Status of Elettra, top-up and other upgrades

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ESLS XVIII Workshop

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Past and Present Configurations



2008 and 2010: transition years



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



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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





- 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).





- 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€



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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

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Booster

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

- <u>Acceptable</u> operations established. Booster operates at <u>full cycle (2.5 GeV) and up to 3 Hz</u>
- 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.



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Elettra Availability



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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

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View the operating status of the beamline.

<u>View</u> the Photon Beam.

elettra

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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%



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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.



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Systems stability during top-up



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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

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Long term stability



Longest run in top-up



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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



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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.

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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



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8th corrector/section



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BPM cooling



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)

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Machine Parameters



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 Tunnet between bunches [ns] 14 2/2 2	
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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 o) [mm] & 5.4	7
Beam dimensions (1 c) &	
ID source point - horizontal/vertical [um] 241/15	283/16
Bending magnet source point - horizontal/vertical [um]	197/30
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Beam divergence (1 o)	25/0
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8. The values shown (taking into account the energy spread) are averages	
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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	0.84 MV (τ _q ~1 s)
(available 1.1MV)	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

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