PHYS 1442 – Section 001
Lecture #1

Wednesday, June 3, 2009

Dr. Jaehoon Yu

- Who am I?
- How is this class organized?
- What is Physics?
- What do we want from this class?
- Brief history of physics
- Some basics …
- Chapter 16
  - Static Electricity and Charge Conservation
  - Charges in Atom
  - Insulators and Conductors
  - Induced Charge

Today's homework is homework #1, due 9pm, next Thursday!!

Announcements

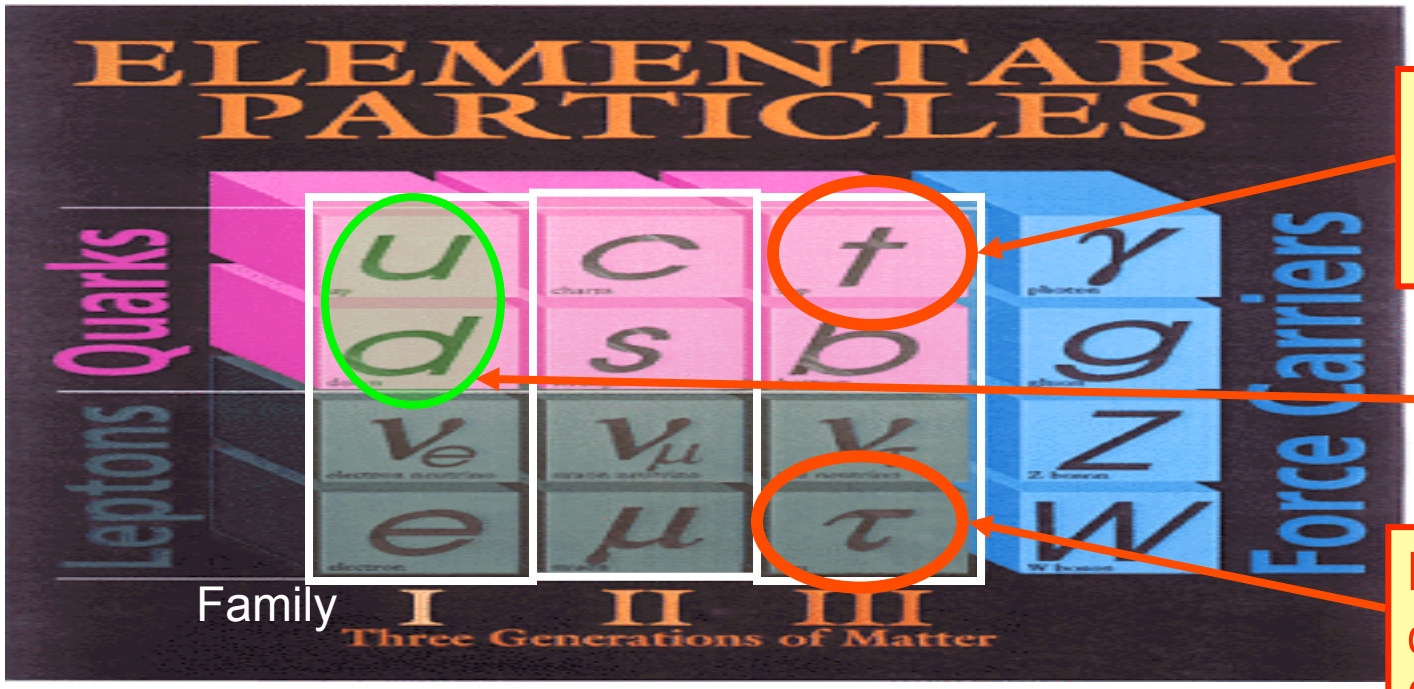
- Plea to you: Please turn off your cell-phones, pagers and computers in the class
- Reading assignment #1: Read and follow through all sections in appendix A by Monday, June 8
  - A-1 through A-8
- There will be a quiz on this and Ch. 16 on Wednesday, June 10

Who am I?

- Name: Dr. Jaehoon Yu (You can call me **Dr. Yu**)
  - Assisted and supplemented by Mr. John Griffis
- Office: Rm 342, Chemistry and Physics Building
- Extension: x22814, E-mail: *jaehoonyu@uta.edu*
- My profession:High Energy Physics (HEP)
  - Collide particles (protons on anti-protons or electrons on anti-electrons, positrons) at the energies equivalent to 10,000 Trillion degrees
  - To understand
    - Fundamental constituents of matter
    - Forces between the constituents (gravitational, electro-weak and strong forces)
    - Origin of Mass
    - Creation of the universe (**Big Bang** Theory)
  - A pure scientific research activity
    - Direct use of the fundamental laws we find may take longer than we want but
    - Indirect product of research contribute to every day lives; eg. WWW
  - Why do we do with this?
    - Make our and future generation's everyday life better

The Particle Physics Standard Model

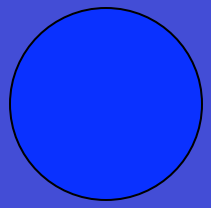
- Assumes the following fundamental structure:



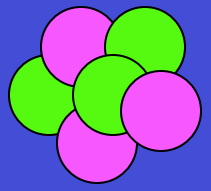
- Three families of leptons and quarks together with 12 force mediators ➔ Simple and elegant!!!

Accelerators are Powerful Microscopes.

They make high energy particle beams that allow us to see small things.



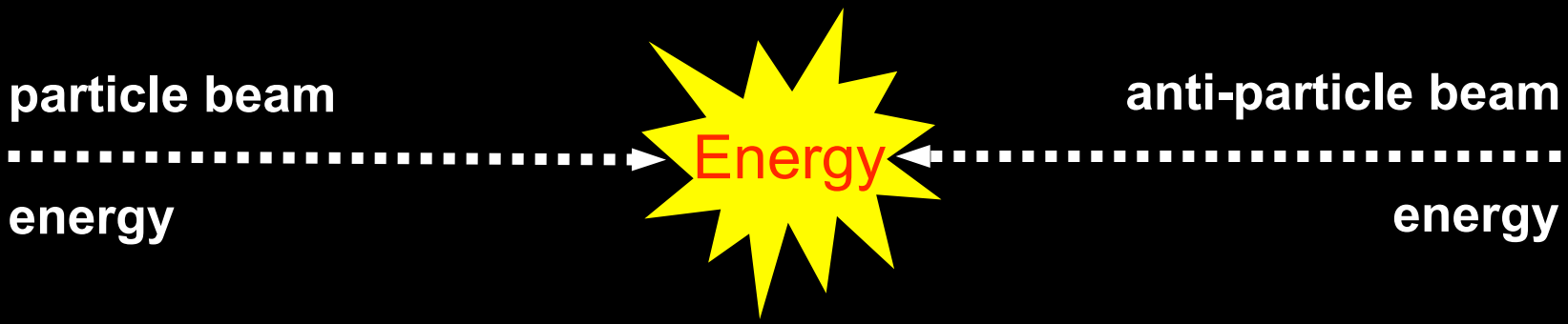
seen by
low energy beam
(poorer resolution)



seen by
high energy beam
(better resolution)

Accelerators are also Time Machines.

They make particles last seen
in the earliest moments of the universe.

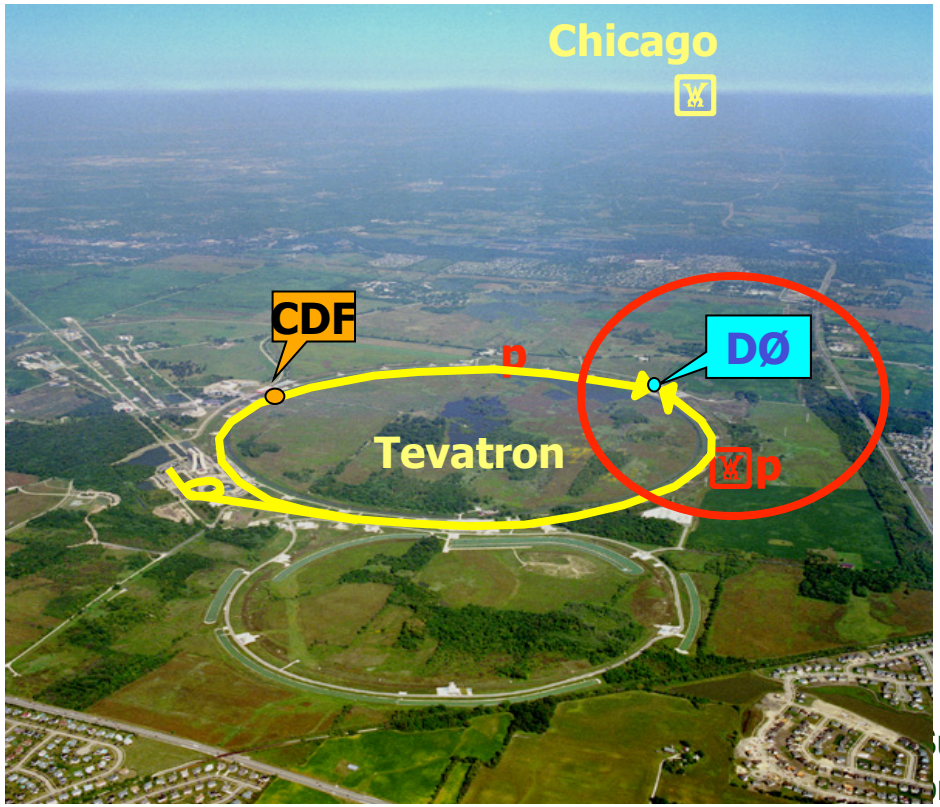


Particle and anti-particle annihilate.

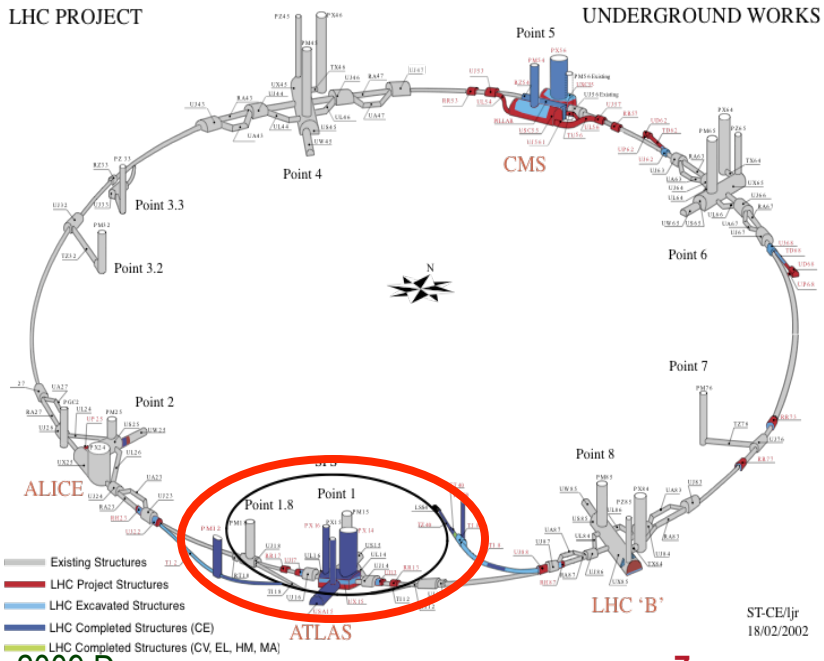
$$E = mc^2$$

Fermilab Tevatron and LHC at CERN

- Present world's Highest Energy proton-anti-proton collider
  - 4km circumference
  - E_{cm}=1.96 TeV (=6.3x10^{-7}J/p➔ 13M Joules on 10^{-4}m^2)
  - Þ Equivalent to the kinetic energy of a 20t truck at a speed 81mi/hr➔ 130km/hr



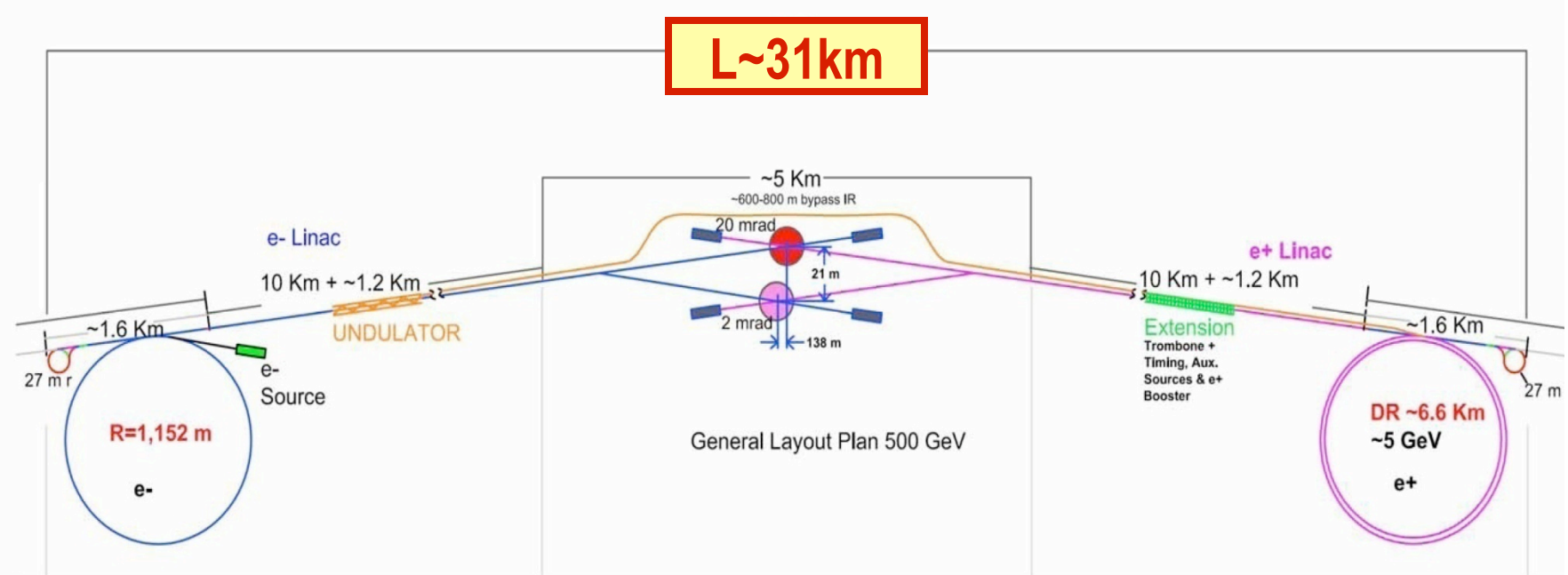
- World's Highest Energy proton-proton collider summer this year
  - 27km circumference
  - E_{cm}=14 TeV (=44x10^{-7}J/p➔ 1000M Joules on 10^{-4}m^2)
  - Þ Equivalent to the kinetic energy of a 20t truck at a speed 711mi/hr➔1140km/hr
  - Þ Was turned on Sept. 08 but an accident shut it down



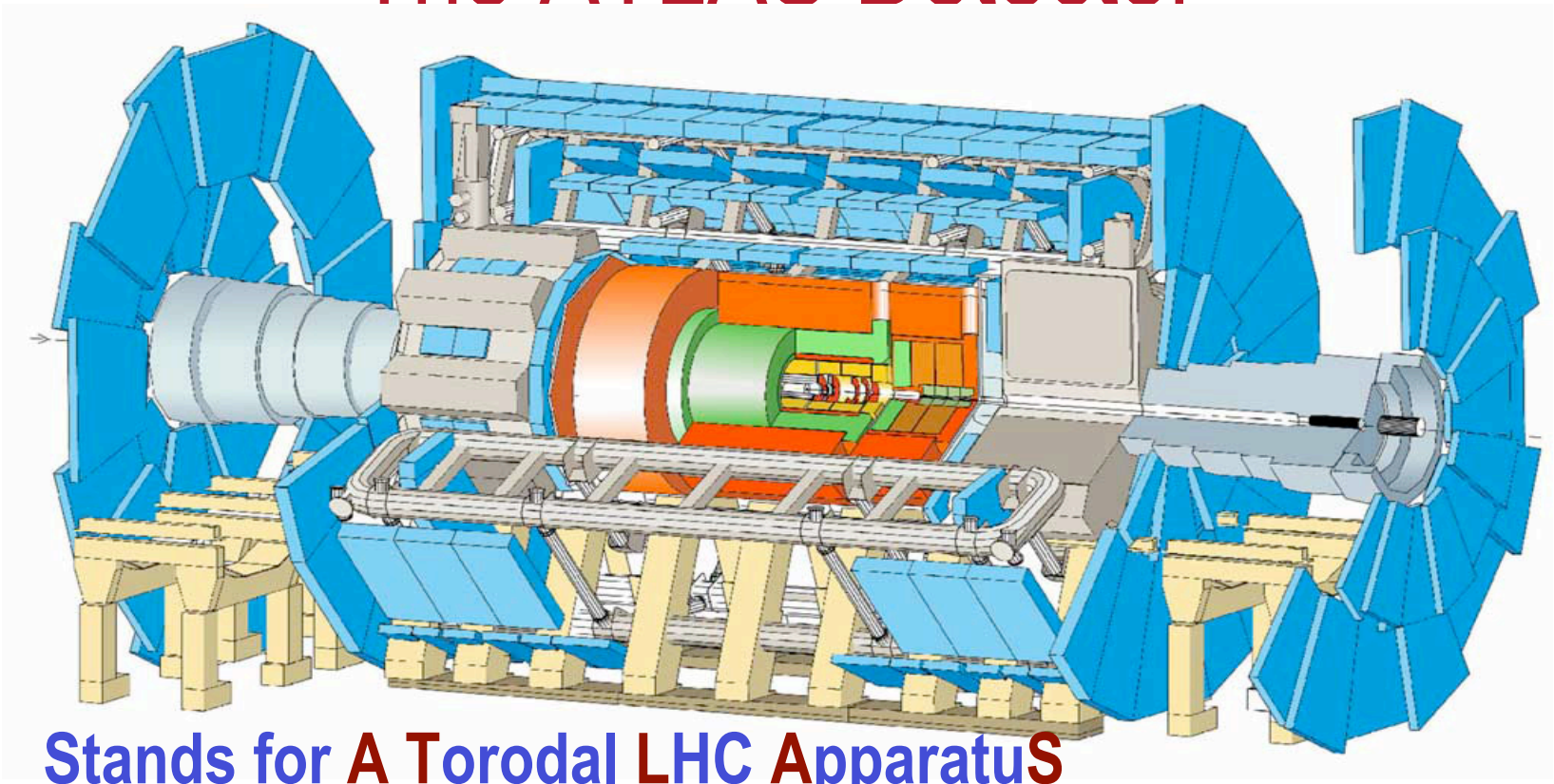
LHC @ CERN Aerial View

The International Linear Collider

- An electron-positron collider on a straight line
- CMS Energy: 0.5 – 1 TeV
- 10~15 years from now
- Takes 10 years to build the accelerator and the detector

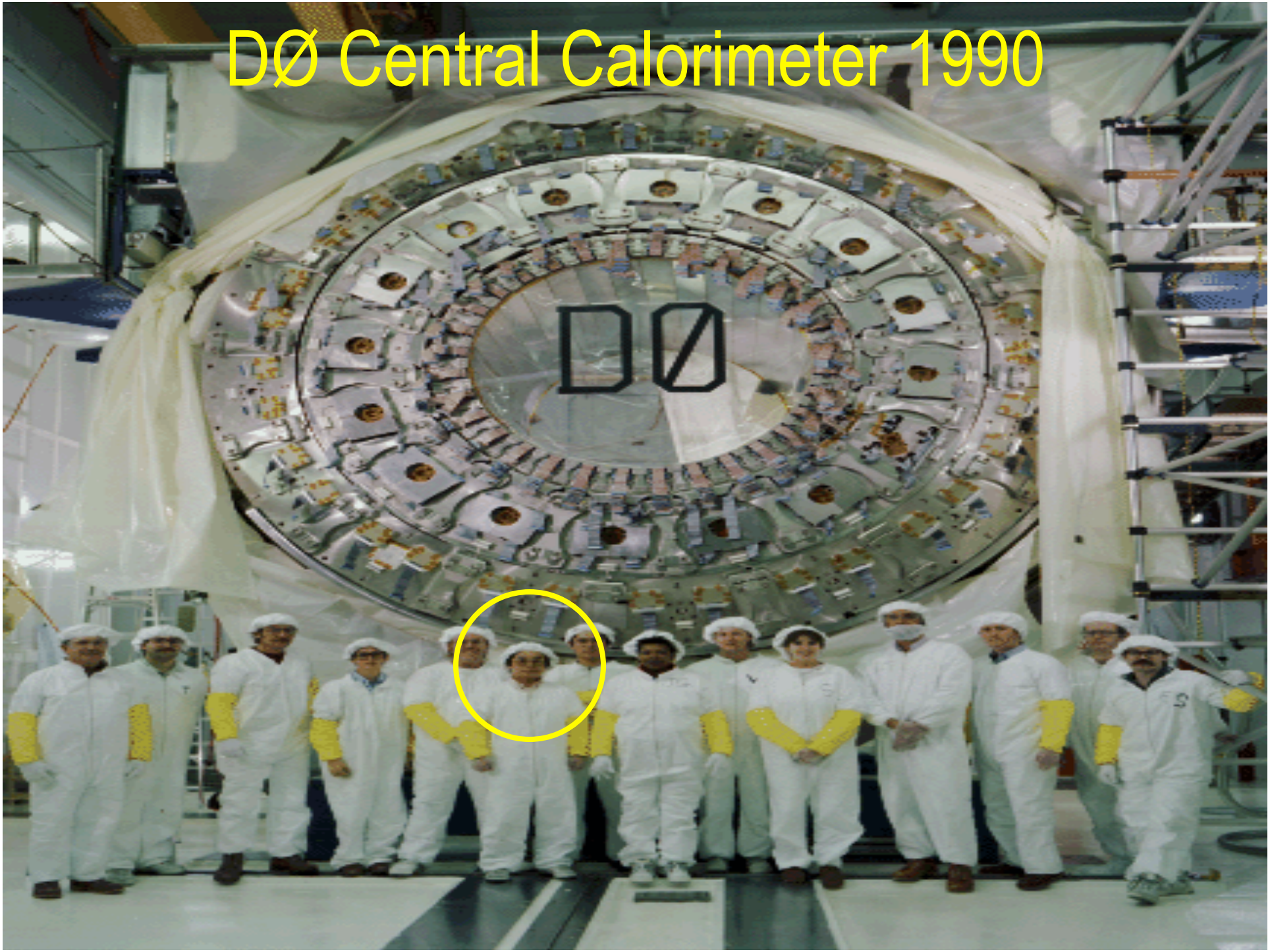


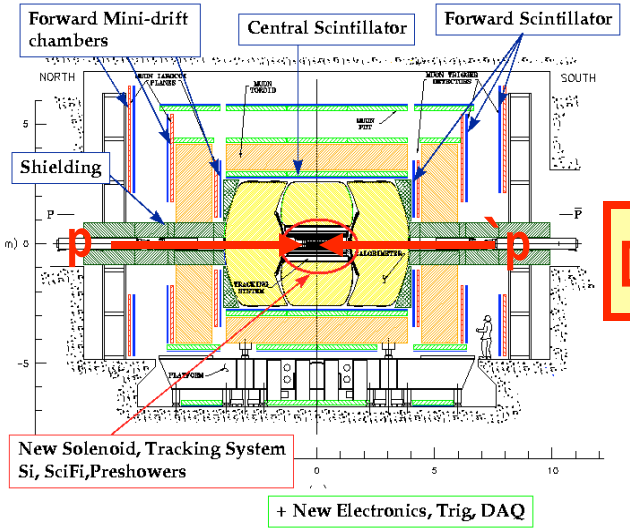
The ATLAS Detector



- **Stands for A Torodal LHC ApparatuS**
- **Weighs 10000 tons and 10 story tall**
- Can inspect **1,000,000,000** collisions/second
- Will record **100 – 200 pp collisions/second**
- Will record over **2×10^{15}** (2,000,000,000,000,000) bytes each year (2 PetaBytes).

DØ Central Calorimeter 1990

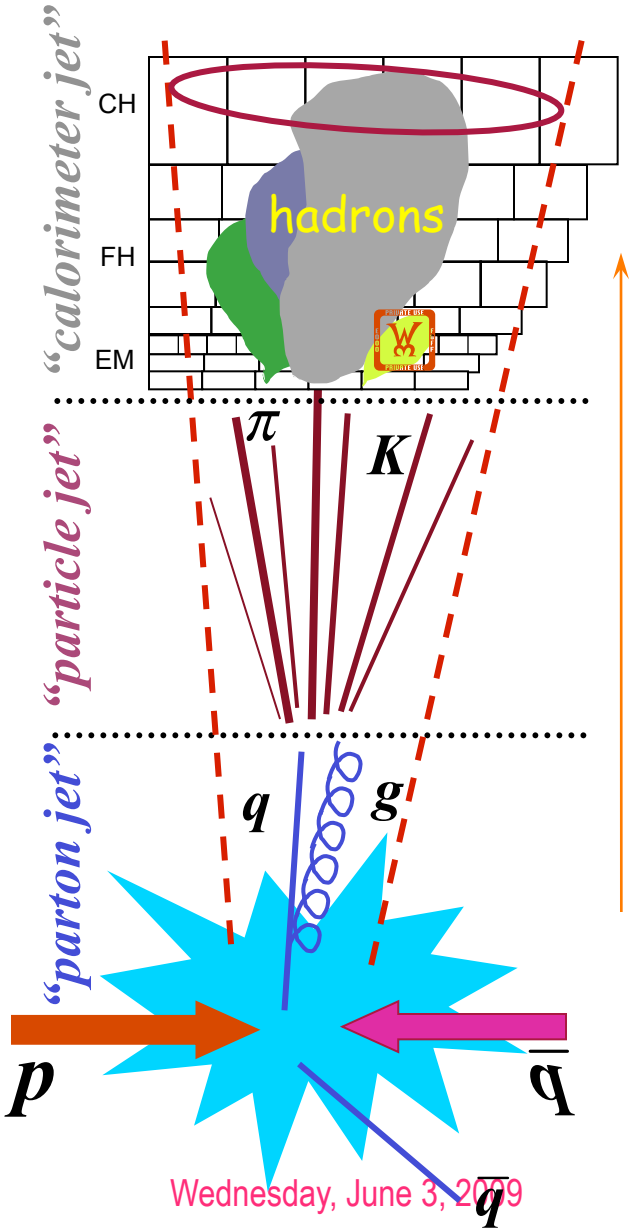


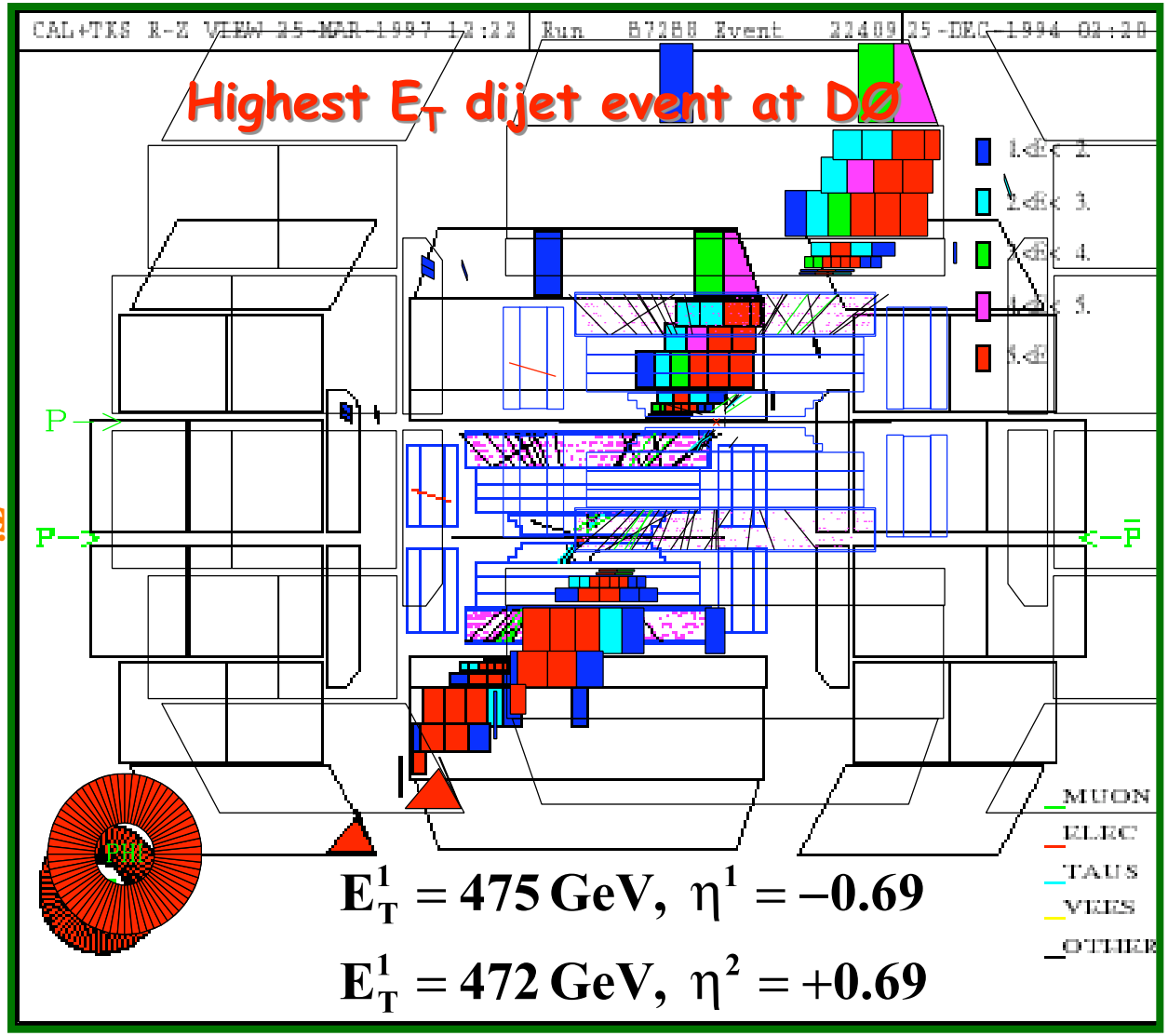


Digital data

Data Reconstruction

How does an Event Look in a Collider Detector?





Information & Communication Sources

- My web page: http://www-hep.uta.edu/~yu/
  - Contact information & Class Schedule
  - Syllabus
  - Homework
  - Holidays and Exam days
  - Evaluation Policy
  - Class Style & Communication
  - Other information
- Primary communication tool is e-mail: Register for PHYS1442-001-SUMMER09 e-mail distribution list as soon possible ➔ Instruction available in Class style & Communication
  - 5 points extra credit if done by next Monday, June 8
  - 3 points extra credit if done by next Wednesday, June 10
- Office Hours: 4:55 – 5:55pm, Mondays and Wednesdays or by appointment

Evaluation Policy

- Homework: 30%, single largest proportion!!
- Exams
  - Final Comprehensive Exam (8/12): 25% each
  - One better of the two term Exams: 20%
    - Total of two non-comprehensive term exams (6/29 and 7/29)
    - One better of the two exams will be used for the final grade
    - Missing an exam is not permissible unless pre-approved
      - No makeup test
      - You will get an F if you miss any of the exams without a prior approval
- Lab score: 15%
- Pop-quizzes: 10%

100%

- Extra credits: 10% of the total
  - Random attendances
  - Special projects
  - Strong participation in the class discussions
  - Planetarium shows and Other many opportunities
- Grading will be done on a sliding scale

Homeworks

- Solving homework problems yourself is the only way to comprehend class material
- An electronic homework system has been setup for you
  - Details are in the material distributed today and on the class web page
  - Student hw page link: https://quest.cns.utexas.edu/student/
  - Download homework #1, solve it, and submit it!!
  - Roster will close Wednesday, June 10
  - Warning: You will get points deducted if you input incorrect answers
    - For multiple choice problems, you could get negative points if you try too many times
- Each homework carries the same weight
- **ALL** homework grades will be used for the final grade
- Home work constitutes **30% of the total** ➔ A good way of keeping your grades high
- Strongly encouraged to collaborate ➔ Does not mean you can copy

Attendances and Class Style

- Attendances:
  - Will be taken randomly
  - Will be used for extra credits
- Class style:
  - Lectures will be on electronic media
    - The lecture notes will be posted on the web **AFTER** each class
  - Will be mixed with traditional methods
  - Active participation through questions and discussions are **STRONGLY** encouraged ➔ Extra credit….
  - Communication between you and me is extremely important
    - If you have problems, please do not hesitate talking to me

Lab and Physics Clinic

- Physics Labs:
  - Begins on June 8, next Monday
  - Important to understand physical principles through experiments
  - 15% of the grade
- Physics Clinic:
  - Free service
  - They provide general help on physics, including help solving homework problems
    - Do not expect answers from them
    - Do not expect them to tell you whether your answers are correct
    - It is your responsibility to make sure that you have done correctly
  - 12 – 6pm, Monday – Thursday
  - SH 224

What can you expect from this class?

- All A's?
  - This would be really nice, wouldn't it?
  - But if it is too easy it is not fulfilling or meaningful….
- This class is not going to be a stroll in the park!!
- You will earn your grade in this class.
  - You will need to put in sufficient time and sincere efforts
  - Exams and quizzes will be tough!
    - Sometimes problems might not look exactly like what you learned in the class
    - Just putting the right answer in free response problems does not work!
- But you have a great control for your grade in your hands
  - Homework is 30% of the total grade!!
    - Means you will have many homework problems
      - Sometimes much more than any other classes
      - Sometimes homework problems will be something that you have yet to learn in class
  - Lab 15%
  - Extra credit 10%
- I will work with you so that your efforts are properly awarded

What do we want to learn in this class?

- Physics is everywhere around you.
- Understand the fundamental principles that surrounds you in everyday lives…
- Identify what laws of physics applies to what phenomena and use them appropriately
- Understand the impact of such physical laws
- Learn how to research and analyze what you observe.
- Learn how to express observations and measurements in mathematical language
- Learn how to express your research in systematic manner in writing
- I don't want you to be scared of PHYSICS!!!

Most of importantly, let us have a lot of FUN!!

Brief History of Physics

- AD 18th century:
  - Newton's Classical Mechanics: A theory of mechanics based on observations and measurements accumulated throughout the human history
- AD 19th Century:
  - Electricity, Magnetism, and Thermodynamics
- Late AD 19th and early 20th century (Modern Physics Era)
  - Einstein's theory of relativity: Generalized theory of space, time, and energy (mechanics)
  - Quantum Mechanics: Theory of atomic phenomena
- Physics has come very far, very fast, and is still progressing, yet we've got a long way to go
  - What is matter made of?
  - How do matters get mass?
  - How and why do matters interact with each other?
  - How is universe created?

Needs for Standards and Units

- Three basic quantities for physical measurements
  - Length, Mass, and Time
- Need a language that everyone can understand each other
  - Consistency is crucial for physical measurements
  - The same quantity measured by one must be comprehendible and reproducible by others
  - Practical matters contribute
- A system of unit called **SI** (*System International*) established in 1960
  - Length in meters (m)
  - Mass in kilo-grams (kg)
  - Time in seconds (s)

SI Base Quantities and Units

Quantity	Unit	Unit Abbrevation
Length	Meter	m
Time	Second	s
Mass	Kilogram	kg
Electric current	Ampere	A
Temperature	Kelvin	k
Amount of substance	Mole	mol
Luminous Intensity	Candela	cd

- *There are prefixes that scales the units larger or smaller for convenience (see pg. 7)*

Prefixes, expressions and their meanings

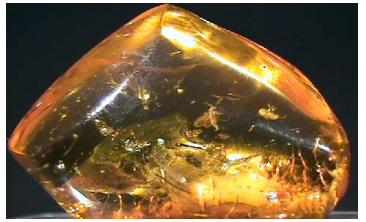
- deca (da): 10^{1}
- hecto (h): 10^{2}
- kilo (k): 10^{3}
- mega (M): 10^{6}
- giga (G): 10^{9}
- tera (T): 10^{12}
- peta (P): 10^{15}
- exa (E): 10^{18}
- deci (d): 10^{-1}
- centi (c): 10^{-2}
- milli (m): 10^{-3}
- micro (m): 10^{-6}
- nano (n): 10^{-9}
- pico (p): 10^{-12}
- femto (f): 10^{-15}
- atto (a): 10^{-18}

How do we convert quantities from one unit to another?

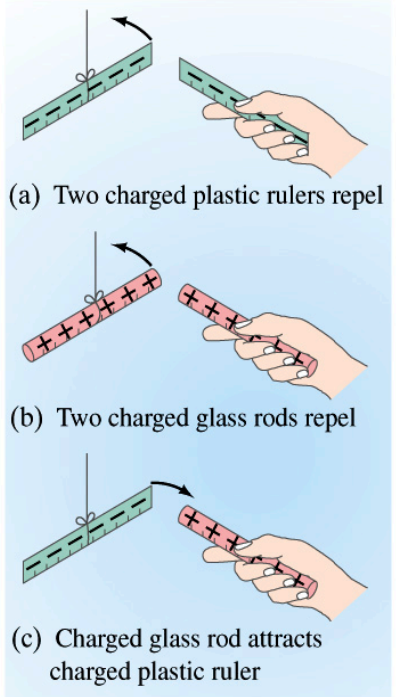
Unit 1 =	Conversion factor X	Unit 2
1 inch	2.54	cm
1 inch	0.0254	m
1 inch	2.54×10^{-5}	km
1 ft	30.3	cm
1 ft	0.303	M
1 ft	3.03×10^{-4}	km
1 hr	60	minutes
1 hr	3600	seconds
And many	More	Here….

Static Electricity; Electric Charge and Its Conservation

- Word electricity is from Greek word *elecktron*=amber, a petrified tree resin that attracts matter if rubbed



- Static Electricity: an amber effect
  - An object becomes charged or "posses a net electric charge" due to rubbing
  - Can you give some examples?
- Two types of electric charge
  - Like charges repel while unlike charges attract
  - Benjamin Franklin referred the charge on glass rod as the positive, arbitrarily. Thus the charge that attracts glass rod is negative. ➔ This convention is still used.
- Electric Charges are quantized!



Static Electricity; Electric Charge and Its Conservation

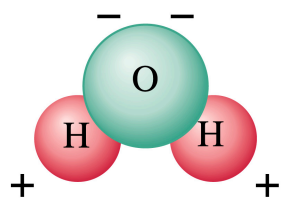
- Franklin argued that when a certain amount of charge is produced on one body in a process, an equal amount of opposite type of charge is produced on another body.
  - The positive and negative are treated algebraically so that during any process the net change in the amount of produced charge is 0.
    - When you comb your hair with a plastic comb, the comb acquires a negative charge and the hair an equal amount of positive charge.
- This is the **law of conservation of electric charge.**
  - **The net amount of electric charge produced in any process is ZERO!!**
    - If one object or one region of space acquires a positive charge, then an equal amount of negative charge will be found in neighboring areas or objects.
    - No violations have ever been observed.
    - This conservation law is as firmly established as that of energy or momentum.

Electric Charge in the Atom

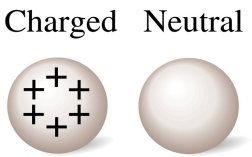
- It has been understood through the past century that an atom consists of
  - A positively charged heavy core ← What is its name?
    - This core is nucleus and consists of neutrons and protons.
  - Many negatively charged light particles surround the core ← What is the name of these light particles?
    - These are called electrons
    - How many of these?

As many as the number of protons!!

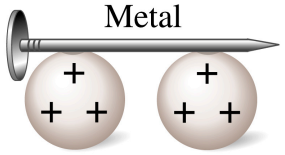
- So what is the net electrical charge of an atom?
  - Zero!!! Electrically neutral!!!
- Can you explain what happens when a comb is rubbed on a towel?
  - Electrons from towel get transferred to the comb, making the comb negatively charged while leaving positive ions on the towel.
  - These charges eventually get neutralized primarily by water molecules in the air, that are polar.



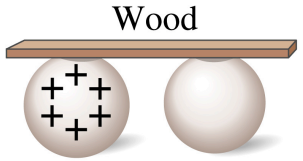
Insulators and Conductors



- Let's imagine two metal balls of which one is charged
- What will happen if they are connected by
  - A metallic object?
    - Some charge is transferred.
    - These objects are called conductors of electricity.
  - A wooden object?
    - No charge is transferred
    - These objects are called nonconductors or insulators.



(b) Conductor

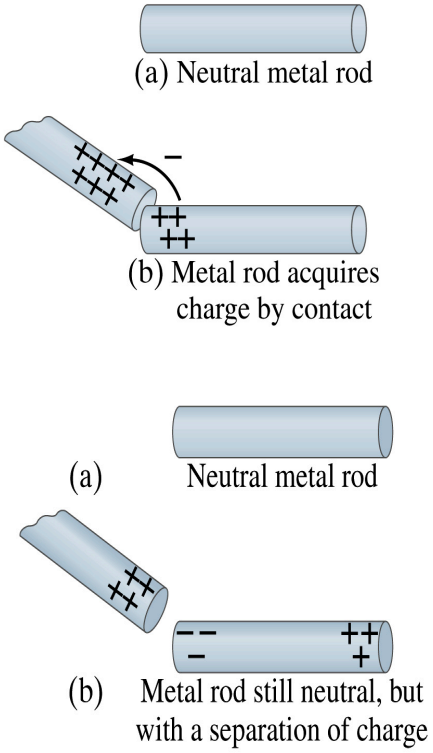


(c) Insulator

- Metals are generally good conductors whereas most other materials are insulators.
  - There are third kind of materials called, semi-conductors, like silicon or germanium ➔ conduct only in certain conditions
- Atomically, conductors have loosely bound and easily freed electrons while insulators have them tightly bound!

Induced Charge

- When a positively charged metal object is brought close to an uncharged metal object
  - If the objects touch each other, the free electrons in the neutral ones are attracted to the positively charged object and some will pass over to it, leaving the neutral object positively charged.
  - If the objects get close, the free electrons in the neutral ones still move within the metal toward the charged object leaving the opposite of the object positively charged.
    - The charges have been "induced" in the opposite ends of the object.



Induced Charge

- We can induce a net charge on a metal object by connecting a wire to the ground.
  - The object is “grounded” or “earthed”.
- Since it is so large and conducts, the Earth can give or accept charge.
  - The Earth acts as a reservoir for charge.
- If the negative charge is brought close to a neutral metal
  - The positive charges will be induced toward the negatively charged metal.
  - The negative charges in the neutral metal will be gathered on the opposite side, transferring through the wire to the Earth.
  - If the wire is cut, the metal bar has net positive charge.
- An **electroscope** is a device that can be used for detecting charge and signs.
  - How would this work?