PHYS 1444 – Section 003
Lecture #1

Monday, Aug. 29, 2005

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 21
  - Static Electricity and Charge Conservation
  - Charges in Atom
  - Insulators and Conductors
  - Induced Charge

Today's homework is homework #2, due noon, next Monday!!

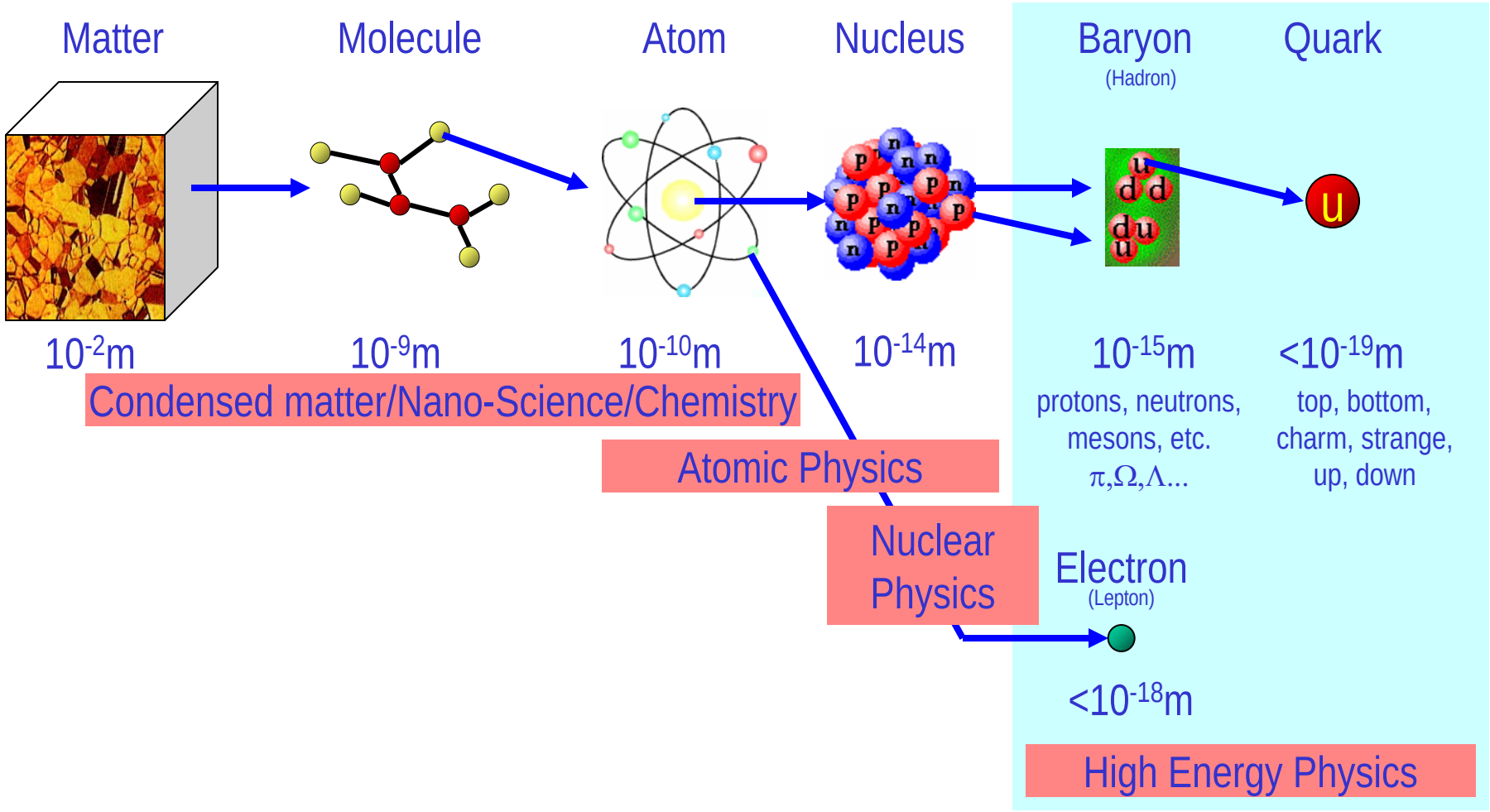
Announcements

- Plea to you: Please turn off your cell-phones, pagers and computers
- Reading assignment #1: Read and follow through all sections in appendix A by Wednesday, Sept. 1
  - A-1 through A-7
- There will be a quiz on this and Ch. 21 on Wednesday, Sept. 7.

Who am I?

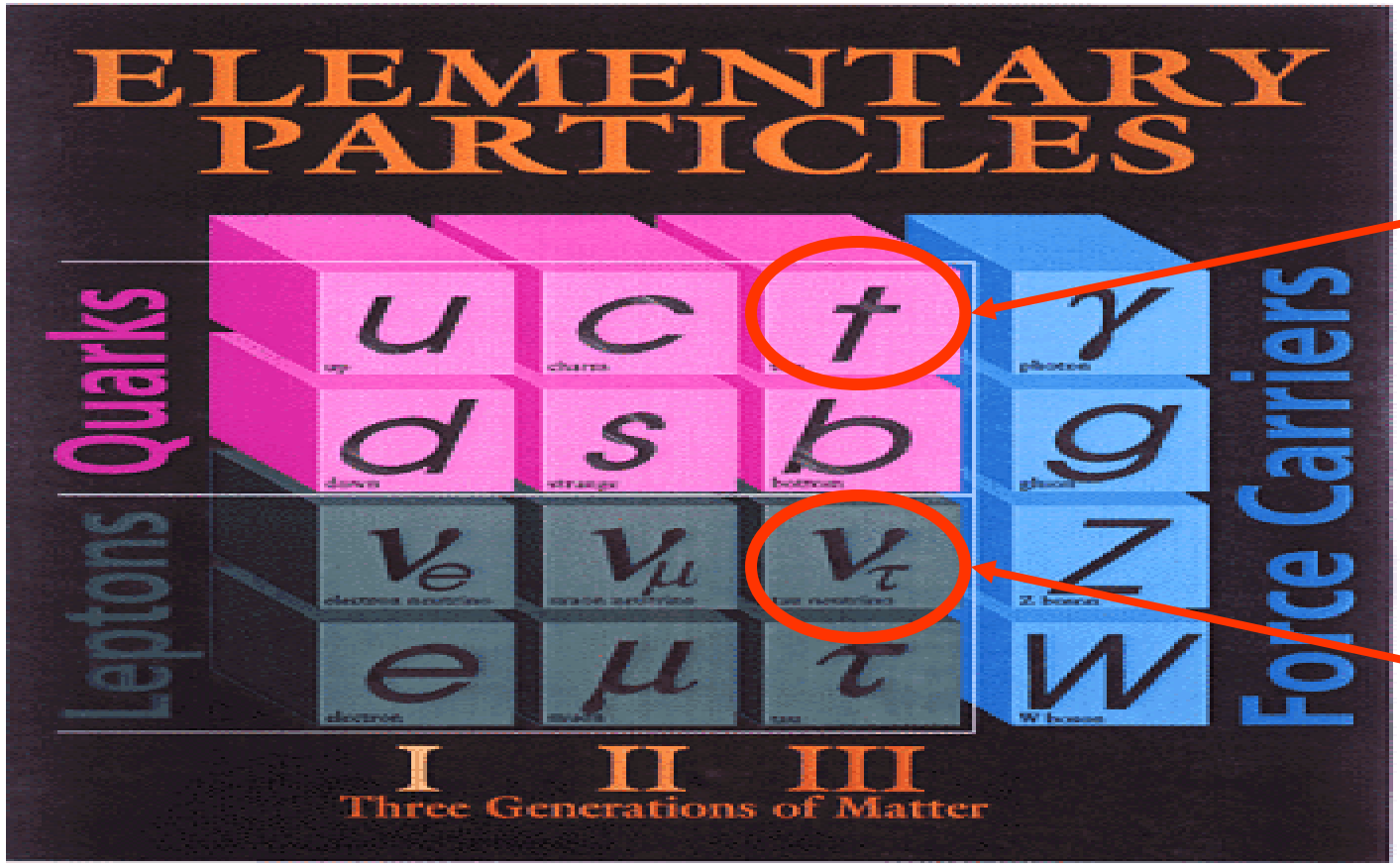
- Name: Dr. Jaehoon Yu (You can call me Dr. Yu)
- Office: Rm 242A, Science Hall
- Extension: x22814, E-mail: *jaehoonyu@uta.edu*
- My profession:High Energy Physics (HEP)
  - Collide particles (protons on anti-protons or electrons on anti-electrons, positrons) at the energies equivalent to 10,000 Trillion degrees
  - To understand
    - Fundamental constituents of matter
    - Forces between the constituents (gravitational, electro-magnetic, weak and strong forces)
    - Origin of Mass
    - Creation of 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

Structure of Matter



The Standard Model

- Assumes the following fundamental structure:



Discovered in 1995

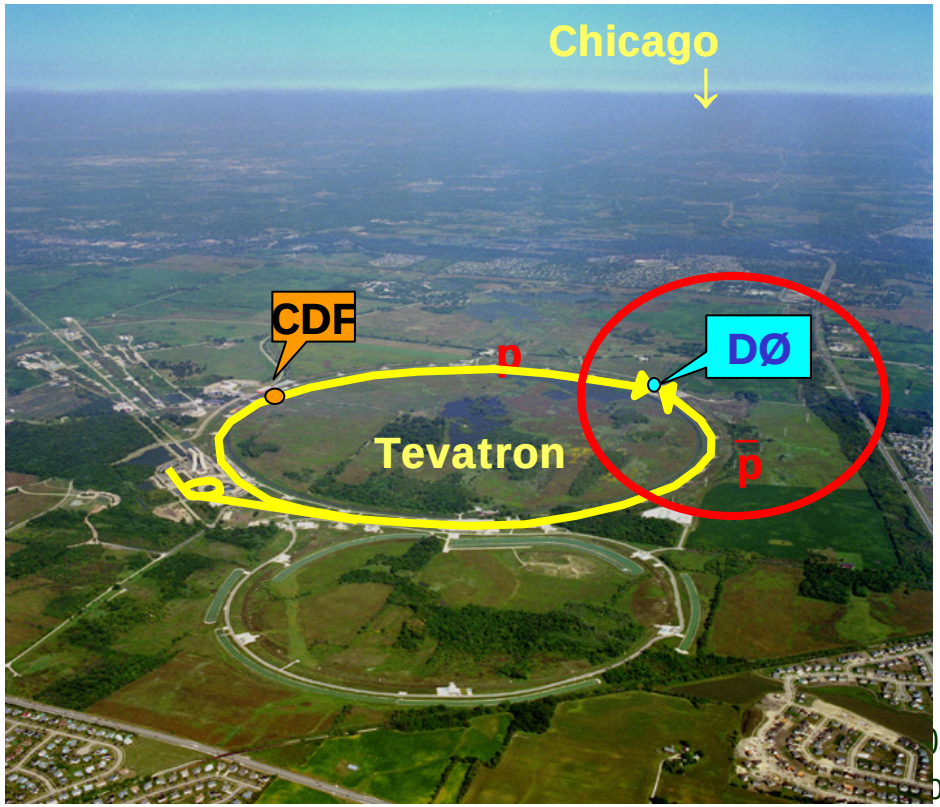
Directly observed in 2000

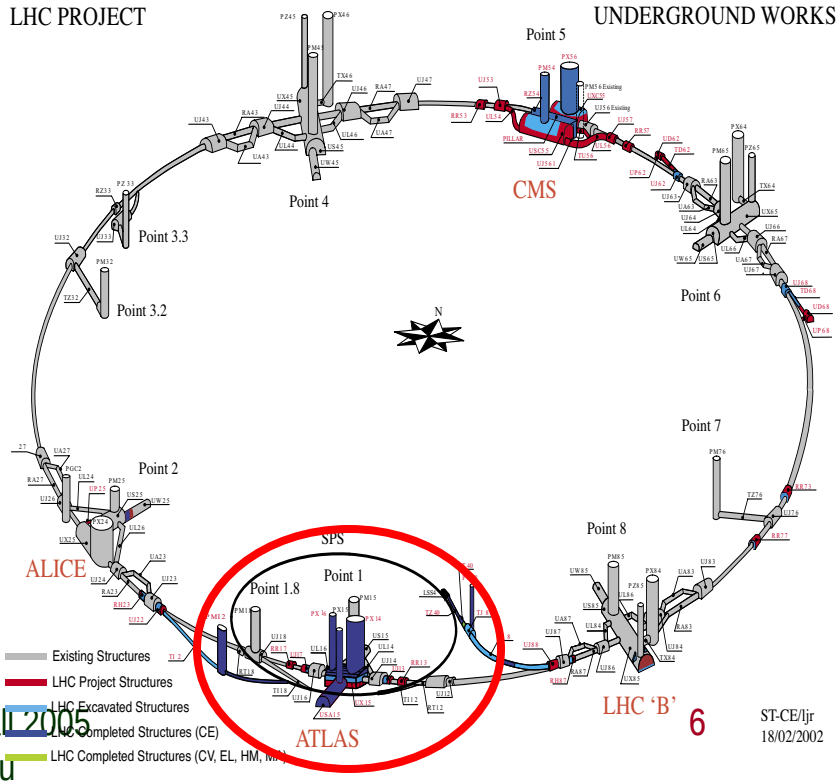
Fermilab Tevatron and LHC at CERN

- Present world's Highest Energy proton-anti-proton collider
  - E_{cm}=1.96 TeV (=6.3x10^{-7}J/p➔ 13M Joules on 10^{-4}m^2)

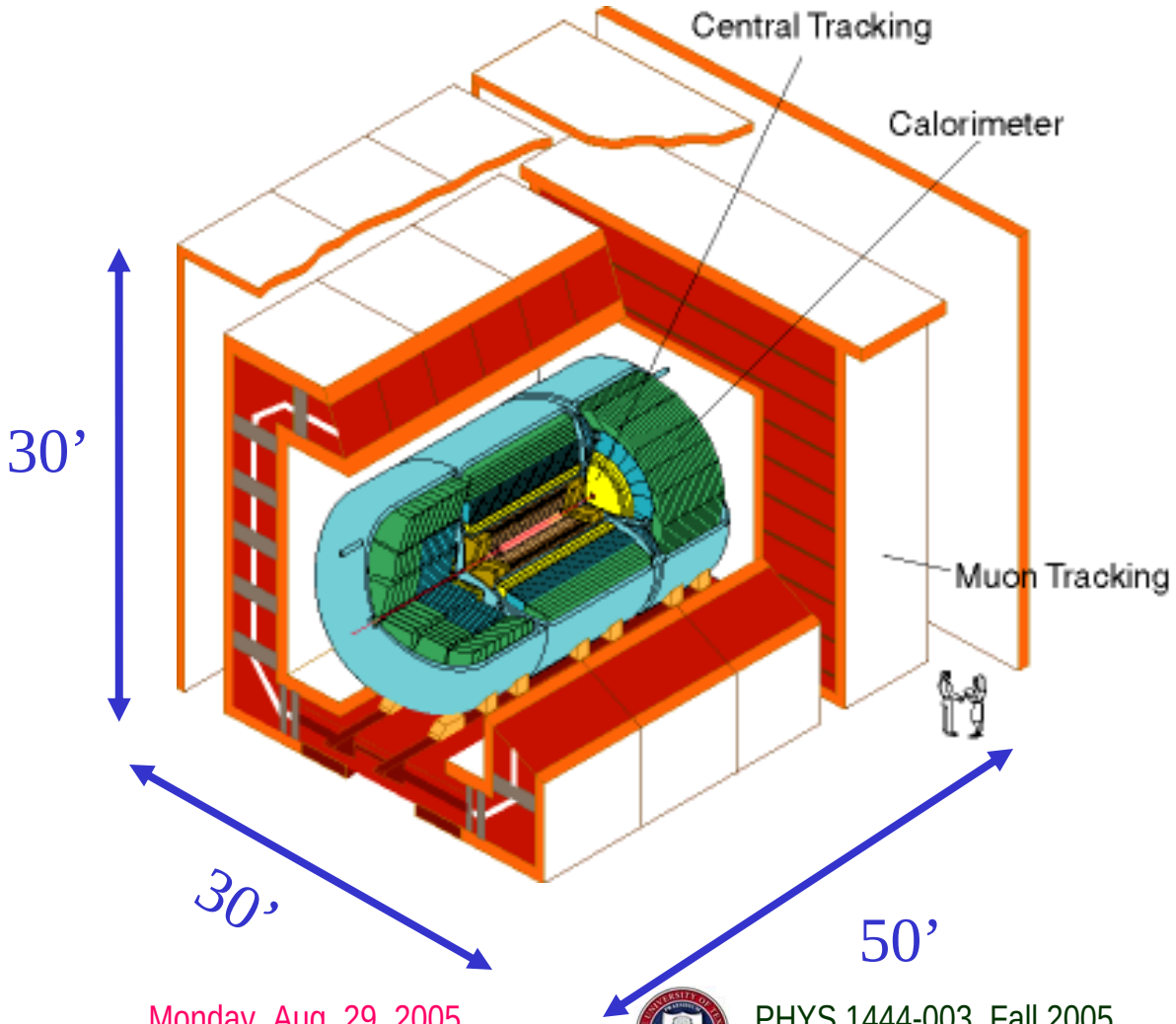
  ⇒Equivalent to the kinetic energy of a 20t truck at a speed 80 mi/hr
- World's Highest Energy proton-proton collider in 2 years
  - E_{cm}=14 TeV (=44x10^{-7}J/p➔ 1000M Joules on 10^{-4}m^2)

  ⇒Equivalent to the kinetic energy of a 20t truck at a speed 212 mi/hr



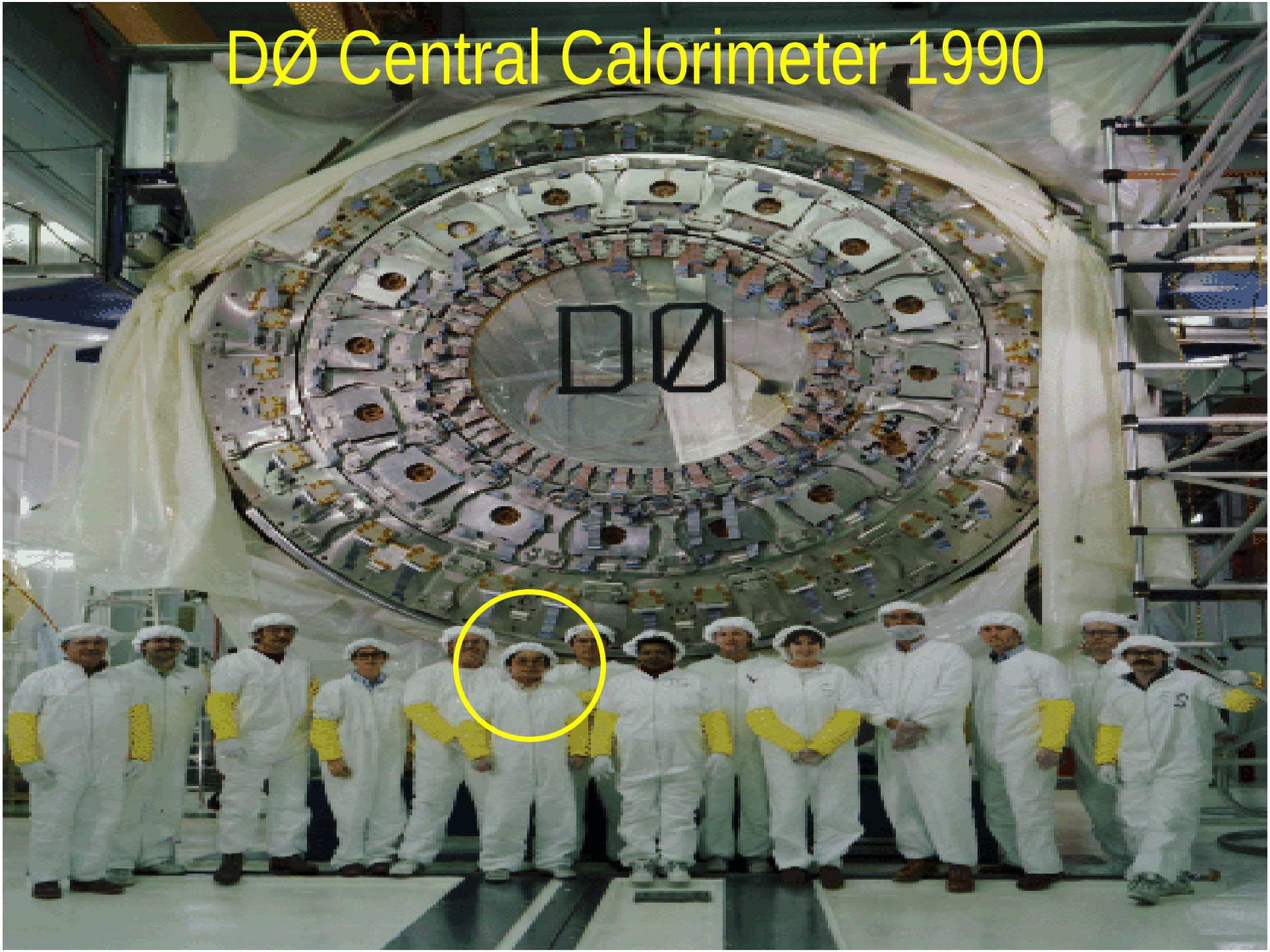


DØ Detector: Run II

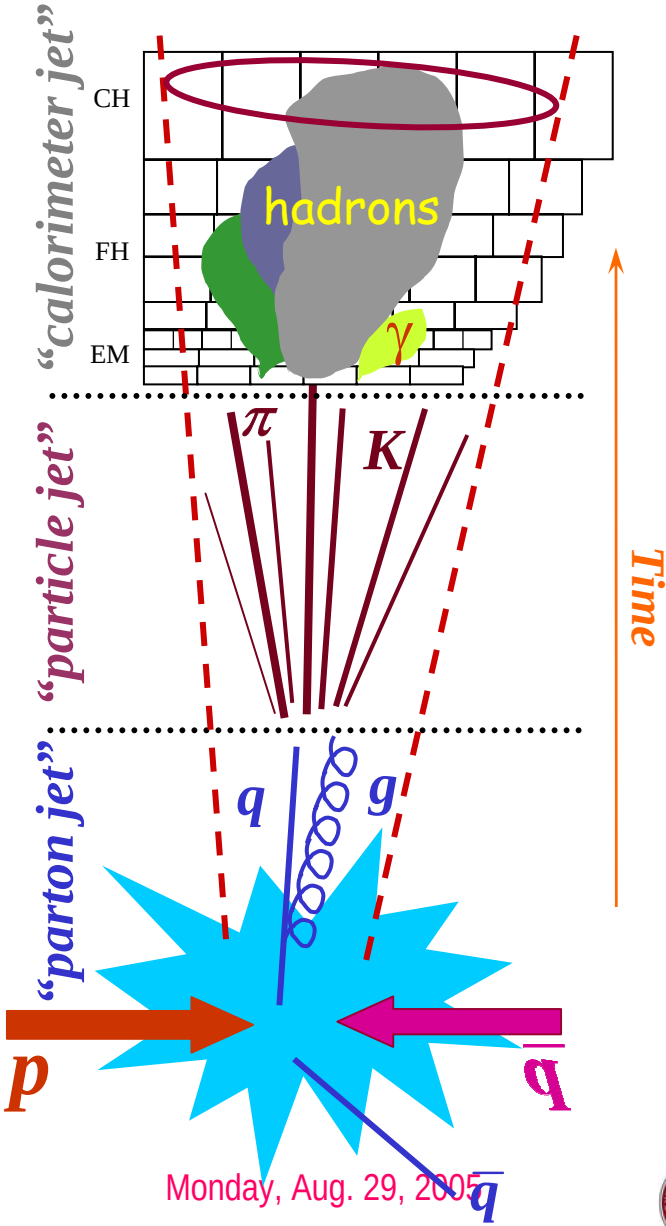


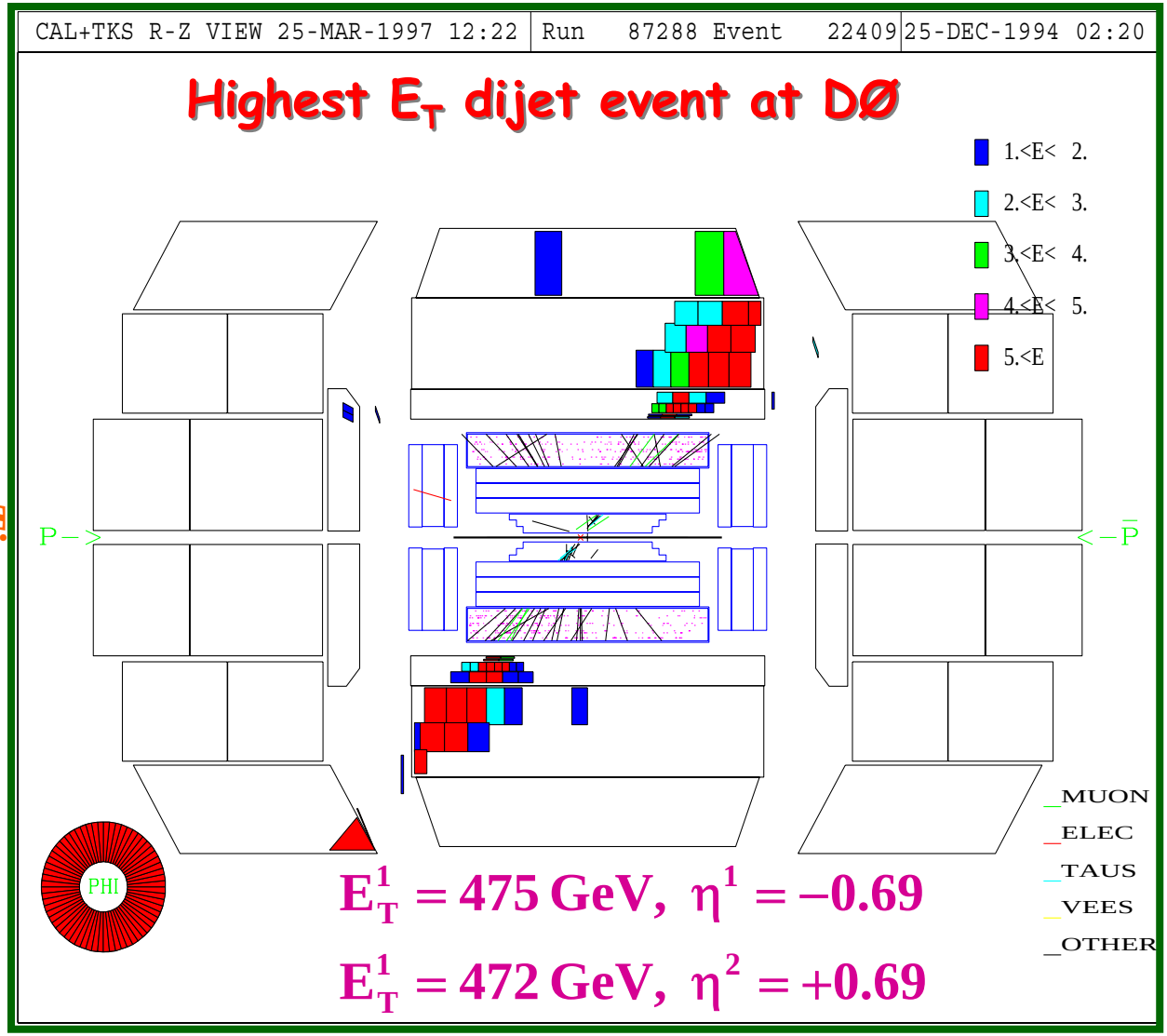
- Weighs 5000 tons
- Can inspect 3,000,000 collisions/second
- Will record 50 collisions/second
- Records ~12.5M Bytes/second
- Will record 2 Peta bytes in the current run.
- Has over a 100 million parts

DØ Central Calorimeter 1990



How does an Event Look in a Collider Detector?





Information & Communication Source

- 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 PHYS1444-003-FALL05 e-mail distribution list as soon possible ➔ Instruction available in Class style & Communication
  - 5 points extra credit if done by this Wednesday, Aug. 31
  - 3 points extra credit if done by next Wednesday, Sept. 7
- Office Hours: 2:30 – 3:30pm, Mondays and Wednesdays or by appointments
  - My office door is wide open for you!!!

Evaluation Policy

- Term Exams: 45%
  - Total of three non-comprehensive term exams (10/12, 11/9 & 12/5)
  - Best two of the three will be used for the final grade
  - Each will constitute 22.5% of the total
  - 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: 20%
- Homework: 20%
- Pop-quizzes: 15%

100%

- Extra credits: 10% of the total
  - Random attendances
  - Strong participation in the class discussions
  - Other many opportunities
- Will be on sliding scale unless everyone does very well

Homeworks

- Solving homework problems is the only way to comprehend class material
- An electronic homework system has been setup for you
  - Details are in the material distributed last week and on the web
  - https://hw.utexas.edu/studentInstructions.html
  - Download homework #1 (1 problem), attempt to solve it, and submit it ➔ You will receive a 100% credit for HW#1
    - This HW is due at 6pm today. So you still have some time to take advantage!
  - Roster will close next Wednesday, Sept. 7
    - 16 of you have already signed up and solved the problem!! Great job!!!
- Each homework carries the same weight!!
- Home work will constitute 20% of the total ➔ A good way of keeping your grades high
- Strongly encouraged to collaborate ➔ Does not mean you can copy
- Take advantage of the Physics Clinic: 12 – 6pm, M – F, SH008

Attendances and Class Style

- Attendances:
  - Will be taken randomly at the beginning of each class
  - 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….

Why do Physics?

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

Theory
- Establish limited number of fundamental laws, usually with mathematical expressions
- Predict the nature's course

⇒Theory and Experiment work hand-in-hand

⇒Theory works generally under restricted conditions

⇒Discrepancies between experimental measurements and theory are good for improvements

⇒Improves our everyday lives, though some laws can take a while till we see amongst us

What do we want from this class?

- Physics is everywhere around you.
- Understand the fundamental principles that surrounds you in everyday lives…
- Identify what law 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 languages.
- 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
- 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)

Definition of Base Units

SI Units	Definitions
1 *m (Length) = 100 cm*	One meter is the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second.
1 *kg (Mass) = 1000 g*	It is equal to the mass of the international prototype of the kilogram, made of platinum-iridium in International Bureau of Weights and Measure in France.
1 *s (Time)*	One second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Cesium 133 (C^{133}) atom.

- *There are prefixes that scales the units larger or smaller for convenience (see pg. 7)*
- *Units for other quantities, such as Kelvins for temperature, for easiness of use*

Prefixes, expressions and their meanings

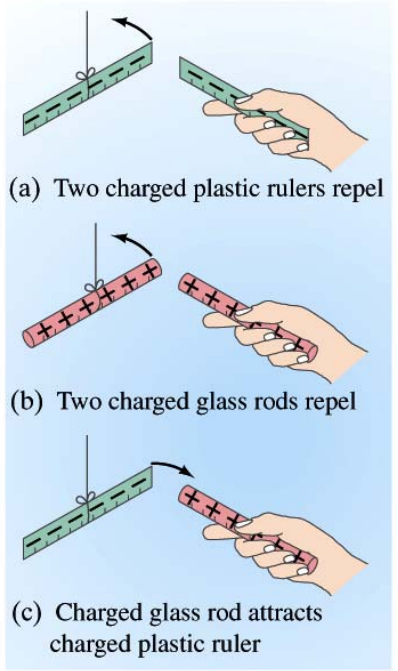
- deca (da): 10^{1}
- hecto (h): 10^{2}
- kilo (k): 10^{3}
- mega (M): 10^{6}
- giga (G): 10^{9}
- tera (T): 10^{12}
- peta (P): 10^{15}
- exa (E): 10^{18}
- deci (d): 10^{-1}
- centi (c): 10^{-2}
- milli (m): 10^{-3}
- micro (μ): 10^{-6}
- nano (n): 10^{-9}
- pico (p): 10^{-12}
- femto (f): 10^{-15}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

- 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.


(a) Two charged plastic rulers repel

(b) Two charged glass rods repel

(c) Charged glass rod attracts charged plastic ruler

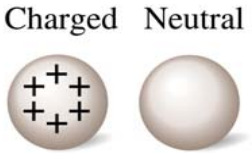
Static Electricity; Electric Charge and Its Conservation

- 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 found.
    - This conservation law is as firmly established as that of energy or momentum.

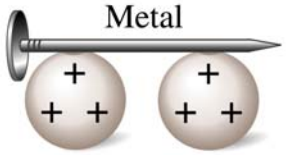
Electric Charge in the Atom

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

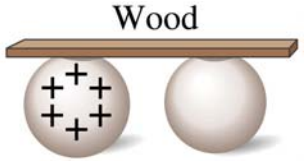
Insulators and Conductors



- 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

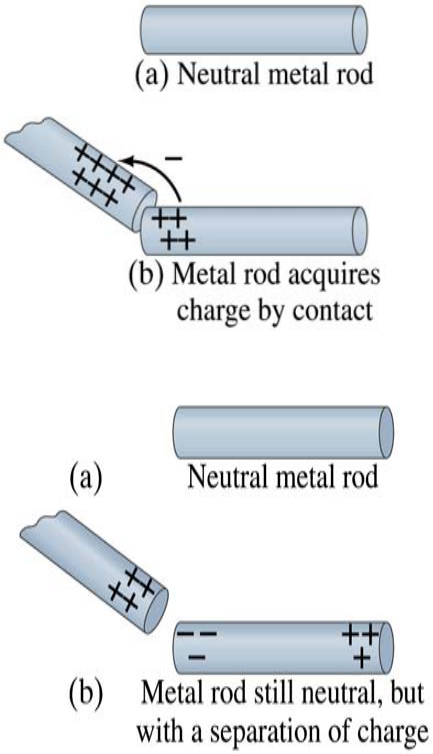


(c) Insulator

- 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 electrons while insulators have them tightly bound!

Induced Charge

- If 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 the 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.
  - How does this work?