EUROfusion

Active MHD spectroscopy with the upgraded JET Alfven Eigenmode Active Diagnostic

RA Tinguely, et al

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JET PSFC EPFL cea INFLPR ipfn INSTITUTO DE PLASMAS E FUSÃO NUCLEAR CCFE CULHAM CENTRE FOR FUSION ENERGY OAK RIDGE National Laboratory Laboratorio Nacional de Fusión Ciemat IFPiLM

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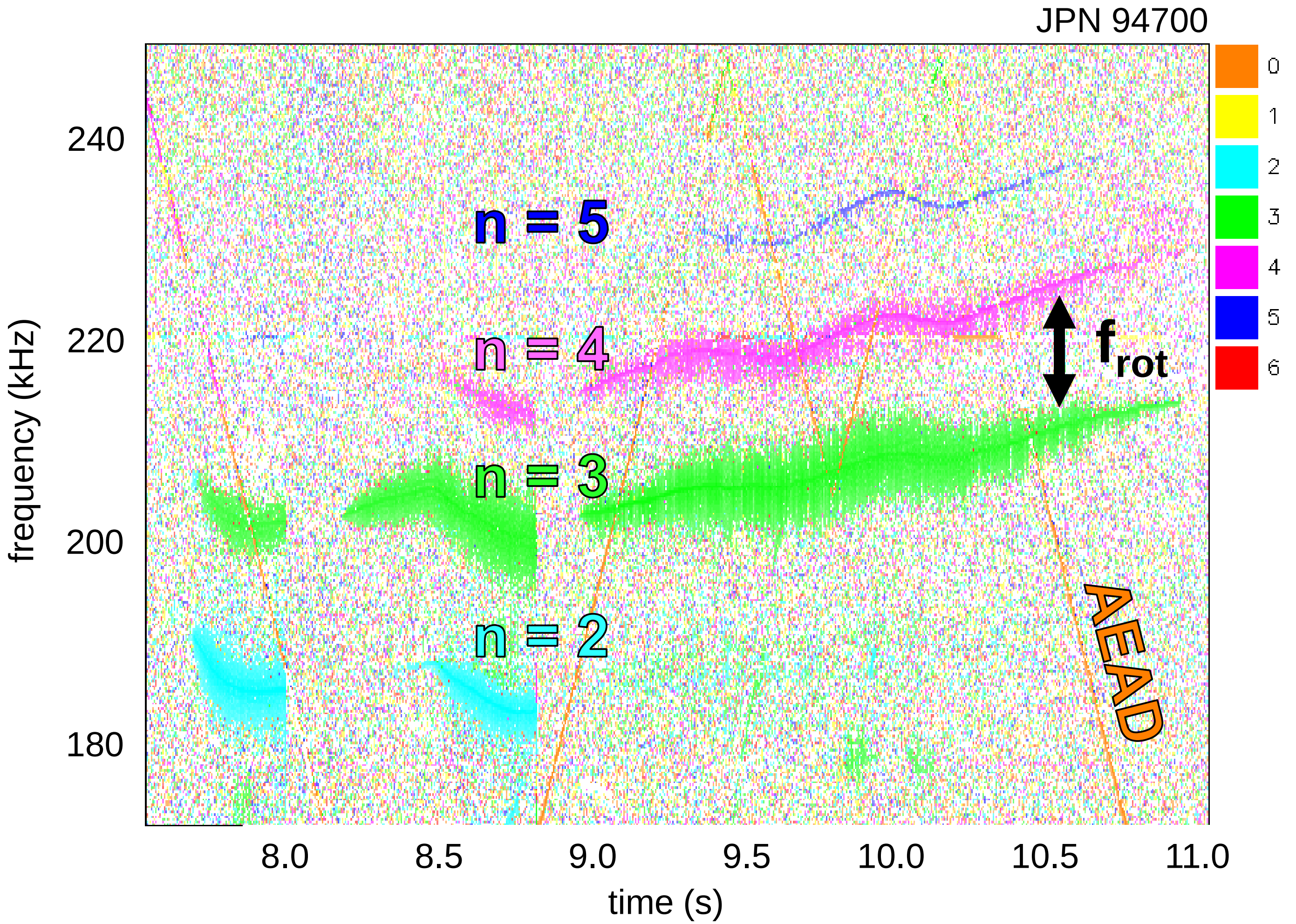
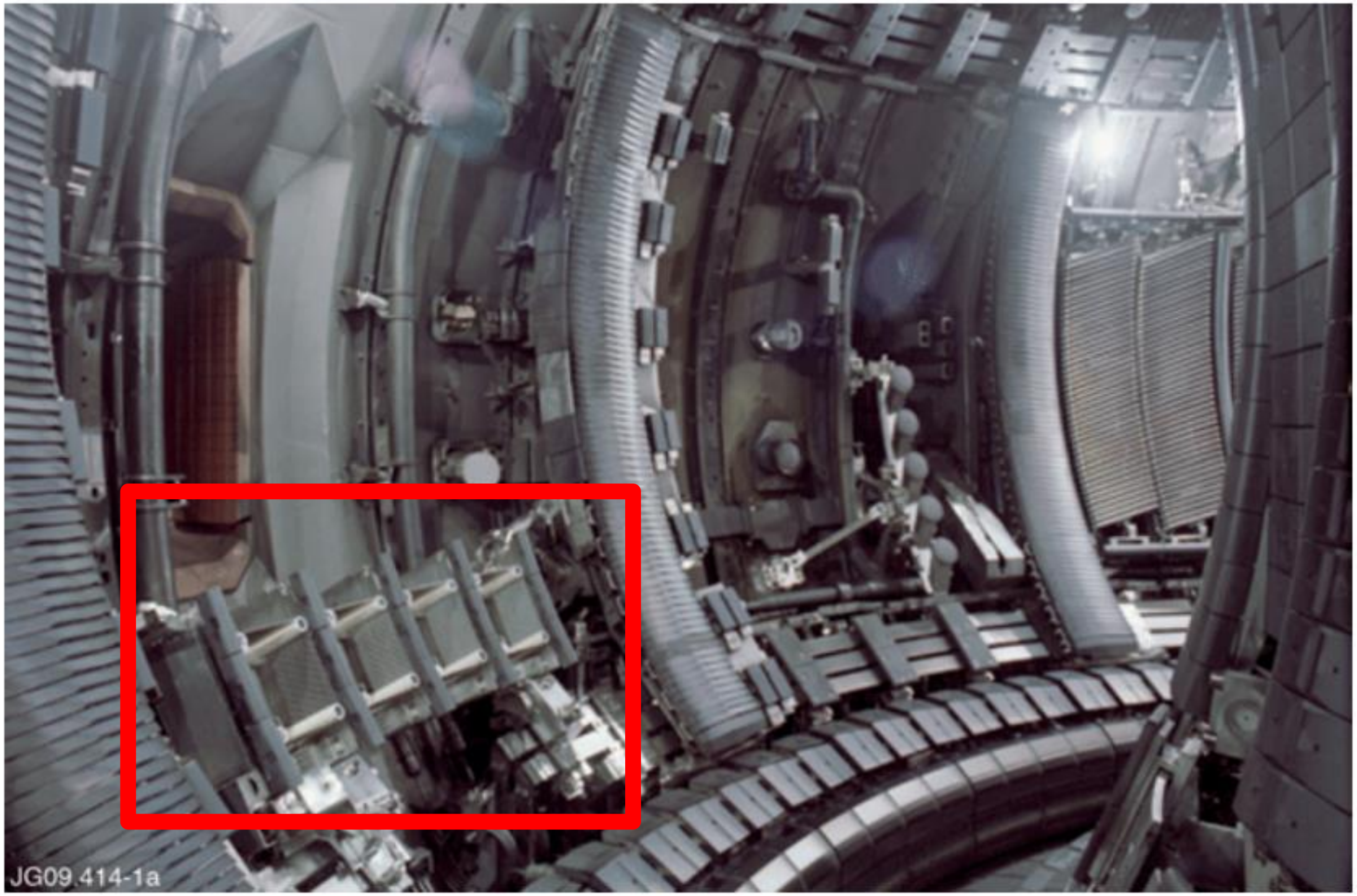
(Passive) MHD Spectroscopy uses *destabilized* modes to infer q_{min}, f_{rot}, and more

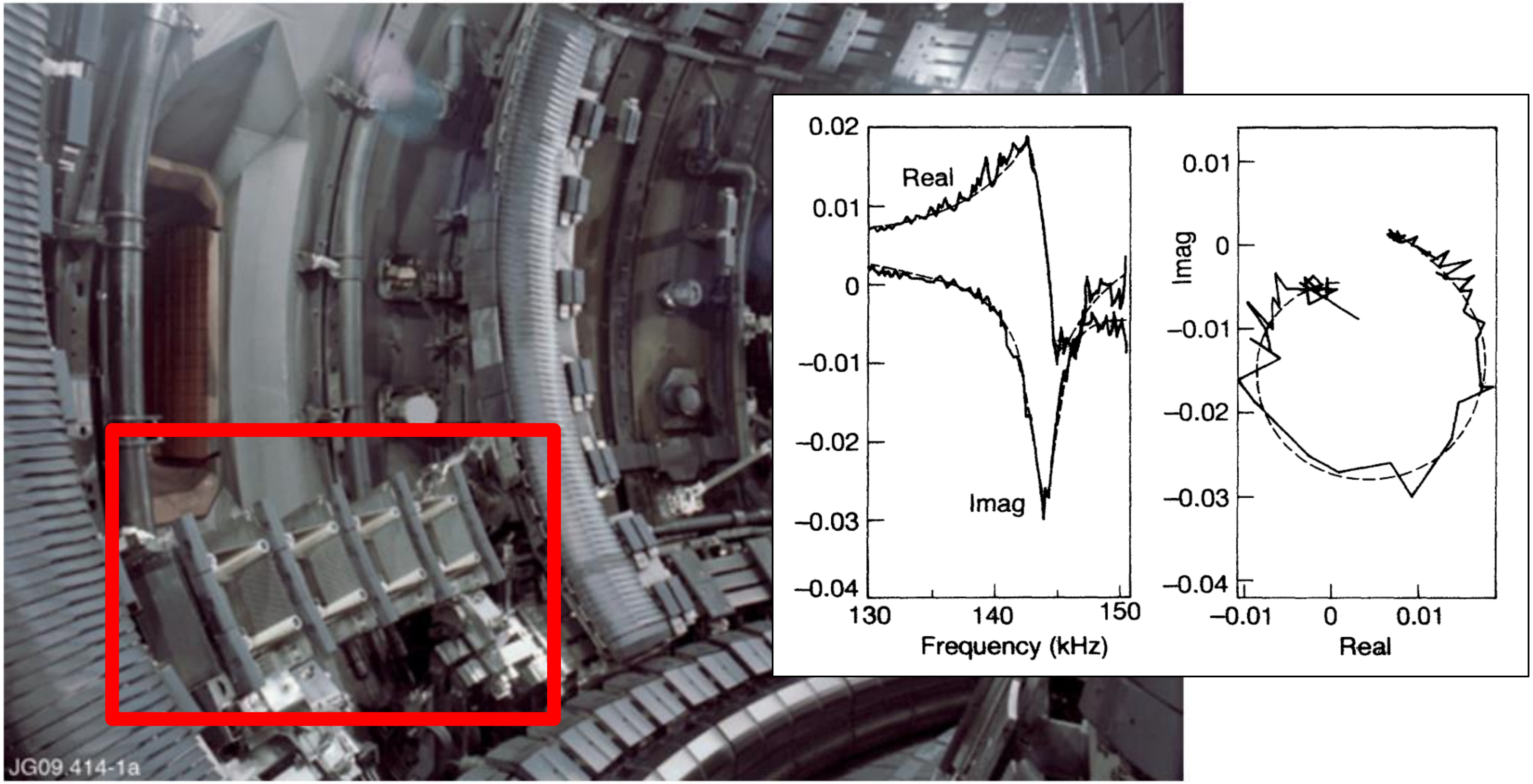


AE Active Diagnostic (AEAD) actively probes *stable* AEs with f = 25-330 kHz, |n| < 20



T Panis 2010 Nucl. Fusion 50
P Puglia 2016 Nucl. Fusion 56

AE Active Diagnostic (AEAD) actively probes *stable* AEs with f = 25-330 kHz, |n| < 20

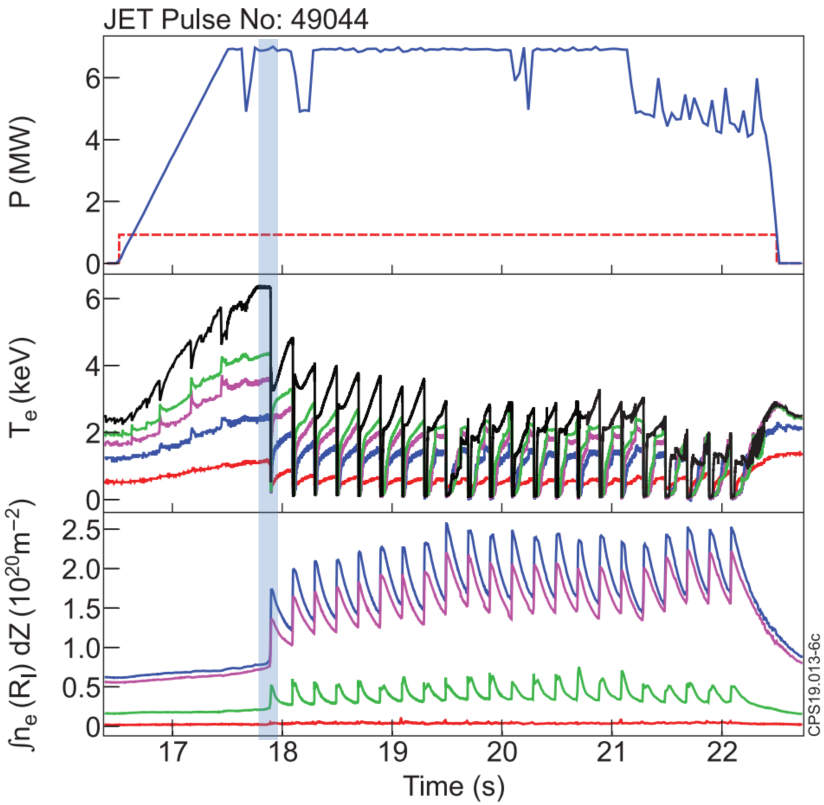


T Panis 2010 Nucl. Fusion 50
P Puglia 2016 Nucl. Fusion 56

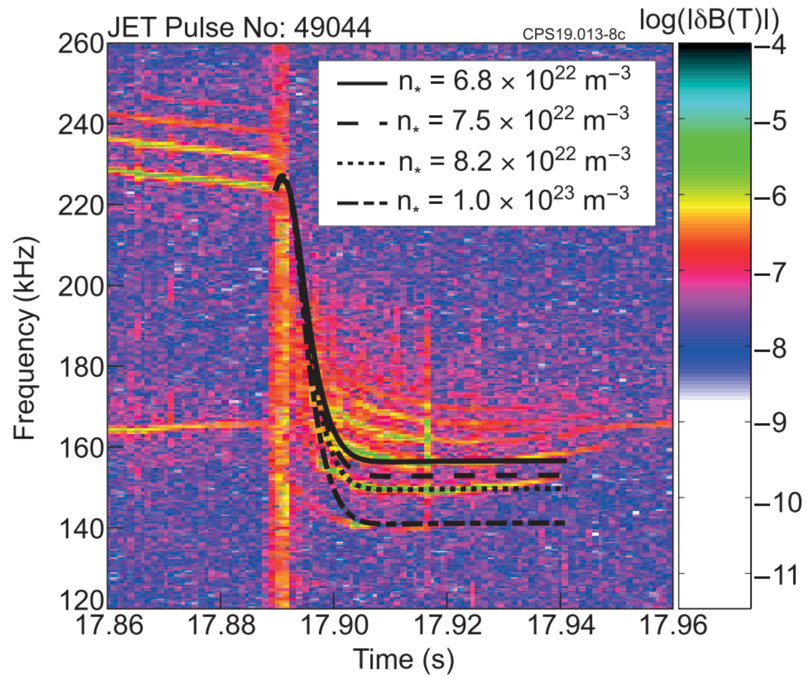
A Fasoli 1995 Phys. Rev. Lett. 75

Pellet fueling

(Passive) MHD Spectroscopy uses destabilized modes to infer pellet fueling



$$f_{AE} \propto \frac{B}{\sqrt{\mu_0 \sum m_i n_i}}$$



S.E. Sharapov 2018 Nucl. Fusion 58
H.J.C. Oliver 2019 Nucl. Fusion 59

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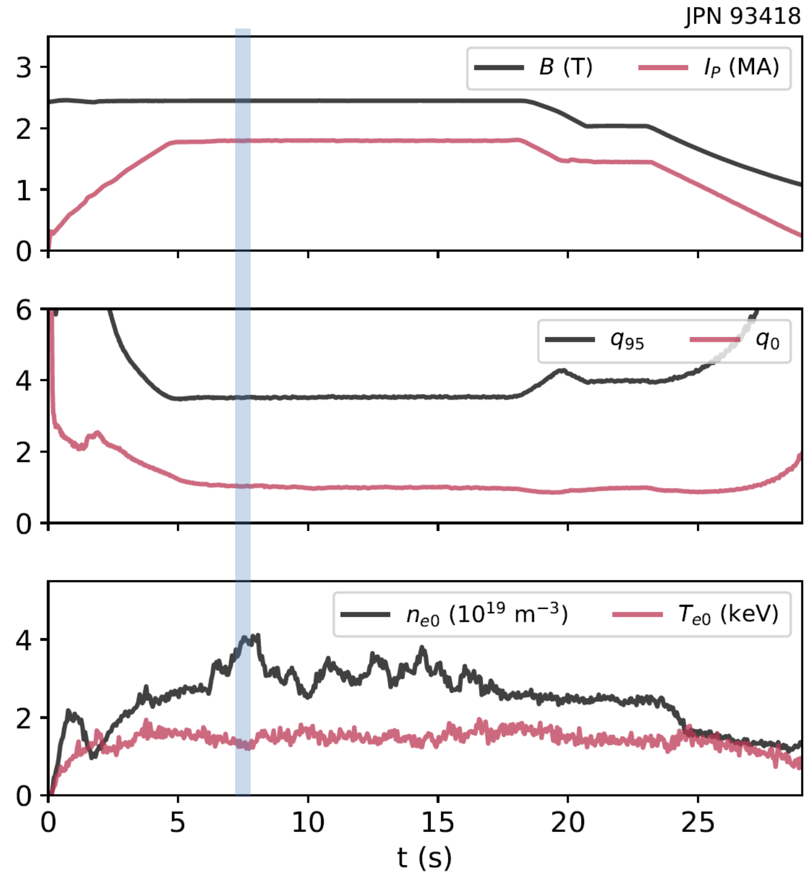
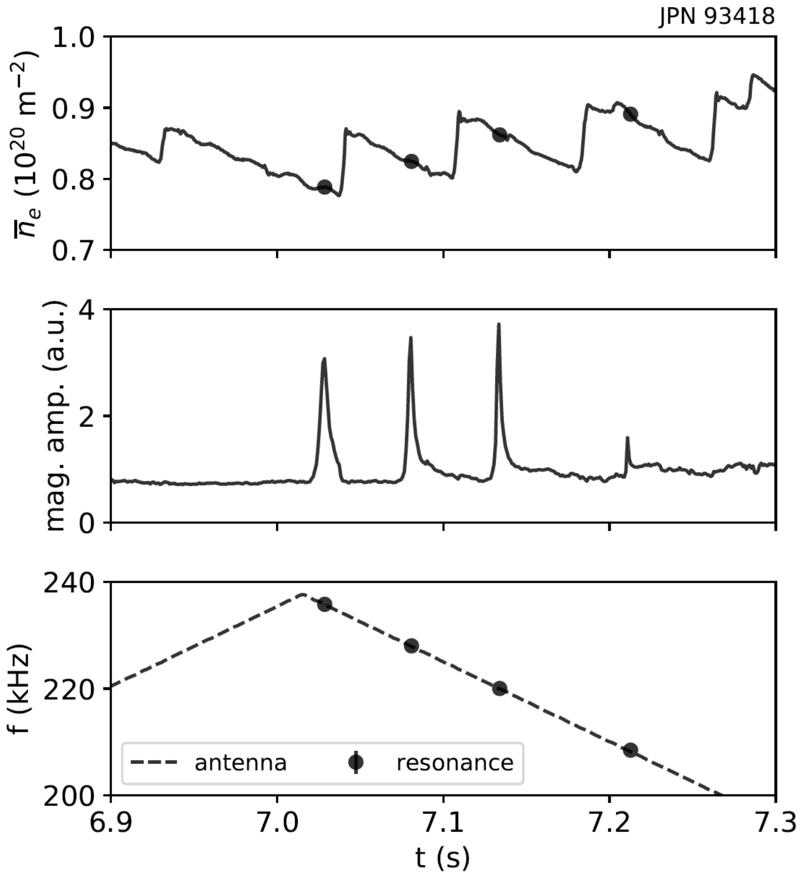
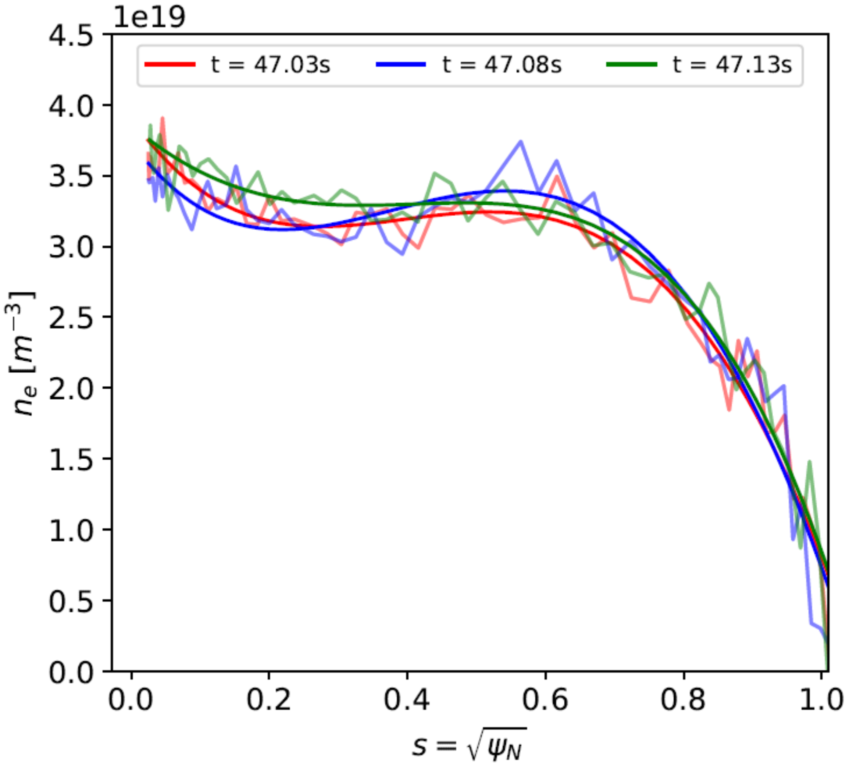
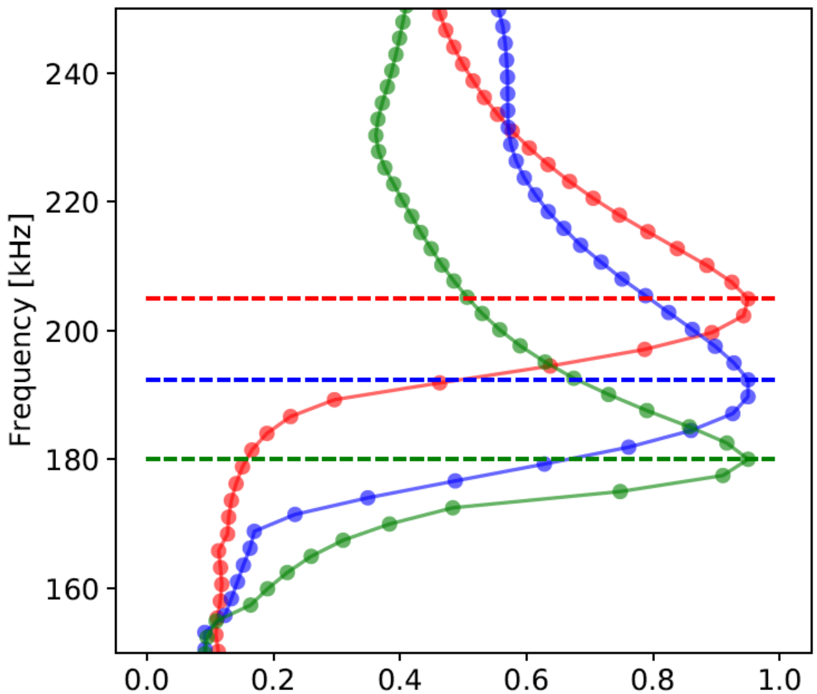
AEAD "sees" pellet injections via decreasing resonant frequency





CASTOR-antenna modeling agrees with experimental measurements





antenna power coupled to mode (a.u.)

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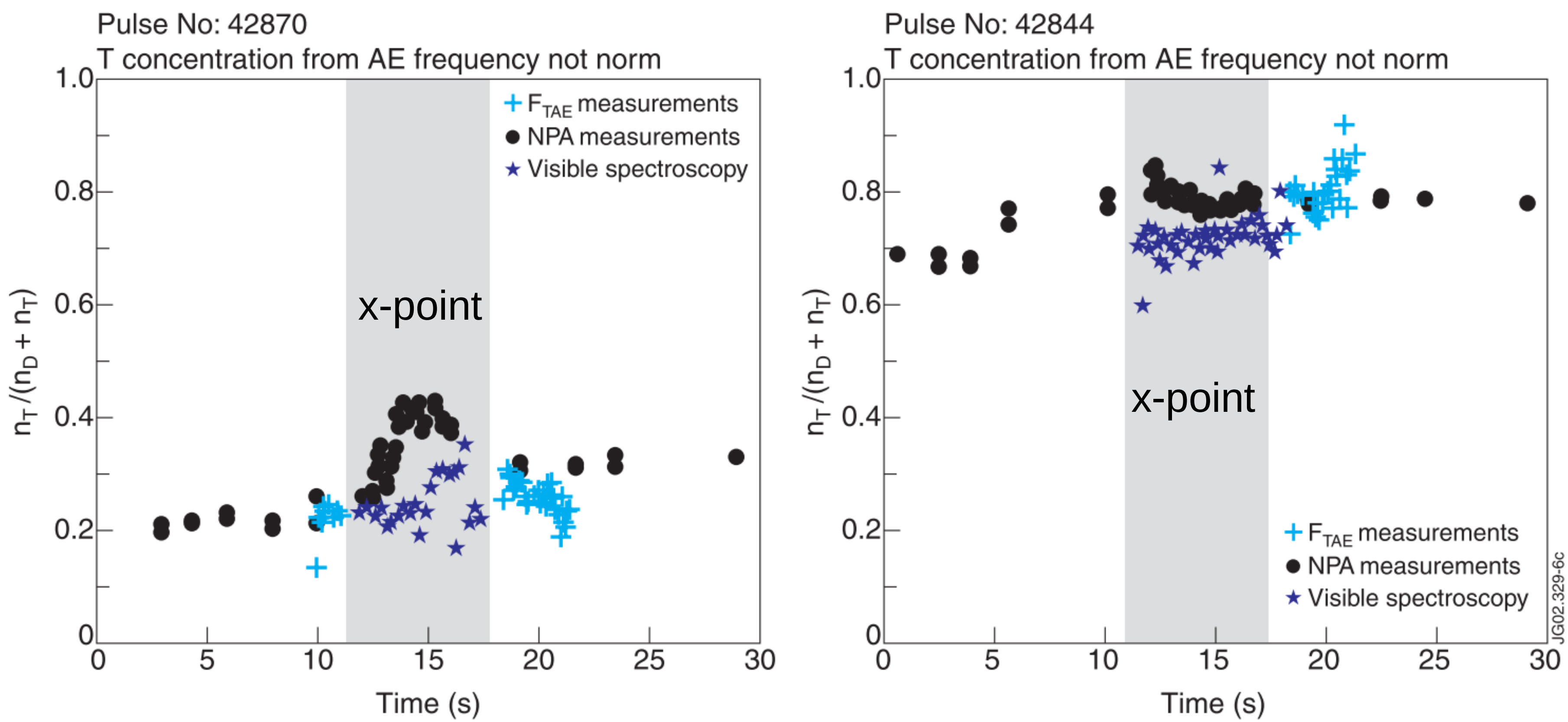
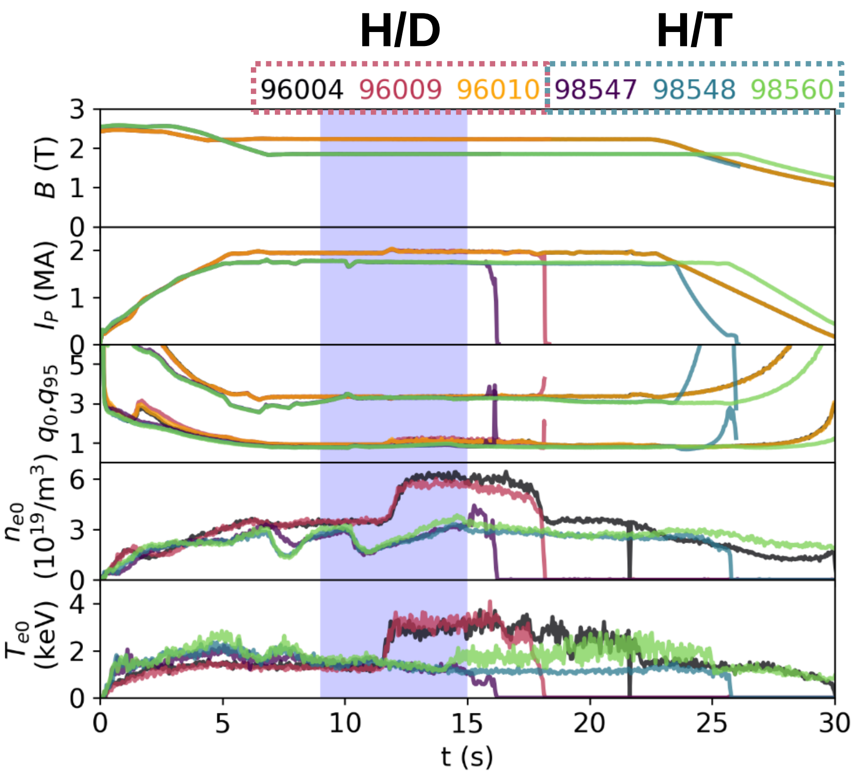
Isotope ratio

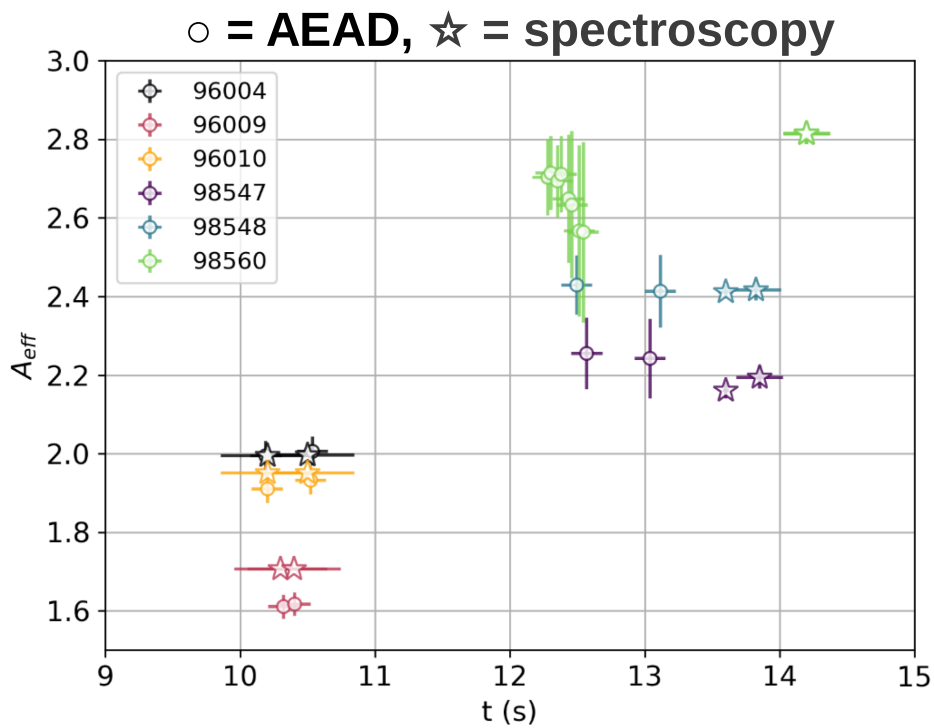
Pre-upgrade AEAD could assess D/T ratio in limiter configuration



A Fasoli 2002 PPCF 44
D Testa 2015 Nucl. Fusion 55

AEAD measures H/D and H/T ratios before the 2021 DT campaign

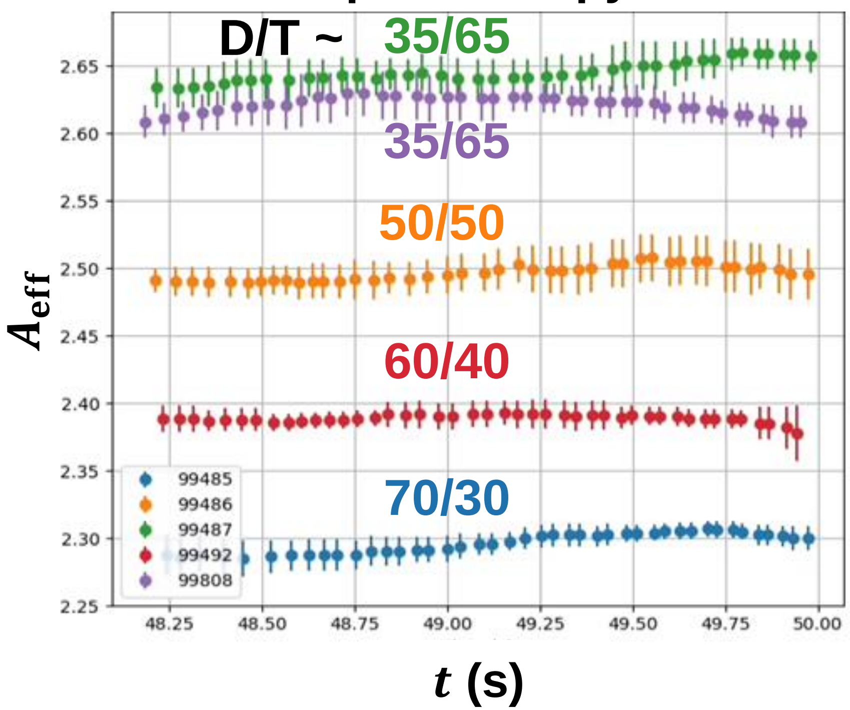




RA Tinguely 2021 EPS

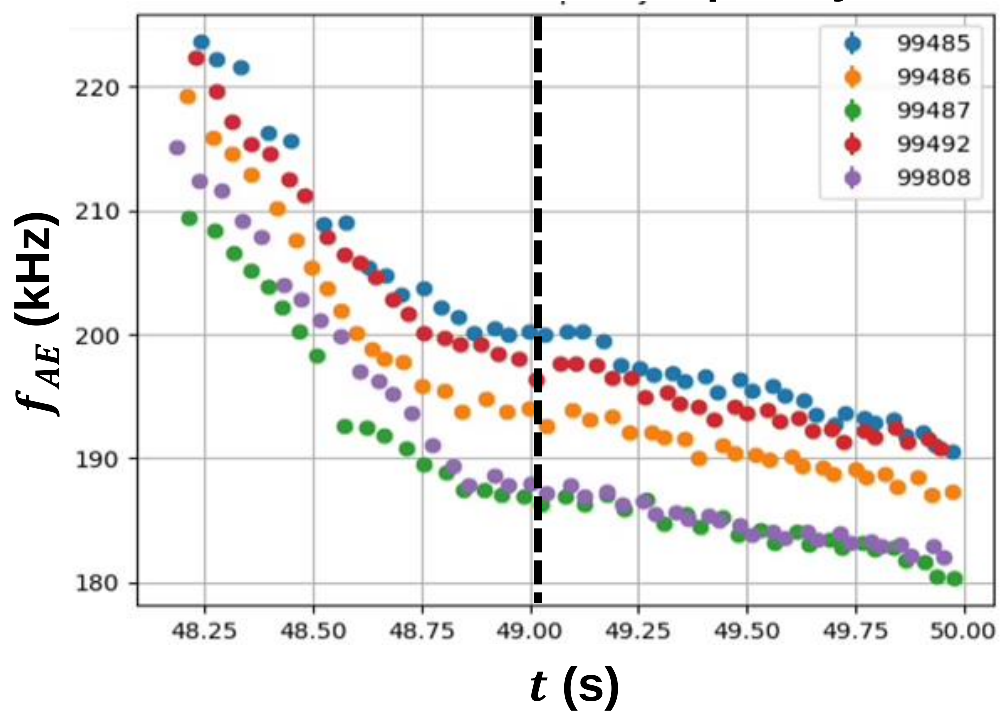
AEAD also measures D/T ratio in the 2021 DT campaign

spectroscopy



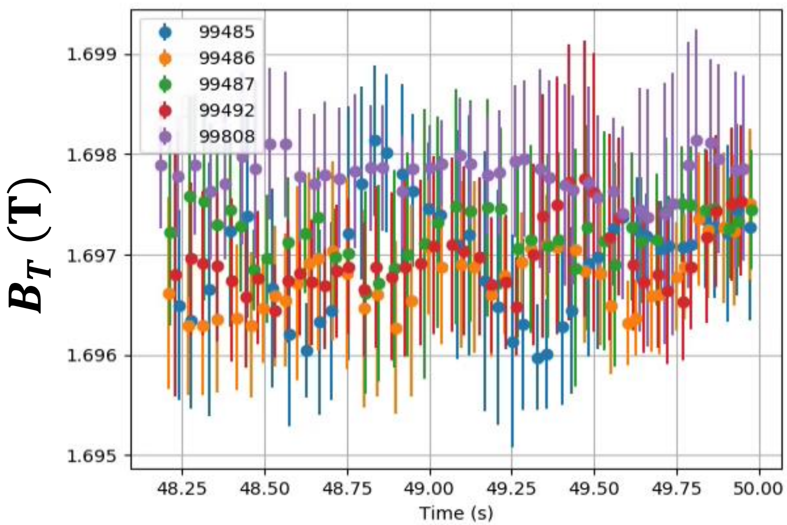
$$A_{\text{eff}} = \sum_i A_i n_i / n_e$$

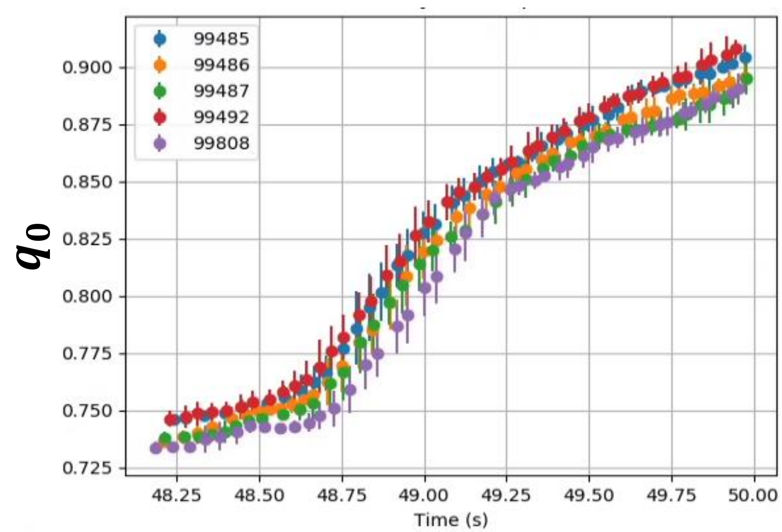
AEAD resonant frequency

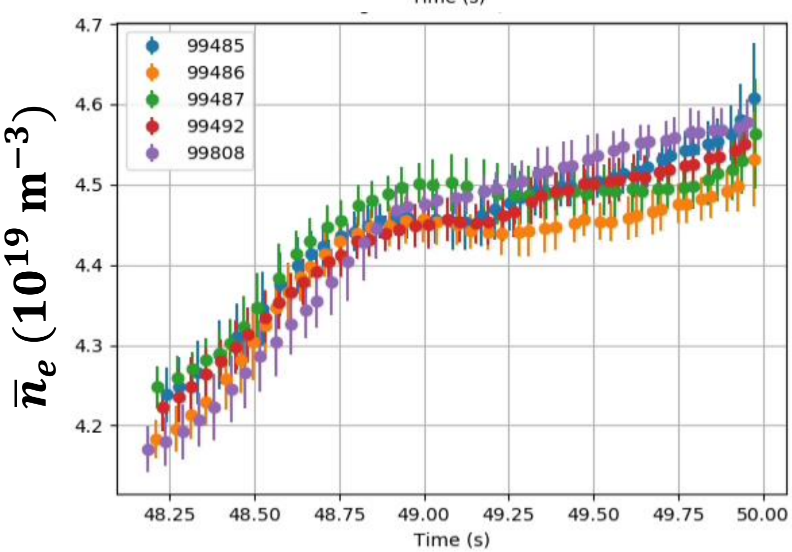


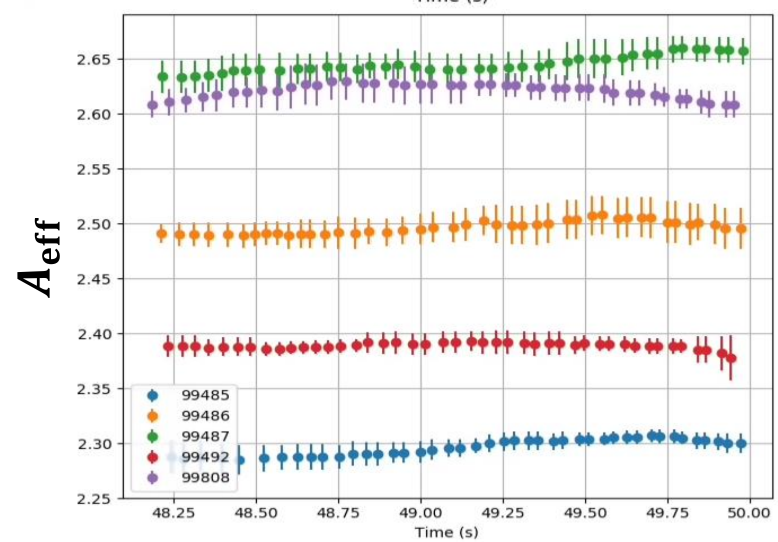
$$f_{AE} \propto \frac{1}{qR} \frac{B}{\sqrt{\mu_0 \sum m_i n_i}}$$

The change in Alfven frequency is dominantly due to the D/T ratio



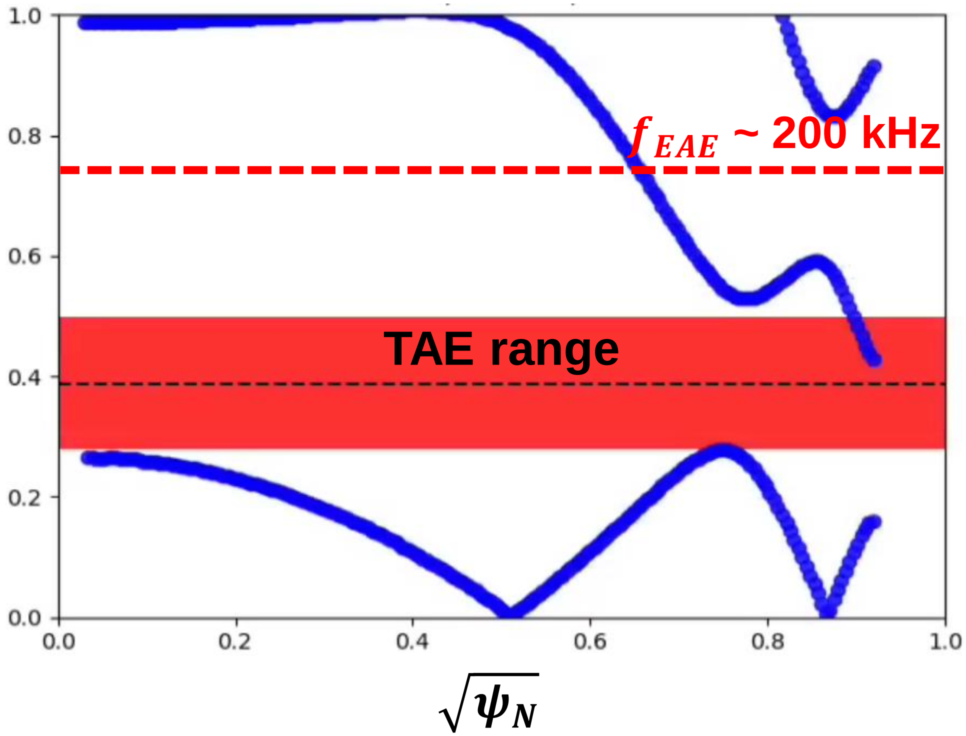




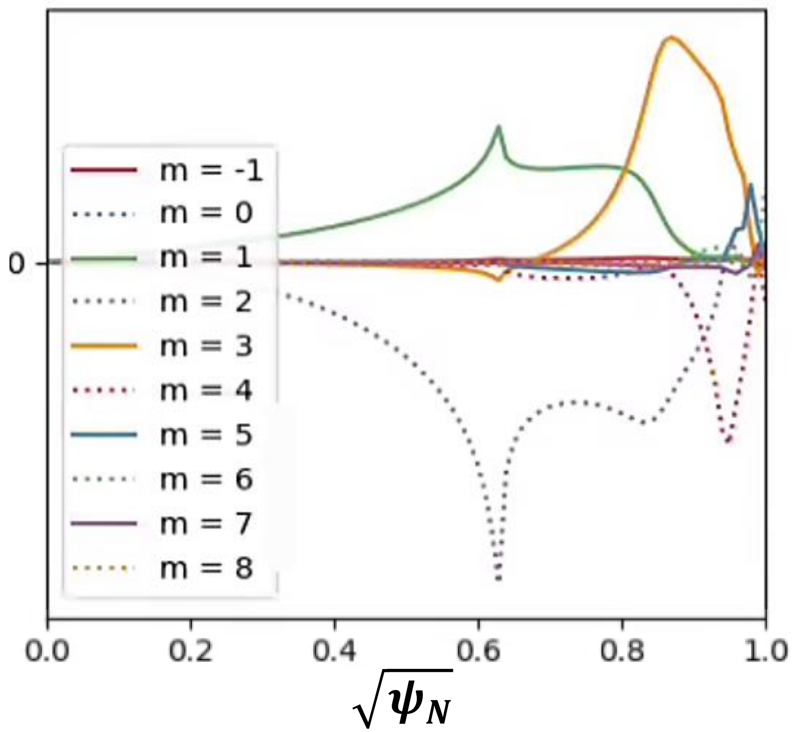


HELENA + CSCAS + MISHKA identifies edge-localized n = 1 EAEs for all pulses

Alfven continuum, n = 1



poloidal mode structure



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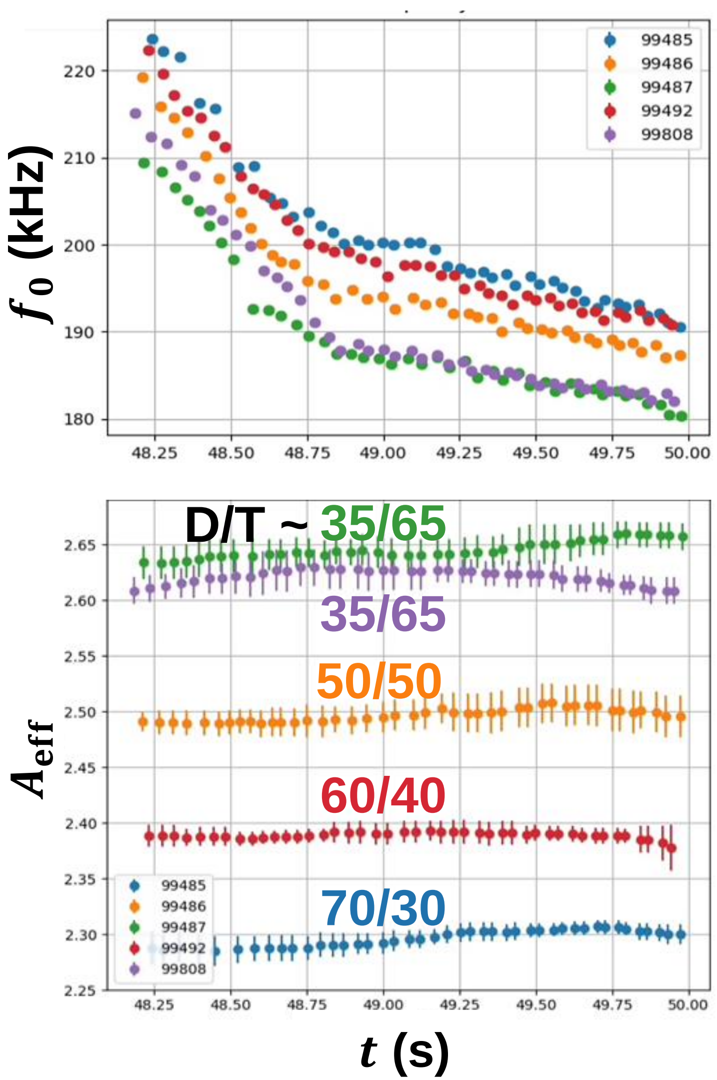
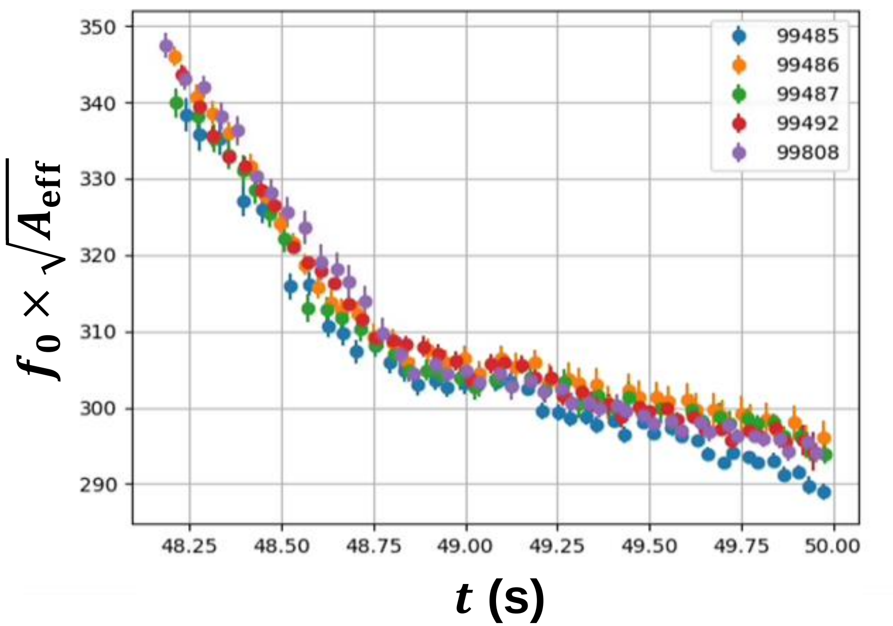
AEAD complements and confirms D/T ratio measurement



$$f_0 \propto \frac{1}{\sqrt{A_{\mathrm{eff}}}} \qquad A_{\mathrm{eff}} = \sum_i A_i n_i / n_e$$



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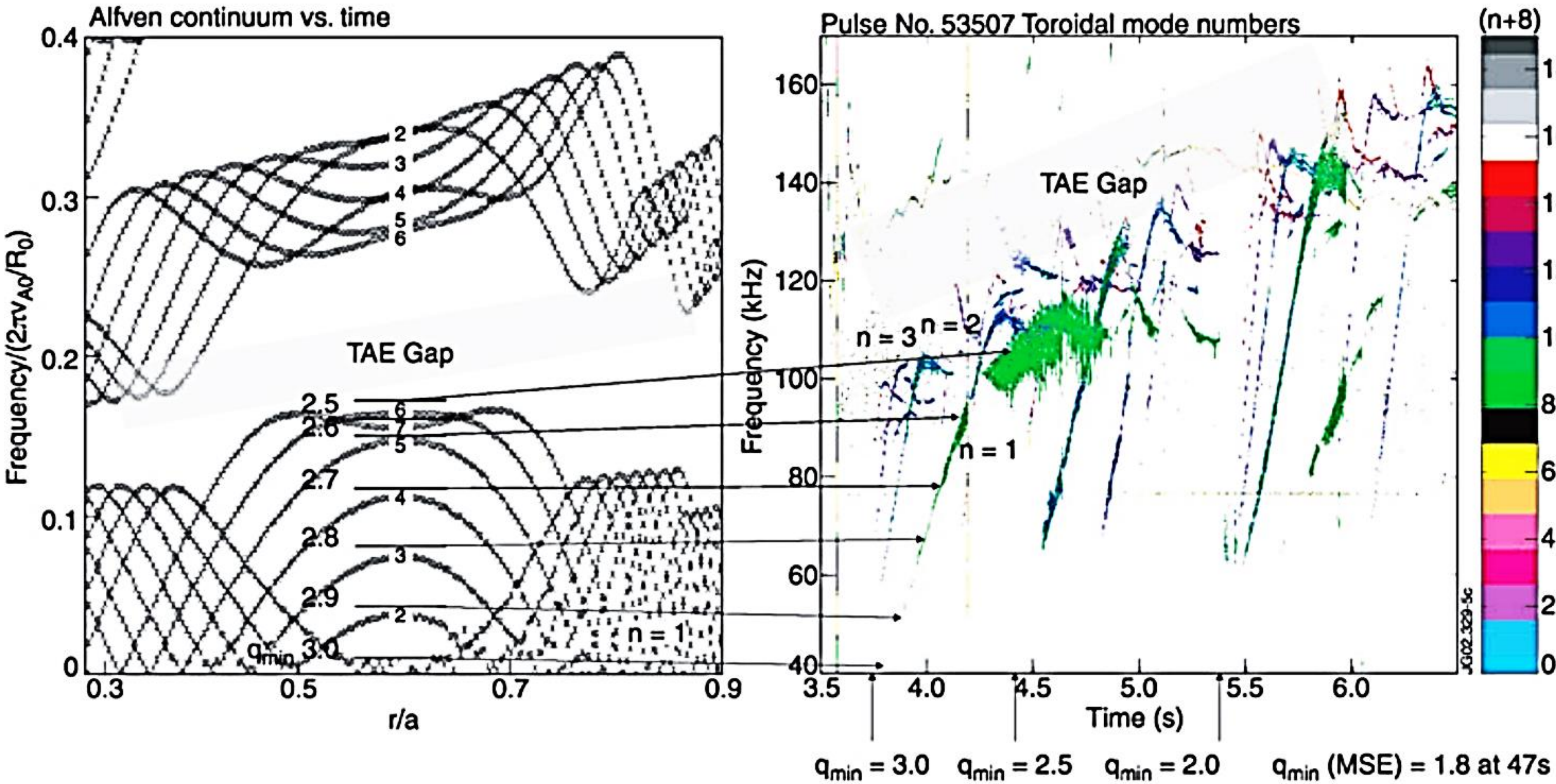
Summary

- MHD spectroscopy can provide complementary measurements of many plasma parameters
- *Active* MHD spectroscopy is needed when MHD is *not* destabilized
- Pellet fueling can be monitored by the changing resonant frequency of stable Alfven Eigenmodes
- Isotope ratio can be assessed when other plasma parameters are constant
- The JET AEAD often probes edge-localized AEs… but future systems could push to the core

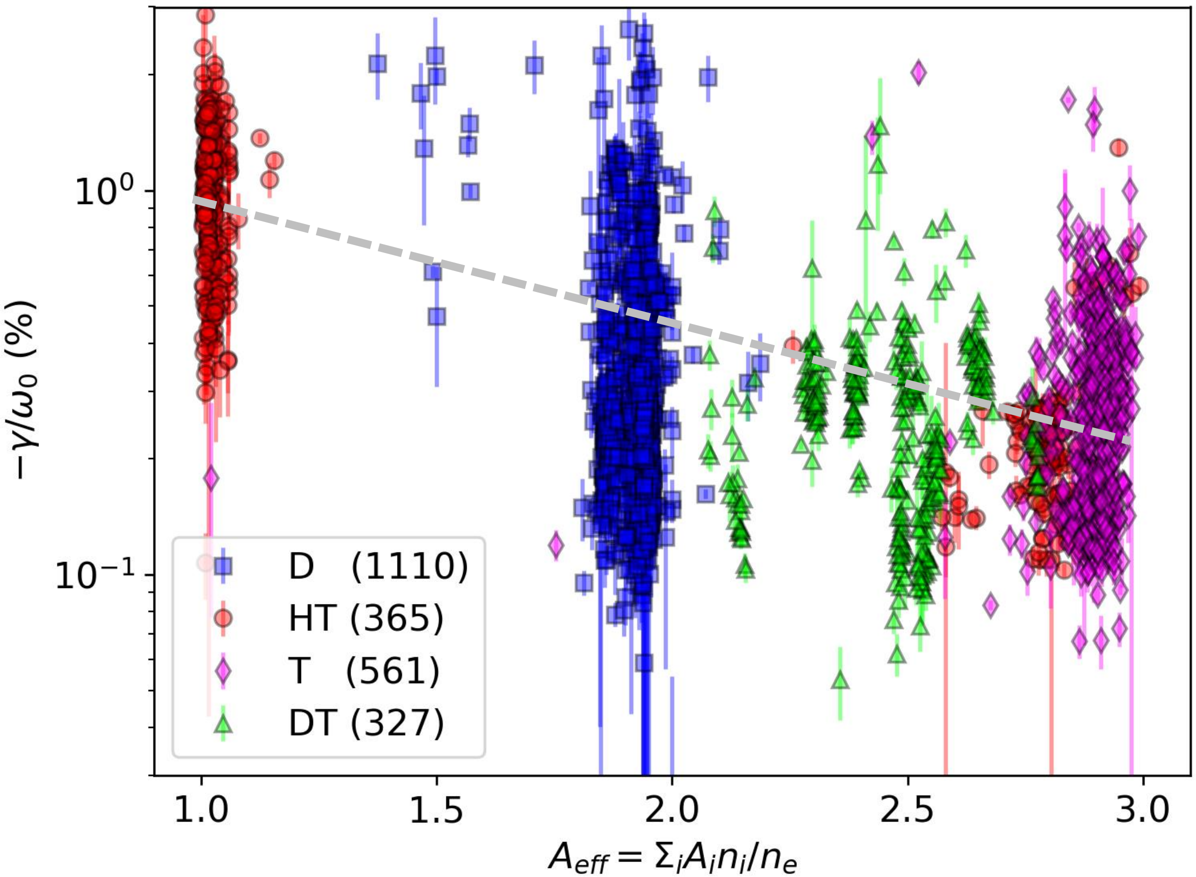
Bonus slides

(Passive) MHD Spectroscopy uses *destabilized* modes to infer q_{min}, f_{rot}, …



A Fasoli 2002 PPCF 44

Damping decreases with effective mass → possible mode conversion to kinetic Alfvén waves



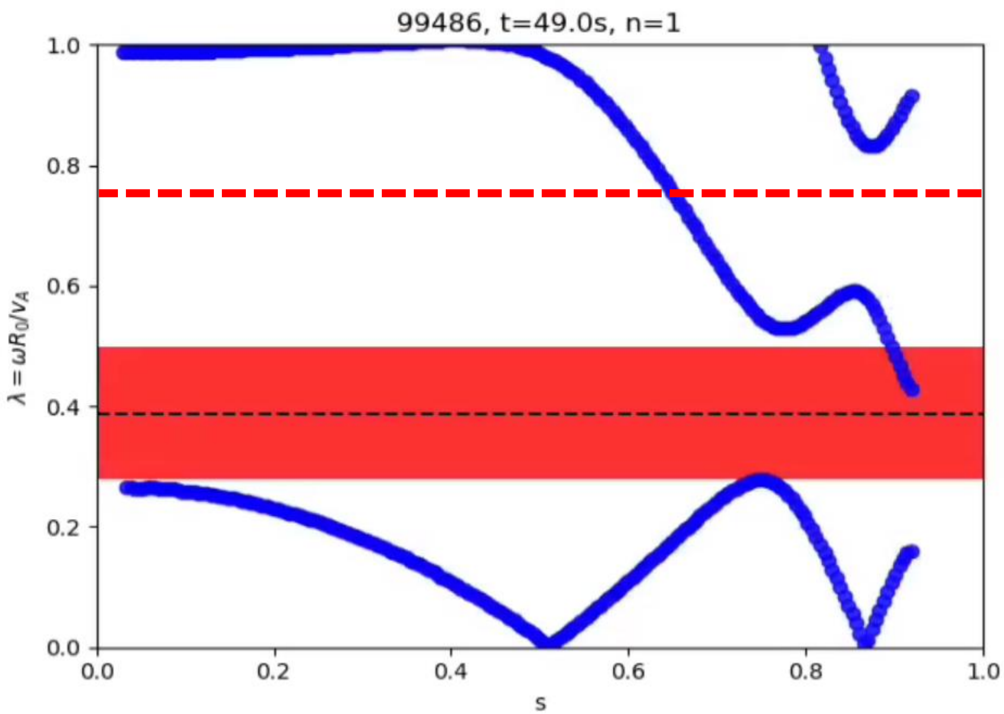
B_0	$\in$ [1,2.5] T
I_P	$\in$ [1,3] MA
P_{ICRH}	$\leq$ 1 MW
P_{NBI}	$\leq$ 1 MW

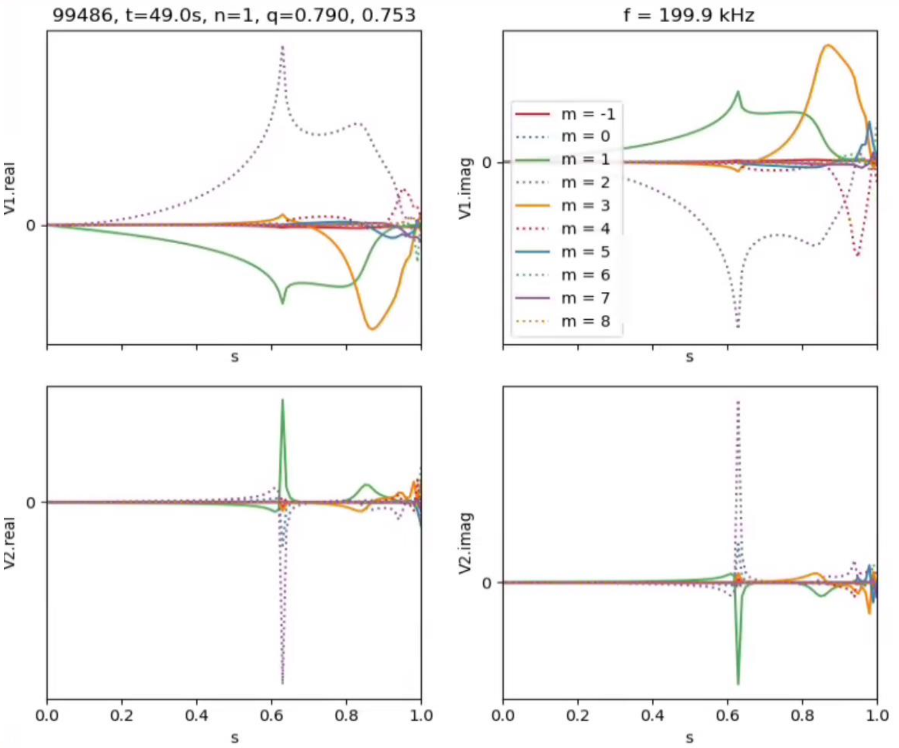
A Fasoli 2000 Phys. Lett. A 265
D Testa 2012 Nucl. Fusion 52
RA Tinguely 2021 EPS P4.1001

Abstract

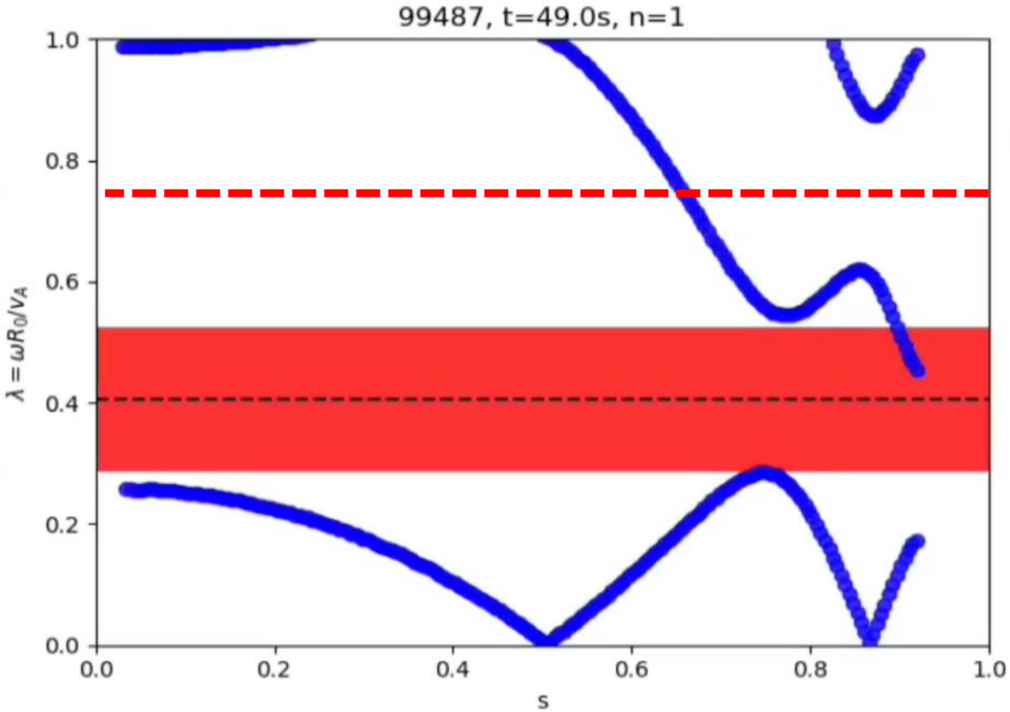
In this talk, we present two examples of active MHD spectroscopy achieved with JET's upgraded Alfven Eigenmode Active Diagnostic (AEAD), which resonantly excites stable AEs. First, the isotope ratio is estimated for a series of plasmas with different Hydrogen, Deuterium, and Tritium concentrations, and good agreement is found with neutral gas analysis, especially in DT. Second, the increasing density from pellet injection is monitored via the changing stable AE frequency and compared with MHD codes, showing good agreement. Such an active antenna system could be used as a complementary diagnostic in future tokamaks during quiescent periods when MHD is not destabilized.

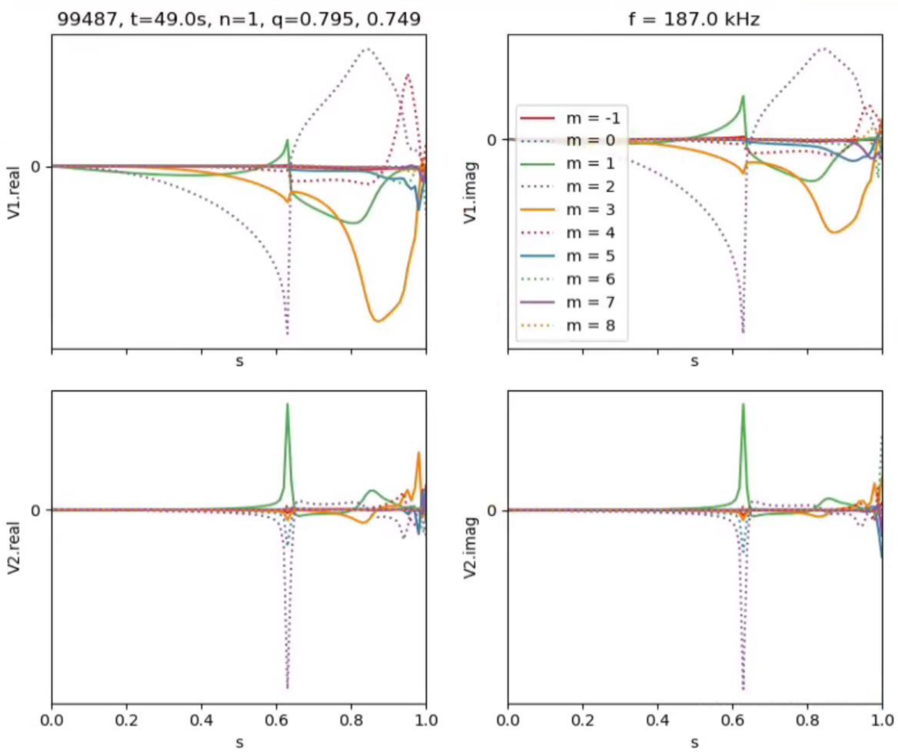
Edge localized n=1 EAE, JPN 99486



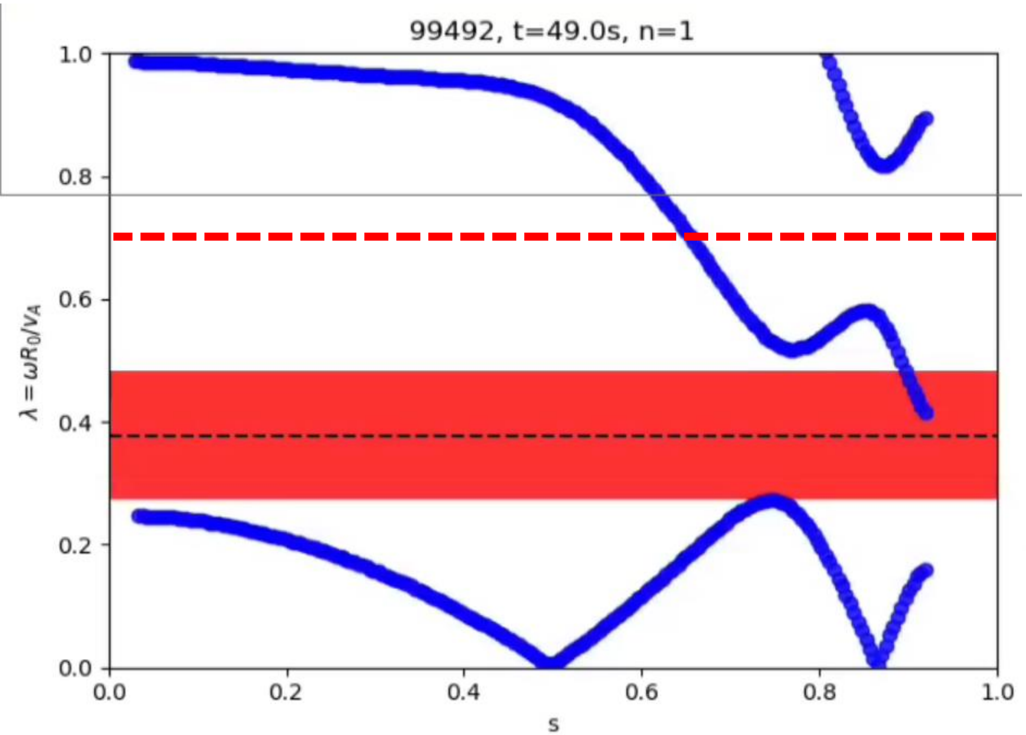


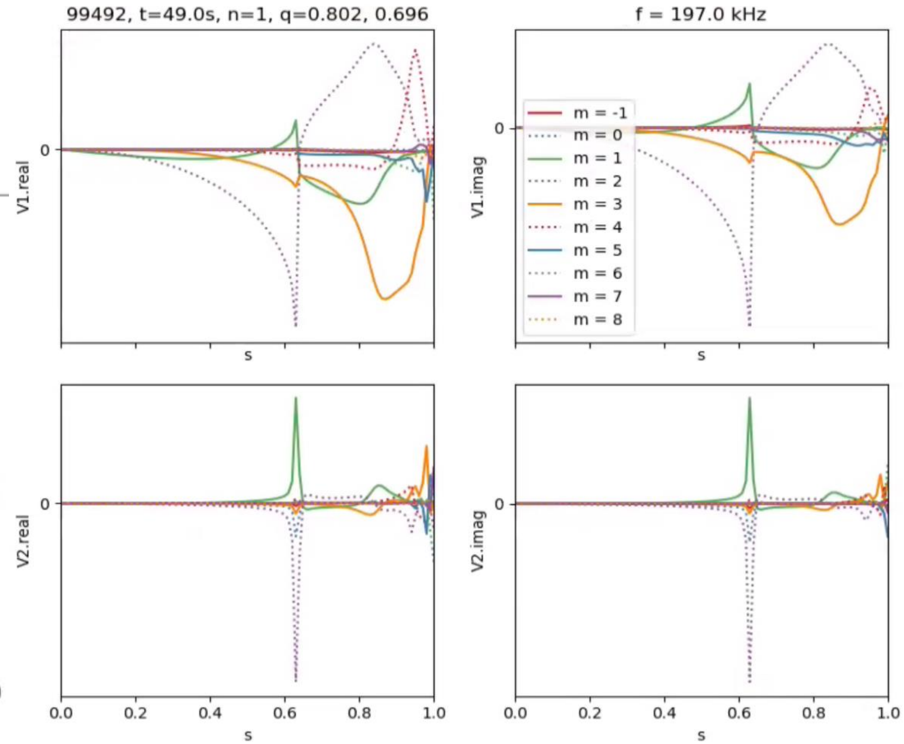
Edge localized n=1 EAE, JPN 99487



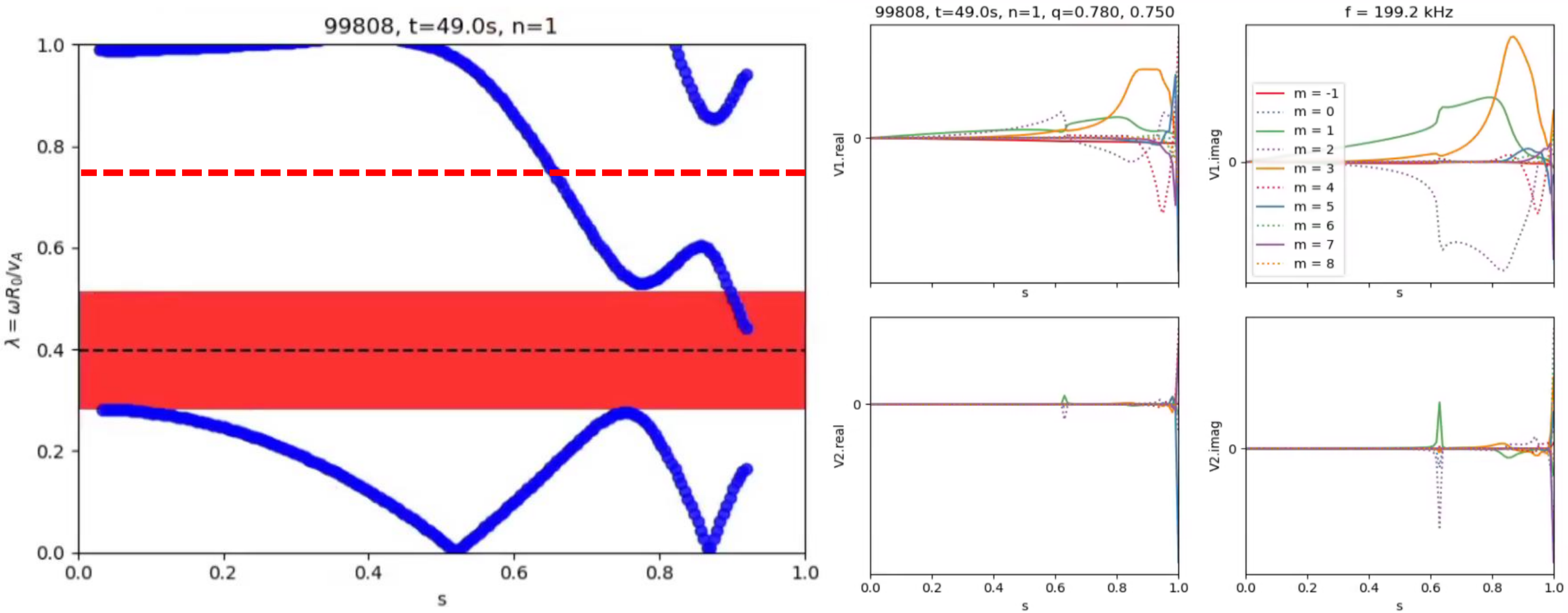


Edge localized n=1 EAE, JPN 99492





Edge localized n=1 EAE, JPN 99808



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