CERN Large Hadron Collider

Ref: www.cern.ch

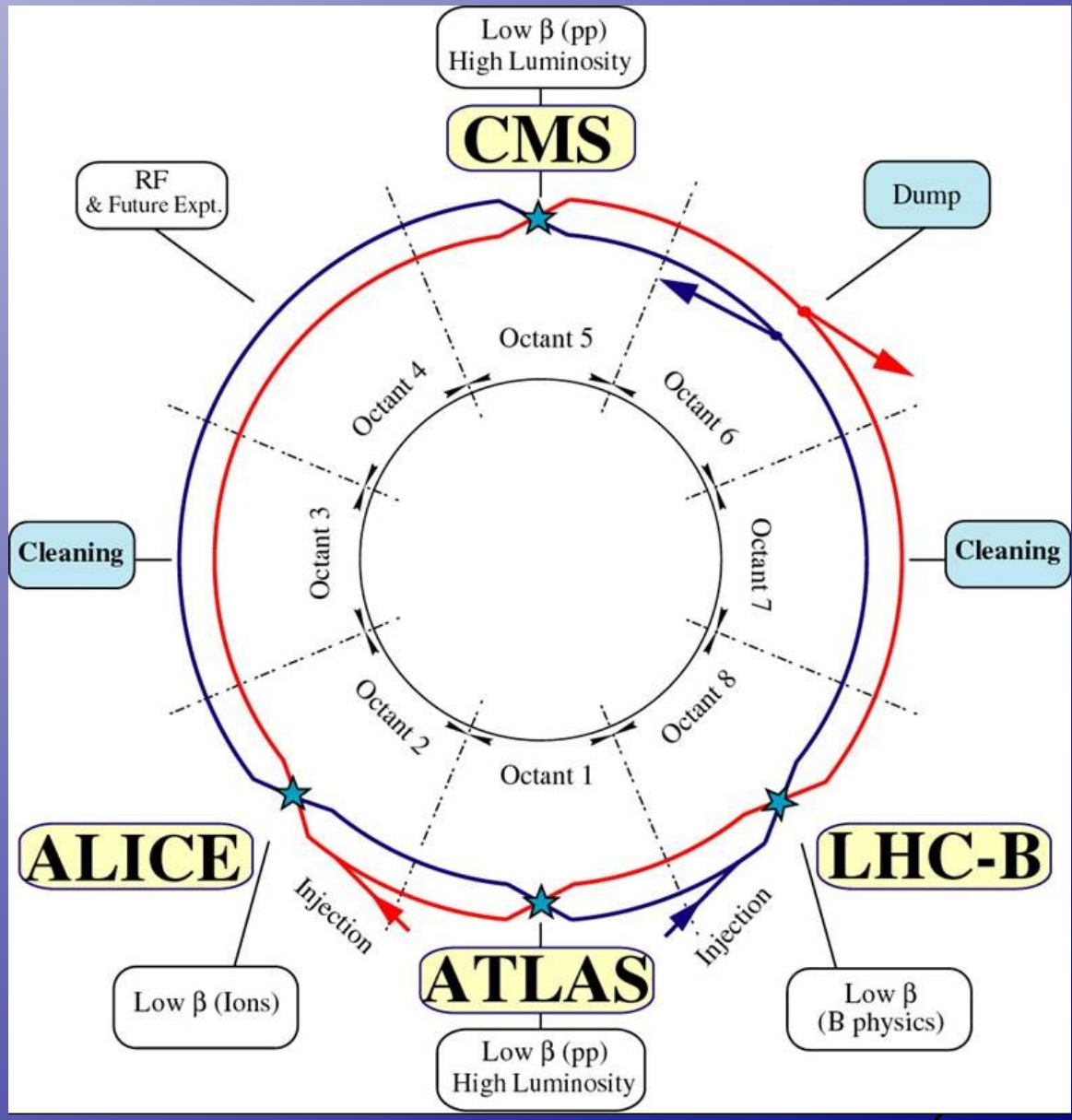
What did the LHC do?

Energies & Modes:

Proton-Proton
2011 3.5+3.5 TeV
2012 4+4 TeV
1380 on 1380 bunches
1368 on 1262 bunches

Lead-208 (82+)-Lead
2011 1.38+1.38 TeV/u
2012 none (?)
358 on 358 bunches

Proton-Lead
2013 4.0+1.577TeV/u
338 on 338 bunches



What “will” the LHC do?

Restart in early 2015.

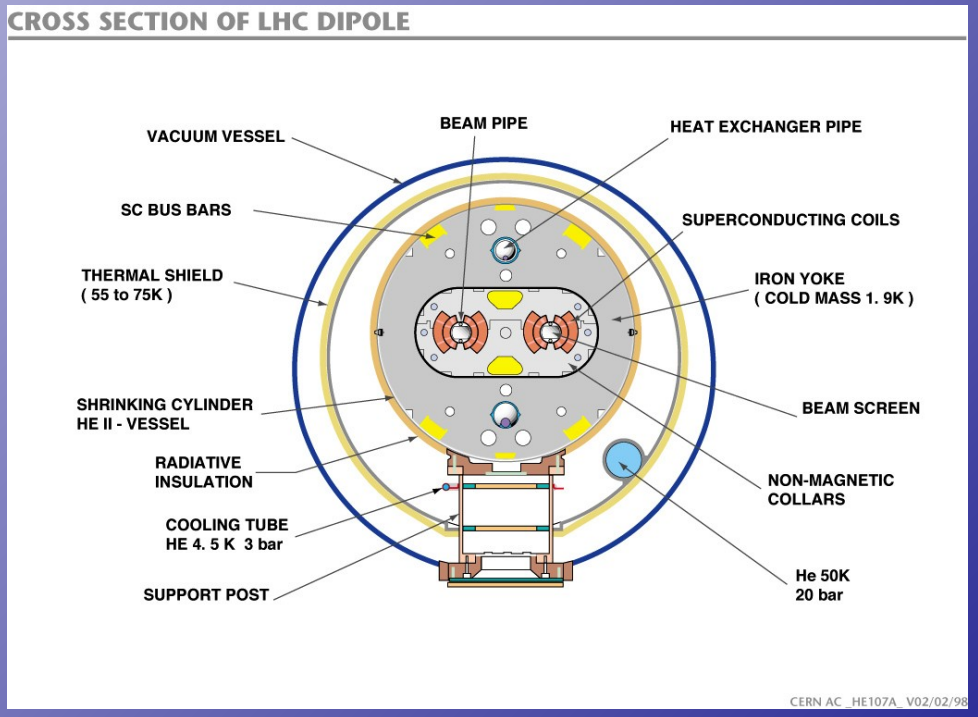
Beam energy increase from 4 TeV to 6.5 TeV. So 13 TeV in proton-proton collisions.

Consider shortening the spacing from 50 ns to 25. Can decrease the bunch population for same luminosity.

Long term:

HL-LHC, high luminosity
LHeC, electron beam

LHC Magnets for your students...



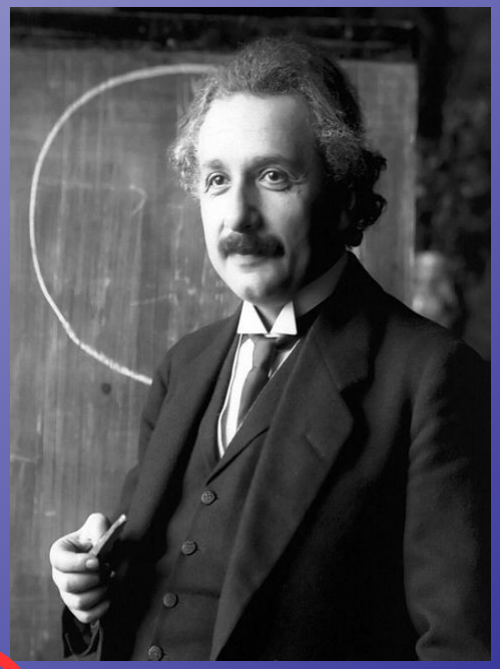
Usual dipole magnet (normally conducting), has a lot of iron and current in its wire coils.

Magnetic field limited to all the magnetic domains in the iron aligned, about 1.8 Tesla.

Superconducting dipole magnet has no iron and a lot of current current in its wire coils.

Magnetic field limited by how well you make your supercond. wire and how much current it can carry.

More Magnets...



A little Special Relativity...

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$E = \gamma M c^2$$

Just like the textbooks, almost...

$$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$$

And the centripetal force for circular motion,

$$F = \frac{\gamma M v^2}{r}$$

All together

$$\frac{\gamma M v^2}{r} = qvB$$

In Accelerator physics it is usually written in the form

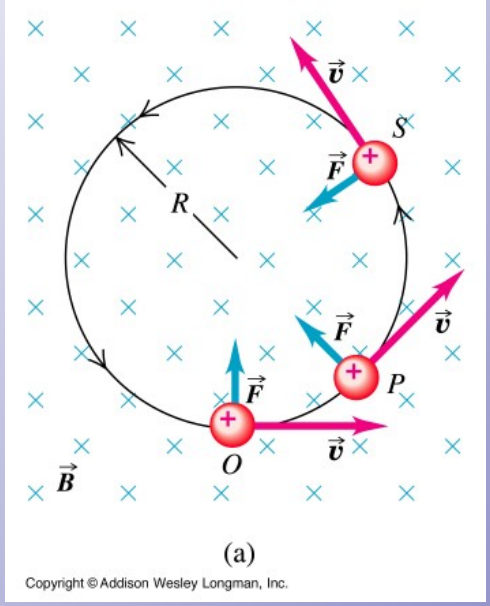
$$B r = \frac{\gamma M v}{q}$$

More Magnets...

$$E = \gamma M c^2$$

What we are doing:

$$B r = \frac{\gamma M v}{q}$$



Some numbers for the LHC:
1232 Dipole Magnets, 15m Length, 27km circumference
7 TeV Design, 11850 Amps, 8.33 Tesla
4 TeV actual, 6770 Amps, 4.8 Tesla

The radius of curvature of the orbit at 4.8 Tesla AND 4 TeV is...

$$r = 2660\,\mathrm{m}$$

The radius of curvature of the orbit at 8.33 Tesla AND 7 TeV is...

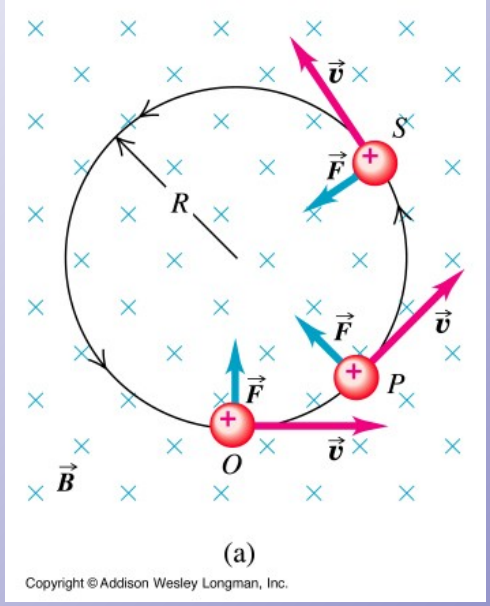
Any guesses?

More Magnets...

$$E = \gamma M c^2$$

What we are doing:

$$B r = \frac{\gamma M v}{q}$$



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The radius of curvature of the orbit at 4.8 Tesla AND 4 TeV is... $r = 2660\,\mathrm{m}$

The radius of curvature of the orbit at 8.33 Tesla AND 7 Tev is... $r = 2680\,\mathrm{m}$

The LHC ring does not change here. Its size is fixed, r is fixed.

Links

https://lhc-statistics.web.cern.ch/LHC-Statistics/#

http://www.lhcportal.com/

http://home.web.cern.ch/topics/large-hadron-collider

http://cds.cern.ch/record/1165534/files/CERN-Brochure-2009-003-Eng.pdf

http://home.web.cern.ch/

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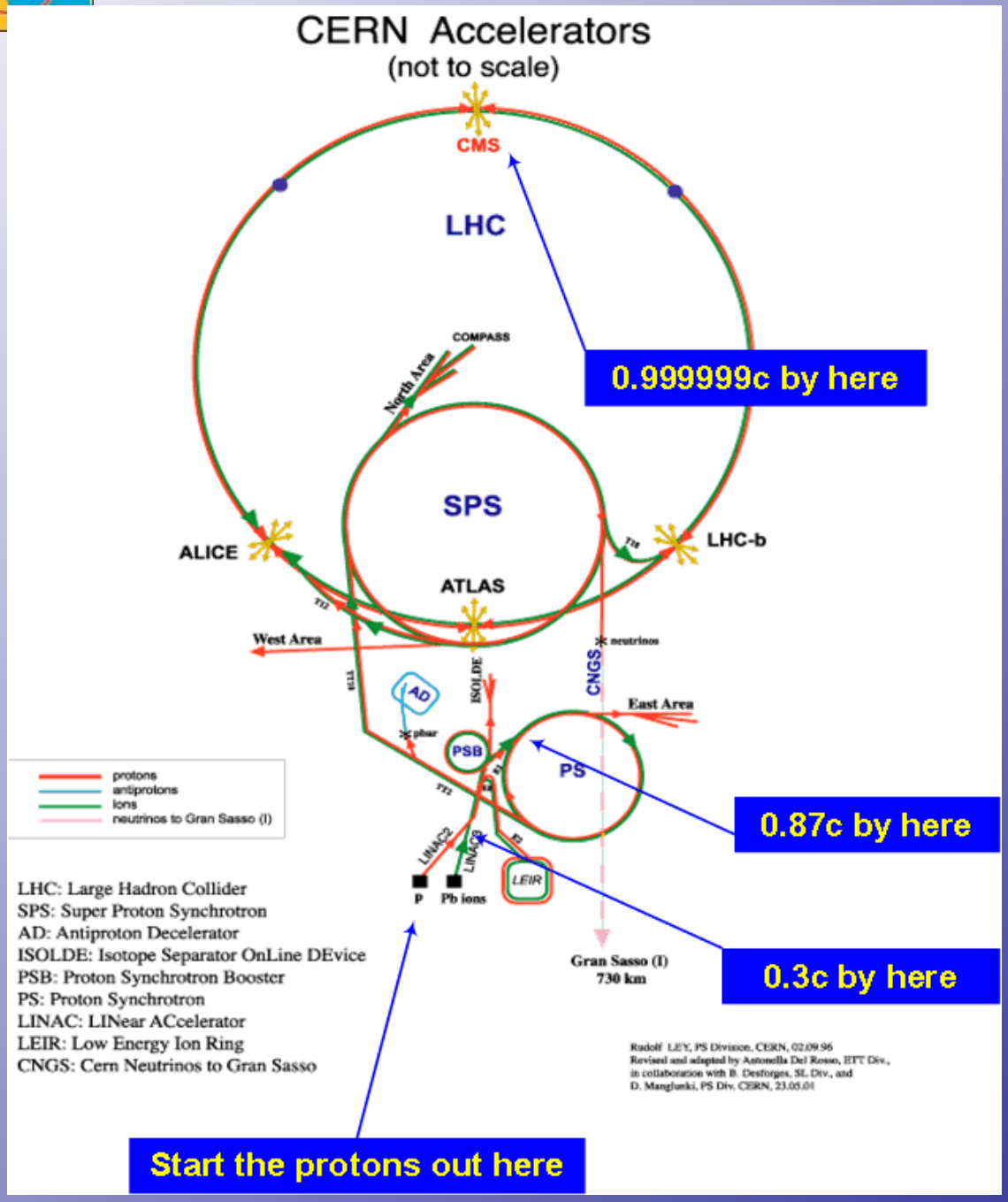
Large Hadron Collider (LHC)



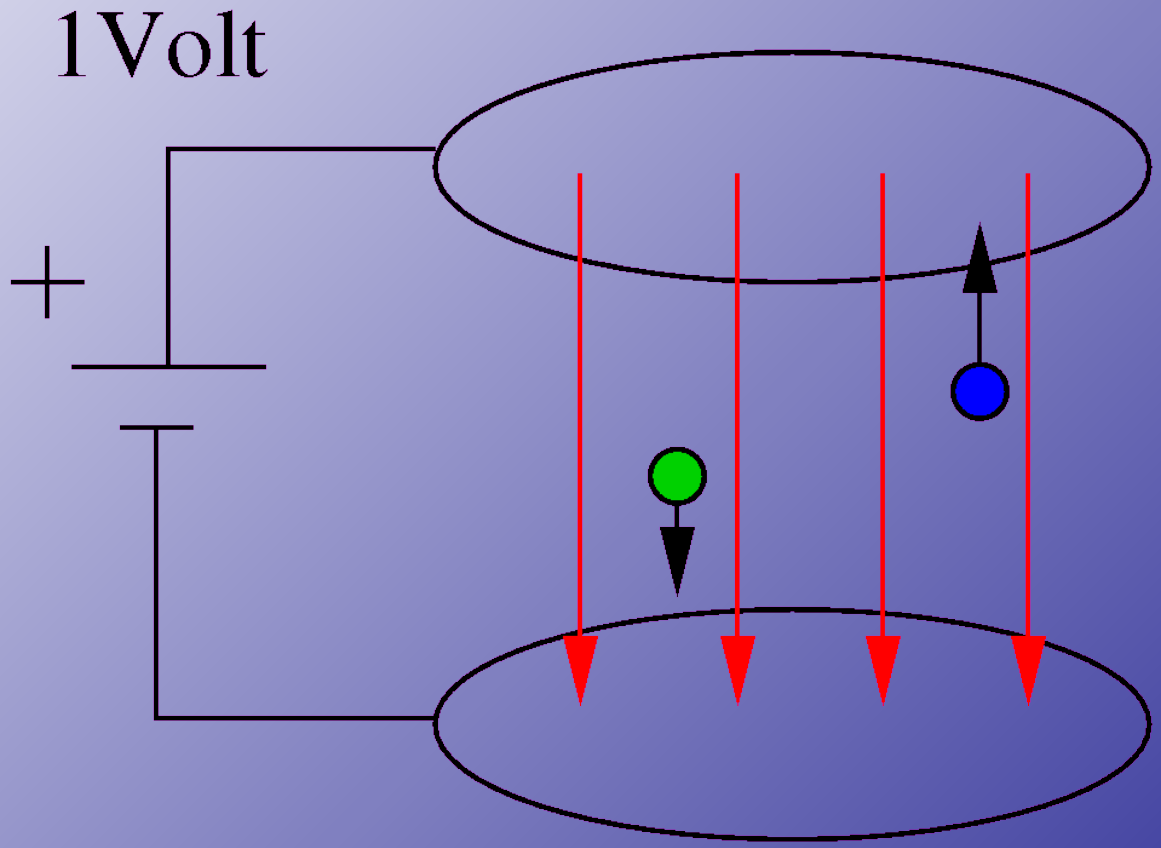
Circumference 27 km
Two beams opposite directions
proton on proton 8 TeV
1380 on 1380 bunches

Energies:

Linac	50 MeV
PSB	1.4 GeV
PS	28 GeV
SPS	450 GeV
LHC	3.5 TeV
	4.0 TeV
(soon)	6.5 TeV

Ref: Introduction to Accelerators, Elena Wildner, CERN

Units?



Proton, heavy, +e

Electron, light, –e