PHYS 1443 – Section 001
Lecture #1

Tuesday, May 29, 2007
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
- Standards and units
- Dimensional Analysis
- Fundamentals
- One Dimensional Motion

Today's homework is homework #1, due 7pm, this Friday!!

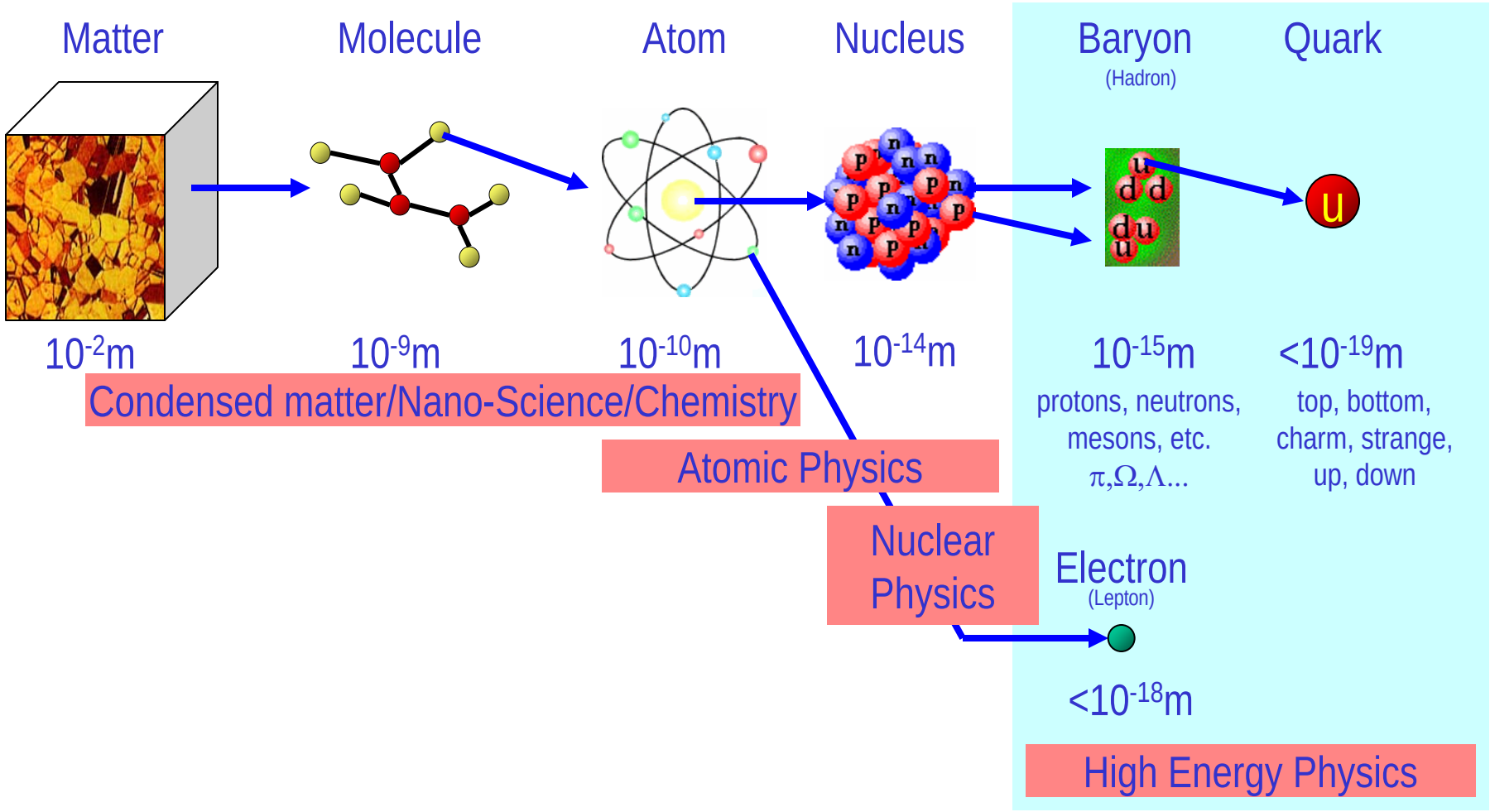
Announcements

- Reading assignment #1: Read and follow through all sections in appendices A and B by Thursday, May 31
  - There will be a quiz on Thursday, May 31, on this reading assignment
- Wednesday and Thursday classes will be taught by Mr. V. Kaushik
  - Tomorrow's class will be slightly shorter

Who am I?

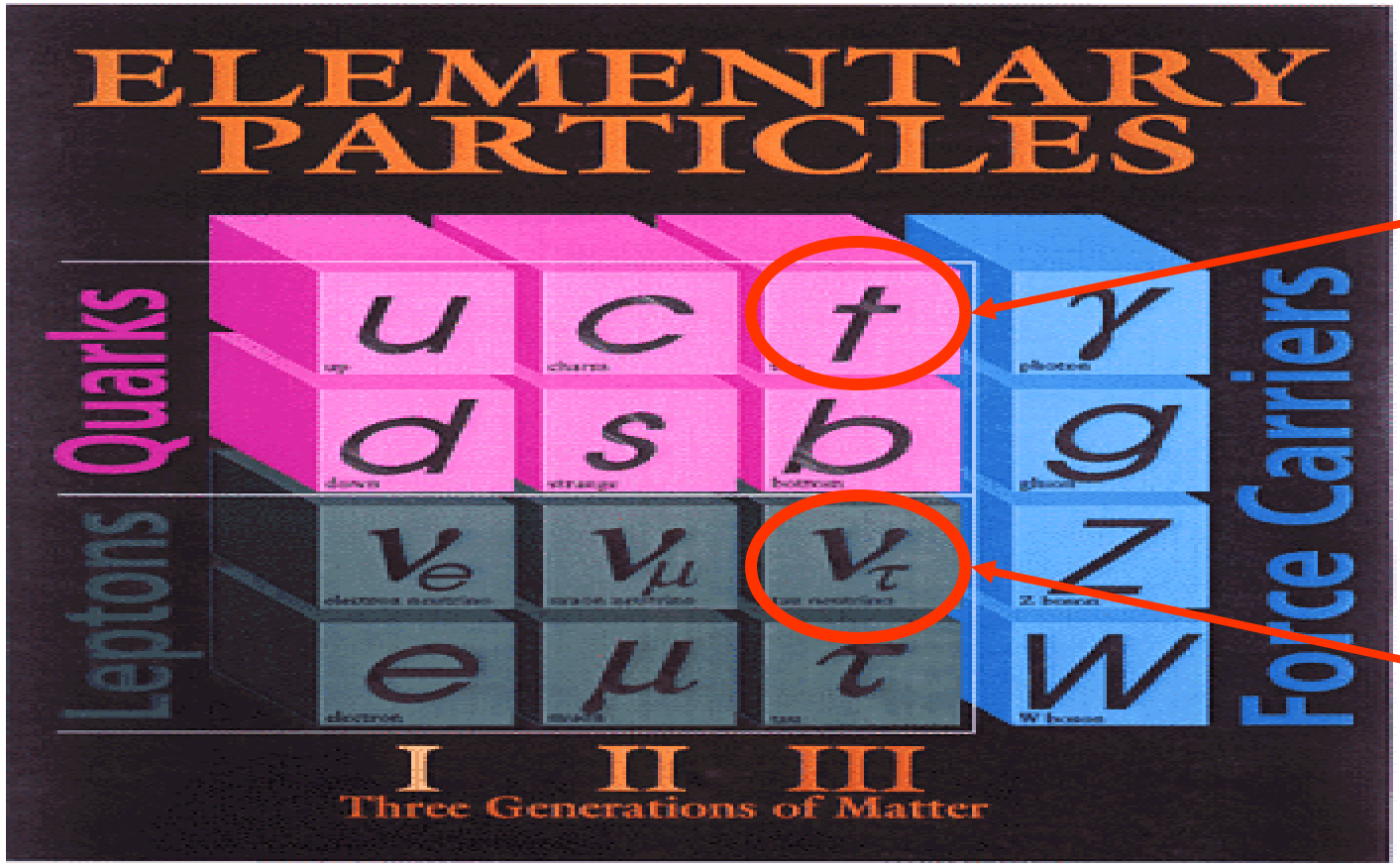
- Name: Dr. Jaehoon Yu (You can call me Dr. Yu)
- Office: Rm 342, Chemistry and Physics Building
- Extension: x22814, E-mail: *jaehoonyu@uta.edu*
- My profession:High Energy Physics (HEP)
  - Collide particles (protons on anti-protons or electrons on anti-electrons, positrons) at the energies equivalent to 10,000 Trillion degrees
  - To understand
    - Fundamental constituents of matter
    - Interactions or forces between the constituents
    - 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:

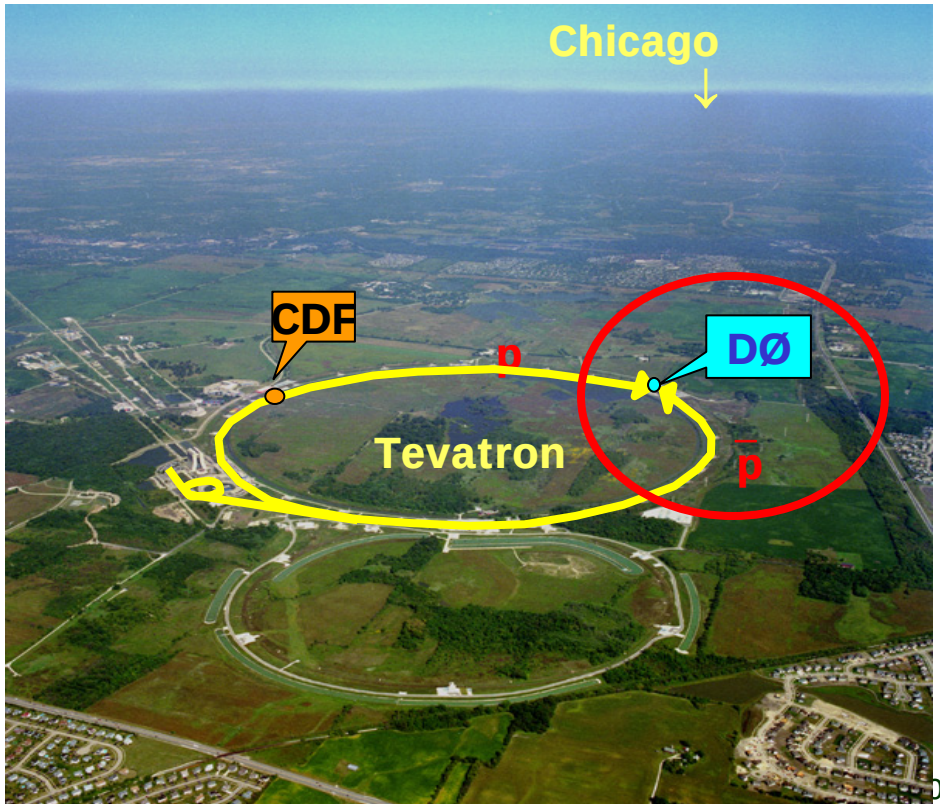


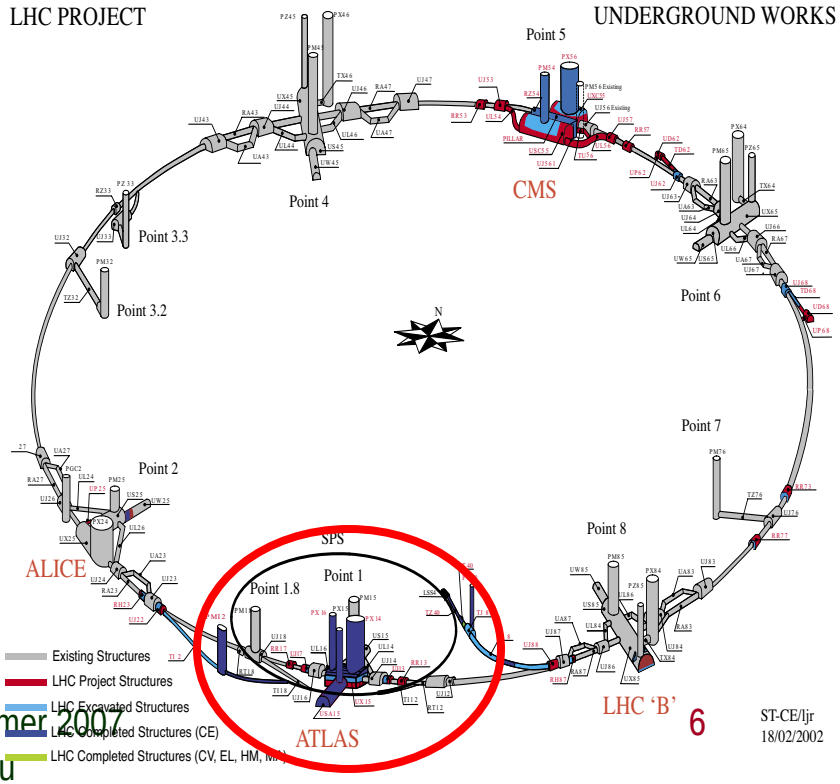
Discovered in 1995

Directly observed in 2000

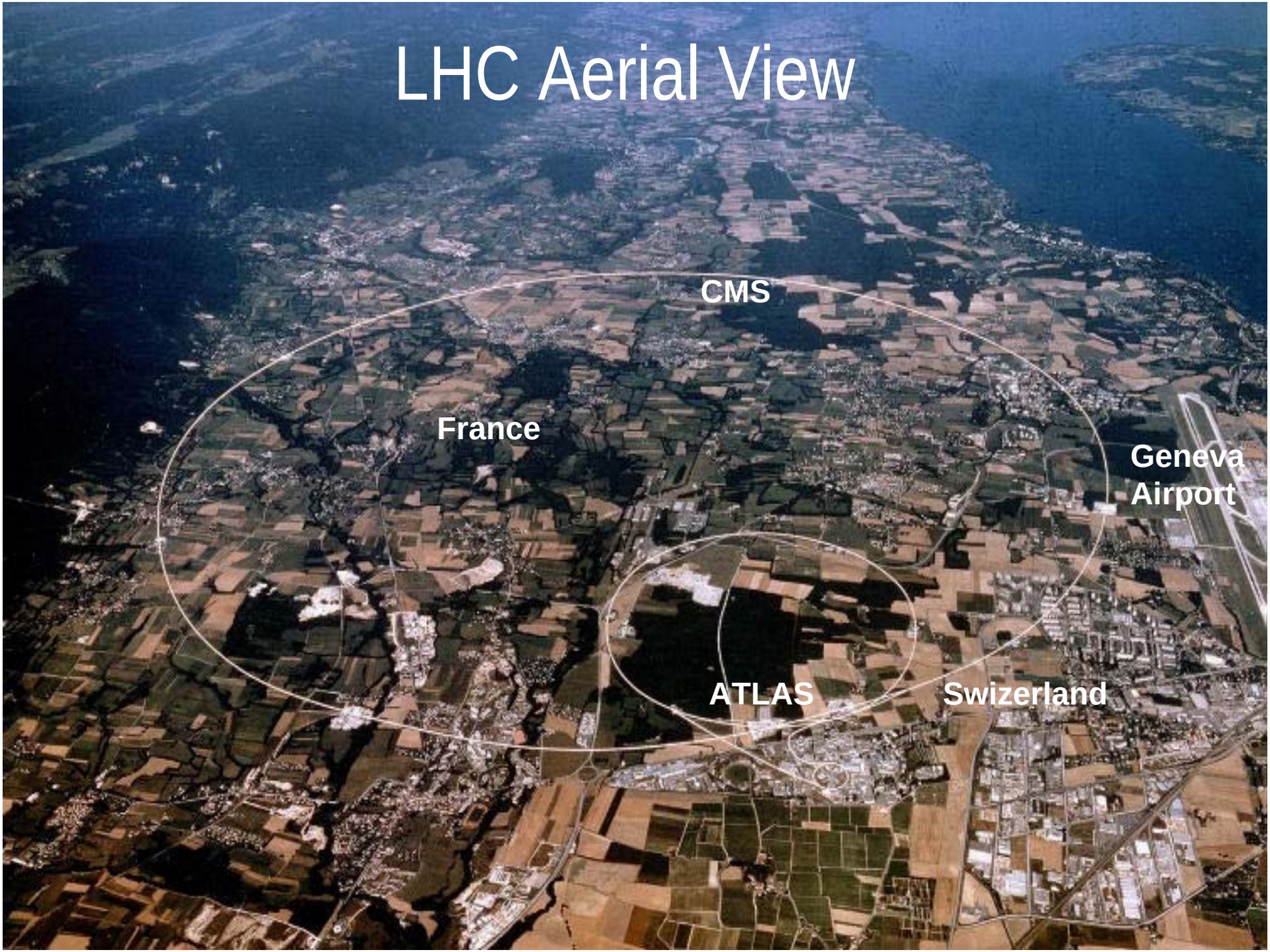
Fermilab Tevatron and LHC at CERN

- Present world's Highest Energy proton-anti-proton collider
  - 4km circumference
  - 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 81mi/hr➔ 130km/hr
- World's Highest Energy proton-proton collider end of this year
  - 27km circumference
  - 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 711mi/hr➔1140km/hr

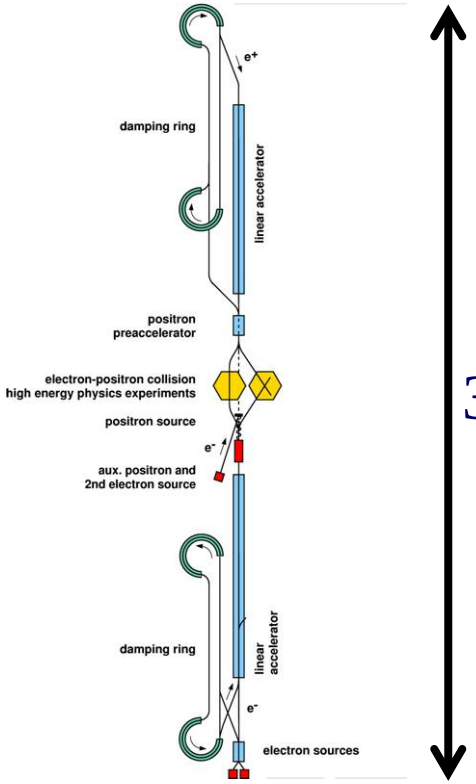




LHC Aerial View



The International Linear Collider



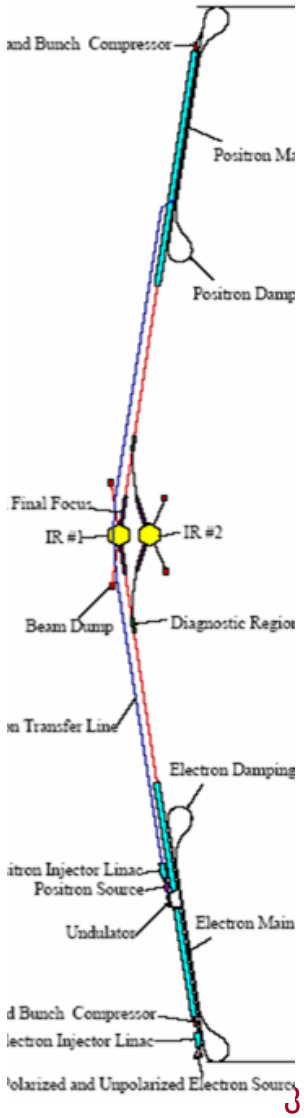
33km

TESLA TDR
500 GeV (800 GeV)

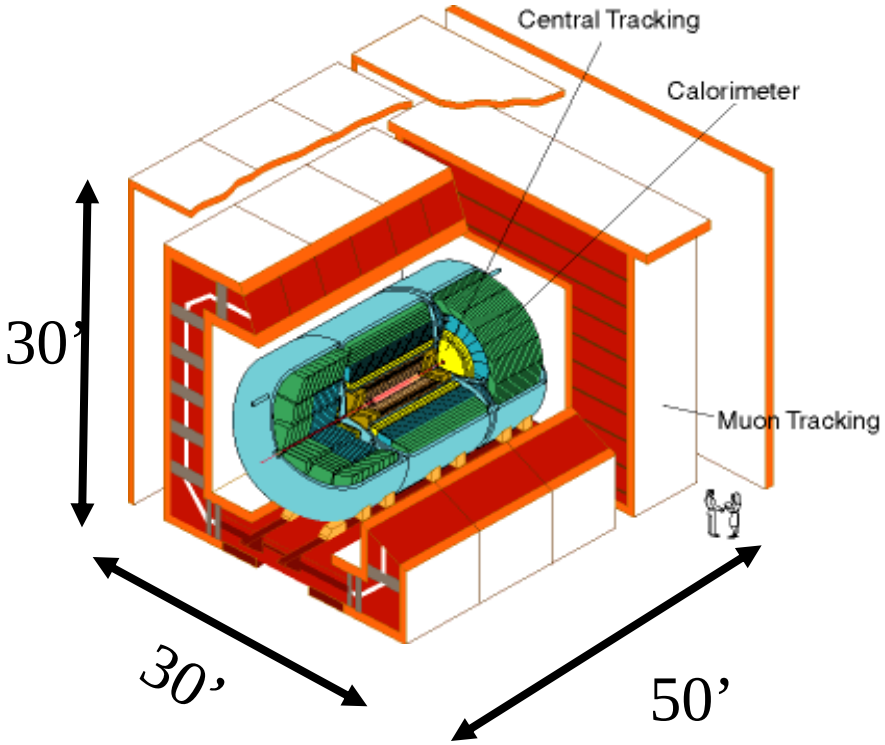
- Long~ linear electron-position colliders
- 10 – 15 years from now
- Takes 10 years to build an accelerator and the detectors

47 km

US Options Study
500 GeV (1 TeV)

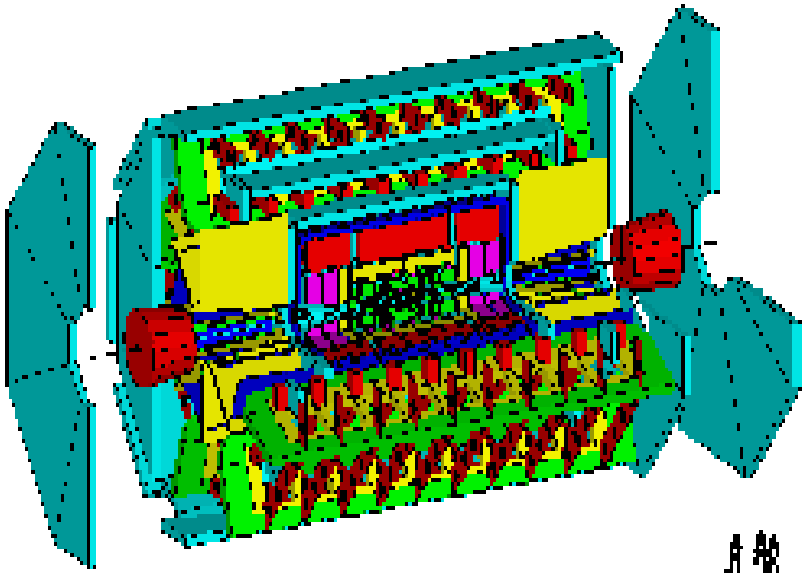


DØ Detector



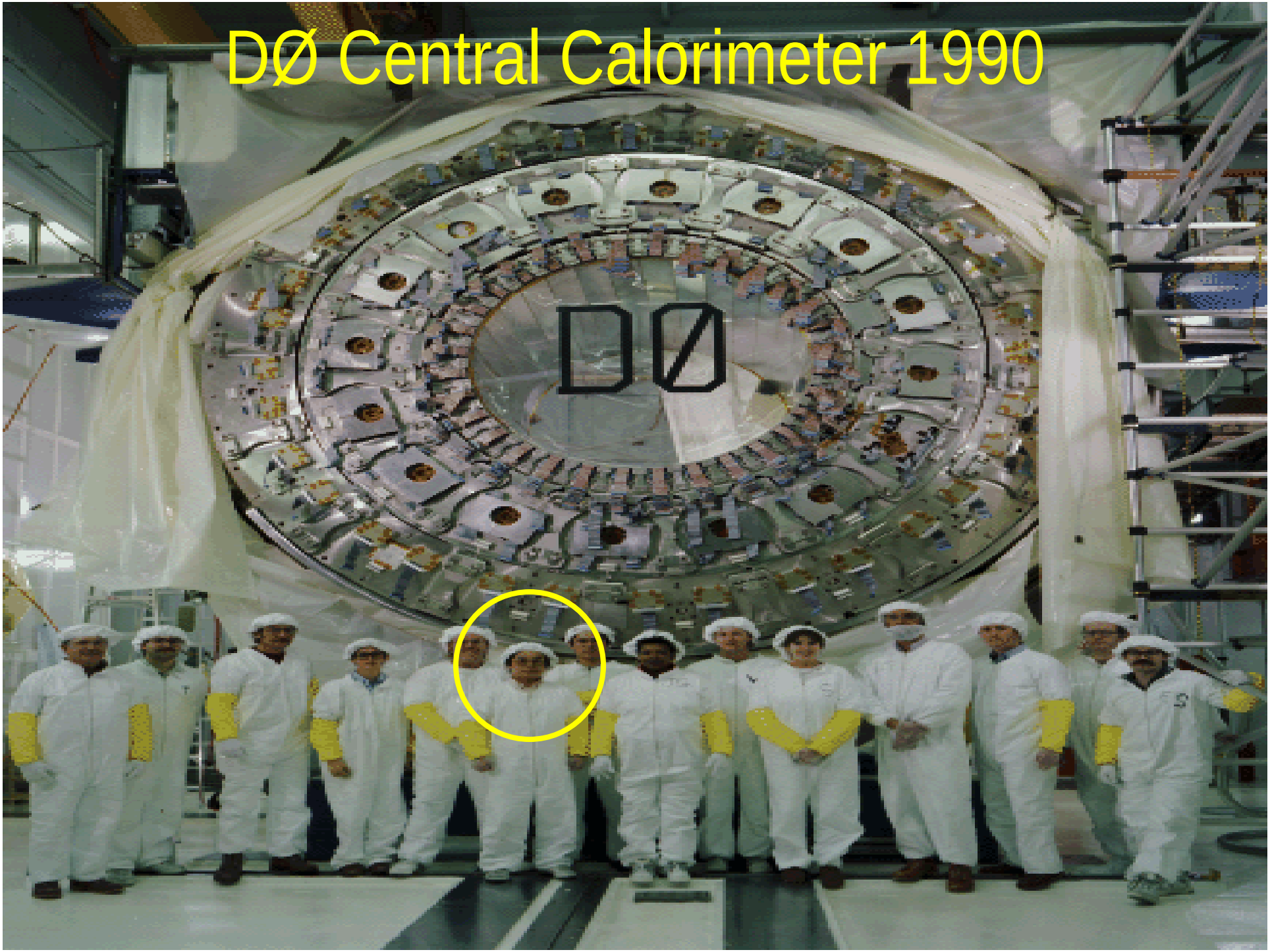
- Weighs 5000 tons and 5 story tall
- Can inspect 3,000,000 collisions/second
- Record 75 collisions/second
- Records approximately 10,000,000 bytes/second
- Records 0.5×10^{15} (500,000,000,000,000) bytes per year (0.5 PetaBytes).

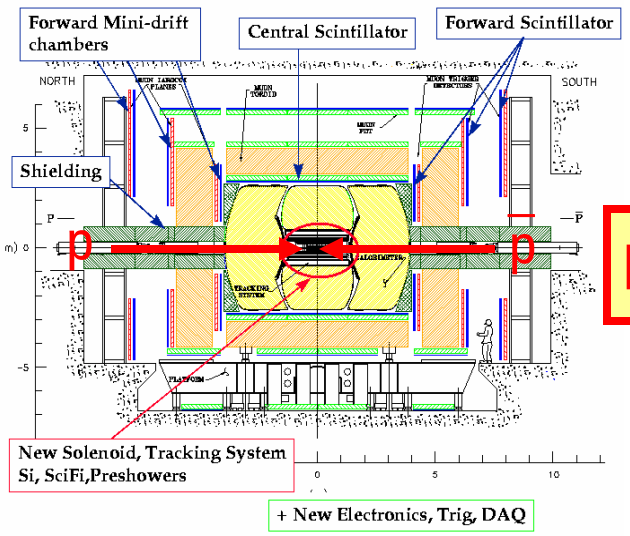
ATLAS Detector



- Weighs 10000 tons and 10 story tall
- Can inspect 1,000,000,000 collisions/second
- Will record 100 – 200 collisions/second
- Records approximately 300,000,000 bytes/second
- Will record 1.5×10^{15} (1,500,000,000,000,000) bytes each year (1.5 PetaByte).

DØ Central Calorimeter 1990

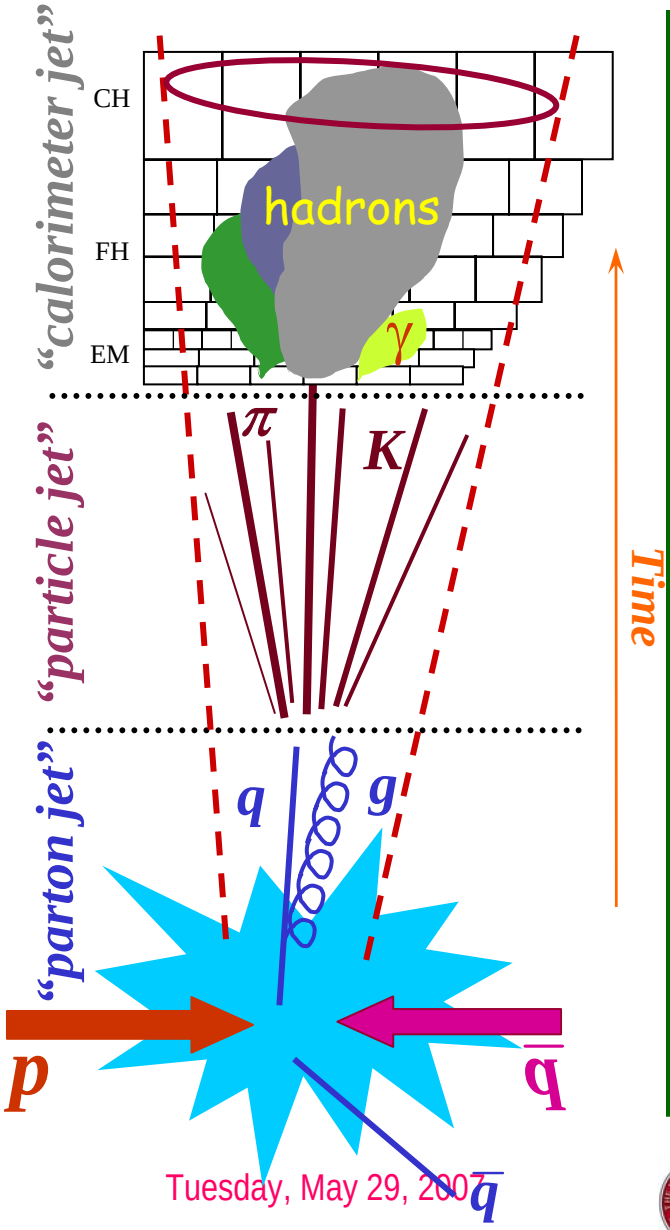


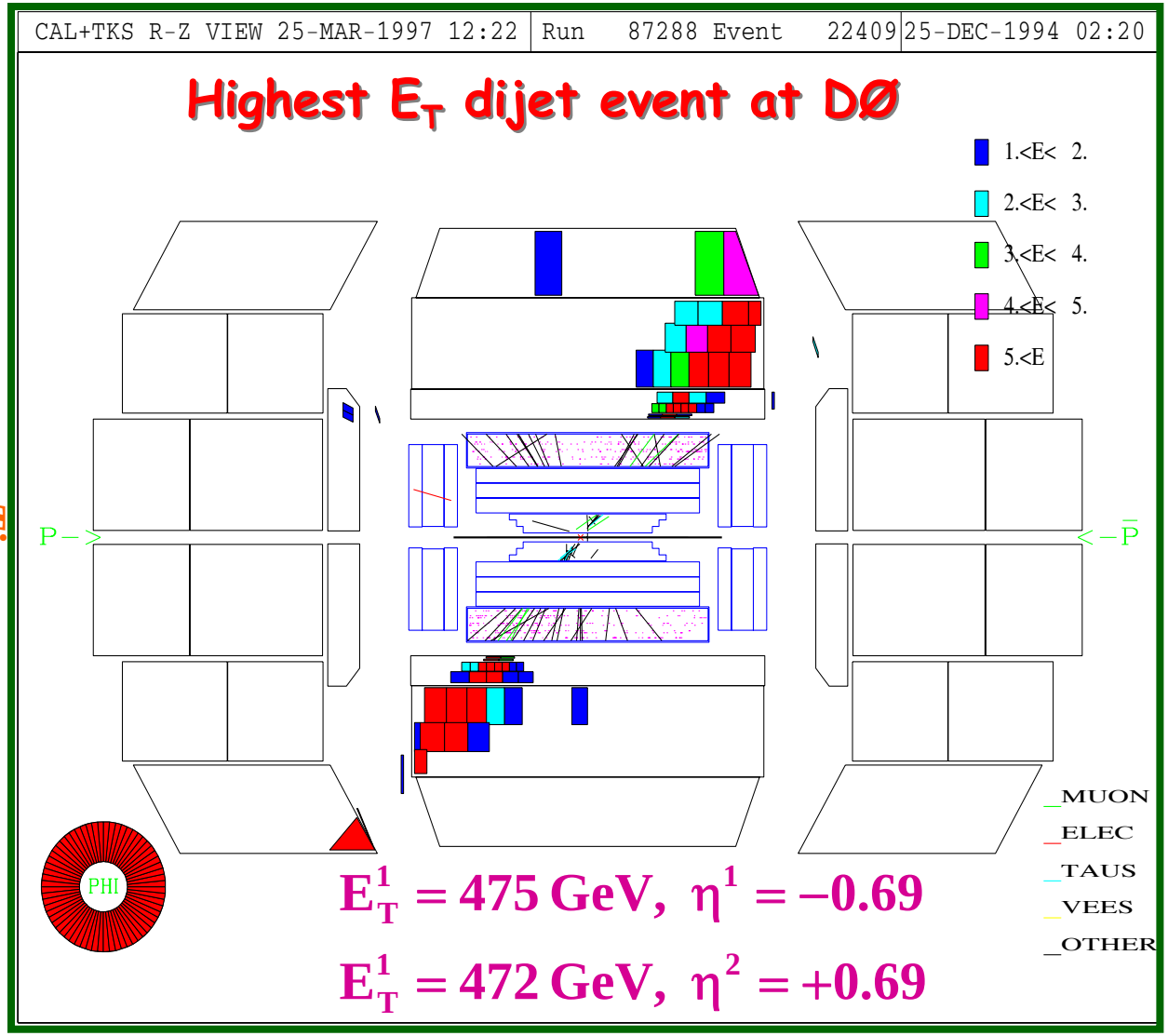


Digital data

Data Reconstruction

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 PHYS1443-001-SUMMER07 e-mail distribution list as soon possible ➔ Instruction available in Class style & Communication
  - 5 points extra credit if done by next Monday, June 4
  - 3 points extra credit if done by next Wednesday, June 6
- Office Hours: 10:00 – 11:00am, Mondays, Wednesdays and Thursdays or by appointments

Evaluation Policy

- Term Exams: 45%
  - Total of two exams (6/14 and 7/2)
  - Both exams 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: 25%
- Pop-quizzes: 10%

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 today 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
  - Roster will close Friday, June 1
- Each homework carries the same weight
- ALL homework grades will be used for the final grade
- Home work will constitute 25% 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….

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

Models, Theories and Laws

- Models: A kind of analogy or mental image of a phenomena in terms of something we are familiar with
  - Often provides insights for new experiments and ideas
- Theories: More systematically improved version of models
  - Can provide quantitative predictions that are testable and more precise
- Laws: Certain concise but general statements about how nature behaves ➔ The statement must be found experimentally valid
- Principles: Less general statements of how nature behaves
  - Has some level of arbitrariness

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 Internationale*) was 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}

International Standard Institutes

- International Bureau of Weights and Measure http://www.bipm.fr/
  - Base unit definitions: http://www.bipm.fr/enus/3_SI/base_units.html
  - Unit Conversions: http://www.bipm.fr/enus/3_SI/
- US National Institute of Standards and Technology (NIST) http://www.nist.gov/

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….

Examples 1.3 and 1.4 for Unit Conversions

- Ex 1.3: A silicon chip has an area of 1.25in^2. Express this in cm^2.

What do we need to know?

$$1.25\ \text{in}^2 = 1.25\ \text{in}^2 \times \left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)^2$$

$$= 1.25\ \text{in}^2 \times \left(\frac{6.45\ \text{cm}^2}{1\ \text{in}^2}\right)$$

$$= 1.25 \times 6.45\ \text{cm}^2 = 8.06\ \text{cm}^2$$

- Ex 1.4: Where the posted speed limit is 65 miles per hour (mi/h or mph), what is this speed (a) in meters per second (m/s) and (b) kilometers per hour (km/h)?

$$1\ \text{mi} = (5280\ \text{ft})\left(\frac{12\ \text{in}}{1\ \text{ft}}\right)\left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)\left(\frac{1\ \text{m}}{100\text{cm}}\right) = 1609\ \text{m} = 1.609\ \text{km}$$

(a) $$65\ \text{mi/h} = (65\ \text{mi})\left(\frac{1609\ \text{m}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 29.1\ \text{m/s}$$

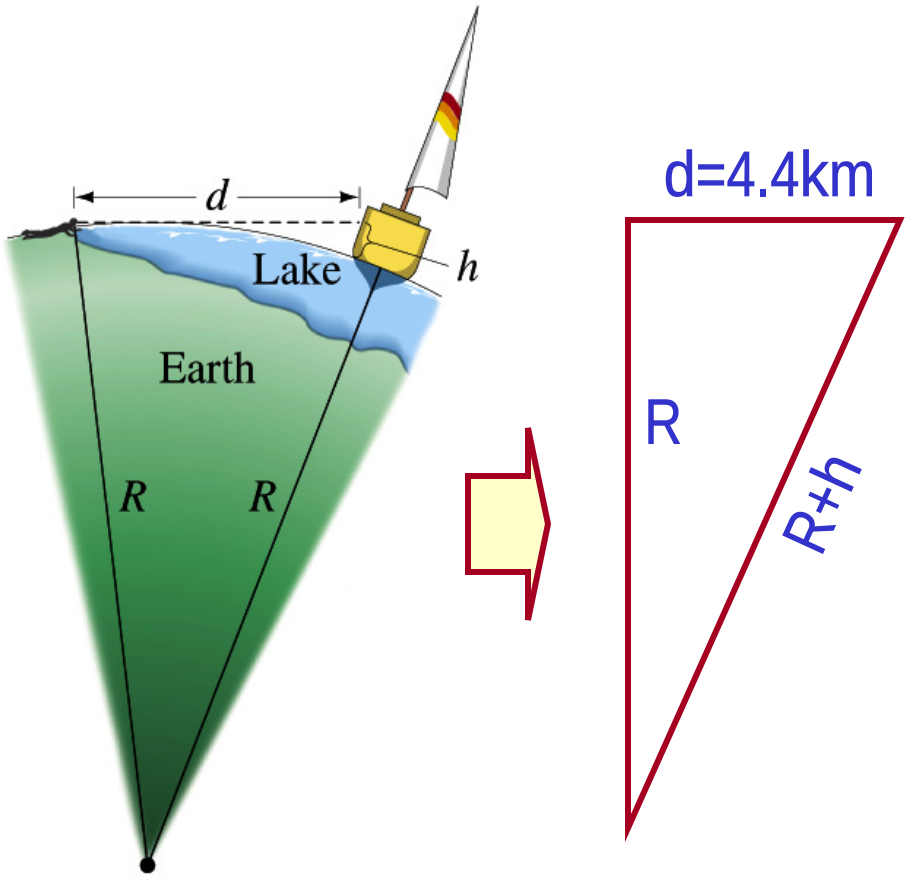
(b) $$65\ \text{mi/h} = (65\ \text{mi})\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right) = 104\ \text{km/h}$$

Estimates & Order-of-Magnitude Calculations

- Estimate = Approximation
  - Useful for rough calculations to determine the necessity of higher precision
  - Usually done under certain assumptions
  - Might require modification of assumptions, if higher precision is necessary
- Order of magnitude estimate: Estimates done to the precision of 10s or exponents of 10s;
  - Three orders of magnitude: 10^3=1,000
  - Round up for Order of magnitude estimate; $8x10^7 \sim 10^8$
  - Similar terms: “Ball-park-figures”, “guesstimates”, etc

Example 1.8

Estimate the radius of the Earth using triangulation as shown in the picture when d=4.4km and h=1.5m.



Pythagorian theorem

$$(R+h)^2 \approx d^2 + R^2$$

$$R^2 + 2hR + h^2 \approx d^2 + R^2$$

Solving for R

$$R \approx \frac{d^2 - h^2}{2h}$$

$$= \frac{(4400m)^2 - (1.5m)^2}{2 \times 1.5m}$$

$$= 6500km$$