

FCC-ee - PE&D Activities in the Different Countries

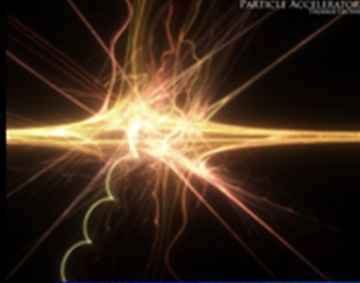
There have been iterations with the restricted ECFA members about the future colliders situation in their countries, in particular regarding PE&D, so we can have a global overview of the situation.

We will briefly review them and see that there are broadly 4 categories,

- FCC-ee effort well started, well supported
- FCC-ee effort getting organized
- No FCC-ee effort started
- Priority FCC/ILC or FCC-hh vs. ee unclear

We also have received slides, which will be presented by their authors, from:

- Italy, France, UK, Switzerland, Belgium, Austria, Portugal, Hungary, Korea, USA
- This will be followed by short summary for all other European countries
- Then discussion



FCC in Italy

- ❖ Good support in general from INFN
- ❖ Organization and participation
 - 91 researchers/17 FTE from 15 INFN units/National Labs
 - Increasing since start of activity in 2016
- ❖ Work in progress
 - Software: physics, detector simulation, infrastructure
 - Accelerator R&D: MDI, Magnets
 - Detector R&D: Silicon sensors, Drift chamber, Dual Readout calorimeters, Micro-Rwell chambers
- ❖ Funding:
 - Funding from INFN at few 100 kEuro level for 2021
 - Additional funding from EU grants:
 - AidaInnova, Cremiln+, FEST

FCC-France in 2020

Well established ILC-France R&D effort but **FCC is the long term priority of French HEP** hence a complete FCC scientific structure has been set-up in 2020.

- Responsible IN2P3 (Master Project FCC-Phys): **Gregorio Bernardi**
- Responsible IN2P3 (Master Project FCC-Acc.): **Jean-Luc Biarotte**
- Responsible IRFU : **Roy Aleksan**

+ FCC-contacts in the **10 IN2P3 participating labs** & in the 2 related **R&D master-projects**
IPHC-Strasbourg, IP2I Lyon , LAPP-Annecy , LPSC Grenoble , LPC Clermont , IJC-Lab Orsay,
CPPM Marseille, LPNHE Paris, LLR Palaiseau, L2IT, Toulouse , **Microvertex for LC, CALICE**

Groups are growing in each lab, since IN2P3 and IRFU encourage a participation in FCC-ee in parallel to HL-LHC. Heavy Flavor community strongly support FCC-ee.

Long term goal is to merge all the existing e+e- expertise (physics and detectors in particular)

1st FCC-France workshop devoted to physics & detectors on 14-15 May 2020, (1.5 day)

138 participants, with a strong foreign component <https://indico.in2p3.fr/event/20792/>

2nd FCC-France workshop for physics-detectors-accelerator on 20-21 Jan 2021 (2 days).

FCC-France already involved in several **Case Studies** (Higgs, EW, HF, Top).

- R&D :**
- Need to get critical masses on new future projects before decision @IN2P3 on their funding (e.g. LAr calorimetry, Pixels)
 - Current Lines on R&D geared towards ILC (which can be converted to FCC) are continued (CALICE, CMOS-microvertex). Allocation of funds will be known end of November.
 - R&D on TPC is continuing/funded at Saclay.

FCC-UK group established, with contacts in every institute (summer '20)

Fri 11 September: FCC-UK kickoff meeting

- On zoom; ~75 participants (including ILC & CePC enthusiasts)
- Presentations of physics (mostly in the AM) and R&D (mostly in the PM) opportunities
- Agenda: <https://conference.ippp.dur.ac.uk/event/933/>

Mon 28 September: UK Particle Physics Advisory Panel (“PPAP”) “Town Hall” meeting (community includes no-collider HEP people)

- First such post-European Strategy update meeting
- Not a presentations-type agenda/meeting. Breakout rooms to brainstorm on “strengths & opportunities” for UK groups
- PPAP will use input to produce new roadmap (to be used for providing funding on future collider projects) by early next year?

Fri 16 October: provided written input to PPAP

- Three UK-centric documents (ee, hh, eh), along with a joint “umbrella” statement

Fri 20 November: next scheduled PPAP meeting

- Update on the roadmap process and inputs received

January/February: PPAP update

- Roadmap: rough draft of the first UK plans?

Contacts: Christos Leonidopoulos
Guy Wilkinson

- FCC, next to the exploitation of LHC, the highest scientific goal in the CH input into the Update of the ESPP:

Full exploitation of the LHC should remain as the first priority for the European particle physics programme, in parallel with an intensified R&D and design effort to realise the next large project at CERN in the future, namely FCC. The Swiss particle physics community considers that Europe should pursue an ambitious plan to lead high energy frontier physics.

- Strong Accelerator R&D "Stimulus Package" Program CHART:
 - ❑ CERN, EPFL, ETHZ, ETH domain, UniGE PSI, State Secretariat of Education, Research and Innovation
- National collaboration forming:
 - ❑ 2 FCC/FCC-ee workshops (UniGE/UZH) planned under auspices of CHIPP in 2021
 - ❑ Joint detector development grant planned for 2022-2024 to SNF
 - ❑ one SNF base grant already attributed for simulation of FCC-ee vertex detector – PD advertisement at <https://inspirehep.net/jobs/182810> and PhD positions at <https://inspirehep.net/jobs/1828622>

Contact: Rainer Wallny

FCC-ee in Belgium

Belgian HEP: Profile

- Belgium hep-ex heavily invested in CMS @LHC
 - Instrumentation efforts GEM muon and Tracker endcap
 - no other large collider experiment communities at LHC
- Existing collaboration hep-ex and hep-ph collider physics through inter-university network "be.h" with focus on SM scalar boson and its connection to BSM
- Active hep-ph community incl FCC-ee
- National funding profile to gain sustained funding expected to remain challenging until on various roadmaps

No coordinated national effort yet

Status: investigating collaboration within Belgium and with neighbouring countries

Recent FCC-ee efforts:

- UC Louvain driving common tools MGaMCatNLO and DELPHES
 - Groups of Fabio Maltoni and Marco Drewes (both UCL) contributors to CDR
- UGhent and UCLouvain are on CALICE
- Vrije Universiteit Brussel involved with physics studies CDR
 - dominantly in undergraduate student projects, focus mostly on top quark physics

Details detector/R&D activities FCC-ee:

- Ghent U and UCLouvain CALICE (SDHCAL) effort through link CMS RPC, including testing of prototypes for 1 m³ SDHCAL chambers
 - *JINST 10 (2015) 10, P10039, JINST 11 (2016) 04, P04001*
 - Currently on slow burner (no active grants) but interested in reviving collaboration
 - Opportunities funding hardware projects?

Recent news:

VUB (F. Blekman) together with UZurich (F. Canelli) very recently acquired bilateral funding together for PD & PhD students to work full-time on FCC-ee:

- Jet flavour tagging algorithmic development, tracking and appropriate physics with those tools, in collaboration with tracker R&D at University of Zurich (F. Canelli)
- Postdoc: <https://inspirehep.net/jobs/1828103>
- Doctoral student x2: <https://inspirehep.net/jobs/1828622>



Future Accelerator Activities in Austria

- **Technische Universität Wien (focus on accelerator development)**
 - Characterisation of different Nb₃Sn wires for the FCC 16T program
 - Development of Thallium-based REBCO superconductor for thin-films for vacuum chamber coatings
 - several PhD thesis on optics design for FCC-ee, FCC-he and HE-LHC within the CERN doctoral program
 - several Master thesis (at CERN) on beam diagnostics, beam-matter-interaction, etc.
- **Institut für Hochenergiephysik (focus on detector and physics)**
 - new interest group on future accelerators with members from various working groups (CMS, Belle, Detector development)
 - focus on physics and detector studies, activities will ramp up soon

Portuguese Effort Towards Future Colliders

- Diverse set of contributions to European Strategy Update
 - HL-LHC, HE-LHC, FCC
 - Higgs, top, BSM, QCD in dense medium, flavour ...
- Strong pheno/theory community
 - Flavour physics, Higgs, BSM, Neutrinos, QCD, ...
 - Good collaboration theory/experiment
- Community getting organised
 - Ongoing series of workshops to join theory/experiment community towards the future
- R&D programme in an embryonic phase
 - Calorimetry, scintillating materials, ...
 - Applying for funding



CERN-LFCC-2018-04
March 20, 2019

Higgs Physics at the HL-LHC and HE-LHC

Report from Working Group 2 on the Physics of the HL-LHC, and Perspectives at the HE-LHC



CERN-LFCC-2018-03
December 23, 2019

Standard Model Physics at the HL-LHC and HE-LHC

Report from Working Group 1 on the Physics of the HL-LHC, and Perspectives at the HE-LHC

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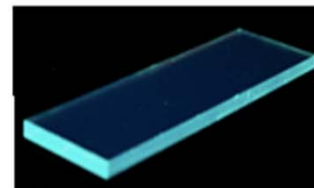
Regular Article

FCC-hh: The Hadron Collider

Future Circular Collider Conceptual Design Report Volume 3

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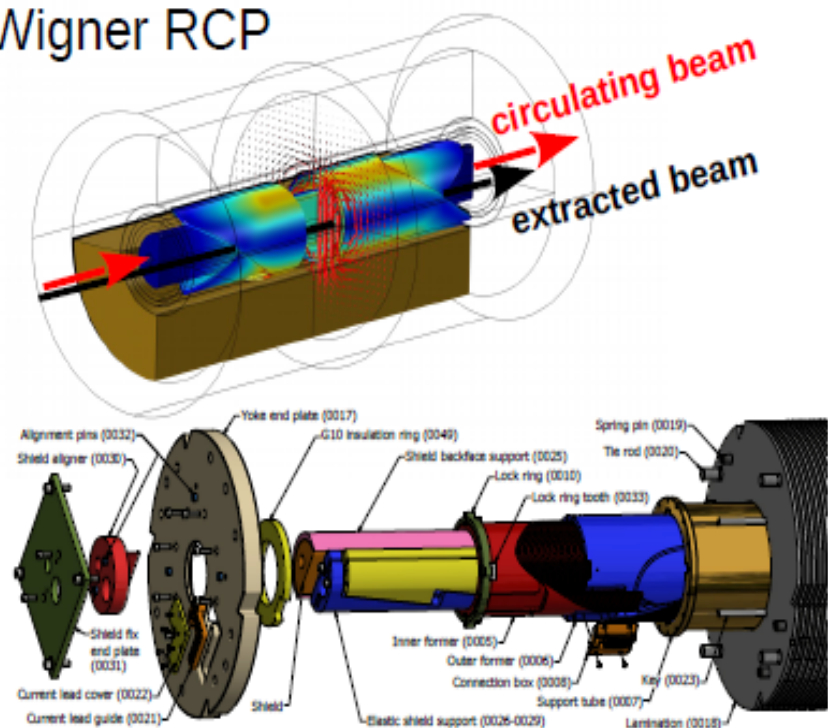
3 Dec 2019



HUNGARY: Recent Focus Developments for FCC

SuShi septum for FCC beam extraction

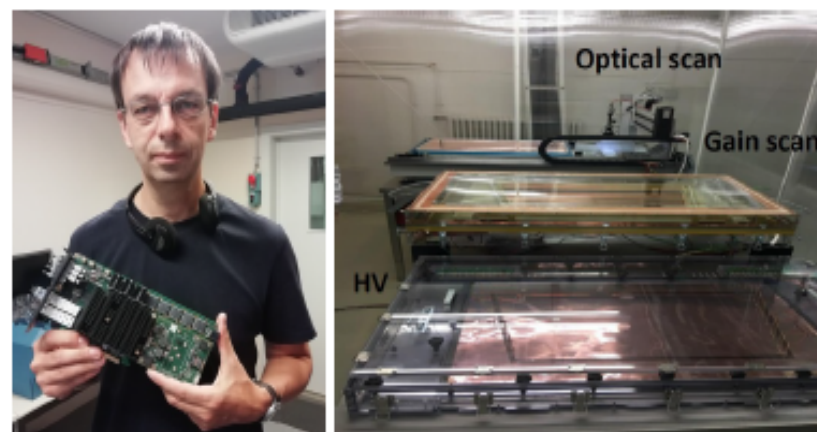
- New concept using a passive superconducting shield
- Concept, design, simulation, manufacturing, assembly, impregnation @ Wigner RCP



Péter Lévai

References for earlier projects

- DAQ & Data analysis, Wigner Datacenter, ALICE DAQ, ALICE O2 CRU, optical & GBT FPGA technologies, parallel simulation framework development (HIJING++)
- Detector R&D, clean rooms @ Wigner RCP, Silicon Pixel (MAPS), MWPC, GEM (ALICE TPC) technologies



FCC R&D Status in Korea

- Detector R&D activity

- Dual-Readout Calorimeter R&D since 2017

- Participate in the FCC-ee CDR published in 2019 (IDEA detector)
- Plan to build full size prototype detector
- Big national R&D funding: ~\$2M/5y, 2020 - 2025)
- 4 faculties, 3 postdocs, and 11 students in the R&D team

- Potential participation: silicon tracker, RPC/GEM, trigger

- Experts from ALICE, BELLE, CMS experiments in Korea

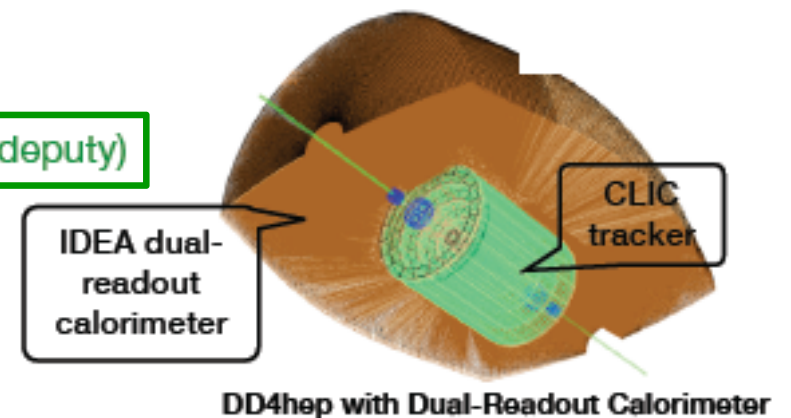
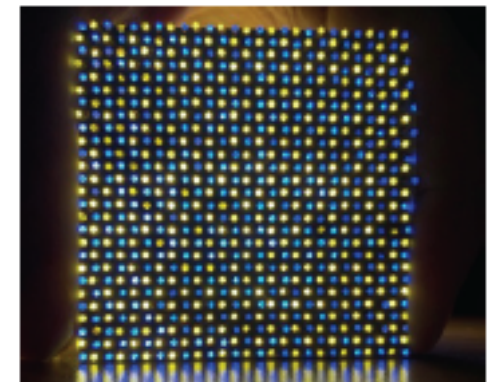
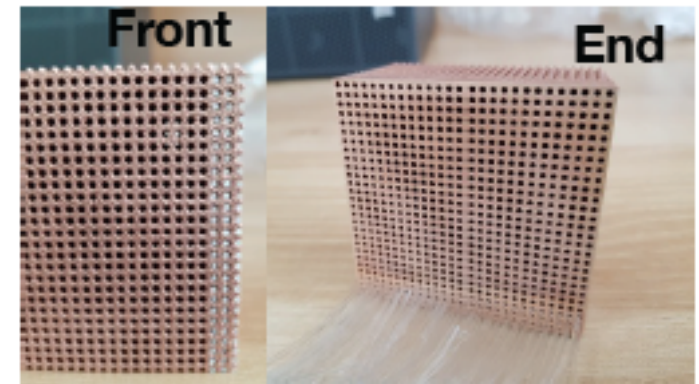
- ML applications are under study using HPC and super-com

- Organize Korea FCC consortium recently

- Prof. Pyungwon Ko (KIAS), Prof. Hwidong Yoo (Yonsei Univ., deputy)

- Many other faculties join (from both exp. and th.)

3D printed copper block for prototype dual-readout calorimeter



US FCC-ee Efforts

FCC-ee and the Snowmass'21 Process

The Snowmass Process is organized by the Division of Particles and Fields (DPF) of the American Physical Society. Snowmass is an opportunity for the entire HEP community to come together to **identify and document a vision for the future of particle physics** in the U.S. and its international partners. Process started early in 2020 and will conclude next Summer.

Coordinated the submission of **FCC-ee LOIs** to inform and engage community. Work on LOIs is ongoing. Paper expected by March '21.

Under the leadership of Sarah Eno, formed of group (O(30) US PIs) interested in e+e- physics. Organized lecture series to inform this group more broadly and share expertise.

We see this group as a seed for a future US - FCC-ee group. Considering an in-person workshop during the Fall 2021.

US funding agencies have expressed support for CERN and its future projects

=== **Germany** rECFA: Peter Schleper

Frank Simon

Work is currently done to set up a “Future Collider Forum” in Germany, which will serve as a platform to bring together people working on various aspects of physics and detector questions for any kind of future energy-frontier collider (primarily ILC, CLIC, FCC-ee, FCC-hh, Muon Collider), to exploit commonalities and synergies. This forum has evolved out of the “Linear Collider Forum” present for more than a decade, which has worked quite successfully.

=== **Netherlands** rECFA: Stan Bentveltsen

Only stripped version of a strategy so far due to covid. Real discussions about future accelerators postponed until post-covid. However very interested in an e+e- collider. It may be difficult to get the funding for a FCC tunnel, especially after the world has changed due to covid. There are not only the instrumentation challenges, but also the motivation of young people. The recognition of individuals in large collaborations is becoming increasingly important in the coming years.

=== **Spain** rECFA: (C. Lacasta Llacer)

Juan Alcaraz

Spain getting re-organized on this matter, following ESPP, moving from an ILC/FCC-hh forum to a wider future collider forum, i.e. including FCC-ee.

=== Sweden

rECFA: David Milstead

Rebeca Gonzalez Suarez

Sweden has not taken too much of a stand other than wanting an e+e- collider. There is nobody presently working on the ILC. There is some involvement on CLIC but it's limited. **There is interest in the FCC-ee.**

=== Denmark

rECFA: Mogens Dam

Mogens Dam

Denmark has a rather small community of high energy physicists contributing mainly to ATLAS and ALICE. **There is support in the community for the ESPP and the integrated FCC project.**

=== Norway

rECFA: Alex Read

There are no significant new actions in Norway toward a future accelerator and program since the preparation of input to the ESU. Given the efforts on the Phase 2 upgrades, new significant R&D programs and efforts for physics preparation for a future collider is at lower priority

=== Finland

rECFA: Kati Lassila-Perini

Katri Huitu

Finland contributes to the CERN-based developments of the next generation particle colliders **(CLIC and FCC) R&D programmes**. We emphasize that CERN, as the European Particle Physics Laboratory, should play a key role in any international post-LHC high-energy facility.

=== **Czech Rep.** rECFA: Marek Tasevsky

Regarding the future ee collider, the Czech community preferences may be ordered this way: FCC-ee, ILC, CLIC. We have a long and fruitful tradition of cooperating and delivering to CERN. No strong roots in CLIC. **The priority is FCC-ee.**

=== **Slovakia** rECFA: Pavol Stríženec

No strong preference about ee collider in Slovakia. Groups are too small, and oriented more on proton/HI physics. It is not clear if any involvement in ee collider will be possible in the near future

=== **Poland** rECFA: Tadeusz Lesiak

Marcin Chrzaszcz

FCC effort being organized. The Epiphany conference on Future of Particle Physics <https://epiphany.ifj.edu.pl/> on 7-10 January 2021 will mostly focus on FCC.

=== **Bulgaria** rECFA: Plamen Iaydjiev

Bulgarian community is small and mainly focused on the CMS experiment, with also groups in neutrino physics, nuclear physics (Isolde) and fixed target experiments (rare kaon decays). So far, no group has expressed particular interests in the field of ee collider.

=== **Romania** rECFA: Mario Bragadireanu

The outcome of HL-LHC early runs, might tell if the next CERN based accelerator should be an e+e- or hh collider, hence **the construction of a circular tunnel with a circumference of about 100 km, that can accommodate an hh or e+e- collider is the most appropriate approach.** The R&D for high temperature superconducting (HTS) magnets should be pursued with high priority.

More countries (4)

=== Croatia

rECFA: Mirko Planinic

Past experience has shown that measurements at the limit of precision and sensitivity often provide clues of new physics before the latter can be revealed directly by high-energy collisions. There is also a need for precision measurements of the Higgs boson properties and of EW interactions above the weak scale. In Croatia, **no strong opinions about future ee-collider except that we would like it to be at CERN if possible.**

=== Serbia

rECFA: Peter Adžic

High Energy physicists from Serbia are strongly oriented to the CERN projects (presently ATLAS and CMS) and this will be also the case in the future. **We generally support FCC** and our interest will go to this direction. Although there is a formal (not significant) connection of a few people with CLIC, this project is not the option, particularly if ILC gets approved.

=== Slovenia

rECFA: Marko Mikuž

30 physicists altogether, in Atlas / Belle 2. Pretty muck booked with the upgrade. No group on FCC. If there is a Z factory, b-physics will be our interest. Wherever it will be, but rather ILC go forward, and CERN focus on hh aspect. FCC-ee if ILC does not happen, but it will imply much larger scale / timelines.

More countries (5)

=== Greece

rECFA: Paris Spicas

The only future collider that Greek physicists are involved in is the FCC(ee/hh). So the question of other options, like ILC is not on the table. People assume that CLIC is not a good long-term solution.

=== Cyprus

rECFA: Panos Razis

Mostly involved with the search for physics Beyond the Standard Model **we favor the construction of the FCC** (where also Higgs physics can be explored initially), as it can provide a long-term future for particle physics.

=== Turkey

rECFA:Mehmet Zeyrek

Turkey is not attached to any of the future projects, **but our community supports FCC**. Turkish groups are mainly active in ATLAS/CMS. A small-scale experimental group is also active in Belle II. Similarly, a small group of physicists have been involved to CLIC in connection to ILC.

=== Israel

rECFA: Eilam Gross

Israel is part of the CERN community and will keep acting like that. It has the infrastructure for both detector studies and construction and will join future experiments on a physics merit basis. There is an ongoing activity in various detector related fields. There is also a related activity in the theoretical frontier investigating how can new physics models be probed with HL-LHC and future colliders.

Different situations in Different Countries

- FCC-ee effort well started
- FCC-ee effort getting organized
- No FCC-ee effort started
- Priority FCC/ILC or FCC-hh vs. ee unclear

For the next strategy, a much larger consensus must be reached on the future machine, namely FCC-ee (followed by hh), since FCC-hh is out of reach without the ee first step.

➔ How long will it take to all converge to bullet 1 ?

➔ What would be the procedure ?

Common R&D ?

Common workshops of the different ee-collider communities?

Other approach ?

