Energetic particle driven instabilities during the L-H transition in ASDEX Upgrade

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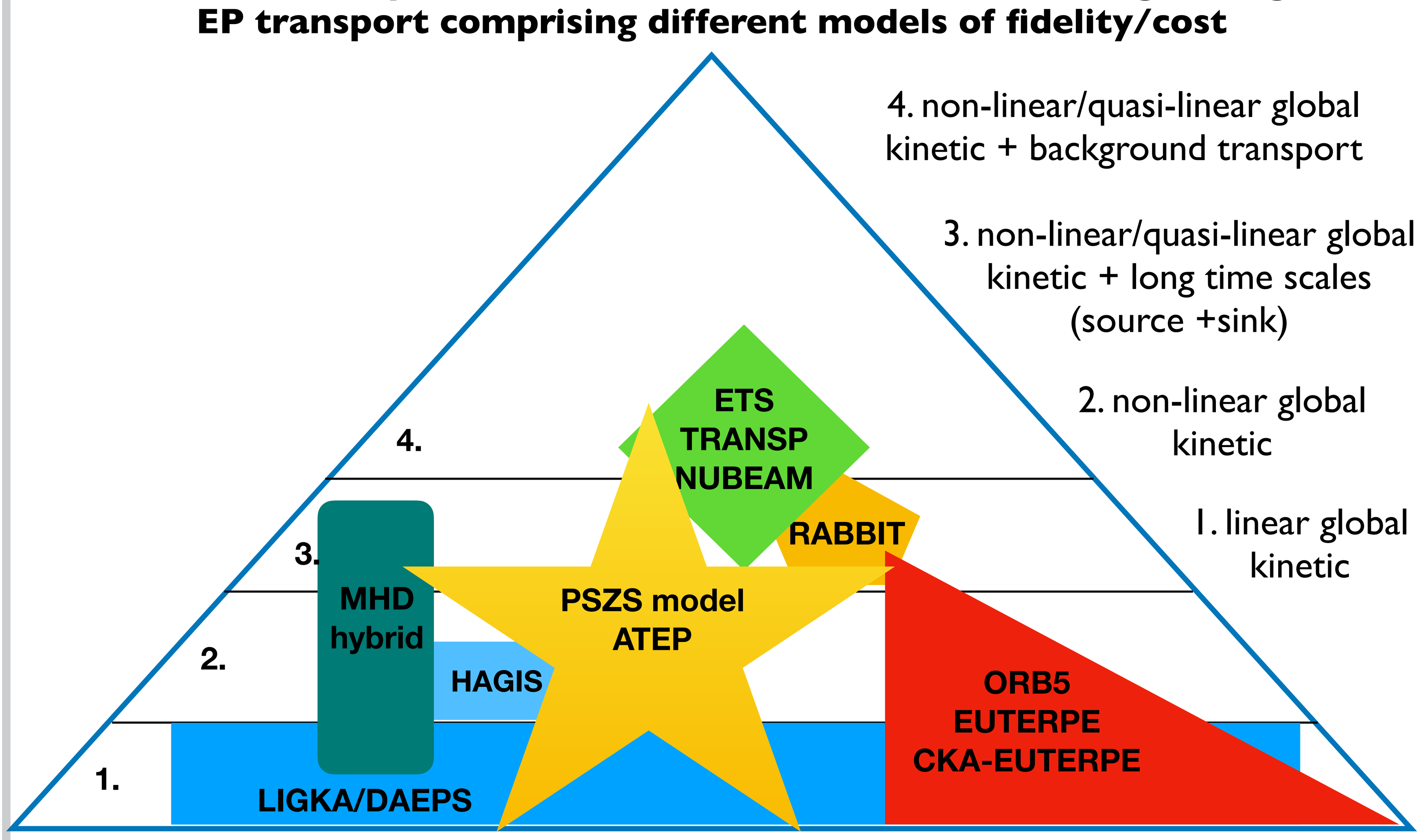
motivation & main results

- off-axis NB heating is crucial for current profile control, particularly in ramp-up phases
- ASDEX Upgrade (AUG) scenarios with exclusive off-axis heating brings $E_{NB}/T_{thermal}$ and $\beta_{fast}/\beta_{termal}$ closer to future experiments
- what is the effect of the observed EP instabilities on the background profiles?
- validate stability and transport tools on extended AUG data base, including experimental isotope studies: different βs, H,L-modes
- use IMAS to develop and validate an automated EP stability workflow - model trends instead of single time points
- validation of linear stability model as basis for the implementation of reduced EP transport models

motivation: develop IMAS based tool to calculate electromagnetic, global EP transport comprising different models of fidelity/cost



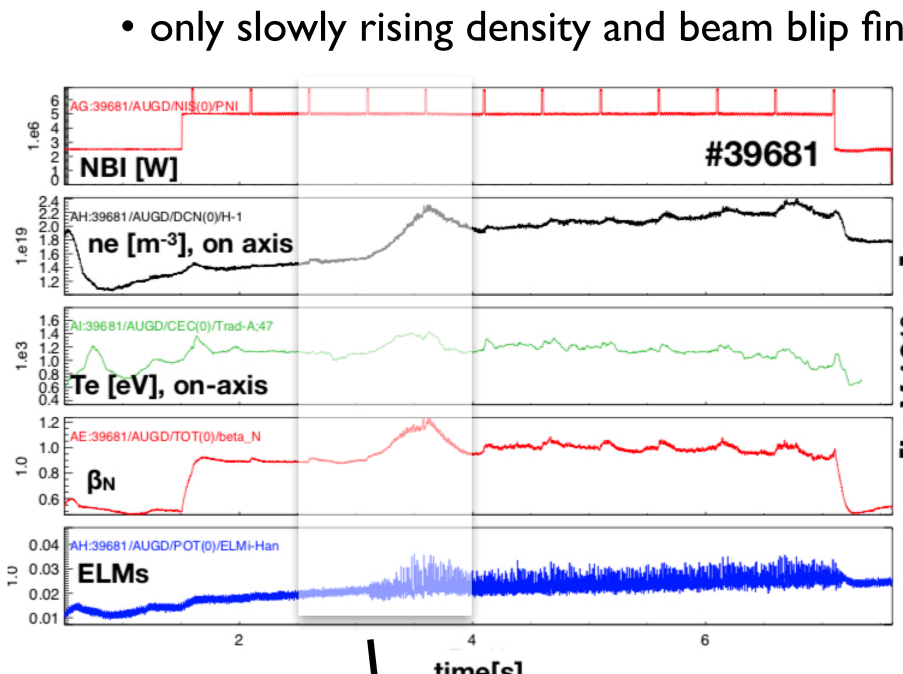
first implementation of ATEP code finished; this poster: verification and validation [4,5]

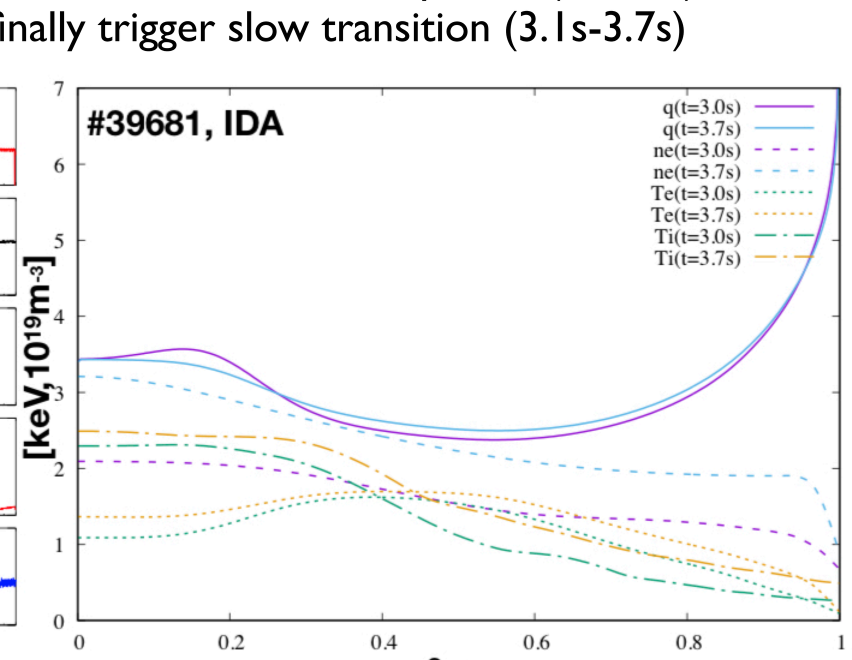
Dedicated isotope studies of strongly non-linear EP dynamics on ASDEX Upgrade [3]

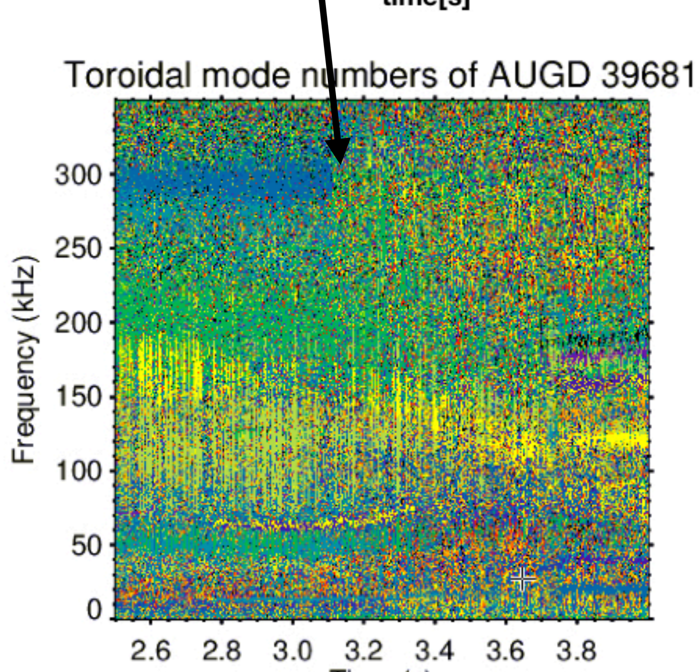
- with sub-Alfvénic beams (2.5-5MW)
- in current flat-top with stationary plasma conditions
- compatible with tungsten wall
- for EP physics relevant parameters: $\beta_{EP}/\beta_{thermal}$ ~1, $E_{NBI}/T_{i,e} \approx 100$
- database for different isotope mixes: deuterium (D) and hydrogen (H)

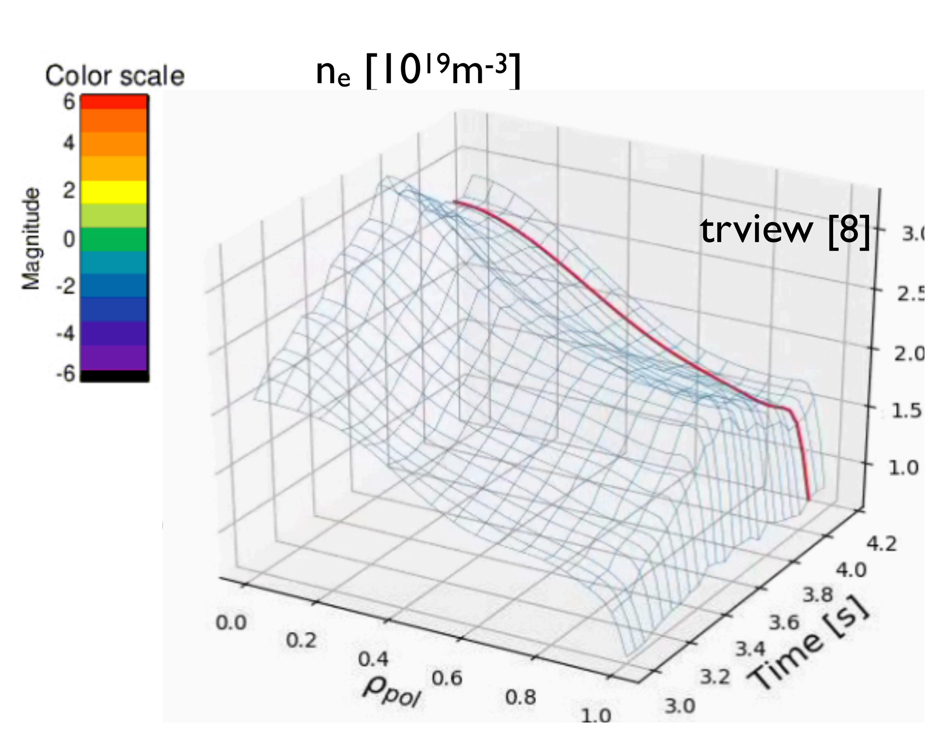
ideal for modelling: smooth transitions between different regimes:

- due to H-D mix, L-H transition does not occur with 5MW NBI power (1.5s-3s)
- only slowly rising density and beam blip finally trigger slow transition (3.1s-3.7s)





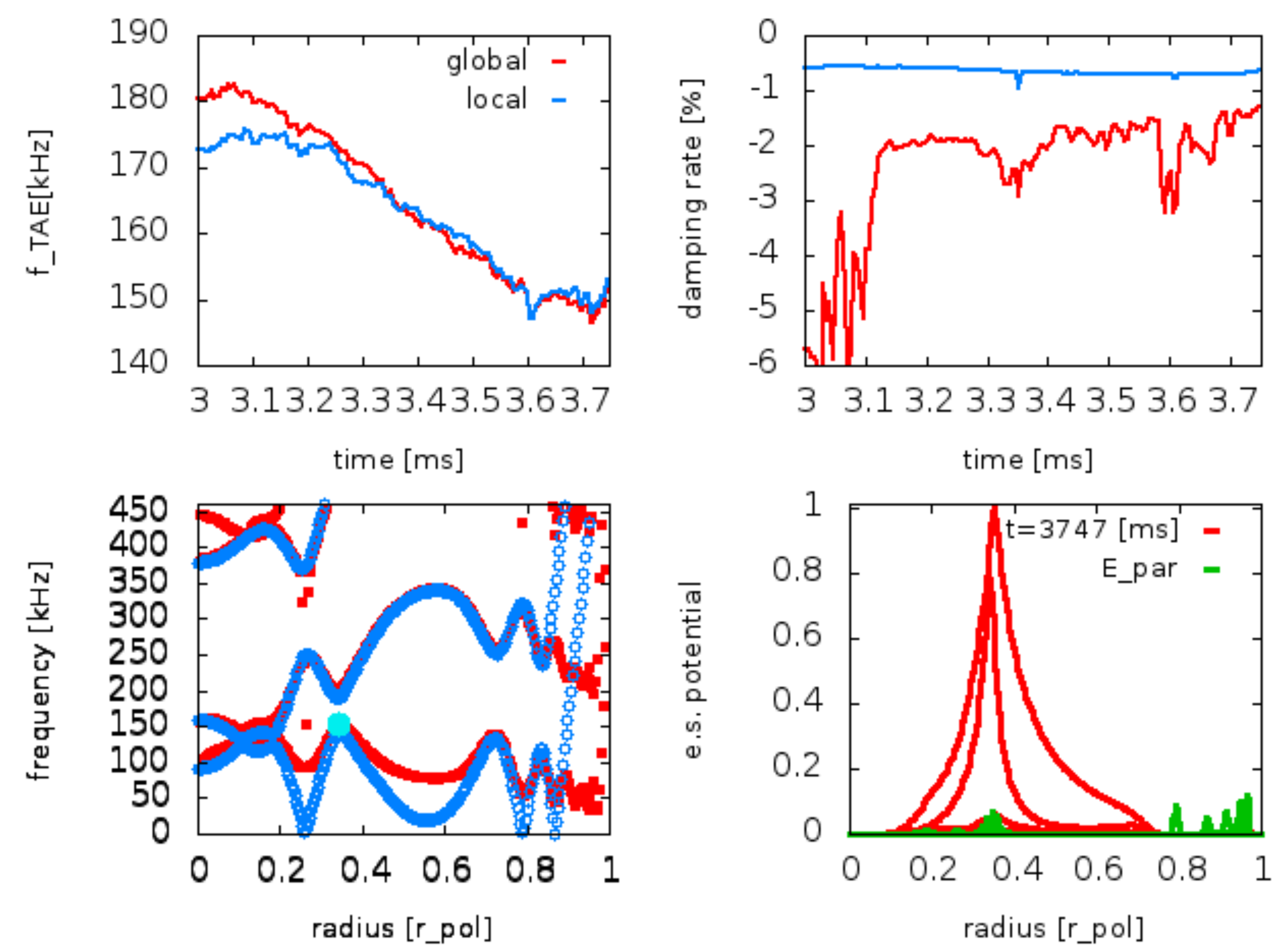




- modes in electron (positive mode numbers) and ion (negative mode numbers) diamagnetic directions are driven by positive and negative EP gradients
- as density rises, n=2 TAE drops in frequency
- although drive remains constant, TAE transitions from strongly bursting to steady-state
- n=-2 kink mode q=2.5 surface
- comparison of theoretical TAE mode frequency and experimental measurements allows us to determine local isotope mix ratio (experiment: H/H+D=0.35-0.45 line integrated)
- prominent n=-2 EAE at 300 kHz observed - too high frequency for principal resonances with NB ions (93keV) - unclear excitation mechanism, but probably similar to [Maraschek PRL, 1997]
- EAE jumps to 340kHz and then disappears in early LH transition - increased damping or different drive [10]?

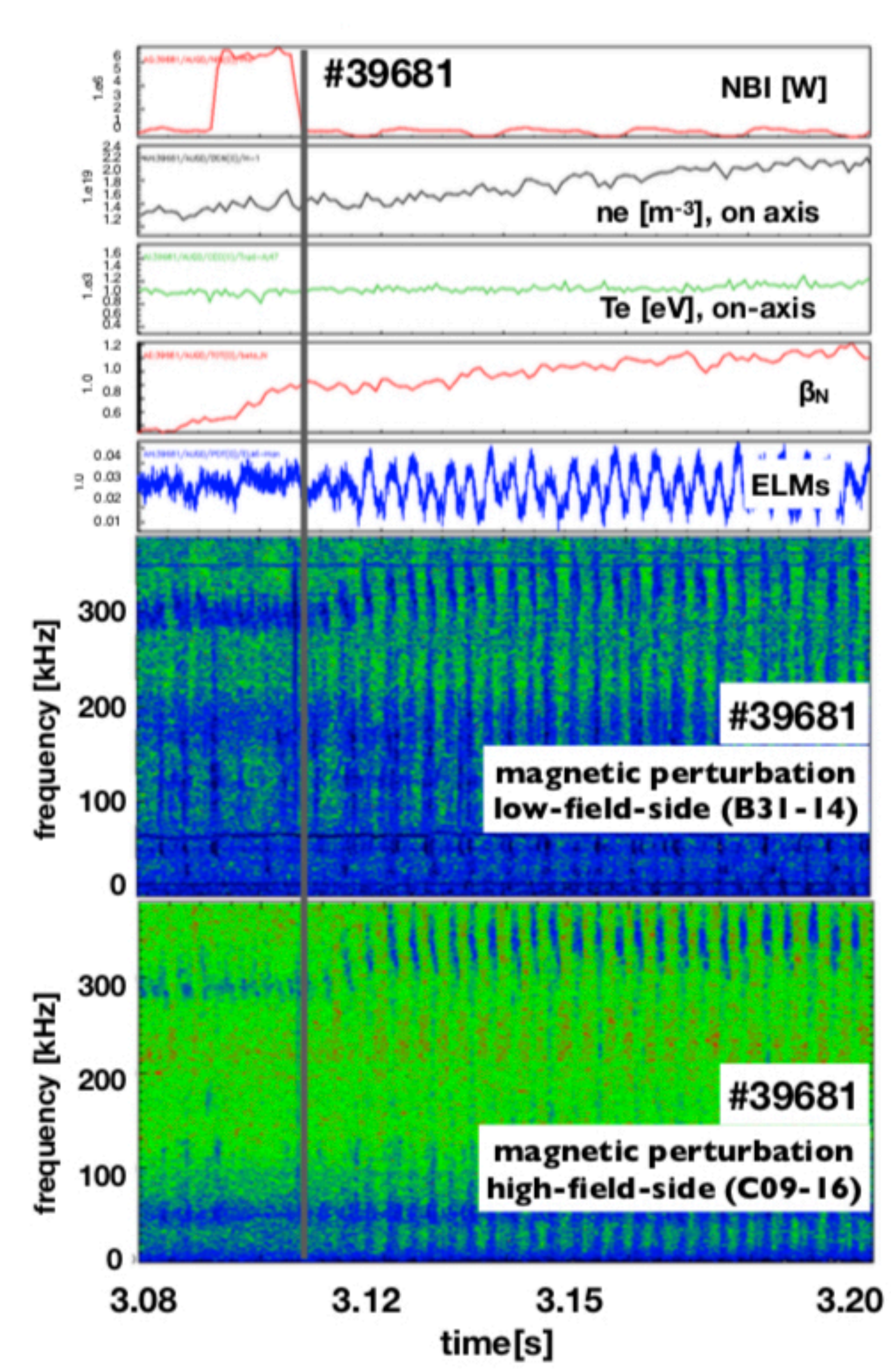
fully automated analysis using EP Stability WF, based on IDA and IMAS

- IDA [7] profiles and equilibria are stored in IDS using Trview [8] on Gateway
- automated EP stability workflow [1,2,6] is used to process co and counter-propagating TAEs
- here: 160 time slices with 5ms resolution: Helena, LIGKA local, global [9]

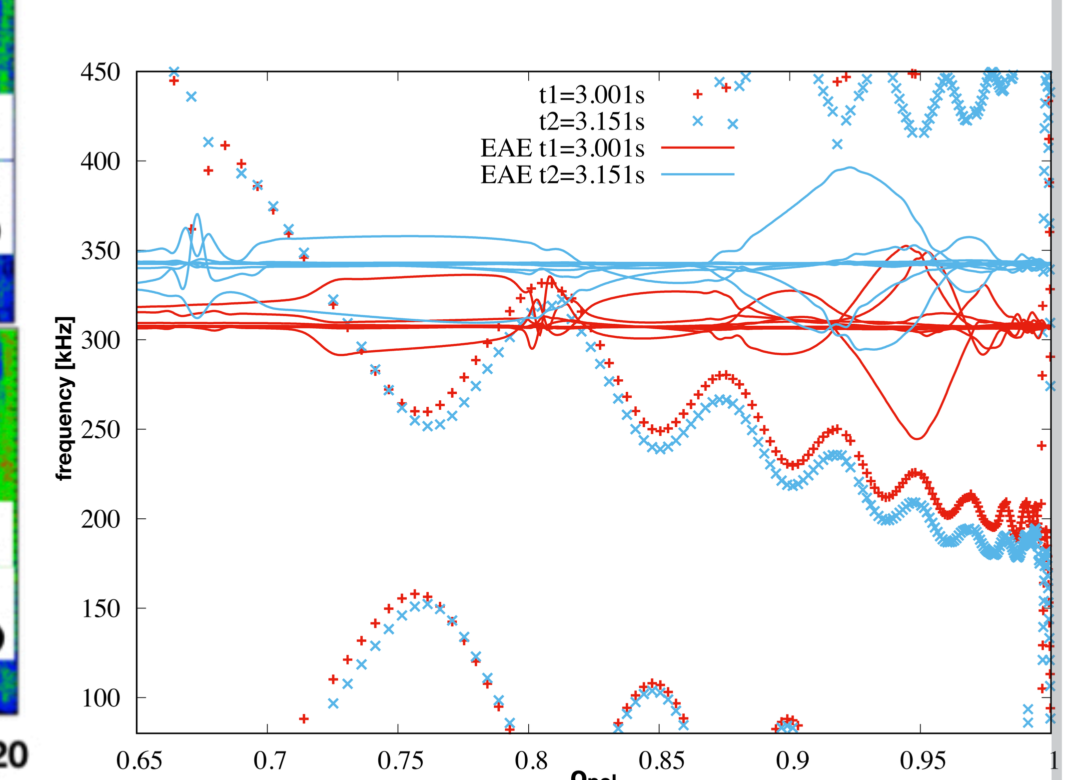


- note: damping rates can jump by 100% within 10 ms - core continuum damping very sensitive to q
- trend from high to low damping during the transition as observed in experiment
- all linear information stored in IDSs, uncertainty analysis based on IDA data possible

constrain nature of n=-2 mode at 300 kHz:



- n=-2 continua do not change significantly during the phase when 300kHz mode jumps to 340 kHz and then disappears
- LIGKA analysis shows that various weakly damped EAEs are present in gap between 250-400kHz
- jump in f seems to correspond to different EAEs at different time points
- since damping properties do not change, the underlying drive mechanisms must change
- change in ballooning structure not observed when comparing EAE mode structures



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