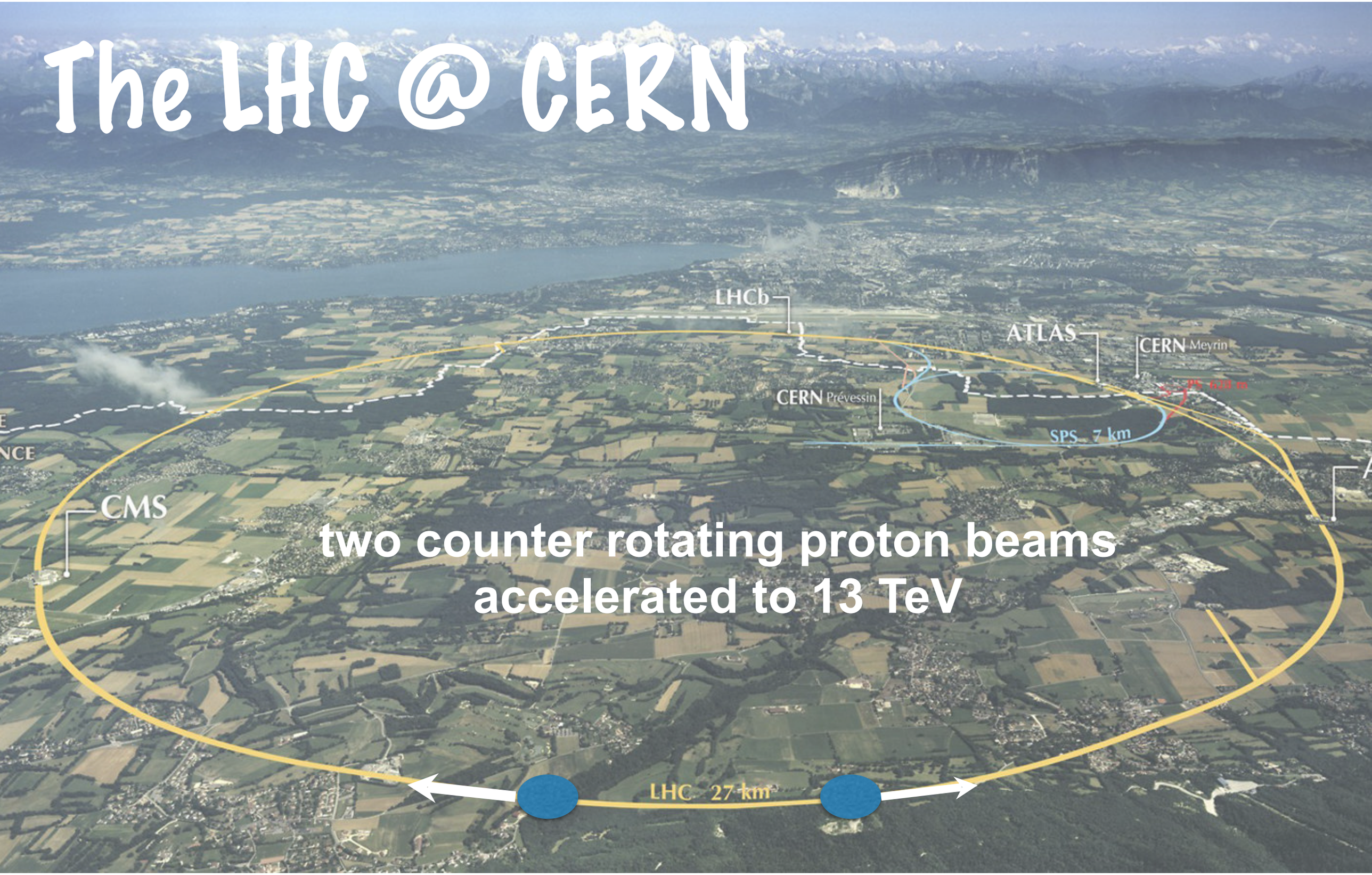
CMS in 10 min

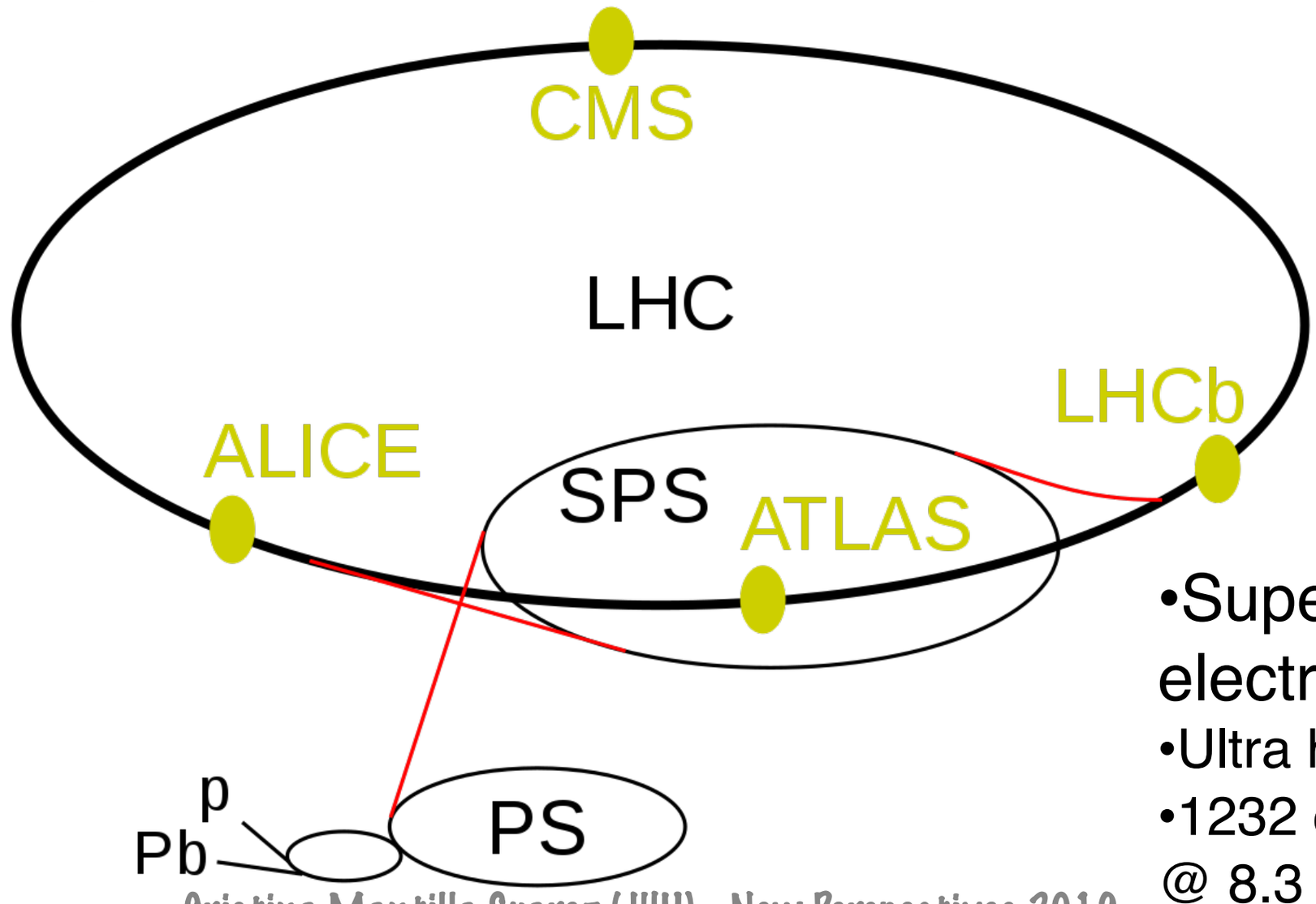
Cristina Mantilla Suarez (Johns Hopkins)
New Perspectives 2019

The LHC @ CERN


LHCb
ATLAS
CERN Meyrin
CERN Prévessin
PS 628 m
SPS 7 km
CMS
two counter rotating proton beams
accelerated to 13 TeV
LHC 27 km

Accelerator (13 TeV)

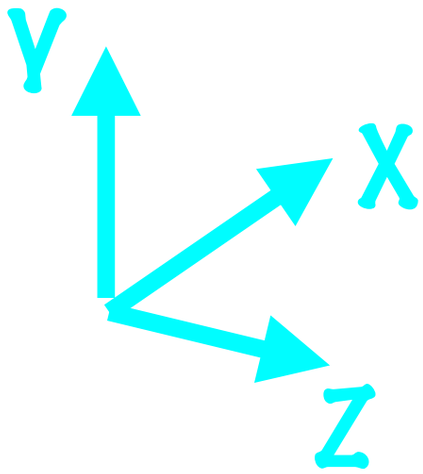
- Accelerates protons to 6.5 TeV using 5 different accelerators
- Proton bunches cross every 40 MHz (25ns)
- ~10^{11} protons per bunch

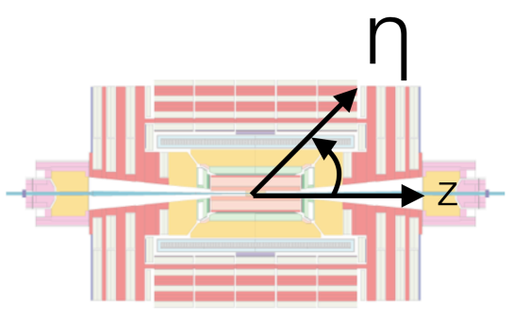


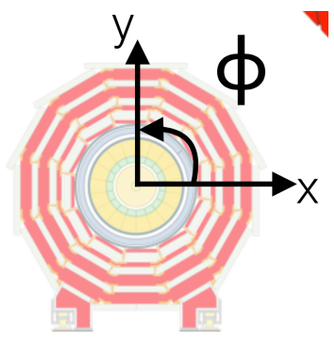
- Superconducting electromagnets
- Ultra high vacuum
- 1232 dipole magnets @ 8.3 Tesla

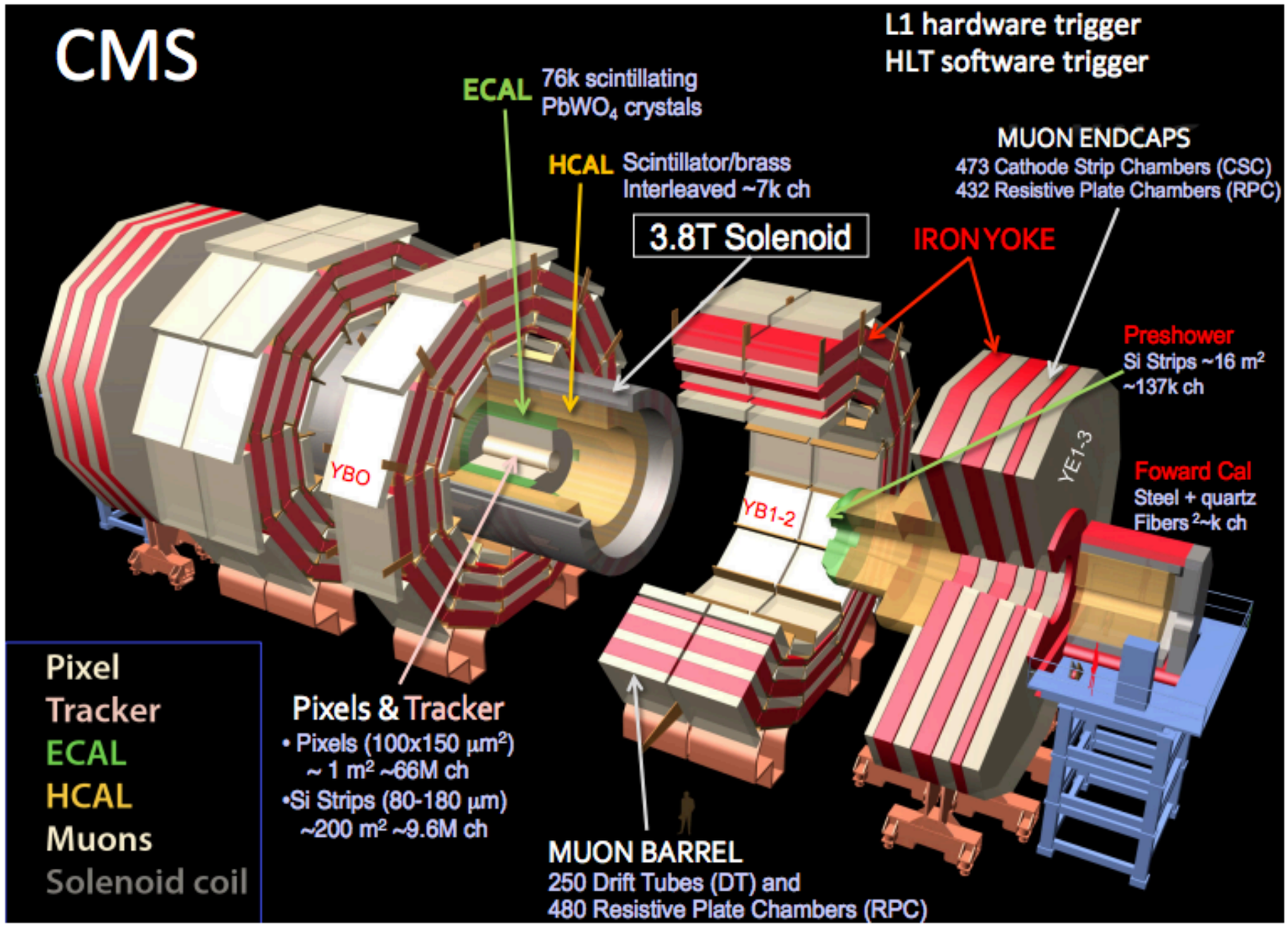

LHCb
ATLAS
CERN Meyrin
CERN Prévessin
PS 628 m
SPS 7 km
CMS
Compact Muon Solenoid
LHC 27 km

CMS Detector





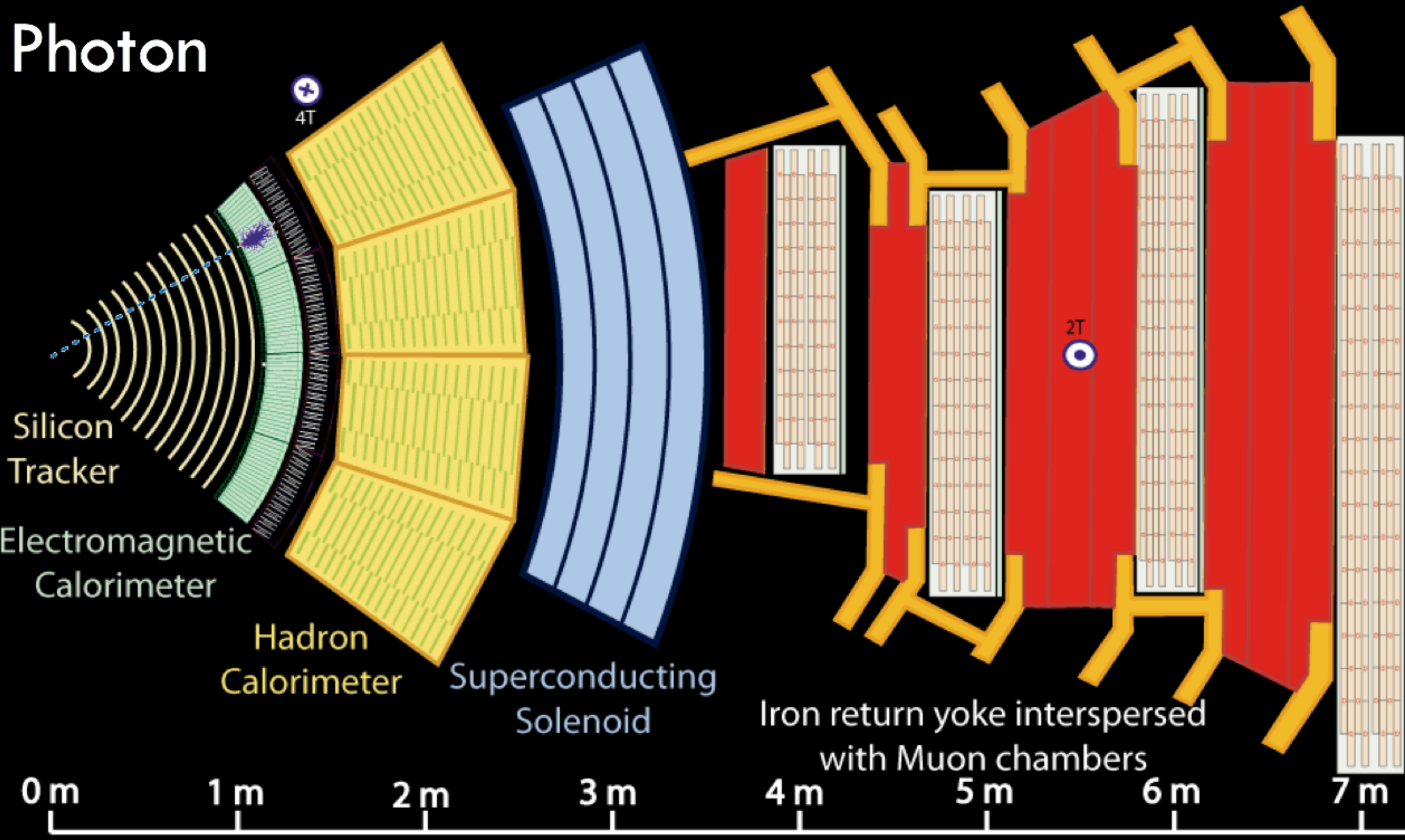




CMS Particle ID

- **What do we ultimately measure?**
  - Momentum (p_T), Position, Energy
- **What can we identify in CMS? (final state)**
  - Muons
  - Electrons
  - Photons
  - Charged and neutral hadrons *(composite of quarks)*

Photon



Key:

Muon

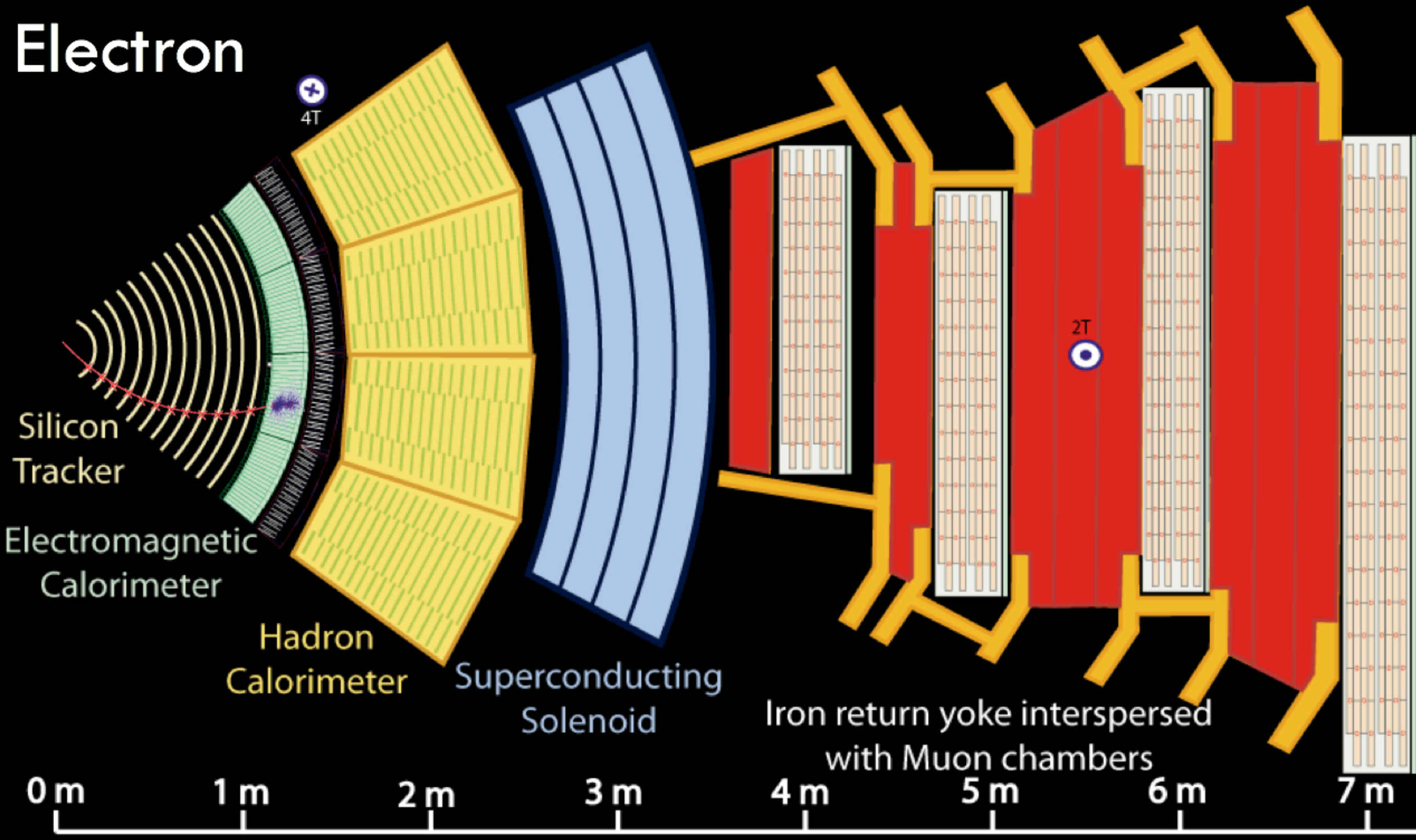
Electron

Charged Hadron (e.g. Pion)

Neutral Hadron (e.g. Neutron)

Photon

Electron



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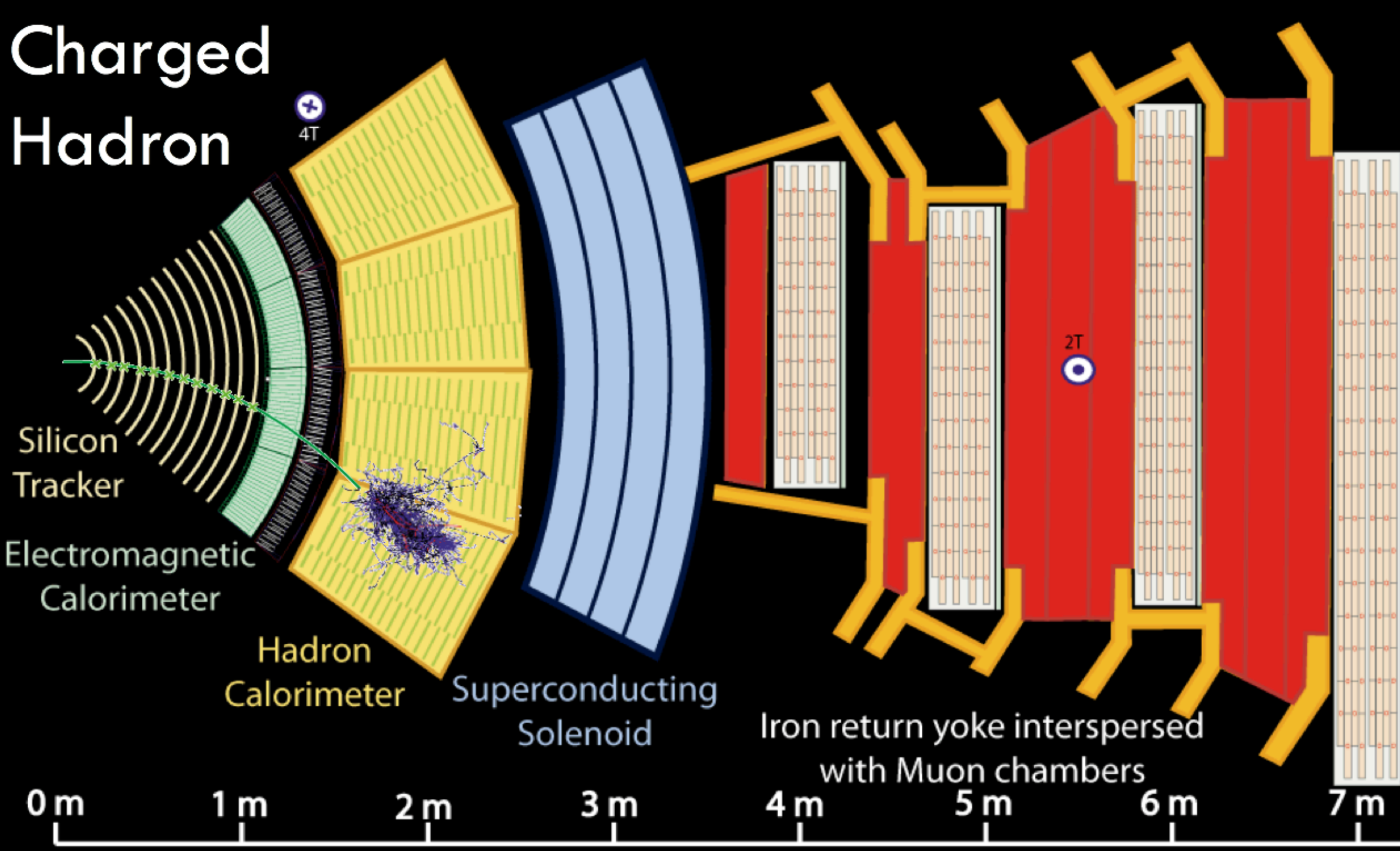
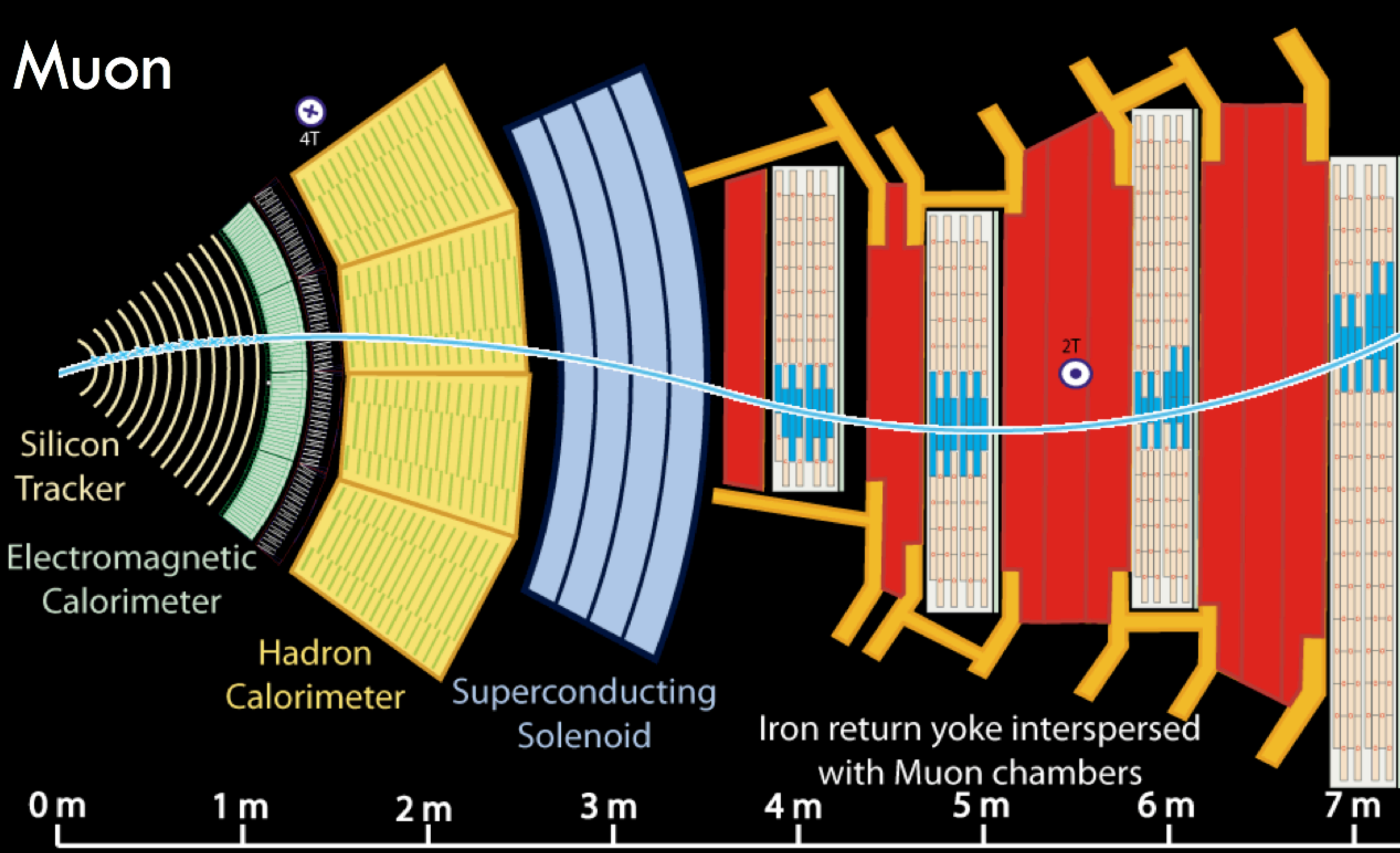

Charged Hadron
4T
2T
Silicon Tracker
Electromagnetic Calorimeter
Hadron Calorimeter
Superconducting Solenoid
Iron return yoke interspersed with Muon chambers
0 m
1 m
2 m
3 m
4 m
5 m
6 m
7 m
Key:
Muon
Electron
Charged Hadron (e.g. Pion)
Neutral Hadron (e.g. Neutron)
Photon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Key:
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Charged Hadron (e.g. Pion)
Neutral Hadron (e.g. Neutron)
Photon

Reconstruction @CMS

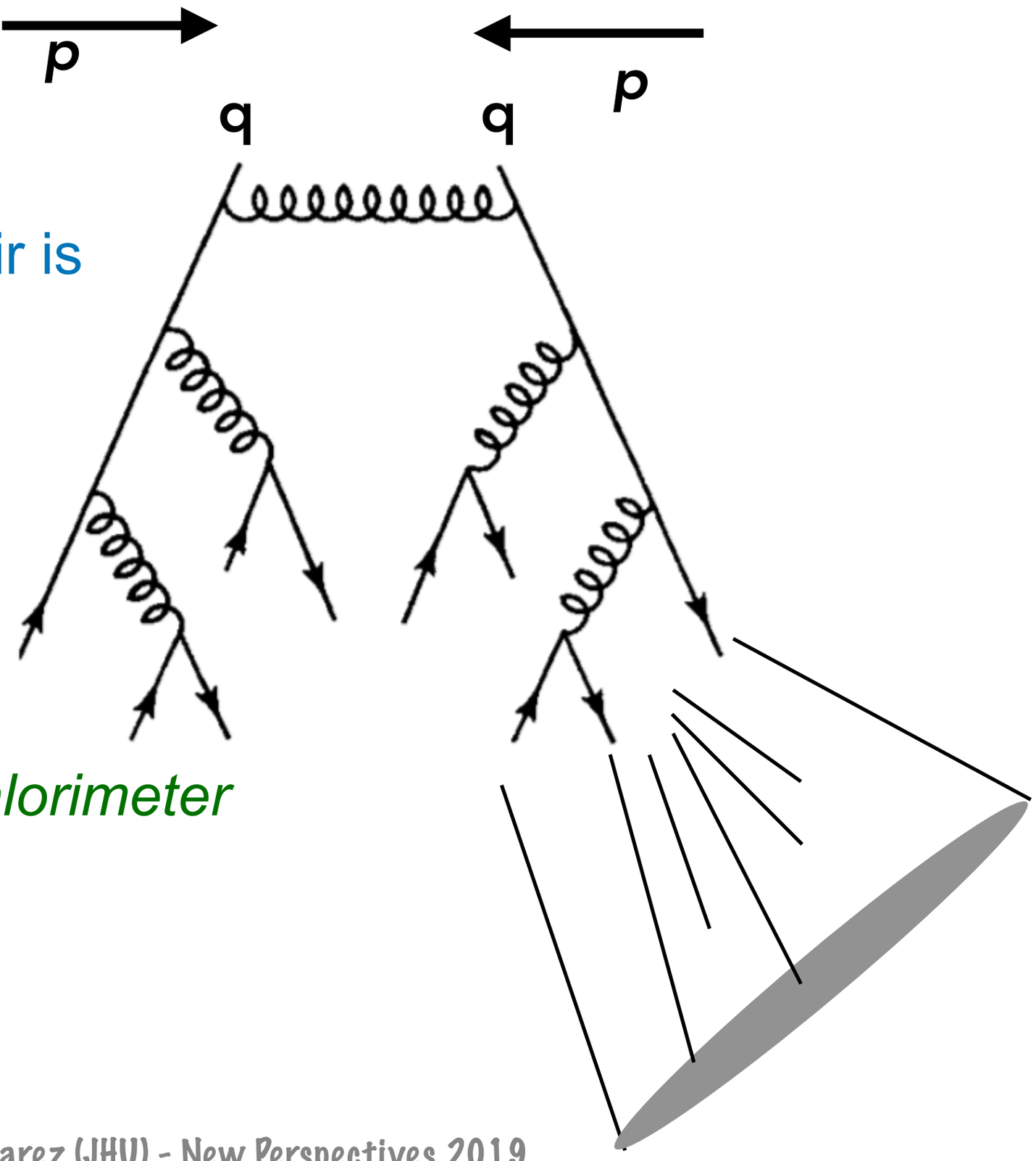
- Particle flow (PF) combines information from all sub-detectors
  - **Muon:** Tracker+ Muon hits
  - **Electron:** Tracker + ECAL Deposit
  - **Charged Hadron:** Tracker + HCAL Deposit
  - **Photon:** ECAL Deposit
  - **Neutral Hadron:** HCAL Deposit
- **Charged and neutral hadrons are clustered into jets**

Jets @CMS

A quark-antiquark pair is produced

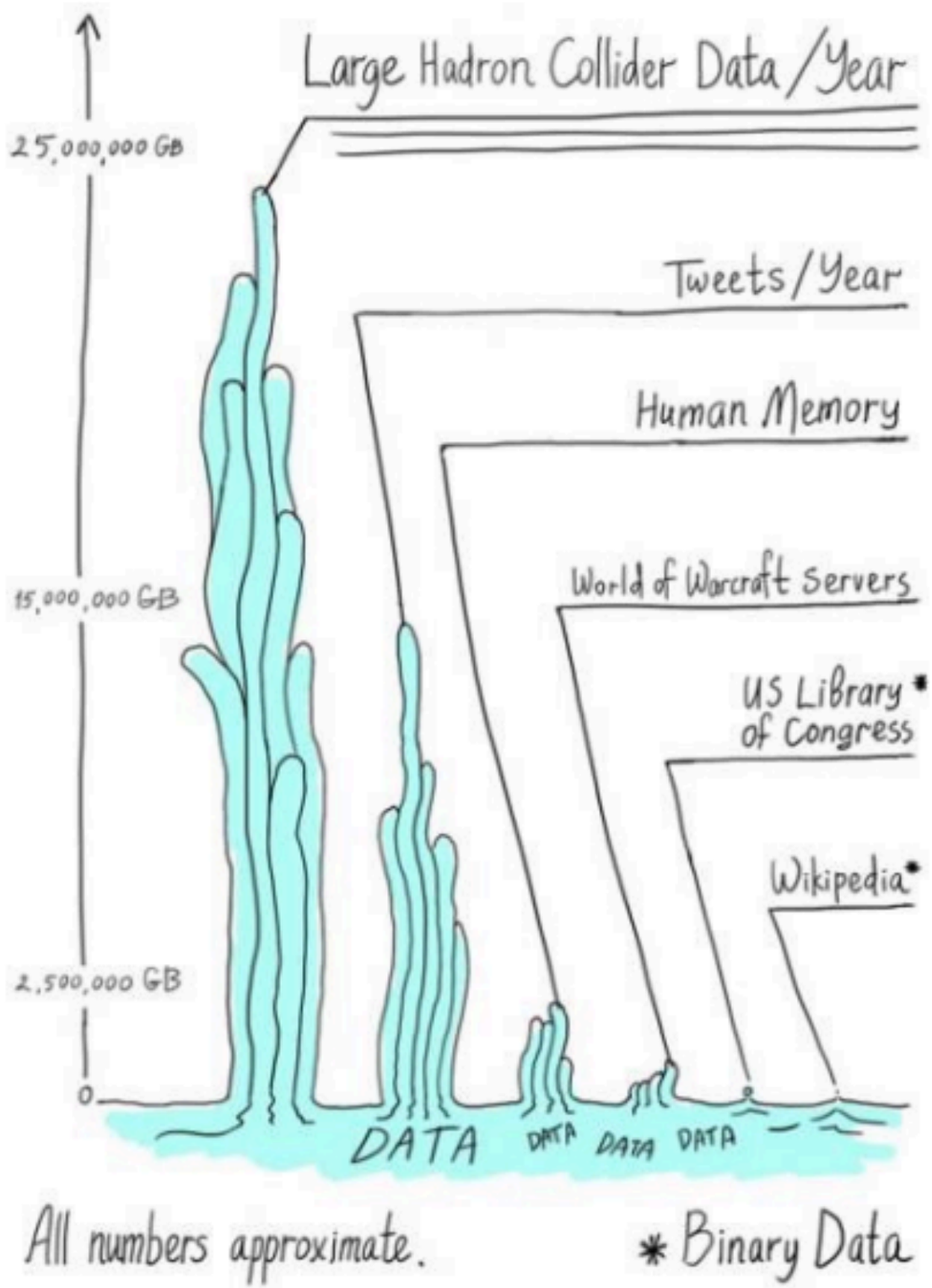
Collimated spray of particles

Energy deposits in calorimeter

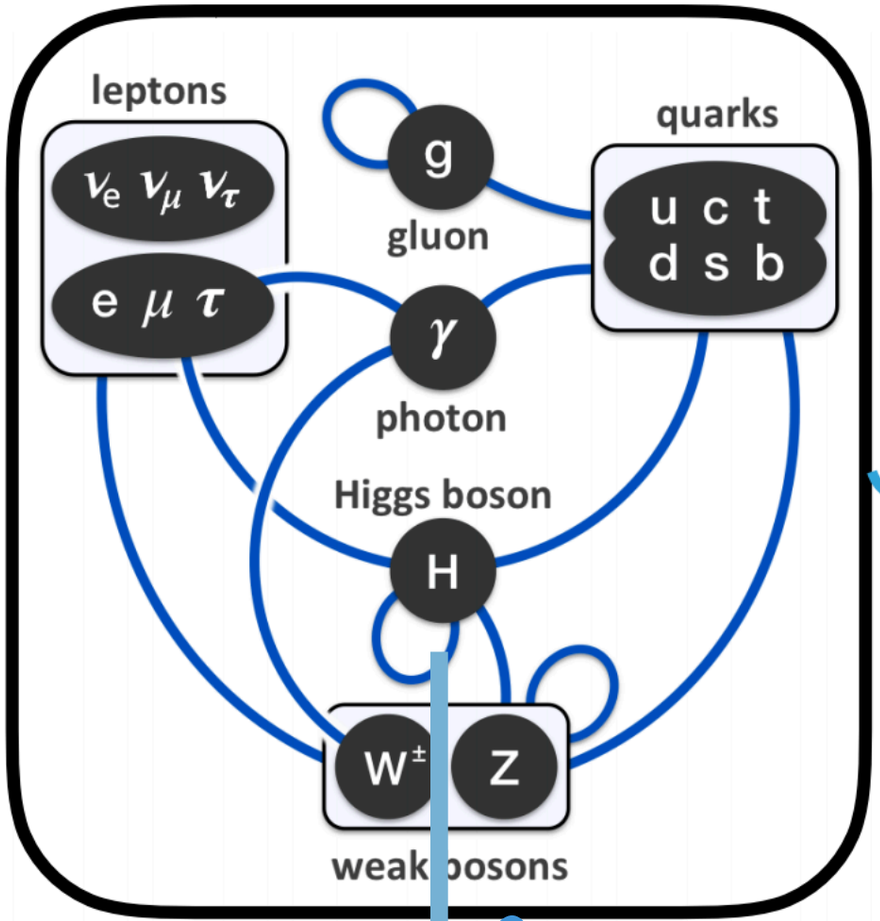


Trigger @CMS

- LHC collisions **~40 MHz**
- Level 1 trigger (hardware based) **~100 kHz**
- High-level trigger (software based) **~1 kHz**
- ***Rejection: 99.9995%***



Physics @ CMS



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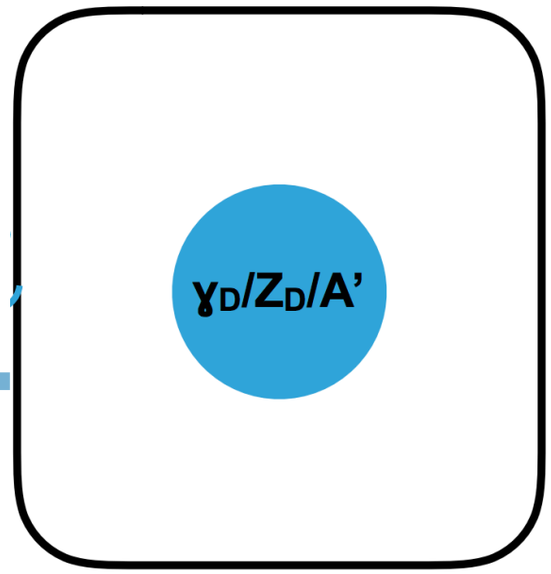
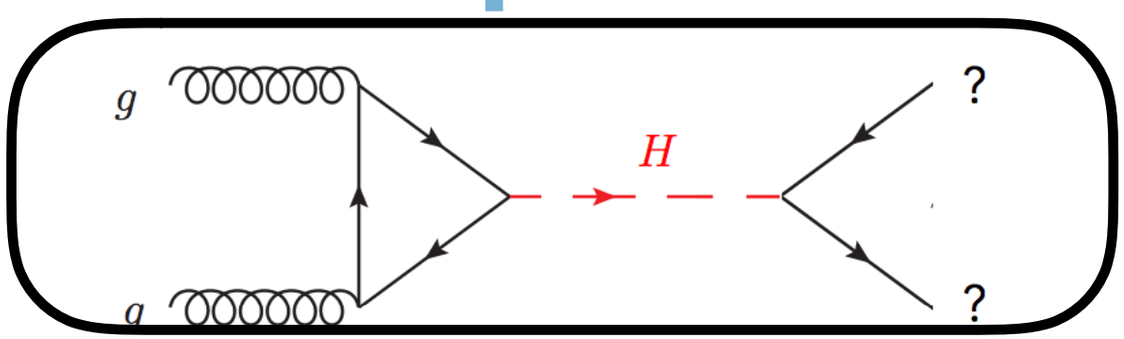
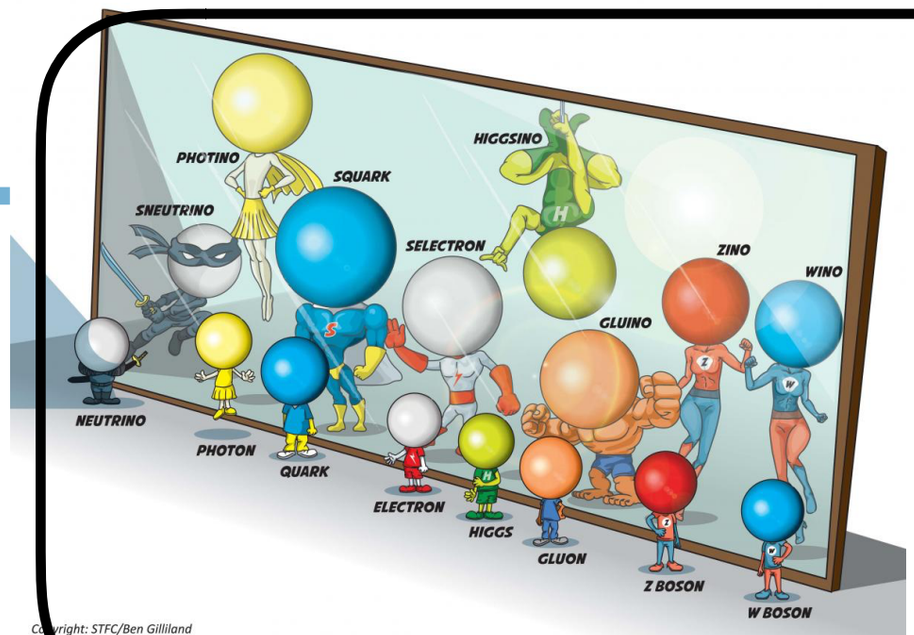
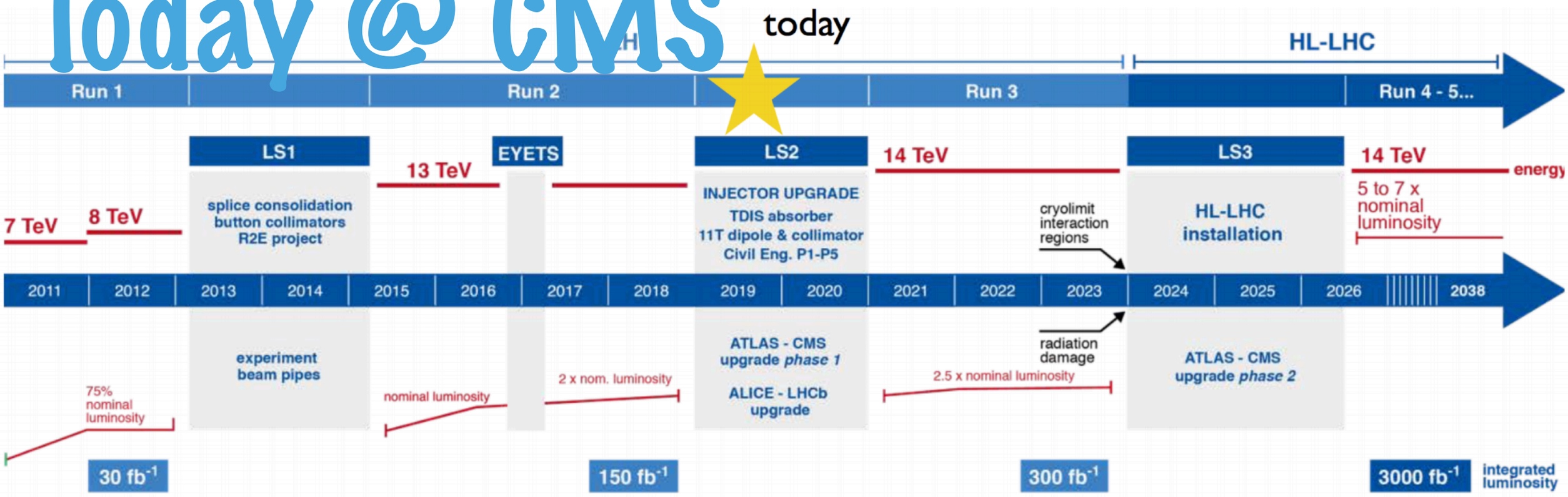


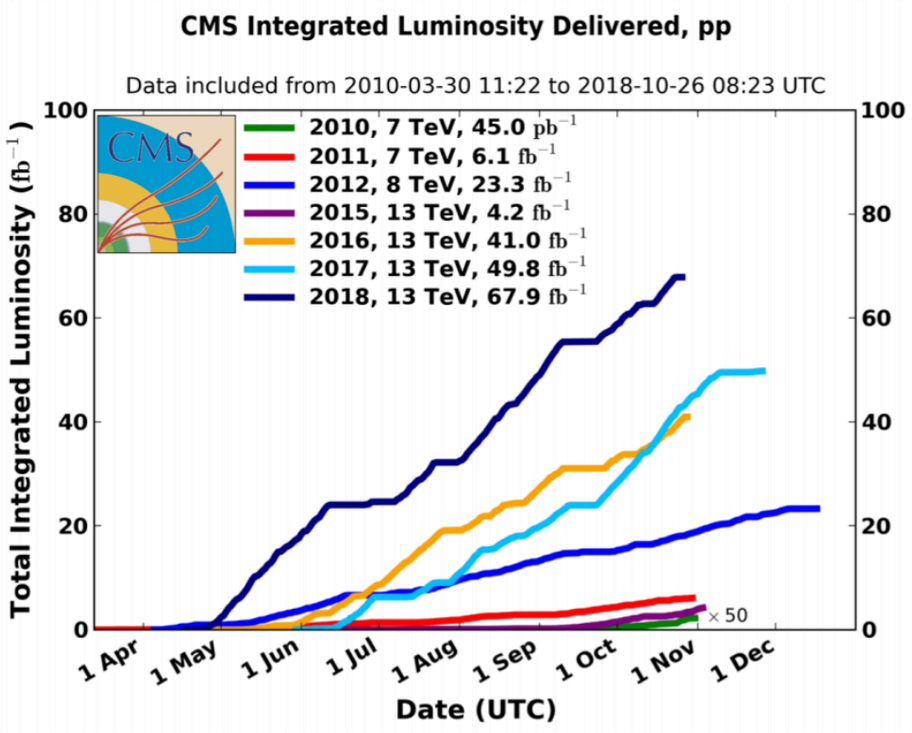
DM





Today @ CMS





- Luminosity (L) ~ number of collisions per unit time:~140fb^{-1}
- **But 95% of the total LHC data still to come** (and be studied)!

HL-LHC @ CMS

L1-Trigger/HLT/DAQ

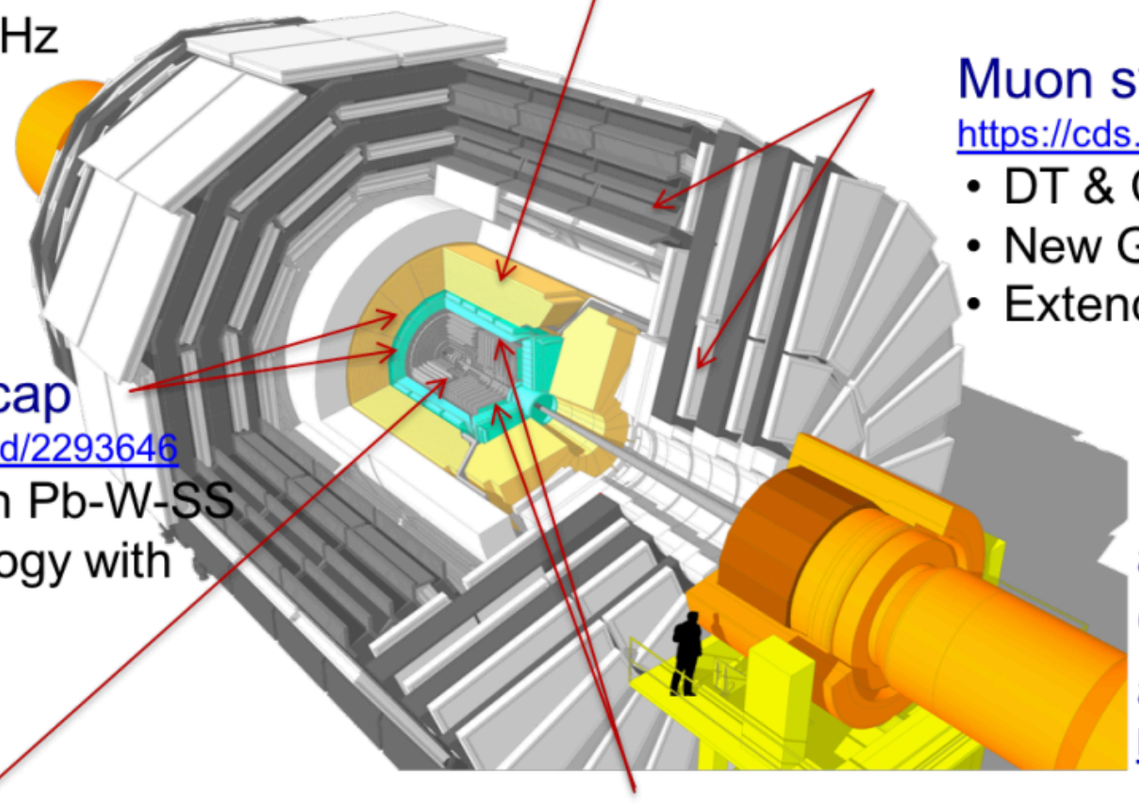
https://cds.cern.ch/record/2283192
https://cds.cern.ch/record/2283193

- Tracks in L1-Trigger at 40 MHz for 750 kHz PFlow-like selection rate
- HLT output 7.5 kHz

Barrel Calorimeters

https://cds.cern.ch/record/2283187

- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards



Muon systems

https://cds.cern.ch/record/2283189

- DT & CSC new FE/BE readout
- New GEM/RPC $1.6 < \eta < 2.4$
- Extended coverage to $\eta \simeq 3$

Calorimeter Endcap

https://cds.cern.ch/record/2293646

- Si, Scint+SiPM in Pb-W-SS
- 3D shower topology with precise timing

Beam Radiation Instr. and Luminosity, and Common Systems and Infrastructure

https://cds.cern.ch/record/2020886

Tracker https://cds.cern.ch/record/2272264

- Si-Strip and Pixels increased granularity
- Design for tracking in L1-Trigger
- Extended coverage to $\eta \simeq 3.8$

MIP Timing Detector

https://cds.cern.ch/record/2296612

- $\simeq$ 30 ps resolution
- Barrel layer: Crystals + SiPMs
- Endcap layer: Low Gain Avalanche Diodes

CMS @ New Perspectives

Scintillator Tiles for the High Granularity Calorimeter of the CMS Detector at the HL-LHC	*Ramanpreet SINGH*
Layout and performance of GE1/1 chambers for the CMS muon spectrometer upgrade	*Mr. Aashaq SHAH*
Reconstructing proton-proton collision positions at the Large Hadron Collider with a D-Wave quantum computer	*Andrew WILDRIDGE et al.*

Coffee break: Coffee break

One West, Fermi National Accelerator Laboratory 10:30 - 11:00

Searching for Dark Matter with Semi-Visible Jets at CMS	*Colin FALLON*
One West, Fermi National Accelerator Laboratory	11:00 - 11:15
Search for Supersymmetry at CMS in Events with Large Jet Multiplicity and Low Missing Transverse Momentum at sqrt(s)=13 TeV	*Christopher MADRID*
Search for dark photons with CMS and fixed-target experiments	*Andre STERENBERG FRANKENTHAL*
One West, Fermi National Accelerator Laboratory	11:30 - 11:45