PAUL SCHERRER INSTITUT

Felix Armborst & Jonas Kallestrup on behalf of the SLS & SLS 2.0 Teams

SLS Status and SLS 2.0 Upgrade

30th European Synchrotron Light Sources Workshop, Grenoble, December 14th - 15th, 2022

Outline

I. SLS Status

1. Statistics up to 1st of November 2022
2. Outages 2022
3. Crises

courtesy of
Andreas Lüdeke,
Christian Geiselhart,
Markus Jörg,
Lukas Stingelin,
Lorenz Moser

II. SLS 2.0

1. Synchrotron Radiation at PSI
2. SLS 2.0 Milestones
3. Machine Highlights
4. Brightness and IDs

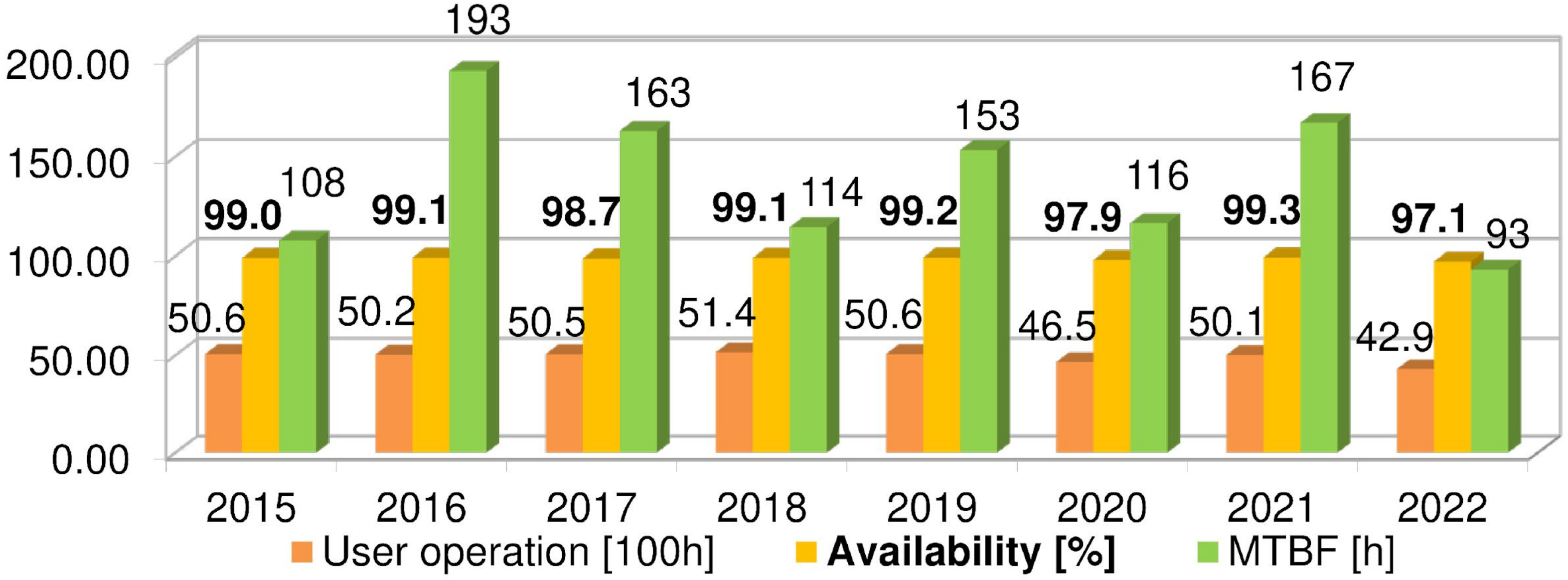
courtesy of
Masamitsu Aiba,
Martin Paraliev,
Thomas Schmidt,
Lukas Stingelin

PAUL SCHERRER INSTITUT

SLS Operation Statistics 2022

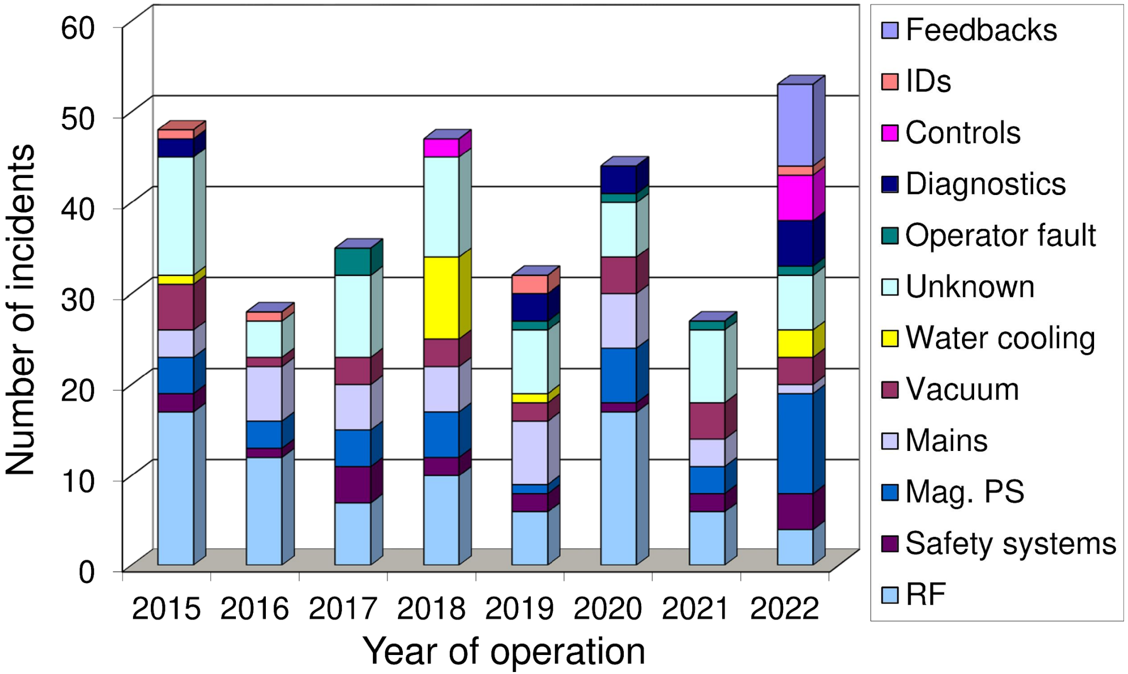
The year 2022 was troublesome (up to 1. Nov. 2022 = 85% of planned operation)

- Beam availability 97.1% so far
- More and longer outages



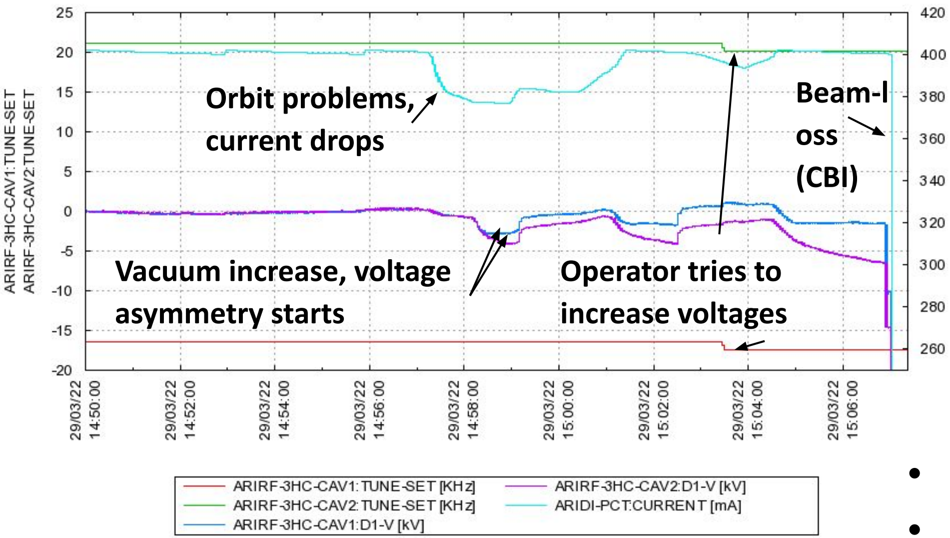
SLS Operation Statistics 2022

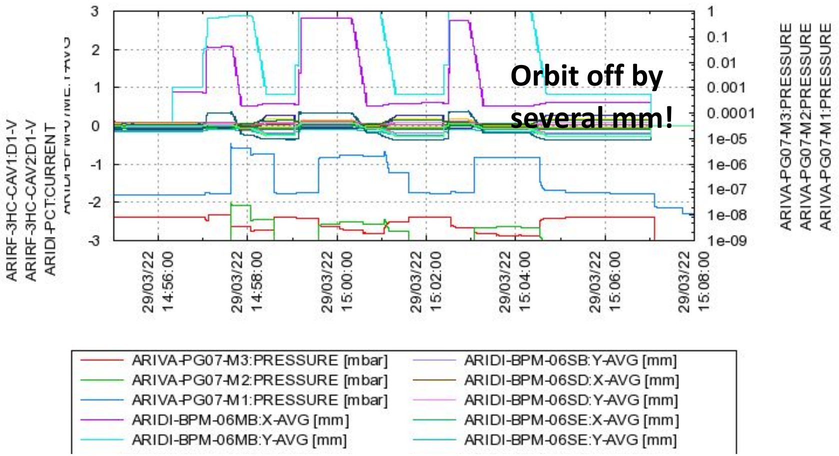
- Many outages due to system upgrades, partly related to the SLS 2.0 project
  - ➢ Upgrades require in-situ testing (vxWorks, EPICS, BPM electronics, …)
  - ➢ Reduced maintenance due to experts working on new systems

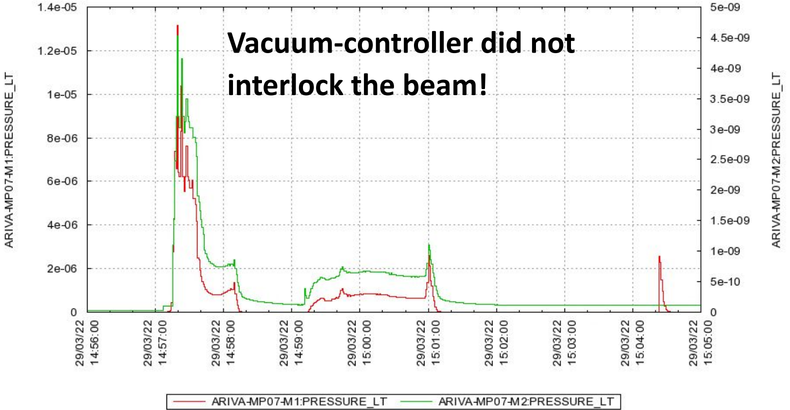


- ○ Feedbacks: BPMs, FPFB/Timing & ⬇️
- ○ Controls: updates (vxWorks, EPICs, …)
- ○ Mag. PS: Ventilators, Controllers & ⬆️

Super-3HC: March 2022 Incident







- MD shift with experimental orbit bumps
- BPM system failure → large orbit excursion
- 1E-5 mbar! vacuum at absorbers before and after Super-3HC
- Asymmetry is permanent
  - ➢ Always observed during accumulation with drifts over 10s of minutes until new equilibrium reached

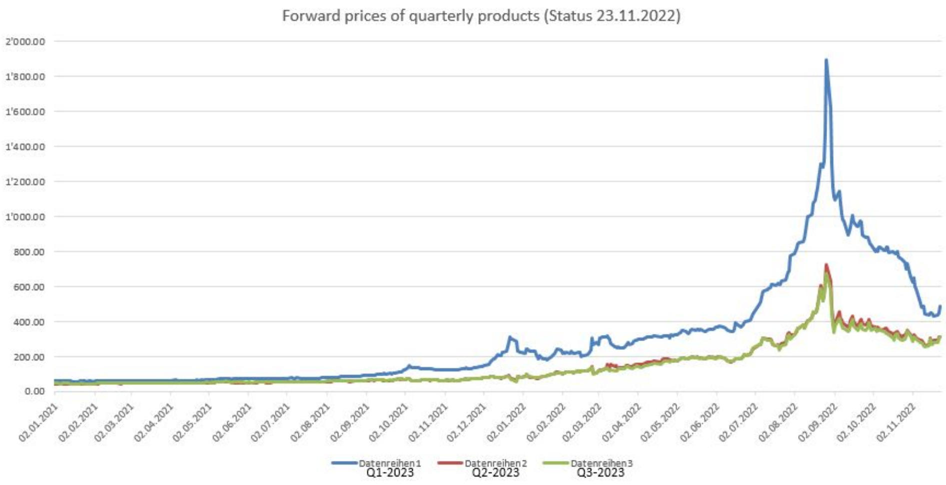
COVID

BAU 04.04.2022
LO I 01.07.2021
LO II+ 20.04.2021
LO II 11.05.2020
LO III 16.03.2020

Situation acc. to Epidemic Act	Situation/ Scenario PSI	Description	Empl. on campus (Ø PSI)	Management
Normal Situation	**Business as usual**	The operation of PSI runs without significant or general restrictions.	«100%»	Usual management rhythm Directorate - Divisions
Special Situation	**Limited Operations I**	• Business trips and visits (to and from certain countries) are being restricted • Ordered home office as well as precautionary home office and officially ordered quarantine and isolation for returnees and affected persons	up to 100% (effectiv. 70% to 100%)	At the beginning of the pandemic, the divisions still have a large degree of autonomy within the general guidelines of the Pandemic Team on behalf of the Director. As the situation escalates, more and more competences are transferred to the Pandemic Team. Once the situation has calmed down, the pandemic team prepares the transition to normality by gradually loosening measures.
Special Situation / Extraordinary Situation	**Limited Operations II**	• Business trips and visits are limited to what is necessary and largely replaced by telephone and video conferencing solutions • General guidelines for action, in particular – split offices und split teams, limited number of people per room – home office for personnel not urgently needed on site – wherever possible, meetings are moved to the web, with a focus on collaboration tools • Definition of «vital services» operated on behalf of the Pandemic Team	40% to max. 50% **60%**	
	Limited Operations III	LLO II plus further restrictions in operation: business trips and visits are suspended, extensive home office, certain operating units are being closed.	15% to 20%	
Extraordinary Situation	**Sleep Mode**	Corresponds largely to the operation over the festive season, but for a longer period. Only explicitly defined units are still in operation. As in LO III, it must be ensured that no damage is caused to equipment and facilities (monitoring and minimal maintenance of the infrastructure).	max. 5%	
	Lockdown	PSI is closed and secured. The whole communication is digital.	SIZ plus maintenance	

Energy Crisis

Somewhat fortunate situation at PSI for 2023 / 2024 thanks to energy **hedging** policy



Year	Purchased Energy	Price exkl. grid cost	Coverage ratio according to forecast from Q1-22
2023	131'697 MWh	75.89 CHF/MWh	103 %
2024	116'504 MWh	92.36 CHF/MWh	104 %
2025	85'541 MWh	83.80 CHF/MWh	70 %
2026	35'040 MWh	91.55 CHF/MWh	ca. 25 %

120 kW emergency diesel generator to avoid helium loss and long downtime of proton therapy facility after **black out**

PAUL SCHERRER INSTITUT

Energy Saving Measures

SLS (670 MWh + 4500 MWh from Darktime)

- ➢ Jan. shutdown: + 10 days
- ➢ March shutdown: + 8 days, April shutdown: -3 days
- ➢ Darktime: fixed to start 2. Oct. 2023
- ➢ (SLS 2.0 with 30% reduced power consumption)

SwissFEL (625 MWh)

- ➢ Jan. shutdown: +1 week
- ➢ March shutdown: +1 week, April shutdown: -1 week
- ➢ 3 weeks with reduced RF rate or turned off Linac 3

HIPA (4650 MWh + 900 MWh)

- ➢ Shutdown extended +2.5 week
- ➢ Possible reduction of beam current: 1.8 mA ⇒ 1.6 mA

Non-accelerator facilities (2750 MWh)

➔ ~14 GWh saved 2023

➔ Critical Q1 defused by shifting shutdowns thus reducing energy costs

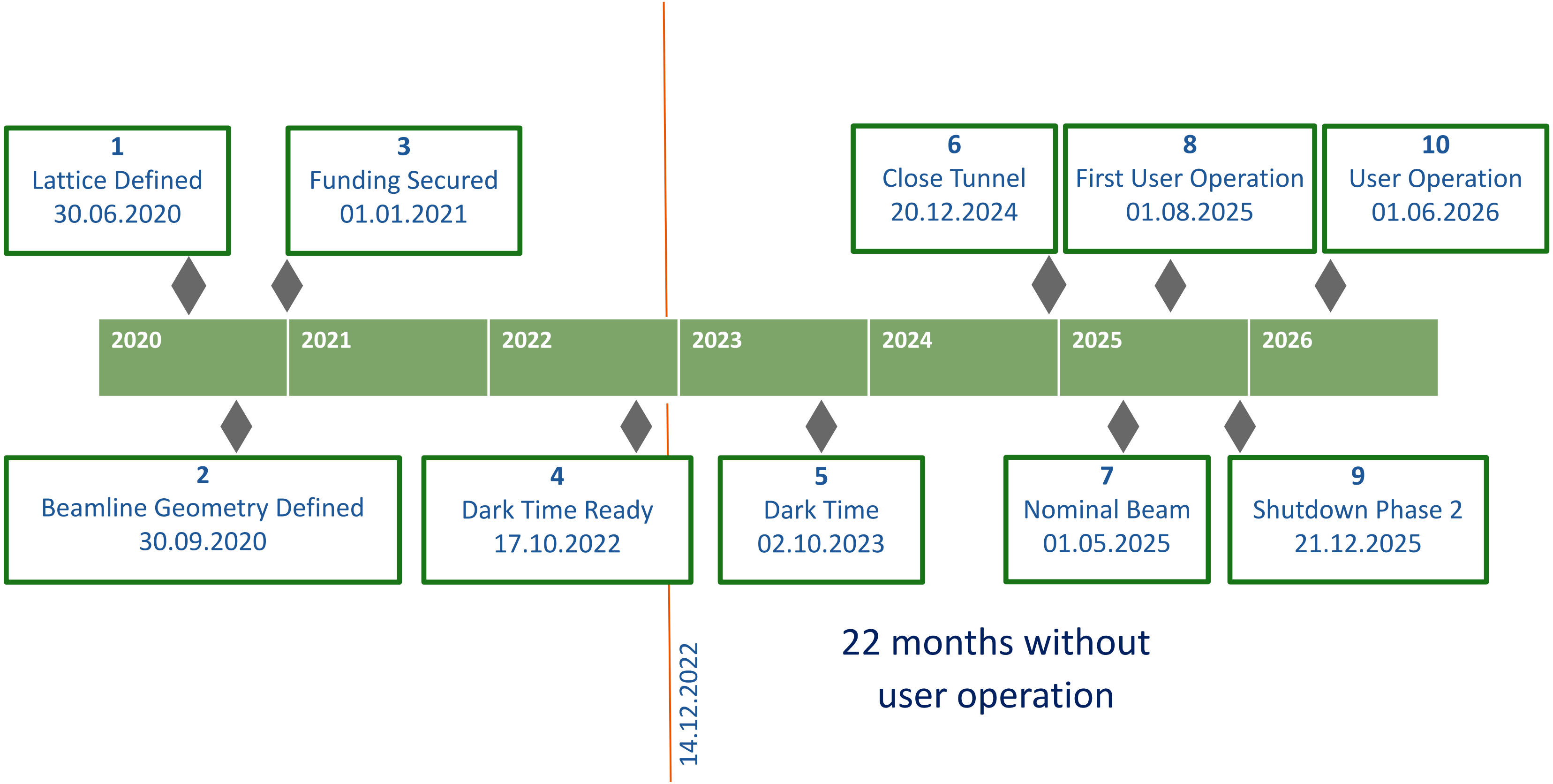
Helium Shortage 4.0

- Only 14 plants in total
- 2-3 plants provide 80% of supply
- Multiple supply disruptions
  - Gas leaks, fires and explosions
  - Sanctions against Russia

PSI situation

- Currently no Helium available on the market
- All storage tanks are filled as of now
- In spring 2022 additional bundles of bottles were purchased with foresight
- Helium reserve at PSI will last until early summer 2023
- Situation for other large customers more critical
- PSI no longer supplies its own helium to third parties
- Service for liquefaction is kept up
- Prioritisation / allocation are also being considered at PSI

SLS 2.0 - Milestones

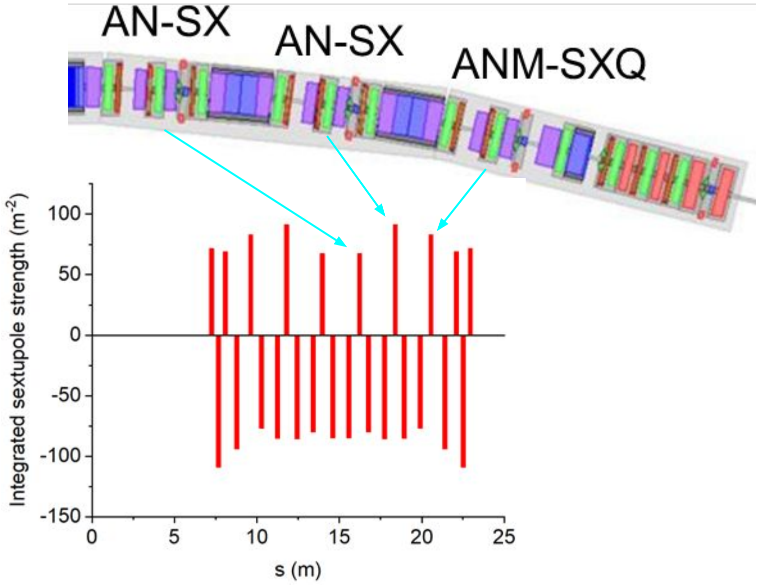


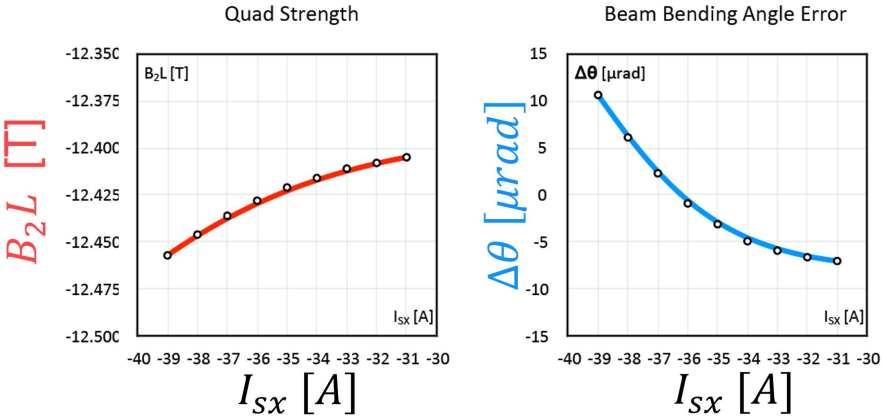
Magnet Cross-talk

- Dense lattice
  - ➢ Cross-talk between neighbouring magnets
  - ➢ Performance evaluated for magnet groups
- **Static effects**

  Due to existence of neighboring magnets
- **Dynamic effects**

  Due to excitation of neighboring magnets
- **Correction f**
  - ➢ Targets
    - Beam path (x,x')
    - Linear optics
    - Nonlinear optics
  - ➢ Knobs
    - Transverse- and longitudinal positions
    - Gradients





SLS 2.0 Magnet Cross-talk: Consequences

↯ AN (off-axis, PM quad = anti-bend) <> CH + CV: asymmetric excitation of correctors

✔ Switch ordering of correctors (AN <> CV + CH), add magnetic shielding, shortening of sextupole by 10 mm

↯ OC magnet (octupole, norm. quad, skew quad) had internal cross talk. Skew quad and norm. quad magnetic centres dependent on octupole excitation…

✔ heat treatment to homogenize the magnetic material properties.

↯ quad gradient issue in OC <> AN combination (~30 mm iron-to-iron separation).
AN: 83.9 T/m ⟶ 79.7 T/m. OC: 5.6 T/m ⟶ 8.8 T/m

✔ increased separation (sextupole shortened by 10 mm) + OC yoke thickness (30 ⟶ 72.7 mm)

Permanent Magnet Thick Septum

- Thick septum to be permanent magnet based
  - ➢ no <u>dynamic</u> leakage field
  - ➢ compact
  - ➢ shot-to-shot stability

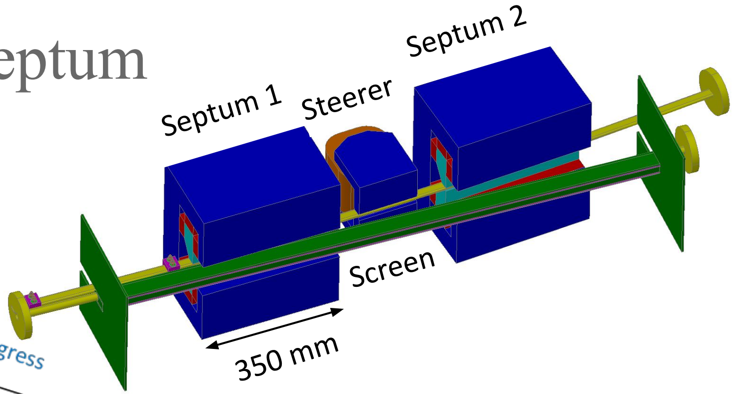
Two permanent magnet blocks

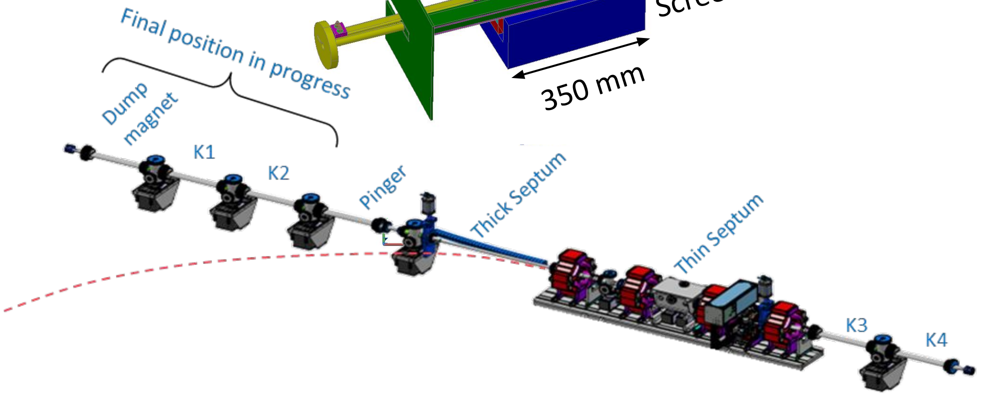
- PM type: SmCo (Br = 0.95 T)
- Main field: 1.6 T
- Length: 350 mm
- Leakage field int.: 78 µTm (0.16 ppt)
  (Earth field 50 µT, 350 mm = 17.5 µTm)
- Gap: 10 mm

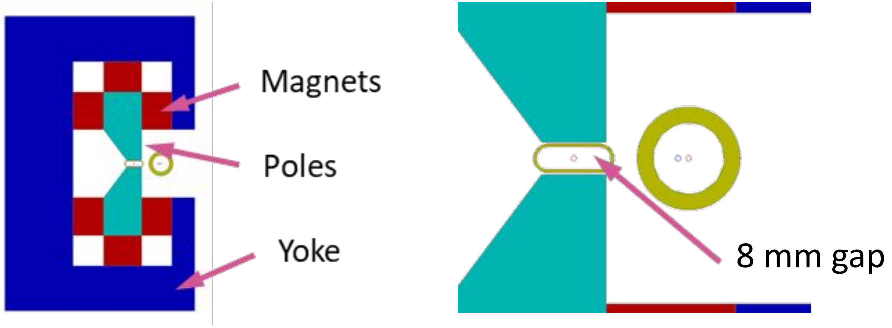
Preliminary

DC electromagnet steerer

- Length: 150 mm
- Field: ±3% of main field
  ⇒ max: ± 0.23 T (± 5 A, 6.5 W)
- Gap: 10 mm

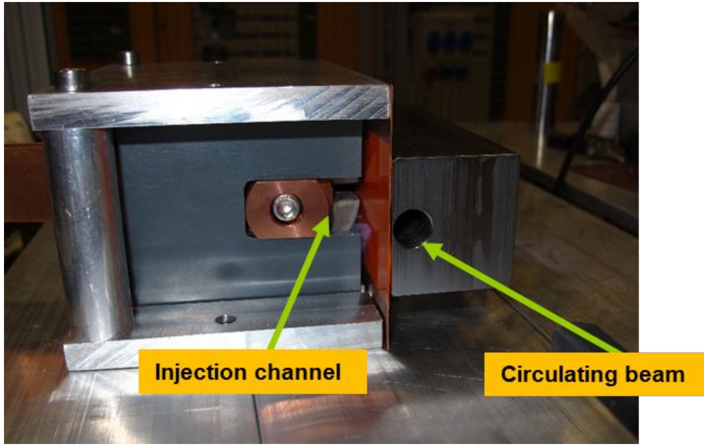


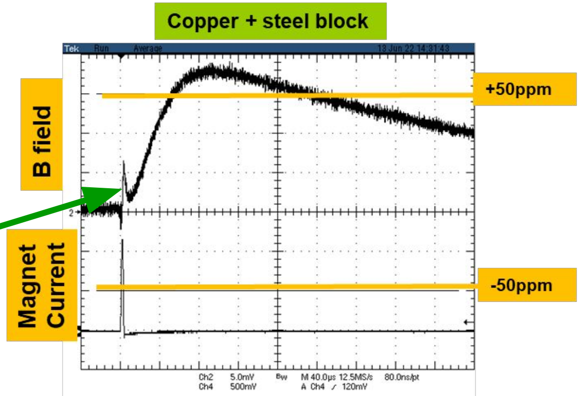




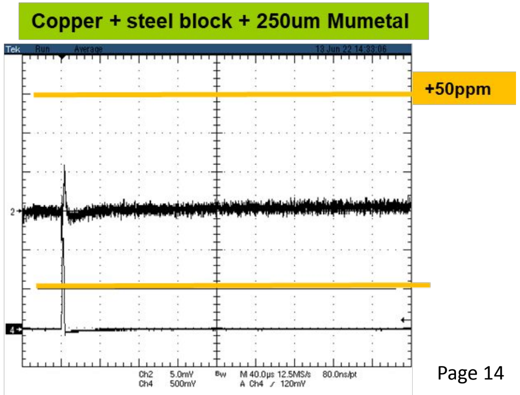
Leakage Field of Thin Septum Pre-prototype

- In-vacuum thin eddy current septum
  - 300 mm length
  - ~ 1 mm blade: .5 copper + .1 mumetal + .4 iron
  - 330 mT ⇒ 11 mrad
- Goal: ≤ 2.37 uTm (17 ppm over ~400 mm) for ≤ 10% emittance dilution
- Pre-prototype, in-air
  - Direct- and leakage field well-suppressed
- Tests made with **half-sine** pulse while real magnet will be **full-sine** ⇒ order of magnitude better suppression of leakage field.



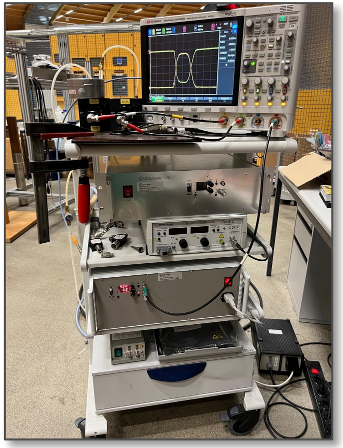


Magnet current ca. 2kA
Horizontal scale 40 us/div
Spike is artifact, not magnetic field



Fast Kicker Pulse Generation

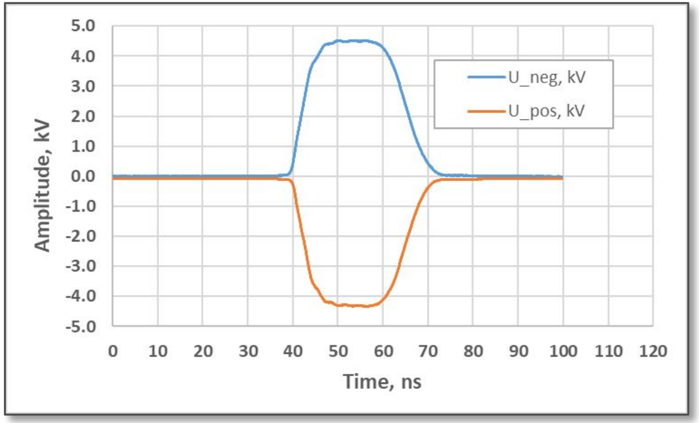
- PSI 5 kV pulse generator prototype based on multi-stage Marx generator
  - ➢ successful and kept as a fallback solution
- FID 5 kV pulse generator based on drift step recovery diodes (DSRD)



FID GmbH 5 kV positive/negative pulse generator

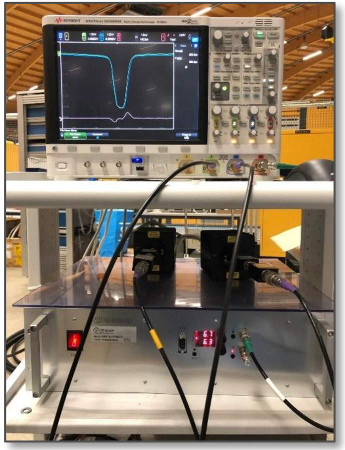
Measurement setup with 20 m cables - for pulse generator protection

Measured output pulse FID



Full pulse length ~30 ns

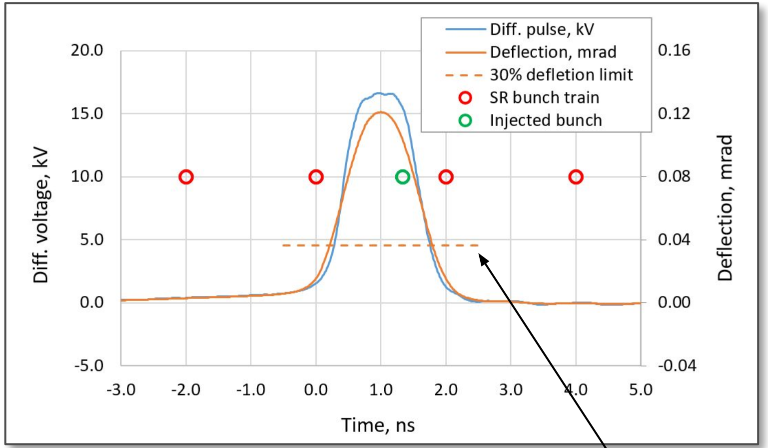
Super-fast Kicker Pulse Generation



FID GmbH 10 kV positive/negative pulse generator

Measurement setup with 20 m cables - for pulse generator protection

Measured differential output pulse of a single stage (1 device) of the FID prototype and estimated deflection

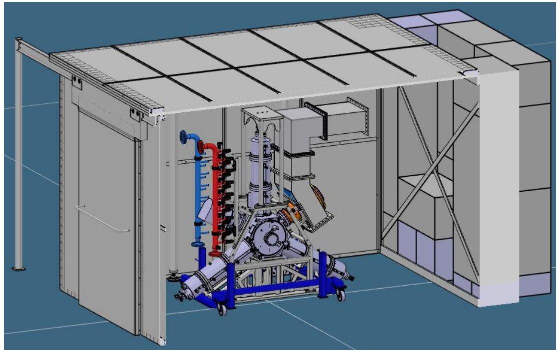


Full pulse length ~2 ns

30% disturbance limit for adjacent bunches

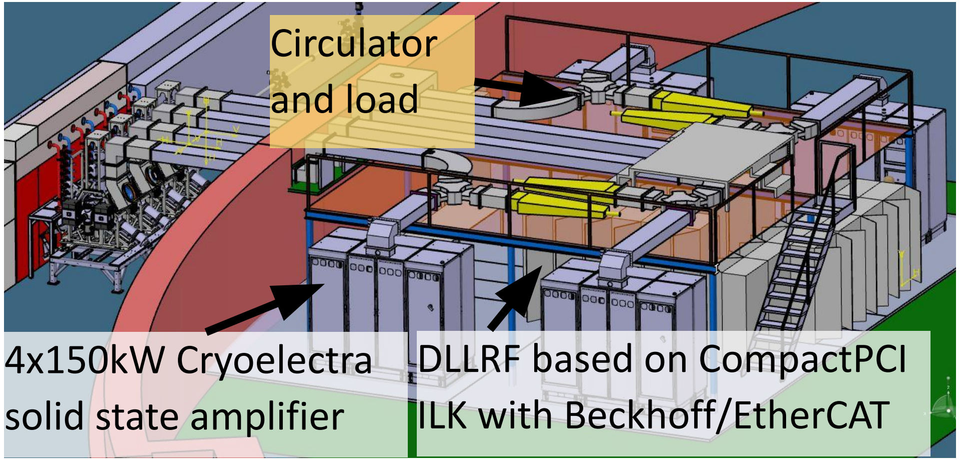
Radio Frequency Systems for SLS 2.0

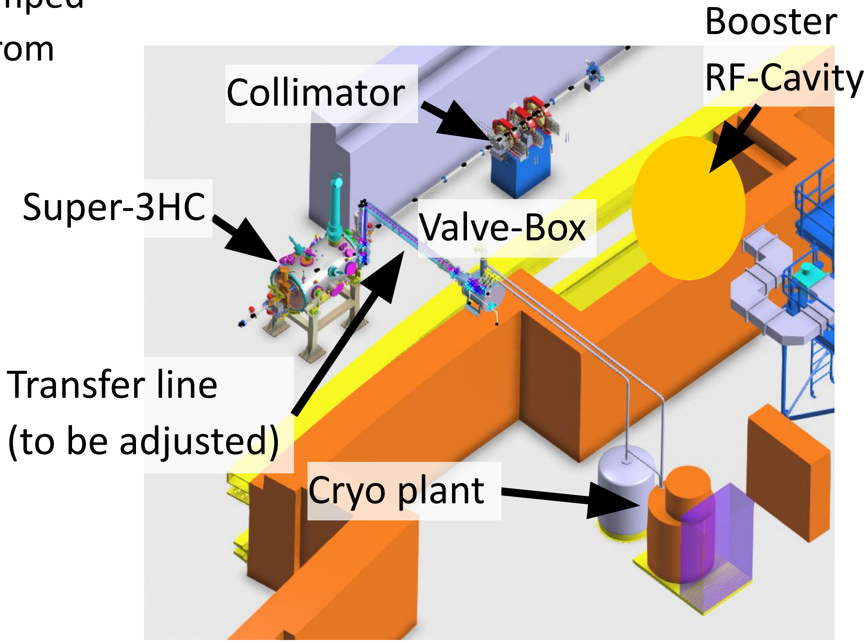
Main RF-System	SLS 2.0	SLS
Total voltage [kV]	1780	2080
Voltage per cavity [kV]	445	520
Wall loss per cavity [kW]	30	40
Required RF-power with beam and maximum ID Power [kW]	**124**	100
Optimal coupling	3.4 … 4.3	2.5



New Teststand with lead-shielding

500MHz HOM-damped cavities ordered from RI (4+1spare)





SLS 2.0 Brilliance

reduced emittance

× 24 (10...20 keV)

+ Higher energy (2.7 GeV)

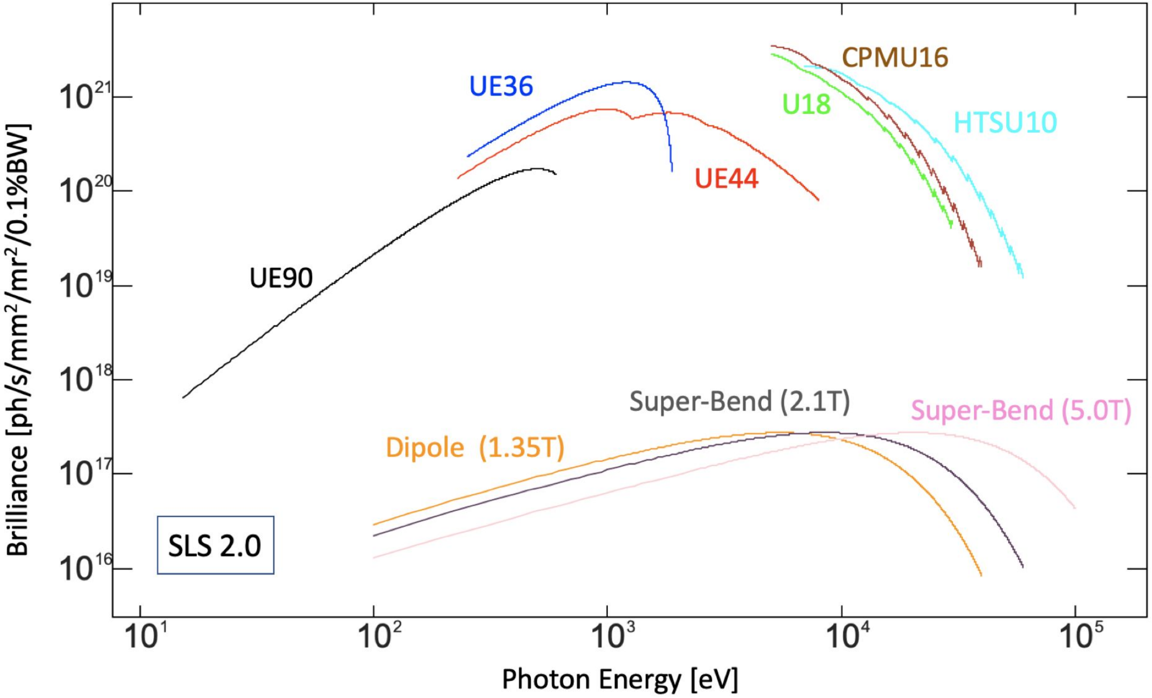
× 59 (10...20 keV)

+ CPMU16

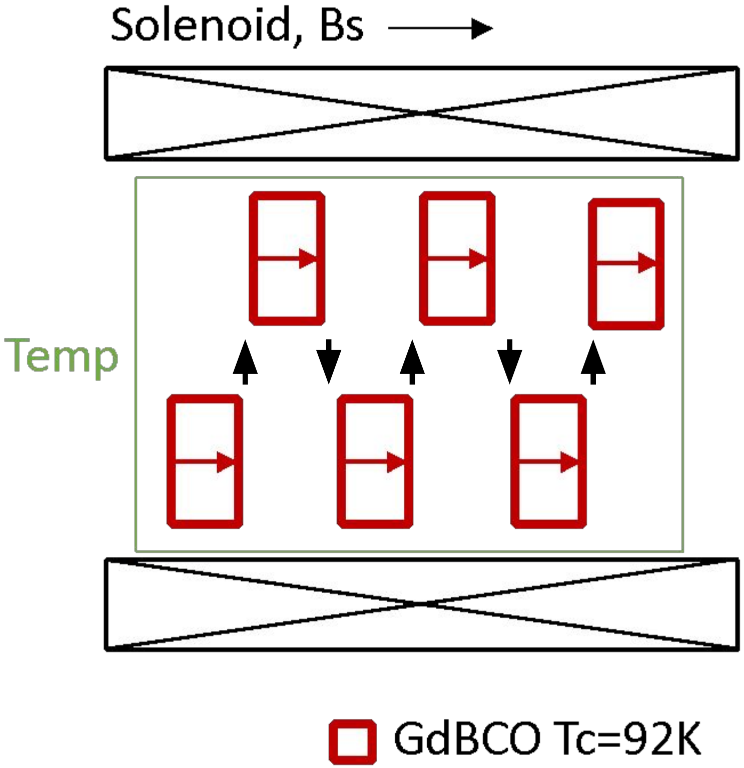
× 140 (10 keV) ... 870 (20 keV)

+ HTSU10

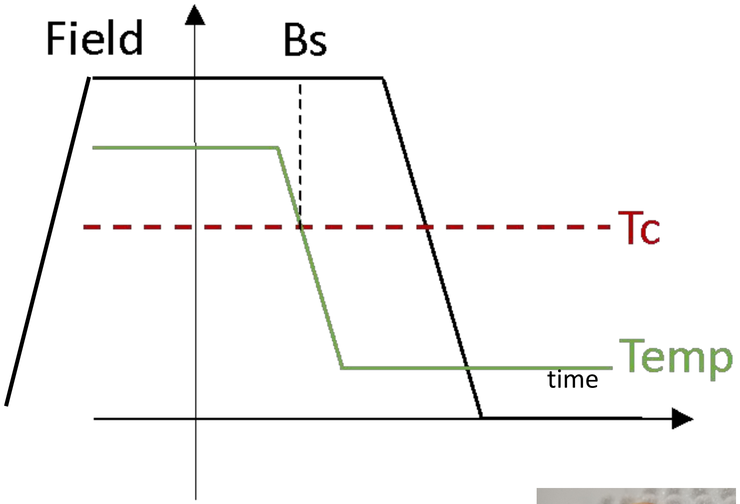
× >1000 above 20 keV

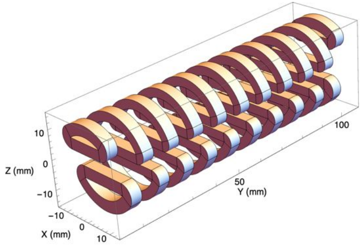


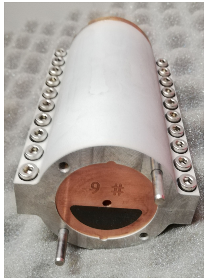
Superconducting Staggered Array Undulator



Example of *field cooling* magnetisation





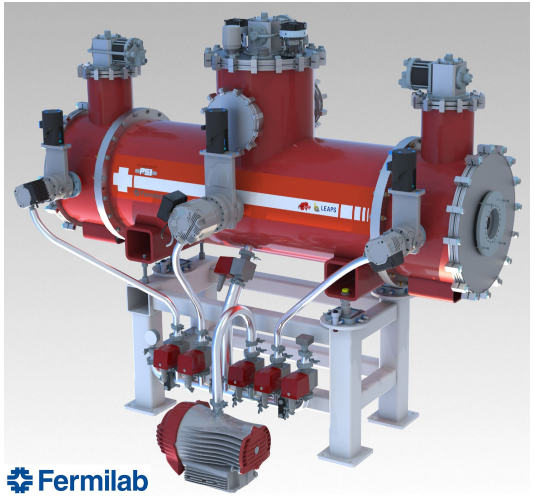


T. Kii et al. AIP Conference Proceedings 1234, 539 (2010)

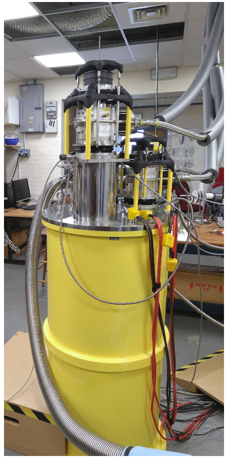
PAUL SCHERRER INSTITUT

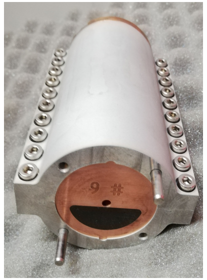
High-temperature Superconducting Undulator HTSU10

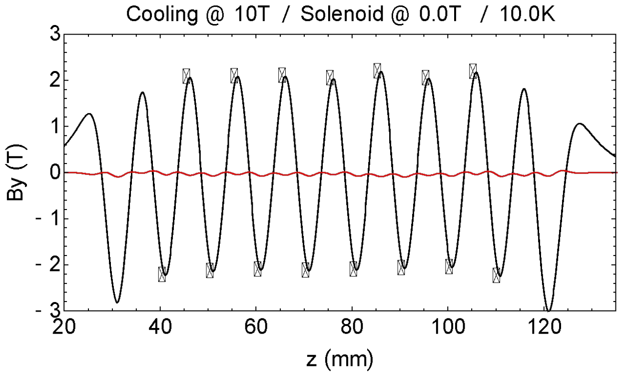
Active length [m]	1.0
Total length [m]	< 2
Period length [mm]	10
Magnetic gap [mm]	4.0
Magnetic Field [T]	2.1
Sc Coil Field [T]	12
K	2
HTS temp [K]	10
LTS temp [K]	4.0

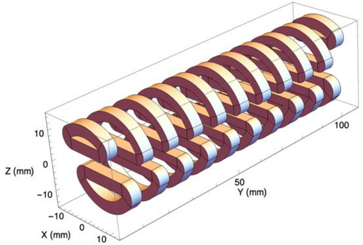


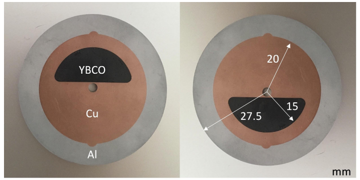
Tests at University of Cambridge



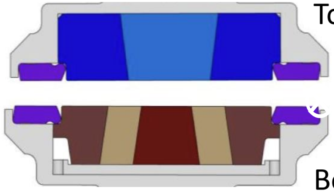








SLS 2.0 Insertion Devices



Top magnet module

Bottom Pole module

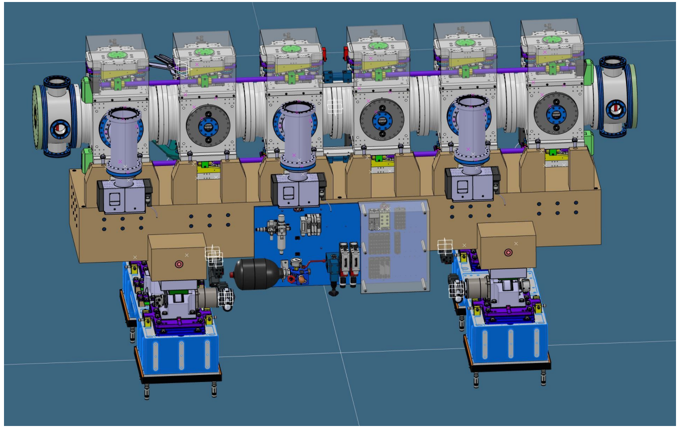
Hard X-ray

Compact, Modular, In-vacuum

3x U17 / CPMU16

hydraulic driven wedges → 4 – 13.5 mm gap

Magnetic force compensation



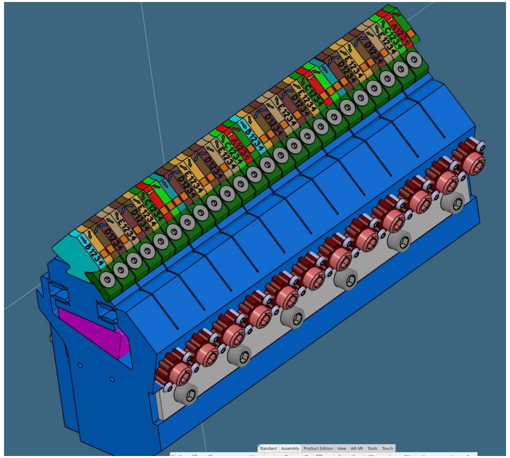
Soft X-ray

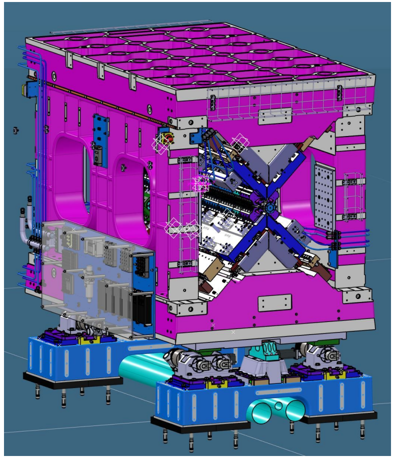
Modified SwissFEL APPLE X undulators

UE36kn / UE90kn

Knot[1)] magnet structures for on-axis heat load reduction, Bx 1.5x period length of By

[1)] S. Sasaki, *et al.*, Proc. PAC'13, pp1043, published in JaCoW Conference Proceedings Webpage (accelconf.web.cern.ch/AccelConf/pac2013).





PAUL SCHERRER INSTITUT

PSI

Thank you for your attention
And thanks to the many colleagues
who provided slides and input
for this presentation

Swiss Light Source

PAUL SCHERRER INSTITUT

SLS 2.0 Information

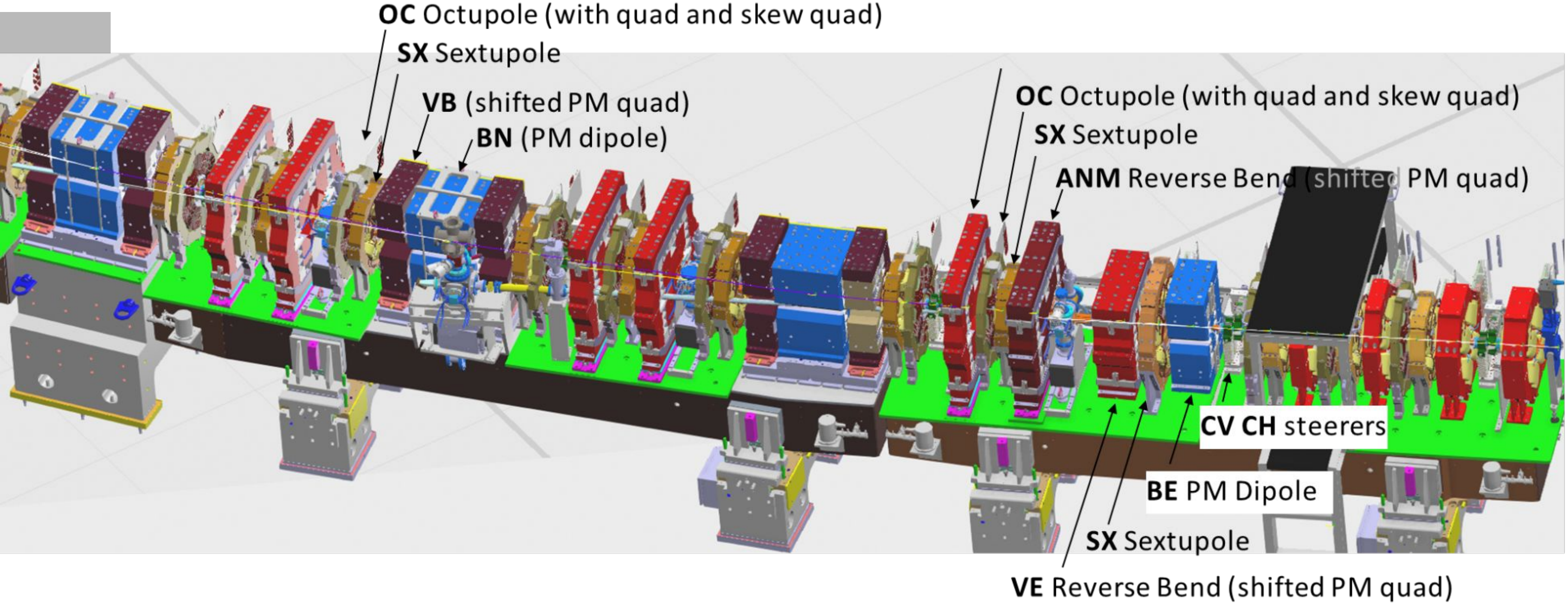

PAUL SCHERRER INSTITUT

SLS2.0 Storage Ring
Technical Design Report

https://www.psi.ch/de/sls2-0

https://ados.web.psi.ch/SLS2/

Magnet cross-talk: extra slide



Magnet Cross-talk: Procedure

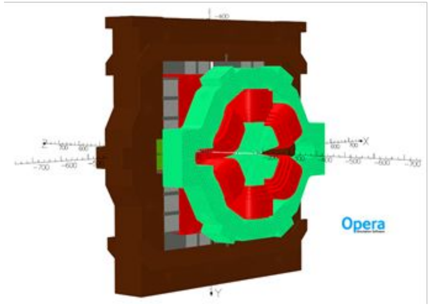
3D field modeling (Opera)
- ⇒ 3D field table: Bx, By, Bz, 1-mm grid
  - ⇒ Polynomial coefficients along beam path(1)
    - ⇒ Kick-Drift Array (KDA): 1-mm slices, including ≤12-poles(1)
      - ⇒ "Field adjustment" and linear optics checks
        - ⇒ Tracking with tracy-null(2) using KDAs ⇒ DA and lifetime

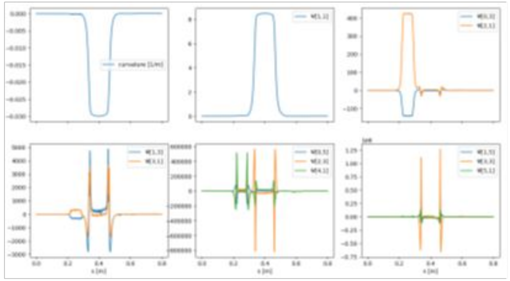
Iterate!

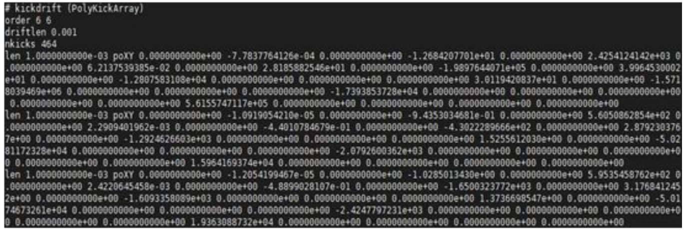
$$\tilde{b}_x^{(i)} = \sum_{jpq} \Psi_{jpq}\, p x_i^{p-1} y_i^q \; T\left(\frac{s_i - j\Delta s}{\Delta s}\right)$$

$$\tilde{b}_y^{(i)} = \sum_{jpq} \Psi_{jpq}\, q x_i^{p} y_i^{q-1} \; T\left(\frac{s_i - j\Delta s}{\Delta s}\right)$$

3D model ⟶ Multipole coefficients ⟶ KDA file (First three slices)





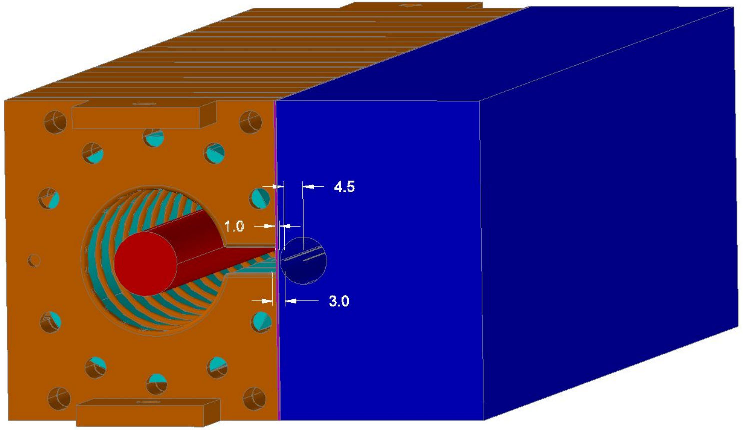


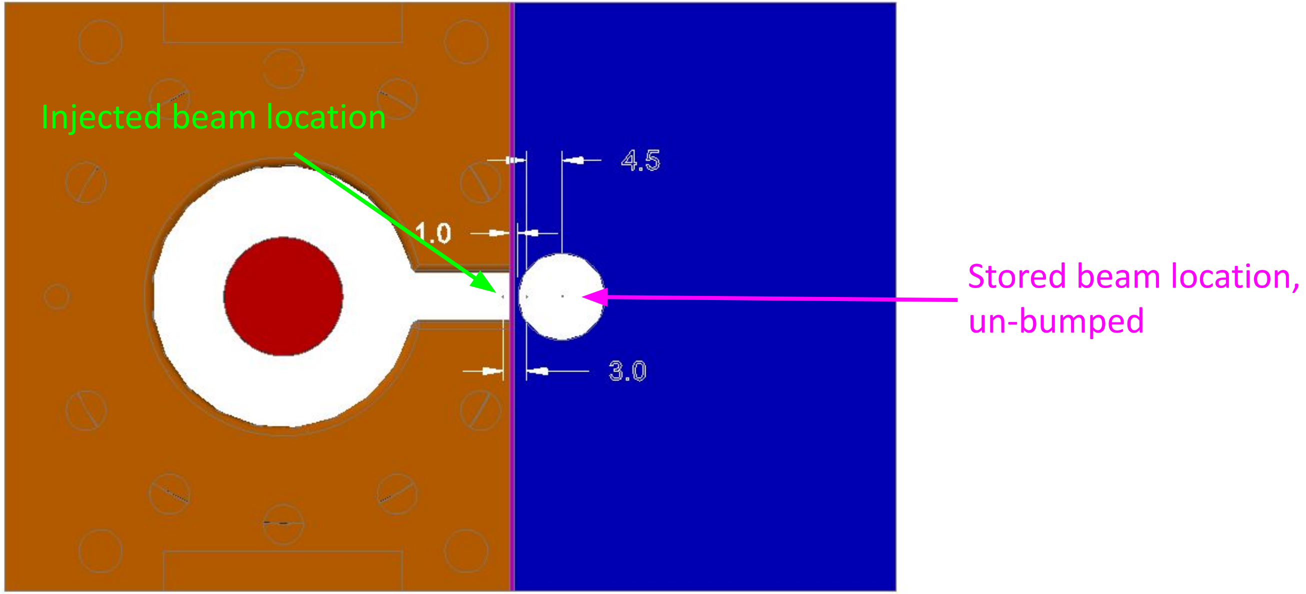
```
# kickdrift (PolyKickArray)
order 6 6
driftlen 0.001
nkicks 464
len 1.0000000000e-03 poXY 0.0000000000e+00 -7.7837764126e-04 0.0000000000e+00 -1.2684207701e+01 0.0000000000e+00 2.4254124142e+03 0
.0000000000e+00 6.2137539385e-02 0.0000000000e+00 2.8185882546e+01 0.0000000000e+00 -1.9897644071e+05 0.0000000000e+00 3.9964530002
e+01 0.0000000000e+00 -1.2807583108e+04 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 3.0119420837e+01 0.0000000000e+00 -1.571
8039469e+06 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 -1.7393853728e+04 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00
 0.0000000000e+00 0.0000000000e+00 5.6155747117e+05 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00
len 1.0000000000e-03 poXY 0.0000000000e+00 -1.0919054210e-05 0.0000000000e+00 -9.4353034681e-01 0.0000000000e+00 5.6050862854e+02 0
.0000000000e+00 2.2909401962e-03 0.0000000000e+00 -4.4010784679e-01 0.0000000000e+00 -4.3022289666e+02 0.0000000000e+00 2.879230376
7e+00 0.0000000000e+00 -1.2924626603e+03 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 1.5255612030e+00 0.0000000000e+00 -5.02
81172328e+04 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 -2.0792600362e+03 0.0000000000e+00 0.0000000000e+00 0.0000000000e+0
0 0.0000000000e+00 0.0000000000e+00 1.5964169374e+04 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00
len 1.0000000000e-03 poXY 0.0000000000e+00 -1.2054199467e-05 0.0000000000e+00 -1.0285013430e+00 0.0000000000e+00 5.9535458762e+02 0
.0000000000e+00 2.4220645458e-03 0.0000000000e+00 -4.8899028107e-01 0.0000000000e+00 -1.6500323772e+03 0.0000000000e+00 3.176841245
2e+00 0.0000000000e+00 -1.6093358089e+03 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 1.3736698547e+00 0.0000000000e+00 -5.01
74673261e+04 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 -2.4247797231e+03 0.0000000000e+00 0.0000000000e+00 0.0000000000e+0
0 0.0000000000e+00 0.0000000000e+00 1.9363088732e+04 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00 0.0000000000e+00
```

(1) B. Riemann, IPAC'21, https://doi.org/10 .18429/JACoW-IPAC2021-TUPAB238
(2) Variant of tracy developed by B. Riemann for tracking with kick-drift array

Thin septum - extra slide

- Septum blade composition
    - 0.5 mm copper
    - 0.1 mm mu-metal
    - 0.4 mm iron (part of iron block

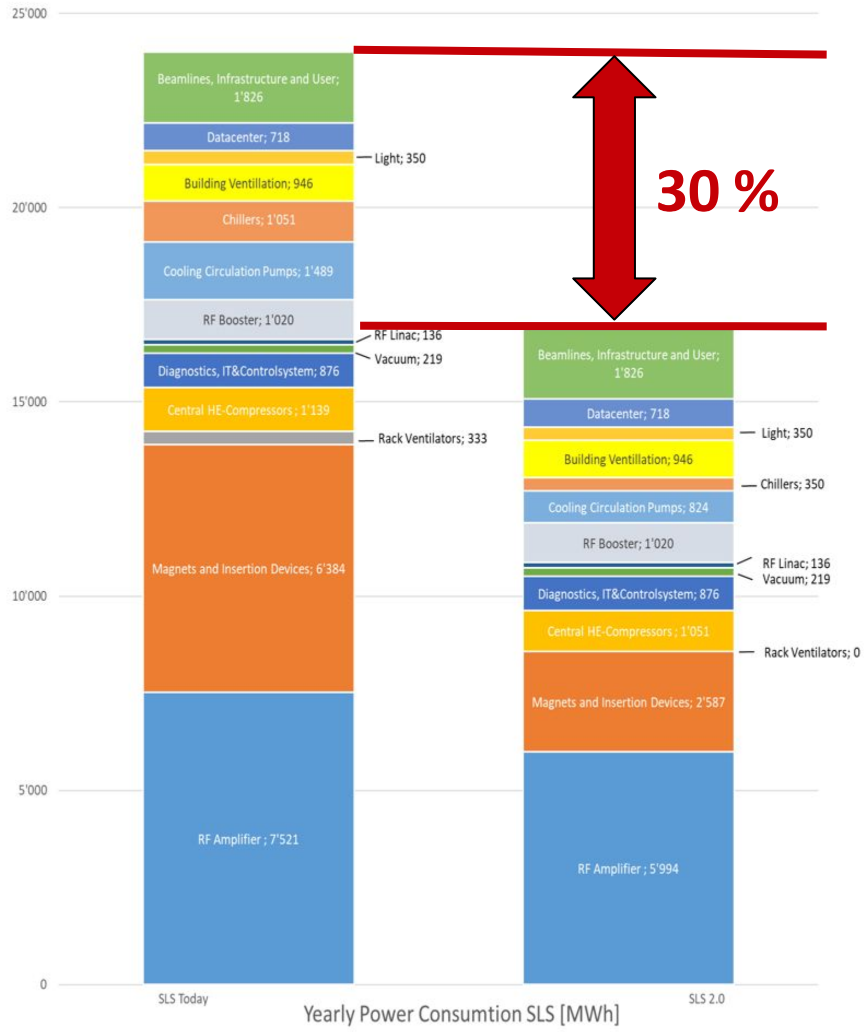




PAUL SCHERRER INSTITUT

SLS Upgrade

Power Consumption



SLS 2.0 - Timeline of Synchrotron Radiation at PSI

Plan for **B-Factory @ PSI**
for particle physics
and synchrotron radiation

abandoned 1989

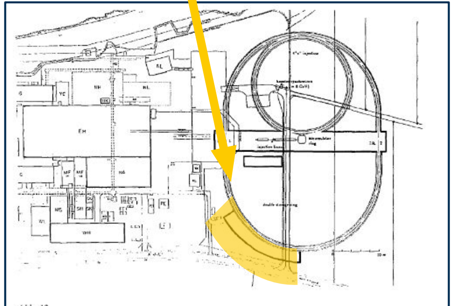
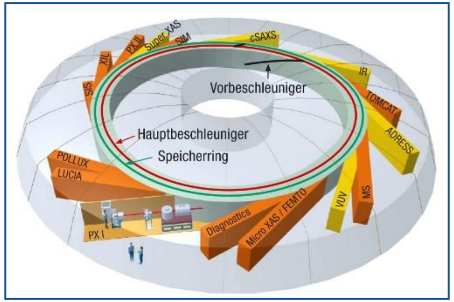


Abb. 10
Die Anordnung der Speicherringe und Gebäude für die vorgeschlagene B-Mesonenfabrik auf dem Areal des PSI.

1989

Swiss Light Source **SLS**
First beam Dec. 2000

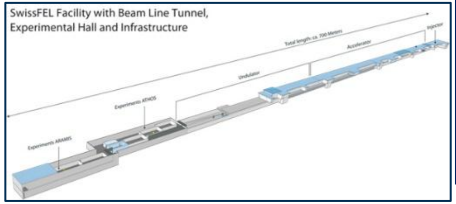
X-rays become cornerstone of PSI science program



2000

SwissFEL
First beam Dec. 2016

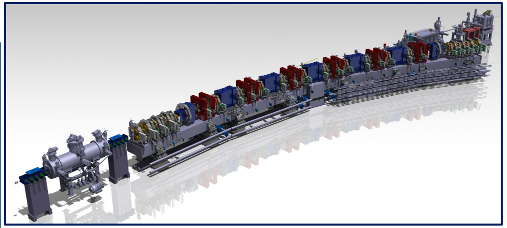
One of presently 5 X-ray-FEL facilities worldwide



2016

SLS 2.0
First beam 2025

Cutting edge
- Accelerator design & technology
- Beamlines
- Data acquisition & processing



2025

SLS Upgrade

SLS 2.0 Goals

Project Goal

Continue to provide SLS users optimum conditions for their experiments

Methods

New MBA storage ring in existing building and new IDs

→ *Increased photon brilliance → higher resolution, faster measurements*

Increase of beam energy from 2.4 GeV to 2.7 GeV and s.c. superbends

→ *Increased X-ray flux*

→ *Access to shorter X-ray wavelength*

Some new beamlines, many upgraded beamlines

→ *New scientific opportunities*

New concepts for data acquisition, processing and storage

→ *Capability for increased data rate and new sophisticated analysis algorithm*

PAUL SCHERRER INSTITUT

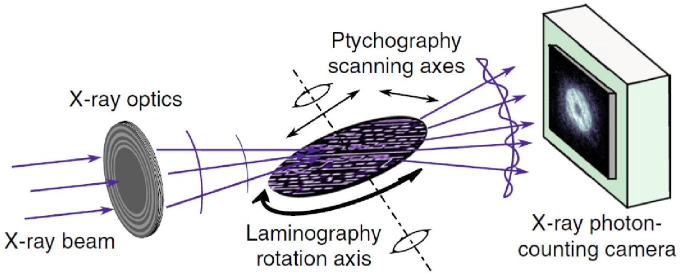
SLS Upgrade

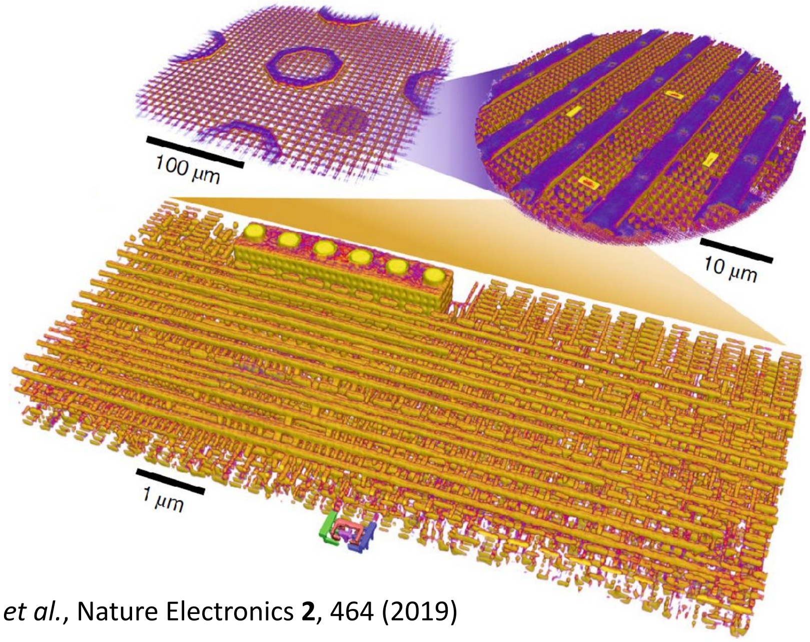
SLS 2.0 Science Cases

- Ptychography (cSAX)
- Tomography (TOMCAT, iTOMCAT, cSAX)]
- Macromolecular Crystallography (PXI, PX II, PX III)

Profiting from

- ➢ Higher Brightness & Flux
- ➢ Higher resolution
- ➢ Quicker measurements (22 h -> 8 s)



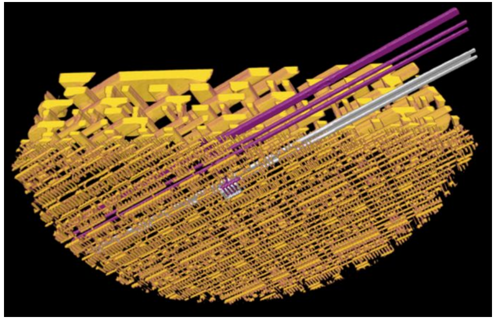


M. Holler *et al.*, Nature Electronics **2**, 464 (2019)

SLS Upgrade

Example for Performance Increase: Ptychography at CSAX

5800 resolution elements/s

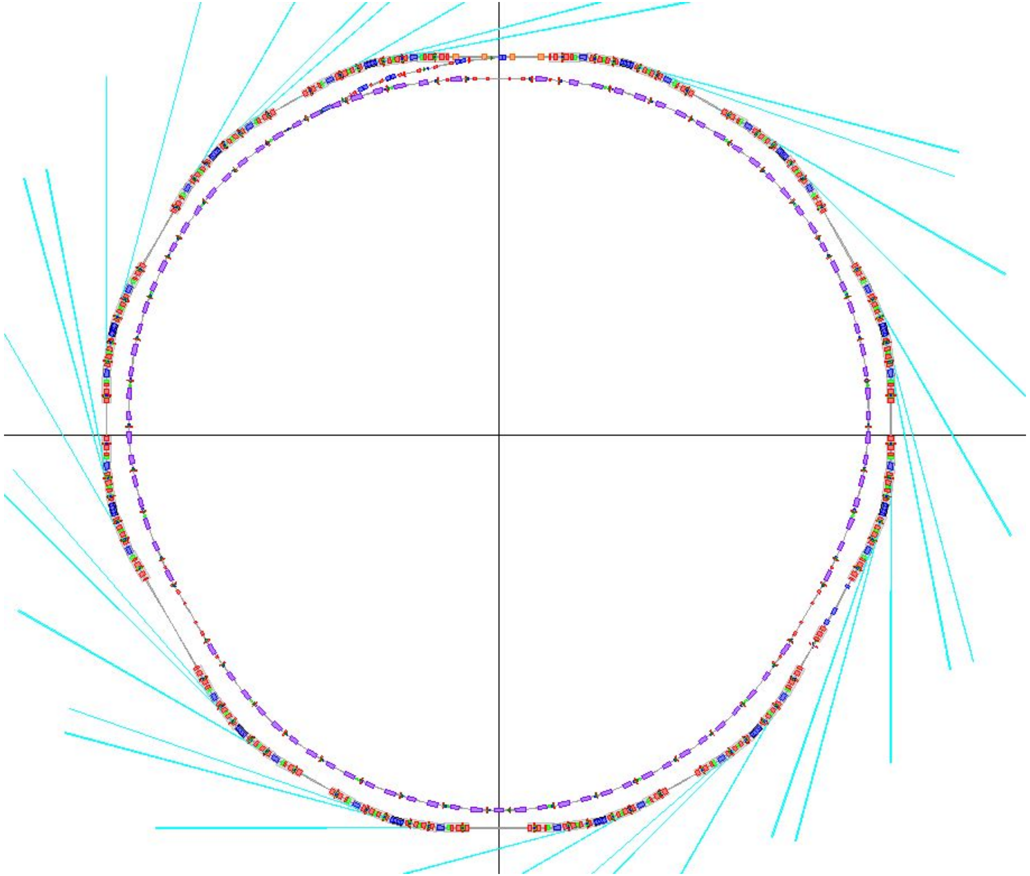


M. Holler *et al.*,
Nature **543**, 402 (2017)

DEVELOPMENT	RESOLUTION (nm)	TIME	computing power (a.u.)
State of the art	**14.6**	**22 h**	**1**
SLS 2.0	6.2	41 min	32
+ new undulator	4.6	13 min	100
+ broadband	2.6	1.3 min	1000
+ efficient optics	1.5	8 s	10000

SLS Upgrade

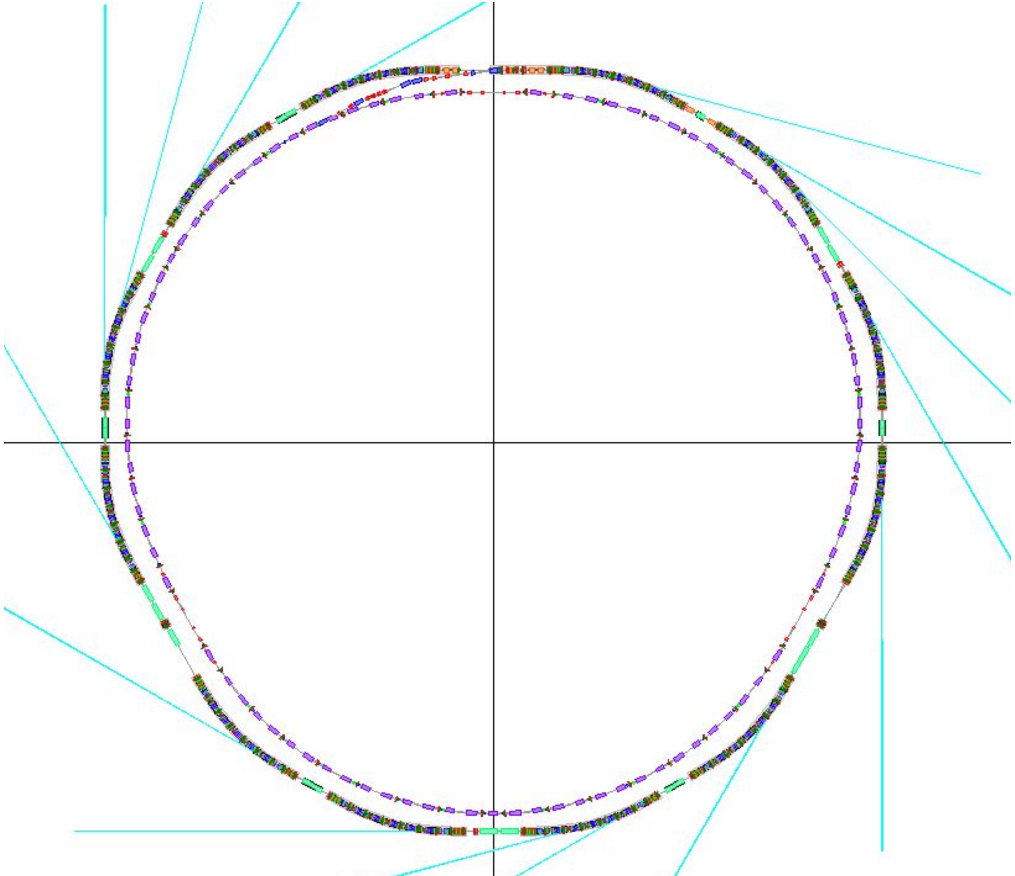
SLS Today



- Circumference **288 m**
- Straights
  - **3** × Long
  - **3** × Medium
  - **6** × Short
  - Total Length ~ **80 m**
- Beam Current **400 mA**
- Beam Energy **2.41 GeV**
- Emittance **5.5 nm**

SLS Upgrade

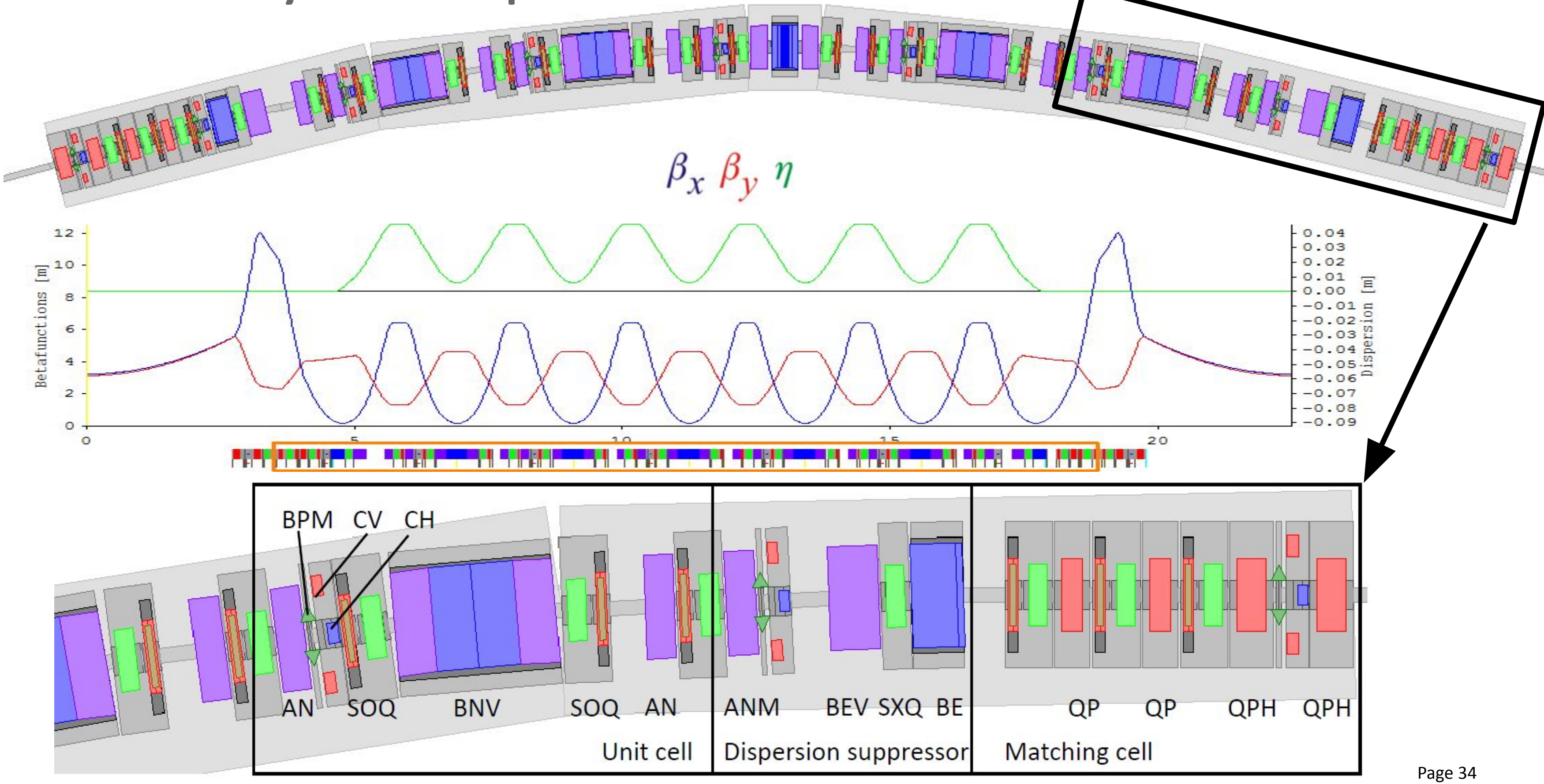
SLS 2.0 Compared to Existing SLS



- **Maintained**
  - Circumference **288 m**
  - Straights
    - **3** × Long
    - **3** × Medium
    - **6** × Short
    - Total Length **~80 m**
  - Beam Current **400 mA**
- **Almost Maintained**
  - Source Point Positions |shifts| < **70 mm**
- **Improved**
  - Emittance **157 pm** (from 5500 pm)
  - Energy **2.7 GeV** (from 2.41 GeV)

SLS Upgrade

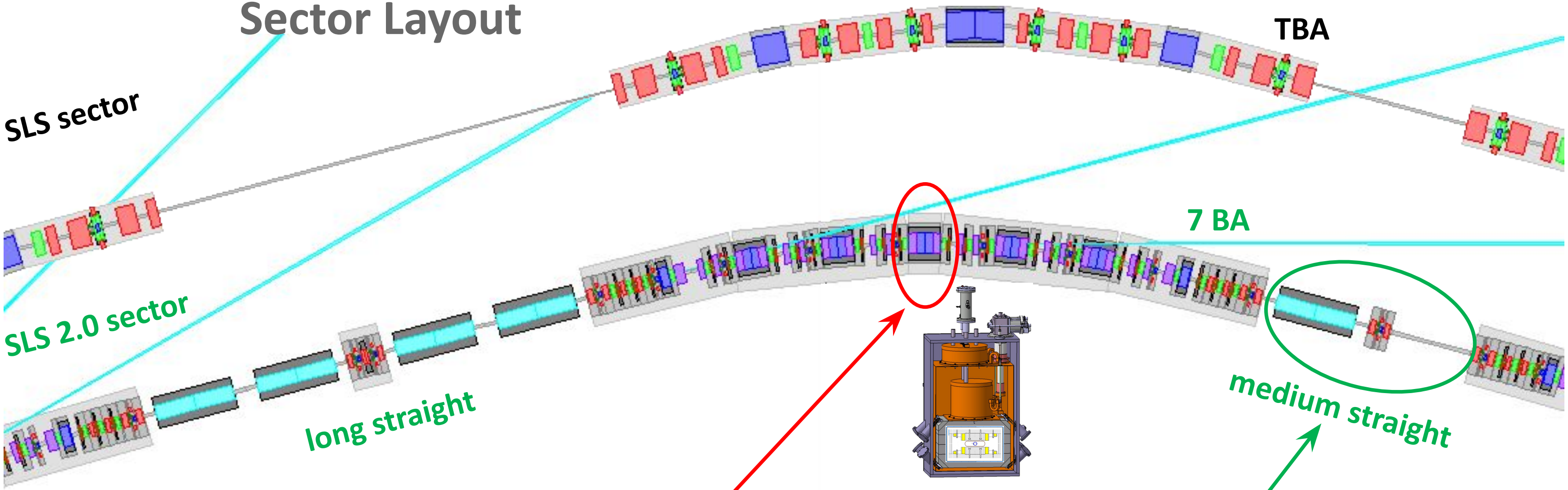
Layout and Optics of Arc



PAUL SCHERRER INSTITUT PSI

SLS Upgrade

Sector Layout

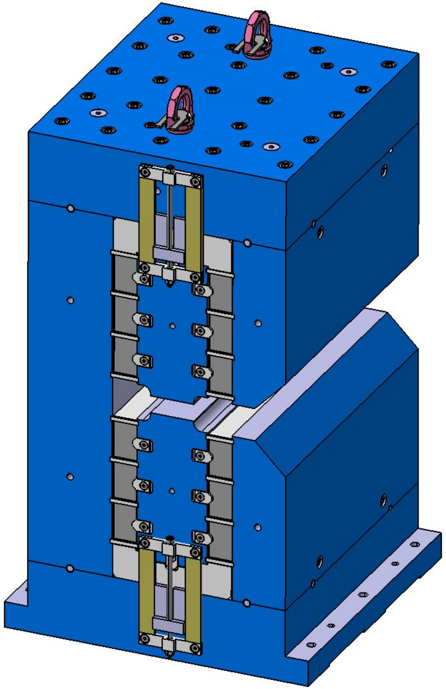


- **optional superconducting super-bends (5 T) in arc centers**
  → 3 sc super-bends planned in centers of arcs 02, 06 and 10
- **long straights 05L and 09L split from beginning**
  → quadrupole doublets for variable splitting of standard straights

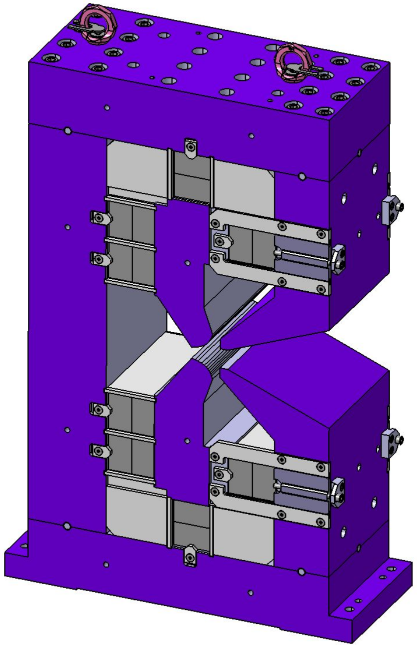
PAUL SCHERRER INSTITUT PSI

SLS Upgrade

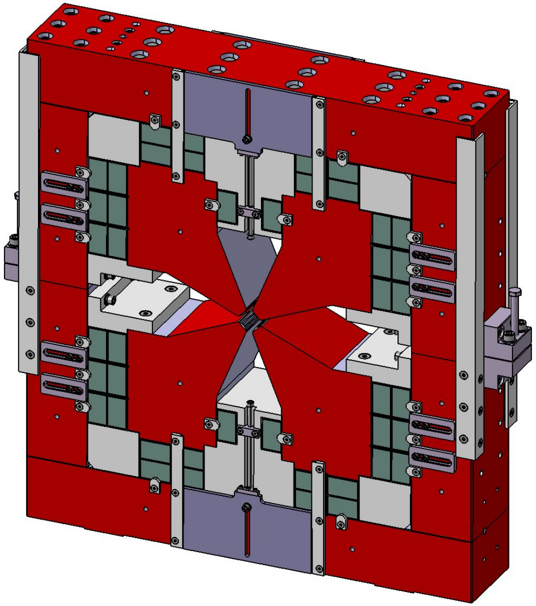
Permanent Magnets



Main Dipole



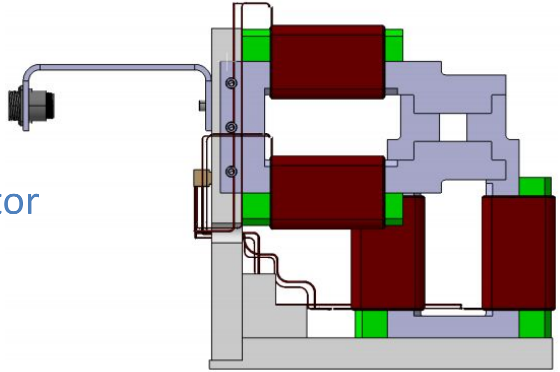
Combined Function

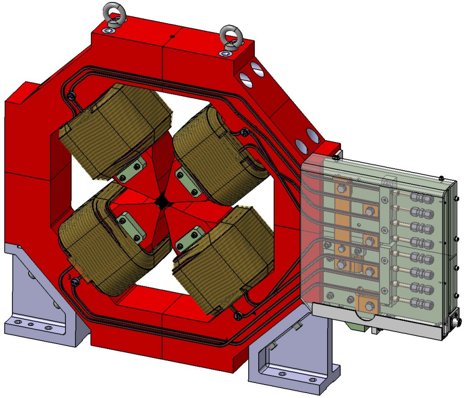


Reverse Bend

SLS Upgrade
Electromagnets

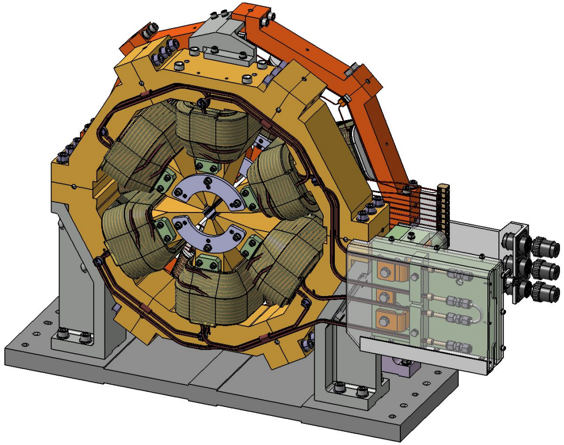
Orbit Corrector

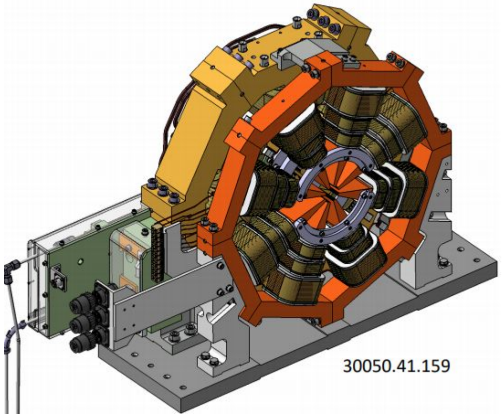




Quadrupole

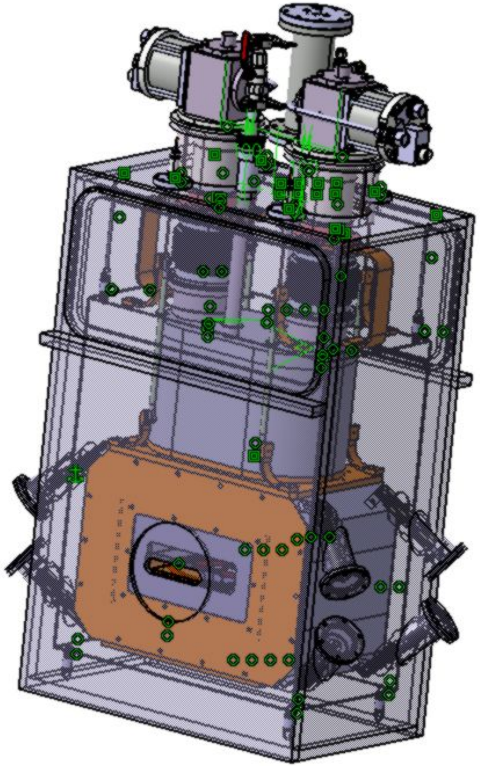
Sextupole



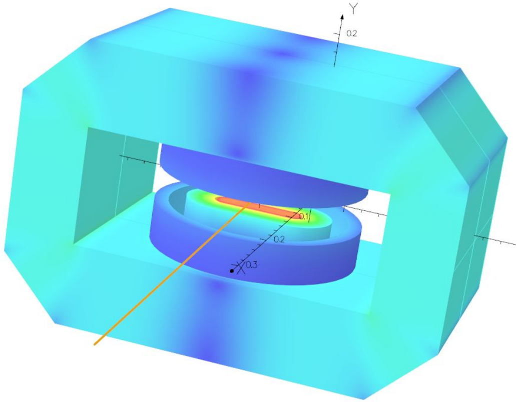


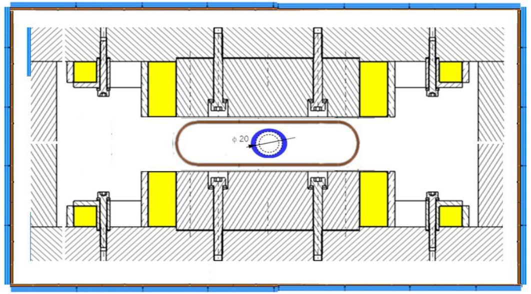
Octupole

SLS Upgrade
Suber Bends



5 Tesla SC-Dipole





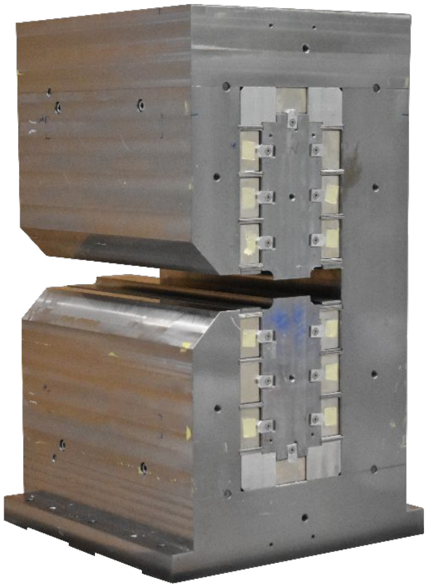
PAUL SCHERRER INSTITUT

SLS Upgrade

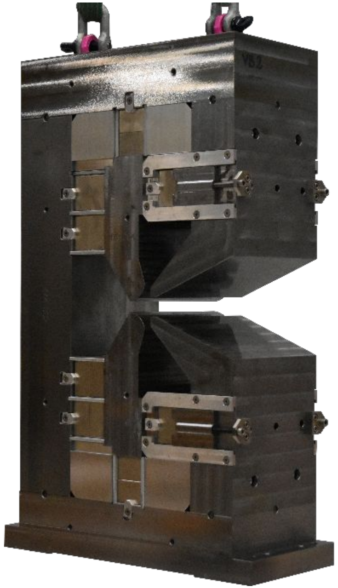
Magnets

- approx. 18’200 kg of permanent magnet material
- approx. 1270 new power supplies and controllers

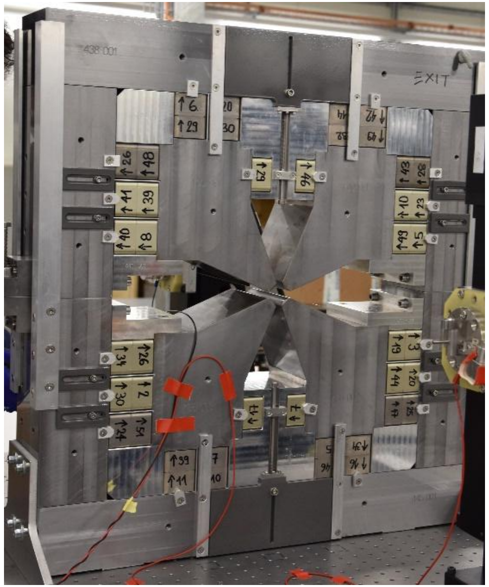
Main Dipole



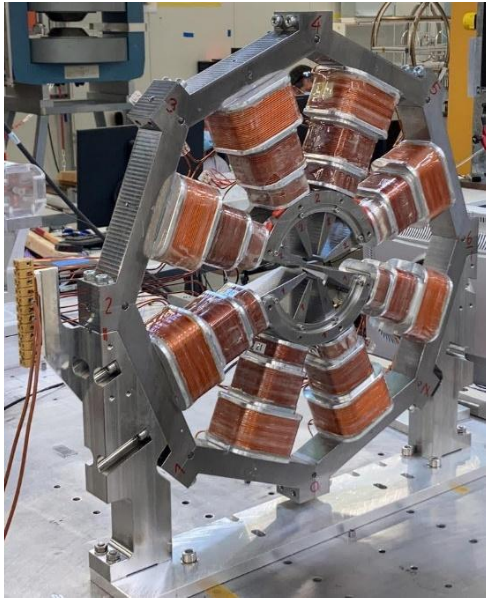
Combined Function



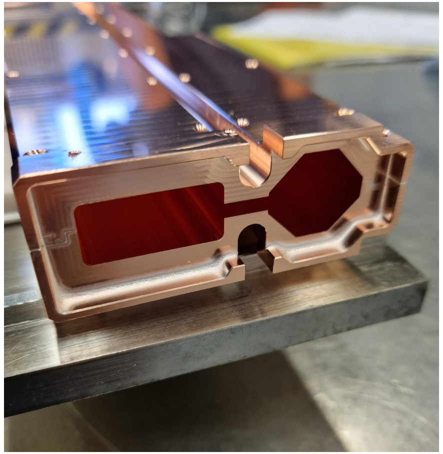
Reverse Bend



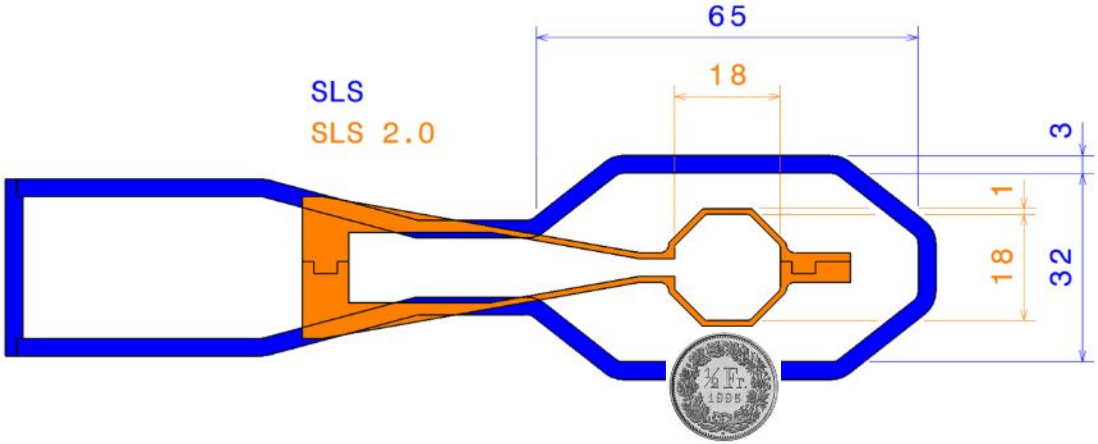
Octupole +
Quadrupole &
Skew Quadrupole



SLS Upgrade
Vacuum Chamber



- Chambers walls material: Cu OFE
- NEG Coating reduces Photon Stimulated Desorption Rate
  - 500 nm coating
- Ion Getter pumps at each Absorber
- No bellows within arc, No in-situ baking
  - Activation of 18 m long sector outside tunnel
  - Transport of 18 m lor



PAUL SCHERRER INSTITUT

SLS Upgrade

Technical Advances and Innovations for SLS 2.0

SLS 2.0 requires technical innovations…

- vacuum system — small diameter copper chambers and ultra-thin NEG-coatings
- magnets — high gradient electro-magnets and permanent magnet technology
- on-axis injection — thin septum and ultra-fast, high-field pulsers and kickers
- SC super-bends — integrated vacuum chamber design with Nb-Ti conductor provides B ≈ 5 T

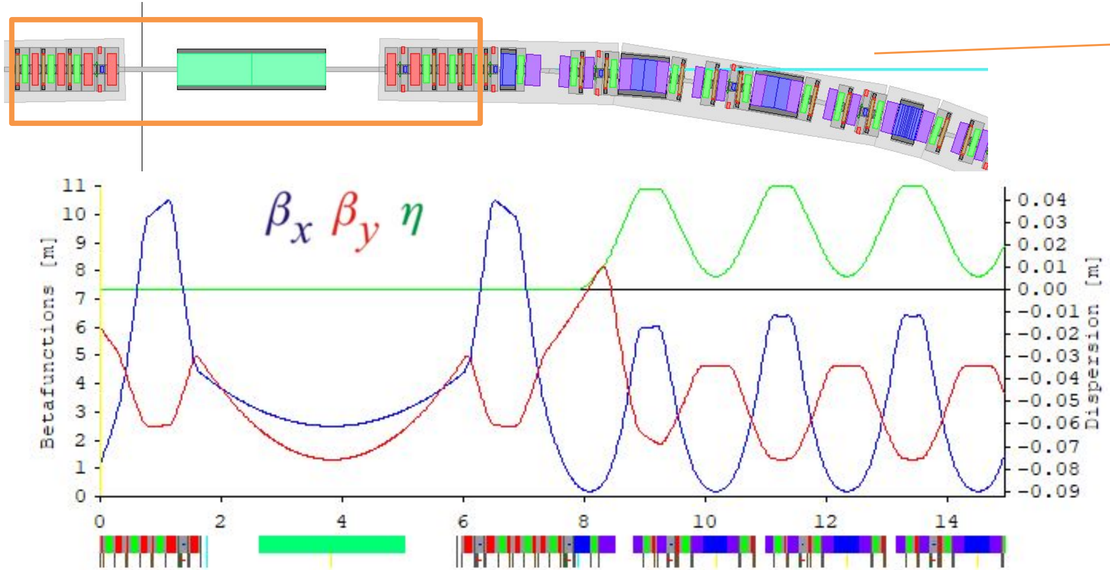
…and state-of-the-art technologies

- **solid state RF amplifiers** — high efficiency, increased reliability and low noise performance
- **digital electronics** — power supplies, BPMs & Feedbacks, LLRF, NPP, motor controllers...
- **photon monitors** — reliable and feedback-ready photon beam (position) measurements
- **pixel detectors** — for next generation imaging applications
- **science IT** — extremely large data volumes and data reduction at the source

SLS Upgrade

Sector Layout - Short straights

4 quad pairs for matching symmetry and tunes



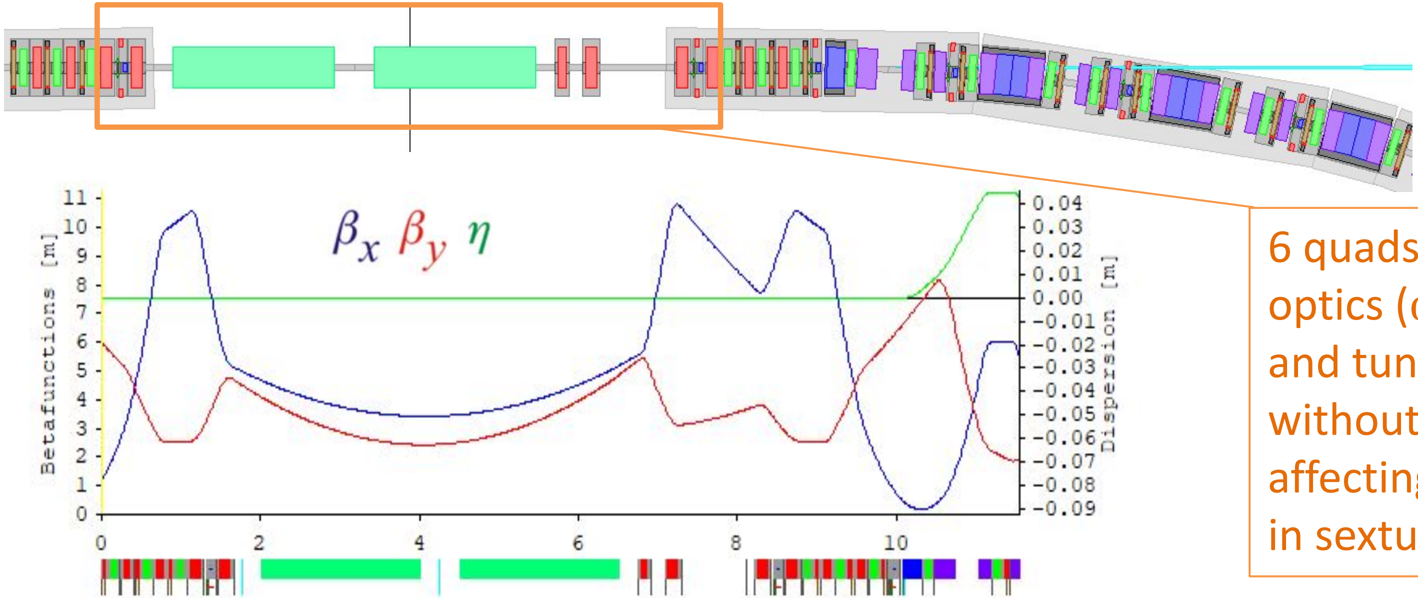
[2S] 4S 6S **8S** 10S 12S Gross / net length: 4.31 / 4.11 m

Source point (midpoint) shift vs. SLS-1: $\Delta R = -2.2$ mm, $\Delta S = 0$ mm

$\beta_{x/y} = 2.52 / 1.30$ m ⇨ Four hard X-ray beam lines can stay

SLS Upgrade

Sector Layout - Medium straights



6 quads to match optics ($\alpha_{x/y}$, $\beta_{x/y}$) and tunes without affecting optics in sextupoles.

3M, 7M, 11M Gross / net length: 6.55 m / 4.98 + 0.82 m

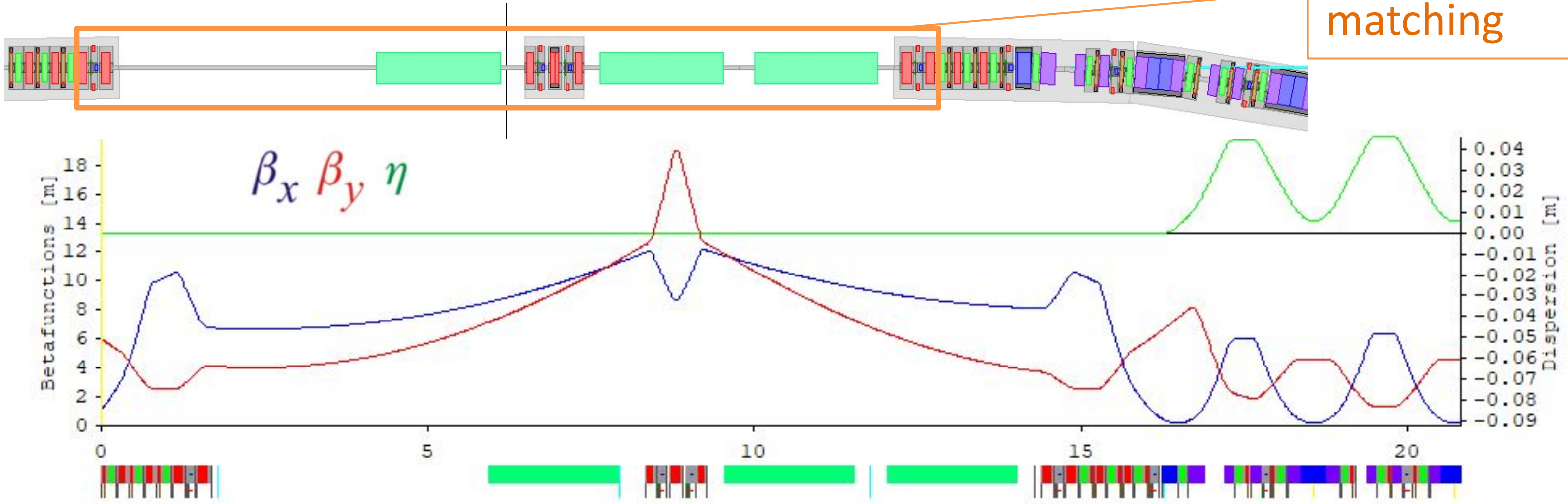
Source point shift vs. SLS-1: $\Delta R = +67$ mm, $\Delta S = -685$ mm

$\beta_{x/y} = 3.40 / 2.40$ m

SLS Upgrade

Sector Layout - Long straights

7 quads for matching



5L: 4 x RF cavity ||| -------ID------- -----ID-----

9L: 3[rd] HC -----ID----- ||| -----ID----- -----ID----- (see plot ⇧)

Source point shift $\Delta R = +67$ mm, $\Delta S = -2975 / +3755$ mm (5L)
vs. SLS-1 (mid of sub-straights) $\Delta S = -3755 / +2975$ mm (9L)

$\beta_{x/y} = 7 \ldots 12 / 4 \ldots 13$ m

PAUL SCHERRER INSTITUT

SLS Upgrade

Diagnostics - Devices and measurements

- Beam position
  - 120-130 (t.b.d.) BPM-stations
    - resolution < 50 nm rms in orbit mode
  - orbit, tunes, optical functions, coupling etc.
- Beam size
  - Two beam lines, dispersive and non-dispersive
    - visible/near-UV π-polarization and interferometry
    - X-ray pinhole and Fresnel zone plate
  - emittances and energy spread
- Time structure
  - Streak camera, photo diode and multi-bunch feedback pickup
  - bunch length and filling patterns
- Beam current
  - Current transformers, beam loss monitors
  - current, lifetime, injection efficiency
- Booster-to-ring transfer line
  - Screens and BPMs → beam parameters
  - Current transformer and loss monitors → transmission