# Detecting Exoplanet Magnetic Fields

Stevo Bailey

# Outline

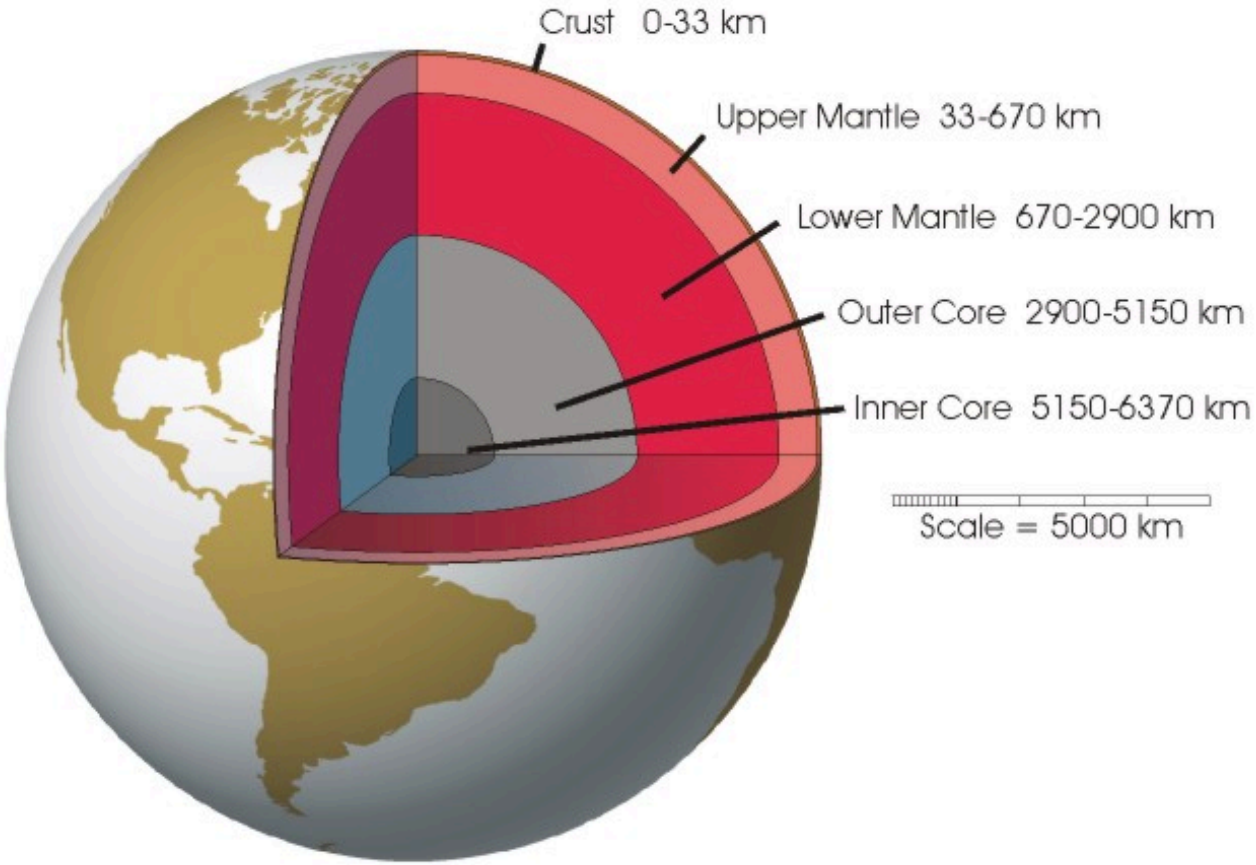
- Motivation
- Exoplanet modeling
- Improving detection
- Limitations
- Conclusions

# Motivation

http://wae.blogs.starnewsonline.com/files/2013/02/One-Life.jpg

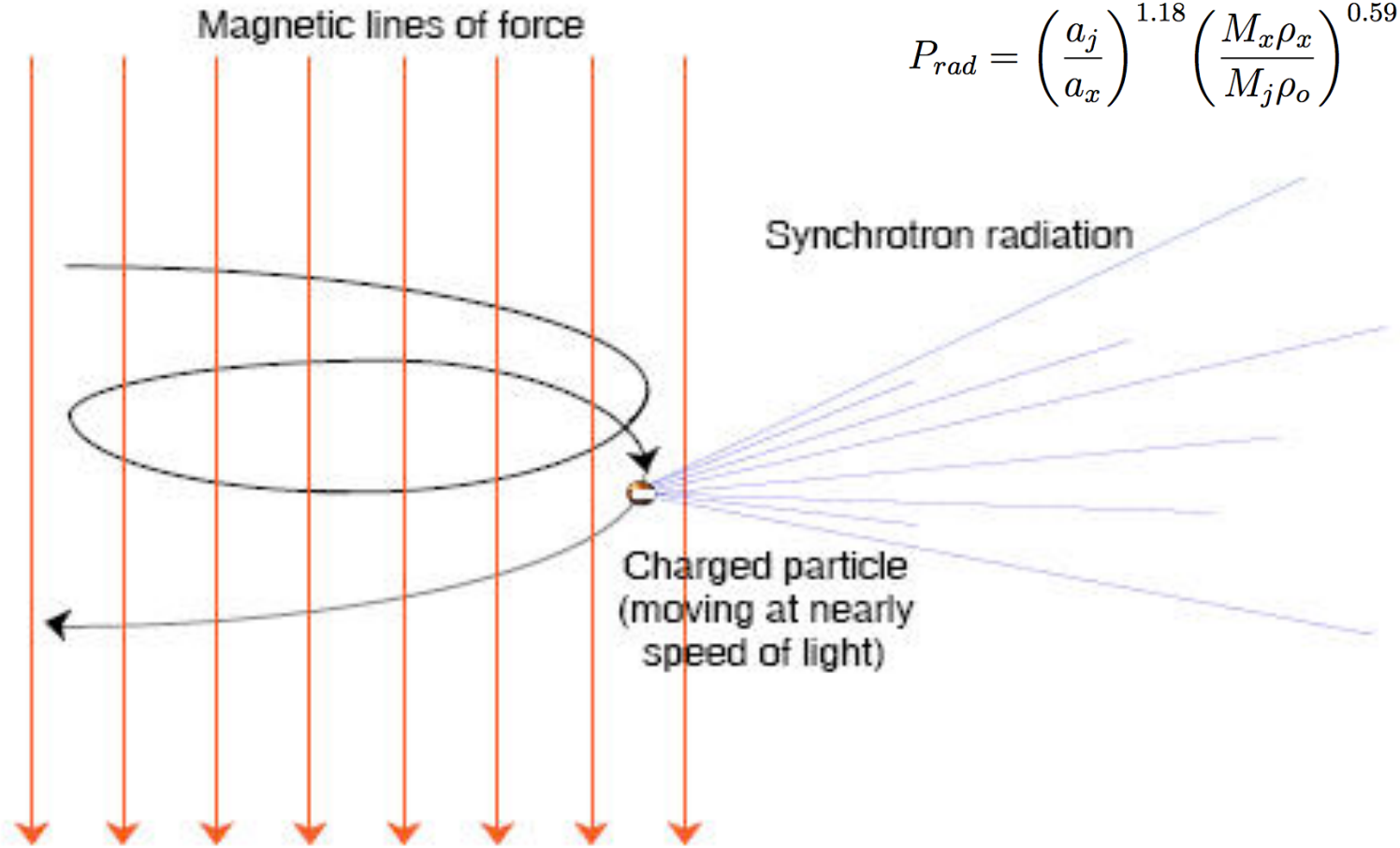
# Exoplanet Model

- Differentiated planet
- Earth-like boundary conditions
- Strong convection
- Active dynamo




http://facweb.bhc.edu/academics/science/harwoodr/GEOL101/STUDY/images/Interior2.jpg

# Cyclotron Emission




$$P_{rad} = \left(\frac{a_j}{a_x}\right)^{1.18} \left(\frac{M_x \rho_x}{M_j \rho_o}\right)^{0.59} \left(\frac{V_x}{V_o}\right)^{2.06} 4 \times 10^9$$

$$\Phi = \frac{P_{rad}}{4\pi s^2 \Delta f}$$

$$f_c = \frac{eB}{2\pi m_e}$$

http://astronomyonline.org/Science/Images/RadioAstronomy/Figure15a.jpg

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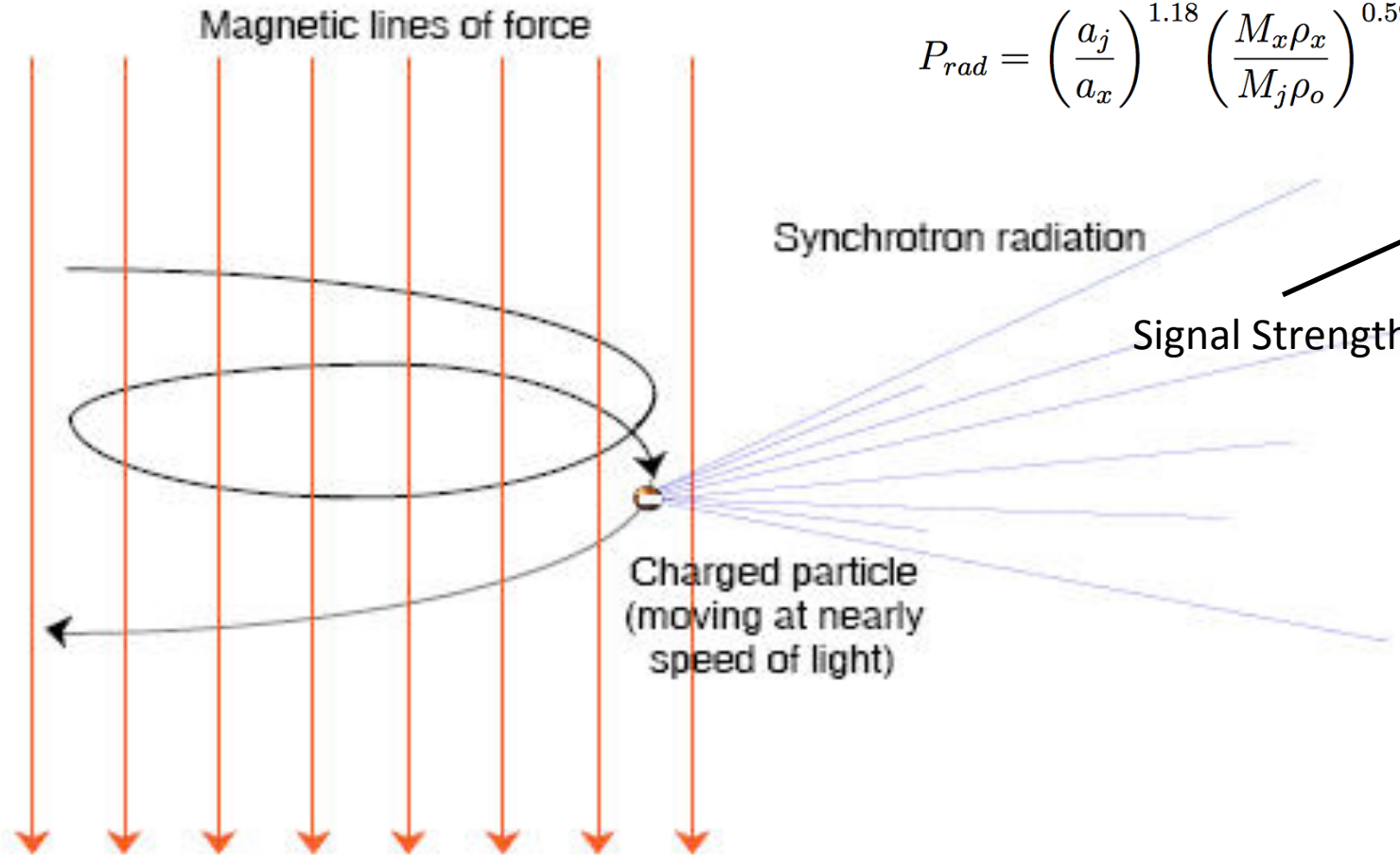


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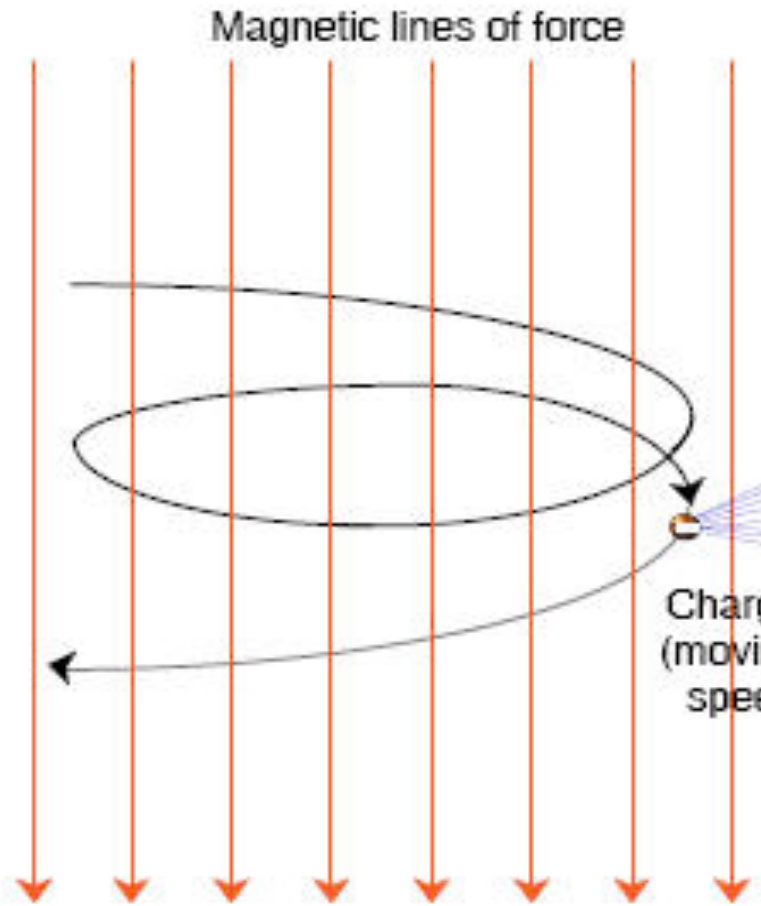


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Synchrotron radiation

$$\Phi = \frac{P_{rad}}{4\pi s^2 \Delta f}$$

Signal Strength

$$f_c = \frac{eB}{2\pi m_e}$$

Frequency

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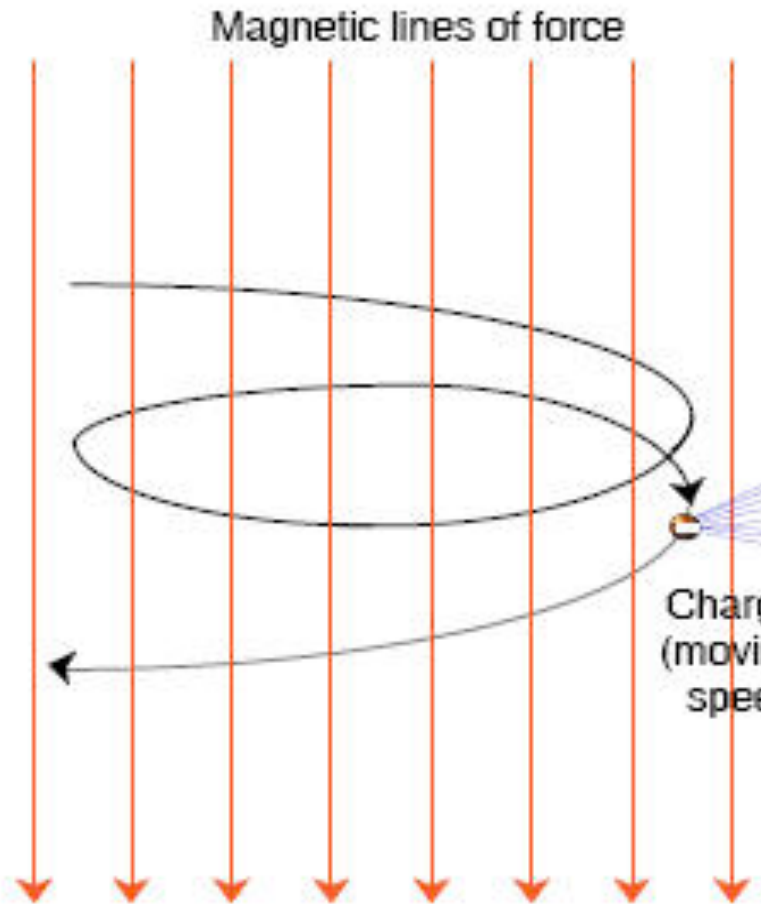


Solar Wind Properties

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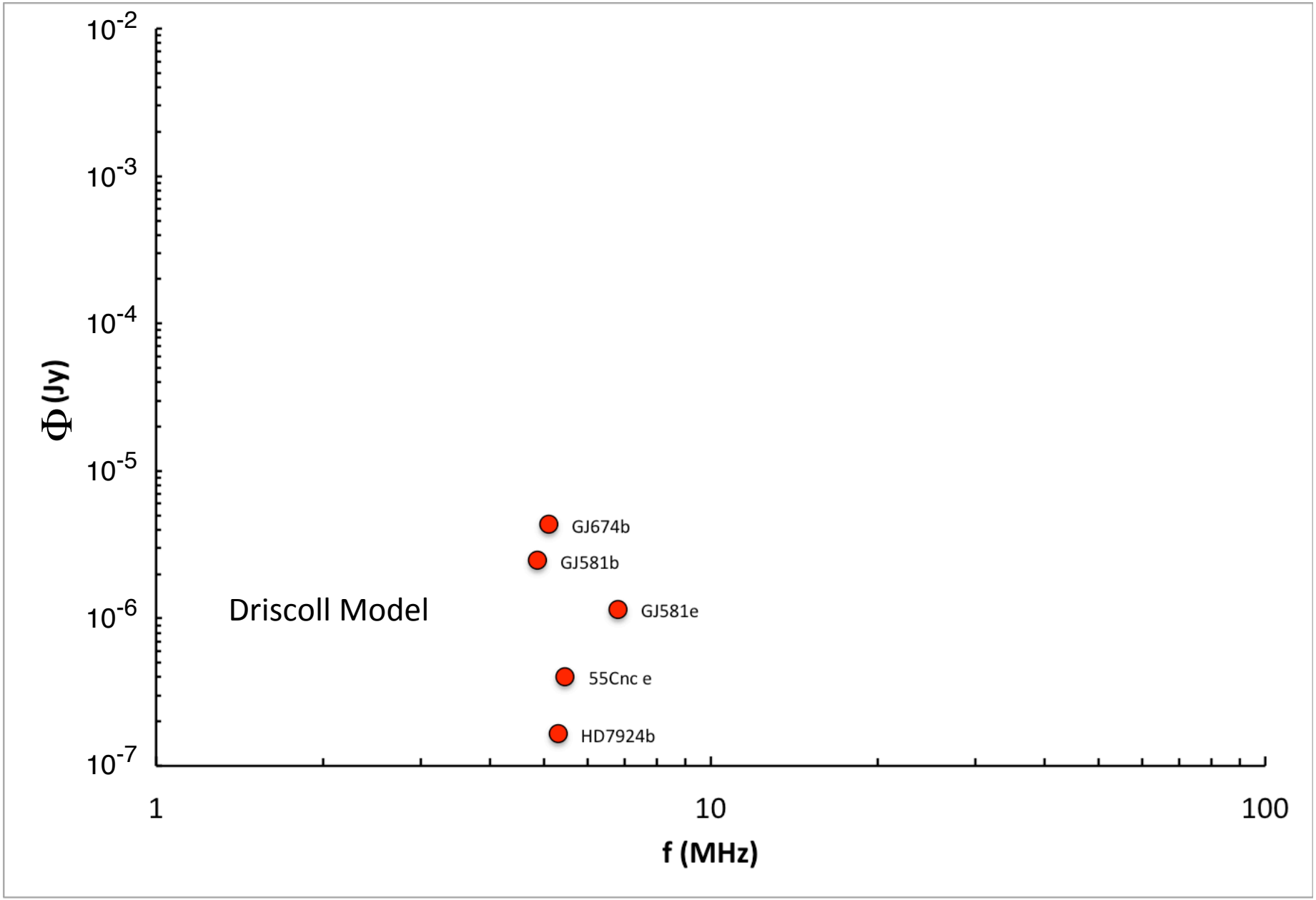


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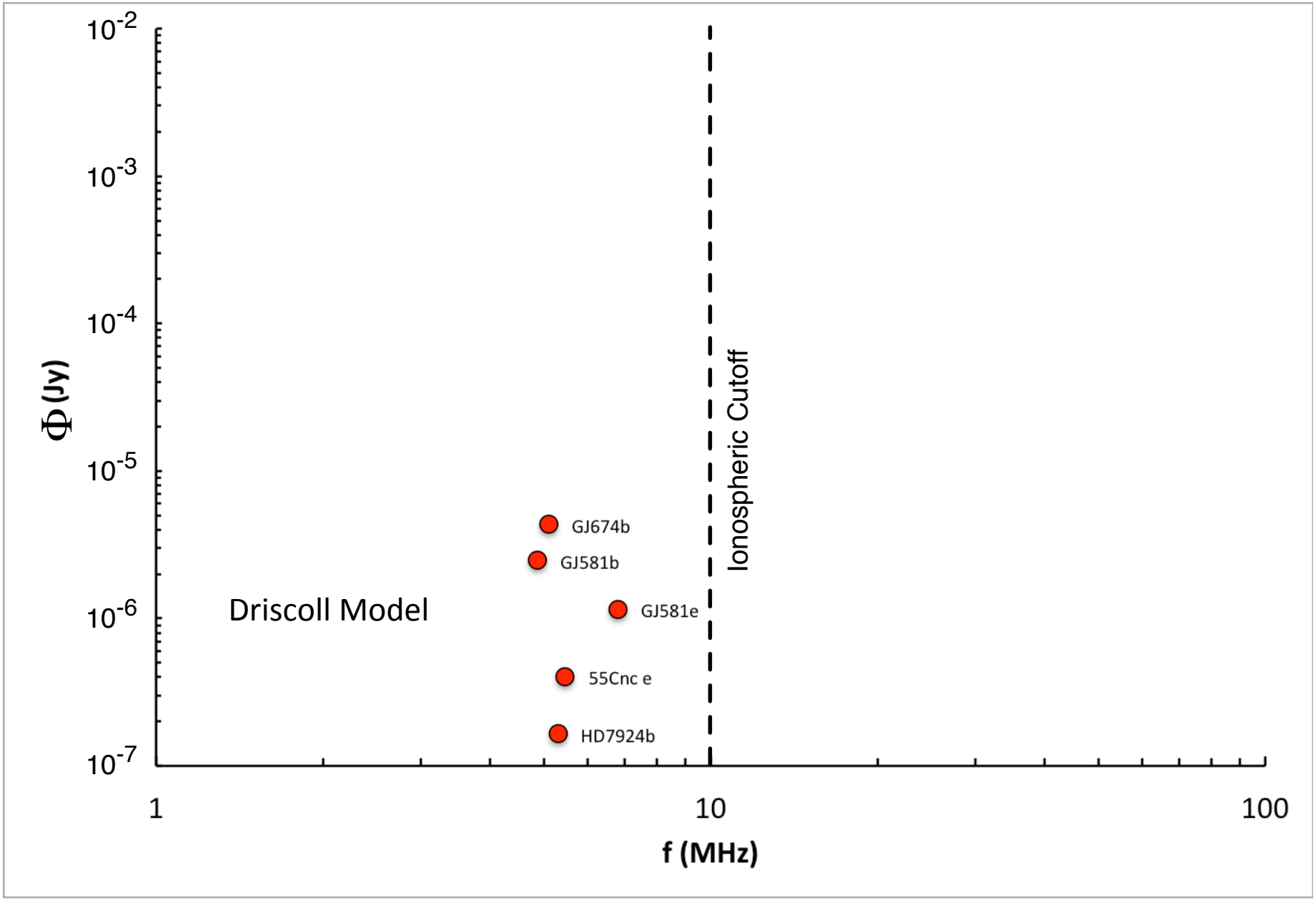


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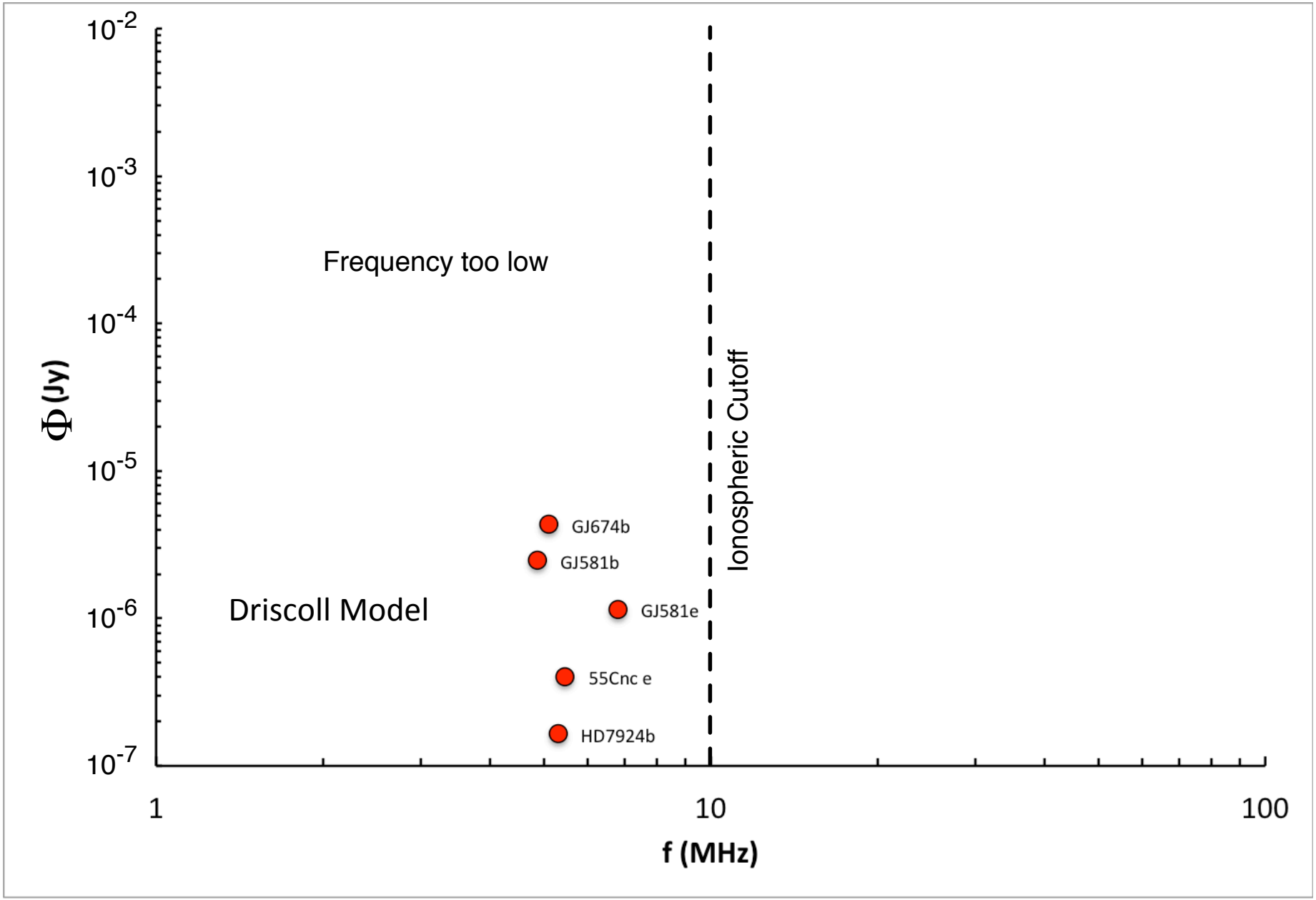


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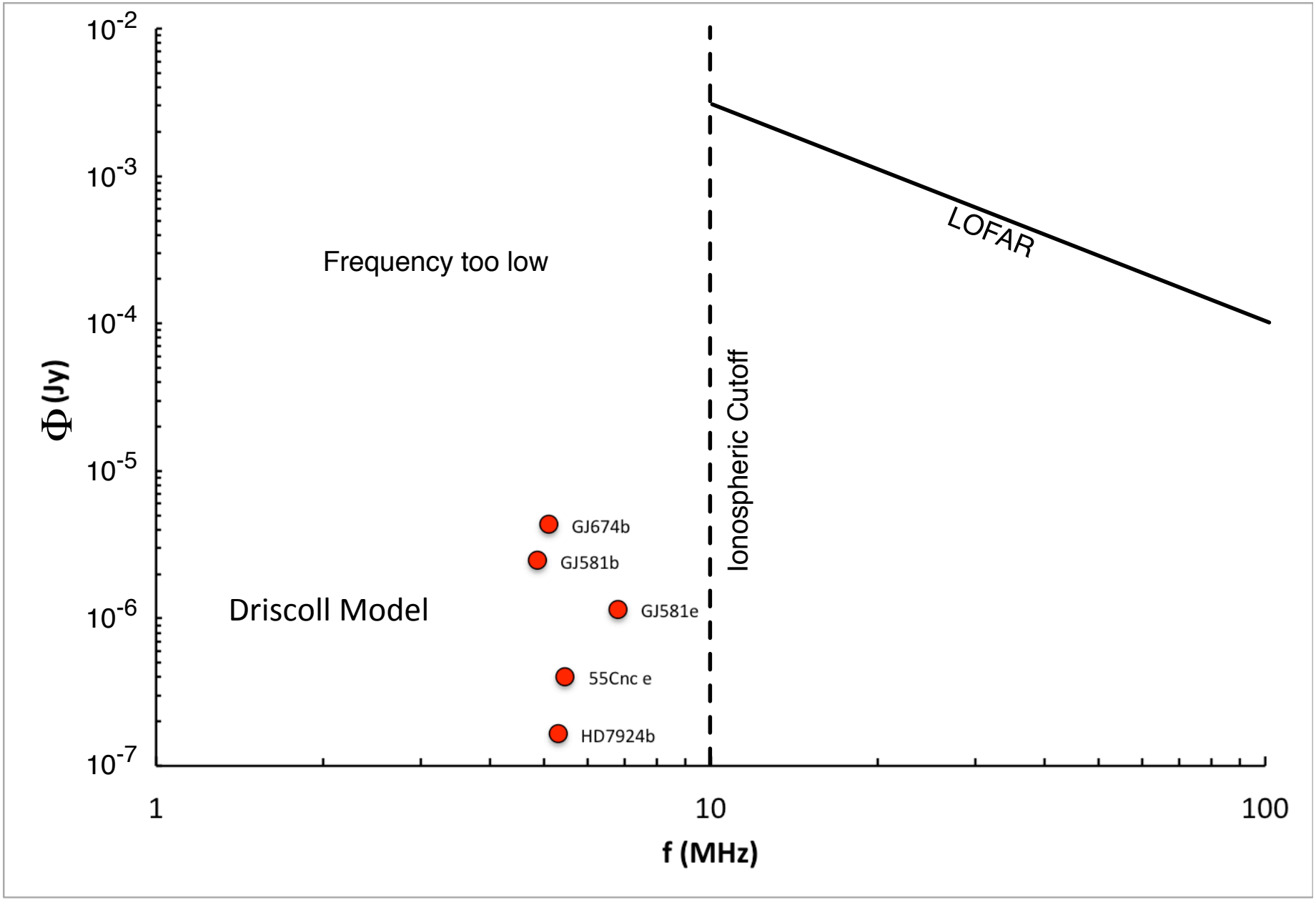


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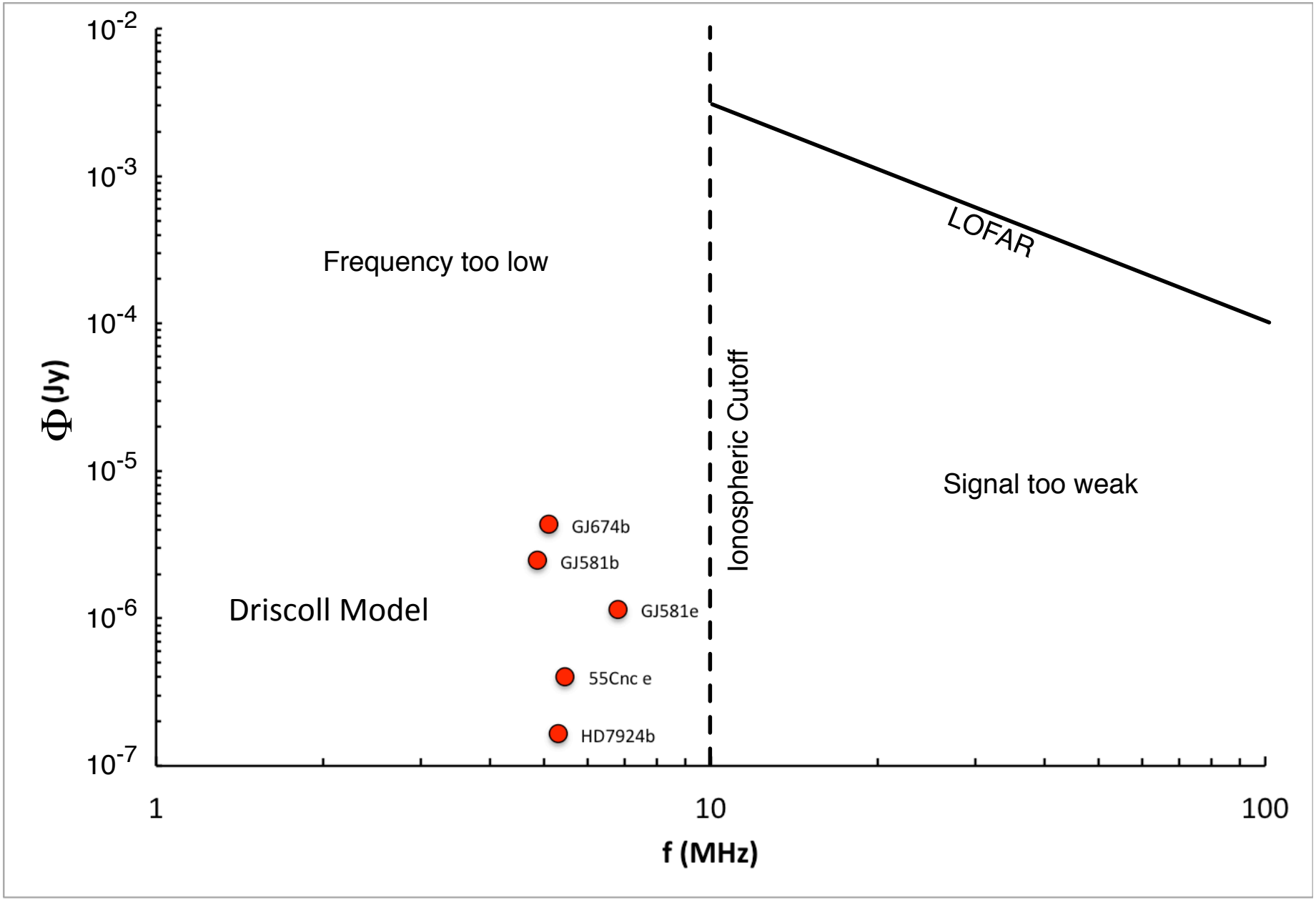


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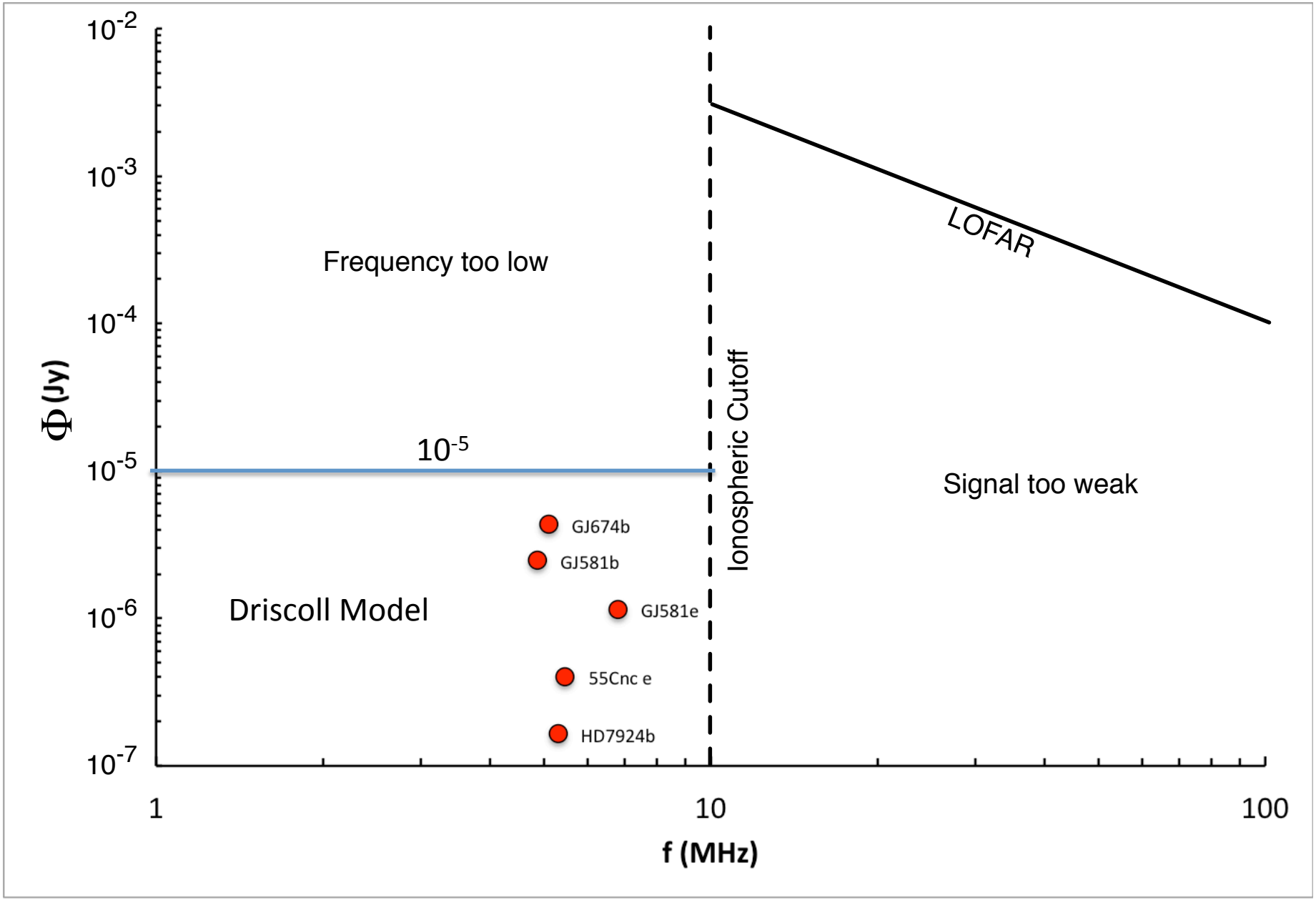


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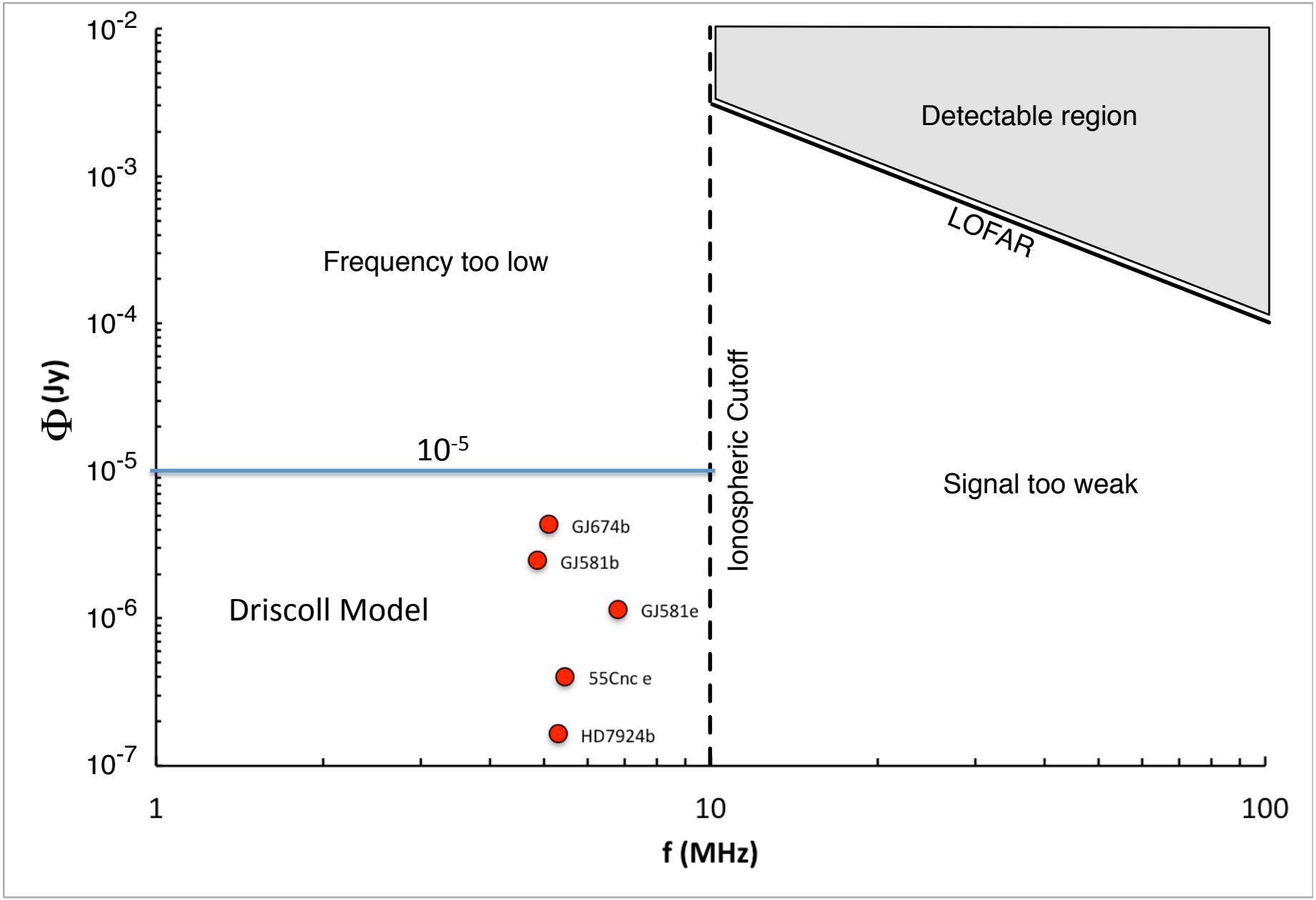


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# Improving detection

1. Boosting signal strength
2. Better detection range

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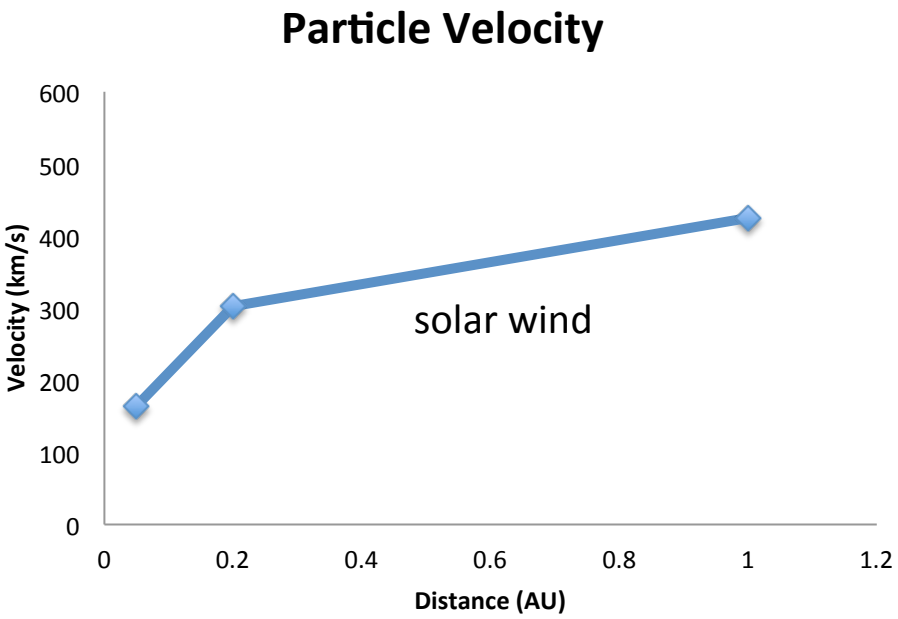
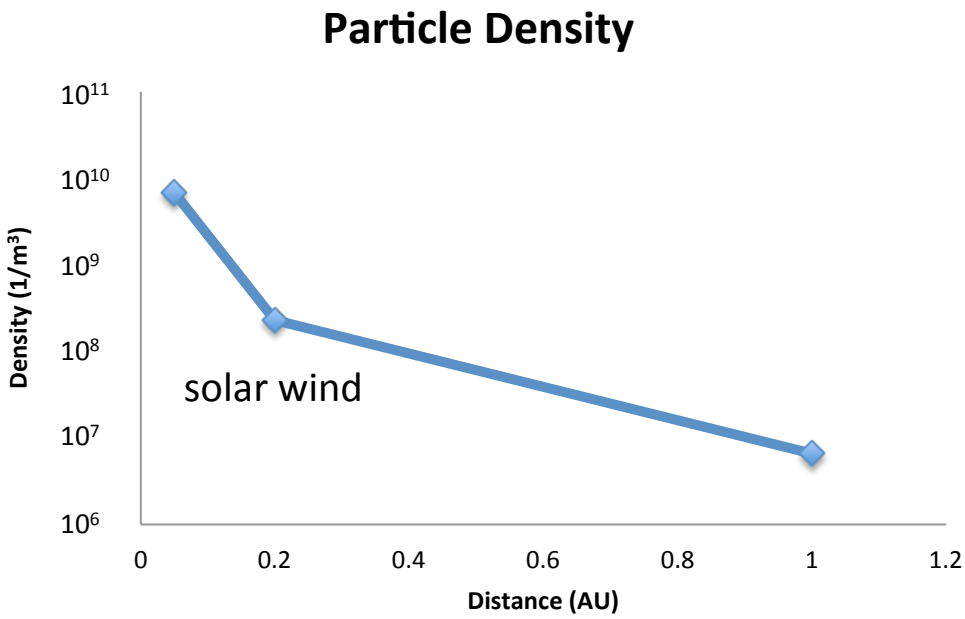
1. **Boosting signal strength**
2. Better detection range

# Solar Wind

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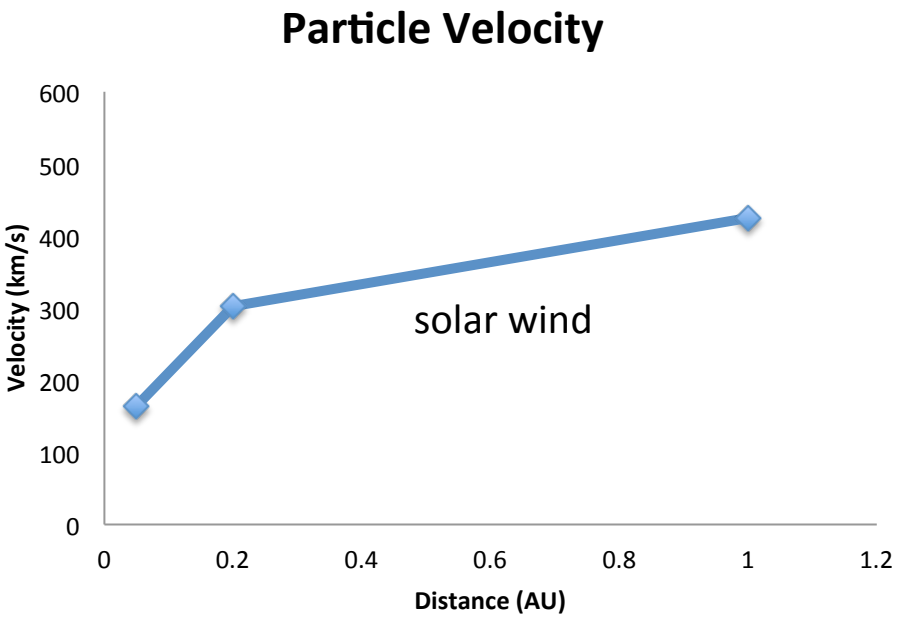
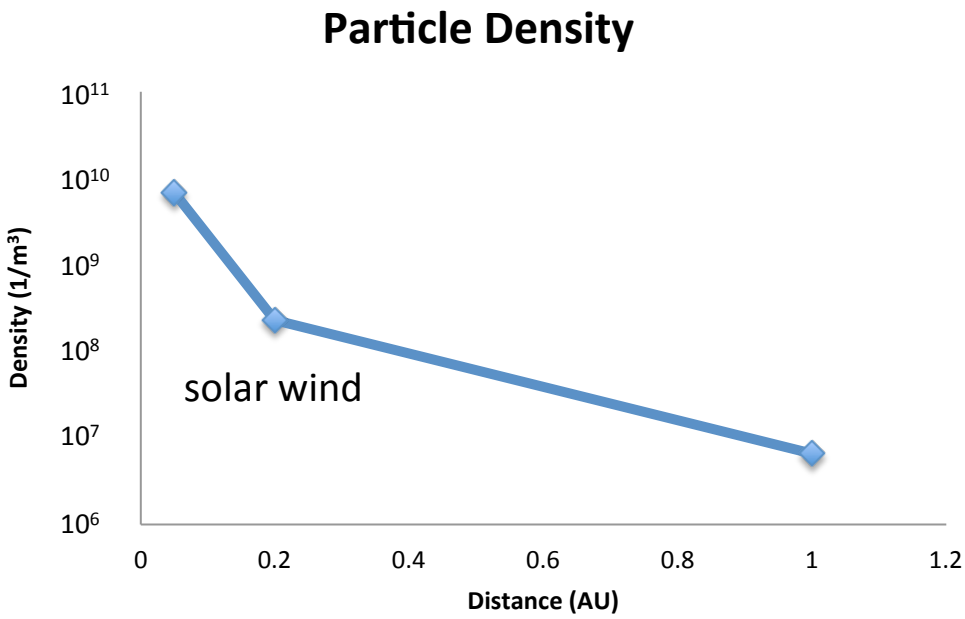
# Coronal Mass Ejections!

# Solar Wind

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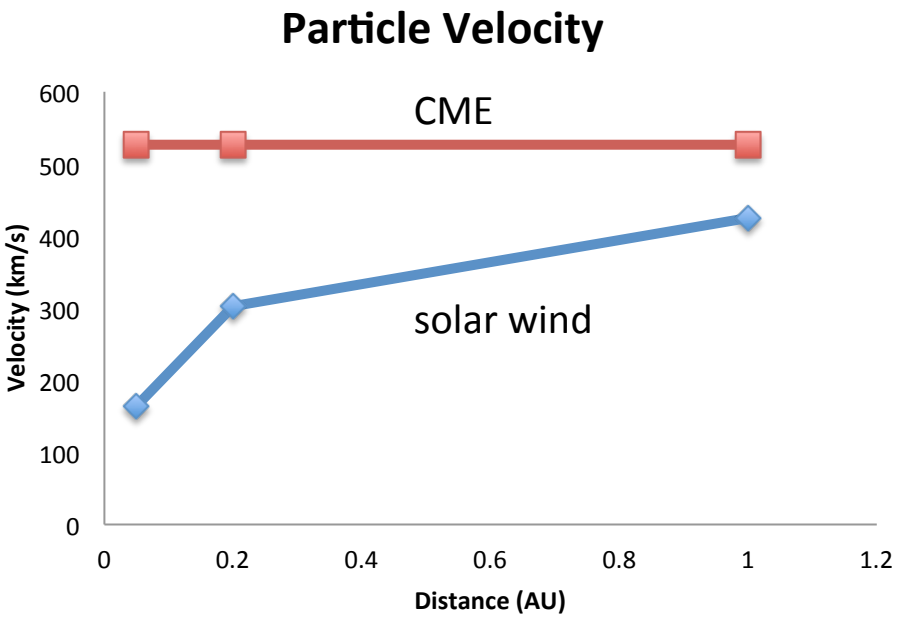
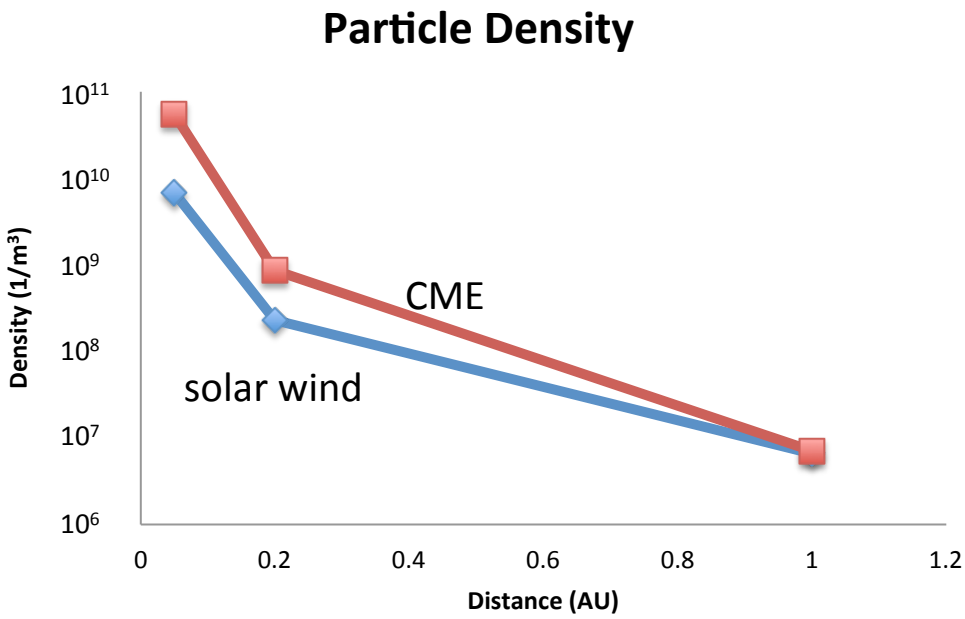
# Coronal Mass Ejections (CMEs)

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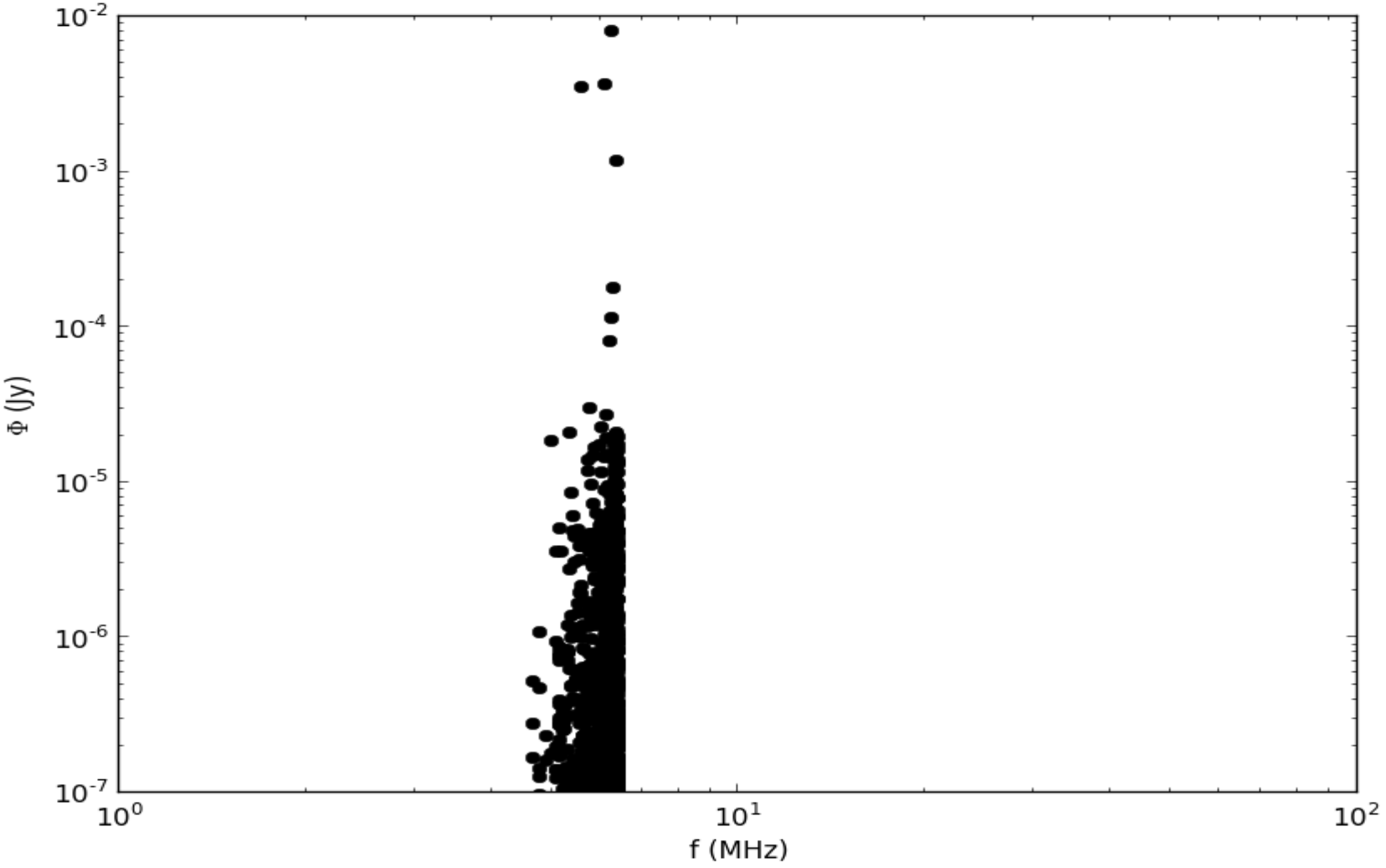
# CME Model Results




http://www.exoplanet.eu/catalog/

kepler.nasa.gov/Mission/discoveries

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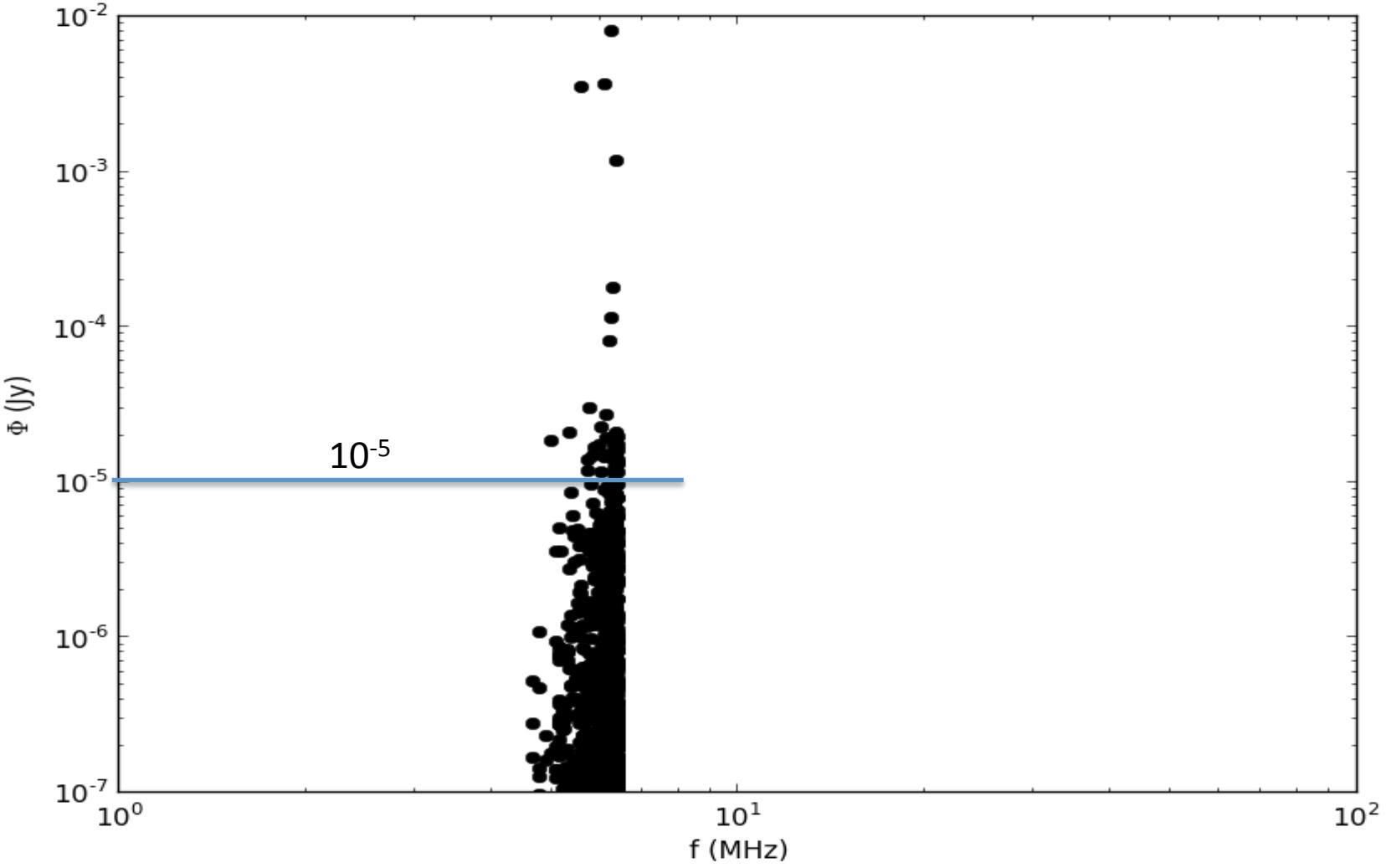


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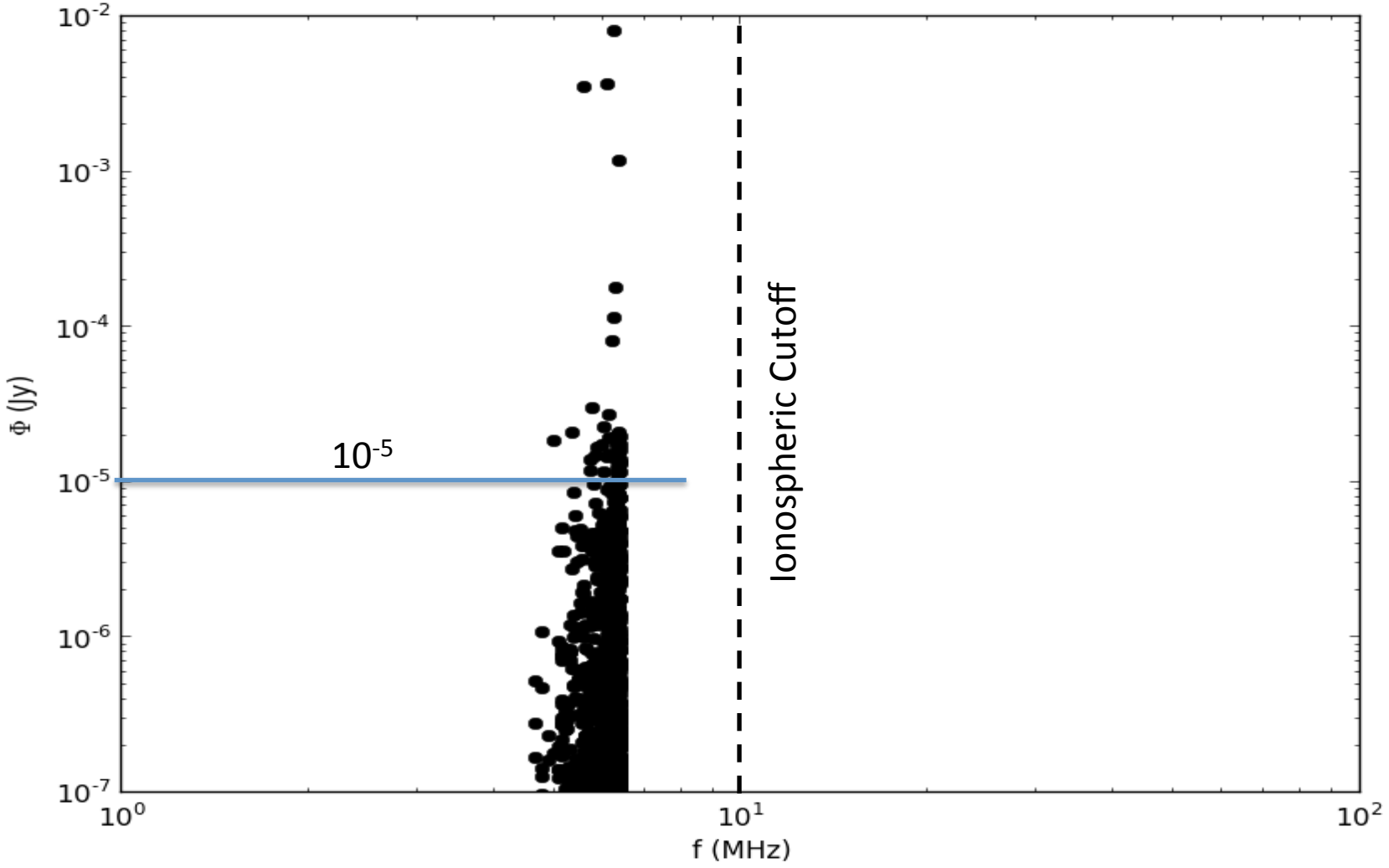


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http://lunar.colorado.edu/~jaburns/publicfiles/tiny/files/astronomy.moon.pdf

# LOw frequency Lunar Array (LOLA)

LOLA vs. LOFAR:

- Same resolution requires a bigger array for lower signal frequencies
- Better sensitivity: lower noise on Moon, better technology

# Cost of LOLA

**$15B total estimate**

$7.5B to transport antennas:

- Size: 3x3x1.7m
- Weight: 100lbs
- Amount: 20,000 antennas
- Falcon Heavy = 40,000lb payload
- 50 trips x $150M/trip

$7.5B estimated other overhead:

- Base station, deployment, construction, power, and maintenance

BONUS:

- Reuse hardware designs

http://en.wikipedia.org/wiki/File:A_low-band_antenna_of_LOFAR.jpg

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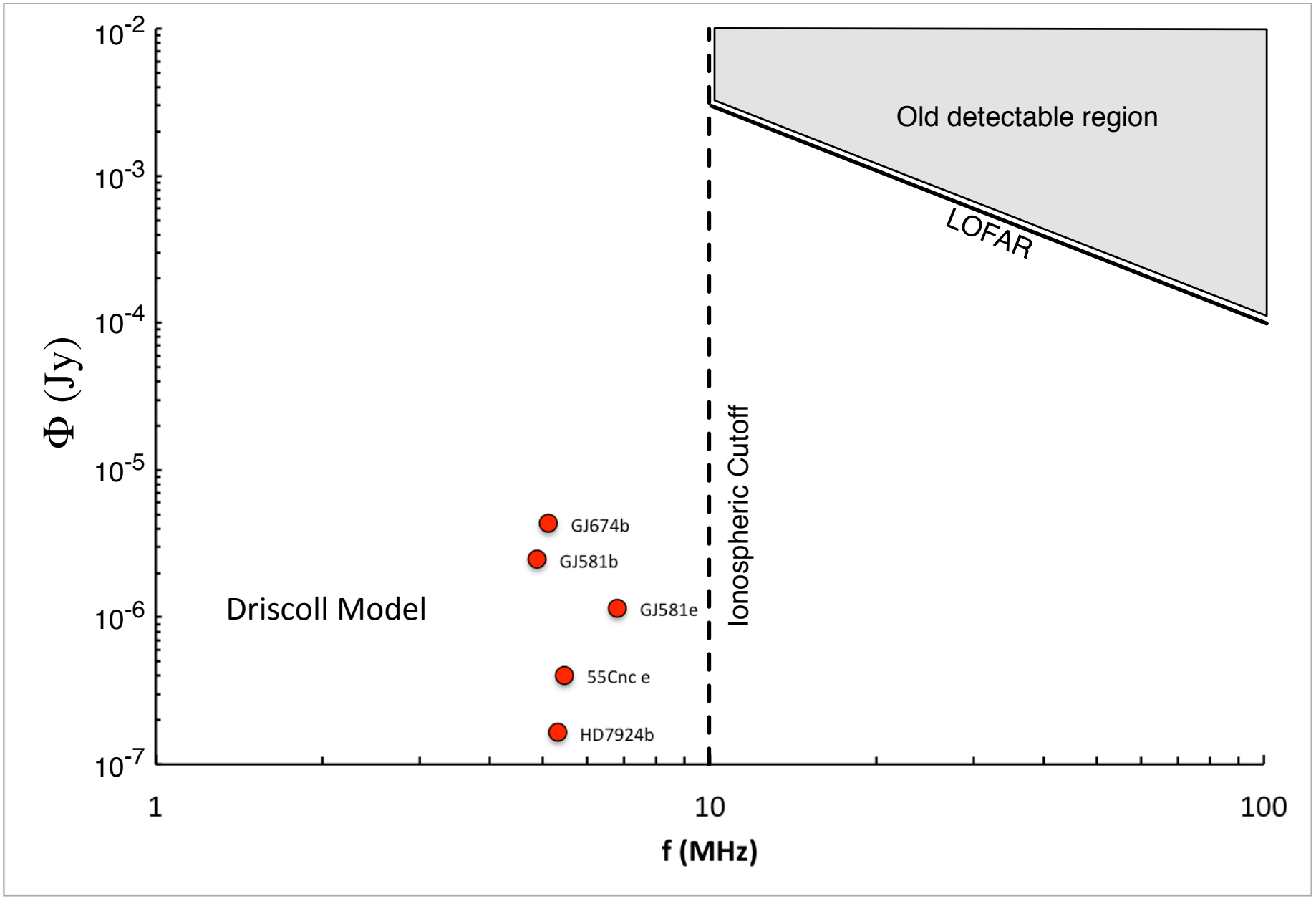


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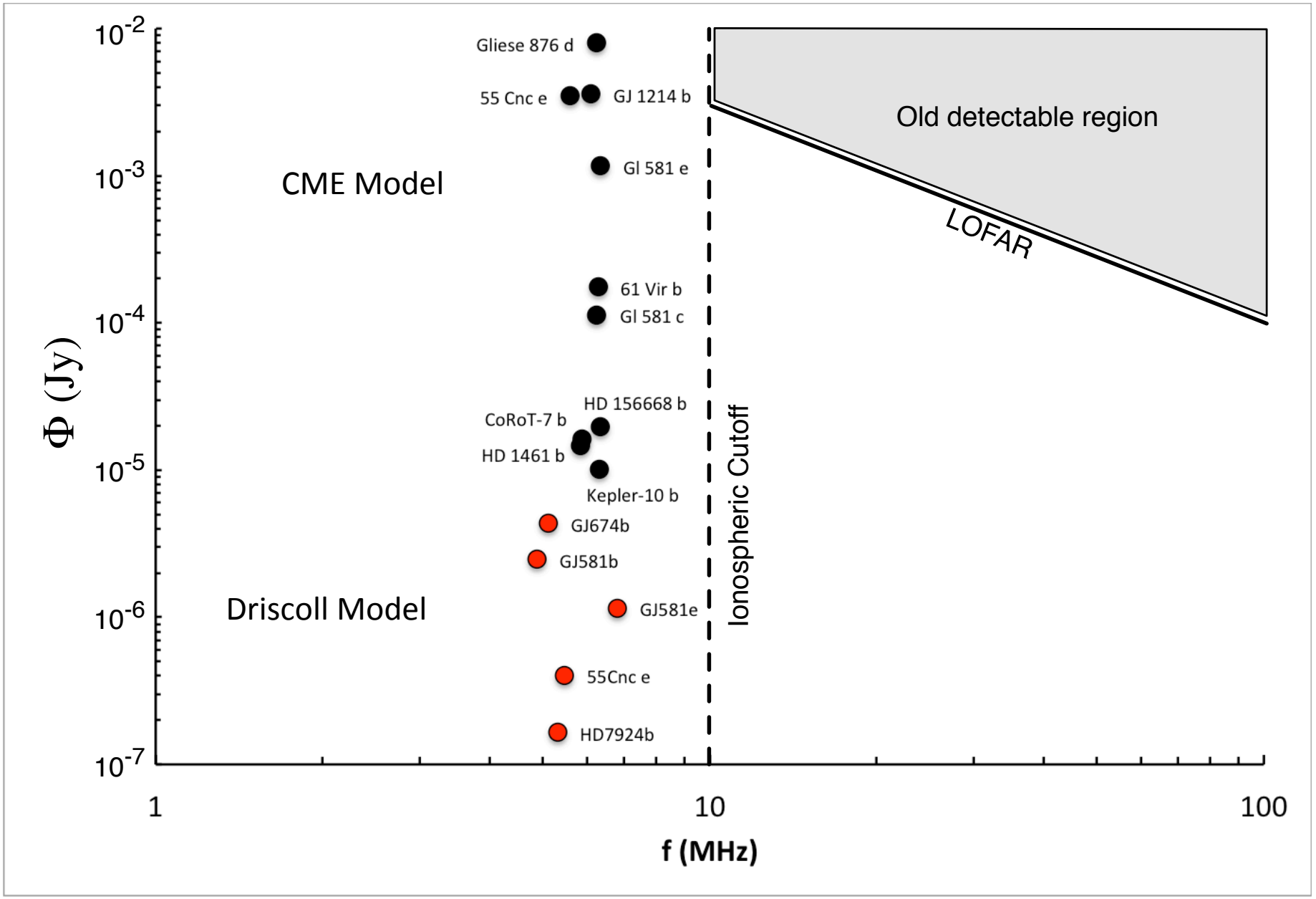


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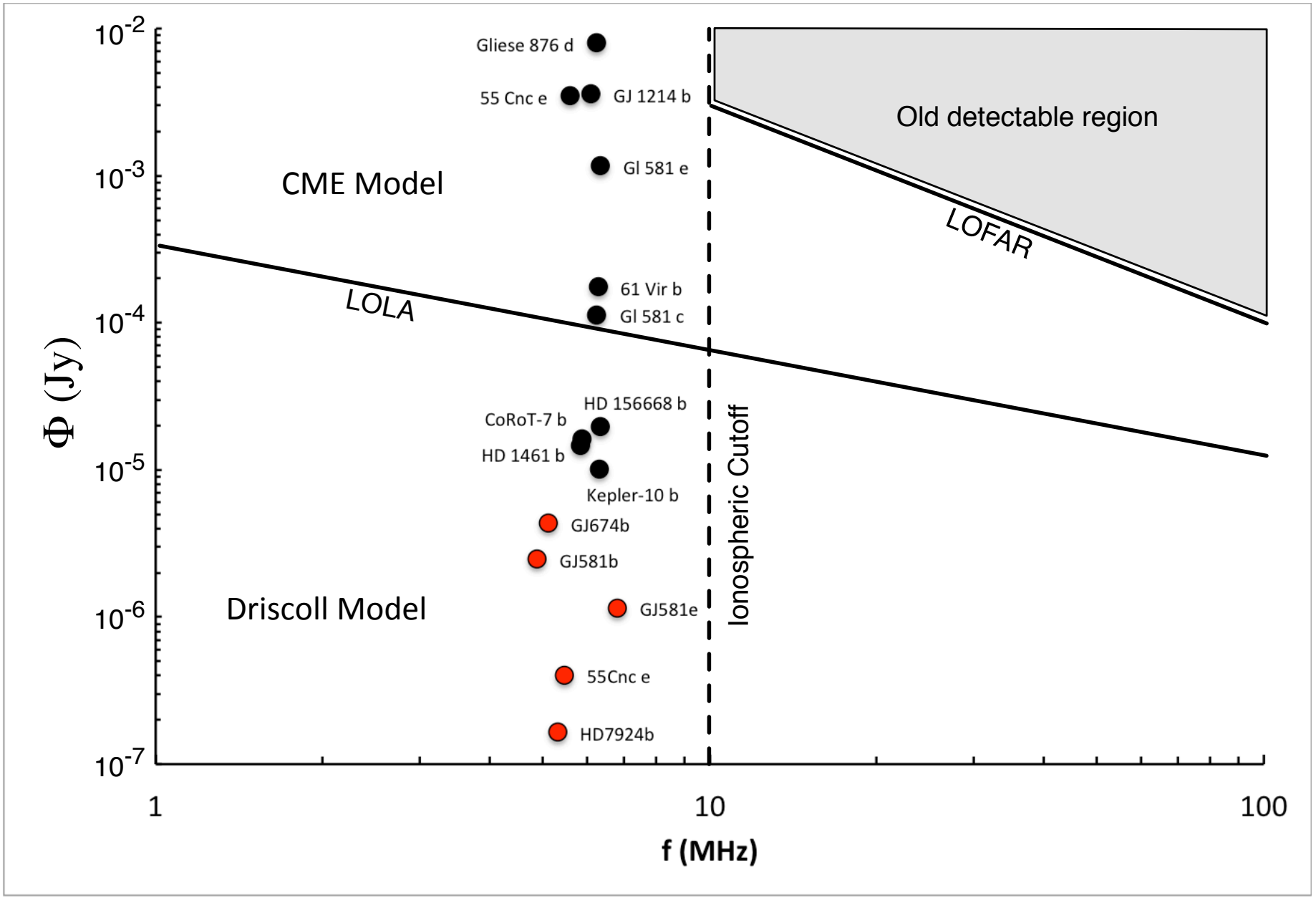


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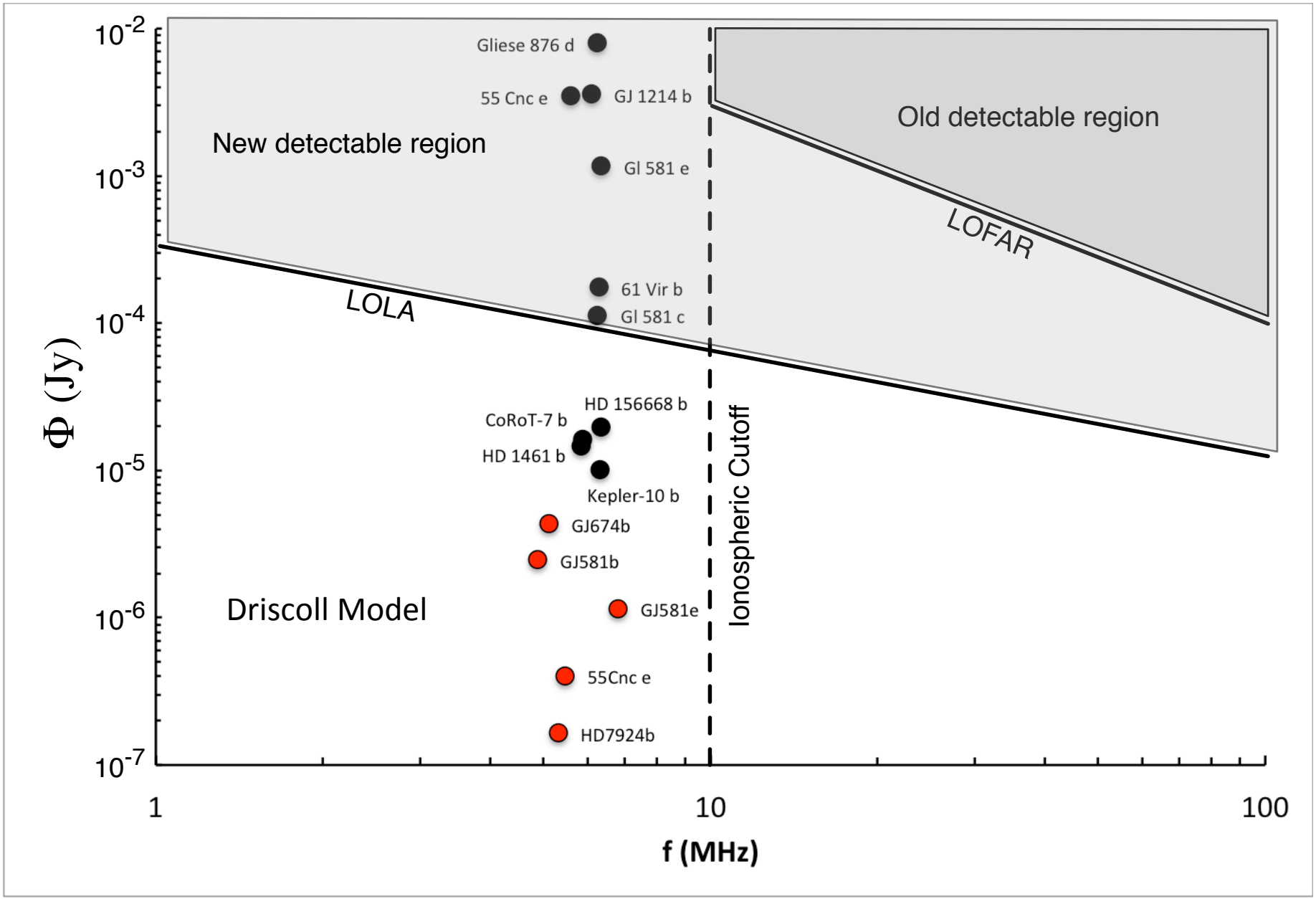


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# Limitations

- Exoplanet Model
  - Optimistic dynamo
  - Stellar magnetic fields
- CMEs
  - Infrequent
  - Temporal
  - Localized
- LOLA
  - Expensive
  - Construction time

# Conclusions

- Exoplanet magnetic field signals currently undetectable
  - too weak
  - too low frequency
- Timely coronal mass ejection events may boost signal strength significantly
- An expensive, low-frequency telescope on the Moon could detect these signals

Target exoplanets:

- Gliese876 d
- 55Cnc e
- GJ1214 b
- GI581 e
- 61Vir b
- GI581 c