PHYS 1441 – Section 002
Lecture #1

Wednesday, Aug. 26, 2020

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

Today's homework is homework #1, due 11pm, Monday, Aug. 31!!

Requirements for Online Class

- COVID – 19 forces us into a special and difficult circumstance
  - I have never done online classes before late March 2020
  - Keeping grades fair to all students very important
    - I apologize for this but at times the policies may be very strict
- Be sure to prepare a camera and a headset (or an earphone) with mic so that you can show yourself and listen and speak.
- Be in a quiet, isolated area during the class, especially during the quiz and exam period so that you can focus on the class.
- Prepare a ring bound notebook for you to take notes during the class and keep the exercises you practice in the class.
- Prepare a calculator.
- Have your zoom display name the same as it is on MyMav!
  - Zoom settings ➔ profile ➔ edit my profile ➔ edit the top portion on web

Basic Rules of the Online Classes

- I will take attendance as if we are in the classroom!
  - Your mic will be automatically muted when joining the class
    - Please locate the video, mute/unmute, chat buttons and test
  - **Unmute** the mic when your name is called then mute after answering
- Mute your mic during the lecture expect for questions or answers
- If you have a question, "raise hand", unmute your mic, pronounce your name and ask your question, as if you are in the class
- Use only the **appropriate languages** on mic and on chat!
- Lecture notes and recordings will be available after each class
- Polls will be used to engage you in the class and thus you are strongly encouraged to participate in the poll (poll 1)

Announcements

- Plea to you: Please turn off all your other electronic devices, including cell-phones and all types of computers before the start of all classes, except for the one used for the class!
  - Keep only the class zoom session on your computer!
- Reading assignment #1: Read and follow through all 9 sections (A1 – A9) in appendix A (math formulae) by Monday, Aug. 31
- There will be a quiz on this and what we have learned on Ch. 21 on next Wednesday, Sept. 2.

Why do we do science?

- Anything and everything we do must be built upon the fundamental **HUMANITY and Human Decency**!!
  - Science without humanity will be harmful to us all!
  - Policies without solid, sound science base will damage the entire humanity!
    - US COVID – 19 response (~6M confirmed cases, **>182k deaths** and growing!)
    - Italy COVID – 19 response (~261k confirmed cases, **~35k deaths**!)
    - SK COVID – 19 response (>18k cases, **310 deaths**!)
      - https://coronaboard.com
- I want to teach you in this class
  - Physics knowledge you need to maximally optimize your career and life
  - But more importantly to help you become an independent thinker with a deep sense of fundamental humanity and human decency!

What is the human decency?

- Compassion and empathy to fellow human beings!
  - Respect and care for other human beings
  - Listen and give efforts to understand
  - Put aside one's own greed
  - Help others when others are in need
- True sense of courage
  - Be able to own one's mistakes and correct for them
  - Capable of acknowledging that others could be better than oneself
  - Capable of thank others for their efforts
  - Be able to stand up for the whole human race!

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
    - Fundamental forces between the constituents
    - Origin of Mass
    - Search for Dark Matter and Making of Dark Matter Beams
    - The creation of the Universe
  - A pure scientific research endeavor
    - 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 in the first place?
    - Make everyday lives better and help the whole humanity live well as an integral part of the universe

We always wonder…

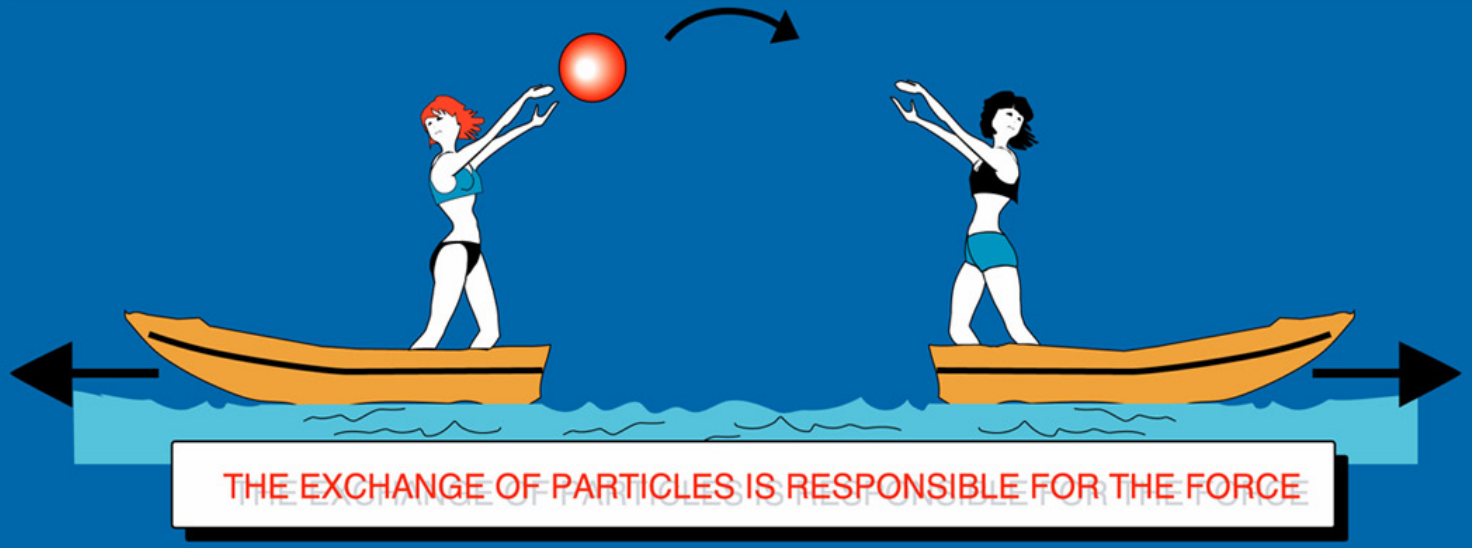
- What makes up the universe?
- How does the universe work?
- Where do we all come from?

High Energy Physics

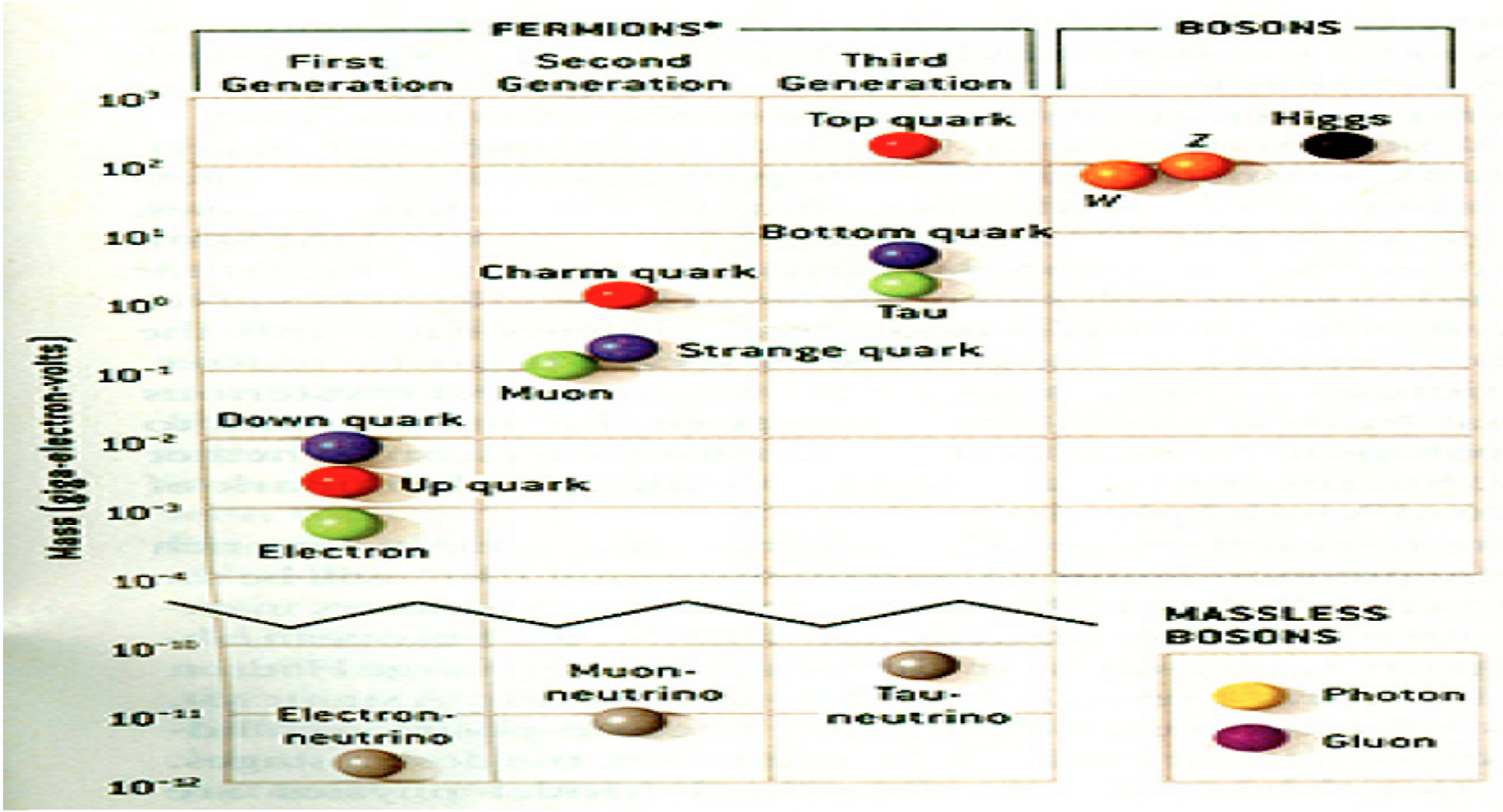
- Definition: A field of physics that pursues understanding the fundamental constituents of matter and basic principles of interactions between them.
- Known interactions (forces):
  - Gravitational Force
  - Electromagnetic Force
  - Weak Nuclear Force
  - Strong Nuclear Force
- Current theory: The Standard Model of Particle Physics

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



HEP and the Standard Model



- Total of 16 particles (12+4 force mediators) make up all the visible matter in the universe! ➔ Simple and elegant!!!

Periodic Table of the Elements

1 1IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.99	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.789
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [286]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

Lanthanide Series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Semimetal | Nonmetal | Halogen | Noble Gas | Lanthanide | Actinide

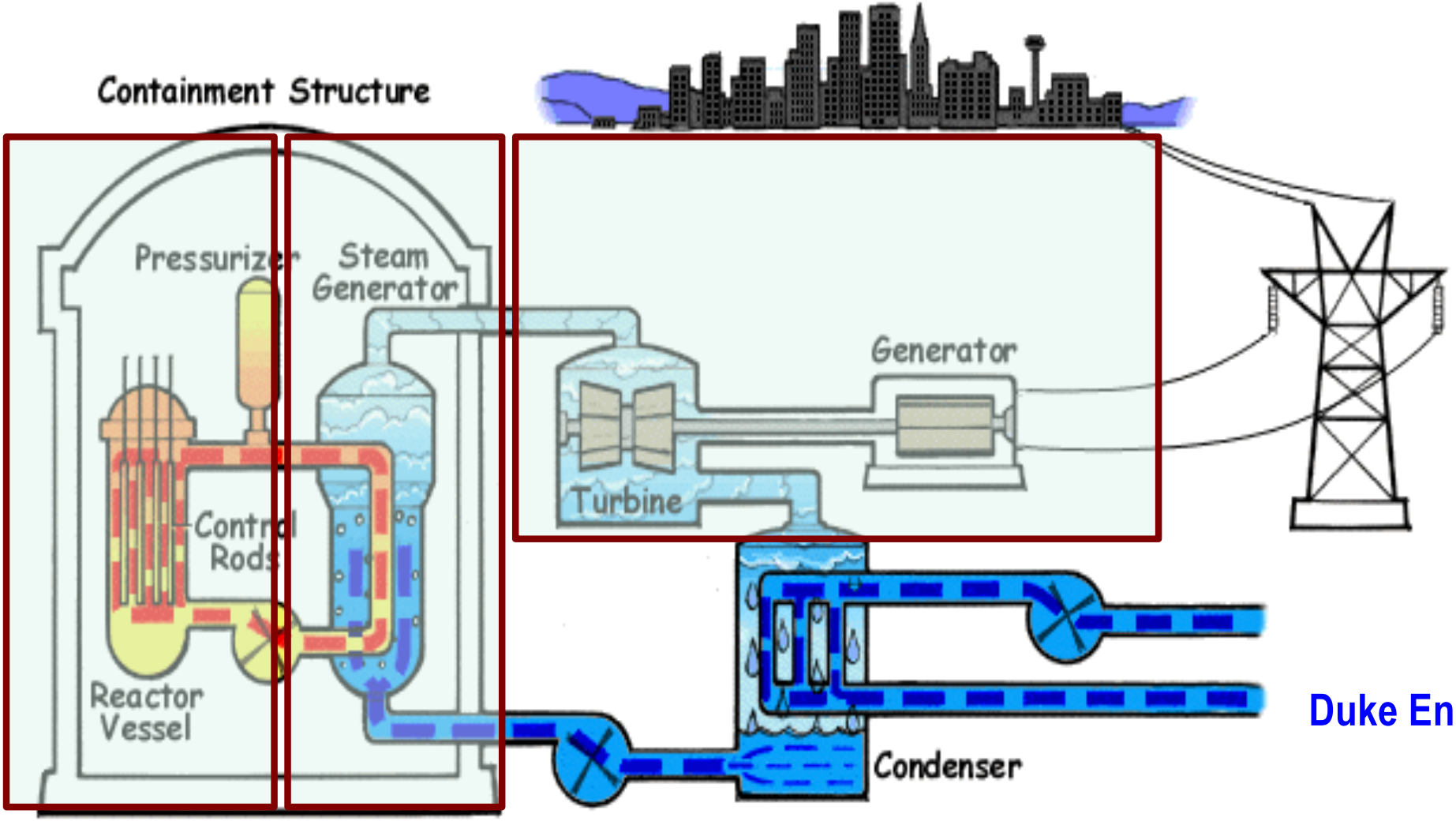
HEP and the Standard Model

- 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!

What are some issues in HEP?

- Why is the mass range so large ($0.1m_p$ – $175\ m_p$)?
- Is the particle discovered at the LHC really the Higgs particle?
- Why is the matter in the universe made only of particles?
- Neutrinos have mass!! (**OMG!! The SM is broken!!!**)
  - What are the mixing parameters, particle-anti particle asymmetry and the neutrino mass ordering?
- Why are there only four apparent forces?
  - Were they all unified at the Big Bang?

How does a nuclear power plant work?



Duke Energy

My 1000 year dream: Skip the whole thing!

Make electricity directly from nuclear force!

So what's the problem?

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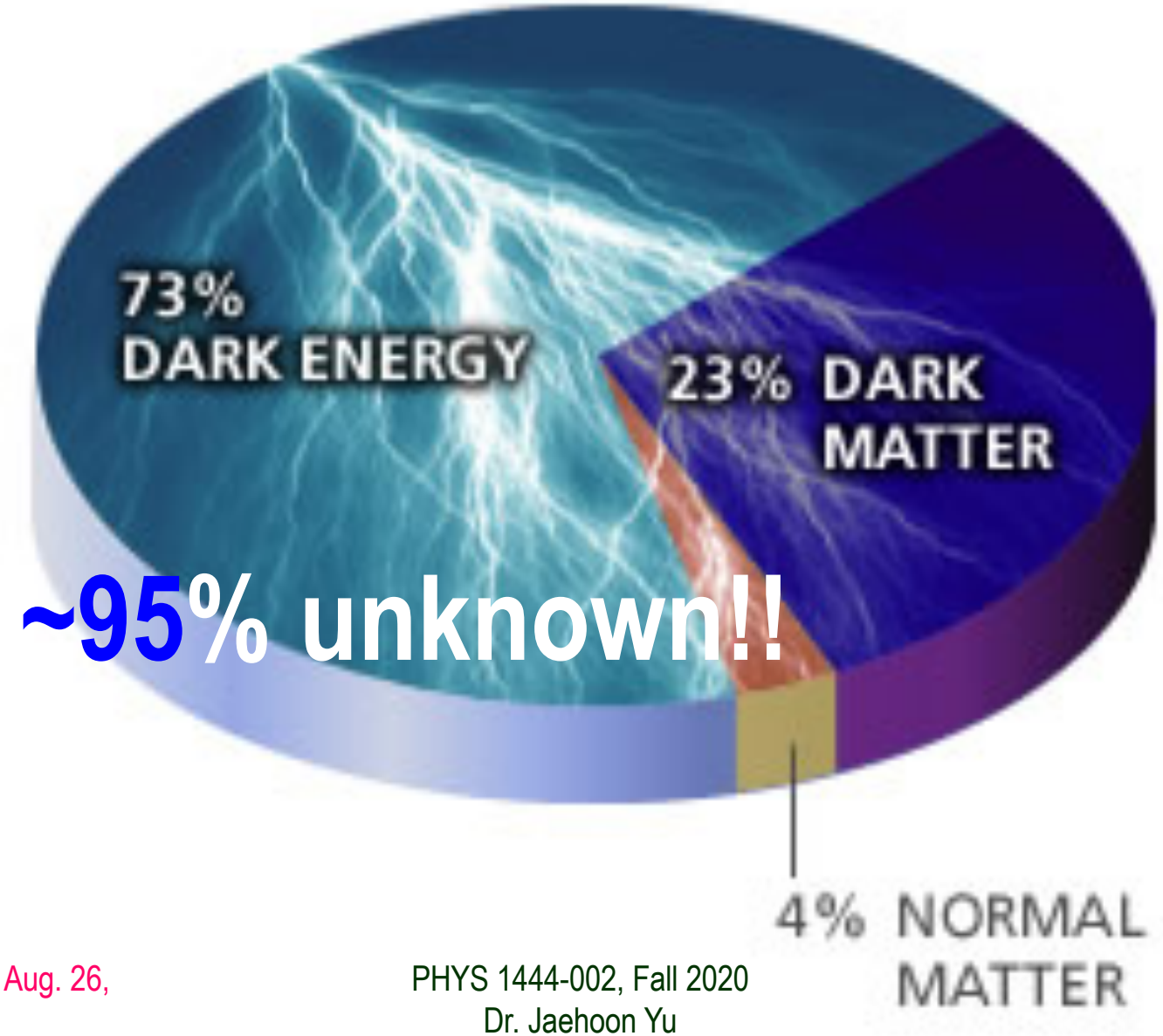
- Is the picture we present the real thing?

What makes up the universe?



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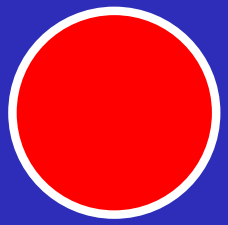
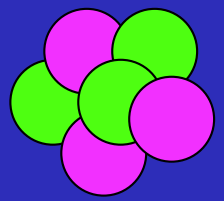
- Why are there only four apparent forces?
  - Were they all unified at the Big Bang?
- Is the picture we present the real thing?
  - What makes up the remaining ~95% of the universe?
- Are there any other particles we don't know of?
  - Big deal for the new LHC Run and in the new experiment in the US!
- Where do we all come from?
- How can we live well in the universe as an integral partner?

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.

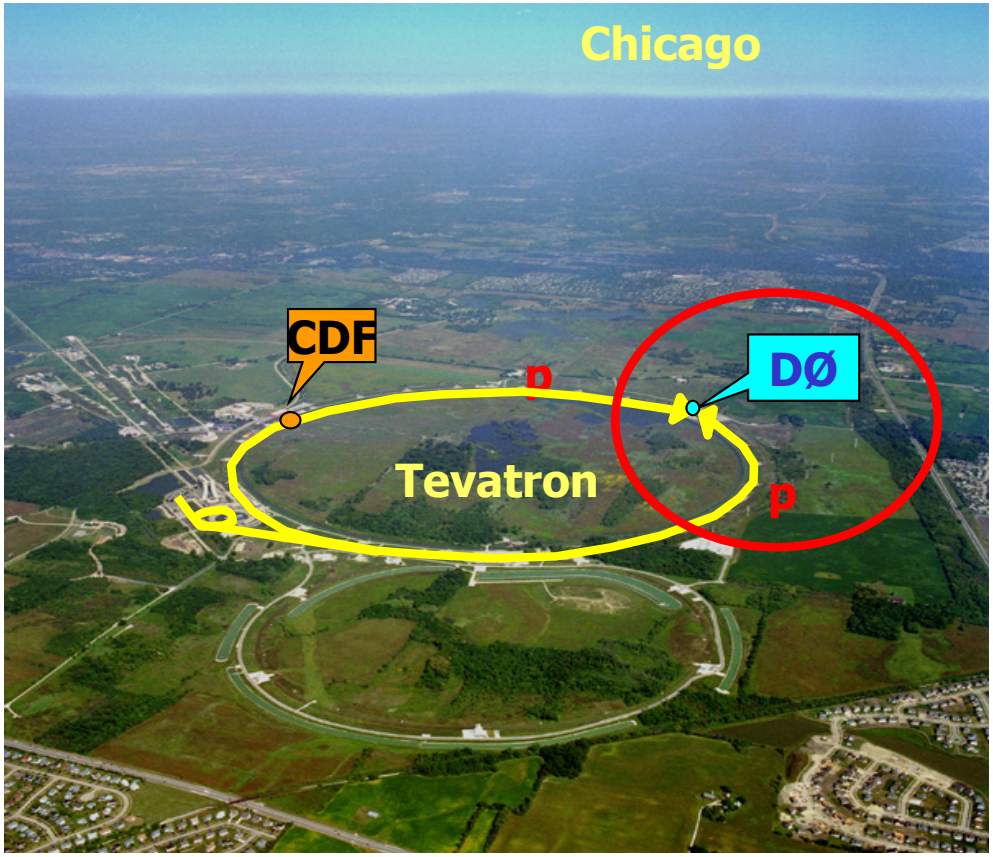
They make particles last seen
in the earliest moments of the universe.

Particle and anti-particle annihilate.

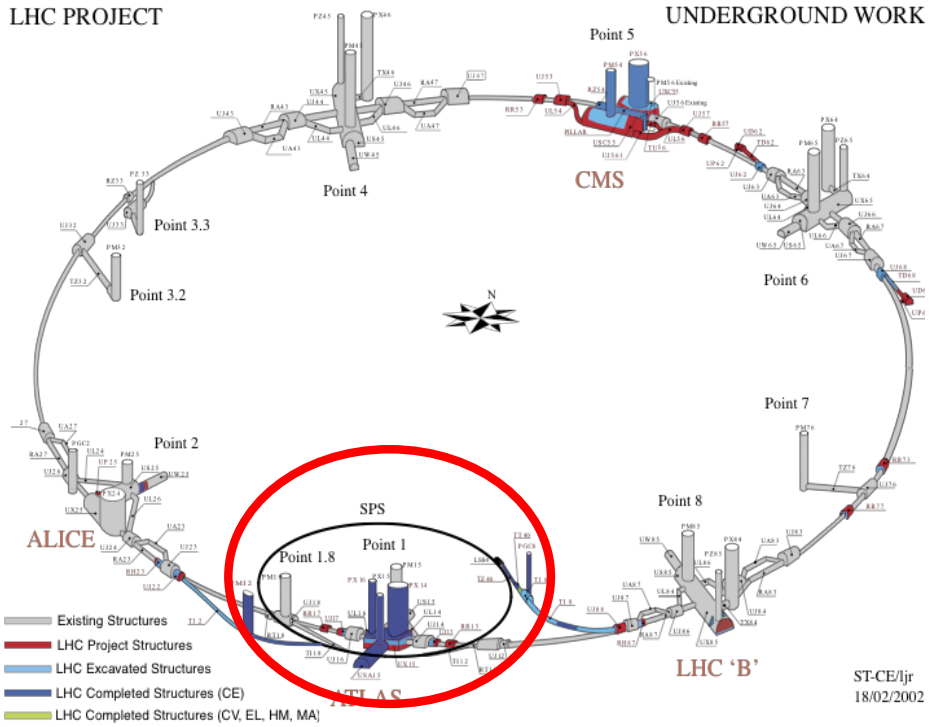
$$E = mc^2$$

Fermilab Tevatron and LHC at CERN

- World's Highest Energy proton-anti-proton collider
  - 4km (2.5mi) circumference
  - E_{cm}=2 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 130km/hr
    - ~100,000 times the energy density at the ground 0 of the Hiroshima atom bomb
  - **Tevatron was shut down in 2011**
  - **New frontiers with high intensity proton beams including the search for dark matter with beams!!**

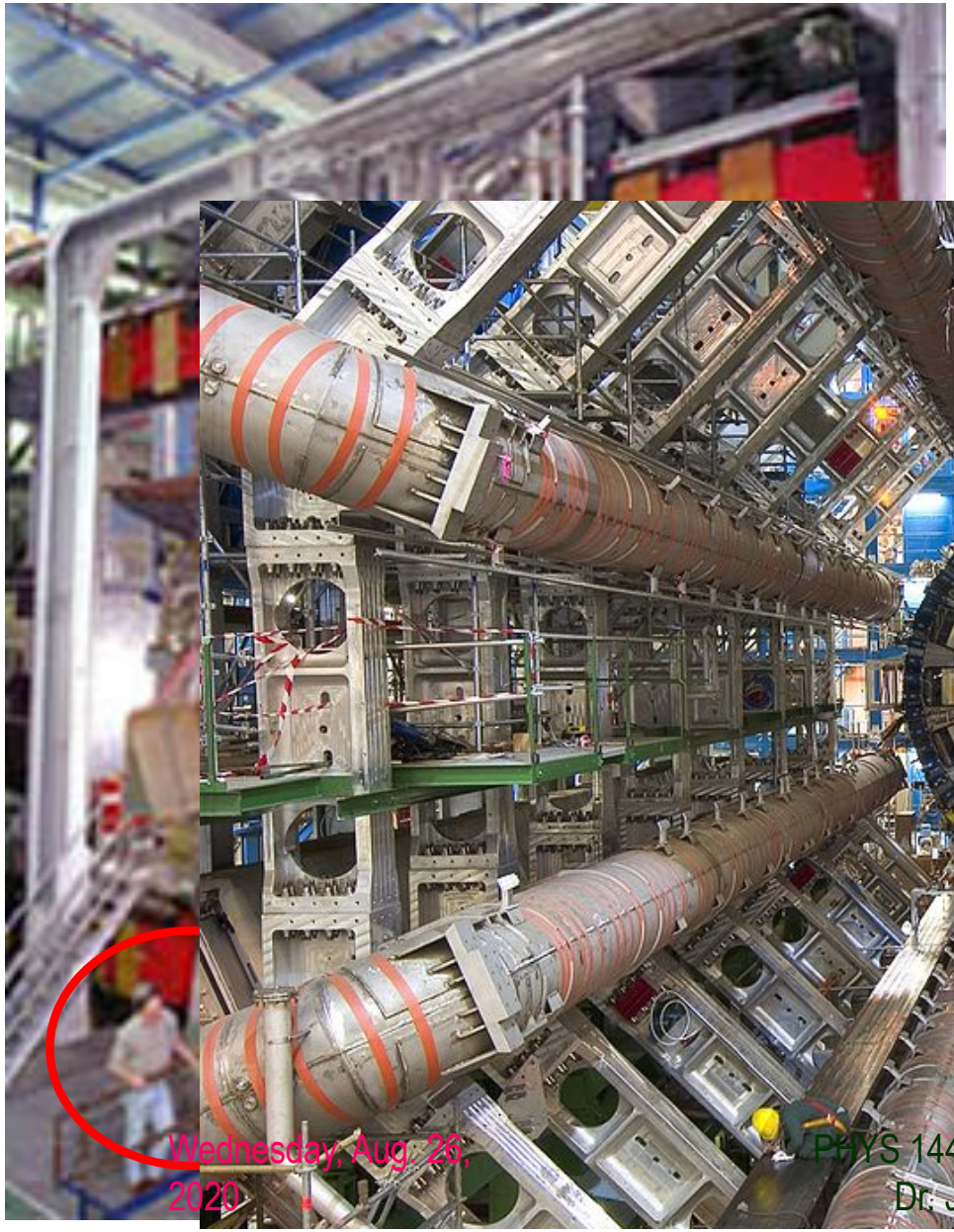


- World's Highest Energy p-p collider
  - 27km (17mi) circumference, 100m (300ft) underground
  - Design E_{cm}=14 TeV (=44x10^{-7}J/p➔ 362M Joules on the area smaller than 10^{-4}m^2)
  - ➢ Equivalent to the kinetic energy of a B727 (80tons) at the speed 310km/hr
    - ➢ ~3M times the energy density at the ground 0 of the Hiroshima atom bomb
- **Discovered a new heavy particle that looks Higgs in 2012**
- **Search for new particles has been ongoing!!**
- **Shut down for HL LHC➔ About to resume!!**

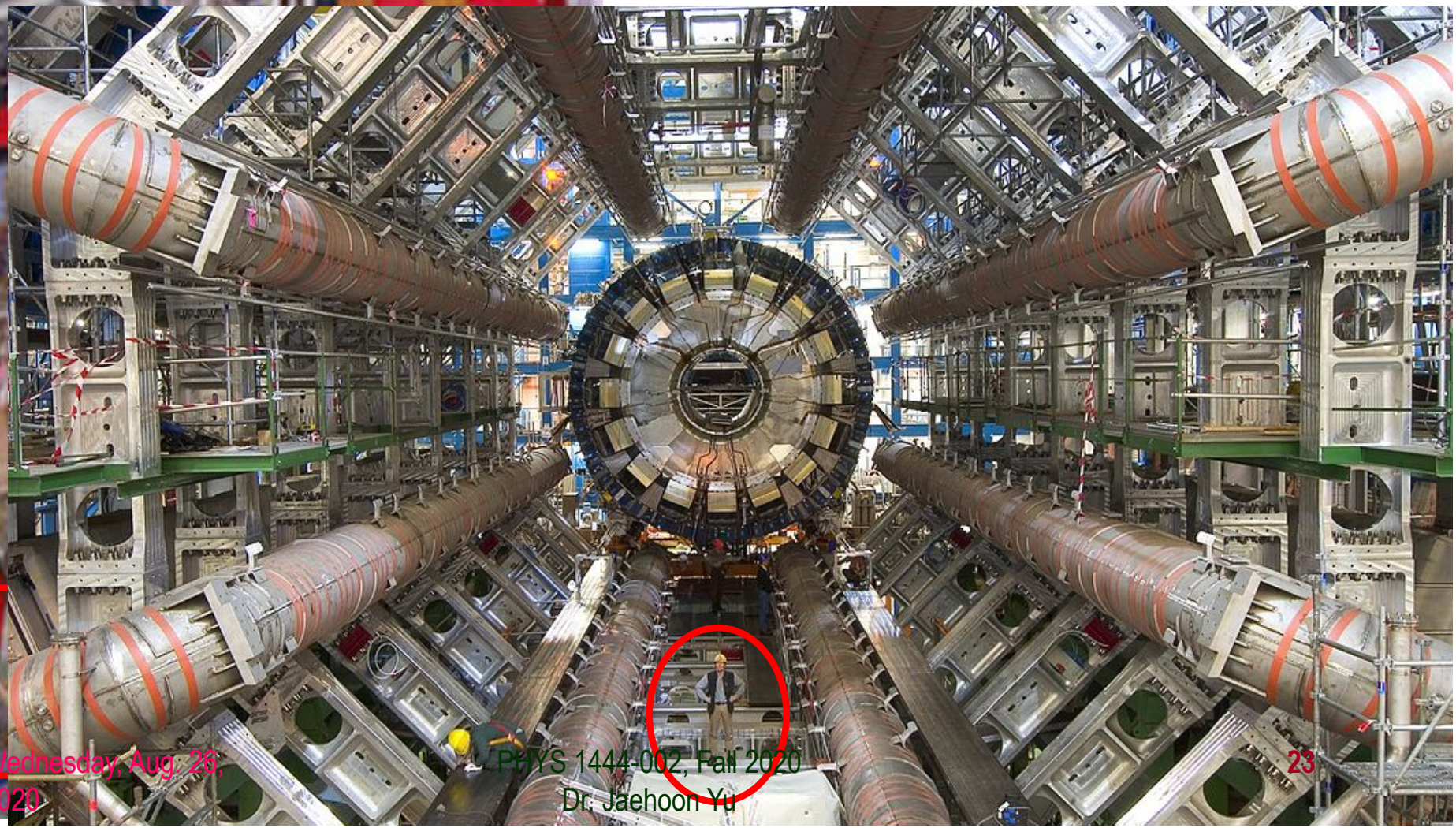


LHC @ CERN Aerial View

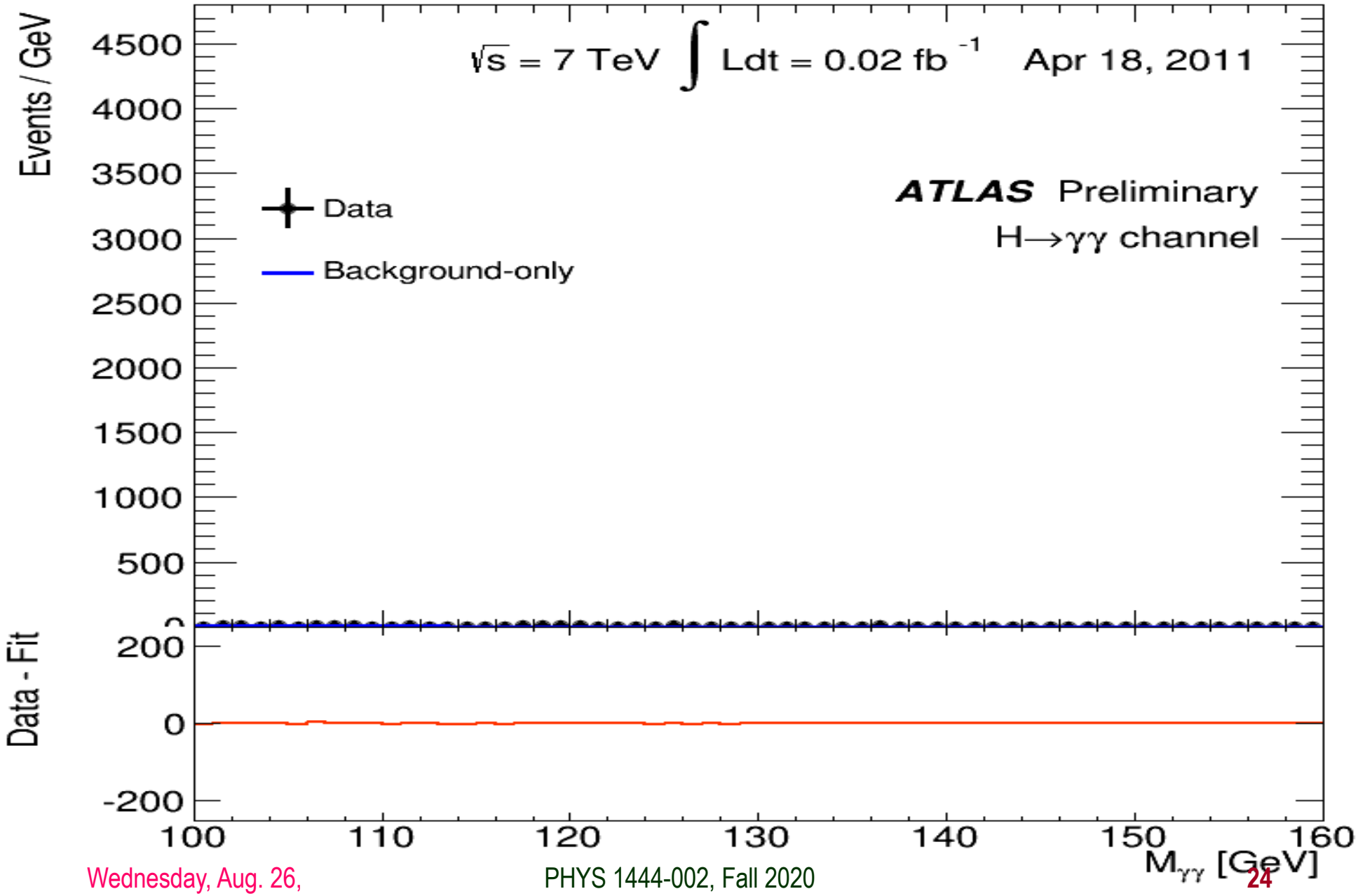
DZero Detector at Fermilab near Chicago



ATLAS Detector in Geneva Switzerland

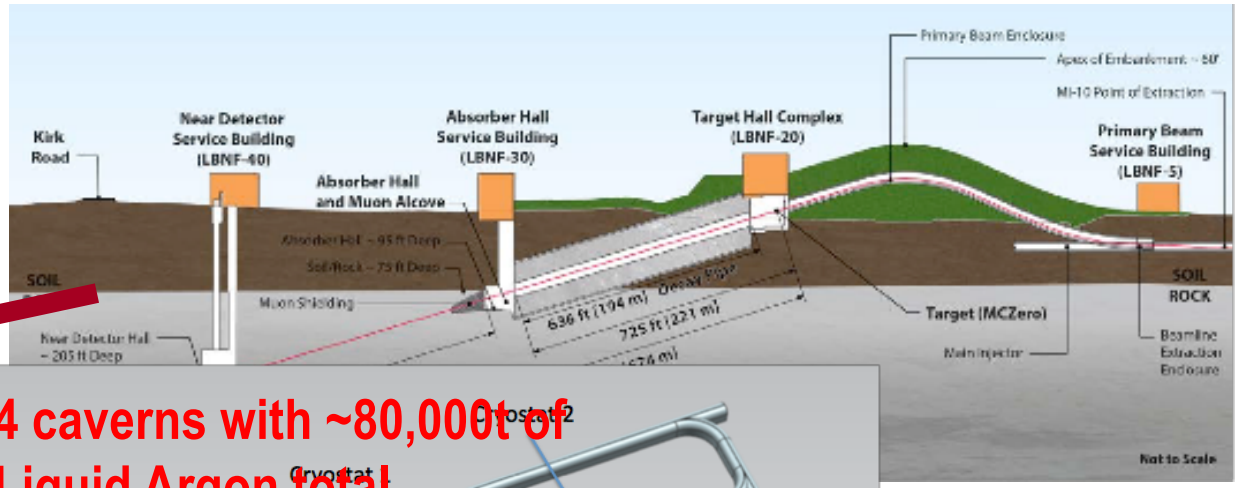


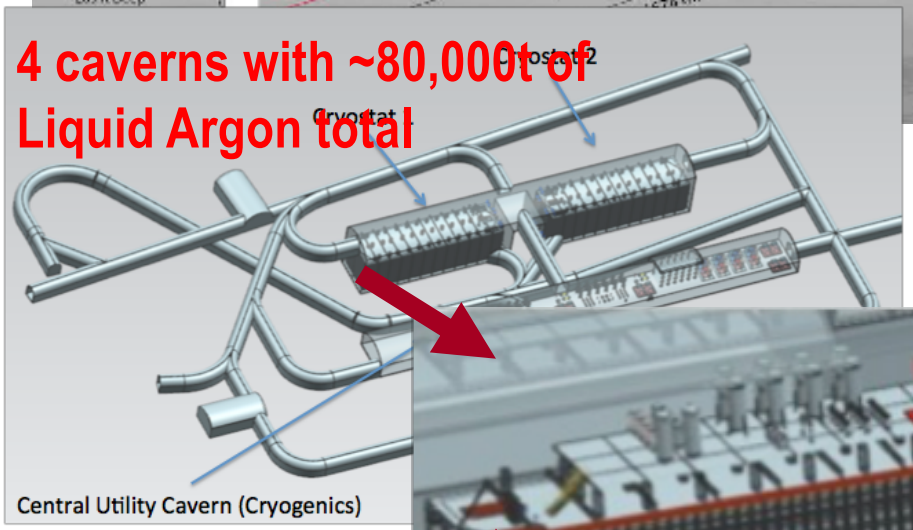
What did statistics do for Higgs→ γγ?

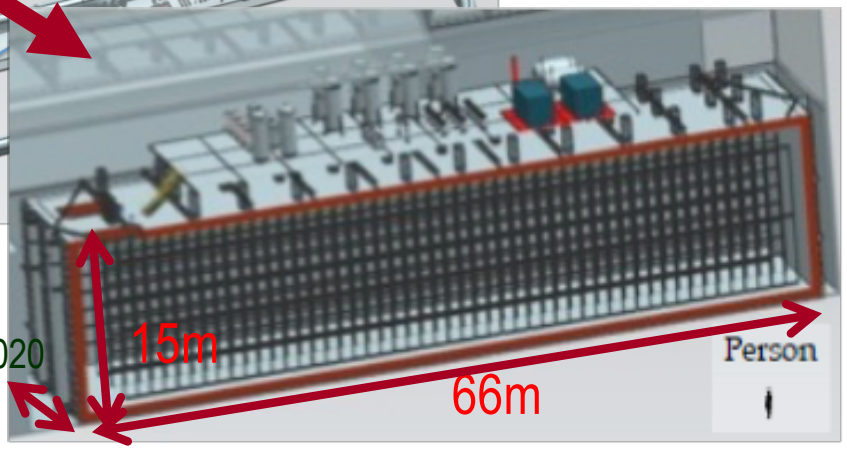


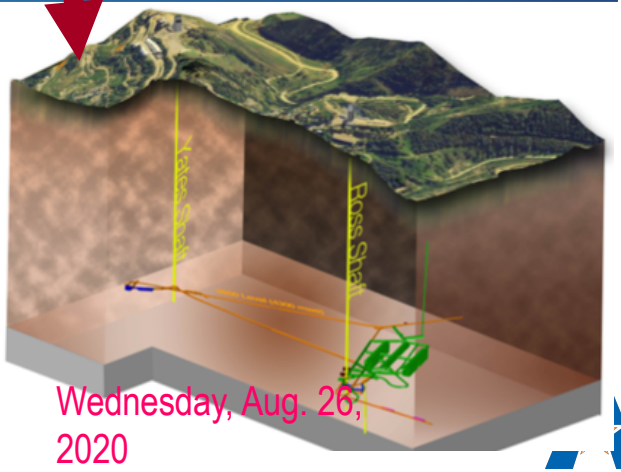
The Next Big Thing - DUNE Experiment

- Stands for Deep Under Ground Neutrino Experiment
- The $1.5B flagship long baseline (1300km) ν experiment
  - 1500m underground in South Dakota







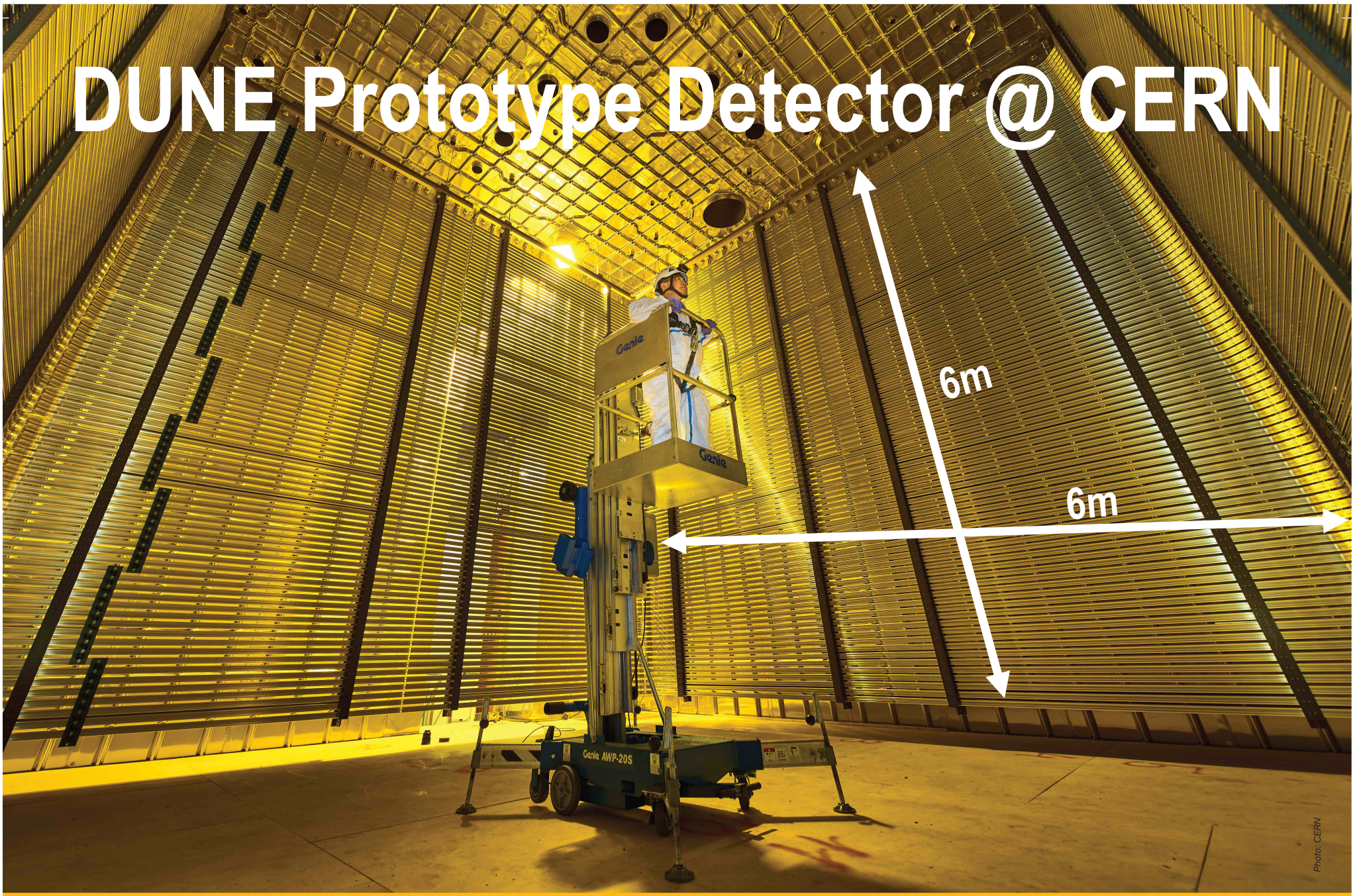


15m

The Map of the DUNE Experiment

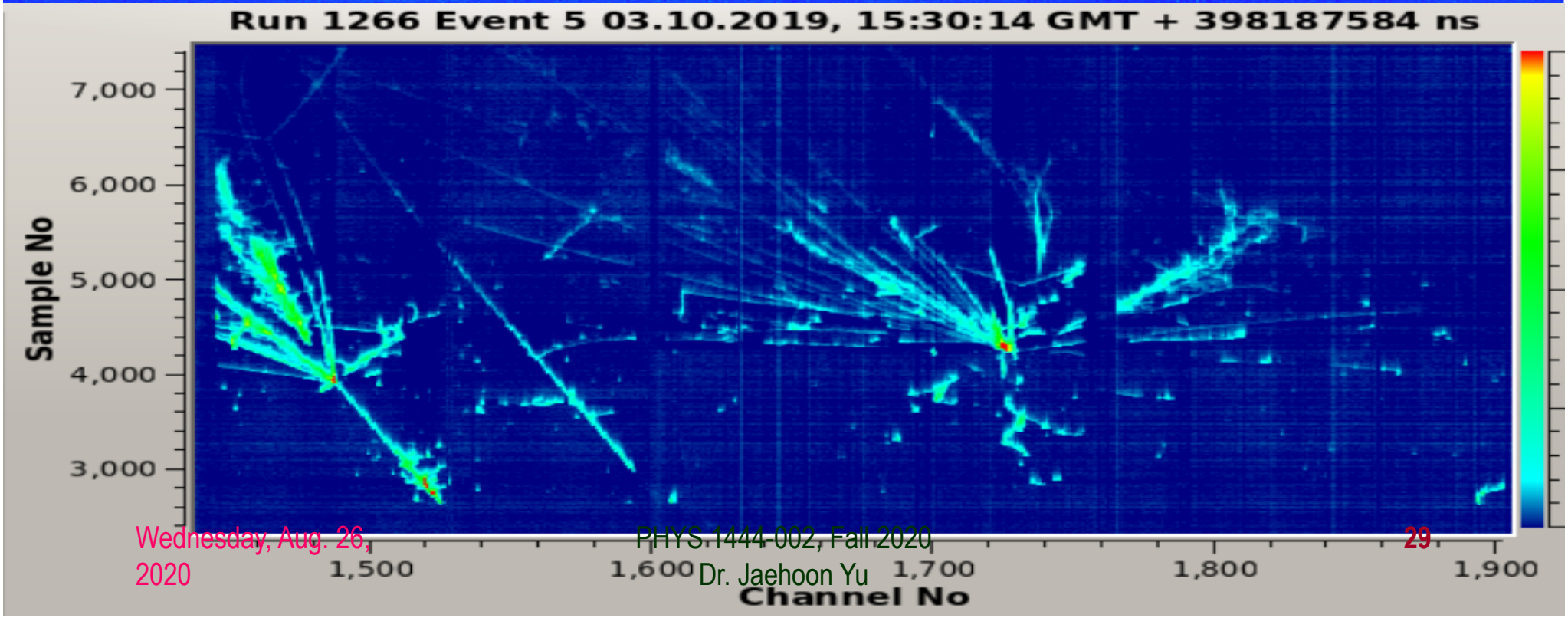
1106 collaborators
184 institutions
31 countries

Hector Carranza @ CERN

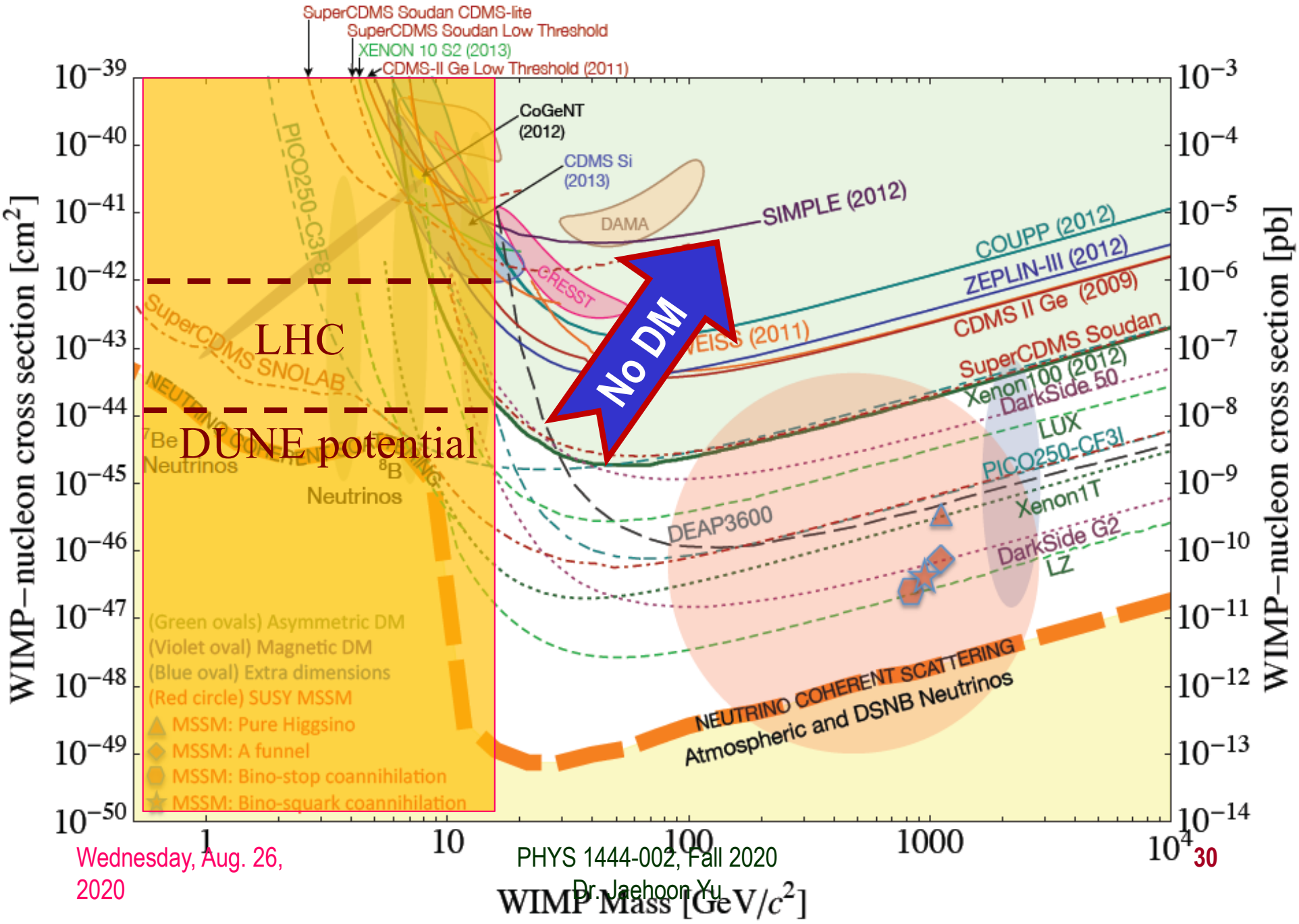

DUNE Prototype Detector @ CERN
6m
6m
Genie
Genie
Genie AWP-20S
Photo: CERN

ProtoDUNE Event

Beam halo (high energy) muon with bremsstrahlung initiated E.M. shower



Let's Look for Dark Matter!!



So why is HEP relevant to me?

- HEP explores the most fundamental nature of the Universe!
- Discoveries will realize our 1000 year dreams
- The discovery of the dark matter and making of dark matter beams will take us to the next Quantum level
- Outcome and bi-products of HEP research improves our daily lives directly and indirectly
  - WWW came from HEP


WHERE THE
WEB
WAS BORN

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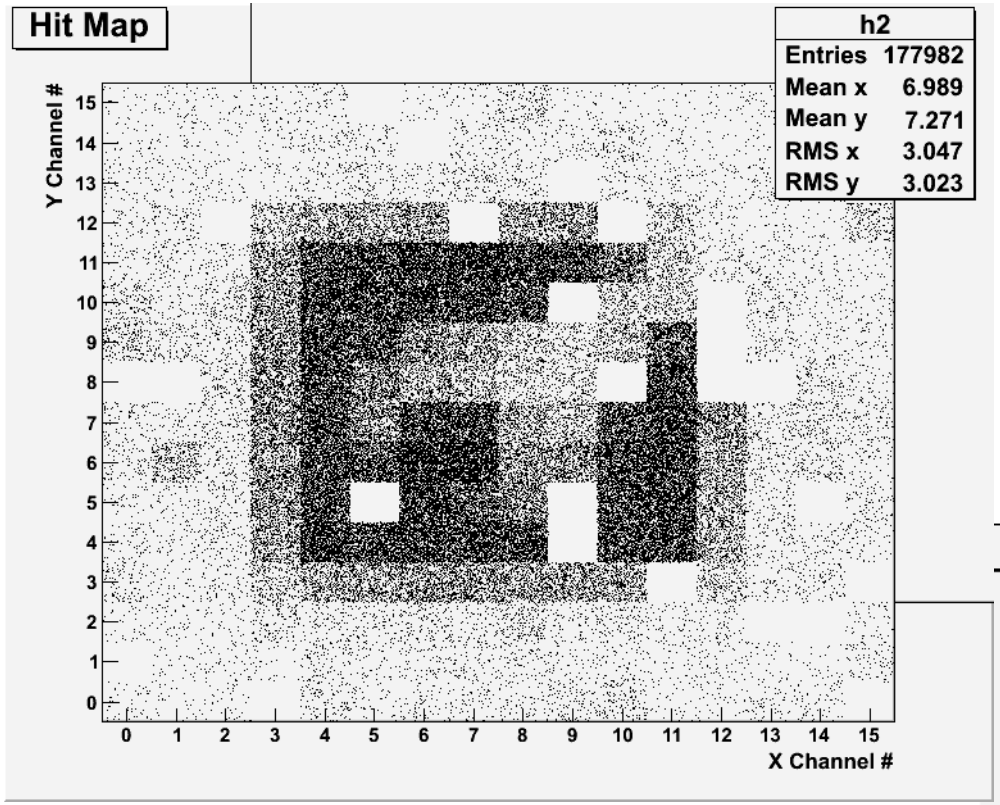
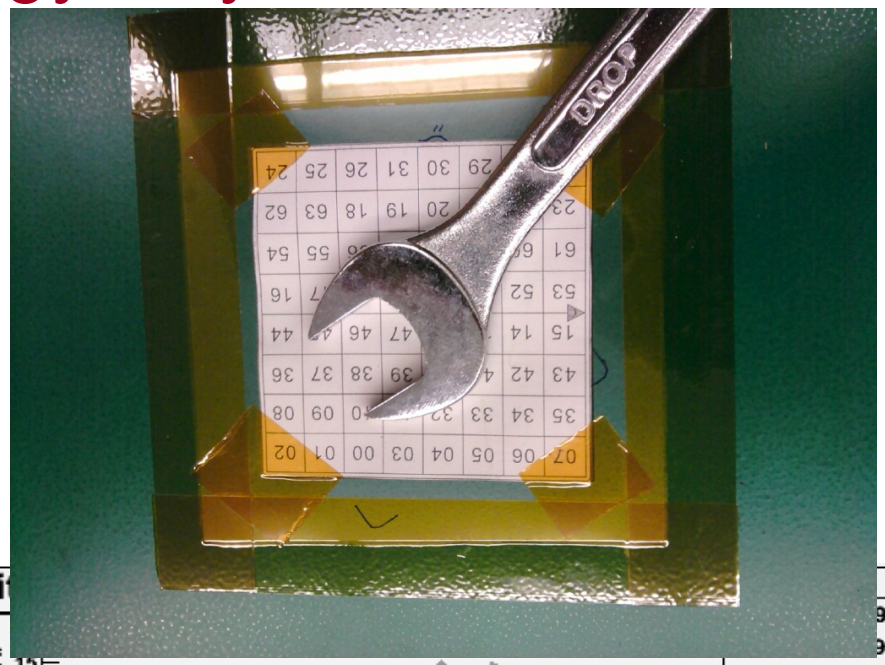
- Outcome and bi-products of HEP research improves our daily lives directly and indirectly
  - WWW came from HEP
  - Advanced detector technologies like GEM will make a large screen low dosage X-ray imaging possible

Bi-product of High Energy Physics Research

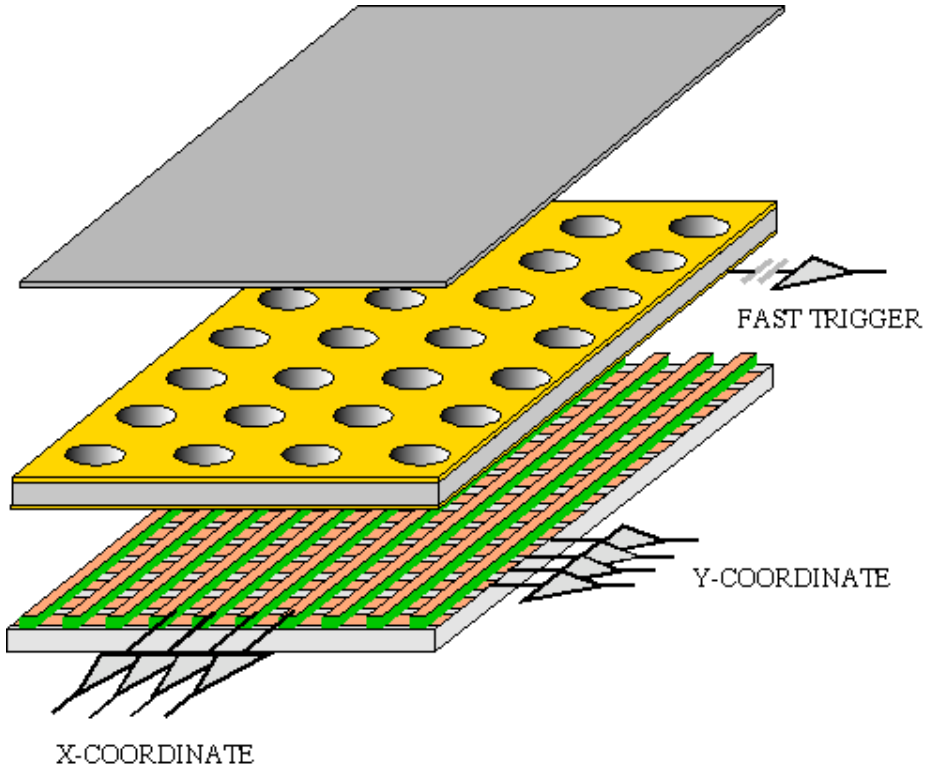




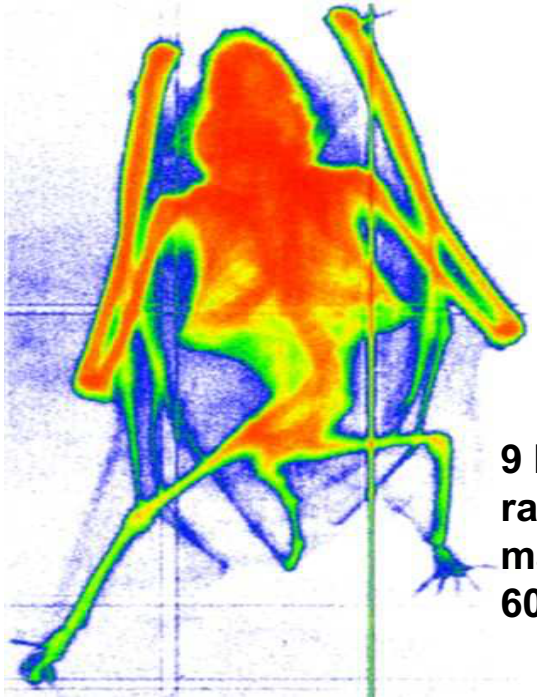
Can you see what the object is?
(GEM Detector X-ray Image)

GEM Application Potential

Using the lower GEM signal, the readout can be self-triggered with energy discrimination:



FAST X-RAY IMAGING



9 keV absorption radiography of a small mammal (image size ~ 60 x 30 mm^2)

A. Bressan et al,
Nucl. Instr. and Meth. A 425(1999)254
F. Sauli, Nucl. Instr. and Meth.A 461(2001)47

Let's all dream,

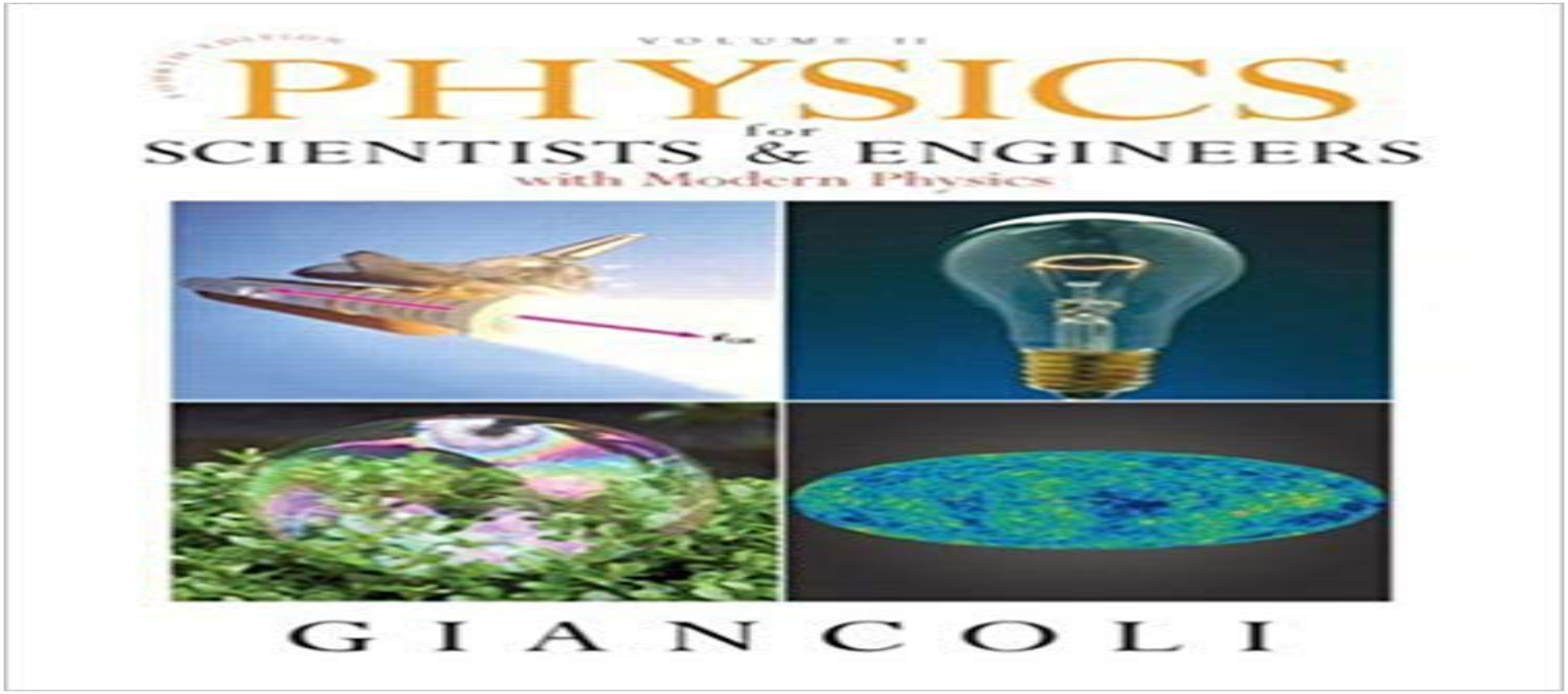
not just for tomorrow,

not just for the next year,

but for 1000 years into the future for the whole humanity!!

Textbook

- Title: Physics for Scientists and Engineers with Modern Physics
  - 4th edition (but used should be fine except for a few minor differences)
- Author: D.C. Giancoli
- ISBN13: 978-0132273596
- ISBN10: 9780132273596



Information & Communication Source

- Course web page: http://www-hep.uta.edu/~yu/teaching/fall20-1444-002/fall20-1444-002.html (Canvas has a link to this page)
  - Lecture notes and recordings
  - 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 often read!!
- Office Hours: 2:30 – 2:30pm, MW or by appointments on zoom

Evaluation Policy

- Homework: 25%!!!
- Exams
  - Final Comprehensive Exam (11am, Wed., 12/16/20): 23%
  - Mid-term Comprehensive Exam (1pm, Mon., 10/19/20): 20%
  - One better of the two term Exams (9/23/20 and 11/11/20): 12%
  - 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 no matter how well you've been doing in class!
- Lab score: 10% (Starts Monday, Sept. 14, **www.uta.edu/physics/labs**)
- Pop-quizzes: 10%

100%

- Extra credits: 10% of the total
  - Random attendances
  - Strong participation in the class discussions
  - Special projects (BIGGGGG!!!)
  - Special seminars
- Grading will be done on a sliding scale

Homework

- Solving homework problems is the only way to comprehend class material: ~1 homework per week
- An electronic homework system has been setup for you
  - Details are on the class web
  - https://quest.cns.utexas.edu/student/courses/list
  - Choose the course **PHYS1444-fall20**, unique number **44120**
  - Download the homework, solve the problems and submit them online
  - Multiple unsuccessful tries will deduct points after one free try
  - Roster will close at 11pm next Monday, Aug. 31
  - You need a UT e-ID (NOT the UTA NetID): Go and apply at the URL https://idmanager.its.utexas.edu/eid_self_help/?createEID&qwicap-page-id=EA027EFF7E2DA39E if you don't have one.
- Each homework carries the same weight
- Homework problems will be **slightly ahead of the class and tough**!
- **No** homework will be dropped from the final grade!!
- Homework will constitute **25% of the total** ➔ A good way of keeping your grades high
- Strongly encouraged to collaborate ➔ Please be fair and keep integrity

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 and video recording will be posted on the class web page **AFTER** each class
  - 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

- 10% addition to the total
  - Could boost a B to A, C to B or D to C
- What constitute for extra credit?
  - Special projects (biggest!!)
  - Attendances
  - Strong participation in the class discussions
  - Other opportunities ➔Special seminars

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
    - Show your work! Just putting the right answer for free response problems does not work!
- But you have a great control (up to 45%) of your grade in your hands
  - Homework is 25% of the total grade!!
    - Means you will have many homework problems
      - Sometimes much more than any other classes
      - Some homework problems will be something that you have yet to learn in class
      - Exam problems will be easier than homework problems but the same principles!!
  - Lab 10%
  - Extra credit 10%
- I will work with you so that your efforts, despite COVID –19 related hardship are properly rewarded

What do we want to learn in this class?

- Physics is everywhere around you.
- Skills to understand the fundamental principles that surrounds you in everyday lives…
- Skills to identify what laws of physics applies to what phenomena and use them appropriately
- Understand the impact of physical laws and apply them
- Learn skills to think, research and analyze observations.
- Learn skills to express observations and measurements in mathematical language
- Learn skills to express your research in a systematic manner in writing
- But most importantly the confidence in your physics ability and to take on any challenges laid in front of you!!

Even more importantly, let us have a lot of FUN!!

Specifically, in this course, you will learn…

- Concept of Electricity and Magnetism
- Electric charge and magnetic poles
- Electric and Magnetic Forces and fields
- Electric and magnetic potential and energies
- Propagation of electric and magnetic fields
- Relationship between electro-magnetic forces and light
- Behaviors of light and optics
- Special relativity and quantum theories

How to study for this course?

- Keep up with the class for comprehensive understanding of materials
  - Come to the class and participate in the discussions and problems solving sessions
  - Follow through lecture notes
  - Work out example problems in the book yourself without looking at the solution
  - Have many tons of fun in the class, asking lots of questions!!!!!
- Keep up with the homework to put the last nail on the coffin
  - One can always input the answers as you solve problems. Do NOT wait till you are done with all the problems.
  - Form a study group and discuss how to solve problems with your friends, then work the problems out yourselves!
- Prepare for upcoming classes
  - Read the textbook for the material to be covered in the next class
- The extra mile
  - Work out additional problems in the back of the book starting the easiest problems to harder ones