Riccardo Giacconi's Impact on NASA

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It is a privilege to be representing NASA at this symposium. Administrator Bridenstine and Associate Administrator Zurbuchen send their regrets. They trusted that I could adequately represent NASA at this occasion. It gives me great personal pleasure to represent NASA and to be the first speaker.

In spite of the title in the agenda, I will speak about Riccardo Giacconi's impact on NASA. And since I am now a bureaucrat rather than a scientist, I am referring to programmatic impacts rather than scientific impacts.

Like most of the other speakers, and unlike most of my colleagues at NASA Headquarters, I knew Riccardo personally. I was a graduate student at the Center for Astrophysics during the Einstein Observatory mission. But that was well after he had made his first impact on NASA.

The Small Astronomy Satellite 1 – Uhuru - was a game changer for NASA and the astrophysics community. During the 1960s, the X-ray sky had been revealed through a series of sounding rockets. Some of them were sponsored by NASA, and some of them, including the ones by Riccardo's team at AS&E, had other sponsors. As other speakers will describe, the existence of these sources, and their rich and varied phenomenology, was unexpected. With sounding rockets, the sources could only be studied one-at-a-time for minutes-at-a-time. Riccardo formulated an orbital mission, one capable of taking sounding rocket tested techniques (proportional counter detectors, scanning collimators) and applying them to the whole sky for a year or more. This was NASA's Small Astronomy Satellite 1, SAS-1 or Uhuru. Riccardo proposed an all sky X-ray survey to NASA. NASA accepted the proposal and funded the SAS-1 mission for development, launch, and operations. Riccardo's team at AS&E and SAO developed the payload, conducted the science operations, processed the data, and published the discoveries.

I suggest that SAS-1, or Uhuru, was NASA's first PI-led observatory. How many other powerful PI-led small missions have we had at NASA, especially in astrophysics? How many other all-sky surveys have we conducted in other bands of the electromagnetic spectrum to open new windows on the universe? Recently, in 2018, NASA launched a PI-led, all-sky survey that is principally a survey for transiting exoplanets in our local part of the Galaxy, but is additionally a time domain survey of every object brighter than 16th magnitude. In 2019, NASA selected an all-sky near-infrared spectroscopic survey that will allow fundamental measurements of the origin and evolution of the universe and its chemical composition.

The High Energy Astrophysics Observatory 2 – HEAO-2 or Einstein Observatory – was another game changer for NASA and the astrophysics community. HEAO-2 was not a survey satellite; it was a space telescope with a suite of instruments, i.e., an observatory.

HEAO-2 was launched in 1978, while I was a graduate student at the Center for Astrophysics. I recall very clearly a meeting of the Center's High Energy Astrophysics Division to vote on a name for HEAO-2. I assume this was before launch, but I do not remember that detail. I do recall that Riccardo, through a process unknown to me, had arrived at the two finalist names and was putting them up for a popular vote. The two finalists were Einstein and Pequod. Albert Einstein, one of the most famous scientists in history, of course had formulated the Theory of Relativity and other laws of physics that would be tested by the HEAO-2 observations. The Pequod was Captain Ahab's whaler in the novel Moby Dick; I recall some connection to exploration (a NASA value even then) and New England (home of the Center for Astrophysics). History shows that Einstein Observatory won the popular vote, and Pequod was voted off the island. Perhaps someone else at this Symposium knows how those two finalists were arrived at. I was a lowly second-year graduate student. As an experienced manager, leader, and most important parent, I know that you do not ask a question if you do not want to know the answer. I would not be surprised if the nominations were perhaps manipulated in some way to yield the result that Riccardo wanted.

Something else I do not know. At NASA, HEAO-2 is never called the Einstein Observatory. It is always called HEAO-2. And neither of the other HEAOs were named after launch – they were just HEAO-1 and HEAO-3. I am sure there is a story there. But naming satellites is not the impact on NASA that I want to highlight.

The Einstein Observatory was the first NASA observatory with a Guest Observer program. The HEAO-2 observing program was opened to investigation ideas from outside the HEAO-2 consortium. External astronomers could and did request observations through an organized call for proposals. Once their data had been acquired, they could visit the data center at the Center for Astrophysics, use the analysis tools, and receive expert help from the operations staff.

This model has served NASA well with all of its subsequent space telescopes. Today even small PI-led missions like NuSTAR and NICER have Guest Observer programs. This innovation sits at the core of NASA's portfolio of astrophysics observatories. As evidence, consider the 2019 Senior Review of Astrophysics Operating Missions. The Senior Review Panel, like all prior senior review panels, rates the missions by their science productivity; and the science productivity of pointed missions is dominated by the success of its General Observing program.

I met Riccardo during the period prior to the launch of the Einstein Observatory. When I was a second year graduate student, I was searching for a thesis topic. During this period, Riccardo invited me to his office. As far as I can recall this was the first time I had had a personal conversation with him. Riccardo pointed out to me that the Einstein Observatory would be so sensitive that it would detect X-rays emitted by the coronae of main sequence stars like the Sun. At that time, the Sun was the only main sequence star whose X-ray brightness had been measured. Riccardo continued that the Einstein Observatory would be able to measure the X-ray brightness of stars along the entire main sequence. He said that this would be a great thesis topic, for the first time to construct the X-ray Hertzsprung-Russell diagram. I cannot recall whether I thought about the offer for a while, or whether I responded immediately. I declined the offer. I did not become an X-ray astronomer so I could study main sequence stars. I wanted to study black holes and neutron stars and other exciting phenomena. But think about it. I turned down an offer for Riccardo Giacconi, the father of X-ray astronomy and future Nobel Laureate, to be my thesis advisor. Who knows how things might have turned out if I had accepted; I might have been invited to give the kickoff talk at a symposium in his memory.

From the Center for Astrophysics, Riccardo went to the Space Telescope Science Institute in 1981 to become its first Director. This was not an easy transition for NASA. The Space Telescope Science Institute was established in response to a National Academies study, the

Horning Report. After AURA won the competition to manage the Institute, Riccardo was invited to apply for, and was then selected to be, the first director.

NASA was an unwilling convert to the fact that an academic setting was a vibrant one for managing a space observatory. NASA preferred to manage both the development and the operation of its science missions at a NASA Center. NASA was not accustomed to delegating science operations – and responsibility for the science success of a mission – to a contractor (I am using NASA speak here, apologies to my AURA colleagues). Riccardo established the strong role for the Institute – a role that we now take for granted – in ensuring the scientific success of Hubble, and eventually NASA and the Institute agreed on roles and responsibilities. Riccardo introduced a number of initiatives that were instrumental in Hubble's eventual success.

- A guide star catalog to ensure Hubble could point stably and accurately anywhere in the celestial sky.
- Resident experts on the instruments so that the Institute could support community users without relying on the instrument builders for technical expertise.
- Most importantly, the need for funding for the users of the observatory.

This was a seminal change. When prior NASA observatories were made available to external users, such as the Einstein Observatory and the International Ultraviolet Explorer, those users received only observing time when their proposals were selected. If they did not have other sources of funding, then their science investigations might not be carried through. They would have to apply for research funding through a separate process. This "double jeopardy" meant that observatories might not be as scientifically productive as possible.

As the first Great Observatory, with a cost far exceeding any previous NASA astrophysics missions, science success was an imperative. A committee was assembled to estimate the appropriate size of grants for using Hubble and analyzing the data. The recommendations of this committee were accepted, and the first funded Guest Observer program was established for Hubble. To this day, a key component of the Hubble budget is the funding for the Guest Observer program. Now all NASA missions have funded user programs. For target-driven space telescopes like Hubble and Chandra and NuSTAR and NICER, users receive funding for conducting their science investigations. For survey missions, users receive funding for mining the data.

Speaking of data, Riccardo also established a data archive for Hubble data. This archive became the core around which the MAST (originally the Multimission Archive at the Space Telescope Science Institute, now the Mikulski Archive for Space Telescopes), NASA's first astrophysics data archive, was built. This is the model for NASA's other astrophysics data archives, the HEASARC (High Energy Astrophysics Science Archive Research Center) and the IPAC (Infrared Processing and Analysis Center). Yet another of Riccardo's impacts on NASA.

To summarize Riccardo's impact on NASA and how NASA does astrophysics missions:

- He established the first PI-led astrophysics mission, Uhuru. Today the advantages of PI-led missions for generating compelling science results at modest costs are well established and are repeatedly endorsed by National Academies reports including Decadal Surveys.
- He established the first Guest Observer program for a NASA space telescope, the Einstein Observatory. Today every pointed astrophysics mission has a Guest Observer program to amplify and maximize the mission's science output.
- He established the first funded Guest Observer grants program, and the first astrophysics data archive, at the Space Telescope Science Institute. Today every NASA astrophysics mission has a funded community science program to ensure that the best science ideas, as established through peer review, will be carried through and influence the state of knowledge in astrophysics.
- And he directed the most scientifically productive NASA mission of all time, and arguably the most productive science experiment of all time, the Hubble Space Telescope.

That is a lot of impact on NASA.