PHYS 3313 – Section 001
Lecture #1

Monday, Jan. 13, 2014
Dr. Jaehoon Yu

- Who am I?
- From Higgs to Dark Matter!!
- How is this class organized?
- What do we want from this class?
- What is Physics?
- Brief history of modern physics

Announcements

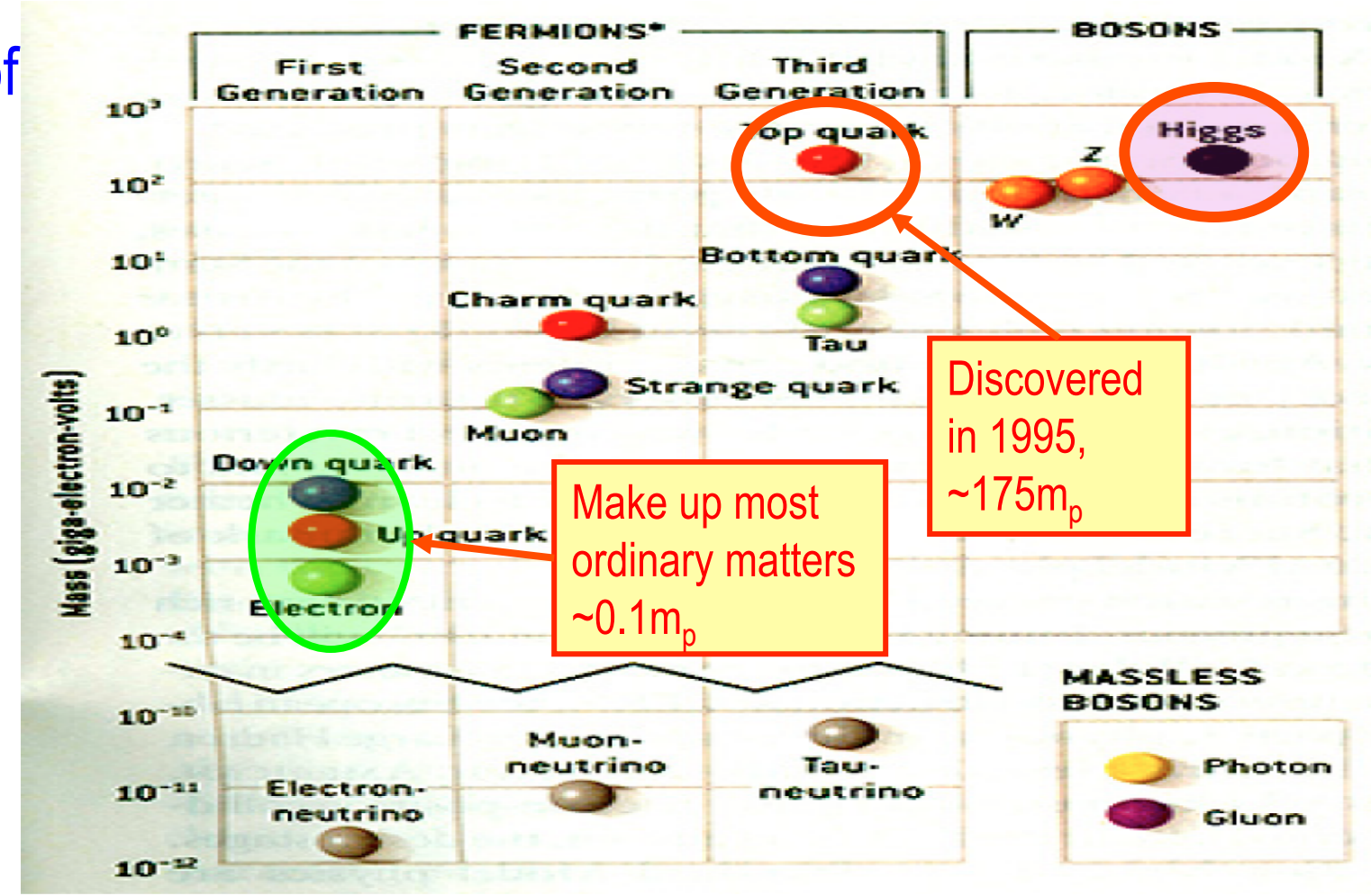
- Plea to you: Please turn off your cell-phones, pagers and computers in the class
- Reading assignment #1: Read and follow through appendices 3, 5, 6 and 7 by Tuesday, Jan. 21
  - There will be a quiz next Wednesday, Jan. 22, on these reading assignments
- No class Monday, Martin Luther King Day

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 Particle 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
  - Why do we do with this?
    - Make our everyday lives better

HEP and the Standard Model

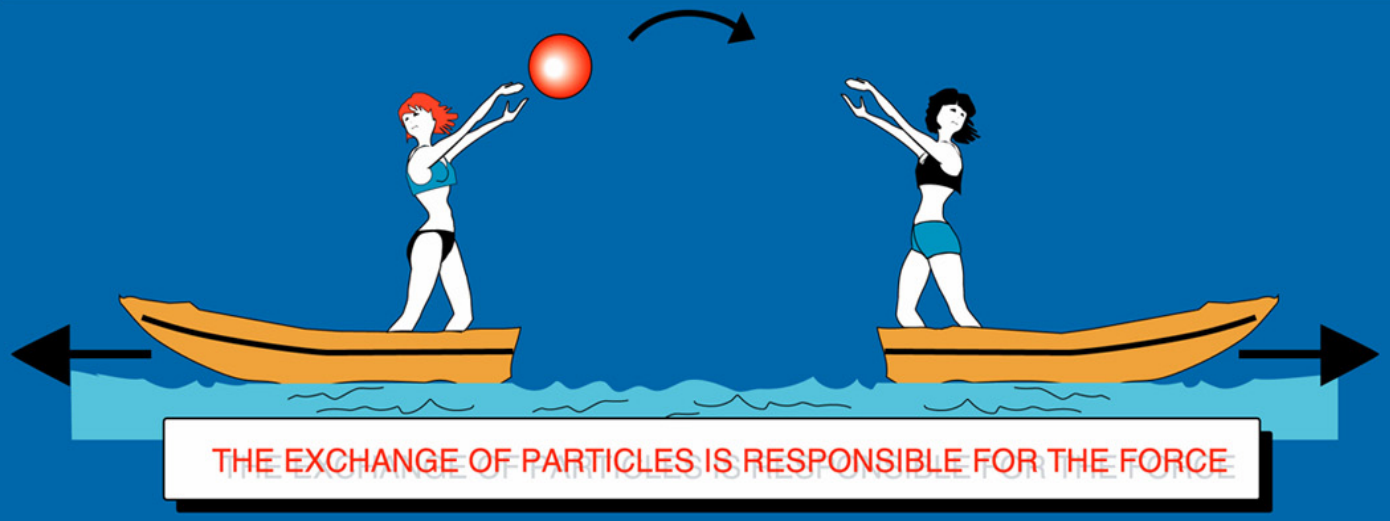
HEP: A field of physics that studies the fundamental constituents of matter and basic principles of interactions between them.



- Total of 16 particles (12+4 force mediators) make up all the visible matter in the universe! ➔ Simple and elegant!!!
- Tested to a precision of 1 part per million!

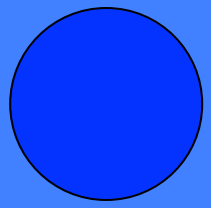
The forces in Nature

TYPE	INTENSITY OF FORCES (DECREASING ORDER)	BINDING PARTICLE (FIELD QUANTUM)	OCCURS IN :
STRONG NUCLEAR FORCE	~ 1	GLUONS (NO MASS)	ATOMIC NUCLEUS
ELECTRO -MAGNETIC FORCE	~ 10^{-3}	PHOTONS (NO MASS)	ATOMIC SHELL ELECTROTECHNIQUE
WEAK NUCLEAR FORCE	~ 10^{-5}	BOSONS Z^{o} , W^{+} , W^{-} (HEAVY)	RADIOACTIVE BETA DESINTEGRATION
GRAVITATION	~ 10^{-38}	GRAVITONS (?)	HEAVENLY BODIES

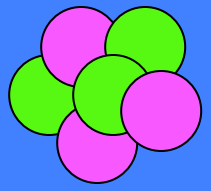


Accelerators are Powerful Microscopes.

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



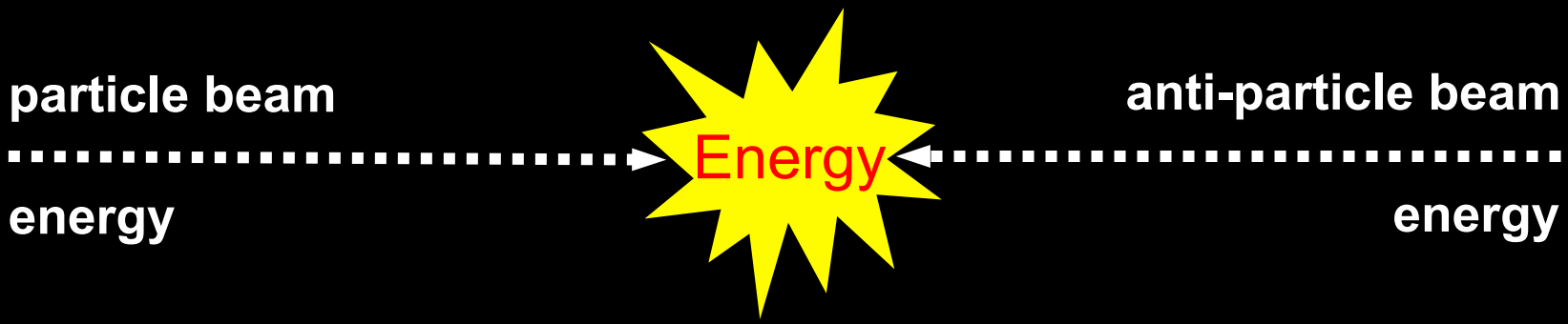
seen by
low energy beam
(poorer resolution)



seen by
high energy beam
(better resolution)

Accelerators are also Time Machines.

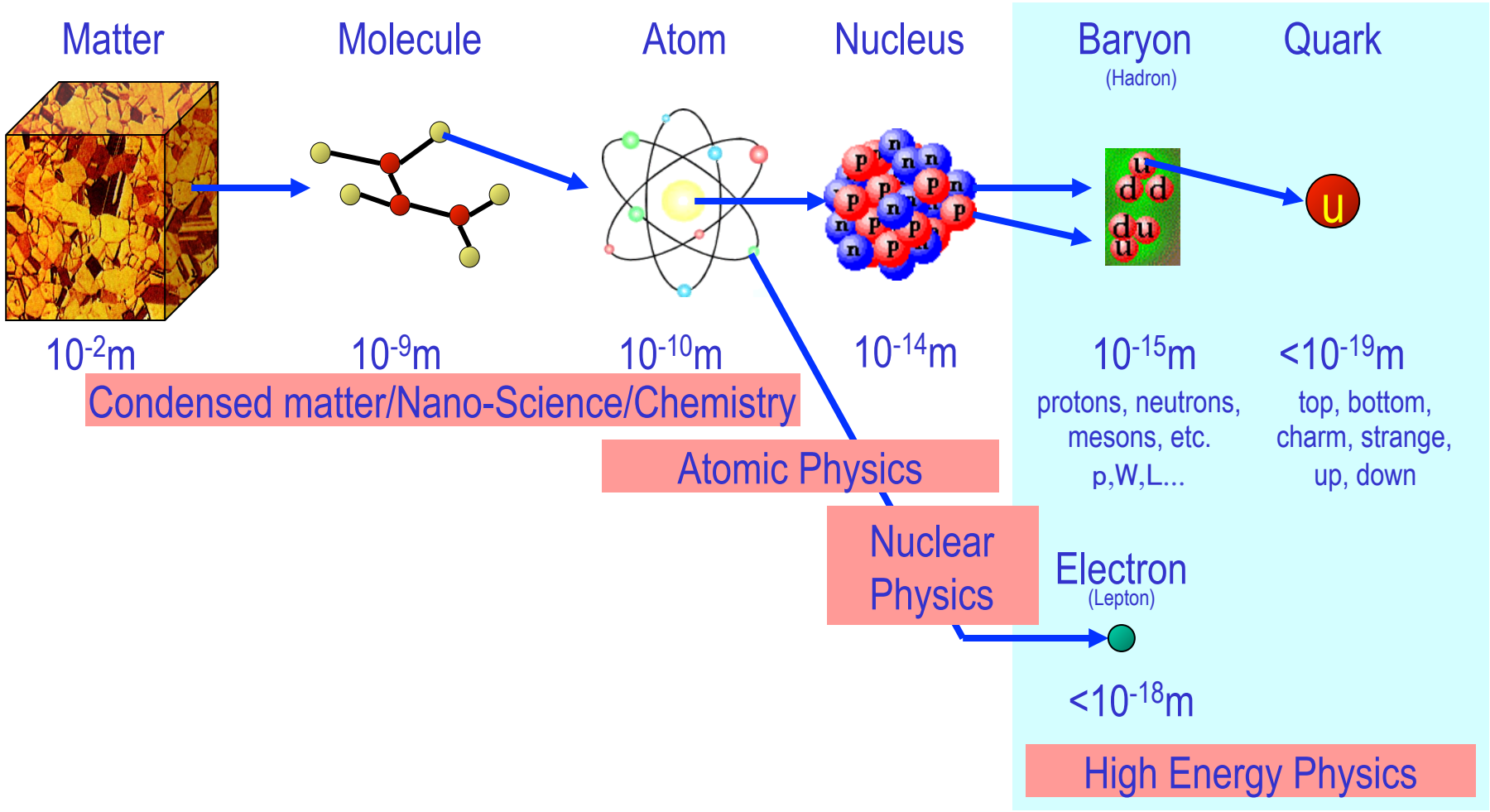
They make particles last seen
in the earliest moments of the universe.



Particle and anti-particle annihilate.

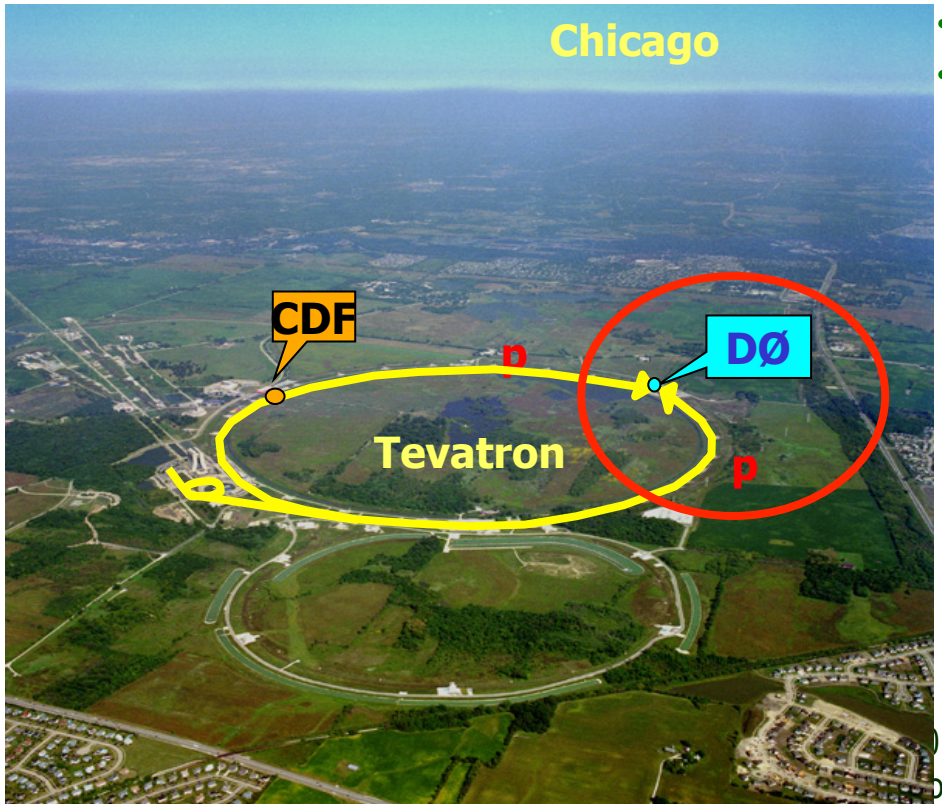
$$E = mc^2$$

Structure of Matter

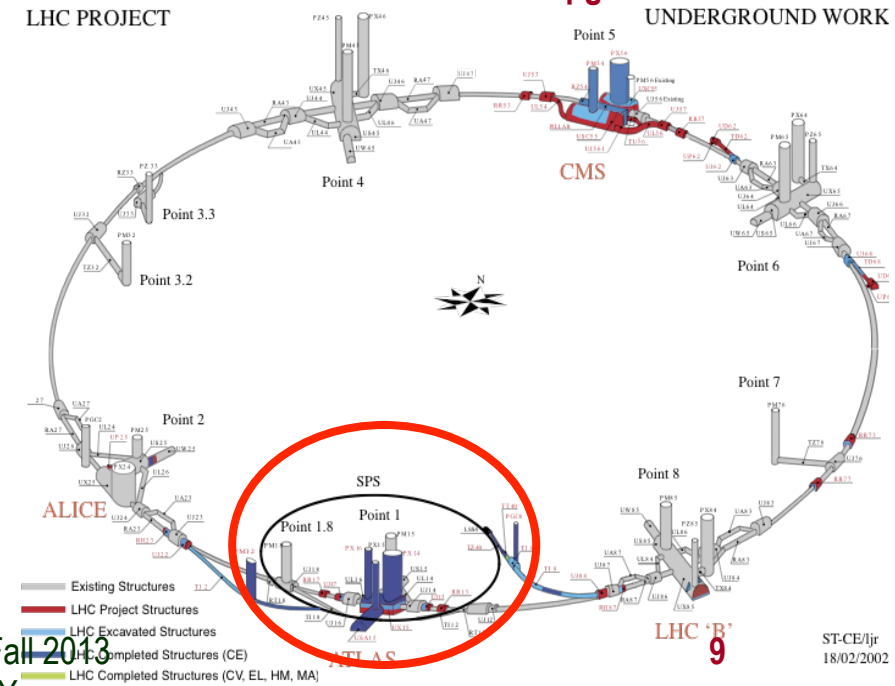


Fermilab Tevatron and LHC at CERN

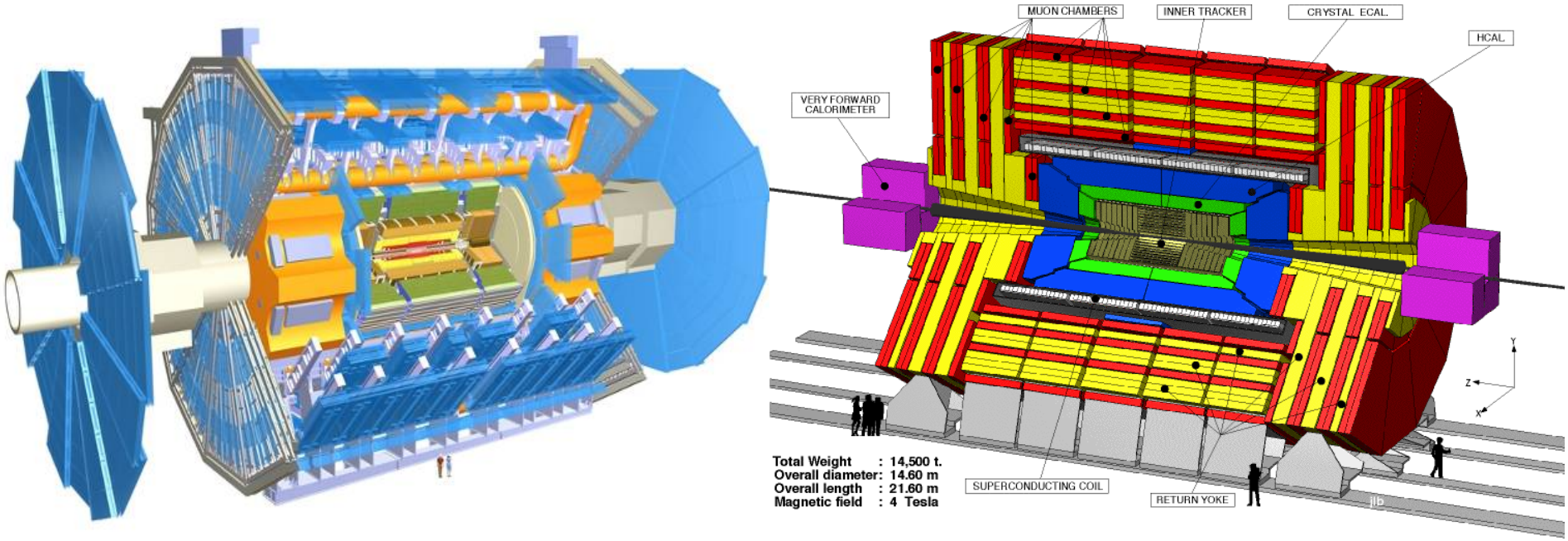
- World's Highest Energy proton-anti-proton collider
  - 4km circumference
  - E_{cm}=1.96 TeV (=6.3x10^{-7}J/p➔ 13M Joules on the area smaller than 10^{-4}m^2)
  - Equivalent to the kinetic energy of a 20t truck at the speed 81mi/hr➔ 130km/hr
    - ~100,000 times the energy density at the ground 0 of the Hiroshima atom bomb
  - **Tevatron was shut down on Sept. 30, 2011**
  - **Vibrant other programs running, including the search for dark matter!!**



- World's Highest Energy p-p collider
  - 27km circumference, 100m underground
  - Design E_{cm}=14 TeV (=44x10^{-7}J/p➔ 362M Joules on the area smaller than 10^{-4}m^2)
  - ➢ Equivalent to the kinetic energy of a B727 (80tons) at the speed 193mi/hr ➔ 312km/hr
    - ➢ ~3M times the energy density at the ground 0 of the Hiroshima atom bomb
- First 7TeV collisions 2010 ➔ The highest energy humans ever achieved!!
- **Large amount of data accumulated in 2011 – 2013**
- **Shutdown in Feb. 2013 for 18mo for upgrade**



The ATLAS and CMS Detectors



- **Fully multi-purpose detectors with emphasis on lepton ID & precision E & P**
- **Weighs 7000 tons and 10 story tall**
- Records **200 – 400 collisions/second**
- Records approximately **350** MB/second
- Record ~2 PB per year ➔ **200*Printed material of the US Lib. of Congress**

What is the Higgs and What does it do?

- When there is perfect symmetry, one cannot tell directions!

What? What's the symmetry?

- Where is the head of the table?
- Without a broken symmetry, one cannot tell directional information!!

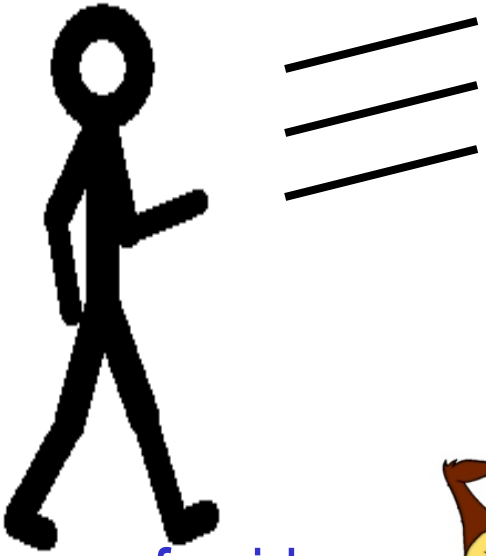
What is the Higgs and What does it do?

- When there is perfect symmetry, one cannot tell directions!
- Only when symmetry is broken, can one tell directions
- Higgs field works to break the perfect symmetry and gives mass to all fundamental particles
- Sometimes, this field spontaneously generates a particle, the Higgs particle
- So the Higgs particle is the evidence of the existence of the Higgs field!

So how does Higgs Field work again?

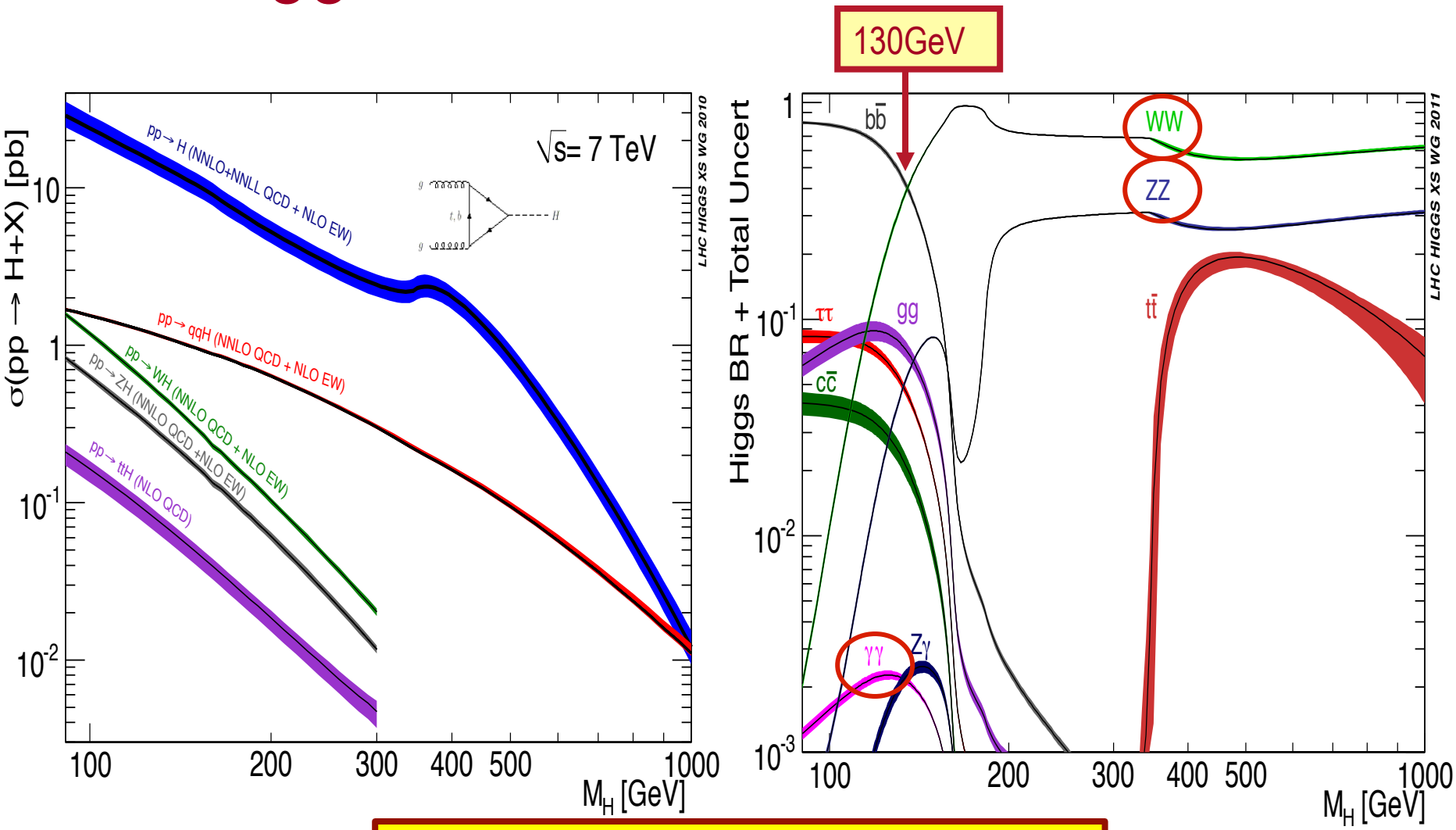
- Person in space ➔ no symmetry breaking

- Person in air ➔ symmetry can be broken
- Sometimes, you get



Just like a tornado is a piece of evidence of the existence of air, Higgs particle is a piece of evidence of Higgs mechanism

Higgs Production X-sec and BR



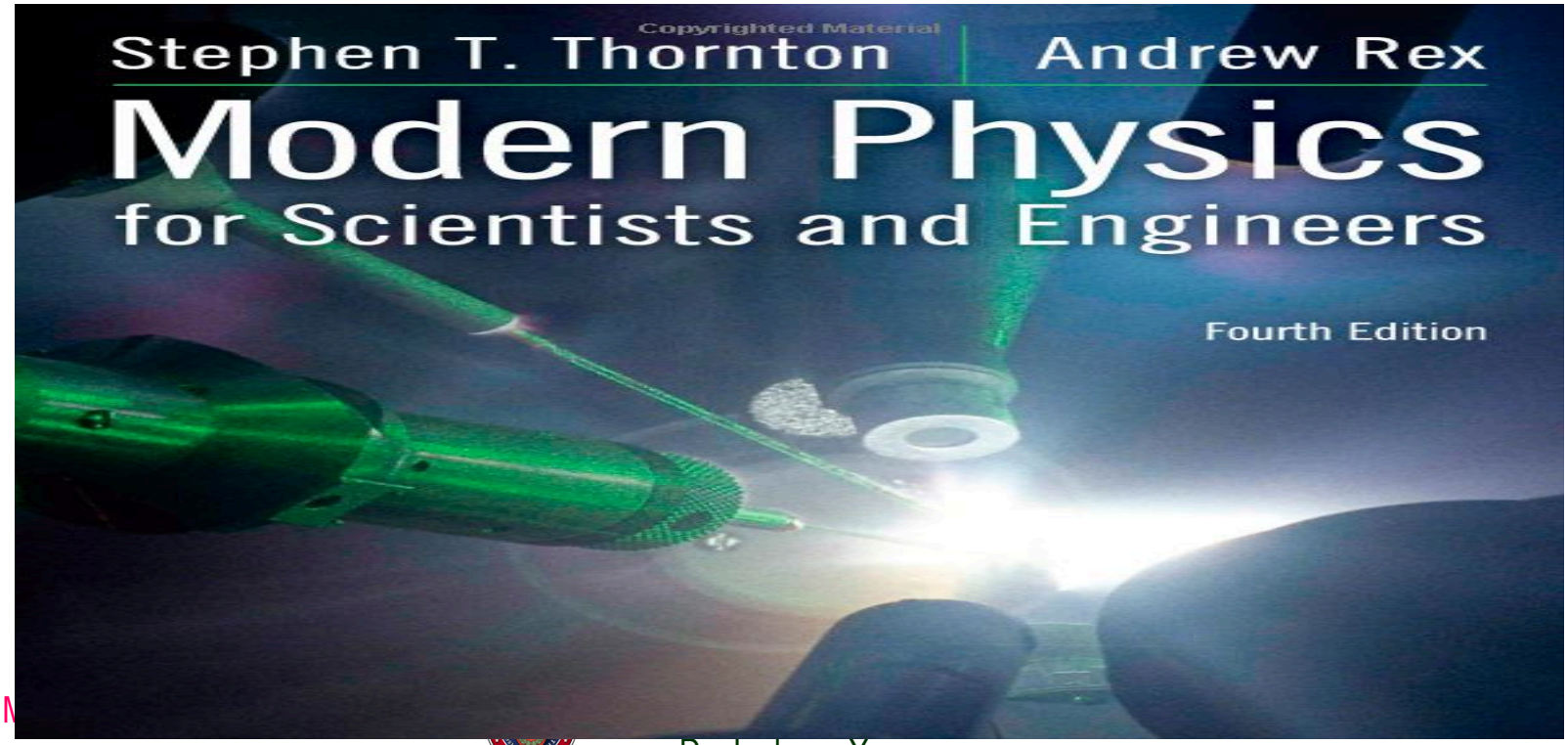
Higgs mass is not given in the theory!!

Information & Communication Source

- Course web page: http://www-hep.uta.edu/%7Eyu/teaching/spring14-3313-001/spring14-3313-001.html
  - Contact information & Class Schedule
  - Syllabus
  - Homework
  - Holidays and Exam days
  - Evaluation Policy
  - Class Style & Communication
  - Other information
- Primary communication tool is e-mail: Make sure that your e-mail at the time of course registration is the one you most frequently read!!
- Office Hours: 2:30 – 3:40pm, Mondays and Wednesdays or by appointments

Textbook

- Title: Modern Physics for Scientists and Engineers
  - 4^{th} edition
- Authors: S.T. Thornton and A. Rex
- ISBN: 978-1-133-10372-1



Evaluation Policy

- Homework: 30%
- Exams
  - Mid-term Exam (Wed., Mar. 5): 20%
  - Final Comprehensive Exam (11 – 1:30pm, Mon, May. 5): 25%
  - 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
- Group Research Project: 15%
- Pop-quizzes: 10%

100%

- Extra credits: 10% of the total
- Grading will be done on a sliding scale
- 55% of the grade is in your hand!!

Homework

- Solving homework problems is the only way to comprehend class material
- Consists of a lot of reading, deriving and writing
- Each homework carries the same weight
- **ALL** homework grades will be used for the final grade
- Home work will constitute **30% of the total**
  - A good way of keeping your grades high
- Strongly encouraged to collaborate
  - Just make sure to submit your own answers written in your OWN way!!

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

Extra credit

- Up to 10% addition to the total
  - Could boost a B to A, C to B or D to C
- What constitute for extra credit?
  - Random attendances
  - Physics Colloquium Participations
  - Strong participation in the class discussions
  - Special projects
  - Watch the valid planetarium shows
  - Many other opportunities

Valid Planetarium Shows

- Regular running shows
  - Expoplanets – Thursdays at 6:00, Saturdays at 5:30pm and Sundays at 1:30pm
  - Back to Moon for Good – Fridays at 6:00pm and Saturdays at 2:30pm
- Shows that need special arrangements
  - Astronaut
  - Bad Astronomy
  - **Black Holes (can watch up to 2 times!)**
  - Experience the Aurora
  - IBEX
  - Ice Worlds
  - Magnificent Sun
  - Mayan Prophecies
  - Nanocam
  - Stars of Pharaoes
  - Two Small Pieces of Glass
  - Unseen Universe: The Vision of SOFIA
  - Violent Universe
  - We Are Astronomers
- How to submit for extra credit?
  - Obtain the ticket stub that is signed and dated by the planetarium star lecturer of the day
  - Collect the ticket stubs
  - Tape all of them on a sheet of paper with your name and ID written on it
  - Submit the sheet at the end of the semester when asked

What can you expect from this class?

- All A's would be perfect for you, wouldn't it?
  - But easy come easy go
  - Must put in efforts to make it last and meaningful….
- This class is going to be challenging!!
- 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 of your grade in your hands, up to 45%!!!
  - 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
      - Exam's problems will be easier that homework problems but the same principles!!
  - Extra credit 10%
- I will work with you so that your efforts are properly rewarded

What do we want to learn in this class?

- The physics that provided fundamentals to the technical progress for us
- Learn concepts of quantum theory for microscopic phenomena and relativity for phenomena with high speed
- Learn physical principles that we still exploit
- Learn skills to express observations and measurements in mathematical language
- Learn skills to research literatures and express your research in systematic manner in writing
- Build up confidence in your physics abilities and to take on any challenges laid in front of you!!

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

In this course, you will learn…

- Concepts and derivation of many of the modern physics
  - History at the beginning of the new era
  - Special relativity
  - Quantum theory
  - Atomic physics
  - Condensed Matter physics
  - Nuclear physics
  - Particle Physics
- Focus on learning about the concepts with less complicated math
  - You will learn some Quantum calculations and understand the concept of probabilities
- Expectation at the end of the semester: You will be able to understand what fundamental physics provides bases for the current technology