 5-cell PETRA type cavity.

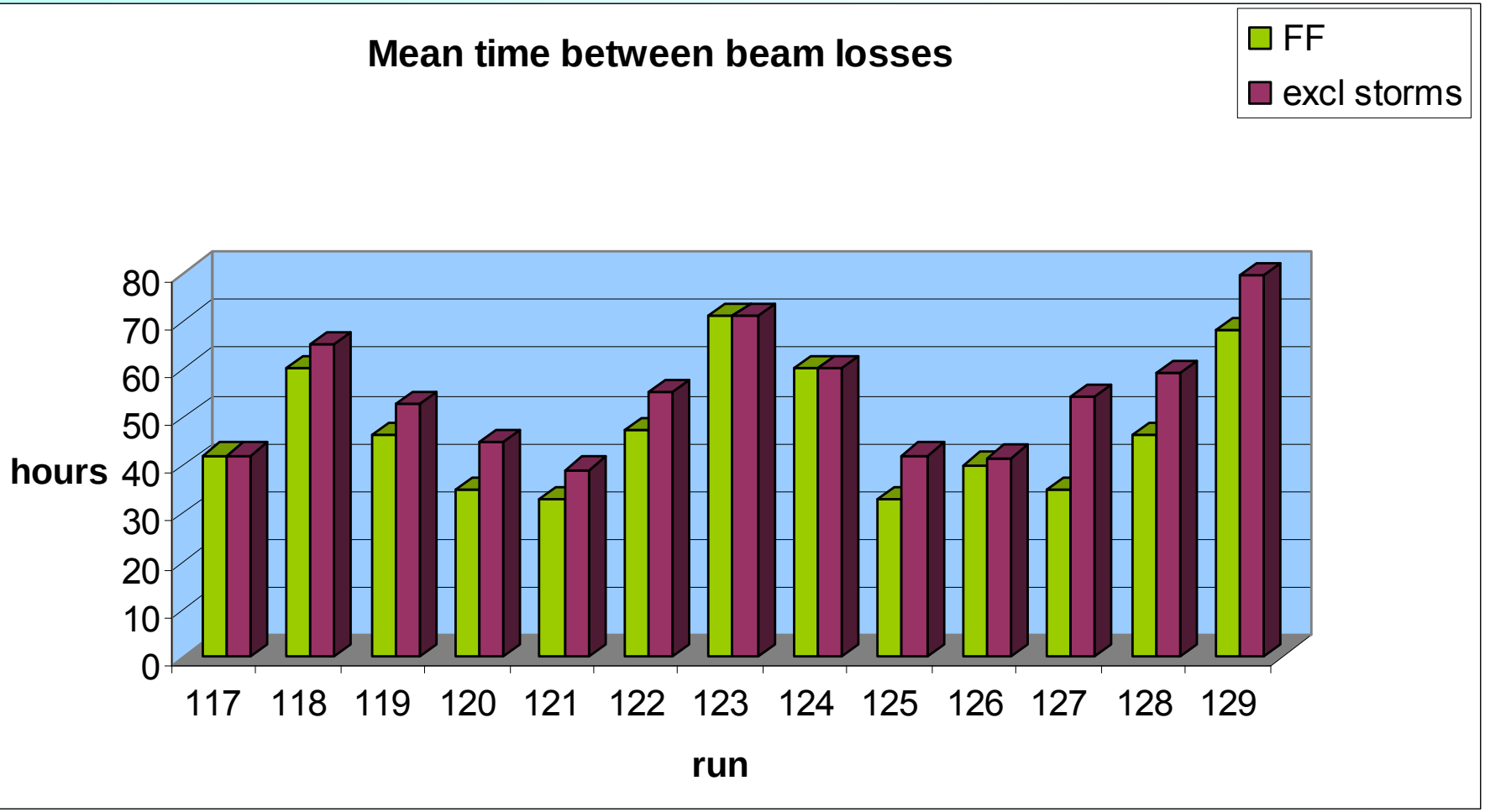
Power transmission via coaxial line.



Elettra Availability




Systems Failures in % of User Downtime
2010
30
25
20
15
10
5
0
Power Supplies
Vacuum Components
Instrumentation
Magnets/Pulsed Magnets
General inj/Setup/delays
Radio Frequency
High Level Software
Controls & feedbacks
Control Access
Interlocks
Insertion Devices
Pre-injector
Instability
Water/Air Compr/Condiz
Electricity
Storms/big-interruptions
Miss-handling
Beamlines
Other
3HC

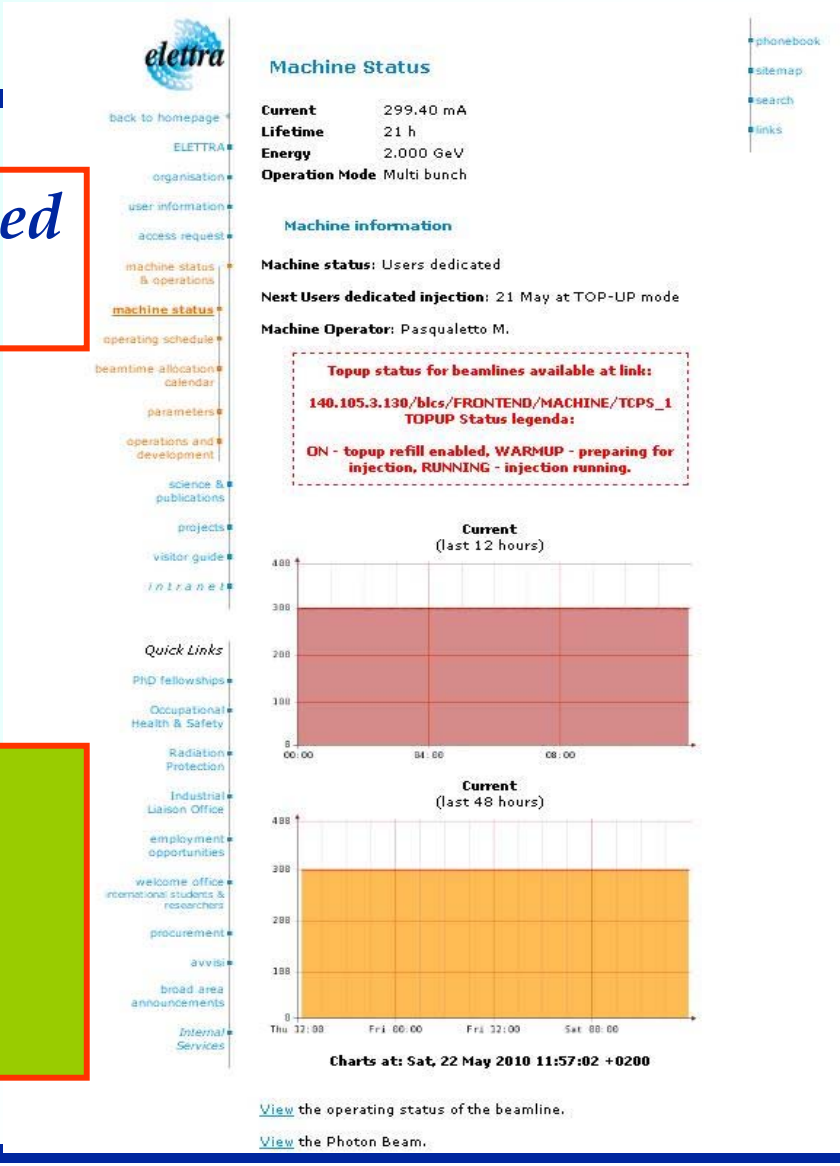

Mean time between beam losses
FF
excl storms
hours
80
70
60
50
40
30
20
10
0
117
118
119
120
121
122
123
124
125
126
127
128
129
run

Top Up

Implementation to the machine achieved within one year (2009)

Radioprotection measurements finished as scheduled by end of March 2010. However due to 2 low gap chamber installation during the April shutdown some more controls were required in May.

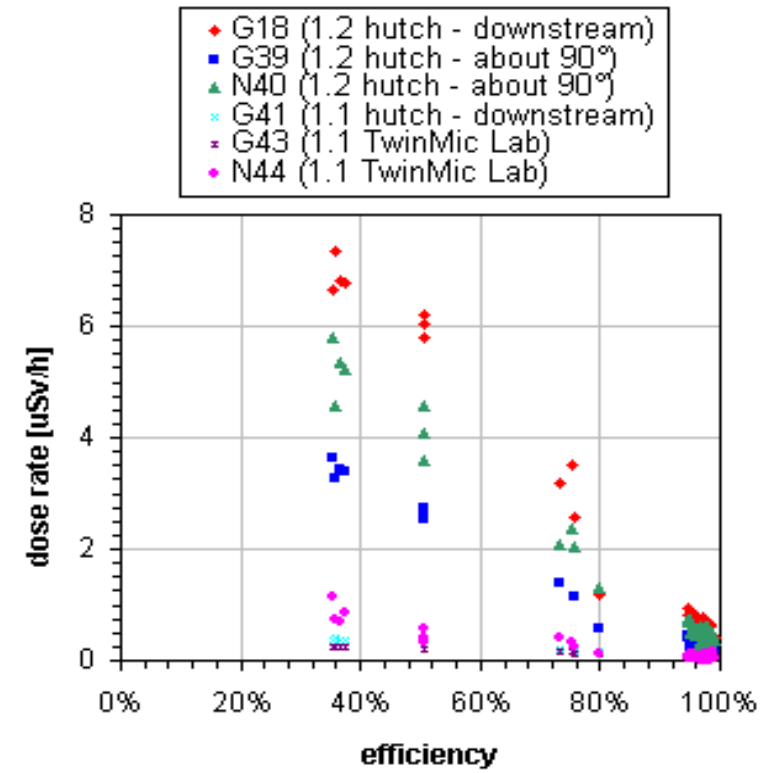
On May 10, top-up operations for users was implemented at 2.0 GeV.
On May 24, top-up operations for users was implemented at 2.4 GeV



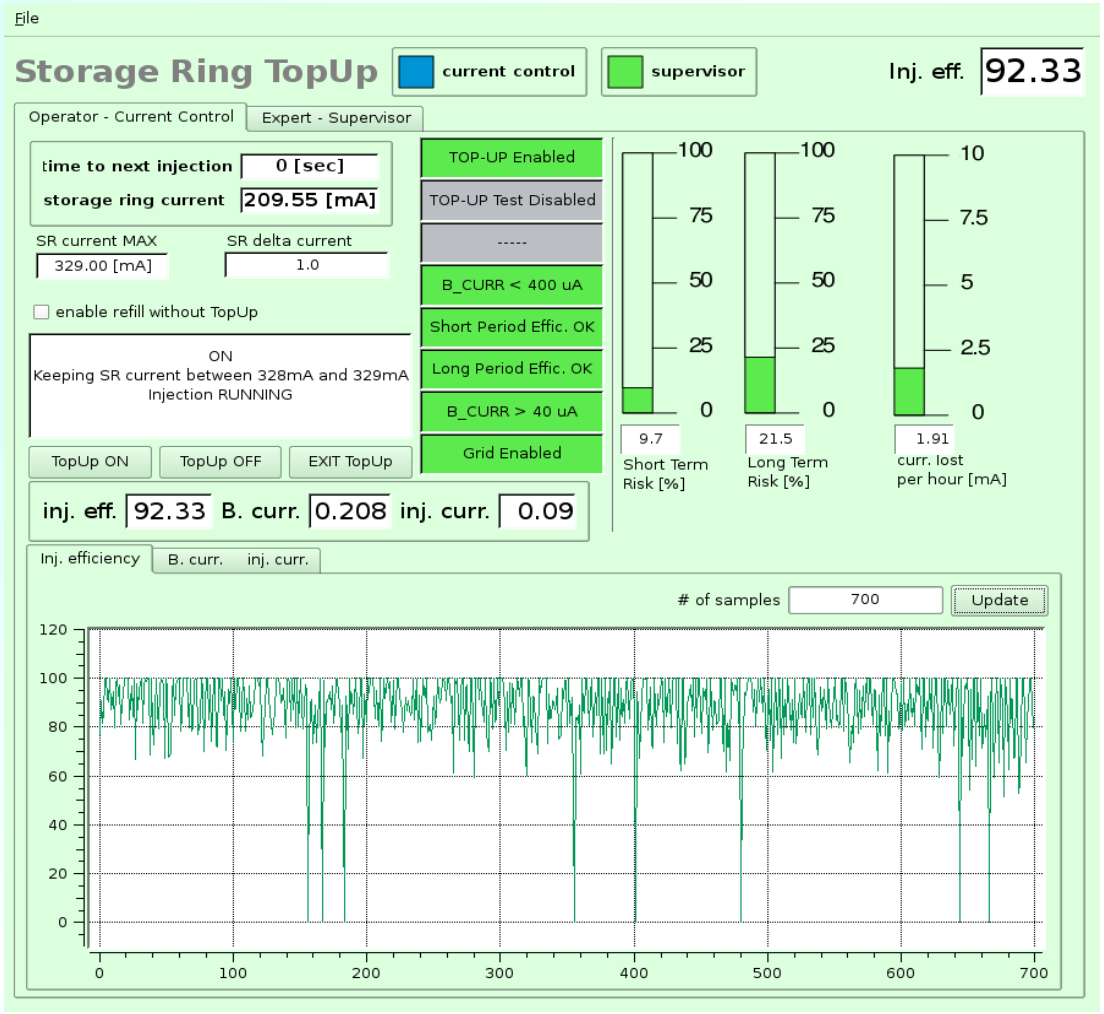
Operating in top-up

- Fixed current mode (1mA) every 6 min at 2 GeV , 20 min at 2.4 GeV in about 20 pulses at 2 Hz
- Total current loss budget 10 (5 at 2.4 GeV) mA /hour. This allows efficiencies in the range 100 - 60% otherwise blocks top-up for the rest of the hour
- Each beam line is interlocked with dosimeters; above a certain radiation level the beam line is blocked for 4 hours
- Fast dcct already installed will allow bunch to bunch fill for hybrid operations refilling also the single bunch.

Top-up controller



Although at the beginning only 20% of user time was programmed, immediately users wanted top-up at 100%



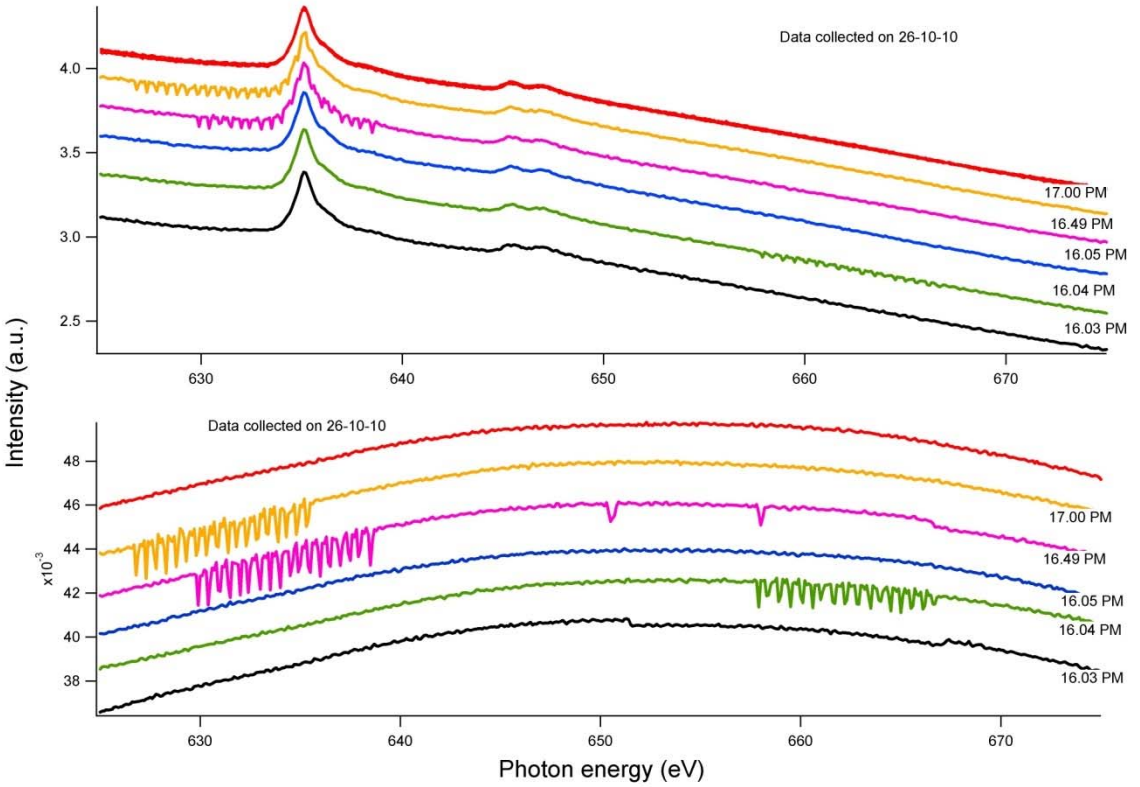
Gating

Provided via internet, upon request we provide additional interface boards. In general few beam lines make use of it.

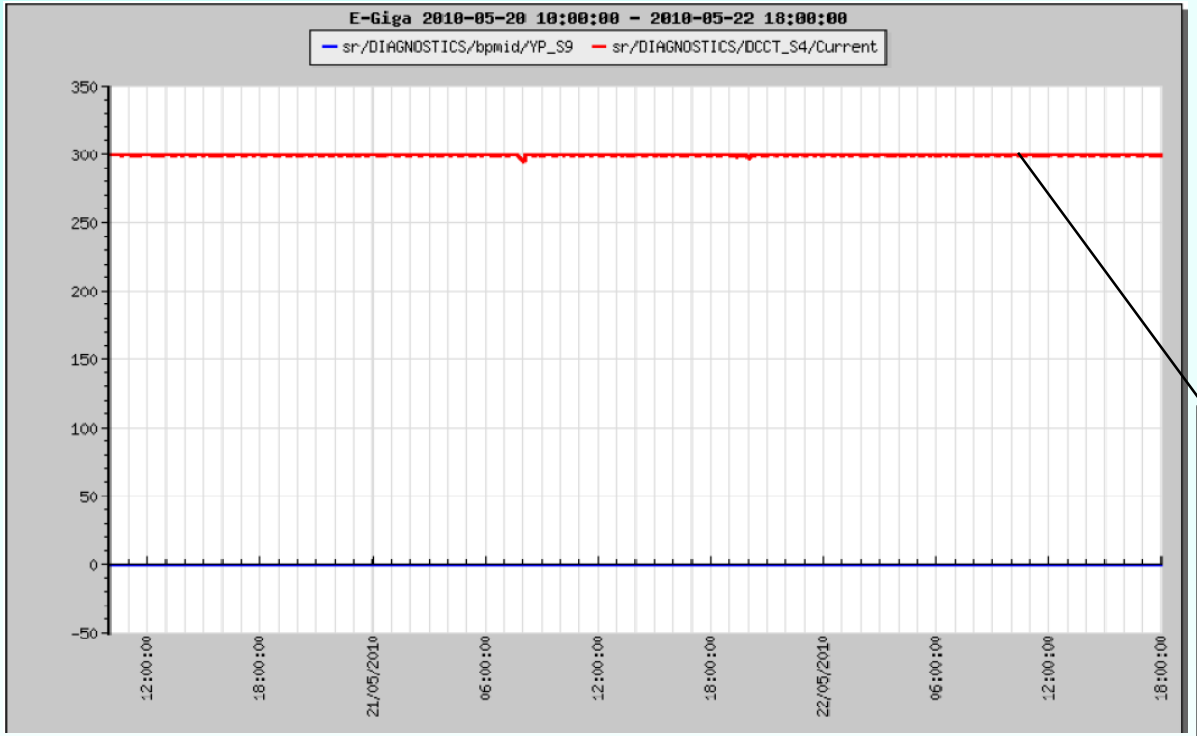
Sometimes certain beam lines (in fast measurements) can get disturbed by the kick of the injection system during top-up.

Usually either the disturbance is marginal or by adjusting the kickers becomes marginal.

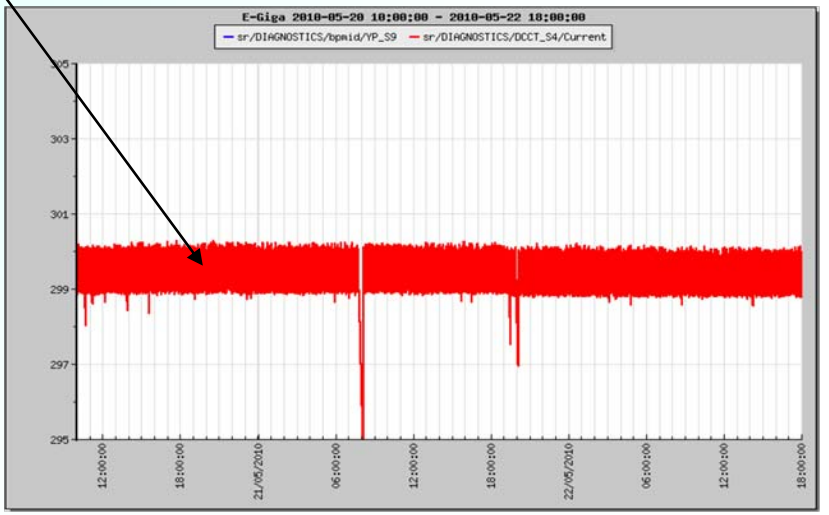
Some beam lines however like the IR always use gating.



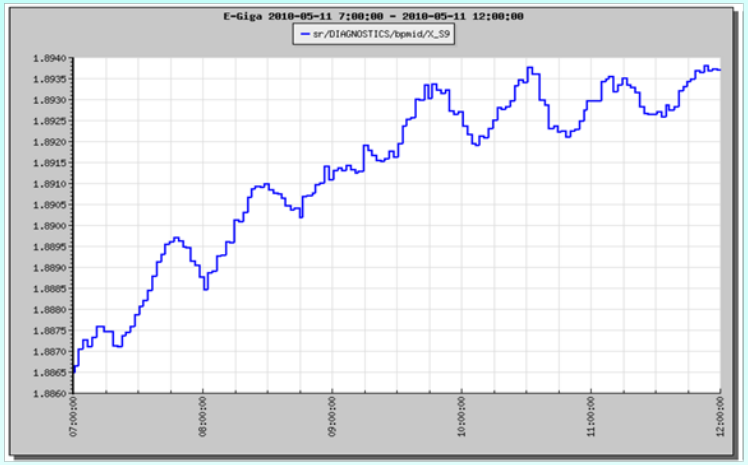
Systems stability during top-up



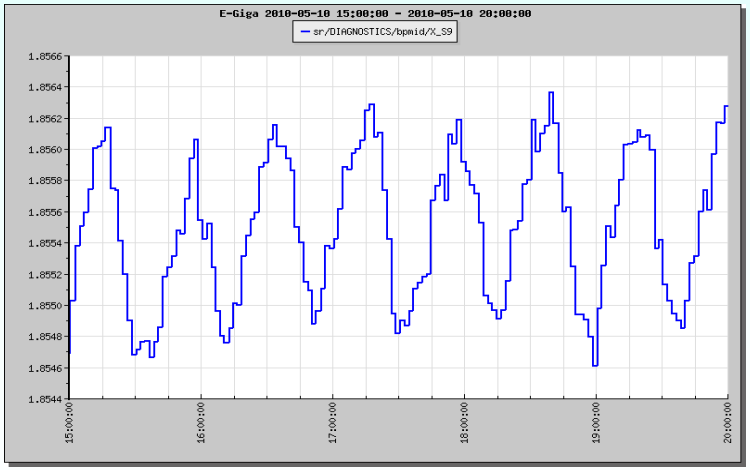
> 90% homogeneity within 1 mA in 56 hours



e-bpm system – ambient temperature effects



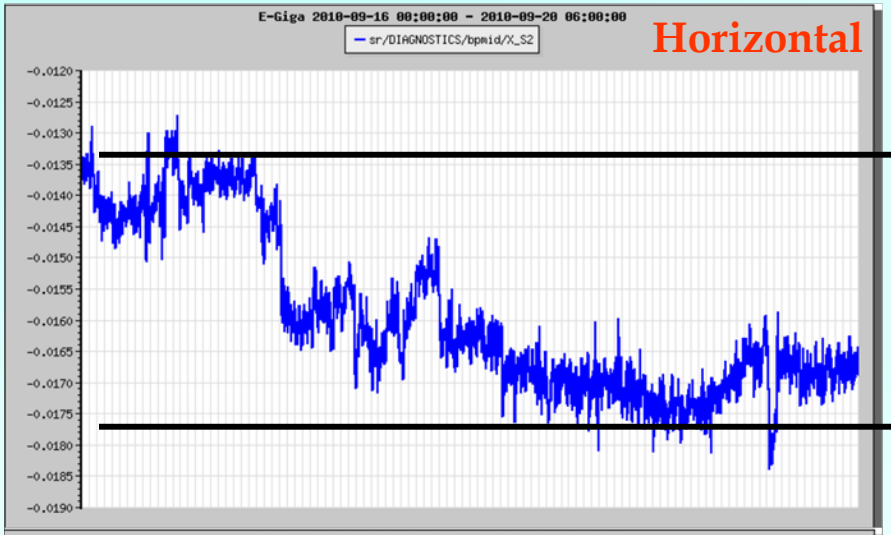
No top up, current decay from 330 to 260 mA – slow drift of horizontal beam position in the middle of ID9 of about 7 um in 5 hours

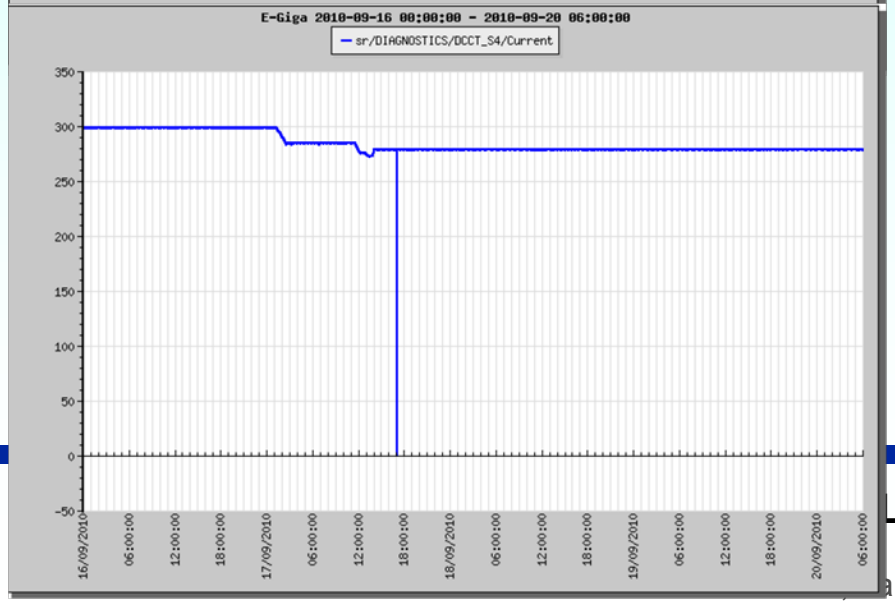


Oscillations are due to the Libera e-bpm electronics being affected by ambient temperature oscillations in the Service Area (± 2 deg) due to a fault on the air conditioning system.

Top up at 300 mA – no drift, peak to peak 1.5 um

Long term stability



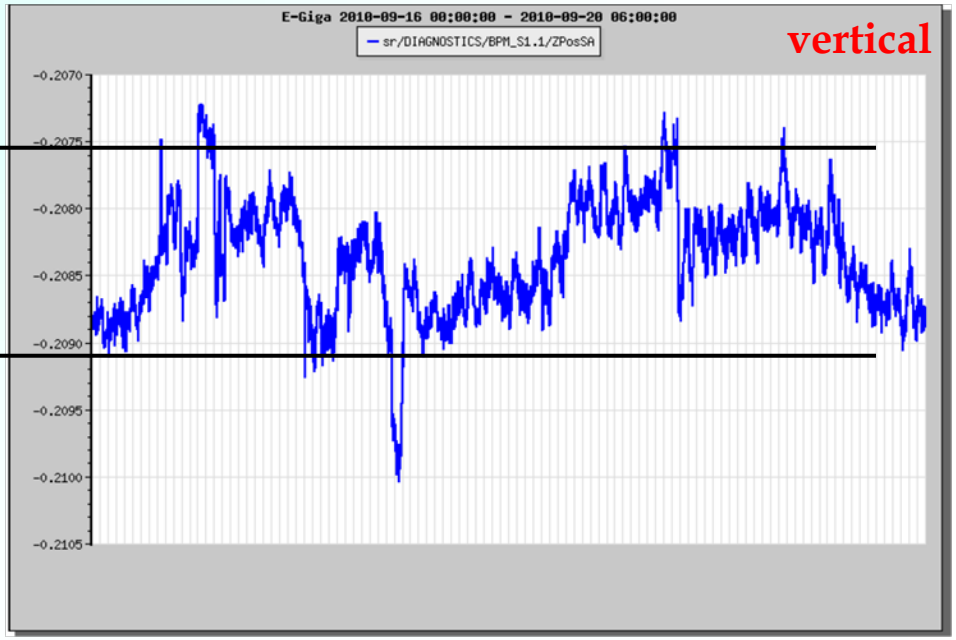


from 16/9/2010 00:00 to 20/9/2010 06:00

for 102 hours

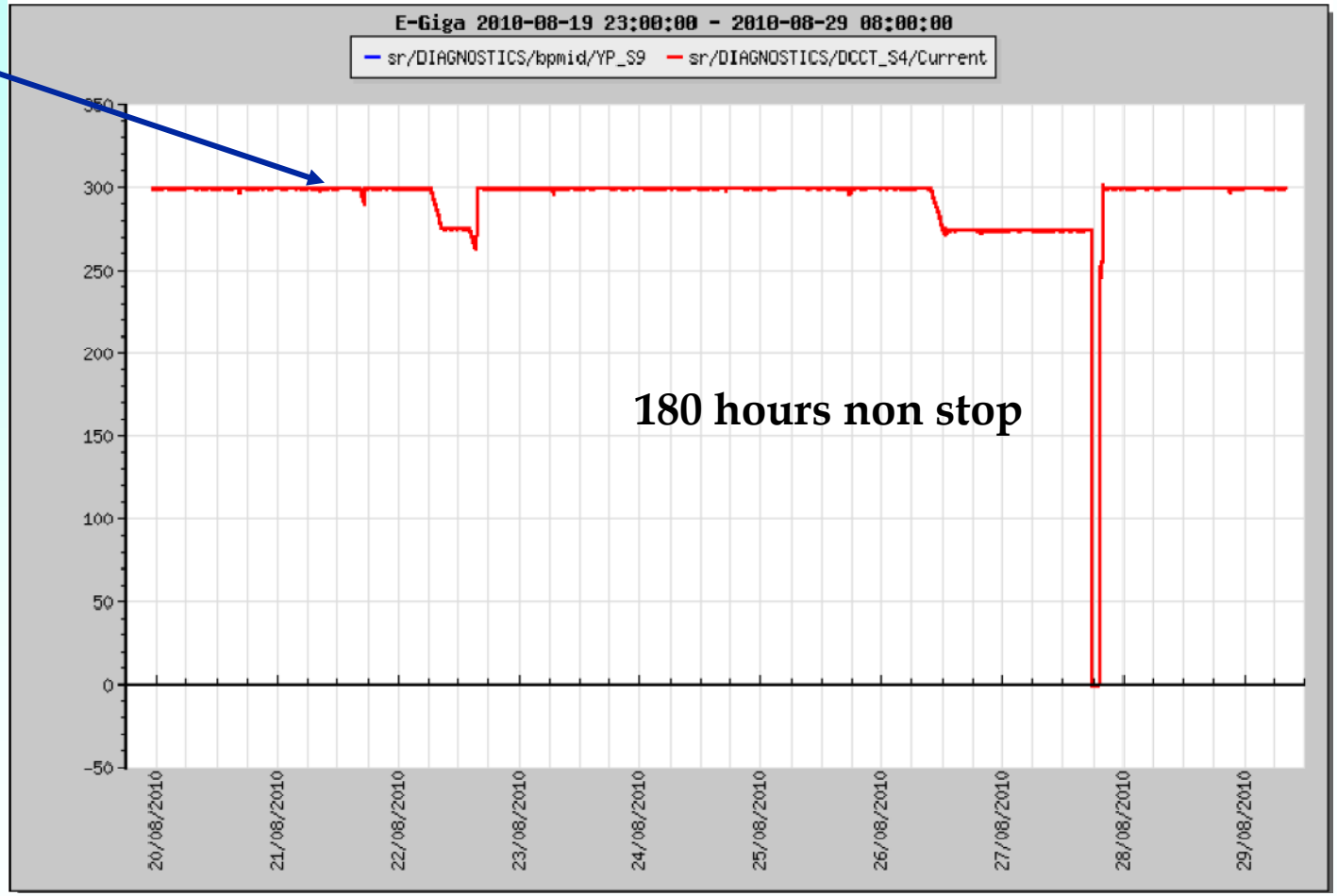
4 μm

1.5 μm



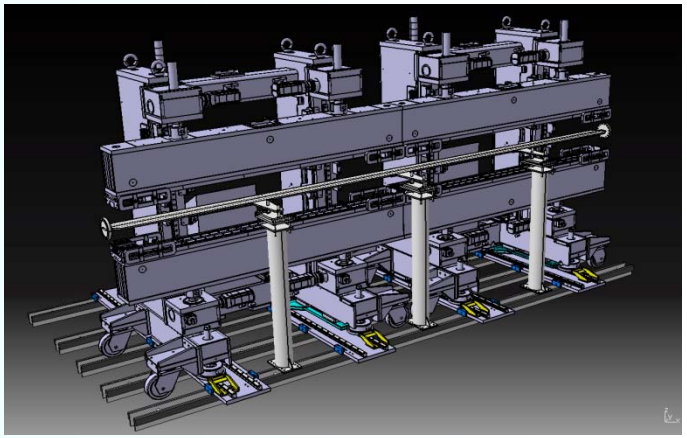
Longest run in top-up

Beam current



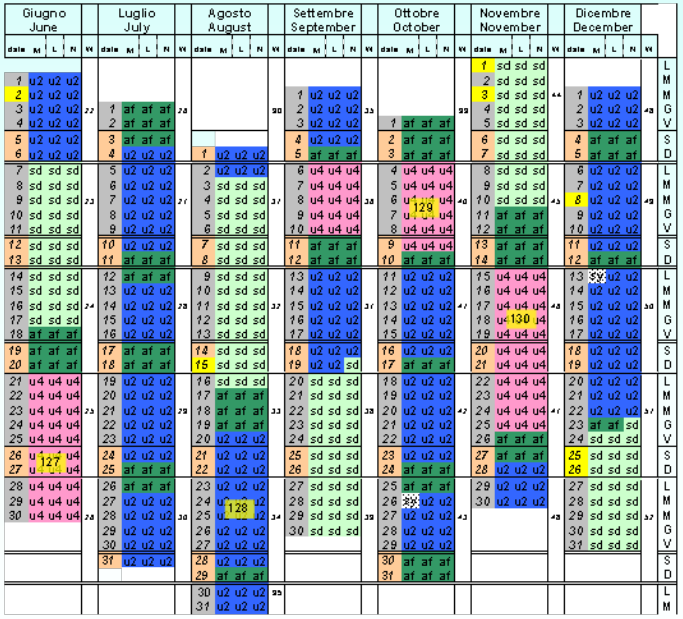
Ongoing projects

- Installed 2 low gap (9 mm) chambers
- New Undulator (KYMA) for SuperESCA
- Ambient temp stabilization
- Air cooling of hot points
- Realignment
- BBA
- 8th corrector
- Photon bpm



Re-Alignment

A complete realignment is underway. The strategy has been defined and the work is programmed in 3 phases, June and September (survey / bpm tests) and November - December (alignment). The second semester of the Elettra user program has been modified accordingly. Important elements are that more network points will be set, survey will include the bpms and data from BBA will also be used.



old

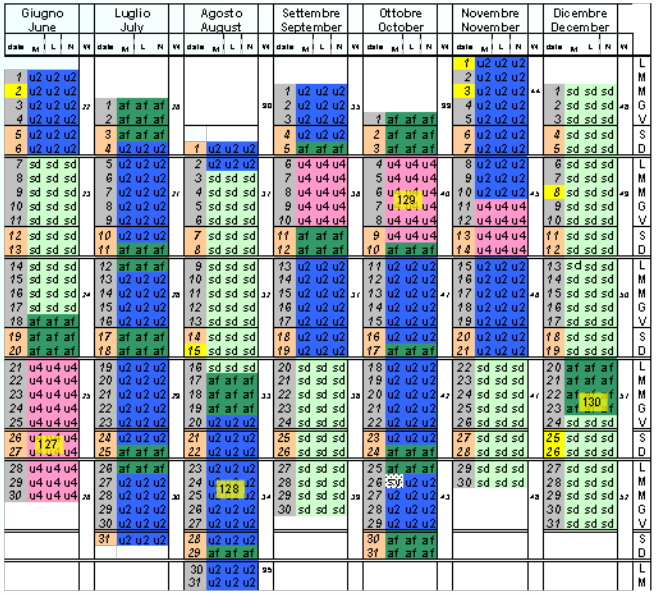
6672 h tot

5000 h user

New

Tot 6256 h

User 4720 h



BBA

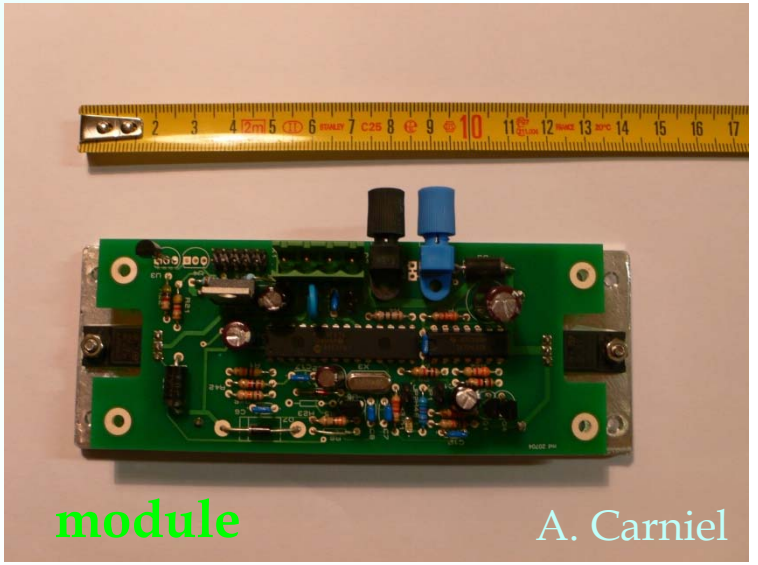
A beam based alignment project has been approved. All 108 quads will be shunted with modules. Already the prototype is working and expect to have all modules installed and functioning by the shutdown November / December 2010

Automatic measuring algorithm in simulations, use local bumps

	H (micron)	V (micron)
BPM 1.4	300	150
BPM 1.5	400	90
BPM 1.3	80	50
BPM 1.2	150	0

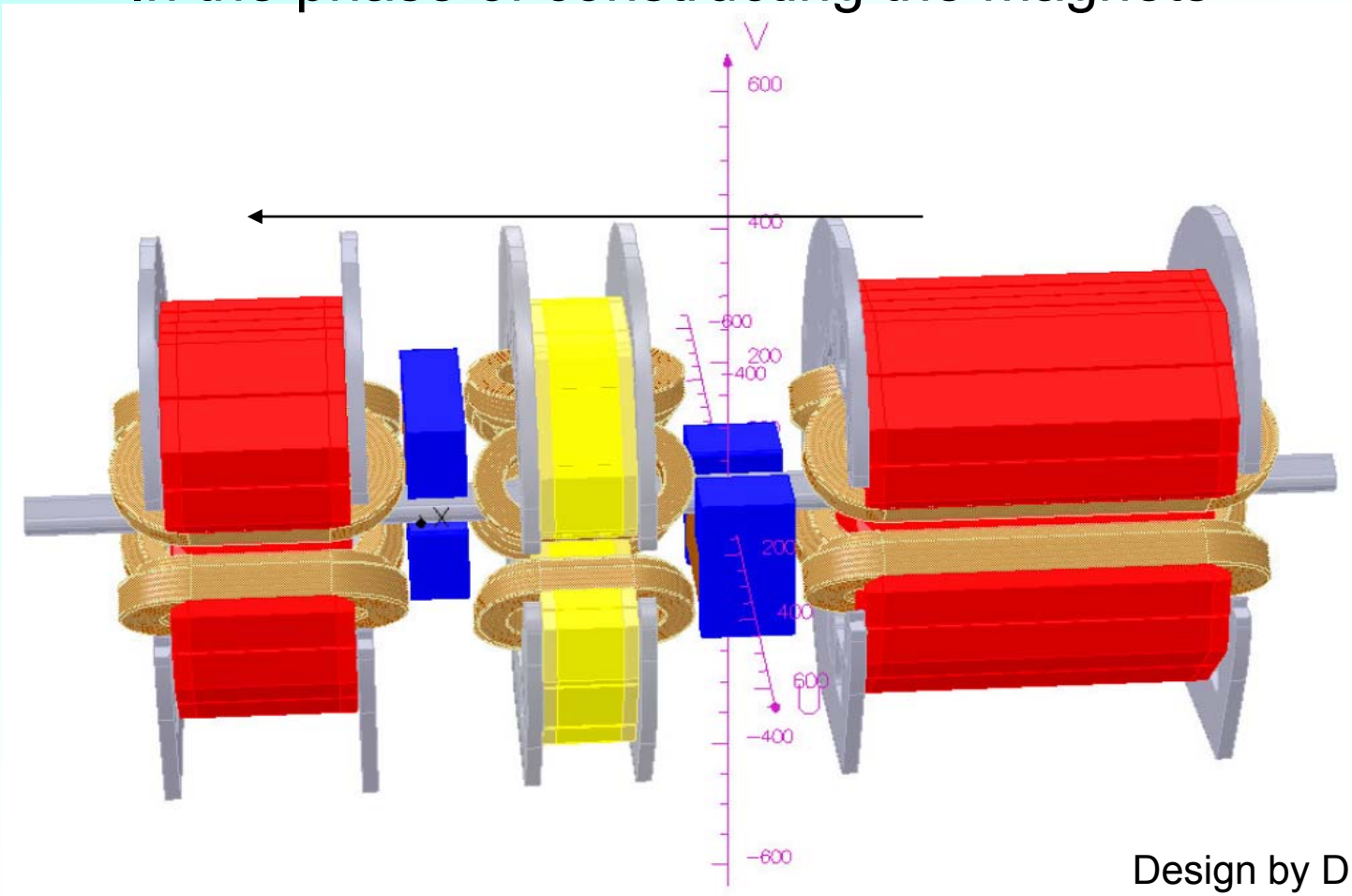
	H (micron)	V (micron)
BPM 9.5	300	600
BPM 9.2	1700	0
BPM 9.3	-445	0
BPM 9.4	200	-100

	H(micron)	V(micron)
BPM 12.1	3022	219



8th corrector/section

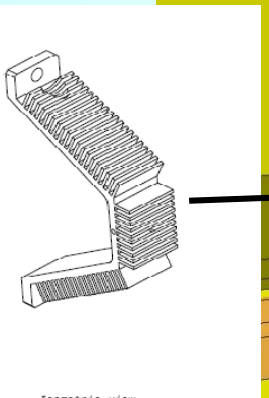
In the phase of constructing the magnets

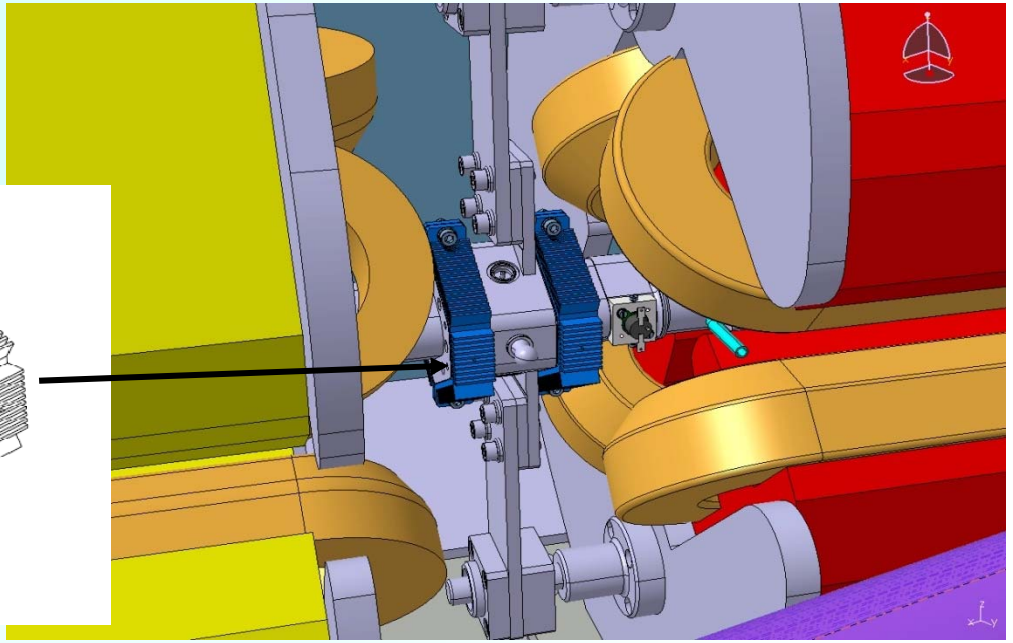


Design by D. Castronovo

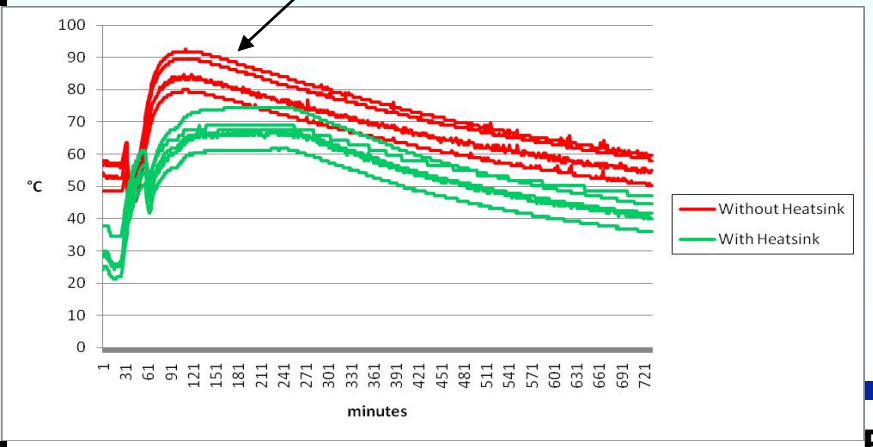
BPM cooling

24 hottest bpms (after dipoles) will be air-cooled with a fan system





dangerous for vacuum leak



With a fan the temp drops between 40 and 50 deg

G. Loda and R. Geometrante

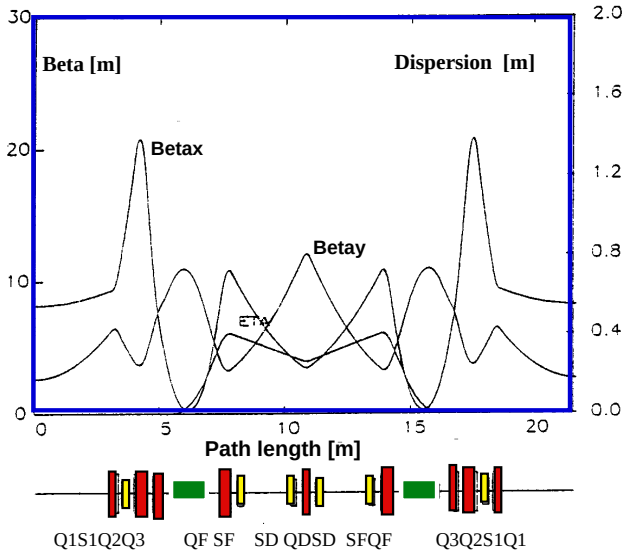
Conclusions

- Elettra updates to keep up with the most recent sources
- Top up at both 2 and 2.4 GeV is now the regular mode of operations and it has been indeed a long way i.e. from lacking a full energy injector to top-up
- A big effort towards reproducibility and stabilization is currently under way
- Near future: Upgrade to 2.5 GeV, get Long. FB functional, install skew elements etc.

Many thanks to

all members of the Elettra team (ODAC project)

Machine Parameters



Beam energy [GeV]		2	2.4
Storage ring circumference [m]	259.2		
Beam height in experimental area [m]	1.3		
Number of achromats	12		
Length of Insertion Device (ID) straight sections [m]	6(4.8 utilizabile per ID's)		
Number of straight sections of use for ID's	11		
Number of bending magnet source points	12		
Beam revolution frequency [MHz]	1.157		
Number of circulating electron bunches	1 - 432		
Time between bunches [ns]	864 - 2		
Tunes: horizontal/vertical	14.3/8.2		
Natural emittance [nm-rad]		7	9.7
Energy lost per turn without ID's [keV]		255.7	533
Maximum energy lost per turn with ID's [keV] (all)		315	618.5
Critical energy [keV]		3.2	5.5
Bending magnet field [T]		1.2	1.45
Geometrical emittance coupling %	≤ 1%		
Spurious dispersion (at the centre of IDs): horizontal (rms max/min) [cm]	6/2.		
Spurious dispersion (at the centre of IDs): vertical (rms max/min) [cm]	2/0.5		
Operation mode	multibunch		
One refill per day (09:30) of duration (incl. ramping etc.) [min]	30		
Injection energy [GeV]	0.75 / 0.9 / 1		
Injected current [mA]		320	140
Machine dominated by the Touschek effect			
Energy spread (rms) %		0.08	0.12
Lifetime [hours]		8.5	26
Bunch length (1 σ) [mm] &		5.4	7
Beam dimensions (1 σ) &			
ID source point - horizontal/vertical [μm]		241/15	283/16
Bending magnet source point - horizontal/vertical [μm]		139/28	197/30
Beam divergence (1 σ) &			
ID source point - horizontal/vertical [μrad]		29/6.	35/8.
Bending magnet source point - horizontal/vertical [μrad]		263/9	370/13
&: The values shown (taking into account the energy spread) are averages, obtained from a consideration of different angle and position values of the spurious dispersion and can very by ±10%			

Booster

Magnet lattice	**FODO with missing magnets**
Maximum energy	**2.5 GeV**
Injection energy	**100 MeV**
RF frequency	**499.654 MHz**
Circumference	**118.8 m**
Revolution period	**396 ns**
Harmonic number	**198**
Equilibrium emittance (2.5 GeV)	
Normal Emittance Optic	**226 nm.rad**
Low Emittance Optic	**166 nm.rad**
r.m.s. energy spread (2.5 GeV)	**7.18 10^{-4}**
Energy loss per turn (2.5 GeV)	**388 keV**
Damping times (h,v,l) (2.5 GeV)	**5.1, 5.1, 2.6 ms**
Betatron tunes Q_x , Q_y	**5.39, 3.42** **6.8 , 2.85**
Natural chromaticities ξ_x, ξ_y	**-6.6, -4.7** **-11.1, -5.2**
Momentum compaction factor	**0.0443** **0.0308**
Maximum β_x, β_y, D_x	**10.8, 13.8, 1.621 m** **15.0, 17.2, 1.683 m**
Peak effective RF voltage *(available 1.1MV)*	**0.84 MV (τ_q~1 s)** **0.73 MV (τ_q~1 s)**

	Nominal	Low Emitt.	
Beam energy	2.5	2.5	GeV
Beam current	5	5	mA
Energy loss	388	388	keV
Harmonic number	198	198	
Revolution freq.	2.524	2.524	MHz
RF frequency	499.654	499.654	MHz
Mom. compaction	0.0433	0.0308	
Quantum lifetime	1	1	sec.
Overvoltage factor	2.16	1.58	
Total RF voltage	840	730	kV
Energy acceptance	3.07E-3	3.07E-3	
Cavity power	25.20	19.03	kW
Beam power	1.94	1.94	kW
Total RF power	27.14	20.97	kW