

The "Astropeiler Stockert Story"

Part 1: Overview of the 25m dish

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Introduction

This is the first part of a series of articles to introduce and describe the "Astropeiler Stockert", a radio observatory located on the Stockert Mountain in Germany. This observatory comprises of a 25m dish, a 10m dish and some other smaller instruments. It is maintained and operated by a group of amateurs and is as of today the world's most capable radio observatory in the hands of amateurs.

In this series of articles I wish to describe the setup, the instrumentation and the observational results achieved.

This second part of the series will deal with the 25m telescope describing it's construction and functionality.

The site

The radio observatory is located about 30km south-west of the city of Bonn in a rural area.



Aerial view of the site. Photo courtesy of Klaus Göhring

The site includes the main 25m dish mounted on an octagonal building, a 10m dish on an equatorial mount, a building with labs and a conference room and two other buildings. One of these buildings is rented out, the other is awaiting restoration.

The 25m dish

The main telescope building is concrete structure which supports the 25m dish. Inside the building there is the control room on the first floor. A historical exhibition and a lecture room are located on the ground floor. In addition there is some office space, a kitchen to keep the operators happy, and the rooms for the machinery.



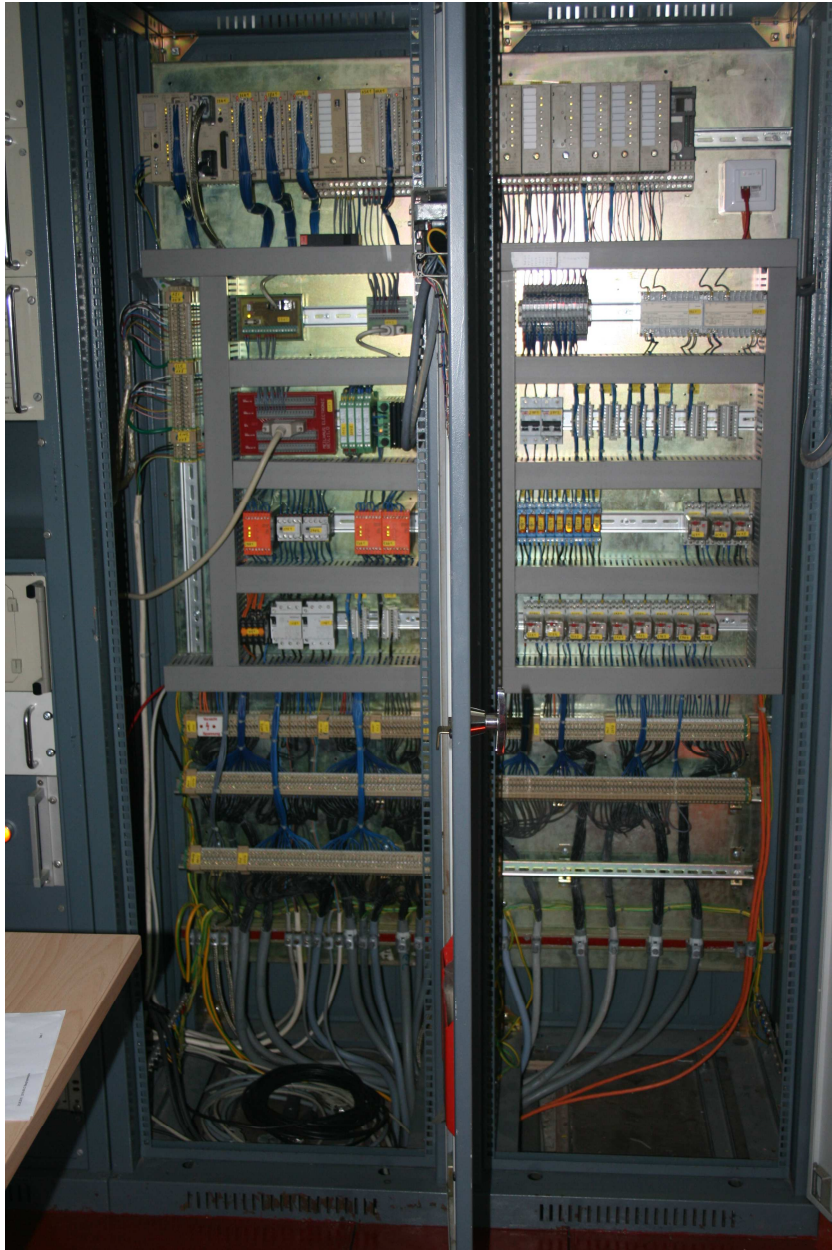
25 meter dish

The moving parts of the 25m dish have a total weight of about 90 tons. It is an Elevation over Azimuth construction. All mechanical parts including the motors are still original from the 50s, whereas the control system has been completely rebuilt using industrial control systems.

The dish is a aluminium mesh construction with a steel structure underneath. It is a comparatively deep dish with an f/D ratio of 0.3. The receiver is mounted in a prime focus configuration supported by a four leg structure.

Dish control

The motion of the dish is controlled by a two layer structure of hard- and software. The lower layer directly controlling the azimuth and elevation motors, the brakes, end switches and other safety relevant systems is implemented using an industrial SPC shown below:



SPC racks

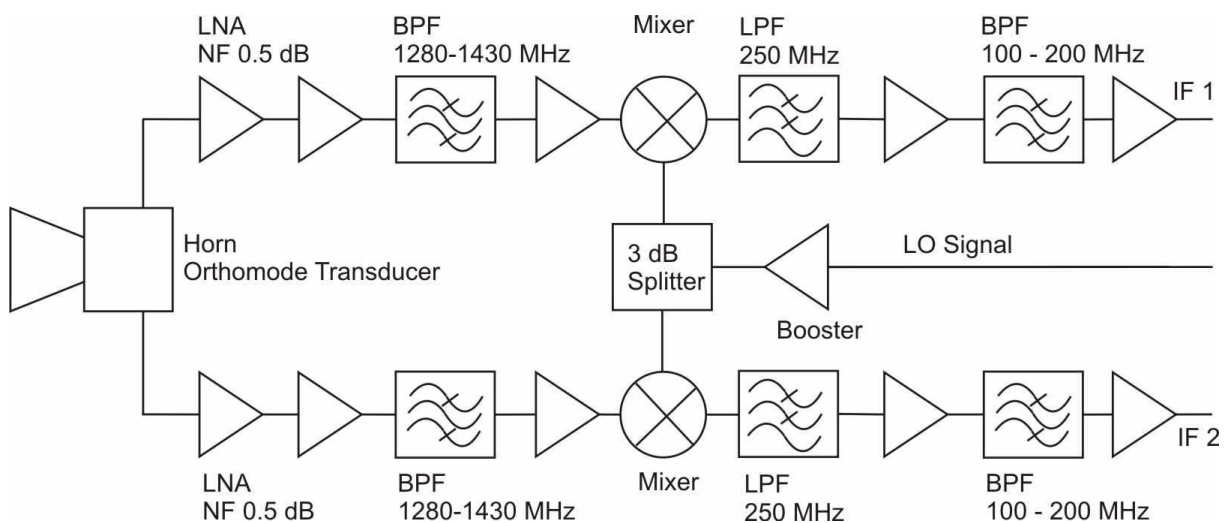
The upper layer, based on a Linux PC, implements the azimuth/elevation control loops using high resolution angular encoders for position feedback. This PC also performs the coordinate conversion between celestial or galactic coordinates and the machine coordinates.

Receiver

The receiving horn of the receiver is a cylindrical waveguide with Chaparral type rings, adjusted for a target illumination taper of 12 dB. At the receiving horn, the signals are picked up in both linear polarizations. The first amplifier stage are LNAs with a noise figure of 0.5 dB.

The operating frequency ranges from 1280 to 1430 MHz. The signal is down converted to an IF of 100 to 200 MHz inside a box located at the prime focus. The local oscillator (LO) can be adjusted to select any 100 MHz wide range inside the primary frequency range. The LO signal is fed in via a cable from the control room and amplified by a booster amplifier at the receiver.

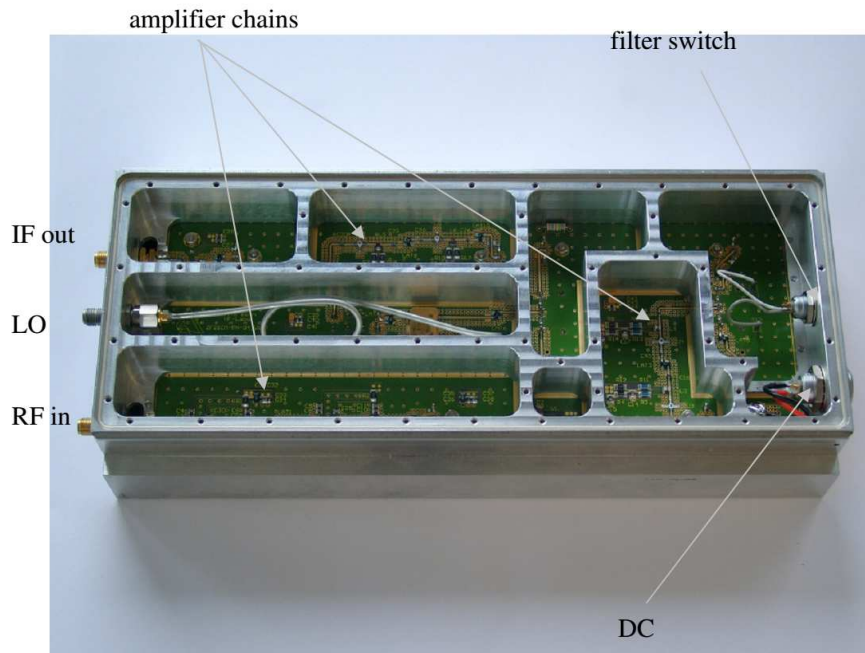
The overall gain from LNA input to IF output is about 100 dB.



Schematic overview of receiver

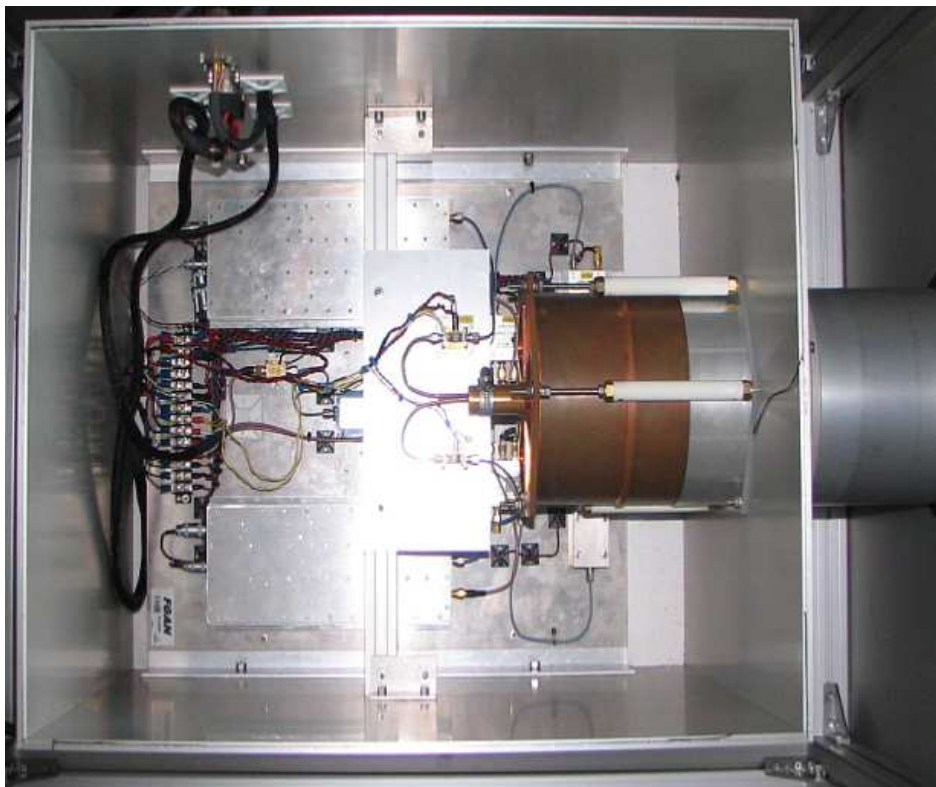
One of the polarizations can be switched to 18 cm (not shown in the schematic) to allow observation of OH masers. A calibration signal from a noise diode can be injected via a small pin in the receiving horn.

All circuitry with the exception of the LNAs, the LO booster and the noise diode are contained a RF tight box (the "IF box") as shown in the picture below.



Inside of the "IF Box"

The complete receiver assembly, comprising the LNA's, the IF boxes, noise diode and LO booster amplifier is housed in a water tight box which is mounted in the prime focus.



Inside of the receiver box



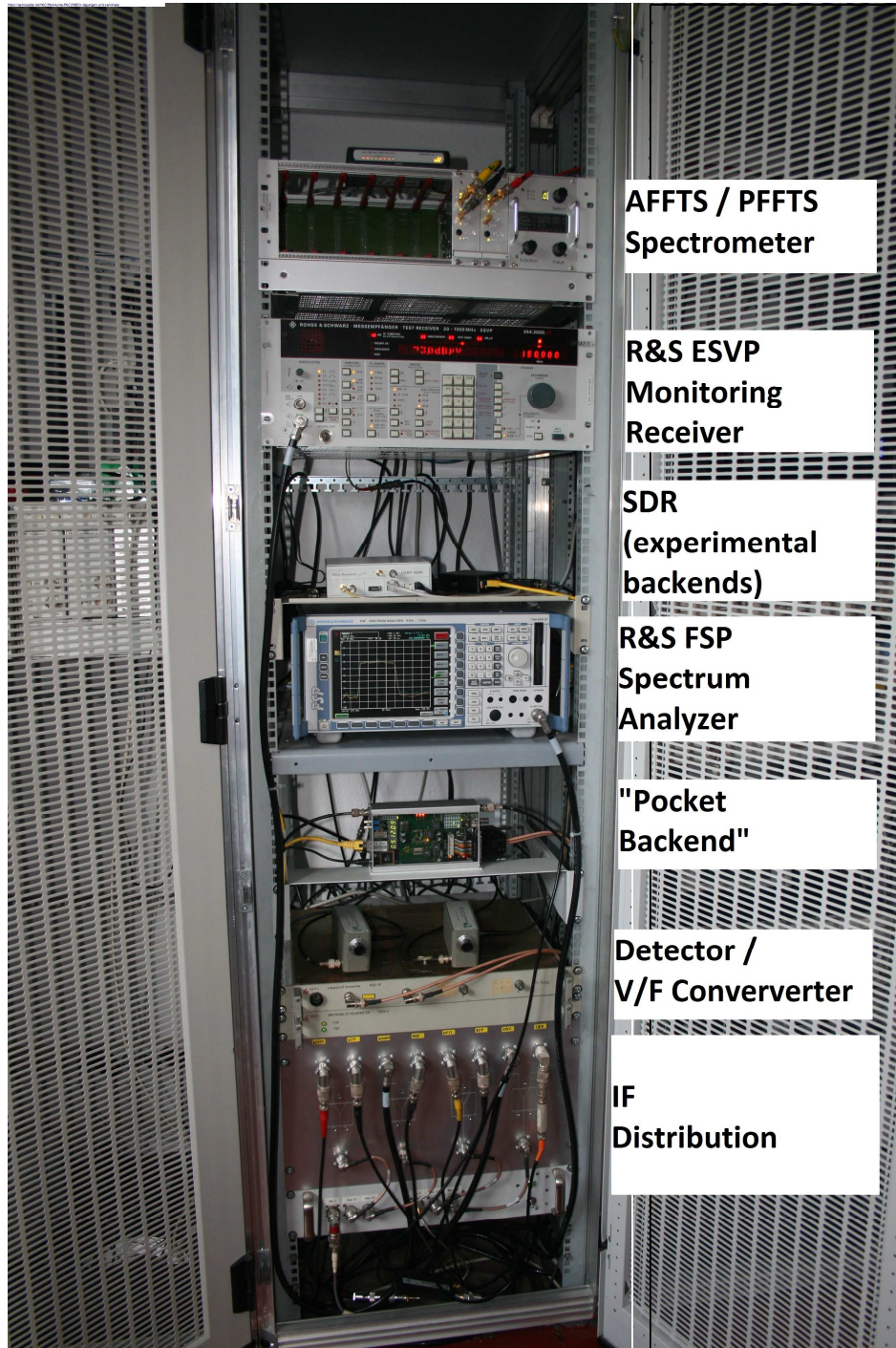
Mounting the receiver at the prime focus is a major task and requires strict safety procedures

Backends

The IF signal from the receiver is brought down to the control room via high quality coax cables. It is fed via a distribution system to several backends and monitoring instruments as shown in the rack photo (from bottom to top):

The IF signal from the receiver for both polarizations passes through a distribution amplifier and a passive distribution network. This network provides four outputs for each polarization.

For continuum observation, the signal is fed into a power detector which is followed by a V/F converter. This generates a signal with a frequency proportional to the received power. A so called "pocket backend" evaluates this signal with selectable integration times and delivers the data to the measurement computer.



Backend Rack

A Rohde&Schwartz FSP Spectrum Analyzer is used for overall signal quality monitoring and RFI identification.

Presently, various options to use software defined radios as backends are under investigation. Both low end solutions with a RTL dongle and a high end solution using an Ettus research N200 are part of this exercise.

A Rohde&Schwartz ESVP receiver is used for analyzing sources of RFI.

The main instrument for most of the observations performed is placed at the top of the rack.

This instrument is a Fast Fourier Transform Spectrometer (FFTS) developed by the Digital Group of the Effelsberg Telescope. It is used in two different operating modes:

- AFFTS; used for spectral observations. In this mode, the spectral resolution is set to about 6 kHz over the full IF bandwidth. A spectrum is dumped every second. For a detailed description please refer to [1].
- PFFTS; used for Pulsar observations. In this mode, the spectral resolution is about 500 kHz, and the time resolution is down to 54 μ sec. This is sufficient to observe even the fastest millisecond pulsars.

A description of the PFFTS mode can be found in section 3.2 of [2].

All backends are clocked from a common rubidium source. The same applies to the local oscillator for the receiver. Absolute timing is derived from a GPS receiver which provides an IRIG-B timecode signal to the backends and also provides ntp service to the computer network.

Computer Systems

All backend systems are connected to a measurement computer which collects and processes the data. As a general rule, data from all observation is kept on storage and backup systems so that reprocessing is possible at a later time. The total storage capacity installed is more than 30 TB. Pulsar observations are the most demanding in terms of storage requirements as several MByte/s are generated in that operating mode.

All computer systems used are based on Debian Linux as operating system. The underlying concept of the software structure is that there are functional modules which communicate via TCP/IP to master "hubs" which accept and disseminate information. There are two hubs: One deals with all information elements which are related to the positioning of the telescope. The other hub deals with the instrumentation.

References:

[1] B. Klein et al., High-resolution wide-band Fast Fourier Transform spectrometers, <https://arxiv.org/pdf/1203.3972>

[2] E.D. Barr et al., The Northern High Time Resolution Universe Pulsar Survey I: Setup and initial discoveries, <https://arxiv.org/pdf/1308.0378>