

PHY294H

- Professor: Joey Huston
- email: huston@msu.edu
- office: BPS3230
- textbook: Knight, Physics for Scientists and Engineers: A Strategic Approach,
Vol. 4 (Chs 25-36), 3/E + MasteringPhysics
0321844297
MasteringPhysics (complete ebook) access card stand alone
0321753054
- Homework will be with Mastering Physics (and an average of 1 hand-written problem per week)
 - ◆ first MP assignment due Wed Jan. 20; first hand-written problem as well
- Quizzes by iclicker (sometimes hand-written)
- Lectures: MTWTh 11:30-12:20
- Course website: www.pa.msu.edu/~huston/phy294h/index.html
 - ◆ lectures will be posted frequently, mostly every day if I can remember to do so

-
- Occasionally there will be guest lecturers, as for example Wednesday and Thursday this week

Get Started with MasteringPhysics

**You
Need:**



- **Email:** The email you use for school.
- **Course ID:** A Course ID looks something like MCprofessor12345. Ask your instructor for your Course ID!
- **Access code or credit card:** The required access code comes either with your book or by itself at your bookstore. Alternatively, you can buy instant access with a credit card or PayPal account during registration.

Purchase Access

Bookstore:

An **Access Code** is included in a package available for purchase at the bookstore. You will redeem the code during the registration process.

<insert package ISBN
and price>

OR

Online Purchase:

Use a Credit Card or PayPal account to purchase **instant access** online during the registration process.

Step 1

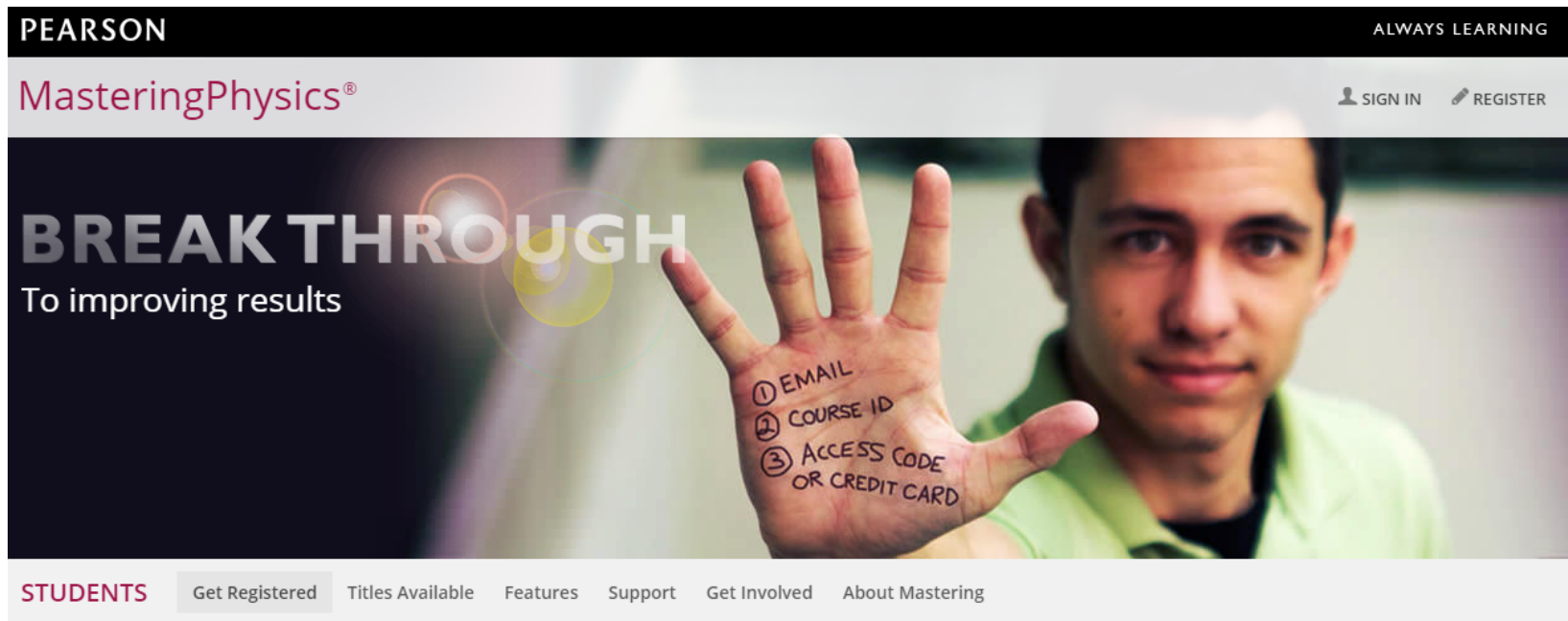
Go to www.MasteringPhysics.com

Under the large Register Now section on the right side of the page, click the **Student**

The screenshot displays the MasteringPhysics.com homepage. At the top, a black header bar contains the 'PEARSON' logo on the left and 'ALWAYS LEARNING' on the right. Below this, the word 'Mastering' is written in a large, stylized font. A yellow banner across the top of the main content area reads: 'Exciting updates are now available. See what's new!'. The main content area has a dark background. On the left, a large graphic with the text 'BREAKTHROUGH' and 'To improving results' is shown, along with a small bar chart and a paragraph stating: 'Our goal is to help every student succeed. We're working with educators and institutions to improve results for students everywhere. Learn more >'. Below this, there are three red boxes with white text: 'EDUCATORS >' (with links: Features, Get Trained, Support, More...), 'STUDENTS >' (with links: Get Registered, Support, More...), and 'ACADEMIC EXECUTIVES >' (with links: Results, Features, More...). On the right side, there is a 'Sign In' section with the text 'Already registered? Sign in with your Pearson account.' and a red button labeled 'SIGN IN' with a user icon. Below this is a link 'Check your browser >'. Further down is a 'Register Now' section with the text 'Need access? Start here!'. This section contains two red buttons: 'STUDENT' (with a pencil icon) and 'EDUCATOR' (with a pencil icon). A large green arrow points from the 'STUDENT' button towards the center of the page. At the bottom, a green footer bar contains 'ALWAYS LEARNING' on the left and 'PEARSON' on the right.

Step 2

Read through the onscreen instructions and select your **location**.



Do you have these 3 things?

Email

You'll get some important emails from your instructor at this address.

Course ID

A Course ID looks something like this: MPprofessor12345.

Note: Not all courses require a Course ID. Please check with your instructor.

Access code or credit card

You can buy an access code packaged with your textbook or as a standalone access code kit. Or you can buy instant access with your credit card or PayPal account.

Select your location

In US or Canada >

Outside US and Canada >



Step 3

Check off whether or not you have a **Course ID**. If you have a **Course ID** provided by your instructor, type it in and press **Go**. If your course does not require an ID, click on the radio button below and click **Next**. *Check with your professor to be sure!*

Do you have a Course ID from your instructor?

If not, ask your instructor if he or she will be providing a Course ID.

☒ **Yes, I have a Course ID**

Enter the Course ID (including hyphens) provided by your instructor:

MPHUSTON48047

Go >

Sample Course ID: Lastname12345

☐ No, my course doesn't require an ID

Next >

Step 4

Check off whether or not you have an **Access Code**. If you don't have one, you can purchase access online. You will need the correct textbook title, author, and edition. Check with your professor to get this information or your course syllabus.

Do you have an access code?

An access code may have been included with your textbook or in a Student Access Card/Kit available from your campus bookstore.

Your access code may look like this:

SIMPLE-FRILL-TONLE-WEIRS-CHOIR-FLEES

If you do not have an access code, you can buy access with a credit card or PayPal account.

- ☐ Yes, I have an access code
- ☐ No, I need to buy access

Step 5

Before continuing, make sure you read & accept the License Agreement. After this, either **Create** a new Pearson username/password, or, if you've already registered for another Pearson product, enter that username/password. If you have an **Access Code**, enter it on the bottom of the page.

The screenshot shows the 'Steps to Register' progress bar at the top with three steps: 'Access Information' (selected), 'Account Information', and 'Confirmation & Summary'. The main heading is 'Access Information'. Below it, there's a question 'Do you have a Pearson Education account?' with radio button options for 'Yes' and 'No', and a link 'Not sure if you have an account?'. Below that is an 'Access Code' input field. Underneath the field is the text 'Enter your access code.' and a section for the 'Access Code' itself, which consists of six individual input boxes separated by hyphens. To the right of these boxes is an example code: 'SIMPLE-FRILL-TONLE-WEIRS-CHOIR-FLEES'. At the bottom right are 'Cancel' and 'Next' buttons.

PEARSON

Steps to Register

Access Information Account Information Confirmation & Summary

Access Information

Do you have a Pearson Education account?

Yes

No

[Not sure if you have an account?](#)

Access Code

Enter your access code.

* Access Code


Switch to a single box for pasting your access code

Example
SIMPLE-FRILL-TONLE-WEIRS-CHOIR-FLEES



Cancel Next

Step 6


Fill out the appropriate information fields, then click **Next**. If you entered an **Access Code**, you will be brought to a page from which you can access your product. If not, enter your payment information so that you can **Purchase Access**, after which you'll be granted access.

Steps to Register

☒ Access Information ☒ Account Information ☐ Confirmation & Summary

Account Information * Fields are required [Video Tutorial](#)  [Help](#) 

MasteringChemistry for Brown, LeMay Chemistry: The Central Science, 13e - with eText
Welcome back, NICK. Review your account information and update as needed.

Personal Information 


*First Name

*Last Name

Instructors might send course information to your email address. Important subscription and system information will also be sent to you.


*Email Address
Enter a valid email address. [See acceptable characters.](#)
[Don't have an email address?](#)

*Re-type Your Email Address

School Location 

*School Country

Select A Country ▼

May we contact you? 

☒ Let me know about other Pearson Education products and services to help me succeed.


◀ Back

Cancel

Next ▶

Step 7

You're now registered! Click **Log In Now**. If prompted, enter your Student ID. That's it!



Steps to Register

✓ Access Information

✓ Account Information

● Confirmation & Summary

Confirmation & Summary

Print This Page

You have subscribed to a Pearson Education online product. Please [print this page](#) as your receipt. You will also receive a confirmation email for your records.

You now have access to.

Mastering

Log In Now ▶

If you need to review or edit your account information, visit your [Account Summary](#) page.

Role: Student	Account ID:
Expiration Date:	Order ID:
Section or Module:	Login Name:

You also have access to...

?

Need help?

Visit www.MasteringPhysics.com
and click the “Student” button under
“Register Now” for:

- Helpful videos
- Frequently Asked Questions
- System Requirements
- Other helpful “getting started” info!

Or visit our 24/7 Technical Support site at
<http://247pearsoned.custhelp.com>.

Send us a Tweet at @PearsonSupport

Introduction

What is fundamental?

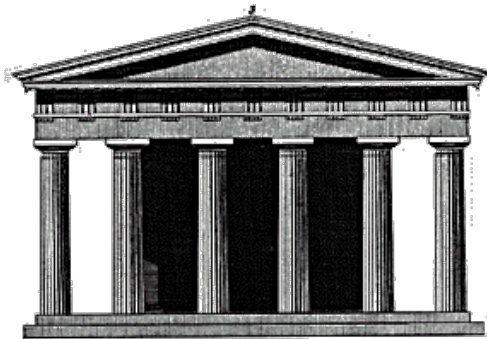


- ✶ The TWO most fundamental questions about the universe are:
- ◆ What is it made of?
 - ◆ How is it all held together?



Four Fundamental Elements

- The Hunt for the answers to those two questions has been going on for a very long time.
- It really started with the Greeks.



(c) Andy Brice 1998

...and Two Fundamental Forces

- There were two fundamental forces:
 - ◆ Love
 - ◆ Strife
- This picture is a tad too simple....

Let's jump ahead 2000 years or so

- Four fundamental forces (that we know about):

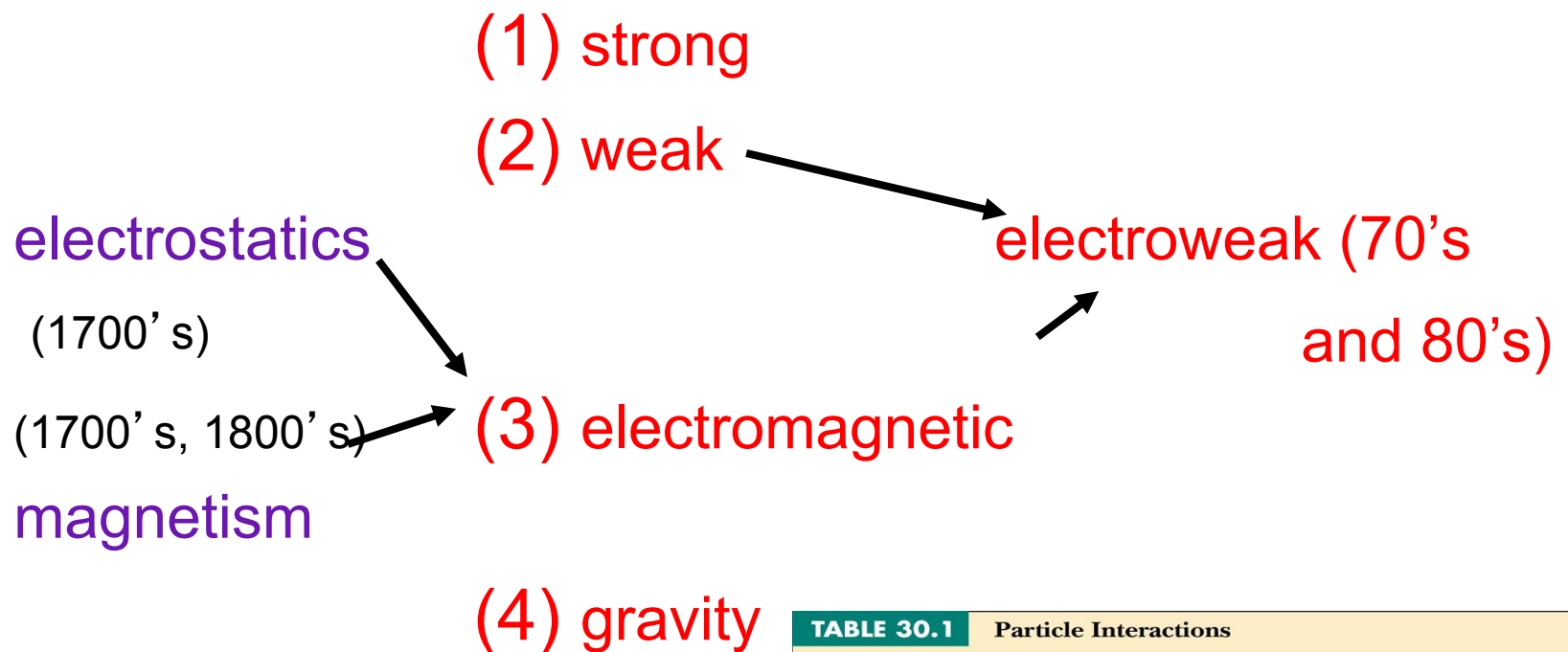


TABLE 30.1 Particle Interactions

Interaction (Force)	Relative Strength ^a	Range of Force	Mediating Field Particle
Strong	1	Short (~ 1 fm)	Gluon
Electromagnetic	10^{-2}	Long ($\propto 1/r^2$)	Photon
Weak	10^{-6}	Short ($\sim 10^{-3}$ fm)	W^{\pm} and Z^0 bosons
Gravitational	10^{-43}	Long ($\propto 1/r^2$)	Graviton

^a For two quarks separated by 3×10^{-17} m

What am I trying to do in my research?

(1) strong

(2,3) electroweak

(4) gravity

GUT

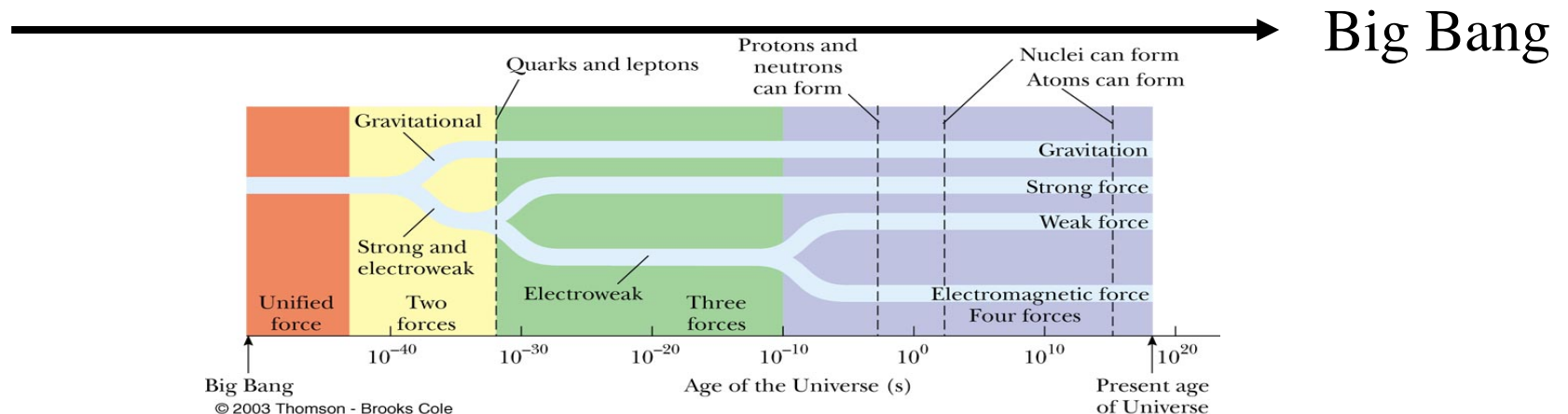
TOE



+

Grand Unified Theory

= Theory of Everything



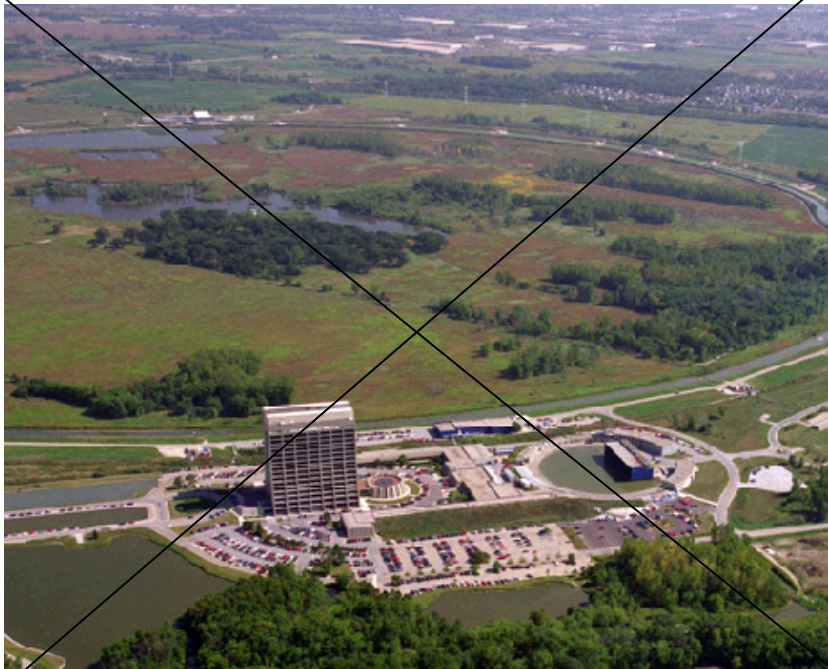
What is high energy physics all about?

- In high energy physics, we are attempting to understand the fundamental laws and forces which govern the universe, as well as to discover all of its fundamental constituents
- ...and pretty neat questions as to how many dimensions the universe really has
- ...and whether for high energy collisions whether gravity can be strong enough to create black holes



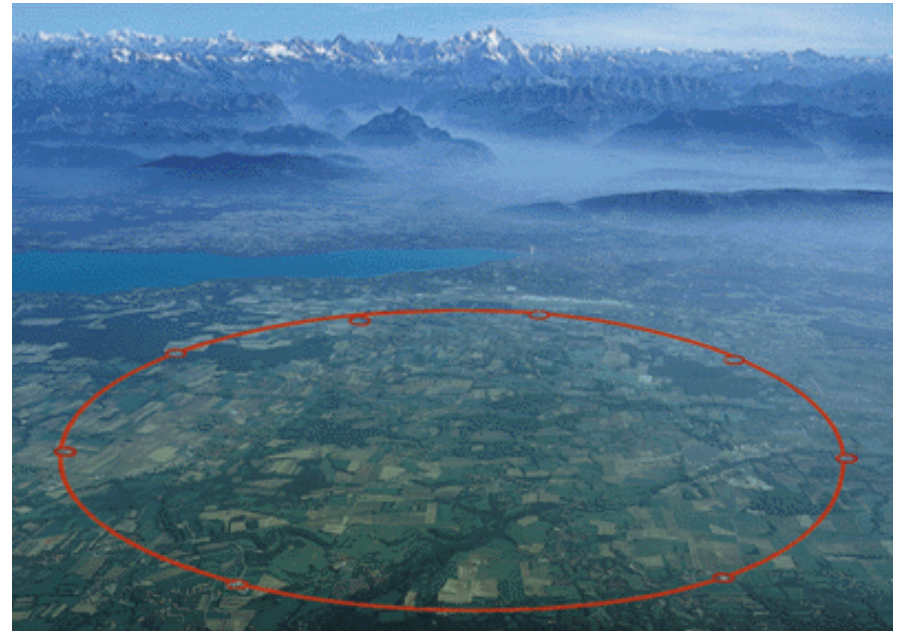
To do so takes big accelerators

Fermilab, near Chicago



Fermilab is still running but the Tevatron (protons colliding with anti-protons) shut down in 2012

CERN, near Geneva, Switzerland



The CERN LHC started running in 2008, took data in 2010, 2011, 2012 and 2015 (protons colliding with protons) and is now starting up again.

...and big detectors

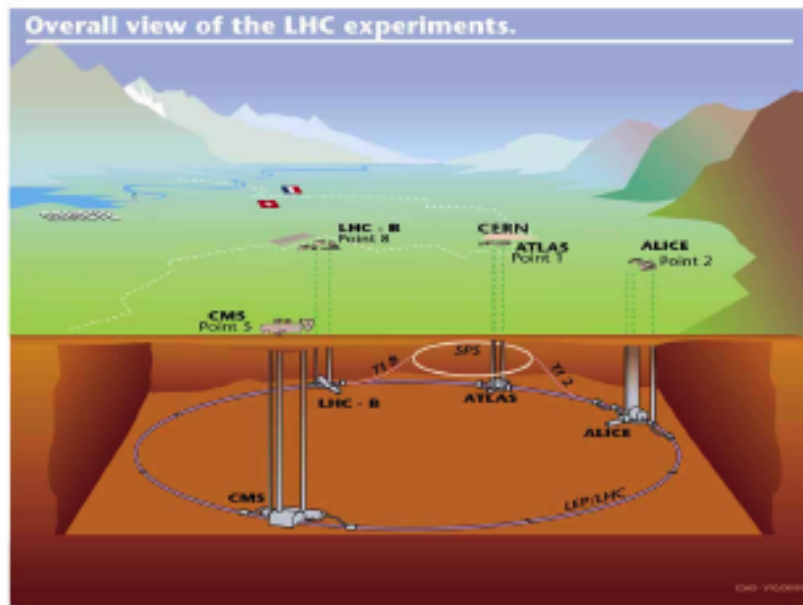
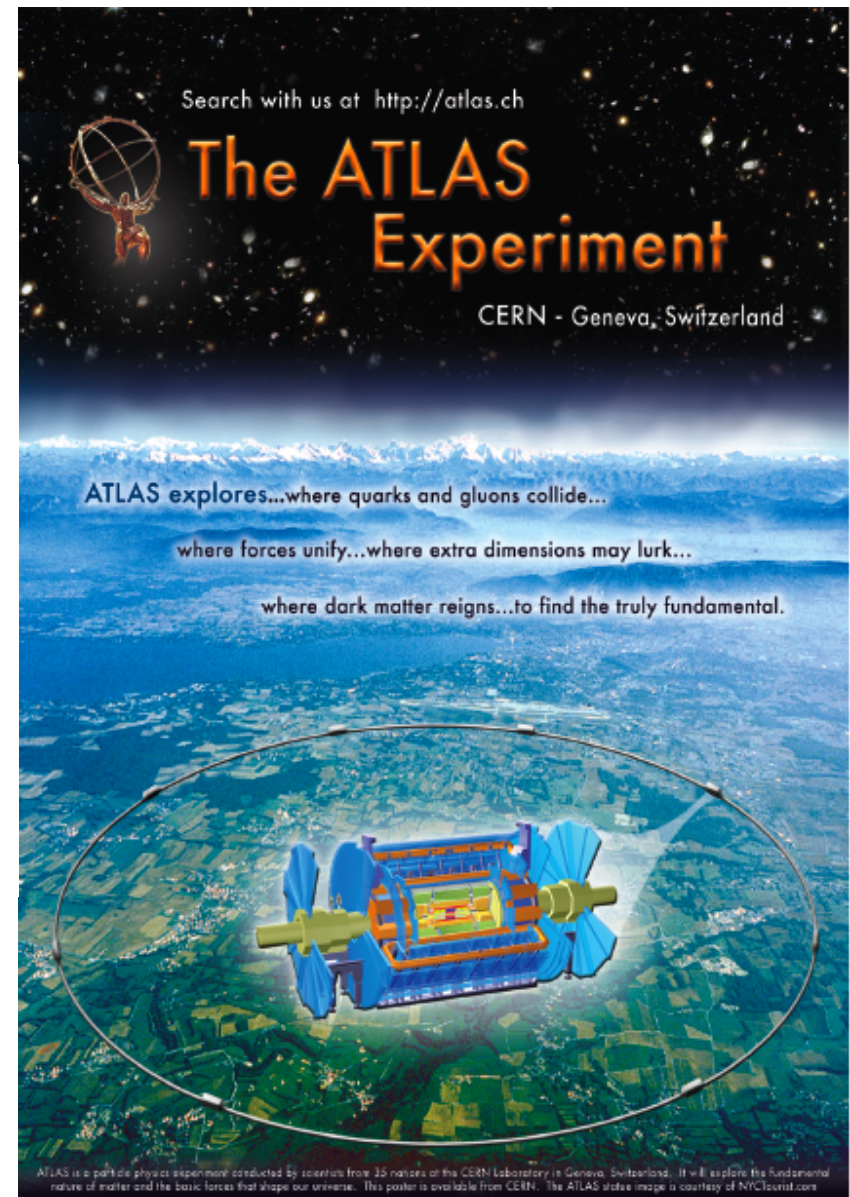


Figure 1: A Schematic diagram of the LHC complex, the smaller ring is the SPS which feeds protons into the LHC for further acceleration [2]



...we did not

The screenshot shows a YouTube video player with a blue background and white text. The text reads: "Did Nostradamus predict a particle accelerator will create a black hole that destroys earth?" and "From Revelation13.net". The video player includes a progress bar, a volume icon, and a "2008 Diet Of The Year:" label. Below the video player, there are buttons for "Share", "Favorite", "Playlists", and "Flag". The "Share" button has icons for MySpace, Facebook, and Digg. The "Rate" section shows 387 ratings and a "Views: 58,620" count. To the right of the video player, there is a sidebar with a "Subscribe" button and a list of other videos from the channel "revelation13net". The sidebar includes a "More From: revelation13net" section with a list of videos and their view counts.

YouTube – Did Nostradamus predict the LHC will create a Black Hole?

http://www.youtube.com/watch?v=ozjq80IF9dg

Search: black holes and LHC

Resumation...tal at MSU MTA SZTAKI: ... Dictionary CSCNotesLis...las < TWiki PatVancouve...las < TWiki PhysicsAnaly...las < TWiki Quick guide...nda monitor http://www...ession.mp3 Quick guide...nda monitor

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Did Nostradamus predict the LHC will create a Black Hole?

Did Nostradamus predict a particle accelerator will create a black hole that destroys earth?

From Revelation13.net

2008 Diet Of The Year:™ Ads by Google

Rate: ★★☆☆☆ 387 ratings Views: 58,620

Share Favorite Playlists Flag

MySpace Facebook Digg (more share options)

From: revelation13net Joined: 2 years ago Videos: 81 Subscribe

Added: February 04, 2008 (More info)

Copyright 2008 by T. Chase.
A prophecy of French prophet Nostradamus, 9 44, may predict the CERN Large Hadron Collider LHC proton particle accelerator being built near Geneva on the France Swiss bor...

Embed: Customize

<object width="425" height="344"><param name="movie" value="h

More From: revelation13net

- the Antichrist in Russia From: revelation13net
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- Who is Mabus in French Prophet Nostradamus Prophecy 2 62 09:02 From: revelation13net

...and unfortunately no evidence of black holes so far

Tom Hanks at CERN

- We produce anti-matter, but not enough to blow up the Vatican



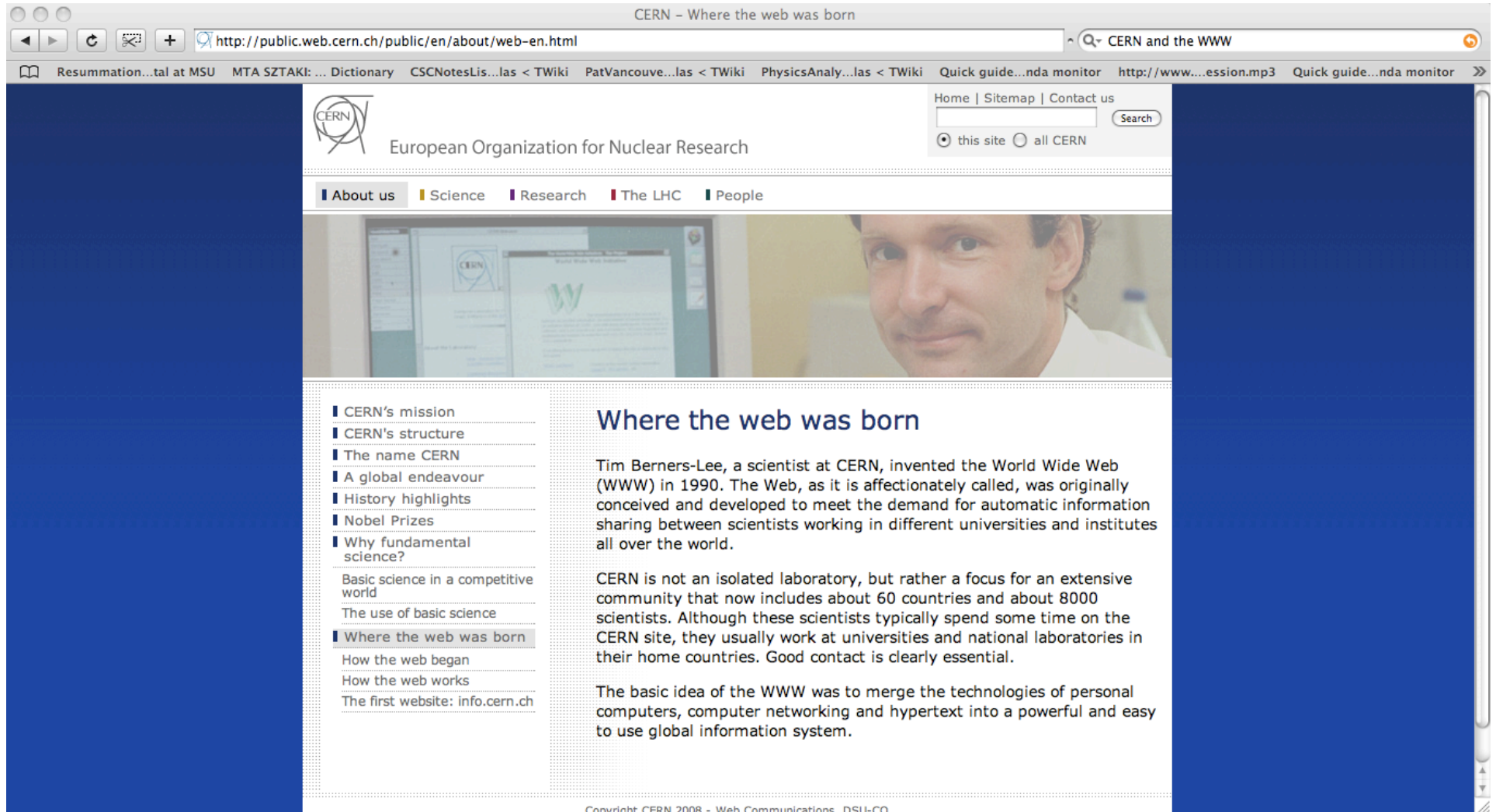
In *Angels & Demons* Tom Hanks plays Harvard academic Robert Langdon, who discovers evidence of the resurgence of an ancient secret brotherhood called the Illuminati - the most powerful underground organization in history.

When Langdon finds evidence that the Illuminati have stolen antimatter from a secret laboratory at CERN, which they plan to use as a devastating weapon to destroy the Vatican, he and CERN scientist Vittoria Vetra begin a race against time to recover the antimatter and prevent catastrophe.

But what is antimatter? Is it real? Is it dangerous? What is CERN?

<http://angelsanddemons.cern.ch/>

...but we did



...and this is the home of

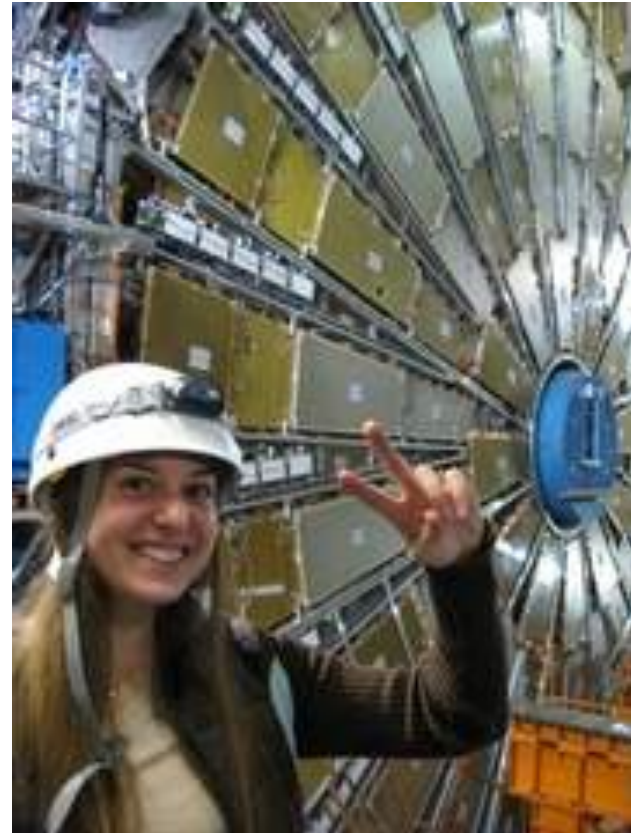


First picture ever posted on the web

I may play some of their music this semester

...and we do have a rap song

- MSU grad's particle physics rap is [YouTube](#) hit
 - ◆ Katie McAlpine
 - ◆ With an intro from MC Hawking



...in front of my experiment

...and we did

- Discover the Higgs bosons

Physicists Find Elusive Particle Seen as Key to Universe



Pool photo by Denis Balibouse

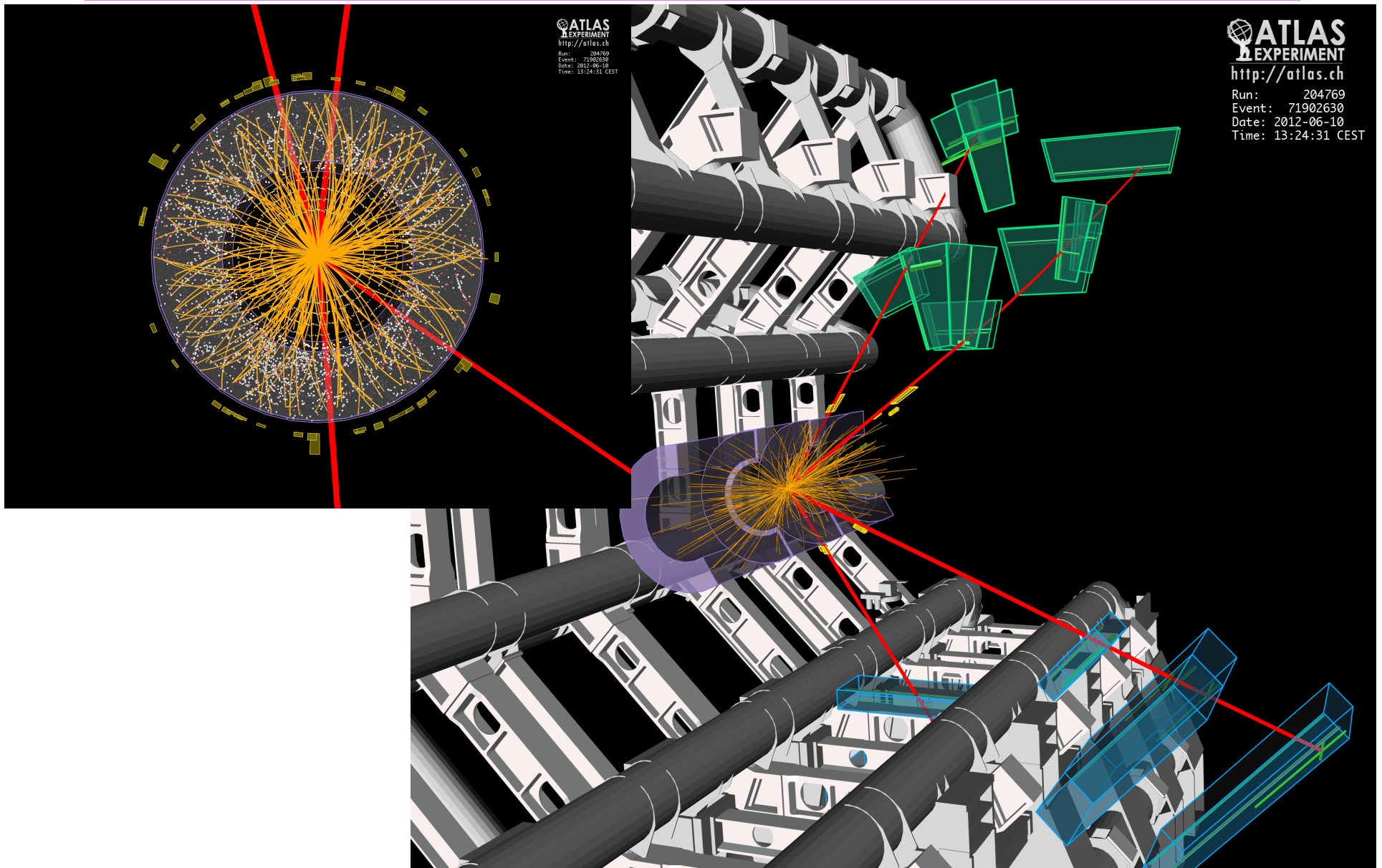
Scientists in Geneva on Wednesday applauded the discovery of a subatomic particle that looks like the Higgs boson.

By DENNIS OVERBYE

Published: July 4, 2012 | 122 Comments

I didn't get there early enough for a seat.

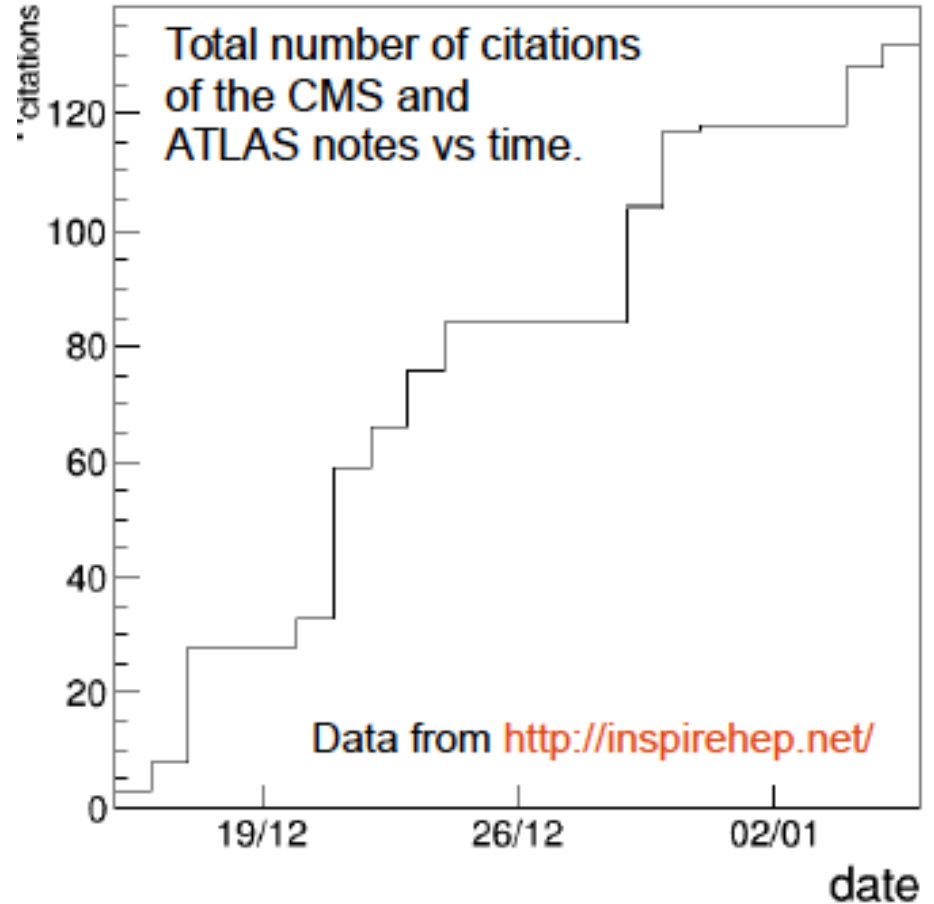
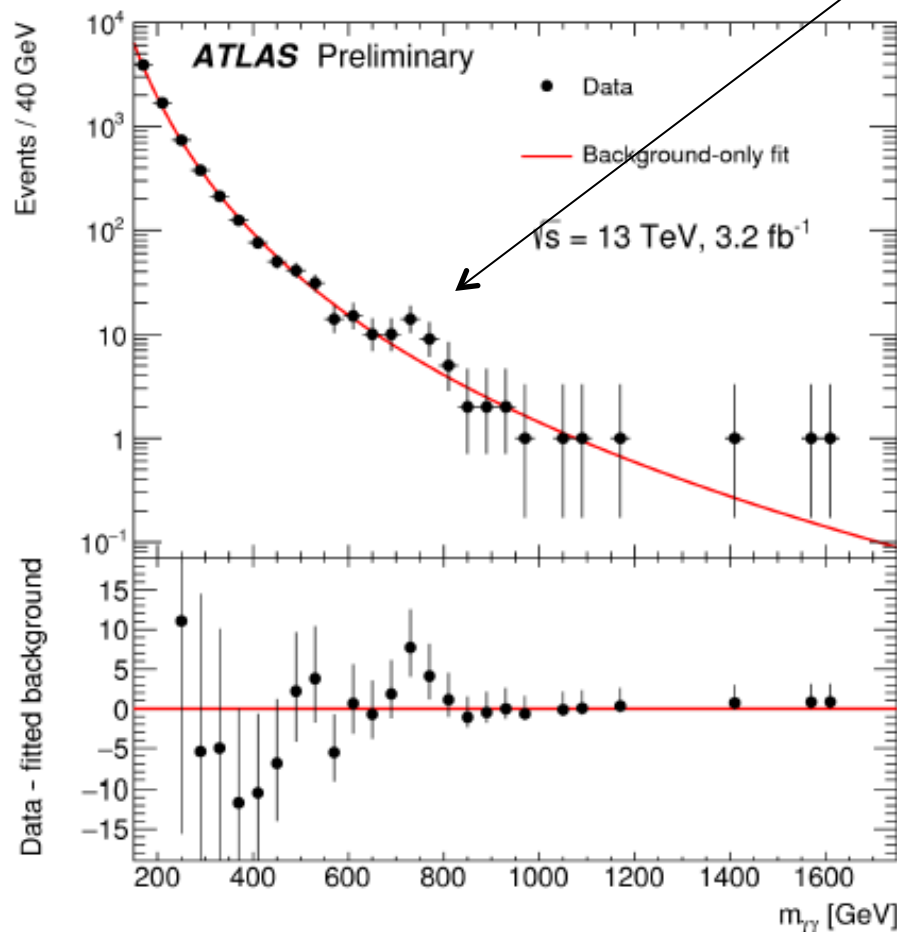
Higgs candidate event



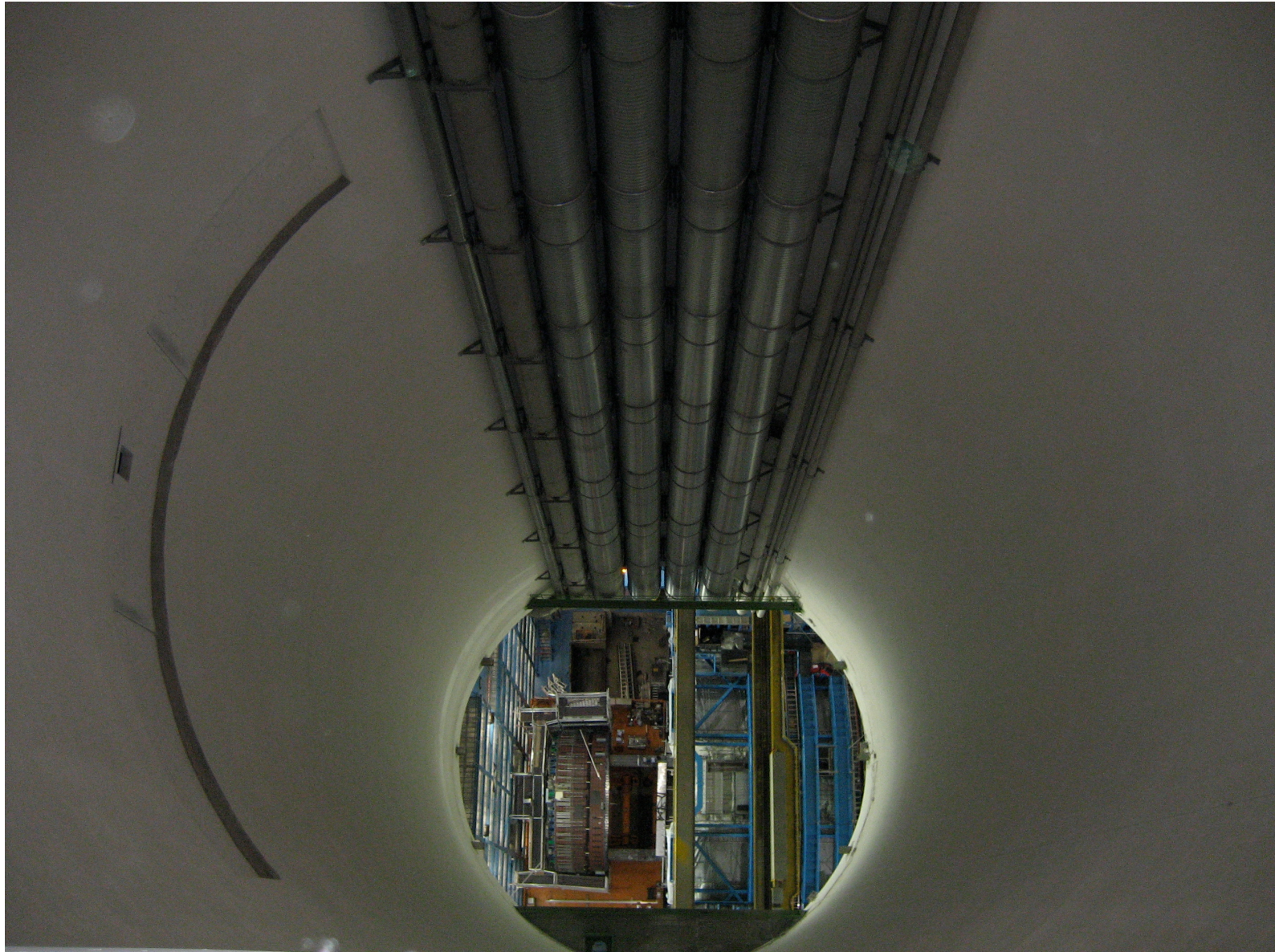
I'll keep you posted

Physicists in Europe Find Tantalizing Hints of a Mysterious New Particle

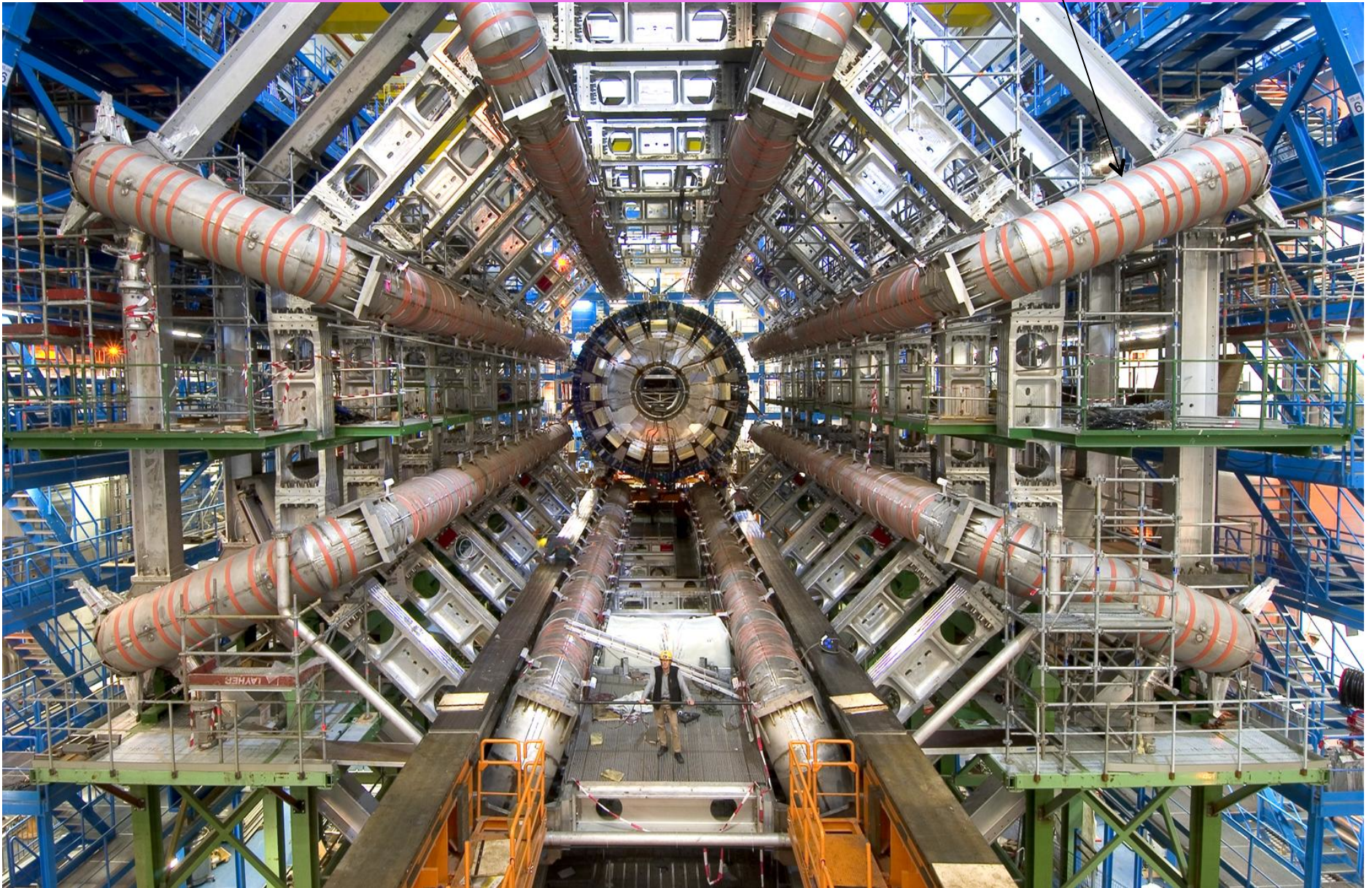
By DENNIS OVERBYE DEC. 15, 2015



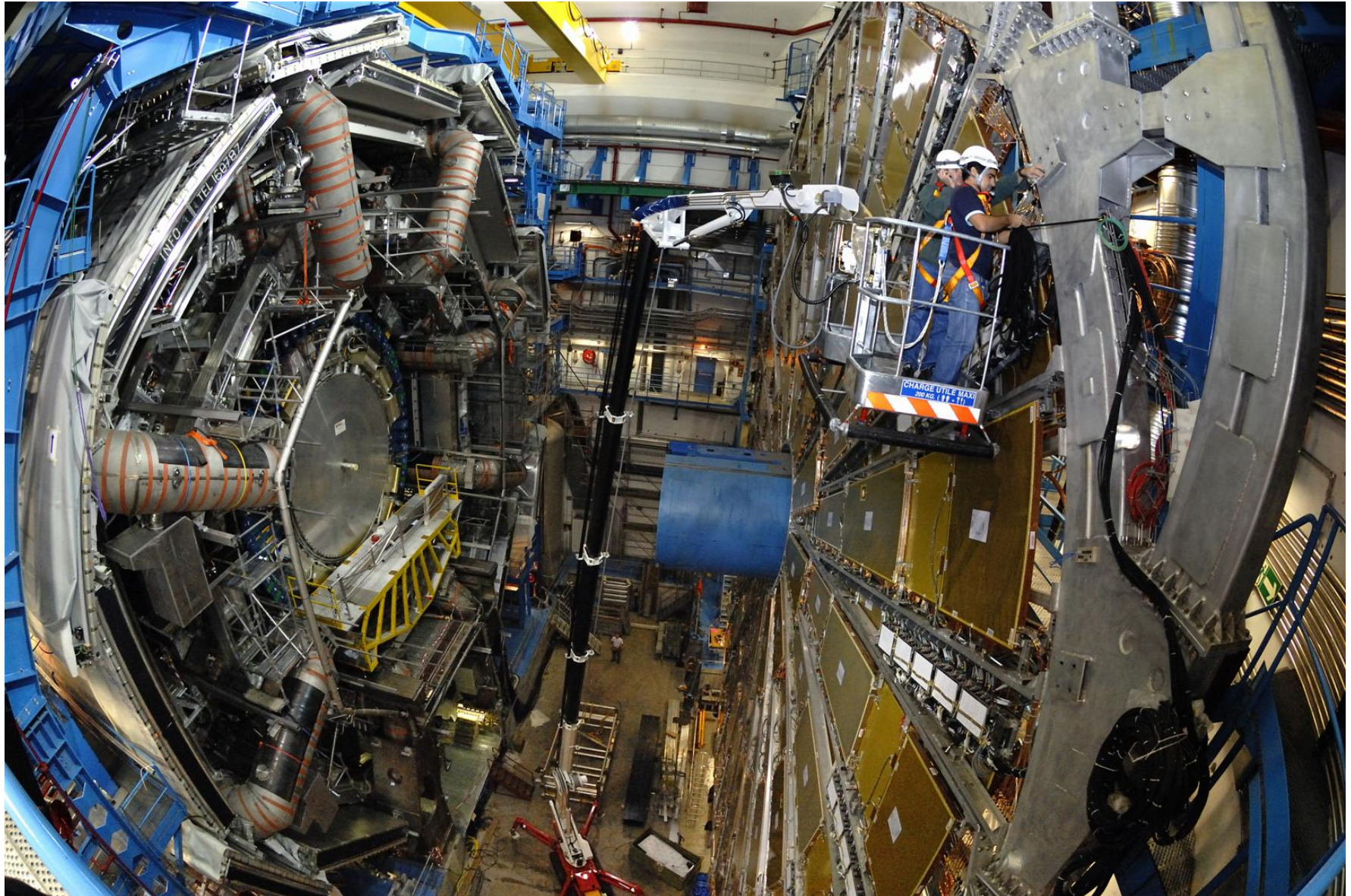
Looking down (100 m) into my experiment



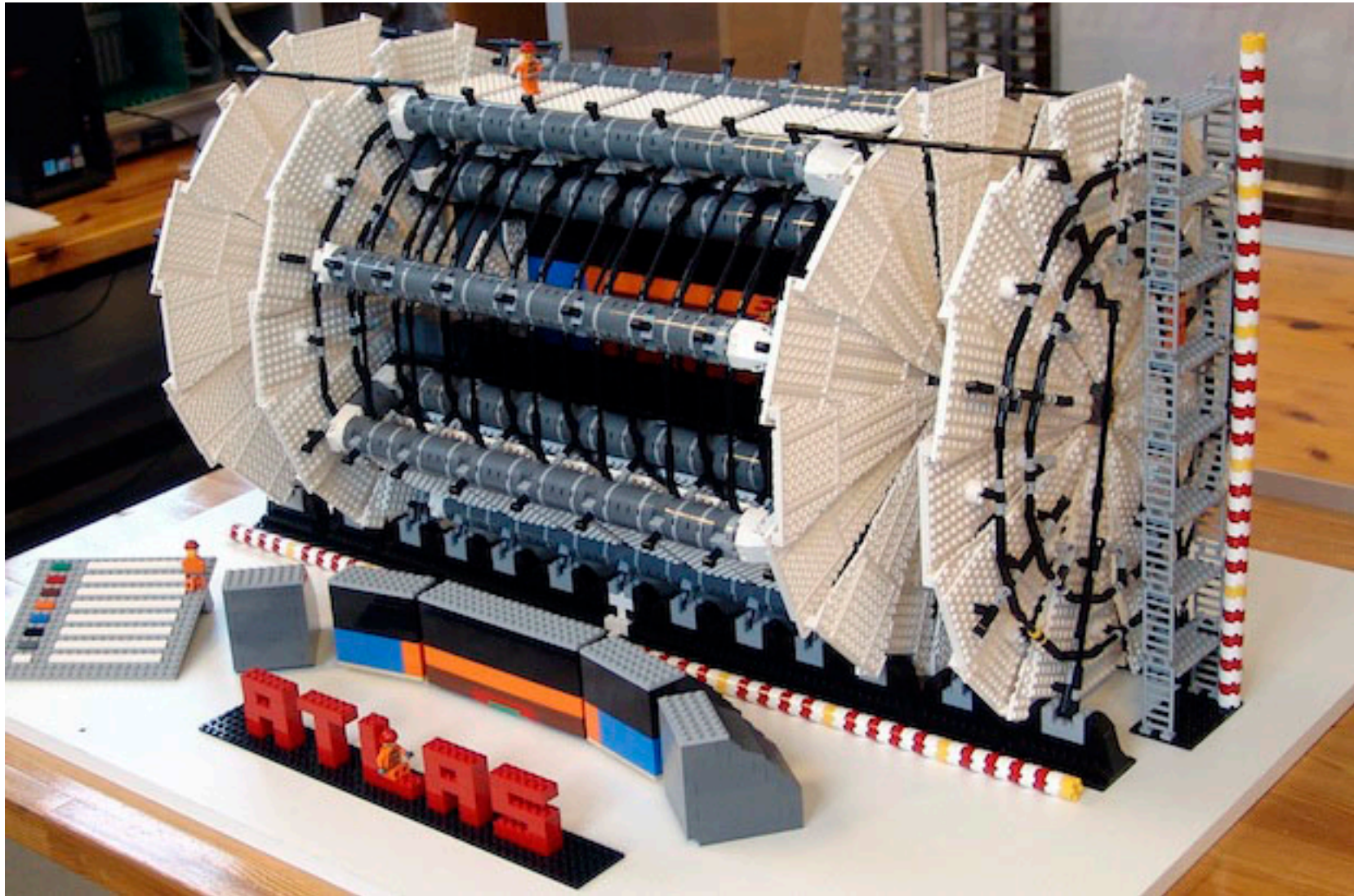
Toroid magnet



http://atlaseye-webpub.web.cern.ch/atlaseye-webpub/web-sites/pages/UX15_webcams.htm



Lego model of ATLAS



...still looking for a place to put it

Occasionally I will throw in stuff from BBT



Let's go back to electrostatics

- ...and thus back to the ancient Greeks
- The Greeks started the science of electrostatics (like almost everything else)
 - ◆ they observed that when amber was rubbed, it would attract small objects like feathers or straw
 - ▲ or like rubbing a balloon against your shirt
 - ◆ in fact our word for electricity comes from the Greek word for amber, *electron*



© 2003 Thomson - Brooks Cole

So not much happened for 2000 years or so

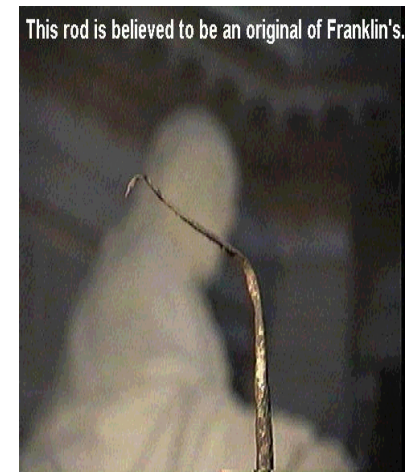
- In the 16th century, investigations revealed that there appeared to be two types of electricity
 - ◆ vitreous: from rubbed glass, animal hair
 - ◆ resinous: from rubbed amber, silk
- How is one different from the other?
 - ◆ 2 bodies charged with vitreous electricity repel each other, as do 2 bodies charged with resinous electricity
 - ◆ a body charged with resinous electricity will attract a body charged with vitreous



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Is this the final story (should you write down vitreous and resinous)?

- No...and no
- In the mid-1700's, Benjamin Franklin proposed what he called a "one-fluid" theory of electricity. He proposed that every body had a normal amount of electricity.
- When a body is rubbed against another, some of the electricity is transferred from one body to another
- One body has an excess of electricity, the other a deficit
 - ◆ this is a great advance, one of the first conservation laws
- He described the excess as having a + charge and the deficit a -charge



Can we stop now?

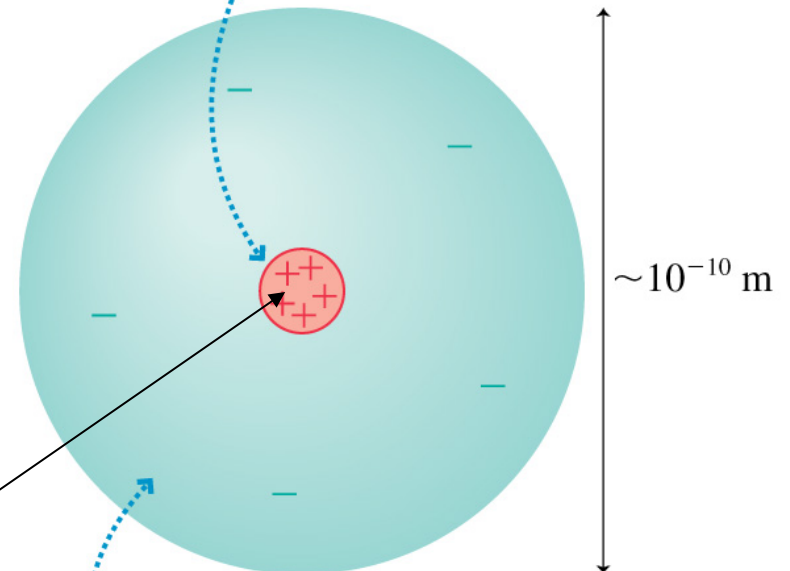
- Benjamin Franklin's theory was an advance
 - ◆ he unified the concepts of lightning and static electricity
- but not quite right
- In particular his choice of signs will come back to haunt us when we get to circuits
- Let's briefly review atomic structure

to give you an idea of the relative scale of the nucleus, Rutherford referred to it as the “fly in the cathedral”

The nucleus of the atom consists of protons + neutrons

Charge on proton = $e = +1.6 \times 10^{-19} \text{ C}$

The nucleus, exaggerated for clarity, contains positive protons.



The electron cloud is negatively charged.

Each normal atom has as many electrons as protons

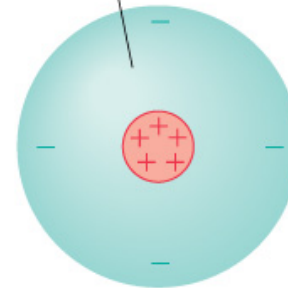
Charge on electron = $-e = -1.6 \times 10^{-19} \text{ C}$

So every normal atom is neutral

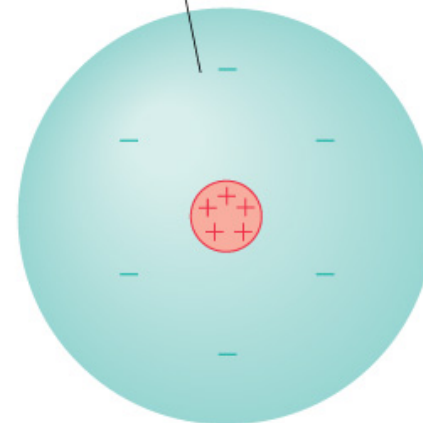
What do we know?

- All electrical charges are multiples of e
 - ◆ i.e. charge is quantized
- The protons are stuck inside the nucleus
- The outermost electrons are the ones that can come off by rubbing
 - ◆ i.e. electrostatic effects result from transfer of electrons and not of positive charges
- I can remove electrons from an object (ionization) in which case it becomes positive
- I can add electrons to an object in which case it becomes negative
- Total charge is always conserved

A positive ion with net charge $q = +e$

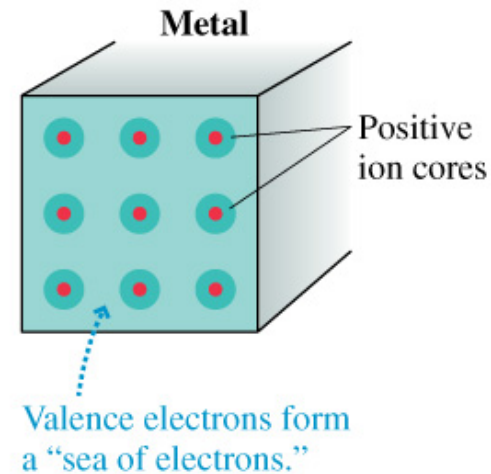
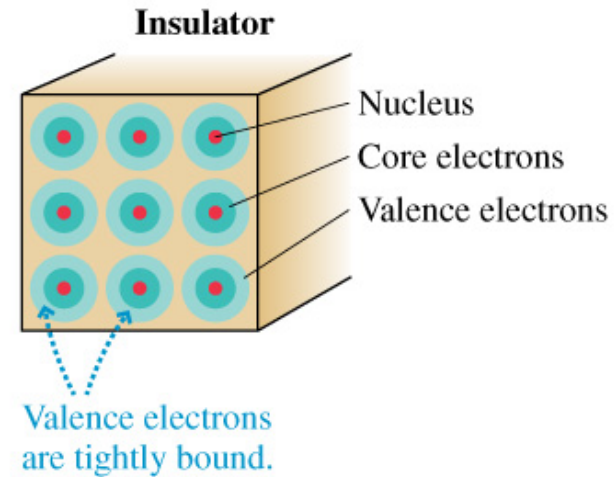


A negative ion with net charge $q = -e$

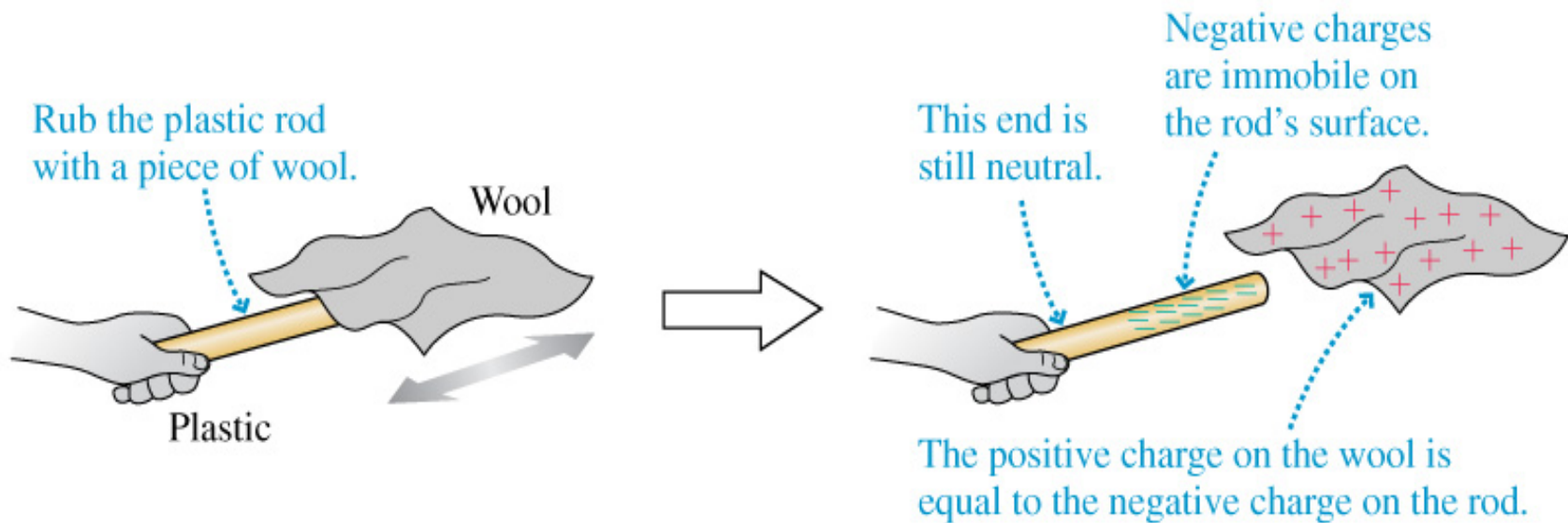


Conductors and insulators

- If outermost electrons are free to move within the material, we call the material a conductor
- If they're not free to move (but can still be rubbed off), we call the material an insulator
- Third possibility is that a material can be a semi-conductor
- Now what happened with the glass rod and silk, plastic rod and wool



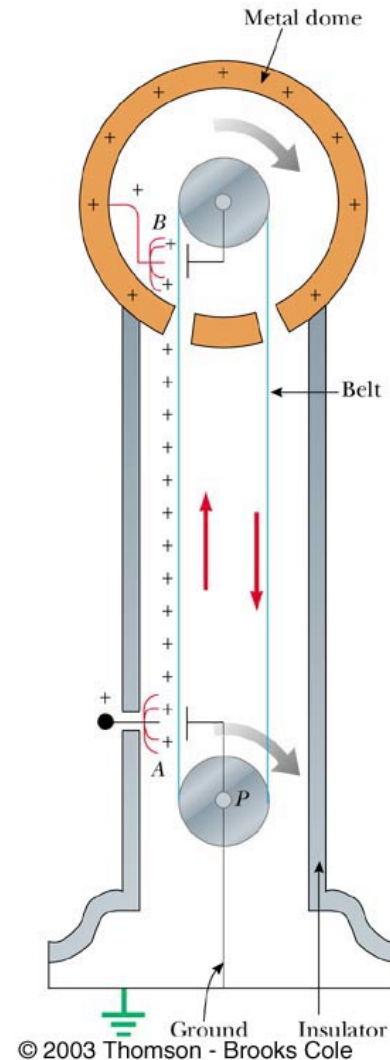
Charging insulators



...and the reverse for glass rod and silk

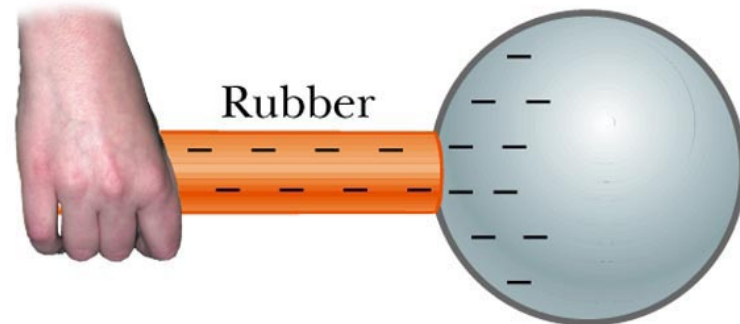
Another way of extracting charges

- The van de Graf machine
- Has a belt which transfers charge to the metal dome
- Does it take electrons up to the dome or transfer electrons away from the dome?

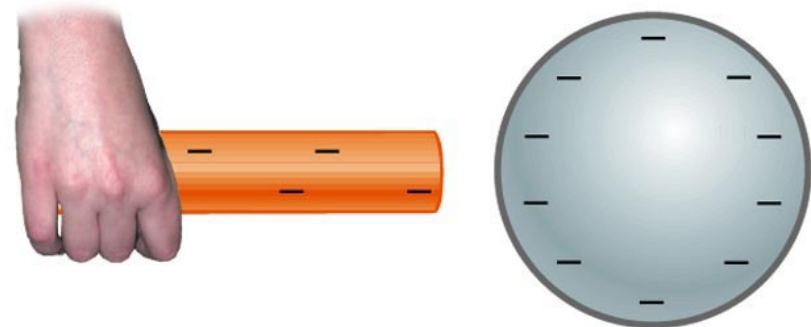


Charging an object (directly)

- Suppose I bring a rubber rod that has an excess negative charge in contact with a conductor; what happens?
- Some of the negative charge is transferred to the conductor
- Since the electrons are free to move inside the conductor, and since negative charges repel, they try to get as far away from each other as possible
- Charge is uniformly distributed over the surface of the conductor (none in the interior)



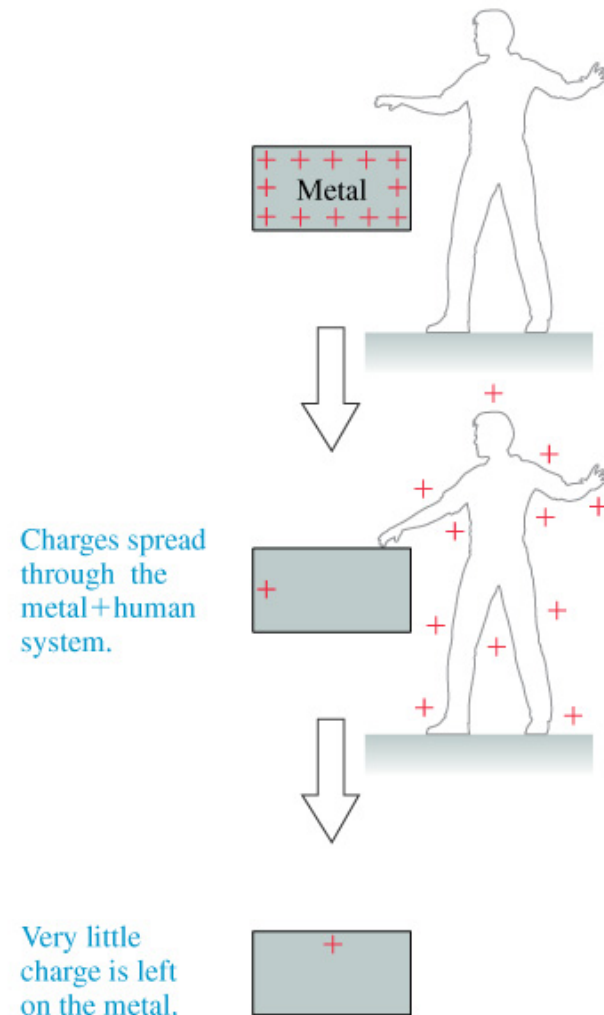
(a) Before



(b) After

Charging a human

- ...or discharging a metal plate
- Body consists largely of salt water and thus is a reasonably good conductor
- When touching the metal, some of Cl^- ions on skin surface transfer extra electron to metal
- Leaving body with an excess of Na^+ ions, and thus a net positive charge
- By grounding objects, we are trying to prevent the buildup of any significant charge on them
- Excess charge shared with the earth
 - ◆ for example, by 3rd prong on electrical plug
- Moist air is a (relatively poor) conductor
 - ◆ that's why electrostatic demonstrations are always dangerous to do in late August



Let's try this with an electroscope

- Why do you think we would use gold leaf?

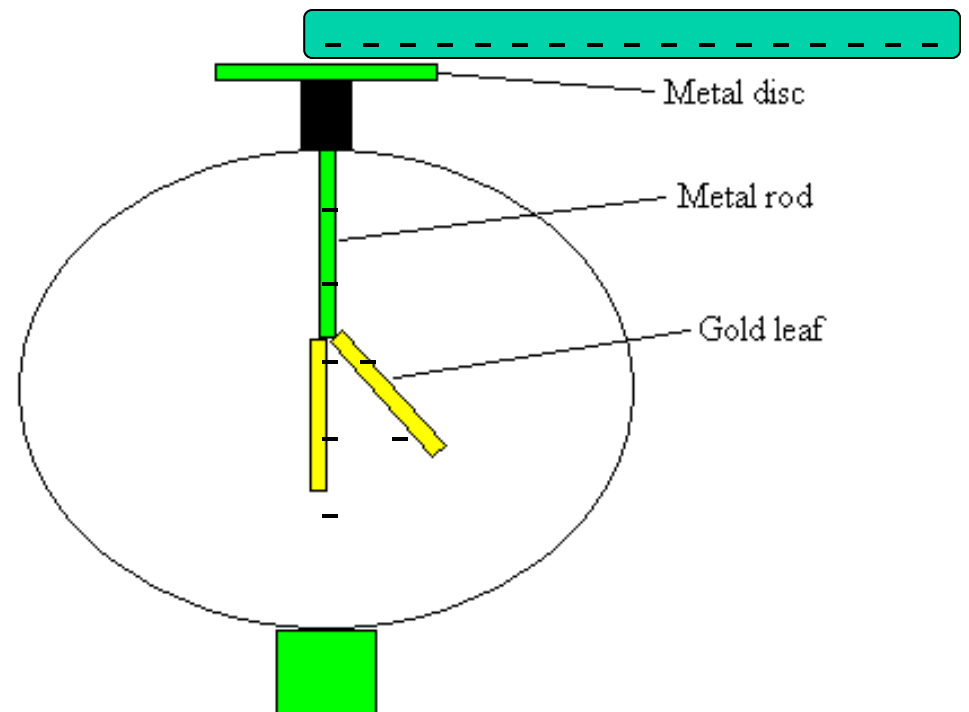


Figure 2: The classical electroscope

Charging by induction

- How can I see an effect when I haven't touched the electroscope?

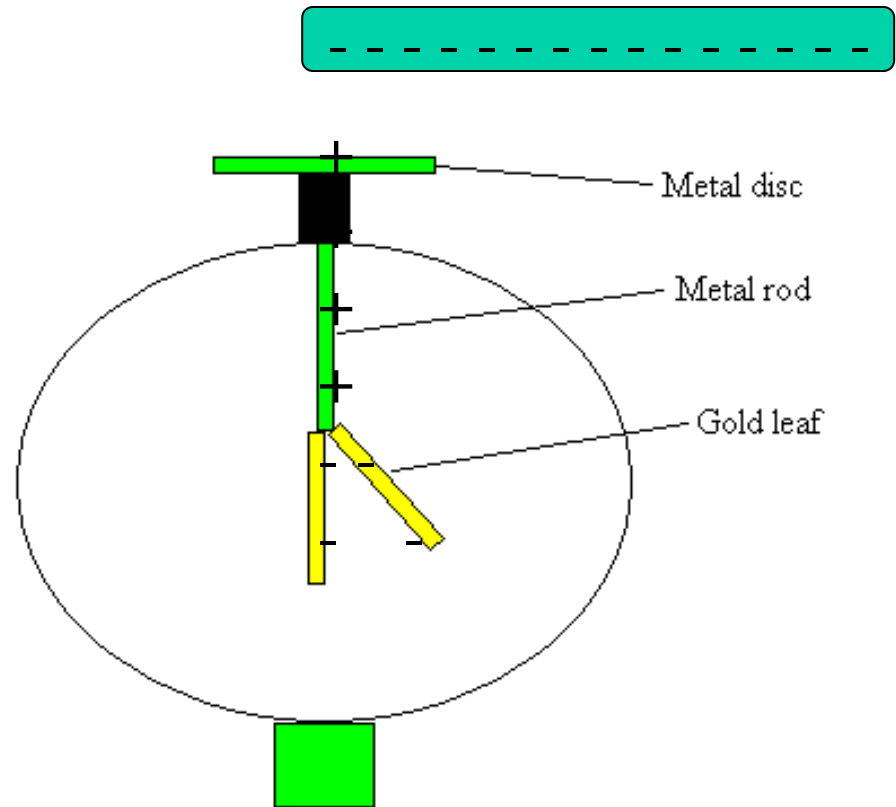


Figure 2: The classical electroscope