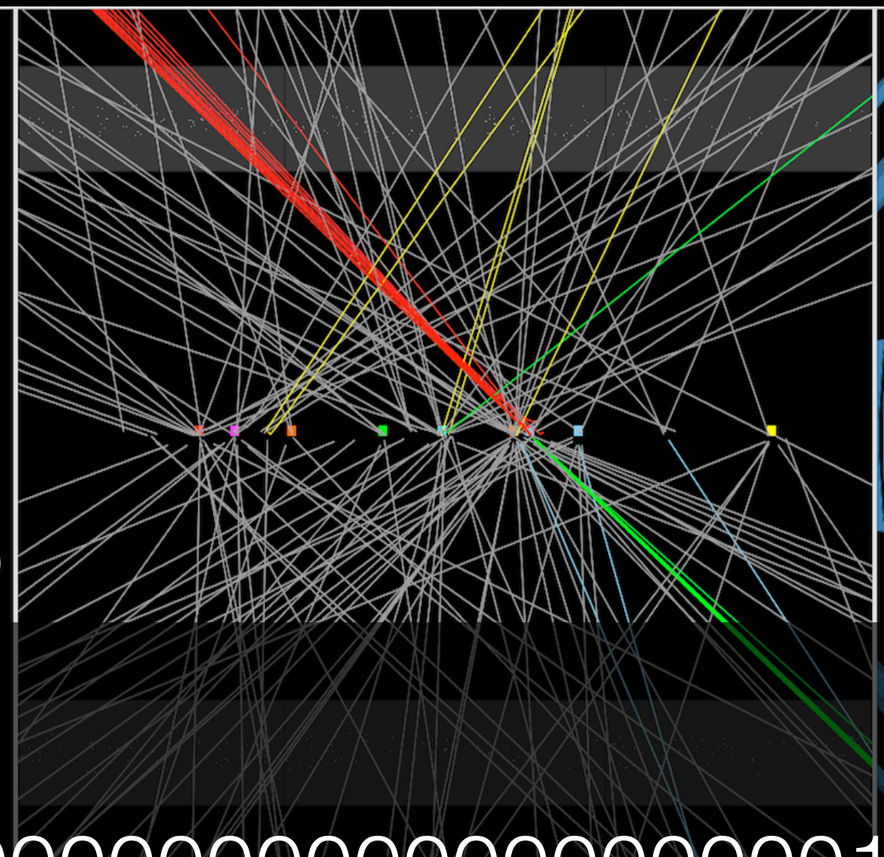
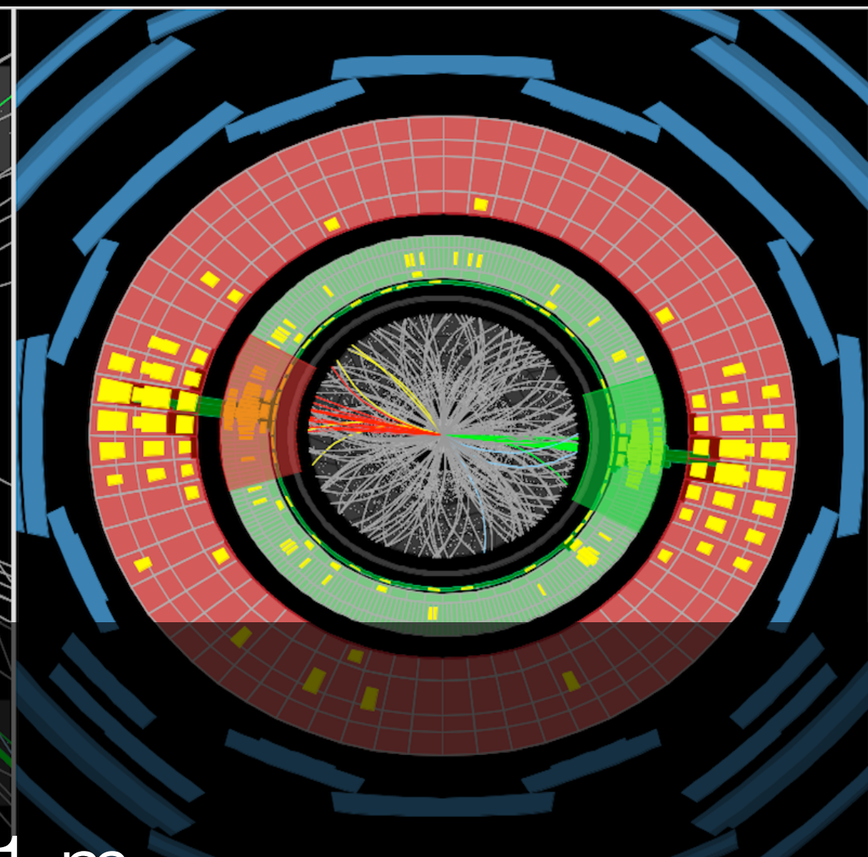
100,000,000,000,000,000,000,000,000,000 m

ATLAS EXPERIMENT

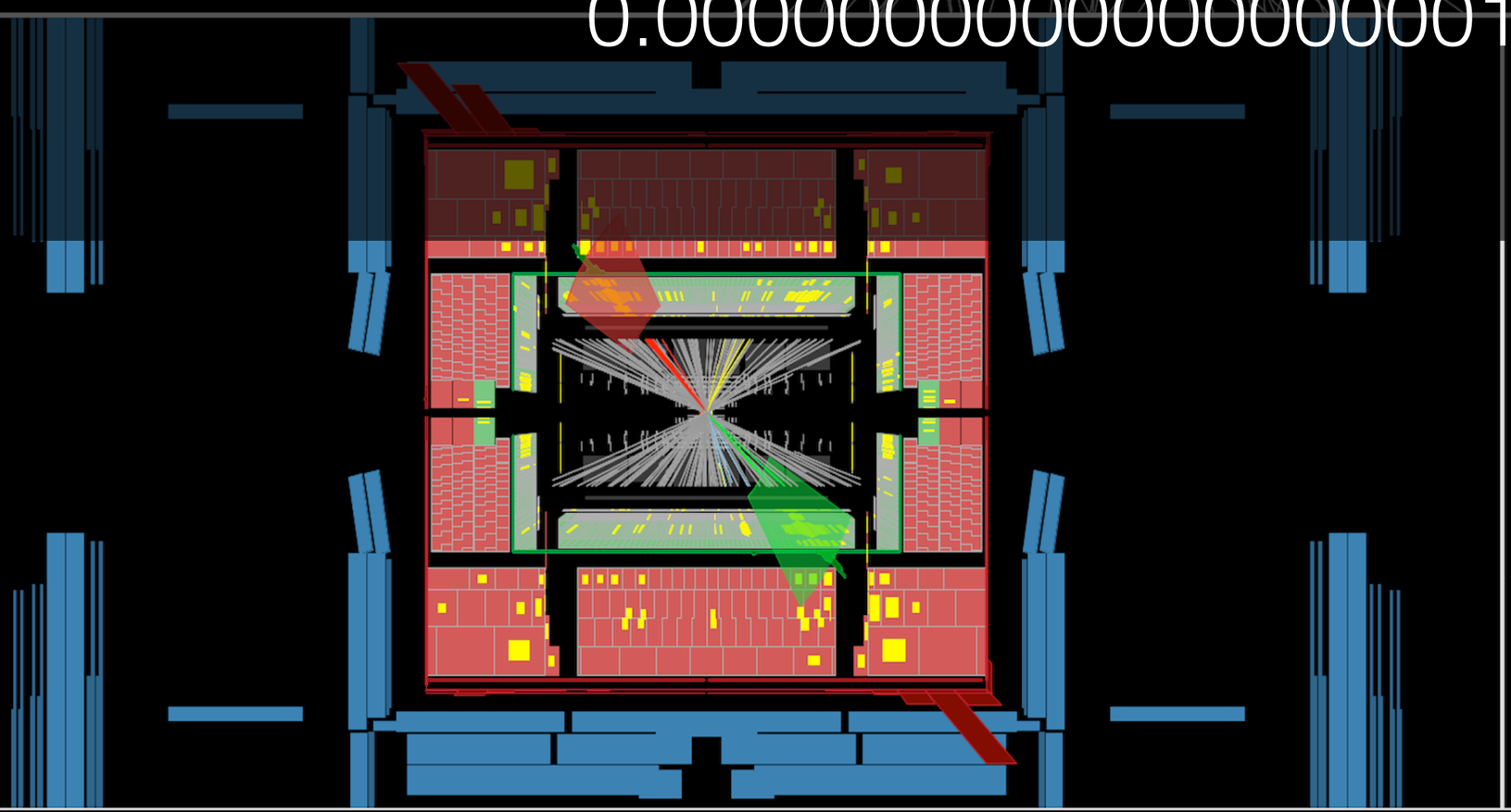
Run Number: 201269, Event Number: 80898559

Date: 2012-04-14 22:30:13 CEST





0.00000000000000000001 m



the universe is beautiful!

and humans seem to be able to understand it.

because the universe seems to obey mathematical rules

welcome

to ISP220

Quarks, Spacetime, and the Big Bang

welcome

to ISP220

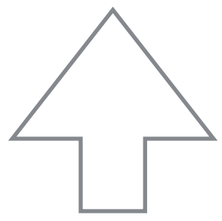
Quarks, Spacetime, and the Big Bang

Because we'll talk about elementary particles

welcome

to ISP220

Quarks, **Spacetime**, and the Big Bang

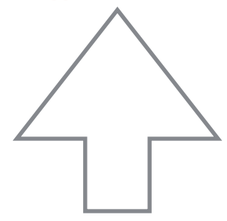


Because we'll spend a lot of time on Einstein's theories of Relativity

welcome

to ISP220

Quarks, Spacetime, and the **Big Bang**



Because we'll talk about the beginning of the Universe

isp220 studies:

the **largest**

and

the smallest

entities of all

the **largest**?

Cosmology

the smallest

particle physics

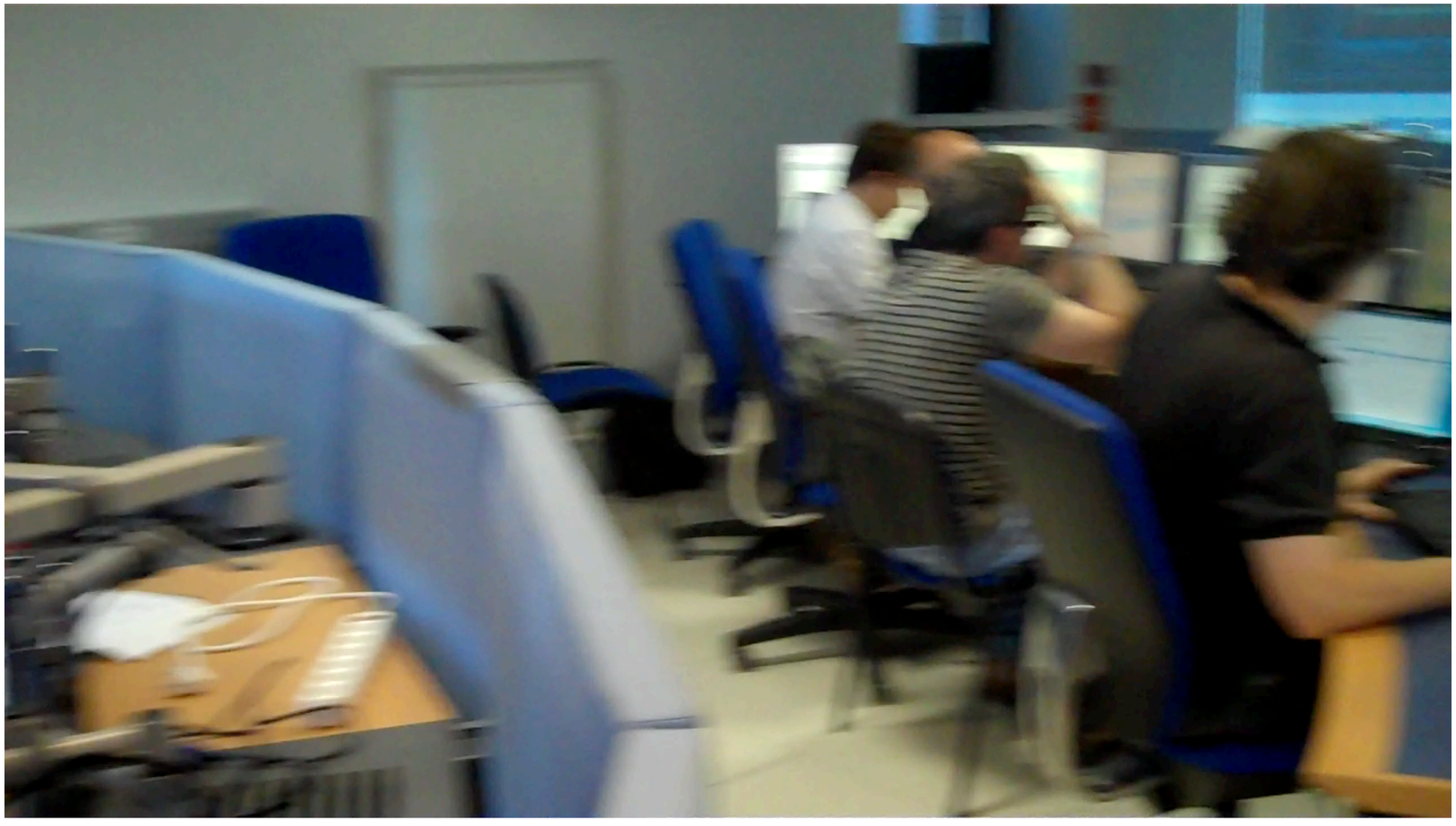
So.
A course on particle physics?

"hmm. I think I've heard that before..."

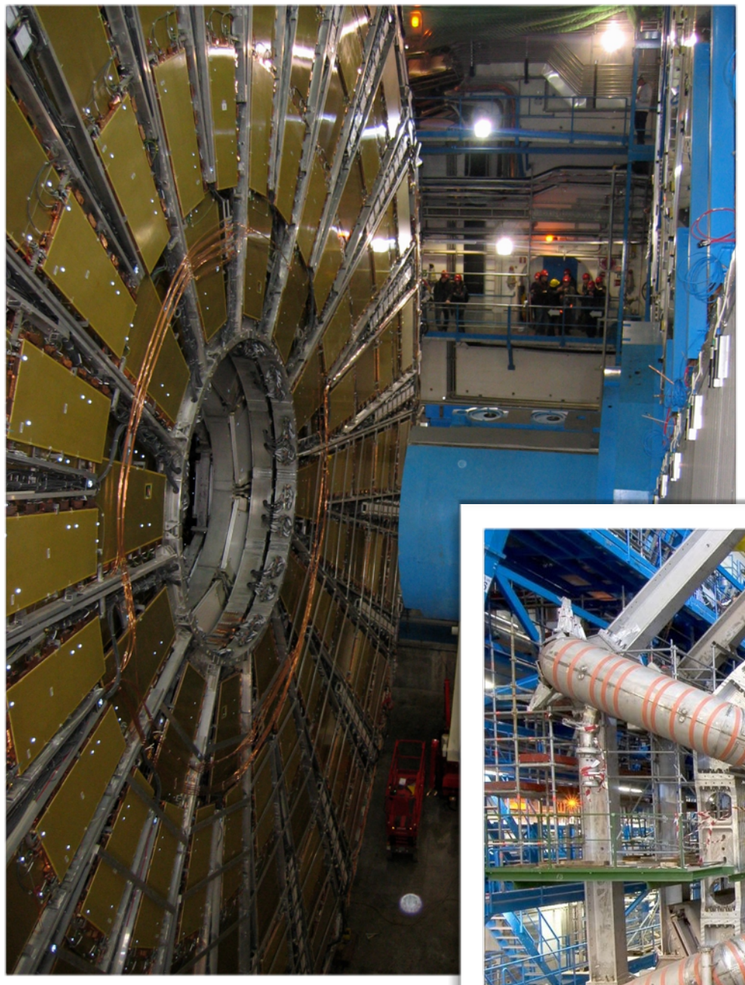
yes, that one

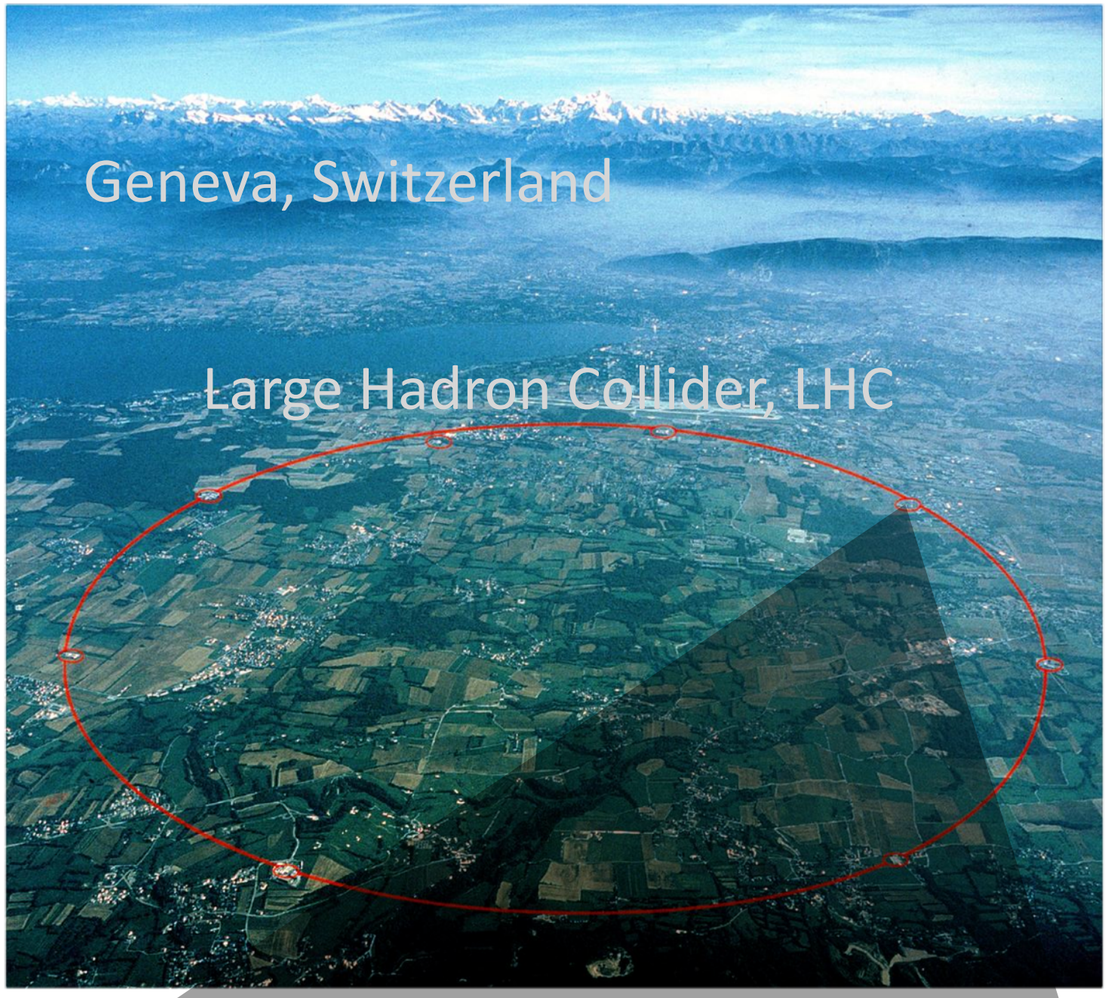
some artistic license

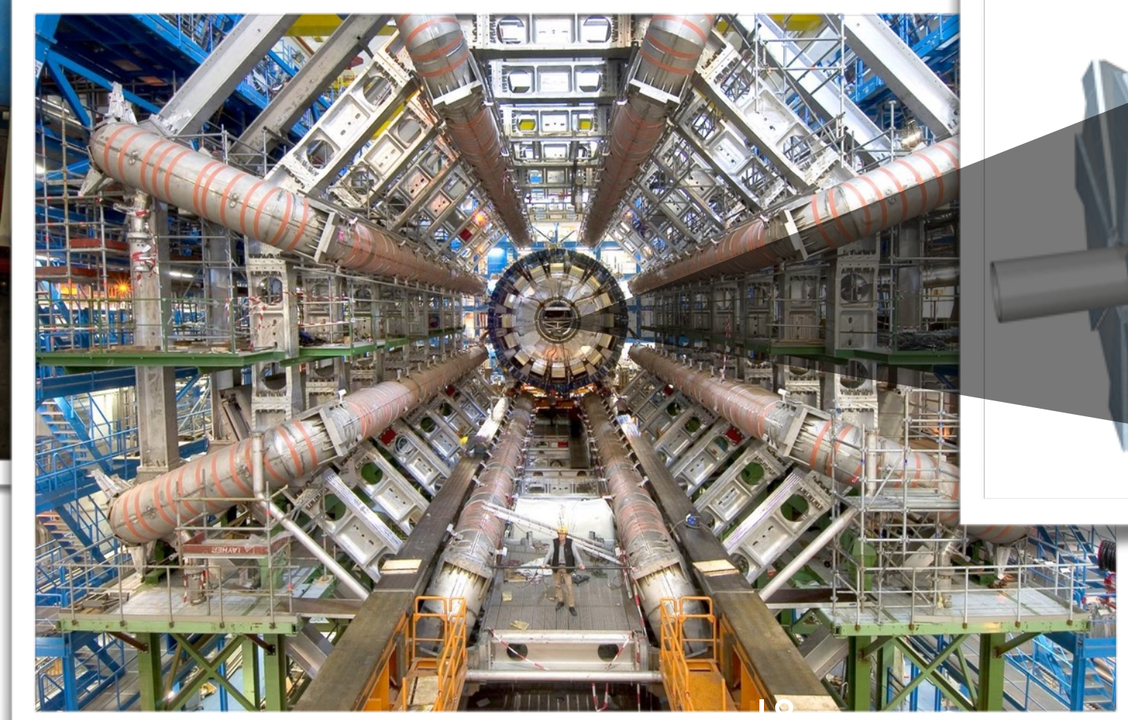
the real control room

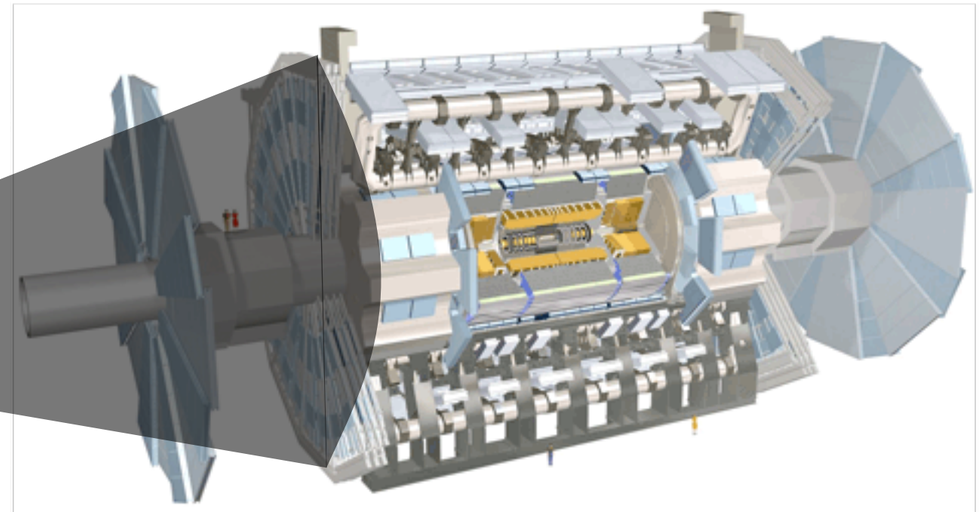


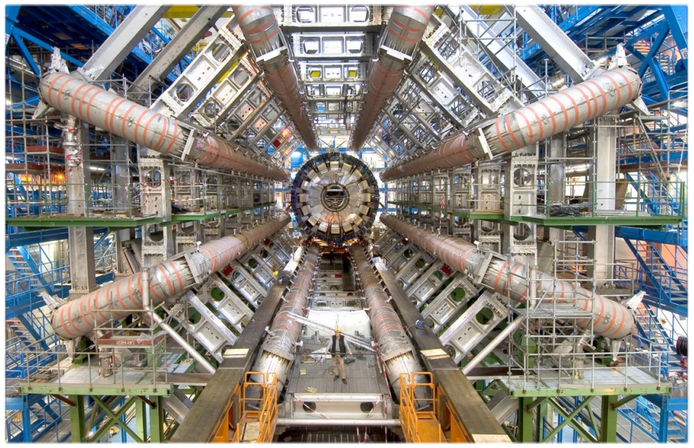

North Sea
Dublin
Amsterdam
London
Brussels
Brussel
English Channel
Luxembourg
Paris
Berlin
Warsaw
Prague
Vienna
Bratislava
Budapest
Berne
Alps
Ljubljana
Zagreb
Belgrade
Bucuresti
Sarajevo
Monaco
Ligurian Sea
Isola d'Elba
Rome
Prishtine
Sofia
Podgorica
Skopje
Tirane
Isola di Procida
Isola di Capri
Kerkyra
Ionian Sea
Athens
Isola Lipari
Sicilia (Sicily)
Gozo
Vilnius
Minsk
©2010 Google




Geneva, Switzerland
Large Hadron Collider, LHC








CERN

research university

science faculty have dual duties

teaching

research

who pays taxes?

thanks.

the real ‘‘why’’

It’s a privilege to actually receive a salary to do this work.

You graciously pay for our research and I’d like you to be able to appreciate the results and its future.

I’d like to tell you about this work.


Chip
Brock
University Extinguished Professor,
Physics & Astronomy, MSU
MICHIGAN STATE
UNIVERSITY
MSU Global

www.pa.msu.edu/~brock/

Instaper | WorkFlowy-Kim | PAC | stretch | google | LHC/ATLAS | DPF | EEPaC | working | ATLAS | » | Other Bookmarks

research teaching profession about contact

chip brock

university distinguished professor

I am an experimental Particle Physicist and a member of
the faculty of Michigan State University

www.pa.msu.edu/~brock/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WWW.ENTERTAINMENTWALLPAPER.COM

you're participating in a century-old, uniquely American college experience

Abbott Lawrence Lowell, Harvard President 1909:

"A discussion of the ideal college training would appear to lead to the conclusion that the best type of liberal education in our complex modern world aims at producing men who know a little of everything and something well."

"General Education"

...at MSU: Integrative Studies

look at the goals of the Center for Integrative Studies in General Science:

http://cisgs.msu.edu/about.html

you're not physicists, so I know that you're

brave and fearless to take this course.


COMING
ATTRACTIONS

this is a

Big Questions course

The Big Questions

1. What is the Nature of Space and Time?

2. Did the Universe have a Beginning?

3. Will the Universe end?

4. Is there only one Universe?

5. What was the nature of the Early Universe, just after the Big Bang?

6. Was there anything before the Big Bang?

7. Why are galaxies clumped into filament structures?

8. Do Gravitational Waves exist?

9. Do Black Holes radiate?

10. What is the origin of ultra-high-energy Cosmic Rays?

11. What is the nature of Nothing?

12. What is the nature of Something! What is Mass in general?

13. What is the nature of the Higgs Boson(s)?

14. What new physics does the 2012 Higgs Boson-like particle point to?

15. What is the nature of Gravity and is there a Quantum Theory of Gravity?

16. What are the masses and nature of Neutrinos?

17. What is Dark Energy?

18. How many Fundamental Forces of Nature are there?

19. Why is Gravity so weak?

20. Is there a single, Theory of Everything?

21. How many Fundamental Particles are there?

22. Why do the particles have the masses that they do?

23. Are Quarks and Leptons made of other particles?

24. Are elementary particles strings?

25. What is the nature of Dark Matter?

26. Where is all of the Antimatter?

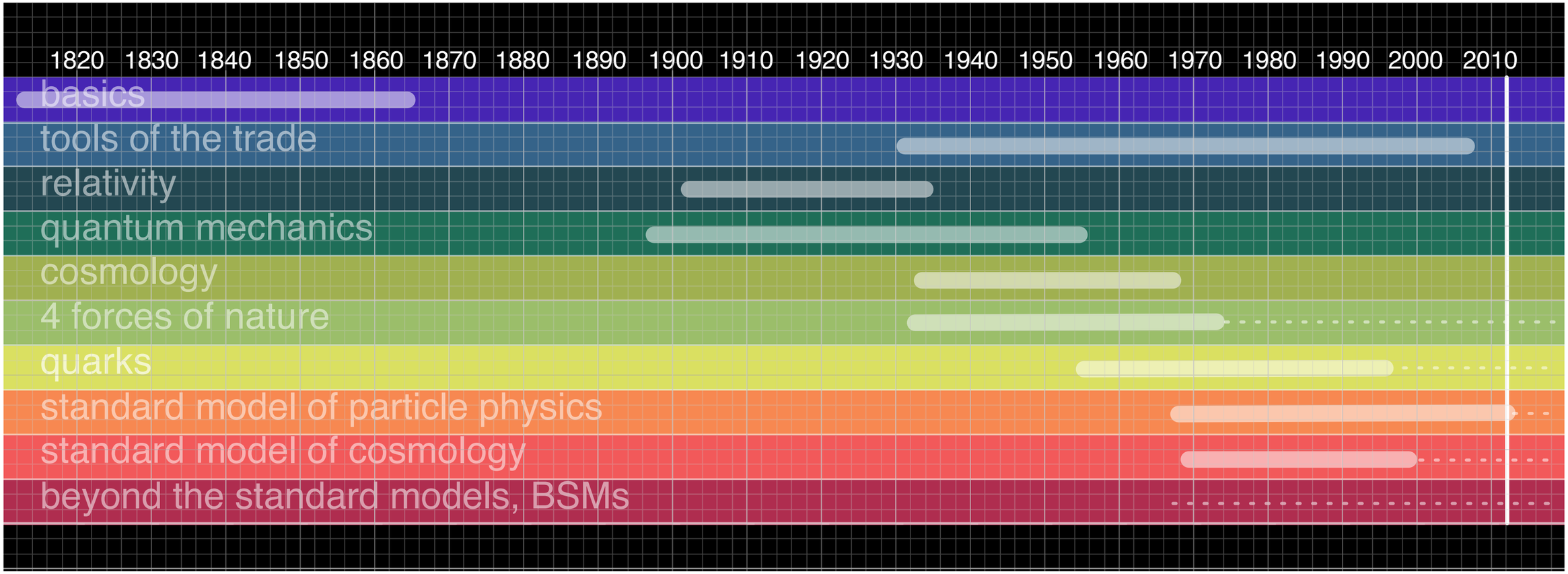
27. Is the Proton "forever" or can it decay?

key:

blue: a particle physics question

green: a cosmology question

yellow: a bigger question than only cosmology or particle physics!



Four distinct themes

- Foundations …”regular physics”…bare minimum

  very brief and gentle.

- Einstein’s Relativity

  Special and General Theories, including the beginning of quantitative cosmology

- Quantum Mechanics

  and the beginnings of particle physics

- Modern Cosmology ↔ Modern Particle Physics

  Current - right now - challenges

the big bang

connected these two fields

of cosmology and particle physics

ISP220 is a course about our Origins

we are here

biggest

expansion for 13.8 By

!

big bang

only "particles" and forces

smallest

idiosyncratic

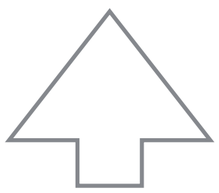
introduction alert

you're asking yourself

So, self. How is this relevant to my life?

after all, you're happy being a collection of

protons, neutrons, and electrons



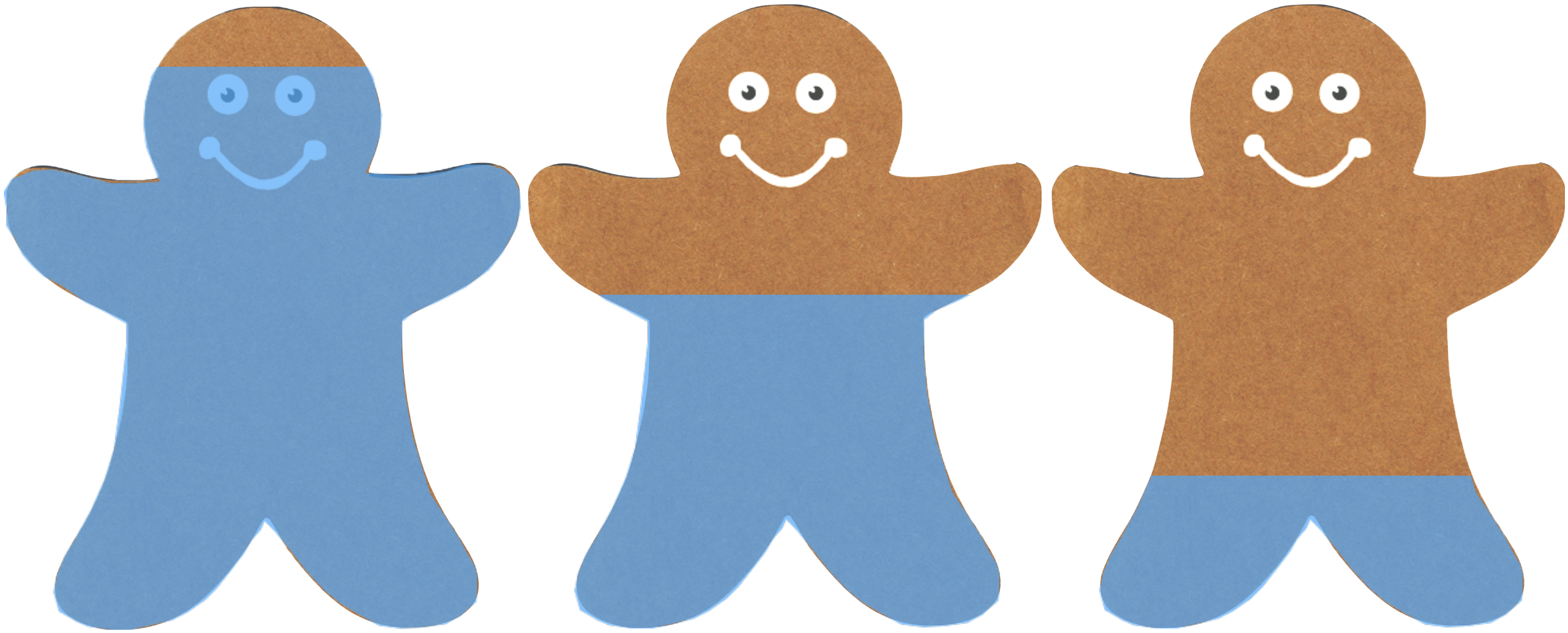
(or just up and down quarks)

let’s make this

all about you

your-self

intricately bonded to particles and the cosmos



90%

60%

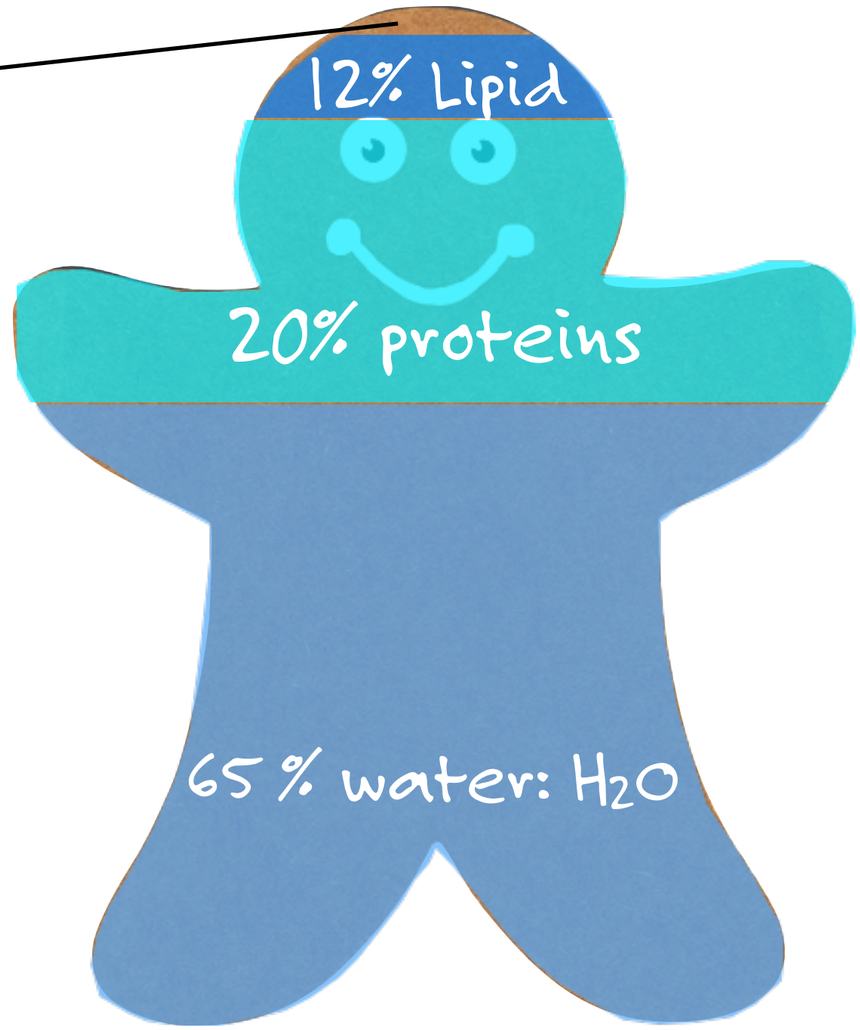
20%

Made from nuclear fusion in stars.

Made in nuclear fusion in exploding stars.

Made in the big bang.

1.5% inorganic
1% RNA
0.4% organics
0.1% DNA

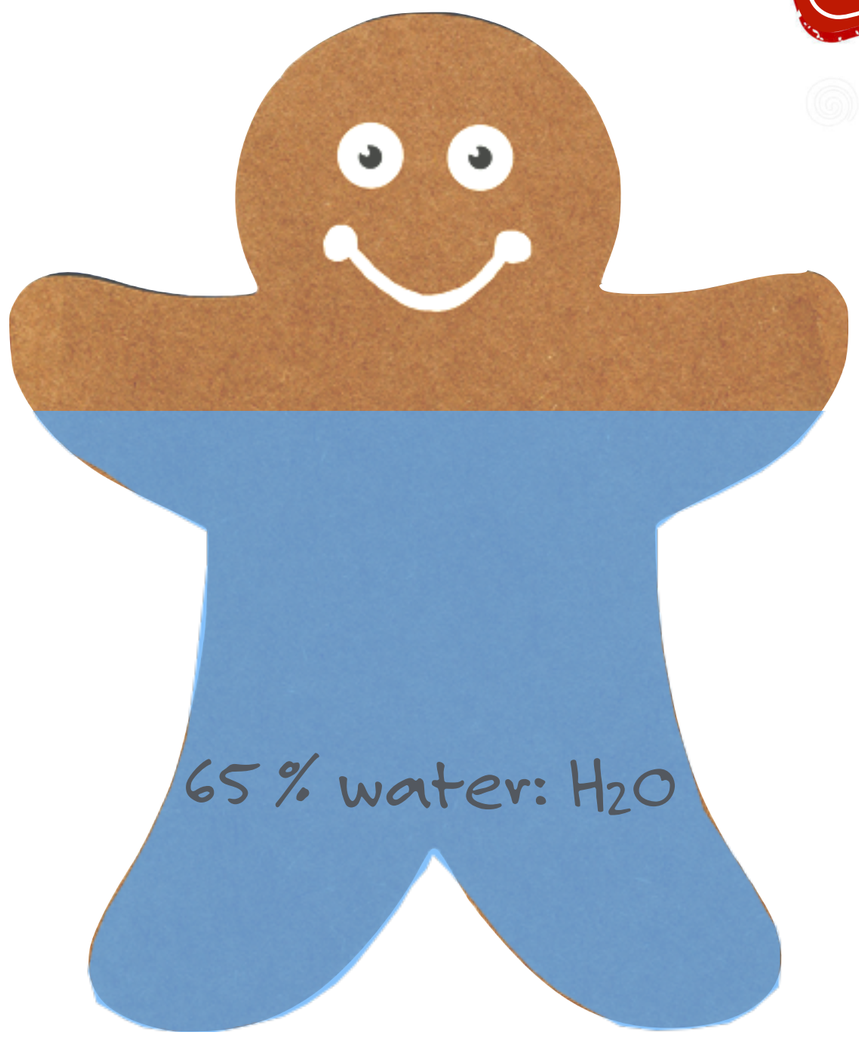


H, O, N, C

H, O

P, S, Na, K, Cl, Mg, Si, F, Fe, Zn, Rb, Sr, Br, Al, Cu, Pb, Cd, B, Mn, Ni, Li, Ba, I, Sn, Au, Zr, Co, Cs, Hg, As, Cr,Mo, Se, Be, V, U, Ra

60-70%



60-70%

The body: about 7×10^{27} atoms

65% of that is H: 13.7By old

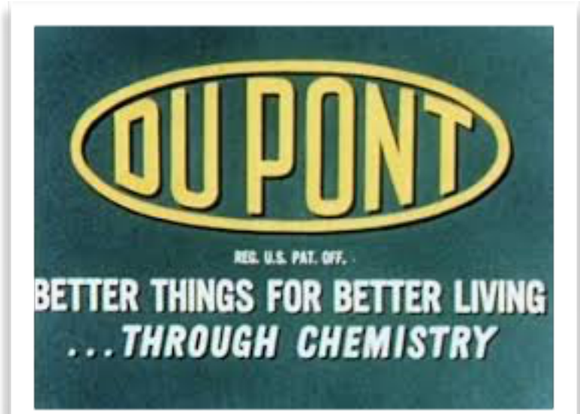
assume 70kg:

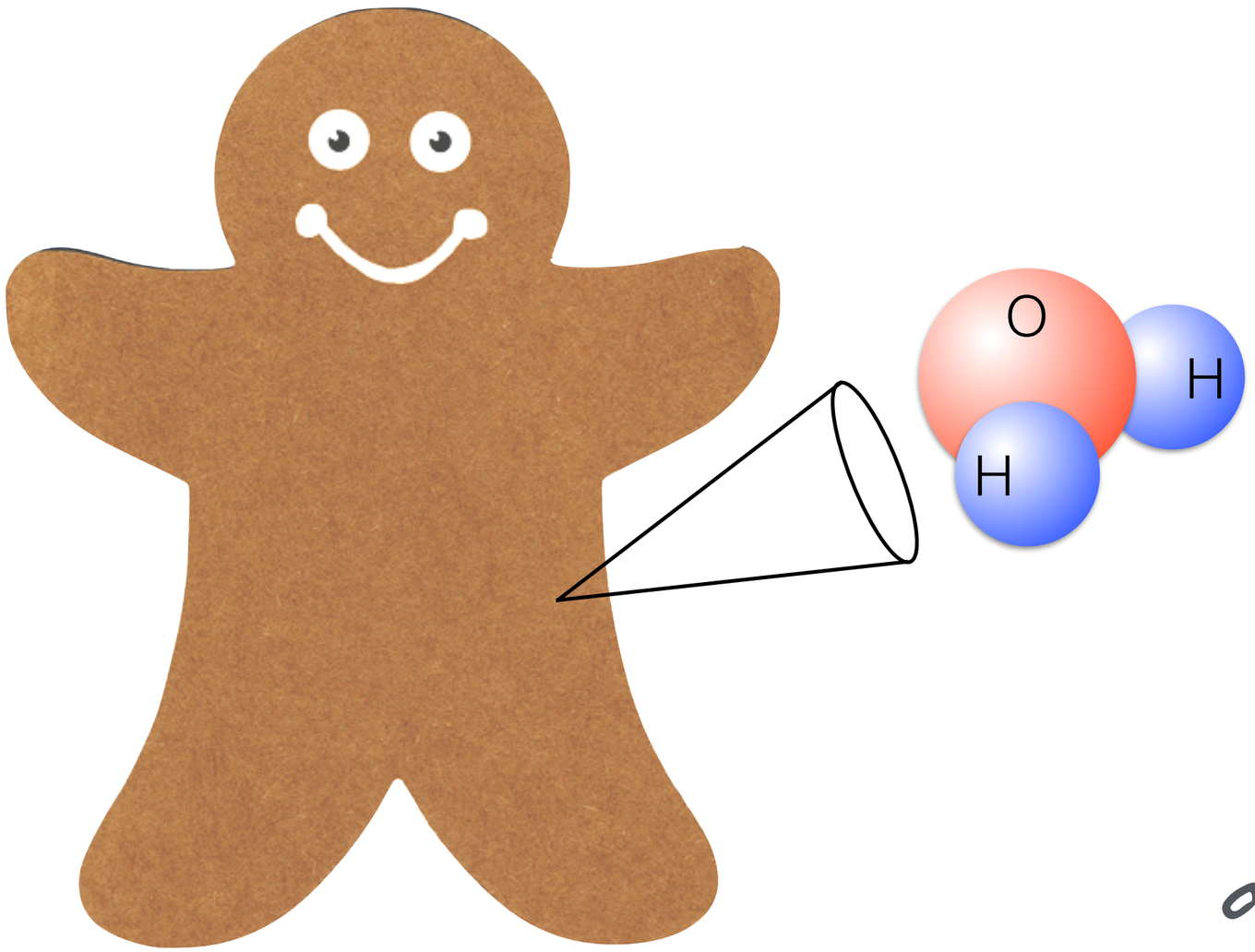
4.2×10^{28} protons
1.4×10^{28} neutrons
4.2×10^{28} electrons

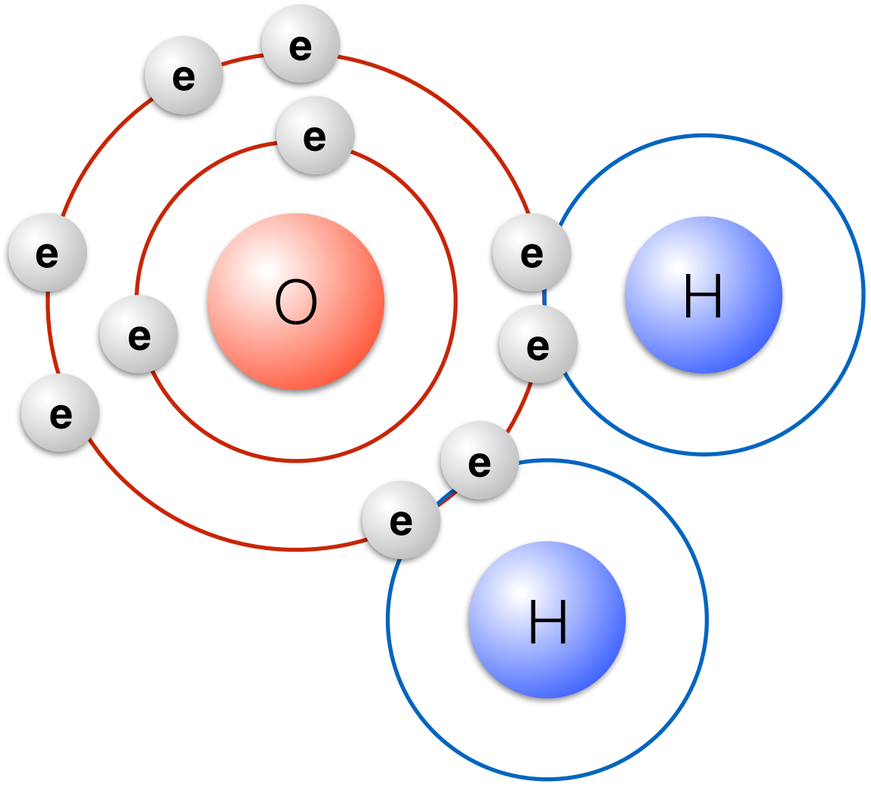
} water alone

a little chemistry factory

think about water.



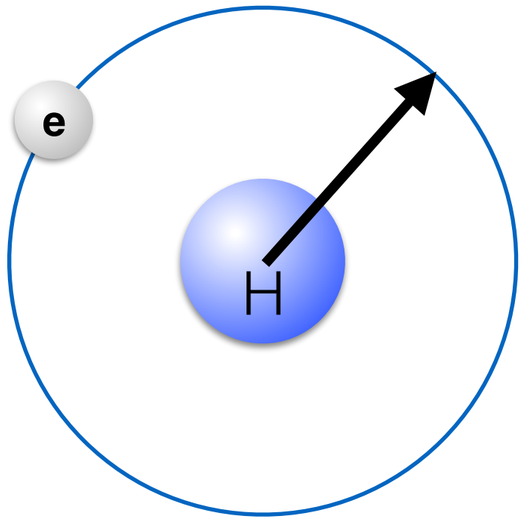


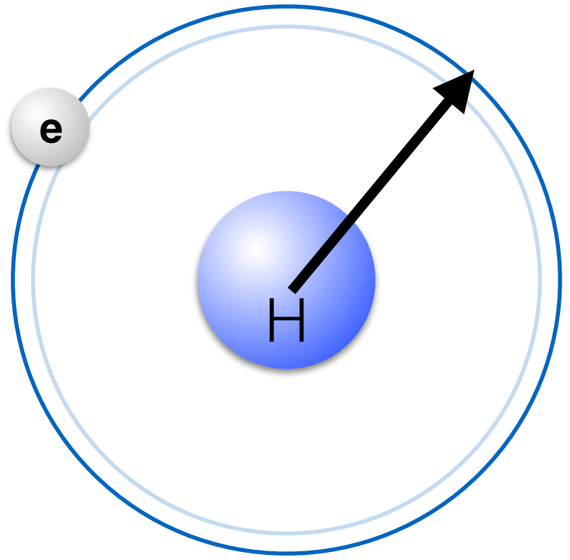


a precise, little machine

suppose

the electron mass was few % *lighter*?





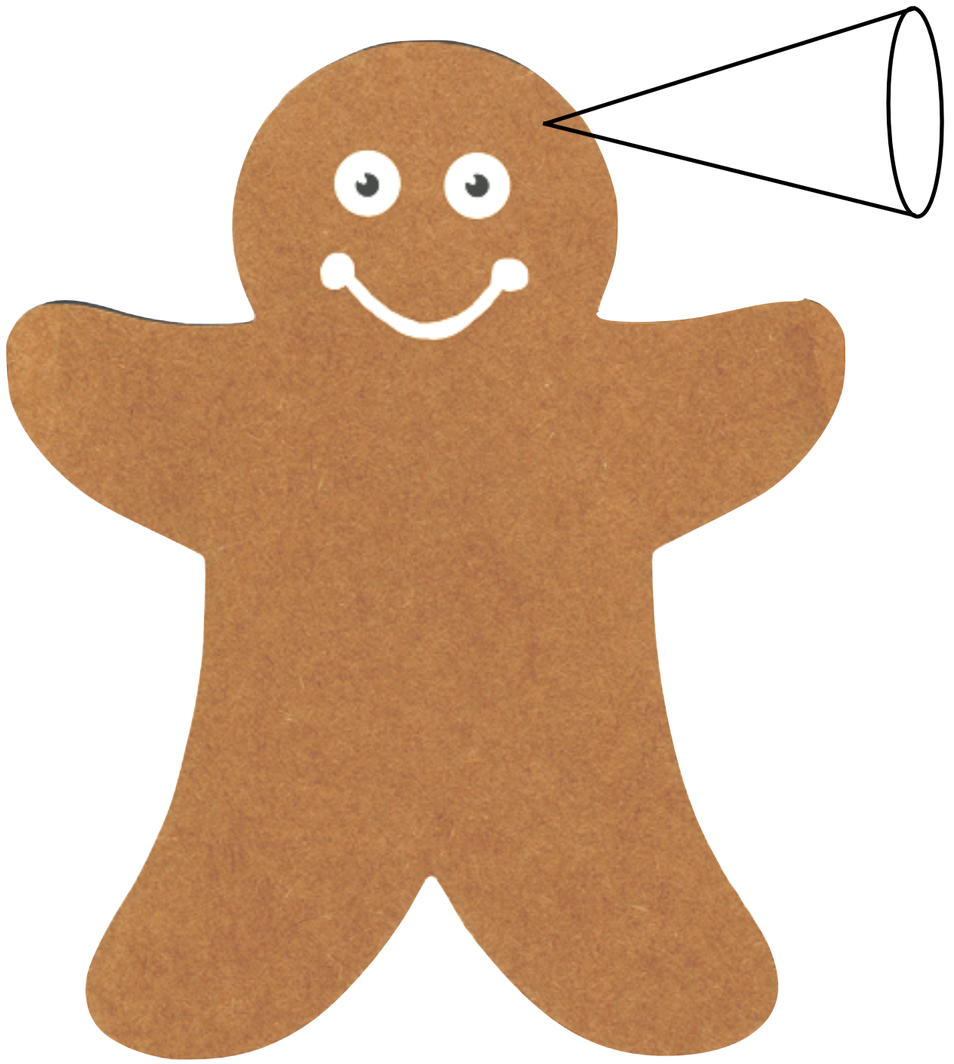
all of chemistry changes

the BB's production of H changes

formation of stars changes

a little radioactivity factory

those trace inorganics?



potassium includes ^{40}K

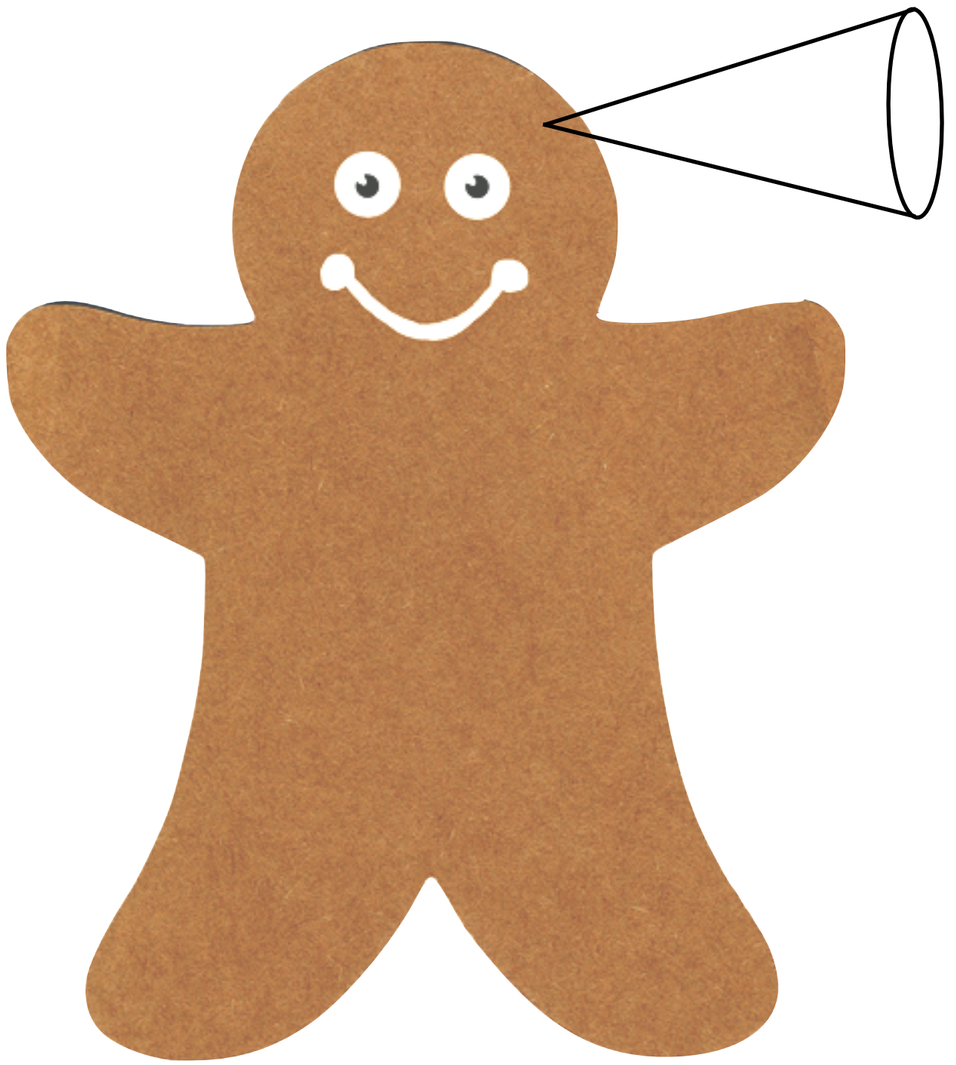
^{40}Ar + anti electron + neutrino

^{40}Ca + electron + neutrino

$e^+ + e^- \rightarrow$ 2 gamma rays

a little radioactivity factory

those trace inorganics?



carbon includes ^{14}C

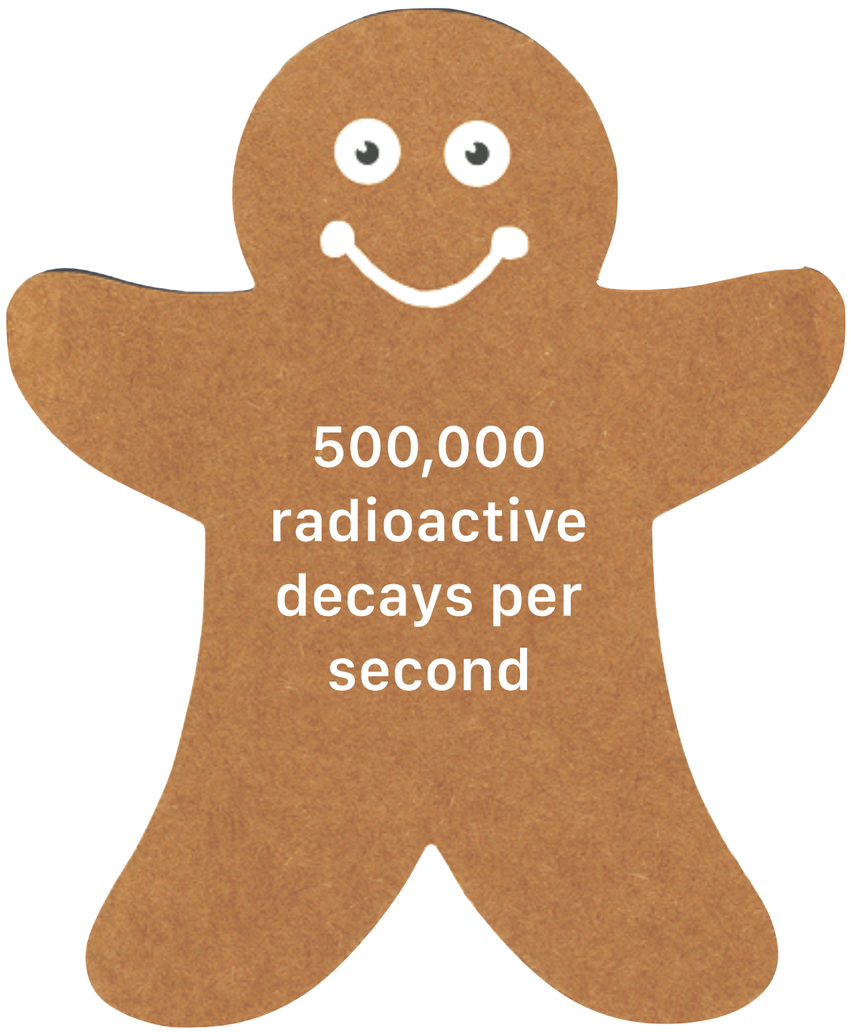
^{14}N

+ electron

+ neutrino

a little radioactivity factory

you internally expose yourself about 4 X-rays' worth



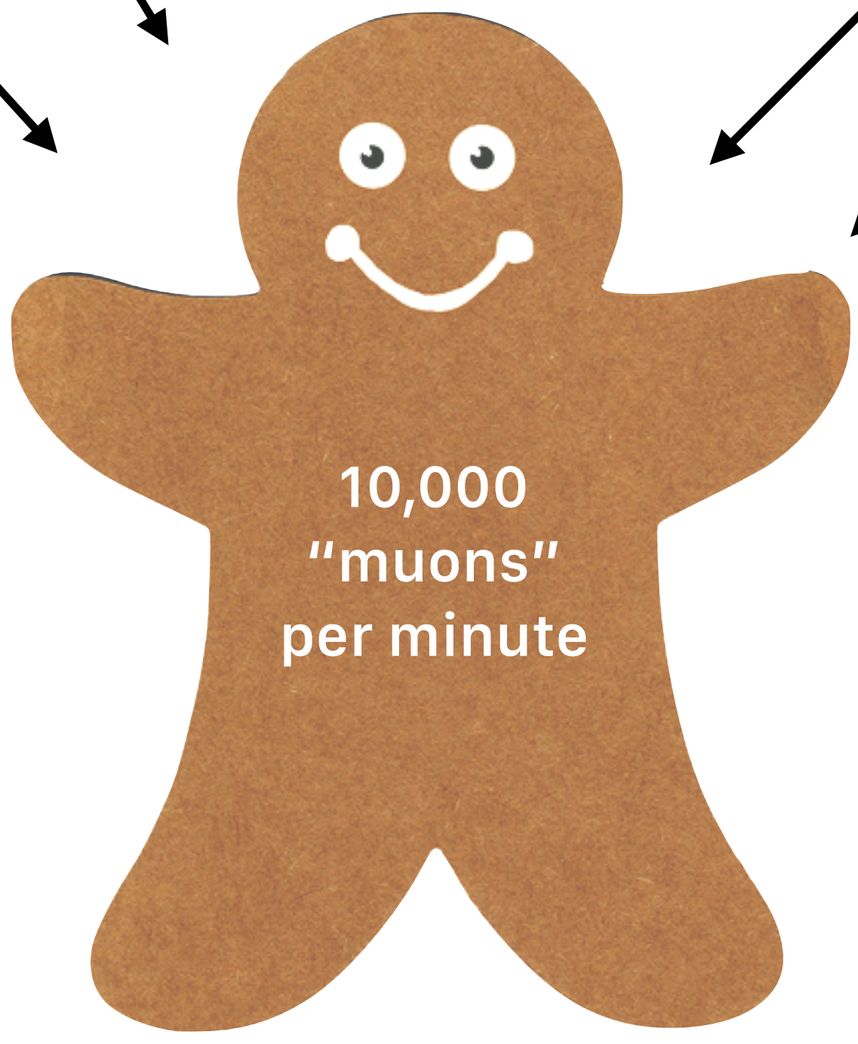
your honey

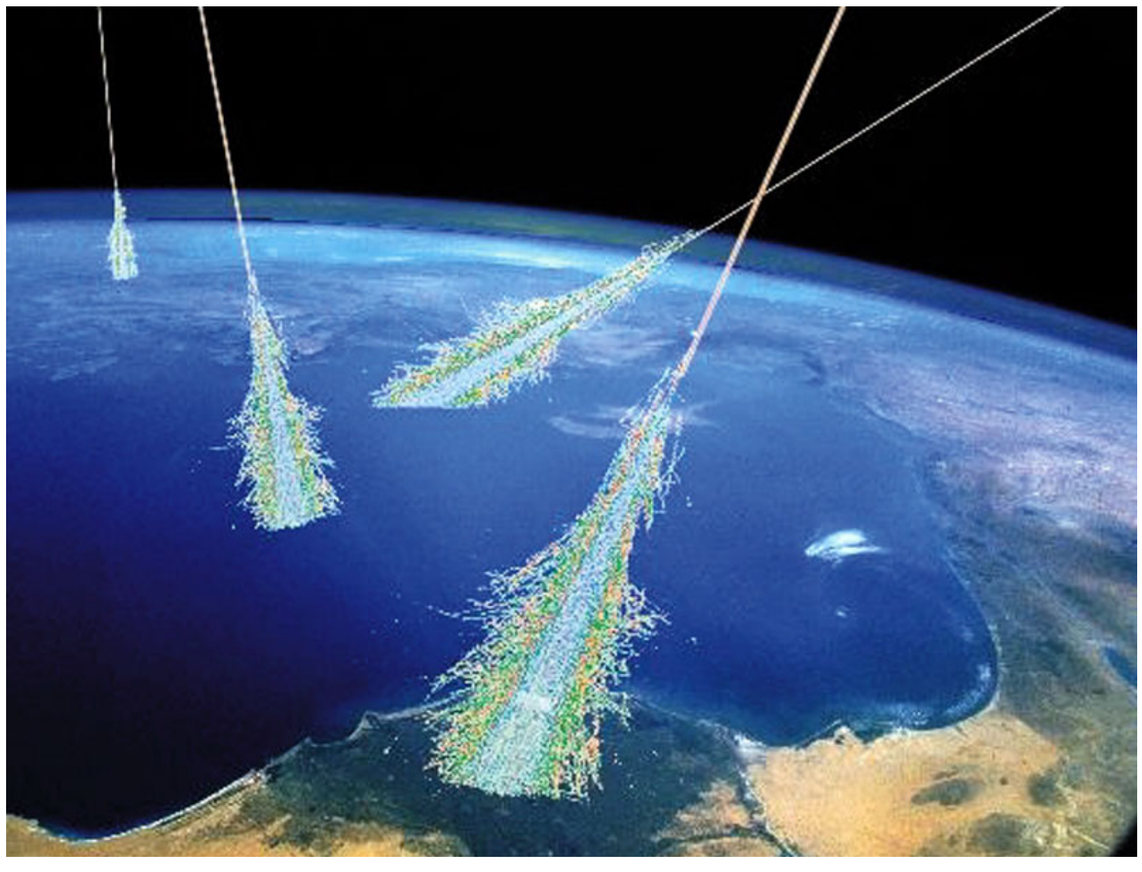
about an X-ray per week

attack from above

constantly bathed

in cosmic rays





that’s not all

constantly bathed

in microwaves from the big bang

galactic dark matter particles

neutrinos from the big bang

Higgs field from the first picosecond of the universe

vacuum Λ energy

so just sitting there

You’re experiencing much of particle physics:

antimatter

neutrinos

muons

vacuum particle production

dark matter

relic big bang radiation

Higgs Field

gluons

Einstein’s special theory of relativity

did you dry your hands

in the fancy air-driers?

it turned on because of Quantum Mechanics

so just ~~sitting there~~ existing

You're experiencing much of particle physics:

antimatter

neutrinos

muons

vacuum particle production

dark matter

relic big bang radiation

Higgs Field

gluons

Einstein's special theory of relativity

quantum mechanics

did you use GPS?

works because of General Relativity

so just ~~sitting there~~ existing

You’re experiencing much of particle physics:

antimatter

neutrinos

muons

dark matter

relic big bang radiation

**Higgs Field*

**gluons*

Einstein’s special theory of relativity

quantum mechanics

Einstein’s general theory of relativity

ISP220

leads you to appreciate all of this

and more

the mechanics

of ISP220

lots of moving parts

in ISP220

resources

text books

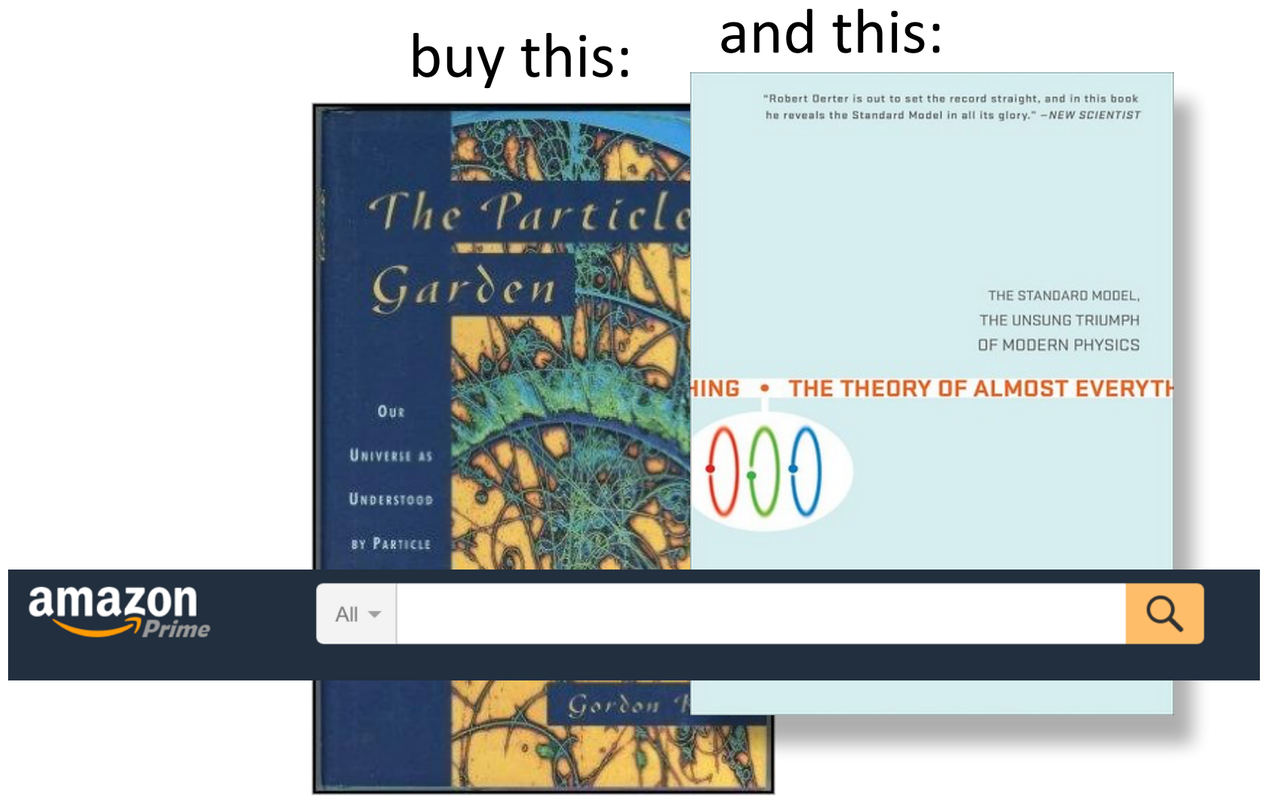
http://www.chipbrock.org

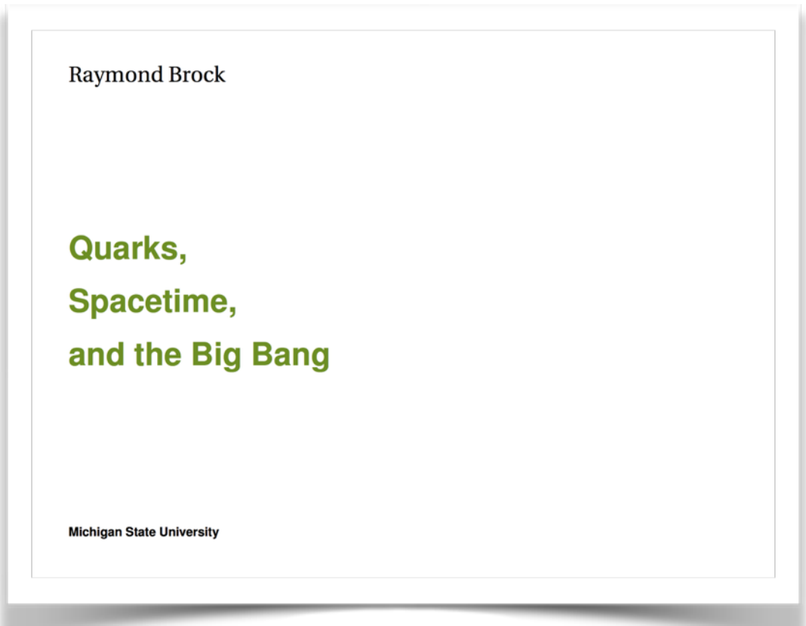
Facebook Group

MasteringPhysics

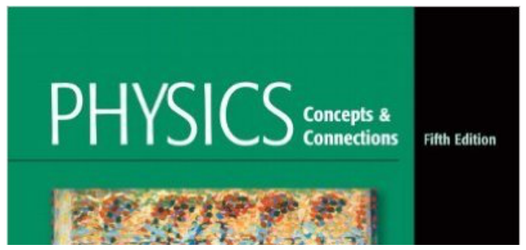
blogs and websites

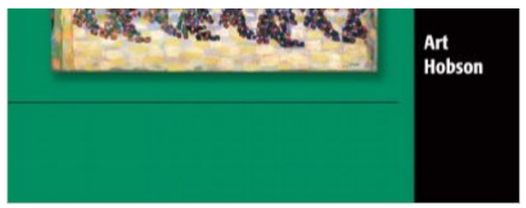
I recommend:



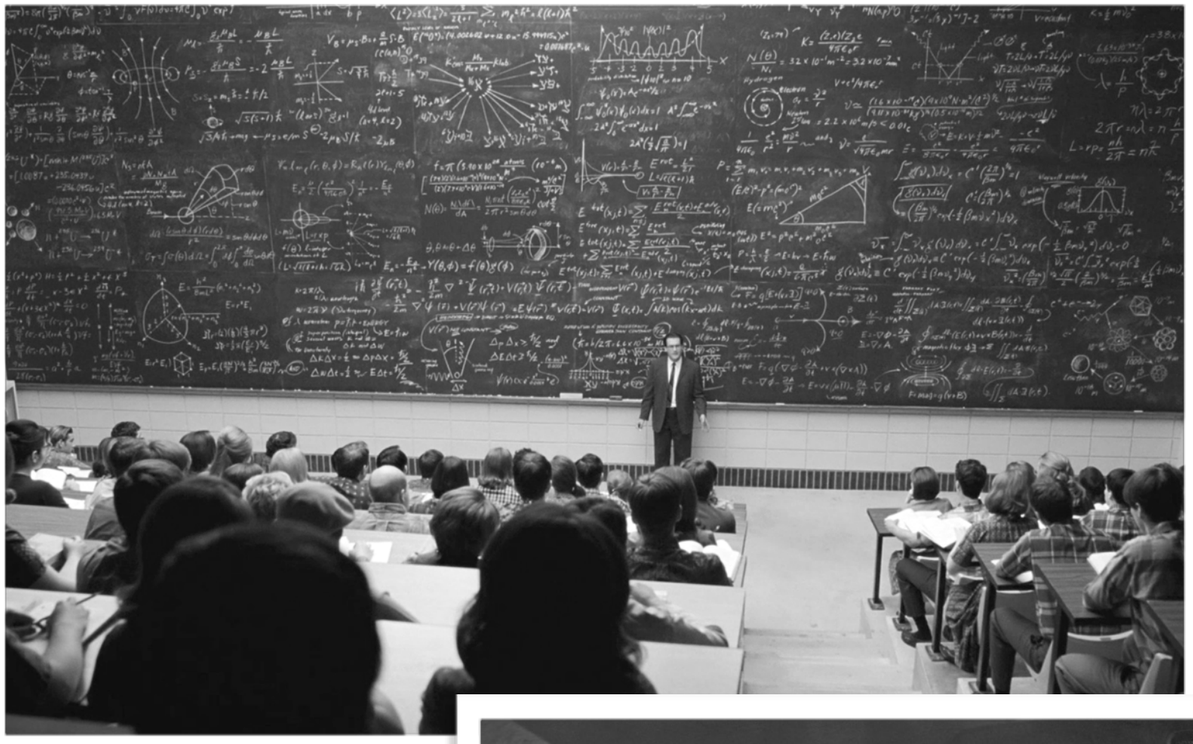


buy this:

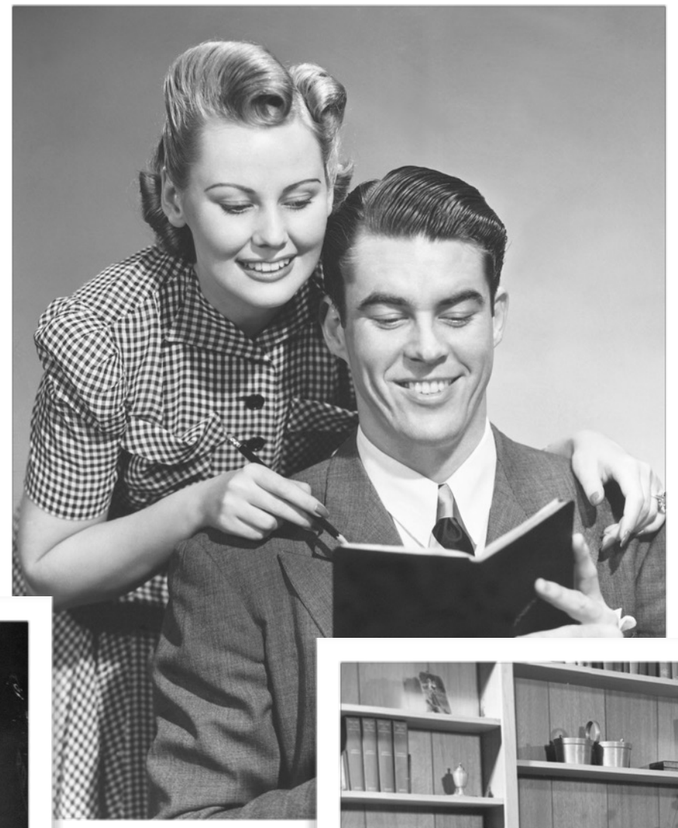




a combination of sources



I'll lecture



You'll read some on-line material

You'll watch some videos

in fact

flipping ISP220

for about 5 weeks, we'll be in "flipped mode"

"flipping" means:

instead of real-time lecture, content is over video

instead of lectures, on Thursdays we'll do other stuff:

- *questions*
- *biography*
- *demonstrations*
- *hand-in stuff*

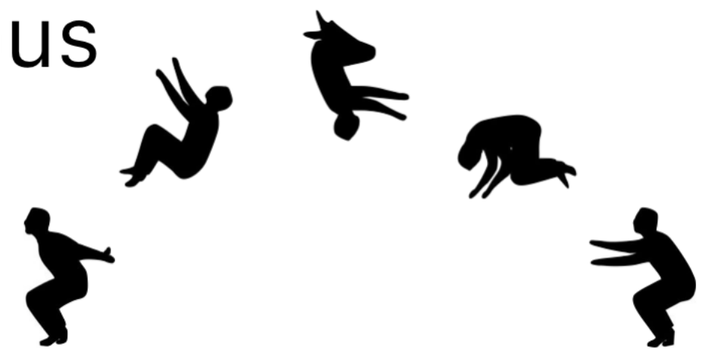
On Tuesdays? You're watching videos!

first month or so:

today/Thursday: indeed, lectures on motion/momentum

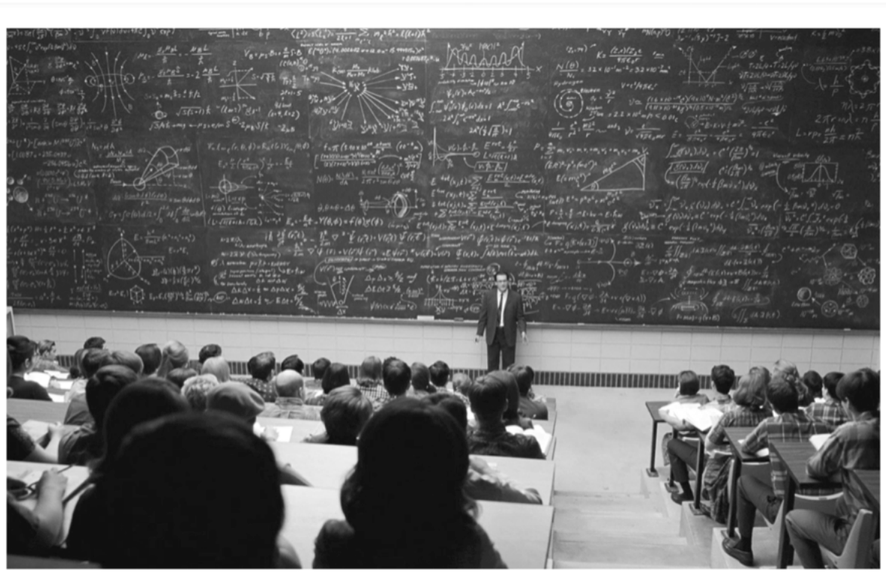
this material *also* recorded and in syllabus

week 2 through I suspect week 5 flip:



& "other stuff" Thursday

rest of semester

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Google
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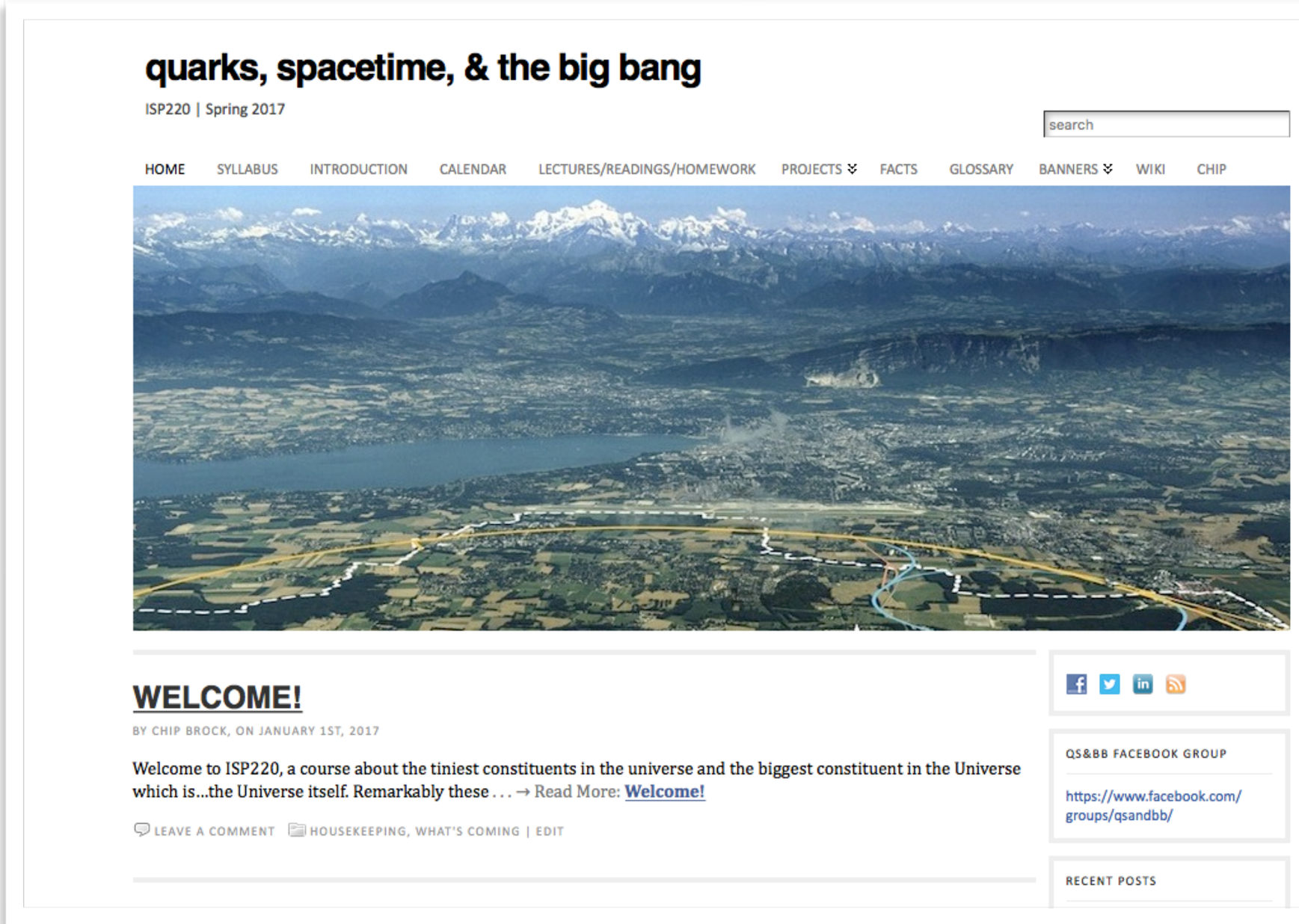

quarks, spacetime, & the big bang
ISP220 | Spring 2017
search
HOME SYLLABUS INTRODUCTION CALENDAR LECTURES/READINGS/HOMEWORK PROJECTS FACTS GLOSSARY BANNERS WIKI CHIP
WELCOME!
BY CHIP BROCK, ON JANUARY 1ST, 2017
Welcome to ISP220, a course about the tiniest constituents in the universe and the biggest constituent in the Universe which is...the Universe itself. Remarkably these . . . → Read More: Welcome!
LEAVE A COMMENT HOUSEKEEPING, WHAT'S COMING | EDIT
QS&BB FACEBOOK GROUP
https://www.facebook.com/groups/qsandbb/
RECENT POSTS

read the syllabus carefully

In a nutshell:

you dial up your grade by what you choose to do

homework

every week, everything is game: lectures, textbook readings, manuscript, demos

2 midterms, final, quizzes, and projects. Lots of projects.

bookmark:

http://www.chipbrock.org

course website

http://www.pearsonmylabandmastering.com/northamerica/masteringphysics/

homework

http://www.facebook.com/groups/qsandbb/

QS&BB Facebook Group…by invitation only

http://www.pa.msu.edu/~brock/file_sharing/QSandBB/lectures/

the ftp site where I'll store all lecture slides

http://qsbbwiki.wikispaces.com

the wiki where you'll do many of the projects

M

word

two points

1. functions are a magic language

English versus Algebra

Example: Newton's Universal Law of Gravitation

> "The force of attraction experienced by two masses on one another is directly proportional to the product of those two masses and inversely proportional to the square of the distances that separate their centers. The constant of proportionality is called the Gravitational Constant which is $6.67408 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$."

How would you measure the Gravitational Constant?

English versus Algebra

Example: Newton's Universal Law of Gravitation

"The force of attraction experienced by two masses on one another is directly proportional to the product of those two masses and inversely proportional to the square of the distances that separate their centers. The constant of proportionality is called the Gravitational Constant which is $6.67408 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$."

English Sentence

How would you measure the Gravitational Constant?

doesn't lead to something new

Algebra versus English

Example: Newton's Universal Law of Gravitation

$$F = G\frac{mM}{R^2}$$

How would you measure the Gravitational Constant?

$$G = \frac{FR^2}{mM}$$

Algebra versus English

Example: Newton's Universal Law of Gravitation

Algebra Sentence

$$F = G\frac{mM}{R^2}$$

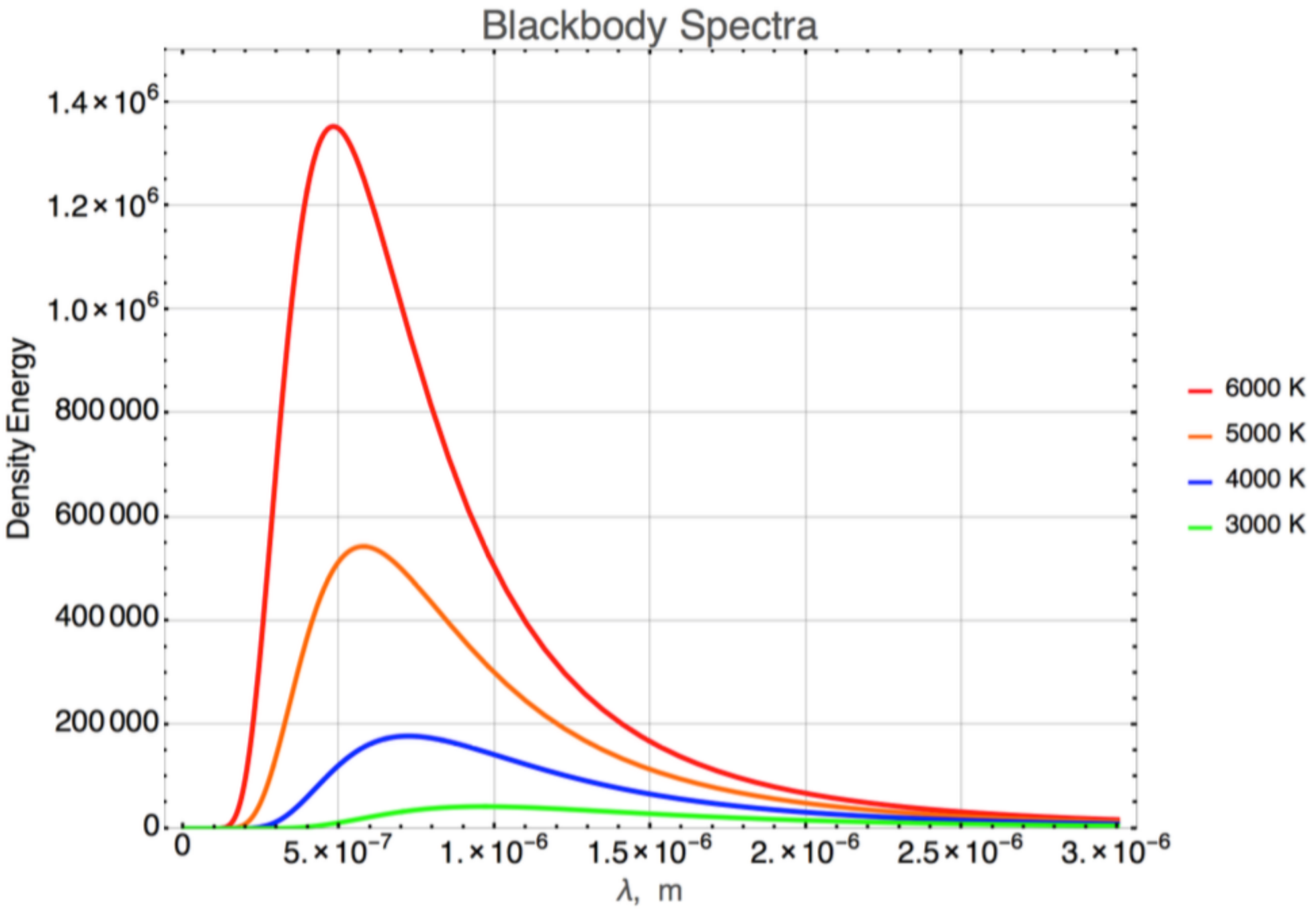
How would you measure the Gravitational Constant?

magic: $G = \frac{FR^2}{mM}$

two points

1. functions are a magic language

2. functions can be plotted


Blackbody Spectra
Density Energy
1.4×10^6
1.2×10^6
1.0×10^6
800 000
600 000
400 000
200 000
0
0
5.×10^-7
1.×10^-6
1.5×10^-6
2.×10^-6
2.5×10^-6
3.×10^-6
λ, m
6000 K
5000 K
4000 K
3000 K

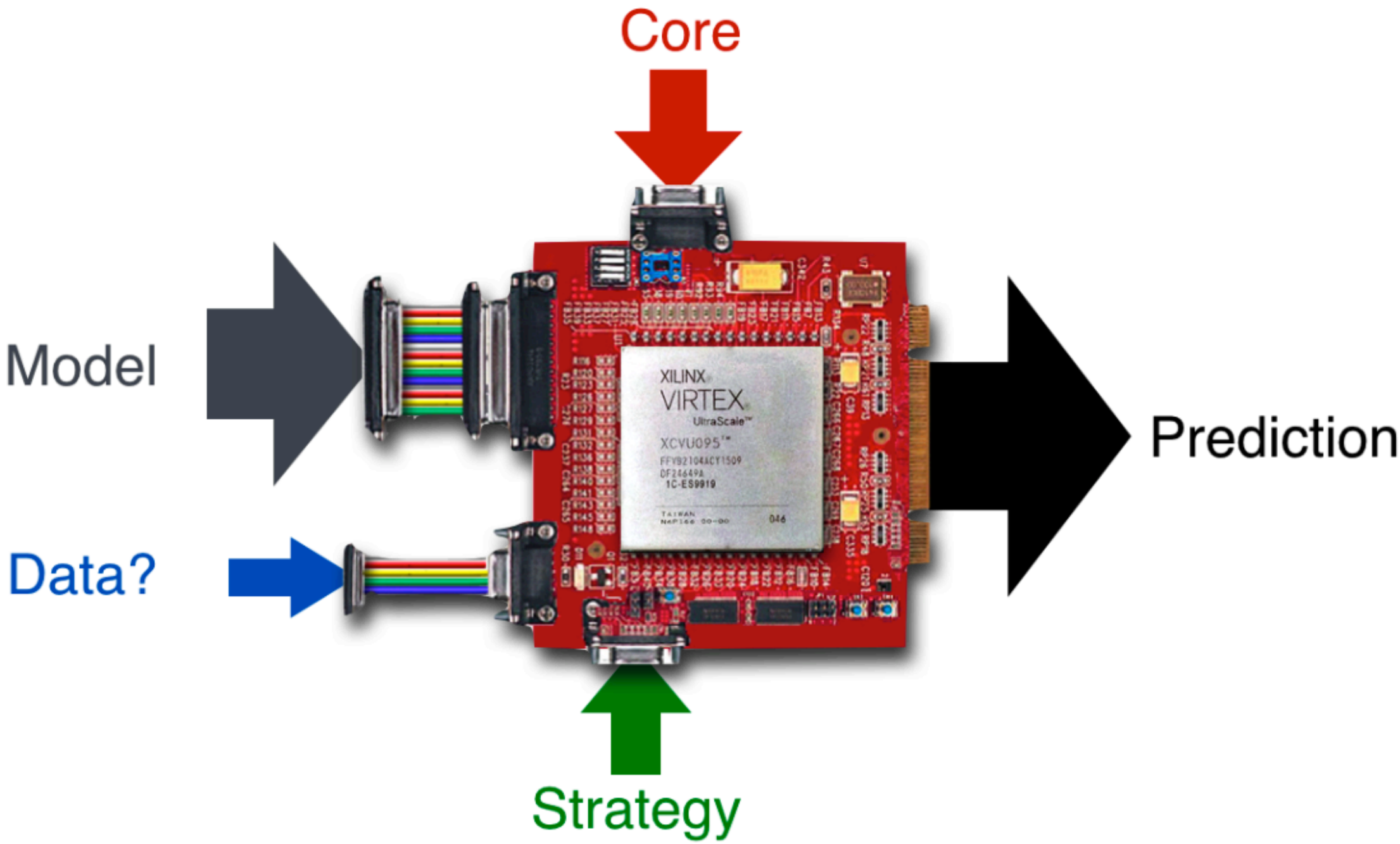
3 ~~two~~ points

1. functions are a magic language

2. functions can be plotted

3. models of the universe are sometimes complicated

our universe can be complicated…treat models:



I assume

that you went to high school

and that you can manage really simple algebra and scientific notation

see my manuscript, Chapter 2 “Everyone Needs Tools,” for mathematical review

and that you’ll always ask if you don’t understand something

how to get ahead

come to class

do the work

use your hands.

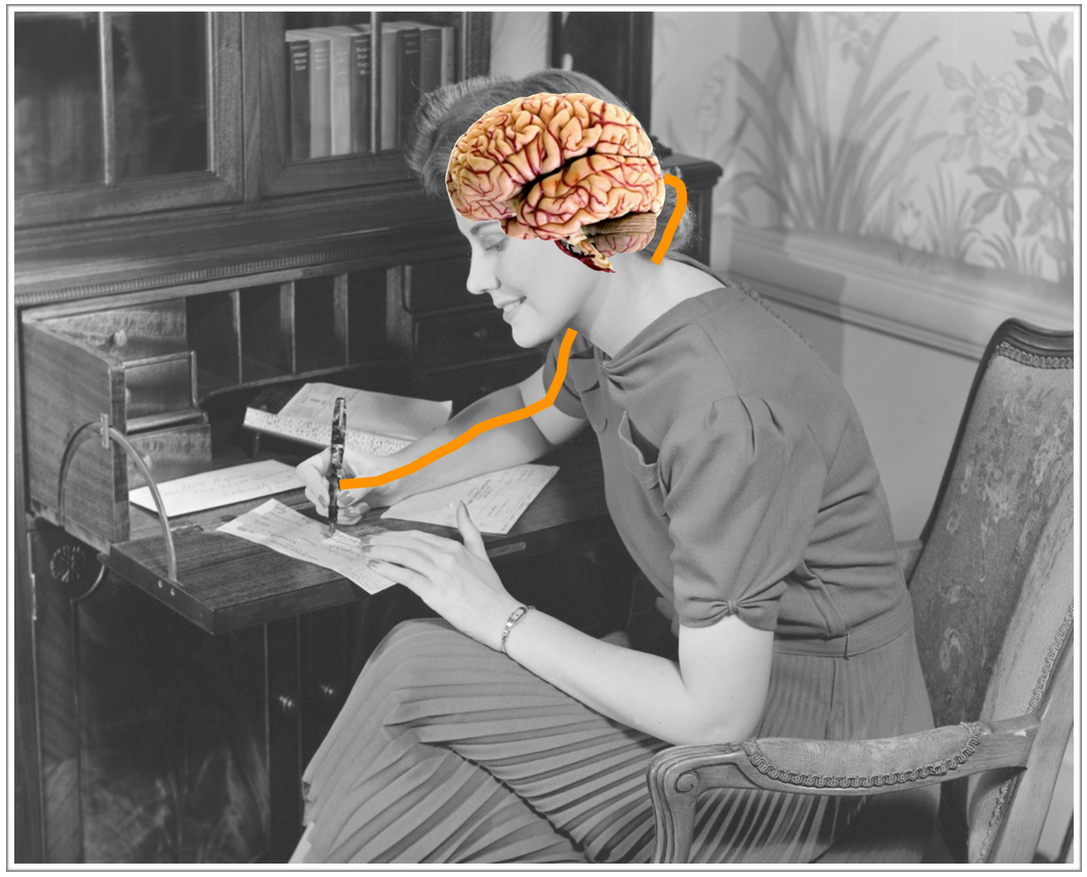
my experience

about learning anything involving logical reasoning

how I do it, even today

you can't "read" mathematics

you must copy it.



with your fingers

SO

bring a notebook to class

no computers, phones, iPads, or fraternity brothers

how I'd do your job

come to class

watch and listen to lectures and demonstrations

take brief notes

if something goes by quickly—jot the slide # and look later

*if it still bothers you, **ask** and maybe I'll make a movie*

when I go to the tablet…write with me

you've got friends

check the website for my office hours

in-person and virtual (Skype and Facebook)

and for those of our TA:

Daniel Coulter

in-person (TBA) and virtual (Facebook)

how to get ahead

come to class

do the work

use your hands.

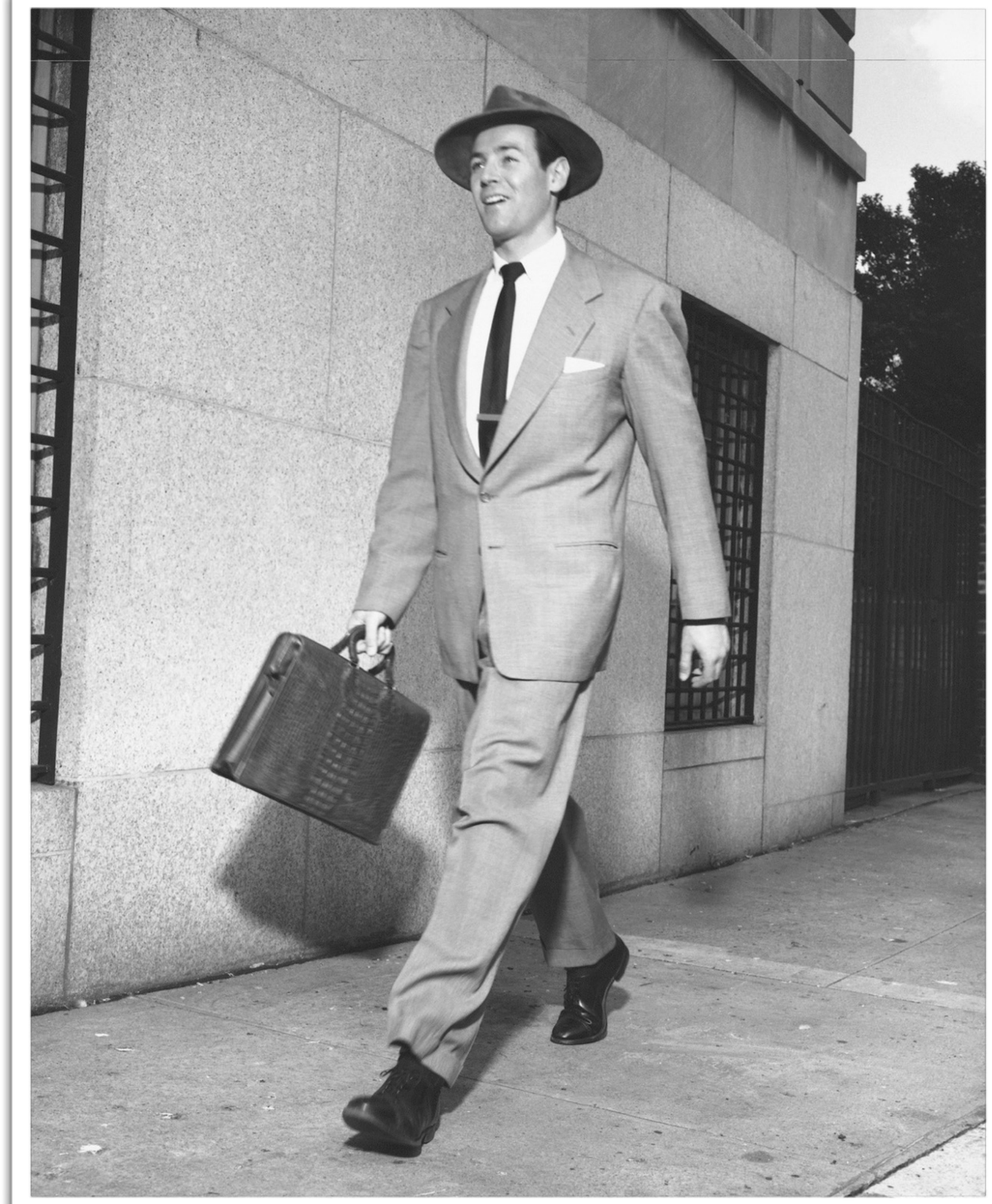
you'll be fine

my goals for you

To learn of discoveries, theories, and puzzles in particle physics and cosmology

To learn some visualization tools and apply them to understanding some experimental and theoretical techniques

To meet some of the historical and contemporary physicists who built both of these fields



let’s get to work