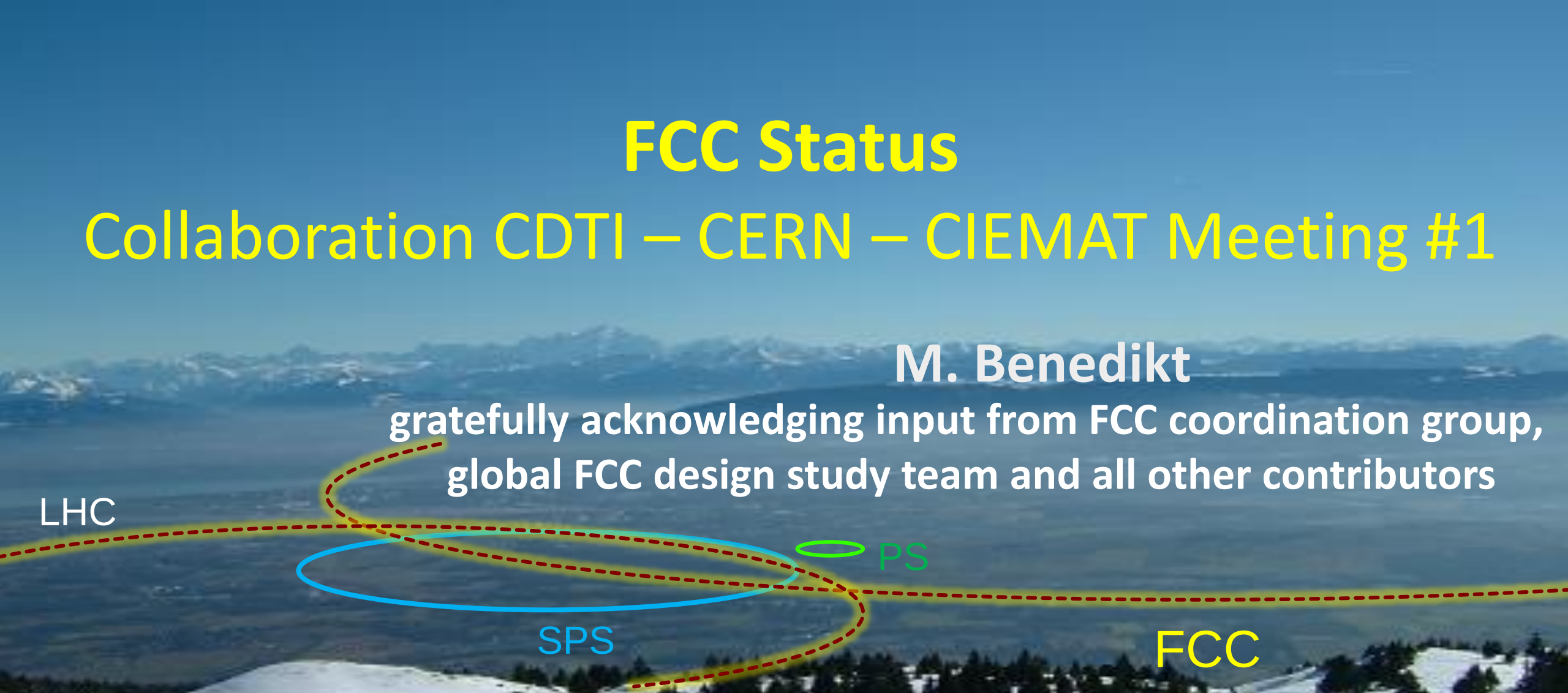
FCC Status

Collaboration CDTI – CERN – CIEMAT Meeting #1

M. Benedikt

gratefully acknowledging input from FCC coordination group, global FCC design study team and all other contributors



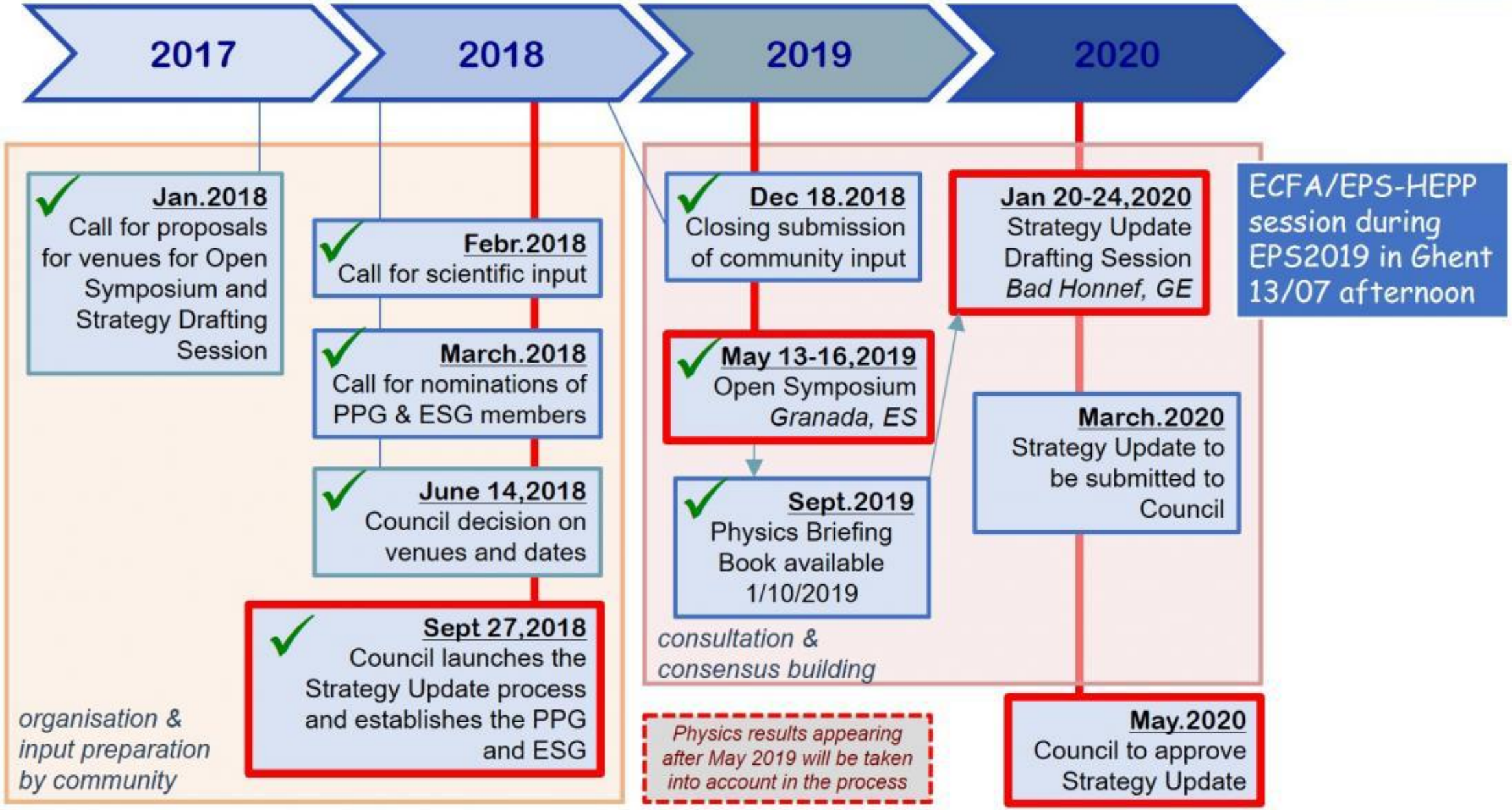
http://cern.ch/fcc

*Work supported by the **European Commission** under the **HORIZON 2020 projects EuroCirCol**, grant agreement 654305; **EASITrain,** grant agreement no. 764879; **ARIES**, grant agreement 730871; and **E-JADE,** contract no. 645479*

European Commission | Horizon 2020 European Union funding for Research & Innovation

photo: J. Wenninger

EPPSU 2020 timeline



European Particle Physics Strategy Update (EPPSU)

Statement from the European Strategy Group after the Bad Honnef drafting meeting (20-24 Jan. 2020)

- The drafting session of the European Strategy Group preparing the next European Particle Physics Strategy Update took place in Bad Honnef (Germany) between 21-25 January 2020. After a week of fruitful discussions involving senior figures of European and international particle physics, **convergence was achieved on recommendations** that will guide the future of the field.
- The drafting session marks a key stage of the strategy update process. The attendees of the Bad Honnef drafting session successfully carried out their ambitious task of identifying a set of priorities and recommendations. They built on the impressive progress made since the last update of the European Strategy for Particle Physics, in 2013, and the rich input received from the entire particle physics community in the current update process.
- The next step in this process will be to submit the document outlining the recommendations to the CERN Council. It **will be discussed by the Council in March** and submitted for final approval at an extraordinary **Council Session on 25 May, in Budapest, Hungary**. Once approved, it can be made public.

The European Strategy Group

(CERN Council 16 – 20 March 2020)

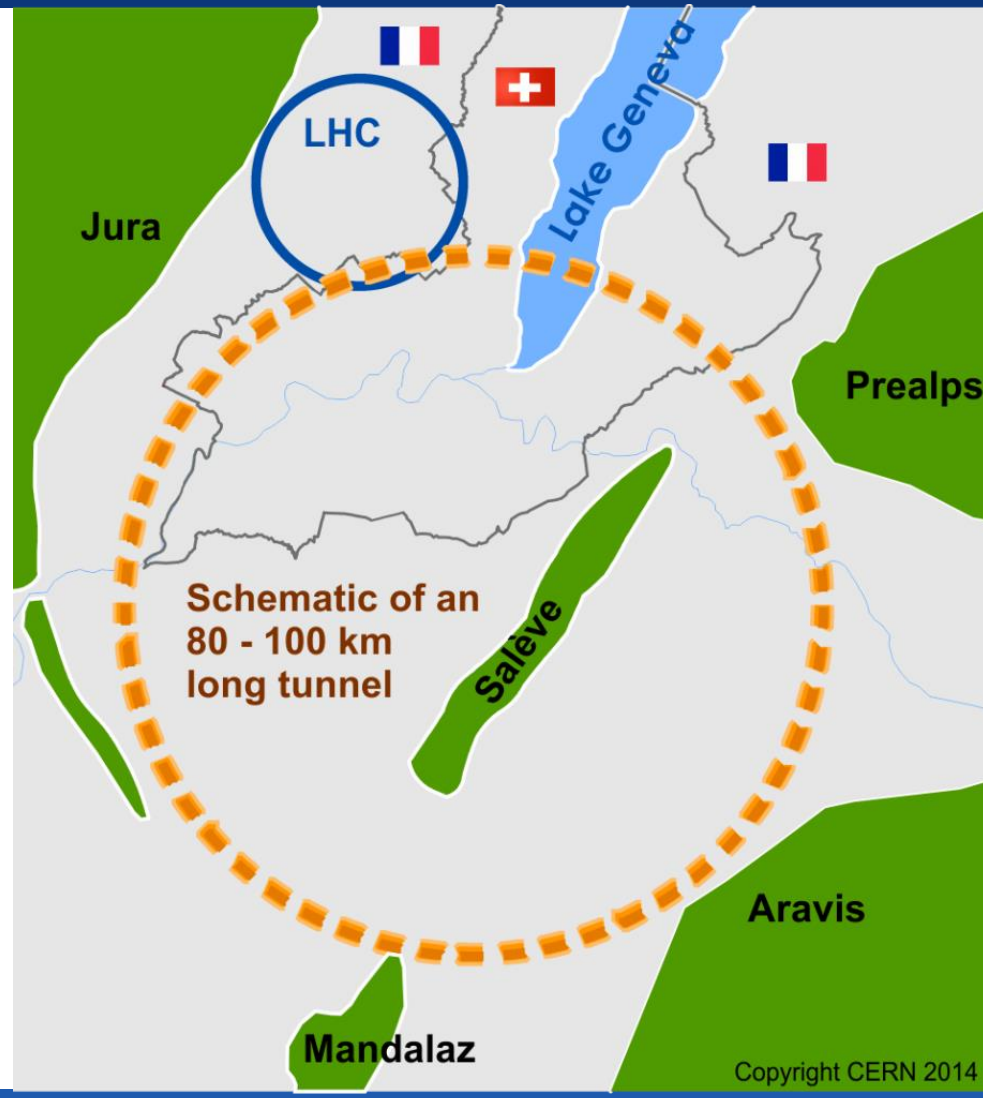
FCC overall strategy and status

CERN management fully supports the FCC Integrated Programme that was submitted to the ESG in December 2018.

- Peparations for all activities as identified in the FCC integrated project plan.

Technical areas:

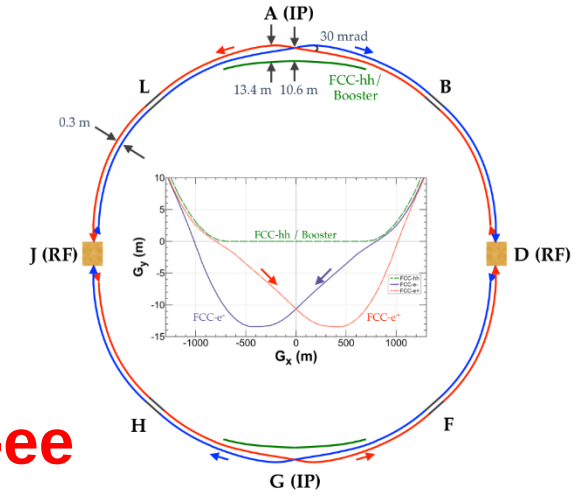
- Increase efforts on FCC-ee design including injector optimisation.
- FCC-ee 4 IP study with potential for energy saving, larger user community, shorter running time.
- Key technology programs SCRF and high-efficiency RF production for FCC-ee and HF SC magnets for FCC-hh.



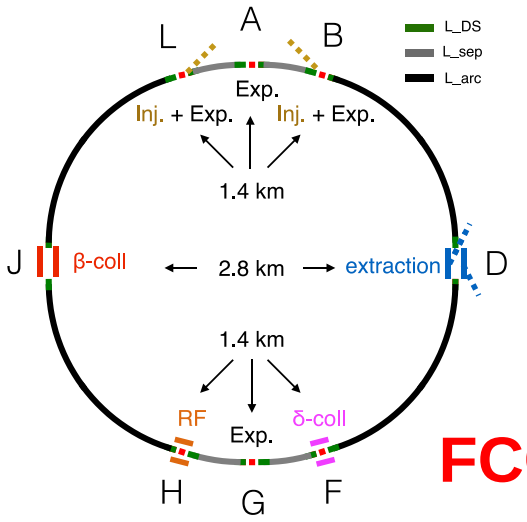
The FCC integrated program inspired by successful LEP – LHC programs at CERN

Comprehensive cost-effective program maximizing physics opportunities

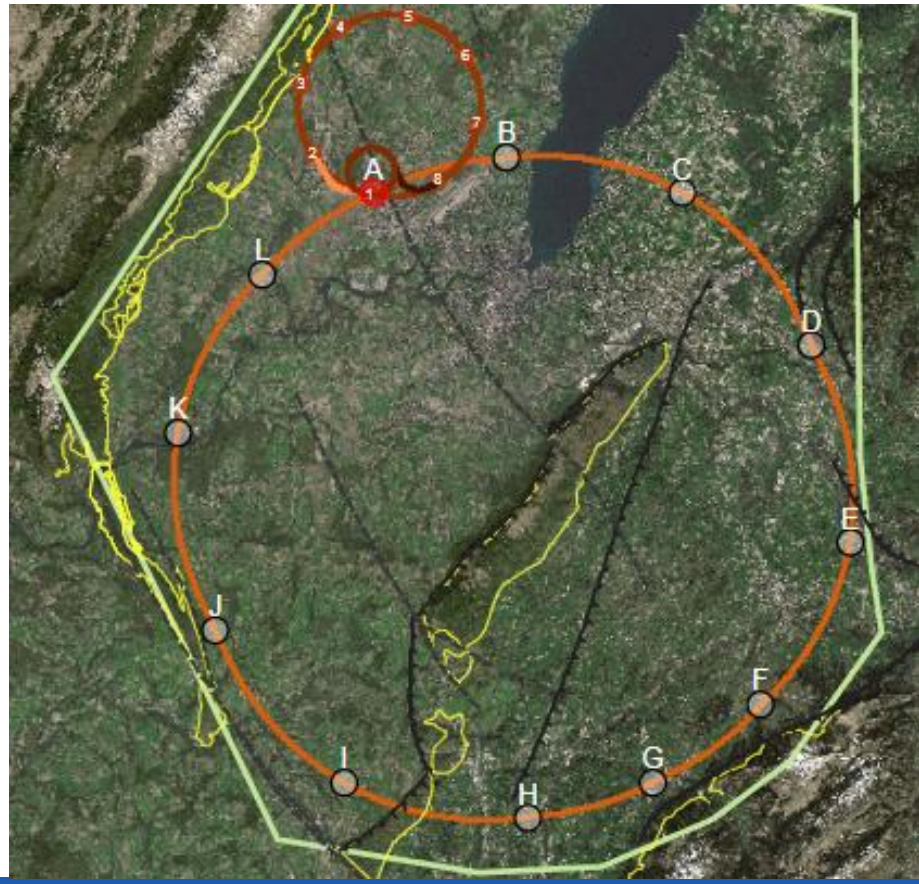
- **Stage 1: FCC-ee (Z, W, H, tt) as first generation Higgs factory, EW and top factory at highest luminosities.**
- **Stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, with ion and eh options.**
- Complementary physics
- Integrating an ambitious high-field magnet R&D program
- Common civil engineering and technical infrastructures
- Building on and reusing CERN's existing infrastructure.
- FCC integrated project plan is fully integrated with HL-LHC exploitation and provides for seamless continuation of HEP.



FCC-ee

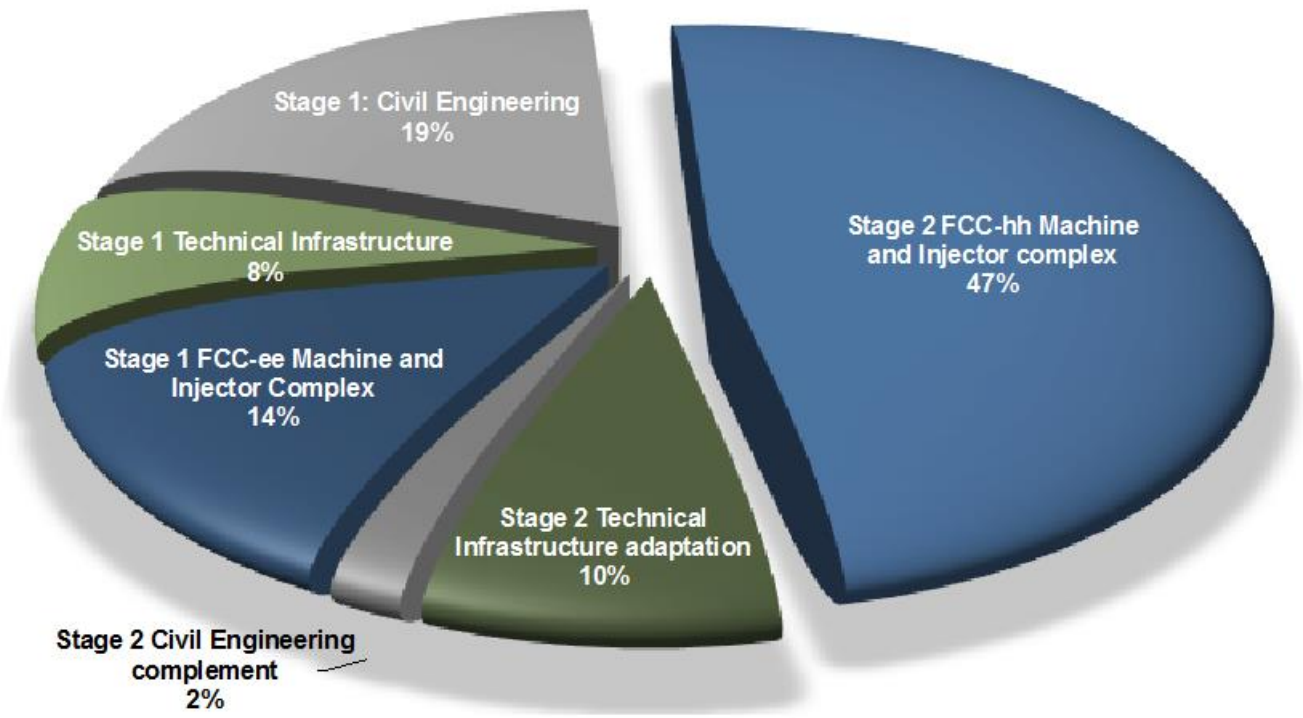


FCC-hh



FCC-integrated cost estimate

Domain	Cost in MCHF
Stage 1 - Civil Engineering	5,400
Stage 1 - Technical Infrastructure	2,200
Stage 1 - FCC-ee Machine and Injector Complex	4,000
Stage 2 - Civil Engineering complement	600
Stage 2 - Technical Infrastructure adaptation	2,800
Stage 2 - FCC-hh Machine and Injector complex	13,600
TOTAL construction cost for integral FCC project	**28,600**



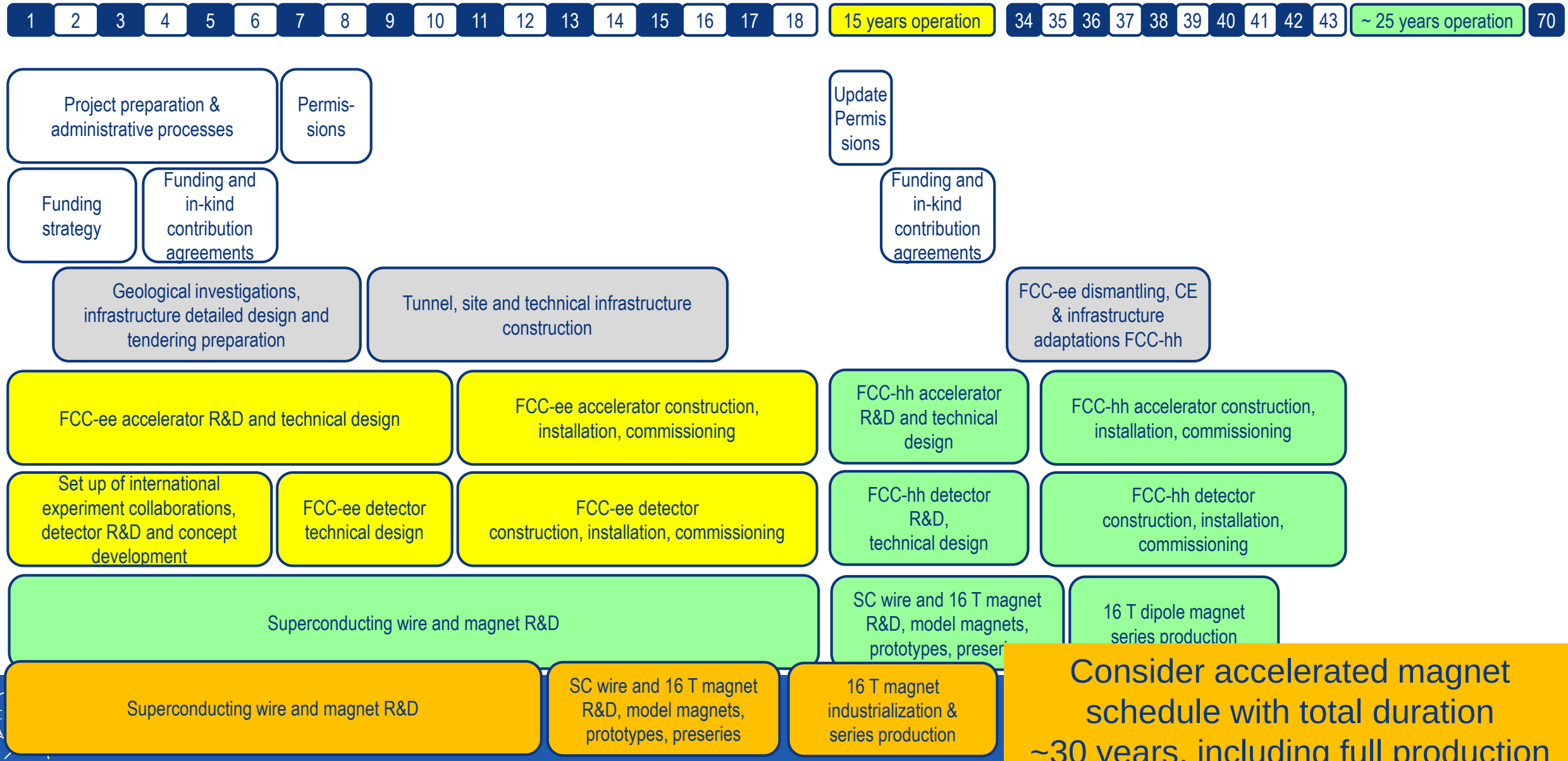
Total construction cost FCC-ee (Z, W, H) amounts to 10,500 MCHF & 1,100 MCHF (tt).

- Associated to a total project duration of ~20 years (2025 – 2045)

Total construction cost for subsequent FCC-hh amounts to 17,000 MCHF.

- Associated to a total project duration of ~25 years (2035 – 2060) (FCC-hh stand alone 25 BCHF)

FCC integral project technical schedule



Consider accelerated magnet schedule with total duration ~30 years, including full production

FCC main goals for 2020 - 2026

Overall goal:

- Perform all necessary steps and studies to enable a definitive project decision by 2025/26, at the anticipated date for the next ESU, and a subsequent start of civil engineering construction by 2028/29.

This requires successful completion of the following four main activities:

- Develop and establish a governance model for project construction and operation
- Develop and establish a financing strategy, including in-kind contributions
- Prepare and successfully complete all required project preparatory and administrative processes with the host states (debat public, EIA, etc.)
- Perform site investigations to enable CE planning and to prepare CE tendering..

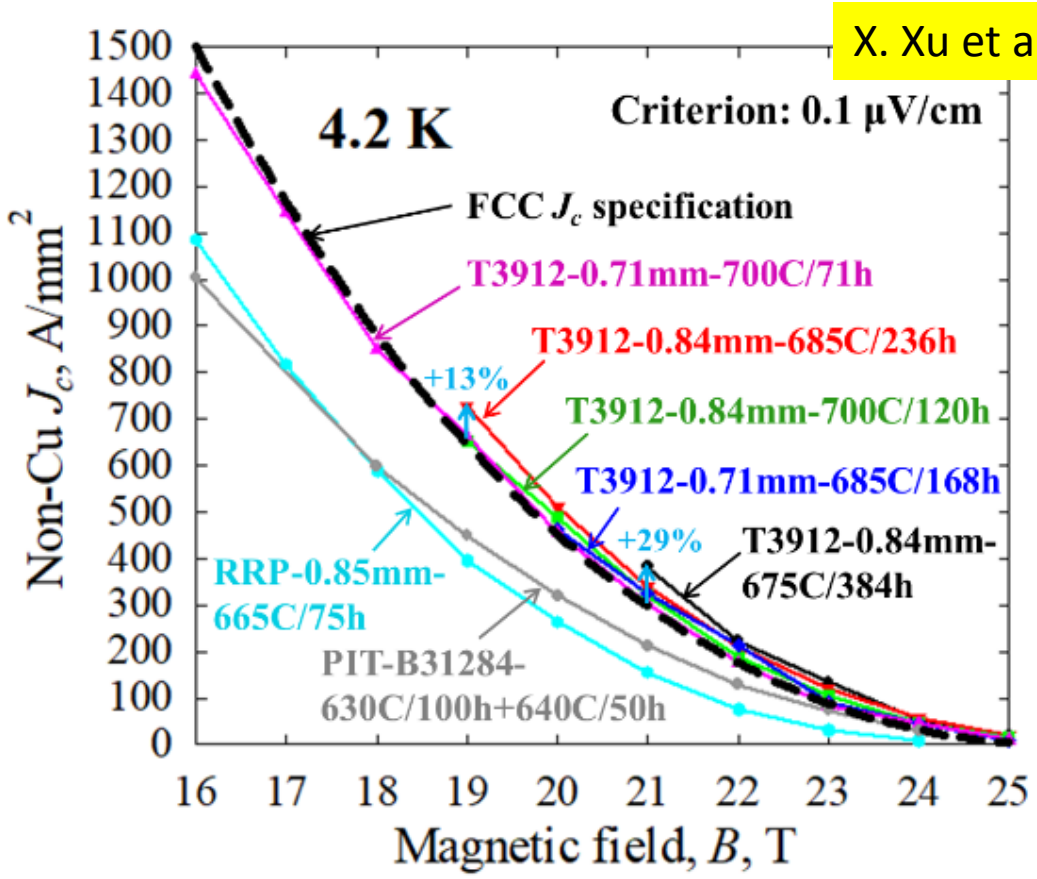
In parallel development preparation of TDRs and physics/experiment studies:

- Machine designs and main technology R&D lines
- Establish user communities, work towards proto experiment collaboration by 2025/26.

Status Nb_3Sn superconductor for 16 T

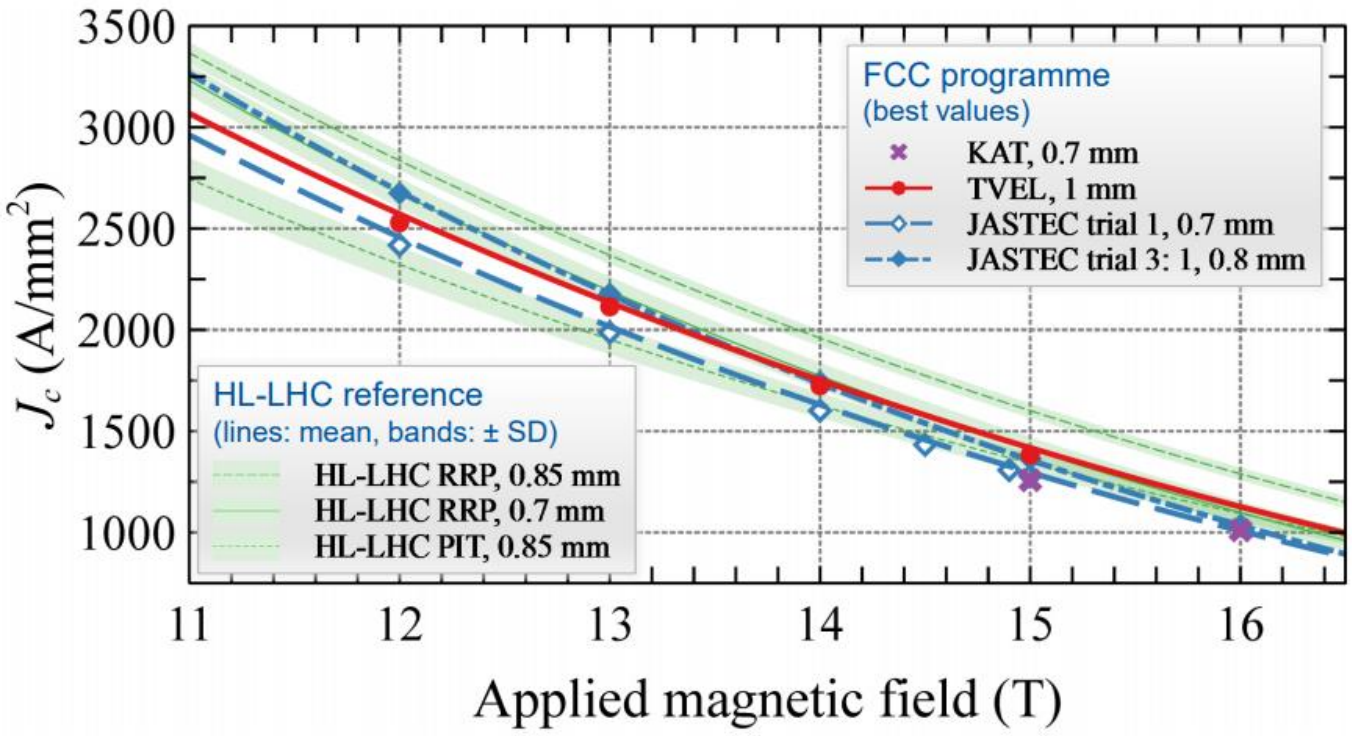
recent US wires with Artificial Pinning Centres "APCs" have reached FCC target J_c (50% above HL-LHC wire, →size & cost) …

X. Xu et al.



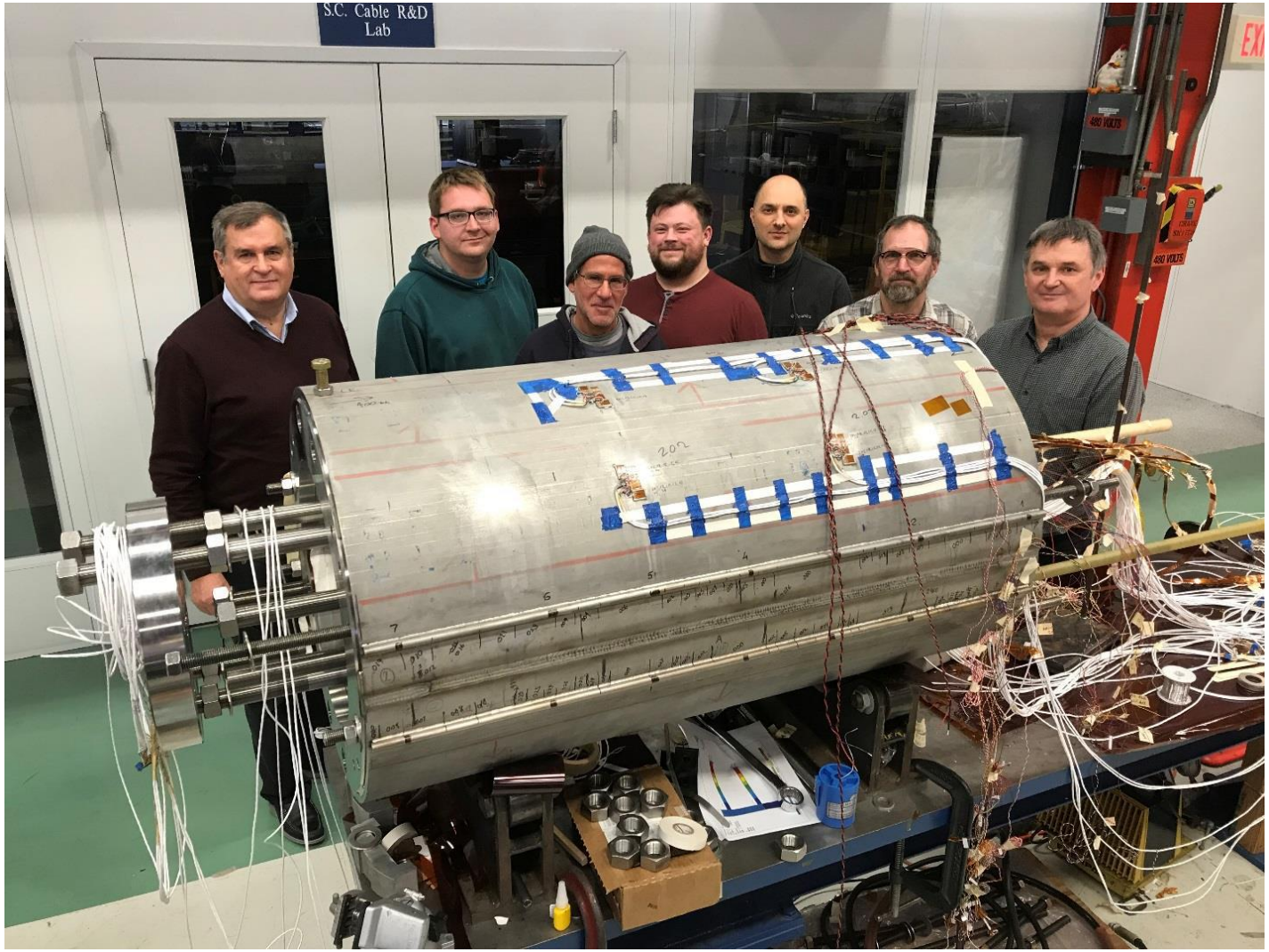
… and after only few years, new suppliers from Japan, Korea and Russia already achieve HL-LHC J_c specification.

- high B_{c2} (28.8 T at 4.2 K)

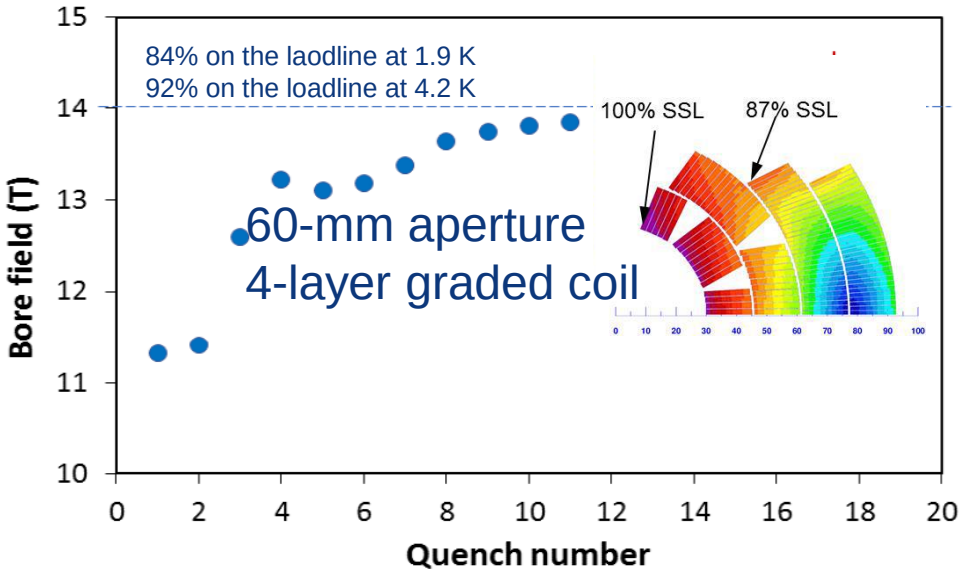


FNAL, Hyper Tech Research Inc., and Ohio State, X. Xu et. al., https://arxiv.org/abs/1903.08121 ;
NHMFL, FAMU/FSU: S. Balachandran et al. https://arxiv.org/ftp/arxiv/papers/1811/1811.08867.pdf

US – MDP: 14 T magnet tested at FNAL



→ A. Zlobin et al., NAPAC2019, MOPL020



- 15 T cosϑ 4-layer dipole demonstrator
- Staged approach: In first step pre-stressed for 14 T
- Tests at higher field foreseen with additional pre-stress for 14.5 or 15 T

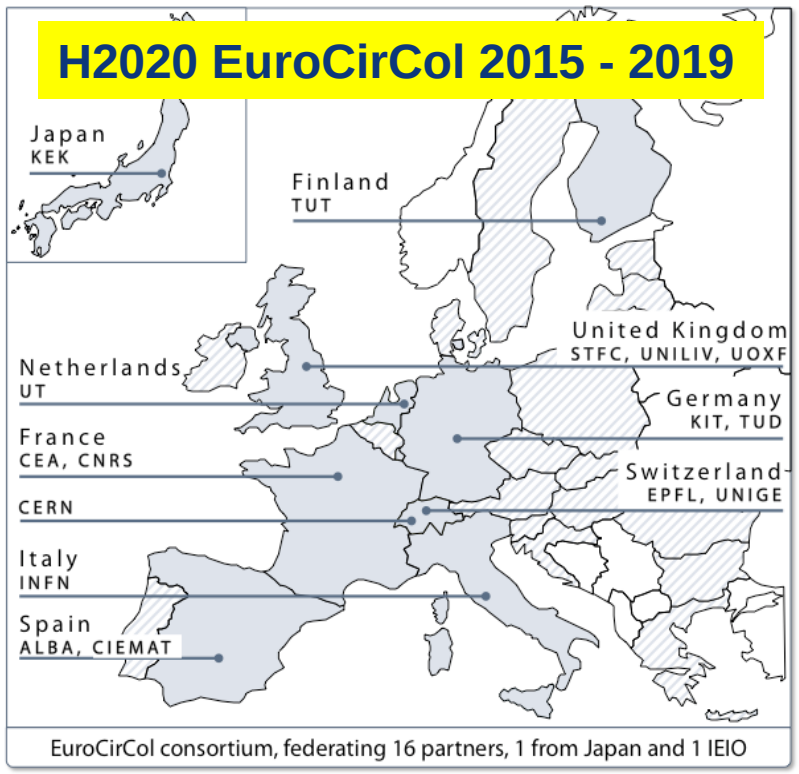
FCC high-field magnet R&D strategy

Remain focused on FCC 16 T program and increase resources, this is THE baseline for FCC-hh

- **Understand technology and performance limits of Nb3Sn**
- **Understand potential systematic advantages/disadvantages of all coil design/magnet options**
- **Basis for final optimization of the FCC-hh magnet in 10-15 years.**

1. **Continuation of Nb3Sn wire program**
   - **Consolidation of Jc increase via artificial pinning centres and subsequent "industrialization"**
   - Increase focus on other conductor targets (RRR, filament size, stability, etc) and work towards **cost target**
2. **Continuation of associated wound conductor and other R&D programs**
   - Reinforcement of international R&D collaboration, strengthening the network by systematically involving external partners in their specific areas.
   - Coupled, **with industry, a process technology optimization program** (wiring, curing, impregnation, etc.)
3. Continue **16 T model program with partners (CEA, CIEMAT, INFN, PSI, US MDP, BINP):**
   - **Attractive and challenging goals range 14 – 16 T, double vs. four-layer designs, EuroCirCol designs**
   - **Permanently feed R&D results and industrialization aspects back into magnet design.**

CDTI – CERN – CIEMAT collaboration scope



Natural continuation of the successful EuroCirCol collaboration:

WP5 - design of 16 T Nb_3Sn magnets

- **Construction of magnet laboratory at CIEMAT**
- **Building up in-house expertise for design and fabrication of Nb_3Sn high field magnets**
- **Construction of 16 T short model magnets in the context of the FCC 16 T Nb_3Sn magnet program.**

Conclusions

- In the course of ESU evolution, the integrated FCC programme, featuring FCC-ee as first step, followed by a ~100 TeV FCC-hh as long-term goal, is being confirmed as a highly interesting option for CERN's future research infrastructure.
- Lower energy hadron colliders such as HE-LHC and a low-energy FCC-hh, based on NbTi, are less favored due to limited physics potential and non-complementarity with FCC-hh, while being still "expensive" machines.
- These developments confirm the FCC strategy and also the 16 T high field magnet program as central pillar for a future highest energy hadron collider.
- It is hoped that the ESU will pave the way for preparatory activities towards FCC while recommending explicitly strong associated R&D programs with ambitious goals.
- For high-field magnet R&D in the context of the FCC integrated program, this would mean to develop cost optimized and reliable designs, ready to industrialize and build by ~2040, so that from 2050 onwards, the magnets for a new machine could be installed.