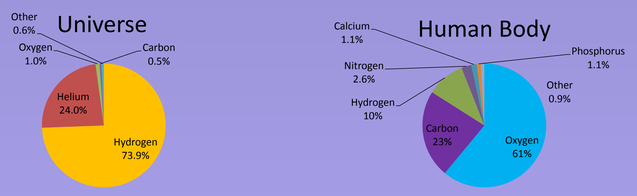
Measurement of $^{16}O(\gamma,\alpha)^{12}C$ with Bubble Chamber and Bremsstrahlung Beam at Jefferson Lab Injector

Jefferson Laboratory, Argonne National Laboratory, Fermi National Laboratory, University of Illinois

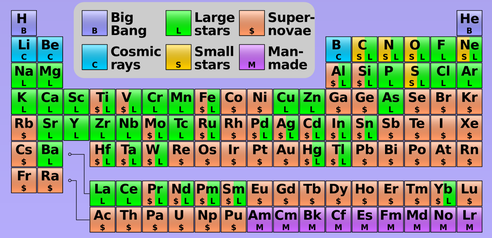
JEFFERSON LAB OPEN HOUSE April 30, 2016

Motivation

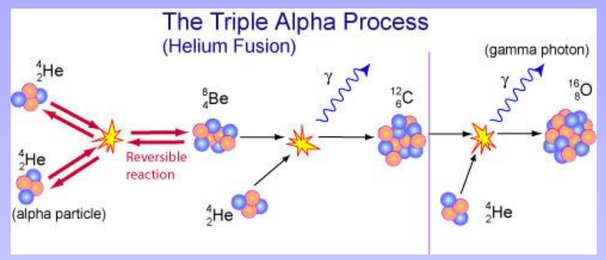
Relative Abundance of Elements by Weight

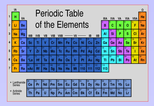


- **Big Bang Nucleosynthesis:** quark–gluon plasma → p, n, He
- **Stellar Nucleosynthesis:** H burning, He burning, CNO cycle
- **Supernovae Nucleosynthesis:** Si burning
- **Cosmic Ray Spallation**

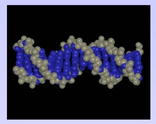


Stellar Helium Burning





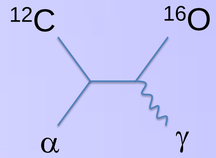
Affects the synthesis of most of the elements of the periodic table



Sets the $N(^{12}C)/N(^{16}O)$ (≈0.4) ratio in the universe

Determines the minimum mass a star requires to become a supernova

Time Reversal Reaction

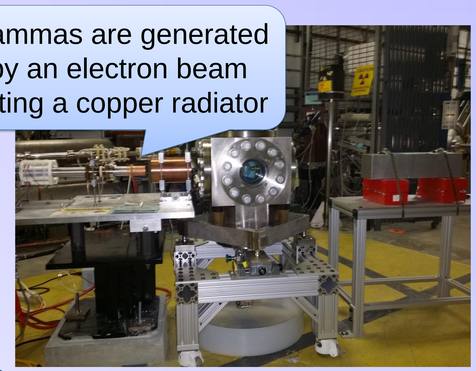


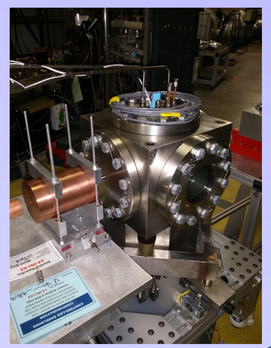
beam | target | signal

$$\gamma + {}^{16}O \rightarrow {}^{12}C + \alpha$$

- Extra gain (factor of 100) by measuring time reversal reaction
- Target density up to 10^4 higher than conventional targets. Number of ^{16}O nuclei = $3.5 \times 10^{22}/cm^2$ (3.0 cm cell)
- Solid Angle and Detector Efficiency = 100%
- Electromagnetic debris (electrons and gammas, or positrons) do NOT trigger nucleation (detector is insensitive to γ-rays by at least 1 part in 10^{11}).

Gammas are generated by an electron beam hitting a copper radiator





Bubble Chamber

Use Nitrus Oxide (N_2O, laughing gas) as target
T = -10˚C, P = 20 atm

1 Cell is cooled then filled with room temperature gas

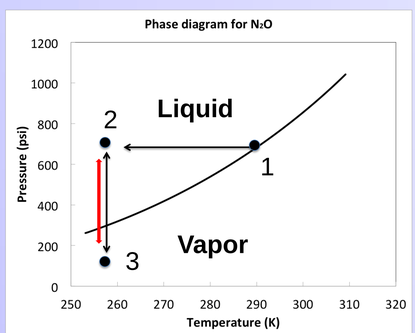
2 Gas is cooled and condenses into liquid

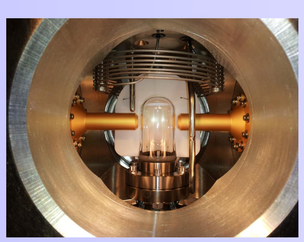
3 Once cell is completely filled with liquid, pressure is reduced creating a superheated liquid

3 Nuclear reactions induce bubble nucleation

2 High speed camera detects bubble and repressurizes

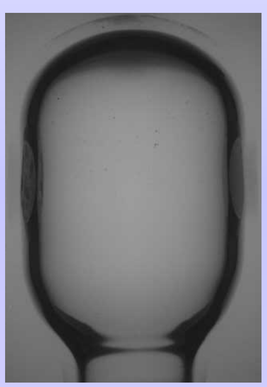
3 System depressurizes and ready for another cycle





Bubbles

LabVIEW processes images from 100 Hz digital camera



Summary

- Helium – carbon fusion to form oxygen is very important reaction
- It is easier to measure the disintegration of oxygen to helium and carbon when bombarded with gammas
- At Jefferson Lab, we use electron beam to generate gammas
- These gammas hit oxygen nuclei in laughing gas
- The laughing gas is very unstable liquid and the helium and carbon will heat the small part of it and vaporize it
- The bubble generated is monitored by a camera

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