History of Radio Astronomy at ETH Zurich

Arnold O. Benz

September 21, 2019
40 year Anniversary of the Bleien Observatory

Radio astronomy underwent a rapid development in the 1960s, both in instrumentation and observations. At ETH Zurich, Prof. Georg Epprecht at the Microwave Laboratory was looking for interesting work for his engineering students. He wrote the first proposal to the Swiss National Science Foundation in collaboration with Swiss the Federal Observatory (Eidgenössische Sternwarte, Prof. Max Waldmeier) in 1968. The proposal was accepted and on October 1, 1968, Dr. Hans Asper and two more engineers started work at the Microwave Laboratory. The goal was to develop a digital radio spectrometer controlled by a computer. It later became the Ikarus spectrometer. However, the digital instrument turned out to be too ambitious at that time.

In 1970 Dr. O. Meyer, an experienced physicist from the Weissenau Observatory in Germany, started at the Sternwarte. He was accompanied by Michael Perrenoud, then a graduate student in physics. They proposed to build first a spectrometer on analog basis, using photographic film recording. This instrument was finished and saw first light at August 28, 1972. A 5 m dish was mounted on the roof of the meridian building at the Sternwarte. The instrument became known as the Daedalus spectrometer.

On October 1, 1972, two astrophysicists joined the Sternwarte, Dr. Arnold O. Benz and Dr. Guy L. Tarnstrom. The first publication using Daedalus data appeared already on March 19, 1973 (A.O. Benz, Nature, 242, 38-39: “Harmonic Structure in a Solar Type V Burst”).

The situation for work at the Sternwarte was difficult. Meyer left and the others joined the new Group for Radioastronomy (RAG) at the Microwave Laboratory on January 1, 1974. It had a dual leadership: Astronomy Dr. A. Benz, instrumentation Dr. H. Asper.

The digital instrument, Ikarus, registered the first radio burst on December 14, 1974. Since interference at the Sternwarte was becoming severe, the two spectrometers were moved to Dürnten (Zürcher Oberland). In addition to the 5m dish, a new 7m dish, a gift from Weissenau Observatory, was put into operation. Regular observations became possible. However, the thirst of the astronomers for new observations was not satisfied. On August 3, 1977, the first external observations were carried out at the Arecibo 300 m dish. Arnold Benz and Hansruedi Fitze observed the Sun by radar, but found only strong fluctuations. On June 25, 1978, a lever of the drive for the 7 m antenna in Dürnten broke and Ikarus observing stopped for half a year.

In 1979 the observing site in Dürnten was recalled by the military. On June 13, 1979, the two dishes and all the equipment were moved to Bleien near Gränichen AG, then a place of low interference. The dishes were flown by helicopter. Already on August 4, the observing began at the new observatory (engineers: Mike Perrenoud, René Jung, Frieder Aebersold). On November 10, 1979, the Bleien Radio Observatory had its open doors. It was a rainy day and more than a thousand people came. The ETH press office helped by building a wooden bridge from Mattenhof to the observing room. There was an exposition on Radio Astronomy at the Restaurant Bleien in parallel.

On February 14, 1980, NASA launched the Solar Maximum Mission. A. Benz was guest investigator and spent a six month sabbatical at the Goddard Space Flight Center in Greenbelt, MD, in 1981. This opened the way to combine radio and X-ray data. X-rays became equally important to radio in the following years (Markus Aschwanden).

On April 1, 1980, Prof. Jan Stenflo started and opened the new Institute **of** Astronomy at ETH in the Physics Department of ETHZ. The Radio Astronomy Group (headed by Arnold Benz) became part of it.

On April 22, 1982, Ernst Fürst (Max-Planck.Inst. Bonn) and Arnold Benz first detected radio emission from a dwarf nova using the 100m dish in Effelsberg. The Ikarus spectrometer in Bleien was put out of service on August 25, 1983, to be replaced by a new digital spectrometer, Phoenix. The observing room was replaced by a new container. In the meantime, observations were made at the Very Large Array in New Mexico (USA). Phoenix started to operate in Bleien on August 27, 1984 (engineers: Mike Perrenoud, René Jung, Frieder Aebersold, Peter Povel, Werner Stehling). Its spectrum ranged from 100 to 3000 MHz. A major emphasis was on short-duration narrowband spikes (Benz, Solar Physics, 104, 99-110 (1986) “Millisecond Radio Spikes”). Even more cited were observations of broadband pulsations (542 citations, Roberts, B.; Edwin, P. M.; Benz, A. O. 1984 ApJ. 279, 857-865). In 1987 the new instrument was moved to Bern for observations between 6 to 8 GHz for the first high spectral resolution observations in this high-frequency range. A first event was registered on April 19, 1988. The observations discovered that coherent solar radio emission is emitted up to about 8 GHz.

Phoenix was moved back to Bleien on May 30, 1989, and recorded solar radio bursts again in the range 0.1 – 3 GHz starting on June 22. The spectrometer was used in the Max’91 worldwide champagne June 22 – 30 1989 and for joint observations with the VLA July 29 – August 3, 1989., An international CESRA workshop took place in Braunwald August 27 - 31, 1989. The Bleien data took a prominent place. After the workshop, many international participants toured the Bleien Observatory. On September 19, 1989, Phoenix collaborated in an attempt to observe solar radio bursts with VLBI. During the peak of solar activity from June 22, 1989, to August 1990, Phoenix surveyed the 0.1 – 3 GHz range. These were the first observations in this band and were used to classify the different burst types in decimeter wavelength range (Isliker & Benz, Astronomy and Astrophysics Suppl., Vol. 104, 145-160 (1994) “Catalogue of 1-3 GHz solar flare radio emission”).

In the first part of the 1990s a major focus was on radio observations of stars. It included stellar VLBI and the first resolution of a radio star. The culmination was the detection of the relation between stellar X-ray flux and gyro-synchrotron radio emission (Güdel & Benz 1993 ApJ.405L.63 “X-Ray/Microwave Relation of Different Types of Active Stars”; Benz & Güdel 1994 A&A 285, 621).

In 1997 it became clear that Phoenix was not going to last for the coming solar maximum. The senior engineer, Werner Stehling, left and Christian Monstein took his place. He managed to build a greatly improved spectrometer within 18 months. Phoenix-2 was calibrated and able to quantitatively measure circular polarization. The range was now from 0.1 to 4 GHz in frequency-agile mode (Peter Messmer, André Csillaghy).

On February 2, 2002, the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) was launched by NASA. It had important Swiss contribution by PSI (hardware) and ETH (software). The satellite operated until October 1, 2018. RHESSI made it possible to compare and combine solar radio and X-ray observations. A great number of studies and publications resulted from this approach, most of them using data of Phoenix-2 (Ph.D. students: Pascal Saint-Hilaire, Gunnar Paesold, Paolo Grigis, Marina Battaglia).

In 2004 Christian Monstein and Hansueli Meyer built a dual-channel frequency-agile spectrometer from cheap commercially available consumer electronics. The spectrometer was duplicated by apprentices and distributed around the world during the International Heliophysical Year (2007). It developed into a system, e-CALLISTO, that today provides 24-hour coverage of the solar radio events in the range 45 – 870 MHz and includes more than 164 instruments in 27 countries.

The dream of a high-sensitivity multichannel spectrometer became realistic with the advent of high-speed electronics allowing online Fast Fourier transformation. In collaboration with Acqiris, Geneva, who had developed a rapid sampler, and FHWN, Windisch, Phoenix-3 was build. The new spectrometer, Phoenix-3, was the radio telescope with the broadest frequency range (0.1 – 5 GHz) in the world. First tests were made in millimeter wavelengths at the KOSMA telescope on Gornergrat observing molecular lines in star forming regions. Phoenix-3 became fully operational in Bleien in August 2009. For the first time it became possible to resolve narrowband spike bursts in time and frequency. Phoenix-3 remained the leading spectrometer in its frequency range in the world as long as it operated (until 2012).

In 1998 ESA selected the Herschel Space Observatory as the European corner stone in the little-known far infrared and terahertz regime. The Radio Astronomy Group joined as the Swiss lead for the Heterodyne Instrument for Far Infrared (HIFI), a spectrometer in the 0.3 - 2 THz range. The hardware contributions included the housing (Common Optics Assembly, built at HTS Wallisellen) and the second amplifier (IF2, built at the Institute for High-frequency Technology at ETHZ, Prof. W. Bächtold). The astronomical preparatory work involved the studies of molecular chemistry and line frequencies in star forming regions (Pascal Stäuber). Herschel was launched on May 14, 2009, and operated until April 29, 2013. The Radio Astronomy Group was involved in 63 publications, including the first discovery of the molecules H_2O^+, SH^+, and OH^+ in space.

In 2007 the Radio Astronomy Group became a part of the new Institute **for** Astronomy at ETH Zürich and moved to the Hönggerberg Campus in 2008. In 2010 Arnold Benz retired. The work continued for a while, but eventually the last Ph.D. students (Simon Bruderer and Susanne Wampfler) and the post-docs left. Today only Christian Monstein still has an employment and Arnold Benz continues on a voluntary basis. Since 2014, Bleien is used extensively for extragalactic work such as the detection of extragalactic Fast Radio Bursts and red-shifted HI emission. The Radio Astronomy Group is slowly dispersing. At the moment of writing, the observatory is however fully operating. E-CALLISTO, operated by Christian Monstein, is in full swing. The solar data, stored at FHNW in Windisch, are used by a large community around the world.

Some 128 publications in refereed journals are based on Bleien data (2019 and counting). Four of them appeared in the highly esteemed journal “Nature”. Four more Nature articles, one in “Science” and another 26 publications used observations from other radio telescopes. 13 Dissertations at ETH Zurich used observations from Bleien. Three dissertations are related to the Herschel Space Observatory. An even larger number of Diploma Theses and many more Semester Projects resulted. During the whole time (1968-2010) the Swiss National Science foundation supported significantly the hardware work.