The ATLAS Experiment at the LHC

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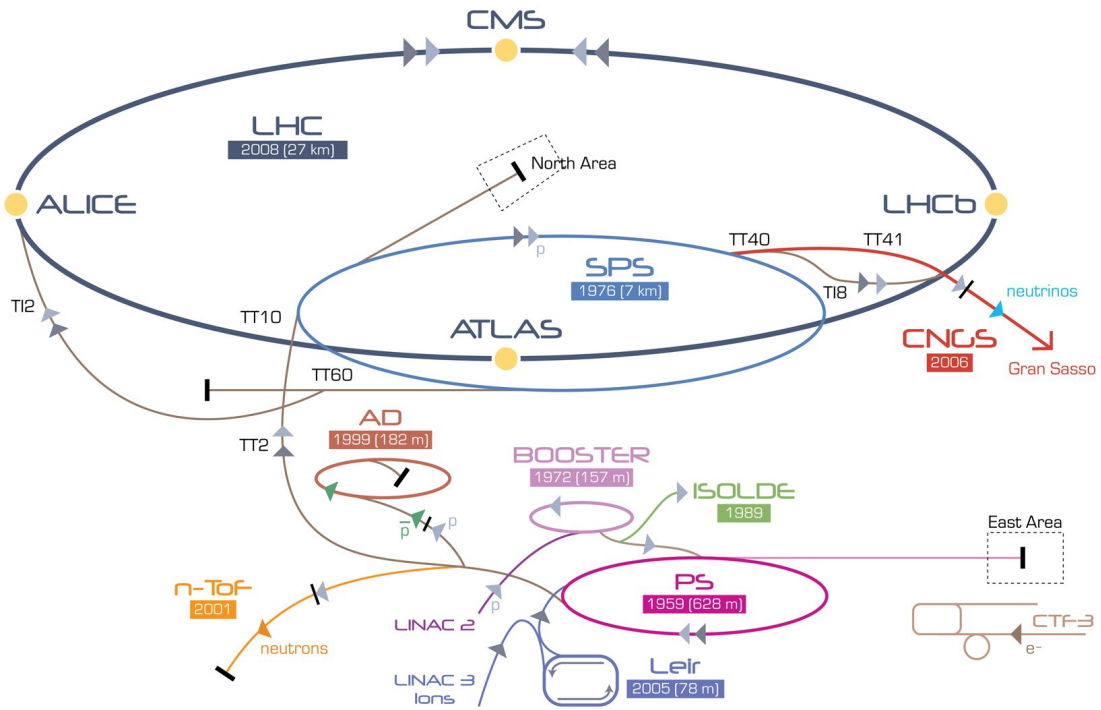
MAX-PLANCK-GESELLSCHAFT

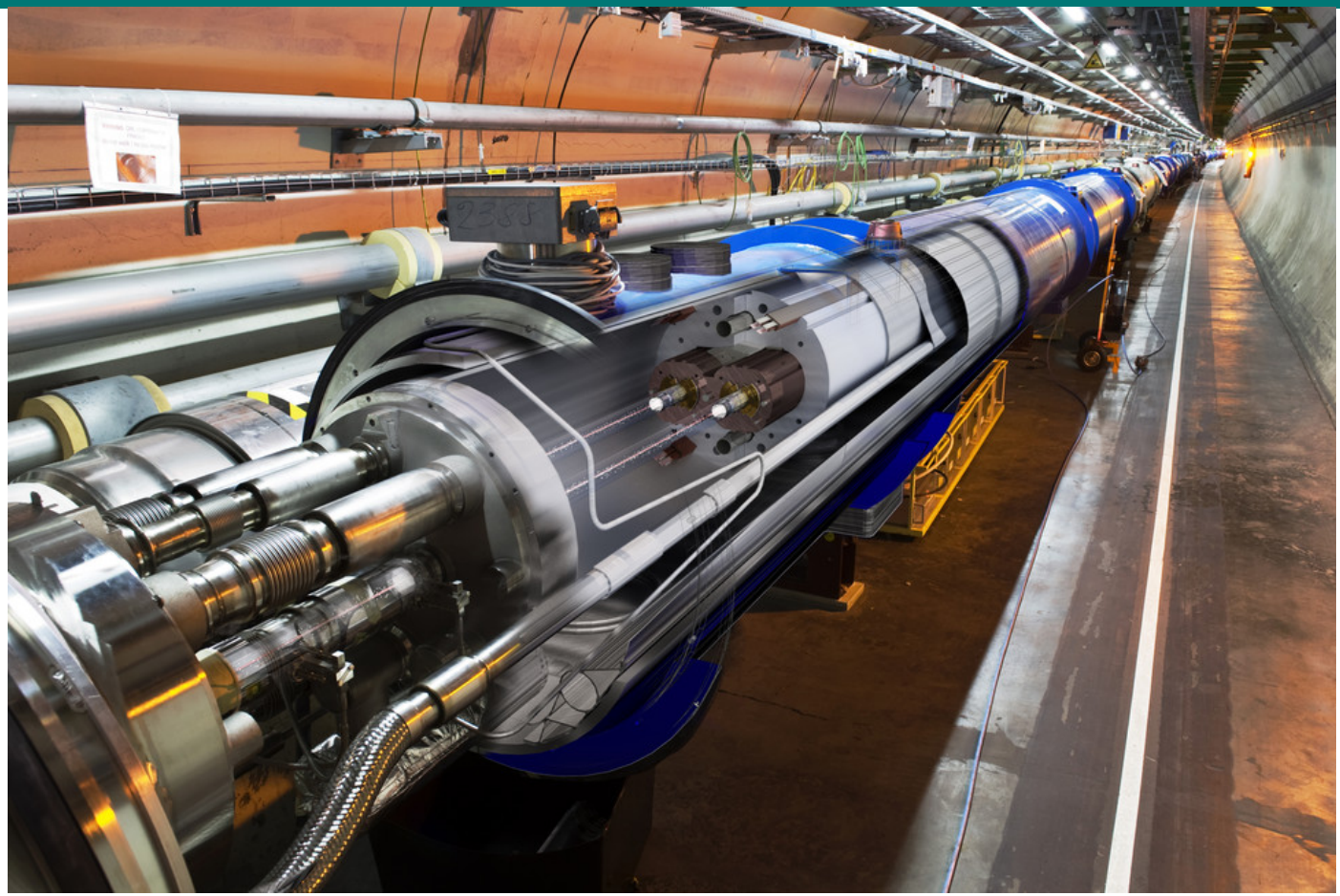
Large Hadron Collider (LHC)

- Located at CERN, Geneva
- Circumference 27 km
- Collides bunches of protons (pp-collider)
- Perform particle physics at unprecedented energies.

year	$\sqrt{s}$	$\int dt\, L$
2011	7 TeV	$4.6\,\text{fb}^{-1}$
2012	8 TeV	$20.3\,\text{fb}^{-1}$
2015-2018	13 TeV	$150\,\text{fb}^{-1}$



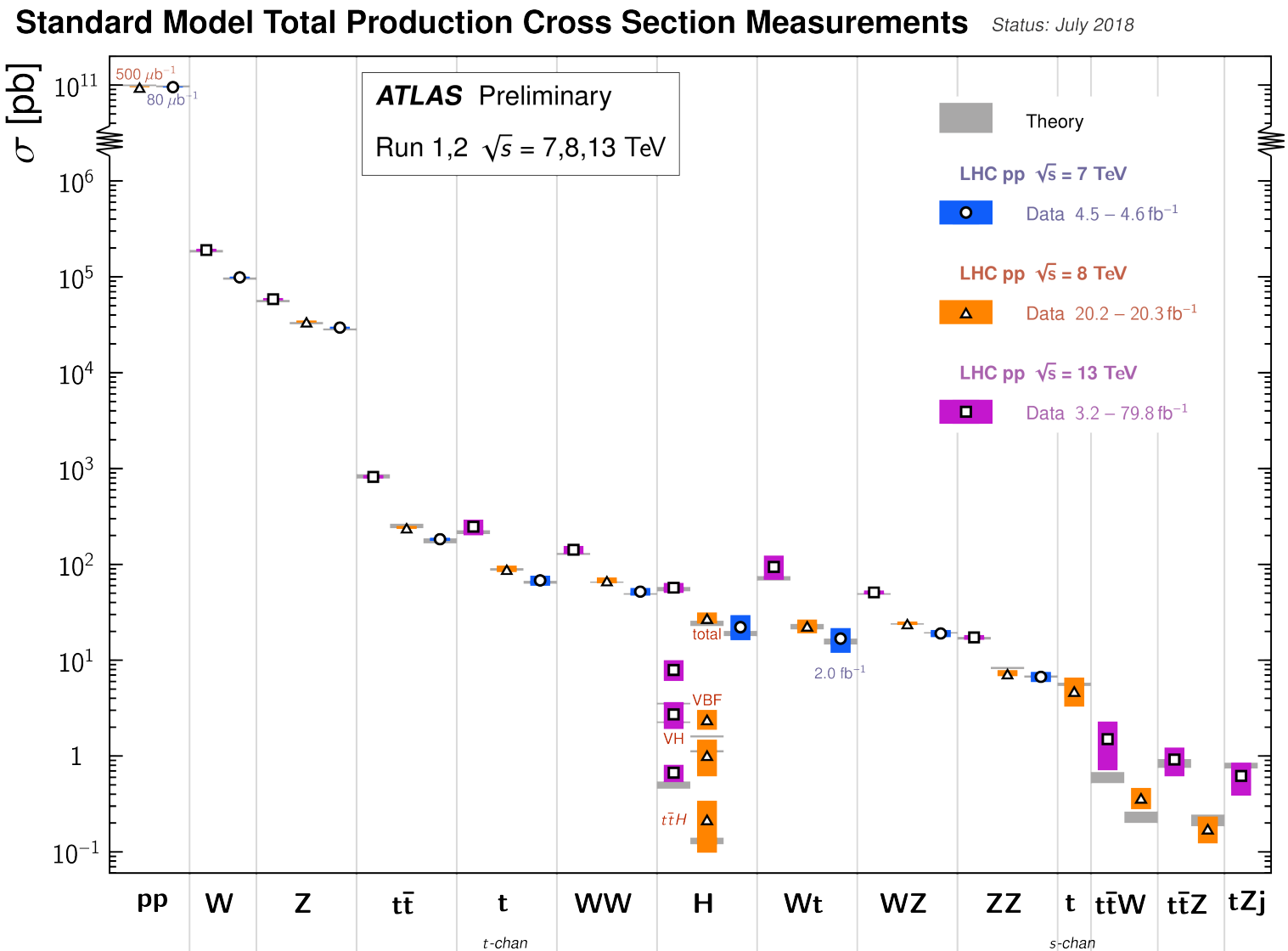
Large Hadron Collider (LHC)



- Each proton beam has 2808 bunches.
- Each bunch consists of 10^{10} protons.
- Frequency of colliding bunches is 40 MHz.

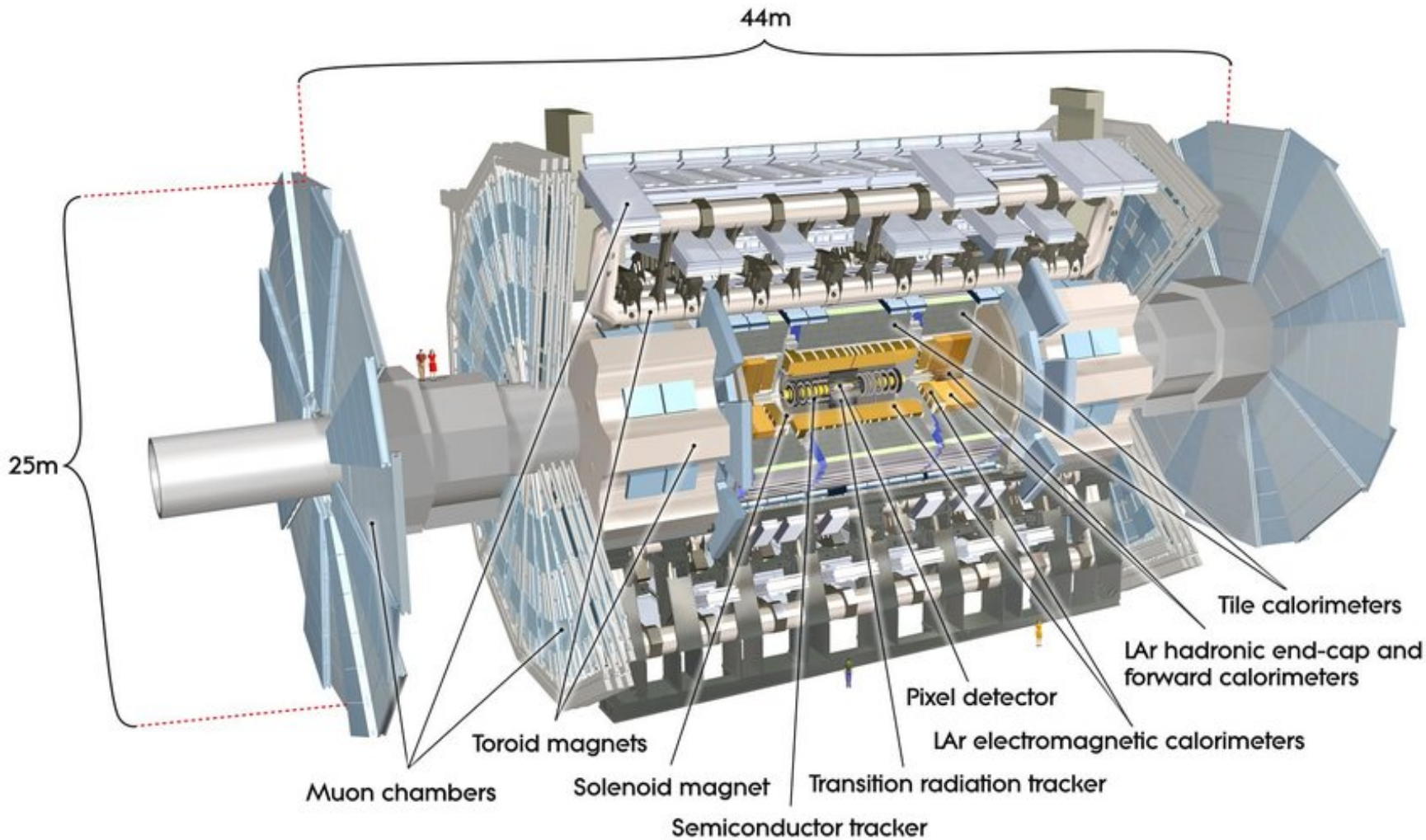
The LHC generates about 1.5 billion particle collisions per second!

Large Hadron Collider (LHC)



Main challenge: finding rare processes in QCD environment.

A Toriodal LHC ApparatuS Detector (ATLAS)

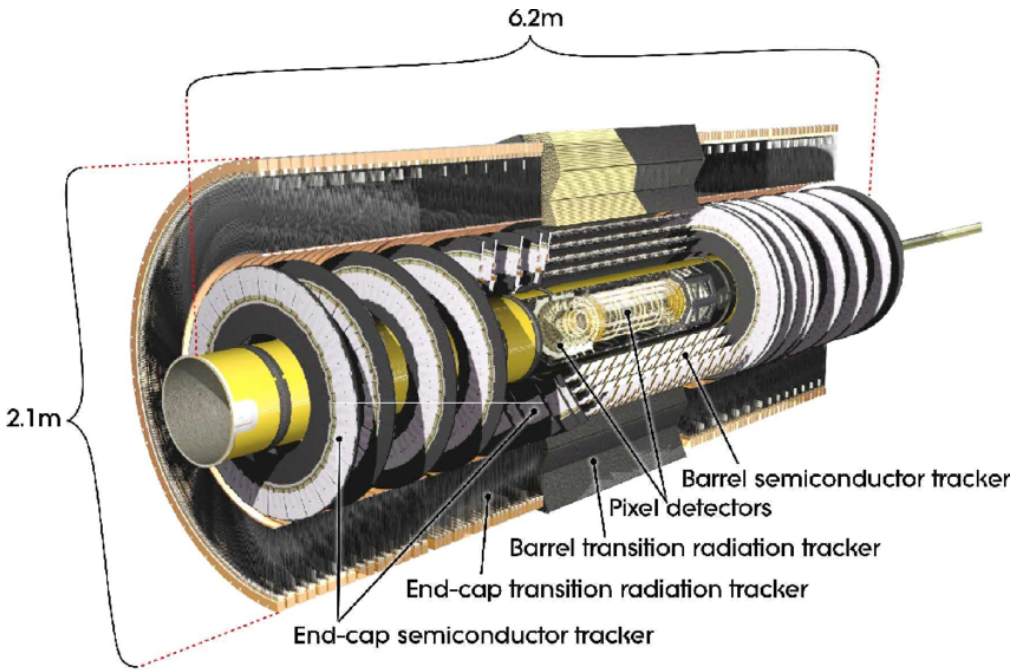


Inner detector

- Measures direction, momentum of electrically charged particles.
- Surrounded by a 2 T soleniod magnetic field.
- High tracking and vertexing performance.

The ID consists of three different systems of sensors:

- Pixel Detector
- Semiconductor Tracker (SCT)
- Transition Radiation Tracker (TRT)



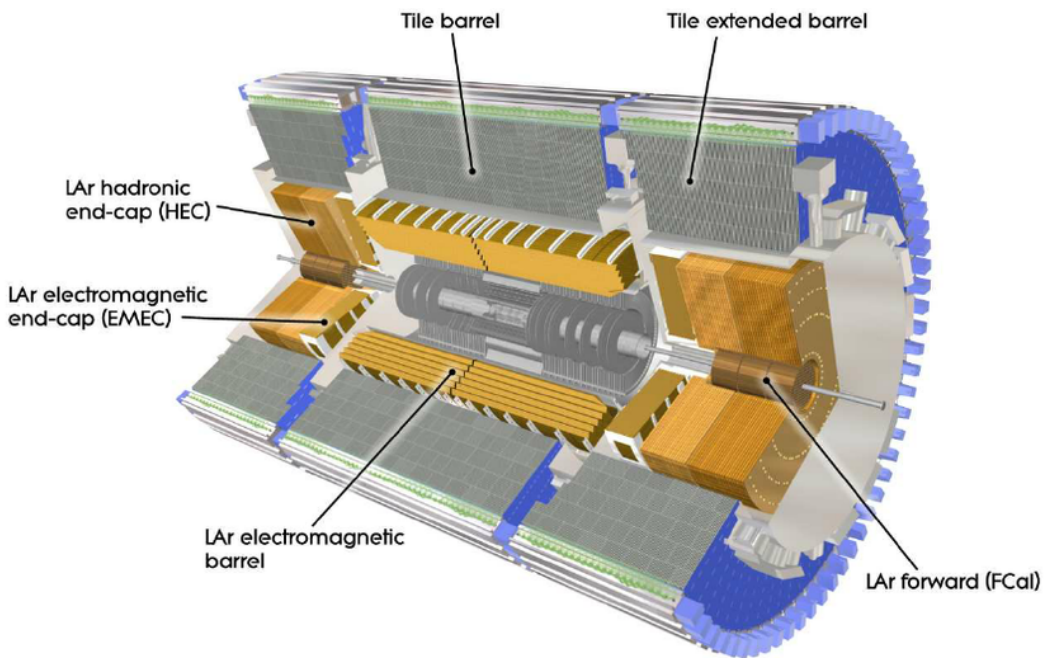
Calorimeters

Electromagnetic calorimeter (EM):

- Measures the energy of eletromagnetic interacting particles (i.e. electrons, photons).
- Lead as absorber and liquid argon (LAr) as active material.

Hadronic calorimeter (HCAL):

- Measures the energy of strongly interacting particles.
- Steel as absorber and scintillating tiles as active material.



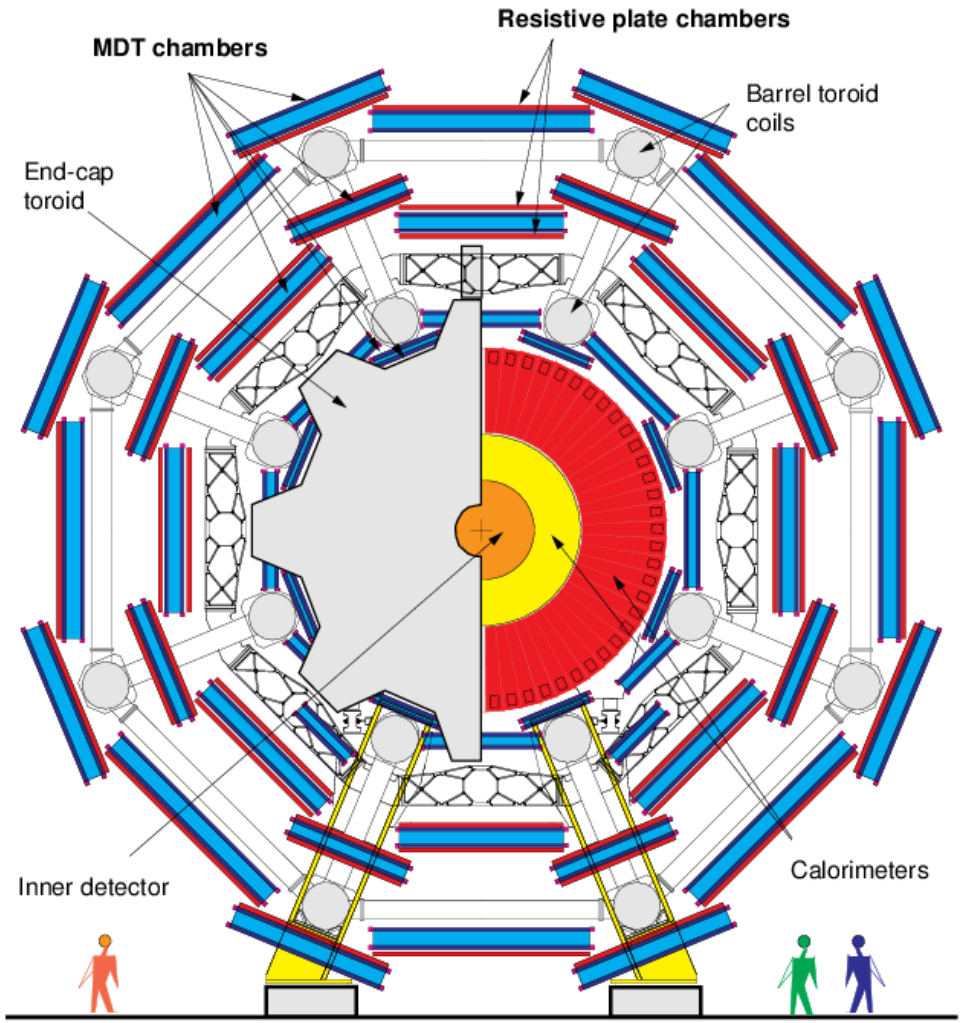
Muon spectrometer

Muons pass the calorimeters without significant energy loss in the calorimeters.

$\rightarrow$ Outermost layer of ATLAS.

- Fast trigger chambers (TGC, RPC)
- High resolution tracking detectors (MDT, CSC)

A toroidal magnetic field of 0.4 T is used to measure the momenta.

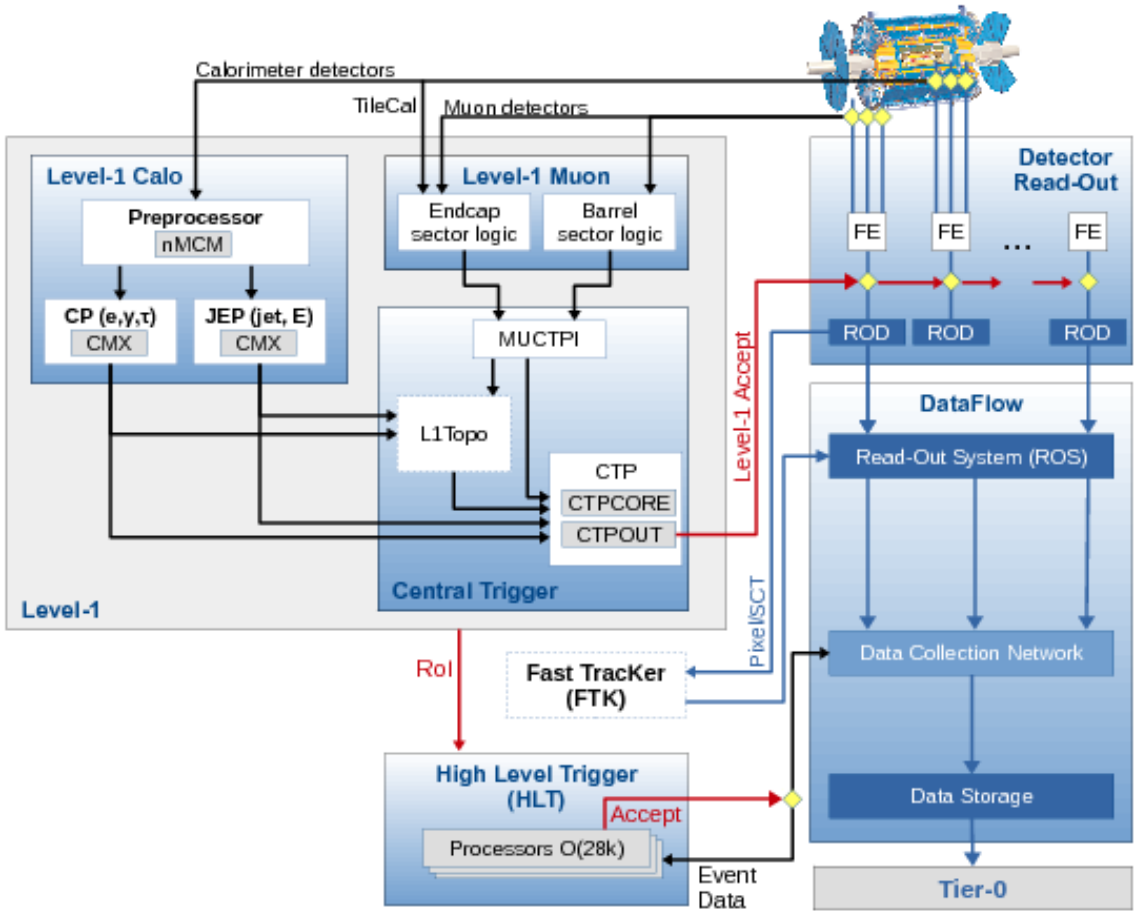


ATLAS Event Size and Trigger System

- Average event size is about 1.5 MB.
- 40 MHz bunch crossing rate leads to 1 PB s^{-1}.

Highly selective and efficient trigger system needed!

- Level-1 hardware based.
- High-Level trigger software based.



→ Reduction from 40 MHz to 1 kHz.

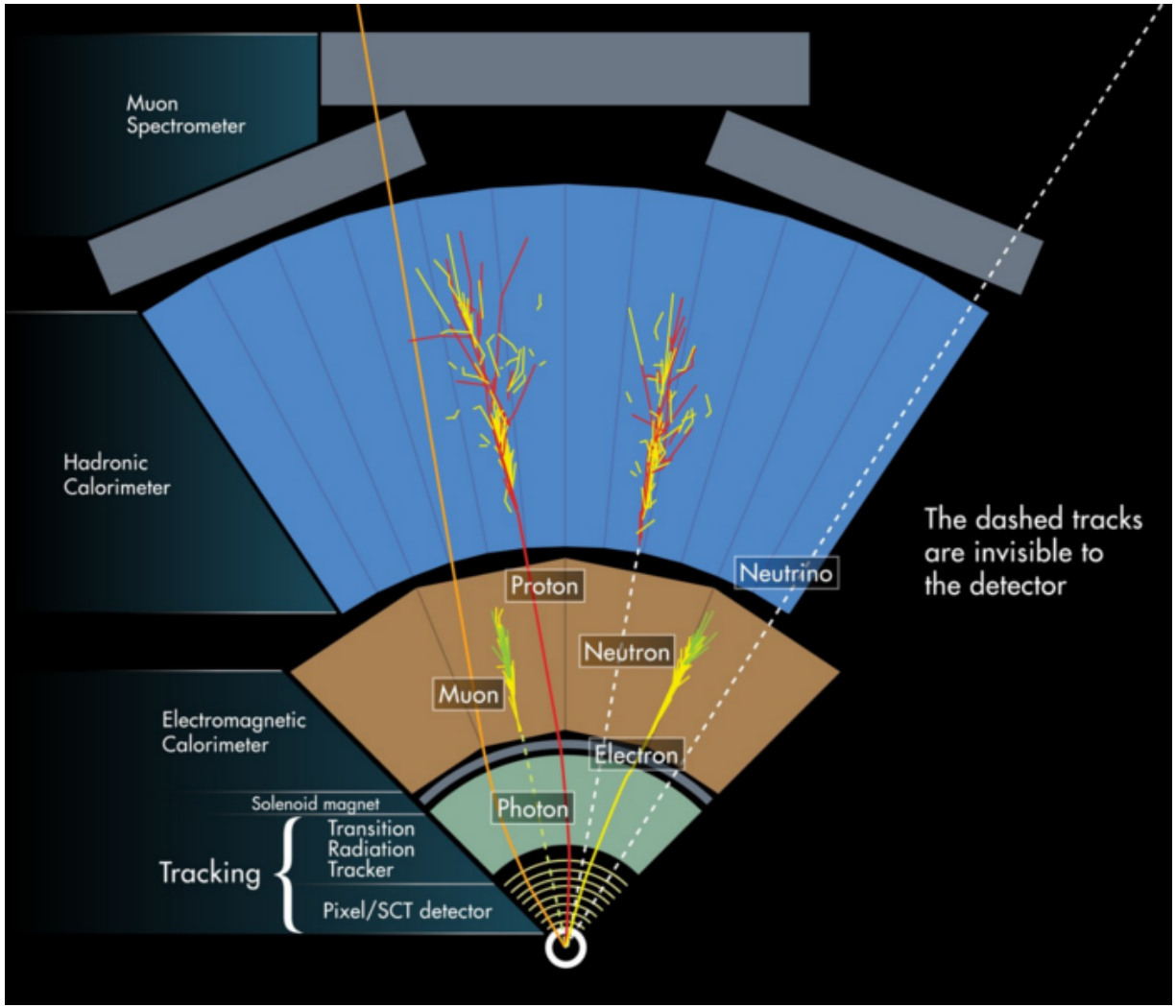
Electron and photon identification

Electron identification:

- Energy deposits in the EM calorimeter.
- Track.

Photon identification:

- Energy deposits in the EM calorimeter.
- No Track.



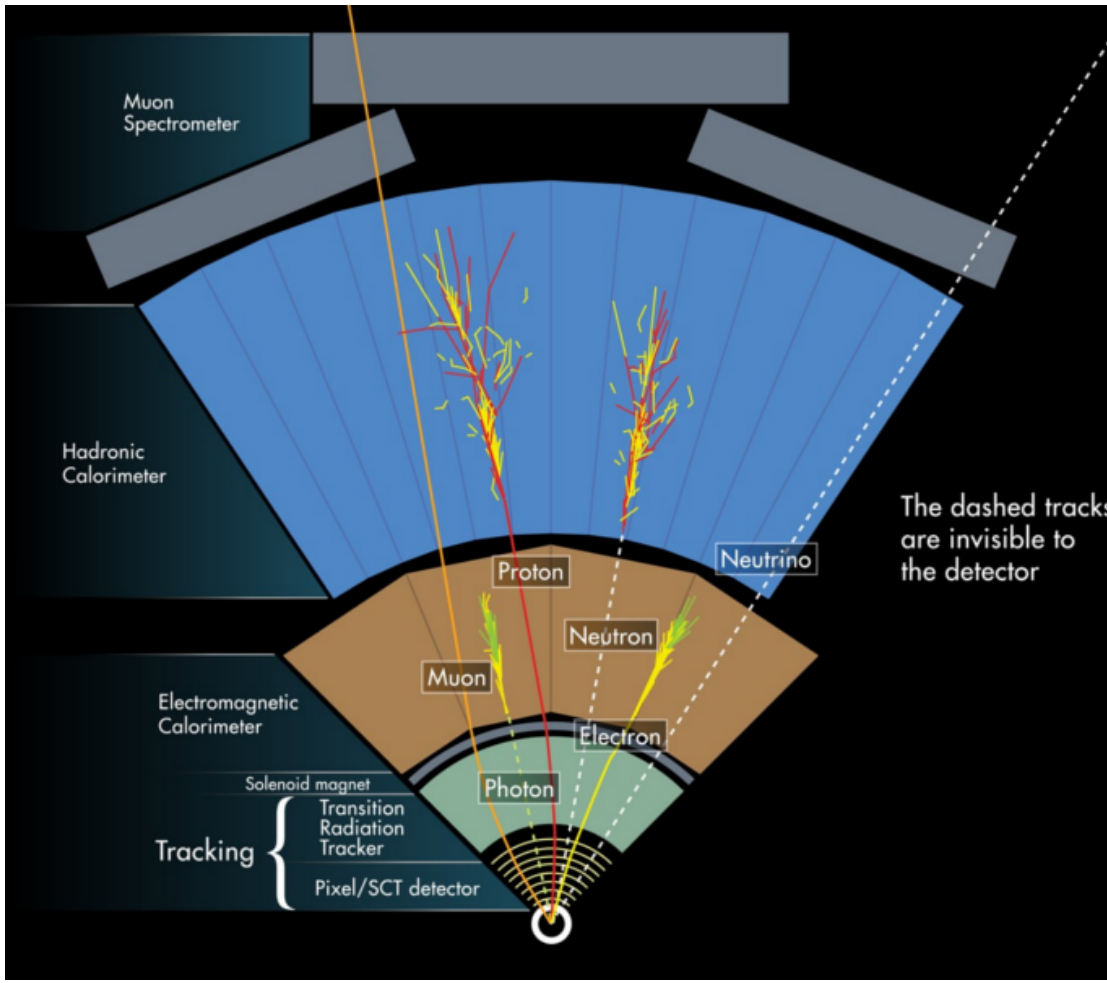
Jet and muon identification

Jet identification:

- Collimated bunch of hadrons.
- The *anti-*k_t algorithm combines energy cluster.
- B hadrons has non-zero lifetime.
- Jets with secondary vertices are tagged as b-jet.

Muon identification:

- Combine ID and MS track measurement.
- Momentum is determined by bending it in the transversal plane.
- High momentum resolution up to large transverse momentum.

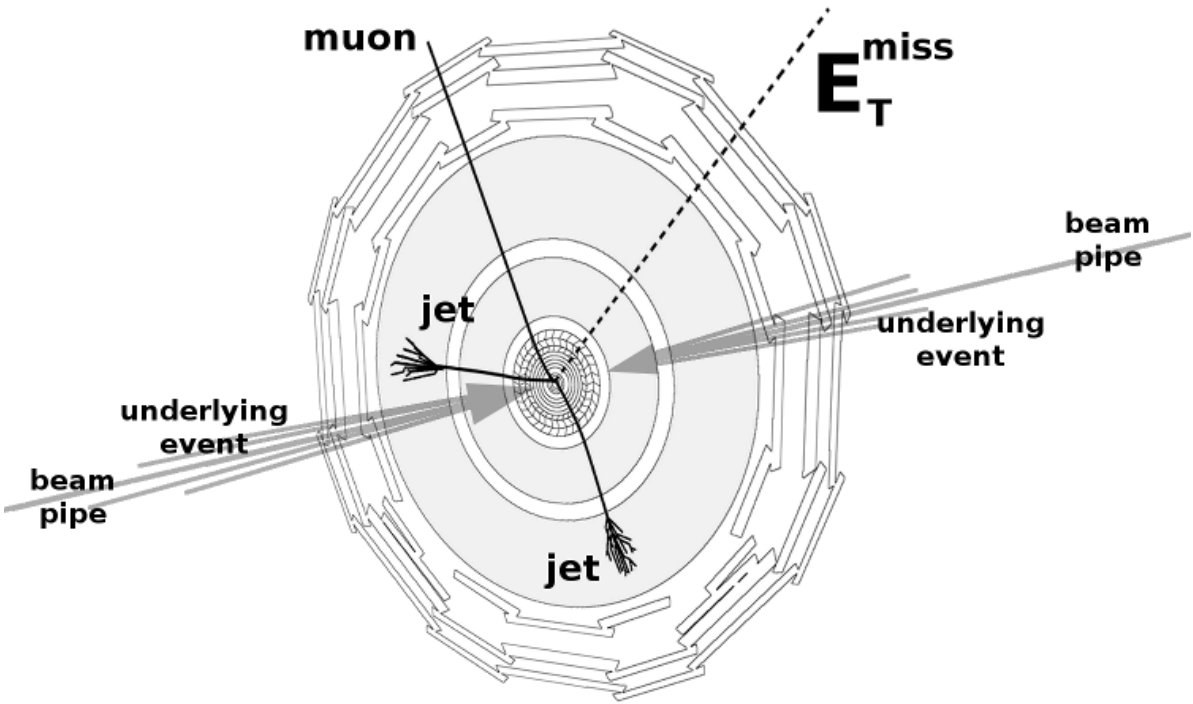


Missing Transverse Energy

Particles not interacting with detector material (i.e. neutrinos) are lost.

- Momentum balance in transversal plane is conserved in collisions.
- Measure the imbalance in sum of all calorimeter energy:

$$E_{\mathrm{T}}^{\mathrm{miss}} = -\sum_{\mathrm{i}} |\vec{p}_T(i)|$$



$\rightarrow$ Sensitive to production of any non-interacting particle (dark matter).

Summary and Outlook

- LHC is a pp collider currently operating at $\sqrt{s} = 13\,\text{TeV}$.
- ATLAS is one of the two general multi-purpose detectors at LHC.
- High precision of the Standard Model and searches beyond Standard Model at high energies.
- Discovered the Higgs-boson in 2012.
- Upgrade to High-Luminosity LHC in 2024.