The LHC as a microscope

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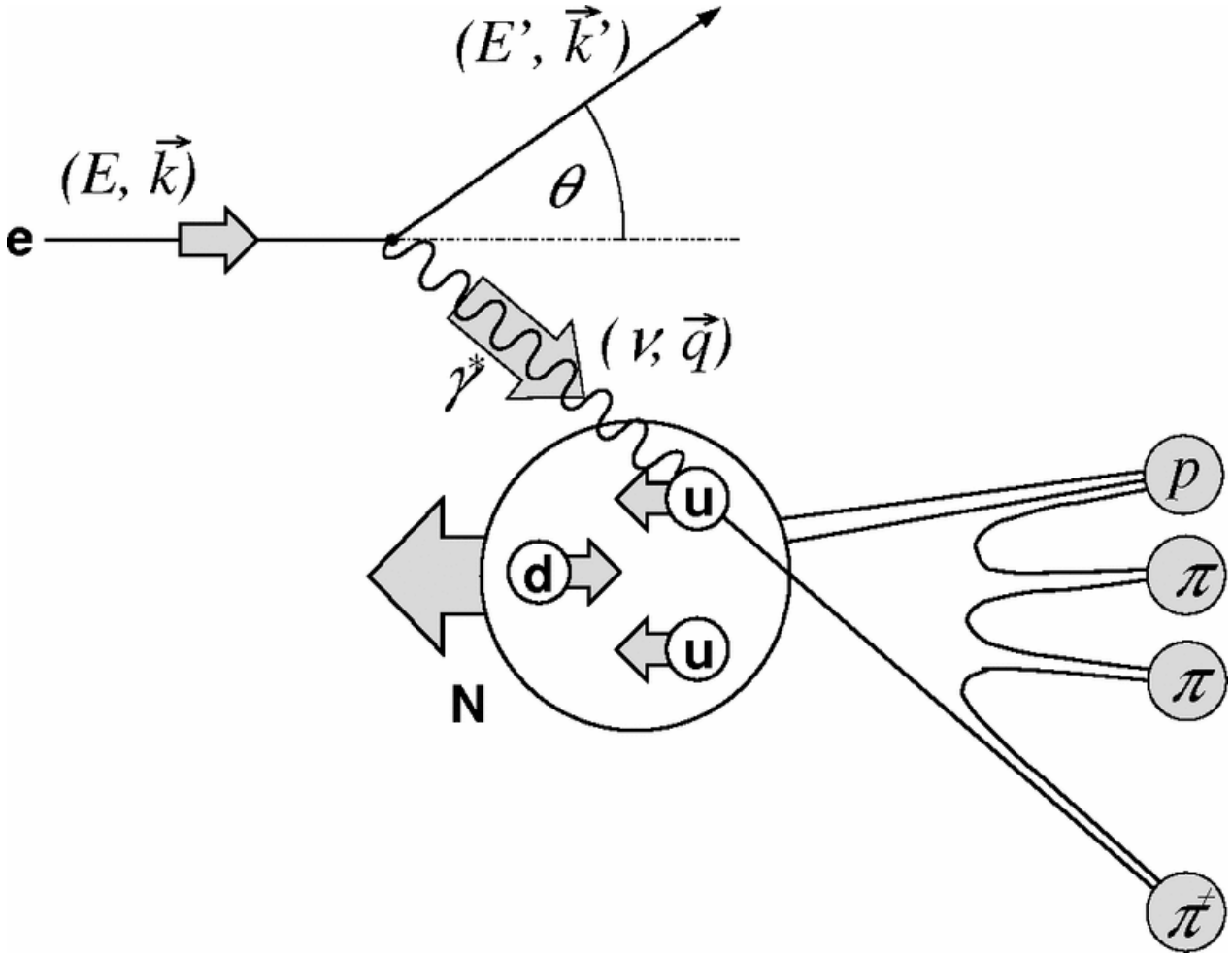
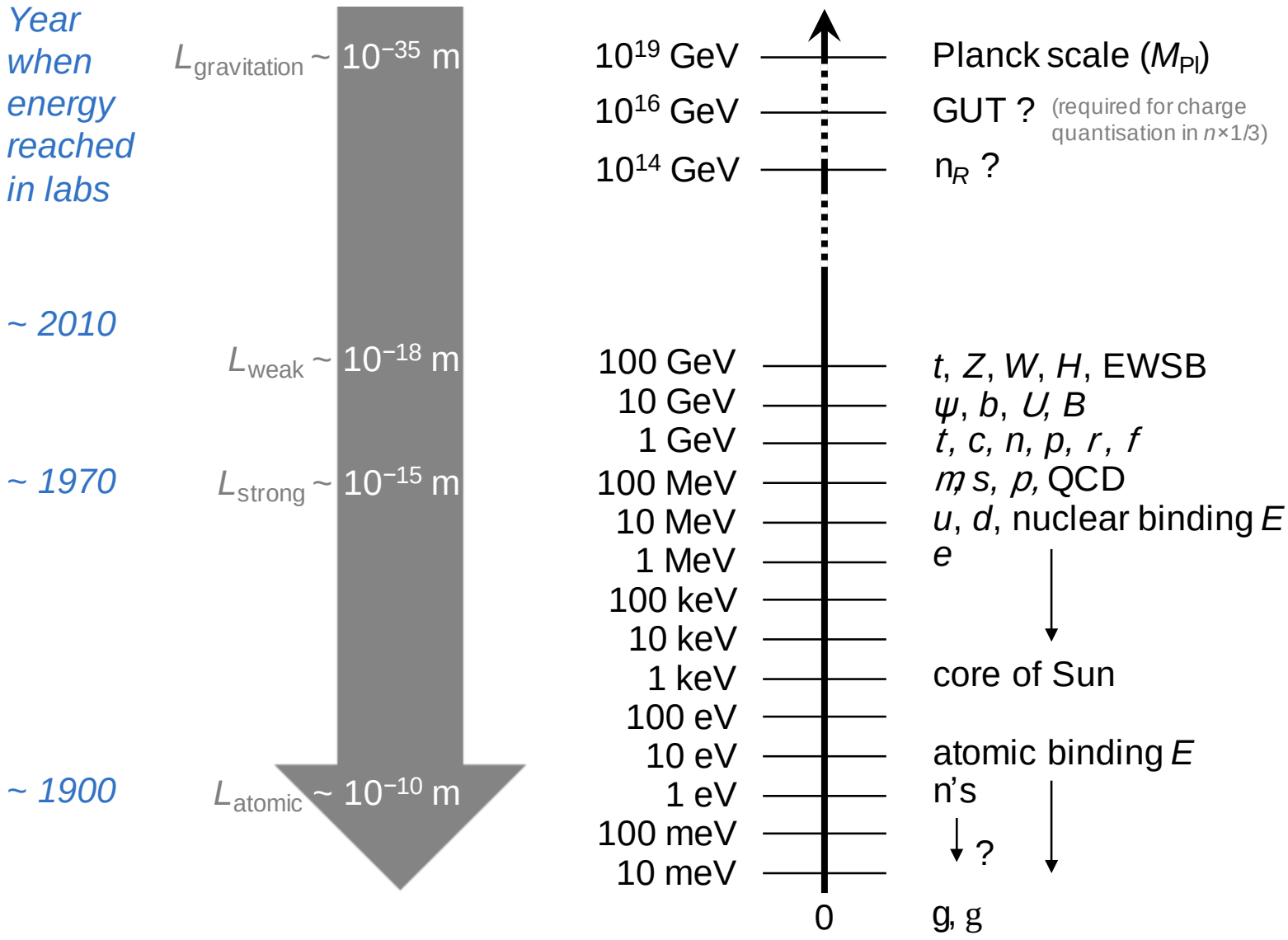
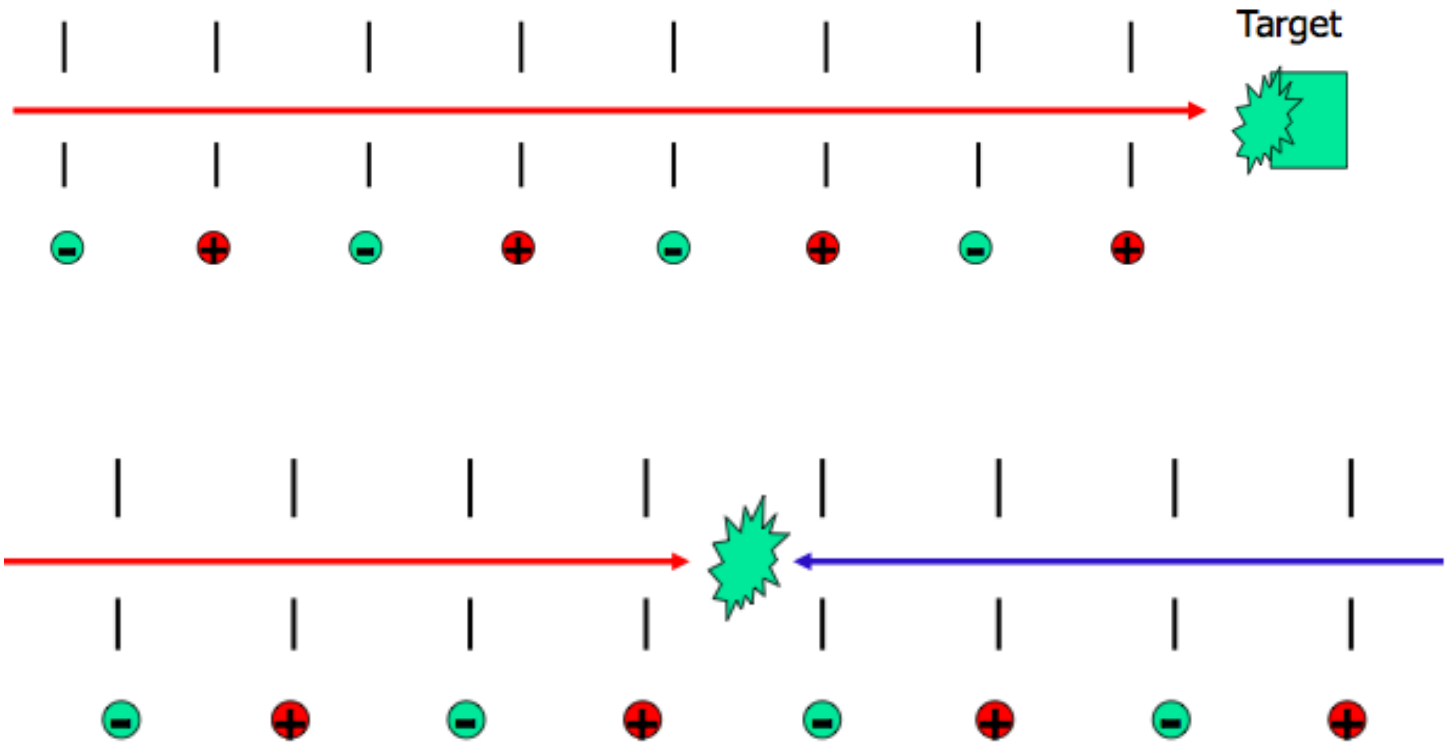
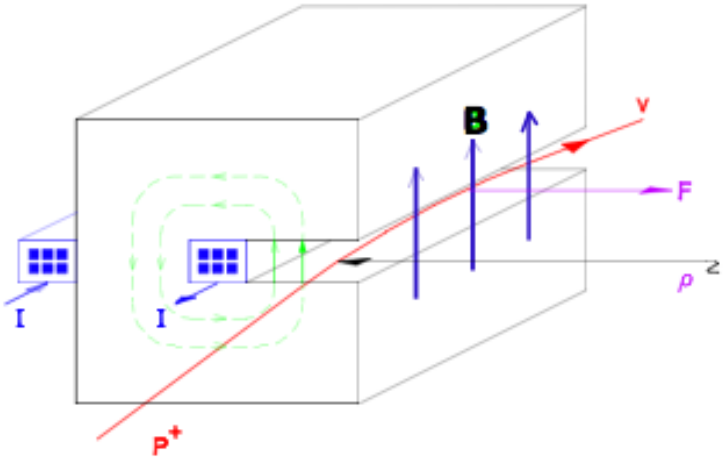
Outline

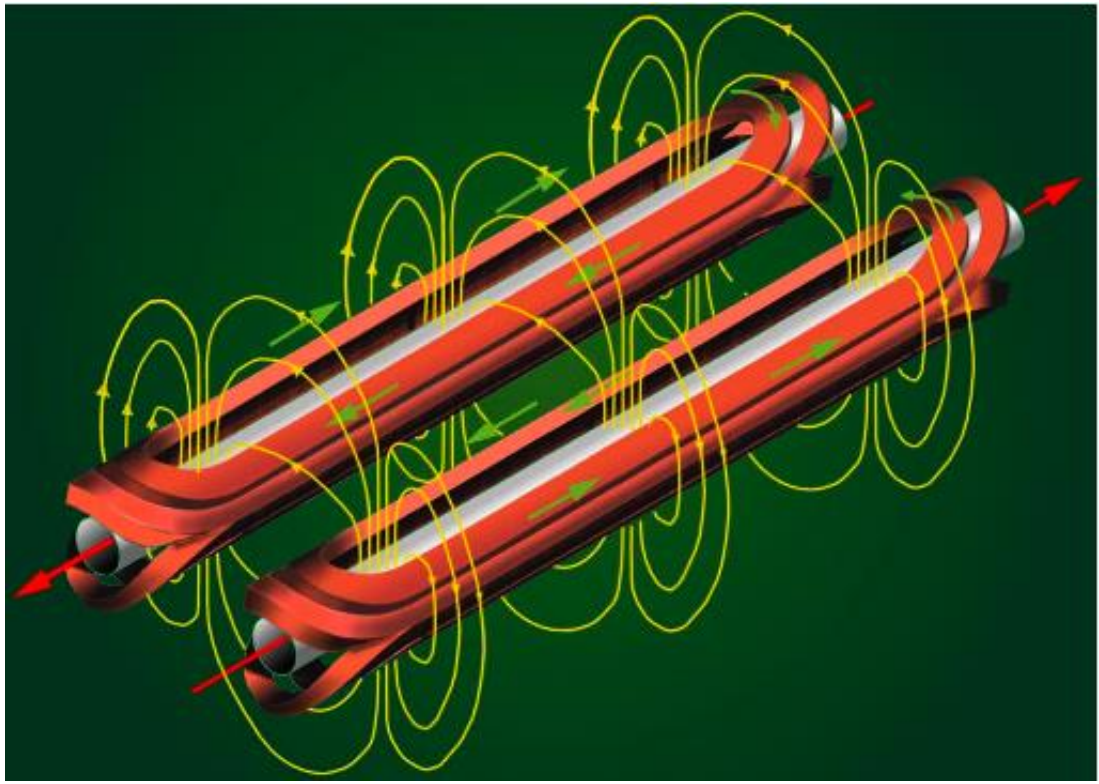
- II

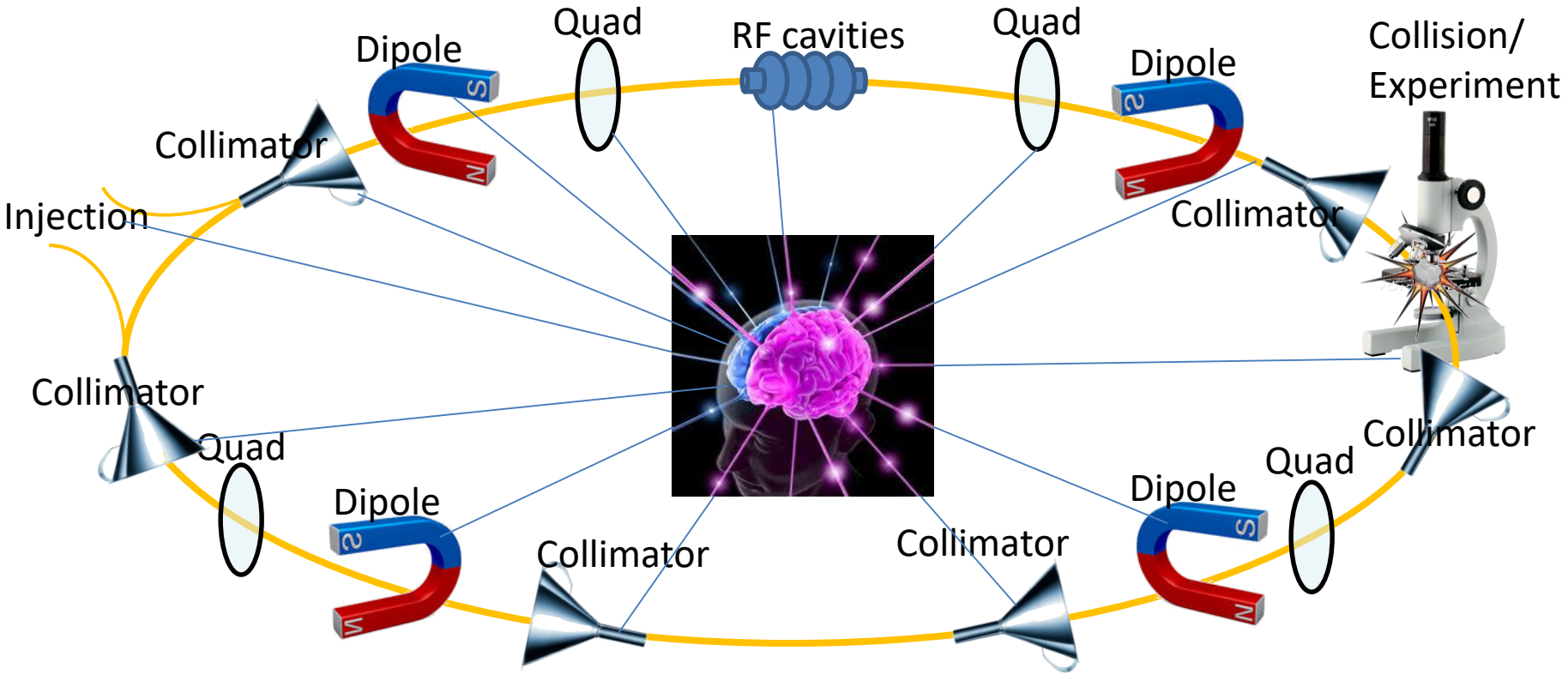

(E', k')
θ
(E, k)
e
(ν, q)
γ*
u
d
u
N
p
π
π
π

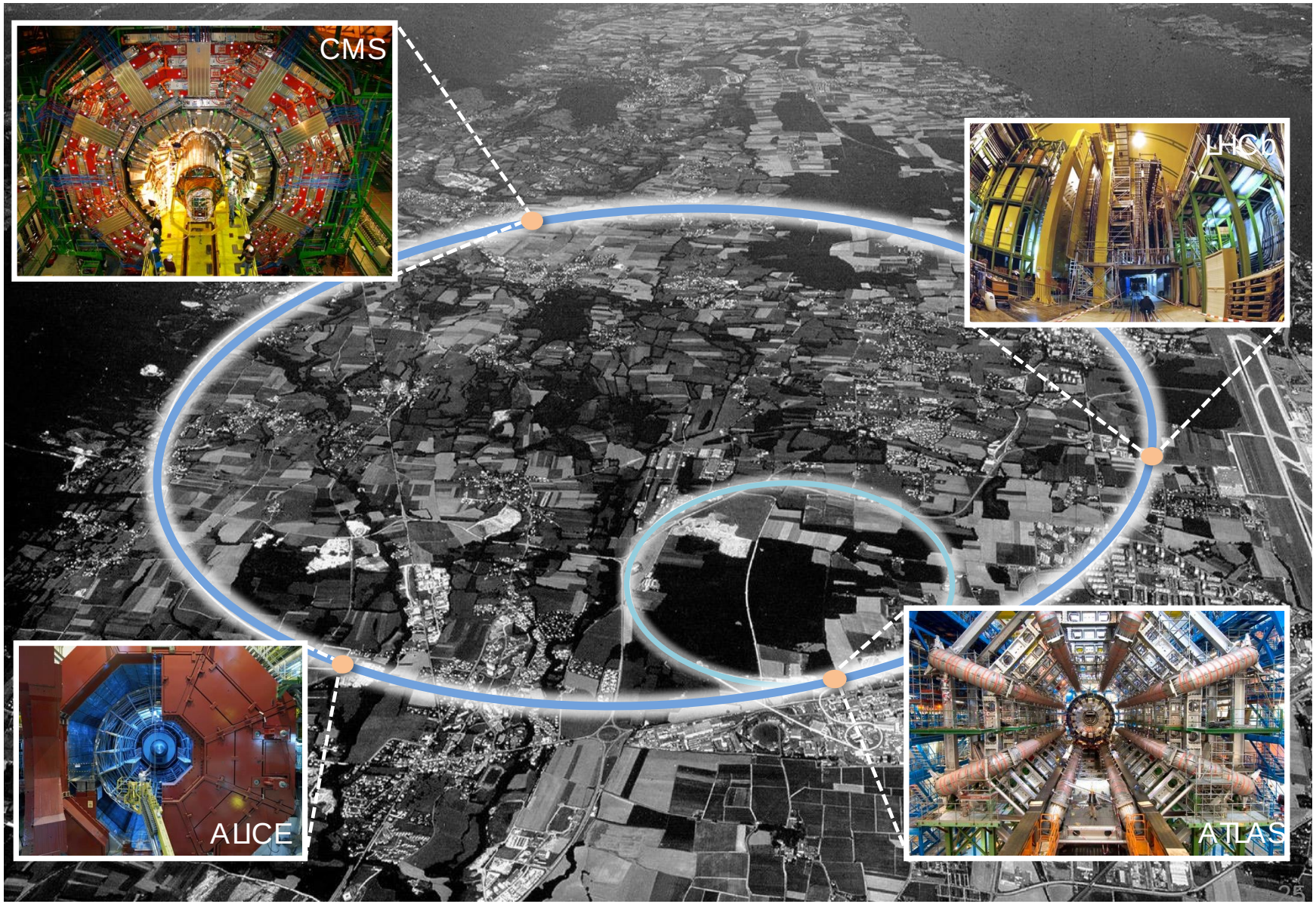

Year when energy reached in labs
~ 2010
~ 1970
~ 1900
$L_{gravitation}$ ~ 10^{-35} m
L_{weak} ~ 10^{-18} m
L_{strong} ~ 10^{-15} m
L_{atomic} ~ 10^{-10} m
10^{19} GeV
10^{16} GeV
10^{14} GeV
Planck scale (M_{Pl})
GUT ?
(required for charge quantisation in n×1/3)
n_R ?
100 GeV
10 GeV
1 GeV
100 MeV
10 MeV
1 MeV
100 keV
10 keV
1 keV
100 eV
10 eV
1 eV
100 meV
10 meV
0
t, *Z*, *W*, *H*, EWSB
ψ, *b*, *U*, *B*
t, *c*, *n*, *p*, *r*, *f*
m, *s*, *p*, QCD
u, *d*, nuclear binding *E*
e
core of Sun
atomic binding *E*
n's
?
g, g

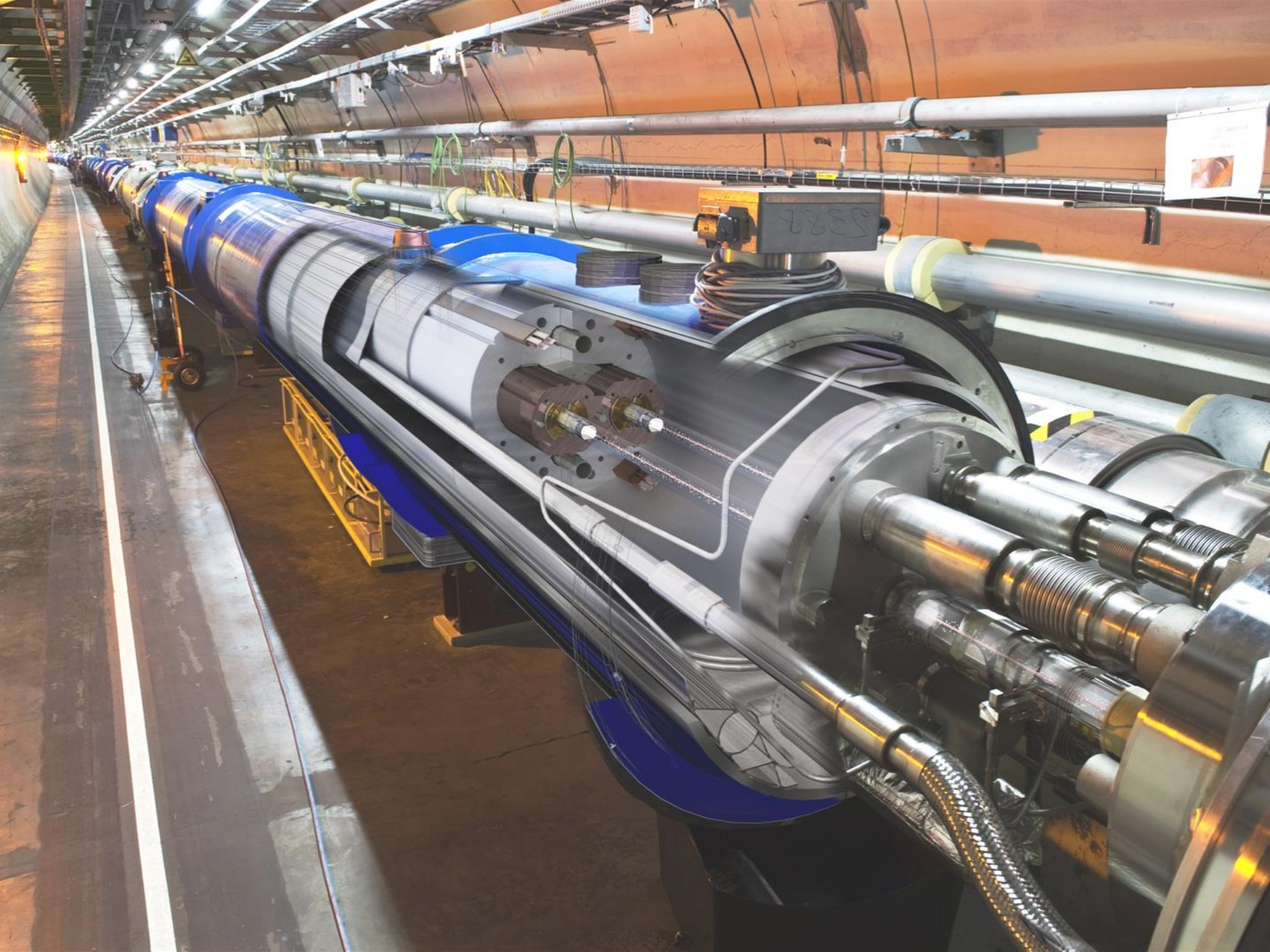

Target


B
v
F
I
I
z
ρ
P+

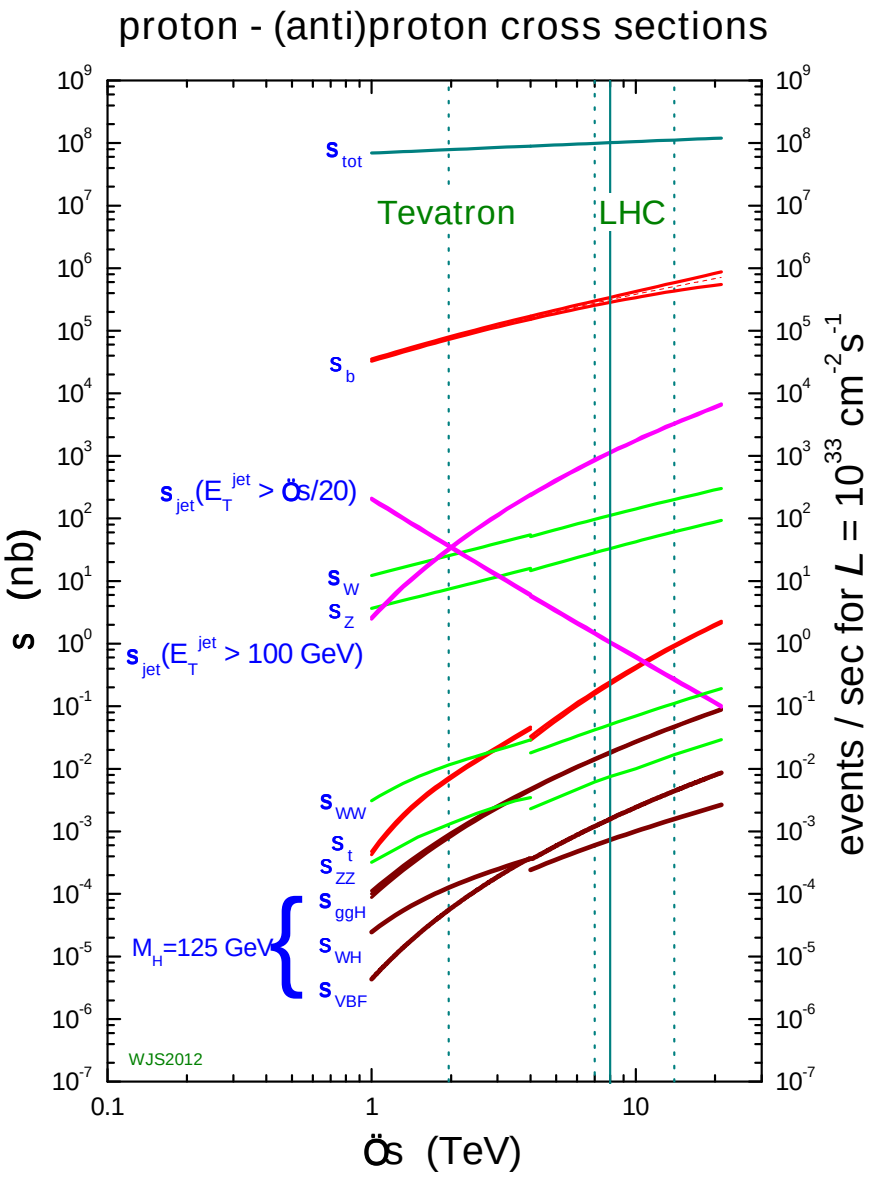


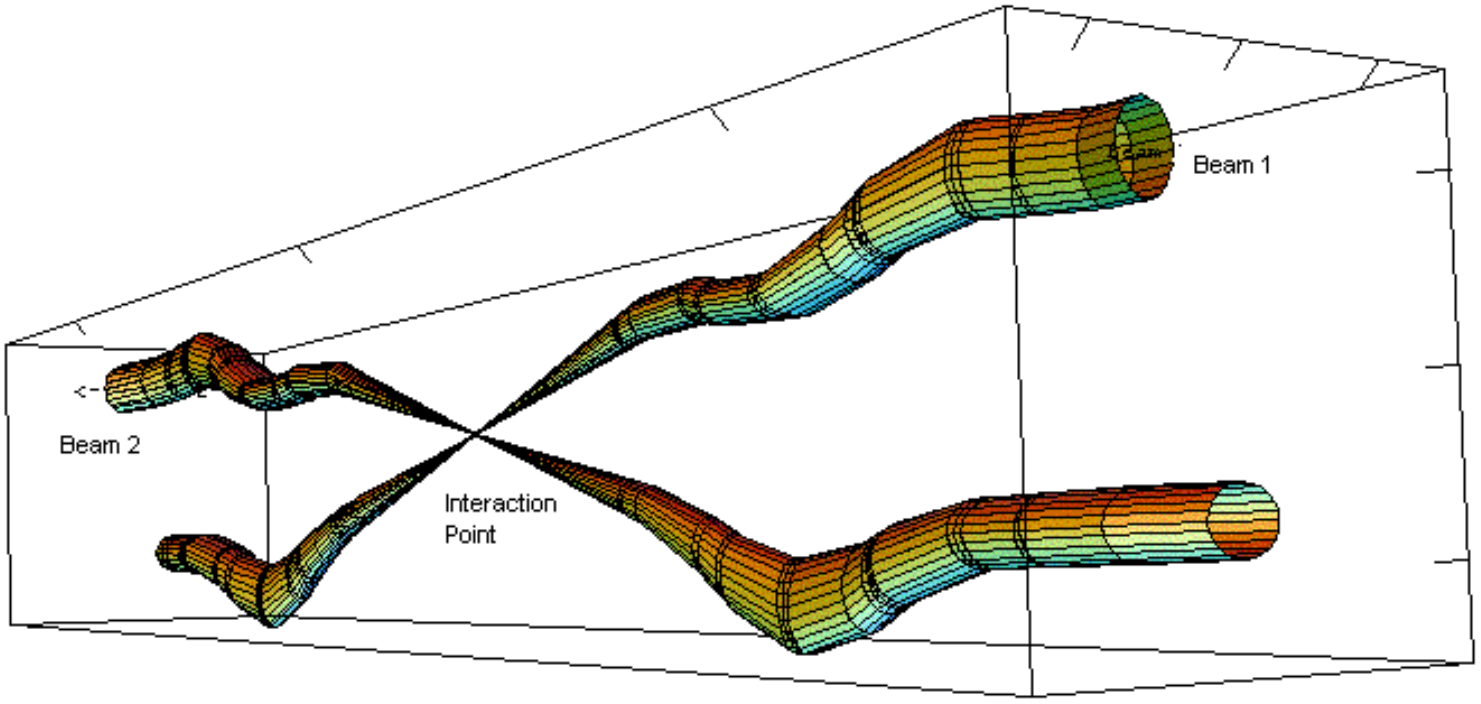

Dipole
Quad
RF cavities
Quad
Dipole
Collision/
Experiment
Collimator
Injection
Collimator
Collimator
Collimator
Quad
Dipole
Collimator
Collimator
Dipole
Quad


CMS
LHCb
ALICE
ATLAS



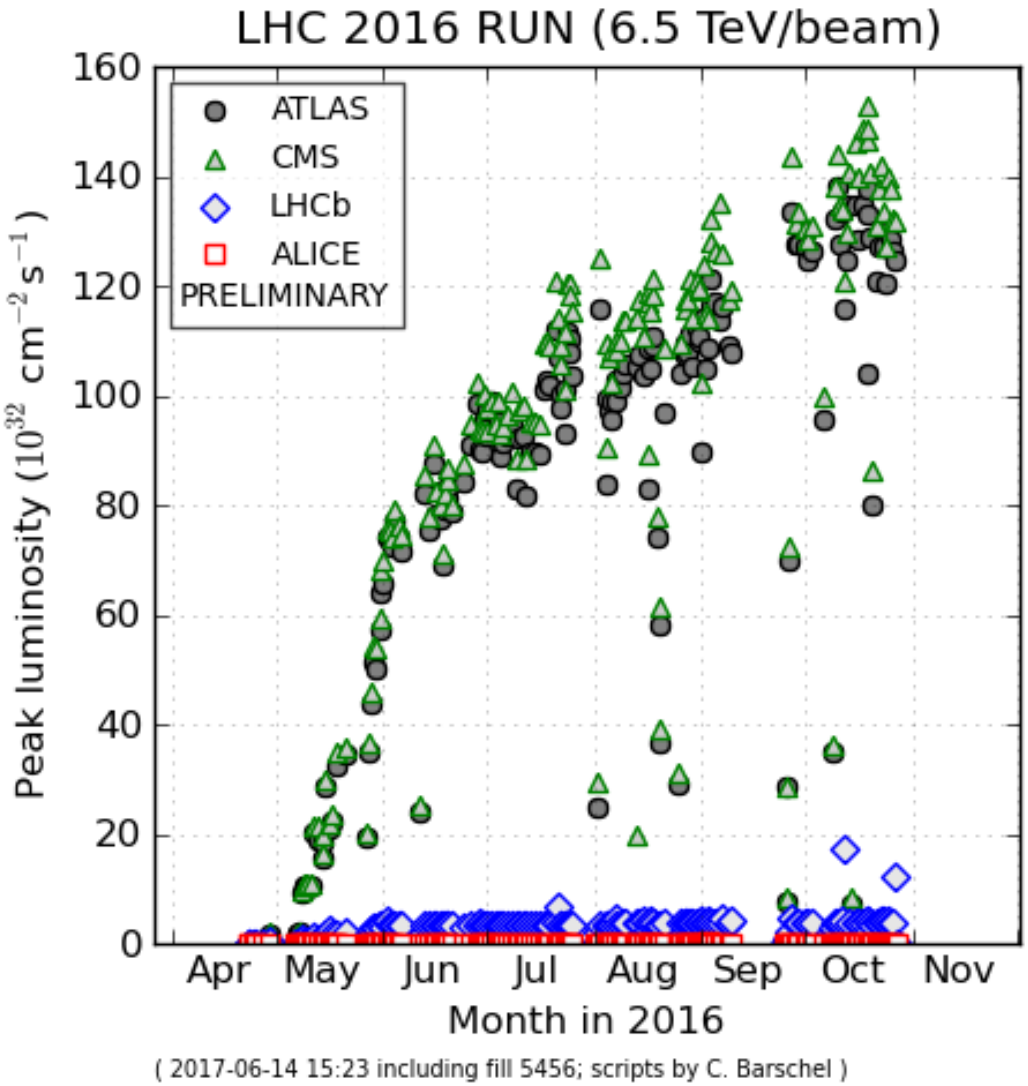
Cross sections

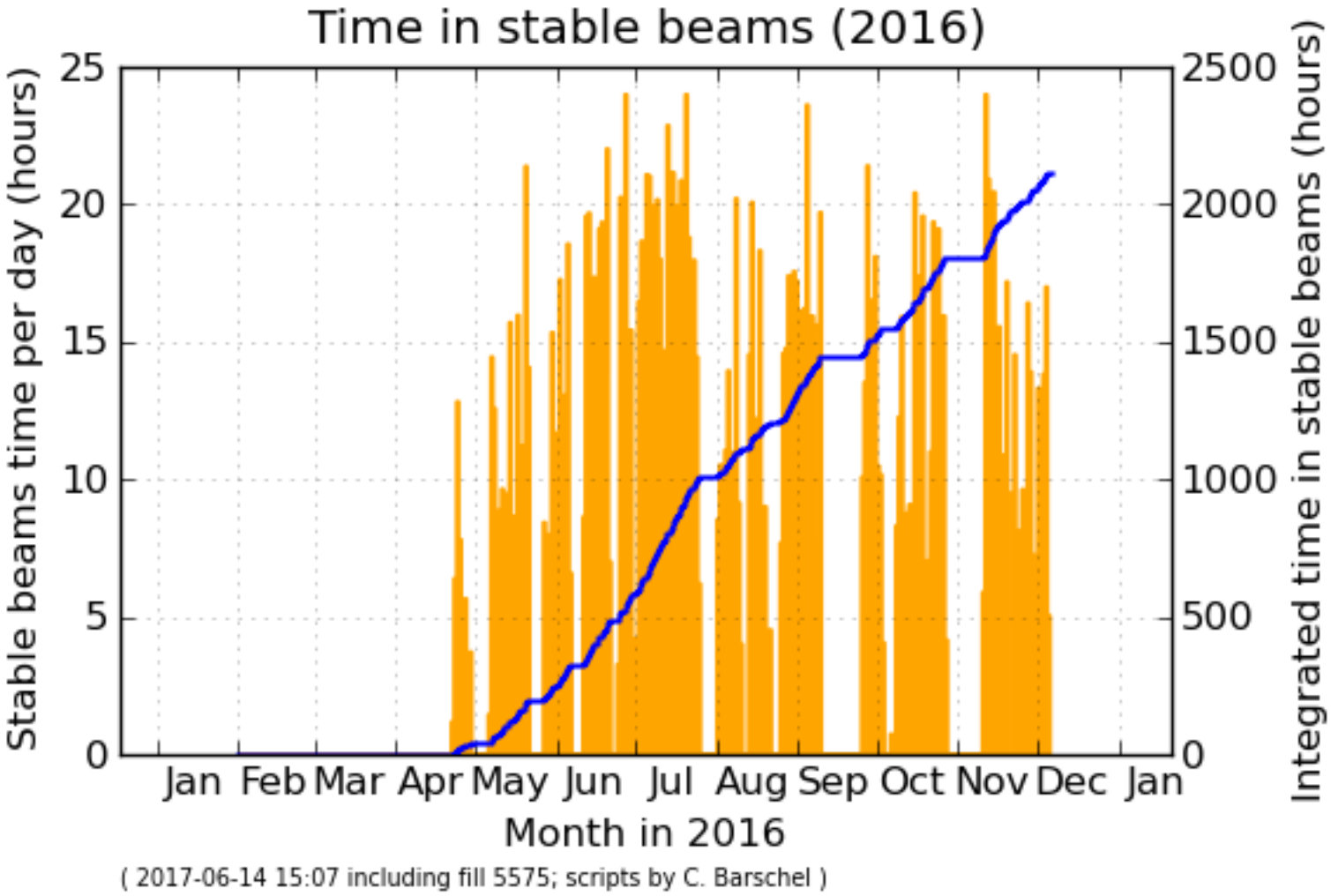


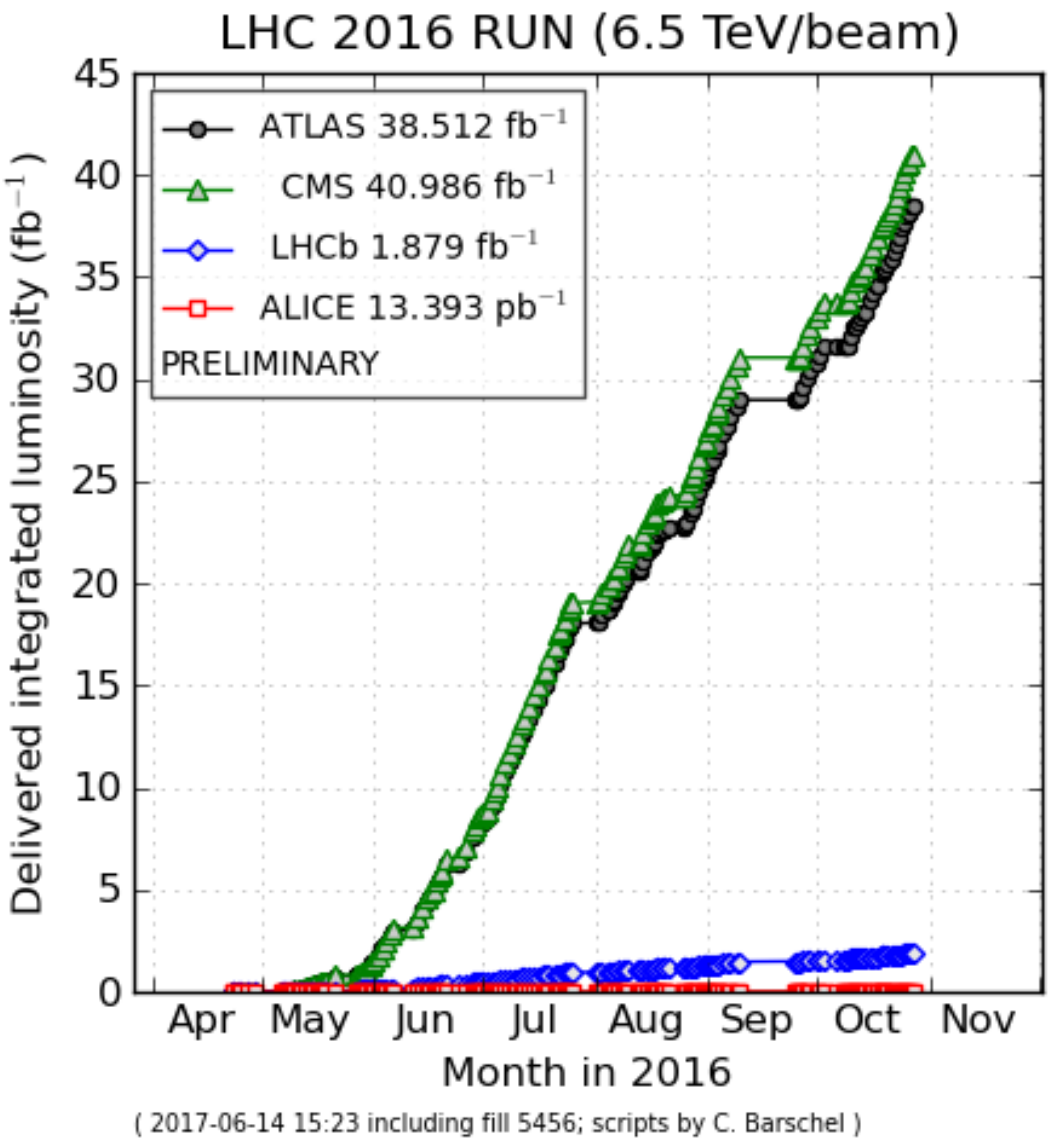


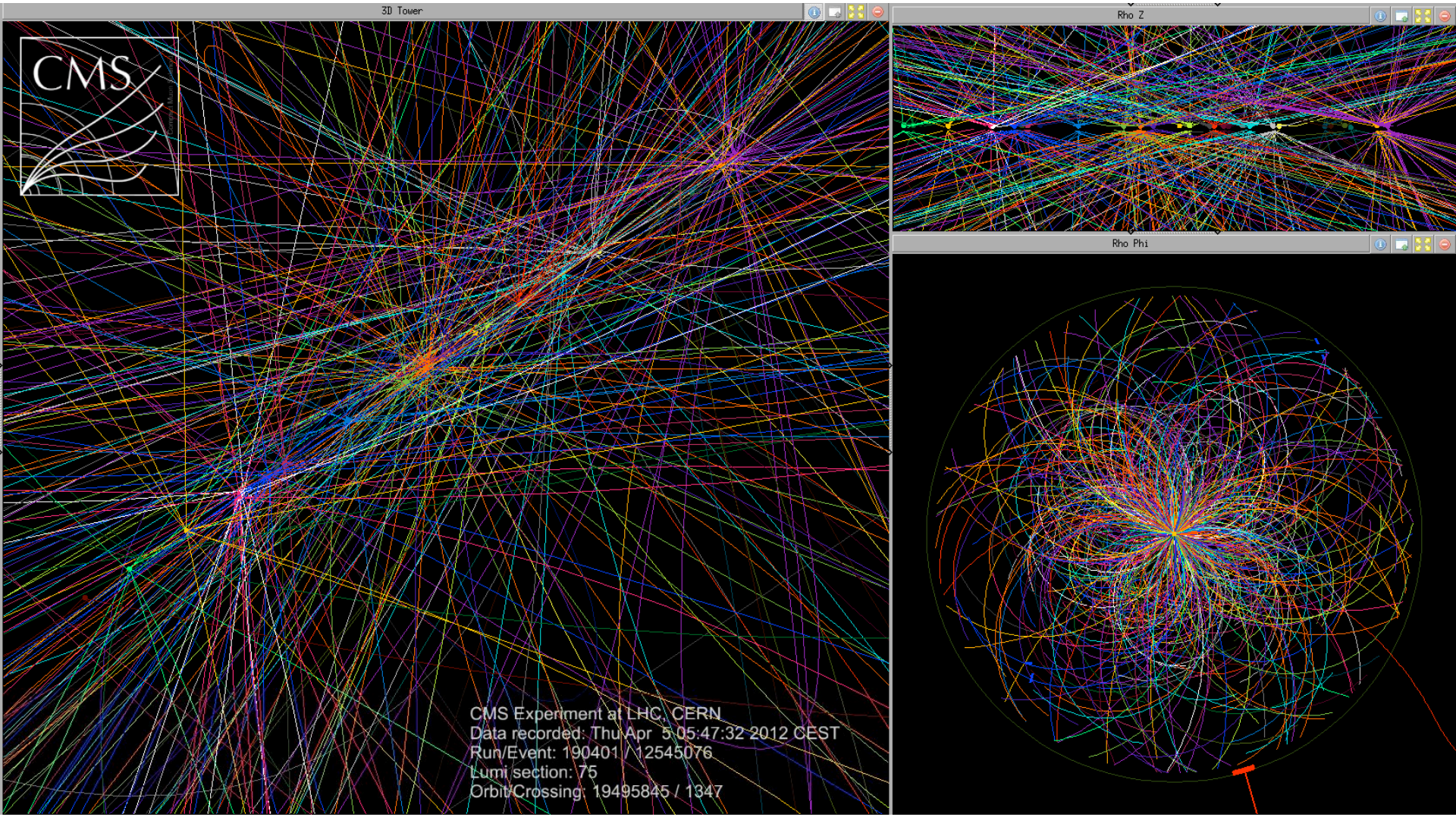
Relative beam sizes around IP1 (Atlas) in collision

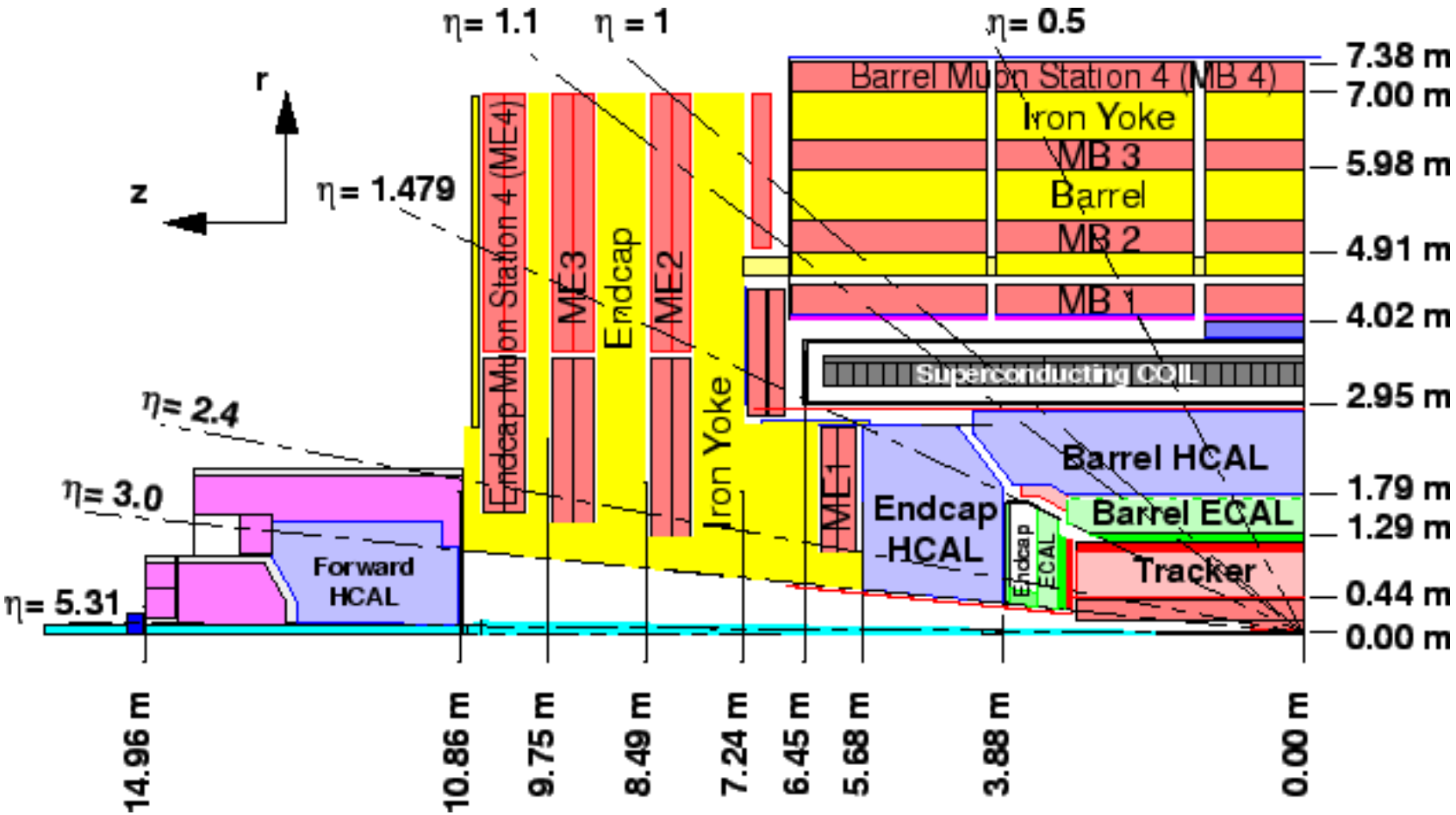
[Let's play with it!]


LHC 2016 RUN (6.5 TeV/beam)
ATLAS
CMS
LHCb
ALICE
PRELIMINARY
Peak luminosity (10^{32} cm^{-2}s^{-1})
0
20
40
60
80
100
120
140
160
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Month in 2016
(2017-06-14 15:23 including fill 5456; scripts by C. Barschel)

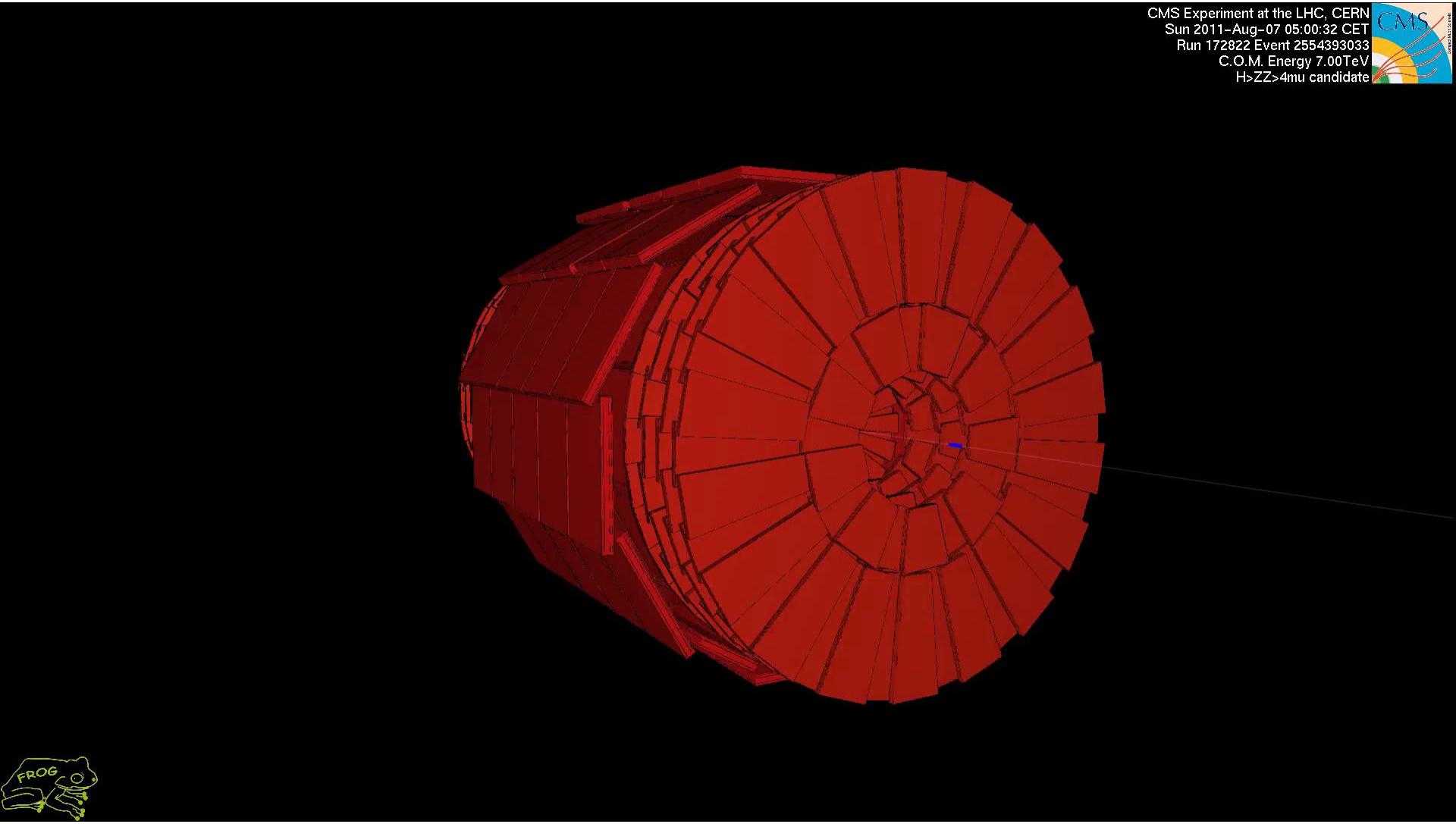

Time in stable beams (2016)
Stable beams time per day (hours)
Integrated time in stable beams (hours)
0
5
10
15
20
25
0
500
1000
1500
2000
2500
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Month in 2016
(2017-06-14 15:07 including fill 5575; scripts by C. Barschel)


LHC 2016 RUN (6.5 TeV/beam)
ATLAS 38.512 fb^{-1}
CMS 40.986 fb^{-1}
LHCb 1.879 fb^{-1}
ALICE 13.393 pb^{-1}
PRELIMINARY
Delivered integrated luminosity (fb^{-1})
0
5
10
15
20
25
30
35
40
45
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Month in 2016
(2017-06-14 15:23 including fill 5456; scripts by C. Barschel)

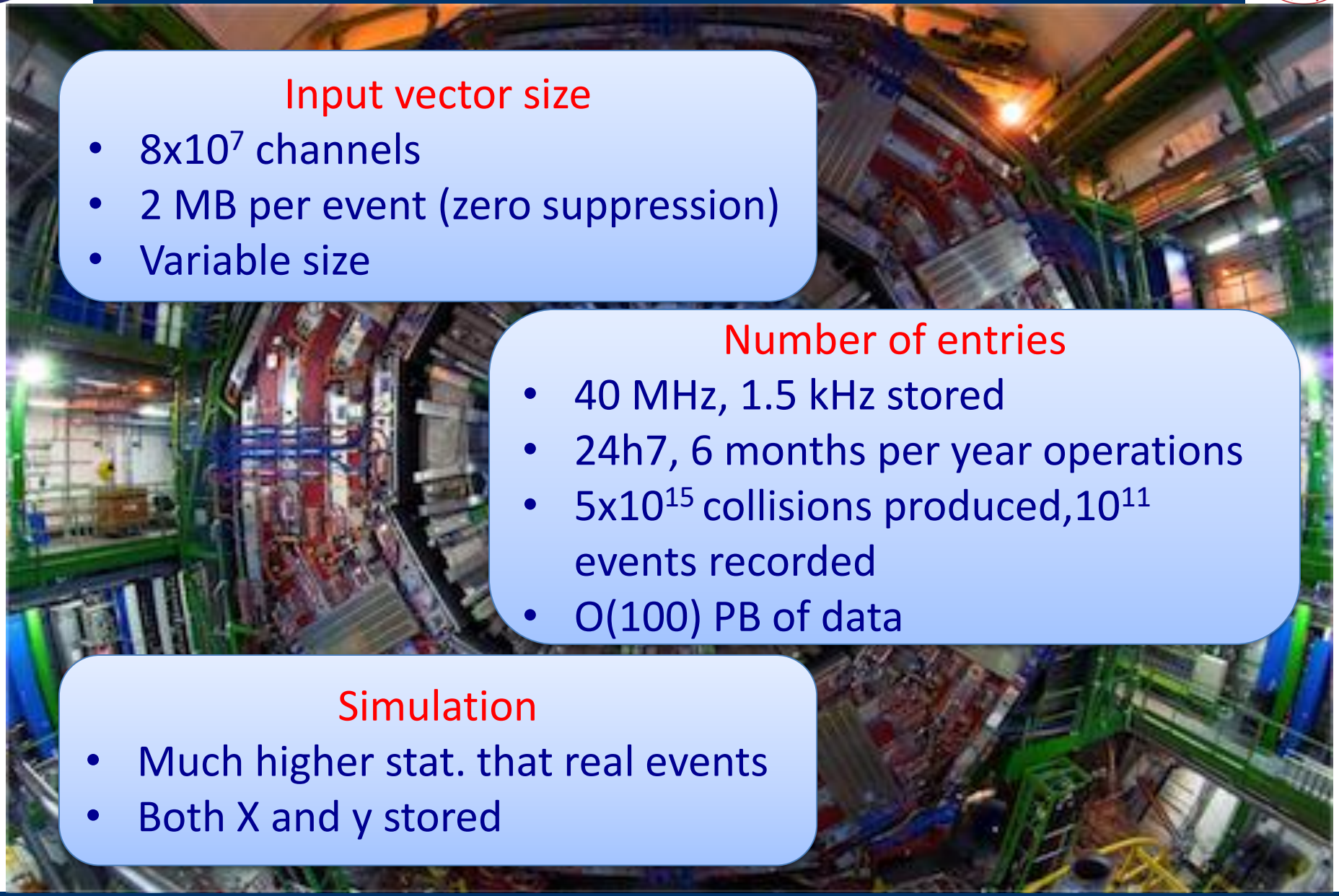

3D Tower
Rho Z
Rho Phi
CMS
CMS Experiment at LHC, CERN
Data recorded: Thu Apr 5 05:47:32 2012 CEST
Run/Event: 190401 / 12545076
Lumi section: 75
Orbit/Crossing: 19495845 / 1347


η= 1.1
η = 1
η= 0.5
r
z
η= 1.479
Barrel Muon Station 4 (MB 4)
Iron Yoke
MB 3
Barrel
MB 2
MB 1
Superconducting COIL
Endcap Muon Station 4 (ME4)
ME3
Endcap
ME2
Iron Yoke
ME1
Barrel HCAL
Endcap HCAL
Barrel ECAL
Endcap ECAL
Tracker
η= 2.4
η= 3.0
η= 5.31
Forward HCAL
7.38 m
7.00 m
5.98 m
4.91 m
4.02 m
2.95 m
1.79 m
1.29 m
0.44 m
0.00 m
14.96 m
10.86 m
9.75 m
8.49 m
7.24 m
6.45 m
5.68 m
3.88 m
0.00 m

$E^2 = m^2c^4 + p^2c^2$


CMS Experiment at the LHC, CERN
Sun 2011-Aug-07 05:00:32 CET
Run 172822 Event 2554393033
C.O.M. Energy 7.00TeV
H>ZZ>4mu candidate
CMS

The digital cameras



Input vector size

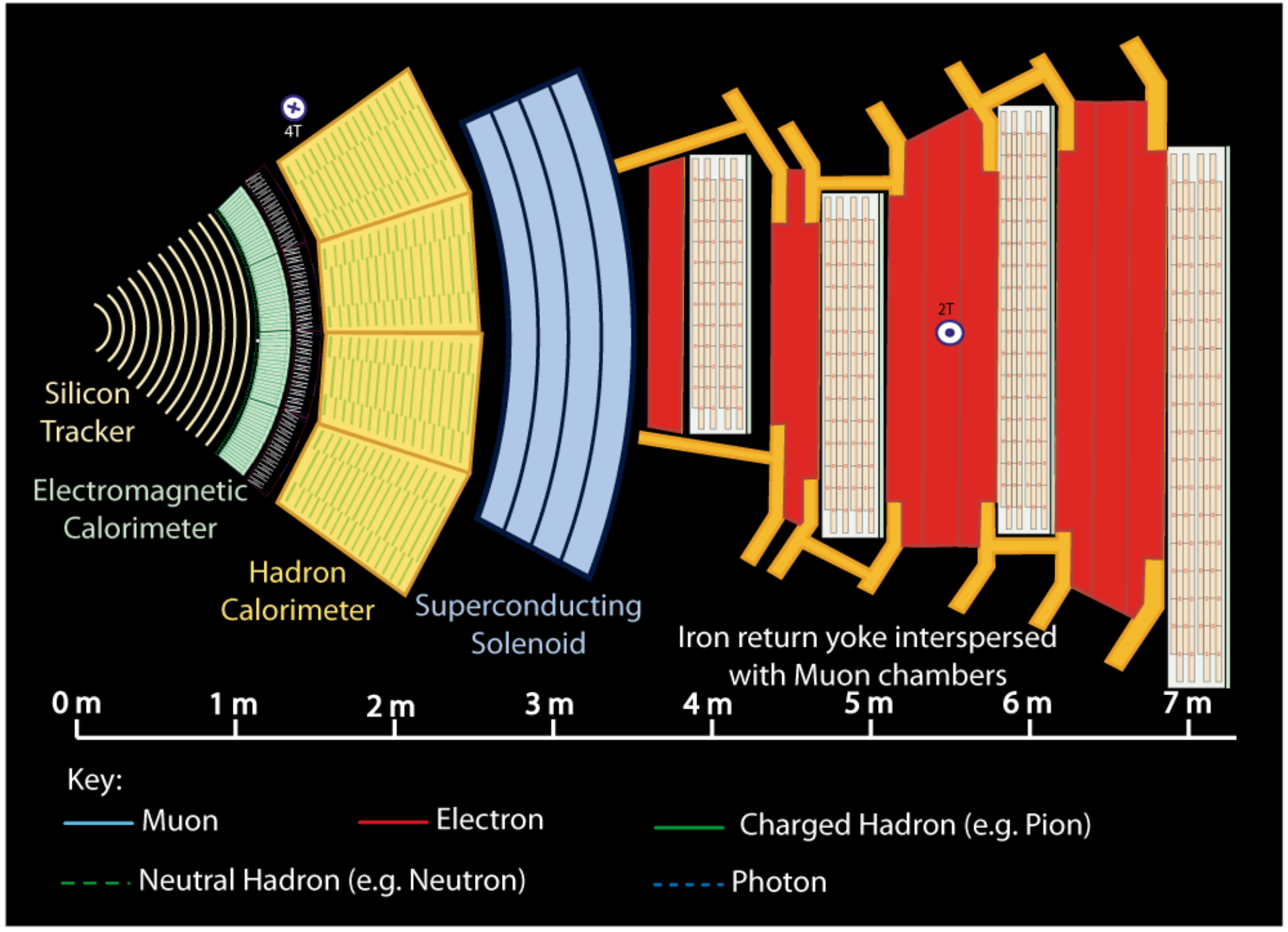
- $8x10^7$ channels
- 2 MB per event (zero suppression)
- Variable size

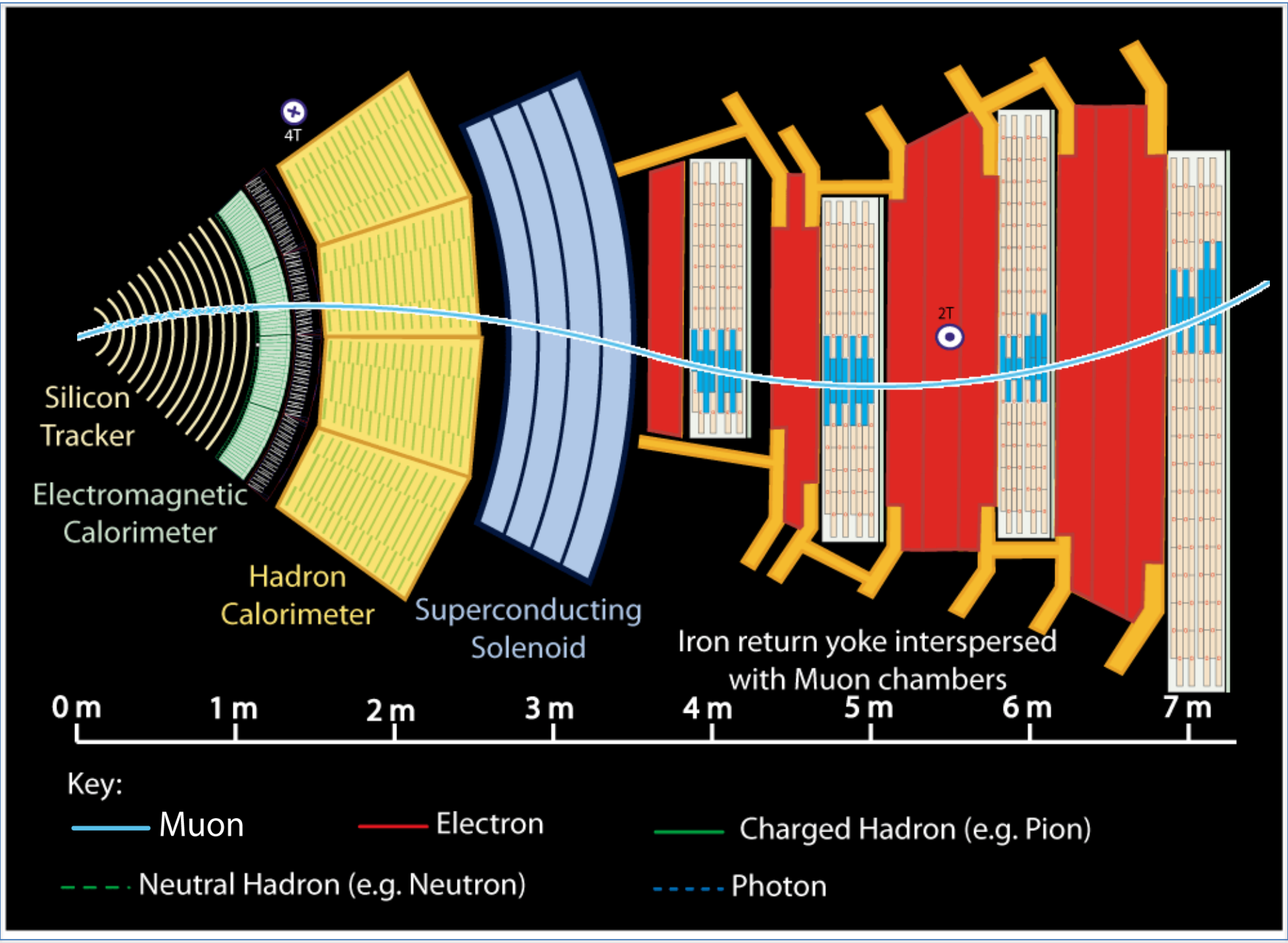
Number of entries

- 40 MHz, 1.5 kHz stored
- 24h7, 6 months per year operations
- $5x10^{15}$ collisions produced, 10^{11} events recorded
- O(100) PB of data

Simulation

- Much higher stat. that real events
- Both X and y stored


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


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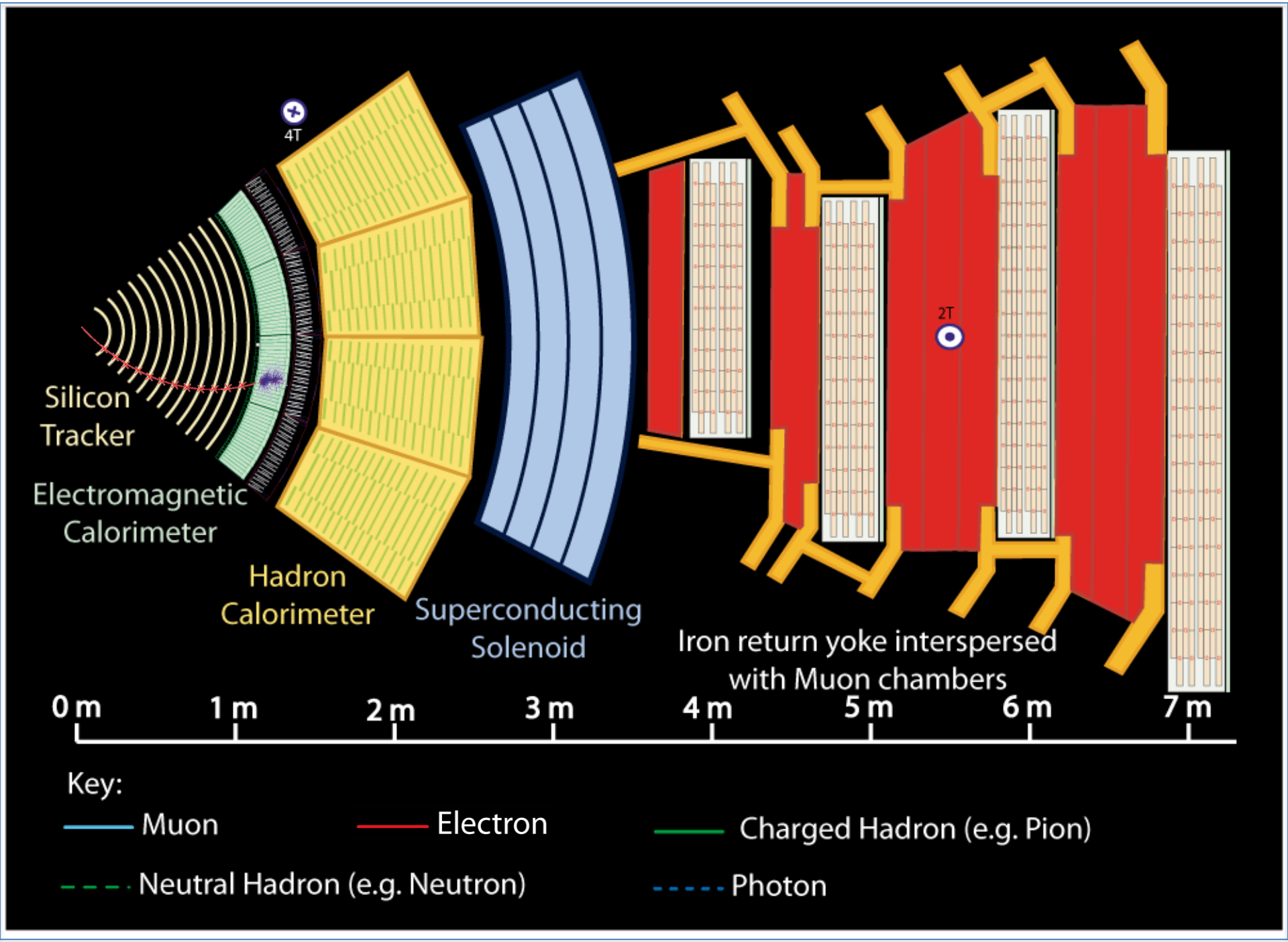
4T
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Silicon Tracker
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1 m
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Key:
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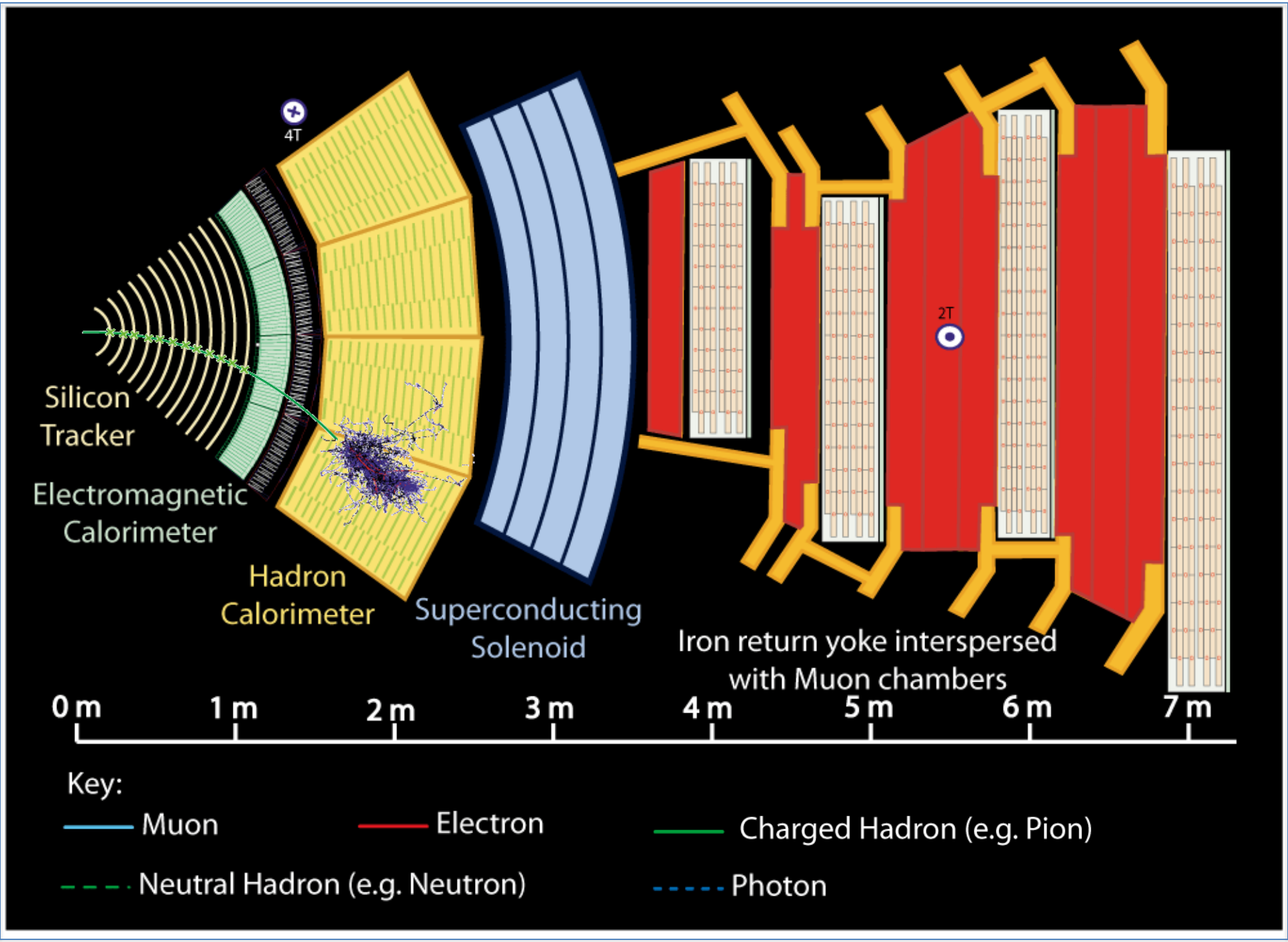
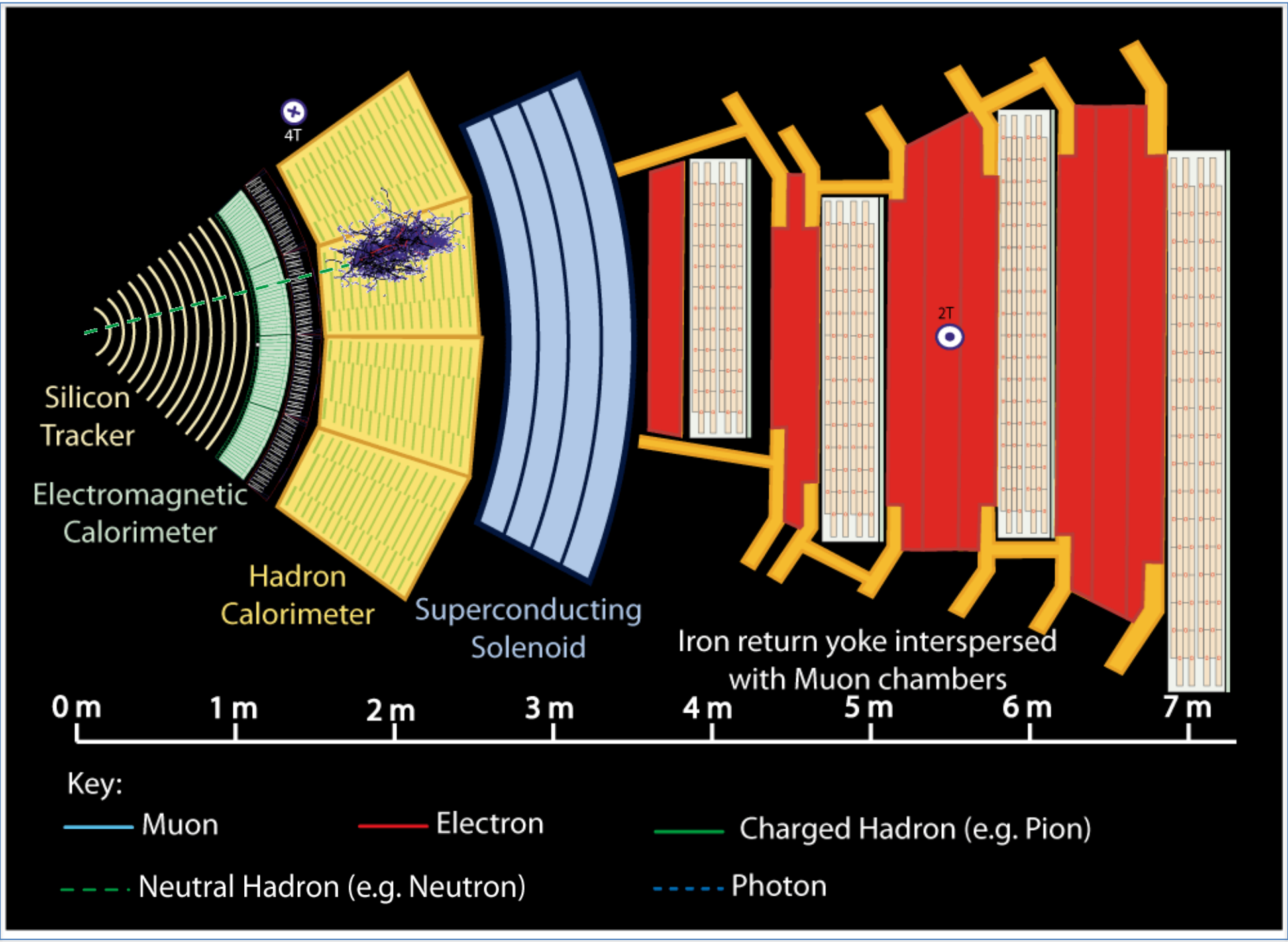
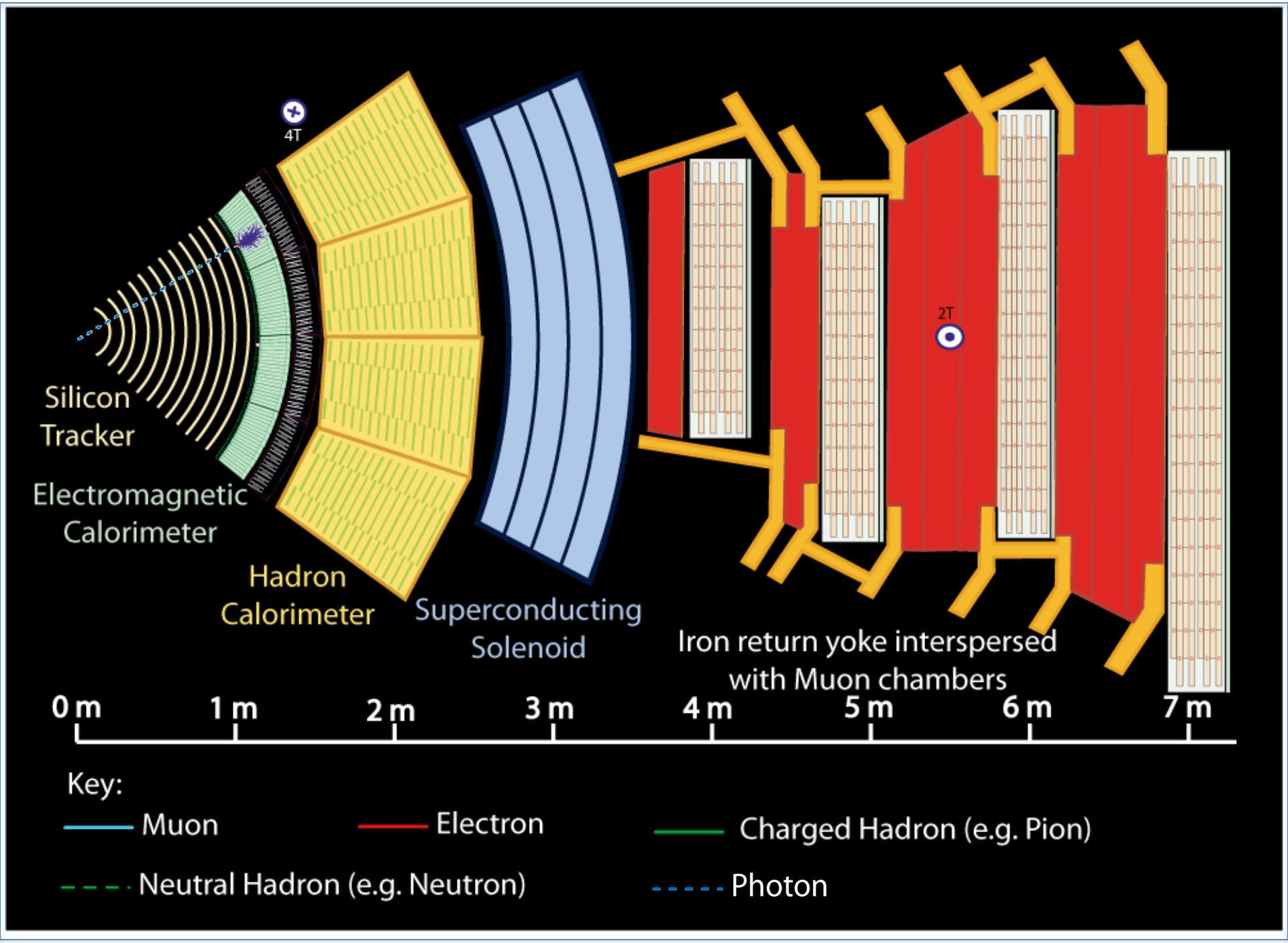
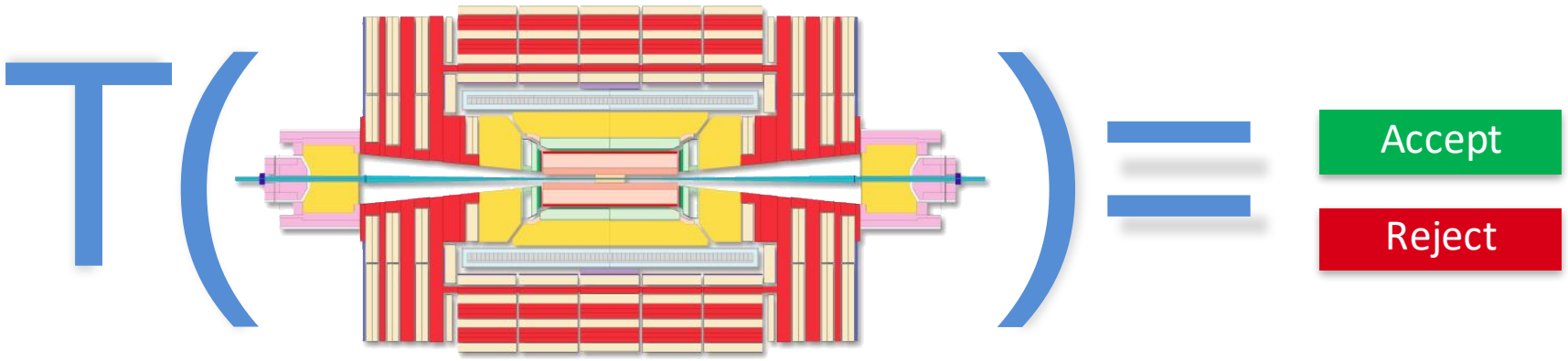
Charged Hadron (e.g. Pion)
Neutral Hadron (e.g. Neutron)
Photon


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


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


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


T
Accept
Reject

BACKUP