EJSM RADAR STUDIES: JOVIAN RADIO ENVIRONMENT

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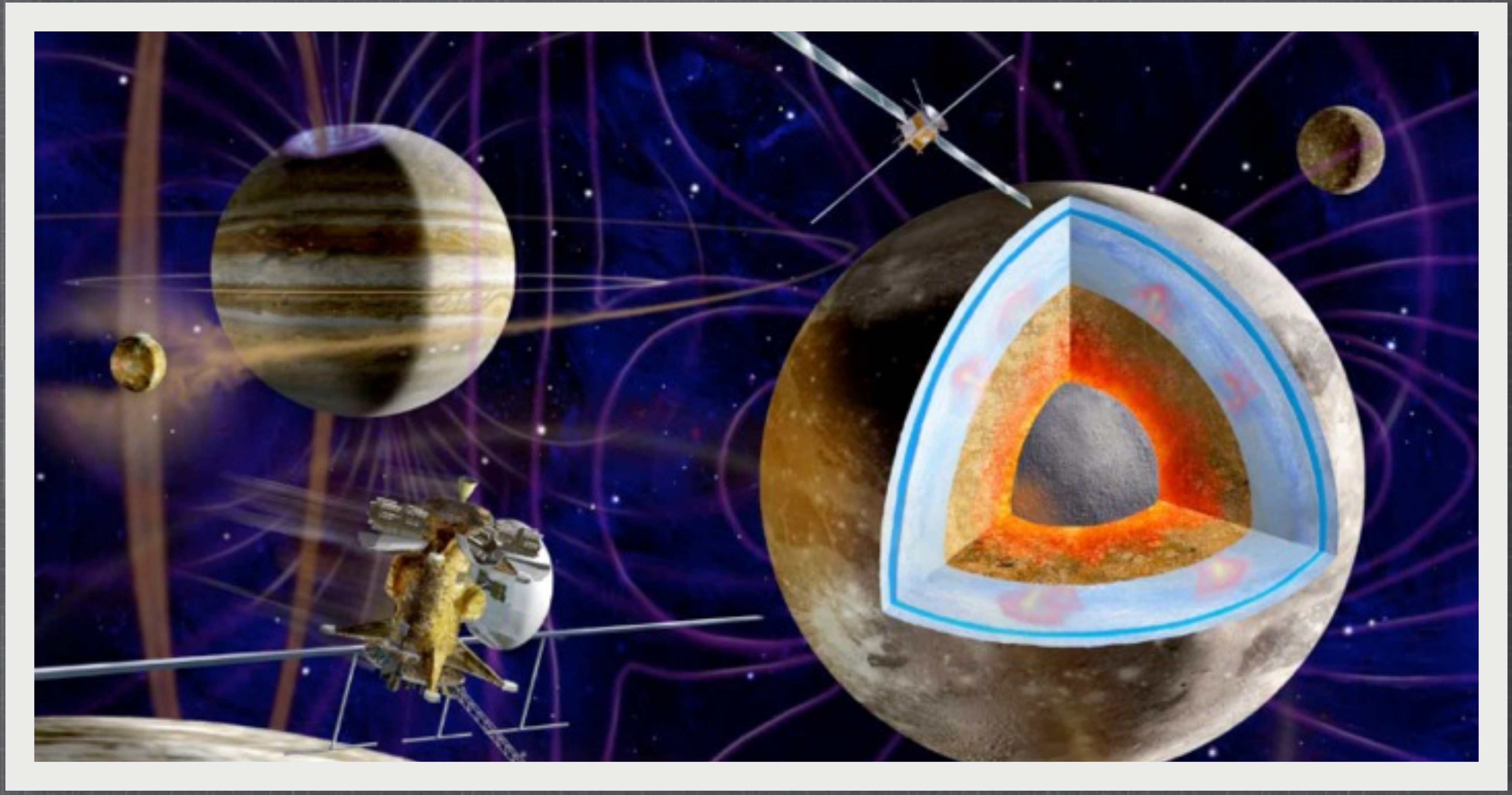
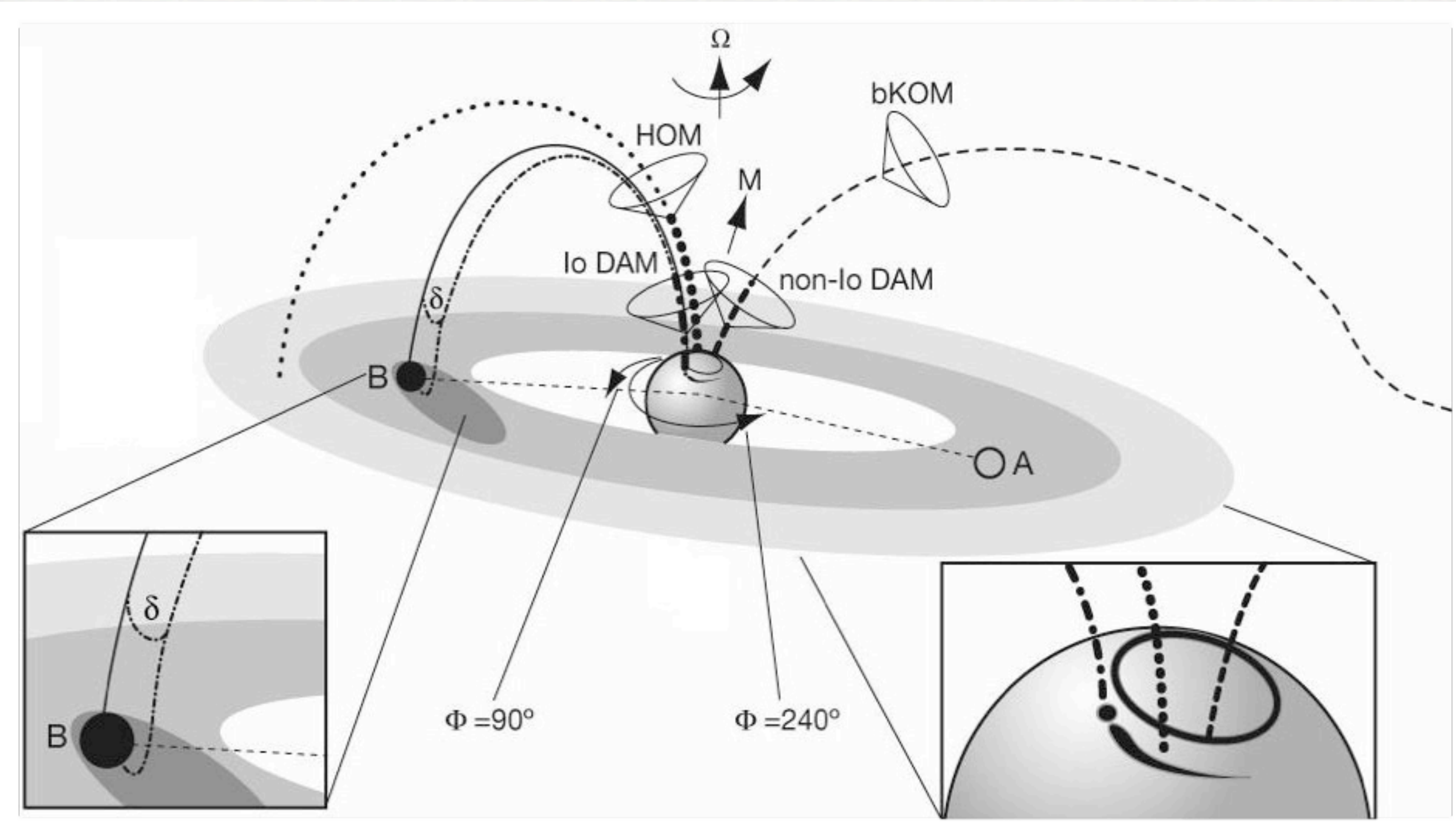


LOW FREQUENCY RADIO SOURCES AT JUPITER

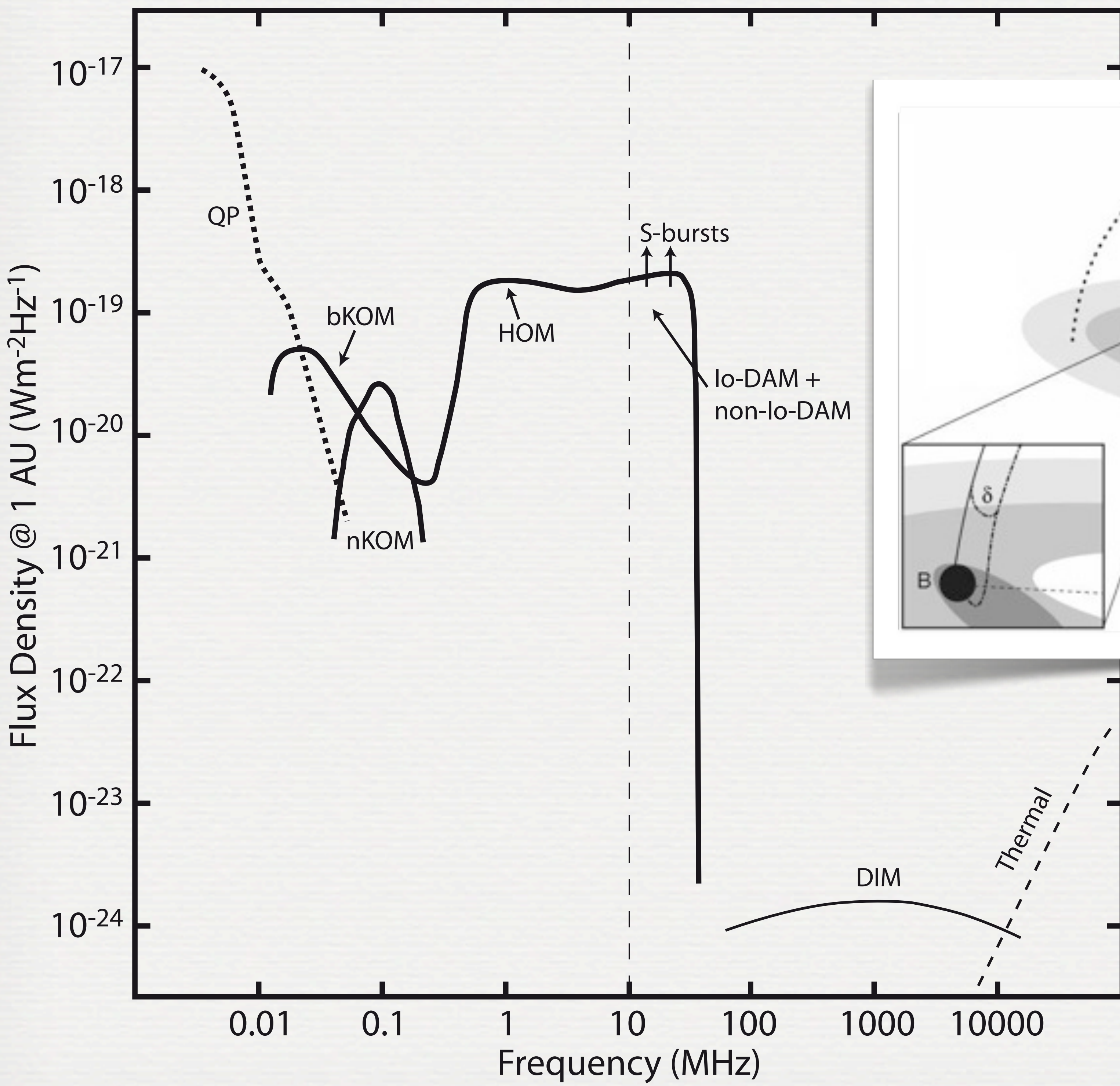


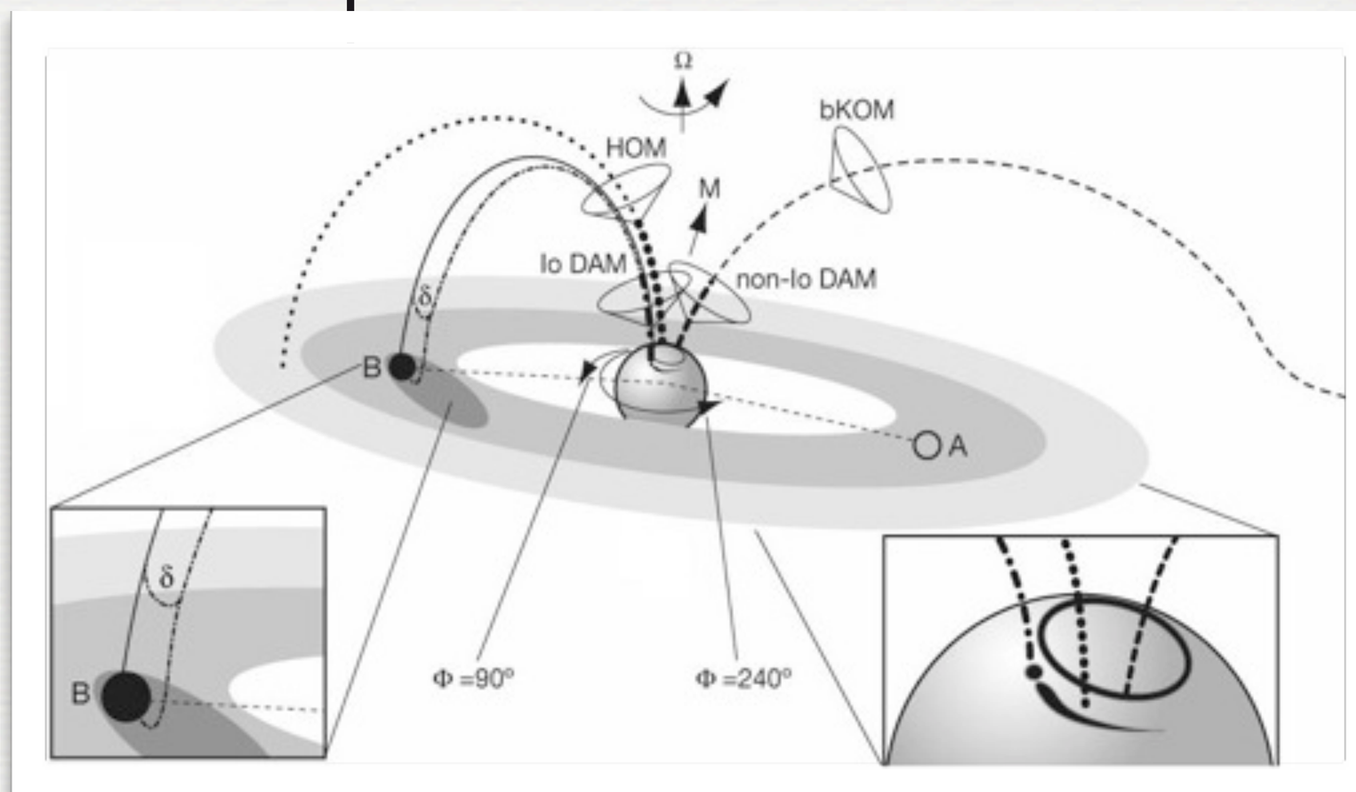
RADIO EMISSION PROPERTIES

- Very intense:
  up to ~10 orders of magnitude more intense than jupiter black body (non-thermal).
- Sporadic
- Localized sources:
  auroral sources (above ~3 to ~40 MHz)
- Beamed
- Polarized

JOVIAN RADIO SPECTRUM

spectrum of average flux density
when there is emission





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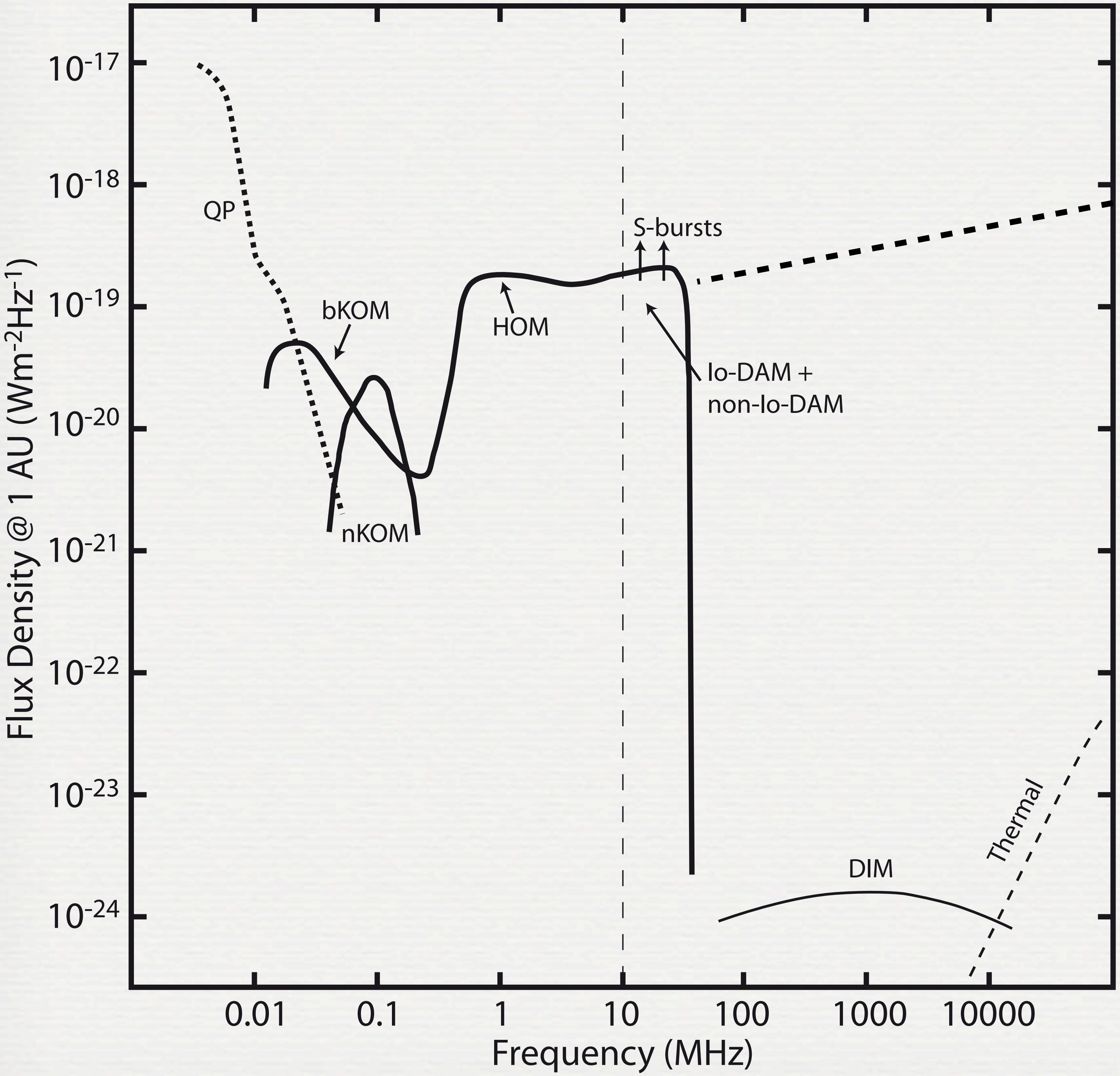

Non-Thermal Radio emissions (Auroras)

→ 10^{-19} $Wm^{-2}Hz^{-1}$ @ 1AU

⇒ 20 10^{-15} $Wm^{-2}Hz^{-1}$ @ Io

⇒ 5 10^{-15} $Wm^{-2}Hz^{-1}$ @ Europa

⇒ 2 10^{-15} $Wm^{-2}Hz^{-1}$ @ Ganymede

⇒ 0.6 10^{-15} $Wm^{-2}Hz^{-1}$ @ Callisto

JOVIAN RADIO SPECTRUM

spectrum of average flux density
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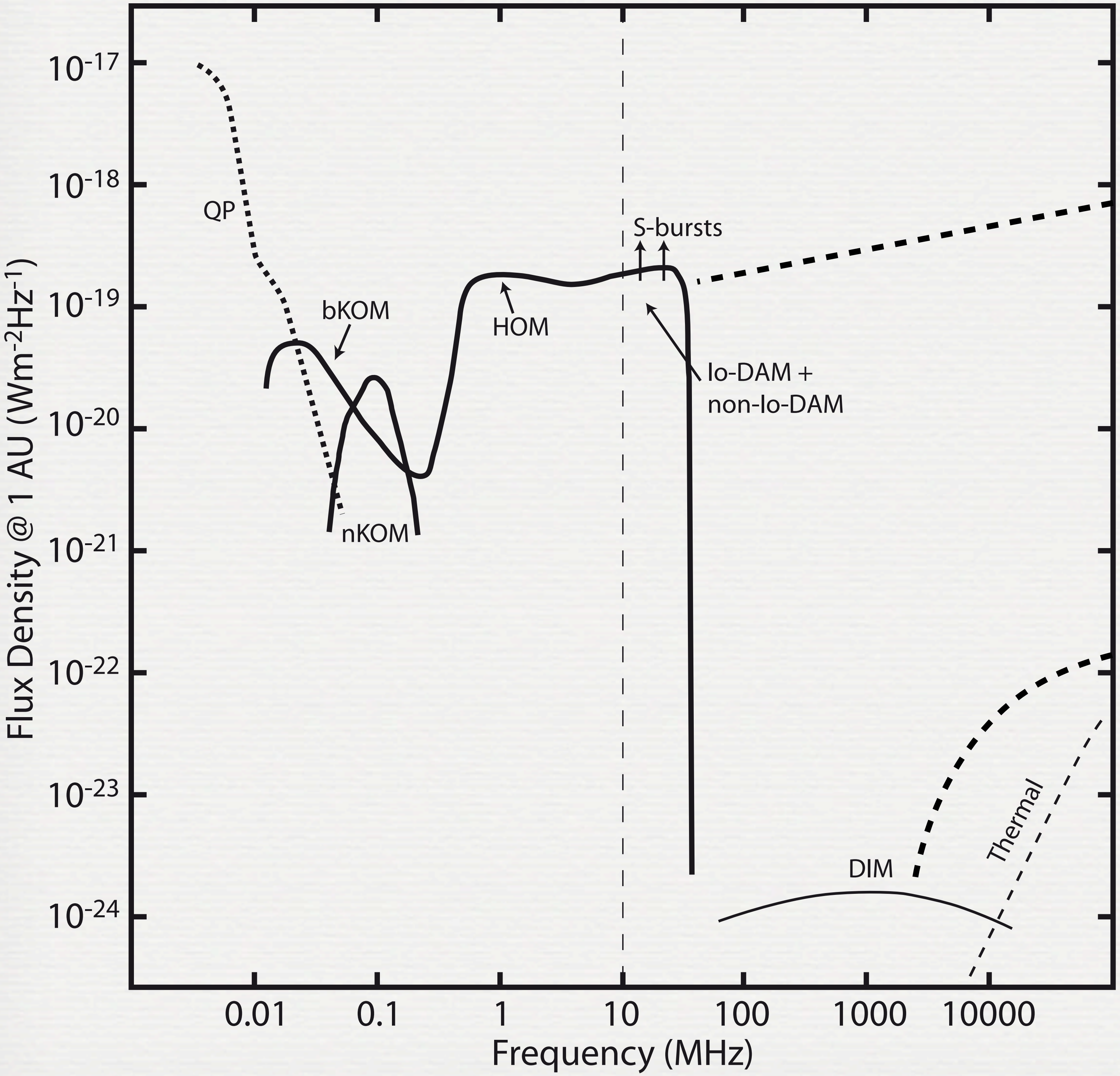

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Synchrotron emission (Radiation Belts)

→ 10^{-24} $Wm^{-2}Hz^{-1}$ @ 1AU

⇒ 20 10^{-20} $Wm^{-2}Hz^{-1}$ @ Io

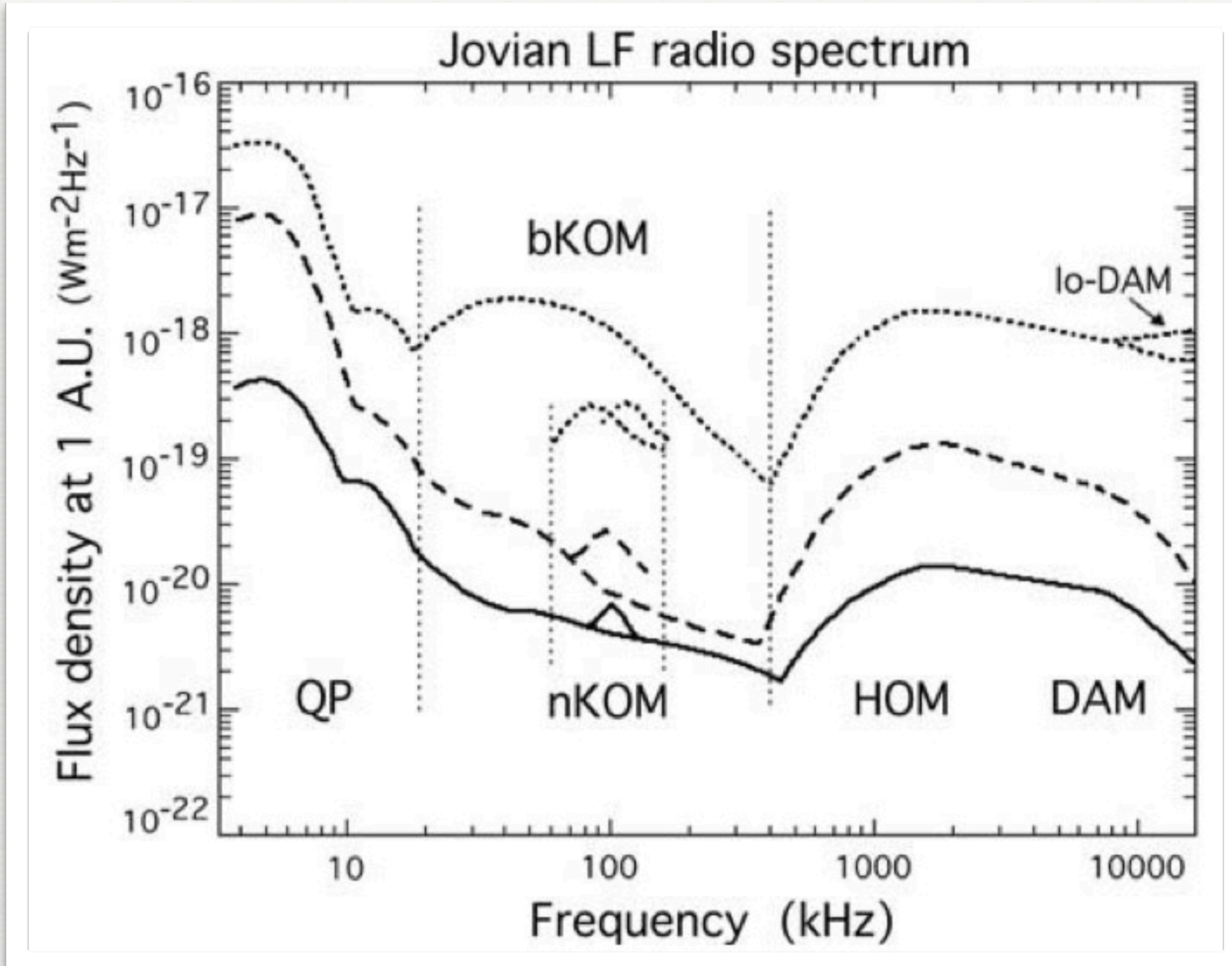
⇒ 5 10^{-20} $Wm^{-2}Hz^{-1}$ @ Europa

⇒ 2 10^{-20} $Wm^{-2}Hz^{-1}$ @ Ganymede

⇒ 0.6 10^{-20} $Wm^{-2}Hz^{-1}$ @ Callisto

NB: numbers are only orders of magnitudes

JOVIAN RADIO SPECTRUM



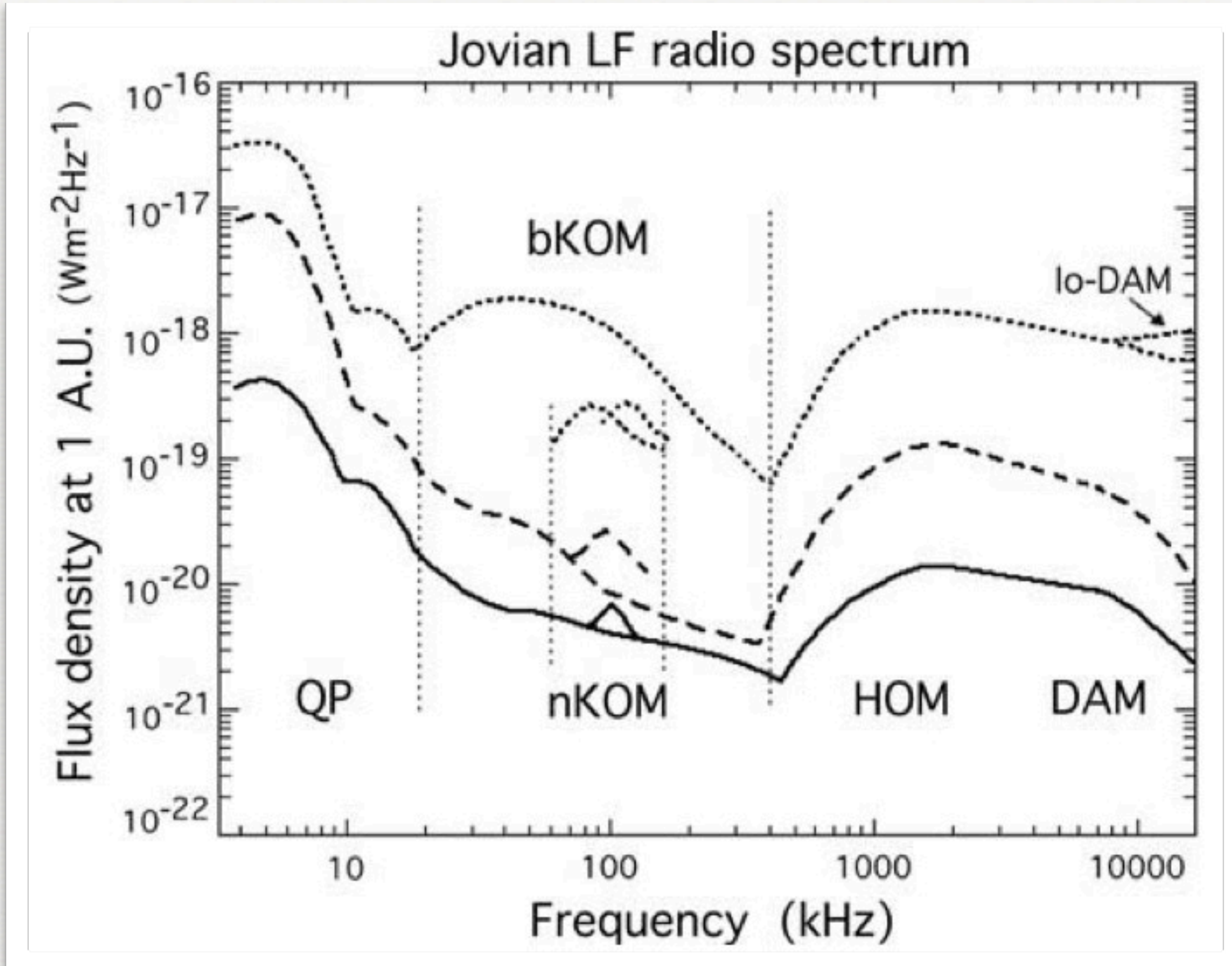
1% level
= peak spectrum

10% level
= mean spectrum
when emission is active

50% level
= mean spectrum (all times)

From Cassini/RPWS data **[Zarka et al. JGR 2004]**

JOVIAN RADIO SPECTRUM



1% level
= peak spectrum

10% level
= mean spectrum when emission is active

50% level
= mean spectrum (all times)

Used for calculations on previous slide

From Cassini/RPWS data **[Zarka et al. JGR 2004]**

JOVIAN RADIO SPECTRUM

Non-Thermal Radio emissions (Auroras)

Average flux density when emission is active		*Peak flux density*	
~10^{-19} $Wm^{-2}Hz^{-1}$	@ 1AU	~10^{-18} $Wm^{-2}Hz^{-1}$	@ 1AU
⇒ 20 10^{-15} $Wm^{-2}Hz^{-1}$	@ Io	⇒ 20 10^{-14} $Wm^{-2}Hz^{-1}$	@ Io
⇒ 5 10^{-15} $Wm^{-2}Hz^{-1}$	@ Europa	⇒ 5 10^{-14} $Wm^{-2}Hz^{-1}$	@ Europa
⇒ 2 10^{-15} $Wm^{-2}Hz^{-1}$	@ Ganymede	⇒ 2 10^{-14} $Wm^{-2}Hz^{-1}$	@ Ganymede
⇒ 0.6 10^{-15} $Wm^{-2}Hz^{-1}$	@ Callisto	⇒ 0.6 10^{-14} $Wm^{-2}Hz^{-1}$	@ Callisto

INTERFERENCES FOR RADAR STUDIES ?

- When the jovian sources are active and visible, peak flux density of radio emissions is evaluated to:
    - 20×10^{-14} $Wm^{-2}Hz^{-1}$ @ Io
    - 5×10^{-14} $Wm^{-2}Hz^{-1}$ @ Europa
    - 2×10^{-14} $Wm^{-2}Hz^{-1}$ @ Ganymede
    - 0.6×10^{-14} $Wm^{-2}Hz^{-1}$ @ Callisto

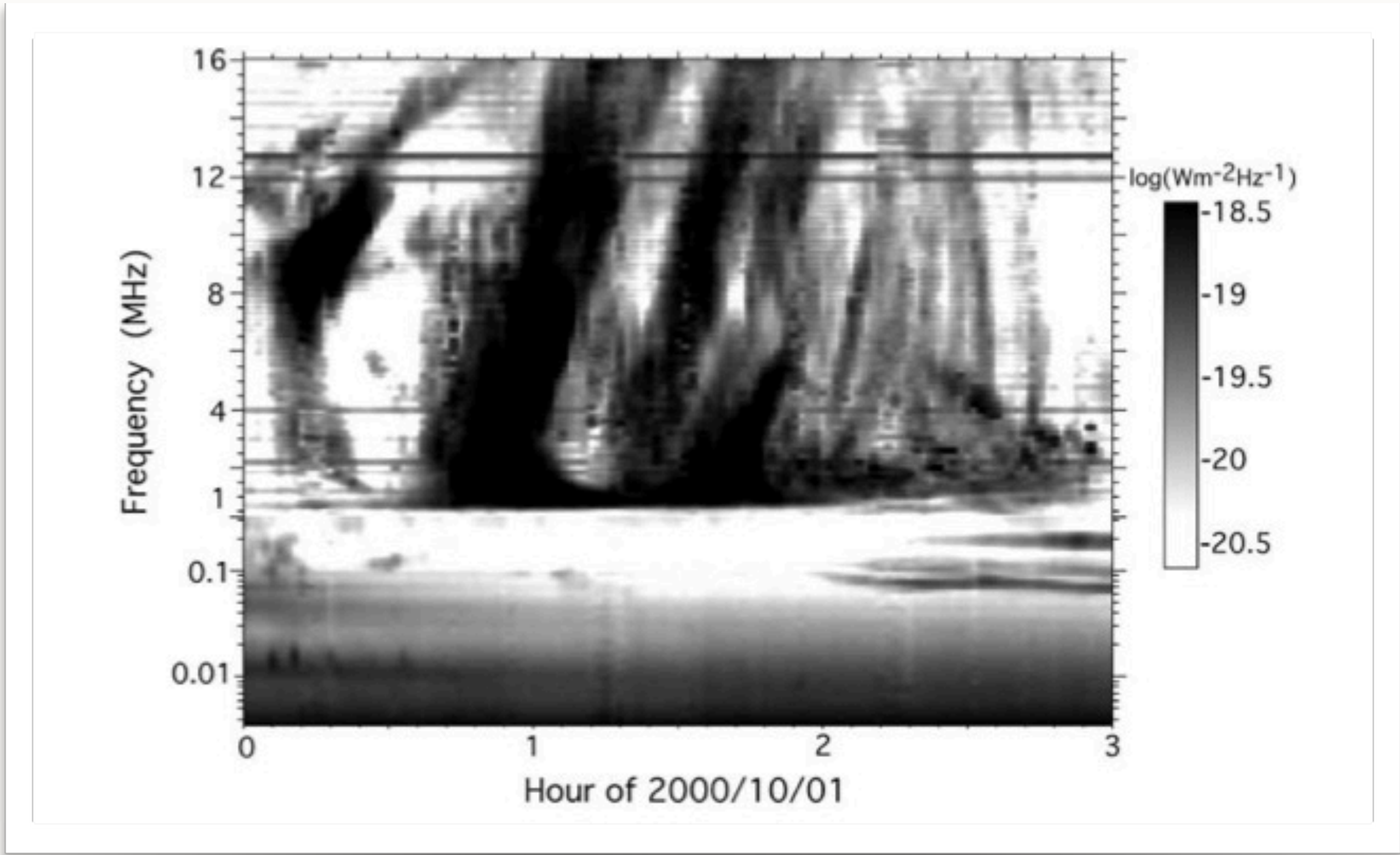
- (Very) rough estimate of echo signal (20 W, 10 MHz band, 200 km orbit, 1% reflexion): $\sim10^{-13}$ $Wm^{-2}Hz^{-1}$ *[numbers to be check with radar teams!]*

VARIABILITY

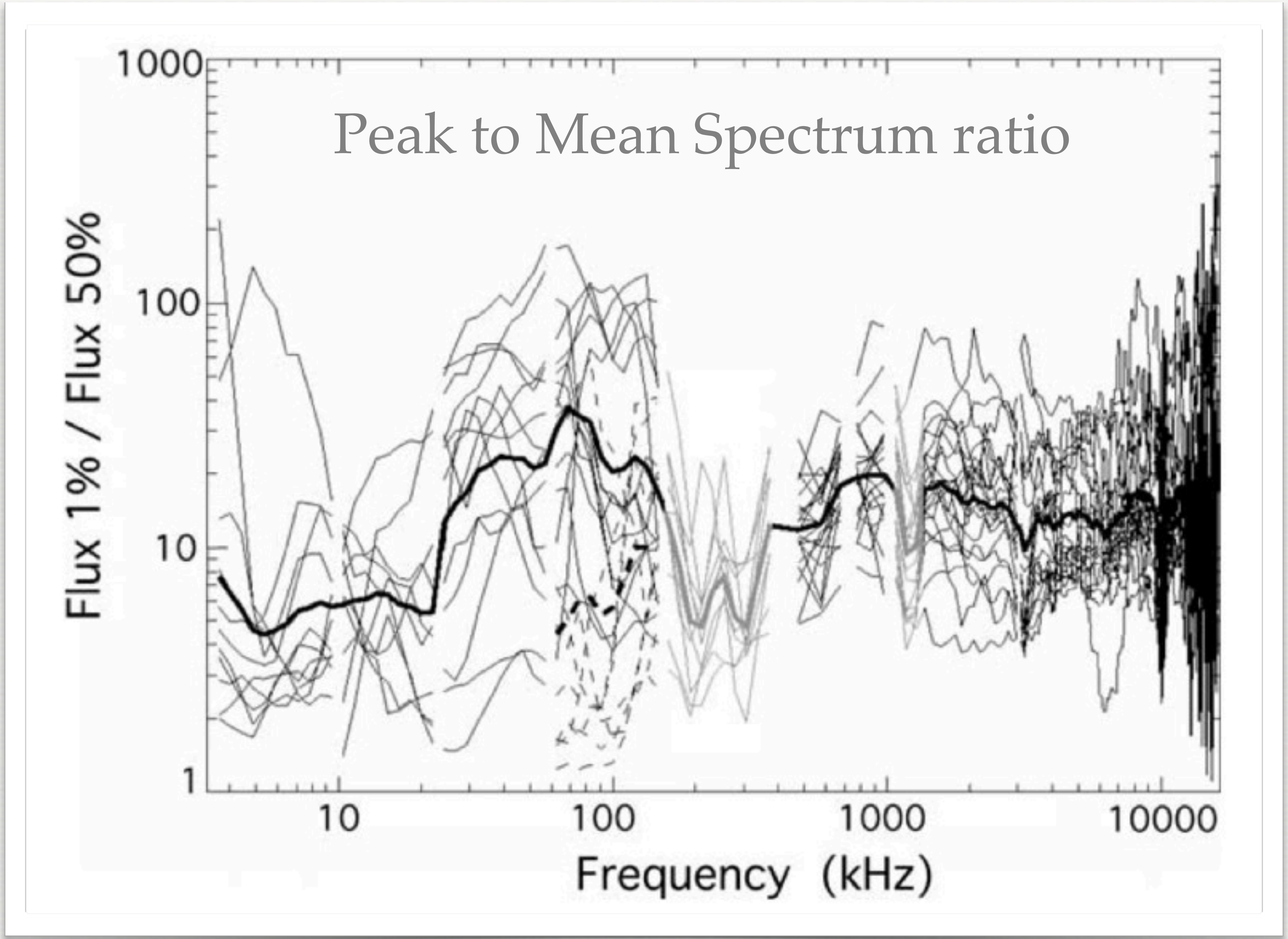
- Visibility is predictable (we know where/when we could observe them)
- Occurrence is known on average (we know their periodicities)
- **But:**
  - sporadic
  - absolute occurrence *(within visibility and periodicity patterns)* is not predictable.

VARIABILITY

- Example (Cassini/RPWS)

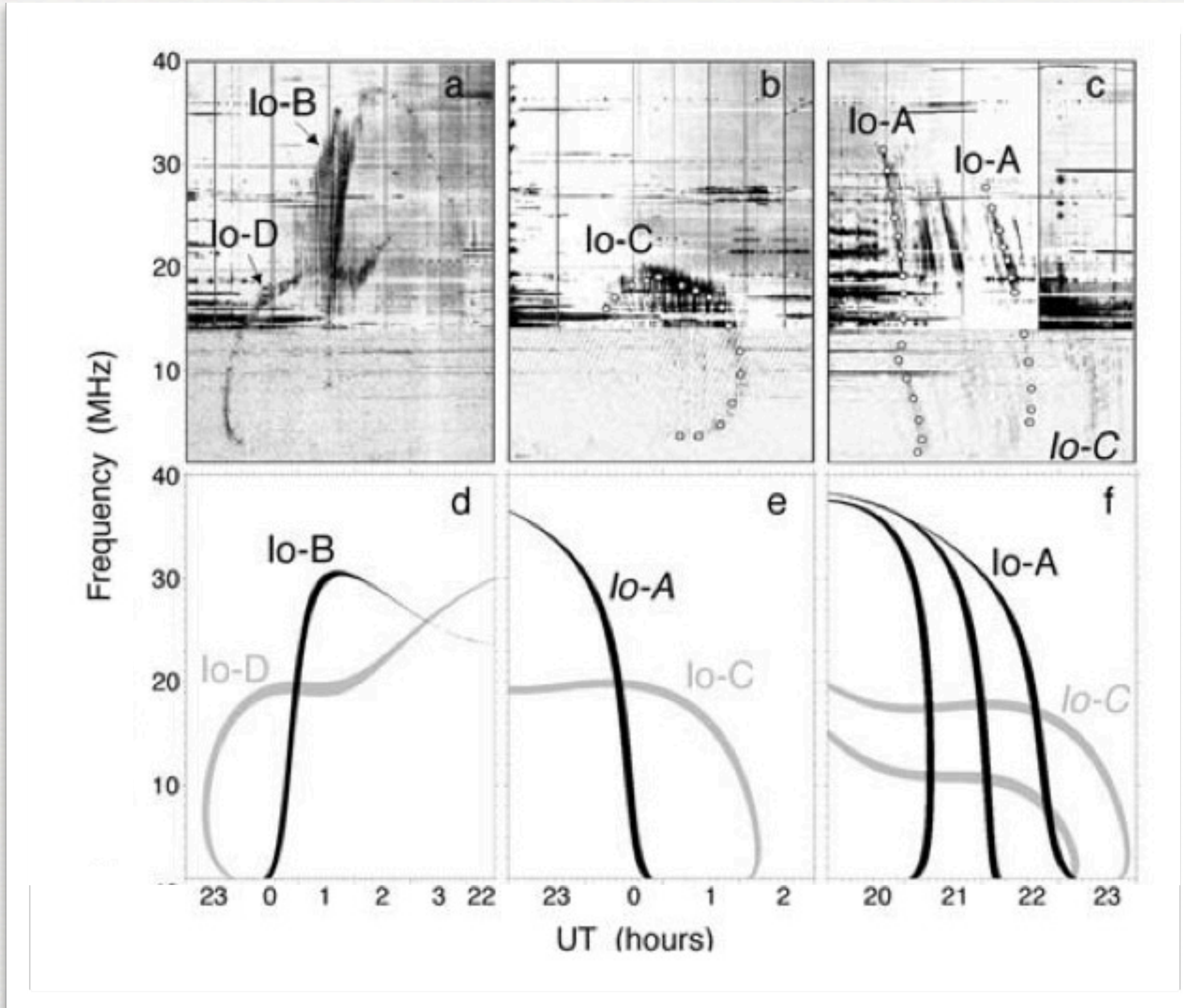


SPORADICITY

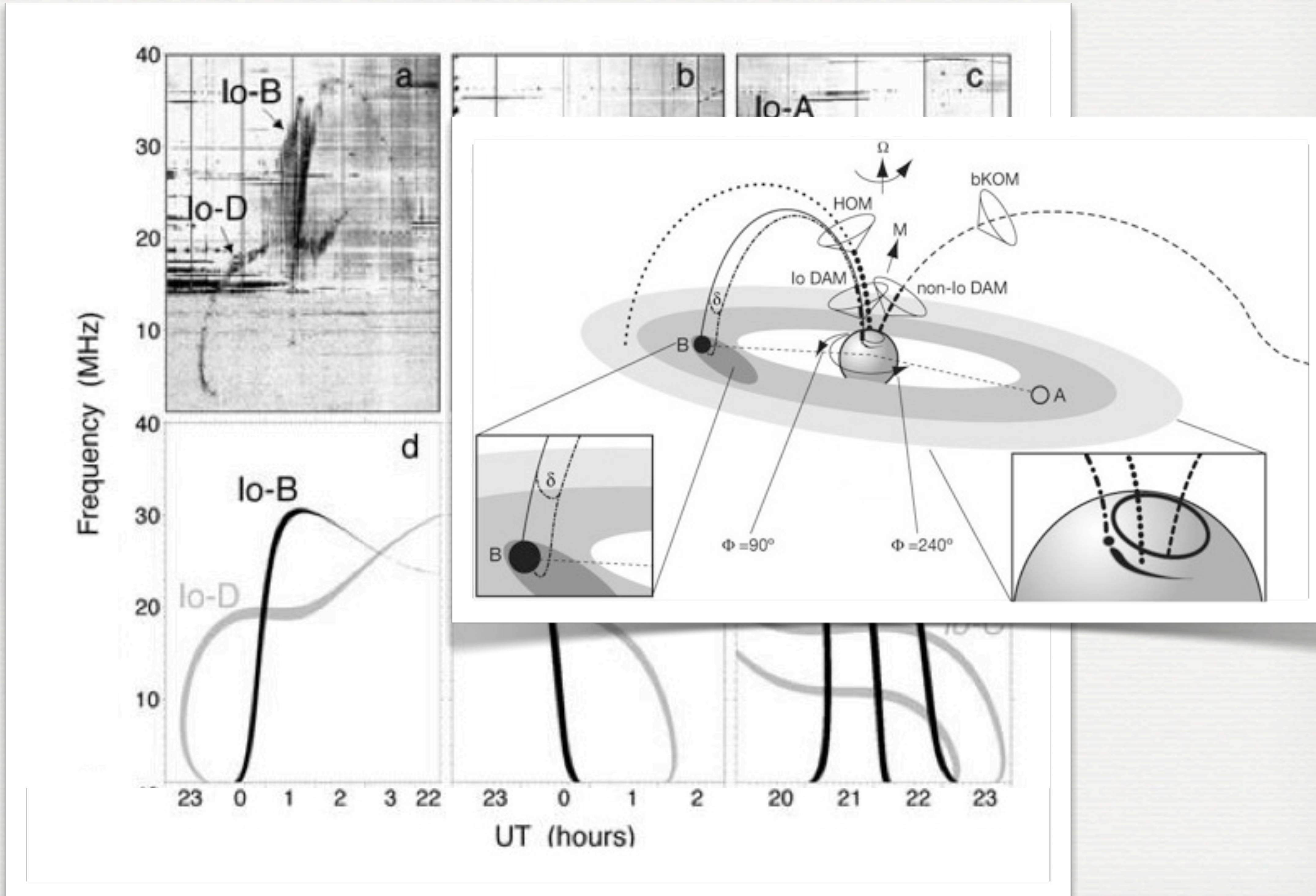


[Zarka et al. JGR 2004]

RADIO EMISSION VISIBILITY MODELING



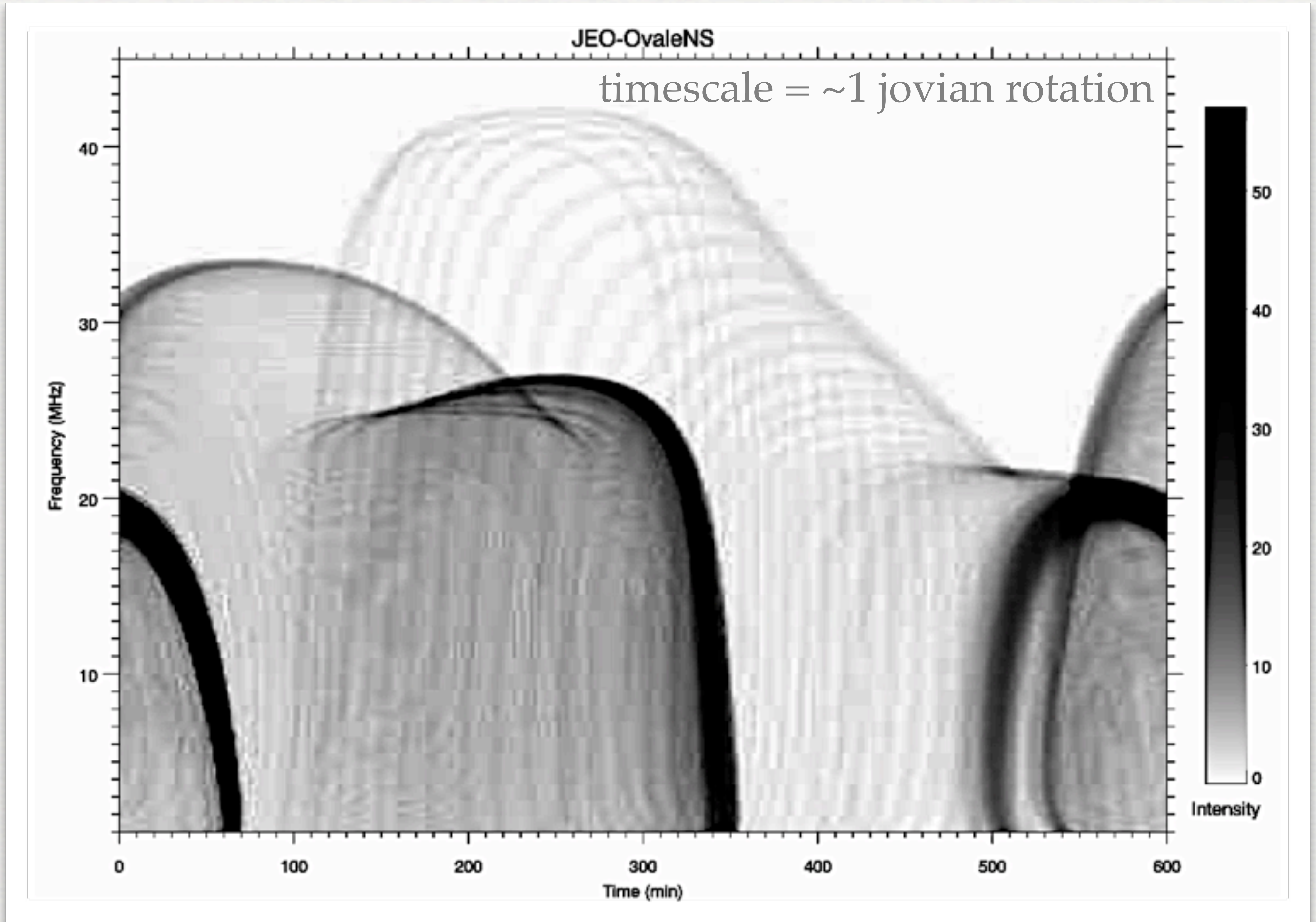
RADIO EMISSION VISIBILITY MODELING



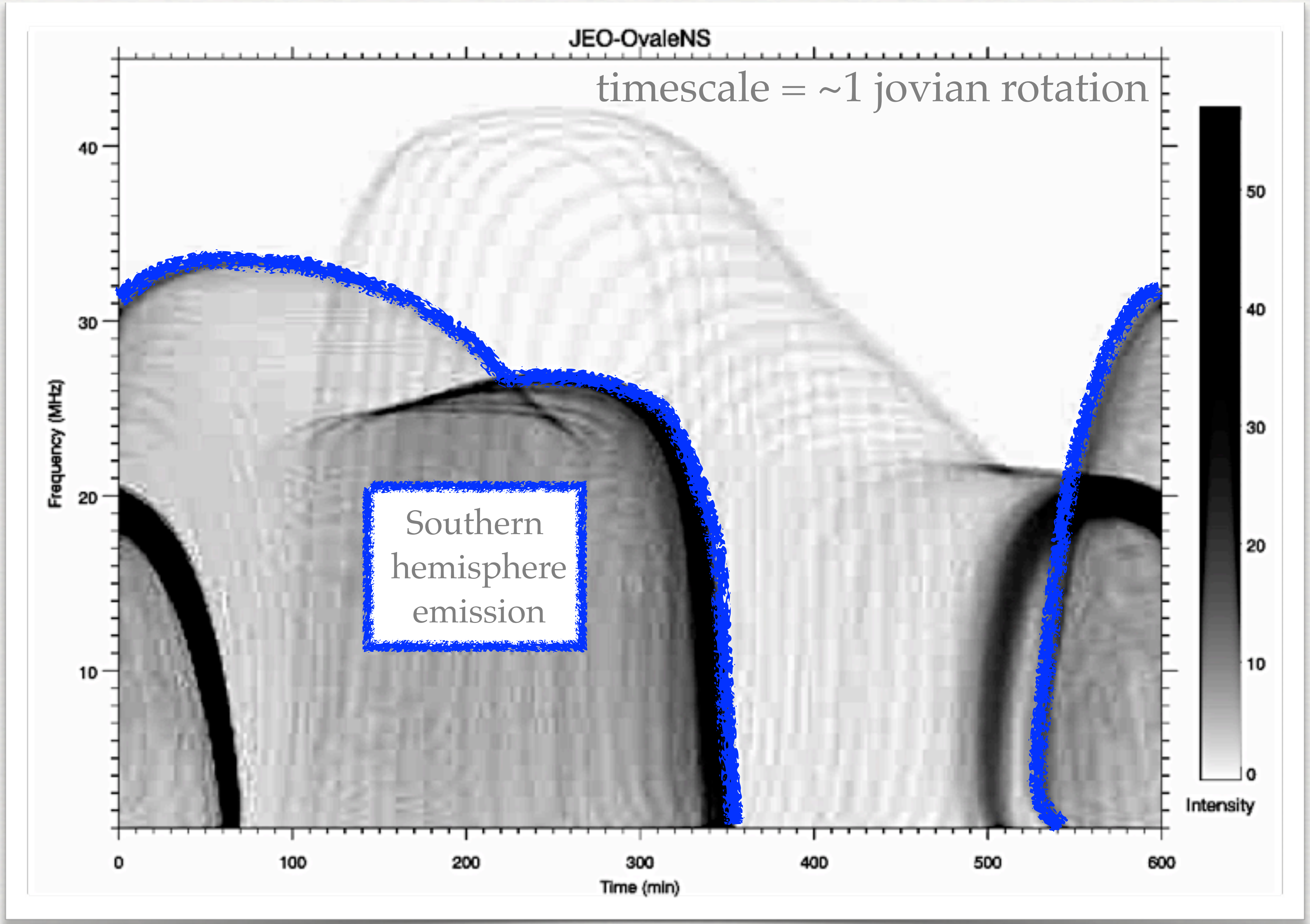
RADIO EMISSION VISIBILITY MODELING

1. Auroral sources (HOM and Non-Io-DAM)
   - located on magnetic field lines with footprints on main auroral oval.
   - variable emission angle [Hess et al. 2008]
   - Model periodicity: 9 hr 55 min = 1 Jovian rotation.
2. Io controlled sources (Io-DAM)
   - located on magnetic field line passing by Io (+ lead angle)
   - variable emission angle [Hess et al. 2008]
   - Model Periodicity: 17 day 13 hr 12 min = 1 Jovian rotation (9 hr 55 min) × 1 Io orbital period (42 hr 29 min).

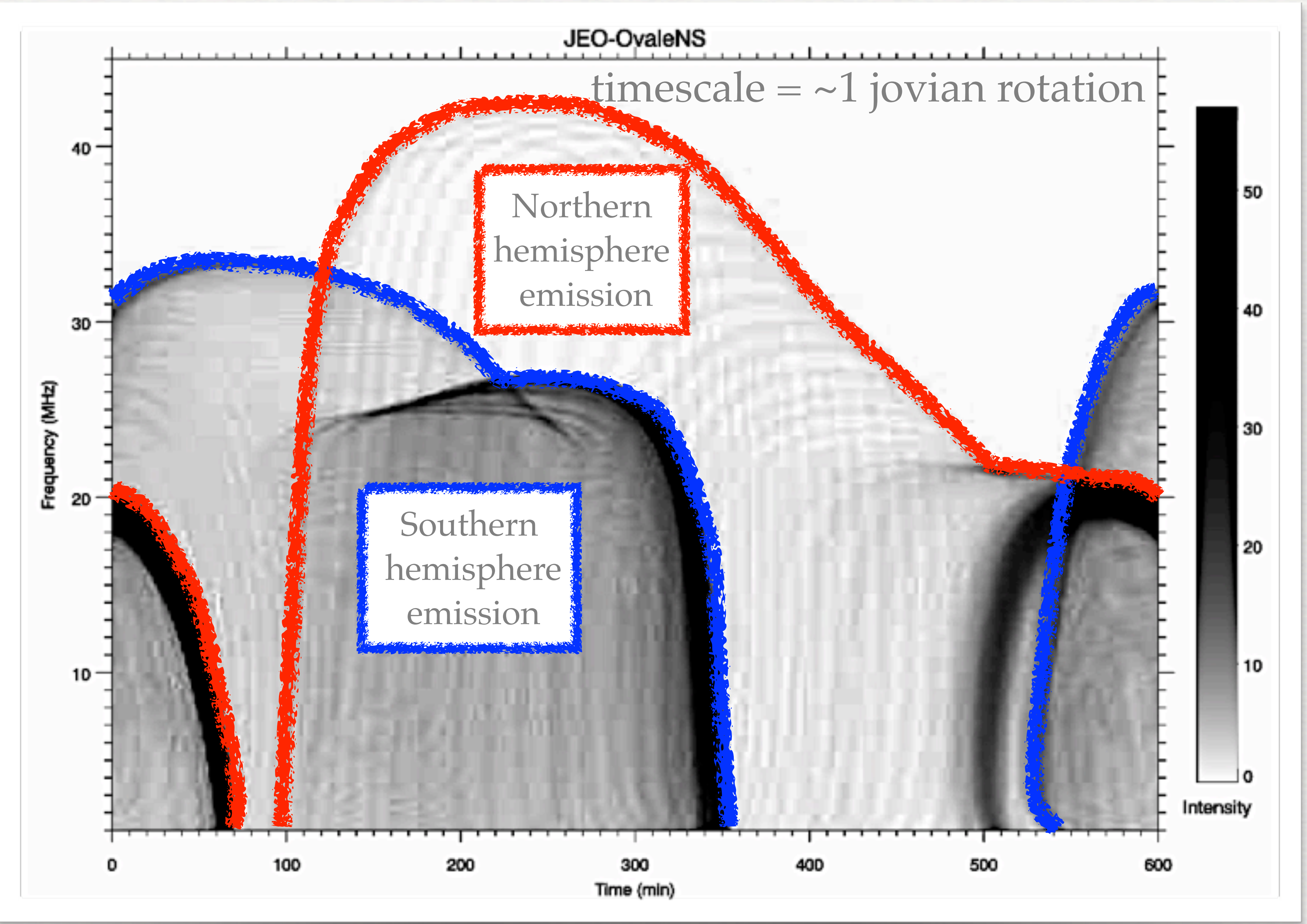
AURORAL RADIO BACKGROUND FOR EJSM/JEO



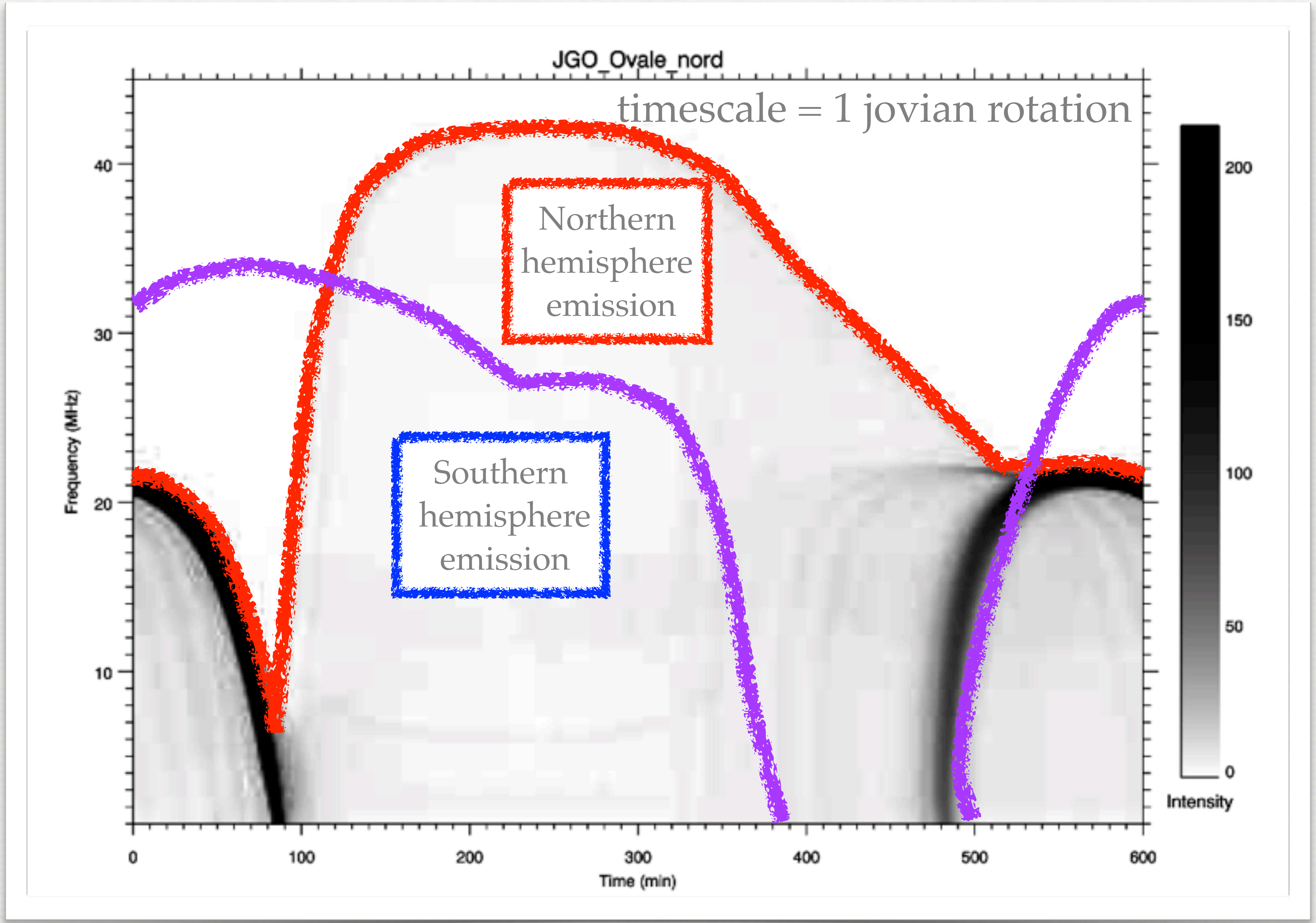
AURORAL RADIO BACKGROUND FOR EJSM/JEO



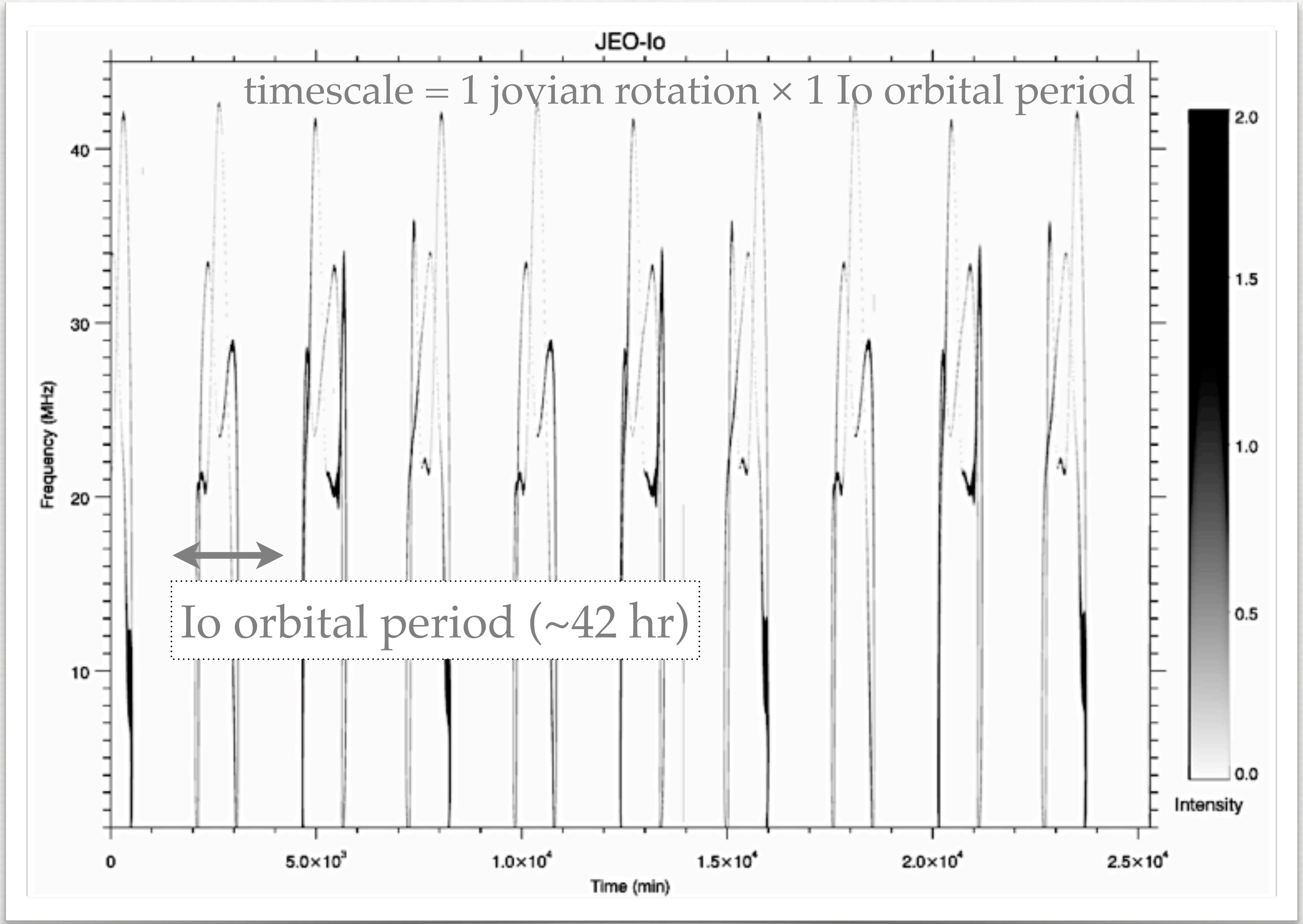
AURORAL RADIO BACKGROUND FOR EJSM/JEO



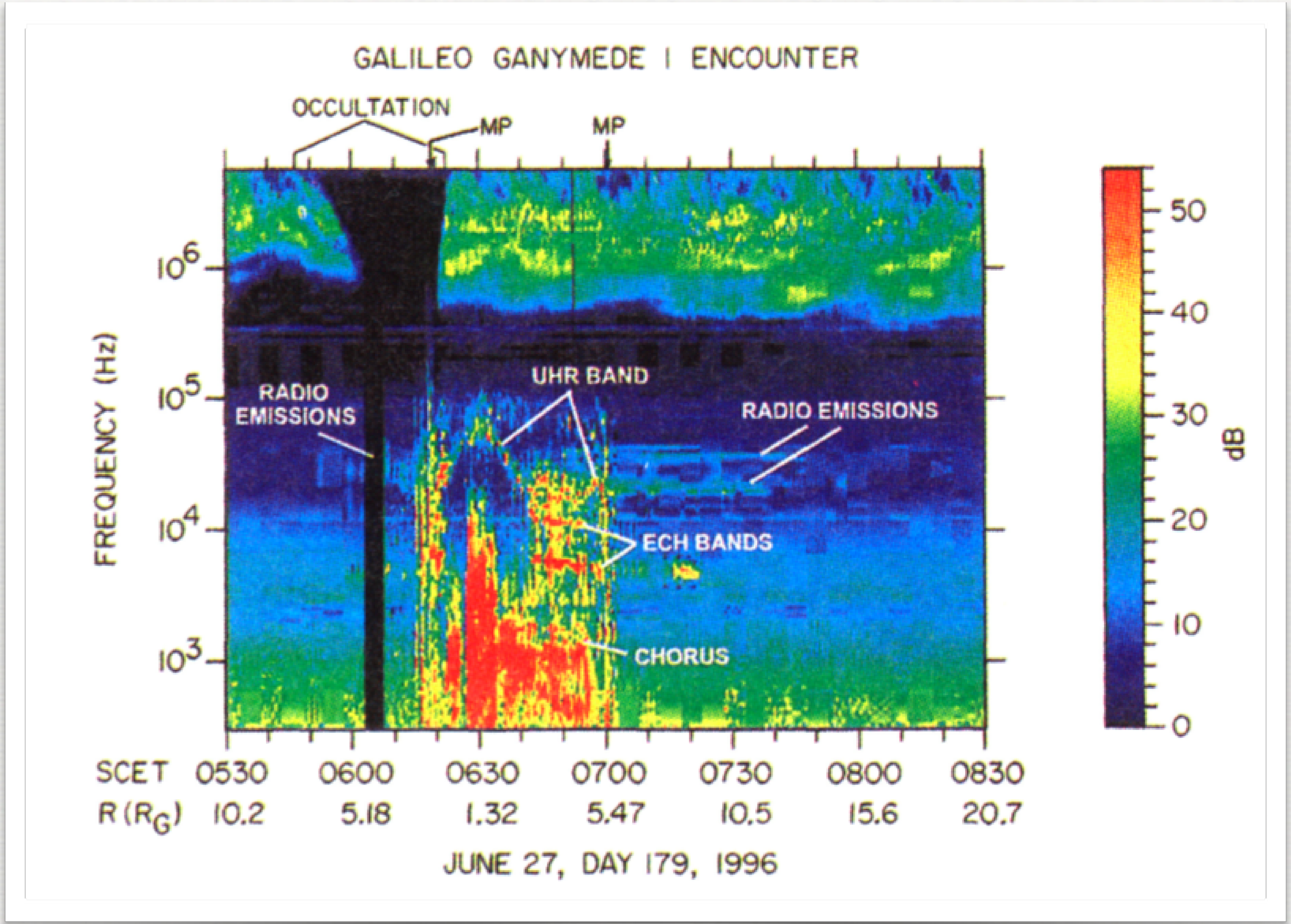
AURORAL RADIO BACKGROUND FOR EJSM/JGO



IO-CONTROLLED RADIO BACKGROUND FOR EJSM/JEO



GALILEO/G1 FLYBY



[Kurth et al., GRL 1997]

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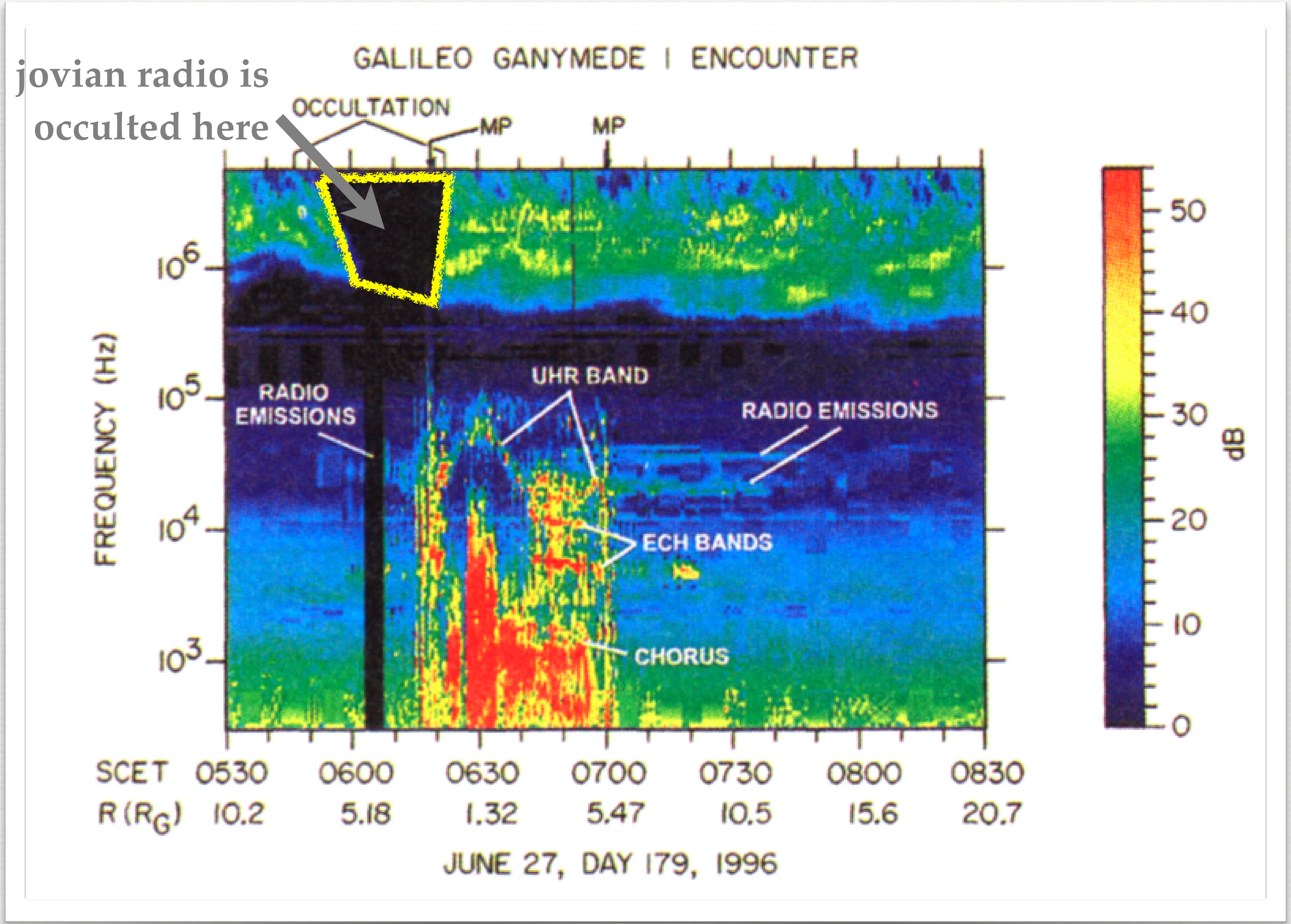


[Kurth et al., GRL 1997]

RADIO EMISSION VISIBILITY MODELING

- Auroral emissions:
  visibility enveloppe is predictable.
  - at all times below ~22 MHz.
  - less than 50% of time above ~35 MHz.
  - no noise above ~42 MHz.

- Io controlled emissions:
  clean periods are predictable for entire frequency range.

- Otherwise: physical occultations.

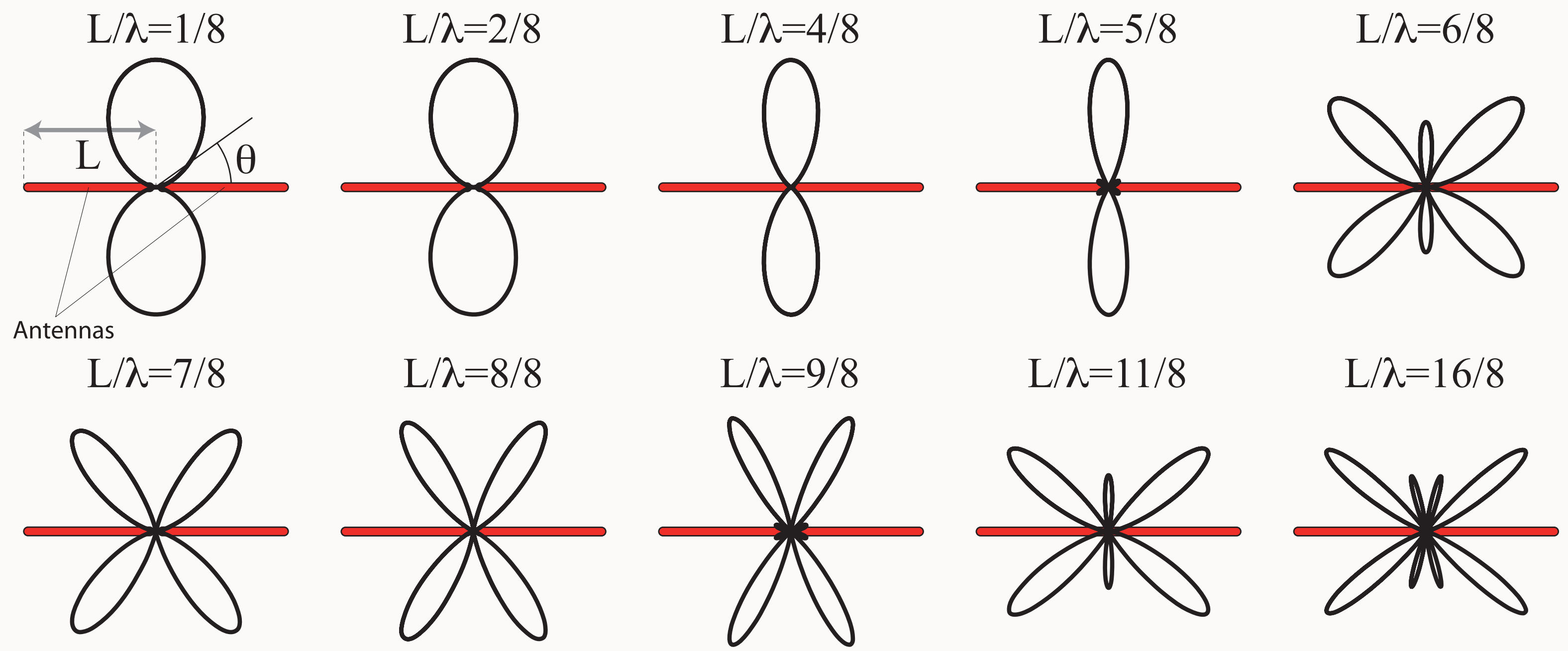
  - Preliminary results, to be updated soon!
  - Next presentation in EGU 2010
  (abstract submitted to session PS5.3)

LOCALIZATION & POLARIZATION

- All emissions are fully polarized (circular or elliptical).
- Emission localization is roughly predictable (Radio instrumentation can localized accurately) => link with RPW instrument for monitoring ? *(probably too early to decide anything at this point)*
- Apparent polarization is thus predictable => can this be used to discriminate radar echoes from natural radio emissions ?

DIPOLE ANTENNA DIRECTIVITY

- The radar antenna is a dipole: in its short antenna regime *(when λ >> L, i.e. F < 2MHz for 10m antenna)* such an antenna shows a null along the antenna axis.
- At higher frequencies, the antenna pattern is more complex, and should be modeled (*Graz team (H.O. Rucker) has been asked to look at that*) but the null in the antenna axis still exist.



CONCLUSION & PERSPECTIVES

- Echo signals may be of the order of peak flux density of non-thermal radio emissions.
- No interference from radiation belt synchrotron radiation.
- Possible use of physical occultation of jovian radio emissions, and of dipole antenna null.