

From High Energy Physics to High Energy Astrophysics – Thomas Cline

Thank you. It is my great privilege to be here to honor our friend Elihu. It was also my privilege to have met him - 10 years before he started at Goddard - when he changed my career, as I will explain. The story of Elihu in those ten years is what Jean Swank asked me to outline for this Tribute.

In 1955, when Elihu was just short of his 24th birthday, we were at the Cosmotron, at Brookhaven Laboratory on Long Island. The Cosmotron was the ultimate particle accelerator then. It made K mesons and the excited states of nucleons some years before the higher-energy Bevatron would make proton-antiproton pairs, and long before the next generation of accelerators at Fermi Lab and CERN. I was a research assistant during the summer between college and grad school at MIT, whereas Elihu, a little older, was already working on his thesis from MIT with an experiment there.

I'll never forget how we met: while at my desk on the Cosmotron floor, surrounded by racks of electronics used in the days before computers, I would sometimes hear loud explosions at random, in the back, somewhere. Finally, I had to check that out, and found a young man, who looked up briefly with a modest grin. He was attending to a multi-plate expansion cloud chamber, designed to expose the tracks of particles crossing through it when appropriately triggered by counters. The young man was Elihu, engaged in a particle experiment on the polarization of the lambda hyperon. We were in the company of senior researchers doing basic physics; some of them would joke about beating one or another to a great discovery or to a Nobel Prize. Val Fitch, for example, had a bench nearby; he ultimately made such accomplishments. But Elihu was not one to joke, and was not one to express such grandiosity. I soon came to enjoy many enlightening conversations with Elihu.

Now, that was 1955, only 10 years after the Manhattan Project, where many of the MIT physics Profs had spent the war, including Bruno Rossi. Elihu admired Rossi greatly. Although Elihu had taken George Clark's cosmic ray course and was doing his thesis with Dave Caldwell, two others in Rossi's group, it was Rossi himself who became Elihu's ideal of a role model. Proximity to Bruno Rossi had undoubtedly prompted Elihu to think deeply about cosmic radiation and its relationships to, and influence on, other natural phenomena. This dedication would last him a lifetime.

I am just one of the many who benefited from Elihu's influence. Despite the exciting particle physics atmosphere at the Cosmotron then, in 1955, Elihu suggested that I divert from that specialty to go into cosmic rays, and for that I should take Bruno Rossi's course when starting MIT. During the next Spring term, I did so, and was hired as research assistant in the cosmic ray group.

Elihu viewed Rossi as was one of the Greats in modern physics, both for inventing digital electronic logic long before its modern developments, and for making a number of discoveries in cosmic rays and elementary particles, the least of which may be finding an antiproton in the high-altitude cosmic radiation. Elihu used to tell me that Rossi and Giuseppe Occhialini, Rossi's first thesis student, were well known for the Nobel-winning experiments they closely influenced, but missed being named for. For example, Rossi's thesis advisor Walter Boethe got one, as they say, because of Rossi's thesis, and Occhialini had been in on the pi meson and in on the cloud chamber. One might include Giacconi's prize for x-ray astronomy in such a list; it came a half century after 1958, when we at MIT watched Giacconi and Rossi publish their invention of the focusing x-ray telescope.

Elihu also admired the way Rossi collected such a talented array of associates: besides those I mentioned, Clark and Caldwell, there was William Kraushaar, who was Jim Earl's thesis advisor and later on my own, and then Gordon Garmire's. Bill ultimately became the Father of gamma-ray astronomy, as you know. And, John Linsley was doing a huge air shower experiment in New Mexico, and Stan Olbert and Livio Scarsi were there, and Beppo Occhialini for a while, on his sabbatical.

Rossi did not direct research so much as he unleashed talent. Elihu clearly took a great deal of inspiration from Rossi's style.

After Elihu finished at MIT, he had a post-doc at the proton synchrotron in Saclay (where he may have developed his interest in French cooking, something that prompted him to later join an international culinary society). And, with his doing post-doctoral work in the Princeton cosmic ray group and his teaching physics at Rutgers, it happened that I preceded him at Goddard by nearly five years. His first four publications from Brookhaven were three Phys Rev Letters and one Phys Rev paper, all in the year 1958. He was first author of all four! Phys Rev Letters is to Phys Rev as Ap J Letters is to Ap J, obviously, so that was truly an amazing accomplishment. Also, before he came to Goddard, Elihu published six more papers on topics including instrumentation, meson physics, and cosmic rays, with four of these as first author. It is clear that Elihu was destined to be one of Goddard's Greats. More than any of Rossi's proteges since Occhialini, Elihu fulfilled the promise of that role model.

In closing - one may ask: why, long ago, would Elihu have recommended cosmic rays to anybody, when it was clearly a field then decades beyond its prime, rather than particle physics, a field that was then taking off? I'm sure that since Elihu appreciated the fact that the cosmic ray field was the parent discipline to so much of nuclear and particle physics, that he was *prescient* in his view that from a cosmic-ray orientation, one might best initiate new research departures. Clearly, Elihu was entirely correct. Only a few years after expressing that wisdom, the cosmic ray physicist James van Allen discovered the Earth's trapped radiation: hence, we now have what is known as Space Science. And, only a few years after the van Allen belts were found, Frank McDonald, in his Goddard cosmic ray lab, had founded his multifarious research groups and created the HEAO spacecraft series, bringing to maturity what we now call High Energy Astrophysics. One of these research groups, that Frank started, proposed and flew COBE, which ultimately brought Goddard its first Nobel prize. *And*, Frank McDonald brought Elihu Boldt into the Lab. Elihu had been indeed prescient.

Here is a photograph showing Elihu and others, at a coffee break, during our time at MIT. Elihu is in the center with Hale Bradt on his far right and with me on his far left.

