

Perspective on the European Strategy Update from the Americas



Open Symposium - Update of the European Strategy
for Particle Physics

May 15, 2019

Young-Kee Kim

The University of Chicago

Chair-Elect (2019) & Chair (2020)

Division of Particles and Fields (DPF) of American Physical Society

DPF does not advise the funding agencies.

Americas: Particle Physics Scientific Drivers

Great promise for discovery over the next 10-20 years

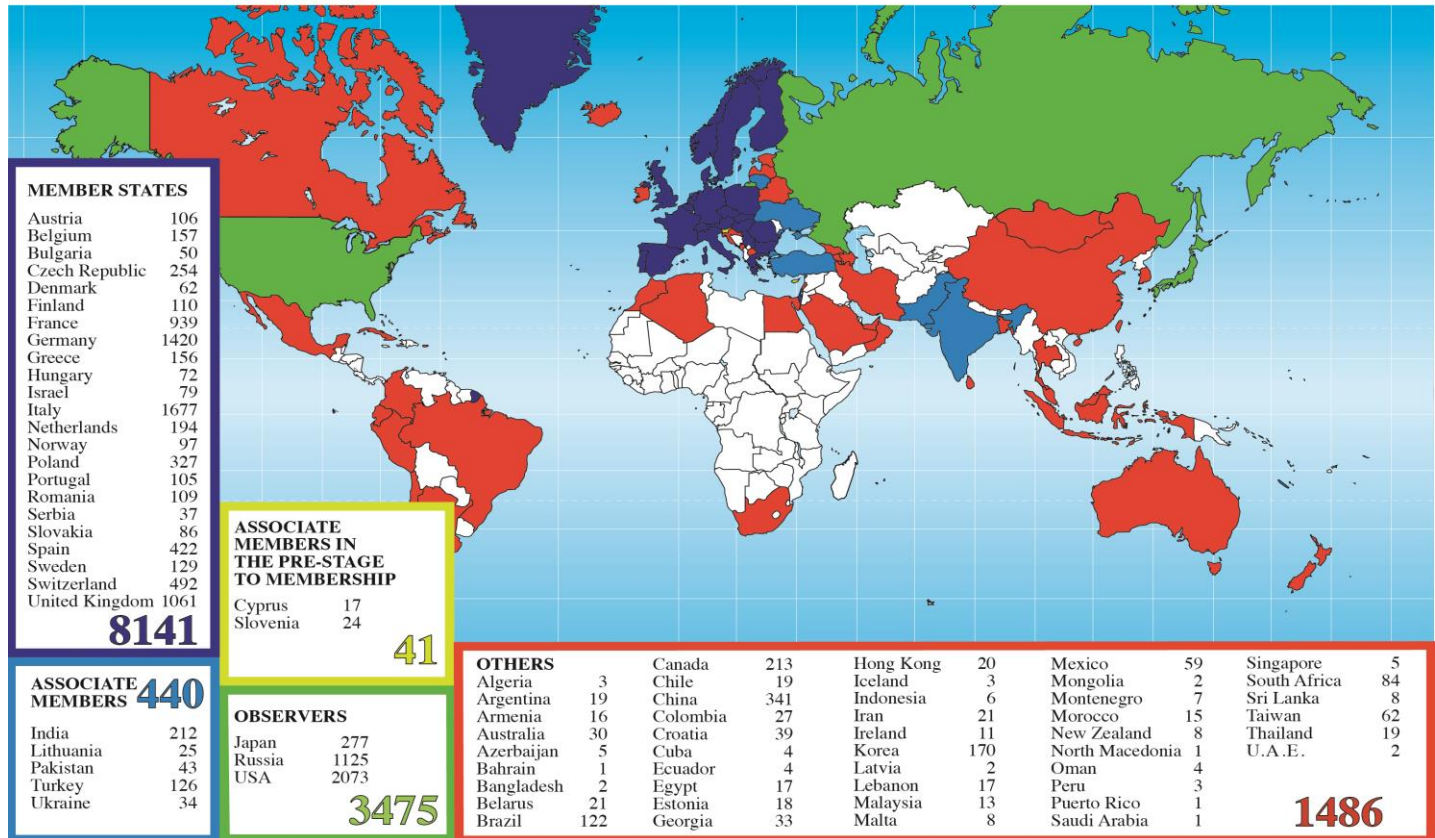
- Use the Higgs boson as a new tool for discovery
 - Explore the unknown: new particles, interactions, and physical principles
 - Pursue the physics associated with neutrino mass
 - Identify the new physics of dark matter
 - Understand cosmic acceleration: dark energy and inflation
- What is the nature of physics at the electroweak scale and beyond?
 - What structures underlie the forces and matter in the universe?
 - What is the nature of neutrino masses?
 - What is the nature of dark matter in the universe?

Particle Physics is Global

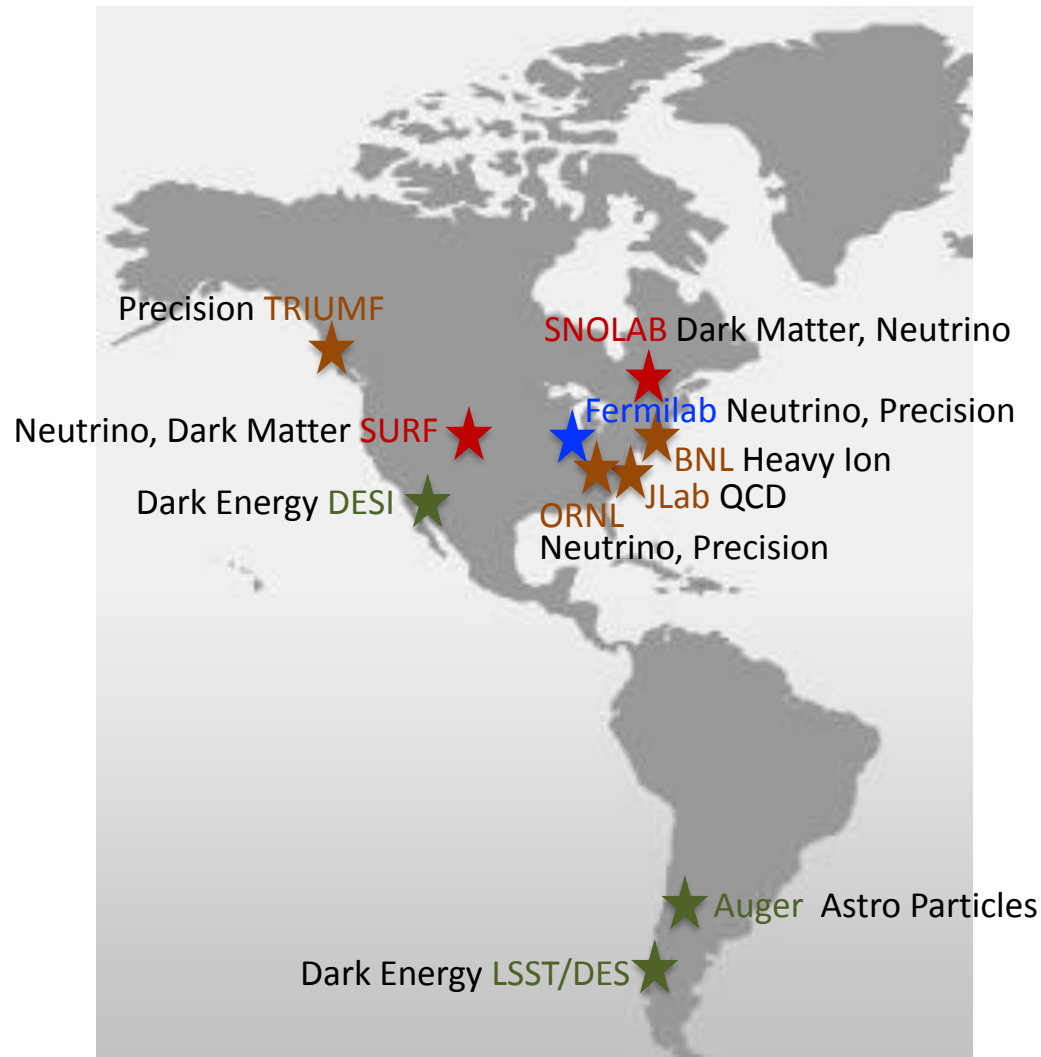
CERN



Distribution of 13,583 CERN users by location of institution (78 countries)



Facilities in Americas for the World Community



Facilities for accelerator science + R&D in U.S.
ATF (BNL), FAST (FNAL), FACET (SLAC), BELLA (LBNL), AWA (ANL)

U.S.: Fermilab

Short- & long-baseline neutrino program
Muon program



More than 4,000 users from 52 countries

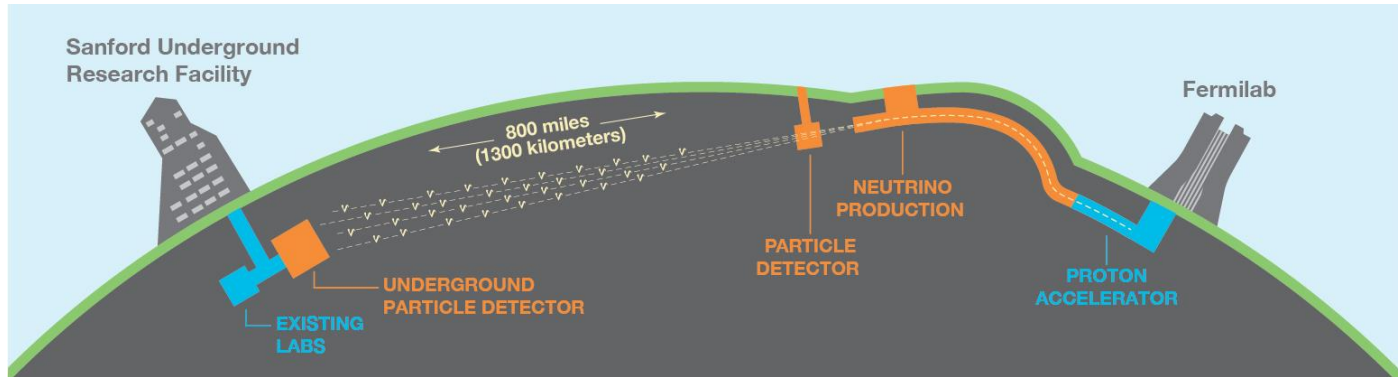
- Africa: 3
- Americas: 12
- Asia: 7
- Middle East: 4
- Europe: 26

More than 100 nationalities



NOV 2018

U.S.: SURF



Dark Matter and Neutrino

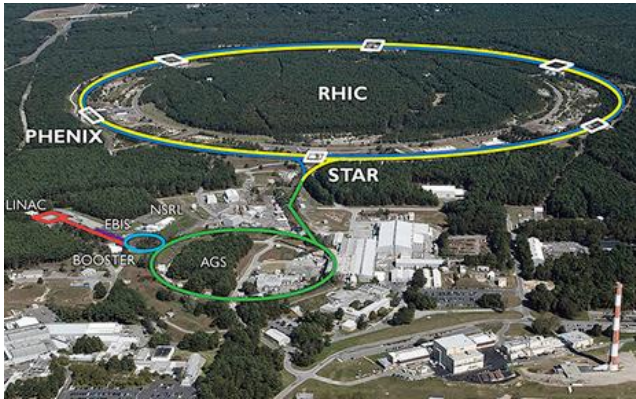
LZ: ~250 collaborators
37 institutions in 5 countries

DUNE: ~1,000 collaborators
179 institutions in 30 countries plus CERN



U.S.: BNL and JLab

BNL

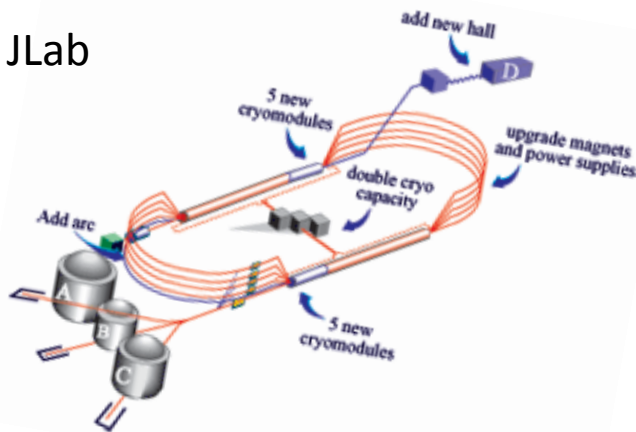


RHIC heavy ion collider



RHIC: ~1,000 users from 24 countries

JLab



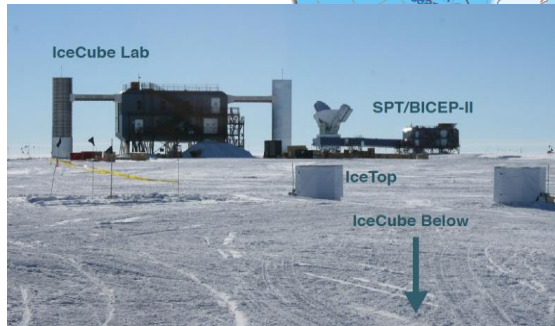
Electron accelerator



1,630 users in 278 institutions from 39 countries

Other U.S. Facilities

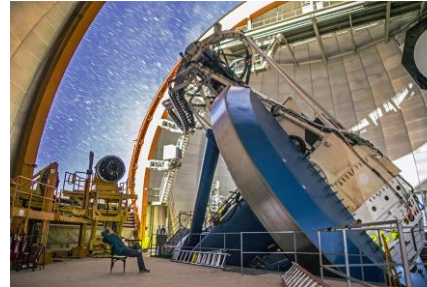
Neutrinos



IceCube Neutrino Observatory in Antarctica

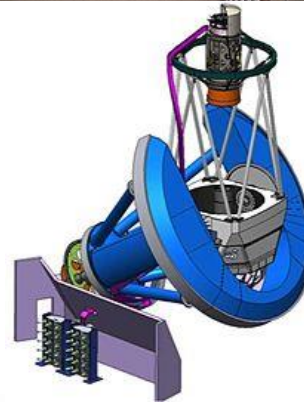
- ~270 scientists
- 49 institutions
- 12 countries: US, Germany, Belgium, Sweden, Australia, Canada, Denmark, Japan, New Zealand, South Korea, Switzerland, UK

Dark Energy



DES at CTIO, Chile

- ~400 scientists from 26 institutions
- 7 countries: U.S., Australia, Brazil, Germany, Switzerland, Spain, UK



DESI at Kitt Peak, U.S.

- 450 scientists from 73 institutions
- 11 countries: U.S., Australia, Brazil, China, France, Germany, Korea, Mexico, Spain, Switzerland, UK

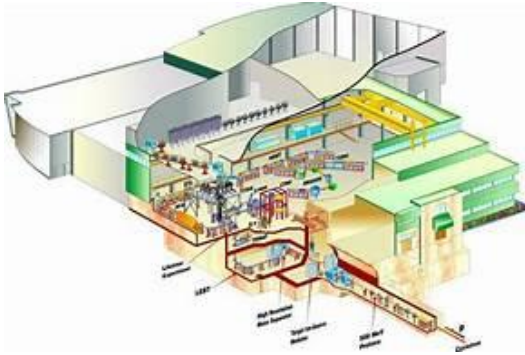


LSST, Chile

- Material contributions from U.S., Brazil, Chile, France

Canada: TRIUMF and SNOLAB

TRIUMF



Radioactive beam facilities
Fundamental symmetry



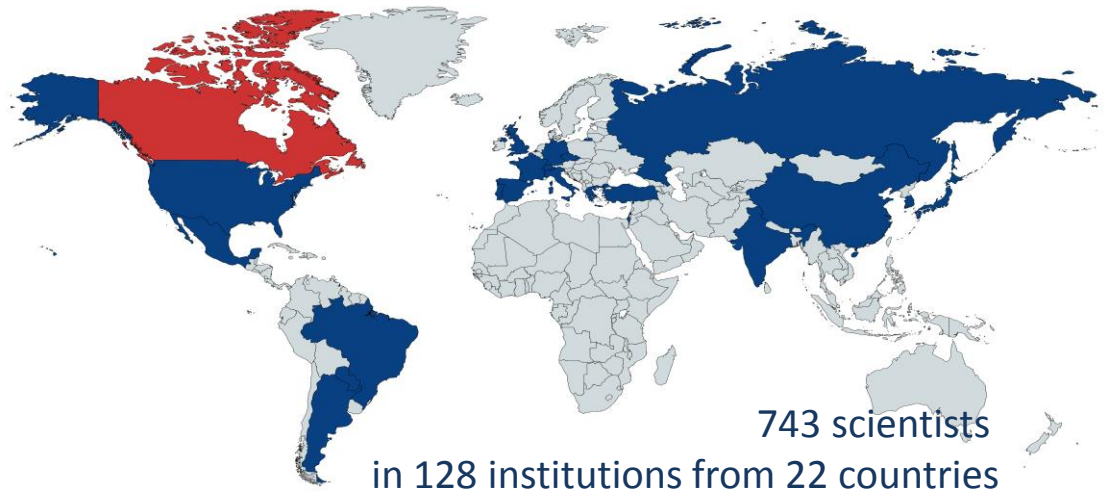
SNOLAB

Dark Matter and Neutrino



DEAP, SNO+
SuperCDMS

Global Argon Dark Matter Collaboration



The worldwide particle physics community can together address
the full breadth of the field's most urgent scientific questions
with
each major player hosting a unique world-class facility at home
and partnering in high-priority facilities hosted elsewhere.

Strategic Planning Process and Execution

Latin America

Canada

U.S.

Latin America

Many nations have growing particle physics communities

October 2018: Ministers + Heads of state approve creation of LASF4RI (Latin American Strategy Forum for Research Infrastructure) and pilot projects HECAP (High Energy, Cosmology and AstroParticle Physics) is a pilot project

Latin American Strategy for HECAP next steps:
Multi-National Scientific Community Based Effort



Argentina's planning (Feb. 12, 2019)



Latin America's planning (April 30-May 1 2019)

<http://www.ictp-saifr.org/workshop-on-the-latin-american-strategy-forum-for-research-infrastructure/>

Latin America: HECAP Landscape Analysis

Initial list of current experiments and facilities in/with Latin American participation

Gravitation and cosmology	<ul style="list-style-type: none">• LIGO, QUBIC• DES/DESI/LSST/SDSS
Colliders	<ul style="list-style-type: none">• ATLAS, CMS• LHCb, ALICE
Astroparticles	<ul style="list-style-type: none">• AUGER, LAGO• HAWC, ALPACA, SGSO
Neutrinos	<ul style="list-style-type: none">• DUNE• NOvA
Infrastructures	<ul style="list-style-type: none">• ANDES (proposed underground lab)• LNLS:SIRIUS (Brazilian Synchrotron Light Source)

<https://sites.google.com/view/lastrategyforum/home>

At this stage, intended to document, not to prioritize

- Significant capacity building in LA over the last decade enhancing hardware capabilities and leadership → Stronger LA presence in European experiments
- LA considers crucial to have a cutting-edge accelerator-based experiment running all the time, not only for the great/unique theoretical and experimental progresses, but also for keeping the best students within our field and also within Science.

Canada

- Long Range Plan (LRP): 2017 – 2021
 - Drafted by committee of 11 subatomic physicists (nuclear + particle)
 - Appointed by NSERC (funding agency)
 - Members: 1/3 non-Canadians
 - Observers: 7 from IPP(Institute of Particle Physics), CINF(Canadian Institute for Nuclear Physics), TRIUMF, SNOLAB, CFI(Canada Foundation for Innovation), NSERC
 - LRP Committee Mandate:
 - Identify subatomic physics scientific ventures and priorities
 - that would ensure continuous Canadian global scientific leadership covering the period 2017-21 and look ahead to 2026
 - Provide budgetary estimates (funding ranges for prioritized endeavors)
 - Extensive and broad input
 - Documents from IPP/CINF (particle/nuclear physics communities)
 - Surveys of Canadian subatomic physicists
 - Two town hall meetings.

Canadian Long Range Plan: 2017 – 2021

- Research in theoretical subatomic physics
- Ongoing flagship facilities and experiments
 - TRIUMF radioactive beam facilities and experiments
 - SNOLAB and its experiments
 - ATLAS experiment
 - T2K experiment
- Strategic smaller-scale efforts giving breadth
 - ALPHA, JLab and offshore rare isotope beam experiments, IceCube
- Projects operational in the coming years
 - ATLAS at HL-LHC, Belle II, Hyper-K, ILD at ILC, MOLLER and SoLID at Jlab, nEXO at SNOLAB, and UCN/nEDM at TRIUMF
- Generic accelerator and detector R&D

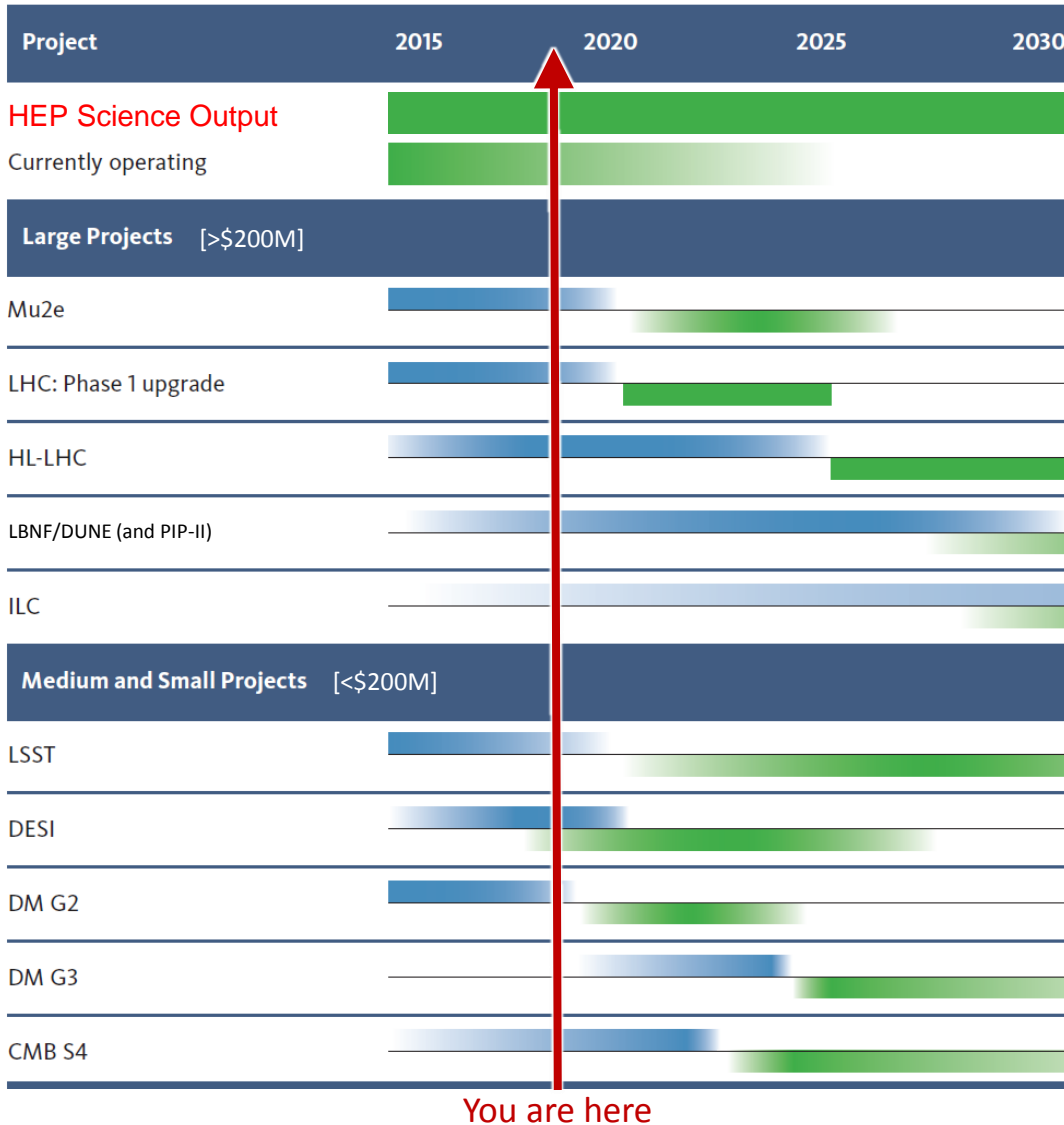
United States

- P5 Strategic Plan for Particle Physics (2014)
 - 10 year plan in the context of a 20-year vision
 - 2012-2013: Snowmass community-wide studies
 - Organized by DPF (Similar to the PPG process)
 - 2013-2014: P5, Particle Physics Project Prioritization Panel
 - Subpanel of HEPAP, High Energy Physics Advisory Panel for DOE and NSF funding agencies
 - P5 takes the scientific input from Snowmass and formulates a strategic plan to address the science within specified funding constraints
- Long-Range Plan for Nuclear Science (2015)
 - Funded by Nuclear Physics Offices of funding agencies
 - Fundamental Symmetries and Neutrinos
 - QCD: Structure of Hadrons and Phases of Strongly Interacting Matter
- Decadal survey on Astronomy and Astrophysics (2010)
 - Dark Energy
 - Cosmic Microwave Background

U.S.: P5 Implementation Status – FY 2019

Legend:

- **Approximate Construction**
- **Expected Physics**



All projects on budget & schedule

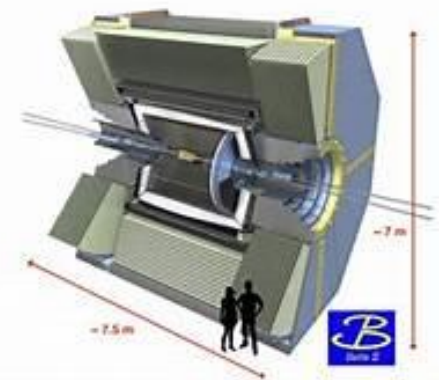
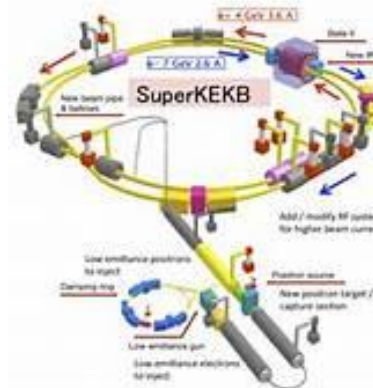
- Projects fully funded in FY19
 - Muon g-2: 1st beam 2017
 - Mu2e : 1st data in ~2020
 - LHC detector upgrades (ATLAS, CMS, LHCb): on track for 2019/20 installation
 - LSST: full science operations 2023
 - DESI: 1st light on April 1, 2019
 - DM-G2(SuperCDMS,LZ,ADMX) 1stdata ~2020
- HL-LHC accelerator and detector upgrades started on schedule
- LBNF/DUNE & PIP-II schedules advanced due to strong support by Admin & Congress
- ILC: cost reduction R&D while waiting for decision from Japan
- DM-G3: R&D limited while fabricating G2
- CMB S4: developing technically-driven schedule to inform agencies, NAS Astro 2020 Decadal Survey
- Broad portfolio of small projects running

U.S.: Other Important Programs

- Neutrinoless double beta decay
 - LNGS: CUORE, CUPID
 - WIPP: EXO
 - SURF: Majorana, GERDA
 - SNOLAB: SNO+, nEXO
- Long- & short-baseline and solar neutrinos / neutrino interactions
 - Fermilab: NOvA, MicroBooNE, SBND, ICARUS
 - T2K, Super-K
 - LNGS: BOREXINO
 - ORNL: COHERENT, PROSPECT
- Dark Matter
 - LNGS: DARKSIDE, SABRE, XENON
 - SNOLAB: DEAP, PICO
 - Y2K: COSINE
 - Small Projects New Initiatives ([document](#))
- Flavor
 - KEK: Belle-II at SuperB
 - KEK: KOTO at J-PARC
 - IHEP: BES-III at BEPC
- Fundamental symmetries
 - EDMs

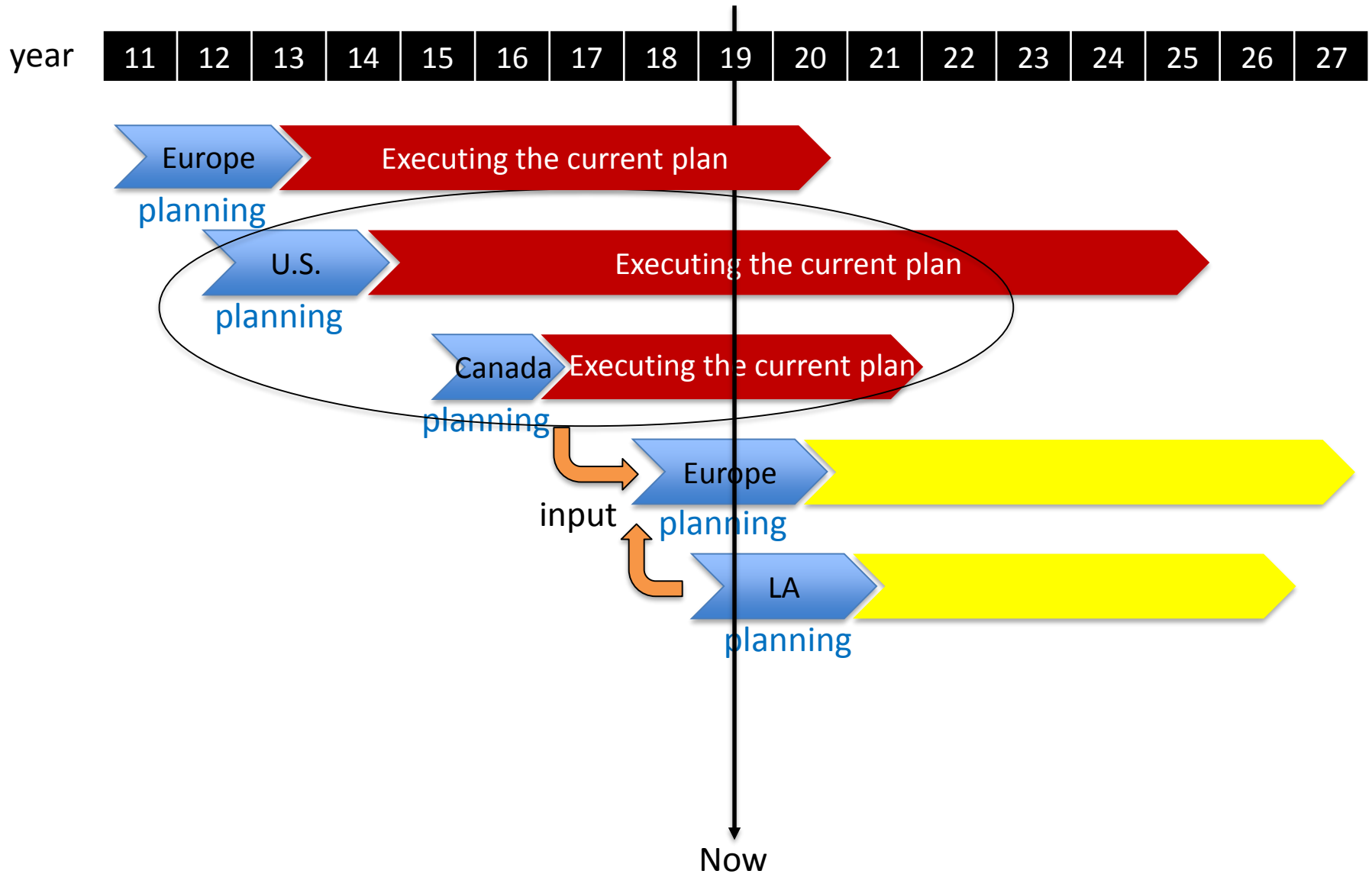


LNGS, Gran Sasso, Italy



KEK, Japan

Planning and Executing



U.S. Community Submission to ESG

- APS Division of Particle and Fields (DPF) white papers
 - Developed by the DPF Executive Committee and the group of editors. Input was solicited from the community.
 - Recent progress on the 2014 P5 recommendations
 - The 2014 P5 strategy has been tremendously successful
 - Research interests in the U.S. community beyond the P5 timescale
 - Activities within the U.S. and global communities on theory, accelerator development, computing, and detector R&D

APS Division of Particles and Fields Response to European
Strategy Group Call for White Papers:
Community Planning and Science Drivers

DPF Executive Committee and Strategy Whitepaper Editing Group
dpfstrategy@fnal.gov

December 18, 2018

Abstract

This white paper describes the community strategic planning process organized by the DPF, and summarizes U.S. particle physics community input on activities and aspirations. This is the first of two documents, covering the five P5 Science Drivers.

(149) Progress on P5;
Research interests beyond the P5 timescale

(150) Activities on theory, accelerator,
computing, detector R&D

APS Division of Particles and Fields Response to European
Strategy Group Call for White Papers:
Tools for Particle Physics

DPF Executive Committee and Strategy Whitepaper Editing Group
dpfstrategy@fnal.gov

December 18, 2018

Abstract

The U.S. particle physics strategy process is summarized in a companion white paper that also describes U.S. activities related to the five P5 science drivers. Additional activities within the U.S. particle physics program that are critical to progress in our field are described here.

U.S. Community Submission to ESG

- Other submissions include:
 - Future Colliders
 - ILC (66, 77, 107), CLIC (145, 146), CEPC (29, 51), FCCee,eh,hh (132, 133, 135, 136, 140), HE-LHC (160)
 - Neutrinos
 - Deep Underground Neutrino Experiment, DUNE (123)
 - The Short-Baseline Neutrino Program at Fermilab (137)
 - Status of Fermilab's Neutrino Facilities (167)
 - Dark Matter
 - MAGIS-1K: A 1000 m Atom Interferometer Device for Searches in Dark Matter and Gravity Waves (161)
 - Flavor Physics
 - Charged LFV. using Intense Muon Beams at Future Facilities (25)
 - Electron-Ion Collider
 - Electron Ion Collider Accelerator Science and Technology - Designs, R&D and Synergies with European research in Accelerators (74)
 - Synergies between a U.S.-based Electron-Ion Collider and the European research in Particle Physics (99)

Canadian Community Submission to ESG

- IPP, CINP, TRIUMF and SNOLAB prepared the Canadian Roadmaps Submission:
 - Summary of the 2017-21 Canadian Subatomic Physics LRP
 - Updates since recent broad community consultations associated with the LRP
 - Connections to the European Particle Physics Strategy and prospects for further collaboration
 - McDonald and Perimeter Institutes reviewed and provided input

Canadian Submission to the European Particle Physics Strategy Update

Submission Theme: National Road Maps

Prepared by:
Institute of Particle Physics
Canadian Institute of Nuclear Physics
TRIUMF
SNOLAB

Contact: J.M. Roney, Director, Institute of Particle Physics
director@ipp.ca

December 18, 2018

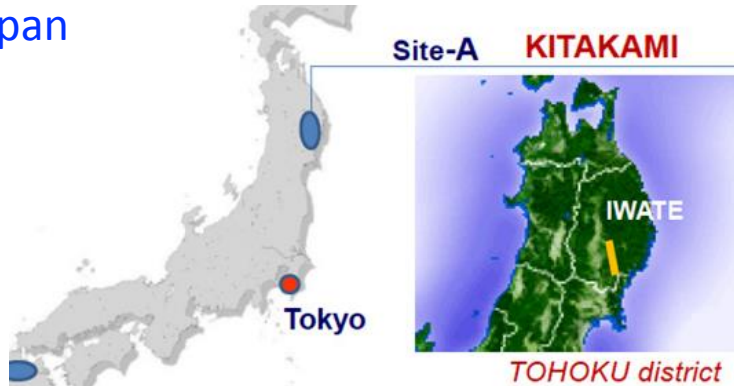
(157)

Note that IPP Council, the elected representatives of the Canadian particle physics community, worked on the submission as did the CINP Board, which consists of the elected representatives of the Canadian nuclear physics community.

Future Potential Projects Under Consideration by the American Community

Future Collider Options

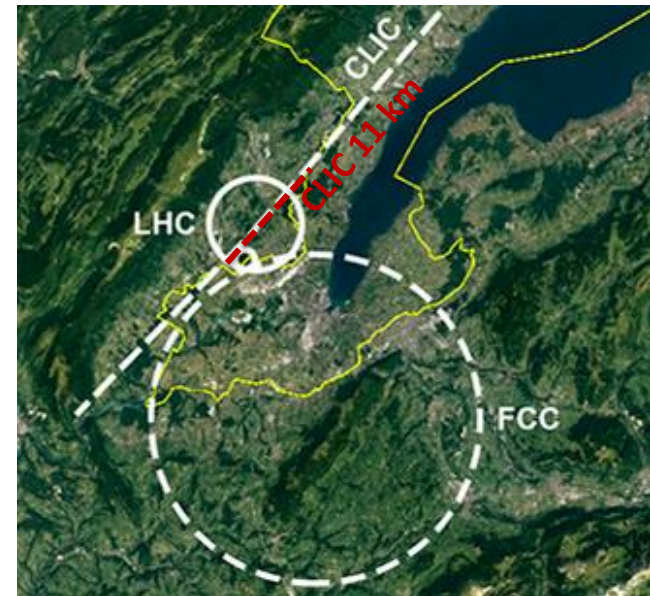
Japan



30 – 50 km ILC (e^+e^-)
250 GeV Higgs \rightarrow ~ 1 TeV

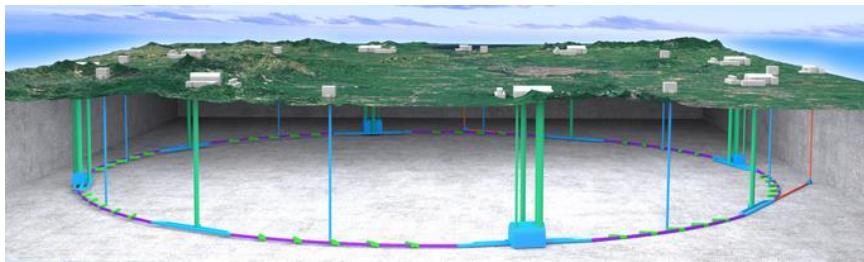
Europe

11 km – 50 km CLIC (e^+e^-)
380 GeV (Higgs, Top) \rightarrow 1.5 TeV, 3 TeV



~ 100 km FCC
 e^+e^- (Z factory, 240 GeV Higgs \rightarrow 365 GeV Top)
ep, pp (~ 100 TeV)

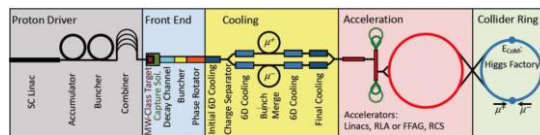
China



CEPC (e^+e^-) 240 GeV Higgs \rightarrow pp (~ 75 TeV)

~ 100 km

Muon collider:
Higgs \rightarrow 3~14 TeV
(currently no funding)



Plasma Wakefield Acceleration-based
 e^+e^- Linear Collider

Next Collider Options

ILC

[Statement by American Linear Collider Committee \(US+Canada\)](#)
ALCC stance vis-a-vis discussions concerning the International Linear Collider in the context of the European Strategy for Particle Physics (2020) ALCC, March 27, 2019

The Americas Linear Collider Committee supports the ICFA position confirming the international consensus that [“the highest priority for the next global machine is a ‘Higgs Factory’ capable of precision studies of the Higgs boson.”](#) We remain convinced that the ILC best meets all of the requirements needed to probe detailed properties of the Higgs boson. The ILC has the potential for a future upgrade in energy, can sustain beam polarizations that increase its ability to do precision measurements, and is the most technically mature proposal for an electron-positron collider now available.

The recent statement by MEXT in Japan stated that further consideration by the Science Council of Japan and intergovernmental discussions are necessary before Japan would be in a position to make a bid to host the ILC. Unfortunately, this does not fit naturally into the timetable for finalizing the European Strategy recommendation. On the other hand, it appears that high-level interactions between the U.S. DOE and the Japanese principals, government and DIET, continue to be positive. We understand that the DOE remains interested in discussing with senior Japanese officials about ILC and the possibility of hosting it in Japan.

The ALCC is supportive of any electron-positron project that can distinguish the Standard Model from new physics models through precision measurements of the Higgs production and decay couplings. However, given the strengths of the ILC noted above and the recent progress in obtaining support for it within Japan, [we urge that the European Strategy group support the completion of the process underway in Japan to decide on a bid to host the ILC](#)

CLIC

- CLIC and normal conducting high-gradient activities
- O(200) signatories for CDR
- Detector design and R&D
- Ongoing studies on physics potential

FCC-ee, ep, pp

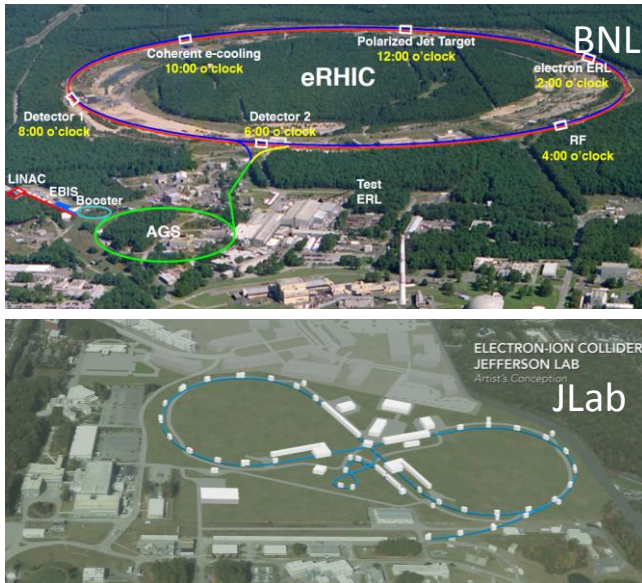
- Deep expertise in accelerator technologies including high field magnets and SCRF
- O(500) engaged; O(100) co-authored European Strategy Documents
- Ongoing studies on physics potential and detector design
- Long and productive cooperation on joint projects in US and at CERN

CEPC

- Pre-CDR & CDR on arXiv with international contributions
- O(100) participated
- Detector design and R&D

Electron-Ion Collider (U.S.)

- DOE Office of Nuclear Physics (not Office of High Energy Physics)
- Science Drivers
 - How does the mass of the nucleon arise?
 - How does the spin of the nucleon arise?
 - What are the emergent properties of dense system of gluons?
- Status
 - Two concepts being developed: Realization could be as early as 2028-2030
 - CD-0 (Approve Mission Need) is planned for FY 2019



Neutrinos, Dark Matter, CMB

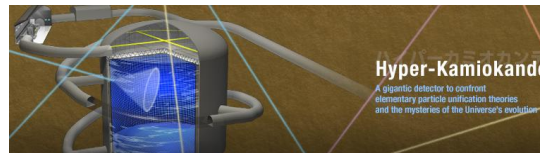
Next Generation
Experiments:

Neutrinoless
double beta decay

Dark Matter
(DM-G3)

CMB
(CMB-S4)

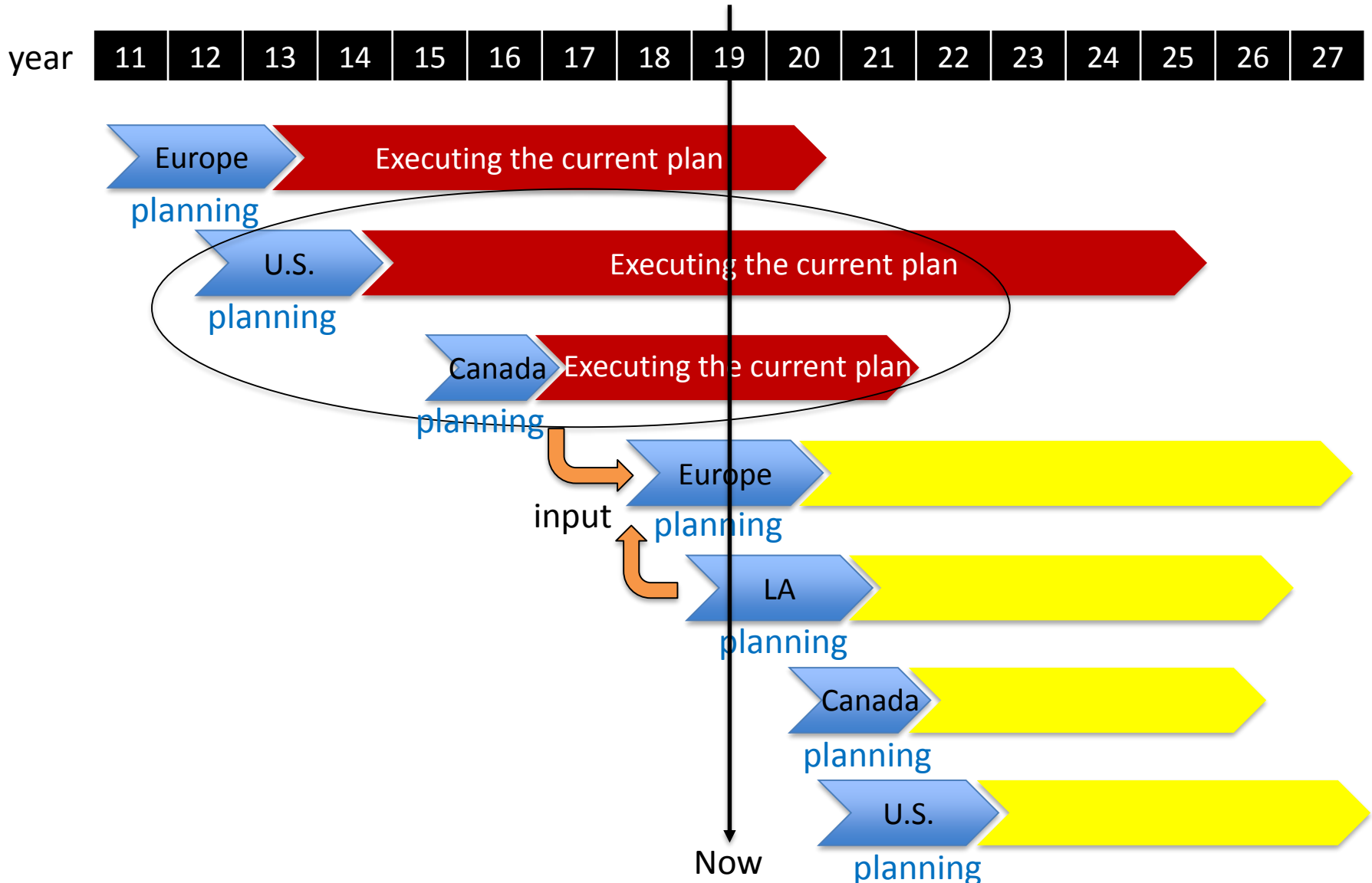
Hyper-Kamiokande



ANDES Underground Laboratory



Planning and Executing



Conclusions: Successes from 2013 ESG

- Americas program priorities
 - US 2014 P5, Canada 2017 LRP, LA priorities
- Americas' strong participation at CERN
 - including LHC, HL-LHC (magnets, detectors, computing, ...), anti-protons, neutrino platform, ...
- Americas' strong participation in other European projects
 - in scope of the 2012 ESG
- R&D for future program
 - Magnet R&D, SRF, Plasma wakefield acceleration, ...
 - Detector R&D, Computing, ...
- Support of facilities outside of Europe
 - Neutrino statement from the 2012 ESG document → CERN's contribution to the LBNF/DUNE program in a substantial way.

Conclusions: Towards 2020 ESG

- Support of Americas' current plan
 - Importance of current high-priority projects such as HL-LHC, DUNE, ...
- Beyond mid-2020's
 - Scientific drivers of the current plans are still valid
 - More capable facilities and broader programs
 - R&D of enabling technologies for future (accelerator, detector and computing)
- Support of facilities and activities outside of Europe
 - DUNE/LBNF, SNOLAB, CMB-S4, EIC,
 - A statement in the ESG document plays a significant role for success of facilities outside of Europe that serves the European / worldwide community
- The American community
 - will continue with its strong partnership with Europe
 - would like to see positive steps toward a new collider: an e+e- collider might be the first one to be realized: O(1000) American community

Closing Remarks

The worldwide particle physics community can together address the full breadth of the field's most urgent scientific questions with each major player hosting a unique world-class facility at home and partnering in high-priority facilities hosted elsewhere.

Contributors to this presentation

- Latin America
 - Ezequiel Alvarez, Marta Losada, Maria Teresa Dova, ...
- Canada
 - Brigitte Vachon, Michael Roney, Jonathan Bagger, Nigel Smith, ...
- Europe
 - Fabiola Gianotti, Walter Wuensch, Steinar Stapnes, Lucie Linssen, Michelangelo Mangano, Alain Blondel, Aidan Robson, Philip Burrows, ...
- U.S.
 - Andy Lankford, JoAnne Hewett, Dmitri Denisov, Prisca Cushman, Joe Incandela, Tao Han, Patty McBride, Steve Ritz, Steve Kahn, Josh Frieman, Michael Levi, Marcela Carena, Hugh Montgomery, Jim Brau, Andy White, Ed Blucher, Ashutosh Kotwal, Jim Siegrist, Glen Crawford, Alan Stone, Saul Gonzalez, Jim Whitmore, Nigel Lockyer, Doon Gibbs, Stuart Henderson, Vladimir Shiltsev, Kurt Riesselmann, Rik Yoshida, Andrei Seryi, Abhay Deshpande, Berndt Mueller, Tom Browder, Rafael Lang, Kate Scholberg, Bob Bernstein, Elizabeth Worcester, Sheldon Stone, Jodi Cooley, Tim Tait, Bob Tschirhart, Matthew Szydagis, ...