Strategies and Plans in Other Regions: Asia and Pacific

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CoEPP/The University of Melbourne

Particle Physics is NOT Regional

Regional Roadmaps are highly correlated

- ***Regional Roadmaps are correlated*** as facilities are highly resource dependent:
  - ***Large-scale facilities must be international and inter-regional***
- Facilities are chosen and designed to meet the ***priority goals of the field***.
- National Priorities, Strategies and Funding will show variation but ***will follow the Roadmaps.***
  - Countries play to National/Institutional/Industrial strengths
  - However **all funding strategies make reference to international plans**.
- Asia/Pacific too!
- Asia has no unifying structure: no “United States of Asia”; no “Asian Union”
  - ***Japan and China are the dominant players***, with ***international-scale HEP facilities***
  - Korea, India, Taiwan, Australia, … **collaborate in the international particle program**, as well as **maintaining smaller national programs**

Asian Strengths in Particle Physics

- ***Good participants global activities***
  - Collaborating in all major particle physics collaborations
- ***Flavour Physics***
  - Japan: KEKB / Belle —> SuperKEKB / Belle II
  - China: BEPC / BES —> BEPC II / BES III
- ***Neutrino Physics***
  - Reactor Experiments
    - China (Daya Bay —> JUNO)
    - Korea (RENO, NEOS)
  - SuperKamiokande —> HyperKamiokande (J-Parc high-power proton source)
  - GeoNeutrinos -> Kamland

Many other activities, …

- LFV
  - Japan (J-Parc): Comet, …
- Underground Experiments
  - Dark Matter Experiments:
    - Japan - XMASS; China - PANDA-X; Korea - KIMS, COSINE-100; Australia: SABRE(South)
- Cosmic Ray Experiments
- Space-based Experiments

Underground Facilities – Worldwide

Eye on the sky: the Large High Altitude Air Shower Observatory in Sichuan Province in southwest China will attempt to understand the origins of high-energy cosmic rays. (Courtesy: IHEP/LHAASO Collaboration)

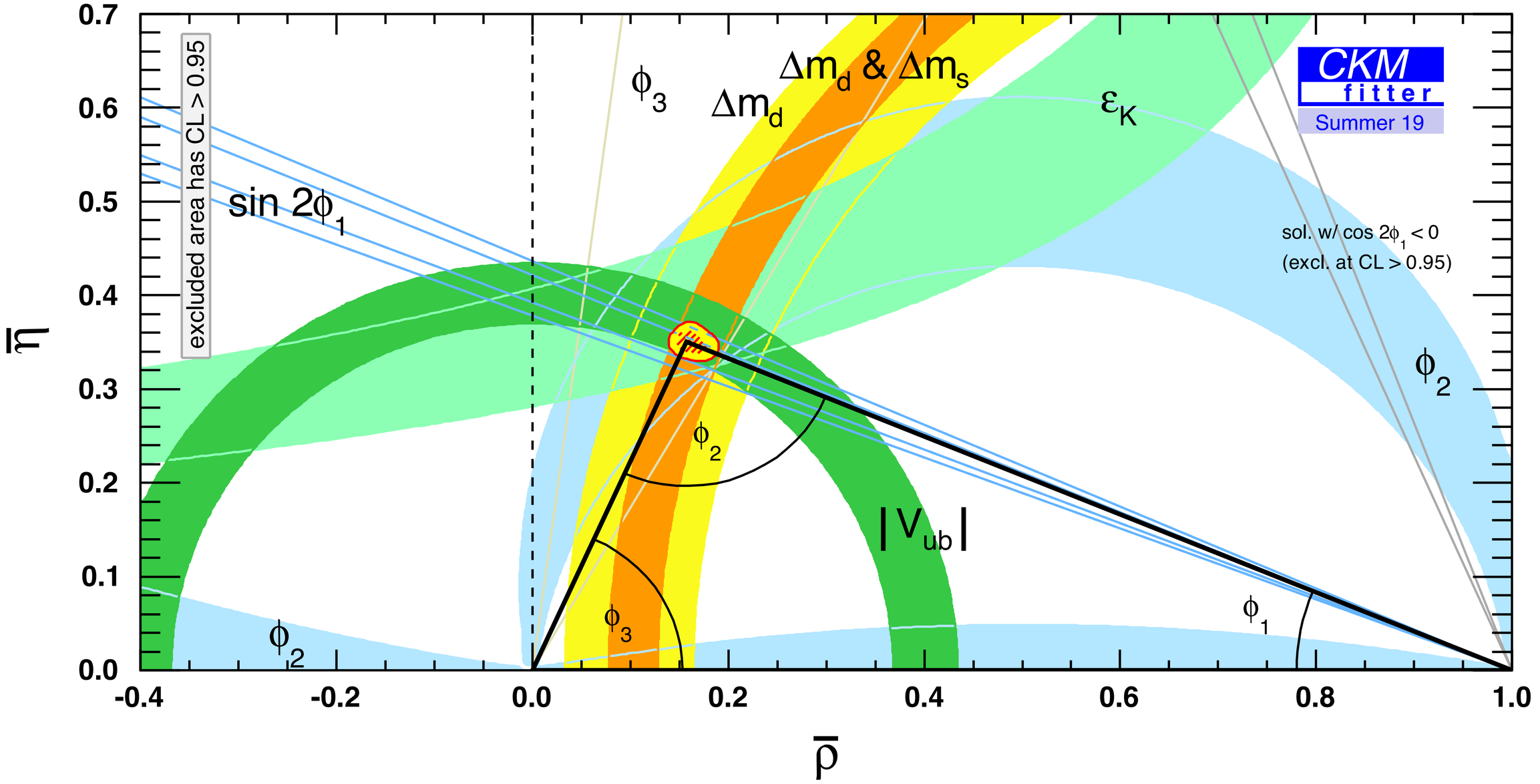
LHAASO: Large High Altitude Air Shower Observatory

4410 m above sea level in the Haizi Mountain in Sichuan Province in southwest China.

Precision Frontier

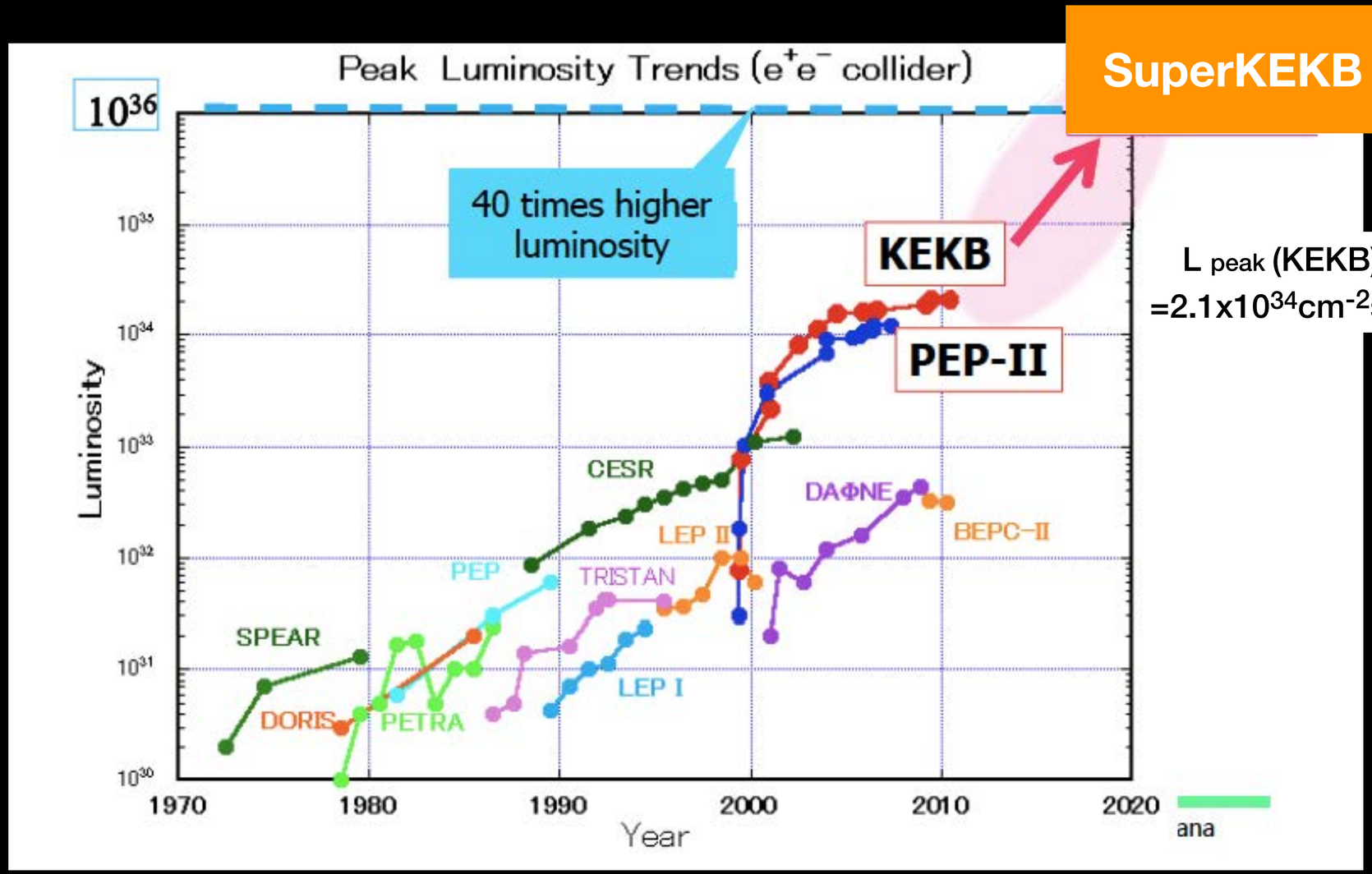
- Japan: SuperKEKB/Belle II

- China: BEPC II /BES III



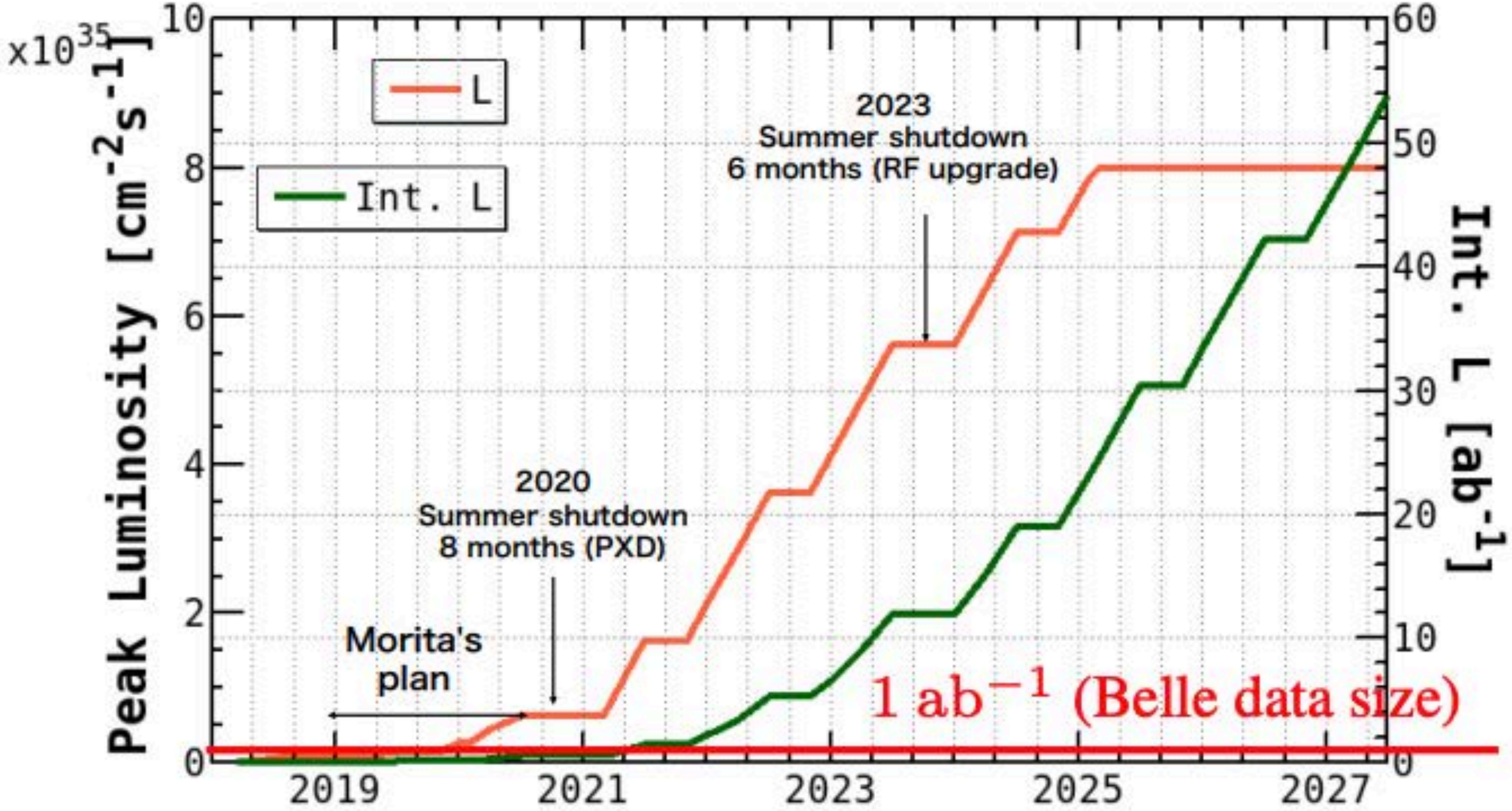
http://ckmfitter.in2p3.fr/www/results/plots_summer19/ckm_res_summer19.html

Precision Flavour …



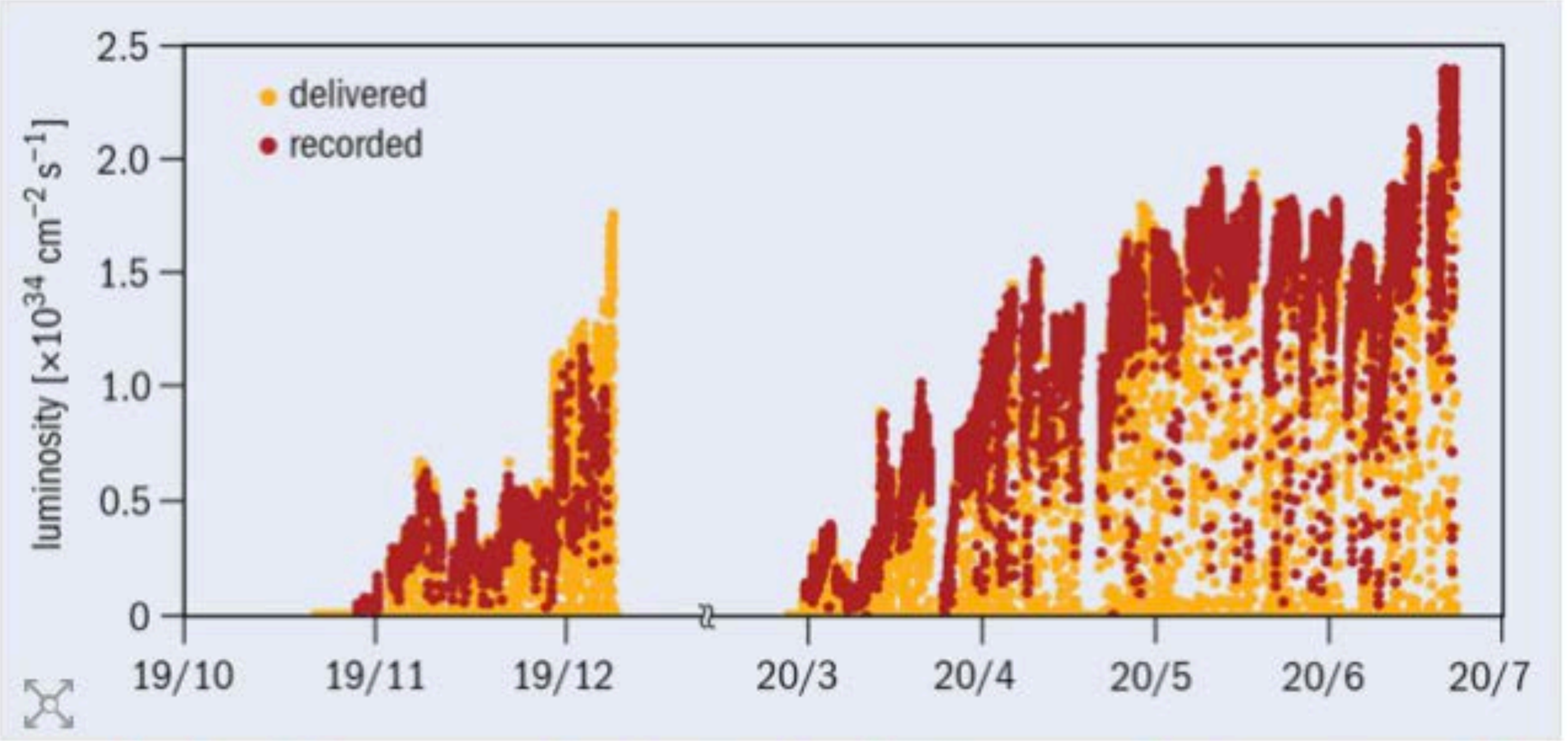
L peak (KEKB) $=2.1\times10^{34}cm^{-2}s^{-1}$

Belle II Expectations



KEK reclaims luminosity record

30 June 2020

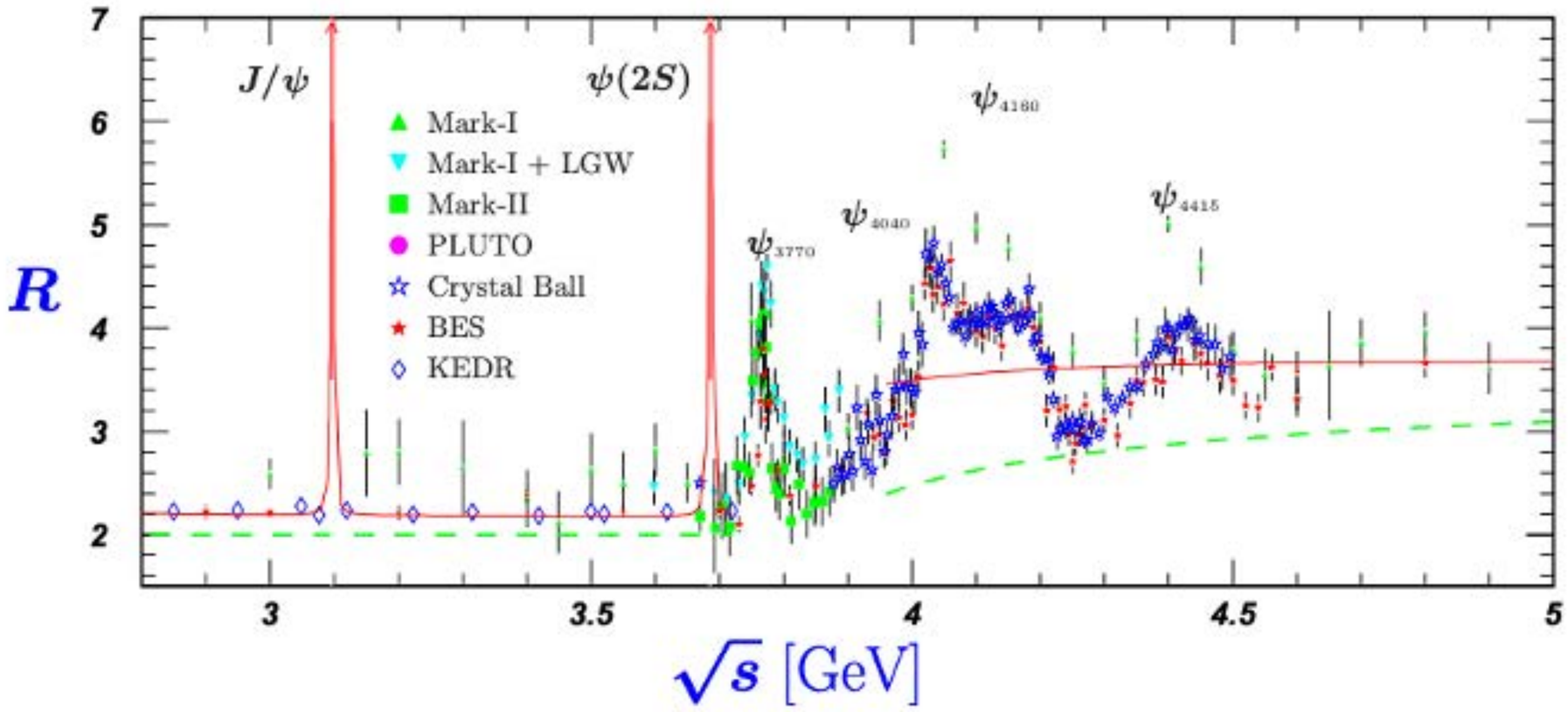


Record breaker The instantaneous luminosity of SuperKEKB measured at 5-minute intervals from late 2019 to 22 June 2020. Values are online measurements and contain an approximate 1% error. Credit: KEK

BEPC II / BES III

Plans for a decade more operation

- Increased Luminosity in ~4GeV region
- Improve measurement for QCD contribution to R



BEPC II / BES III

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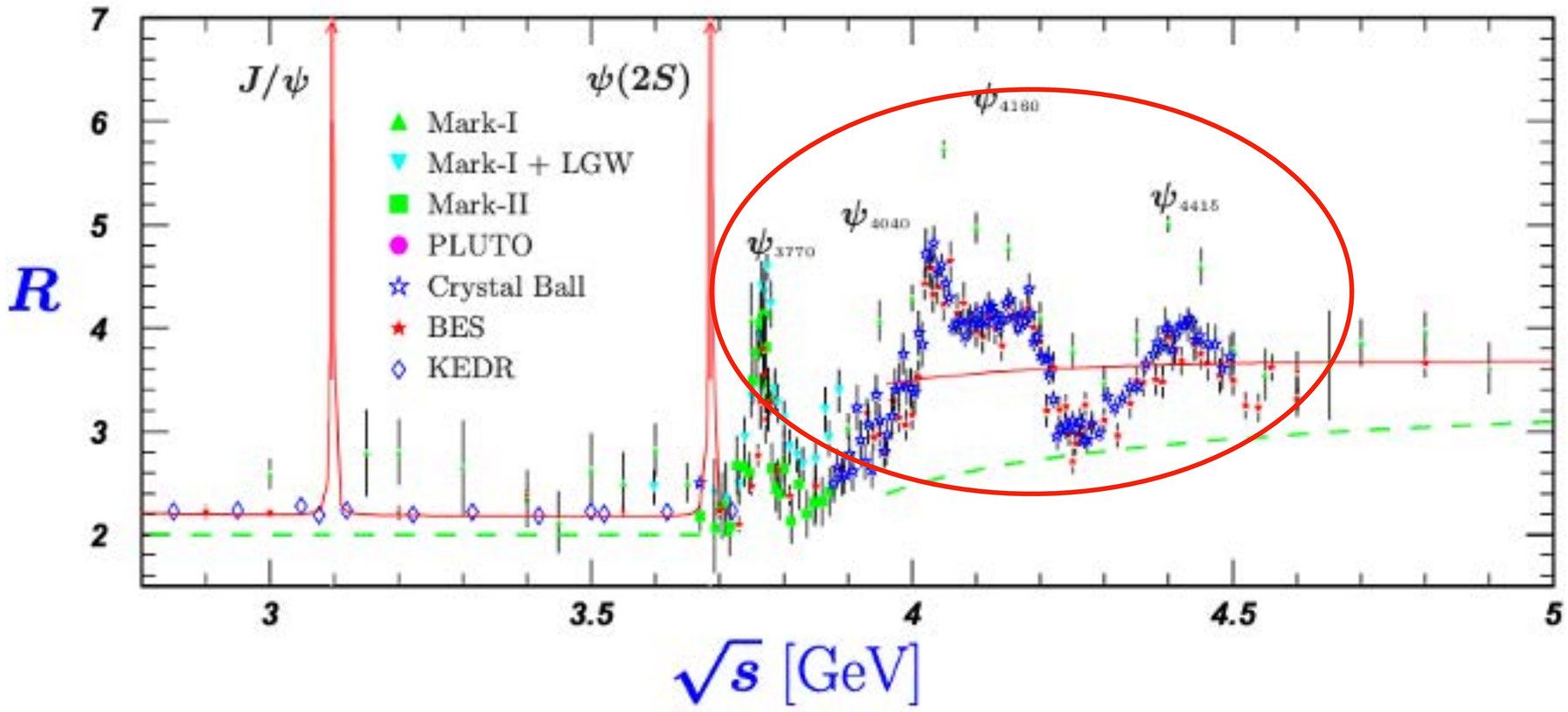


BES III

Multinational Collaboration

BEPC - Example of US-China Collaboration

- Beijing Electron-Positron Collider (BEPC) largely inspired by SLAC
- Deng Xiaoping and Jimmy carter signed the US-china Agreement on Cooperation in Science and Technology
  - Annex: Joint Committee on Cooperation in High Energy Physics, which met annually until ~2017
- T.D Lee convinced his friend Pief Panofsky (founding director of SLAC) to serve as offical US Advisor to the Chinese Govt.
- Personal and professional interactions were very important in developing shared programs
- BEPC and BEPC II have been a very visible result of what now may seem an unlikely collaboration

Neutrino Physics

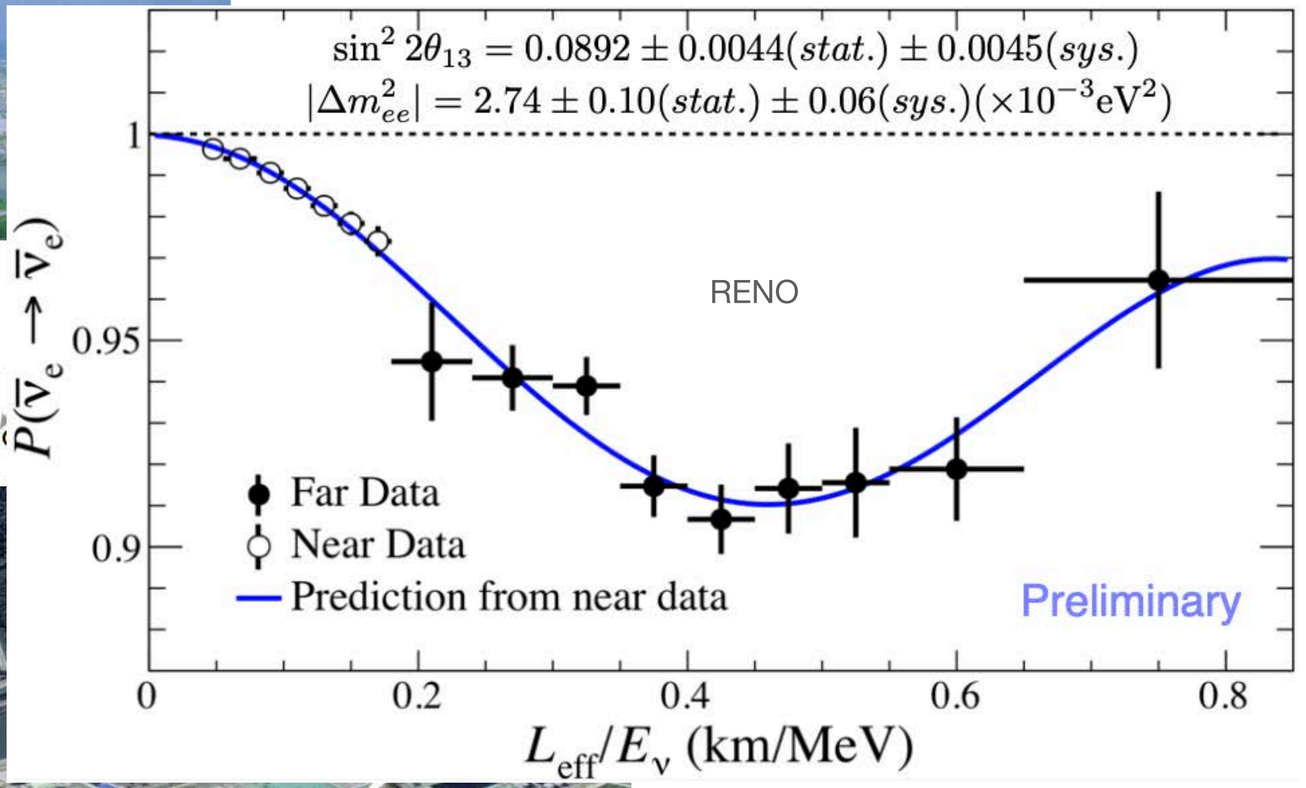
- Japan: J-Parc/SuperKamiokande/HyperKamiokande
    - Kamland
- China: Daya Bay / JUNO
- Korea: RENO/NEOS
- India: INO

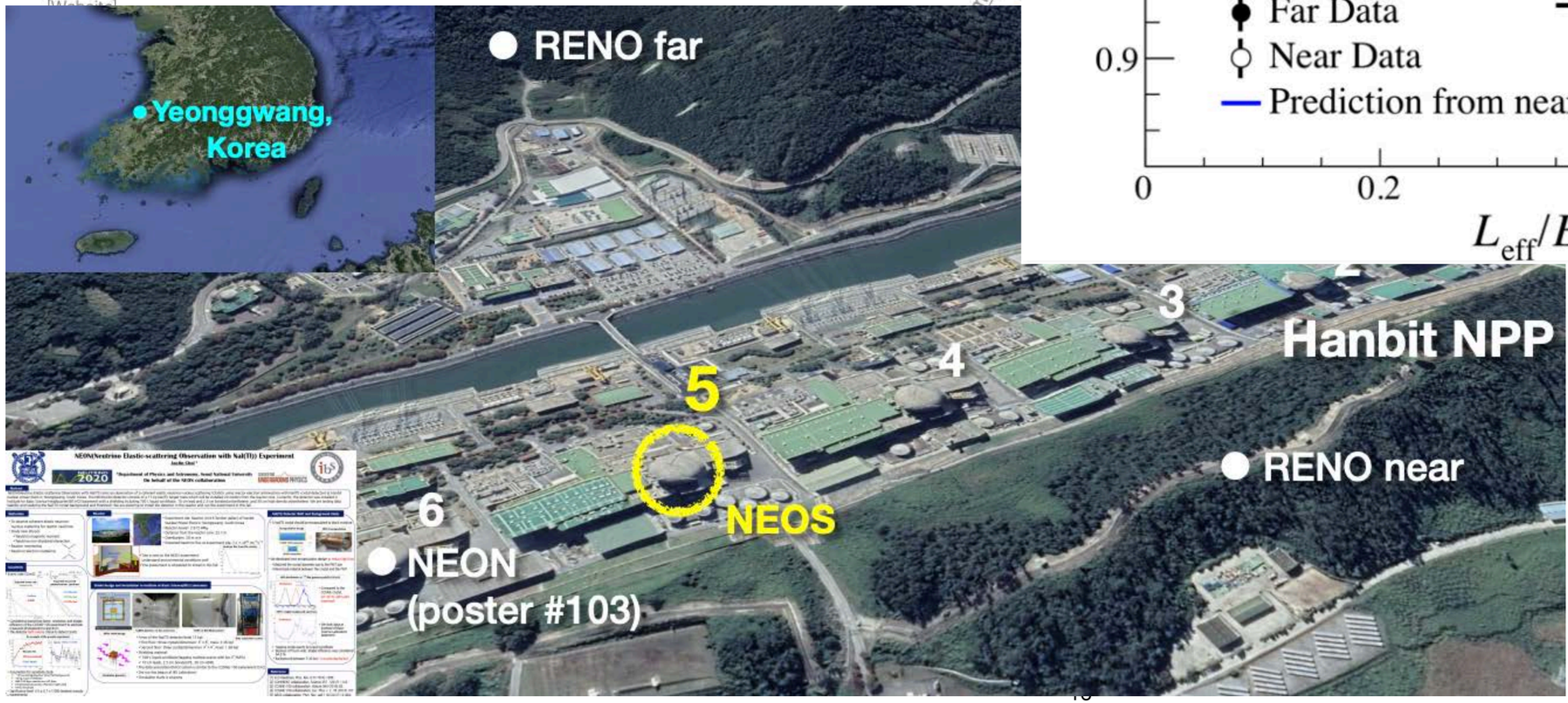
- (The Neutrino is Japan’s national particle)

RENO: Reactor Experiment for Neutrino Oscillation

RENO is a short baseline reactor neutrino oscillation experiment in South Korea. The experiment was designed to either measure or set a limit on the neutrino mixing matrix parameter θ_{13}, a parameter responsible for oscillations of electron neutrinos into other neutrino flavours. RENO has two identical detectors, placed at distances of 294 m and 1383 m, that observe electron anti-neutrinos produced by six reactors at the Hanbit Nuclear Power Plant (the old name: the Yeonggwang Nuclear Power Plant) in Korea.

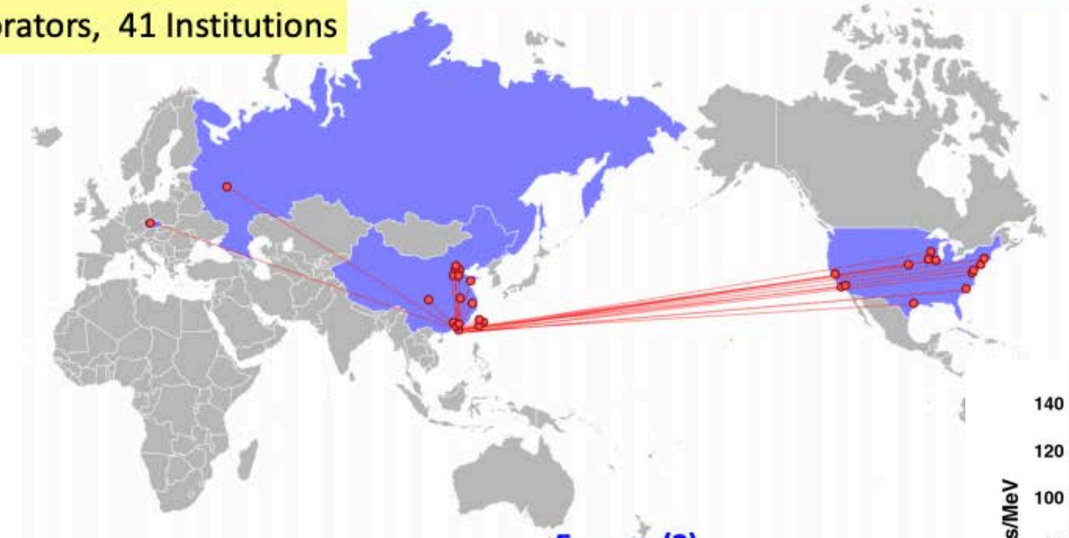
[Website]





The Daya Bay Collaboration

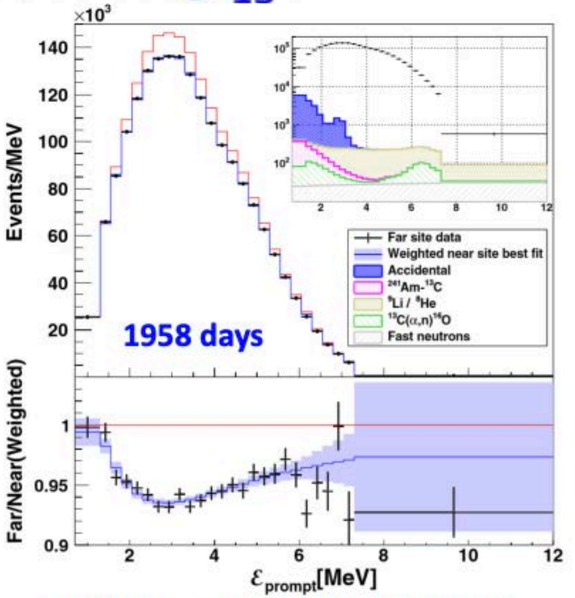
191 Collaborators, 41 Institutions



Asia (24)
Beijing Normal Univ., CGNPG, CIAE, Congqing Univ., Dongguan Univ. Tech., ECUST, GXU, IHEP, Nanjing Univ., Nankai Univ., NCEPU, NUDT, Shandong Univ., Shanghai Jiao Tong Univ., Shenzhen Univ., Tsinghua Univ., USTC, Xian Jiaotong Univ., Zhongshan (Sun Yat-sen) Univ., Chinese Univ. of Hong Kong, Univ. of Hong Kong, National Chiao Tung Univ., National Taiwan Univ., National United Univ.

Europe (2)
Charles Univ., JINR Dubna

North America (15)
Brookhaven Natl Lab, Illinois Institu State, Lawrence Berkeley Natl Lab, Temple University, UC Berkeley, Un California Irvine, UIUC, Univ. of Wis William & Mary, Yale

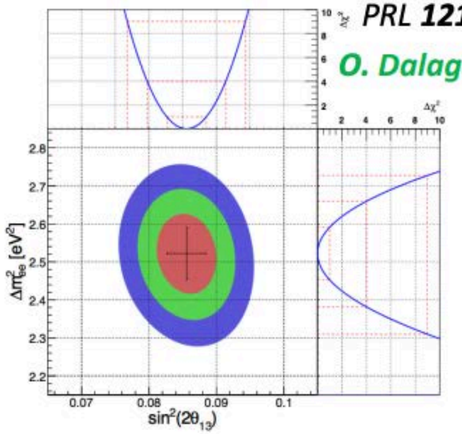


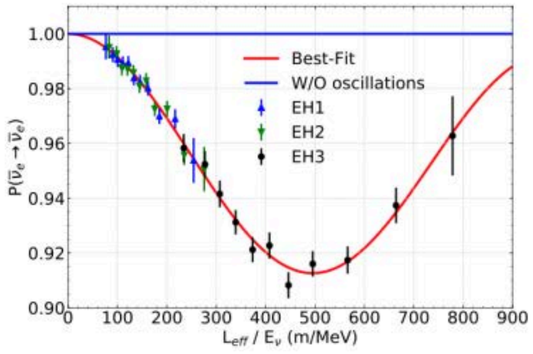
$\sin^2 2\theta_{13} = 0.0856 \pm 0.0029$

$|\Delta m^2_{ee}| = (2.52 \pm 0.07) \times 10^{-3}$ eV²

$\Delta m^2_{32} = (2.47 \pm 0.07) \times 10^{-3}$ eV² (NO)

$\Delta m^2_{32} = (-2.58 \pm 0.07) \times 10^{-3}$ eV² (IO)





*PRL **121** 241805 (2018)*

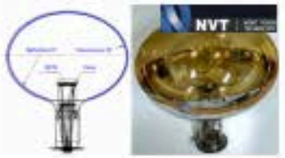
O. Dalager's Poster #531

JUNO Timeline

2014
- International collaboration established
- Conceptual design

2015
- PMT production line setup
- CD parts R&D
- Civil construction start

2016
- PMT production start
- CD parts production start
- Yellow book published



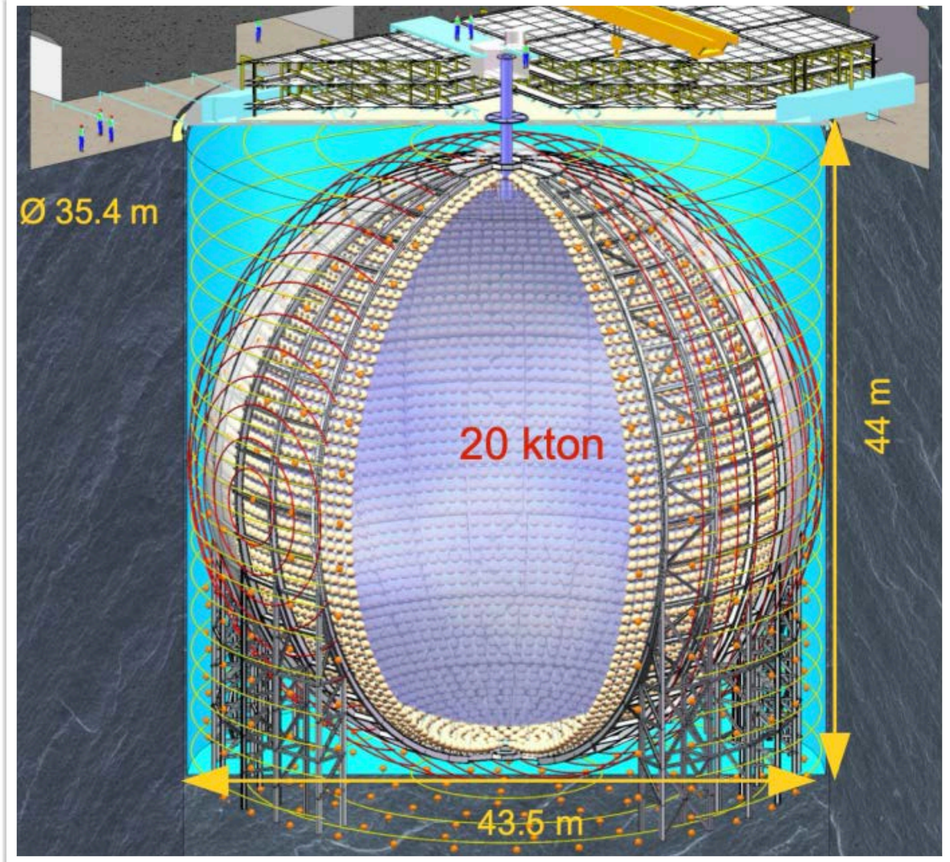
2017
- PMT testing start
- TT arrived

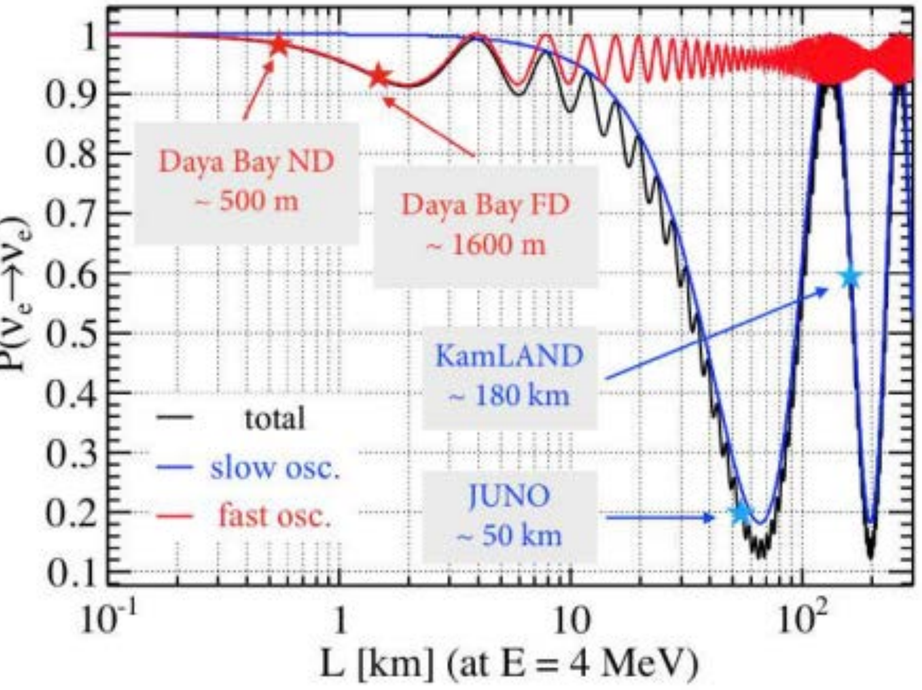
2018
- PMT potting
- Start delivery of surface building
- Start production of acrylic sphere

2019-2021
- Electronics production starts
- Civil construction and lab preparation completed
- Detector construction

2022
- Detector ready for data taking

Yue Meng, Neutrino2020





JUNO collaboration

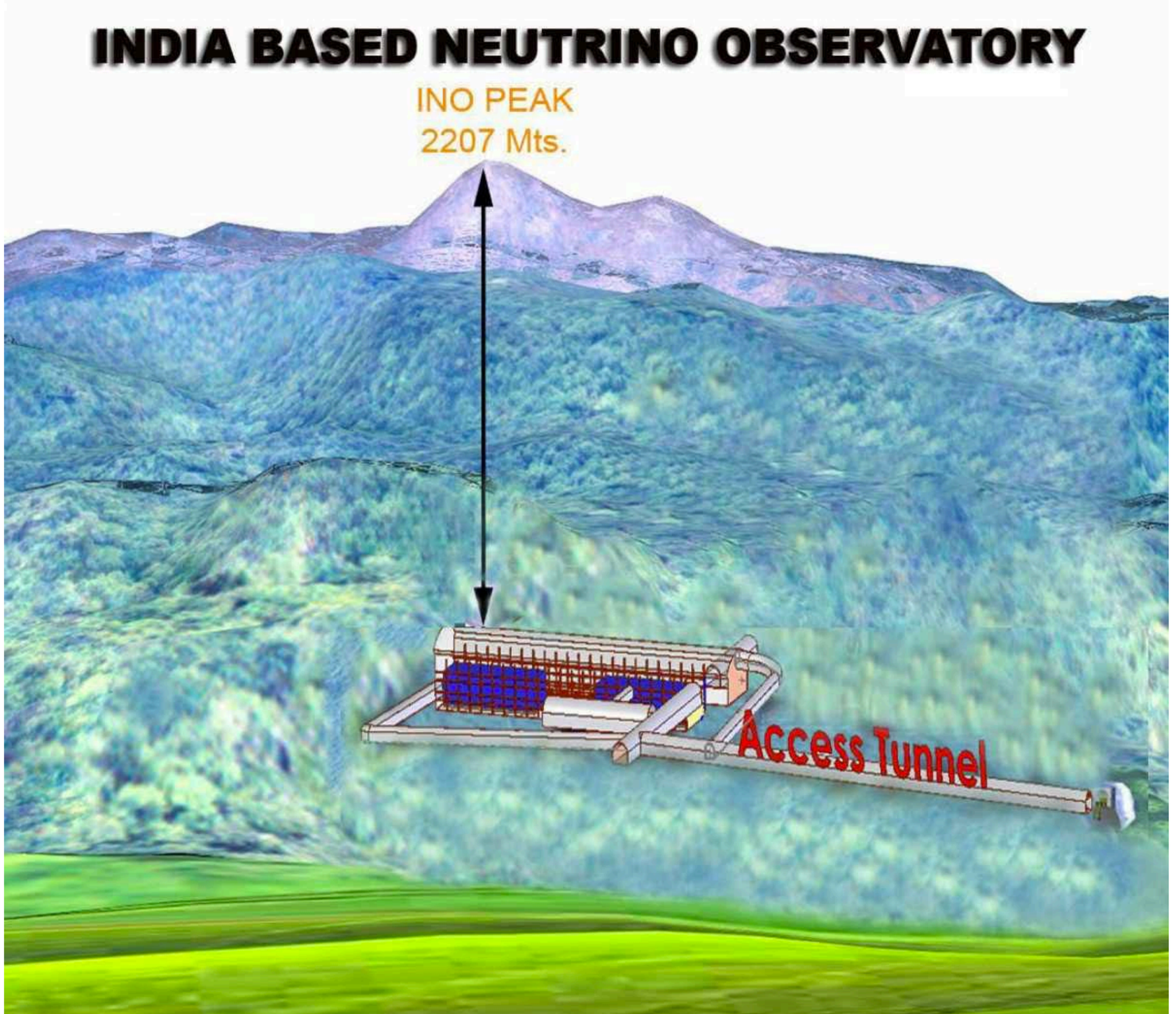
Collaboration established on July 2014
Now 77 institutions ~600 collaborators

China IMP-CAS
China Jilin U.
China Jinan U.
China Nanjing U.
China Nankai U.
China NCEPU
China NUDT
China Peking U.
China Shandong U.
China Shanghai JT U.
China SYSU
China Tsinghua U.
China UCAS
China USTC
China U. of South China
China Wu Yi U.
China Wuhan U.
China Xi'an JT U.
China Xiamen University
China Zhengzhou U.

Armenia Yerevan Physics Institute
Belgium Université libre de Bruxelles
Brazil PUC
Brazil UEL
Chile PCUC
Chile UTFSM
China BISEE
China Beijing Normal U.
China CAGS
China ChongQing University
China CIAE
China CUG Beijing
China DGUT
China ECUST
China ECUT Nanchang City
China Guangxi U.
China Harbin Institute of Technology
China IGG Beijing
China IGG Wuhan
China IHEP

Czech Charles U.
Finland University of Oulu
France LAL Orsay
France CENBG Bordeaux
France CPPM Marseille
France IPHC Strasbourg
France Subatech Nantes
Germany FZJ-ZEA
Germany RWTH Aachen U.
Germany TUM
Germany U. Hamburg
Germany FZJ-IKP
Germany U. Mainz
Germany U. Tuebingen

Italy INFN Catania
Italy INFN di Frascati
Italy INFN-Ferrara
Italy INFN-Milano
Italy INFN-Milano Bicocca
Italy INFN-Padova
Italy INFN-Perugia
Italy INFN-Roma 3
Latvia IECS
Pakistan PINSTECH (PAEC)
Russia NR Moscow
Russia JINR
Russia MSU
Slovakia FMPICU
Taiwan National Chiao-Tung U.
Taiwan National Taiwan U.
Taiwan National United U.
Thailand NARIT
Thailand PPRLCU
Thailand SUT
USA UMD1
USA UMD2
USA UCI


INDIA BASED NEUTRINO OBSERVATORY
INO PEAK
2207 Mts.
Access Tunnel

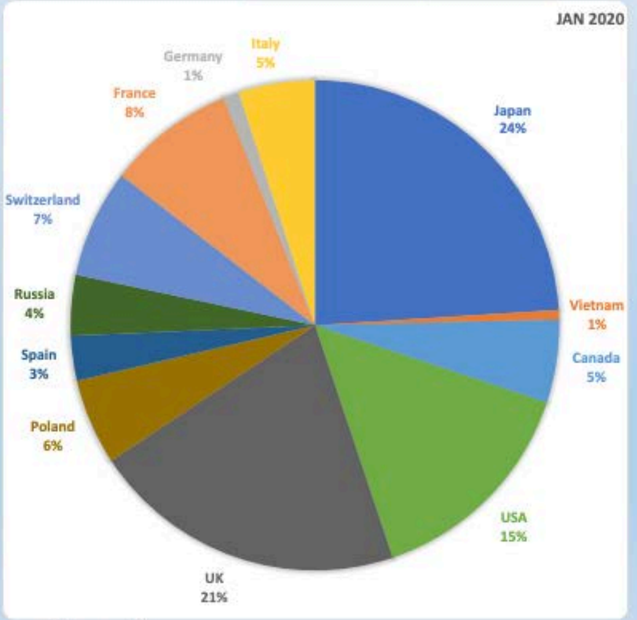
T2K Collaboration

~500 members, 69 institutes, 12 countr

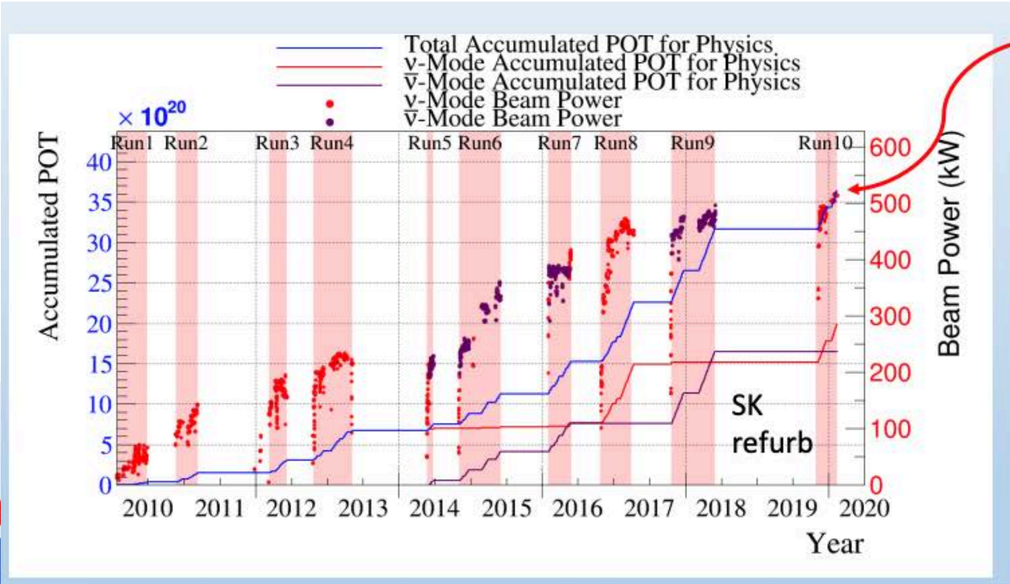
Asia	117
Japan	114
Vietnam	3

Americas	96
Canada	26
USA	70

Europe	262
France	40
Germany	5
Italy	24
Poland	27
Russia	19
Spain	14
Switzerland	34
UK	99



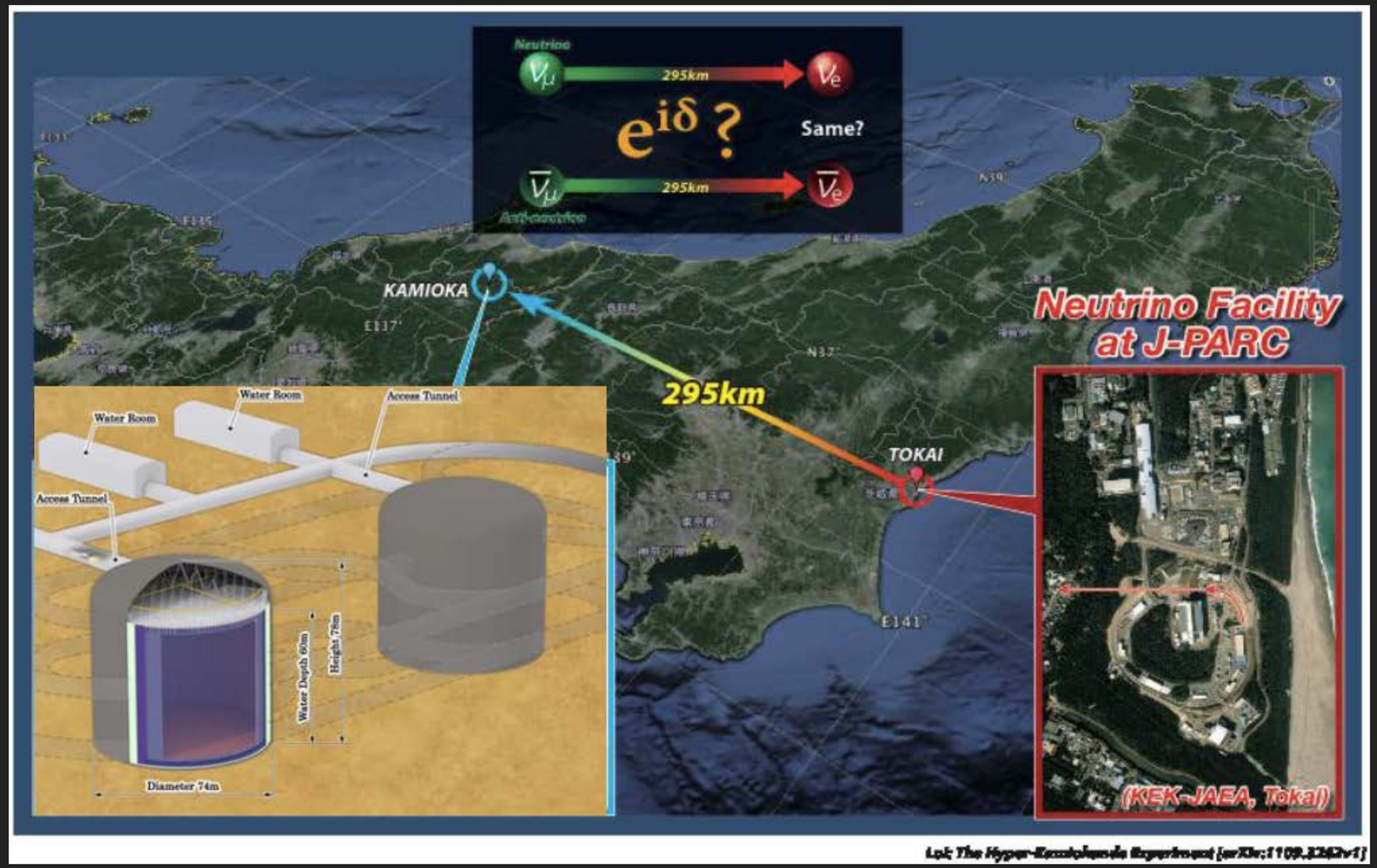
Patrick Dunne (p.dunne12@imperial.ac.uk)



- 515 kW stable operation achieved this year
- Has allowed an increase of 33% in ν-mode data since 2018
- Total of 1.97×10^{21} protons on target (POT) in ν-mode and 1.63×10^{21} in $\bar{\nu}$-mode

Patrick Dunne (p.dunne12@imperial.ac.uk)

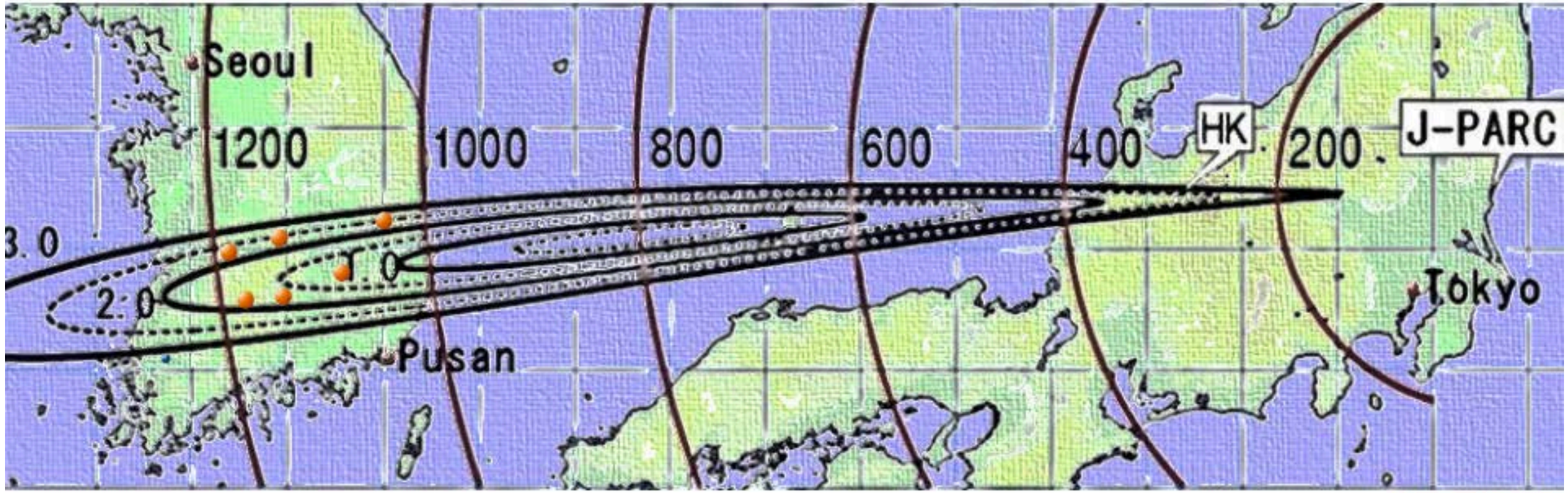
TOKAI TO HYPER-KAMIOKANDE (T2HK)



Or Even placing a second tank in Korea

An alternative possibility is to put a second tank in Korea

- Work on the second tank could conceivably start much sooner
- This is possible because of the off-axis choice (c.f. NuMI, Dune)



Imperial College London

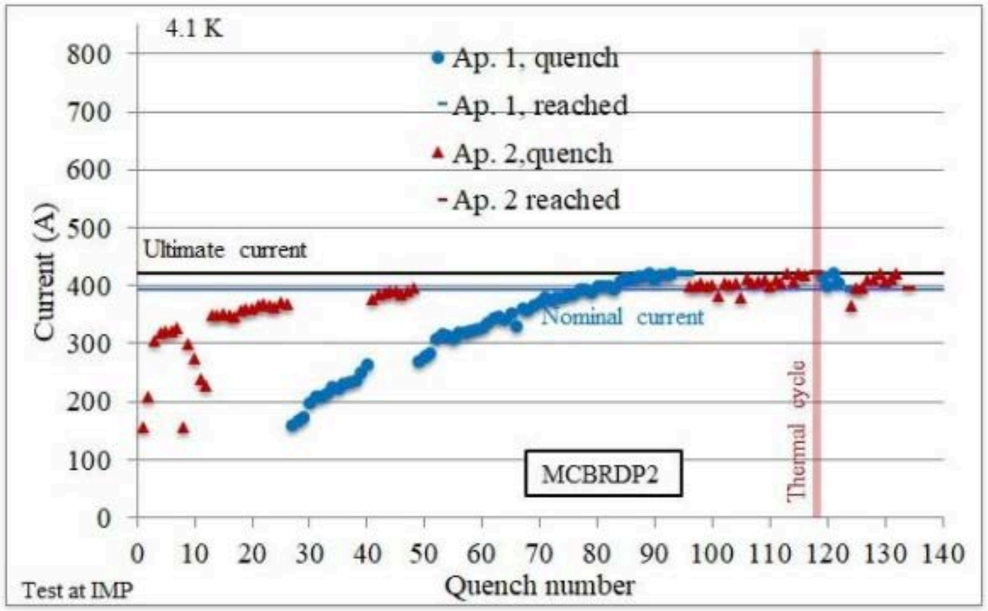
Technology

A few examples …

- S/C magnets, eg. :
  - ATLAS Solenoid (Japan)
  - Belle II Final focus
  - HL-LHC D2

First D2 corrector prototype manufactured by IHEP collaboration

18 September, 2020



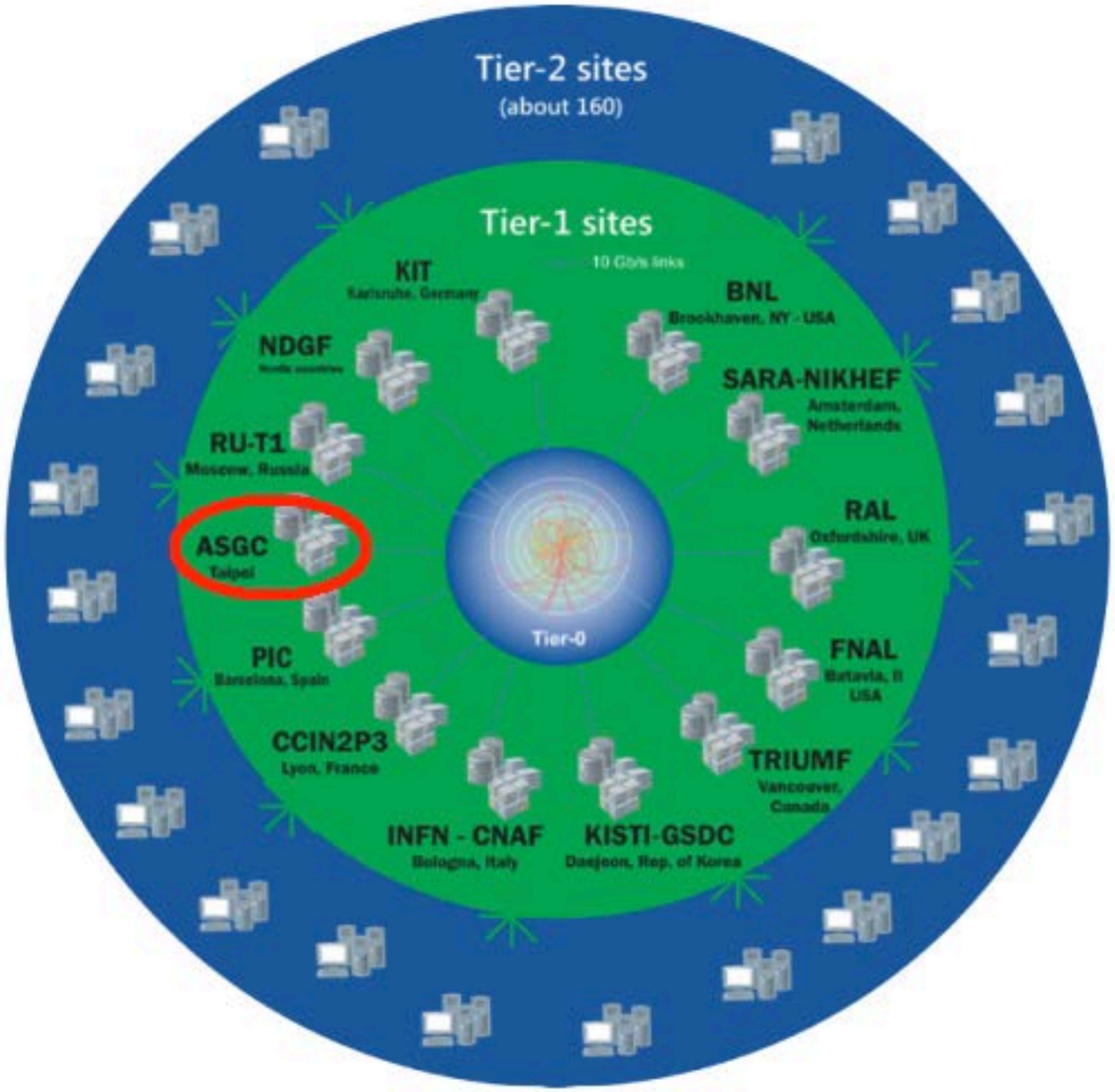
May-August 2020: Training of the first prototype of D2 corrector manufactured by IHEP collaboration

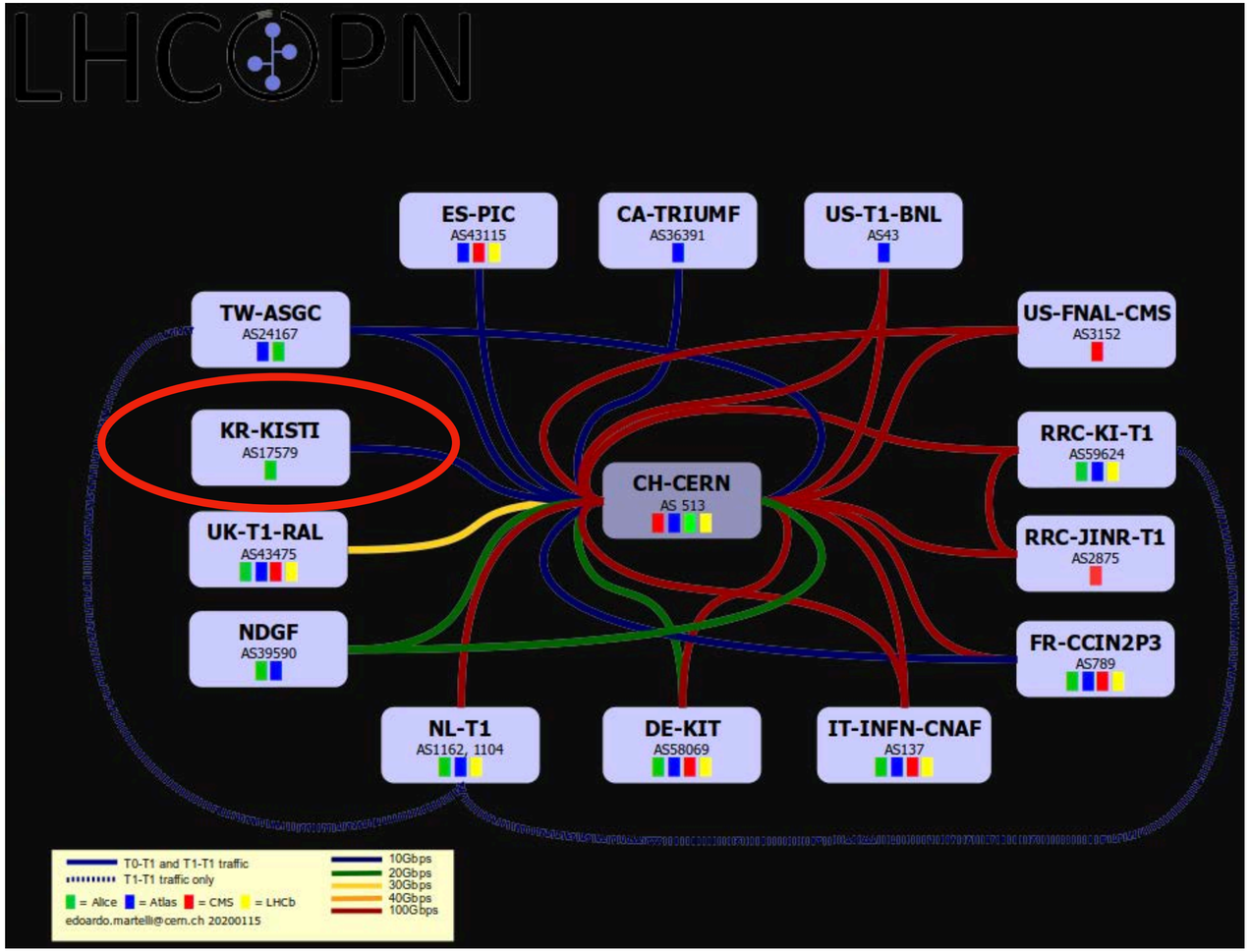
- SRF (ILC RF modules: Japan, but also in China)
- Photo Detectors, Silicon detectors, …
- Electronics, Optical Links, …
- …

Computing

Asian nations important in WLCG

Computing Important throughout Asian Physics





CERN : Our field's cornerstone

- CERN formed as International Organisation
  - Treaty organisation (*hard to achieve today*)
  - Post-war reformation of Europe (*unusual initial condition*)
  - Strong multi-national political support is critical
  - Not reliant on a single national budget or party
  - Hailed as a highly successful, leading example of international cooperation
- Competitor to USA in science
  - Transatlantic competition was influential right through to LHC/SSC
  - Then:
    - LEP surpassed SLC, SSC cancelled, LHC surpassed Tevatron
  - Strong scientific goals and guaranteed resourcing were essential

At the United Nations … in a conference entitled “The CERN Model, United Nations and Global Public Goods” CERN representatives discussed with UN delegates the laboratory’s model for international cooperation.

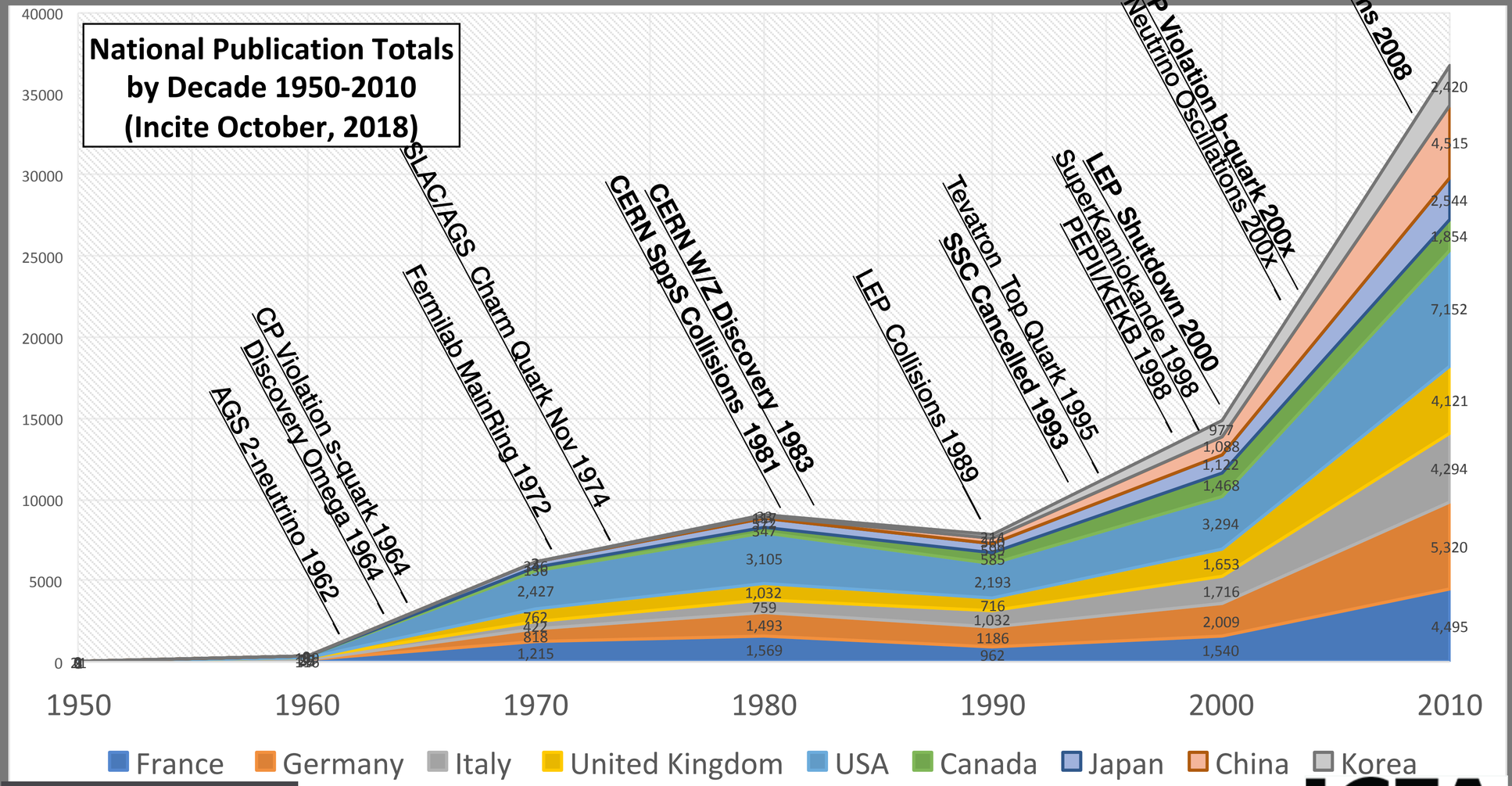
CERN DG elect Fabiola Gianotti highlighted the importance of CERN’s ‘consensual governance’.
“At CERN, ideas are the drivers of research,” said Gianotti. “At the laboratory, ***authority comes from intellectual ability, not hierarchy, so any student can contribute to the scientific discussion … people are animated by a strong common passion for science.***”

at the UN General Assembly since 2012 (Image: CERN)

Publications

- All Countries Benefit -

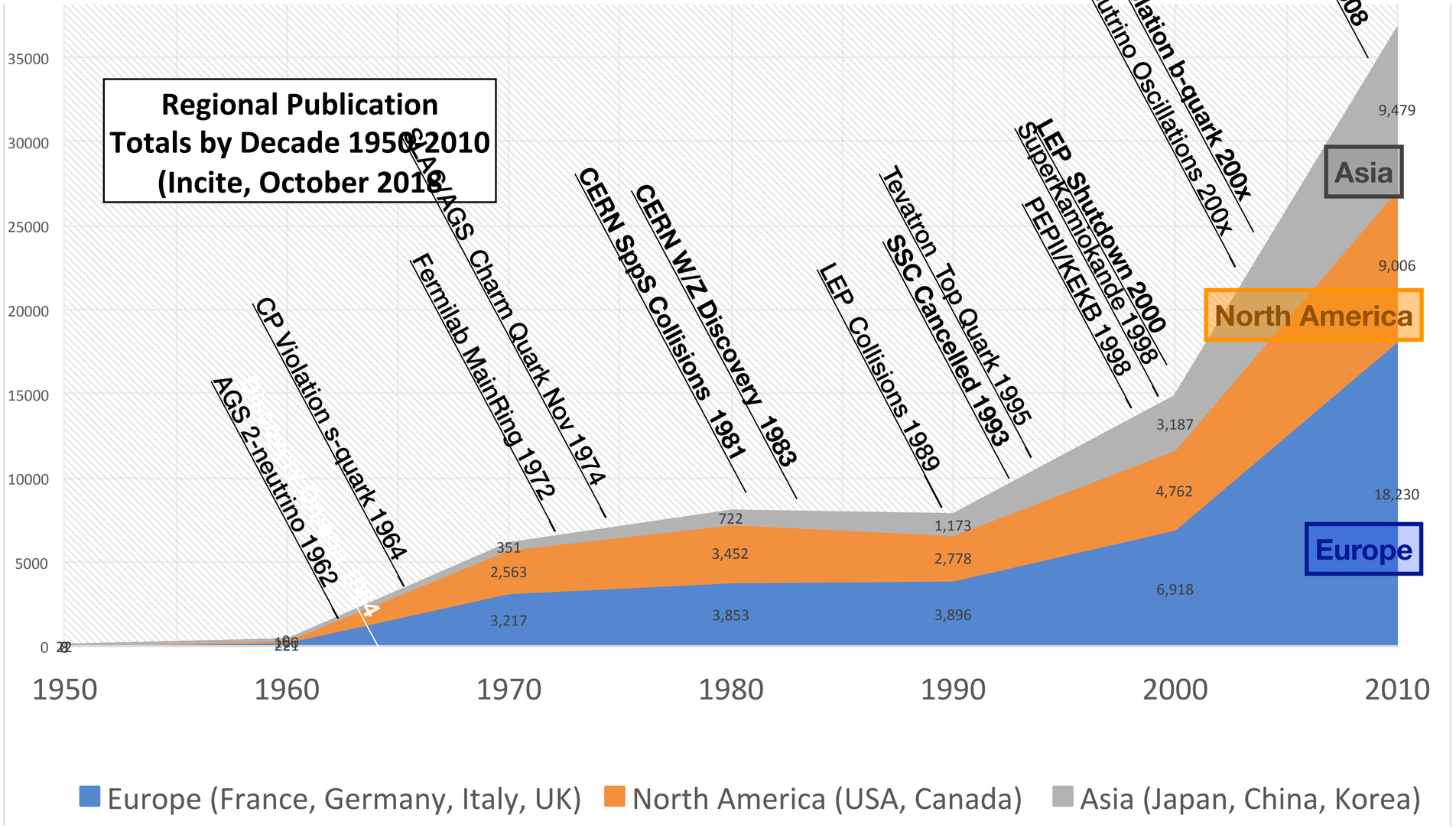
(Inspire, October 2018)



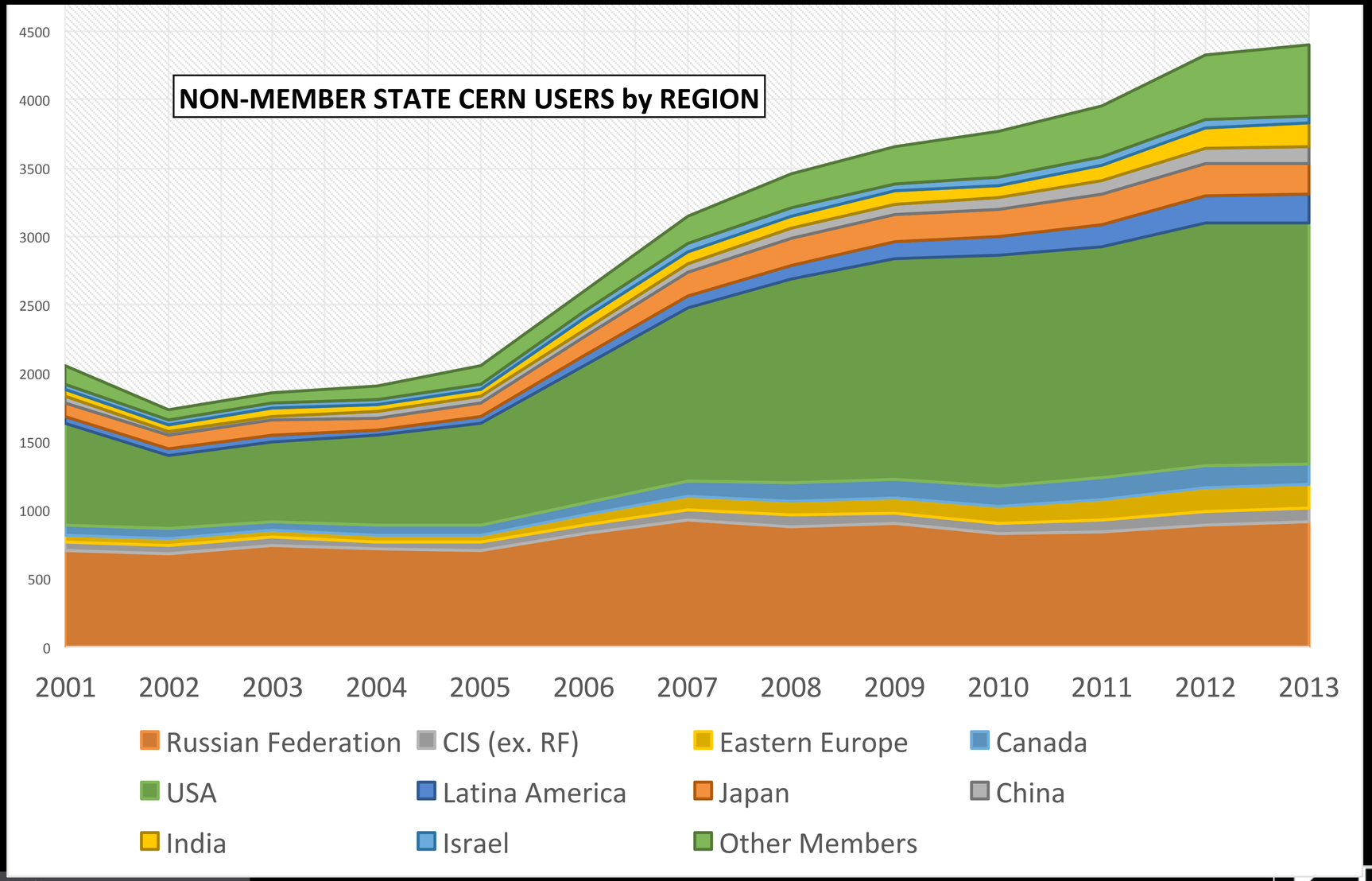
Publications

- All Regions Benefit -

(Inspire, October 2018)



Non-Member State CERN Users



2020 Update of the European Strategy for Particle Physics

High-priority future initiatives

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.

B. Innovative accelerator technology …

https://europeanstrategy.cern/

250GeV Higgs Factory

Asian Higgs Factory?

Experience in e+e- (KEK, IHEP)

Cost: 250 GeV (-1TeV)
a different beast form a 100TeV pp Collider
1/400 energy

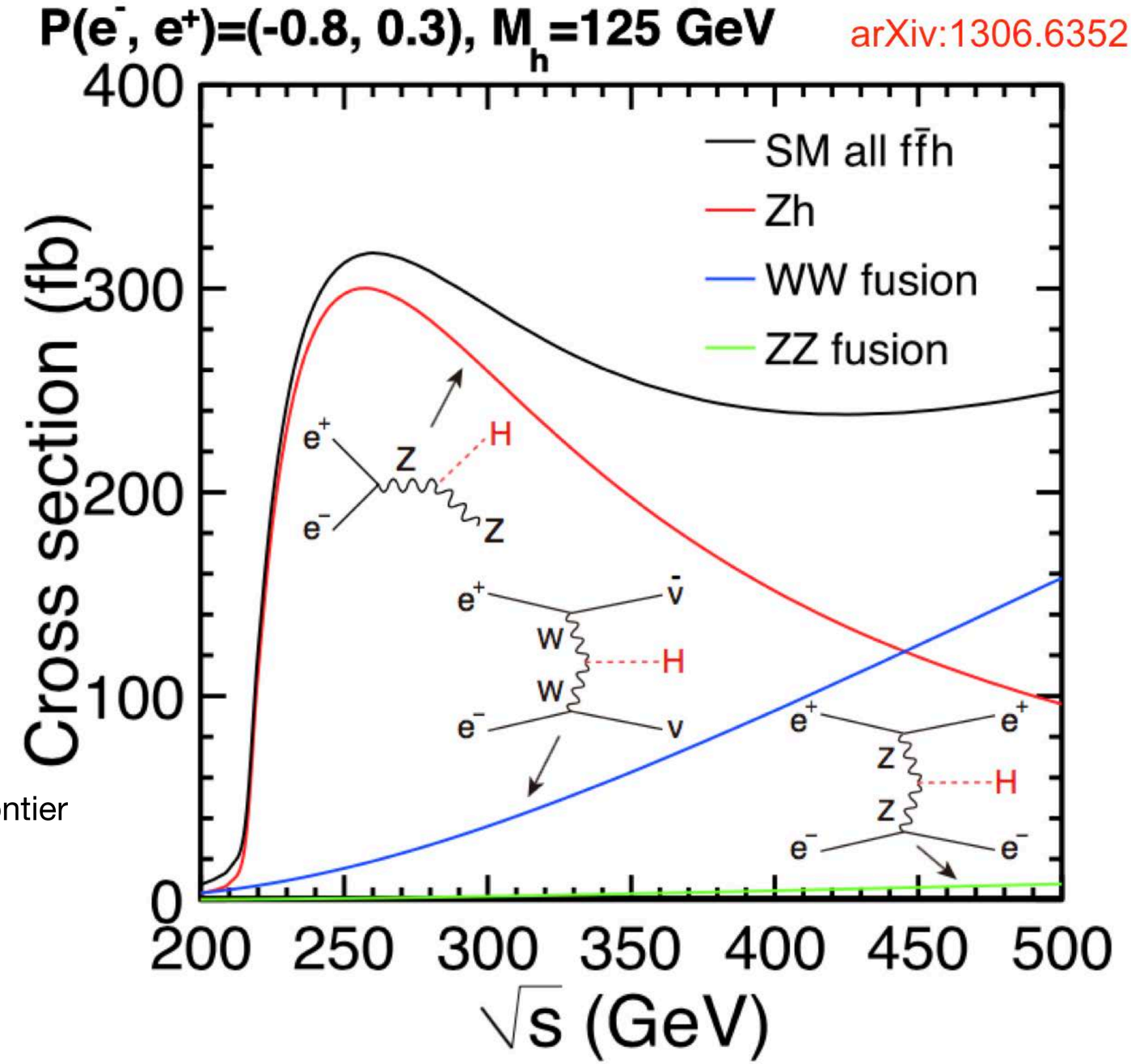
ILC:
Reduced footprint, new technology

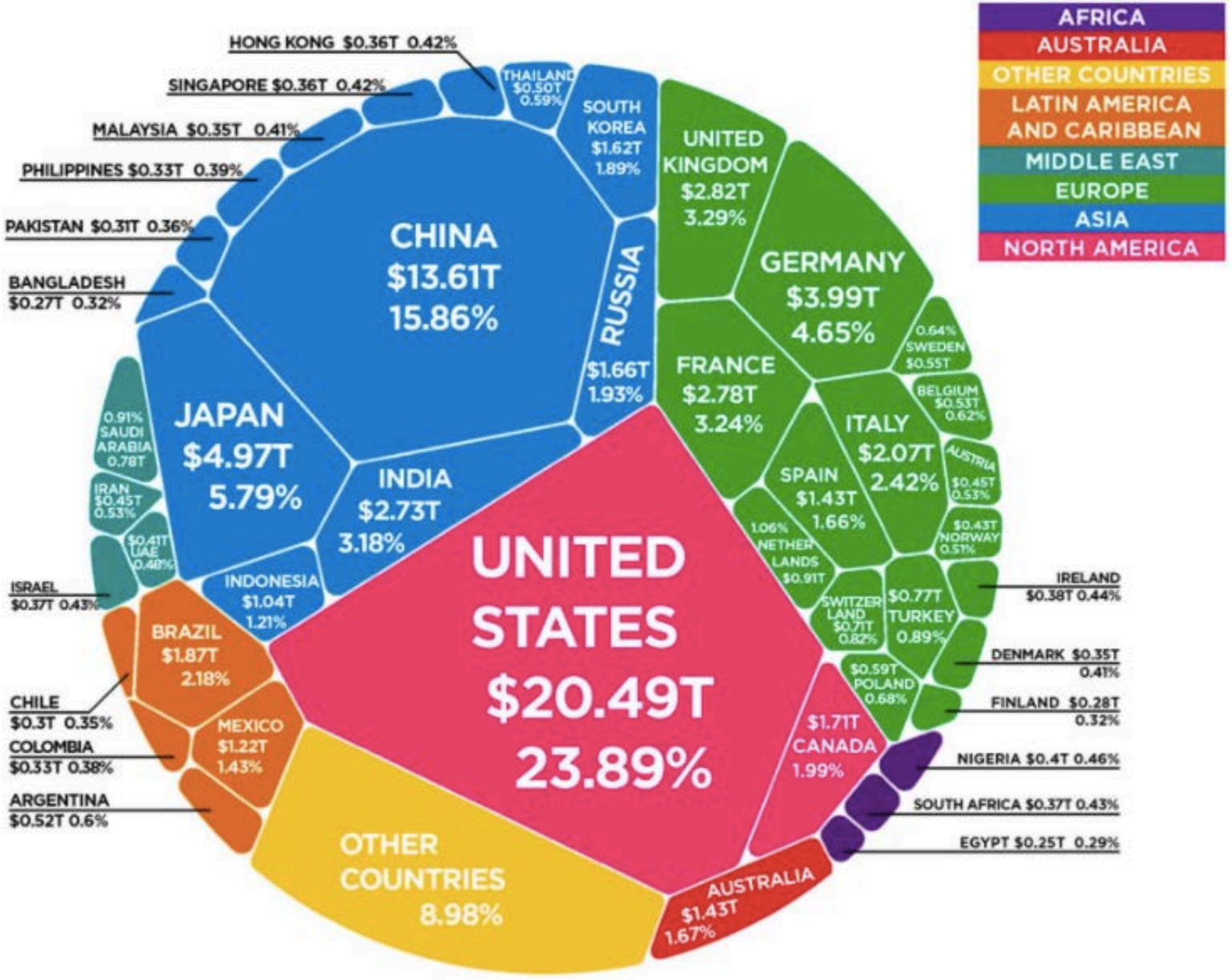
CEPC?
Cheap tunnelling in China

Both will required International Collaboration

Neither would block CERN's drive to next Energy Frontier

No outcome assured:
Need to develop various options
Support multiple centres of expertise
Possibly more host funding for the field





Article & Sources:
https://howmuch.net/articles/the-world-economy-2018
https://databank.worldbank.org

howmuch.ne

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

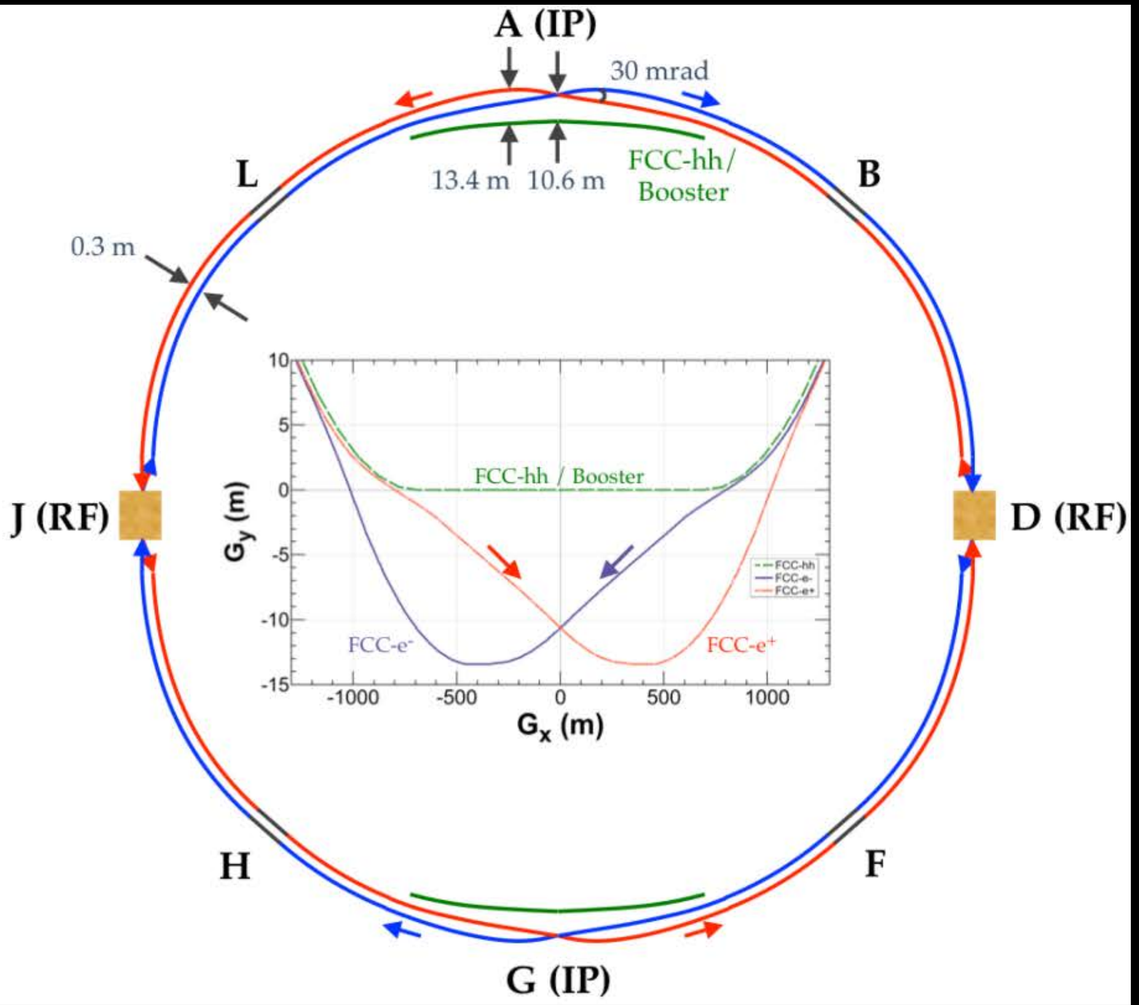
Asian Growth

World Economic Forum: By 2030 Asia will contribute to 60% of Global Growth

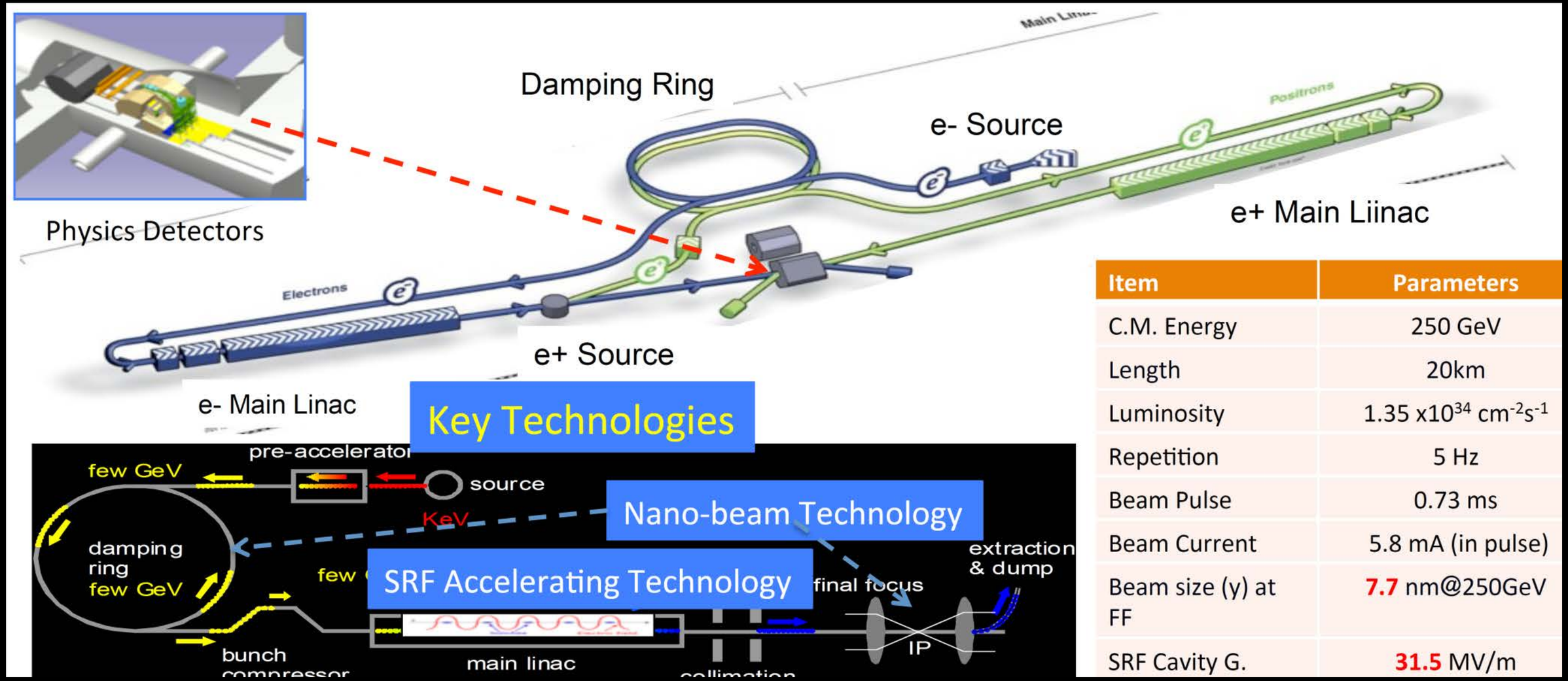
- Burgeoning middle class - demand for advanced education and research
- Digital Transformation - jobs revolution
  - (eg. 53 Million workers in ASEAN will need to be retrained!)
- Science should not be led by Commerce/Industry
  - Particle Physics has been an incredibly efficient innovator.
  - We must persuade our governments that our field has much more ahead.

FCC(ee), CEPC

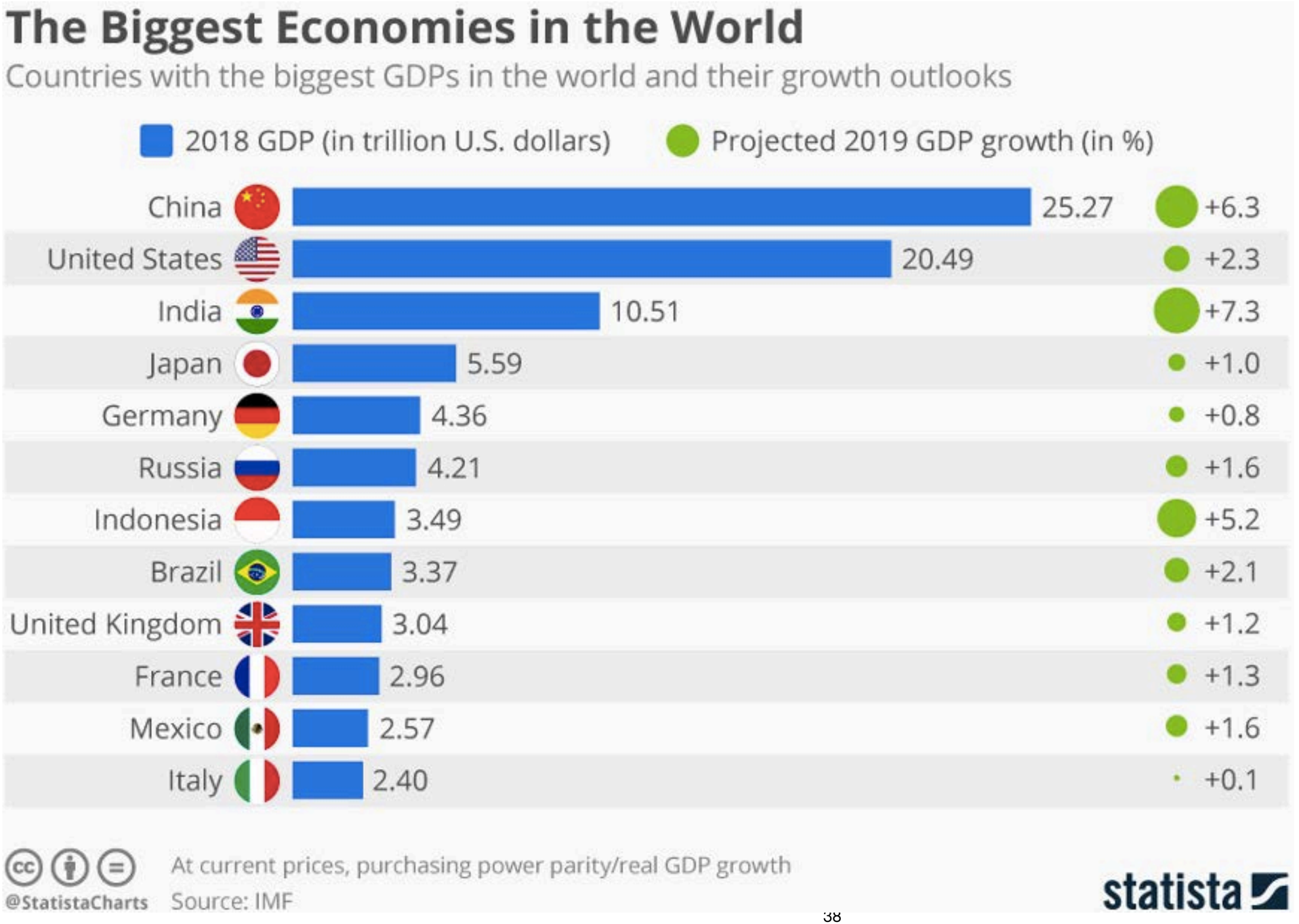
- **Double ring** e+ e- collider ~100 km
- **Follows footprint of FCC-hh**, except around IPs
- **Asymmetric IR layout and optics** to limit synchrotron radiation towards the detector
- **2 IPs, large** horizontal crossing angle **30 mrad, crab-waist optics**
- **Synchrotron radiation power 50 MW/beam** at all beam energies
- **Top-up injection** scheme for high luminosity
- Requires **booster synchrotron in collider tunnel**



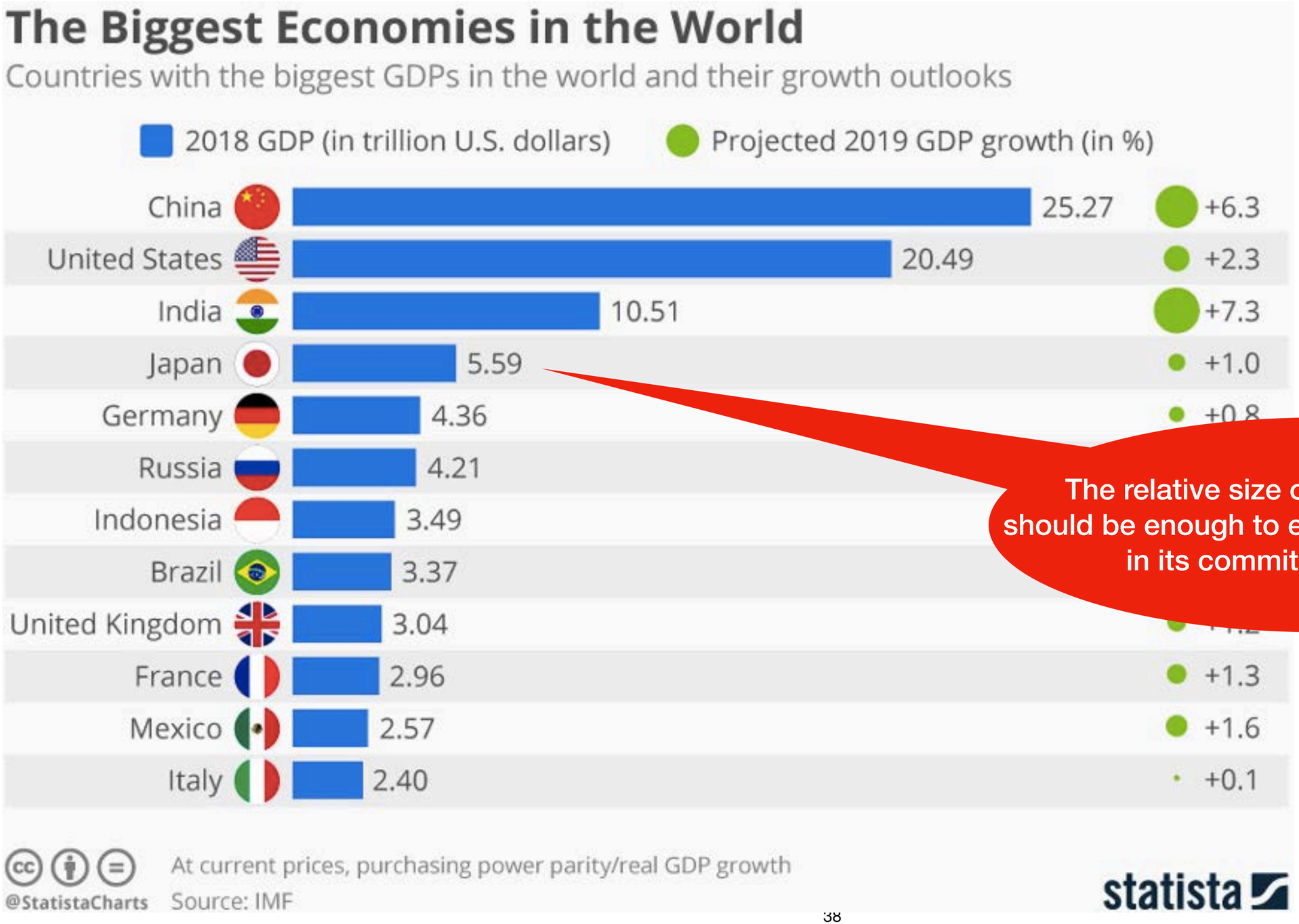
ILC250



Item	Parameters
C.M. Energy	250 GeV
Length	20km
Luminosity	1.35 x10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	**7.7** nm@250GeV
SRF Cavity G.	**31.5** MV/m



At current prices, Purchasing Power Parity (PPP)



The relative size of the Japanese GDP should be enough to explain its relative caution in its commitment to the ILC.

At current prices, Purchasing Power Parity (PPP)

Population differences

- Japan: 126 million
- USA: 328 million
- Europe: 740 million
- Russia: 144.5 million
- China: 1.44 billion
- India: 1.38 billion

ILC is not “just” a new accelerator

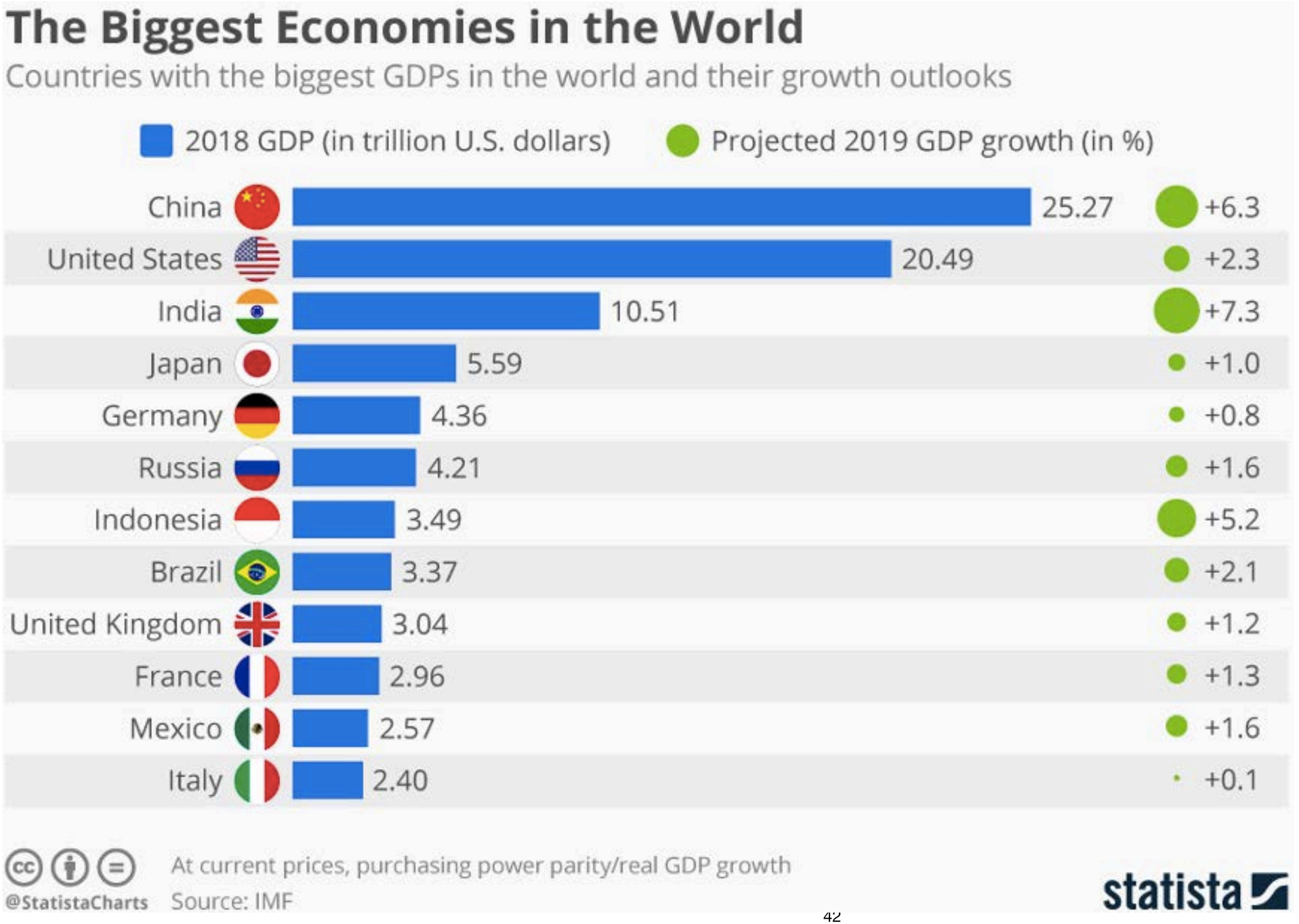
- The ILC is a new multi-billion dollar international laboratory, that must exist for decades.
- It is not a new facility in an well established laboratory
- Our community must not underestimate the significance of the undertaking
- At the same time as we support CERN, Fermilab, BNL, KEK & J-Parc, …
  - We must have and display unwavering, dominant support form our field worldwide.

So How Affordable is the ILC?

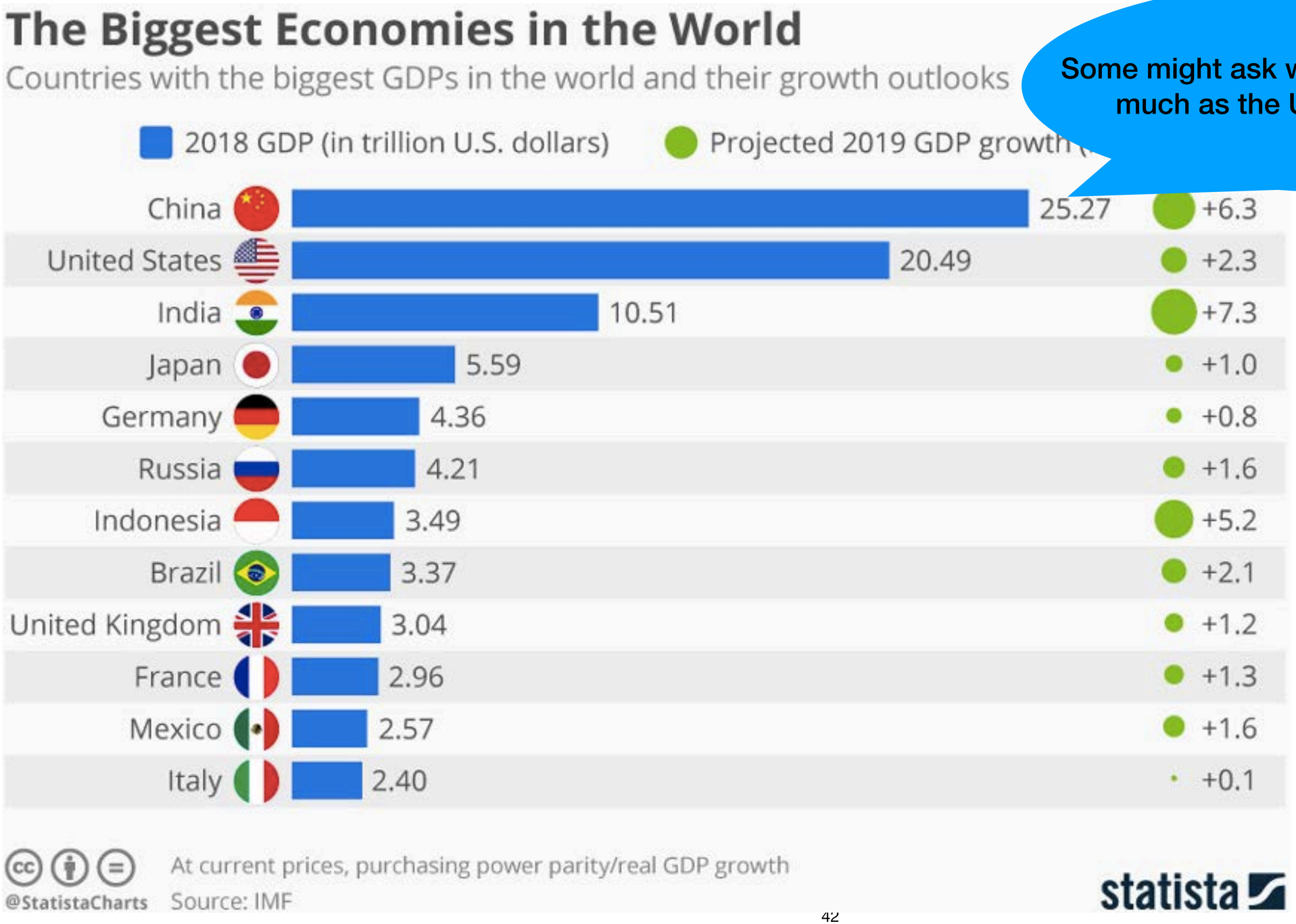
Using the Economist's Big Mac index

- LHC cost ~$5 Billion, approved 1995
- Big Mac (US) 1995 $2.32 compared with 2015 $4.79 —> Factor x2
- In Big Macs, the LHC would cost >$10 B today.
- The ~$6 Billion price tag for the ILC250 would appear very reasonable (at least if the cost can be shared)

(Need to be a big careful: In Japan Big Mac's cost less in 2015 than in 1995!)

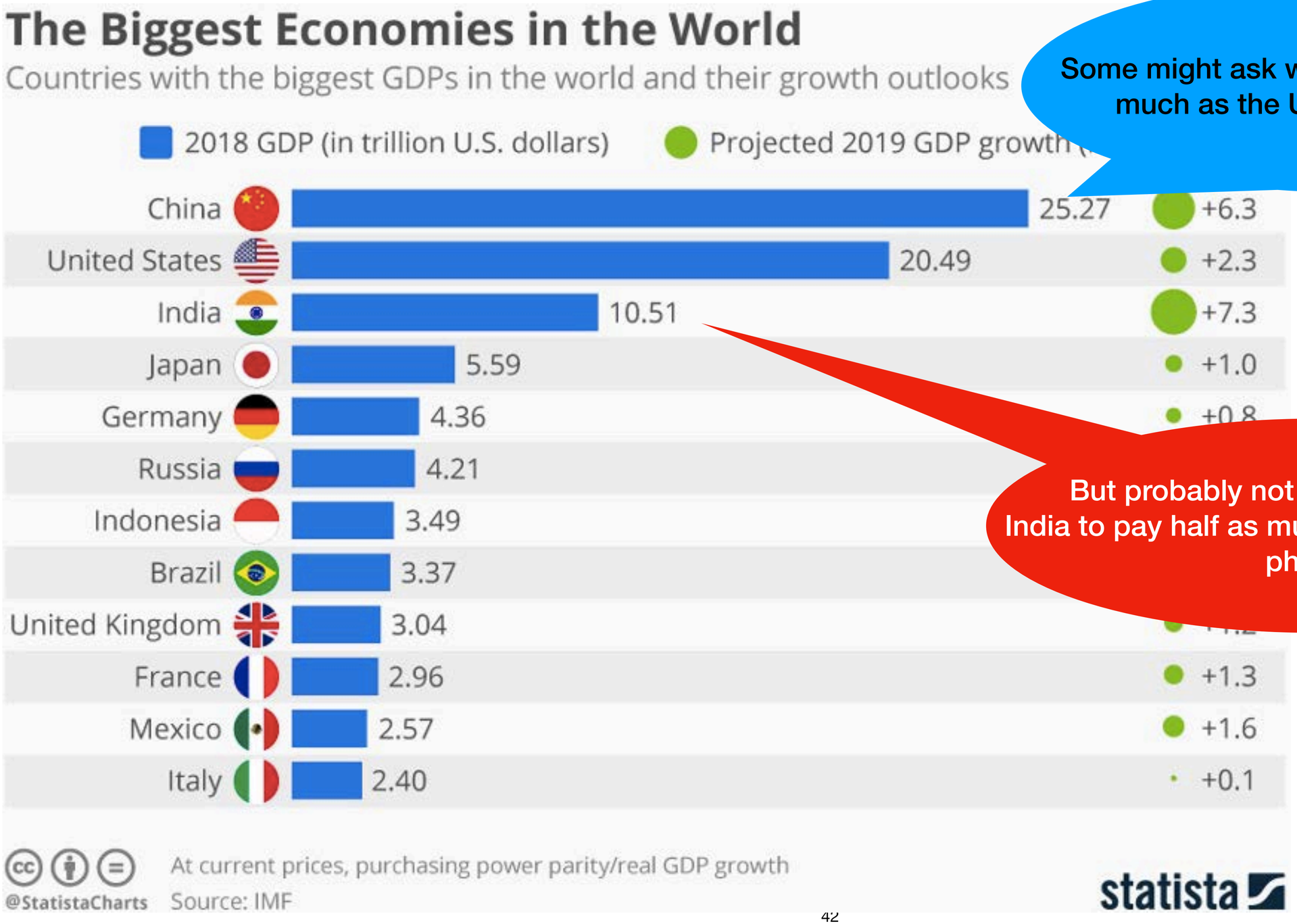


At current prices, Purchasing Power Parity (PPP)



Some might ask why China is not paying as much as the US on particle physics

At current prices, Purchasing Power Parity (PPP)



Some might ask why China is not paying as much as the US on particle physics

But probably not many would expect India to pay half as much as the US on particle physics

At current prices, Purchasing Power Parity (PPP)

Can HEP get beyond China's image problem in the West?

CoEPP
ARC Centre of Excellence for Particle Physics at the Terascale

Geoffrey Taylor

Economist (Jan 2019)

"China is hurtling up the rankings of scientific achievement. It has spent many billions of dollars on machines to detect dark matter and neutrinos, and on institutes galore that delve into everything from genomics and quantum communications to renewable energy and advanced materials."

"From better batteries and new treatments for disease to fundamental discoveries about, say, dark matter, the world has much to gain from China's efforts."

"Some in the West may feel threatened by China's advances in science, and therefore aim to keep its researchers at arm's length. … But to extend an arm's-length approach to ordinary research would be self-defeating. Collaboration is the best way of ensuring that Chinese science is responsible and transparent."

Source: https://www.economist.com/leaders/2019/01/12/how-china-could-dominate-science

Physics must aim to Remain Above National Politics

Lessons from COVID-19?

- The political/national/economic world is entangled as much as the environmental/microbiological/natural world.
- Solutions required international plans and programs
  - The benefits of shared responsibility, shared solutions
- Large scientific facilities require the same approach:
  - Shared vision, shared responsibility, share benefits.

ICFA - International Development Team

- To make preparations for the ILC Pre-Lab in Japan
  - the first step of the preparation phase of the ILC project
- Mandate ~18months
- Executive Board:
  - **Tatsuya Nakada** (EPFL), Chair–Executive Board and Working Group 1
  - **Steinar Stapnes** (CERN), Regional Representative–Europe
  - **Andy Lankford** (University of California, Irvine), Regional Representative–Americas
  - **Geoffrey Taylor** (University of Melbourne), Regional Representative–Asia-Pacific
  - **Shinichiro Michizono** (KEK), Chair–Working Group 2
  - **Hitoshi Murayama** (University California Berkeley/ IPMU-University of Tokyo), Chair–Working Group 3
  - **Yasuhiro Okada (KEK)**, KEK Liaison

http://newsline.linearcollider.org/2020/09/25/icfa-and-the-ilcs-international-development-team/

Conclusion

- There are many opportunities for world-wide particle physics in Asia existing and planned.
- Conversely, Asian science contributes greatly to the international field in Europe and the USA.
- History shows that scientific collaboration is remarkably resilient even in times of stress in international politics.
- Particle Physics must not miss the opportunities presented by the Asian Century
- I hope Snowmass 2020 and the following P5 will reflect the opportunities