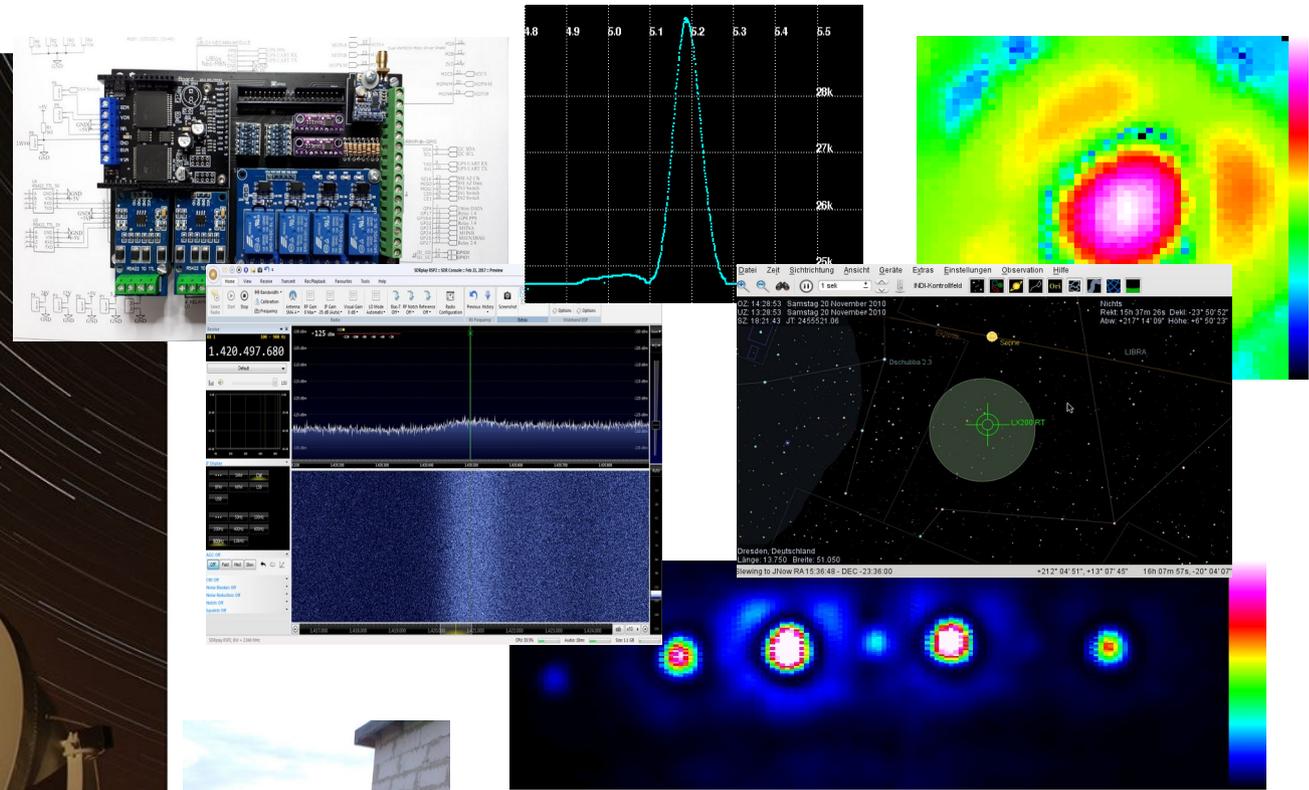
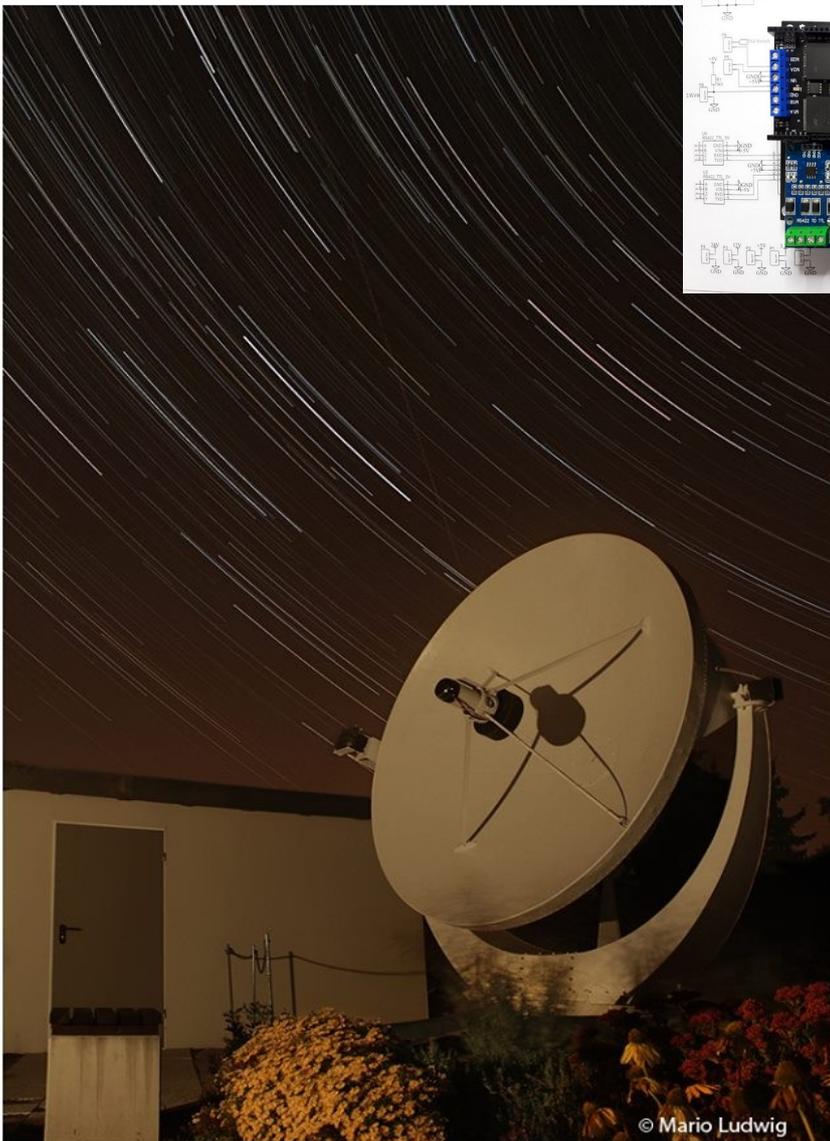


PiRaTe – Das Pi Radio Telescope

Ein 3m Amateur-Radioteleskop an der Sternwarte Radebeul (Dresden)



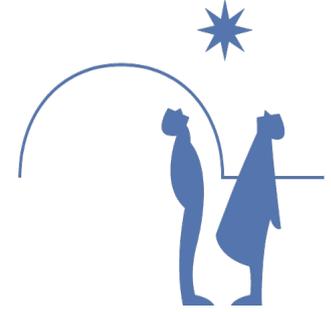
von
Hans-Georg Zaunick

π_{++}



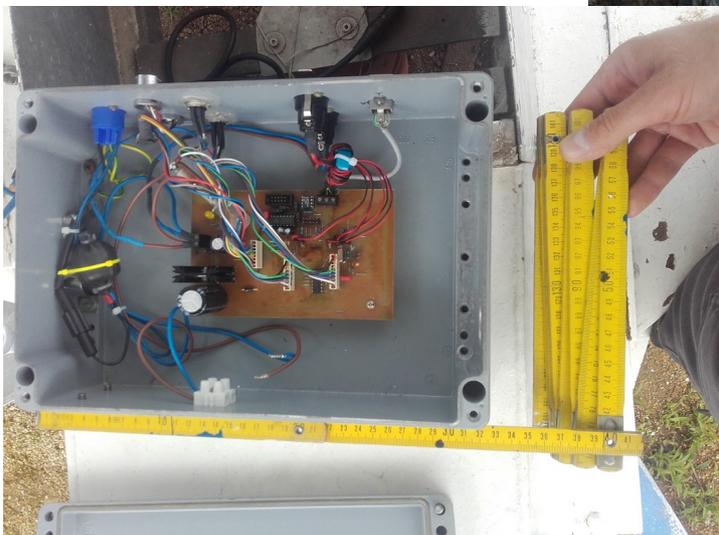
Pi and More – 22. April 2023

© Mario Ludwig



Radioastronomie an der Sternwarte Radebeul

2004 Errichtung des Radioteleskops

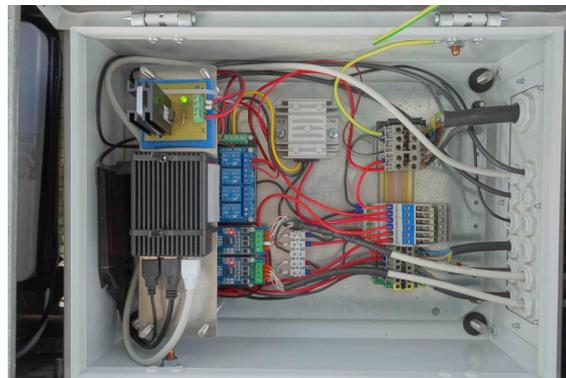
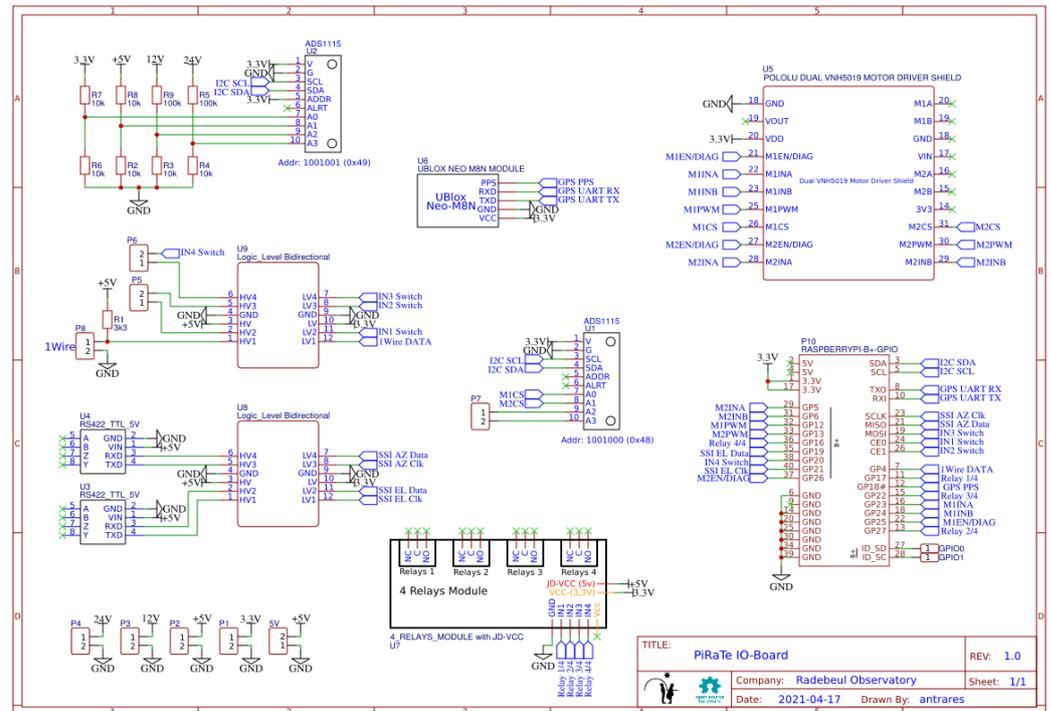
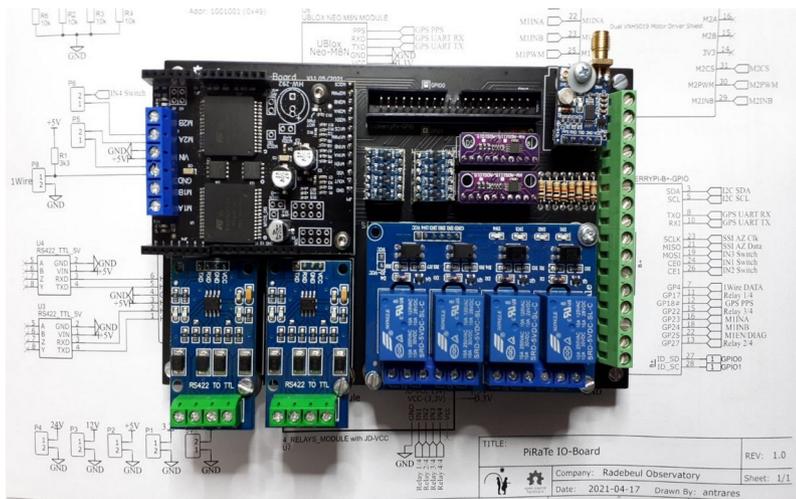


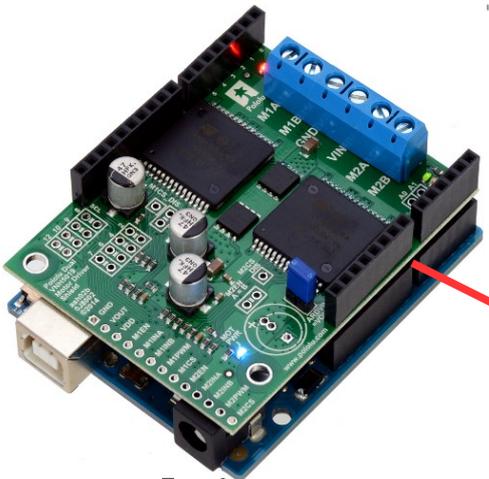
DIY-Steuerung:

- ATmega128 mit LX200 Interface+Inkrementalencoder+PWM Motoransteuerung
- Zerstörung durch Wasserschaden 2011

Die PiRaTe Steuerung (2021)

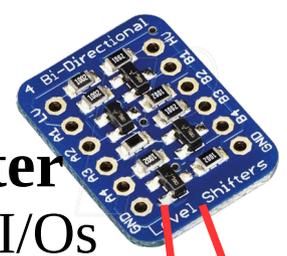
- Kompletter Neubau der Steuerung 2020/2021
- Raspberry-Pi + Off-the-Shelf Module und Komponenten
- Software: möglichst bestehende, modulare und Open-Source Lösungen
- Wartungsfreundlich + Robust
- Remote-Betrieb





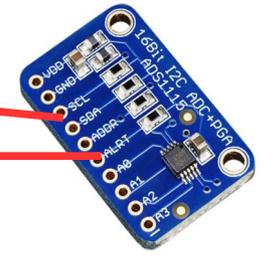
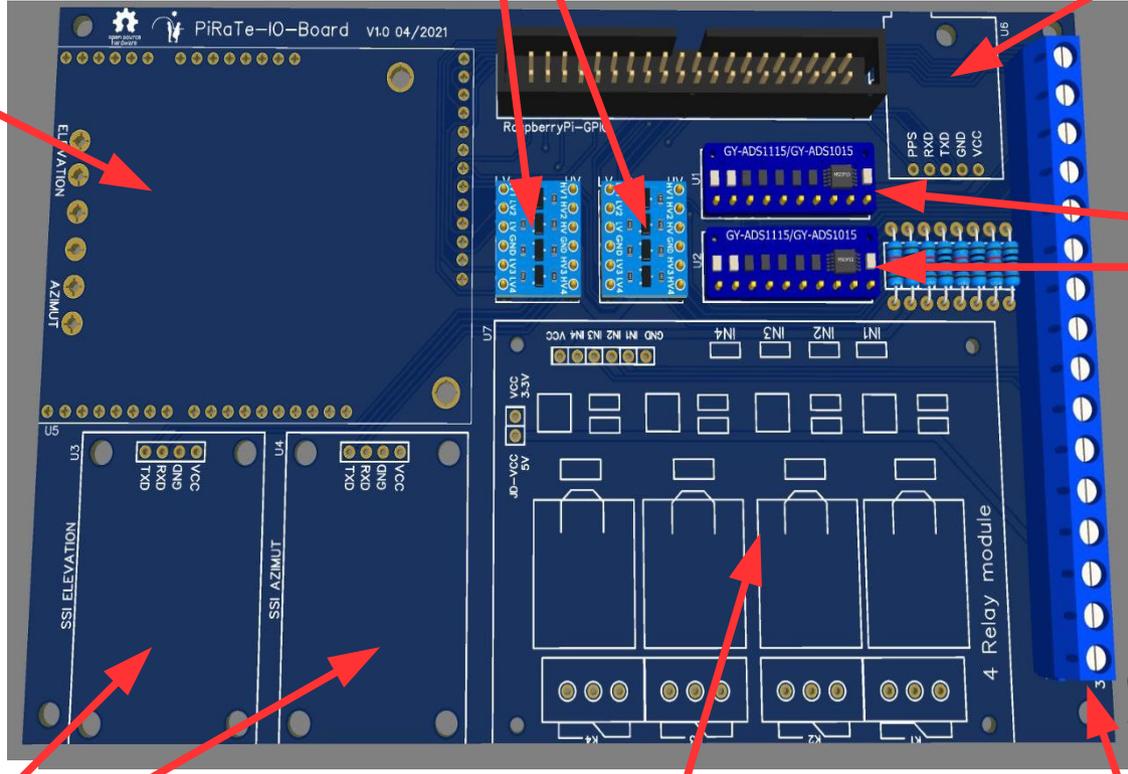
Arduino Motor Driver Shield (Pololu)
Zum Antrieb von zwei 24V DC-Motoren @max 12A

Level Shifter
Für digitale I/Os

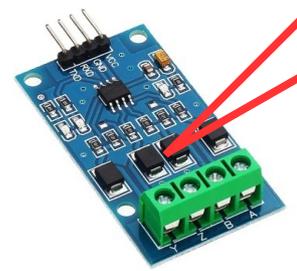


Ublox GNSS Receiver

Zeitsync des RPi und Koordinaten für Astro-Magic



ADS1115 Breakout Board
•4ch 16bit ADC
•Zum Messen der Motorströme, Versorgungsspannungen, Analoge Eingänge



RS422-TTL Converter
Anschluß der Pos-Encoder (SSI diff. bus)

4ch Relais-Modul
Zum Schalten und Walten



Digital+Analog I/Os+1wire

PiRa

Positions-Encoder

Encoder an übersetzter
Sekundärwelle der
Azimutachse

Entscheidung für Industriestandard Absolut-Encoder:

- Ultrarobust, IP65
- Serielles SSI Interface
- Differentielle Datenleitungen f. hohe Störfestigkeit
- Gleiches System/Protokoll – viele Hersteller
- 12 oder 13 bit Single-Turn und Multi-Turn Auflösungen
- Viele Angebote Ebay, AliExpress: 30...800€



Baumer Multiturn-Drehgeber, absolute Encoder
GXM2S.Z20

Artikelzustand: **Gebraucht**

Preis: **EUR 49,00**

Sofort-Kaufen

In den Warenkorb

Preisvorschlag:

Preisvorschlag senden

Auf die Beobachtungsliste

Sicher einkaufen

eBay-Ki Sie erhalten oder bei [Mehr](#)

Angaben zu [santacruz_1](#) (86) 100% Positive Bewertungen Angemeldet als

Preisvorschlag [besseren Preis](#)

Versand aus Deutschland Lieferung in ca. 3 Werktagen 30 Tage Rücknahme

Abholung: Lieferung an Abholstation möglich

Versand: EUR 5,20 Standardversand | [Weitere Details](#)

Standort in: Deutschland, Deutschland

Versand nach: Weltweit | [Ausschussliste anzeigen](#)

Lieferung: Bis ca. Sa. 11 Sep. nach 35452

Zahlungen:



PiRaTe - Pi++ 22.04.23



Encoder mit direkter Kopplung der Elevationsachse

Software

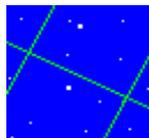
Steuerung über INDI Protokoll



<https://www.indilib.org/>

- Open Source, Cross Platform, 22 Client-Apps verfügbar (inkl. IOS / Android)
- Weit verbreitet zur Steuerung von Remote-Teleskopen
- XML-basierter Datenaustausch
- Treiber beschreiben sich selbst (describe)
- Clients stellen vom Treiber gewünschte Eigenschaften zur Laufzeit zum Lesen/Schreiben zur Verfügung
- Steuerung eines Treibers mit mehreren Clients (lokal oder remote)

Cartes du Ciel



HNSky



iIndi



Telescope.touch



Stellarium

Software

Fernsteuerung - KStars



The screenshot displays the KStars software interface with several windows open:

- RT300 Camera - Mozilla Firefox:** Shows a live video feed of the RT300 radio telescope structure.
- plotfile.eps - sun_scan_2408201_2.pdf - Mozilla Firefox:** Displays a radio scan plot titled "Sun @ 12 GHz" for "24 Aug 2021 09:30 UTC Radio Astronomy Group - Observatory Radebeul (Germany)". The plot shows a bright central source with a color scale from 0 to 50.
- KStars:** The main window shows a star chart with the Sun at the center, labeled "Sun" and "PI Radiotelescope". The location is "Dresden, Germany" with coordinates "+137° 29' 12\", +43° 50' 59\"".
- radioid - Konsole:** A terminal window showing a list of radio scan data points with columns for RA, Dec, and other parameters.
- INDI Control Panel:** A control panel for the PI Radiotelescope with tabs for Weather Watcher, GPSD, and various control functions like Connection, On Set, Eq. Coordinates, Abort Motion, Tracking, Parking, and Scope Status. It includes buttons for Connect, Disconnect, Track, Slew, and Park/UnPark.

Software

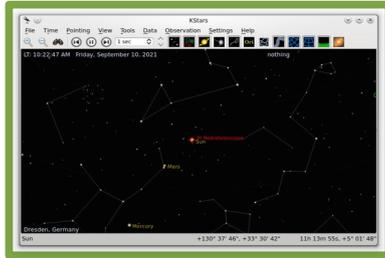


Der Radiotelescope Task Scheduler - RaTSche

Clients



```
piert300:~$ indi_getprop -t 1 -l "Pi Radiotelescope.*" | head
Pi Radiotelescope.CONNECTION.CONNECT=on
Pi Radiotelescope.CONNECTION.DISCONNECT=off
Pi Radiotelescope.DRIVER.INFO.DRIVER_NAME=Pi Radiotelescope
Pi Radiotelescope.DRIVER.INFO.DRIVER_EXEC=indi_pirt
Pi Radiotelescope.DRIVER.INFO.DRIVER_VERSION=1.0
Pi Radiotelescope.DRIVER.INFO.DRIVER_INTERFACE=1
Pi Radiotelescope.PULLING.PERIOD.PERIOD_MS=200
Pi Radiotelescope.AZ_ENC.SETTING.AZ_ENC_ST_BITS=12
Pi Radiotelescope.AZ_ENC.SETTING.AZ_ENC_MT_BITS=12
Pi Radiotelescope.EL_ENC.SETTING.EL_ENC_ST_BITS=13
piert300:~$
```



Definition von Tasks - Taskfiles

```
# start_time mode priority alt_period user x1 y1 x2 y2 stepx stepy int_time ref_cycle max_duration comment
2021/09/04 11:30:00 unpark 1 0 rtuser * * * * * 0.1 "unpark"
2021/09/01 10:50:00 maintenance 1 0 rtuser * * * * * 1 "maintenance cycle"
2021/09/03 17:28:00 drift 1 0 rtuser 180 60 * * * * 5 * 0.5 "transit scan test"
2021/09/04 14:15:00 track 1 -1 rtuser 10.9 7.0 * * * * 10 * 1.0 "test sun track 12GHz"
2021/09/03 18:30:00 horscan 2 0 rtuser 170 24 190 34 0.5 0.5 0.5 * 0.1 "Test scan Az/Alt"
2021/09/04 11:31:00 equscan 2 1 rtuser 10.7 4 11.25 10 0.015 0.15 1 * 3 "sun scan 12GHz"
2021/09/04 13:30:00 park 1 0 rtuser * * * * * 0.1 "park"
2021/09/03 10:41:00 maintenance 1 -1 rtuser * * * * * 0.1 "maintenance cycle"
```

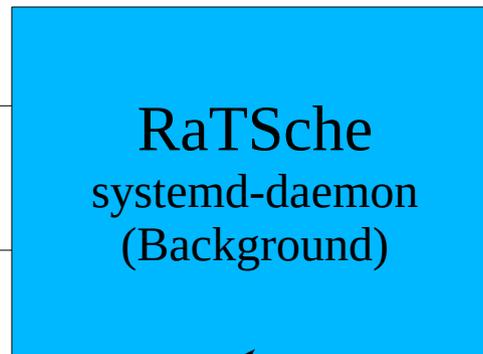
LAN/WAN

PiRaTe - RPi



indiservert

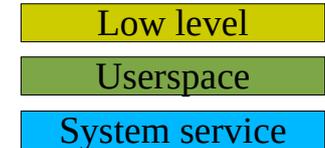
INDI-
Commands



Message
Queue

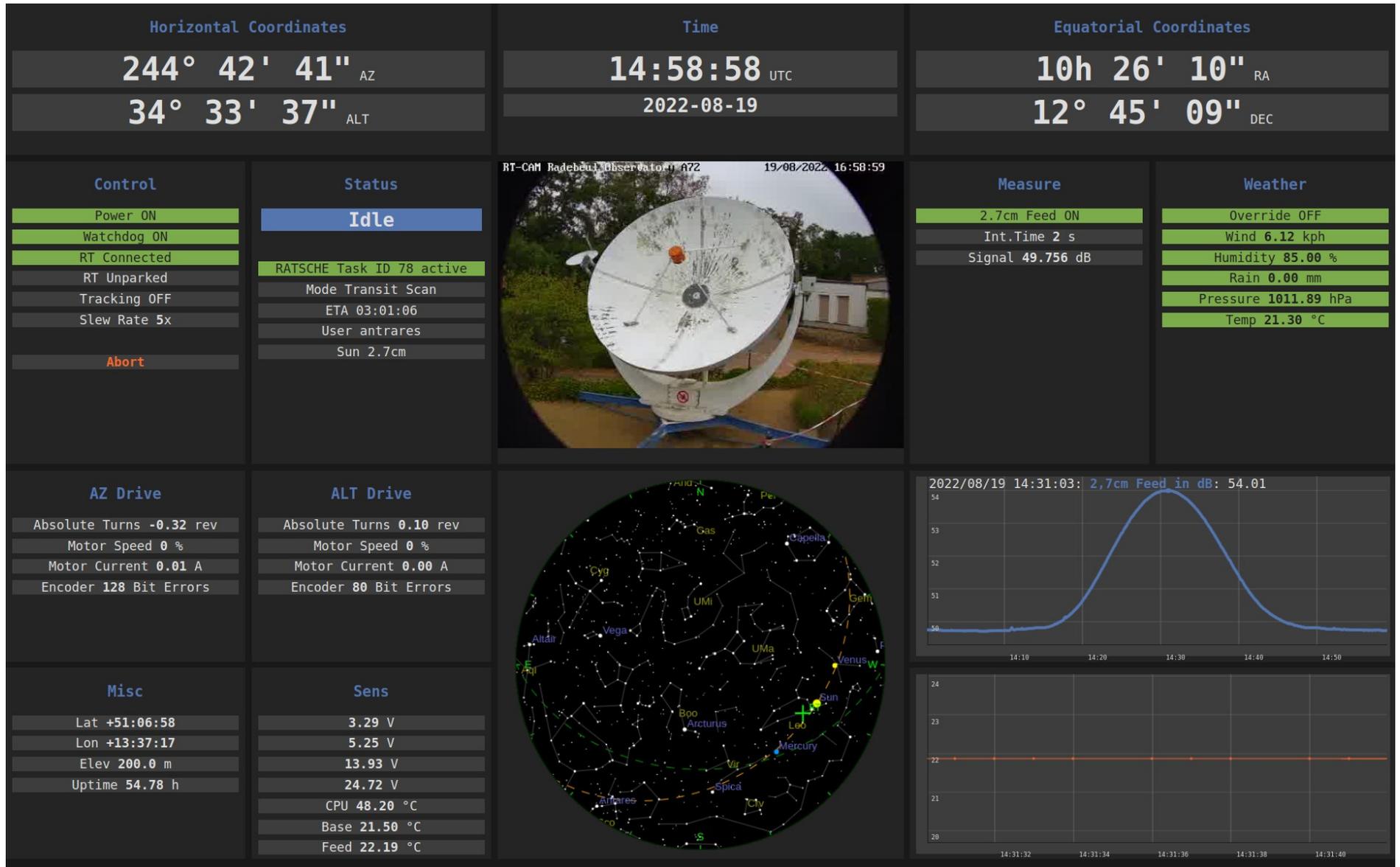


MQTT



Software

Das WebUI-Dashboard JS-Frontend mit MQTT-Endpoints für INDI-Variablen und Ratsche Tasks



Software



Der WebUI-Task-Scheduler

JS-Frontend mit MQTT-Endpoints für INDI-Variablen und Ratsche Tasks

Task List																	09:16:02 UTC		
Task	Date	Time	Mode	Priority	Alt-Period	User	Lower left X	Lower left Y	Upper right X	Upper right Y	Increment X	Increment Y	Int-Time	Ref-Cycle	Max-Duration	Elapsed	ETA	Status	Comment
80	2022/08/20	13:00:00	Park Scope	immediate when free	-1 h	antrares	0:00:00	0:00:00	0:00:00	0:00:00	0	0	0 s	0	00:06:00	00:00:00	00:06:00	Queued	park scope
79	2022/08/20	09:12:00	RA/Dec Grid Scan	immediate when free	-1 h	antrares	9:28:09	4:53:34	10:28:09	19:53:34	0.033	0.5	5 s	0	02:00:00	00:03:58	01:56:02	Active	Sun Scan 2.7cm
78	2022/08/19	14:00:00	Transit Scan	immediate when free	-1 h	antrares	244:37:41	34:33:37	0:00:00	0:00:00	0	0	2 s	0	04:00:00	04:00:00	00:00:00	Finished	Sun 2.7cm
77	2022/08/18	13:34:00	Transit Scan	immediate when free	-1 h	antrares	235:51:14	39:36:50	0:00:00	0:00:00	0	0	10 s	0	01:00:00	01:00:00	00:00:00	Finished	Sun 2.7cm
74	2022/08/18	10:05:00	RA/Dec Grid Scan	immediate when free	-1 h	antrares	8:03:27	5:53:43	10:33:27	25:53:43	0.066	1	1 s	0	06:00:00	01:21:14	00:00:00	Finished	Sun/Venus 2.7cm
72	2022/08/16	16:25:00	Maintenance	ignore	-1 h	antrares	0:00:00	0:00:00	0:00:00	0:00:00	0	0	0 s	0	06:00:00	05:59:60	00:00:00	Finished	...
71	2022/08/16	13:11:00	Transit Scan	immediate when free	-1 h	hgz	0:00:00	51:00:00	0:00:00	0:00:00	0	0	1 s	0	06:00:00	03:10:50	00:00:00	Stopped	longtime north pole, 2.7cm, secondary antenna
70	2022/08/16	08:47:00	Transit Scan	immediate when free	-1 h	hgz	148:04:23	48:58:14	0:00:00	0:00:00	0	0	2 s	0	02:00:00	02:00:00	00:00:00	Finished	transit scan sun, 2.7cm, secondary antenna
68	2022/08/15	10:00:00	Transit Scan	immediate	-1 h	uku	180:00:00	90:00:00	0:00:00	0:00:00	0	0	1 s	0	00:03:22	00:00:00	00:00:00	Cancelled	Spectrum/Raum
67	2022/08/15	09:27:00	RA/Dec Grid Scan	immediate	-1 h	hgz	9:02:23	5:20:40	10:14:23	22:50:40	0.033	0.5	2 s	0	03:00:00	02:19:30	00:00:00	Finished	Sun Scan 2.7cm secondary antenna
64	2022/08/15	03:00:00	RA/Dec Grid Scan	immediate	-1 h	antrares	23:45:55	-10:17:49	0:45:55	4:42:11	0.017	0.25	5 s	0	04:00:00	04:00:00	00:00:00	Finished	Moon 2.7cm
63	2022/08/14	21:44:00	Az/Alt Grid Scan	low priority	-1 h	antrares	150:00:00	25:00:00	200:00:00	38:00:00	0.5	0.5	1 s	0	05:00:00	03:21:02	00:00:00	Finished	Sats 2.7cm
62	2022/08/14	20:03:00	Az/Alt Grid Scan	immediate when free	-1 h	Thomas	170:00:00	25:00:00	190:00:00	35:00:00	1	1	1 s	0	01:00:00	00:22:26	00:00:00	Finished	Astra/Hotbird test
61	2022/08/12	12:20:00	Maintenance	ignore	-1 h	antrares	0:00:00	0:00:00	0:00:00	0:00:00	0	0	0 s	0	24:00:00	23:59:60	00:00:00	Finished	...
60	2022/08/11	13:00:00	Goto RA/Dec	immediate	-1 h	uku	9:24:51	15:11:26	0:00:00	0:00:00	0	0	0 s	0	00:06:00	00:00:25	00:00:00	Finished	Sun
59	2022/08/11	11:00:00	RA/Dec Grid Scan	immediate when free	-1 h	uku	9:04:47	10:11:40	9:44:49	20:11:40	0.133	2	5 s	0	01:00:00	00:07:05	00:00:00	Finished	Sun
57	2022/08/09	21:51:00	RA/Dec Grid Scan	immediate when free	-1 h	antrares	19:04:58	-30:06:40	19:24:57	-25:06:40	0.066	1	5 s	0	03:00:00	00:06:27	00:00:00	Finished	Moon 93% Scan
56	2022/08/08	21:20:00	RA/Dec Grid Scan	immediate	-1 h	uku	17:52:43	-30:16:28	18:10:43	-25:16:28	0.1	1	5 s	0	01:00:00	00:00:00	00:00:00	Cancelled	Moon 80% Scan
55	2022/08/07	15:05:00	RA/Dec Grid Scan	asap when optimal	-1 h	hgz	8:45:30	11:27:30	9:30:30	21:27:30	0.02	0.25	1 s	0	03:00:00	02:02:21	00:00:00	Finished	Sun Scan
54	2022/08/07	15:00:00	RA/Dec Grid Scan	asap when optimal	-1 h	hgz	9:07:60	11:27:30	9:07:60	21:27:30	0.02	0.25	1 s	0	03:00:00	00:01:58	00:00:00	Stopped	Sun Scan
53	2022/08/07	09:30:00	RA/Dec Grid Scan	asap when optimal	-1 h	hgz	8:37:60	6:27:30	9:37:60	26:27:30	0.02	0.3	2 s	0	04:00:00	04:00:00	00:00:00	Finished	Sun Scan
52	2022/08/06	17:00:00	Az/Alt Grid Scan	immediate when free	-1 h	antrares	170:16:12	28:34:12	175:46:12	34:04:12	0.25	0.25	10 s	0	04:00:00	01:49:20	00:00:00	Finished	test Astra 1
51	2022/08/06	15:00:00	RA/Dec Grid Scan	immediate when free	-1 h	hgz	8:34:50	9:11:44	9:34:50	24:11:44	0.033	0.5	2 s	0	02:00:00	01:42:41	00:00:00	Finished	Sun Scan
50	2022/08/06	13:02:00	RA/Dec Grid Scan	asap when optimal	-1 h	hgz	8:04:50	4:11:44	10:04:50	29:11:44	0.02	0.3	5 s	0	05:00:00	01:55:13	00:00:00	Stopped	Sun Scan
49	2022/08/06	12:54:00	RA/Dec Grid Scan	asap when optimal	-1 h	hgz	8:34:50	5:41:44	9:34:50	27:41:44	0.02	0.25	5 s	0	04:00:00	00:06:02	00:00:00	Stopped	Sun Scan
48	2022/08/05	21:20:00	Park Scope	immediate	-1 h	Thomas	0:00:00	0:00:00	0:00:00	0:00:00	0	0	0 s	0	00:06:00	00:00:26	00:00:00	Finished	park rt
47	2022/08/05	20:55:00	Goto Az/Alt	low priority	-1 h	Thomas	173:01:12	31:19:12	0:00:00	0:00:00	0	0	0 s	0	00:06:00	00:00:21	00:00:00	Finished	goto Astra 1 A-H
46	2022/08/05	17:52:00	RA/Dec Grid Scan	immediate when free	-1 h	hgz	14:26:11	-25:03:00	15:26:11	-10:03:00	0.035	0.5	10 s	0	04:00:00	02:20:14	00:00:00	Stopped	Scan Moon
45	2022/08/05	11:38:00	RA/Dec Grid Scan	immediate when free	-1 h	antrares	8:32:02	9:23:47	9:32:02	24:23:47	0.1	1	10 s	0	00:00:00	00:40:51	00:00:00	Finished	Sun Scan
44	2022/08/05	00:42:00	RA/Dec Grid Scan	immediate when free	-1 h	antrares	8:32:12	9:23:04	9:32:12	24:23:04	0.066	1	10 s	0	04:00:00	01:02:46	00:00:00	Finished	Sun Scan
43	2022/08/04	19:30:00	Az/Alt Grid Scan	immediate when free	-1 h	antrares	170:31:12	28:49:12	175:31:12	33:49:12	0.2	0.2	10 s	0	12:00:00	02:28:26	00:00:00	Finished	Astra 1 A-H 19,2° Ost
42	2022/08/03	14:40:00	Transit Scan	immediate when free	-1 h	uku	172:00:00	32:50:13	0:00:00	0:00:00	0	0	20 s	0	01:00:00	01:00:00	00:00:00	Finished	Moon transit
40	2022/08/01	15:45:00	Goto RA/Dec	immediate when free	-1 h	uku	11:38:46	6:13:55	0:00:00	0:00:00	0	0	0 s	0	01:00:00	00:00:15	00:00:00	Finished	Moon transit
39	2022/08/01	15:00:00	Tracking Scan	immediate when free	-1 h	uku	11:37:19	6:28:48	0:00:00	0:00:00	0	0	0 s	0	00:06:00	00:00:00	00:00:00	Cancelled	Moon transit
38	2022/08/01	14:30:00	Goto RA/Dec	immediate	-1 h	uku	11:40:08	5:59:13	0:00:00	0:00:00	0	0	0 s	0	00:06:00	00:00:26	00:00:00	Finished	Moon transit
37	2022/08/01	12:15:00	Goto Az/Alt	immediate when free	-1 h	uku	138:00:00	39:06:00	0:00:00	0:00:00	0	0	0 s	0	01:00:00	00:00:02	00:00:00	Finished	Moon transit
35	2022/08/01	01:45:00	Goto Az/Alt	immediate when free	-1 h	uku	139:00:00	39:10:23	0:00:00	0:00:00	0	0	0 s	0	01:00:00	00:00:22	00:00:00	Finished	Moon transit
34	2022/07/31	13:00:00	Goto Az/Alt	immediate when free	-1 h	uku	175:00:00	50:21:04	0:00:00	0:00:00	0	0	0 s	0	00:30:00	00:00:00	00:00:00	Stopped	Moon transit
31	2022/07/29	10:15:00	Transit Scan	immediate when free	-1 h	uku	175:00:00	57:30:00	0:00:00	0:00:00	0	0	20 s	0	01:30:00	01:30:00	00:00:00	Finished	sun transit
30	2022/07/29	10:15:00	Goto Az/Alt	immediate when free	-1 h	uku	175:00:00	57:30:00	0:00:00	0:00:00	0	0	0 s	0	01:30:00	00:00:00	00:00:00	Stopped	sun transit
27	2022/07/26	10:33:00	Transit Scan	immediate when free	-1 h	hgz	227:49:12	58:46:12	0:00:00	0:00:00	0	0	10 s	0	03:00:00	03:00:00	00:00:00	Finished	transit scan moon+sun
26	2022/07/26	10:31:00	Goto RA/Dec	immediate when free	-1 h	hgz	6:00:00	26:35:24	0:00:00	0:00:00	0	0	0 s	0	00:06:00	00:00:10	00:00:00	Finished	goto start pos for moon transit scan

Empfangstechnik

Kommerzielle Sat-TV Technik: Ku-Band (10,7..12,75 GHz)

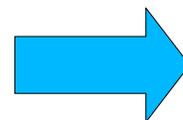


Zum Messen der Feldstärke:

- Für erste Versuche: Satfinder
- Besser: log. Detektor (AD8313)



*RF Power Detector –
Makis (SV1AFN)
<https://www.sv1afn.com/>*



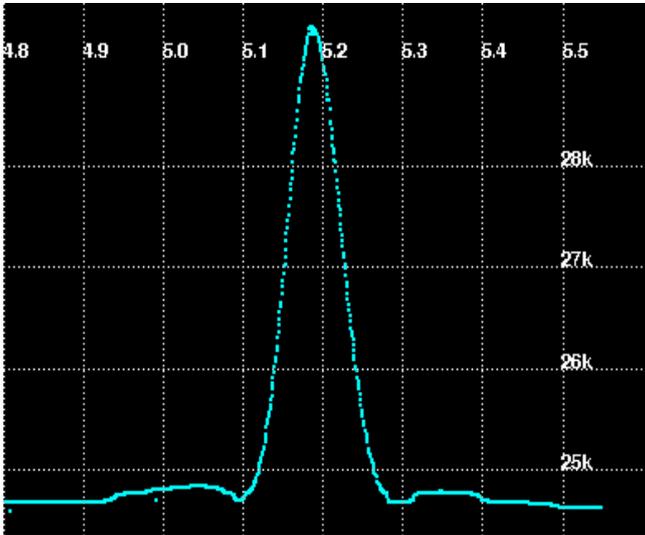
**Exzellente Hardware
für Radioastronomie**

Sat-LNB (Preis: 5€)
Rauschmaß: „0.1dB“
(tatsächlich eher ~0.8dB)

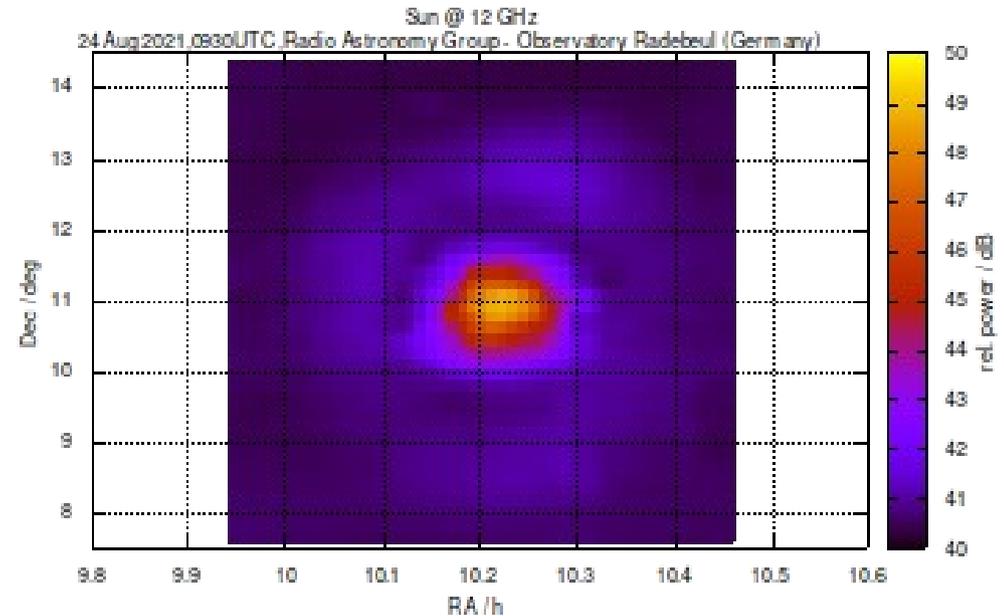
Beobachtungen – Ku-Band

Sonne

- 2d Raster scan mit wählbarem Stepping automatisiert durch Definition eines 2d-Scan-Tasks → Abfrage von INDI-Variablen in Loop
- Aufzeichnen der Koordinaten und des dB-linearen Outputs am log. Detektor (AD8313)



```
piert300:~/data/ratsche $ head -n 29 task_equscan20210907_26149
# RA/Dec Grid Scan
# Task ID: 4
# Submit time: 2021/09/07 07:15:49.000000000
# Schedule time: 2021/09/07 07:14:30.000000000
# Start time: 2021/09/07 07:15:49.185791000
# Max run time: 3h
# User: hgz
# Priority: 2
# Comment: Sun scan 12GHz
#-----
# Start coordinates: RA=10.8h Dec=2deg
# End coordinates: RA=11.4h Dec=10deg
# Step size: RA=0.015h = 0.225deg Dec=0.2deg
# Integration time: 1s
# time az alt ra dec adc1 adc2 temp
1630998981.930211523 119.4603 24.0573 10.80048 2.0289 41.4095 0.0557 15.6
1630998985.030842082 119.4655 24.2330 10.79463 2.1734 41.4005 0.0557 15.6
1630998987.866254766 119.2053 24.4088 10.80228 2.4504 41.3335 0.0557 15.6
1630998990.817548058 119.1168 24.5846 10.80089 2.6415 41.2864 0.0558 15.6
1630998993.595627824 118.9399 24.7604 10.80425 2.8767 41.2479 0.0558 15.6
1630998996.609384481 118.9399 24.9801 10.79701 3.0602 41.2117 0.0558 15.6
1630998999.400686753 118.7733 25.1120 10.80141 3.2533 41.1803 0.0557 15.6
1630999002.296033808 118.6796 25.2877 10.80050 3.4467 41.1532 0.0557 15.5
1630999005.042792340 118.5183 25.4196 10.80459 3.6371 41.1231 0.0558 15.5
1630999007.830178121 118.5183 25.5954 10.79893 3.7836 41.1174 0.0557 15.5
1630999010.586022431 118.3518 25.8151 10.79972 4.0497 41.0920 0.0558 15.5
1630999013.385297222 118.1488 25.9469 10.80582 4.2606 41.0694 0.0558 15.5
1630999016.246383991 118.1488 26.1227 10.80014 4.4068 41.0763 0.0557 15.5
1630999019.252241028 118.0812 26.2106 10.80108 4.5136 41.0767 0.0557 15.5
```

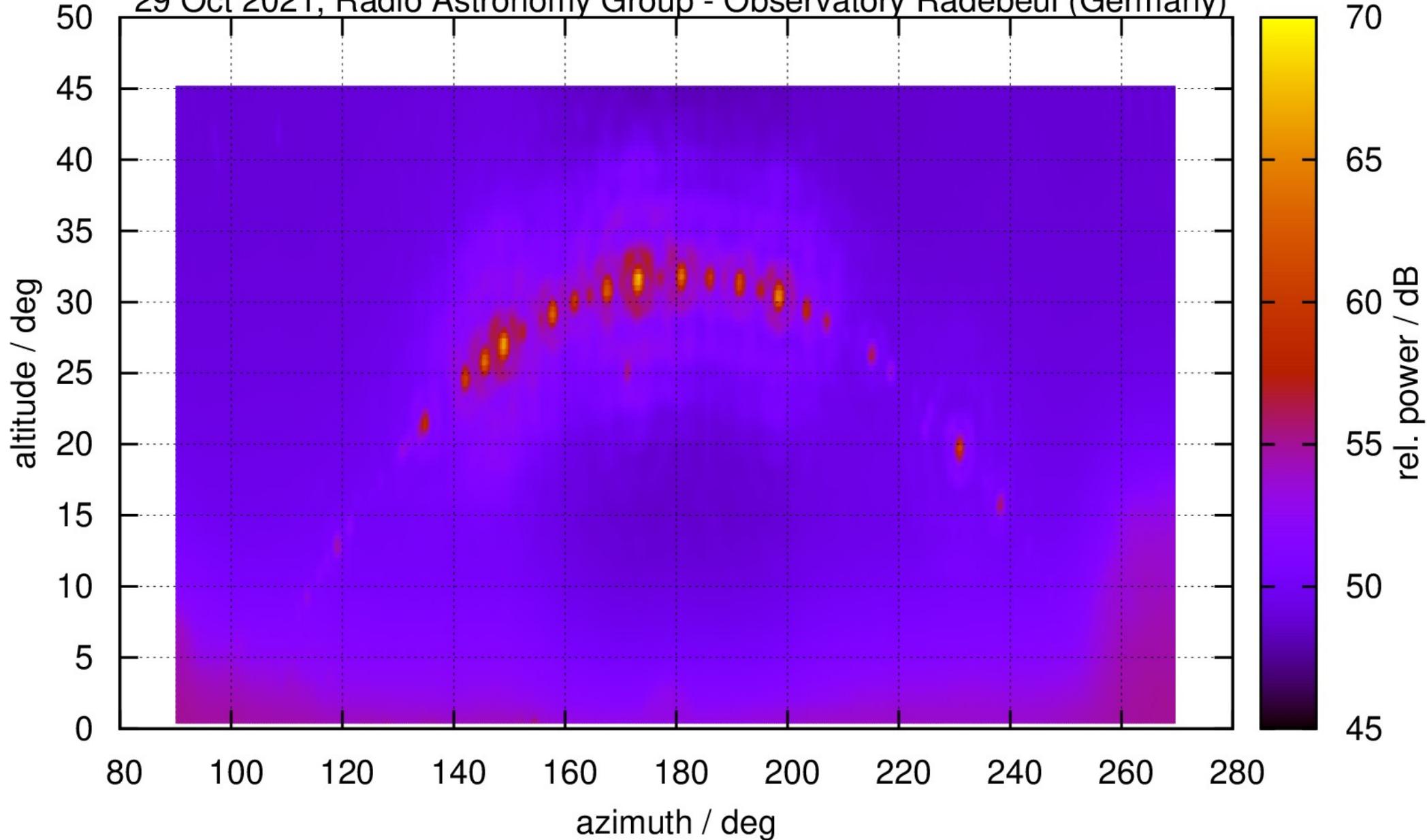


Problem: Sat-LNB optimiert für Offset-Schüsseln – Ausleuchtung im Primärfokus des Radioteleskops <50%

Beobachtungen – Ku-Band

Geostationary Satellites @ 12 GHz

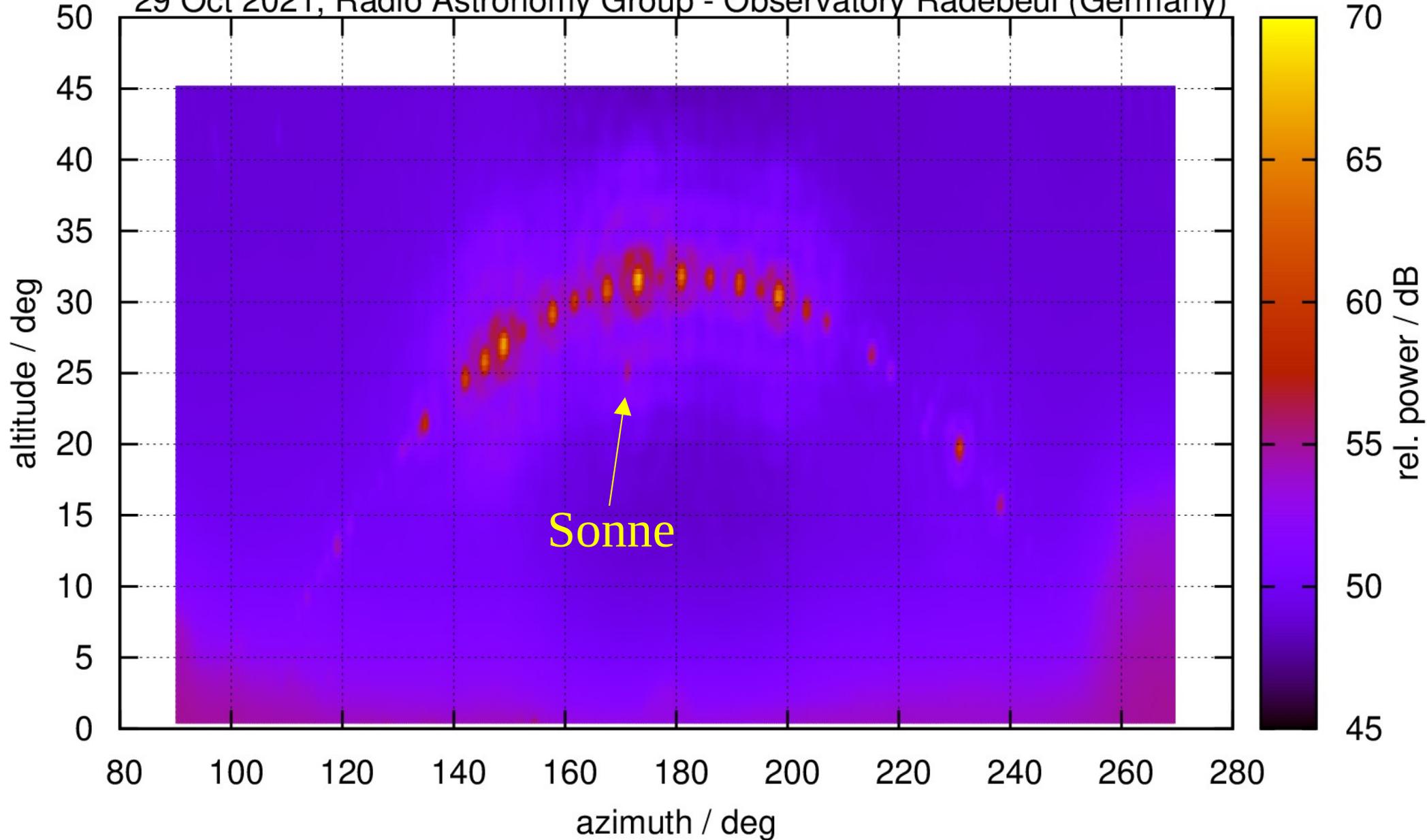
29 Oct 2021, Radio Astronomy Group - Observatory Radebeul (Germany)



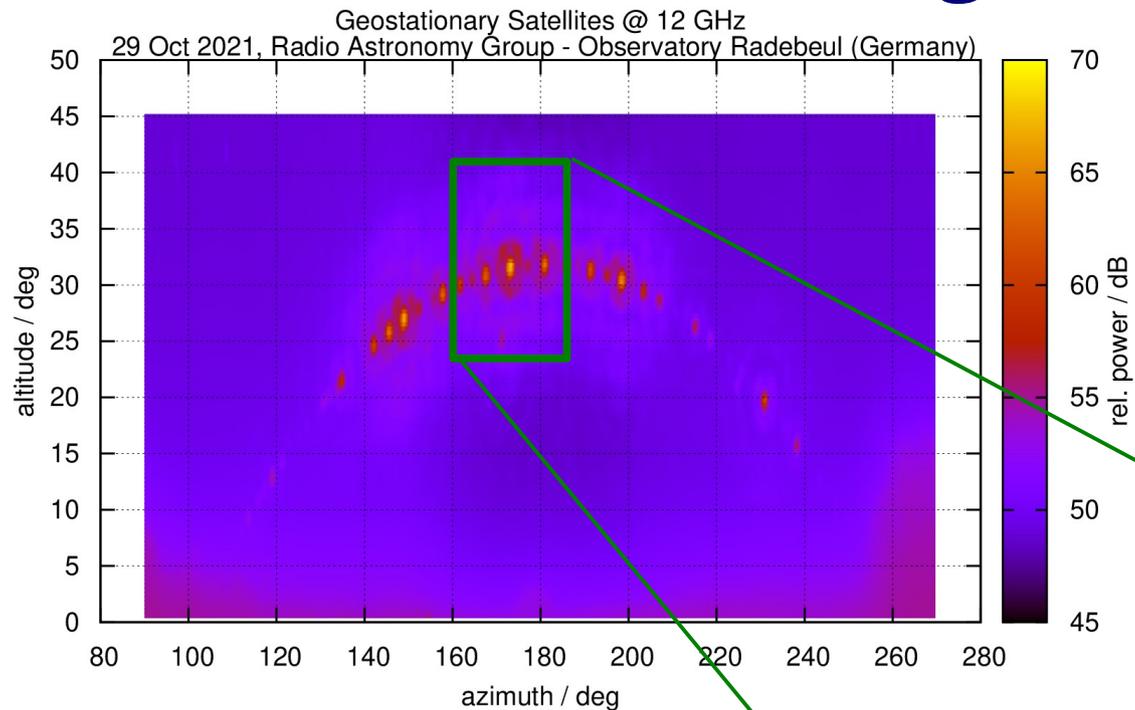
Beobachtungen – Ku-Band

Geostationary Satellites @ 12 GHz

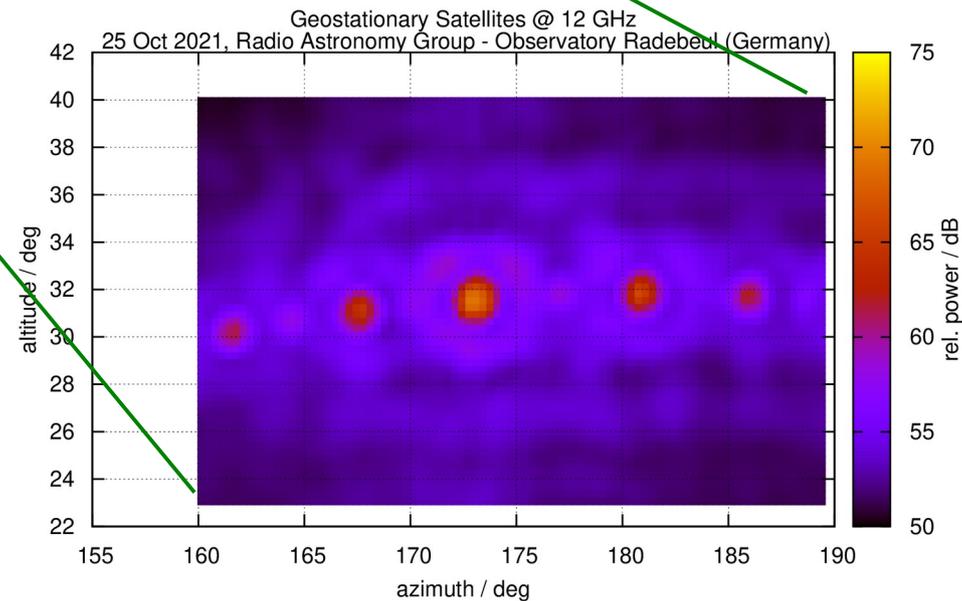
29 Oct 2021, Radio Astronomy Group - Observatory Radebeul (Germany)



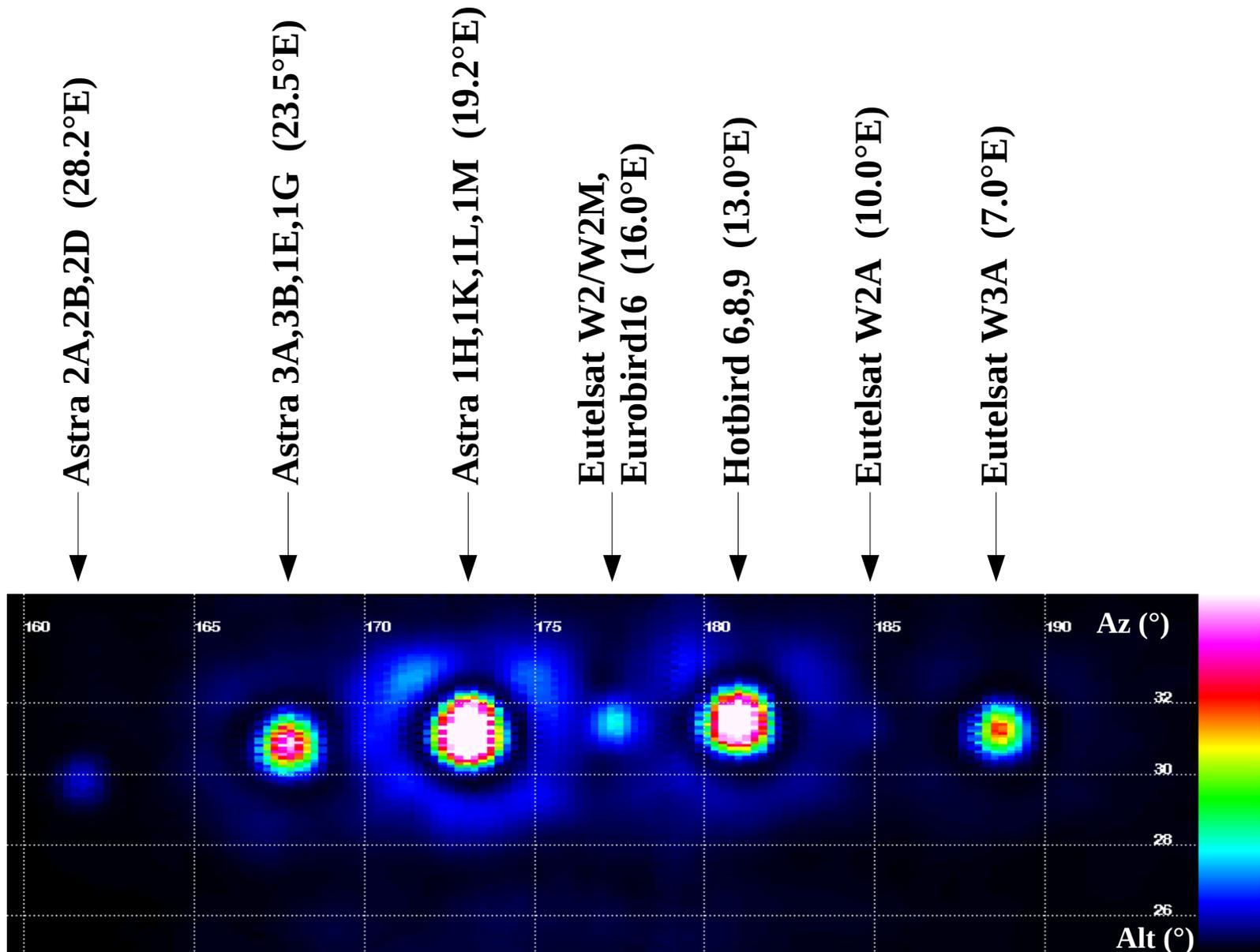
Beobachtungen – Ku-Band



TV-Satelliten

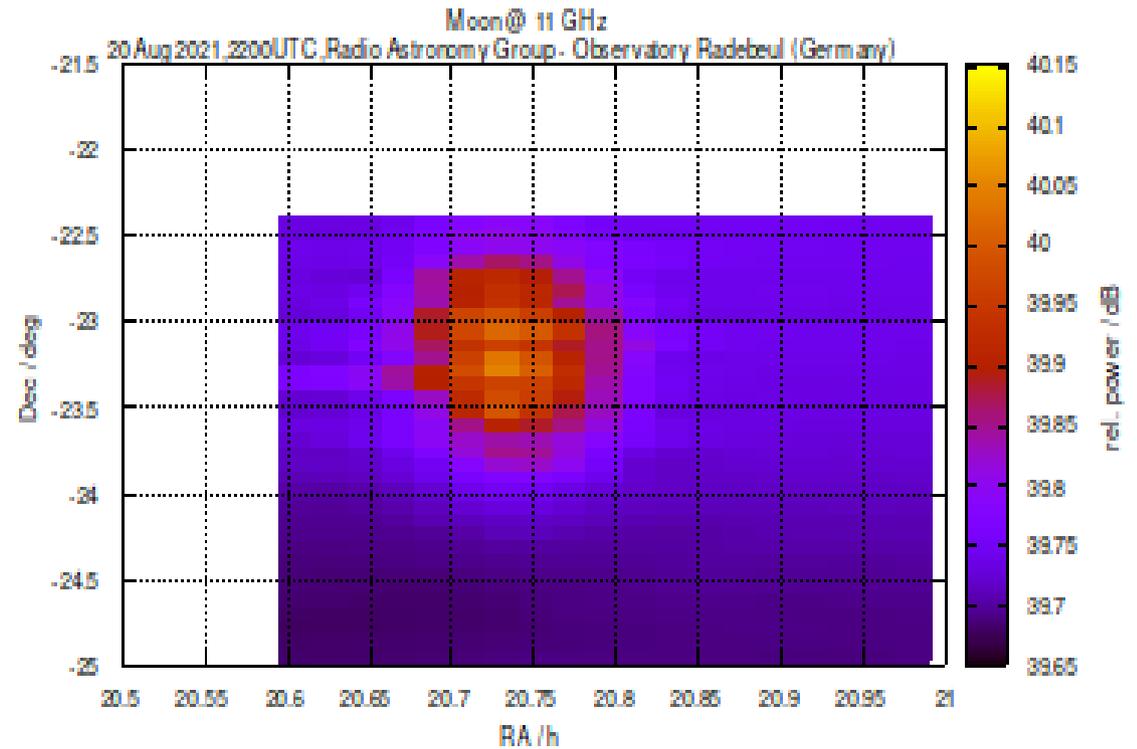
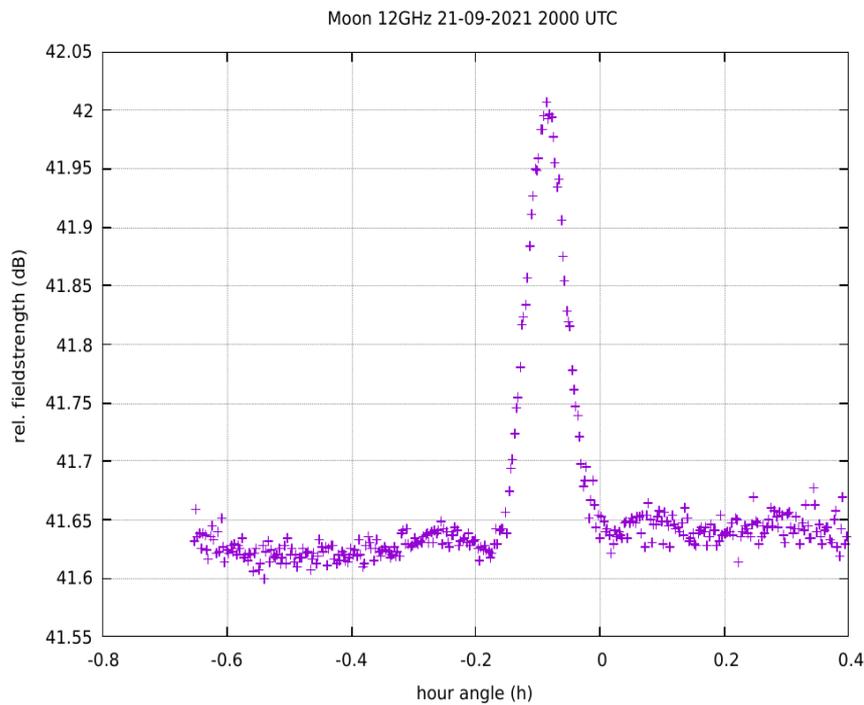


Beobachtungen – Ku-Band



Beobachtungen – Ku-Band

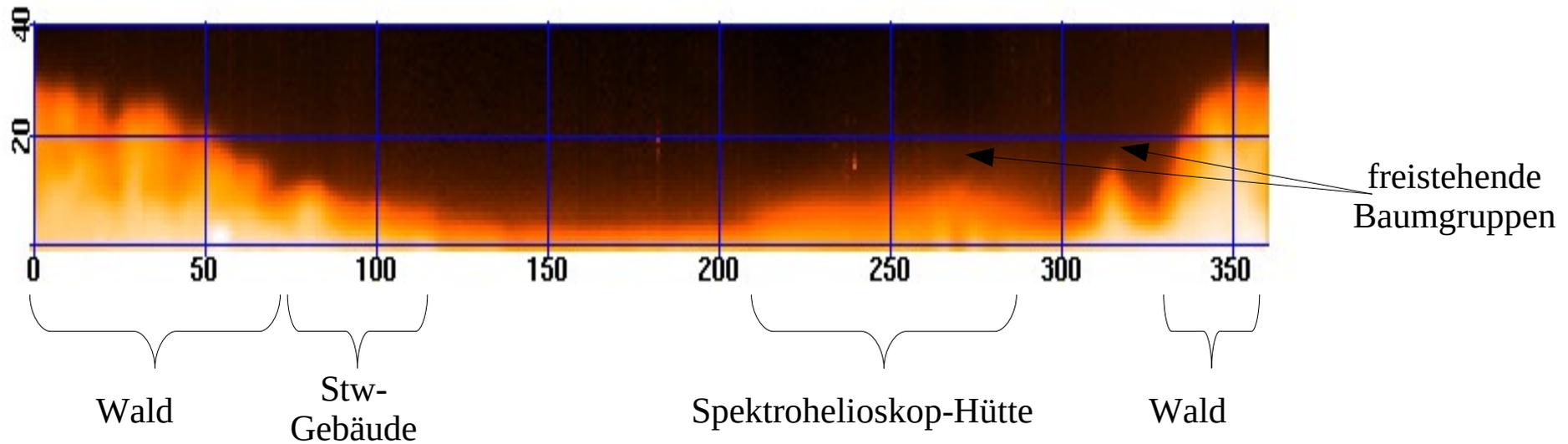
Mond



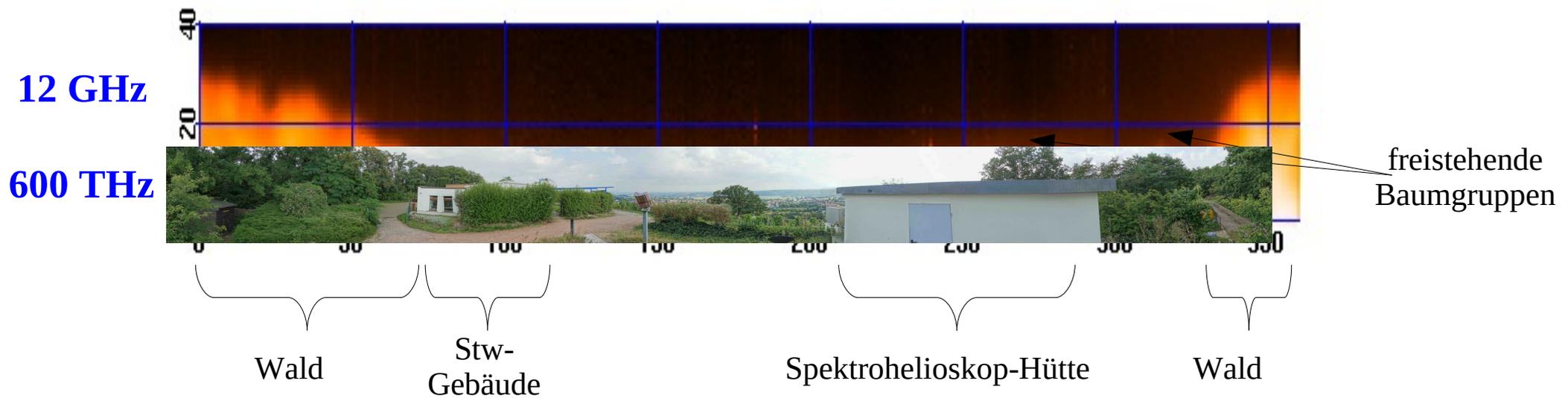
96% Beleuchtung

Beobachtungen Horizontlinie@12GHz

12 GHz



Beobachtungen Horizontlinie@12GHz

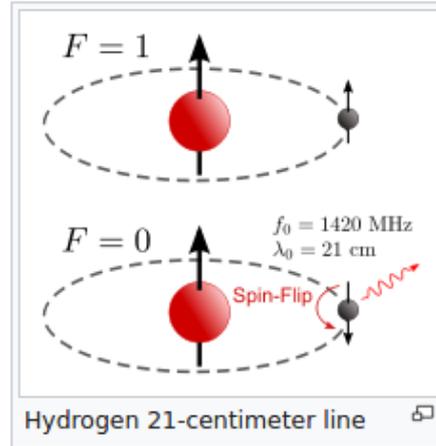




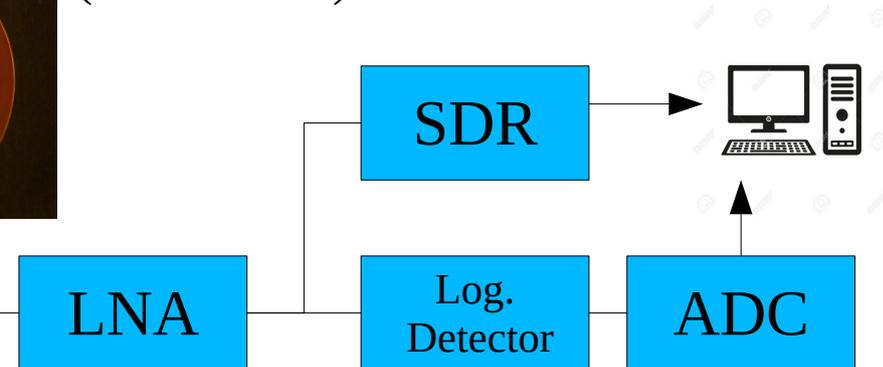
WIKIPEDIA
The Free Encyclopedia

Empfangstechnik 1420 Mhz/21cm/HI-Linie

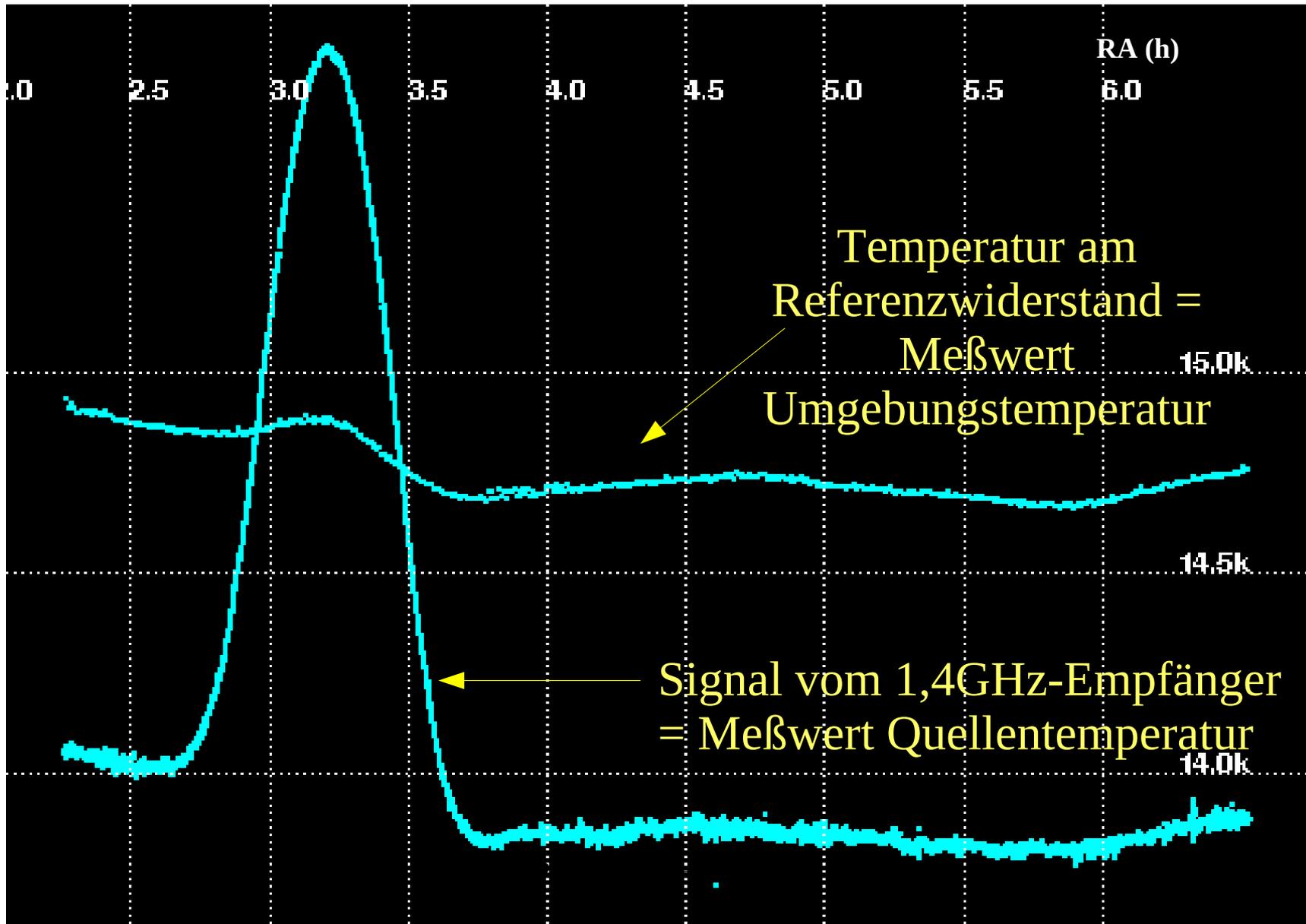
The **hydrogen line**, **21-centimeter line**, or **H I line**^[1] is the **electromagnetic radiation spectral line** that is created by a change in the energy state of neutral hydrogen atoms. This electromagnetic radiation has a precise frequency of 1 420 405 751.768(2) Hz,^[2] which is equivalent to the **vacuum wavelength** of 21.106 114 054 160(30) cm in **free space**. This wavelength falls within the **microwave region** of the **electromagnetic spectrum**, and it is observed frequently in **radio astronomy** because those **radio waves** can penetrate the large clouds of interstellar **cosmic dust** that are **opaque to visible light**. This line is also the theoretical basis of the **hydrogen maser**.



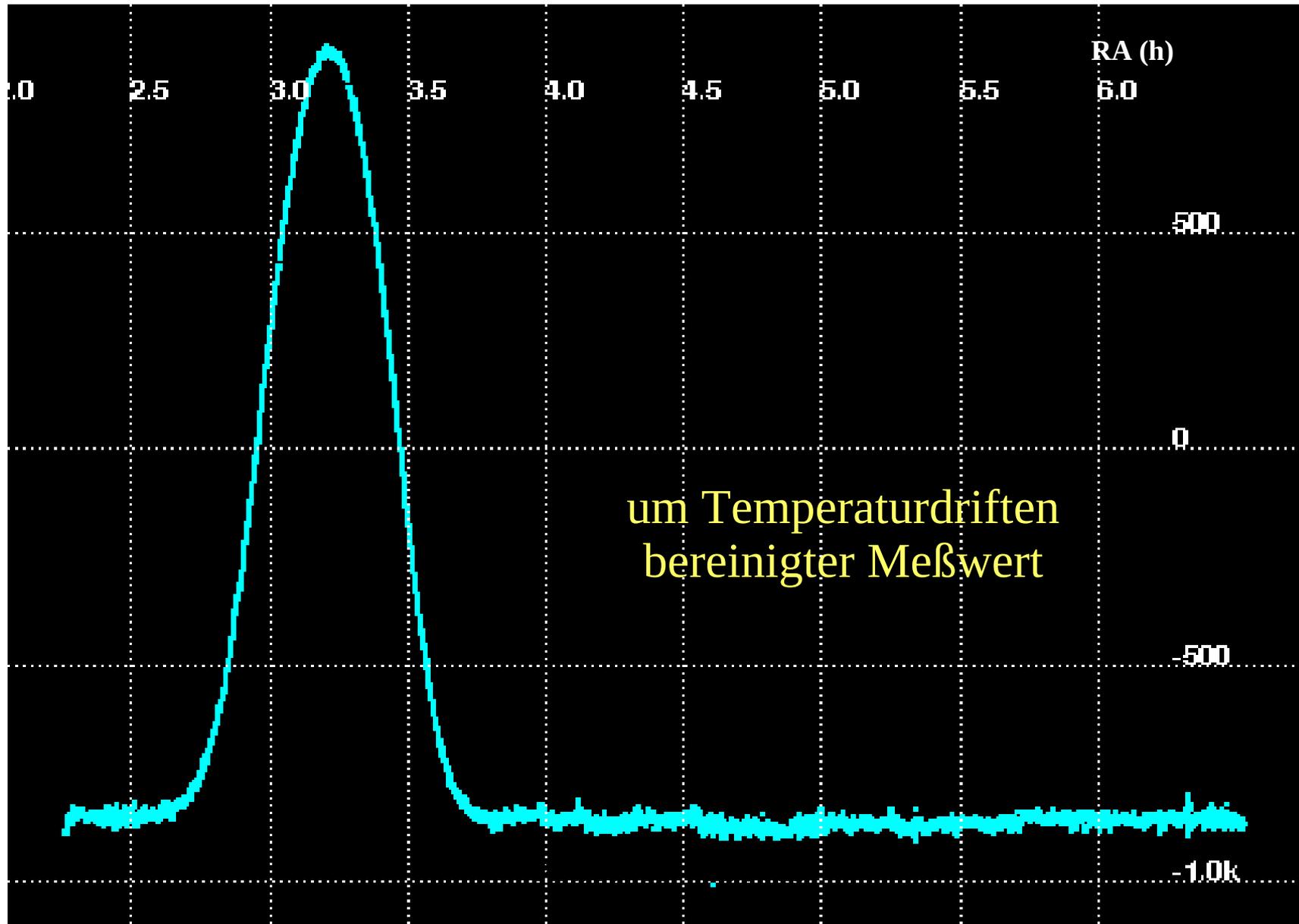
Hohlleiter-Chokering-Erreger
(Kumar Feed)



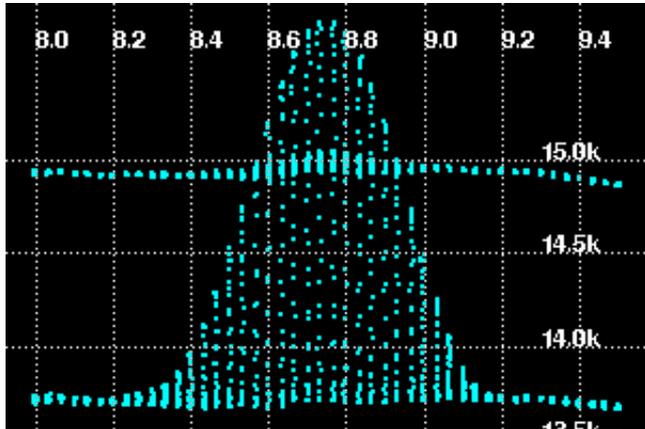
Beobachtungen Sonne@21cm



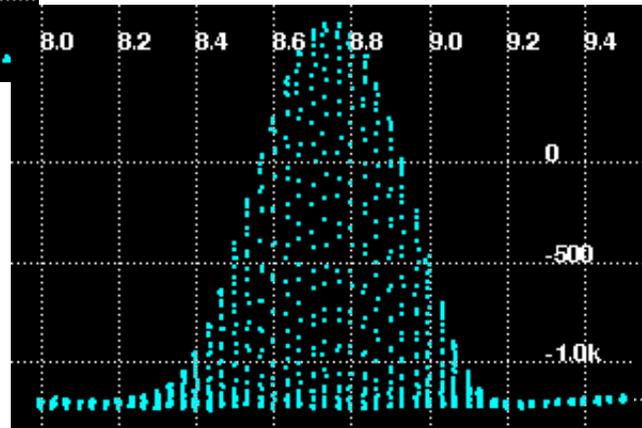
Beobachtungen Sonne@21cm



Beobachtungen Sonne@21cm

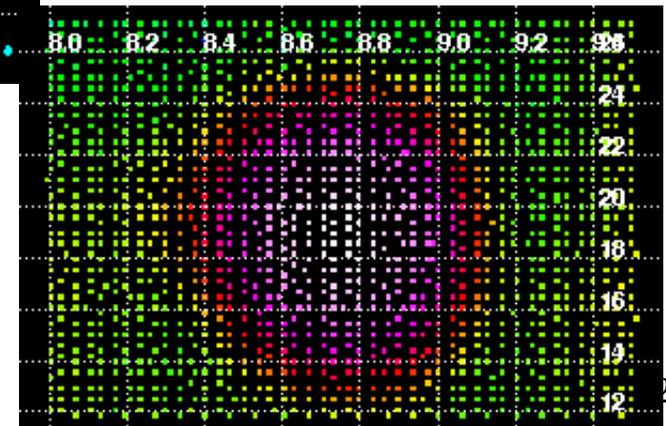


→ Scan in regelmäßigem Gitter
(Äquatorial/Horizontalsystem)

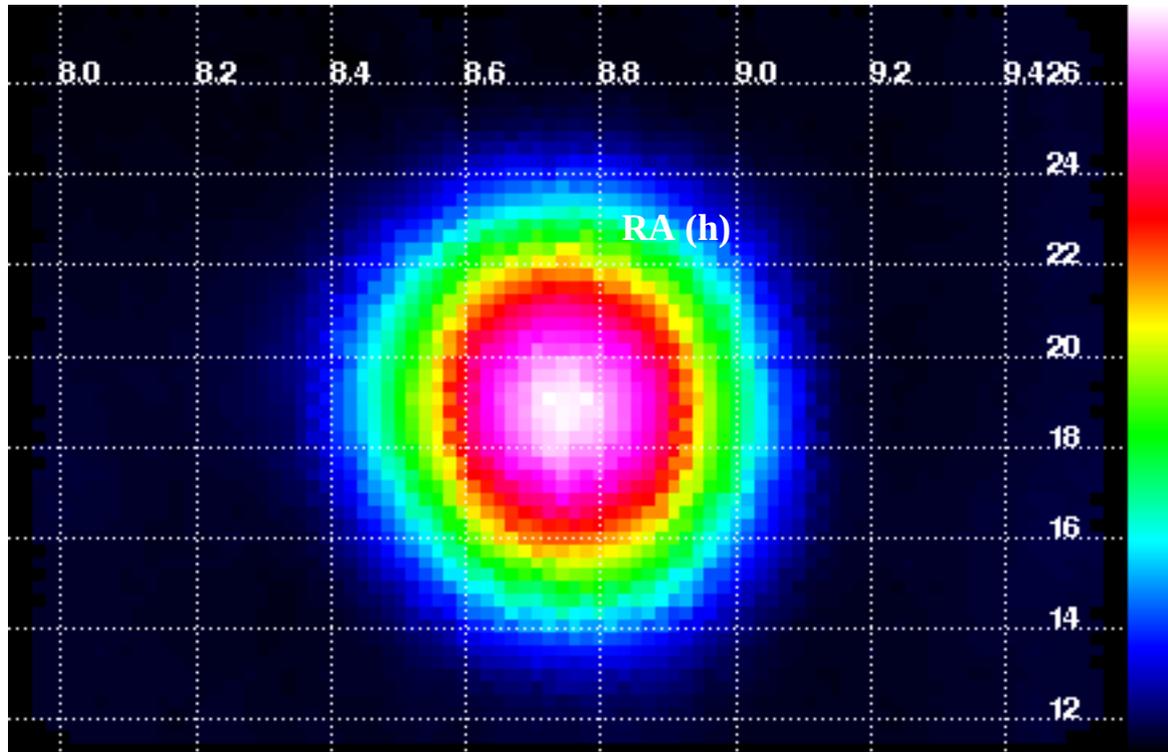


→ Referenzbereinigung

→ Füllen des Raumgitters mit Meßwerten

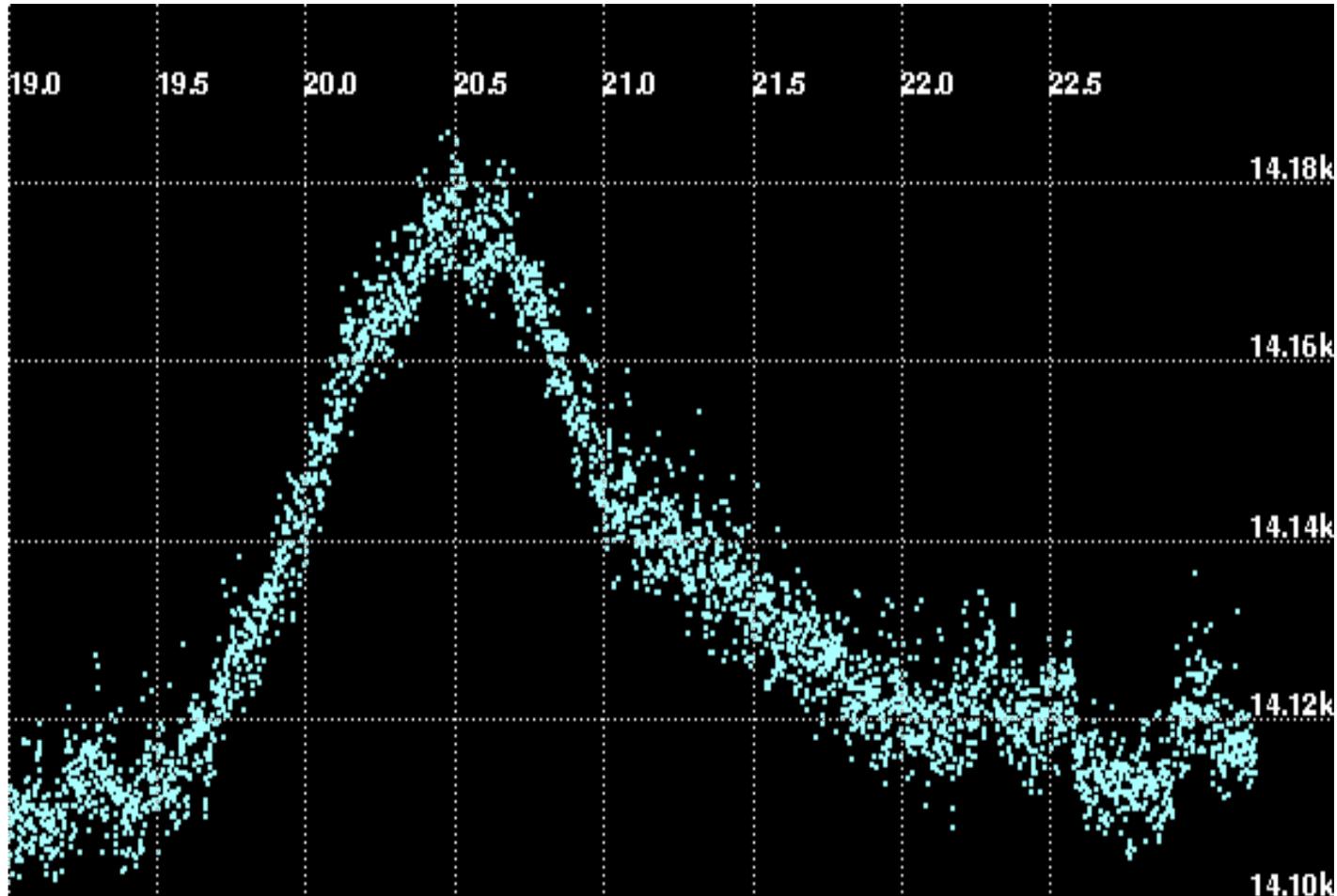


Beobachtungen Sonne@21cm



- Anpassen des Binnings
- (vorsichtige) Interpolation fehlender Gitterpunkte („Löcher“)

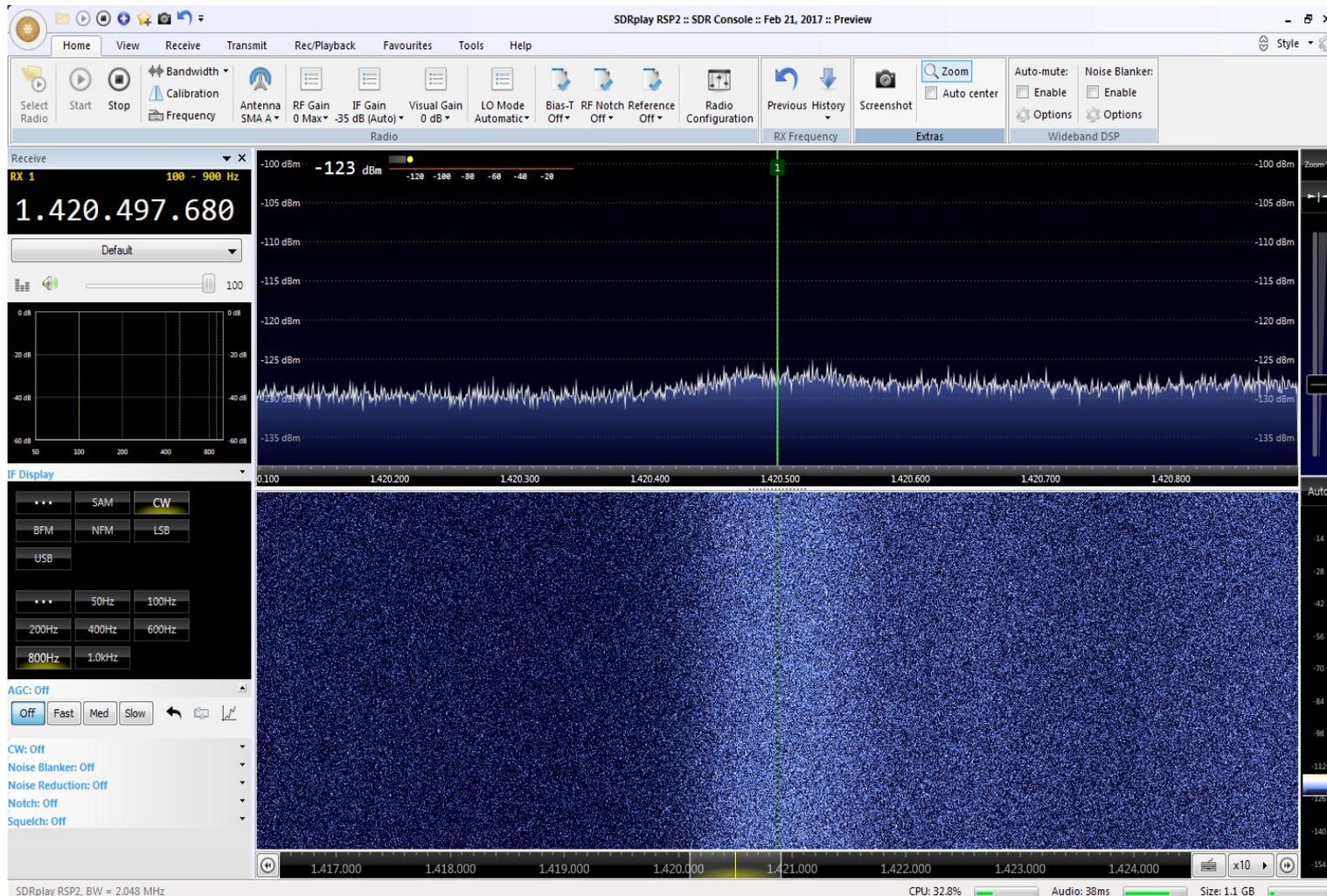
Beobachtungen Milchstrasse@21cm



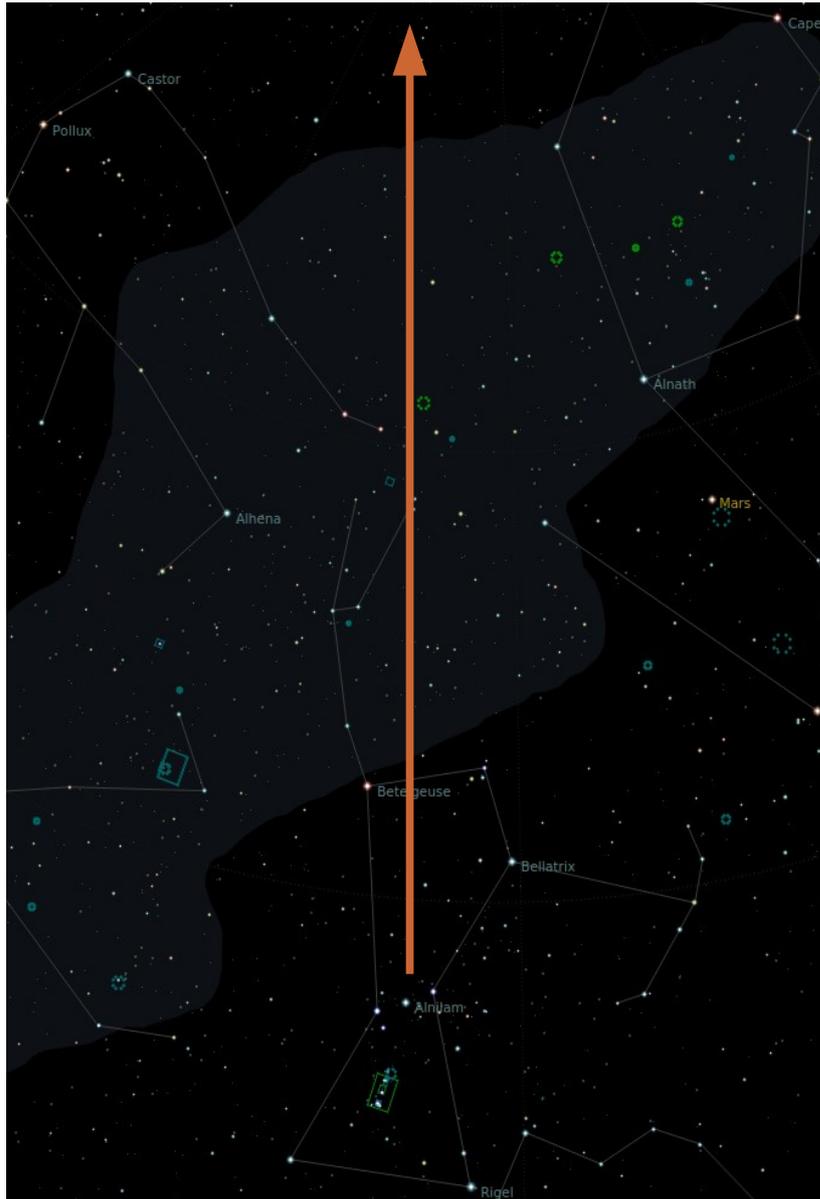


Beobachtungen Spektrum@21cm

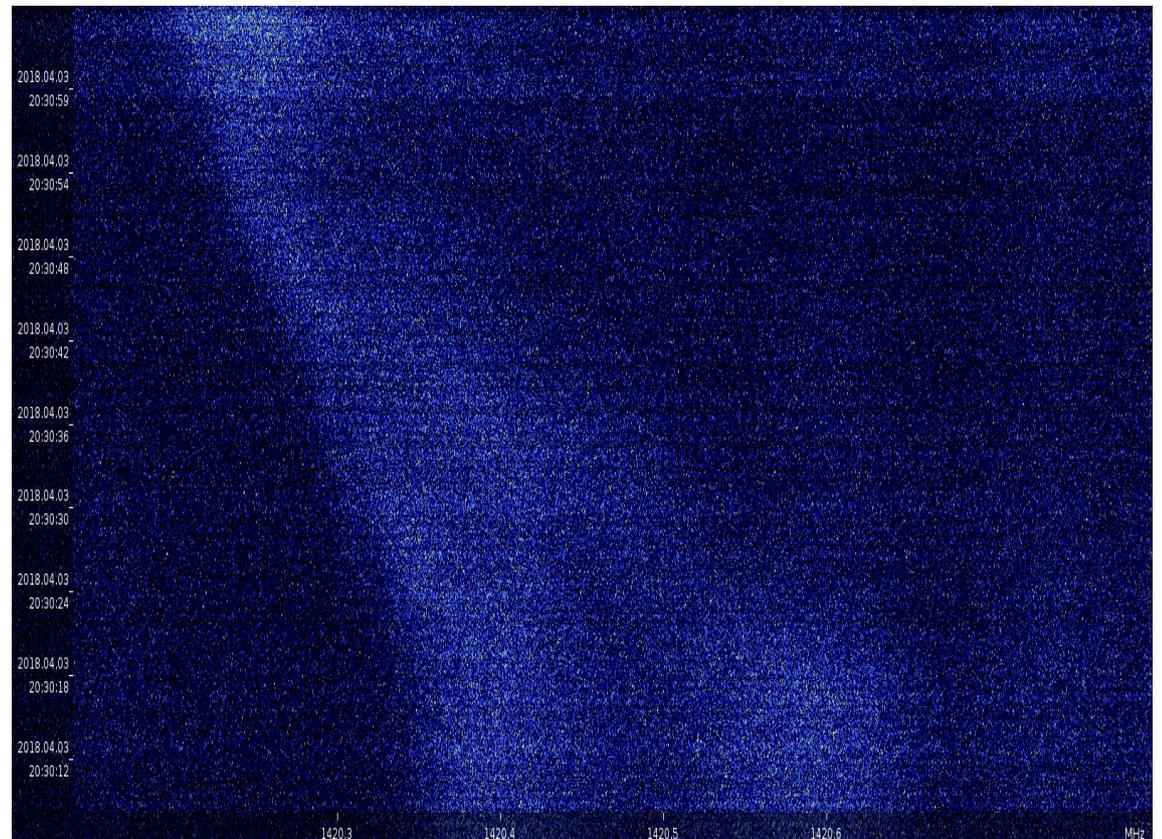
Auswertung mit USB-SDR Stick, Anbindung als WebSDR geplant



Beobachtungen Milchstrasse@21cm



Bewegung durch einen Milchstraßenarm
→ 21cm-Linie Doppler-verschoben, je nach
Radialgeschwindigkeit



Das Projekt

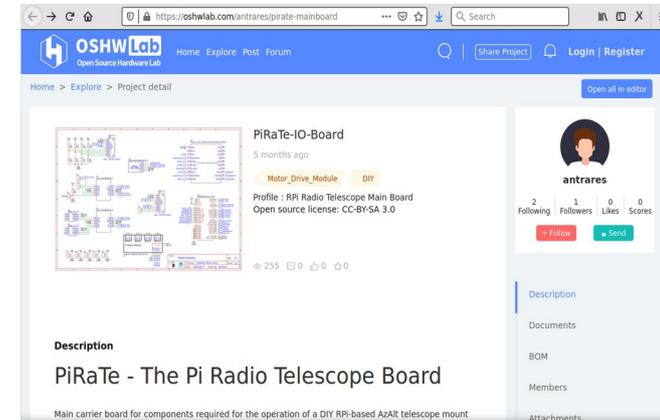
PiRaTe ist...

Hardware

Basis-PCB und Beschreibung der verwendeten
Add-On Boards



<https://oshwlab.com/antrares/pirate-mainboard>



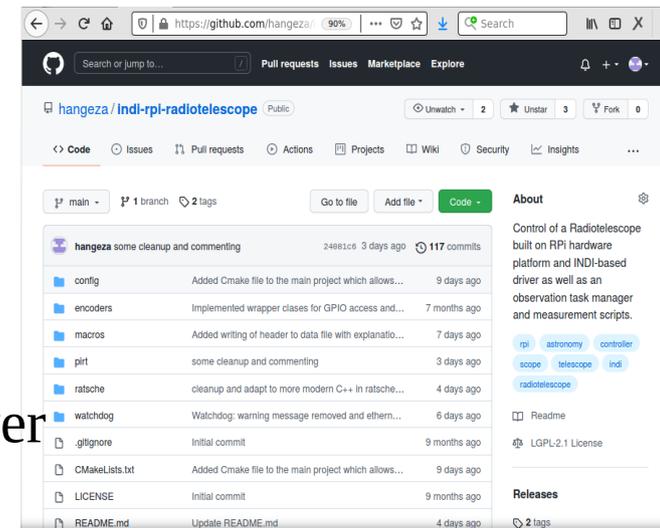
Software :

- indi-pirt – INDI-Treiber für RPi
- RaTSche – Radiotelescope Task Scheduler
- rt_scripts – Bash-Macros für komplexe Mess-/Positionierungsprogramme
- Service macros – systemd service units für indiserver und ratsche
- RTData – 1d und 2d Visualisierung von Datenreihen



<https://github.com/hangeza/indi-rpi-radiotelescope>

<https://github.com/hangeza/RTData>



Die Radioastronomie-Gruppe

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2016-11-20

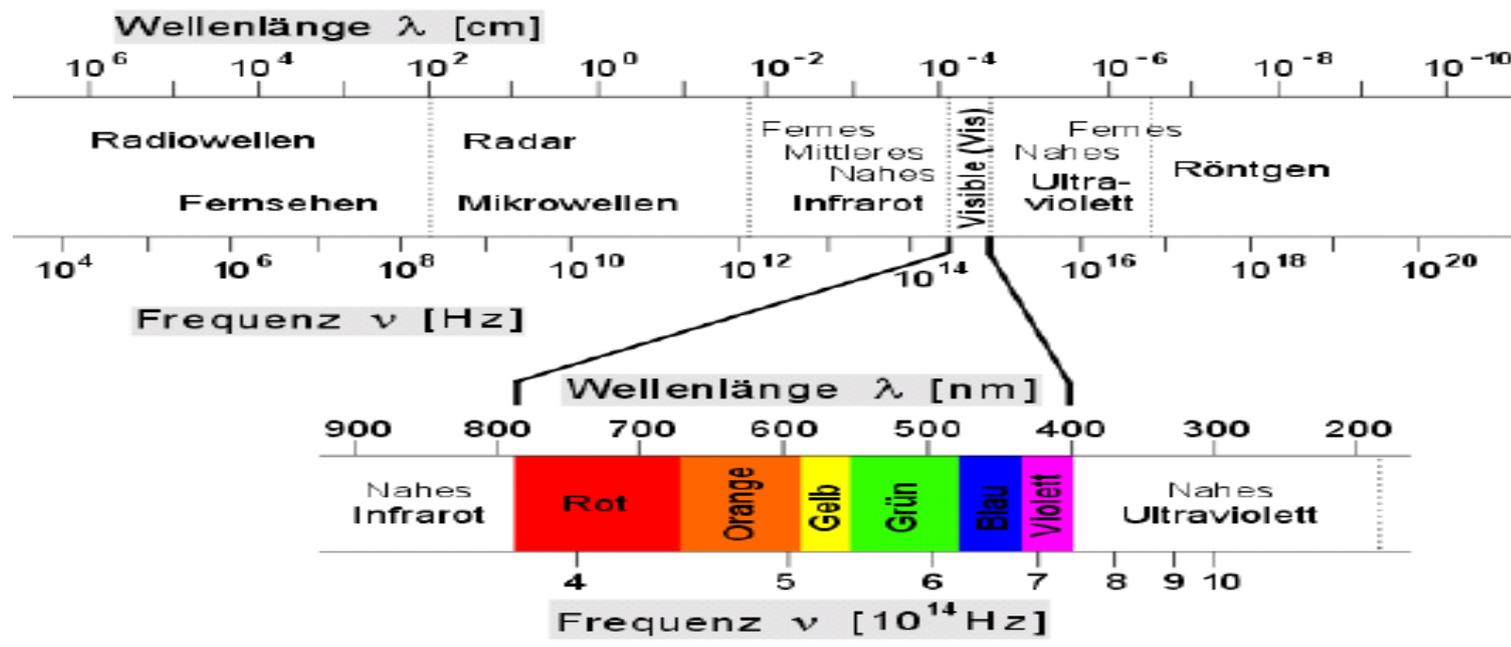
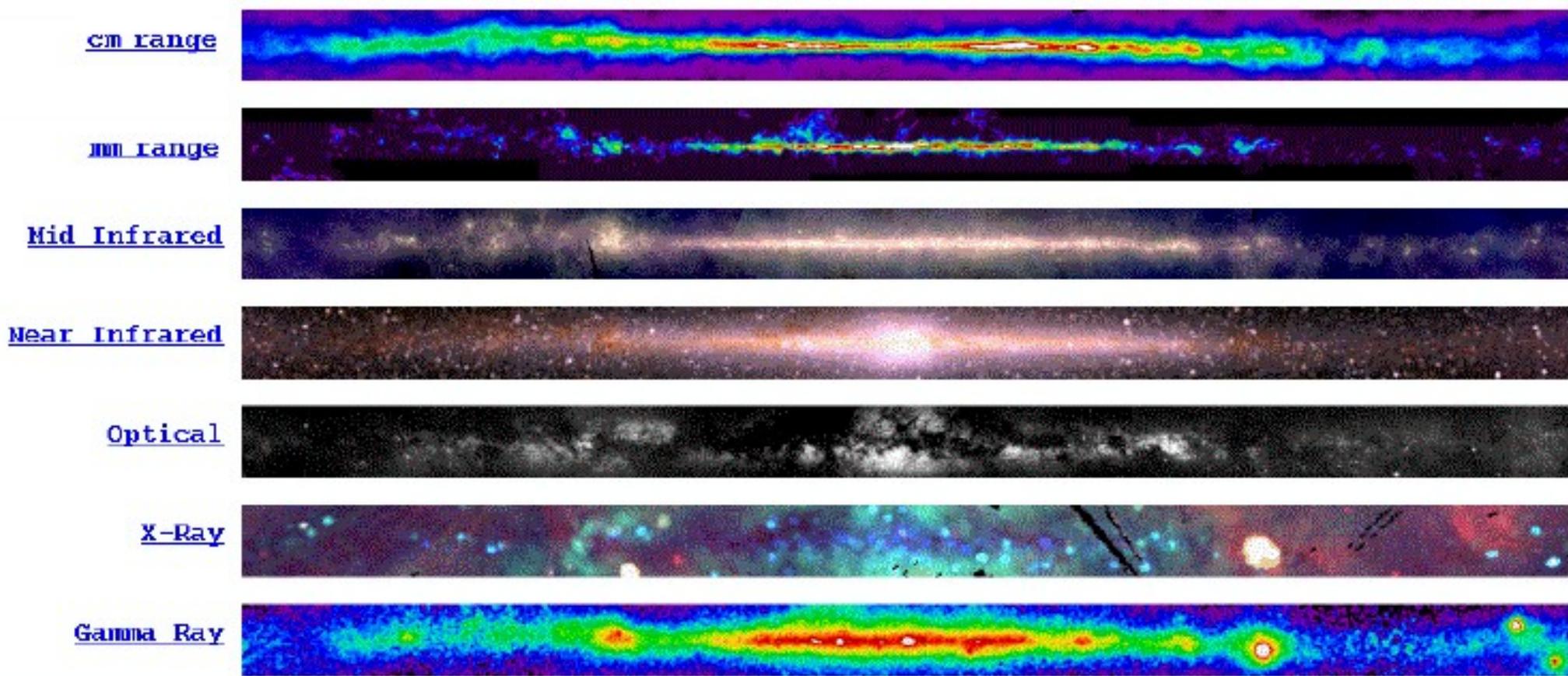
01

Backup Slides

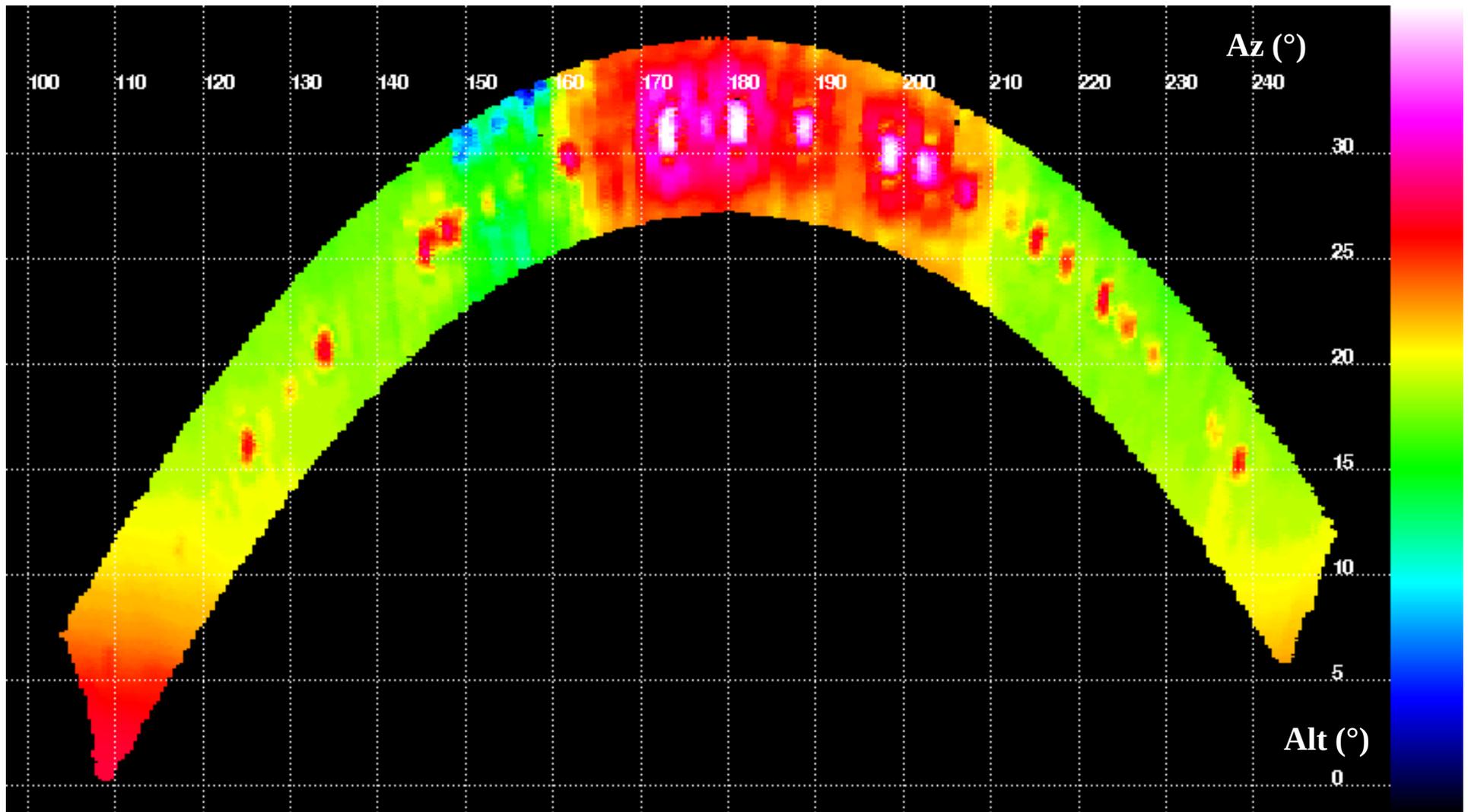
Vergleich der benutzten Feedsysteme

Beobachtungsfrequenz (GHz)	Feedsystem	Rauschzahl (dB)	Gain an Sonne (dB)	Theoret. Auflösung (°)	Gemessene Auflösung (°)
11	Sat-LNB	0,3	10	0,64	1,0
1,4	Ringdipol	0,5	6	5	7,8
1,4	Rillenhorn	0,5	10,5	5	5,45

$$\sin\alpha = 1.22 \frac{\lambda}{D}$$

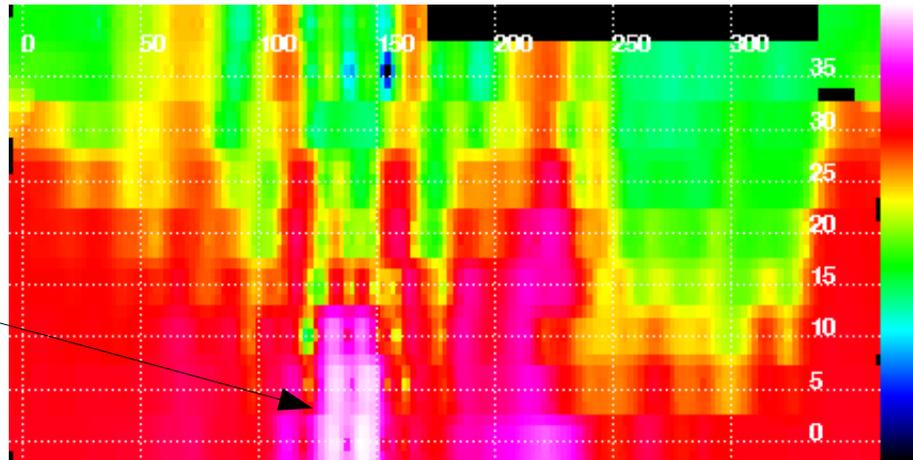


Beobachtungen – Ku-Band

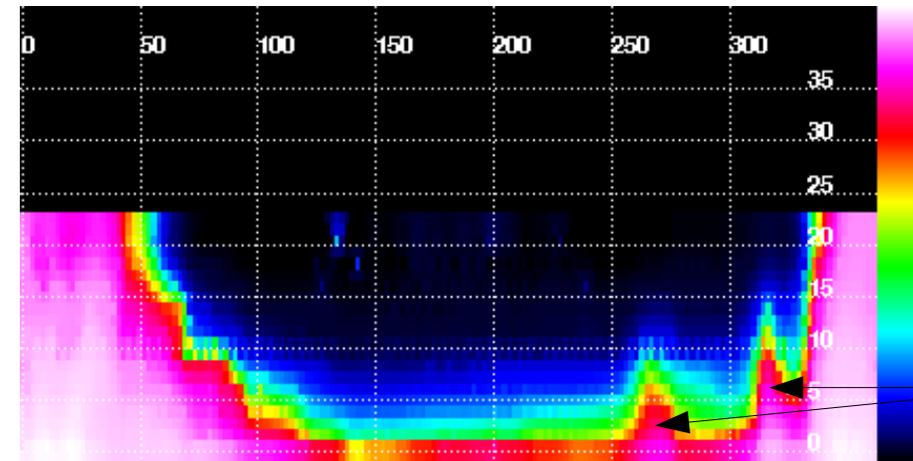


Beobachtungen Horizontlinie@1,4GHz

Tschechischer
TV-Sender
(703,25 Mhz),
Einmischen als
Subharmonische
von 1,4GHz



1,4 GHz



12 GHz

freistehende
Baumgruppen

Wald Stw-
Gebäude SPH Wald