Reunion FCC-contacts

vendredi 24 janv. 2025, 09:00 → 10:30 Europe/Paris

09:00 → 09:20 **News + FCC-contacts** — 20m

Orateur: Gregorio Bernardi (APC Paris CNRS/IN2P3)

09:20 → 09:40 **Debriefing du Symposium, Rédaction du report** — 20m

09:40 → 10:20 **Next steps / Tour de table des EoI et des différentes contributions** — 40m

Orateurs: Catherine Biscarat (L2I Toulouse, CNRS/IN2P3, UT3), Farès Djama (CPPM), Gaelle Boudoul (IP2I/AICP (CNRS/IN2P3)), Giovanni Marchiori (APC Paris), Jean-Baptiste De Vivie De Regie, Luc Poggioli (LPNHE Paris), Marco Delmastro (LAPP), Nicolas Morange (IJCLab), Stephane Monteil (Laboratoire de Physique de Clermont - UCA/IN2P3), Suzanne GASCON-SHOTKIN (IP2I Lyon/Université Claude Bernard Lyon 1), Vincent BOUDRY (LLR - CNRS, École polytechnique/IPP Paris), Ziad EL BITAR (IPHC)

ESPPU inputs

ESPPU process discussed on Friday by Karl Jakobs.

Feasibility Study Final Report can surely be considered an input, but in addition:

- Request for document giving answers to technical questions on each large-scale project. This presumably to be overseen by FCC Coordination;
- We should foreseen targeted inputs to individual Working Groups;
- Other ?

Our current proposal, concerning physics

- PED overview
- QCD
- EW/Higgs/Top
- Flavour
- BSM
- FCC-hh

Other five documents would also make mention of FCC-hh, but this additional one would pull things together, plus make mention of other opportunities

We are seeking approval for this proposal from Michael Benedikt (obtained) and from Karl Jakobs (in progress).

Remarks on physics inputs

- Main body of each document cannot exceed 10 pages (but additional material can be included);
- No time to embark on new studies. But there is an opportunity to include results that arrived too late to be included in FS FR;
- Most of the Working Groups have also defined (or want to define) benchmark channels, for which they want numbers. Presumably makes sense to include them in these documents.
- As comparisons will be made, and fits performed, we should ensure our assumptions (particularly for Higgs) are consistent with other projects.

Process to be overseen by Michelangelo, with technical support from Carlo.

Other inputs

Detector inputs foreseen – see ‘Detector EoI’ item;

Anything from computing, or MDI ?;

Nothing foreseen from EPOL. All technical information in FS FR;

What else? *e.g.* should we make a submission on ‘sustainability’ ?;

Personal view: let us not dilute our message by submitting too much.

https://europeanstrategyupdate.web.cern.ch/sites/default/files/Benchmark_measurements_processes.pdf

1.1 Higgs physics benchmarks

- Precision of the measurement of the Higgs mass (and width, when a determination is possible).
- Single Higgs couplings: sensitivity to BSM in Higgs couplings to SM particles.
  - From Kappa fits, in combination with HL-LHC, two possible versions:
    - All SM coupling modifiers AND non-SM Higgs decays
    - All SM coupling modifiers WITHOUT non-SM Higgs decays
  - From SMEFT fits: Baseline established with BSM/Flavor WGs. (See also Effective Field Theory Interpretations section). Details on specific information about the inputs needed for these fits are provided below, regarding the Higgs/EW/Top sectors.
  - For the preparation of these studies we will need the projected uncertainties on the corresponding Higgs observables at each different energy and with correlations, when available.
    For instance, for e+e- Higgs factories, the signal strengths for each production x decay channel:
    $\sigma_{ee\to ZH}(incl.)$,
    $\sigma_{ee\to ZH} \times BR(H \to bb, cc, ss, gg, \tau\tau, \mu\mu, WW^*, ZZ^*, \gamma\gamma, Z\gamma)$,
    $\sigma_{ee->H\nu\nu(VBF)} \times BR(H \to bb, cc, ss, gg, \tau\tau, \mu\mu, WW^*, ZZ^*, \gamma\gamma, Z\gamma)$

- Shape of the Higgs potential. Precision on Higgs self-coupling
  - From HH production
  - From single-Higgs measurement, via SMEFT fit
  - In both cases, whenever possible:
    - Exclusive determination (i.e. assuming $\kappa\lambda$ as the only free parameter of interest and everything else fixed to the SM value)
    - Inclusive determination ($\kappa\lambda$ + any other parameter of interest entering in the relevant observables). Specify what extra parameters of interest are considered (i.e. not fixed to the SM value)

1.2 Electroweak physics benchmarks

- Precision Electroweak measurements:
  - Projected uncertainties on Electroweak precision observables (without imposing any assumption about fermion universality)
    - On-shell Z measurements: M_Z, Γ_Z, σ^0_{had}, R_f, Asymmetries (A^f_{FB}, A_f), etc.
      with $f = e, \mu, \tau, b, c, s, ...$
    - On-shell W measurements: M_W, Γ_W, BR($W \to e\nu$, $\mu\nu$, $\tau\nu$),...
    - Other Observables/Pseudo-Observables. E.g. definitions and expected precision in observables used for determination of anomalous triple gauge couplings (aTGC) from diBoson production.
    - When reporting the uncertainties of these or any other observables where systematics are expected to be important, please **indicate explicitly any relevant assumptions made in the estimations of such systematics, and in particular those related to assumed improvement in the theory side.**
  - EW couplings: sensitivity to BSM in Z and W couplings to SM fermions.
    - From SMEFT fits: Same setup used in "Single Higgs Couplings"
- Other probes of Electroweak symmetry breaking/Multi-Boson processes
  - E.g. Longitudinal Vector Boson Scattering (VBS): Same-sign VBS @ Hadron colliders, VBF/VBS at lepton colliders.

1.3 Top physics benchmarks

- Top-quark properties and interactions:
  - Top-quark mass precision
  - Top-quark properties from SMEFT fits:
    - Top-quark EW couplings (Ztt, Wtb)
    - Top-quark Yukawa coupling
    - Other interactions entering in Top processes, depending on assumptions chosen in SMEFT fit, e.g. four-fermion interactions, Top-dipole operators
  - As in the EW and Higgs part, it would be useful to have the definitions and projected uncertainties of the observables used in the interpretation.

3 Flavour physics

Flavour physics is one of the areas with the largest number of interesting observables. The benchmarks we propose are meant to compare the potential, in this area, of the multi-purpose experiments at lepton or hadron colliders, hence are focused only on heavy quarks (b and c) and τ physics. This by no means implies that other class of observables, such as EDMs or rare decays of light quarks and leptons will not be considered: simply they do not require an explicit list of benchmarks and will be analysed on a case-by-case basis. Also in the case of heavy quarks and τ physics the list below is far from exhaustive; however, it serves the purpose of comparing the potential of different multi-purpose facilities. With these caveats, this is the proposed list.

- Rare FCNCs with ν's and τ,s: $BR(B \to K^{(*)}\tau\tau)$, $BR(B \to K^{(*)}\nu\nu)$
- Rare leptonic B decays: $BR(B_{s,d} \to \mu\mu)$
- LFV in τ decays: $BR(\tau \to 3\mu)$, $BR(\tau \to \mu\gamma)$,
- τ lifetime, $BR(\tau \to \mu\nu\nu)$ and $BR(\tau \to e\nu\nu)$ (τ universality tests)
- CP violation in neutral D-meson mixing
- Time-dependent CP violation in $B_s \to \phi\phi$
- CKM elements from W decays

4 BSM physics

The main goal is to collect the information from the input to the strategy to explore the potential of on-going and future experiments to answer open questions that need physics beyond the standard model.
This group naturally overlaps with the activities of the Flavor, Electroweak, and Neutrino physics and cosmic messengers and Dark sectors. In this section, we foresee to focus on:
Specific questions and corresponding new physics scenarios that can be constrained or discovered at present and future experiments, through multi-pronged approaches, combining collider data with other experiments and observations at different scales.

- New gauge forces (Z', W'...): U(1)-Y-universal, U(1)$_{B-L}$ (universal and 3rd gen), HVT SU(2)$_L$ custodial, HVT Right-handed
- Compositeness (indirectly from EFT fits): Scenario discussed in 1905.03764 + 4q, 2q-2l
- Extension of the minimal real scalar sector giving 1st order EW phase transition and possibly stability: scenario discussed in e.g. 2303.03612
- Minimal dark matter (WIMP) global: see e.g. 2107.09688
- Flavor (together with flavor group): scalar and vector leptoquarks with third generation specificities
- SUSY (direct only collider, global on with specific assumptions): see Briefing Book 2020
- Portals (dark photon, dark higgs, HNLs, axions, ALPs): see Briefing Book 2020

8 Accelerator technologies

For large accelerator projects guidelines for input have already been defined in a separate document which is available via the Strategy web pages:

https://europeanstrategyupdate.web.cern.ch/sites/default/files/Project_inputs_ESPP2026.pdf

9 Detector instrumentation

The PPG requests that the following information and/or specifications (instead of “benchmarks”) be given for each proposal submitted to the ESPPU dealing with detector instrumentation. Each project, be it on individual detection technologies or on devices/systems (tracker, calorimeter,...), should address the following points:

- What are the key performance indicators (KPIs) of your technology and which performance does your technology achieve in terms of these KPIs?
- What is the current technology readiness level (TRL, in the spirit of ISO norm 16290:2013) of your technology? How do you expect the technology to scale from lab prototypes to full detector systems (concerning mechanical integration, powering, cooling, readout)? If applicable: please start from the assessment by the ECFA detector roadmap and report updates.
- What are status and time scales for the project? At which point in time have you achieved or do you intend to achieve: proof of principle, concept validation (by full simulation), initial prototype, lab test, beam test, “slice” of full system, full system? Cover hardware, software and firmware aspects.
- Which DRD collaboration(s) are the most relevant to your technology? Is your technology already covered in one or more of them?
- What is the environmental impact of your technology/device/system and which measures are taken to reduce it?

10 Computing

- Describe the amount and type of **resources** you expect to need along the timeline of the initiative:
  - With resources split into [computing resources | interconnections | facilities | person power required] in the various expected runs/periods.
  - Add which external initiatives | events the planning is depending on.
- Furthermore, specific input on the **software tools** and environment should be provided in meaningful detail:
  - Use and/or design of specific software tools for diverse required activities.
  - A special emphasis should be provided on the envisaged role of the AI/ML tools in these use-cases.
  - A special emphasis on the external (commercial) software requirements should be provided (e.g. virtualization tools, storage solutions, database solutions).
  - What type of collaboration you think the software tool development would need between different institutions.

EoIs - Motivation and Status

Reminder

Purpose of the EoIs:

- show that there is a community of institutes interested in development of dedicated sub-detector systems for the FCC
  - has not been done explicitly before. - only implicitly vial technologies addressed in DRD proposals
- trigger interactions in the community on how to get (self-) organised around sub-detectors
  - not parallel to, but largely within DRDs - and PED DetCon WG
  - may set up sub-detector printed structure later

Satellite meeting

- more than 50 presentations (40 after coffee break)
- worked very well (end 13:05)
- many new groups we had not seen - invited them to DetCon meetings, to be followed up
- new possibilities for joining efforts appeared in the meeting

Next Steps: Write EOIs

Content

Joining activities and merging EOIs is an on-going process

- we may initiate a few more matches today
- can of course also happen later, at any time
- or, vice versa, joint activities can and probably will submit separate funding requests

Content, on 2-4 pages (3-6 for concepts):

- The scope of planned activties for the next 3-5 years
- The Partners (Institutes) and their expertise
- The names of one or two contact persons
- The connection with technological activities in the DRD framework
- The engineering and simulation connections with concept groups
- References to relevant more detailed documentation of the technologies

Important: no duplication
sub-detectors remain embedded in DRDs and connected to concepts

Next Steps: Submit EOIs

The Calls

Deadline Jan 31 for submission of EOIs to **PED** (us) (maybe 10 days extension

- for editorial feedback and iteration

Inclusion in combined FCC submission

- we will write an executive summary or cover letter (3 pages or so)
  - explain calls, plus some statistics on submissions, and table of EoIs
  - to be circulated with all submitters
- staple together EoIs in pdf format in supporting document to common FCC submission
  - cannot be attached directly - as was planned originally - due to 10 page limit
- include clickable table of content in main (summary) document, similar to groped EoI google doc
  - such that EoIs can be directly accessed from there
  - probably use indico

Expect some independent submissions

- from concept groups
- from large sub-detector groups - here we strongly encourage the 2-4 page short EoI in addition

New: benchmarks from PPG: need to discuss how to deal with these

Editorial team:
Srini Rajagopalan,
Guy Wilkinson,
with MD, MAP, FS

ECFA HET Factory study: Status of the Report

- Status of study report
- The next steps

THE UNIVERSITY *of* EDINBURGH

Christos Leonidopoulos

The Big Picture

- Capture the Physics Case & ECFA study activities
  - Demonstrate what can be achieved at a future collider
  - Encourage synergies among projects & build e^+e^- community
- Physics Performance (WG1)
  - Forum to collect and discuss physics potential
  - Particular initiative: Develop thematic areas to concentrate common work → Focus topics
- Analysis Methods (WG2) & Detector Technologies (WG3)
  - Cross-referenced with Physics Topics (WG1)
  - Legacy: Common software, common studies/discussions

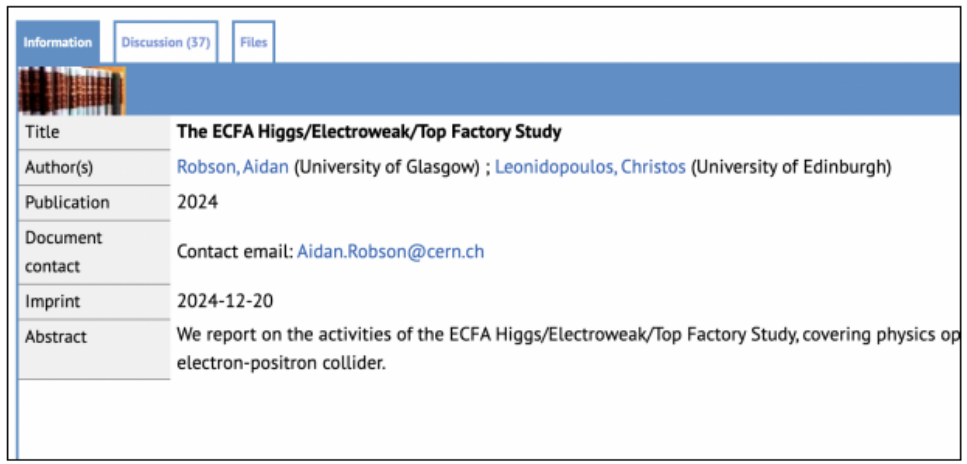
- Report:
  - Coherent & self-contained: should be a useful document
  - Focus on new studies (avoid already published material)
  - With references to more detailed notes/papers, when available

Timeline: what has happened

- 20 October: deadline for analysis teams to submit 2-page summary
- 20 Oct – 10 Nov: Compilation & editing by WG1 subgroup conveners & editors and WG2/WG3 editors (+coordinators & chief editors)
- 10 – 27 Nov: Editing by WG1 coordinators, WG2/3 editors & coordinators, and chief editors
- 27 Nov – 18 Dec: Editing by chief editors
- 18 December: circulation of 1st draft to contributors, IAC, P-ECFA/R-EFCA
- 17 January: Deadline for comments on 1st draft
- 24 January: Deadline for final results/plots from contributors

https://cds.cern.ch/record/2920434

- February: incorporation of comments & latest results/plots
- 21 February: Final version sent to P-ECFA/R-ECFA
- 7-8 March: R-ECFA approval during country visit, followed by arXiv



In case you are having difficulty accessing the CDS area for the ECFA Higgs/electroweak/top factory report, then please check that the email address you use to log in to CDS is a member of the e-group ECFA-Workshop-Higgs-factory . You can do that at the interface https://e-groups.cern.ch, by searching for ECFA-Workshop-Higgs-factory and if necessary adding your email address. It can take an hour or so for the e-group membership to propagate to the CDS permissions.

Status Feasibility Study Final Report

Volume 1 (≈ 220 pages)

Internal Reviewers: Carlos Lourenco & Srini Rajagopalan

1. Physics and Experiments – Overview
2. Specificities of the FCC Physics Case
3. Theoretical Calculations
4. Machine-Detector Interface
5. Detector Requirements
6. Detector Concepts
7. Software and Computing
8. Energy Calibration, Polarisation, Monochromatisation
9. Community Building
10. Outlook and Further Steps
11. References

FCC Cavern Infrastructure

Volume 2 (≈ 400 pages)

Part I Introduction to the FCC integrated project (10 pages)

Part IIa FCC-ee Collider design (60-70 pages)
Internal Reviewers: Jean-Paul Burnet, Patrick Janot, John Jowett, Helmut Burkhardt

Part IIb FCC-ee Collider & Booster technologies (50 pages)
Internal Reviewers: Tor Raubenheimer, Erk Jensen

PART III FCC-ee Booster (50 pages)
Internal Reviewers: Jean-Paul Burnet, Wolfgang Bartmann, John Seeman

Part IV FCC-ee Injector Complex (40 pages)
Internal Reviewers: Frank Zimmermann, Tor Raubenheimer, Antoine Chance

PART V Technical Infrastructure for FCCs (100 pages)
Internal Reviewers: Johannes Gutleber, Tim Watson

Part VI Safety (~40 pages)
Internal Reviewers: Johannes Gutleber, Tim Watson

Part VII The FCC-hh Collider as a second step (50-60 pages)
Internal Reviewers: Frank Zimmermann, Michelangelo Mangano, Vladimir Shiltsev

Volume 3 (≈ 120 pages)

1. Civil Engineering (≈50 pages)
Internal Reviewers: Klaus Hanke, Johannes Gutleber

2. Territorial Implementation (≈20 pages)
Internal Reviewers: Tim Watson, Yann Lechevin, Klaus Hanke

3. Environmental Aspects (≈20 pages)
Internal Reviewers: Jean-Paul Burnet

4. Sustainability (≈30 pages)
Internal Reviewers: Jean-Paul Burnet, Roberto Losito

Timeline

Volume 1 (PED)

- Submission for copy editing on-going (Chapter by chapter as they are getting ready)
- Edit by John Poole/Panos Charitos: Monday, **10th February 2025**
- Submission to Extended Directorate (ED): Tuesday, **11th February 2025**
- Receive comments from ED: Friday, **28th February 2025**
- At the moment, access limited to editors. Some chapters are completely frozen. Others are still being edited. Please send all comments to CG/PJ/MLM+Carlos/Srini.
- Important that the document is as complete as possible by the end of January
- Critical proof-reading and finalisation of the figure after feedback from ED.

Volume 2 (Accelerator)

- Submission for copy editing: **Monday, 3rd February 2025**
- Edit by JP/PC: Tuesday, **25th February 2025**
- Submission to ED: Wednesday, **26th February 2025**
- Receive comments from ED: Friday, **7th March 2025**

Volume 3 (Civil Engineering, Implementation)

- Submission for copy/editing: Monday, **16th December 2024**
- Edit by JP/PC: Wednesday **8th January 2025**
- Submission to ED: Friday, **tbc**
- Comments from ED: **tbc**

- Finalize volumes for publication/submission to European Strategy: Monday, 17/03/25
- Circulate to editors for any final remarks: Monday, 24/03/25
- **Submit to the European Strategy Update: Monday, 31/03/25**

Authorlist

- Discussion with Panos on 17/01/25:
  - Invitation to claim authorship will be circulated soon (list of authors of MTR+FCC-feasibility mailing list - TBC by Michael B.). It will need to be forwarded to whoever you know has contributed to the preparation of your section(s). It is important that no one feels forgotten/excluded. The list should be inclusive.
  - Indico site being prepared
  - People will be invited to say which volume they have been contributed to
- Authors vs. Supporters? Still to be discussed with Michael B.
- Comment added by MLM: we need to discuss authorship of FCC submissions to ESPPU. Proposal: be more exclusive than for the FSR and keep only those who really contributed. To be reviewed by WG conveners. Should be harmonise among different contributions.

EoI's/Notes on National (or Regional) FCC Activities

Goal: give an overview of scope or activities related to future e+e- colliders in the country/region:

Can be presented as compact notes (3-6 pages) along the line:

Assuming FCC moves forward, we would continue/start to contribute in these fields:

- List of Detector/R&D scope and activities
- List of Software/Analysis scope and activities
- List of Theory scope and activities
- List of any other scope and activities within PED

with references to Feasibility study, EoI's, ECFA or other notes.
We can refer to results obtained in local workshops (and list them)
We list institutions participating, detailing in which field they contribute.

Is it a good idea to submit such notes ?

They are useful to demonstrate the number of institutes/groups working or interested to work on FCC, and in which domain.

We would need several of these national notes to have an impact.

Which kind of signature should they have (Institutions + one contact for each institution?)

The FCC-France contacts, on behalf of the FCC-France team:
Roy Aleksan (IRFU), Gregorio Bernardi (IN2P3), Auguste Besson (IPHC), Catherine Biscarat (L2IT), Farès Djama (CPPM),
Gaelle Boudoul (IP2I/AICP), Didier Contardo (IP2I/DRD), Giovanni Marchiori (APC), Jean-Baptiste De Vivie De Regie (LPSC),
Luc Poggioli (LPNHE), Marco Delmastro (LAPP), Nicolas Morange (IJCLab), Stephane Monteil (LPCA),
Suzanne GASCON-SHOTKIN (IP2I), Vincent BOUDRY (LLR), Ziad EL BITAR (IPHC)
Email contact: gregorio.bernardi@cern.ch

Which Level of details ?

References to FCC Feasibility Study and to subdetector and detector concept EOI's

Reference to DRD

First draft of each note by 15th of February to give a chance to iterate before submission ?

The FCC Feasibility Study and the FCC-France contributions in view of the future HEP Collider

The FCC-France contacts, on behalf of the FCC-France team:
Roy Aleksan (IRFU), Gregorio Bernardi (IN2P3), Auguste Besson (IPHC), Catherine Biscarat (L2IT), Farès Djama (CPPM), Gaelle Boudoul (IP2I/AICP), Didier Contardo (IP2I/DRD), Giovanni Marchiori (APC), Jean-Baptiste De Vivie De Regie (LPSC), Luc Poggioli (LPNHE), Marco Delmastro (LAPP), Nicolas Morange (IJCLab), Stephane Monteil (LPCA), Suzanne GASCON-SHOTKIN (IP2I), Vincent BOUDRY (LLR), Ziad EL BITAR (IPHC)
Email contact: gregorio.bernardi@cern.ch

The FCC feasibility study (FCC-FS), recommended by the 2020 European strategy, will be delivered as an input to the next strategy in March 2025. Its mid-term report (delivered end of 2023) [1] has been reviewed extensively and no showstopper were found, confirming the competitiveness and soundness of the project. This note is based on that report and its current update, and gives a brief overview of our contributions to its Physics/Experiment/Detector (PED) part.

The FCC-FS mid-term report has 8 chapters:

1 Placement scenario, 2 Civil engineering, 3 Implementation with the Host States, 4 Technical Infrastructure. 5 FCC-ee Collider Design and Performance, 6 FCC-hh accelerator, 7 Cost and financial feasibility, 8 Physics and experiments,

and this note addresses contributions to chapter 8. However, given its growing importance, we want also to remind here the major effort developed by the collaboration in the 45 pages of chapter 3 which describes how the FCC community pays attention to the societal and environmental impact of the project and how it mitigates it in a pioneering way for our field. This is described in particular in the following subsections:

3.2 Updated territorial constraints and environmental challenges in an environmental information system; 3.3 Preliminary results of road access studies; 3.4 /3.5 / 3.6 Launch of railway access study / agricultural study / analysis of the environmental initial state ; 3.7 Development of a sustainable energy supply concept; 3.9 Molasse re-use potentials, based on the outcome of the ' Mining the Future®' international, challenge-based competition ; 3.10 Documentation of the first batch of socio-economic benefit potentials: a) Summary of the net incremental socio-economic benefits; b) Summary of the value-added and job market impact; c) Summary of regional and local benefits;) The public or common good value of the FCC

These studies are continuing and their updates will be documented in the FS report for the next ESPPU by March 2025.

On the Physics side, with its high luminosity, its clean experimental conditions, its multiple interaction regions, and a range of energies that covers the four SM heaviest particles, the FCC-ee offers a uniquely broad and powerful physics exploration programme as a Higgs, Electroweak, QCD, flavour and top factory, with high potential for discoveries. The current baseline plan considers operating detectors at 4 interaction points (IPs), spanning the e^+e^- centre-of-mass energies around the Z pole, the WW threshold, the ZH production maximum, up to the $t\,t^-$ threshold, and possibly a run at the H pole, to measure the Hee Yukawa coupling. The envisioned 16 years experimental programme is summarised in the following table together with the numbers of events expected at each energy. The H pole run would add 5 more years of data taking.

Besides, the FCC-ee is the only proposed collider with four IPs, with which the FCC science value for the investment is maximised, in multiple ways: (i) by providing an overall net gain in integrated luminosity; (ii) by allowing for a range of detector solutions to cover all physics opportunities, thus broadening the FCC attractiveness to an extended scientific community; (iii) by strengthening the robustness of systematic uncertainty estimates and of discovery claims; (iv) by improving the discovery potential and the many measurements, like the Higgs boson couplings, that are statistically limited; (v) by opening several key physics targets that are tantalisingly close with only two IPs, such as the first 5σ measurement of the Higgs boson self-coupling; (vi) by giving the unique opportunity to access the Higgs boson coupling to electrons through the process $e^+e^- \rightarrow H$ at $\sqrt{s} = 125$ GeV.

The run at the Z pole promises comprehensive measurements of the Z line shape and many Electroweak Precision Observables with fifty-fold improved precision with respect to the current constraints, as well as direct and uniquely precise determinations of the $\alpha_{QED}(m_Z)$ and $\alpha_S(m_Z)$ interaction couplings. The comparison of these data with commensurately accurate SM predictions is a way to reveal the existence of new physics through virtual loops or mixing: a factor of 50 in precision corresponds to a factor of 7 in energy scale, representing a step towards discovery similar to that from LHC to FCC-hh. Beyond much higher precision, this Z pole run also enables otherwise unreachable flavour (b, τ) physics, studies of QCD and hadronization, the search for rare or forbidden decays, and the exploration of the dark sector.

In general, FCC-ee is superior in terms of performance to all other proposed future e^+e^- collider in all physics domains (Higgs, Electroweak, Top, Heavy Flavour, QCD, Long Lived particle searches, except for the measurement of the Higgs self-coupling through the "direct" HH production, which can be achieved only with an upgraded linear collider (beyond the base-line 250 GeV ILC), and possibly for some rare and specific scenarios.

Given the outstanding FCC physics potential, the FCC-France community is active since many years, and has increased its involvement after the creation of the IN2P3 master-projet FCC-PED in January 2020. It is now composed of 12 groups, 11 from IN2P3 Labs and one from IRFU, comprising approximately 60 active physicists and engineers. The group-contacts meet at least once every month to organize the work, and the whole community has an annual workshop (shared with the FCC-Italian community every two years), and an annual jamboree for the student presentations. The web sites of the 7 workshops, already organised (including one ECR workshop) are available at: https://indico.in2p3.fr/category/1261/, where the 3rd ECFA workshop on future e^+e^- colliders, organized by FCC-France in Paris in October 2024 is also visible. A public event on FCC and its societal

The FCC-France contributions are generally performed inside the FCC working groups and are documented in various forms. The contributions in Physics and Performance cover many subjects which will be studied at FCC and a non-exhaustive list is given below (each subject is submitted or is about to have its individual submission to GT01 or GT02).

- In Higgs Physics:
  - Expected Measurements of the Higgs Boson Mass and ZH Production Cross Sections
  - Study of the Higgs boson couplings to Heavy quarks
  - Perspectives in measurement of the Higgs boson width via the ZH/H—>ZZ* cross section measurements
  - Measurement of the HWW coupling in the channel ee-->H$\nu\nu$, H-->WW hadronic
  - Prospects for Higgs boson self-coupling indirect measurement from the 240 & 365 GeV runs.

- In Electroweak, QCD, Top and Heavy Flavour Physics:
  - Prospects for QCD and Lund Jet Plane studies
  - Measuring A_{FB}^{b} and R_b with exclusive b-hadron decays
  - Study of rare decays of heavy-flavoured particles and corresponding detector requirements
  - Study of the prospects for CKM profile (V_{cb}, CKM angles, mixing-induced phases from tree & penguin)
  -
- In Physics beyond the Standard Model, Theory and Phenomenology:
  - Search for Heavy Neutral Lepton, and comparisons between Fast and Full Simulation
  - Search for Axion-Like Particles decaying into a pair of gluons
  - Timing-based mass measurement of exotic long-lived particles
  - Search for new light (pseudo-)scalar particles
  - Theoretical studies: precision electroweak physics tests, top quark physics, couplings and width of the Higgs boson, extensions to the scalar sector, flavour physics, composite particles, baryogenesis.
  -
- Contributions have also been made to the FCC software, both in fast and detailed simulations:
  - The FCC Software for PED studies
  - Tracking Resolution Studies with CLD Detector
  - CaloFlux: A Tool to Estimate Fluxes in Calorimeters at Colliders

The performance and the R&D of a number of options for the various detector components of possible future detectors are being studied. In particular we have been contributing to the following, but other R&D lines are also underway.

- Calorimeter Developments:
  - ALLEGRO, a detector concept with a liquid-argon based highly granular electromagnetic calorimeter
  - SiW-ECAL : Preparation of ILD-CC : SiW-ECAL at FCC-ee
  - T-SDHCAL & T-MRPC
  - GRAINITA: characterization of a novel crystal-grain calorimeter featuring high energy-resolution.
  -
- Tracking and Vertex Detectors:
  - Expression of Interest (EoI) for a Vertex Detector at FCCee (FCC-SEED)
  - Precision timing in a Monolithic CMOS technology; EoI for Time of Flight layers for PID.
  - TPC: studies to adapt from ILC to FCC environment.

In conclusion, the FCC feasibility study should converge smoothly by March 2025, including the French contributions. FCC France looks forward to a positive recommendation to the realization of the FCC project from the upcoming French and European strategy processes, and a rapid approval in the future. This would eventually produce the outstandingly precise physics results expected with this new facility, potential new discoveries, and ensure that the physics program of the HEP community will not be interrupted for a long time at the end of HL-LHC in 2041. FCC France also looks forward in being joined by many more colleagues as soon as possible, in particular when the HL-LHC upgrade work will near completion, in order to build the new generation of detectors which will allow to develop the FCC-ee potential. The FCC-ee results will eventually pave the way to the FCC-hh in the long-term future, which also has an outstanding and complementary physics programme.

PED in the pre-TDR phase

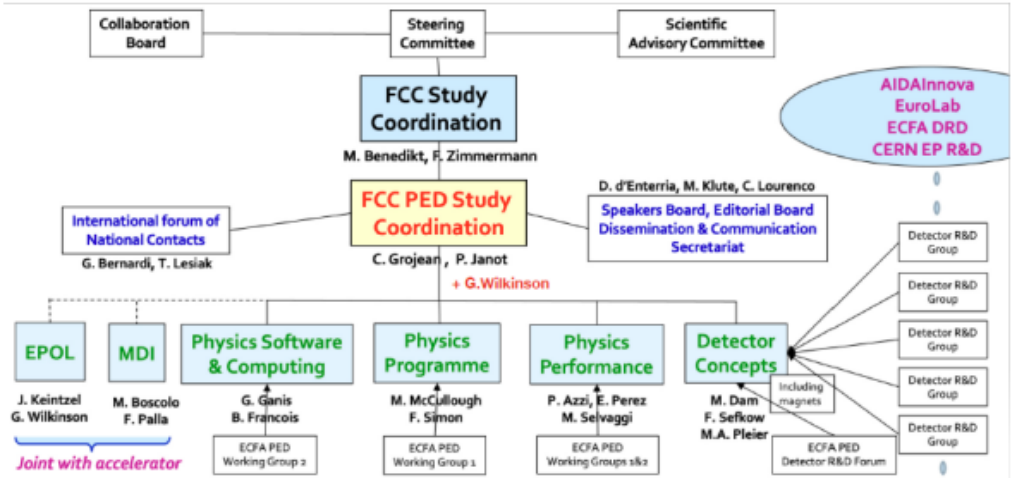
The pre-TDR phase is, to all intents and purposes, beginning now, although our energies are still invested in the finalisation of the FS Report and submissions to the ESPPU. It will last through until when CERN Council is asked to approve the project, which in current planning is late 2027 / early 2028 (but who knows).

→ our job is to provide CERN Council with sufficient PED-related information necessary for them to make approval decision

The importance of this phase has already been recognised by the CERN management, with the establishment of the FCC EP group, and the allocation of non-trivial additional resources, some of which are ring-fenced for PED activities.

PED organisation in the pre-TDR phase

Question 1: is our current organisation optimal for this new phase ?



- I will propose no alternatives today, but the question remains open.

Question 2: do we have all the right people for the task (both in the Coordination itself and as conveners of the separate working groups) ?

- If you know of suitably motivated people who can help, please let us know !
- Equally essential that all those with responsibilities are able to commit fully during this period. If any are unsure, please come and discuss with us.

Physics programme & performance

Continue to sharpen the physics motivation, explore what is needed for the key measurements, and investigate new opportunities

New challenges are emerging (*e.g.* is lumi now limiting error on Γ_z ?)

New ideas are being proposed (*e.g.* $\alpha_{EM}(m_Z^2)$ through e^+e^- angular distributions – see arXiv:2501.05508)

Certain wide fields remain relatively uncultivated, *e.g.* flavour physics

Much theoretical progress required in many areas, particularly EWPOs !

Current renaissance in FCC-hh studies – how to keep this going?

What is best way to make progress?

- Focused workshops (in particular to stimulate international theory community) ?
- Encouragement to bring studies to level of journal publication ?

Critical question: what software/computing developments are required ?

Detectors (+MDI)

- Converge on detector concepts suitable for whole FCC-ee programme.
- Consolidate detector requirements with case studies, and understand what systematic uncertainties we will encounter, and how to reduce them. (much will need to be done at generator level – cannot simulate 10^{13} Z^0)
- Confirm cost of FCC-ee detector, with reduced uncertainties.
- Understand procedures for opening, vertex detector replacement *etc*.
- Concrete proposals concerning trigger and data flow.
- Forge productive partnerships with DRD Collaborations.

News about National Strategy Community Meetings

DK_ESPP_sum.pdf | FCC USA ped 22jan... | FrenchStrategyCom... | french-symposium-... | mchrzasz_PED_su...

FCC(-ee) is clearly recognised at the best option for a future flagship project at CERN

The other options are scientifically inferior: 1. **ILC-250/500** has lower luminosity, its EW programme is maigre and it has no flavour programme, 2. **muC** needs intense R&D and it is not ready as a next-collide project, 3. **LHeC** is not a flagship projet and it is not a gap-filler because of it costs (risk of being a dead-end instead of a gap-filler), 4. **FCC-hh** direct is challenging time-wise

If **CEPC goes ahead** FCC-hh or ILC-550

If **FCC-ee is not financially feasible**: ILC is viewed as an attractive option but the costing will give important input

Strong case for **accelerator R&D**: high field magnets, SRF cavities, plasma wake-field acceleration, muon-collider, energy recovery linacs

French Strategy Symposium
20-21 January

LUN. 20 JANVIER

13:00 → 13:30 Contexte et attendus du symposium

Présidents de session: Christelle Roy, Franck Sabatié

13:30 → 15:30 Restitution et discussions par les groupes de travail thématiques

13:30 GT1: Modèle standard et au-delà

Orateurs: Ana Teixeira, Fabrice Couderc, Marie-Hélène Genest

Contribution-of-the-... GT1.pdf

14:30 GT2: Physique de la saveur et tests des interactions fondamentales

Orateurs: Christopher Smith, Giulio Dujany, Yasmine Amhis

GT2 - Minutes de la ... GT2.pdf

15:30 → 16:00 Pause café

16:00 → 18:00 Restitution et discussions par les groupes de travail thématiques

16:00 GT3: Neutrinos (en particulier expériences à longue ligne de base)

Orateurs: Sara Bolognesi, Stéphane Lavignac, Anselmo Meregaglia

SlidesGT3Symposiu...

17:00 GT4: QCD et collisions d'ions lourds

Orateurs: Carlos Munoz Camacho, Cyrille Marquet, Michael Winn

presentation_ESPP...

MAR. 21 JANVIER

08:30 → 10:15 Discussion sur les sujets transverses

08:30 Théorie

Orateurs: Ana M. Teixeira (LPCA - Clermont), Christopher Smith (LPSC), Cyrille Marquet (CPHT - Ecole Polytechnique), Stephane LAVIGNAC (IPhT Saclay)

Th-transverse-Symp...

08:45 Instrumentation et R&D

Orateurs: Didier Contardo (IN2P3/CNRS), Philippe Schwemling (Université Paris Cité and CEA/Irfu/DPhP)

ESPPU-F_Intrument...

09:05 Calcul et données

Orateurs: Etienne Augé (IN2P3), Federico Ferri (CEA Paris-Saclay, IRFU), Sabine Crépé-Renaudin (IN2P3)

ESPPU CetD présen...

09:35 Physique des particules hors-collisionneurs et aux interfaces

Orateurs: Marie-Helene Genest (LPSC-Grenoble, CNRS/UGA (FR)), Sara Bolognesi (CEA Saclay)

Hors-collisionneur.p...

10:15 → 10:45 Pause café

10:45 → 11:45 Discussion sur les sujets transverses

10:45 Carrière des jeunes scientifiques, formation

Orateurs: Louis D'Eramo (LPCA - Clermont), Louis Portales (CEA Paris-Saclay, IRFU, DPhP)

ECR ESPPU Sympo...

11:00 Développement durable

Orateurs: Emilien Chapon (CEA / Irfu / DPhP), Jessica Leveque (LAPP), Samuel Calvet (LPCA / IN2P3 / CNRS)

Session transverse_...

11:45 → 13:30 Restitution et discussions par le groupe de travail sur les scénarios de machines

Présidents de session: Cristinel Diaconu (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR)), Maarten Boonekamp (CEa-Saclay), Stephane Monteil (Laboratoire de Physique de Clermont - UCA/IN2P3), Jeremy andrea (IPHC)

ESPPU-GTS_sympo...

13:30 → 15:30 Repas (+ session de travail pour les coordinateurs de groupes)

15:30 → 16:30 Présentation de la synthèse

Présidents de session: Ana Margarida TEIXEIRA (LPC Clermont), Anselmo Meregaglia (LP2I Bordeaux), Carlos MUNOZ CAMACHO (IJCLab), Christopher Smith (LPSC), Cristinel Diaconu (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR)), Cyrille Marquet (CPHT - Ecole Polytechnique), Fabrice Couderc (CEA), Giulio Dujany (CNRS - IPHC), Maarten Boonekamp (CEa-Saclay), Marie-Helene Genest (LPSC-Grenoble, CNRS/UGA (FR)), Michael Winn (DPhN/IRFU/DRF/CEA Paris-Saclay), Sara Bolognesi (CEA Saclay), Stephane LAVIGNAC (IPhT Saclay), Stephane Monteil (Laboratoire de Physique de Clermont - UCA/IN2P3), Yasmine AMHIS (IJCLab), Jeremy andrea (IPHC)

16:30 → 17:00 Clôture par les directions des organismes

Présidents de session: Christelle Roy, Franck Sabatié

Overview of received contributions

- About 60 contributions received.
- Contributions from laboratories:
  - 2 contributions from IRFU, 10 contributions from in2p3 institutes (CPPM, IP2I, LAPP(2), LPNHE, IPHC, LLR, GANIL(2), IJCLab).
- Contributions from projects
  - FCC, LCF, Muon Collider, LHCb, Belle2, EIC, LHeC...
- Various topical contributions to GT1-4
  - Higgs, EWK, top, QCD, detector concepts, networking, computing, AI, sustainability etc...
- Covers several options for the next collider at CERN, and also discuss other colliders and experiments (Belle 2, EIC, LHC, HL-LHC etc…).
- Transversal : sustainability, computing/AI, R&D.

2. Strategic positioning

- Ensure that CERN remains the leader of high energy physics.
  - Long term scientific and technology (societal) impact,
  - Maintain ability to perform large scale scientific programs,
  - Also in view of potential competition with other continents.
  - As a hub of expertise for non-collider experiments
    - Neutrino physics, Dark Matter experiments, QED precision measurements,
  - As a platform that demonstrates the rôle of fundamental (physics) research impact for society

- France to benefit from this positioning:
  - As a host country,
  - Maintain scientific leadership in key FR areas,
  - Perform a strong and balanced R&D,
  - Preserve and develop Know-how in FR Laboratories,
  - Positive impact on the French visibility, attractiveness, education and links to universities.

3. Transverse aspects

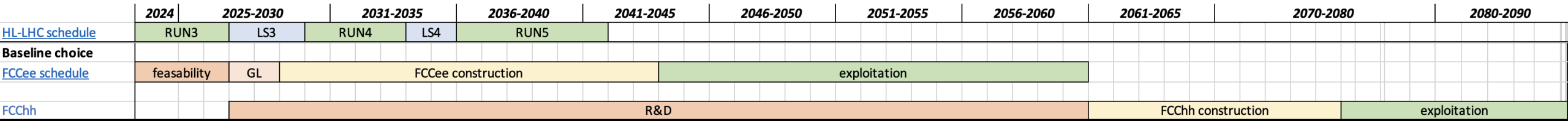
- Strong feedback from the community on Eco-responsibility and Sustainability.
  - There is a clear expectation from the community to work on minimising the ecological footprint, even stronger expectations for the young researchers,
  - Minimising the ecological impact of any future collider is particularly important for the acceptance of the project not only by society, but also within our own community,
  - Should be accounted for in R&D programs.

- Cost is an important aspect, not in the focus of the current process:
  - Direct comparisons of physics benefits vs cost is non-trivial,
  - The projects with the highest physics impact are also the most costly, ~10-15 GCHF for the construction only.

- International context and inter-dependencies:
  - Contributions from non-European countries is of course essential.
  - Other competitive projects might appear on other continents.

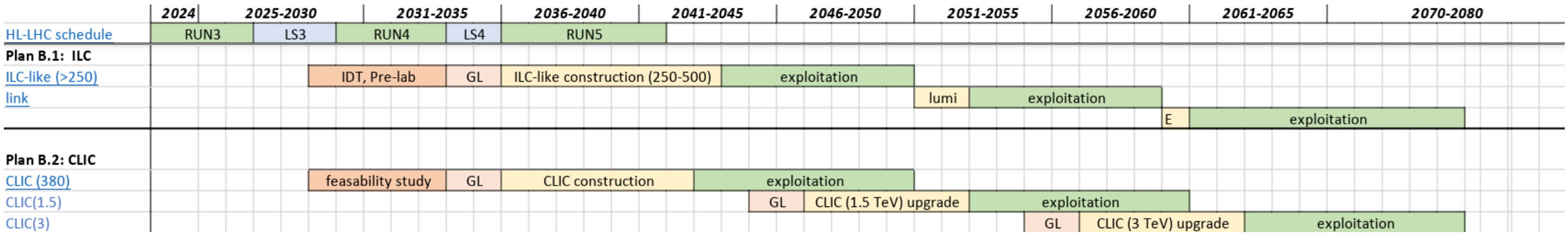
Baseline choice for the future collider at CERN

- FCC has high priorities in a large fraction of the contributions:
  - FCCee as first priority for the GT1 and GT4 (Tera-Z+FCChh), Tera-Z with a circular collider as a priority for GT2,
  - IN2P3: lab/oratory contributions support in the FCC program,
    IRFU : “strong support for the FCC integrated program as “Option A” “.
  - A majority of received contributions are dedicated or mentioning FCCee as the next future collider at CERN.
  - The environmental impact of the project is a major aspect.
- This has been confirmed during the GTS December meeting to reach a consensus:
  - Clear agreement for the next collider at CERN: **FCCee**
  - Opportunity to explore the energy frontier by the **FCChh** in a later stage.



Case 1 Beyond the main priority
Europe leads the development of future accelerators

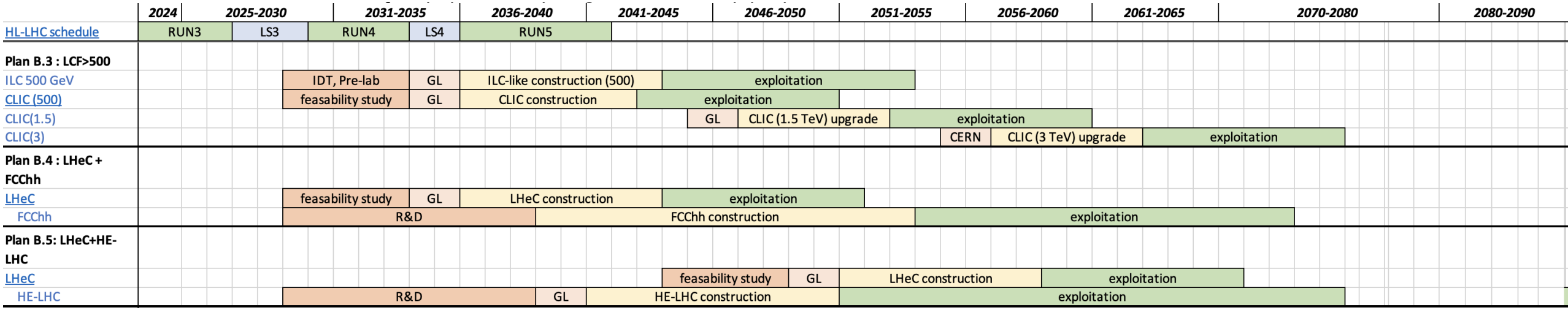
- If the reasons that prevent the realization of FCC do not apply, LCF is the next best Higgs factory, with reduced luminosity but potential to reach higher energies.



- "LEP3", i.e. a new e+e- collider in the LEP tunnel, has significantly less scope than the FCC or LCF, but is still in line with the 2020 ESPPU.
  - energy range limited between the Z pole and the HZ cross-section peak
  - O(10) times less luminosity than FCC-ee.

Case 2 Beyond the main priority an e+e- collider is being constructed elsewhere

- "Elsewhere" Linear : **FCC-ee remains the best option**.
- "Elsewhere" Circular :
  - **LCF to be considered only if it provides sufficient complementarity**
    - i.e. the baseline project should reach the TeV scale.
  - **alternatively, a hadronic program could be pursued**. Options for Europe:
    - if affordable, build the FCC tunnel and move straight to FCC-hh (100 TeV);
    - if not, revert to HE-LHC (FCC magnets in the LHC tunnel : ~25 TeV)
    - either way :
      - less time for high-field magnets R&D to converge: an increased effort is needed;
      - an electron-proton collider such as the LHeC is required to bring the knowledge of the proton structure at a level appropriate for the



Clôture

- Réussite du symposium grâce à l'implication et à la motivation de tous

➢ Quel prochain collisionneur pour le CERN ?

- Un message clair s'est dégagé ! Merci.
- Projet préféré : choix affirmé pour FCC-ee, permettant d'envisager le projet d'après, FCC-hh
  - En travaillant à minimiser l'impact environnemental du projet

➢ Alternatives éventuelles : arbre des possibles bien esquissé

- Document de synthèse attendu pour le 27 janvier
- Contribution française pour le 31 mars

Expand communication

Ask the Symposium participants to join the FCC-Phys-All-List ?

Work with IN2P3 communication

Increase the size of the collaboration

Propose to the colleagues who got closer to FCC to do concrete work

Make another effort to fully integrate ILC colleagues

Organize further FCC-France

All our Labs can join CERN FCC group with team Leader (+deputy possibly)

Produce updated National note with reference to all contributions done to the ESPP

Can we put more coherence in our proposals ?

Next FCC France ?

Where, When ?