

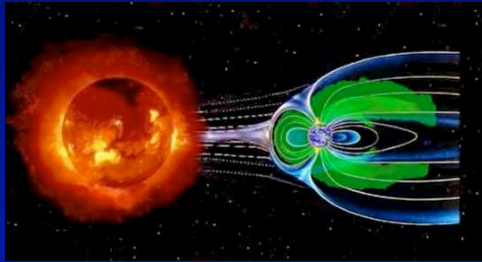
Detection of exoplanetary radio emission with LOFAR

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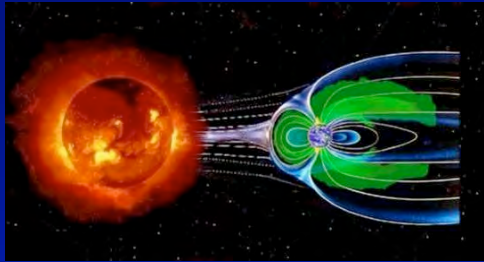
Planetary radio emission



	Flow	weakly/not magnetized (solar wind)	strongly magnetized (Jovian magnetosphere)
Obstacle			
	weakly/not magnetized (Venus, Io)	no intense cyclotron emission	unipolar interaction (Jupiter-Io)
	strongly magnetized (Earth, Jupiter)	magnetospheric interaction (solar wind - Jupiter)	dipolar interaction (Jupiter-Ganymede)

[Zarka, Ecole de Goutelas, 2005]

Planetary radio emission



Expect similar emission from **extrasolar planets** - but how much?

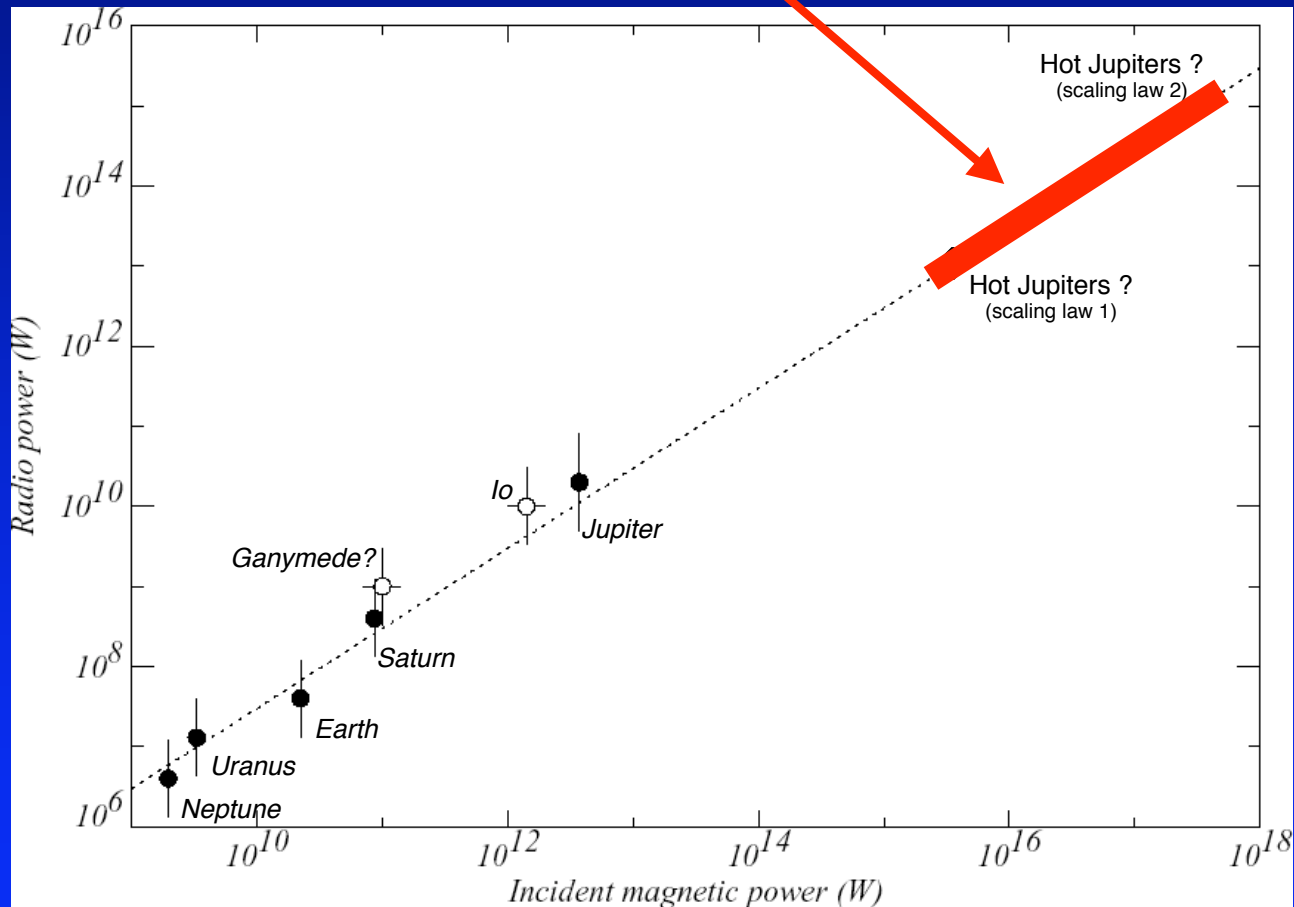
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Exoplanetary radio emission

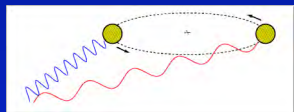
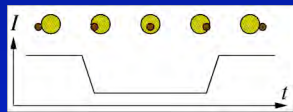
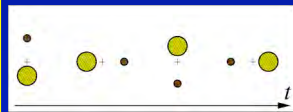
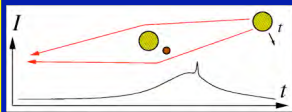

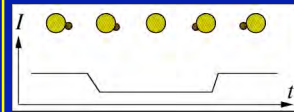
Expect similar emission from **extrasolar planets** - but how much?

[Farrell et al,
JGR, 1999;
Zarka et al,
A&SS,
2001;
Zarka,
ASP, 2004]



Much stronger than solar system planets!

Exoplanets: Observations

Doppler shift	Transit	Astrometry	Micro-lensing	Direct obs.	Second. Transit
					
1995 (51 Peg b)	2000 (HD209458b)	2002 (Gl 876 b)	2003 (O235/M53)	2004 (2M1207)	2004 (HD209458b)
>150	9	1	3	0-3	2

Radio emission as additional source of information?

Radio search motivation

Why to search for planetary radio emission?

- modulation \Rightarrow planetary rotation
- cutoff-frequency \Rightarrow magnetic field
- good intensity ratio \Rightarrow direct observation
- good intensity ratio \Rightarrow planet search?

Best candidates

Where to search for planetary radio emission?

- systems close to solar system
- strongly magnetized object (planet or star)
- close-in planets (Hot Jupiters)
- young systems
- active stars (CMEs)

Best candidates

Where to search for planetary radio emission?

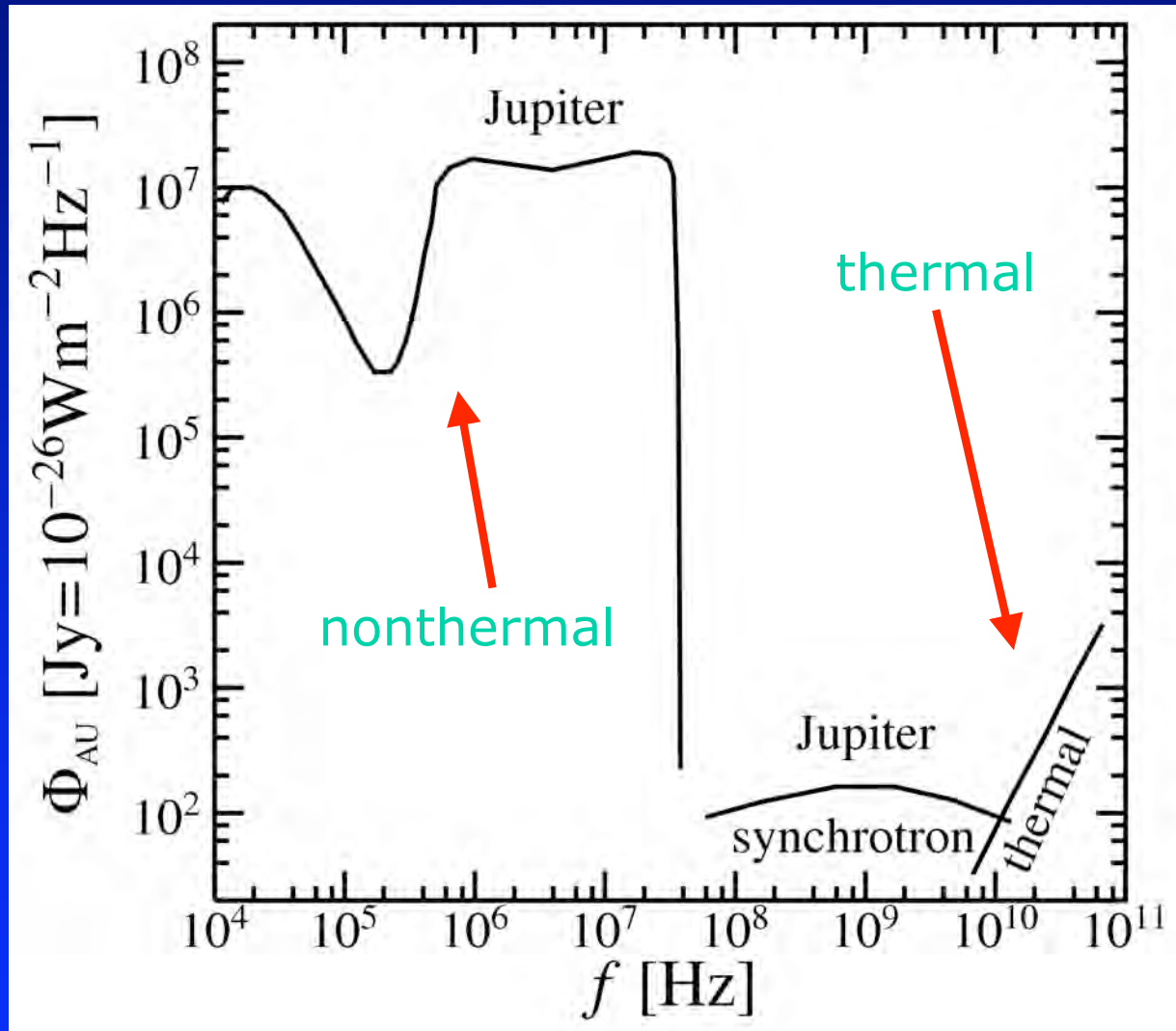
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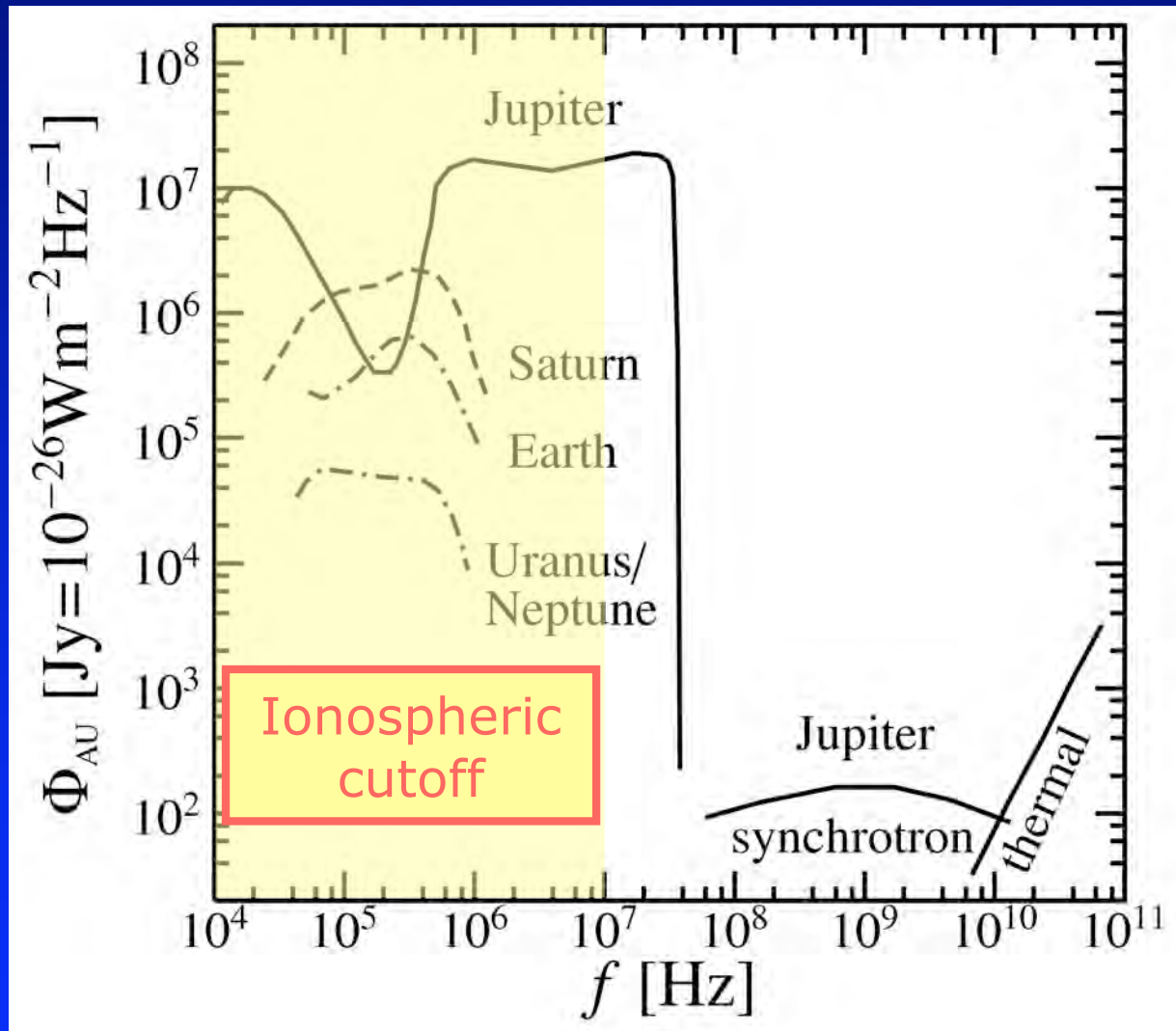
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Radioplanets: Solar system



flux
normalized
to 1 AU

Radioplanets: Solar system



Jupiter: strong
magnetic moment
↓
emission **above**
ionospheric cutoff

flux
normalized
to 1 AU

Magnetic moments: Scalings

require cutoff frequency > 10 MHz

$$f_c \propto \frac{eB_p}{m_e}$$

\Rightarrow requires large magnetic field

\Rightarrow strongly magnetized object
(planet or star)

Best candidates

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Planetary radio emissions

Emitted radio
power:

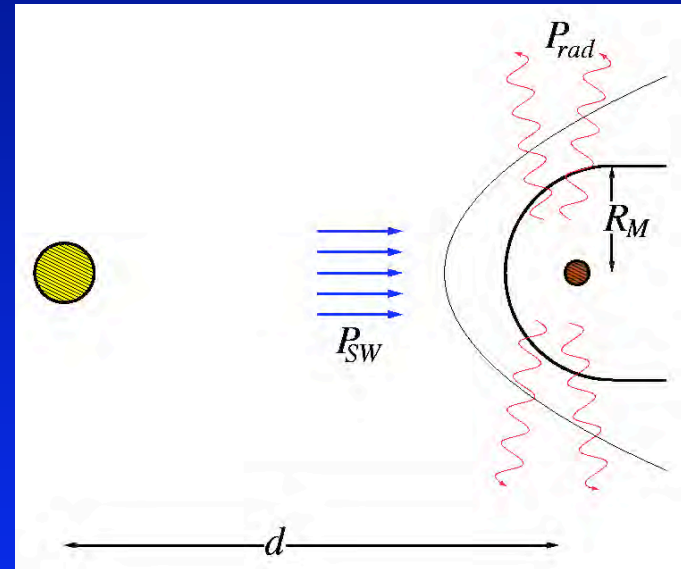
$$P_{rad} \propto P_{input}$$

[Zarka et al, Astrophys.
Space Sci., **277**, 293, 2001]

Power input:

$$P_{input} \propto \frac{R_M^2}{d^2} P_{sw}$$

(solar wind)



large power input for close-in planets

Best candidates

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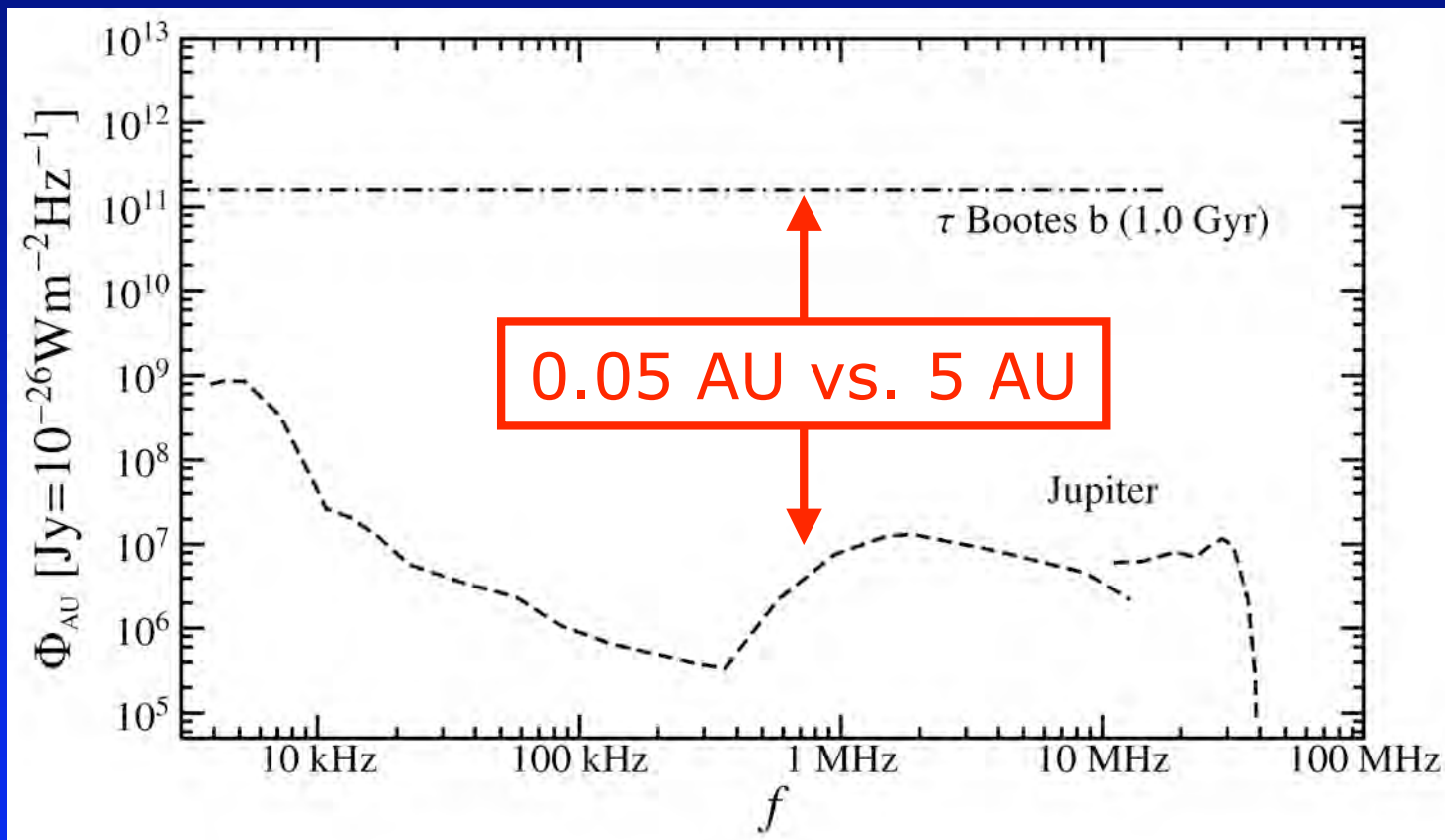
Best candidates

τ Bootes b = a good candidate!

- systems close to solar system 15.6 pc
- strongly magnetized object
(planet or star) 2.7 M_J
- close-in planets (Hot Jupiters) 0.05 AU
- young systems 1 Gyr
- active stars (CMEs)

Candidate planet: tau Bootes

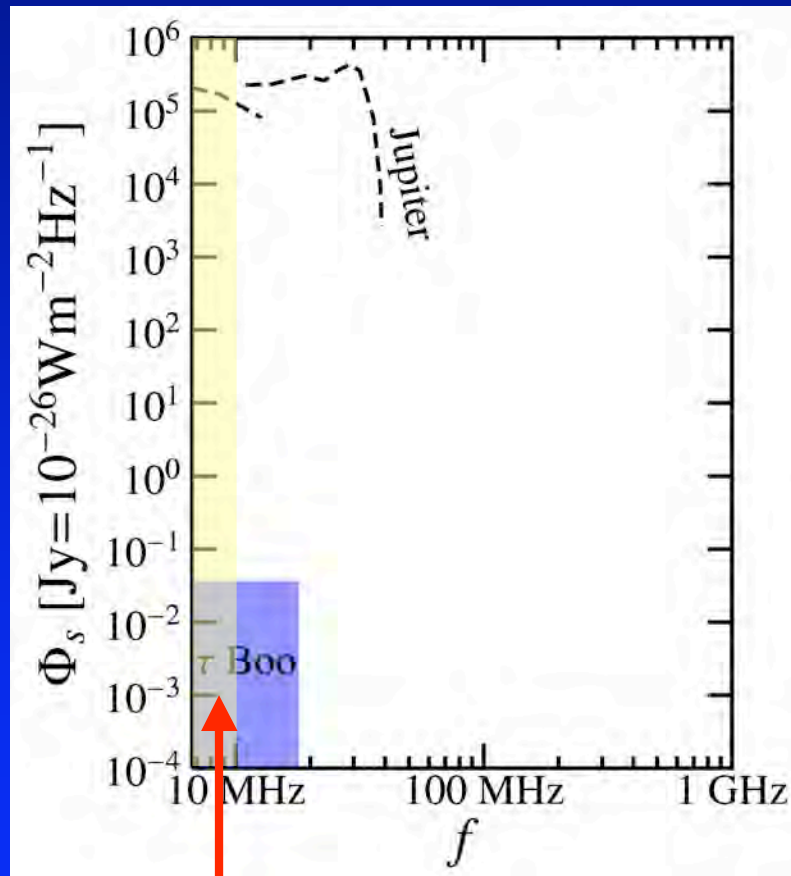
Flux normalized to 1 AU



dependence on
planetary orbit

Radioplanets: Detection

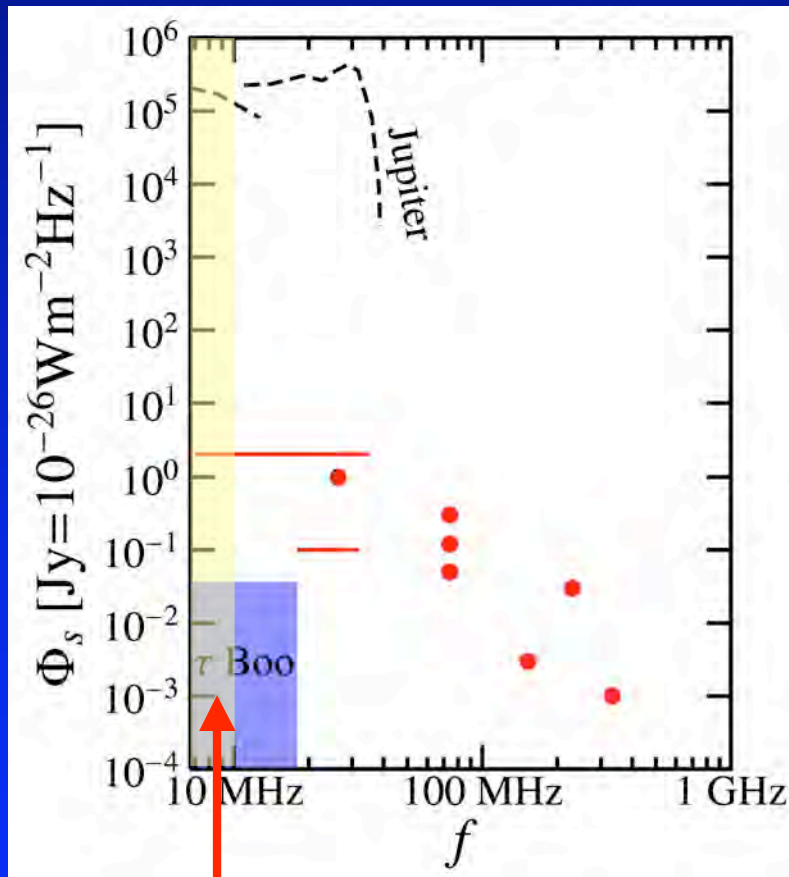
Flux reaching Earth



not observable (ionosphere)

Radioplanets: Detection

Flux reaching Earth

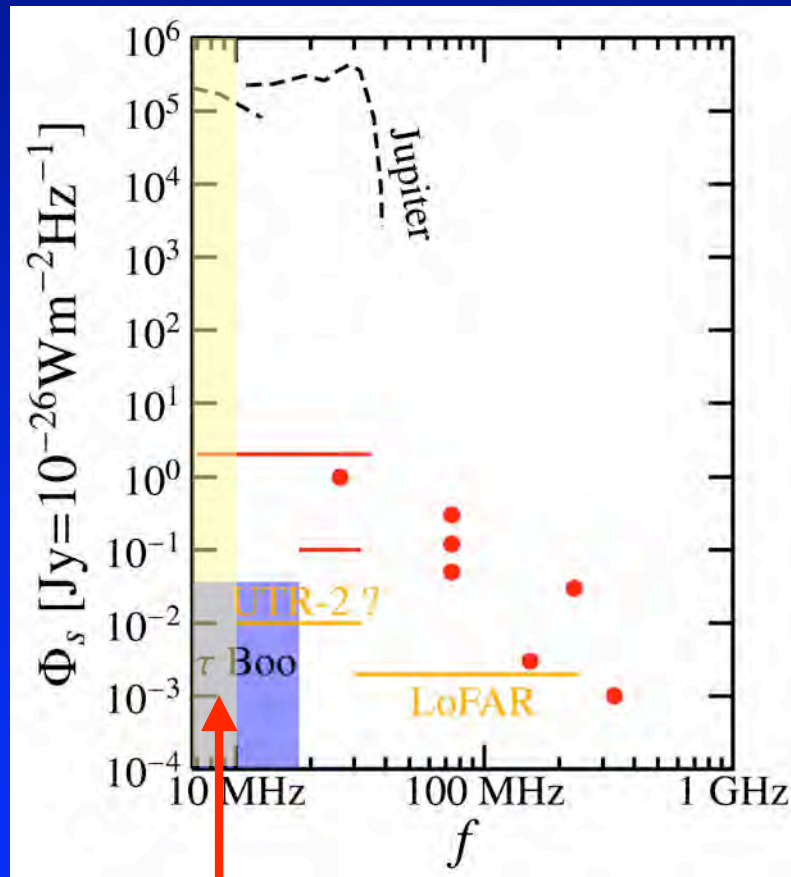


not observable (ionosphere)

Non-detections (1977-2005):
sensitivity not
sufficient too high
frequency

Radioplanets: Detection

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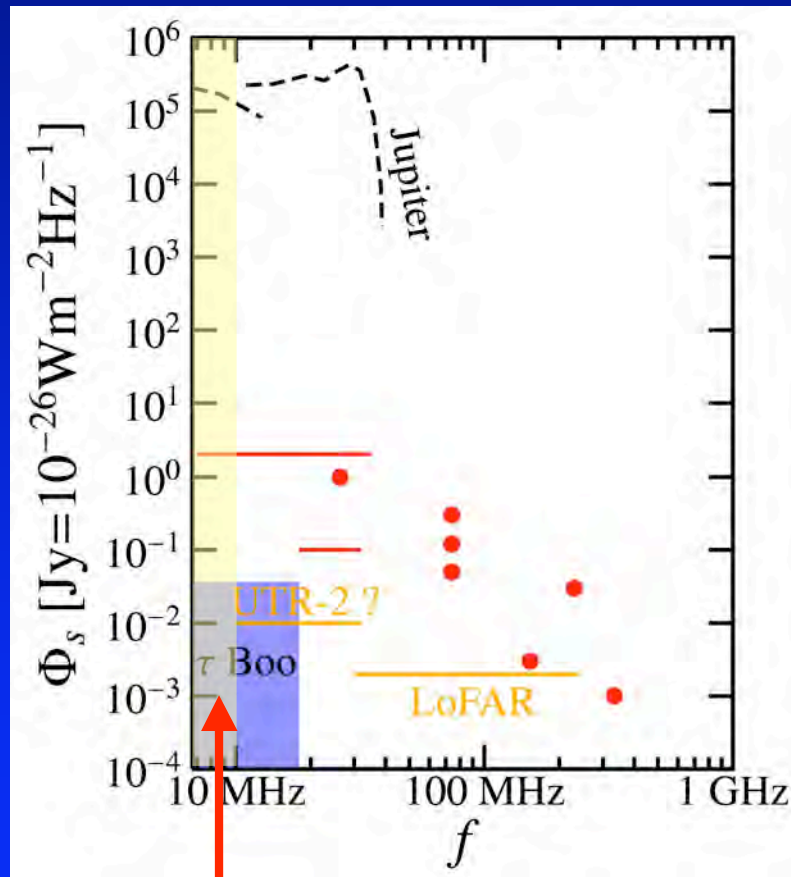
UTR-2: improved sensitivity at 10-35 MHz ready 2006?

LoFAR: sensitivity: few mJy at 30-240 MHz ready 2006/08?

[Grißmeier et al, 51 Peg b, 2005]

Summary: Why LOFAR?

Flux reaching Earth



not observable (ionosphere)

Expected emission:

- low frequency (~ 20 MHz)
- low sensitivity (~ 100 mJy)
- circular polarization

⇒ LOFAR

The End