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FCCIS

Future Circular Collider Innovation Study

Horizon 2020 Research and Innovation Framework Programme, Research and Innovation Action

MILESTONE REPORT

PROGRESS REVIEW 1

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Abstract:

Agenda and draft minutes of board meetings available in document management system. Work progress reviewed and aligned in the form of a workshop with presentations on Indico site. Contributions for Open Access proceedings with SN (Gold) approved.

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Delivery Slip

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TABLE OF CONTENTS

1. INTRODUCTION

Following its approval, the FCCIS project held its kick off meeting in November 2020, coupled to the 4th FCC physics week in the "FCC November Week 2020" (FCC NoW 2020). This meeting reviewed the challenges to deliver an implementation plan and a feasibility study for a new Research Infrastructure based on a new tunnel of ~100 km circumference, that could successively host an electron-positron (FCC-ee) and proton-proton collider (FCC-hh). The meeting, hosted virtually, offered numerous opportunities for cross-talks between the different scientific communities that are coming together under the FCCIS project. During FCC NoW the first FCCIS General Assembly meeting and Executive Board meeting took place, defining the key priorities and tasks for each of the project WPs and all participating members.

In addition, during the first reporting period, the FCCIS WP1 successfully organized two reviews with panels of international experts, validating the approach adopted by the FCC study management and offering an independent evaluation and critical guidance for the next steps. The first of these meetings focused on the FCC-ee pre-injector complex and the second on the design of FCC-ee SRF cavities, which is one of the most critical accelerator components for the overall machine performance and efficiency. Further reviews of other key areas will take place in the subsequent months.

2. FCCIS GOVERNANCE BODIES MEETINGS

2.1. GENERAL ASSEMBLY

The General Assembly (GA) is the highest-level decision-making body in the FCCIS project. The first GA meeting took place on 9 November 2020, at the launch of the project during the FCC November Week 2020. Prof. Anke-Susanne Müller of KIT Karlsruhe was elected for the role of GA President. All the GA members are listed here: FCCISGeneralAssemblyMembers < FCC < TWiki (cern.ch)

The agenda, list of participants and the minutes are available on Indico, with access restricted to the GA members: FCCIS General Assembly meeting 01 (9 November 2020) · Indico (cern.ch)

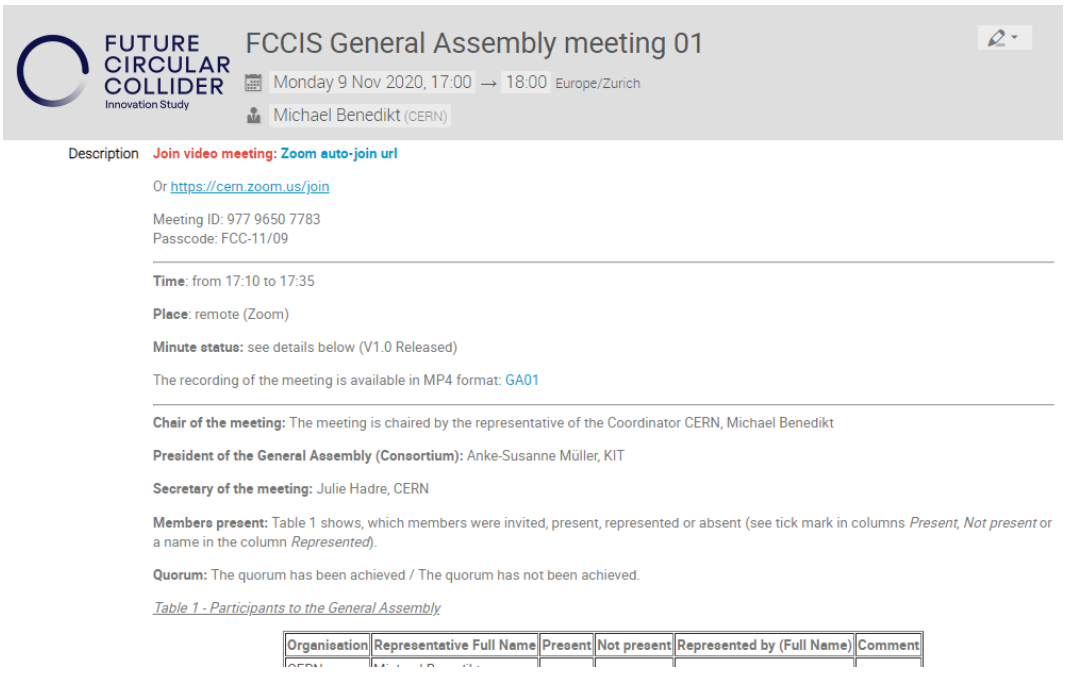

Figure 1 – Screenshot of the indico page for the first meeting of the FCCIS General Assembly

2.2. EXECUTIVE BOARD

The Executive Board (EB) implements the decisions of the General Assembly and proposes changes in the project and consortium plan to the GA, including changes of the CA and GA annexes.

The EB meets monthly, via the Zoom videoconferencing system. The EB consists of the Project Coordinator (PL and deputy), Work Package Leaders and their deputies.

The EB members are compiled at: FCCISExecutiveBoardMembers < FCC < TWiki (cern.ch)

For each meeting, the agenda, list of participants and the minutes are posted in the Indico category FCCIS Executive Boards · Indico (cern.ch), with access restricted to the EB members.

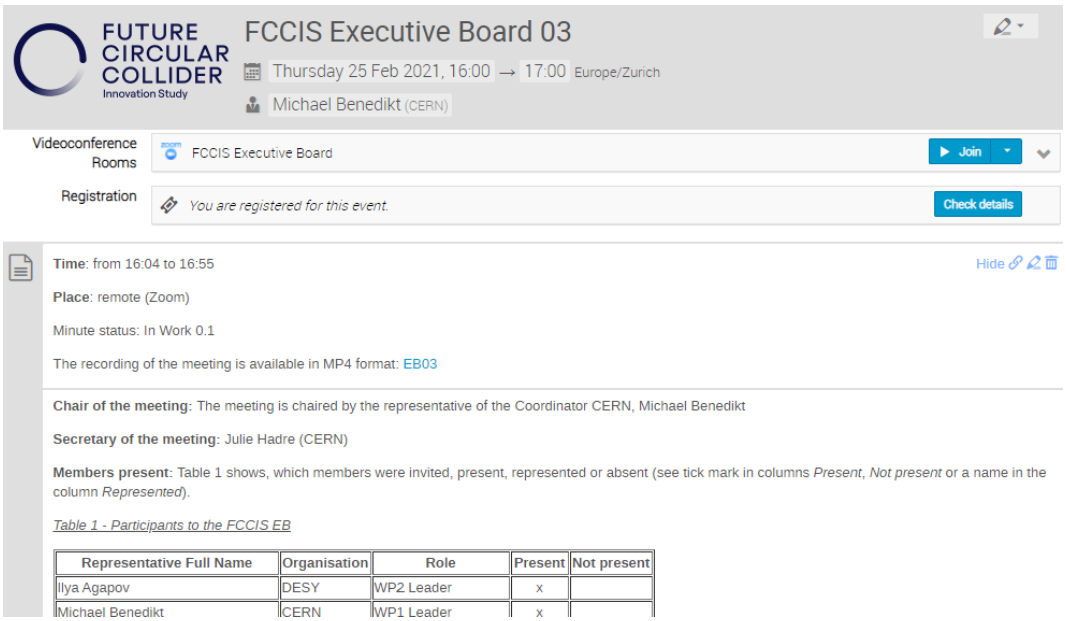

Figure 2 – Screenshot of the indico page for the third meeting of the FCCIS Executive Board

3. FCC REVIEWS

3.1. REVIEW OF FCC-EE INJECTOR

A review for the FCC-ee pre-injector complex took place remotely on 19 April 2021 (presentations and discussions) and on 22 April 2021 (closed session). The meeting was restricted to presenters, invited experts and reviewers.

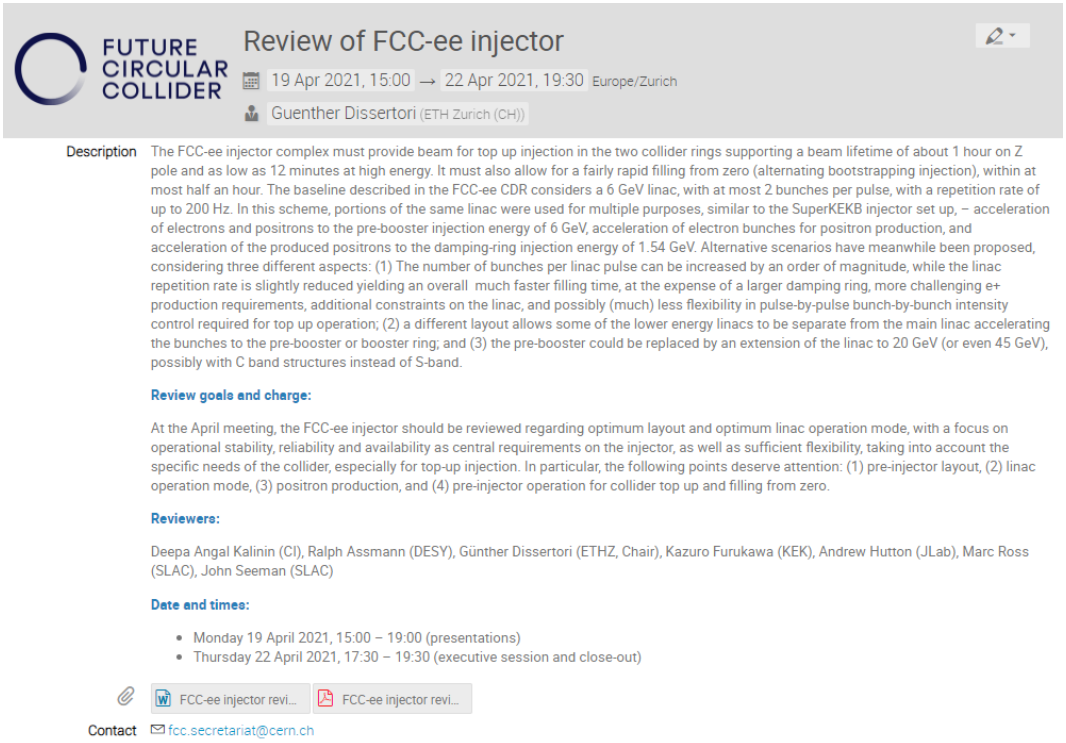

Figure 3 – FCC-ee injector review
Review of FCC-ee injector (19-22 April 2021) · Indico (cern.ch)

3.1.1. Scope of the review

The FCC-ee injector complex must provide beam for top up injection in the two collider rings supporting a beam lifetime of about 1 hour on Z pole and as low as 12 minutes at high energy. It must also allow for a fairly rapid filling from zero (alternating bootstrapping injection), within at most half an hour. The baseline described in the FCC-ee CDR considers a 6 GeV linac, with at most 2 bunches per pulse, with a repetition rate of up to 200 Hz. In this scheme, portions of the same linac were used for multiple purposes, similar to the SuperKEKB injector set up, – acceleration of electrons and positrons to the pre-booster injection energy of 6 GeV, acceleration of electron bunches for positron production, and acceleration of the produced positrons to the damping-ring injection energy of 1.54 GeV. Alternative scenarios have meanwhile been proposed, considering three different aspects: (1) The number of bunches per linac pulse can be increased by an order of magnitude, while the linac repetition rate is slightly reduced yielding an overall much faster filling time, at the expense of a larger damping ring, more challenging e+ production requirements, additional constraints on the linac, and possibly (much) less flexibility in pulse-by-pulse bunch-by-bunch intensity control required for top up operation; (2) a different layout allows some of the lower energy linacs to be separate from the main linac accelerating the bunches to the pre-booster or booster ring; and (3) the pre-booster could be replaced by an extension of the linac to 20 GeV (or even 45 GeV), possibly with C band structures instead of S-band.

3.1.2. Review goals and charge

A group of international experts reviewed the FCC-ee injector regarding optimum layout and optimum linac operation mode, with a focus on operational stability, reliability, and availability as central requirements on the injector, as well as sufficient flexibility, considering the specific needs of the collider, especially for top-up injection. In particular, the following points deserve attention: (1) pre-injector layout, (2) linac operation mode, (3) positron production, and (4) pre-injector operation for collider top up and filling from zero.

3.1.3. Reviewers

Deepa Angal Kalinin (CI), Ralph Assmann (DESY)[1], Günther Dissertori (ETHZ, Chair)[2], Kazuro Furukawa (KEK), Andrew Hutton (JLab), Marc Ross (SLAC)[3], John Seeman (SLAC)

3.1.4. Agenda

Table 1 – FCC-ee injector review 19 April 2021 agenda

Presentation title	Presenter(s)
CDR layout – new layout	Alexej Grudiev (CERN)
Filling schemes through injector chain: baseline vs multi-bunch parameters	Salim Ogur (CERN)
Advantages/disadvantages for the collider of initial filling and top-up operation single vs multi-bunch	Katsunobu Oide (KEK)
Positron source advantages/disadvantages of single bunch vs multi-bunch operation	Iryna Chaikovska (CNRS/IJCLab) Riccardo Zennaro (PSI)
Qualitative comparison of linac design and complexity with single vs multi bunch operation	Paolo Craievich (PSI)
Linac wakefields & beam loading for multi-bunch operation	Andrea Latina (CERN)

3.1.5. Conclusions

Particular focus was put on the pre-injector layout, linac operation modes, positron production, and pre-injector operation for the top-up injection. Compared to the CDR, the pre-injector layout was simplified, with each linac now operating only at one beam energy. In addition, the higher electron beam energy at the target allows for a higher positron yield.

Further topics being reviewed are the number of bunches per linac pulse and a comparison between the lifetime in the collider and the filing time for different scenarios, which even in the worst case and for the more stringent 4IP case feature a safety margin of a factor 2. One last key topic is the use of a 20 GeV linac instead of the SPS Pre-Booster-Ring, as in the case of the latter, the operation as PBR would only allow for limited beam for studies of other users.

The conclusions and the reviewers' recommendations will be presented during the FCC Annual Meeting 2021, that will take place remotely from 28 June 2021 to 2 July 2021 (FCC Week 2021 website: https://indico.cern.ch/e/fccw2021).

[1] Member of the FCC Advisory Committee

[2] Chair of the FCC Advisory Committee InternationalAdvisoryBoard < FCC < TWiki (cern.ch)

[3] Member of the FCC Advisory Committee

3.2. REVIEW OF FCC-ee SRF SYSTEM

A review for the FCC-ee SRF system took place remotely on 20 April 2021 (presentations and discussions) and on 22 April 2021 (closed session). The meeting was restricted to presenters, invited experts and reviewers.

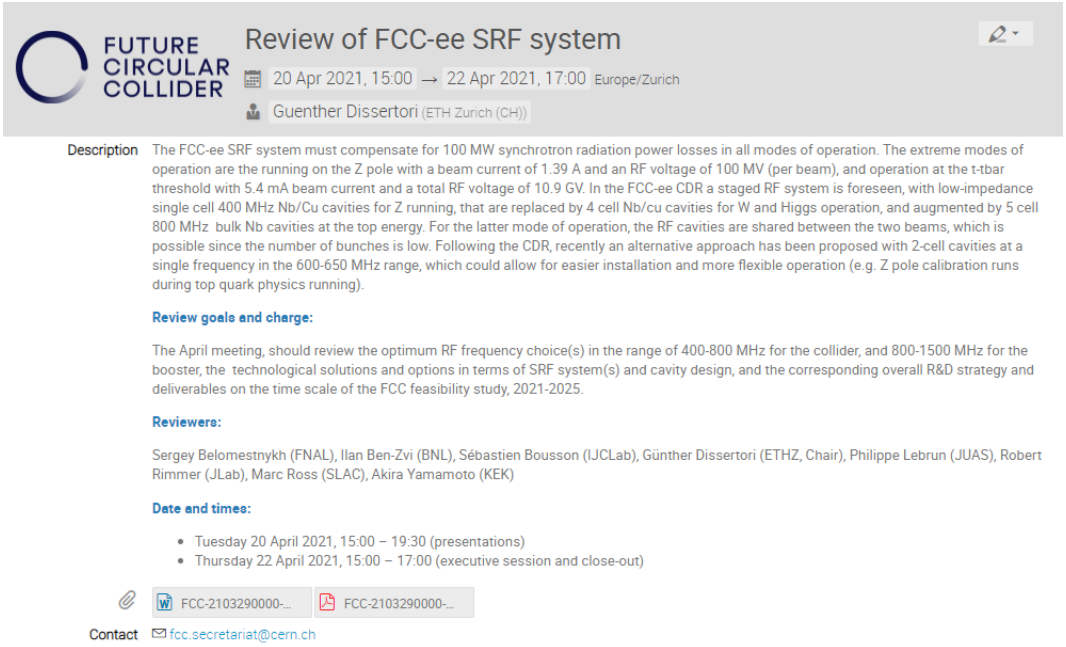

Figure 4 – FCC-ee SRF system review
Review of FCC-ee SRF system (20-22 April 2021) · Indico (cern.ch)

3.2.1. Scope of the review

The FCC-ee SRF system must compensate for 100 MW synchrotron radiation power losses in all modes of operation. The extreme modes of operation are the running on the Z pole with a beam current of 1.39 A and an RF voltage of 100 MV (per beam), and operation at the t-tbar threshold with 5.4 mA beam current and a total RF voltage of 10.9 GV. In the FCC-ee CDR a staged RF system is foreseen, with low-impedance single cell 400 MHz Nb/Cu cavities for Z running, that are replaced by 4 cell Nb/cu cavities for W and Higgs operation, and augmented by 5 cell 800 MHz bulk Nb cavities at the top energy. For the latter mode of operation, the RF cavities are shared between the two beams, which is possible since the number of bunches is low. Following the CDR, recently an alternative approach has been proposed with 2-cell cavities at a single frequency in the 600-650 MHz range, which could allow for easier installation and more flexible operation (e.g., Z pole calibration runs during top quark physics running).

3.2.2. Review goals and charge

A group of international experts reviewed the optimum RF frequency choice(s) in the range of 400-800 MHz for the collider, and 800-1500 MHz for the booster, the technological solutions, and options in terms of SRF system(s) and cavity design, and the corresponding overall R&D strategy and deliverables on the time scale of the FCC feasibility study, 2021-2025.

3.2.3. Reviewers

Sergey Belomestnykh (FNAL), Ilan Ben-Zvi (BNL), Sébastien Bousson (IJCLab), Günther Dissertori (ETHZ, Chair)[4], Philippe Lebrun (JUAS)[5], Robert Rimmer (JLab), Marc Ross (SLAC)[6], Akira Yamamoto (KEK)[7].

3.2.4. Agenda

Table 2 - FCC-ee injector review 20 April 2021 agenda

Presentation title	Presenter
Baseline & alternative perspectives	Olivier Brunner (CERN)
Effect of RF frequency change on luminosity performance	Dmitry Shatilov (BINP)
Cavity options for FCC-ee	Franck Peauger (CERN)
The SWELL cavity development	Igor Syratchev (CERN)
Beam-cavity interactions for FCC-ee	Ivan Karpov (CERN)
Cavity Engineering & Fabrication	Said Atieh (CERN)
SRF & Substrate Preparation	Guillaume Rosaz (CERN)
SWELL Cryomodule Development	Vittorio Parma (CERN)
Conclusions and R&D plans for the feasibility phase	Frank Gerigk (CERN)

3.2.5. Conclusions

The optimum frequency for the RF cavities lies in the range of 400-800 MHz for the collider and 800-1500 MHz for the booster. An innovative design of Slotted Waveguide Elliptical (SWELL) cavity with either 600 MHz or 650 MHz - appropriate for the different running scenarios of FCC-ee - was presented and reviewed during this meeting. The reviewers endorsed the proposed R&D strategy, while suggesting considering possible synergies with other projects, like the EIC. The baseline scenario of running FCC-ee at 400 MHz during the first stage should also be thoroughly reviewed as part of the feasibility study.

The conclusions and the reviewers' recommendations will be presented during the FCC Annual Meeting 2021, that will take place remotely from 28 June 2021 to 2 July 2021 (FCC Week 2021 website: https://indico.cern.ch/e/fccw2021).

[4] Chair of the FCC Advisory Committee InternationalAdvisoryBoard < FCC < TWiki (cern.ch)
[5] Member of the FCC Advisory Committee
[6] Member of the FCC Advisory Committee
[7] Member of the FCC Advisory Committee

3.3. REVIEW OF FCC SITE STUDIES AND PLACEMENT

A review for the FCC site studies and placement will take place remotely on 7 June 2021 (presentations and discussions) and on 8 June 2021 (closed session). The meeting will be restricted to presenters, invited experts, reviewers, and observers. A simultaneous translation from English to French and from French to English will be provided for both sessions.

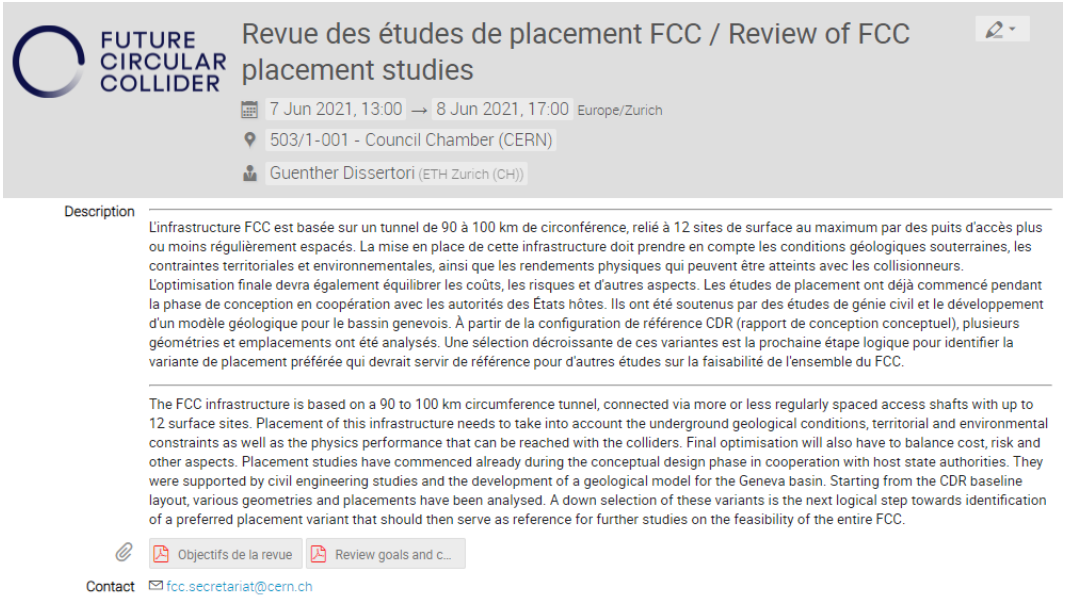

Figure 5 – FCC placement studies review
Revue des études de placement FCC / Review of FCC placement studies (7-8 June 2021) · Indico (cern.ch)

3.3.1. Scope of the review

The FCC infrastructure is based on a 90 to 100 km circumference tunnel, accessed via nearly regularly spaced shafts with up to 12 surface sites. Placement of this infrastructure needs to consider the underground geological conditions, territorial and environmental constraints as well as the physics performance that can be reached with the proposed colliders. Further optimisation must also balance cost, risk, and other aspects. Placement studies already started during the conceptual design phase and were refined in cooperation with host state authorities. They were supported by civil engineering studies and the development of a geological model for the Geneva basin. Starting from a baseline layout, various geometries and placement scenarios have been developed. A down-selection through more detailed analysis of these variants is the next logical step towards identification of a preferred placement scenario that should then serve as reference for further studies on the feasibility of the entire FCC.

3.3.2. Review goals and charge

The June meeting should review the status and methodology of FCC placement studies with the goal to support the down-selection of variants towards a preferred implementation scenario. The review should comment and advise on the following points and questions:

- the methodology applied for the placement studies,
- the adequacy and relative importance of the boundary conditions and constraints identified,
- the impact on physics/machine performance,
- the overall suitability of placement scenarios as basis for development of a preferred scenario,
- the further planning and next steps of the placement optimisation process.

3.3.3. Reviewers

Ralph Assmann (DESY)[8], Günther Dissertori (ETHZ, Chair)[9], Gregor Herten (University Freiburg)[10], Jean-François Hotellier (GADZ), Philippe Lebrun (JUAS)[11], Yung Loo (ARUP), Steve Myers (ADAM SA), Franz Pacher (AMBERG), Andrew Parker (Cambridge University)[12], Nedim Radoncic (AMBERG), Bernhard Stacherl (GEOCONSULT), Matt Sykes (ARUP), Tim Watson (ITER)[13].

Representatives from the Canton de Genève and from the Région Rhône-Alpes will also participate as observers.

3.3.4. Agenda

Table 3 – FCC placement studies review 07 June 2021 agenda

Presentation title	Presenter(s)
Introduction	Günther Dissertori (ETHZ), Michael Benedikt (CERN)
Conditions, constraints and methodology	Johannes Gutleber (CERN) Volker Mertens (CERN)
Civil engineering aspects and constraints	John Osborne (CERN)
Geological data gathering and 3 D geology model	Andera Moscariello (UNIGE)
Overview on placement investigations	Johannes Gutleber (CERN) Volker Mertens (CERN)
Placement scenarios with 12 and 8 surface sites	Johannes Gutleber (CERN) Volker Mertens (CERN)
Assessment of scenarios from tunnelling/geological viewpoint	Werner Dallapiazza (ILF) Stefan Eder (ILF) Cyril Thomas (GADZ)
Optics and luminosity performance	Katsunobu Oide (KEK)
Beam transfer and injection scenarios	Wolfgang Bartmann (CERN)
Discussion	All

3.3.5. Conclusions

The conclusions and the reviewers' recommendations will be presented during the FCC Annual Meeting 2021, that will take place remotely from 28 June 2021 to 2 July 2021 (FCC Week 2021 website: https://indico.cern.ch/e/fccw2021).

[8] Member of the FCC Advisory Committee

[9] Chair of the FCC Advisory Committee InternationalAdvisoryBoard < FCC < TWiki (cern.ch)

[10] Member of the FCC Advisory Committee

[11] Member of the FCC Advisory Committee

[12] Member of the FCC Advisory Committee

[13] Member of the FCC Advisory Committee

4. FCC ANNUAL MEETING

The annual conference 'FCC Week 2021' will take place remotely from 28 June to 2 July 2021. The FCC worldwide community now stands at 144 institutes in 32 countries. The aim of the 2021 collaboration week is to bring together the FCC/FCCIS community to share results, to solidify the vision of a circular post-LHC particle-collider research infrastructure and to discuss and plan together for the upcoming study phase that should demonstrate the feasibility of the FCC by end 2025.

The FCC Week programme will follow the same format as FCC meetings in previous years. The first day, will be dedicated to plenary sessions, while parallel sessions will take place from 29 to 1 July inclusive. Summaries will be presented in the morning of the last day, on 2 July. Presentations will be by invitation only.

FCC Week website: https://indico.cern.ch/e/fccw2021

Version: 0.9 Date: 04.05.2021

FCC Week 2021 Programme

Day	Monday 28 June	Tuesday 29 June		Wednesday 30 June		Thursday 1 July		Friday 2 July	Day
Time	Plenary	Parallel 1	Parallel 2	Parallel 1	Parallel 2	Parallel 1	Parallel 2	Plenary	Time
08:30-09:00									08:30-09:00
09:00-09:30	Opening	Technology R&D	FCCIS WP3 (Integrate Europe)	FCC SRF	FCC-hh accelerator	FCC-ee accelerator / FCCIS WP2	Technical Infrastructures	Summaries	09:00-09:30
09:30-10:00									09:30-10:00
10:00-10:30									10:00-10:30
10:30-11:00									10:30-11:00
11:00-11:30	FCC feasibility phase	FCC-ee accelerator / FCCIS WP2	FCCIS WP4 (Impact & Sustainability)	FCC-ee accelerator / FCCIS WP2	EASITrain	FCC-ee accelerator / FCCIS WP2	Technical Infrastructures	Summaries	11:00-11:30
11:30-12:00									11:30-12:00
12:00-12:30									12:00-12:30
12:30-13:00									12:30-13:00
13:00-13:30		Radio Frequency					Radio Frequency		13:00-13:30
13:30-14:00									13:30-14:00
14:00-14:30	Physics, Experiments & Detectors		FCCIS WP5 (Leverage & Engage)	FCC-eh	Civil Engineering	FCC-ee accelerator / FCCIS WP2			14:00-14:30
14:30-15:00									14:30-15:00
15:00-15:30									15:00-15:30
15:30-16:00									15:30-16:00
16:00-16:30	Physics, Experiments & Detectors	FCC-ee accelerator / FCCIS WP2	Physics, Experiments & Detectors	FCC-ee accelerator / FCCIS WP2	FCCIS WP5 (Leverage & Engage)	Technology R&D	Physics, Experiments & Detectors		16:00-16:30
16:30-17:00									16:30-17:00
17:00-17:30									17:00-17:30

Figure 6 – FCC Week 2021 draft programme overview (governance meetings are not displayed here)
https://indico.cern.ch/event/995850/page/22435-programme-at-a-glance

5. CONTRIBUTIONS FOR OPEN ACCESS PROCEEDINGS PUBLICATION

Together with Springer/Nature, a beneficiary of the FCCIS consortium, the publication of a special issue of EPJ Plus (https://www.springer.com/journal/13360) focusing on FCC-ee is planned for year 2021, based on the contributions given during the FCC November Week 2020.

The exact title of the special issue is "A future Higgs & Electroweak factory (FCC): Challenges towards discovery" and will include 34 essays covering the accelerator, experimental, theoretical and software challenges of the FCC-ee project. An international committee of 8 Guest Editors, together with the journal's Editorial Board, will supervise the review process and ensure a high quality of the published essays.

The planned publication should serve as a precious reference document, helping to evaluate the progress toward the realisation of FCCs since the publication of the FCC Conceptual Design Report, and covering in a concise, albeit solid way the challenges lying ahead for the accelerator design, experiments and detector development, the theoretical questions and, last but not least, the computational and software challenges that need to be tackled. Presenting the challenges and opportunities that a project like FCC offers can also inform a wider community of scientists and engineers working on similar topics and attract new partners from academia, research centres and the industry to the diverse and dynamic environment offered by the FCC collaboration.