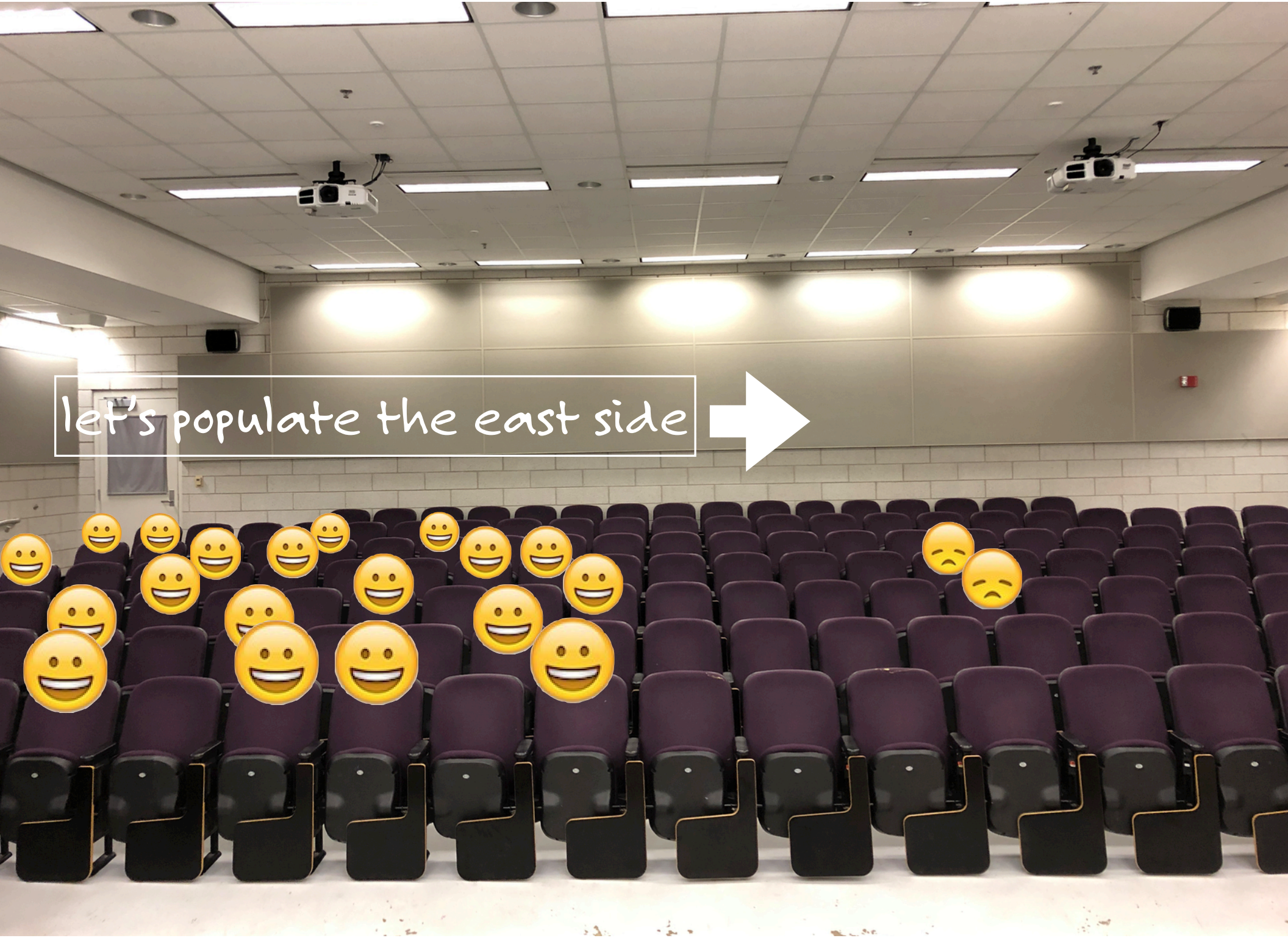
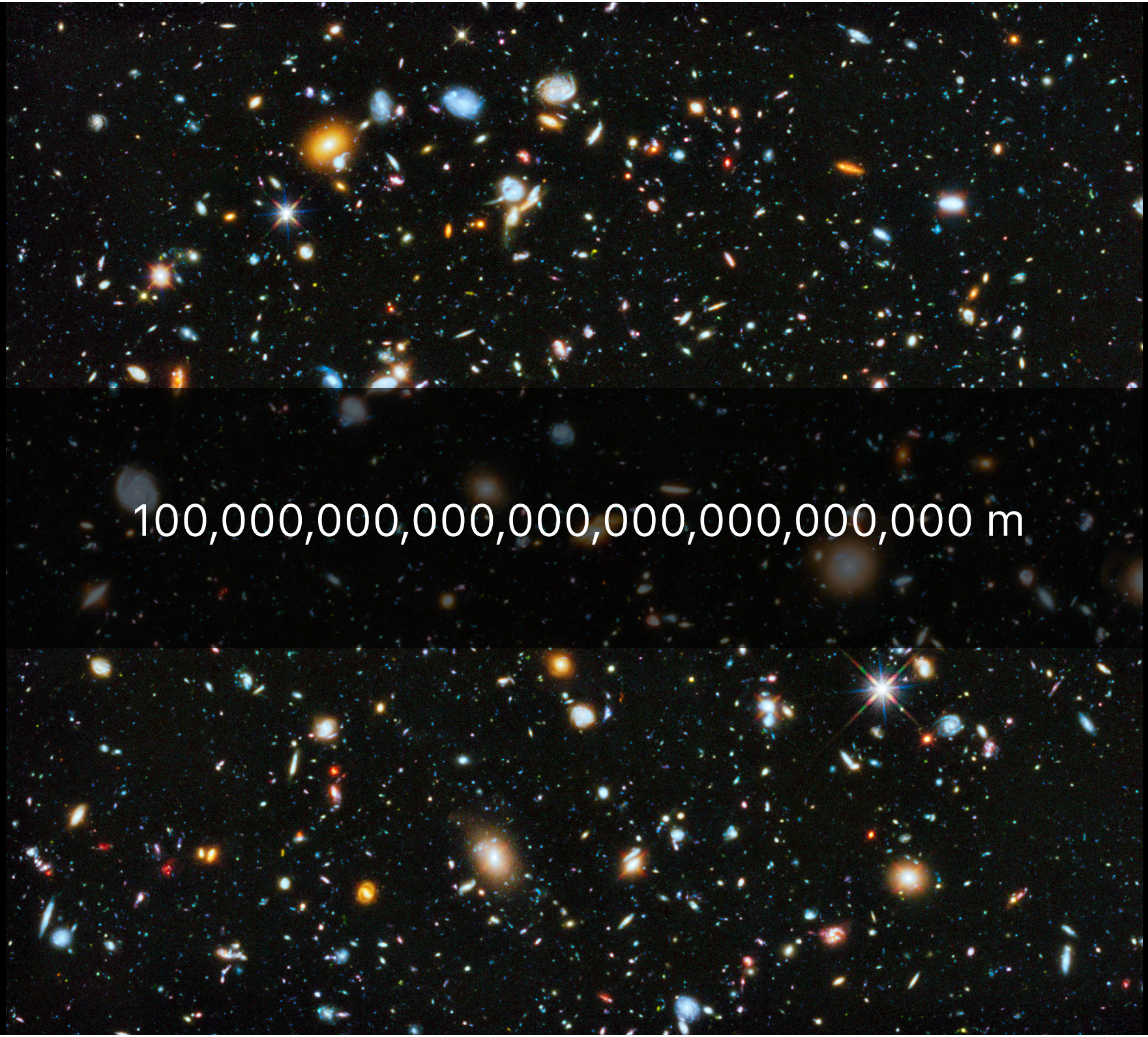

let's populate the east side

ISP220

QUARKS, SPACETIME, AND THE BIG BANG


Karl
Gude
MICHIGAN STATE UNIVERSITY
MSU Global
FELLOW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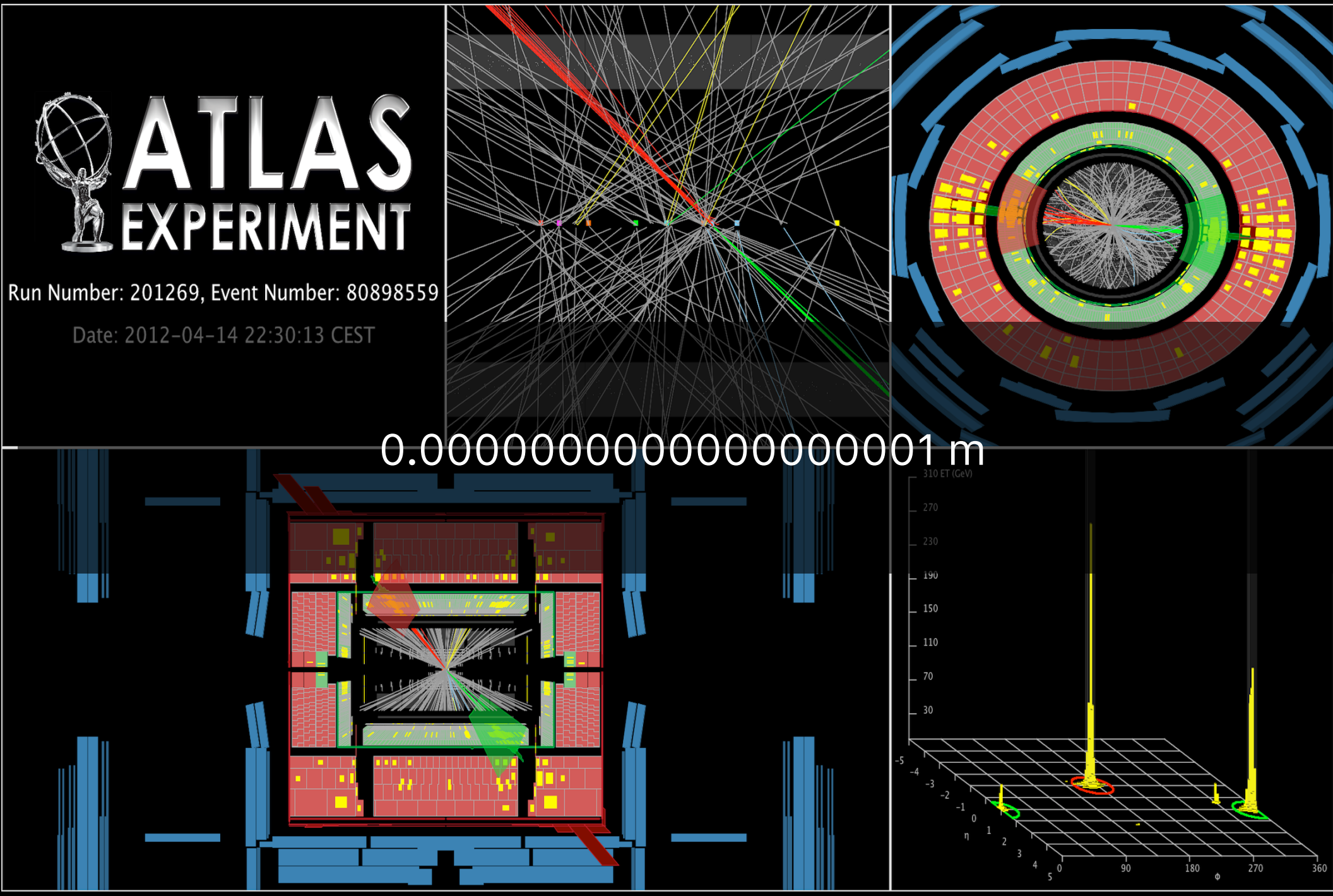
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-4
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-2
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90
180
270
360
φ

Raymond Brock, 1950
HS: 1968

Raymond O Brock, 1895 - 1992
HS: 1913

Kimberly Brock, 1986
HS: 2004

Frances A Brock, 1921 - 1999
HS: 1939

Raymond L Brock, 1922 - 2011
HS: 1940

Terry Brock, 1981
HS: 2000

Kimberly Brock, 1986
HS: 2004

welcome

to ISP220

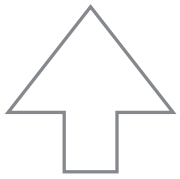
Quarks, Spacetime, and the Big Bang


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

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

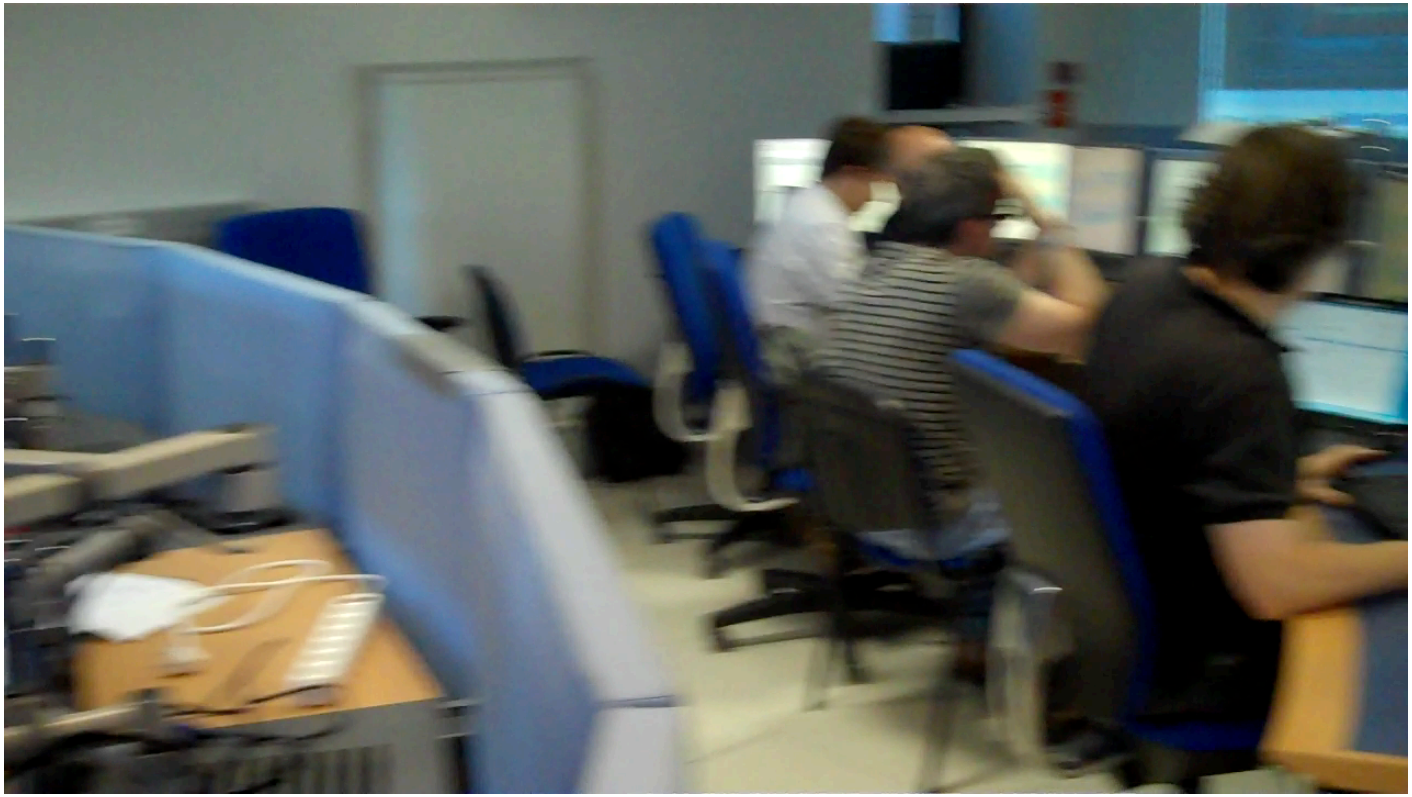
So.
A course on particle physics?

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

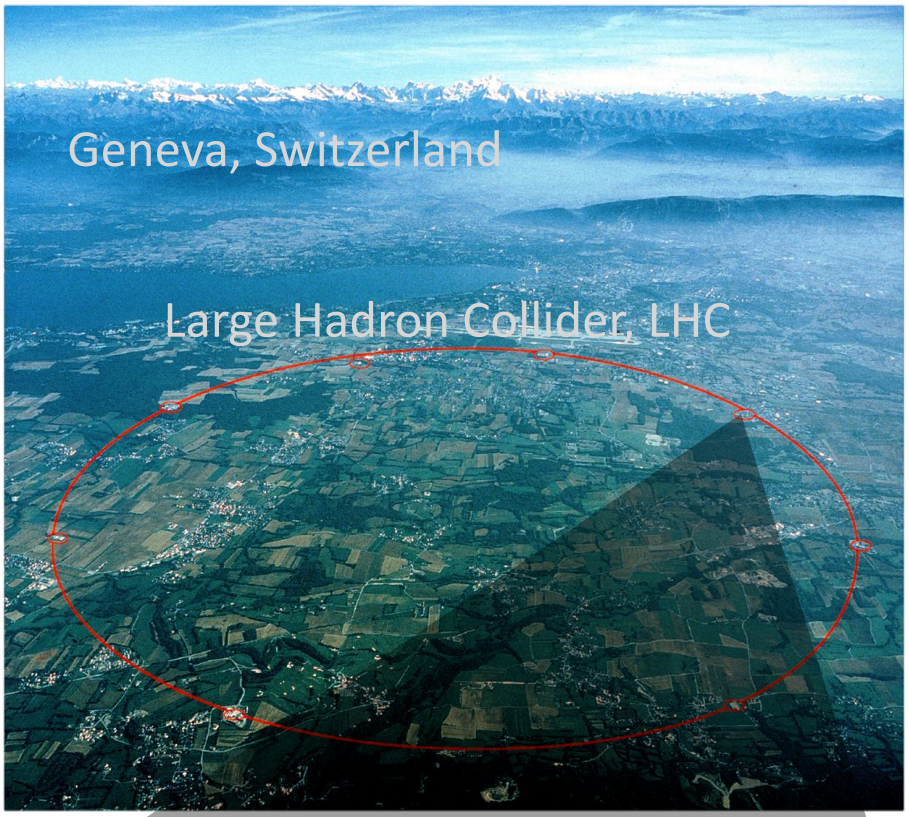
yes, that one

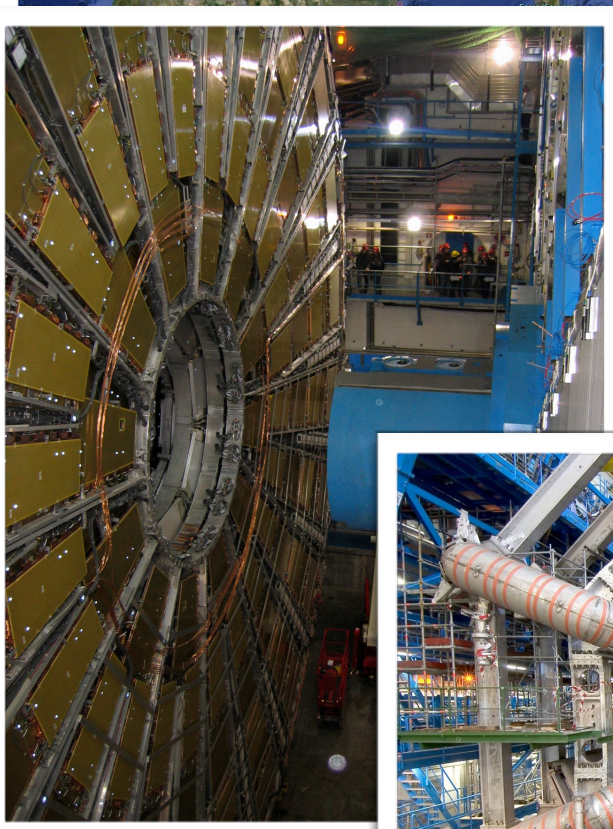
some artistic license

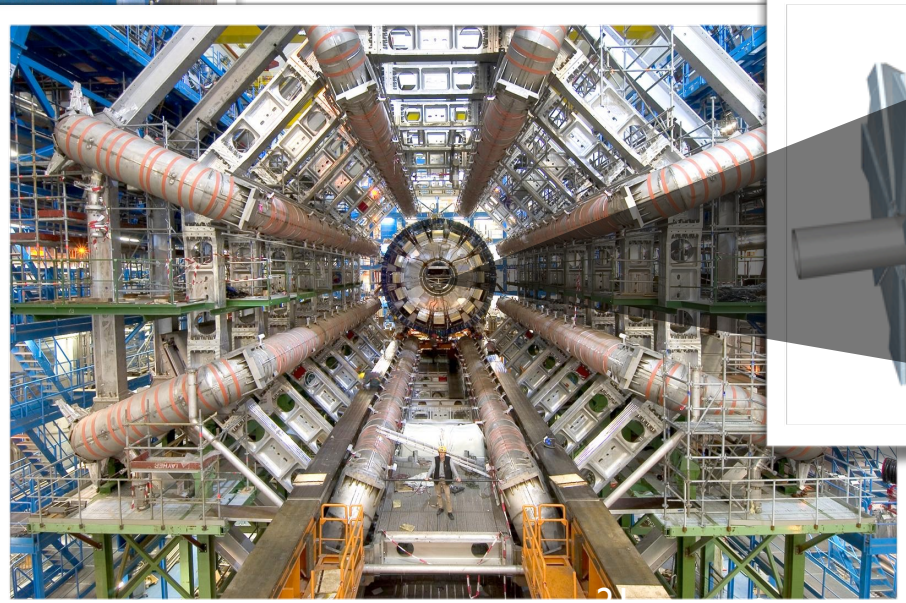
the real control room

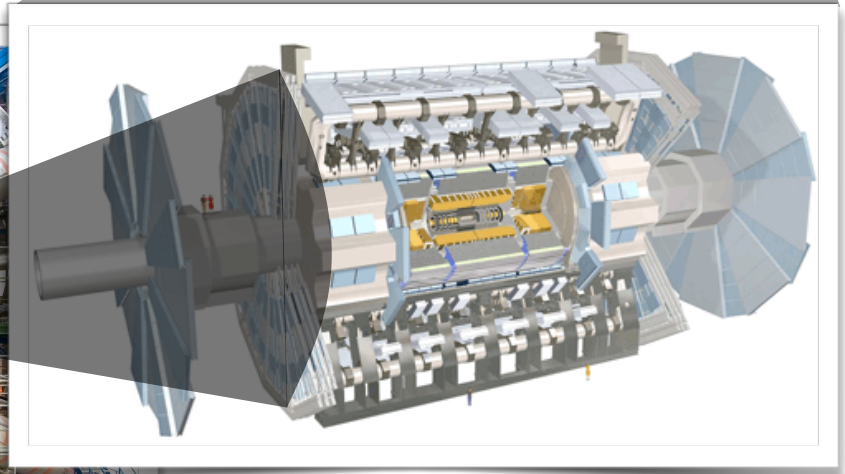



North Sea
Dublin
London
Amsterdam
Brussels
Brussel
English Channel
Luxembourg
Paris
Berlin
Warsaw
Prague
Vienna
Bratislava
Budapest
Berne
Alps
Ljubljana
Zagreb
Belgrade
Bucuresti
Bay of Biscay
Monaco
Ligurian Sea
Isola d'Elba
Rome
Sarajevo
Podgorica
Skopje
Prishtine
Sofia
Tirane
Isola di Procida
Isola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


Geneva, Switzerland
Large Hadron Collider, LHC

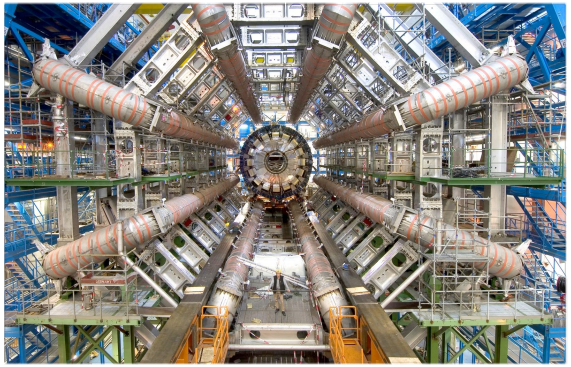


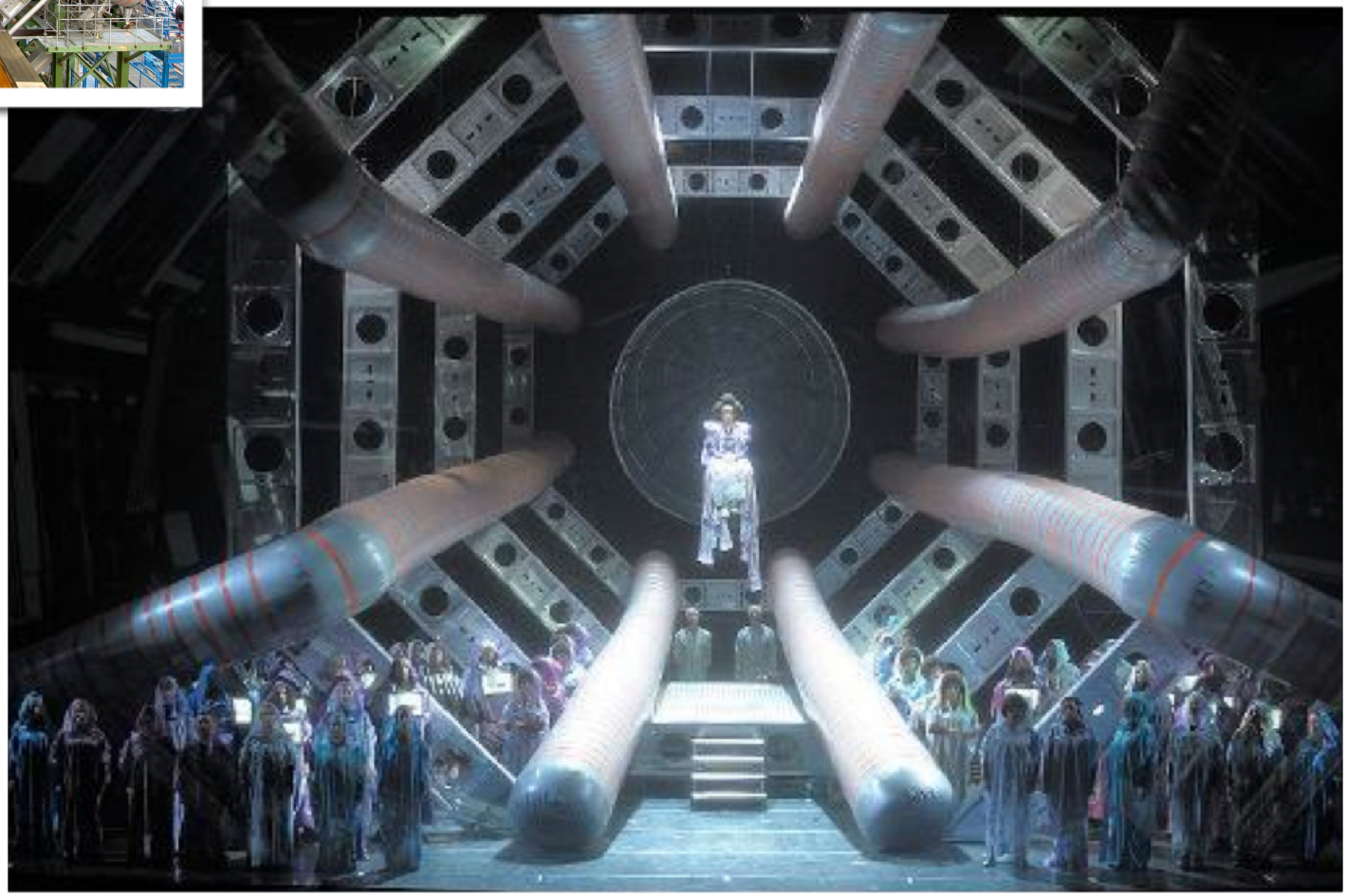


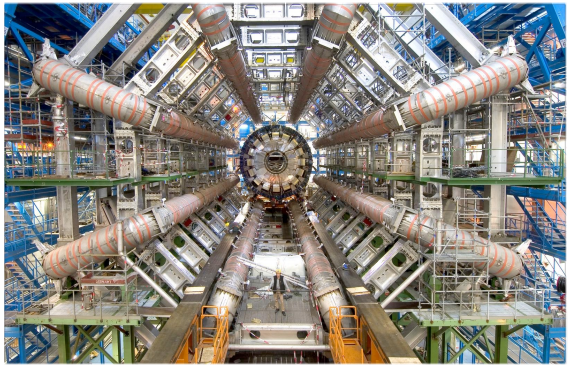


somehow our experiment

generates attention







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.

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/


ANGELS & DEMONS
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.

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

not everything is the same

Understand.

For example to *Understand* a recipe means that you've prepared a meal using it. It doesn't mean that you created the recipe.

Appreciate.

To *Appreciate* a recipe you would realize that to sweeten it you'd add sugar, but not be able to predict exactly how much to add. You'd need an expert, but you'd know who to ask and what to request.

Familiarize.

Continuing with the food analogy, you might be *Familiar* with the idea that recipes for chocolate cookies exist, but you'd need the web or a cookbook in order to Appreciate or Understand one.

you're asking yourself

"Self, how can I do that?"

Answer: a little bit of reading, a little bit of algebra

and your pencil.

lots of moving parts

in ISP220

QS&BB in 3 parts

Part 1

“classical physics”

motion, forces, momentum, energy, electricity, magnetism, waves, electromagnetism

Part 2

relativistic physics

special relativity

general relativity

20th century cosmology

Part 2

“field theory”

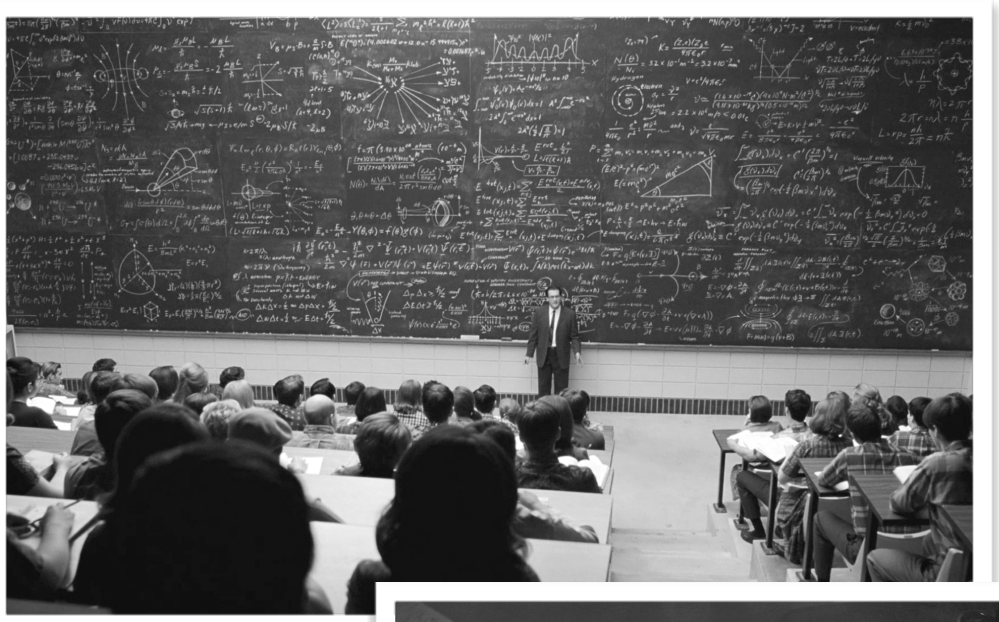
quantum mechanics

+ relativity

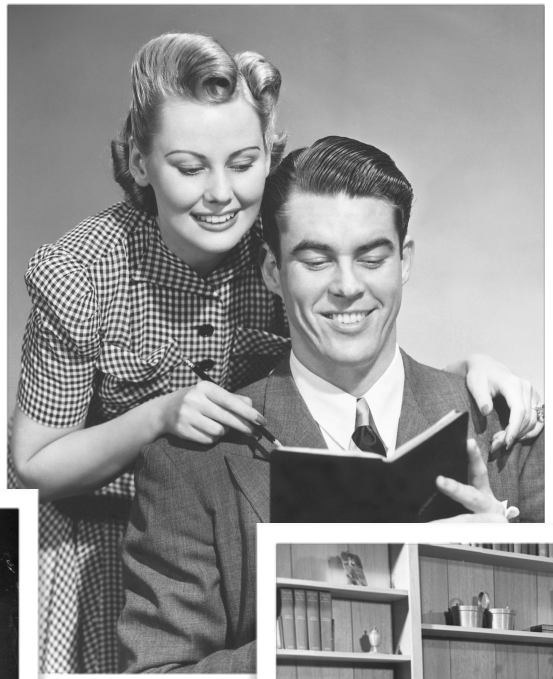
particle physics

current cosmology

a combination of sources



I'll lecture



You'll read the texts

You'll read some on-line material

You'll watch some videos

primary source

All of Part 1 content

1. we'll call it: "the book"

2. videos in support, section by section

QS&BB

Quarks, Spacetime, and the Big Bang

1. Hi.

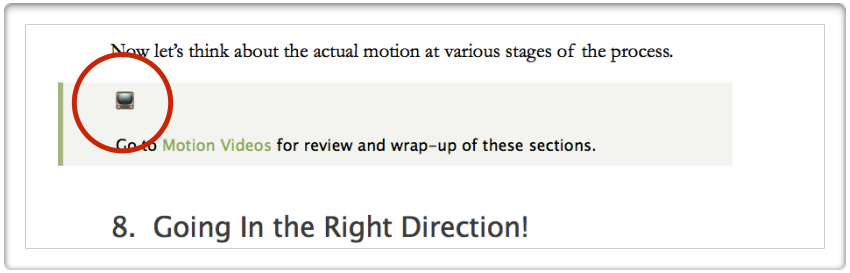
Welcome to the detailed content of Quarks, Spacetime, and the Big Bang.

The subject chunks of QS&BB are segmented into individual "lessons." Each is a topic on its own, although most lessons will assume familiarity with the previous ones. You can get back to this page by going "home" in the sidebar.

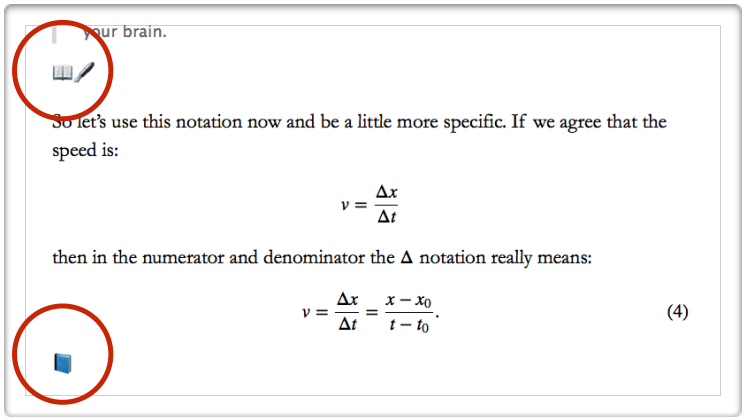
1.1 Outline of Lessons

sign posts along the way

periodically go to a video:



get out your pencil:



resources

text books

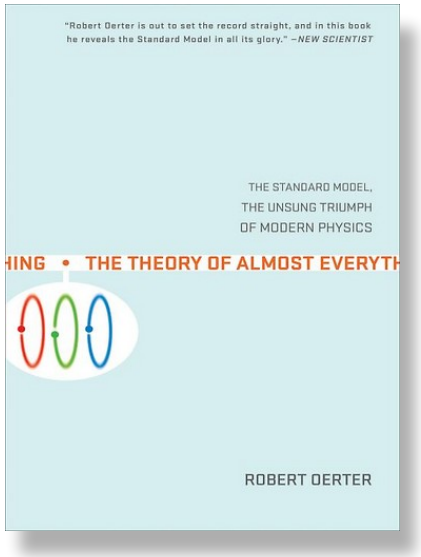
http://www.chipbrock.org

Facebook Group

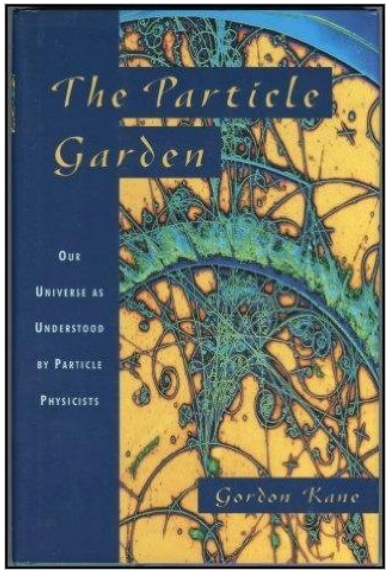
MasteringPhysics

blogs and websites

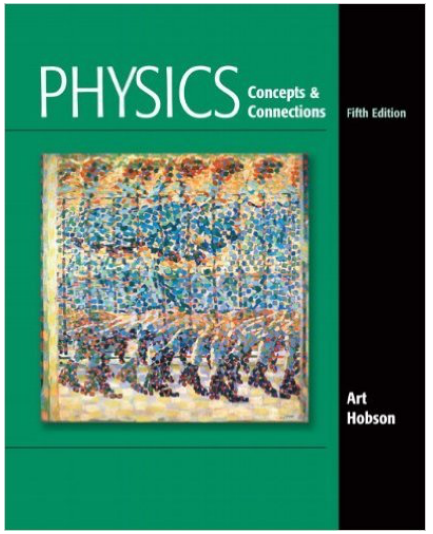
buy this:



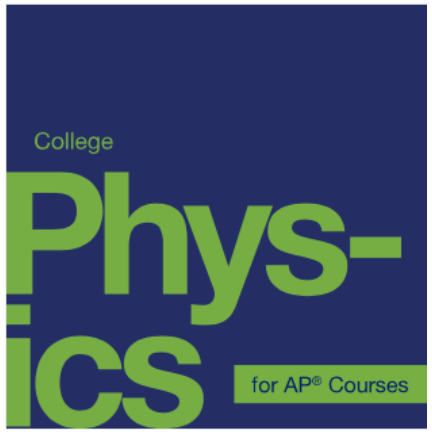
maybe buy this:



maybe buy this:



use this for free:

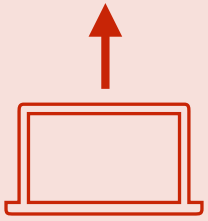


long view

Part 1

meet only Tuesdays

the "book"



videos in support

mid February

Parts 2 and 3

meet Tuesdays and Thursdays

lecture

“only Tuesday” schedule

Part 1: tuesday to tuesday:

starting wednesdays….

you read the on-line book, take notes, work examples, watch review videos

tuesday’s class

readings quiz

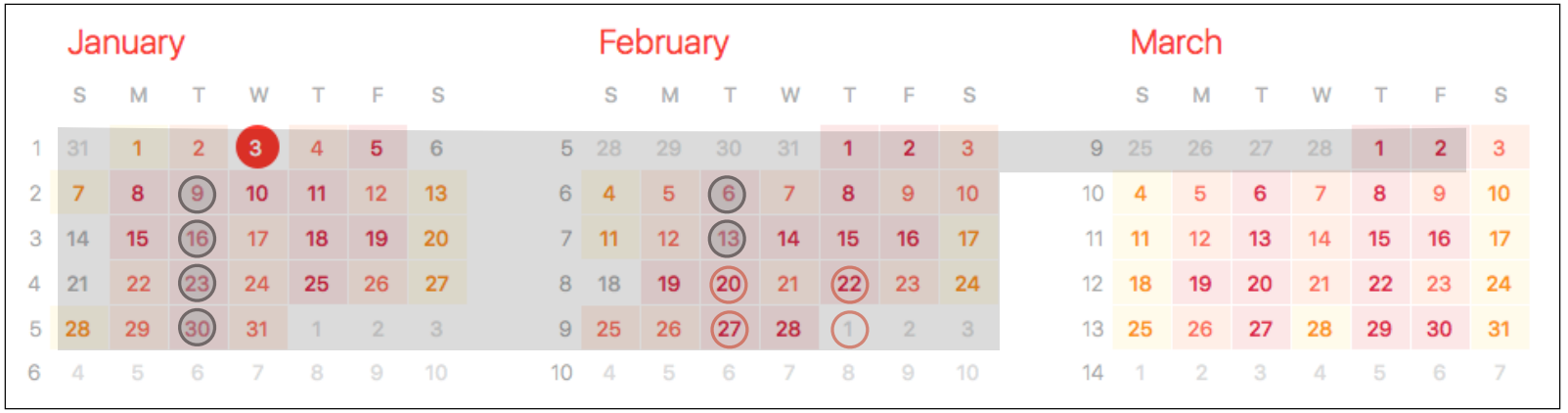
interactive questions

demos

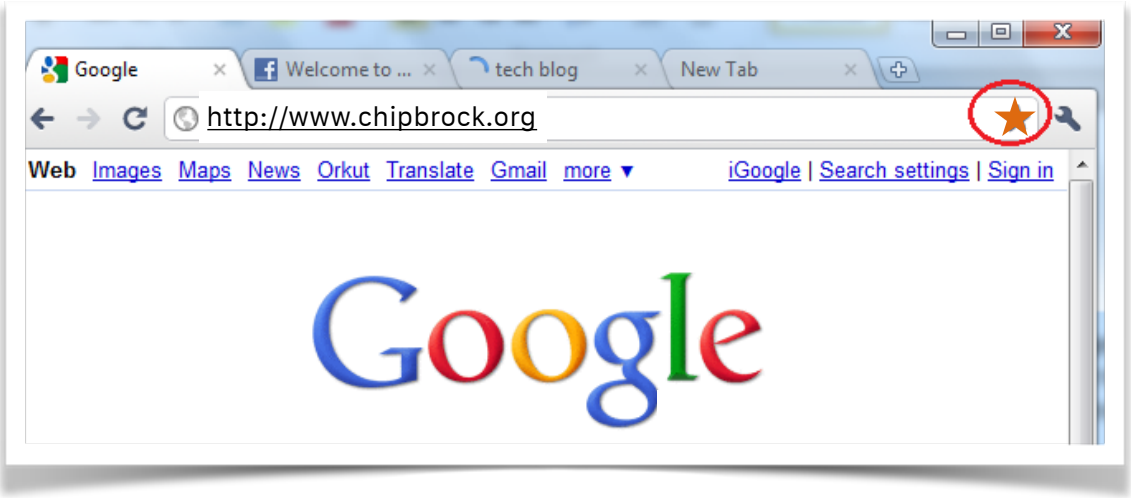
collaborative projects

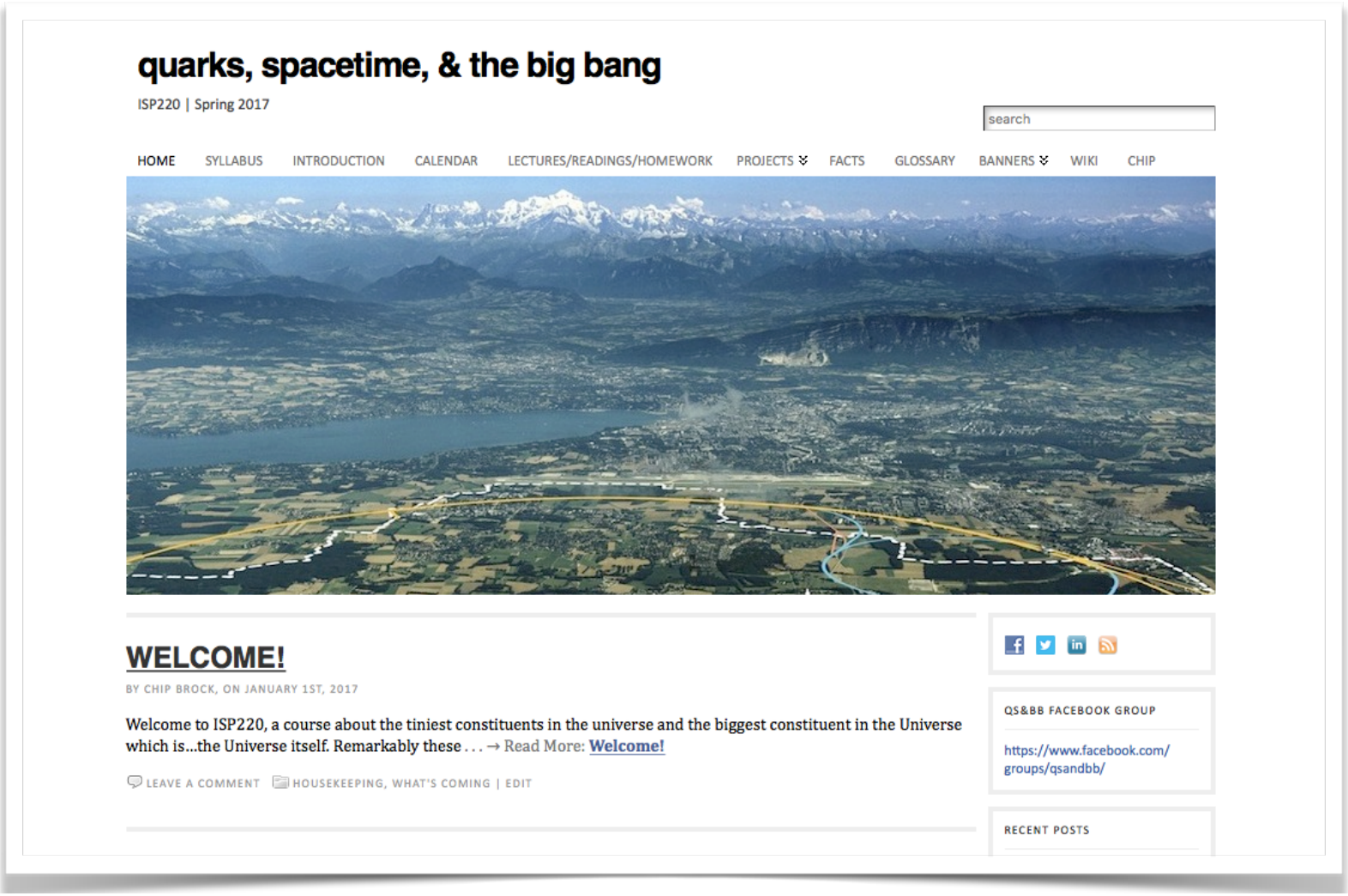
startin

you read th
watch syn



Tuesday	activity	Thursday	activity
Jan 9, Introduction	today!	Jan 11, no class	preparing Lesson 4
Jan 16, Lesson 4. Motion	quiz, demos, in-class project	Jan 18, no class	preparing Lessons 5, 6
Jan 23, Lessons 5, 6 Momentum, Collisions	quiz, demos, in-class project	Jan 25, no class	preparing Lessons 7, 8
Jan 30, Lessons 7, 8 Energy, Early Cosmology	quiz, demos, in-class project	Feb 1, no class	preparing Lessons 9, 10
Feb 6, Lessons 9, 10 Gravitation, Charges & Magnets	quiz, demos, in-class project	Feb 8, no class	preparing Lessons 11, 12
Feb 13, Lessons 11, 12. Faraday's Fields,	quiz, demos, in-class project	Feb 15, no class	preparing Lessons 13, 14
Feb 20, Lessons 13, 14. Waves and Accelerators	no quiz, lecture, demos	Feb 22, Yes, class!	lecture!
Feb 27, Special Relativity	lecture	March 1, Special Relativity	lecture
Spring Break!			


Google
Welcome to ...
tech blog
New Tab
http://www.chipbrock.org
Web Images Maps News Orkut Translate Gmail more ▾
iGoogle | Search settings | Sign in
Google


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

your contributions

simple problem-based homework every week

2 on-line exams, like homework

readabook: from a list, choose a book to carefully read and review

a final-exam project done in groups

announced and unannounced quizzes

some extra stuff you can do for points

read the syllabus carefully

700 pts

homework, 2 midterms, final, quizzes, and projects.

HW: (13 @30pts each)	56%
in-class work (5 @15 pts each)	10%
exams: (2 @60pts each)	17%
book: (1 @20 pts)	3%
flipping-period quizzes: (5 @5 pts each)	4%
random quizzes: (4 @10 pts each)	6%
random attendance: (2 @5 pts each)	1%
final: (1 @20 pts):	3%

extra.

another book @20pts, a biography @20pts, poster @20pts:

18% equivalent

an experiment

If you:

- have never had a physics or chemistry course
- are really nervous about ISP220
- are disciplined and like to write
- then you might qualify to be 1 of 5 “ISP220 journalists”

ISP220 Journalists don’t do the problem-based homework for 5 weeks

- rather, you submit a journal every week during the 5 “flip period” weeks
- according to a given outline
- cannot miss a week!
- instructions in the lectures/readings/homework tab … not yet

bookmark:

http://www.chipbrock.org

course website

https://qstbb.pa.msu.edu/ed/

"the book"

https://qstbb.pa.msu.edu/storage/isp220_video_2018/

the videos

https://qstbb.pa.msu.edu/storage/isp220_slides_2017/

the ftp site where I'll store all lecture slides

https://qstbb.pa.msu.edu/storage/Homework_Projects/

periodic homework and project materials

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

MasteringPhysics

http://qsbbwiki.wikispaces.com

the wiki where you'll do some of the projects

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

QS&BB Facebook Group...by invitation only

I assume

that you went to high school

and that you can manage really simple algebra and scientific notation

see The Book, Lesson 3 for review

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

how to get ahead

come to class

do the work

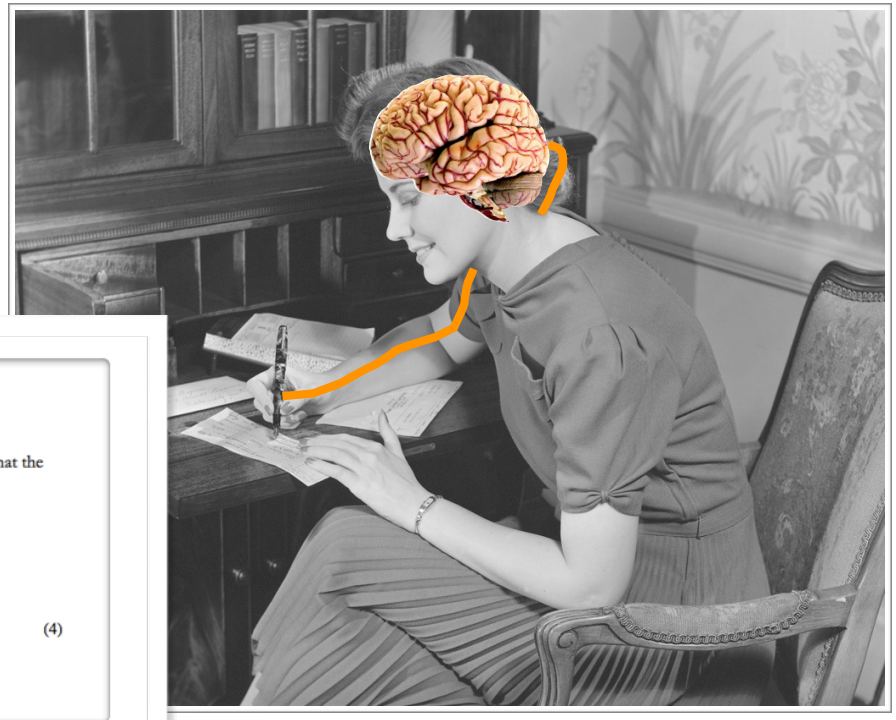
use your hands.

my experience

about learning anything involving logical reasoning

how I do it, even today

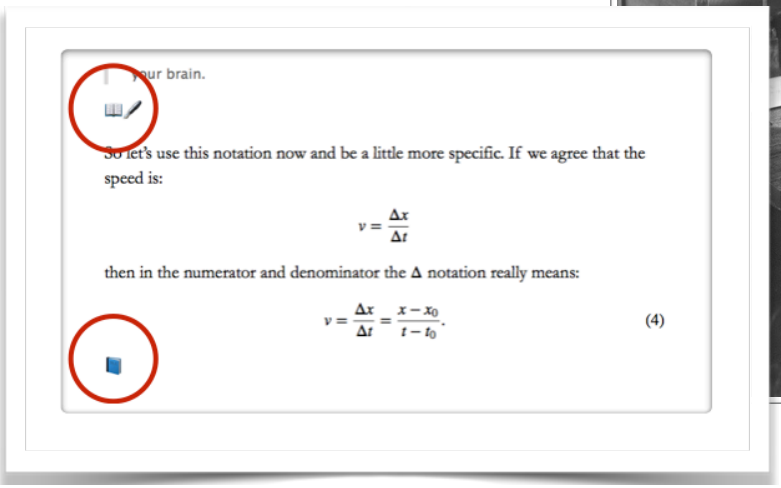
you can't "read" mathematics



you must copy it.

with your fingers

remember?



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 (he'll doodle for a time) and virtual (Facebook)

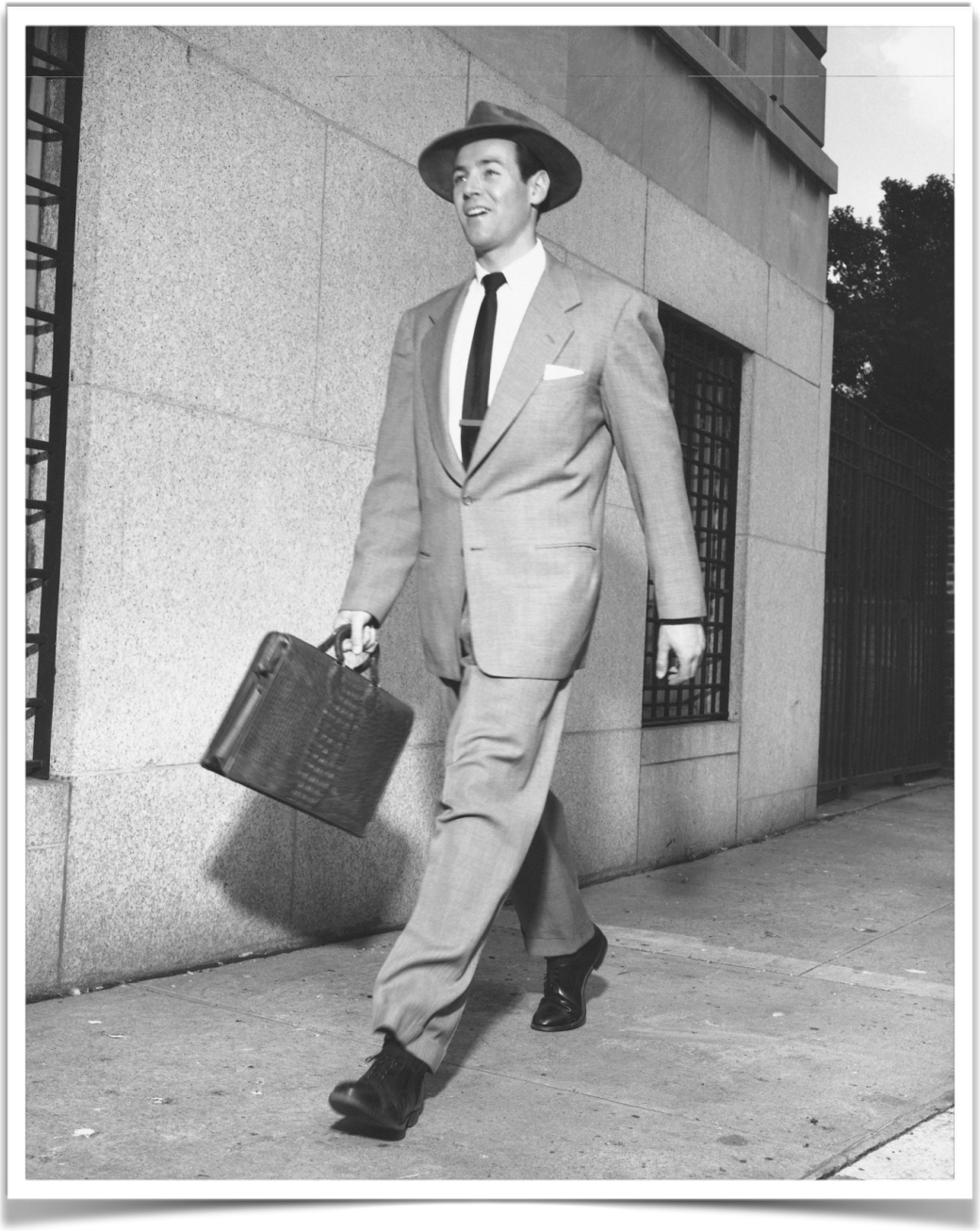
how to get ahead

come to class

do the work

use your hands.

you'll be fine



let’s get to work

some random notions

How I think of you and me

Laws, Theories, and Models

A fly-over of QS&BB

How I think of you and me

you

you’re not likely going to be a professional scientist

I’d like you to become a knowledgable spectator

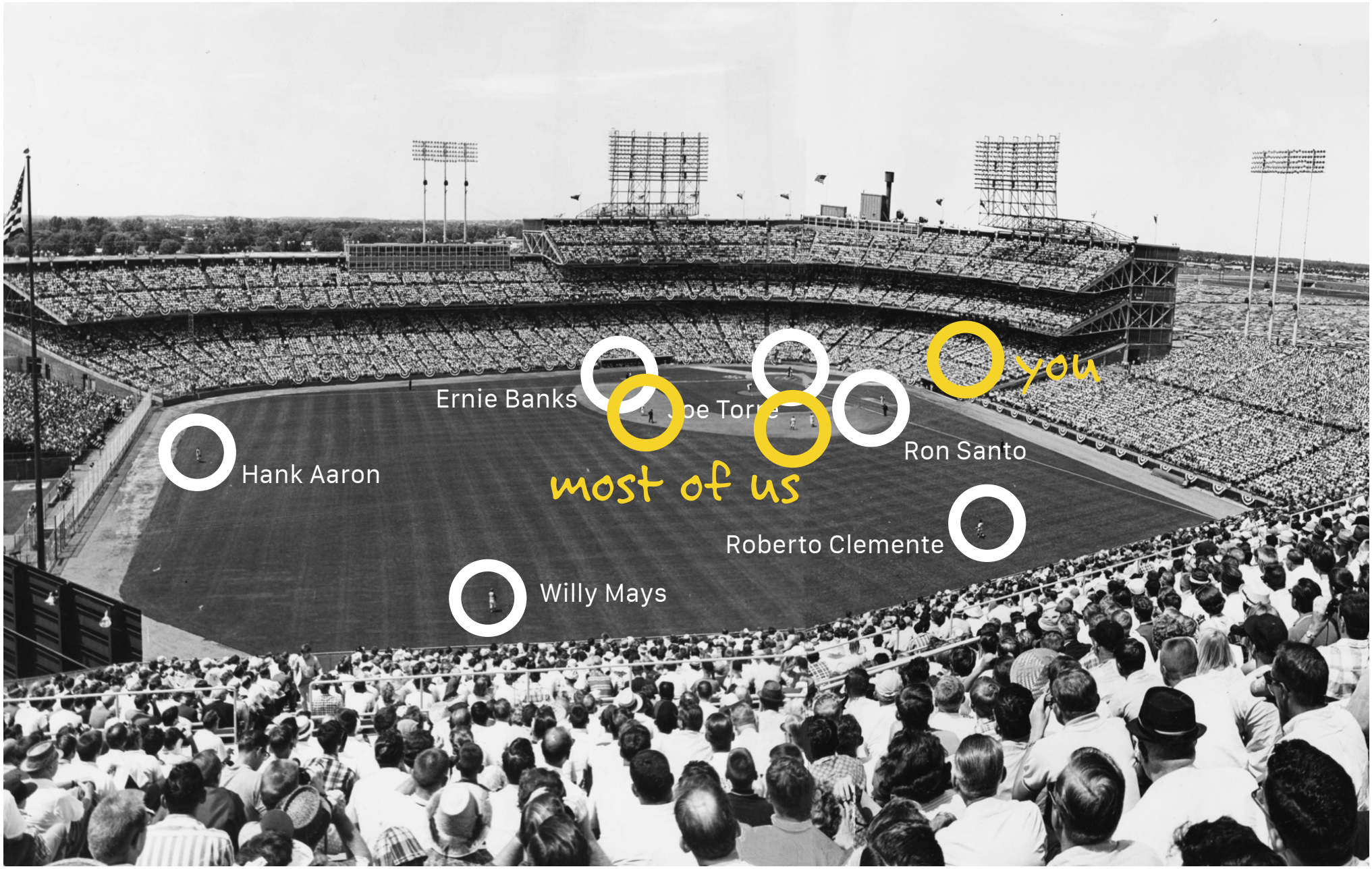
"You can observe a lot by just watching."
Yogi Berra

July 13, 1965 MLB All Star Game

me

some hate the “great man” history of science

I understand it perfectly



July 13, 1965 MLB All Star Game: 19/500 future Hall of Fame

Laws, Theories, and Models

ask me

about Florida

The L word

"Law"

don't like it.

there are no "Laws" of nature

Florida's idea of a Law of Nature:

Newton's Law of Gravitation: $F_{12} = G\frac{M_1 M_2}{R_{12}^2}$

Newton's **theory** of Gravitation

Newton's **l**aw of Gravitation

Theories

It’s all theories, all the way down

- better word: “framework”
  - *The Theory of Relativity is …a theory*

Acceptable theory

- highly trusted
- we don’t “believe” in theories of nature
  - *we test them and we question them*

models

Mother Nature seems to be a mathematician

- we have no idea why
- it just is

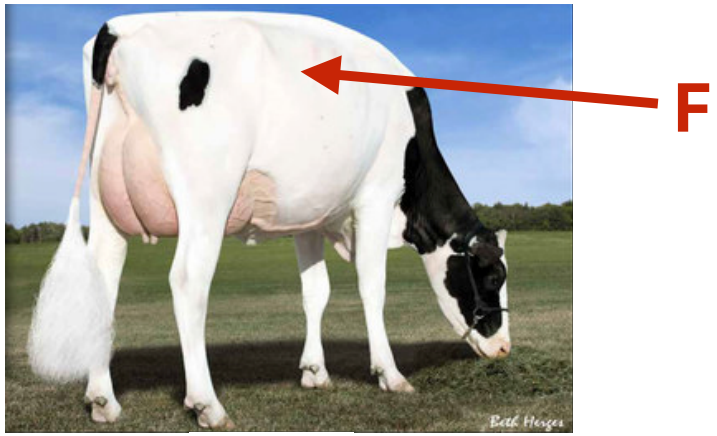
A model is a mathematical "algorithm" built within the confines of one or more theories

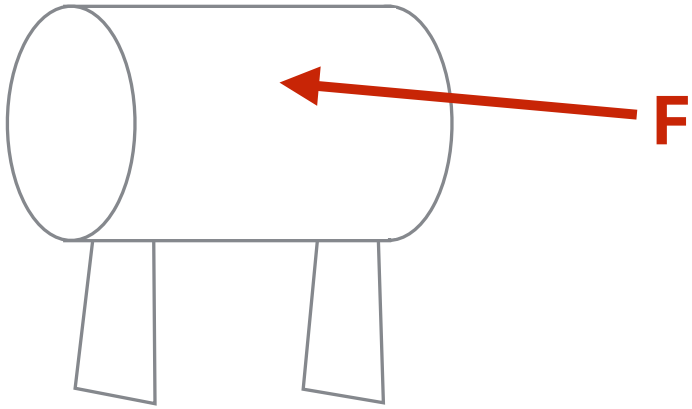
- not mean to be perfect
- Goldilocks-acceptable
- matched to need and testability

a well-know problem

Cow Tipping...what's it take for high school boys to tip a cow?

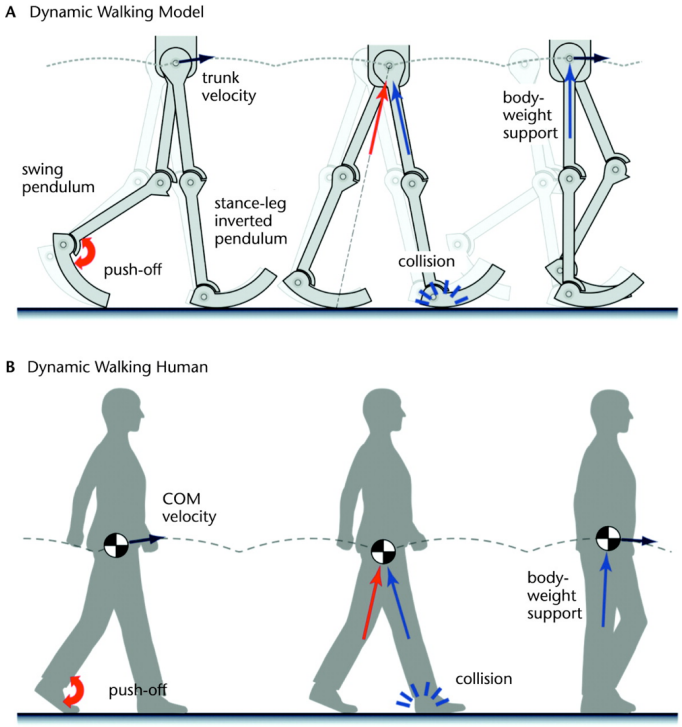
Go tip cows? Make a model.



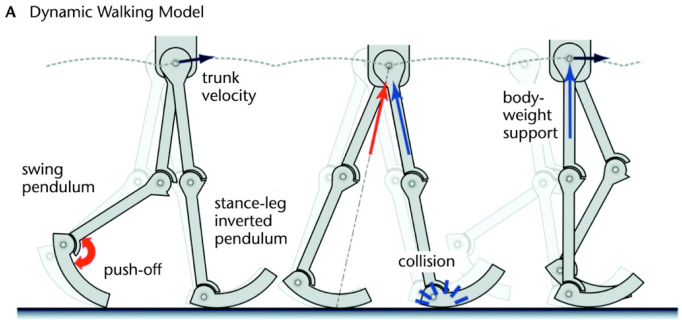


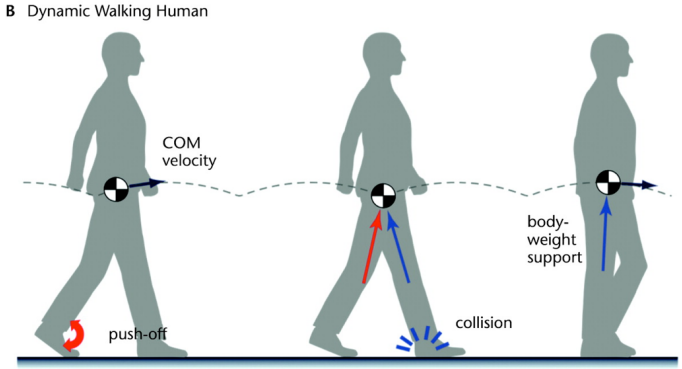
a model

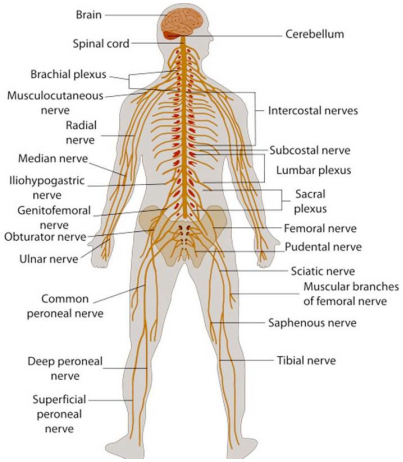
I can draw free-body diagrams and make a model of walking

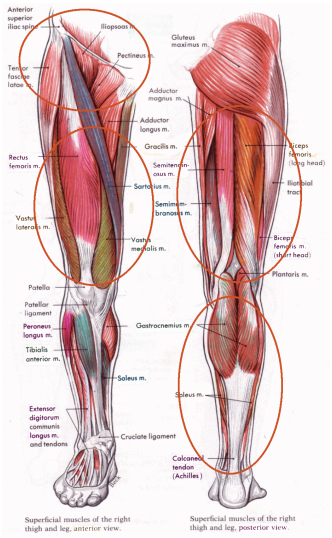


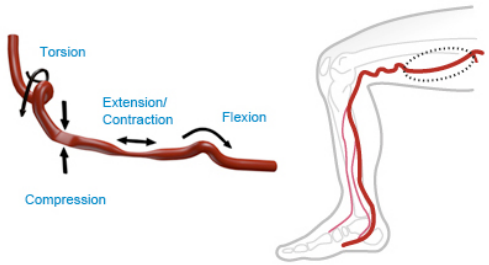
I can draw free-body diagrams and make a model of walking



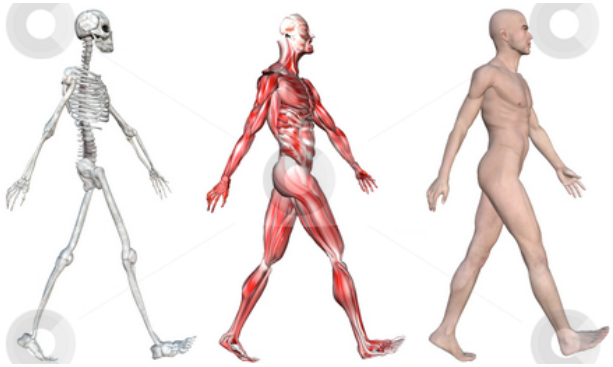








But it's not the actual physiology of walking!




SOAP

20th century physics

was interesting

3 theories developed

Special Relativity
General Relativity
Quantum Mechanics

many, many models of phenomena

"Standard Model of Particle Physics"

"Standard Model of Cosmology"

QS&BB

is all about them

the 3 theories

the 2 big models


COMING
ATTRACTIONS

what we don't know

Lots.

what banged?

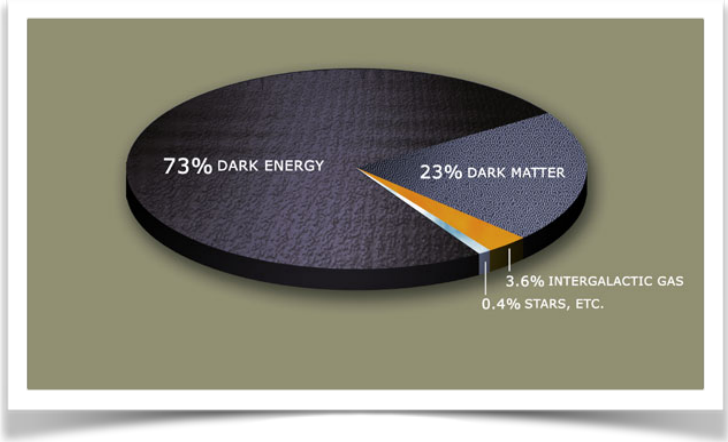
gravity and quantum mechanics don't mix

much of the universe is missing

neutrinos behave very strangely

where is all of the antimatter?

do the forces unify?



idiosyncratic

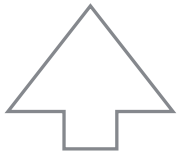
introduction alert

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



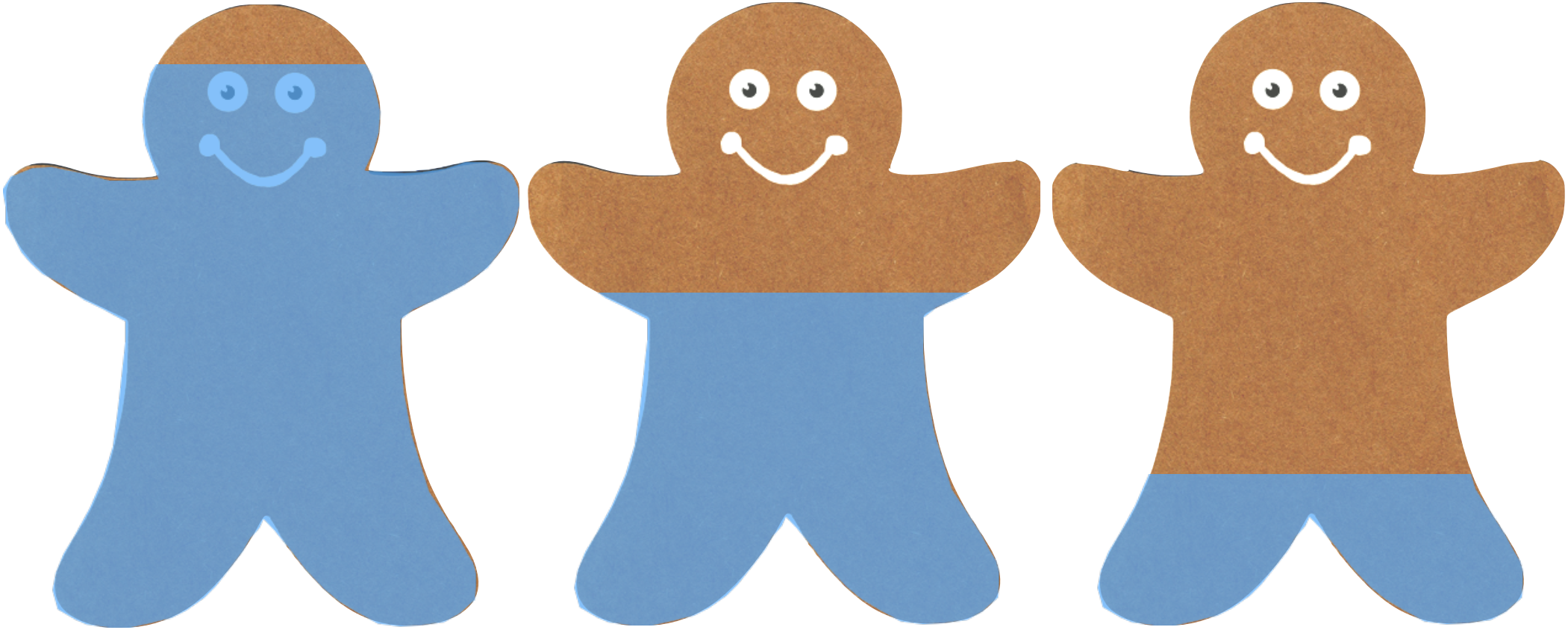
(or just up and down quarks)

let's make this

all about you

your-self

intricately bonded to particles and the cosmos

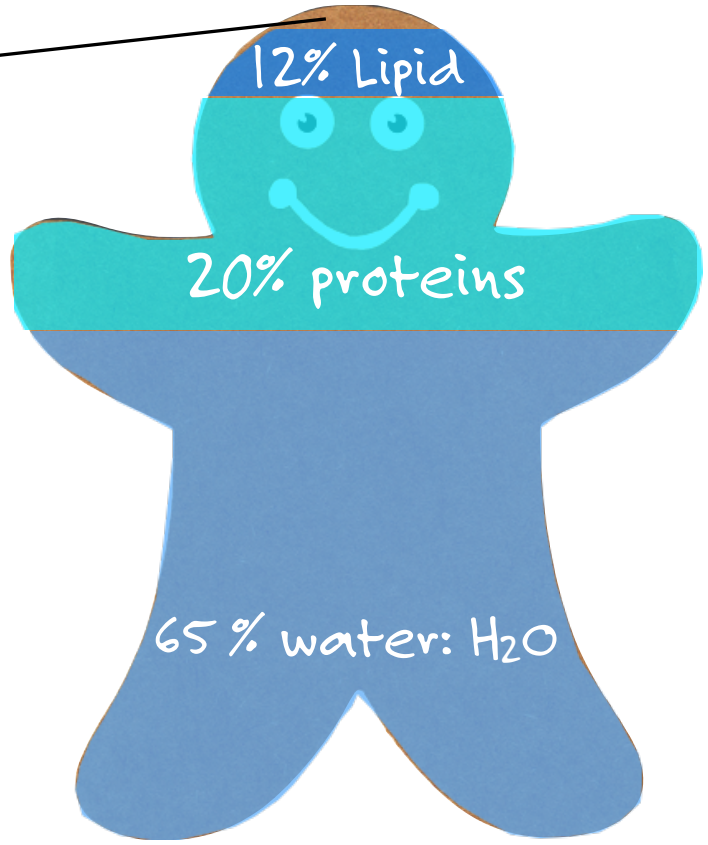


Made from nuclear fusion in stars.

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: 13.772By old

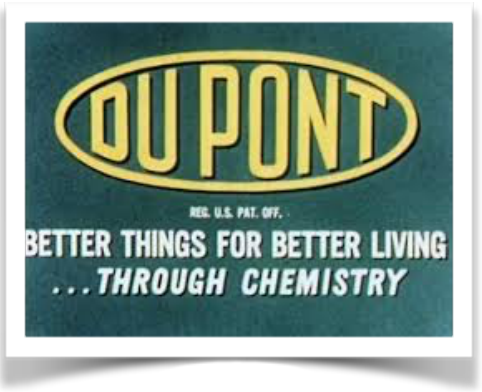
assume 70kg:

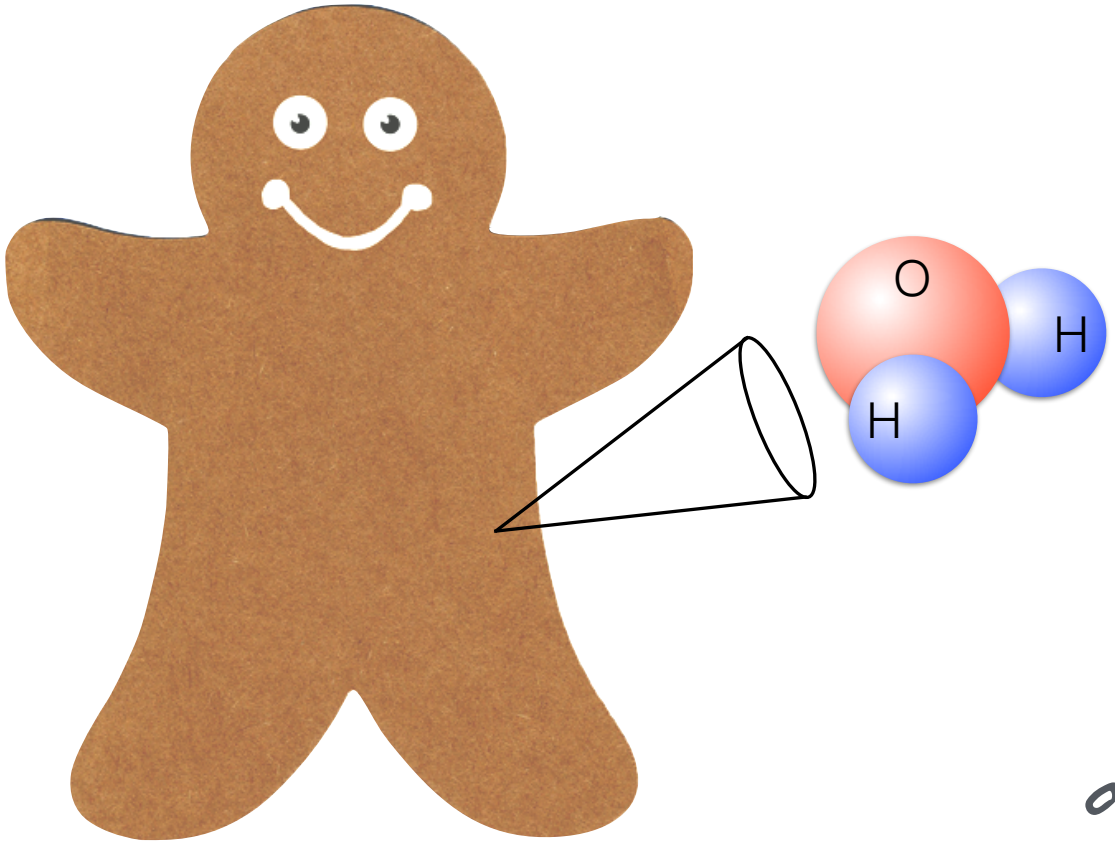
4.2×10^{28} protons
1.4×10^{28} neutrons
4.2×10^{28} electrons

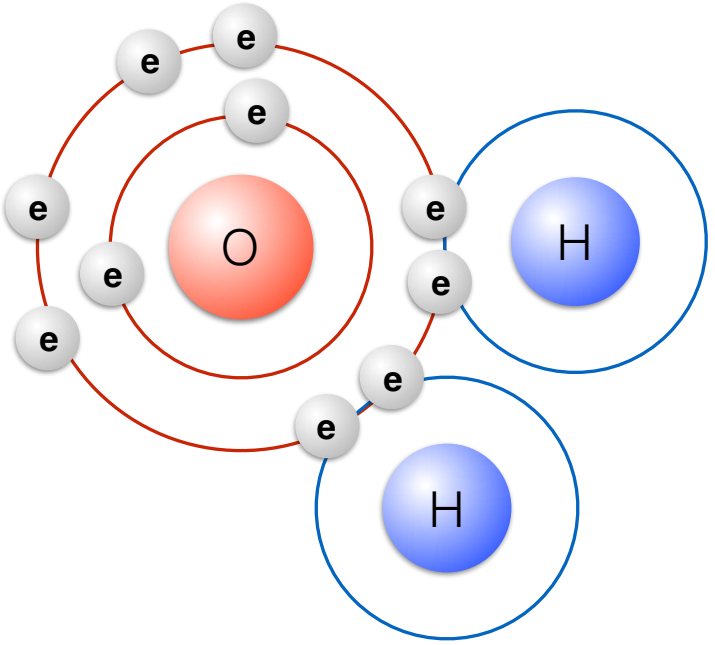
} water alone

a little chemistry factory

think about water.



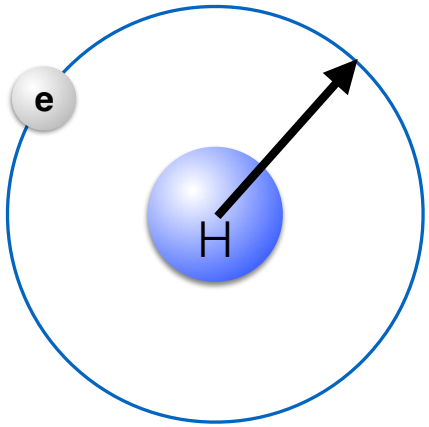


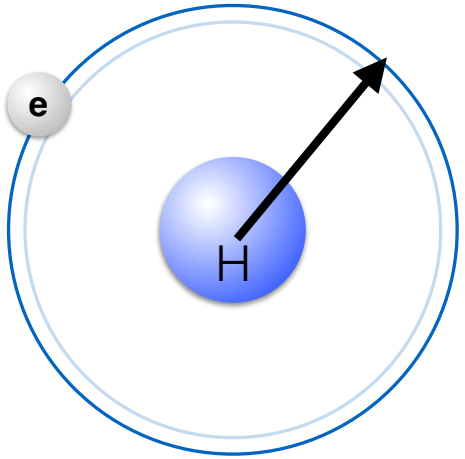


a precise, little machine

suppose

the electron mass was few % *lighter*?





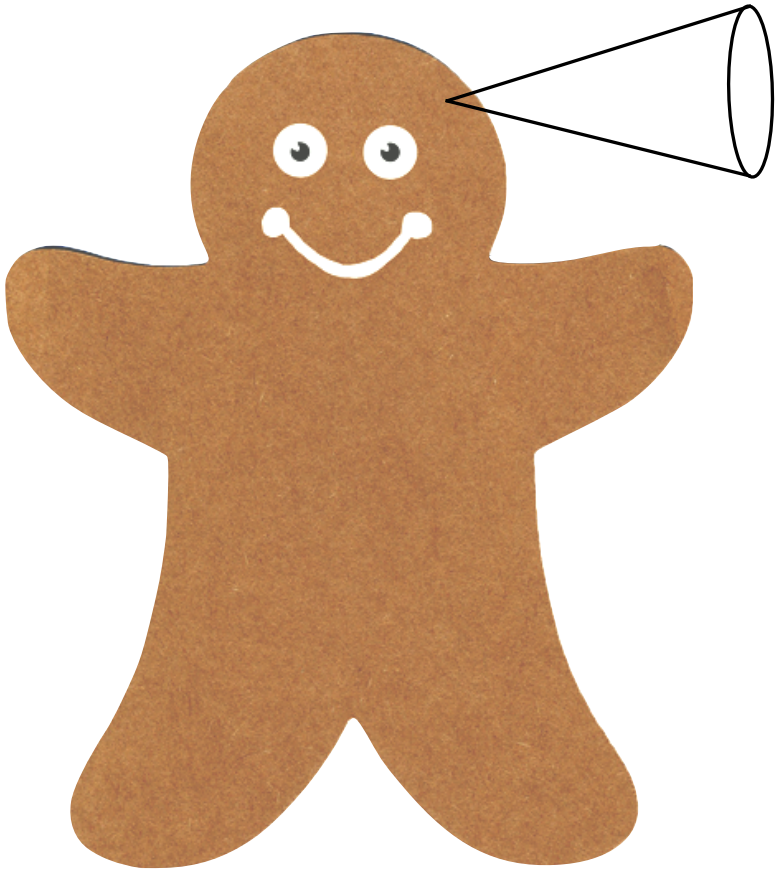
all of chemistry changes

the BB's production of H changes

formation of stars changes

a little radioactivity factory

those trace inorganics?



potassium includes ^{40}K

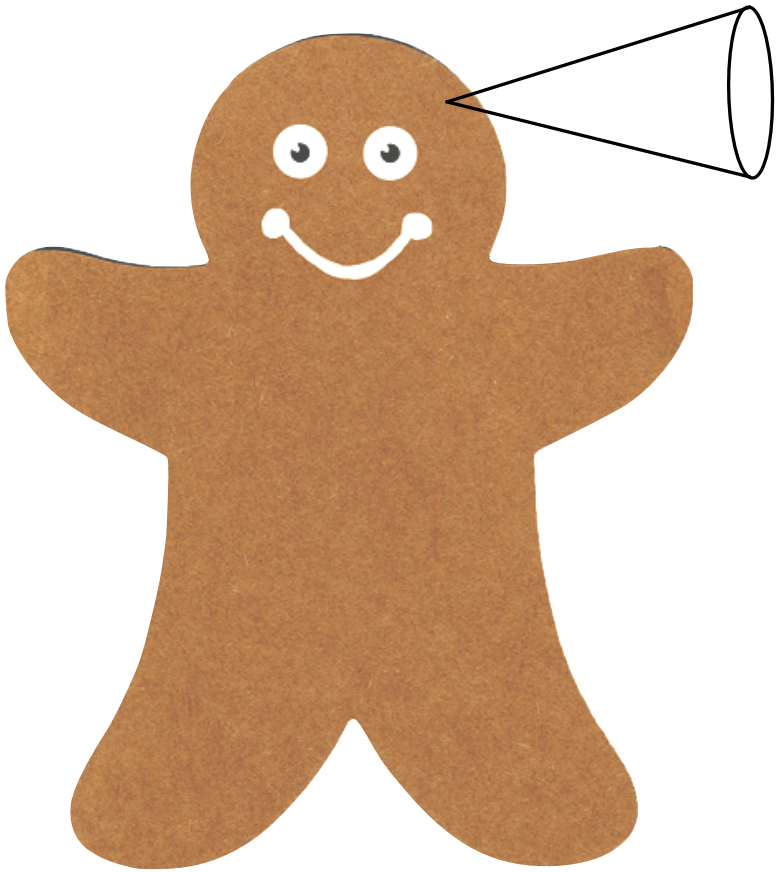
^{40}Ar + anti electron + neutrino

^{40}Ca + electron + neutrino

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

a little radioactivity factory

those trace inorganics?

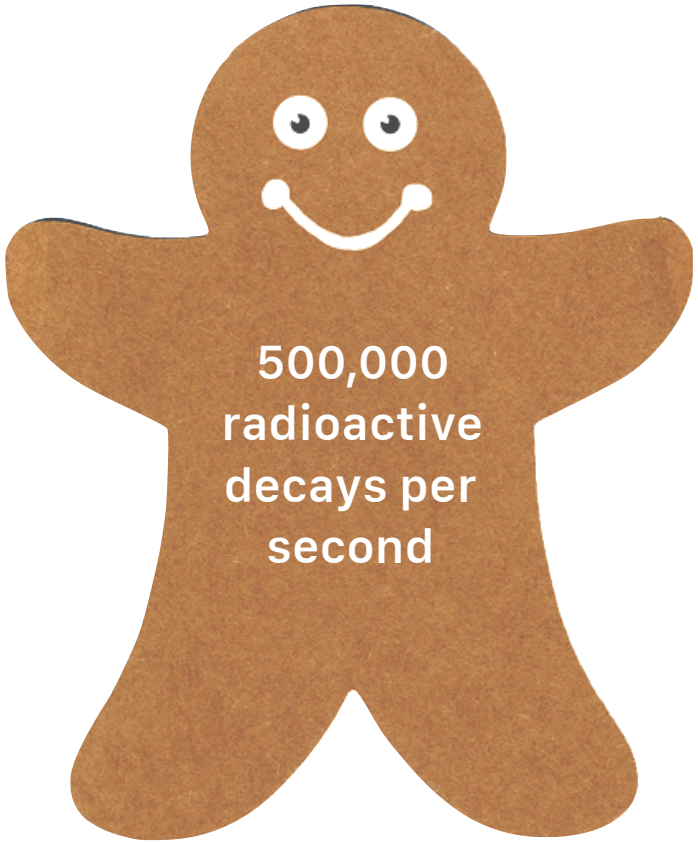


carbon includes ^{14}C

^{14}N
+ electron
+ neutrino

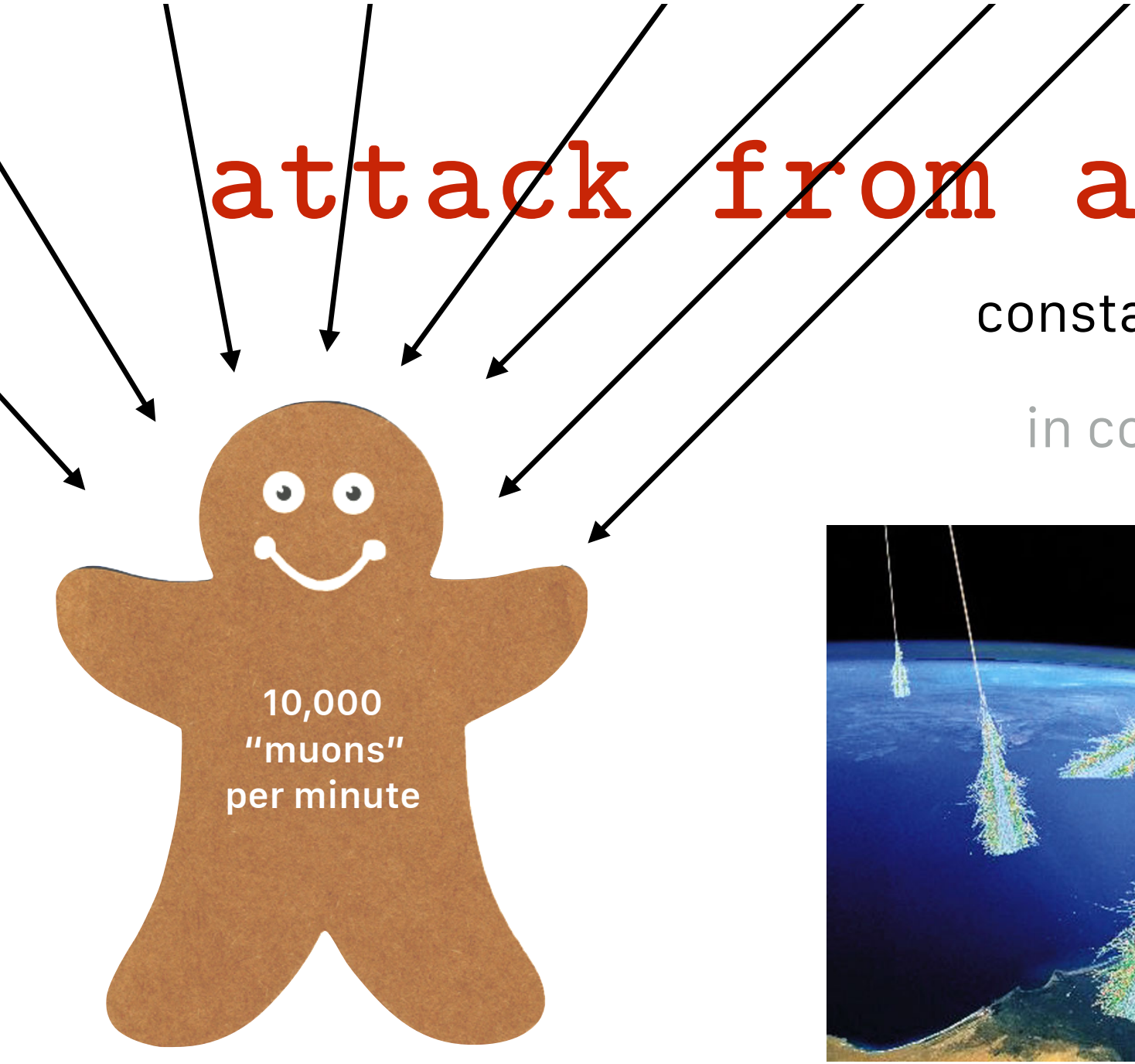
a little radioactivity factory

you internally expose yourself about 4 X-rays' worth



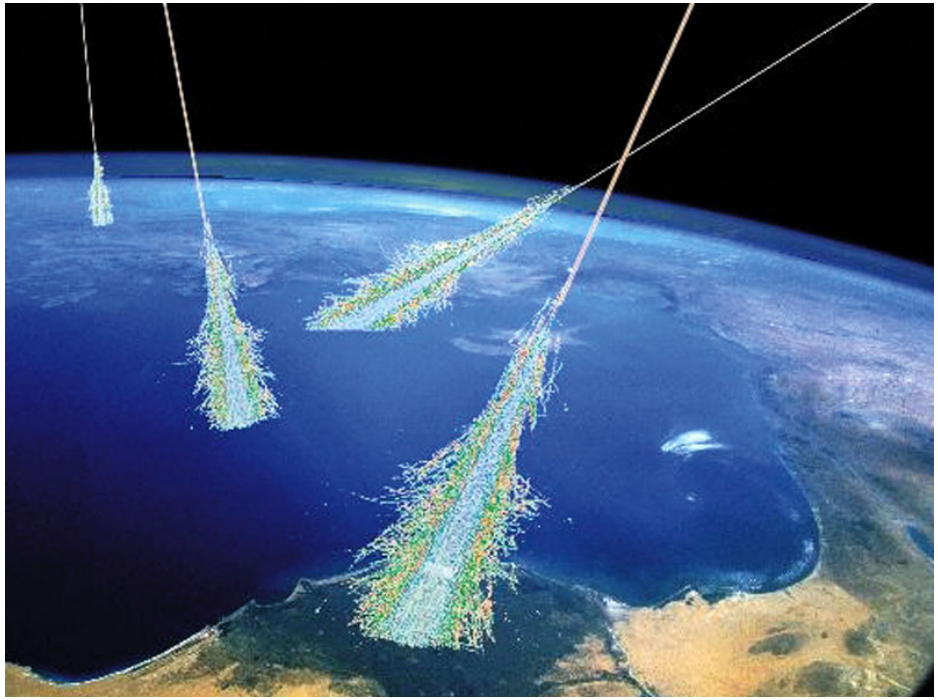
about an X-ray per week

attack from above

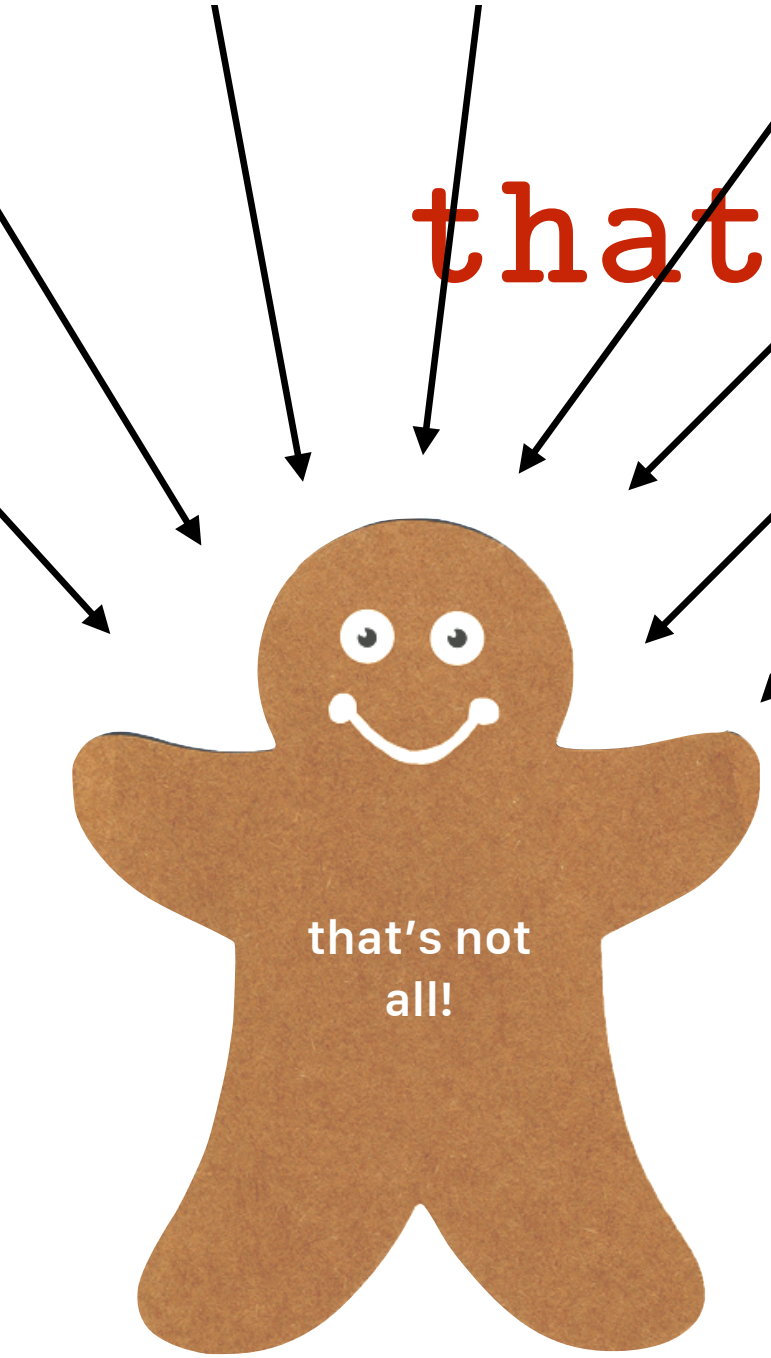


constantly bathed

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

fine tuning of masses so that chemistry works*

dark matter

relic big bang radiation

**Higgs Field*

**gluons*

Einstein's special theory of relativity

quantum mechanics

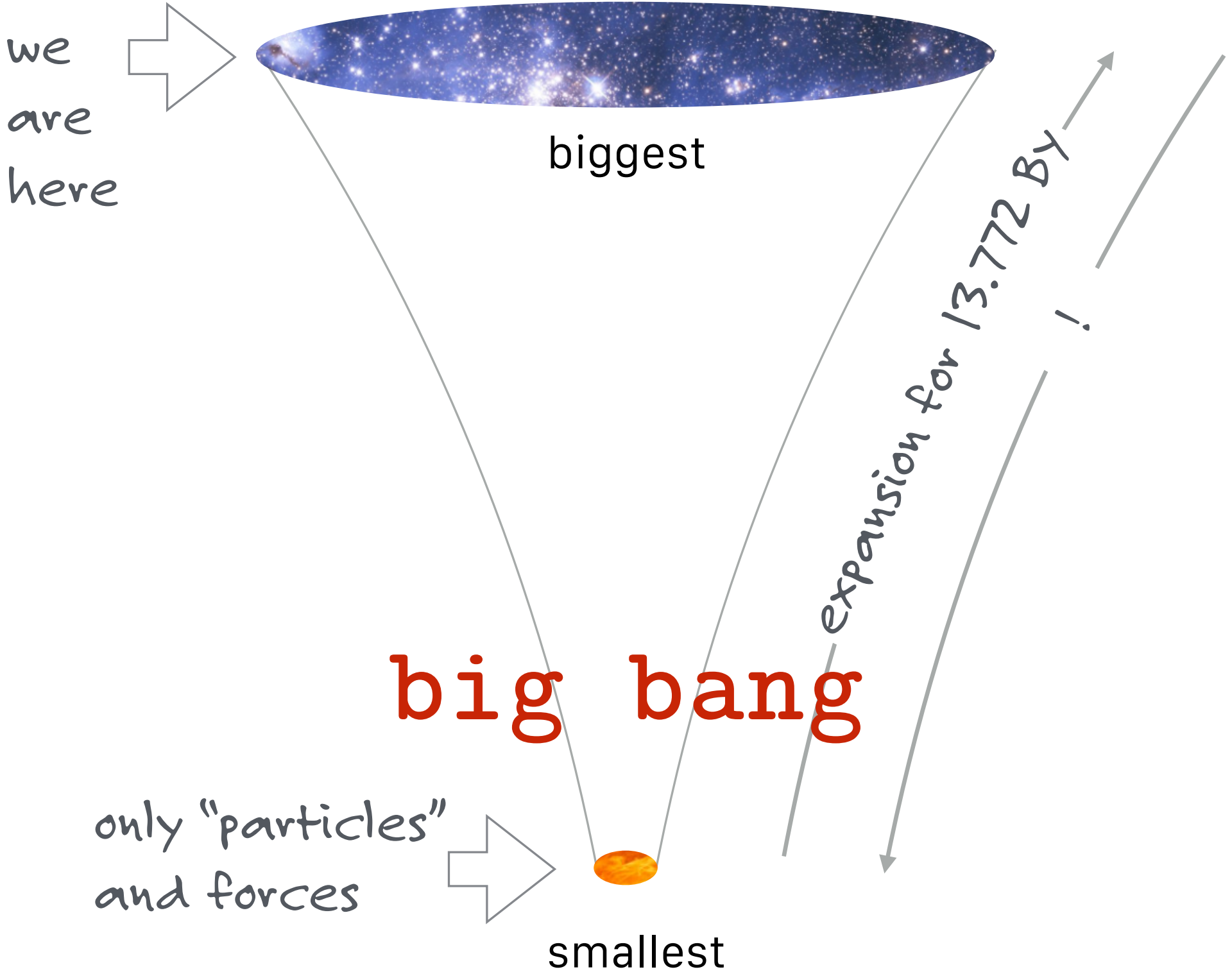
Einstein's general theory of relativity

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 13.772 By
!
big bang
only "particles"
and forces
smallest

ISP220

leads you to

understand, appreciate, and become familiar with

all of this

and more

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?

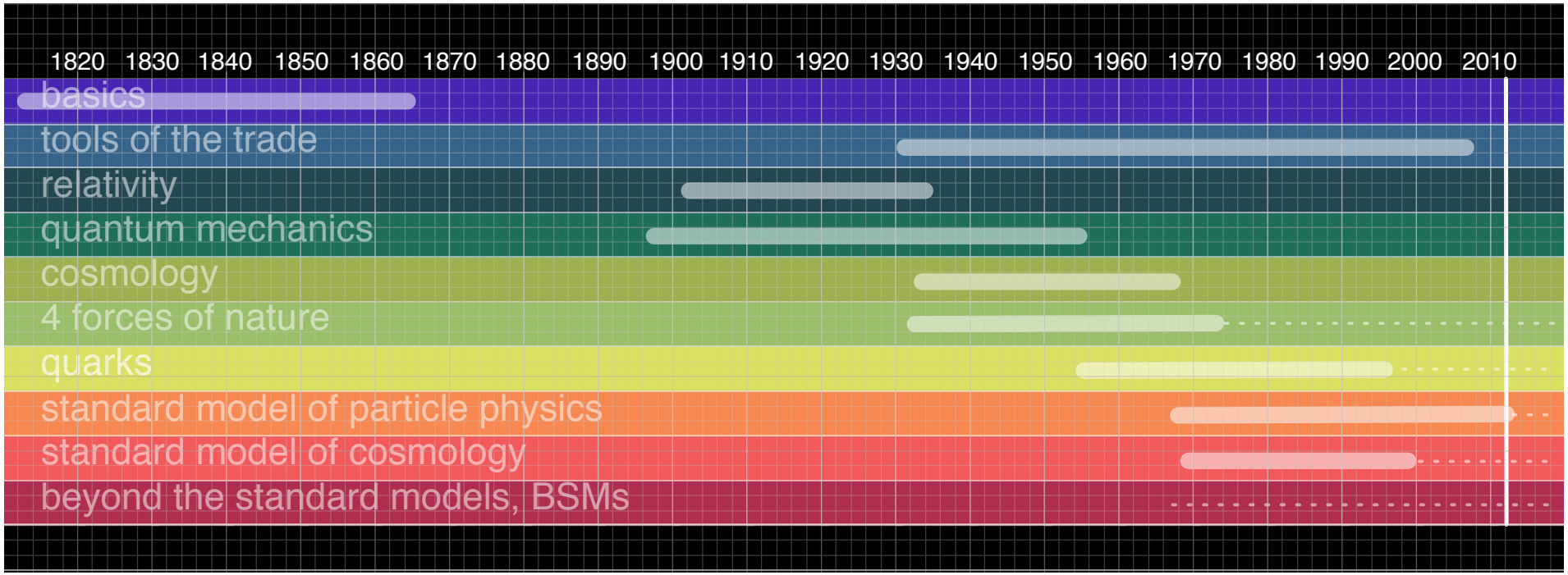
27. Is the Proton "forever" or can it decay?

key:

blue: a particle physics question

green: a cosmology question

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



Three distinct themes

- "Foundations" ..."regular physics"...bare minimum

  very brief and gentle.

- Einstein's Relativity

  Special and General Theories, including the beginning of quantitative cosmology

- Field theories

  particle physics and the early universe

  Current - right now - challenges

`with that`

start reading and watching