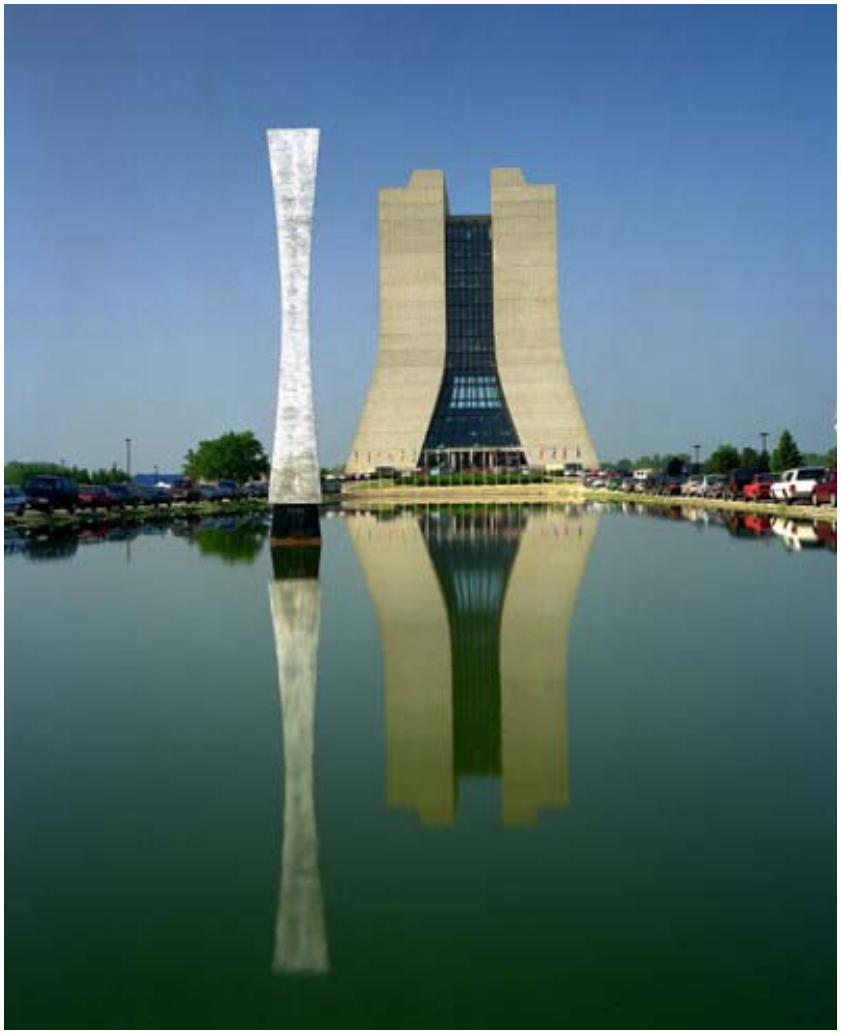
Magnets in High Energy Physics



Welcome to Fermilab

Ask-A-Scientist

1 May 2011

Fermilab

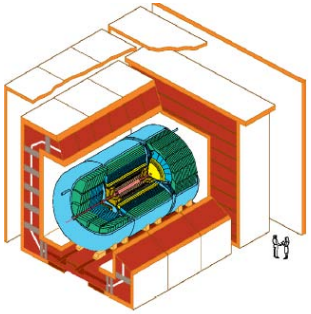
Fermi Research Alliance

Office of Science / U.S. Department of Energy

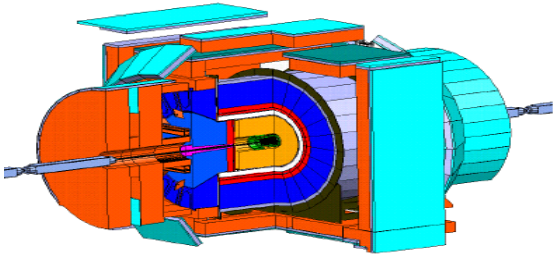
Fermilab: High energy particle physics research

What is the universe made of?

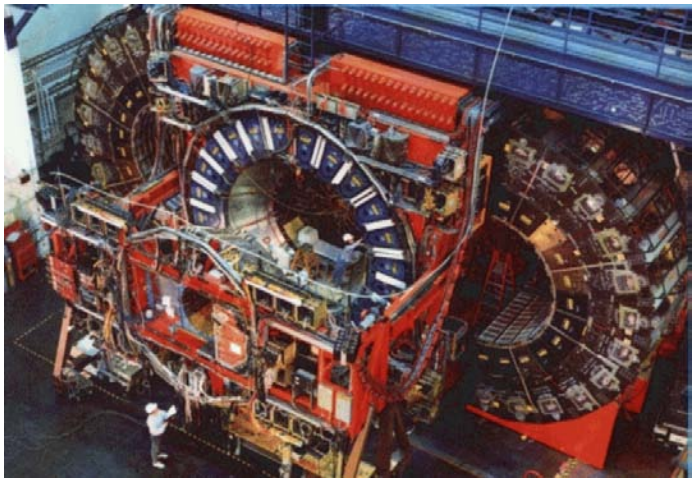
How do the pieces interact?

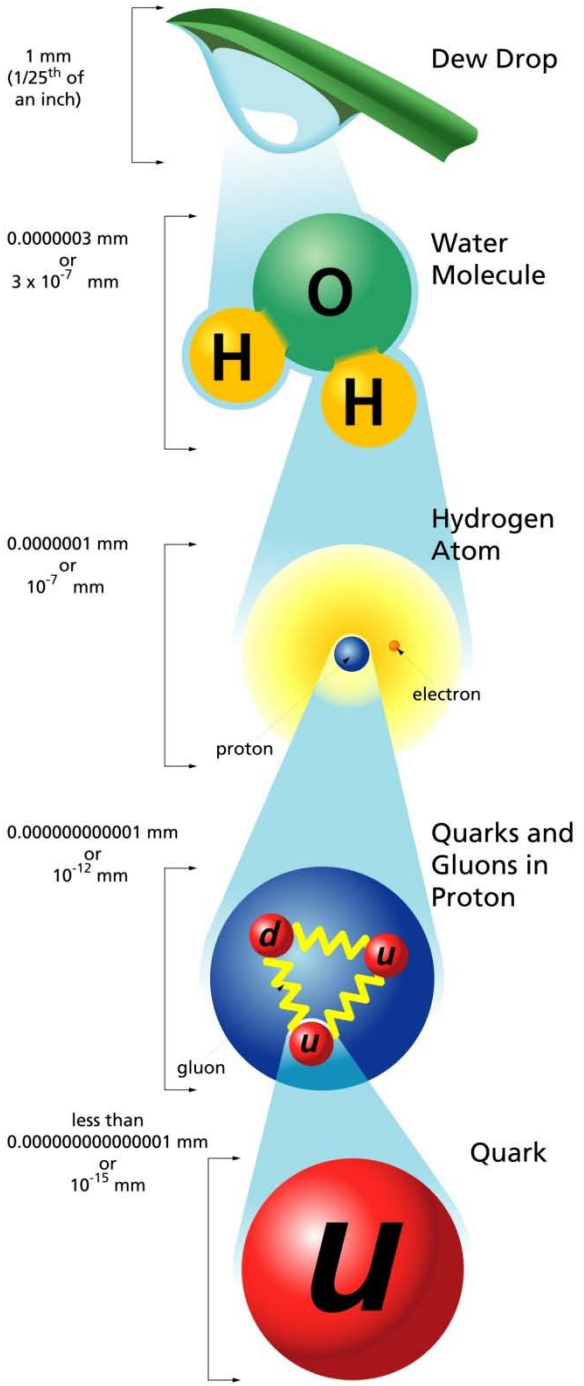


DØ Detector



CDF Detector



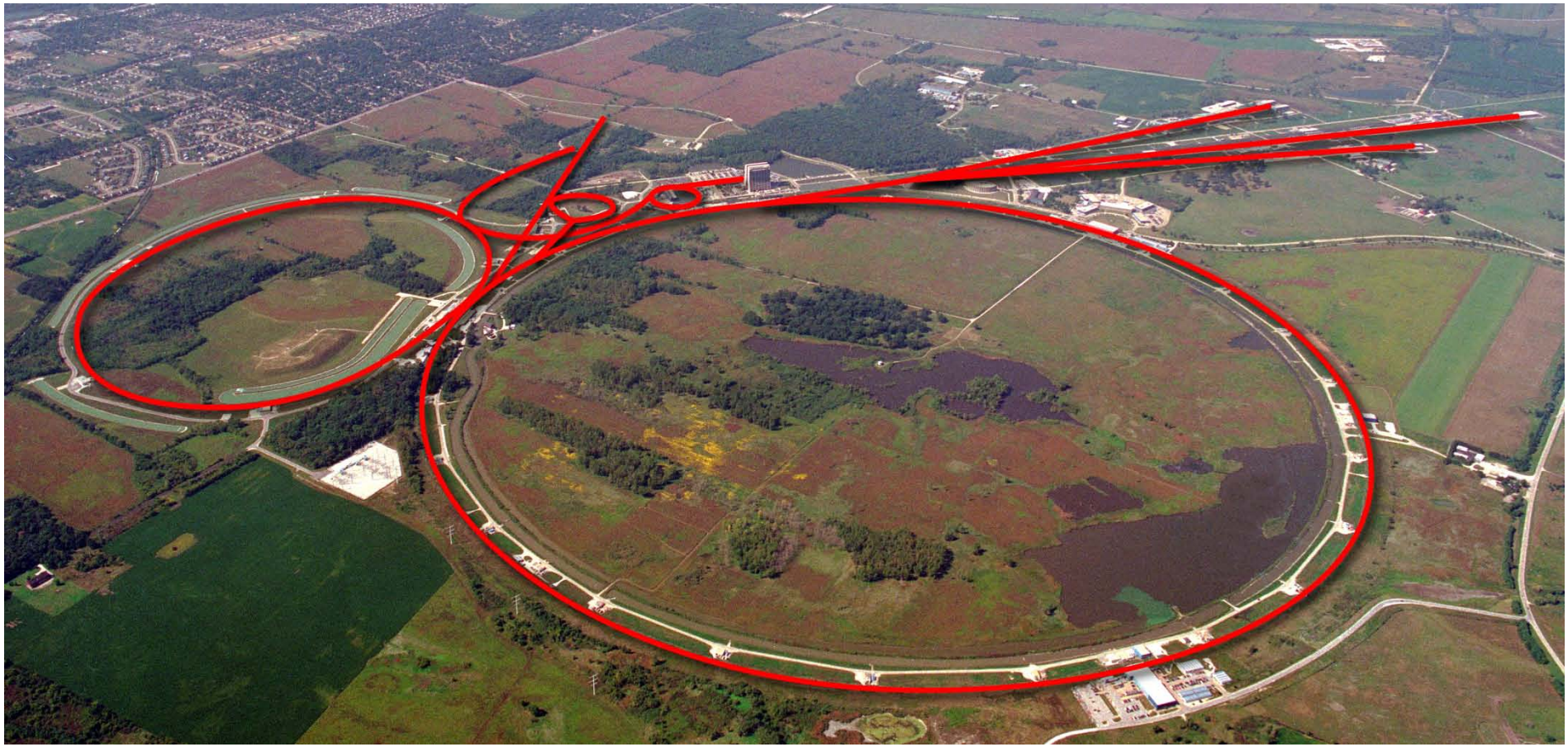


Where do new particles come from?

$$E = mc^2$$

$$m = E/c^2$$

Fermilab Accelerator Complex



Cockcroft-Walton 750 KeV

velocity = 0

LINAC 400 MeV

0.71 c

Booster 8 GeV

0.994 c

Main Injector 150 GeV

0.994 c

Antiproton "Bottle"

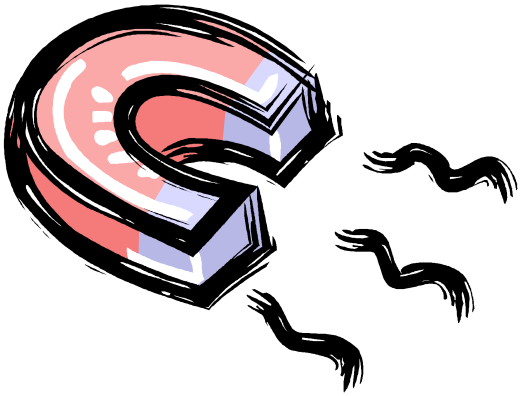
@ 8 GeV

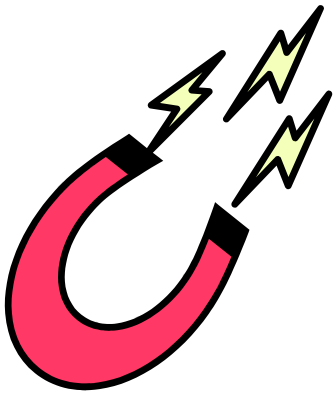
Tevatron 1000 GeV = 1 TeV

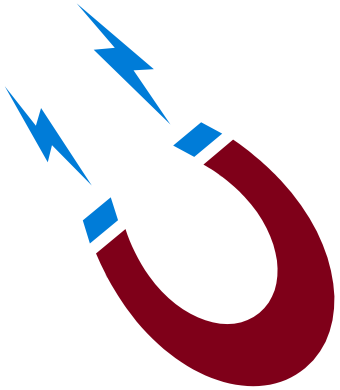
0.99998 c

0.9999995 c

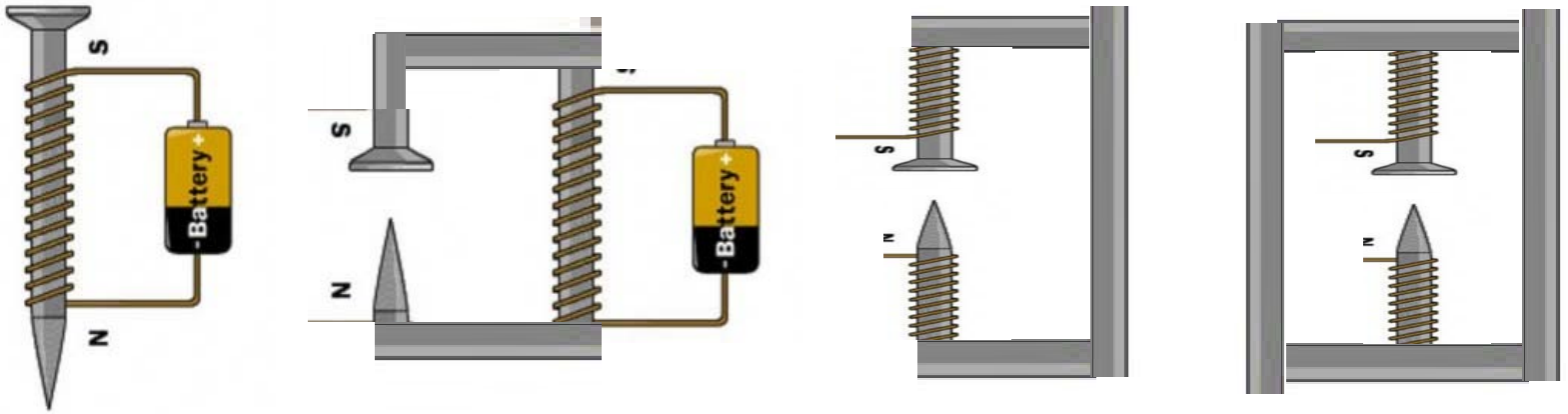
What is a Magnet?

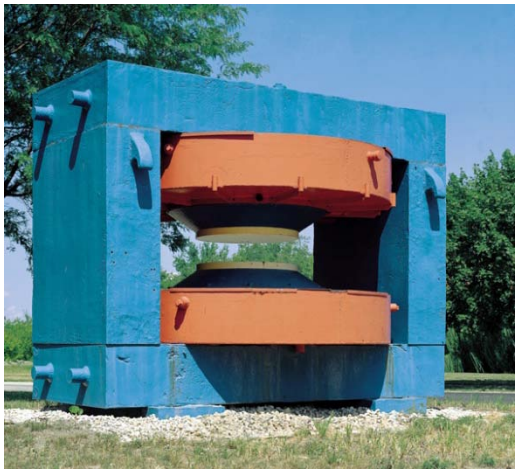






How to make a magnet





Basic uses of magnetic fields

- Measure particles

  Experiments use magnets to analyze events

- Control particles

  Accelerators use magnets to steer beams

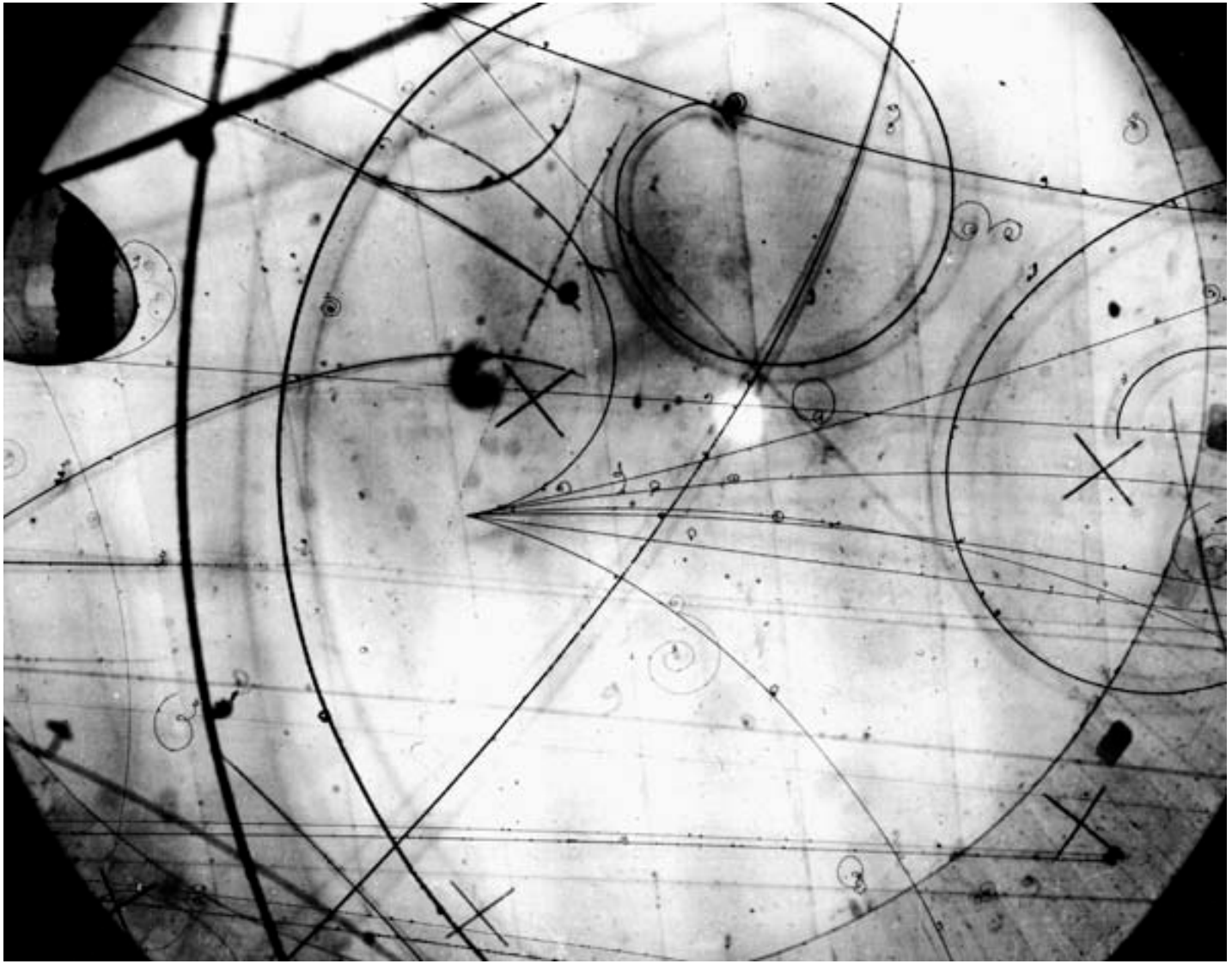
A charged particle moving in a magnetic field feels a force

The force is sideways

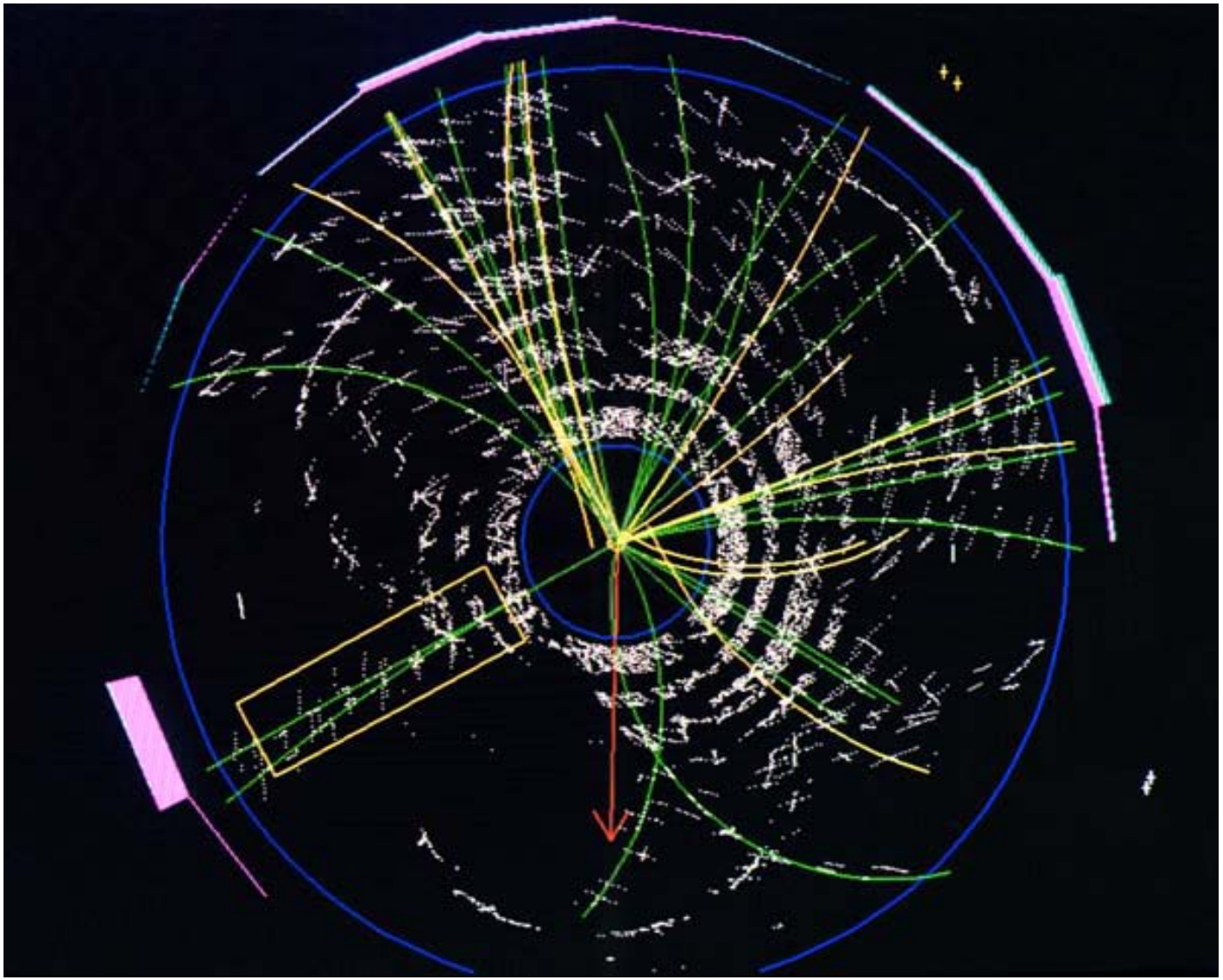
$\Rightarrow$ The particle bends in a circle

- Strong magnetic field, small circle
- High momentum particle, big circle

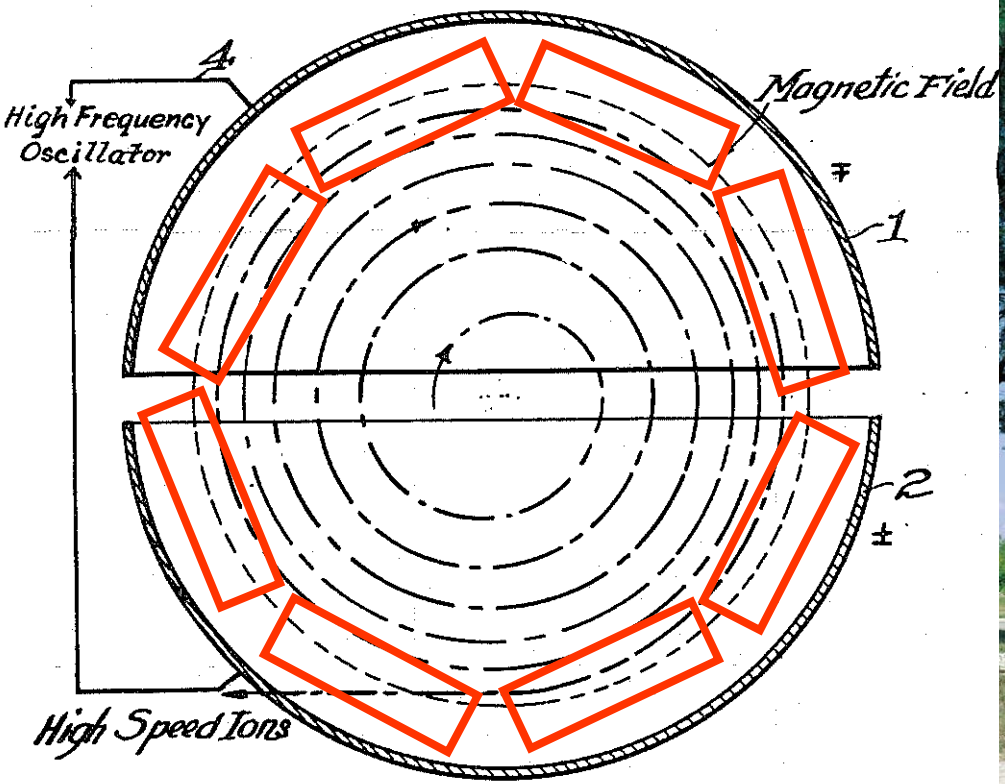
Bubble chamber tracks

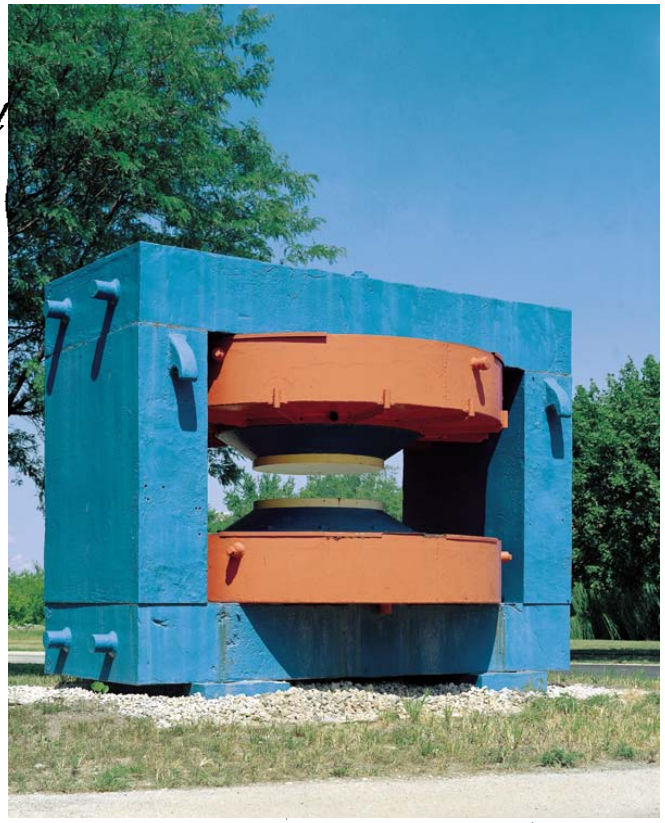


Collider detector tracks (CDF)



Cyclotron

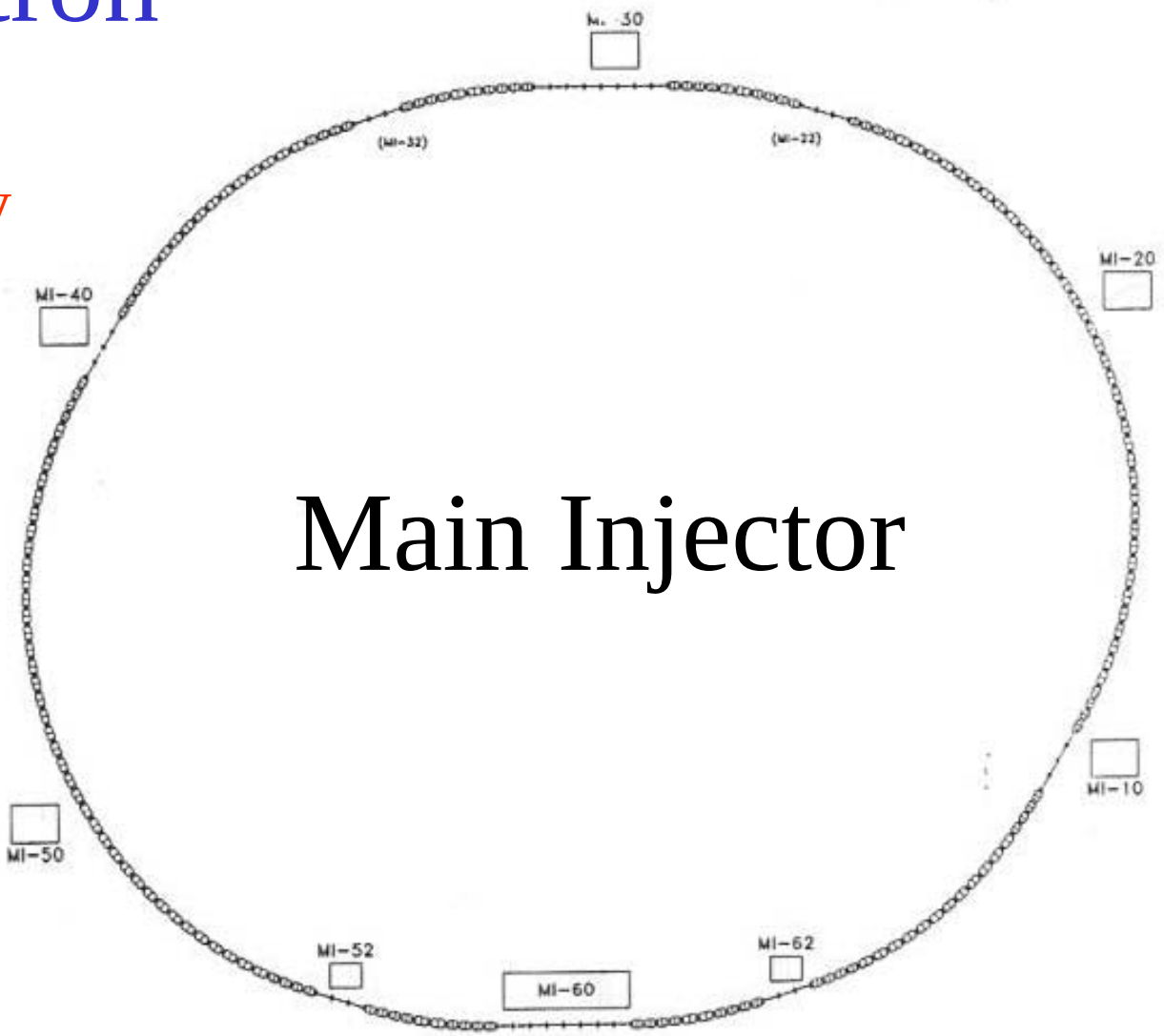




Ernest Lawrence

Synchrotron

String together many long skinny magnets in a big ring.

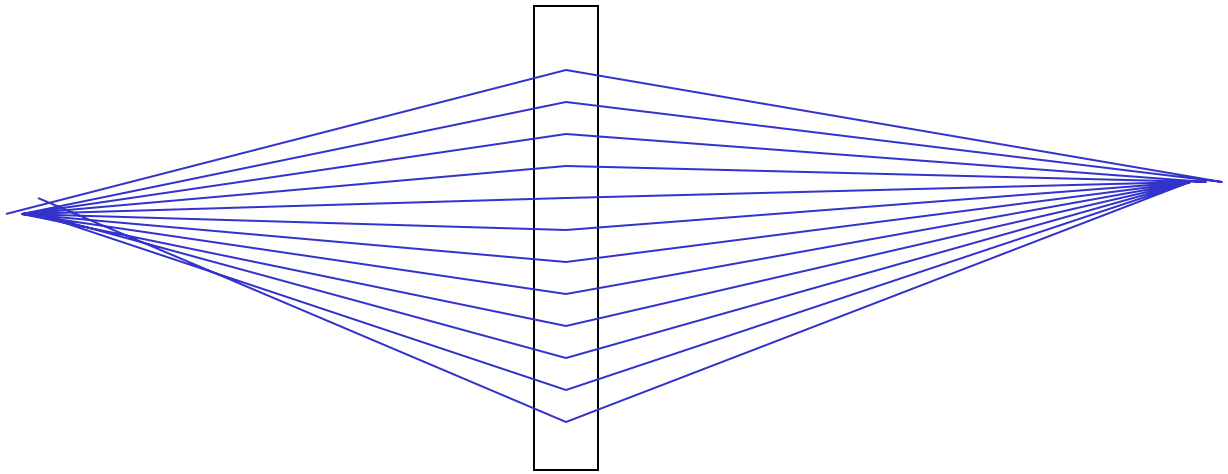


A Synchrotron Magnet

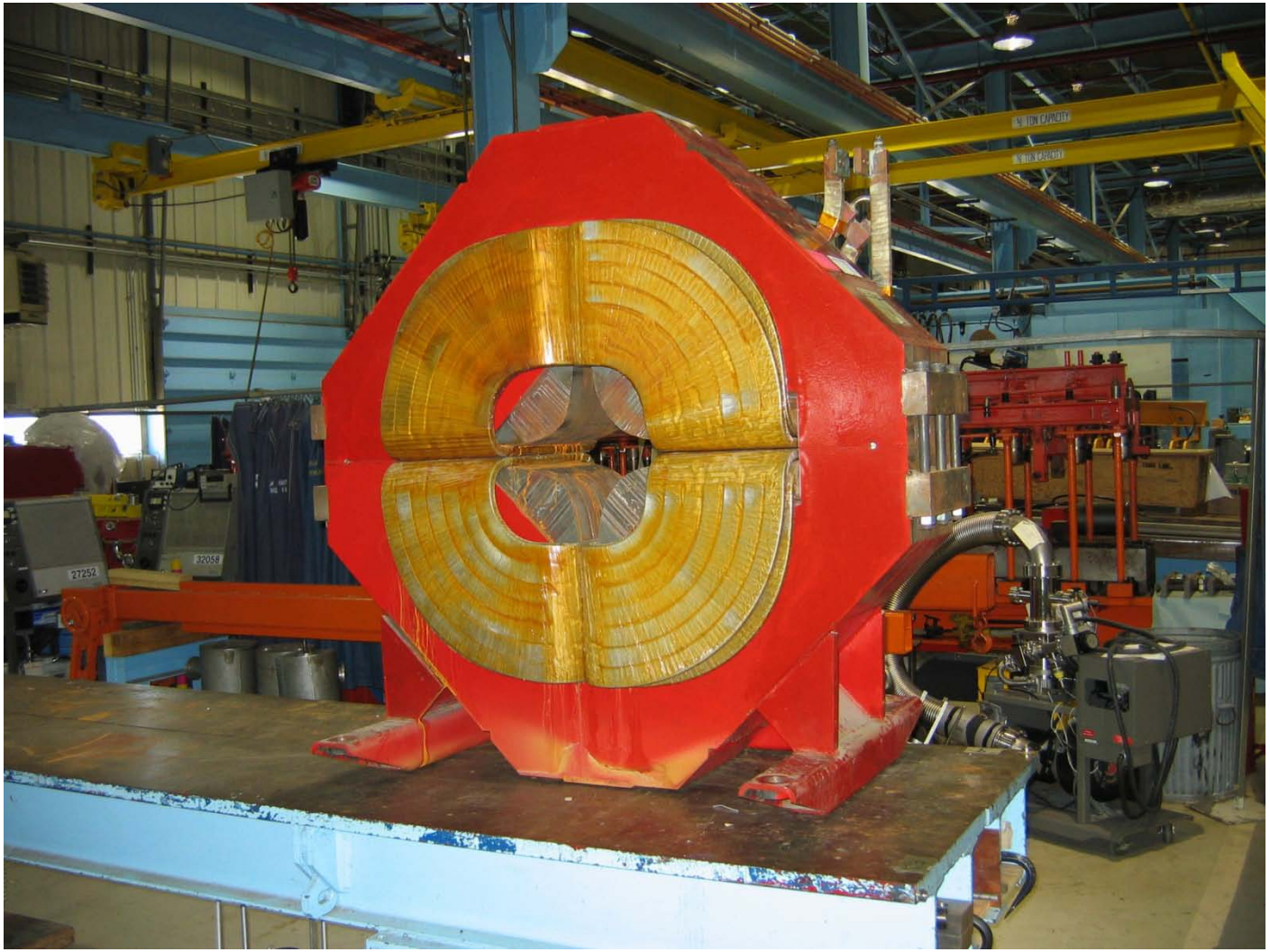
Magnets in Main Injector

Focusing magnets

- Beam tends to spread out
- Must constantly focus the beam
- Special magnets do the job



Focusing magnet



Magnet work at Fermilab

- Design, build, refurbish, repair, and test magnets for current operations
- Designed and built special, high-strength, large aperture quadrupole magnets for LHC
- Develop even higher strength magnets for future projects

Even stronger magnets

- $M = E/c^2$
- Making higher mass particles requires more energy
- Higher energy requires stronger magnets
- Stronger magnets require more electric current
- More electric current requires superconducting wire

More to do at Fermilab

- www.fnal.gov
- Lederman Science Center
- Buffalo, prairie viewing
- Bicycling, walking
- Concerts, dancing
- Lectures, seminars
- Educational programs