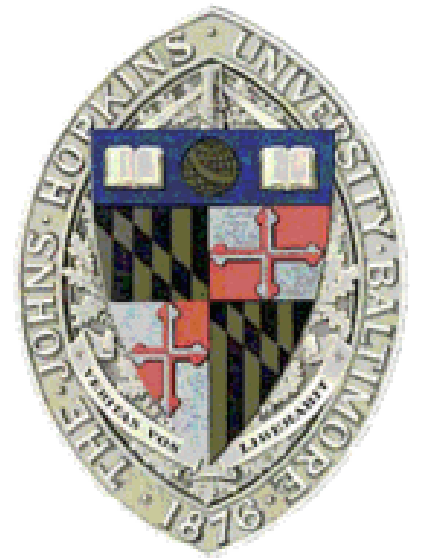


A Virtual Trip to ICHEP-2020: the Science Festival and the Higgs Boson



Andrei Gritsan

Johns Hopkins University



August 3, 2020

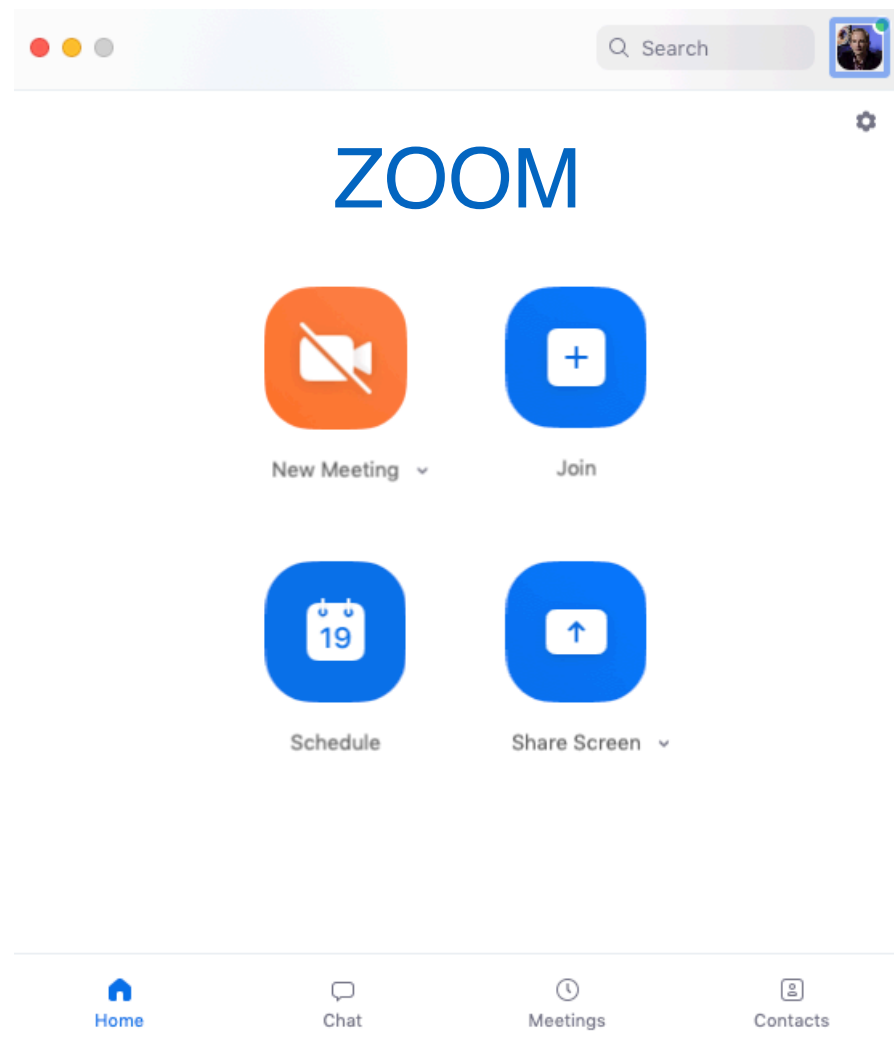
Johns Hopkins University QuarkNet Physics Workshop

Two reports at ICHEP-2020 conference

- International Conference on High Energy Physics (ICHEP)

- major summer event in particle physics, every 2 years
- planned to be in Prague this week
- moved to **ZOOM** instead

<http://ichep2020.org>



- Part I:
Science Festival in Washington DC
10 year of experience
- Part II:
Some highlights from Higgs physics

Part I

Science Festival in Washington DC

- We all (in education/research) value **fundamental science**
 - public awareness of the importance is not for granted
 - alarming signals even in countries with strong history of science
 - goal: create interest of the nation's youth in science
- Planned a big event in April 2020, but COVID-19... <https://usasciencefestival.org>

The Festival premiered on the National Mall in 2010 but was later moved to the Walter E. Washington Convention Center where it attracted more than 350,000 participants in 2016, making it the largest event housed in the convention center.



A Message from Our Founder

"A nation gets what it celebrates! As a culture, we celebrate movie stars, rock stars, and athletes and we generate a lot of them, but we don't celebrate Science and Engineering. Strengthening the STEM educational foundation of our nation is vital to our future economy and the health, safety, and well-being of America's families." - *Larry Bock*

(1959-2016)

[LEARN MORE](#)

Science Festival in Washington DC

- Exhibit on “**Science of the Large Hadron Collider**” by JHU-CMS group
 - started in October 2010, first event in DC: <https://usasciencefestival.org>
 - repeated every 2 years since: 2010, 2012, 2014, 2016, 2018, + ...
 - LHC-related exhibits later by **NYU**, then by **FNAL** and **US-LUA**
 - also run at the annual **Johns Hopkins Physics Fair at Spring Festival**
- See an article back in 2010: Hadron collisions reach out to people in Washington
http://cmsinfo.web.cern.ch/cmsinfo/Media/Publications/CMStimes/2010/11_01/index.html



undergraduate students
graduate students
postdocs
faculty
from Johns Hopkins U.

Science Festival in Washington DC

- Started as a small exhibit, but with essential elements

cosmic ray detectors / counter

dark room

posters

experts
(T-shirts)

2 days in DC



e⁻ beam in E/B

computer simulation
event displays

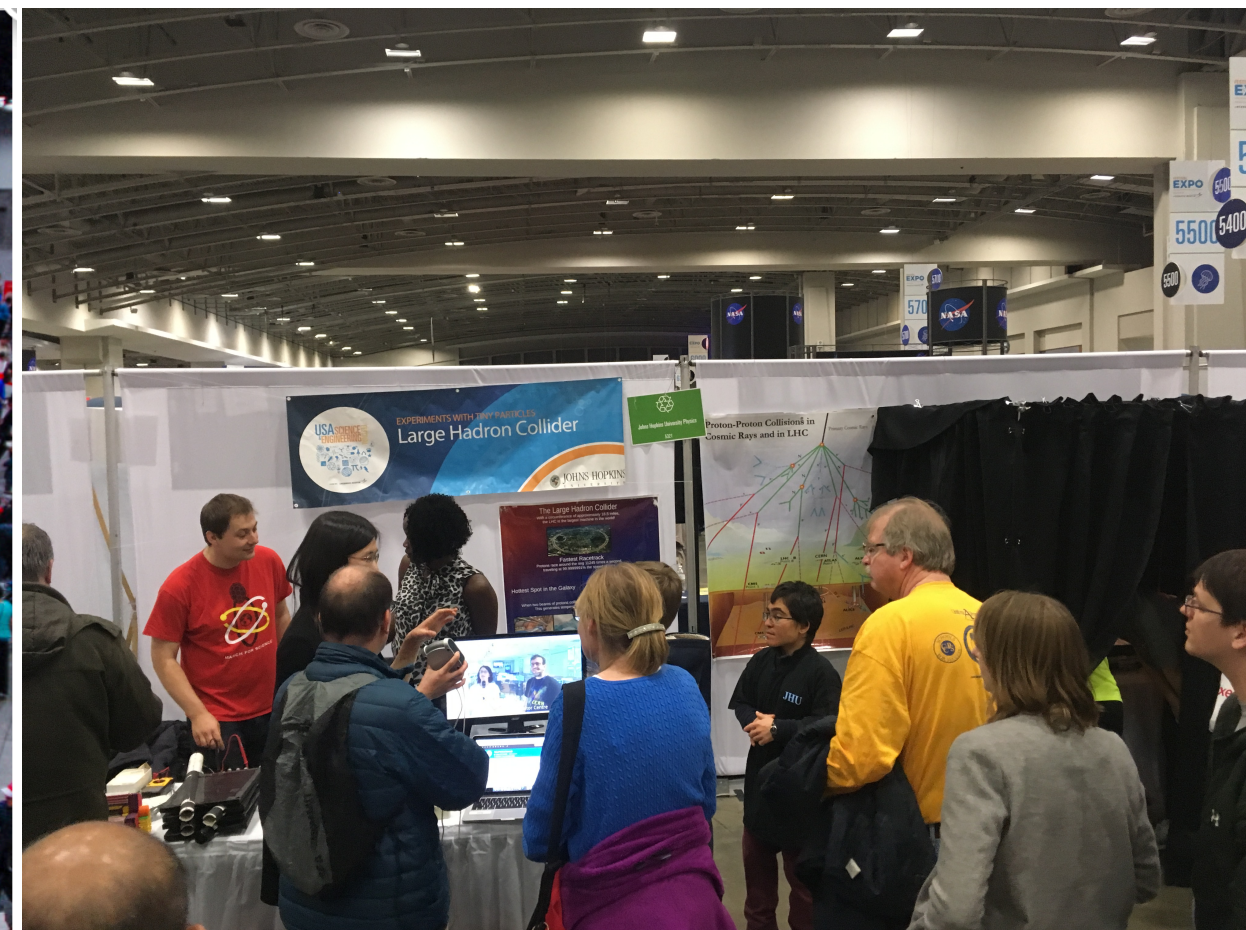
literature/handouts/prizes

cloud chamber

Festivals in DC and JHU

- Over years, the exhibit and the DC Festival grew in size, moved indoors
 - estimated 350,000 visitors at each Festival
 - enlarged the LHC exhibit in size and content
 - coordinated LHC-related exhibits with **FNAL** and **US-LUA**
- Physics Fair at JHU Festival draws large local crowds (16 times by now)

<http://physics-astronomy.jhu.edu/events/annual-physics-fair/>



Science Festival in DC in 2018

- In 2018 joined forces with Fermilab exhibit (Spencer Pasero)
- People from U Maryland (LHCb) & FNAL (CMS) joined the exhibit
- Coordination and contribution US LHC User Association (US LUA)

Verena Martinez (U. Mass)
David Miller (U. Chicago)
Harvey Newman (Caltech)
Yangyang Cheng (Cornell)





USA Science and Engineering Festival

April 7-8 2018



Verena Martinez
Andrei Gritsan
David Miller
Yangyang Cheng
Harvey Newman

Slide from US LUA (Harvey Newman)



USA Science and Engineering Festival

April 7-8 2018

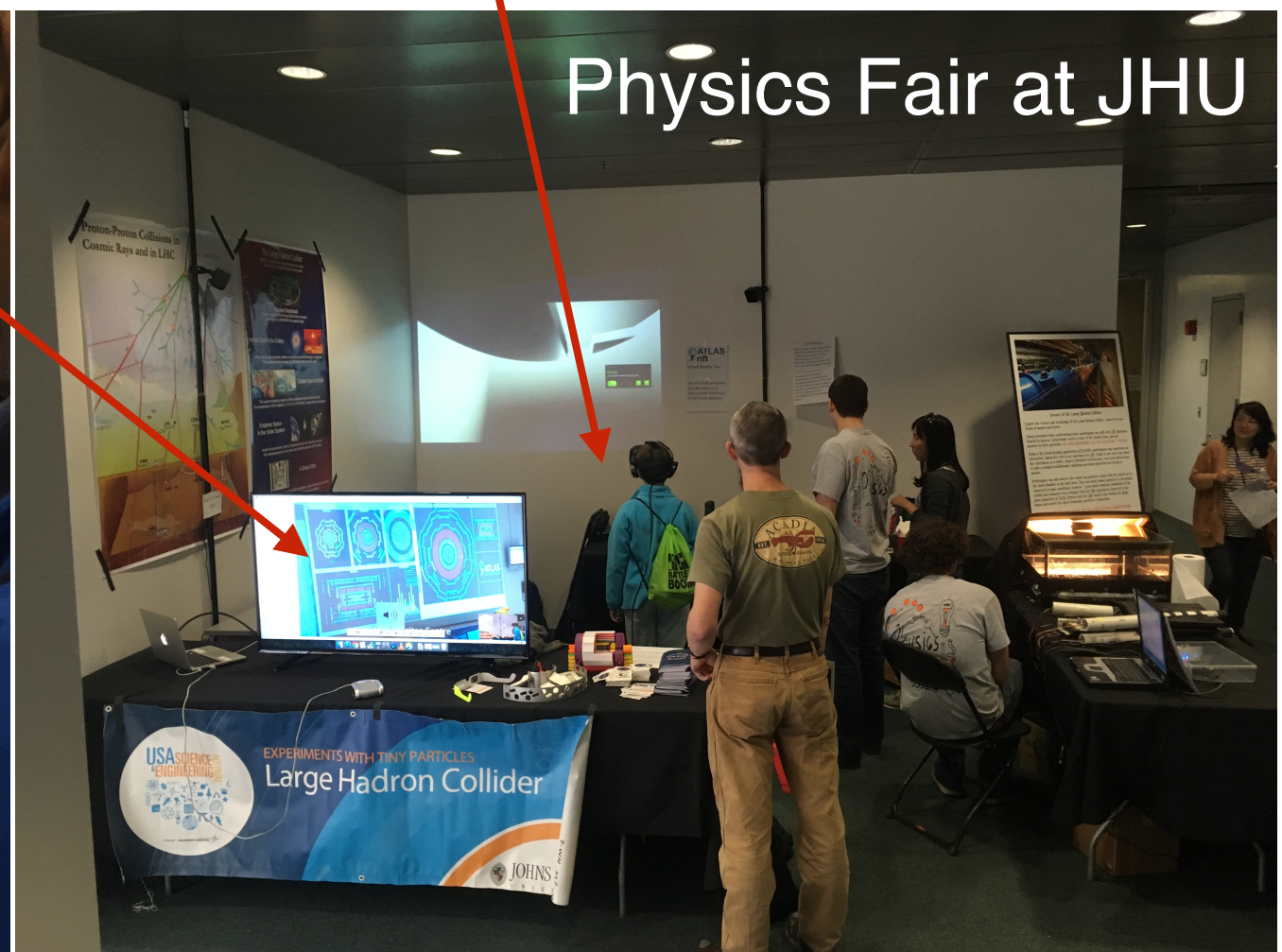


LHC Exhibit at Festivals in DC and JHU

- Enlarged the LHC exhibit in size and content

virtual visit to CERN (ATLAS control)

virtual reality (of ATLAS)



Virtual Reality of LHC

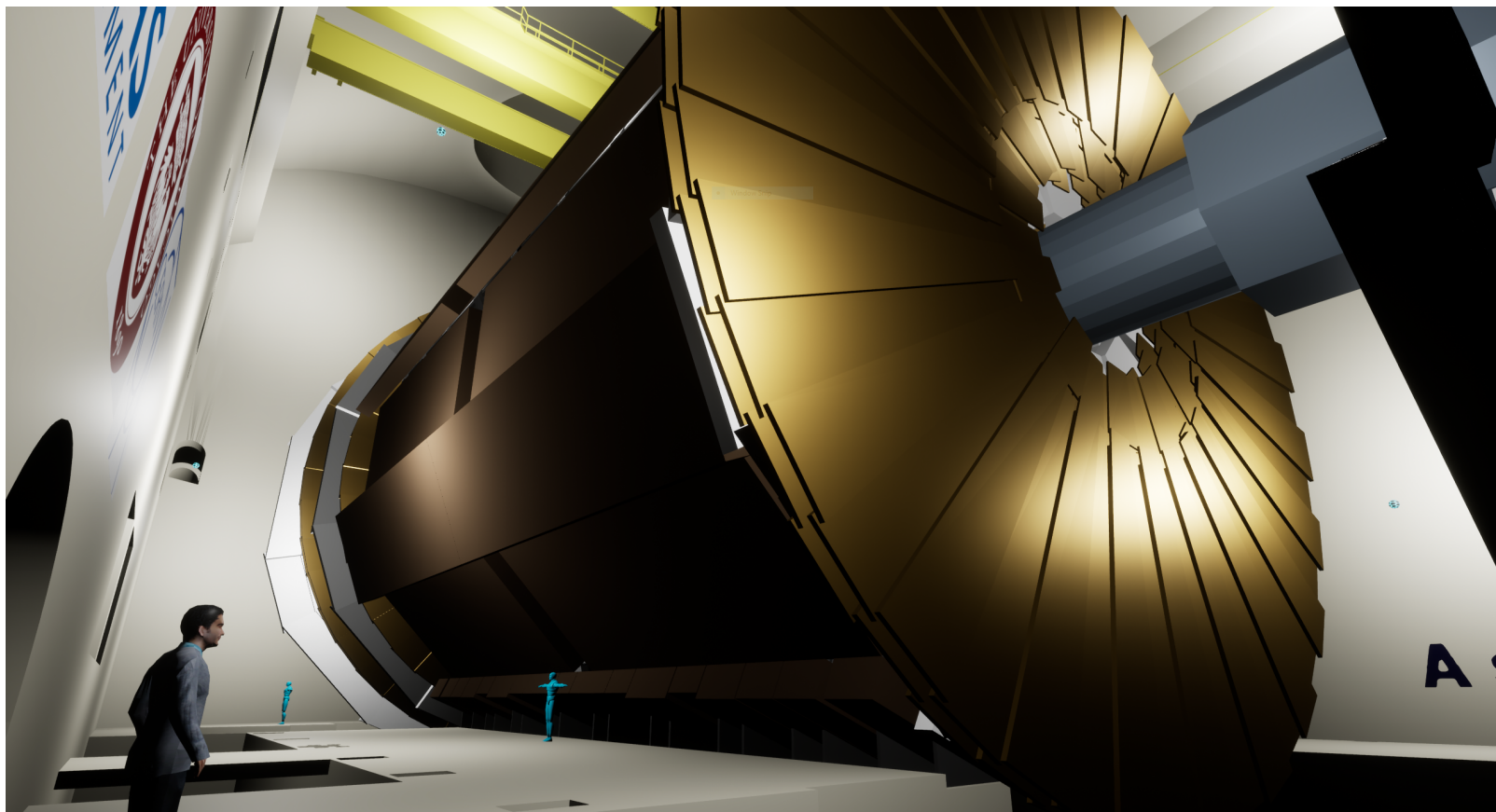
- ATLASrift is a Virtual Reality application <https://atlasrift.web.cern.ch> — provides an interactive, immersive visit to the ATLAS

Used the HTC Vive virtual reality headset with full 360 degree tracking over a 1.5m x 1.5m space

Powered by a enthusiast level PC running Windows 10

Dedicated graphics card, modern CPU, and at least 8 GB of RAM required

Box built by JHU grad student (L. Corcodilos) →



Virtual Visit to CERN

- ATLAS VV: using web-based video conferencing tools, participants talk with a physicist, receive a tour of the ATLAS control room, and get answers to your questions.

<https://atlasvirtualvisit.web.cern.ch>

(similar VV exists at CMS)

Good attraction

What is needed:

- enthusiastic guides
- good enough internet
- Vidyo on a laptop
- big display
- good microphone/speakers



LHC Exhibit - The Particle World

- The core of the LHC exhibit has been
Four-layer cosmic μ detector — part of QuarkNet project
Cloud chamber and e⁻ beam in E/B — effective way to show particles



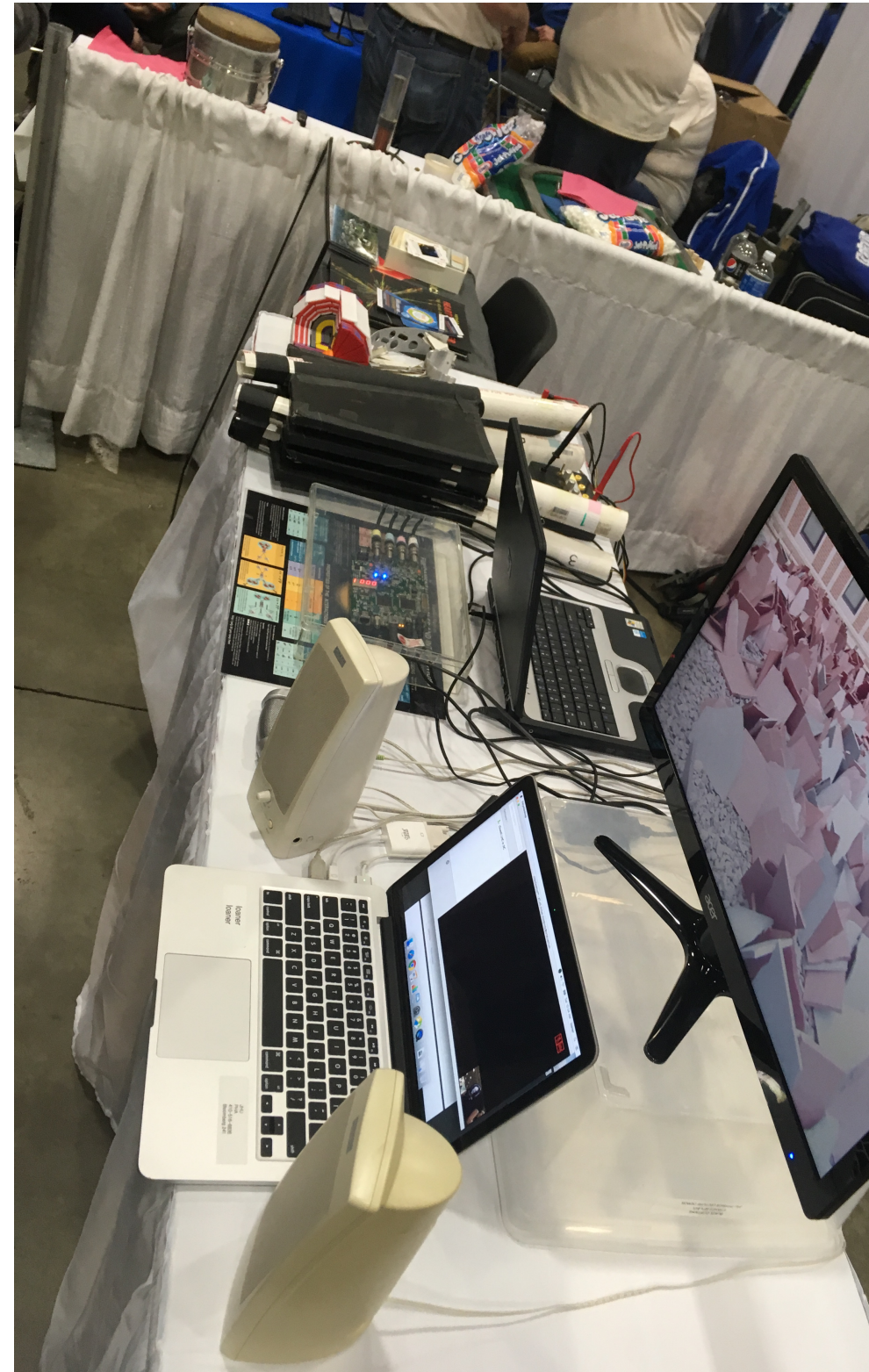
Do not forget the kids

- Plenty of other close-to-HEP demos with magnets, liquid N, etc
Gauss' rifle: a magnet linear accelerator dropping “weightless” magnet in a metal tube
superconducting train, **frozen stuff**,..
(though did not carry from JHU to DC)



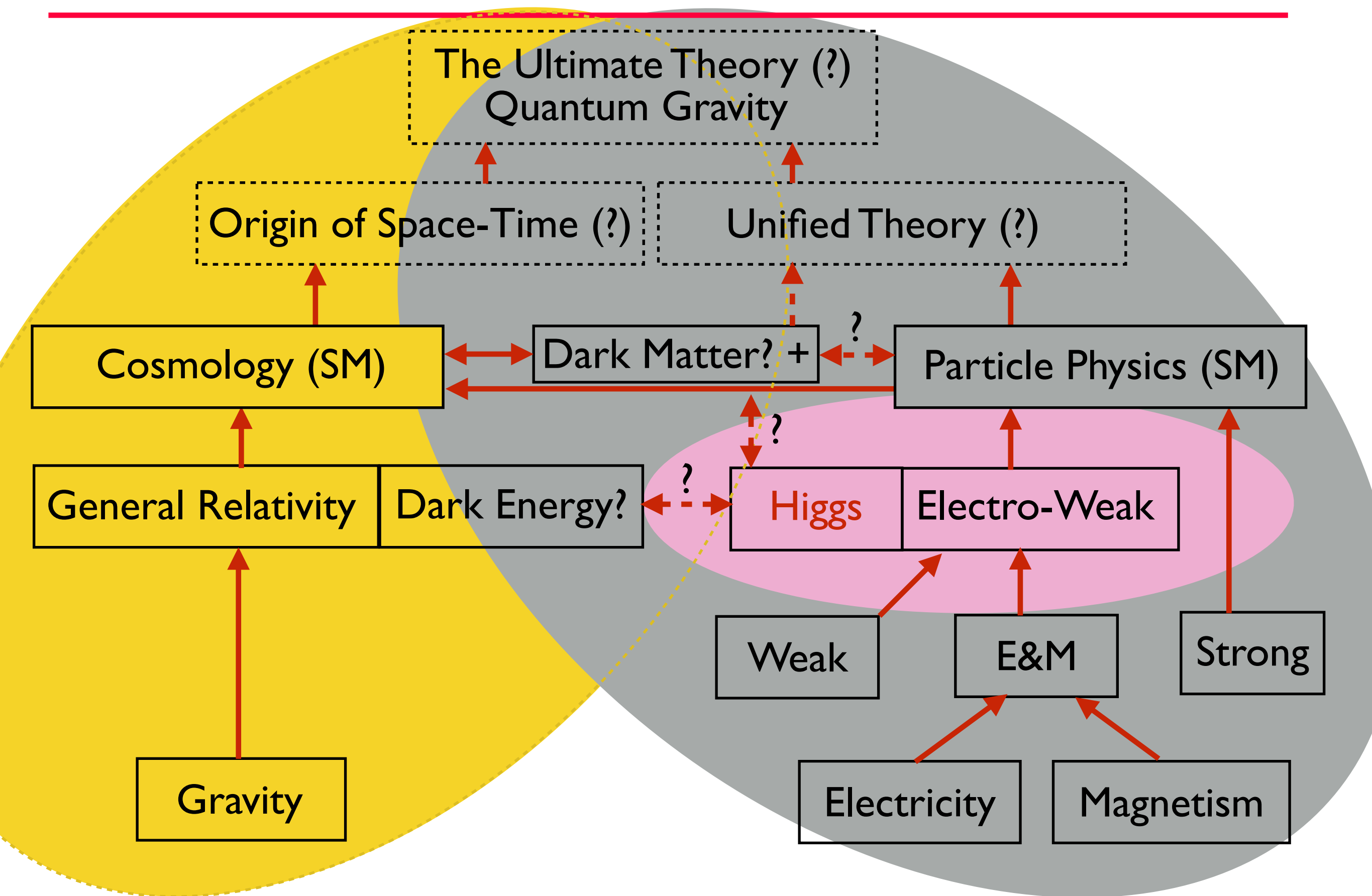
Summary of Part I

- Public awareness of the **importance of science** cannot be taken for granted
- With this in mind, develop effective ways to promote the value of LHC, **make connection**
- A number of relatively **simple demonstrations** targeted to all ages
affordable to most university groups
most effective in context of a larger event
- Keep people interested in science
engage the **youth**
keep us engaged

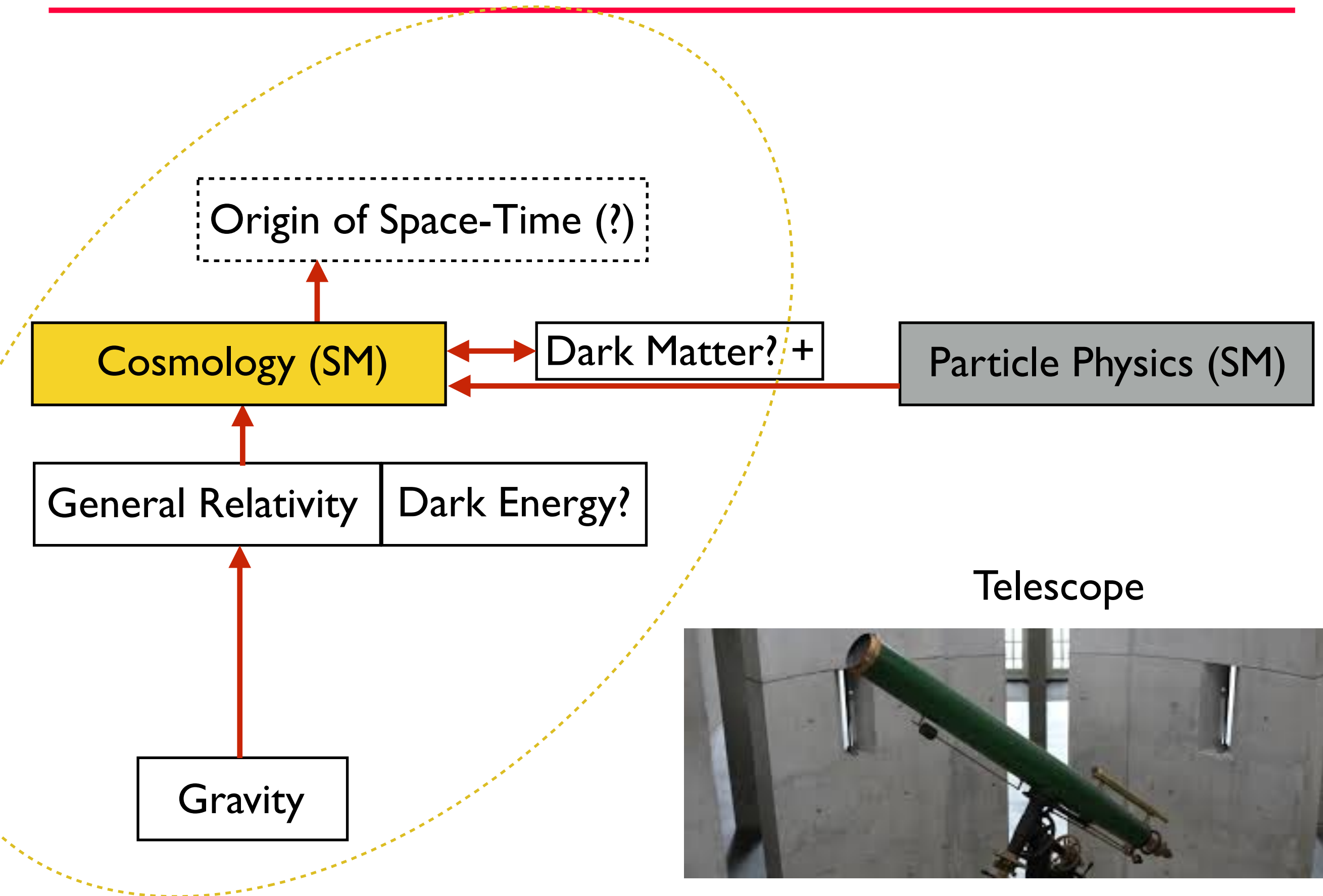


Part II

Standard Model (SM) and Beyond

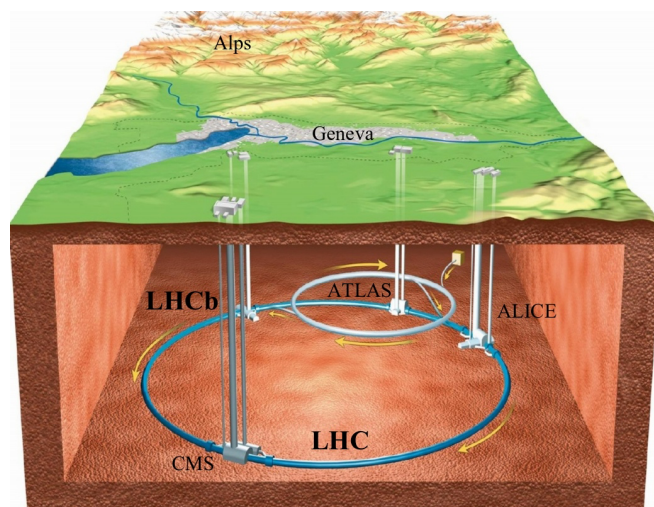


Astrophysics

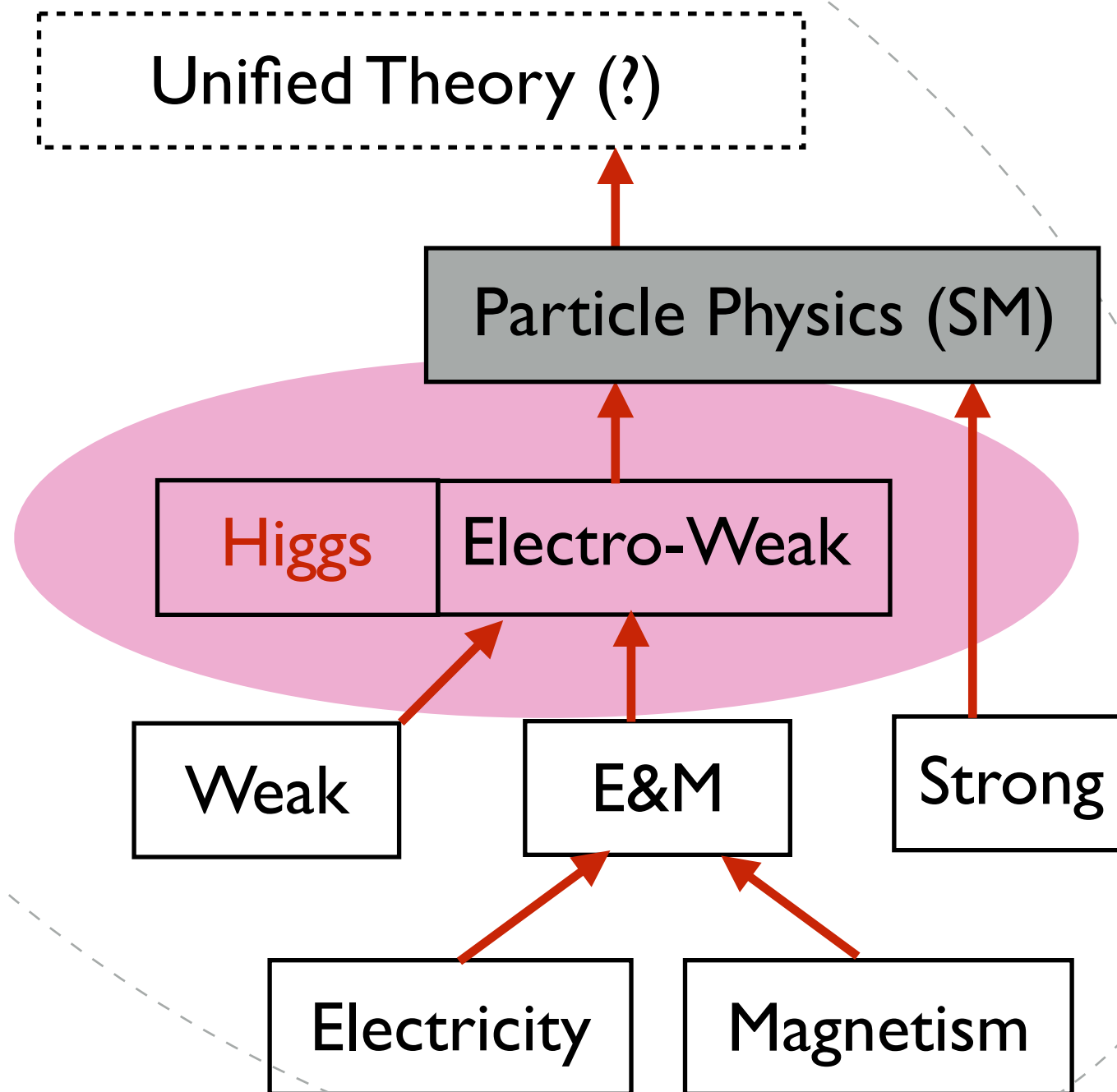


Particle Physics

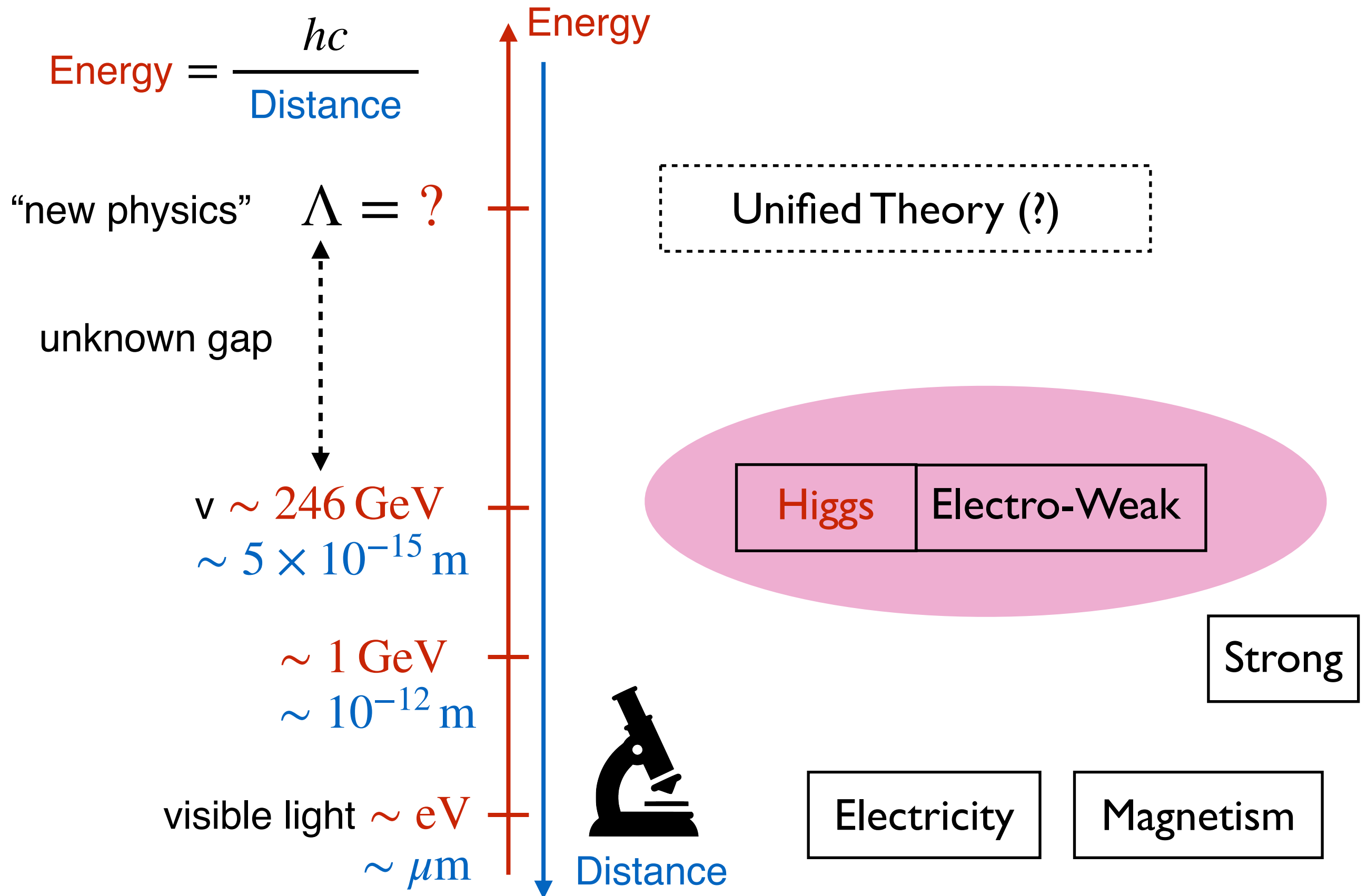
Microscope

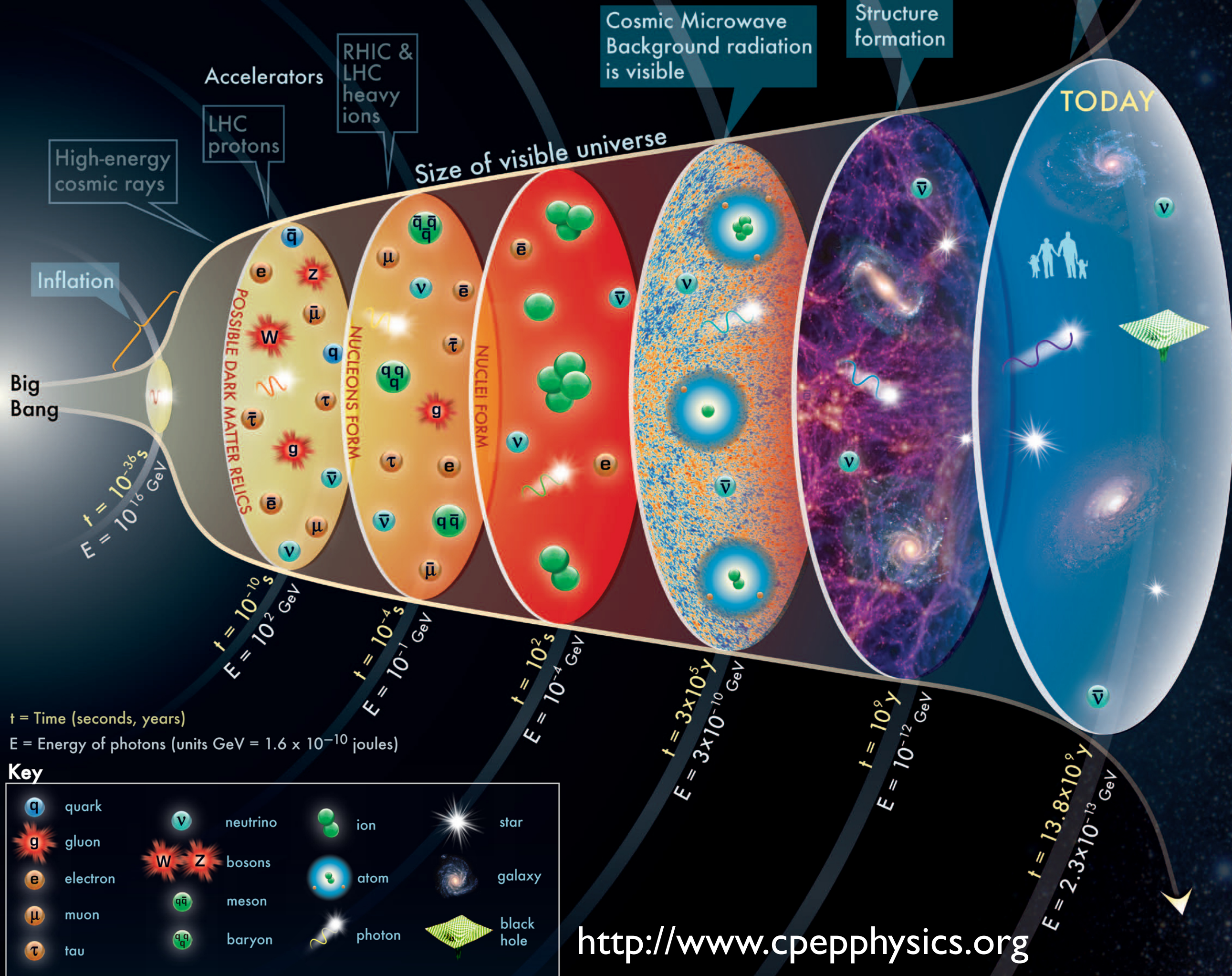


Large Hadron Collider

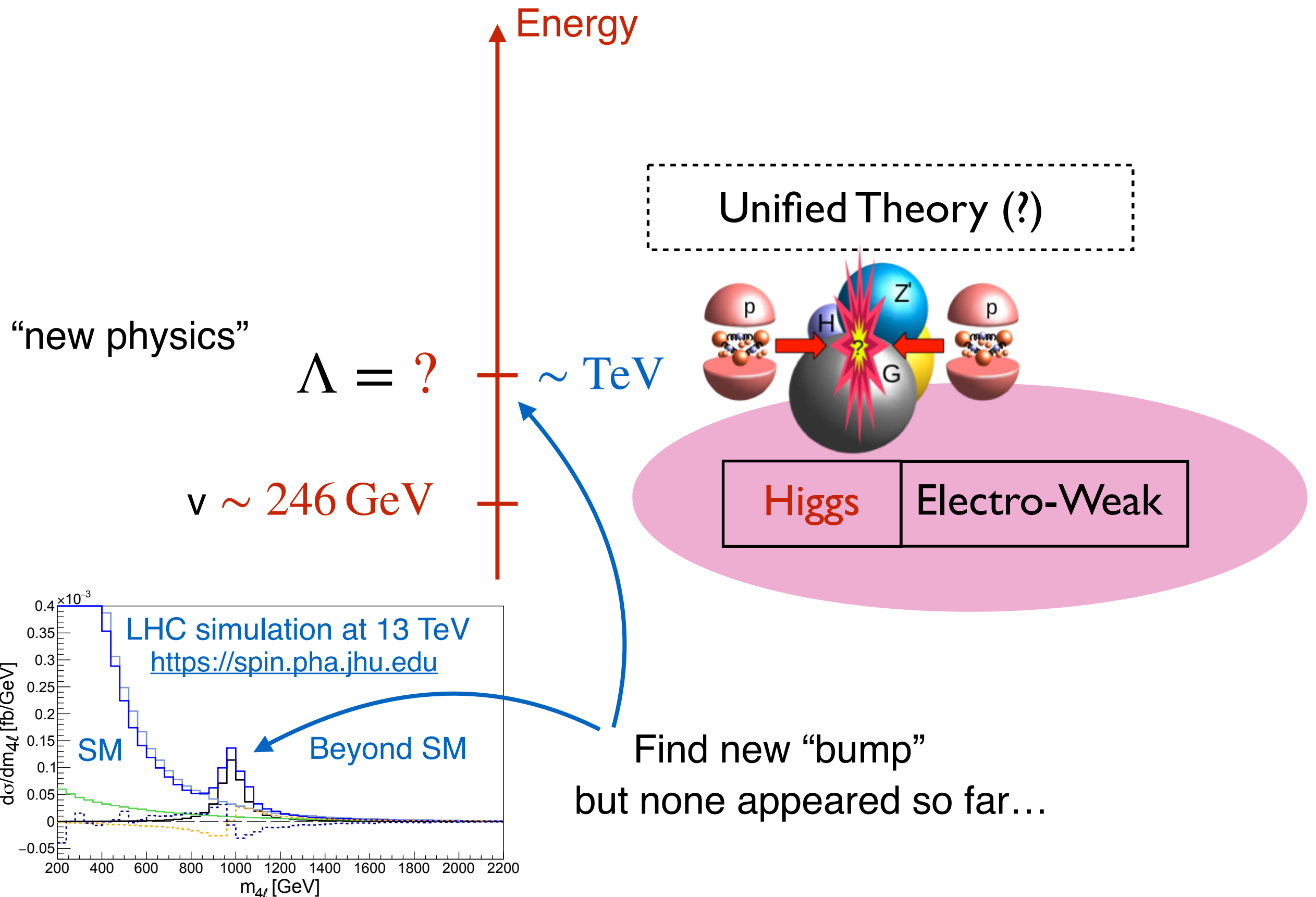


Scales in Particle Physics

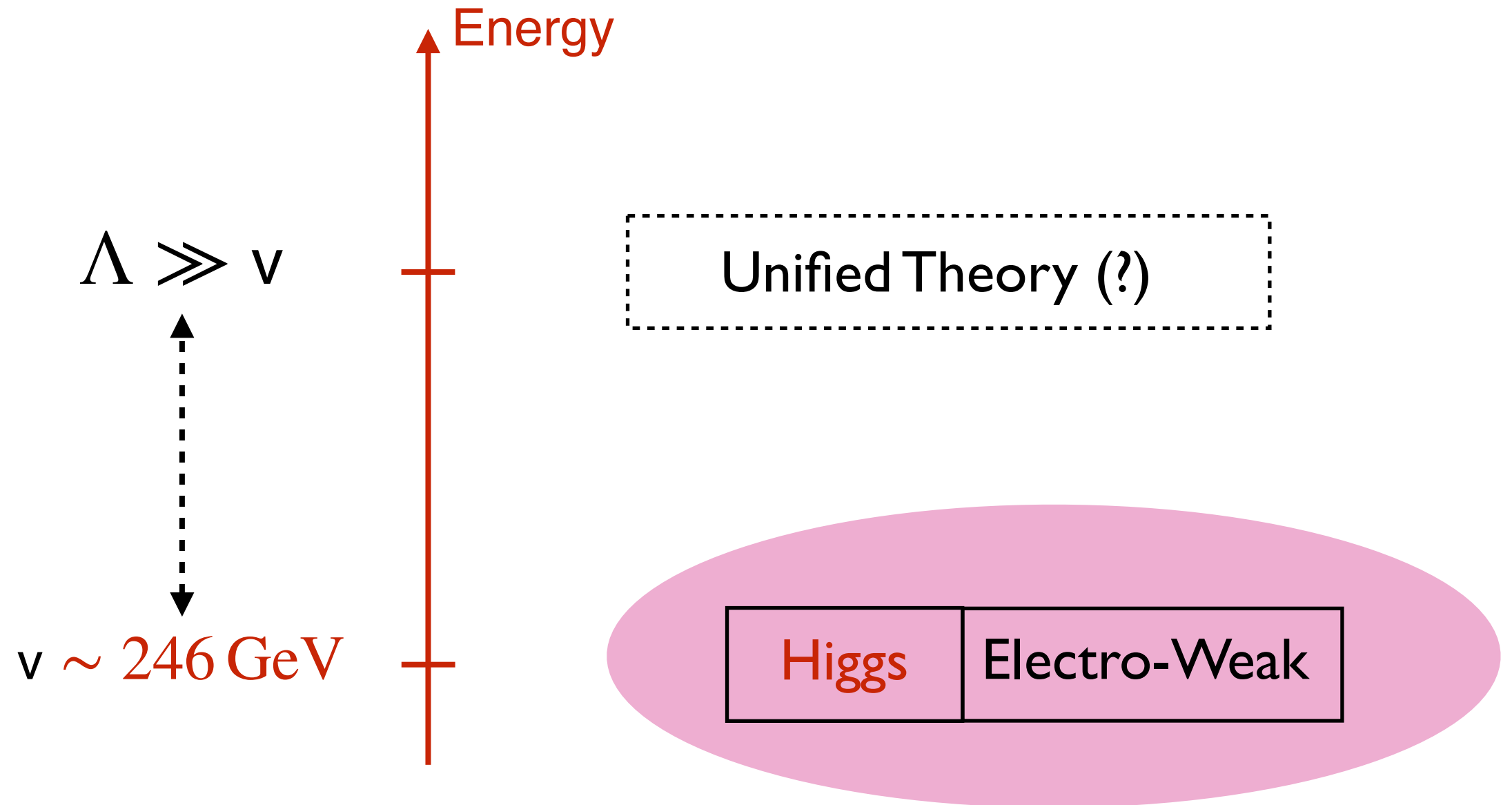




“Optimistic” Scale in Particle Physics



“Pessimistic” Scale in Particle Physics



Particle Physics (SM)

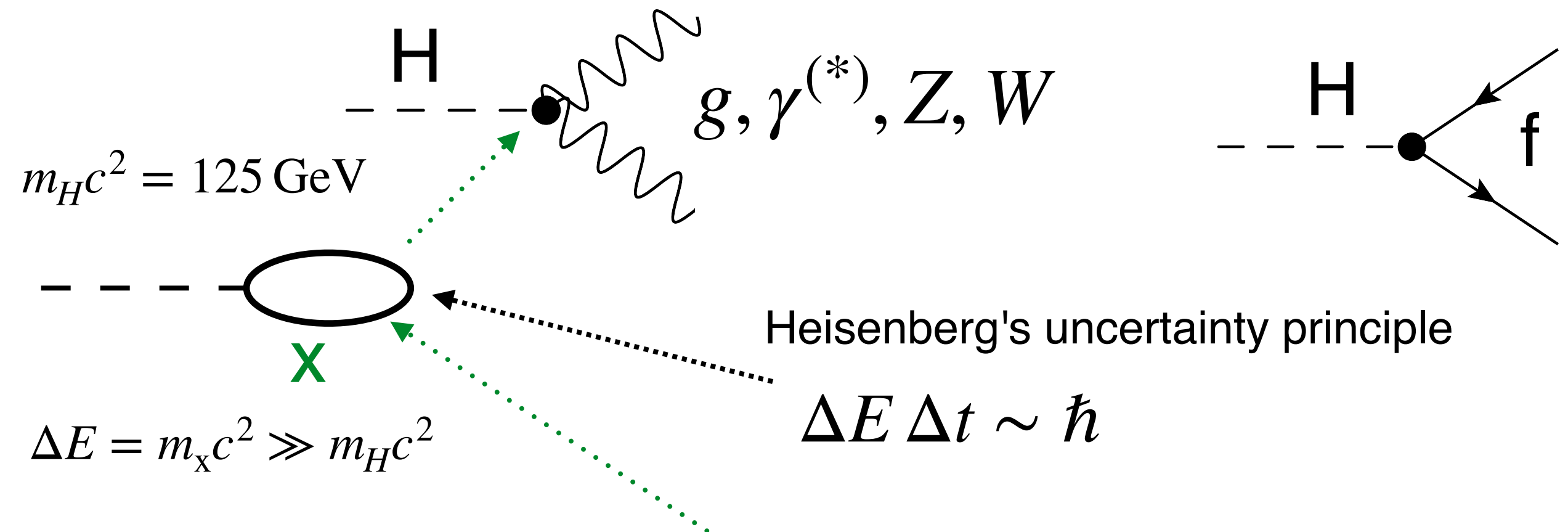
is an Effective Field Theory (EFT)

precise up to $\sim \left(\frac{v}{\Lambda}\right)^2$

Effective Field Theory (EFT)

- Effective Field Theory

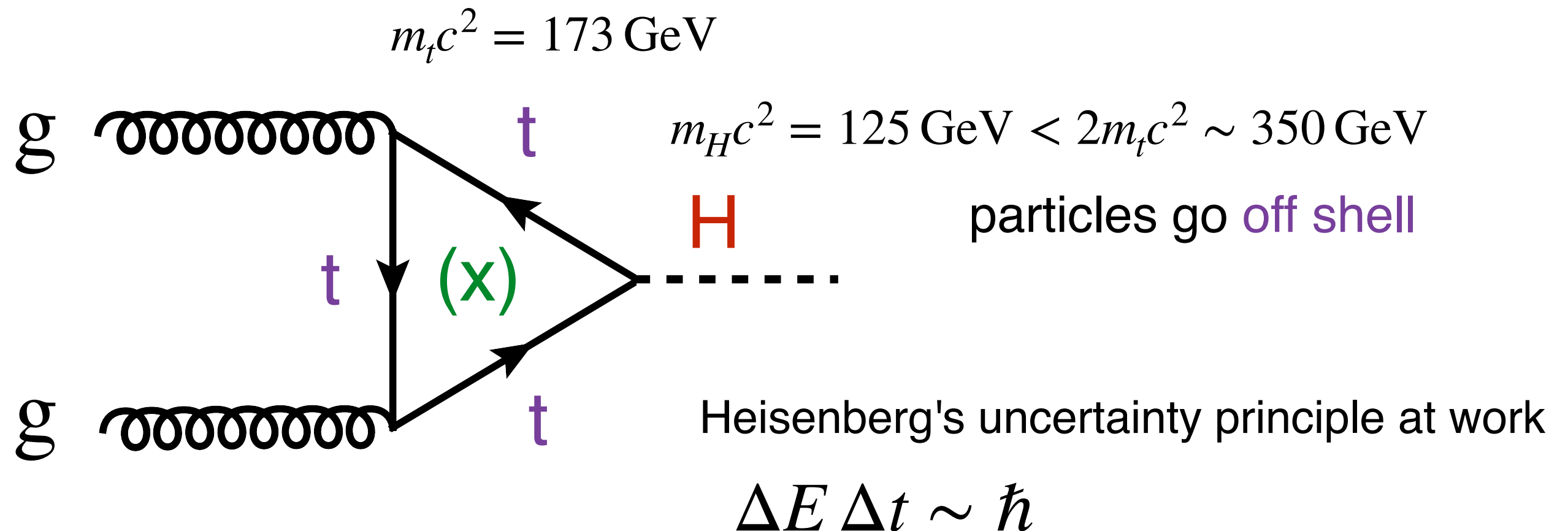
- describes energies (of interest) below Λ (underlying dynamics)
- no “new physics” up to $\Lambda \gg m_H$



- we do not know what is in the **loop**, in EFT we do not need to know
- heavy particles are integrated out \Rightarrow **point-like interaction**

Loop effects in SM

- “Heavy” loops happen in SM:

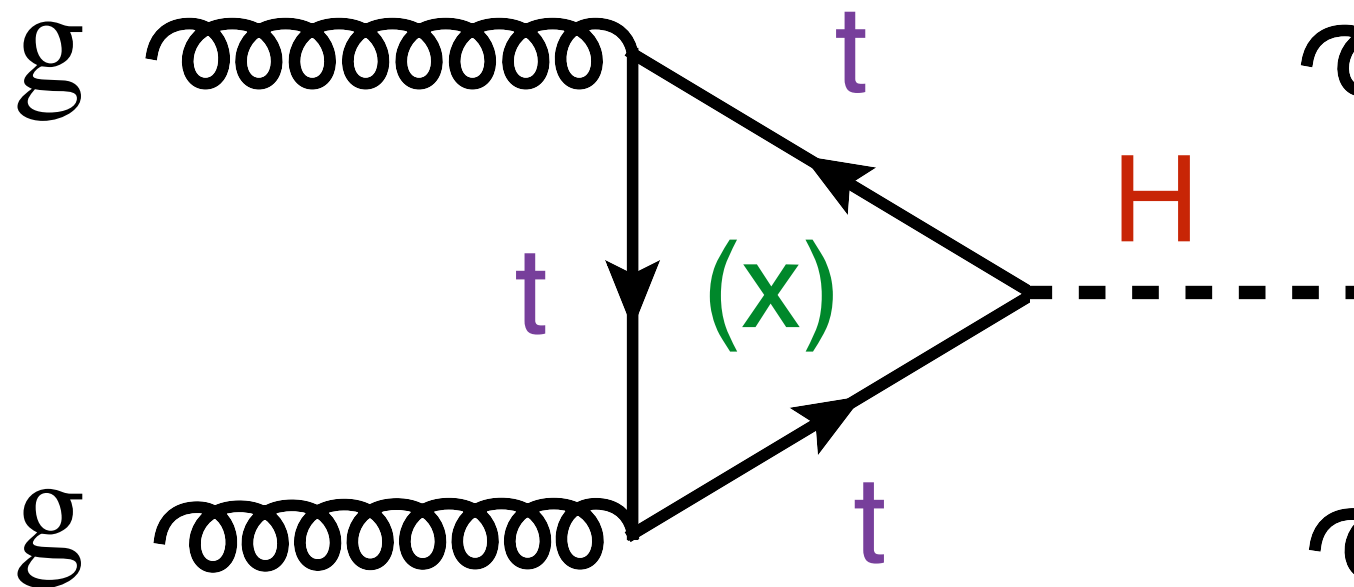


- Motivates our search for new heavy states (x)

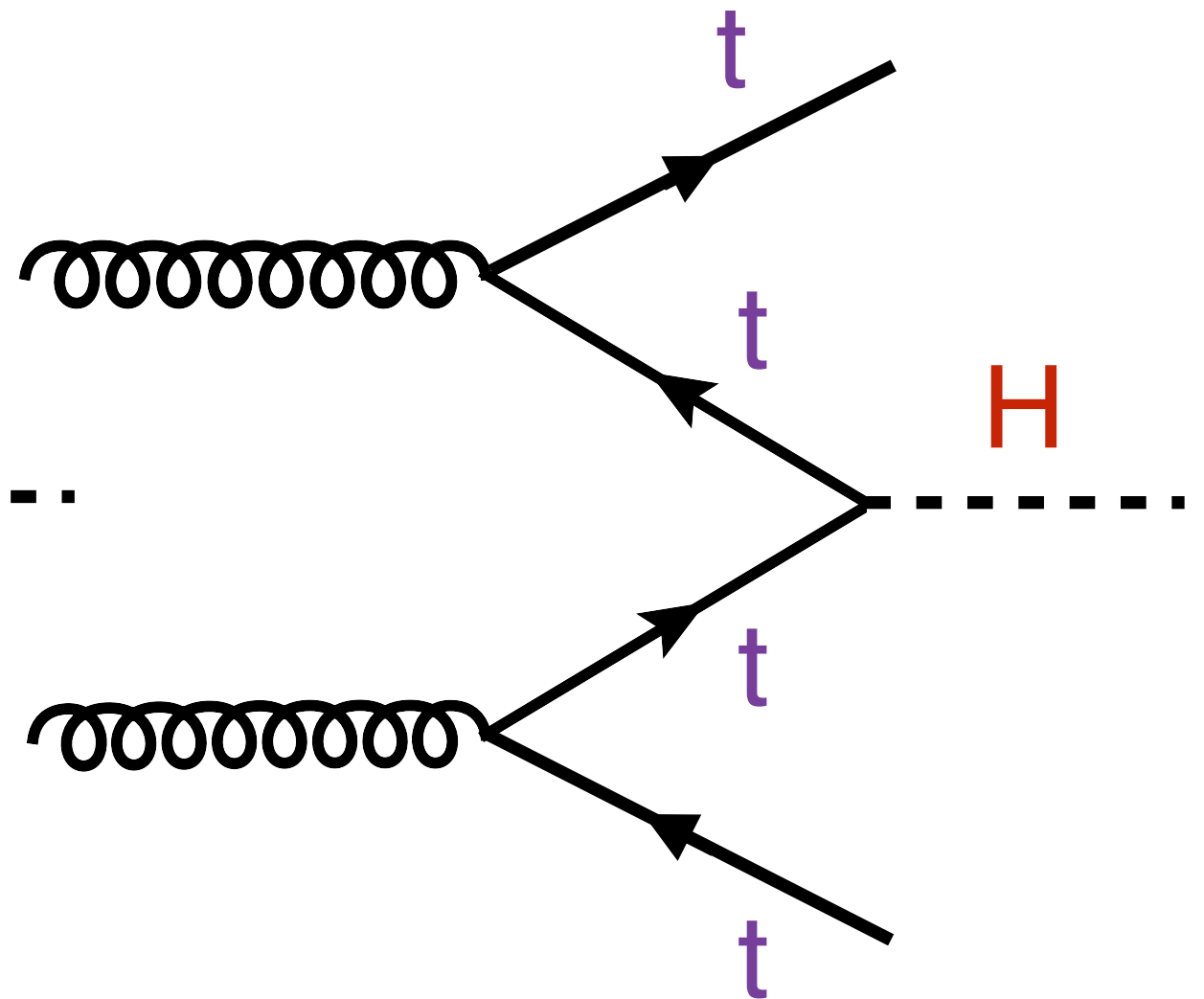
Study the Higgs

- Closed loop:

- Open the loop:

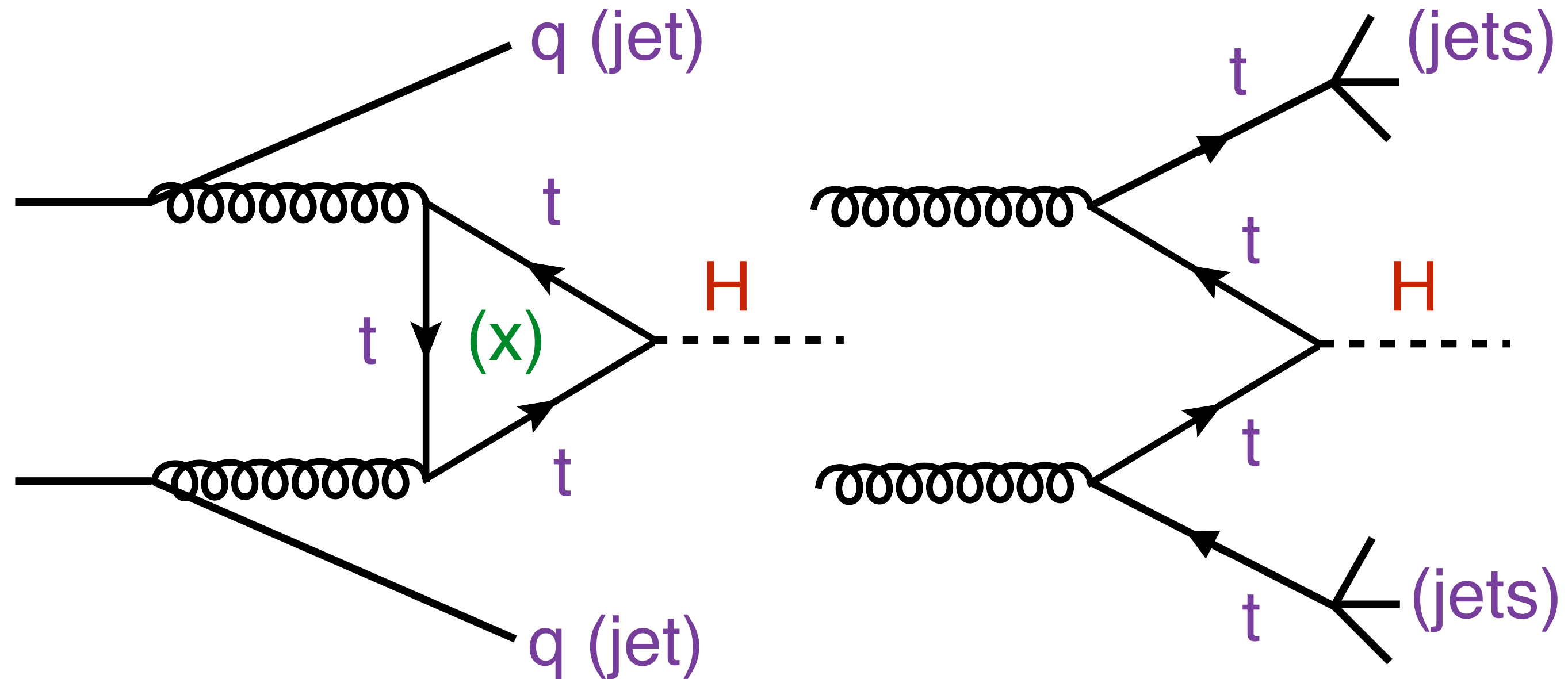


gluon fusion H production



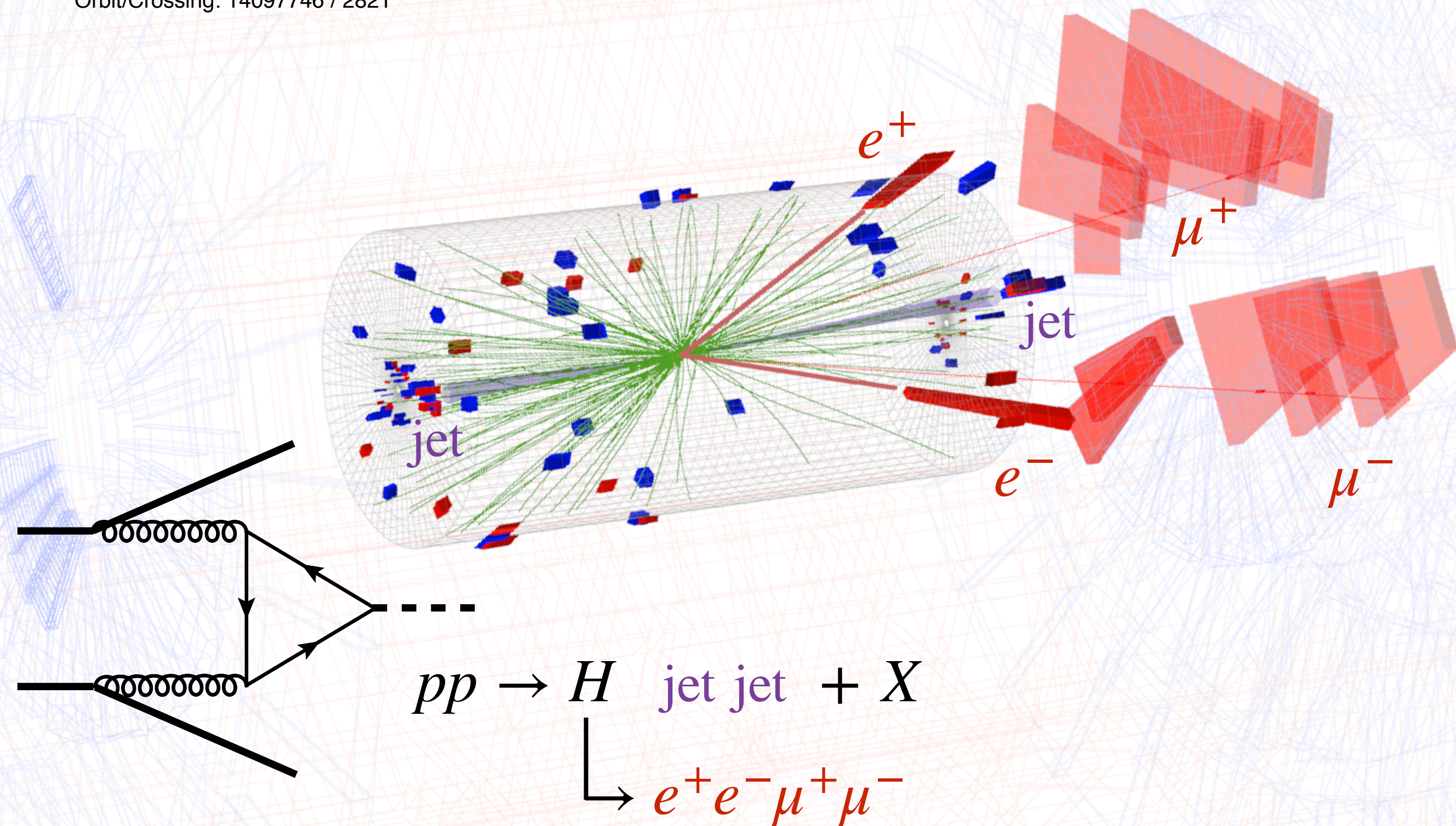
$t\bar{t}$ H production

Study the Higgs

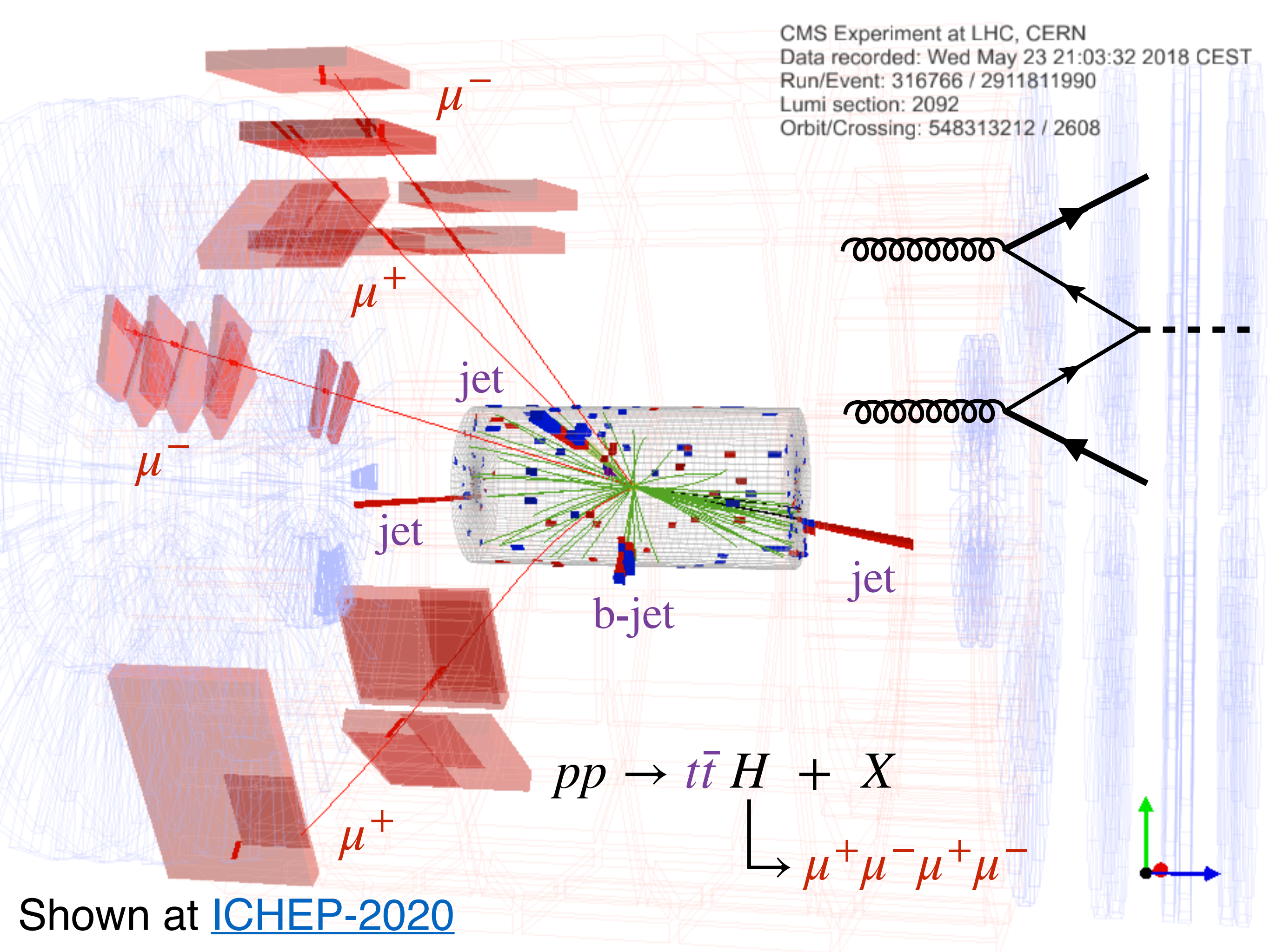


CMS Experiment at LHC, CERN
Data recorded: Thu Jun 28 14:00:31 2018 EDT
Run/Event 318874 / 88897146
Lumi section: 54
Orbit/Crossing: 14097746 / 2821

Shown at [ICHEP-2020](#)

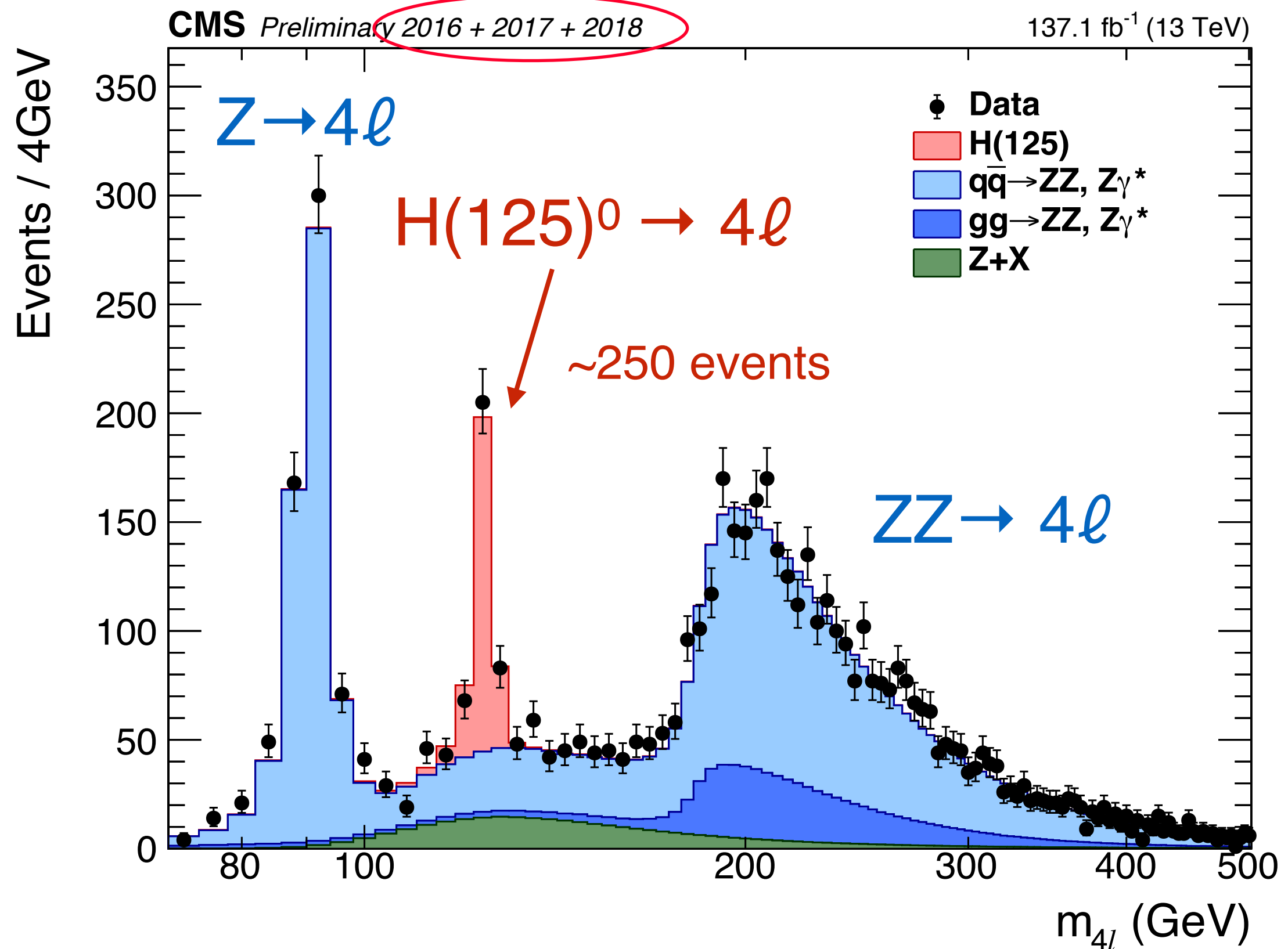


CMS Experiment at LHC, CERN
Data recorded: Wed May 23 21:03:32 2018 CEST
Run/Event: 316766 / 2911811990
Lumi section: 2092
Orbit/Crossing: 548313212 / 2608



Shown at [ICHEP-2020](#)

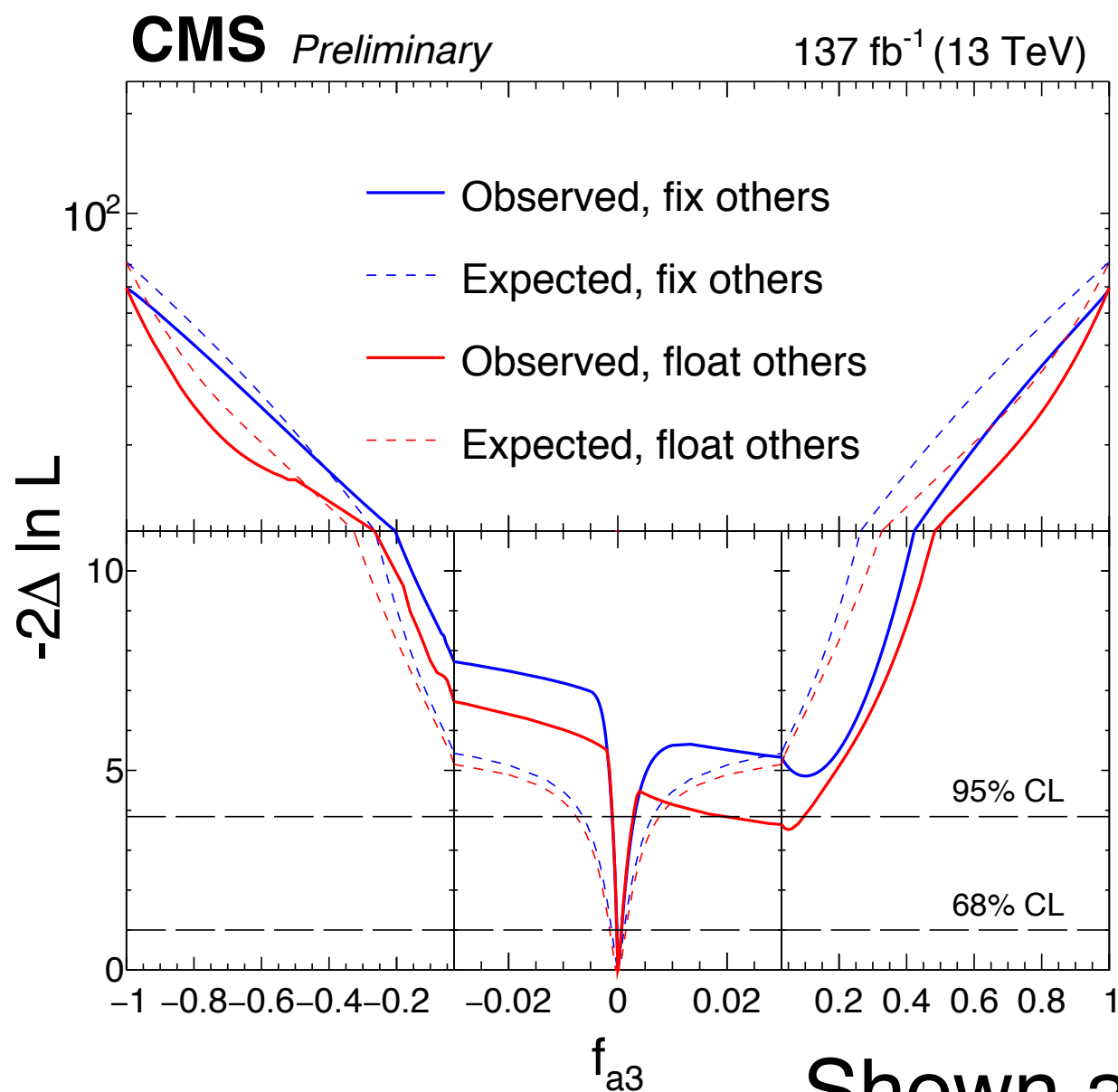
Higgs $\rightarrow 4\ell$ boson yield



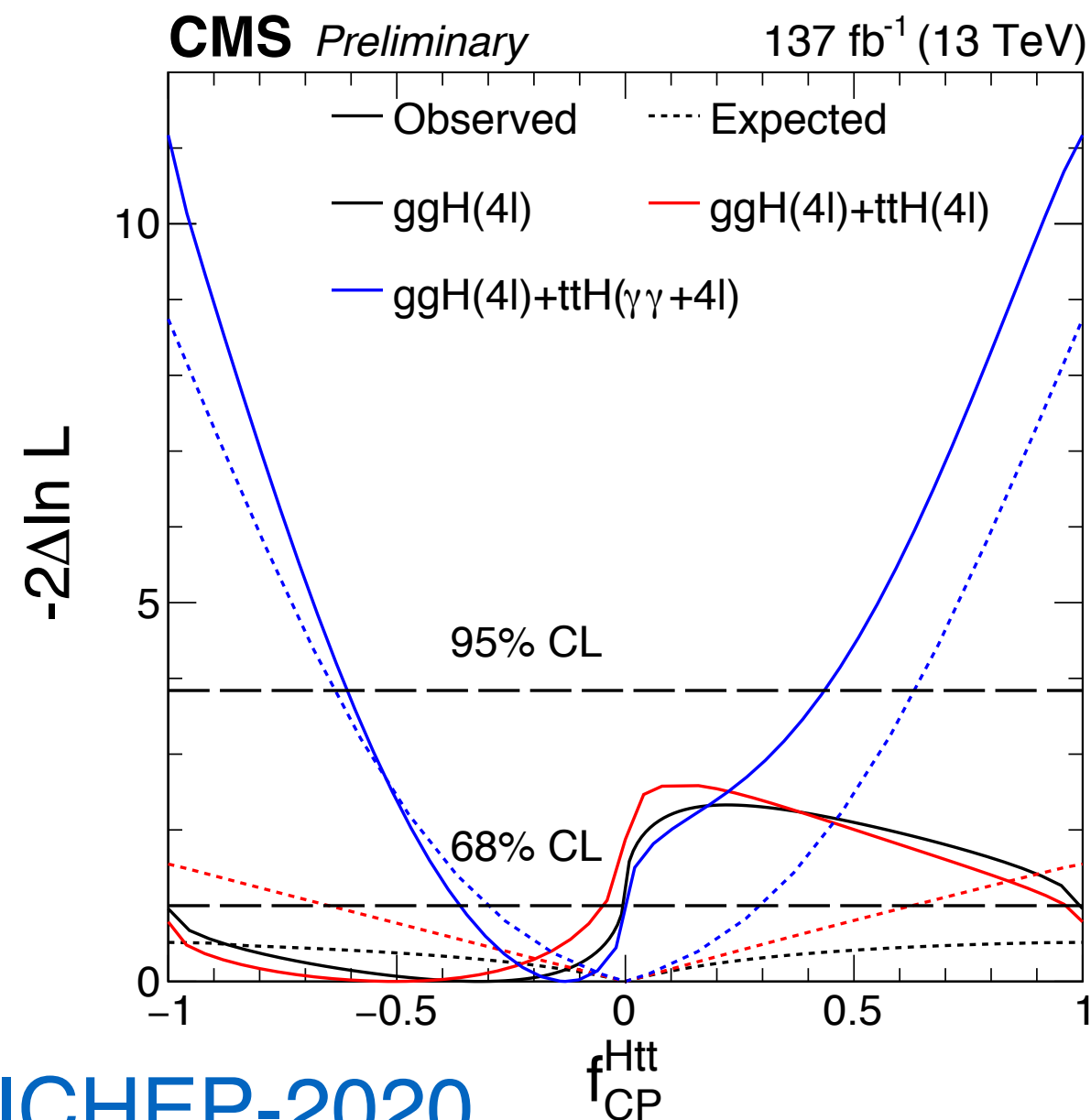
Test for anomalous contributions

- Approach in Effective Field Theory (EFT) $\text{deviations} \sim \left(\frac{v}{\Lambda}\right)^2$

Vector boson couplings of H (HVV)



fermion couplings of H (Hff)



Shown at [ICHEP-2020](#)