



# FCC WEEK 2021

28 June – 2 July

## Report on the status of the FCC Physics, Experiments & Detectors Informal Forum of National Contacts

Gregorio Bernardi, APC-Paris, CNRS/IN2P3

on behalf of the FCC-PED-National contacts

ONLINE EVENT

Register Here:

<https://indico.cern.ch/e/fccw2021>

# Two body approach to enlarge the FCC collaboration

## FCC Global Collaboration Working Group and FCC national contacts

Following the recommendations of the ESPP 2020, *Europe, together with its international partners, should investigate the technical and financial feasibility (...) of the colliders and related infrastructure (...) as a global endeavor*, the FCC global collaboration working group has been established. Its current members are:

**FGC working group**

M. Benedikt(CERN), F. Zimmermann, FCC study leader and deputy  
A. Blondel (IN2P3&Geneva), P. Janot (CERN) FCC PED coordinators  
J. Ellis (Kings College London), P. Charitos (CERN) from the FCC Coordination group  
G. Bernardi(IN2P3), T. Lesiak (Krakow) (dep. M. Chrzaszcz), conveners of the FCC-PED Informal Forum of National Contacts

## FCC-PED Informal Forum of National Contacts

**FCC-PED IFNC**

As stated in the FCC lepton collider CDR, one of the highest priorities and largest challenges of the FCC study is *the creation of a world-wide consortium of scientific contributors who reliably commit resources to the development and preparation of the FCC-ee science project from 2020 onwards"*

Given the broad and varied nature of the particle physics scientific community, a bottom-up approach has been followed with the creation of an Informal Forum of National Contacts (IFNC), comprising one (sometimes two) contact persons from individual countries susceptible to contribute to the study: CERN member states, associate member states and non-member states.

# Purpose and mandate of the FCC-PED IFNC

- establish communication on FCC PED studies with the national particle physics communities, their own local institutions and funding bodies, assist with the organization of information events within the national communities.
- Inform the local communities on the practical means of participation to the studies,
  - facilitate registration of individuals to the study and the formal participation of institutions to the FCC organization, by means of MOUs leading to the entry of these institutions in the FCC collaboration board.
- reciprocally, serves as a forum for the FCC PED coordinators to alert the national contacts on opportunities for roles of responsibility in the study; or on important opportunities for contributions to the studies.

The conveners of the IFNC are Gregorio Bernardi (from IN2P3) and Tadeusz Lesiak (dep. Marcin Chrzaczsz) (from Krakow). The forum meets several times a year.

# Common Challenges in All Countries

- Increase the FCC community w/o weakening HL-LHC
- Collaboration building
- More studies needed, in particular ElectroWeak factory constraints not much studied so far
- Getting funding
- Merge with LC community ?

# FCC-ee – PE&D Activities in the the different Countries

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

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

- FCC-ee effort well started, with some support
- FCC-ee effort getting organized
- No FCC-ee effort started
- Priority FCC vs. ILC or FCC-hh vs. FCC-ee is unclear

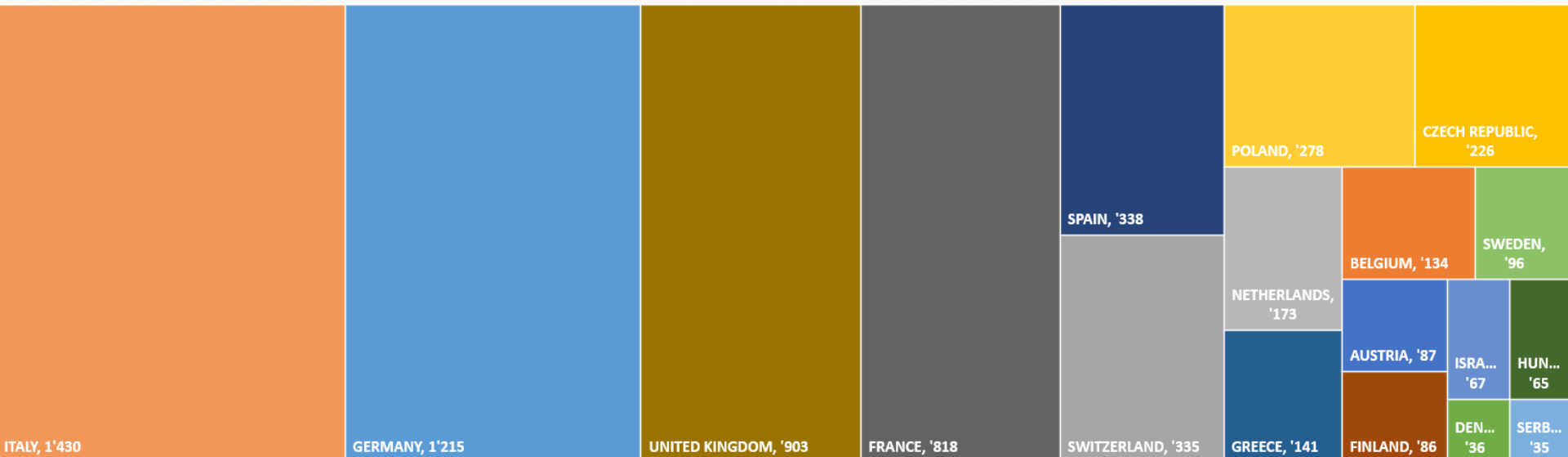
# Brief reports from countries involved in FCC

## FCC participating countries showing size of their current total CERN User community

Zone de graphique

### CERN MEMBER STATES

AUSTRIA BELGIUM SWITZERLAND CZECH REPUBLIC GERMANY DENMARK SPAIN FINLAND FRANCE  
UNITED KINGDOM GREECE HUNGARY ISRAEL ITALY NETHERLANDS POLAND SERBIA SWEDEN



In the following,

- Dedicated slides from the biggest Member States and from the most active countries/regions.
- Shorter statements for the other participating countries interested also in PED activities (some only have accelerator activities).
- No discussion here of some special cases:  
Japan, China, India, Russia, Ukraine, Pakistan

### 23 Member States

Austria – Belgium – Bulgaria – Czech Republic – Denmark – Finland – France – Germany – Greece – Hungary – Israel – Italy – Netherlands – Norway – Poland – Portugal – Romania – Serbia – Slovakia – Spain – Sweden – Switzerland – United Kingdom

### 9 Associate Member States

Cyprus – Estonia – Slovenia  
Croatia – India – Lithuania – Pakistan – Turkey – Ukraine

### 6 Observers

Japan – Russia – USA  
European Union – JINR – UNESCO

# FCC in Italy

Contact: F. Bedeschi

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 a few 100 kEuro level for 2021

Competition for funding with Muon collider activity which is ramping up

Additional funding from EU grants:

AidaInnova, Cremiln+, FEST

# FCC in Germany / Austria / Belgium / Netherland

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

Frank Simon

“**Future Collider Forum**” setup 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. It's an evolution out of the “Linear Collider Forum” which has worked successfully.

FCC-focused workshop planned for Fall 2021 to identify/encourage FCC interest in Germany.

=== **Austria**      rECFA: Manfred Jeitler

Jochen Schieck

Unfortunately the Strategy Update did not lay out a clear preference for one of the ee collider projects but somehow keeps all of them in the game. Most experimental activity in the direction towards ILC / FCC is happening at HEPPY. No dedicated manpower to work full-time on ILC or FCC, but several people interested and willing to contribute. **We formed a “Future Accelerators” group** which tries to follow all activities, including FCC, ILC and the Muon Collider.

=== **Belgium**      rECFA: Nick Van Remortel

Jorgen d'Hondt

Heavily invested in CMS. No coordinated national effort yet, but **several local FCC-ee efforts** and investigating collaboration with neighbouring countries. Active hep.ph community including on FCC. VUB and UZurich recently acquired together bilateral funding for PD & PhD full time on FCC-ee

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

Only stripped version of a strategy so far due to covid. Real discussions 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..

# FCC in the UK

Christos Leonidopoulos  
Guy Wilkinson

FCC group established (summer '20) and all UK institutes interested in FCC-ee, but:

- In many cases there is an overlapping interest with ILC (longstanding involvement)
- There are also strong opinions on best way to advance the prospects of FCC-eh and FCC-hh

Sept 2020: FCC-UK kick-off meeting, which attracted significant interest and ~75 participants

Since then, input has been provided to the update of the UK Particle Physics Roadmap (Advisory body on HEP)

**A draft exists** (as of last week) **in which FCC-ee figures prominently**, but is not prioritised over ILC. Draft recommendation is to support activities that have application on both projects.

Meanwhile, an organisational structure within the UK is being developed, with separate UK coordinators for FCC-ee, FCC-hh and FCC-eh, and an overall spokesperson who will represent UK at FCC fora.

The UK community looks forward to using the opportunity of the general FCC PED Workshop which will take place in Liverpool in early February 2022 to catalyse increased UK interest (local organising committee already had kick-off meeting)

# FCC in France

Longstanding 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. - Resp. IN2P3 : **Gregorio Bernardi** - Resp. IRFU : **Roy Aleksan**

FCC-contacts in 12 participating labs & in the 2 related IN2P3 R&D projects ( $\mu$ vertex for FC, CALICE) meet monthly

**IN2P3 and IRFU encourage a reasonable participation in FCC-ee in parallel to HL-LHC**  
**Current effort to increase synergy on physics and detectors studies on e+e- (along the ECFA roadmap)**

**Physics Case Studies and related detector constraints** (Higgs, EW, HF, Top)

- some presented at this FCC week (ZH inclusive x-section,  $B_c \rightarrow \tau \nu$ ).
- CP violation/Flavour Physics,  $Z-\nu_e$  coupling measurement, FCC sensitivity to invisible ALPs
- W mass measurements @ WW threshold (PhD thesis, now finished)

**R&D @IN2P3:** - Need to get critical masses on new future projects before decision @IN2P3 on their funding  
- The current Lines on R&D geared towards ILC which can be converted to FCC are continued  
- Other R&D are also progressing (e.g. Lar Calorimetry).

**R&D @ IRFU:** - TPC (R&D common with ILC)  
- WiFi connections (intra detector), Large Surface Fast Timing detector for ToF using micromegas

## Workshops:

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)

150 participants <https://indico.in2p3.fr/event/23012/>

Student Jamboree on Physics case studies (25/6/2021). 10 new starting studies (EW,Higgs,QCD,HF)

<https://indico.in2p3.fr/event/24614/>

**3rd FCC-France workshop for physics-detectors-accelerator on 30/11-2/12 2021 (3 days in Annecy)**

# FCC in Spain & Portugal

## === Spain

rECFA: (C. Lacasta Llacer)

Juan Alcaraz

- **Future collider efforts currently centralized in the “Spanish Network on Future accelerators”:**
  - Historical focus on:
    - ILC-related detector R&D: silicon tracking, CALICE
    - **FCC: MoU signed by several institutions, mostly FCC-hh magnet/accelerator developments until now**
    - ILC / CLIC physics+detector studies
  - Small community working on these matters (with basically zero budget); growing it takes time, pandemic status does not help, more urgent priorities (HL-LHC, ...)
- **Agreed plan:**
  - Integrating progressively FCC analysis/detector efforts in the existing network
  - Ensuring synergy with past/current linear collider activities. Everything assumed to happen under an “ee Higgs factory studies” umbrella:
    - **Current ECFA PED initiative and coming CERN structures for future colliders: extremely useful for re-ramping up**

## === Portugal

rECFA/contact:

Patricia Conde Muíño

- Diverse set of contributions to European Strategy Update, HL-LHC, HE-LHC, FCC, Higgs, top, BSM, QCD
- Strong pheno/theory community (Flavour physics, Higgs, BSM, Neutrinos, QCD, ...)
- **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

# FCC activities in Switzerland

Rainer Wallny

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

- National collaboration forming:
  - ❑ Joint detector development grant planned for 2022-2024 to SNF
  - ❑ one SNF base grant already attributed for simulation of FCC-ee vertex detector – PD
  - ❑ 2 FCC/FCC-ee workshops (UniGE/UZH) planned under auspices of CHIPP in 2021

Florenca Canelli & Anna Sfyrla

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Registration open!


 **7 September 2021**  
<https://indico.cern.ch/event/1040241/>


 Physics, detectors and accelerators: status of existing efforts within the FCC study and explorations of Swiss interests & expertise applicable to a future high-energy circular collider


 Introduction to international FCC efforts and identification of common grounds of activities within Switzerland


 **UNIVERSITÉ DE GENÈVE**  
Host:

**2**

 **26-28 January 2022**  
<https://indico.cern.ch/event/1041452/>

 Physics, detectors and accelerators: expressions of interest for participation to concrete projects

 Identification of interested parties for collaborative activities; potentially also participating to common efforts for fund raising (e.g. FLARE)

 **University of Zurich**  
Host:

Workshops sponsored by the UniGe and the UZH; supported by CHIPP;

## « Nordic » Countries

National contact

### === Sweden

rECFA: Rebecca Gonzalez Suarez

Rebecca Gonzalez Suarez

See next slide

### === Denmark

rECFA: Mogens Dam

Mogens Dam

Denmark has a rather small community of high energy physicists contributing mainly to ATLAS and ALICE. **There is strong 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 (FCC&CLIC) R&D programmes. We emphasize that, as the European Particle Physics Laboratory, **CERN should play a key role in any international post-LHC high-energy facility.**

+ Associate members states (or soon to be)

### === Estonia

### === Latvia

### === Lithuania

# FCC Sweden / Nordic Countries

- **1st FCC Nordic day** in March this year
  - <https://indico.uu.se/e/fccnordic>
  - Co-chaired with Denmark
  - Including Denmark, Finland, Norway and Sweden
  - Estonia also invited
  - Potential Nordic funding options to be explored
  - Lines of communication opened
  - 67 people connected, good feedback, to be followed-up
- **Interest increasing from different groups**
- Since last meeting of the national contacts
  - Work continues in Uppsala University in long-lived particles
    - <https://indico.cern.ch/category/5664/>
    - Project and master students continuously trained
    - Heavy Neutral Leptons at the FCC-ee as benchmark

**Latest master  
thesis, defended  
this month**



## « Eastern Countries »

### === Poland

rECFA: Tadeusz Lesiak

Marcin Chrzaszcz

**FCC effort being organized.** More institutes are joining the effort in promoting FCC around Poland and forming consortium. The Epiphany conference on Future of Particle Physics <https://epiphany.ifj.edu.pl/> held in January 2021 focused on FCC.

### === Czech Rep.

rECFA: Marek Tasevsky

Jana Faltova

Regarding the future ee collider, **the priority is FCC-ee. For current work, see next slide.**

### === Hungary

rECFA: Peter Levai

**Preference would be ILC in Japan and FCC-hh at CERN.** More competence today in FCC physics and construction, than in ILC related expertise. The groups on LHC are more interested in hadron physics (and HI collisions), than on EW/Higgs precision measurements

### === Romania

rECFA: Mario Bragadireanu

HL-LHC early runs might tell if the next machine should be an ee or hh collider, hence **the construction of a 100 km circular tunnel, that can accommodate both ee and hh is the most appropriate approach.**

### === Slovakia

rECFA: Pavol Striženec

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

### === Bulgaria

rECFA: Plamen Laydjiev

We are mainly focused on the CMS experiment, with also groups in neutrino physics, nuclear physics and rare kaon decays. So far, no group has expressed particular interests in ee collider physics.

# FCC activities in Czech Republic

Charles University (CUNI) is a member of FCC Collaboration since 2017

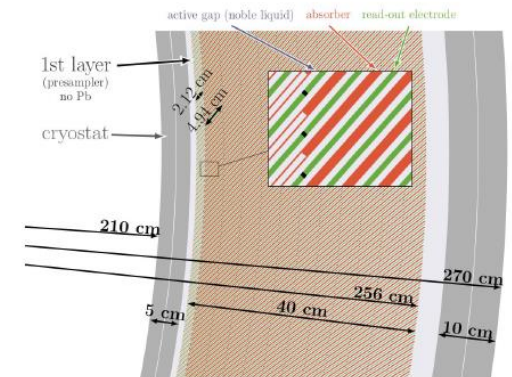
Involvement in the high granular noble liquid calorimeter

- A benchmark option for FCC-hh detector, considered also as an option for FCC-ee
- Promising results based on MC simulations, several R&D projects started recently (low material cryostat, design of the feed-throughs, read-out electrodes)
- Results of Monte Carlo simulations for FCC-hh summarised in FCC Conceptual design report, Volume III. Detailed report in CERN-FCC-PHYS-2019-0003.

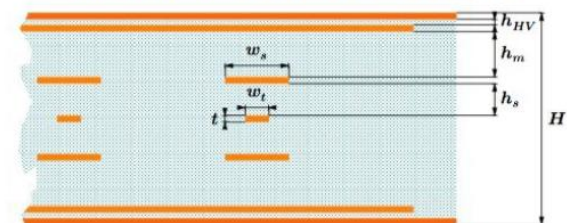
- Optimisation of the detector design for FCC-ee based on the MC simulations
  - **Work in progress:** Electronic noise, energy leakage, energy resolution
  - **Plan:** Optimisation of the geometry of the detector (e.g. material, thickness of absorber and sensitive gap, plate inclination angle, cell sizes)
- R&D project on design of the read-out electrodes
  - **Plan:** Monte Carlo simulations of physics events to determine the optimal granularity, timing performance
  - Supported by H2020/AIDAinnova
- Development of the reconstruction software in FCCSW
  - **Work in progress:** Corrections for the energy reconstruction
  - **Plan:** Clustering, object reconstruction & particle flow

1.0 FTE dedicated to FCC in 2021

1.5 FTE planned in 2022



Calorimeter read-out, side view (perpendicular to the signal traces)



# Serbia / Slovenia / Croatia

## === Serbia

rECFA: Peter Adžic

Lidija Zivkovic

High Energy physicists in Serbia are strongly oriented to the CERN projects (presently ATLAS and CMS) **We generally support FCC** and our interest in the future will also go in this direction. **We are getting organized and planning to form the team for FCC (ee/hh)** activities and for this, physicists which are to lead such team have already been named. Although there is a formal (not significant) connection of a few people from Serbia with CLIC activities, this project is not our 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 yet, but 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 larger scale / timelines.

## === Croatia

rECFA: Mirko Planinic

Measurements at the limit of precision and sensitivity often provide clues of new physics before it 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 the type of future ee-collider except that we would like it to be at CERN if possible.**

# Greece / Israel / Cyprus / Turkey

## === Greece

rECFA: Paris Sphicas

The only future collider that Greek physicists are involved in is the FCC(ee/hh). Other options, like ILC are not on the table and we think that CLIC is not a good long-term solution.

## === 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.

## === 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.

## === 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 +small-scale activity in Belle II and CLIC.

## 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 Marc '22

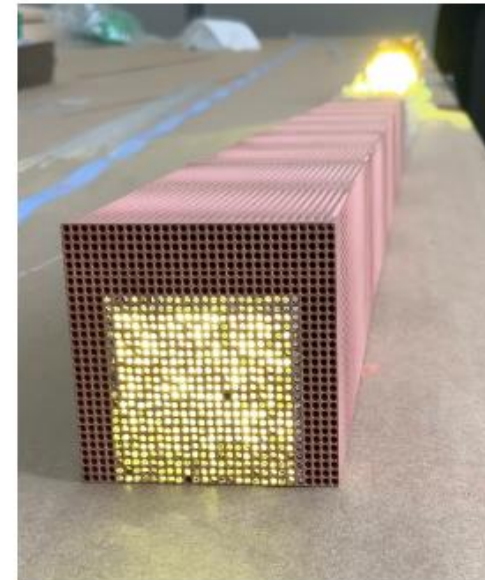
Under the leadership of Sarah Eno, formed of group (O(30) US PIs) interested in e+e- physics. Organized lecture series to inform this group more broadly and share expertise.

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

# FCC activity in Korea

- Organization: Prof. Pyungwon Ko (KIAS), Prof. Hwidong Yoo (Yonsei Univ., deputy)
  - Korea Future Collider Consortium (KFCC) has been organized ([homepage](#))
    - More than 30 physicists (both theorists and experimentalists) are participating the consortium
    - First workshop was held at last Feb. with various invited speakers ([indico](#)) successfully
  - Discussion to add the FCC R&D (both TH and EXP) to Korea-CERN program  
Detector R&D has been started
- Detector R&D
  - Dual-Readout Calorimeter R&D is on-going (5 year R&D funding: \$2M)
    - First two regular-size modules are being built
    - Various prototype module including 3D metal-printing is being tested for engineering aspects
    - Test-beams experiments with low energy beams are planned at domestic facilities
  - More R&D programs (FPGA-based electronics with ML integration, high speed data link etc.) are under discussion



# Some Conclusions

- FCC-ee effort well started in some countries
- FCC-ee effort getting organized in most Member States and in several non-MS and Observer states
- More contacts will be taken in the coming months

For the next strategy, a full consensus must be reached on the future machine, namely FCC-ee, followed by hh, since FCC-hh seems impossible to reach without the first ee step.

→ Best would be to converge fast on the consensus

→ What could be the procedure ?

- Common workshops of the different ee-collider communities
- Common R&D
- Additional approaches ?