# A PANtastic Week!

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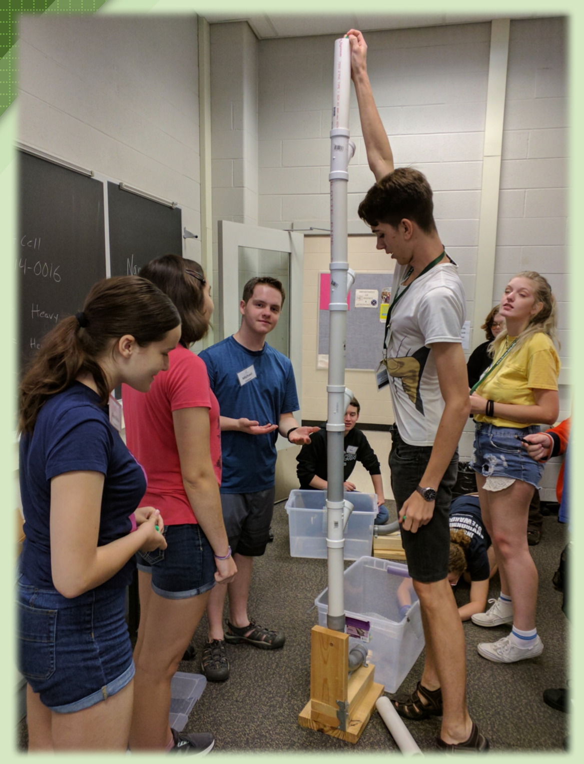
## Day 1

Our first day at PAN, we were introduced to the basic concepts of nuclear physics.

We started with magnetic marble "Carbon-12 nucleus" collisions in order to observe for ourselves how particle colliders create new isotopes. *(left)*



-Particle accelerators cause these collisions by using very high voltage.

The first superconducting cyclotron in the world, at NSCL, is on the MSU campus.

-Pancake, football, and bubble shaped nuclei all exist.

We then learned about binding energy by calculating the binding energy of different isotopes and then assembling a table of the nuclides with Lego bricks. The heights of the brick towers corresponded to the binding energies per nucleon of the different isotopes. *(top)*

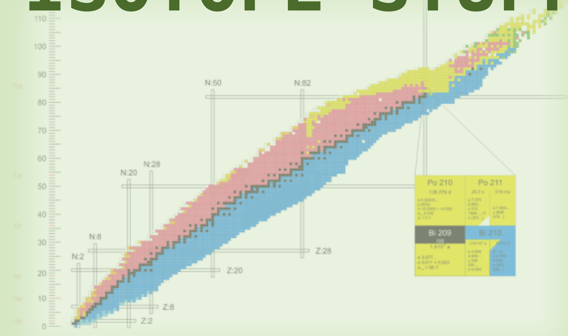
-Nuclei always want to get to a lower energy state

-Isotopes are unstable because of excess energy.

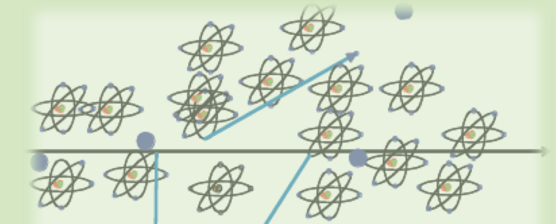
-The most stable nuclei have the highest binding energy holding them together

-Binding energy comes from the mass of their own nucleons (protons and neutrons)

### ISOTOPE STUFF



## Day 2



### DETECTORS

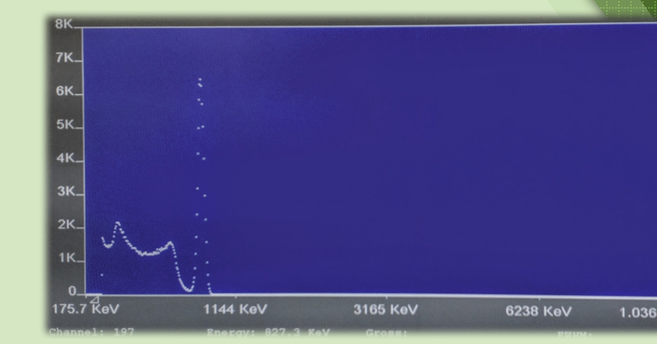
-The goal of radiation detectors is to determine properties such as the mass, energy, & velocity of particles.

-Radiation in the form of charged particles can be detected with an electrical field.

-Gamma radiation can be observed using a scintillator.

We started our day off with a talk from experimental nuclear physicist Marco Cortesi about particle and radiation detectors and how they work.

We headed to the lab to learn how to use actual radiation detectors *(top)* in order to find out the identity of a "mystery isotope" by graphing its gamma ray counts and comparing them to known gamma ray energies of radioisotopes . *(right)*

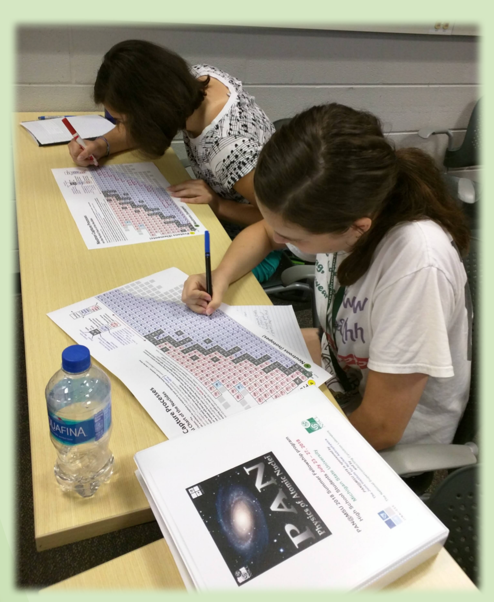


The software we calibrated with cobalt 60 was called UCS20, which maps gamma ray counts.

Using a detector, these gamma rays were counted and logged into UCS20, where visible "photopeaks" began to take shape.

Using the measured energies of its photopeaks, the isotope (which turned out to be manganese 54) was then found on the LBNL radiation search engine.

## Day 3



Nuclear astrophysicist Luke Roberts gave a talk about how the elements were created in the early universe and inside stars and supernovae, and we learned about neutron capture by charting its path through the chart of nuclides *(left)*

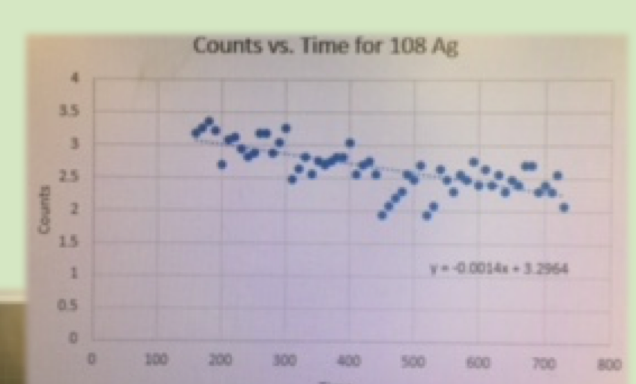
Then, to become more familiar with nuclear physics, we carried out an experiment using radiation detectors called Geiger-Müller counters in order to calculate the average half-life of two unstable isotopes of silver, 108Ag and 110Ag *(bottom),* 286.07 sec.

### THE LIFE OF A STAR

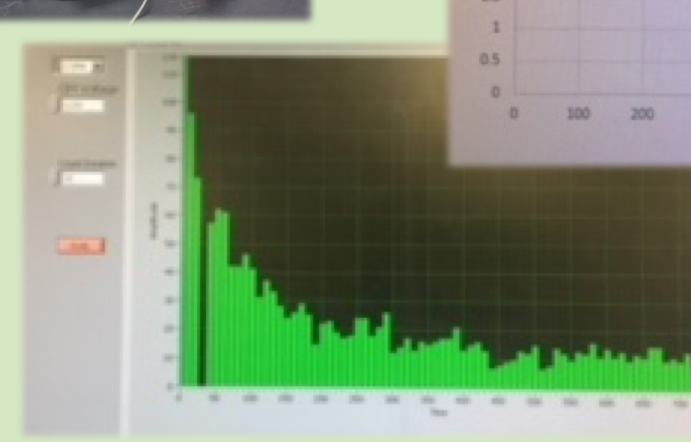
Stars like our sun first go through a long, multi-billion-year process of fusing hydrogen atoms together into helium.

More massive stars burn heavier elements, all the way up to iron.

The heaviest elements are created through neutron capture and beta decay.







Geiger-Müller counters detect radioactivity given off by a radioactive isotope.

Shown here is the half life curves for silver 108.

## Day 4

The fourth day of PAN started with a talk from astronomer Brian O'Shea, who enlightened us about the life cycle of galaxies, how different wavelengths of light are used by telescopes, and what Fermi Bubbles are. *(right)*

Later, theoretical nuclear physicist Alex Brown came in to talk about quantum properties and guided us through a theoretical nuclear shell model experiment *(bottom)*.

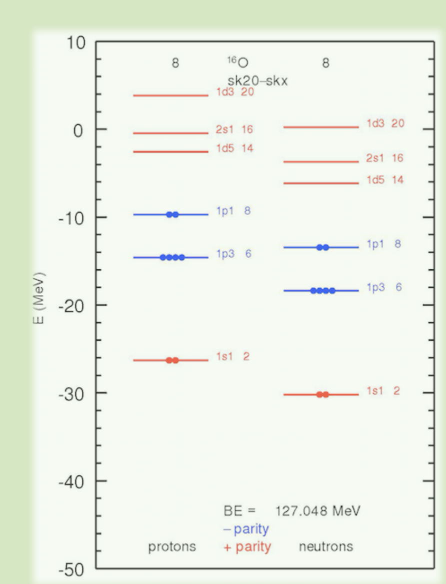
### SPACING OUT

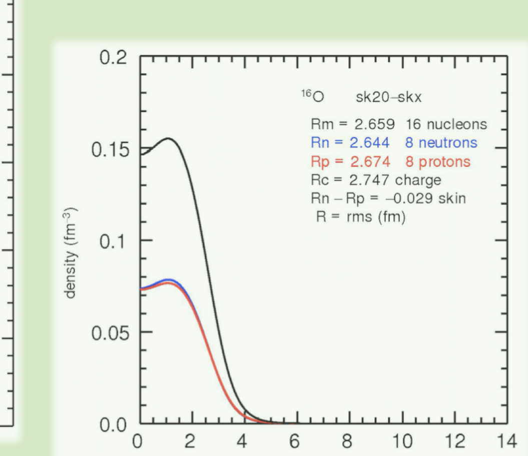
Fermi Bubbles are streams of very hot and very fast plasma, traveling close to the speed of light, coming out of supermassive black holes observed in the center of galaxies like ours.

Dr. Brown wrote a program that can predict properties of nuclei. These are predicted values of oxygen 16.

Like electrons, protons and neutrons also exist in different energy states *(right)*

The program also graphed the density of the nucleus as a function of distance from the center. *(far right)*





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