My Work at CERN

Phase-2 CMS tracker upgrade and Drell-Yan process analysis

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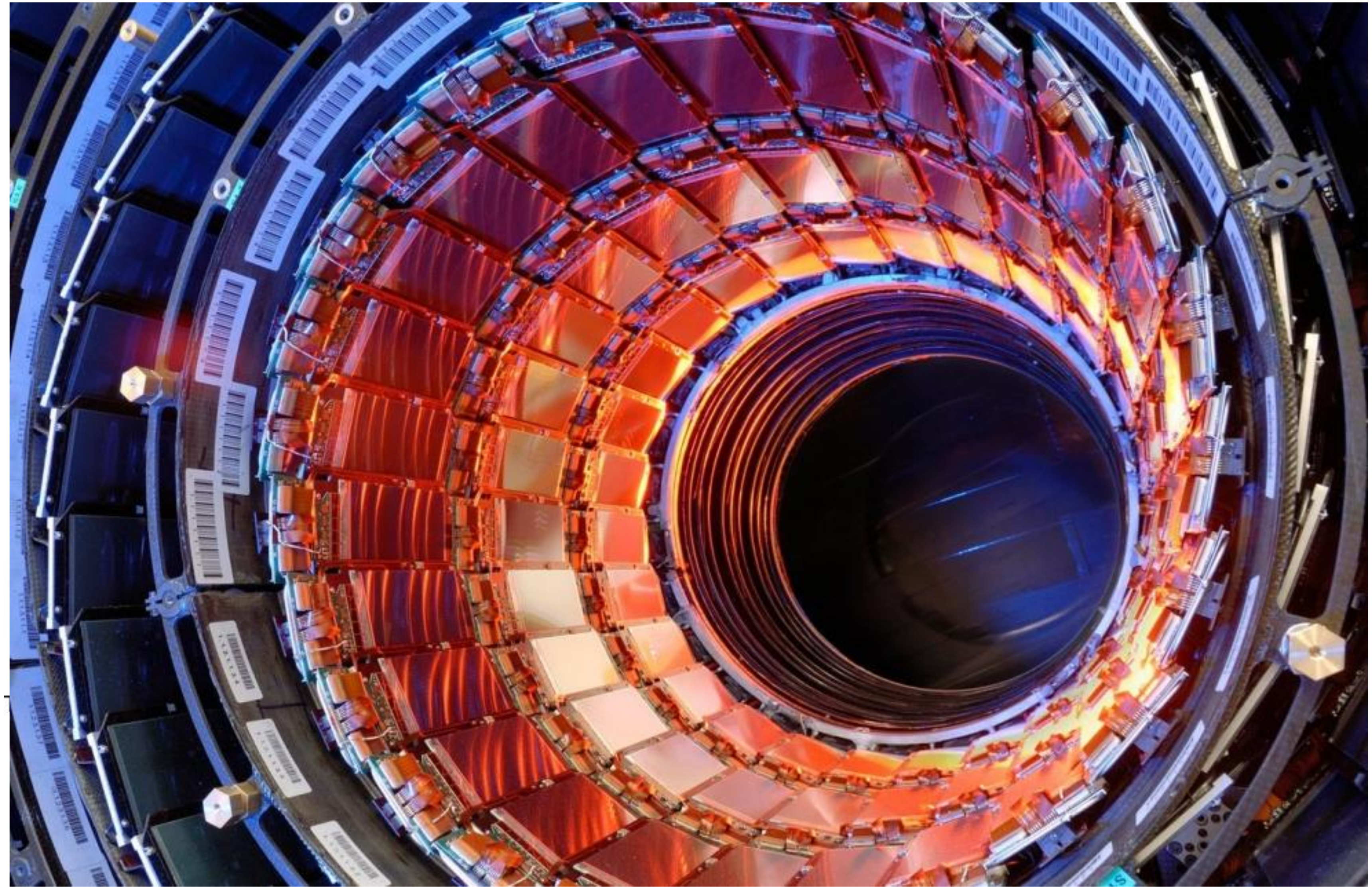
Outline

- Phase-2 upgrade of the CMS tracker
  - CMS and its tracker
  - Phase-2 upgrade
  - My contribution
- Drell-Yan process analysis
  - Drell-Yan process
  - My contribution

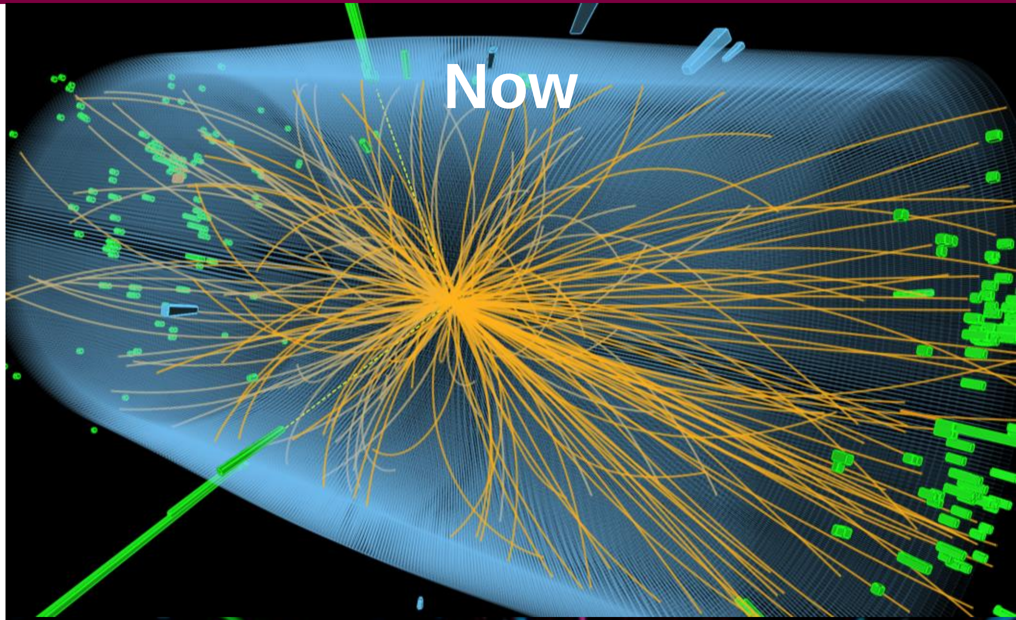
Compact Muon Solenoid (CMS) and its tracker

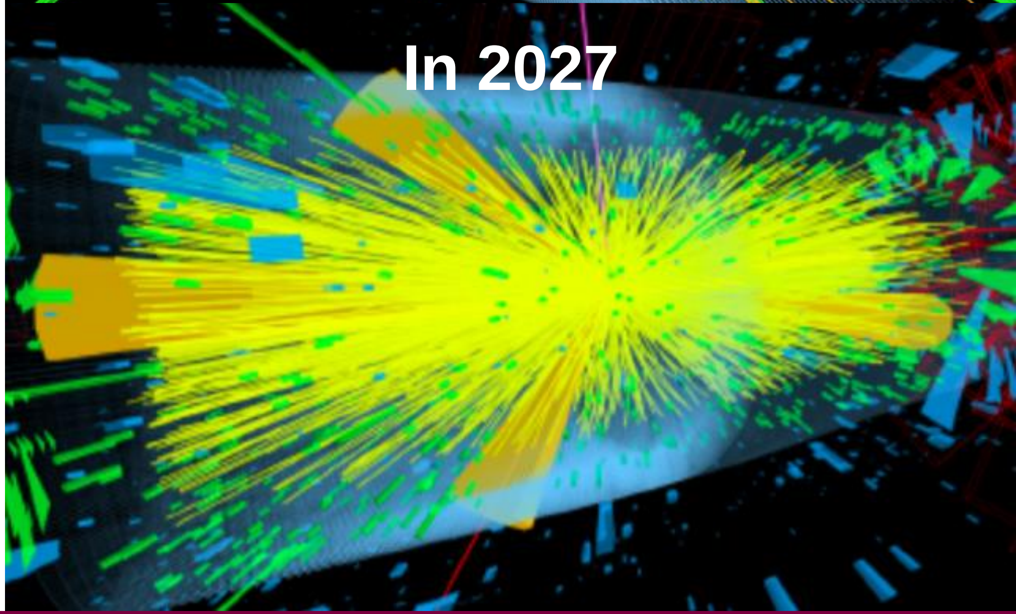


- CMS is a multipurpose particle detector at the LHC
- It consists of many layers, each with different purpose
- The innermost layer is the silicon tracker
- It detects the tracks of charged particles
- Tracker has two parts: inner and outer

CMS Phase-2 upgrade

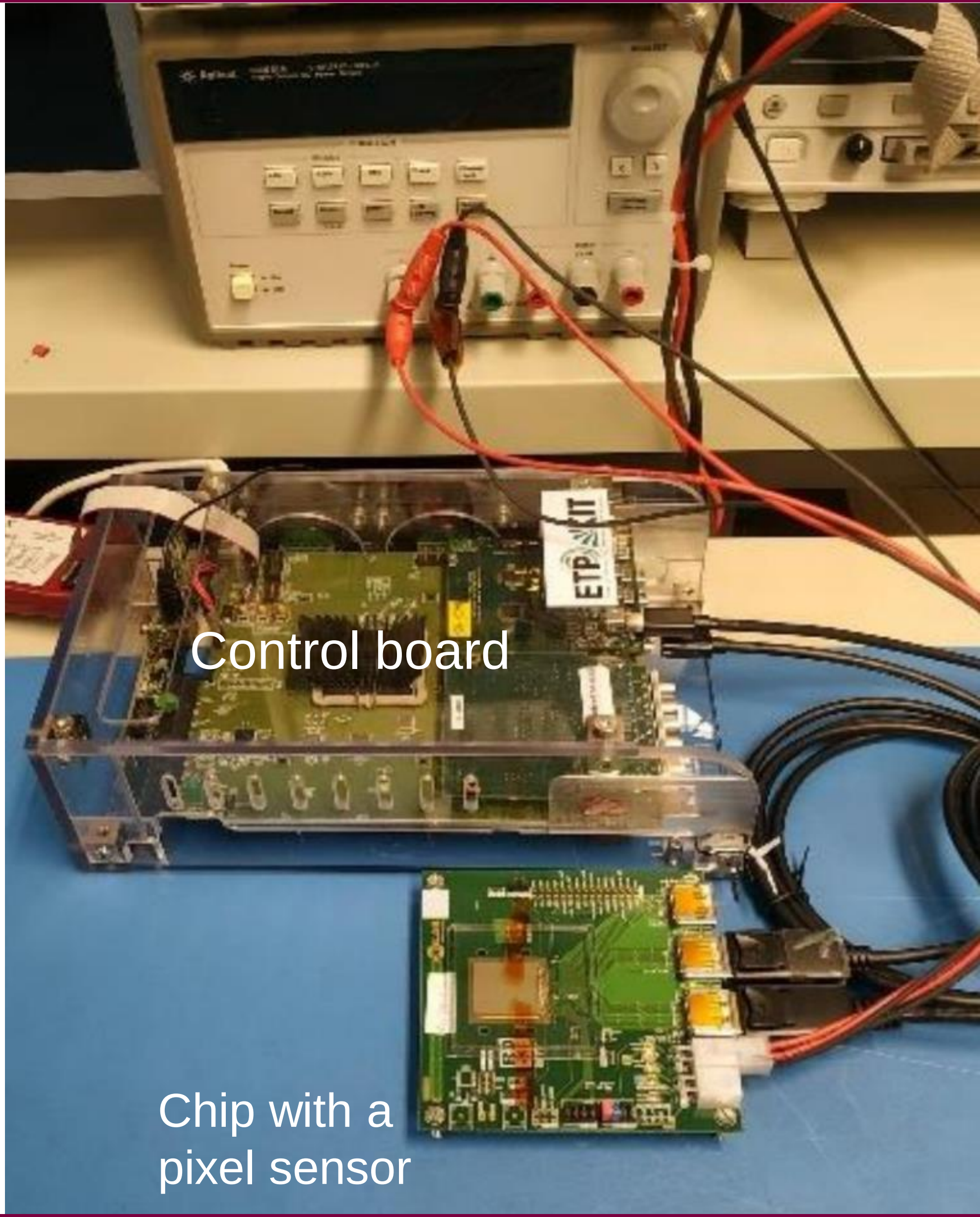
- The High-Luminosity LHC upgrade is planned for 2025-2027 which will result in tenfold increase in luminosity
- This means ~10 times more proton-proton collisions occurring during the same crossing of proton bunches
- This poses a big challenge for particle detectors, especially its innermost layers
- The CMS tracker will have to be significantly upgraded
- The new tracker must have:
  - A lot better granularity to separate many tracks
  - High radiation-hardness to withstand ten times increased radiation doses





My contribution

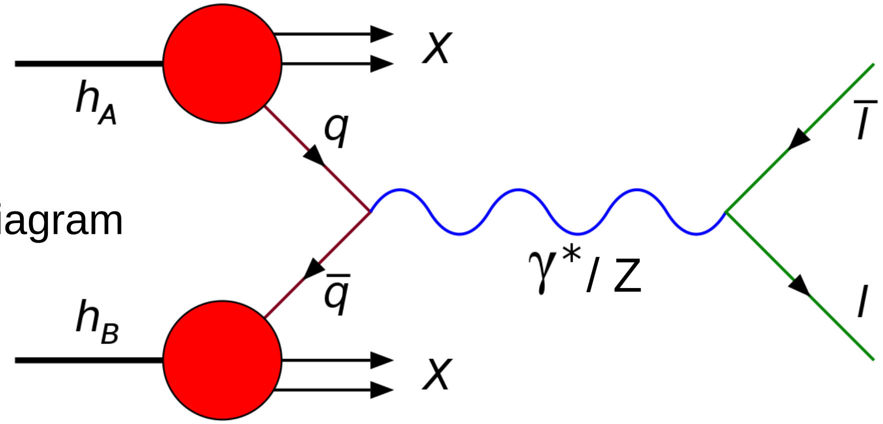
- The new tracker prototypes are already in preparation
- I am currently working with pixel detector prototypes for Inner Tracker
- My work involves:
  - Developing the data acquisition software for the new tracker
  - Performing test measurements to characterize the prototypes, testing their performance and reporting to chip designers and other software developers
  - Optimizing tracker calibration routines by finding optimal parameters for calibration
- I currently use the setup that is present at CERN via remote connection
- When the COVID situation settles, I am planning to do some hands-on work with the prototypes at CERN, possibly participate in beam tests



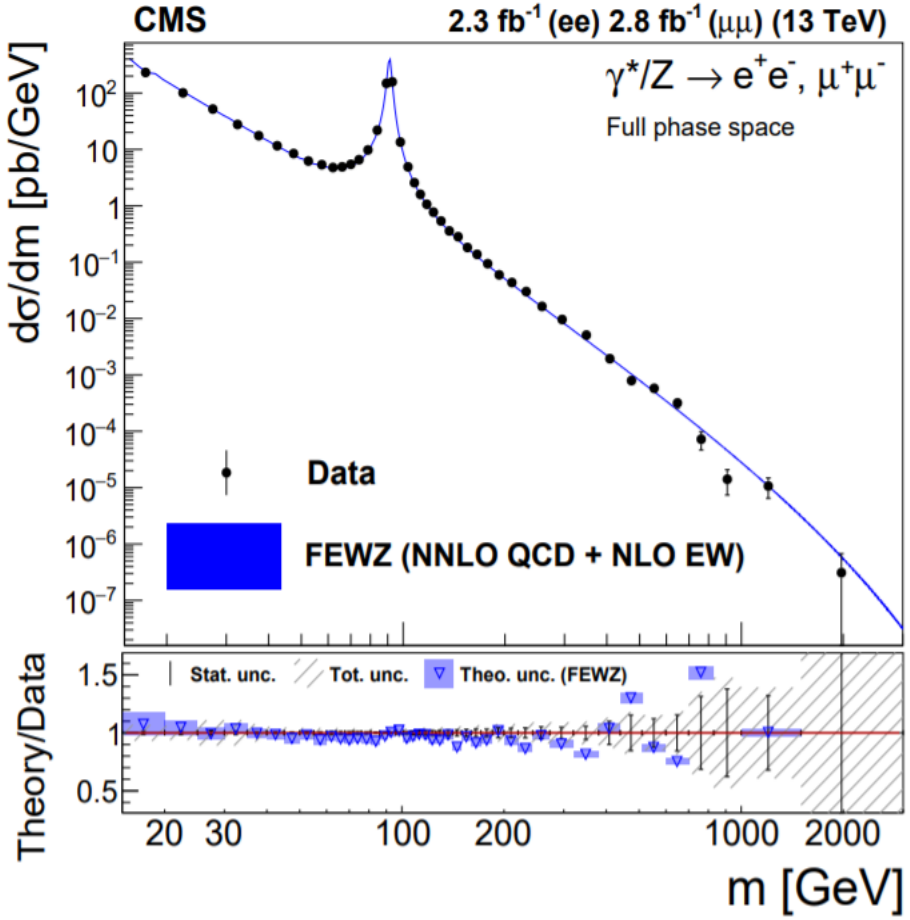
Drell-Yan process (DY)

- When two protons collide, a quark and an antiquark may annihilate and create a photon or a Z boson
- The newly produced particle then decays into a lepton-antilepton pair
  - E.g., an electron and a positron
- Physicists measure the Drell-Yan process cross section with increasing precision every year
  - This is done by measuring the frequency of the occurrence of this process
- More and more precise measurements help theorists better understand the inner structure of the proton

DY process diagram



DY differential cross section $\mathrm{d}\sigma/\mathrm{d}m$

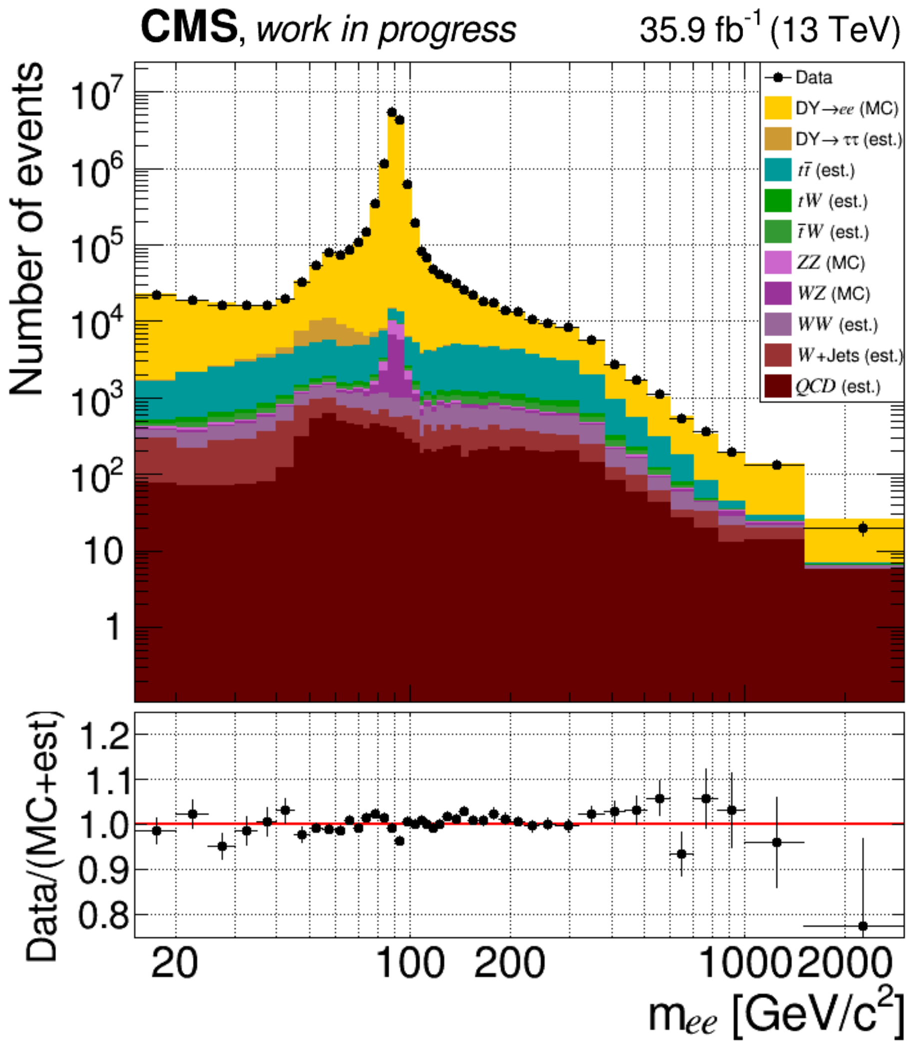


The CMS Collaboration. JHEP 12 059, 2019

My contribution

- As with any real-life measurement, there is some amount of background distorting our results
- In our case this corresponds to all the other physics processes that may produce the same or similar particles as the Drell-Yan process
- The background needs to be estimated and subtracted from measured distributions
- The simplest way to do this is by using computer simulation
- My task is to make higher quality estimations by making use of additional detector data (the so-called data-driven methods)
- I am working in collaboration with the international Drell-Yan analysis group

DY signal (yellow) and backgrounds (other colors)



Thank you for your attention!

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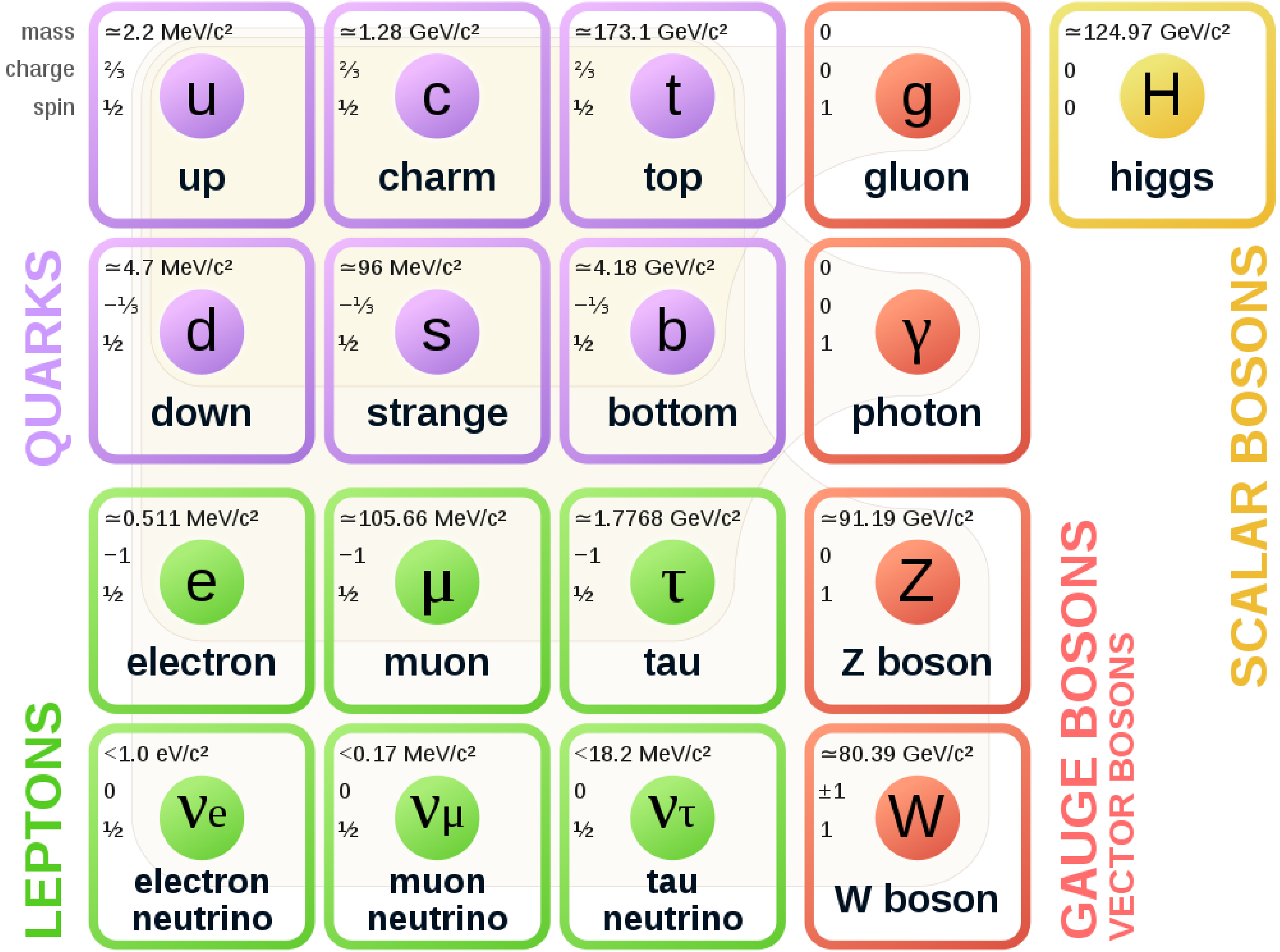
Standard model

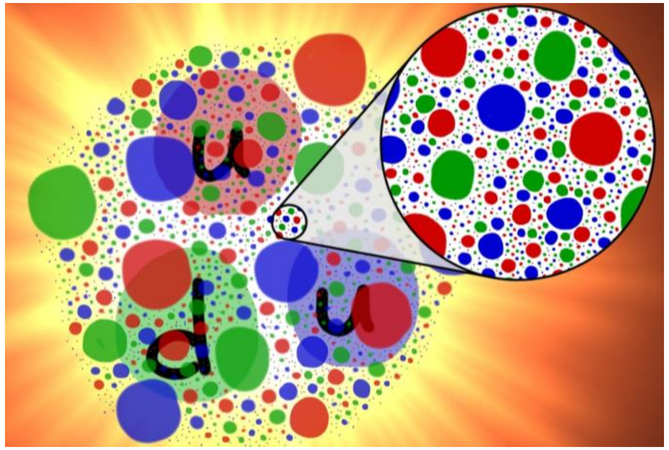


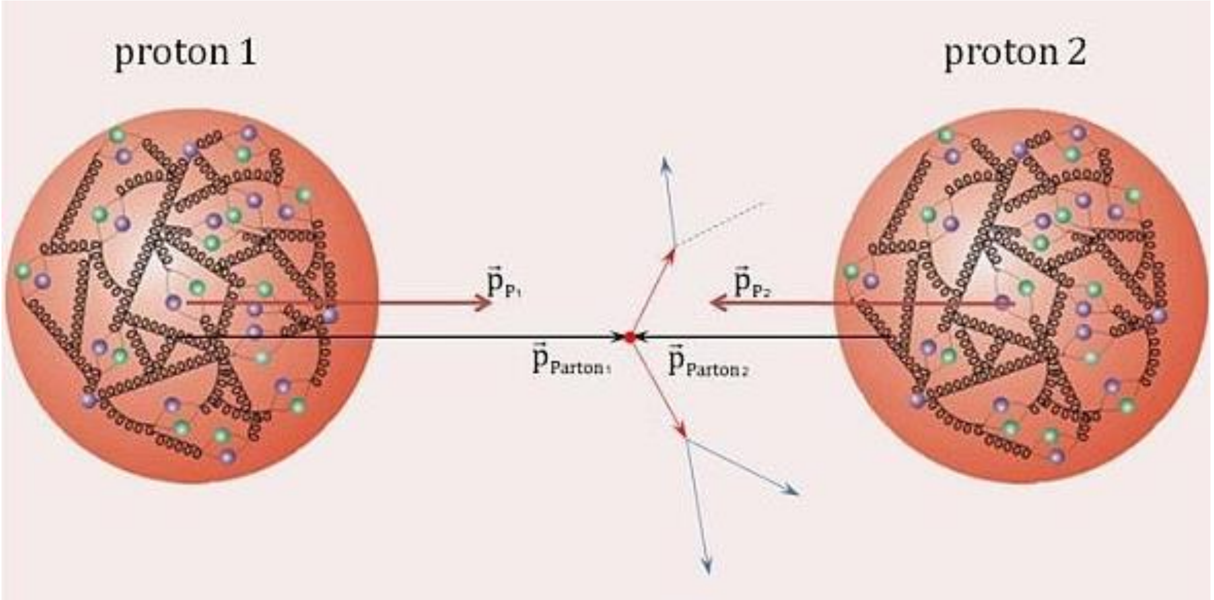
Wikimedia Commons: MissMJ

Proton structure and pp collisions

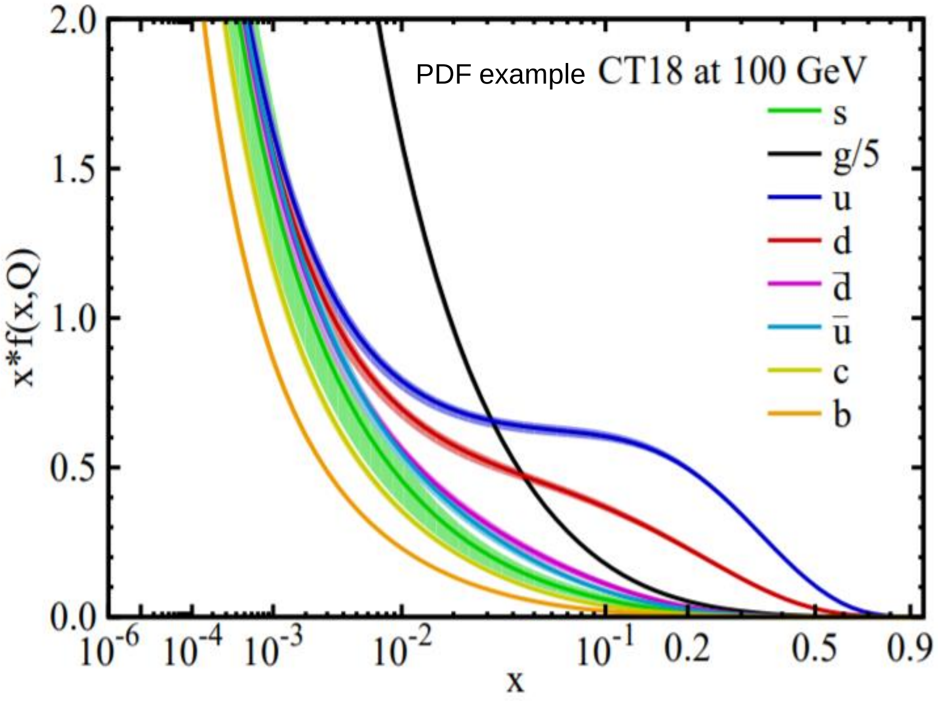
- Proton consists of three valence quarks and quark-gluon “sea”
- The structure of the proton is described using parton distribution functions (PDFs)
- Interactions between non-valence quarks are possible in proton-proton collisions

https://news.fnal.gov/2012/05/quarks-and-gluons-and-partons-oh-my/





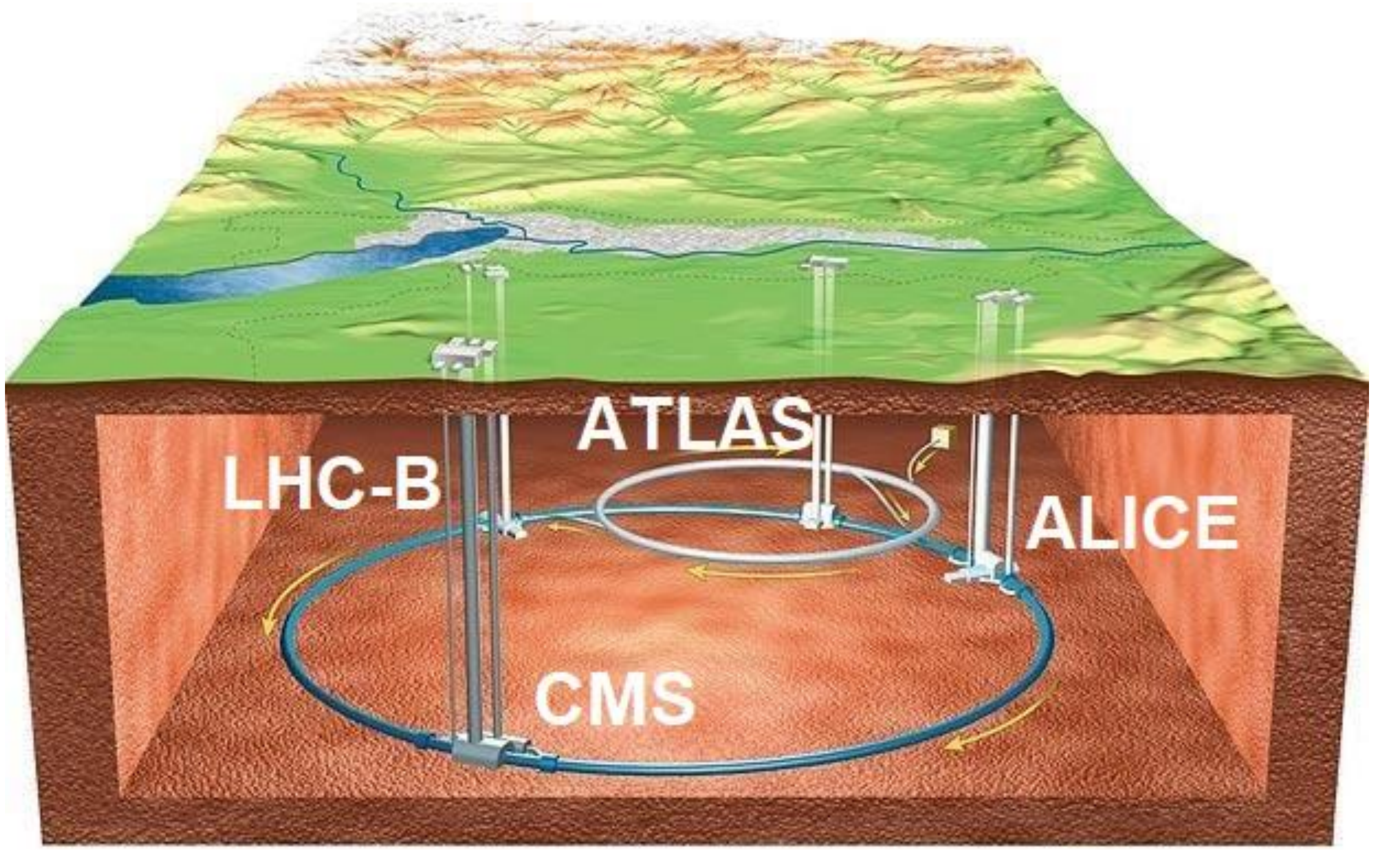
https://atlas.physicsmasterclasses.org/en/zpath_protoncollisions.htm



T.J. Hou et al. MSUHEP-19-025, 2019.

Large Hadron Collider

- Large Hadron Collider (LHC) is the largest particle collider ever made
- It produces 13 TeV proton collisions; it is the highest collision energy achieved by humanity so far
- Compact Muon Solenoid (CMS) is one of the four largest experiments at LHC



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