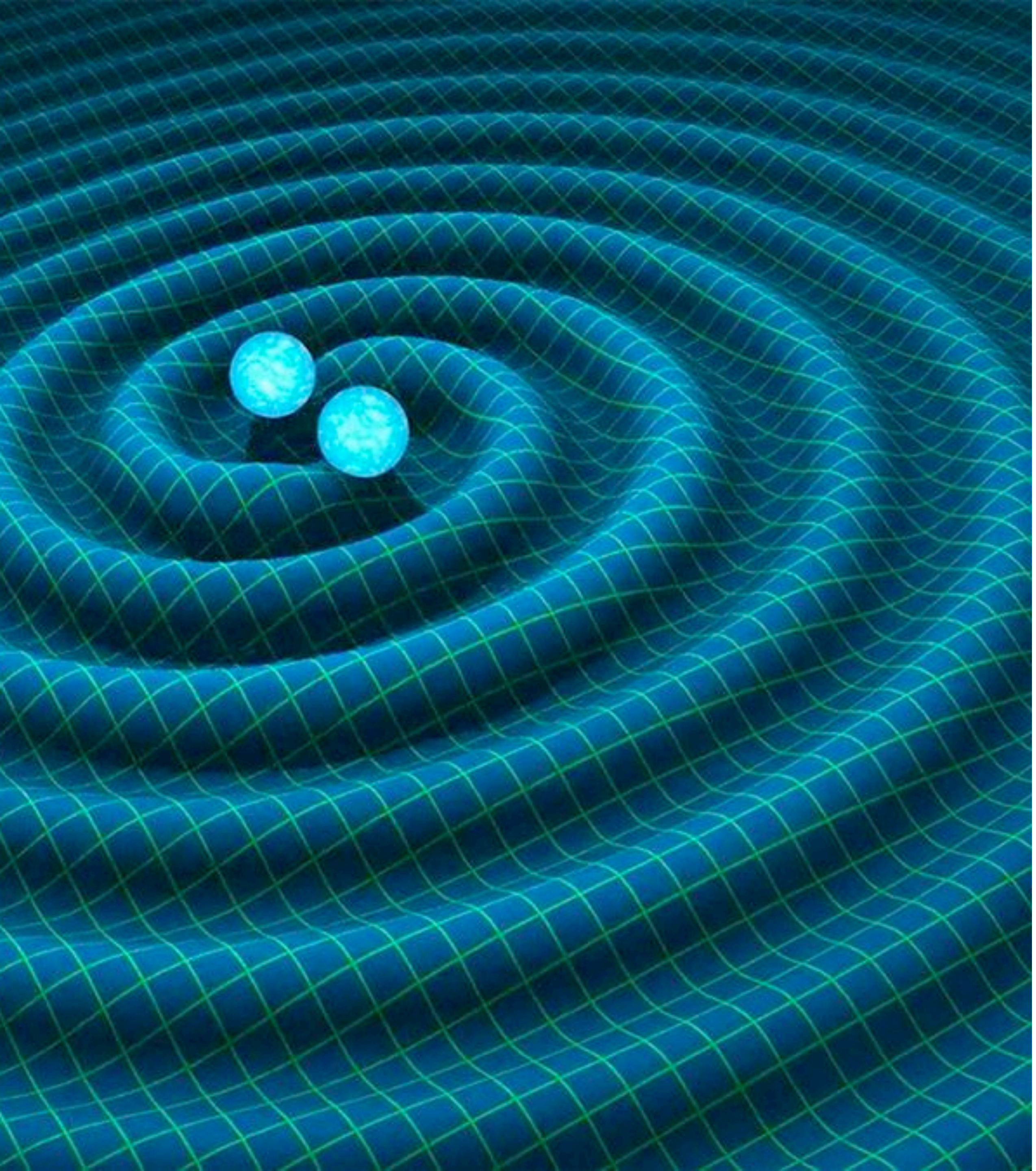
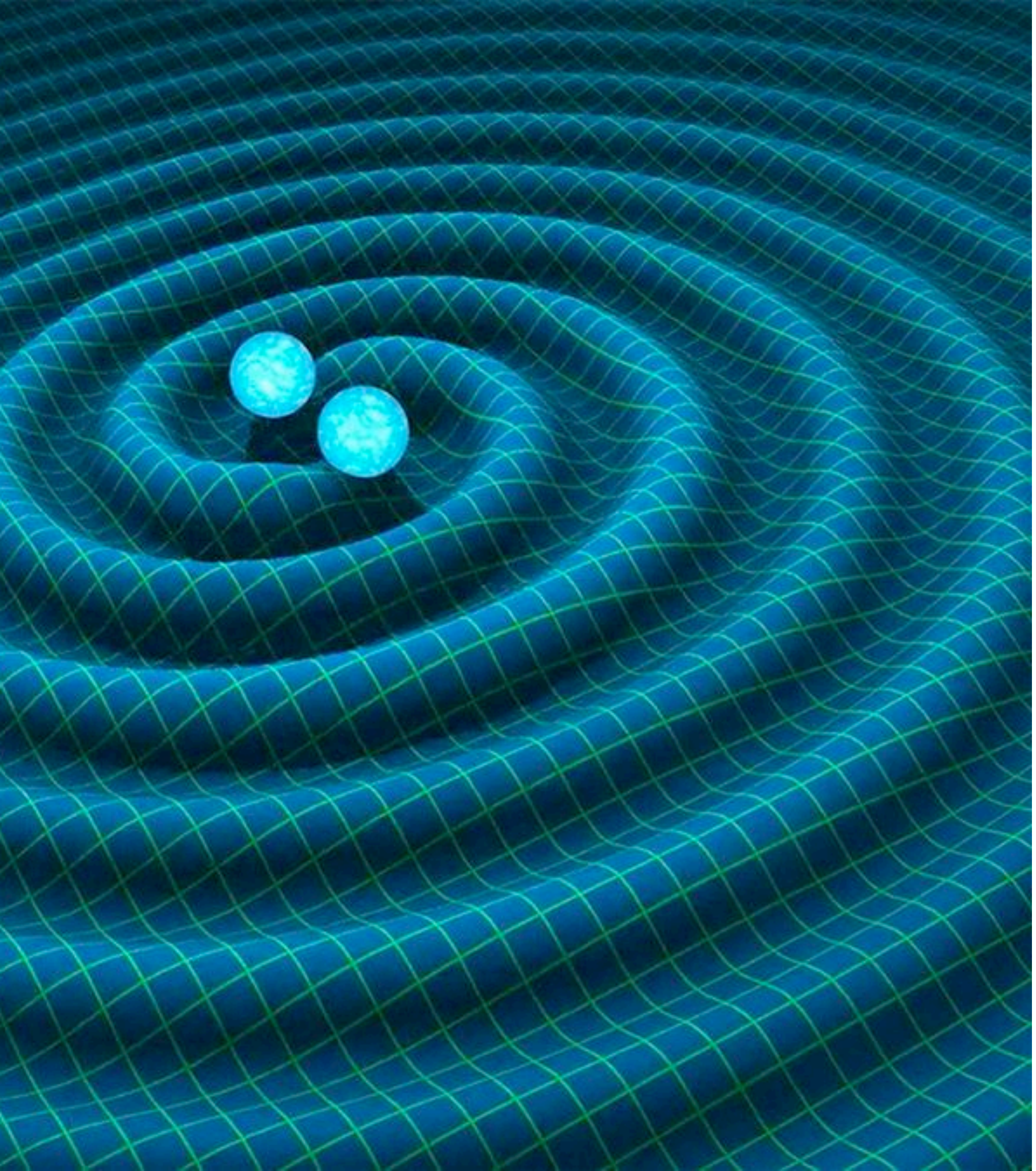
Theory input

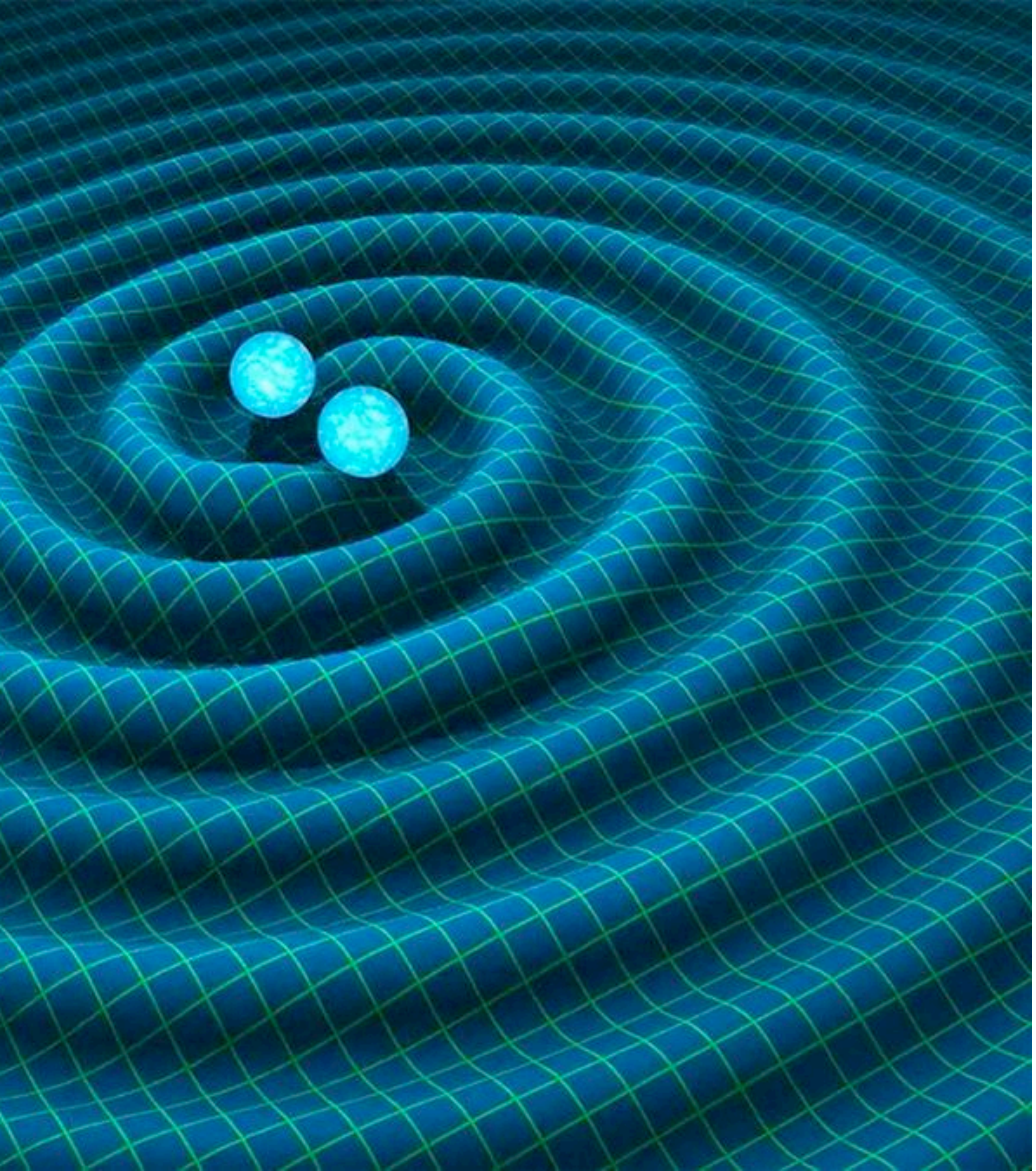
Germán RODRIGO

ASFAE2022/009 | PID2020-114473GB-I00 | PROMETEO/2021/071

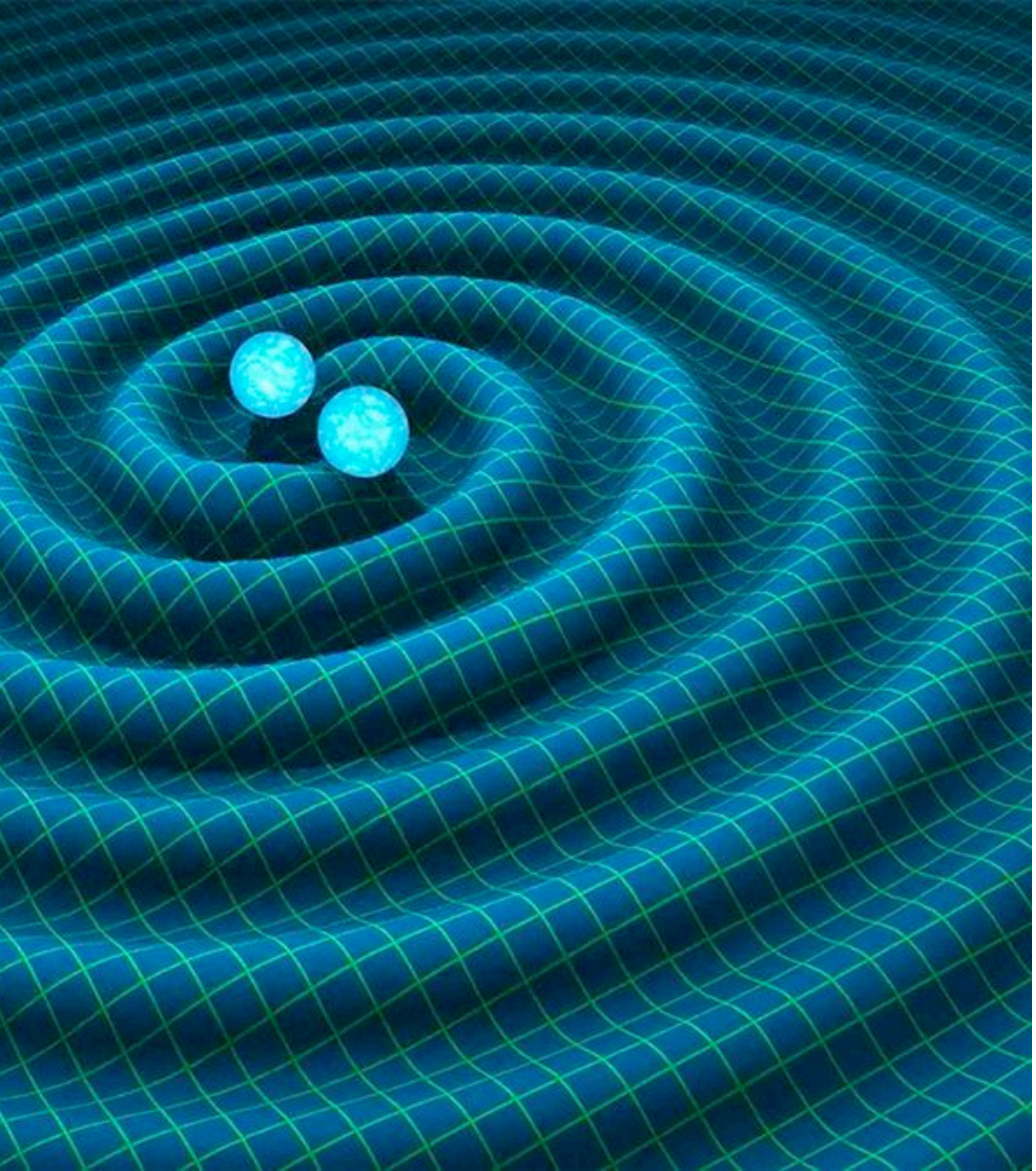




- **Gravitational waves** discovered in 2016



- **Gravitational waves** discovered in 2016
- No new discovery from 2016 !!!



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- Would you fund me?

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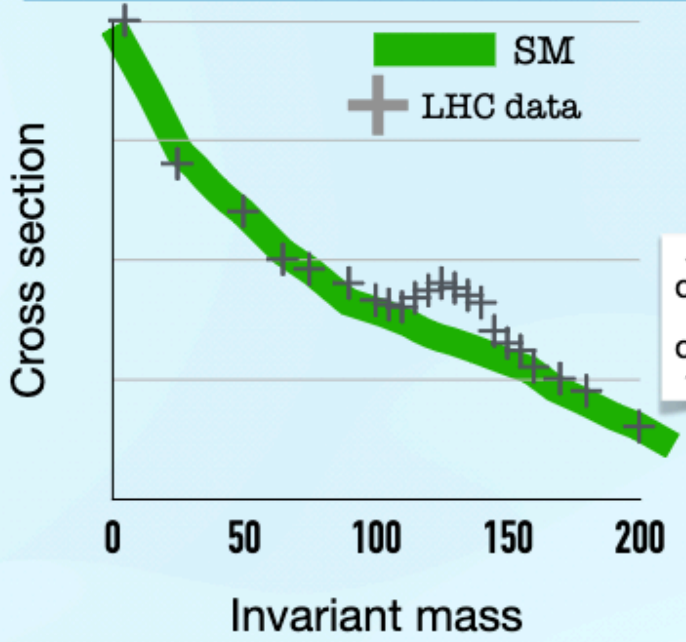
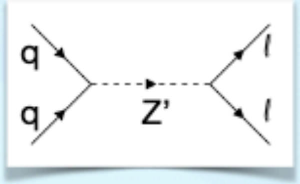
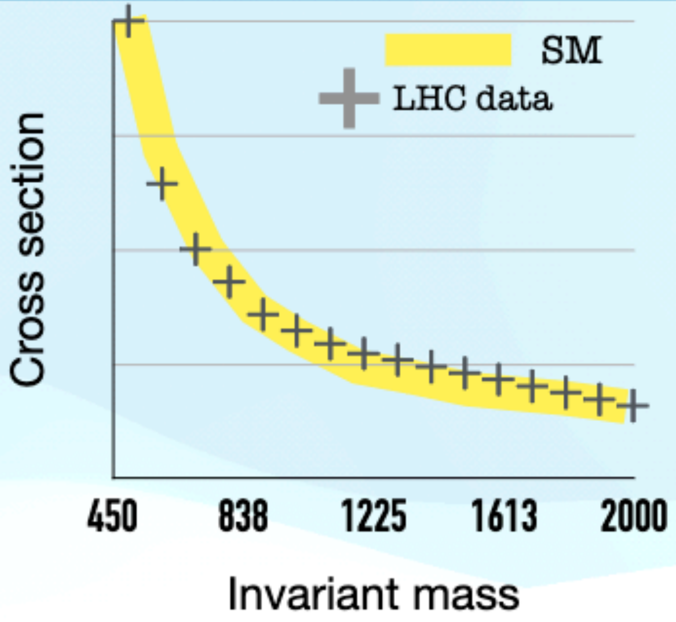
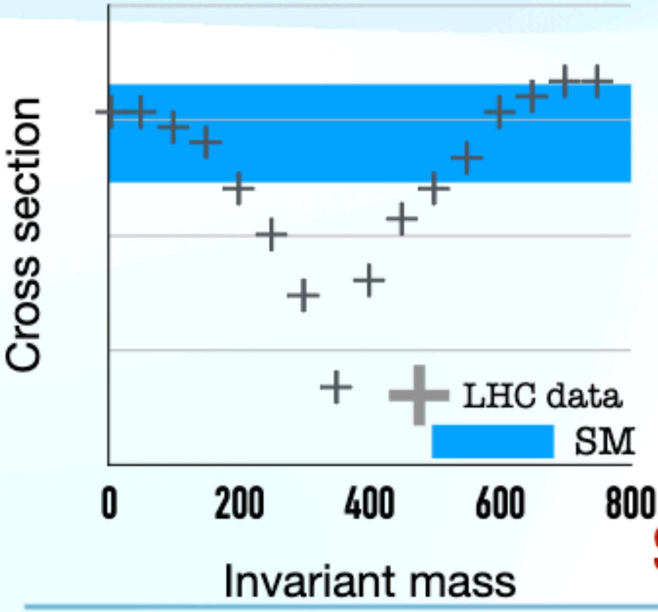
We are looking for new discoveries

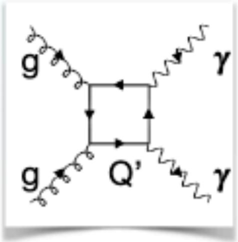
Essentially, two possible scenarios



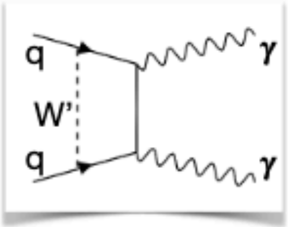








Small deviations from SM



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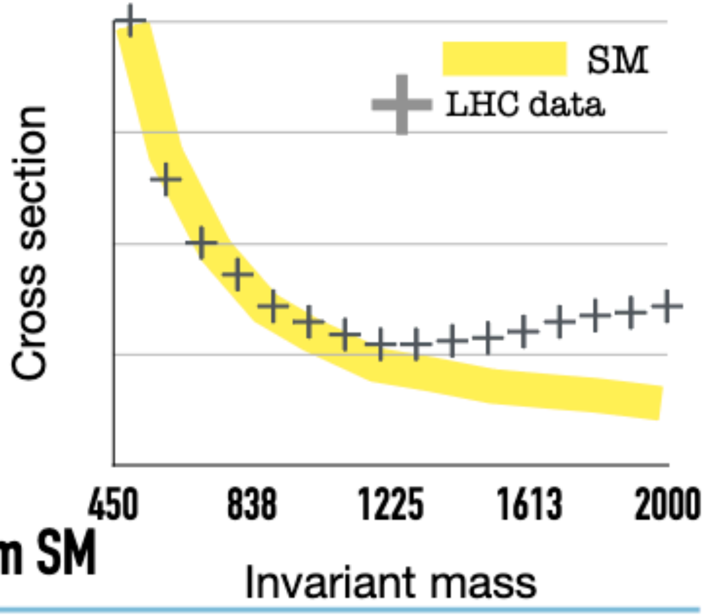
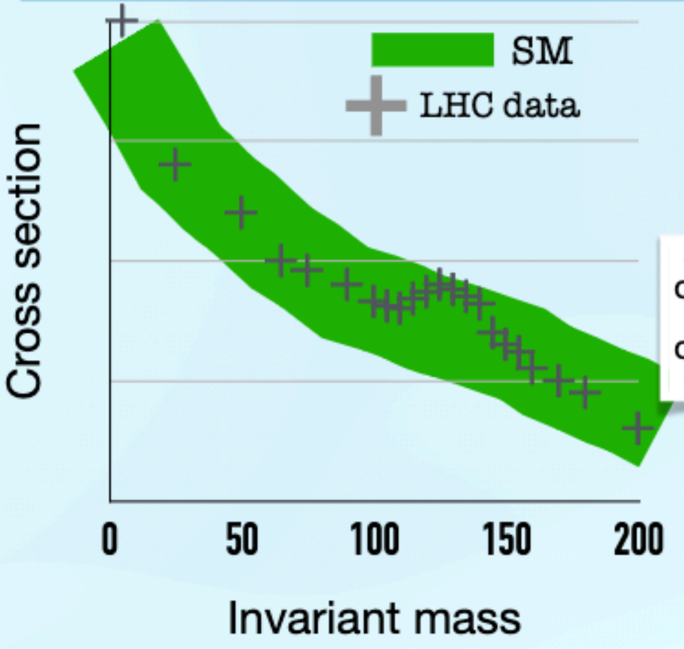
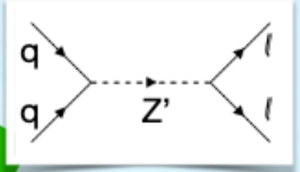




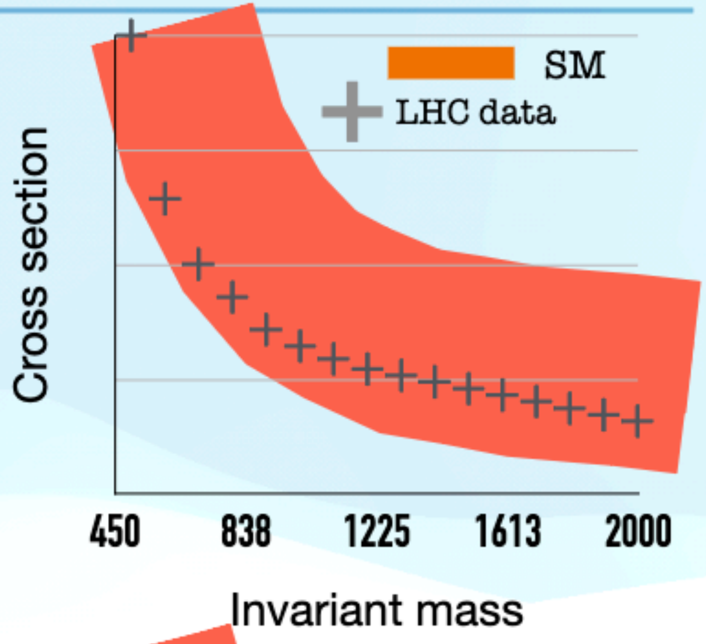
We are looking for new discoveries

Essentially, two possible scenarios

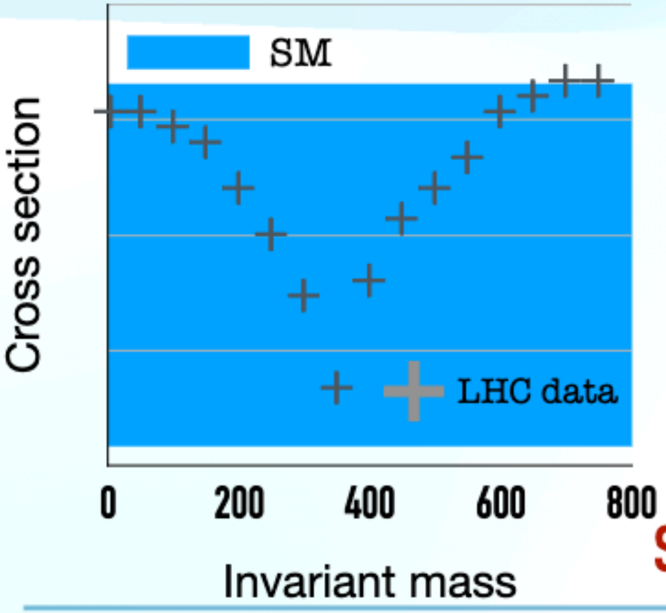


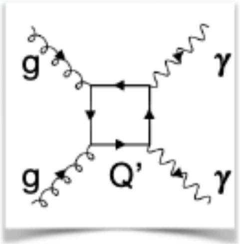
New resonances

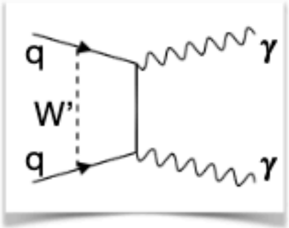
New interactions

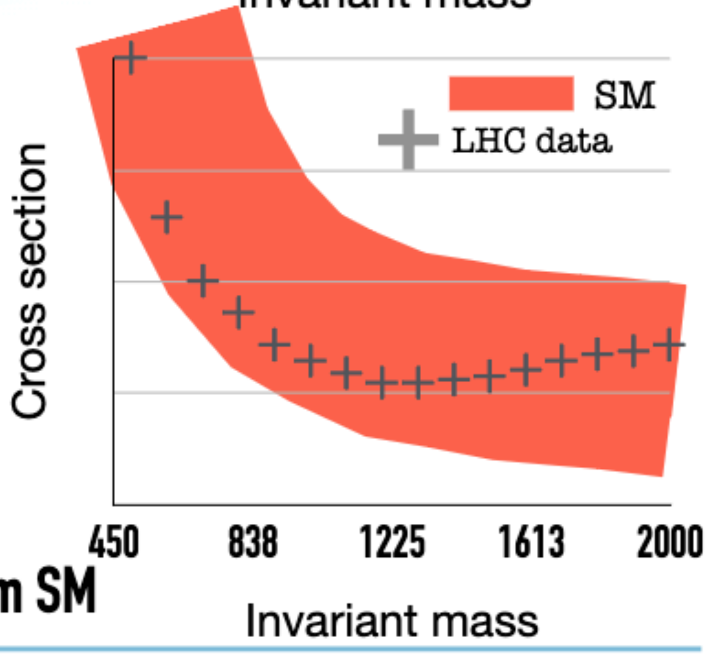


In both scenarios precision is a key ingredient





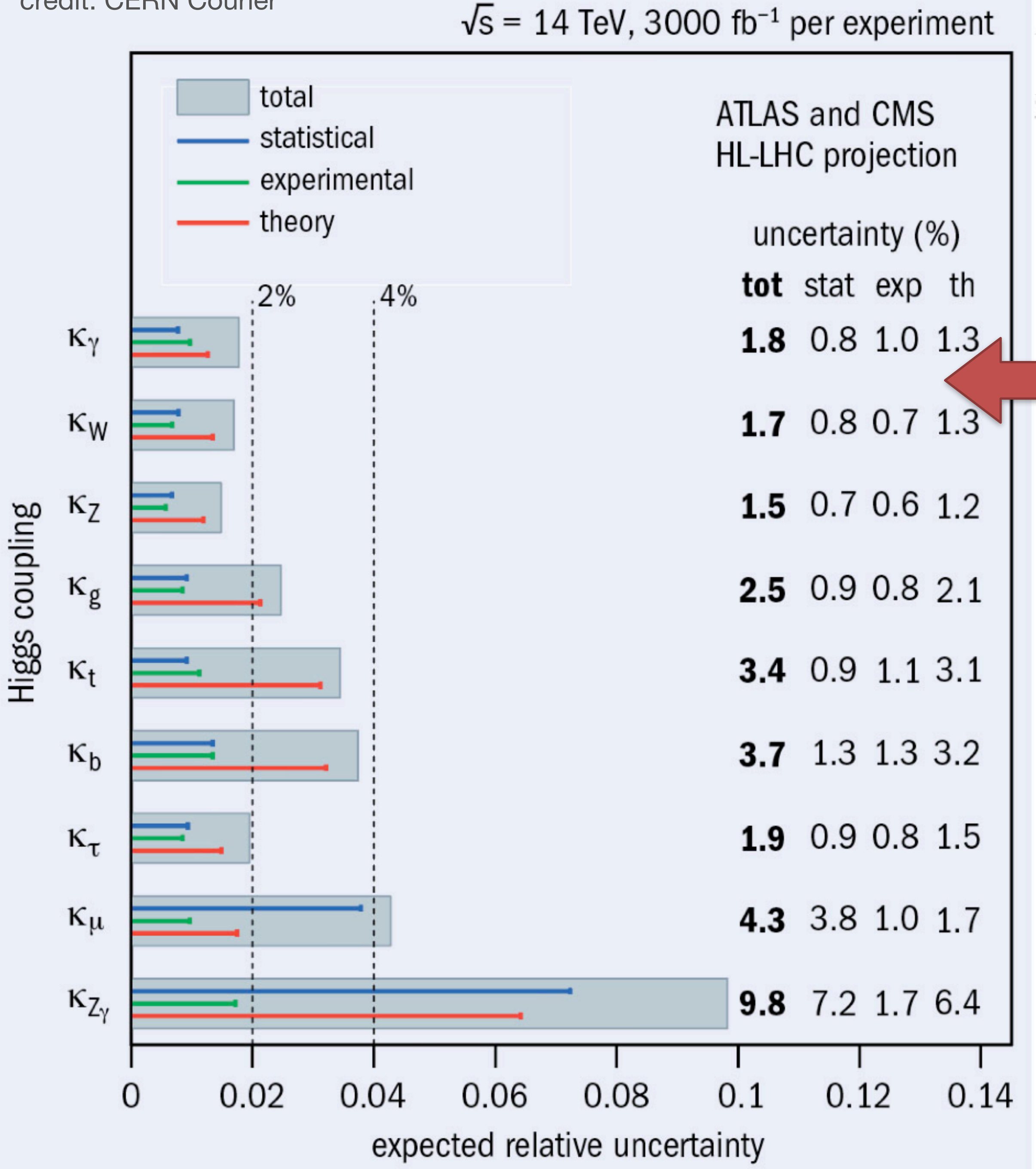




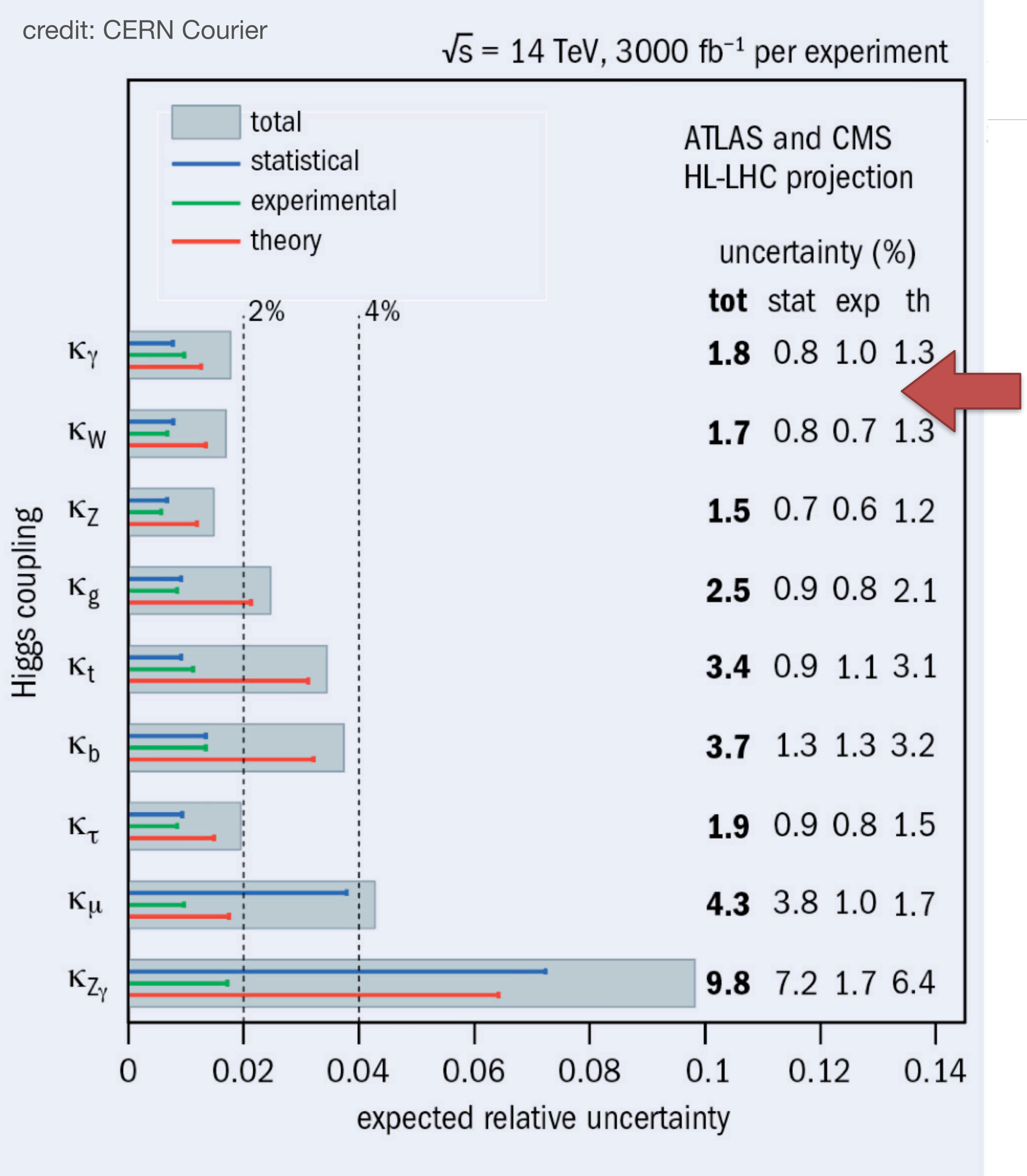
Small deviations from SM

Small deviations from SM

credit: CERN Courier



- Theory is the main **limiting factor** to achieve precision measurements
- Very optimistic projections that today are unreachable



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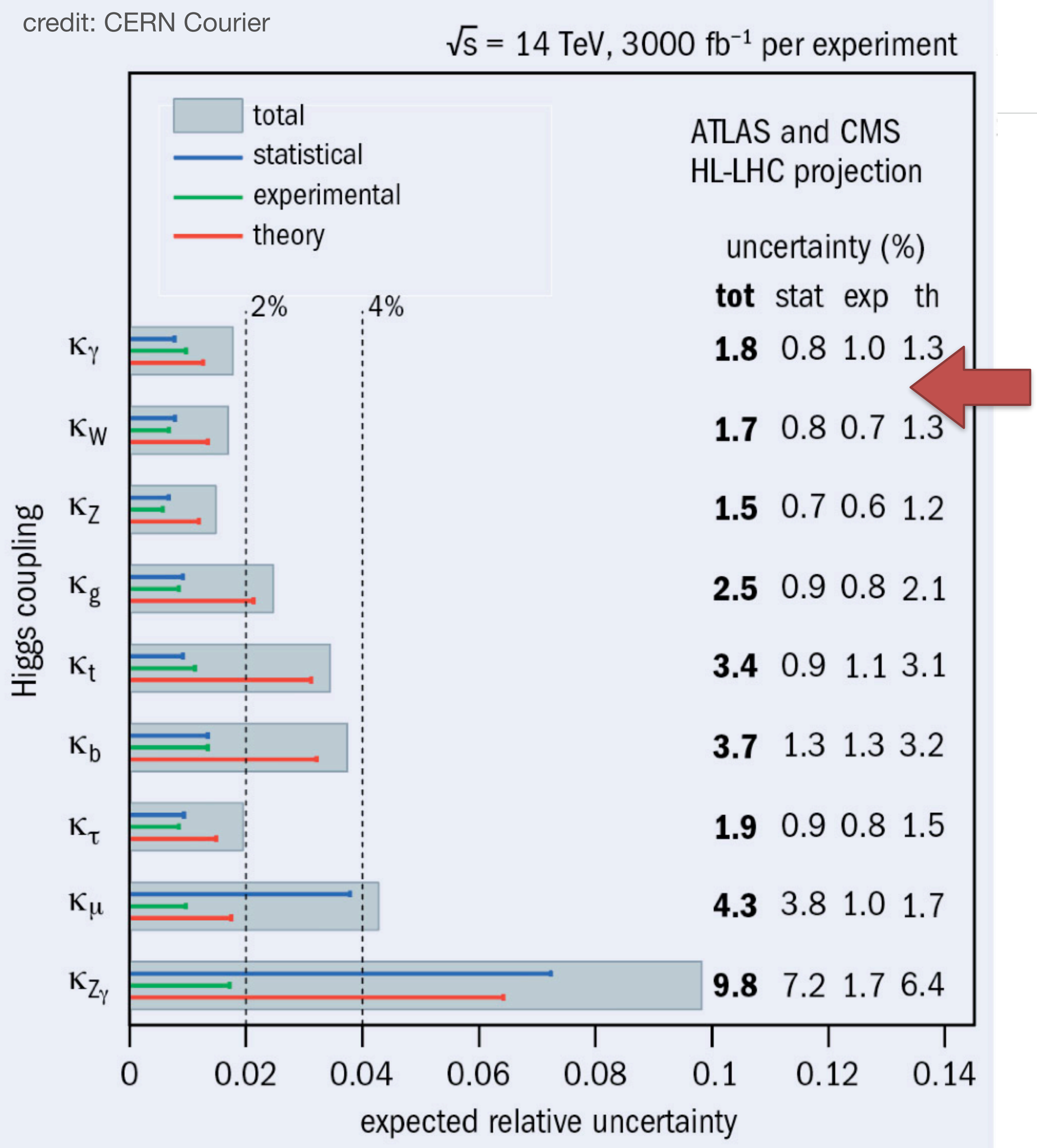
- Years of CPU/GPU in large-scale clusters and huge energy consumption in the best scenario

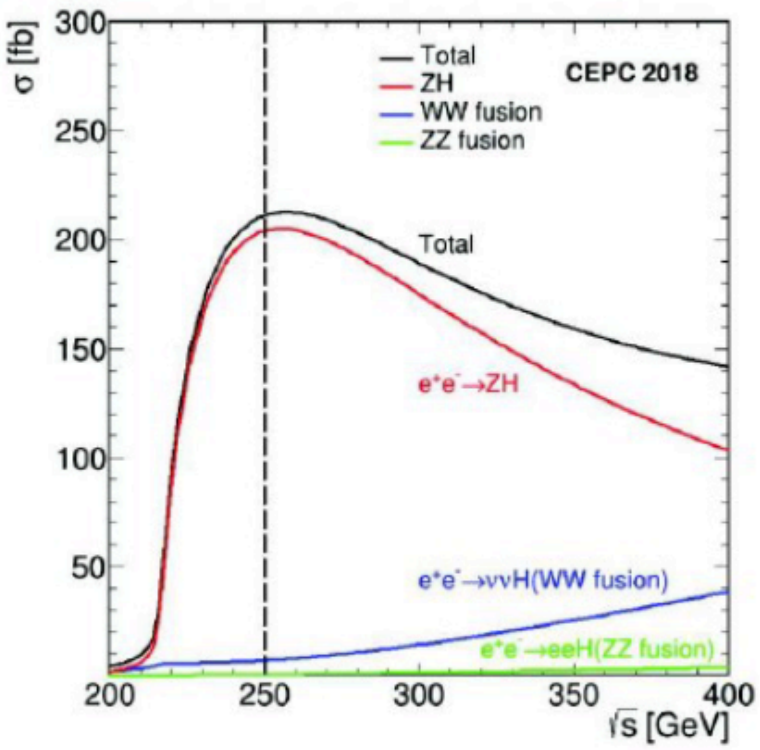


- Theory is the main **limiting factor** to achieve precision measurements
- Very optimistic projections that today are unreachable
- Years of CPU/GPU in large-scale clusters and huge energy consumption in the best scenario
- Need to go beyond the current state of the art in theoretical predictions at high-energy colliders

Ayres Freitas, Loops & Legs 2024

- **Application**: ee→HZ: dominant Higgs prod. process at e+e- colliders below 500 GeV
- Expected precision:

ILC	1.2%	[1903.01629]
CEPC	0.5%	[1811.10545]
FCC-ee	0.4%	[EPJ ST 228, 261]

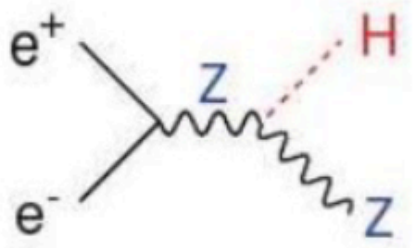


- Need higher-order corrections:

	$\alpha(0)$ scheme	G_μ scheme
$\sigma^{\rm LO}$ [fb]	223.14	239.64
$\sigma^{\rm NLO}$ [fb]	229.78	232.46
$\sigma^{\rm NNLO,EW\times QCD}$ [fb]	232.21	233.29

Gong et al. '16
Chen, Feng, Jia, Sang '18

EW NNLO expected O(1%)

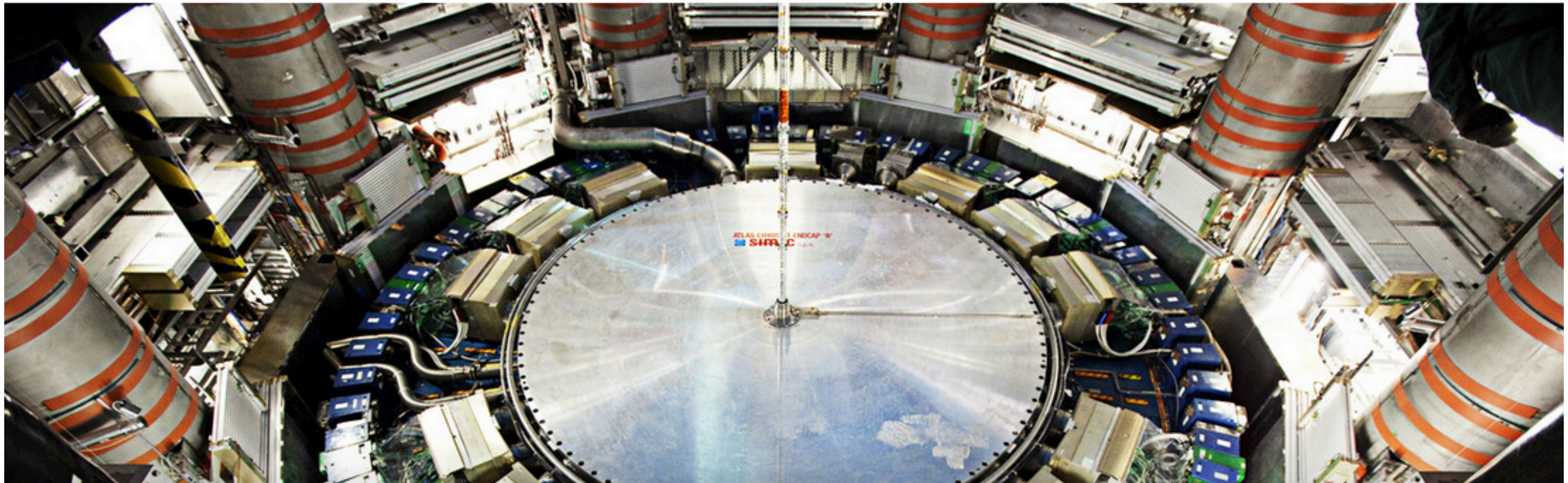


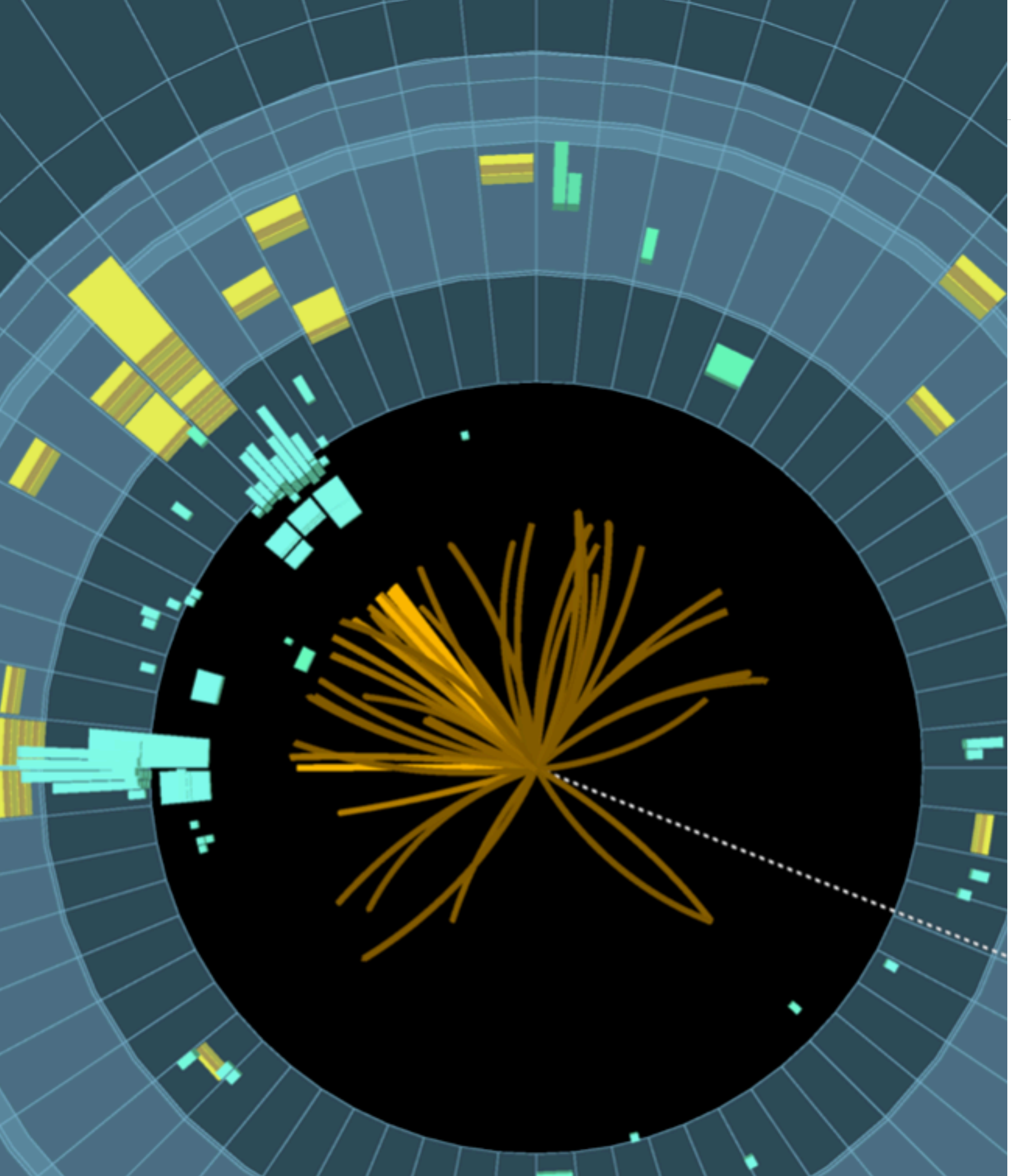
https://www.xataka.com/investigacion/fisicos-quieren-entender-como-boson-higgs-estabiliza-nuestro-universo-afortunadamente-tienen-plan

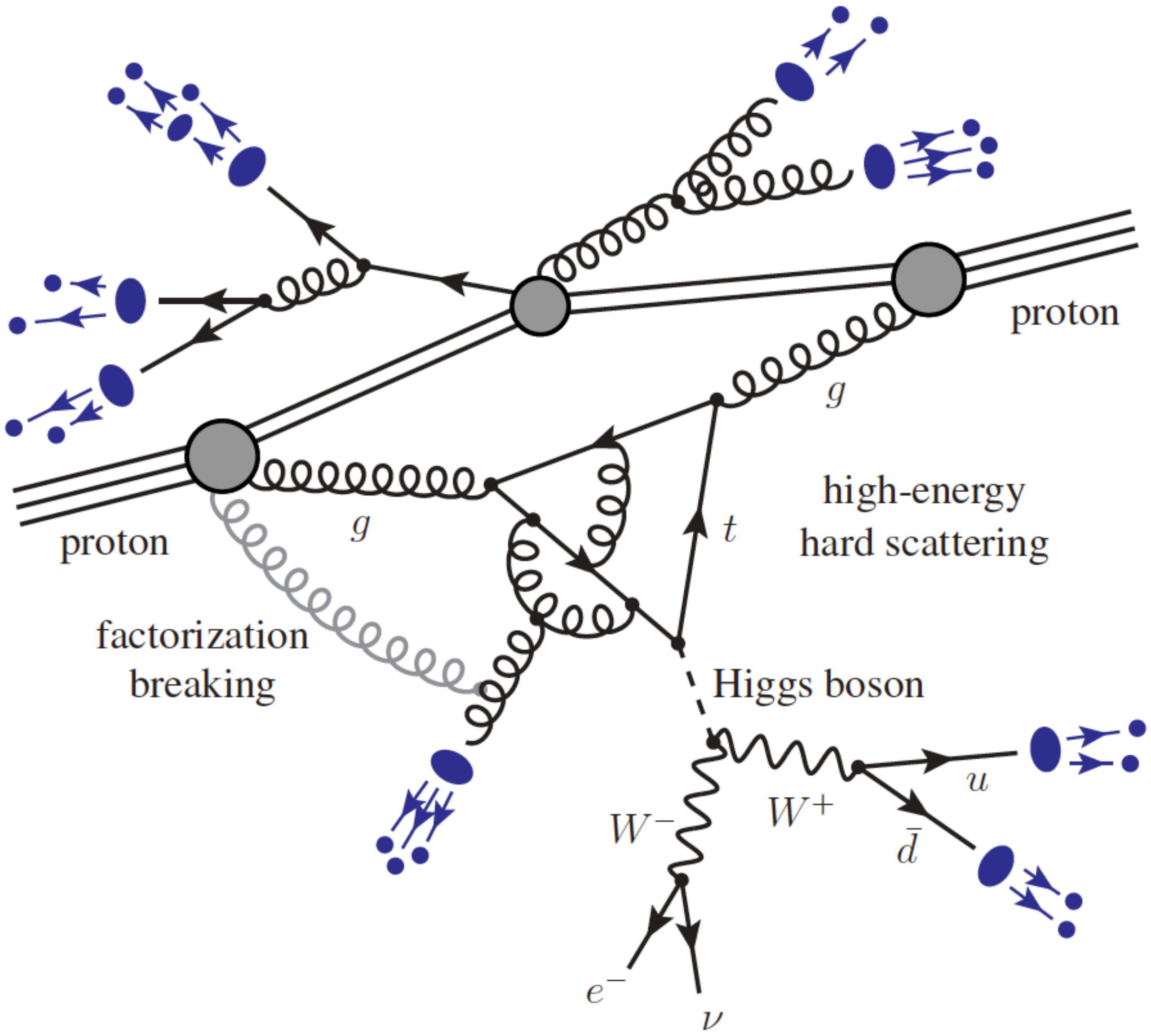
Los físicos quieren entender cómo el bosón de Higgs estabiliza nuestro universo. Afortunadamente, tienen un plan

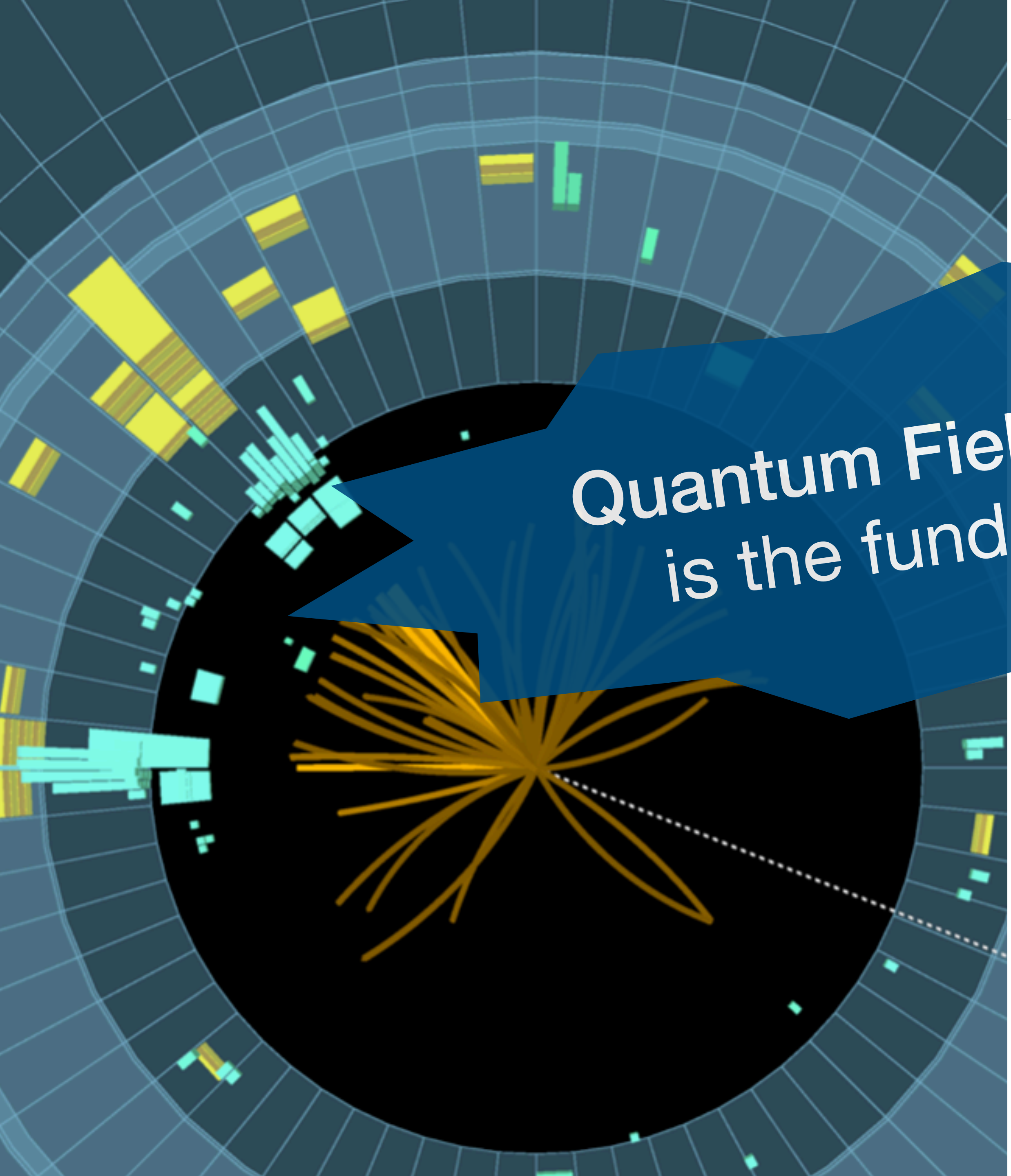
- El fenómeno conocido como producción 'di-Higgs' es muy escurridizo, aunque es esencial en el Modelo Estándar
- La interacción entre dos bosones de Higgs parece ser la clave para entender por qué nuestro universo es estable

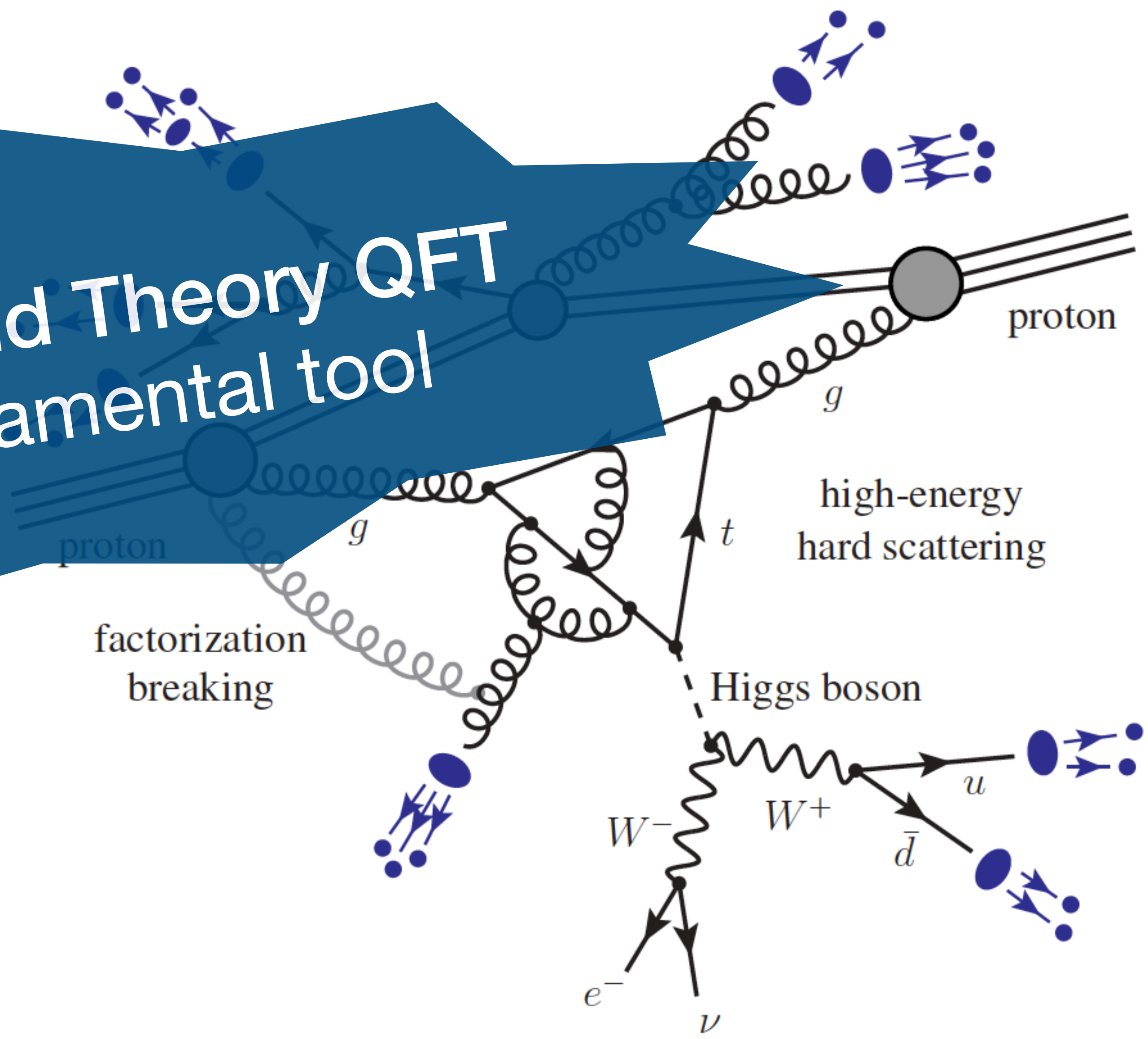
Sin comentarios



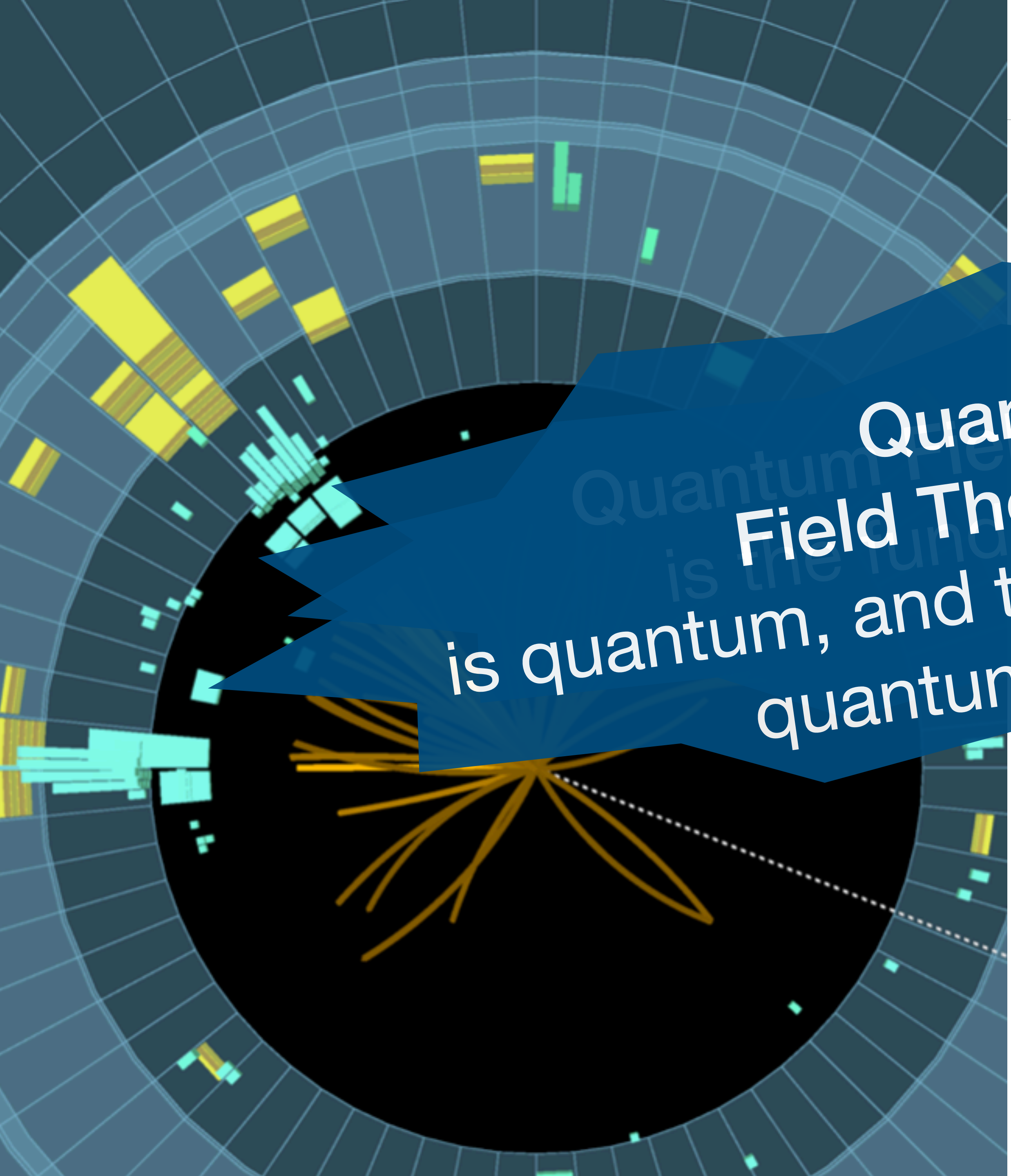



proton
proton
g
g
t
high-energy
hard scattering
factorization
breaking
Higgs boson
W−
W+
u
d̄
e−
ν

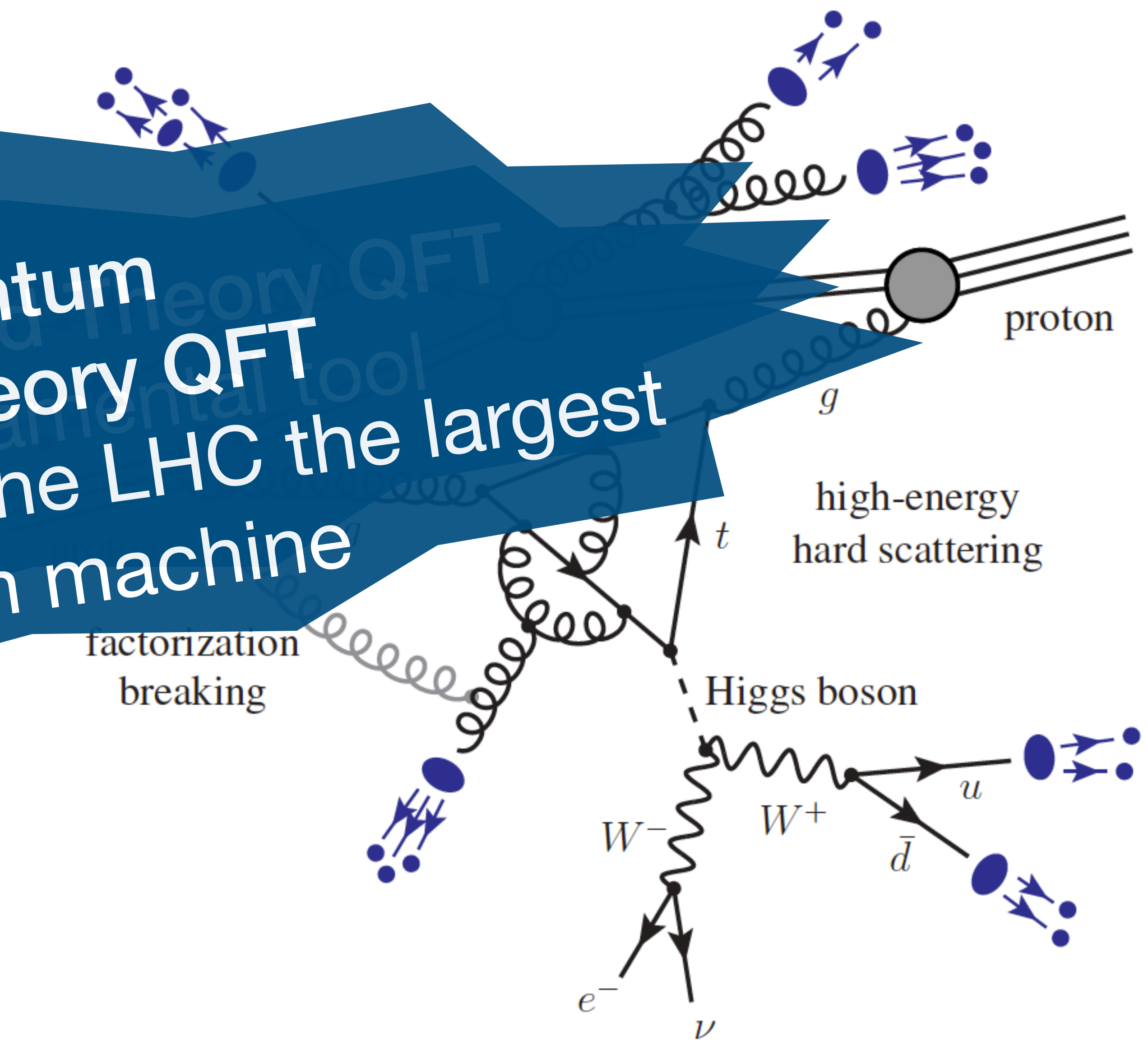




Quantum Field Theory QFT is the fundamental tool



Quantum
Field Theory QFT
is quantum, and the LHC the largest
quantum machine



Exploring the Quantum Universe

Pathways to Innovation and Discovery in Particle Physics

Report of the 2023 Particle Physics Project Prioritization Panel

Particle physics studies the smallest constituents of our vast and complex universe. At such small scales, the fundamental principles of quantum physics prevail. Remarkably, the entire observable universe, now billions of light years across, was once so small as to be quantum in nature. This quantum history of the universe is imprinted on its large-scale structure.

Executive Summary: **Investing in the scientific workforce and enhancing computational and technological infrastructure is crucial.** To achieve this goal, funding agencies should support programs that foster a supportive, collaborative work environment; help recruit and retain diverse talent; and reinforce professional standards. Targeted increases in support for **theory**, **general accelerator R&D**, **instrumentation**, and **computing** will bolster areas where US leadership has begun to erode.

Recommendation 4: Invest in a comprehensive initiative to develop the resources—theoretical, computational, and technological—essential to realizing our 20-year strategic vision. This includes an aggressive R&D program that, while technologically challenging, could yield revolutionary accelerator designs that chart a realistic path to a 10 TeV pCM collider.

4b. Enhance research in theory to propel innovation, maximize scientific impact of investments in experiments, and expand our understanding of the universe

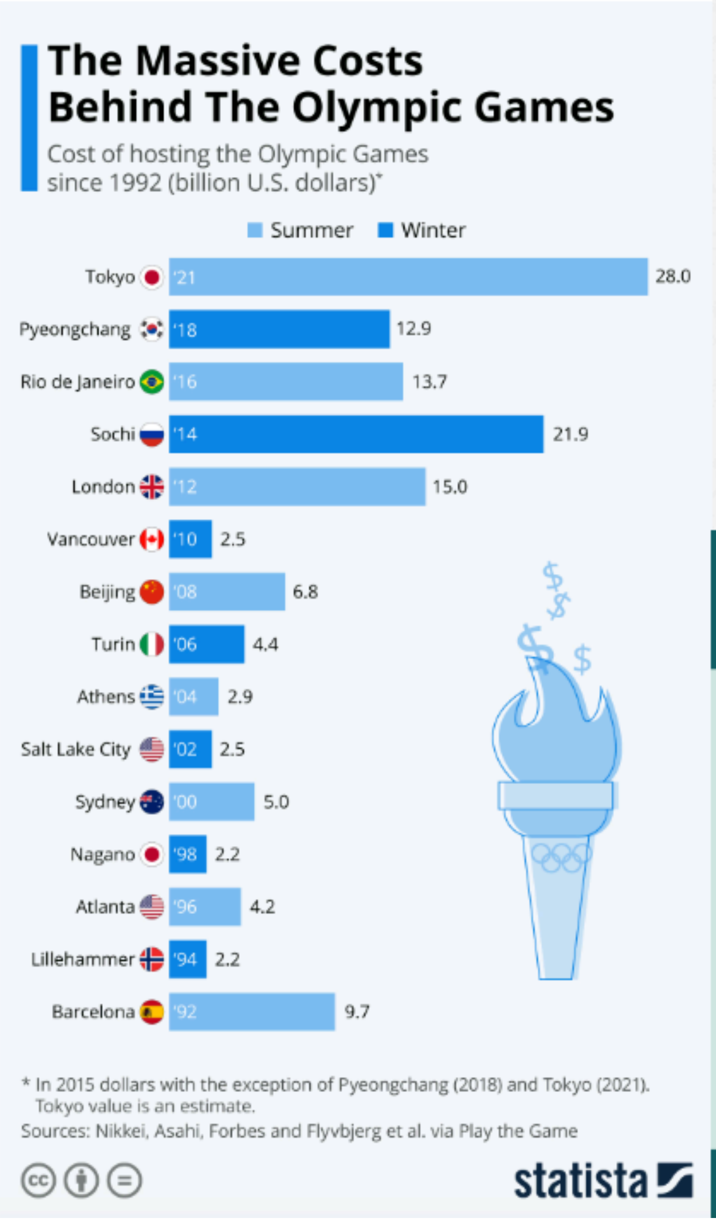
Higgs boson physics can only be studied at high-energy collider experiments, which are currently limited to the LHC and HL-LHC. Longer-term, future colliders, described be- low, will further our understanding of the Higgs boson by testing its couplings to lighter quarks, by improving the precision of the Higgs couplings, and by measuring the Higgs potential. **Advances in theoretical calculations** of Higgs properties will be required to fully understand the experimental results.

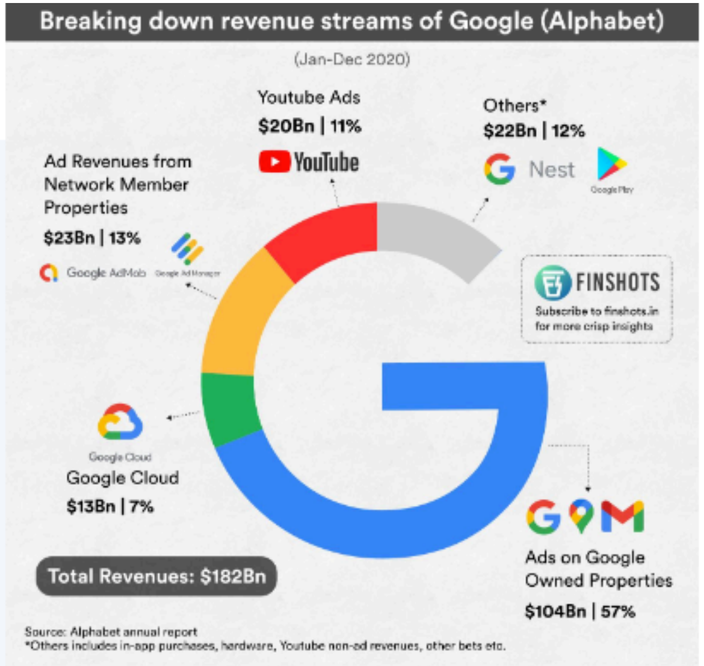
4

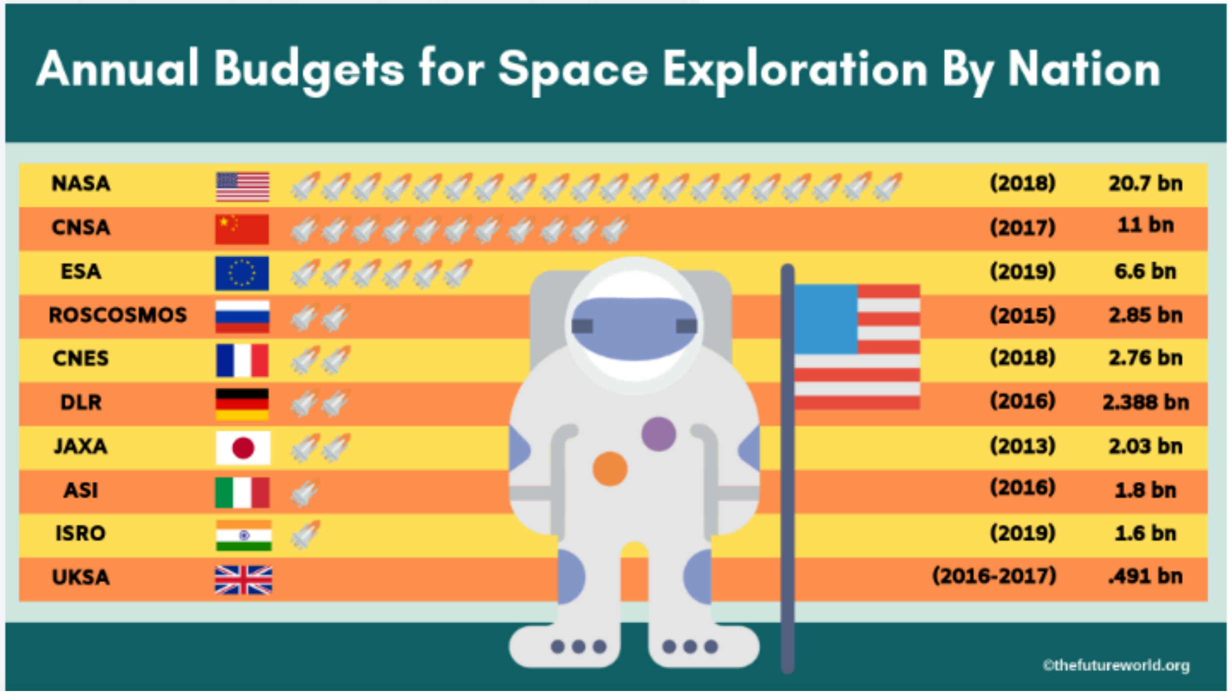
Other essential scientific activities for particle physics

B. Theoretical physics is an essential driver of particle physics that opens new, daring lines of research, motivates experimental searches and provides the tools needed to fully exploit experimental results. It also plays an important role in capturing the imagination of the public and inspiring young researchers. The success of the field depends on dedicated theoretical work and intense collaboration between the theoretical and experimental communities. ***Europe should continue to vigorously support a broad programme of theoretical research covering the full spectrum of particle physics from abstract to phenomenological topics. 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 with direct impact on experiments should be supported, including recognition for the activity of providing and developing computational tools.***

European Strategy Update


The Massive Costs Behind The Olympic Games
Cost of hosting the Olympic Games since 1992 (billion U.S. dollars)*
Summer Winter
Tokyo '21 28.0
Pyeongchang '18 12.9
Rio de Janeiro '16 13.7
Sochi '14 21.9
London '12 15.0
Vancouver '10 2.5
Beijing '08 6.8
Turin '06 4.4
Athens '04 2.9
Salt Lake City '02 2.5
Sydney '00 5.0
Nagano '98 2.2
Atlanta '96 4.2
Lillehammer '94 2.2
Barcelona '92 9.7
* In 2015 dollars with the exception of Pyeongchang (2018) and Tokyo (2021). Tokyo value is an estimate.
Sources: Nikkei, Asahi, Forbes and Flyvbjerg et al. via Play the Game
statista


Breaking down revenue streams of Google (Alphabet)
(Jan-Dec 2020)
Youtube Ads
$20Bn | 11%
Others*
$22Bn | 12%
Ad Revenues from Network Member Properties
$23Bn | 13%
FINSHOTS
Subscribe to finshots.in for more crisp insights
Google Cloud
$13Bn | 7%
Ads on Google Owned Properties
$104Bn | 57%
Total Revenues: $182Bn
Source: Alphabet annual report
*Others includes in-app purchases, hardware, Youtube non-ad revenues, other bets etc.


Annual Budgets for Space Exploration By Nation
NASA (2018) 20.7 bn
CNSA (2017) 11 bn
ESA (2019) 6.6 bn
ROSCOSMOS (2015) 2.85 bn
CNES (2018) 2.76 bn
DLR (2016) 2.388 bn
JAXA (2013) 2.03 bn
ASI (2016) 1.8 bn
ISRO (2019) 1.6 bn
UKSA (2016-2017) .491 bn
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