PHYS 3446
Lecture #1

Tuesday January 20, 2015

Dr. Andrew Brandt

1. **Syllabus and Introduction**
2. **High Energy Physics at UTA**
3. **Higgs**

Please turn off your cell-phones, pagers and laptops in class

Thanks to Dr. Yu for developing initial electronic version of this class

http://www-hep.uta.edu/~brandta/teaching/sp2015/teaching.html
will be "online" this week

My Background+Research

B.S. Physics and Economics College of William&Mary 1985
PH.D. UCLA/CERN High Energy Physics 1992
(UA8 Experiment-discovered hard diffraction)

1992-1999 Post-doc and Lab Scientist at Fermi National Accelerator Laboratory
-1997 Presidential Award for contributions to diffraction
-Proposed and built (with Brazilizn collaborators) DØ Forward Proton Detector
-Physics Convenor
-Trigger Meister

1999 Joined UTA as an Assistant Professor
2004 promoted to Associate Professor
2010 promoted to Full Professor

- Funding from NSF, DOE, and Texas over 10M$ as PI or Co-PI

My Main Research Interests

- High Energy Physics (aka Particle Physics)
- Physics with Forward Proton Detectors (detect protons scattered at small angles)
- Fast timing detectors (How fast? Really really fast!)

http://www.youtube.com/watch?v=By1JQFxfLMM&feature=related

- Triggering (selecting the events to write to tape): at ATLAS must choose most interesting 300 out of up to 40,000,000 events/sec
- Higgs Discovery
- Dark Matter
- Weapons of Mass Destruction **(detection of)**

Grading

- Only test is a Midterm: 25%
  - No Final
  - Test will be curved if necessary
  - No makeup tests
- Homework: 15% (penalty for late hw)
- Lab score: 25% (details soon)
- Project: 25% (discover susy?)
- Pop Quizzes: 10%

Attendance and Class Style

- Attendance:
  - is **STRONGLY** encouraged, to aid your motivation I give pop quizzes
- Class style:
  - Lectures will be primarily on electronic media
    - The lecture notes will be posted **AFTER** each class
  - Will be mixed with traditional methods (blackboard)
  - Active participation through questions and discussion is encouraged

Physics History

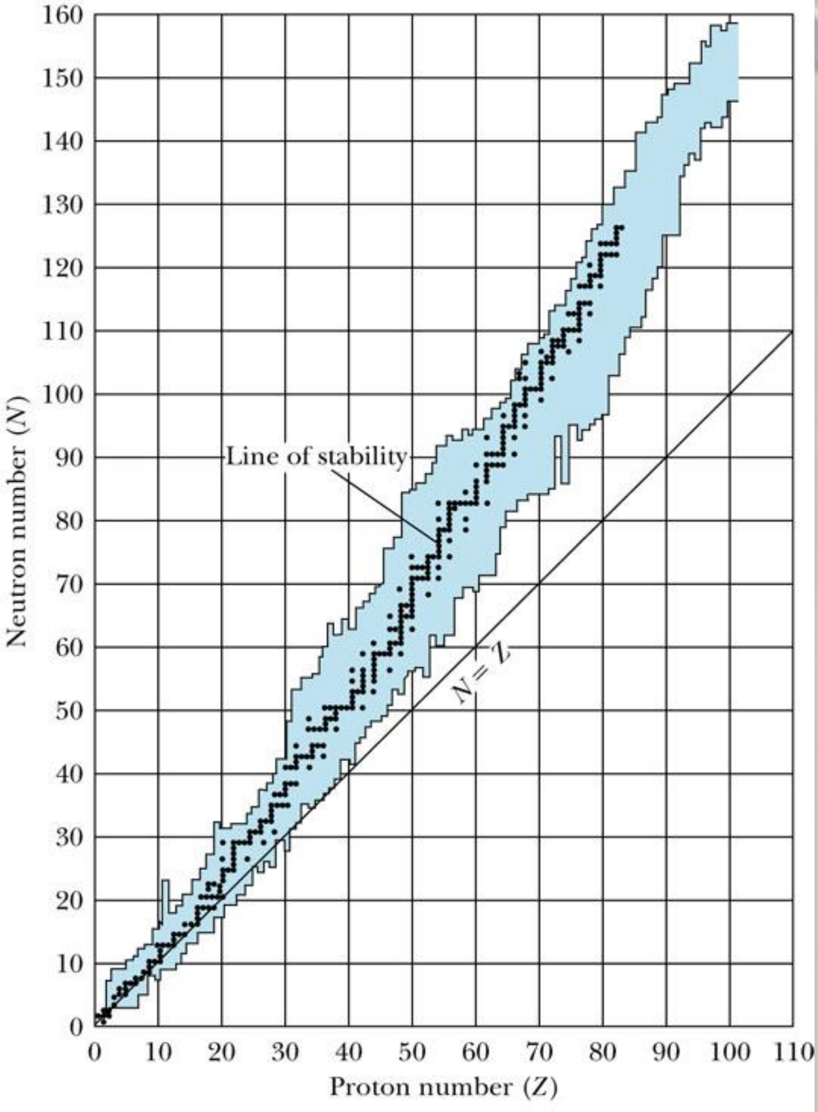
- Classical Physics: forces, motion, work, energy, E&M, (Galileo, Newton, Faraday, Maxwell)
- In modern physics (Einstein, Planck, Bohr) we covered relativity, models for the atom, some statistical mechanics, and finished with a bit of discussion about the nucleus and binding energy circa 1930 when the neutron was discovered
- What's new in physics since 1930?

Physics History

- I’m going to have to respectfully disagree with you Leonard…
- 1937 muon discovered (who ordered that?)
- With advent of particle accelerators came particle zoo
- There was a need to classify all the new particles being discovered and try to understand the underlying forces and theory

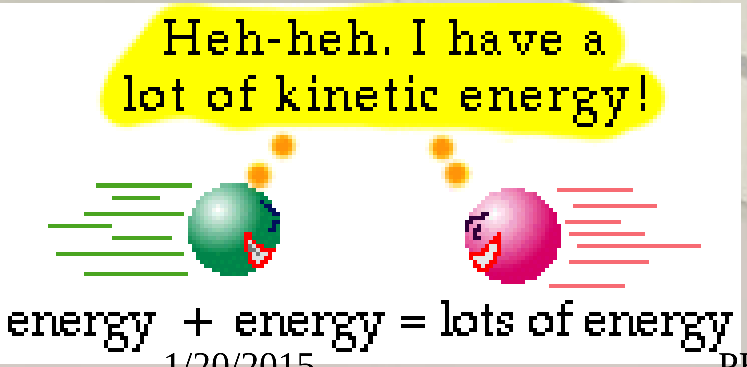
Course Material

- Nuclear Physics
  - Models of atom
  - Cross sections
  - Radiation
- High Energy Experiment
  - Energy deposition in matter
  - Particle detector techniques
  - Accelerators
- HEP Phenomenology
  - Elementary particle interactions
  - Symmetries
  - The Standard Model
  - Beyond the Standard Model



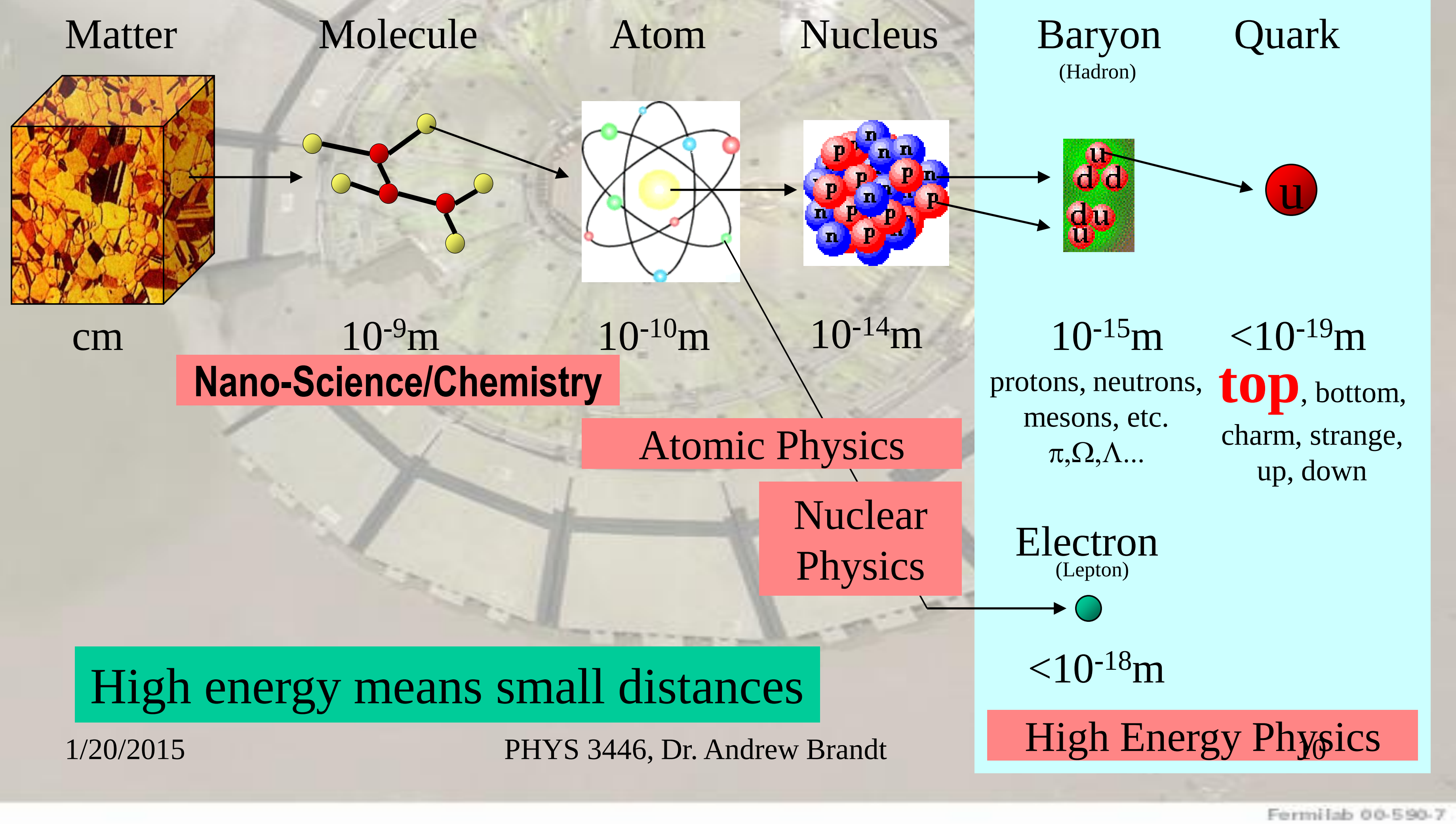
High Energy Physics at UTA

UTA faculty **Andrew Brandt**, Kaushik De, Amir Farbin, Andrew White, Jae Yu along with many post-docs, graduate and undergraduate students investigate the basic forces of nature through particle physics studies at the world's highest energy accelerators

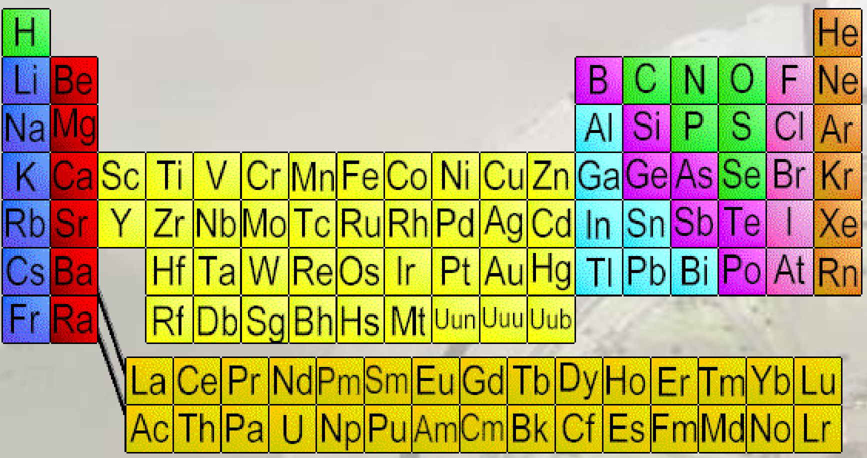


In the background is a photo of a sub-detector of the 5000 ton DØ detector. This sub-detector was designed and built at UTA and operated at Fermi National Accelerator Laboratory near Chicago.

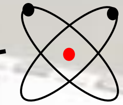
Structure of Matter



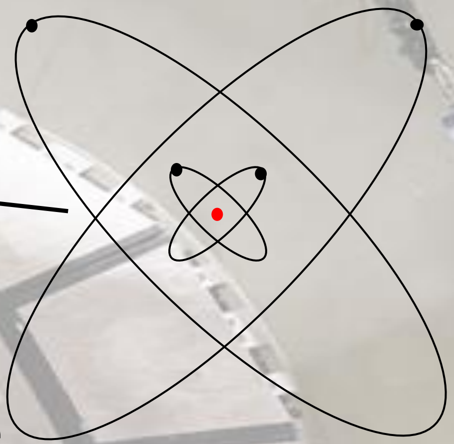
Periodic Table



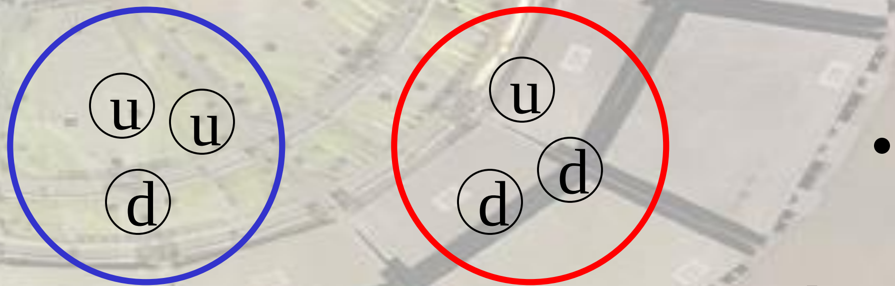
Helium



Neon



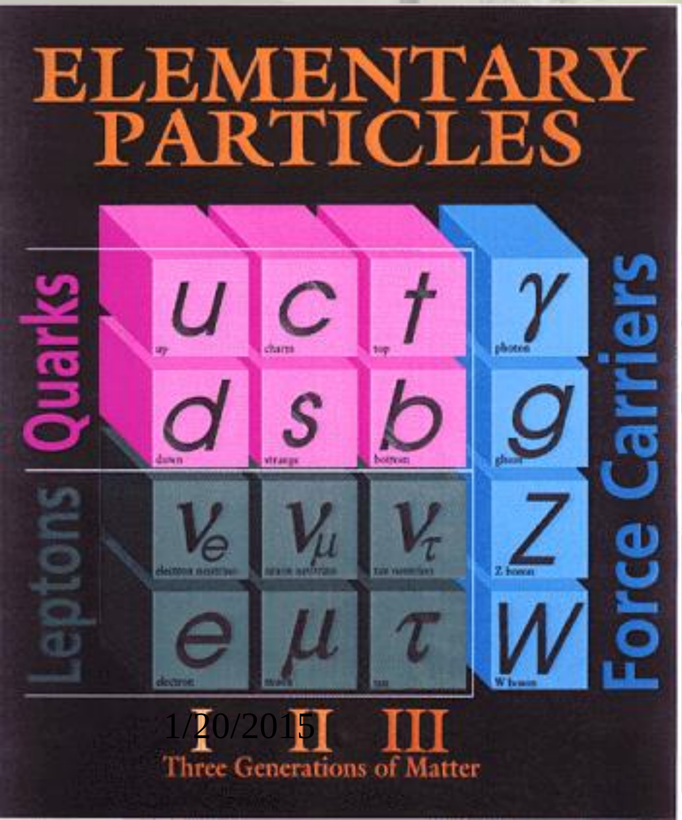
All atoms are made of protons, neutrons and electrons



Proton Neutron Electron

Gluons hold quarks together

Photons hold atoms together



What is High Energy Physics?

- Matter/Forces at the most fundamental level.
- Great progress! The "STANDARD MODEL"
- BUT… many mysteries

=> Why so many quarks/leptons??

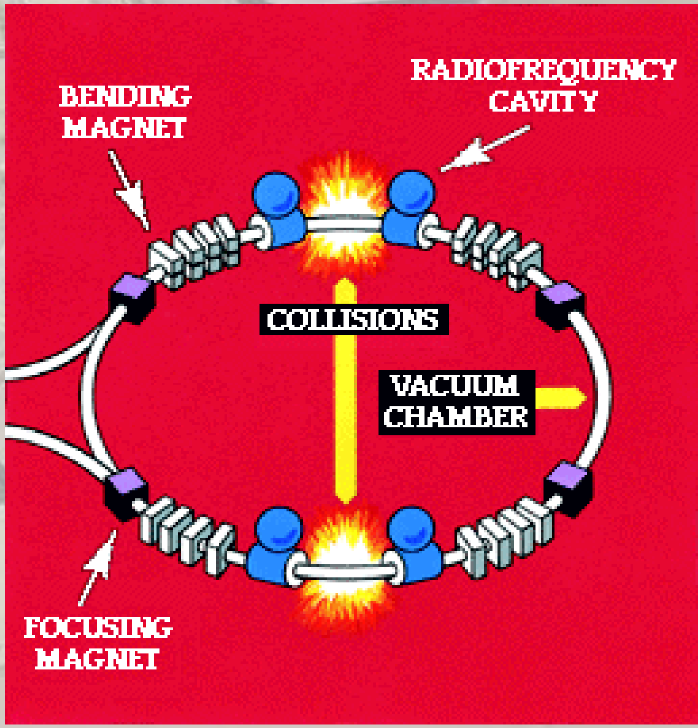
=> Why four forces?? Unification?

=> Where does mass come from??

=> Are there higher symmetries??

⇒What is the "dark matter"??

⇒Will the LHC create a black hole that destroys the Earth?



NO! See: http://public.web.cern.ch/Public/en/LHC/Safety-en.html

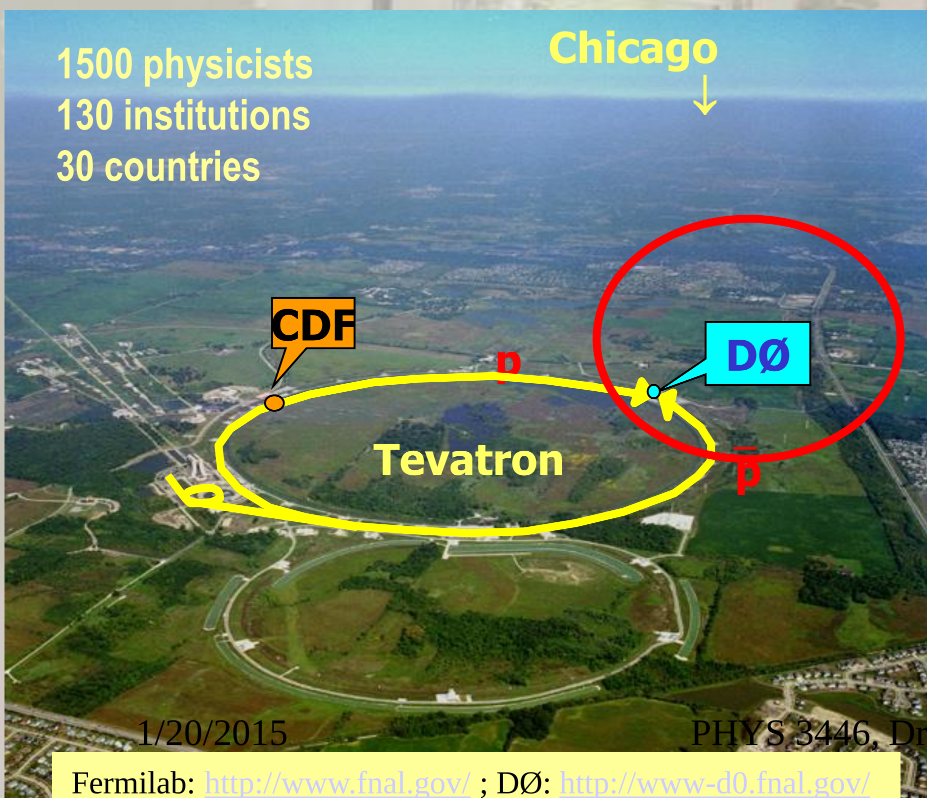
Role of Particle Accelerators

- Smash particles together
- Act as microscopes and time machines
  - The higher the energy, the smaller object to be seen
  - Particles that only existed at a time just after the Big Bang can be made
- Two method of accelerator based experiments:
  - Collider Experiments: $p\bar{p}$, pp, e^+e^-, ep
  - Fixed Target Experiments: Particles on a target
  - Type of accelerator depends on research goals

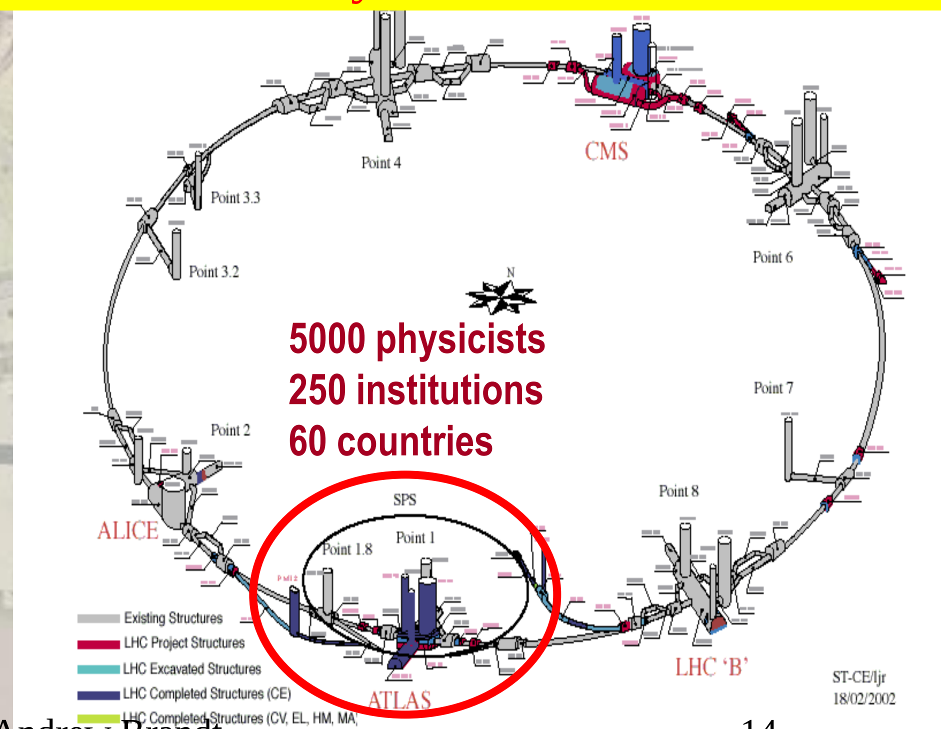
Fermilab Tevatron and CERN LHC

- Currently Highest Energy proton-anti-proton collider
  - E_{cm}=1.96 TeV (=6.3x10^{-7}J/p➔ 13M Joules on $10^{-4}m^2$)
  - ⇒Equivalent to the K.E. of a 20 ton truck at a speed 81 mi/hr

- Highest Energy (proton-proton) collider since fall 2009
  - E_{cm}=14 TeV (=44x10^{-7}J/p➔ 1000M Joules on $10^{-4}m^2$)
  - ⇒Equivalent to the K.E. of a 20 ton truck at a speed 711 mi/hr
  - ⇒Currently 7 TeV collisions

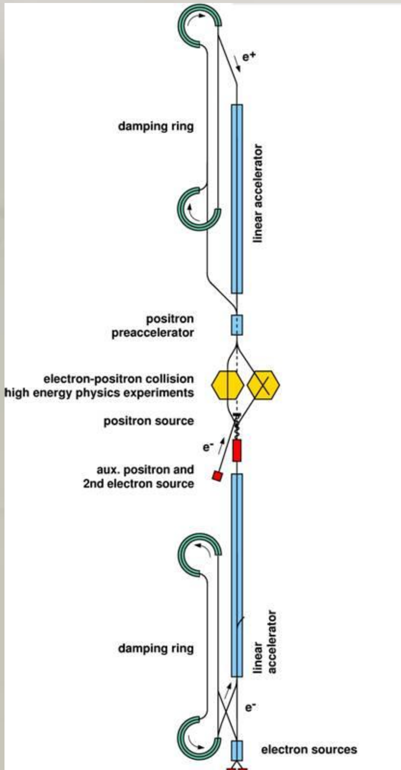


Fermilab: http://www.fnal.gov/ ; DØ: http://www-d0.fnal.gov/



CERN: http://www.cern.ch/ ; ATLAS: http://atlas.web.cern.ch/

The International Linear Collider



European Design
500 GeV (800 GeV)

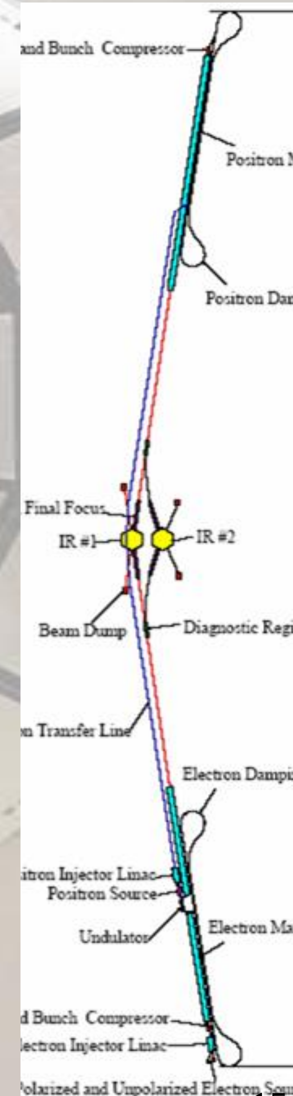
33km=

21mi

- Long~ linear electron-position colliders
- Optimistically 15 years from now
- Takes 10 years to build an accelerator and the detectors

47 km

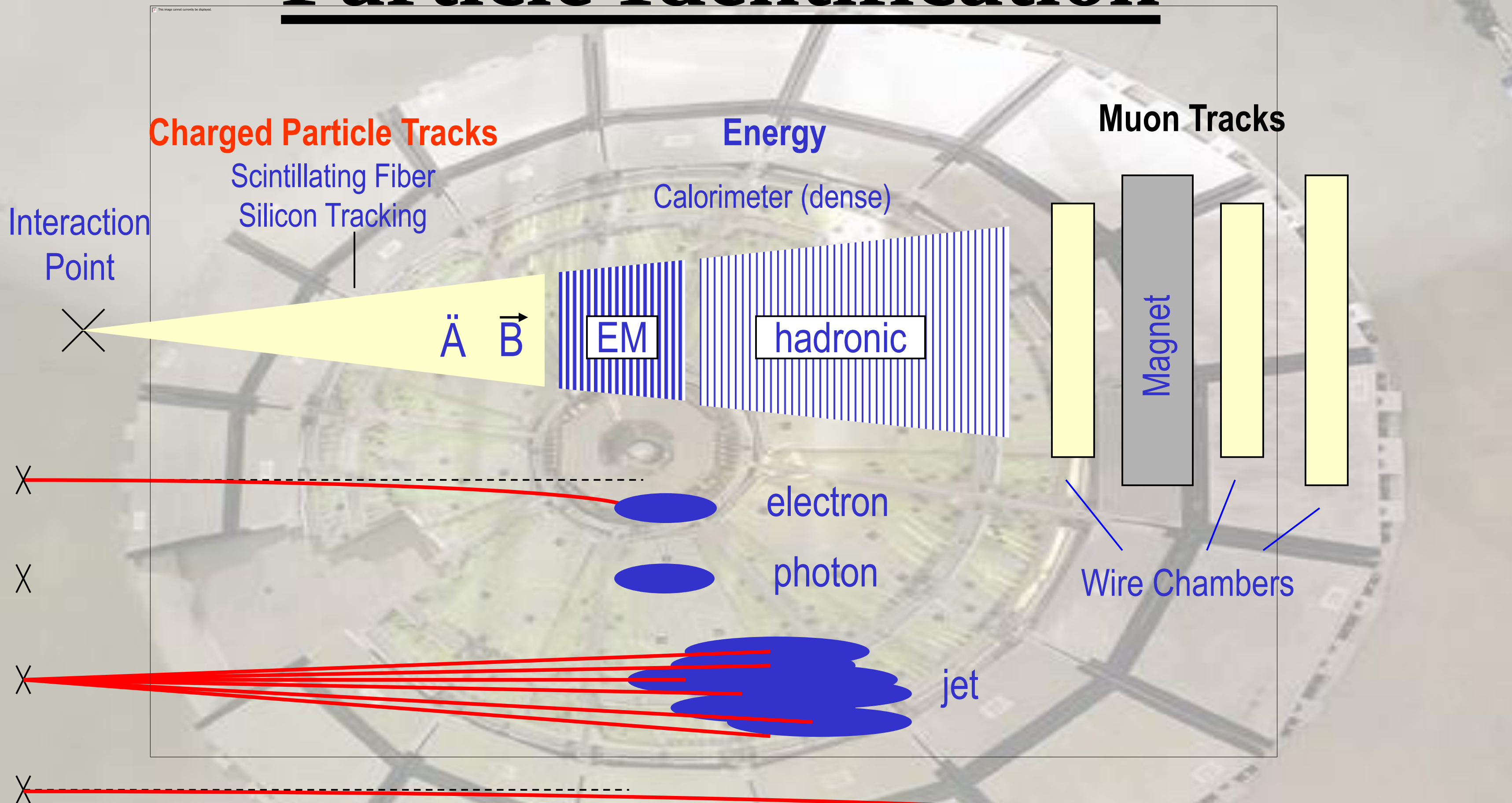
=29 mi

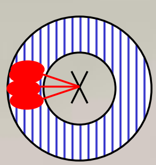


Dr.White is co-spokesman of SiD detector

US Design
500 GeV (1 TeV)

Particle Identification

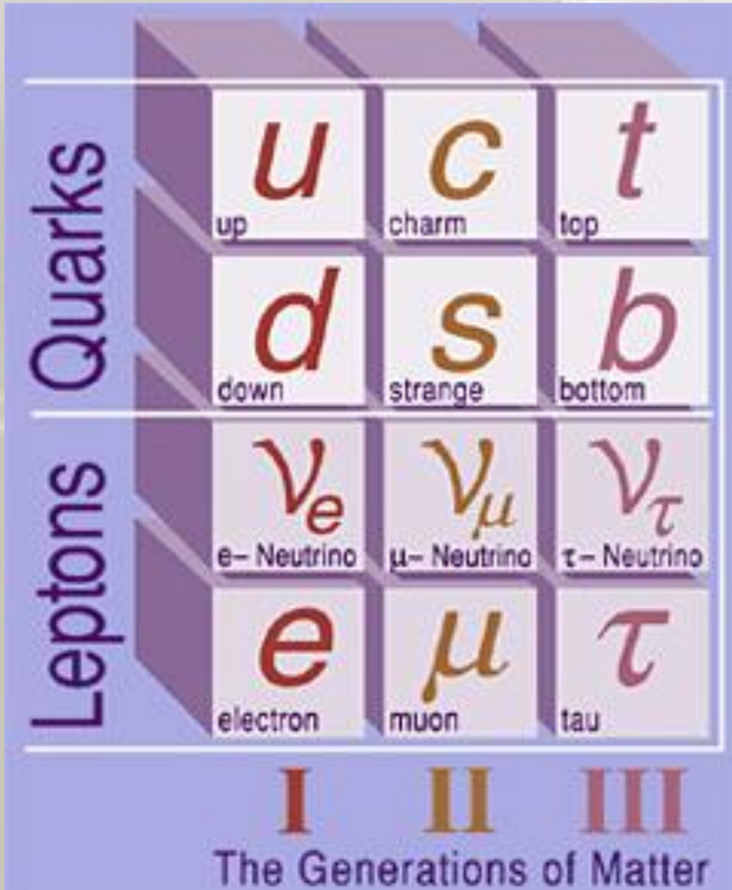




neutrino (or any non-interacting particle missing transverse momentum)

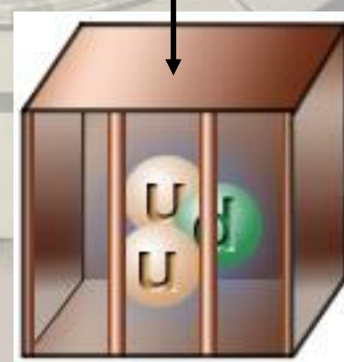
We know x,y starting momenta is zero, but along the z axis it is not, so many of our measurements are in the xy plane, or transverse

The Standard Model



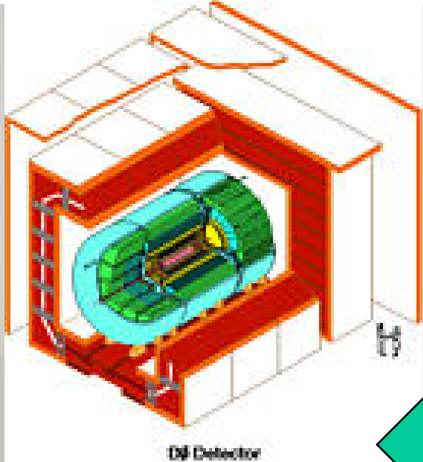
Standard Model has been very successful but has too many parameters, does not explain origin of mass. Continue to probe and attempt to extend model.

The strong force is different from E+M and gravity!
new property, color charge
confinement - not usual $1/r^2$

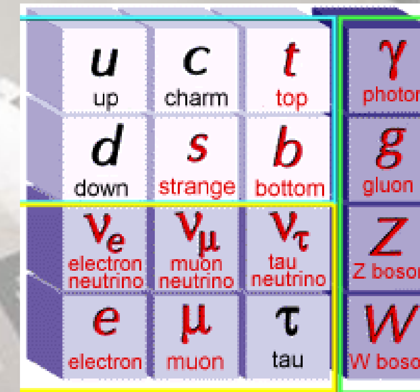


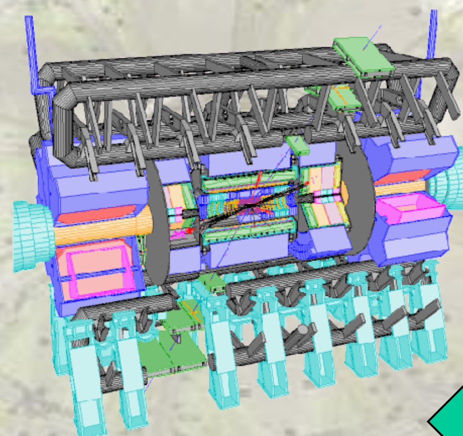
- Current list of elementary (i.e. indivisible) particles
- Antiparticles have opposite charge, same mass

UTA and Particle Physics

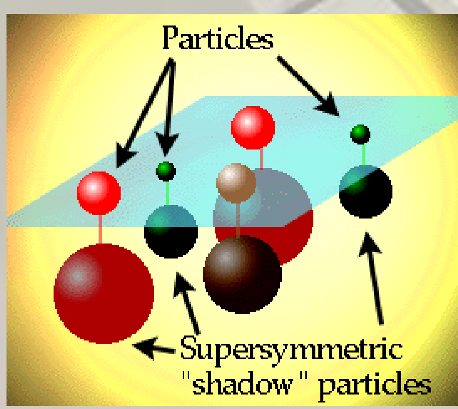


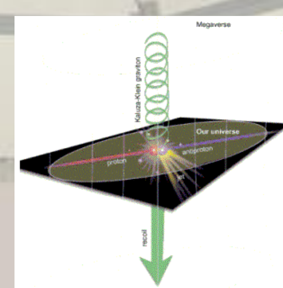
Fermilab/Chicago





CERN/Geneva





ILC? U.S.?

Building Detectors at UTA

High Energy Physics Training + Jobs

EXPERIENCE:

1) **Problem solving**
2) **Data analysis**
3) **Detector construction**
4) **State-of-the-art high speed electronics**
5) **Computing (C++, Python, Linux, etc.)**
6) **Presentation**
7) **Travel**

JOBS:

1) **Post-docs/faculty positions**
2) **High-tech industry**
3) **Computer programming and development**
4) **Financial**

Fermilab 00-590-7

Pre-lecture Conclusions

- Nuclear and Particle picks up where Modern Physics left off
- One of the current frontiers of physics is high energy or particle physics: very interesting (I think!)
- Nobel Prize possibilities
- Other interesting areas of physics at UTA

  include nano-bio physics, astrophysics, nano-magnetism, etc.

Summary

- If you are here to learn about Nuclear/Particle Physics this should be an interesting and fun class, if you are here because you need four hours of physics….

  a) get out while you still can **OR**

  b) it will still be an interesting and fun class (up to you)
- It is an opportunity to learn about high energy physics from a high energy physicist
- Lab takes time, there will be reading outside of main text
- See me if interested in UG research project in particle physics

Why Do Physics?

Exp. {
- To understand nature through experimental observations and measurements (**Research**)

Theory {
- Establish limited number of fundamental laws, usually with mathematical expressions
- Explain and predict nature

⇒Theory and Experiment work hand-in-hand

⇒Theory generally works under restricted conditions

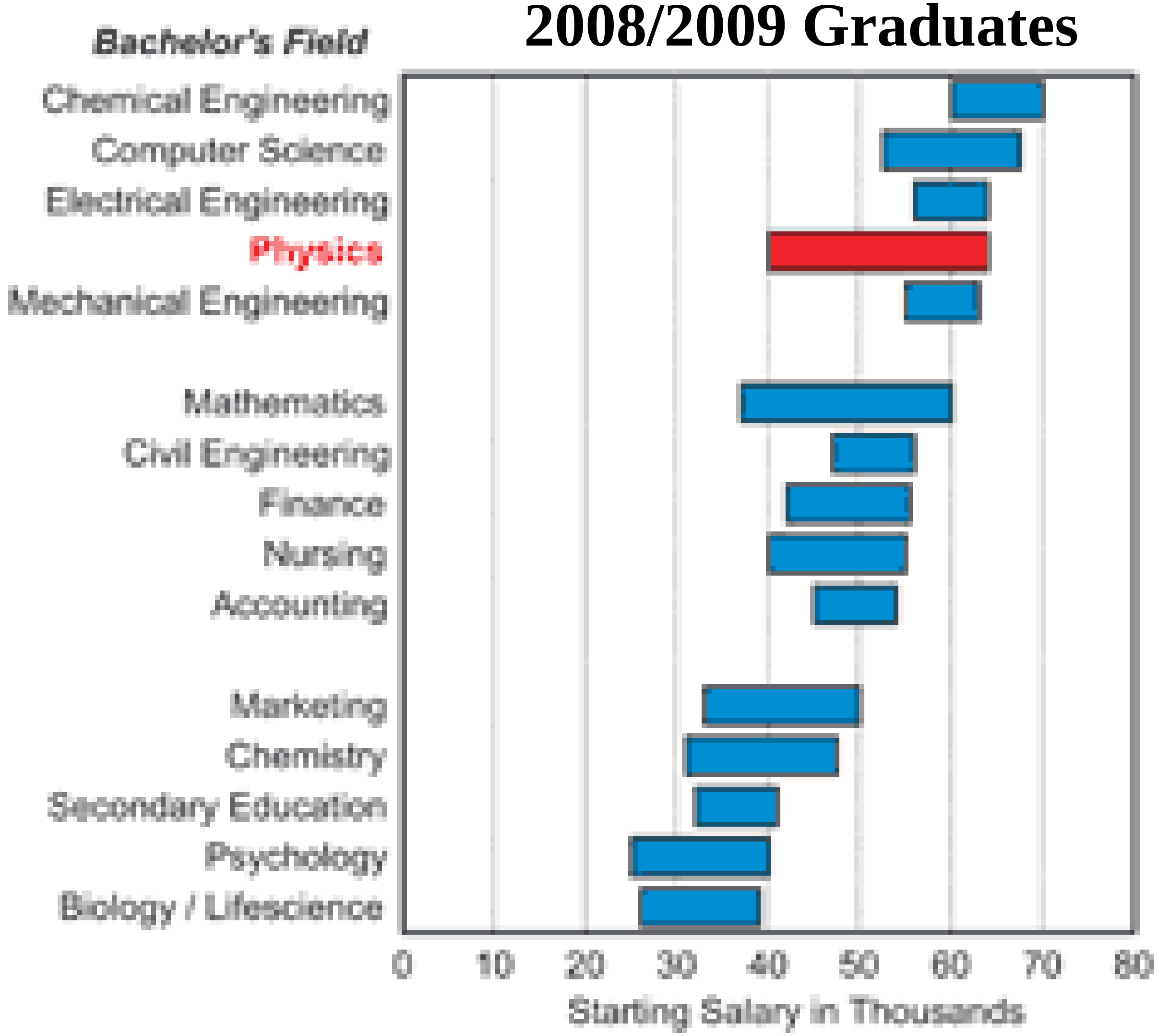
⇒Discrepancies between experimental measurements and theory are good for improvement of theory

⇒Modern society is based on technology derived from detailed understanding of physics

Why Do Physics Part Deux

http://www.aps.org/publications/apsnews/200911/physicsmajors.cfm

2008/2009 Graduates



1.7% unemployment

While engineering starting salaries are typically higher than physicists, mid-career salaries are virtually identical
101k$ for engineering
99k$ for physics

What Do Physicists Do?