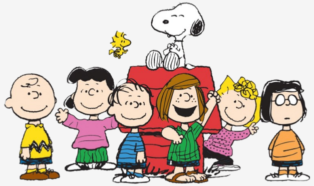
PAUL SCHERRER INSTITUT



Michael Boege for the SLS 2.0 BD Team :: GFA :: Paul Scherrer Institute

Masamitsu Aiba
Felix Armborst (>9/23)
Simona Bettoni
Jan Chrin (<4/24)
Jonas Kallestrup
Volker Schlott
Yacine El-Yamani
Michael Boege

Update Commissioning Plan

SLS 2.0 Machine Advisory Committee Meeting 12.-13.06.23

Commissioning: MAC Comments/Recommendations

Comments:

→ A combined-function H/V corrector is feasible with good frequency response and low cross talk. An example is the 15-cm-long eight-pole fast corrector designed by NSLS-II for APS-U, which delivers sufficient field for a 500 □rad kick at 6 GeV. The frequency response is good up to ~10 kHz, where the phase shift is ~45 degrees. → standalone after observing a strong decapole in sextupoles with H/V corrector in SLS.

→ The BPM offset measurement accuracy seems much better than is claimed by others (e.g. ALS-U, APS-U). Although such accuracy is not in fact needed, performing measurements on SLS would be worthwhile to support the conclusion. → the accuracy of ~1-2 um is "needed", SLS measurements will be shown.

→ It does not appear that an end-to-end simulation of the lattice commissioning process has been completed. This is possible using software toolkits from ALS-U/DESY and APS-U. →end-to-end simulation results using the ALS-U/DESY toolkit will be presented.

→ The commissioning sequence includes at some point setting up of the safe beam dump system. It was unclear when this is needed, e.g. up to what current it is safe to dump the beam without the system. →Beam dump system will be set up in phase 4 before going to high current.

→ No information was presented on the anticipated speed of vacuum conditioning or fill patterns that might be appropriate and feasible in light of the potential for more significant ion issues during vacuum conditioning. → will be addressed (filling pattern 390-90 for ion cleaning).

→ Low- and intermediate-energy rings in particular can experience beam dynamics issues due to insertion devices. Compensation for such effects as gaps change is not always straightforward, particularly in lattices with challenging nonlinear dynamics. → It is planned to correct for all linear effects using feed-forward tables.

Recommendations:

→ Provide an estimate of the time required for each commissioning activity. Map this to a realistic daily and weekly schedule, considering personnel limitations, allowing for vacuum conditioning, and reserving time for modifications or repairs that might be needed.→ will be presented.

→ Reconsider the use of on-axis injection to simplify establishing the first few turns. → will be presented.

→ Use modelling of pressure response to stored current as a function of dose to develop a strategy for vacuum conditioning and set reasonable expectations for how much current will be delivered at the end of the commissioning period. → will be presented.

→ Apply one of the available toolkits for end-to-end lattice commissioning simulation. Use the end results in simulations of nonlinear dynamics to predict expected injection efficiency and lifetime. → will be presented.

→ Establish, based on analysis of the potential for beam damage to vacuum chambers, the maximum current that may be safely stored prior to commissioning of the safe beam dump system. → will be addressed.

→ Consider more carefully the effects of the full suite of planned insertion devices in a lattice with realistic errors and corrections, covering their effects on nonlinear dynamics and correction methods. → will be addressed.

Commissioning Nucleus Team CNT Meeting

> The CNT team defines the commissioning process and coordinates the different tasks during commissioning.
> The number of team members is kept small on purpose in order to ease the decision-making process.
> Schedule: every 6 weeks before and weekly during commissioning

Members of the CNT:

- F. Armborst: Machine Protection and Operations Coordination
- M. Böge: Synchrotron Beam Dynamics, Chair CNT
- M. Brinkmann: Operations
- R. Ganter: Project Representation and Storage-Ring Components
- J. Honegger: Technical Coordination (for machine and beamline aspects)
- J. Raabe: Beamlines and End Stations

Commissioning Phases (Recall from last MAC)

The commissioning can divided into seven phases:

- *Phase 1 – Linac, booster and transfer line commissioning*
- Phase 2 – First-turn in storage ring
- Phase 3 – Second-turn and multi-turn
- Phase 4 – Accumulation, basic feedbacks and linear optics
- Phase 5 – Nominal beam current with advanced settings and feedbacks
- Phase 6 – Insertion device and collimator setup, making first photon beams
- Phase 7 – Finalization

Commissioning Phases and Shifts

Distribution of shifts (5*12h day shifts / week) over the different phases :

- Phase 2 – 1 (+3)
- Phase 3 – 1
- Phase 4 – 8 (+3) → setting up of safe and emergency beam dump
- Phase 5 – 15 (+5) → most critical phase reaching nominal beam current
- Phase 6 – 9
- Phase 7 – 10

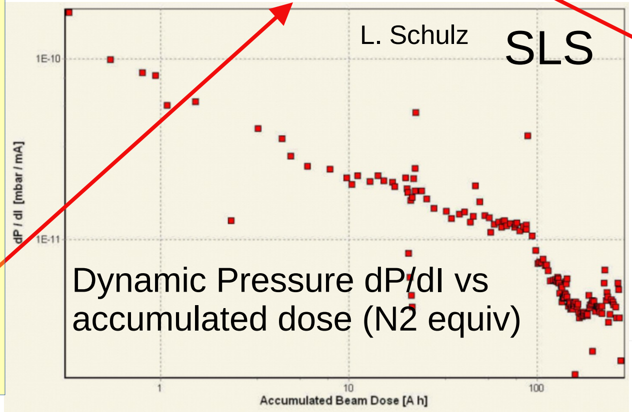
Phase 4: <100 mA dumped slowly with MBFB or fast kicker

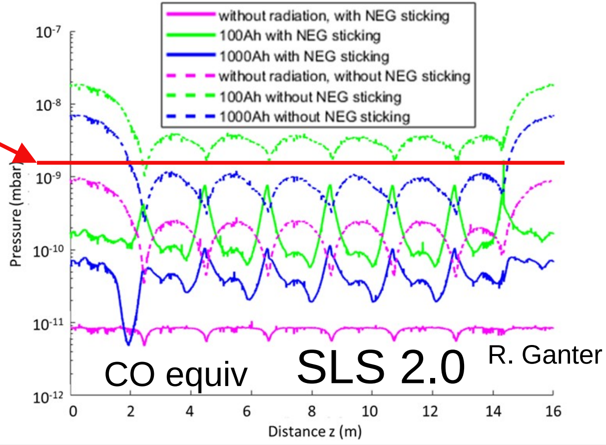
→ In total 44 (+11) shifts corresponding to 11 weeks (~3 months)

→ Assuming 30 night shifts (6 weeks) at 400 mA

→ accumulated 144 Ah

In 2001 the dose of 100 Ah was needed for the vacuum conditioning of SLS (Target: 2 *10e-9 mbar):





Expecting same dP/dI for SLS 2.0 !

Commissioning: Alternative On-Axis Injection

- Kicker-bump + Short pulse kicker (→ Fast kicker or pinger from SLS)
  - realizes an on-axis injection and even accumulation (stored beam, off-axis)
  - if fast kicker is not ready on Day-1 a pinger from SLS to be installed
  - fallback approach to the corrector-based method presented at the last MAC; *static correctors would be more reliable on Day-1*

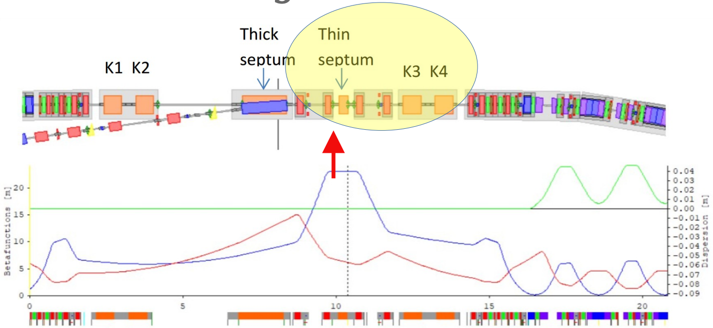
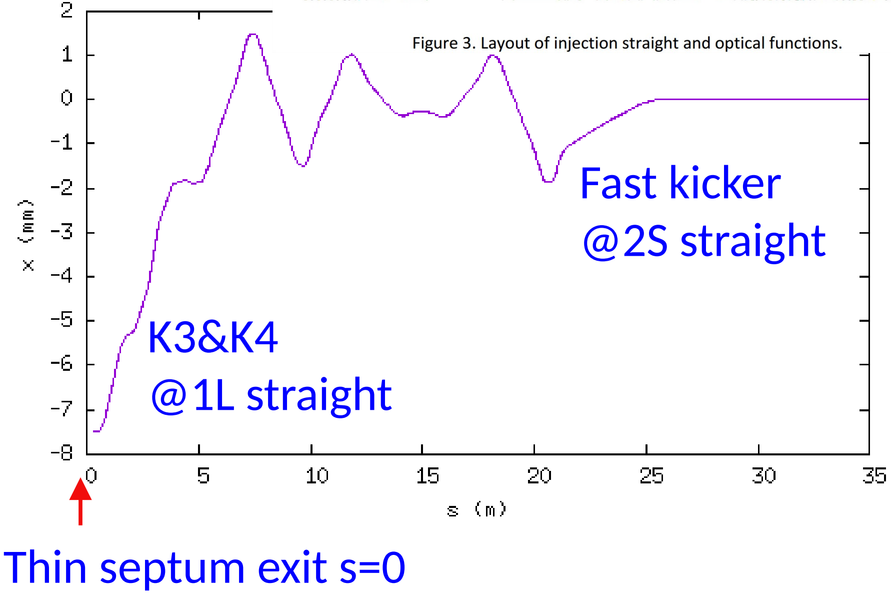
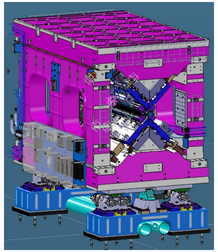


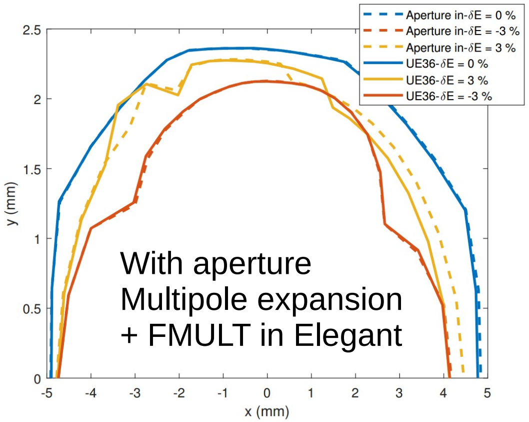
Figure 3. Layout of injection straight and optical functions.



Impact of Ids on the SLS 2.0 Dynamic Aperture

Straights	Undulator	Period [mm]	Length Total [m]	N_{period}	Vacuum gap [mm]	K	B_{peak} [T]
2S	HTSU10	10	2.0	98			
4S	CPMU14	14	2.3	120			
8S	CPMU16	16	3.5	185			
6S/10S/12S	U18	18	3.5	164			
7M	UE44	44	3.5	75			
3M/11M/5Lb1	2×UE36	36	2×2.0	2×53	8.0 ∅	3.65	1.09
5L-b2	U70	70	1.5	21	9.0	4.80	0.73
9L-a2	UE36	36	2.0	53	9.0 ∅	3.65	1.09
9L-b	2×UE90	90	2×2.0	2×20	9.0 ∅	10.0	1.19

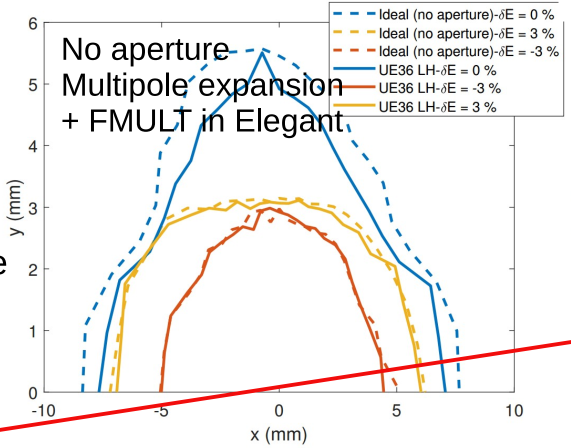


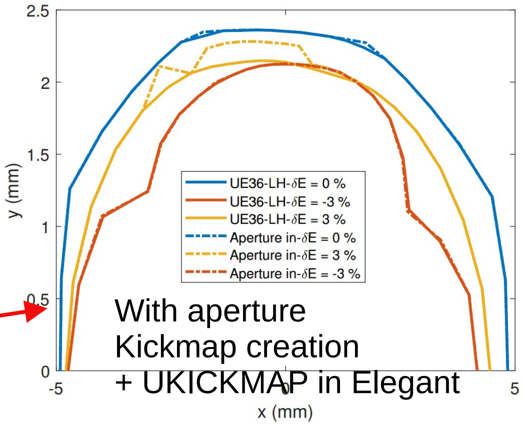


We concentrated on the UE36 APPLE X elliptical undulator in linearly horizontal polarization mode

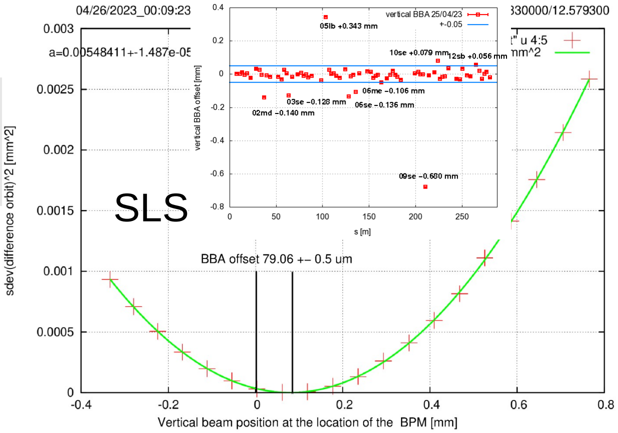
DA calculation performed with Elegant validated by TRACY:
3D field map from Radia → reference trajectory → Multipoles perpendicular to the reference trajectory → linear optics correction → FMULT (5000 turns)

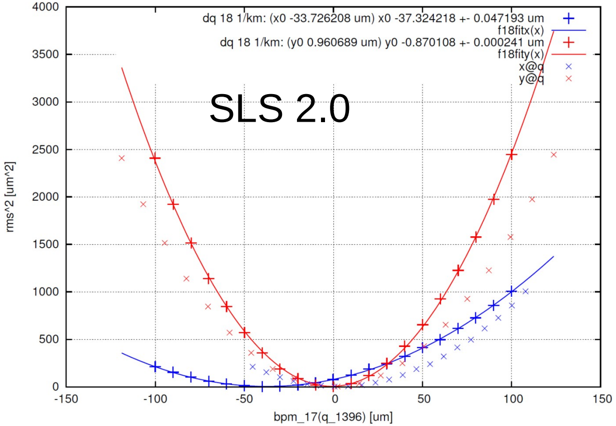
Result: No degradation of DA for the ideal lattice with physical apertures !

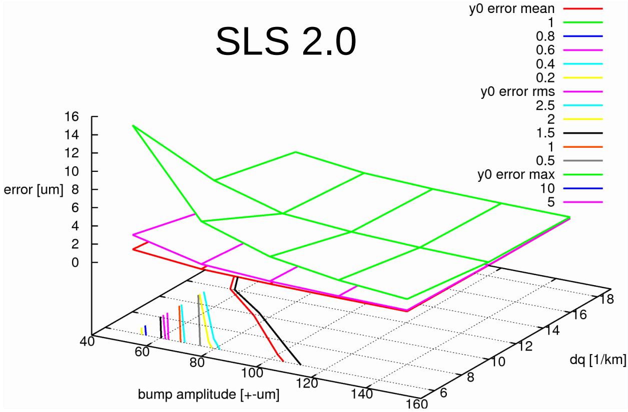




Beam-Based Alignment at SLS and SLS 2.0

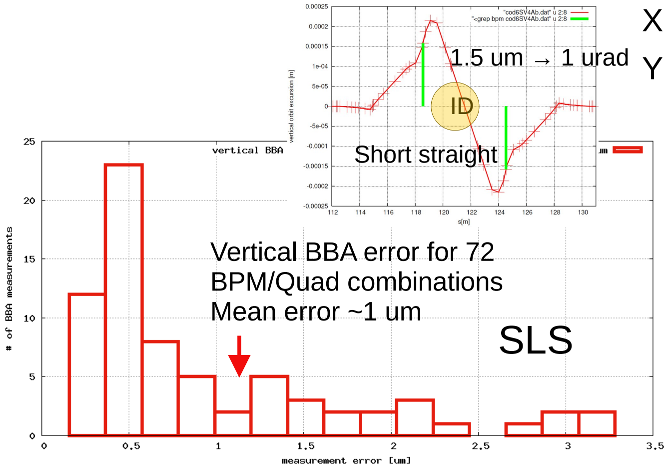






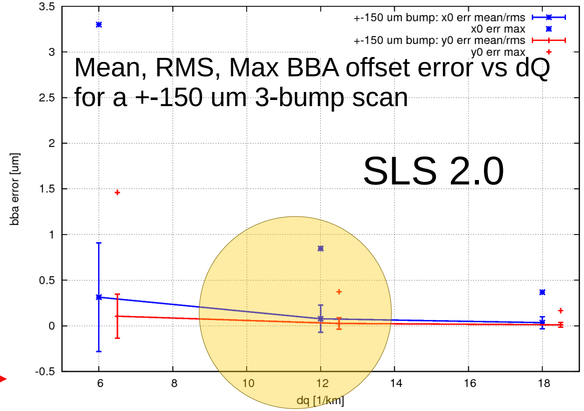
X Red = vertical BPM reading [um]

Y Red = vertical rms difforbit^2 [um]



A mean (max) error of ~1-2 um (~3 um) is needed in order to fulfill the reproducibility requirements of the beamlines @ SLS !

Note: Resolution Not needed for sufficient DA !

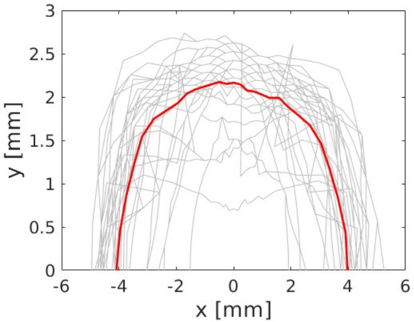


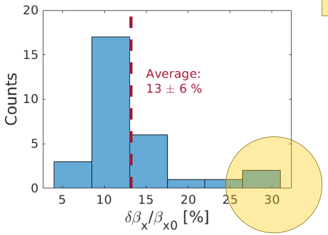
Simulated Commissioning (SC) results for SLS 2.0

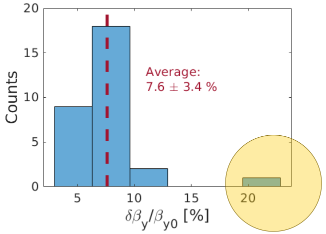
SC Toolkit based on AT https://sc.lbl.gov/ Author: T. Hellert

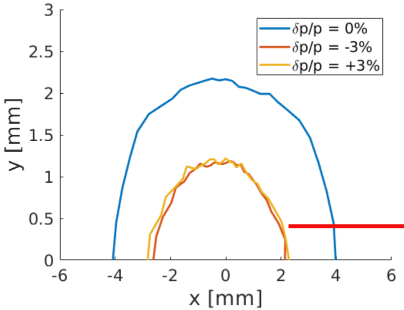
Scenario: 30 seeds (→ all surviving), on-axis injection, booster energy adjustment, threading with sextupoles off, assumed BPM error after BBA 30 um rms (→ full BBA procedure simulated separately), cavity on, RF adjusted, orbit correction (hard correction (no eigenvalue cut) without saturating correctors)

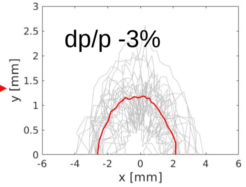
Without Optics Correction



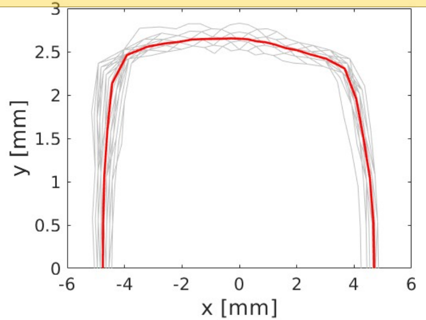


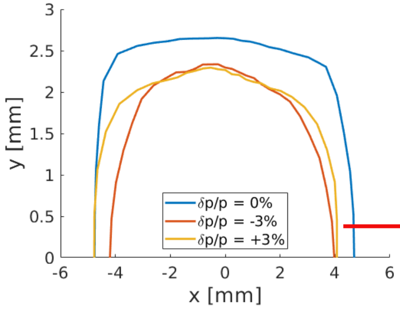


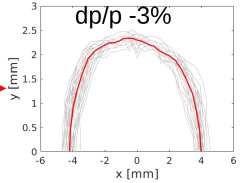




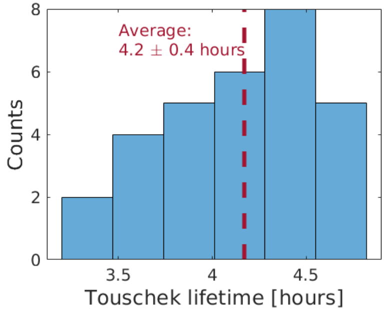
With Optics Correction (→ LOCO)
1.7 ± 0.21 % horizontal, 1.5 ± 0.18 % vertical.







Half lifetime without 3HC



Thank You for Your attention !

Hope we will do as good as ...