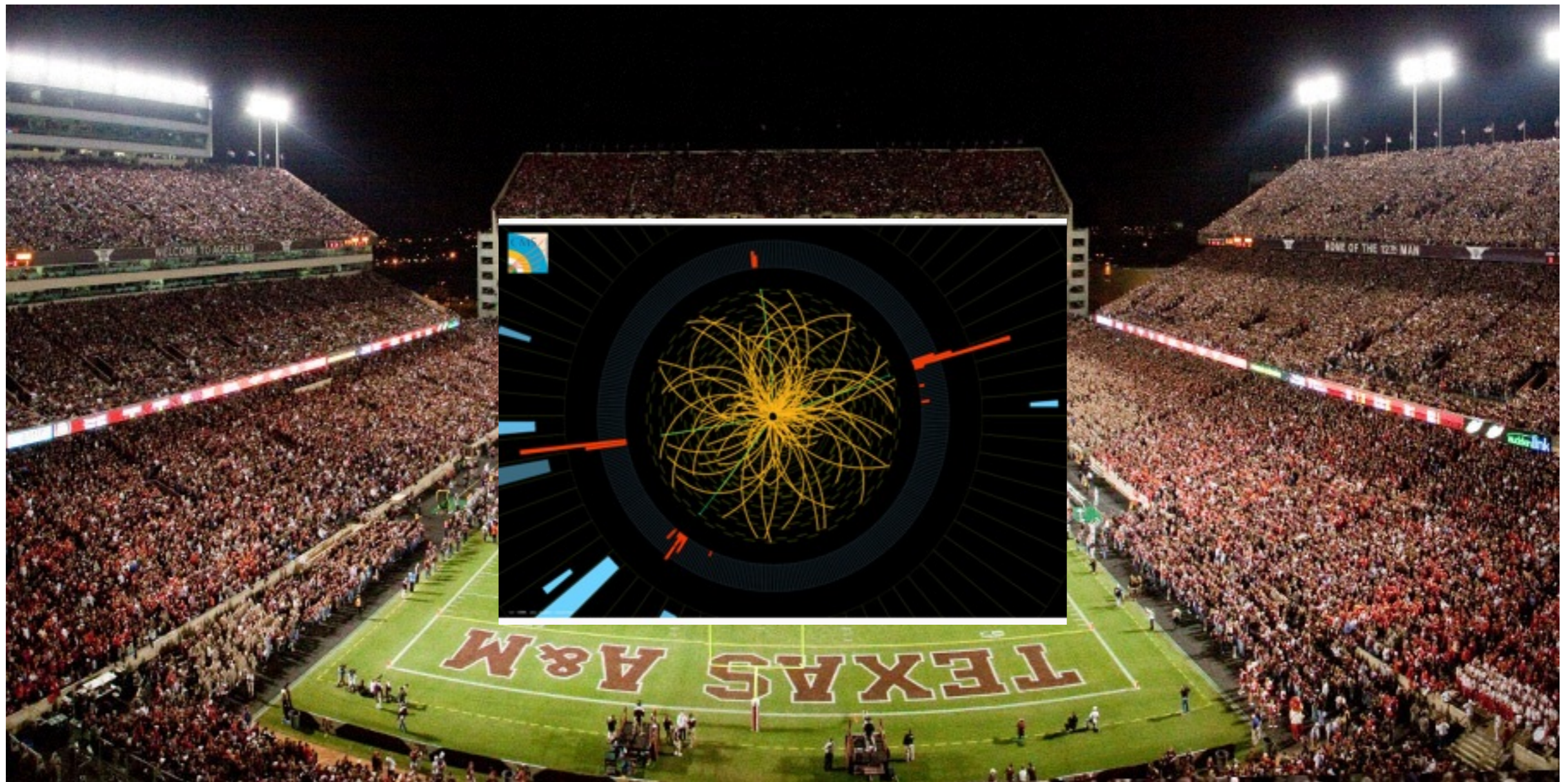


CMS Virtual Visit: Texas A&M University



Post-doctoral fellow:
Dr. Rishi Patel

MYSTICAL! BIG SCIENCE MACHINE

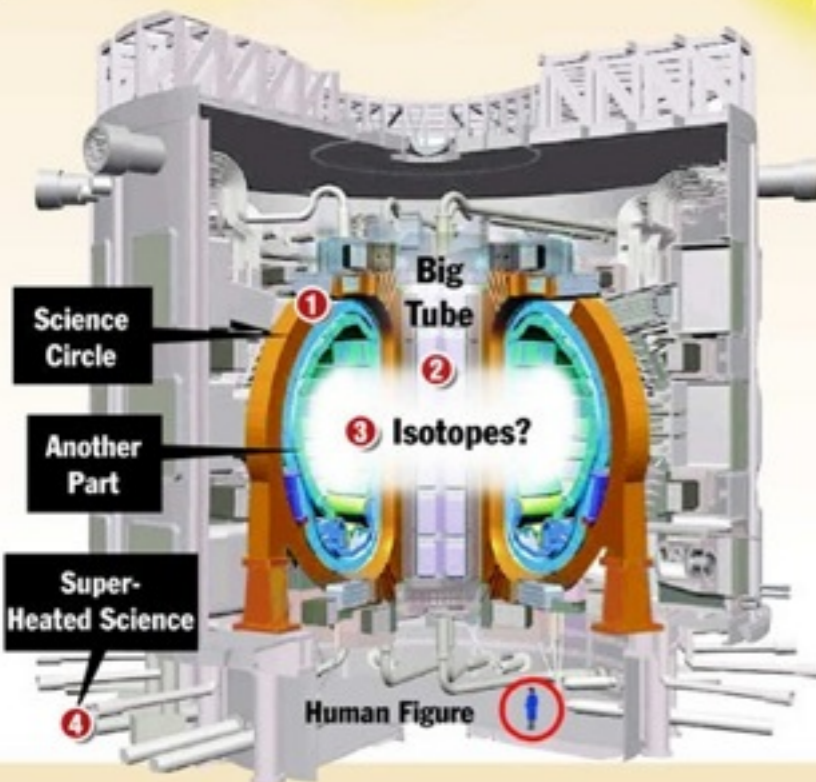
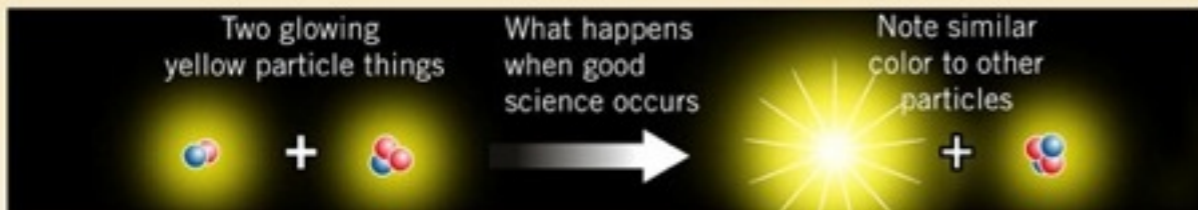
Not so Mystical:

Everyone has a mini household particle accelerator : TV

Onion Science Thursday

Giant Machine Creates Science

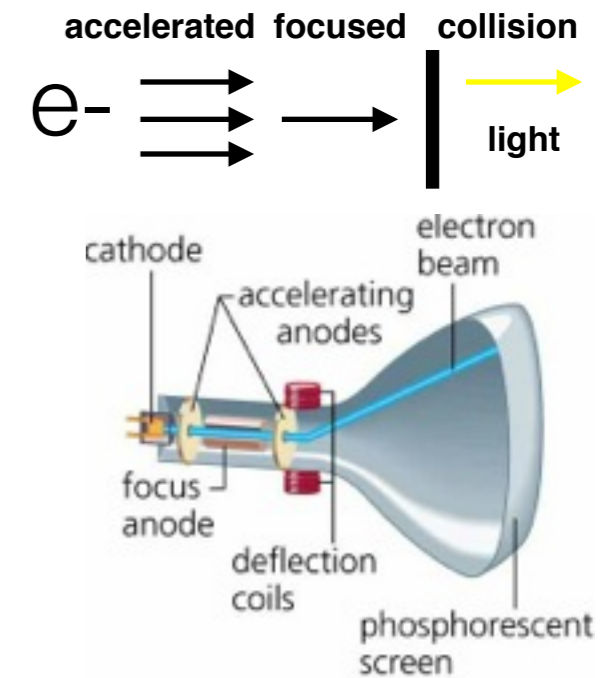
The Onion explains the inner workings of the complex, expensive science thing.



A Science Machine

The expensive device will test and execute more science than ever before.

- 1 Scientists make sure machine's On/Off button switched to On
- 2 Parts of the machine begin to move, at first slowly, and then rapidly
- 3 A lot of science begins to generate
- 4 Many things light up and sounds of thunder happen
- 5 Science ends



A bigger version:

The Alps

collide protons

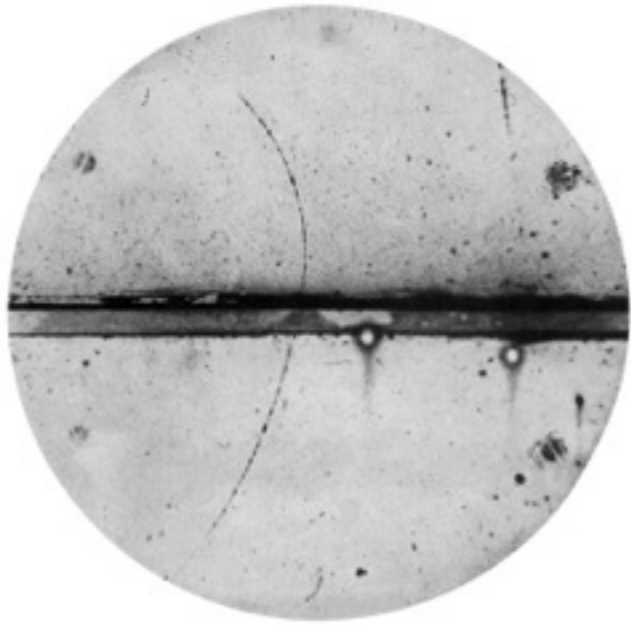


Large Hadron Collider

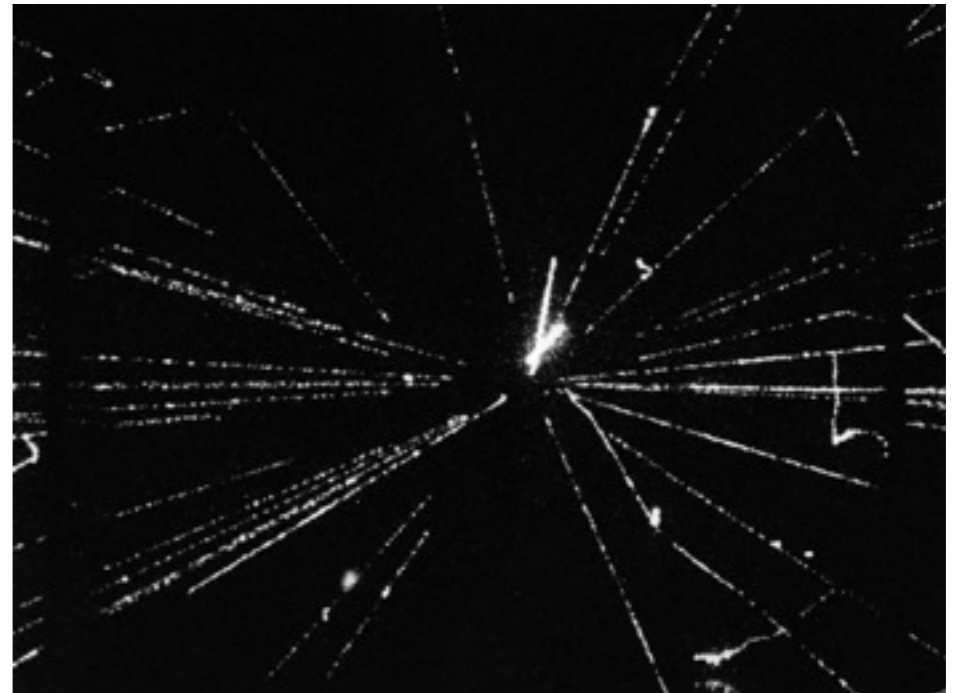
The **CMS** detector functions as sets of TV screens where particles flood every set

What's been on Particle TV?

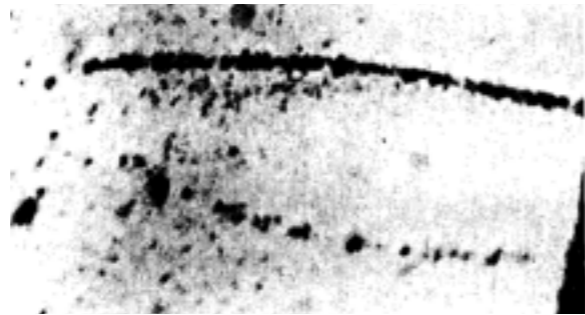
1932
Discovery of
anti-matter



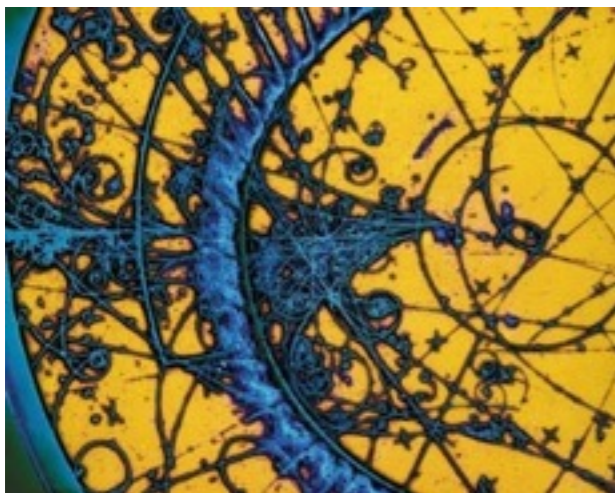
proton colliding with an anti-proton
1970



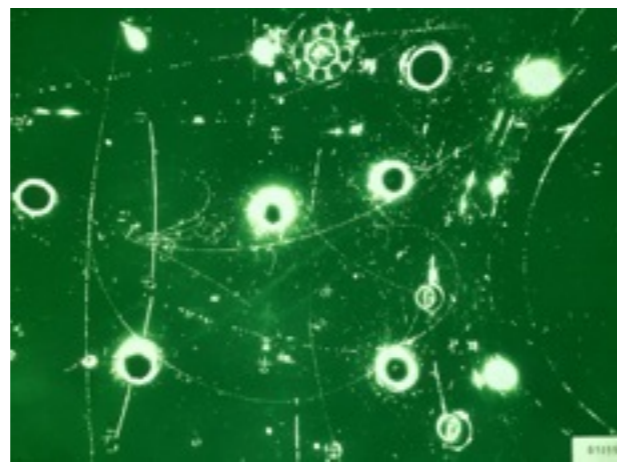
1932
Discovery of Muon



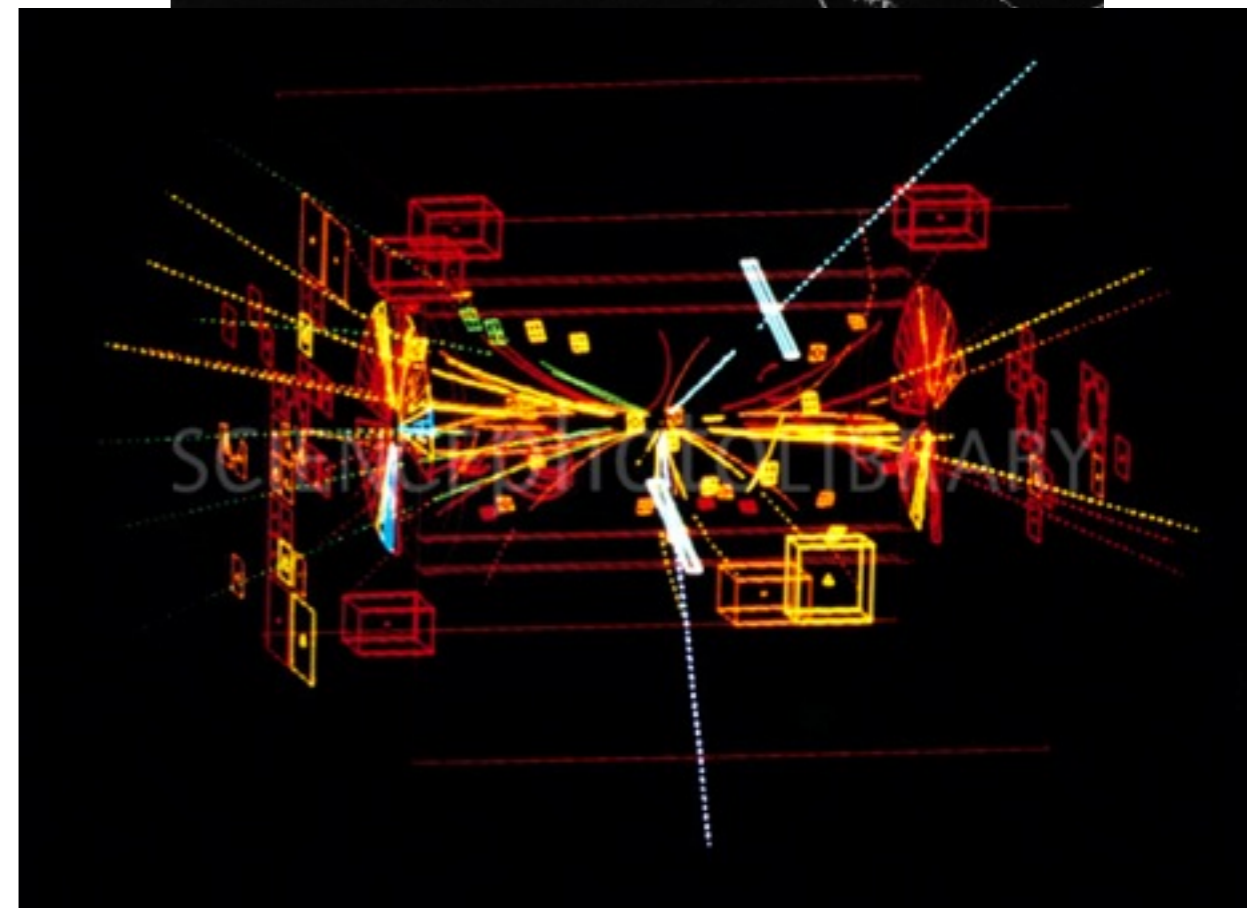
1970



1970

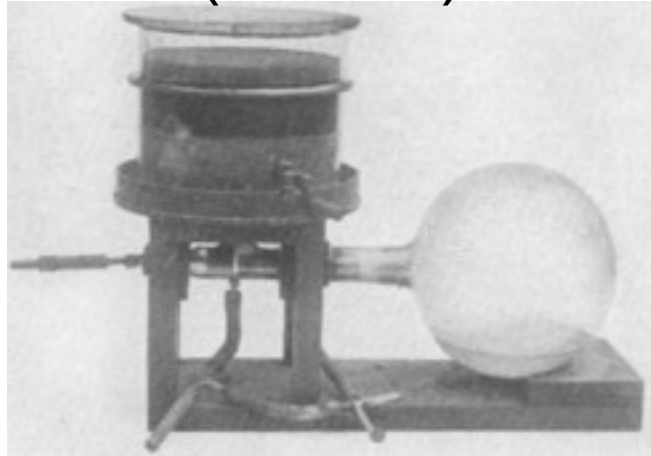


Evidence of neutrinos in
“weak interactions”

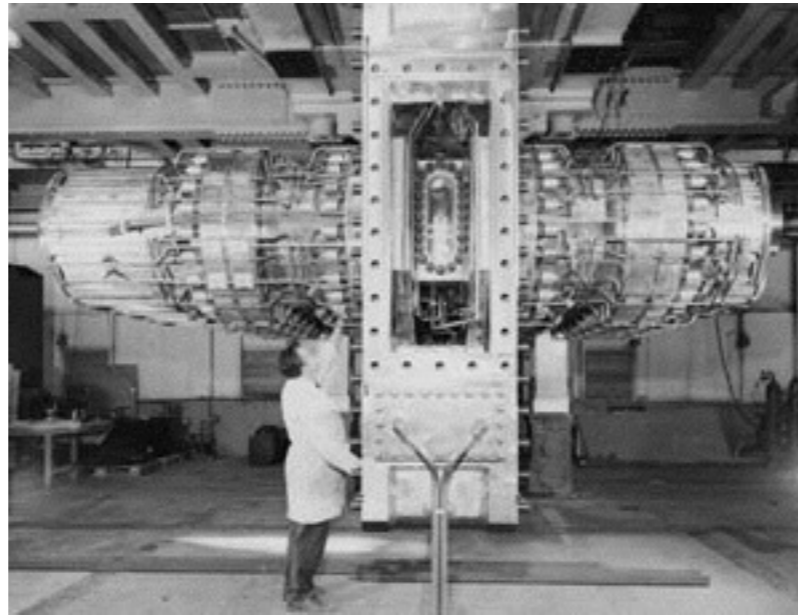


1983: Discovery of Z-boson

cloud chamber
(1911)



bubble chamber(1969)



Super Proton
Synchrotron
1976

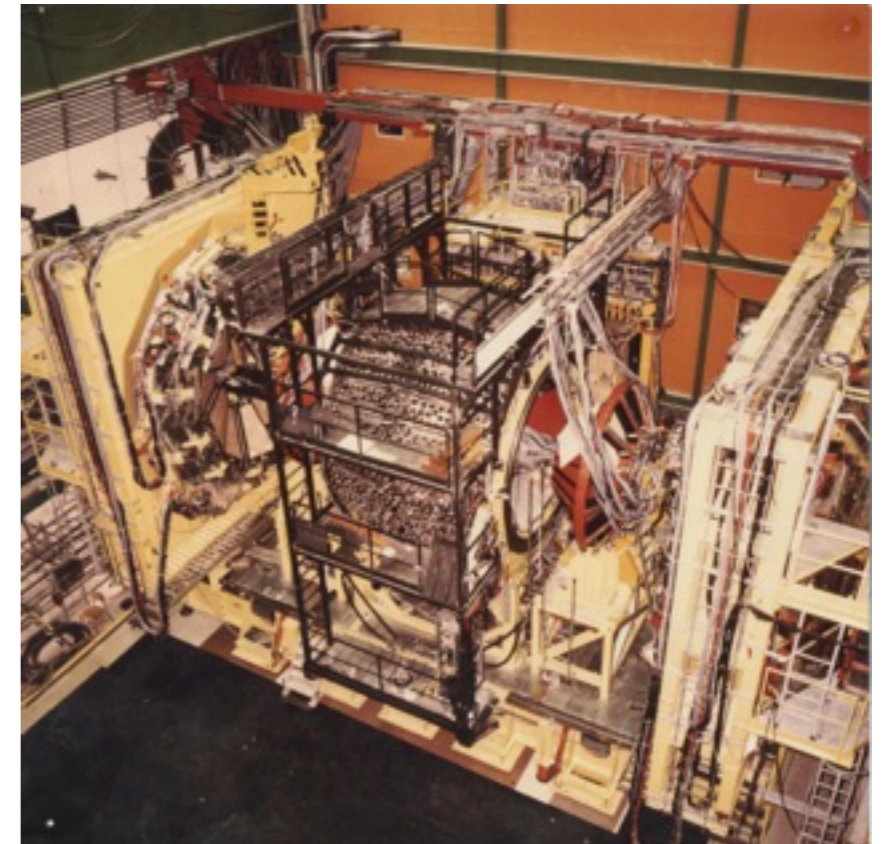


UA2 Experiment:1982

stream spark
chamber (1962)

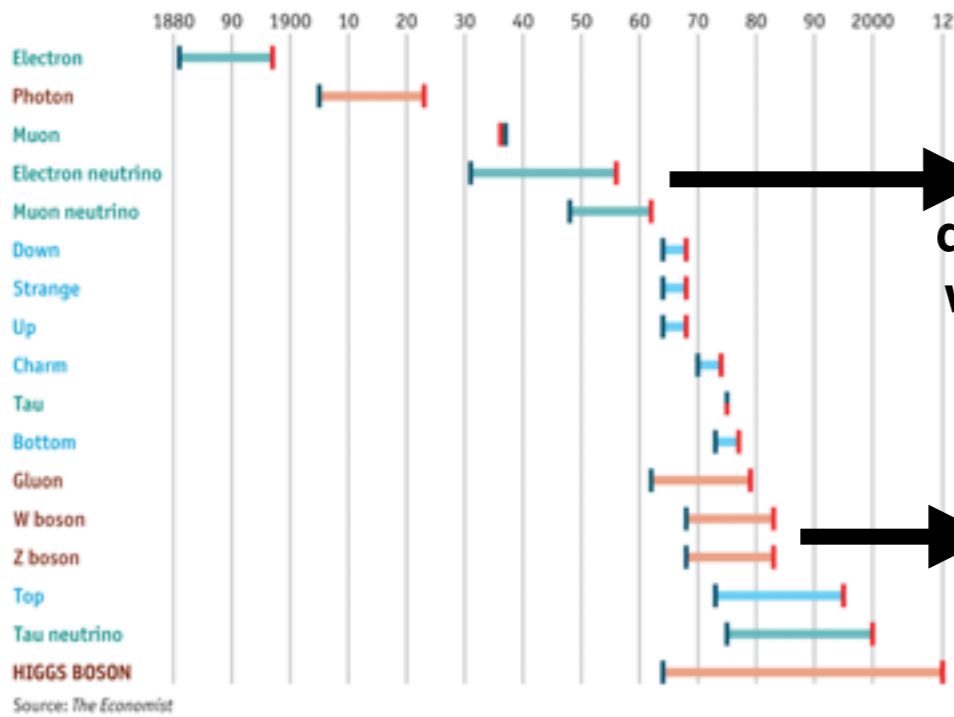


Alternating Gradient
Synchrotron (1960)



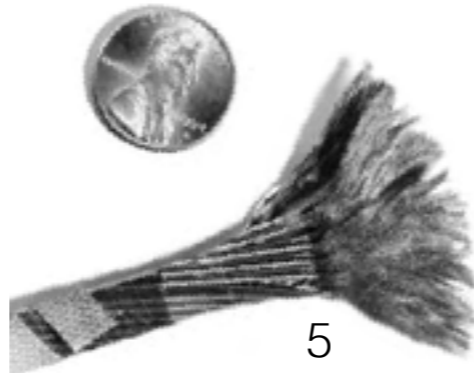
Why do our Experiments get BIGGER?

The Standard Model of particle physics
Years from concept to discovery



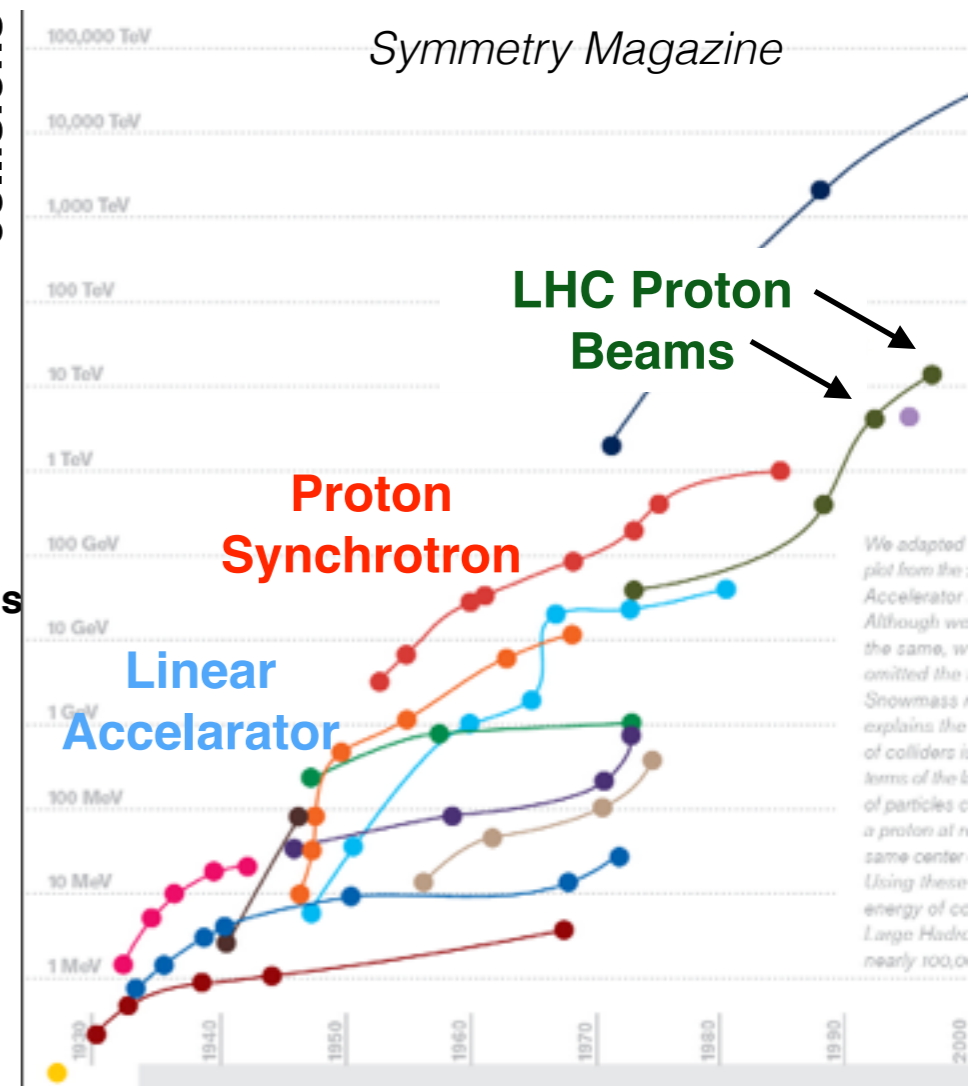
From 1960s on these discoveries were all made with particle accelerators

To produce interesting heavy particles we need to whip our protons harder to get closer to the speed of light



Livingston Plot

Energy you pump into your collisions



Symmetry Magazine

LHC Proton Beams

Proton Synchrotron

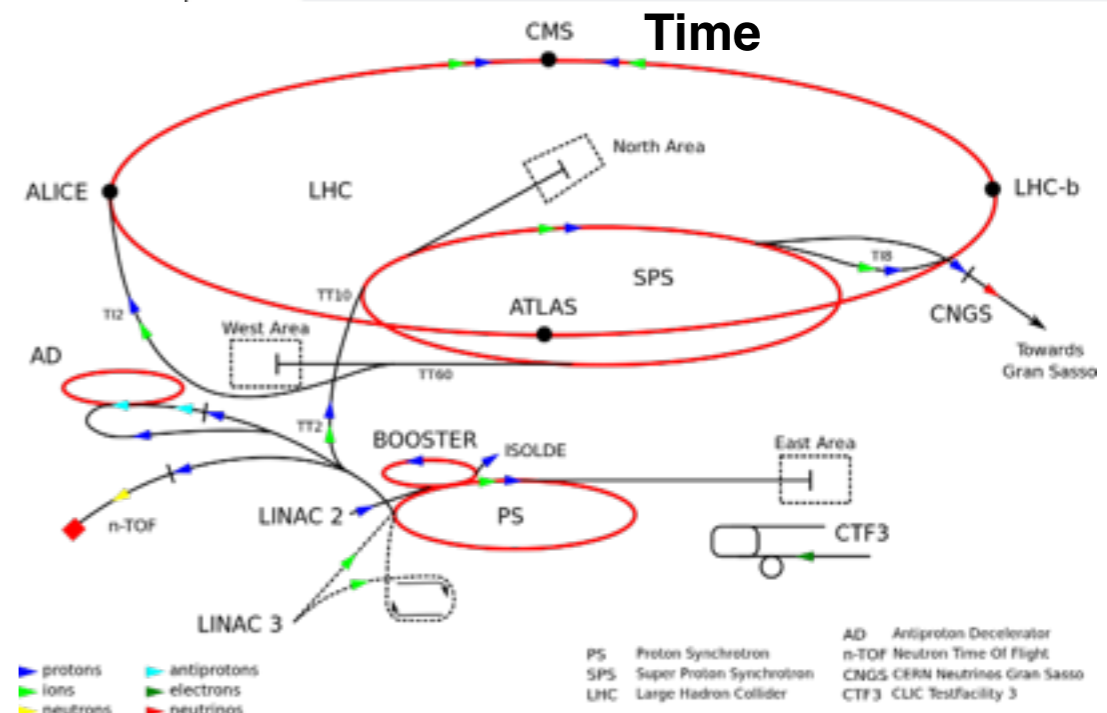
Linear Accelerator

We adapted plot from the Accelerator. Although we the same, we omitted the Snowmass explains the of colliders in terms of the of particles c a proton at n same center Using these energy of cc Large Hadc nearly 100,0

Jul 4th 2012 by The Economist

The accelerator technology is limited by mainly by the magnets used to bend protons into a ring (particles want to go straight)

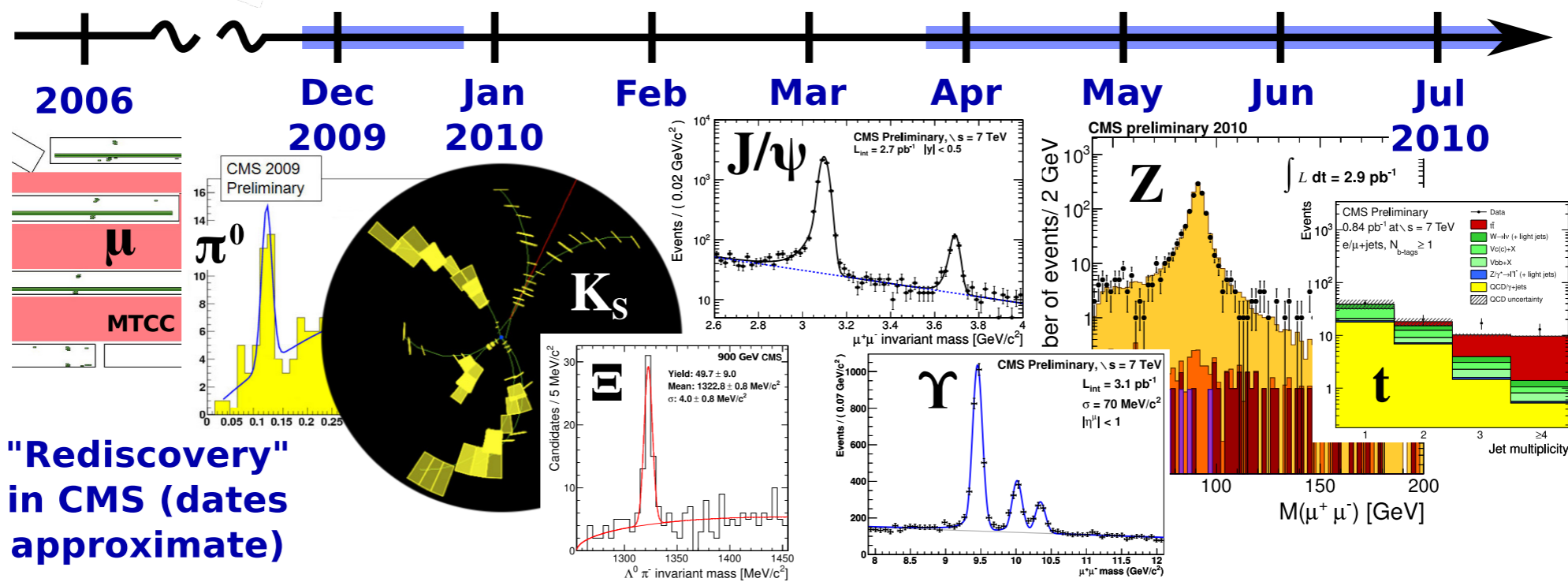
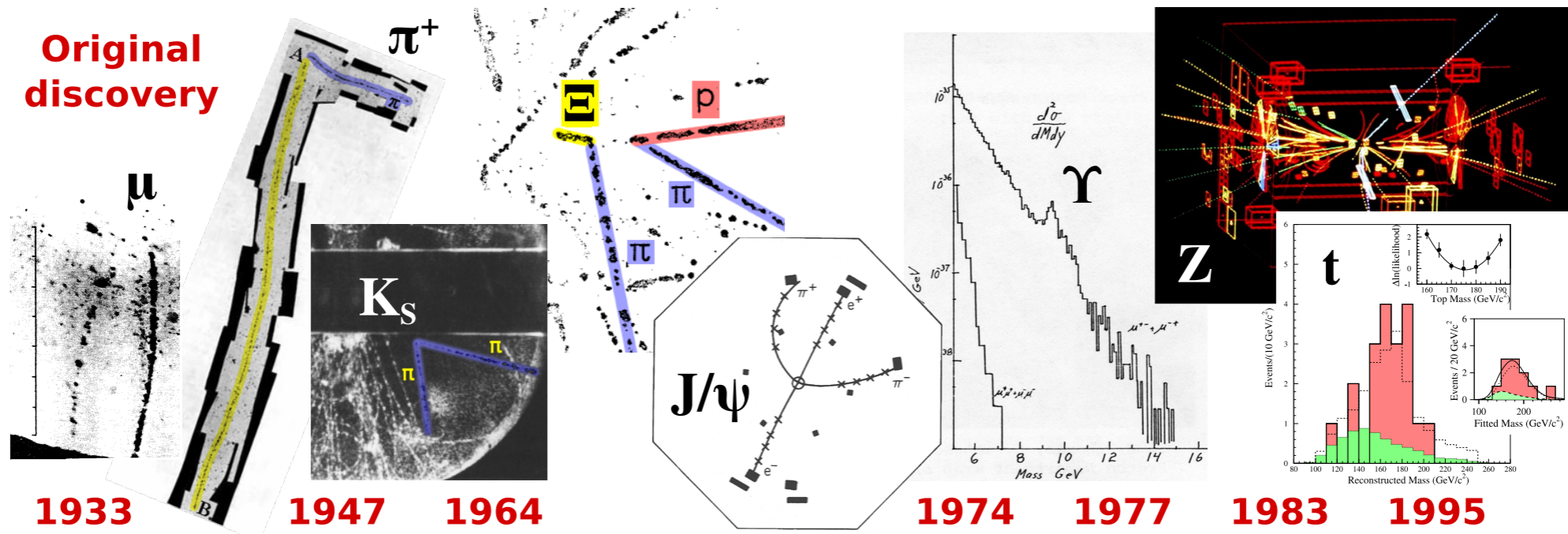
A rare alloy called Niobium titanium is used to make a super conducting magnet: it is very brittle and delicately superconducting at a certain temperature



■ protons ■ antiprotons
 ■ ions ■ electrons
 ■ neutrons ■ neutrinos
 PS Proton Synchrotron AD Antiproton Decelerator
 SPS Super Proton Synchrotron n-TOF Neutron Time Of Flight
 LHC Large Hadron Collider CNGS CERN Neutrinos Gran Sasso
 CTF3 CLIC Testfacility 3

Rediscovering the Standard Model

Jim Pivarski 16/44



Mini-Big Bang

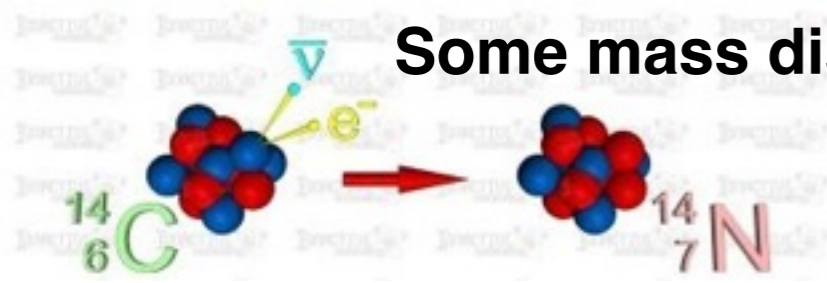
Matter locks away energy:

Fundamental Physics Goal:

What are the most basic exchanges of energy?

Radioactive decay

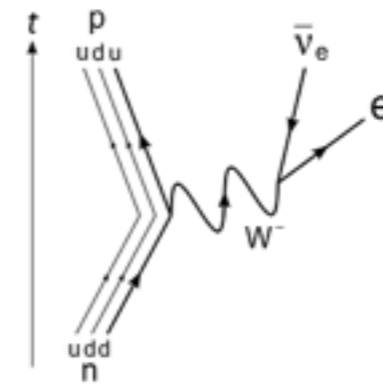
Some mass disappears?



Particle Picture:

Like a **football play**:

The football is energy



THE BIG BANG

From all the above particle plays we want to figure out the rules of the game

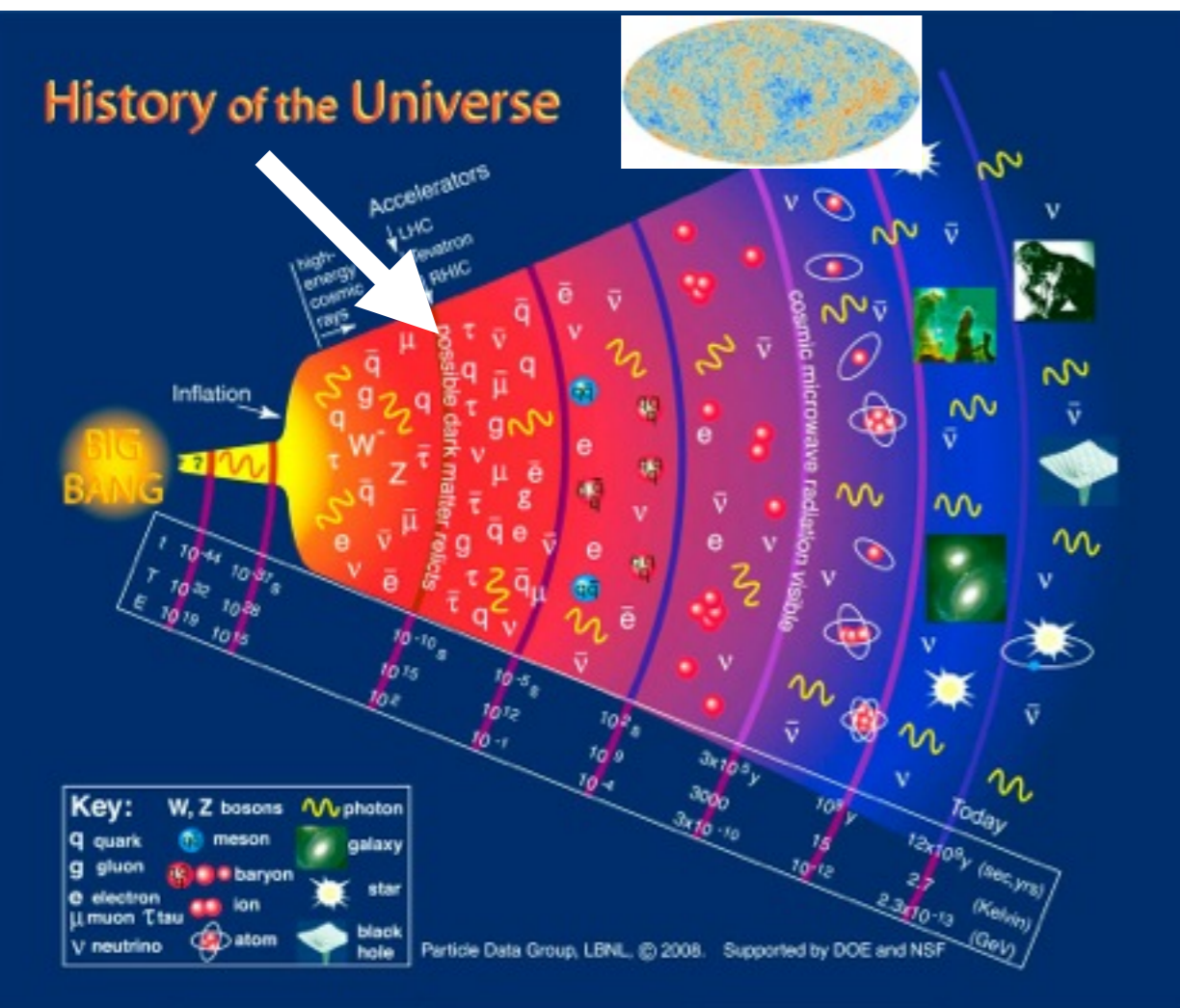
What we know:

Standard Model: All of the particles and energy exchanges we have seen so far

What we don't know:

Are there missing particles and missing interactions?

What gives the universe its structure?

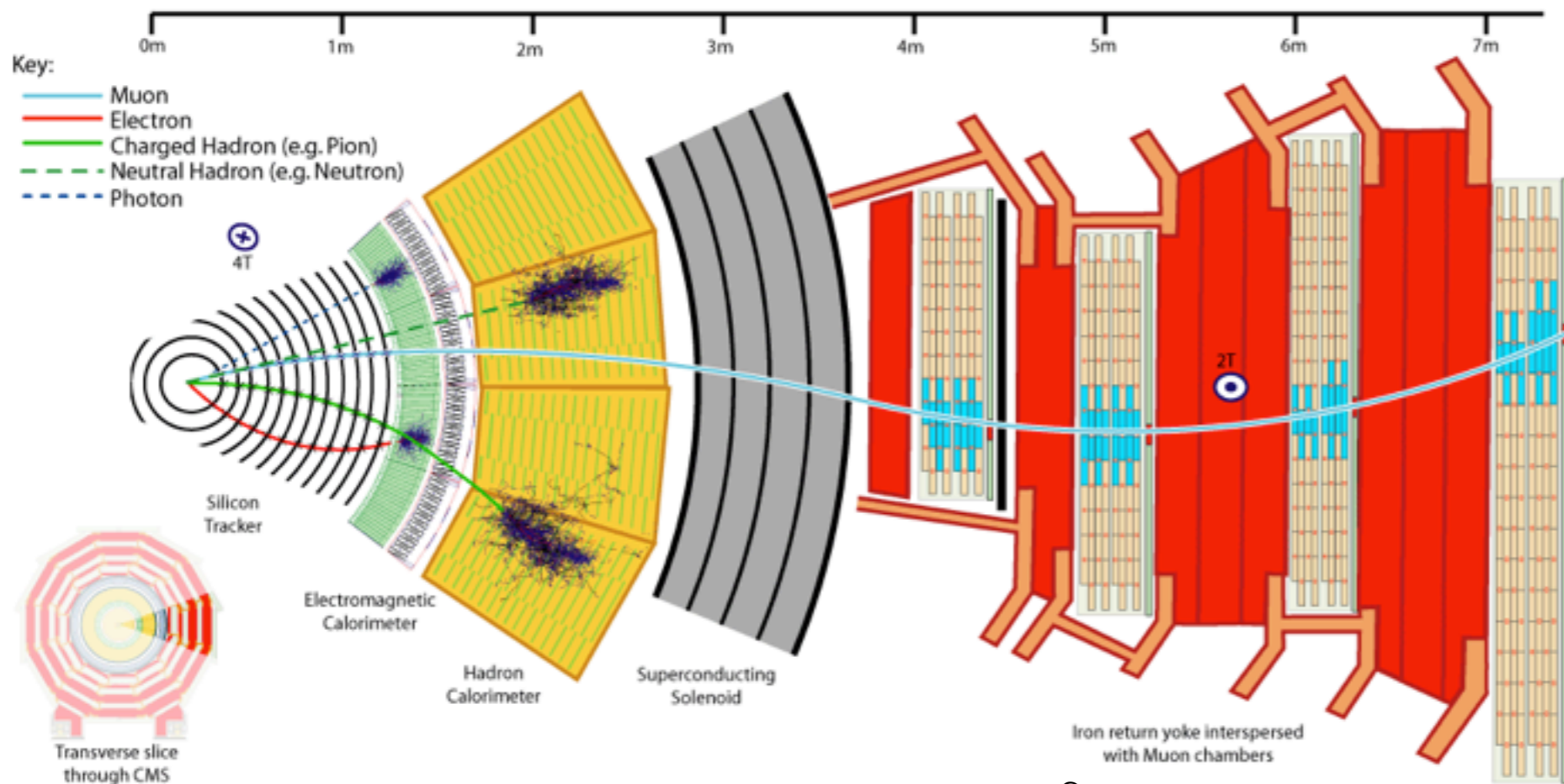
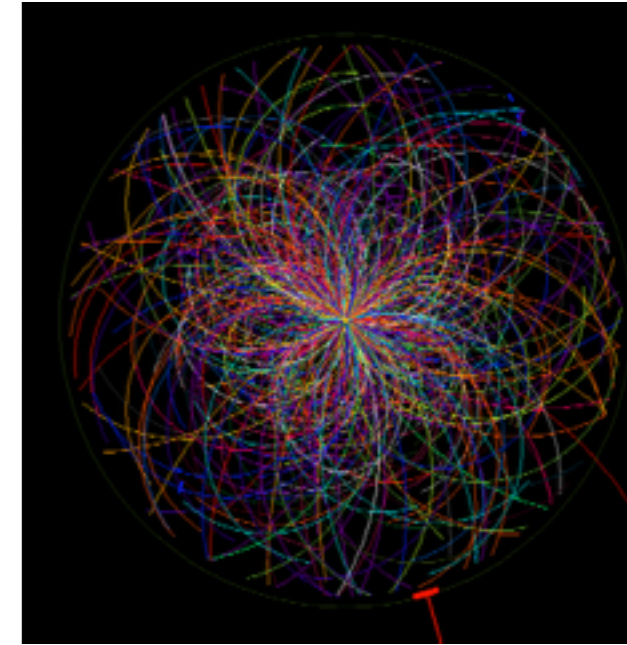


CMS: High Speed digital Camera



Mini big bang is a messy picture and the LHC produces **600 million collisions** each second (in one second have **TERAbytes of data**)

Very Fast Measurements within Electronics: **Trigger system** throws away all the bad or uninteresting pictures.



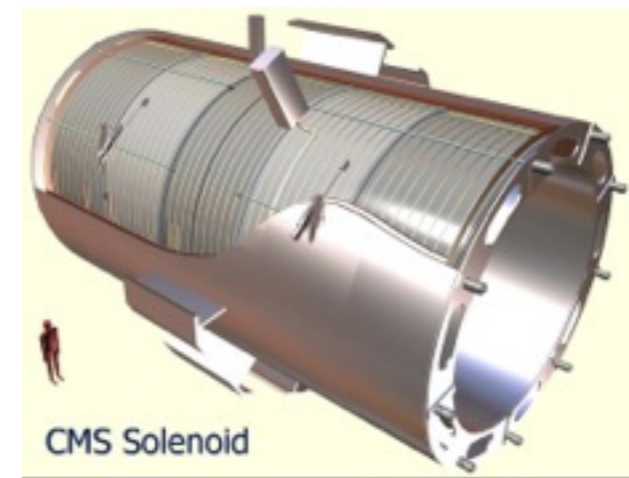
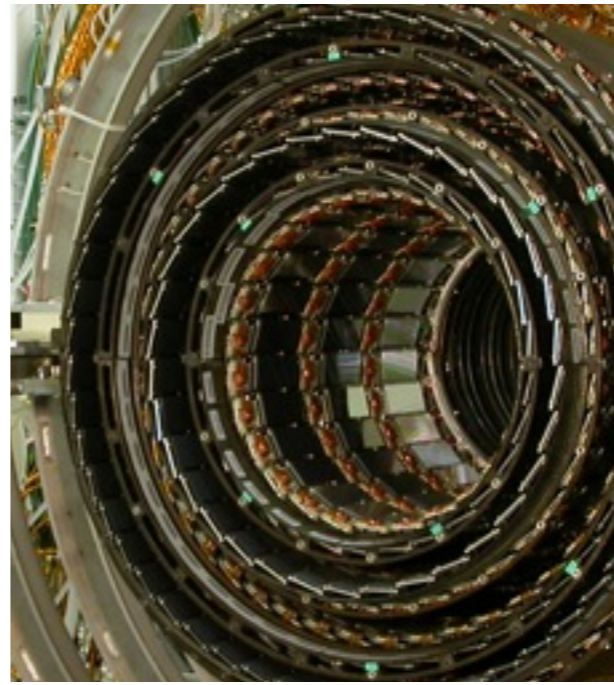
The first 8TeV collision that set a world record

Physicists then carefully look at the remainder of millions of good pictures, and very carefully separate them

CMS: Swim with the particles through the detector

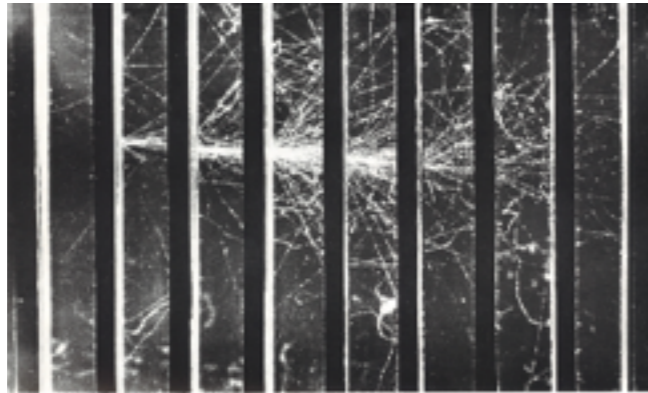
1m

Particles swim through an ocean of Silicon sensors (62 Million!) Charged particles leave footprints

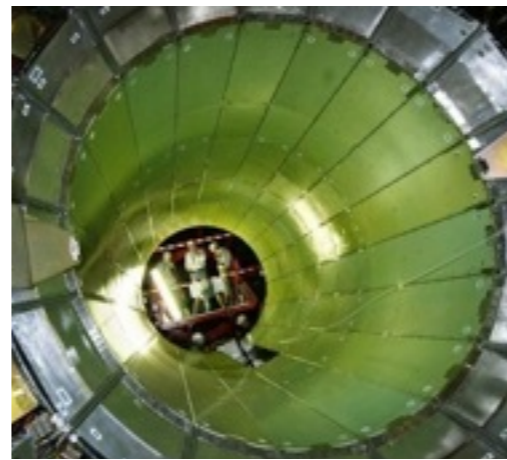


3m

Particles of light and electricity get stuck and shred into a bouquet of light and electricity



only one particle sees the outer part of the detector: muon



2m

Heavy particles get shredded into light ones



3m

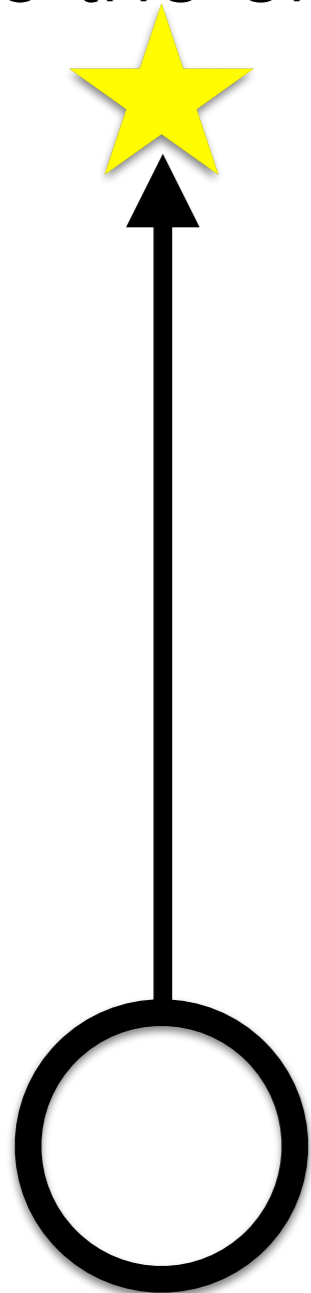
(10ft)

7m
(22ft)

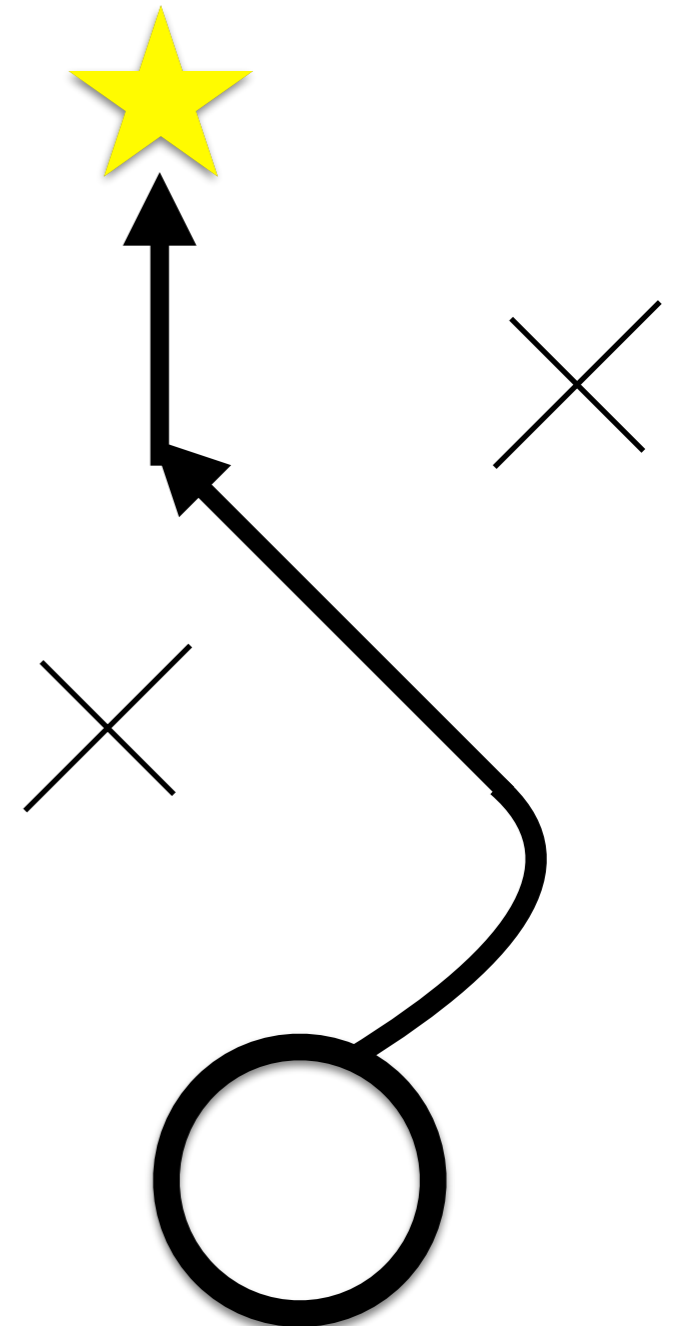
Higgs Field and Aggie Football

Think of mass as resistance to acceleration: inertia $F=ma$

Massless particles
get to the end zone quick



Massive particles
in a Higgs Field



Now there is resistance
defensive line:

This resistance is mass, the runner has
to dodge and it slows the runner down
slowing his average speed

CERN WILL NOT END THE WORLD

Some Facts:

- The creation of a black hole results from crushing a lot of mass into a small space (Crush the Earth into 3mm) Not easy!
- Particle Collisions happen in the universe all the time:
 - High energy particles produced in the sun slam into the moon at collision energies much larger than anything we could create on Earth and a black hole has not swallowed the moon!

My Advice: Don't buy black hole insurance

CERN BRINGS THE WORLD TOGETHER

Robert Wilson (1st Directory of Fermilab):

“It only has to do with the respect with which we regard one another, the dignity of men, our love of culture. . . . It has to do with are we good painters, good sculptors, great poets? I mean all the things we really venerate in our country and are patriotic about. . . . It has nothing to do directly with defending our country except to make it worth defending.”

