
Summary of LERD at LER2016 low emittance ring desing

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***Diamond Light Source
and
John Adams Institute, University of Oxford***

Low Emittance Ring Design

5 sessions – 25 talks; topics:

Commissioning/operation results (MAX IV, NSLS-II)

Updates/design progress (SIRIUS, SOLEIL, APS-U, CHESS, Diamond II, ALS U, HEPS, ELETTRA2.0, DIAMOND II, Spring-8, Lit-J)

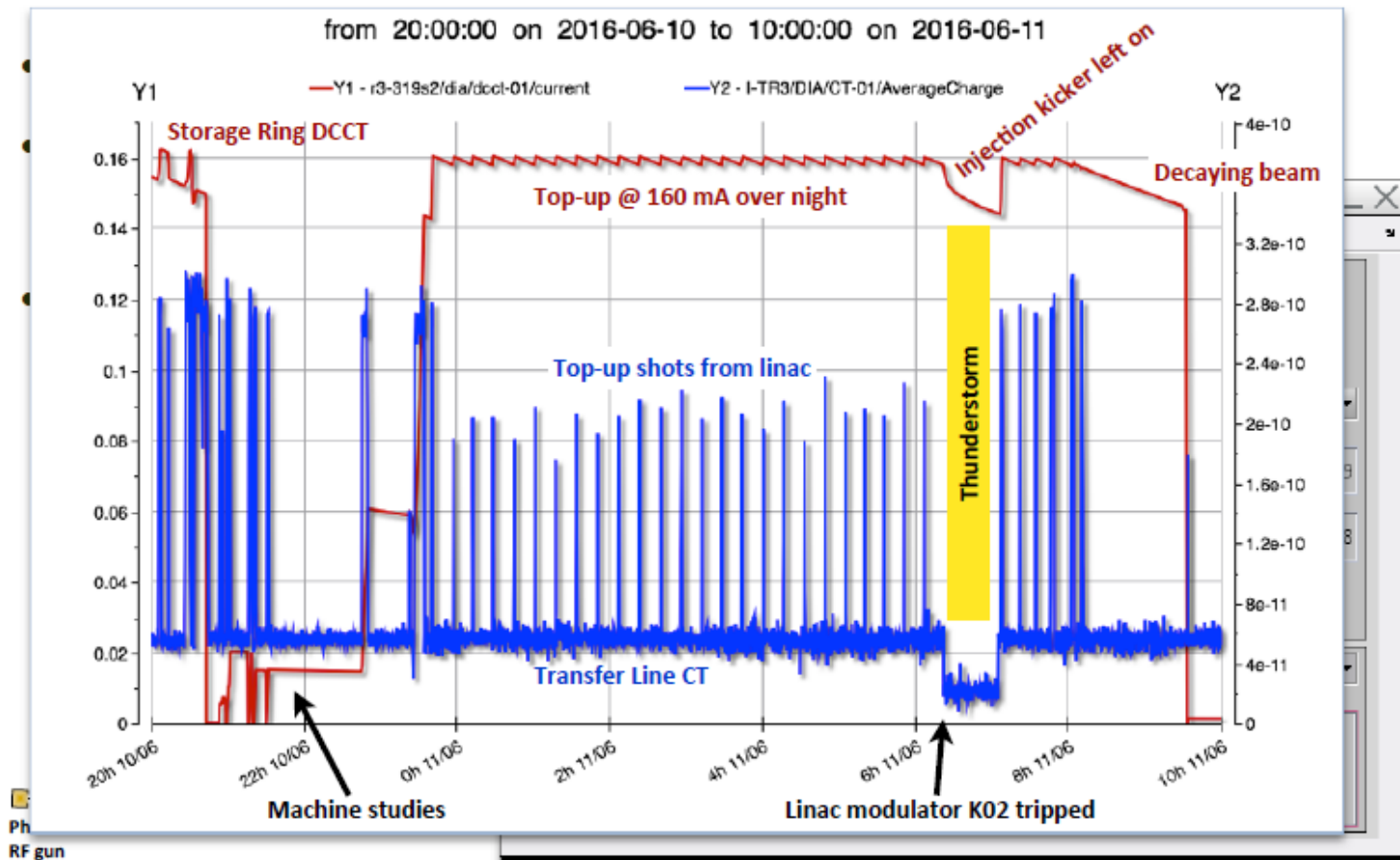
Optimisation tools (Huang, Ehrlichmann, Hua-Yu, ...)

Analysis of performance (ESRF optics, ESRF-EBS lifetime, Spring-8 injection, Top-up injection in HEPS, V emittance APS, crab cavities at SPEARIII)

<https://indico.cern.ch/event/574973/>

MAX IV commissioning (S. Leemann)

3 GeV Storage Ring Commissioning (cont.)



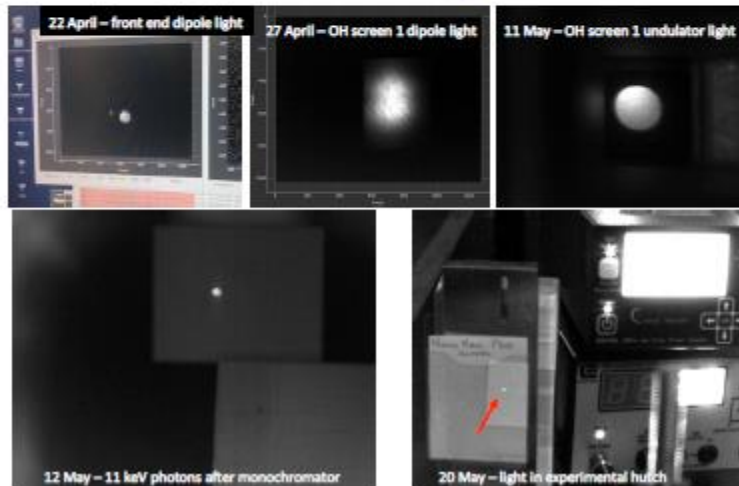
MAX IV commissioning (S. Leemann)

3 GeV Storage Ring Commissioning (cont.)

- First two IVUs installed during Feb 2016 shutdown
 - Hitachi, 18 mm period, 4.2 mm magnetic gap, 2 m length, 1.3 T peak field
 - for BioMAX and NanoMAX beamlines
- ID, FE & BL commissioning started Apr 2016

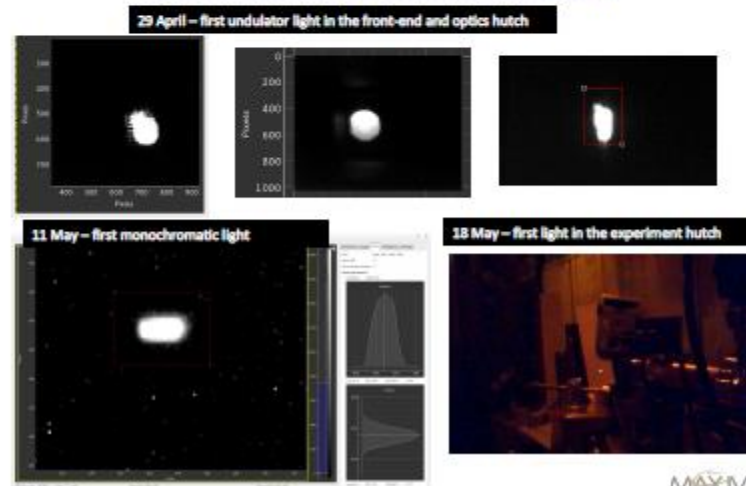
NanoMAX commissioning

Courtesy U. Johansson



BioMAX X-ray commissioning

Courtesy T. Ursby



MAX IV

Sirius progress (F. E. De Sa)

Sirius building (Aug. 2016)



Budget

- Accelerators 94 M €
- 13 beamlines 133 M €
- Building 200 M €
- Human Res 53 M €
- Total 480 M €

Schedule

- Jan.2015 start of building construction
- Sep.2017 start of machine installation
- Aug.2018 start of SR commissioning
- Jan.2019 phase 1 operation (20 mA, NCC)
- Jul.2019 phase 2 operaton (100 mA, SCC)

Sirius progress Magnets (F. E. De Sa)

Partnership LNLS/WEG



LNLS: simulation, design & magnetic measurement



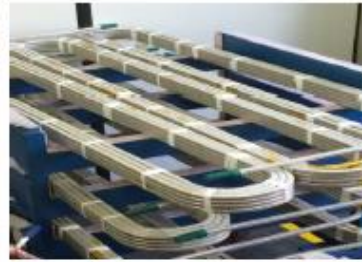
- 15.000 employes in this plant
- 50.000 electric motors/day

Sirius progress Magnets (F. E. De Sa)

Magnets production



- A strategic decision for the production of Sirius magnets was to start with the booster magnets with tolerance requirements approaching the ones required for the storage ring.
- Delivery of all booster magnets will be completed by Dec. 2016.



Sirius progress Vacuum (F. E. De Sa)

Fully NEG coated strategy with copper chamber



Ø 24mm

Copper Chamber

Cooling Tube

An 200 Co AlNco Magnet

Low impedance flange

Zero gap copper seal

Pumping Station

Crotch absorber, Ion pump, NEG cartridge, Vacuum gauges

BPM

BPM Flanges

RF shielding

Dipole chamber

ID radiation extraction

Keyhole design

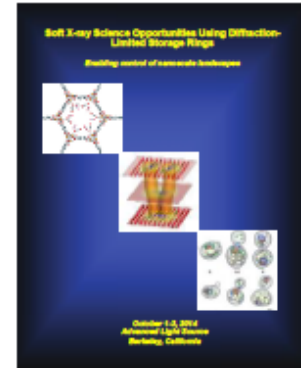
0.3 mm SS sector

For fast orbit correctors

ALS-U (D. Robin)

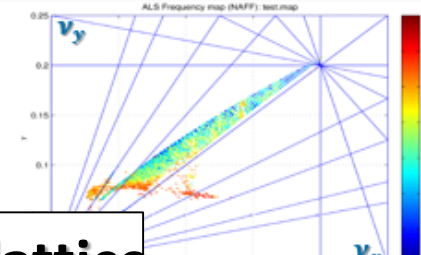
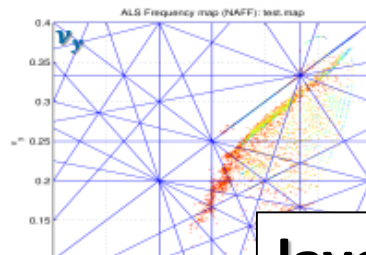
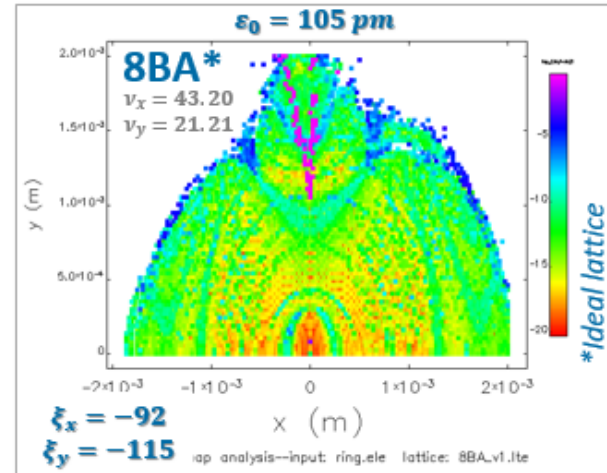
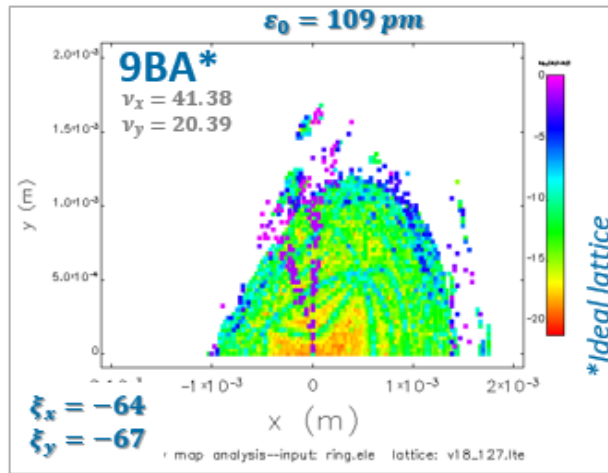
ALS-U Timeline and Status

- Jul 2013** BESAC Subcommittee on Future X-ray [Pages from sxr_workshop_report.pdf](#)
“The Office of Basic Energy Sciences should ensure that U.S. **storage ring** x-ray sources reclaim their world leadership position.”
- Oct, 2014** *Workshop on Soft X-ray Science Opportunities using Diffraction-Limited Storage Rings, LBNL* – result presented at Feb 2015 BESAC Meeting
- Since FY14** Received funding from LBNL for R&D as well as pre-project development. In FY16 received funding from BES for Research and Development for the Advanced Light Source Upgrade
- Jun 2016** BESAC Prioritization Panel grades ALS-U as “Absolutely Central” to contribute to world leading science and as “Ready to Initiate Construction”
- Sep 2016** ALS-U receives approval of Mission Need (CD-0) from DOE/BES

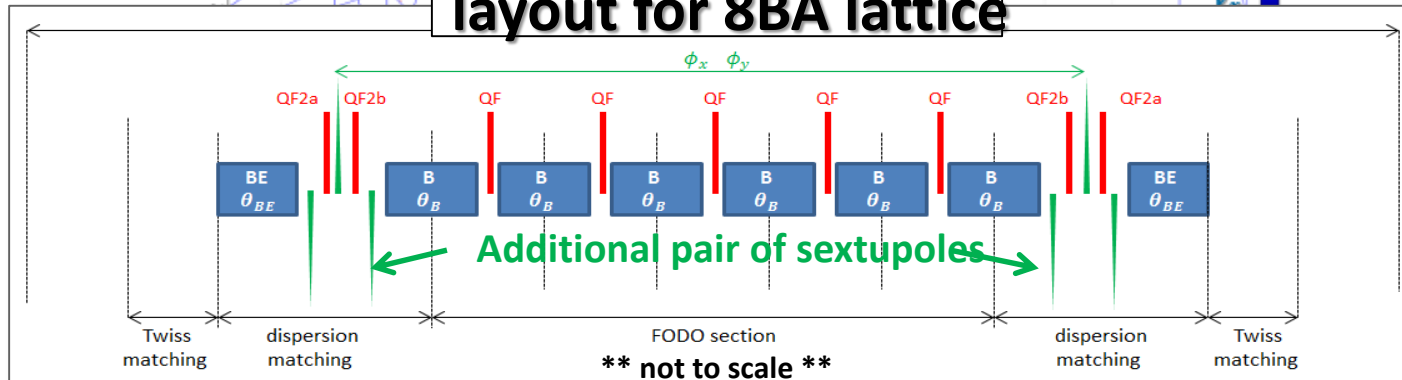


ALS-U lattice design (M. Venturini)

8BA DA is superior to 9BA's in spite of larger chromaticities



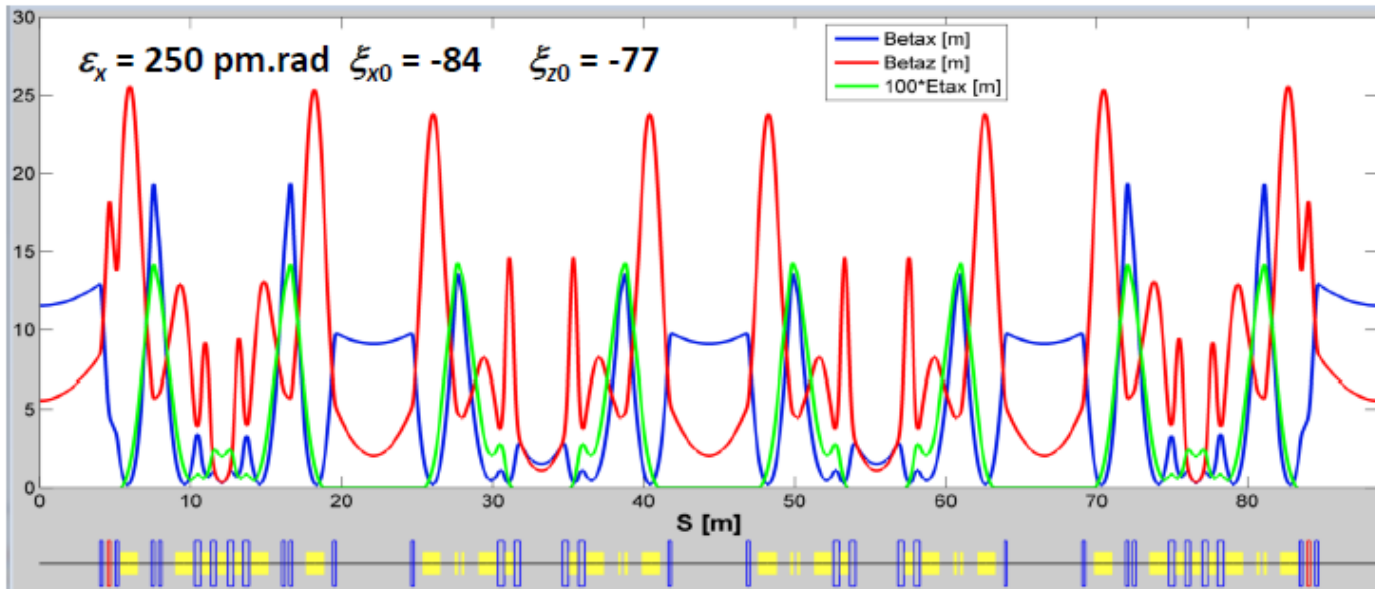
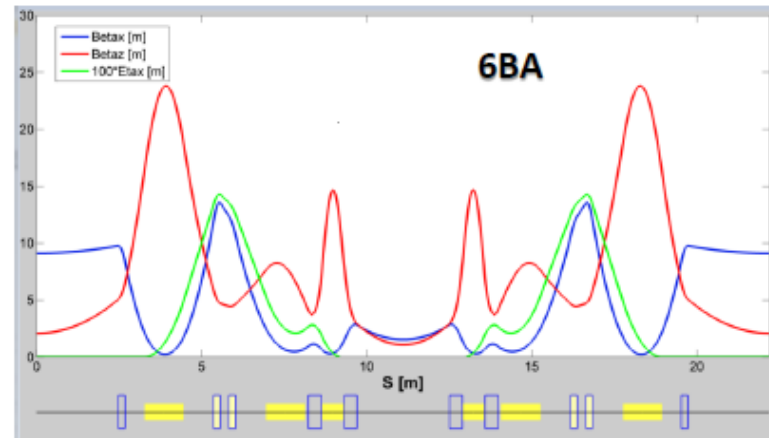
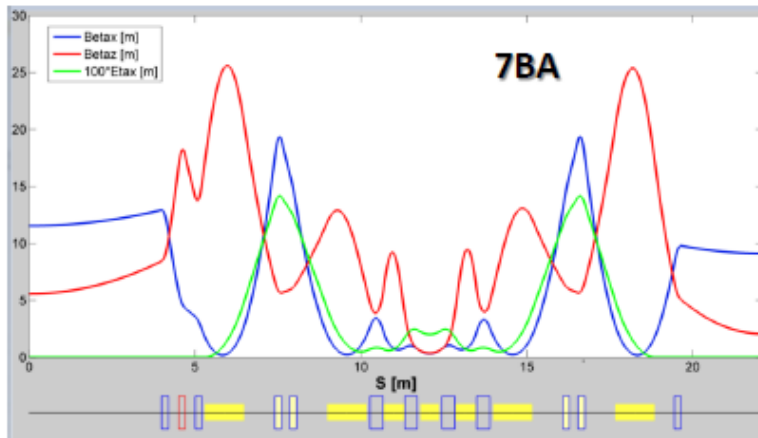
layout for 8BA lattice



SOLEIL plan (A. Nadji)



Lattice based on 7BA (à la ESRF) and 6BA (à la Diamond)



SOLEIL plan (A. Nadji)



Strategy

The Final requirements should derive from future science goals.

Target date: 2025

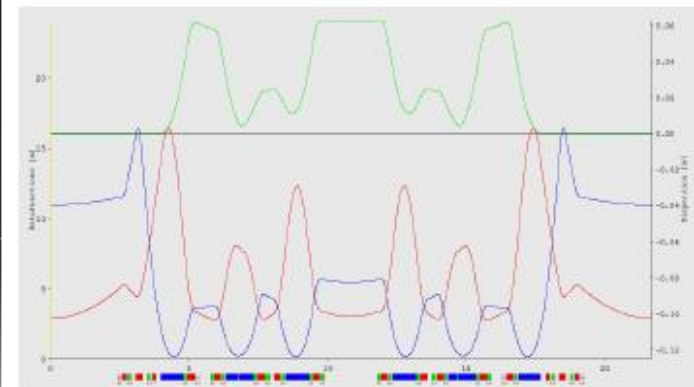
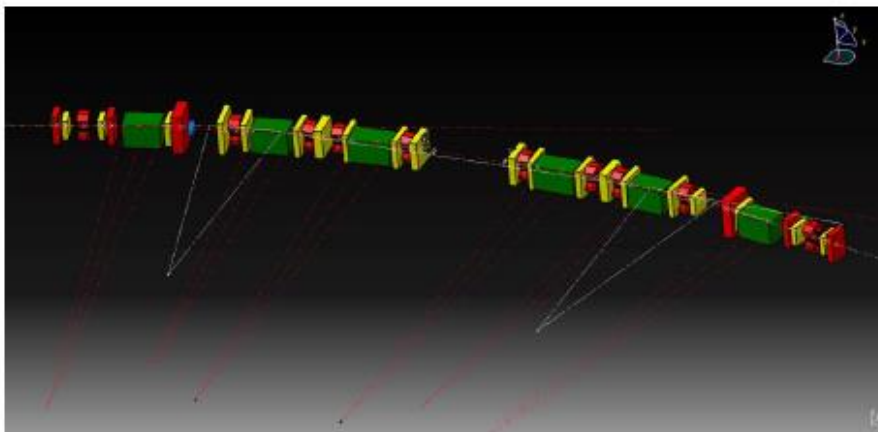
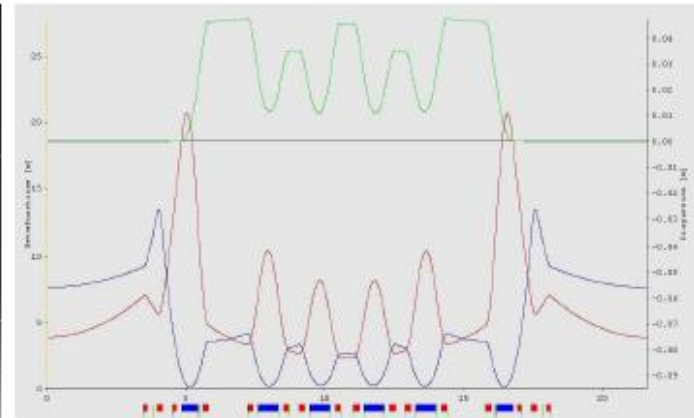
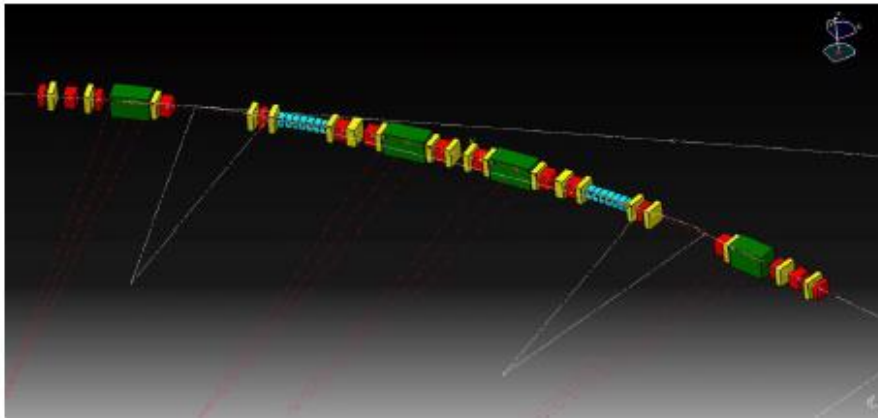
First directions:

- Higher brilliance and coherence fraction.
- Short « intense » pulses.

ELETTRA 2.0 plan (E. Karantzoulis)



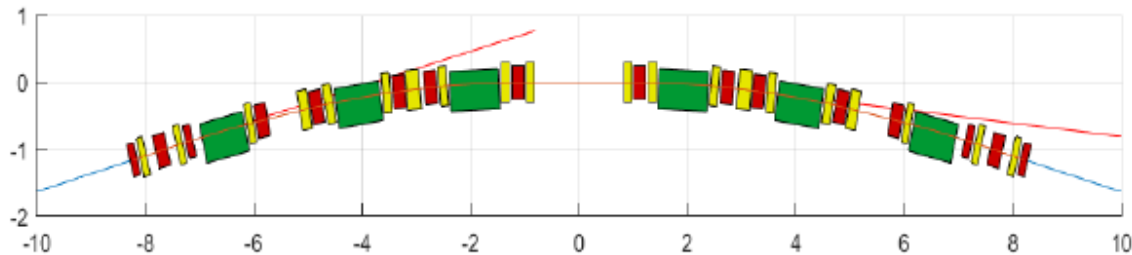
2 principal configurations



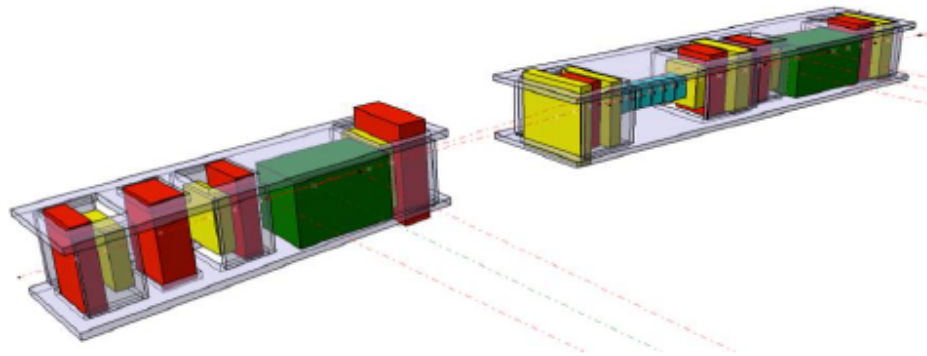
ELETTRA 2.0 plan (E. Karantzoulis)



Physical interference control



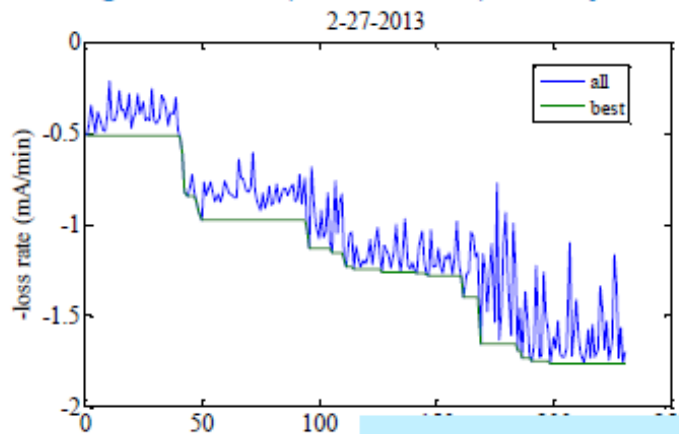
Old concrete support bases will not be reused, new girders will be constructed, propose 3D because magnets are thin.



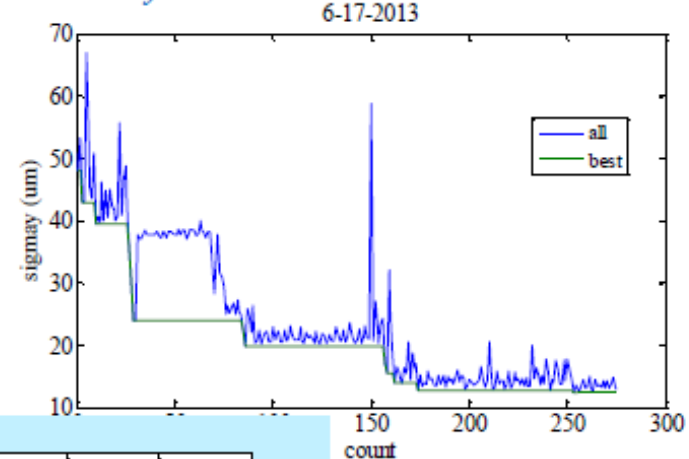
Online dynamics optimisation (X. Huang)

Coupling correction experiments on SPEAR3 with RCDS SLAC

Using loss rate (normalized) as objective

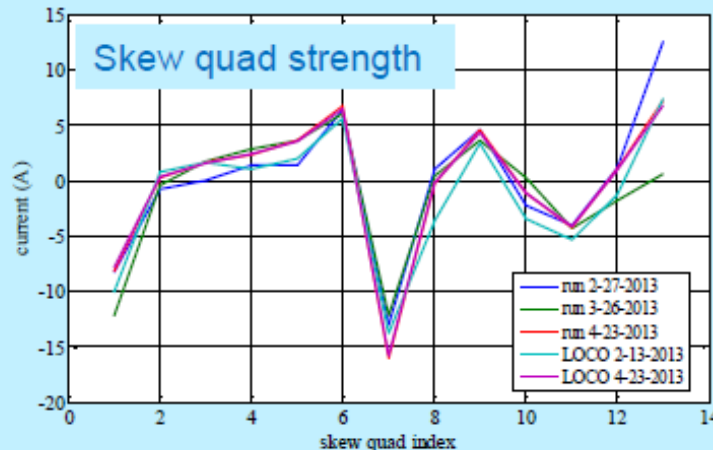


Using σ_y from pinhole camera as objective



Beam loss rate is measured as a function of beam current change (no fitting). Noise signals were taken at 500 mA

Initially all 13 skew quadrupoles were off initially. At 500 mA, the best correction was achieved (5.2 hrs)



Beam size at 0.3 micron. Skew quadrupoles were off initially. The resolution is limited.

Online dynamics optimisation (X. Huang)

Applications of RCDS on real-life problems

SLAC

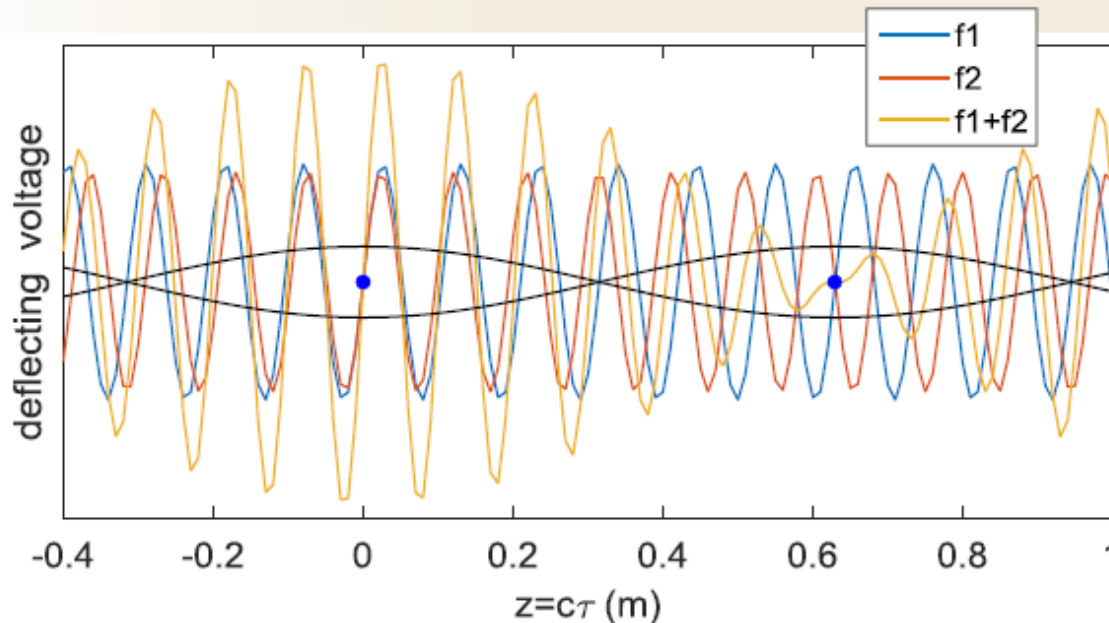
- SPEAR3
 - Kicker bump matching
 - Transport line optics
 - Transport line steering
 - GTL steering and optics
 - Injection efficiency w/ sextupoles X. Huang, J. Safranek, PRSTAB 18, 084001 (2015)
- LCLS
 - Undulator taper optimization J. Wu, K. Fang, X. Huang, 2014-2016
- BEPC-II luminosity optimization
 - Steering and coupling H. Ji, et al, Chinese Physics C 2015 Vol. 39 (12)
 - Interaction point beta
- ESRF S. M. Liuzzo, et al, IPAC'16, THPMR015
 - beam lifetime w/ sextupoles
 - Injection steering

Two frequency crab cavity scheme (X. Huang)

A. Zholents, NIMA 798, 111 (2015)

The two-frequency crab cavity scheme

SLAC



Two frequencies:

$$f_1 = n f_0,$$

$$f_2 = \left(n + \frac{1}{2}\right) f_0$$

Half of the buckets are tilted, the other half are un-affected.

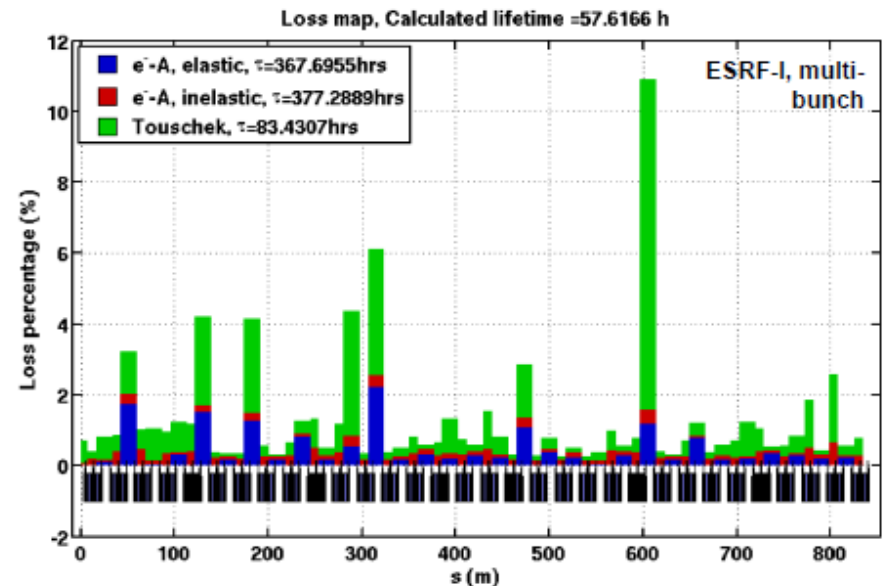
Advantages of the new scheme:

- (1) Short pulses are available all around the ring.
- (2) No strict phase advance requirement for lattices.
- (3) Crab cavities occupy only one straight section (and only one cryostat for SRF)
- (4) Both cavities contribute to tilting (less total deflecting voltage required)
- (5) Beamlines can easily switch between short pulse mode and regular mode.

ESRF-EBS lifetime/losses analysis (R. Versteegen)

V. VACUUM LOSSES AND CONDITIONING

- Vacuum losses will be dominant over Touschek losses during the commissioning and conditioning of the new machine,
- Following a similar method as for Touschek scattering, scattered electrons can be generated and tracked after colliding with residual gas atoms,
- It includes a detailed pressure profile along the ring, as well as a custom gas composition,
- The losses are determined by
 - the vertical angle acceptance for elastic collisions,
 - by the negative side of the momentum acceptance for the inelastic collisions.



HEPS Injection studies (Z. Duan)

Two RF systems 3rd HC – play with amplitude and phase to manipulate RF buckets for **on axis** injection and operation
IBS induced parameter changed at injection (Top-Up)

Longitudinal dynamics of a double-RF system

$$H(\phi, \delta; t) = \frac{h_f \omega_0 \eta}{2} \delta^2 + \frac{e \omega_0}{\pi E_b \beta^2} \left[\sum_{i=1}^{N_f} V_f^i \cos(\phi + \phi_f^i) + \frac{h_f}{h_h} \sum_{j=1}^{N_h} V_h^j \cos\left(\frac{h_h}{h_f} * \phi + \phi_h^j\right) + \phi \frac{U_0}{e} \right]$$

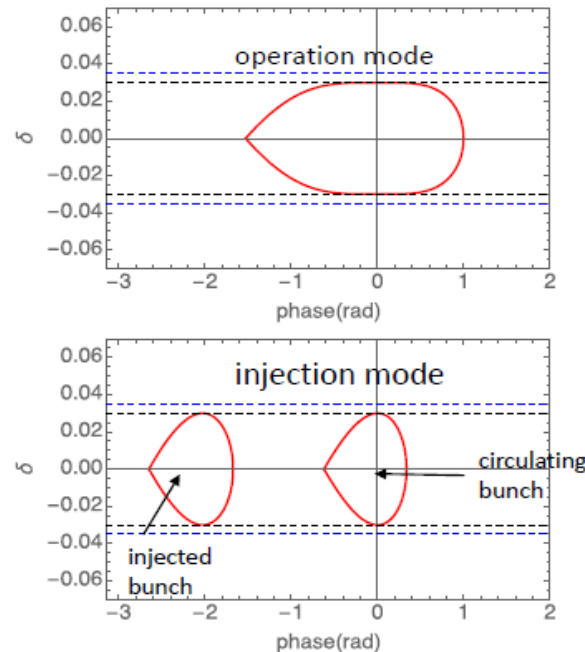
- Fundamental RF system: 166.6MHz, Nf=4
- 3rd harmonic RF system: 499.8MHz, Nh=2
- Same settings for cavities with the same frequency

$$V_f = 4V_f^i, \phi_f = \phi_f^i, V_h = 2V_h^i, \phi_h = \phi_h^i$$

- 4 free variables (V_f, ϕ_f, V_h, ϕ_h)
- One constraint to fix longitudinal phase of circulating beam relative to the cavities

$$V_f \sin \phi_f + V_h \sin \phi_h = U_0$$

- Longitudinal dynamics can be solved to achieve required RF acceptance, in particular, evolution between operation and injection modes.



Semi-analytical approach to nonlinear dynamics (L. Hua Yu)

Write one turn map of Taylor expansion as square matrix

Simplest example of nonlinear map :

$$\begin{aligned}x &= x_0 \cos \mu + p_0 \sin \mu + \epsilon x_0^2 \sin \mu \\p &= -x_0 \sin \mu + p_0 \cos \mu + \epsilon x_0^2 \cos \mu\end{aligned}$$

Use $z = x - ip$ and $z^* = x + ip$

$$\begin{aligned}z &= e^{i\mu} z_0 - \frac{i}{4} \epsilon e^{i\mu} z_0^2 - \frac{i}{2} \epsilon e^{i\mu} z_0 z_0^* - \frac{i}{4} \epsilon e^{i\mu} z_0^{*2} \\z^* &= e^{-i\mu} z_0^* + \frac{i}{4} \epsilon e^{-i\mu} z_0^2 + \frac{i}{2} \epsilon e^{-i\mu} z_0 z_0^* + \frac{i}{4} \epsilon e^{-i\mu} z_0^{*2} \\z^2 &= e^{2i\mu} z_0^2 - \frac{i}{2} \epsilon e^{2i\mu} z_0^3 - i \epsilon e^{2i\mu} z_0^2 z_0^* - \frac{i}{2} \epsilon e^{2i\mu} z_0 z_0^{*2} \\zz^* &= z_0 z_0^* + \frac{i}{4} \epsilon z_0^3 + \frac{i}{4} \epsilon z_0^2 z_0^* - \frac{i}{4} \epsilon z_0 z_0^{*2} - \frac{i}{4} \epsilon z_0^{*3} \\z^{*2} &= e^{-2i\mu} z_0^{*2} + \frac{i\epsilon}{2} e^{-2i\mu} z_0^2 z_0^* + i \epsilon e^{-2i\mu} z_0 z_0^{*2} + \frac{i\epsilon}{2} e^{-2i\mu} z_0^{*3} \\z^3 &= e^{3i\mu} z_0^3 \\&\dots \\z^{*3} &= e^{-3i\mu} z_0^{*3}\end{aligned}$$

$$\tilde{Z} = (1, z, z^*, z^2, zz^*, z^{*2}, z^3, z^2 z^*, zz^{*2}, z^{*3}), \longrightarrow Z = MZ_0,$$

Fast computation of nonlinear dynamic quantities (detuning, action variations, ...)

Conclusions

Many excellent talks (cannot fit in this short summary)

MAX IV well in its commissioning, SIRIUS and ESRF-EBS being built

Many projects in design phase. Slowly but steadily gaining approval

APS-U CD1 February 16

ALS-U CD0 September 16

Optimisation !

from lattice design to operation

LERD topical workshop in Lund 1-2 December

<https://indico.maxiv.lu.se/event/193/>

Topical workshop on lattice design

Lund 1-2 December 2016



The screenshot shows a web browser window with the URL <https://indico.maxiv.lu.se/event/193/>. The browser tabs include "Low Emittance Rings worksho...", "indico.cern.ch", "Portal", and "2nd Workshop on Low Emi...". The browser's address bar shows "File Edit View Favourites Tools Help". The browser's search bar shows "Amazon.co.uk - Online S...", "Booking.com", and "TripAdvisor". The browser's navigation bar shows "iCal export More" and "Europe/Stockholm English Login".

2nd Workshop on Low Emittance Ring Lattice Design

1-2 December 2016
Elite Hotel Ideon Lund
Europe/Stockholm timezone

Overview

Scientific Programme

Timetable

Contribution List

Author List

Registration

Registration Form

Participant List

Accommodation

Social events

Site visit

The 2nd Workshop on Low Emittance Ring Lattice Design will be held from 1-2 December 2016, organized jointly by Paul Scherrer Institut and MAX IV Laboratory, hosted by MAX IV. The workshop will focus on the following topics:

- Design Concepts
- Design Tools / Tools for Non-linear Optimization
- Error Sensitivity / Alignment Strategies / Correction Schemes
- Influence of Collective Effects on Designs

The sessions will start with tutorial like educational talks which prepare the floor for short contributions on particular aspects followed by discussions. All participants are invited to propose contributions to the organizing committee. Furthermore, we wish to bring your attention to the [XXIV European Synchrotron Light Source Workshop](#), which is organized in close connection to this workshop.

EuCARD-2 is co-funded by the partners and the European Commission under Capacities 7th Framework Programme, Grant Agreement 312453.

Contact: [Michael Böge](#)

Thank you !