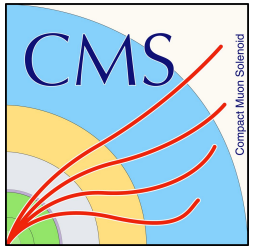
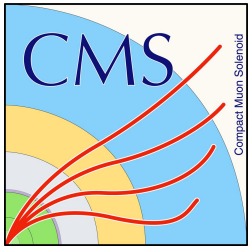


Fermilab

Compact Muon Solenoid Experiment (CMS) in 10 Minutes

Grace Cummings

New Perspectives, 27 June 2023



Fermilab

THE LARGE HADRON COLLIDER IN 1.5 MINUTES

Compact Muon Solenoid Experiment (CMS) in ~~10~~ 8.5 Minutes

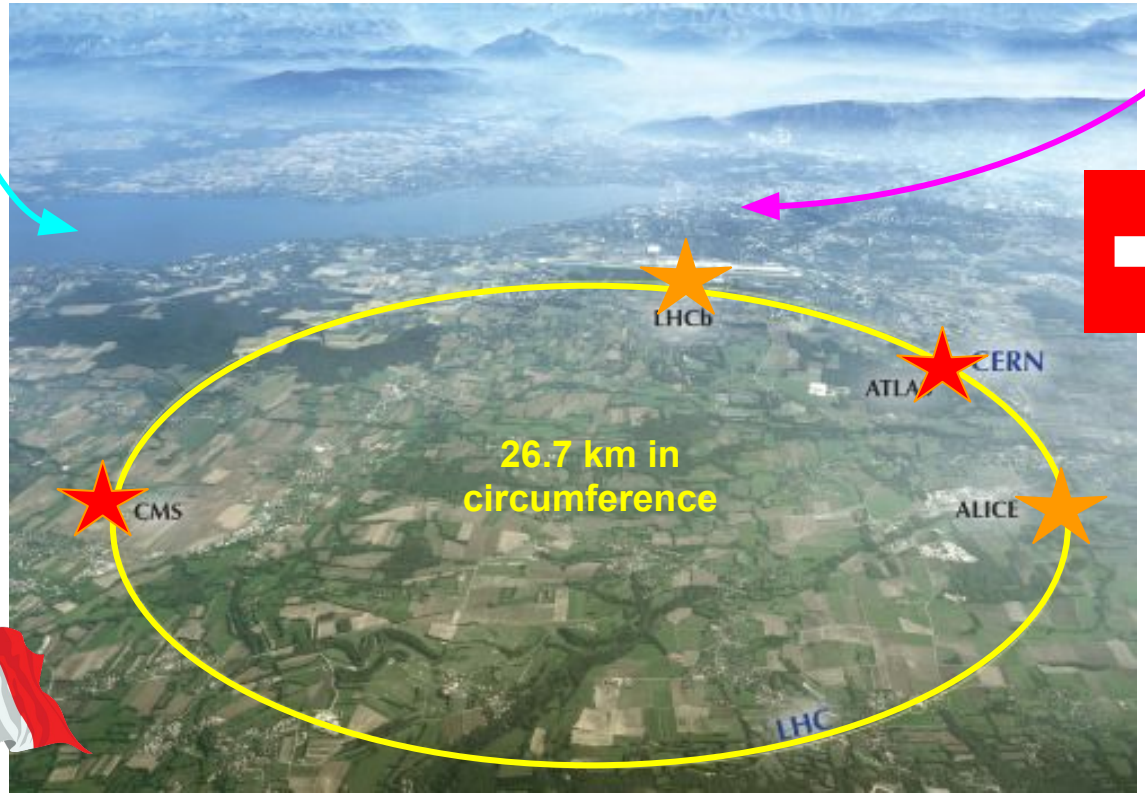
Grace Cummings

New Perspectives, 27 June 2023

The Large Hadron Collider (LHC)

Geneva, Switzerland

Lac Léman (Lake Geneva)



Partially in Switzerland!

Partially in France!

Why a *Collider*?

Bigger energies = Bigger particles

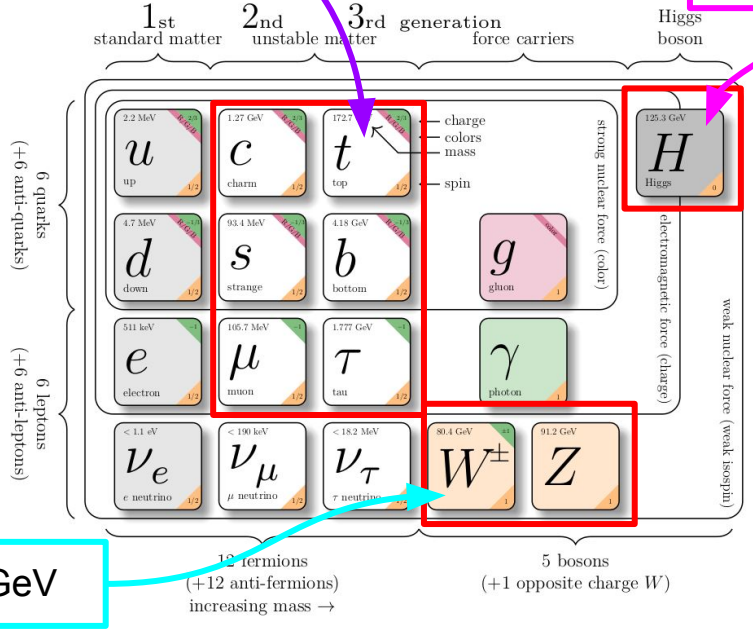
All of the energy in both beams can be used to produce heavy particles

Electroweak scale physics!

Top quark, 173 GeV

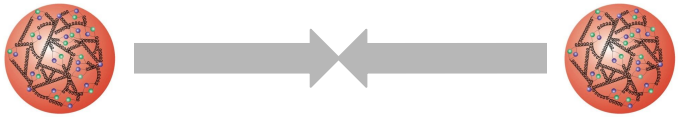
Higgs boson, 125 GeV

W boson, 80 GeV



Why a 13(+/-) TeV *Collider*?

Bigger energies = Bigger particles

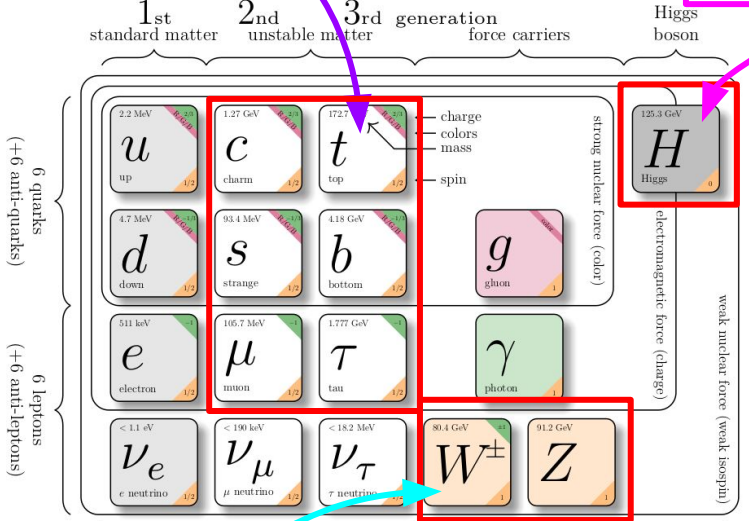


Actually colliding quarks + gluons inside the protons - each carry a fraction of the total energy

Electroweak scale physics!

Top quark, 173 GeV

Higgs boson, 125 GeV

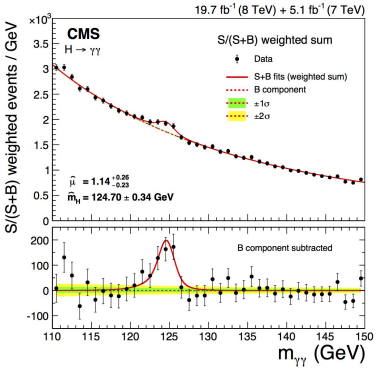


W boson, 80 GeV

The Large *Hadron* Collider (LHC)

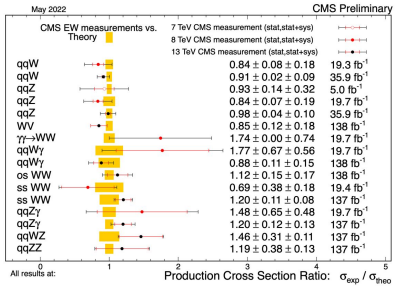
Proton-Proton Collisions

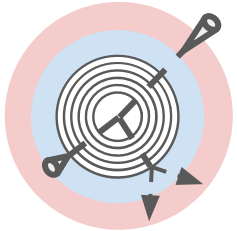
Run 1: 7 and 8 TeV



Higgs Boson Discovery!

Run 2: 13 TeV

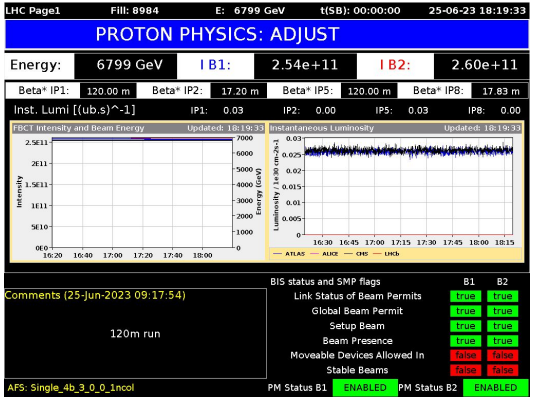


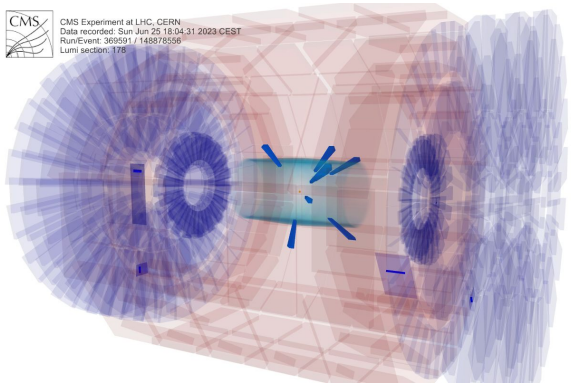


SM observations and New Physics Searches!

Run 3: 13.6 TeV

We are here!

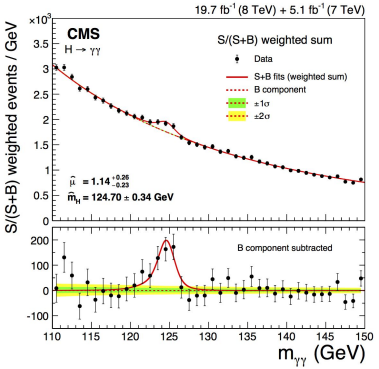




The Large *Hadron* Collider (LHC)

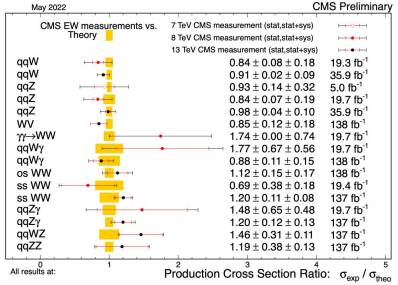
Proton-Proton Collisions

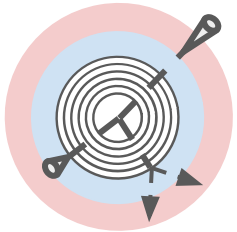
Run 1: 7 and 8 TeV



Higgs Boson Discovery!

Run 2: 13 TeV





SM observations and New Physics Searches!

Run 3: 13.6 TeV

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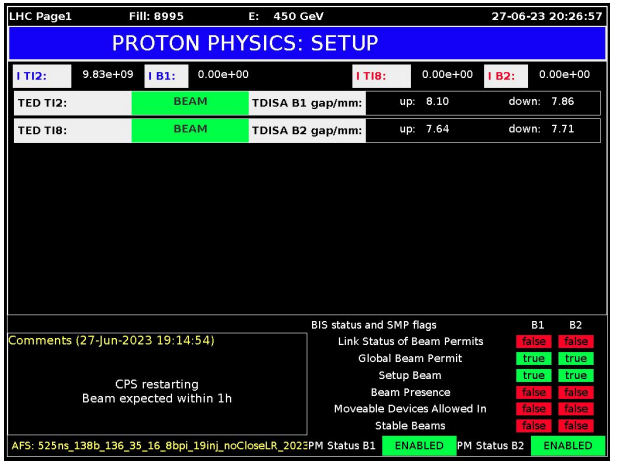
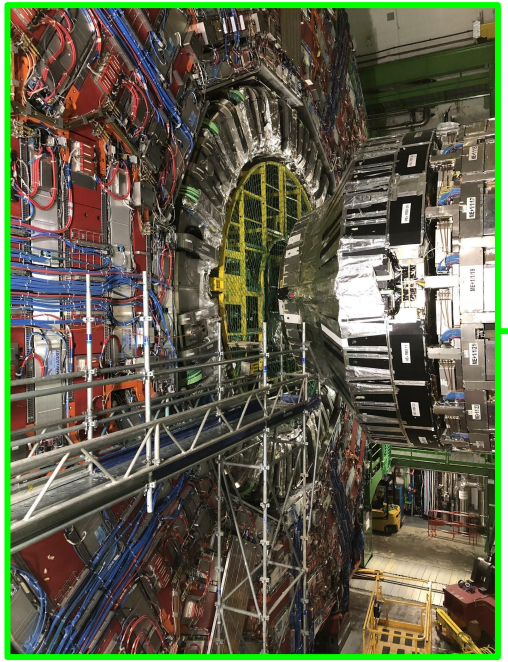
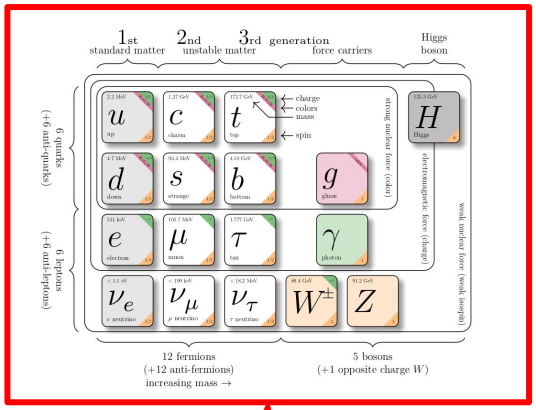
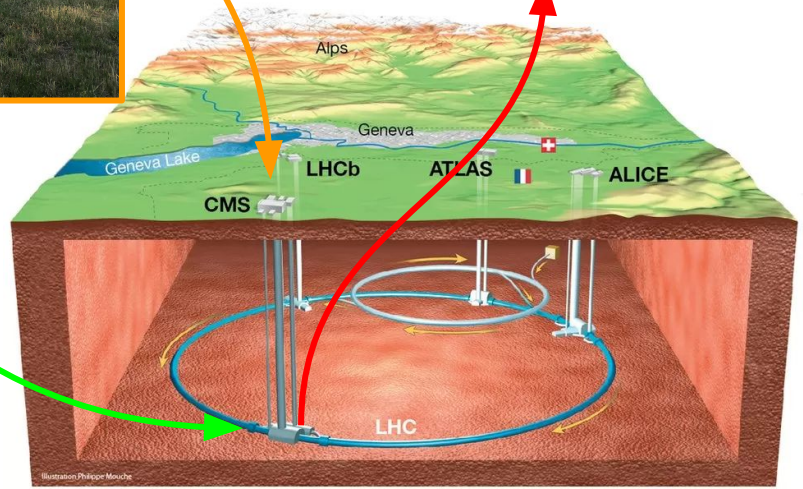


The CMS Experiment at the LHC

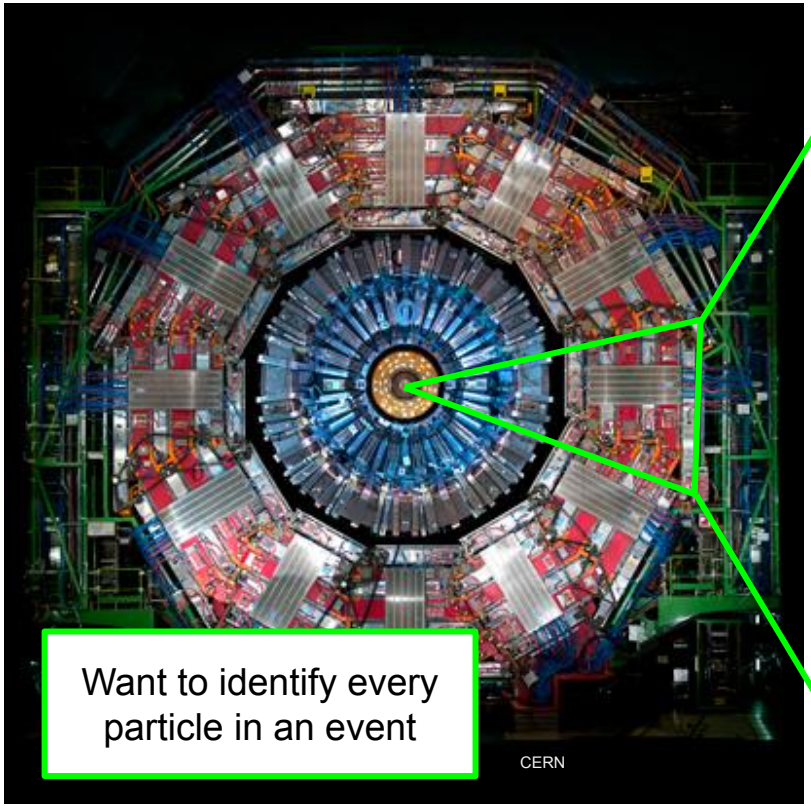


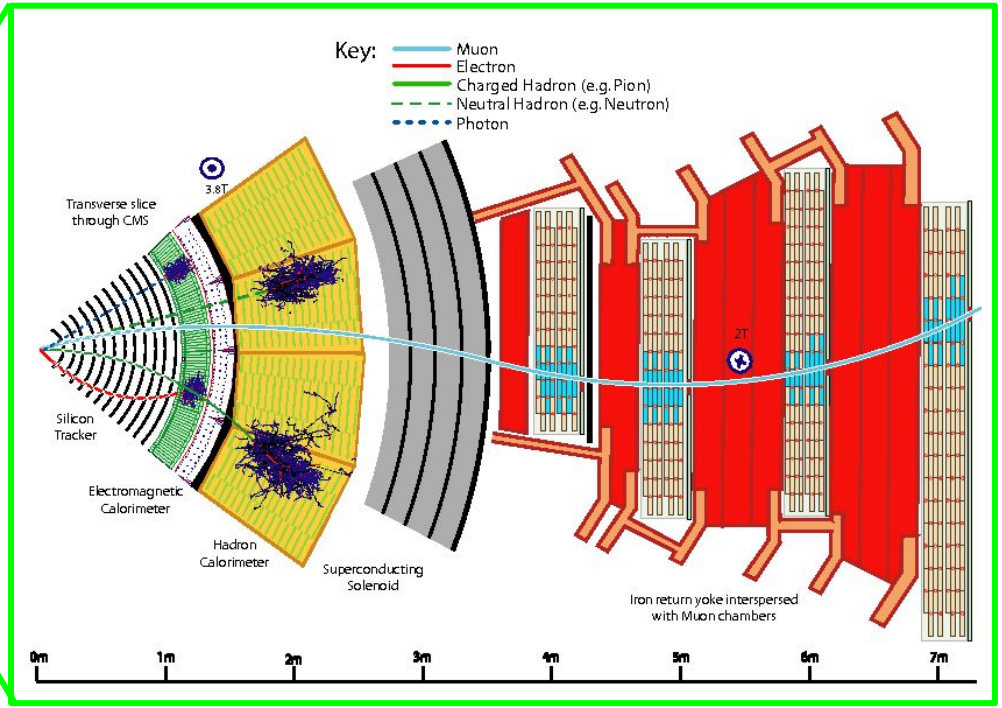


General purpose, discovery machine!

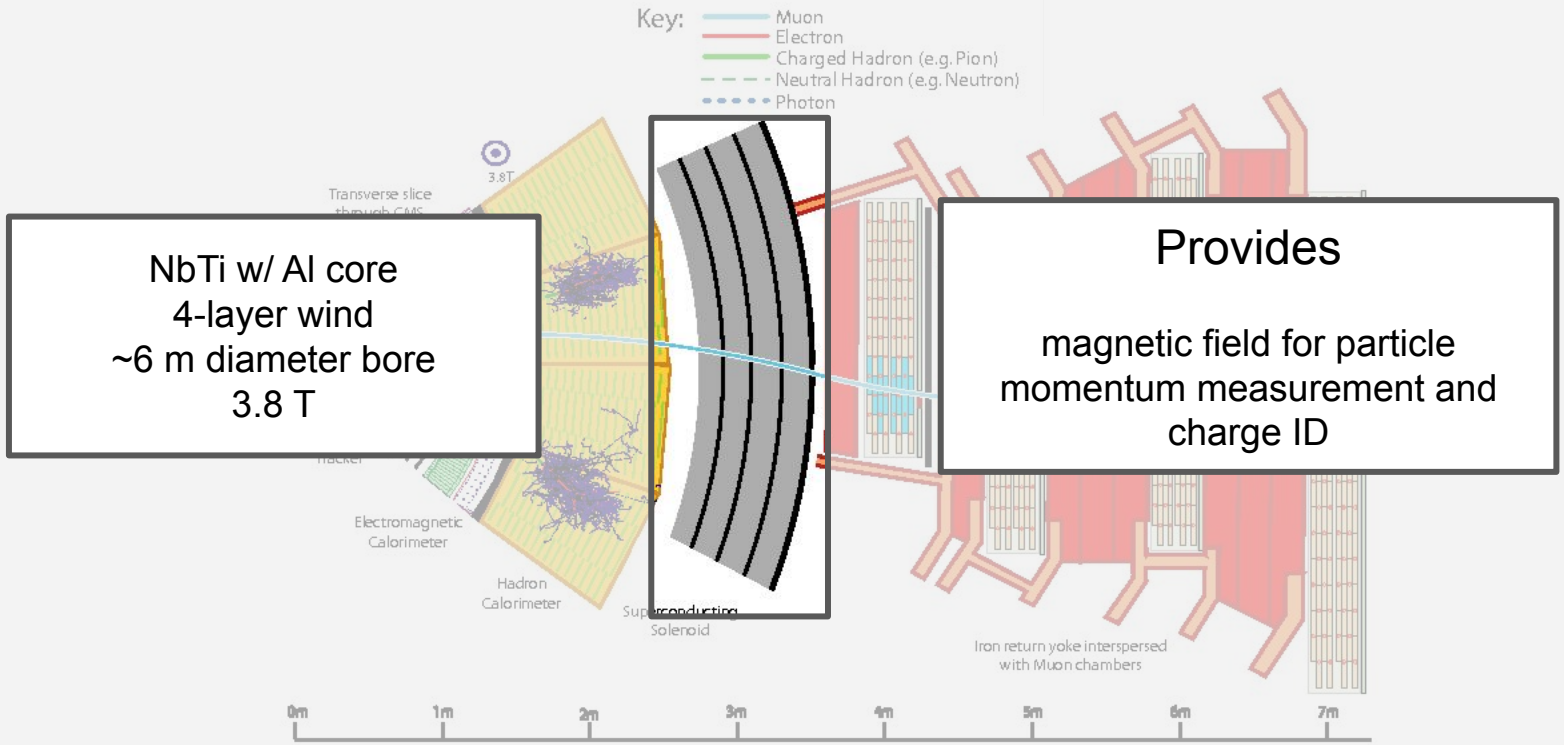


Compact Muon Solenoid Experiment





CMS at the LHC - Superconducting Solenoid

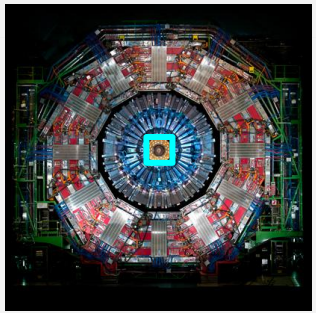


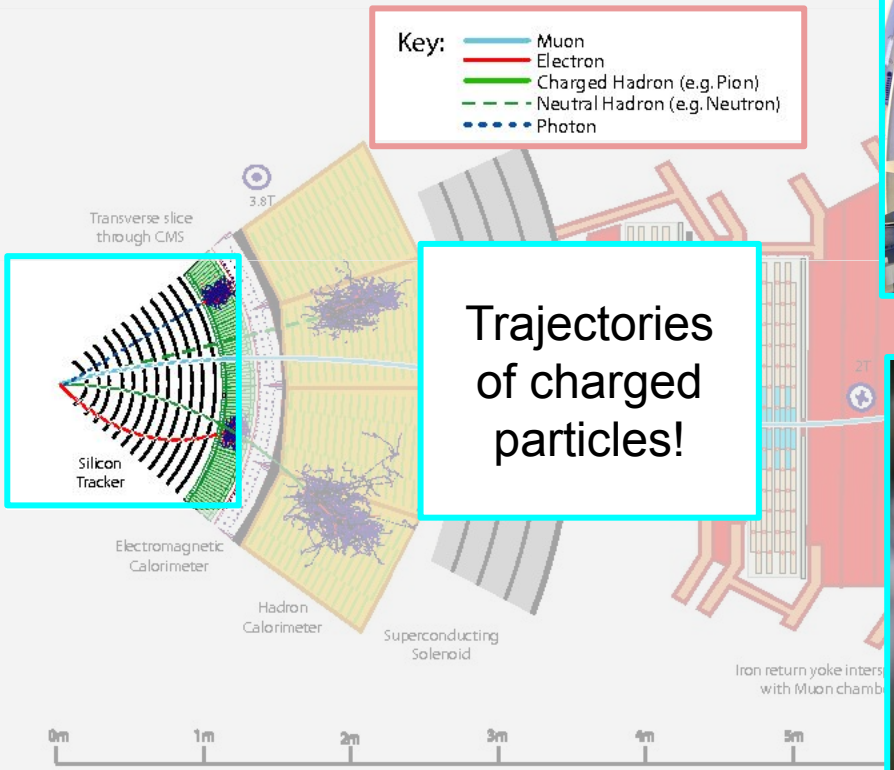
NbTi w/ Al core
4-layer wind
~6 m diameter bore
3.8 T

Provides

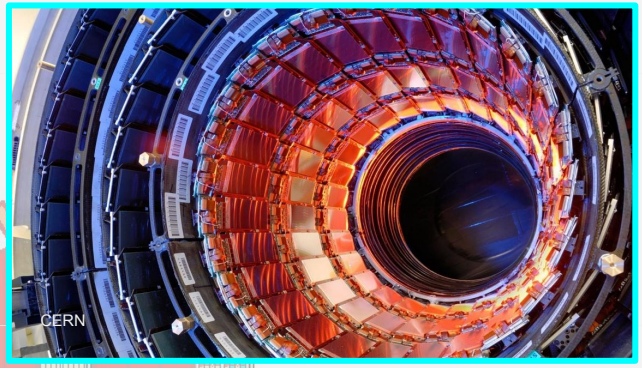
magnetic field for particle momentum measurement and charge ID

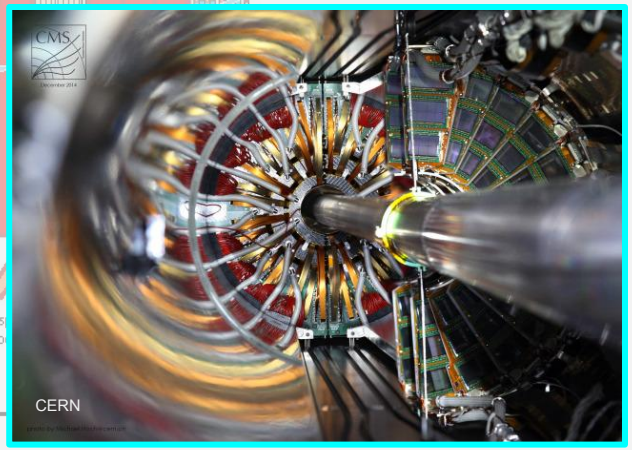
CMS at the LHC - Silicon Tracker



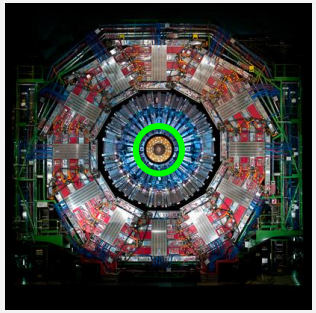


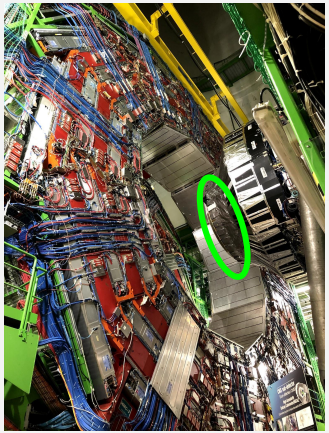
Trajectories of charged particles!

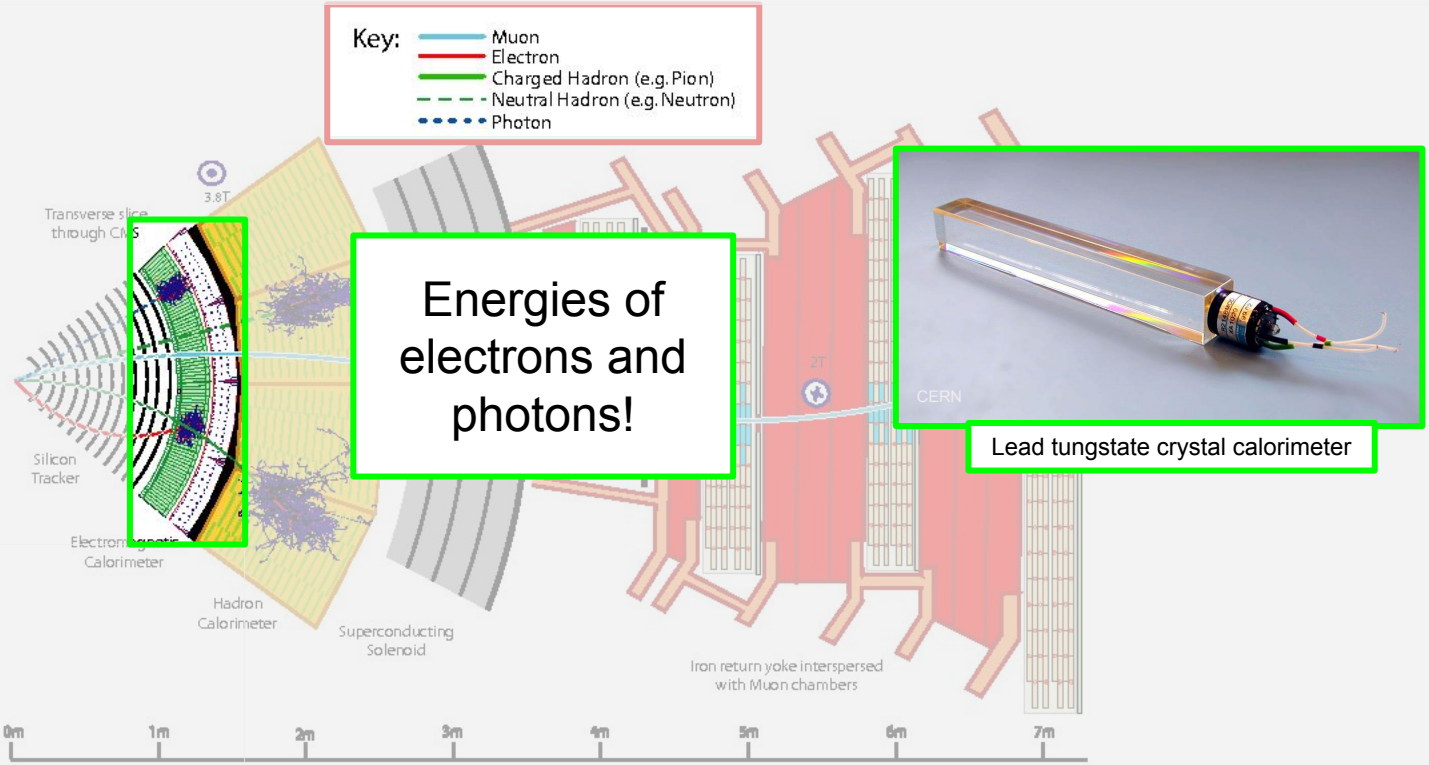




CMS - Electromagnetic Calorimeter (ECAL)



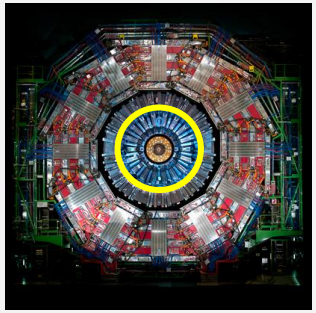


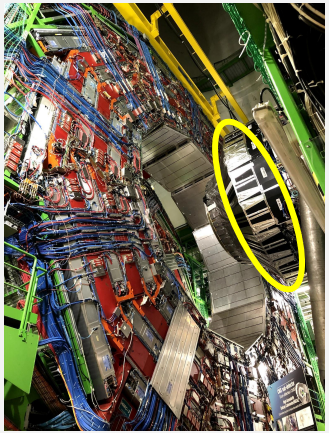


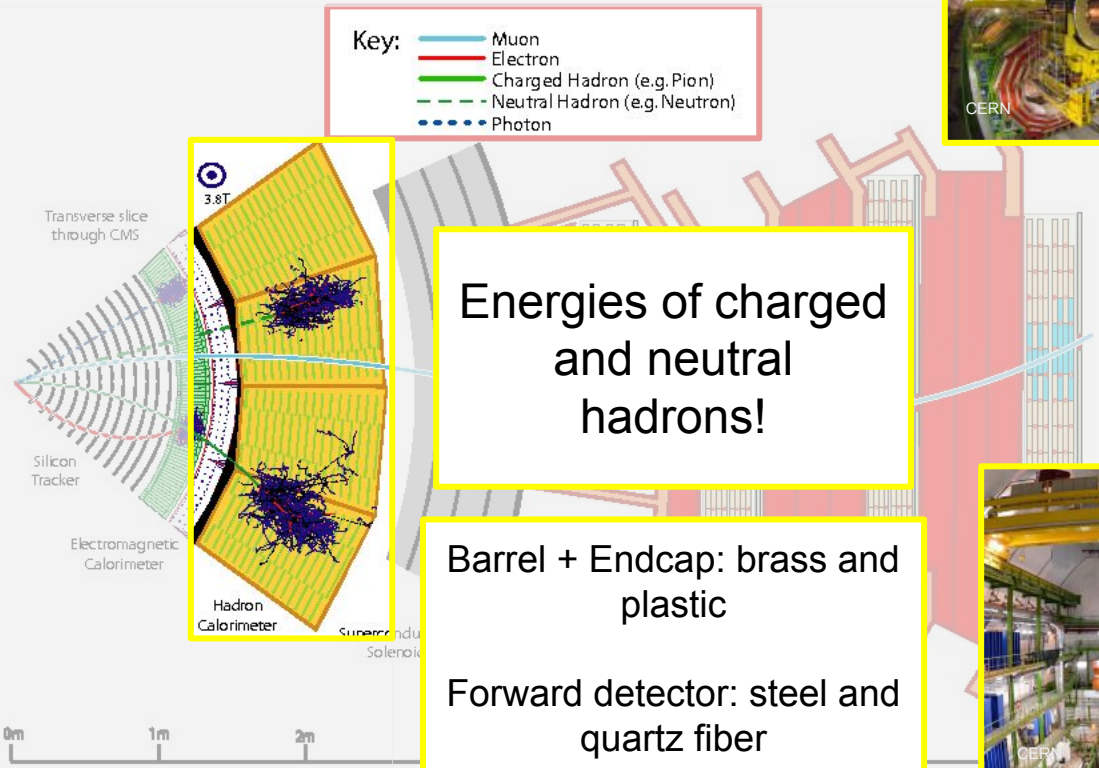
Energies of electrons and photons!

Lead tungstate crystal calorimeter

CMS - Hadron Calorimeter (HCAL)





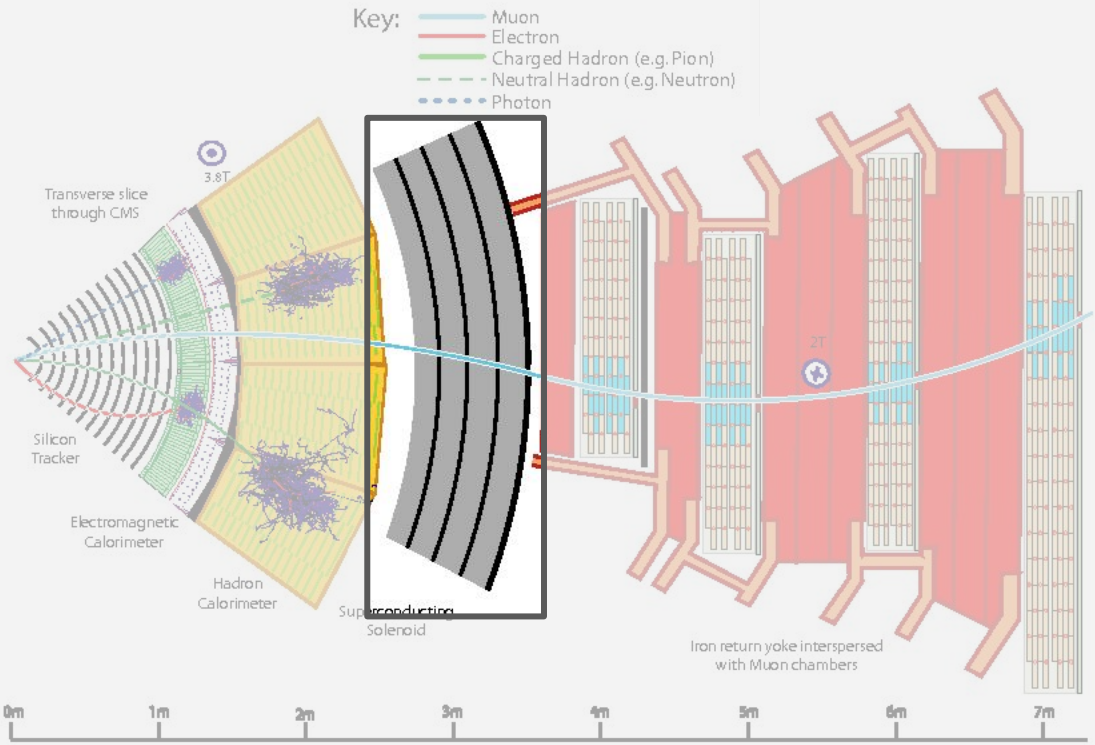


Energies of charged and neutral hadrons!

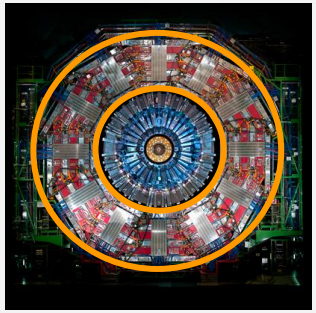
Barrel + Endcap: brass and plastic

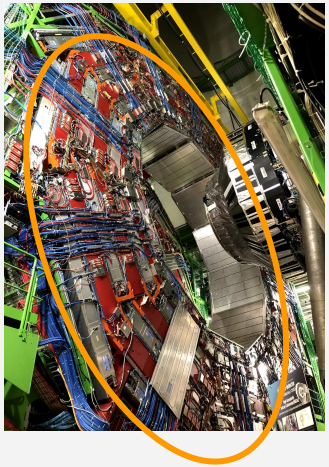
Forward detector: steel and quartz fiber

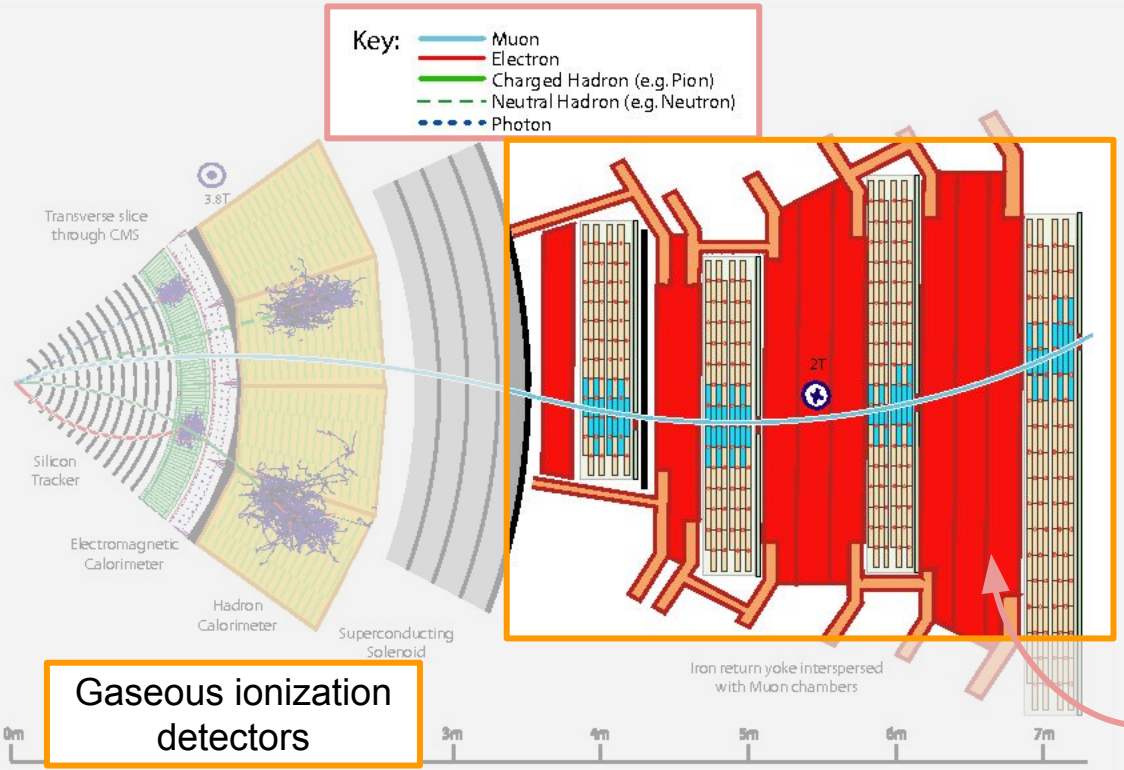
CMS at the LHC - Superconducting Solenoid



CMS at the LHC - Muon System and Flux Return





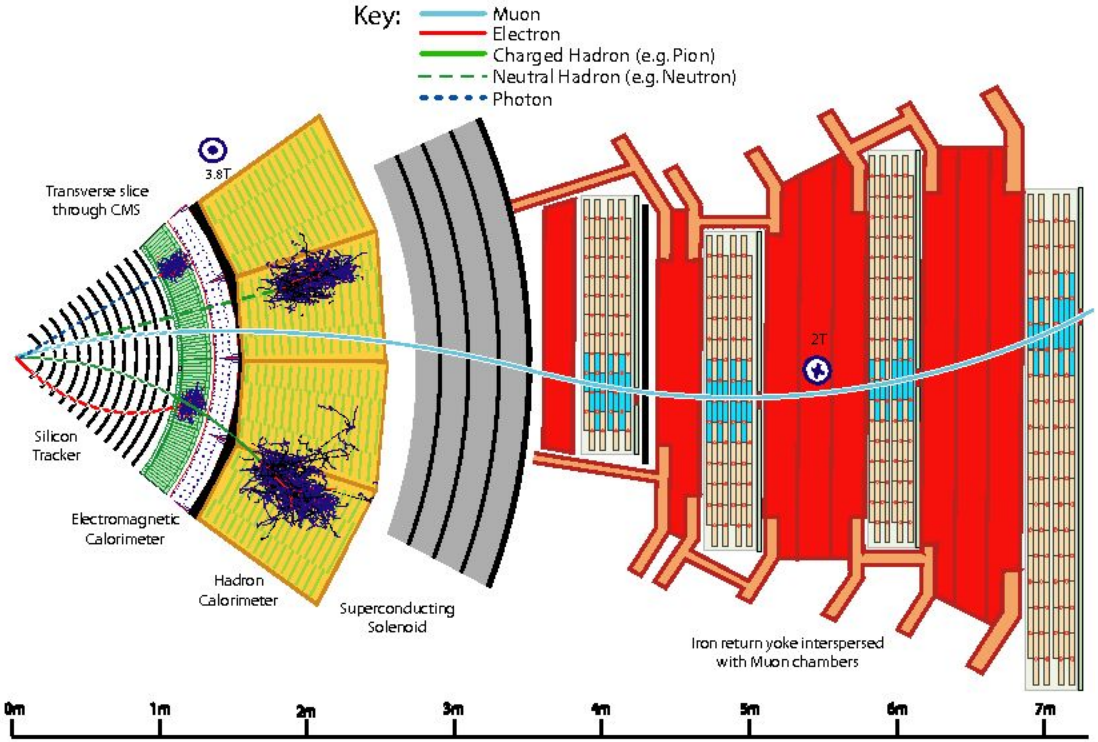


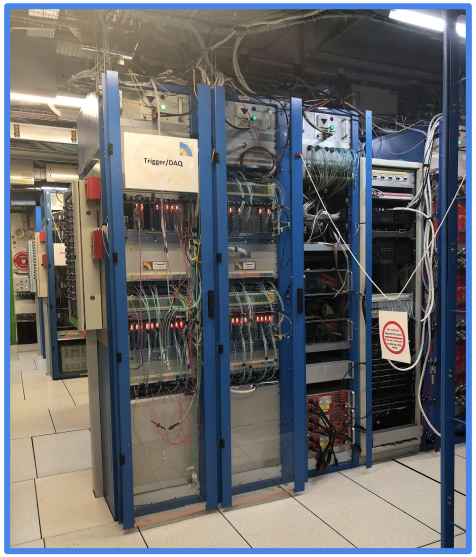
Muon trajectories and particle ID

Gaseous ionization detectors

Iron for magnetic flux return

CMS Subsystems - the interactions



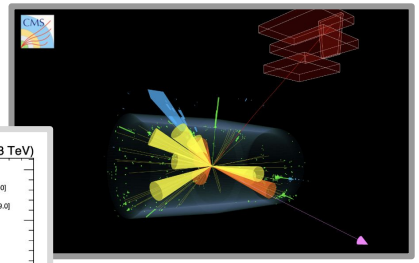


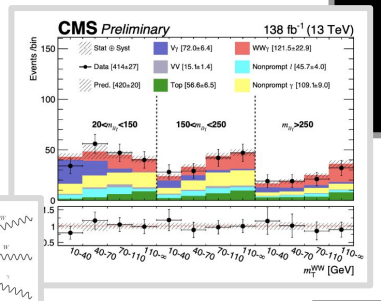
Trigger!

Physics Menu (some examples)

Standard Model Measurement

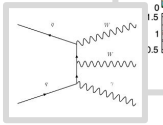
Observations of rare decays, precision measurements





$WW\gamma$

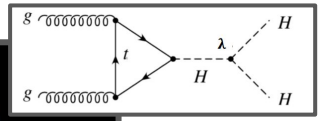
SMP-22-006

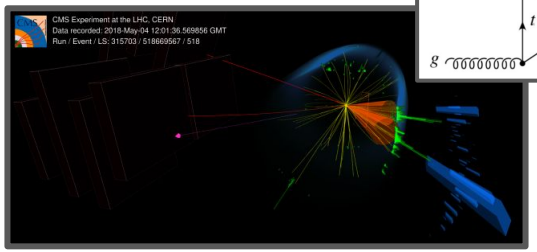


4 Top production!

TOP-22-013

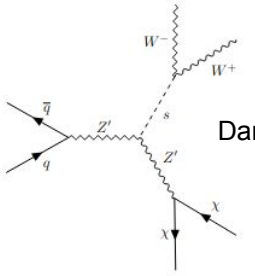
See Beren's top talk!



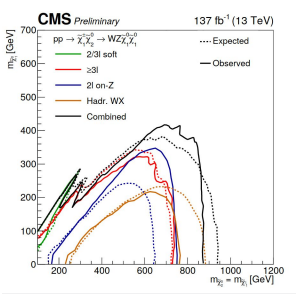


Di-higgs on the horizon!

Beyond the Standard Model Searches

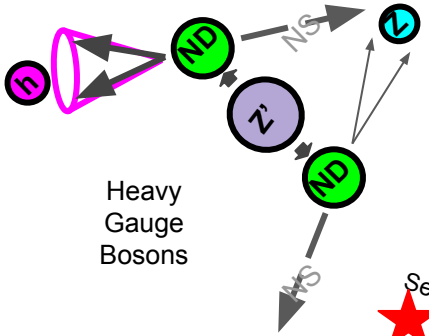


Dark Matter



SUSY

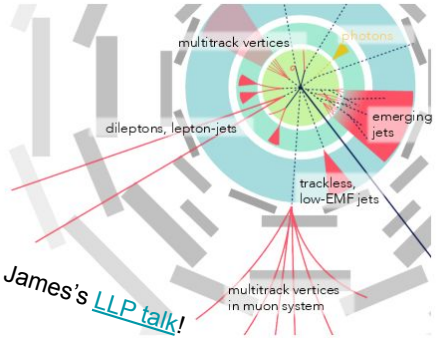
SUS-21-008



Heavy Gauge Bosons

See James's LLP talk!

Long Lived particles

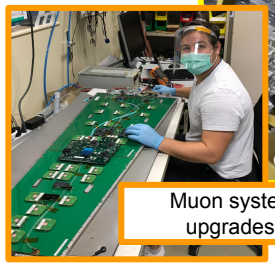


Heather Russell

CMS Subsystems - the upgrades!

Before Run 3 (ish)

New electronics for HCAL

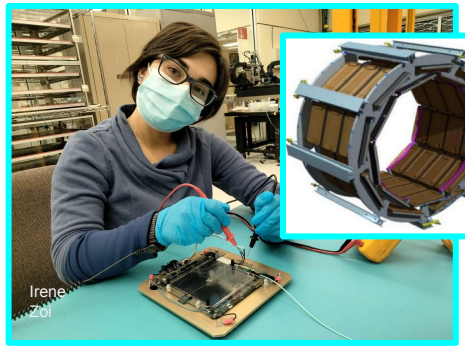


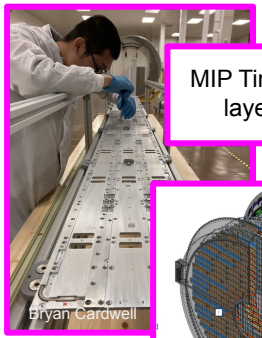
Muon system upgrades!

New trigger hardware

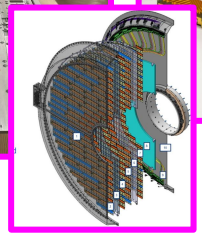
New pixel! Extra layers

Upgrades allow for new trigger capability in Run 3!



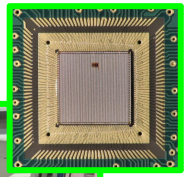


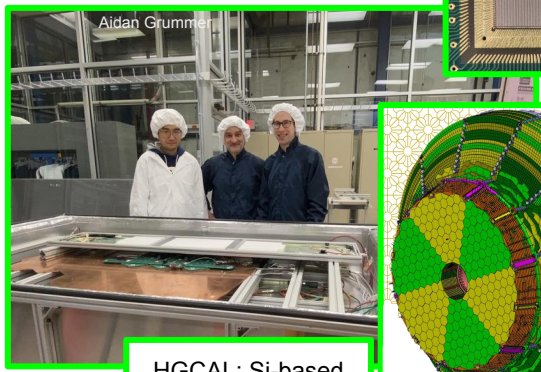
MIP Timing layer



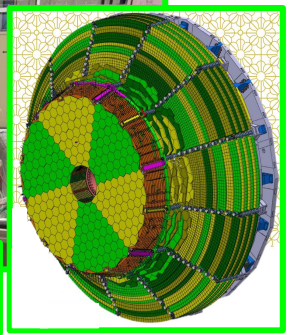
Before Run 4

See Ryan's HGCAL Talk!





HGCAL: Si-based EM calorimeter!



Brand-new technologies in Run 4 (high granularity, track-trigger, picosecond timing)

In Summary

As many types of physics as detector components (and collaborators)

Forefront of instrumentation and our understanding of the *heavy parts* of the Standard Model and beyond