

Regional Strategic Studies

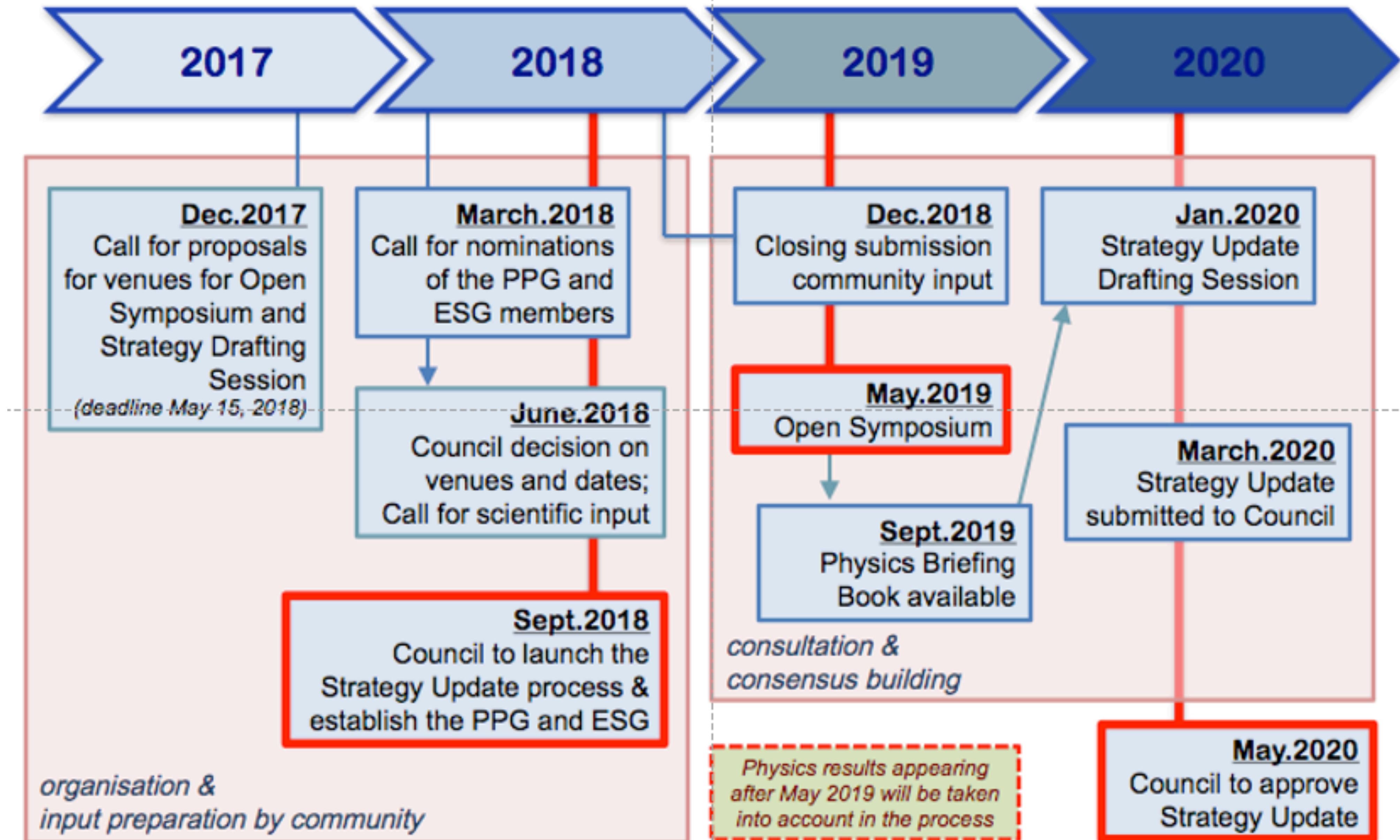
CEPC Workshop 2020

Geoffrey Taylor, CoEPP/University of Melbourne, October, 2020

Regional Planning and Roadmaps

- ***High Energy Particle Physics is not regional, it is Global.***
- ***Planning of programs and facilities is coherent, not independent.***
- ***European Particle Physics Strategy Update and US Snowmass/P5 are not independent.***
- ***The HEP community expects a high level of cooperation and collaboration in planning, building an operation of HEP facilities.***
- ***We must keep our national funding agencies and ministries convinced of the benefits of shared global facilities over independent national facilities***
- ***Our community may need to be flexible in requirements being imposed to guarantee government support***

European Particle Physics Strategy *Update*



The previous update: The European Particle Physics Strategy (2013)

<https://cds.cern.ch/record/1567258/files/esc-e-106.pdf> - with the highest priority

- ★ Europe's top priority: exploitation of the full potential of the LHC:
 - HL-LHC upgrade (machine and detectors) ✓
 - Aim to collect 10x data of the initial design, by around (2030). More like by 2037 is current prediction
 - Provide further opportunities for flavour physics and the quark-gluon plasma. ✓
- ★ CERN should undertake design studies for accelerator projects in a global context. ✓
Emphasis on proton-proton and electron-positron high-energy frontier machines.
 - Including a vigorous accelerator R&D programme:
 - High-field magnets ✓
 - High-gradient accelerating structures ✓
 - In collaboration with national institutes, laboratories and universities worldwide. ✓
- ★ Europe looks forward to the [ILC] proposal from Japan to discuss a possible participation. ✓
- ★ CERN should develop a neutrino programme:
 - Substantial European role in future in leading long-baseline neutrino projects in the US and Japan. ✓

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2020 Update of the European Strategy for Particle Physics

<http://cds.cern.ch/record/2721370/files/CERN-ESU-015-2020%20Update%20European%20Strategy.pdf>

- Continuing two key aspects of the 2013 Strategy:
 - The successful completion of the **high-luminosity upgrade** of the machine and detectors should **remain the focal point of European particle physics**, together with continued innovation in experimental techniques. **The full physics potential of the LHC and the HL-LHC, including the study of flavour physics and the quark-gluon plasma, should be exploited.**
 - Europe, and CERN through the Neutrino Platform, should continue to **support long baseline experiments in Japan and the United States**. In particular, they should continue to collaborate with the United States and other international partners towards the successful implementation of the Long-Baseline Neutrino Facility (LBNF) and the Deep Underground Neutrino Experiment (DUNE)

Possible scenarios of future colliders

- Proton collider
- Electron collider
- Electron-Proton collider

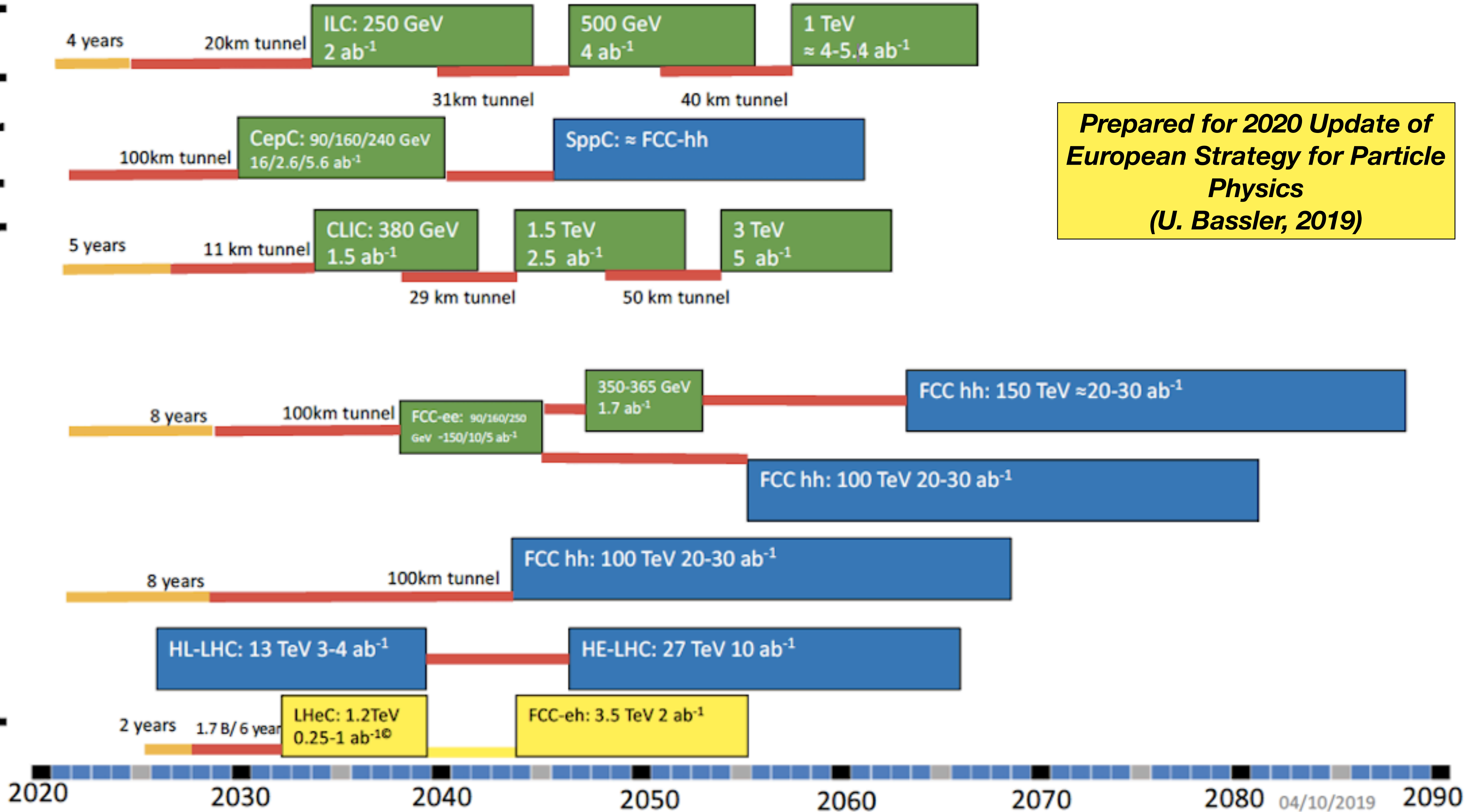
- Construction/Transformation: heights of box construction cost/year
- Preparation

Japan

China

CERN

*Prepared for 2020 Update of
European Strategy for Particle
Physics
(U. Bassler, 2019)*



2020 UPDATE OF THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS ctd.

High-priority future initiatives (I)

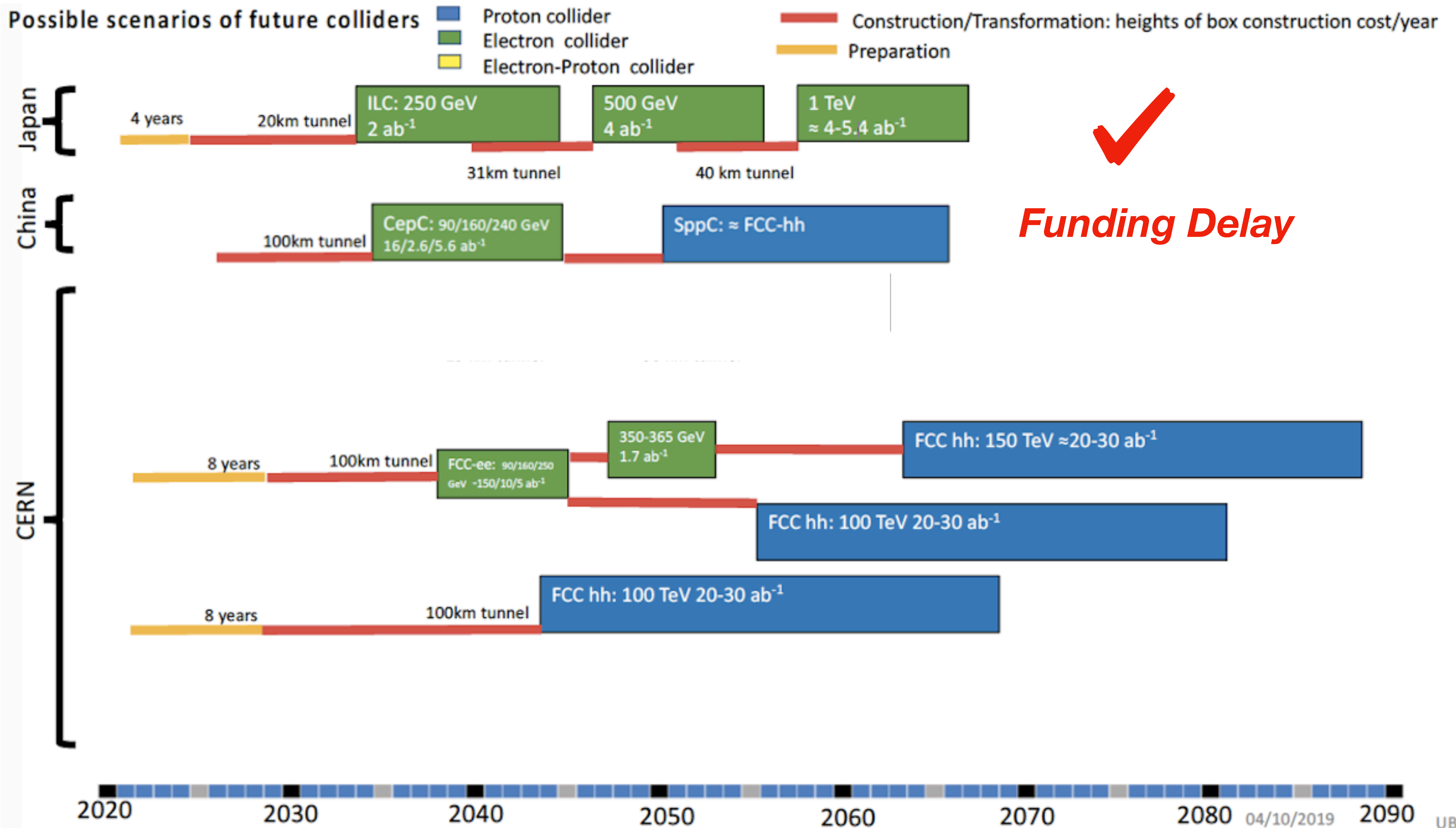
- A. An electron-positron Higgs factory is the highest-priority next collider.** For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology:
- *the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;*
 - *Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.*

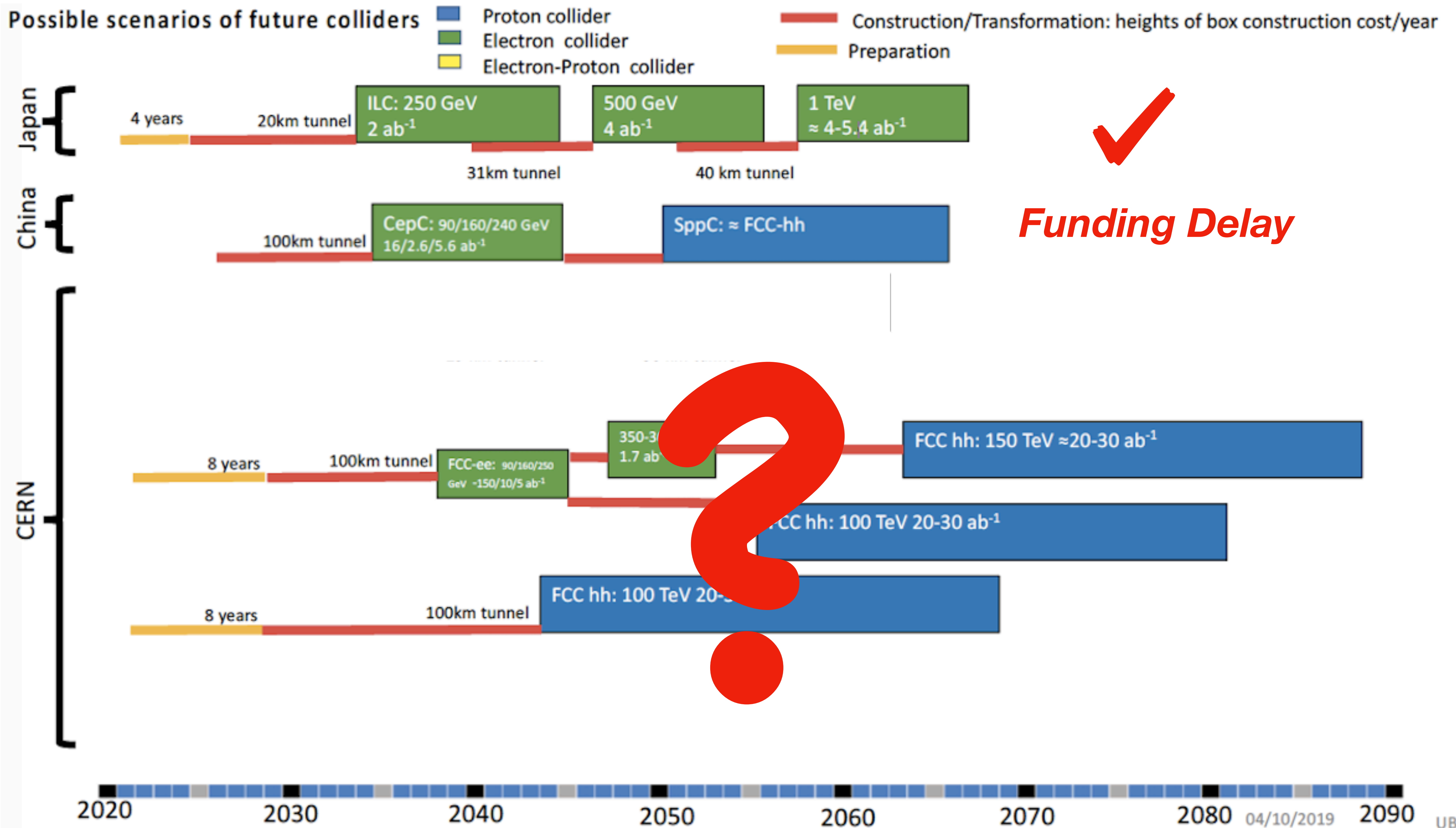
The timely realisation of the electron-positron International Linear Collider (ILC) in Japan would be compatible with this strategy and, in that case, the European particle physics community would wish to collaborate.

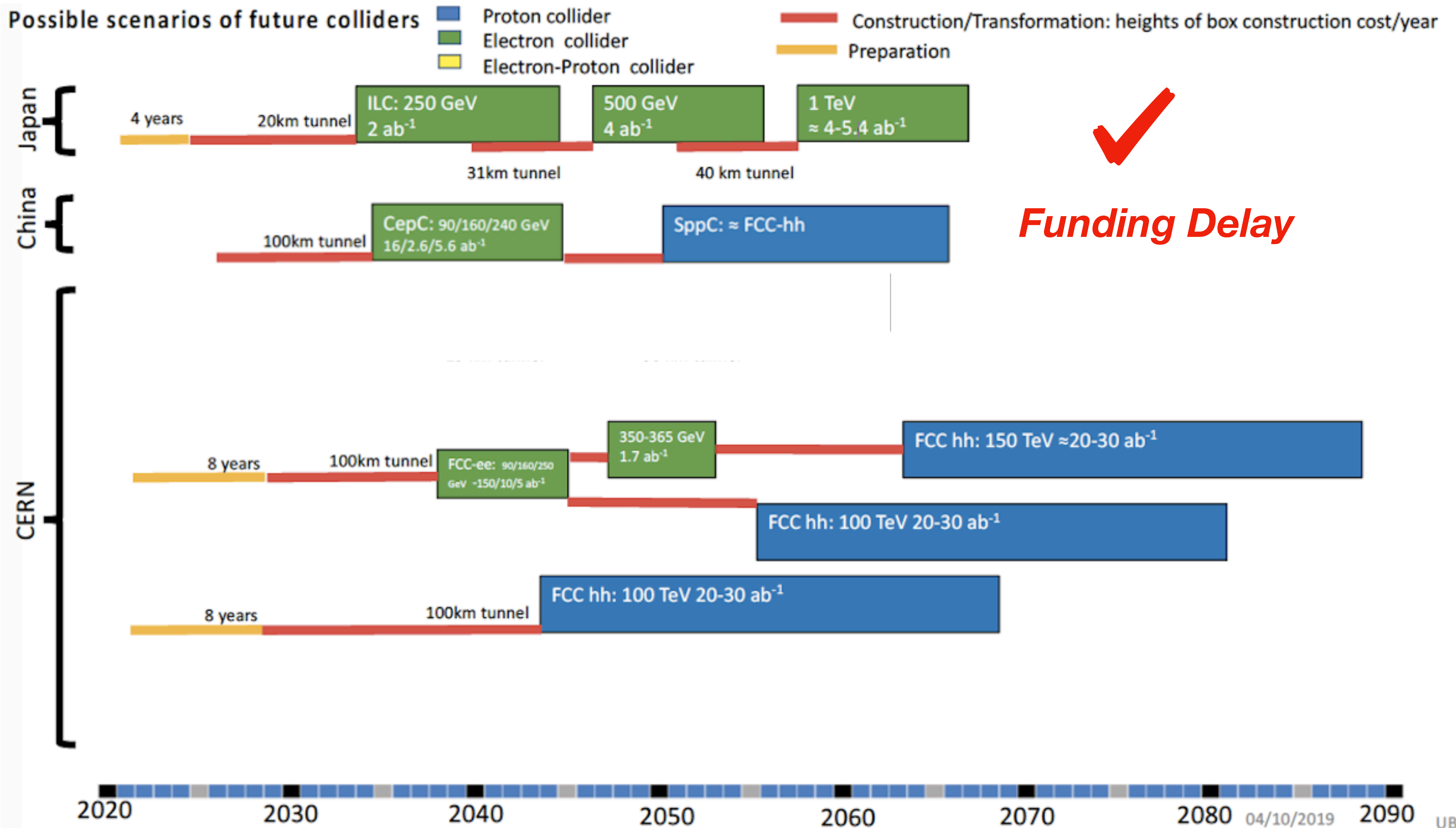
2020 UPDATE OF THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS ctd.

High-priority future initiatives (II)

B. The European particle physics community must intensify accelerator R&D and sustain it with adequate resources. A roadmap should prioritise the technology, taking into account synergies with international partners and other communities such as photon and neutron sources, fusion energy and industry. ...







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Other Activities ...

- A. Experiments in Dark Matter, precision Flavour Physics, EDM, Axions, etc., Europe should be supported, as well as participation in such experiments in other regions of the world.
- B. Europe should continue to vigorously support a broad programme of theoretical research ... The pursuit of new research directions should be encouraged and links with fields such as cosmology, astroparticle physics, and nuclear physics fostered. Both exploratory research and theoretical research ... including ... providing and developing computational tools.
- C. Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited ... increase opportunities for more technology transfer benefiting society at large. Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. ... define a global detector R&D roadmap
- D. The community must vigorously pursue common, coordinated R&D efforts in collaboration with other fields of science and industry, to develop software and computing infrastructures that exploit recent advances in information technology and data science. ... open data and data preservation

2020 UPDATE OF THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS ctd.

Synergies with Neighbouring Fields

- A. Europe should maintain its capability to perform innovative experiments at the boundary between particle and nuclear physics, ...
- B. Synergies between particle and astroparticle physics should be strengthened through scientific exchanges and technological cooperation ...

Environmental and Societal Impact

- A. Minimisation of environmental impact, energy savings, reduced travel
- B. Support early career researchers, principles of equality, diversity and inclusion...
- C. Promote Knowledge and Technology Transfer
- D. Public Engagement

2020 UPDATE OF THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS ctd.

Organisational Issues

- A. An ambitious next-generation collider project will require global collaboration and a long-term commitment to construction and operations by all parties.*** CERN should initiate discussions with potential major partners as part of the feasibility study for such a project being hosted at CERN. In the case of a global facility outside Europe in which CERN participates, CERN should act as the European regional hub, providing strategic coordination and technical support. Individual Member States could provide resources to the new global facility either through additional contributions made via CERN or directly through bilateral and multilateral arrangements with the host organisation.
- B. The relationship between the particle physics community and the European Commission should be further strengthened, ...***
- C. The particle physics community should work with the relevant authorities to help shape the emerging consensus on Open Science ...***

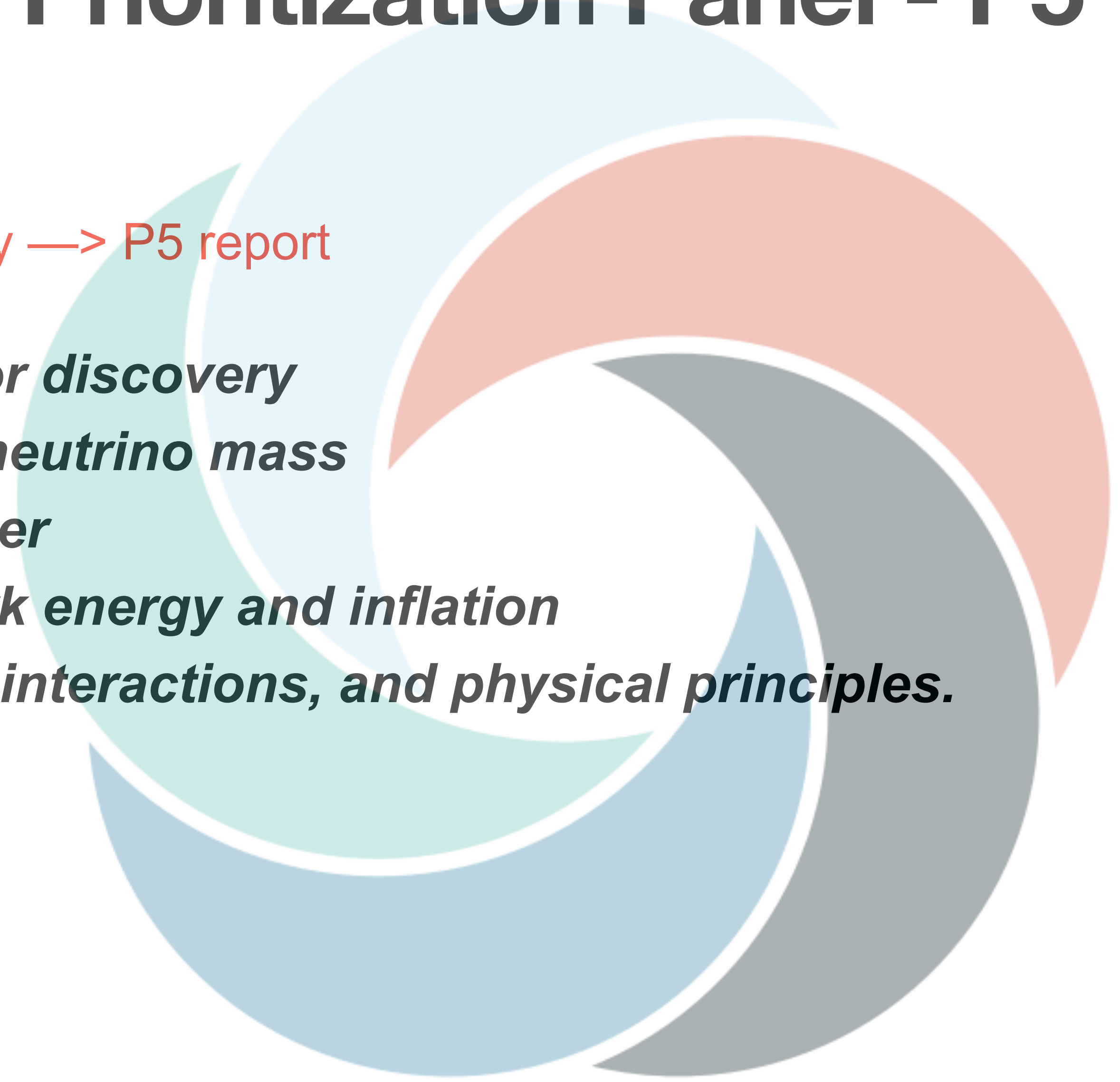
Particle Physics Project Prioritization Panel - P5

Previous Report: 2014

Snowmass, the yearlong community-wide study —> P5 report

Distilled into five Science Drivers for the field:

- ***Use the Higgs boson as a new tool for discovery***
- ***Pursue the physics associated with neutrino mass***
- ***Identify the new physics of dark matter***
- ***Understand cosmic acceleration: dark energy and inflation***
- ***Explore the unknown: new particles, interactions, and physical principles.***



Higgs Program

2014 - P5 Recommendations ctd.

- *Circular e^+e^- accelerators, such as the FCC-ee being studied at CERN and the $C\bar{p}C$ project in Chin will provide the highest precision on Higgs properties.*
- *Study of the Higgs potential via self-couplings as well as Higgs boson contributions to vector boson scattering, a ~ 100 TeV pp collider*

Higgs Timeframes

- The program of Higgs boson measurements that began at the LHC will improve with the higher energy and increased integrated luminosity of the 14 TeV LHC Run 2.
- The HL-LHC will operate in the 2020s, increasing the precision of the available measurements as data accumulates.
- As the pioneering HL-LHC program ramps down in the early 2030s, the complementary ILC could launch operations.
- Together, the HL-LHC and ILC provide a stream of data using the Higgs boson as a tool for discovery for several decades

2014 - P5 ctd

10. Complete the *LHC phase-1 upgrades* and continue the strong collaboration in the LHC with the *phase-2 (HL-LHC) upgrades* of the accelerator and both general-purpose experiments (ATLAS and CMS). The LHC upgrades constitute our highest-priority near-term large project.
11. Motivated by the *strong scientific importance of the ILC* and the recent initiative in Japan to host it, the U.S. should engage in modest and appropriate levels of ILC accelerator and detector design in areas where the U.S. can contribute critical expertise. Consider higher levels of collaboration if ILC proceeds.

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Neutrinos

2014 - P5 ctd

12. *In collaboration with international partners, develop a coherent short- and long-baseline neutrino program hosted at Fermilab.*
13. *Form a new international collaboration to design and execute a highly capable Long-Baseline Neutrino Facility (LBNF) hosted by the U.S. LBNF is the highest priority large project in its timeframe.*
14. *Upgrade the Fermilab proton accelerator complex to produce higher intensity beams. ... Proton Improvement Plan II (PIP-II) ... to provide proton beams of >1 MW (for) LBNF.*
15. *Select and perform ... short term ... small-scale short-baseline experiments that can conclusively address experimental hints of physics beyond the three-neutrino paradigm. ...*

Accelerator Development ...

2014 - P5 ctd

- 23. Support the discipline of *accelerator science through advanced accelerator facilities and through funding for university programs. ...*
- 24. *Participate in global conceptual design studies and critical path R&D for future very high-energy proton-proton colliders.* Continue to play a leadership role in *superconducting magnet technology focused on the dual goals of increasing performance and decreasing costs.*
- 25. *Reassess the Muon Accelerator Program (MAP). ...*
- 26. *Pursue accelerator R&D with high priority at levels consistent with budget constraints. ...*

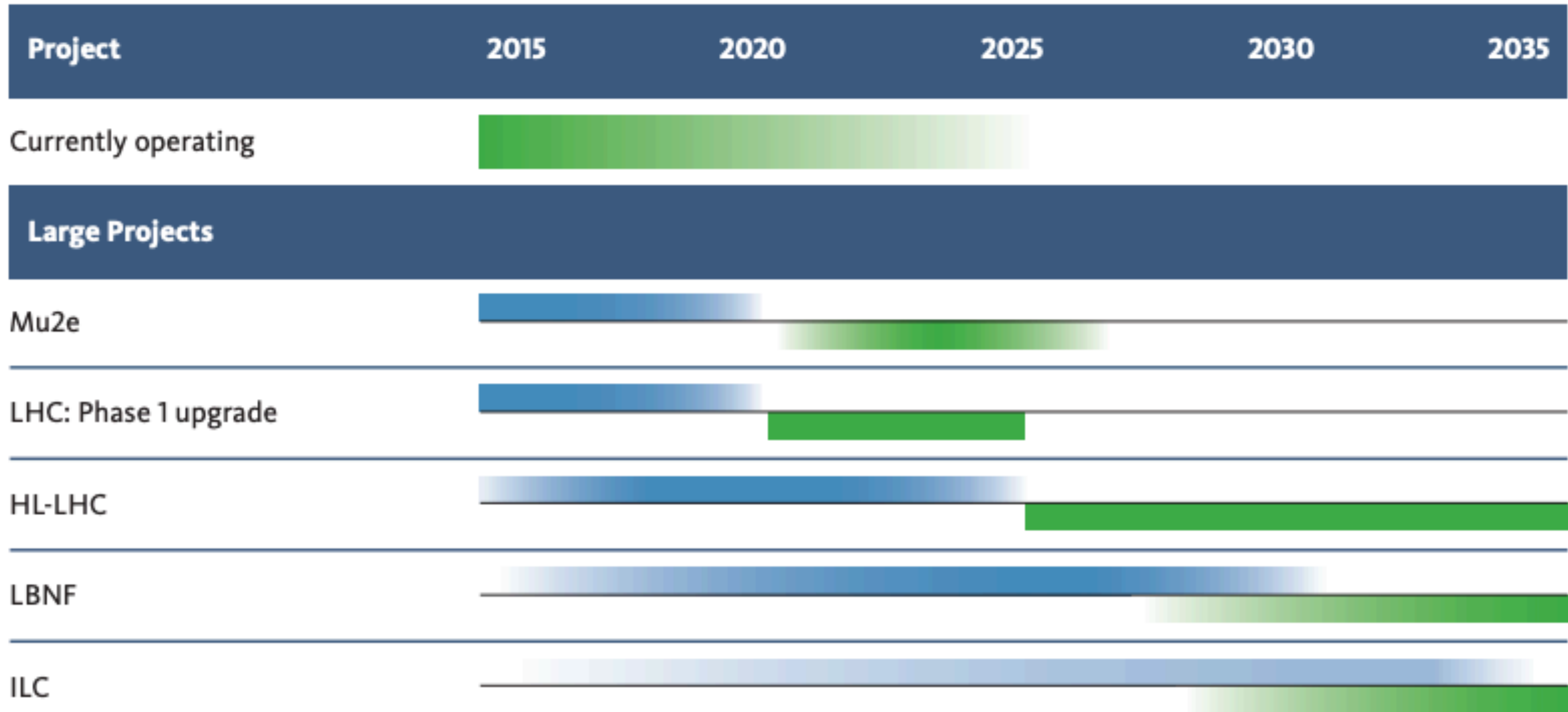
Instrumentation, Universities, Computing ...

2014 - P5 ctd

- 27. *Focus resources toward directed instrumentation R&D in the near-term for high-priority projects. ...*
- 28. *Strengthen university-national laboratory partnerships in instrumentation R&D through investment in instrumentation at universities. Encourage graduate programs with a focus on instrumentation education ...*
- 29. *Strengthen the global cooperation among laboratories and universities to address computing and scientific software needs, ...*

Timelines

P5 (2014) ctd.



Snowmass and P5 Process

2020 - 2022

The U.S. particle physics community has recently commenced a long-range planning process for the field, the “*Snowmass*” process

- Organized by the Division of Particles & Fields of the APS
Chair: Young-Kee Kim (U. Chicago, CEPC-IAC Chair).

Snowmass:

- *Process of about a year and a half*
- *Produce compilation of scientific studies as input to*
 - *Particle Physics Project Prioritization Panel (P5) in 2021-22 deliberations.*

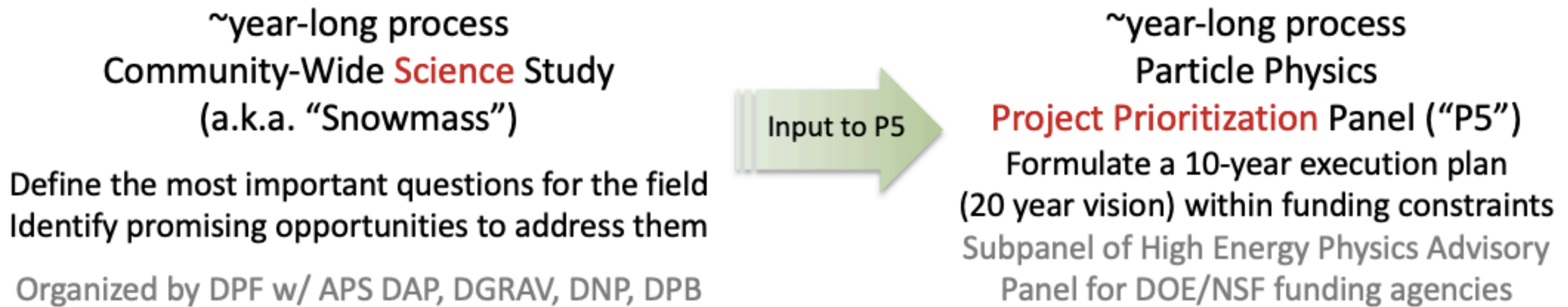
The P5 report:

- *Expected in 2022*
- *Recommend the long-term strategy and priorities for U.S. investments in particle physics for the coming decade.*

Snowmass Community Planning Meeting 5-8 October

<https://indico.fnal.gov/event/44870/timetable/#20201005>

U.S. Strategic Planning Process for Particle Physics



Particle Physics is global:
 Snowmass process involves the international community and strategies/plans from other regions

Particle Physics is not isolated:
 Snowmass process involves communities and their strategies/plans from related fields
 (Accelerator, Nuclear, Astro, Gravitational, AMO, ...)

Frontiers and Topical Groups

30 Frontier conveners + ~250 Topical Group conveners + >40 inter-frontier liaisons + ~25 early career liaisons

10 Frontiers	80 Topical Groups
Energy Frontier	Higgs Boson properties and couplings, Higgs Boson as a portal to new physics, Heavy flavor and top quark physics, EW Precision Phys. & constraining new phys., Precision QCD, Hadronic structure and forward QCD, Heavy Ions, Model specific explorations, More general explorations, Dark Matter at colliders
Frontiers in Neutrino Physics	Neutrino Oscillations, Sterile Neutrinos, Beyond the SM, Neutrinos from Natural Sources, Neutrino Properties, Neutrino Cross Sections, Nuclear Safeguards and Other Applications, Theory of Neutrino Physics, Artificial Neutrino Sources, Neutrino Detectors
Frontiers in Rare Processes & Precision Measurements	Weak Decays of b and c, Strange and Light Quarks, Fundamental Physics and Small Experiments. Baryon and Lepton Number Violation, Charged Lepton Flavor Violation, Dark Sector at Low Energies, Hadron spectroscopy
Cosmic Frontier	Dark Matter: Particle-like, Dark Matter: Wave-like, Dark Matter: Cosmic Probes, Dark Energy & Cosmic Acceleration: The Modern Universe, Dark Energy & Cosmic Acceleration: Cosmic Dawn & Before, Dark Energy & Cosmic Acceleration: Complementarity of Probes and New Facilities
Theory Frontier	String theory, quantum gravity, black holes, Effective field theory techniques, CFT and formal QFT, Scattering amplitudes, Lattice gauge theory, Theory techniques for precision physics, Collider phenomenology, BSM model building, Astro-particle physics and cosmology, Quantum information science, Theory of Neutrino Physics
Accelerator Frontier	Beam Physics and Accelerator Education, Accelerators for Neutrinos, Accelerators for Electroweak and Higgs Physics, Multi-TeV Colliders, Accelerators for Physics Beyond Colliders & Rare Processes, Advanced Accelerator Concepts, Accelerator Technology R&D: RF, Magnets, Targets/Sources
Instrumentation Frontier	Quantum Sensors, Photon Detectors, Solid State Detectors & Tracking, Trigger and DAQ, Micro Pattern Gas Detectors, Calorimetry, Electronics/ASICS, Noble Elements, Cross Cutting and System Integration, Radio Detection
Computational Frontier	Experimental Algorithm Parallelization, Theoretical Calculations and Simulation, Machine Learning, Storage and processing resource access (Facility and Infrastructure R&D), End user analysis
Underground Facilities and Infrastructure Frontier	Underground Facilities for Neutrinos, Underground Facilities for Cosmic Frontier, Underground Detectors
Community Engagement Frontier	Applications & Industry, Career Pipeline & Development, Diversity & Inclusion, Physics Education, Public Education & Outreach, Public Policy & Government Engagement

Regional Planning Rounds

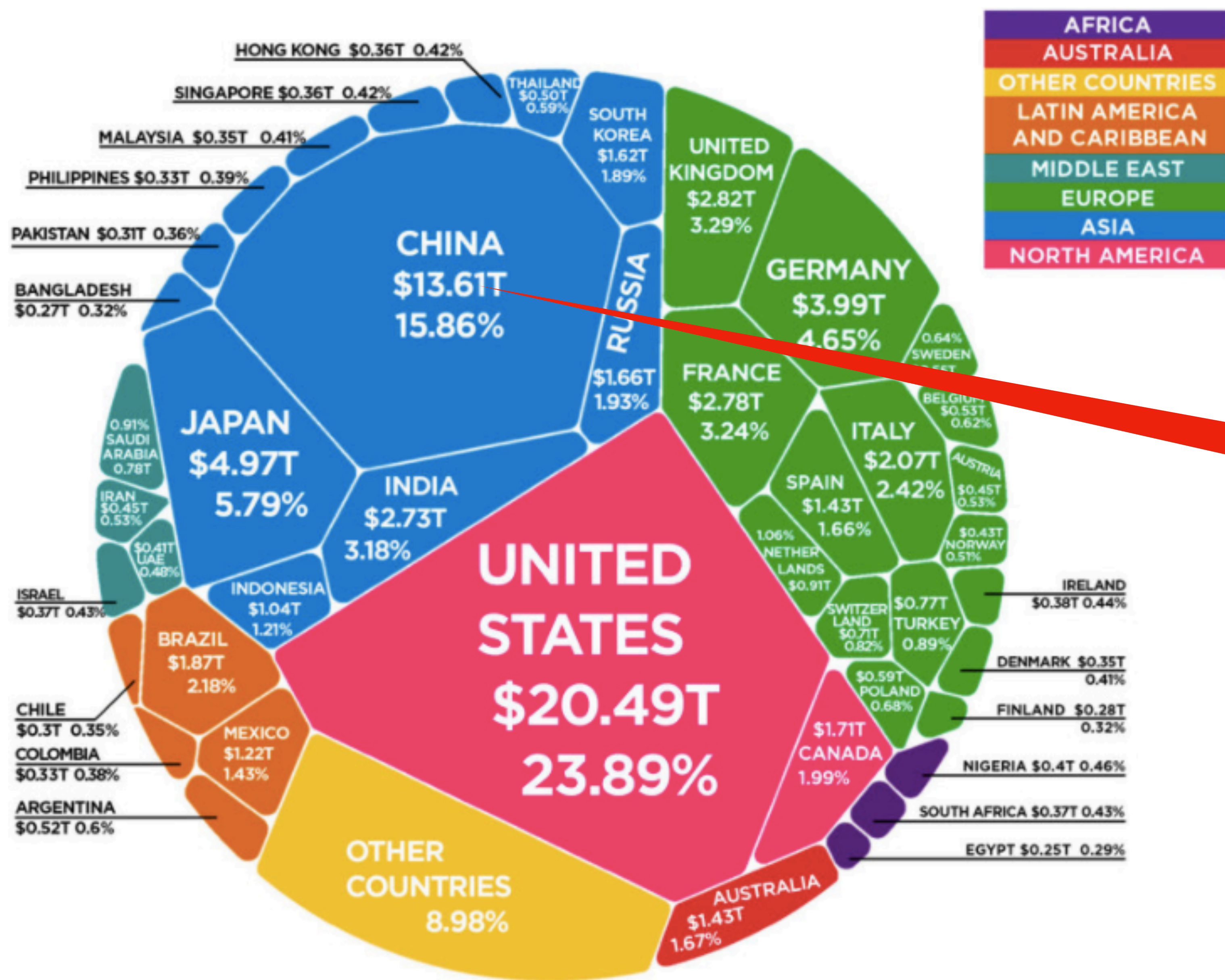
- *These are very detailed, highly intensive processes.*
- *The results are taken very seriously*
- *The programs that follow take much notice of the planning reports*

International politics

- We aim to maintain openness and HEP's unique levels of international cooperation and collaboration.
- It should be noted that in today's world openness will probably need to include **considerations of intellectual property and security protection** for participants.
 - Protections may well need to be seriously considered to assure global participation in the ILC.
- Today, *openness* may well require the development of policies aimed at assuring participating nations of the mutual benefit of multi-lateral engagement in global-scale facilities.
- ***Personal interactions are the foundation*** of this characteristic:
 - Pursue continued cooperation, sharing research, joint publications, ...
- ***Universities interactions are still relatively tolerated:***
 - Active participation in bi-lateral university exchange and research collaboration programs should be a focus.
 - Critical that Staff and Student exchanges are pursued with vigour.

Some recent observations:

- For the new Large Facilities, ***Organisational and Governance issues very important***
 - International funding agencies and ministries need to be part of the resource conversation
- ***US Support CERN and the European Strategy Update***
 - Support the launch of the technical and financial feasibility studies towards proposed FCC
- ***US is committed to remaining a leading player*** in the landscape of large international collaborations for physics
 - Great scientific discoveries come from collaboration and reciprocal exchanges that cross national borders and adhere to the best traditions and shared values
 - Shared scientific values and shared scientific norms will factor into our planning for collaborative partnerships
- Accelerator science and technology are fundamentally dual use:
 - With obvious **security** dimensions for any nation
- American participation in global projects overseas like LHC and US-based projects like LBNF/Dune are outstanding examples of how to do this international collaboration.
 - We welcome more collaborations that ***respect established norms and are win-win***



Part of why the US thinks CHINA should be doing more in Global HEP Facilities

Nominal GDP to measure economic output, which is different than using GDP adjusted for purchasing power parity (PPP)

Article & Sources:

<https://howmuch.net/articles/the-world-economy-2018>

<https://databank.worldbank.org>

Progress in ILC: From IDT to Pre-lab (... and to ILC???)

from M.Yamauchi, AWLC 2020

- ILC Pre-Lab to follow the IDT.
- The key function of the ILC Pre-lab is to complete key tasks:
 - Solve remaining technical issues of the accelerator.
 - Design and implementation of ILC laboratory Governance/Management
 - and ... Launch the ILC laboratory!

However importantly:

- Launch of ILC Laboratory implies the official start of the ILC project

But

- International agreement(s) with cost sharing are required as pre-condition.

➡ The ILC Pre-Lab will also support international negotiations for the ILC

An electron-positron Higgs factory is the highest-priority next collider

- ***This will be a driving statement of all regional planning process in the coming years.***
- ***The ILC is gaining momentum and support***
- ***It is hoped that China will support participation in the ILC as it develops the CEPC***
- ***Physicists must work towards inclusive international collaboration in all global HEP projects***