Bistatic Radar Observations of Small, Slowly Rotating

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with help from the technical staffs at Arecibo and Green Bank

Future of Planetary Radio Astronomy
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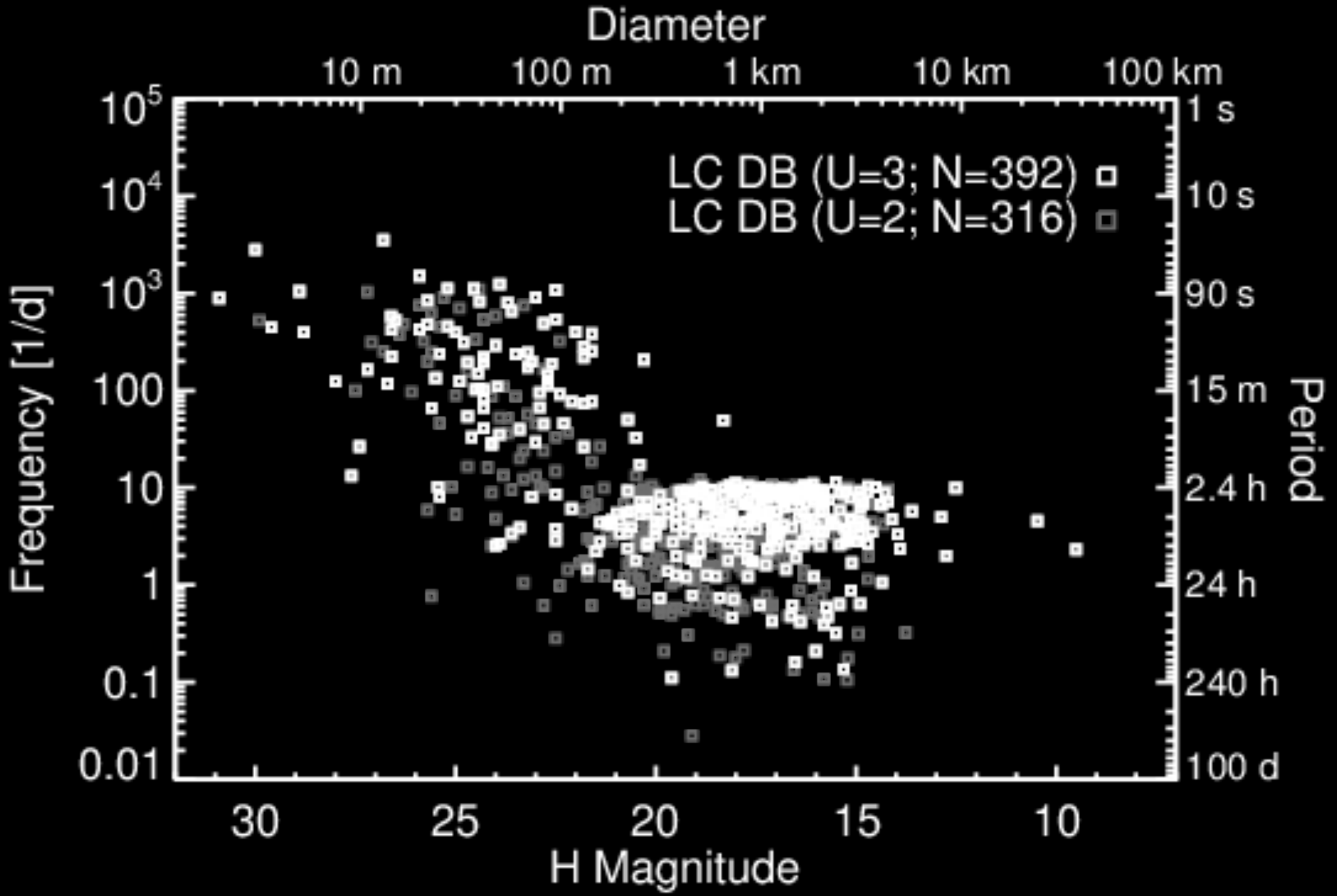
Optically Derived NEA Population



Mathematical Interlude

$$\text{Signal} \propto \frac{P_{\text{tx}} A_{\text{eff,tx}} A_{\text{eff,rx}} D^2}{RTT^4}$$

Want high power, large effective area (gain);
a big and close target is best

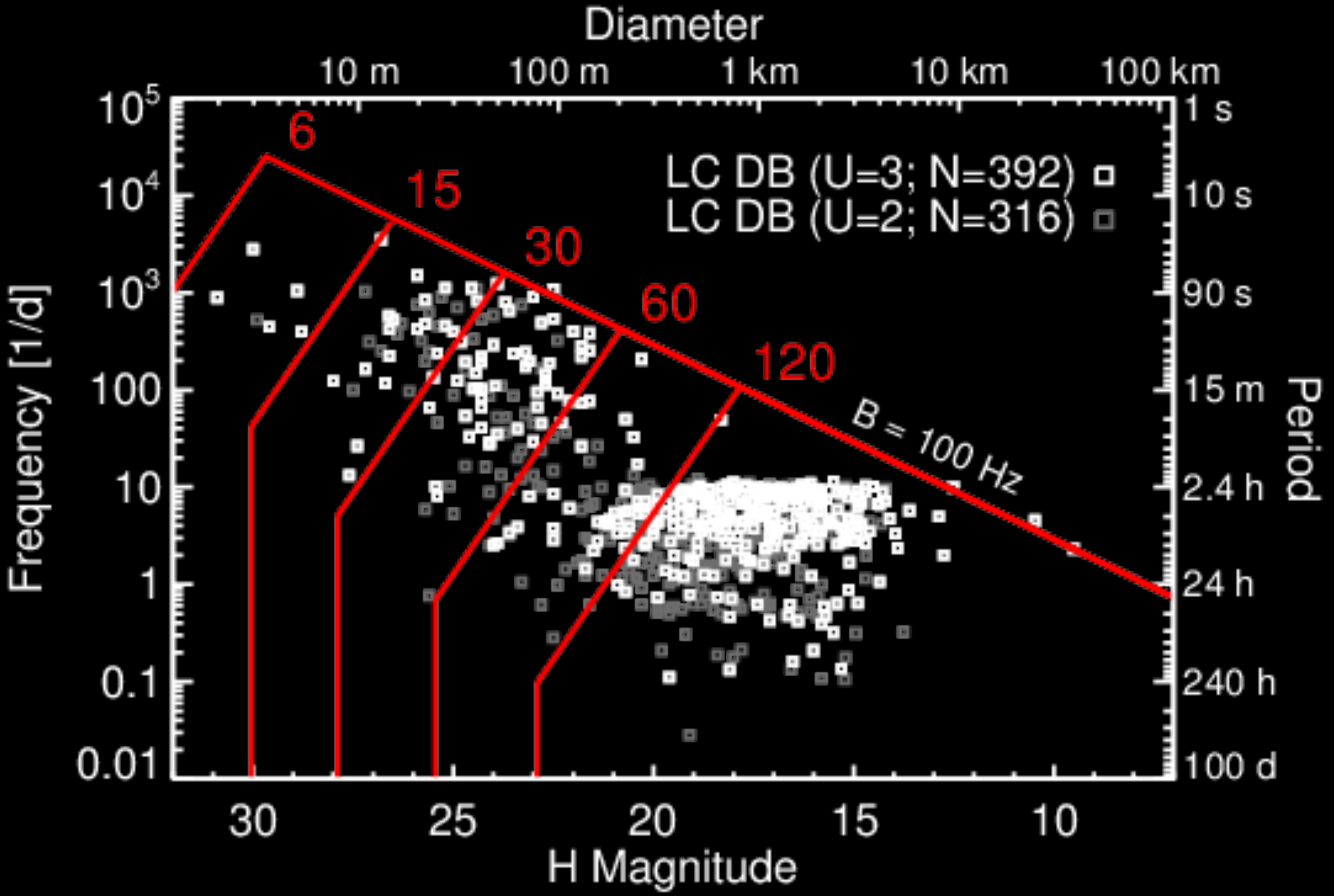
$$\text{Noise} \propto \frac{T_{\text{sys}} B}{\sqrt{B t_{\text{int}}}}$$

Narrow bandwidths improve SNR

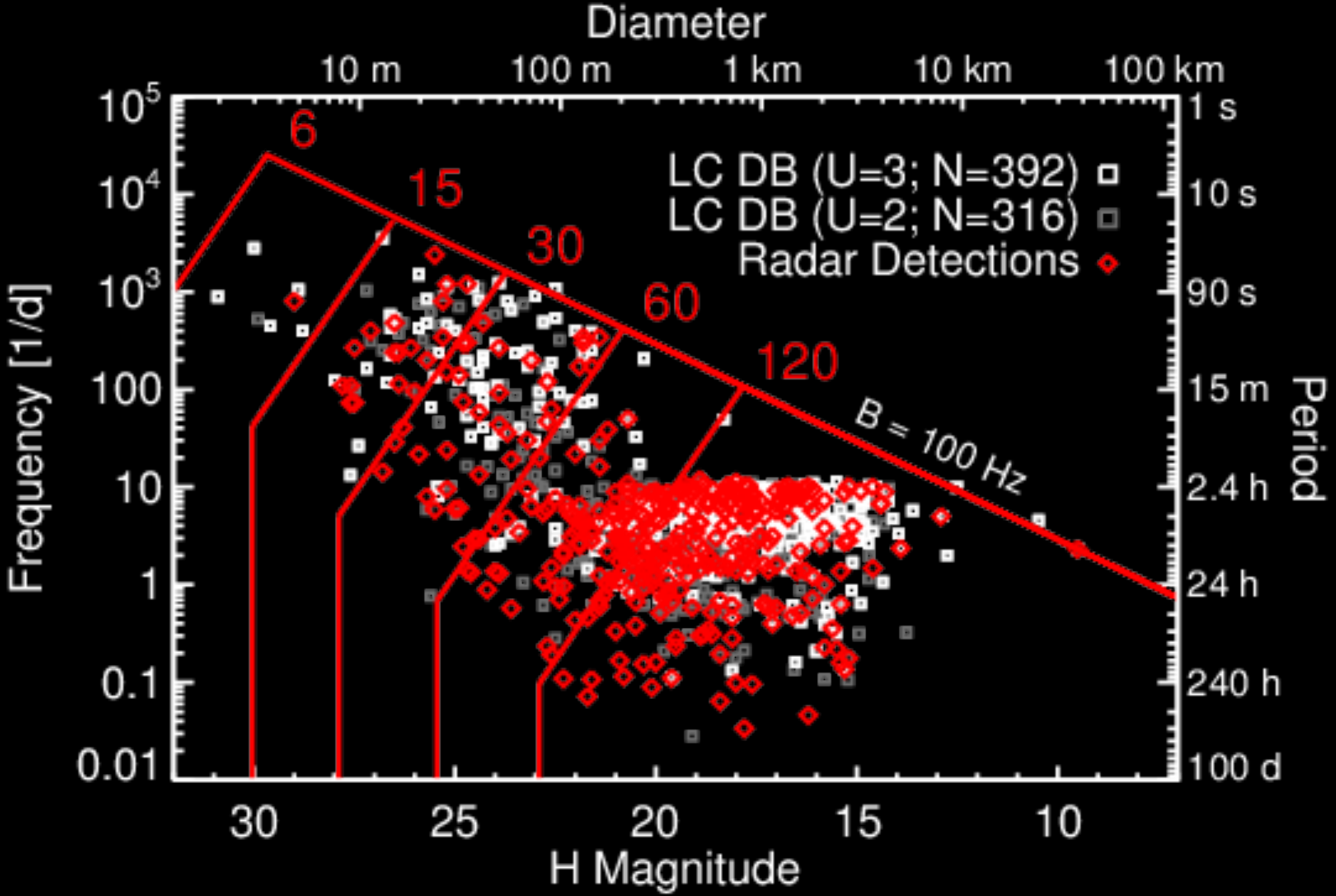
$$B \propto \frac{D}{P} \cos\delta$$

Narrow bandwidths indicates slow rotation
OR a pole-on viewing geometry

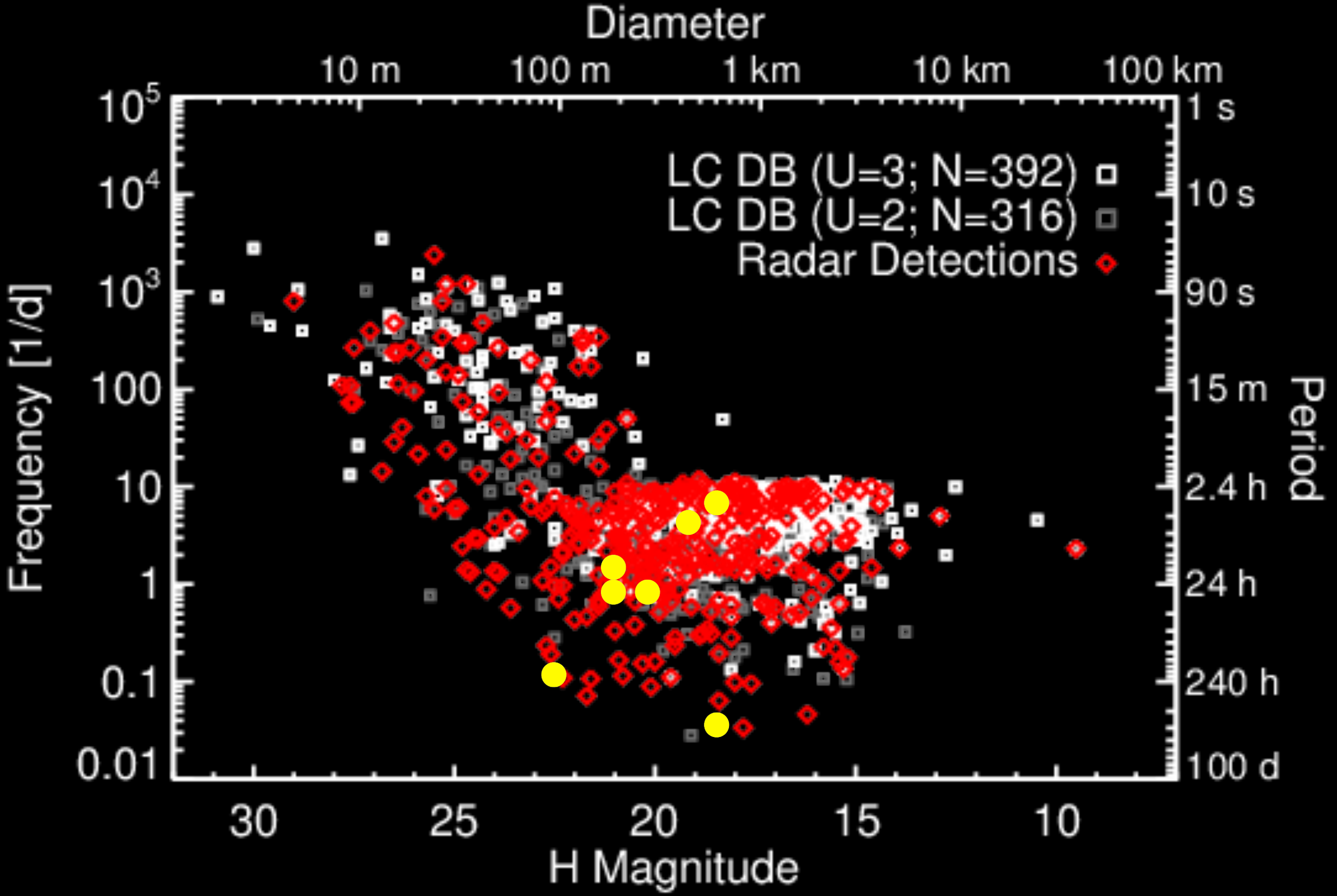
Arecibo Radar Detectability



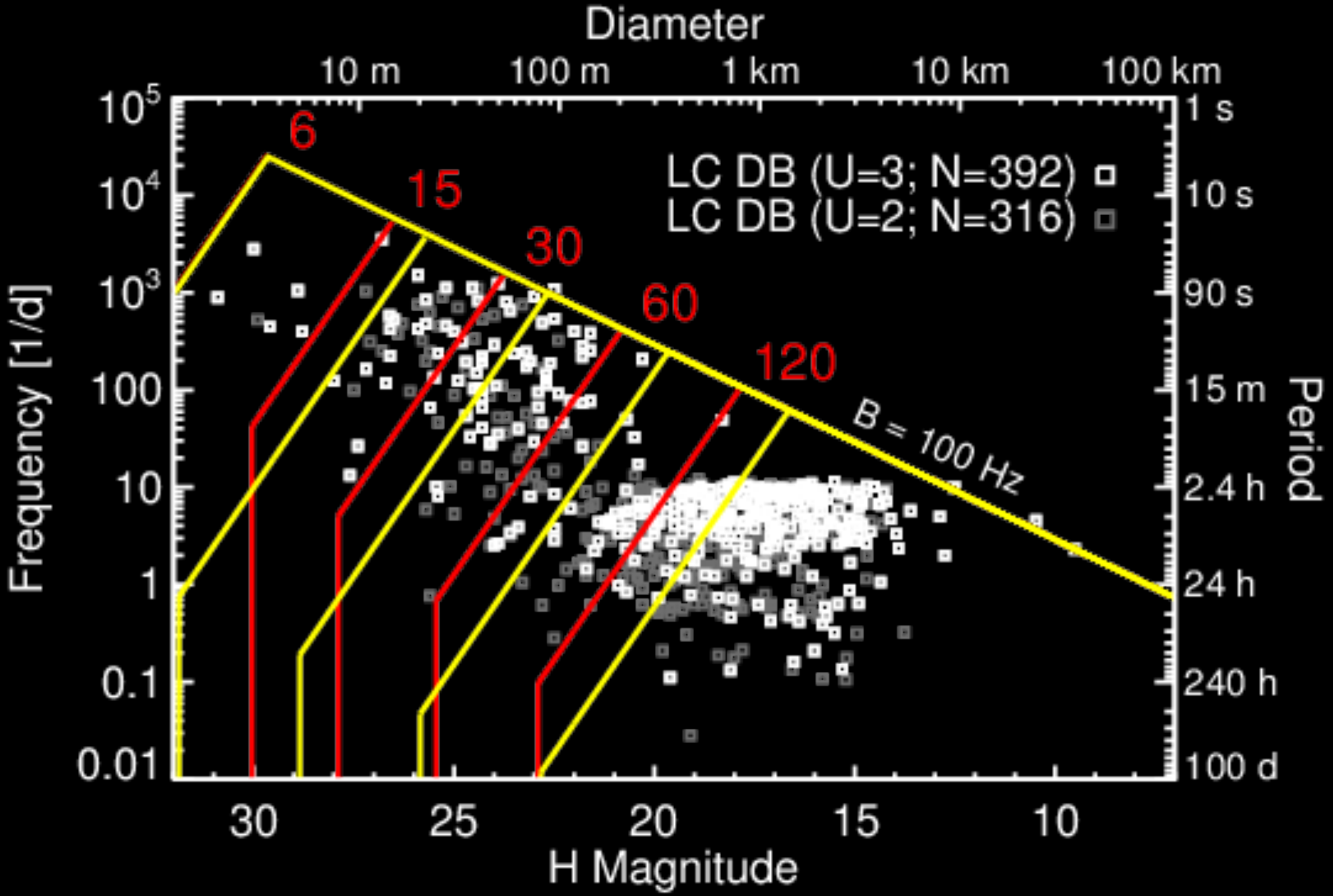
Radar Observed NEAs with Arecibo



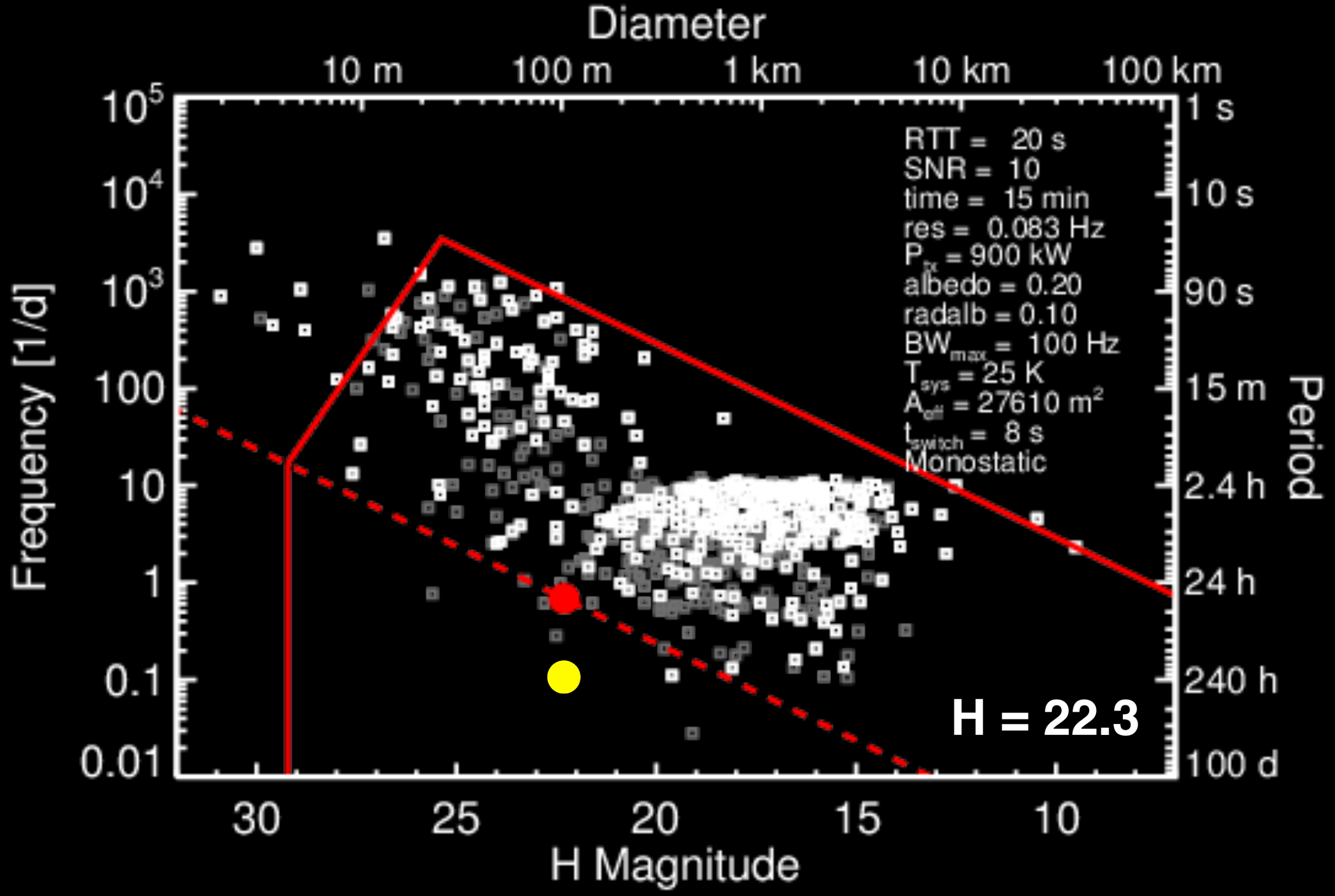
Previous Bistatic AO/GBT Attempts



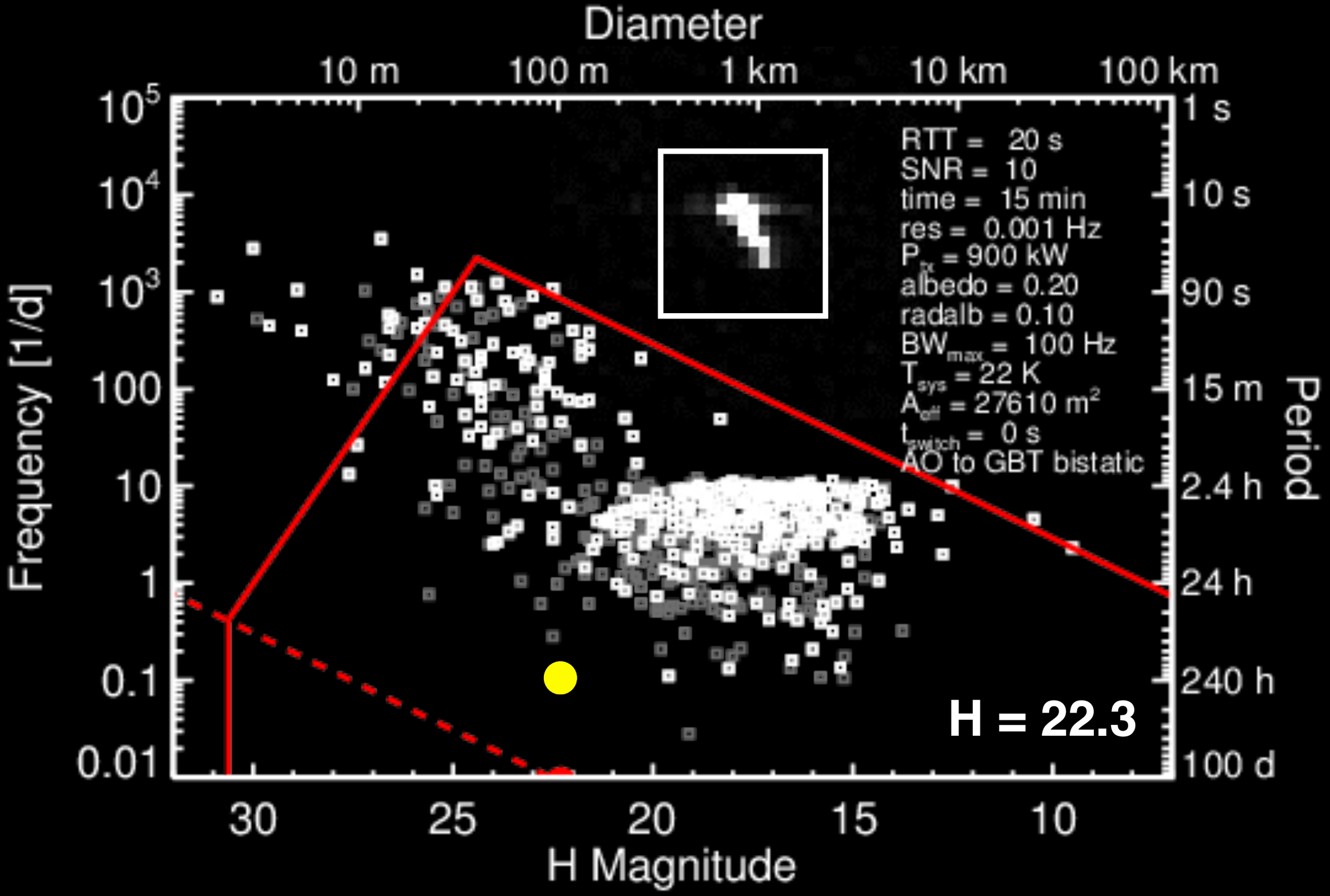
Arecibo/Green Bank Bistatic Detectability



Example: 2001 EC16, AO Monostatic



Example: 2001 EC16, AO/GBT Bistatic



Ideal Candidate?

2010 UP, 2010 Oct 26

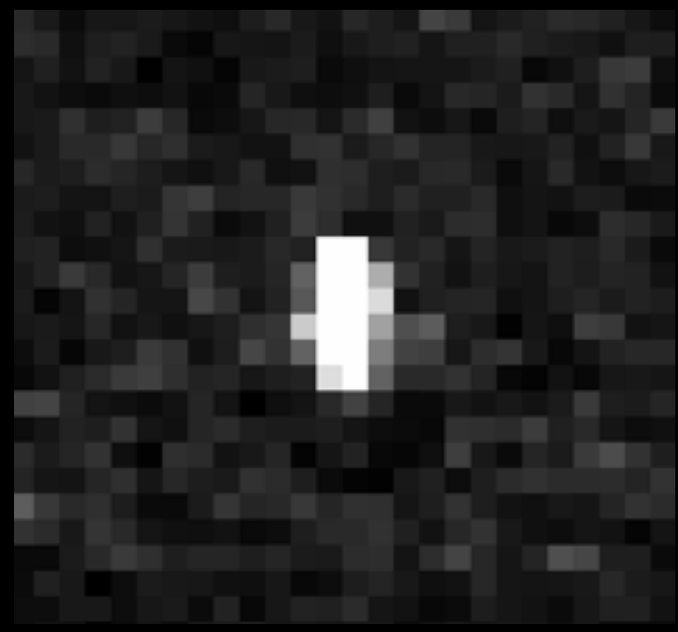
OC
SC

Δf = 0.1 Hz

SC/OC = 0.21

H = 24.7

7.5 m x 0.05 Hz



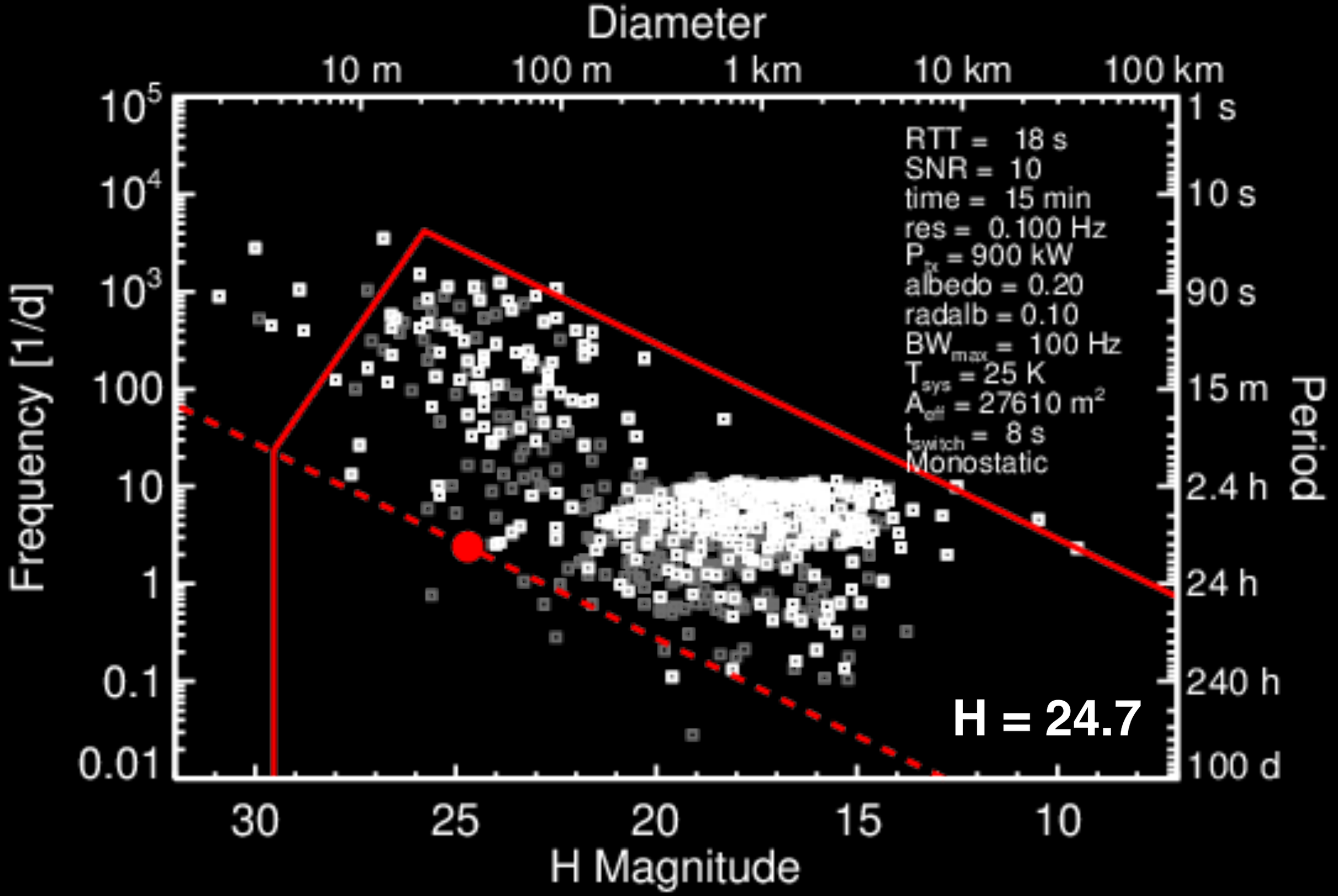
Echo power (std. dev.)

300
250
200
150
100
50
0

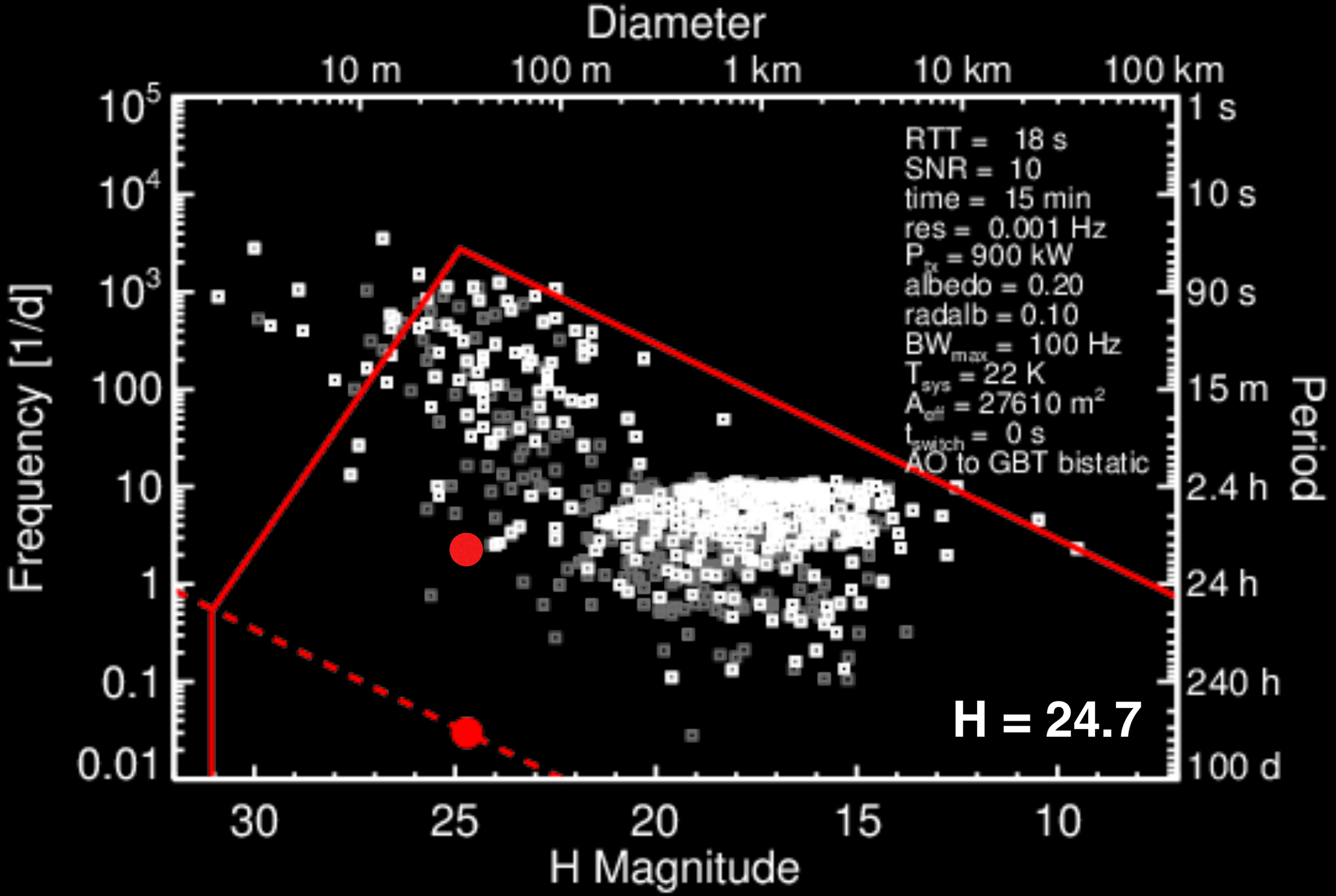
−2
−1
0
1
2

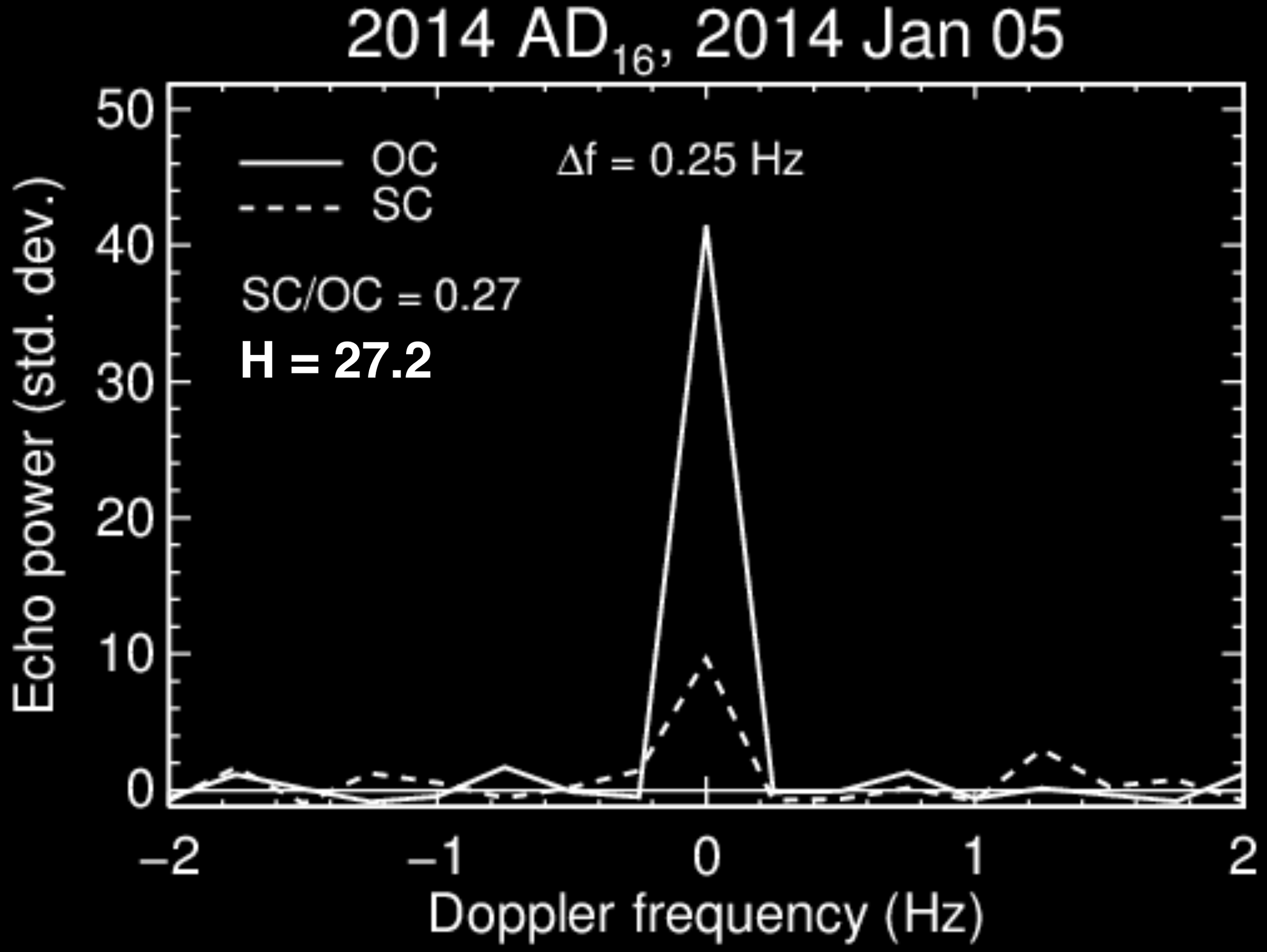
Doppler frequency (Hz)

Example: 2010 UP, AO Monostatic

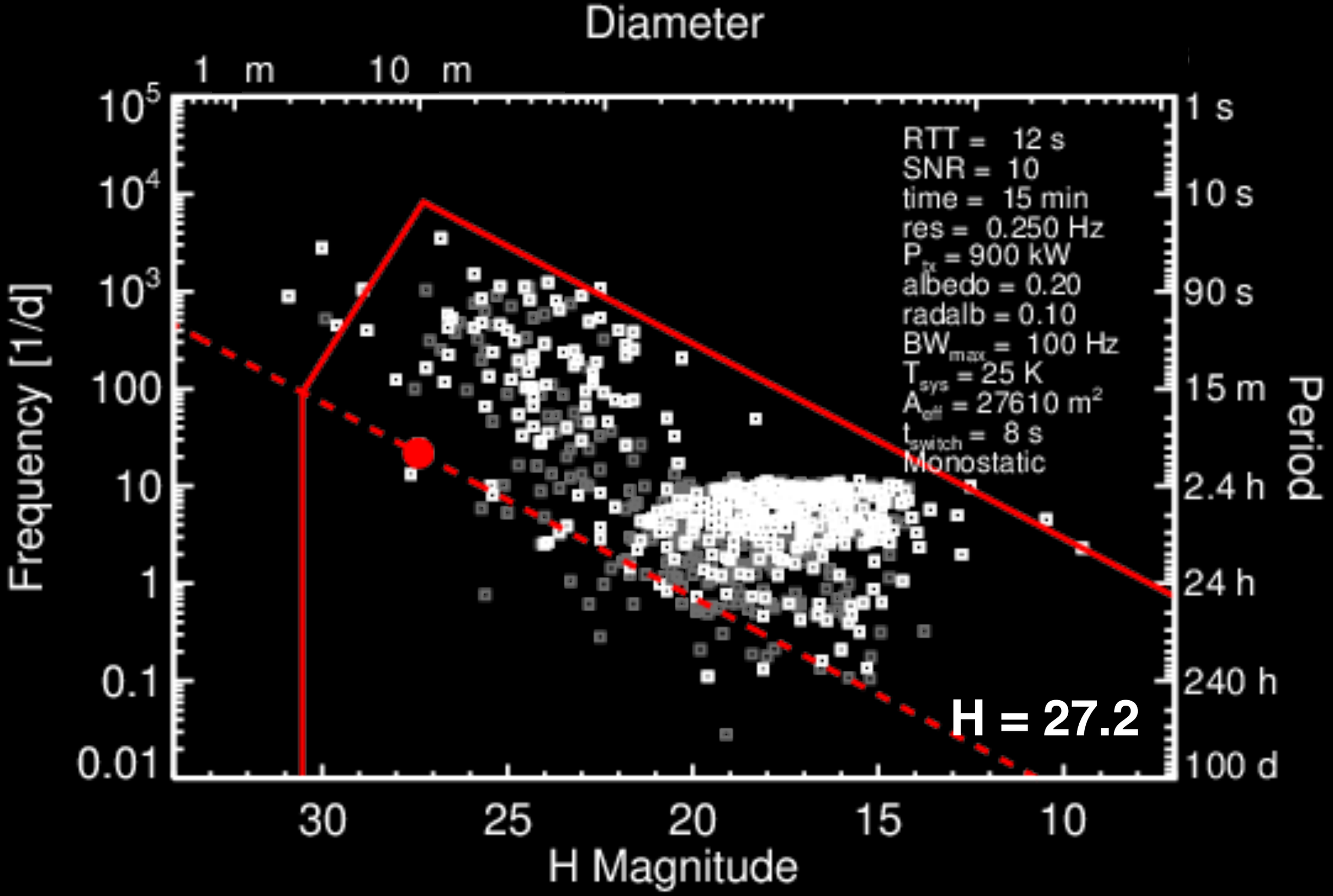


Example: 2010 UP, AO/GBT Bistatic

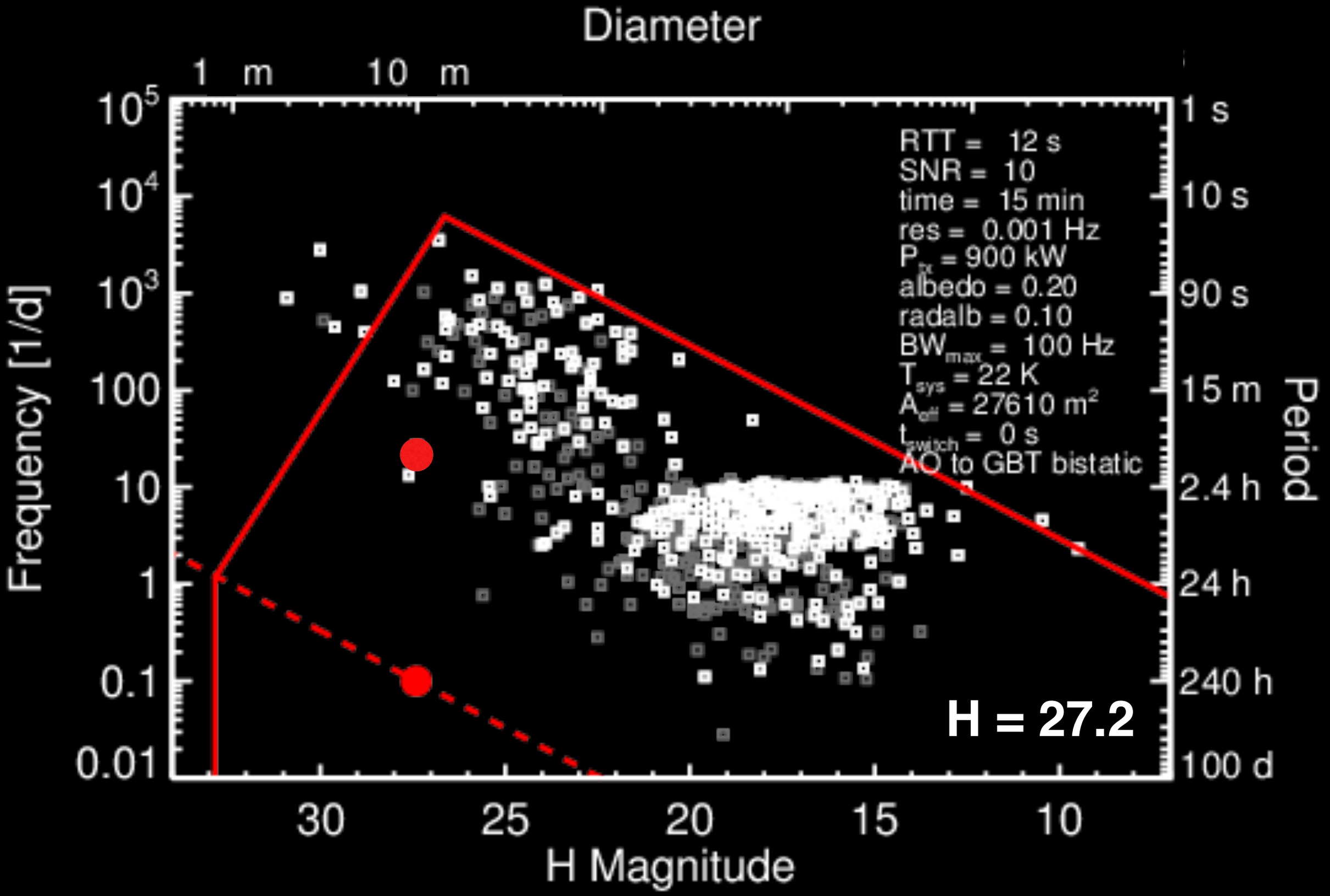



2014 AD16, 2014 Jan 05
OC
SC
Δf = 0.25 Hz
SC/OC = 0.27
H = 27.2
Echo power (std. dev.)
50
40
30
20
10
0
−2
−1
0
1
2
Doppler frequency (Hz)

Example: 2014 AD16, AO Monostatic



Example: 2014 AD16, AO/GBT Bistatic



2014 YQ_8, 2014 Dec 29

OC
SC

Δf = 0.012 Hz

SC/OC = 0.21

H = 23.6

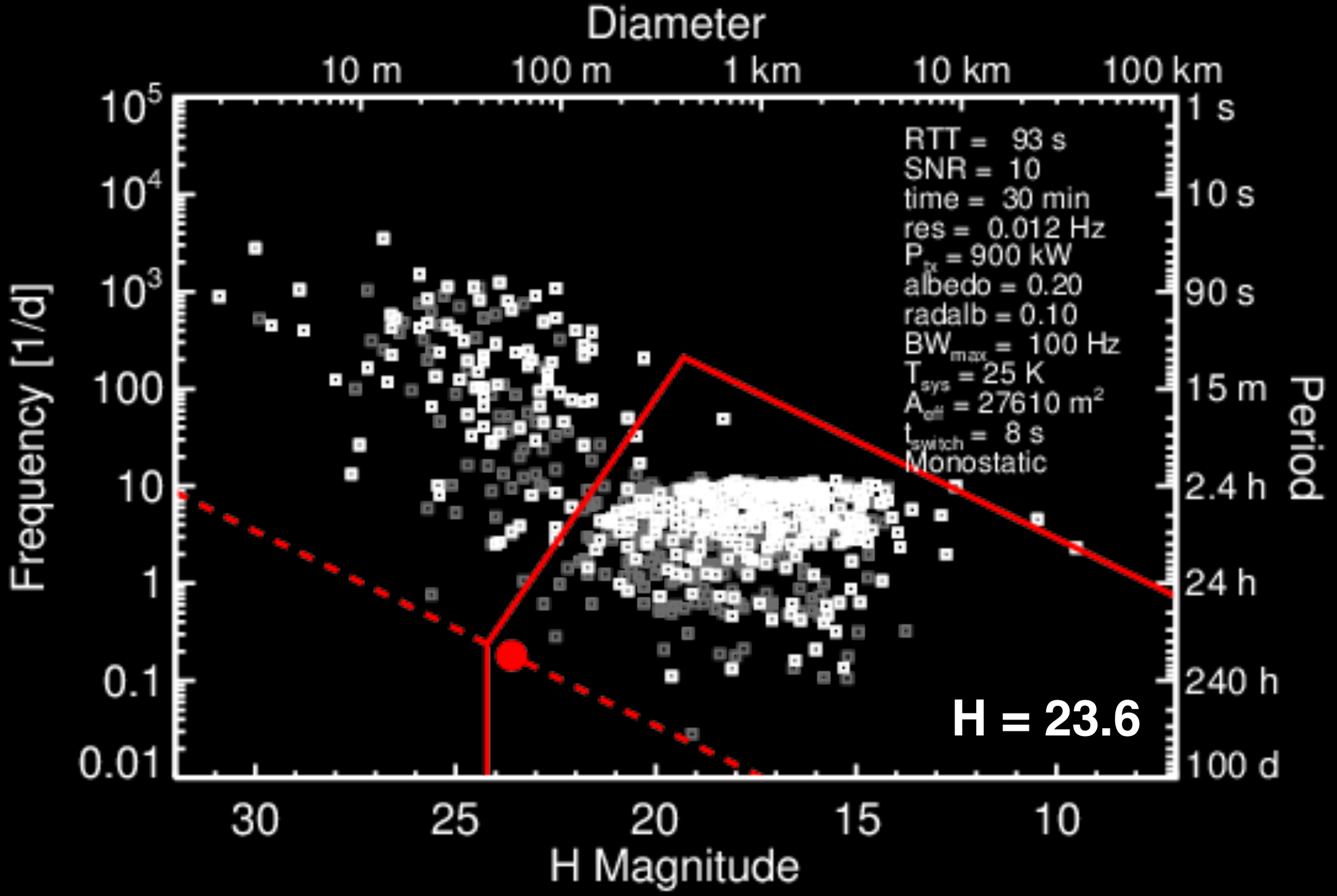
Echo power (std. dev.)

25
20
15
10
5
0

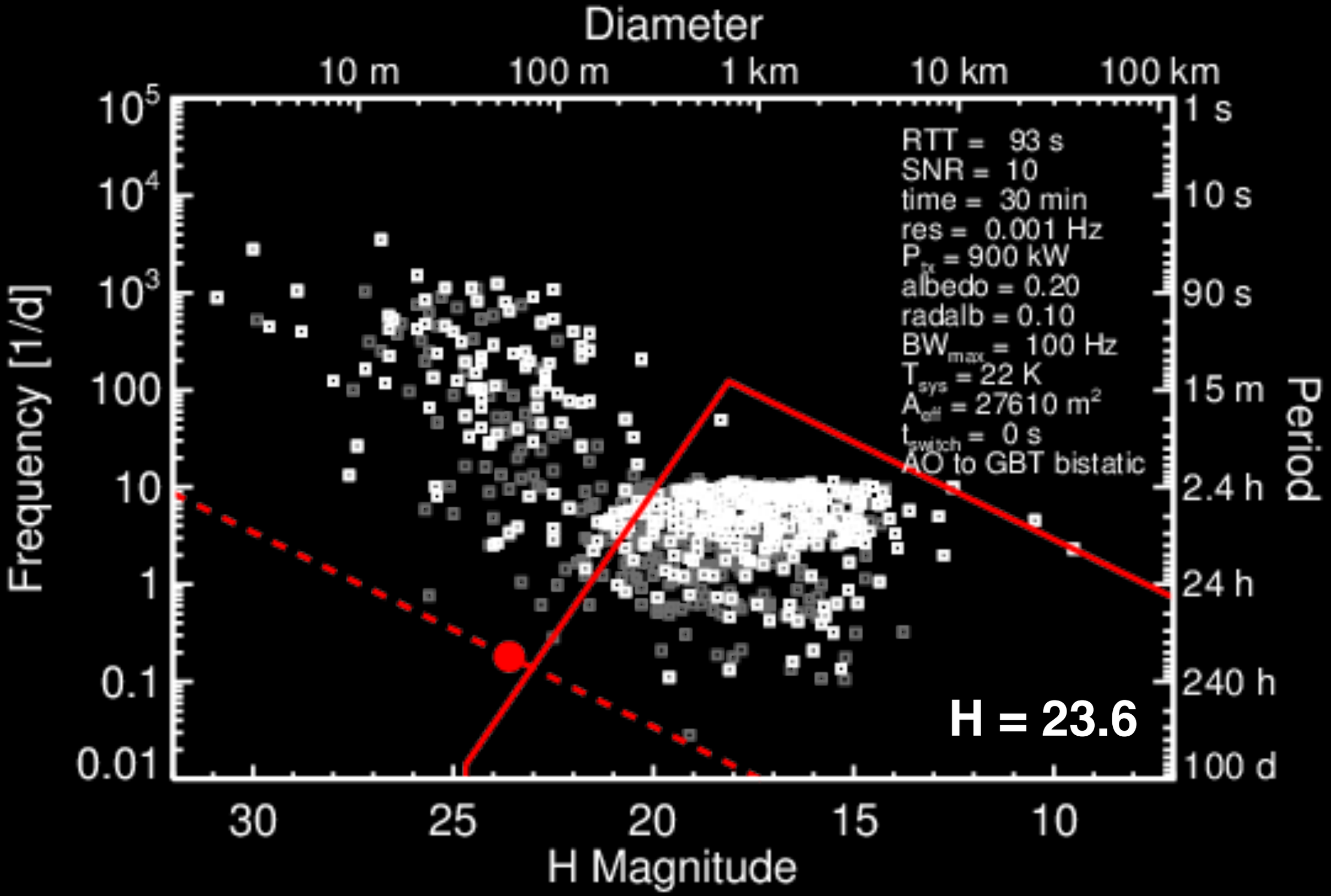
−138.0 −137.9 −137.8 −137.7 −137.6 −137.5

Doppler frequency (Hz)

Example: 2014 YQ8, AO Monostatic



Example: 2014 YQ8, AO/GBT Bistatic

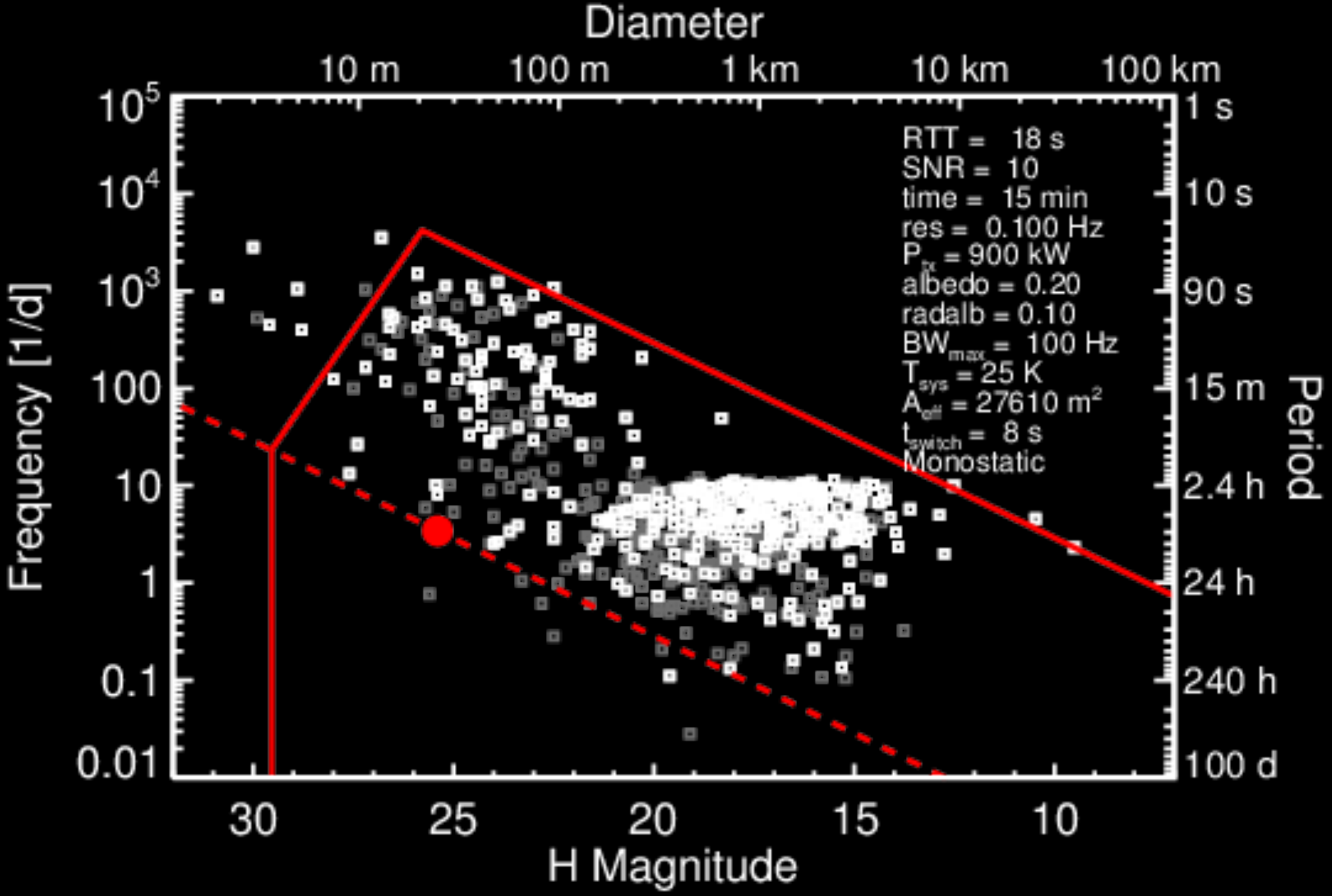


Summary

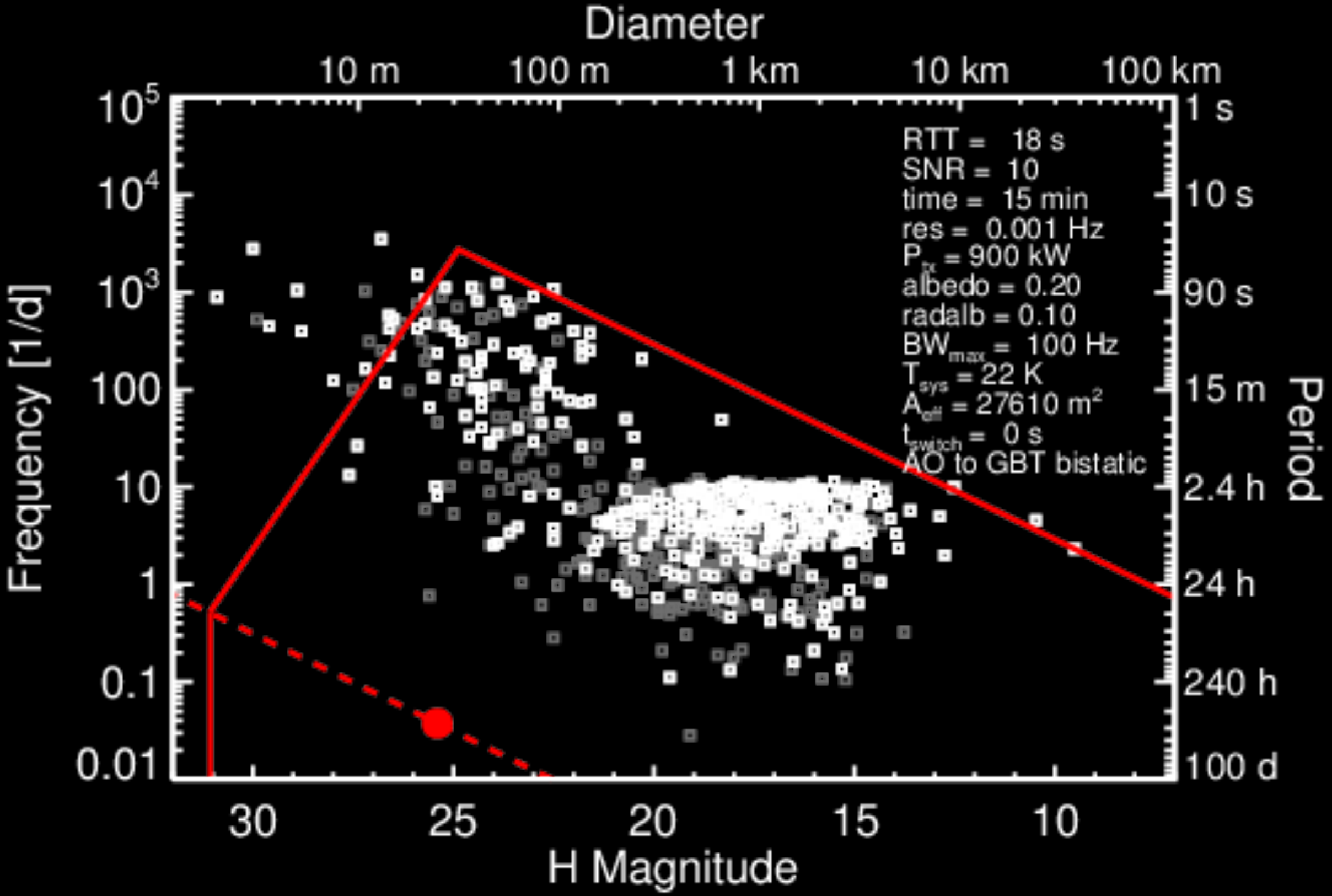
- The opportunity to do AO/GBT bistatic observations of small NEAs could happen a few times per year:
  - Typically newly discovered objects close to Earth and moving rapidly
  - Likely requires coordination in 24 hours or less
  - Observations on consecutive days could help rule out pole-on geometry and resolve a slow rotation
- Bistatic observations could reveal a new population of asteroids otherwise difficult to characterize
- Is potential science gain worth the scheduling/staff headache?

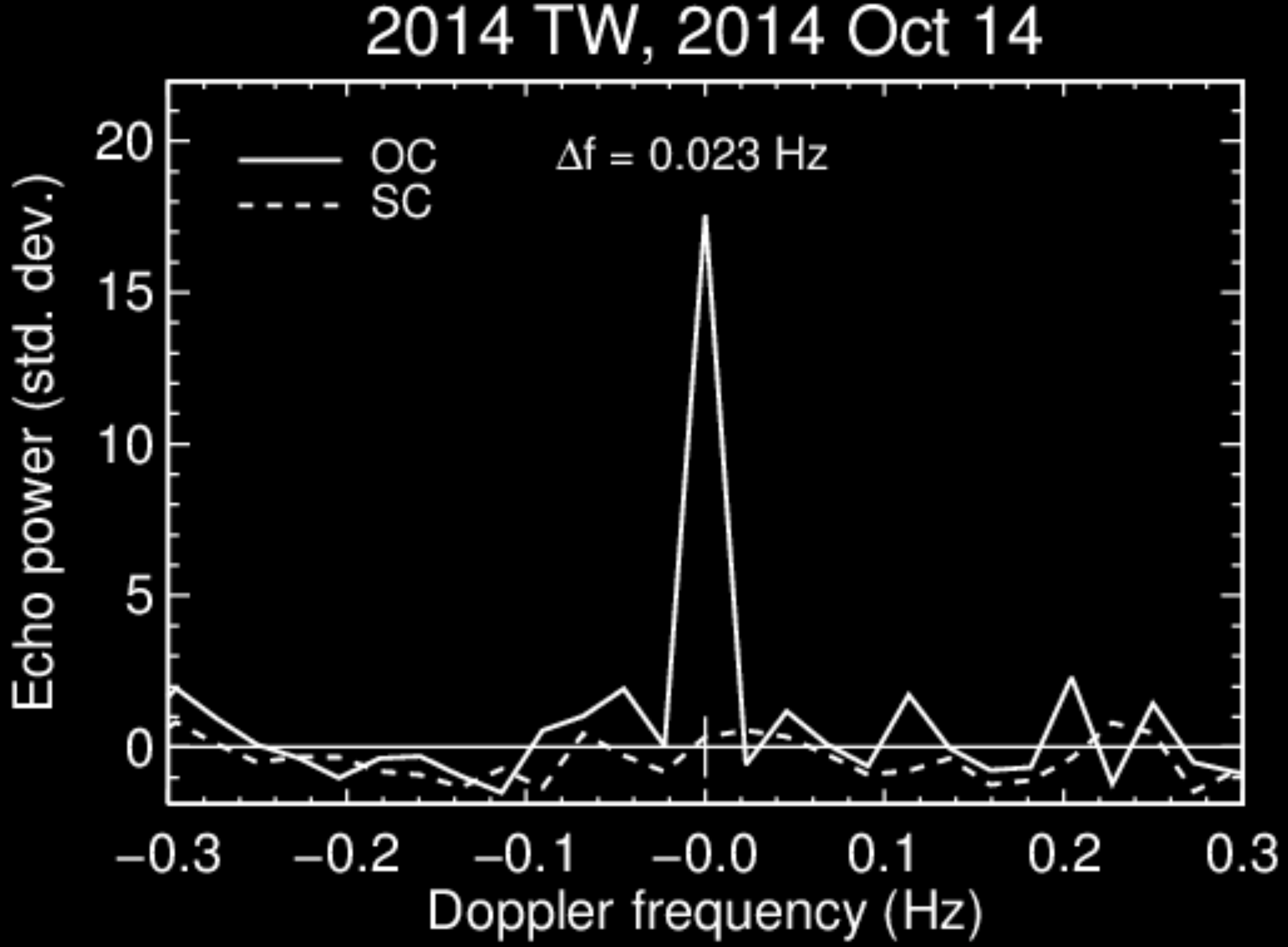
Back-Up Slides

Example: Small, Slowly Rotating NEA

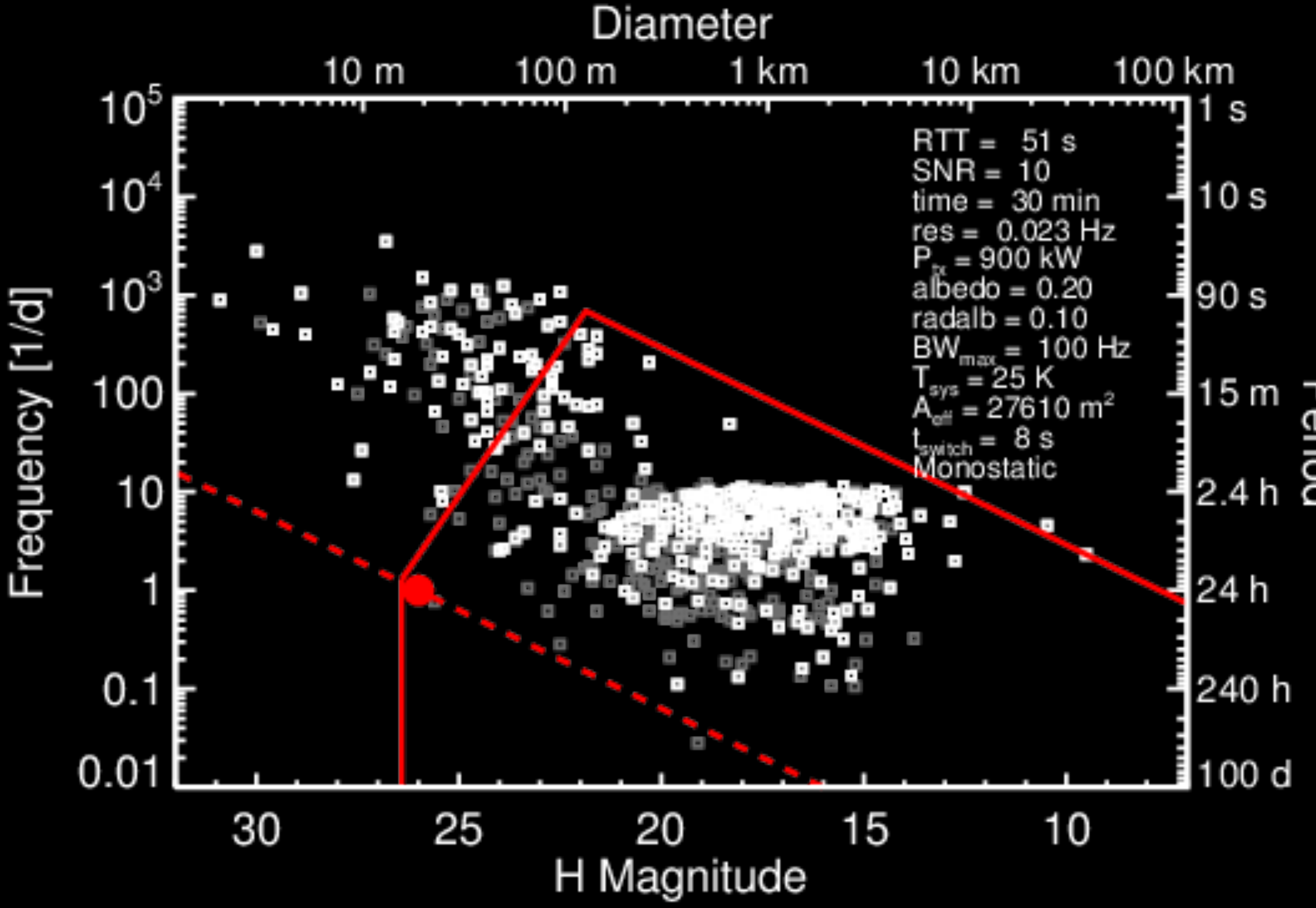


Example: Small, Slowly Rotating NEA

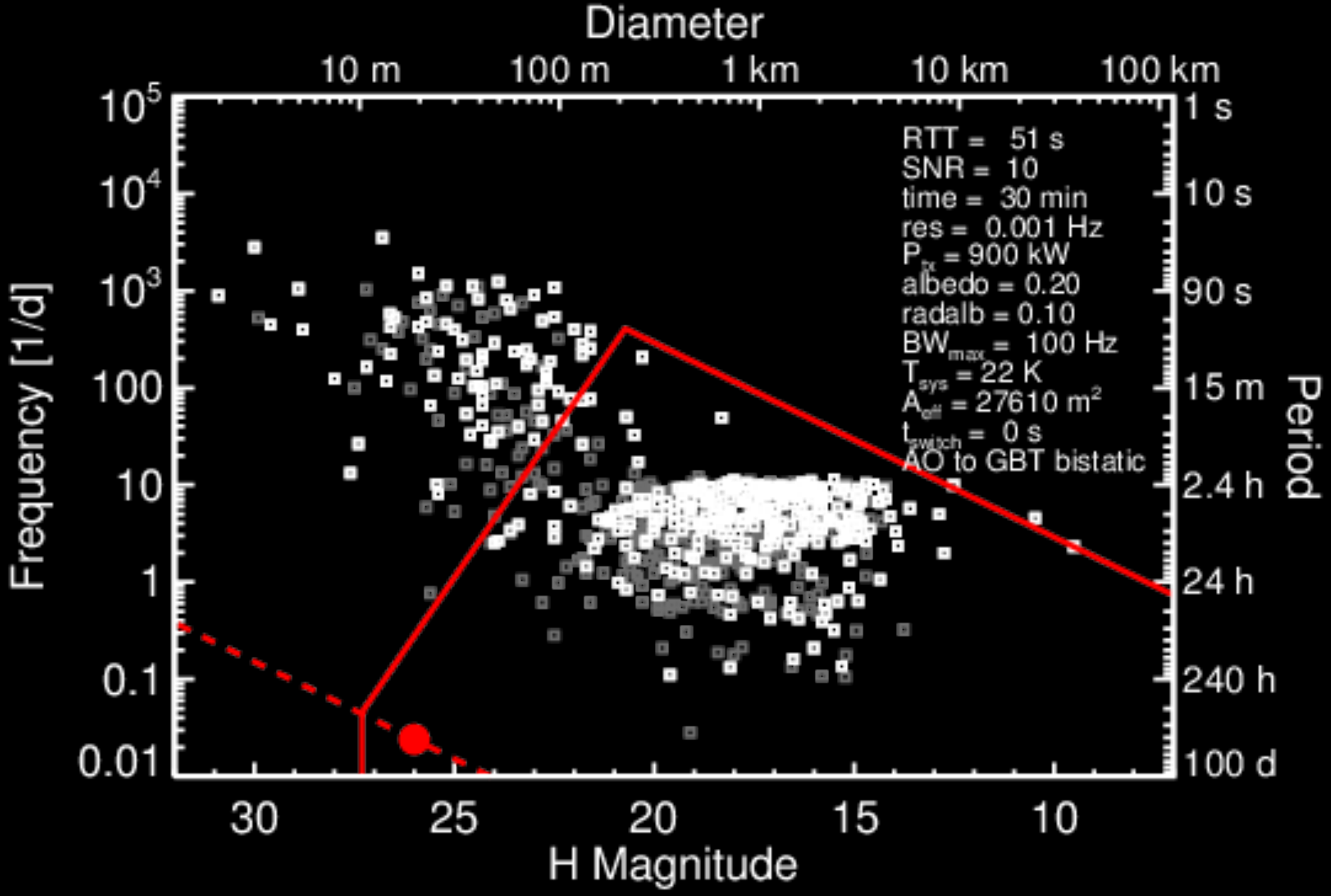


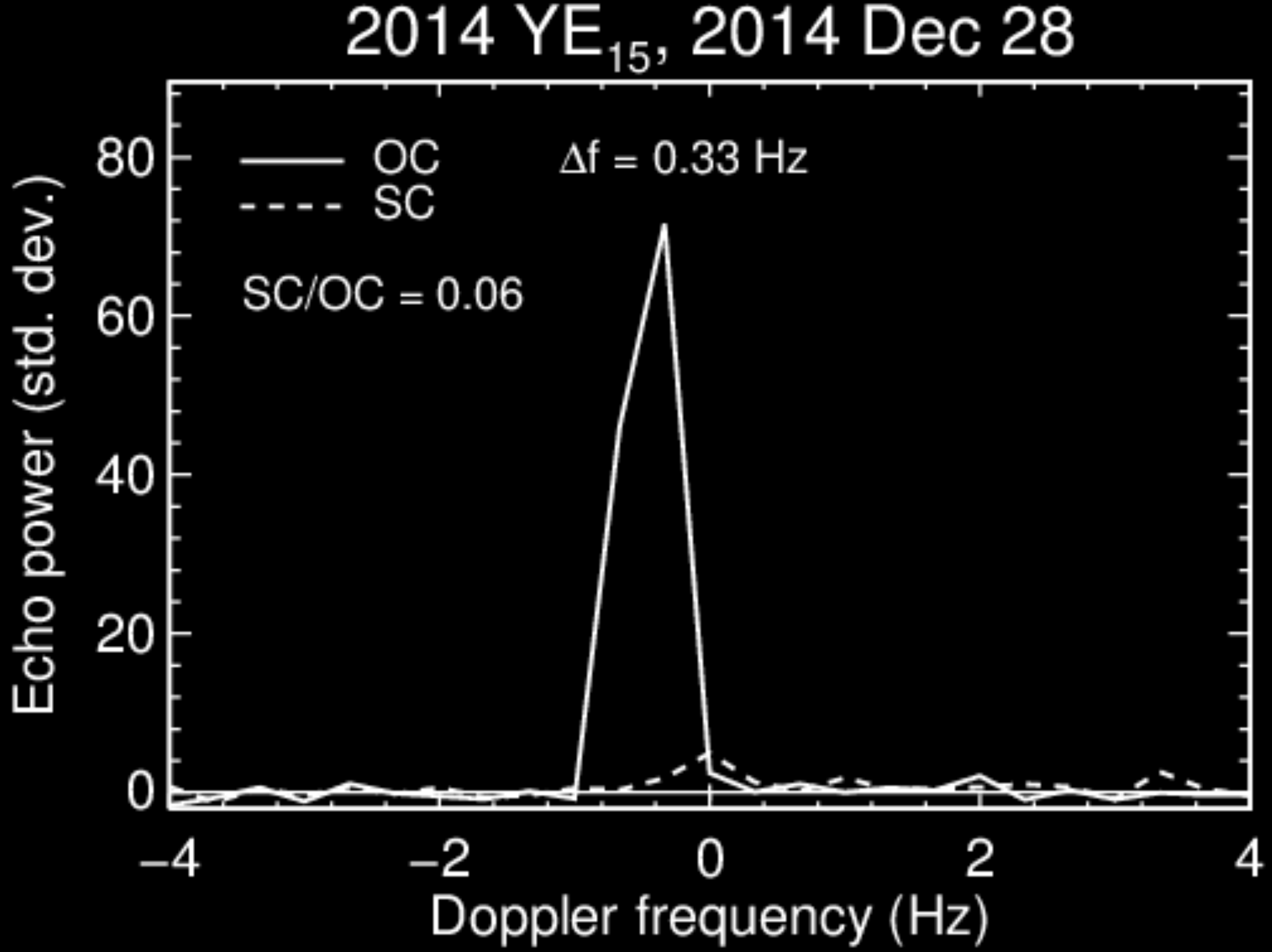

2014 TW, 2014 Oct 14
OC
SC
Δf = 0.023 Hz
Echo power (std. dev.)
20
15
10
5
0
−0.3
−0.2
−0.1
−0.0
0.1
0.2
0.3
Doppler frequency (Hz)

Example: 2014 TW, AO Monostatic

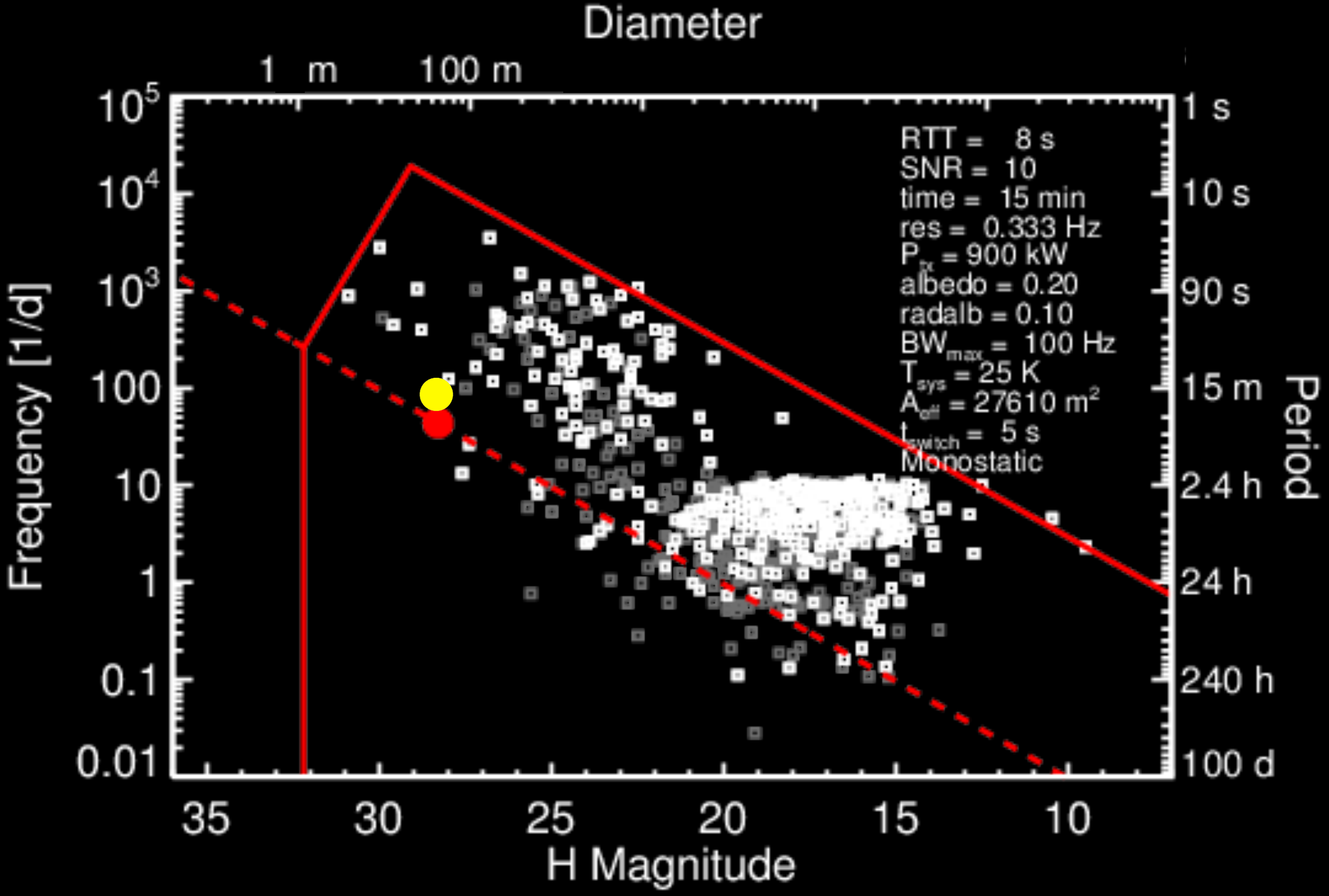


Example: 2014 TW, AO/GBT Bistatic




2014 YE15, 2014 Dec 28
OC
SC
Δf = 0.33 Hz
SC/OC = 0.06
Echo power (std. dev.)
0
20
40
60
80
−4
−2
0
2
4
Doppler frequency (Hz)

Example: 2014 YE15, AO Monostatic



Example: 2014 YE15, AO/GBT Bistatic