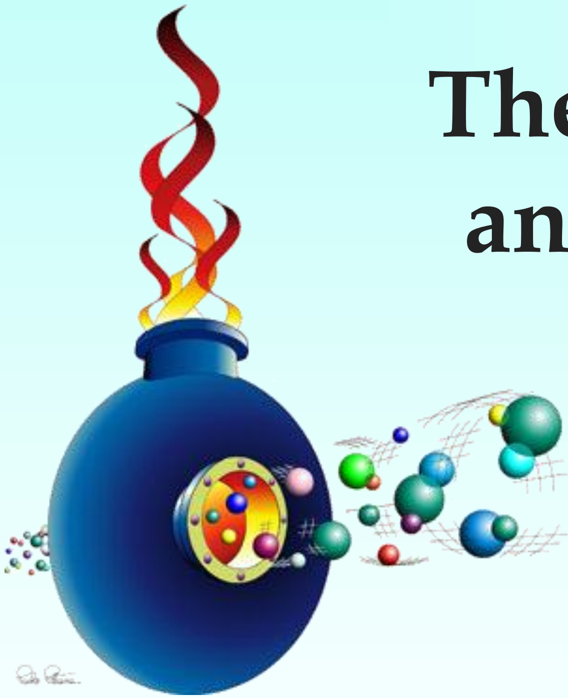


The Elettra Storage Ring and Top-Up Operation

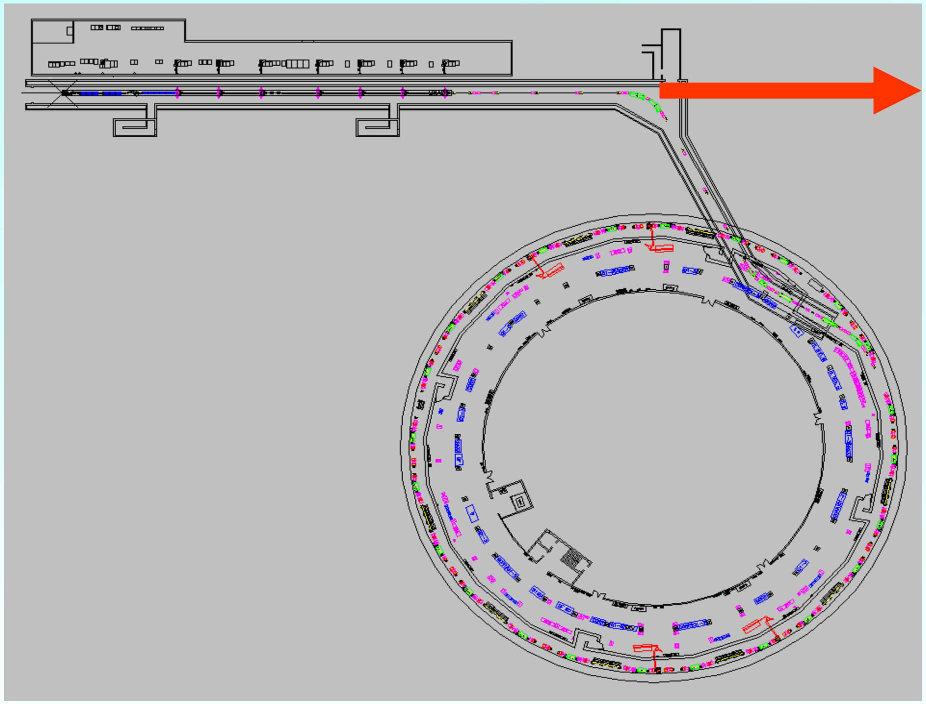
Emanuel Karantzoulis

14th ESLS RF Workshop

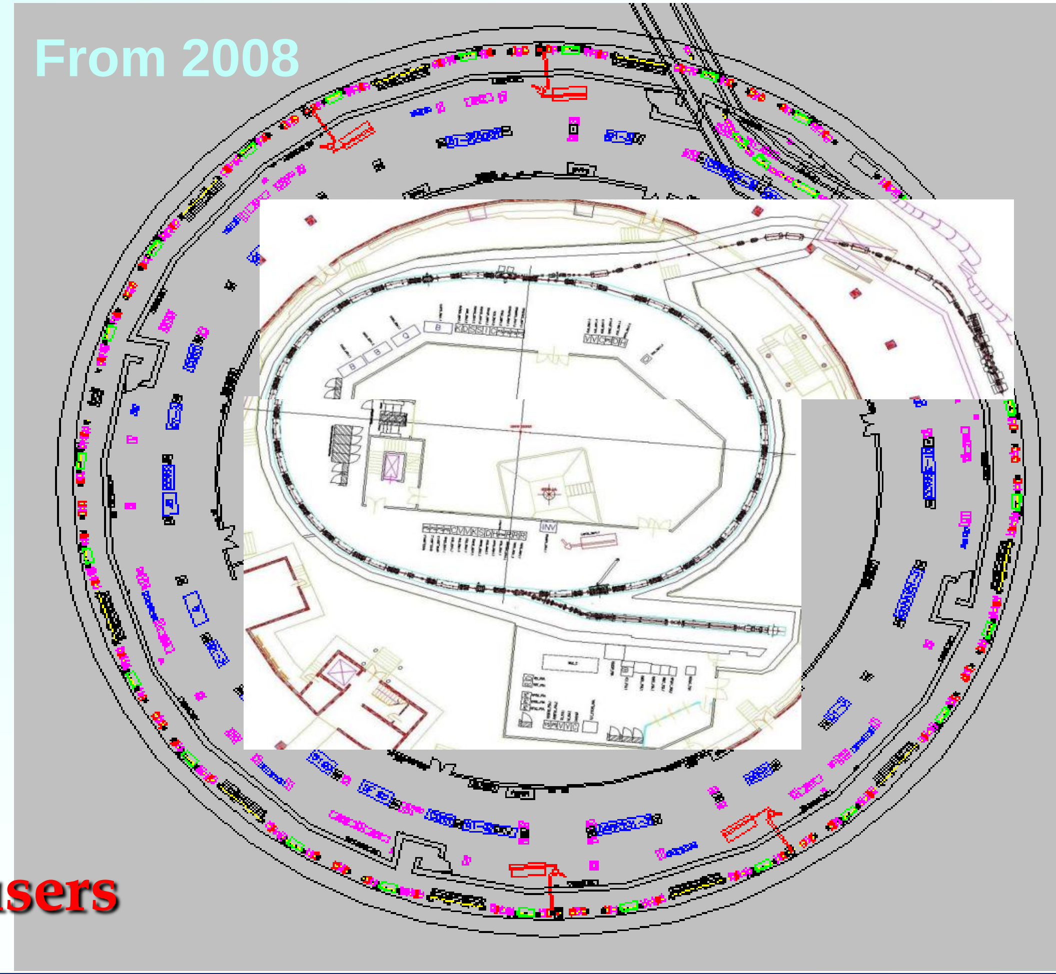
ELETTRA / Trieste, Italy / 2010 September 29 30

Past and Present Configurations

1994- 2007



From 2008



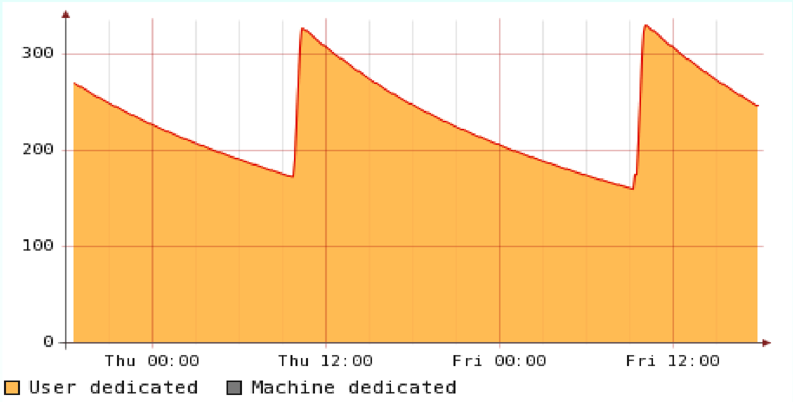
5000 hours /year to the users

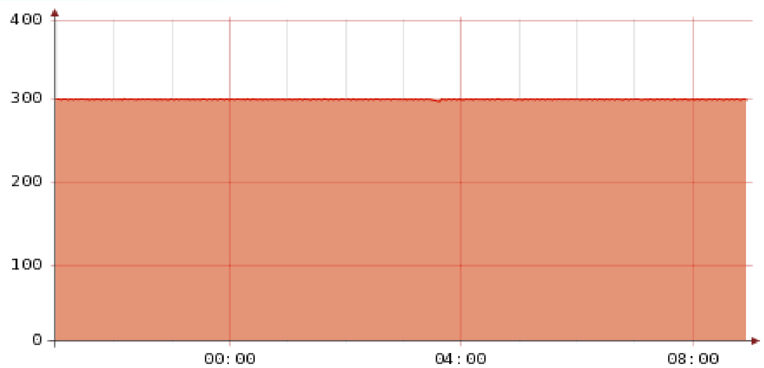
2010: Operations transition year

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

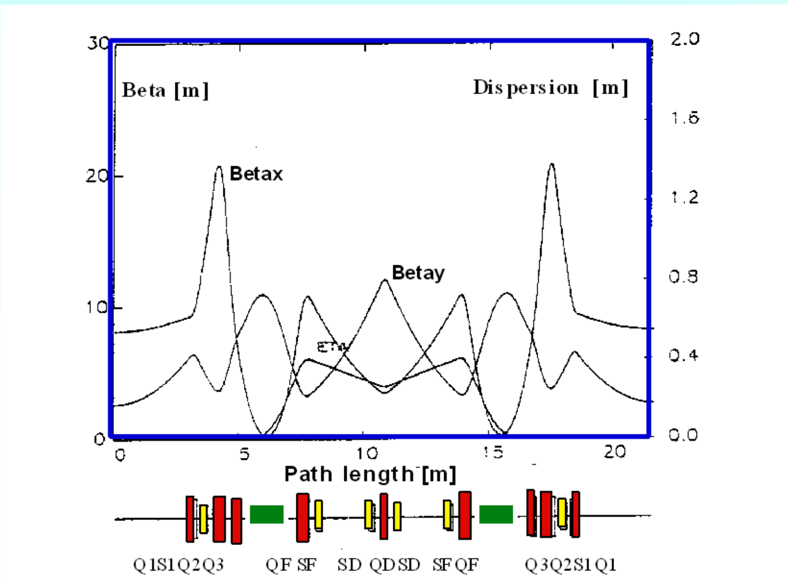
Top-up at 2 GeV (300mA) and 2.4 GeV (140) – FEL upgrades to 2 GeV to be users compatible; for the moment 1.8 GeV 130 nm.

Fill: Any, mainly multibunch and on request hybrid. SB exists but not requested except for FEL.





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%			

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

110 MeV pre-injector

- 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

Performs quite well, still margin for improvement especially on the klystron discharges; many are false

- water/ambient temp stability is vital
- Spare gun and modulator constructed (redundancy)

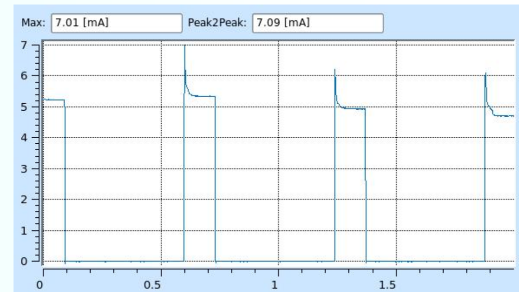
Booster

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

Booster / 2

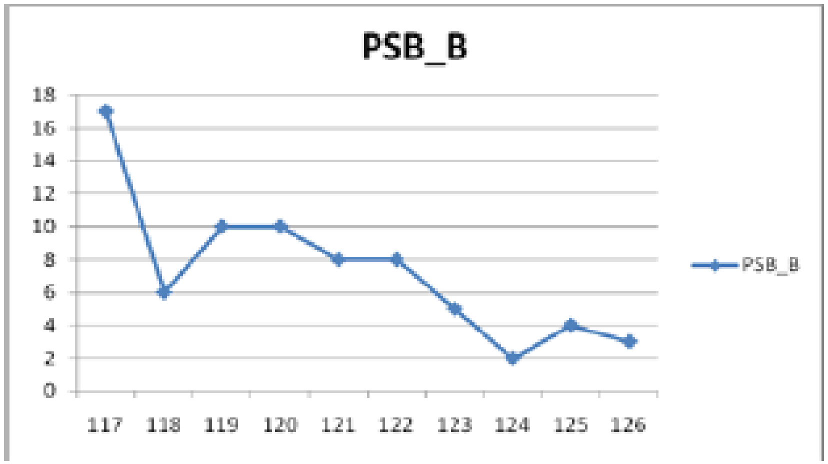
RF plant from Elettra (RF9) 500 MHz 60 kW (TV klystron) and a 5-cell PETRA type cavity. Power transmission via coaxial line. The system performs well.

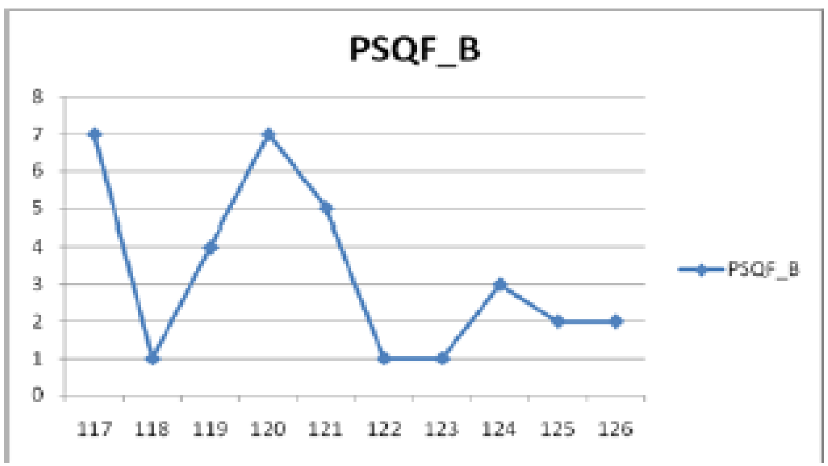


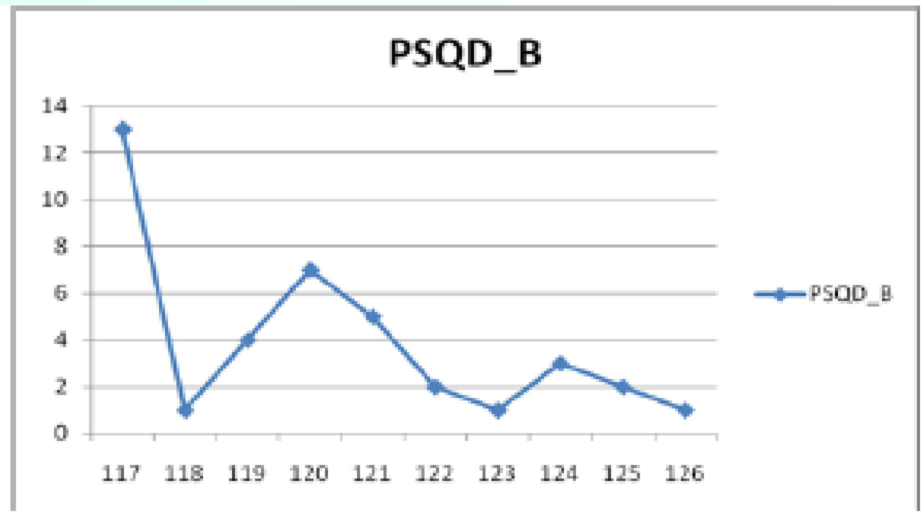
Many problems mainly due to big PSs (also their controls); hard work of about 1 year main problems fixed

- Acceptable operations established. Booster operates at full cycle (2.5 GeV) and up to 3 Hz
- Full energy injection to Elettra at any energy up to 2.4 GeV and any filling (multibunch , single bunch ,few bunch) up to 2.4 Hz rep. rate with efficiencies up to 100%

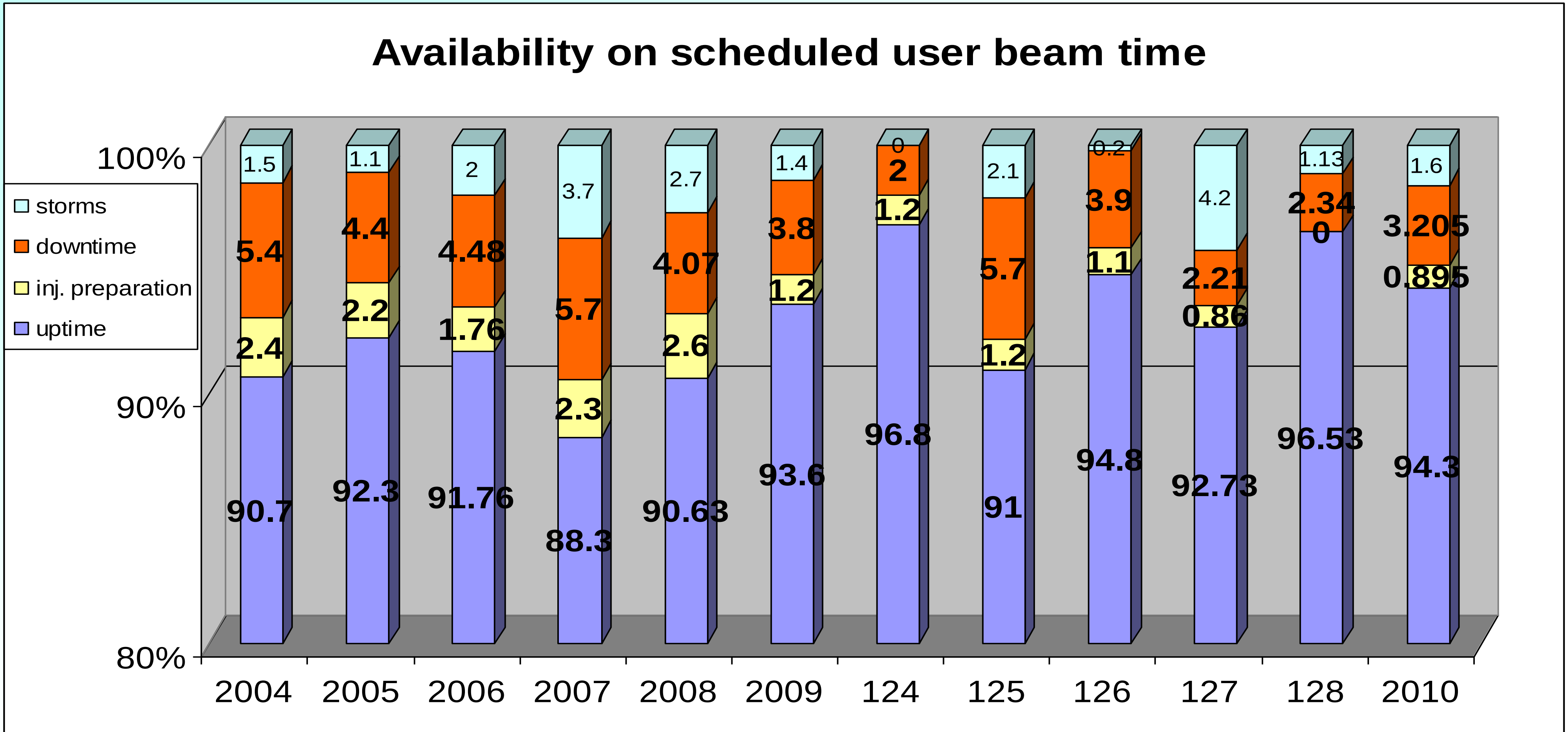
Booster PS faults



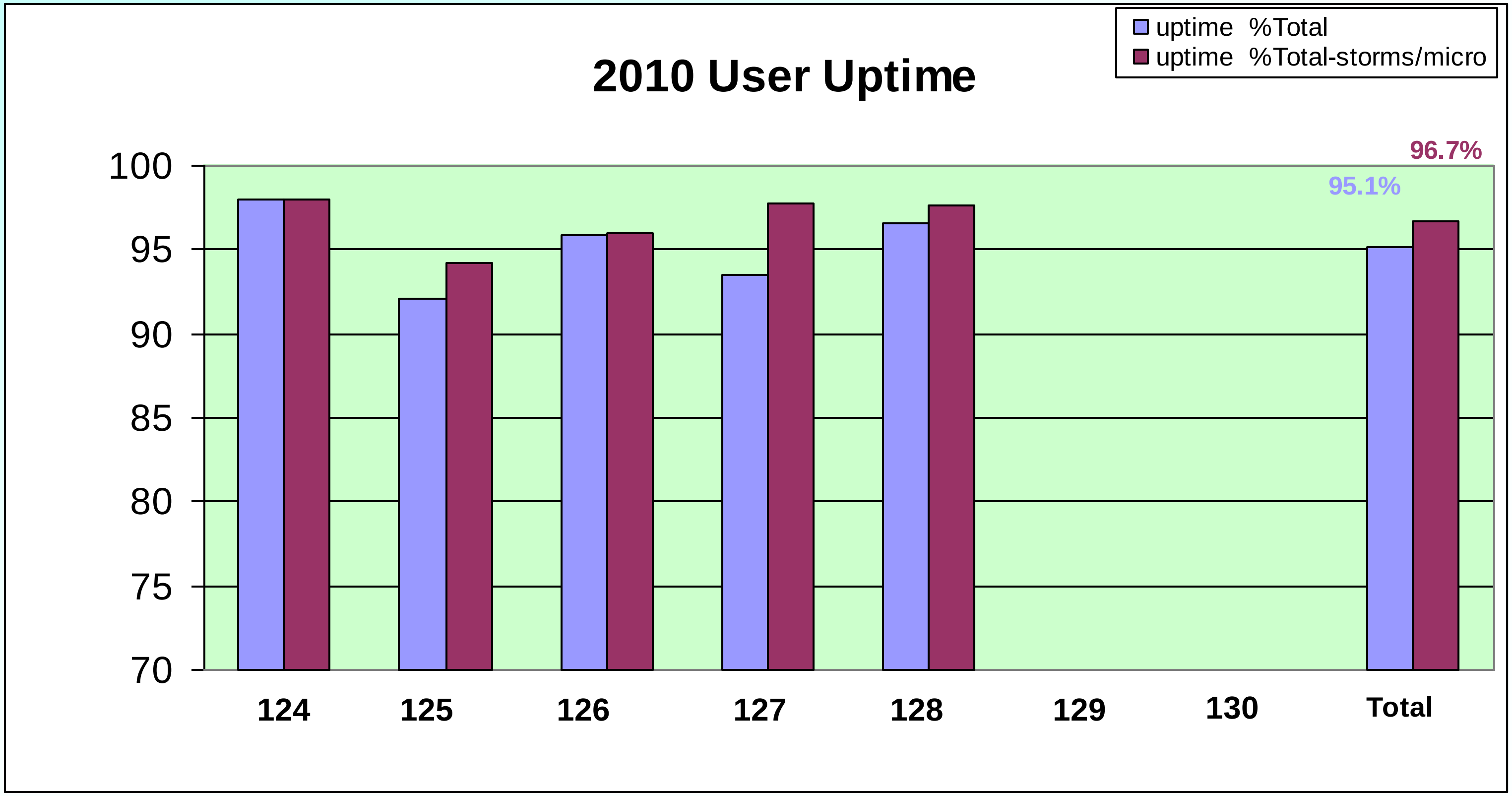


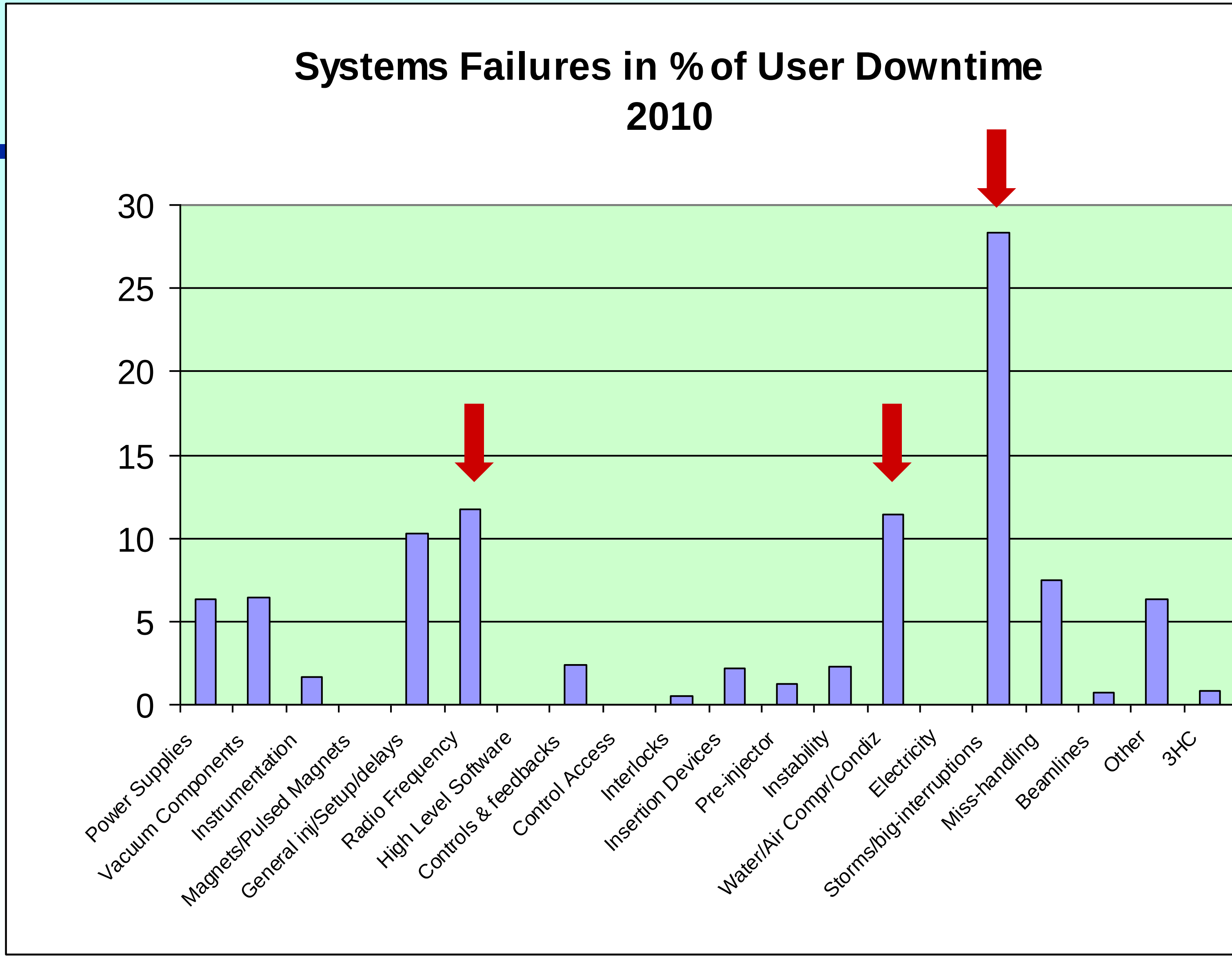


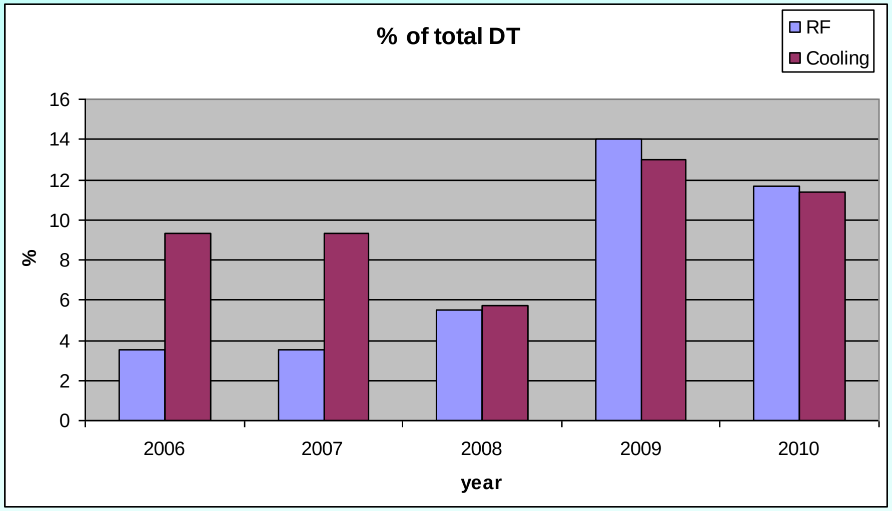
Elettra Availability



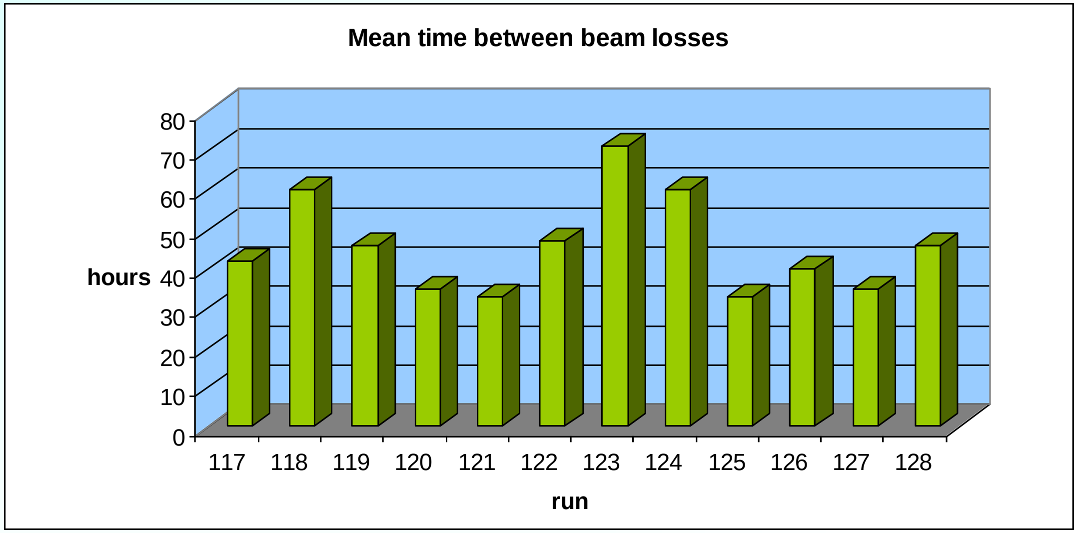
2010 Elettra uptime

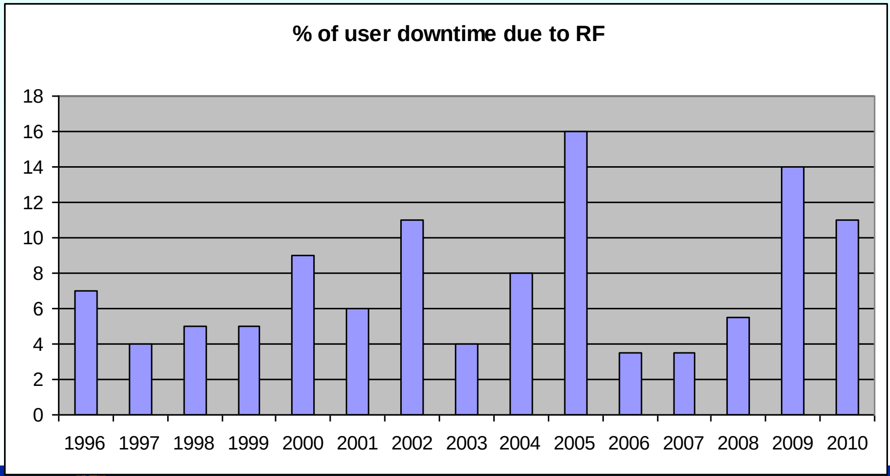



Systems Failures in % of User Downtime
2010
30
25
20
15
10
5
0
Power Supplies
Vacuum Components
Instrumentation
Magnets/Pulsed Magnets
General inj/Setup/delays
Radio Frequency
High Level Software
Controls & feedbacks
Control Access
Interlocks
Insertion Devices
Pre-injector
Instability
Water/Air Compr/Condiz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



Includes air conditioning too





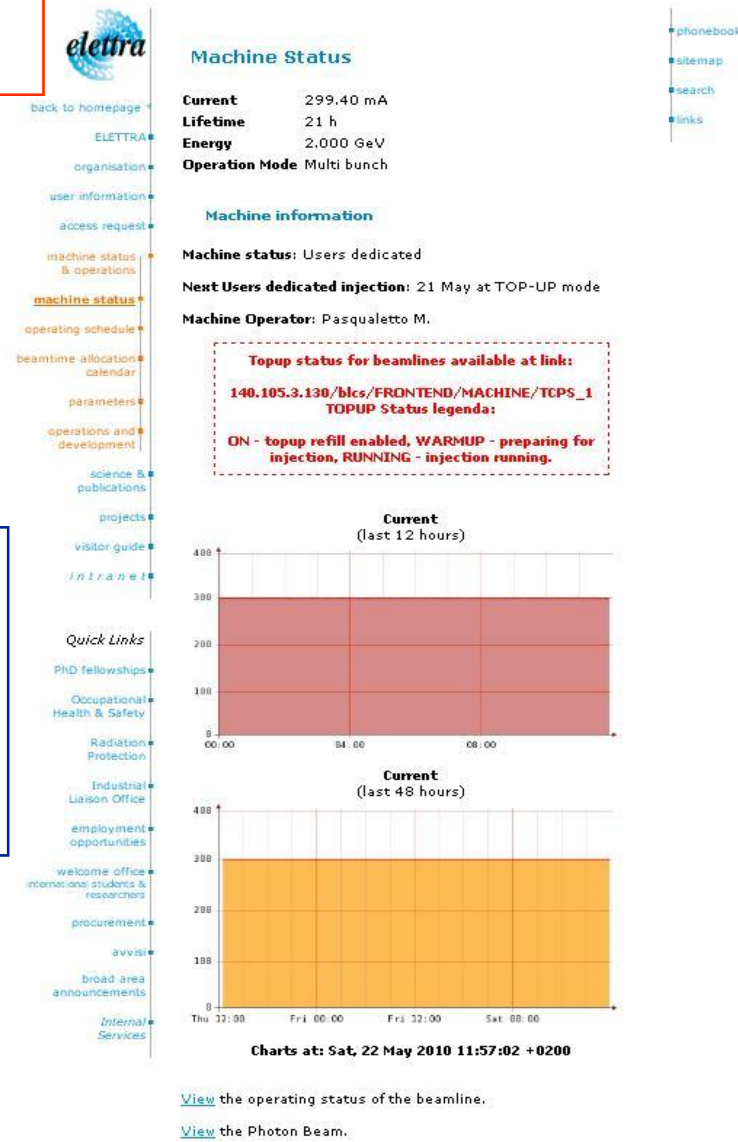
Top Up

Implementation to the machine achieved in 1 year (2009)

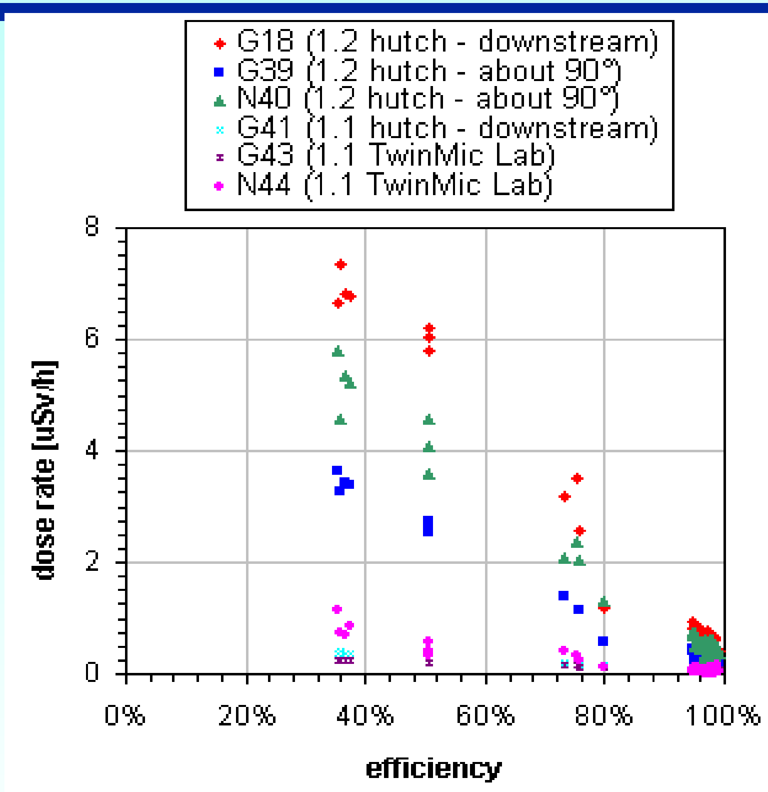
Radioprotection measurements finished as scheduled by end of March 2010. However due to 2 low gap chamber installation during the April shutdown some more controls were required in May.

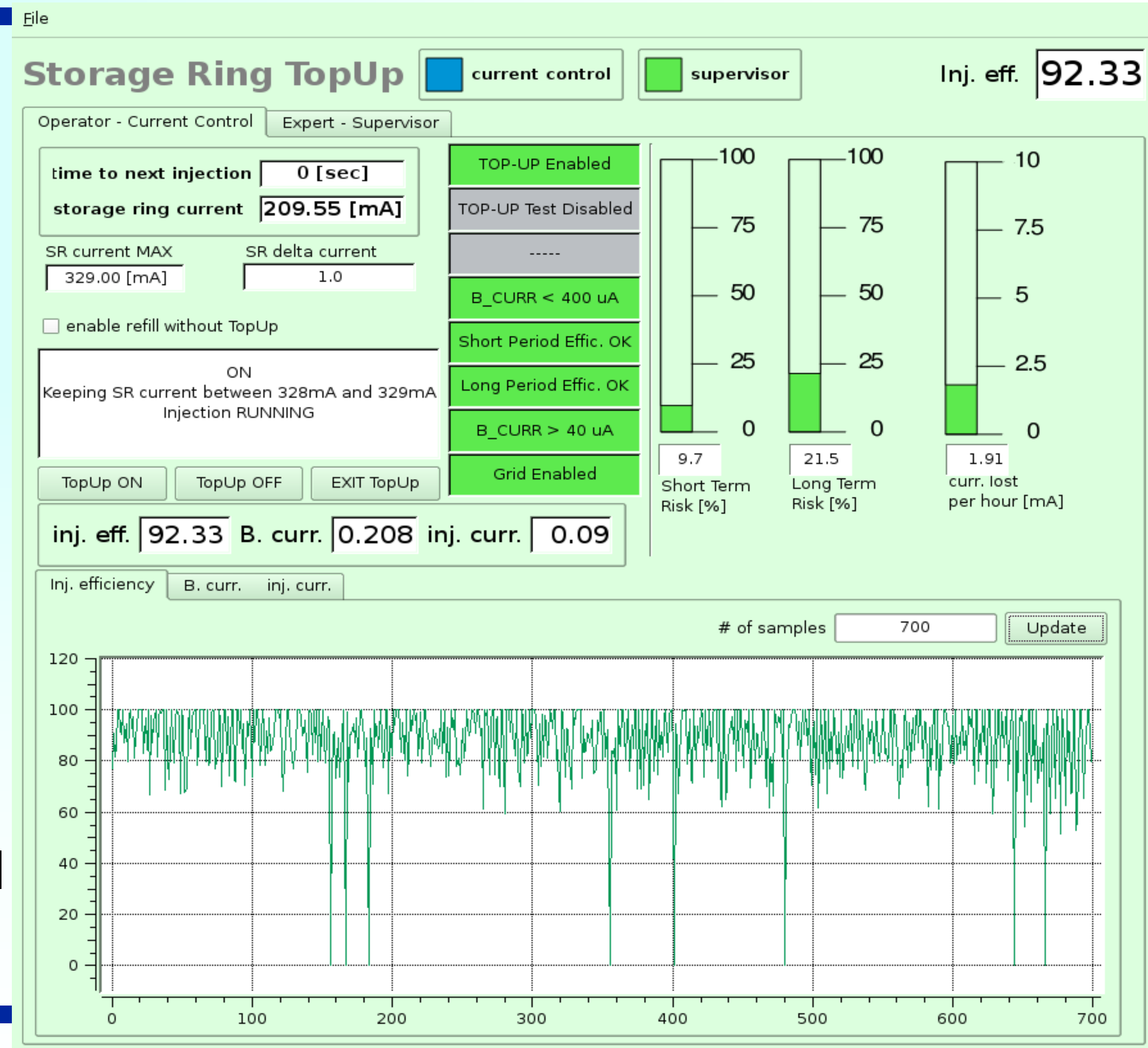
On May 10, top-up operations for users was implemented at 2.0 GeV.
On May 24, top-up operations for users was implemented at 2.4 GeV

Gating is provided via internet, some lines have also additional interface boards provided by the top-up team.



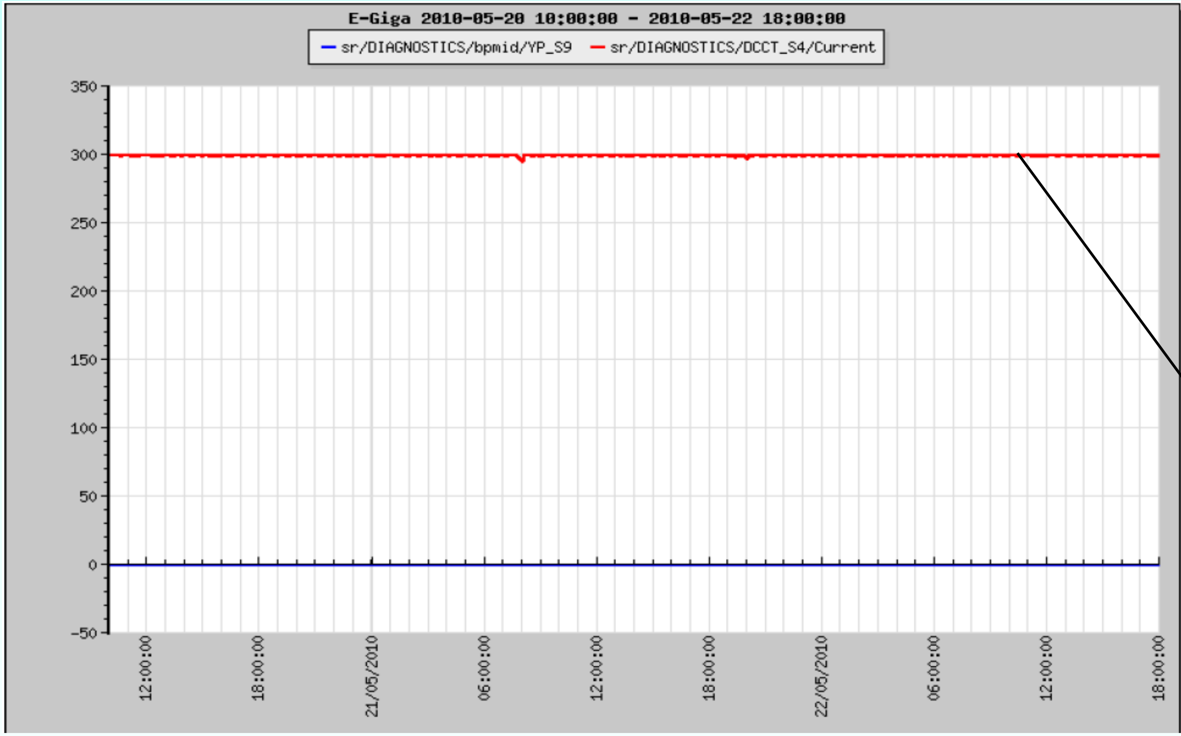
Refill / Top-up controller



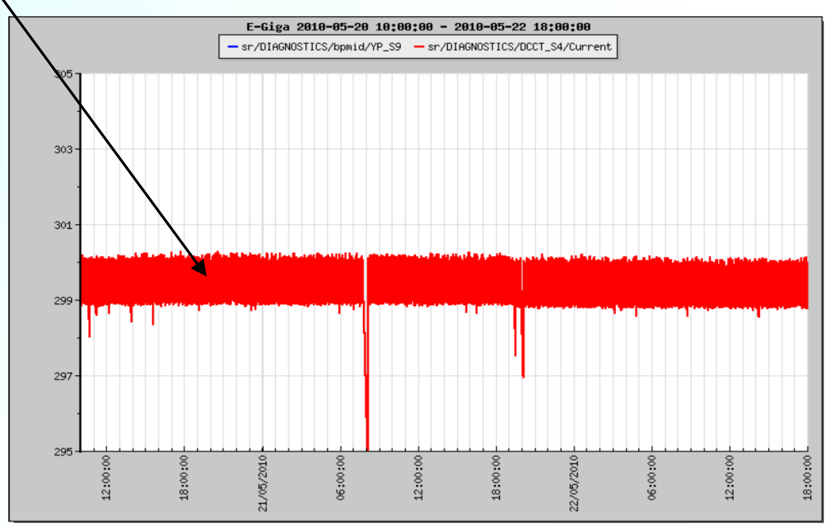


Next, fast dcct already installed will allow bunch to bunch fill

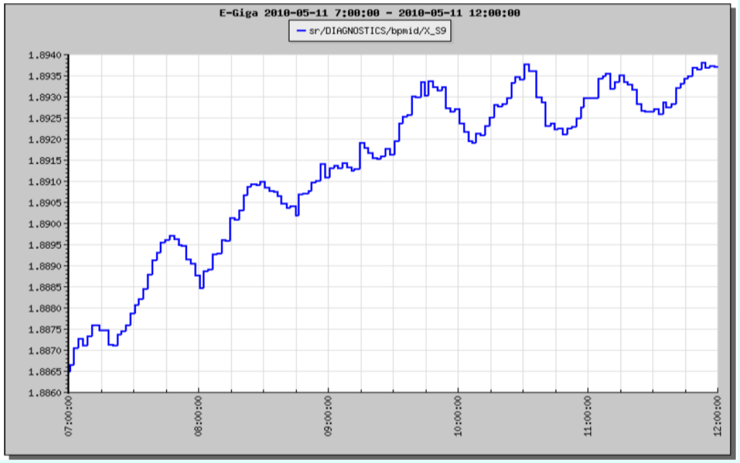
Systems stability during top-up



> 90% homogeneity within 1 mA in 56 hours

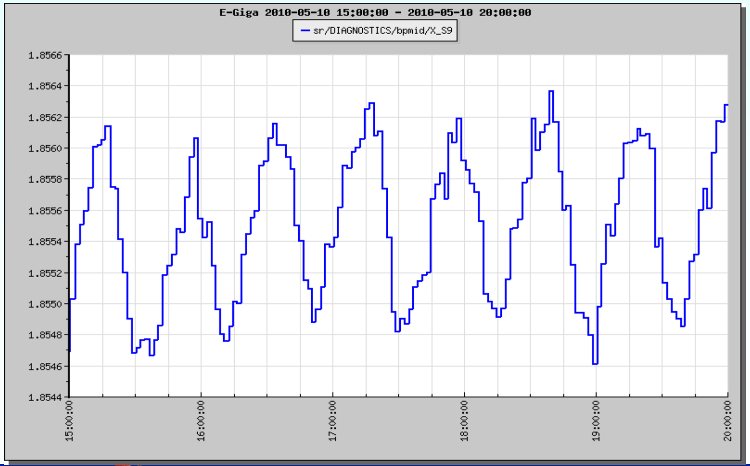


e-bpm system – ambient temperature effects



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).

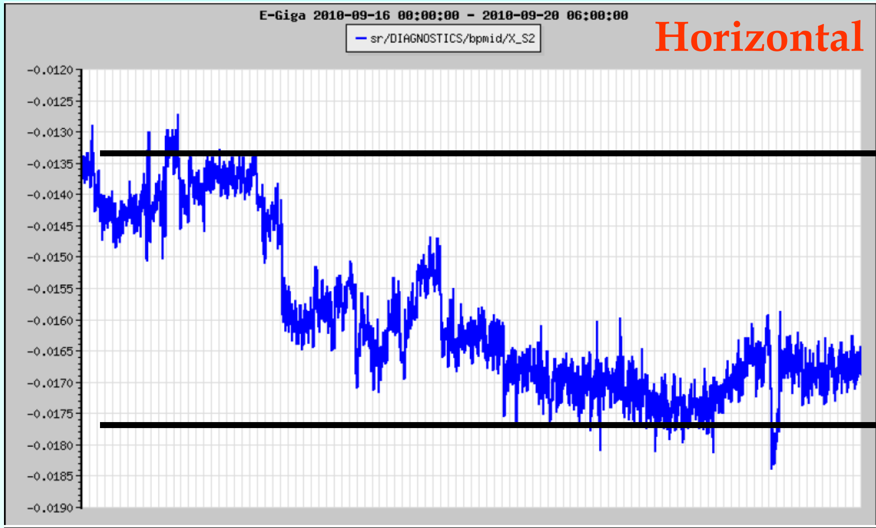


Top up at 300 mA – no drift, peak to peak 1.5 um

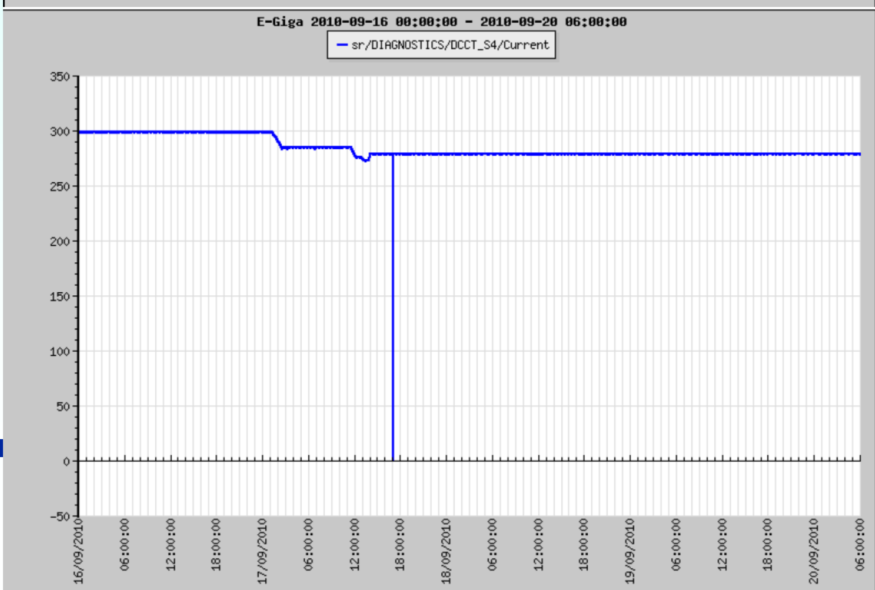
Long term stability

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

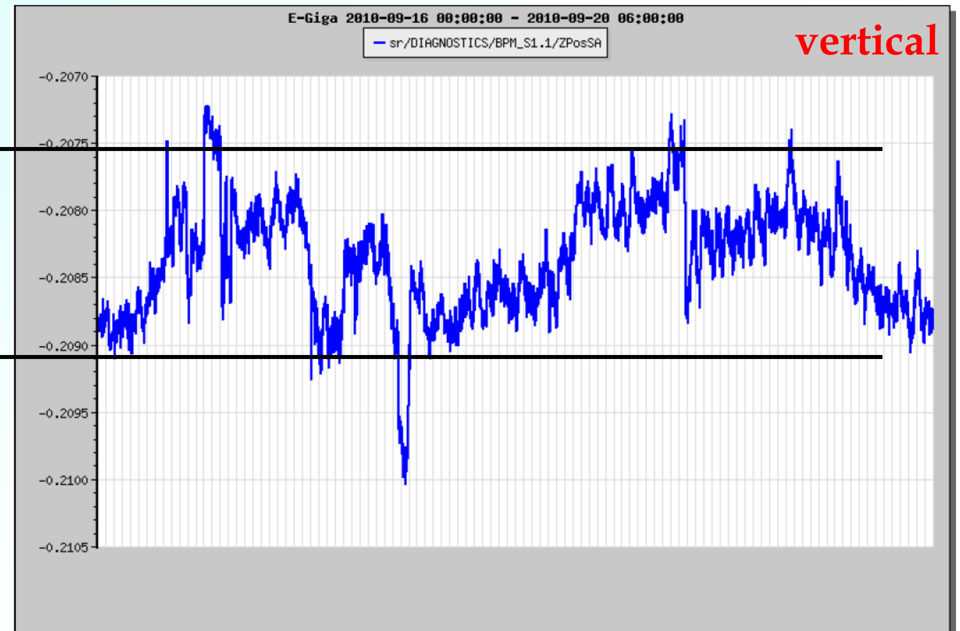
for 102 hours



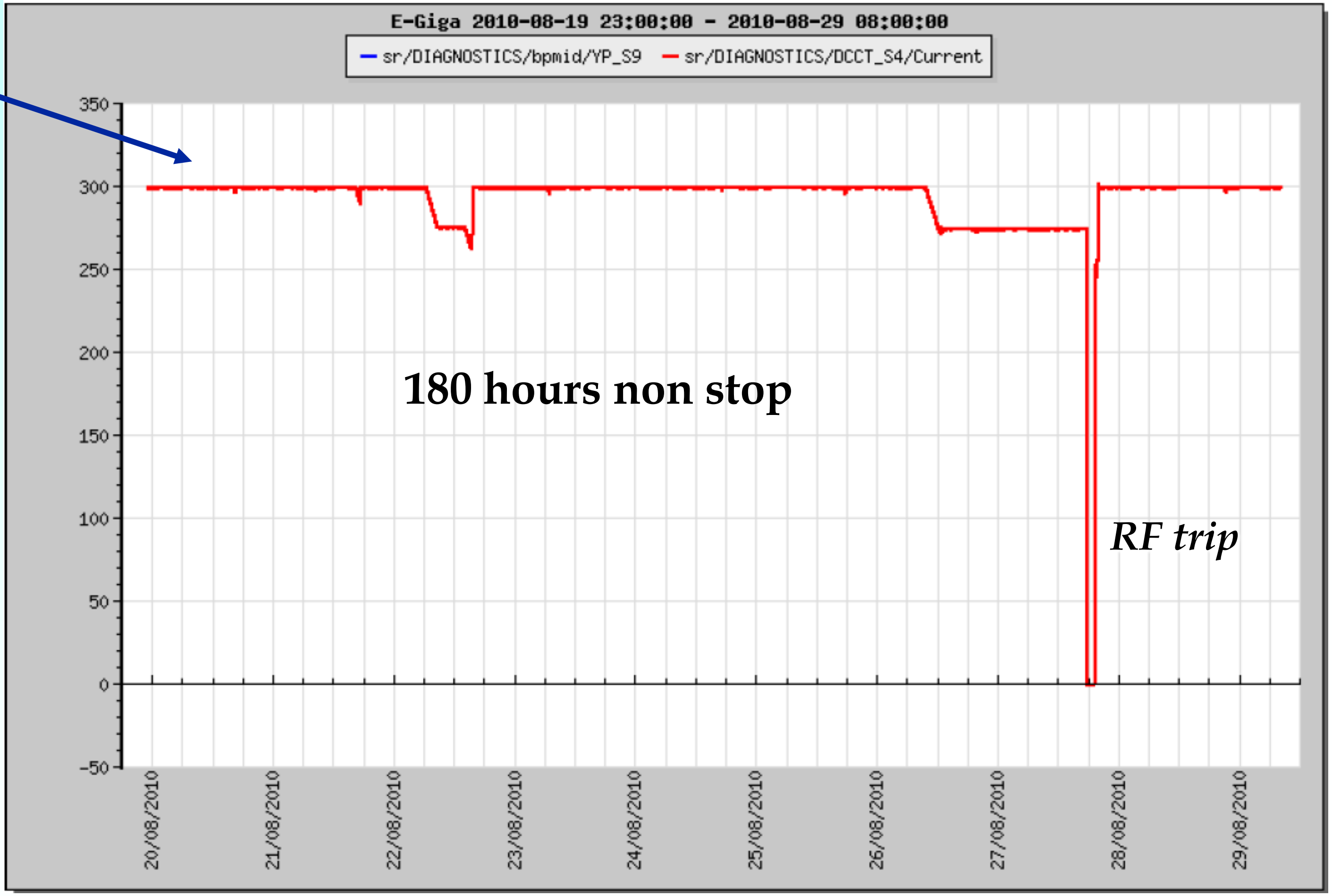
4 µm



1.5 µm



Beam current



Actual working projects

- Installed 2 low gap (9mm) chambers
- Air cooling of hot points to increase the intensity (but users very reluctant)
- Ambient temp stabilization
- Realignment
- BBA
- 8th corrector
- Photon bpm

Present Conclusions

- *Top up is now the regular mode of operations*
- *A big effort towards reproducibility and stabilization is under way*

Acknowledgements to :

A. Carniel, S. Krecic, M. Vento and the operators

G. Gaio, F. Giacuzzo, C. Scafuri , L. Zambon and the controls

K. Casarin, E. Quai, G. Tromba, A. Vascotto and the radioprotection

O. Ferrando and S. Ferry for simulations and algorithms

…and certainly all members of the ODAC project

elettra

Looking to the future (next 3 years)

- Installation of skew elements and other improvements

BUT most important:

- Should we continue with IOTs or move towards solid state? (assume that returning to klystrons is out of question?)

I hope by the end of this workshop we can get some answer

I wish all of you a very successful workshop