PAUL SCHERRER INSTITUT

PSI

Mike Seidel :: Head Large Research Facilities :: PSI

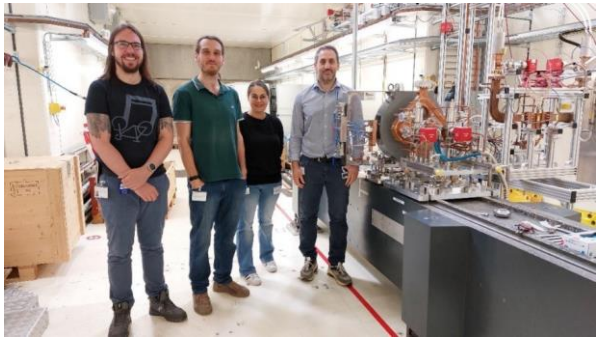
Paul Scherrer Institut

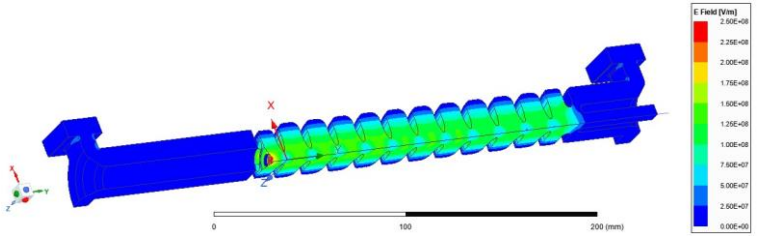
113th Plenary ECFA meeting, November 16, 2023

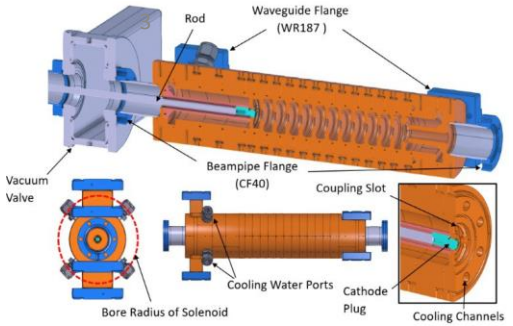
Paul Scherrer Institute – ETH Domain

INFN-PSI COLLABORATION on RF systems

- **Ongoing collaboration in the context of the I.FAST project** on **design, realization and high power test of two different C-band (5.712 GHz) RF electron guns** operating at very high gradient cathode peak field (>160 MV/m):
  - Standing Wave (SW) gun under the **INFN responsibility**
  - Travelling Wave (TW) gun under the **PSI responsibility**
- The **high power test will be performed @ PSI**
- Installation of the LNF SW GUN@PSI (July 2023)
- TW gun under realization
- **Strong synergies between the two lab** on the development of new high repetition rate, high brightness photoinjectors for different type of applications (applied physics, FEL, medical,…)







P. Campana et al

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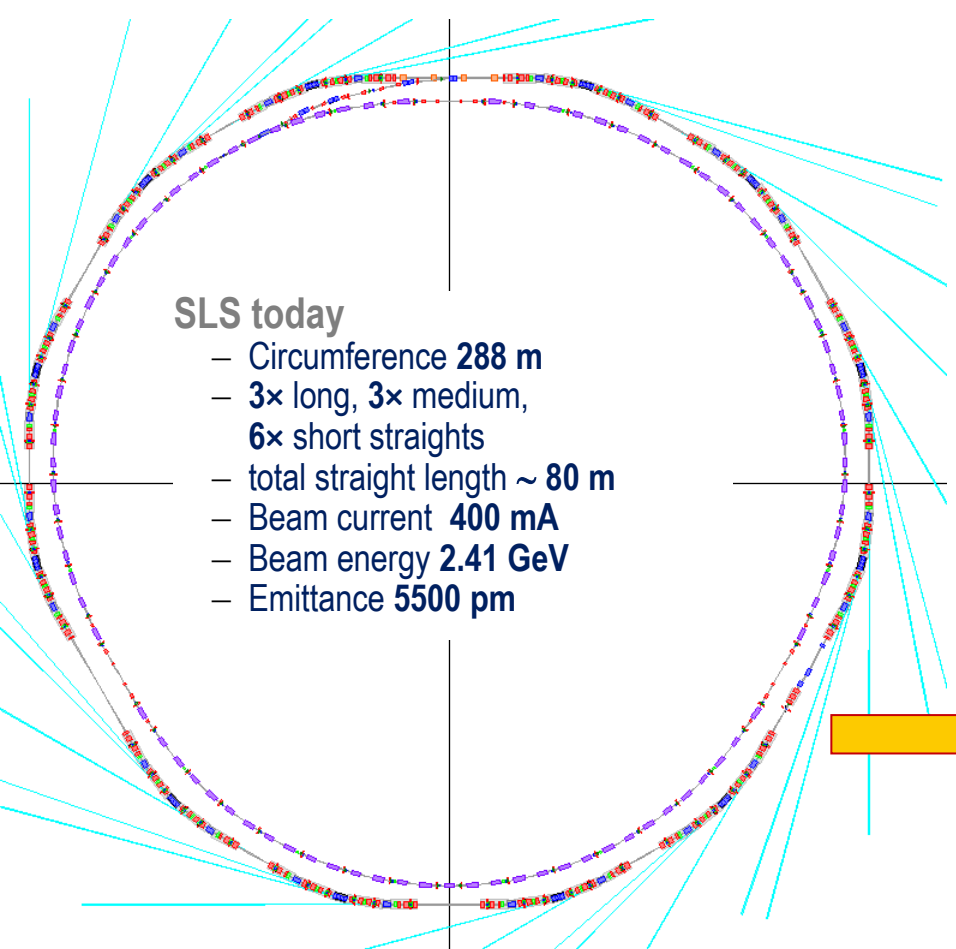
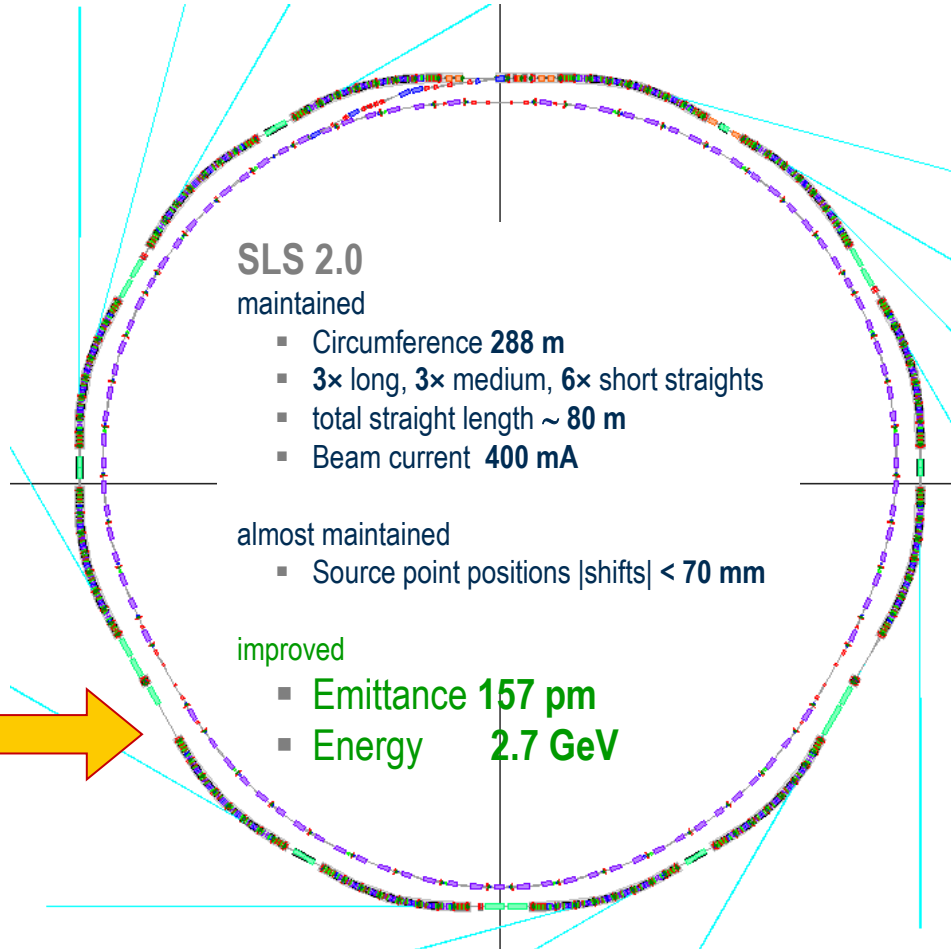
SLS → SLS 2.0



SLS today

- Circumference **288 m**
- **3×** long, **3×** medium, **6×** short straights
- total straight length ~ **80 m**
- Beam current **400 mA**
- Beam energy **2.41 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**

almost maintained

- Source point positions |shifts| **< 70 mm**

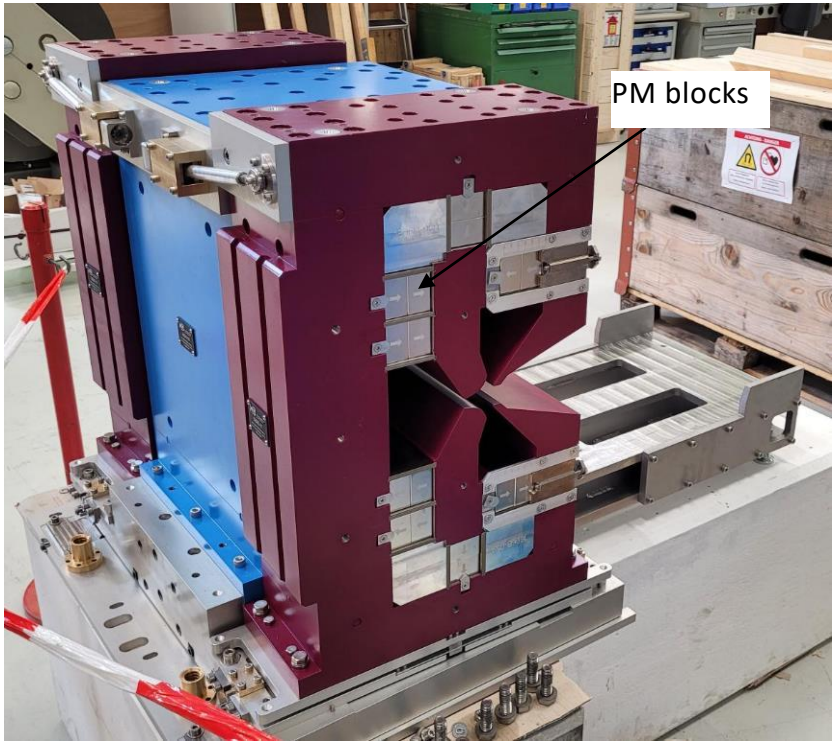
improved

- Emittance **157 pm**
- Energy **2.7 GeV**

Magnet preparation

All **corrector magnets** measured and within specs:

- Horizontal: 600 urad max
- Vertical: 400 urad max



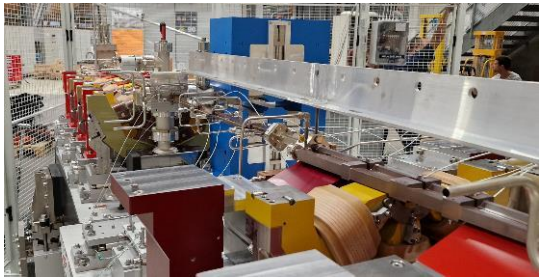
Triplet assembled with Permanent Magnets

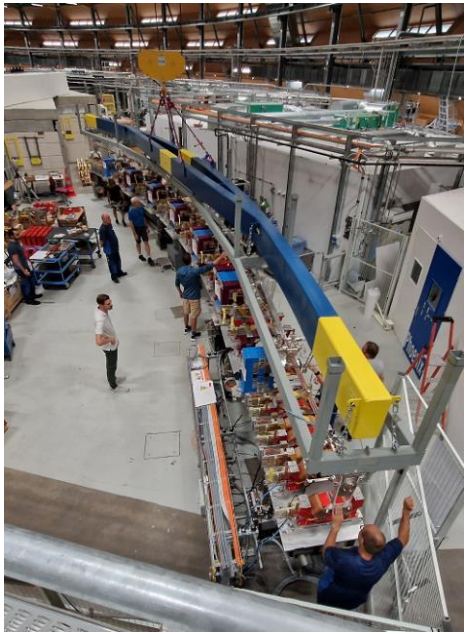
- **Deflection angle: 5.48 °**

Sextupoles

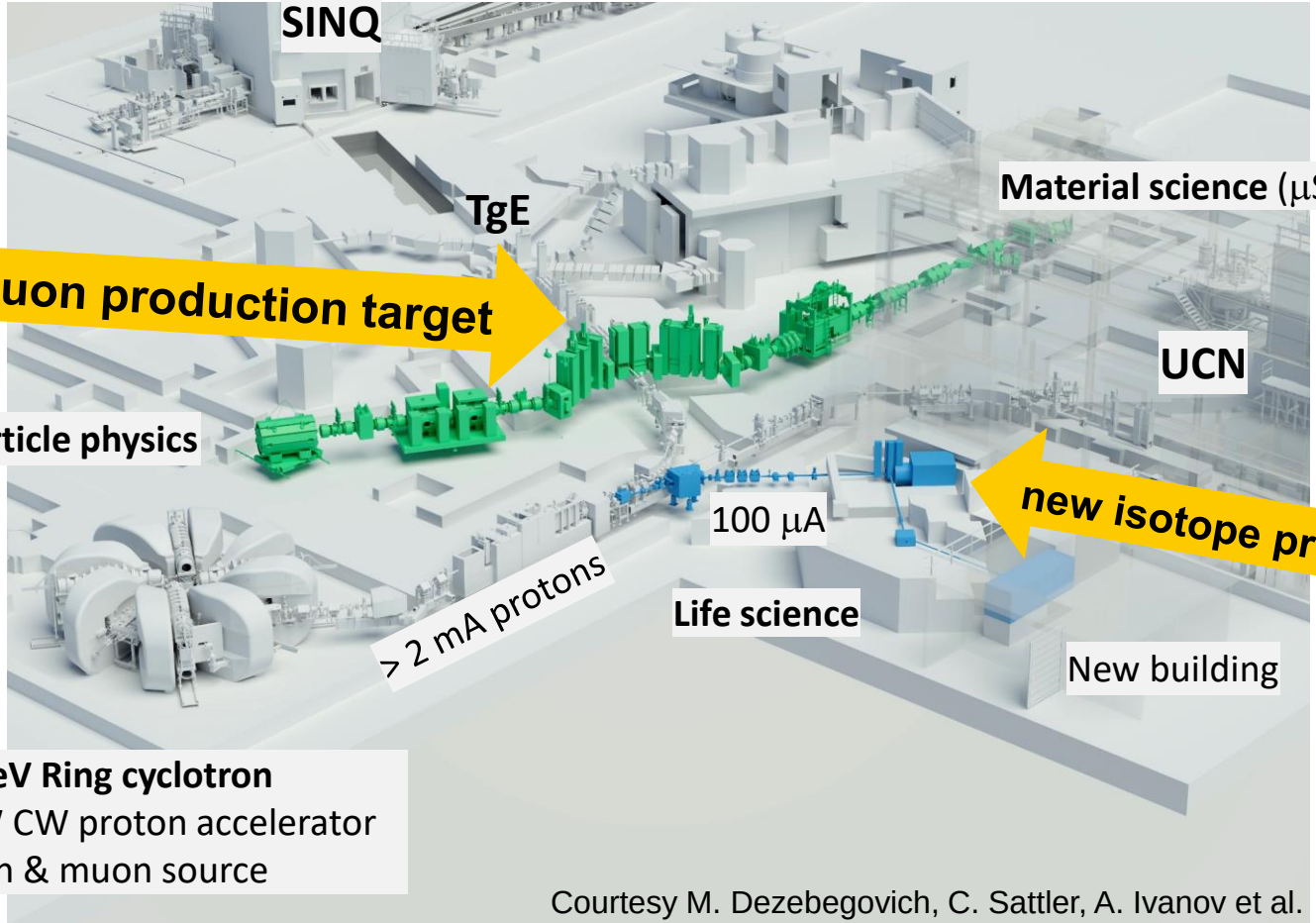
SLS 2.0 I&L: mock-up and first vacuum chamber

Mock-up: marriage of first vacuum chamber with arc on 12.09.2023





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.

IMPACT = HIMB + TATTOOS

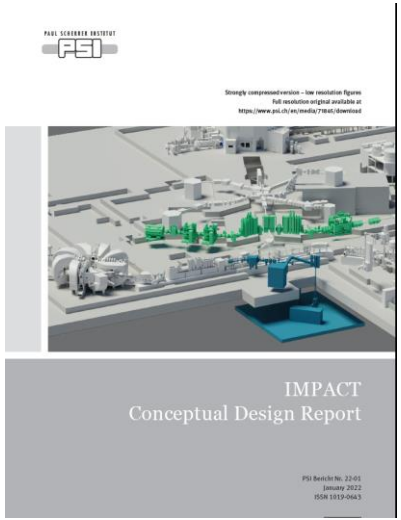
Isotope and Muon Production with advanced cyclotron and target technology

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

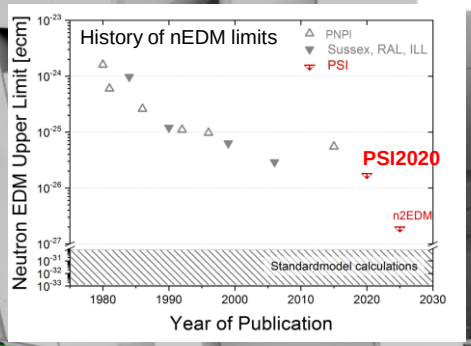
https://www.dora.lib4ri.ch/psi/islandora/object/psi%3A41209

n2EDM - High sensitivity search for a permanent electric dipole moment of the neutron (nEDM)

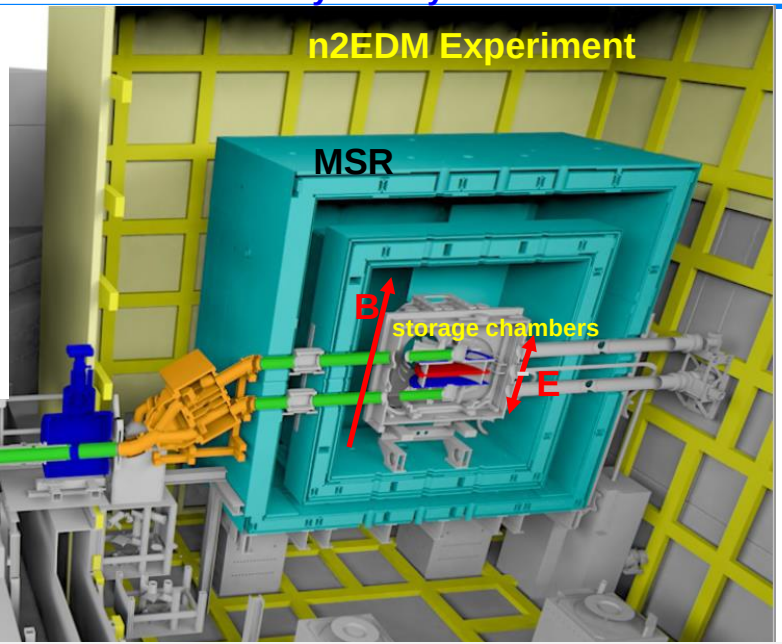
Helps to understand matter-antimatter asymmetry

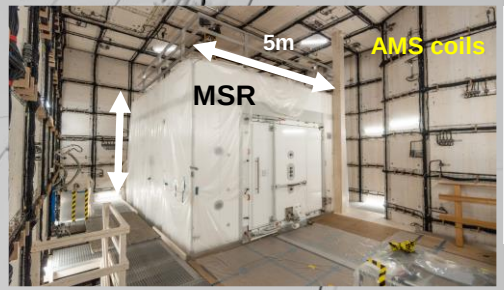
ultracold neutron (UCN) source

solid deuterium based high intensity UCN source in operation since 2011 serves $5x10^6$ UCN every 300s to experiments



n2EDM Experiment





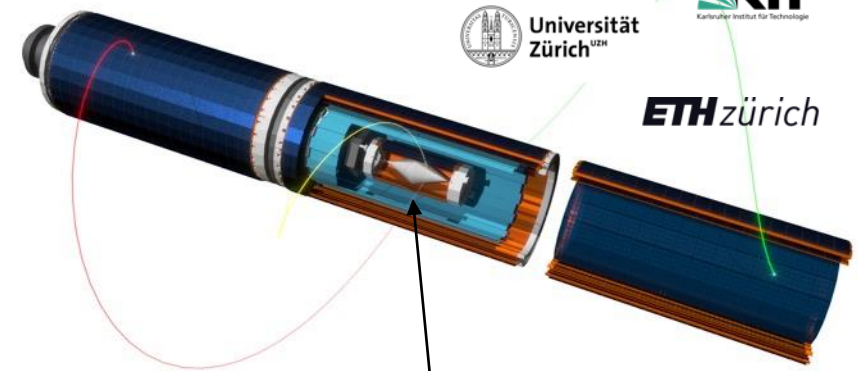
Status:

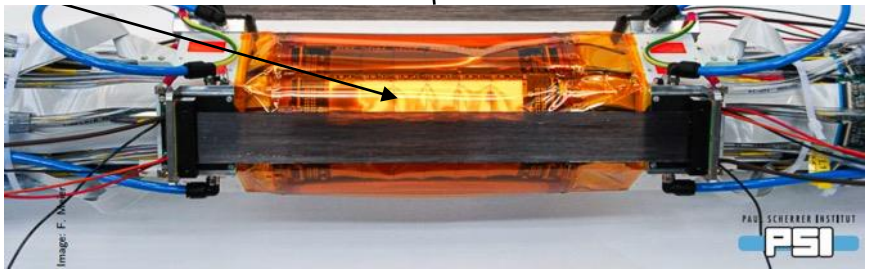
- record magnetically shielded room - shielding factor 100`000 at 0.01Hz - **operating**
- 57 km coils for active magnetic shield - **operating**
- magnetic field system at 1 μT and 60 ppm homogeneity - **operating**
- UCN chambers and beamline - **commissioning**
- start nEDM measurements 2024 - 500 days for **10^{-27} e·cm sensitivity goal in baseline**
- planned 'MAGIC field' phase with further significant improvement

nEDM is part of the European Strategy for Partice Physics and the NUPPEC Lond Range Plan.

The Mu3e experiment

- Search for LFV decay $\mu^+ \rightarrow e^+e^-e^+$
- First phase improves BR sensitivity to $2x10^{-15}$ (**500x improvement**)
  [NIMA: 1014 (2021) 165679]
- Discriminate signal from accidental background and conversion → use **tracking** and **timing** detectors
- Pixel detector with 0.1% X_0 per layer
  - **50μm HVMAPS sensors**
  - Ultralight Kapton mechanics with novel **Helium gas cooling**
- Detector concept validated successfully during integration run in summer 2021
- First physics data taking in **2025**





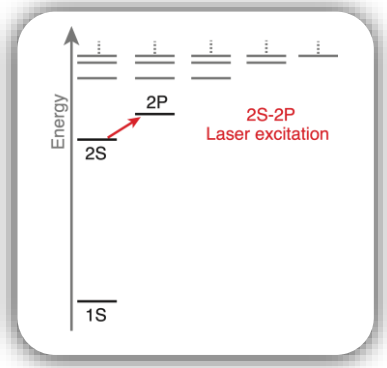
Inner Detector Prototype

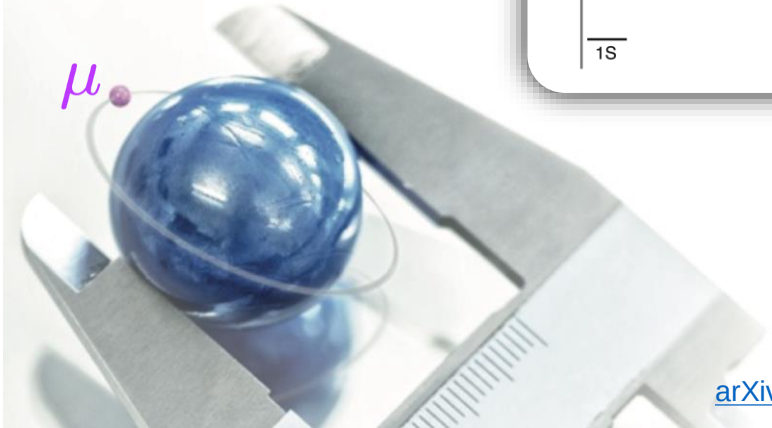
The 3He nuclear charge radius (CREMA collaboration)

Principle

- Measure several 2S-2P transitions in $\mu^3\mathrm{He}^+$ ion (H-like system)
- Extract the nuclear charge radius of ^{3}He 15x better than from electron scattering

$$r(^3\mathrm{He}) = 1.97007(94)\,\mathrm{fm}$$

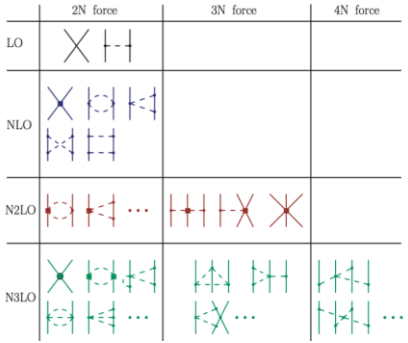




arXiv:2305.11679

Impact

- **Nuclear theory:**
  Similar to masses and magnetic moments this radius is a benchmark for ab initio few-nucleon theories and for the development of the nuclear potential in the chiral approach.



- **Atomic theory:**
  Combined with ongoing measurements in He and He^+ it leads to exquisite tests of bound-state QED for two- and three-body systems with sensitivity to challenging higher-order contributions.

CHART – Switzerland

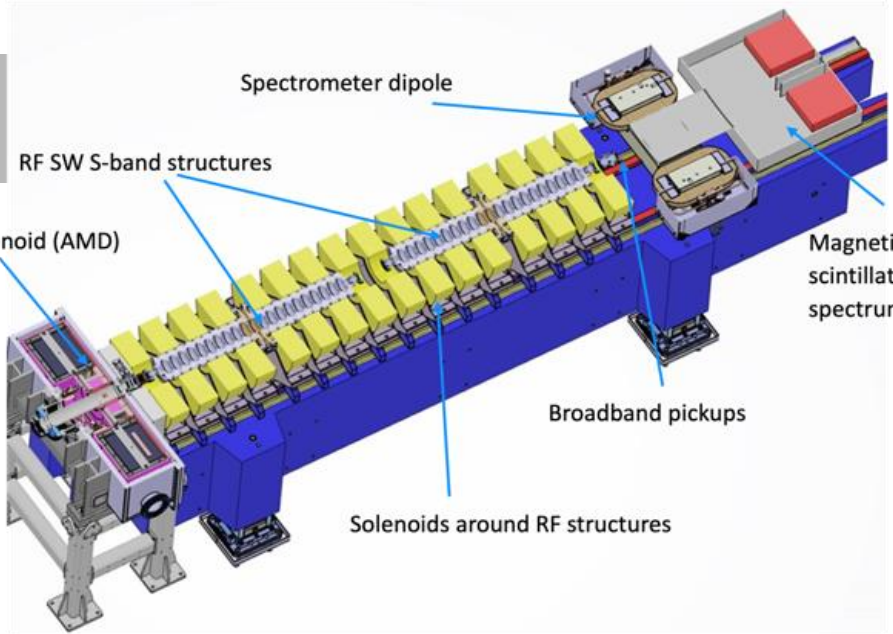
- founded in 2016 as umbrella organization for accelerator research in CH
- to support FCC and develop future accelerator technologies
- co-funded by CERN, PSI, ETHZ, EPFL and U Geneva.

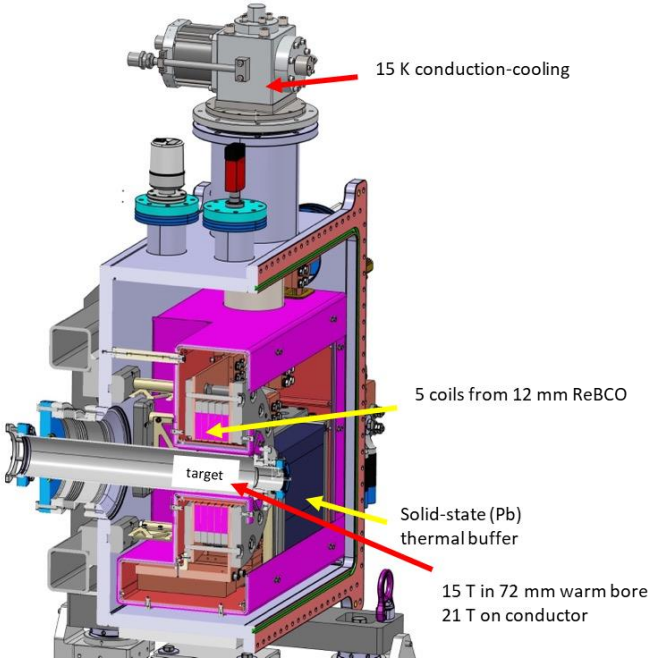
Key contributions to FCC Conceptual Design Study and Feasibility Study in several areas:

- 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

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

HTS superconducting magnet technology: developments

Using non-insulated HTS tapes, technology licensed from Tokamak Energy Ltd.:

18.2 Tesla @ 12K field reached recently in a solenoid with 5 cm diameter aperture (20.3 Tesla field on the conductor)

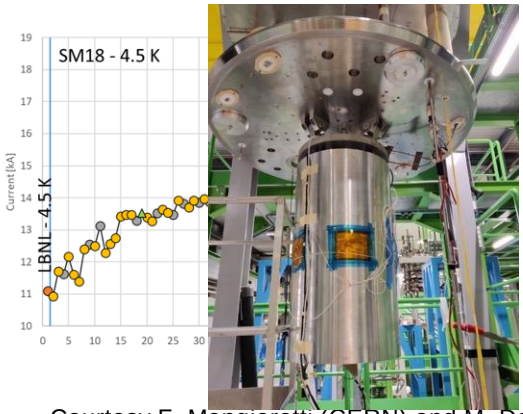
First CCT magnet: Record Field after a Long Delay

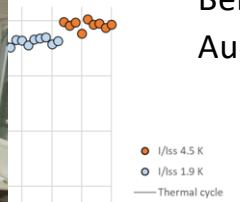
October 2019, the CD1 magnet was finalized and shipped to LBNL, Berkeley, US, for testing, then an Odyssey began:

- The magnet was blocked for 3 months in US customs and the transport crate was heavily damaged by a fork lift, COVID delayed the start of testing by 6 months.
- After several ramps, the LBNL test station had technical problems. The repair grew into an upgrade project.
- Upon invitation by CERN, the magnet was shipped there and arrived in November 2021, but a dangerous electrical incident at CERN interrupted all testing at CERN for several months, upon resumption of testing, HiLumi magnets received priority.

CD1 was eventually tested at CERN in November 2022.

It reached **10.1 T in the bore** at 94% of Iss at 1.9 K; 9.9 T and 100% of Iss at 4.5 K..



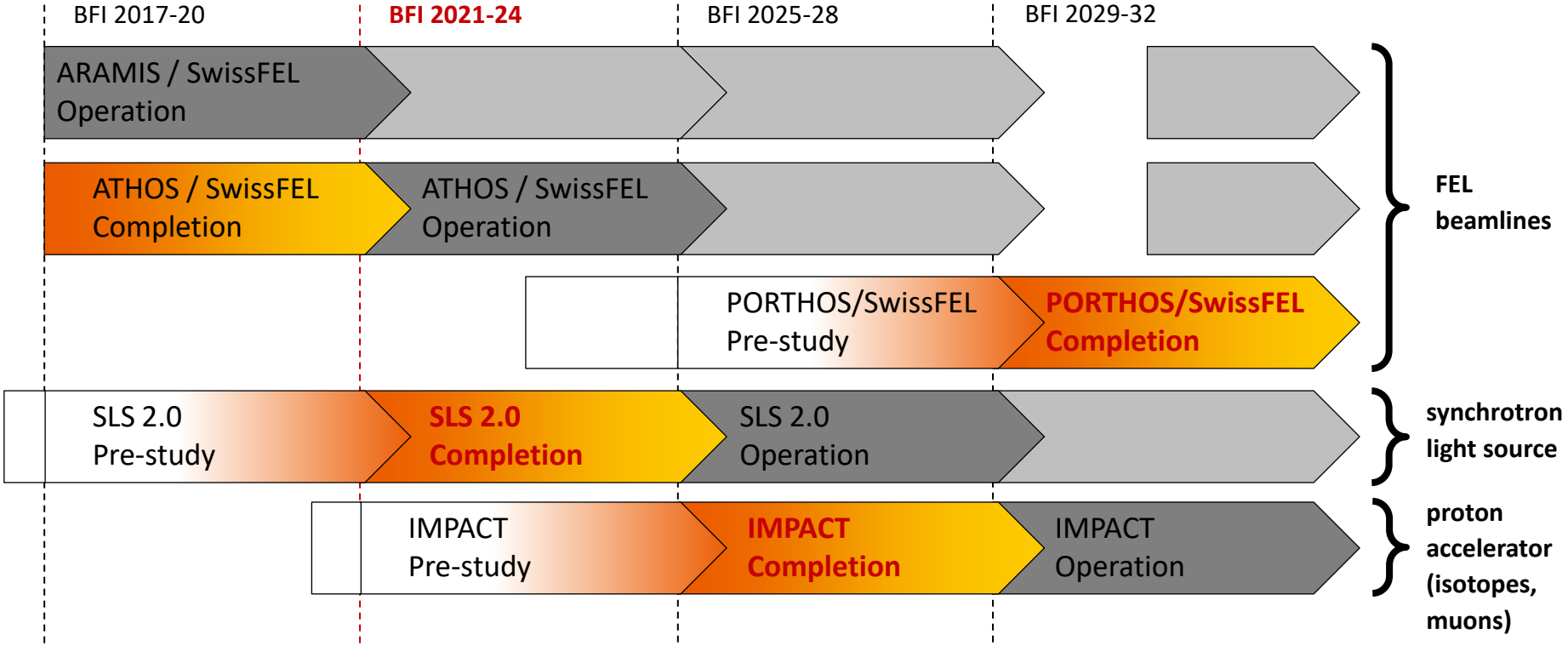


Bernhard Auchmann

Courtesy F. Mangiarotti (CERN) and M. Daly (PSI).

Bottom line: Stress-management works –
no conductor degradation from handling, assembly, powering, cycling.

Strategic Planning of Research Infrastructures



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