Introduction

and a few words on the FCC Feasibility Study

Karsten Köneke, Frank Simon, Georg Weiglein

Future Collider Forum, Zoom, October 2021

The Future Collider Forum

High Level Goals & Motivation

MAX-PLANCK-INSTITUT FÜR PHYSIK

- Support activities in Germany on future colliders
  - A forum for all projects: Compact Linear Colider (CLIC), Future Circular Collider (FCCee/eh/hh), International Linear Collider (ILC), Muon Collider,...
  - Foster the interaction between physics studies (experiment and theory) and activities on the detector and accelerator side
  - Identify and exploit synergies between the activities on the different future projects

- Reduce the threshold for contributions in individual groups: one Forum for future collider activities of all flavours, enable exchange on the “working level”
  - Allow to reach critical mass also with smaller contributions
  - ``Community Meeting”, increase of visibility, especially for younger members

The central mechanisms: Workshops, ~ 1/year, plus possible additional satellite meetings,
for example in the framework of the Terascale Alliance

The Next Three Days

The first workshop

MAX-PLANCK-INSTITUT FÜR PHYSIK

- Wednesday (today): Accelerator technology
- Thursday: Detector concepts and technology
- Friday: Physics case, physics studies

After each talk: Significant time planned for discussions. Please make use of this!

Future Colliders

The Landscape post Strategy

Higgs Factories

The highest priority beyond HL-LHC - technology relatively mature

MAX-PLANCK-INSTITUT FÜR PHYSIK

Linear

International **L**inear **C**ollider

ILC

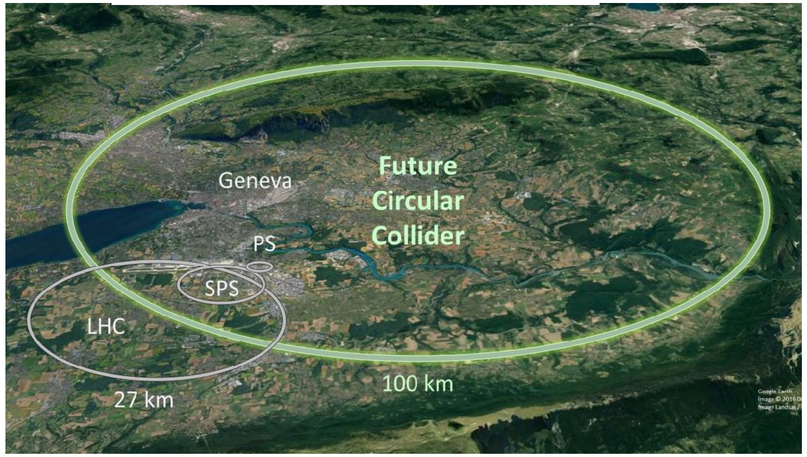
Japan

Circular

Future **C**ircular **C**ollider

FCC-ee

CERN



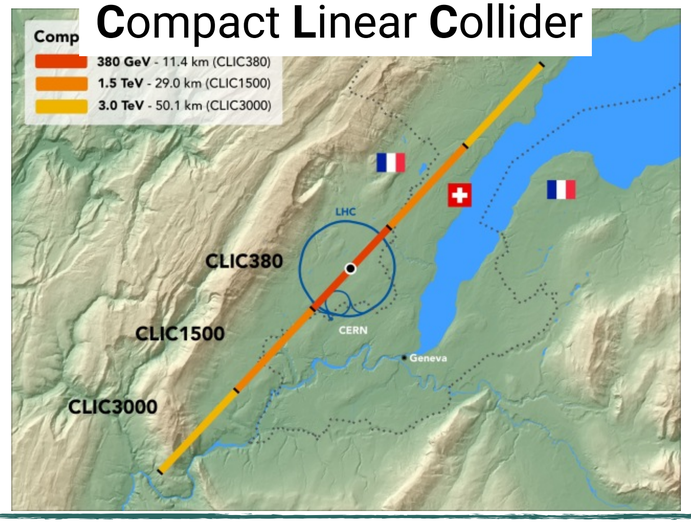
High-level differences:

- Energy reach
- Luminosity

Compact **L**inear **C**ollider

CLIC

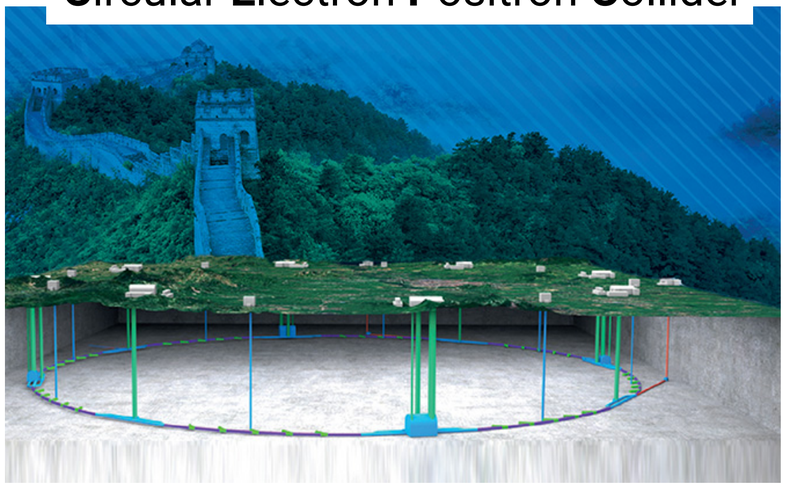
CERN



Circular **E**lectron **P**ositron **C**ollider

CEPC

China



Higgs Factories

The highest priority beyond HL-LHC - technology relatively mature

Linear

International **L**inear **C**ollider

ILC

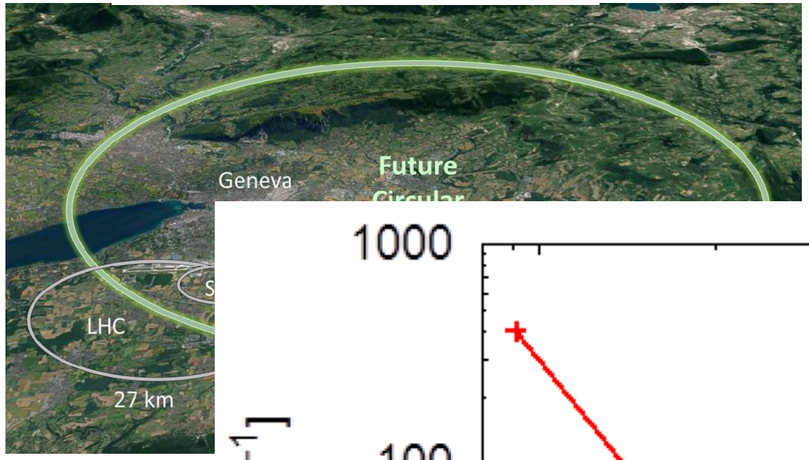
Japan

Circular

Future **C**ircular **C**ollider

FCC-ee

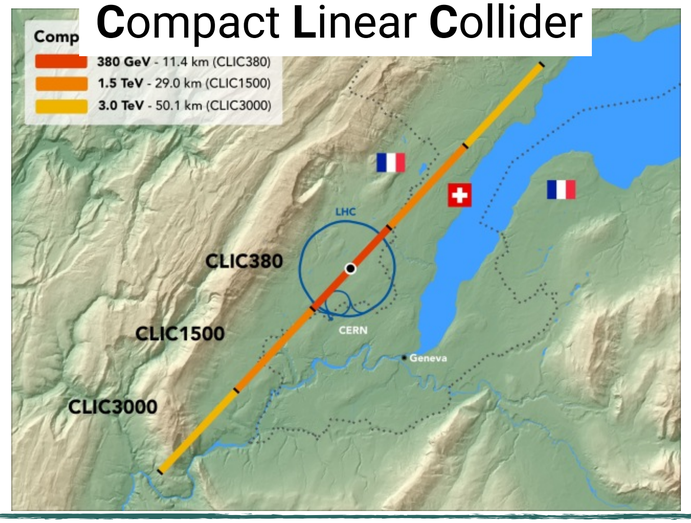
CERN



Compact **L**inear **C**ollider

CLIC

CERN



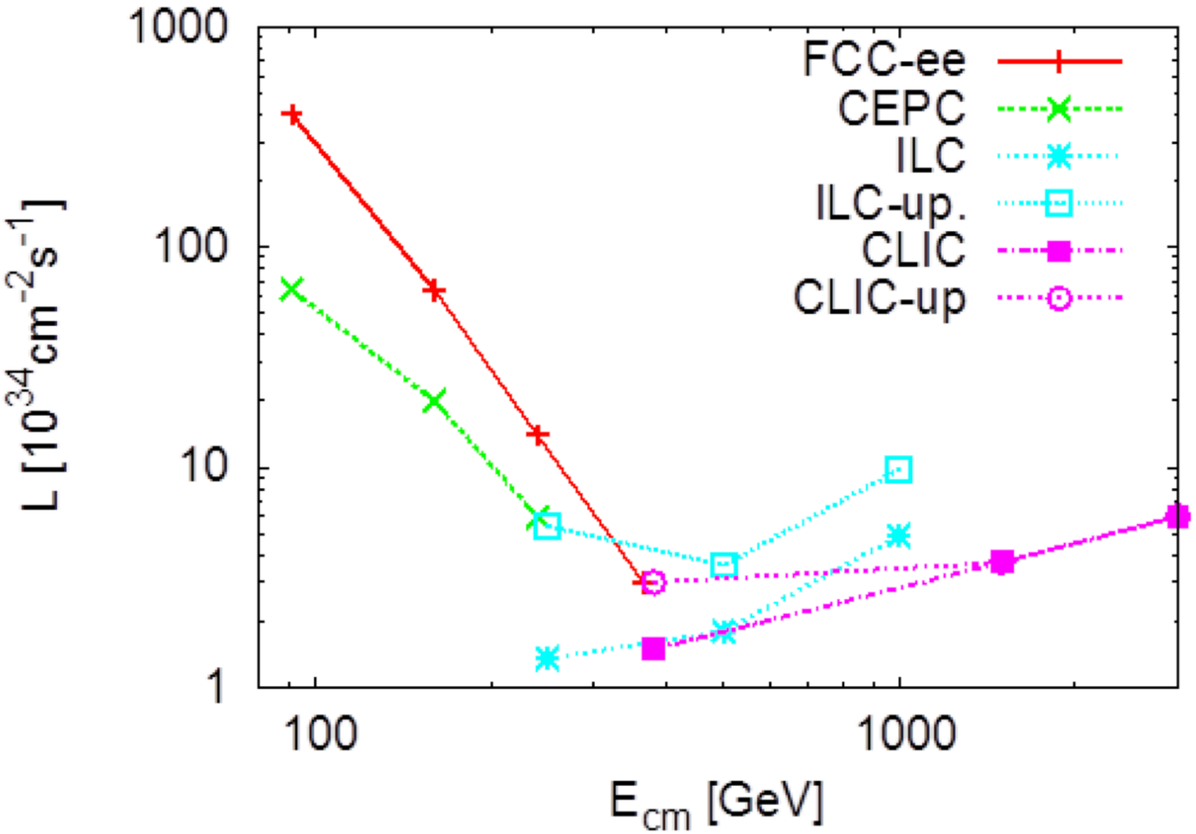
Circular

CEPC

China

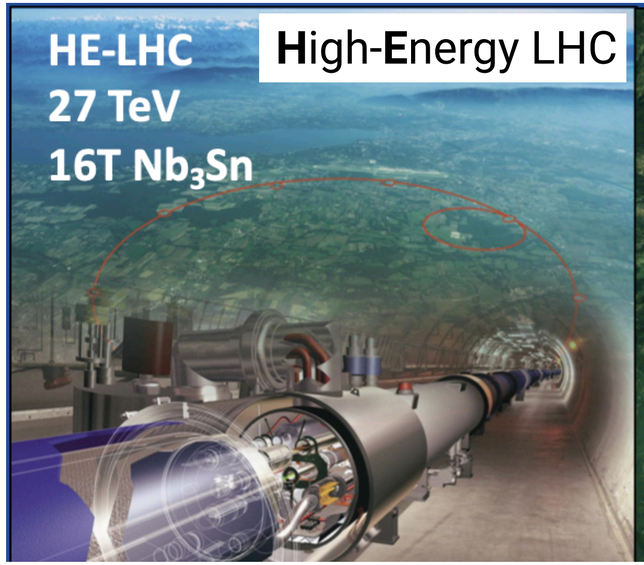
High-level differences:

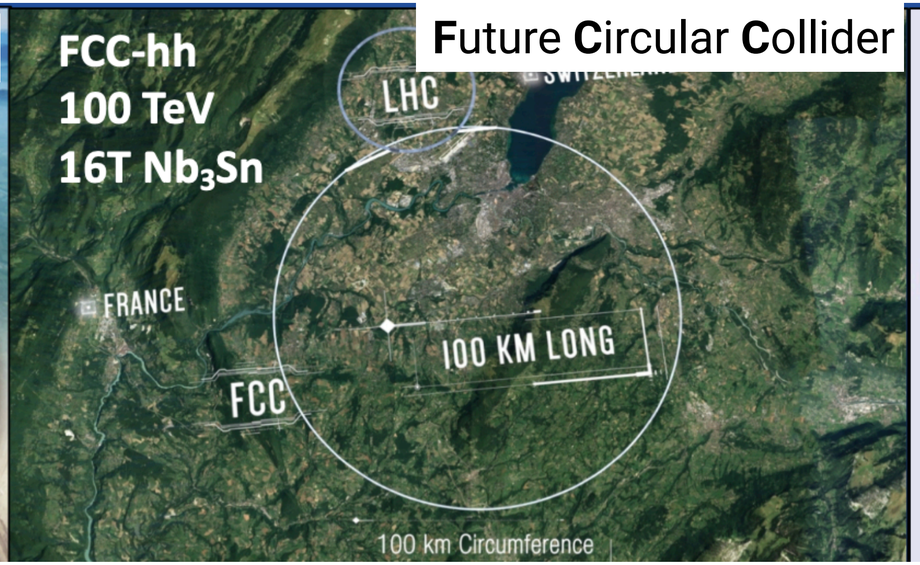
- Energy reach
- Luminosity

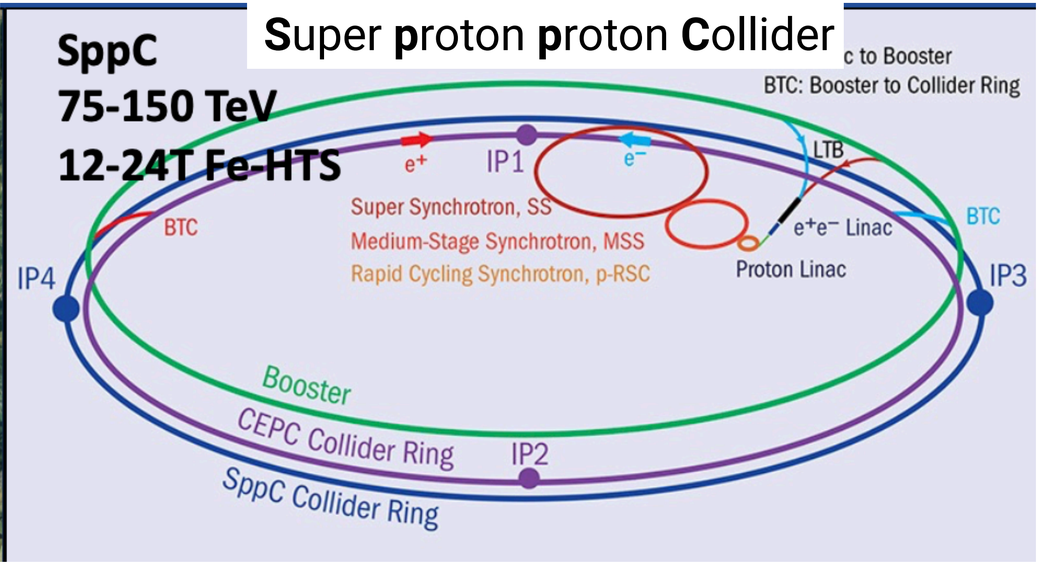


Future Hadron Colliders

The Energy Frontier - Technologically still a way to go



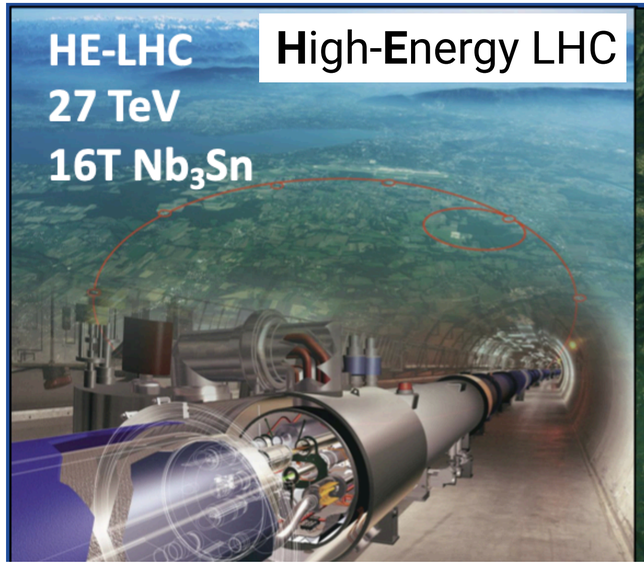


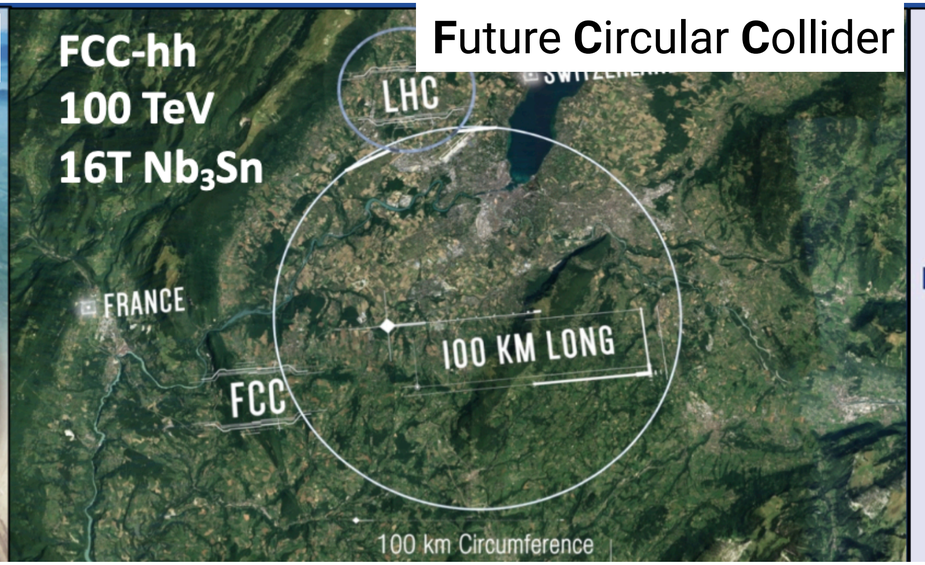


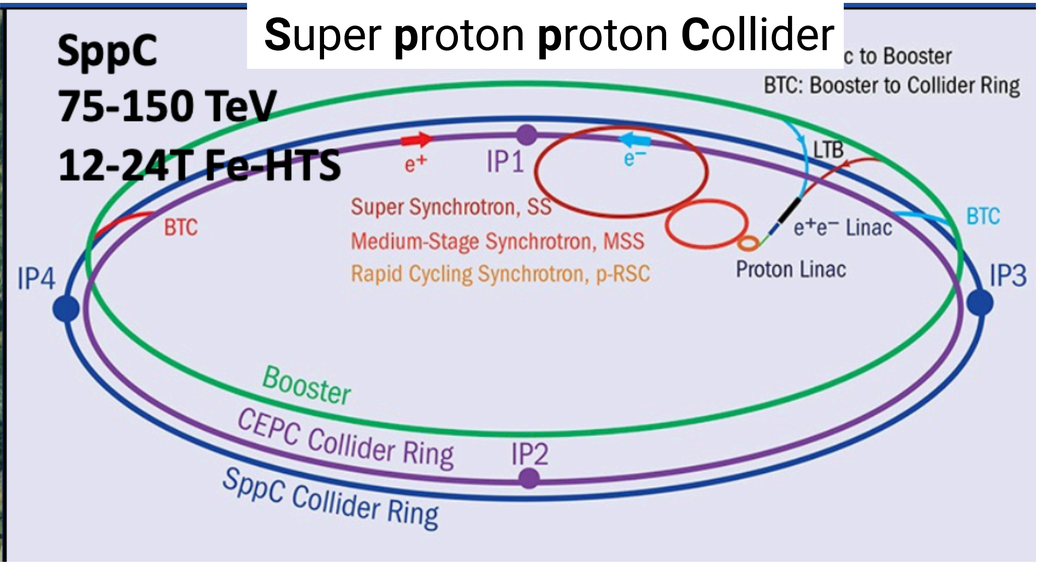
- The main challenge:
  high-field magnets: ~ 16+ T

Future Hadron Colliders

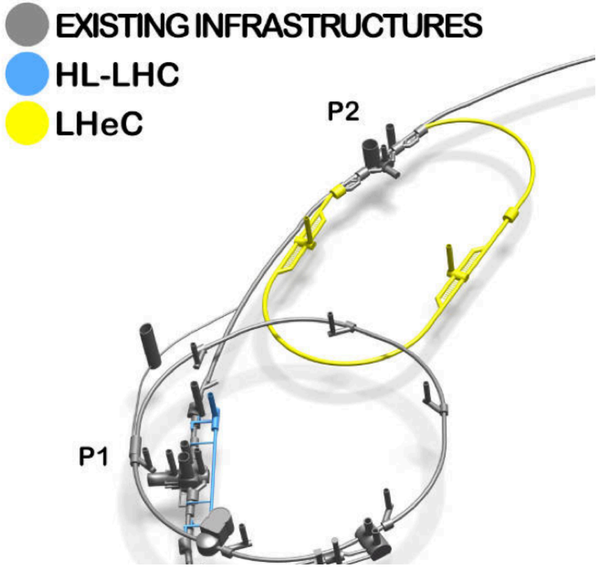
The Energy Frontier - Technologically still a way to go

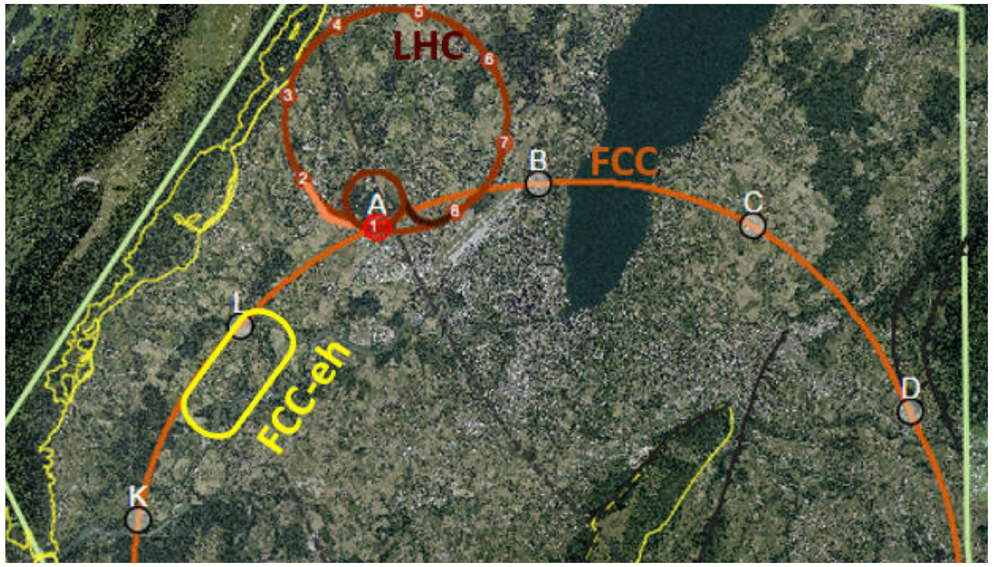






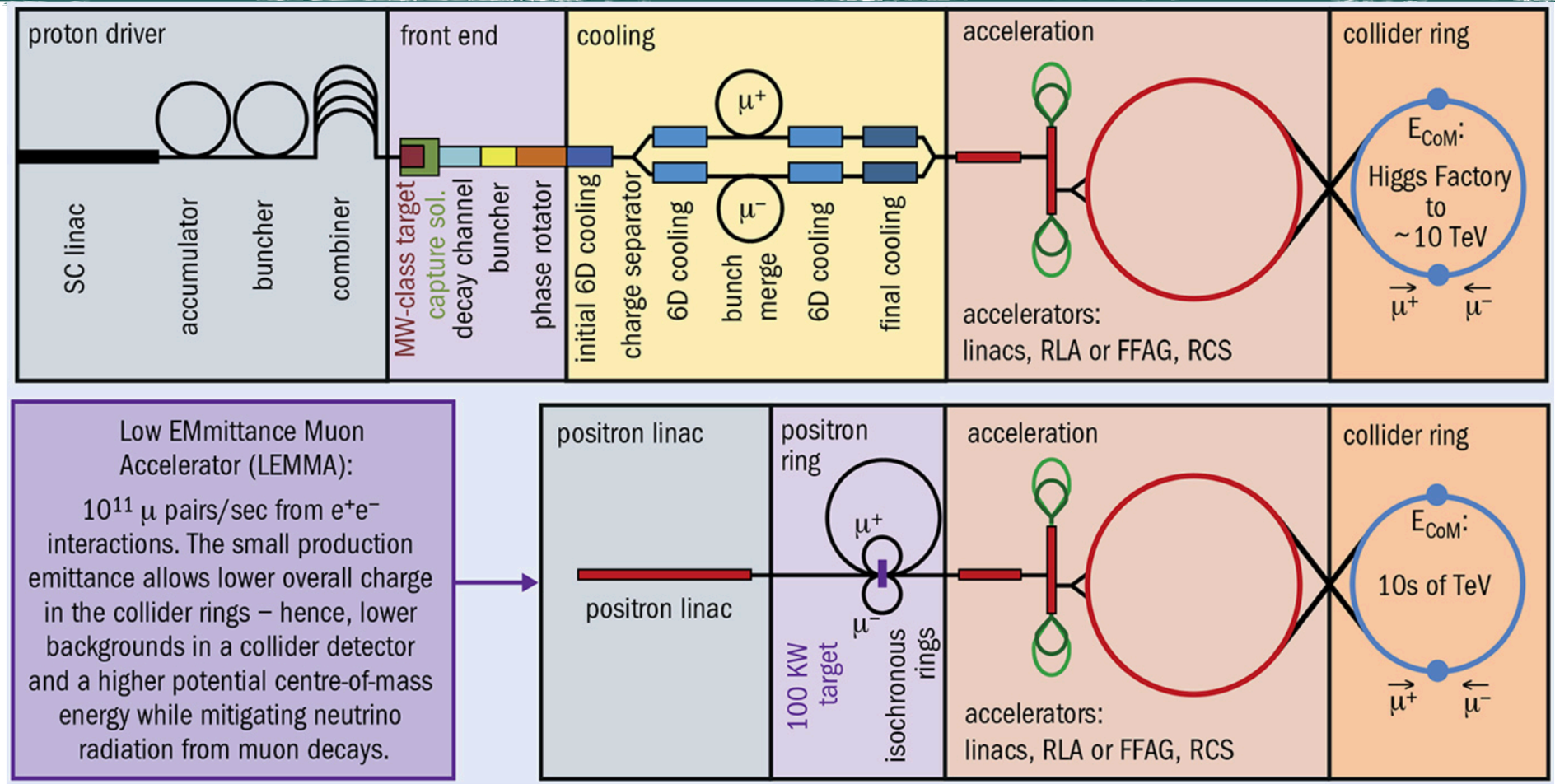
- The main challenge: high-field magnets: ~ 16+ T
- Electron-hadron collisions when combined with ERLs: LHeC, FCC-eh at CERN





Muon Collider

Renewed Interest



- Main challenges:
  - Muon cooling
  - neutrino background
  - radiation

- Currently in an exploratory phase, which could be followed by the definition of a test facility

Main CERN Future Collider Activities

CLIC & Muon Collider

Alternatives and Future Possibilities

MAX-PLANCK-INSTITUT FÜR PHYSIK

CLIC goals by end 2025 (as input to next ESPP):

- ❑ finalise X-band technology towards construction readiness (accelerating structure's conditioning and manufacturing)
- ❑ improve power efficiency (e.g. klystrons, etc.)
- ❑ optimise luminosity for first-stage machine (beam dynamic studies, machine alignment and stability, etc.)

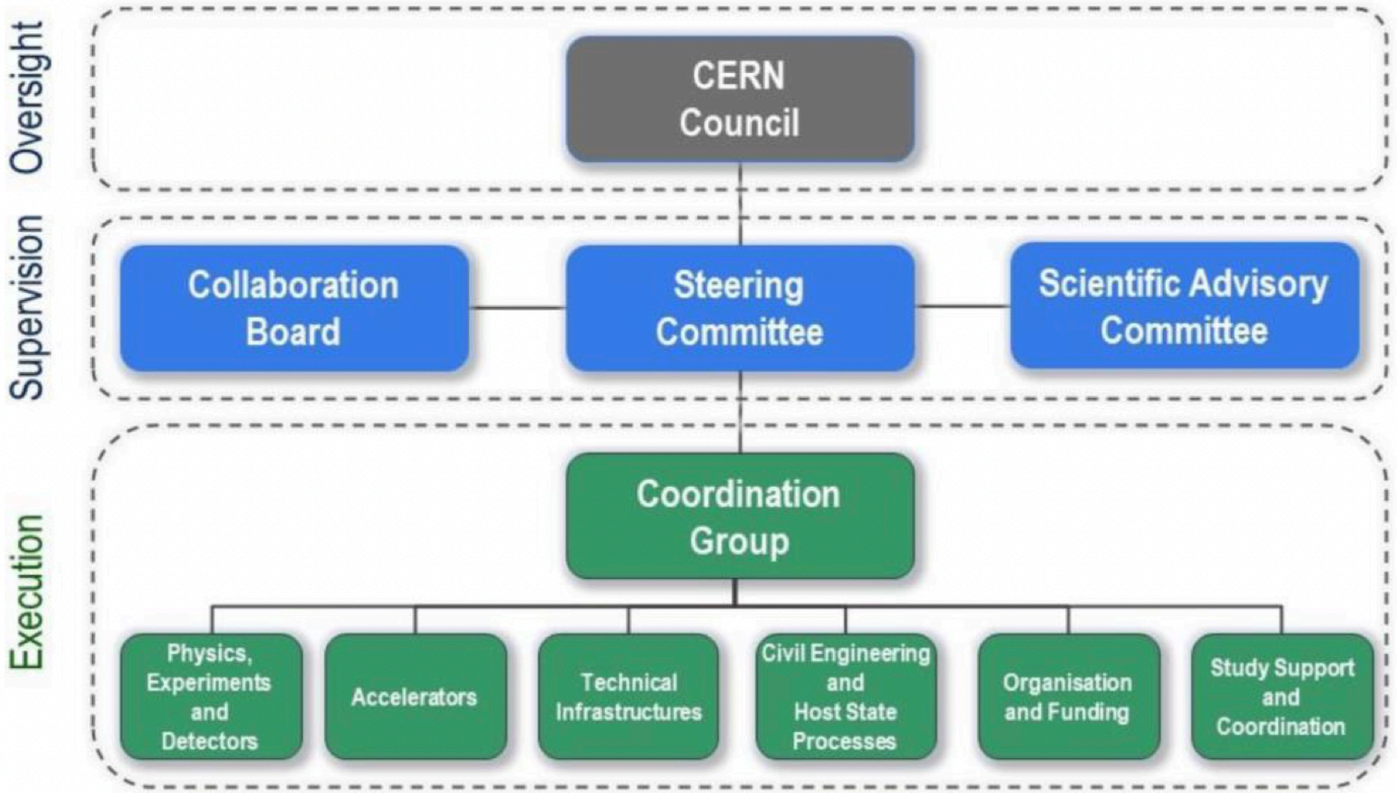
→ "**Project Readiness Report**" by end 2025

Muon collider's goals by end 2025 (as input to next ESPP): work on main challenges, including muon source and cooling, fast-ramping magnets, accelerator and collider rings, neutrino background and civil engineering → determine if **investment in Muon Collider test facility** and CDR **is justified** from a scientific perspective.

Fabiola Gianotti
FCC Week 06/2021

The FCC Feasibility Study

Preparing for the next strategy



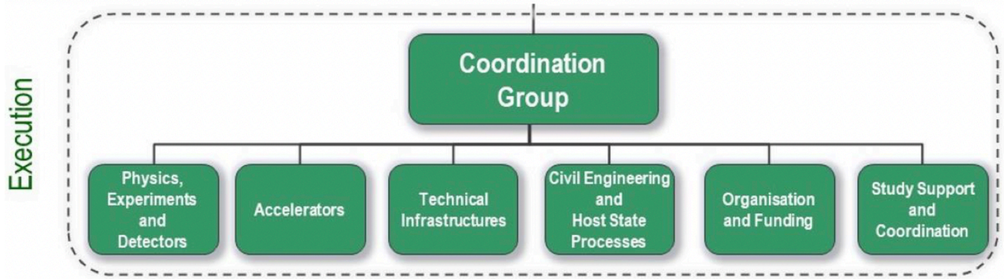
- Tunnel: assess geological, technical, administrative, environmental feasibility -> aim is to demonstrate there is no show-stopper for ~ 100 km ring in Geneva region
- Technologies: superconducting high-field magnets and RF accelerating structures; high-efficiency power production; energy saving and other sustainable technologies
- Funding: development of funding model for first-stage machine (tunnel and FCC-ee, total ~ 10 BCHF) and identification of substantial resources from outside CERN's budget
- "Consensus building": gathering scientific, political, societal support -> communication campaign targeting scientists, governmental and other authorities, industry, general public

Fabiola Gianotti
FCC Week 06/2021

The FCC Feasibility Study

Main Deliverables and Milestones I

Michael Benedikt
FCC Week 06/2021



Physics, experiments and detectors

- ❑ consolidation of physics case for full FCC programme;
- ❑ requirements on theoretical calculations, Monte Carlo generators and other software;
- ❑ detector concepts for FCC-ee and FCC-hh (also based on experience with Phase-2 upgrades);
- ❑ detector design and R&D (synergies with “R&D for future detectors” at CERN and ECFA Detector Roadmap);
- ❑ requirements on accelerator performance, technical infrastructure, computing and integration.

Accelerators

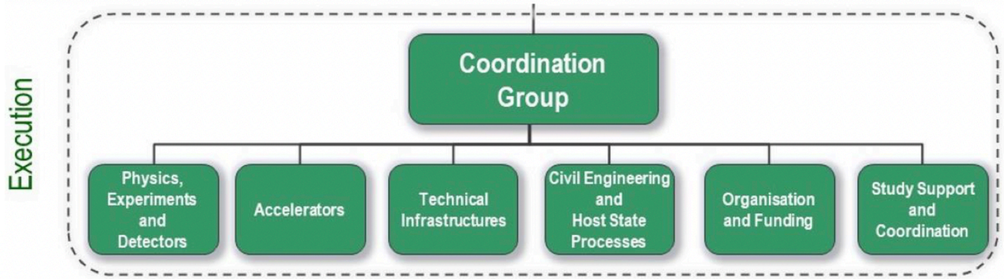
- ❑ design of FCC-ee and FCC-hh, and their injectors;
- ❑ development of key technologies for both colliders, including high-field superconducting magnets, SCRF, high-efficiency power production, and other sustainable and environmentally-friendly technologies; milestones will be finalised once Accelerator R&D roadmap available;
- ❑ machine-detector interface for FCC-ee (final focus magnets and compensation solenoids).

The FCC Feasibility Study

Main Deliverables and Milestones II

MAX-PLANCK-INSTITUT FÜR PHYSIK

Michael Benedikt
FCC Week 06/2021



Technical infrastructures

- ❑ concepts for electricity supply and distribution; optimise electrical system efficiency and stability;
- ❑ design of cooling and ventilation systems; cryogenics systems; efficiency via e.g. waste heat recovery;
- ❑ safety and radiation protection;
- ❑ integration and logistics: integration of components for installation, maintenance and operation; transport concepts on surface and underground for personnel and materials; etc.

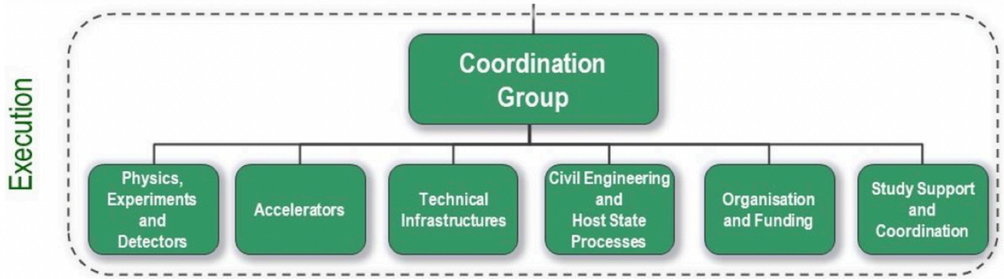
Organisation and funding

- ❑ development of organisational models for design, implementation and operation of future project;
- ❑ preparation of consolidated cost estimate;
- ❑ development of funding concepts and models for the project construction and operation;
- ❑ development of procurement strategy/rules for global project (with major contributions from non-Member States);
- ❑ development of sustainable operational model for colliders and experiments in terms of human and financial resource needs, environmental aspects and energy efficiency).

The FCC Feasibility Study

Main Deliverables and Milestones III

Michael Benedikt
FCC Week 06/2021



Civil engineering and Host-State processes

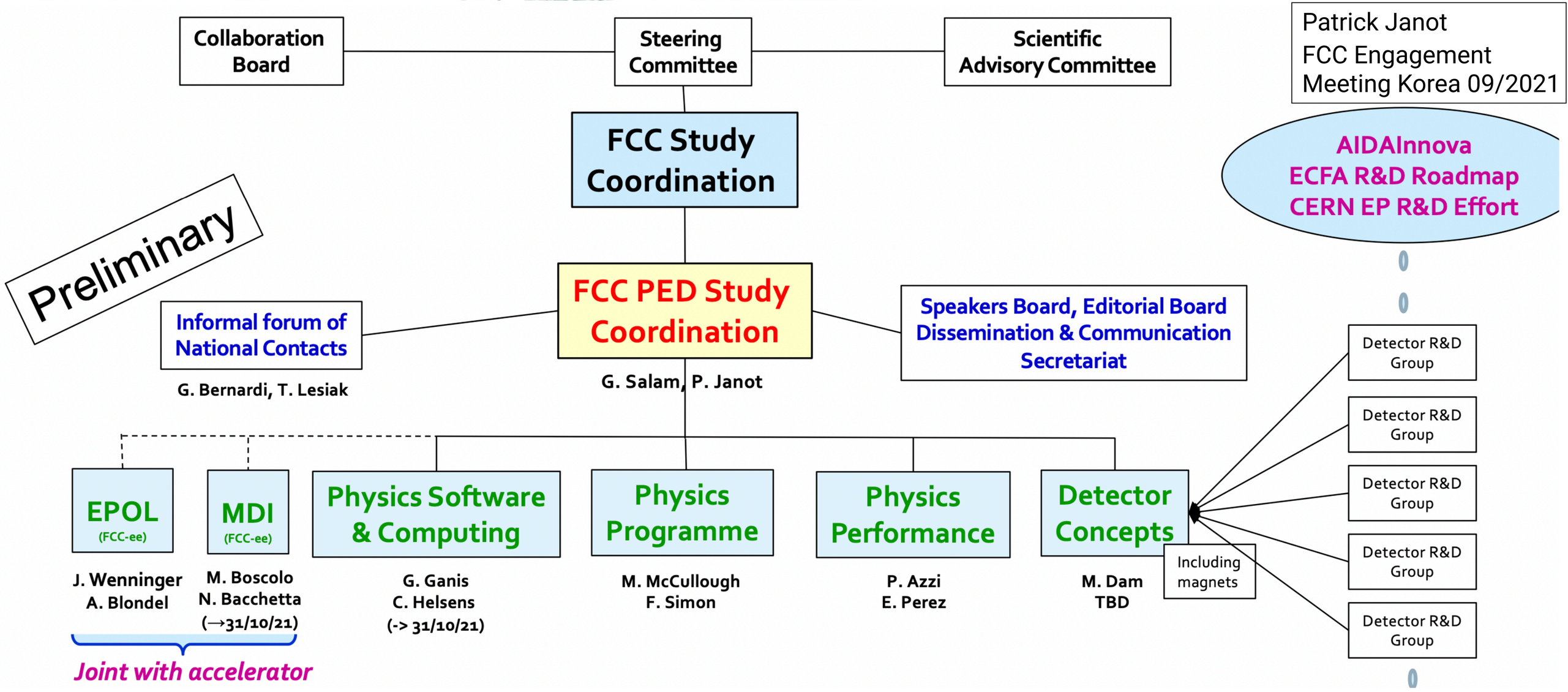
- ❑ planning and management of high-risk area site investigations;
- ❑ pre-design of tunnel and underground structures, including shafts and caverns;
- ❑ development of layout concepts for each of 12 foreseen surface sites, taking into account technical requirements and territorial constraints (buildings, streets, parking spaces, storage, integration of general services, etc.);
- ❑ preliminary concepts and requirements for access to each site; pre-design of surface buildings;
- ❑ development and deployment of communications plan for local areas to support the site investigations;
- ❑ identification and execution of Host-State admin processes needed for possible construction start early 2030s;
- ❑ development of integrated process for environmental evaluation in agreement with regulations in both Host States, and first part of environmental evaluation process and impact study from 2023 onwards;
- ❑ roadmaps and plans for processes that will begin after project's possible approval (e.g. acquisition of land plots for surface sites, public debates, environmental impact study and compensation procedures).

The FCC Feasibility Study

Physics, Experiments and Detectors

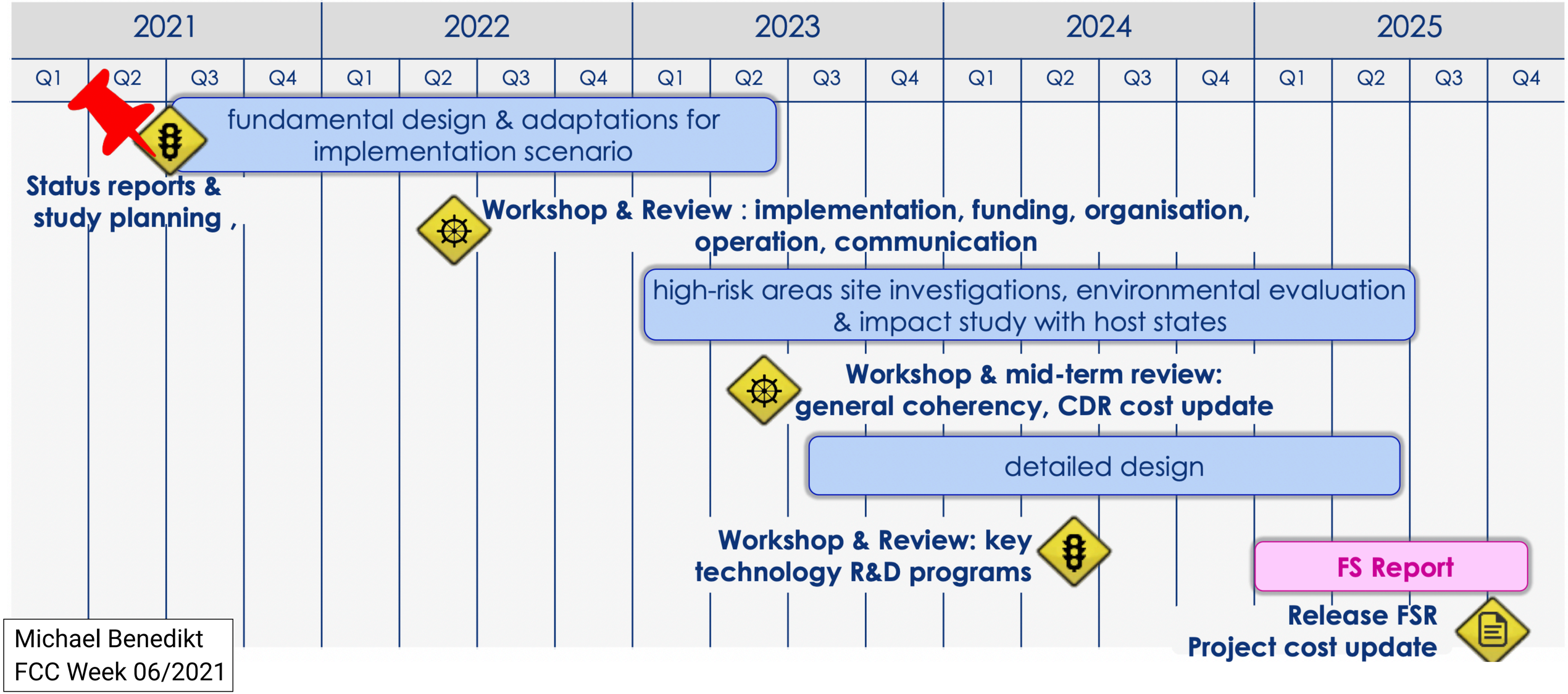
MAX-PLANCK-INSTITUT FÜR PHYSIK

Patrick Janot
FCC Engagement
Meeting Korea 09/2021



The FCC Feasibility Study

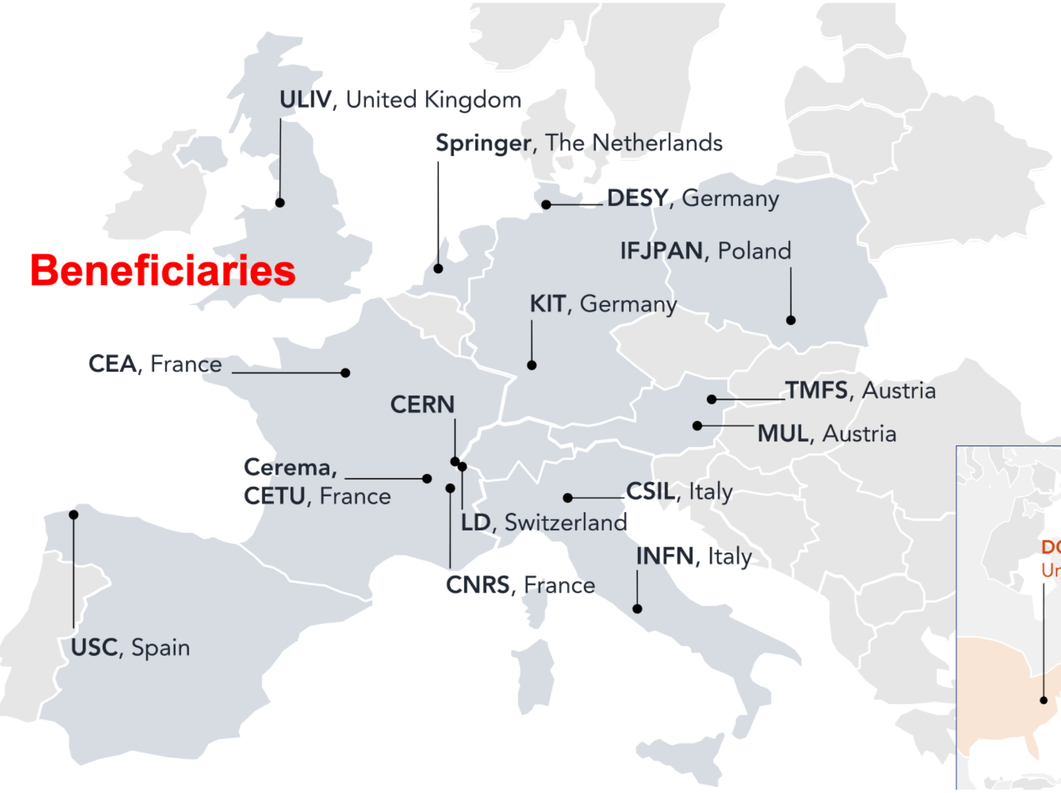
High-level Time Line



Michael Benedikt
FCC Week 06/2021

Current FCC Activities in Germany on the Accelerator Side

Not complete, a few impressions



Beneficiaries

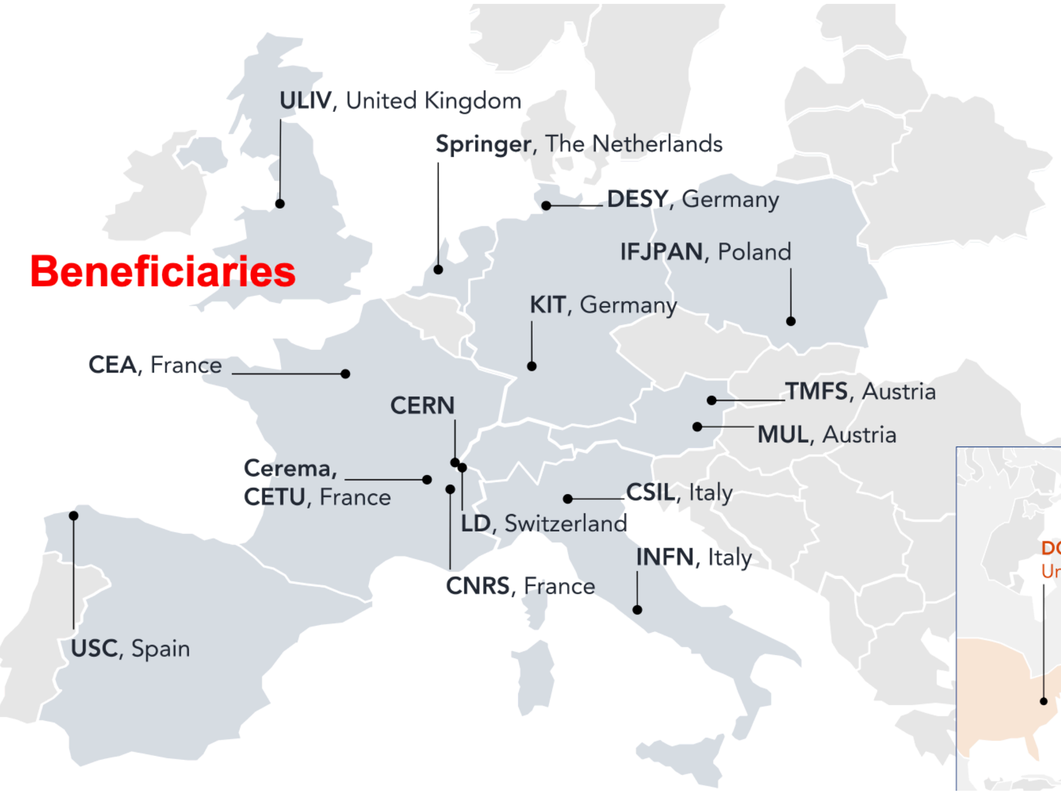
Topic	INFRADEV-01-2019-2020
Grant Agreement	FCCIS 951754
Duration	48 months
From-to	2 Nov 2020 – 1 Nov 2024
Project cost	7 435 865 €
EU contribution	2 999 850 €
Beneficiaries	16
Partners	6

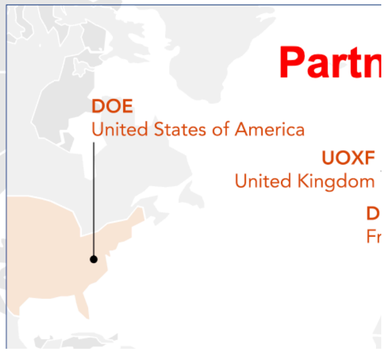
Anke-Susanne Müller

Current FCC Activities in Germany on the Accelerator Side

Not complete, a few impressions

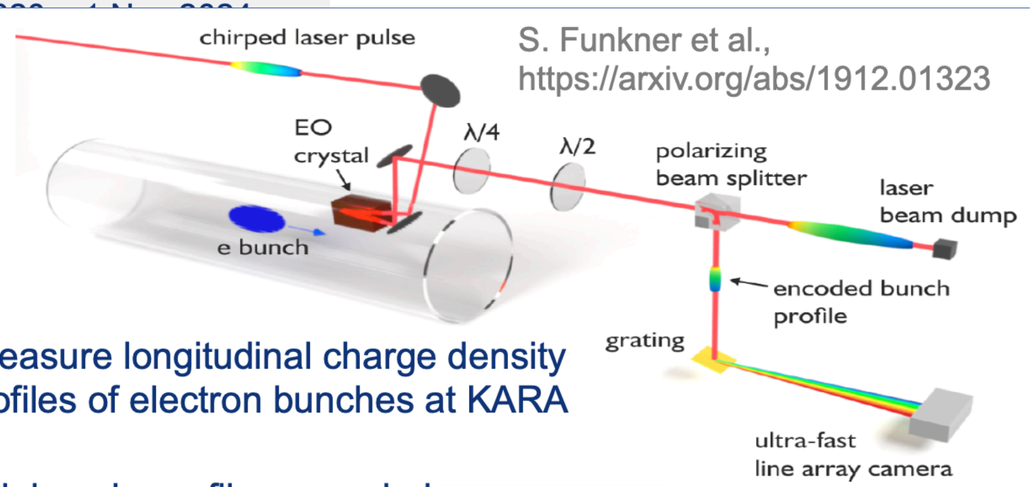
MAX-PLANCK-INSTITUT FÜR PHYSIK





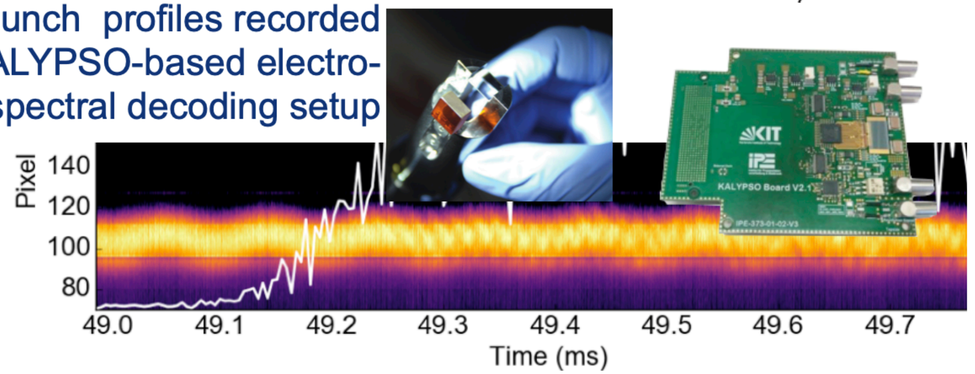
Topic	INFRADEV-01-2019-2020
Grant Agreement	FCCIS 951754
Duration	48 months
From-to	
Project cost	
EU contribution	
Beneficiaries	
Partners	

- Bunch-by-bunch diagnostics for FCC-ee



setup to measure longitudinal charge density profiles of electron bunches at KARA

longitudinal bunch profiles recorded with the KALYPSO-based electro-optical spectral decoding setup

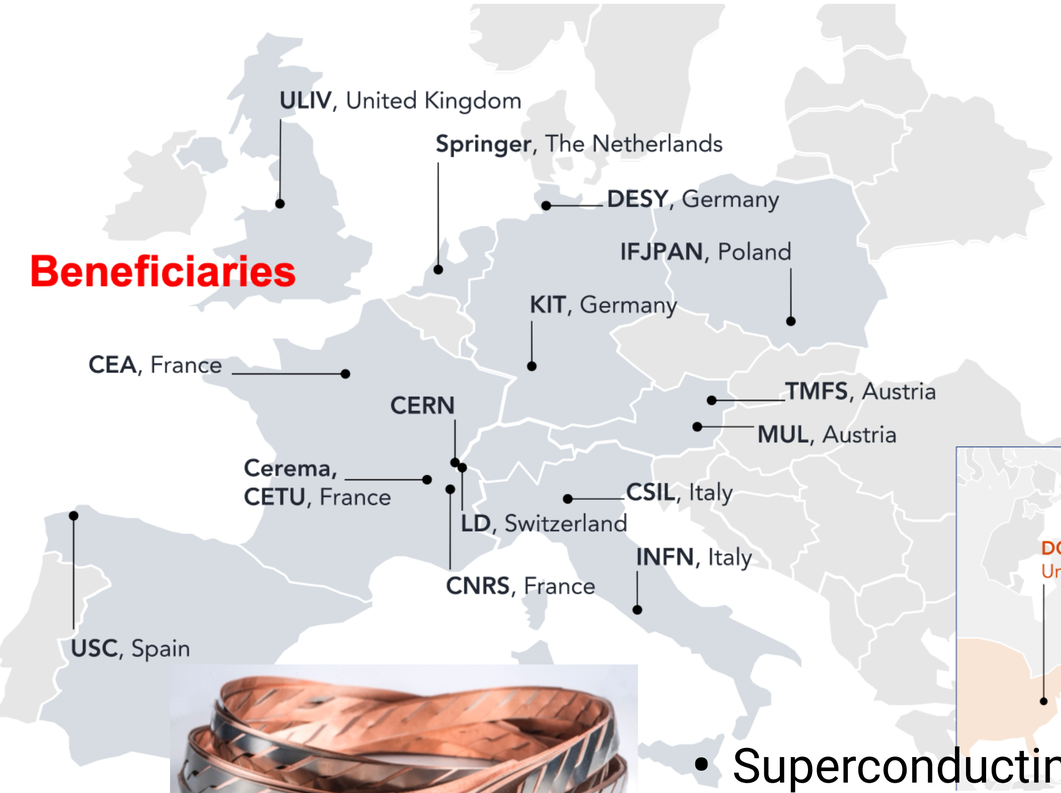


Anke-Susanne Müller

Current FCC Activities in Germany on the Accelerator Side

Not complete, a few impressions

MAX-PLANCK-INSTITUT FÜR PHYSIK

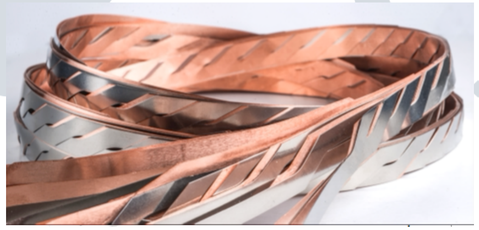


Beneficiaries

Topic	INFRADEV-01-2019-2020
Grant Agreement	FCCIS 951754
Duration	48 months
From-to	
Project cost	
EU contribution	
Beneficiaries	
Partners	

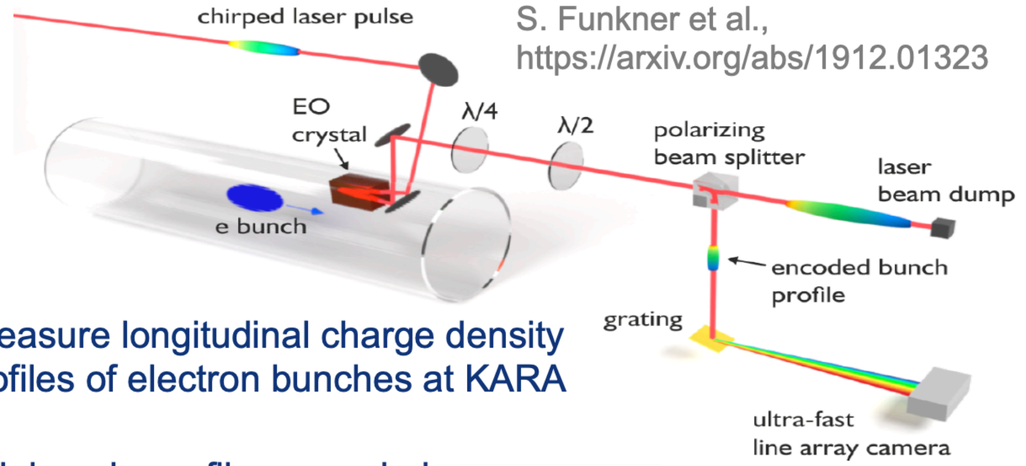
Partn

DOE
United States of America
UOXF
United Kingdom



- Superconducting cables for high-field magnets

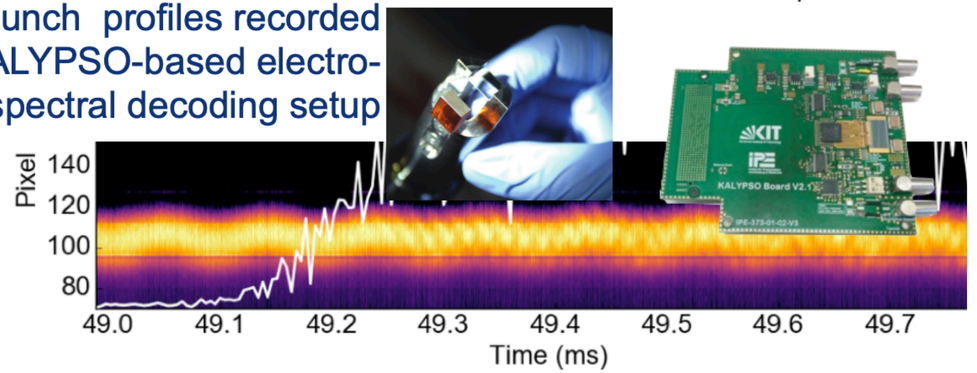
- Bunch-by-bunch diagnostics for FCC-ee



S. Funkner et al., https://arxiv.org/abs/1912.01323

setup to measure longitudinal charge density profiles of electron bunches at KARA

longitudinal bunch profiles recorded with the KALYPSO-based electro-optical spectral decoding setup

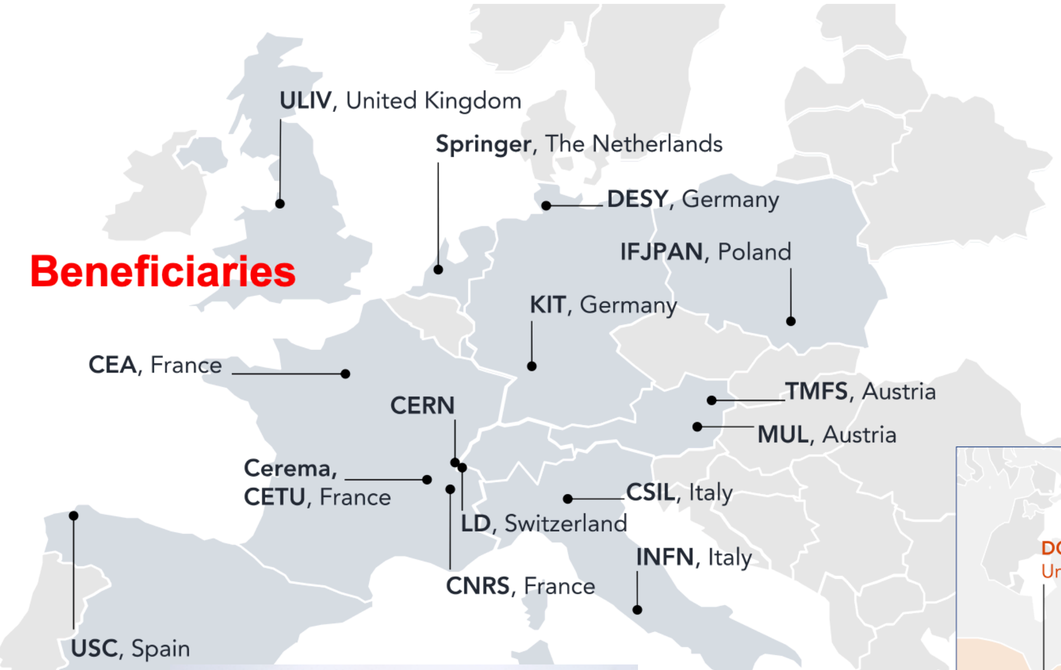


Anke-Susanne Müller

Current FCC Activities in Germany on the Accelerator Side

Not complete, a few impressions

MAX-PLANCK-INSTITUT FÜR PHYSIK



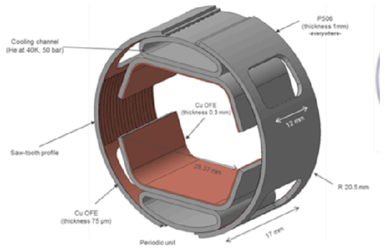
Beneficiaries

Topic	INFRADEV-01-2019-2020
Grant Agreement	FCCIS 951754
Duration	48 months
From-to	
Project cost	
EU contribution	
Beneficiaries	
Partners	

Partn

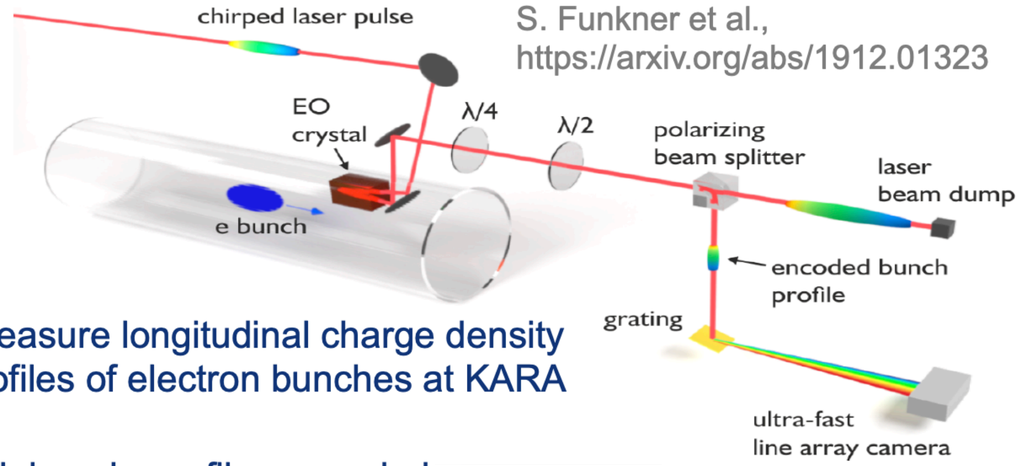
DOE
United States of America
UOXF
United Kingdom

- Superconducting cables for high-field magnets



- Cold synchrotron radiation beam screens for FCC-hh

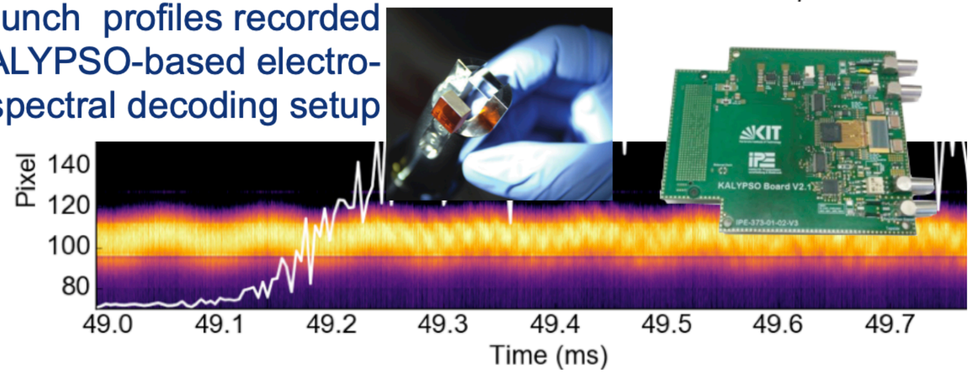
- Bunch-by-bunch diagnostics for FCC-ee



S. Funkner et al., https://arxiv.org/abs/1912.01323

setup to measure longitudinal charge density profiles of electron bunches at KARA

longitudinal bunch profiles recorded with the KALYPSO-based electro-optical spectral decoding setup



… and more.

Anke-Susanne Müller

Looking forward to an interesting workshop, with lots of discussion!