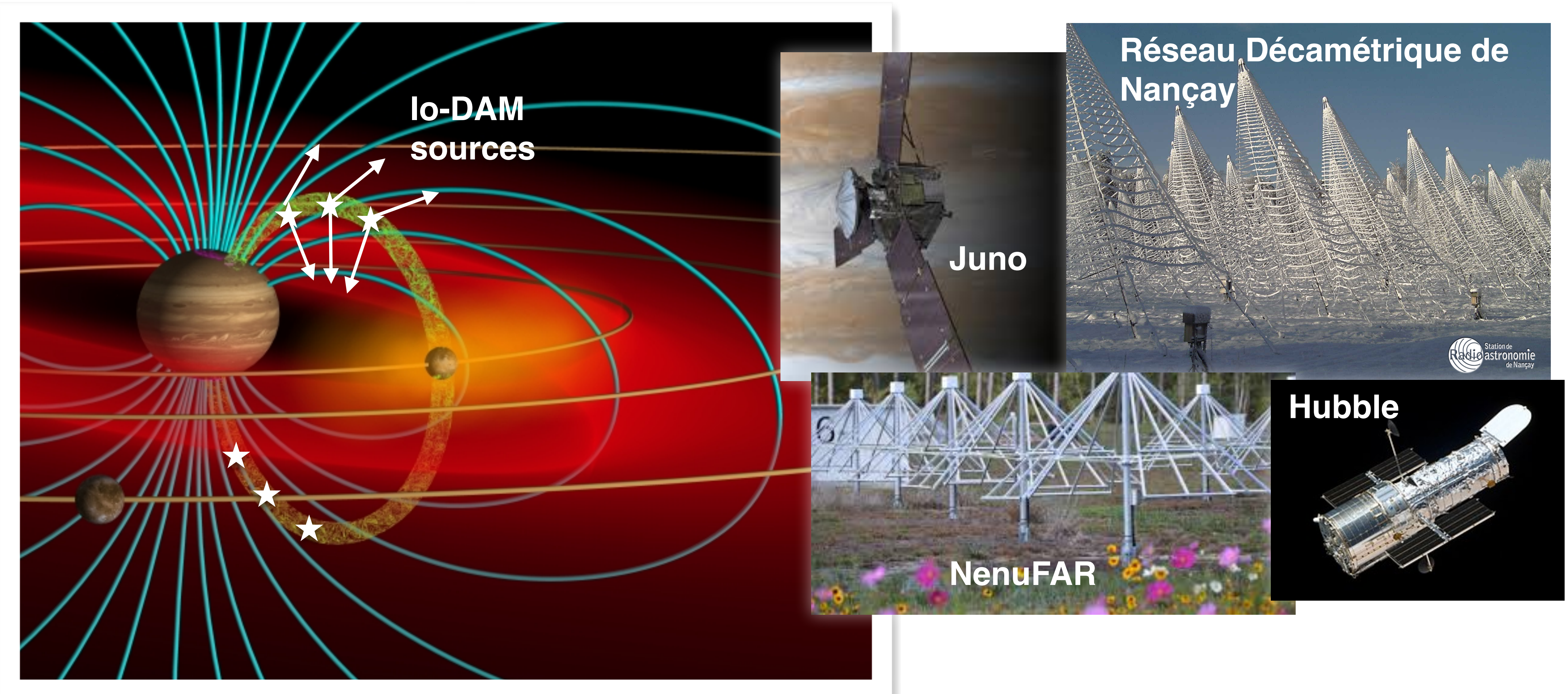
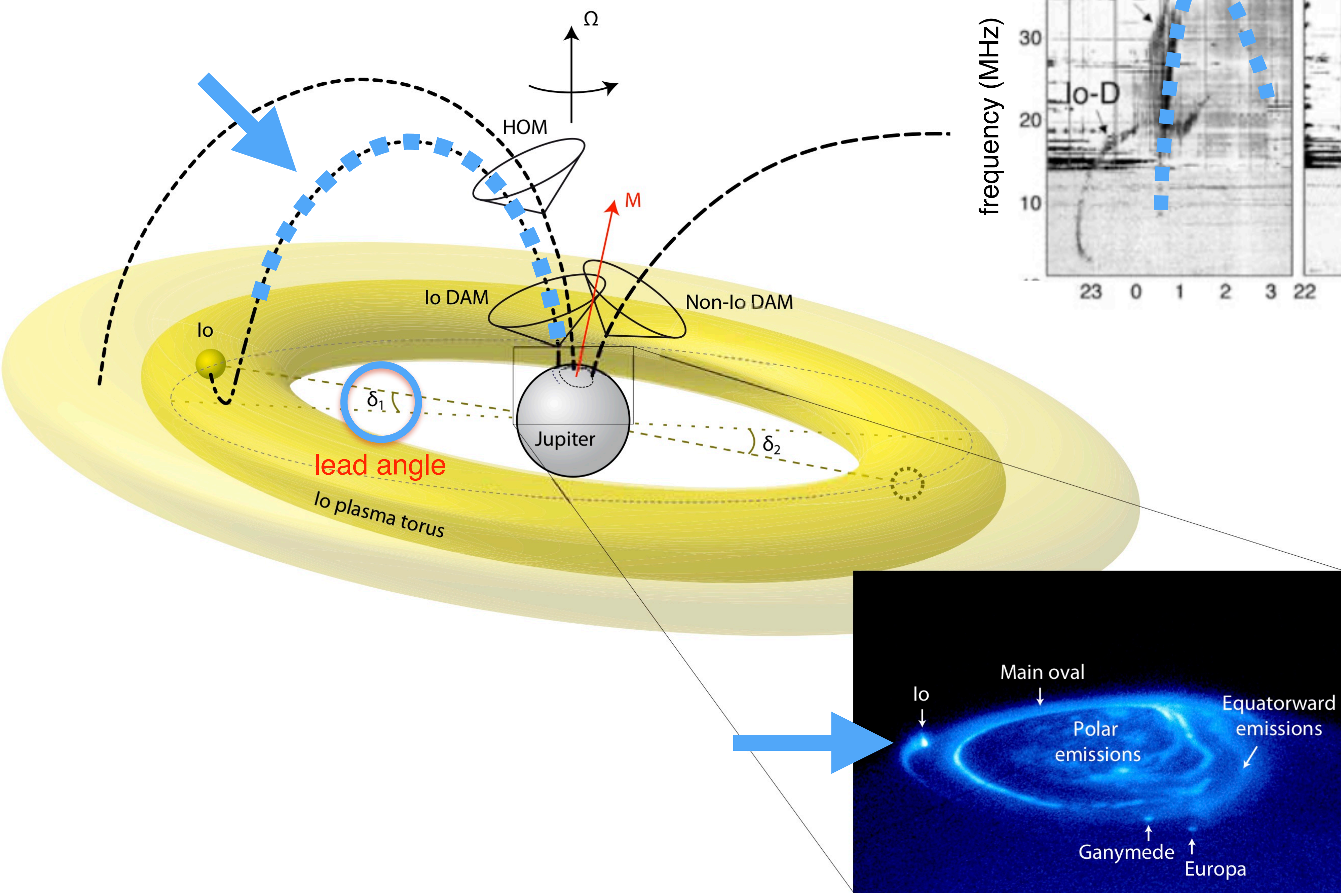
Determining the beaming of Io-Decametric emissions to probe the Io-Jupiter Interaction

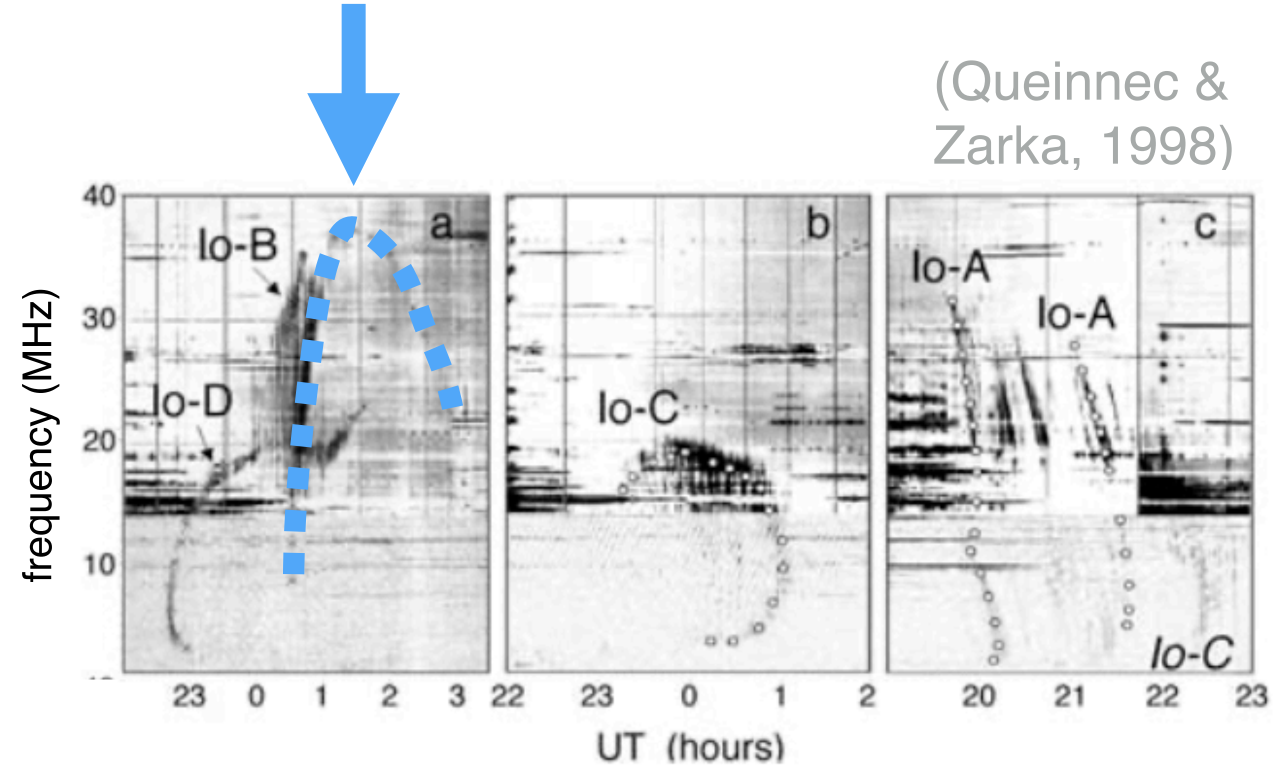


L. Lamy, L. Colomban, P. Zarka, R. Prangé, M. Marques, C. Louis,
W. Kurth, B. Cecconi, J. N. Girard, J.-M. Grießmeier, and S. Yerin

Colloque PNST Marseille, 19 mai 2022

Purpose





(Queinnec & Zarka, 1998)

- Cyclotron Maser Instability (CMI) + e- accelerated by the Io-Jupiter alfvenic interaction
- Powerful decametric emissions induced by Io : f ~ f_{ce}, UV aurorae, **strongly beamed**
- Measuring the beaming requires to locate the active Io Flux Tube => models of B + δ

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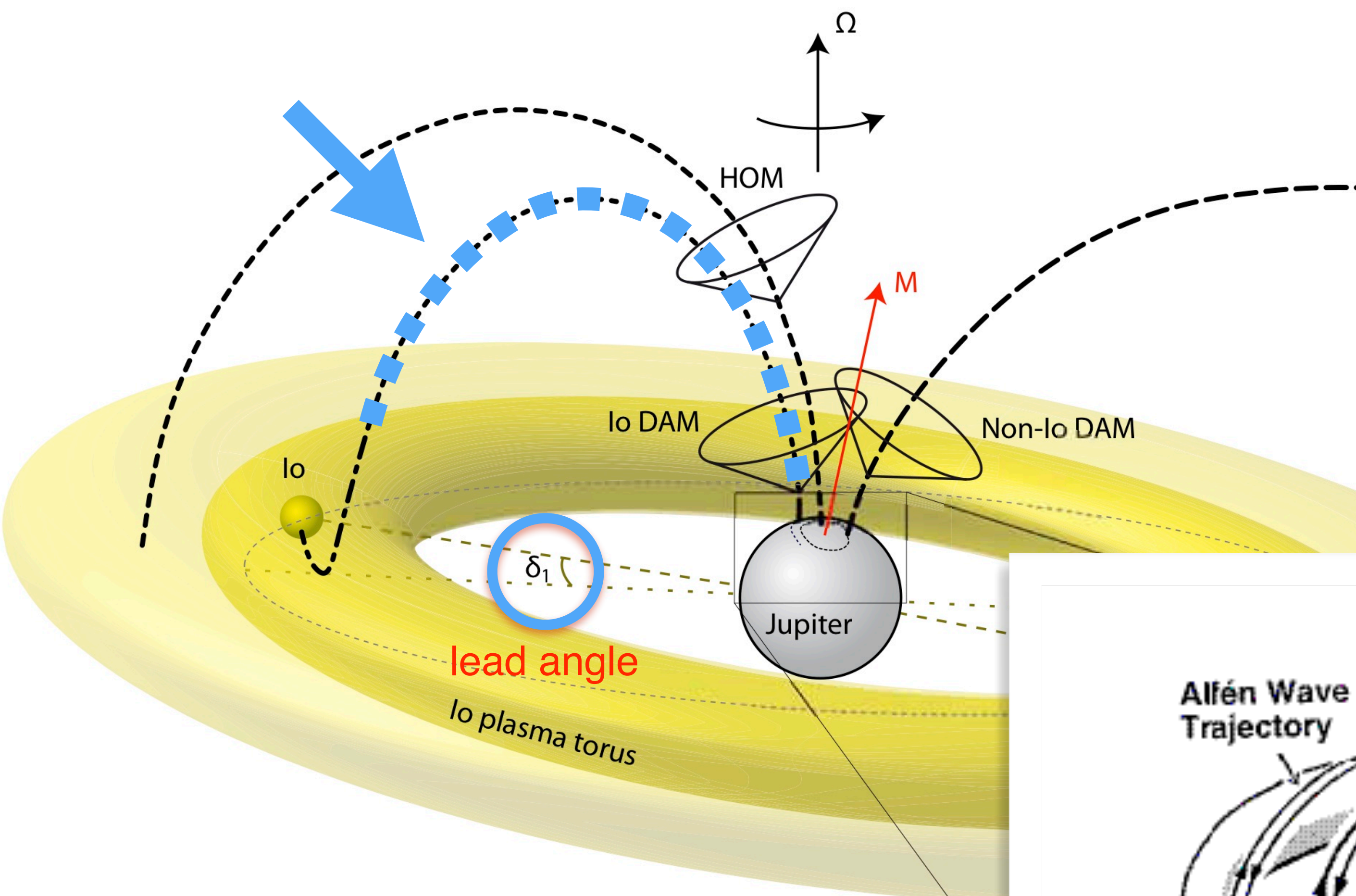
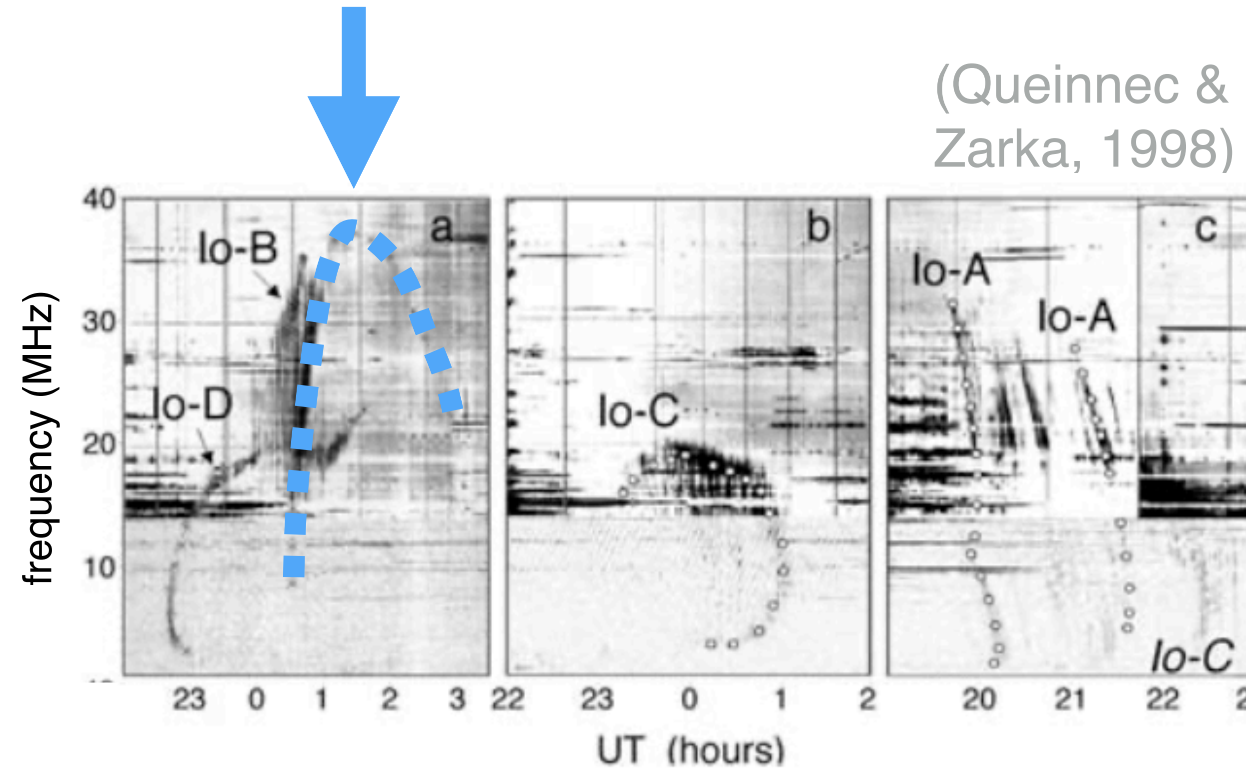
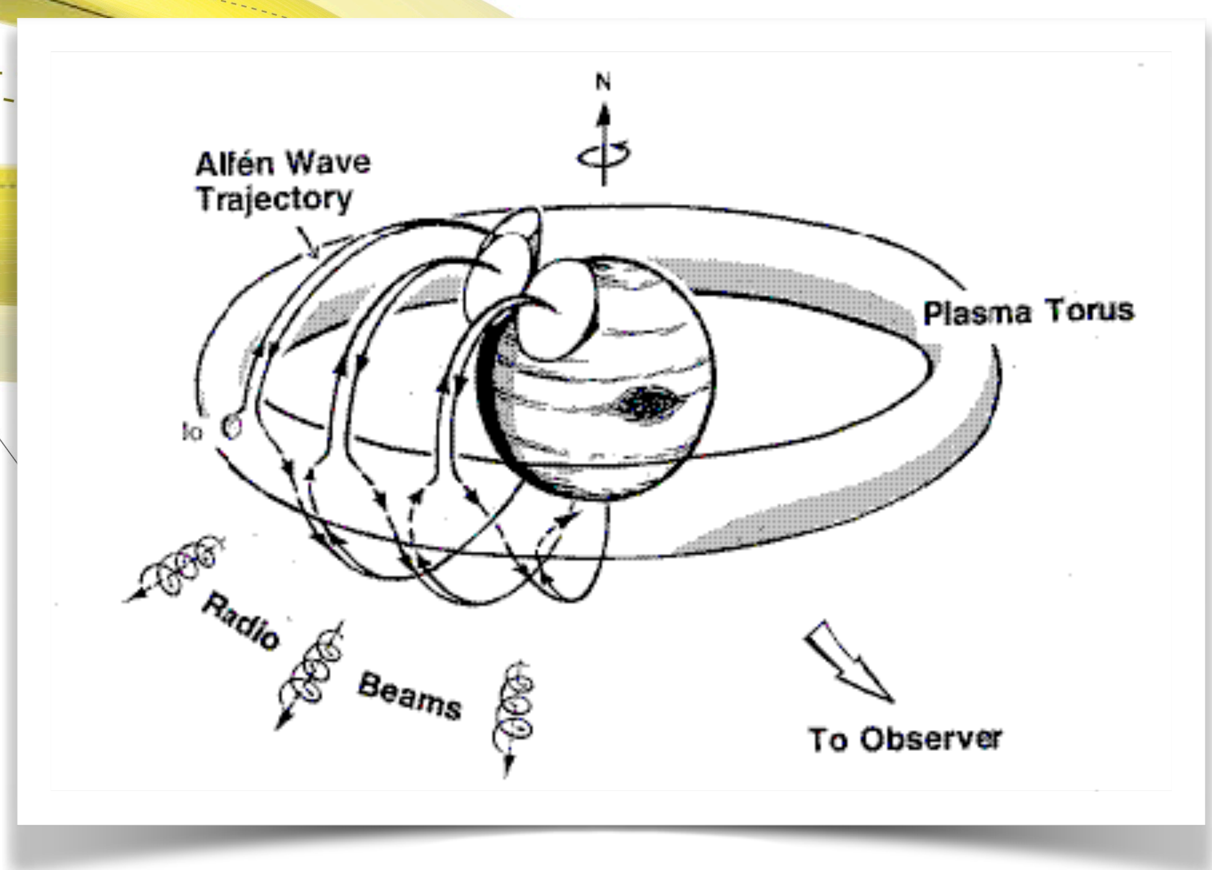


(Queinnec & Zarka, 1998)





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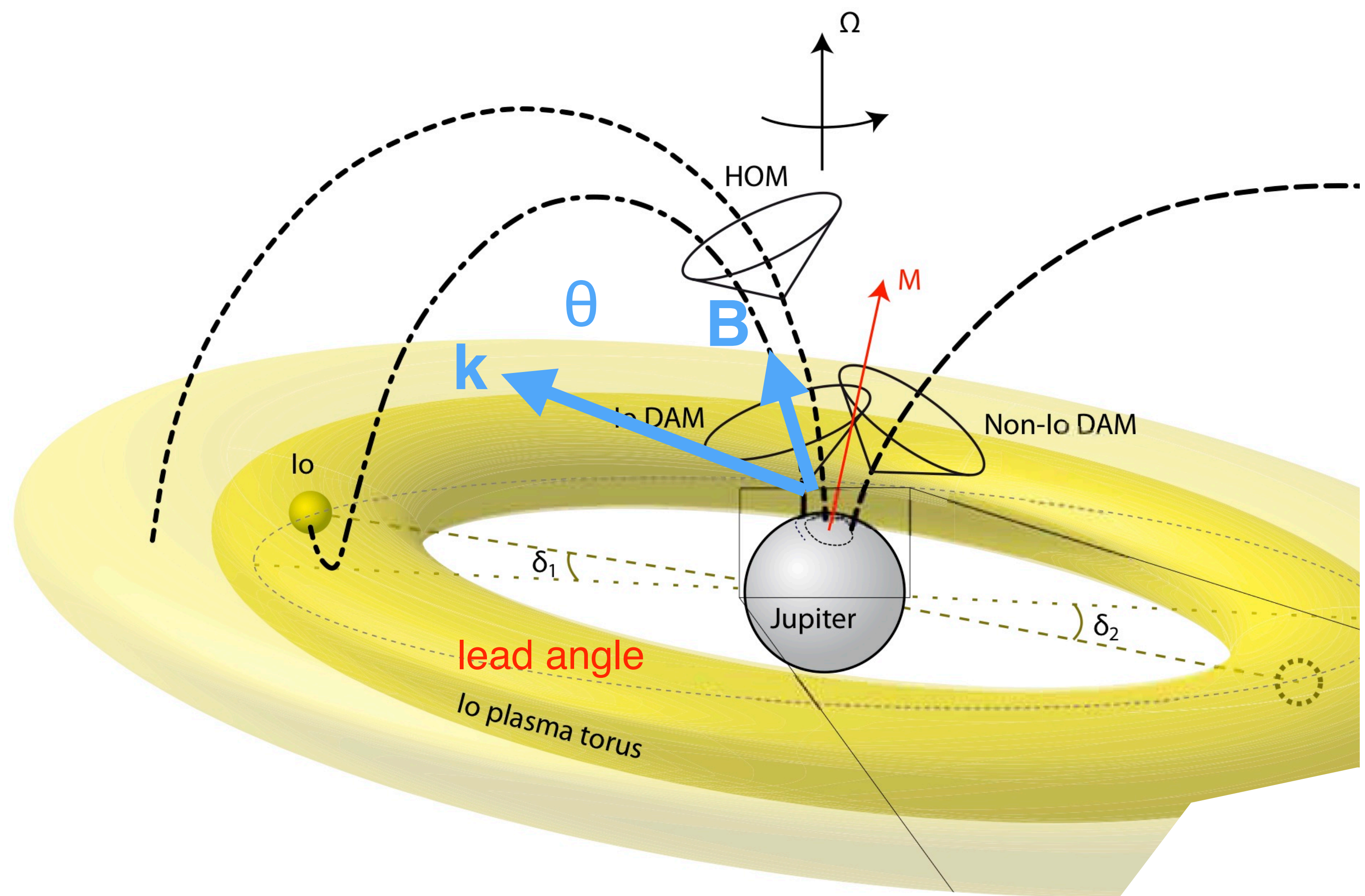

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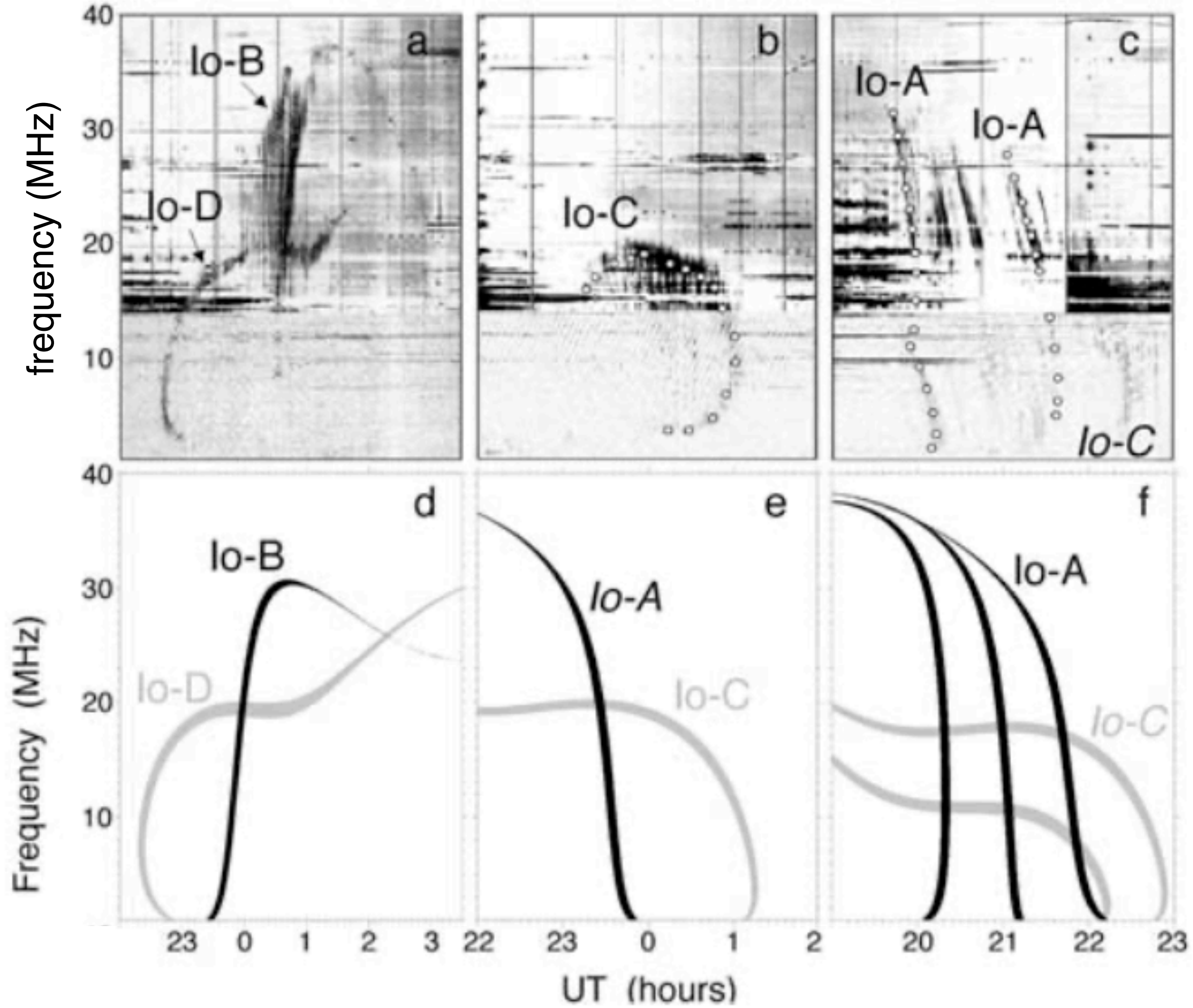
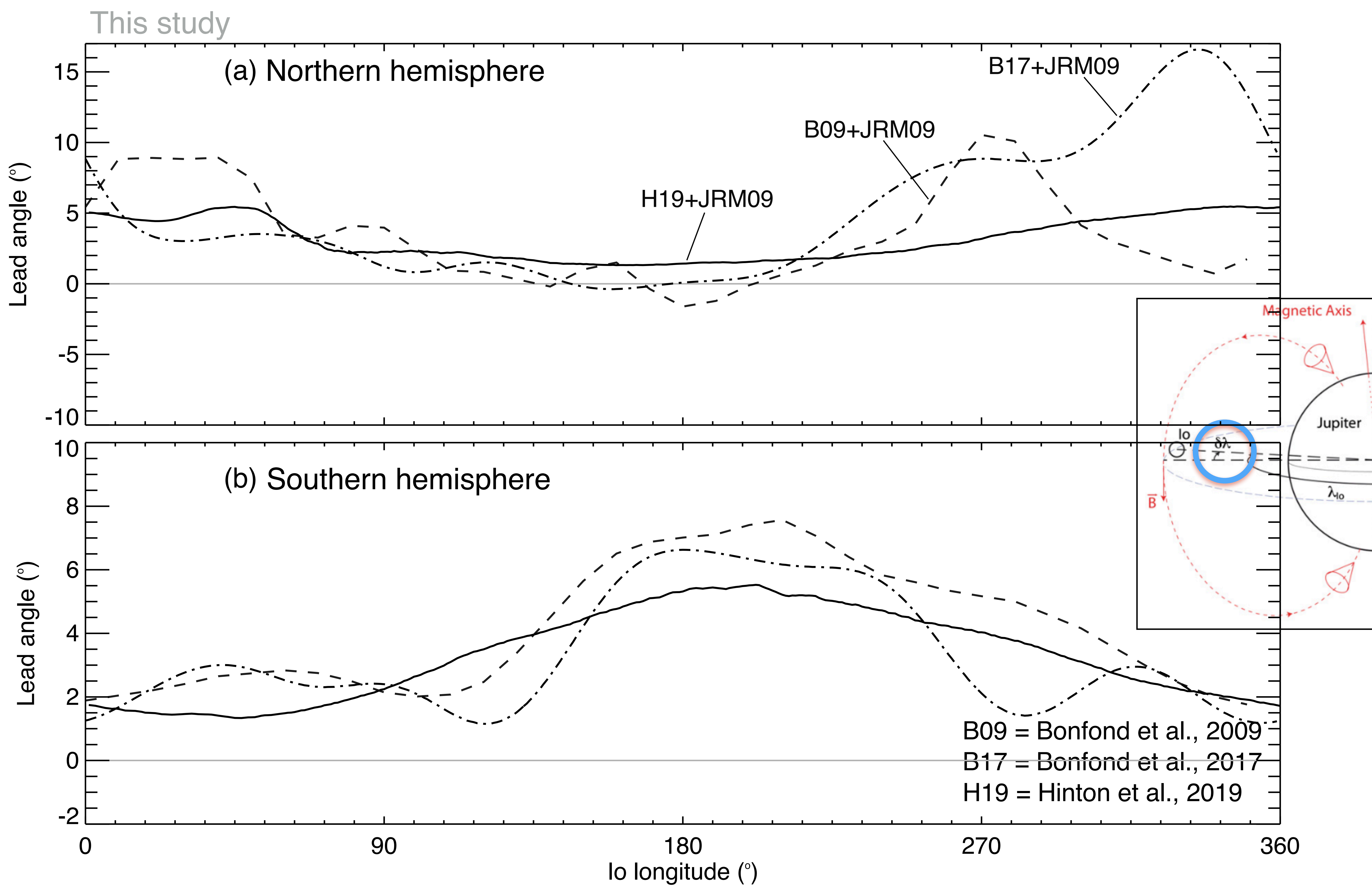


- Io-DAM arcs reproduced with CMI oblique emission driven by loss cone e- of few keV (Hess al., 2008, 2010, Louis et al., 2020, submitted)

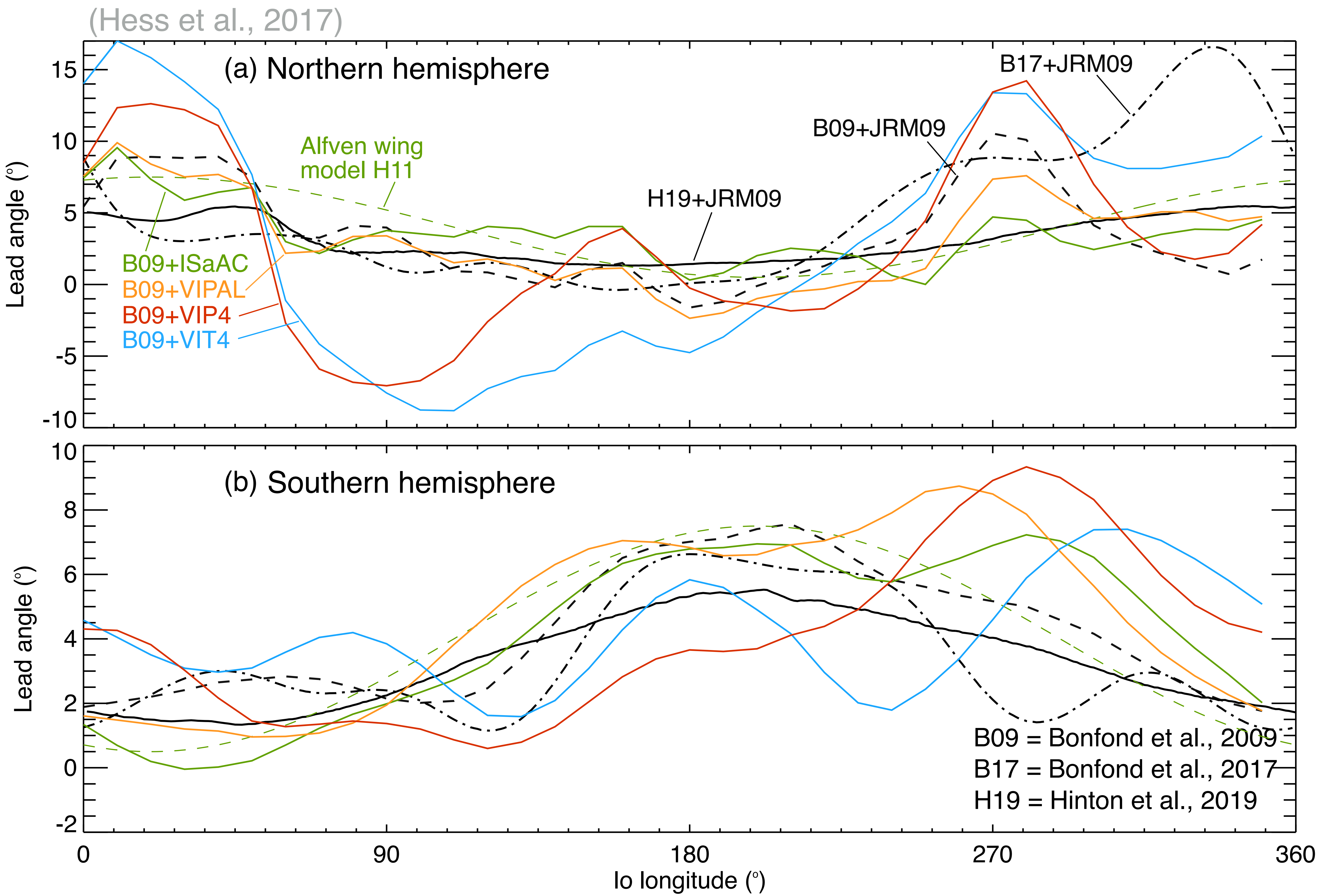
$$\theta = (\mathbf{k},\mathbf{B}) = \arccos\left[(v/c)/\left(1-\omega_{ce}/\omega_{ce,max}\right)^{1/2}\right]$$

* Goal : **determine θ directly (and accurately) and infer v => E(e-)**
- fit Io-DAM arcs in Juno/Nançay observations
- active Io flux tube located with <u>3 different methods</u> (models of δ, radio/UV, radio/radio)
- up-to-date mag. field model = JRM09 + current sheet (Connerney et al., 2018, 2020)

A - Updated models of lead angle

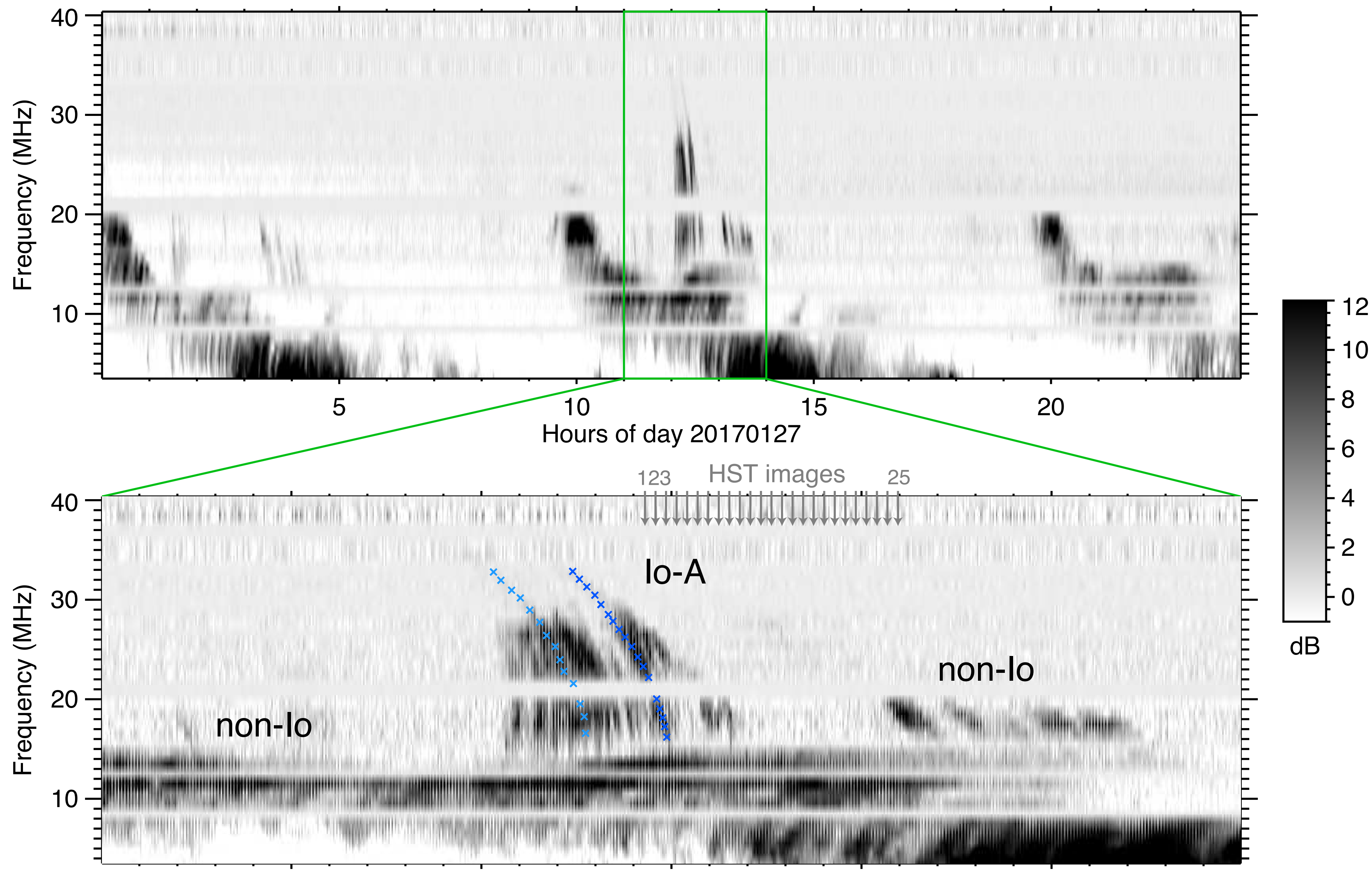


Updated models of lead angle



A - Radio/UV simultaneous observations

* Cross-matching of HST images with catalogs of Juno/NDA Io-DAM events since 2016
=> 1 event : 2017-01-27



Time (h)	11.0	11.5	12.0	12.5	13.0	13.5	14.0
r (Rj)	63.8	63.7	63.6	63.4	63.3	63.2	63.1
CML (°)	201	219	237	256	274	292	310
MLat (°)	14	13.3	11.6	9.1	6.1	2.9	-0.2
MLT (h)	5.1	5.1	5.0	5.0	5.0	5.1	5.1
Io phase (°)	238	226	246	250	255	259	263

A - Radio/UV simultaneous observations

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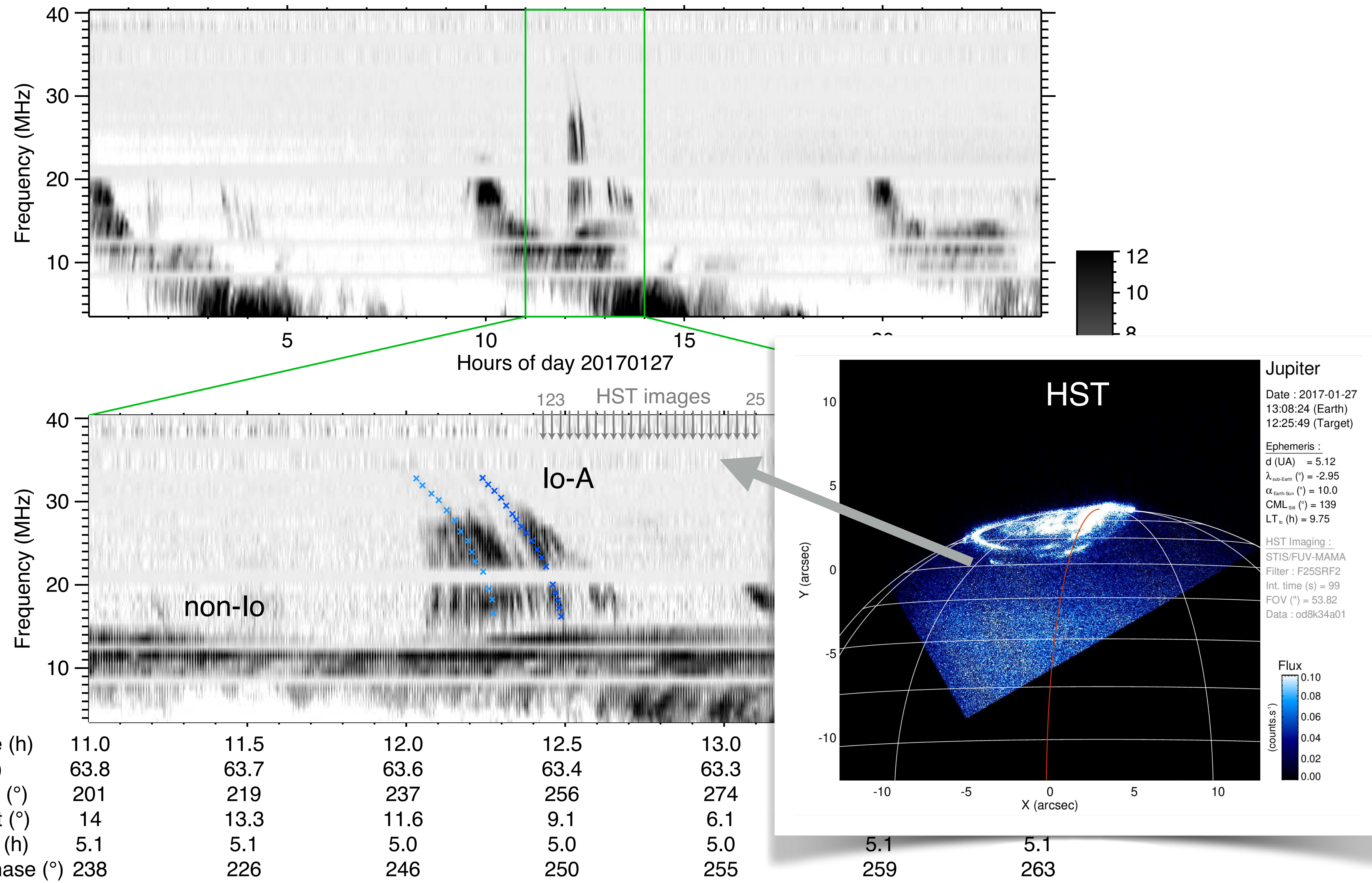

https://apis.obspm.fr

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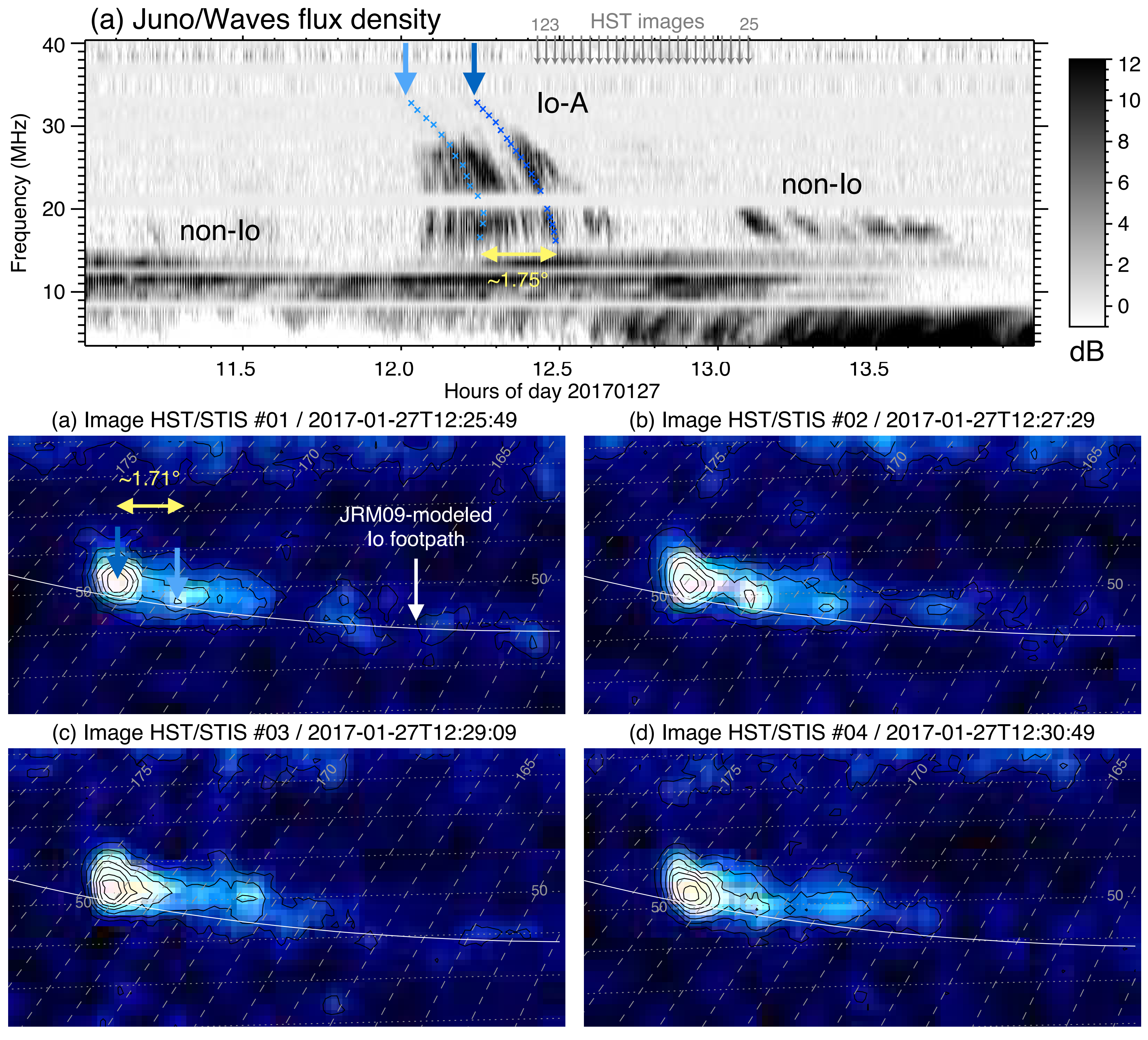

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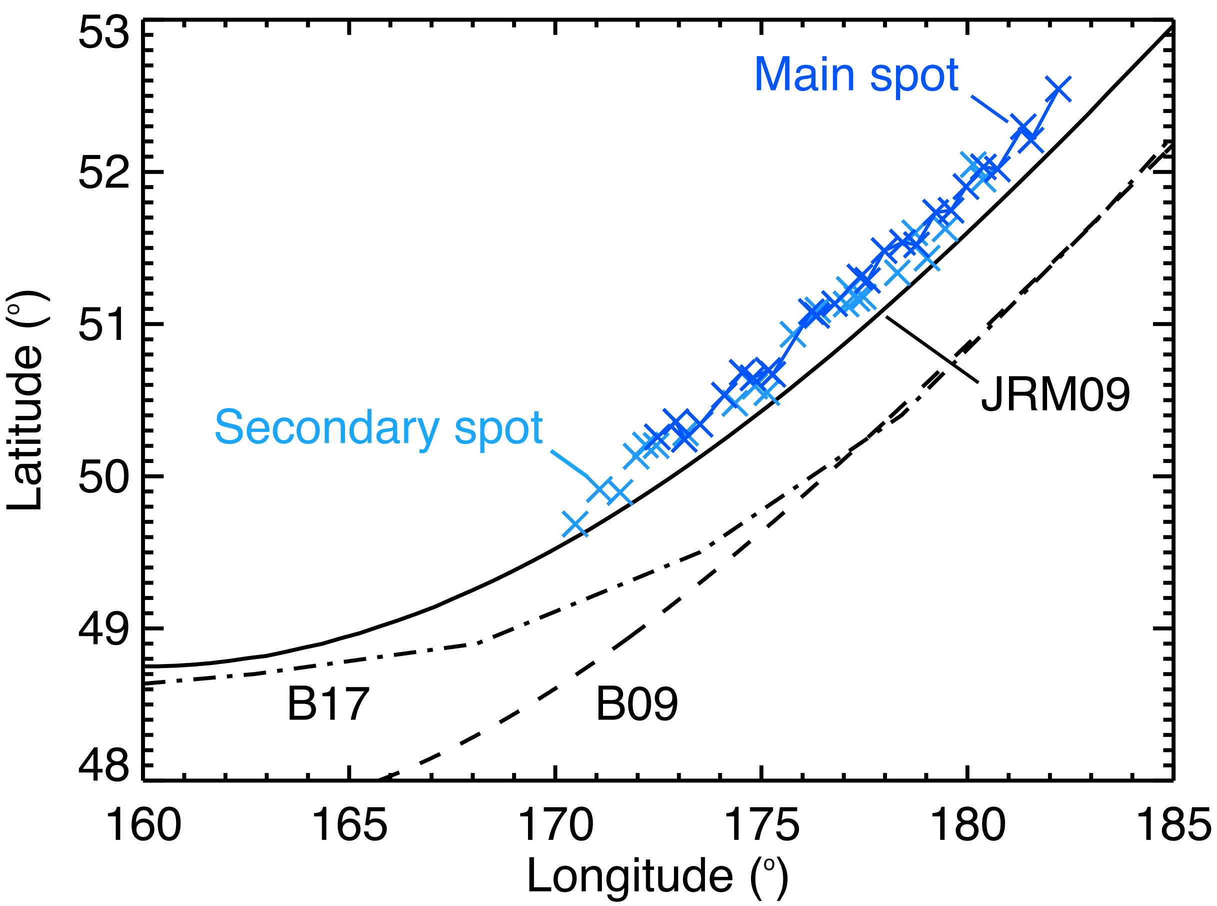
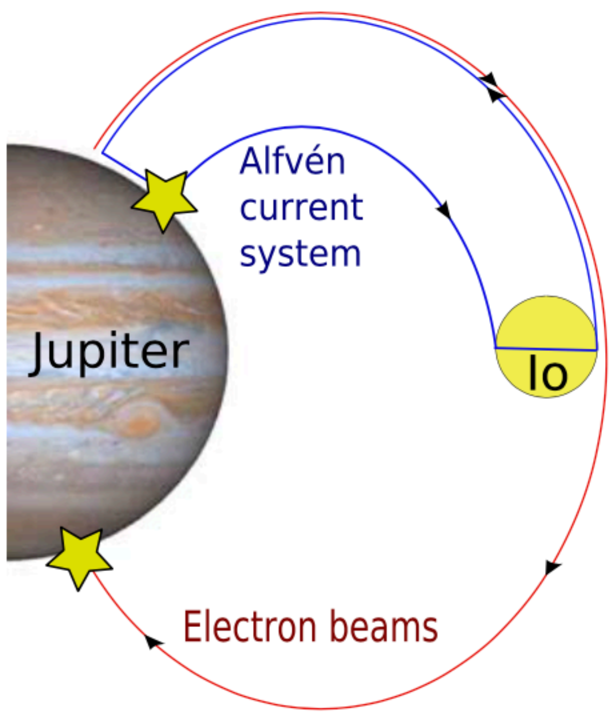
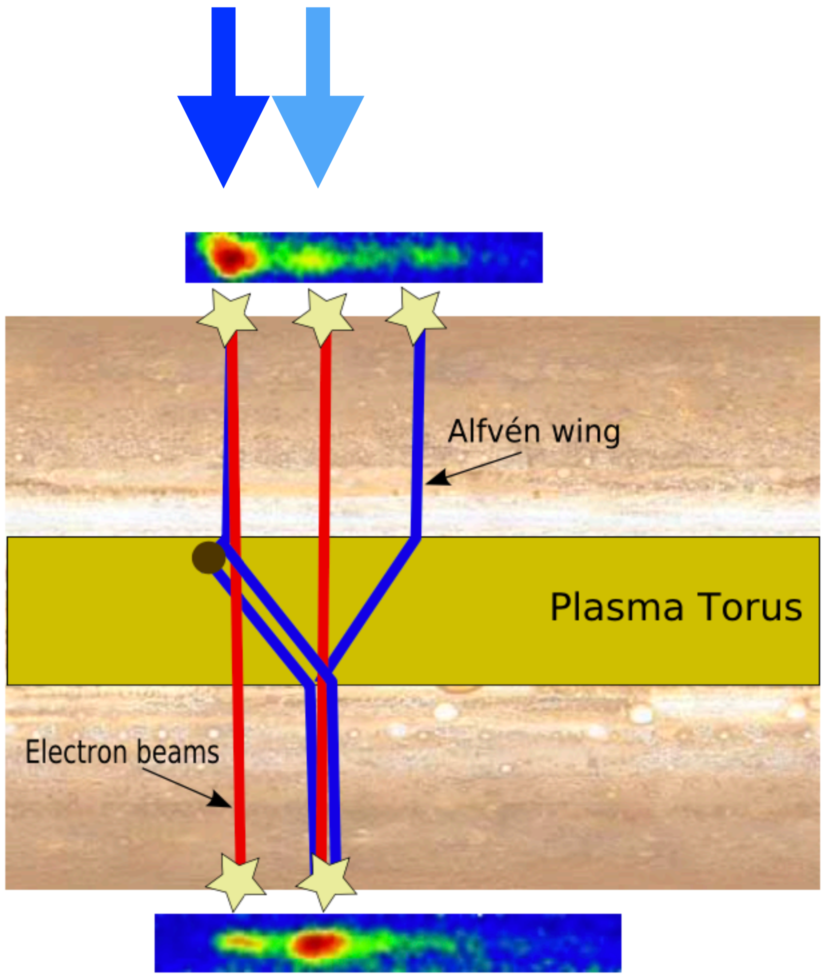


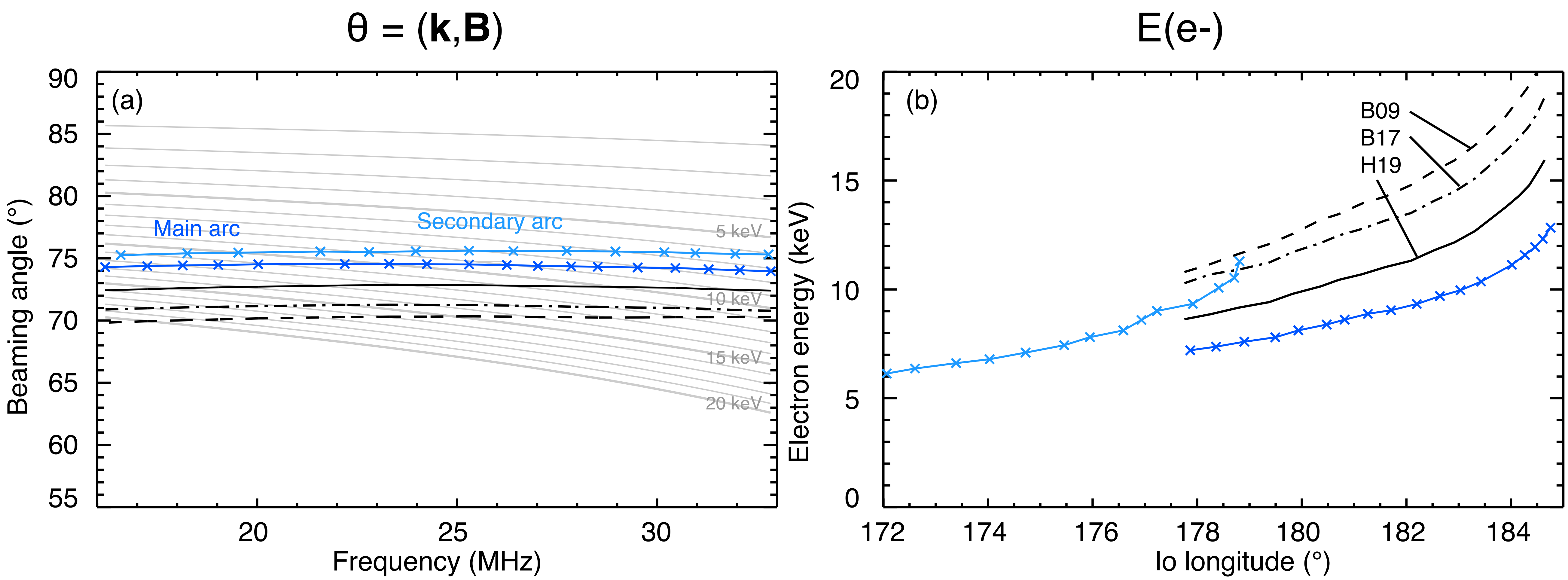




(Bonfond et al., 2008)

- Main UV footprint : coordinates slightly shifted from models (=> proxy of torus density)
- Second footprint : interpreted as the northern counterpart of the southern main footprint

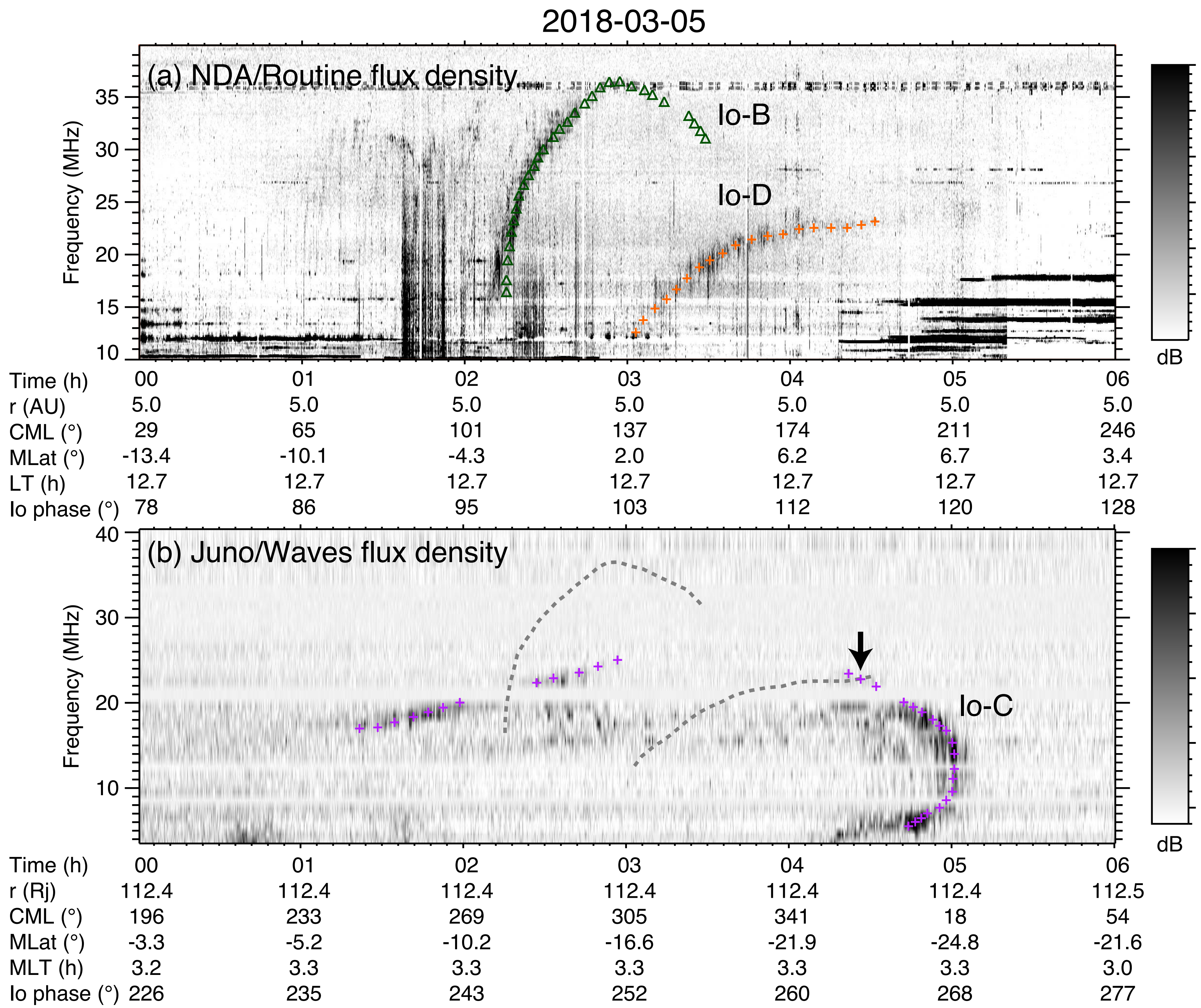
A - Radio/UV simultaneous observations



- Beaming of Io-A main arc fairly reproduced by CMI loss cone model driven by 6-13 keV e-
- Main source of uncertainty = position of the active flux tube
- Beaming => E(e-) varies with f (= altitude) and/or the longitude of Io
- Secondary arc has a slightly larger beaming => slightly less energetic e- of 5-9 keV

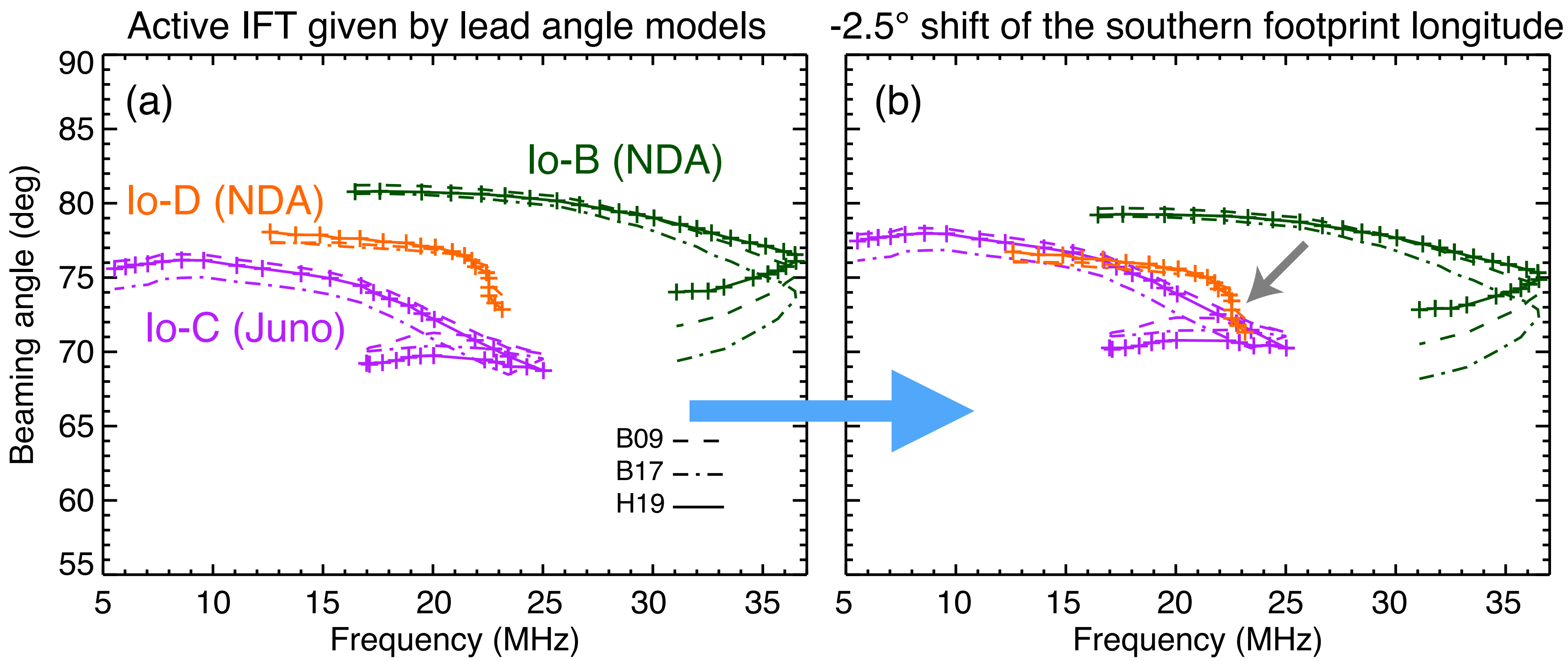
B - Radio bi-point observations

* Cross matching of Io-DAM events simultaneously observed by Juno and Nançay
=> 2 events : 2018-03-05 and 2014-01-29



B - Radio bi-point observations

* 2018-03-05 :



- Io-C and D arcs simultaneously bu Juno/NDA => θ differs by a few °
- Symmetrical beaming recovered by correcting the footprint longitude by -2.5°

B - Radio bi-point observations

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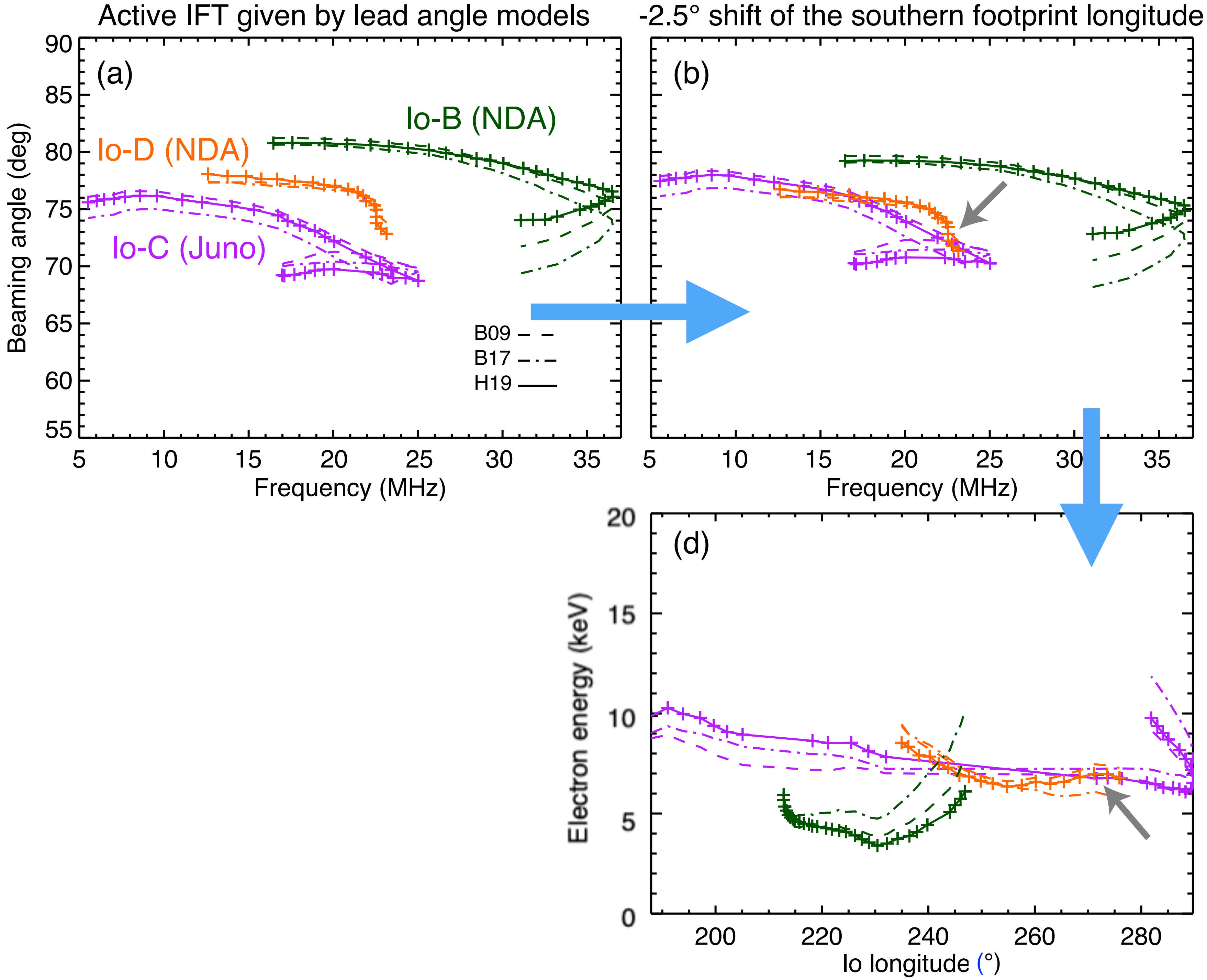
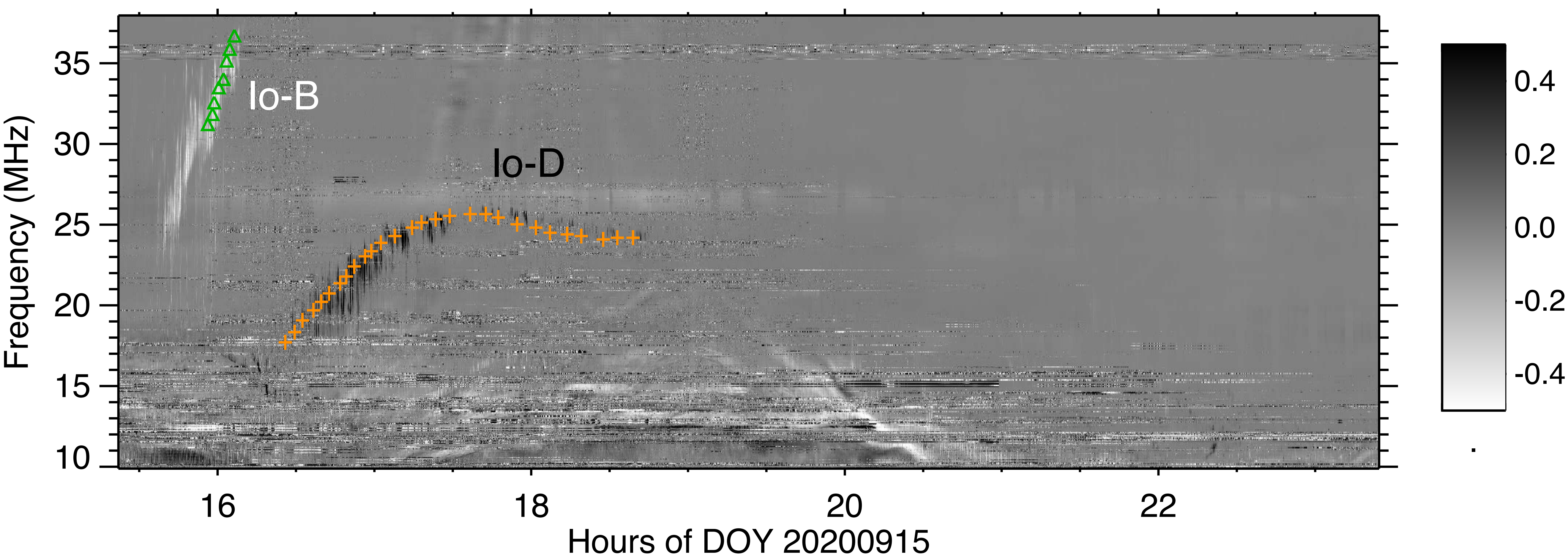


- Io-C and D arcs simultaneously bu Juno/NDA => θ differs by a few °
- Symmetrical beaming recovered by correcting the footprint longitude by -2.5°

=> Electron energy of 6-11 keV varies vs Io longitude **and** frequency (= altitude)

C - Stand-alone radio observations

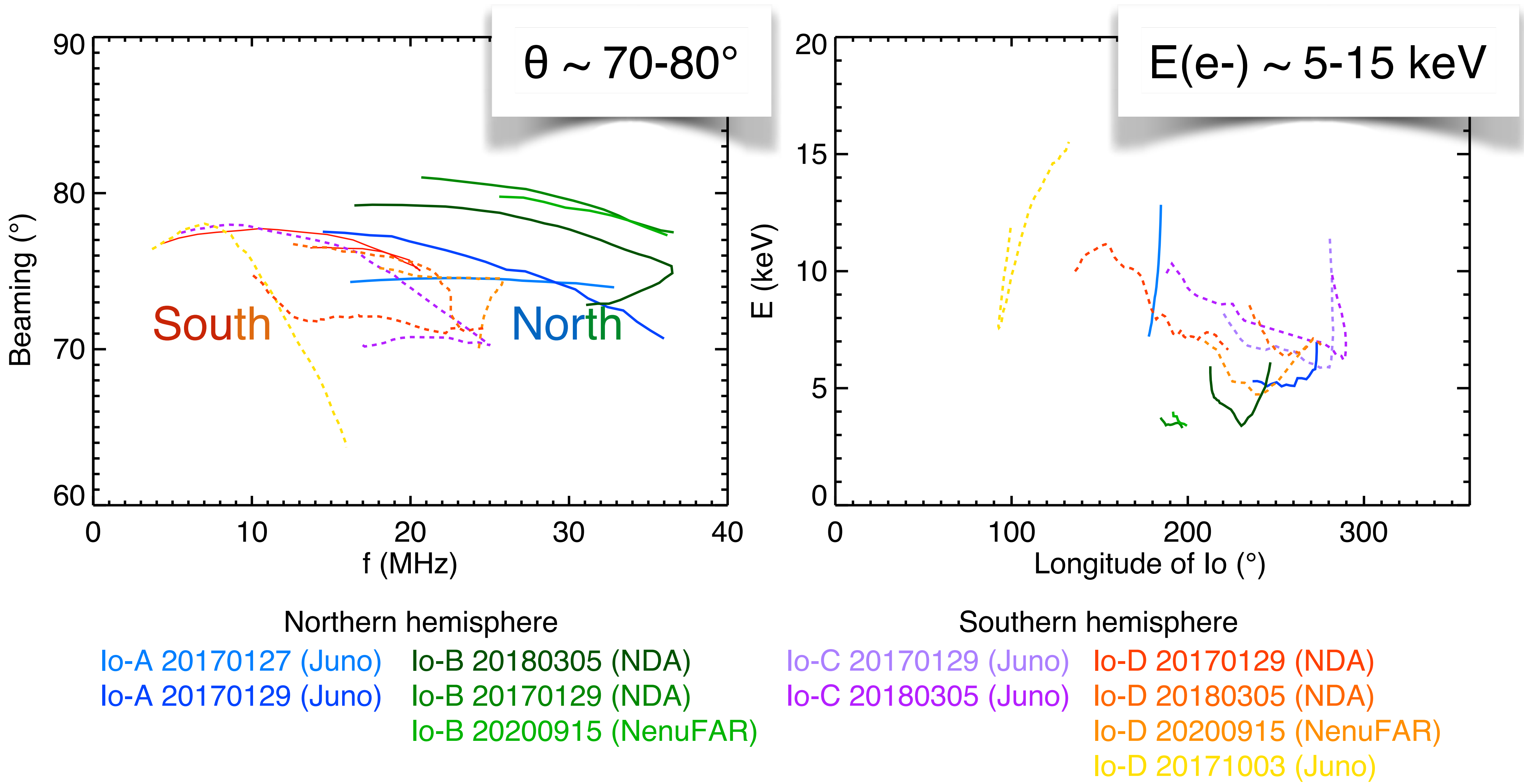
* NenuFAR : value-added = sensitive tracking of faint emissions



* Method applied to the Io-D beaming determined by (Martos et al., 2020) event :
  => works much better

Toward a statistical study

* Overall results :



* Perspectives :
- proof of concept study to accurately measure the Io-DAM beaming => E(e-)
- enlarge the statistics to understand how/why E(e-) varies with time, frequency