Building Neutrino Detectors

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MIT Family Weekend!
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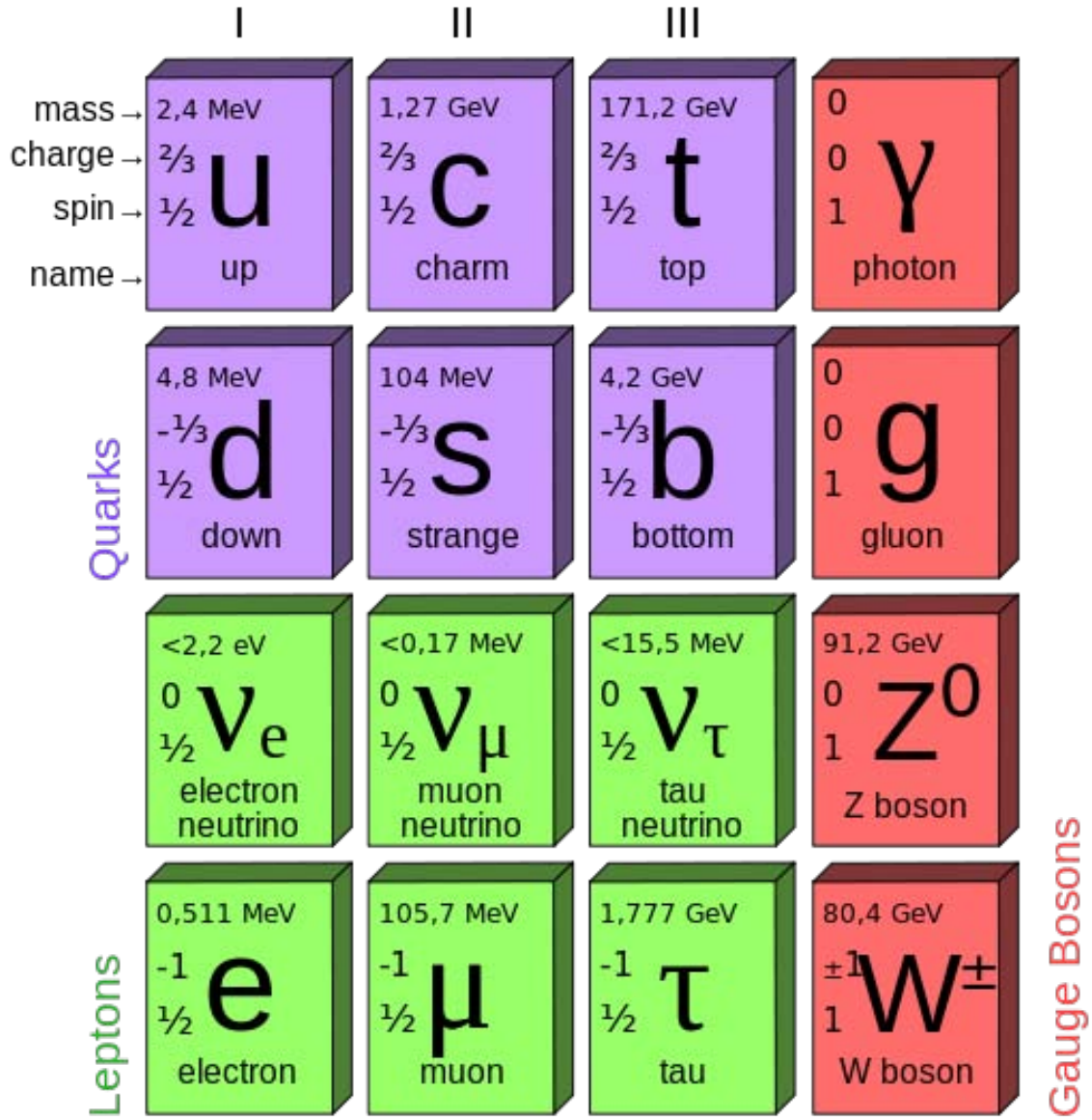
Particle Physics 101: The Standard Model

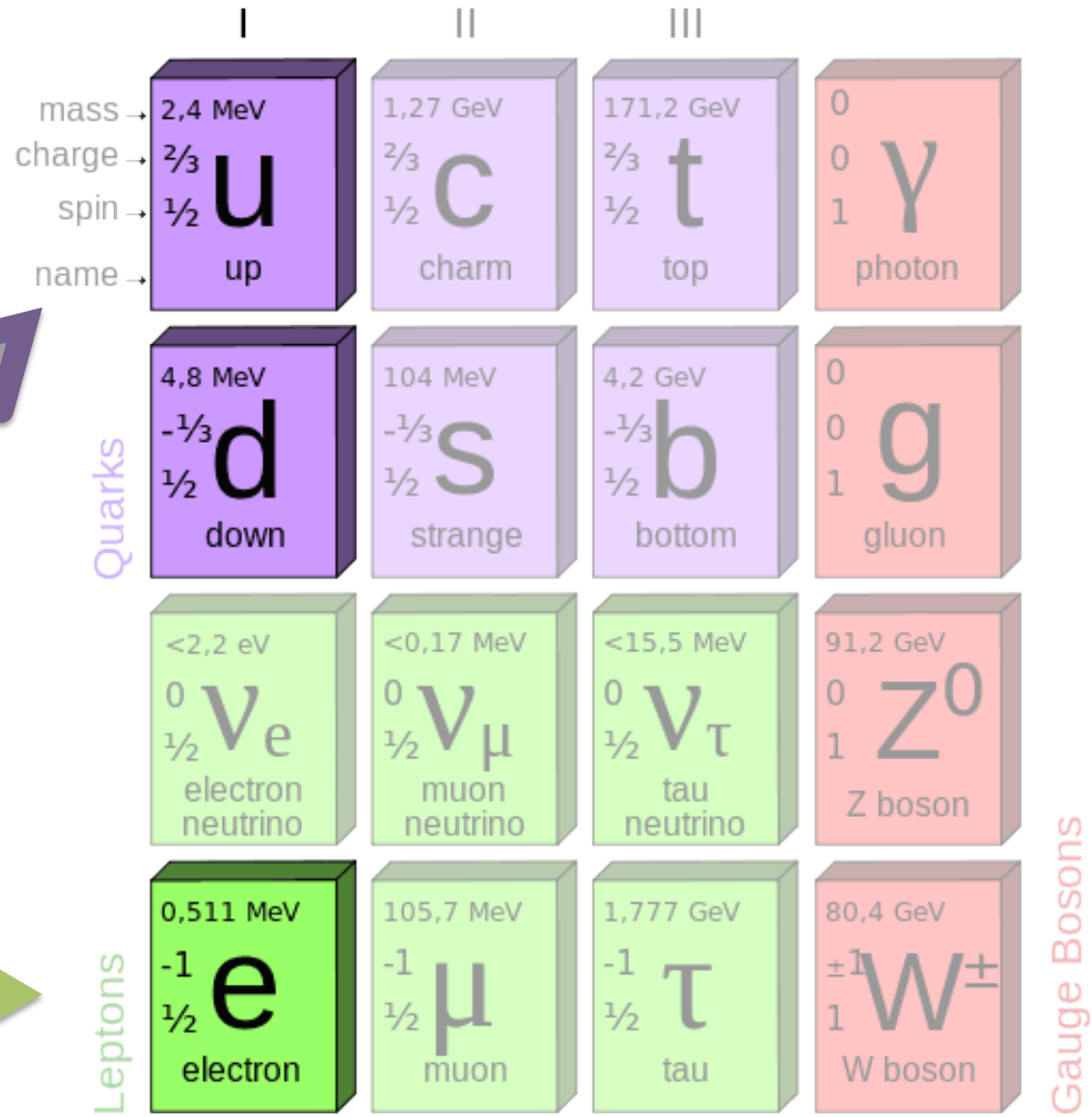
These are the building blocks of the universe.
(As far as we know.)

+ antiparticles of quarks (purple) and leptons (green).



Particle Physics 101: The Standard Model

We're mostly made of these.

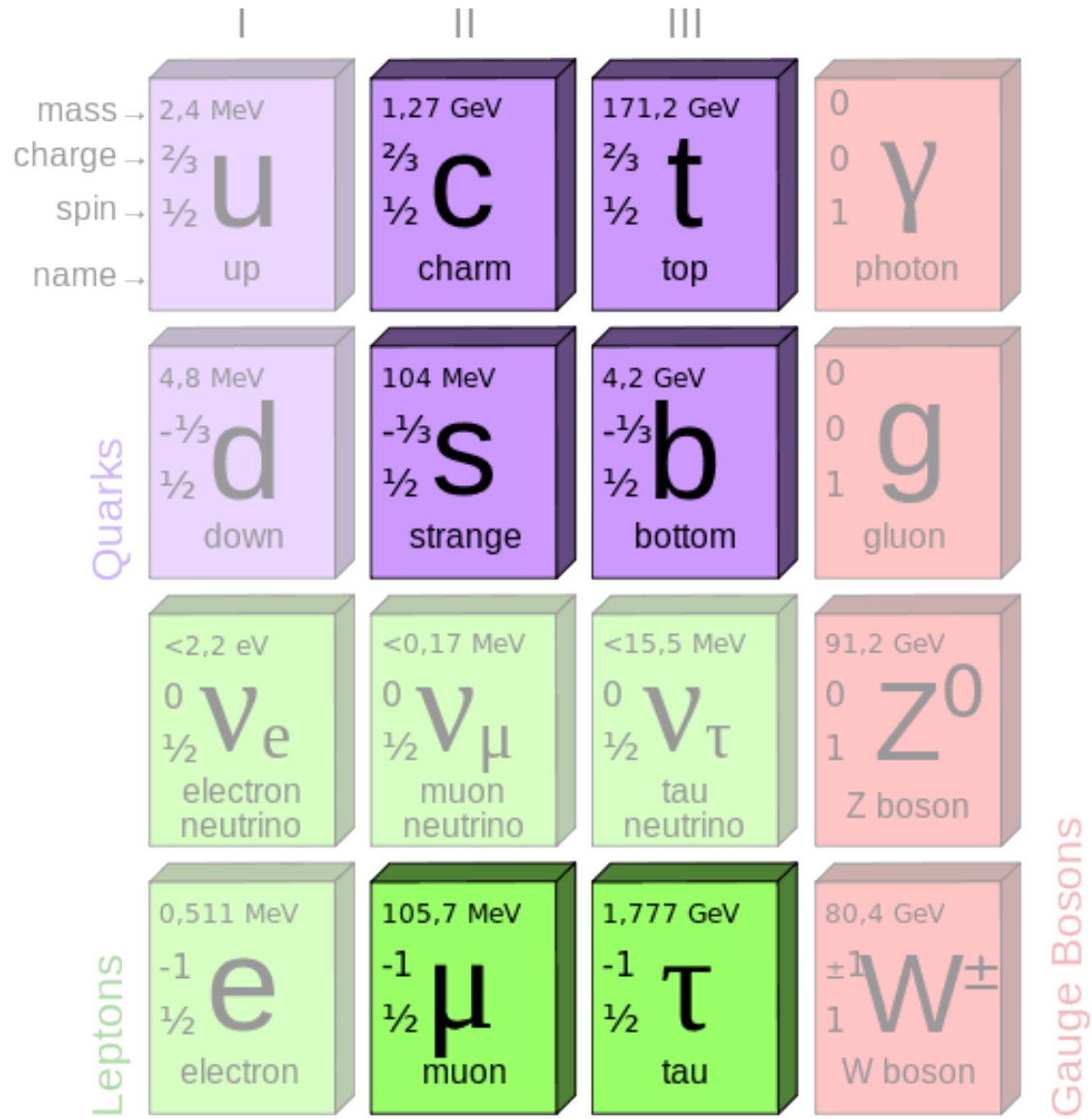


Neutrons and Protons

Electrons

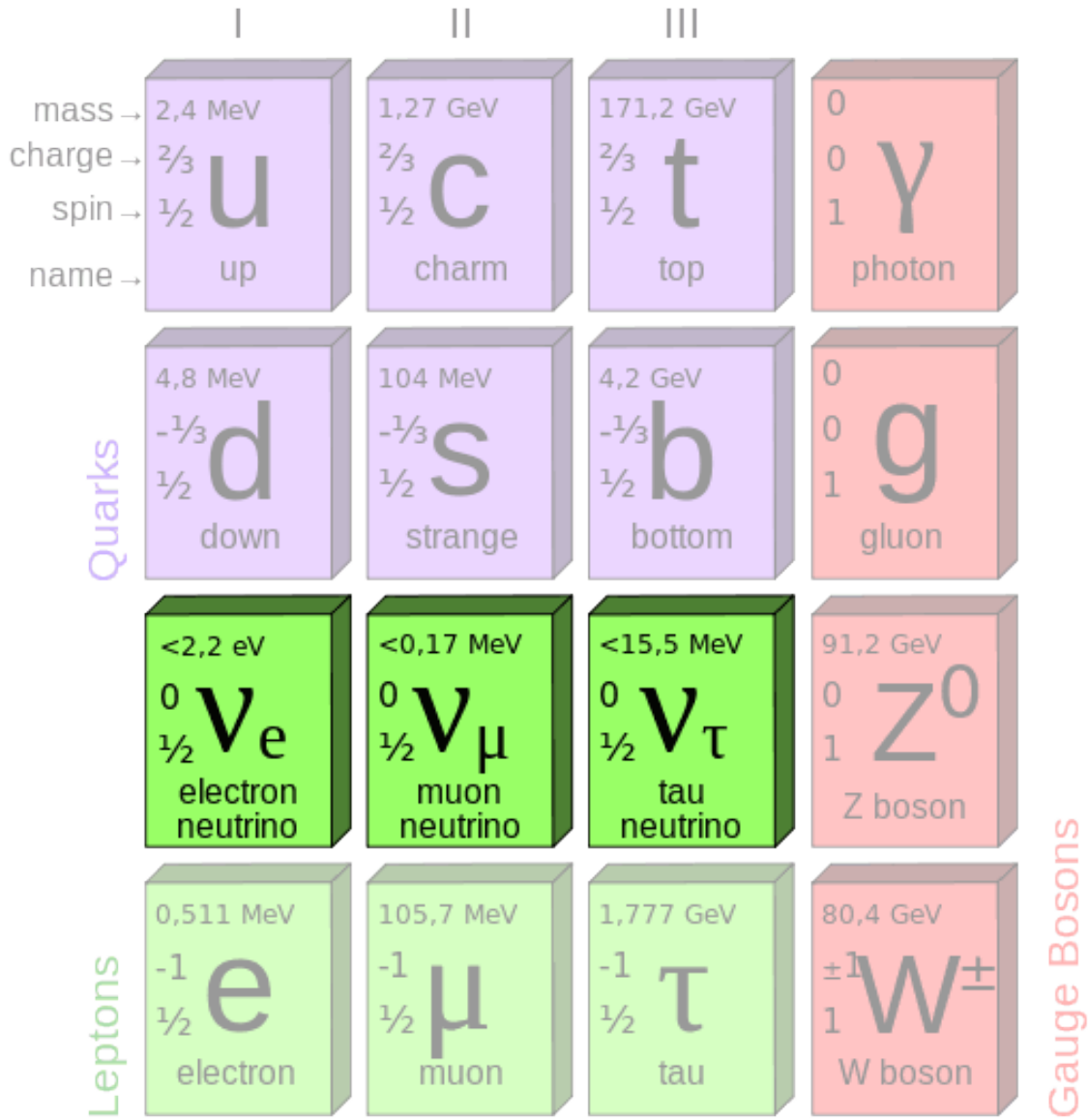
Particle Physics 101: The Standard Model

These occur in very energetic environments but decay to what we're made of.



Neutrinos

Neutrinos are everywhere! Millions inhabit every cubic centimeter of space!



Neutrinos



Neutrinos, they are very small.
They have no charge and have no mass
And do not interact at all.
The earth is just a silly ball
To them, through which they simply pass…
- John Updike (1963)

SOME (2001)

Why are neutrinos interesting and important?

The Standard Model didn't originally include neutrino masses.

But neutrinos change into each other! Thus quantum mechanics says – neutrinos have mass.

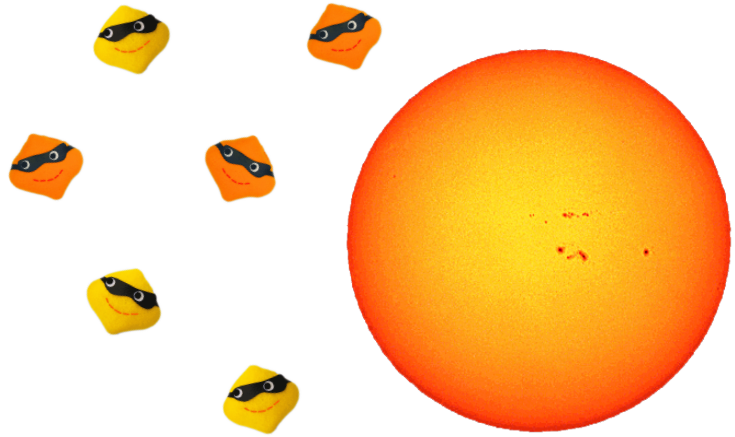
Born as a muon neutrino!

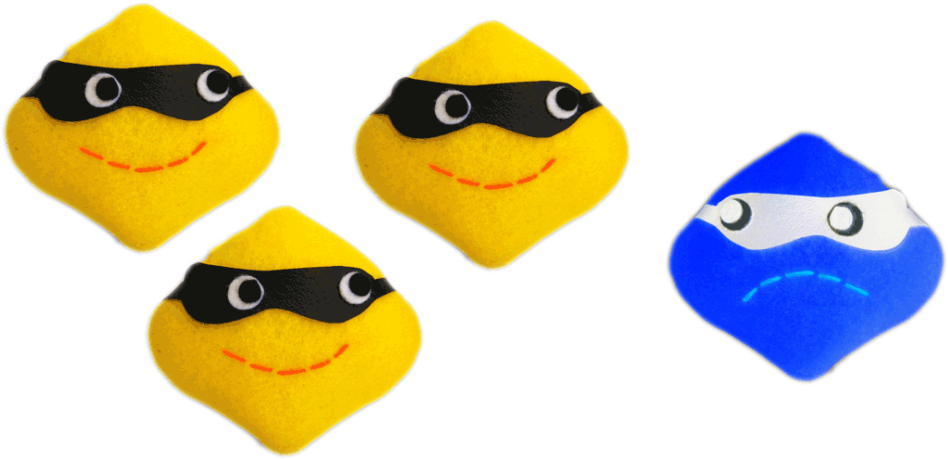
Oscillates as it travels!

Detected as an electron neutrino!

Why are neutrinos interesting and important?

Neutrinos are involved in processes like fusion, fission, and radioactive decay. *Neutrinos make the sun shine!*



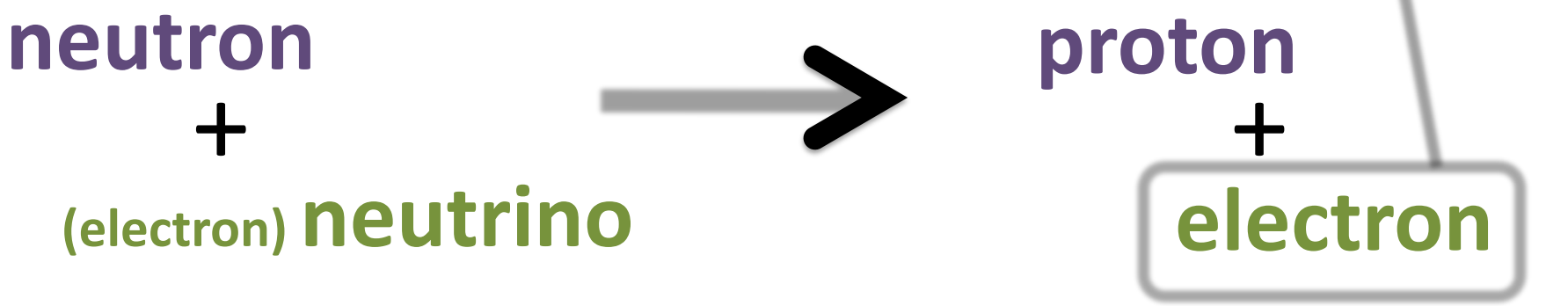


Neutrinos may be able to tell us why there is more matter than antimatter in our universe.

What do you need to detect neutrinos?

You can only detect neutrinos if they interact. Need:

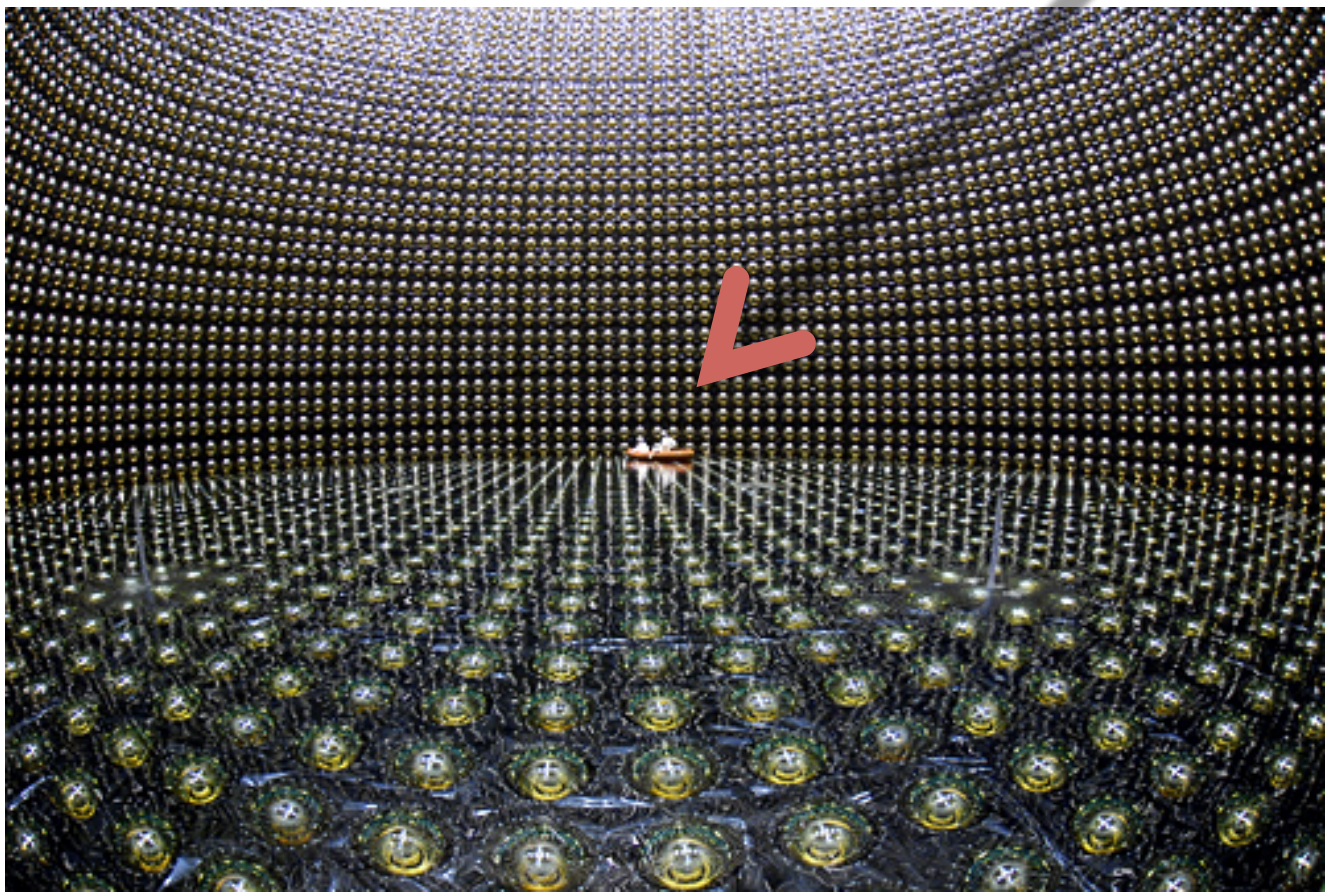
- BIG detectors
- LOTS of neutrinos (sun or beam)
- LOTS of time (5-10 years)



How BIG, you ask?

Super-Kamiokande

That's an inflatable raft with people on it.

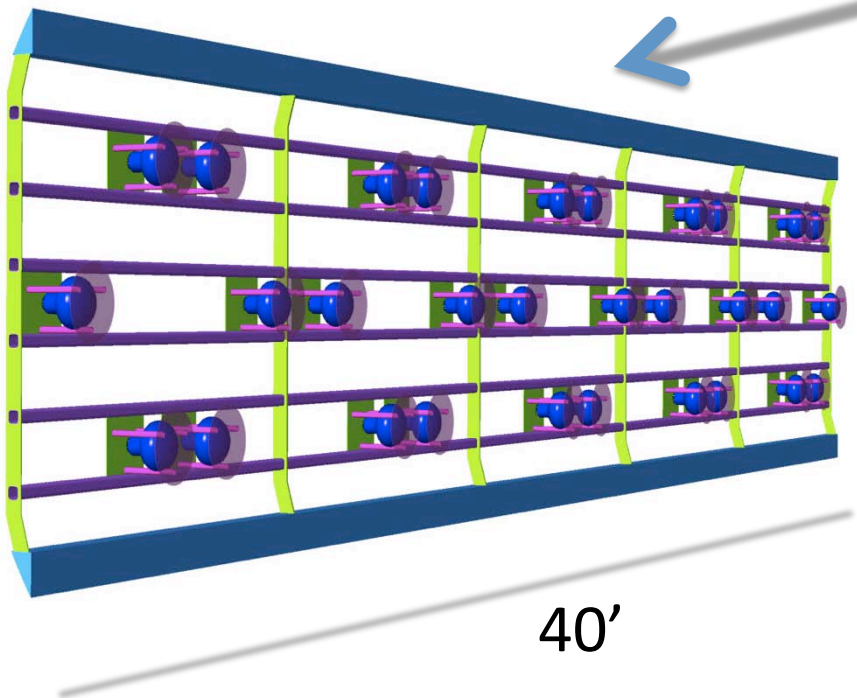


Building Neutrino Detectors (What I have worked on.)

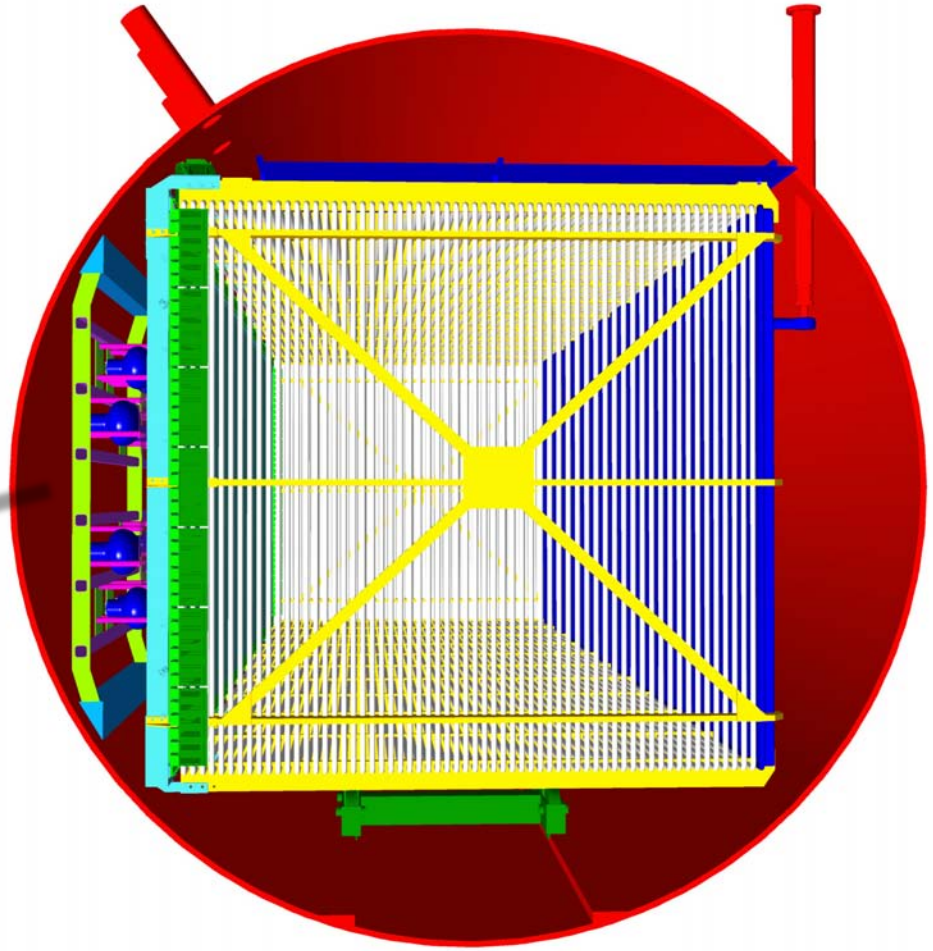
MicroBooNE	A new type of neutrino detector (To be built this summer!)
Light Detection R&D	A new method for increasing light detection coverage in experiments like MicroBooNE
DAEdALUS	An experiment that will investigate matter/antimatter asymmetry. (Currently being designed)

MicroBooNE

- 70 tons of liquid argon
- Detects charged particles created in neutrino interaction

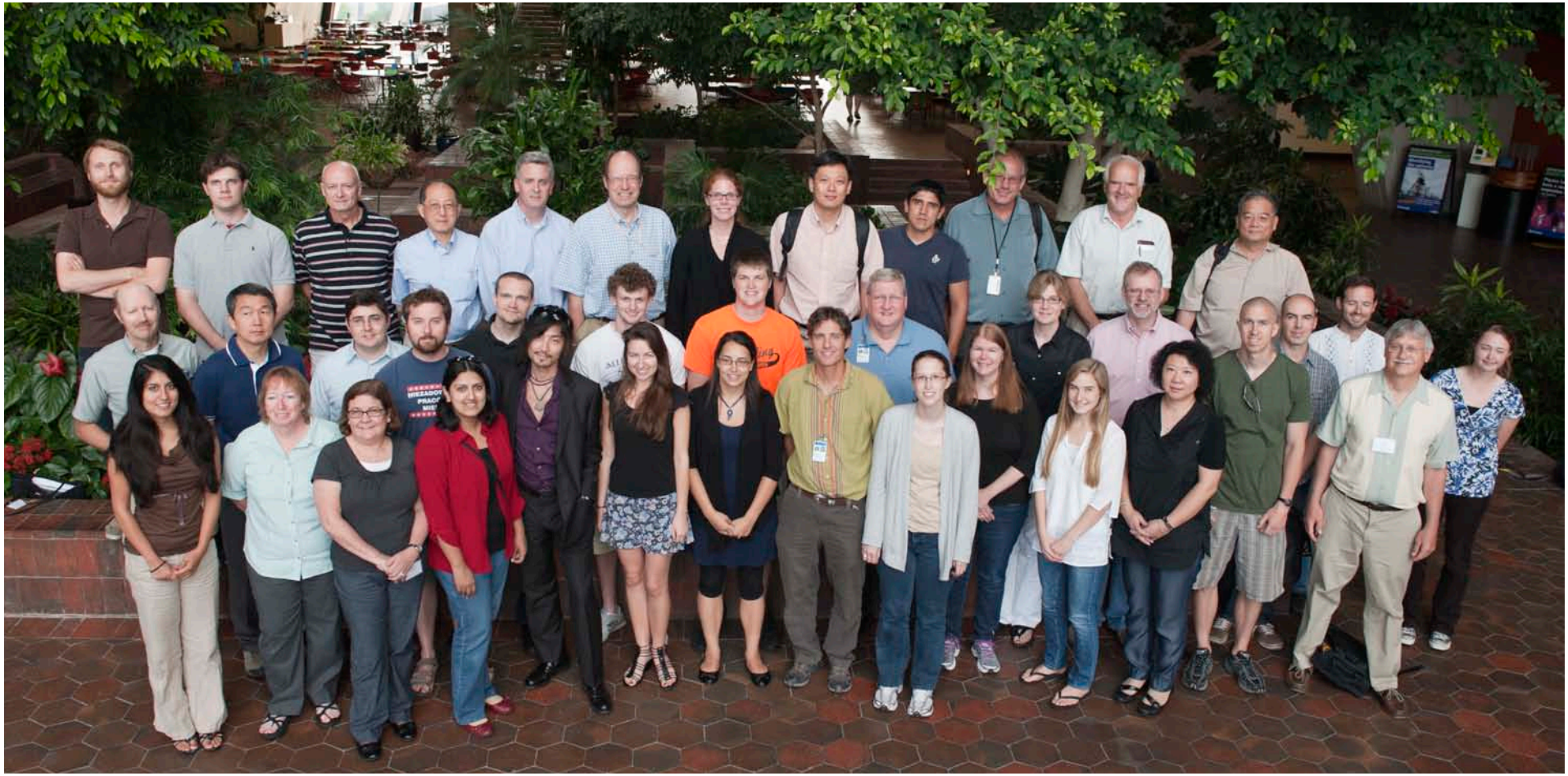


40’



I designed the support structure that will hold the light detectors in the cryostat.

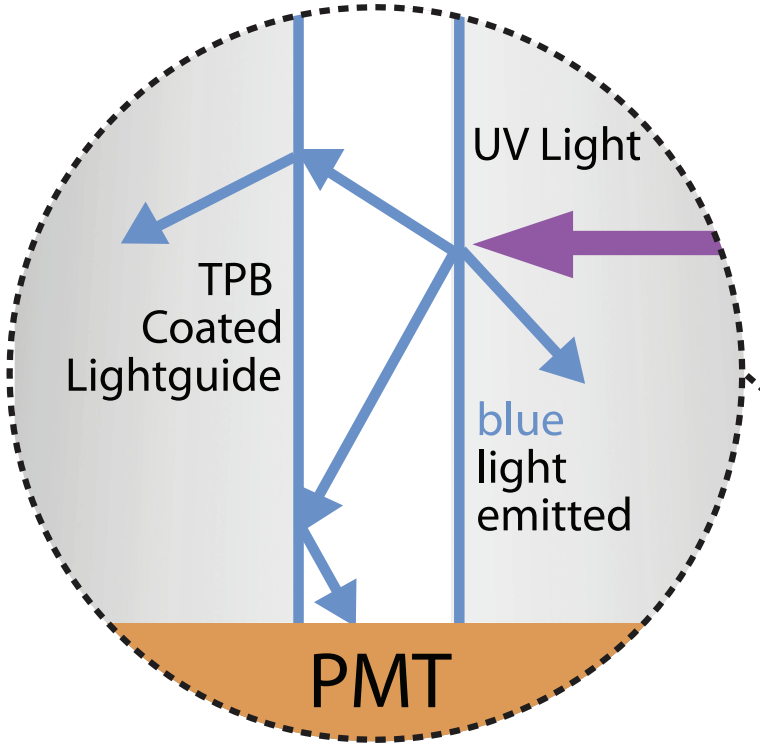
MicroBooNE Collaboration

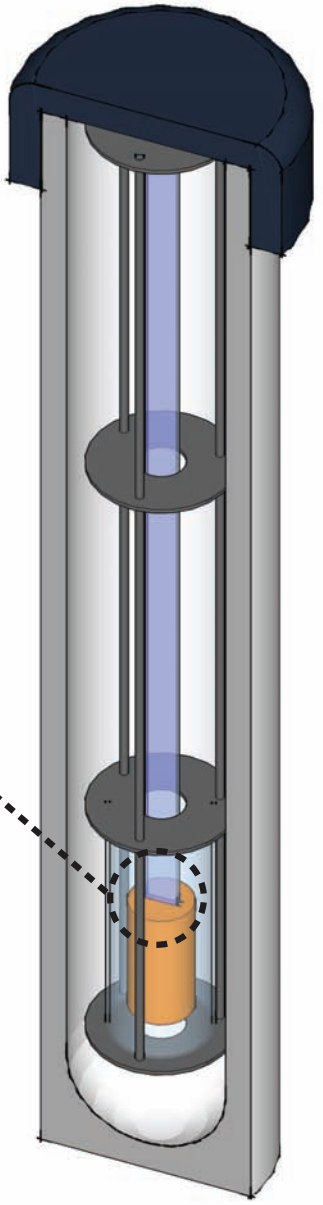


This is how many physicists it takes to design a neutrino detector.

Light Detection R&D

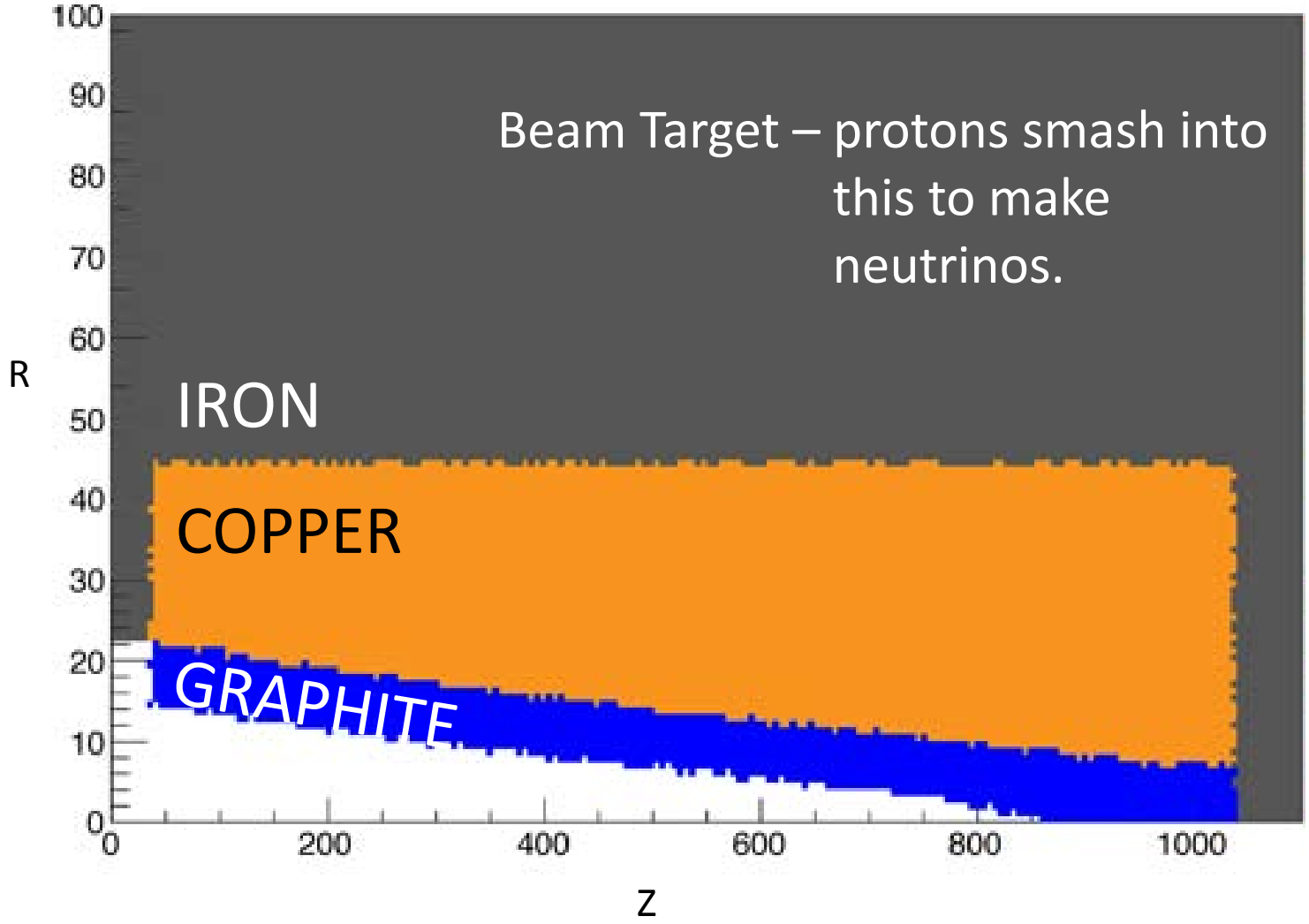
Lightguides relay light from areas in vessel where the light detectors cannot function. (Where there are electric fields)





DAEdALUS

Designing and Simulating Beam Target



Through my UROP I have…

- Learned to program in C++ and Fortran.
- Co-authored 2 papers.
- Worked at Fermilab.
- Made 10+ presentations.
- Given a talk at a conference.
- Competed in poster sessions (and won).

(Me + Old-fashioned bubble chamber)

Through my UROP I have…

- Gone 30 stories underground.
- Stood in a neutrino beam.
- Had a desk!
- Learned SO MUCH!
- Met many grad students, post docs, professors, engineers, AND you!

(Checking out MINOS and MINERvA)

Thank You!

Special thanks to Prof. Janet Conrad and the MIT Neutrino Group and Particle Zoo for neutrino pics ☺

SUPERLUMINAL NEUTRINOS

What is going on?

Neutrinos made HERE

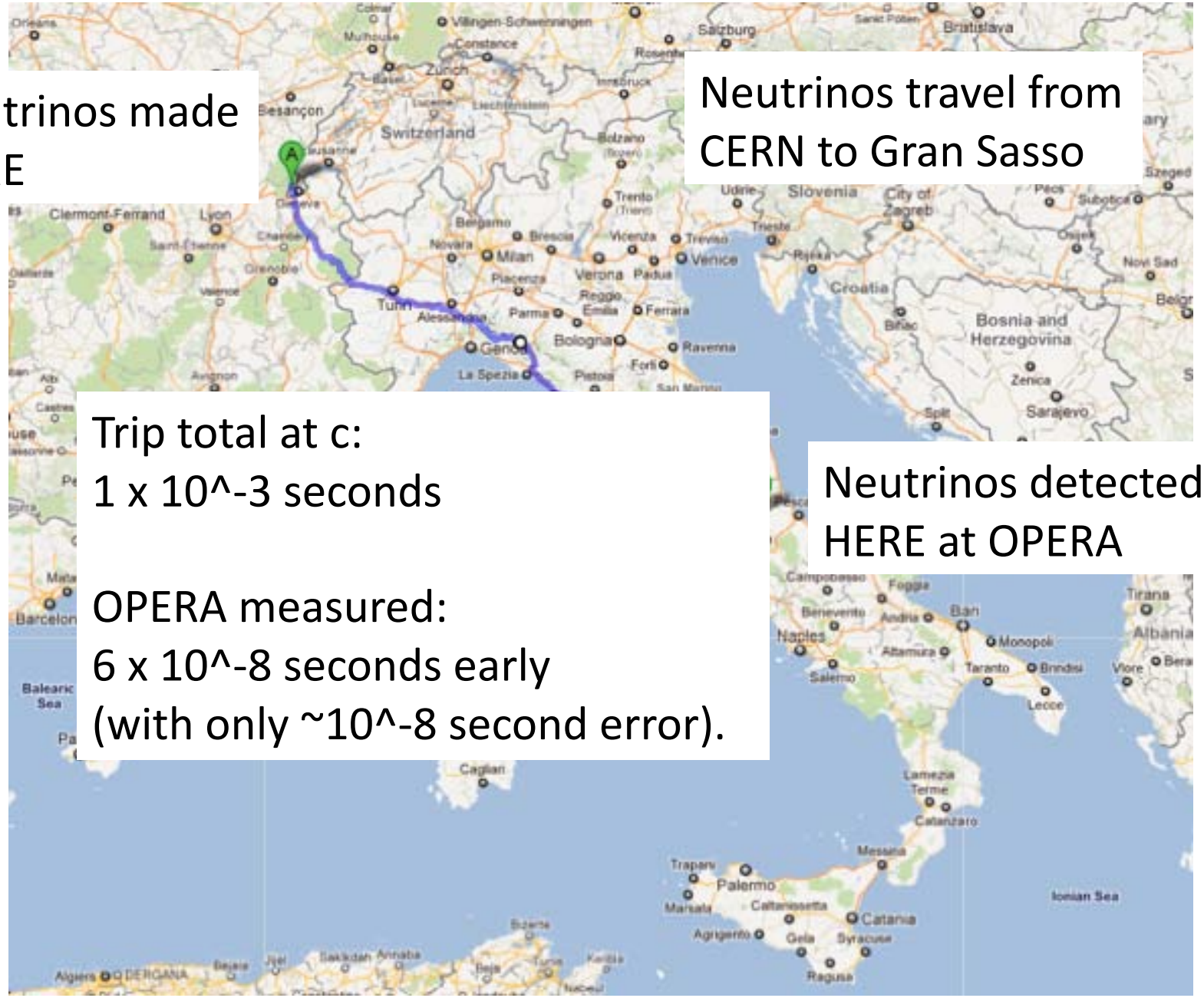
Neutrinos travel from CERN to Gran Sasso

Travel 732 km THROUGH the Earth.

Neutrinos detected HERE at OPERA

Neutrinos made HERE

Neutrinos travel from CERN to Gran Sasso



Trip total at c:
1 x 10^-3 seconds

OPERA measured:
6 x 10^-8 seconds early
(with only ~10^-8 second error).

Neutrinos detected HERE at OPERA


Building 16