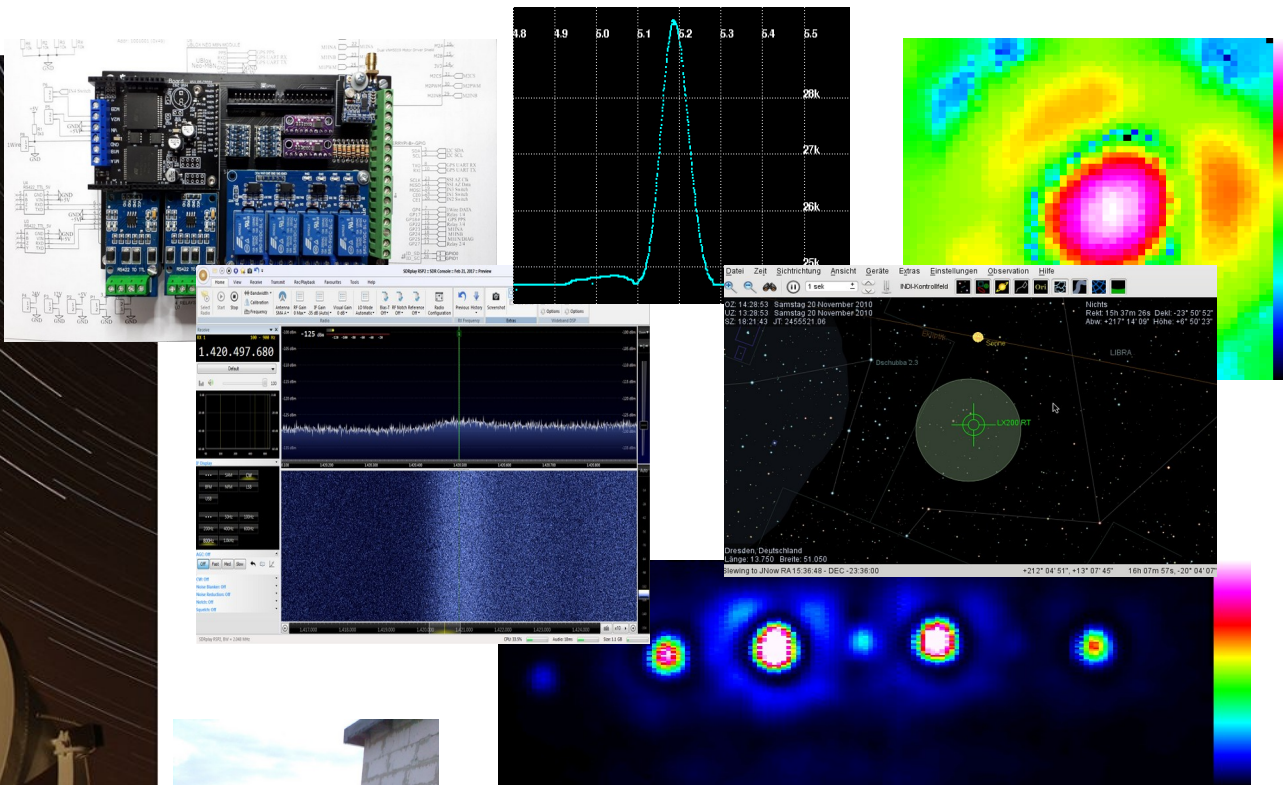
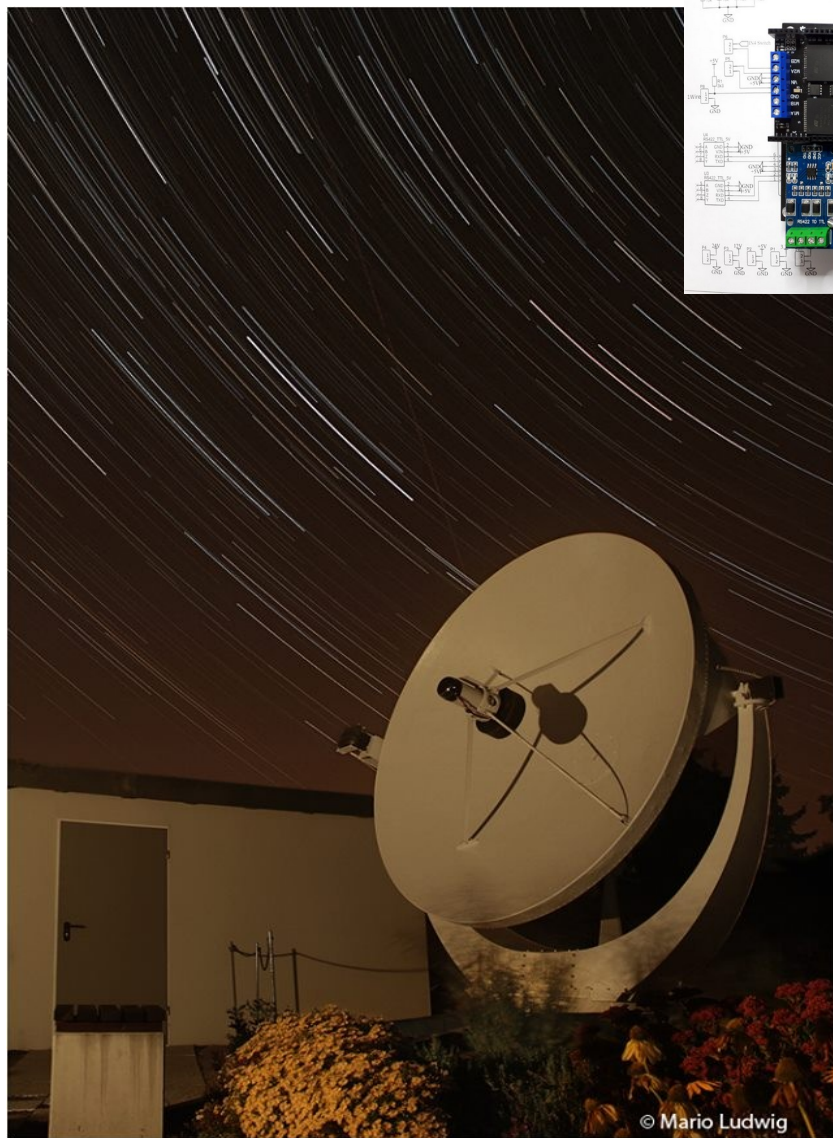
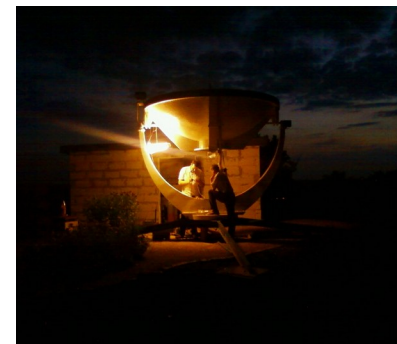


PiRaTe – The Pi Radio Telescope

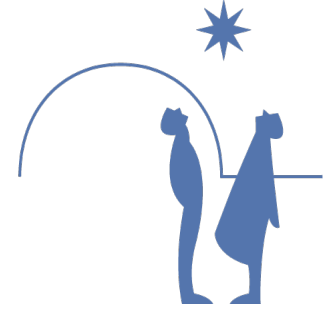
A 3m Amateur Radio Telescope @ Radebeul Observatory
(Dresden)



Hans-Georg Zaunick
(Giessen)

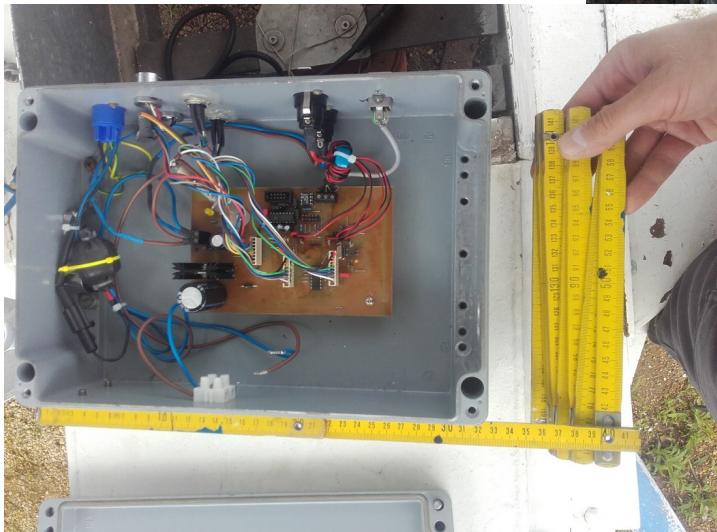


EUCARA 2023 – Sept. 16/17 2023



Radioastronomy at the Observatory Radebeul

2004 Set-up of a 3m RT from surplus ex-Telekom link antenna

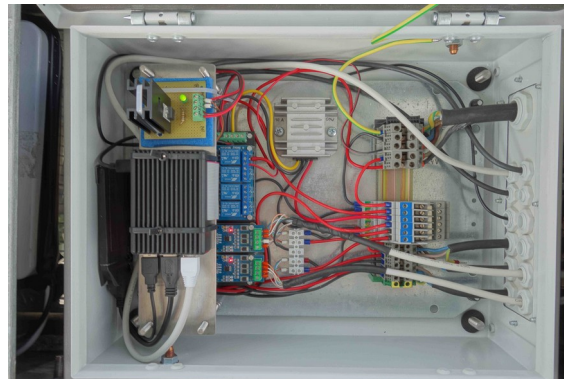
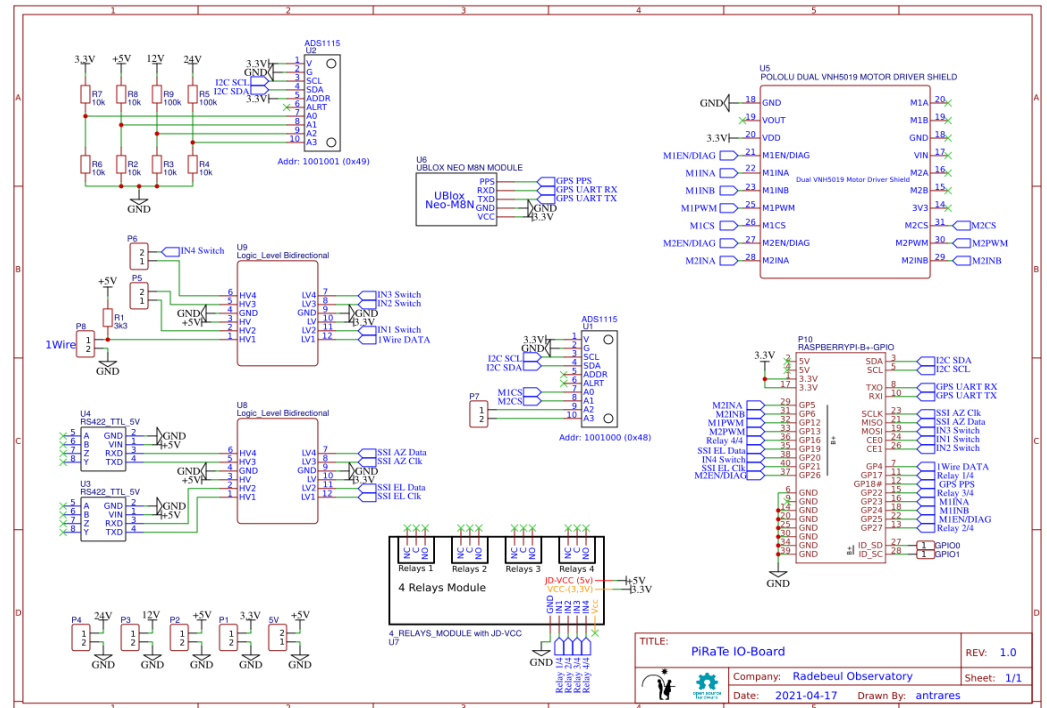
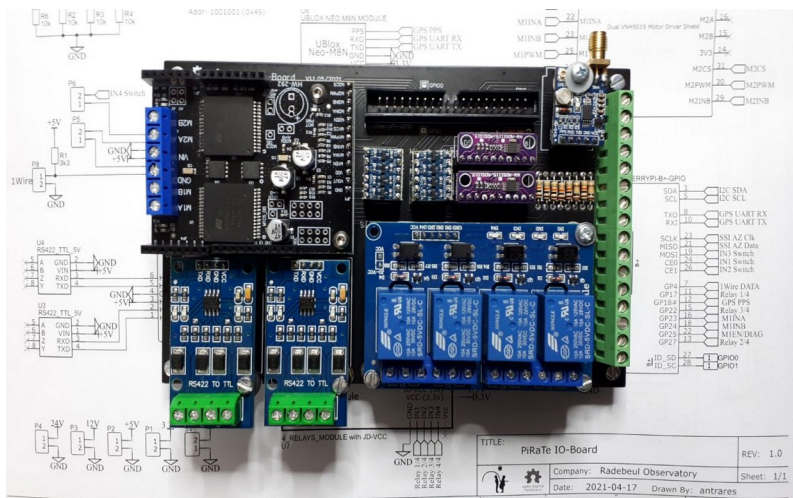


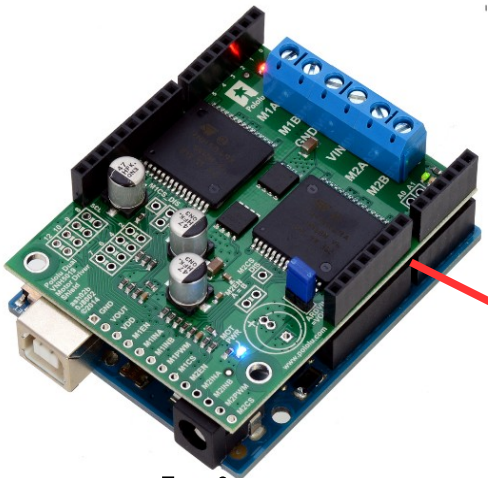
DIY telescope mount and control:

- ATmega128 w/ LX200 interface + incremental encoder + PWM motor drivers
- Destruction through massive water spill in 2011

The PiRaTe control (2021)

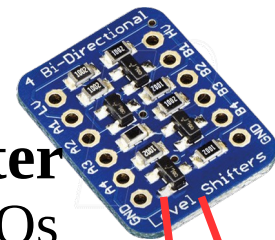
- Complete new construction of mount control from scratch 2020/2021
- Raspberry Pi + off-the-shelf modules and components
- Software: if possible only existing modular open source solutions
- Maintenance friendly + robust
- Remote operation





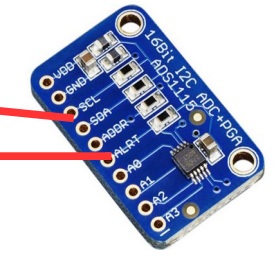
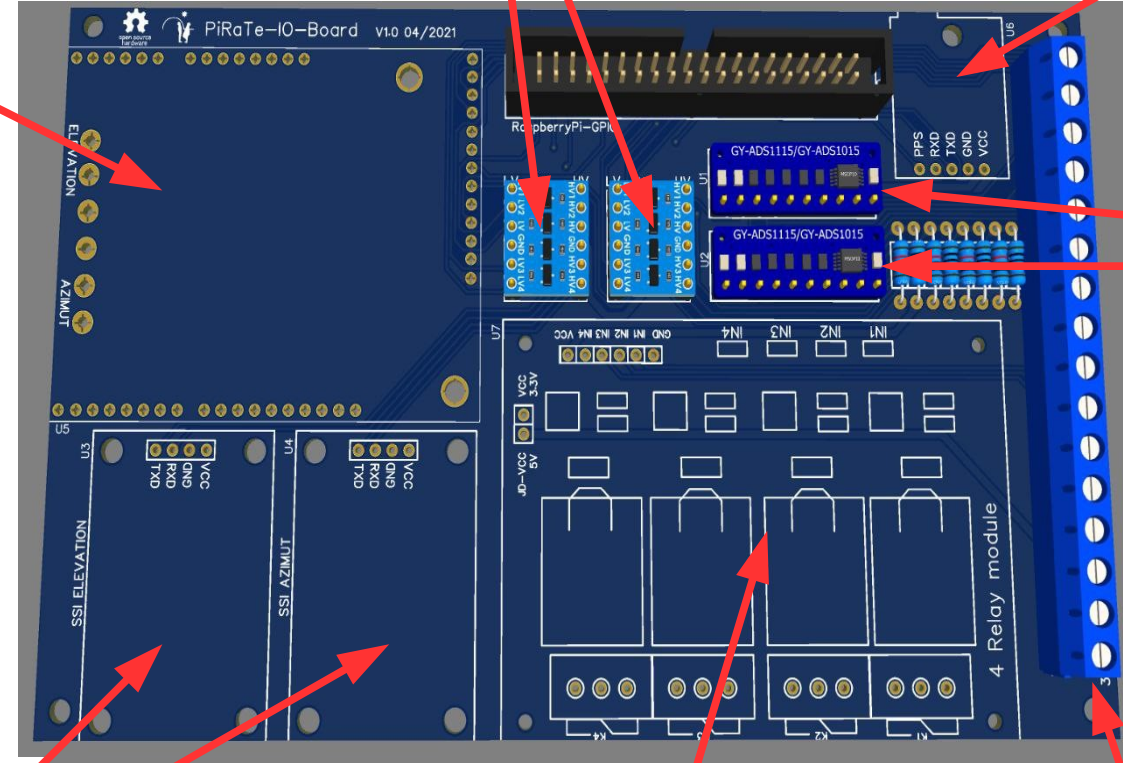
Arduino Motor Driver Shield (Pololu)
Full-bridge driving two 24V DC-Motors @max 12A

Level Shifter for digital I/Os



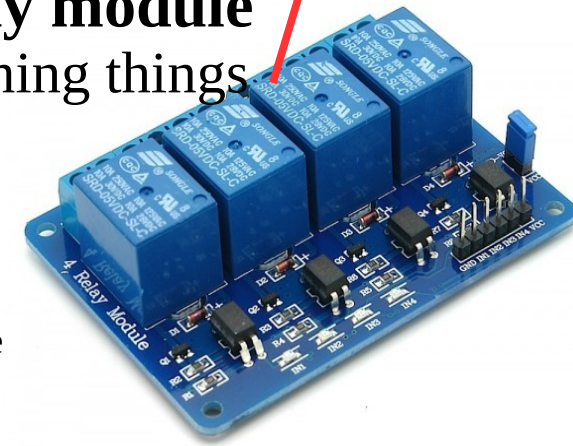
Ublox GNSS Receiver

Time sync of RPi and coord transformations

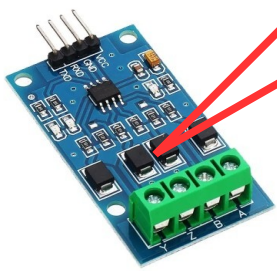


ADS1115 Breakout Board
•4ch 16bit ADC
•measure motor currents, supply voltages, analog inputs

4ch Relay module
For switching things on/off



Digital+Analog I/Os+1wire



RS422-TTL Converter
Interface to pos rotary encoders (SSI diff. bus)

Position Encoders

Encoder at secondary spindle spun-off from Az axis

Decision for industry-standard absolute rot encoder:

- Ultra robust, IP65
- Serial SSI interface
- Differential data lines for high EMI resistance
- common system/protocol – many vendors of devices
- 12 or 13 bit single-turn und multi-turn resolutions
- Many offers: 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 Mehrern

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 | Anschlussliste anzeigen

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

Zahlungen: PayPal VISA Mastercard American Express S-P-A

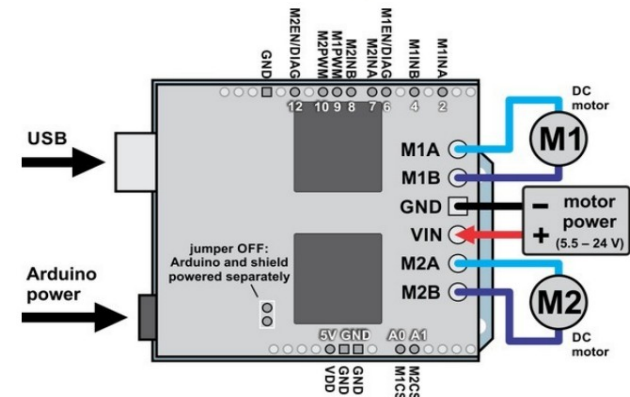
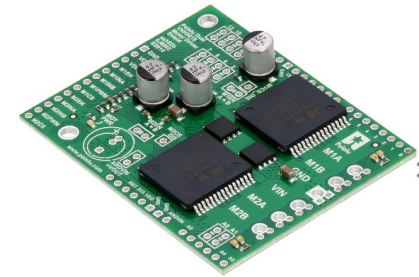


Encoder w/ direct coupling to El axis

Motor Driver

VNH5019 Motor Driver Shield

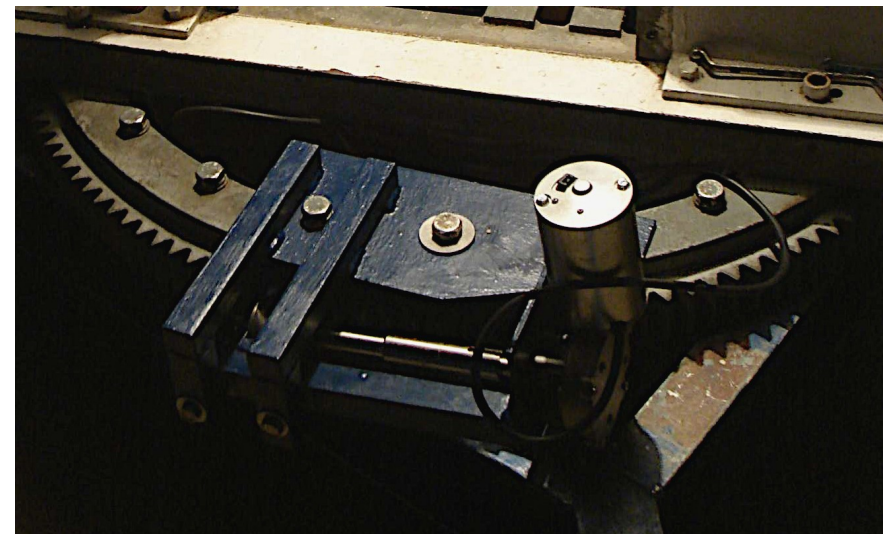
- simple interface: PWM, enable, dir
→ GPIO Pins (hardware PWM)
- additional analog output allowing measurement of motor currents → ADC (ADS1115)



Dual VNH5019 motor driver shield with an Arduino (shield and Arduino powered separately).



drive of Alt axis – friction clutch



drive of Azimuth axis – worm gear

Software

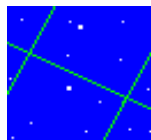
Control through INDI protocol



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

- Open source, cross platform, 22 client apps available (incl. IOS / Android)
- Widely used for remote observatory systems
- XML-based data exchange
- drivers are self-describing
- clients provide the properties demanded by the driver at run time
- control of drivers by multiple clients (local/remote)

Cartes du Ciel



HNSky



iIndi



Telescope.touch



Stellarium

Software

Remote control - KStars



The screenshot displays the KStars software interface with several components:

- RT300 Camera - Mozilla Firefox:** A live video feed of the RT300 radio telescope structure.
- plotfile.eps - sun_scan_2408201_2.pdf - Mozilla Firefox:** A radio scan plot titled "Sun @ 12 GHz" showing a bright central source. The plot axes are RA/h (9.8 to 10.6) and Dec/deg (8 to 14). The plot data is as follows:

RA/h	Dec/deg	Intensity
10.2	11.5	High
- KStars:** A star chart showing the Sun and Regulus. The Sun is marked with a red circle and labeled "Sun". The text "PI Radiotelescope" is visible near the Sun. The location is "Dresden, Germany" with coordinates "+137° 29' 12\", +43° 50' 59\" and time "10h 32m 14s, +11° 47' 22\". The approximate FOV is 6.0 degrees.
- radioid - Konsole:** A terminal window displaying a list of radio scan data points. The data is as follows:

RA (h)	Dec (deg)	RA (h)	Dec (deg)	RA (h)	Dec (deg)	RA (h)	Dec (deg)	RA (h)	Dec (deg)
1629883262	521138242	139.5687	48.0514	10.29404	15.0425	39.6357	0.0564	20.3	
- INDI Control Panel:** A control interface for the PI Radiotelescope. It includes sections for "Weather Watcher", "GPSD", and "PI Radiotelescope". The "PI Radiotelescope" section has tabs for "Main Control", "Connection", "Options", "Encoders", "Axes", "Monitoring", "Motion Control", "Site Management", and "Motors". The "Main Control" section includes buttons for "Connect", "Disconnect", "Track", "Slew", "Eq. Coordinates", "Abort Motion", "Tracking", "Parking", and "Scope Status". The "Scope Status" section includes buttons for "Idle", "Slew", "Tracking", "Parking", and "Parked". A log window at the bottom shows the following messages:

```
2021-08-25T09:22:08: [INFO] Telescope slew is complete.
2021-08-25T09:22:08: [INFO] Slewing to RA: 10:17:24 - DEC: 10:39:00
2021-08-25T09:22:06: [INFO] Telescope slew is complete.
2021-08-25T09:22:05: [INFO] Slewing to RA: 10:17:24 - DEC: 10:48:00
2021-08-25T09:22:04: [INFO] Telescope slew is complete.
```

Software

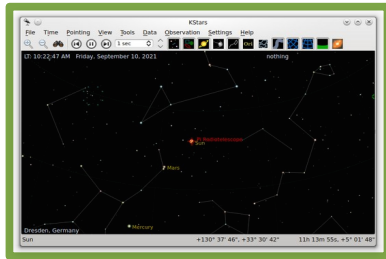


RaTSche - The Radiotelescope Task Scheduler

Clients

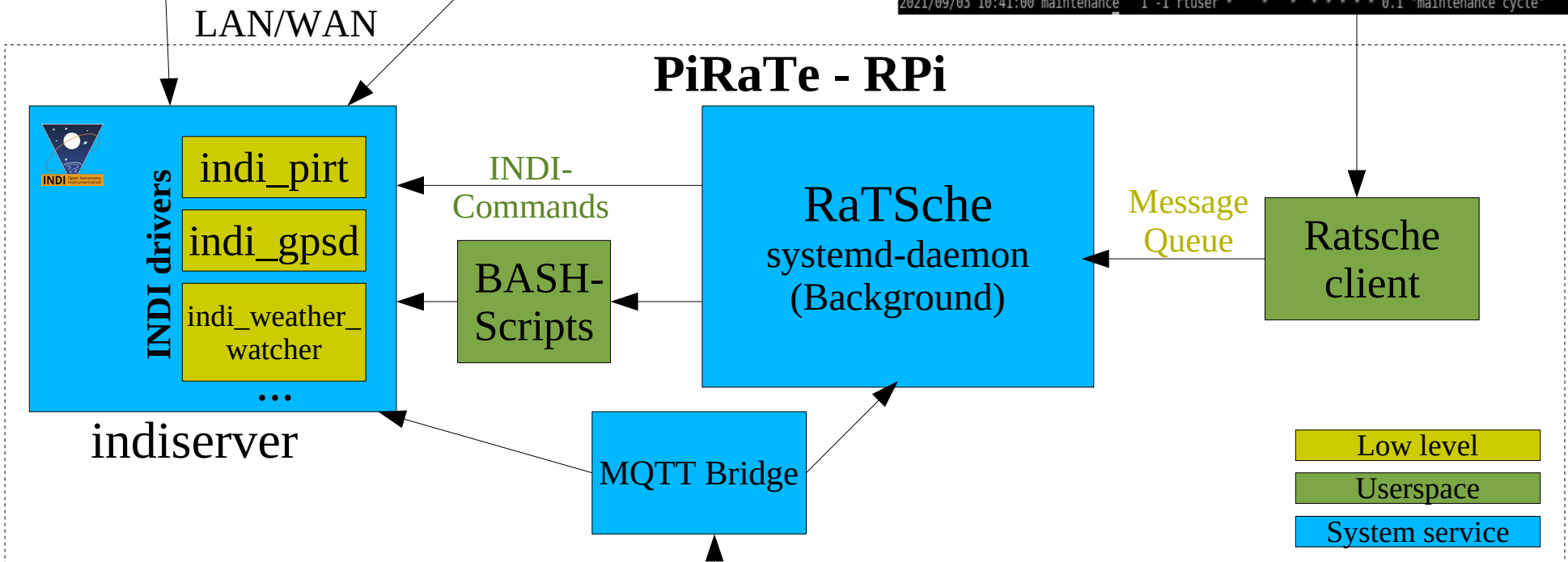


```
piert300:~$ indi_getprop -t 1 -l "Pi Radiotelescope.*" | head
Pi Radiotelescope.CONNECTION.CONNECT=on
Pi Radiotelescope.CONNECTION.DISCONNECT=off
Pi Radiotelescope.DRIVER.INFO.DRIVER_NAME=Pi Radiotelescope
Pi Radiotelescope.DRIVER.INFO.DRIVER_EXEC=indi_pirt
Pi Radiotelescope.DRIVER.INFO.DRIVER_VERSION=1.0
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 of tasks – task files

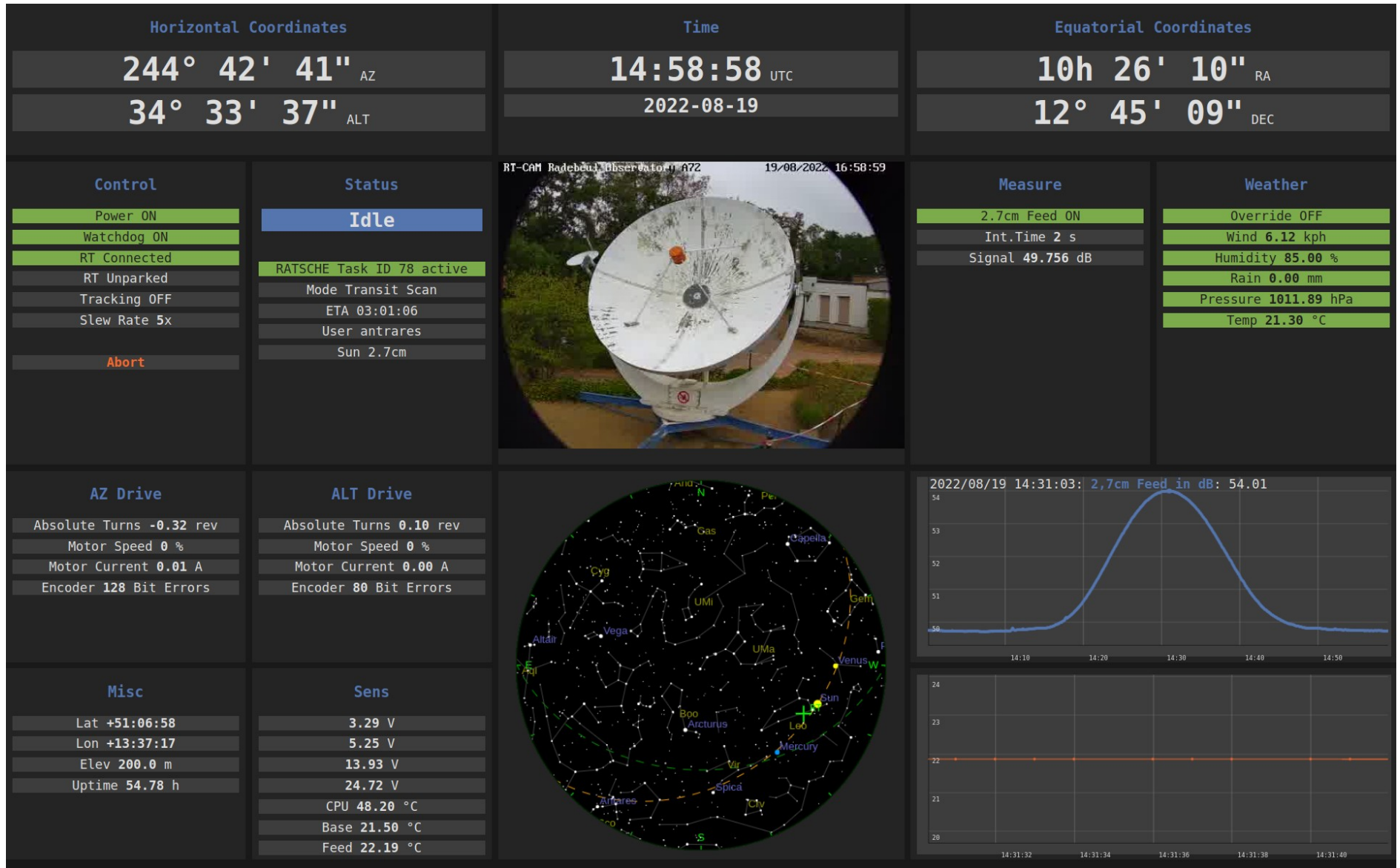
```
# start_time mode priority alt_period user x1 y1 x2 y2 stepx stepy int_time ref_cycle max_duration comment
2021/09/04 11:30:00 unpark 1 0 rtuser * * * * * 0.1 "unpark"
2021/09/01 10:50:00 maintenance 1 0 rtuser * * * * * 1 "maintenance cycle"
2021/09/03 17:28:00 drift 1 0 rtuser 180 60 * * * * 5 * 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"
```



Software

The WebUI Dashboard

JS-Frontend with MQTT endpoints for INDI variables and Ratsche tasks



Software



The WebUI task scheduler

JS-Frontend w/ MQTT endpoints for INDI variables and 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	10 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

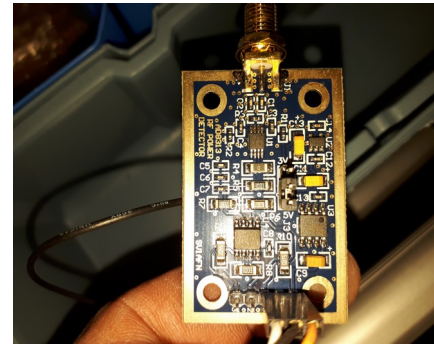
RX hardware

commercial Sat-TV hardware: Ku band (10.7..12.75 GHz)

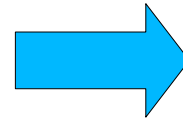


Measuring the field strength:

- First trials: sat finder
- Better: log. detector (AD8313)



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



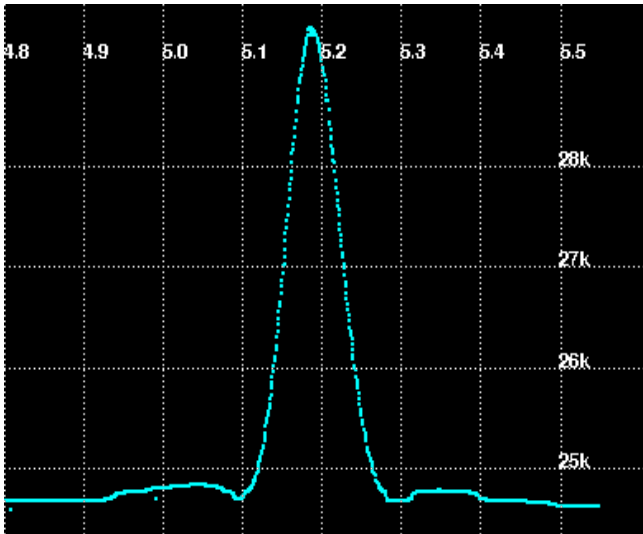
**Excellent hardware for
Radio Astronomy**

**Sat LNB (~5€)
NF: „0.1dB“
(realistically ~0.8dB)**

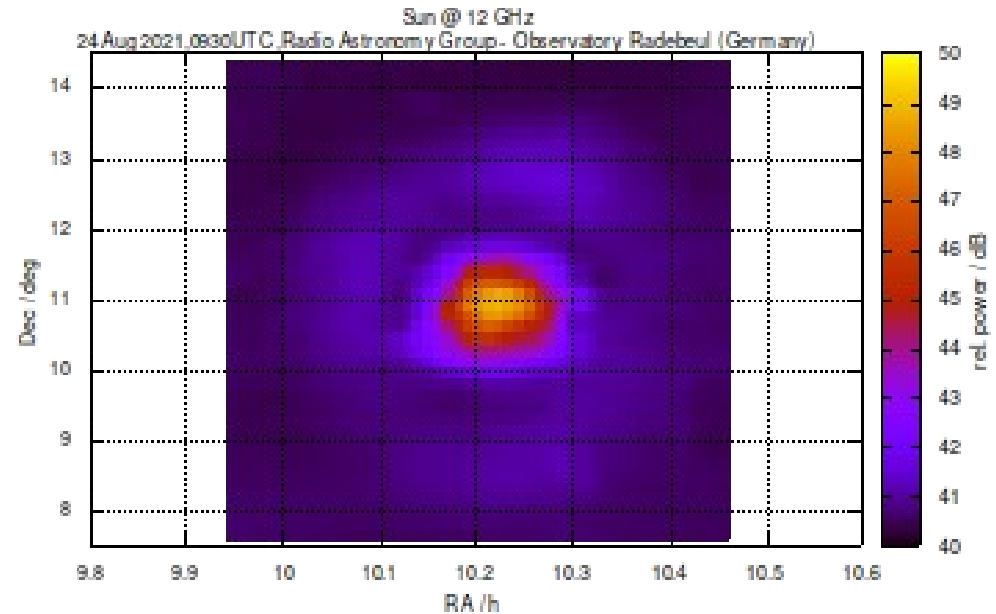
Observations – Ku Band

Sun

- 2d grid scan with adjustable stepping automated through definition of 2d-scan tasks → peek INDI variables in loop
- Record coordinates and dB-linear output of log. detector (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
```

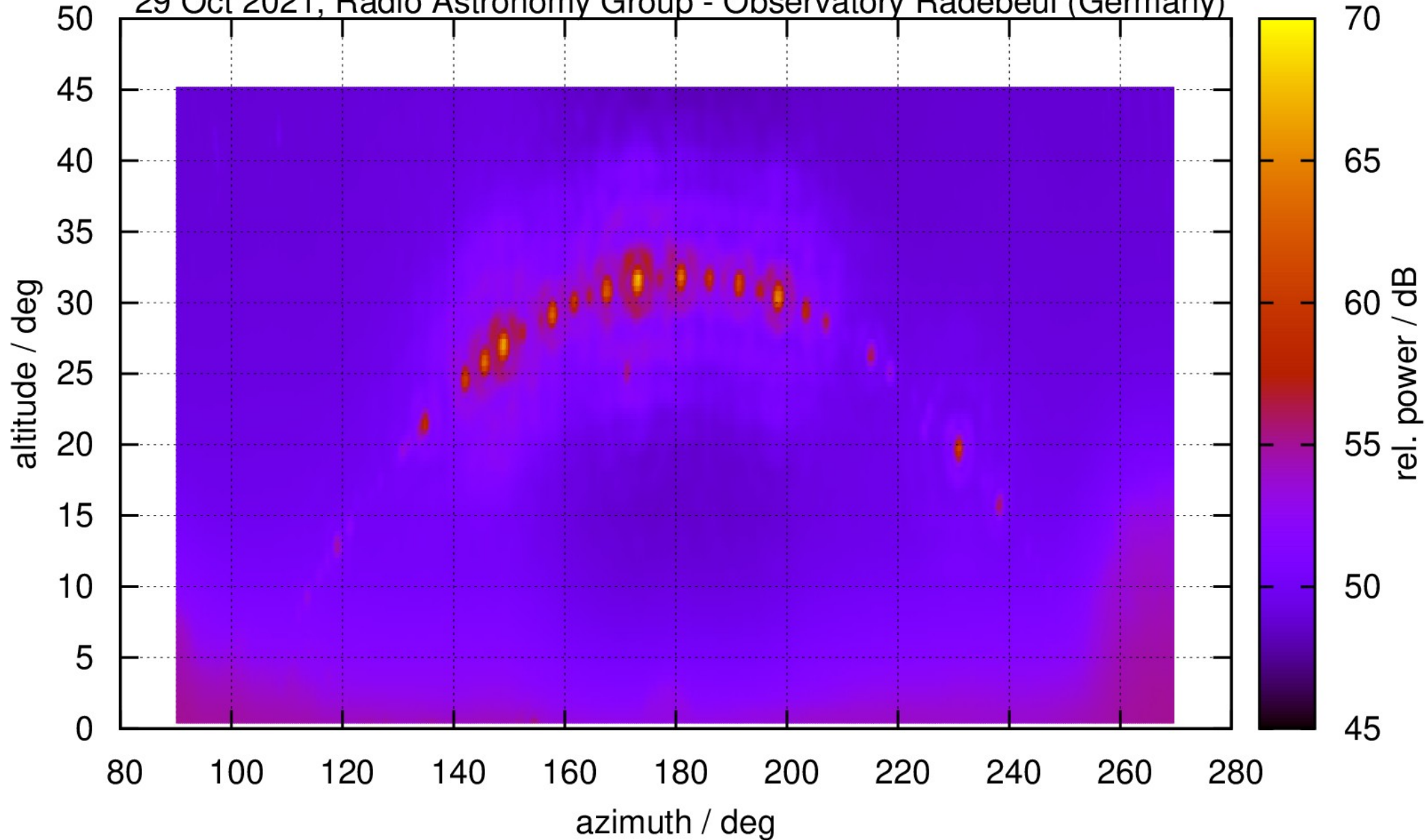


Problem: Sat-LNB optimized for offset dishes – illumination of dish in primary focus <50%

Observations – Ku Band

Geostationary Satellites @ 12 GHz

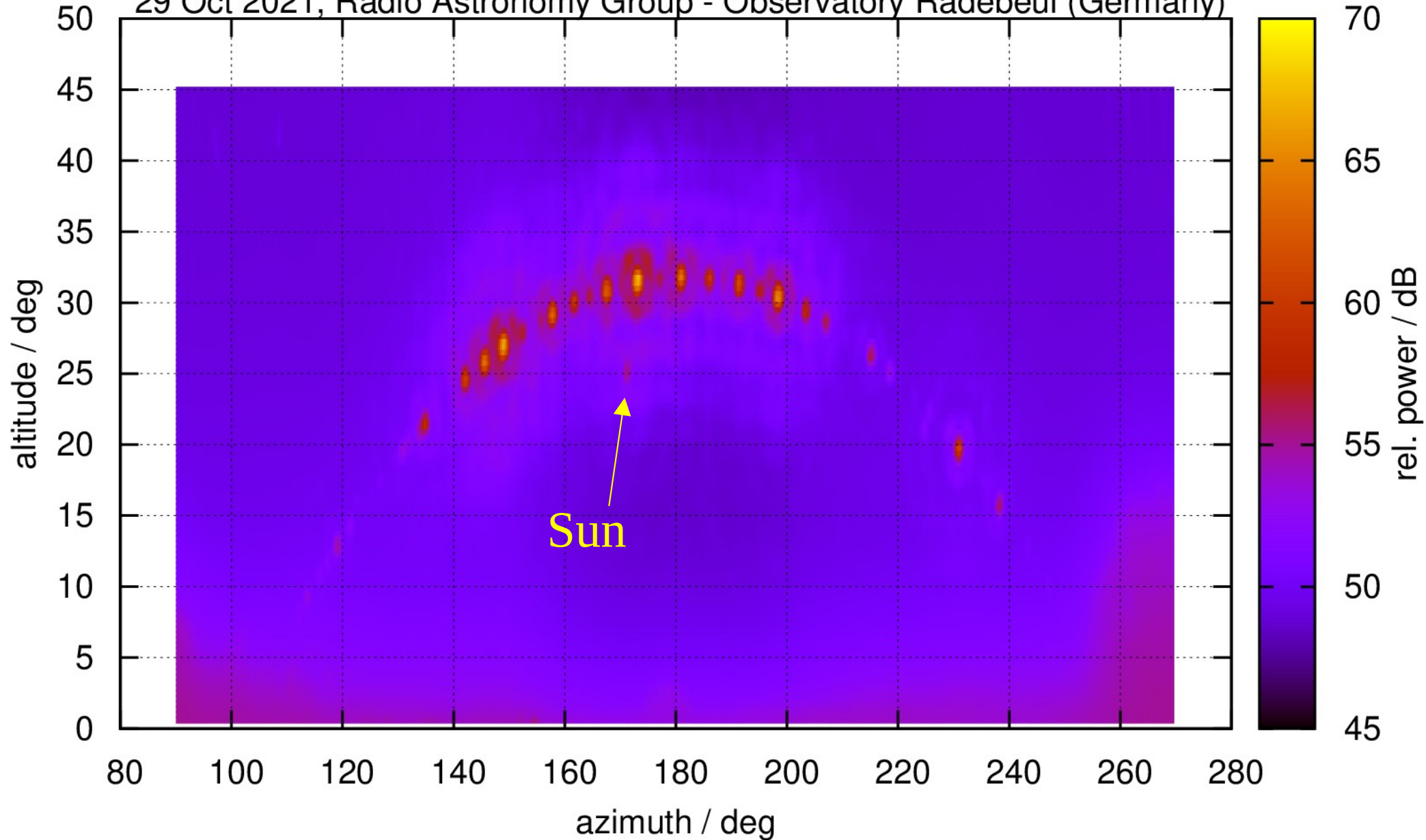
29 Oct 2021, Radio Astronomy Group - Observatory Radebeul (Germany)



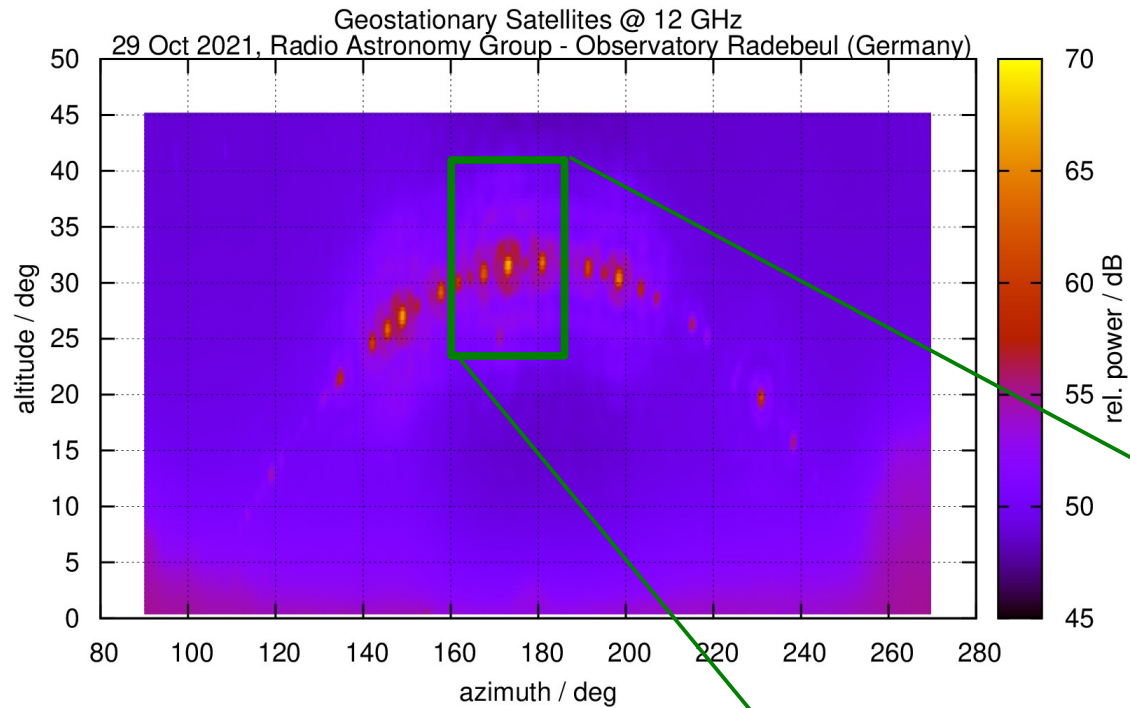
Observations – Ku Band

Geostationary Satellites @ 12 GHz

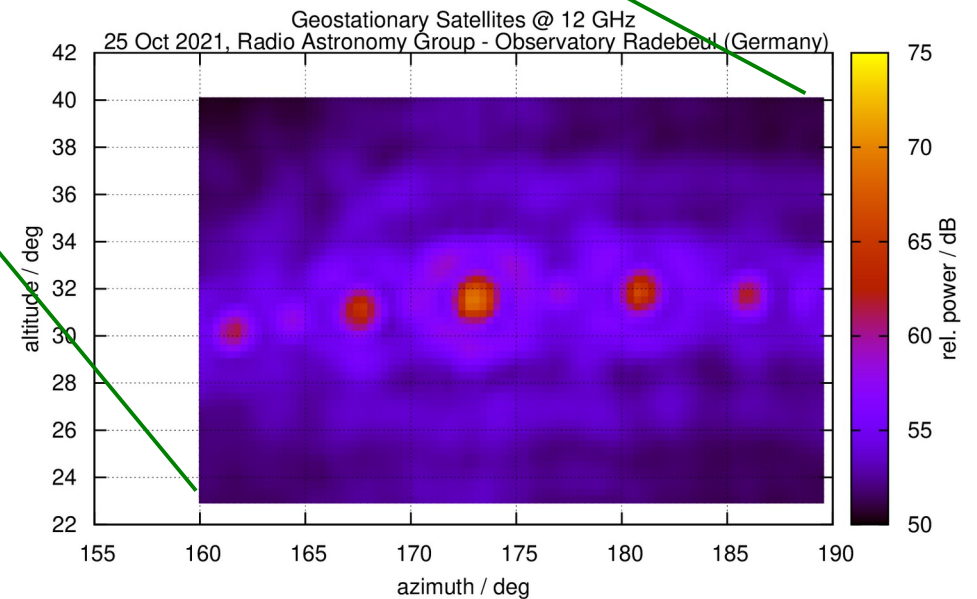
29 Oct 2021, Radio Astronomy Group - Observatory Radebeul (Germany)



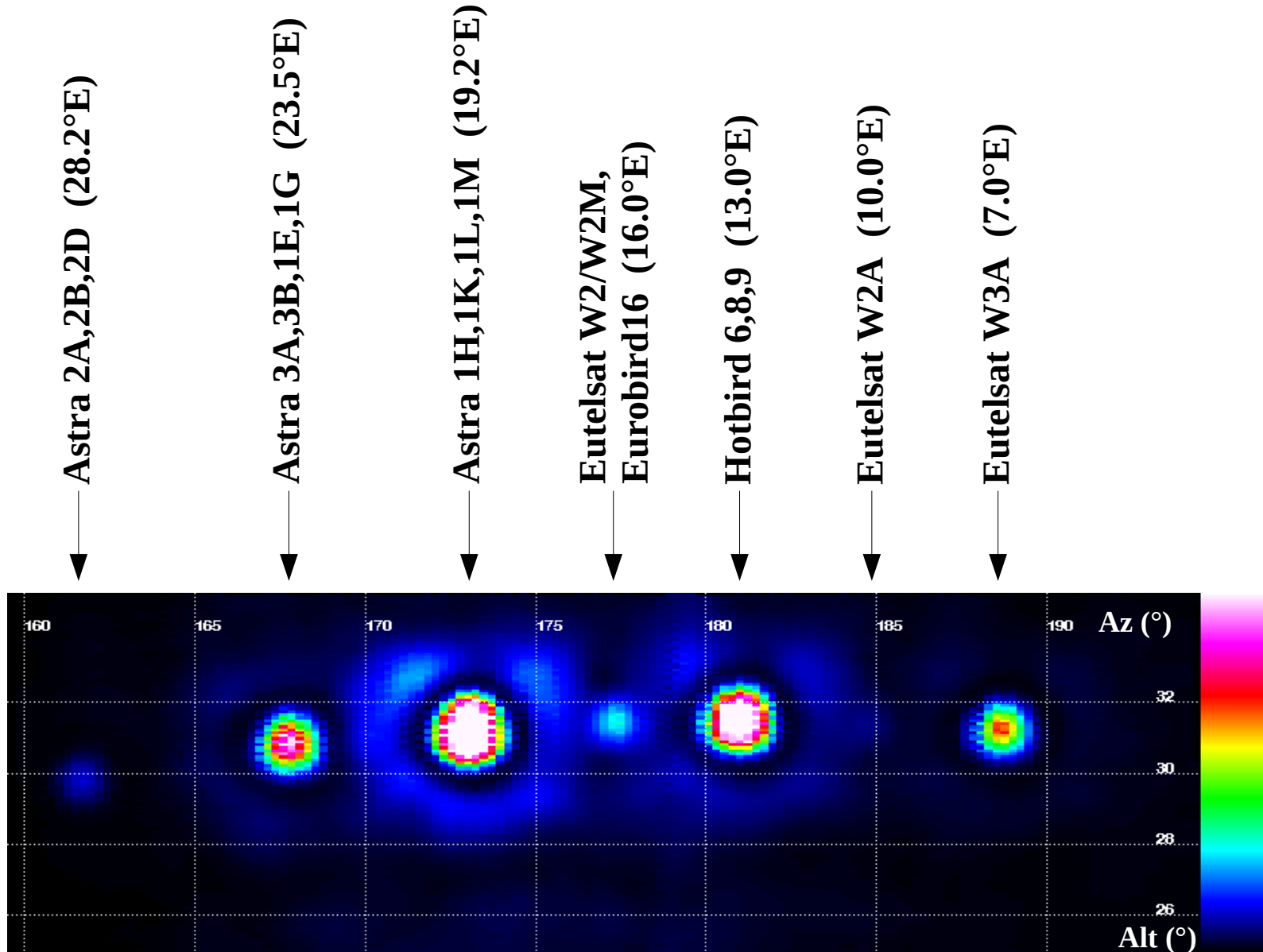
Observations – Ku Band



TV Satellites

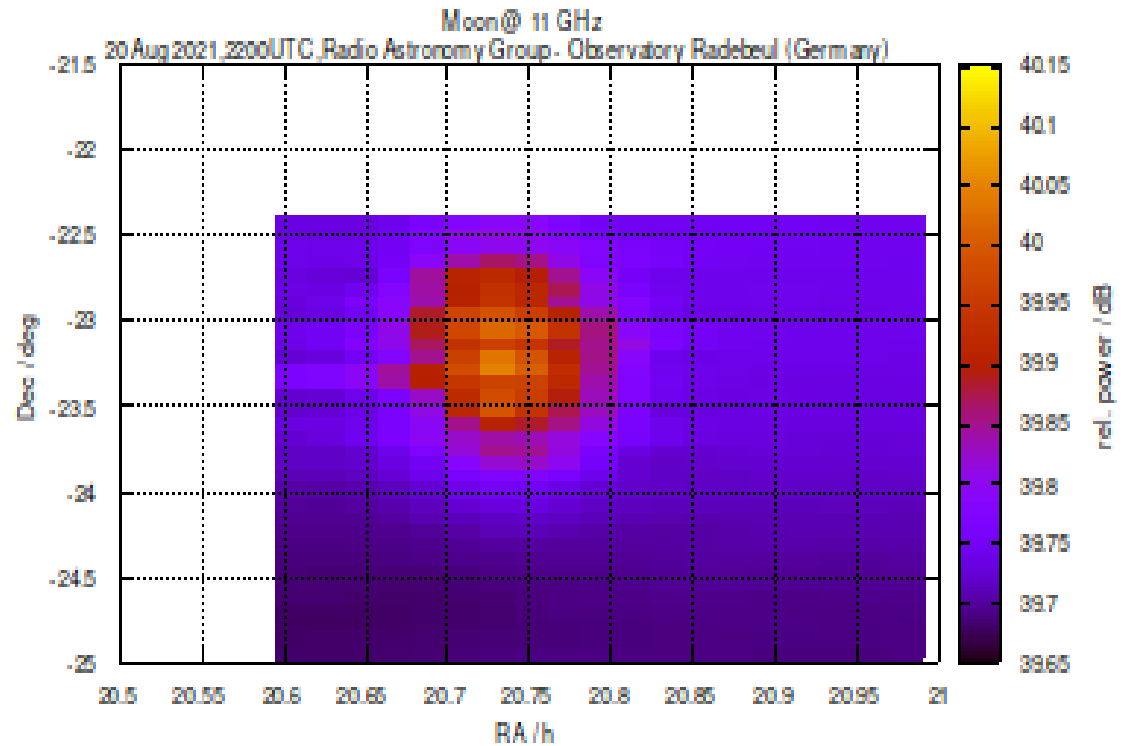
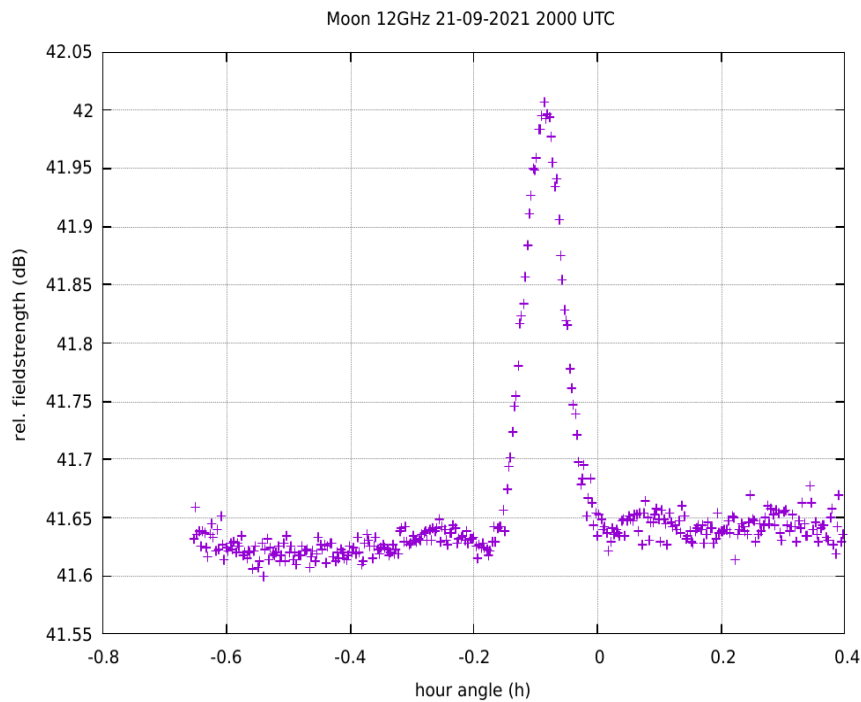


Observations – Ku Band



Observations – Ku Band

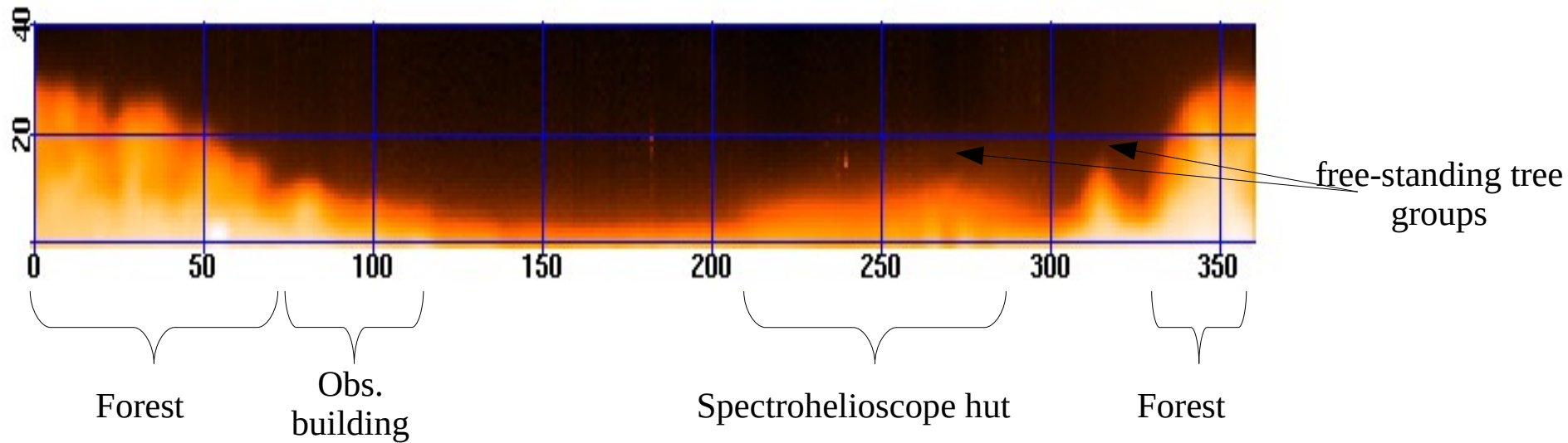
Moon



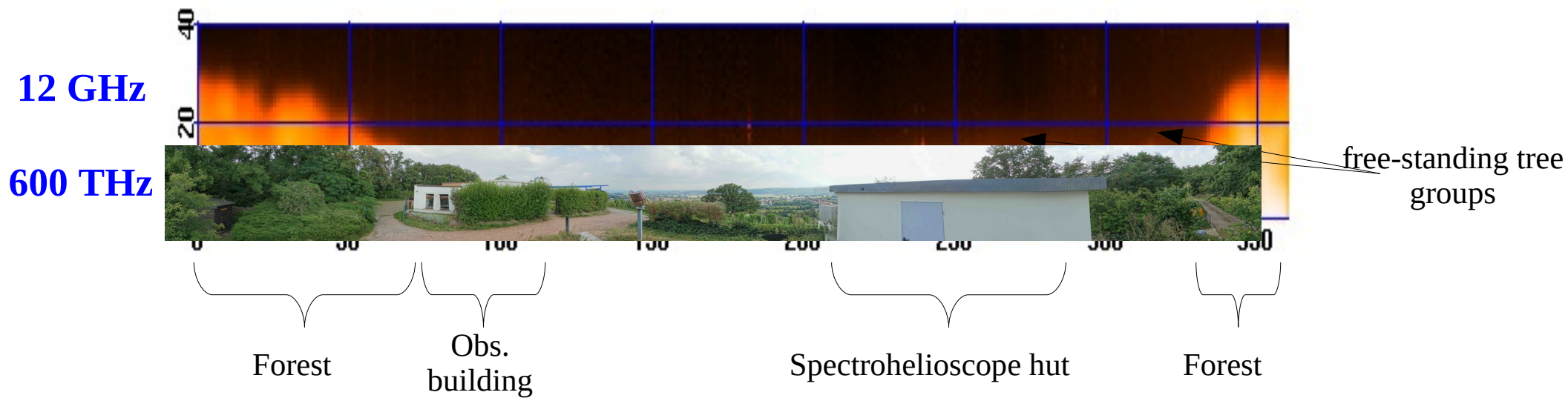
96% illumination

Observations Horizon@12GHz

12 GHz



Observations Horizon@12GHz



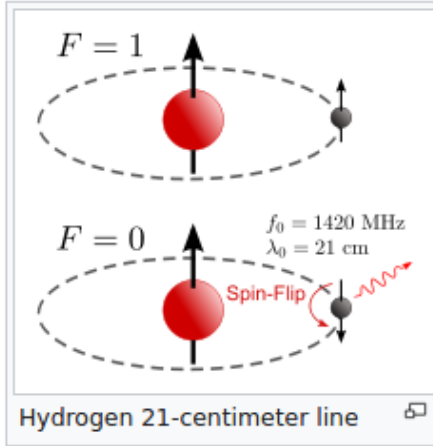


WIKIPEDIA
The Free Encyclopedia

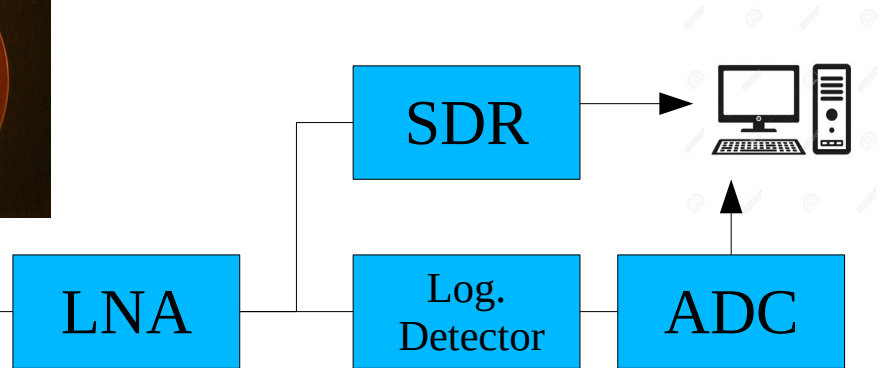
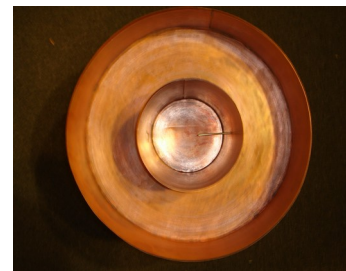
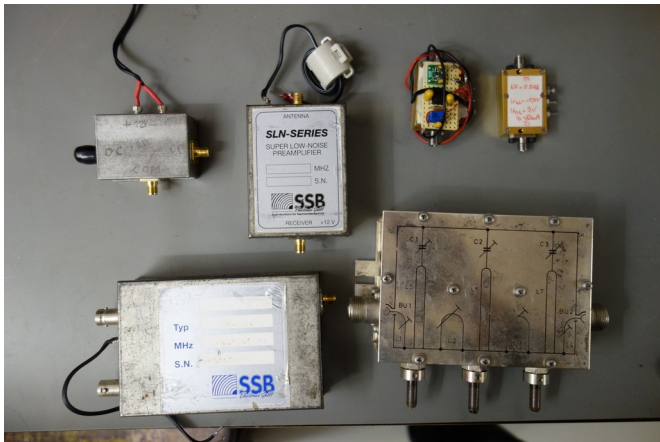
RX hardware

1420 Mhz/21cm/HI

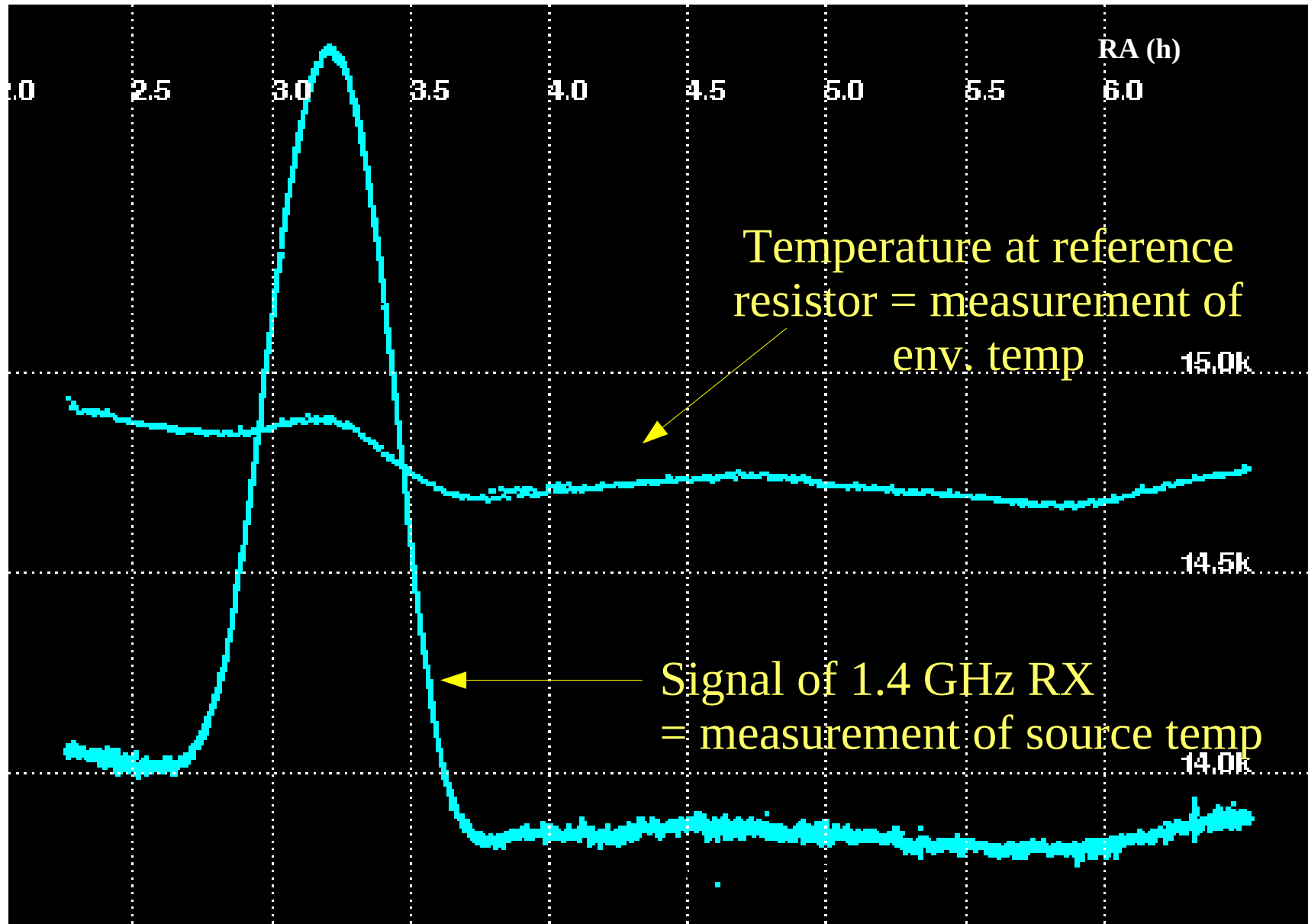
The **hydrogen line, 21-centimeter line, or H I line**^[1] is the **electromagnetic radiation spectral line** that is created by a change in the energy state of neutral hydrogen atoms. This electromagnetic radiation has a precise frequency of 1 420 405 751.768(2) Hz,^[2] which is equivalent to the **vacuum 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**.



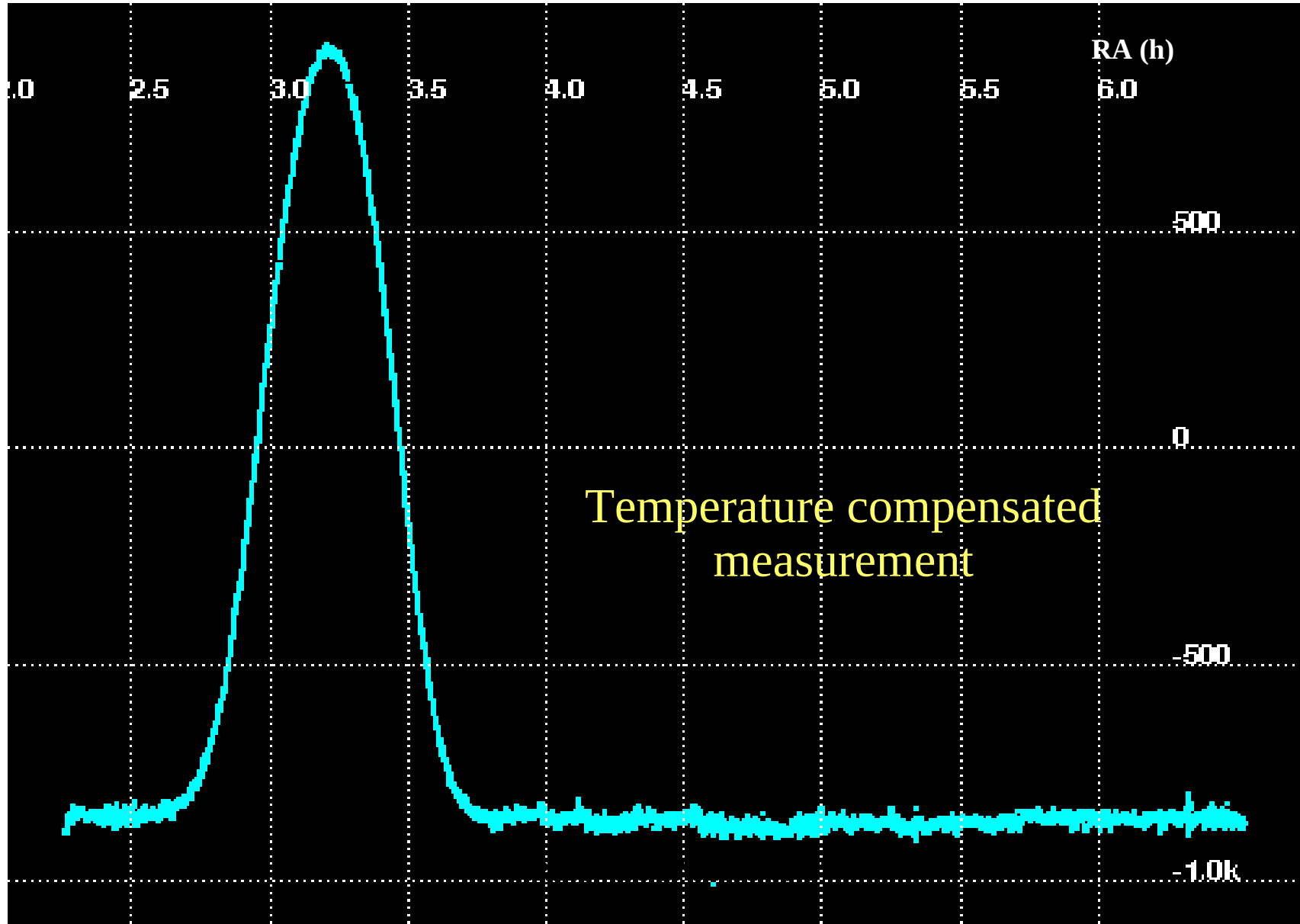
Cavity choke ring feed
(Kumar feed)



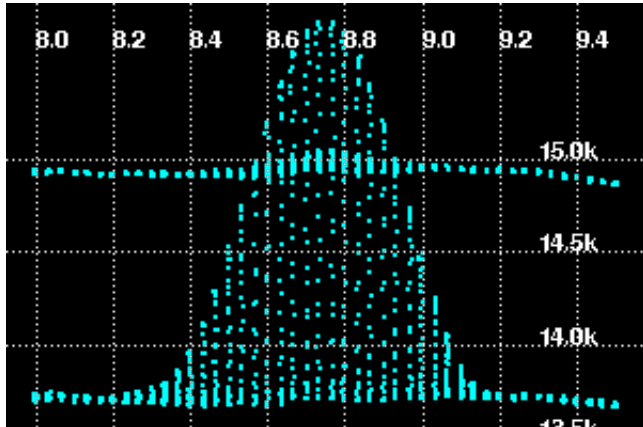
Observations Sun@21cm



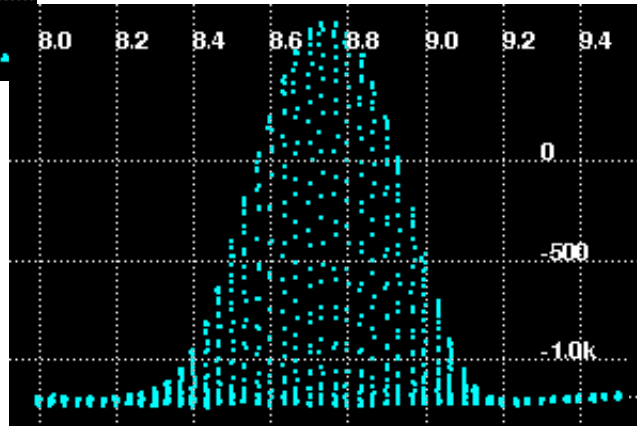
Observations Sun@21cm



Observations Sun@21cm

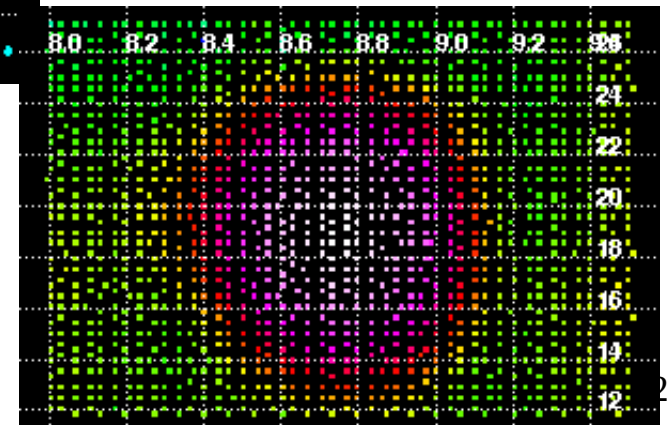


→ Scan in regular 2d grid
(equatorial/horizontal system)

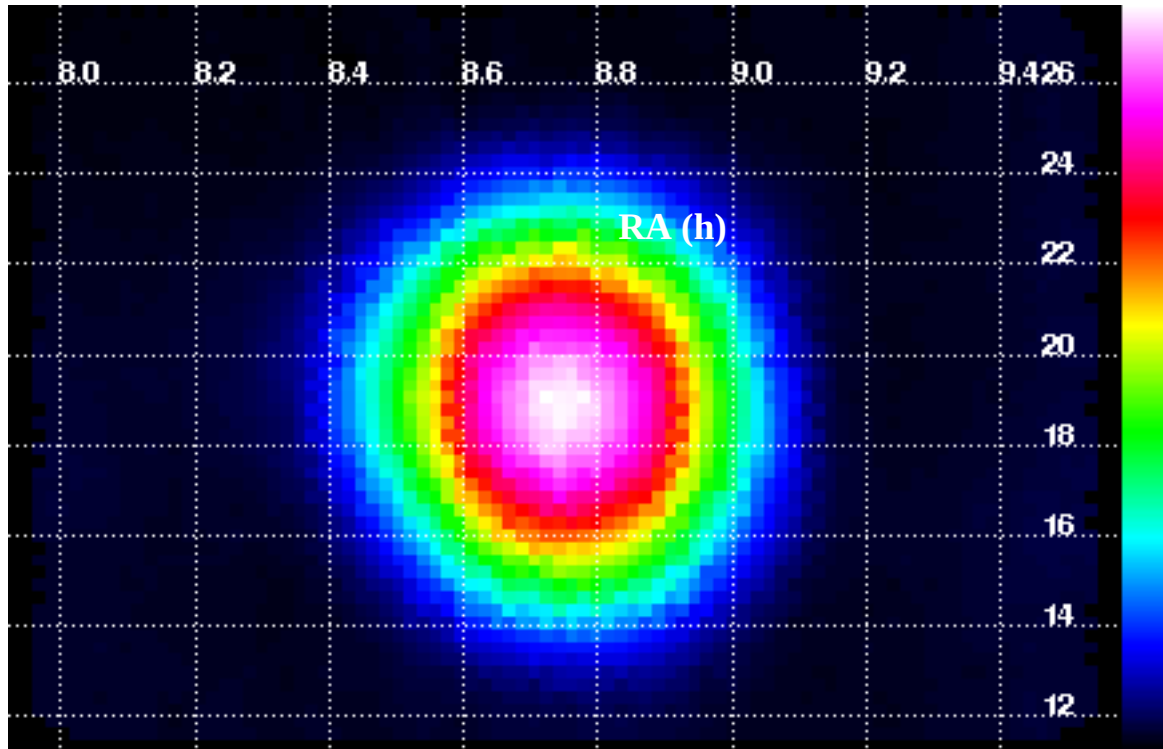


→ Reference
normalization

→ Fill up spatial grid with measurements

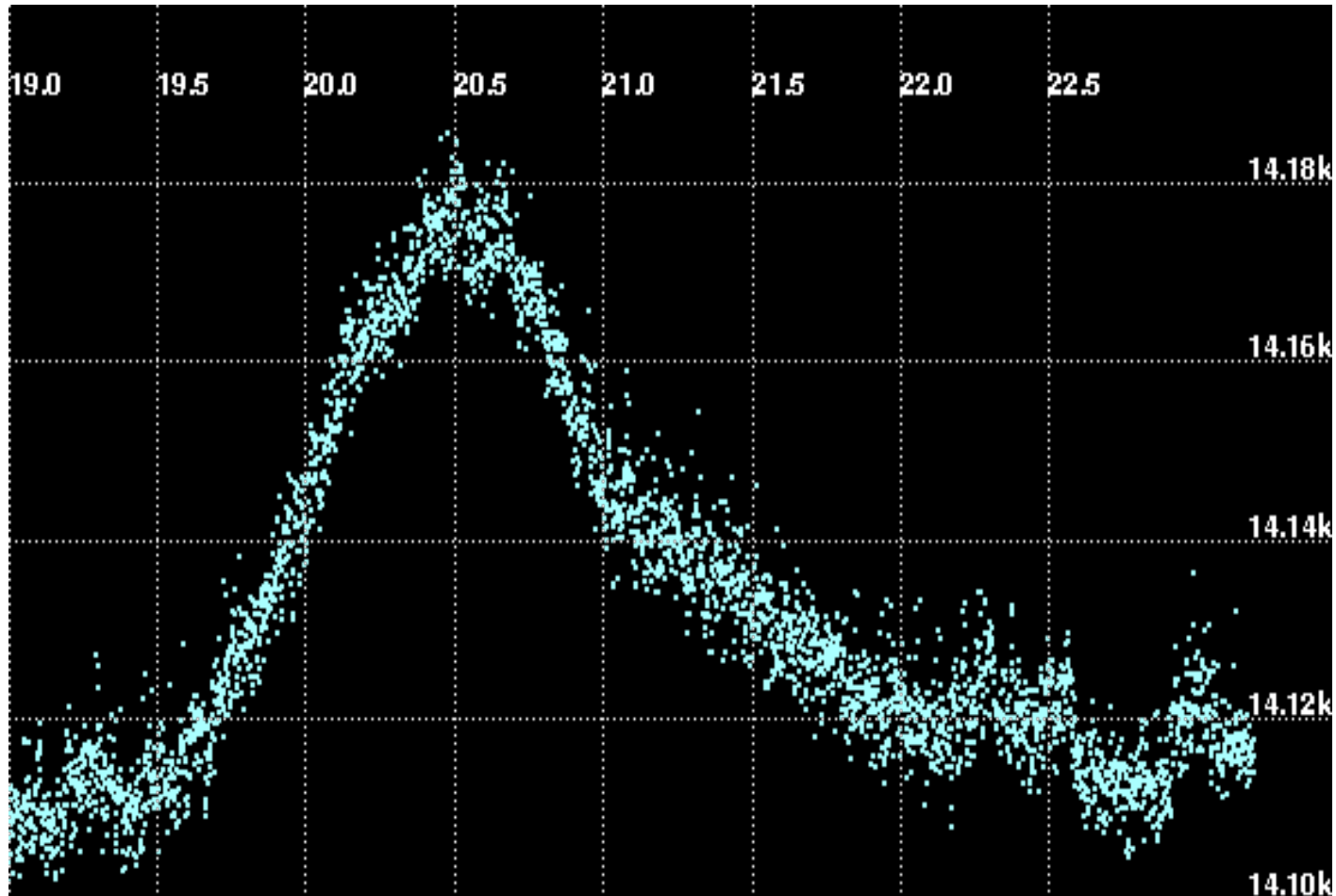


Observations Sun@21cm



- Adjust binning
- (careful) interpolation of missing grid points (“holes”)

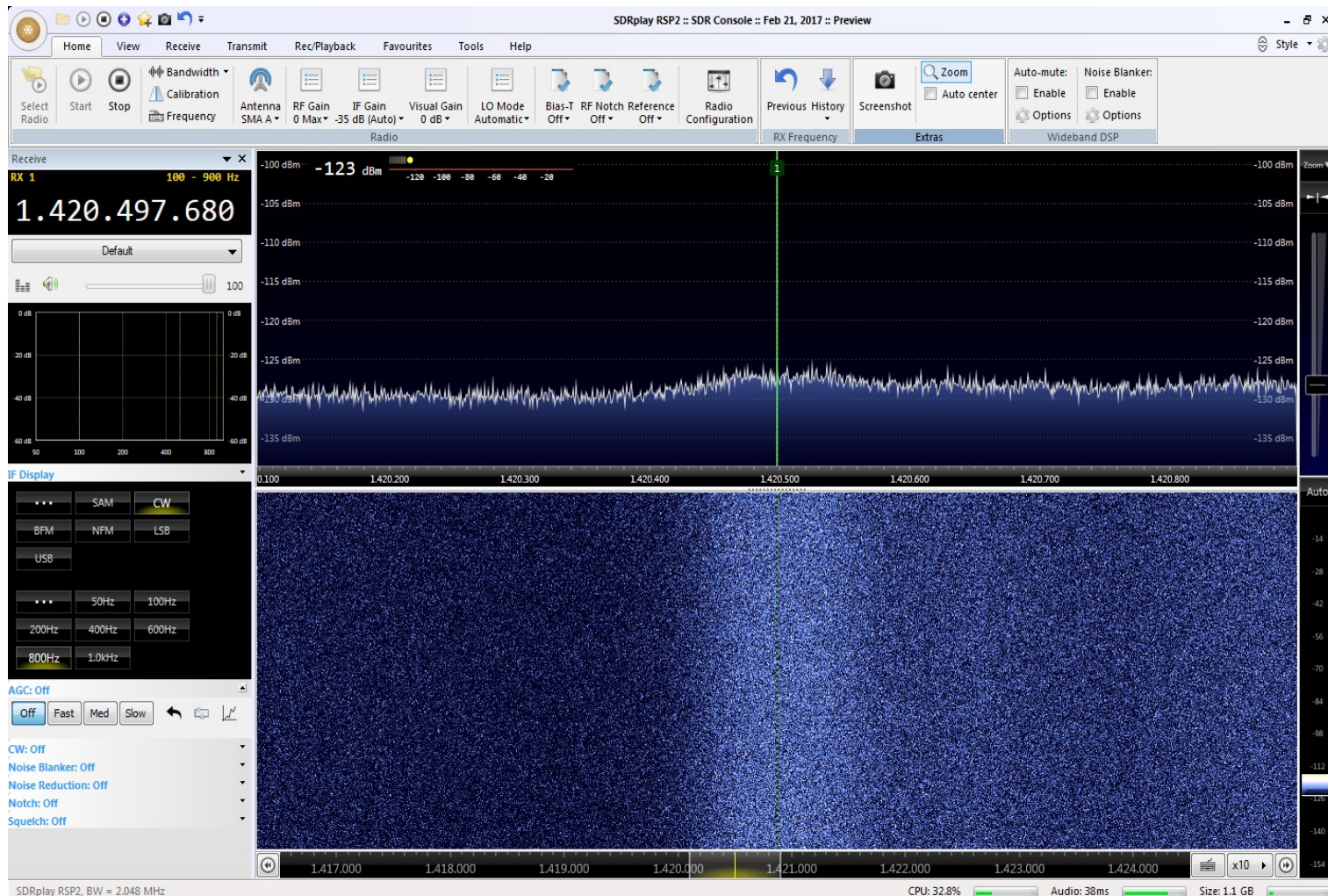
Observations Milky Way@21cm





Observations Spectrum@21cm

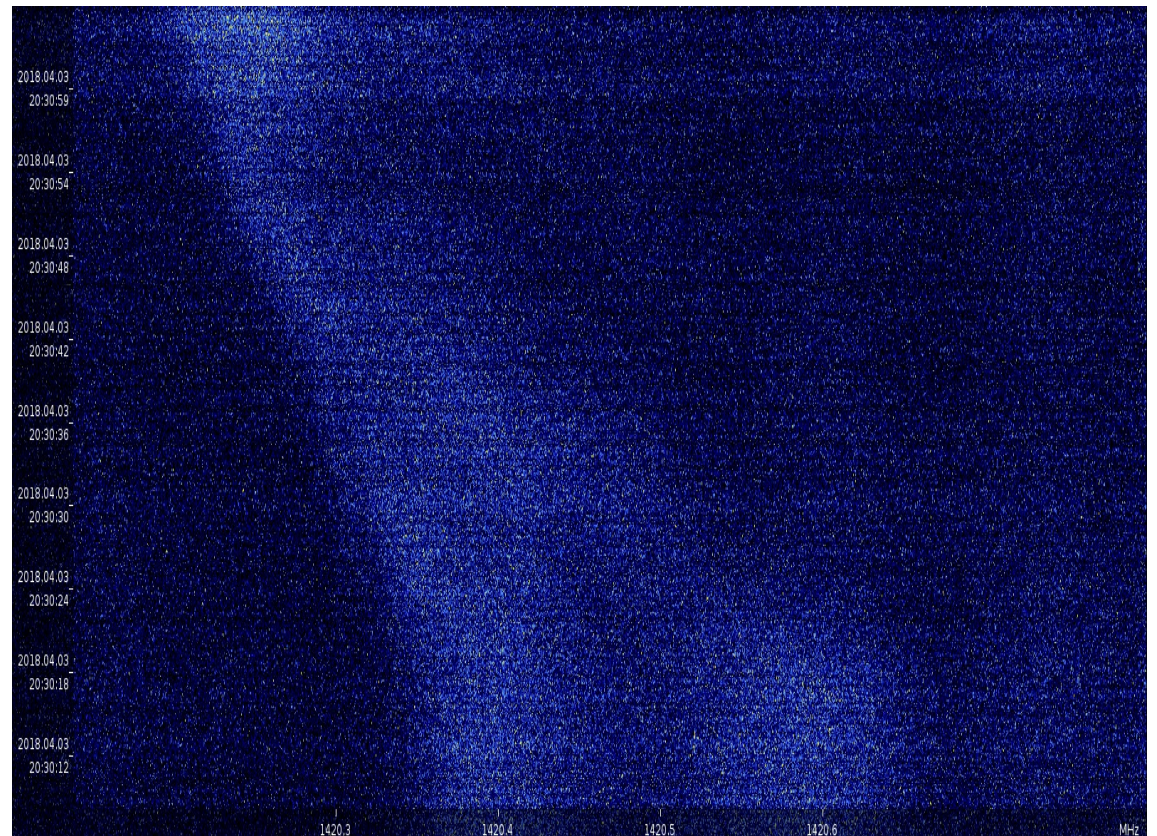
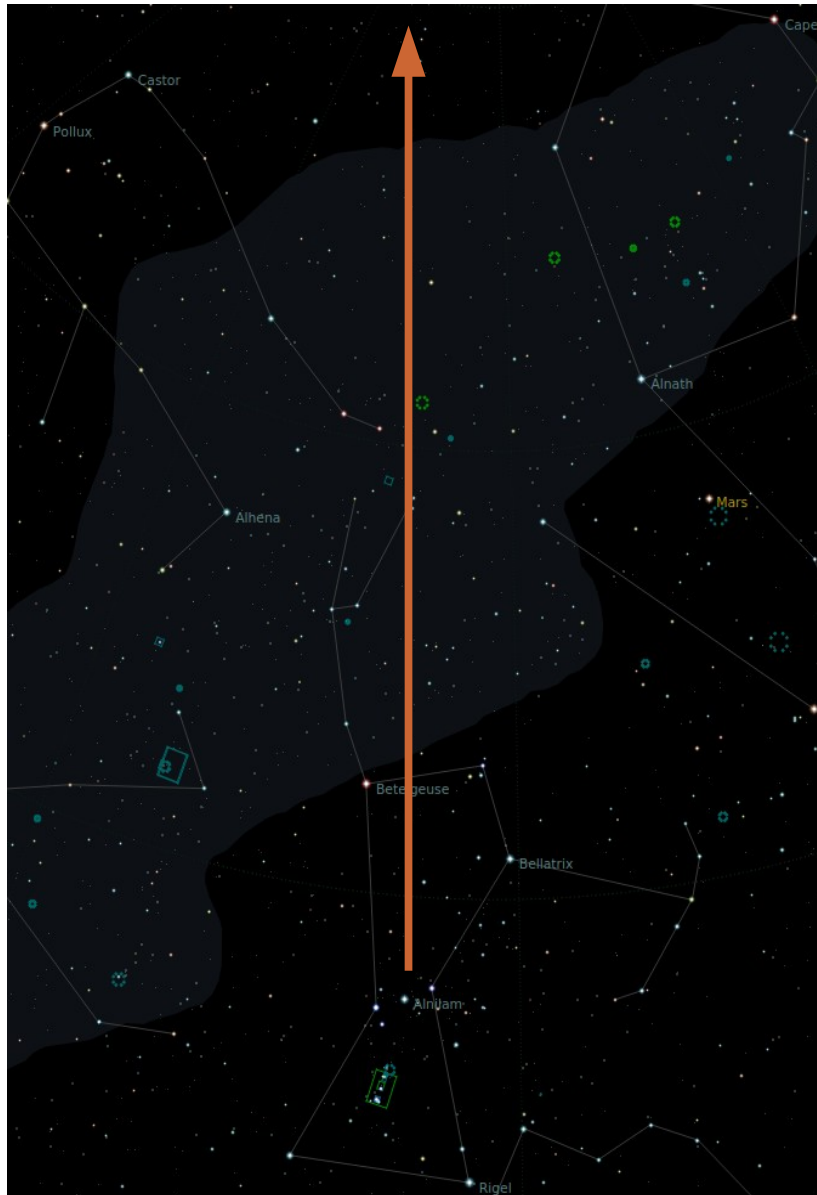
USB-SDR stick, implementation as WebSDR planned



Observations Spectrum@21cm

Moving through the milky way

→ 21cm line appears Doppler-shifted,
depending on radial velocities

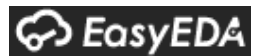


The Project

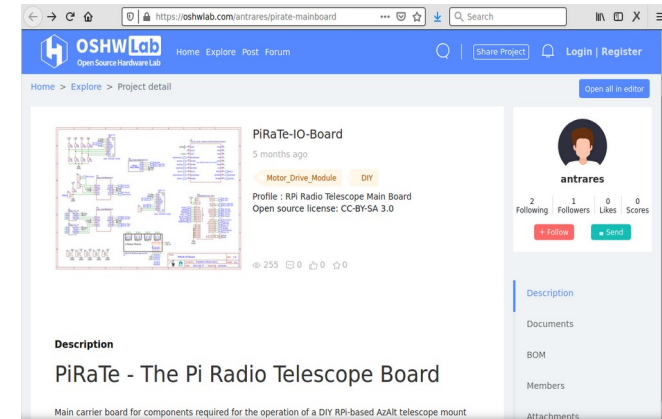
PiRaTe is...

Hardware

Carrier PCB und description of utilized add-on boards



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



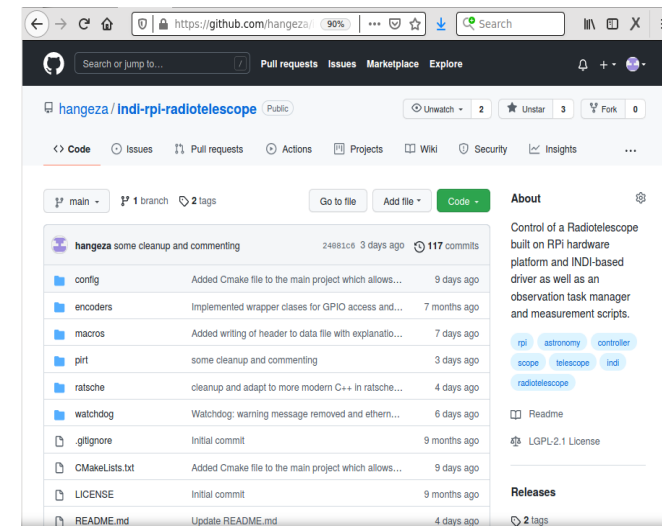
Software :

- indi-pirt – INDI driver for RPi
- RaTSche – Radiotelescope Task Scheduler
- rt_scripts – Bash macros for complex Acquisition programmes
- Service macros – systemd service units for indiserver and ratsche
- RTData – 1d und 2d visualization of data series



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

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



The radioastronomy group

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Torsten Bacher (DD)

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Contact: zaunick@exp2.physik.uni-giessen.de
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R. 12/05/17

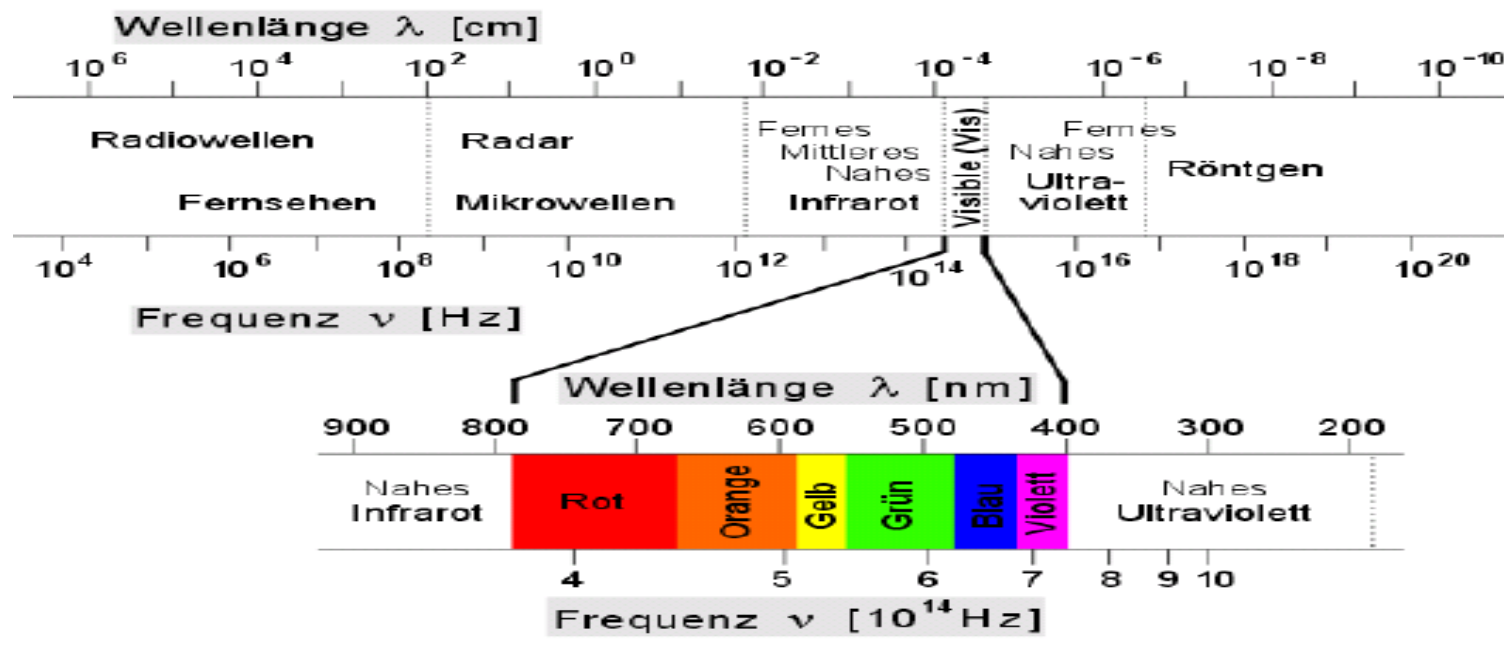
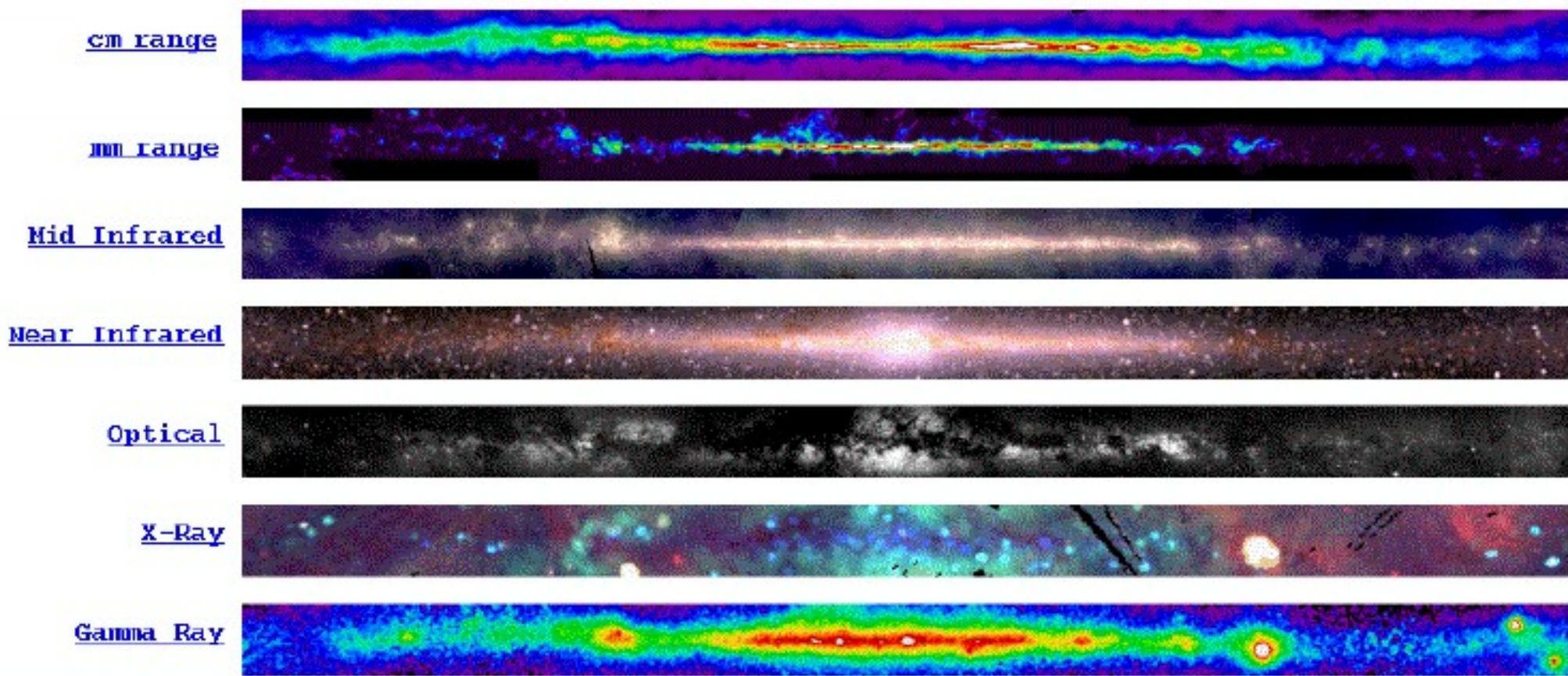
51

Backup Slides

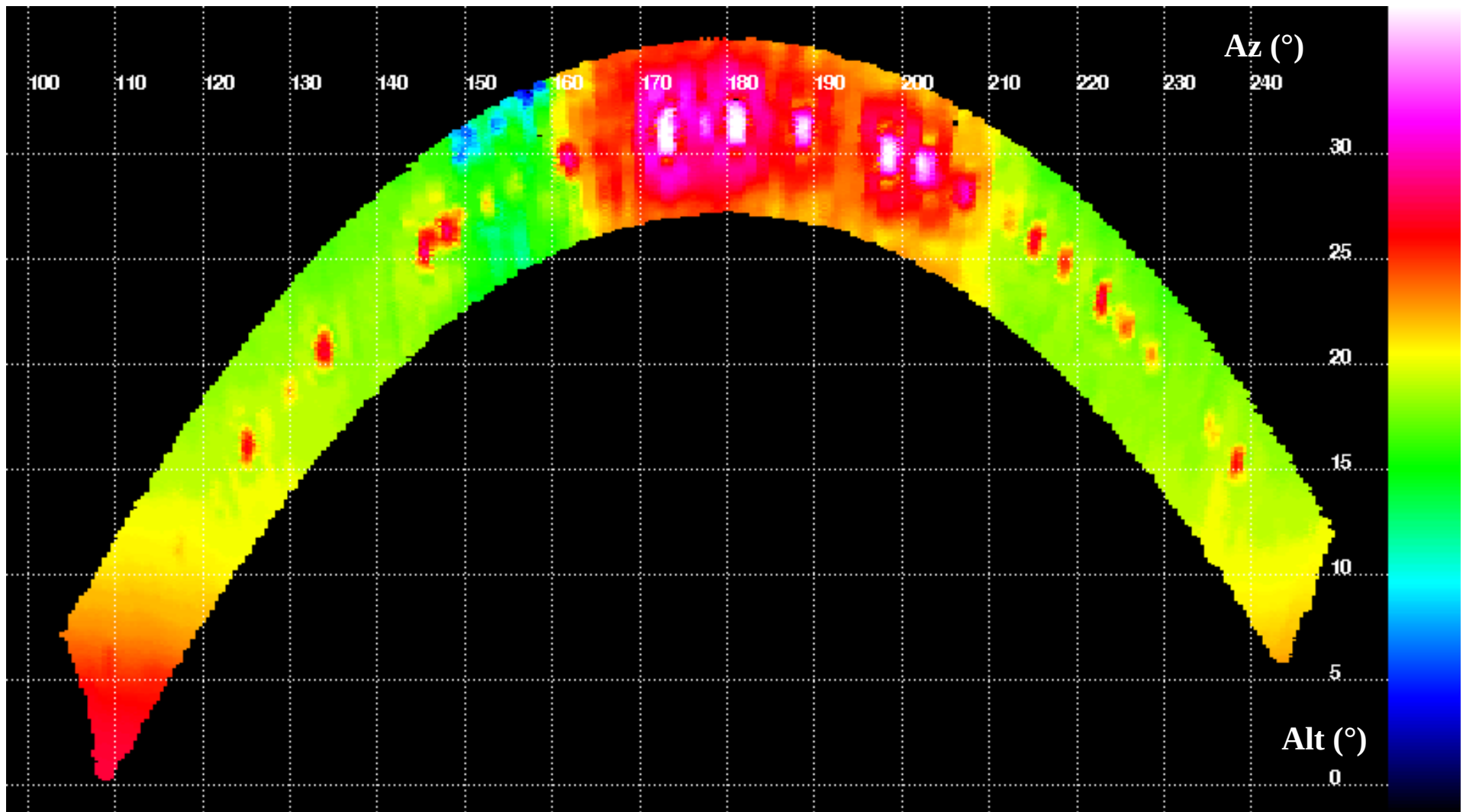
Vergleich der benutzten Feedsysteme

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

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

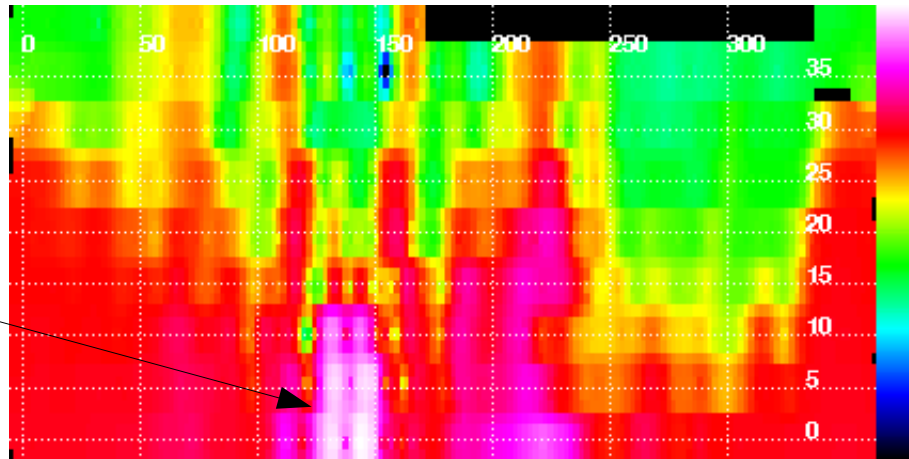


Beobachtungen – Ku-Band

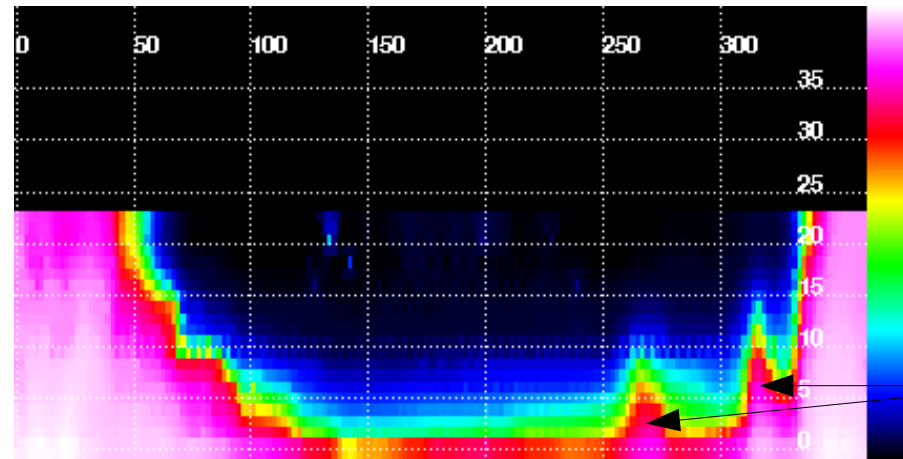


Beobachtungen Horizontlinie@1,4GHz

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



1,4 GHz



12 GHz

freistehende
Baumgruppen

Wald Stw-
Gebäude SPH Wald