US CMS Intern
Introduction
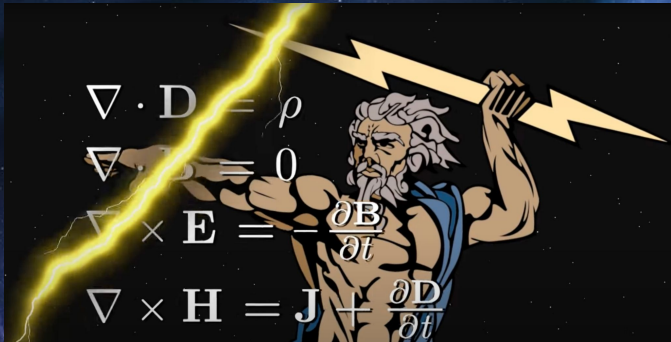# CMS Computing

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What does CMS Experiment do - Particle Physics

How did the universe come to exist?

We have come a long way

$$\nabla \cdot \mathbf{D} = \rho$$
$$\nabla \cdot \mathbf{B} = 0$$
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$
$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

Does the universe have to be this way?

What are the most fundamental rules that govern the cosmos?

$$G_{\alpha\beta} = \frac{8\pi G}{c^4} T_{\alpha\beta}$$

$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

…..and more

We try to find new physics Beyond the Standard Model by recreating Big Bang conditions by colliding particles

For this we need Particle Accelerators (LHC@CERN)

- Particles (protons) travel at the **speed of light** will travel round the 27km ring over *11000 times a second! and* they collide to reproduce an incredible miniscule **universe like condition - debris of particles**
- The temperature of collisions is **ONE BILLION times that of the core of the Sun** (*1 billion times of what is at core of the Sun) or concentrate all energy of the Sun in 20 million years of its life into the volume of a football size*
- **Superconducting Magnets** with a temperature of around **-271 degrees Celsius**, or 1.9 degrees above absolute zero, the LHC is colder than outer space.
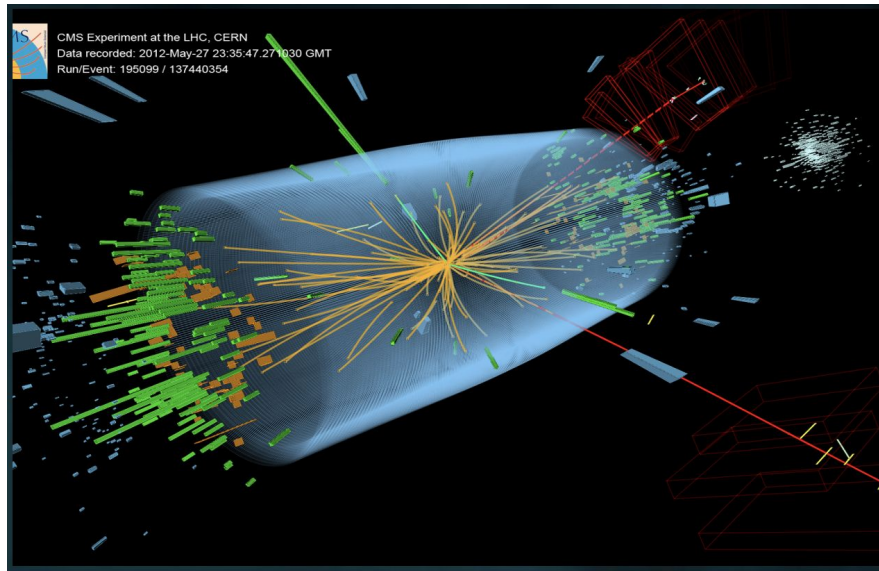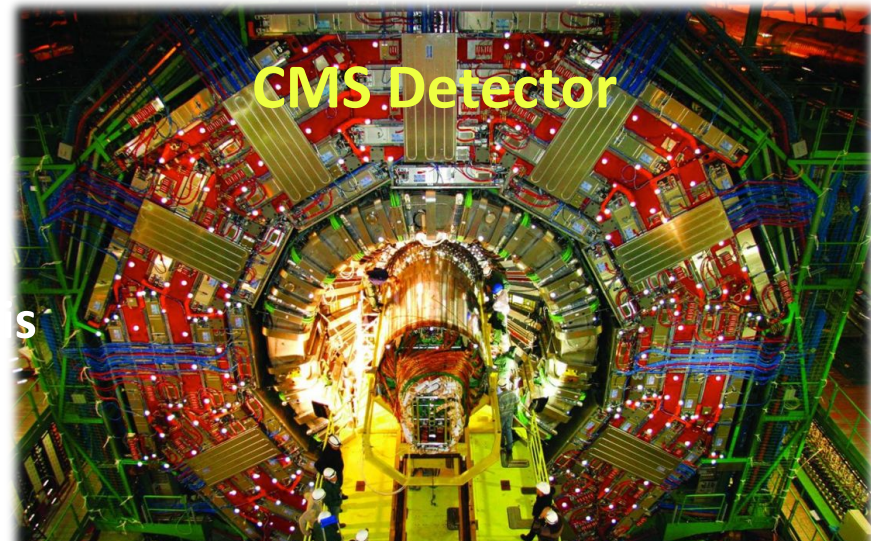
The Large Hadron Collider at CERN, Switzerland

To detect the outcome of collisions we have giant Detectors

- **5-7 story high 20K tonne**
- **3D camera with 100 megapixels**
- **Taking 40 million photos per second!**

CMS Experiment at the LHC, CERN
Data recorded: 2012-May-27 23:35:47.271030 GMT
Run/Event: 195099 / 137440354

Higgs Discovery Nobel Prize 2013

CMS Detector

ATLAS Detector

And we produce lots of data to record, store and analyze

BIG Computing Challenge

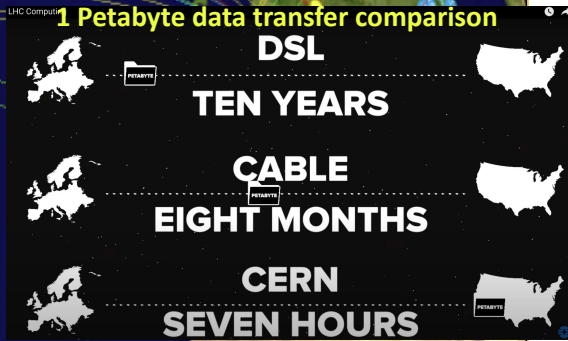**Birth of Cloud computing**
Grid connects >100,000 processors in 34 countries
1 Petabyte/day data
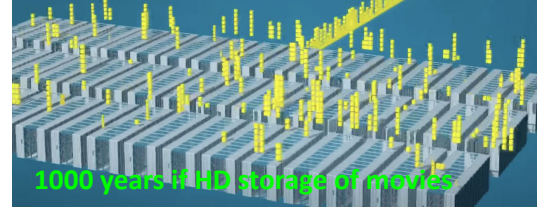**Compare this to local businesses that process 20 Petabyte/day (Google 2010)**
5 million parallel jobs

Fermilab

150 Petabytes of disc storage at CERN
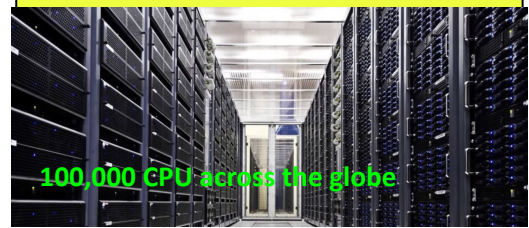
1000 years if HD storage of movies

1 DVD = 5 Gigabytes

1 Petabyte = 10 Lakh Gigabytes
= Stack of 0.25 km of DVDs

Data is generated at 10 Gigabytes/second = 2 DVDs/sec

CERN generates ~100 Petabytes/year

=20 km high stack of DVDs

LHC Computi... **1 Petabyte data transfer comparison**

DSL
TEN YEARS

CABLE
EIGHT MONTHS

CERN
SEVEN HOURS

100,000 CPU across the globe

Fermilab Computing and cmslpc cluster

- Network computers
- Login with ssh and work on those machines
- Can not load software, you do not have sudo privileges
- There already is some codes setup and some CMS software (CMSSW) that also sets up environments that also have some code

First Logging in to the LPC

- https://uscms.org/uscms_at_work/computing/getstarted/uaf.shtml
- https://uscms.org/uscms_at_work/physics/computing/getstarted/uaf.shtml#windows
- Has everyone been able to login?
- Does anyone need help with this?
- When working on the lpc there is your home area which has 2MB of space
- Then a working area which is where you should work called nobackup which has 200 GB
- You need to do kinit every 24 hours

Bash Commands

- Ls and it's options
- Ls lists the files in the area you are on your machine or the lpc
- Ls -alht
- The -l option lists the permissions, owner, size in bytes, last date changed, file name
- -a lists hidden files
- -h makes it human readable is space so MB
- -t sorts by last modified data usually sorted by name

Bash Commands

- cd goes to a specified or back to your home directory
- pwd lists the current directory you are
- Please google useful bash commands and have a look
- https://www.educative.io/blog/bash-shell-command-cheat-sheet

LPC Commands/Editors

- quota -s
- This gives you how much space you have used
- This is both the home and nobackup area
- Editors there are plenty of options out there

CMS Coding

- We use CMSSW to setup the cms environment also sets up root and python3
- The code does reconstruction and connects the processed central files to the ntuples made for analysis
- The code is on github
- https://github.com/cms-sw/cmssw/tree/CMSSW_11_2_X (This is one version of the code)
- How to set it up: https://twiki.cern.ch/twiki/bin/view/CMSPublic/WorkBookRemoteSiteSpecifics#Fermilab

Curriculum for next 3 week enable you to computing

Hope you all have accounts and have tried logging in but for next 3 weeks of curriculum you will do things locally on your laptop and learn (put a table of next 3 weeks - ask Guillermo) and then once you are ready work with your Mentors according to their instructions

You will be self learning mode BUT if you get stucke use slack to ask questions.

Guillermo Fidalgo (UPRM) would help you with curriculum related issues. Your mentors have also signed up but most people would keep an eye on slack.