

Remarks of
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Memorial Symposium for Riccardo Giacconi
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It's an honor to be here to recognize the life and work of Riccardo Giacconi. You have an exciting agenda for the next two days. The range of discussion is a testament to Riccardo's impact on our discipline.

It was pure chance that I walked into the Center for Space Research at MIT in 1969 and asked for a job. I got one analyzing balloon flight data and helping to edit a review article of the new field of X-ray astronomy. That was how I was introduced to the early rocket discoveries of Riccardo Giacconi and others here today.

When I later joined the X-ray rocket/satellite group at Caltech, led by Gordon Garmire, first as a programmer, then as a graduate student in physics, I was introduced to Uhuru, the first orbiting X-ray astronomy satellite. One of my first jobs was doing a fluctuation analysis of the X-ray background, using Uhuru data. I learned later that understanding the nature of the X-ray background was a passion of Riccardo. And X-ray astronomy became my vocation. While I was a graduate student, HEAO-1 was launched and, the next year, the Einstein satellite. Einstein was the first imaging X-ray telescope and discovered that all kinds of cosmic objects emit X-rays at some level. Riccardo was a birth father of both Uhuru and

Einstein. These satellites provided a trove of data, revealing X-ray sources never before seen or even imagined. Truly it was a great time to be a student in a new field, one that opened a new universe with unbelievably strange and energetic phenomena. The nature of much of what those early space telescopes revealed is still not well-understood, leaving lots for new generations of astronomers to explore.

It's been nearly 60 years since Riccardo and his AS&E team launched their x-ray counters on Aerobee rockets from White Sands, New Mexico. They had ideas about what they could expect to see, including fluorescent x-rays from the moon, but as the rocket spun, it detected a sensational spike in x-rays from an extra-solar source, Scorpio X-1. And that was the beginning of an entirely new field of astronomy, for which Riccardo was recognized with a Nobel Prize in 2002.

It's wonderful to see so many of Riccardo's colleagues from the earliest days of x-ray astronomy here with us, including Harvey Tananbaum, Ethan Schreier, George Clark, and Wallace Tucker. I especially want to recognize Harvey and Ethan for their work to make this symposium possible.

The AS&E approach presaged the current emphasis on public-private partnerships to make large-scale scientific projects possible. Throughout his career, Riccardo was part of a major shift in how scientific programs and facilities were managed. From AS&E, to the Einstein Observatory, to Hubble and Chandra, Riccardo had a hand in advancing how we do astronomical research.

A core element of NSF's charter is that the scientific community should guide how we invest in an agenda that supports new advances and breakthroughs. This was a philosophy that Riccardo shared. He advocated for scientific facilities to be developed and managed by the scientists who understood their operations and purpose. In his experience, success relied on cooperation between the technical developers and the ultimate users.

- The Einstein Observatory was built at a time when the astronomical community was shifting focus from individual research projects to national facilities. Part of that shift meant managing how data was collected, reduced, and distributed from instruments like Einstein.
- Effectively managing the Einstein Observatory and the data it produced as a shared resource made it possible for more than a thousand refereed papers based on the Einstein data to be published in the first 10 years after its launch.
- This philosophy also informed his work here at the Space Telescope Science Institute on the Hubble Space Telescope. He knew that technical leadership on the Hubble project would have to match the complexity of STScI's mission.
- The new paradigm for managing Hubble as a shared facility and processing data for broad use helped make Hubble one of astronomy's most productive undertakings.

I met Riccardo in person at the Hubble Space Telescope Institute, which he ran for a dozen years. I was on the Advanced Camera Team for Hubble, then on AURA's Board, and then became NASA's Chief Scientist. Riccardo had a particularly intense relationship with NASA! I was enchanted with the person. I found Riccardo deeply passionate about his work, and deeply

kind. It was not surprising that he was among the first men to step up to signing the Baltimore Charter for Women in Astronomy in 1992. He was supportive to women as scientists.

Riccardo suffered deep, personal family loss, and it was talking with him about this that gave me a full picture of the man. He was about science, yes, but he was very much about people. He was deeply moved by science and by the human condition, our own frailty.

Perhaps that perspective is what made Riccardo's work ethic so unwavering in its pursuit of results. He had a recipe for how he approached a scientific program.

- He would always work at the very limit of what he could conceive and what could be done with the available resources;
- He focused on creating experiments that could yield useful data even if breakdowns meant complete results could not be obtained;
- His instruments were designed to be as simple as possible to attain the data he sought, and he used the best and most professional engineering and managerial talent he could find;
- And he saved money where he could, not just as a matter of responsible management, but so that savings could be plowed back into the research.

You can see that philosophy imprinted on all of the projects he led, and his leadership laid the groundwork for breakthroughs that are happening today. That includes the first image of a black hole that was announced just last month, in which the Atacama Large Millimeter Array played an important

role. And in just a few months, we'll celebrate the 20th anniversary of the launch of the Chandra X-Ray Observatory. Its original mission was expected to last five years, but it continues to produce outstanding results.

As president of Associated Universities, Riccardo's vision helped bolster the National Radio Astronomy Laboratory's status as a leading facility for radio astronomy. The management approach he implemented at AS&E and continued to develop at the Space Telescope Science Institute and the European Southern Observatory made it possible to push the bounds of what NRAO could accomplish, including expanding the Very Large Array and establishing ALMA. ALMA is truly an international collaboration and is one of astronomy's most successful and productive undertakings.

Riccardo's work and leadership have made the new era of multi-messenger astronomy possible. NSF is investing in the future of multi-messenger astronomy by making Windows on the Universe one of our Big Ideas.

The Big Ideas were launched in 2016 to guide investment in fundamental research into the most profound challenges and opportunities facing the science and engineering community in the coming decades. Windows on the Universe and other multi-messenger astronomy projects will revolutionize our understanding of the universe.

Riccardo would have loved NSF's new emphasis on multi-messenger astrophysics. It combines so many aspects of his own career: novel instrumentation, large-scale scientific endeavors, broad collaboration across the astronomy community, and, of course, x-rays, one of the pillars

of multi-messenger astrophysics. One wonders, with his genius for invention and his appetite for exploration, what his own contribution would be today.

The words I will always remember from Riccardo are these: when asked why he was so successful, he said, “I always do my homework.” I’m pleased to see how many people here are “doing their homework” to carry on work that Riccardo inspired, I know that his legacy is in good hands. Being able to be part of this discipline has been immensely fulfilling for me as an astrophysicist, as an administrator, and as the Director of the National Science Foundation.

I want to encourage you all to also continue Riccardo’s dedication to sharing our work with the public. He said that the results and the joy of doing science should be shared with the public at large, and that we should not just dazzle, but entertain and teach as well.

Riccardo also said that he thought that nature was, quote, “out there working busily to prepare samples of the most bizarre objects, just to reward whoever is curious enough to be looking.”

It’s been my great pleasure to be part of the search for those bizarre objects and what they mean. I know that we’ll be building on the foundation that Riccardo laid down for many years to come.