Statistical Characteristics of Harp receptors

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Taishi Nammoto

- Graduated from high school in Japan
- Completed general education at Diablo Valley College in California
- Transferred to University of Hawaii, Hilo and majored physics in this spring
- Intern at East Asian Observatory in this summer (Thank you)
- Plan to obtain Bachelor degree in physics and Minor degree in math in the next spring
- Interested in Space Industry
- Probably start working in Japan after the next spring

Things I learned from this internship

- Operation of python
- Increased the understanding of statistics
- Enhanced the understanding of radio astronomy
- Researchers’ daily effort and passion

Index (Title: Statistical Characteristics of Harp receptors)

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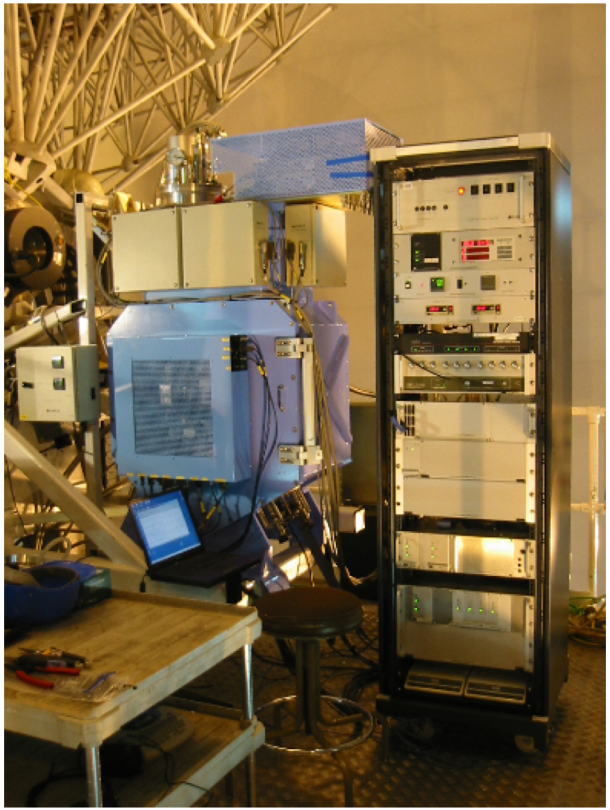
1) Characteristics of Harp receptors
2) Practical use of Data visualization

Introduction

What is Harp receptor?

- a receiver which consists of 16 different receptors
- Aimed at mapping large areas
- Currently 14 receptors are operational
- Each receptor has two sidebands (LSB and USB)



What is TRX?

- TRX is receiver noise temperature (unit: Kelvin)

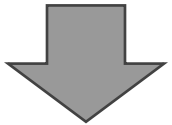
$$P_1(amb) = Gk(T_{RX} + T_{warm})$$
$$P_2(amb) = Gk(T_{RX} + T_{cold})$$
$$P_1(amb) \text{ and } P_2(amb) \text{ are outputs}$$

When TRX value is high

- It would be due to instrumental problems (Trapped flux or something else)
- Operator has to warm up the receptors to remove the trapped flux

What is Trapped flux?

Quantized vortices of magnetic flux tend to be trapped by defects in superconducting film (a part of instrument)

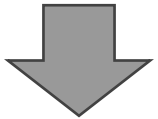


The vortices move by the influence of external magnetic field

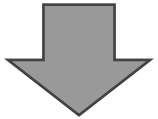
The movement of magnetic flux results in an increment of noise temperature (TRX)

What does ‘warm-up’ mean?

- Add small amount of heat and it will destroy Trapped flux vortices

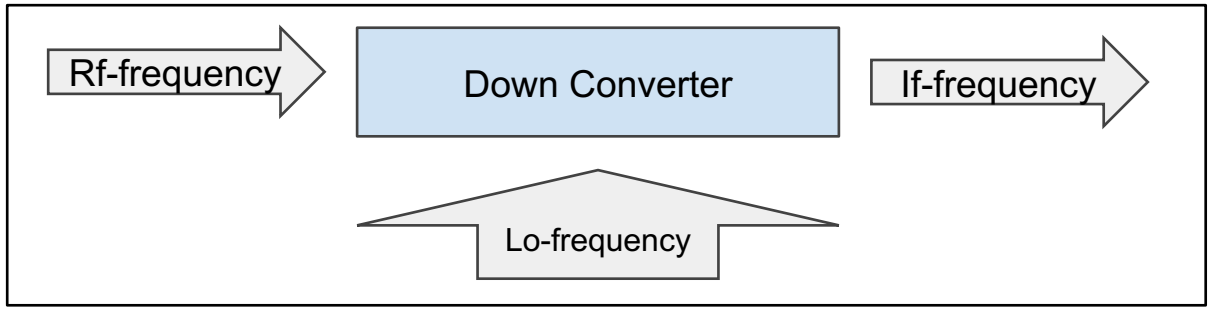


- Noise (TRX) will be decreased



- The operator has to warm up the receptors when high TRX was observed

What is Lo-frequency / Rf-frequency?



(USB) IF frequency = RF frequency - Lo frequency
(LSB) IF frequency = LO frequency - RF frequency

Tonight website

- Tonight website provides info of observations
- Operator checks Tonight website during the operation
- Tonight website shows only Rf-frequency

RFreq	H01	H02	H03	H04	H05	H06	H07	H08	H09	H10	H11	H12	H15	
330.6	226.3	173.6	277.4	263.0	167.3	151.9	163.4	170.1	161.3	166.0	143.8	183.7	140.7	[Trx]
329.3	207.0	165.5	232.8	1057.9	144.4	152.3	153.2	175.8	157.9	151.6	163.1	172.6	139.1	[Trx]
345.8	149.0	111.5	180.7	107.5	108.6	189.3	123.0	122.5	127.5	149.6	189.7	151.7	170.2	[Trx]

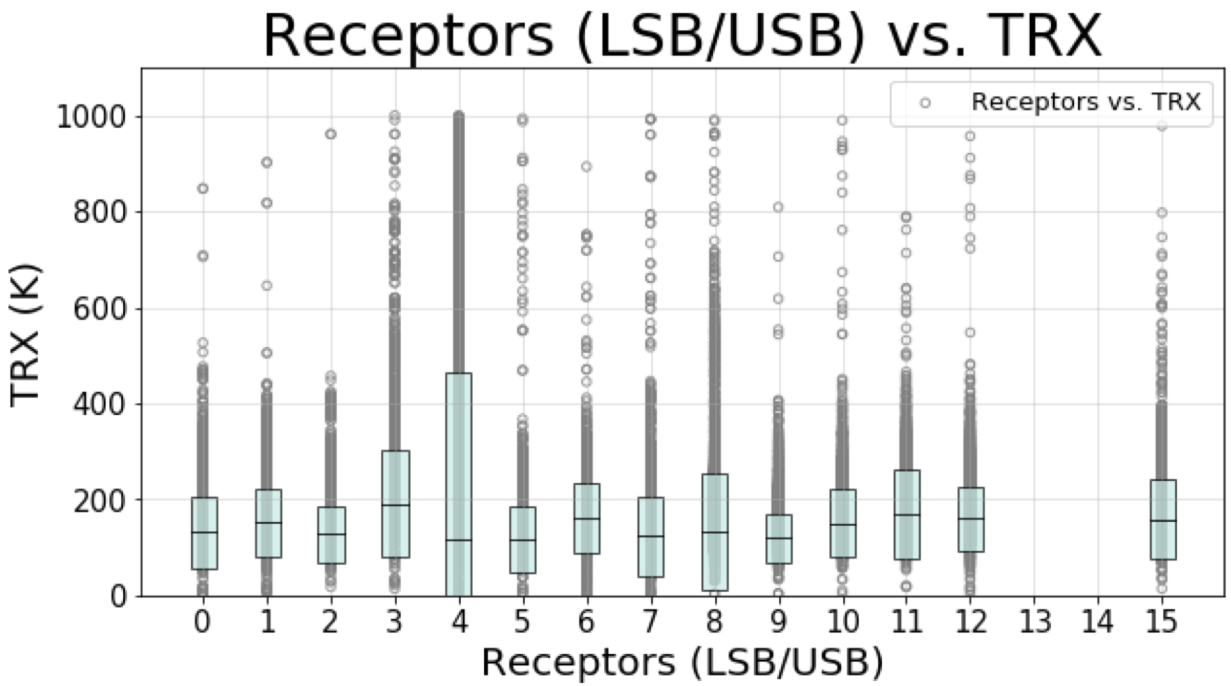
The benefits to know characteristics of Harp receptors

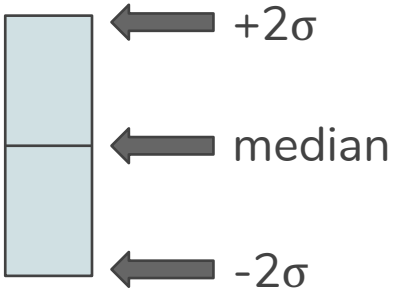
- Enhance understanding of the normal TRX value within several frequency ranges
- Help operators to decide whether they need to warm up the receptors or not

Data source used for this project

- Collected by JCMT
- Filtered when doors are opened
- Includes January, 2015 to May, 2019
- Includes information of 14 receptors

Characteristics of Harp receptors





Plot above

receptor	0	1	2	3	4	5	6	7	8	9	10	11	12	15
median	132.2	151.6	127.5	190.5	117.5	117.6	160.5	123.2	132.0	119.0	149.7	169.1	159.7	157.4
median + one sigma	169.8	186.9	157.4	245.7	290.9	151.7	197.2	164.0	192.8	144.9	184.9	215.8	192.9	199.0
median + two sigma	207.4	222.2	187.2	300.9	464.3	185.9	233.8	204.9	253.6	170.8	220.2	262.5	226.1	240.5

Tonight website

RFreq	H01	H02	H03	H04	H05	H06	H07	H08	H09	H10	H11	H12	H15	
330.6	226.3	173.6	277.4	263.0	167.3	151.9	163.4	170.1	161.3	166.0	143.8	183.7	140.7	[Trx]
329.3	207.0	165.5	232.8	1057.9	144.4	152.3	153.2	175.8	157.9	151.6	163.1	172.6	139.1	[Trx]
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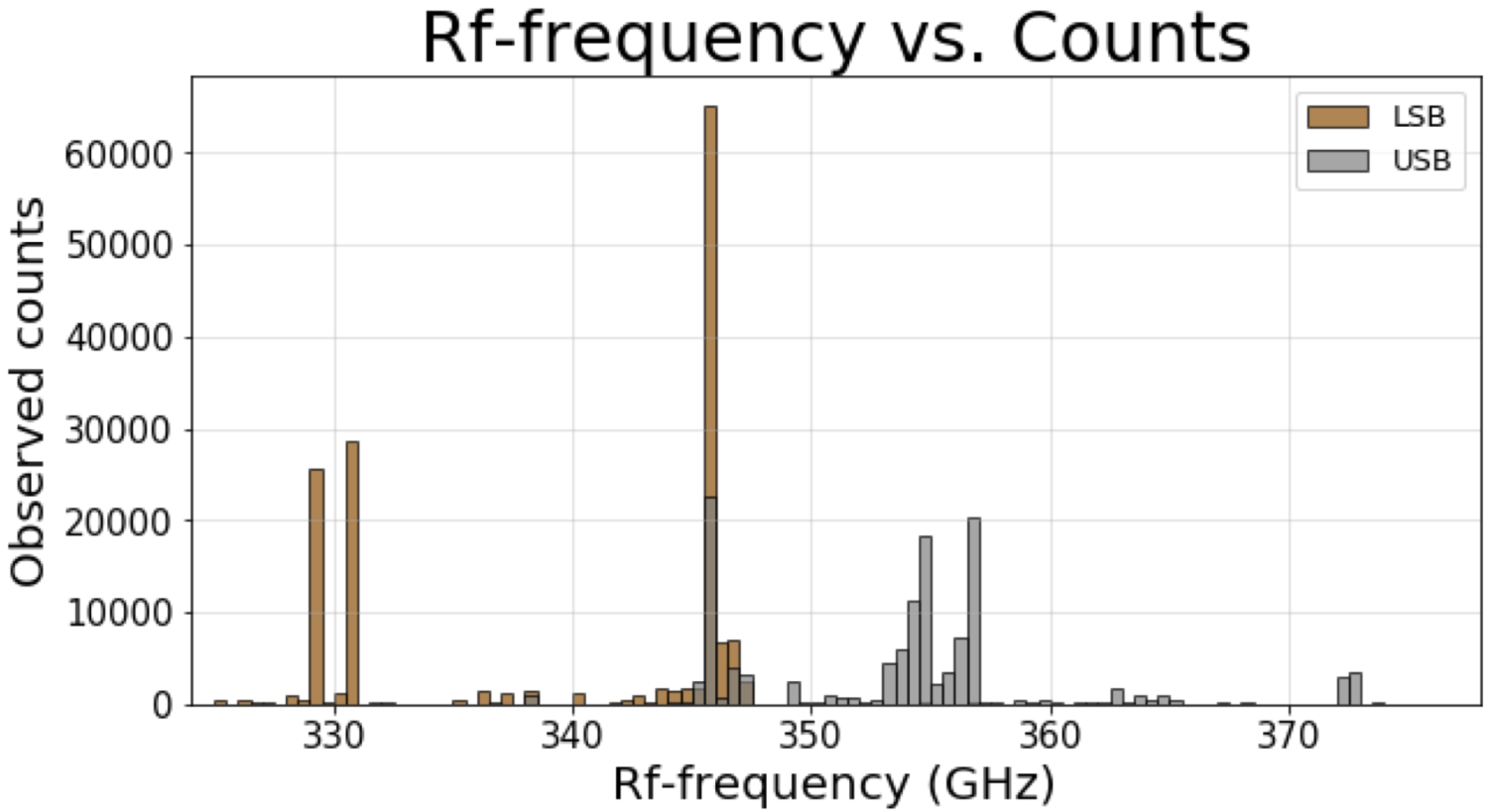
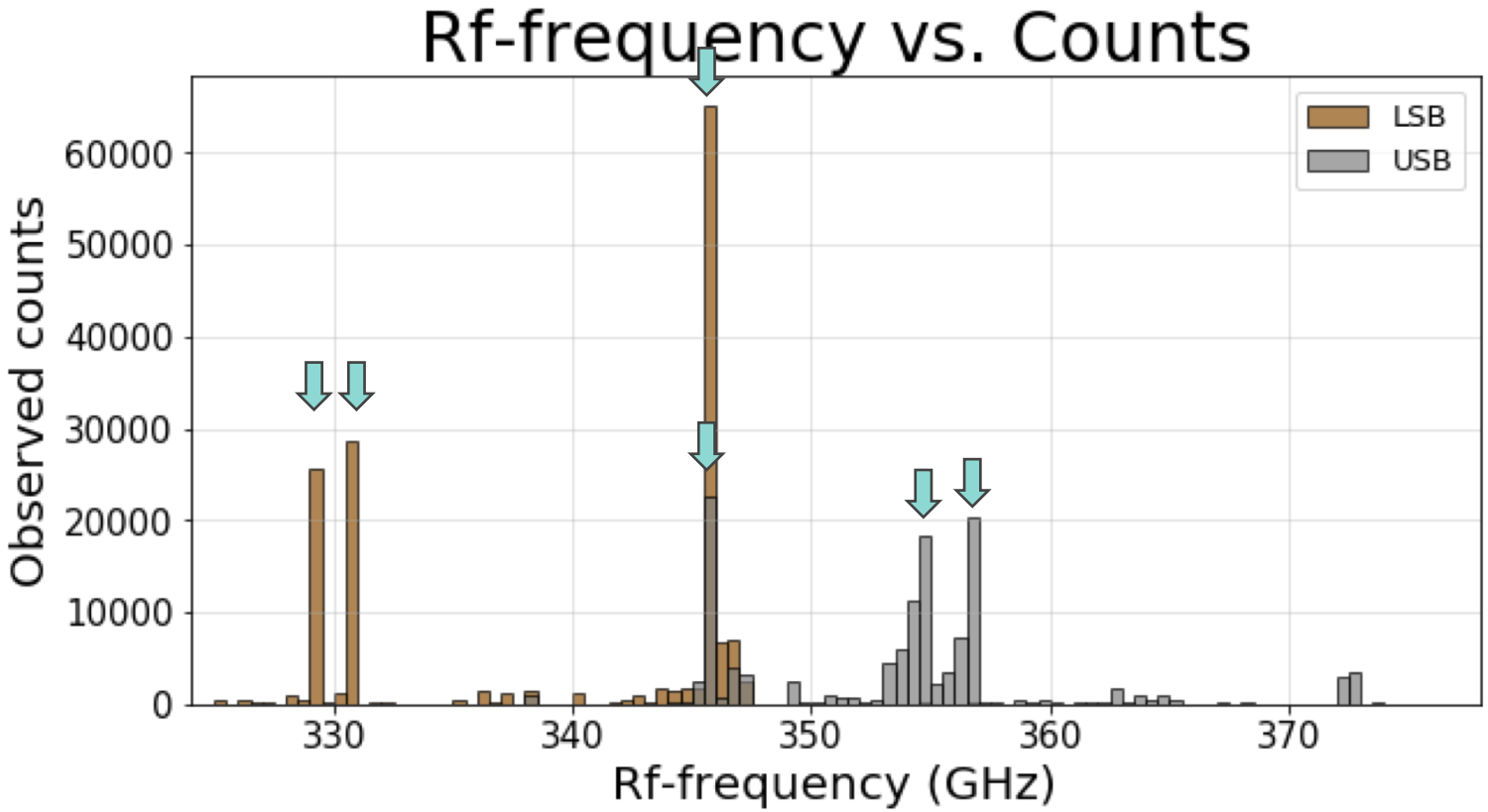


Trait 1: Most observed frequency-ranges are selected

(all receptors follow the same feature)



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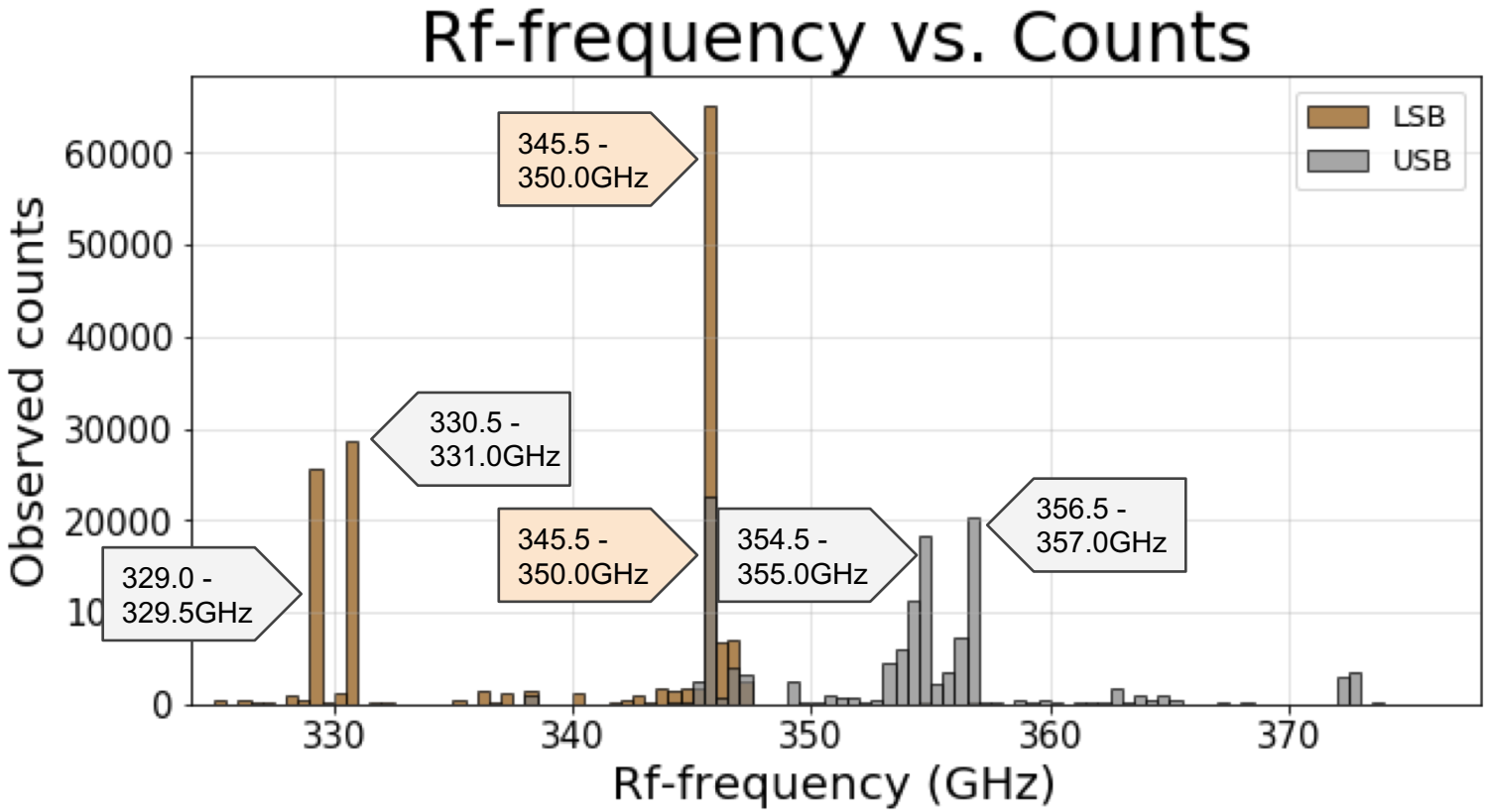

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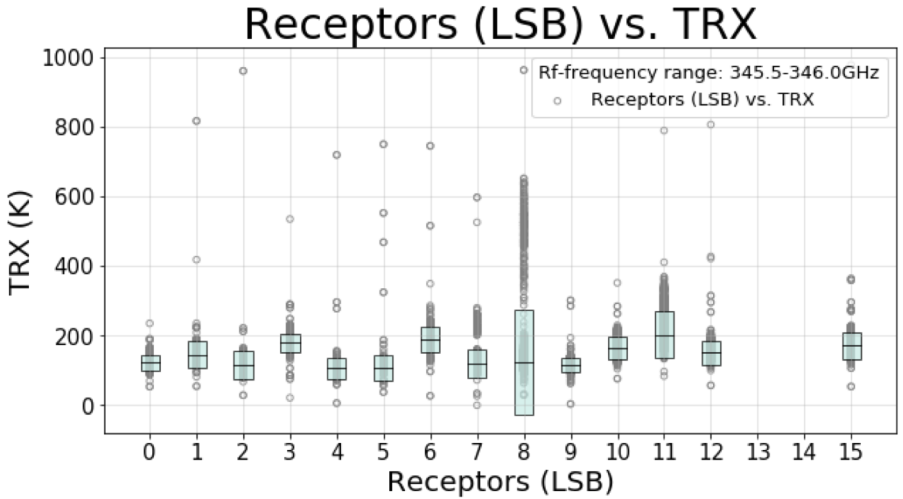
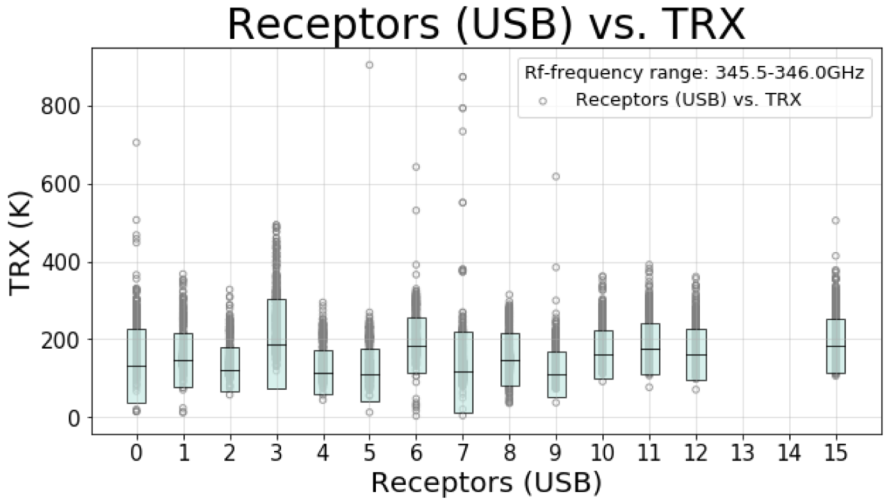




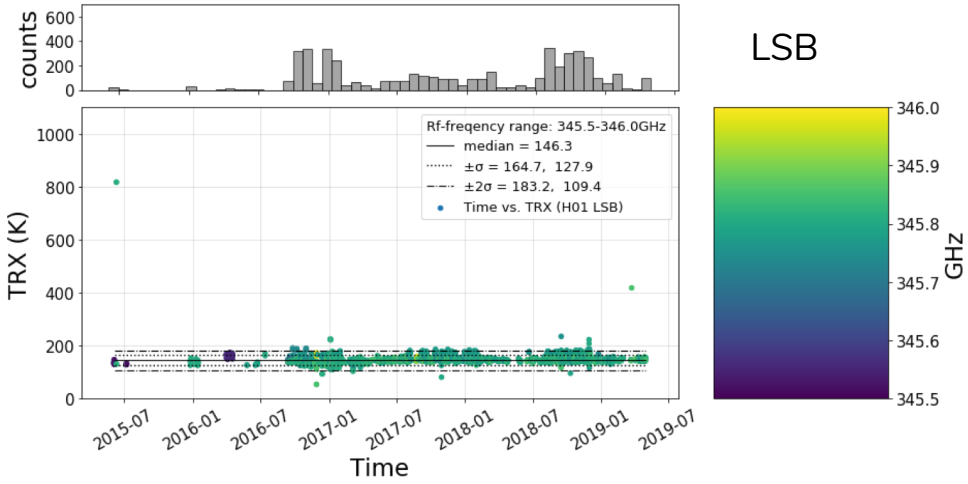
receptor: #0, 1, 2, 3, ..., #15

Rf-frequency: 345.5 - 346 GHz

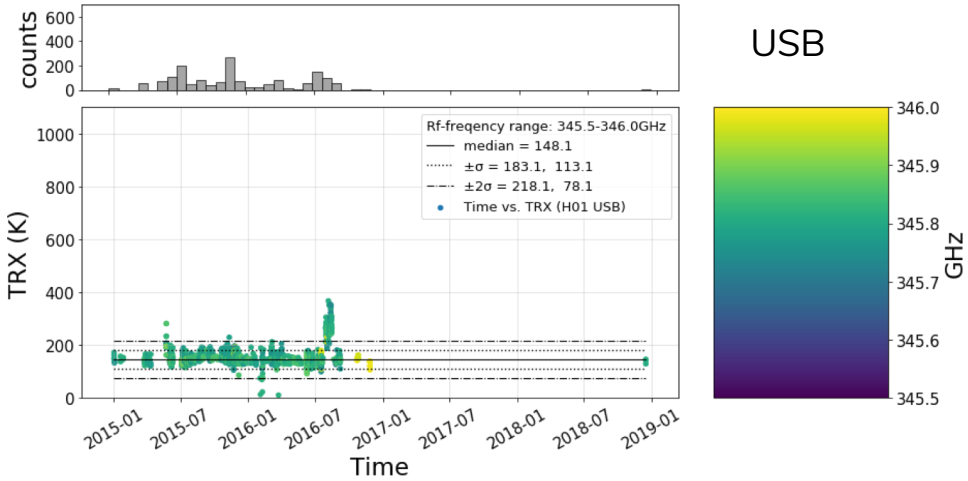
It seems like

$$2\sigma_LSB < 2\sigma_USB$$

It may be appropriate to use LSB sideband between 345.5 - 346 GHz



LSB



USB

receptor: #1

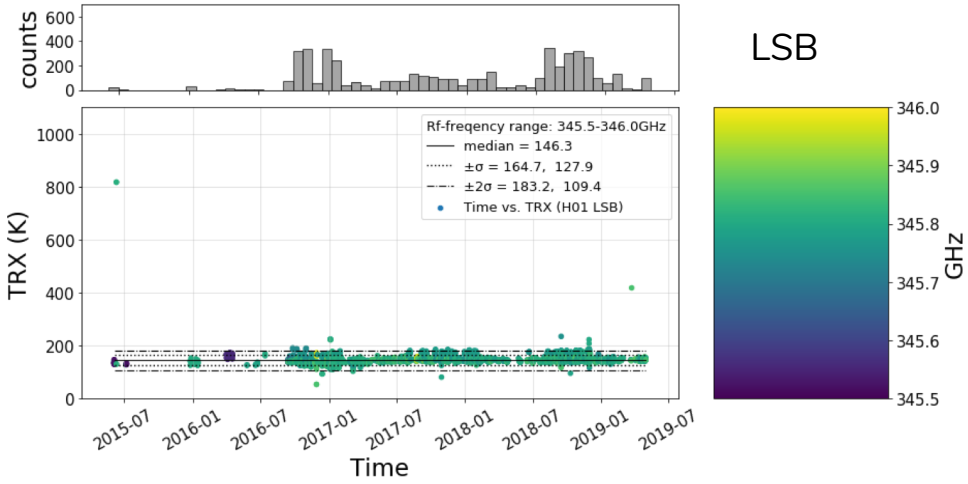
Rf-frequency: 345.5 - 346 GHz

Time: observed over several dates

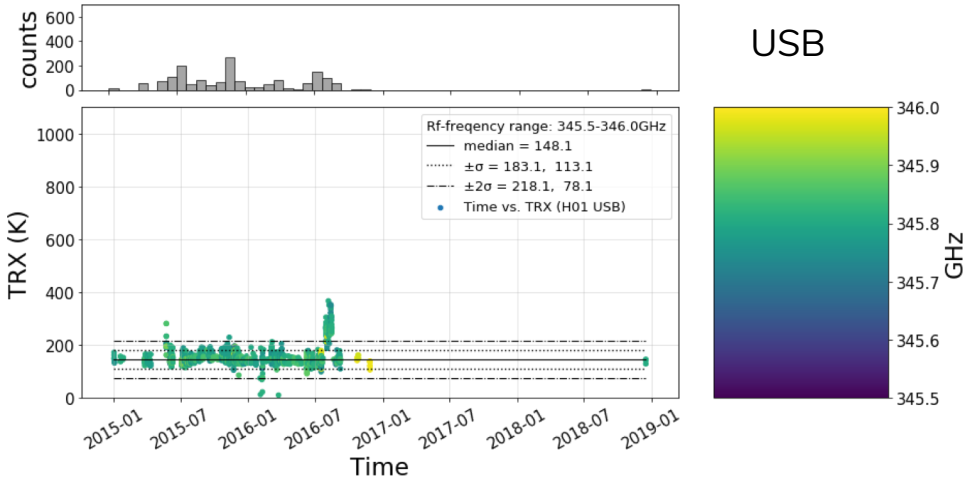
$\sigma_{LSB} = 18.4, \quad \sigma_{USB} = 35.0$

$\sigma_{LSB} < \sigma_{USB}$

It is appropriate to use LSB sideband for receptor #1 between 345.5 - 346 GHz



LSB



USB

receptor: #0, 1 ... #15 (except #8, #11)

Rf-frequency: 345.5 - 346 GHz

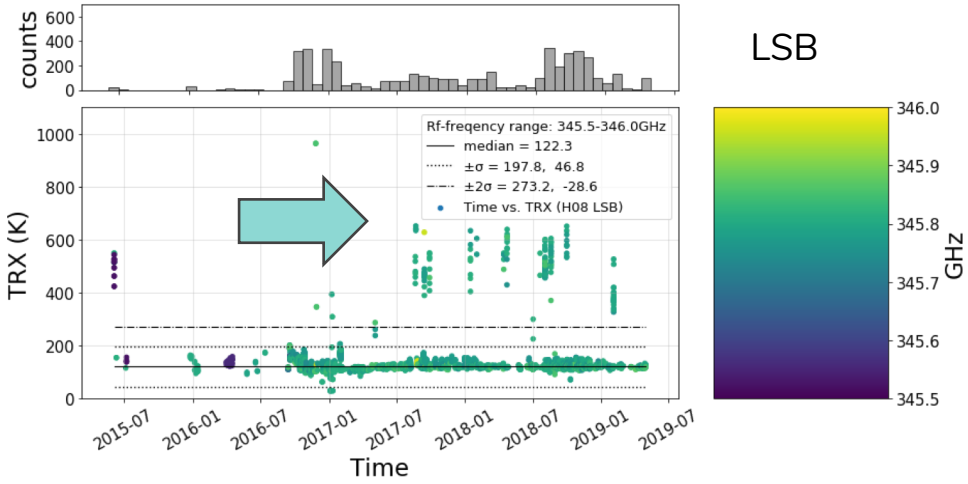
Time: observed over several dates

Trait2:

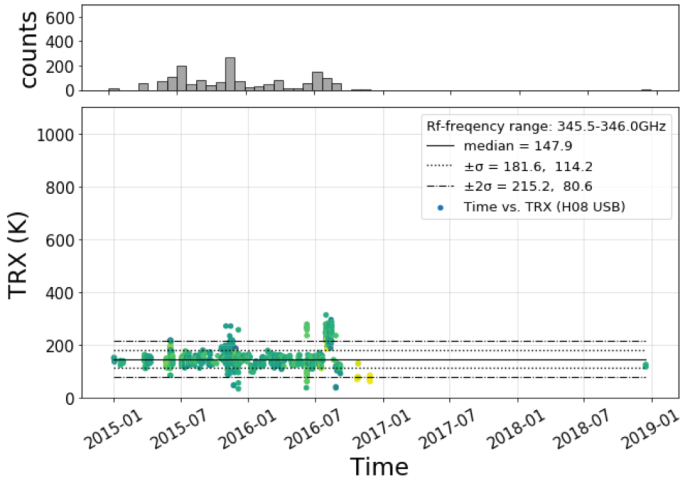
σ_LSB < σ_USB

(345.5 - 346GHz, except H08, 11)

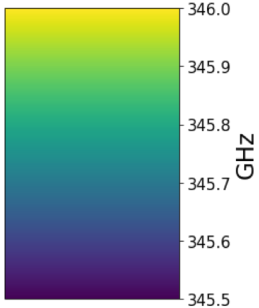
It would be appropriate to use LSB sideband for all Harp receptors except H08 and H11 between 345.5 - 346 GHz



LSB



USB



receptor: #8

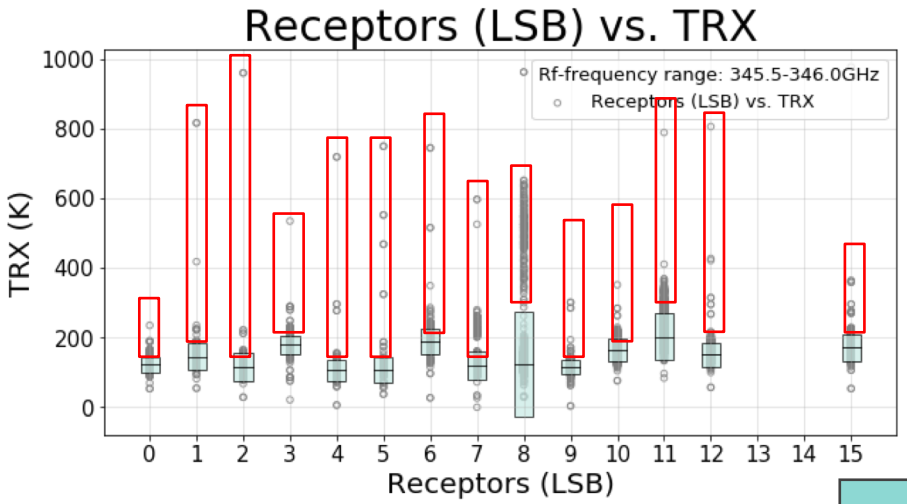
Rf-frequency: 345.5 - 346 GHz

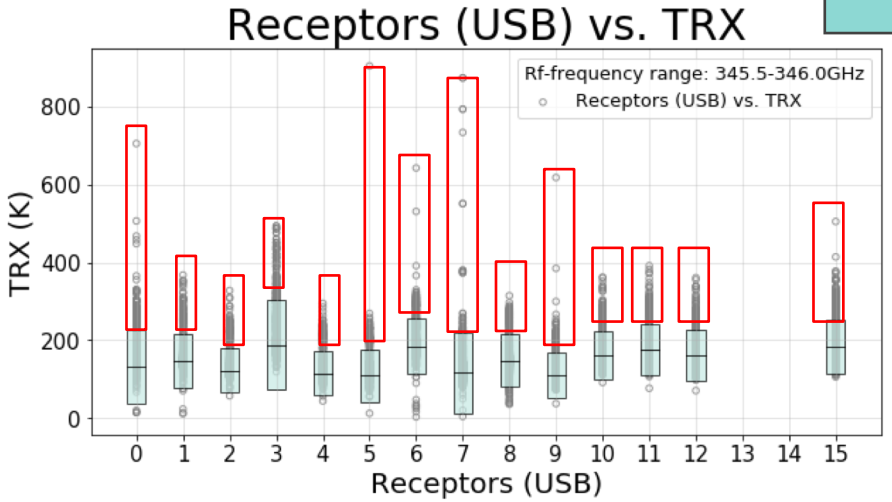
Time: observed over several dates

Trait3:

σ_LSB > σ_USB

(345.5 - 346GHz, H08, 11)





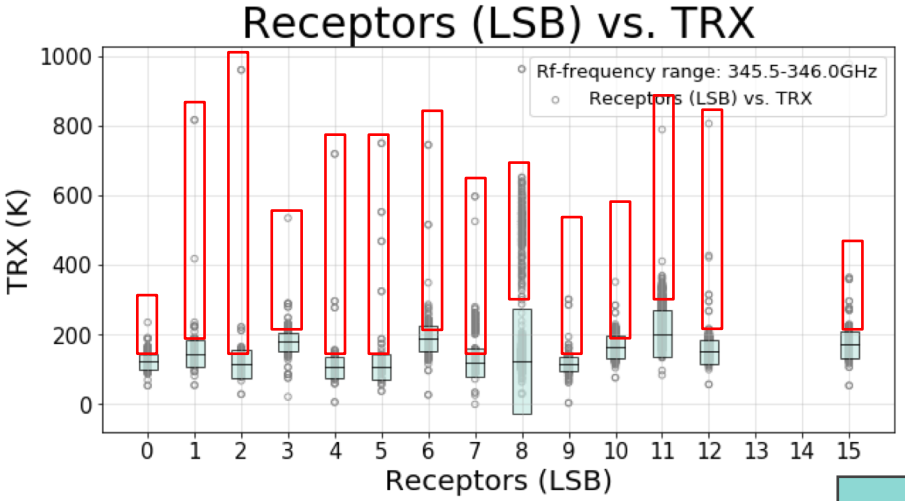
receptor (LSB)	% of unstable TRX
0	5
1	1
2	0
3	1
4	0
5	0
6	1
7	1
8	4
9	3
10	6
11	7
12	2
15	2

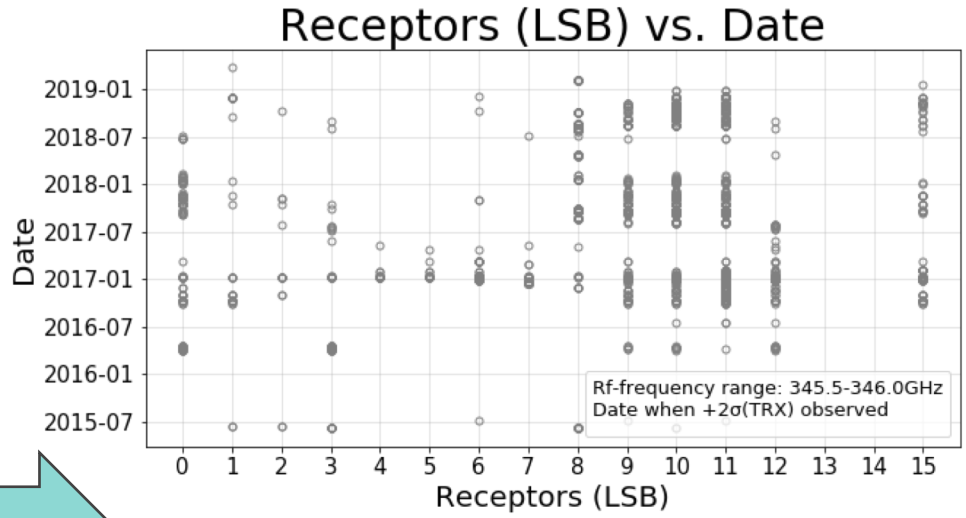
Rounded up at the zero decimal place

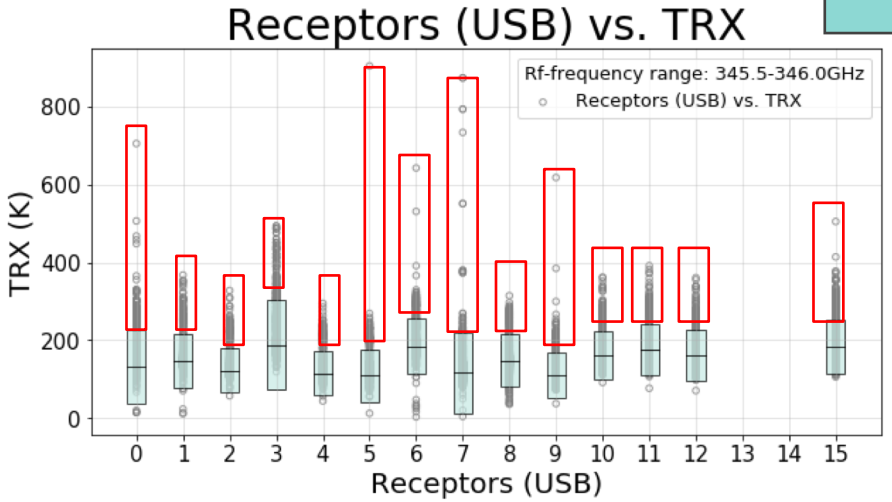
receptor (USB)	% of unstable TRX
0	10
1	6
2	6
3	9
4	6
5	5
6	6
7	3
8	6
9	6
10	6
11	5
12	7
15	6

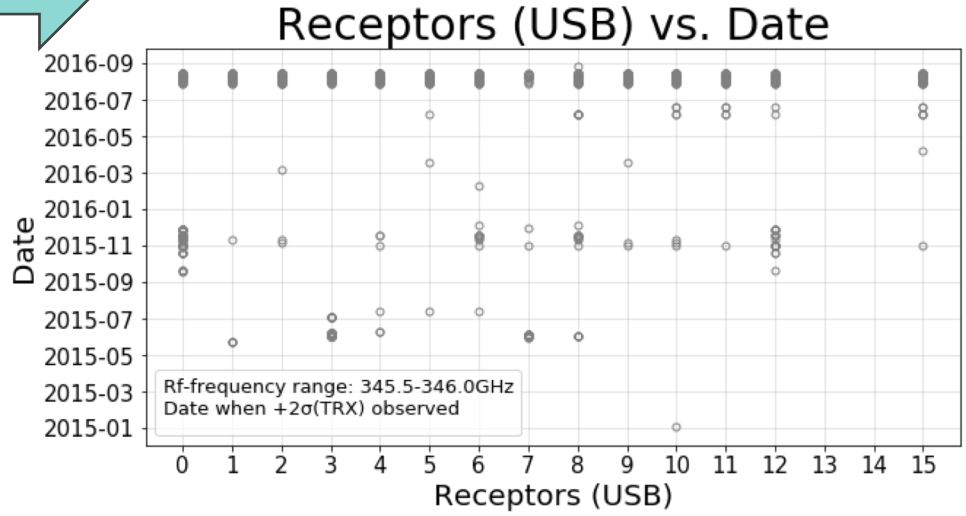
%_LSB < %_USB

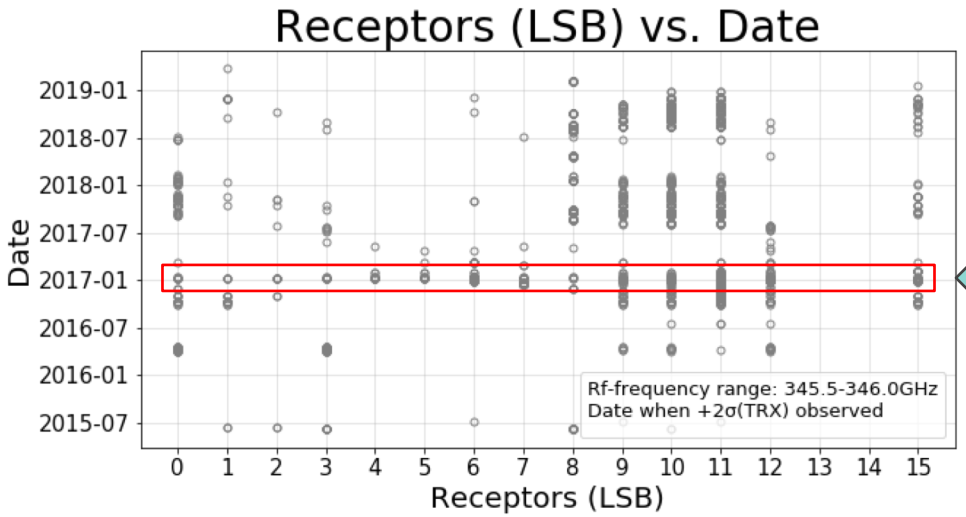
LSB is appropriate to use within 345.5 - 346.0GHz


Receptors (LSB) vs. TRX
Rf-frequency range: 345.5-346.0GHz
Receptors (LSB) vs. TRX
TRX (K)
Receptors (LSB)

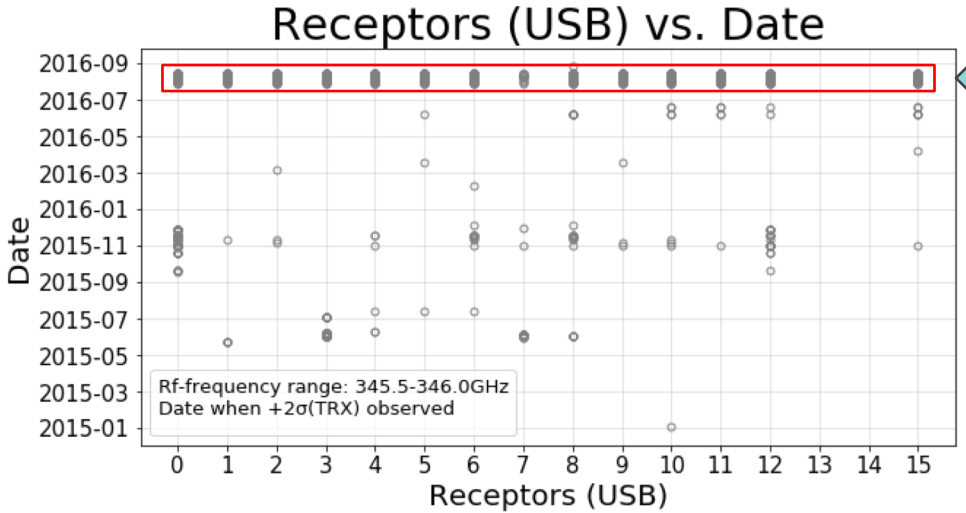

Receptors (LSB) vs. Date
Rf-frequency range: 345.5-346.0GHz
Date when +2σ(TRX) observed
Date
Receptors (LSB)


Receptors (USB) vs. TRX
Rf-frequency range: 345.5-346.0GHz
Receptors (USB) vs. TRX
TRX (K)
Receptors (USB)

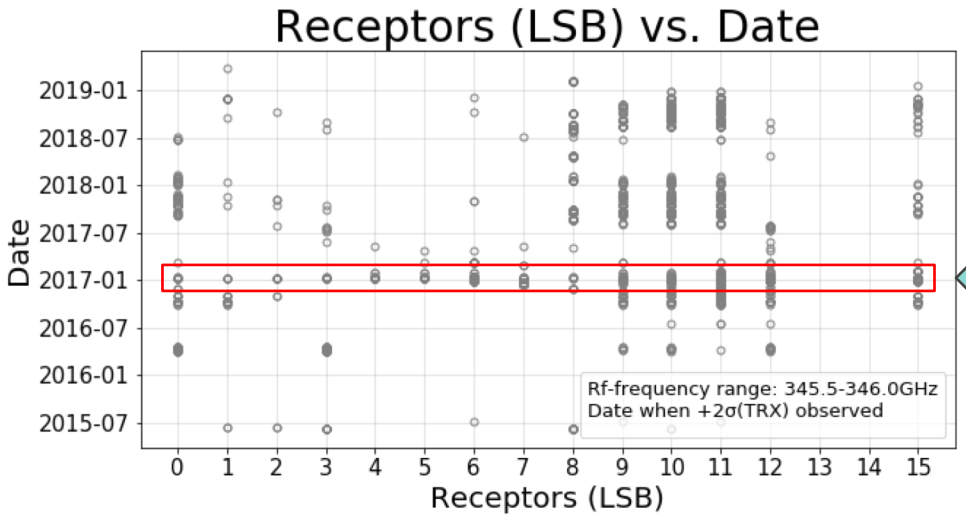

Receptors (USB) vs. Date
Rf-frequency range: 345.5-346.0GHz
Date when +2σ(TRX) observed
Date
Receptors (USB)



All receptors had high TRX at 01/04/2017

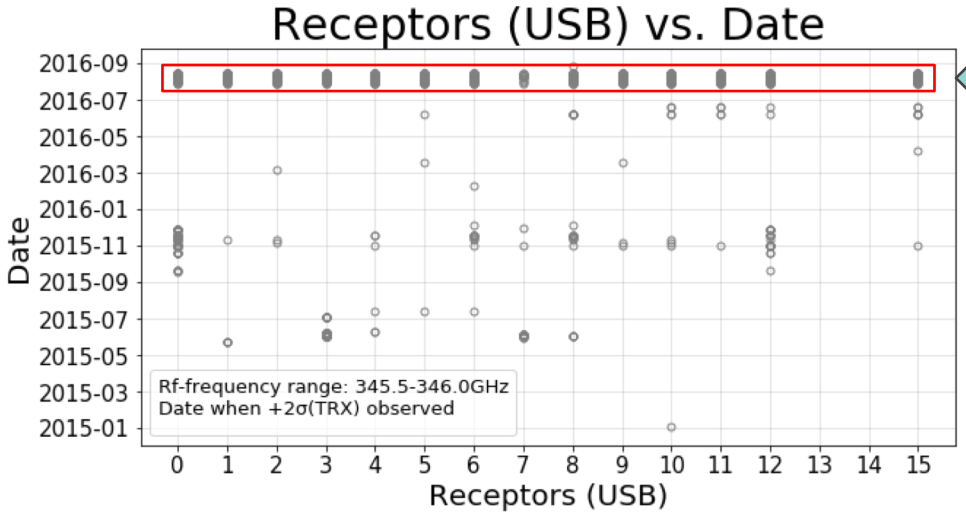


All receptors had high TRX at 08/13/2016



All receptors had high TRX at 01/04/2017

Log Note:
Not warmed up



All receptors had high TRX at 08/13/2016

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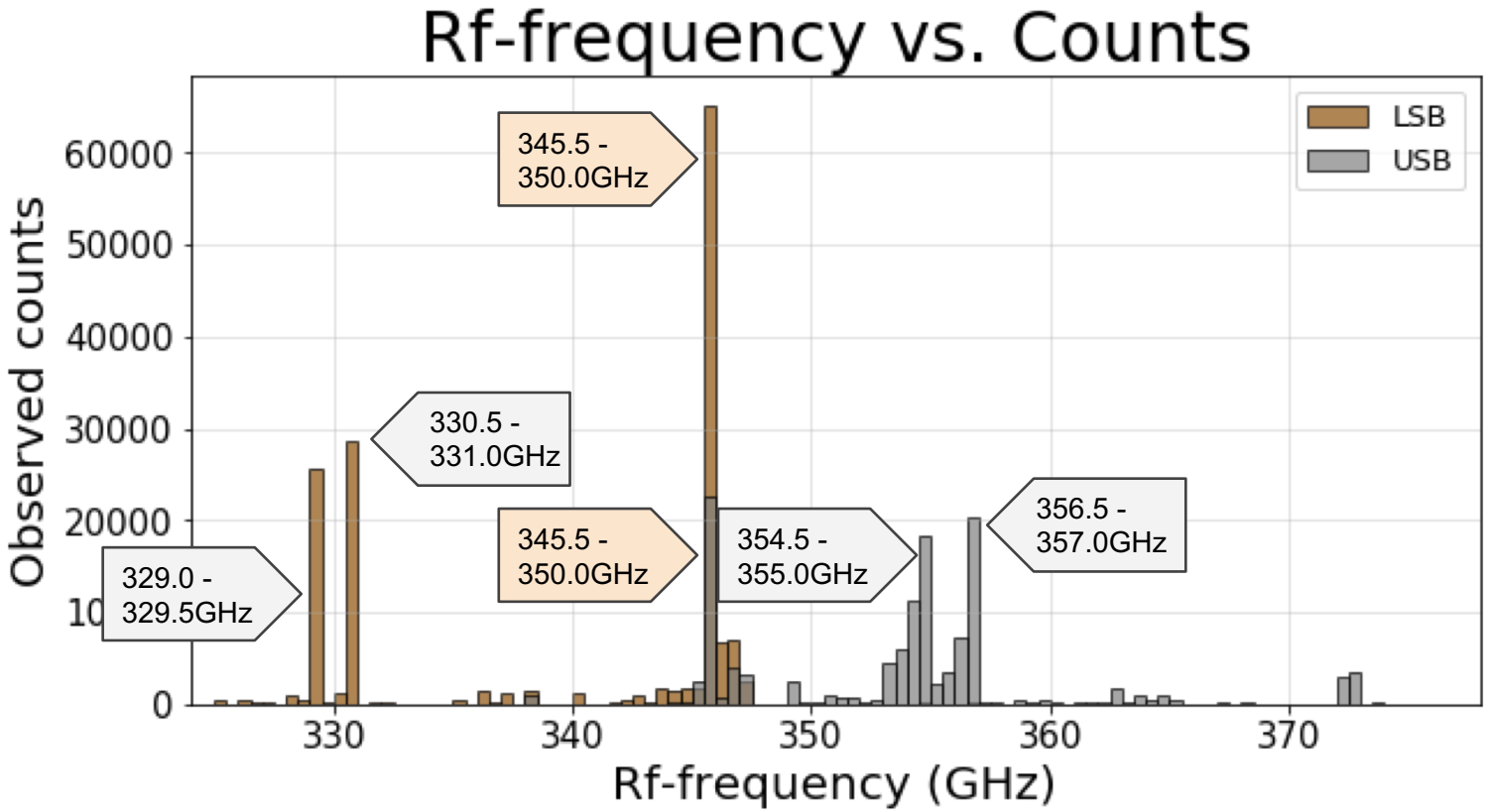

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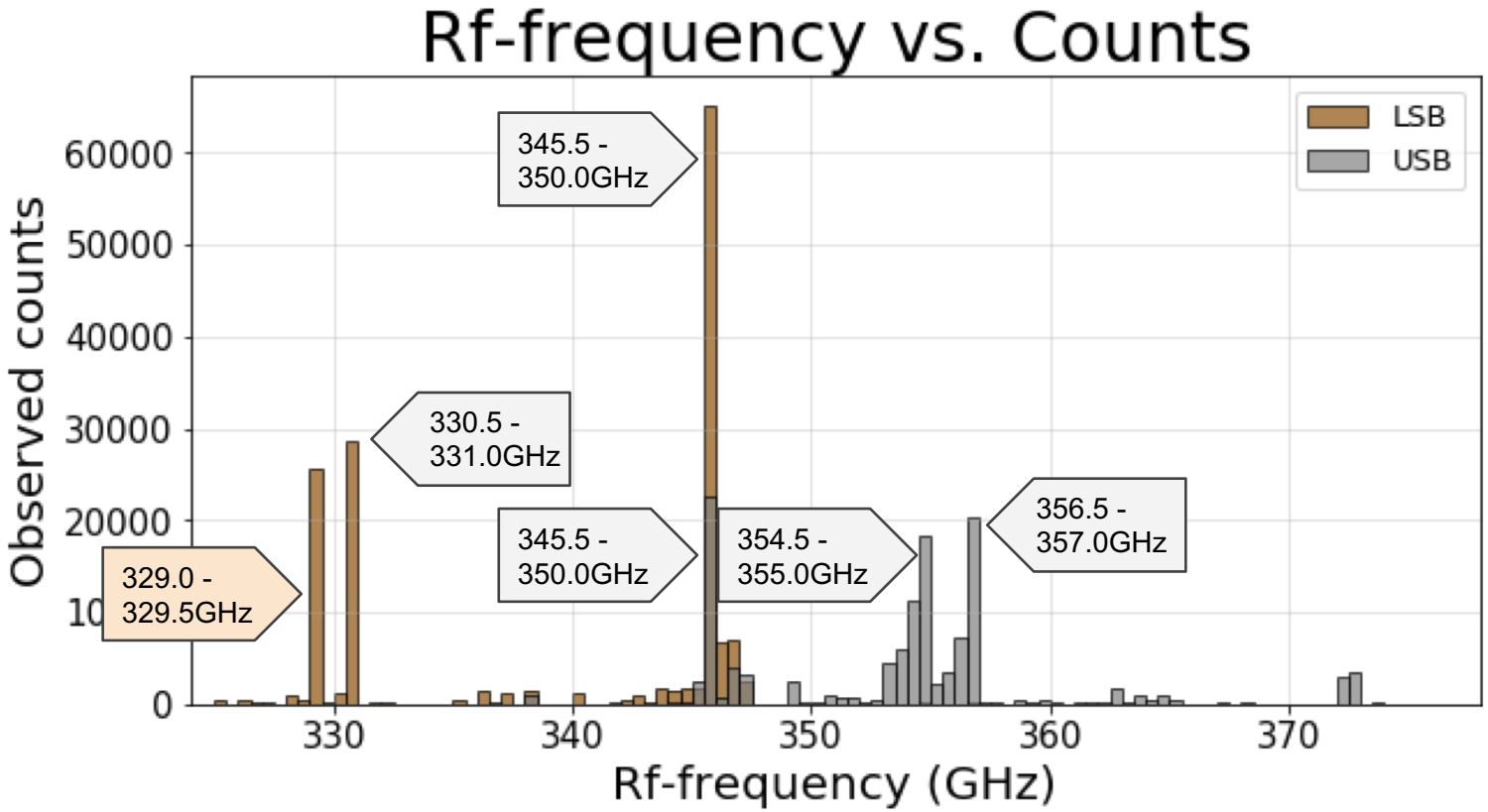

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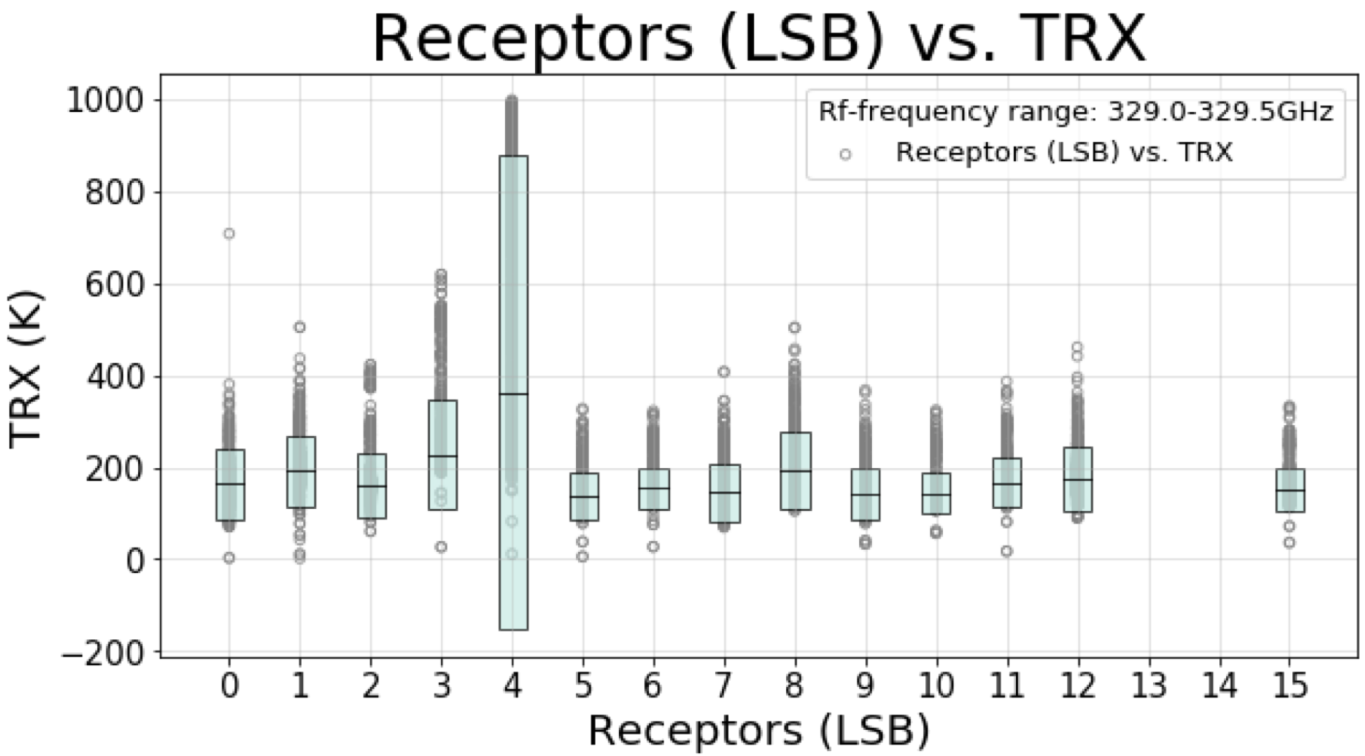


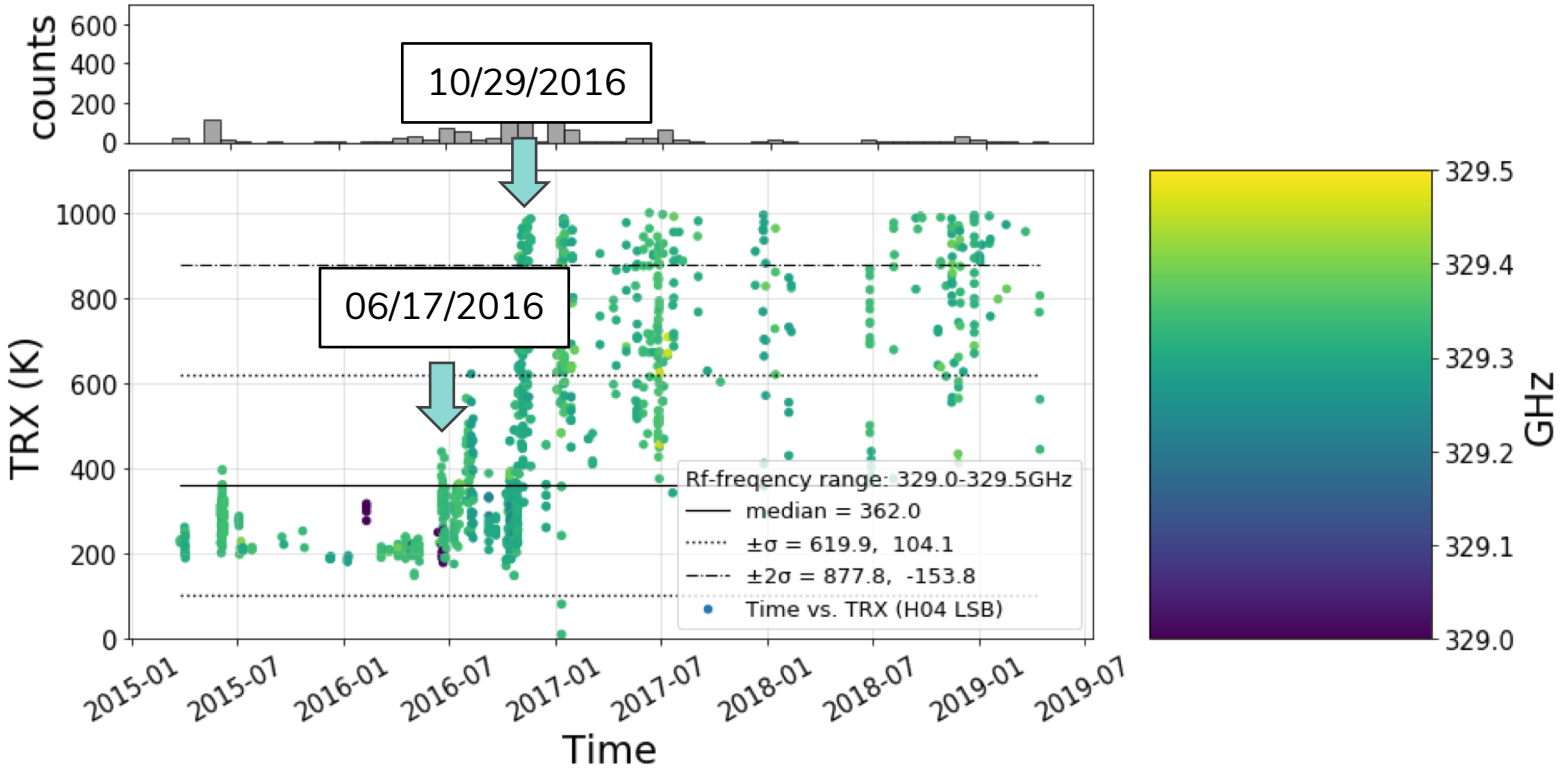
receptor (LSB)	% of unstable TRX
0	3
1	5
2	4
3	5
4	11
5	5
6	4
7	4
8	5
9	4
10	3
11	3
12	4
15	4

Rf-frequency range between 329.0 and 329.5GHz (LSB)

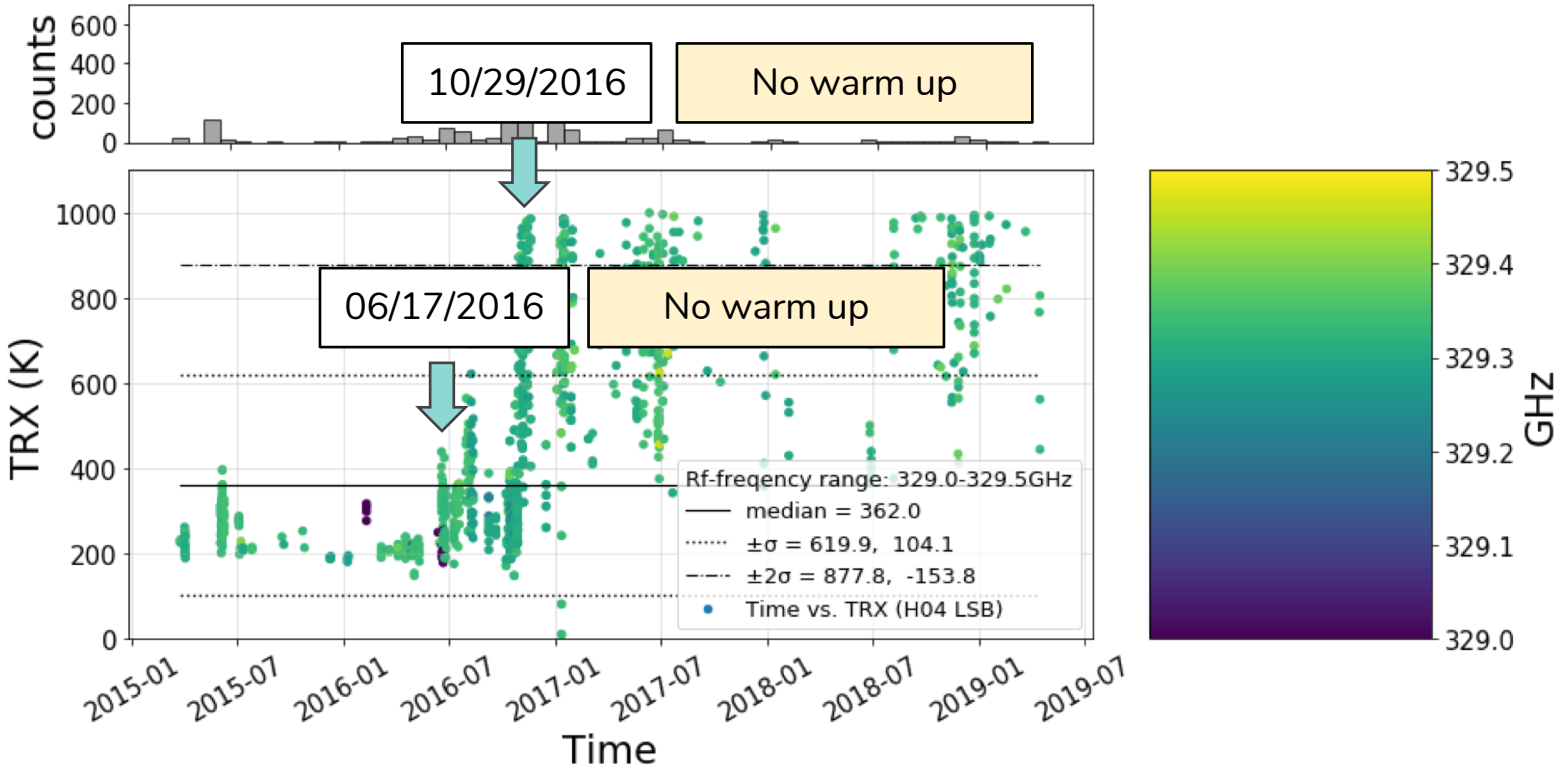
(The box plot shows the two sigma range from the median at the middle line)

Operational Properties at JCMT website

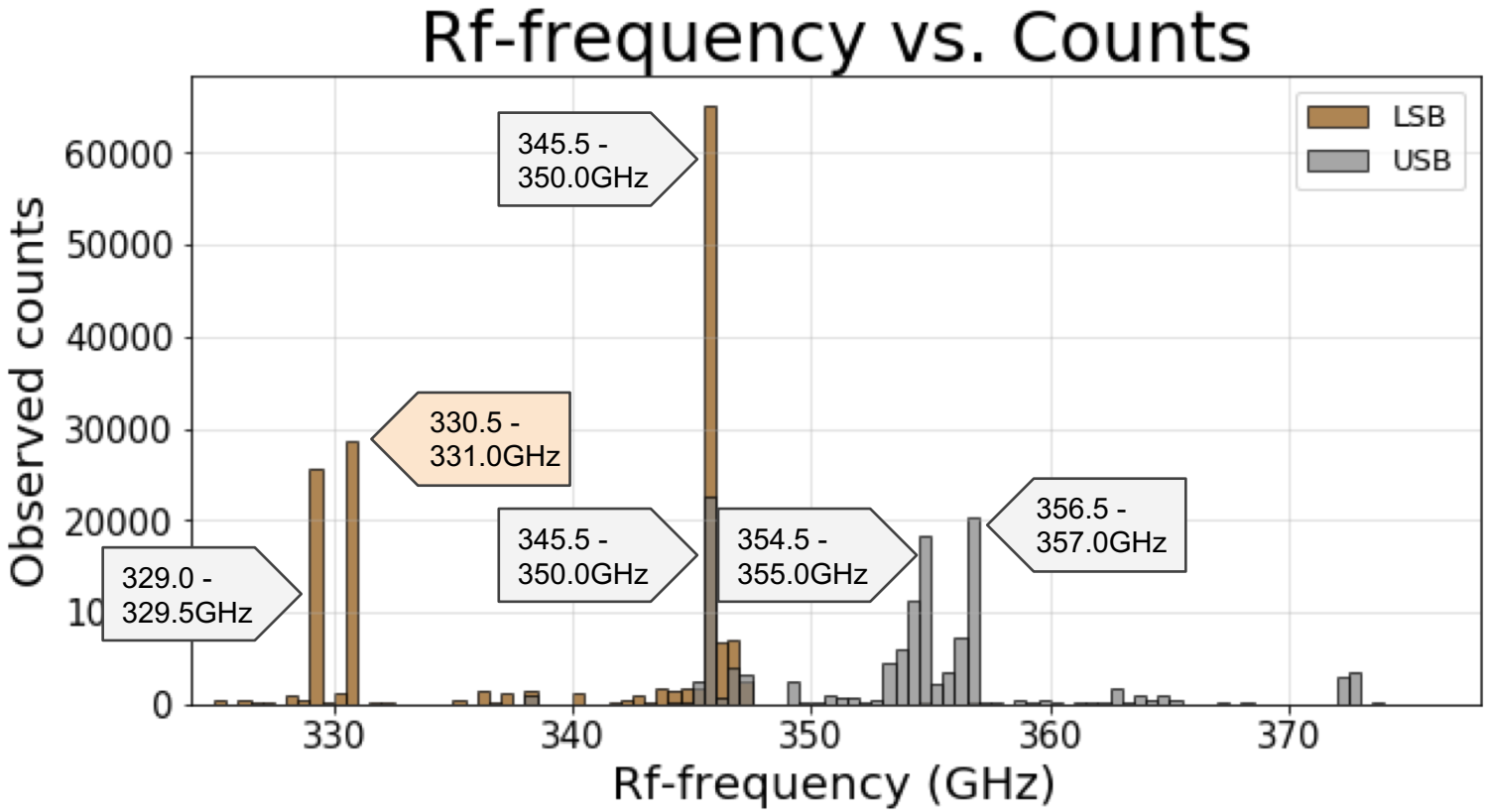
H04 HARP baseline issue below 332 GHz- expected to require mixer change. Possible this summer (Per/Craig, Kuan-Yu)



receptor #4 within 329.0 and 329.5GHz



receptor #4 within 329.0 and 329.5GHz



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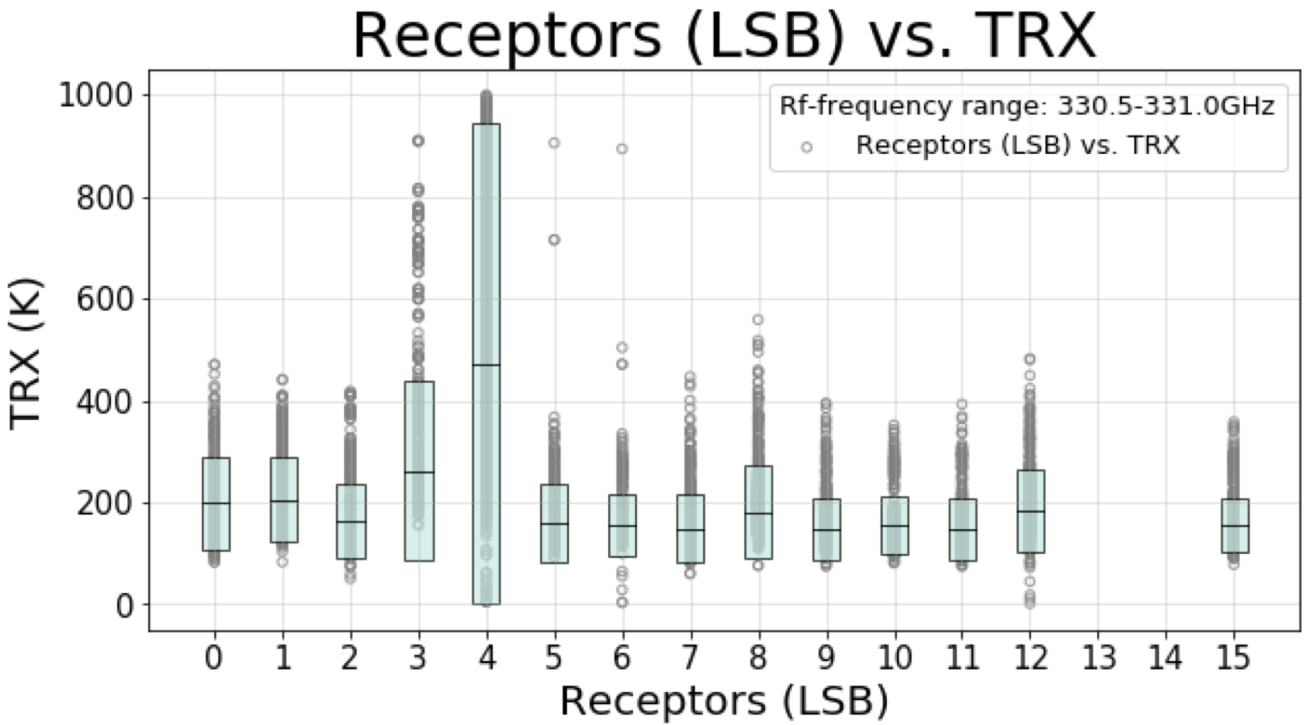
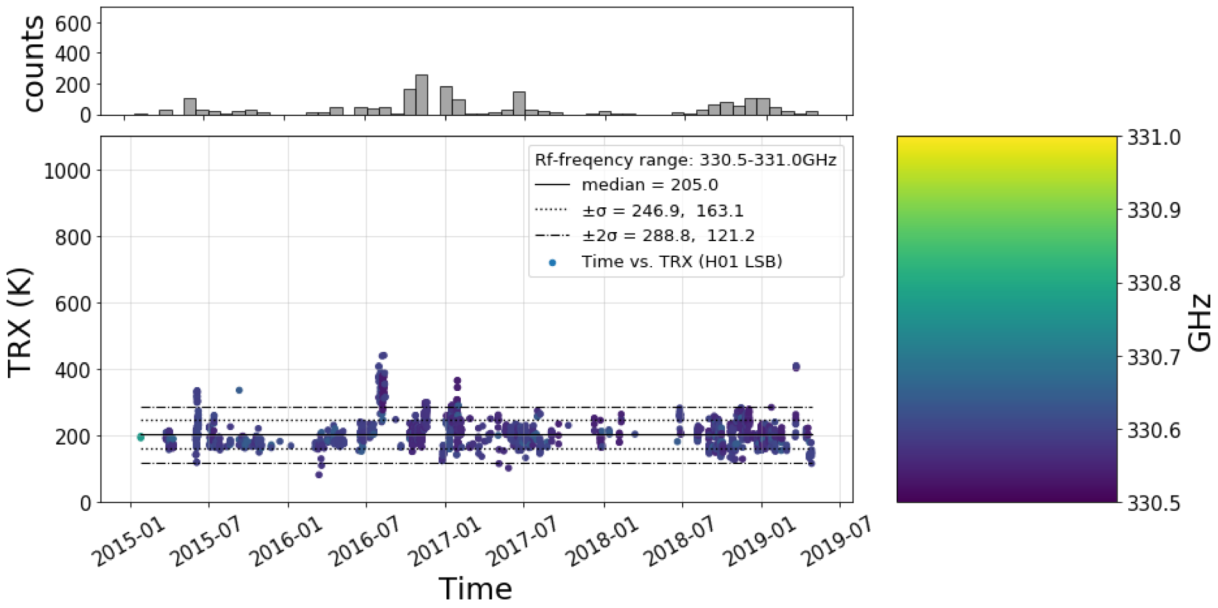


receptor (LSB)	% of unstable TRX
0	3
1	5
2	4
3	4
4	3
5	4
6	3
7	4
8	4
9	4
10	3
11	3
12	3
15	3

Rf-frequency range between 330.5 and 331.0GHz (LSB)

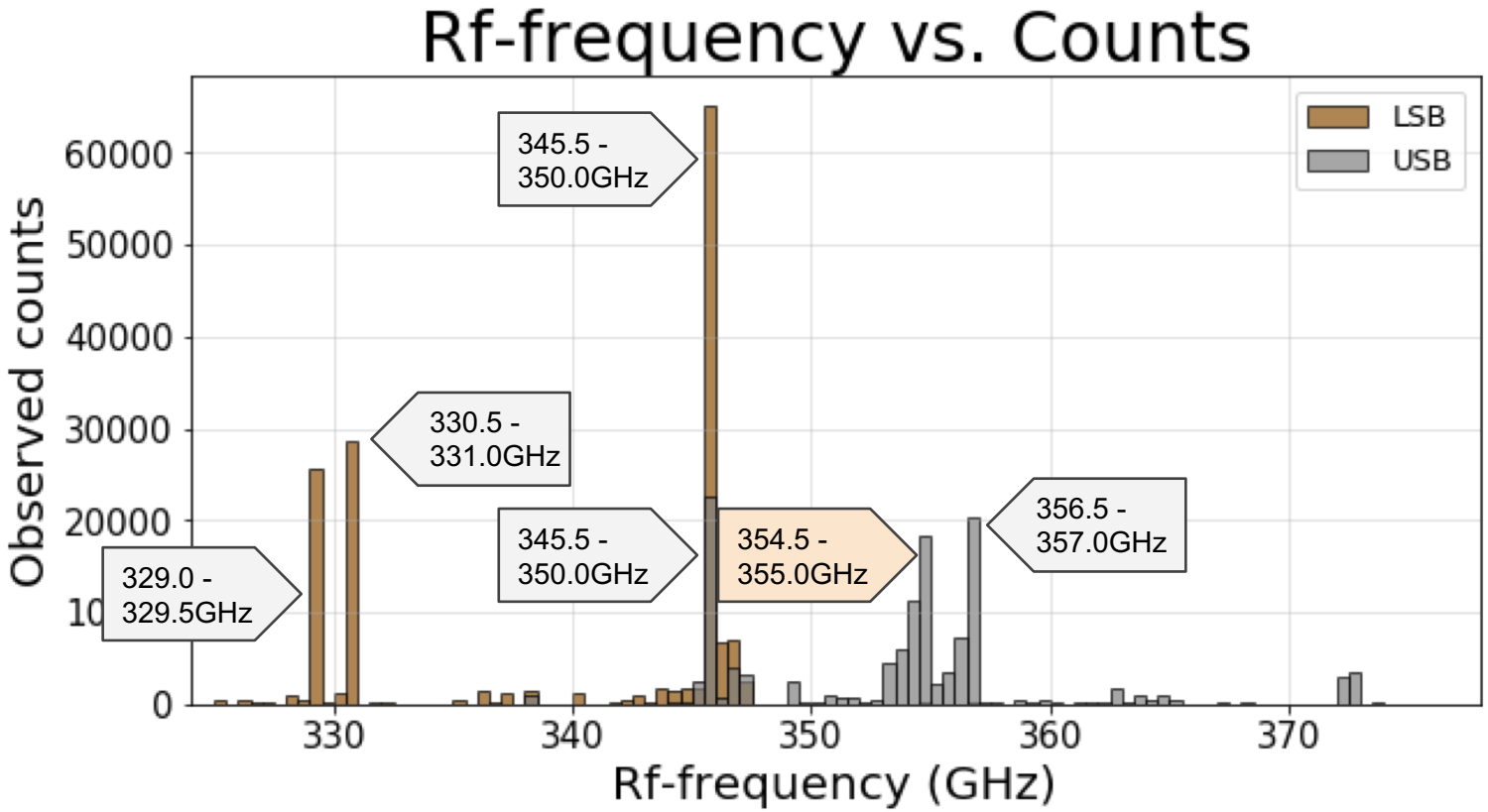
(The box plot shows the two sigma range from the median at the middle line)



receptor #1 within 330.5 and 331.0GHz

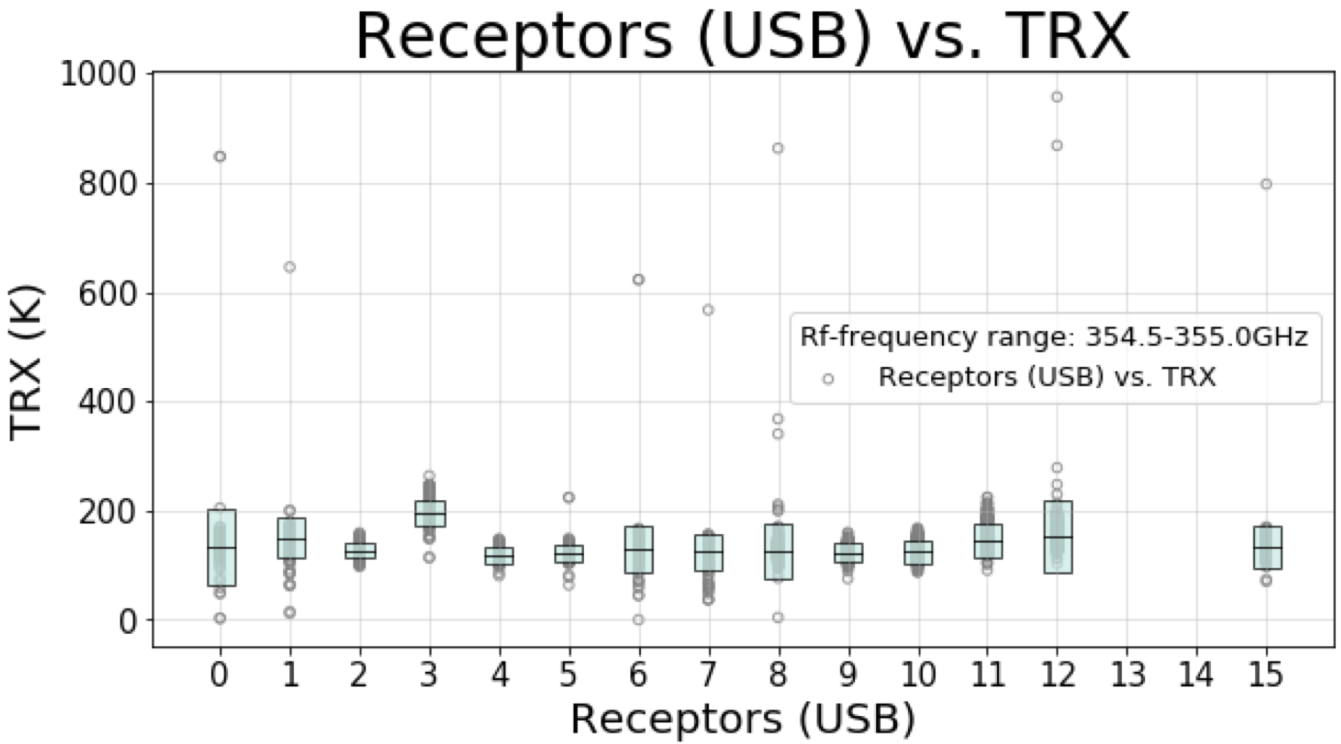
The percentage of high TRX was highest among the other receptors.

TRX was unstable at three different periods before 2015-07 and after 2016-07 and After 2017-01



Trait 1: Most observed frequency-ranges are selected

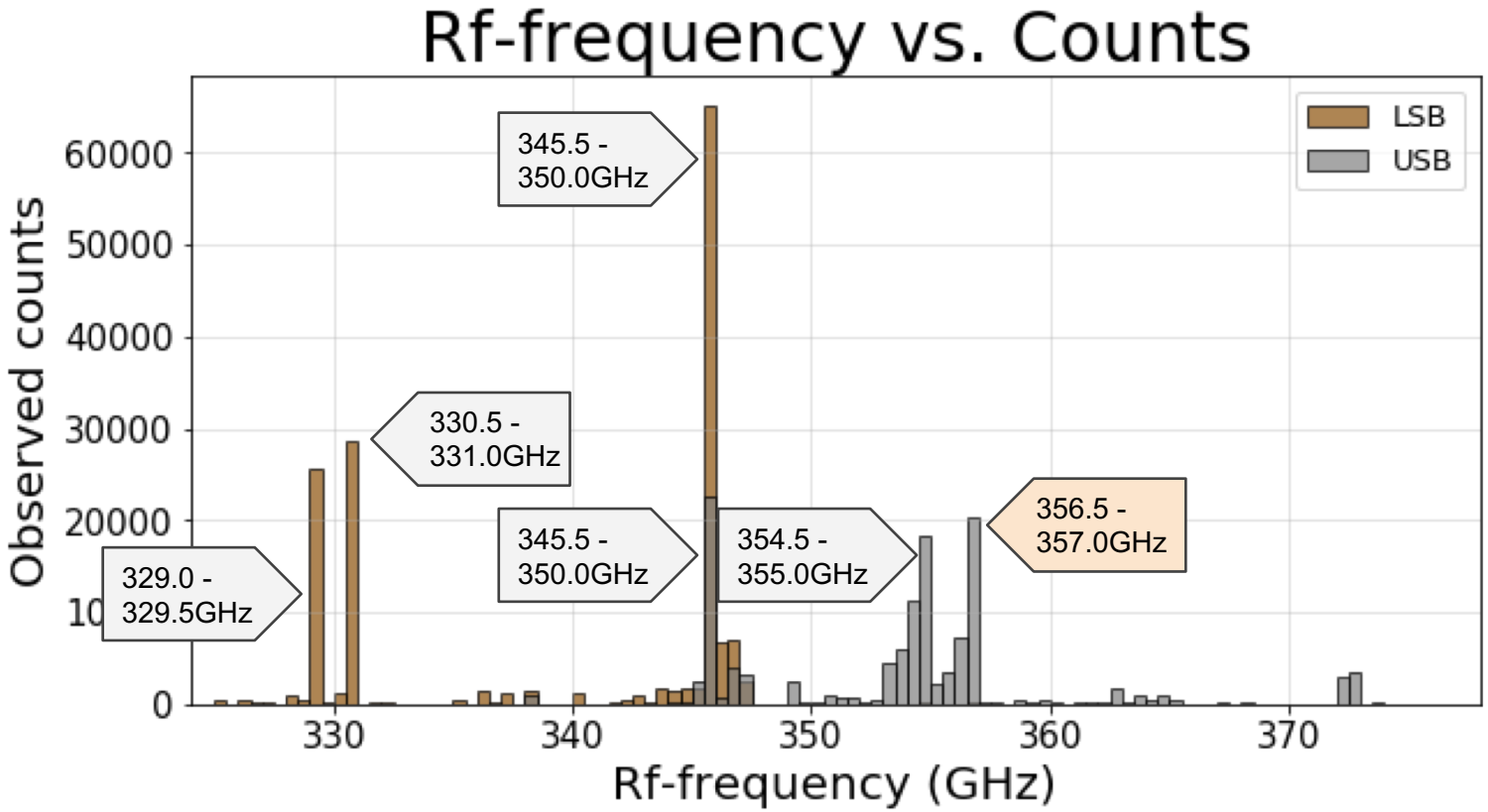
(all receptors follow the same feature)



receptor (USB)	% of unstable TRX
0	0
1	0
2	4
3	3
4	3
5	2
6	0
7	0
8	1
9	3
10	4
11	5
12	0
15	0

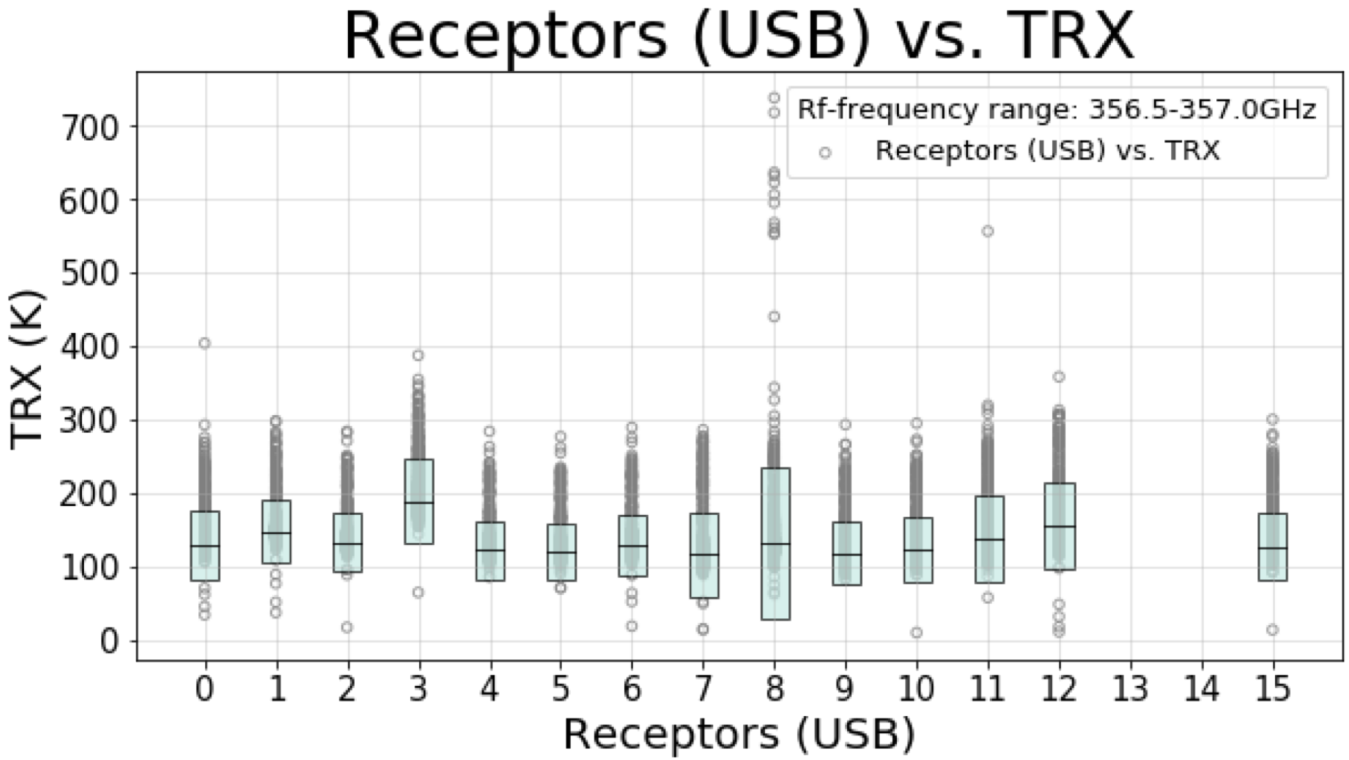
Rf-frequency range between 351.5 and 352.0GHz (USB)

(The box plot shows the two sigma range from the median at the middle line)



Trait 1: Most observed frequency-ranges are selected

(all receptors follow the same feature)

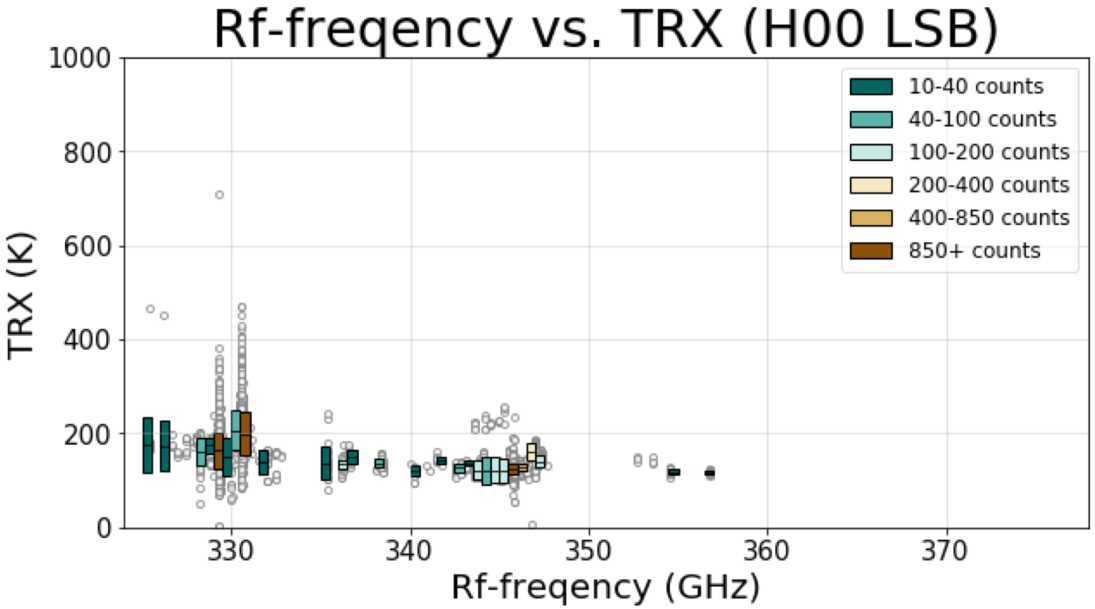


receptor (USB)	% of unstable TRX
0	5
1	5
2	5
3	8
4	5
5	5
6	5
7	6
8	3
9	5
10	5
11	5
12	4
15	5

Rf-frequency range between 356.5 and 357.0GHz (USB)

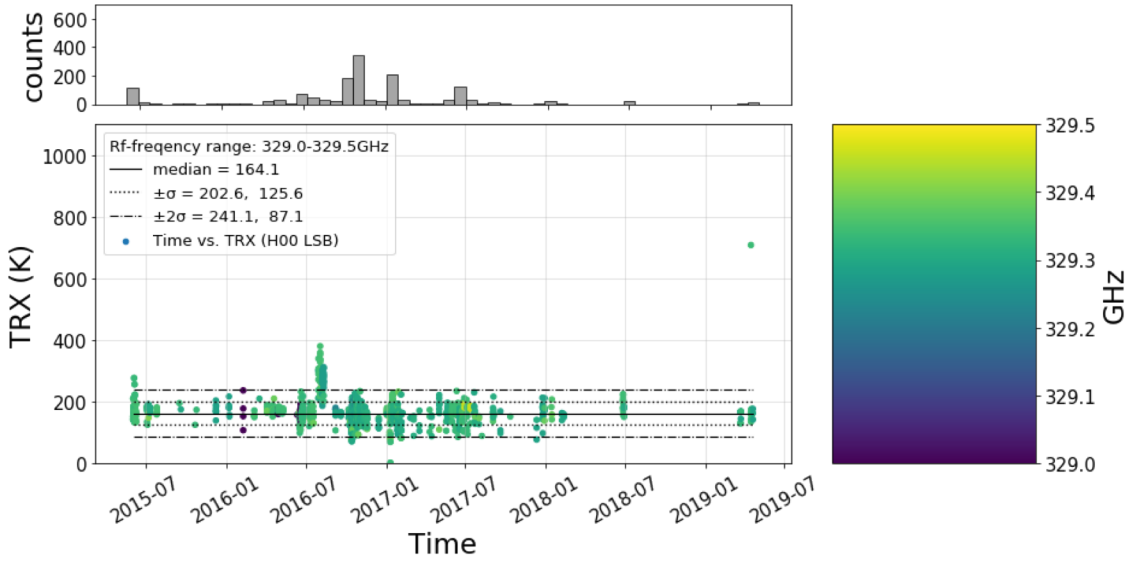
(The box plot shows the two sigma range from the median at the middle line)

My document report



My document report

- Focuses on each receptor
- Includes median and sigma range in several Rf-frequency ranges and Lo-frequency ranges



My report

- Shows frequency range including high TRX
- Shows specific dates when TRX was high and checked the log notes at the dates
- Includes more than 520 plots like this just about Rf-frequency and TRX, Lo-frequency and TRX

Practical use of Data visualization

Tonight website (now)

- Only table is shown
- Hard to know whether TRX value is high or not

RFreq	H01	H02	H03	H04	H05	H06	H07	H08	H09	H10	H11	H12	H15	
330.6	226.3	173.6	277.4	263.0	167.3	151.9	163.4	170.1	161.3	166.0	143.8	183.7	140.7	[Trx]
329.3	207.0	165.5	232.8	1057.9	144.4	152.3	153.2	175.8	157.9	151.6	163.1	172.6	139.1	[Trx]
345.8	149.0	111.5	180.7	107.5	108.6	189.3	123.0	122.5	127.5	149.6	189.7	151.7	170.2	[Trx]

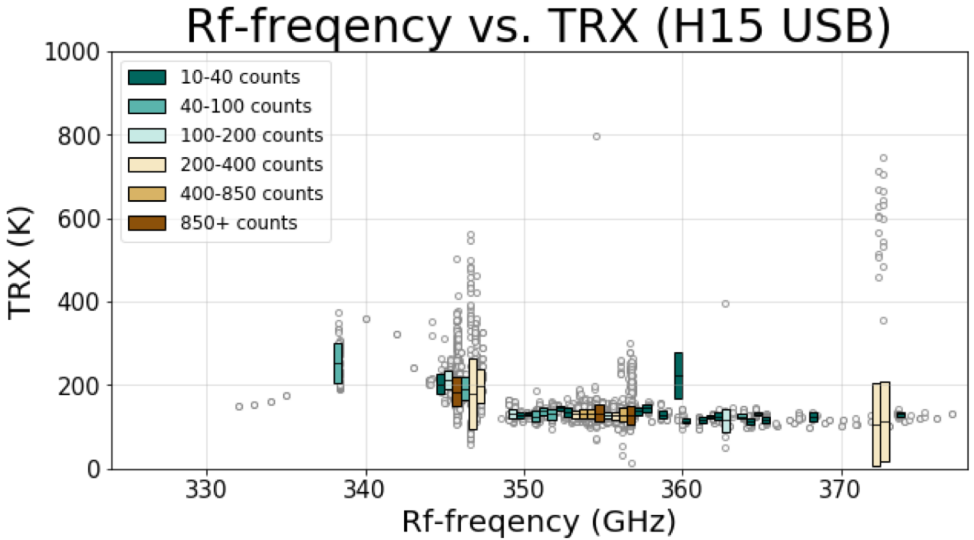
Tonight website

RFreq	H01	H02	H03	H04	H05	H06	H07	H08	H09	H10	H11	H12	H15	
330.6	226.3	173.6	277.4	263.0	167.3	151.9	163.4	170.1	161.3	166.0	143.8	183.7	140.7	[Trx]
329.3	207.0	165.5	232.8	1057.9	144.4	152.3	153.2	175.8	157.9	151.6	163.1	172.6	139.1	[Trx]
345.8	149.0	111.5	180.7	107.5	108.6	189.3	123.0	122.5	127.5	149.6	189.7	151.7	170.2	[Trx]

Only table is shown

Table + Plot

(Add Lo-frequency)



Tonight website's Future

Software which show the notification of high TRX to operator something like ...

RFreq	H01	H02	H03	H04	H05	H06	H07	H08	H09	H10	H11	H12	H15	
330.6	226.3	173.6	277.4	263.0	167.3	151.9	163.4	170.1	161.3	166.0	143.8	183.7	140.7	[Trx]
329.3	207.0	165.5	232.8	1057.9	144.4	152.3	153.2	175.8	157.9	151.6	163.1	172.6	139.1	[Trx]
345.8	149.0	111.5	180.7	107.5	108.6	189.3	123.0	122.5	127.5	149.6	189.7	151.7	170.2	[Trx]

Conclusion

- In frequency range between 345.5 and 350.0GHz, receptors with LSB tend to work better compared to receptors with USB sideband (%_LSB < %_USB, for all) and (σ_LSB < σ_USB, except #8,11)
- Tonight page should add plots because operator sometimes may not notice about high TRX values according to Log Note