FCC-contacts / September 7th 2022

- News FCC / ECFA / Snowmass / IN2P3
- Discussion ressources

PED events until Fall 2023

- Summer conferences
- Snowmass final meeting in Seattle, 17-26 July 2022 https://indico.fnal.gov/event/22303/
- PED coordination meeting, 25 August 2022
- PED BSM and Flavours mini-workshops in September
  - Other topical mini-workshop useful in view of progressing on PED deliverables ?
- 6th PED Workshop in Poland, focused on PED deliverables, 23-27 Jan 2023

  https://indico.cern.ch/event/1176398/

  → Expect several Scientific Programme Committee meetings from end August onwards

  With Pillar and Work-Package coordinators, Physics Group conveners
- FCC Week 2023, 5-9 June 2023, in UK (probably London)
  - Deliverables internal review
- Summer 2023 : write the short reports
- Autumn 2023
  - FCC Feasibility mid-term review by the Council

1. Implementation of the 2021 ECFA Detector R&D Roadmap

- Approved by Plenary ECFA on 18 Nov 2021
- Released in December 2021, after presentation to CERN Council

  Documents available: https://cds.cern.ch/record/2784893
- CERN Council has mandated ECFA to work out a detailed implementation plan
  (in close collaboration with the SPC, the funding agencies and the relevant research organisations in Europe and beyond)
- Likewise, the European Lab Director Group (LDG) was mandated to work out an implementation plan for the **Accelerator R&D Roadmap**

- ECFA **Roadmap Coordination Group*** has worked out a proposal, which was discussed in RECFA and presented to SPC and Council in March and June 2022
  **(Phil Allport, Silvia Dalla Torre, Jorgen D'Hondt, Karl Jakobs, Manfred Krammer, Susanne Kuehn, Felix Sefkow, Ian Shipsey)*

  Some discussions still ongoing, aim for a final plan in September (SPC, Council)
- In the following: short summary of the plan, more detailed presentation by Phil Allport tomorrow

WG 1: Physics Potential

Conveners: Juan Alcaraz (CIEMAT - Madrid), Jorge de Blas (Granada), Jenny List (DESY) and Fabio Maltoni (UC Louvain / Bologna)

WG 2: Physics Analysis Methods

Conveners: Patrizia Azzi (INFN-Padova / CERN), Fulvio Piccinini (INFN Pavia) and Dirk Zerwas (IJCLab)

Setting up WG3 (Detector R&D)

- There is consensus that the R&D activities for a future e+e- collider should be integrated into the Roadmap structure

  Many key issues are in line with the major roadmap detector R&D themes

- Despite this, we consider it useful to have a WG3

  - Interface between RD activities and various e^+e^- collider initiatives

  - Follow-up and update of developing detector requirements

  (Mandate defined)

- Conveners: Mary-Cruz Fouz (Madrid), Giovanni Marchiori (APC Paris), Felix Sefkow (DESY)

Example: Solid State Detectors (TF3)

2022 ECFA e^+e^- Workshop in Hamburg 5 – 7 October 2022

- Status of Working Group activities
- Discussion of future plans
- Interaction between theory and experiments
- "Public Talk" on importance of future e^+e^- collider / new era
  Speaker: Hitoshi Murayama
  + panel discussion
  (involving Fabiola Gianotti, ..)

Registration is open!

https://indico.desy.de/event/33640/

Broad participation is highly welcome!

Next steps proposed by IDT (June 2022)

IDT will organise international discussions, supported by KEK and with MEXT cognisance;

Chaired by Tatsuya Nakada (EPFL Lausanne)

- Develop a general description of the evolution and decision process of a global project, applicable to the ILC, followed by
- Discussion of the specific case of the ILC, i.e. adaptation of the process and possible implementation models

The discussions shall be carried out by an ***International Expert Panel*** consisting of scientists who are experienced in working with large international collaborations and well connected with both the particle physics community and government authorities and CERN

Panel members will make sure that government authorities and CERN are well informed about the status of the discussion and its progress.

Goal: inter-governmental discussions of the ILC should start such that the Pre-lab and international negotiations on the sharing of contributions and responsibilities can be realised

Energy Frontier
Large Experiments

Snowmass Community Summer Study (CSS)

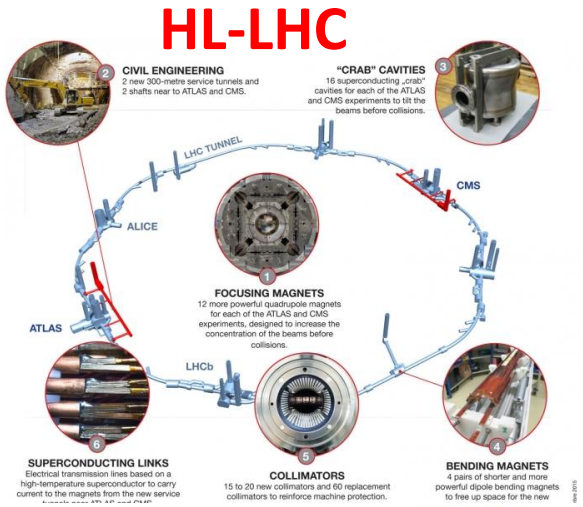
Seattle, July 17-26, 2022

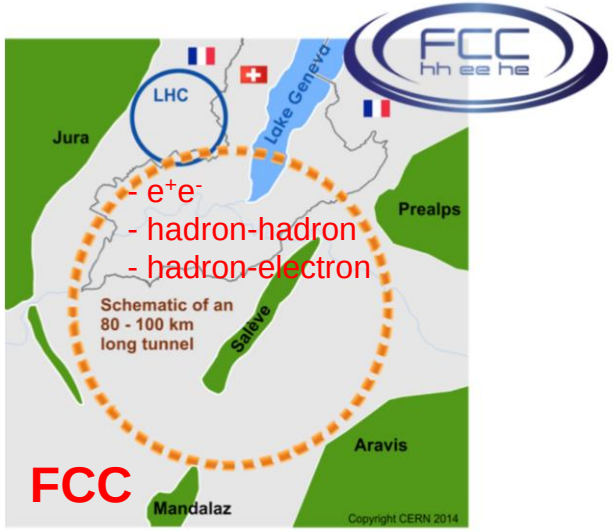
Laura Reina (FSU), Meenakshi Narain (Brown U.), Alessandro Tricoli (BNL)

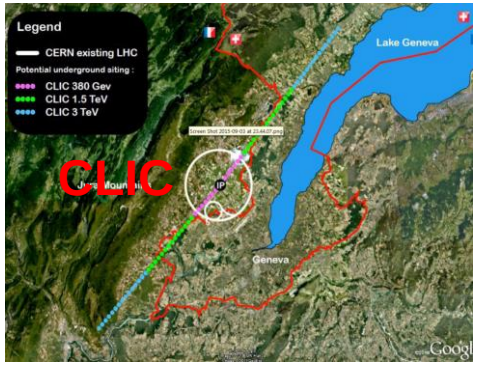
Snowmass EF wiki: https://snowmass21.org/energy/start

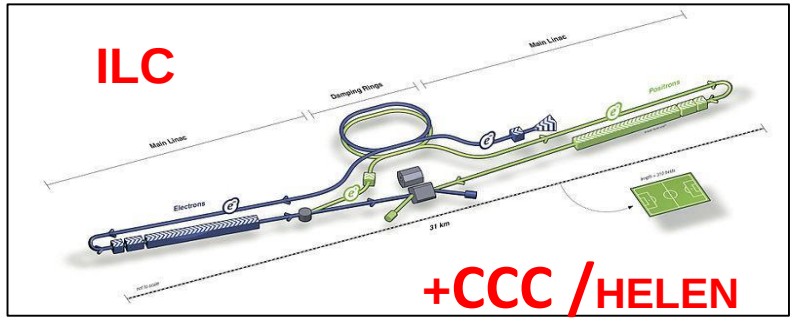
Which machines?

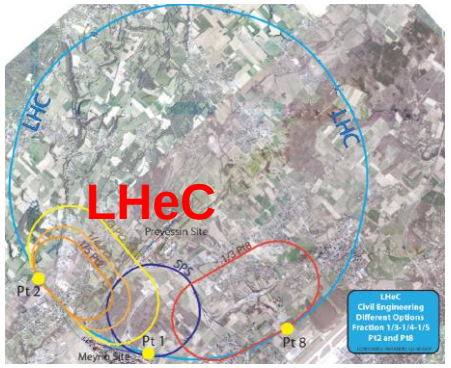
- **Looking for indirect evidence of BSM physics**
  - Need **factories of Higgs bosons** (and other SM particles) to probe the TeV scale via precision measurements
- **Search for direct evidence of BSM physics at the energy frontier**
  - Need to directly reach the **multi-TeV scale**

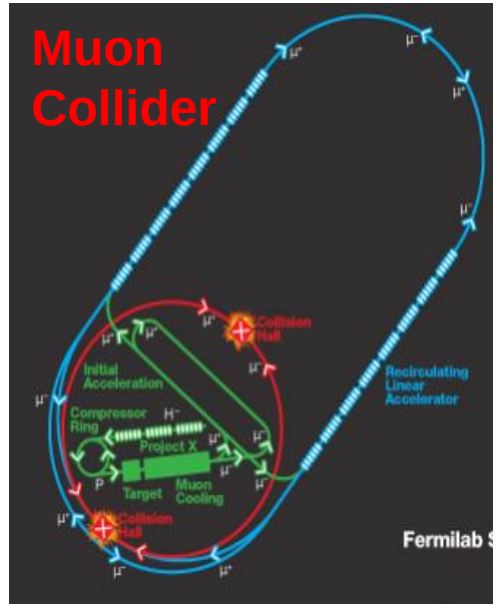


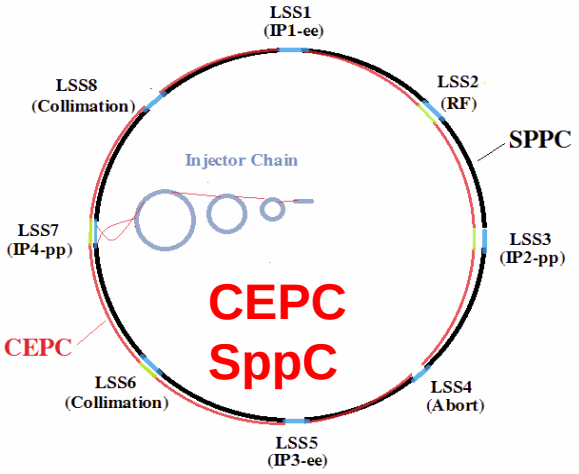




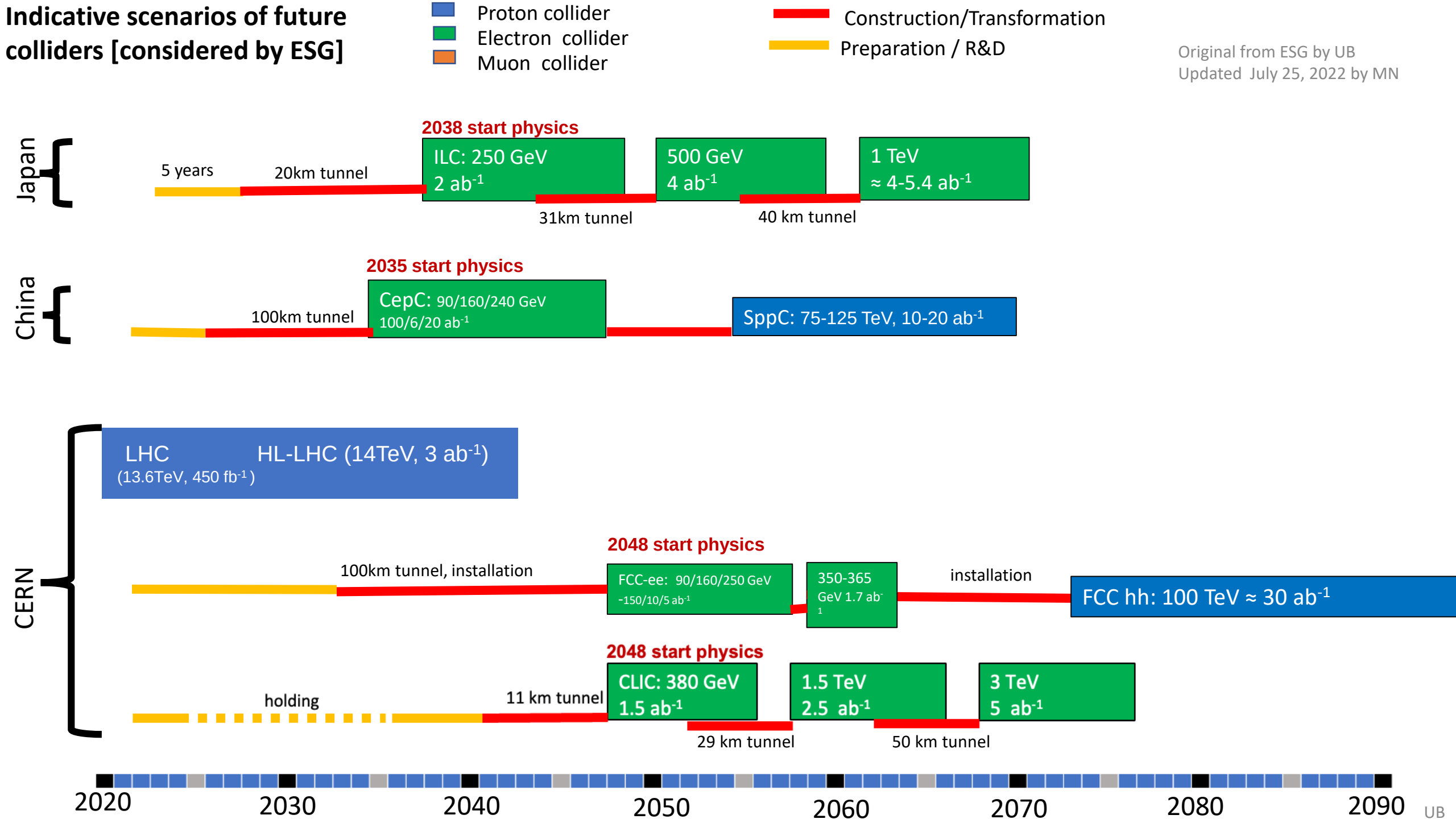








Indicative scenarios of future colliders [considered by ESG]



UB

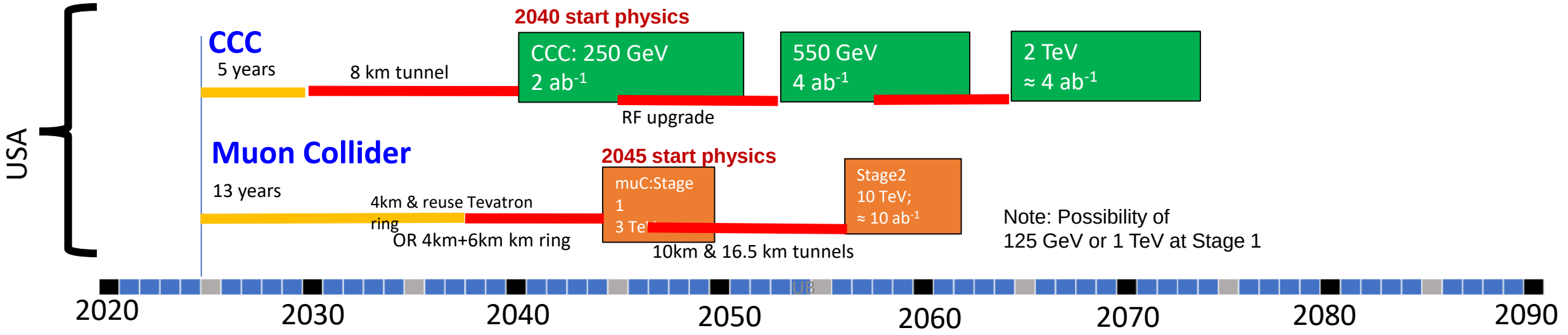
Possible scenarios of future colliders

Proton collider
Electron collider
Muon collider

Construction/Transformation
Preparation / R&D

Original from ESG by UB
Updated July 25, 2022 by MN

Proposals emerging from this Snowmass for a US based collider



- **Timelines technologically limited**
- Uncertainties to be sorted out
  - Find a contact lab(s)
  - Successful R&D and feasibility demonstration for CCC and Muon Collider
  - Evaluate CCC progress in the international context, and consider proposing an ILC/CCC [ie CCC used as an upgrade of ILC] or a CCC only option in the US.
  - International Cost Sharing

- Consider proposing hosting ILC in the US.

Large Projects

Project	Construction Start date (yr)	Construction End date (yr)	Construction Cost B$
Higgs Factories			
CepC	2026	2035	12-18
CCC (higgs Fac)	2030	2040	7-12
ILC (higgs Fac)	2028	2038	7-12
CLIC	2041	2048	7-12
FCC-ee	2033	2048	12-18
Multi-TeV Colliders			
Muon Collider (3 TeV)	2038	2045	7-12
Muon Collider (10 TeV)	2042	2052	12-18
SppC	2043	2055	30-80
HE CCC	2055	2065	12-18
HE CLIC (3 TeV)	2062	2068	18-30
FCC-hh	2063	2074	30-50

Cost estimates from the ITF report by AF. Please refer to the document for explanations now they were estimated and associated caveats

Link to the report on AF wiki

Medium Project Scale R&D requests

Project	R&D Start date (yr)	R&D End Date (yr)	R&D cost M$
Higgs Factory detector R&D	now	2035	~100-150
CCC higgs factory	2024	2028	~100
CCC High Energy	2045	2050	~200
Muon Collider (1-3 TeV)	now	2040	~300
Muon Collider (10 TeV)	2040	2047	~200

Estimated US Contributions
In the spirit of Snowmass numbers are very preliminary. They give an approximate scale.

Need to be vetted further.

Summary

- An opportunity for US to take leadership in colliders

- US EF community strongly supports

1. A fast start of construction of an e+e- Higgs Factory (FCC-ee, ILC, C^3, CLIC) [Large Project]
2. Request for targeted detector R&D for Higgs Factory [in the range of small project costs]
3. Request for investment in R&D towards lowering of costs for Higgs Factory [lower end of medium project costs]
    a. interest in new technologies from early career scientists
4. Request for investment in R&D towards multi-TeV colliders
    a. significant interest for adding muon collider R&D. [lower end of medium project costs]

Towards the (mid-term) FCC-FS review

The main PED deliverables in 2025

- The FCC-FS will be summarized in a FSR to be completed by the end of 2025
  - For Physics, Experiments, Detectors (PED)
    - consolidation of the physics case and detector concepts for both colliders.

CERN/SPC/1161
CERN/3588
Original: English
21 June 2021

In the area of physics, experiments, and detectors, covered by the **Physics, Experiments and Detectors work package**, activities will continue on consolidating the physics case for the integrated FCC programme and the corresponding requirements on theoretical calculations and Monte Carlo generators. The FCC-hh detector concepts will be revisited in light of the evolution of the physics landscape and the experience gained with the High-Luminosity LHC detector upgrades, whilst for FCC-ee several detector concepts are being considered and benchmarked to meet the requirements of ultra-precise Higgs boson and electroweak measurements. The cost drivers for construction and operation will be evaluated and requirements on accelerator performance, technical infrastructure, integration and civil engineering will be formulated. Detector design and R&D will proceed in collaboration with the R&D for future detectors initiative at CERN, and with the activities that will emerge from the Detector Roadmap being developed under the auspices of ECFA.

Mid-term review

Final review

First requirements on CE and TI on 3-4 Oct. 2022 (internal review)

Deliverables for the mid-term review

- A mid-term report is expected by fall 2023, with three deliverables of our choice
  - Section 1: Physics case
    - Documentation of the specificities and complementarity of the FCC-ee and FCC-hh physics cases, in particular for the Standard Model Higgs boson characterization.
      - Should include the FCC-ee standalone physics case (Council specific request)
      - Should include specificities and complementarity with other colliders (our suggestion)

        Other e+e- Higgs factories

        Multi-TeV muon collider
      - Should extend to topics beyond the SM Higgs boson characterization

        See a first list in Christophe's presentation in PED coordination meeting (30 June)
      - Carbon footprint during operation (and installation) is explicitly requested

    - Proposed editors:
      - Michelangelo Mangano, Christophe Grojean, Matthew McCullough, Frank Simon, (Alain Blondel), …
      - Other suggestions from the Physics Groups ?

    - Remark: We already have a lot of material to get inspiration from !

Deliverables for the mid-term review

- Section 2: Theoretical calculations
  - Strategic plan for improved calculations needed to reduce theoretical uncertainties towards matching the FCC-ee expected statistical precision on the most important measurements.
    - Should include a detailed plan for MC generators as well
  - Proposed editors
    - Ayres Freitas, Janusz Gluza (EW) , Staszek Jadach (QED), (Patrick Janot – experiment's side)
    - Requires also QCD and Flavour experts – suggestions ?
- Section 3: Detector requirements
  - First documentation of the main detector requirements to fully exploit the FCC-ee physics opportunities, in particular to reduce experimental uncertainties towards matching the expected statistical precision on the most important measurements.
    - Should include a complete list of requirements, also those for which we don't have a complete study yet
  - Proposed editors
    - Emmanuel Perez, Patrizia Azzi, Mogens Dam, other suggestions ?

How to get there ?

- Some backward scheduling
  - End summer 2023: Have the mid-term review report ready
  - June 2023: FCC week, last chance to present the status of the mid-term deliverables
  - January 2023: FCC PED workshop, structured around our deliverables
    - (Not just the mid-term deliverables, and driven by physics studies)
  - End September 2022: CERN Council meeting
    - More details about the deliverables required by the Council
  - First week of September 2022
    - Provide more information to Michael Benedikt for his presentation before the Council
      - Either 3-5 lines or bullet points

        Offering a better understanding to council members on what each deliverable will describe.
      - These bullet points would (ideally) also serve as subsections.
    - Editors of these bullet points as proposed before
      - Main editors (put everything together): Christophe, Patrick, Michelangelo.
    - Explicit requests from the Council attached to the agenda.

A lot more to explore beyond these deliverables

- Preliminary to-do list - to be amended and completed
  - Document the (physics) arguments for having 2 or 4 interaction regions
    - Includes carbon footprint, plus all arguments we developed a couple years ago
  - Requirements from detectors on experimental sites
    - e.g, position of the booster, need of a secondary cavern, services, etc.
  - Cost drivers and estimates for detectors
  - Required detector R&D
  - Common software framework and computing infrastructure
    - E.g., plug-and-play, analysis framework, etc.
  - International community building
    - Together with the CB, the Global Collaboration WG, the Informal Forum of National Contacts.
  - FCC-hh detector concept
  - Other topics ?

- To be tackled and developed during the PED Workshop in Krakow

Final remark

- We have two final reports to contribute to
  - The final report for the FCC Innovation Study, at the end of 2024
    - See presentation from Panos and Marcin
  - The final report for the FCC Feasibility Study, at the end of 2025

- This might be a sub-optimal use of our time (!)
  - Discussions have started with the project leader to match the two deadlines

News de l'IN2P3

Master-Projets

- Le timing des Master Projets n'est pas encore finalisé
- Plus d'informations en Septembre
- Laurent sera présent lundi 21/11, premier jour de FCC-France-Italie

Post-Docs

- Un post-doc ATLAS-FCC attribué à l'APC (embauche urgente)
  - Search for HH in bbyy or bbtautau on ATLAS
  - L.Argon simulation and Higgs Physics on FCC
- Demandes Postdocs pour 2023

Demandes ressources financières

	CRACOVIE	LONDRES	FCC-France	FCC-meet	ECFA FC	misc	TOTAL		Physiciens: 15% FTE ou plus	Physiciens entre 5 et 10%	total FTE		tot/FTE	(tot-misc)/FTE
	Phys wkshop	FCC-week		CERN	wkshop	& FCC-FR							(FCC-France support not included	
COUT VOYAGE	1500	1800	300	500	1000		TOT	TOT-misc	(* = en tenant compte des L3/M1 encadrés, i.e. +0,2 FTE)				in these two tot)	
APC+FCC-FR	3000	3600	1200	3000	2000	6000	18800	18800	GB(0,9*), GM(0,4*), AL(0,5), pd(0,5), m2(0,3)		2,6		4923	4923
CPPM							0							
IJC Lab							8000	8000			2	?	4000	4000
IPHC	1500	1800	900	1000	1000	2000	8200	6200	ZE(0,6), pd(0,5), GD (0,9), EM(0,5)	AB(0,1), JA(0,1)	2,7		3037	2296
IP2I	3000	5400	1500	1000	2000	4800	17700	12900	GB(0.15), DC (0.2), SG(0.15), GC(.25), AD(0.25), NM(0.15), 2*m2(2*0.3)	GG(0.05), IL (0.1), LM(0.1), RB(0.1)	2,1		8429	6143
LAPP	1500		600		1000		3100	3100	MD(0,3*), m2(0,3)		0,6	?	5167	5167
LLR	1500	3600	1200		1000	1800	9100	7300	RS (0,35*), VB(0,35*), pd(0,3), m2(0,3)		1,3		7000	5615
LPC	1500	1800	900	1000	2000		7200	7200	RM(0,2), SM(0,15), PG(0,5), LR(0,9)	HC(0,1), TM(0,05)	1,9		3789	3789
LPNHE	1500	1800	300	1000	1000		5600	5600	LP(0,8), AB(0,8), BM(0,4), LD(0,2), LP(0,2)	ir(0,1)	2,5		2240	2240
LPSC	1500	0	600	500	1000	1800	5400	3600	m2(0,3)	FM(0,1)	0,4		13500	9000
L2IT							0	0			0		0	
TOTAL-2023							83100	72700			16,1		4789	4143

Demandes ressources humaines

En 2022: 3 Postdocs LHC-FCC attribués:

IPHC : CMS / FCC (tracking for FCC)

LLR : CMS / FCC (Calice for FCC)

APC : ATLAS / FCC (L.Argon simulation for FCC) ➔ TONG LI starting ~15/9/2022

Demandes 2023

IP2I : PostDoc CMS / FCC

LPC : Postdoc LHCb / FCC

LPSC : PostDoc/Etudiant ATLAS / FCC

APC : Etudiant ATLAS / FCC

Préparation FCC France-Italie 21-23 Novembre à Lyon

- Premières discussions informelle avec les italiens sur l'organisation:

Gregorio Bernardi, Didier Contardo, Suzanne Gascon, Angeles Faus Golfe, Giacomo Cacciapaglia,

Franco Bedeschi, Roberto Tenchini, Aleandro Nisati, Manuela Boscolo, Fulvio Piccinini

- Lundi 21/11 démarrage à 12h30 avec lunch commun, puis session plénière introductive.
- Mardi 22/11 2 sessions parallèles: PED (incluant theorie) et Accélérateurs
- Mercredi 23/11 Session plénière de conclusion

Draft agenda / preliminary FCC-Lyon 21-23 November

Sessions: 1h45 -> 5 talks 15+5 (paral.) , 4 talks 20+5 (monday plen.), 3 talks 30+5(wedn. plen.)

Monday 21/11

Welcome and lunch at noon

Plenary session-1 14h-15H45

1)
2)
3)
4)

coffee break

Plenary session-2 16H15-18H

1)
2)
3)
4)

18H15-19H15 Round table, possibly with IN2P3 and INFN responsibles ?

Welcome party 19H30

Tuesday 22/11

Parallel sessions: 1) PED 2) Accelerators 3) Theory

In charge of agendas of the parallel sessions (who can further delegate):
PED: Franco/Roberto/Leandro/Greg/Roy/Suzanne/Didier
Acc.: Manuela/Angeles
Theory: Fulvio/Giacomo

09h-10h45 Parallel-1

	PED-1 (R&D, det concepts)	ACC-1	THEO-1
09:00-09:20			
09:20-9:40			
09:40-10:00			
10:00-10:20			
10:20-10:40			

coffee break

11h15-13h00 Parallel-2

	PED-2 (R&D, det concepts)	ACC-2	THEO-2
11:15-11:35			
11:35-11:55			
11:55-12:15			
12:15-12:35			
12:35-13:00			

Joint Lunch break 13h00-14h00

14H00-15h45 Parallel-3

	PED-3 joint with THEO	ACC-3	free-room
14:00-14:20			
14:20-14:40			
14:40-15:00			
15:00-15:20			
15:20-15:40			

coffee break

16H15-18h00 Parallel-4

	PED-4 joint with THEO	ACC-4	free-room
16:15-16:35			
16:35-16:55			
16:55-17:15			
17:15-17:35			
17:35-18:00			

mini-break

18H15-19h45 Parallel-5

	MDI-PED joint session	Working -1	Working-2....
18:15-18:40			
18:40-19:05			
19:05-19:30			
19:30-19:45			

Workshop dinner 20:30

Wednesday 23/11

Plenary session-3 09h-10H45

Summary/prospects Accelerator
Summary/prospects PED-1 (R&D / detectors)
Summary/prospects Theory

coffee break

Plenary session-4 11H15-13H

Summary/prospects PED-2 (Software/simulation)
Summary/prospects PED-3 (Physics case studies)
Next steps

Farewell Lunch

14-15.30 additional parallel workshops possible

BACKUP

Interactions with Funding Agencies

- Presentation to the Open LHC-RRB on 25th April 2022:
  https://indico.cern.ch/event/1133070/timetable/

- **In general: Support for the plan to set up structured, long-term Detector R&D activities; No major objections raised**

Issues to be clarified: Funding schemes need to be adapted, further iteration on review process, inclusion of non-European partners, industry and neighbouring fields, …

Proposed implementation plan

- We propose to organise long-term R&D efforts into **newly established Detector R&D (DRD) Collaborations**

  Detector technology areas: larger DRD collaborations should be considered
  (one for each of the six areas and an additional similar structure for the transversal topics)

- **DRD Collaborations should be anchored at CERN** → CERN recognition, DRD label

- **Taking full account of existing, well-managed and successful ongoing R&D collaborations and other existing activities**
  (CERN EP R&D programme, EU-funded initiatives, collaborations exploring particular technology areas for future colliders)

- The **formation of new DRD collaborations** should adopt a **community-driven approach;**
  Supported by existing ECFA Detector R&D Roadmap Task Forces;
  Aim to have new structure in place in January 2024

Review and Approval Process

1. Scientific and Resource Reporting and Review by a Detector Research and Development Committee (DRDC)

   Assisted by the ECFA Detector Panel (EDP): the scope, R&D goals, and milestones should be vetted against the vision encapsulated in the Roadmap. (EDP: http://cds.cern.ch/record/2211641/files/, exists, hosted at DESY)

2. Funding Agency involvement via a dedicated Resources Review Board (~once every two years)

3. Yearly follow-up by DRDC → report to SPC → Council

Additional Comments

- As projects develop, **some aspects should be expected to transition into approved experiment-specific R&D** (outside the DRD programme)
- In addition, as stated in the General recommendations (GSR7) funding possibilities for "Blue-sky" R&D" should be foreseen

→ Three areas of Detector R&D:

1. Strategic R&D via DRD Collaborations (long-term strategic R&D lines)
   (address the high-priority items defined in the Roadmap via the DRDTs)

2. Experiment-specific R&D (with very well defined detector specifications)
   (funded outside of DRD programme, via experiments, usually not yet covered within the projected budgets for the final deliverables)

3. "Blue-sky" R&D
   (competitive, short-term responsive grants, nationally organised)

Status of implementation:

- Discussions with existing RD50 and RD51 Collaborations (semiconductor and gaseous detectors, respectively) are ongoing, on how the transition can be realised

- Consensus by all that new structure is needed and should be in place when HL-LHC detector construction is completed (HL-LHC deliverables have to be prioritised by many/all institutes);
  Since both collaborations are only approved until end of 2023, a "natural" date for start-up of the new DRD collaborations seems to be **1. January 2024**

- Aim: - **Ramp-up of the proposed resources (personnel, money) through 2025**
  - **Steady state by 2026**

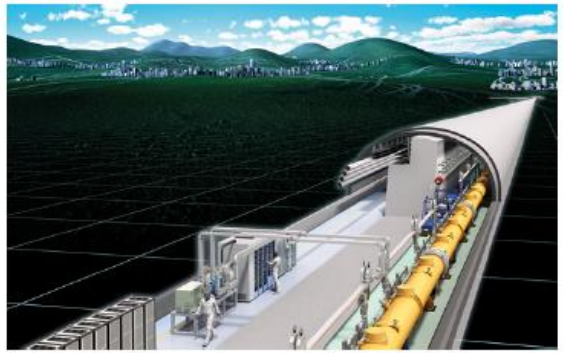
- **Same start-up dates planned for the DRD collaborations in the other areas;**
  Strong support of the plan as well by other technology areas

- Setting up of new DRD collaborations should be done in a bottom-up approach involving the full community;
  To be coordinated by the ECFA Task Force leaders with strong participation of existing RD managements

- Aim to get final endorsement of the structure in September / December Council

- CERN DRD Collaborations are open to all institutes (world-wide) to participate!

5. ILC News, KEK and ICFA statements



- KEK has been working on the realization of the International Linear Collider (ILC) in Japan, together with ILC Japan, a community organization under the Japan Association of High Energy Physicists (JAHEP), the **ILC International Development Team (IDT),** established by ICFA and other supporting organizations around the world.

- In June 2021, IDT published the "Proposal for the ILC Preparatory Laboratory (Pre-lab)," which proposes an outline of the organizational framework, an implementation model, work plan and required resources for the preparatory phase of the ILC.

- At the same time, KEK and JAHEP submitted a report to the Ministry of Education, Culture, Sports, Science and Technology (MEXT) that summarizes progress on ILC activities over the past three years. In response to these developments, MEXT organized an expert panel in July 2021.

- MEXT expressed its view that it could not proceed toward the Pre-lab before having a prospect for the international cost sharing. The Advisory Panel of MEXT for the ILC concluded that it was premature to proceed toward the Pre-lab and recommended re-evaluation of the roadmap of the ILC project in a global context taking into account the progress in other Higgs factory studies.

→ Clear mismatch of views: "International" vs. "Global Project"

Recommendations of the MEXT Panel*:

On 14 February, the panel issued their recommendations, pointing out following five main points:

1. The panel recognizes the academic significance of particle physics and the importance of the research activities, including that of a Higgs factory, and understands the value of international collaborative research. However, the **panel found that it is still premature to proceed into the ILC Pre-lab phase**, which is coupled with an expression of interest to host the ILC by Japan as desired by the research community proposing the project.

2. Given the increasing strain in the financial situation of the related countries, **the panel recommends the ILC proponents to reflect upon this fact and to reevaluate the plan. They should reexamine the approach towards a Higgs factory in a global manner taking into account the progress in the various studies such as the Future Circular Collider (FCC) and ILC.**

3. The panel recommends that the **development work in the key technological issues for the next-generation accelerator should be carried out** by further strengthening the international collaboration among institutes and laboratories, shelving the question of hosting the ILC.

4. For realizing a very large project such as the ILC, cultivating a framework where the related countries can exchange information on their situations and discuss required steps would be important.

5. The panel recommends that the research community should **continue efforts to expand the broad support from various stakeholders in Japan and abroad** by building up trust and mutual understanding through bi-directional communication with the people concerned.

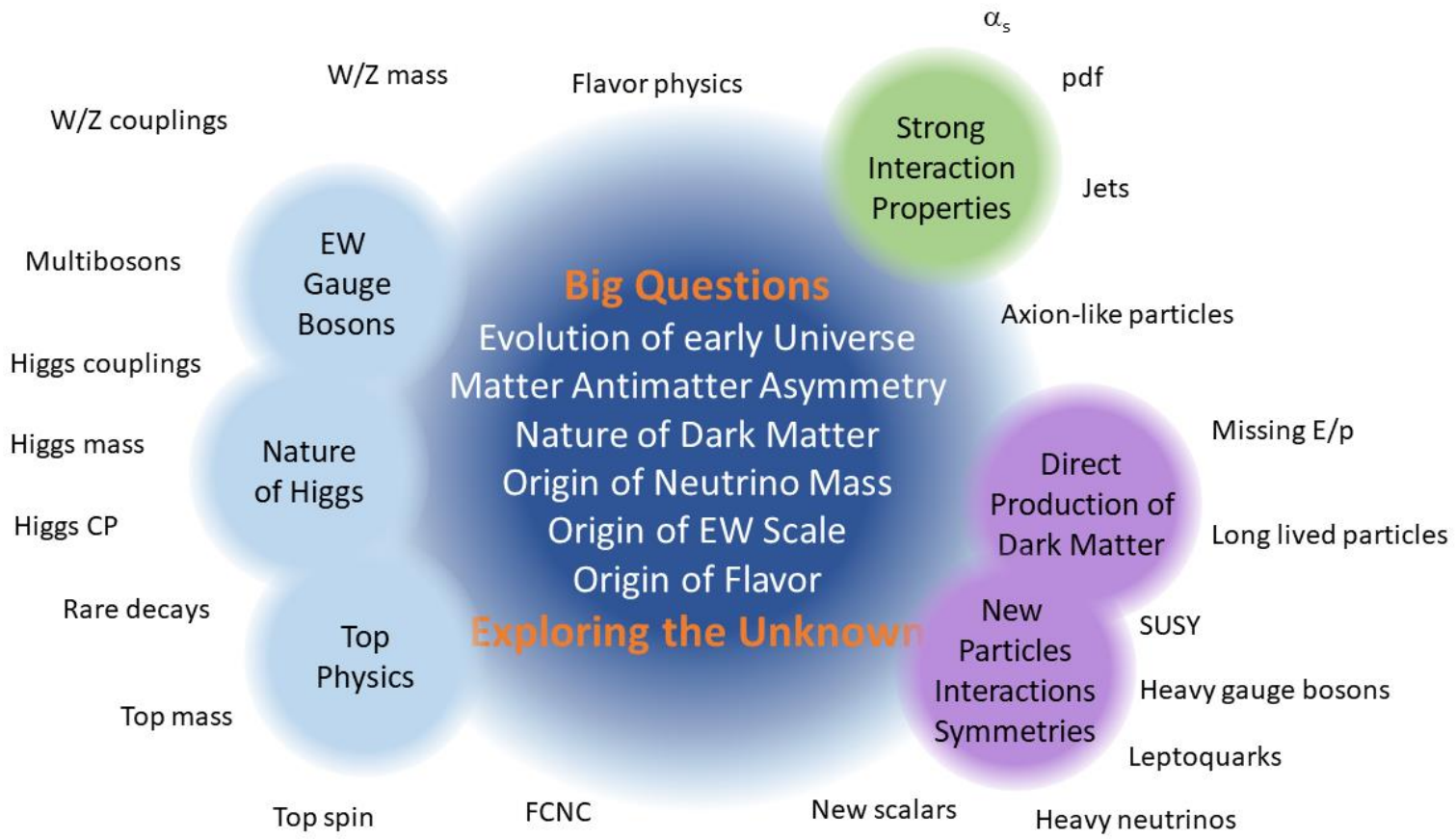
KEK statement*:

In light of the panel's findings, **KEK will make an effort to reexamine the path for realizing the ILC** as a Higgs factory, taking into account the progress in various fronts including the FCC feasibility study. In this process, the interaction with the domestic and international research community as well as the opportunities in the exchange of information through ICFA will be crucial. Also, in collaboration with the IDT, **KEK will propose a framework to ICFA to address some of the pressing accelerator R&D issues** for the Pre-lab, where joint developments will be done by the participating laboratories on the selected subjects. KEK and the Japanese ILC community is committed to further advance important technological and engineering development in the accelerator area and to continue the effort for the realization of the ILC.

Furthermore, KEK, in collaboration with ILC-Japan, will establish a **new organization that will centrally manage ILC communications activities.** The new organization will strengthen activities to communicate the significance of the ILC to all parties involved, such as the general public, academia, or industry, focusing on communicating the importance to build an international laboratory for basic science, which will contribute greatly to the development of a new generation of scientists and advancement of knowledge, science and technology.

Energy Frontier: explore the TeV energy scale and beyond

Aims at investigating open fundamental questions and exploring the unknown, using various probes to discover and characterize the nature of new physics, through the breadth and multitude of collider physics signatures



Energy Frontier Benchmark Scenarios

Higgs-boson factories (up to 1 TeV c.o.m. energy)

Collider	Type	$\sqrt{s}$	$\mathcal{P}[\%]$ e^-/e^+	$\mathcal{L}_{\rm int}$ $\rm ab^{-1}$ /IP	Start Date Const.	Start Date Physics
HL-LHC	pp	14 TeV		3		2027
ILC & C^3	ee	250 GeV	$\pm 80/\pm 30$	2	2028	2038
		350 GeV	$\pm 80/\pm 30$	0.2		
		500 GeV	$\pm 80/\pm 30$	4		
		1 TeV	$\pm 80/\pm 20$	8		
CLIC	ee	380 GeV	$\pm 80/0$	1	2041	2048
CEPC	ee	M_Z		50	2026	2035
		$2M_W$		3		
		240 GeV		10		
		360 GeV		0.5		
FCC-ee	ee	M_Z		75	2033	2048
		$2M_W$		5		
		240 GeV		2.5		
		2 M_{top}		0.8		
μ-collider	$\mu\mu$	125 GeV		0.02		

Multi-TeV colliders (> 1 TeV c.o.m. energy)

Collider	Type	$\sqrt{s}$	$\mathcal{P}[\%]$. e^-/e^+	$\mathcal{L}_{\rm int}$ $\rm ab^{-1}$/IP	Start Date Const.	Start Date Physics
HE-LHC	pp	27 TeV		15		
FCC-hh	pp	100 TeV		30	2063	2074
SppC	pp	75-125 TeV		10-20		2055
LHeC	ep	1.3 TeV		1		
FCC-eh		3.5 TeV		2		
CLIC	ee	1.5 TeV	$\pm 80/0$	2.5	2052	2058
		3.0 TeV	$\pm 80/0$	5		
μ-collider	$\mu\mu$	3 TeV		1	2038	2045
		10 TeV		10		

Accelerator & Detector R&D Needs

(snowmass)

Higgs Factories

Support a fast-start for construction of an e+e- Higgs Factory

Viability of Facilities and Challenges (from AF)

- ILC:
  - Ready to go, polarization
  - Long, e+ source,
  - consider CCC technology for upgrades
- FCCee & CEPC :
  - Ongoing feasibility study
  - Longest, $$, power consumption
- CLIC:
  - Lowest power needs, shortest
  - 2-beams (or klystrons?), tolerances
- Cool Copper Collider or HELEN:
  - **new proposals from Snowmass**
  - lower cost option to ILC/CLIC
  - large gradients at least 70MV/m (HELEN) CCC capability up to 120-155 MV/m

Multi-TeV Machines

Support for R&D for EF multi-TeV colliders

Viability of Facilities and Challenges (from AF)

- CLIC-3 TeV :
  - Established CDR, demo facilities
  - Long, $$$, huge power consumption
- FCChh-100 TeV:
  - Re-use FCCee tunnel, high-L, LHC exp.
  - 20(?) yrs for 16 T magnets, $$$, power
- SPPC-125 TeV:
  - Re-use CepC tunnel, ep 0.12+62.5 TeV
  - (N) yrs for 20 T magnets, $$$, power
- Muon Collider-10(14) TeV:
  - Potentially lowest cost, best Lumi/TWh
  - 6D cooling R , D on many subsystems

Detector R&D Needs

Preparation of a Technical Design for a Detector needs an R&D program

- Highly segmented detectors with good resolution were simulated to make the case for physics studies for Higgs Factories & Multi-TeV Colliders.
- **We do need complex/cutting-edge detectors to meet the ambitious physics goals!**
  The needs extend beyond generic R&D.
  - Address the specific detector challenges for e^+e^- colliders.
- **Such a program needs to start now**
  - to explore the technology to build a full-scale e^+e^- collider detector
  - It takes about 10 years from CD0 to end of construction of a collider detector.
  - **Thus investment in targeted detector R&D for a Higgs Factory has to start soon**!