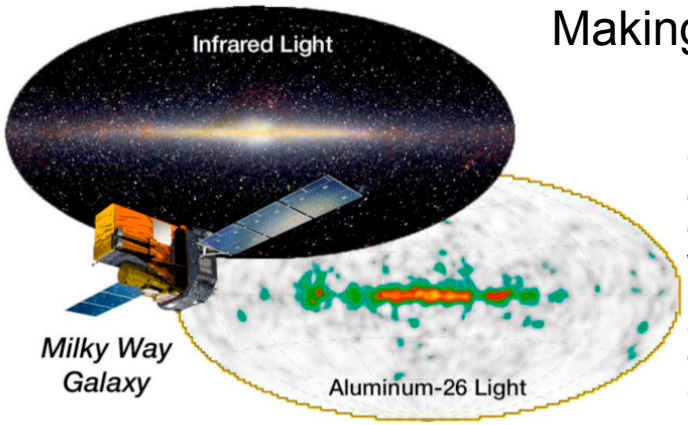
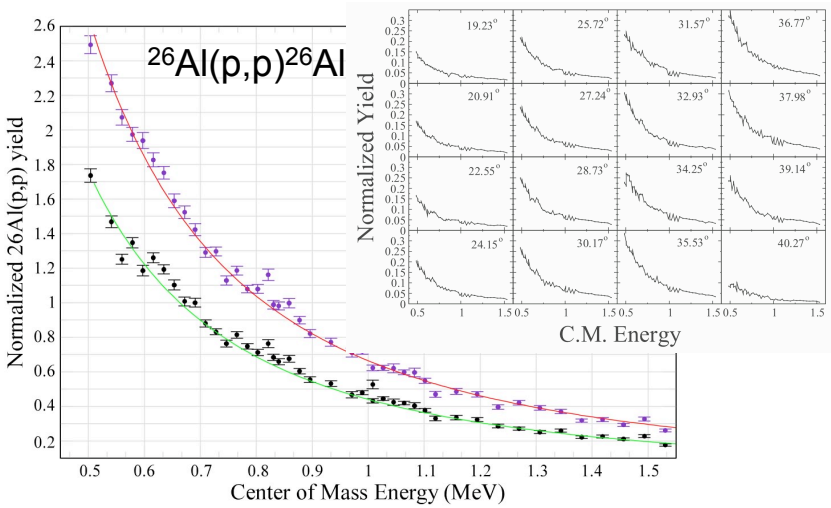
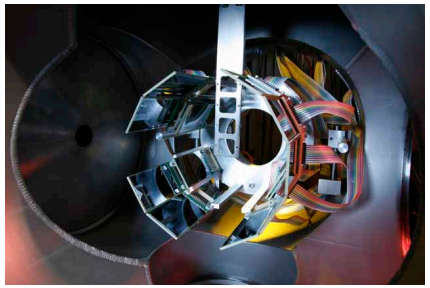
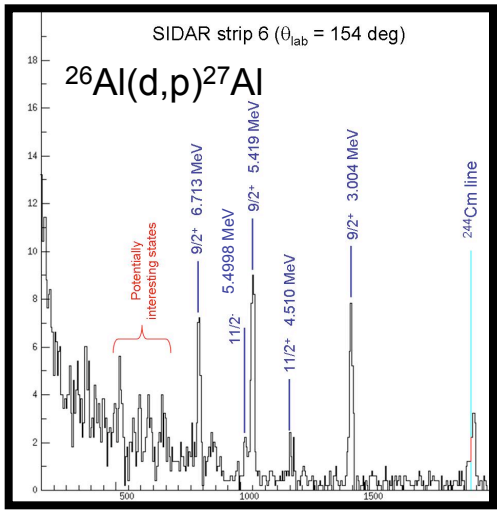
Making Sense of “Aluminum-26 Light”



NASA’s Compton Gamma Ray Observatory spent 10 years at ninety-five thousand miles above Earth using its special “eyes” to gather data on our Milky Way galaxy – not in visible light but in “Aluminum-26 light” that results when radioactive Aluminum-26 decays. When coalesced into a detailed map of our galaxy (the figure at left), numerous hot spots in space are evident. The lumpy distribution, representing a hundred trillion trillion kg of radioactive Aluminum-26, is inconsistent with some models of how the chemical elements are created. Whatever created this Aluminum-26, it must have happened recently — within the last million years or so — because this exotic aluminum spontaneously decays into Magnesium-26 in that time, emitting energy in the form of gamma rays—the source of the hot spots. Leading models suggest stellar explosions such as supernovae and novae as the source of Aluminum-26, but other sites are possible as well.

To help make sense of such maps, we are making laboratory measurements of the thermonuclear reactions that create, and subsequently destroy, this unusual Aluminum in exploding stars. In 2009 at DOE’s Holifield Radioactive Ion Beam Facility in Oak Ridge, Tennessee, a low-energy beam of unstable Aluminum-26 bombarded a target of hydrogen to determine how fast this exotic aluminum is burned up before giving off its special light. If it is all burned up quickly, then no light would be seen by the satellites. Our study involved a search for nuclear resonances in 27Si, “sweet spots” in the nuclear reaction that would destroy more Aluminum than previously thought. By scattering Aluminum-26 off of protons, we are sensitive to the strongest resonances. We measured the scattering at 44 different energies with beam intensities over two million particles per second, covering the entire range of interest for stellar explosions. A sample of the data is shown below left, where deviations from the smooth curves indicate possible resonances. At each energy we measure the distribution of protons as a function of angle (shown in the inset below left), and we are currently fitting this massive data set to determine limits on the strengths and other properties of the resonances. In a companion study, we used a higher energy Aluminum-26 beam to bombard a target of deuterated polyethylene. Surrounding the target with our newly-commissioned ORRUBA detection system (below center), we measured protons emitted from the interaction of target deuterium nuclei with Aluminum-26 in the beam. This enables us to make detailed study of quantum mechanical levels in the Aluminum-27 nucleus that “mirror” the structure of those that can burn up Aluminum-26. With over five million particles per second, we populated a number of levels (below right) that seem to have a strong single particle nature, making them well suited to prodigiously destroy Aluminum-26. We are currently analyzing this data set as well to determine how quickly Aluminum-26 is burned up in exploding stars.



Left: yield from scattering Aluminum-26 off of protons; deviations from charged particle scattering show the presence of resonances
Inset: angular distributions of scattered protons
Below: The ORRUBA detector system
Right: emission of protons after the interaction of deuterium and Aluminum-26