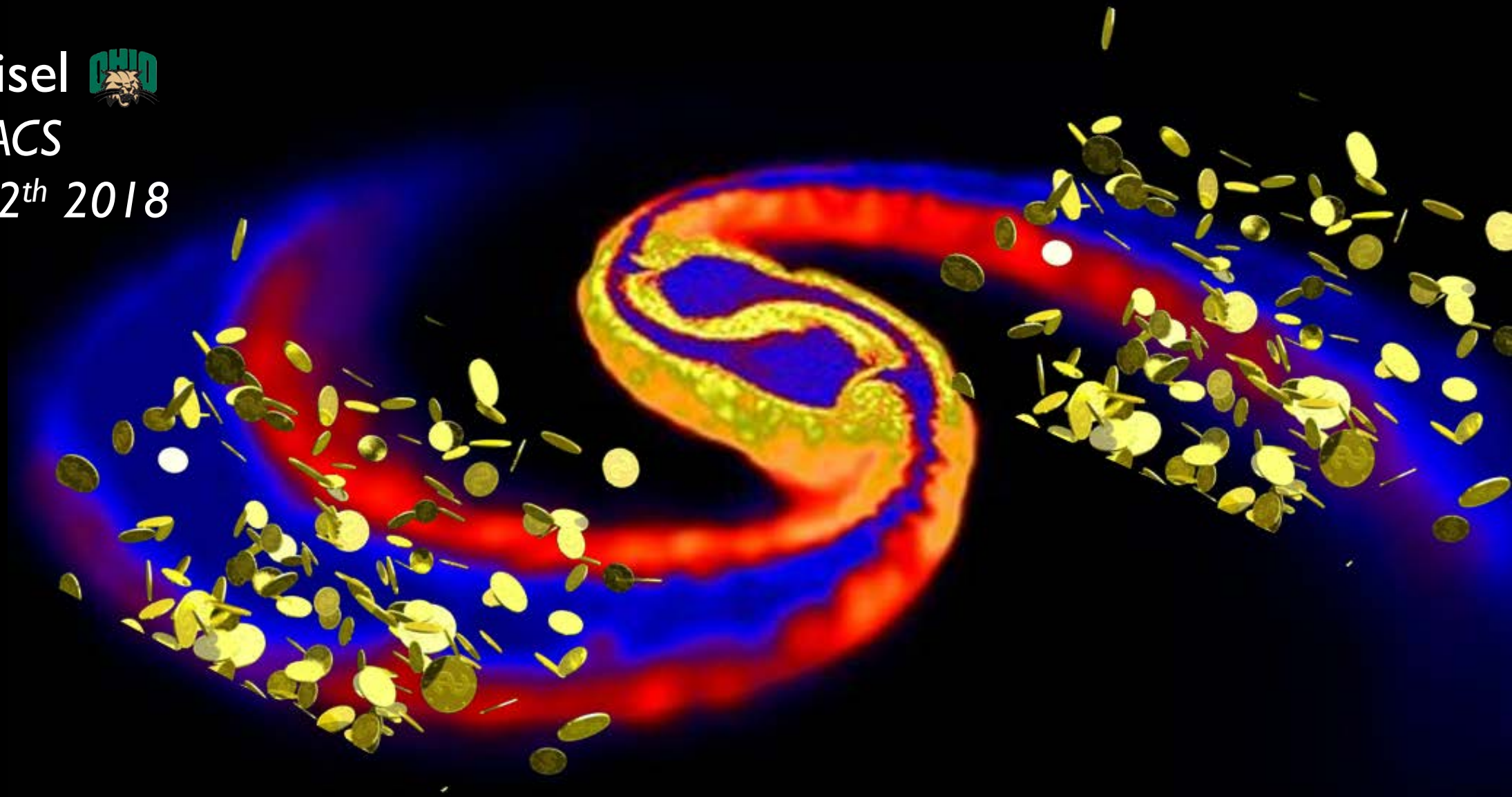
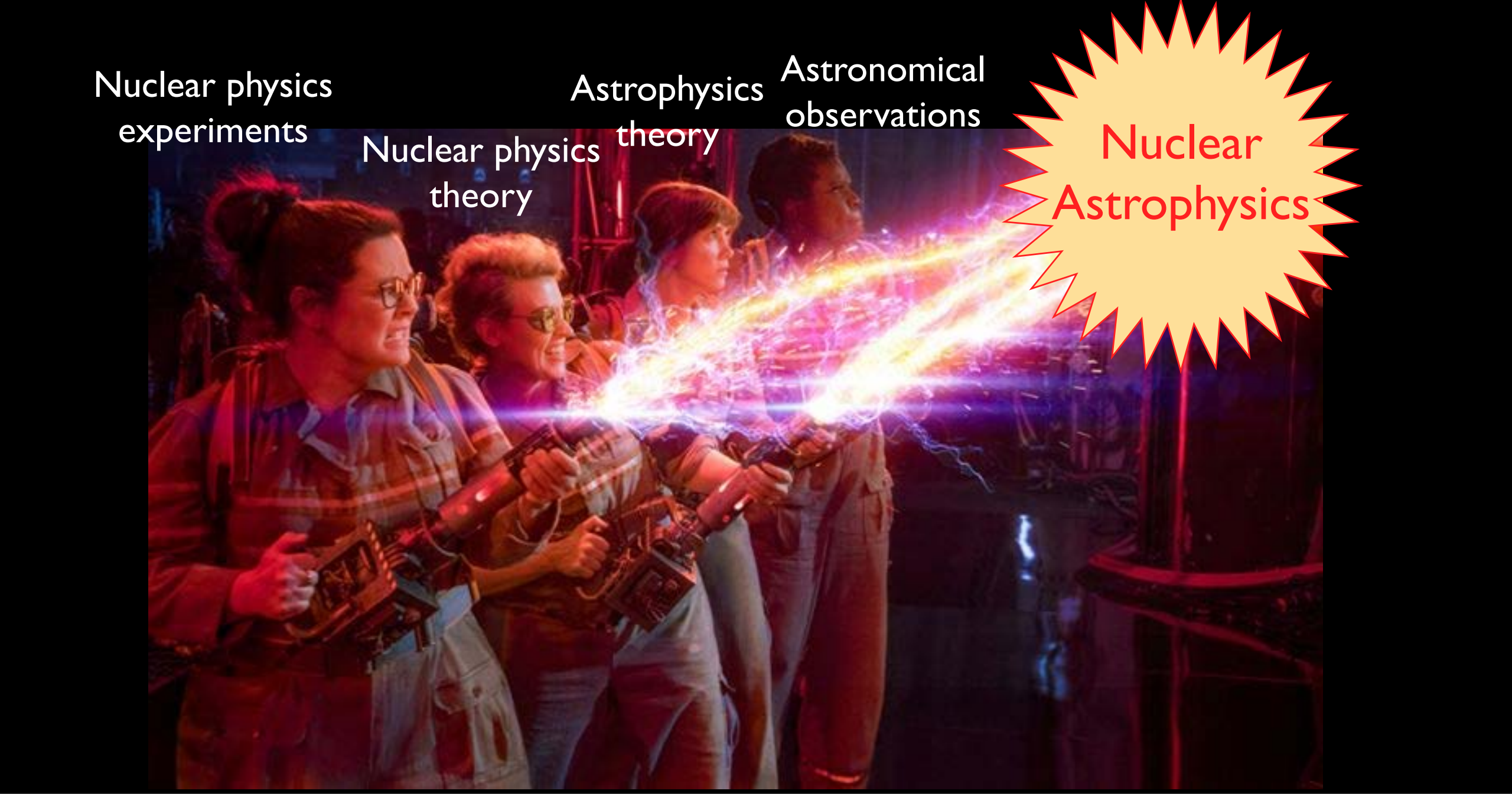
Nuclear Chemistry in the Cosmos:
The Birth of Elements in Stellar Death

Zach Meisel

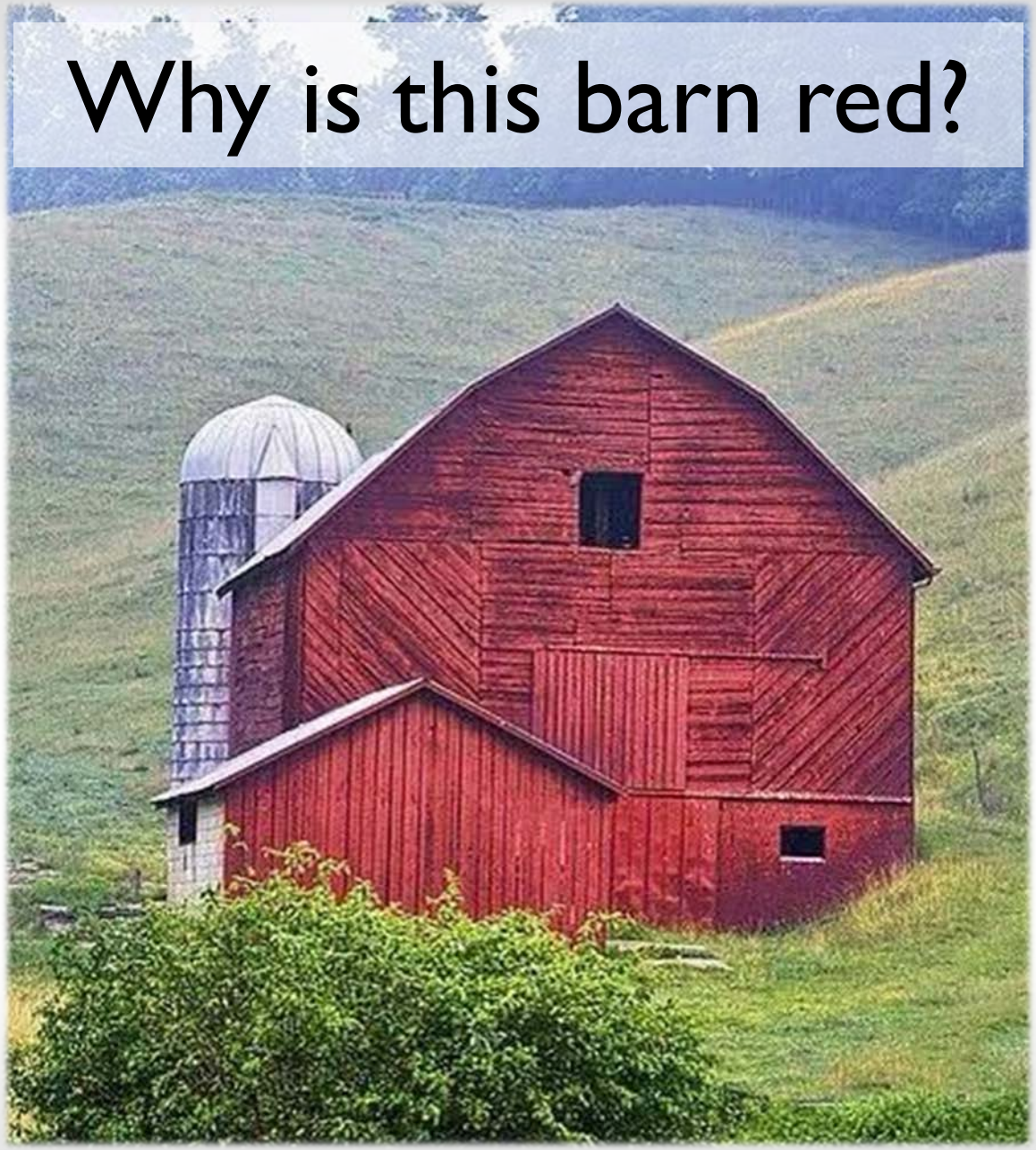
Columbus ACS

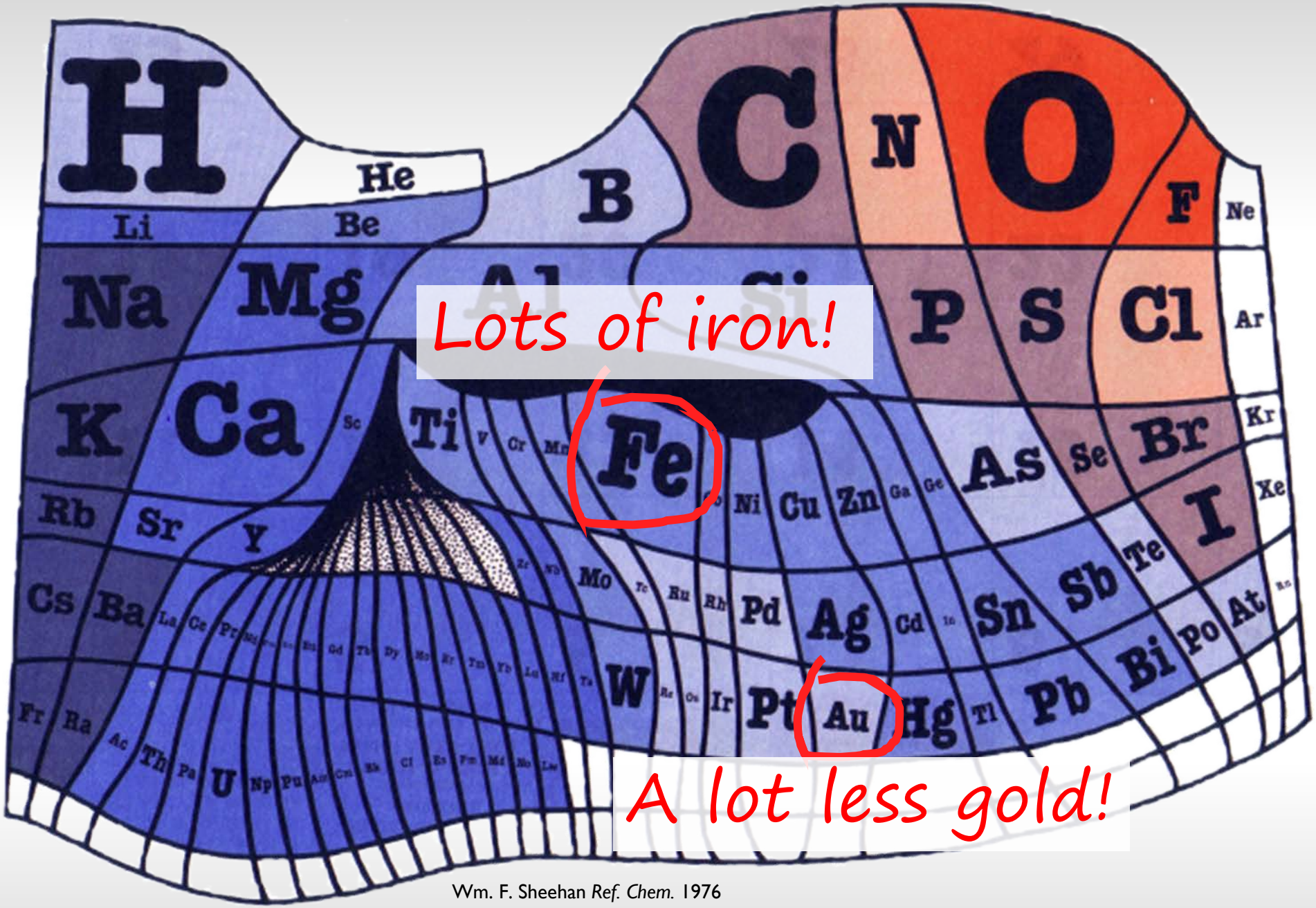
February 12th 2018




Nuclear physics experiments
Nuclear physics theory
Astrophysics theory
Astronomical observations
Nuclear Astrophysics

Why is this barn red?



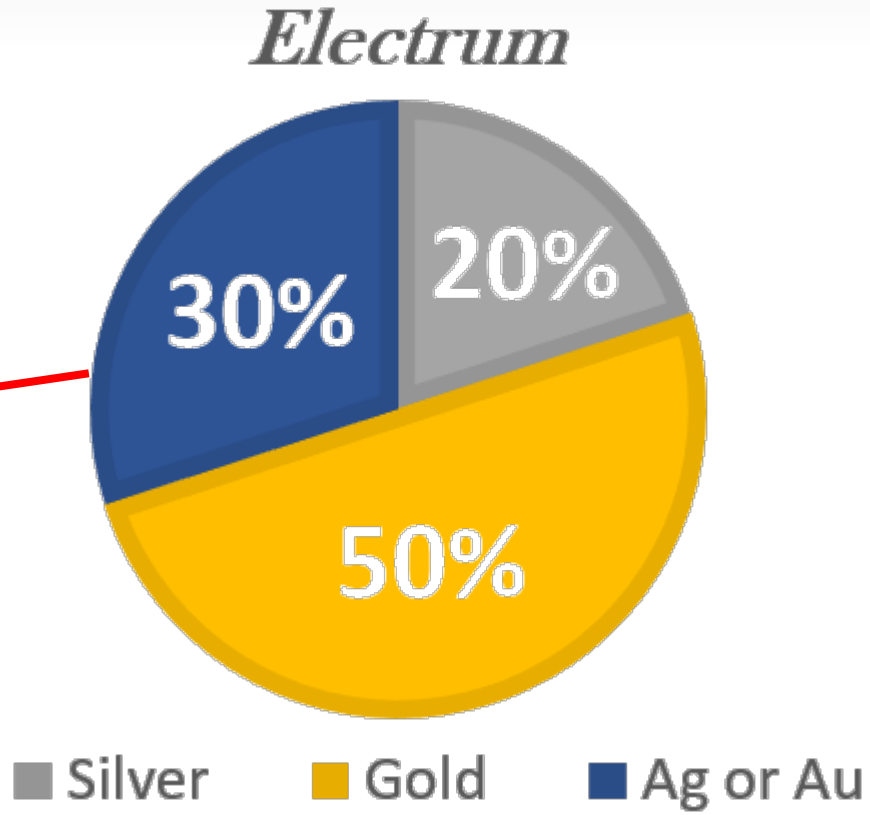


Wm. F. Sheehan *Ref. Chem.* 1976

Where did this come from?

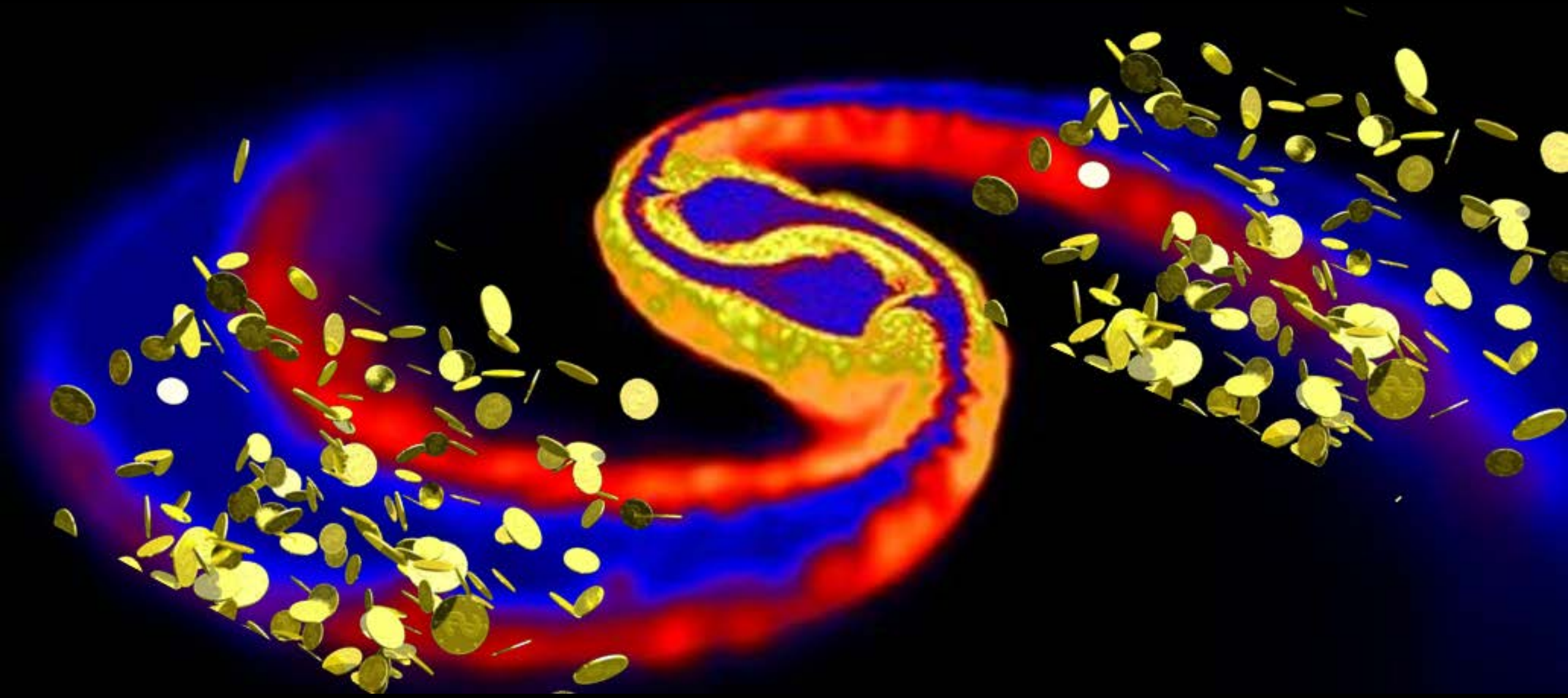
"I am the badge of Phanes"

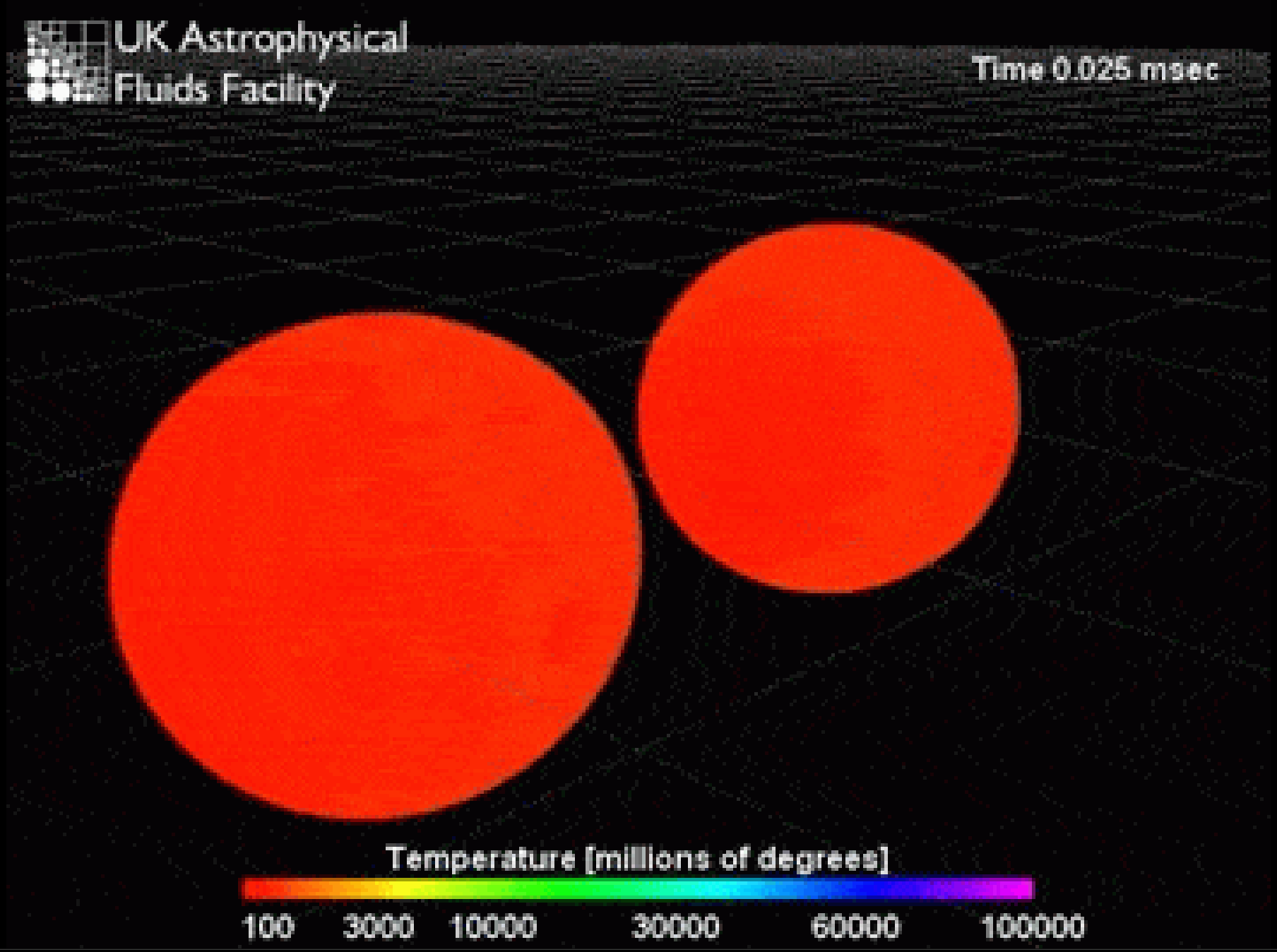
Where did this come from?

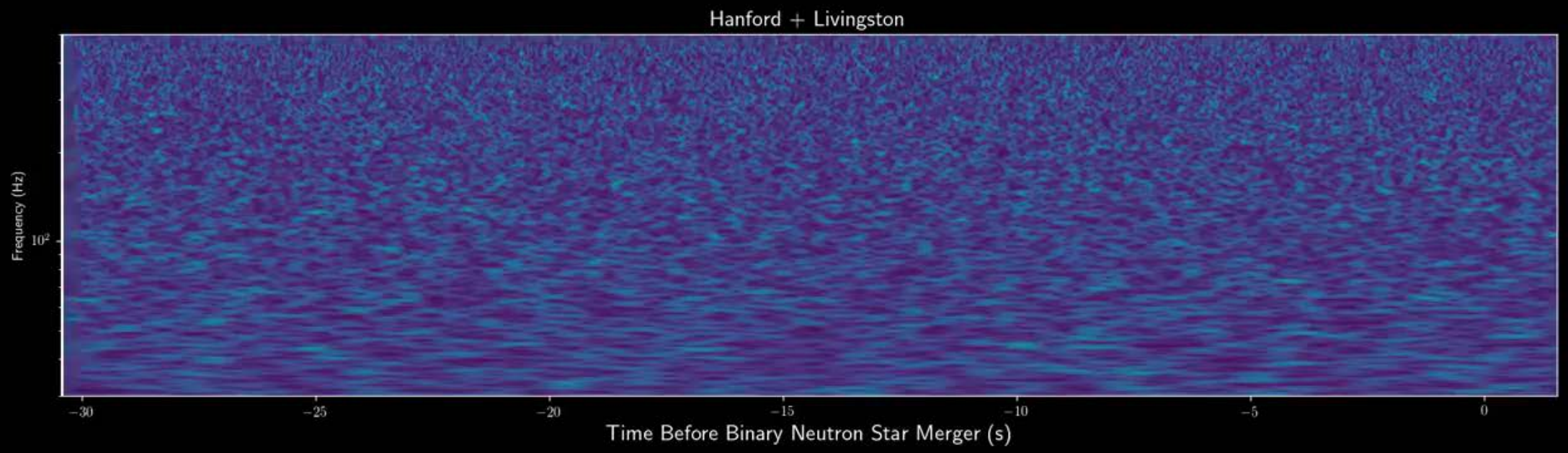


Where is gold made?

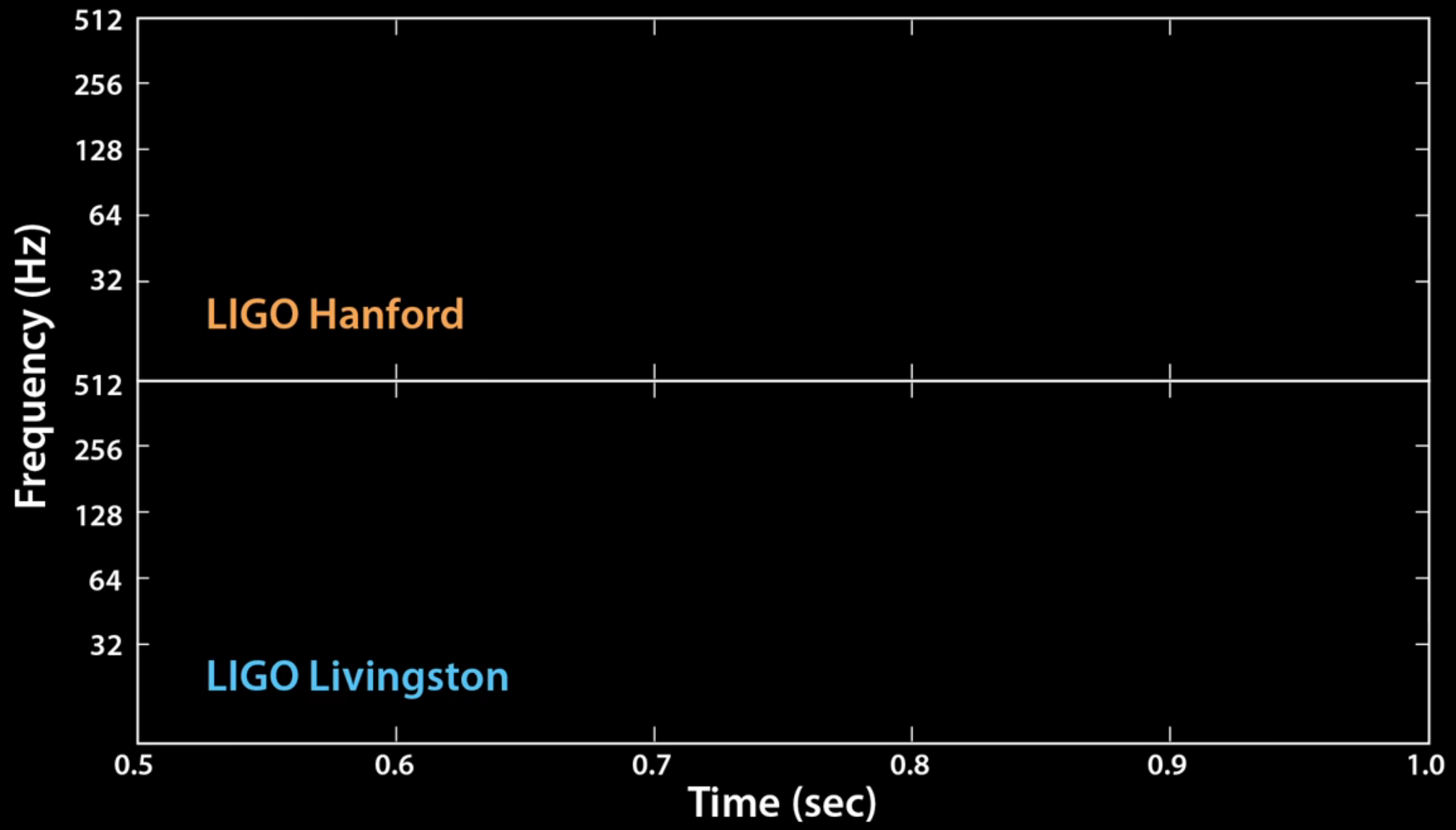
Where is gold made?




UK Astrophysical
Fluids Facility
Time 0.025 msec
Temperature [millions of degrees]
100
3000
10000
30000
60000
100000

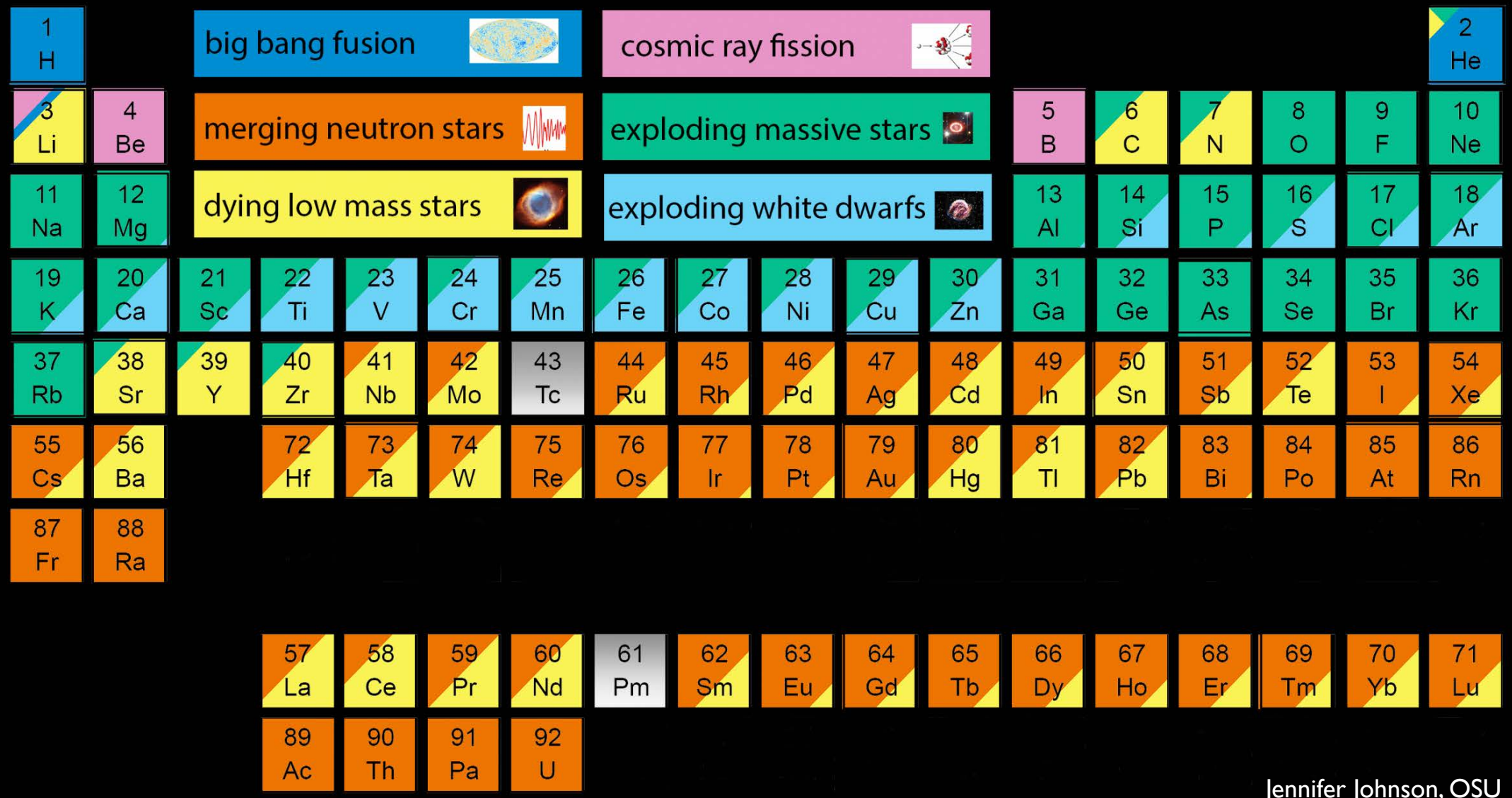


LIGO/VIRGO NS Merger: https://www.youtube.com/watch?v=_SQbalLipjY



LIGO BH Merger: https://www.youtube.com/watch?v=QyDcTbR-kEA

Everything around you was processed in a star



Jennifer Johnson, OSU

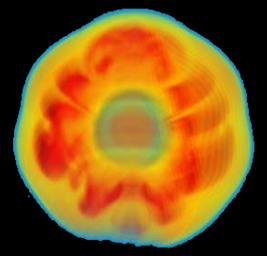
Everything around you was processed in a star

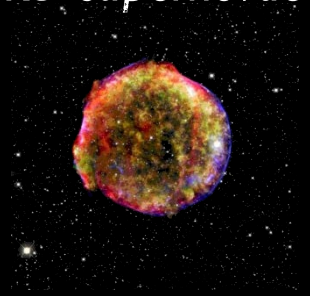
Regular stars made ~1/2 of the stuff around you

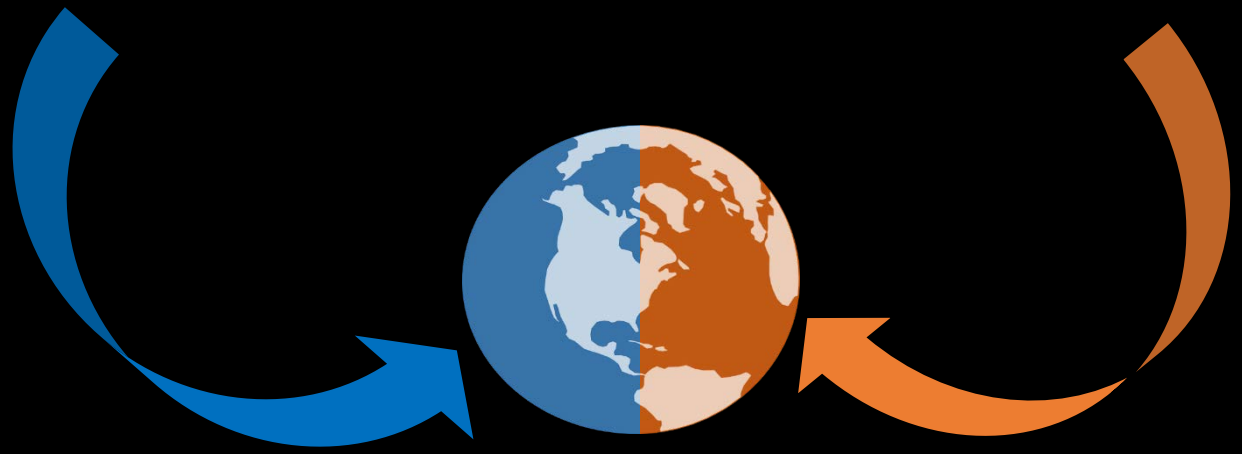
Most stars eventually become *'planetary nebulae'*

Stellar explosions made most of the rest

Some stars explode, like *'supernovae'*





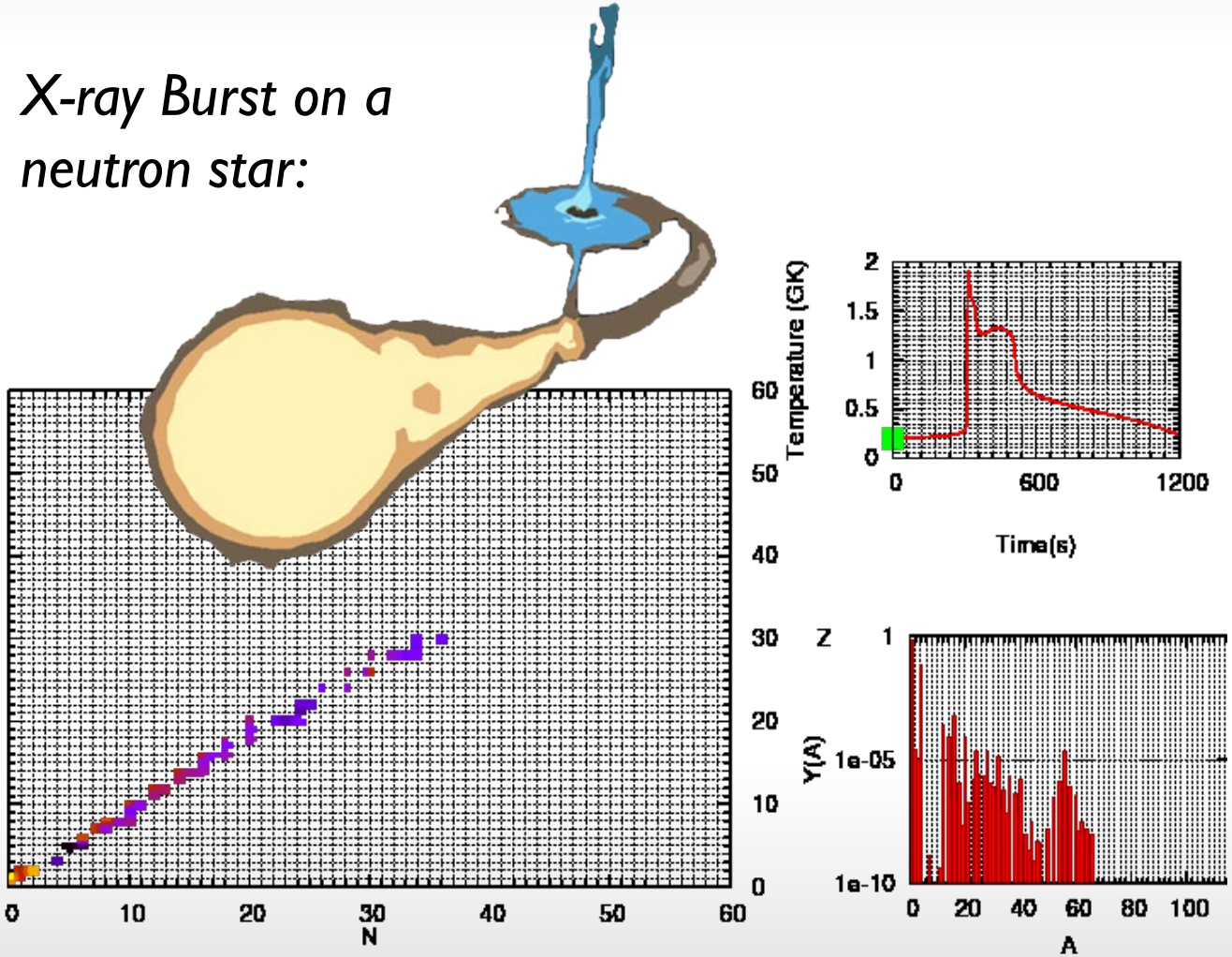


The gas released formed *everything* around you

Much like a chemical reaction, heat release from nuclear reactions can drive explosions

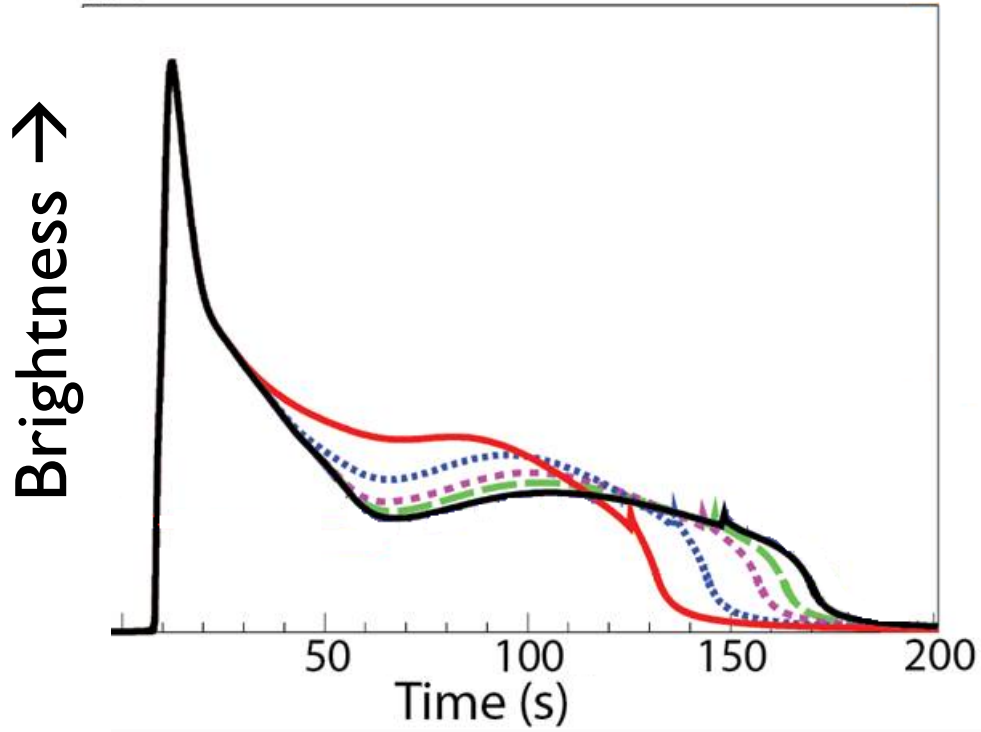
Gummi bear in potassium chlorate:

X-ray Burst on a neutron star:

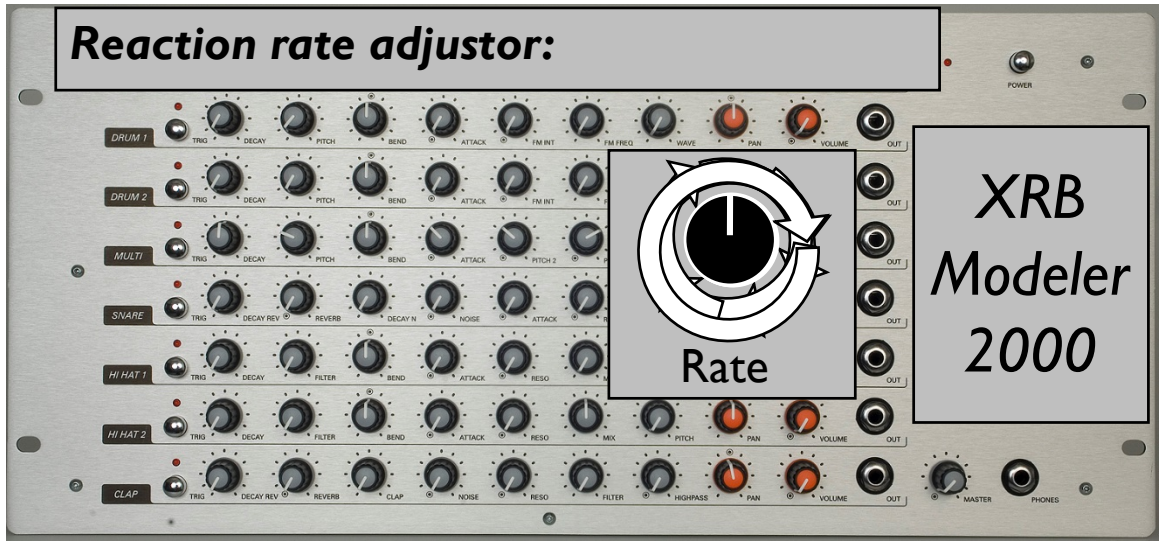


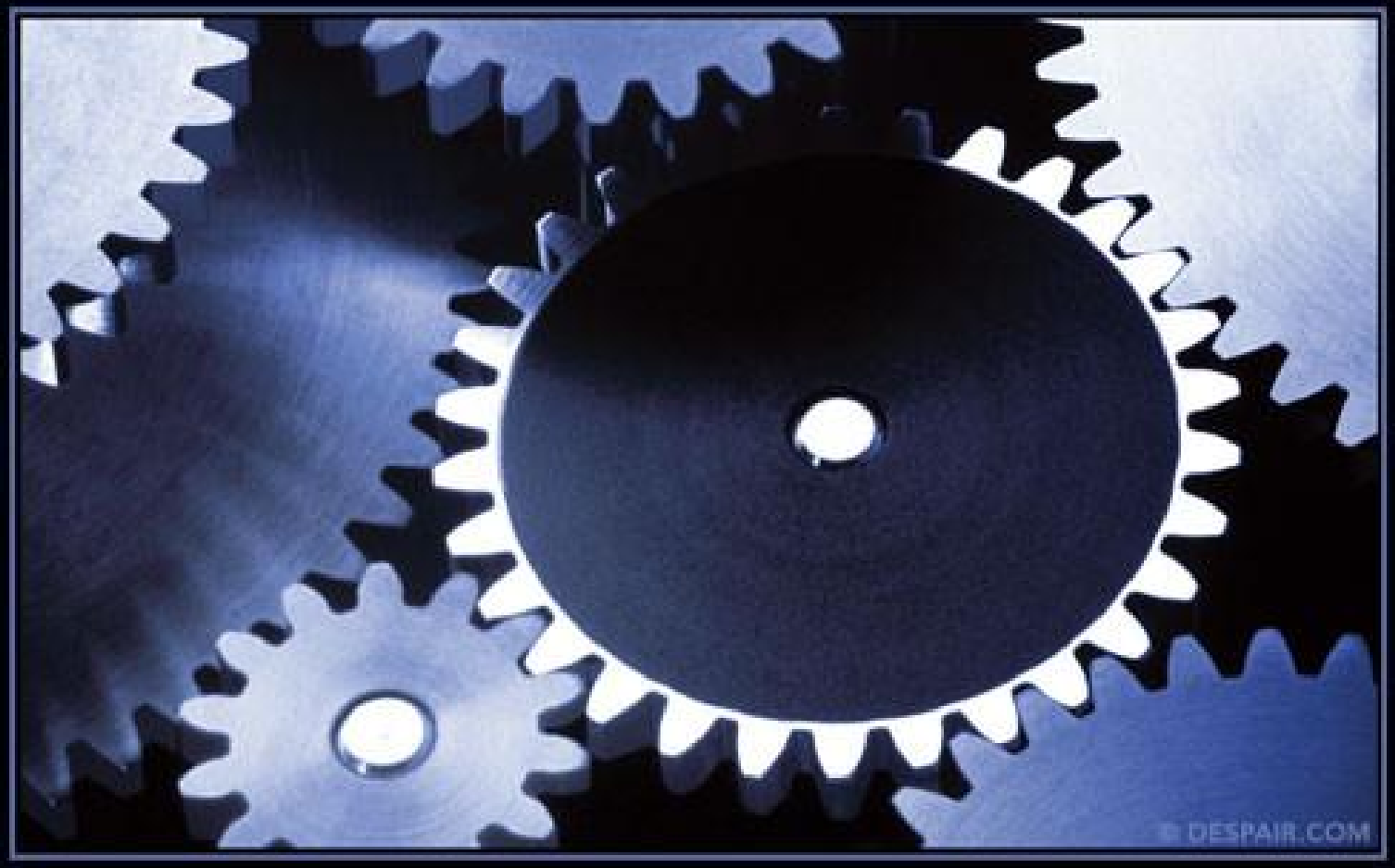
Where does nuclear physics come in?

Model output:



Model:





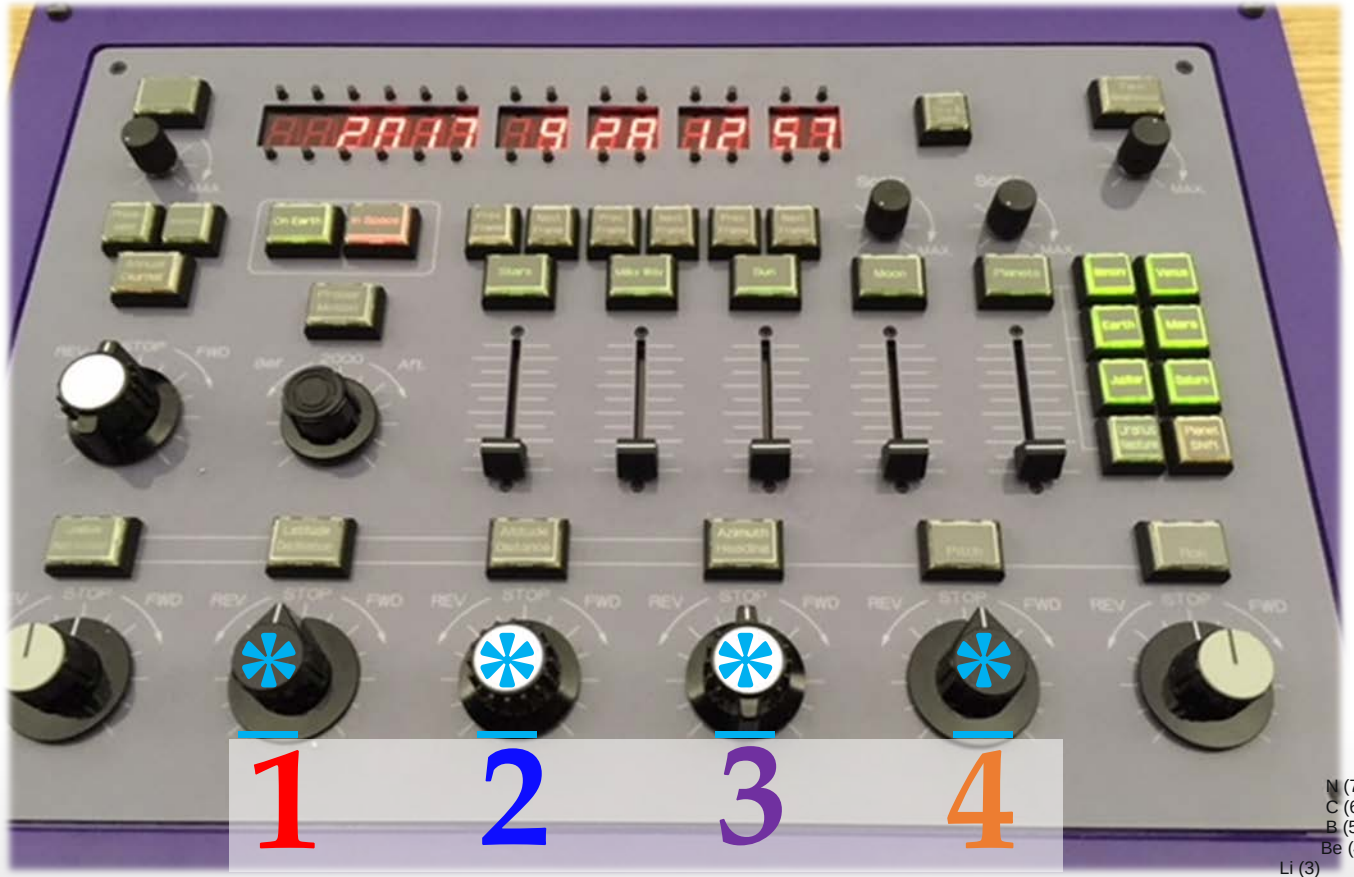
WORTH

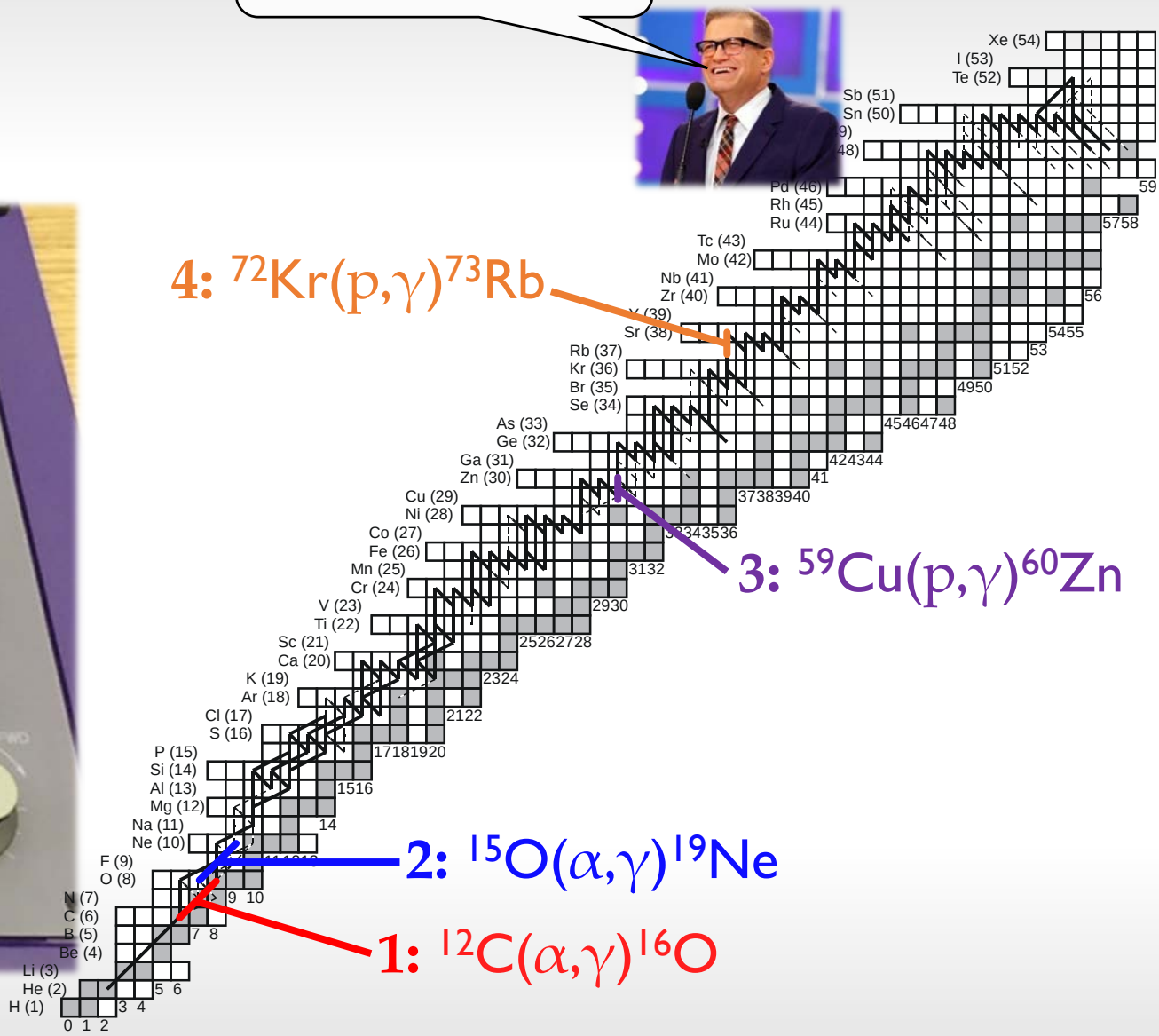
JUST BECAUSE YOU'RE NECESSARY DOESN'T MEAN YOU'RE IMPORTANT.

the Rate Variation is Right

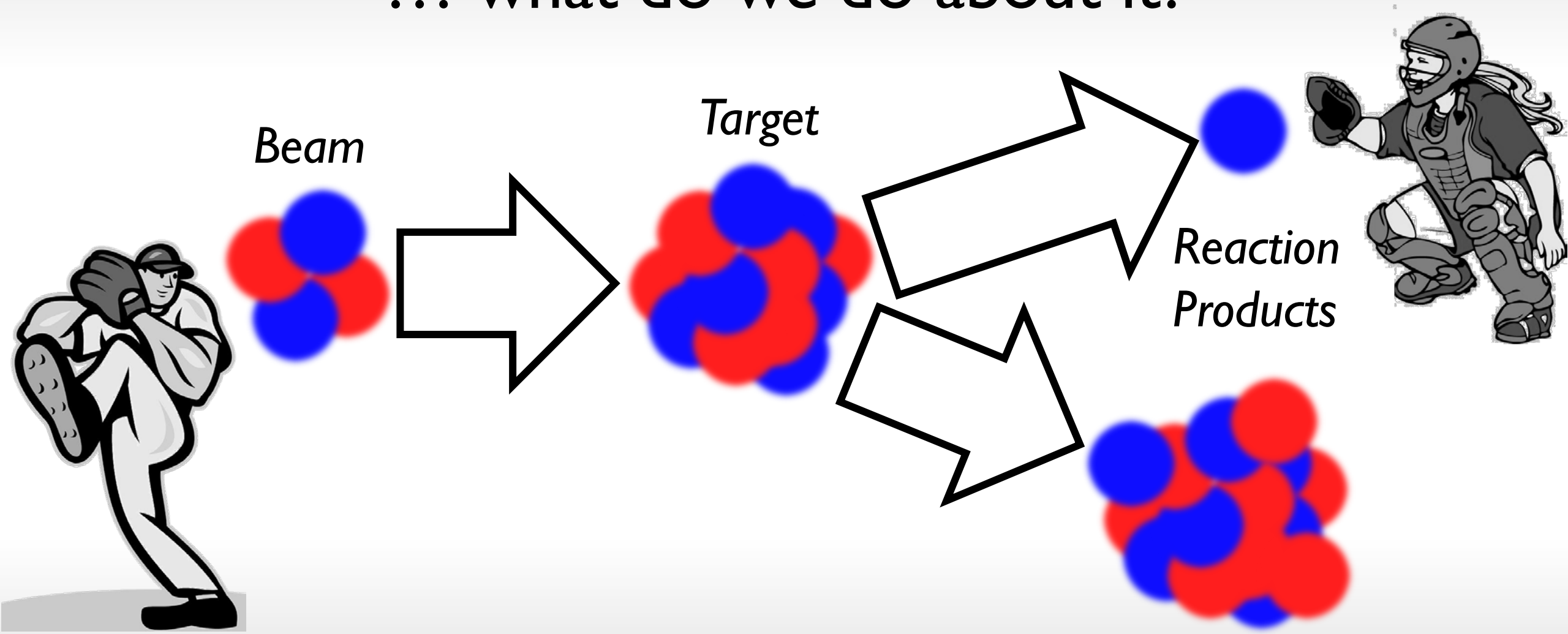
the Rate Variation is Right

Does this rate variation matter?

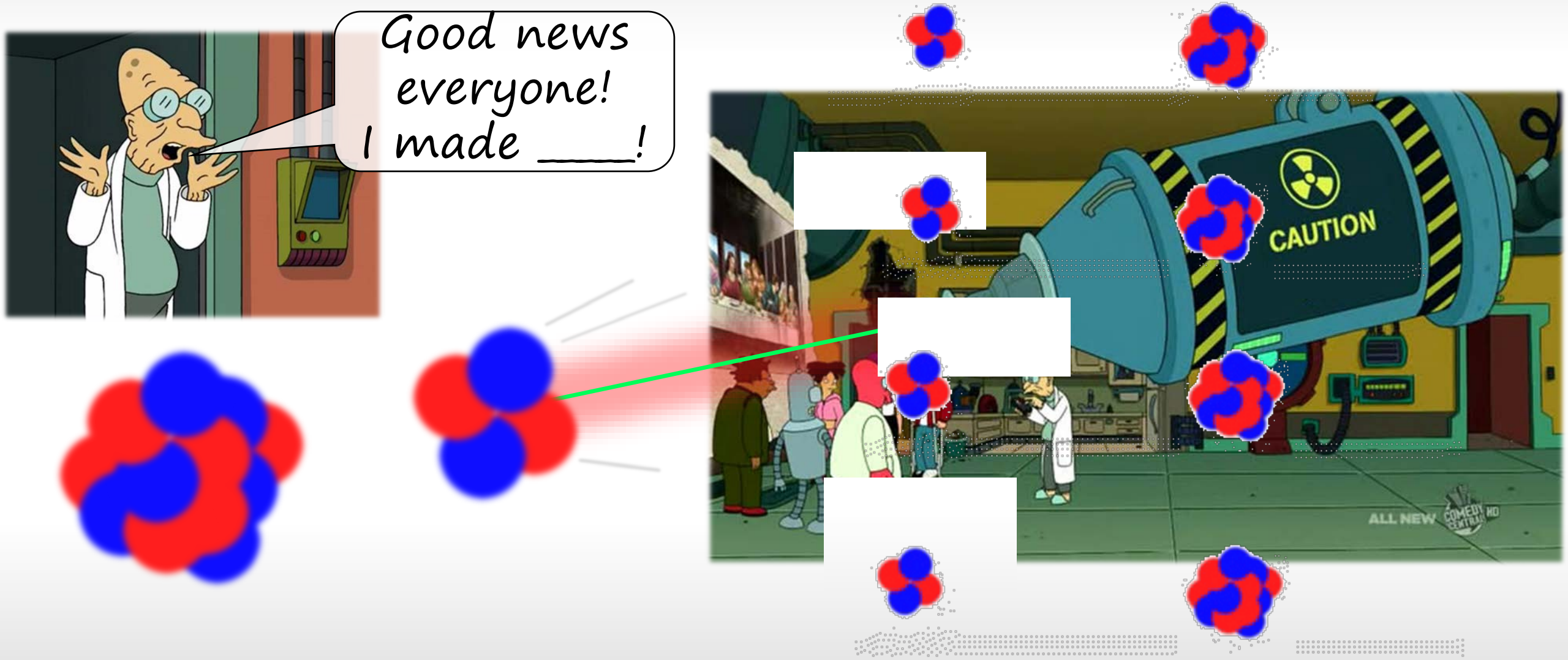




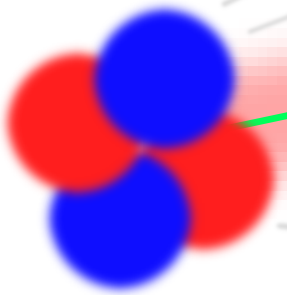
Now that we know what's important … what do we do about it?



Isotope Production: Roulette in the Laboratory



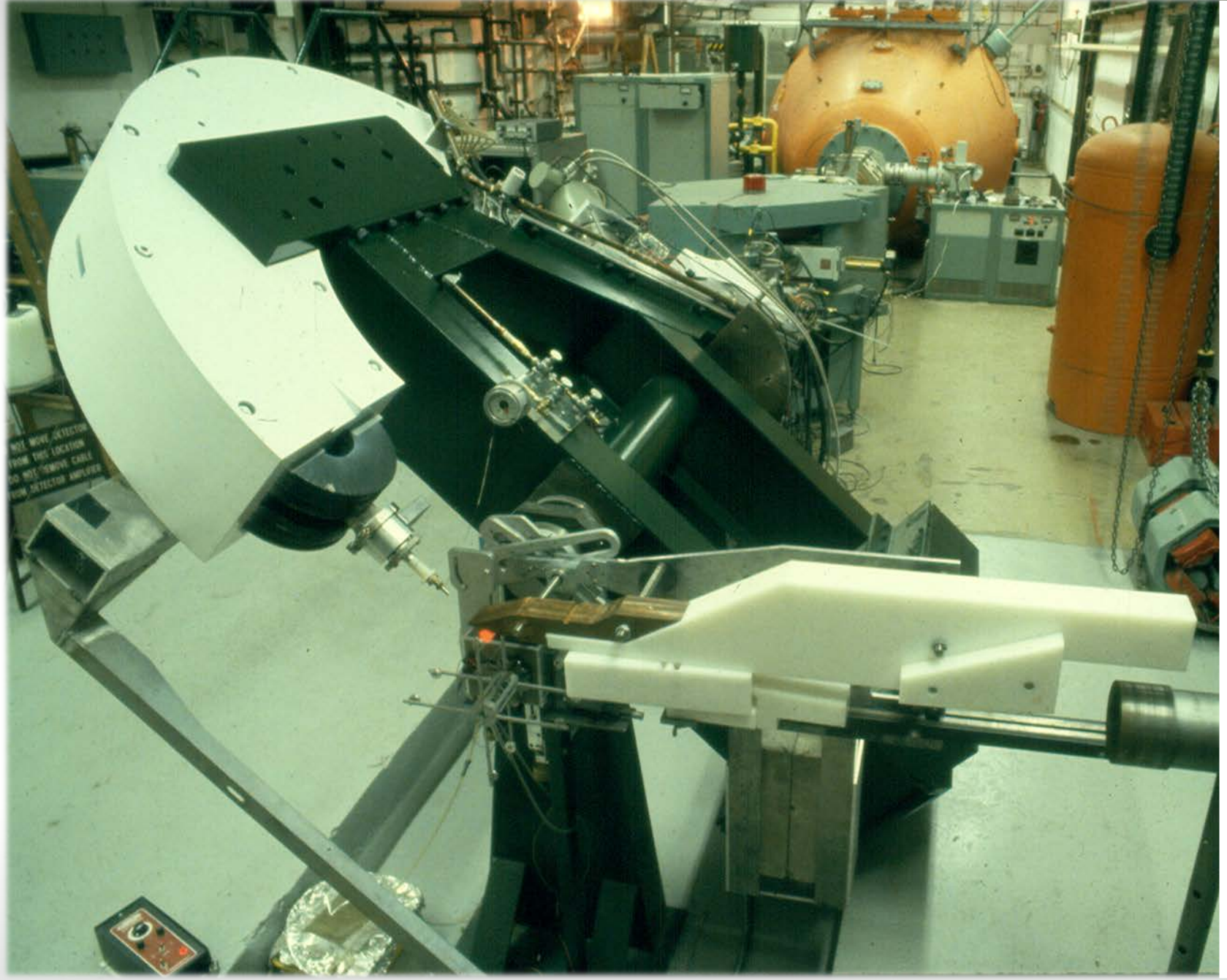
Isotope Production: Roulette in the Laboratory



Beam Acceleration

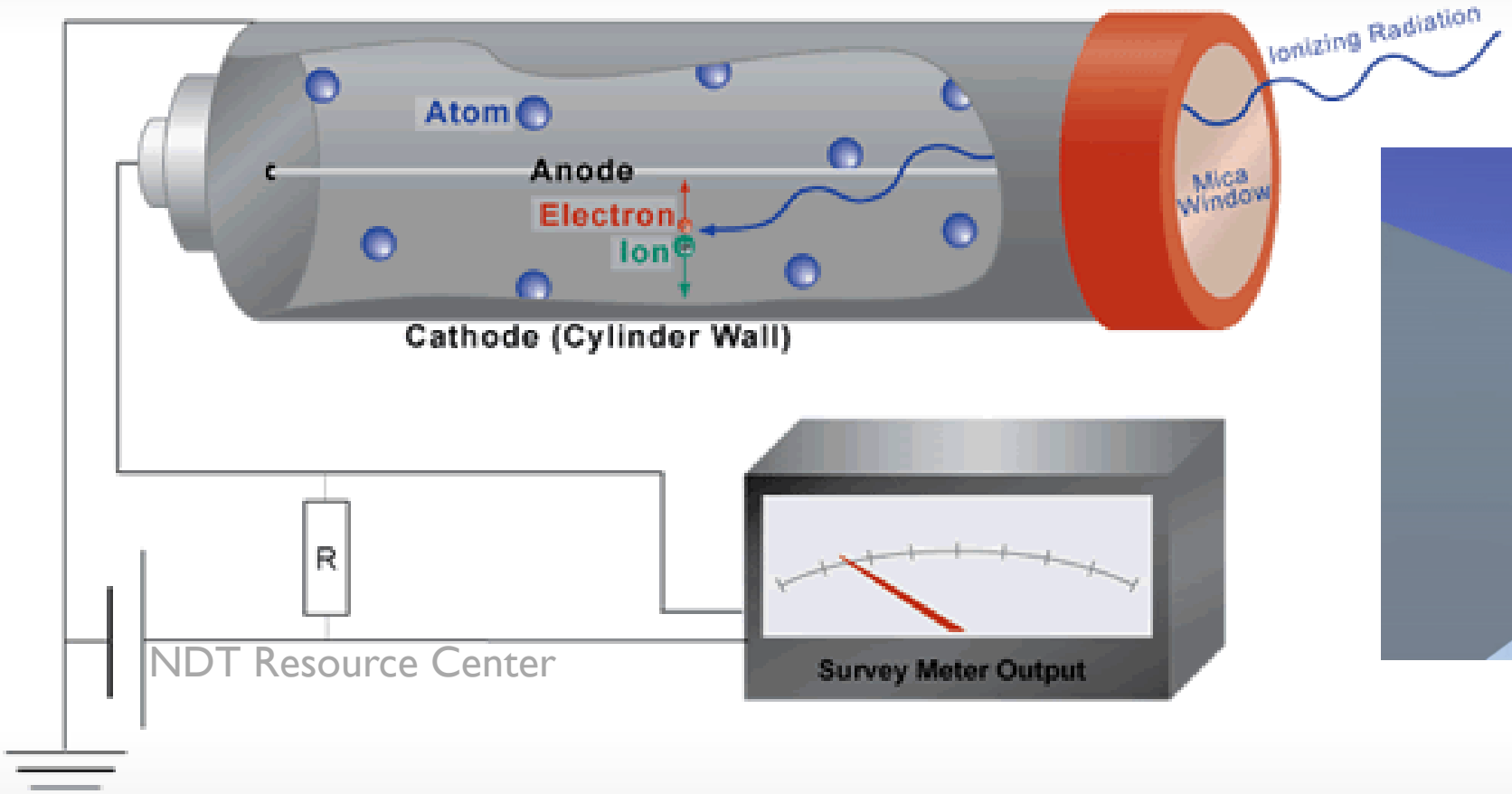
Bill Beaty

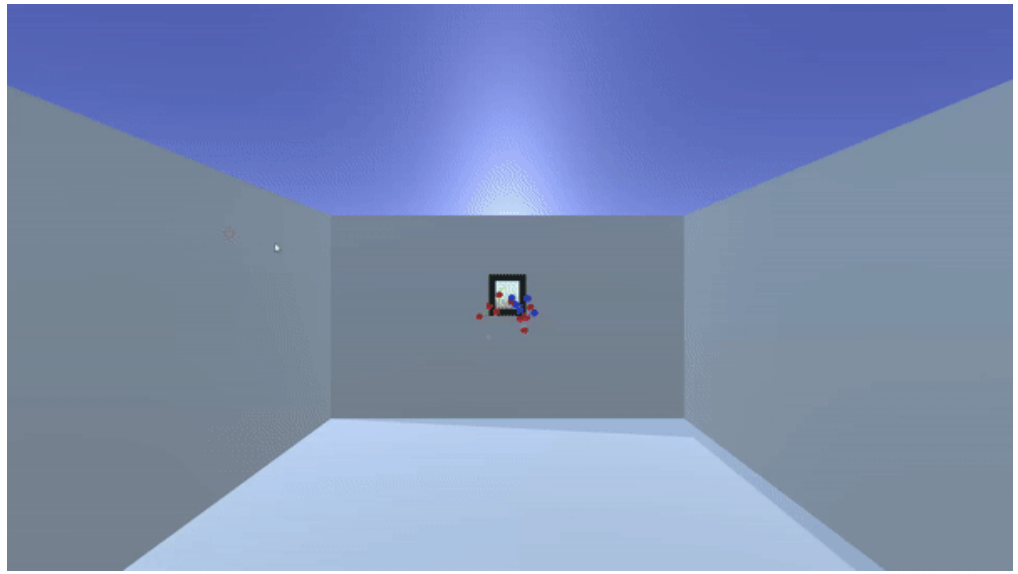
Family Guy



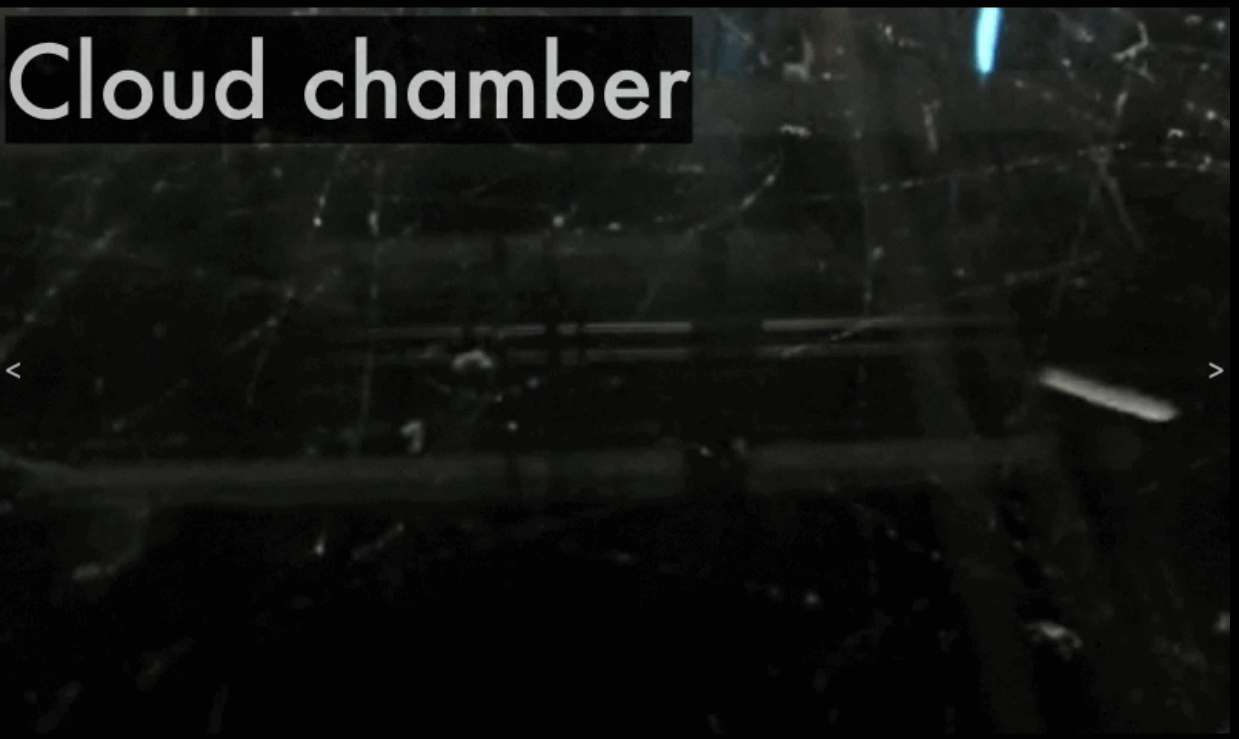
EAL

Radiation Detection



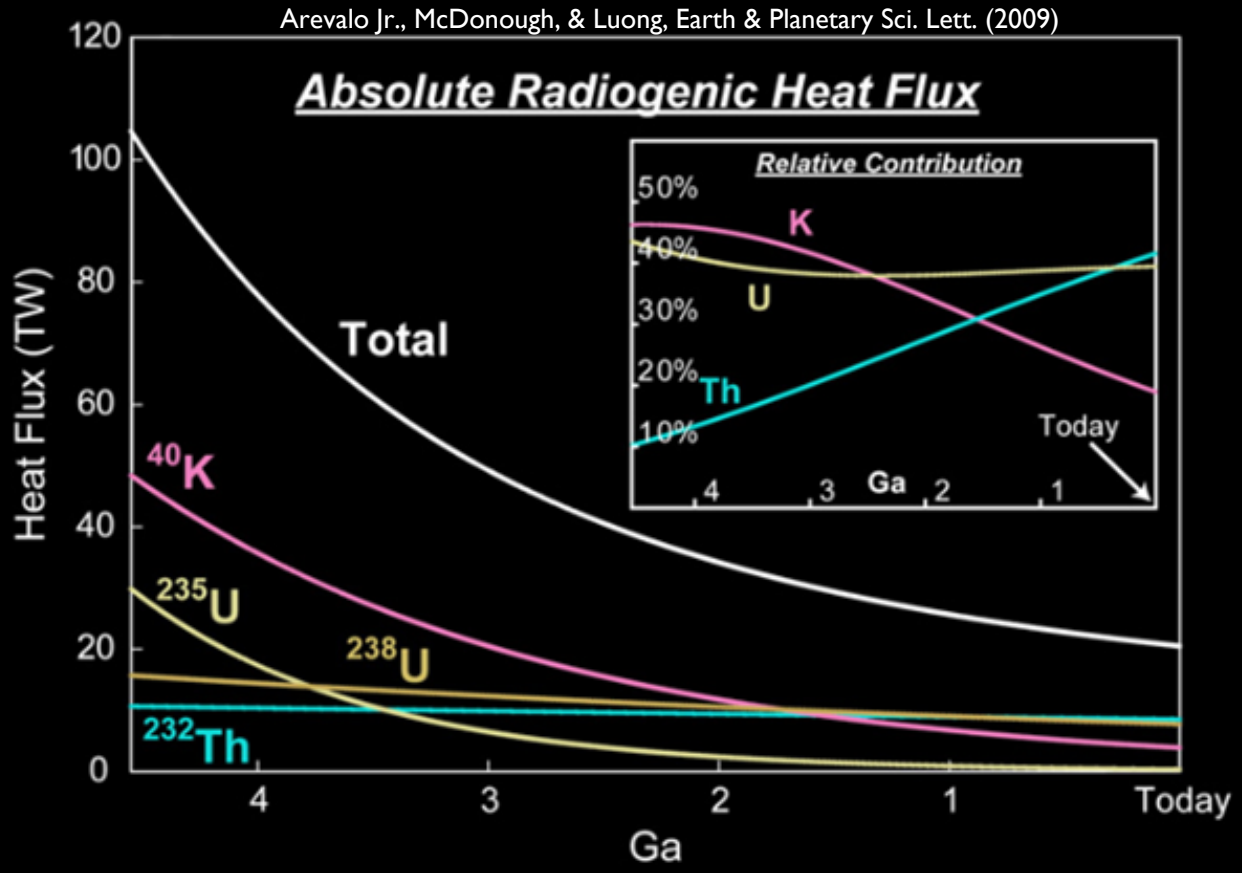


The world is a radioactive place!

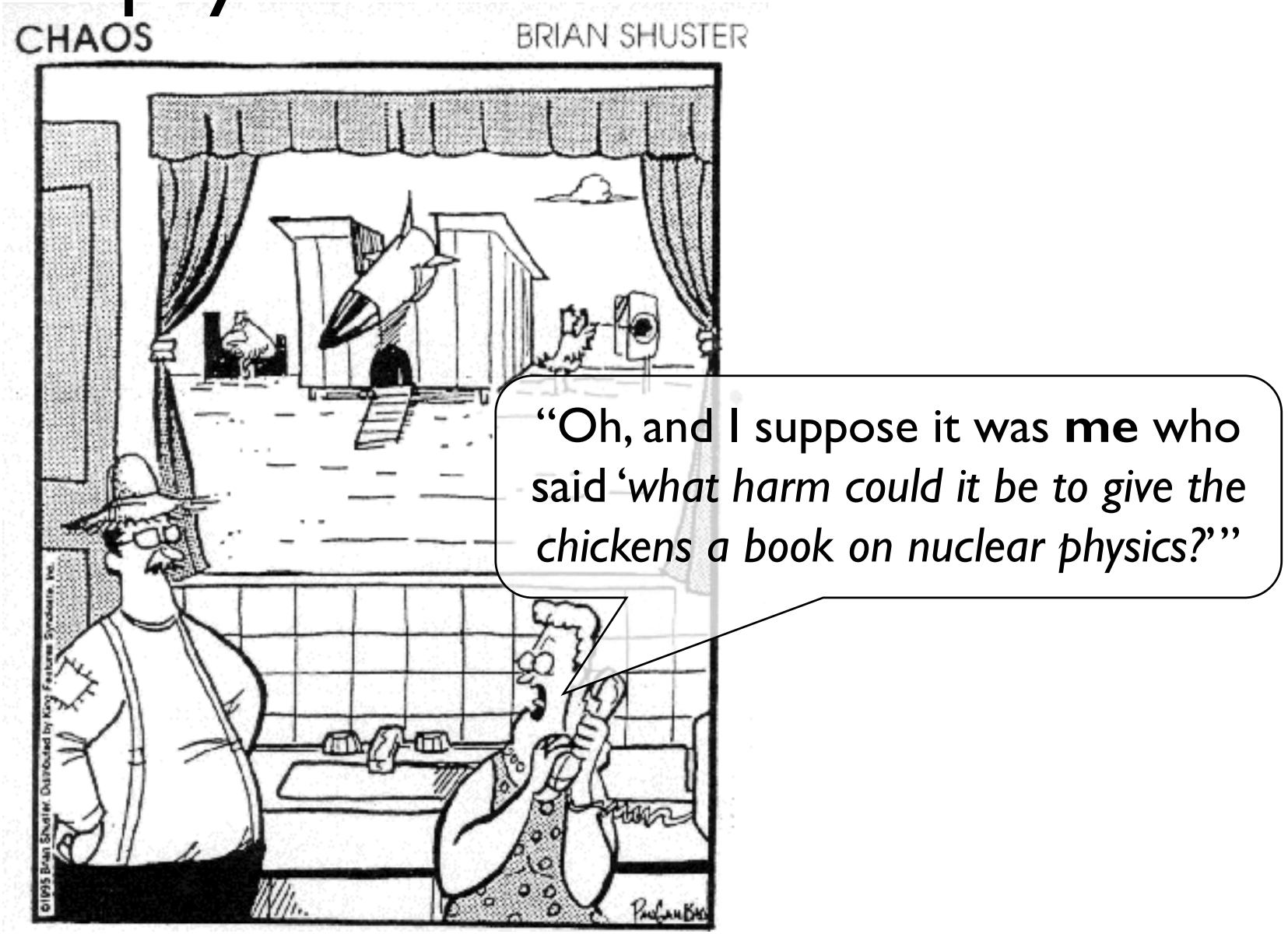


"large diffusion cloud chamber with radon gas double-decaying!"
(Source: bionerd23)
http://www.youtube.com/watch?v=Efgy1bV2aQo

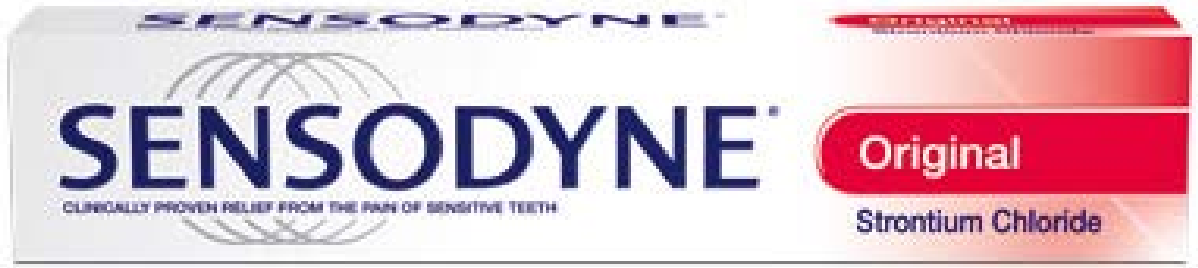
Arevalo Jr., McDonough, & Luong, Earth & Planetary Sci. Lett. (2009)



Nuclear physics can be useful…



Where does strontium come from?

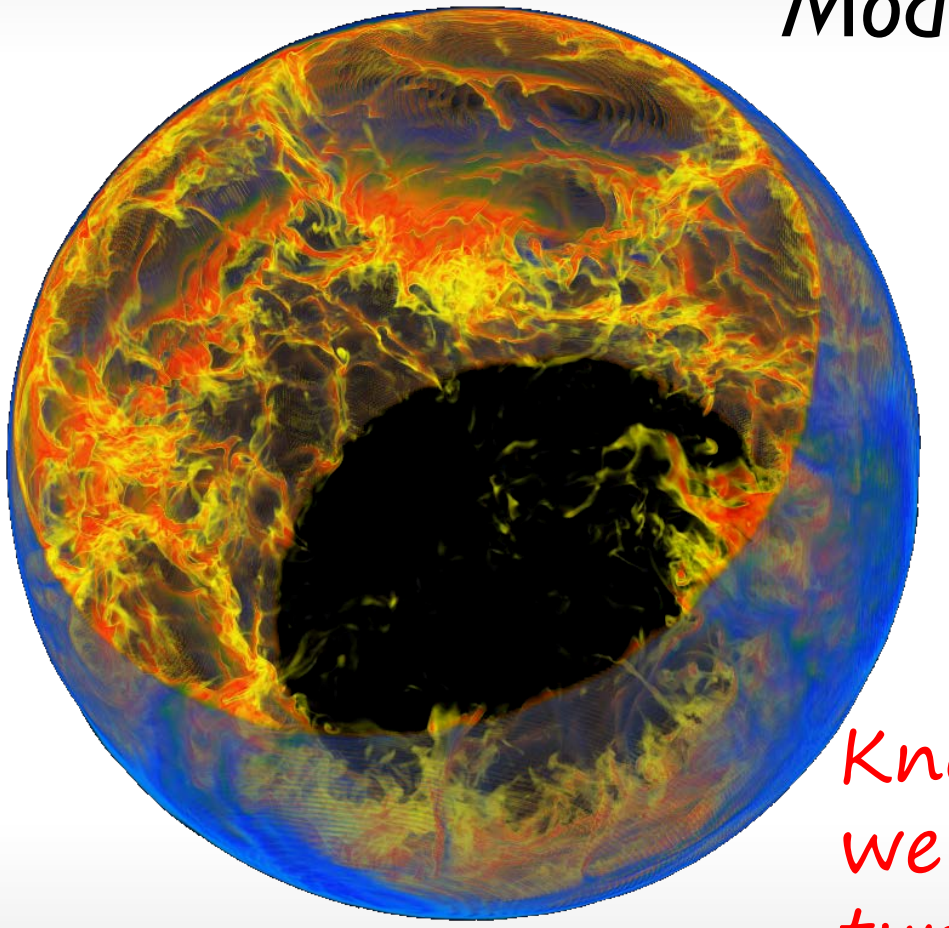


Group	1	2	3
Period 1	1 H		
2	3 Li	4 Be	
3	11 Na	12 Mg	
4	19 K	20 Ca	21 Sc
5	37 Rb	38 Sr	39 Y
6	55 Cs	56 Ba	57-71
7	87 Fr	88 Ra	89-103

Sr is a Ca substitute

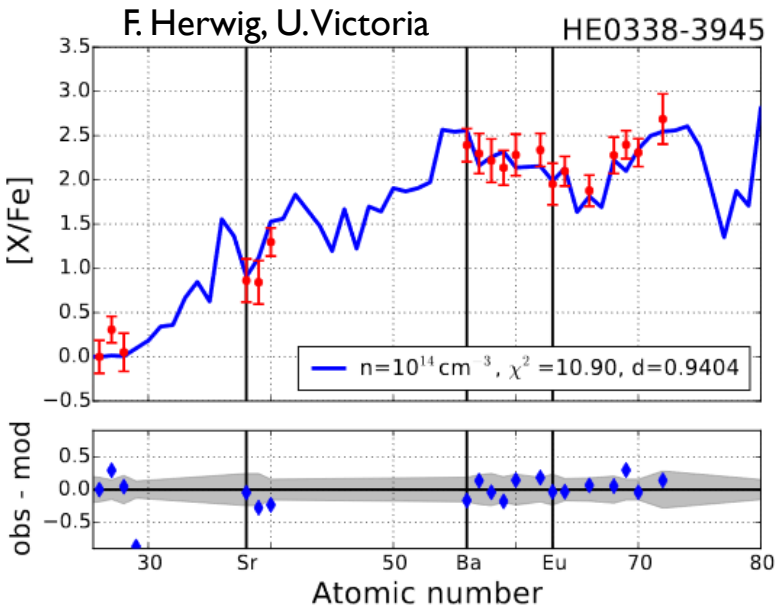
Where does strontium come from?

Sakurai's Object

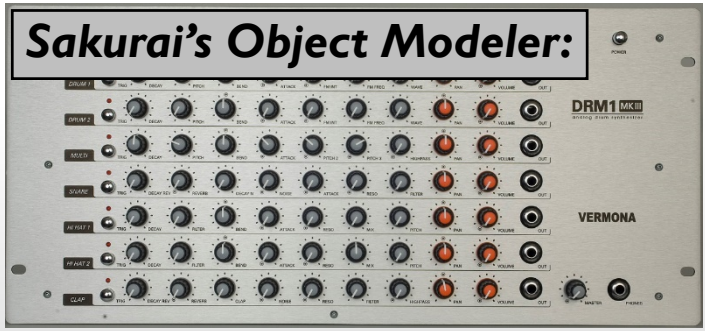


P. Woodward, U Minn.

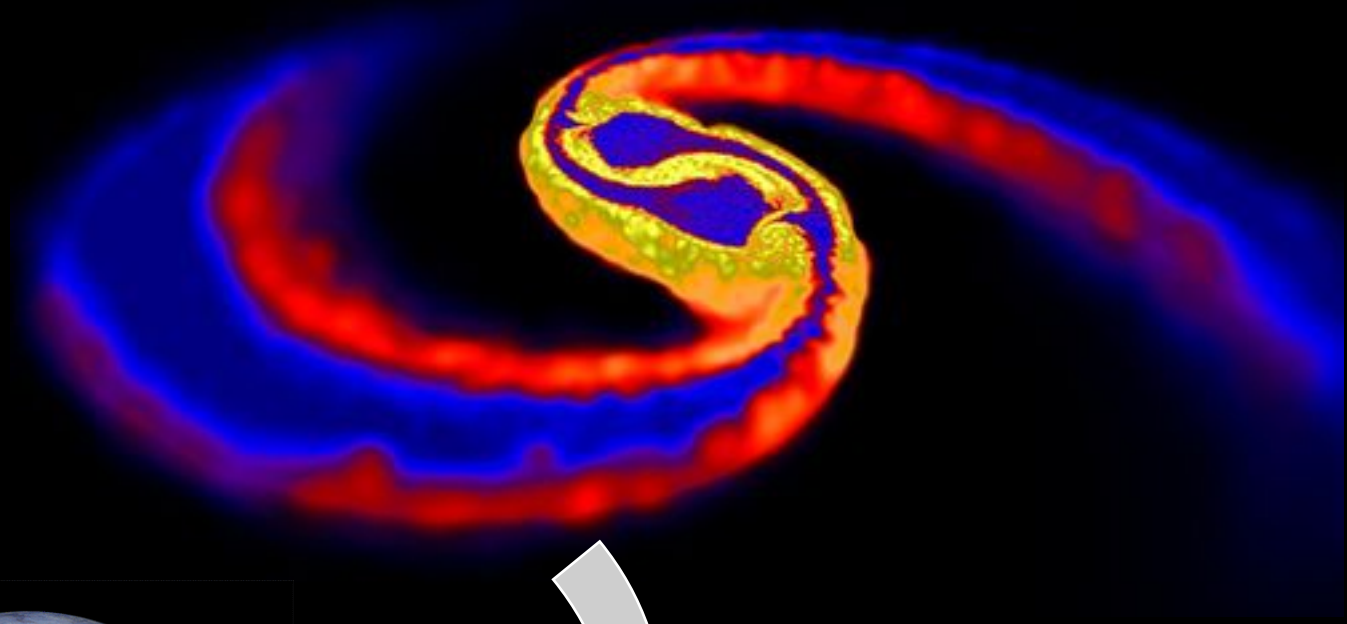
Model Results

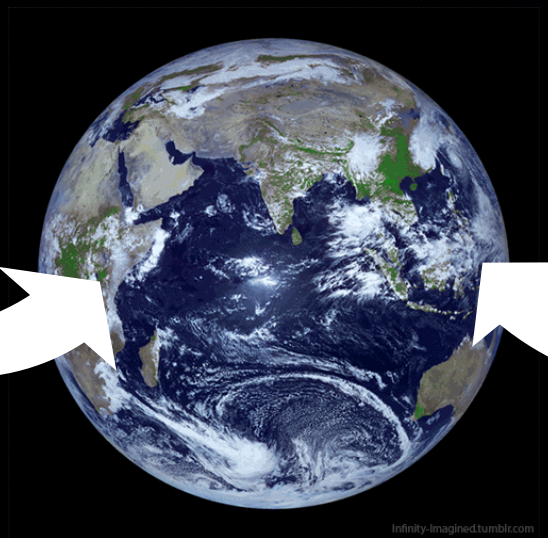


Knobs were tuned here!

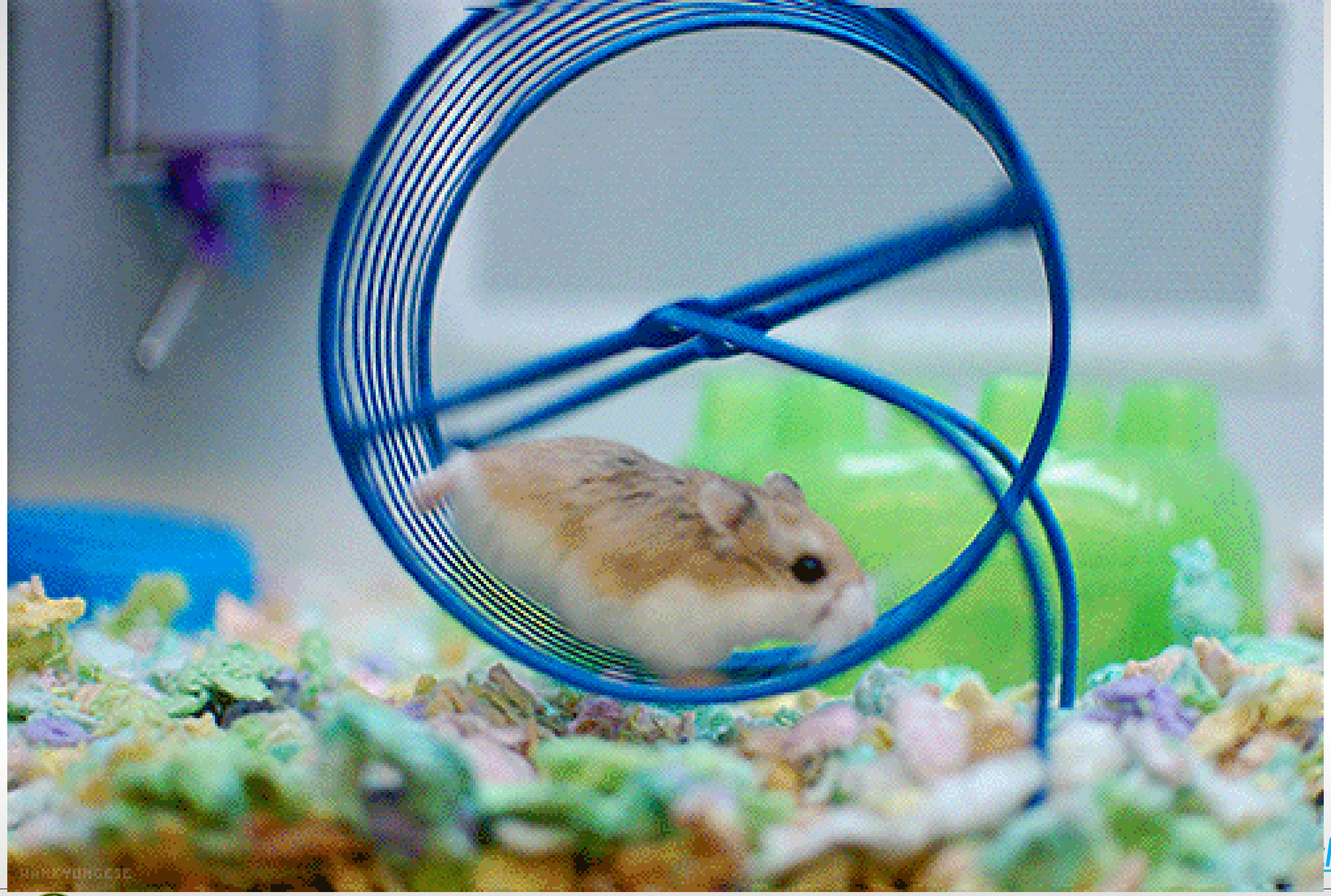


We are star stuff





modeler results follow



the modeler

^{15}C ge!

ne modeler

$^{59}Cu(p,\gamma)$ … nt change!

back to the modeler

Time [sec]

[back to the modeler]