PAUL SCHERRER INSTITUT
PSI

Accelerator Science, Technologies, Applications

Mike Seidel :: PSI/EPFL

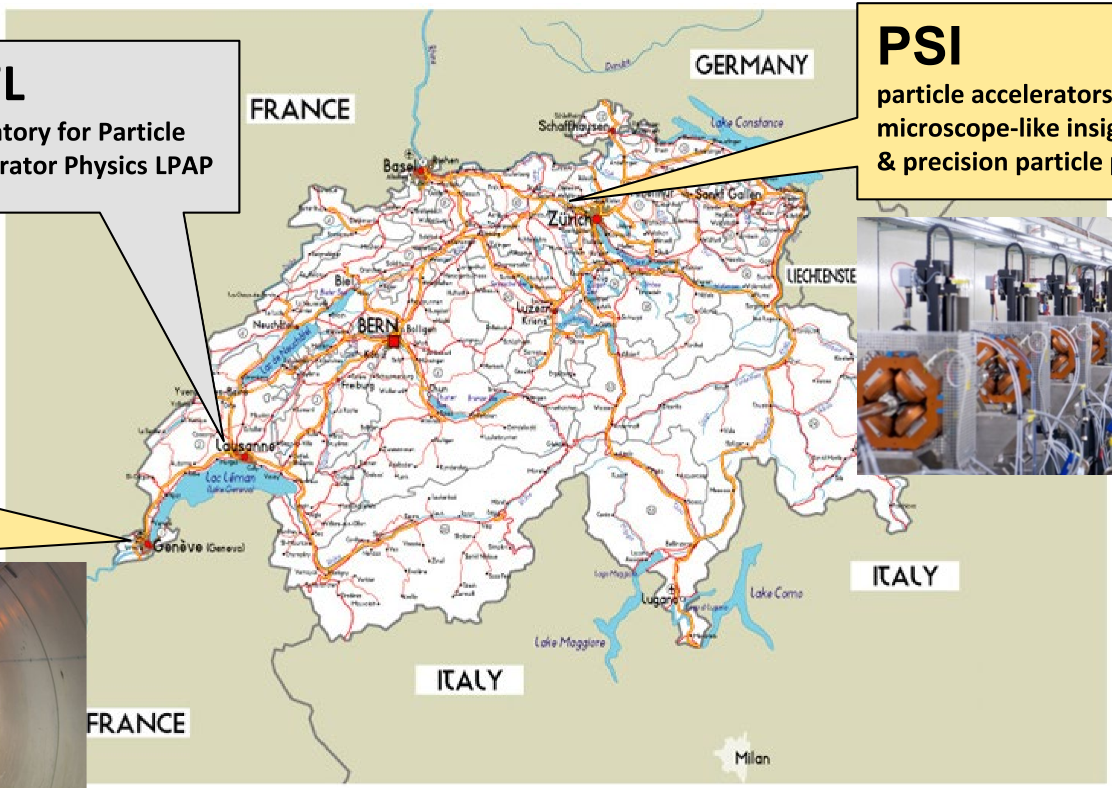
Visit CERN Council President, December 21, 2023

Particle Accelerators for Research at PSI

Complementary Accelerator Research-Facilities in Switzerland

EPFL
Laboratory for Particle Accelerator Physics LPAP

PSI
particle accelerators enable microscope-like insights
& precision particle physics



CERN
particle collider LHC,
sub-atomic insights

Accelerator Research @ EPFL

Research topics:

- PSI facilities: FEL physics, HIPA upgrade, planned SLS2 commissioning
- LHC: electron cloud, crystal collimation, coupled distributions, luminosity meas.
- FCC: lattice optimization, beam-beam, polarization, instabilities
- Separation magnet design for electron FLASH therapy and HIPA isotopes
- SDSC funded project on ML based dynamic aperture determination

[LPAP PhD students, 12 nationalities]

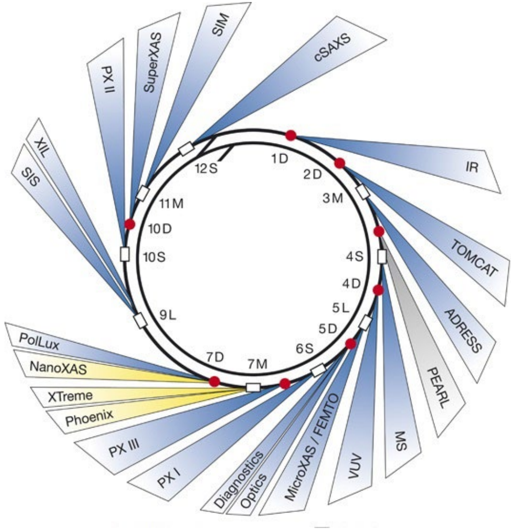
PAUL SCHERRER INSTITUT PSI SLS

Swiss Light Source, SLS

For more than 20 years one of the internationally most successful synchrotron radiation facilities !

SLS Ring

C	= 289 m
E_k	= 2.4 GeV
I_{beam}	= 400 mA
MTBF	> 100 h



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SLS → SLS 2.0

SLS today

- Lattice type **3 bend achromat**
- Circumference **288 m**
- **3×** long, **3×** medium, **6×** short straights
- total straight length ~ **80 m**
- Beam current **400 mA**
- Beam energy **2.4 GeV**
- Emittance **5500 pm**

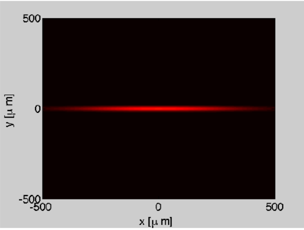
SLS 2.0

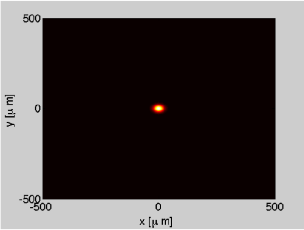
maintained

- Circumference **288 m**
- **3×** long, **3×** medium, **6×** short straights
- total straight length ~ **80 m**
- Beam current **400 mA**
- Building

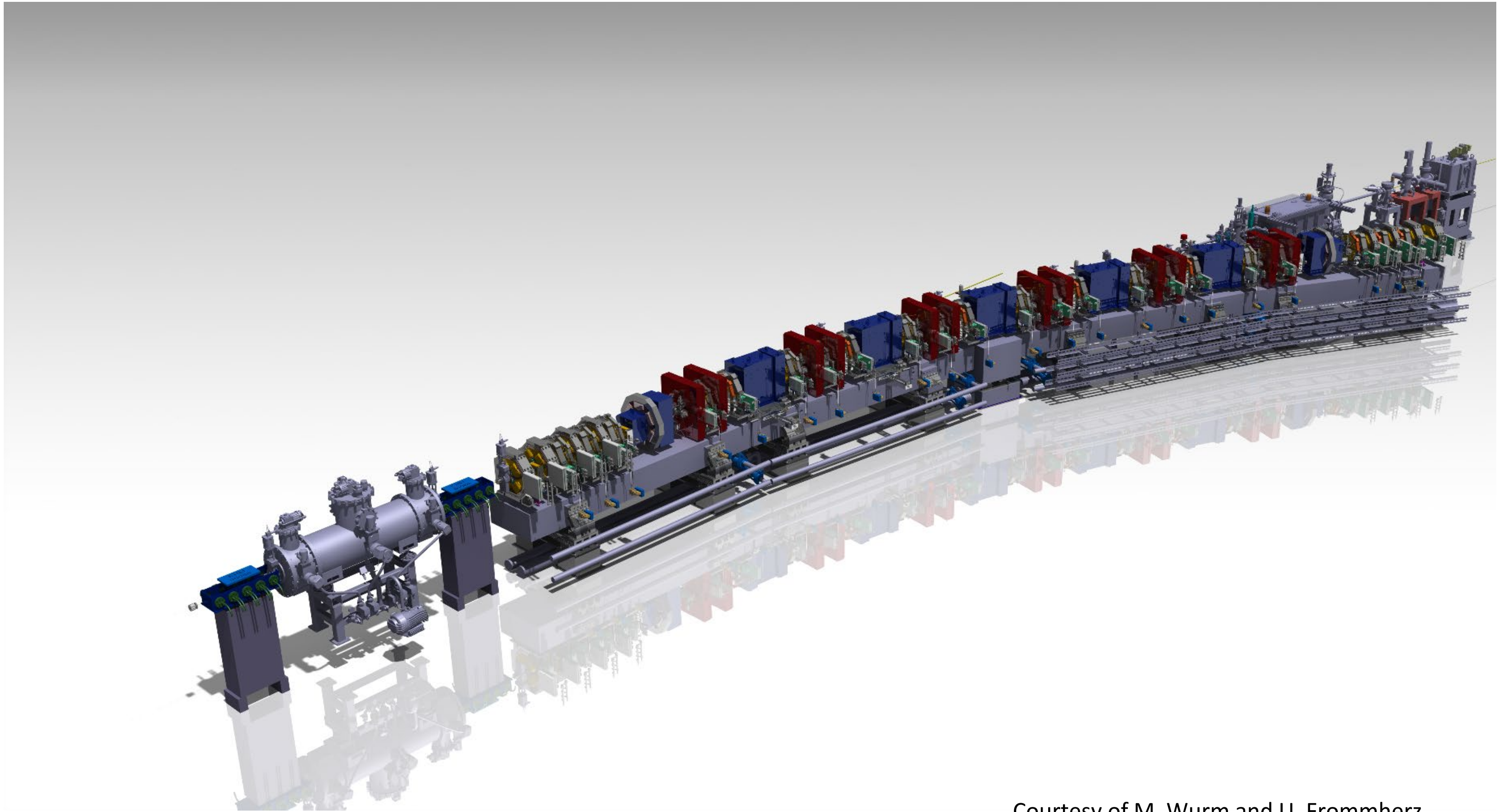
improved

- Lattice type **7 bend achromat**
- Energy **2.7 GeV**
- Emittance **157 pm**



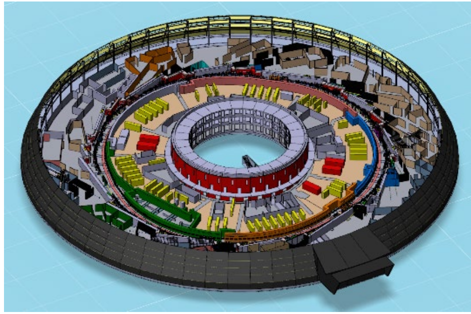


One out of twelve SLS 2.0 MBA sectors



Courtesy of M. Wurm and U. Frommherz

SLS2.0 Schedule installation phase



Key challenge:

Minimize time without user operation!

<table>
<tr><td colspan="12">2023</td><td colspan="12">2024</td><td colspan="12">2025</td><td colspan="12">2026</td></tr>
<tr><td colspan="3">Q1</td><td colspan="3">Q2</td><td colspan="3">Q3</td><td colspan="3">Q4</td><td colspan="3">Q1</td><td colspan="3">Q2</td><td colspan="3">Q3</td><td colspan="3">Q4</td><td colspan="3">Q1</td><td colspan="3">Q2</td><td colspan="3">Q3</td><td colspan="3">Q4</td><td colspan="3">Q1</td><td colspan="3">Q2</td><td colspan="3">Q3</td><td colspan="3">Q4</td></tr>
<tr><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>S</td><td>O</td><td>N</td><td>D</td><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>S</td><td>O</td><td>N</td><td>D</td><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>S</td><td>O</td><td>N</td><td>D</td><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>S</td><td>O</td><td>N</td><td>D</td></tr>
<tr><td colspan="9">SLS user operation in parallel with SLS2.0 preparations</td><td colspan="3">Dis-mantling SLS</td><td colspan="12">Installation new ring</td><td colspan="7">Beam commissioning and vacuum conditioning</td><td colspan="5">user operation with reduced number of beamlines</td><td colspan="5">finalize beamline installations</td><td colspan="7">User operation</td></tr>
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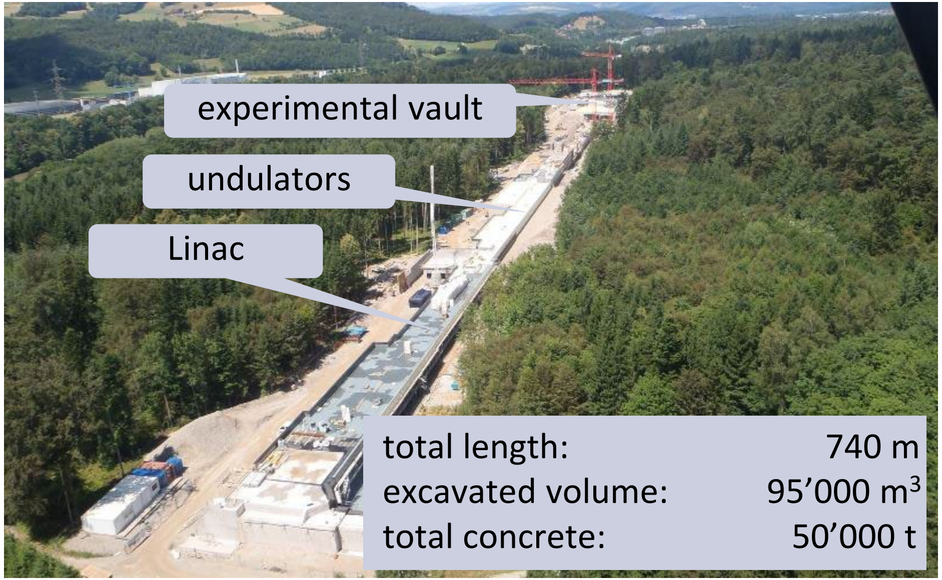
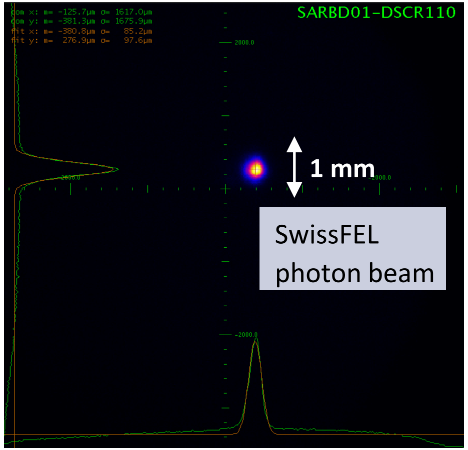
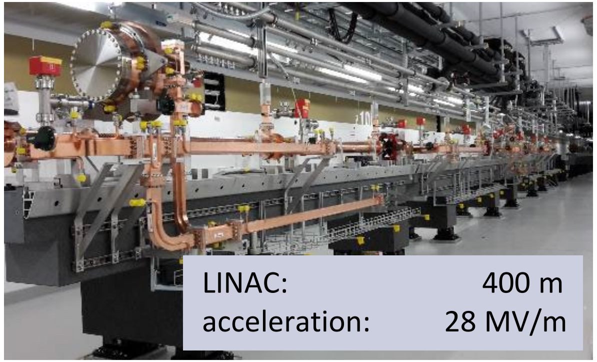
22 month
no user operation

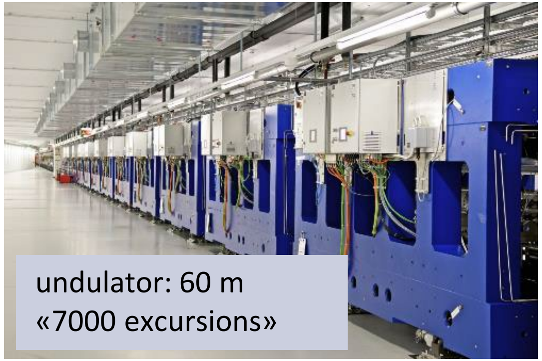
SwissFEL: most modern PSI facility

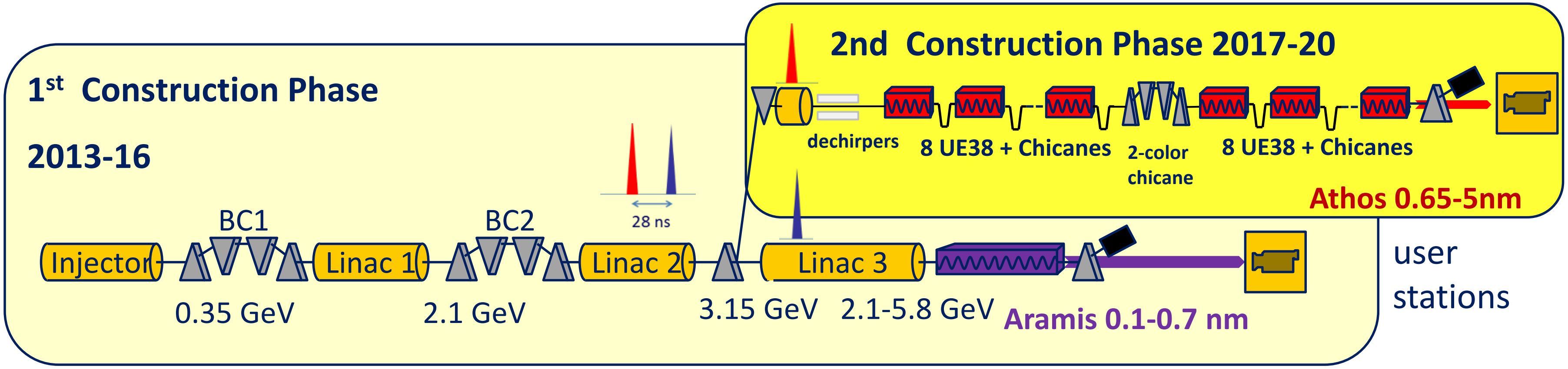




radiation peak power up to 50 GW
= sommer sun on 8 km x 8 km (!)
duration: few femtoseconds







Aramis

Linear polarization, variable gap, in-vacuum Undulators

First users 2018

Athos

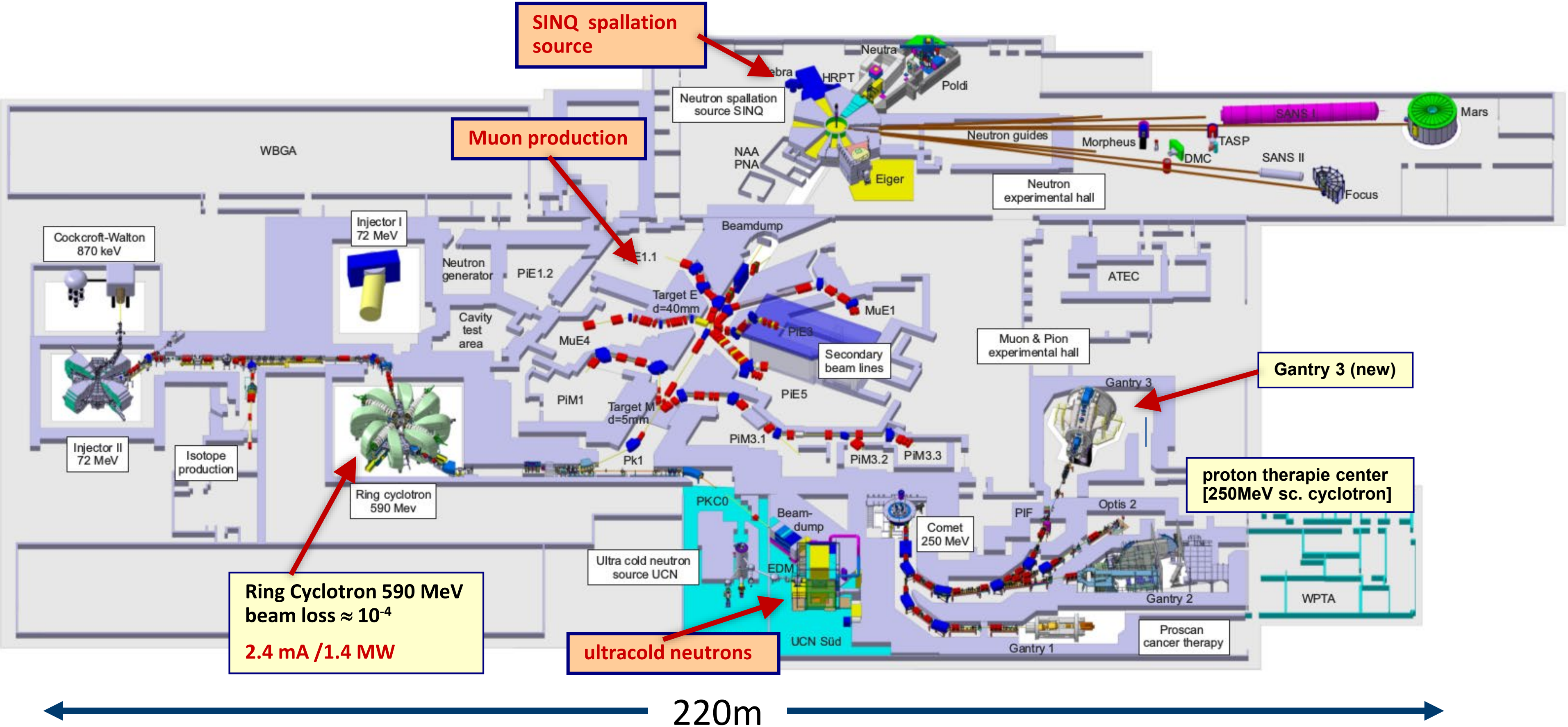
Soft X-ray FEL, variable polarization

First users 2021

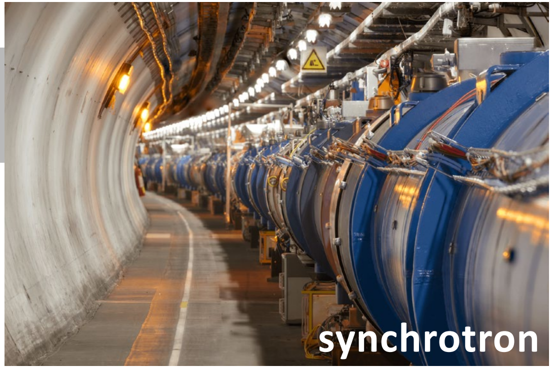
Main parameters of Athos

Photon energy	**250 – 1900 eV**
Pulse duration	1 fs - 20 fs
e^- Energy	2.65 – 3.4 GeV
e^- Bunch charge	10-200 pC
Repetition rate	100 Hz

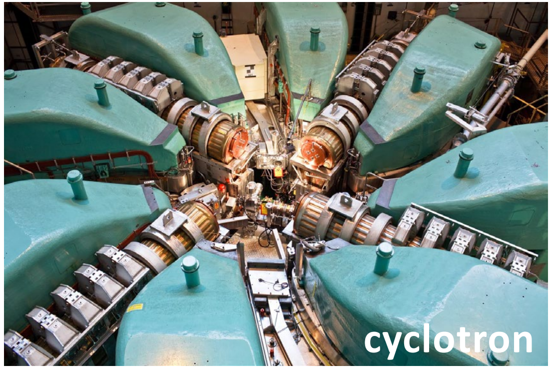
High Intensity Proton Accelerator HIPA



High Energy vs High Intensity



	LHC	PSI-HIPA
beam energy	6‘800 GeV	0.59 GeV
inst. beam power	4 TW	1.4 MW
avg. beam power	~ 30 kW	1.4 MW
grid power	120 MW	10 MW



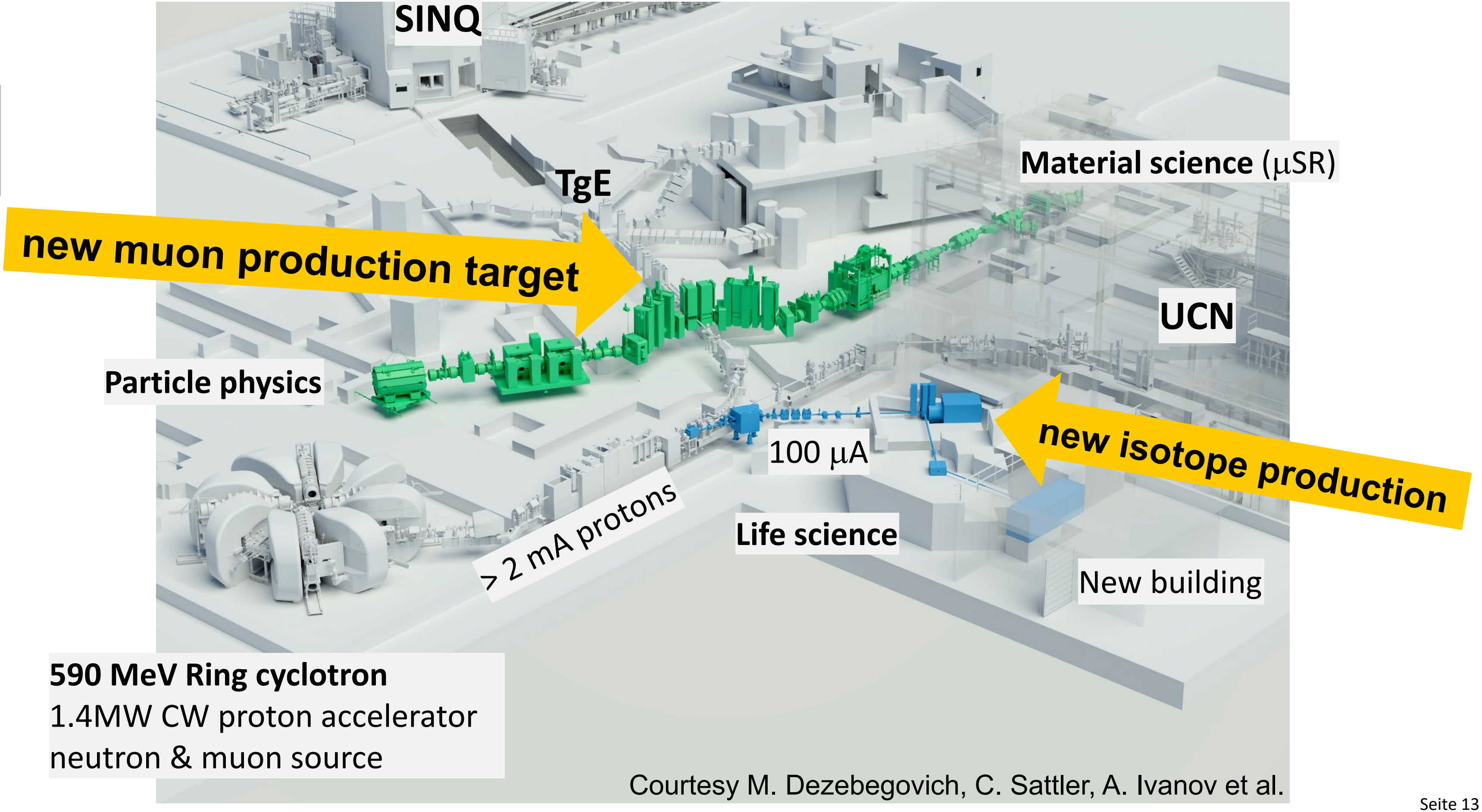
outstanding: energy -> discovery potential

challenges: cost, power consumption, complexity, safe beam operation, reliability

outstanding: intensity-> flux, precision

challenges: radio activation, targetry, power consumption

Upgrade of High Intensity Proton Accelerator



590 MeV Ring cyclotron
1.4MW CW proton accelerator
neutron & muon source

Courtesy M. Dezebegovich, C. Sattler, A. Ivanov et al.

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IMPACT = HIMB + TATTOOS

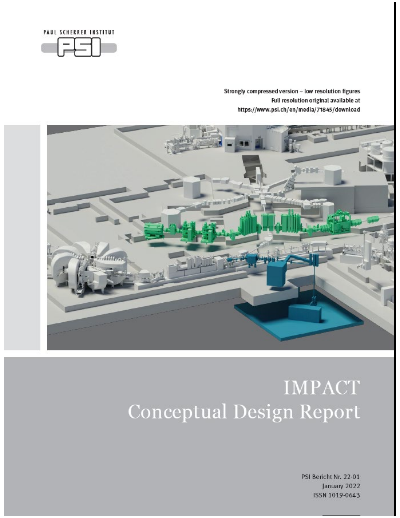
Isotope and Muon Production with advanced cyclotron and target technology

HIMB (High Intensity Muon Beams)

Upgrade of target station M to target station H for 100 x more surface muons

TATTOOS (Targeted Alpha Tumour Therapy and Other Oncological Solutions)

New target station for producing radioisotopes for research in cancer therapy



~ 100 people are involved

PSI divisions BIO, GFA, LOG, NES, NUM

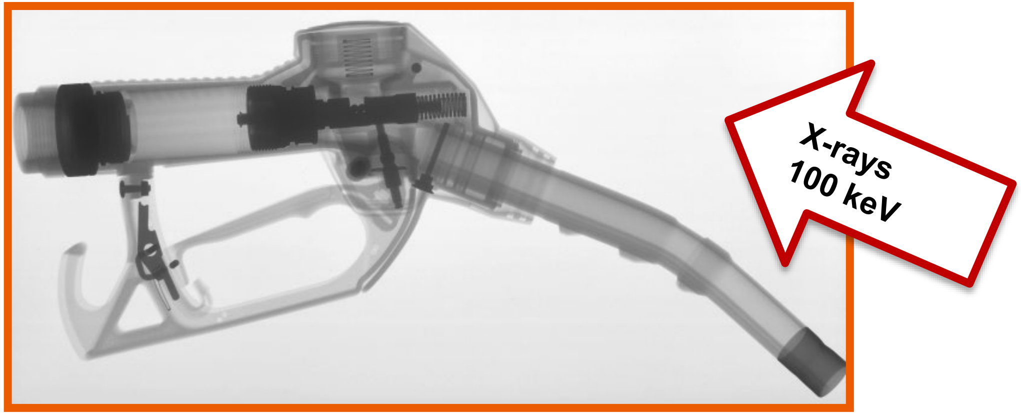
9 subprojects and 35 working groups

Conceptual Design Report (Jan. 2022)

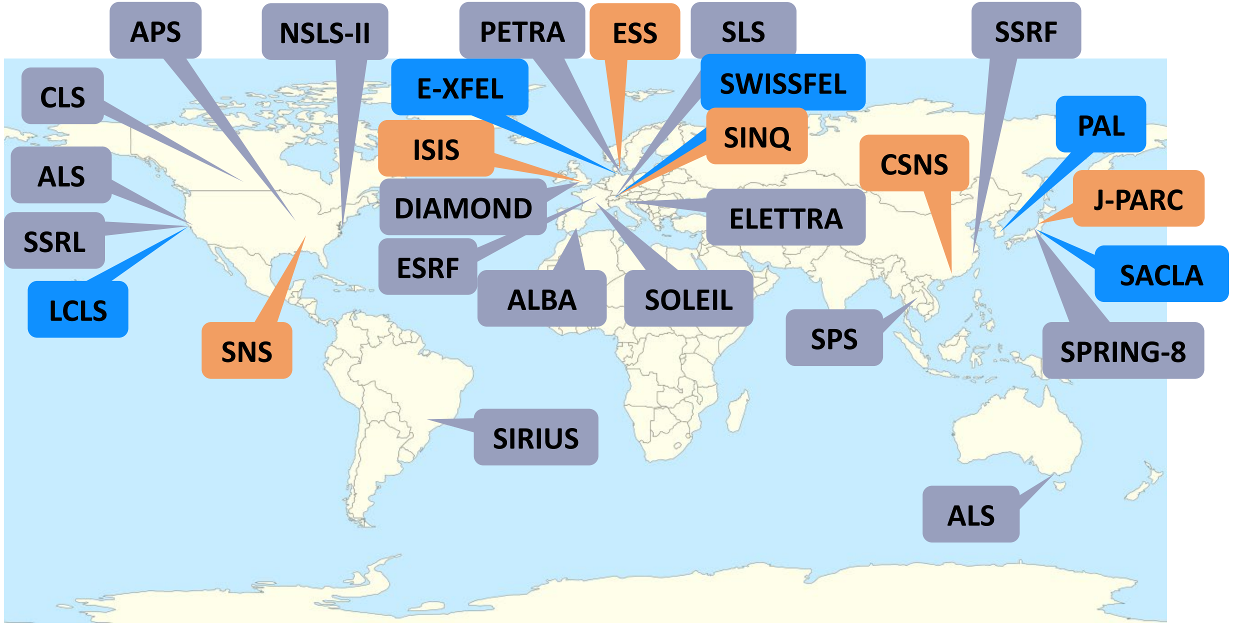
D.Kiselev et al

https://www.dora.lib4ri.ch/psi/islandora/object/psi%3A41209

Neutron radiography vs X-ray Imaging



Light- and Neutron Sources Worldwide



- Synchrotron Light Source
- Free Electron Laser (Å range)
- Neutron Source

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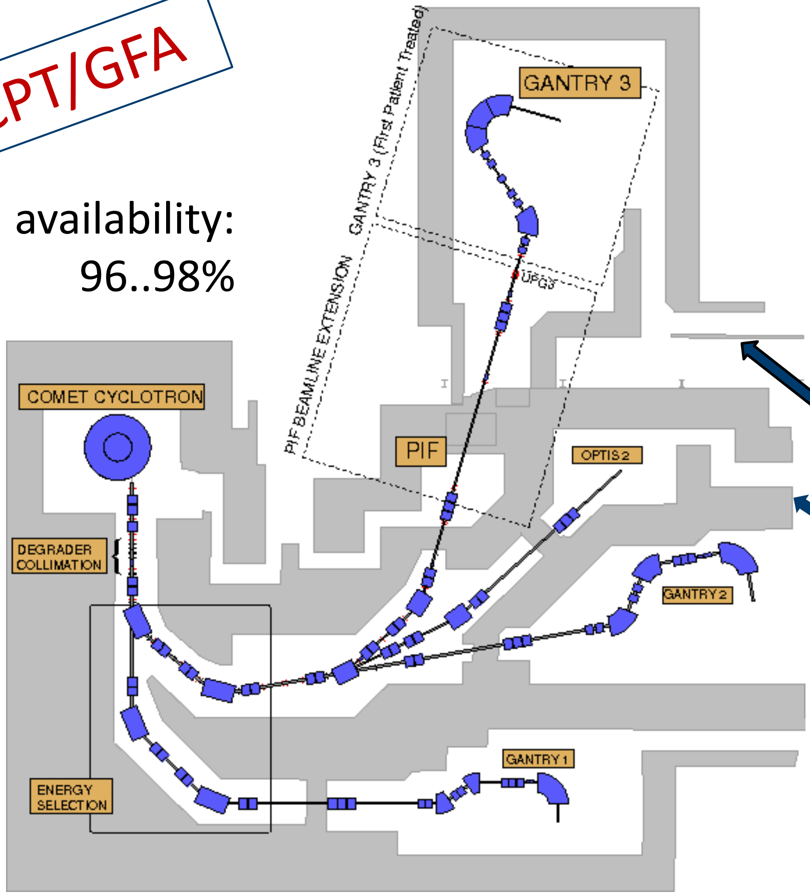
CPT/GFA

availability:
96..98%



July 2018, patient on Gantry 3, Source: ZPT

Gantry 3

OPTIS

Gantry 2

Gantry 1

(last patient 12/2018)

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Compact Superconducting COMET cyclotron

field = 3.8Tesla

extraction radius = 0.8 meters

FUTURE CIRCULAR COLLIDER

CHART – Switzerland

CHART Swiss Accelerator Research and Technology

- founded in 2016 as umbrella organization for accelerator research in CH
- to support FCC and develop future accelerator technologies
- co-funded by CERN, PSI, ETHZ, EPFL and U Geneva.

Key contributions to FCC Conceptual Design Study and Feasibility Study in several areas:

- FCC-hh and FCC-ee beam dynamics and luminosity optimisation and simulation tools
- High-field magnet development and associated technologies
- FCC implementation studies via geology 3 D modelling and geodesy
- FCC-ee injector complex including positron production experiment at PSI
- FCC-ee HTS arc quads and sextupoles with prototype at PSI

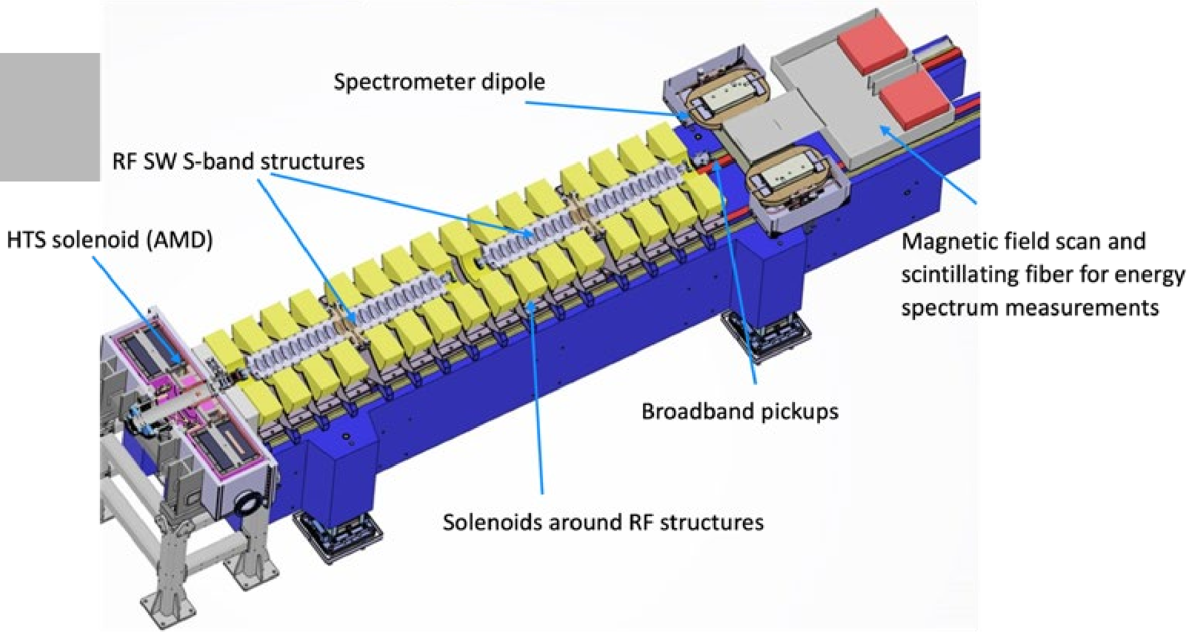
L.Rivkin et al

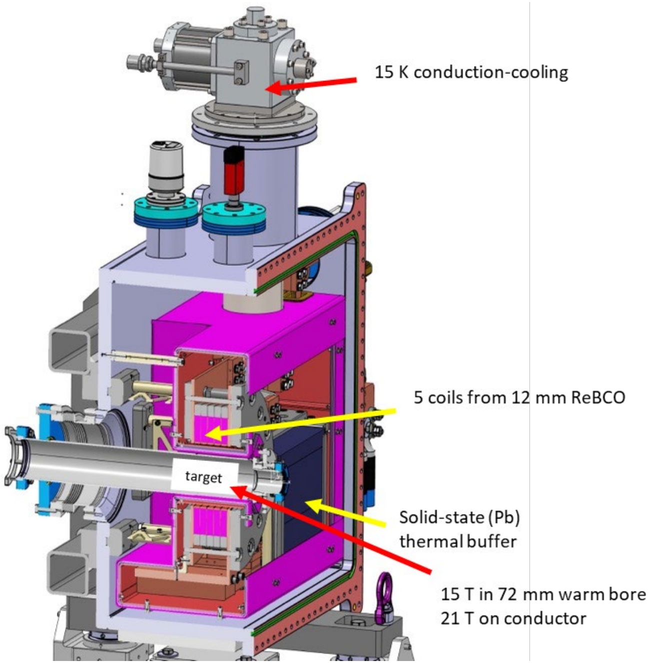
Superconducting Magnet R&D
-> talk B.Auchmann

Comments on strategic aims:

- **Highest fields for a future collider**, requires persistent R&D
- **Single magnet applications**, e.g.: superbends for light sources (high peak field), s.c. undulators (short poles + field strength), s.c. gantry magnets (1/10 of weight), positron source (capture effic.), magnets for sample environments …
- **Energy efficient magnets for medium field levels**, higher operating temperature, e.g.: large aperture HIPA magnets, combined function magnets for FCC-ee

Positron Source with HTS Solenoid





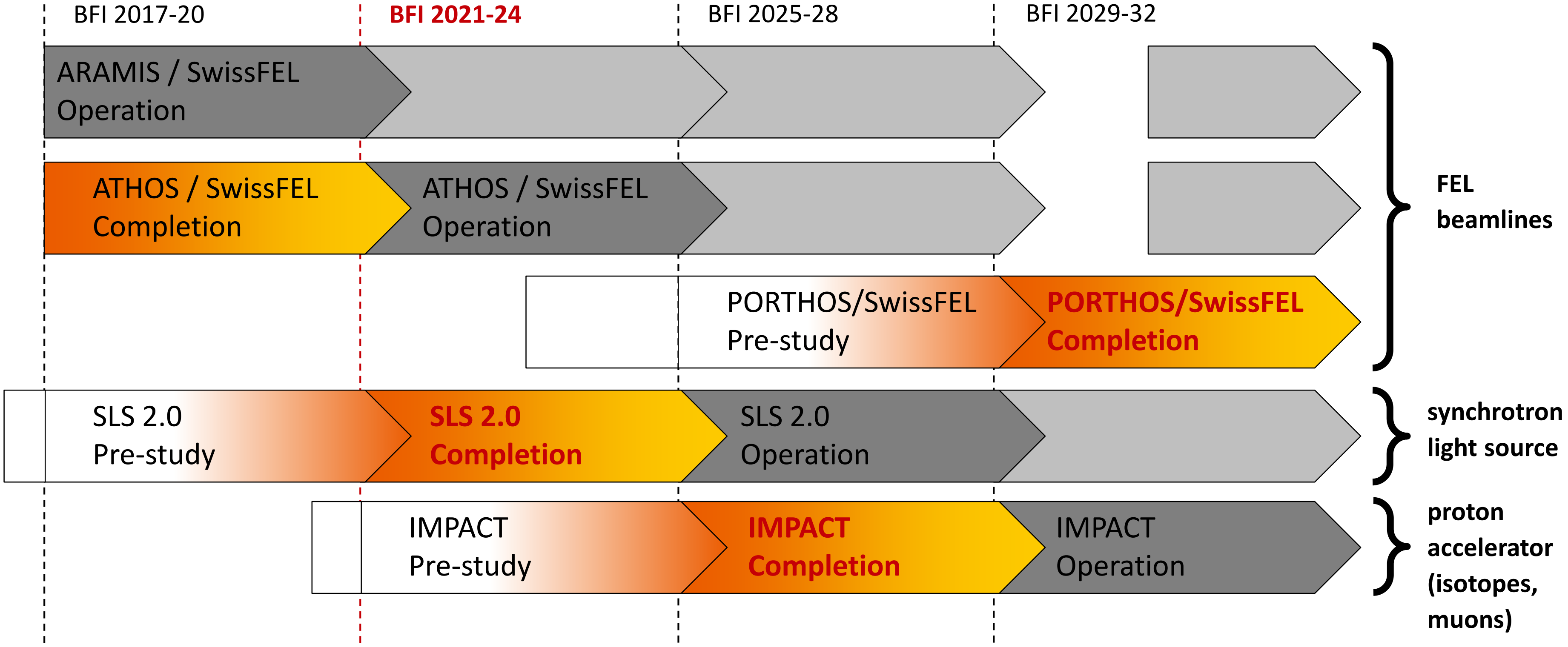
HTS NI target solenoid, to demonstrate high-yield positron source concept

Manufacturing Q3’23-Q2’24

Experiment at PSI’s SwissFEL 2026

Courtesy J. Kosse, T. Michlmayr, H. Rodrigues

Strategic Planning of Research Infrastructures



[CH.Rüegg et al]

Long term planning, financial stability and reserves, and technological development are essential

Thank you for your attention!