ECFA

European Committee for Future Accelerators

yHEP association

Summary of Bonn workshop

Michael Lupberger (yHEP), Leonhard Reichenbach (ECFA-ECR)

German strategy workshop “The future of collider physics”

27 November 2024, DESY

Overview: Agenda

Wednesday, 22 May

yHEP Session

https://desy.zoom.us/j/67945812976

Meeting-ID: 679 4581 2976
Kenncode: 869975

1. **Welcome**
   Speakers: Prof. Lutz Feld (RWTH Aachen), Michael Lupberger (University of Bonn)
   FCatCERN_Practica... Intro yHEP Session ...
2. **Physics Introduction**
   35+15 minutes
   Speaker: Philip Bechtle (University of Bonn)
   PBe_FutureCollider...
3. **The Global Landscape for Future Colliders**
   30+15 minutes
   Speaker: Jenny List (FTX (FTX-SLB))
   jlist_yHEP_collider_l...

15:15 **Coffee break**

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4. **From Strategy Discussions to Decison-Taking for Large Projects**
   30+15 minutes
   Speaker: Karl Jakobs (University of Freiburg)
   KET_Bonn_Decision... KET_Bonn_Decision...
5. **CERN Physics Beyond Collider Program**
   15+5 minutes
   Speaker: Gunar Schnell (HERMES (HERMES Experiment))
   FCatCERN2024_PB...
6. **Discussion**
7. **Navigating social acceptance for large technology infrastructures – how to establish the science-society dialogue?**
   15+5 minutes
   Speaker: Gudrun Haindlmaier (Austrian Institute of Technology)
   CERN_Bonn_Haindl...
8. **Environmentally responsible research at CERN**
   15+5 minutes
   Speaker: Sonja Kleiner (CERN)
   22_05_2024_CERN_...
9. **Discussion**
   Closeout yHEP Ses...

Thursday, 23 May

09:00 → 10:45 **Plenary Session**

09:00 **Introduction - scope and goals of the workshop**
10+5 minutes
Speaker: Prof. Lutz Feld (RWTH Aachen)
FCatCERN_Practica... KET Intro FC@CER...

09:20 **Greeting from CERN Research Director**
5+5 minutes
Speaker: Joachim Mnich (FH (Forschung Hochenergiephysik))

09:30 **The physics case for an e+e- collider at CERN**
35+10 minutes
Speaker: Prof. Milada Margarete Mühlleitner (Karlsruhe Institute of Technology (I
FutureCollidersThe...

10:15 **BMBF's current view to FC @ CERN**
20+10 minutes
Speaker: Eckart Lilienthal
240523 FC@CERN_...

10:45 → 11:30 **Coffee break**

11:30 → 13:05 **Plenary Session**

11:30 **The FCC-ee project**
35+5 minutes
Speaker: Markus Klute (MIT)
2024-05-23-fcc-mk...

12:15 **An Alternative Vision for CERN**
25+5 minutes
Speaker: Jenny List (FTX (FTX-SLB))
alternative_vision_f...

12:45 **Input from yHEP**
15+5 minutes
Speaker: Michael Lupberger (University of Bonn)
yHEPInput.pdf

13:05 → 14:30 **Lunch**

14:30 → 17:50 **Plenary Session**

14:30 **FCC-ee key technologies and technological readiness**
15+5minutes
Speaker: Frank Gerigk (CERN)
FCC-Key-technologi...

14:50 **FCC sustainability aspects,**
Speaker: Johannes Gutleber (CERN)

15:10 **R&D on high-field magnets for FCC-hh and muon cooling**
15+5 minutes
Speaker: Bernhard Auchmann (CERN)
240523_HFM_v2.pp...

15:30 **R&D on plasma acceleration**
15+5 minutes
Speaker: Marlene Turner (CERN)
2024-05-23_Future...

15:50 **Coffee break**

16:10 **Detector concepts & technologies**
30+10 minutes
Speaker: Dr Felix Sefkow (DESY)
FCCeeDetector-KET...

16:50 **Computing&Software: Opportunities, Challenges and R&D**
20+10 minutes
Speaker: Frank Gaede (FTX (FTX Fachgruppe SFT))
gaede_swcomp_fut...

17:20 **Opportunities and challenges in precision predictions**
20+10 minutes
Speaker: Wolfgang Kilian
kilian-theory.pdf

17:50 → 18:00 **Break**

18:00 → 19:30 **Parallel Session: Calorimetry**
Convener: Frank Simon (KIT IPE)

18:00 **Calorimetry - Discussion Starter**
Speaker: Frank Simon (KIT IPE)
CalorimetryIntro.pdf

18:00 → 19:30 **Parallel Session: Computing & Software**
Convener: Frank Gaede (FTX (FTX Fachgruppe SFT))

18:00 **Software - Discussion Starter**
Speaker: Frank Gaede (FTX (FTX Fachgruppe SFT))
gaede_sw_parallel_...

18:00 → 19:30 **Parallel Session: Gaseous tracking**
Conveners: Jochen Kaminski (University of Bonn), Oliver Kortner (MPP)

18:00 → 19:30 **Parallel Session: Si-based tracking**
Conveners: Erika Garutti (UNI/EXP (Uni Hamburg, Institut fur Experimentalphysik)), Jochen Dingfelder (BELLI

18:00 **Welcome & Si-D consortium**
Speakers: Erika Garutti (UNI/EXP (Uni Hamburg, Institut fur Experimentalphysik)), Jochen Ding
DRD3-SiliconD_FCC...

18:05 **Si Detectors for Future Colliders**

18:30 **CMOS sensors for vertex detection at a future collider - status and opportunities**
Speaker: Ingrid-Maria Gregor (DESY/Uni Bonn)
FCBonn_65nm.pdf

18:55 **Fast timing silicon detectors - in Germany (Si-D) and Europe (DRD3)**
Speaker: Dr Joern Schwandt (UNI/EXP (Uni Hamburg, Institut fur Experimentalphysik))
js_Bonn_20240423....

18:00 → 19:30 **Parallel Session: Theory**
Convener: Tilman Plehn (Heidelberg University)

19:30 → 22:00 **Discussion Dinner** 2h
Buffet-style dinner with time for discussions

Friday, 24 May

09:00 → 10:15 **Discussion Session: Community engagement in R&D for FC@CERN**
Conveners: Frank Gaede (FTX (FTX Fachgruppe SFT)), Frank Simon (KIT IPE), Tilman Plehn (Heidelberg University)

09:00 **Slides**
Speakers: Frank Gaede (FTX (FTX Fachgruppe SFT)), Frank Simon (KIT IPE), Tilman Plehn (Heidelberg Uni
EngagementDiscus...

10:15 → 10:45 **Discussion Session: Path towards the ESPP update**
Convener: Heiko Lacker (Humboldt University of Berlin)

10:15 **Slides**
Speaker: Heiko Lacker (Humboldt University of Berlin)
KET-Input-Organisat...

10:45 → 11:15 **Coffee break**

11:15 → 12:15 **Discussion Session: Scenarios for FC@CERN**
Convener: Klaus Desch (University of Bonn)

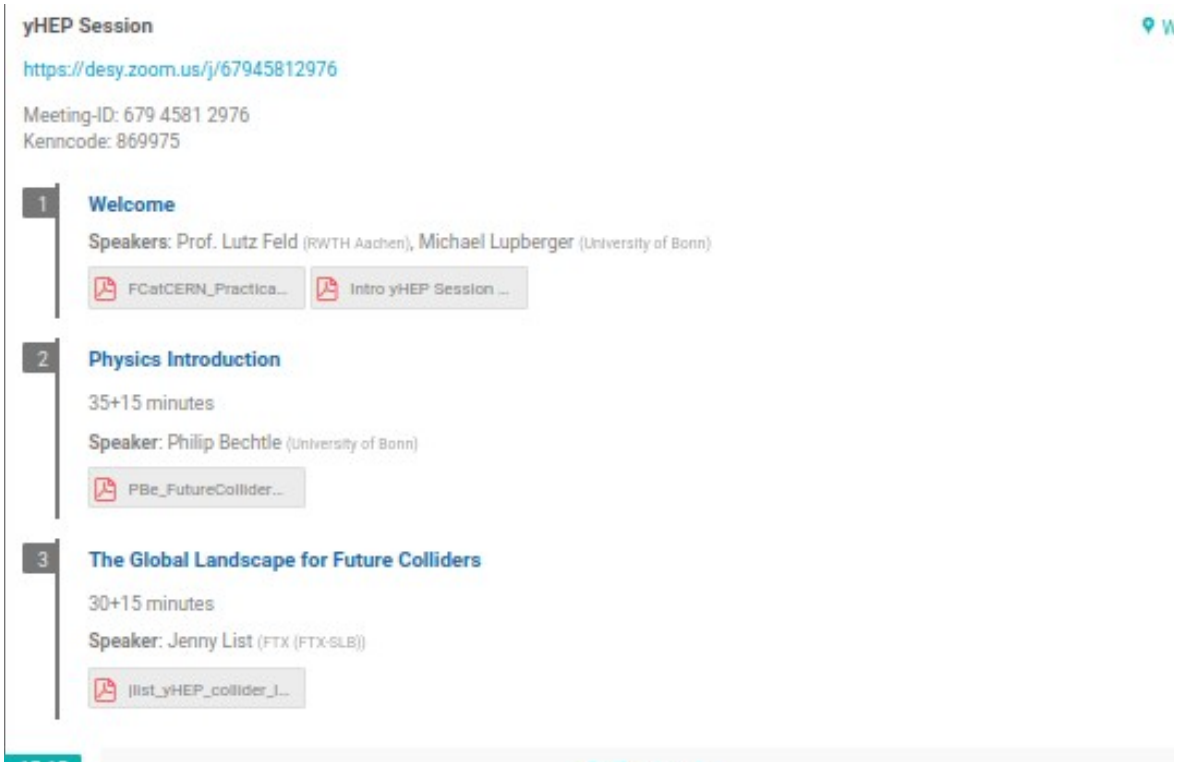
11:15 **Slides**
Speaker: Klaus Desch (University of Bonn)

12:15 → 12:45 **Coffee break**

12:45 → 13:30 **Discussion Session: Attempt of a summary**
Convener: Markus Schumacher (Albert-Ludwigs-Universität Freiburg)

12:45 **Slides**
Speaker: Markus Schumacher (Albert-Ludwigs-Universität Freiburg)
fc@cern-a-o-s-ms-2...

Wednesday
yHEP session I



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35+15 minutes

Speaker: Philip Bechtle (University of Bonn)

PBe_FutureCollider...

3 **The Global Landscape for Future Colliders**

30+15 minutes

Speaker: Jenny List (FTX (FTX-SLB))

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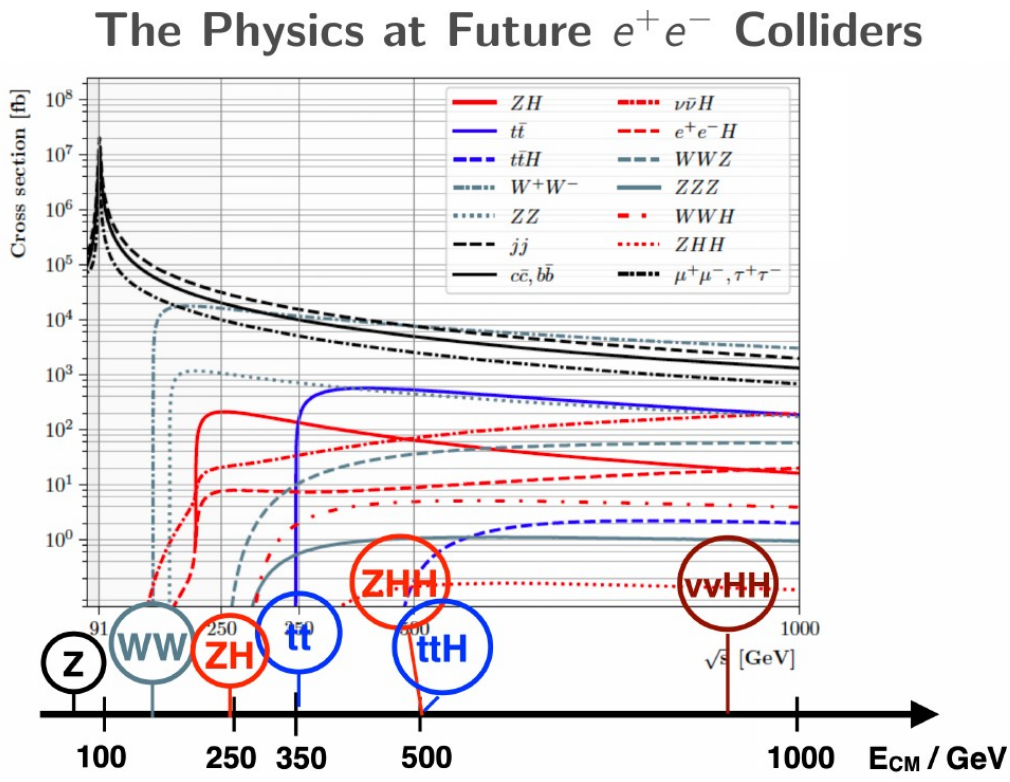
P. Bechtle (Bonn): Physics Introduction¶

Higgs Physics

- Very precise mass → LHC
- Spin → LHC
- Unitarity of WW scattering at $\sqrt{s}_{e^+e^-} \approx 1$ TeV → LHC
- CP → LHC? Admixtures? → e^+e^-
- Total width → LHC? → e^+e^-!
- Absolute couplings → e^+e^-
- Higgs self-coupling → LHC? e^+e^-?

Beyond direct Higgs Physics at the future e^+e^- collider:

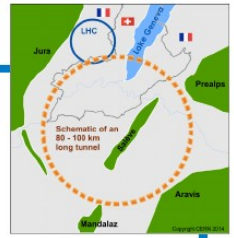
- (Higgs) Quantum Information?
- Triple Gauge Couplings
- Most precise m_t, m_W
- Invisible Higgs decays? Other (invisible?) Higgses?
- Any other sign for new physics . . .
- Much more . . .



J. List (DESY): The Global Landscape for Future Colliders¶

They fall into two classes

Each have their advantages

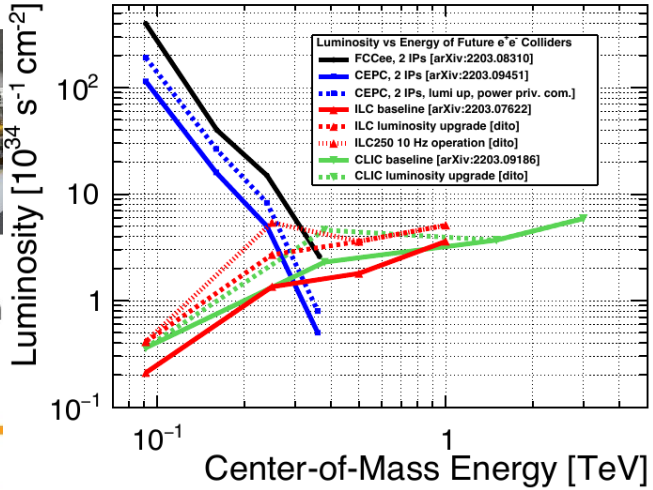


Circular e+e- Colliders

- FCCee, CEPC
- length 250 GeV: 90…100km
- high luminosity & power efficiency at **low energies**
- **multiple interaction regions**
- very clean: little beamstrahlung etc

Linear Colliders

- ILC, CLIC, C^3, …
- length 250 GeV: 4…11…20 km
- high luminosity & power efficiency at **high energies**
- **longitudinally spin-polarised beam(s)**



Long-term vision: re-use of tunnel for pp collider

- technical and financial feasibility of required magnets still a challenge

Long-term upgrades: energy extendability

- same technology: by increasing length
- **or by replacing accelerating structures with advanced technologies**
  - RF cavities with high gradient
  - plasma acceleration ?

K. Jakobs (Freiburg):
From Strategy Discussions to Decison-Taking for Large Projects

- CERN
- CERN Council
- The Scientific Policy Committee
- ECFA European Committee for Future Accelerators
- ECFA-ECR Panel
- Laboratory Directors Group
- KET
- European Strategy for Particle Physics
- FCC Feasibility Study
- ECFA Accelerator R&D Roadmap
- ECFA Detector R&D Roadmap
- DRDs
- PPG, ESG

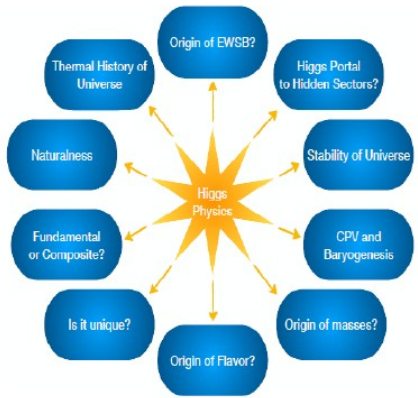
Final Comments

- The decision on the next large accelerator project at CERN must be taken a.s.a.p.
- Convergence in the upcoming Strategy Process is vital!
- Engagement of the full community, including the young generation, is needed; A consensus, i.e. a broad support within the HEP community, must be reached.
- International participation is essential (→ new governance model(?))
- **Important for the realisation of a future collider at CERN:**

  * Convince decision makers of the incredible physics case and of the vital role of high-energy colliders;

    → more efforts needed

  * Continue optimization efforts on power reduction!



Wednesday
yHEP session II

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30+15 minutes

Speaker: Karl Jakobs (University of Freiburg)

KET_Bonn_Decision... KET_Bonn_Decision...

5 **CERN Physics Beyond Collider Program**

15+5 minutes

Speaker: Gunar Schnell (HERMES (HERMES Experiment))

FCatCERN2024_PB...

6 **Discussion**

7 **Navigating social acceptance for large technology infrastructures – how to establish the science-society dialogue?**

15+5 minutes

Speaker: Gudrun Haindlmaier (Austrian Institute of Technology)

CERN_Bonn_Haindl...

8 **Environmentally responsible research at CERN**

15+5 minutes

Speaker: Sonja Kleiner (CERN)

22_05_2024_CERN_...

9 **Discussion**

Closeout yHEP Ses...

G. Schnell (Basque Foundation of Science): CERN Physics Beyond Collider Program

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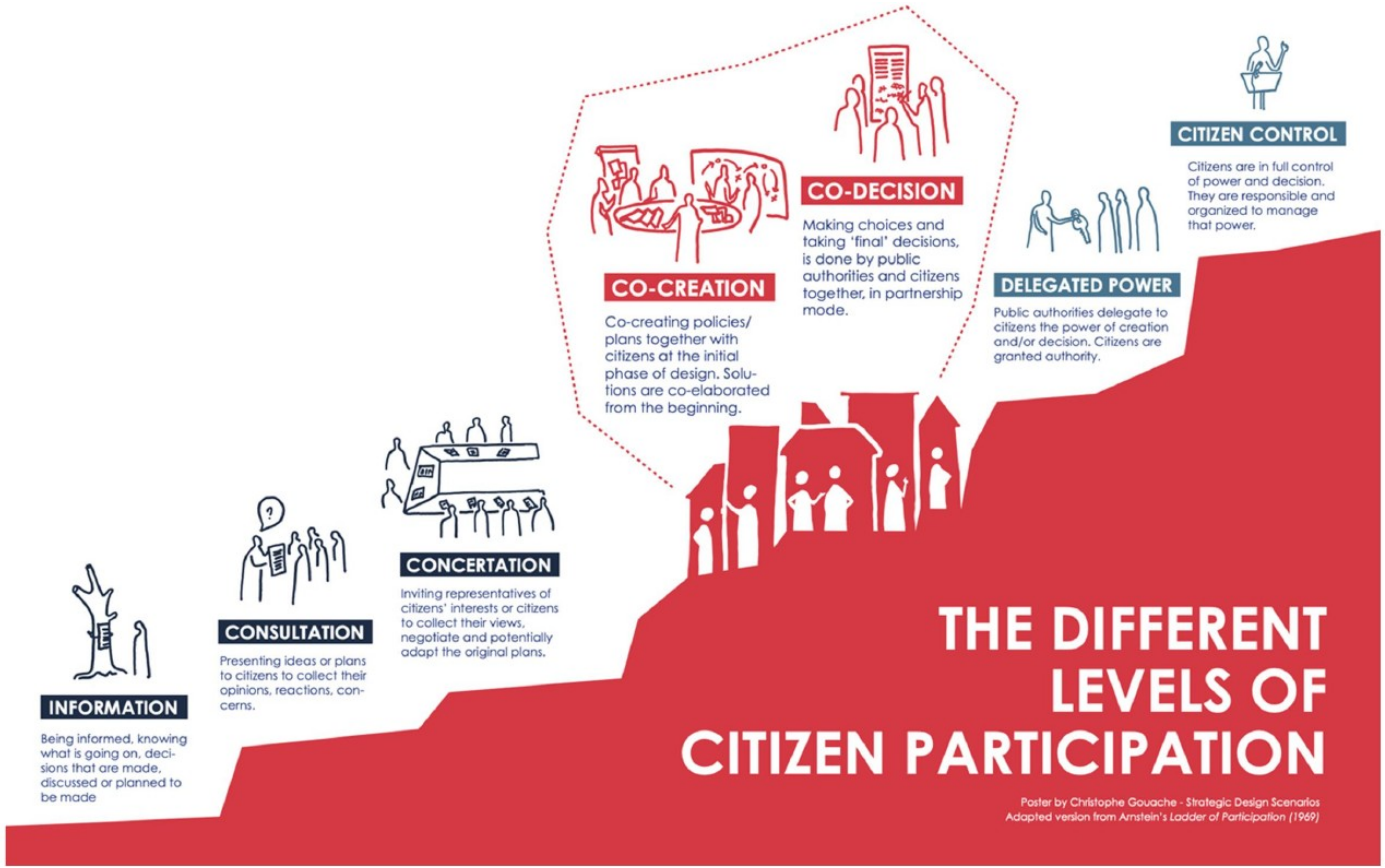
prospectives for young HEP researchers

- CERN is more than just LHC or FCC many forefront activities pursued within PBC & more outside
  - PBC channeling ideas and help preparing a solid & realistic physics case
- PBC projects typically much smaller in collaboration size and scope
  - often leading in their subfield
  - opportunities to get engaged in wide scope of activities with higher visibility and leading roles
- Mix of shorter term and long-term projects, coupled or de-coupled from LHC, e.g.,
  - LLP@LHC (e.g., FFP) with BSM and neutrino physics; LHCb-FT with QCD and BSM aspects
  - recently selected flagship beam-dump experiment SHiP will run way beyond HL-LHC and has several options for extending program
  - in general, existing injector complex up to SPS operational beyond HL-LHC, enabling many of the projects mentioned (or not) today
  - PBC fosters new ideas — also from you!;-) — thus more opportunities potentially on horizon
- PBC diversifies physics research and helps to fully exploit the existing accelerator complex at CERN

Q: Is there space besides/on the way to FCC for a similar PBC program?
A: Concern, hopefully yes

G. Haindlmaier (AIT, Wien):

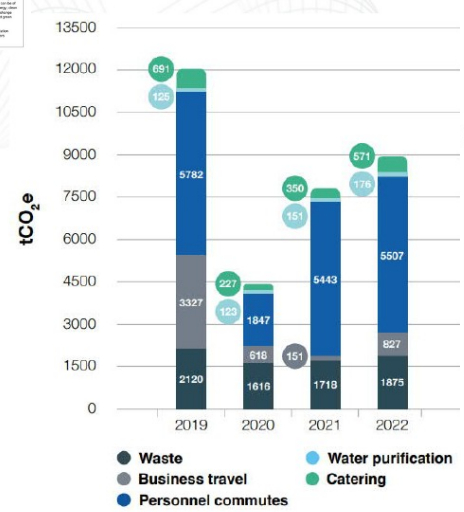
Navigating social acceptance for large technology infrastructures – how to establish the science-society dialogue?



S. Kleiner (CERN): Environmentally responsible research at CERN

Emissions

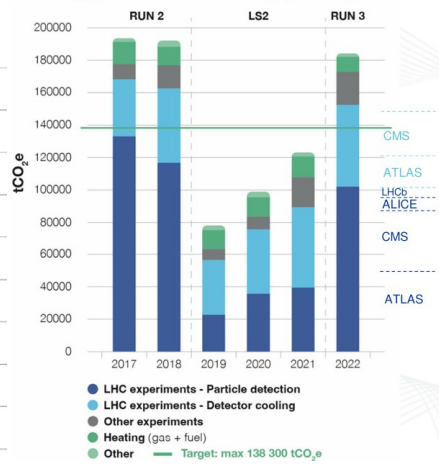
CERN'S TOTAL SCOPE 1, 2 AND 3 EMISSIONS 2021–2022



CERN'S SCOPE 3 EMISSIONS 2019–2022 (EXCLUDING PROCUREMENT)

"Waste" includes the waste t
elimination pathways, as wel
wastewater treatment plants
travel and personnel commu
are included. The calculation
protocol; the emission factor
database, and the impact m
V1.01. All data from previous

Emissions



Scope 1 - direct emissions

Detector cooling
Reduction potential for RUN4 vs 2018 of ~ 40'000 tCO_2e

Particle detection
Reduction potential for RUN4 vs 2018 of more than 13'000 tCO_2e

- Main source of scope 1 emissions linked to F-gases used for detector cooling (mostly PFCs such as C_6F_{14} and C_3F_8) and for particle detection (mostly HFCs such as HFC-134a)

Thursday Morning I

09:00 **Introduction - scope and goals of the workshop**

10+5 minutes

Speaker: Prof. Lutz Feld (RWTH Aachen)

FCatCERN_Practical... KET Intro FC@CERN...

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Speaker: Prof. Milada Margarete Mühlleitner (Karlsruhe Institute of Technology (KIT))

FutureCollidersTheo...

10:15 **BMBF's current view to FC @ CERN**

20+10 minutes

Speaker: Eckart Lilienthal

240523 FC@CERN_...

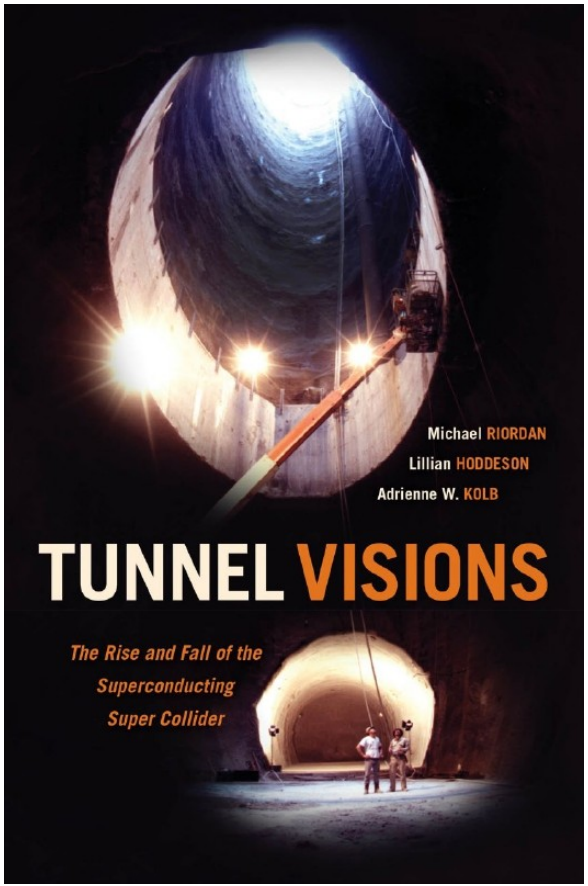
M. Mühlleitner (KIT): The physics case for an e+e- collider at CERN

e^+e^--Colliders: Z/Higgs/Top-Factory in clean e^+e^- environment

- Model-independent Higgs couplings access @ unprecedented precision
- Unique measurement of He^+e^- coupling
- EW precision measurements
- Flavor factory
- Sensitivity to weakly/feebly interacting BSM particles
- Higher energies: direct access to λ_{HHH} and y_t

Tremendous theory effort required to match experimental accuracy

E. Lilienthal (BMBF): BMBF's current view to FC @ CERN



- **Strong commitment of BMBF to CERN**
- **Future of CERN highest priority to BMBF**

But:

- FCC considered as not fundable due to long-term budget constraints
- “Constant CERN funding – at best”
- German community should prepare for alternative scenarios!

Thursday Morning II

11:30 **The FCC-ee project**

35+5 minutes

Speaker: Markus Klute (MIT)

2024-05-23-fcc-mk....

12:15 **An Alternative Vision for CERN**

25+5 minutes

Speaker: Jenny List (FTX (FTX-SLB))

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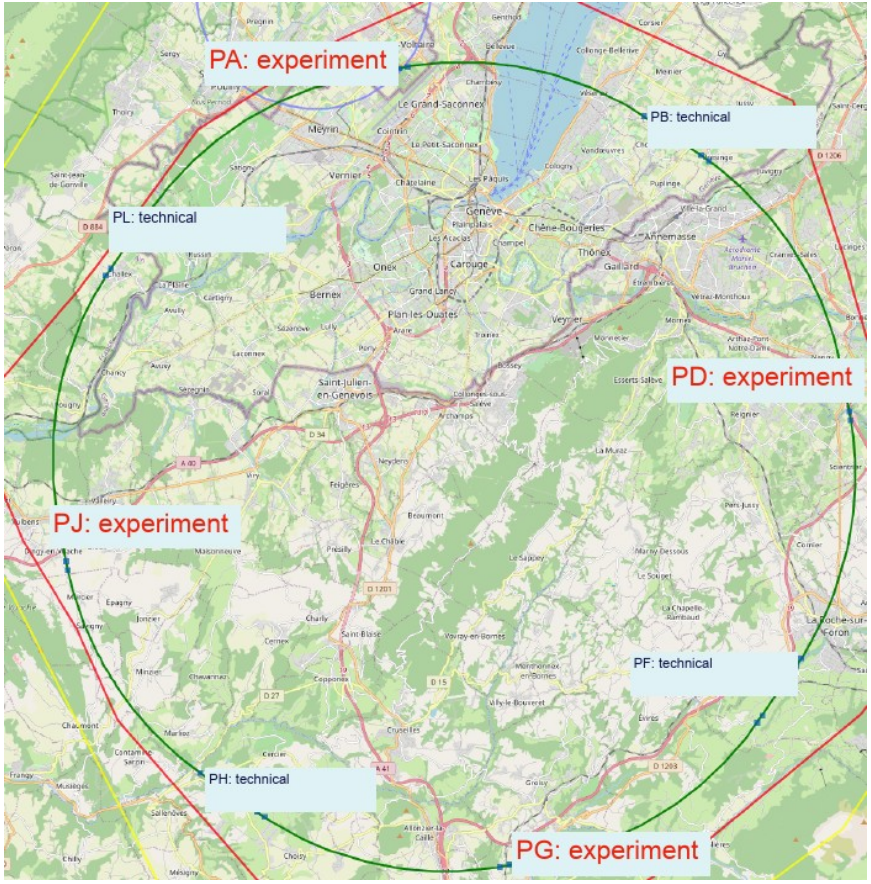
M. Klute (KIT): The FCC-ee project



- General FCC overview and introduction
  - Physics
  - Detector requirements
  - Technical implementation
- News from the feasibility study midterm review
- **No major showstoppers found!**
- First official cost estimate:
  - 12.8 GCHF with 2 IPs Z/WW/ZH
  - 4 IPs: + 710 MCHF, ttbar: +1.5 GCHF
  - Total: ~15 GCHF

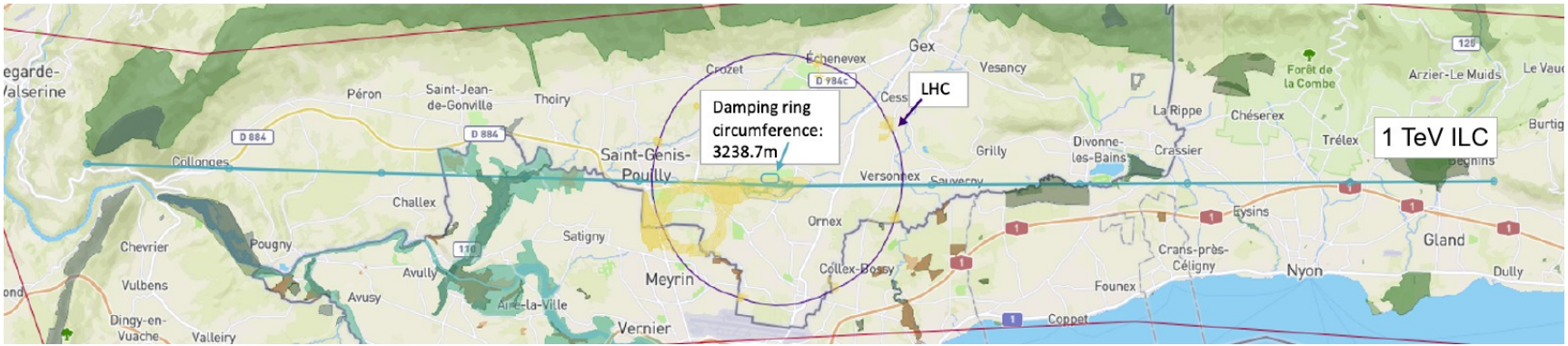
J. List (DESY): An Alternative Vision for CERN

What if FCC unfeasible

- financially?
- scientifically (CEPC approved)?

Proposal: a linear collider facility at CERN

- Covering 250 GeV up to 1 TeV
- Either CLIC or ILC technology (industry support)
- Possibility of 2 IPS
- Possibility of energy/luminosity upgrades
- Much prior design work exists from past studies
- Costing will be updated for the strategy update



M. Lupberger (yHEP): Input from yHEP

A Future Collider young researchers are excited about fulfils these criteria:

- Lepton collider capable to reach HH/tt threshold; precision physics case given
- Is wanted by society and fits it in the mid-to-end-21st century (sustainability, …)
- Is able to use game-changing new acceleration technologies in an upgrade
- Gets into operation < 10 years after HL-LHC and offers a career perspective
- Has a positive societal balance by minimised impact to climate & environment
- Improves ECR prospects in large collaborations & allows balanced PBC prog.
- Is build at CERN or with strong CERN involvement

A wish list is a wish list.

Enthusiasm requires prospects that wishes can be fulfilled!

Thursday Afternoon I

14:30 **FCC-ee key technologies and technological readiness**

15+5minutes

Speaker: Frank Gerigk (CERN)

FCC-Key-technologi...

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15+5 minutes

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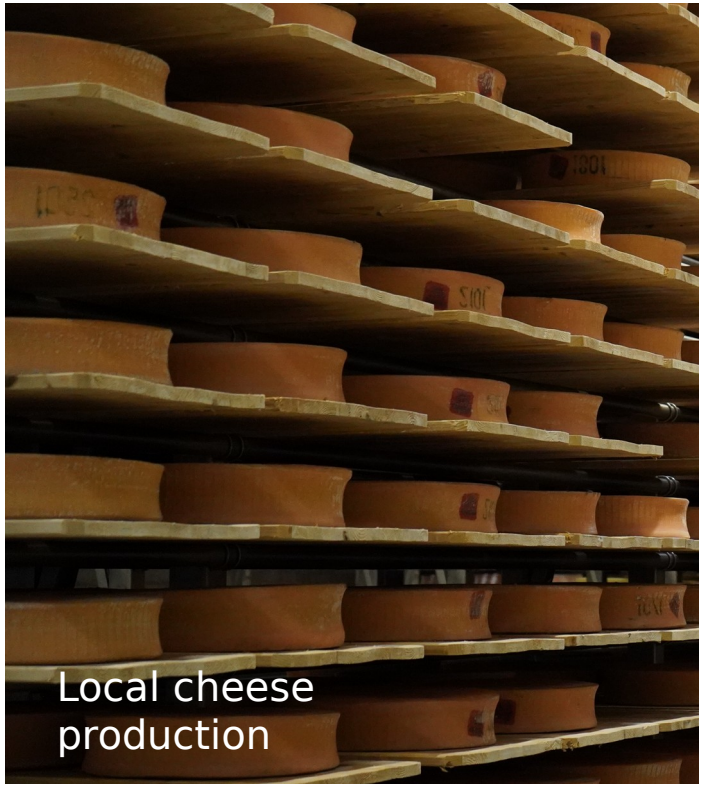
2024-05-23_FutureC...

F. Gerigk (CERN): FCC-ee key technologies and technological readiness

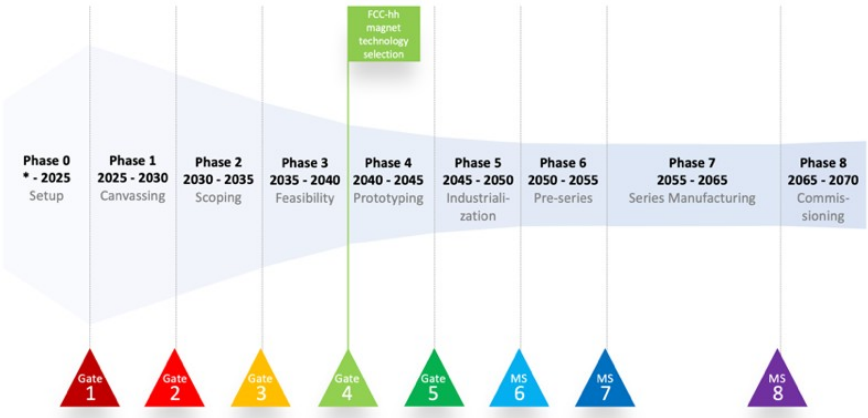
- RF, magnet, and vacuum technology are ready to build this machine today.
- R&D is needed to reach nominal specs, to keep capital cost under control and to ensure and potentially increase energy efficiency.
- Prototyping of cavities, couplers, cryomodules is a time-consuming process and needs to start now.
- CERN is making a strategic investment in a dedicated new SRF facility and is setting up a significant SRF prototyping effort.
- The ttbar starting date (2055) justifies a dedicated research program for Nb3Sn cavities. Any progress until 2040 – 2045 will significantly impact cost & efficiency of the ttbar run. This is the time for a major technological step forward.

J. Gutleber (CERN): FCC sustainability aspects

- Basically every part of the machine needs to be individually tuned towards efficiency and to minimise the impact to the environment
- Many different ways for this are studied
- Examples:
  - Transformation of excavated molasse rock into farmable soil
  - Waste heat re-usage by locals for e.g. cheese production


Local cheese production

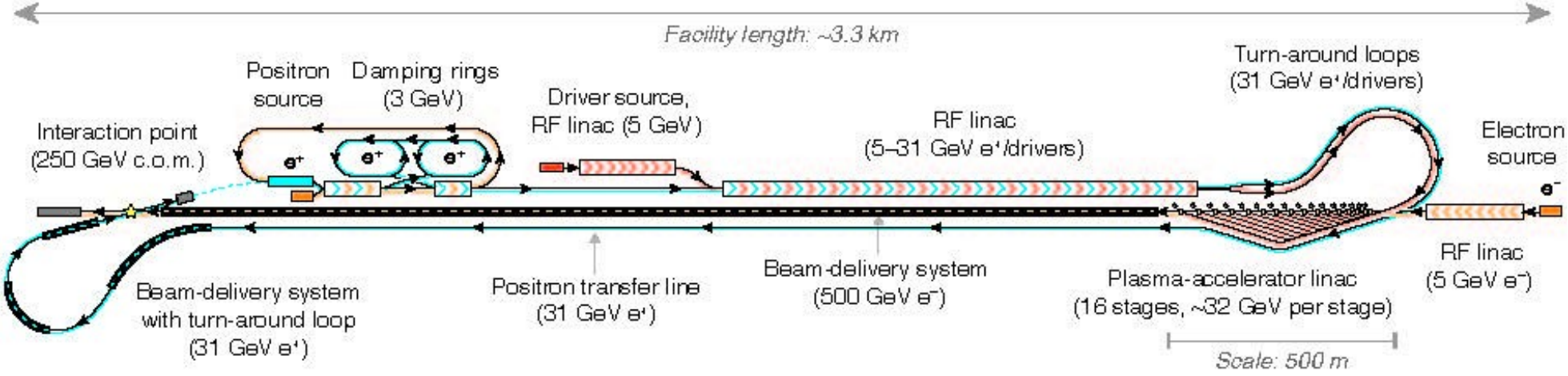
B. Auchmann (CERN):
R&D on high-field magnets for FCC-hh and muon cooling



- HFM Program hosted by CERN, in reaction to last strategy update (https://cern.ch/hfm)
- Testing of FCC demo magnets will ramp up early 2026
- Still many different technology options (HTS vs. Nb3Sn)
- Reply to audience question about FCC-hh magnets: probably **not earlier than 2055**

M. Turner (CERN): R&D on plasma acceleration

- Enables increase of gradients from MV/m to GV/m -> reduce cost and length of accelerators
- Many R&D projects ongoing with strong contributions from Europe and Germany
- Rapid progress is made at many different points
- Smaller projects (plasma based injectors) foreseeable for the not so far future
- Plasma based colliders like HALHF still need (much) more R&D



Thursday Afternoon II

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30+10 minutes

Speaker: Dr Felix Sefkow (DESY)

FCCeeDetector-KET-...

16:50 **Computing&Software: Opportunities, Challenges and R&D**

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Speaker: Frank Gaede (FTX (FTX Fachgruppe SFT))

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17:20 **Opportunities and challenges in precision predictions**

20+10 minutes

Speaker: Wolfgang Kilian

kilian-theory.pdf

F. Sefkow (DESY): Detector concepts & technologies

Summary

Take-home

FCCee detectors represent exciting challenges

- radiation tolerance generally not an issue - but rate capability is, and in tension with ILC-like ambitions for material budget and compactness

There is time and room for new ideas, concepts and technologies

- try them out: demonstrators are collider-agnostic

Gradual and moderate ramp-up in resources

- but timely. and in the right places
- but real (scalable) prototypes will soon have to meet TDAQ electronics specs and will require some engineering

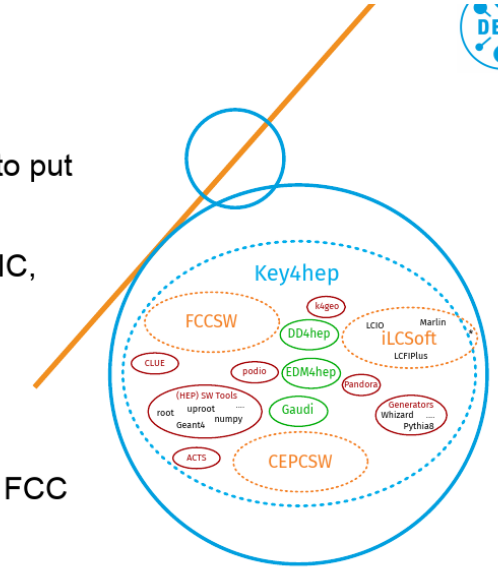
Software: common ILC FCC framework

- full simulations nearing completion - less true at the reconstruction frontier
- CLD suitable infrastructure ready for most studies

F. Gaede (DESY):
Computing & Software: Opportunities, Challenges and R&D

Summary and Outlook

- **Key4hep** started as a new future collider community wide effort in 2020 to put together a modern turnkey software stack
- with growing community of users and contributors: CEPC, CLIC, FCC, EIC, ILC, LUXE, Muon Collider …
  - core tools: DD4hep, EDM4hep(podio), Gaudi
- all future lepton collider detectors in DD4hep (k4geo package)
- reconstruction (and simulation/analysis) tools and algorithm from CEPC, FCC and the linear colliders included in Key4hep stack
- first genuine Key4hep/EDM4hep/Gaudi reconstruction algorithm start to become available (k4Clue, k4ACTS, k4Pandora,….)



- **Key4hep project is the first time that such a large number of experiments develop a common software stack**
- **Progress crucially depends on contributing person power**
- **Now is a great time to get involved in contributing to Key4hep !!**

W. Kilian (U Siegen): Opportunities and challenges in precision predictions

- Many technical challenges but likely to be met if theory/precision community remains active

Conceptual challenges in SM precision calculations

What is the Standard Model?

Superficial picture (LEP I/II) vs. FCC-ee precision

Model/Lagrangian	$\Leftrightarrow$	Pseudo-Observables	$\Leftrightarrow$	Data
$g_1, g_2, g_3, v, \ldots$		$M_W, \Gamma_Z, R_b, \ldots$		event samples

Thursday Evening

Parallel discussions: 18:00-19:30

- Calorimetry
- Computing & Software
- Gaseous tracking
- Si-based tracking
- Theory

and last but not least: dinner :)

Friday

09:00 → 10:15 **Discussion Session: Community engagement in R&D for FC@CERN**

Conveners: Frank Gaede (FTX (FTX Fachgruppe SFT)), Frank Simon (KIT IPE), Tilman Plehn (Heidelberg University)

09:00 **Slides**

Speakers: Frank Gaede (FTX (FTX Fachgruppe SFT)), Frank Simon (KIT IPE), Tilman Plehn (Heidelberg Uni

EngagementDiscus...

10:15 → 10:45 **Discussion Session: Path towards the ESPP update**

Convener: Heiko Lacker (Humboldt University of Berlin)

10:15 **Slides**

Speaker: Heiko Lacker (Humboldt University of Berlin)

KET-Input-Organisat...

10:45 → 11:15 **Coffee break**

11:15 → 12:15 **Discussion Session: Scenarios for FC@CERN**

Convener: Klaus Desch (University of Bonn)

11:15 **Slides**

Speaker: Klaus Desch (University of Bonn)

12:15 → 12:45 **Coffee break**

12:45 → 13:30 **Discussion Session: Attempt of a summary**

Convener: Markus Schumacher (Albert-Ludwigs-Universität Freiburg)

12:45 **Slides**

Speaker: Markus Schumacher (Albert-Ludwigs-Universität Freiburg)

fc@cern-a-o-s-ms-2...

Friday: Summary document

Future Collider at CERN German Community Event

22nd to 24th May 2024 https://indico.desy.de/event/44074

This summary document is available from the agenda page of the meeting at
https://indico.desy.de/event/44074/page/5093-summary-document

KET - Committee for Particle Physics

Preamble

The "Committee for Particle Physics (Komitee für Elementarteilchenphysik (KET)", supported by the Helmholtz Alliance "Physics at the Terascale", organised the "Future Collider at CERN German Community Event", which took place at the University of Bonn from 22nd to 24th May 2024 (https://indico.desy.de/event/44074). The event gathered more than 150 participants from the German particle physics community, who are interested in CERN's planning for a future collider. The focus of this event was set to discuss the opportunities of a potential FCC-ee collider at CERN. The emphasis of the meeting has therefore been on the results of the mid-term review of the CERN FCC Feasibility Study and a discussion of possible German contributions to the FCC-ee in the areas of physics studies, precision predictions, detectors, computing, and accelerators. Several other e^+e^- Higgs factory projects are being discussed in the worldwide particle physics community. This workshop does not predetermine the outcome of the discussion in the German community on the update of the European strategy for Particle Physics (ESPPU). Furthermore, a plan on how to prepare the German contribution to the ESPPU has been discussed. This document summarizes the conclusions from the three discussion sessions on the topics of "Scenarios for FC at CERN", "Community Engagement in R&D for FC at CERN", and "The Path towards the ESPP Update".

Friday: Summary document
1 Scenarios for FC at CERN

There are fundamental questions about our Universe and its microscopic constituents which can only be answered at high energy. Without a new collider, many of these questions will remain unanswered. CERN is the world-leading lab for particle physics. Maintaining this leadership is our goal. A collider flagship project at CERN soon after the full exploitation of HL-LHC is required to obtain answers to these fundamental questions. In addition to a superb physics case, the project has to address ambitious sustainability standards. It should strongly involve the (now) young generation. It needs to attract (positive) interest in society at large and be attractive for industry, driving cutting-edge technologies. Obviously, it needs to be affordable and feasible. The arguments for a new collider project need to be sharpened and the excitement of the community needs to be communicated more intensely to the general public, other fields of science and decision makers.

An e+e− Higgs factory is the highest priority next collider project of the world-wide community and has a rich physics programme. Responding to the 2020 ESPPU, CERN has launched a feasibility study proposing the FCC-ee as a Higgs factory with a hadron collider as a possible later stage. The FCC-ee offers a broad physics programme with excellent opportunities to study the nature of the Higgs boson with unprecedented precision and many other fundamental topics. The achievable measurements will open new routes to finding answers to many of the open questions in particle physics. Germany should embark on this project more strongly. The German particle physics community wants to increase efforts to work out the physics case of the FCC-ee, contribute to theory challenges to achieve the required (beyond-state-of-the-art) precision, prepare to play a major role to develop detectors, software, computing, and to increase involvement in the accelerators both at German laboratories and universities and with industry.

There are uncertainties connected with the financial feasibility and with the global context of the FCC-ee. The BMBF reminded the community that, while the future of CERN remains of highest priority to BMBF, a future collider project at CERN needs an affordable financial plan and that this requires to prepare for different scenarios including one without the FCC-ee. In order to be able to handle the given uncertainties in the context of the next Update of the European Strategy for Particle Physics, an alternative collider project at CERN needs to be identified to address the open fundamental questions in case the FCC-ee would not be built at CERN.

Friday: Summary document

2 Community Engagement in R&D for FC at CERN

The discussion on the engagement of the German community in the FCC Feasibility Study and the subsequent “pre-TDR” phase prior to a possible approval of the project demonstrated that there is a broad consensus for a significant engagement in all aspects of this process.

Prior to the workshop, a survey was conducted among the group leaders in the German community to identify the main topics of interest in different areas, which were covered in the discussion on engagement. A total of 64 group leaders have responded, with slightly less than half of them expecting to still be active in the field in 20 years. The majority of the group leaders expect that their engagement in a Higgs Factory, once a decision is taken, does not depend strongly on the adopted technology choices for accelerators and detectors.

The plans for a stronger engagement begin with the physics case to be documented in the FCC Feasibility Study report and in the ECFA Higgs-Top-Electroweak Factory study, also recognizing the importance of making the case more accessible for the general public and colleagues outside of high energy physics. The community survey showed particular interest in the areas of Higgs and beyond-the-Standard-Model physics, as well as in flavour and top-quark physics.

Significant potential for a broad engagement is seen in physics and detector optimisation studies. Here, a low threshold and easily accessible documentation is crucial to enable the involvement of MSc students from groups without prior activities in a future collider context. It is noted that personnel in groups both at CERN and at DESY are available to support newcomers, but information on this would need to be better publicised, and documentation may need to be improved. The availability of simulation samples is desirable but often not practical for specific studies, placing particular emphasis on easy-to-follow procedures for producing data sets. The community has shown a focus on the CLD detector concept for FCC-ee and the ILD detector concept developed for ILC, both with full simulation capability, with some interest in ALLEGRO. Many groups are indicating generic interest in studies not tied to a particular concept. In general it is seen as premature to commit to a particular detector concept at this point in time. The provisioning of the technical infrastructure to perform these studies is of central importance - a role that falls on the major laboratories CERN and DESY.

Theory is expected to play an active role in the further development of the physics case. The scope of the FCC-ee project requires in-depth studies of the potential of such a machine in view of the challenging questions of fundamental physics: dark matter and the matter-antimatter asymmetry. A traditional strength of the German community is the combination of precision predictions with precision analysis. The case for an e+e− collider rests on direct searches for weakly coupled light new states and on precision measurements sensitive to heavy new physics through quantum effects. In both directions, an e+e− collider should provide significant improvements and qualitatively new insights relative to the LHC program. Visible contributions from the German community are expected in the combination of precision loop calculations, the corresponding simulations, and modern analysis methods. The community survey has indicated particular interest in the areas of BSM phenomenology and Standard Model precision calculations, and activities in the area of Monte Carlo generators.

The activities in detector R&D are aligned with the recently formed DRD collaborations, and are organized in BMBF collaborative research projects, with projects on silicon detectors, on calorimetry and on gaseous detectors receiving funding in the BMBF funding period 2024 – 2027. The participation in the newly formed DRD collaborations is largely enabled with this funding, with significant participation in DRDs 3, 6 and 1, respectively, and additional activities in DRDs 7, 5 and 8. In terms of technology, the survey showed strong engagement in CMOS and LGAD technology for tracking, high granularity calorimetry, and interest in integration topics in DAQ, mechanics and cooling. To strengthen the exchange within the German detector R&D community, common meetings should be held as satellite meetings to the annual Terascale Detector Workshop and/or the annual meeting of the Terascale Alliance. A light-weight coordination structure which includes representatives of the BMBF collaborative research projects and main future collider activities in Germany should be established.KET is charged to provide a proposal of a concept how activities in Germany shall and can be coordinated. The Helmholtz Alliance Physics at the Terascale might be a good environment for such a structure.

In the area of software and computing, key contributions of the community are in the development of Key4hep. The survey also indicated a broad interest in the development of algorithms and analysis. Currently no dedicated funding is available in this area. To broaden the base of activities, knowledge transfer, including workshops and tutorials is seen as important. For the development of novel analysis approaches, the use of activities in the BMBF-funded collaborative research project FIDIUM and in the DFG-funded NFDI consortium PUNCH should be explored.

Friday: Summary document
3 Path towards the ESPP Update

To converge on the German community input to the ESPPU, KET proposes to organise three workshops, one on "Colliders", one on "Non-collider projects", and a "Concluding workshop".

The following venues and dates were presented and also agreed: ”Non-collider”(22.-24.11.24 right after the annual KET meeting, Bad Honnef), ”Colliders” (27.-29.11.24; DESY Hamburg); ”Concluding workshop” (19.01.-22.01.25, Bad Honnef).

As a result of the discussions between KET, KHuK, KAT, and KfB, it was decided that each community prefers to provide its own ESPPU input to preserve the community-specific aspects. However, one should aim for coherence in areas of common topics, e.g. on physics, computing, detector R&D,

the role of CERN.

In order to get the full picture the three workshops organized by KET will nevertheless cover topics from the neighbouring communities, which are connected to particle physics.

The workshop participants agreed with the general plan as well as with the proposed dates and venues and expressed the opinion to focus in the workshops on future projects relevant for strategy discussions.