Syracuse University
Physics Department
Astronomy 101

Neutrinos and astronomy

Ohana Rodrigues

Portuguese word!!!

Biscoito

The Beta Decay

939,565 keV

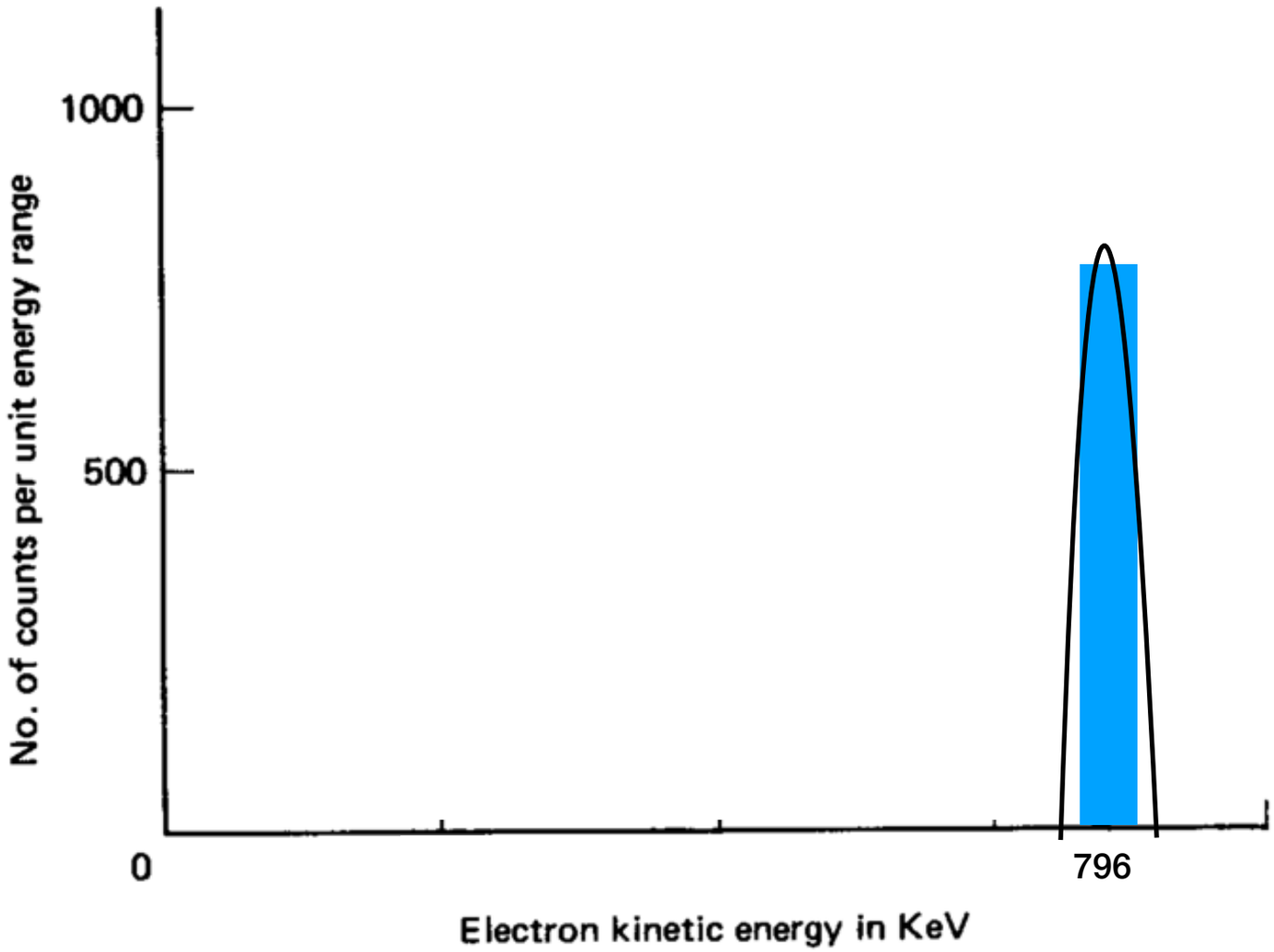
938,272 keV

500 keV

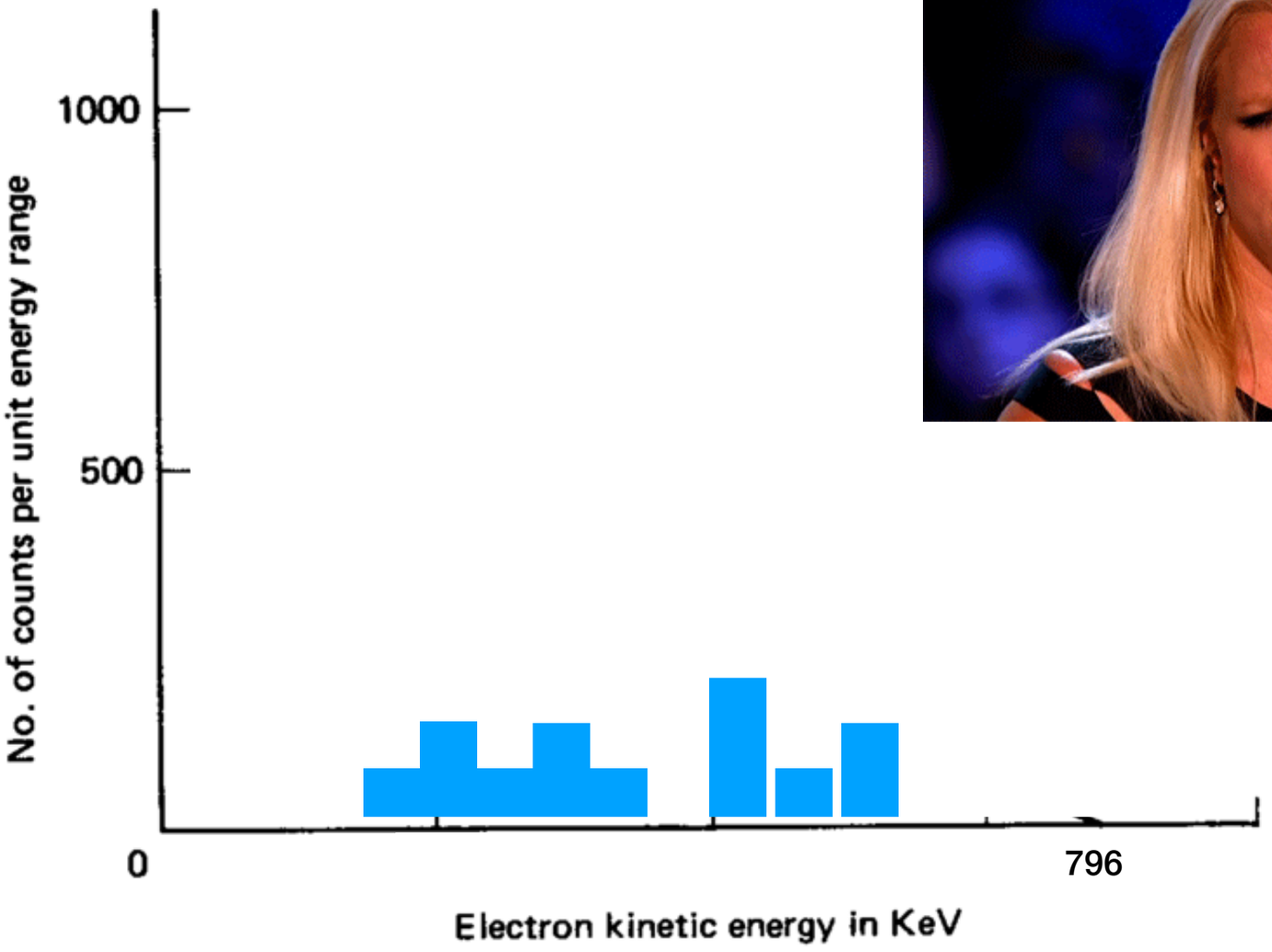
$939565 - 938272 - 500 =$

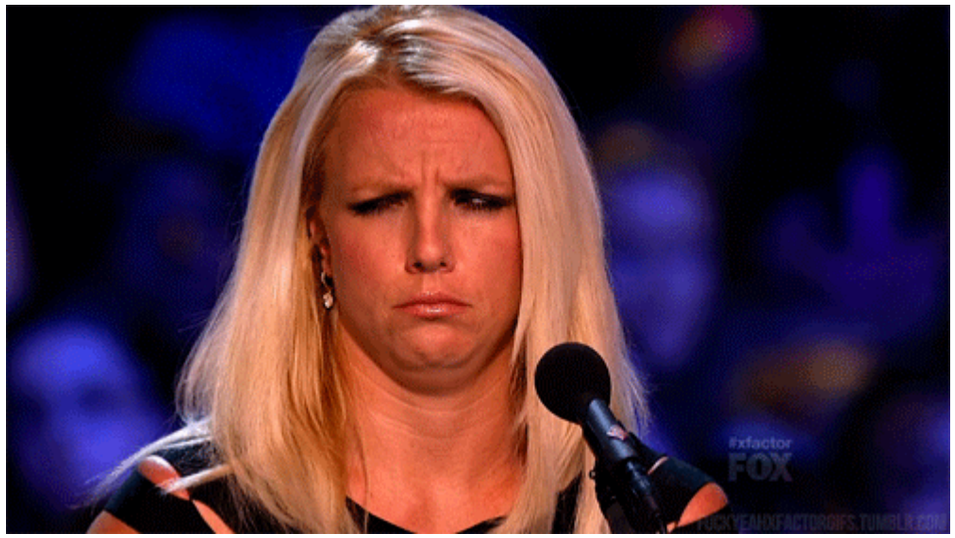
793 keV

The Beta Decay - Expectation

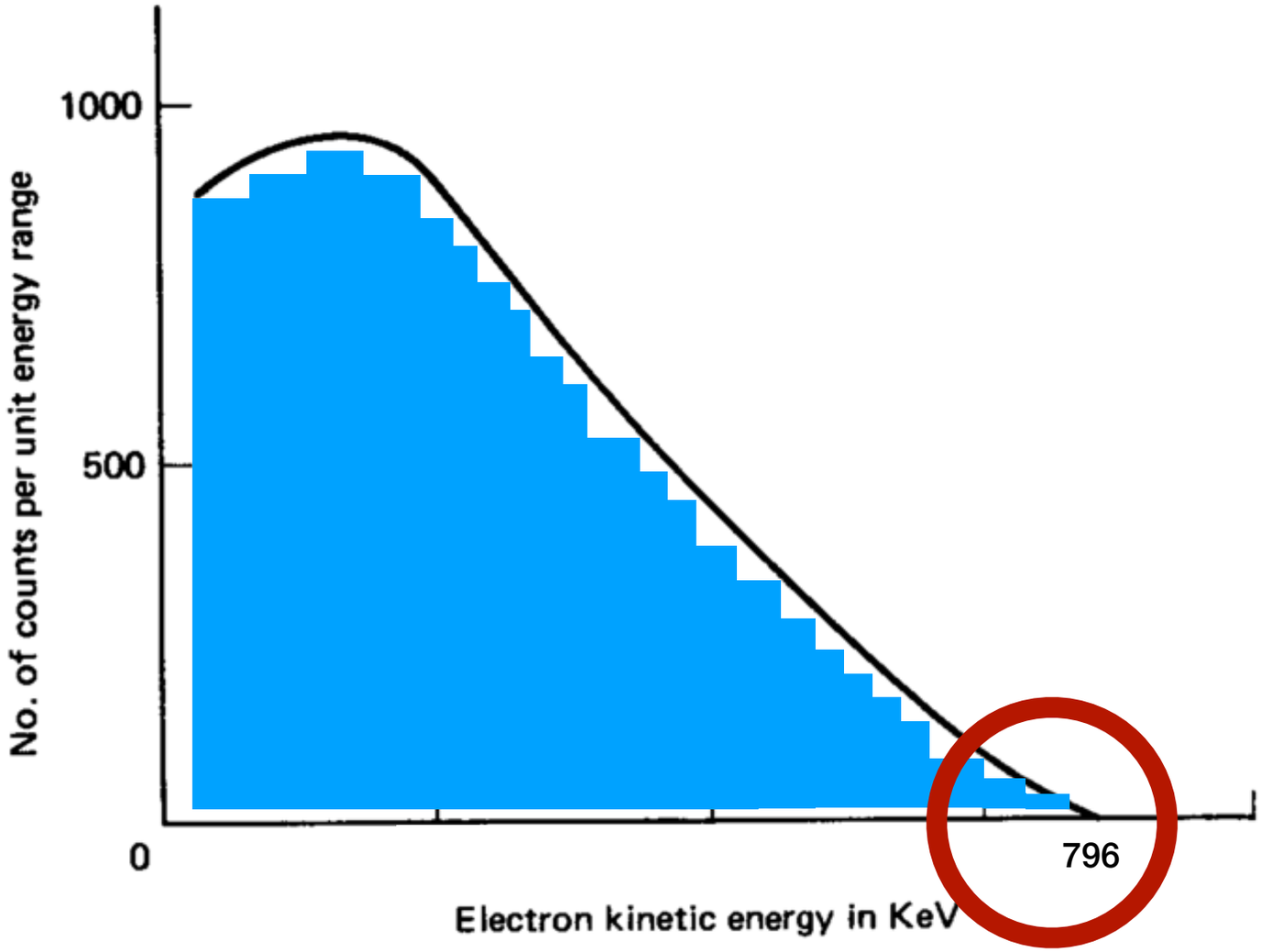


The Beta Decay Problem - Reality





The Beta Decay Problem

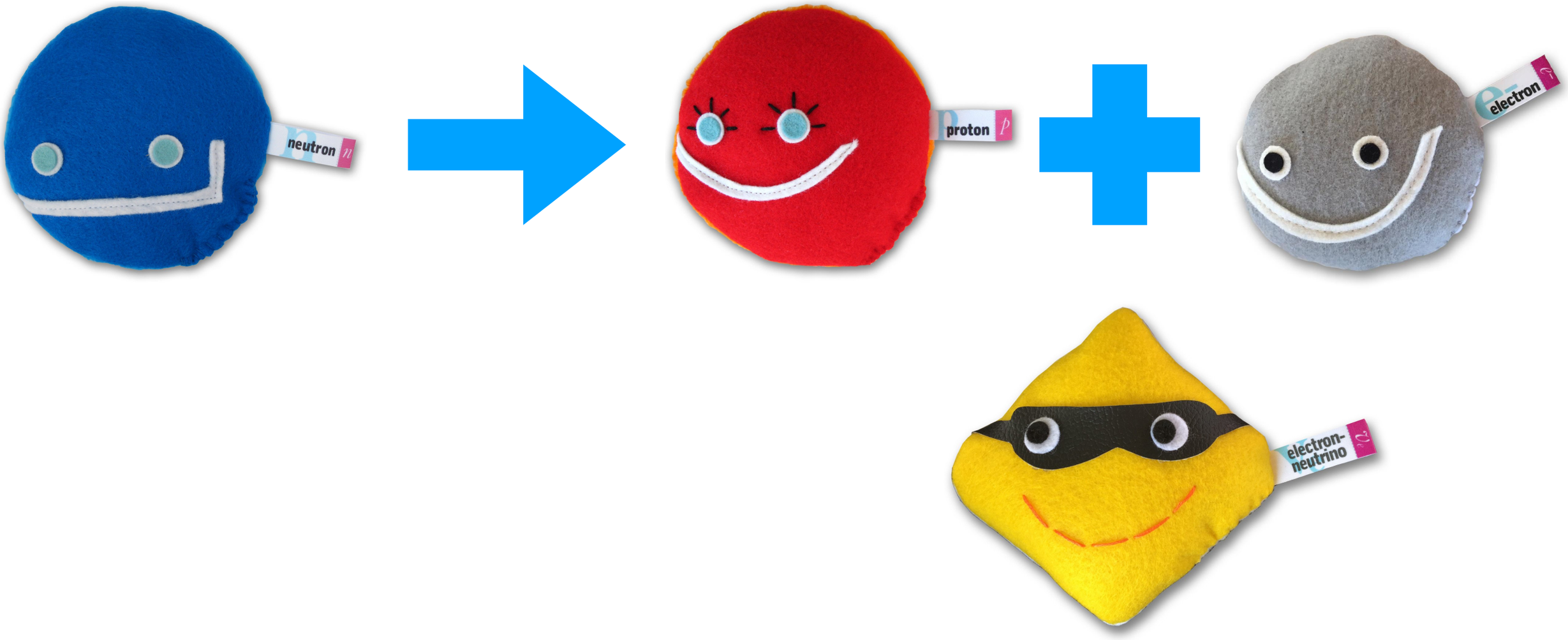


The beta decay problem - Two possible solutions

1. In this decay ENERGY IS NOT CONSERVED !!!

2. There is an invisible particle that carries the missing energy.

The Beta Decay ~~Problem~~ Solution



How Far Can a Neutrino Travel Through Lead ?

140 light-years !!!!

Neutrino's Personality List

1. They don’t like to interact (antisocial members of the particle’s family)

Neutrinos and Their Lepton Partners

They always show up accompanied by their favorite lepton

Electron

Electron-neutrino

Muon

Muon-neutrino

Tau

Tau-neutrino

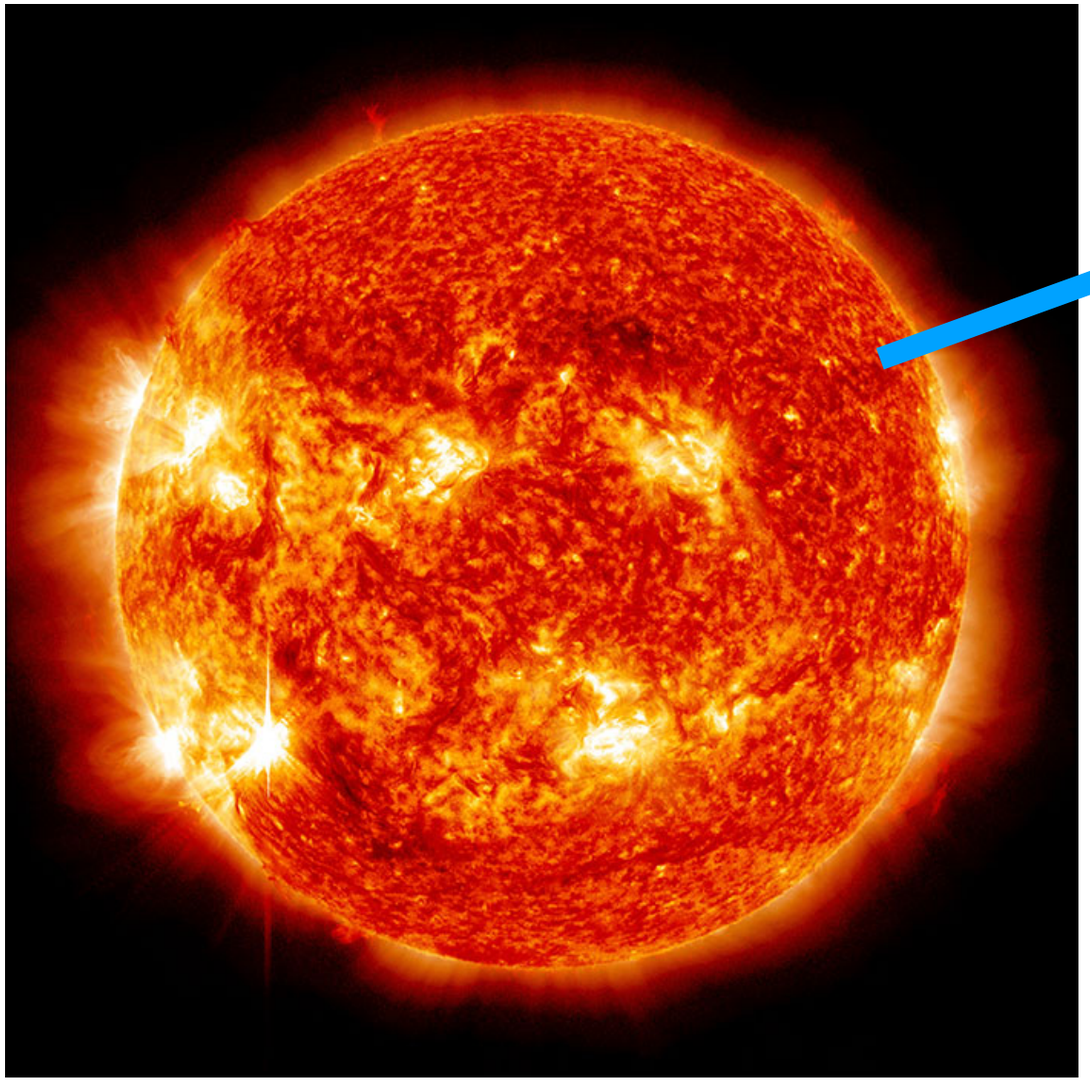
We will name the neutrinos after their lepton partners and call this characteristic “flavor "

Neutrino's Personality List

1. They don’t like to interact (antisocial members of the particle’s family)

2. They come in three flavors:

Solar Neutrinos



Nuclear Fusion

2 x

100 billion of neutrinos per cm^2 per second

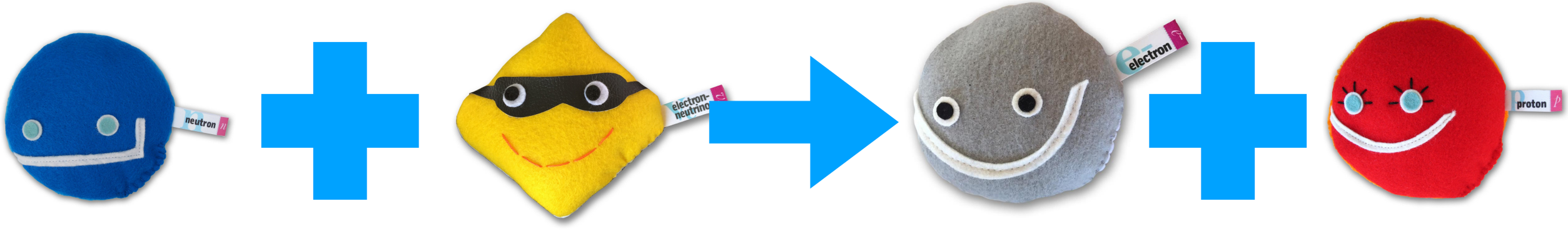
Solar Neutrinos Problem

John Bahcall

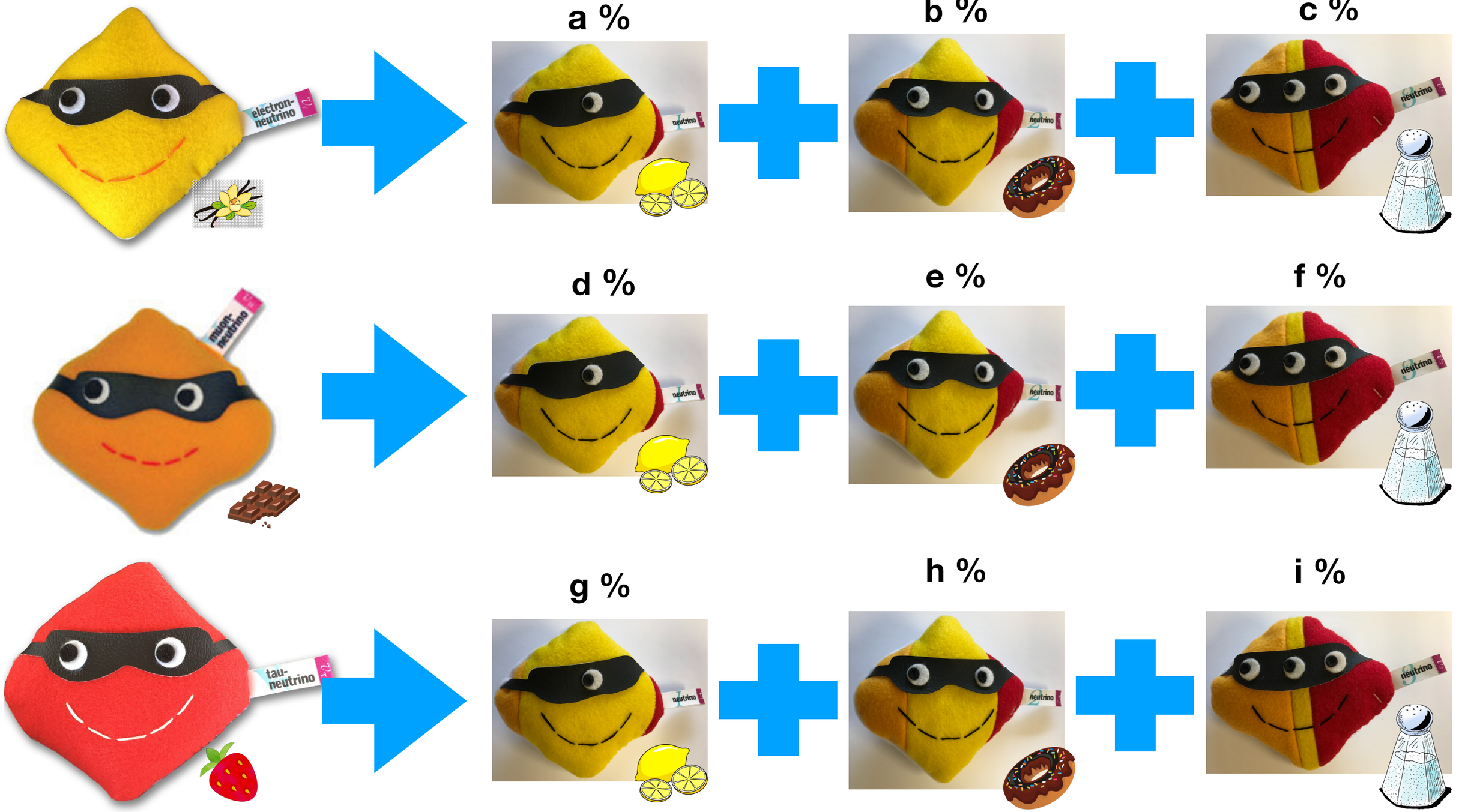
Raymond Davis

Only saw 1/3 of the expected neutrinos !!!!

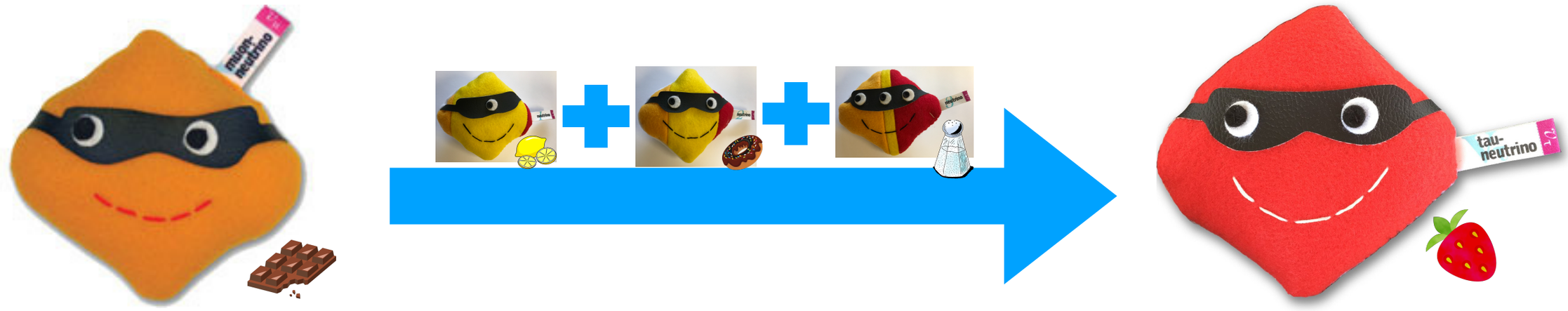
Where were the other 2/3 ????



Solar Neutrinos ~~Problem~~ Solution: Neutrino Oscillation



Solar Neutrinos ~~Problem~~ Solution: Neutrino Oscillation



Produced | Traveling | Interacting

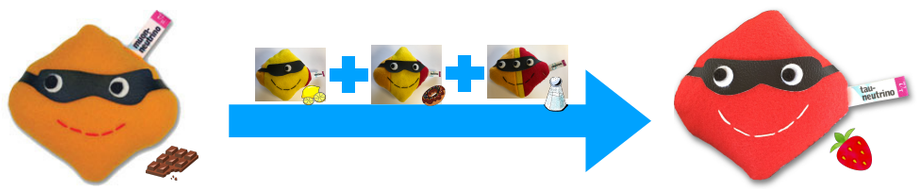
In their way to Earth, the electron-neutrinos produced in the sun turned into the other flavor of neutrinos, and the detector was not sensitive to them!

Neutrino's Personality List

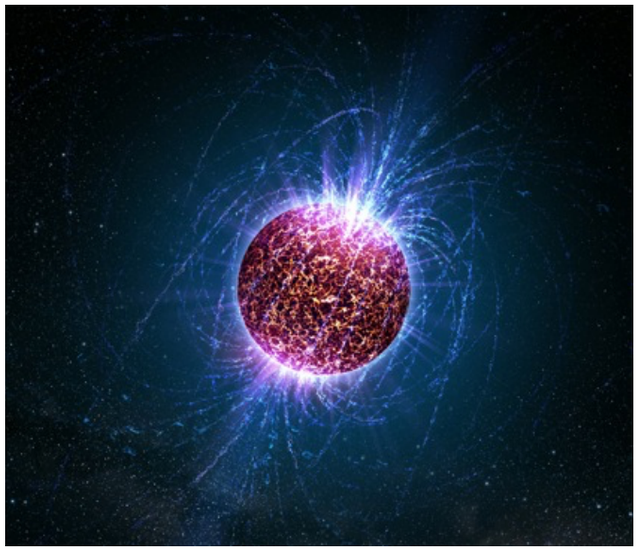
1. They don’t like to interact (antisocial members of the particle’s family)

2. They come in three flavors:

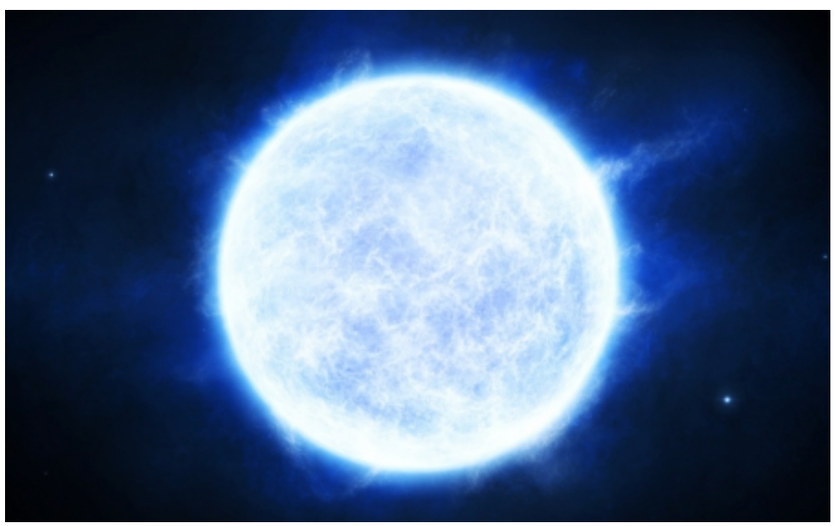
3. When they travel, they "oscillate" between those three flavors !



Supernova neutrinos

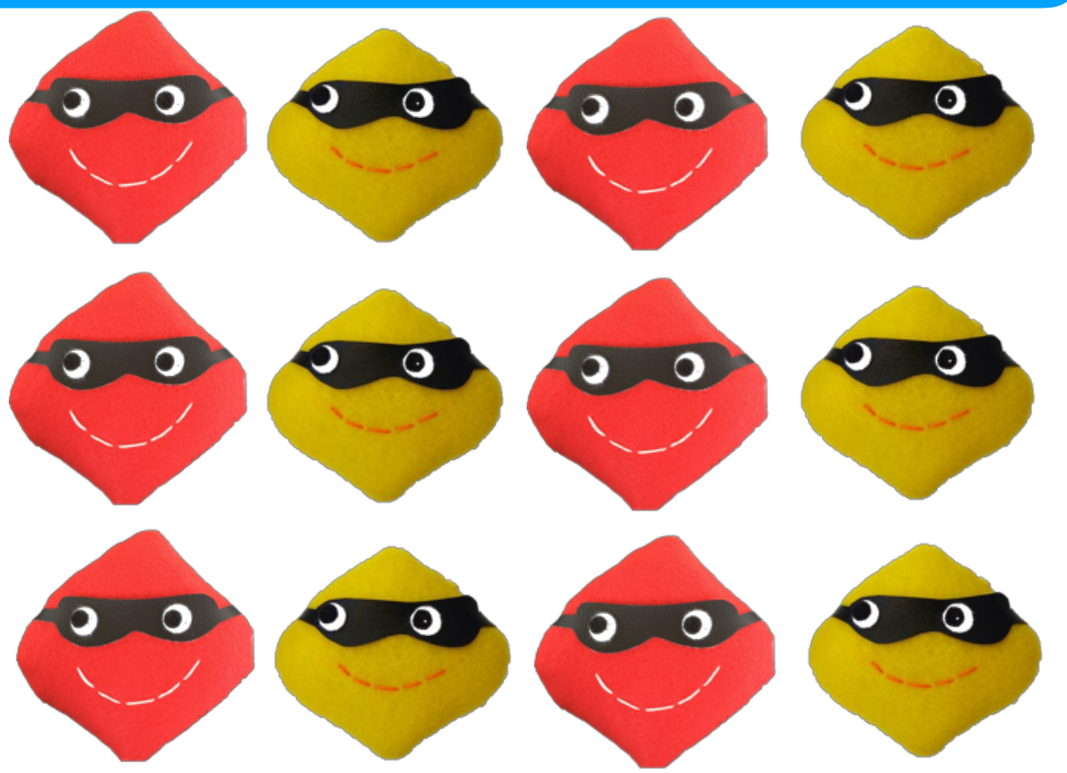


Star explosion

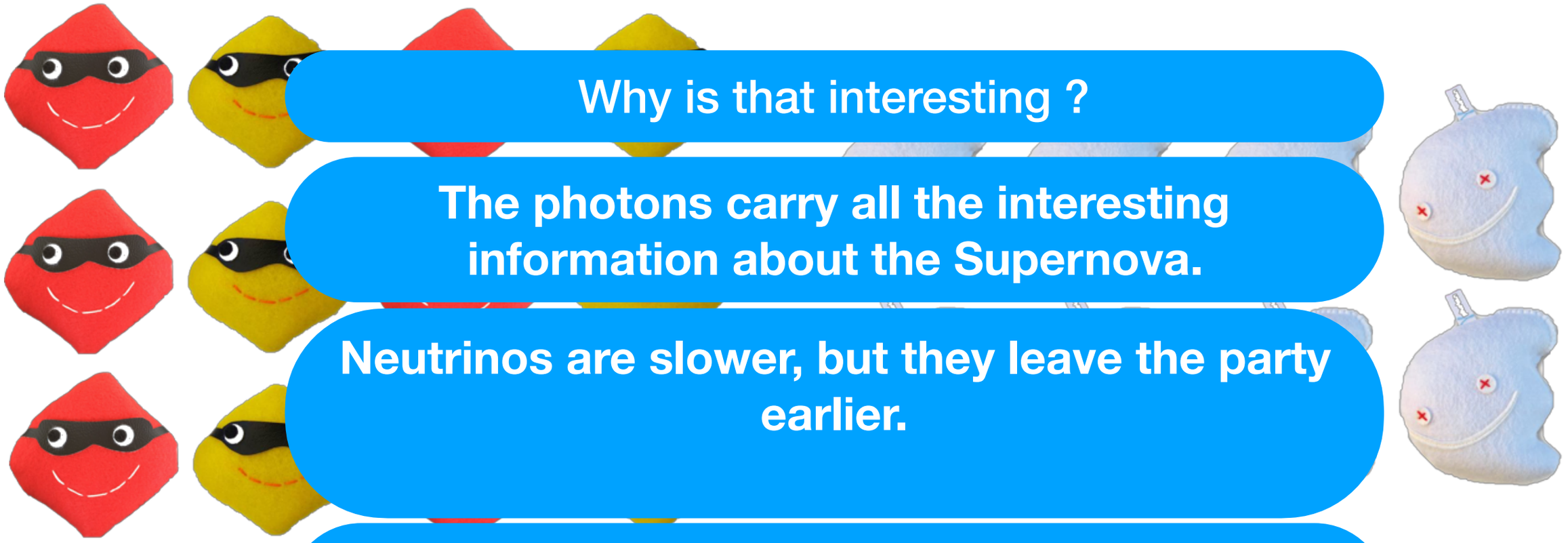


Light == Photons

Neutrinos



Supernova neutrinos



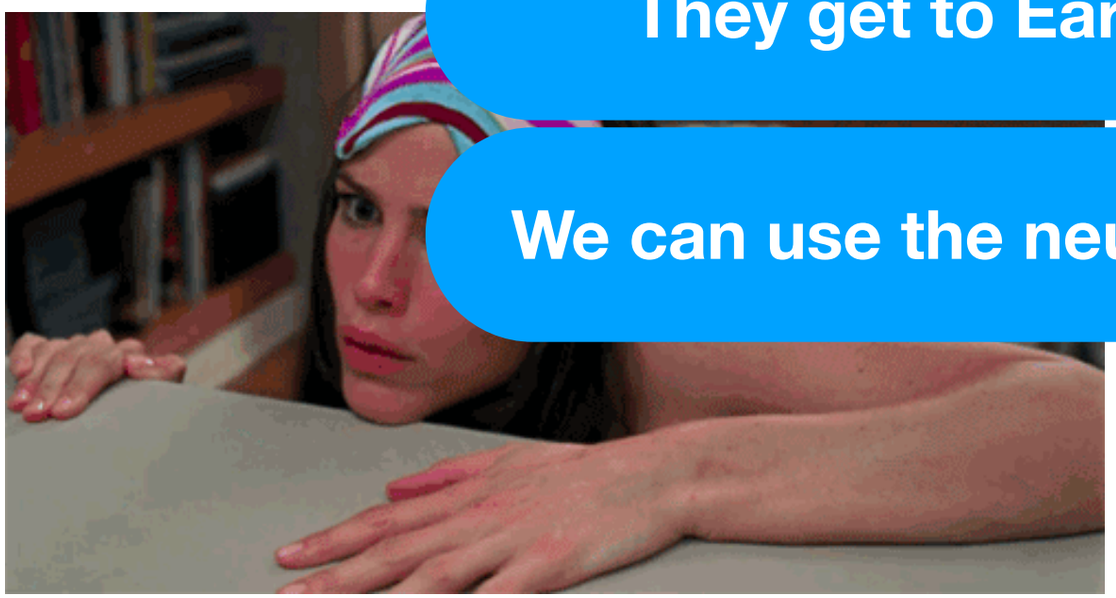
Why is that interesting ?

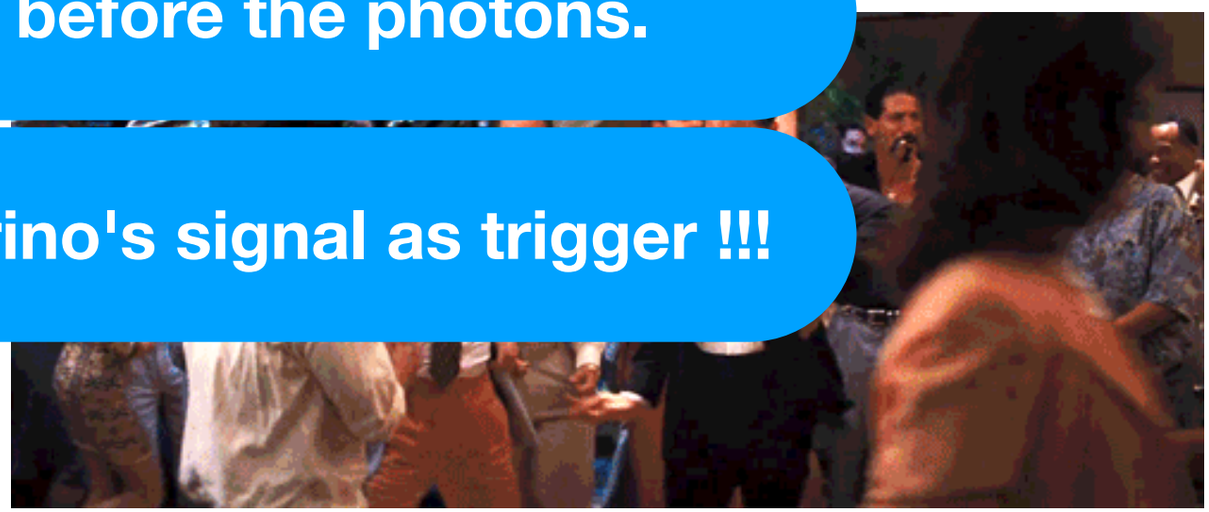
The photons carry all the interesting information about the Supernova.

Neutrinos are slower, but they leave the party earlier.

They get to Earth before the photons.

We can use the neutrino's signal as trigger !!!





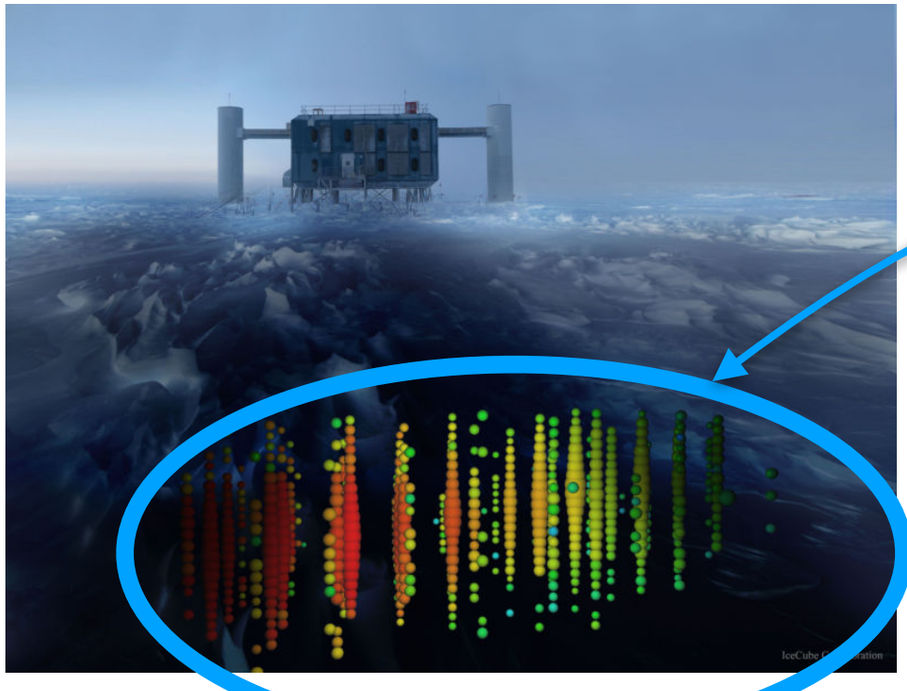
How Do We Measure Supernova Neutrinos?

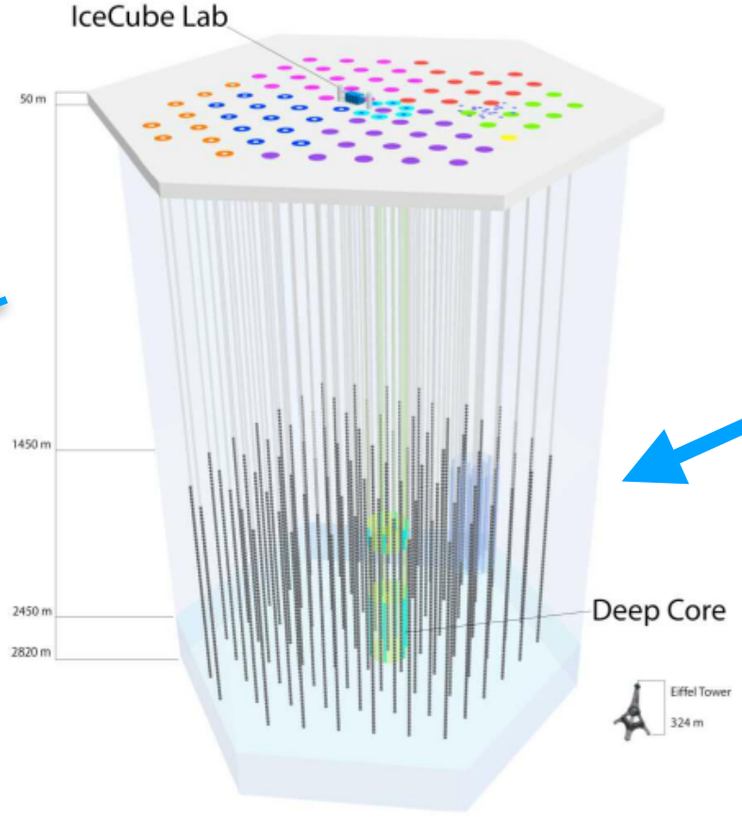
We need a big, dense detector.

We can use the ice at Antarctica !!!

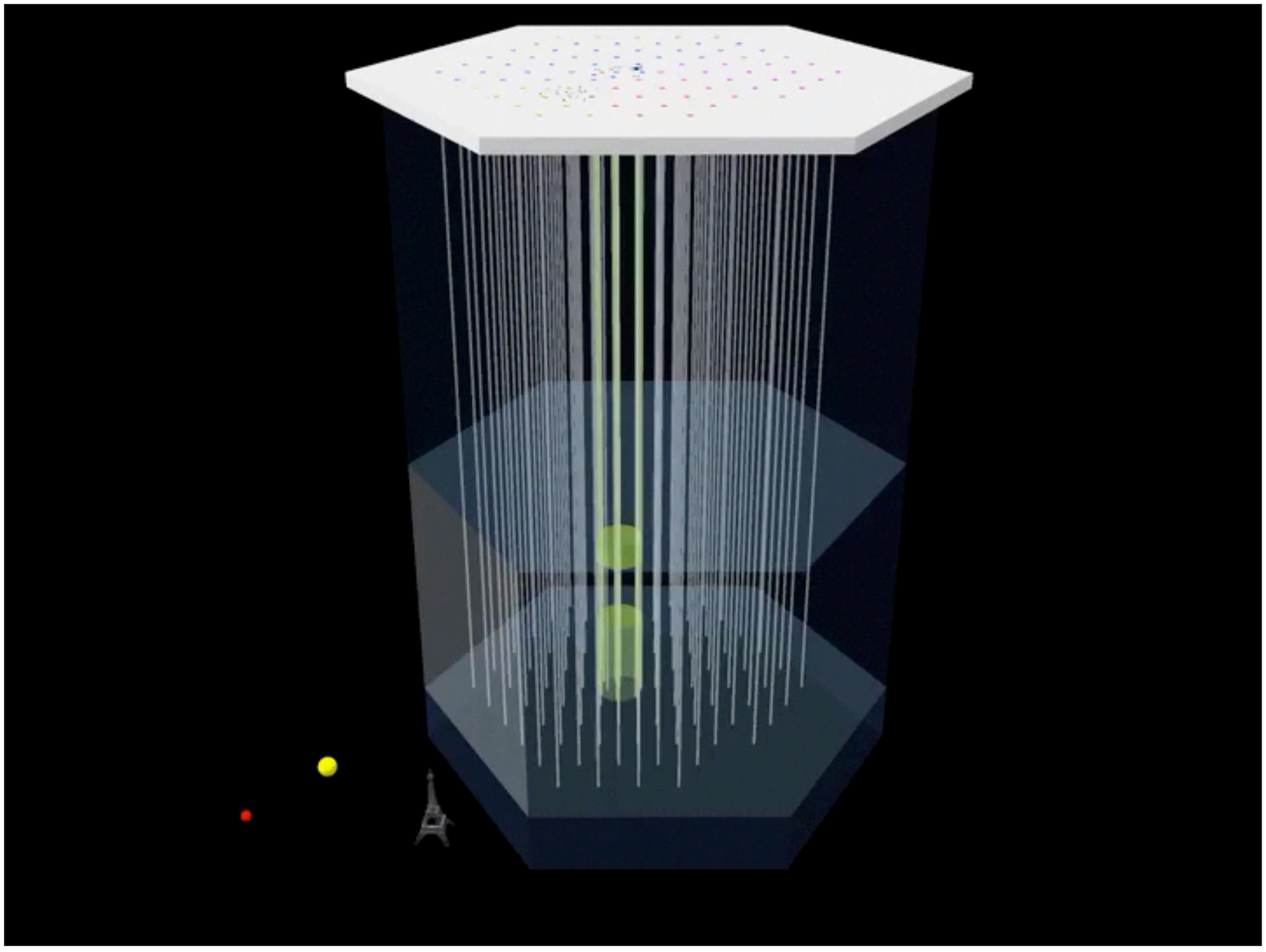
We dig huge holes in the ice

x 60





IceCube Neutrino Observatory



RESEARCH ARTICLE | NEUTRINO ASTROPHYSICS

Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A

The IceCube Collaboration, *Fermi*-LAT, MAGIC, *AGILE*, ASAS-SN, HAWC, H.E.S.S., *INTEGRAL*, Kanata, Kiso, Kapteyn, Liverp…

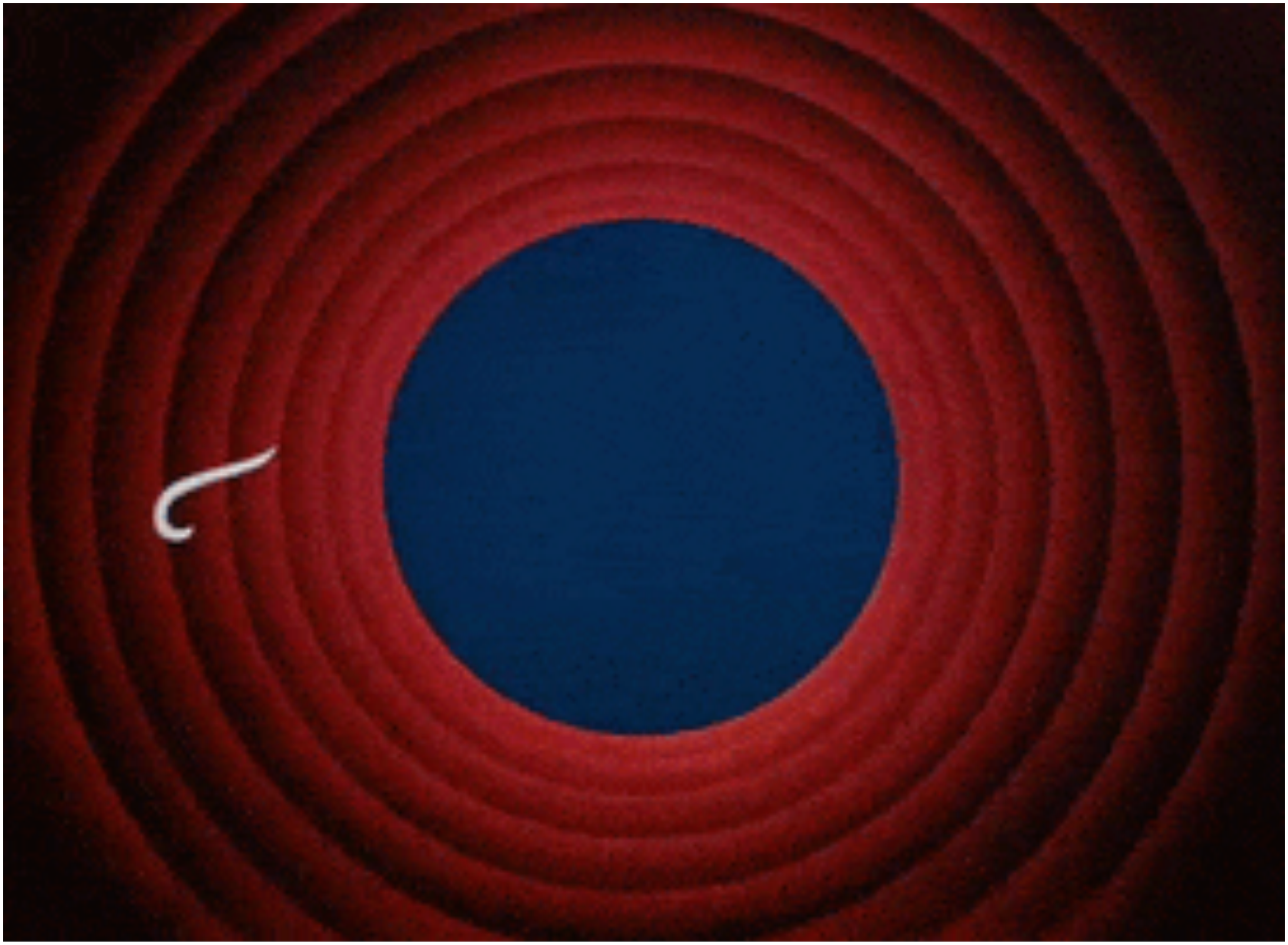
+ See all authors and affiliations

Science 12 Jul 2018:
eaat1378
DOI: 10.1126/science.aat1378

The Particle Zoo

https://www.particlezoo.net/

THANKS!!



References

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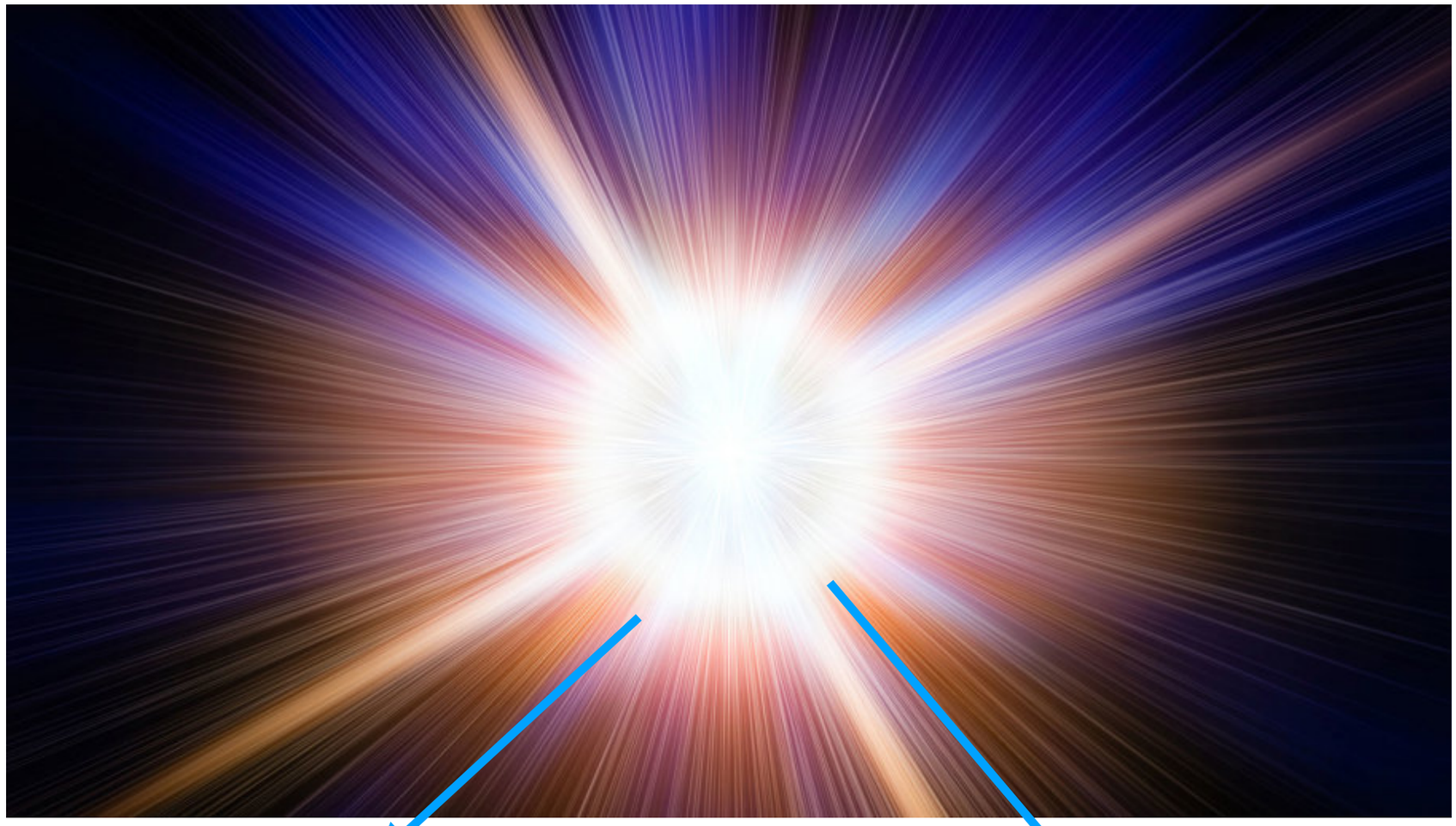
• Kouchner, A., High Energy Neutrino Astronomy and Neutrino Telescopes, available at http://iopscience.iop.org/article/10.1088/1742-6596/593/1/012008/pdf

Backup

Matter- Antimatter Asymmetry



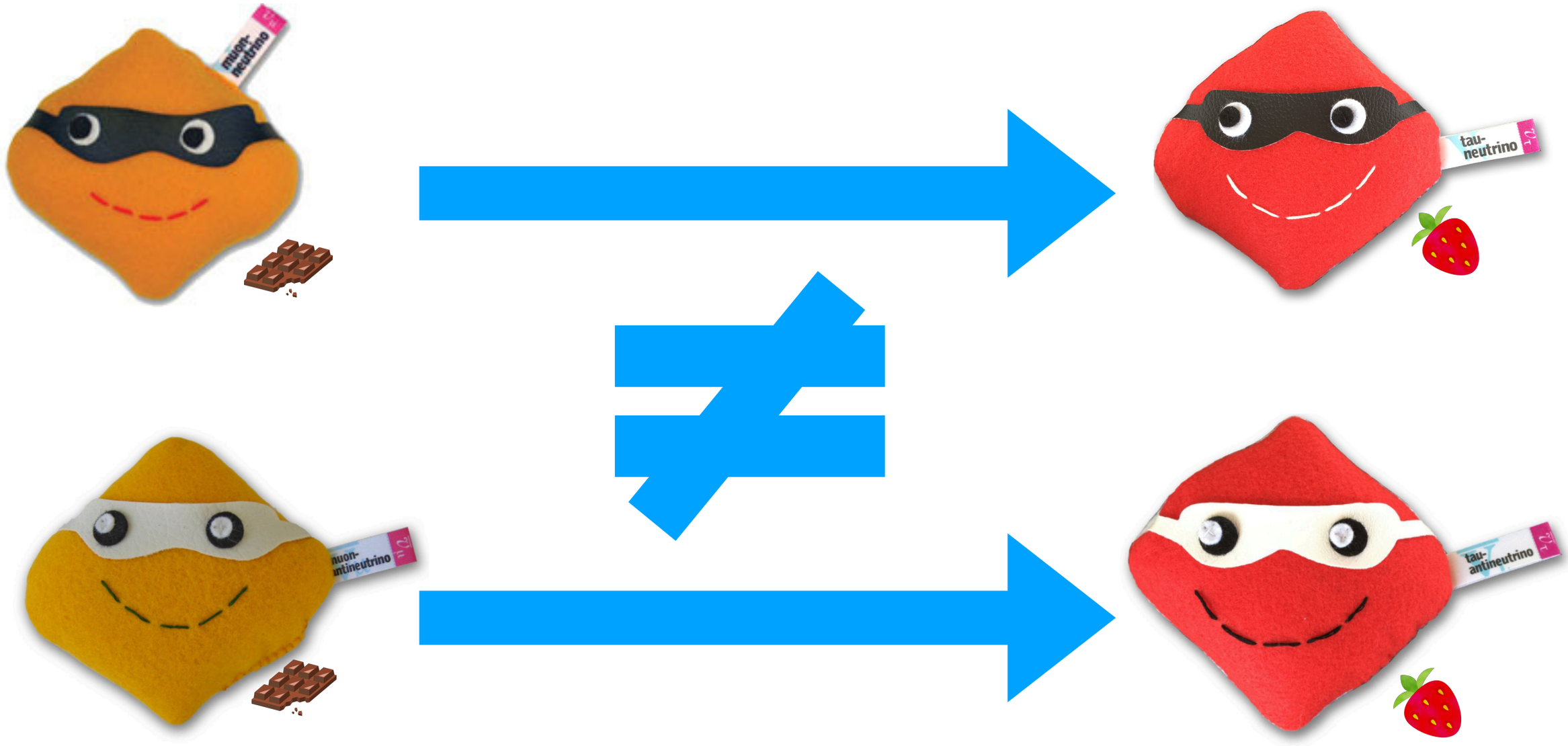
Particles

Antiparticles

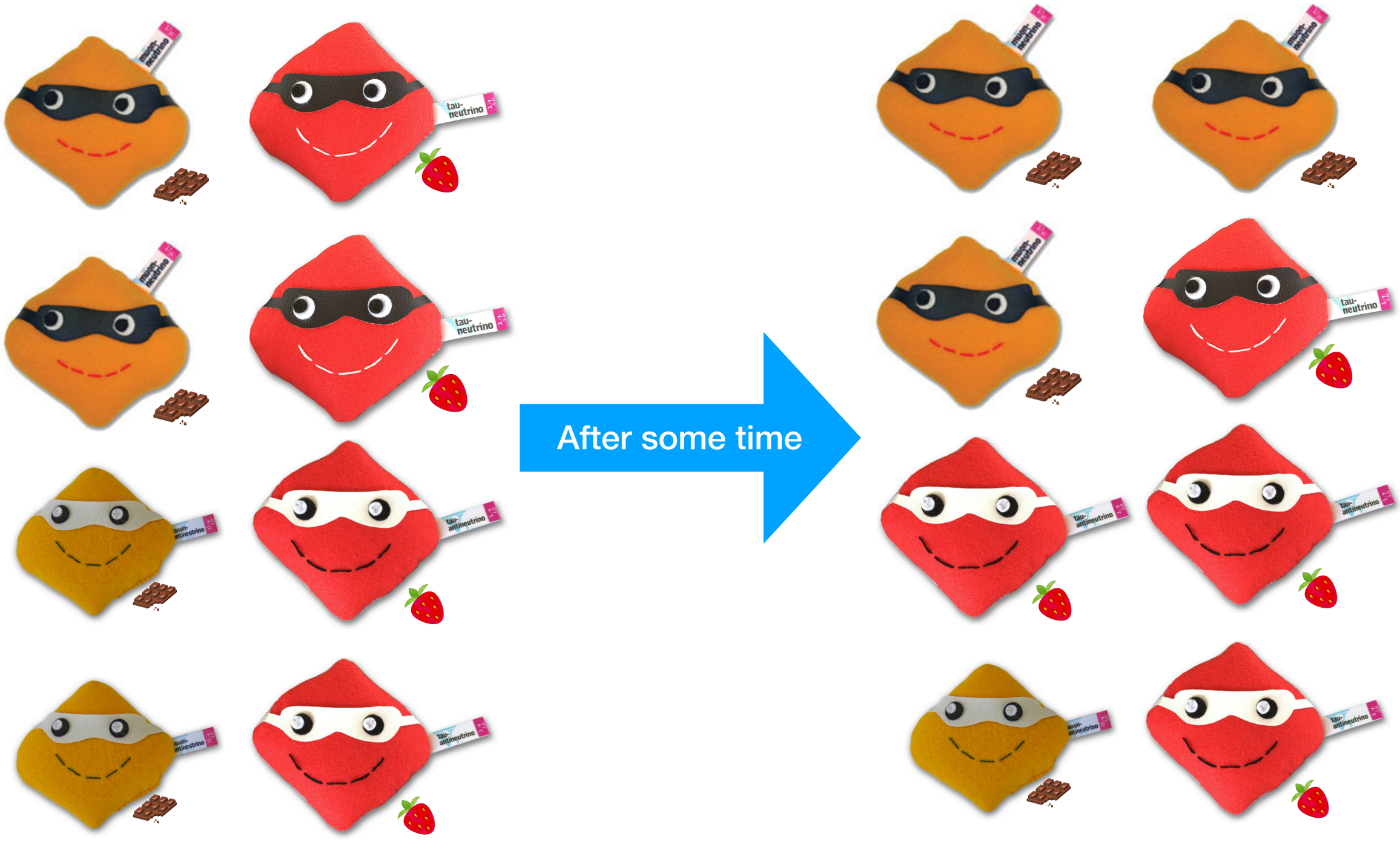
Matter- Antimatter Asymmetry

There should be only photons left!!!

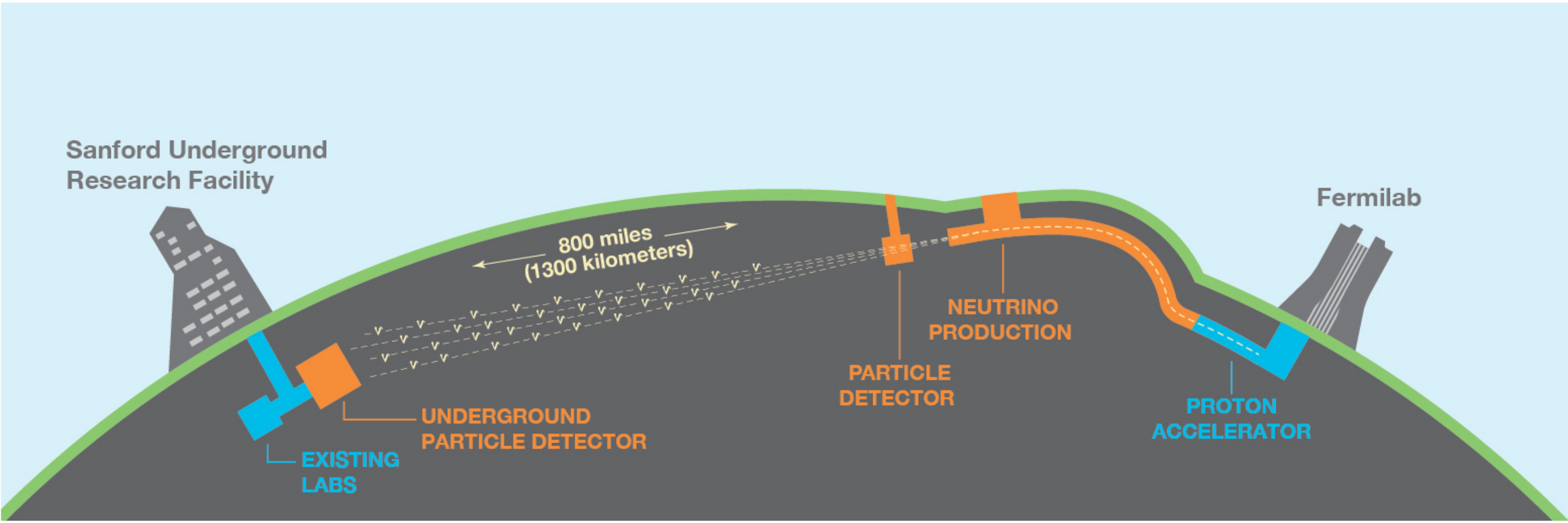
Matter- Antimatter Asymmetry



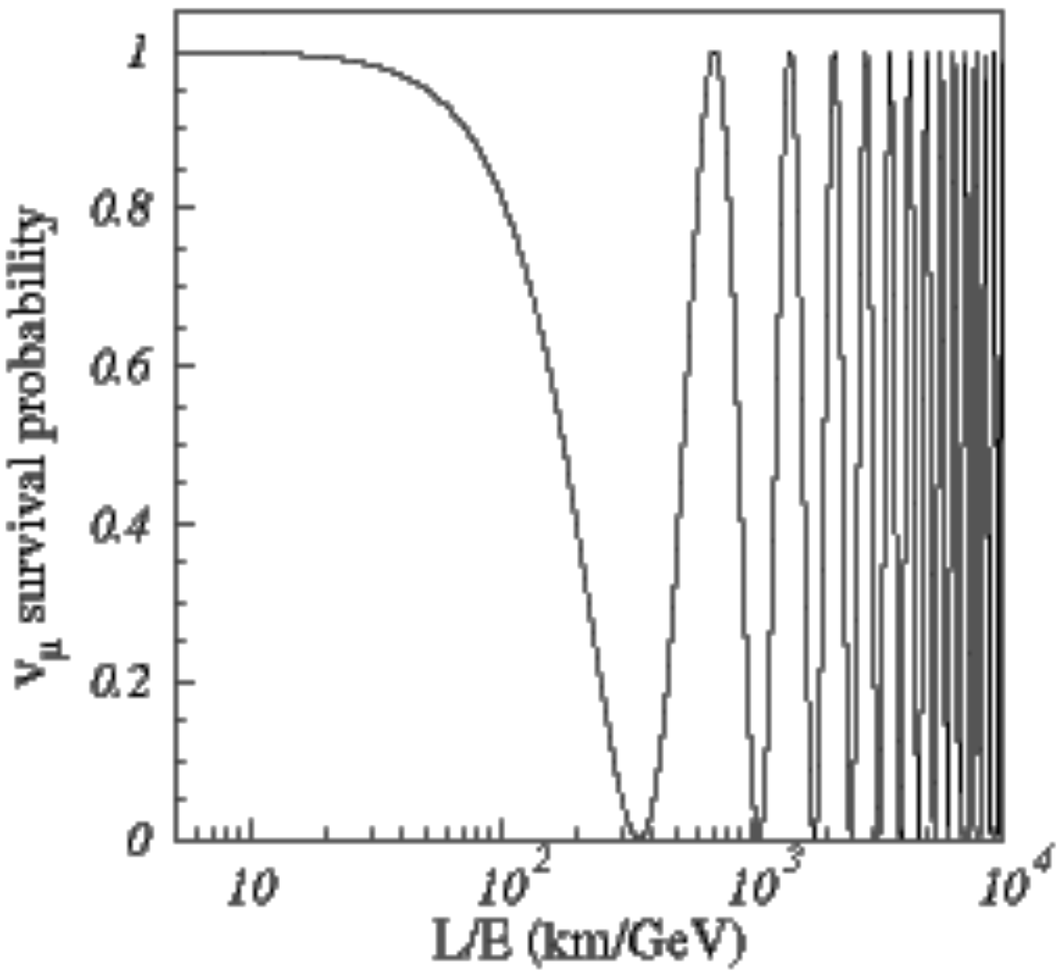
Matter- Antimatter Asymmetry



DUNE


Sanford Underground
Research Facility
800 miles
(1300 kilometers)
Fermilab
NEUTRINO
PRODUCTION
PARTICLE
DETECTOR
PROTON
ACCELERATOR
UNDERGROUND
PARTICLE DETECTOR
EXISTING
LABS

DUNE


1
0.8
0.6
0.4
0.2
0
ν_μ survival probability
10
10^2
10^3
10^4
L/E (km/GeV)