

Green Bank Weather for High Frequency Observing



Ron Maddalena
National Radio Astronomy Observatory
Green Bank, WV



Outline

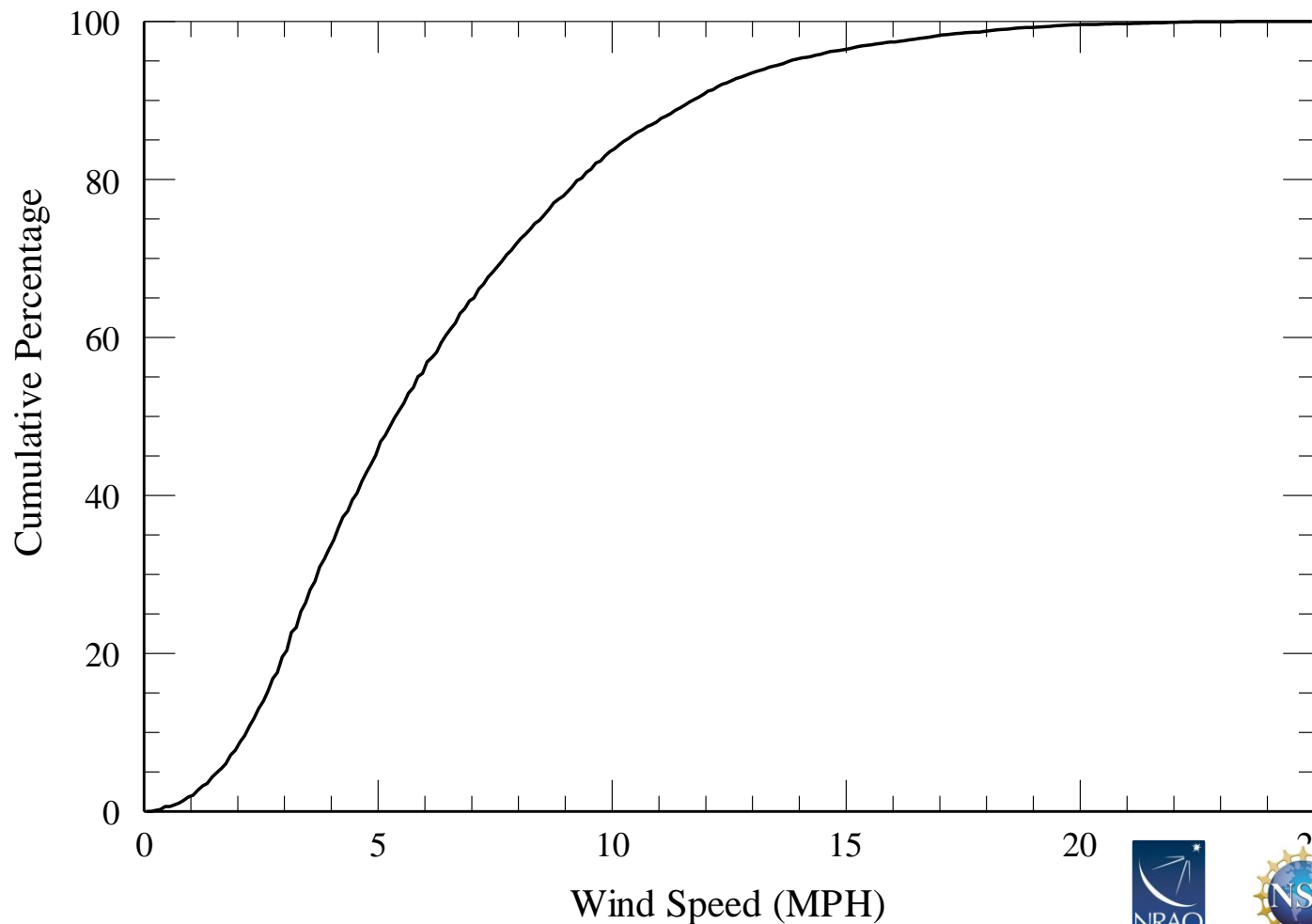
- Wind and Cloud Statistics
- Opacity Statistics
- Precipitable Water Statistics
- Site Comparisons
- Dynamic Scheduling



Green Bank Winds Full-Year Statistics

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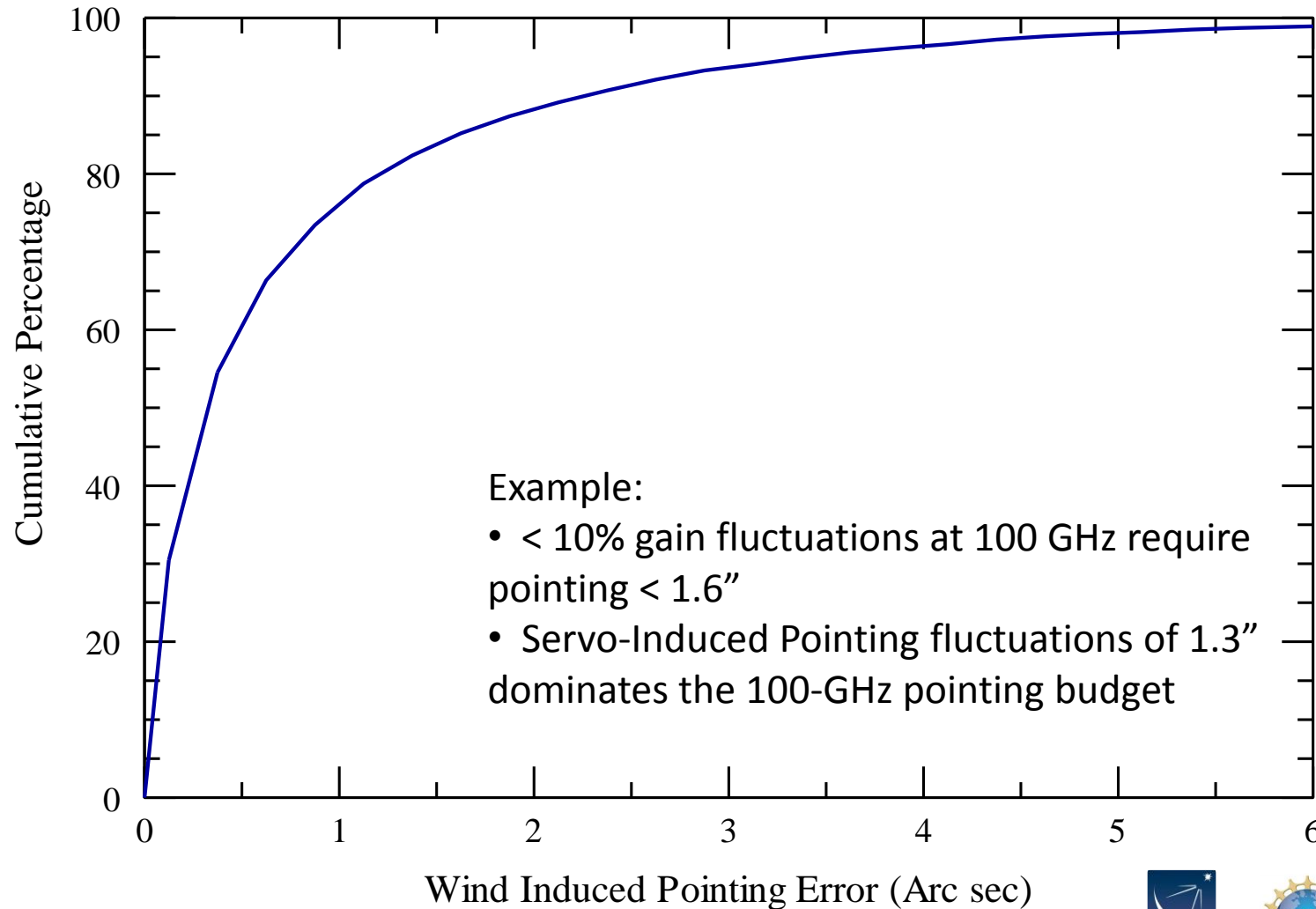
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Winds and Telescope Pointing

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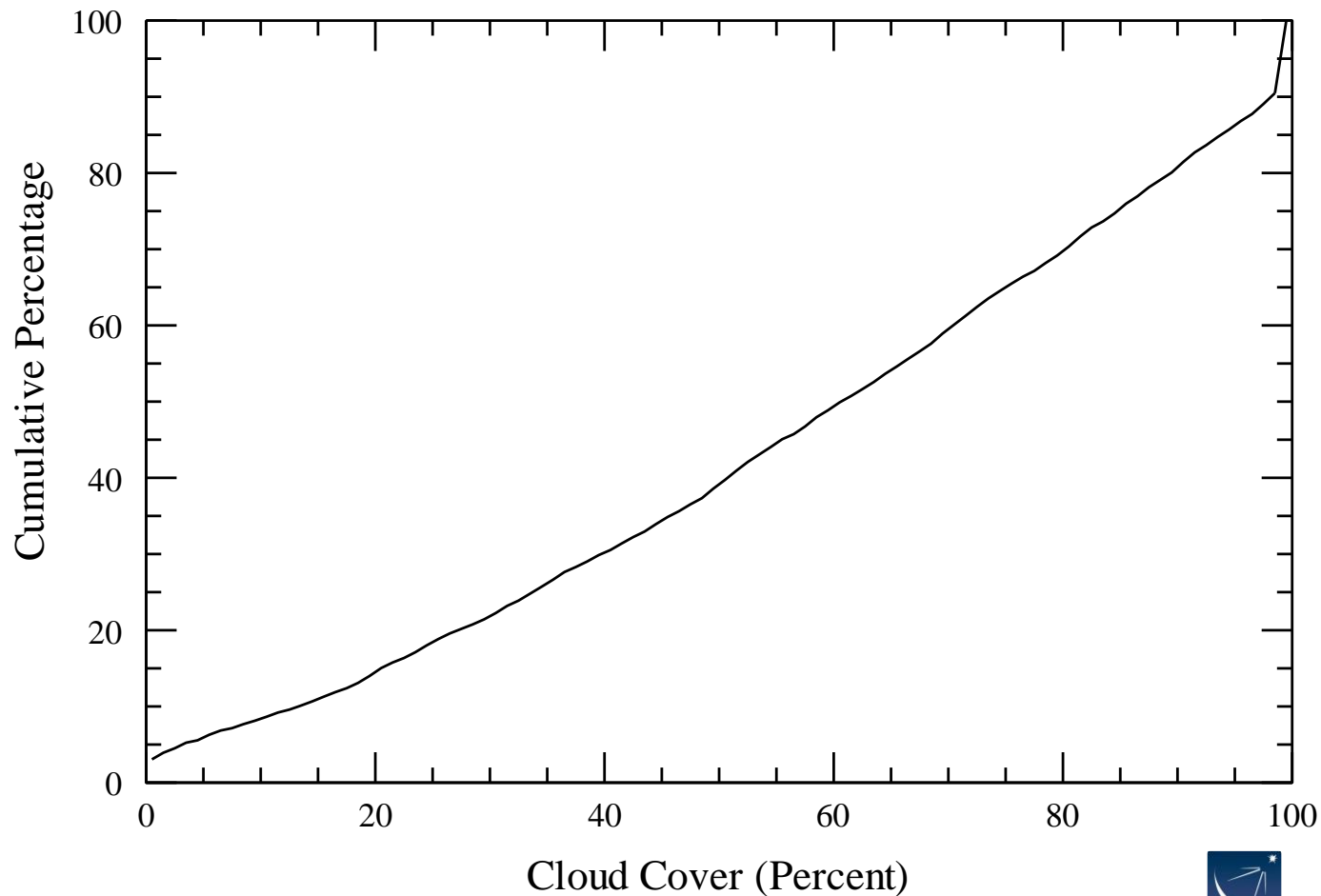
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Green Bank Clouds Full-Year Statistics

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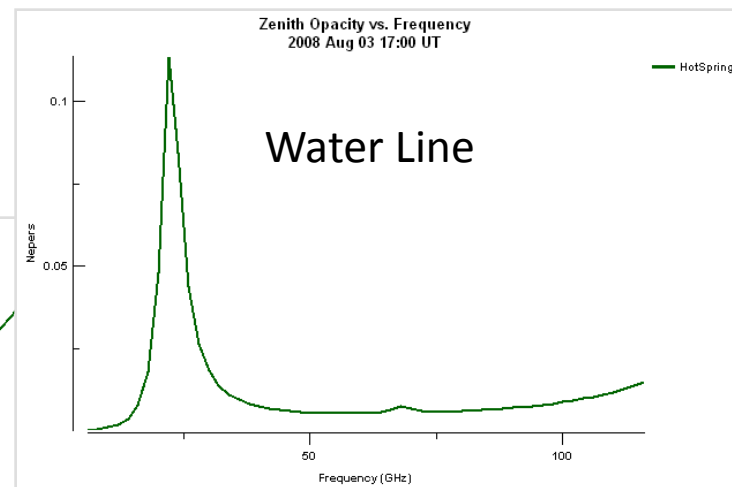
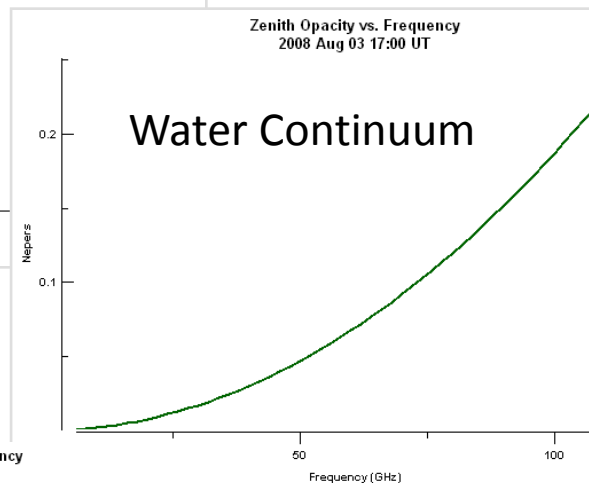
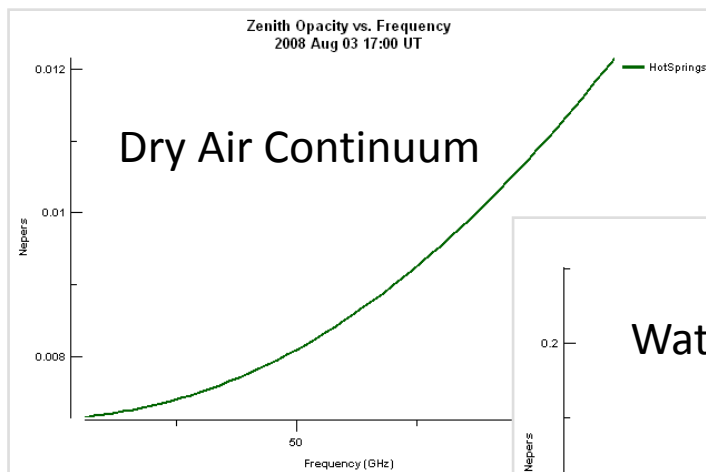
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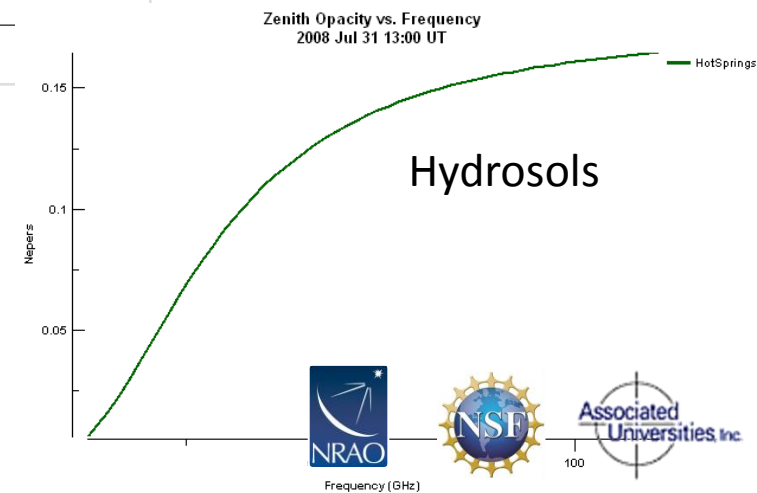
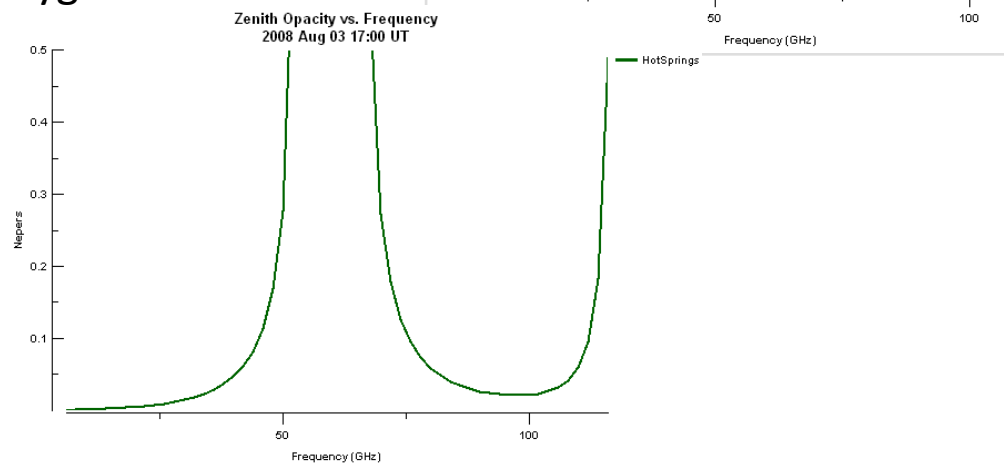
Opacities Components

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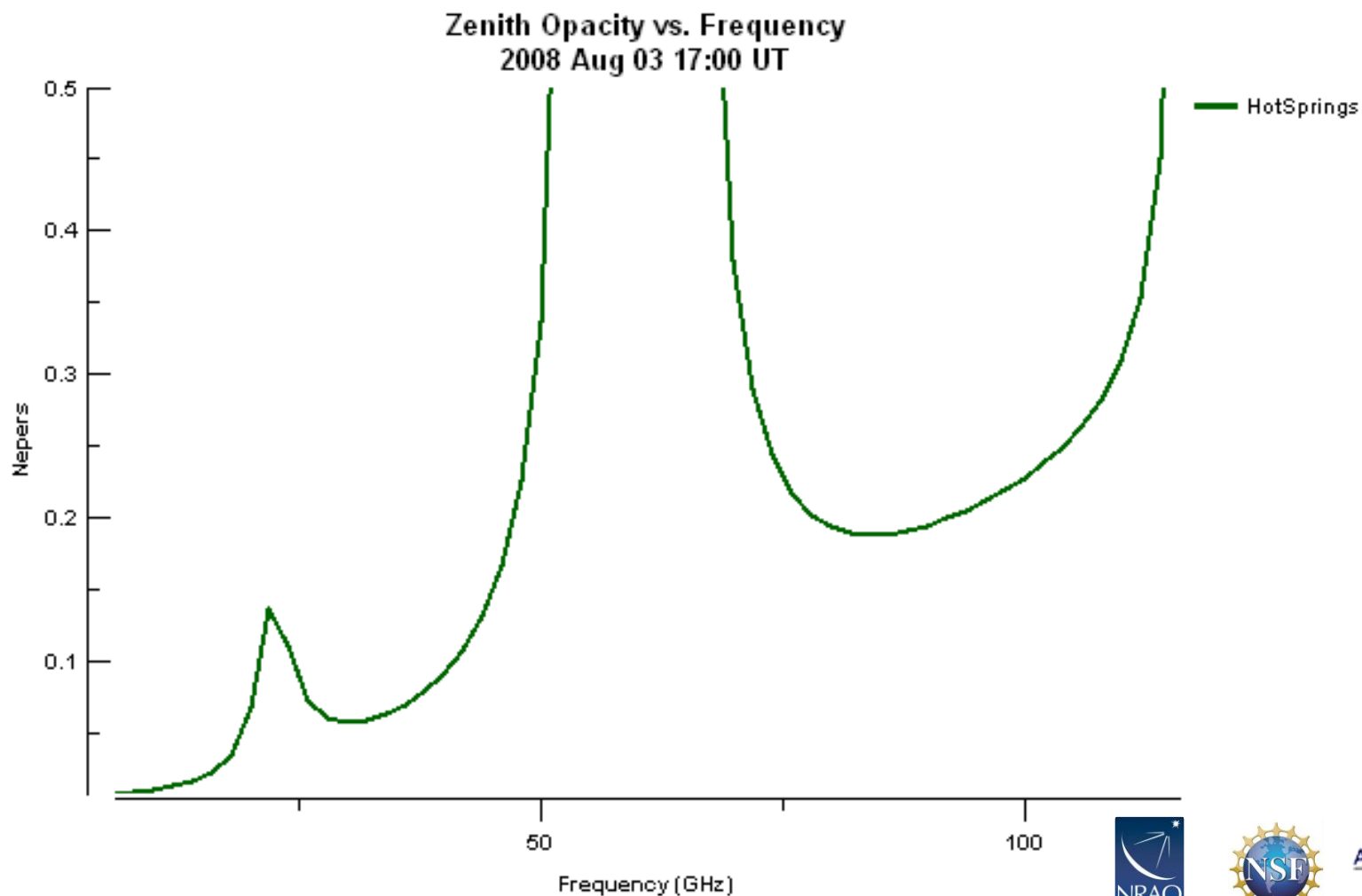
Oxygen Line



Total Opacity

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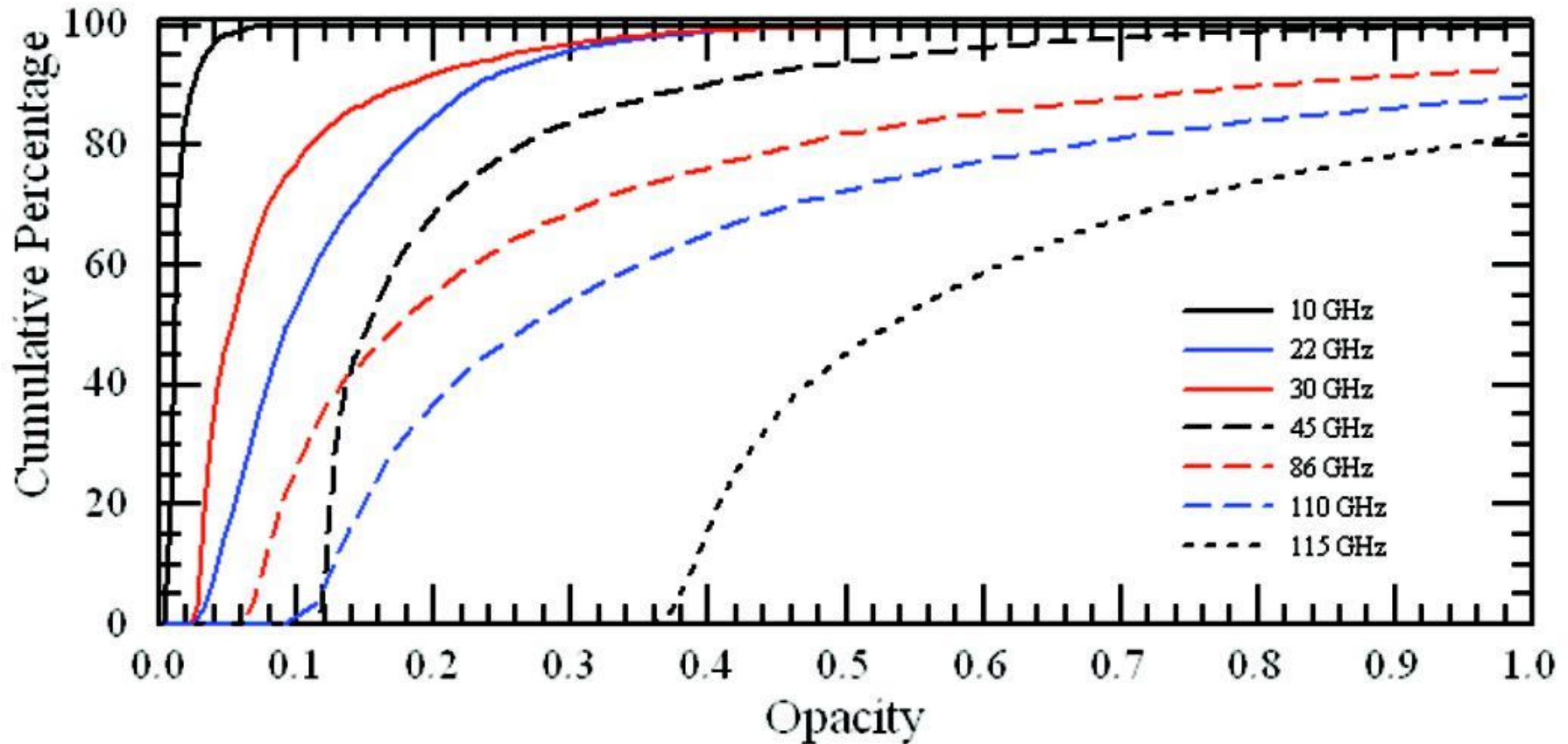
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Green Bank Opacities Full-Year Statistics

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Definitions

$$T_{SYS} = T_{Rcvr} + T_{Spill} + T_{CMB} \cdot e^{-\tau} + T_{Atm} \cdot (1 - e^{-\tau})$$

$$\text{Effective } T_{SYS} = \left[T_{Rcvr} + T_{Spill} + T_{CMB} \cdot e^{-\tau} + T_{Atm} \cdot (1 - e^{-\tau}) \right] \cdot e^{\tau}$$

$$\text{Relative Effective } T_{SYS} = \frac{\text{Effective } T_{SYS}}{\text{Best Possible Effective } T_{SYS}}$$

$$\text{Relative Observing Time} = (\text{Relative Effective } T_{SYS})^2 = \frac{t}{t_0}$$

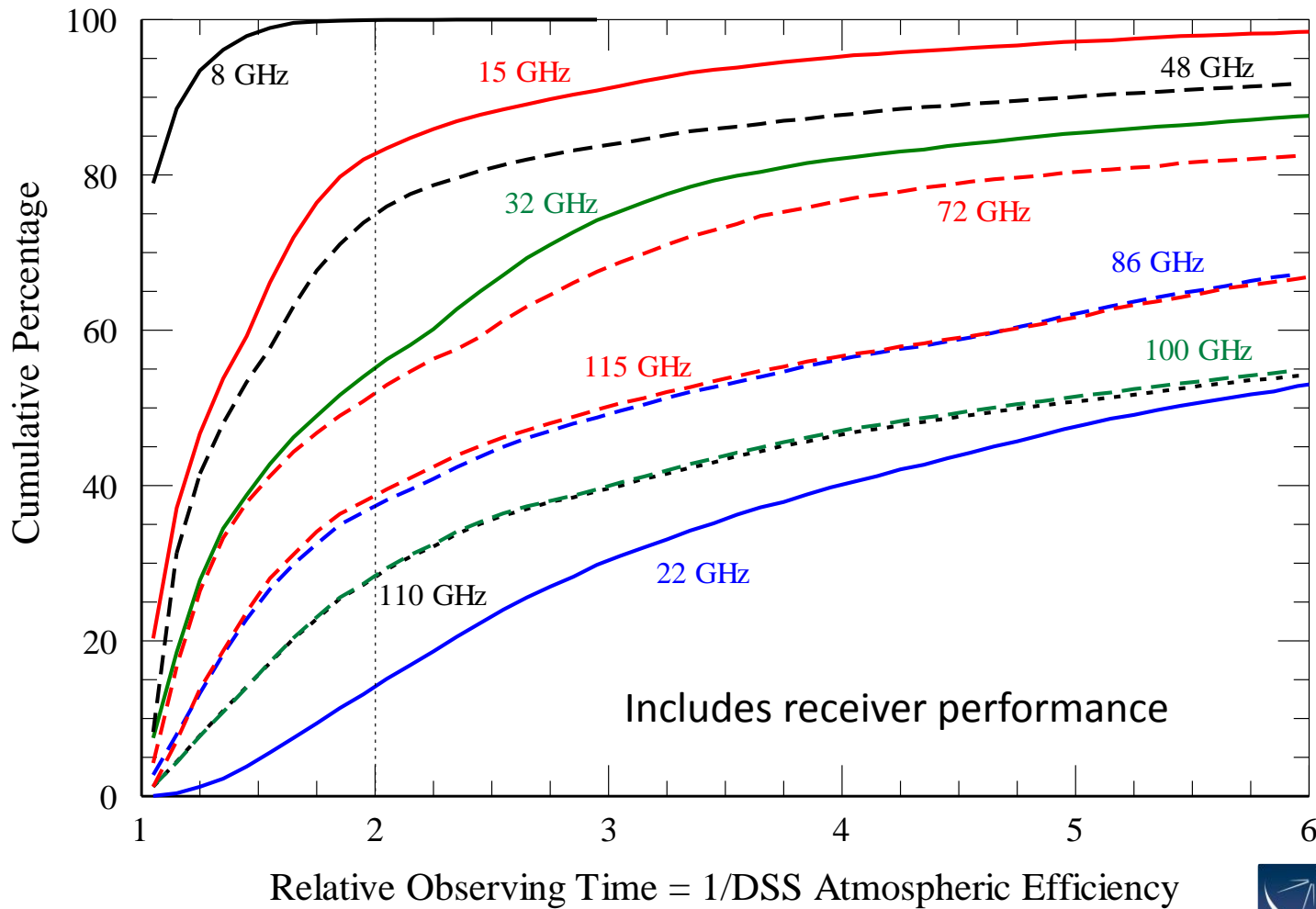
t_0 = time needed to execute an observation with the best of opacity conditions

t = time needed to execute an observation with the current opacity conditions

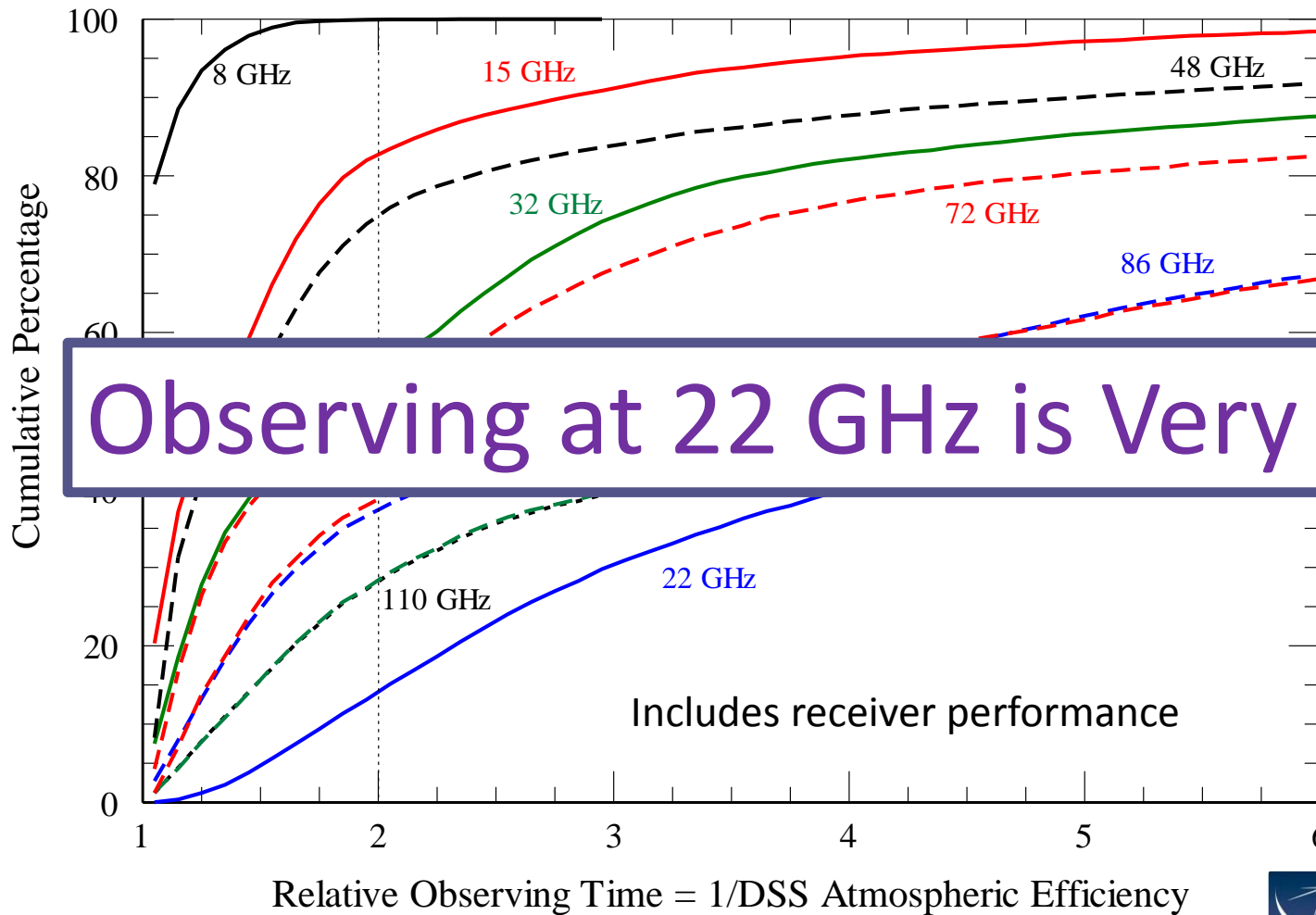
$$\text{DSS Atmospheric Observing Efficiency} = (\text{Relative Observing Time})^{-1} = \frac{t_0}{t}$$



Scheduling Metric



Scheduling Metric



Hours Per Year That the DSS Could Schedule

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Frequency (GHz)	Hours $\pm 10-20\%$
8	7900
15	5700
22	900
32	4000
40	5600
48	5600
72	1800*
86	1200*
100	750*
110	700*
115	1100*

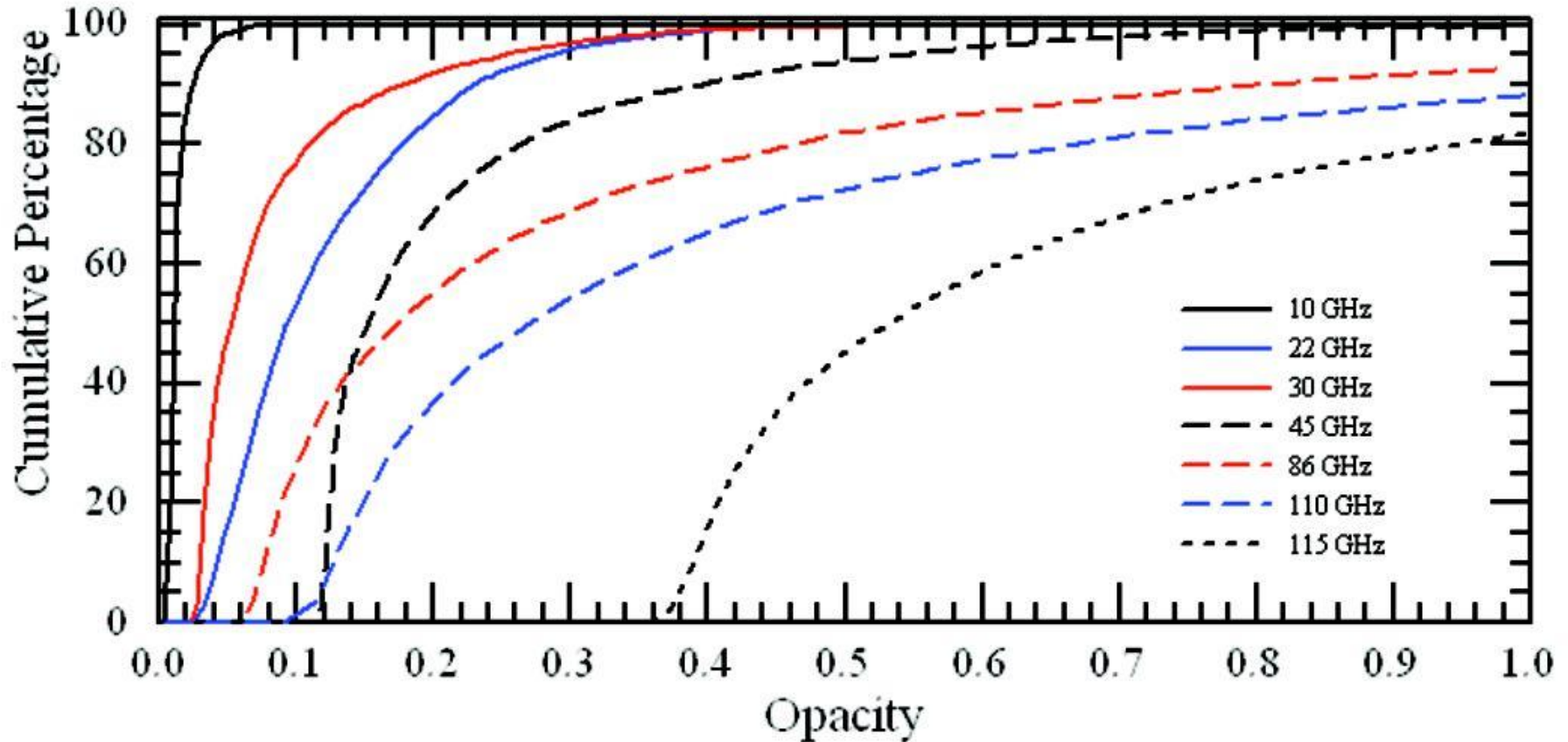
* Only Nighttime Observing Allowed



Green Bank Opacities Full-Year Statistics

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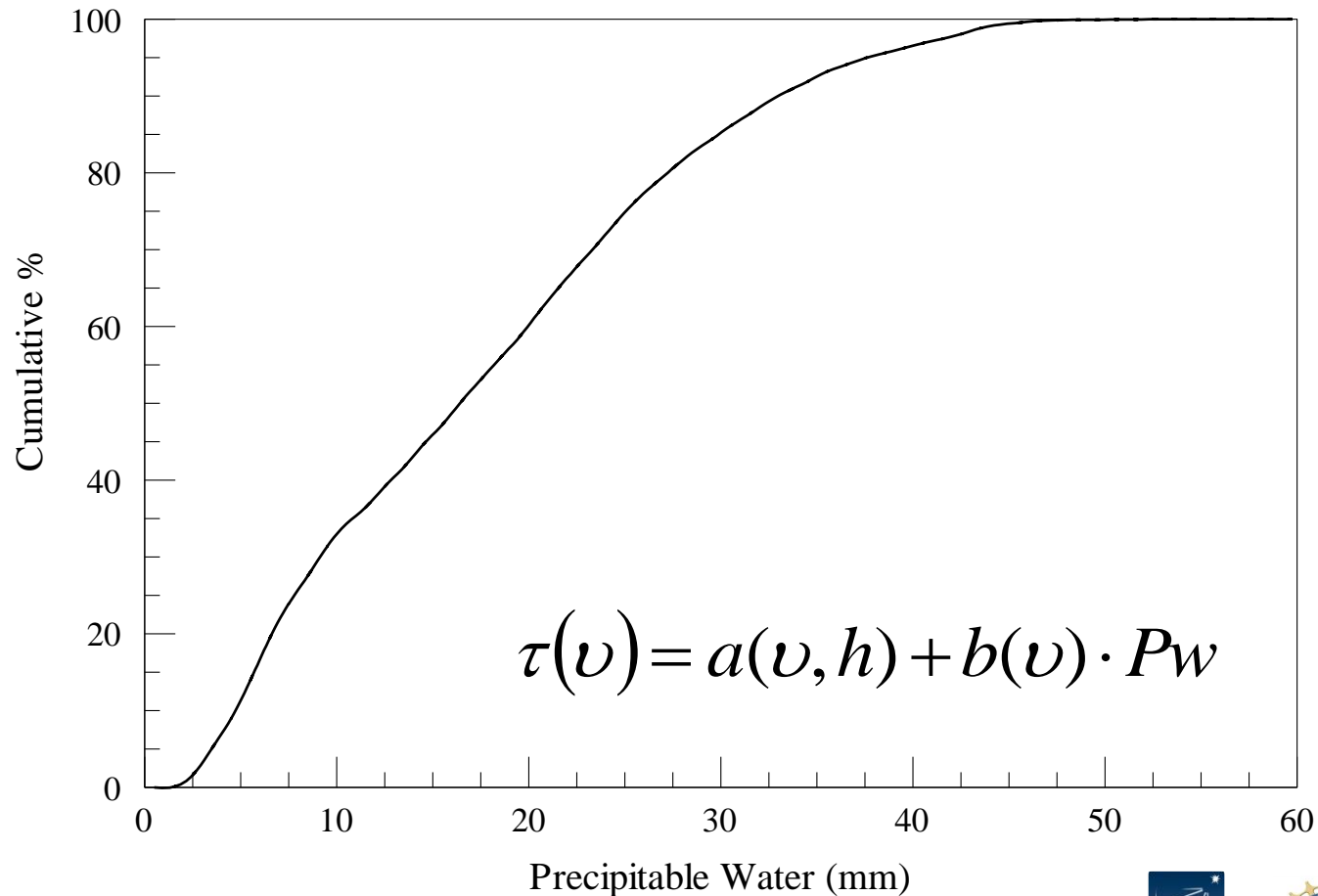


Green Bank – Full Year Precipitable Water Vapor

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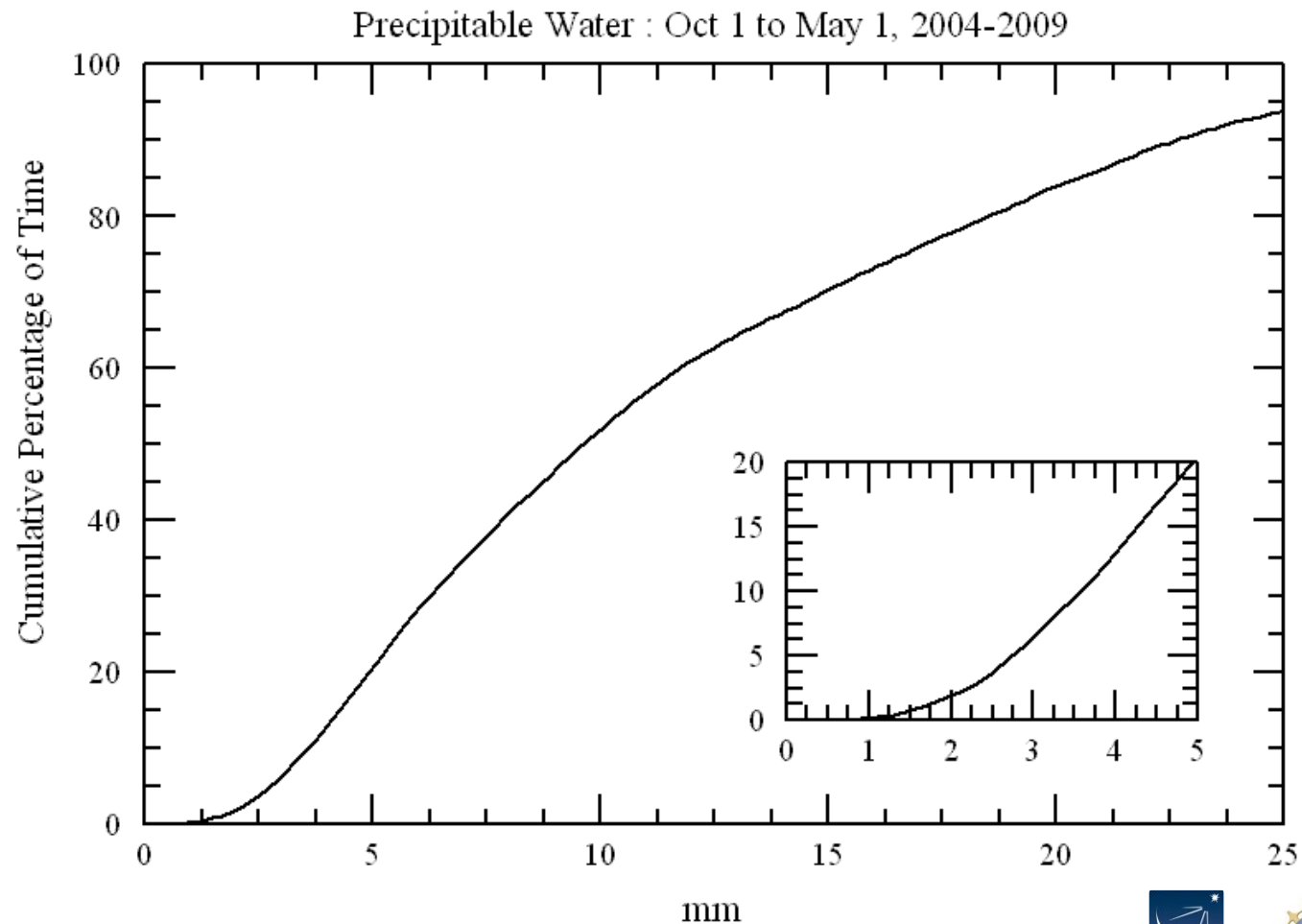
Jan 1, 2012 - Jan 1, 2013



Green Bank – Winter Precipitable Water Vapor

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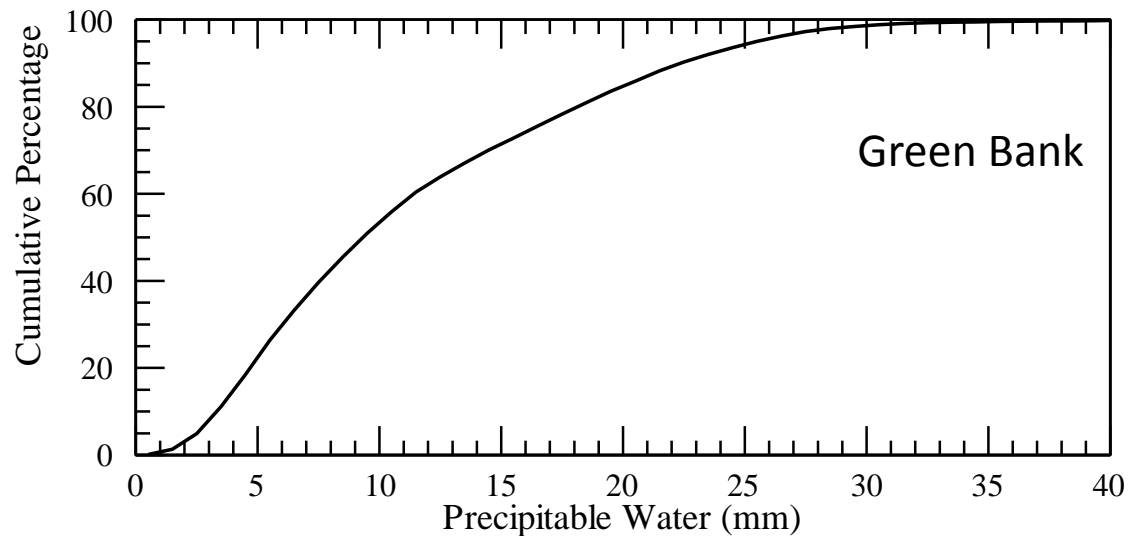
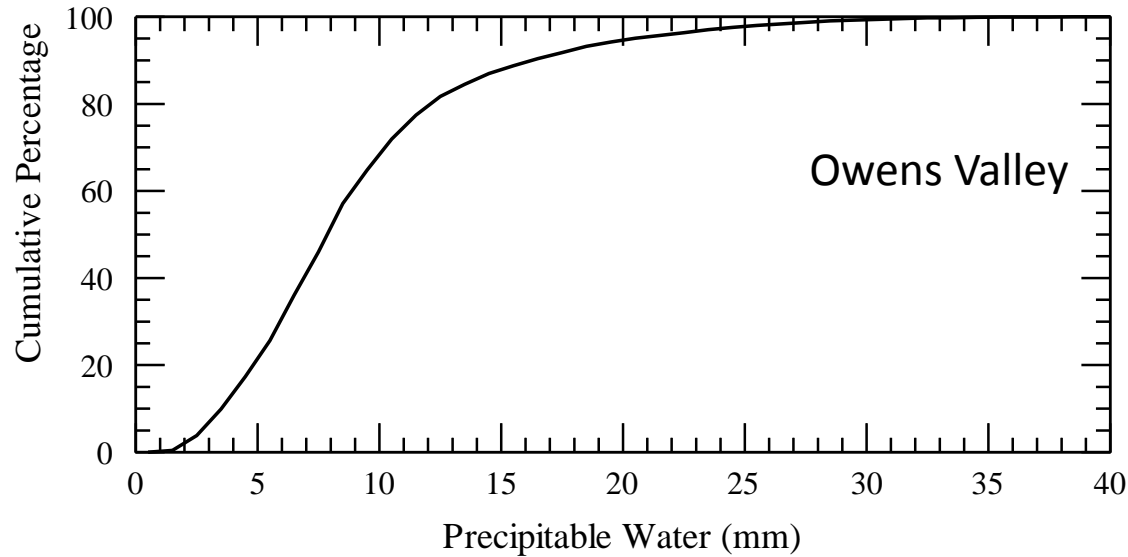


Owens Valley vs Green Bank

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Full Year

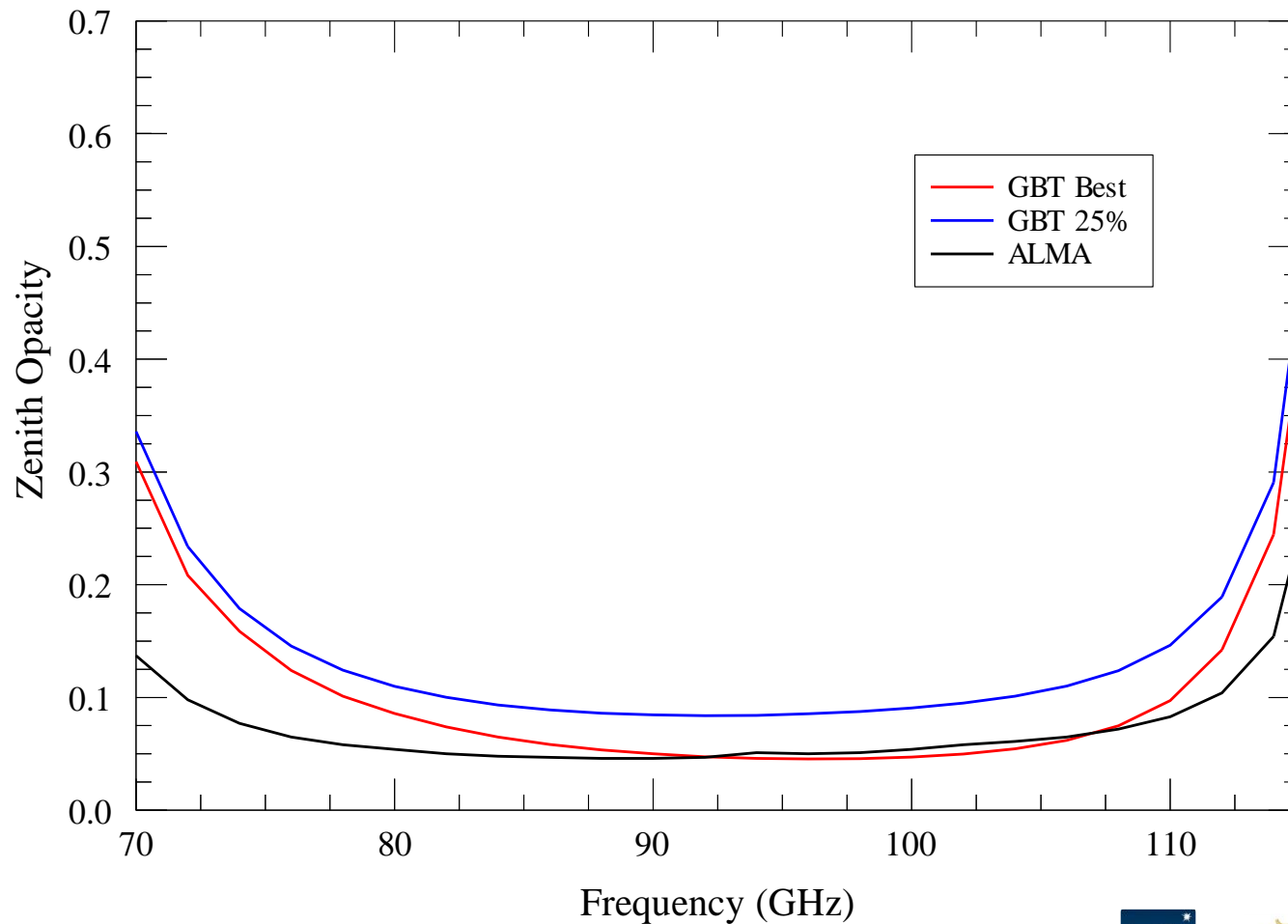


Green Bank vs ALMA

Full Year - Opacities

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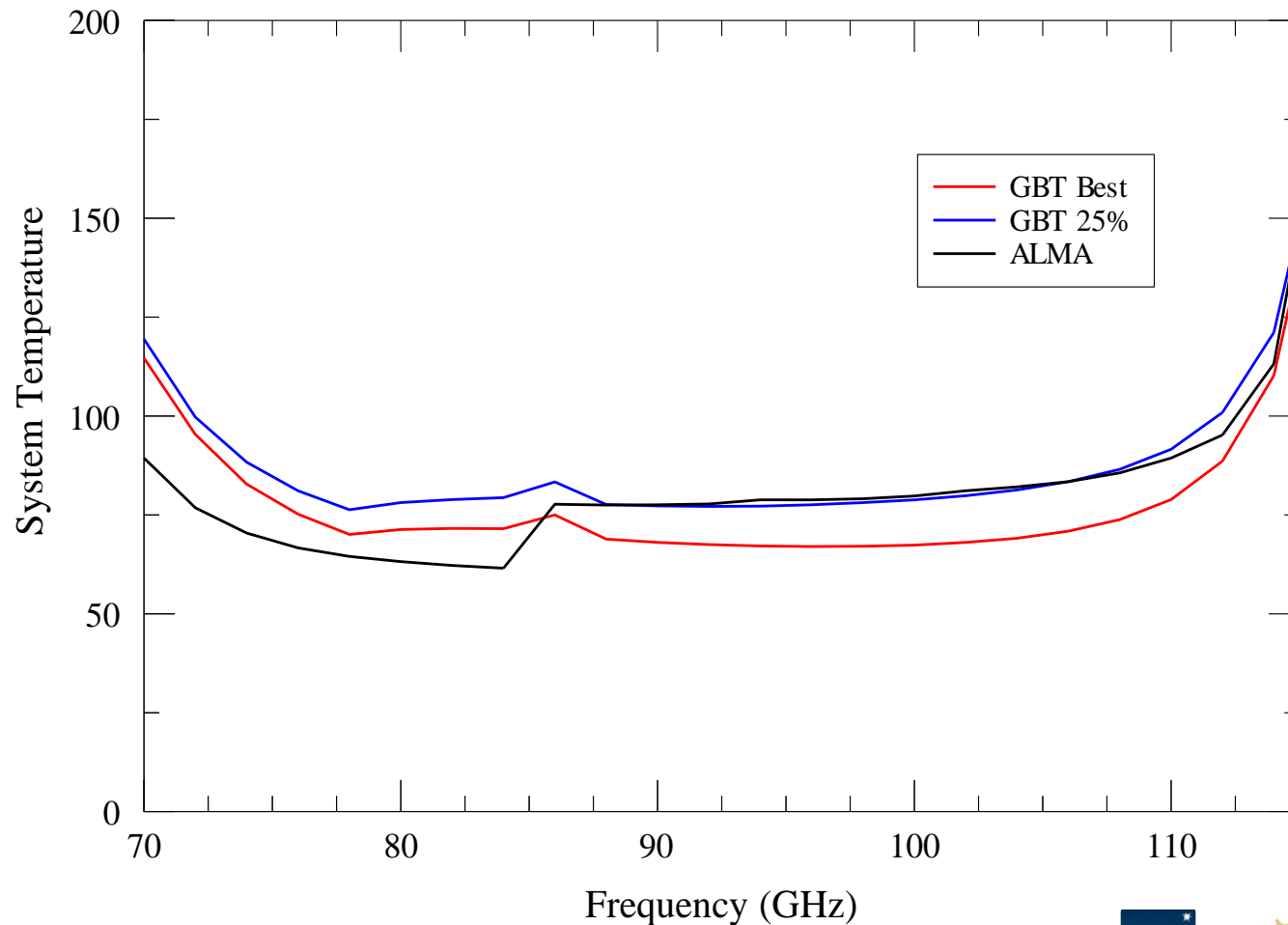


Green Bank vs ALMA

System Temperatures

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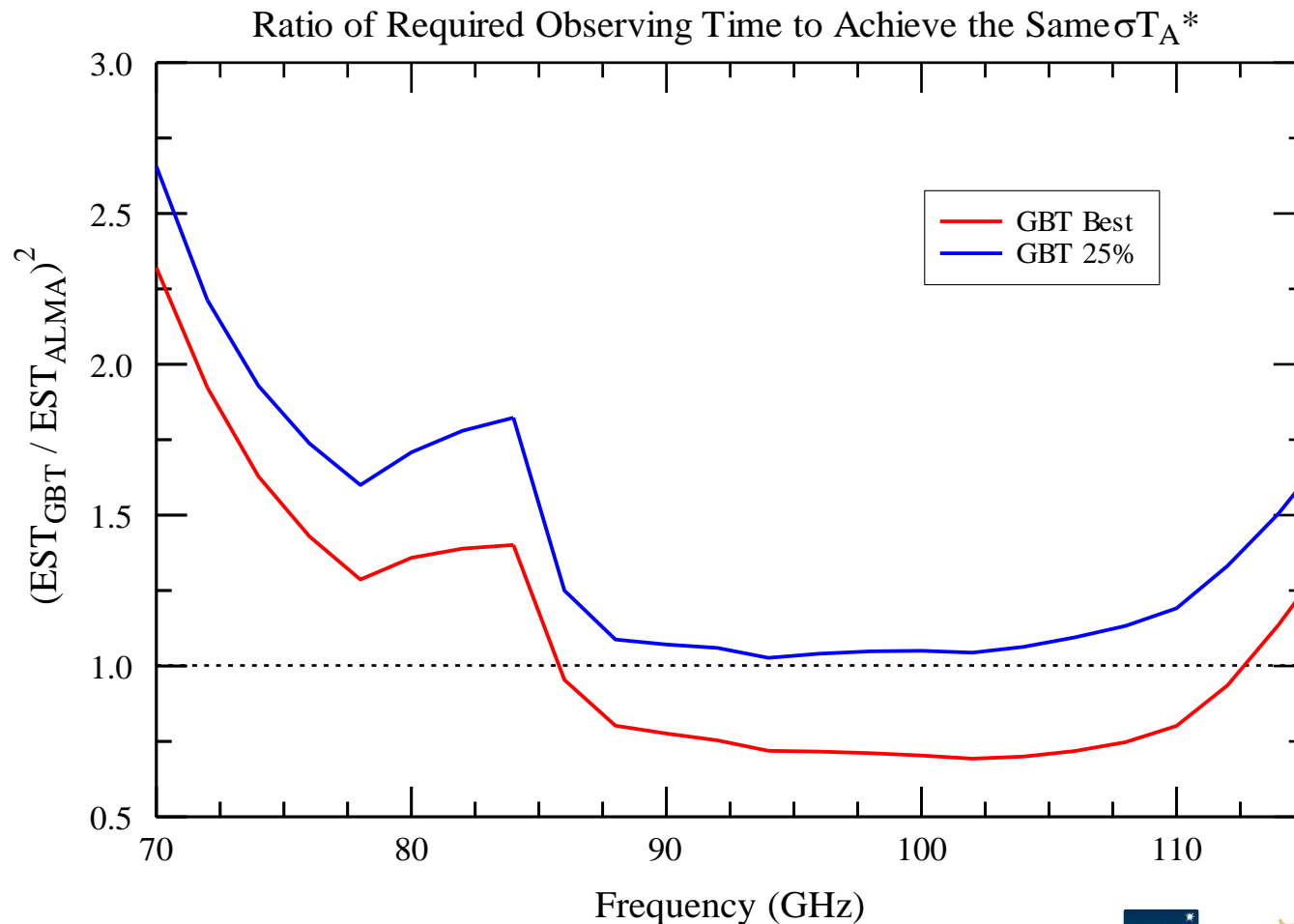


Green Bank vs ALMA

Extended Source (T_A^*)

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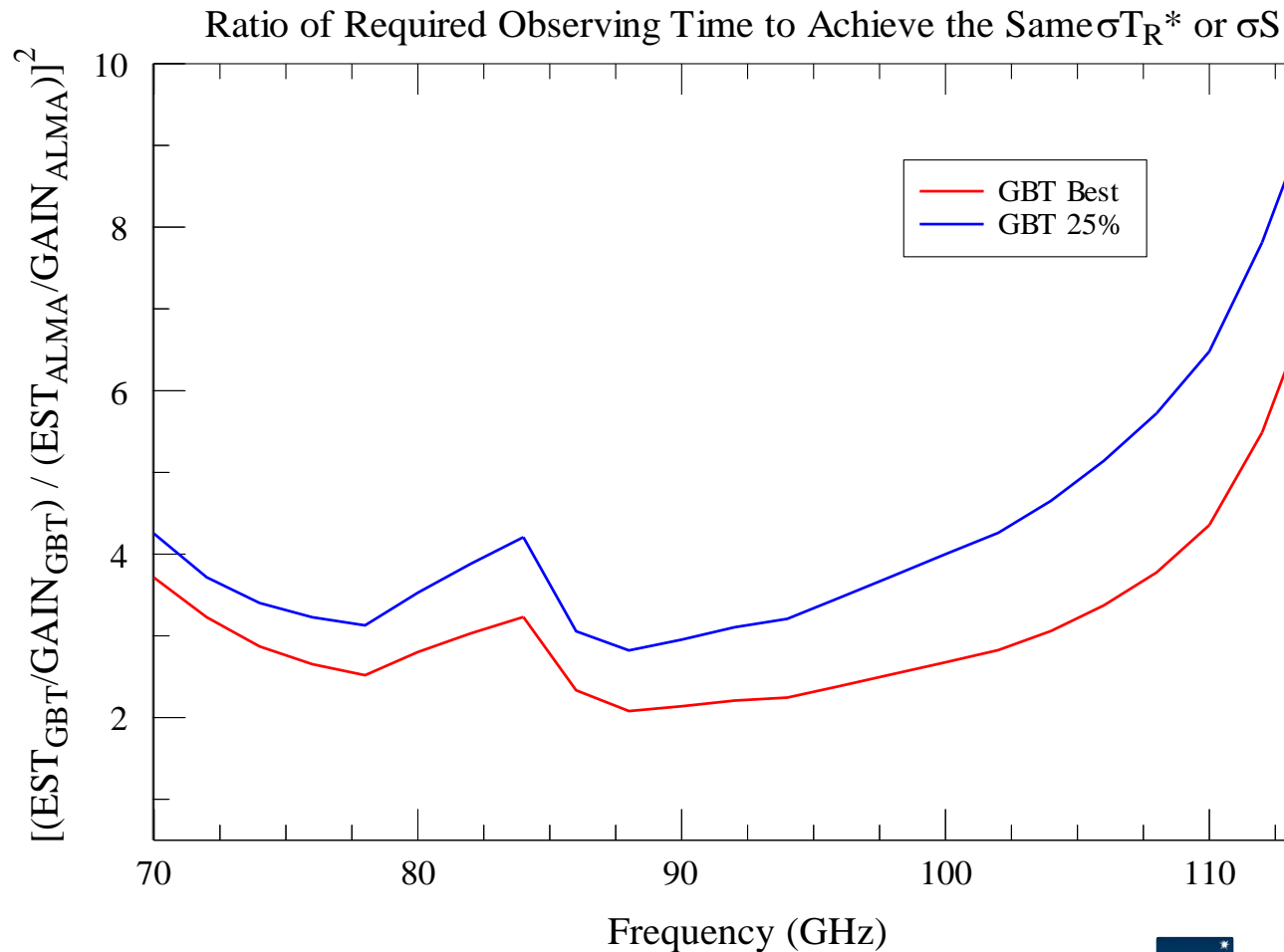


Green Bank vs ALMA

Point-Source (T_R^* or S)

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Green Bank Weather For High Frequency Observing



DSS Overview Efficiencies from Atmospheric Opacities (EffAtmos)

Local Date and Time

Wed
02/04
00:00

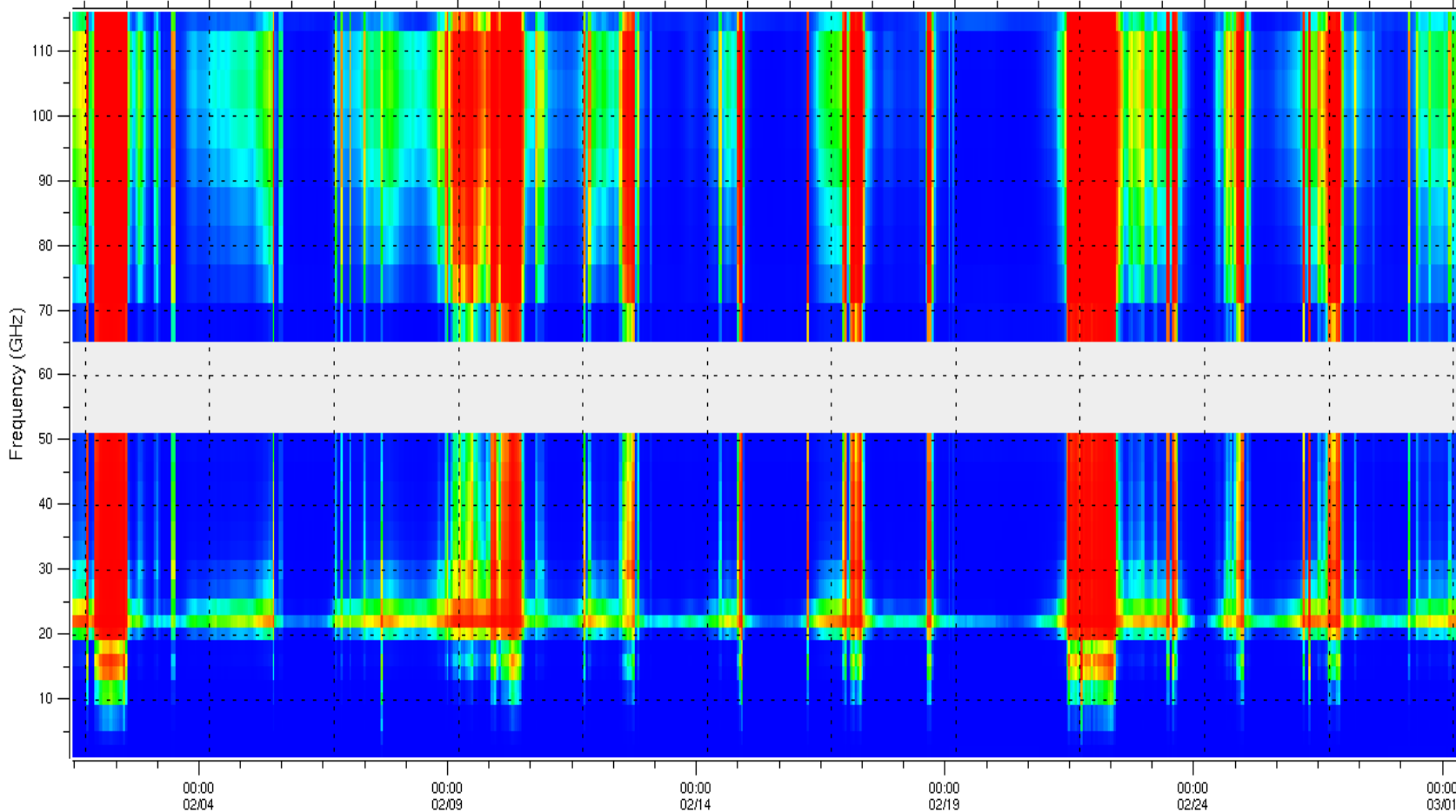
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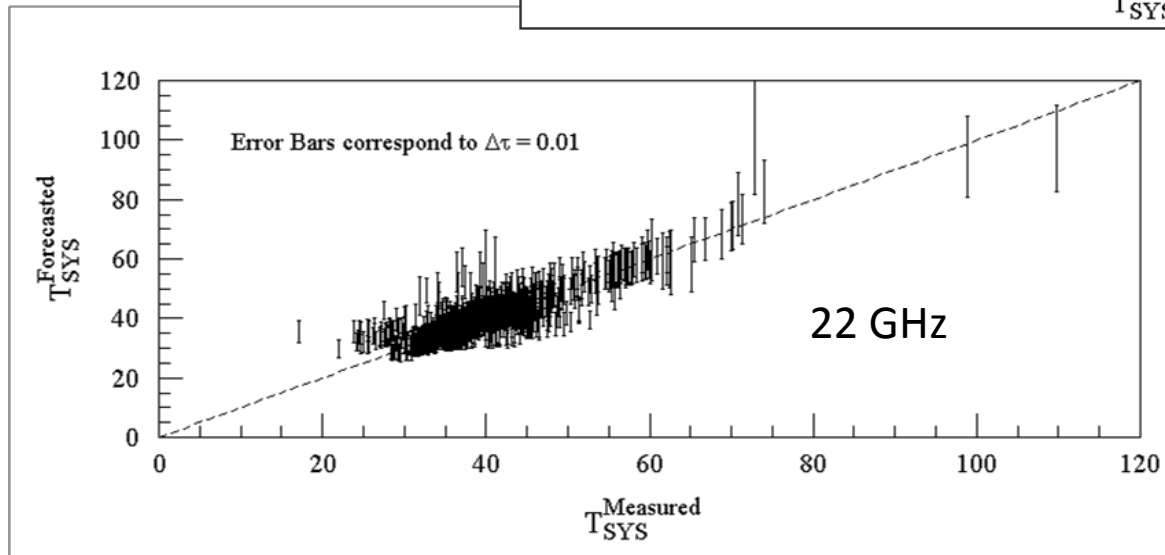
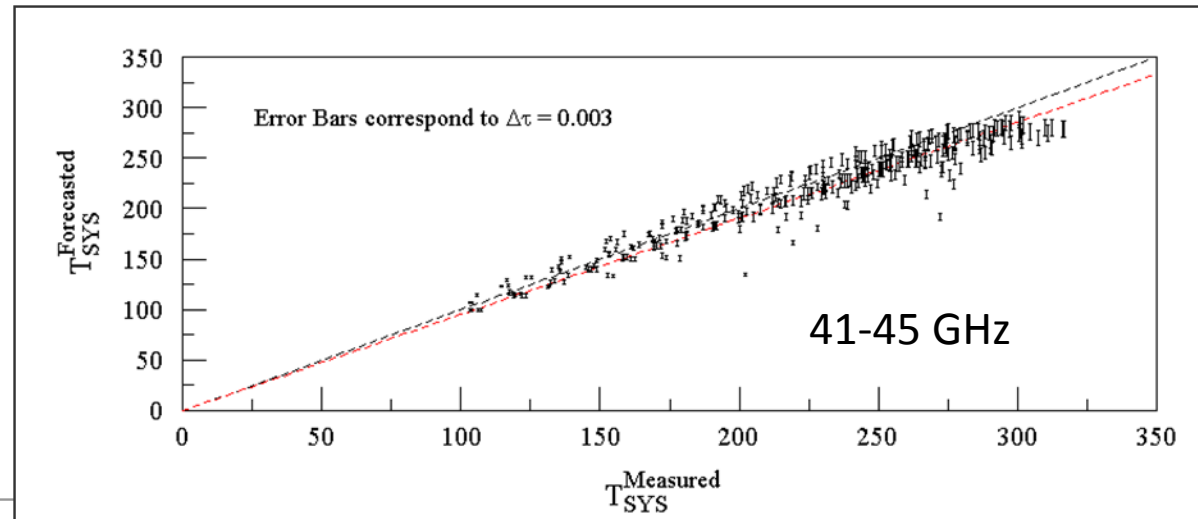
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UT Date and Time

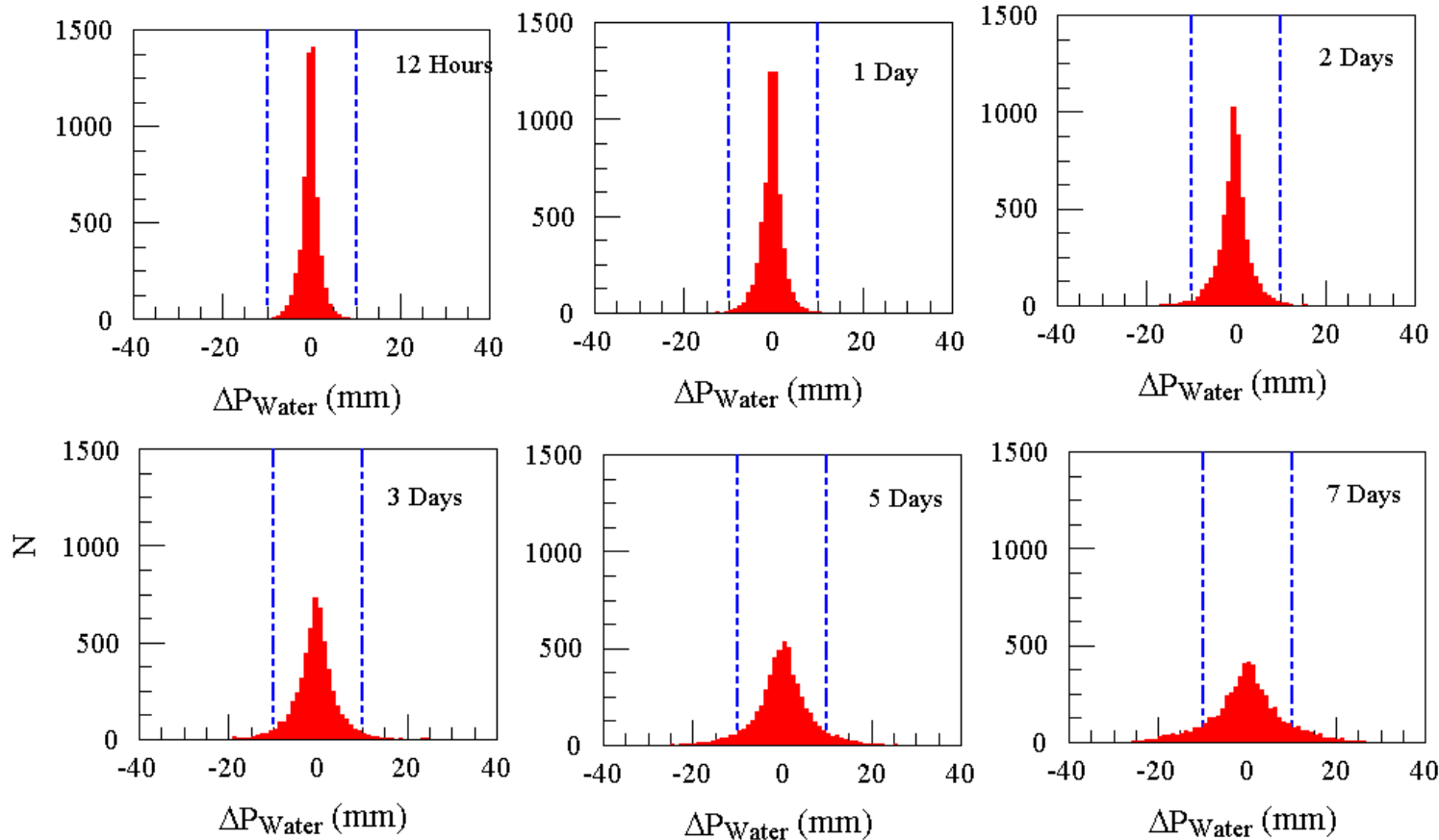


Weather/DSS Accuracy

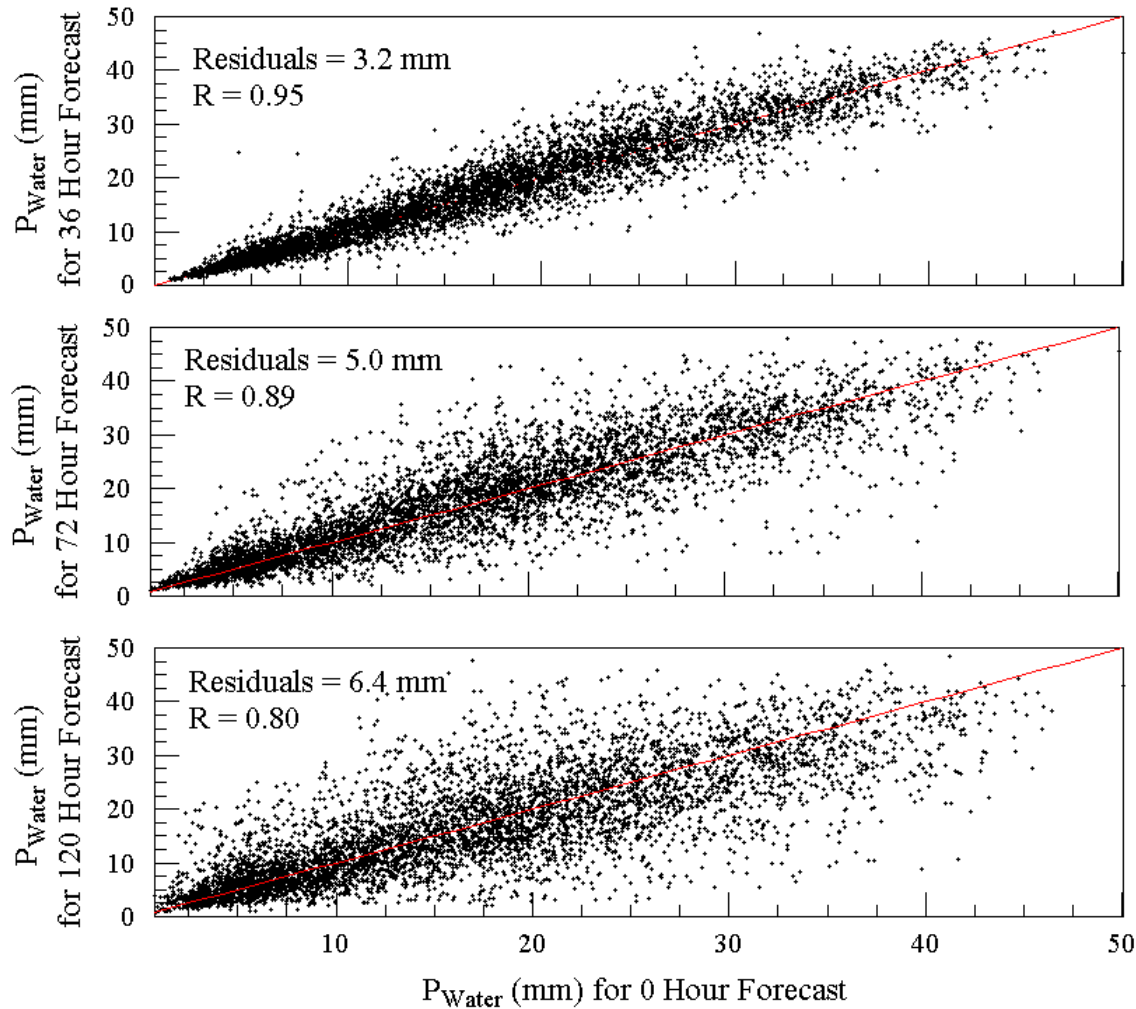


Forecast/DSS Reliability

Change in Forecasted P_{Water}



Forecast/DSS Reliability



Correlation Coefficients

P_{Water}		
Hour	R	rms (mm)
6	0.985	1.76
12	0.978	2.11
18	0.972	2.41
24	0.968	2.58
30	0.960	2.91
36	0.952	3.15
42	0.942	3.46
48	0.932	3.73
54	0.922	4.03
60	0.910	4.35
66	0.898	4.64
72	0.885	4.95
78	0.875	5.19

Winds		
Hour	R	rms (MPH)
6	0.902	2.00
12	0.820	2.65
18	0.797	2.83
24	0.777	2.83
30	0.762	3.00
36	0.753	3.00
42	0.749	3.00
48	0.744	3.00
54	0.734	3.00
60	0.685	3.32
66	0.628	3.61
72	0.577	3.74
78	0.579	3.61

Cloud Cover		
Hour	R	rms (%)
6	0.933	11.1
12	0.900	13.5
18	0.876	14.8
24	0.847	16.2
30	0.828	17.2
36	0.823	17.4
42	0.811	17.9
48	0.789	18.7
54	0.786	18.8
60	0.758	19.8
66	0.734	20.6
72	0.719	21.1
78	0.689	22.0

DSS Overview Efficiencies from Atmospheric Opacities (EffAtmos)

Local Date and Time

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02/04
00:00

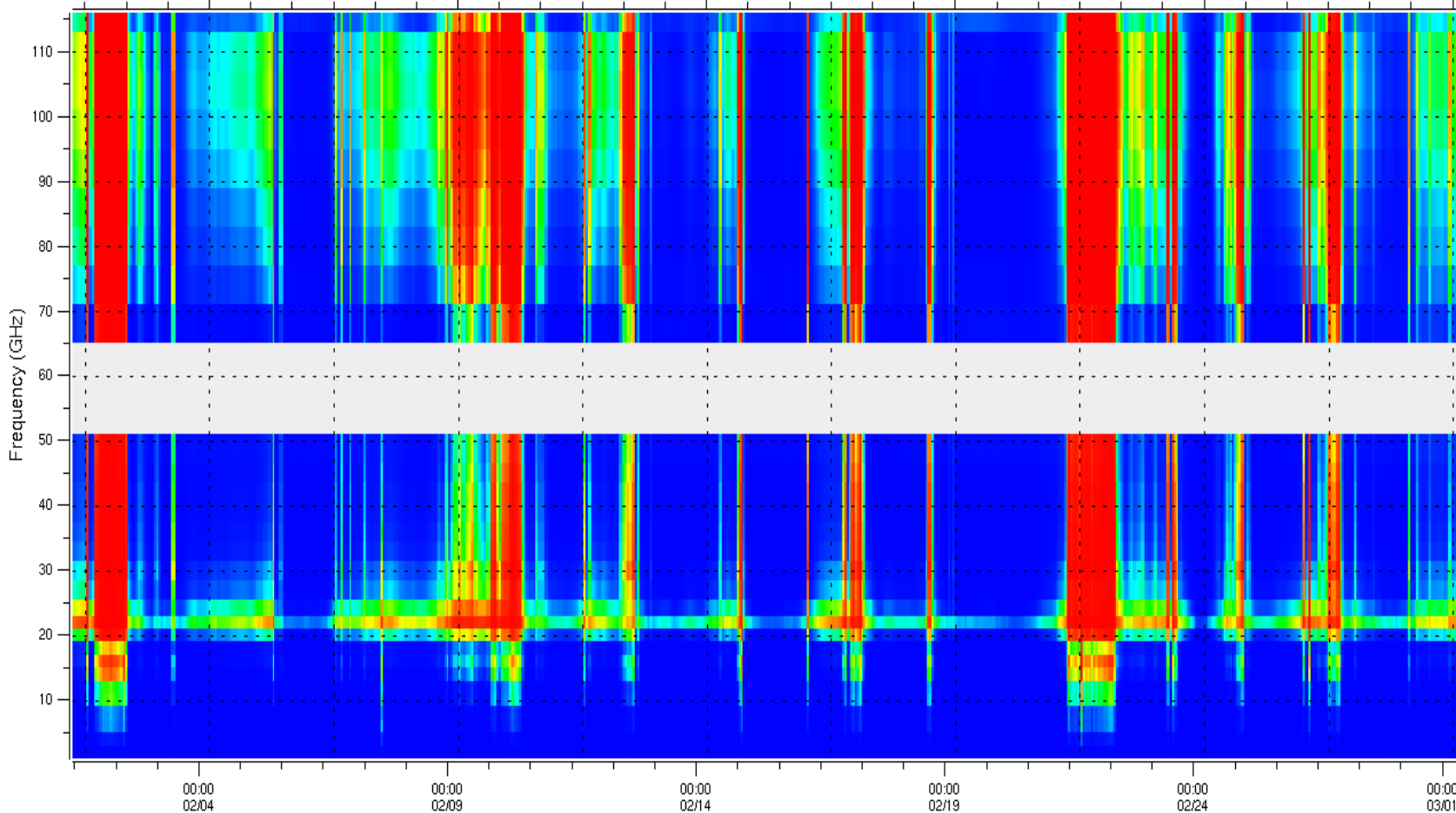
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UT Date and Time



DSS Overview Efficiencies from Tracking Errors (EffTrack)

Local Date and Time

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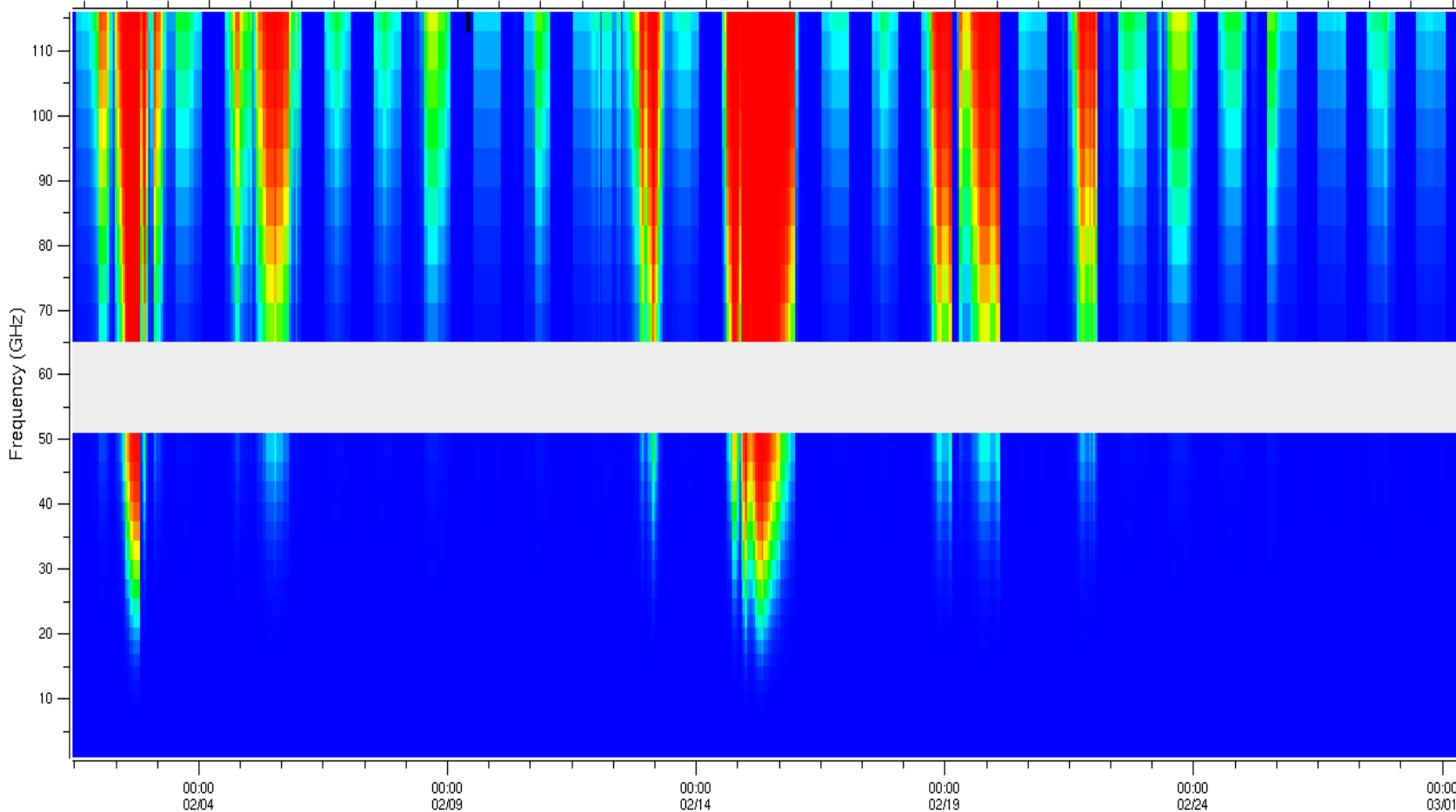
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UT Date and Time



DSS Overview Efficiencies from Surface Errors (EffSurf)

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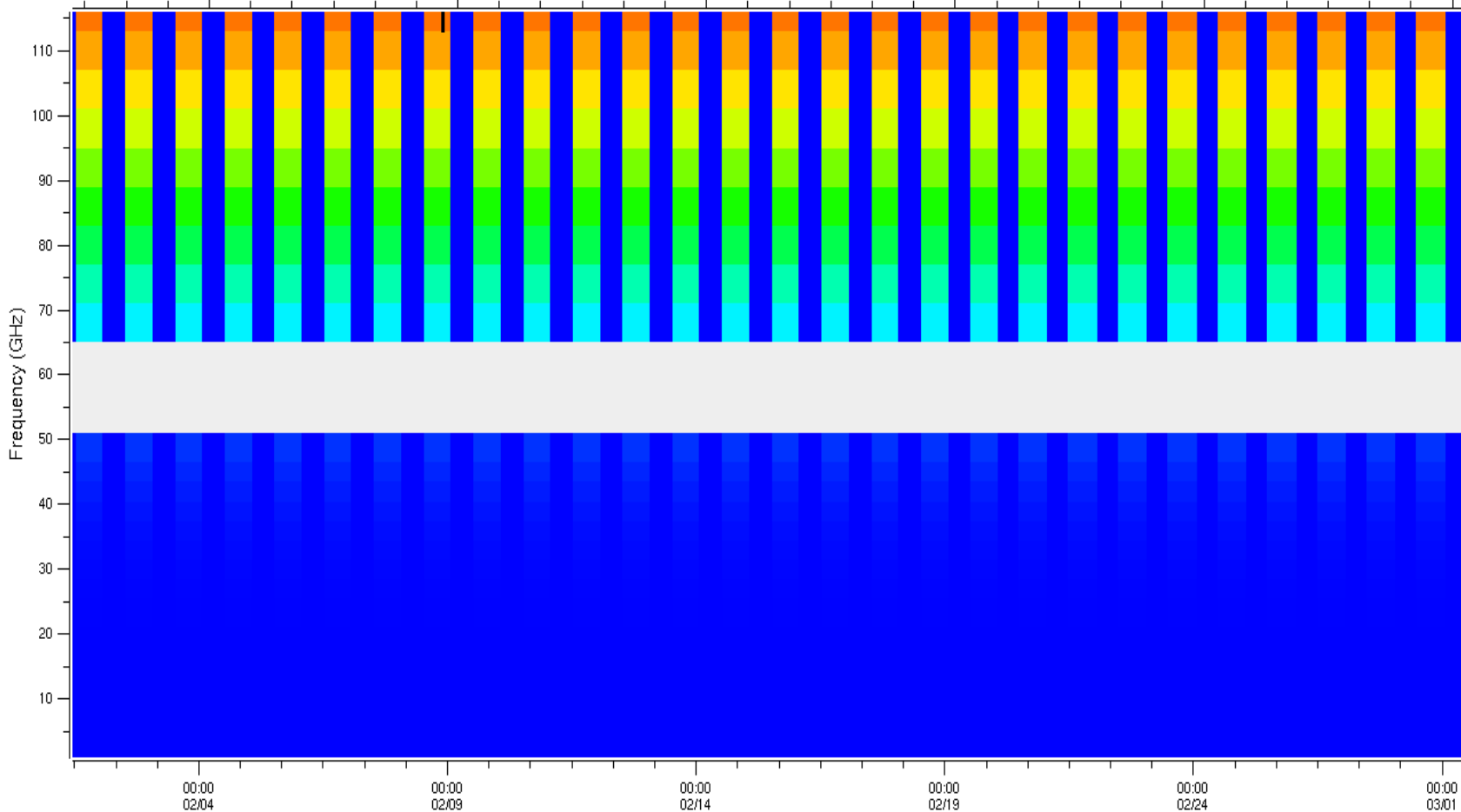
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UT Date and Time



DSS Overview Efficiencies (Eff)

Local Date and Time

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02/04
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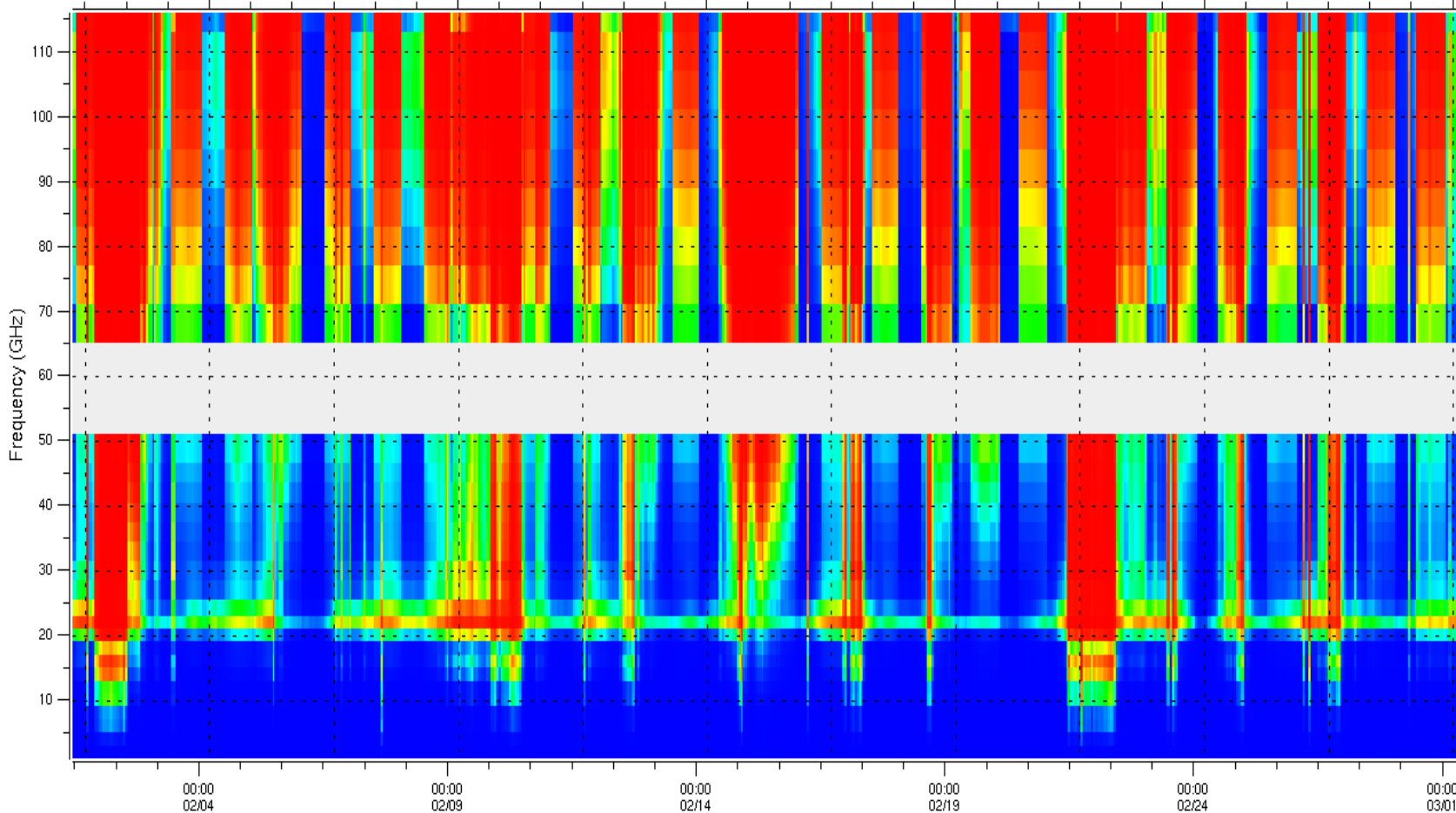
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UT Date and Time



DSS Overview DSS Score (Limits*Efs)

Local Date and Time

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02/04
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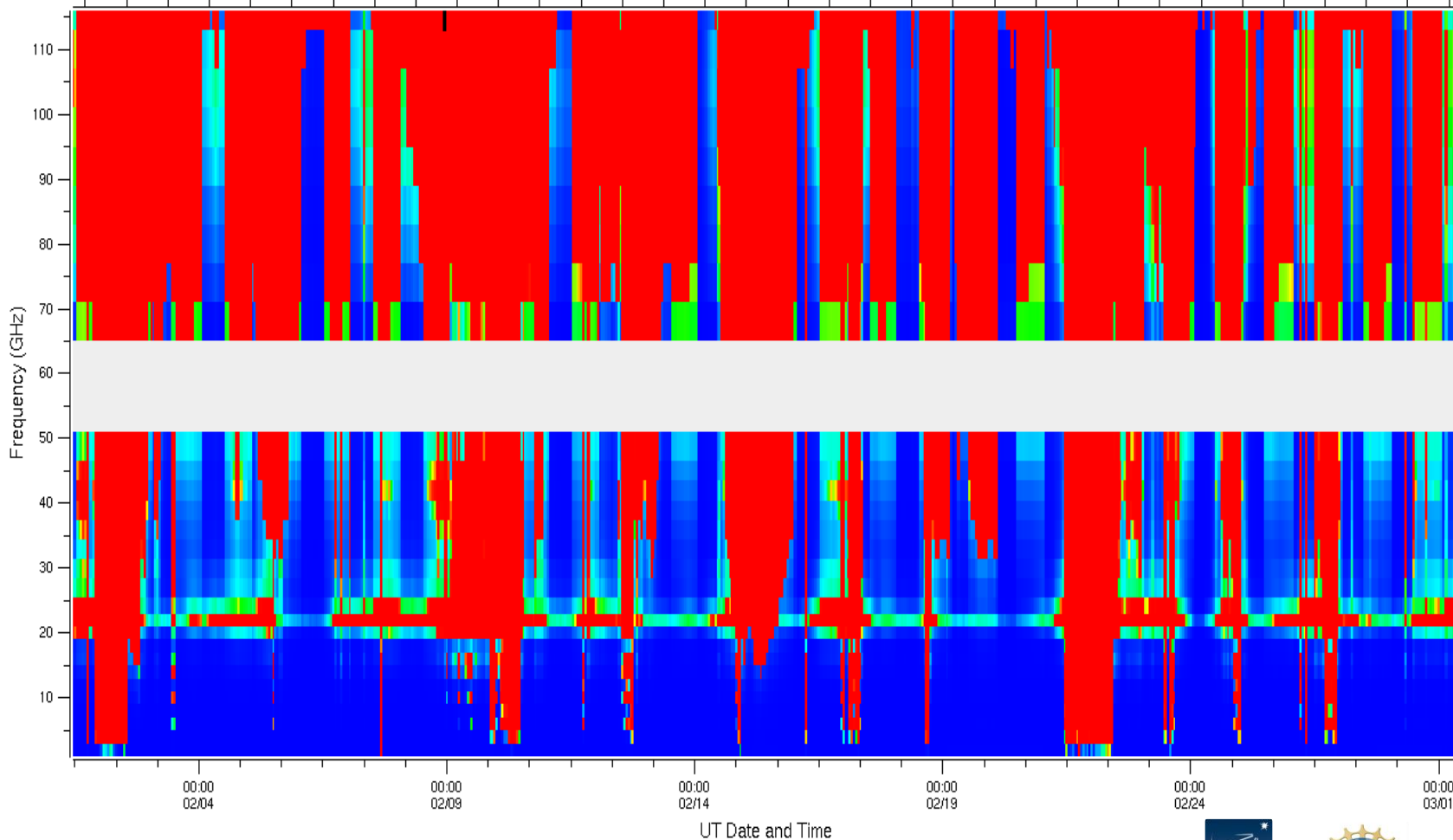
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Summary

- Wind Induced pointing errors are tolerable 80% of the year for 115 GHz
 - However, servo-induced pointing errors are currently more restrictive than wind-induced errors.
- Precipitable Water
 - < 10 mm for 30% of the year
 - < 5 mm for 20% of the winter months
 - As low as 0.8 mm
- Statistics for days with reasonable opacities are comparable to Owens Valley
- Weather under which Green Bank schedules 3-mm observations is comparable to the conditions under which ALMA schedules 3-mm observations.
 - Improvements to the GBT surface and multi-beam receivers will make the GBT a faster mapper than ALMA for low brightness extended emission.



Summary

- **Schedulable hours each year:**
 - W-band: 700-1800 hrs (with 1100 hrs @ CO(1-0))
 - Approximately double this if we could observe at W-band during the day!!
 - Surface and servo errors are larger during the day
 - Q- and Ku-band: 4000-5600 hrs
 - 22 GHz: 900 Hrs (22 GHz is the toughest frequency)
- **Dynamical Scheduling**
 - Tries to balance the scheduling of projects that have a extremely wide range of tolerances to weather conditions
 - Forecasts are sufficiently accurate ($\Delta\tau \sim 0.01$ to 0.03)
 - Reliable to ~ 4 days, though we only schedule for ~ 2 days
 - Could be more aggressively scheduling high frequencies
 - Doesn't add a buffer around those times when conditions undergo large changes.
- **Weather conditions, performance of the GBT, and DSS are synergistic. Suggested changes will enhance the synergy.**

