

CHART Collaboration

Lenny Rivkin

PSI and EPFL

Balsthal



www.chart.ch



Swiss Accelerator
Research and
Technology

EPFL **ETH** zürich

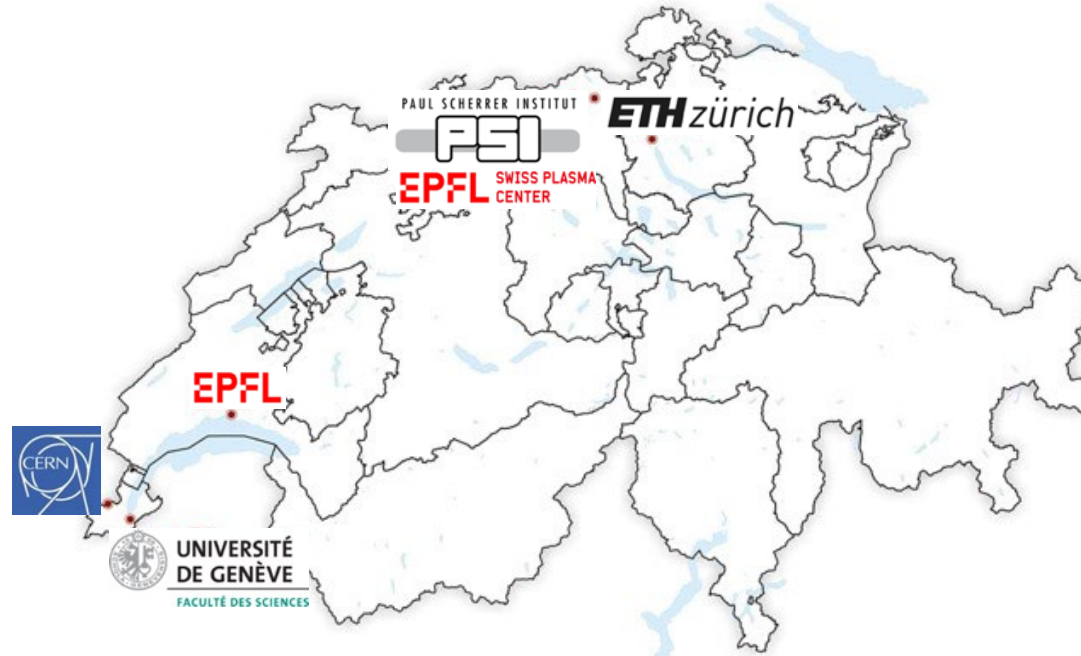


**UNIVERSITÉ
DE GENÈVE**

CHART Applied Superconductivity



- “CHART, the Swiss Center for Accelerator Research and Technology, was founded to support the future oriented accelerator project Future Circular Collider (FCC) at CERN and the development of **advanced accelerator concepts in Switzerland beyond the existing technology**. [...] **The high field magnet R&D has strong synergies with PSI projects** [...]”
- ~50% of the effort directed to Applied Superconductivity for accelerators.



PSI:
MagDev
FCCee HTS4

ETHZ:
MagRes
MagComp
MagNum
MagAM
FCCee CPES

UniGE
WireDev
WireChar



CHART – ongoing projects



- Topics and FTEs of ongoing **HFM projects** in CHART:

Name	Institute	Description	FTE	% Suisse National Funds
MagAM	ETHZ	Additive manufacturing for coil components	1	100
MagComp	ETHZ	Coil composite characterization and constitutive modeling	1	100
MagNum	ETHZ	Model-based systems engineering for magnets	1	100
MagRes	ETHZ	Crack-resistant resin development	1	51
MagDev1	PSI	SC magnet development	8	73
MagDev2	PSI	SC magnet development	8	54
WireChar	UniGE	SC wire and tape characterization	1	50
WireDev	UniGE	Nb ₃ Sn wire development	3	53

Tot 24

- **FCC Feasibility Study** and other CHART projects:

- FCC / LHC Lumi
- FCCee Beam Dynamics Simulation
- FCChh Stability
- FCCEe SPIN POL
- FCCee Lumi
- Muon Collider Feasibility Studies
- FCCee Injector
- FCC Geodesy
- FCCee CPES – cryogenic power supply development (1 FTE)
- FCCee HTS4 – HTS Short Straight Section Demo for FCCee (4 FTE)
- HTS Bulk Undulator – bulk REBCO undulator technology (2 FTE)
- FCC Geology 3D Model

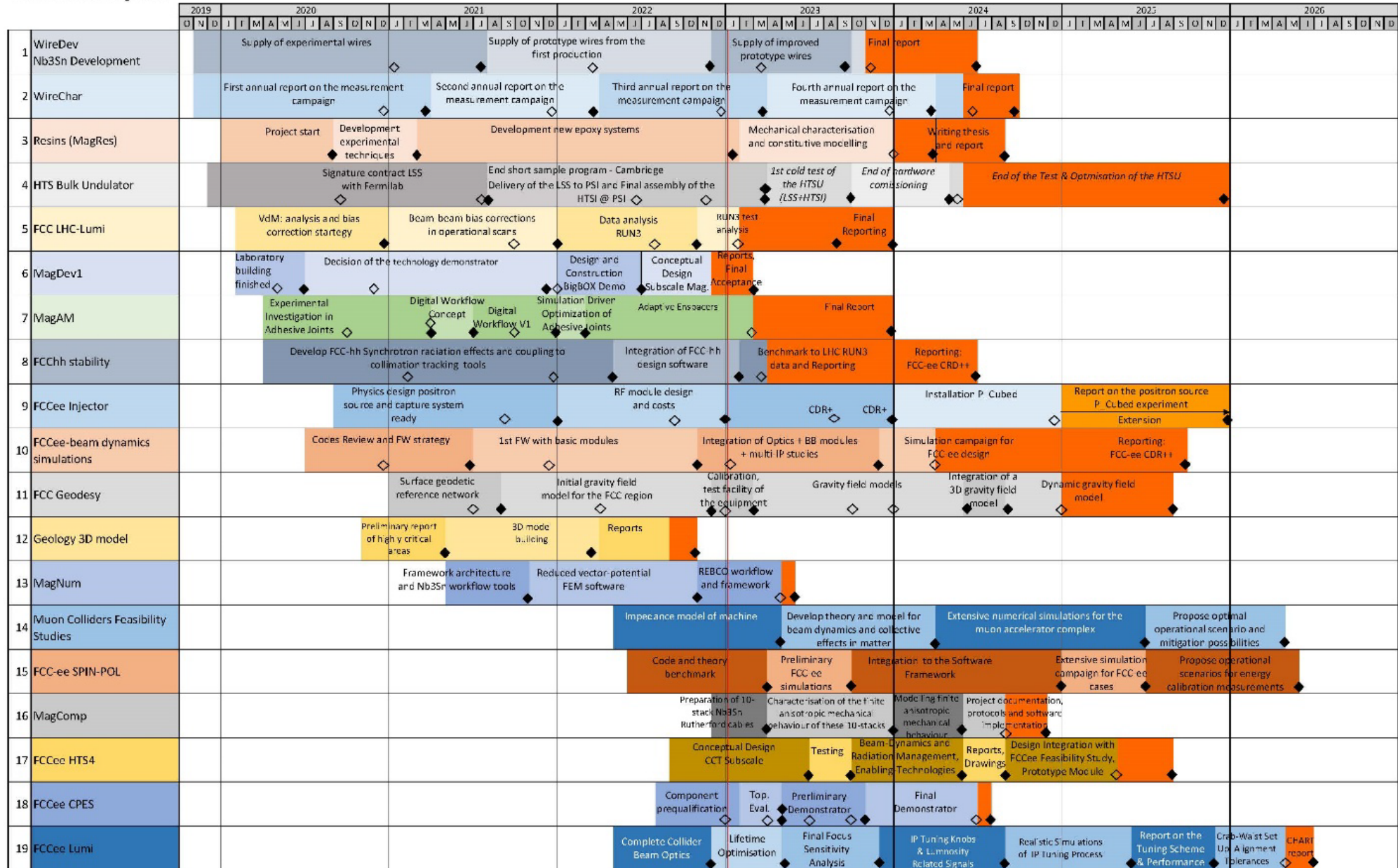
EPFL



ETH zürich



CHART 2 Projects



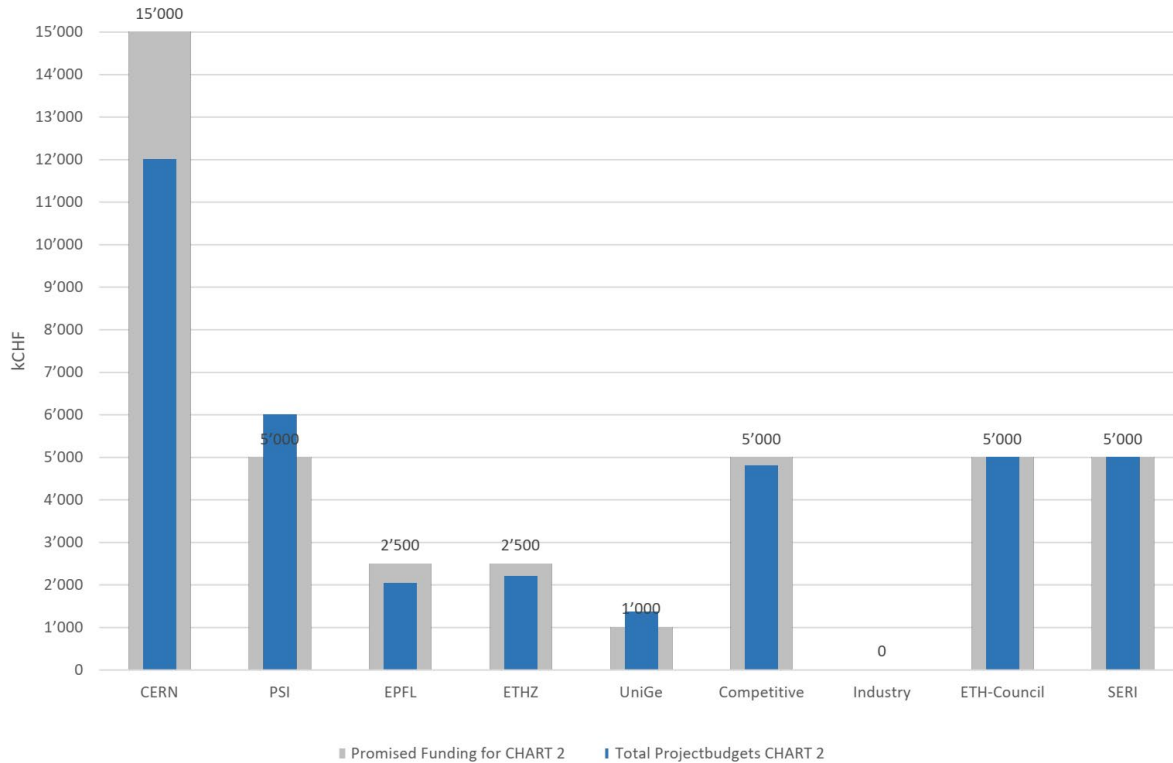
- ◇ Originally planned milestones
- ◆ Currently planned milestones
- Project delay (mainly because of COVID)
- Extension

+ MagDev2, MagMu (-> 40T HTS solenoid for muon collider, HE MuCol), MagNum2

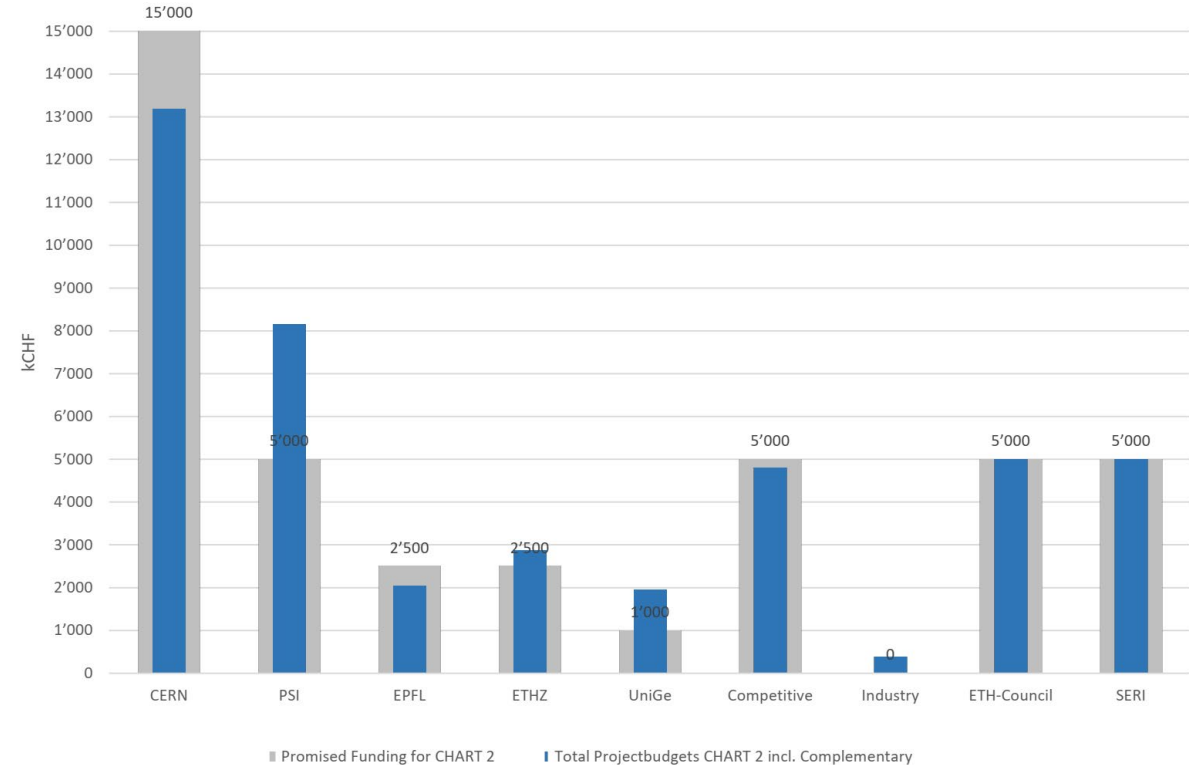
CHART II commitments & spending (Stand 7.3.2023)



Funding Overview and Project Budgets without Complementary

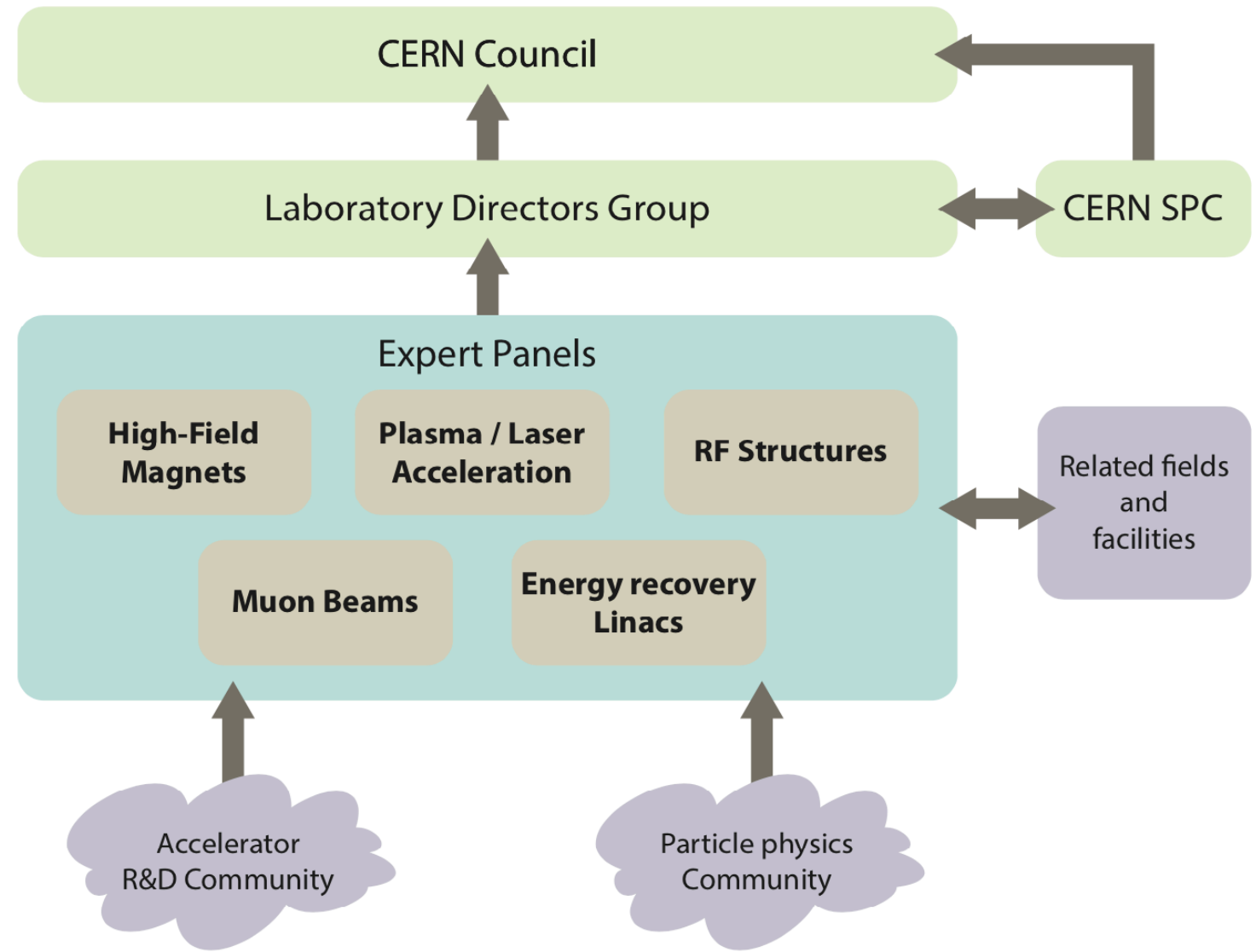


Funding Overview and Project Budgets inclusive Complementary



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra





SYNOPSIS OF THE 2021 ECFA DETECTOR RESEARCH AND DEVELOPMENT ROADMAP

by the European Committee for Future Accelerators Detector R&D Roadmap Process Group



Accelerator R&D for future colliders

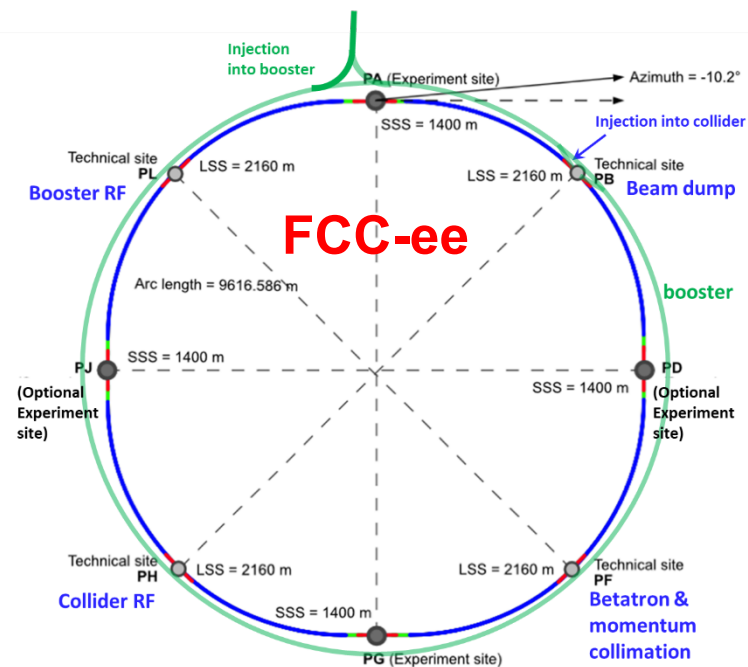
FCC integrated program

comprehensive long-term program maximizing physics opportunities

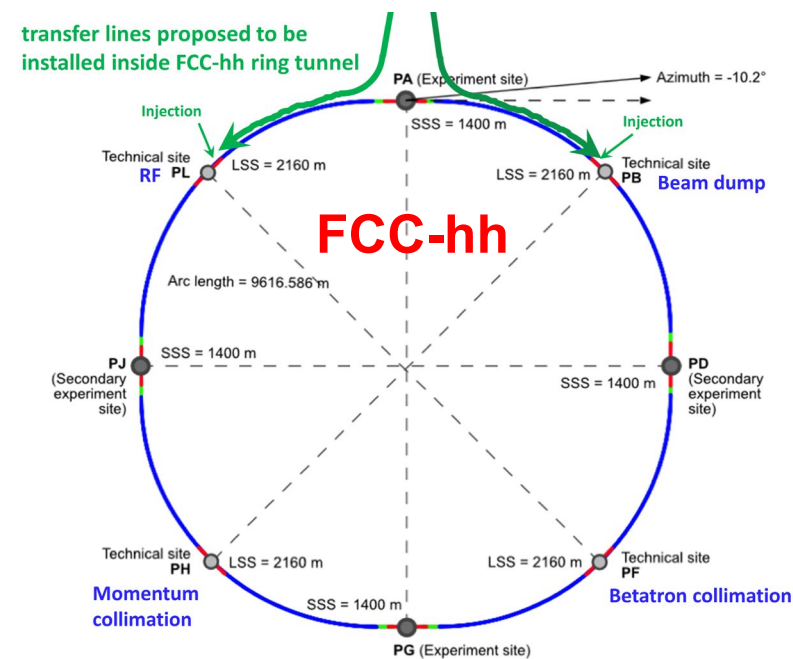
- stage 1: FCC-ee (Z, W, H, $t\bar{t}$) as Higgs factory, electroweak & top factory at highest luminosities
- stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, pp & AA collisions; e-h option
- highly synergetic and complementary programme boosting the physics reach of both colliders (e.g. model-independent measurements of the Higgs couplings at FCC-hh thanks to input from FCC-ee; and FCC-hh as “energy upgrade” of FCC-ee)
- common civil engineering and technical infrastructures, building on and reusing CERN’s existing infrastructure
- FCC integrated project allows the start of a new, major facility at CERN within a few years of the end of HL-LHC



2020 - 2040



2045 - 2063



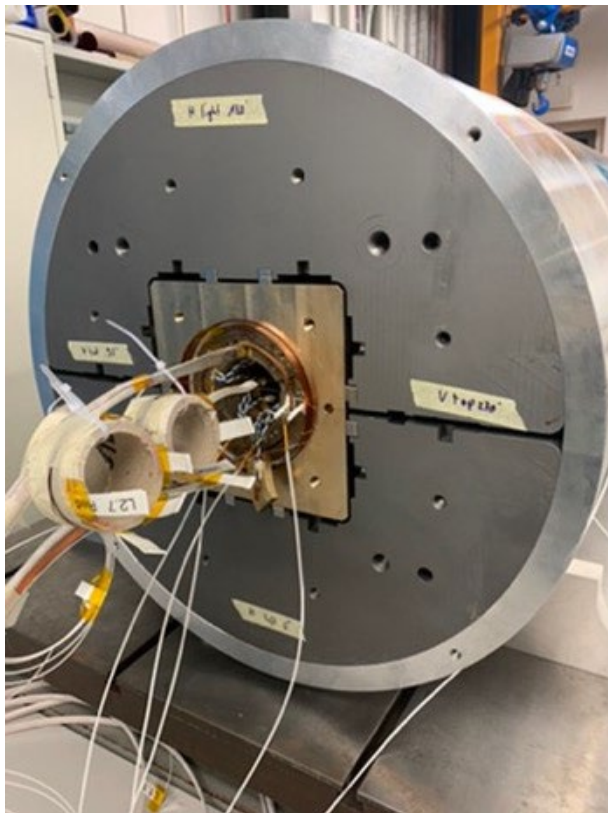
2070 - 2095

Needs long term commitment, good roadmap!

CHART: High Field Magnets



- outstanding team effort on a new type of Canted Cosine Theta, high field magnet
- the first magnet from PSI and very fruitful collaboration with LBNL colleagues.
- eventually tested at CERN in Nov 2022: **10.1 T in the bore at 1.9 K**; 9.9 T at 4.5 K.



MagDev Laboratory



Bernhard Auchmann



Douglas Araujo
Engineer LTS



Jaap Kosse
Engineer ReBCO



Colin Müller
Mechanic LTS



Henrique Rodrigues
Process Engineer ReBCO



Dmitry Sotnikovs
Design Engineer ReBCO



André Brem
Material Scientist



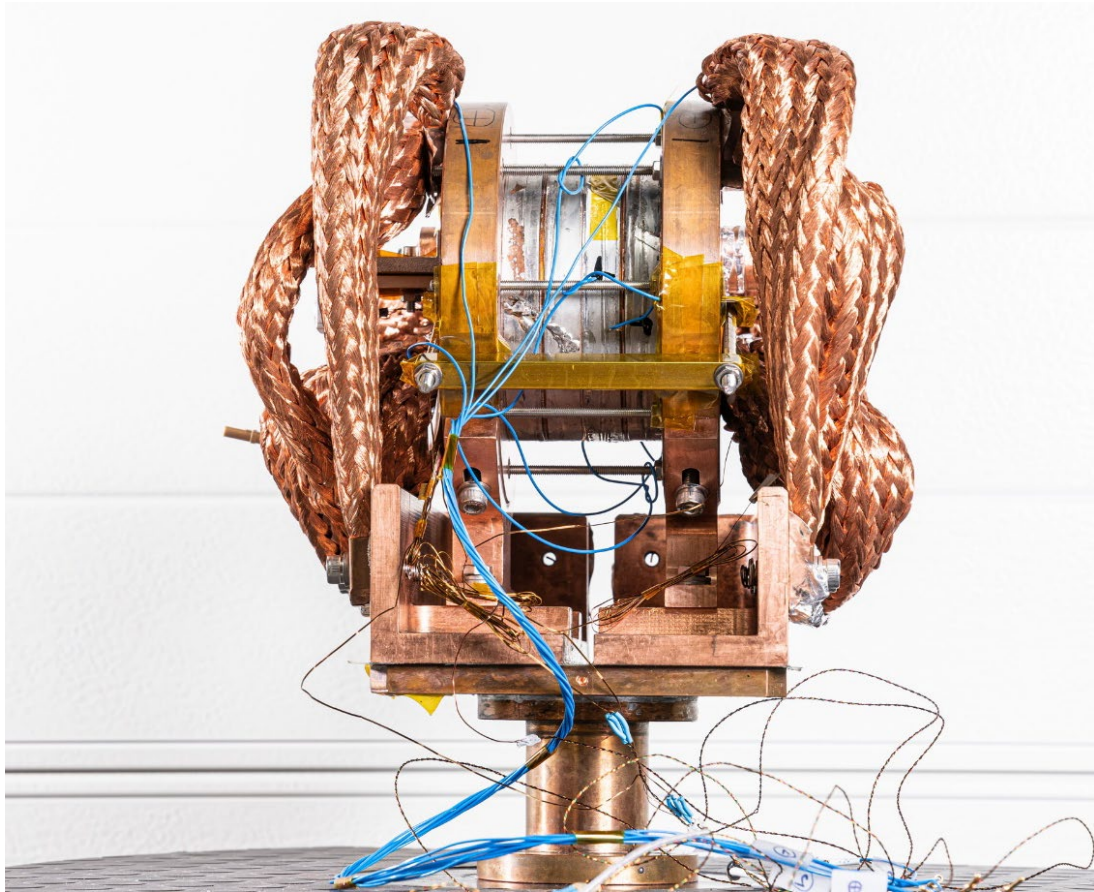
Thomas Michlmayr
CAD, Technical Design

CHART has demonstrated rapid entry into the High Field Magnet R&D

Recent difficulties (degradation issues) with the HL-LHC high field magnets development point to the need to re-examine some of the basics

- ❖ material science input may be urgently needed to understand the conductor robustness under extreme transverse magnetic pressure and longitudinal forces
- ❖ CHART partners have launched a wide front of such projects
- ❖ Test facilities, allowing for a rapid turn-around of small samples

CHART: Magnet technology development High Temperature Superconductor (HTS)

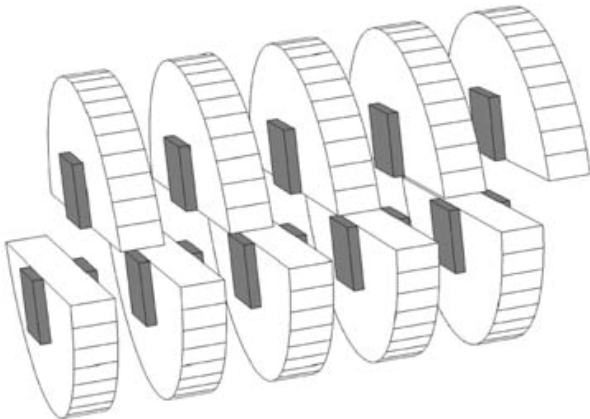


B.Auchmann & CHART magnet team

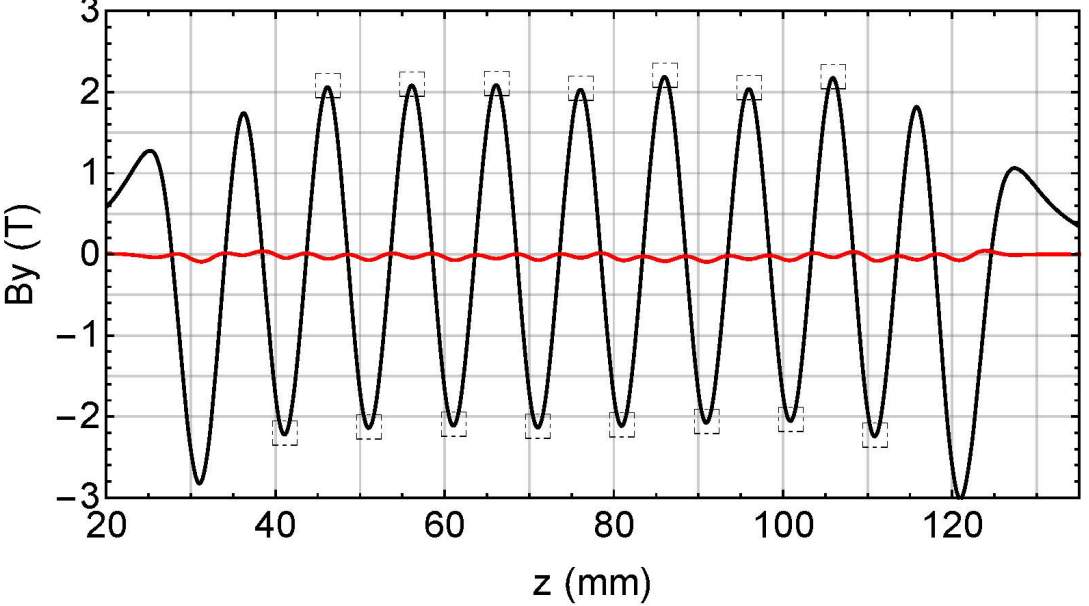
- ReBCO conductor
 - 18.2 Tesla solenoid field
 - Cryogen free cooled @ 12K
- **makes s.c. technology available for smaller & cost efficient accelerators**
- **cryogenic efficiency much improved**
- **Applications for light sources and neutron scattering (recent R'Equip)**

HTS superconducting magnet technology undulators

Using bulk HTS material: has reached 2 Tesla for very short period magnets
Put the structure into a solenoid magnet, cool it and trap the field

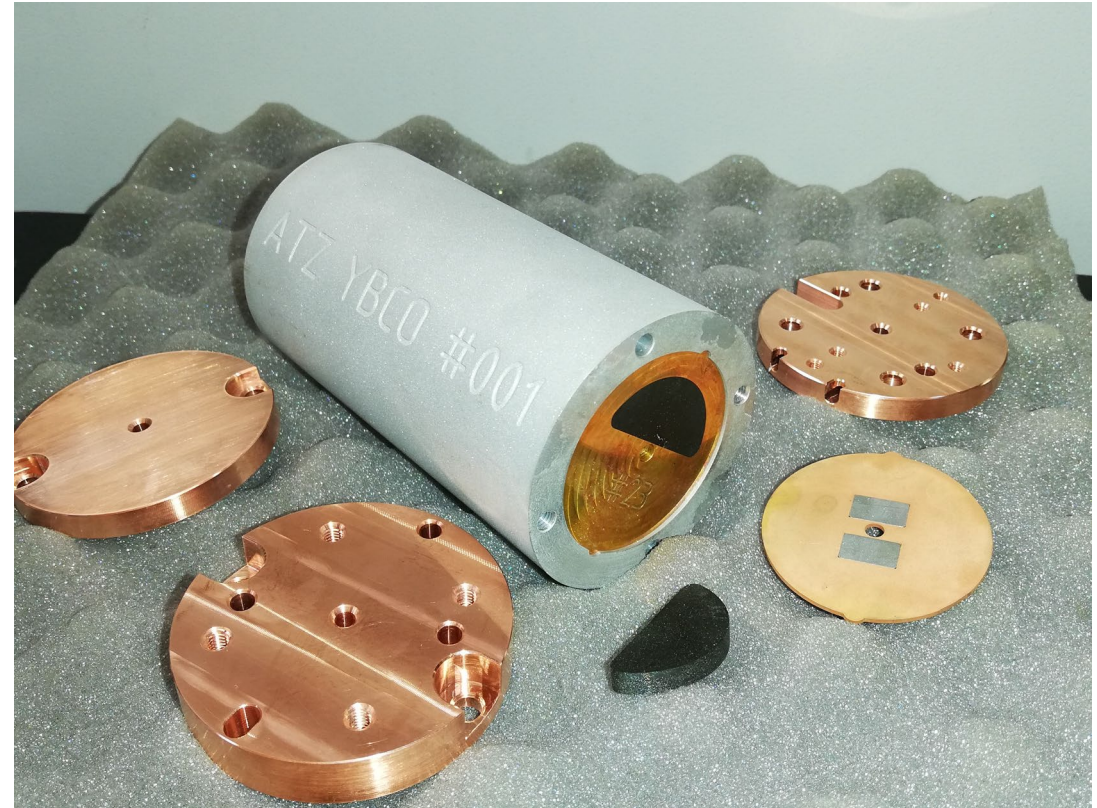
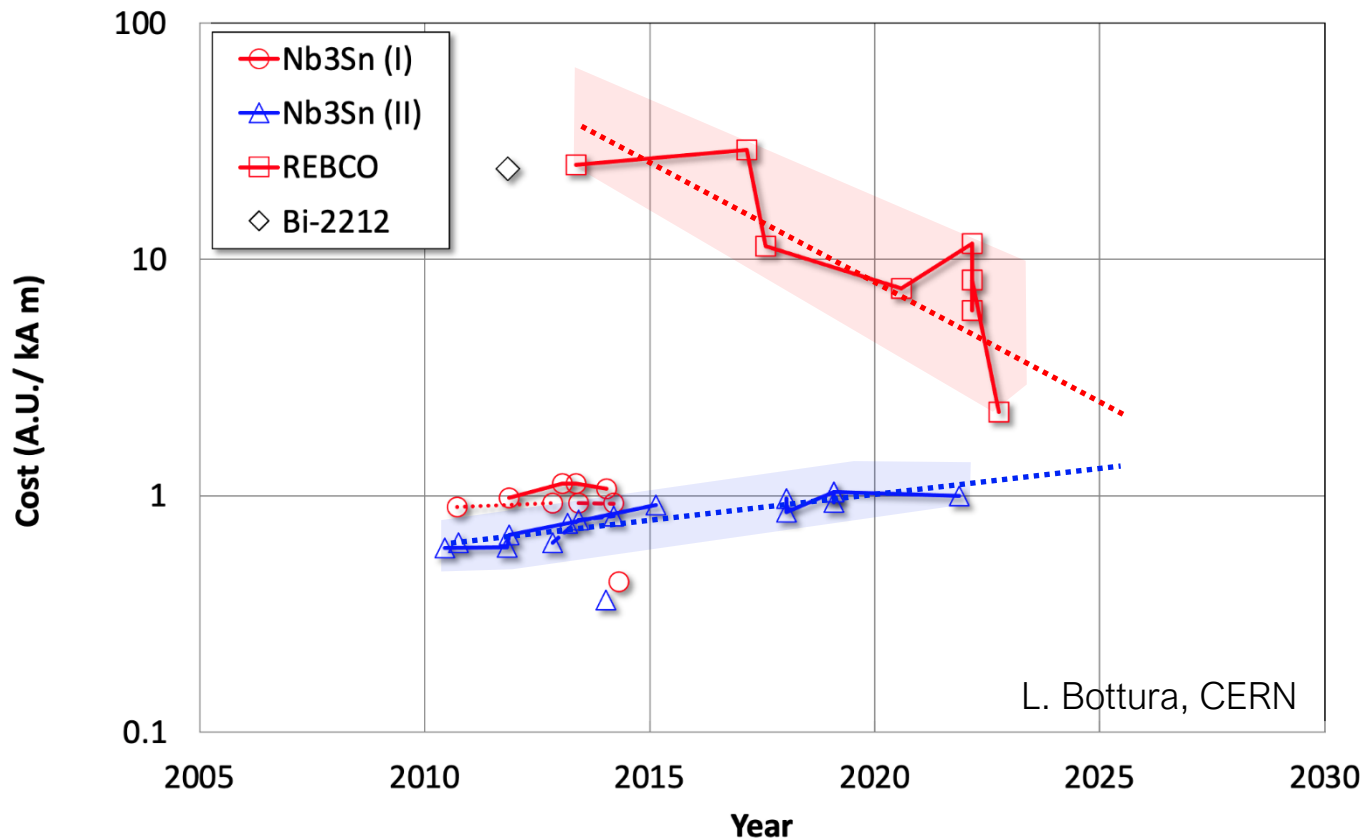


Cooling @ 10T / Solenoid @ 0.0T / 10.0K



HTS Magnet technology developments:

- developments for fusion (Tokamak Energy Ltd., UK)
- HTS based undulators for light sources
- HTS based low power consumption magnets



Marco Calvi, PSI

CHART 2025 - 2028

CHART/RM/02

The present CHART-2 funding is until 2024.
Main lines of development beyond 2024:

- **Future CERN projects: FCCee and FCChh**
- **High Field Magnets**
- High-gradient RF: **positron source**
- Photon science applications: HTS magnets
- **High-gradient plasma and laser:**
light sources and compact accelerators
- **Muon Colliders:** beam stability studies, magnets
- Energy efficient accelerators, ERL options



Swiss Accelerator
Research and
Technology

CHART Roadmap

ACCELERATOR SCIENCE AND TECHNOLOGY RESEARCH AND
DEVELOPMENT

January 18, 2022



Collaborating international partners of CHART include:

- [TU Twente](#), Enschede, Netherlands
- [TU Darmstadt](#), Germany
- [USMDP](#) Magnet Development Program, Berkeley, USA
- [University of Cambridge](#), UK
- [LEAPS](#), League of European Accelerator based Photon Sources
- [BNL](#), Brookhaven National Laboratory, USA
- [KEK](#), High Energy Accelerator Research Organization, Tsukuba, Japan
- [IJCLab](#), Laboratoire de Physique des 2 infinis Irène Joliot-Curie, Orsay, France
- [INFN Frascati](#), Italy
- [SLAC National Accelerator Laboratory](#), Menlo Park, USA
- [University of Oxford](#), UK
- [FERMILAB](#), Fermi National Accelerator Laboratory, USA
- [RIKEN SPring-8 Center](#), Japan
- [Kyoto University](#), Japan
- [ESRF](#), European Synchrotron Radiation Facility, Grenoble, France

Thank you