# Frequency-Dependent Characteristics of the EME Path

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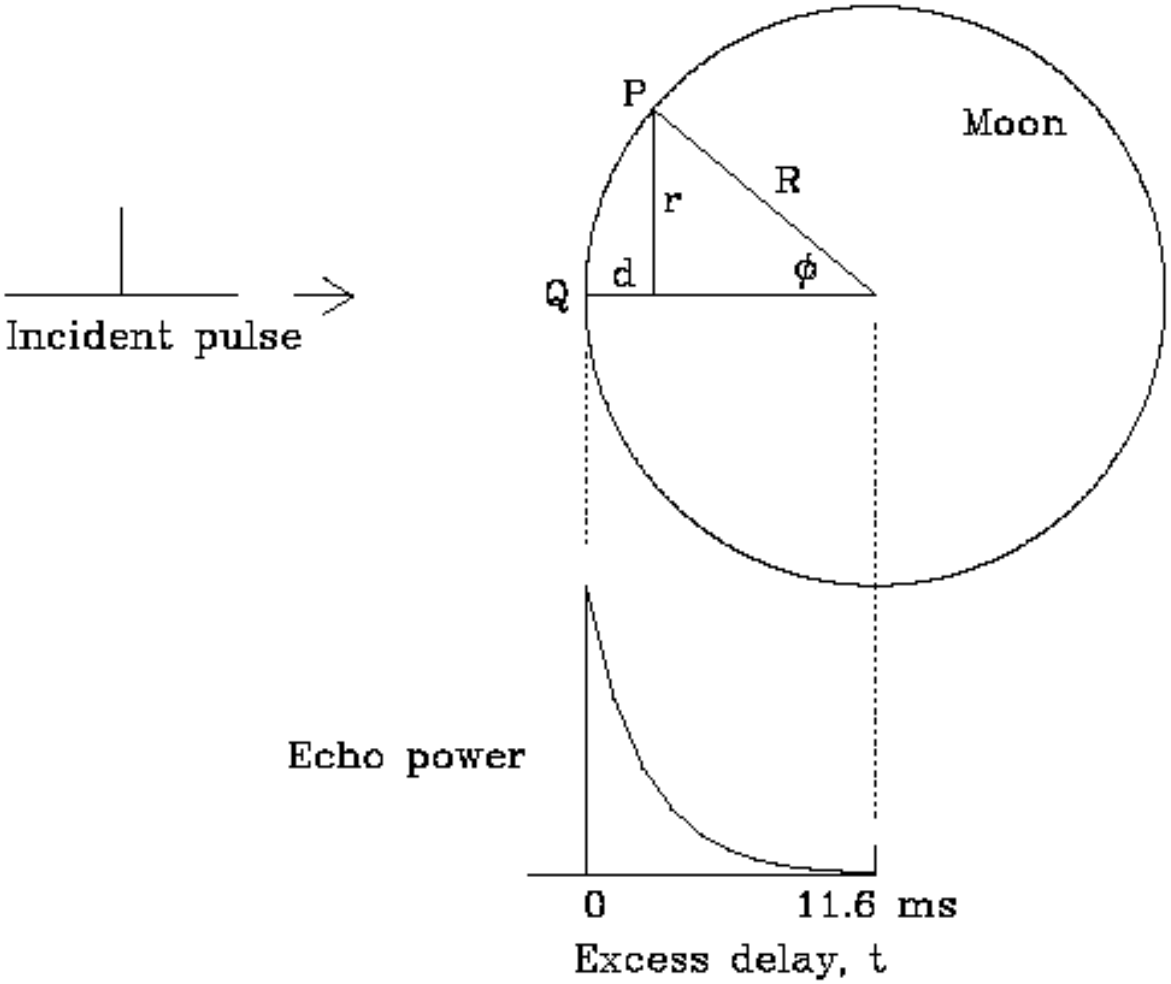
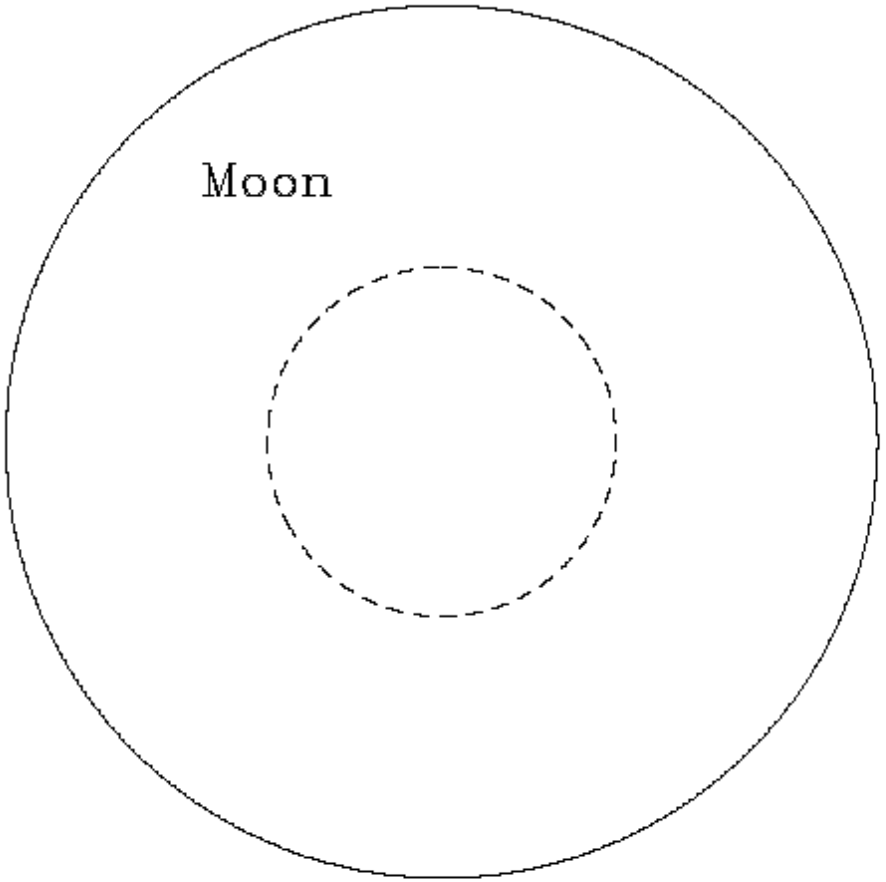
14th International EME Conference, Dallas
August 12 - 14, 2010

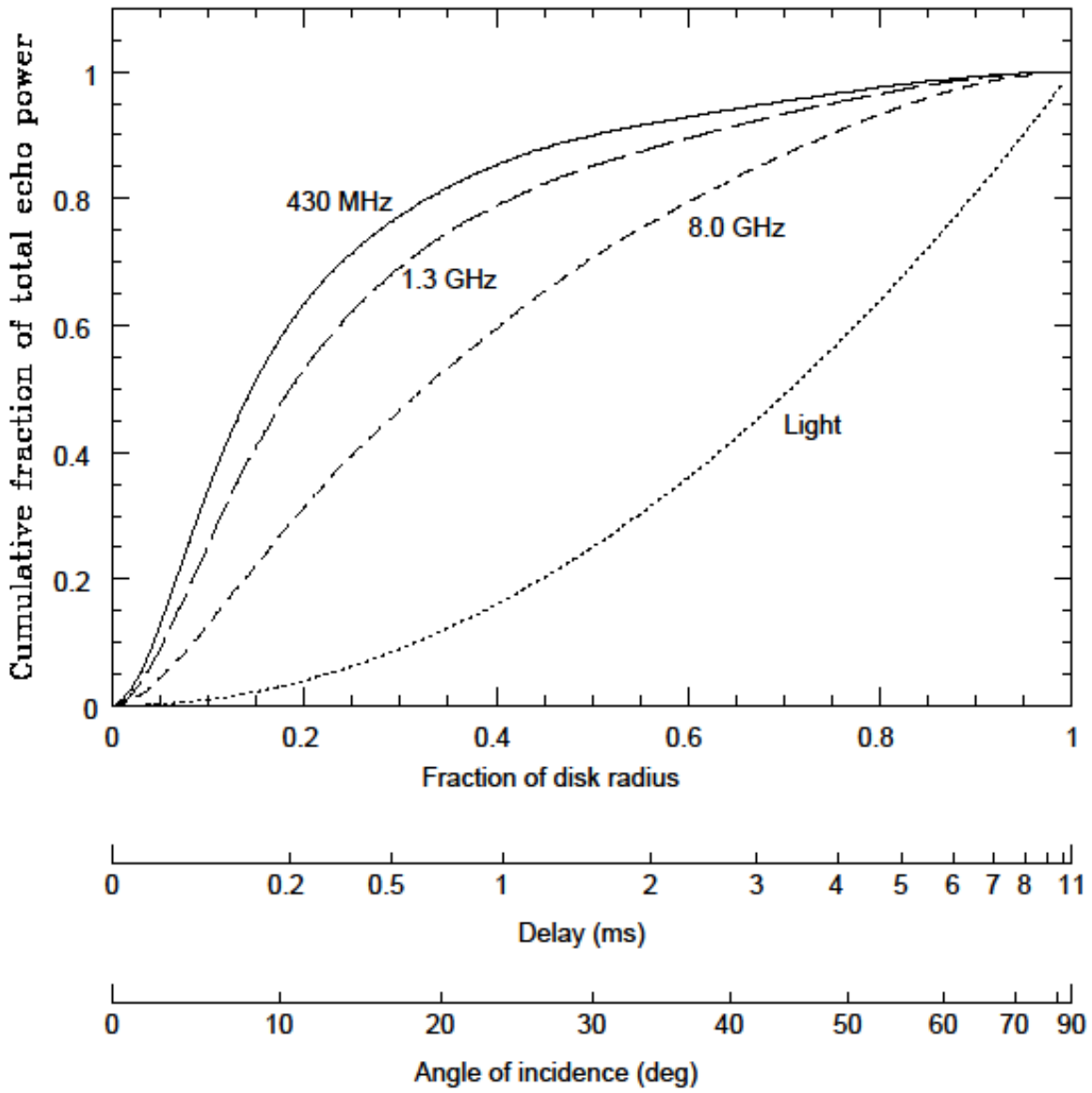
# EME Geometry (side view)



# EME Geometry (from Earth)

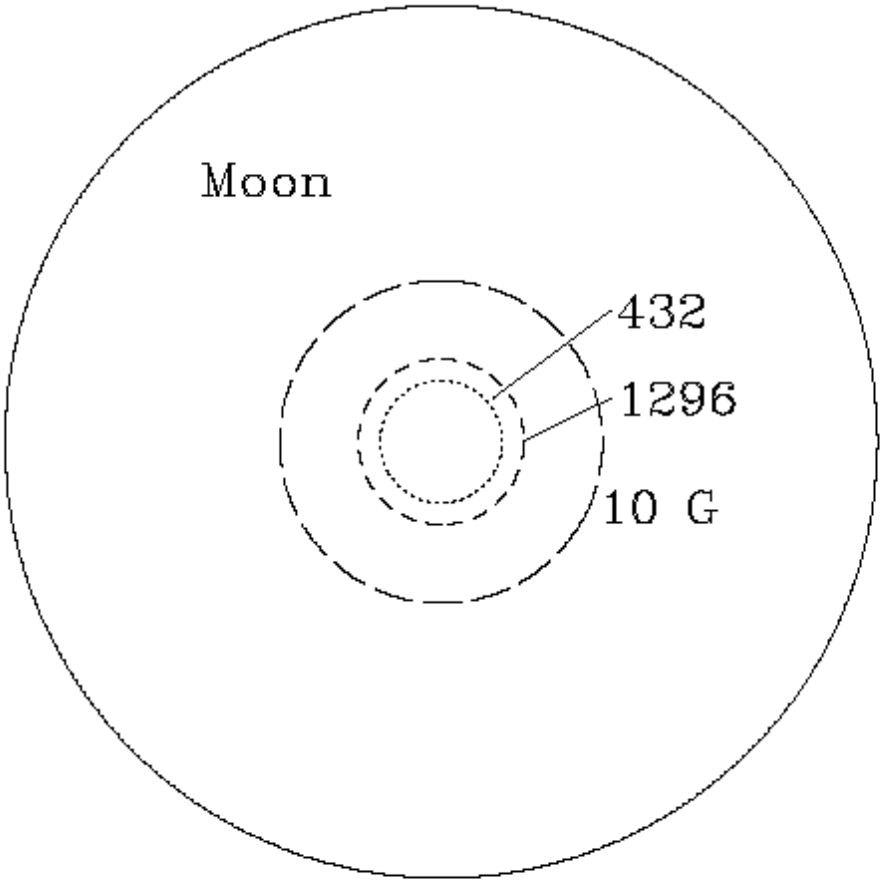


# Cumulative Echo Power

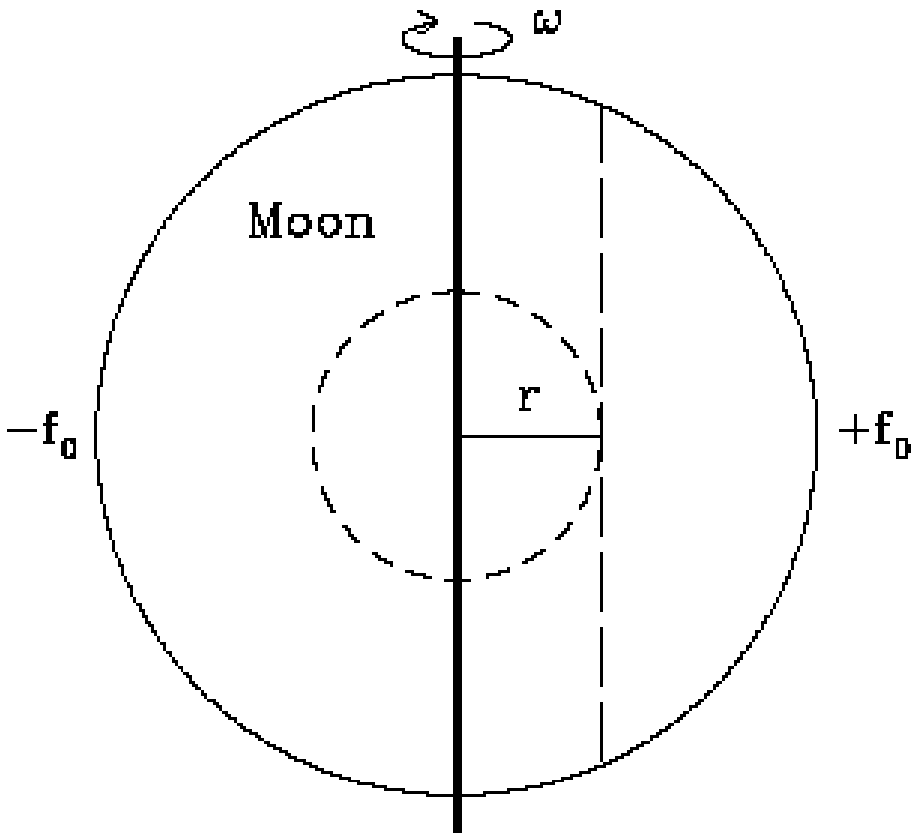



Reference:
Hagfors (1970)

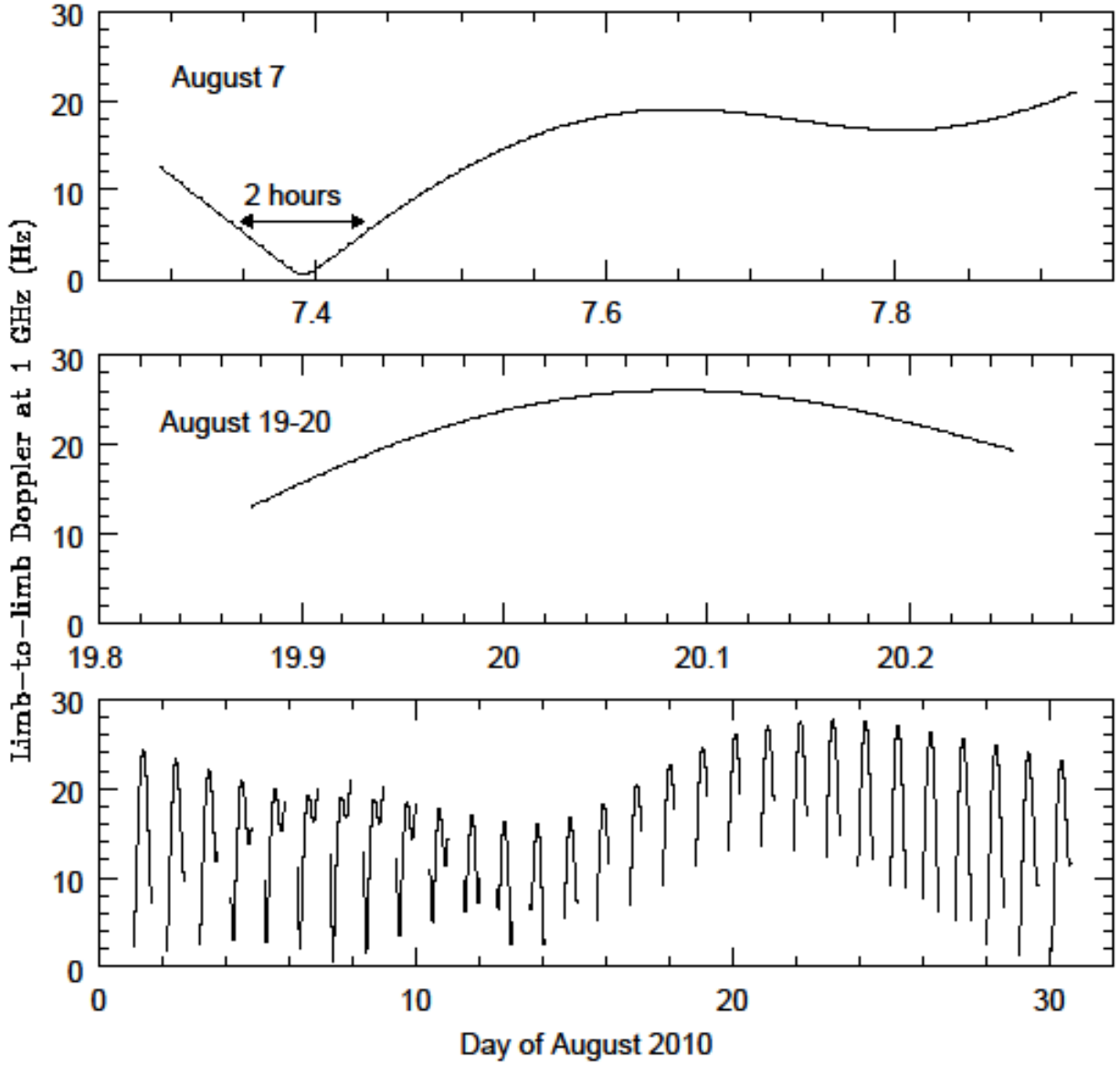
# EME Geometry (from Earth)



# EME Geometry (from Earth)



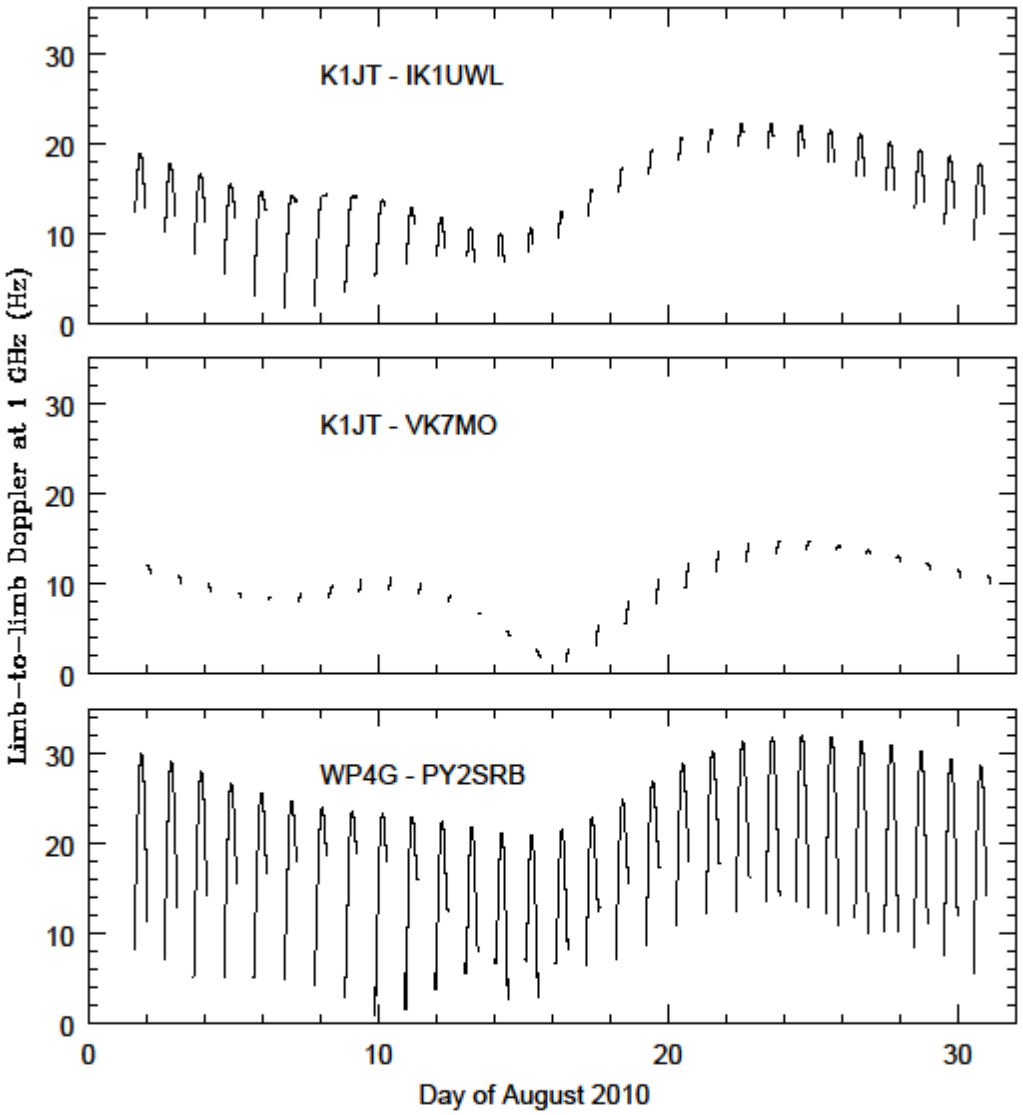
# Predicted Doppler Spread




Self-echos at K1JT

f = 1 GHz

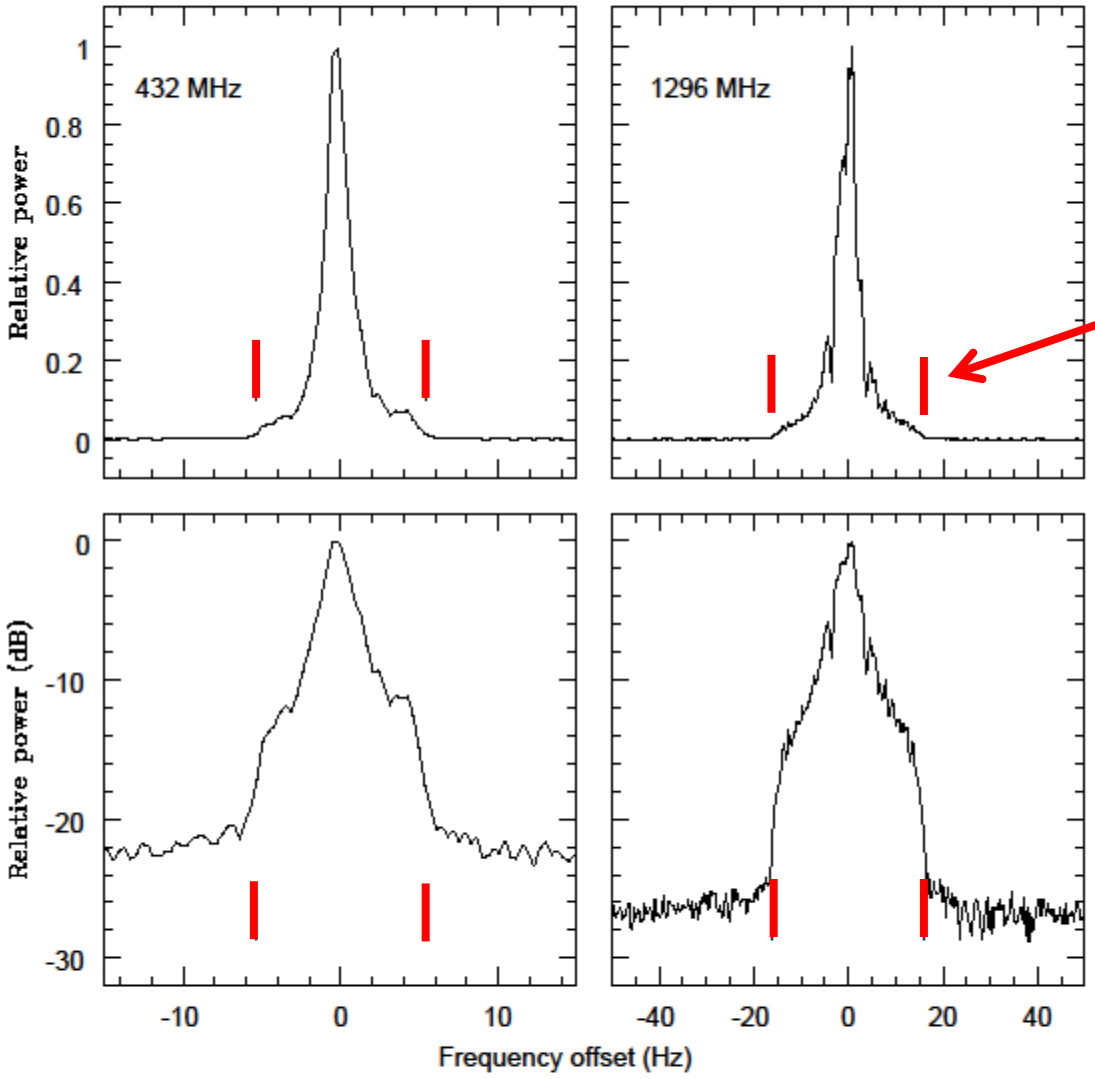
# Two-Station Predictions




f = 1 GHz

Calculations now in WSJT 9.0

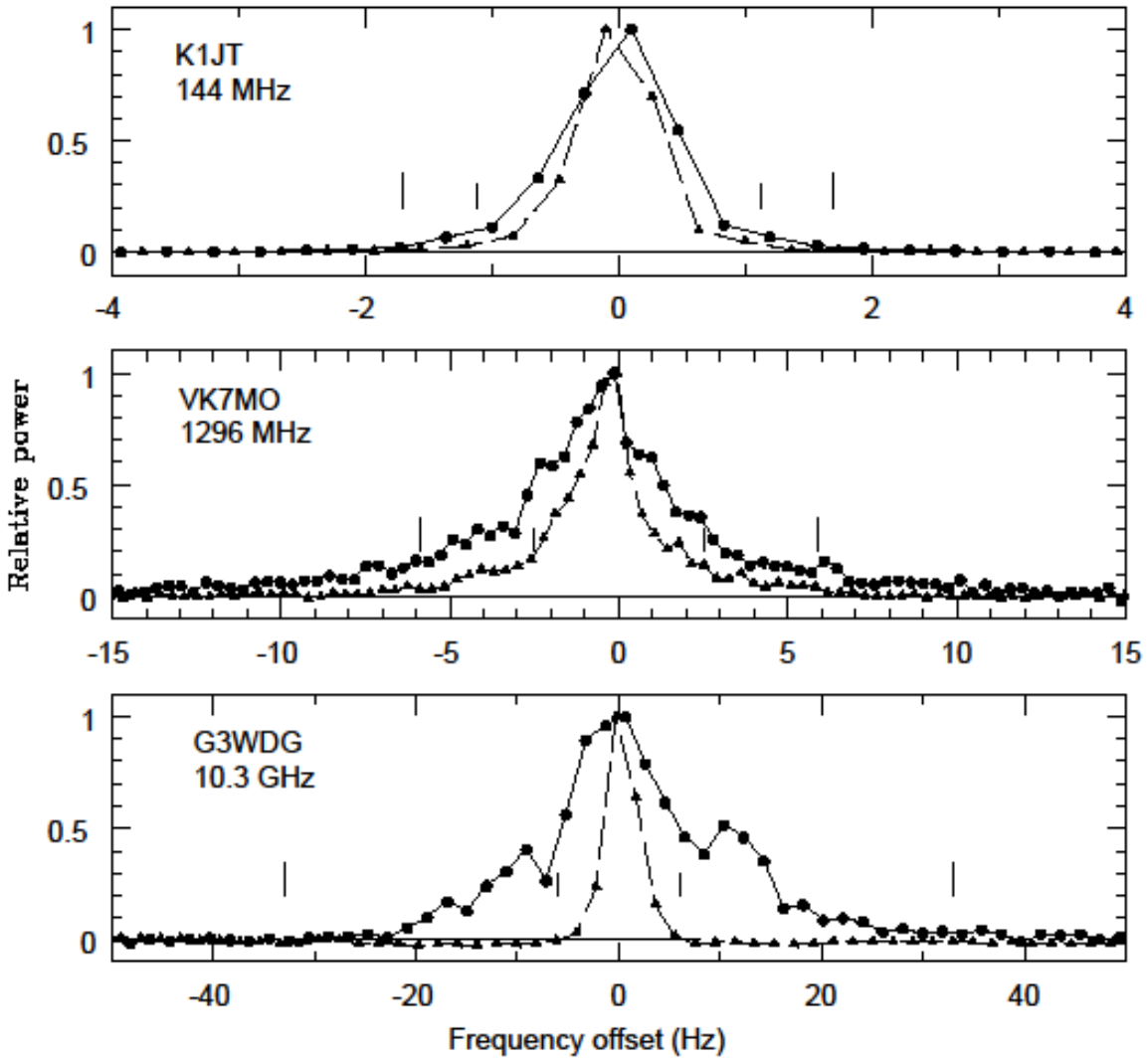
# Measurements at 432 and 1296 MHz




Predicted limb-to-limb Doppler spread

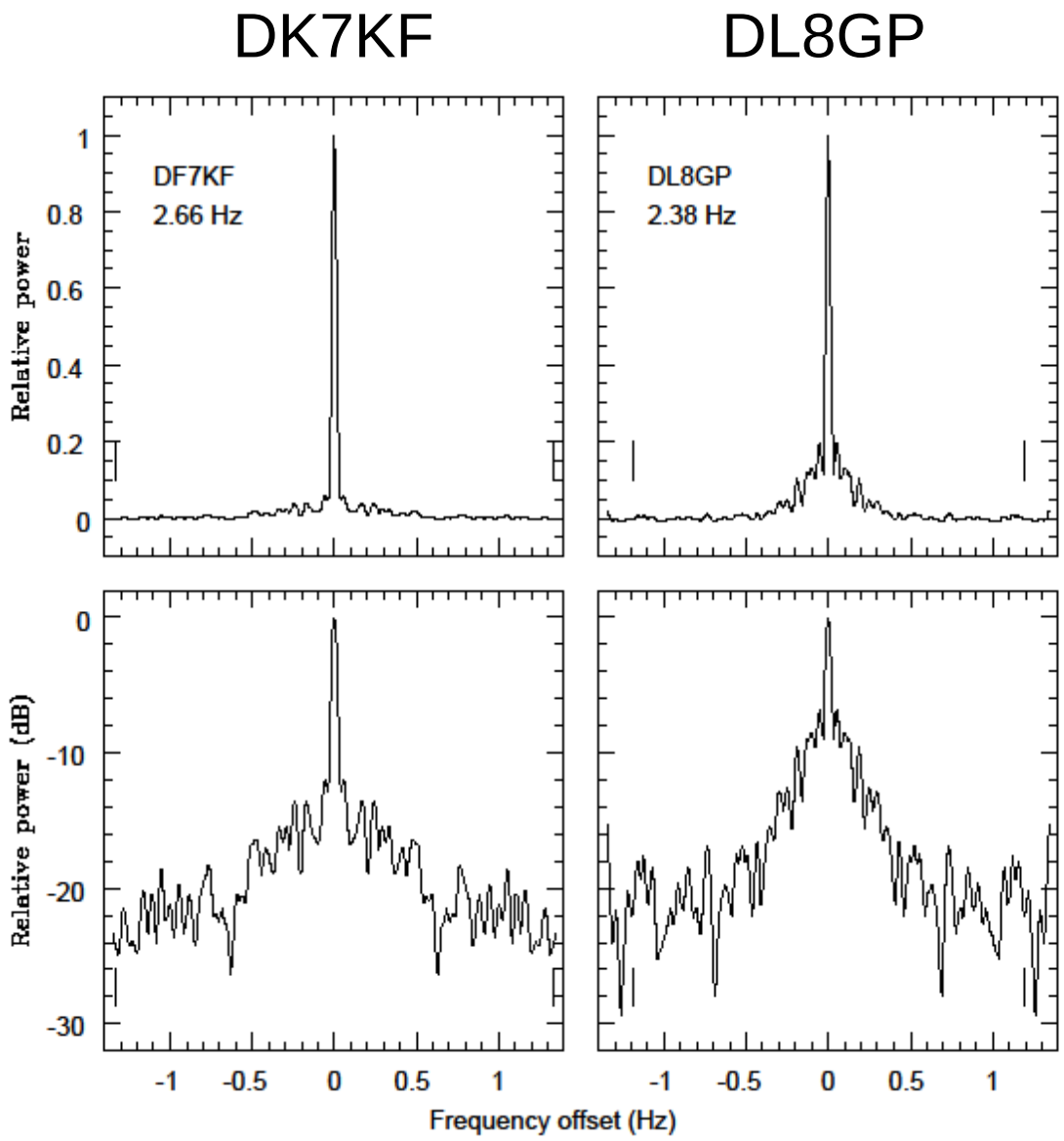
Measurements at K2UYH using WSJT 8.0 Echo Mode

# High and Low Libration Rates



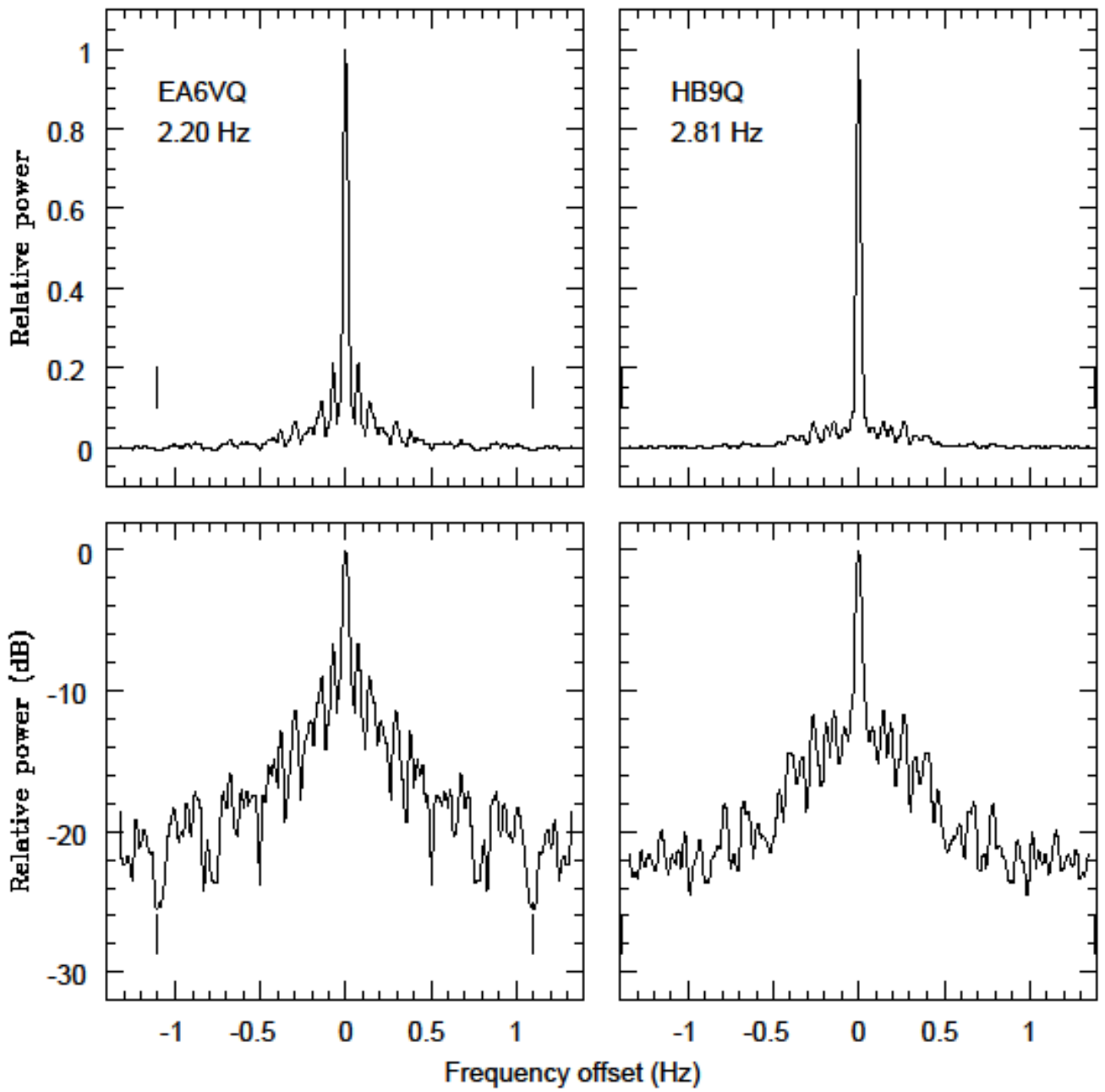

Self-echo measurements using WSJT 8.0

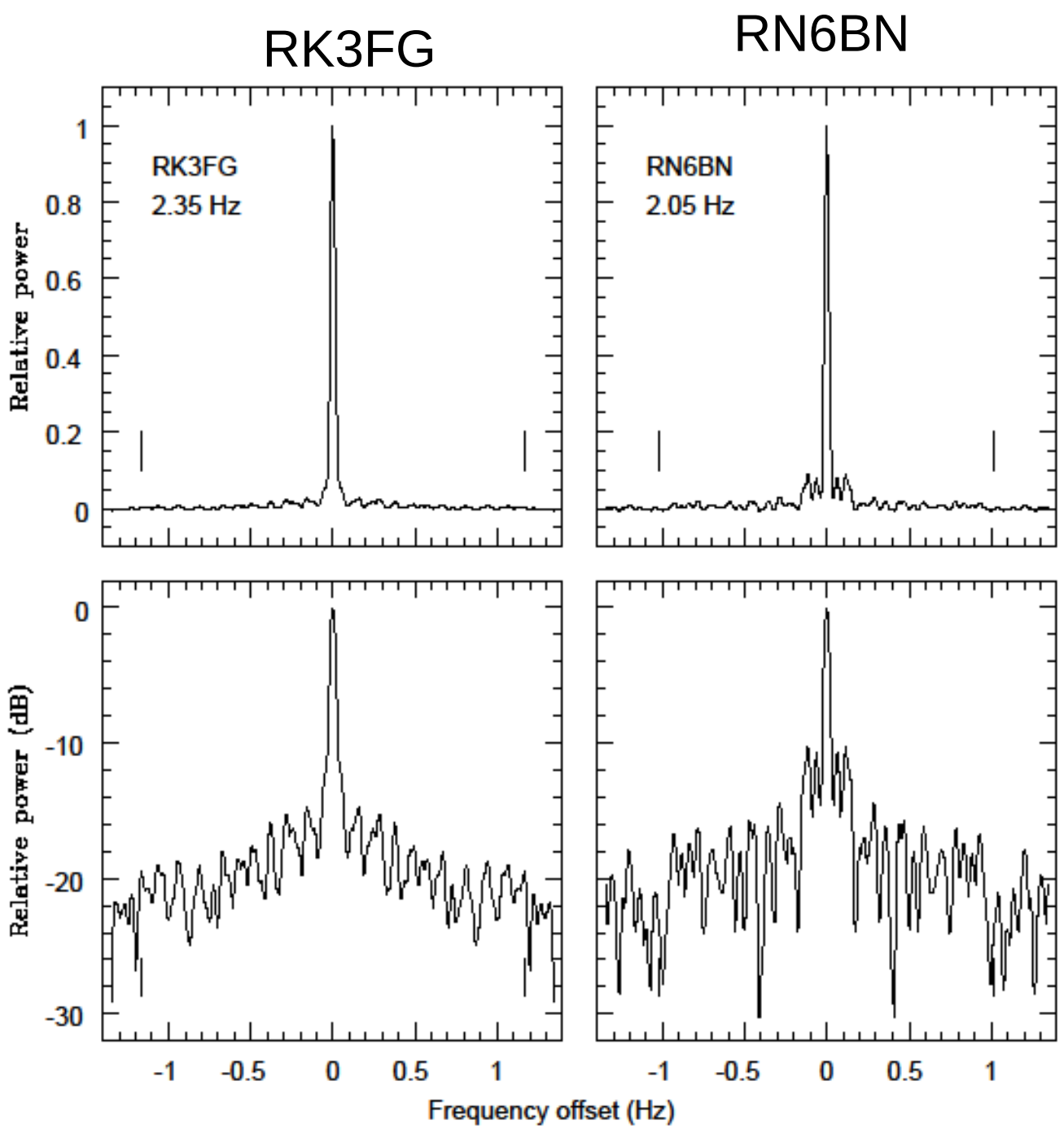
# Bi-Static Measurements - 144 MHz

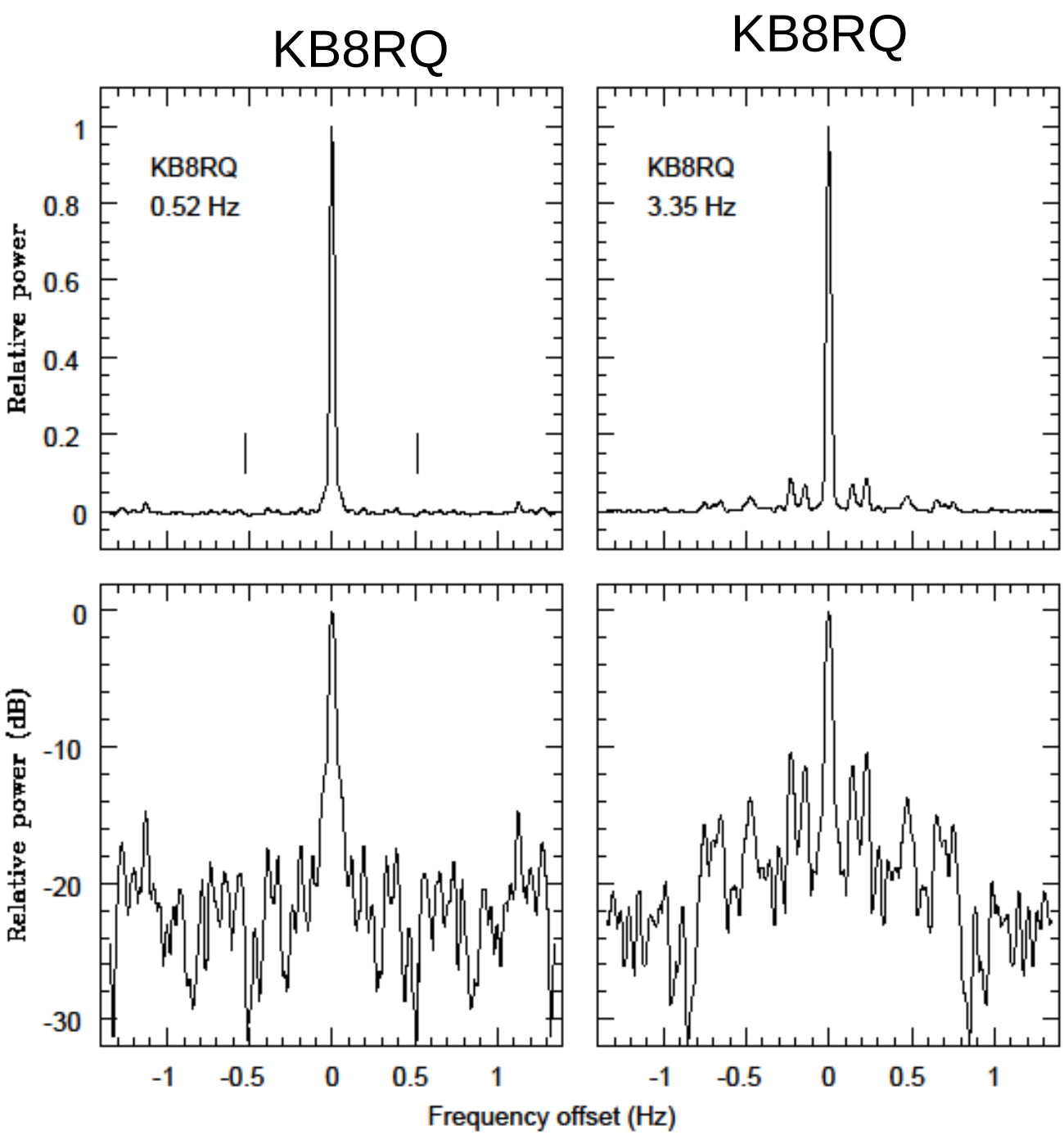



JT65B signals, duration 47 s, received at K1JT

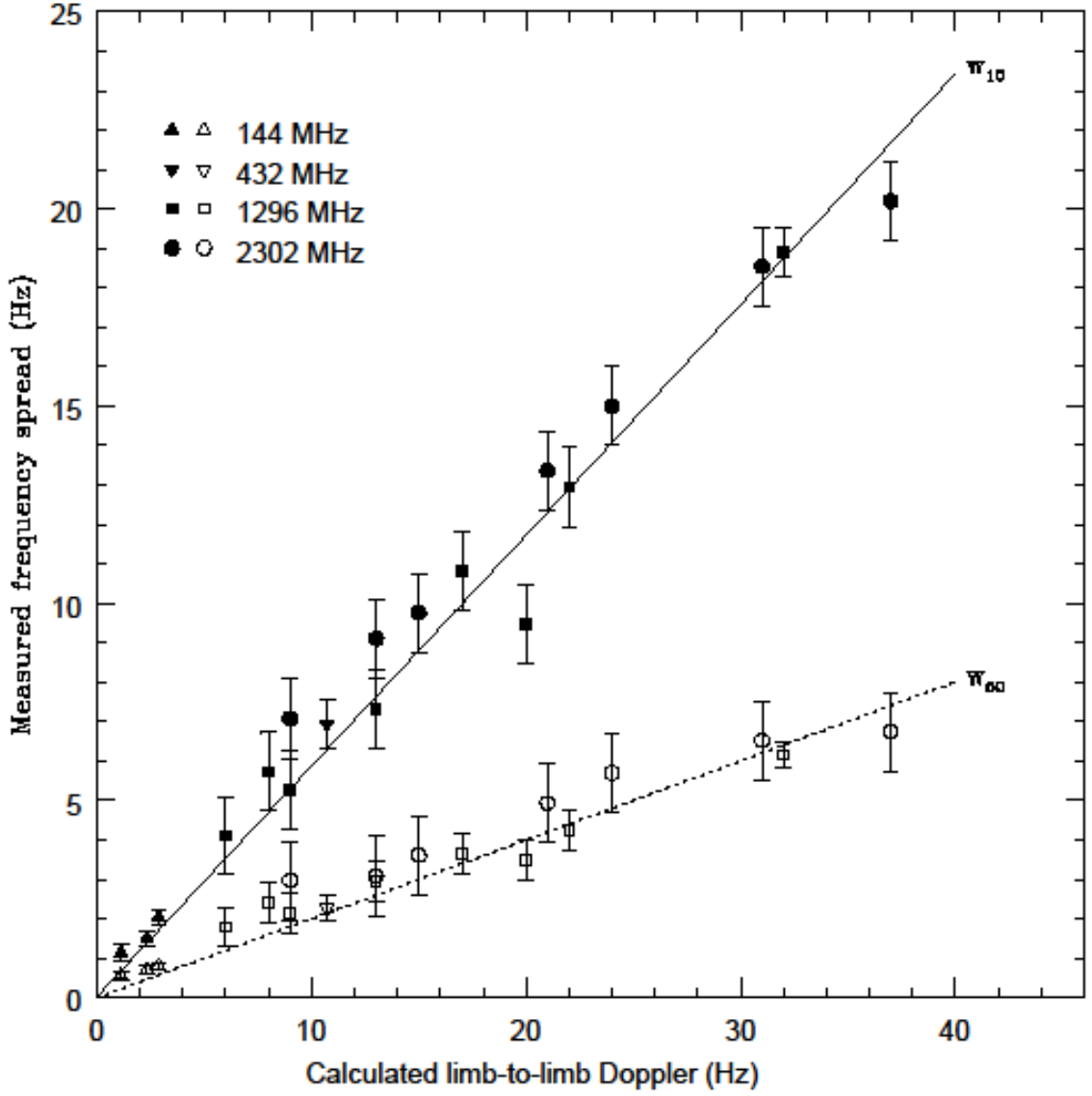
Spectra computed from symbol-to-symbol fading


EA6VQ
HB9Q
EA6VQ
2.20 Hz
HB9Q
2.81 Hz
Relative power
1
0.8
0.6
0.4
0.2
0
Relative power (dB)
0
-10
-20
-30
-1
-0.5
0
0.5
1
Frequency offset (Hz)


RK3FG
RN6BN
RK3FG
2.35 Hz
RN6BN
2.05 Hz
Relative power
1
0.8
0.6
0.4
0.2
0
Relative power (dB)
0
-10
-20
-30
-1
-0.5
0
0.5
1
Frequency offset (Hz)


KB8RQ
KB8RQ
KB8RQ
0.52 Hz
KB8RQ
3.35 Hz
Relative power
Relative power (dB)
Frequency offset (Hz)
1
0.8
0.6
0.4
0.2
0
-10
-20
-30
-1
-0.5
0
0.5
1

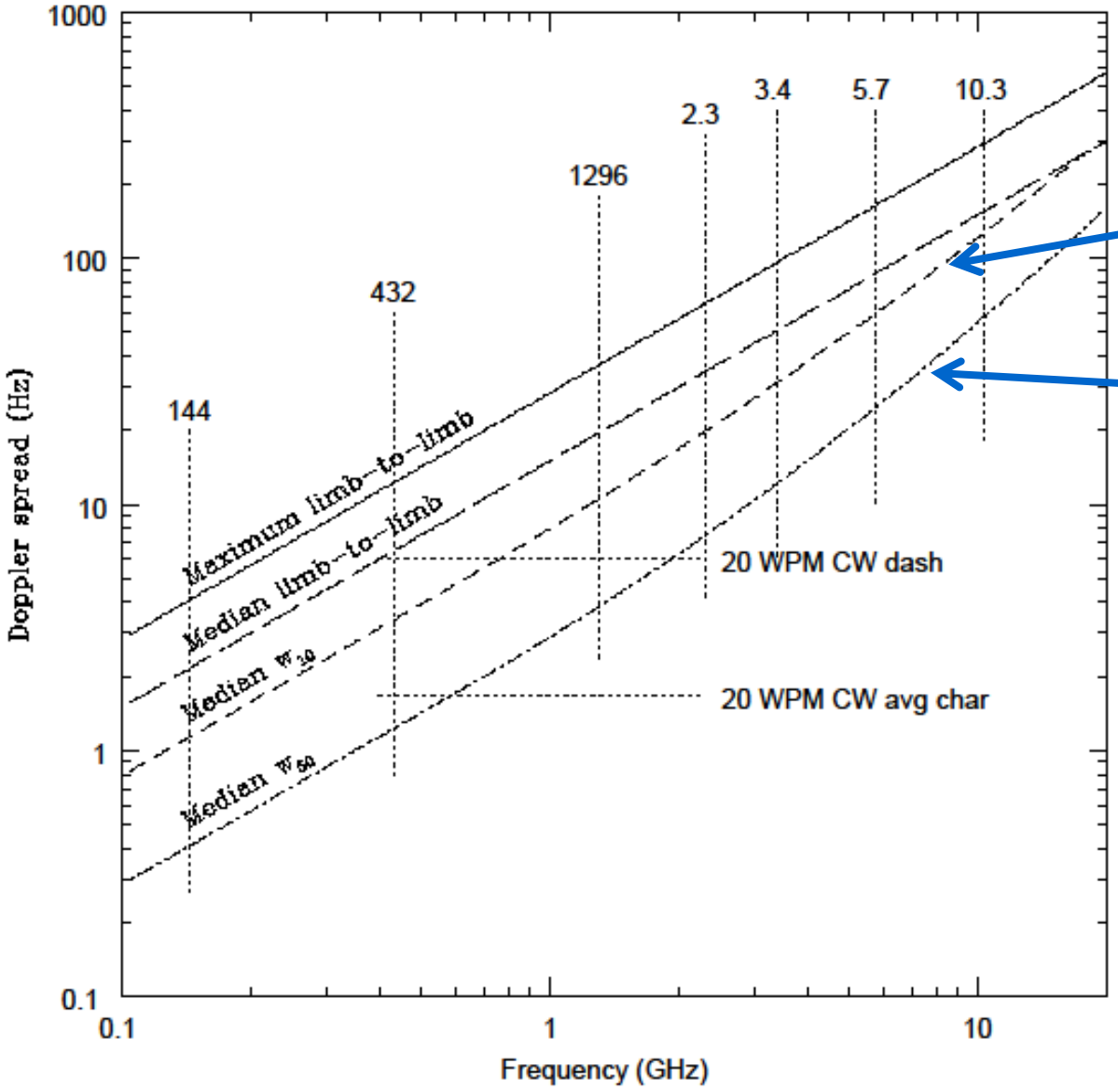
# Summary of Measurements




$W_{10}$

$W_{50}$

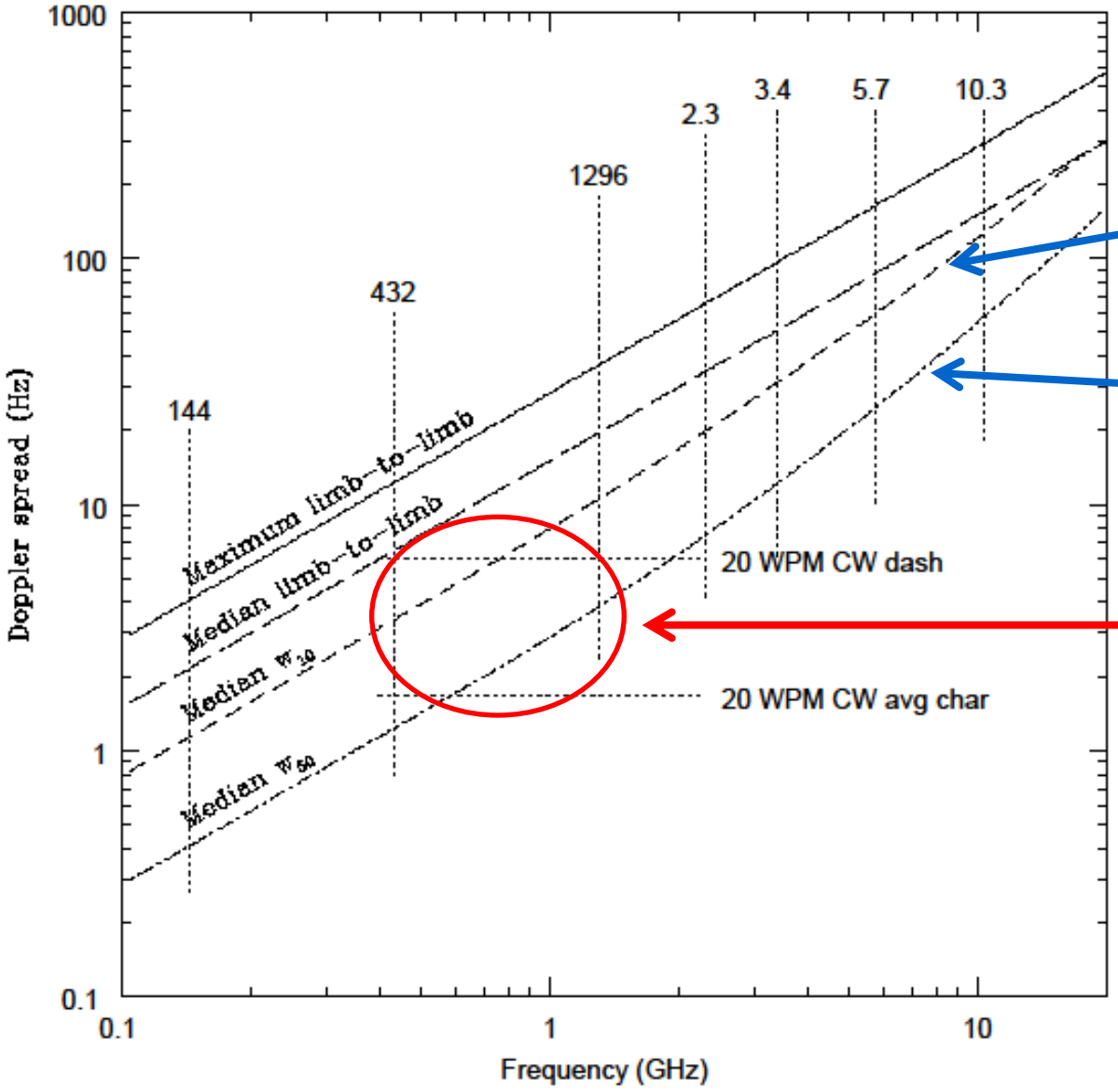
# Implications for Amateur EME




$W_{10}$

$W_{50}$

# Implications for Amateur EME




$W_{10}$

$W_{50}$

Region of difficult-to-copy CW

# Typical Numbers, by Band

| Frequency (MHz) | Maximum Spread (Hz) | Median Spread (Hz) | Median $w_{10}$ (Hz) | Median $w_{50}$ (Hz) |
|---|---|---|---|---|
| 144 | 4 | 2.2 | 1.1 | 0.4 |
| 432 | 12 | 7 | 3 | 1.2 |
| 1296 | 37 | 19 | 10 | 4 |
| 2304 | 65 | 35 | 20 | 8 |
| 3400 | 97 | 51 | 31 | 12 |
| 5760 | 164 | 86 | 60 | 25 |
| 10368 | 295 | 156 | 128 | 58 |

# Summary

- EME echoes are nearly specular at VHF, increasingly diffuse at UHF and up
- Libration fading = Doppler spread – different manifestations of same effect !
- Libration is predictable: depends on station locations, daily and monthly cycles
- Deep libration minima are short (< 2 hours)
- EME at 70 and 23 cm can benefit from well-structured coding/modulation diversity

# Coming WSJT Features

## WSJT 7

- FSK441
- JT6M
- JT65 A-C
- JT4 A-G
- WSPR

## WSJT 9

- FSK441
- ISCAT
- JT65 A-C
- JT4 A-G
- Echo
- JTMS (?)
- JT65AA (?)