# High Energy Physics
# - Future Facilities -

## *Some considerations*

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ICFA Chair

# Many Questions Remain HEP…

Chris Quigg "Dream Machines" (Rev. Acc. Sci. and Techn. 1 (2018) 1-9 )

1. *Beyond the Higgs-boson discovery*
   - more Higgs? additional EWS breaking? other sources of fermion mass? coupling proportional to mass? …
2. *More new physics on the TeV scale and beyond?*
   - quark/lepton compositeness? DM? Vacuum Energy? …
3. *Flavour: the problem of identity*
   - RH CC? additional EW gauge bosons? LFV? why 3 families?
4. *Some outstanding questions in neutrino physics*
   - mass hierarchy? absolute mass? CP violation in neutron oscillations? Majorana particles? sterile neutrinos? …

***— What new facility would you choose!! —***

# Richness of Our Facilities

Non-Accelerator Particle Physics

- *Cosmic Rays*
  - Neutrinos, Gamma-rays, UHE nuclei
- *Reactor Neutrinos*
- *Dark Matter Searches*
  - (WIMPS, Axions, WISPs…)
- *Double Beta-decay*

# Richness of Our Facilities

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- *Reactor Neutrinos*
- *Dark Matter Se les*
  - (WIMPS, A ns, WISPs…)
- *Double a-decay*

Still relatively affordable at national scale

# Richness of Our Facilities

## Accelerator Particle Physics

- *Proton Colliders*
- *Heavy Ion Colliders*
- *Electron-Positron Colliders*
- *Neutrino Beams*
- *…*

# Richness of Our Facilities

## Accelerator Particle Physics

- *Proton Colliders*
- *Heavy Ion Colliders*
- *Electron-Positron Colliders*
- *Neutrino Beams*
- *…*

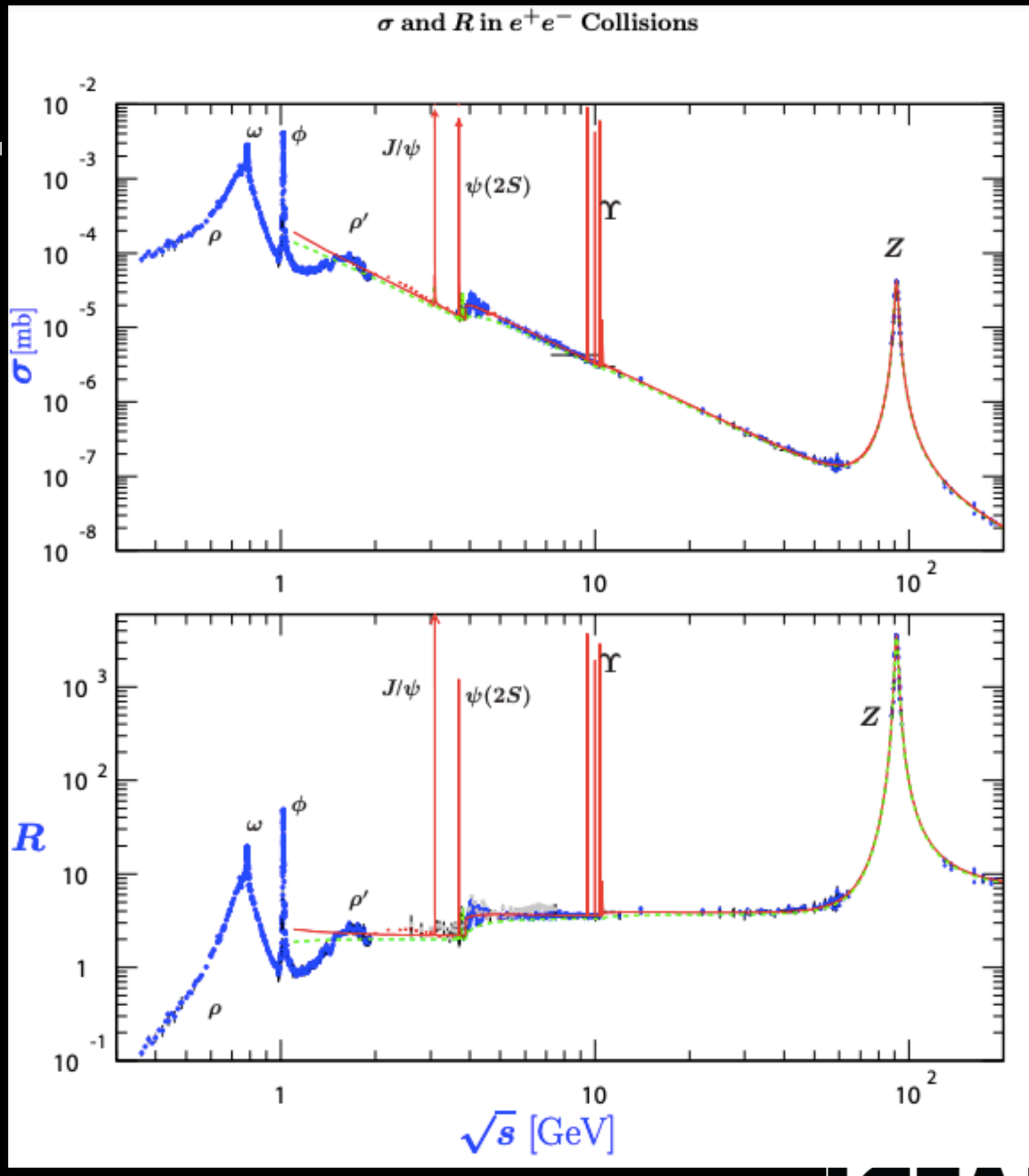
We have been very successful for decades.
International Collaboration is Key

# Higgs Discovery

- A magnificent achievement!
- Yet expectations (amongst physicists as well as the general public) for new discoveries are highly excited!
- We have entered a phase more difficult to sell to the public and to the next generation of physicists

## — PRECISION PHYSICS —

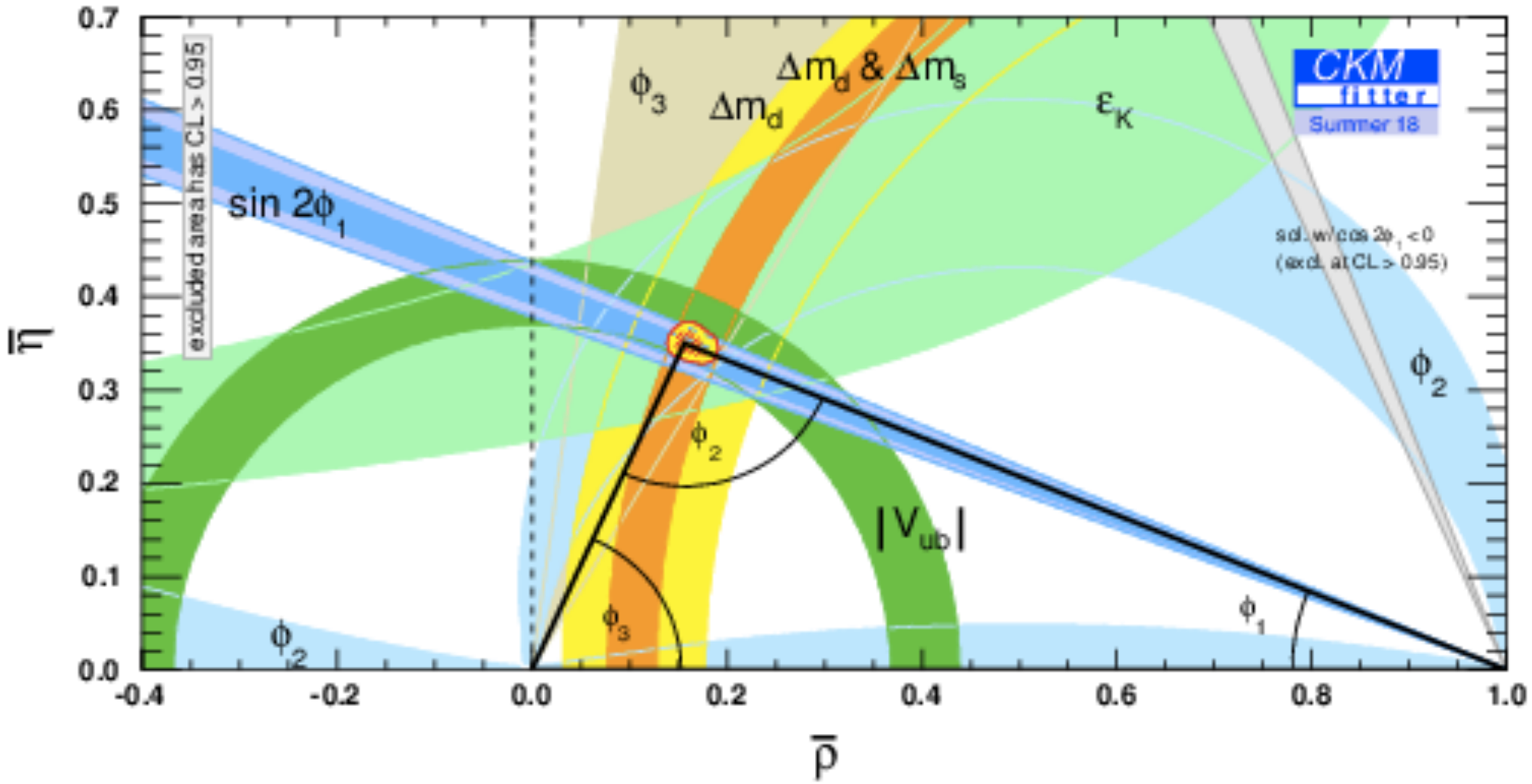
# Precision Era ...



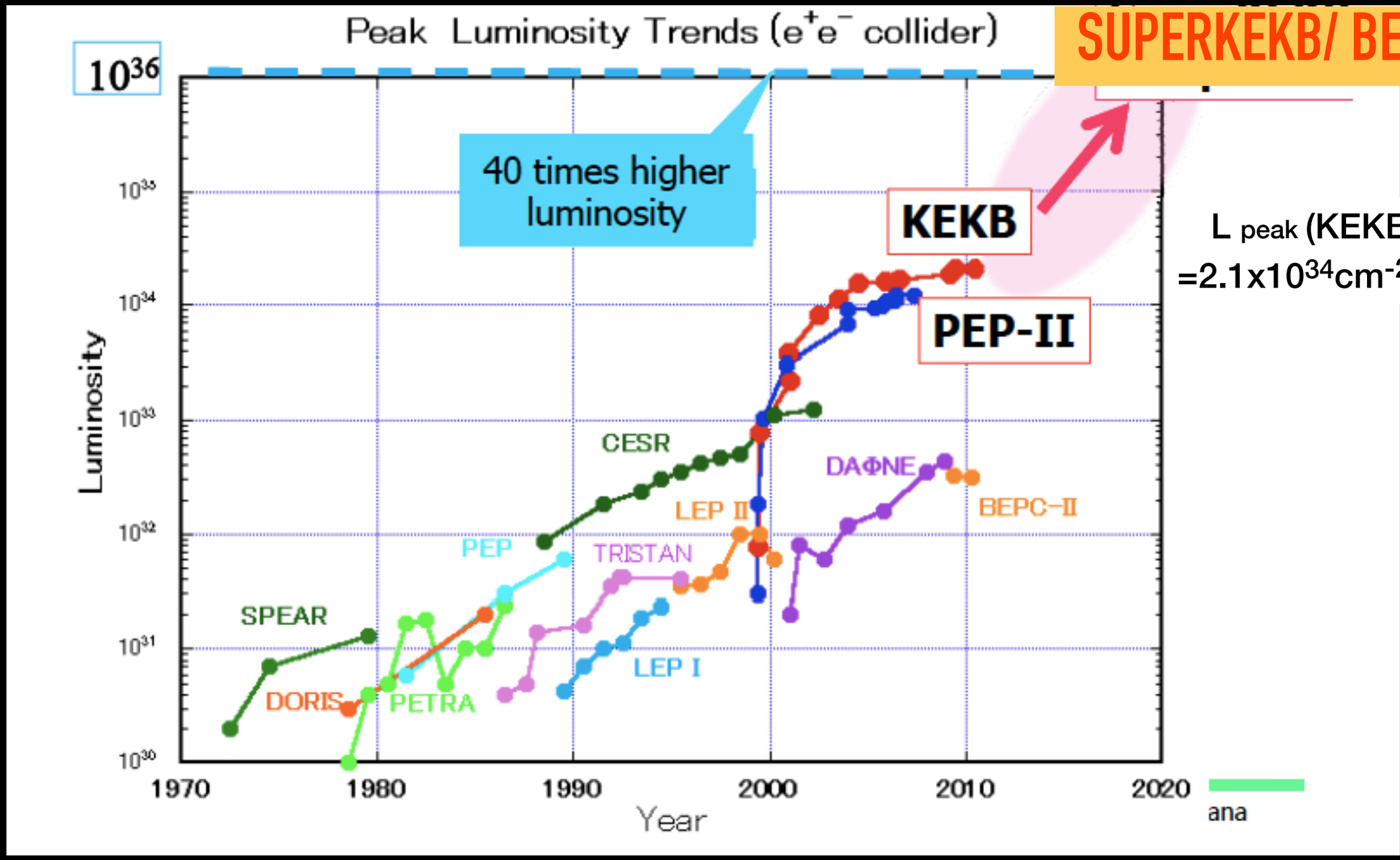

PDG: _http://pdg.lbl.gov/2018/reviews/rpp2018-rev-cross-section-plots.pdf

# Precision Era…

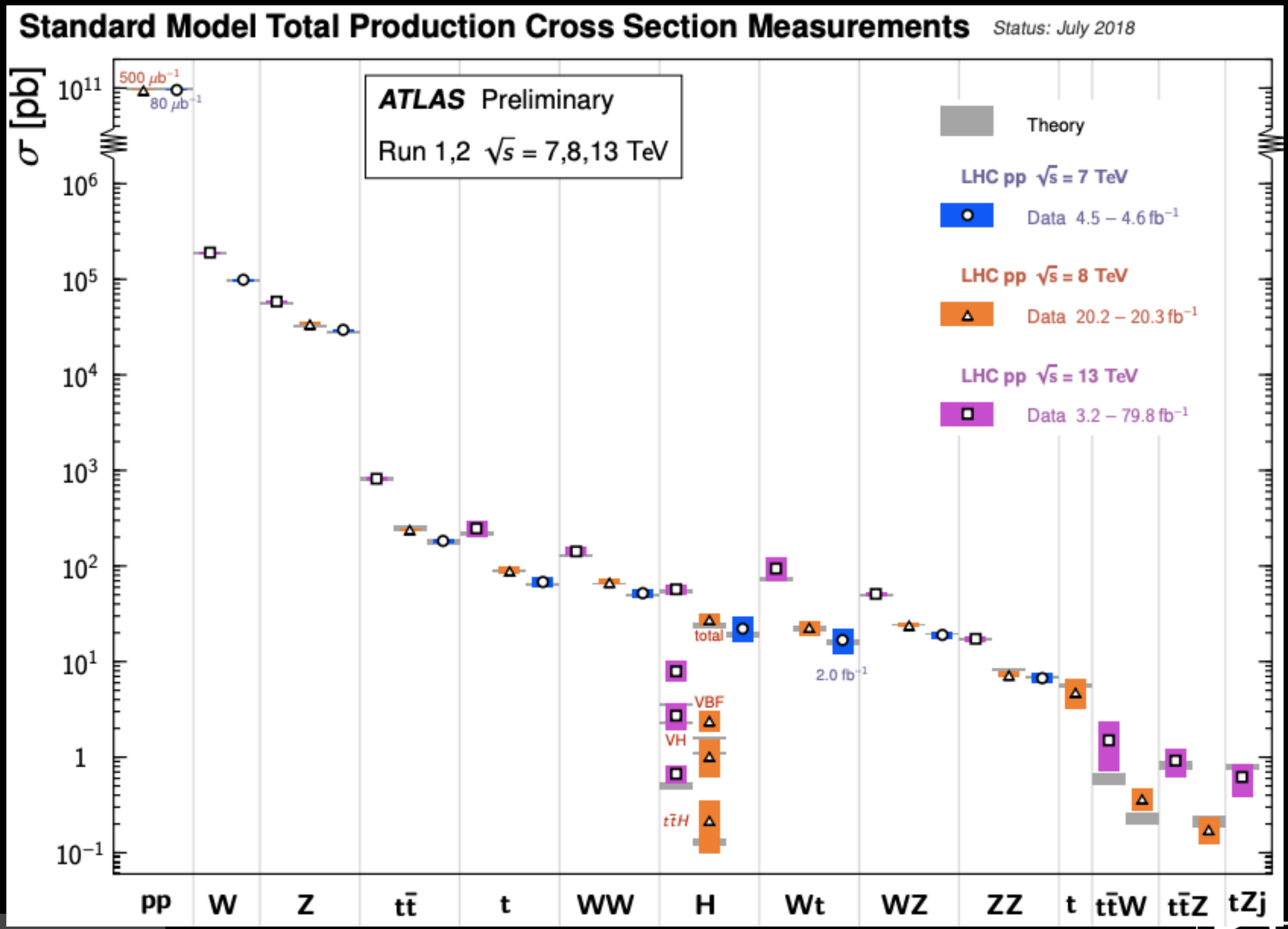
http://ckmfitter.in2p3.fr/www/results/plots_summer18/ckm_res_summer18.html



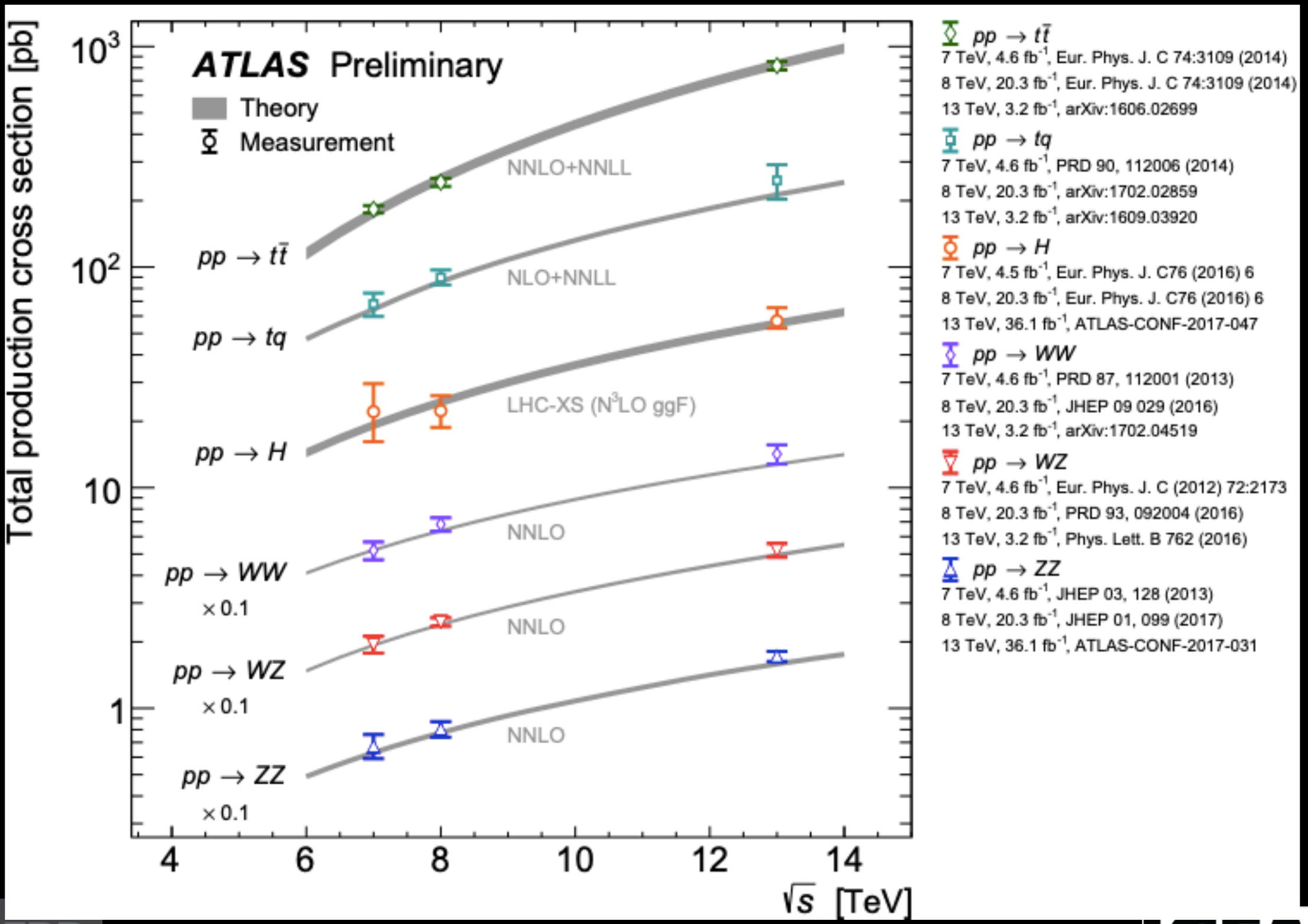
# Precision Flavour …



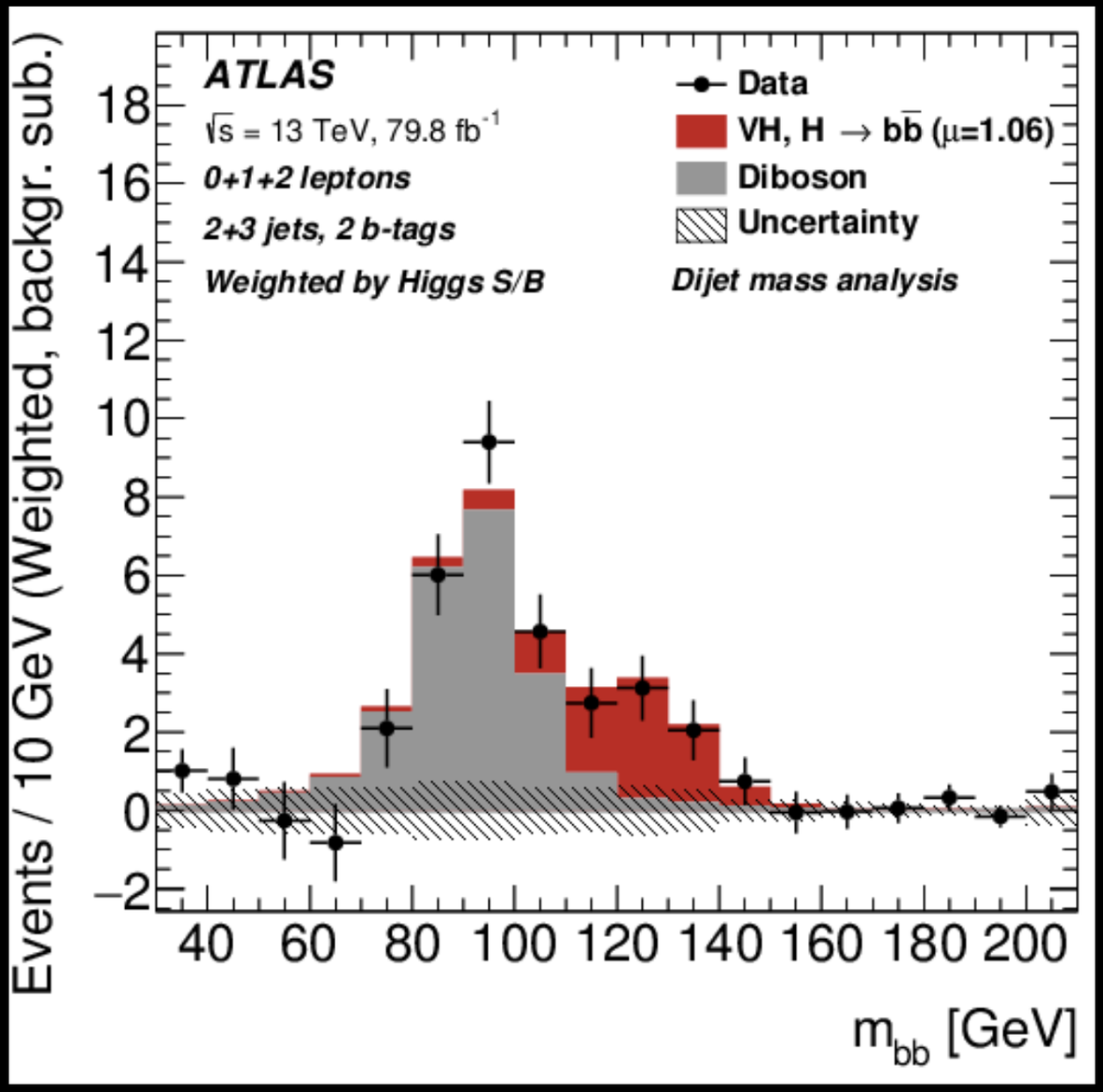
# Precision Era ...

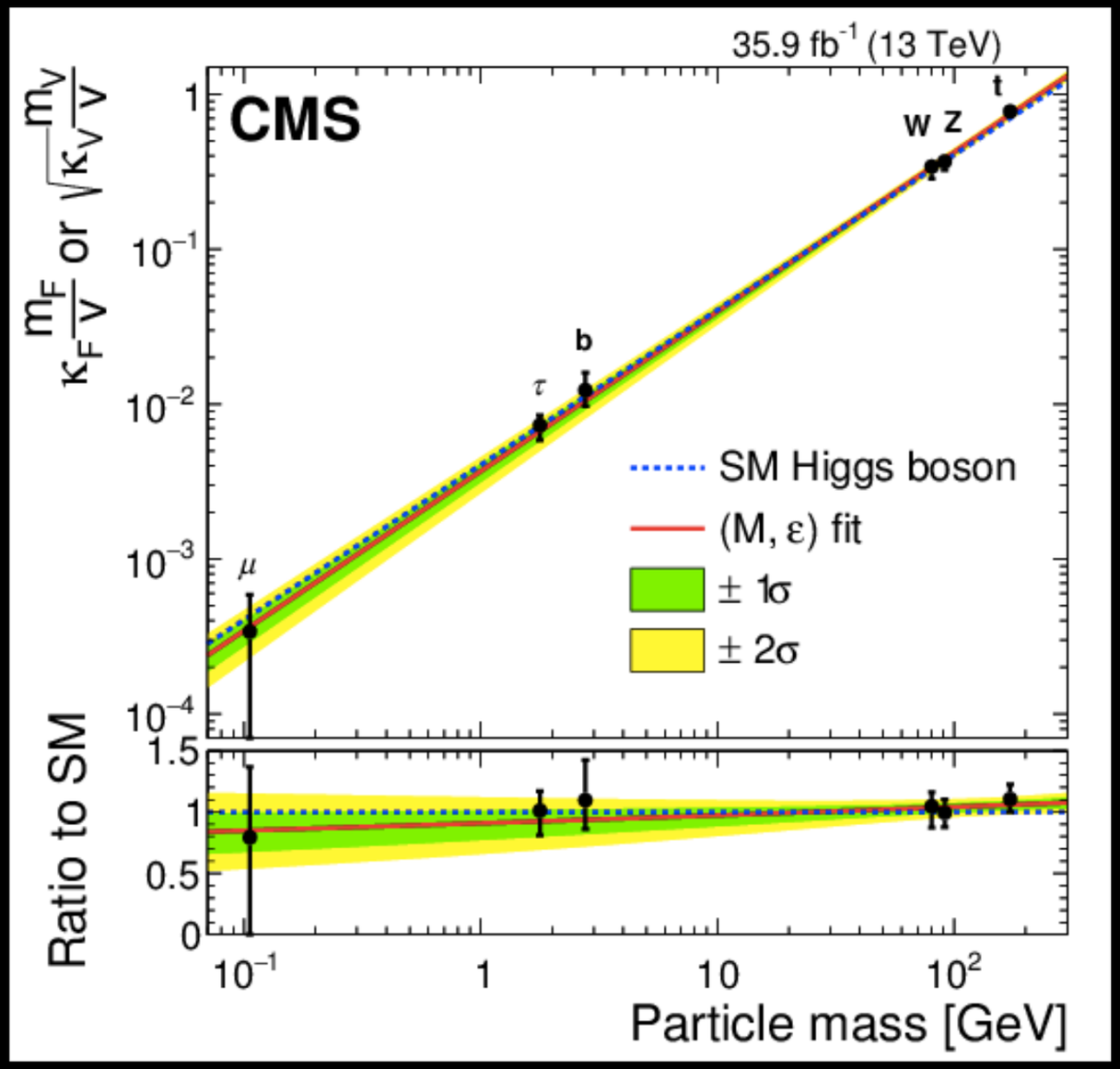


# Precision Era ...

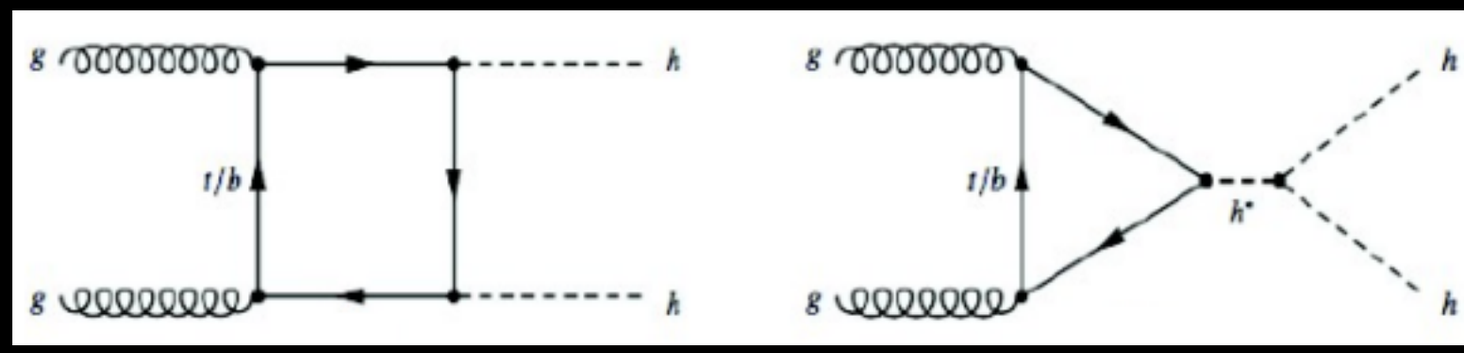


# LHC Precision …




**To be greatly expanded by HL-LHC, incl. coupling to boson and fermions and, perhaps most importantly, triple-H coupling?**



# Precision Era

***ALL CURRENT EXPERIMENTS SEARCHING FOR SUBTLE EFFECTS***
***- PRECISION IS ESSENTIAL -***

- **LHC - ATLAS/CMS:** Following clear distinct Higgs boson discovery (directed search), no new outstanding objects found (now no clear target) - High energy but also outstanding precision.
- **HL-LHC:** Construction well underway - precision key even at highest available energy
- **Belle II / LHCb:** Can quantum corrections uncover unknown particles/ processes - remarkable precision required and possible.
- **Neutrinos (LBNF/DUNE, J-Parc/HyperK, JUNO):** Mass Hierarchy; CP Violation; Majorana?? - precision essential
- **Dark Matter Experiments:** huge range of precision experiments - no clear particle target
- **Particle Astrophysics**
- **EDM-n,** $0\nu\beta\beta$ **, ...**

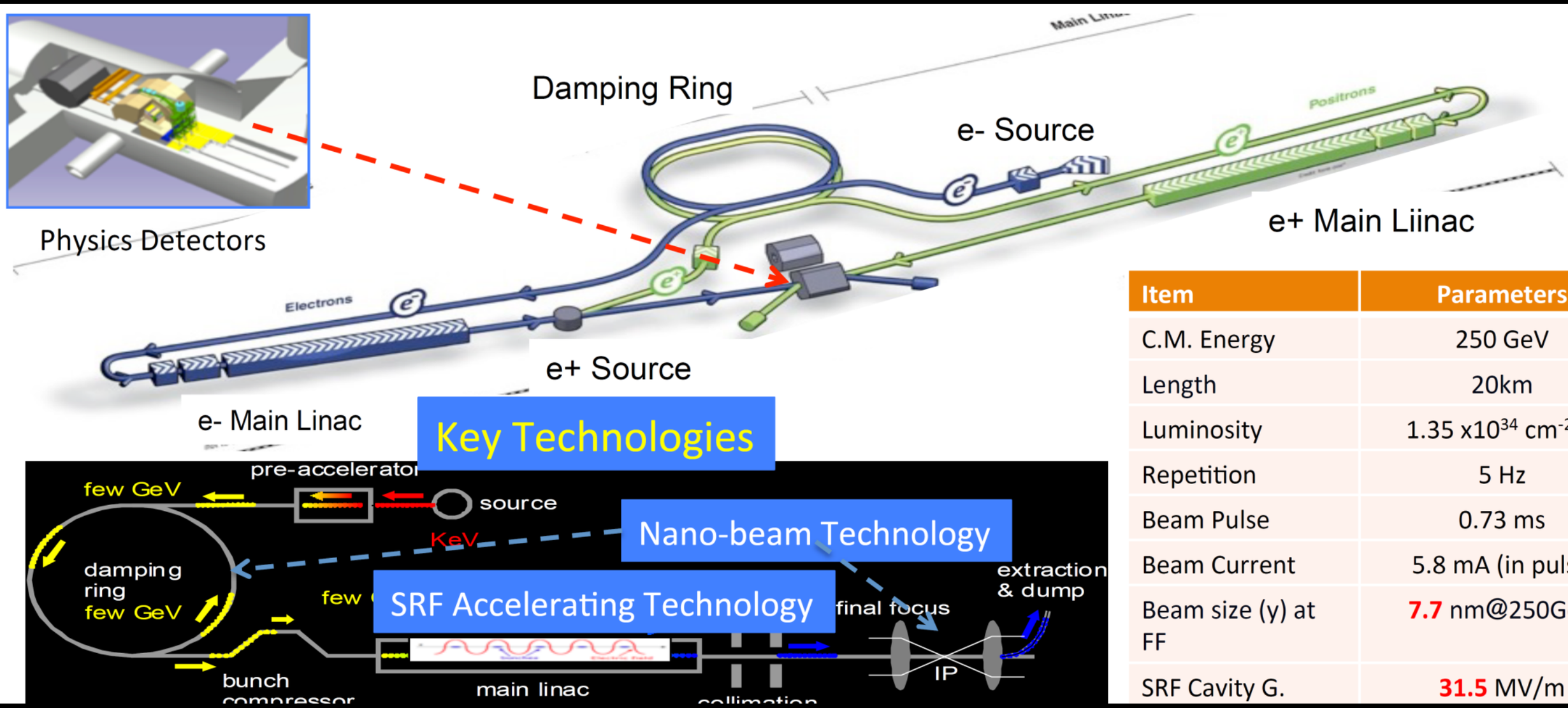
# Never a shortage of options …

- Neutrino Physics
  - *DUNE/LBNF and J-Parc/Hyper-K, from ~2025-26*
  - *Beyond ??? muon-storage-ring neutrino source?*
  - *Reactor Neutrinos - JUNO*
- Flavour Factories
  - *Belle II, LHCb through 2026, 2023?*
  - *Beyond? 100km e+e- as Tera-Z as flavour source?*
- Proton Colliders
  - *LHC, HL-LHC 2026-2036*
  - *… perhaps ~30TeV HE-LHC*
  - *… perhaps ~100TeV 100km facility - SppC, FCC-hh*
- Electron-positron Colliders
  - *ILC, CLIC … linear machines 250GeV to multi-TeV*
  - *CEPC, FCC-ee … circular 90, 160, 250, 370 GeV*
- Perhaps e-H collider?
  - *Precision PDF for precision era*

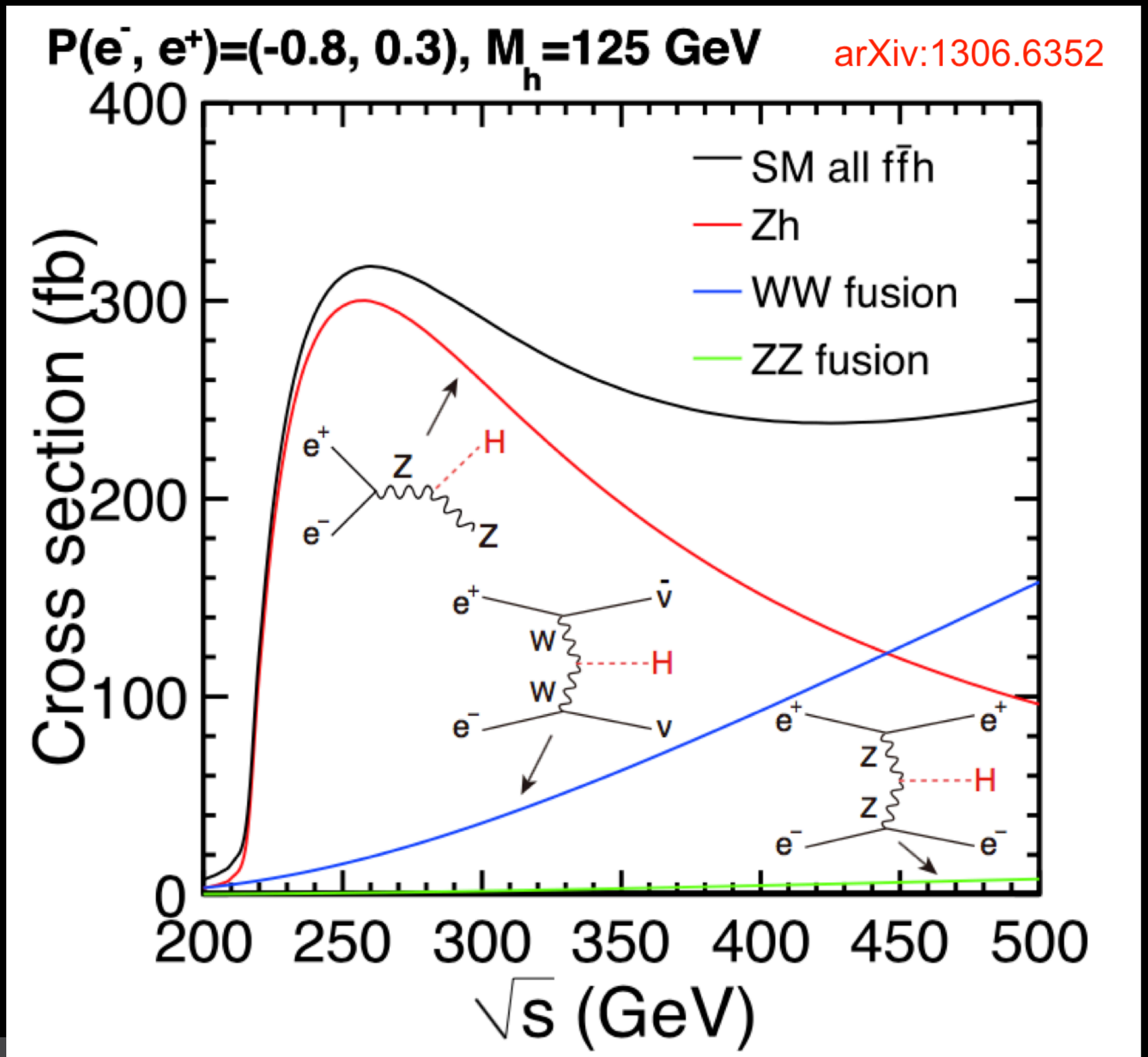
# (Paraphrased) From: FCC Submission to European Strategy Update

- After the Higgs boson, … the precise measurement of Higgs properties and searches for new physics.
  - ➡… strongly motivate the construction of an e+e- Higgs factory and a new pp collider with energy significantly higher than that of the LHC.
- The Higgs boson … spontaneous electroweak symmetry breaking and the mass generation of the known fundamental particles …
  - ➡ important to measure precisely the Higgs-gauge couplings, the Higgs-Yukawa couplings and the Higgs self-couplings.
  - ➡ future Higgs factory would achieve such a goal significantly better than the LHC.
- Such precise measurements also provide an indirect probe for new physics via the Higgs portal.
- … fundamental puzzles such as hierarchy problem and dark matter
  - ➡new physics should emerge at the TeV scale or above.
- A higher energy pp collider crucial for directly exploring new physics either found or not at the LHC.

# ILC250

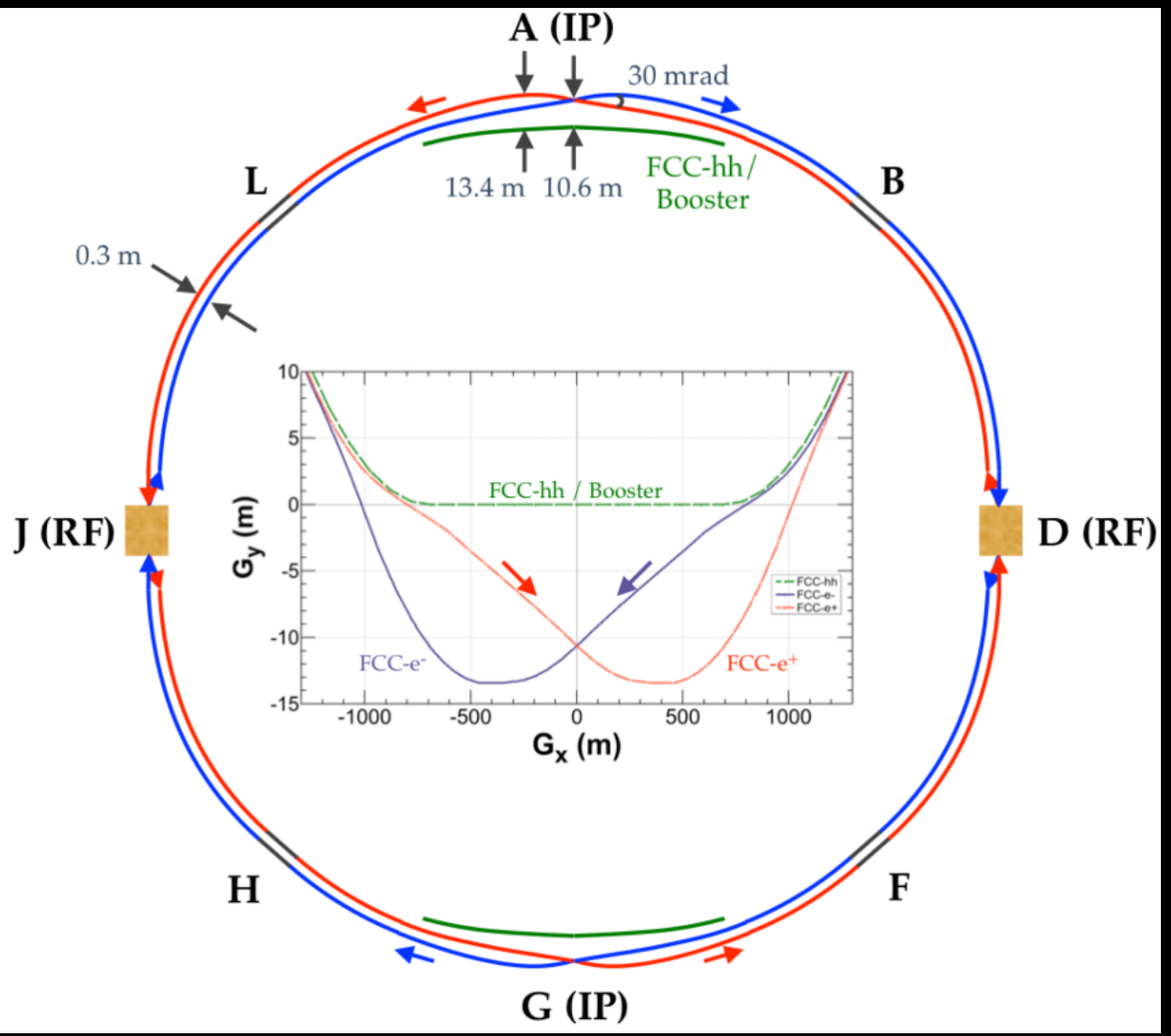



| Item | Parameters |
|---|---|
| C.M. Energy | 250 GeV |
| Length | 20km |
| Luminosity | 1.35 x$10^{34}$ $cm^{-2}s^{-1}$ |
| Repetition | 5 Hz |
| Beam Pulse | 0.73 ms |
| Beam Current | 5.8 mA (in pulse) |
| Beam size (y) at FF | **7.7** nm@250GeV |
| SRF Cavity G. | **31.5** MV/m |

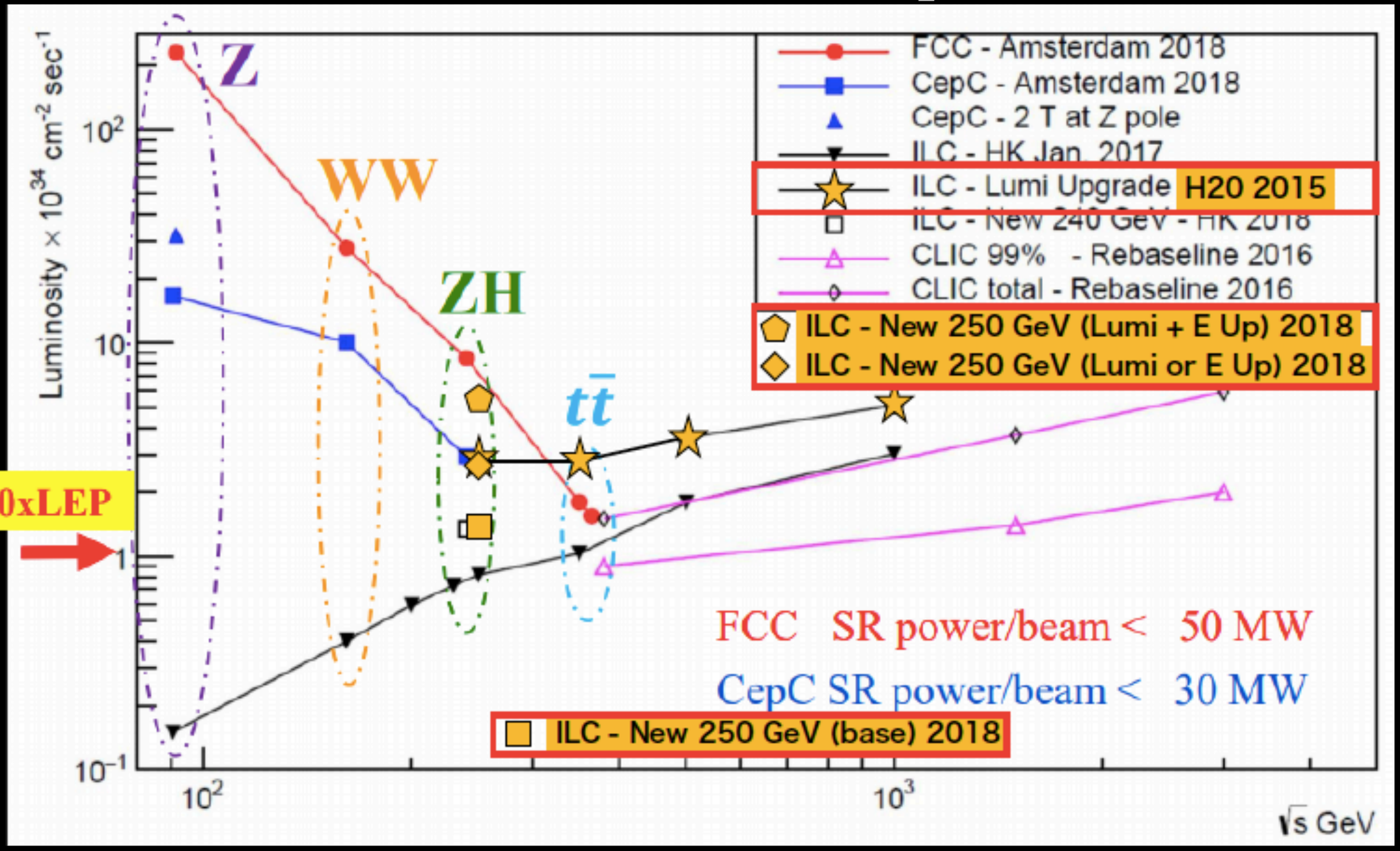

P(e⁻, e⁺)=(-0.8, 0.3), M_h=125 GeV
arXiv:1306.6352
Cross section (fb)
400
300
200
100
0
200 250 300 350 400 450 500
√s (GeV)
SM all ffh
Zh
WW fusion
ZZ fusion
e⁺
e⁻
Z
H
Z
e⁺
ν̄
W
H
W
e⁻
ν
e⁺
e⁺
Z
H
Z
e⁻
e⁻

# 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**

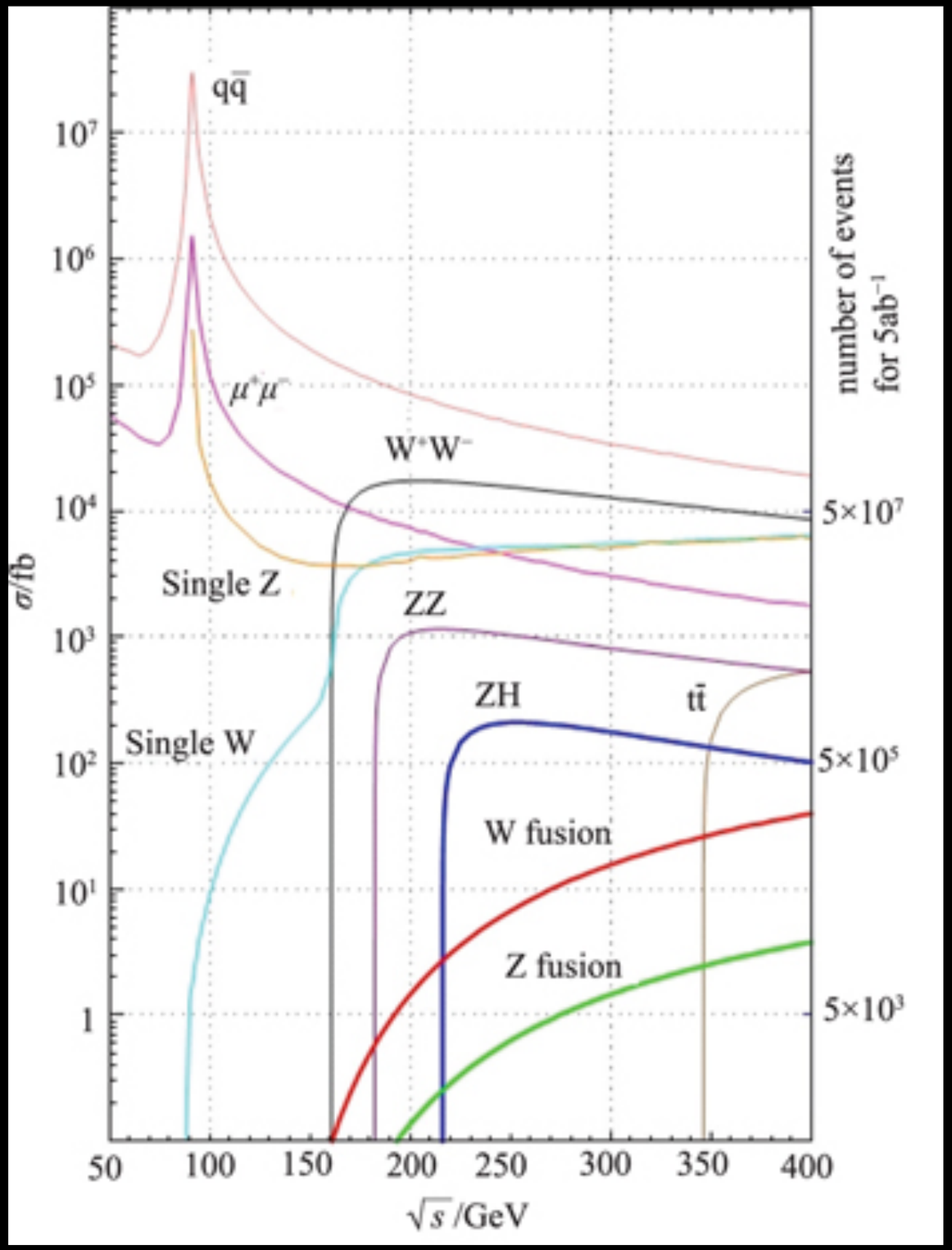


# $e^+e^-$ Lumi Comparison



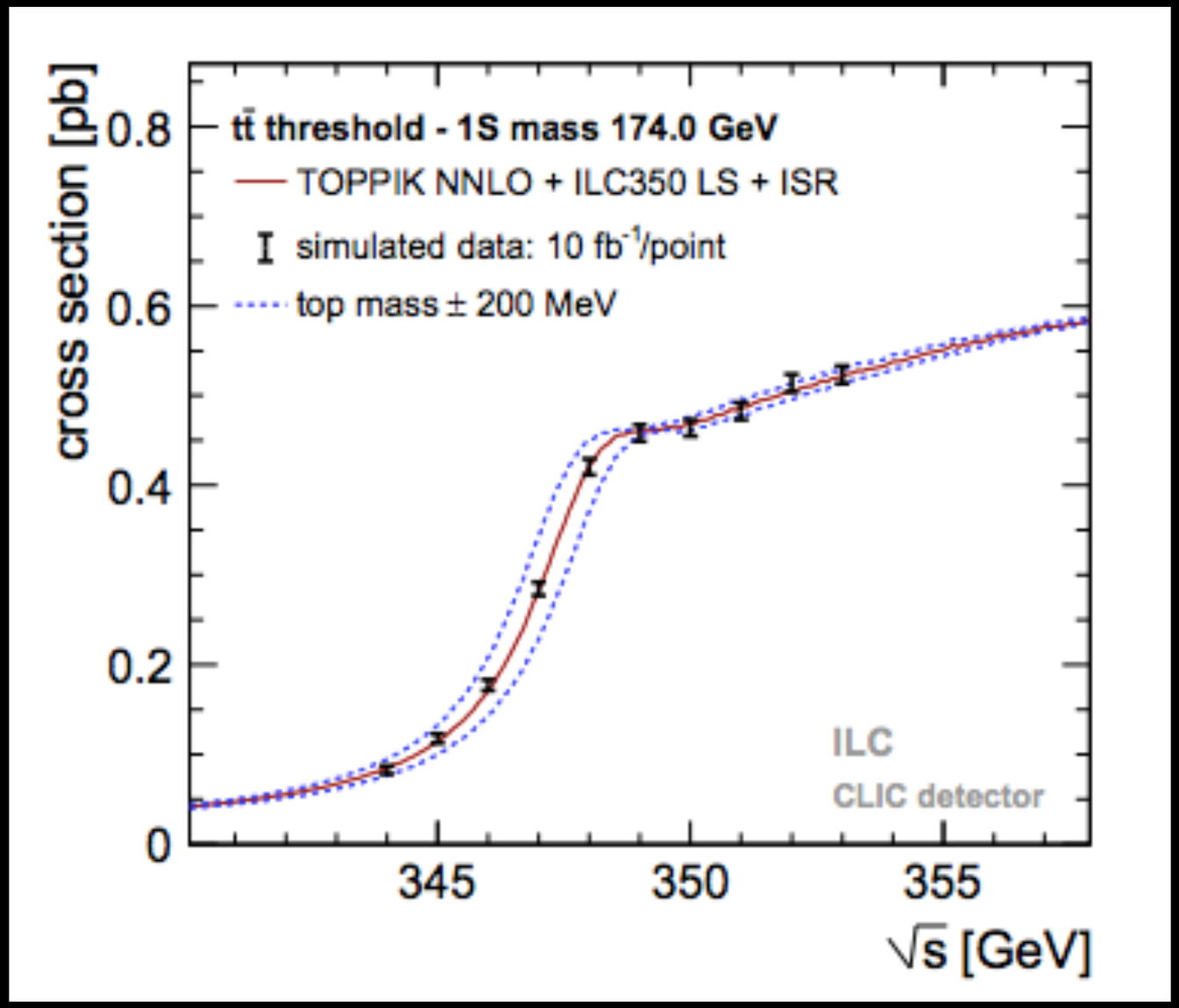

- Original Plot, F. Bedeschi , CEPC Workshop, Rome, May 2018
- Updates Private communication, Keisuke Fujii, IPNS, KEK

# Top-quark threshold
# > 350GeV



# Future Extended Energy - 350-380GeV

arXiv:1611.04492v1 [hep-ex] 14 Nov 2016



# ILC Future Extended Energy - 500GeV

ILC TDR

**500GeV:**
**Higgs self-coupling**

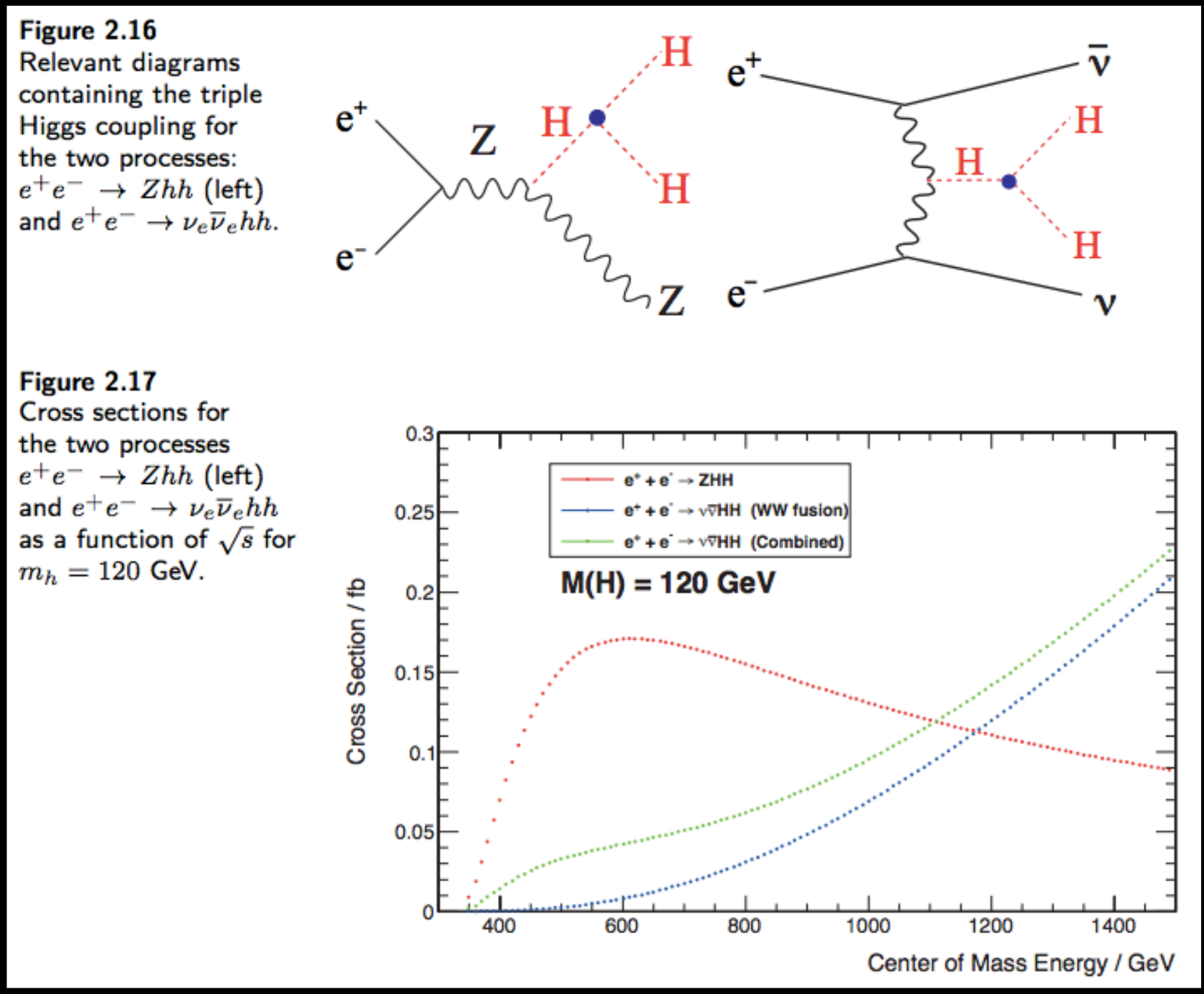
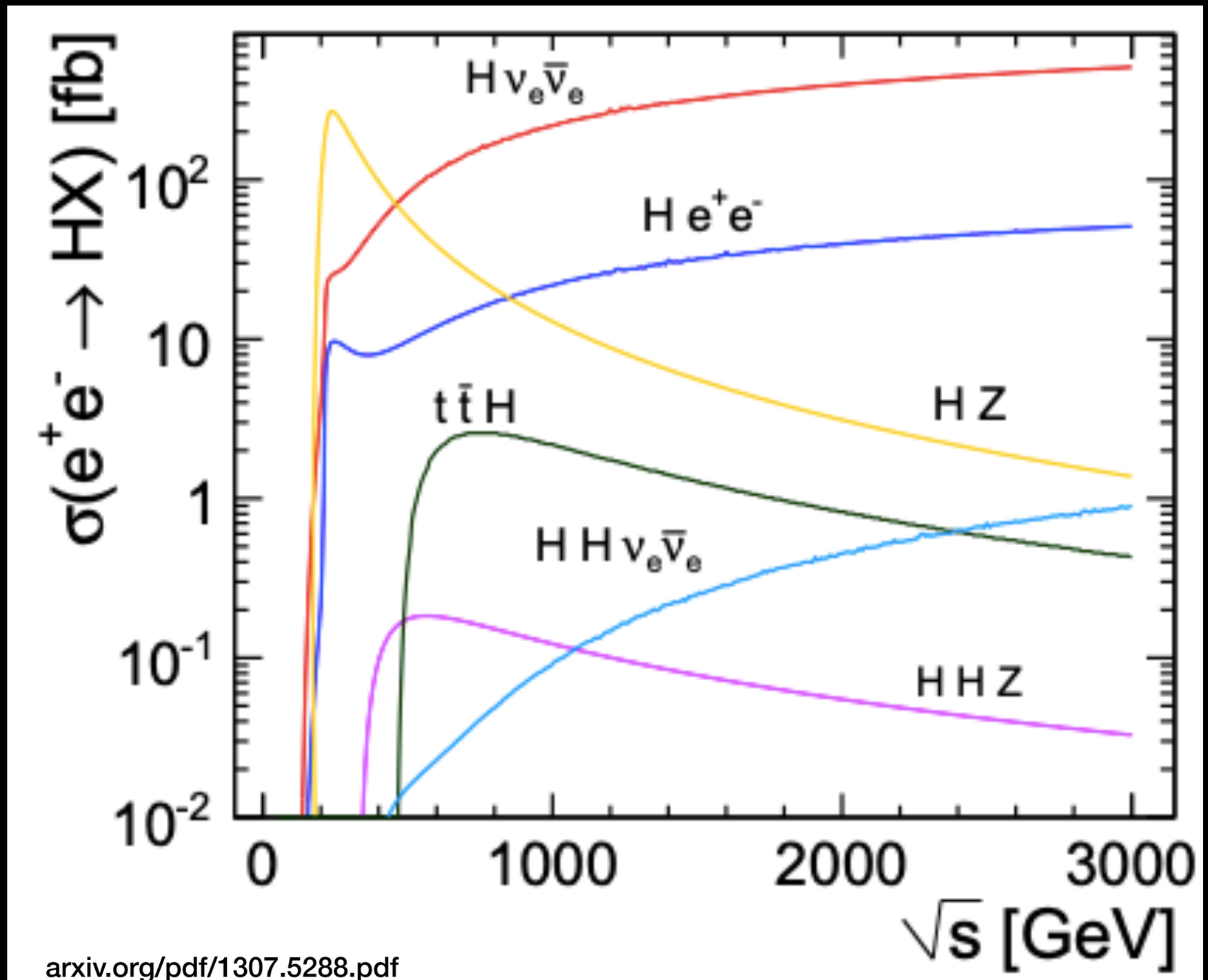



**Figure 2.16**
Relevant diagrams containing the triple Higgs coupling for the two processes: $e^+e^- \to Zhh$ (left) and $e^+e^- \to \nu_e\bar{\nu}_e hh$.

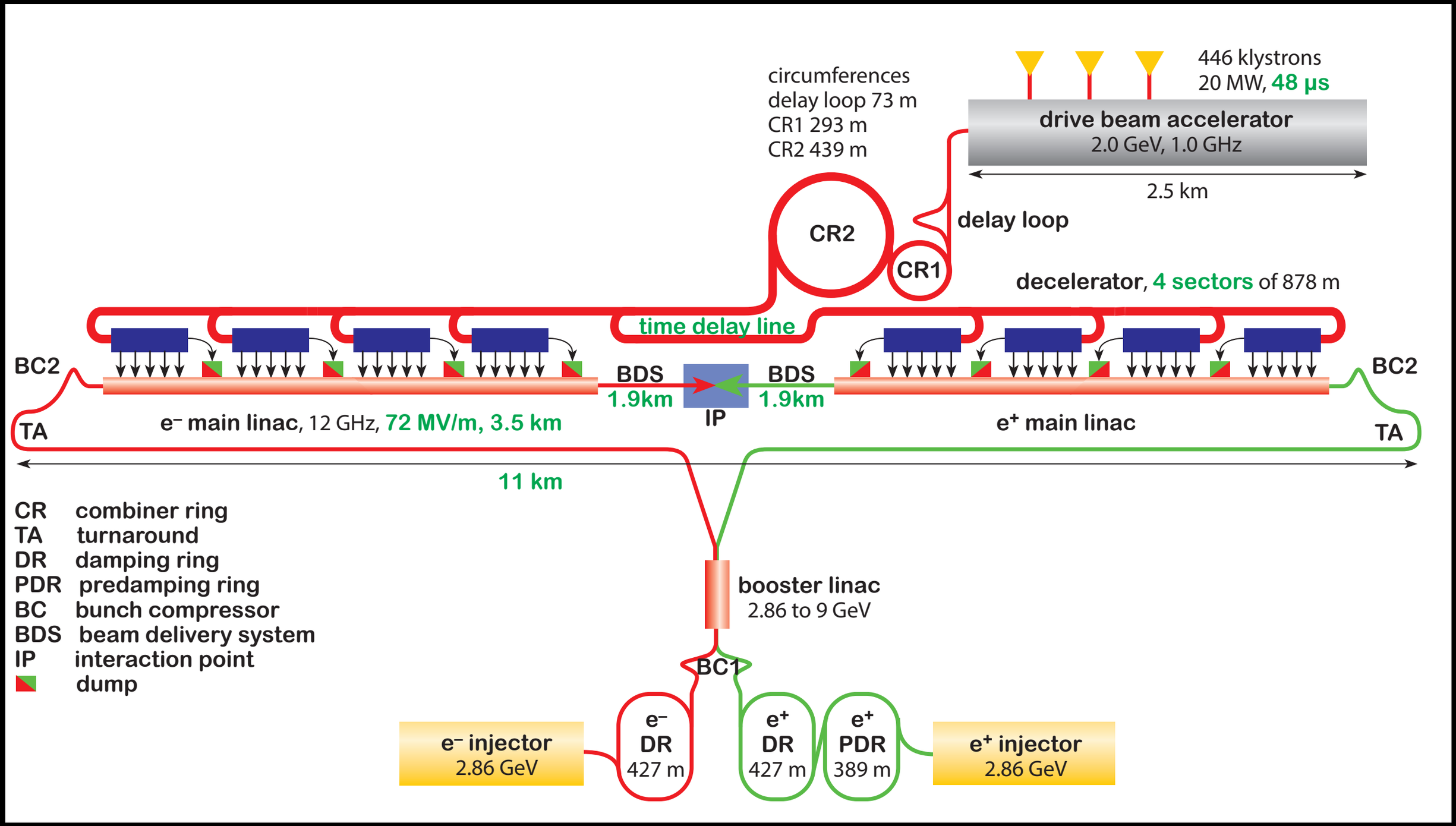
**Figure 2.17**
Cross sections for the two processes $e^+e^- \to Zhh$ (left) and $e^+e^- \to \nu_e\bar{\nu}_e hh$ as a function of $\sqrt{s}$ for $m_h = 120$ GeV.

# … and beyond

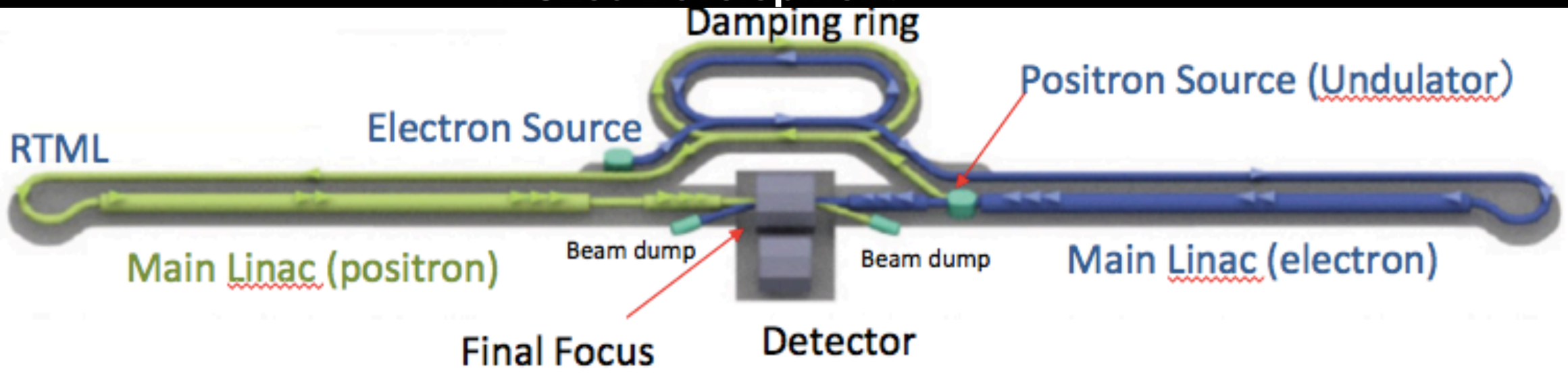



arxiv.org/pdf/1307.5288.pdf

# CLIC

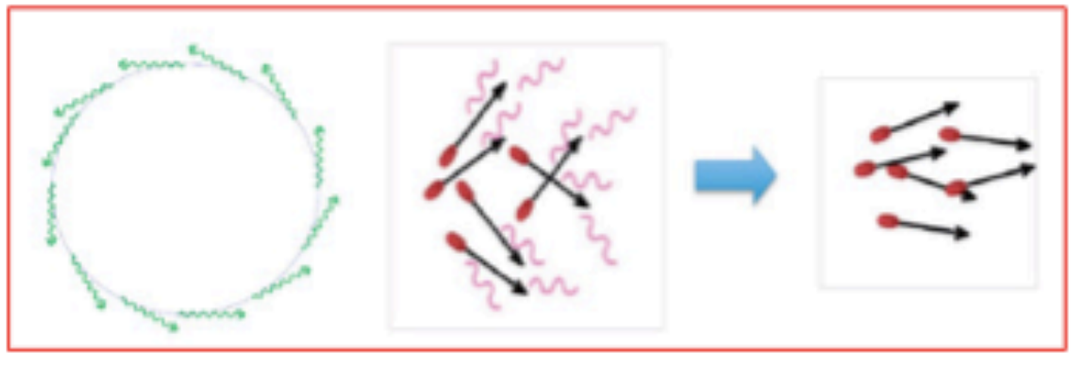

circumferences
delay loop 73 m
CR1 293 m
CR2 439 m
446 klystrons
20 MW, 48 µs
drive beam accelerator
2.0 GeV, 1.0 GHz
2.5 km
delay loop
CR2
CR1
decelerator, 4 sectors of 878 m
time delay line
BC2
BDS
1.9km
IP
BDS
1.9km
BC2
TA
e⁻ main linac, 12 GHz, 72 MV/m, 3.5 km
e⁺ main linac
TA
11 km
CR combiner ring
TA turnaround
DR damping ring
PDR predamping ring
BC bunch compressor
BDS beam delivery system
IP interaction point
dump
booster linac
2.86 to 9 GeV
BC1
e⁻ injector
2.86 GeV
e⁻
DR
427 m
e⁺
DR
427 m
e⁺
PDR
389 m
e⁺ injector
2.86 GeV

# ILC250 Development




**Best performance by combining state-of-the-art technology**

- Sources ***Electron/positron***
  - Polarized electron/positron
- High quality beam ***Damping ring***
  - Low emittance beam
    - Small-size
    - Parallel beam
- Beam Transport ***RTML***
  - Bunch compressor
- Beam acceleration ***Main linac***
  - Superconducting RF acceleration
- Beam collision ***Final focus***
  - Nano-meter beam



Low emittance beam at damping ring

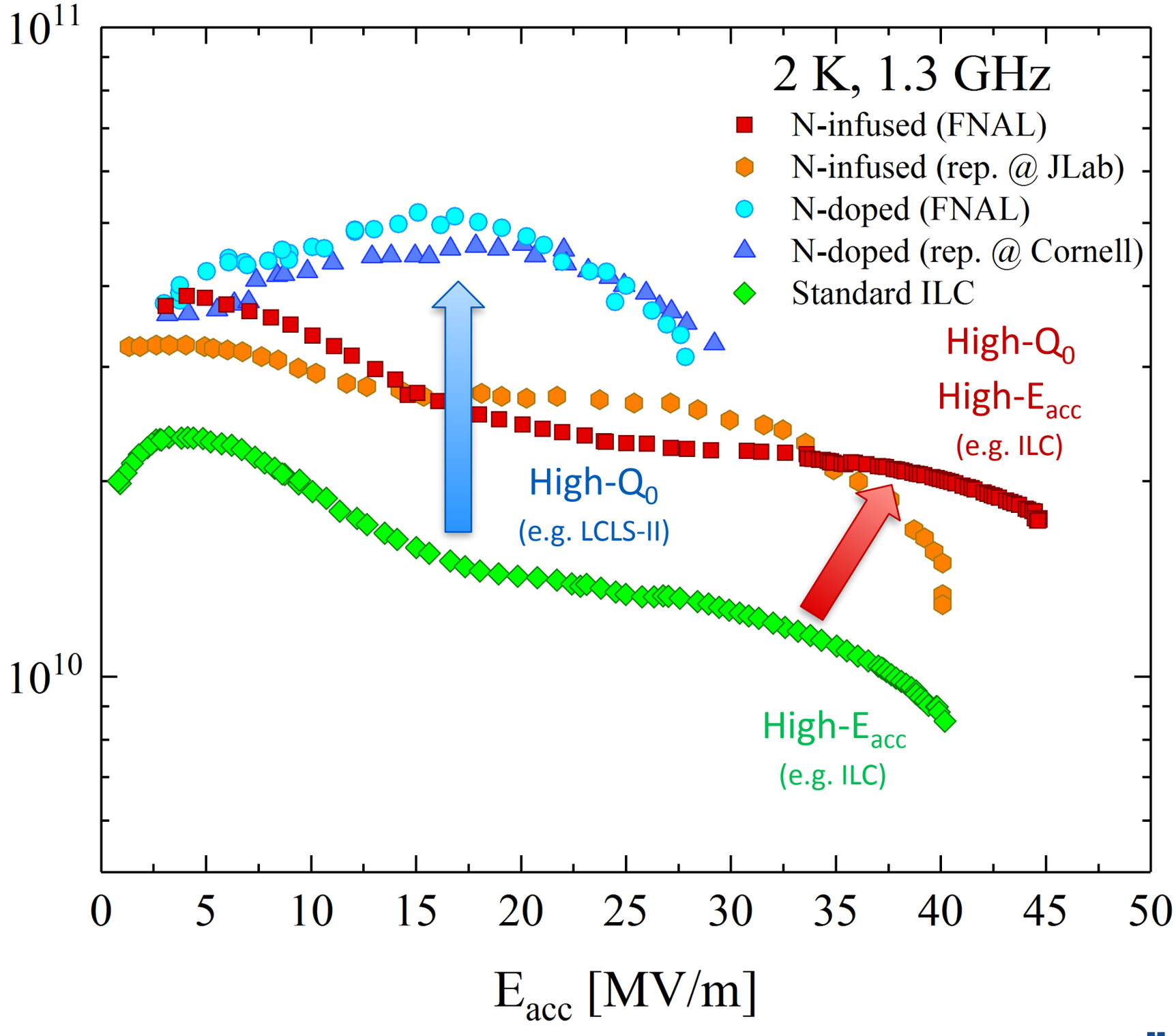
1.3GHz（L-band) SRF cavity

11

# *Superconducting RF Development*

- Remarkable Progress
  - *Increased Acceleration Gradient:*
    - Increased operating margins?
      - Higher energy at fixed tunnel length
  - *Increased Q*
    - Reduced thermal losses
    - Reduced cryogenics

# State-of-the-art treatments






Fermilab

# A Critical Moment for ILC

- After many years of analysis, design and preparation …
- With the benefit of a low-mass Higgs …
- In an environment with complementary/ competitive proposals but with strong international support …

**Japan must make the next move! …**

**… and make it now.**

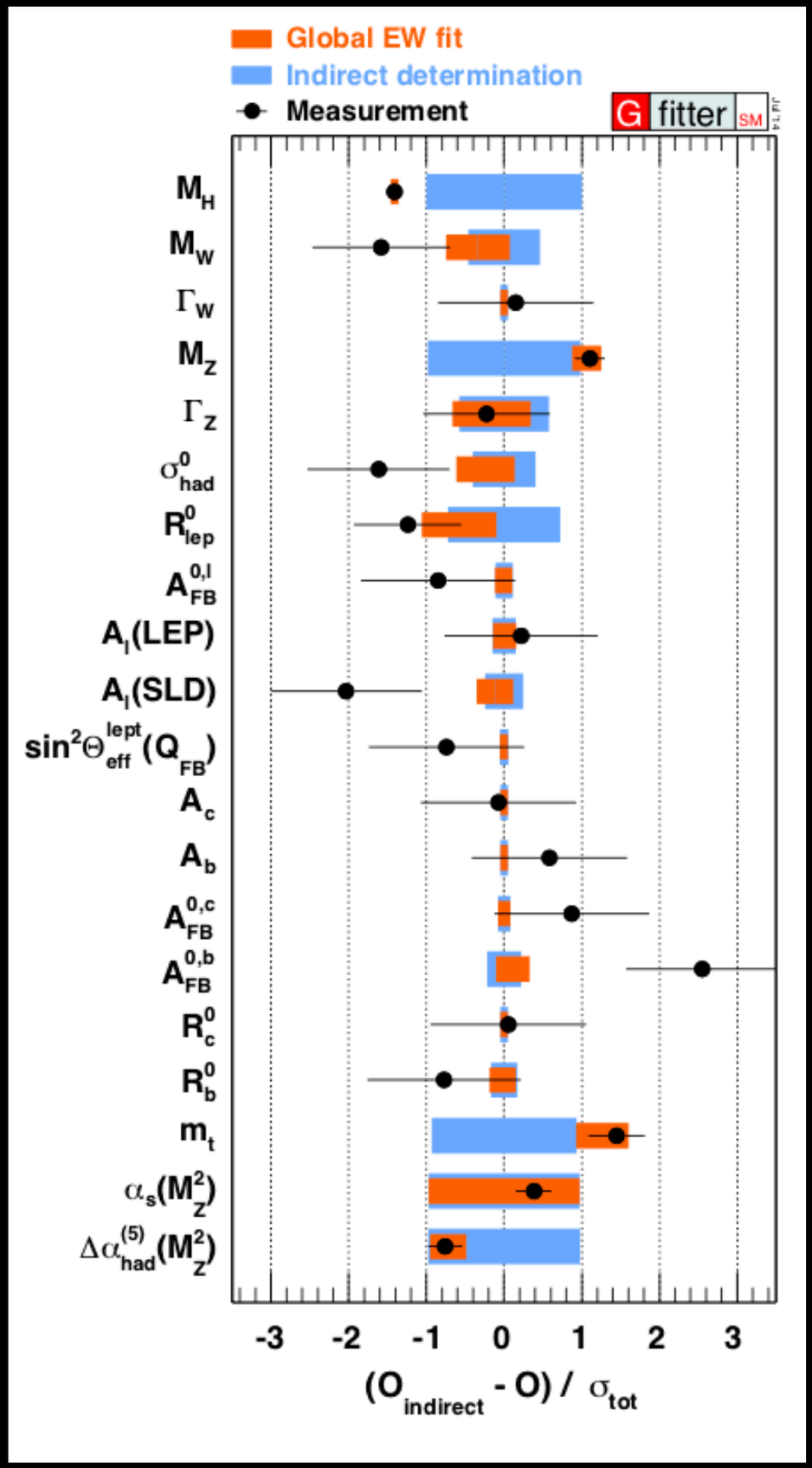
# Some Lessons from History?

1. SLC and LEP: Precision Z-boson, …

- *SLC: new technology using existing facilities*
- *SLC: luminosity limited, reliability*
- *LEP: new scale (27km), new tunnel, relatively straightforward technology*
- *LEP: provided a decade of major successes*
  - *and Tunnel for LHC*
- *SLC: groundbreaking LC, SLD: $A_{LR}$*

## Aside:

- SLD FB asymmetry STILL important in SM fits
- The longterm benefit of polarised beams is surprising.
- Lesson (?): Don't give up on options too early



# Some Lessons from History?

2. SSC and LHC: Higgs Search, …

- *SSC: identified benefit of large radius facility!*
- *Began as a National facility:*
  - Funding continuity was not guaranteed
  - Design and Management: Cost control issues
    - *"Tunnel Visions. The Rise and Fall of the SSC",Michael Riordan, Lilljan Hoddeson and Adrienne W. Kolb University of Chicago Press, 2015*
  - International support/participation/partnering came late
- *CERN site/experience, LEP tunnel: Success for LHC*
- *LHC: Magnet Technology - "stretch goal"*
  - Major 2008 magnet incident highlighted vulnerability
  - Design, management, technology expertise saved LHC
- *SSC Cancellation: US Physicists moved to LHC.*
- *LHC: excellent example of international cooperation.*
  - Major success story

# Some Lessons from History?

3. KEKB, PEPII, LHCb

- *Rich, successful program with constructive competition between Belle and Babar, and LHCb*
  - Both B-factories built at established laboratories
  - LHCb a very successful aspect of the LHC program
- *After SuperB Factory (Europe) demise*
  - Strong Babar migration to SuperKEKB/Belle II
- *Complementarity of Belle II & LHCb remains*

*(TRISTAN - physics desert, but led to KEKB, SuperKEKB)*

# ALL MAJOR DECISIONS MUST BE BY "INTERNATIONAL CONSENSUS"

- Difficult but we have generally succeeded.
  - *Even advising each others' nations/regions in their priority setting and decisions*
- Facilities getting larger
  - *Require Resources on Very Large Scale*
  - *Timescales Very Long*
- Our Field needs to be even better organised

# Warning (perhaps!)

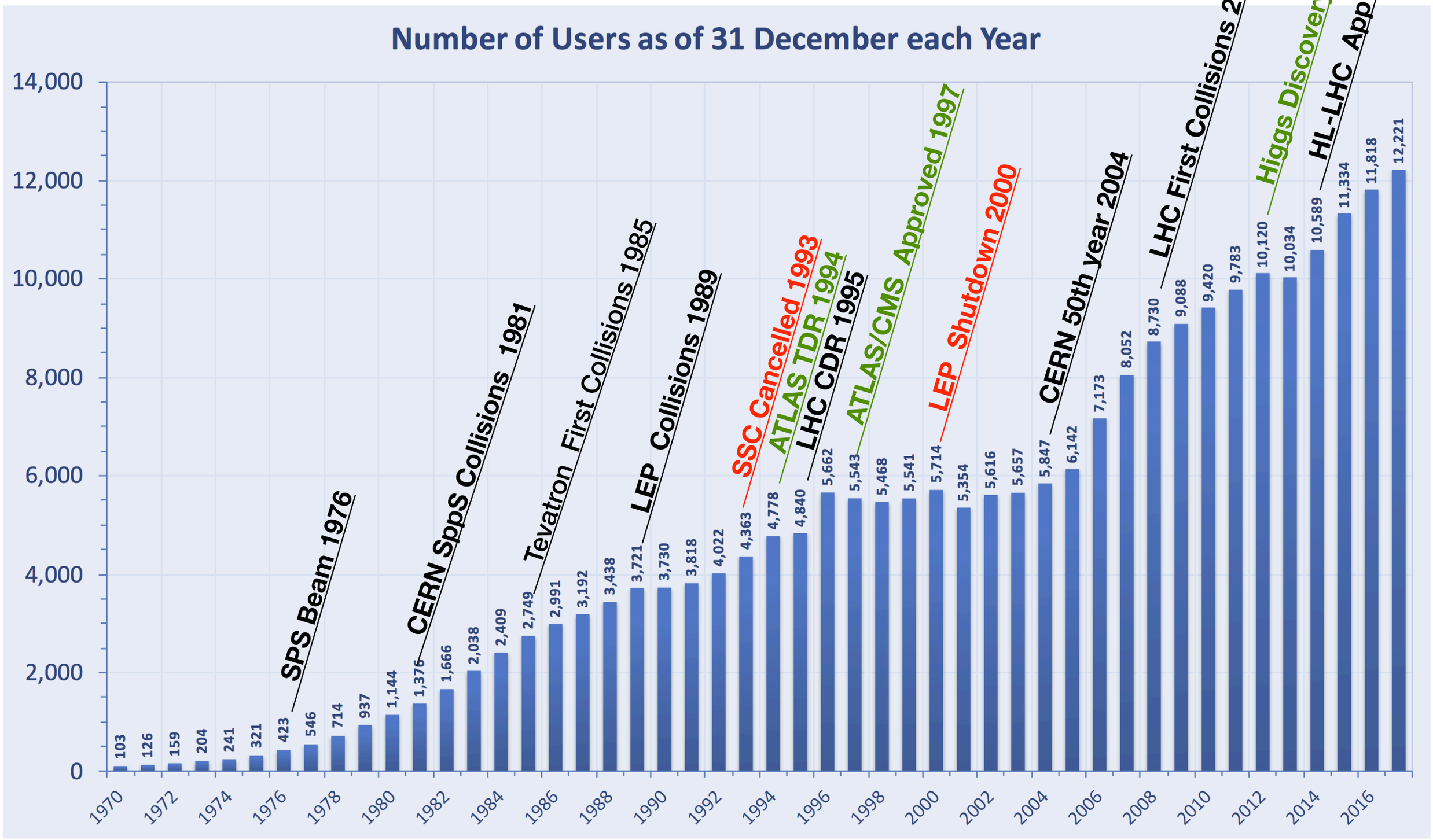
- The LHC is the only successful $Multi-Billion HEP project to date. That was with the CERN budget at its base, and sited at CERN.
  - *And significant international contributions sought early*
- Crossing the threshold to Billions, even though evolutionary, crosses a psychological boundary.
  - *It gets noticed!*
- The SSC showed that governments want much stronger control over multi-billion dollar projects.
  - *Needs managing. Kept in physicists' hands!!!*
- The next frontier machine needs major commitment to political support, and when (if) supported will need to be very well managed for the future  of our field.

# HEP is International

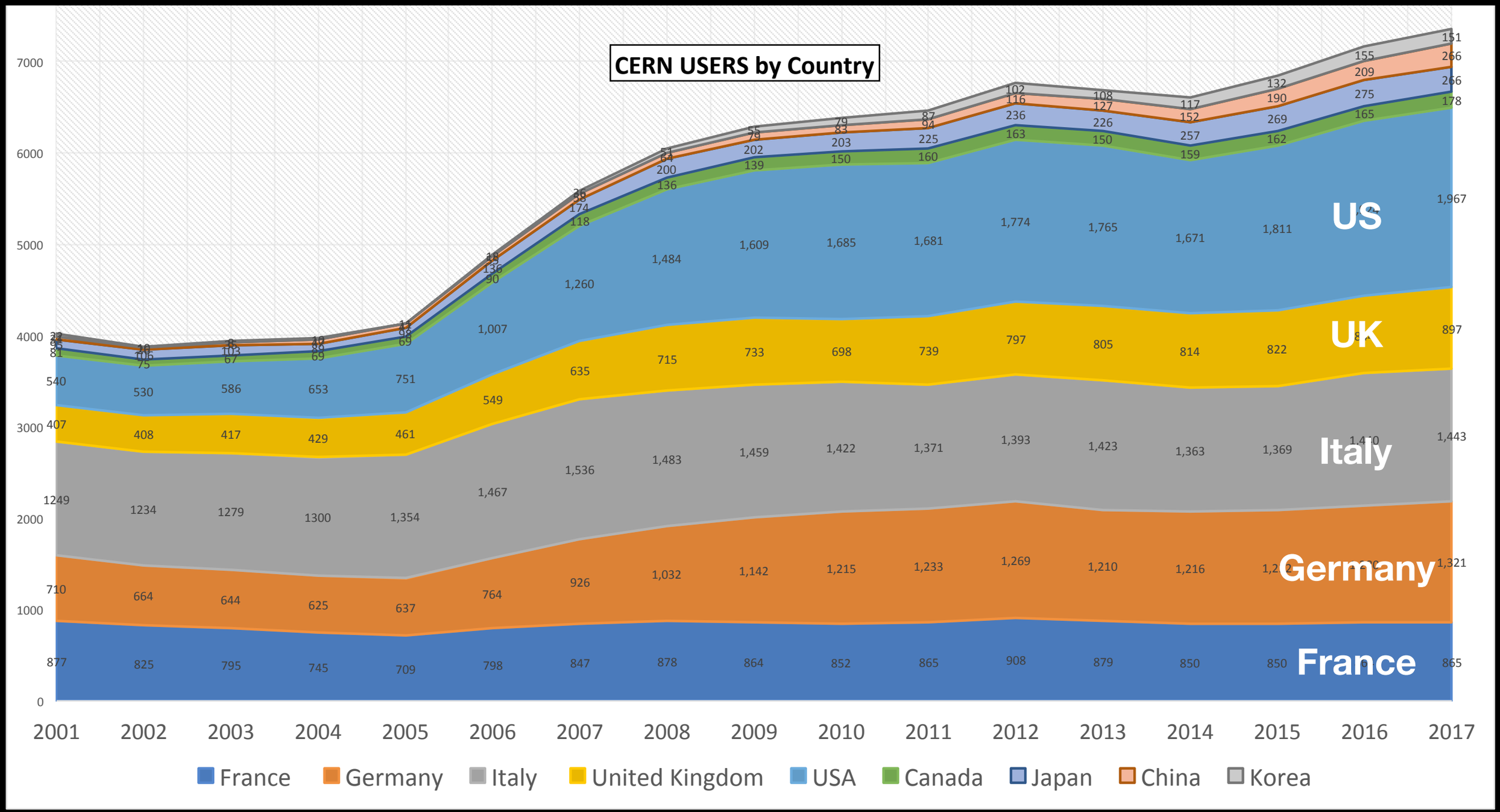
- Nature has Cycles
- International Roles Cycle too:
  - *Economic strength*
  - *Political Will*
  - *Science and Technology Focus*
- Embrace Change
- Exploit Opportunity
- Create Capacity
- Consensus (Compromise??) required

# People are our most important resource

# CERN Users


Number of Users as of 31 December each Year
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
SPS Beam 1976
CERN SppS Collisions 1981
Tevatron First Collisions 1985
LEP Collisions 1989
SSC Cancelled 1993
ATLAS TDR 1994
LHC CDR 1995
ATLAS/CMS Approved 1997
LEP Shutdown 2000
CERN 50th year 2004
LHC First Collisions 2008
Higgs Discovery 2012
HL-LHC App'l 2014
103
126
159
204
241
321
423
546
714
937
1,144
1,376
1,666
2,038
2,409
2,749
2,991
3,192
3,438
3,721
3,730
3,818
4,022
4,363
4,778
4,840
5,662
5,543
5,468
5,541
5,714
5,354
5,616
5,657
5,847
6,142
7,173
8,052
8,730
9,088
9,420
9,783
10,120
10,034
10,589
11,334
11,818
12,221

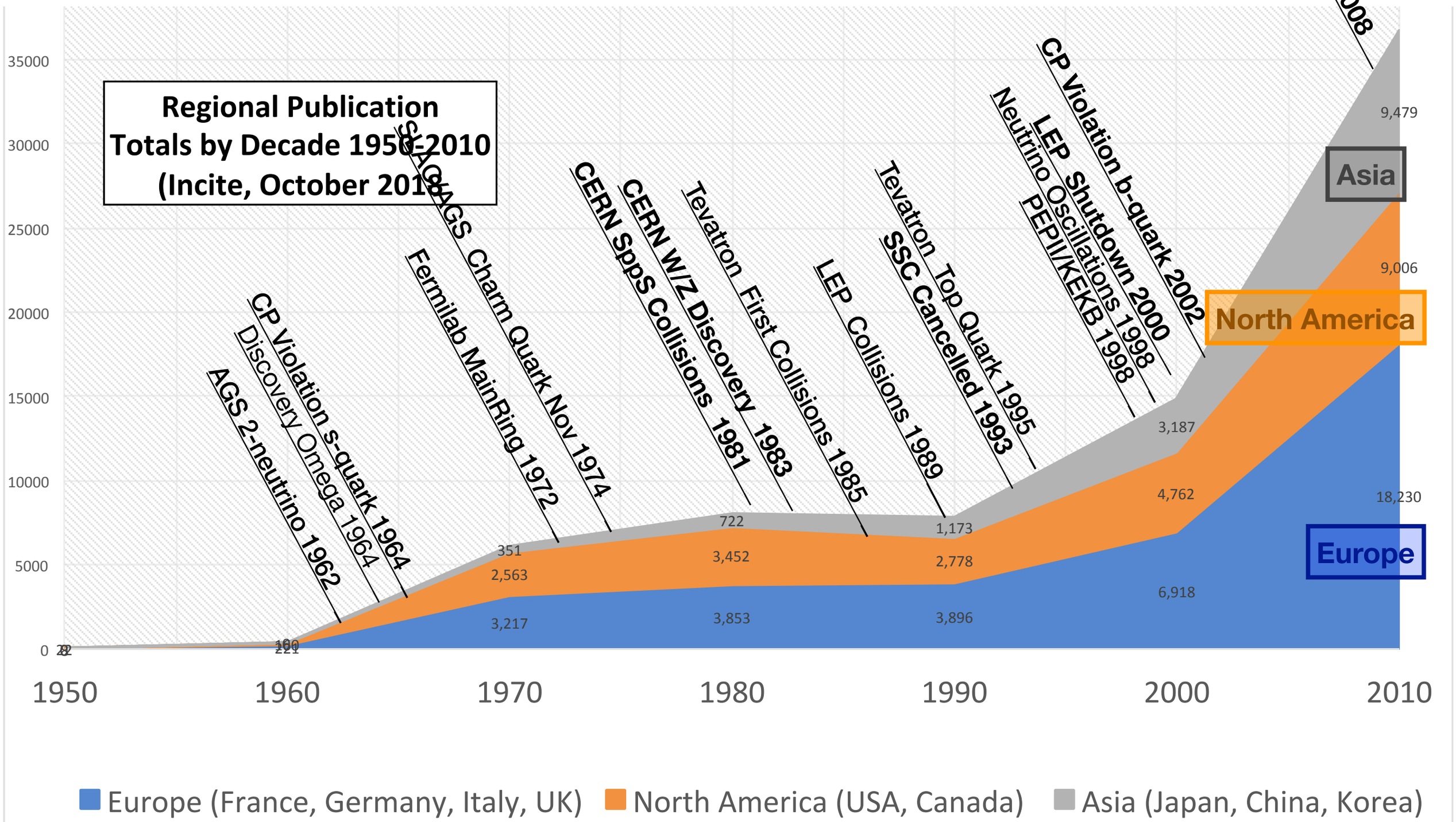
# CERN User Snapshot



# HEP Expt'l Publications

## - All Regions Benefit -

( Inspire, October 2018)



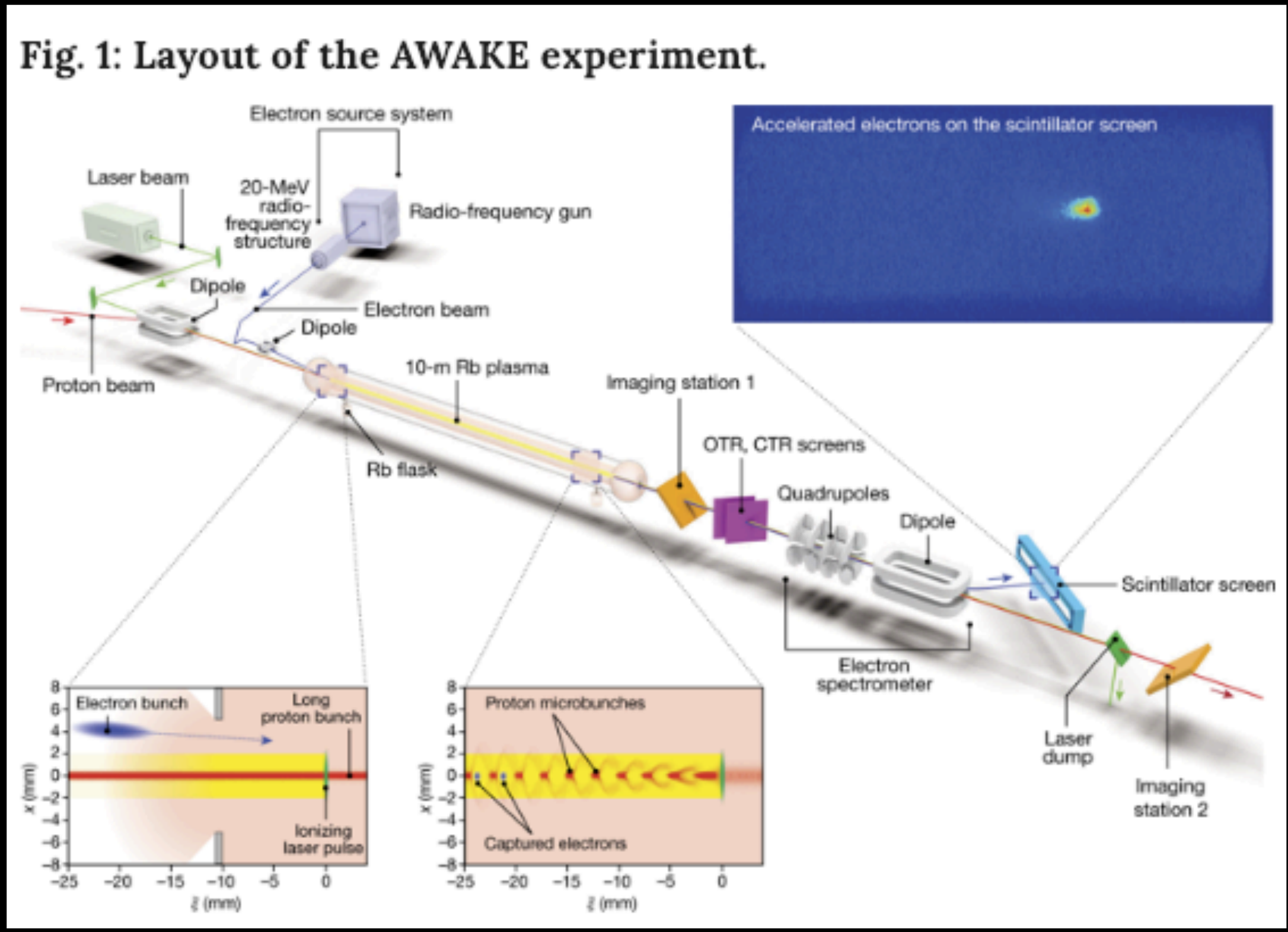
# International Focus has been Flexible

- History shows that our community will go where the facilities are built
- Our community generates improved outcomes at the facilities/laboratories wherever they are situated.
- The growth seen since the beginning of LHC era can be maintained with expanded facilities

# Future Scenario?

- **HL-LHC (2026-2036)**
  - *Approved; Improved searches, Higgs improved precision measurements.*
- **CERN Beyond HL-LHC?**
  - *Option: HE-LHC (28-35 TeV) …from ~2040??*
  - *e-h, Heavy Ion options too.*
  - *CERN: FCC (ee) followed by FCC(hh) and FCC(eh)*
- **ILC250 - Higgs Factory extendable to Top and Multi-Higgs**
  - *Capability to extend to 380GeV and 500GeV?*
  - *Keep longer term capacity for CLIC style 2-beam acceleration >1 TeV*
  - *Perhaps longer term capacity for addition of plasma or laser wake-field sectors - Linear geometry can lend itself better to new techniques?*
- **100km CEPC or FCC(ee) - Precision SM, Higgs Factory**
  - *Giga-Z, W+W-, Higgs Factory 250 GeV*
  - *Capacity for Top physics - tt threshold scan?*
- **Future High Energy Frontier - 100 TeV pp Collider**
  - *Very Large Price-tag.*
  - *Long-term capacity for protons in e+e- tunnel ??*
  - *CERN has infrastructure and expertise*
    - *Value of 100km Tunnel?? $5B*
    - *Value of CERN proton infrastructure (incl. HL-LHC) as injector $10B??*

# The Field Needs New Acceleration Techniques




"Acceleration of electrons in the plasma wakefield of a proton bunch", E. Adli, et al., Nature Vol 561, 363–367 (2018)

# Justification (???)

- CERN is a critical foundation for the field.
  - *Must be maintained.*
  - *At least a 3-decade program at the energy frontier already foreseen!*
  - *Uniquely provides support for a large range of activities on site and internationally*
- CERN leads in high energy proton capability
  - *HL-LHC schedule well underway*
  - *Decades of experience*
    - *Large group of SC Magnet Specialists*
- Maintain High Energy Proton Collider for direct discovery
  - *HE-LHC (?)*
    - *16T Dipoles -> 27TeV;  20T -> 35TeV*
  - *Is this really the moment for serious resource discussions for 100TeV at CERN or elsewhere?*
    - *Multi-tens of billions of Dollars will require specific goals.*
    - *Need strong Physics case.*
    - *Need major cost reduction in magnets*

# Justification (???)

- ILC: linear machine has energy expansion capacity
  - *Initially: 250GeV Higgs factory (ZH)*
  - *Mature design, community well prepared for next step*
  - *SC-RF progress - 380GeV (maybe 500GeV) possible*
- Circular machine:
  - *Excellent Luminosity at low energy*
    - *Giga-Z, W+W- production.*
    - *Precision SM*
  - *Overlap with ILC at 250-370GeV*
    - *Redundancy, systematics check*
    - *Removes need for push-pull detectors at ILC (??)*
  - *Fixed radius - maximum energy is wall-power limited!*
- China new, major player in HEP
  - *CEPC would come with new (Chinese) resources*

# ILC - March Announcement!

- Strong International Support
  - *Critical SC RF development across continents*
  - *Strong detector/physics commitment*
- Many preparations are advanced
  - *TDR, SC/RF, Klystron Efficiency, Site selection, ….*
- Major US commitments (DUNE/LBNF) compatible with ILC Schedule
- Major Japan commitments (SuperKEKB/ BelleII, J-Parc/HyperK) compatible with ILC Schedule

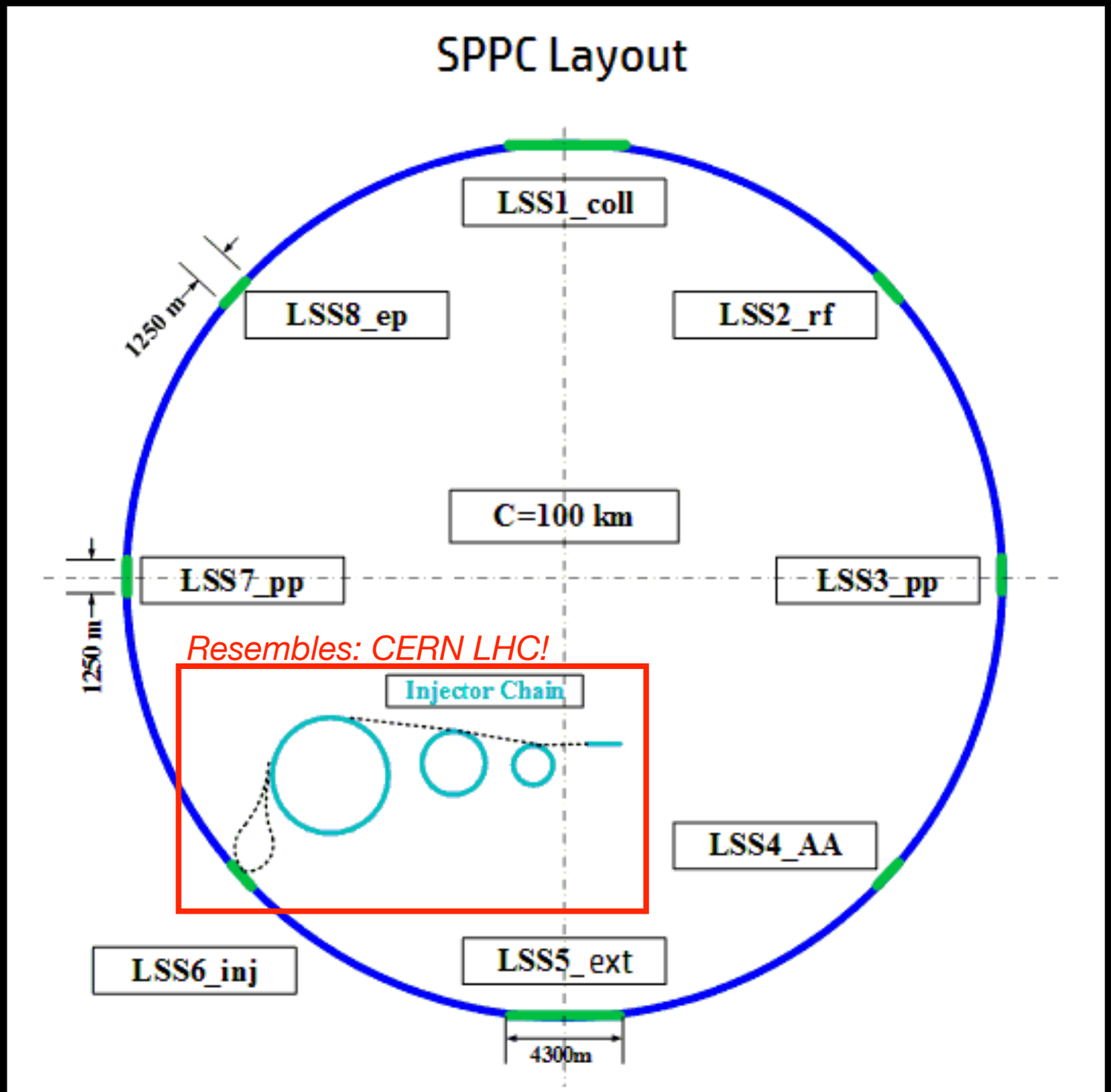
- CLIC and ILC physics communities compatible
  - *CLIC accelerator R&D should continue!*
- FCC-ee and CEPC physics communities compatible
  - *Do we really need two!*
- High energy proton development remains key CERN program
  - *HE-LHC would be important step!*

From: CEPC -CDR Vol.1 Accelerator (IHEP-CEPC-DR-2018-01)

(SPPC):

If we use the LHC ratio of 15 for top to bottom fields the injection energy would be 2.5 TeV. A larger ratio of 20 could be considered, which would mean an injection energy of 1.875 TeV. This would make the injector chain cheaper. We have adopted a compromise with an injection energy of 2.1 TeV.

The injector chain pre-accelerates the beam to reach 2.1 TeV, a four-stage injector chain is proposed: the p-Linac to 1.2 GeV, the p-RCS to 10 GeV, the MSS to 180 GeV and the SS to 2.1 TeV. High repetition rates for the lower energy stages help reduce the SS cycling period. This is important because the SS uses superconducting magnets.



## Any CEPC decision should NOT govern future proton collider decision

- The tunnel for CEPC or FCC-ee will be an important resource but the injection chain is practically the LHC and its injectors (each somewhat lower in energy, but similar)
- The LHC complex (LINAC4, PS, SPS, LHC):
  - ➡ *would cost >10BCHF to replace (wild guess)*
  - ➡ *needs critical development and operational expertise, almost unique to CERN (apologies to Fermilab and Russian colleagues!)*
  - ➡ *Cost of tunnel NOT the major issue and should NOT dominate arguments for future proton machines*

# What's Needed
# - but How to Achieve it? -

From: Future Circular Collider - European Strategy Update Documents Benedikt, Michael (CERN) et al. 15 January 2019 CERN-ACC-2019-0007

**In ten years of physics at the LHC, the particle physics landscape has greatly evolved. Today, an integrated Future Circular Collider programme consisting of a luminosity-frontier highest-energy lepton collider followed by an energy-frontier hadron collider promises the most far-reaching particle physics programme that foreseeable technology can deliver.**

***The Needs of the HEP Field are Identified — How Best to Achieve them?***

**Geneva, 15 January 2019.** Today, the Future Circular Collider (FCC) collaboration submitted its Conceptual Design Report (CDR) for publication.

..updating the European Strategy for Particle Physics, outlining the future of the discipline beyond the horizon of the Large Hadron Collider (LHC). .... The possibility of a future circular collider will be examined during the strategy process, together with the other post-LHC collider option at CERN, the CLIC linear collider.
The FCC study started in 2014 … "to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update". The FCC would provide electron-positron, proton-proton and ion-ion collisions, with the possibility of electron-proton and electron-ion collisions.
CERN DG Fabiola Gianotti. "While presenting new, daunting challenges, the FCC would greatly benefit from CERN's expertise, accelerator complex and infrastructures, which have been developed over more than half a century."
… the Higgs boson could be a door into new physics. Detailed studies of its properties are therefore a priority for any future high-energy physics accelerator.
… requires physics beyond the Standard Model to account for observations such as dark matter and the domination of matter over antimatter …

"The FCC's ultimate goal is to provide a 100-km superconducting proton accelerator ring, with an energy of up to 100 TeV, meaning an order of magnitude more powerful than the LHC", said CERN Director for Accelerators and Technology, Frédérick Bordry.
Using new-generation high-field superconducting magnets, the FCC proton collider … Reaching energies of 100 TeV and beyond would allow precise studies of how a Higgs particle interacts with another Higgs particle, and thorough exploration of the role of the electroweak symmetry breaking in the history of our universe. …

"Proton colliders have been the tool-of-choice for … physics at the smallest scale. A large proton collider would present a leap forward in this exploration and decisively extend the physics programme beyond results provided by the LHC and a possible electron-positron collider." said CERN Director for Research and Computing, Eckhard Elsen.

A 90 to 365 GeV electron-positron machine with high luminosity could be a first step. Such a collider would be a very powerful "Higgs factory"…

The cost of a large circular electron-positron collider would be in the 9-billion-euro range, including 5 billion euros for the civil engineering work for a 100-kilometre tunnel. This collider would serve the worldwide physics community for 15 to 20 years. The physics programme could start by 2040 at the end of the High-Luminosity LHC. The cost estimate for a superconducting proton machine that would afterwards use the same tunnel is around 15 billion euros. This machine could start operation in the late 2050s.

# HEP as International Exemplaire

- CERN - pre-eminent example of international openness and cooperation.
- ASIA, in particular Japan and China, in a very significant position:
  - *Japan in threshold of hosting the ILC*
  - *China wishing to win International  esteem in world-leading research.*
  - *Willing to apply significant resources to this end*
  - *Strengthening their base of expertise.*
- But…
  - *HEP is international, open and collaborative.*
  - *Facilities of significance have open, international participation to continue to provide the best capabilities within a large but fixed resource  envelope*

Robert Eisenstein … played a significant role in organizing the partnership of the United States and the Large Hadron Collider project.

To my mind, CERN remains the prime example of international cooperation in science. Some other institutions have tried to emulate the CERN example but without the same success. It allowed communication in science between countries that were not talking to each other otherwise.

Of course there is also a natural and healthy competition between CERN and the United States. There is nothing wrong with it — it helps us both to be sharp, clever and discovery-oriented. This has been something of enormous value to both sides.

Today, the United States is strongly involved in the LHC project. Co-operation is now more important than ever because particle physics is at a crossroads. All particle physicists have to work together to see that the future is secure. … Some things are easy to overlook. It is easy to take for granted the co-operation and friendly exchange — but this is very rare and very hard to do.

# Now for some (personal) concerns …

# 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

Carlo Rubbia, 2005 UN address .....

"I came for the first time to live at CERN early in 1960. Today, over 45 years later, I feel as ***motivated and enthusiastic for institutionalised international cooperation as I was on the first day***, at the time when such an innovative concept, so popular nowadays, was essentially unknown.

CERN was born … at the threshold of a renewed European prosperity, to ***promote pure science on a global European scale and to create trust and unity between people of different countries, traditions and mentalities*** …

CERN has been for us an extraordinary 'melting pot', gathering a large number of ***remarkable and very young talents from many different countries***. …

… we have been ***able to operate in a unique climate of absolute scientific freedom with an immense enthusiasm and motivation. … in which the resultant combination of the team has been far more relevant than the sum of the separate contributions of each of us.***

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)

# THE 13TH FIVE-YEAR PLAN FOR ECONOMIC AND SOCIAL DEVELOPMENT OF THE PEOPLE'S REPUBLIC OF CHINA (2016–2020)

We will adopt more proactive, more open, and more effective policies to bring in overseas talent, improve the permanent residence system for foreign nationals, and relax the criteria for highly skilled foreign nationals to gain permanent residency. We will move faster to provide more efficient and convenient entry, exit, and residence services for skilled foreign nationals coming to work in China. We will work to increase the number of international students in China, optimize the international student mix, and improve the mechanisms for supporting their training …

4. The Talent 1,000 Initiative Initiative Initiative Initiative Initiative and the Talent 10,000 Initiative

- Attract science strategists and leading talent working in science and technology from overseas who have the capacity to engage in primary innovation, make breakthroughs in key technologies, develop high-tech industries, and drive the development of emerging disciplines;
- Bring in approximately 10,000 high-caliber talented individuals from overseas to make innovations or start businesses …

# Build upon International Status

- New “international” laboratories have a tough act to follow (CERN)
- Huge effort must be applied to continue the reputation for HEP to work transparently across national/political barriers
- All HEP nations must exert great effort to continue flow of ideas, people and resources essential for our field.

# 2019 will be a very important year for HEP

- ILC decision by March
- European Strategy Update process will be well underway
- Will our community embrace a united international approach whilst seeking new resources?

# Thank you

Looking forward to a very stimulating conference.

Thanks to the organisers and participants for this  opportunity