Radio emission mechanisms

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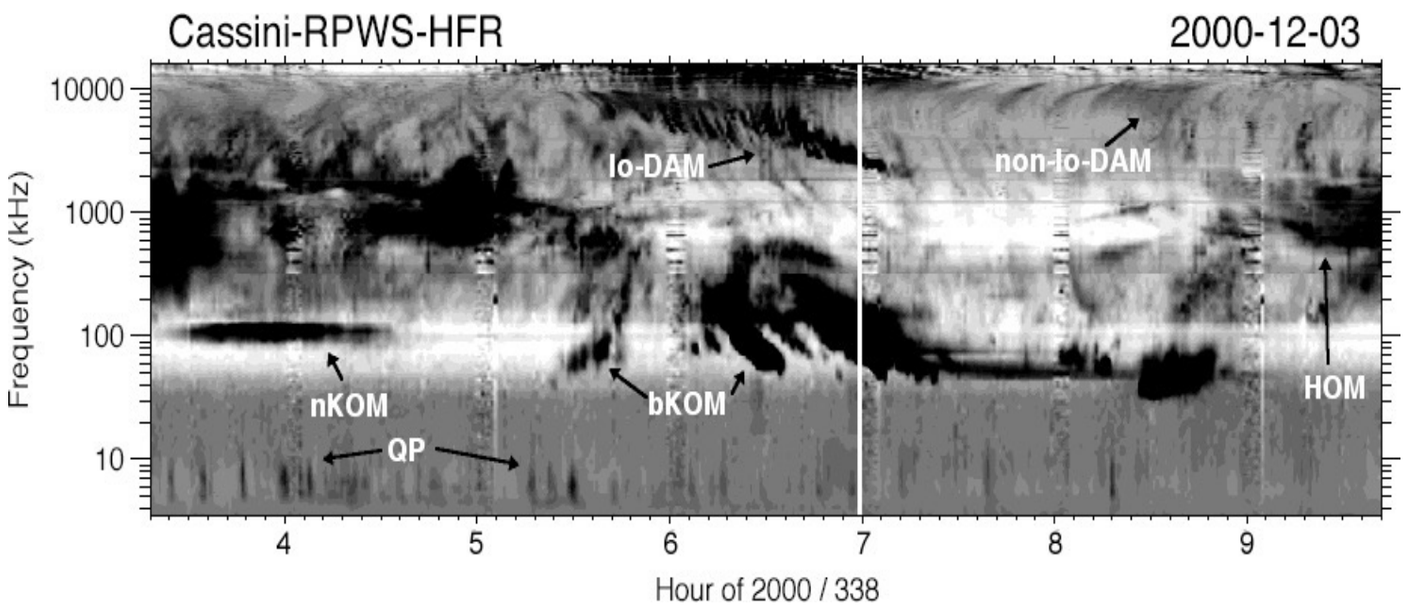
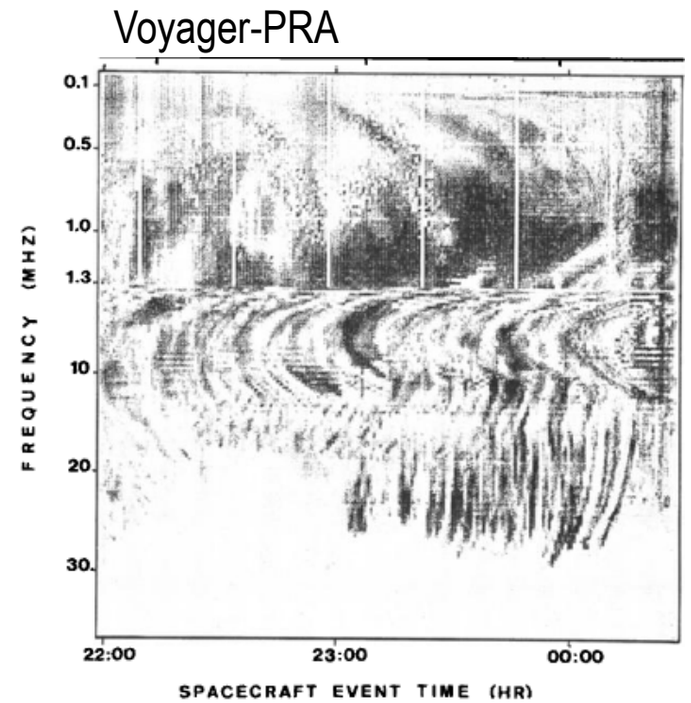
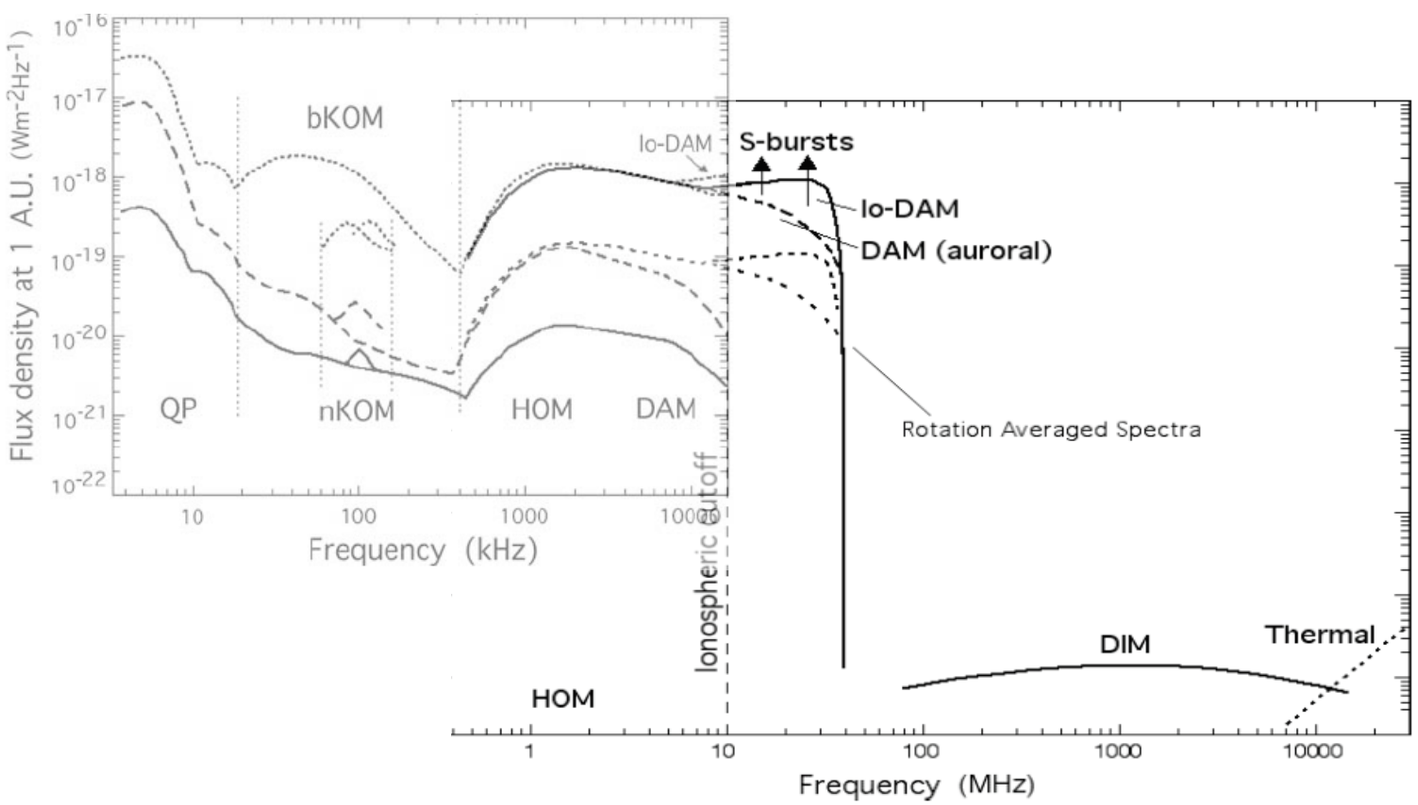
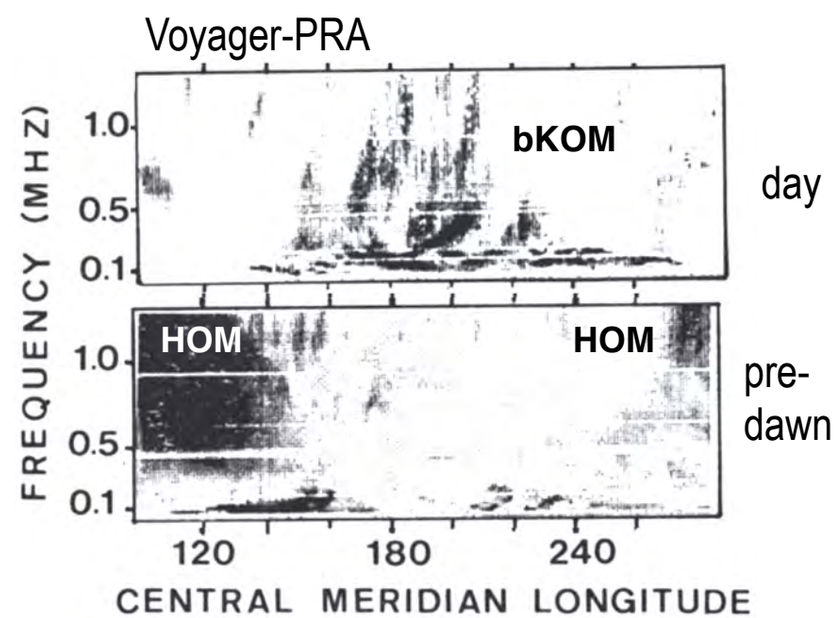
Jupiter radio "zoo"



Galileo-PWS







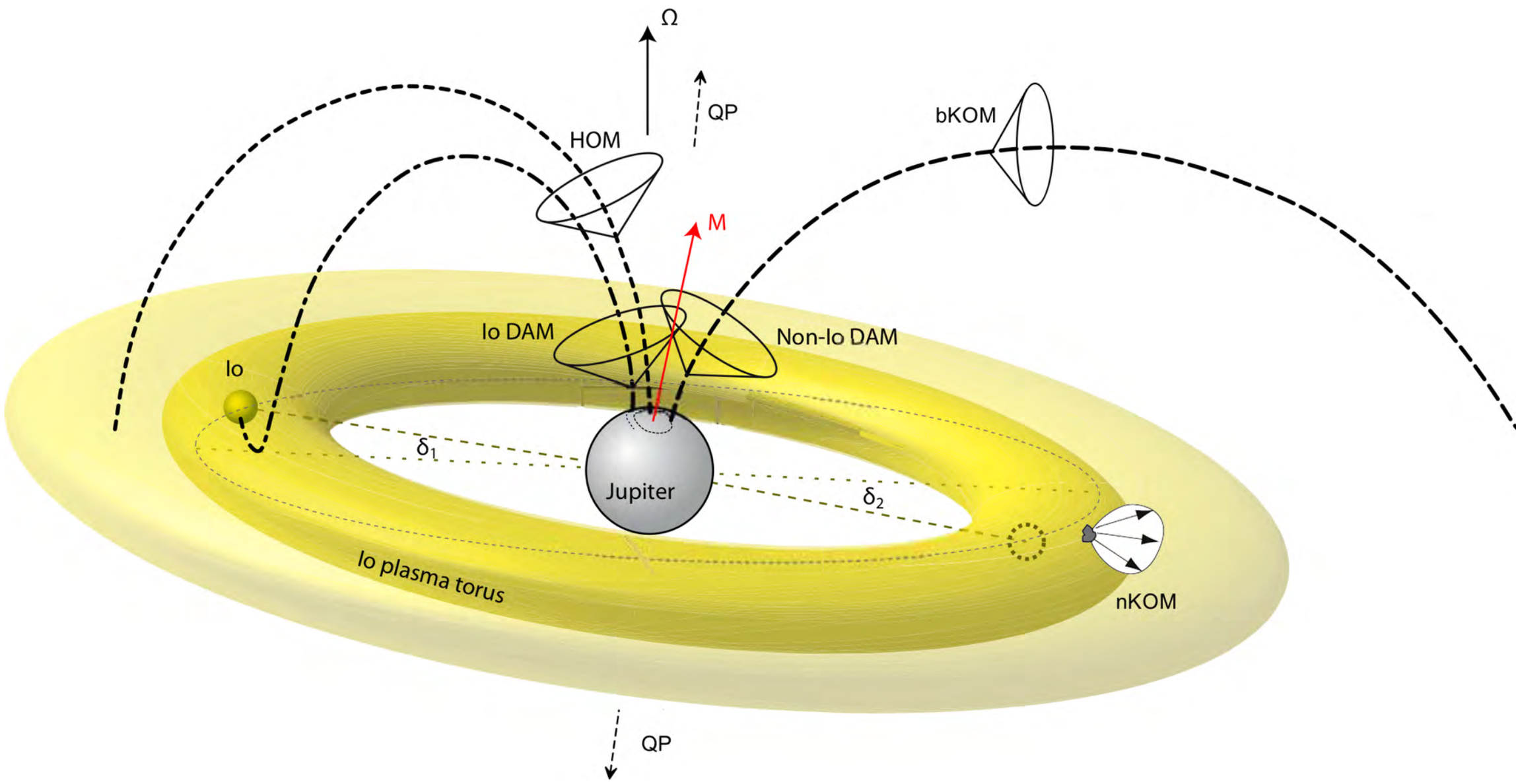
day

pre-dawn

[Boischot et al., JGR 1981]

[Zarka et al., JGR 2004 ; Zarka, PSS 2004]

Source locations

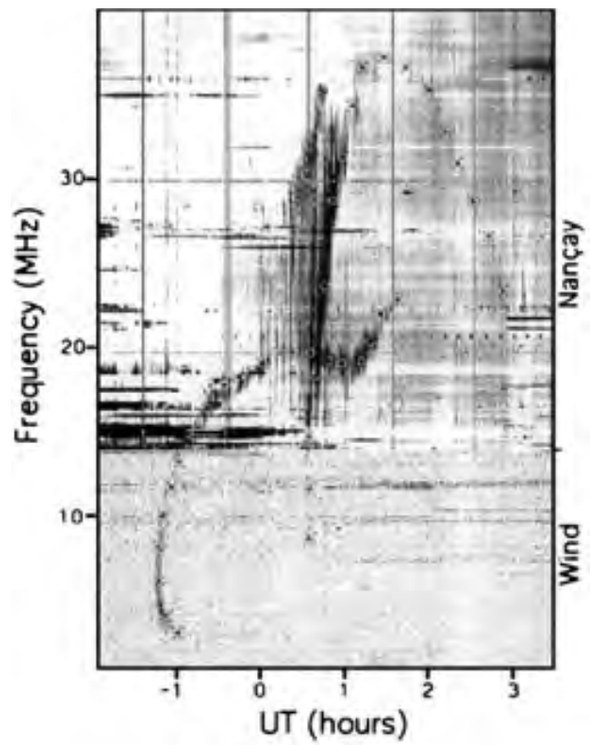


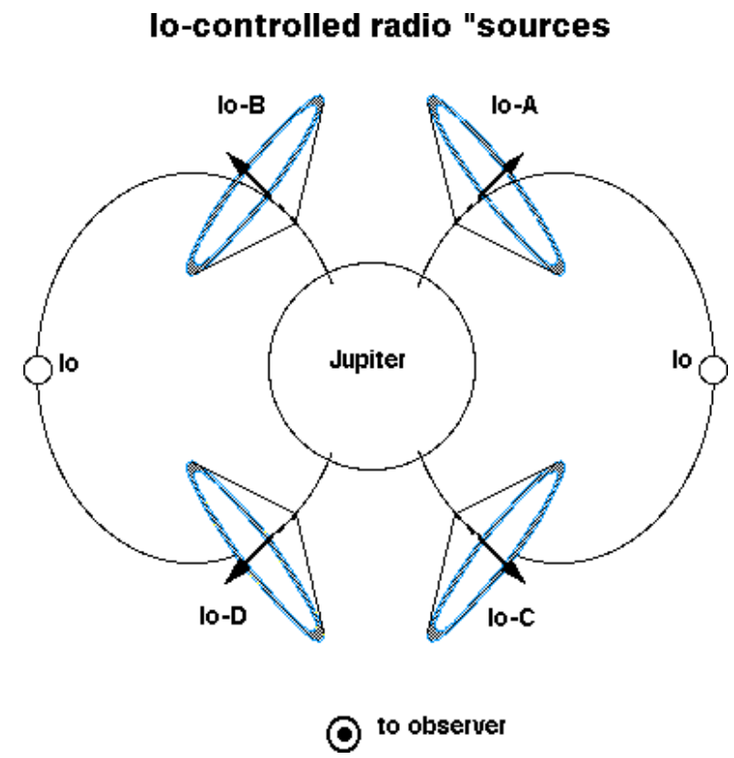
[Zarka, JGR 1998, Geophys. Mon. 2000]

Decameter arcs

- Io-Jupiter,

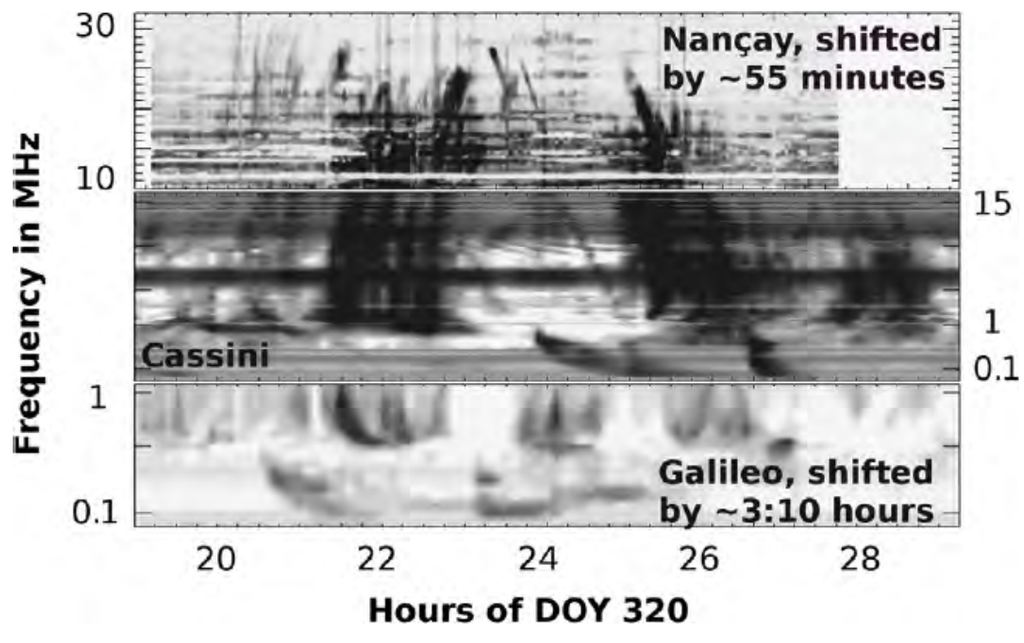
  satellite-Jupiter ?





[Queinnec & Zarka, JGR 1998 ; …]

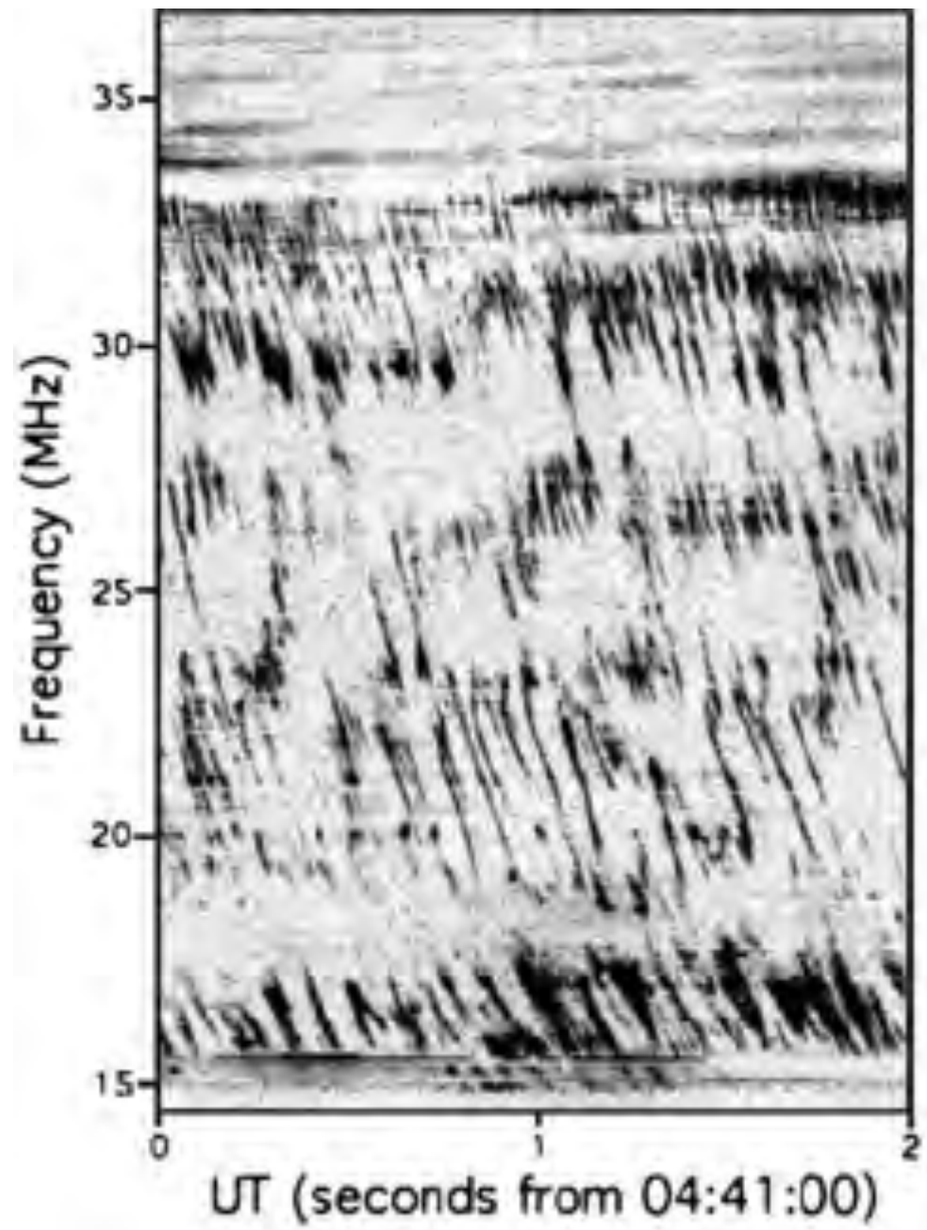
- Auroral



[Hess et al., PSS 2014]

Decameter (S-)bursts

- discrete
- fast drifting with df/dt <0
- quasi-periodic
- complex envelope



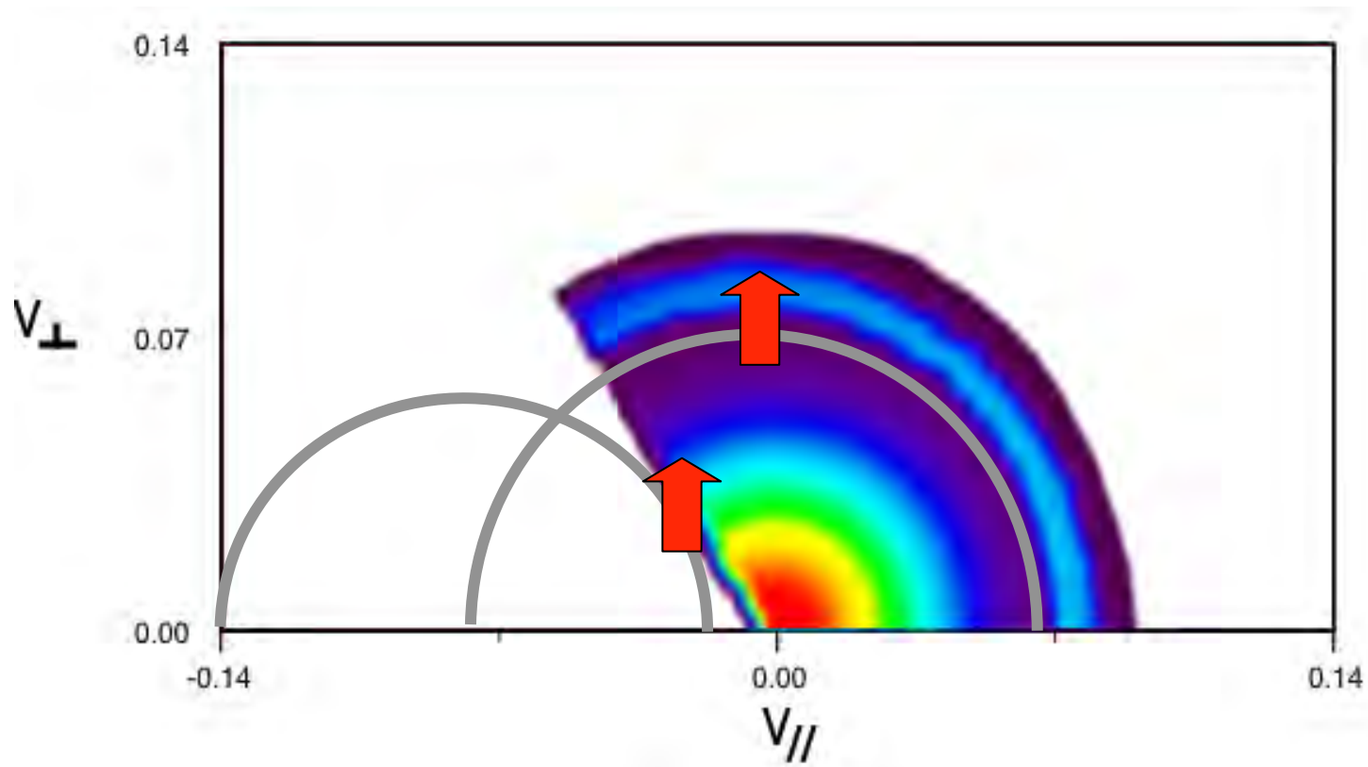
[Ryabov et al., A&A 2014 ; …]

Radiation mechanism

- DAM / HOM / bKOM ? : Cyclotron Maser Instability

Resonance condition : $\omega = \omega_c/\Gamma - k_\parallel v_\parallel$

Growth rate : $\gamma = \frac{\omega_p^2 c^2}{8\omega_c} \int_0^{2\pi} v_\perp^2(\theta) \nabla_{v_\perp} f(\mathbf{v}_0, \mathbf{R}(\theta)) d\theta$

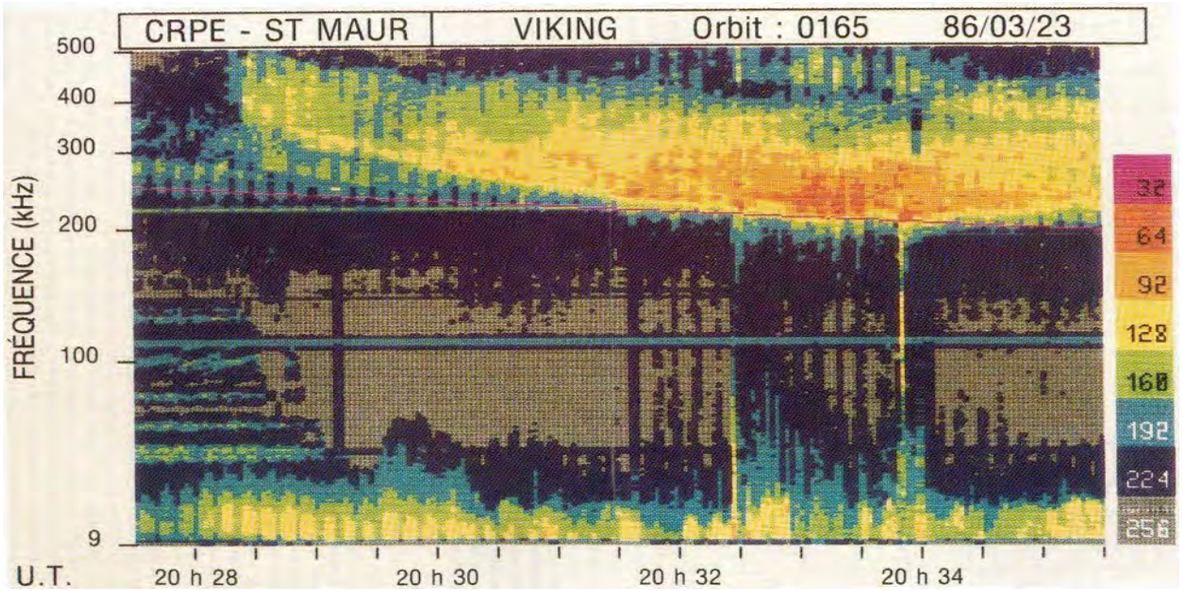


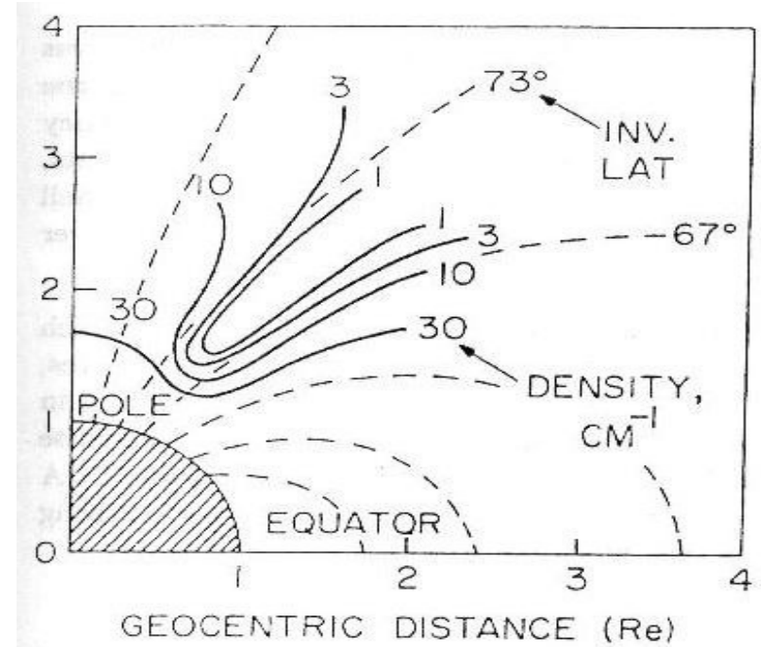
[Wu, SSR 1985 ; Treumann, AAR 2006]

- Regime of operation : Oblique/Loss-cone-driven or Perpendicular/Shell-driven ?

Earth's AKR

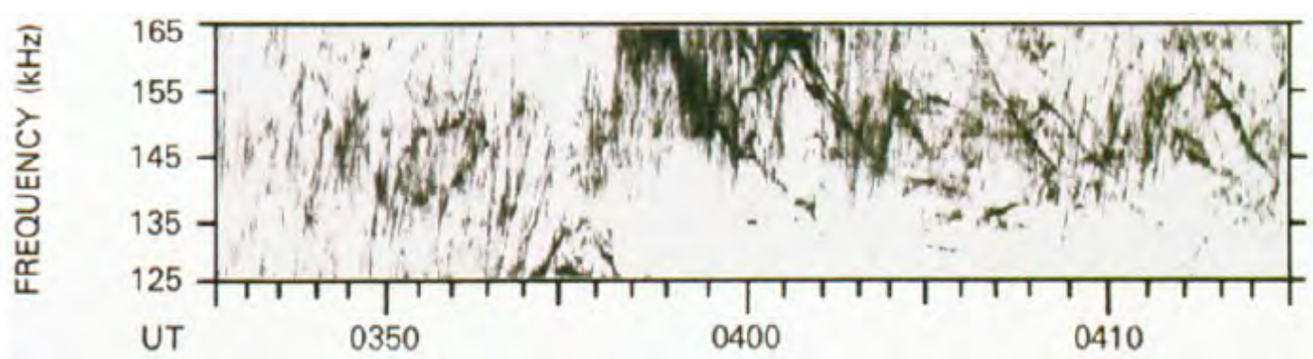
- AKR only in hot plasma cavities





[Roux et al., JGR 1993]

- df/dt >0 and <0

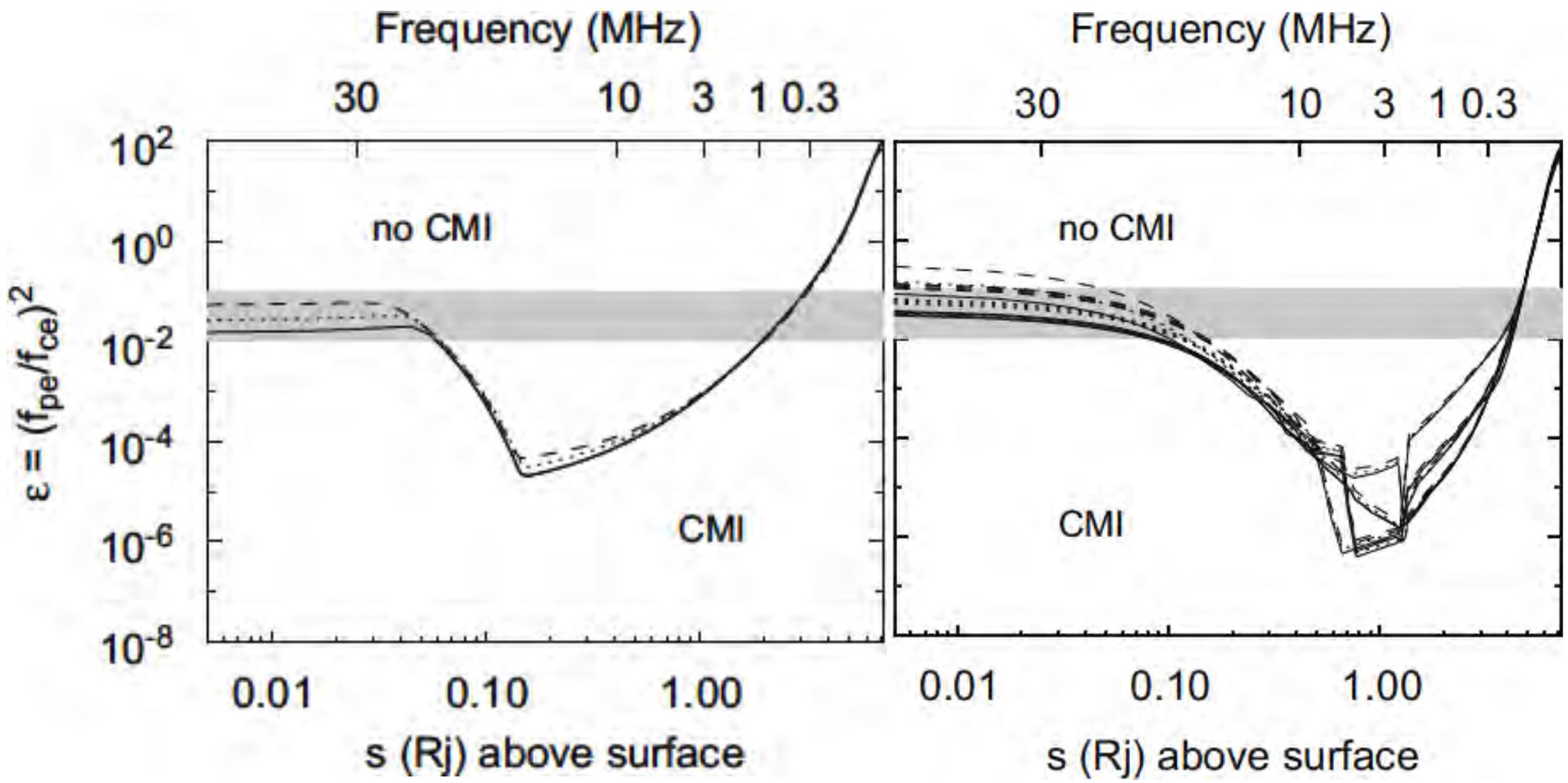


[Baumback & Calvert, 1987]

- Perpendicular/Shell-driven CMI → associated to acceleration structures

Jovian DAM arcs

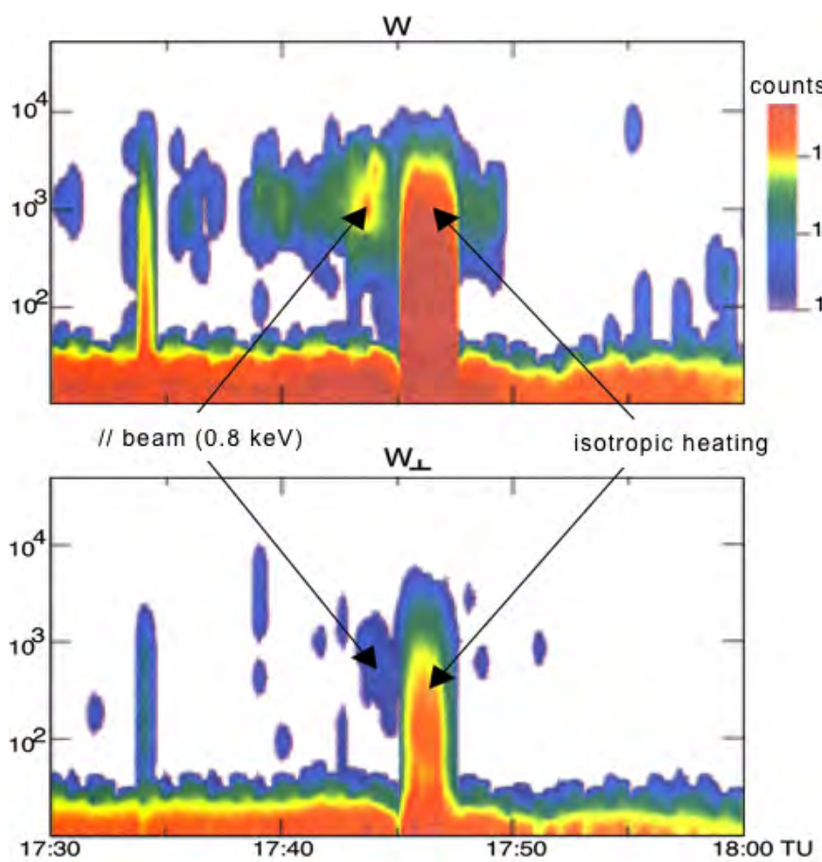
- Cold plasma dominates (no plasma cavities ?)



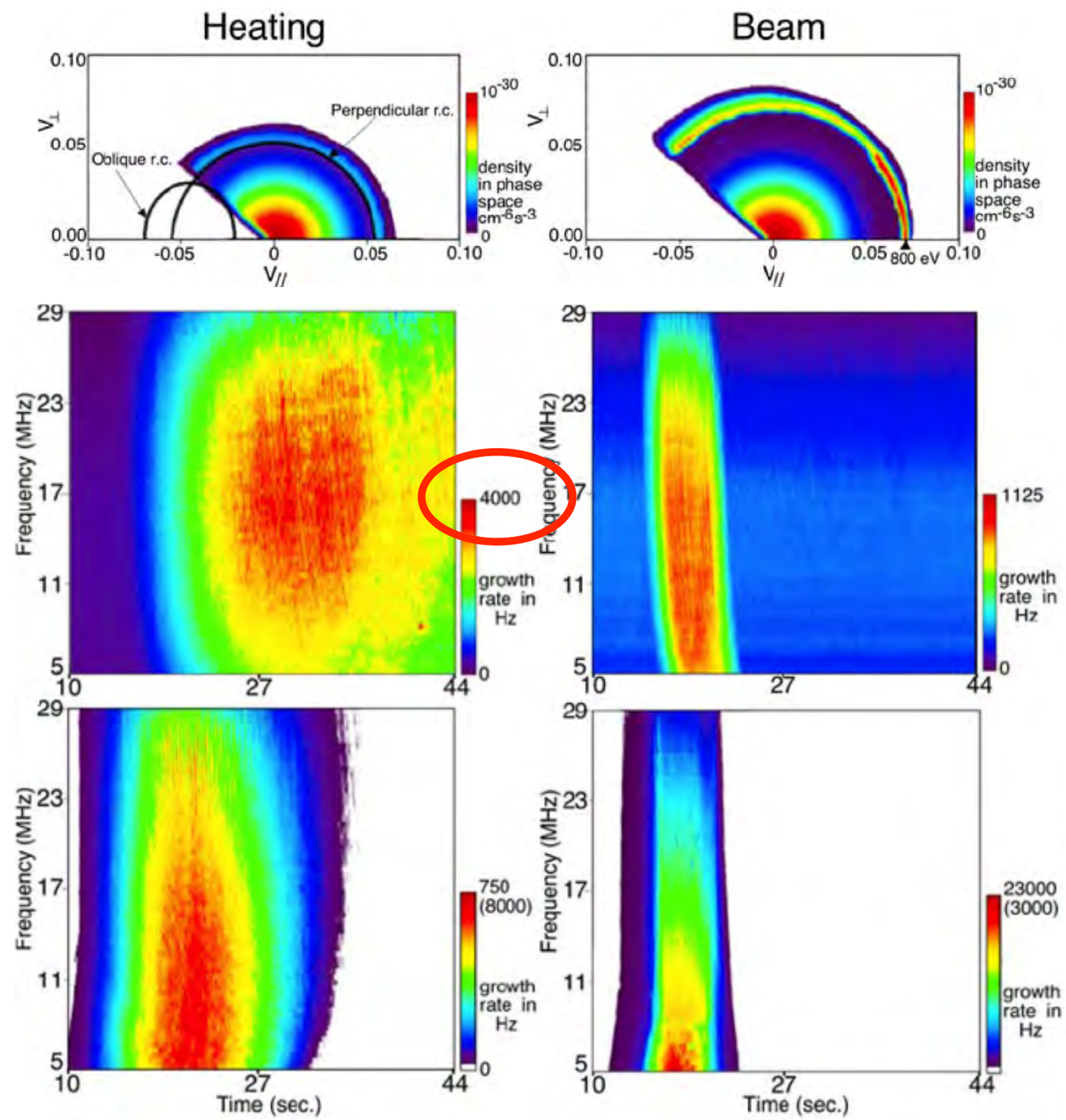
[Zarka et al., PSS 2001 ; Su et al., JGR 2003 ;]

Jovian DAM arcs

- Oblique/Loss-cone-driven CMI has large growth rates



[Frank & Paterson, 1999]



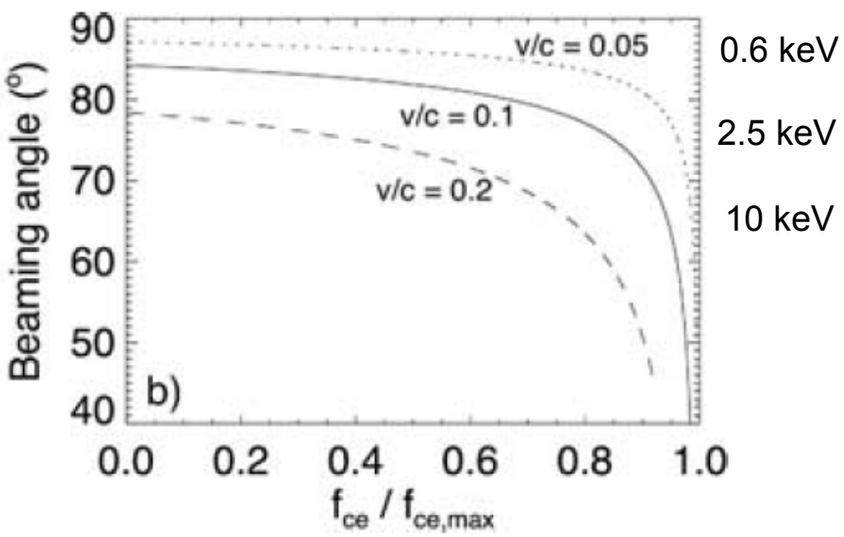
[Hess et al., JGR 2008]

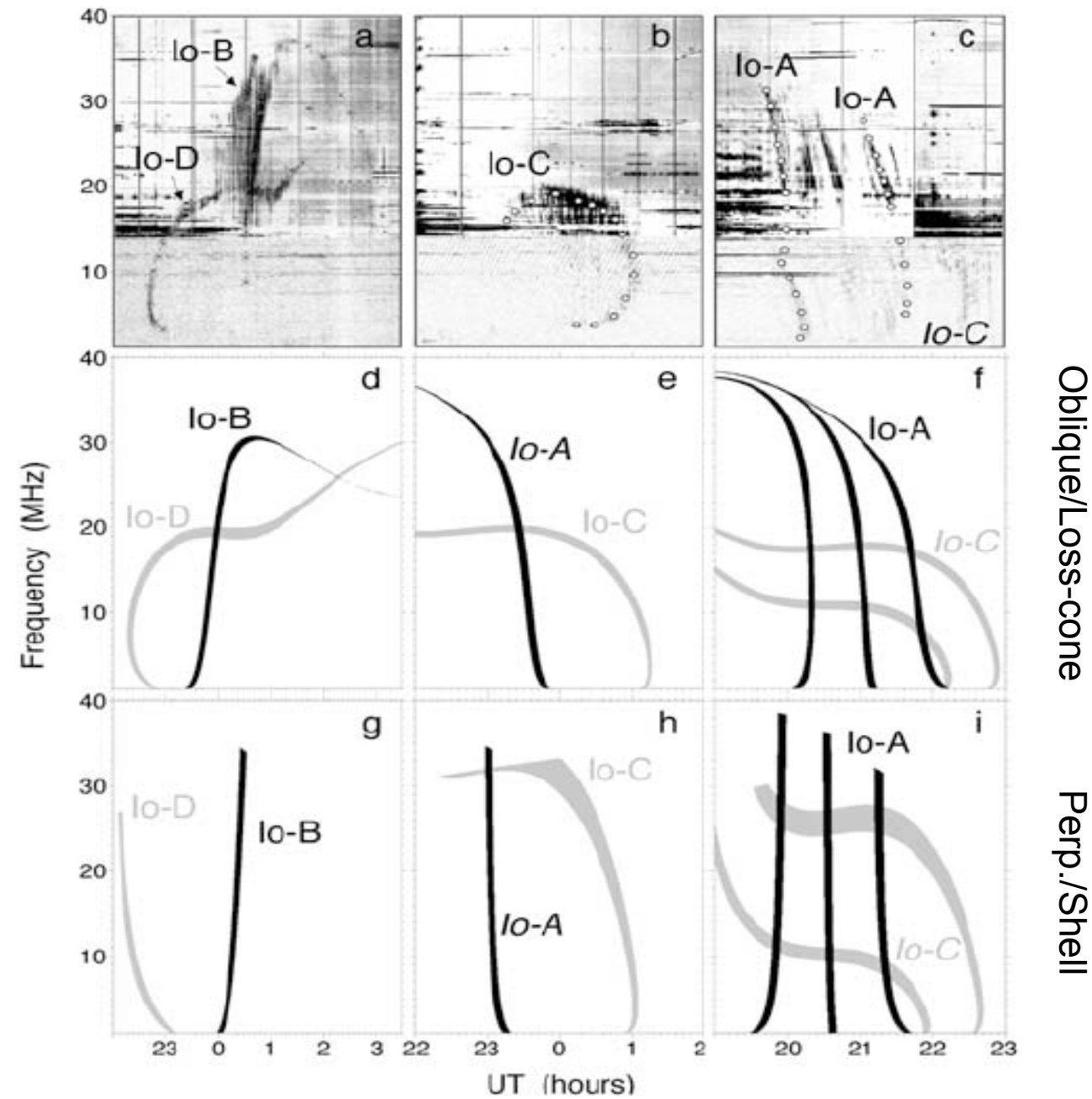
Oblique/Loss-cone

Perp./Shell

Jovian DAM arcs

- ExPRES(SERPE) modeling : favours Oblique/Loss-cone-driven CMI

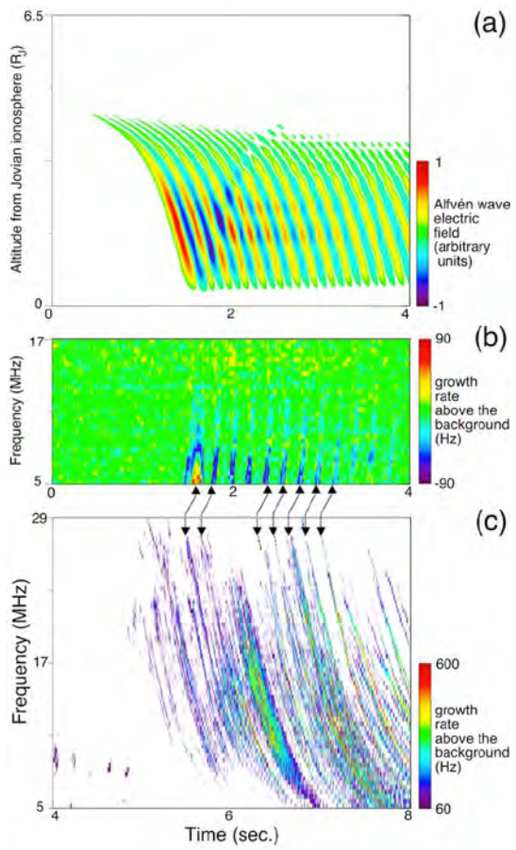


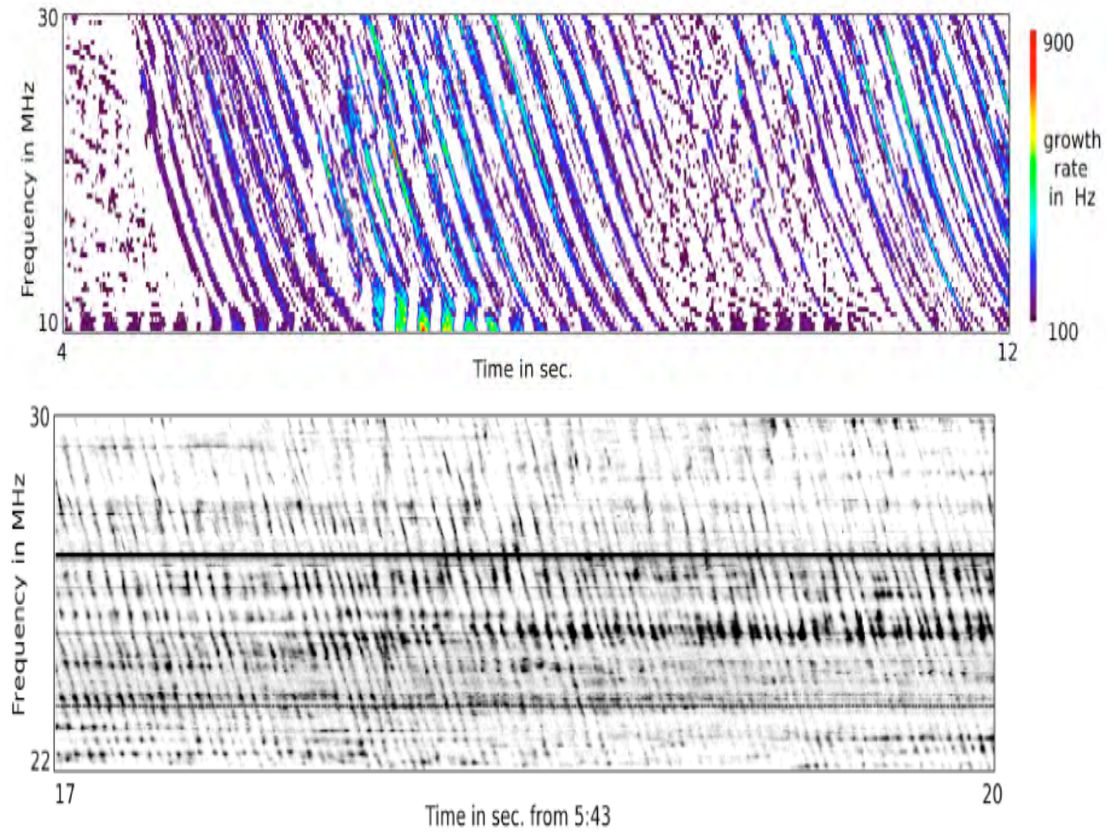


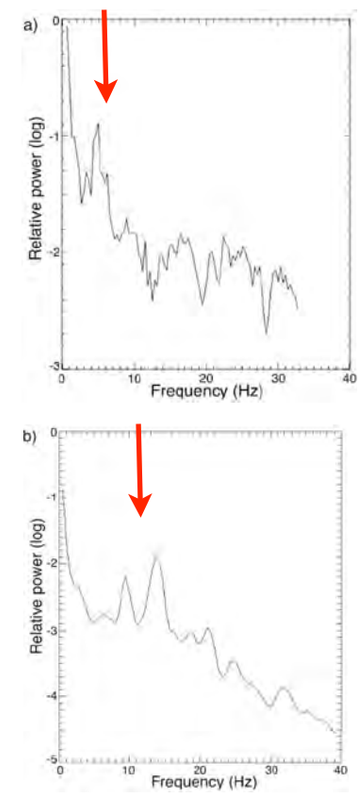
[Hess et al., GRL 2008 ; + to be submitted 2016]

Jovian S-bursts

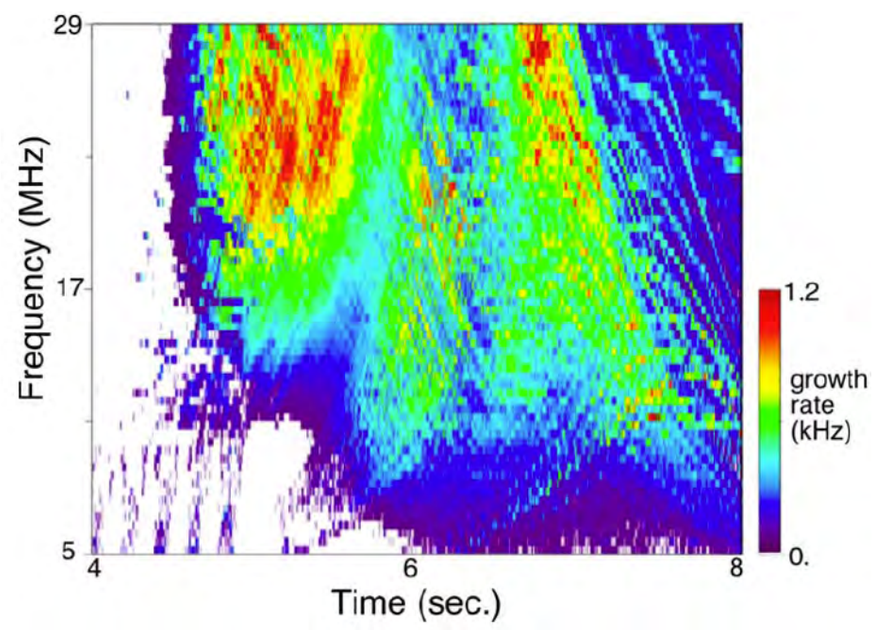
- Oblique/Loss-cone-driven emission from Alfvén waves acceleration of electrons







Oblique/Loss-cone

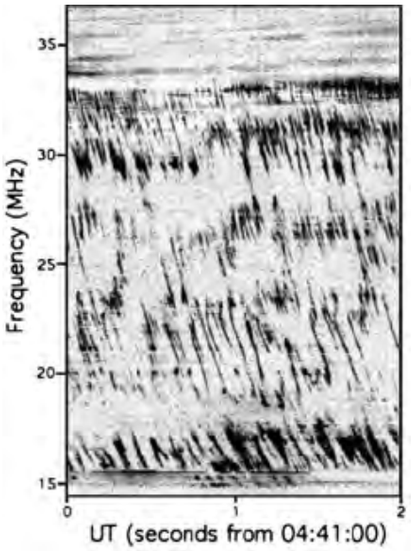


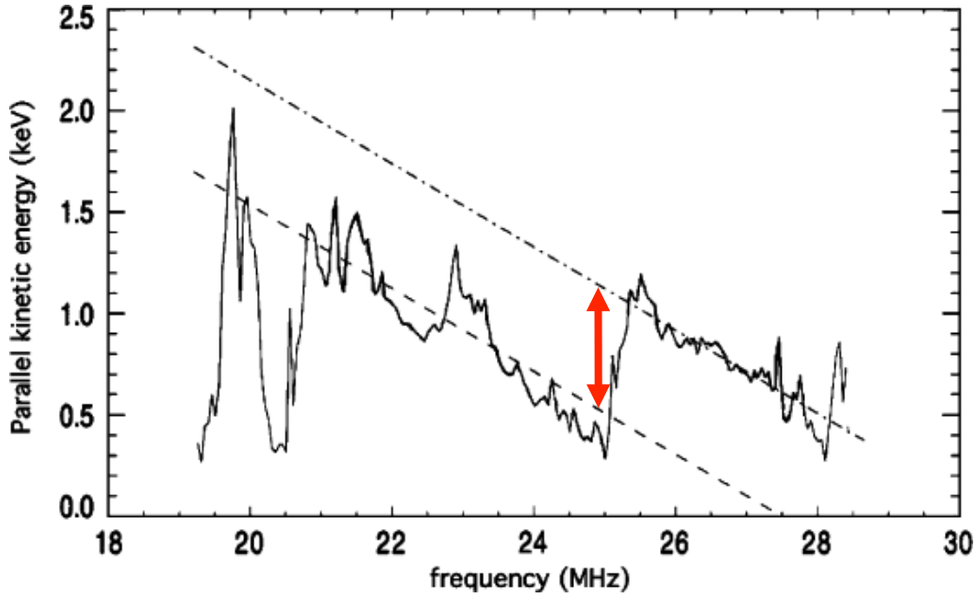
Perp./Shell

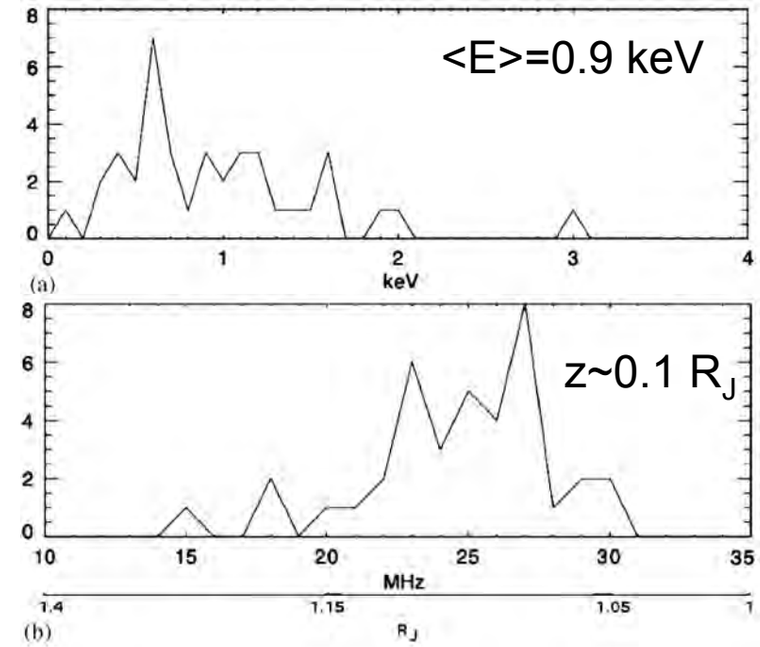
[Hess et al., JGR 2007, GRL 2009]

Jovian S-bursts

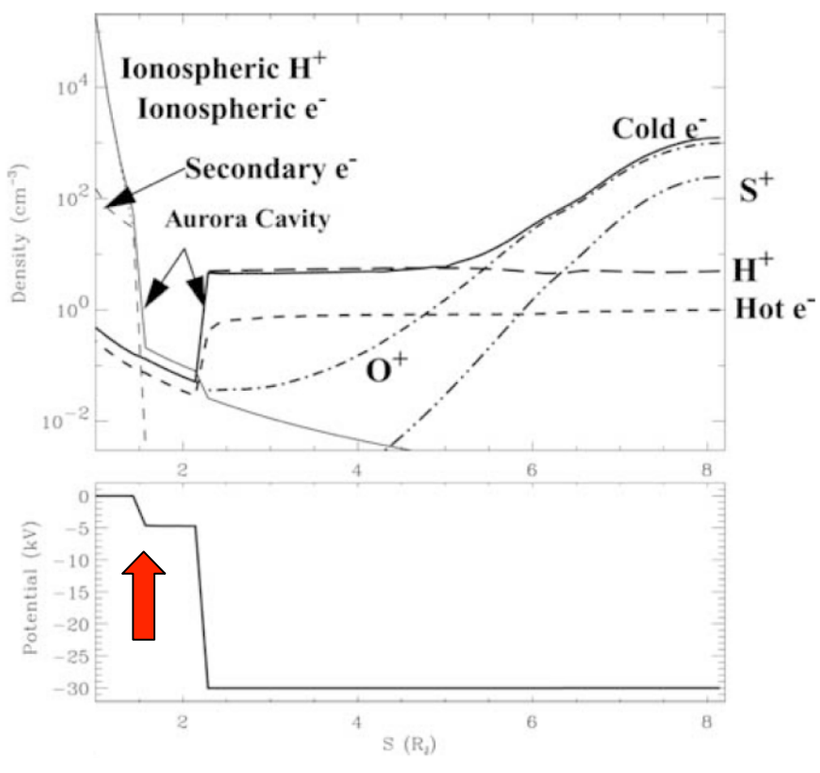
- Double-layers / electron & ion holes along IFT …



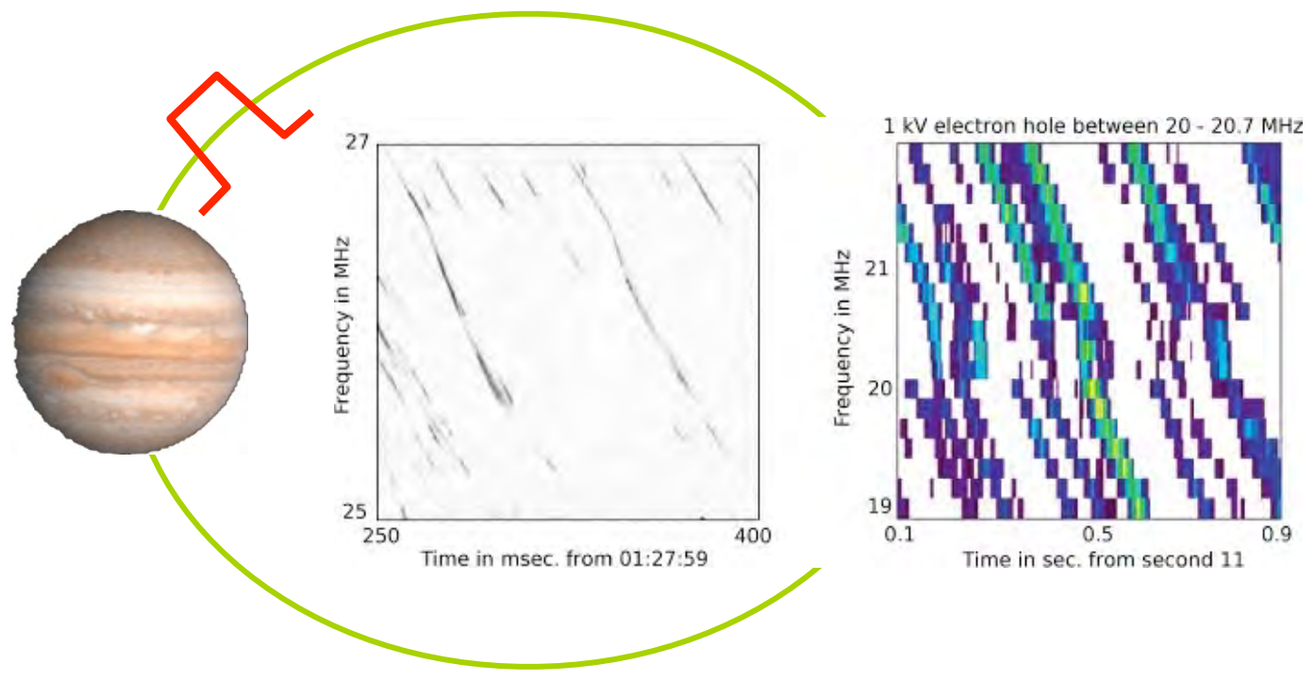




[Hess et al,, PSS 2007]



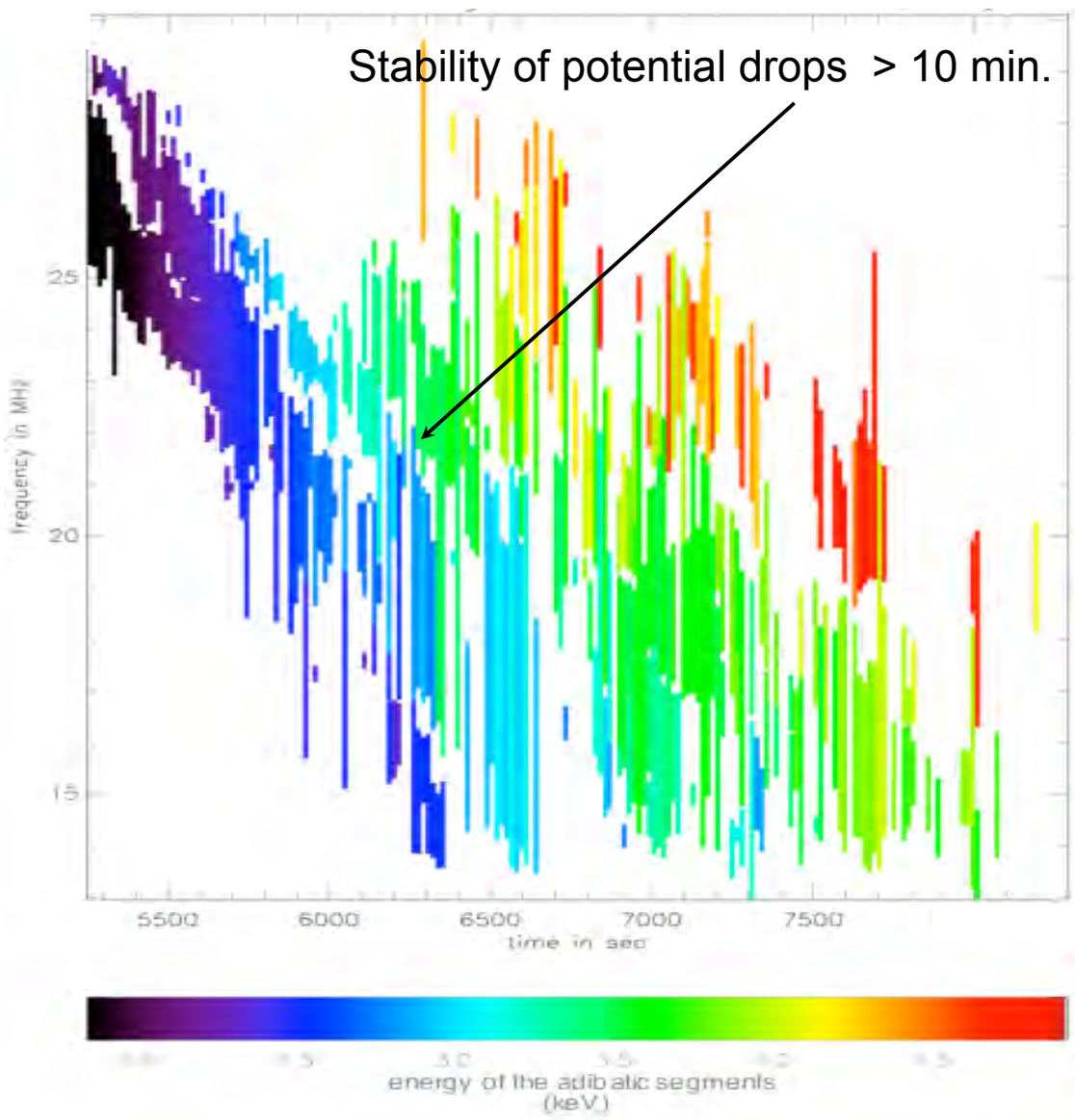
[Su et al., JGR 2003]

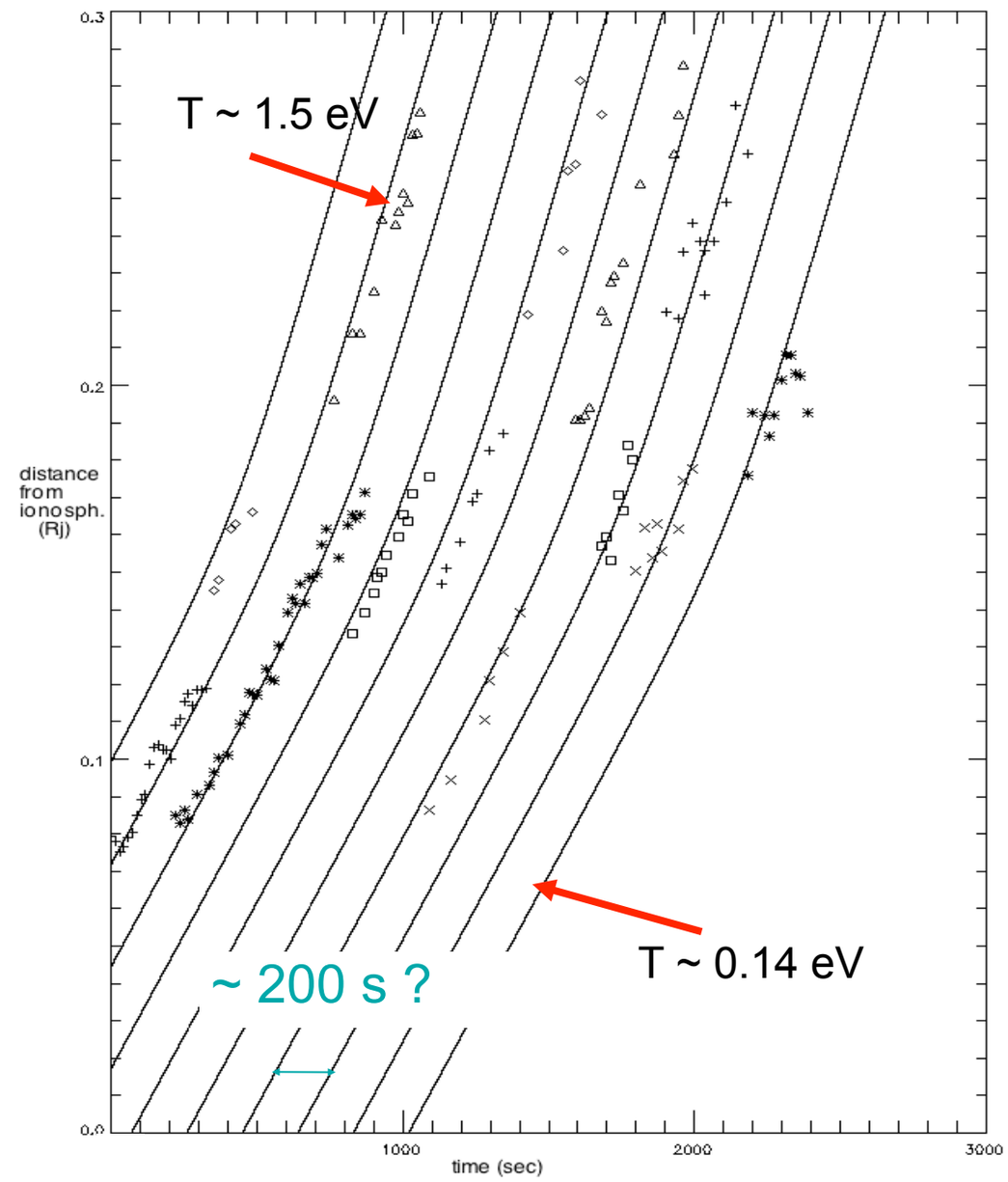


[Hess et al,, GRL 2009]

Jovian S-bursts

- … in motion along the IFT at the local plasma sound velocity

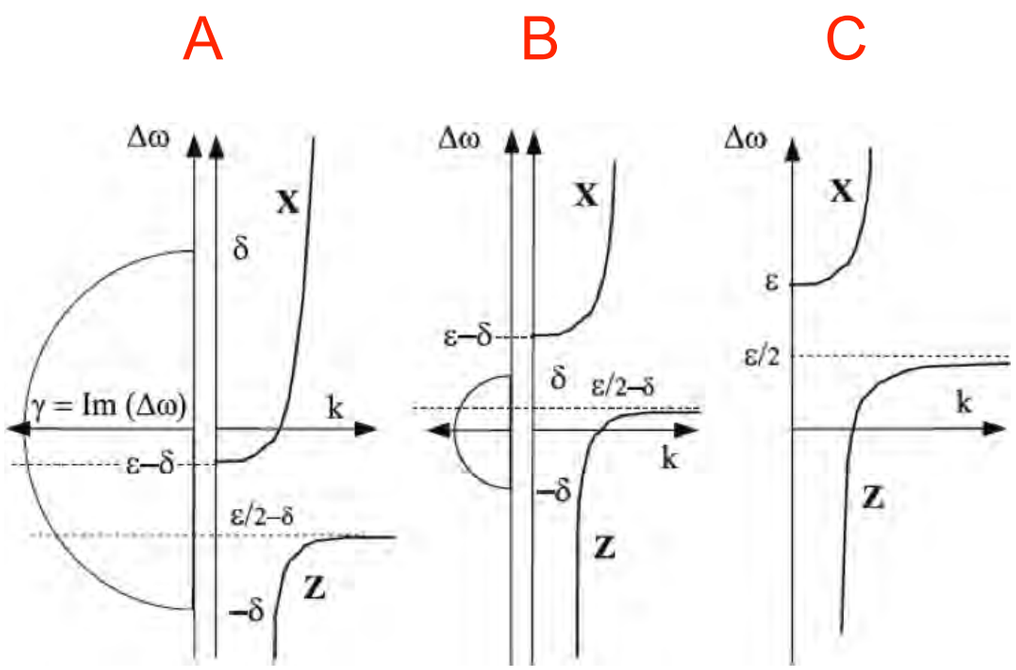




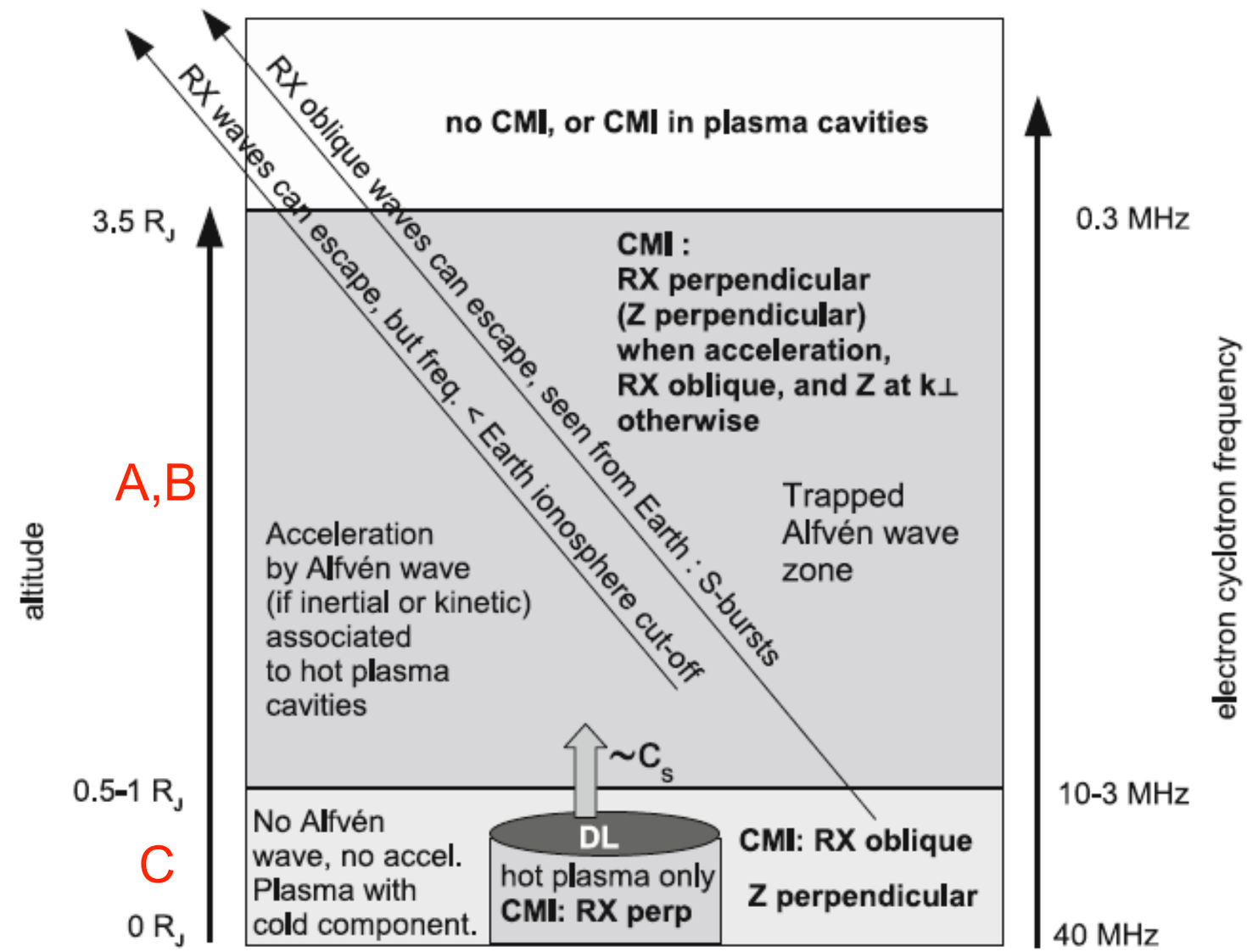
[Hess et al, PSS 2009]

Why oblique mode dominant for Jovian DAM ?

perpendicular propagation

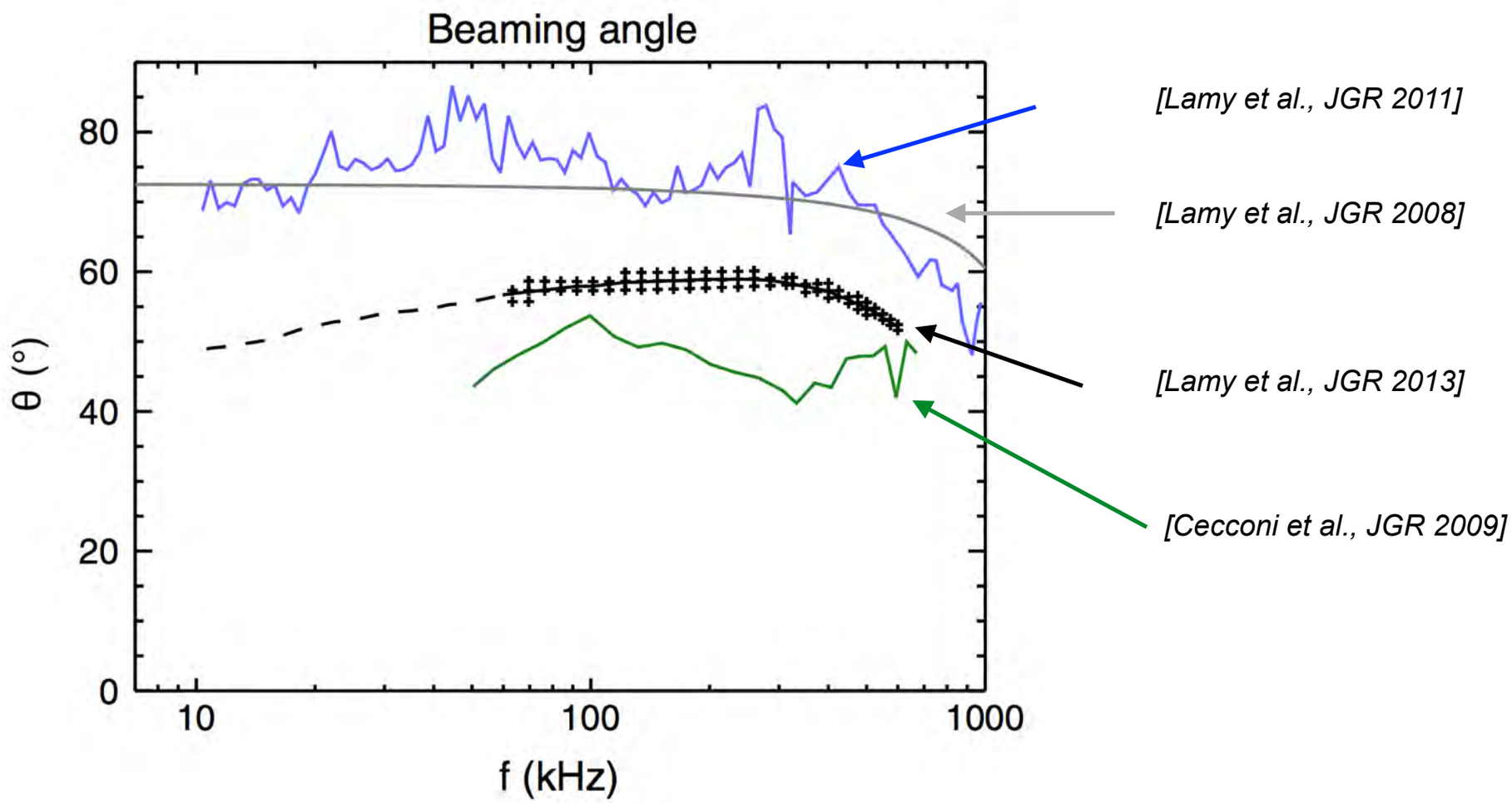


hot medium cold



[Mottez et al, PSS 2010]

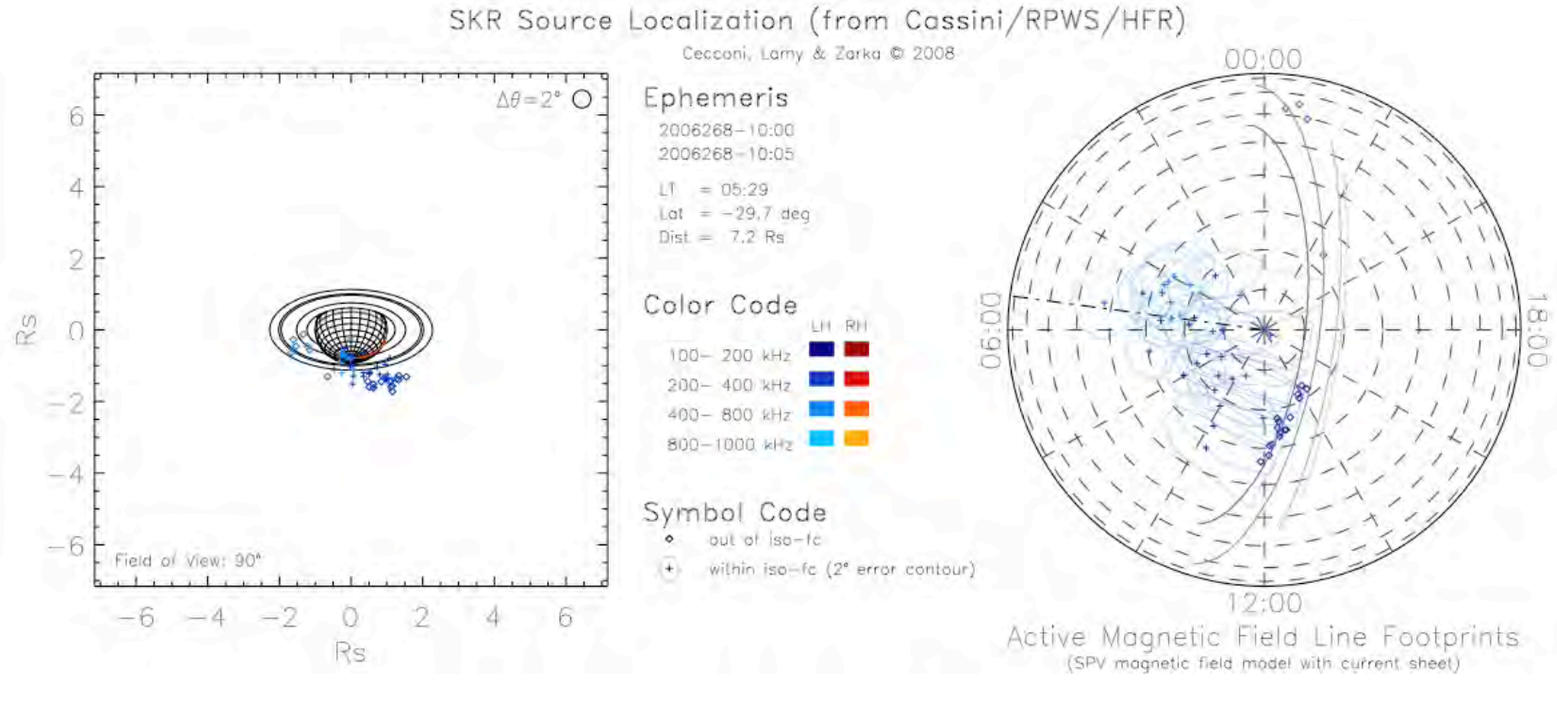
SKR beaming



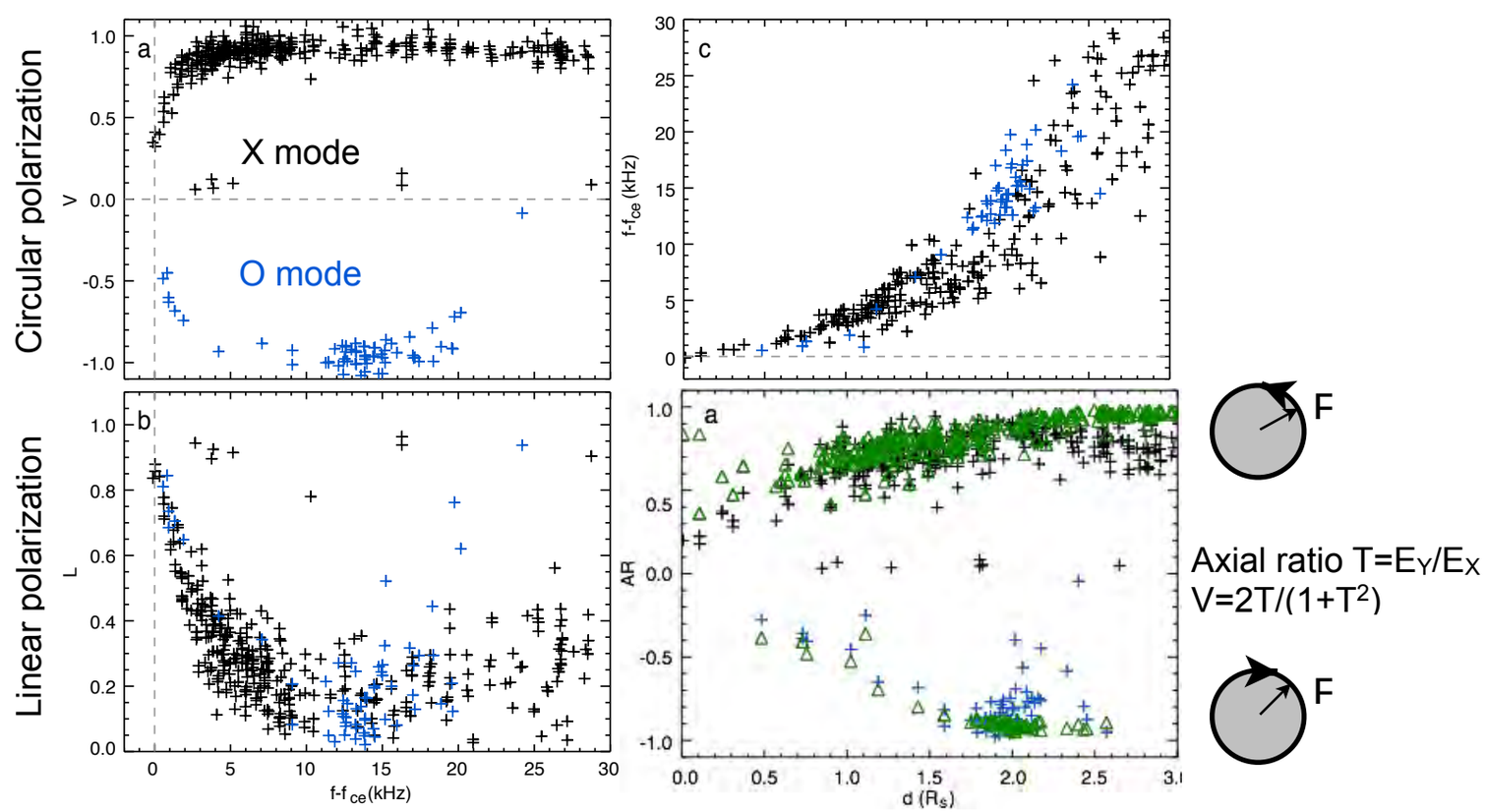
- <u>Remote</u> observations : oblique beaming
- <u>In situ</u> observations : quasi-perpendicular emission

→ role of refraction ?

What JUNO will not do



[Cecconi et al., JGR 2009]



[Lamy et al., JGR 2011]

→ no direct source location, no strong constraint on emission mode, <u>except with S/C spin ?</u>

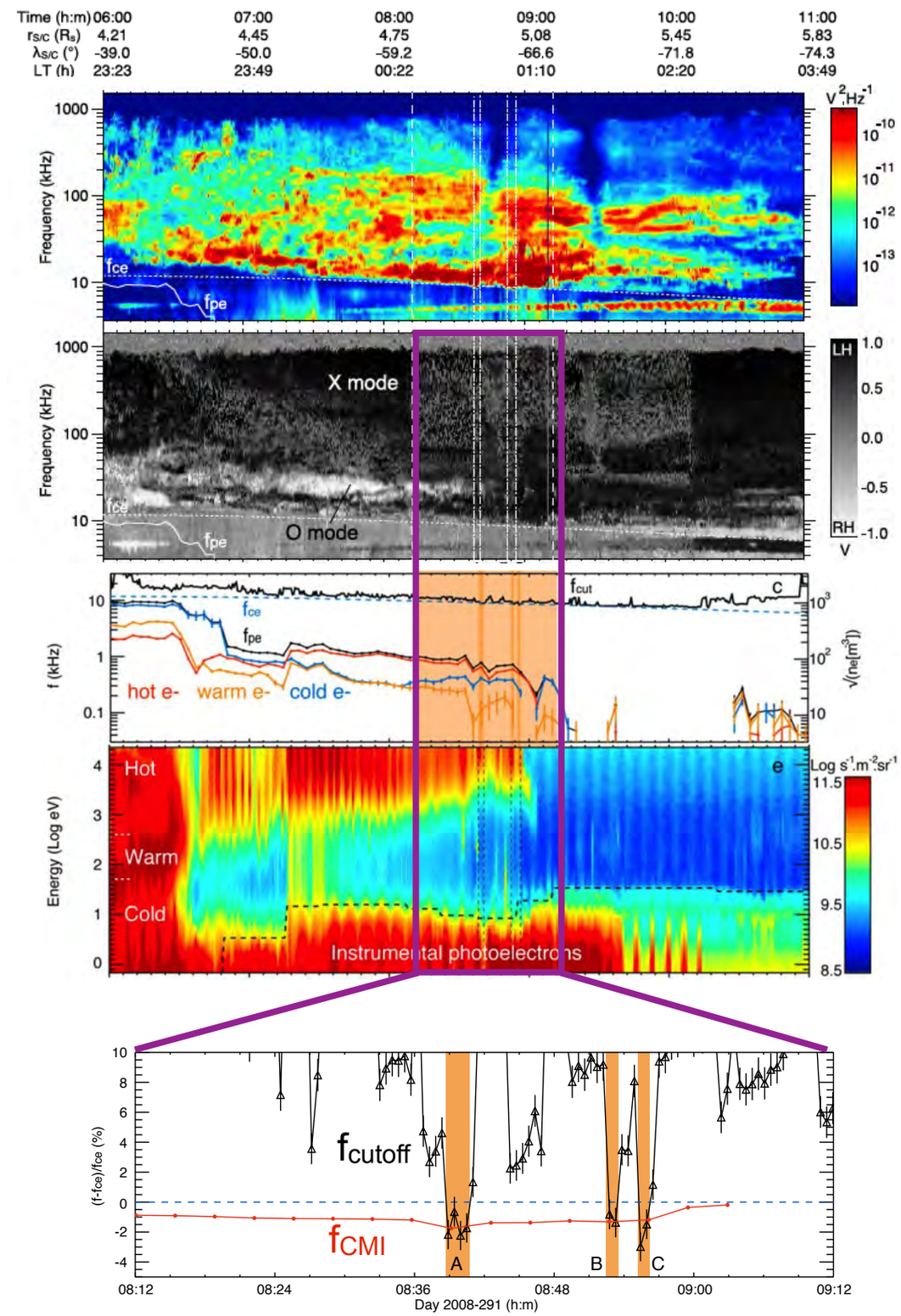
What JUNO will do

- Wave+particle measurements during high latitude sources traversals

→ comparisons with SKR & AKR

[Lamy et al., 2010, 2011,
Mutel et al., 2010,
Bunce et al., 2010,
Schippers et al., 2011,
Kurth et al., 2011,
Menietti et al., 2011]

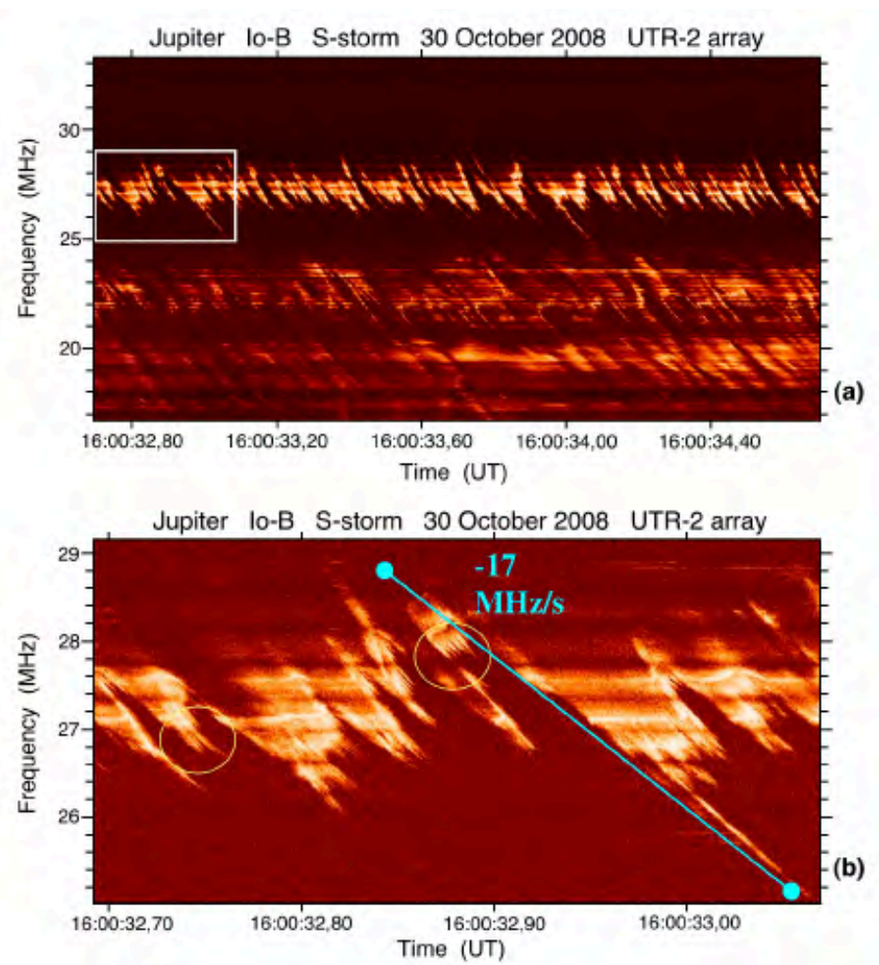
→ f_{CMI} down to several % below f_{ce} above aurora at Jupiter ?



What JUNO will do

- Wave+particle measurements during high latitude sources traversals

→ S-bursts envelope ?

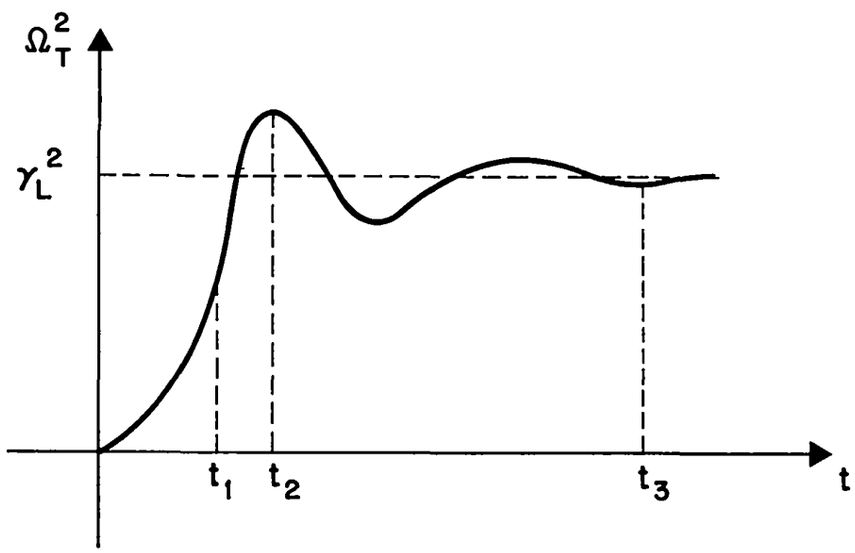


[Ryabov et al., A&A 2014]

→ Max. E field in sources ?

(**predicted 1-10 V/m**) *[Zarka, Juno memo 2006]*

→ CMI saturation ? *[Zarka, MOP 2009]*



→ Identification of saturation mechanism

→ Feedback on source plasma content

→ Implications on exoplanets

What we will do with JUNO

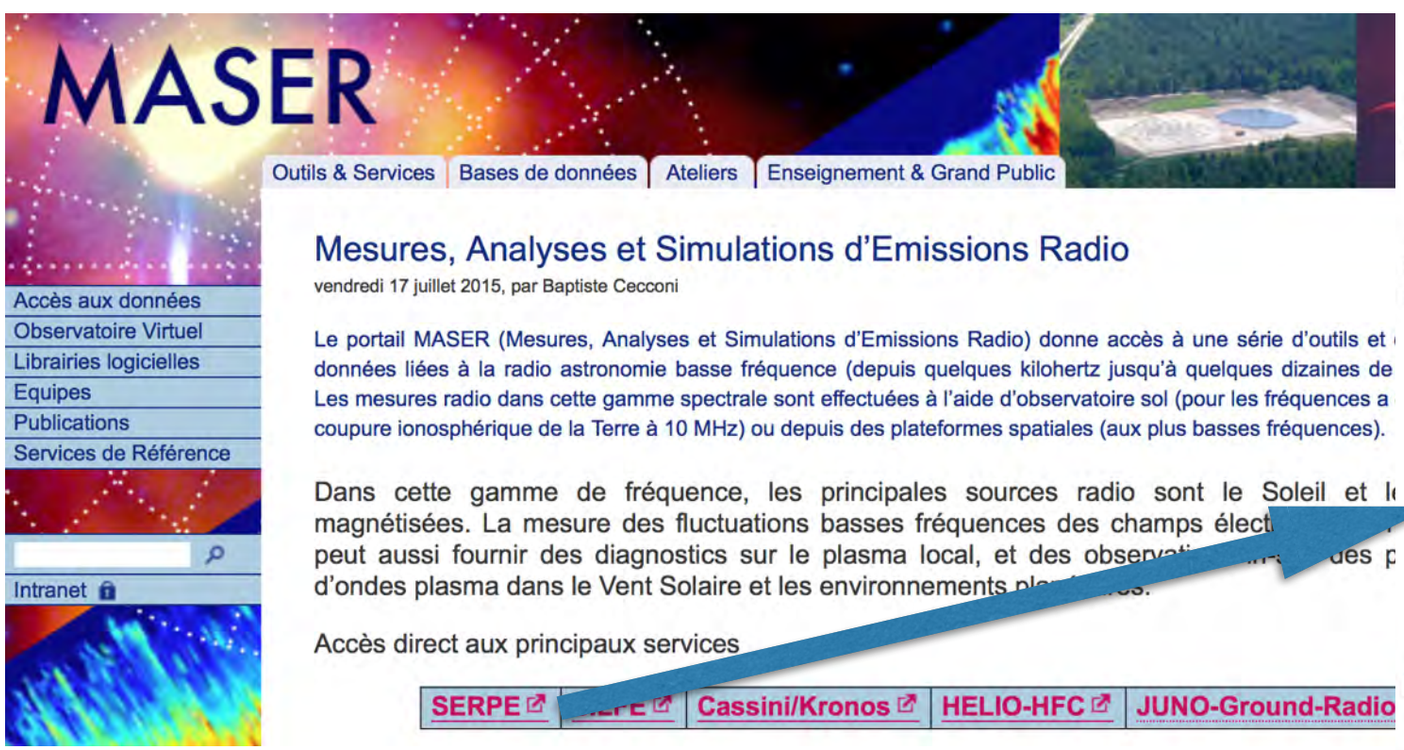
- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes

Astronomy & Astrophysics manuscript no. article˙serpe
November 15, 2014

ExPRES: a tool to simulate planetary and exoplanetary radio emissions

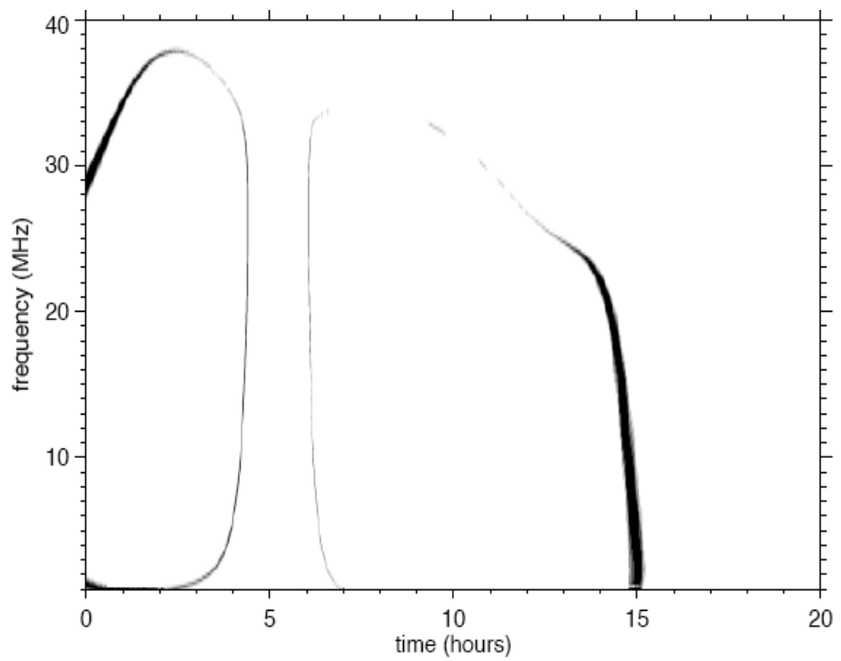
S. L. G. Hess[1,2], P. Zarka[1], B. Cecconi[1], and L. Lamy[1]

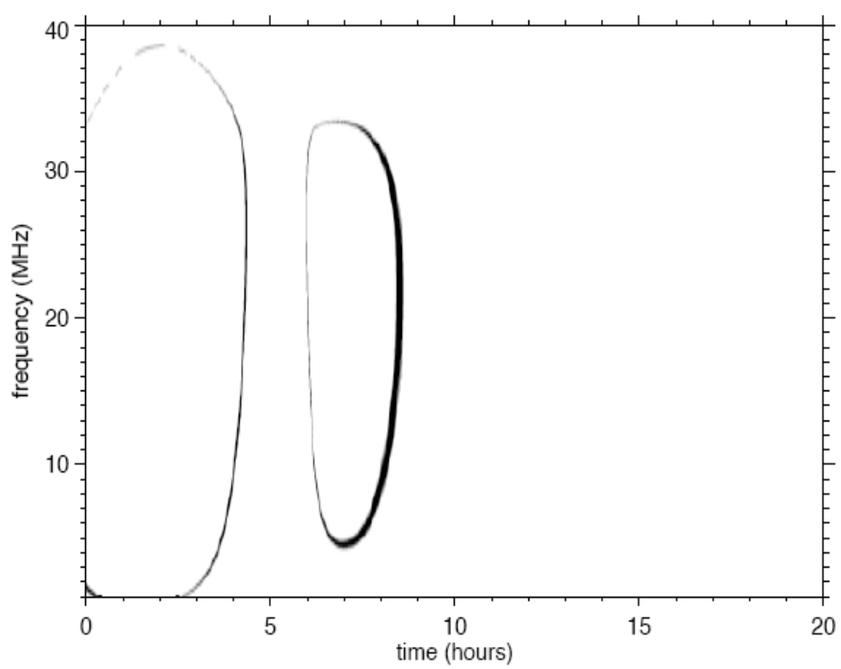
[1] LESIA, Observatoire de Paris CNRS, UPMC, Univ. Paris 7, France, e-mail: philippe.zarka@obspm.fr
[2] Department of Space Environment, ONERA - The French Aerospace Lab, France



What we will do with JUNO

- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes



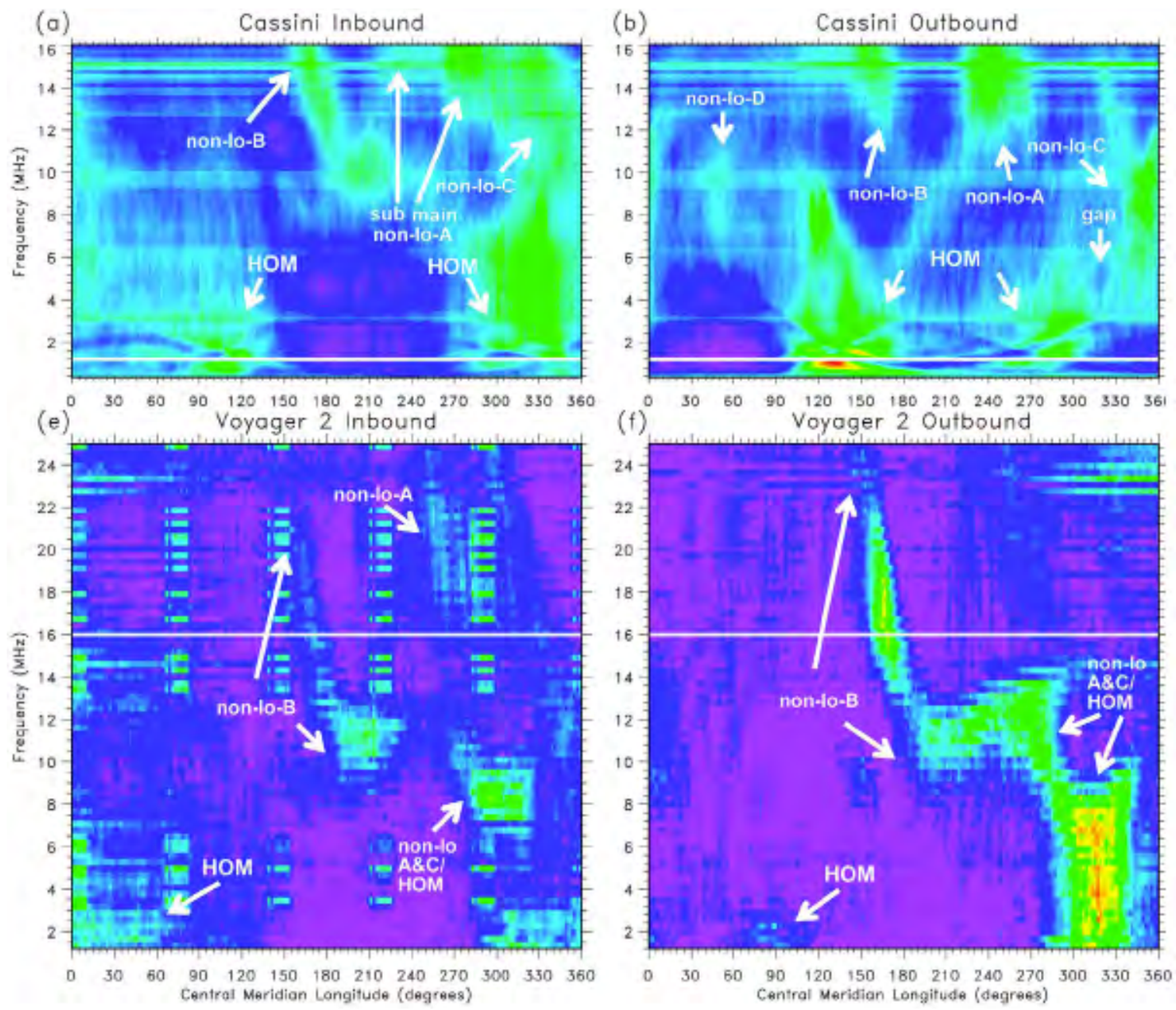


WORK IN PROGRESS

[Louis et al., PNST 2016]

What we will do with JUNO

- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes



[Imai et al., 2011]

What we will do with JUNO

- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes

  Parametric study → Source locations

  Relations between bKOM / HOM / non-Io DAM (QP ? ~~nKOM~~)

  Radio beaming & electrons energy

  Satellite-Jupiter lead angle ⇒ Unipolar/Dipolar interaction

  Relation with UV/IR auroral components ?

- HOM & bKOM as a SW proxy
- Auroral activity → Jovian plasma (sub)corotation ?

- Importance of support Ground-Based DAM observations *[cf. Baptiste's talk]*

  → Cross-correlation (interferometric) measurements WAVES-Ground ?

- Importance of a « perfect » internal B-field model for ExPRES

  of a reliable plasma model for ExPRES & ray-tracing (ARTEMIS-P)

[Gautier, Thesis 2013]