

Fermilab, Science, SMP & What's after SMP?

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Thank you!

- Thank you for registering your child in SMP and helping them explore science and what we do at Fermilab!
- Congratulations to your graduating child! and we hope you consider enrolling their siblings in future SMP sessions
- We hope this has been an useful, informative and engaging experience for your child!

Did you get to see our bisons?

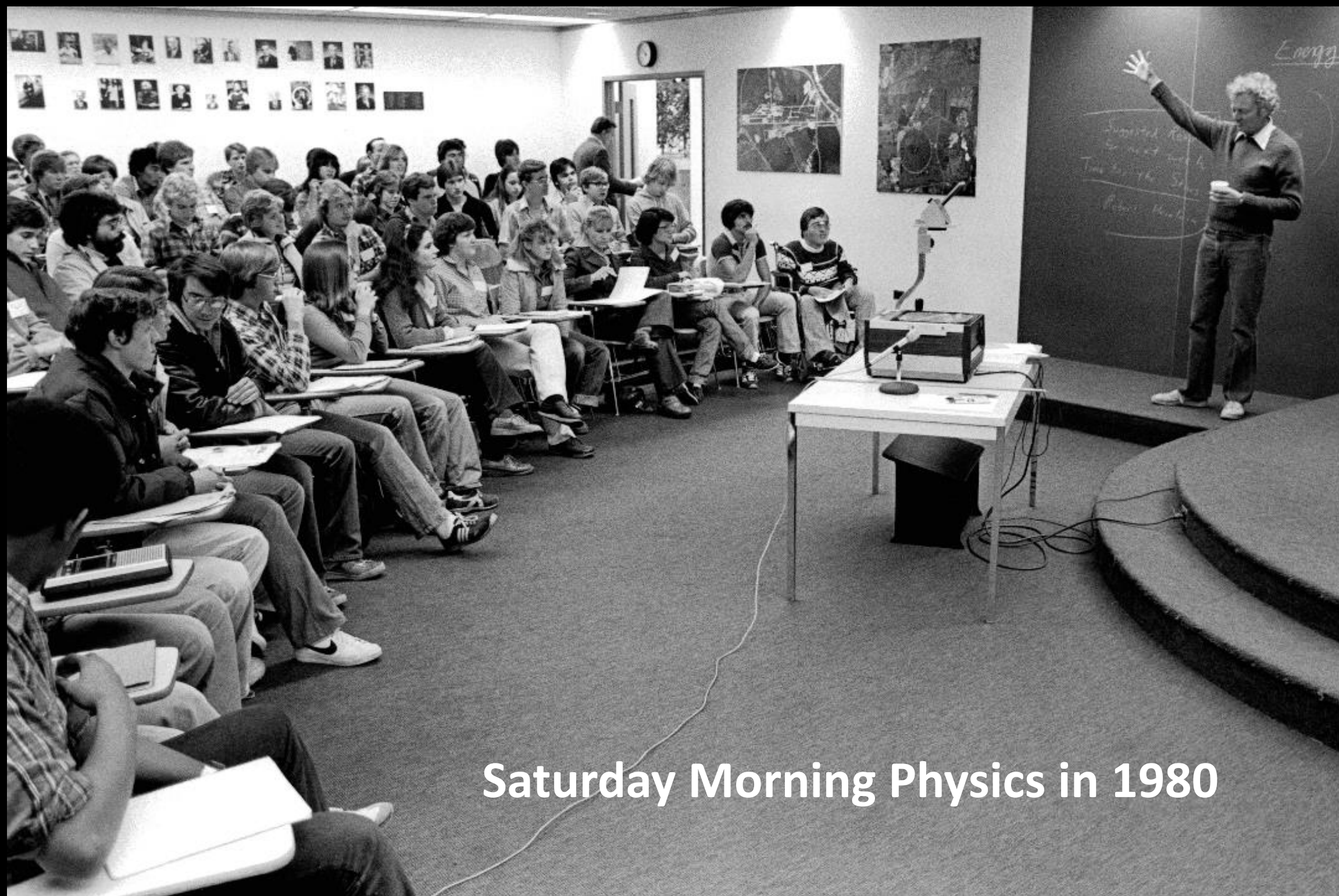


Leon Lederman

July 15, 1922 - Oct. 3, 2018

Fermilab Director
Nobel Prize Winner
Inventor of Saturday Morning Physics



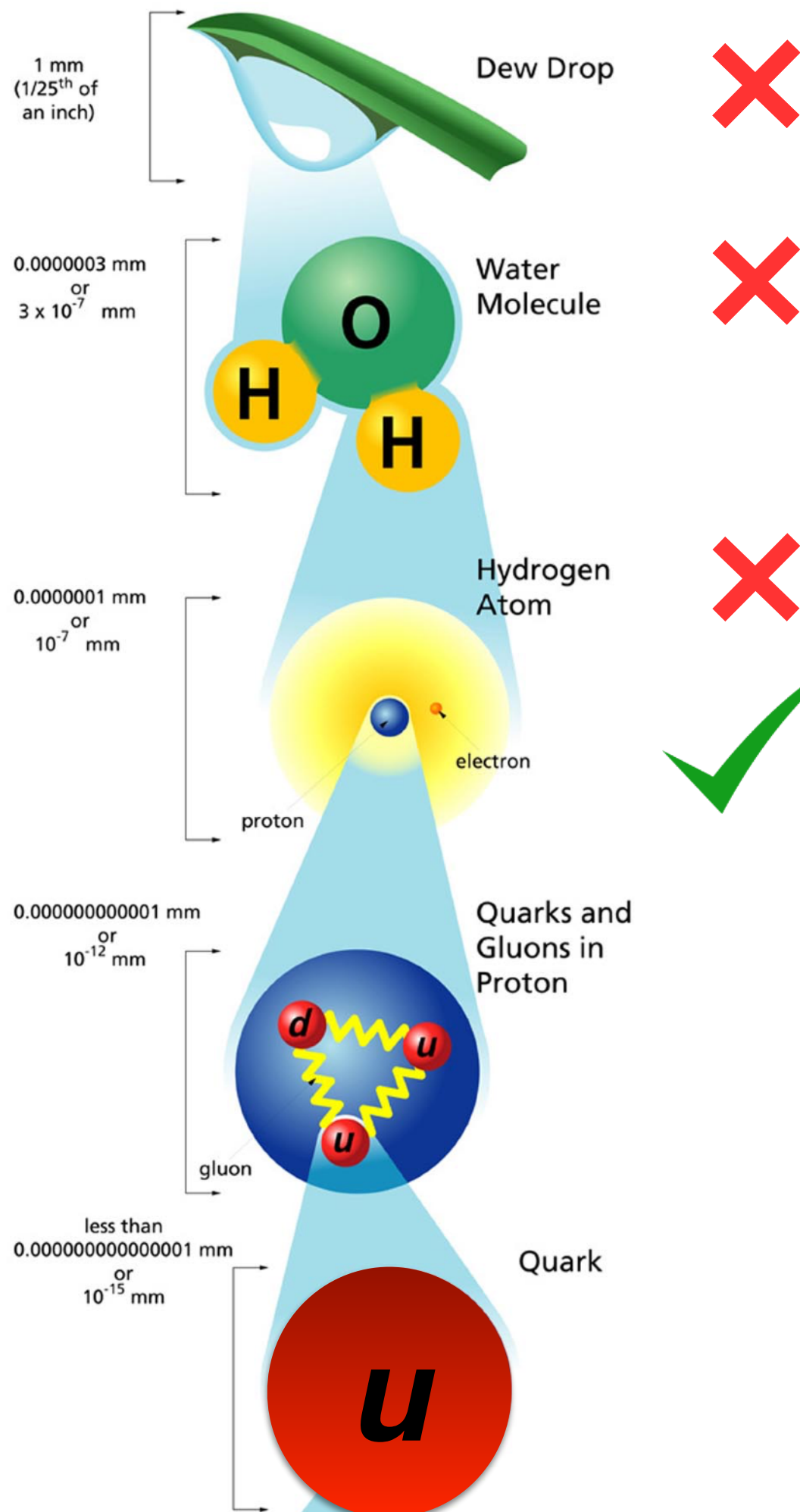


Saturday Morning Physics in 1980

**1988
Nobel Prize
in Physics**



Fermilab & Science



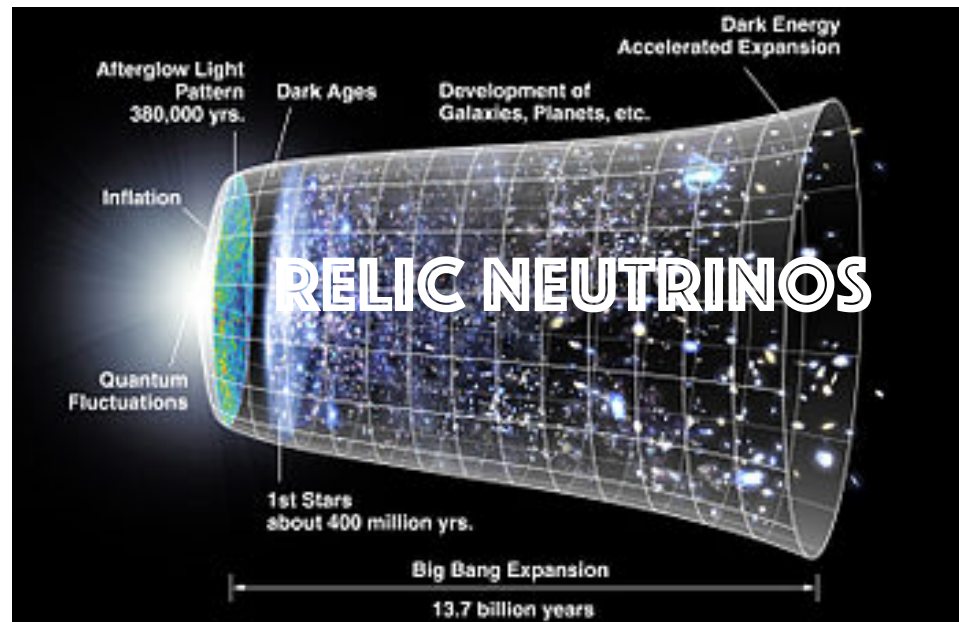
What is the world made
of at the most
fundamental level?

Somewhere here....

Tens of million or
trillion times smaller
than a dew drop

At Fermilab, we make our
own particles and a big part
of our research is studying
“neutrinos”

Good thing: Neutrinos are everywhere!

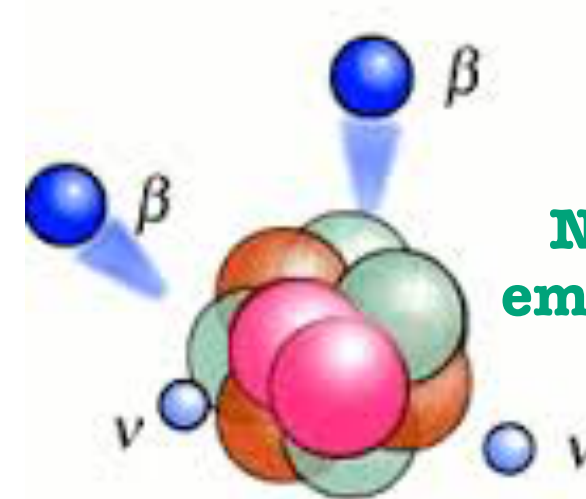
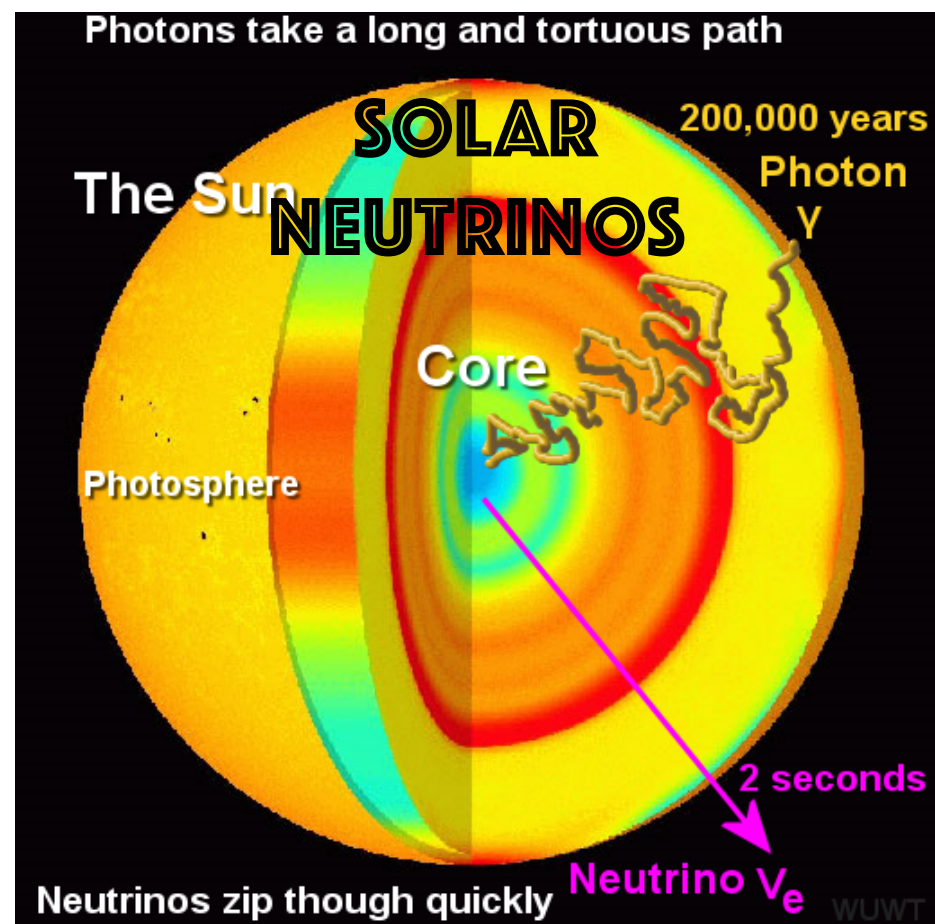


Neutrinos created during big bang are still floating around...trillions of them!



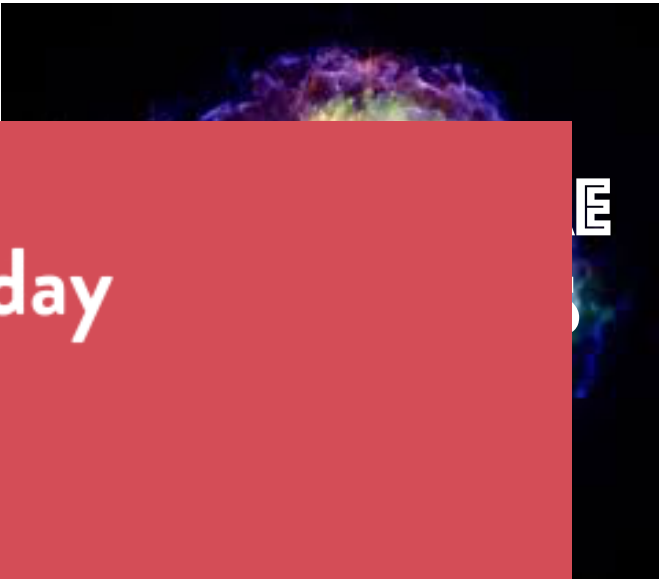
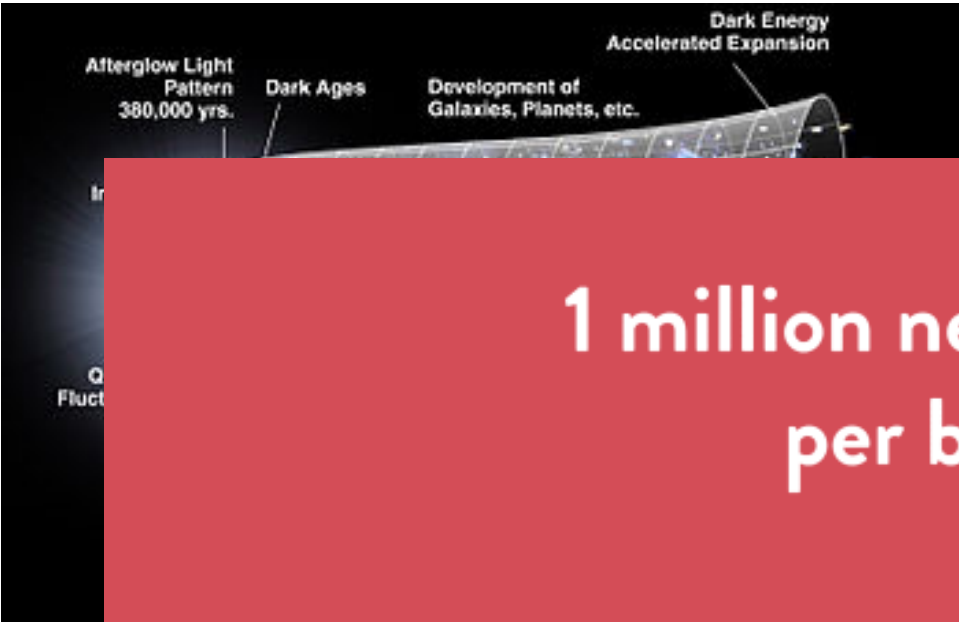
Neutrinos carry 99% of the supernovae explosion

Every star produces a ton of neutrinos



Nucleus also emits neutrinos

Good thing: Neutrinos are everywhere!



1 million neutrinos/day
per banana

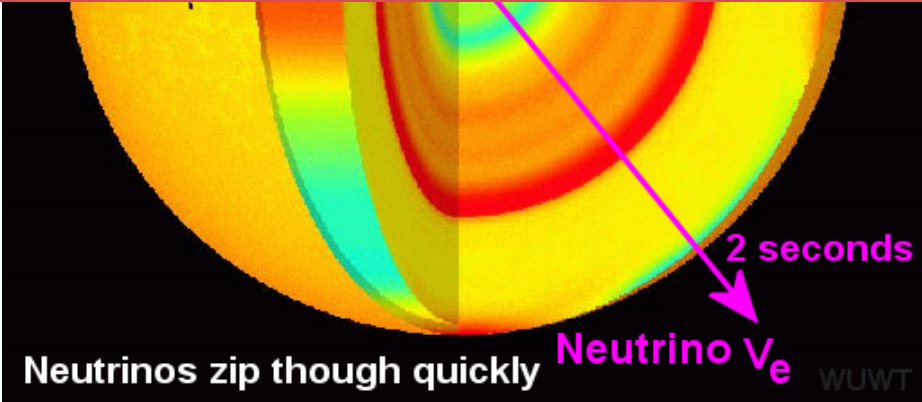
A cartoon illustration of a small green sphere with a face and stick-figure limbs, representing a neutrino, running over a banana peel. The entire scene is set against a solid red rectangular background.

Neutrinos float

of the
sion

Every second
produces
a ton of
neutrinos

Nucleus also
emits neutrinos



Bad thing: Neutrinos are not very sociable

Two things to remember:

1. They are abundant and easy to produce in copious amounts
2. Neutrinos are very, very, very...very weakly interacting



GeV scale neutrinos can travel about 200 earths without interacting



1 MeV neutrino requires about 10 light year of lead to be stopped

(1 light year is about 6 trillion miles)

Bad thing: Neutrinos are not very sociable

Two things to remember:

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For Comparison,

- A proton requires 0.1 mm of lead to stop
- An electron requires 10 mm of lead to stop



1 MeV neutrino requires about 10 light year of lead
to be stopped

(1 light year is about 6 trillion miles)

Bad thing: Neutrinos are not very sociable

Two things to remember:

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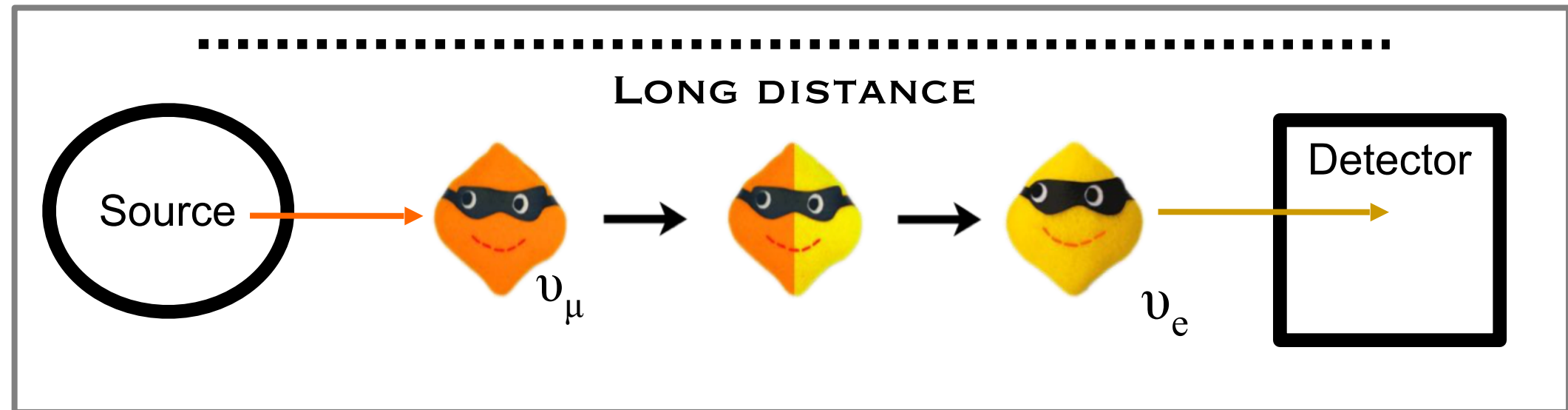
So, how in the world do you detect them?

Bad thing: Neutrinos are not very sociable

1. Produce them in large quantities in a well defined area
2. Put something **very dense**, **very big** and **very sensitive** for neutrinos to interact

Neutrinos can change flavors!

A neutrino created as one flavor can change into another flavor



The Fermilab Neutrino Complex

Linac

Length: 150m

Proton Energy: 400 MeV

Booster (BNB)

Circumference: 468m

Proton Energy: 8 GeV

●
MicroBooNE
470m baseline

Main Injector (NuMI)

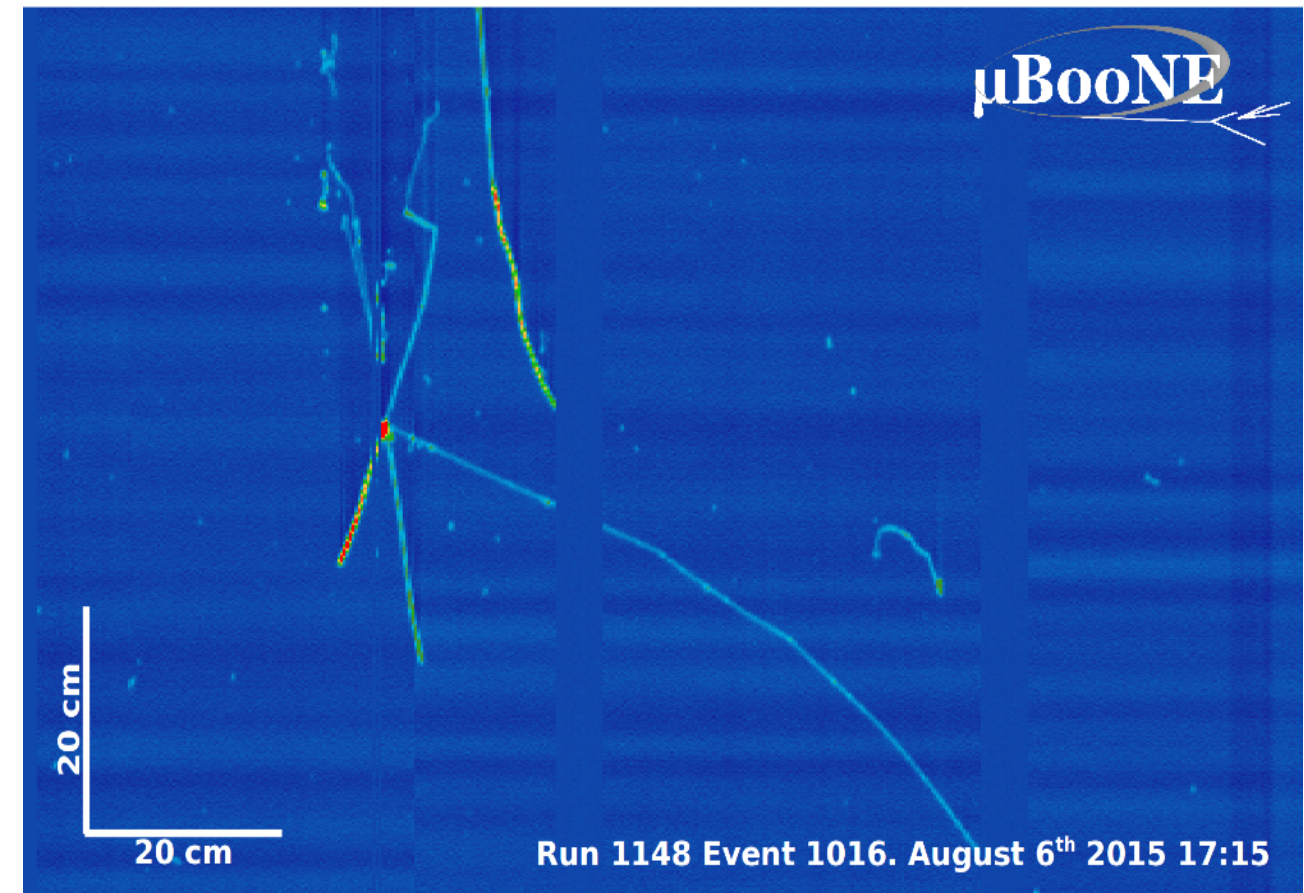
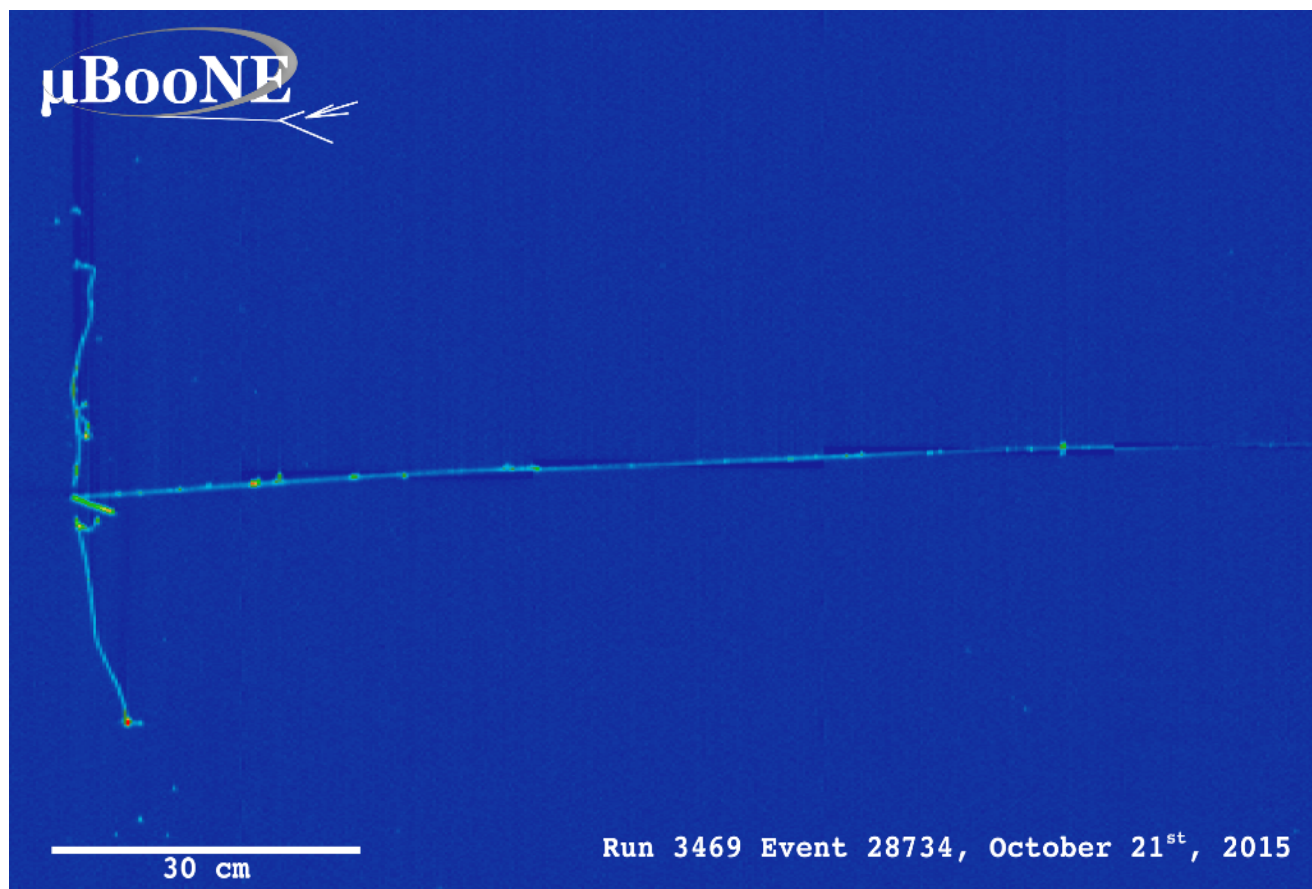
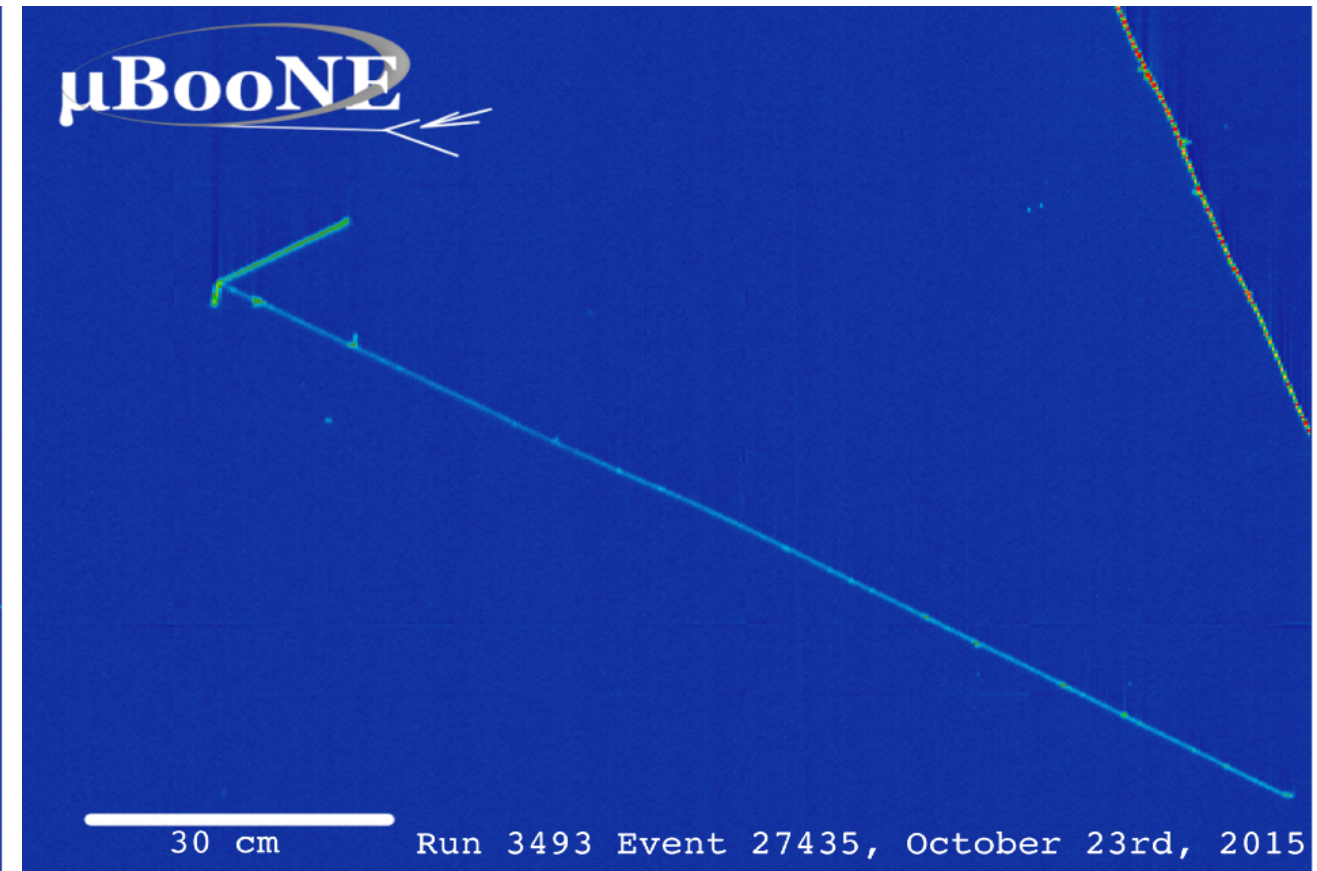
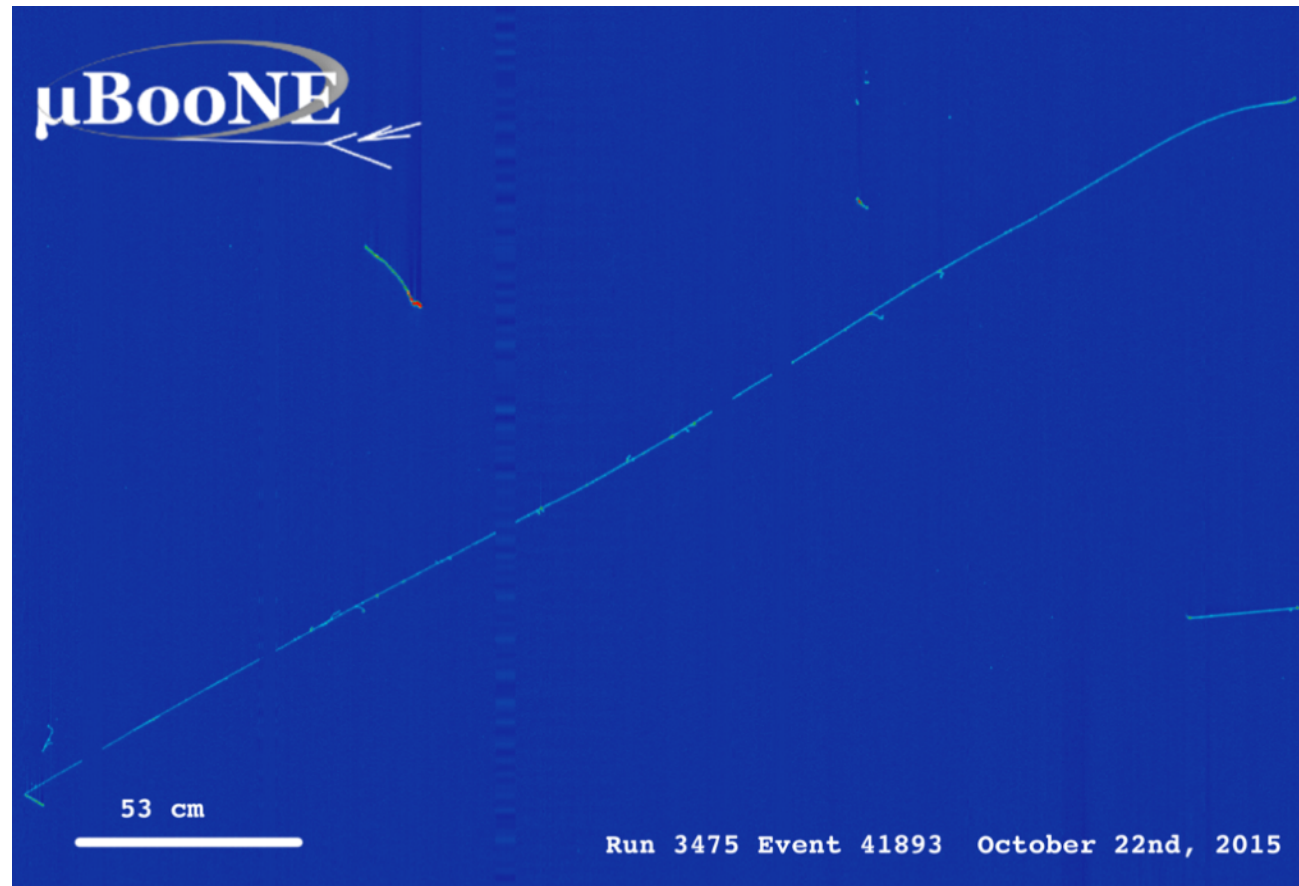
Circumference: 3.3km

Proton Energy: 120 GeV



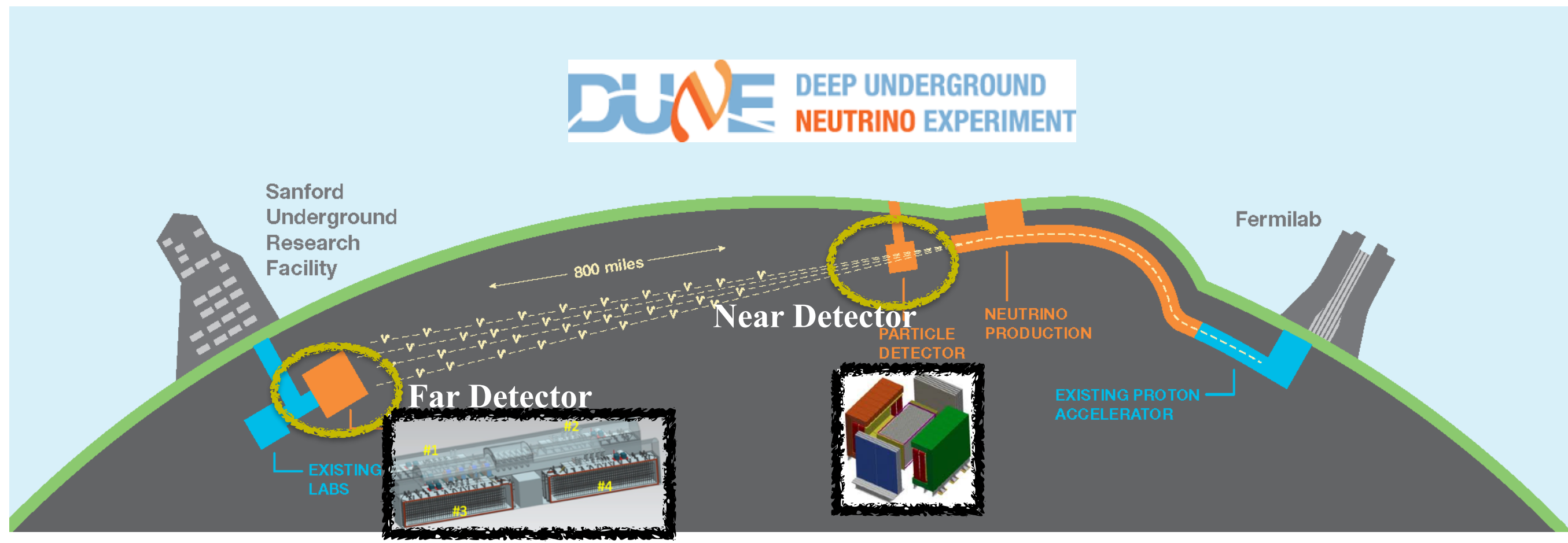
Fermilab produces two neutrino beams through this complex — only facility in the world that can do this!

Here is some valuable “mess” that neutrinos make when they pass through our detector

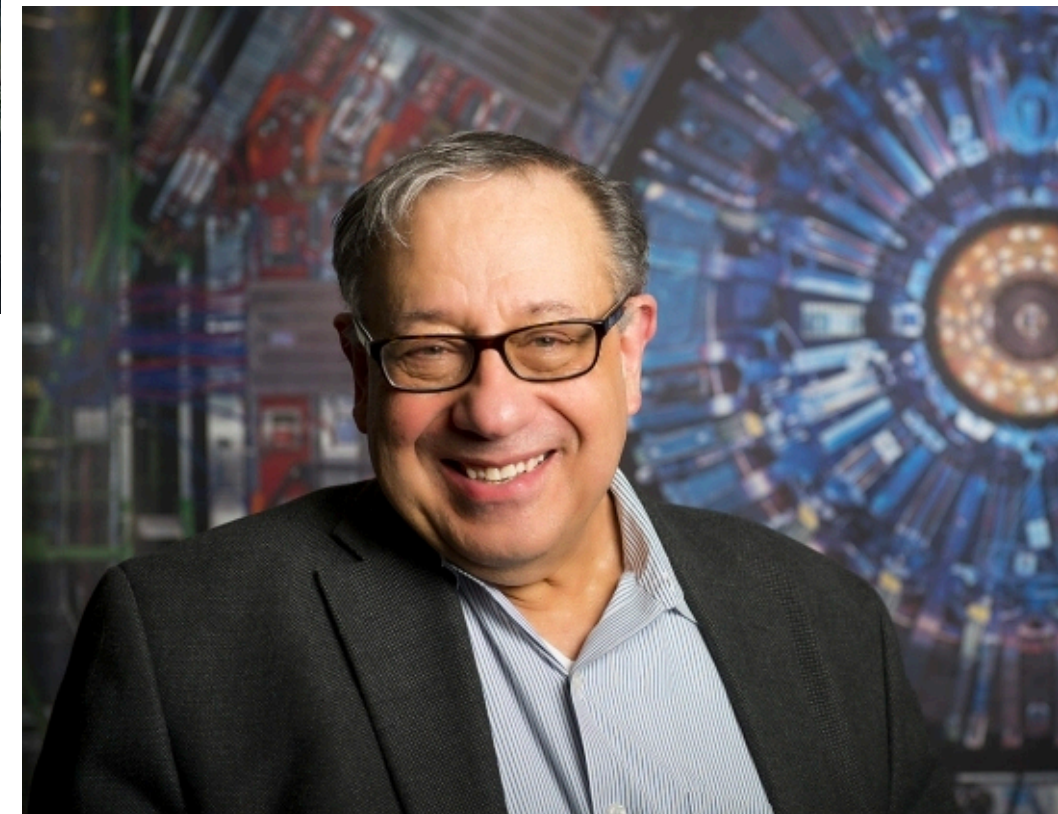
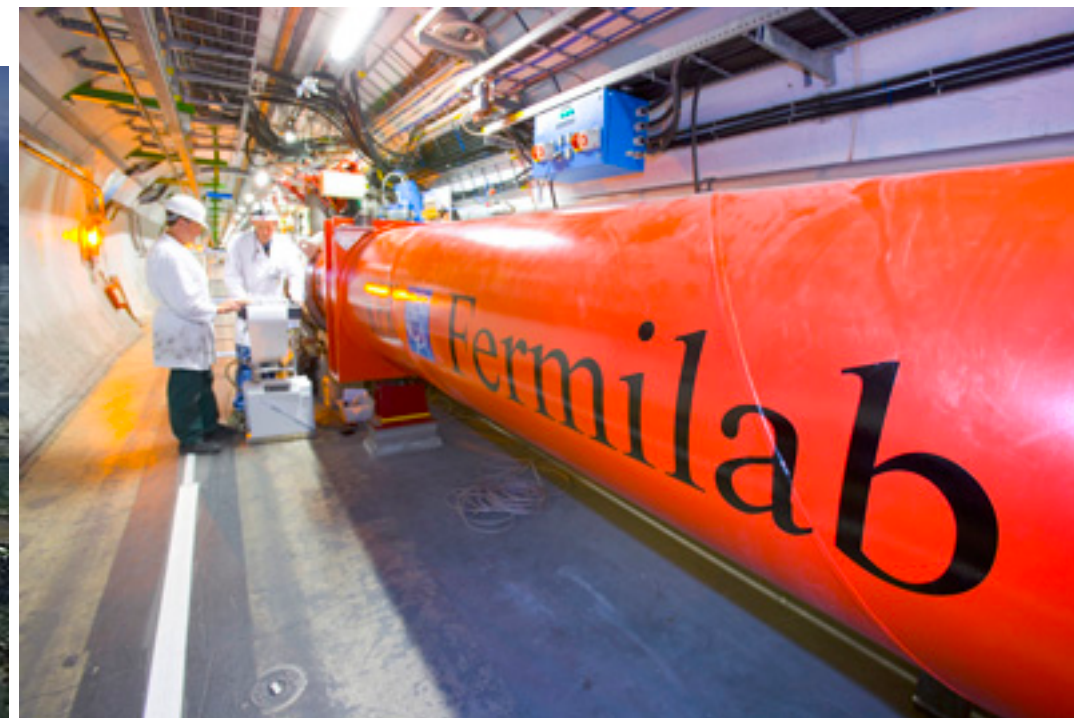


The Deep Underground Neutrino Experiment (DUNE)

- Neutrinos from Fermilab travel to South Dakota 800 miles underground
- Massive detector ~1 mile underground with more than 40 kilotons of active detector mass
- Uses liquid argon — an ultra cold liquid; Argon, a gas at room temperature, condenses to a liquid when cooled below -186°C (-303°F)



Fermilab & the Large Hadron Collider

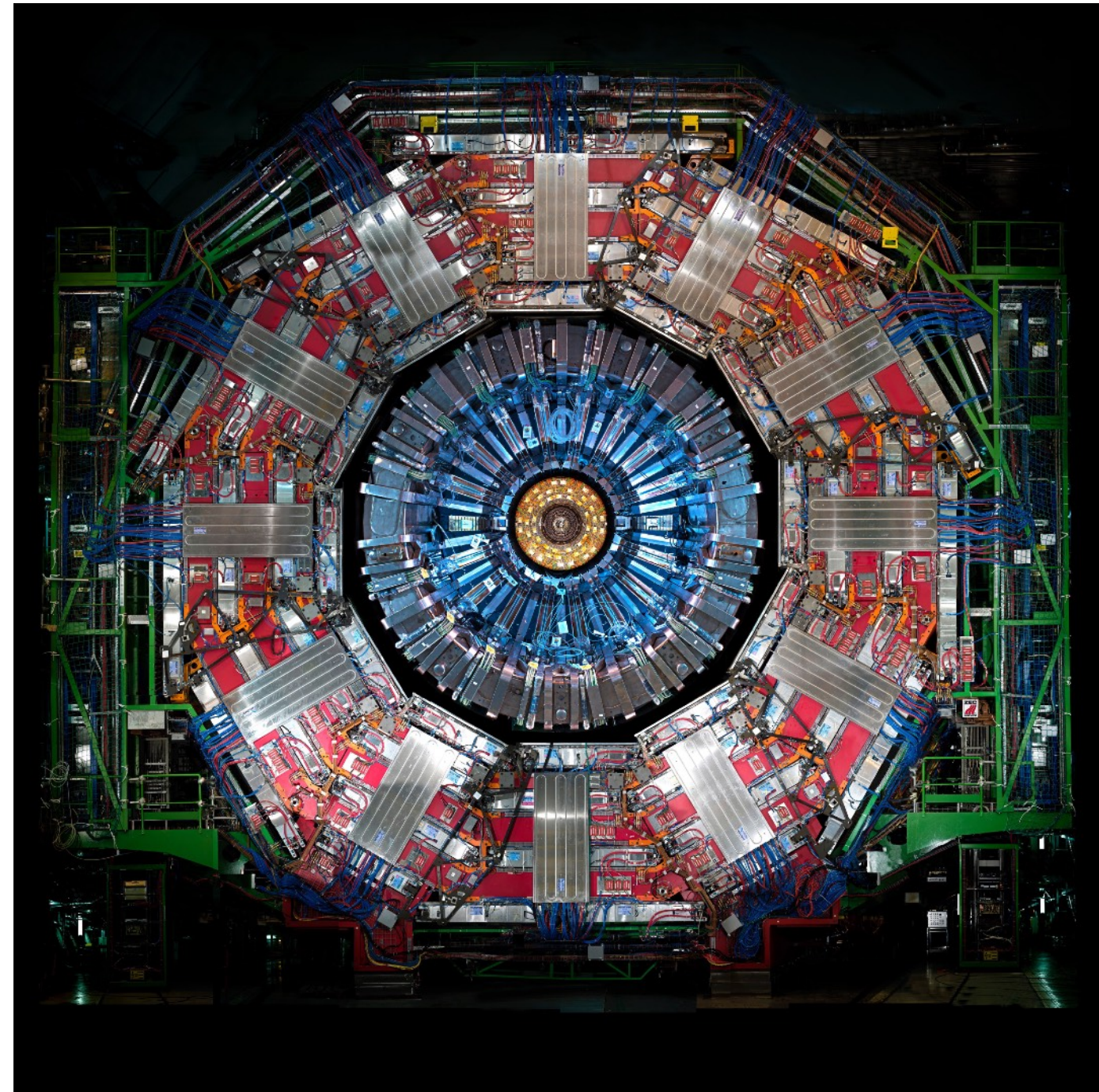


- 27 km circular collider at CERN outside of Geneva, Switzerland
- Collides protons at 13 "TeV" center of mass energy meaning 99.9999997% the speed at light!
- Fermilab involved in many aspects of **CMS experiment**
- Spokesperson for many years 19 was a Fermilab scientist

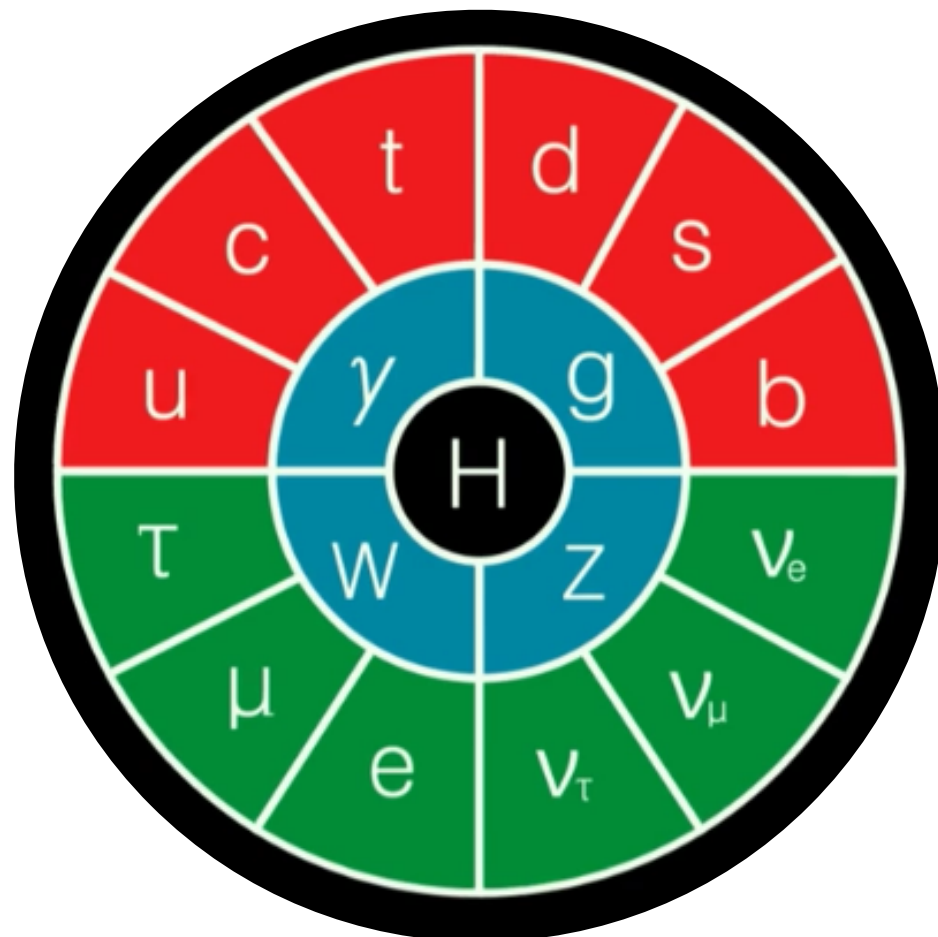
Compact Muon Solenoid (CMS)

<http://cms.cern/detector>

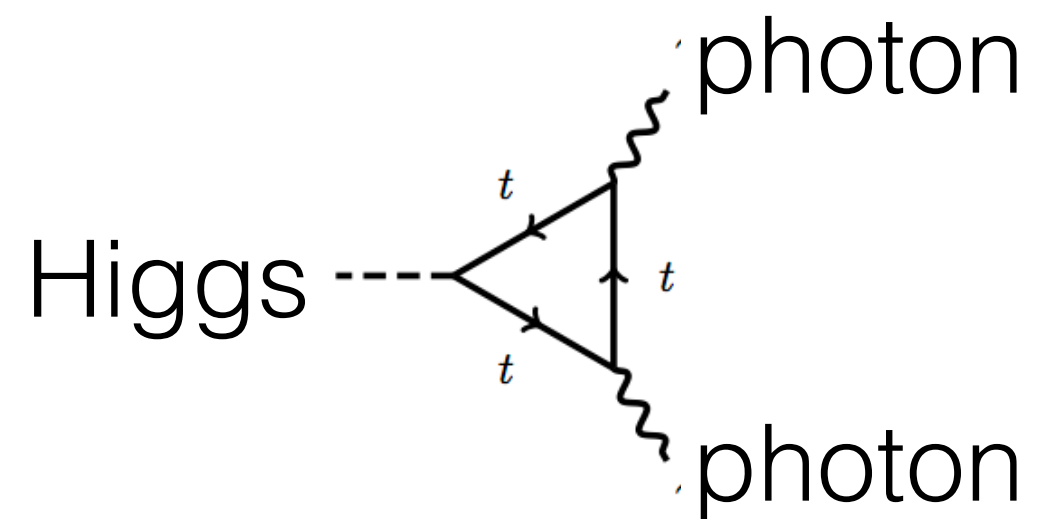
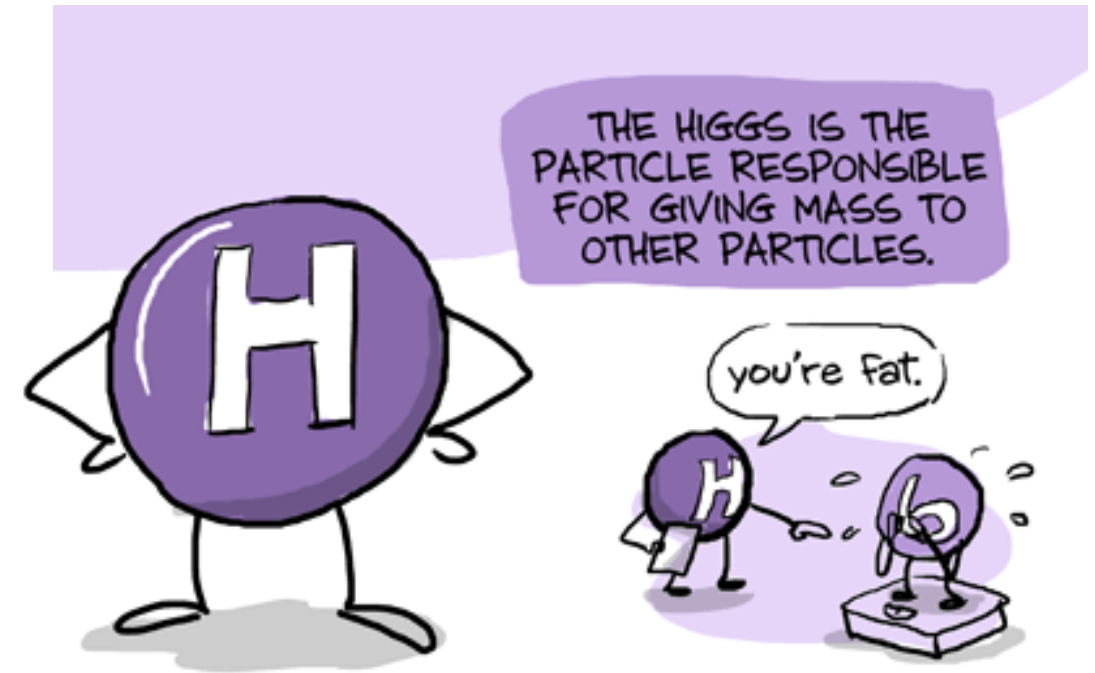
- 3 story tall detector
- Composed of multiple layers for detecting different kinds of particles
- One of the most elusive particles is the Higgs boson



Standard model and the Higgs boson



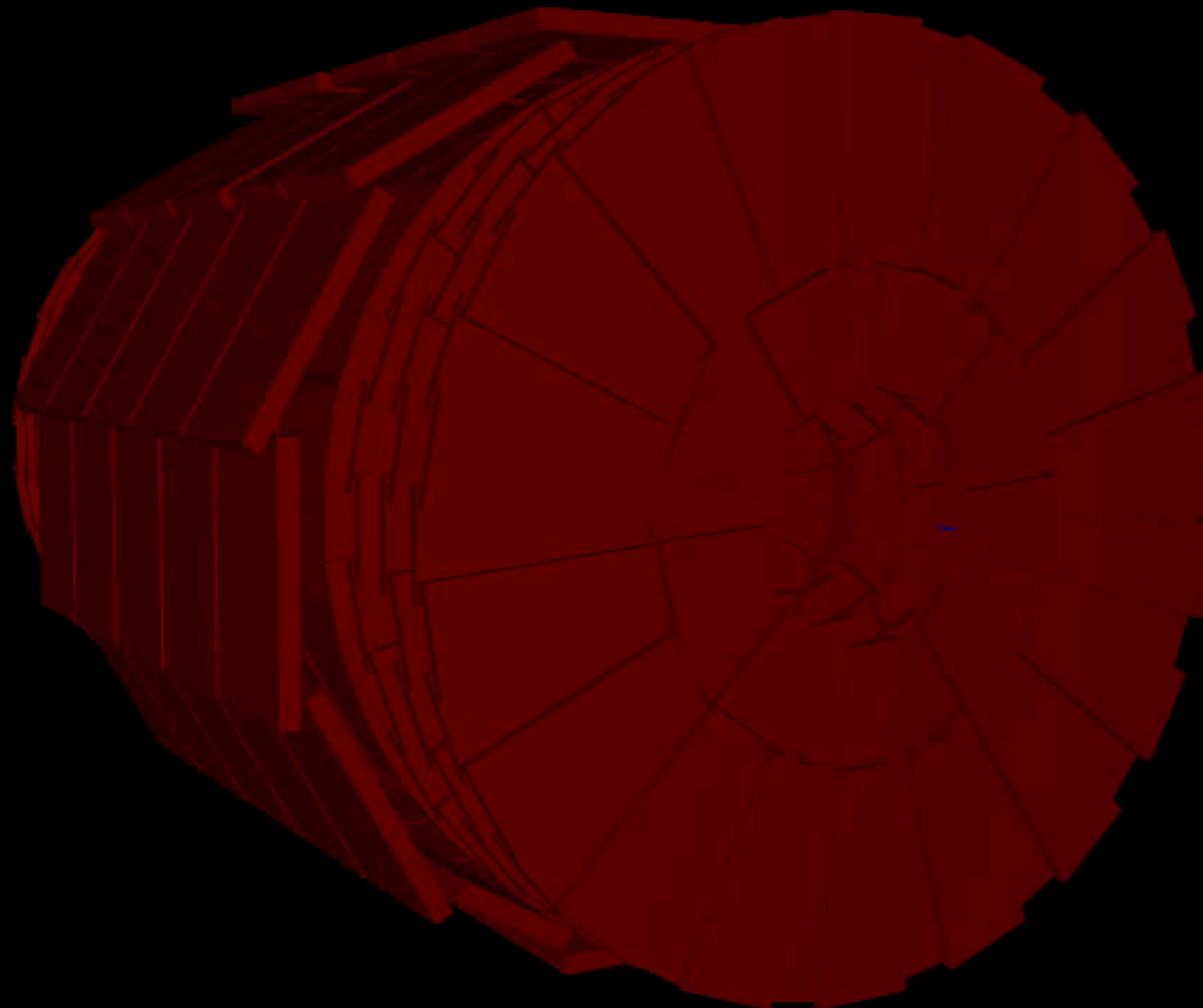
<u>FERMIONS</u>	<u>BOSONS</u>
MATTER	FORCE CARRIERS
■ QUARKS	■ GAUGE BOSONS
■ LEPTONS	■ HIGGS BOSON



Higgs boson discovery

<https://www.youtube.com/watch?v=psMpabzGuLo>

CMS Experiment at the LHC, CERN
Sat 2012-12-09 22:34 CEST
Run 194050 Event 111946235
C.O.M Energy 8.0TeV
H>Gamma Gamma candidate



Fall 2018 SMP

Fall 2017 SMP

Date	Lecture Topic	Speaker, Affiliation
29-Sep-18	Introduction to Science at Fermilab	Pedro Machado, Fermilab
6-Oct-18	Special Relativity	Elliott McCrory, Fermilab
13-Oct-18	Quantum Mechanics	Dan Hooper, University of Chicago
20-Oct-18	Symmetry, Antimatter, and Supersymmetry	Javier Duarte, Fermilab
27-Oct-18	The Standard Model of Particle Physics	Cecilia Gerber, University of Illinois at Chicago
3-Nov-18	Neutrinos	Leo Aliaga, Fermilab
10-Nov-18	Energy and Climate	Elisabeth Moyer, University of Chicago
17-Nov-18	Particle Accelerators	Cindy Joe, Fermilab
24-Nov-18	Thanksgiving Break	
1-Dec-18	Cosmology	Ting Li, Fermilab
8-Dec-18	Particle Detectors	Mandy Rominsky, Fermilab
15-Dec-18	Physics and Society	Tim Meyer, Fermilab COO

- A multitude of topics introduced along with tours to Fermi experiments and research areas
- Many fundamental changes to the program to modernize and improve engagement for students
- Buses provided for onsite tours





SMP Tours

Teaching Tools/Techniques

- Interaction and engagement during the two-hour lecture
 - Interactive teaching tools: Clickers and Flash cards to respond to questions and to trigger two-way discussion
 - Training lecturers with teaching techniques to maintain an engaging classroom
 - More Eyes-on and Show-And-Tell activities
 - Hands-on activities



Show-And-Tell and live demos of how accelerators work — Cindy Joe



understanding how structure of atom (Rutherford scattering) using play-doh balls, pins and screws — Cecilia Gerber

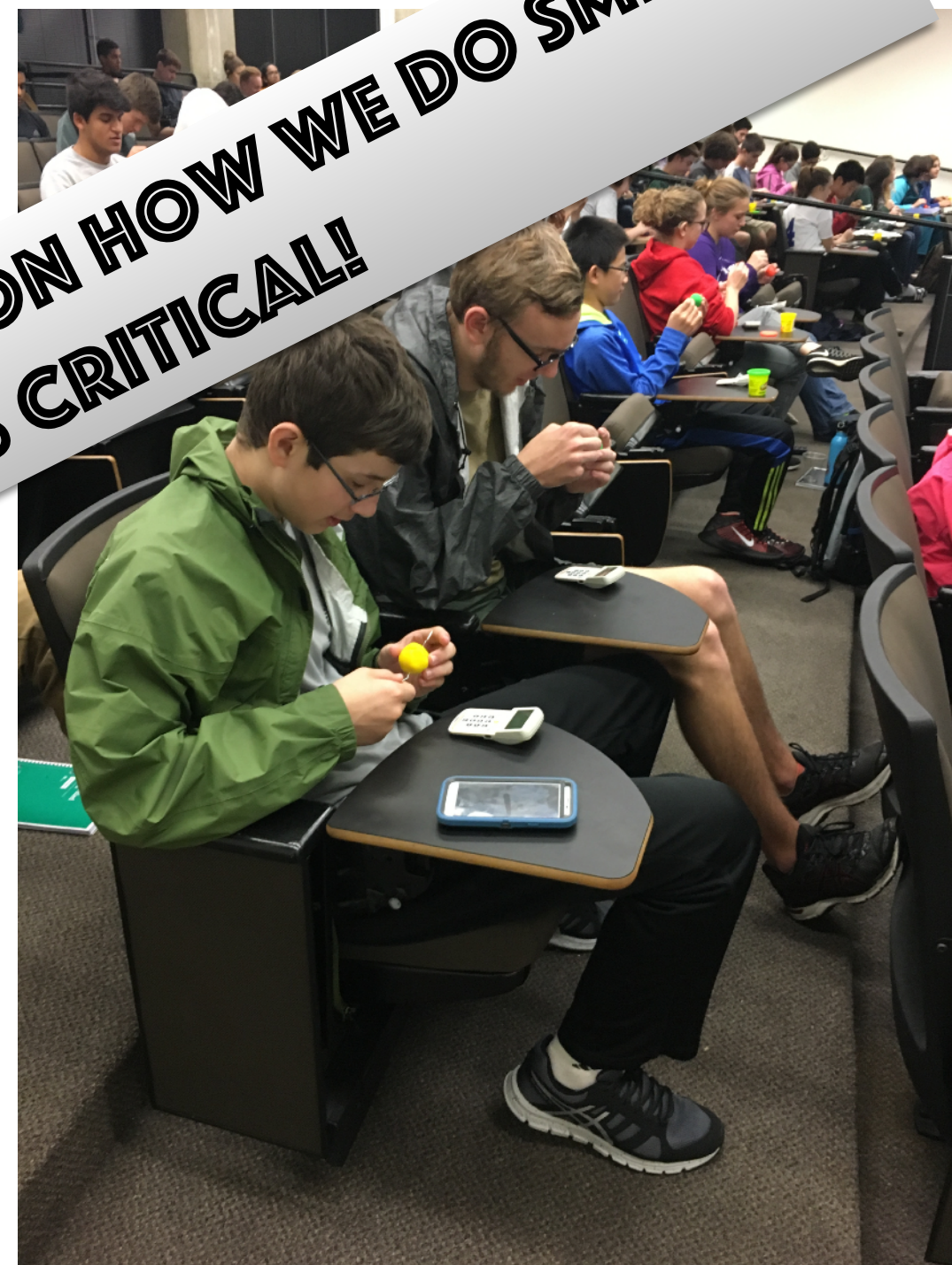


**Climate Lecture
by U Chicago
Prof. Elisabeth Moyer**

Show-And-Tell and live demos of how accelerators work — Cindy Joe



understanding how structure of atom (Rutherford scattering) using marbles, pins and screws —



imate Lecture
by U Chicago
Prof. Elisabeth Moyer

Feedback/Criticism on SMP Fall 2018?

(Feel free to throw tomatoes)



The SMP team

<http://saturdaymorningphysics.fnal.gov/about-us/>

SMP Onsite Coordinators

Co-chairs
of SMP

Sowjanya Gollapinni



Javier Duarte



Ting Li

Robert Bernstein
Senior Advisor



Adam Anderson

Sandra Charles
Program Manager



Elena Gramellini

Rosa Foote
Administrative support



Kirsty Duffy

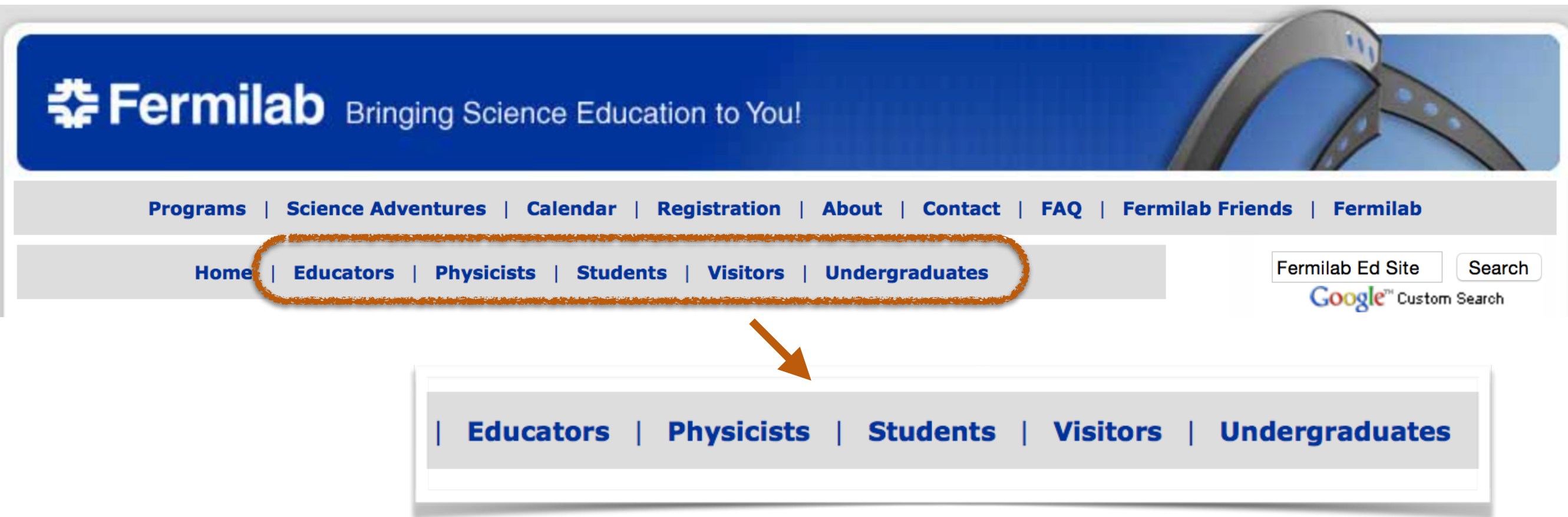
What's after SMP?

both for your graduating SMP child
and their siblings :)

Keep them Engaged

Many ways to do it!

<http://ed.fnal.gov>



- Not just Fermilab — Illinois is rich with laboratories and educational institutes; Chicago area is also rich in opportunities/resources
- Look at Argonne National Lab (ANL), UC, UIC, NIU, IIT etc. — every place has their own education/outreach efforts

Keep them engaged

<http://ed.fnal.gov//home/students.shtml>

Classes



Science Adventures
(K-8)



Fermilab Junior Prairie Rangers
(4-6)



Sat. Morning Physics
(9-12)

ASK-A-SCIENTIST
([http://ed.fnal.gov/
programs/tours/ask-
a-scientist.shtml](http://ed.fnal.gov/programs/tours/ask-a-scientist.shtml))

Special Events



Fermilab Outdoor Family Fair
(K-12)



Wonders of Science
(2-7)



Family Open House
(3-12)



STEM Career Expo
(9-12)

Keep them engaged

<http://ed.fnal.gov//home/students.shtml>

More Opportunities



Science Center's Hands-on Exhibits
(4-8)



Scout Programs
(4-12)



QuarkNet Summer Research
(9-12)



Student Tours
(5-12)

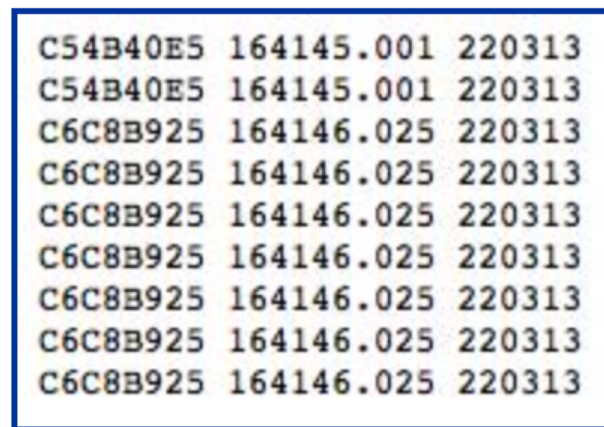
Activities/Games



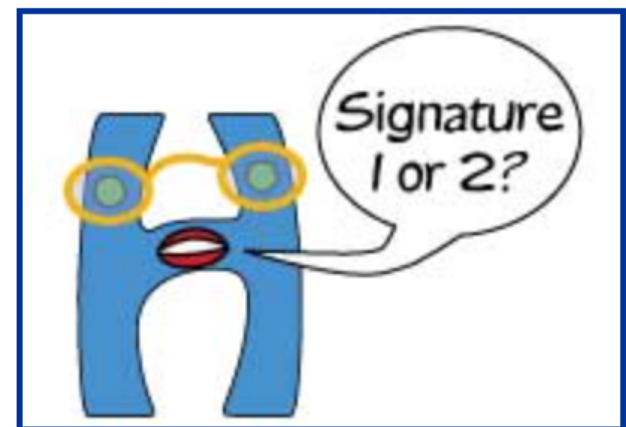
Fermilabyrinth
(6-12)



Decam Interactive
(6-12)



Data-based Investigations
(9-12)



Higgs Game
(9-12)

QuarkNet Internships

(Summer research program)

- <http://ed.fnal.gov/interns/programs/quarknet/index.shtml>
- Eligibility: High School Students in 10-12th grade when applying. Must live in Fermilab area; U.S. Citizenship or permanent resident status required;
- 6 week internship program; students work with scientists on Fermilab research programs



Applications open
March 18, 2019



TARGET Internships

- <http://diversity.fnal.gov/target/>
- **Eligibility:** High School Students in 10-11th grade in Illinois when applying. Proof of evidence to work in U.S. required;
- 6 week (June 24 to Aug. 2) paid internship program; students work with scientists on Fermilab research programs
- The program goals are to encourage students to undertake college study and pursue careers in STEM

Program dates: **June 24 through August 2, 2019**

Application Period & Deadline	December 17, 2018 – February 1, 2019
Interview Invitation – Email	March 1, 2019*
Interviews	April 8, 2019 at UIC (Chicago) April 9, 2019 at Fermilab (Batavia)
Internship Offer – Email	May 2, 2019

Aims to increase the representation of underrepresented minorities and women in STEM fields



Undergraduate Internships

<http://ed.fnal.gov/interns/programs/>

CCI - Community College Internships



For community college students.

Helen Edwards Summer Internship (formerly PARTI)



For physics & engineering majors in European countries.

Lee Teng Undergraduate Internship



For juniors and exceptional sophomores in physics or engineering at U.S. institutions.

SIST - Summer Internships in Science and Technology



For under-represented minorities majoring in STEM fields at 4-year U.S. colleges.

SULI - Science Undergraduate Laboratory Internship



For U.S. citizens or Permanent Resident Aliens in physics or engineering.

VetTech Internship Program



For military veterans to intern as a technician to provide routine technical support for an experiment or group.

Fermilab Cooperative Education Program (Co-Op Program)

<http://diversity.fnal.gov/coop/>

- A longer-term STEM engagement/education program
- Students typically work a minimum of 3 semesters or 4 quarters at Fermilab, alternating periods of full-time study at their institution with full-time employment at the laboratory
- **Eligibility:** Full time undergraduate enrollment in a 4-year program of study at a U.S. college or University for the duration of appointment; Academic standing as a sophomore with a GPA of 3.0 or 4.0; 18 years of age at time of appointment

We encourage applications from students majoring in:

- | | |
|---|--------------------------|
| ▪ Mechanical engineering | ▪ Finance and accounting |
| ▪ Electrical and electronic engineering | ▪ Project management |
| ▪ Computer science and Engineering | ▪ Human resources |
| ▪ Environment, safety and health | ▪ Communications |

Key Dates for all Internships

Internship program	Application requirements	Application period	Program dates	Internship deliverables
TARGET	<ul style="list-style-type: none"> Online application Unofficial transcript Two letters of recommendation 	Dec. 17, 2018-Feb. 1, 2019	June 24-Aug. 2, 2019	<ul style="list-style-type: none"> Oral presentation Exit surveys
QuarkNet Summer Research Programs	<ul style="list-style-type: none"> Online application One letter of recommendation 	March 18-April 5, 2019	June 10-July 19, 2019	<ul style="list-style-type: none"> Entrance and exit surveys Team research abstract Oral presentation
CCI – Community College Internships	<ul style="list-style-type: none"> Online application Unofficial transcript Two letters of recommendation 	Oct. 16, 2018-Jan.10, 2019	June 3-Aug. 9, 2019	<ul style="list-style-type: none"> Entrance and exit surveys Presentation abstract (150-words) Oral presentation Poster presentation Written research project report (6-8 pages)
Cooperative Education Program	<ul style="list-style-type: none"> Online application Unofficial transcript Semester/Quarter worksheet Two letters of recommendation 	Year round	Year round	<ul style="list-style-type: none"> Entrance and exit surveys Presentation abstract (150-words) Oral presentation Poster presentation Written research project report (6-8 pages)
Helen Edwards Summer Internship	<ul style="list-style-type: none"> Online application Unofficial transcript Two letters of recommendation 	Nov. 1-Jan. 7, 2019	June 24-Aug. 30, 2019	<ul style="list-style-type: none"> Oral presentation Poster presentation
Lee Teng Undergraduate Internship	<ul style="list-style-type: none"> Curriculum Vitae Unofficial Transcript Two letters of recommendation 	Nov. 1, 2018-Jan. 2, 2019	June 3-Aug. 9, 2019	<ul style="list-style-type: none"> Oral presentation Written research project report Poster presentation
SIST – Summer Internships in Science and Technology	<ul style="list-style-type: none"> Online application Unofficial transcript Two letters of recommendation 	Dec. 3, 2018-Feb.1, 2019	May 20-Aug. 9, 2019	<ul style="list-style-type: none"> Undergraduate Lecture Series Presentation abstract (150 words) Oral presentation Poster presentation Written research project report
SULI – Science Undergraduate Laboratory Internship	<ul style="list-style-type: none"> Online application Unofficial transcript Two letters of recommendation 	Oct. 16, 2018-Jan.10, 2019	June 3-Aug. 9, 2019	<ul style="list-style-type: none"> Entrance and exit surveys Presentation abstract (1,500-3,000 words) Oral presentation Poster presentation Peer poster or oral presentation review (1 page)
VetTech Internship Program	<ul style="list-style-type: none"> Online application Discharge Papers Names of two references 	Nov. 5, 2018-Jan. 31, 2019	June 3-Aug. 9, 2019	<ul style="list-style-type: none"> Entrance and exit surveys

<http://internships.fnal.gov/high-school-student-programs/>

<http://internships.fnal.gov/undergraduate-programs/>

Closing thoughts

- Science is about society and people
- A science literate population benefits everyone;
More than anything it promotes critical thinking
- Science education is also about social justice;
opportunities for everyone to learn regardless of our differences
- Science and scientific method is about objectivity;
Following that in our everyday life will help rid society of biases

SMP is not just about Fermilab but about science and promoting science literacy from young age.

Thank you for enrolling your children in our program.

More tomatoes!

