ELM Precursors in NSTX

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PRINCETON PLASMA PHYSICS LABORATORY

Abstract

The evolution of ELM magnetic precursors in a series of NSTX discharges without and with lithium and with increasing lithium deposition [1,2] are examined. Data from the high-n Mirnov array were used to estimate the toroidal mode number (n) of the precursors. ELMs were observed to have n=1 and/or n=2 magnetic precursors with some delayed modes in the range from n=2 to n=6, which persist as the lithium coating is increased and ELMs become partially suppressed. The D-alpha signal of a few ELMs is preceded by a slow growing plateau period which appear to be dominated by n=2 to n=6 modes, however, n=1 and/or n=2 modes appear as precursors to the main ELM peak. The observed n=1 precursors may be evidence of SOL currents in NSTX, similar to those observed in DIII-D [3].

[1] R. Maingi, et al., 36th Eur. Phys. Conf. on Plasma Physics, P2.175

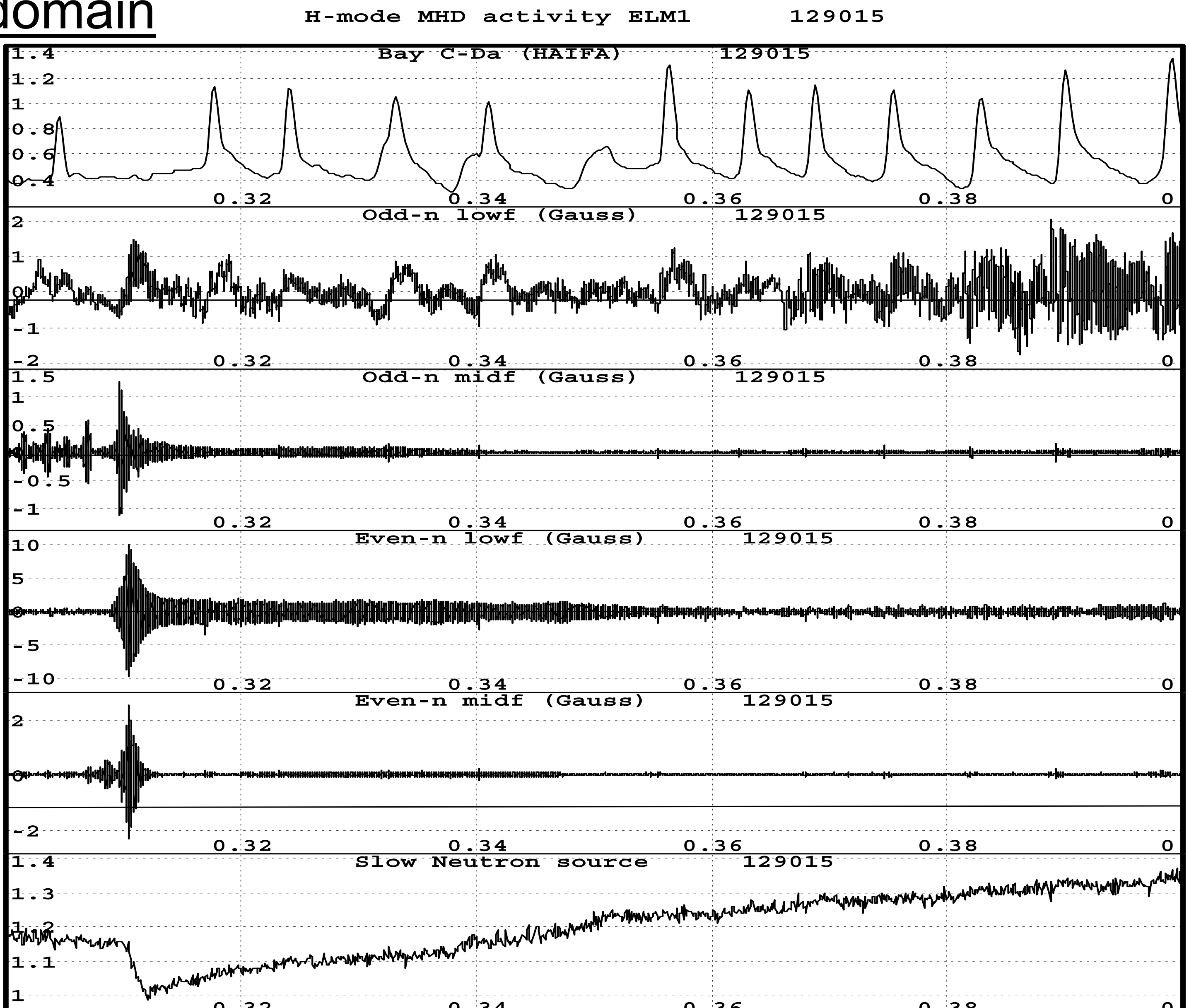
[2] R. Maingi, et al., Phys. Rev. Lett. (2009) at press.

[3] H. Takahashi, et al., Nucl. Fusion 44 (2004) 1075.

NSTX 129015 - without lithium

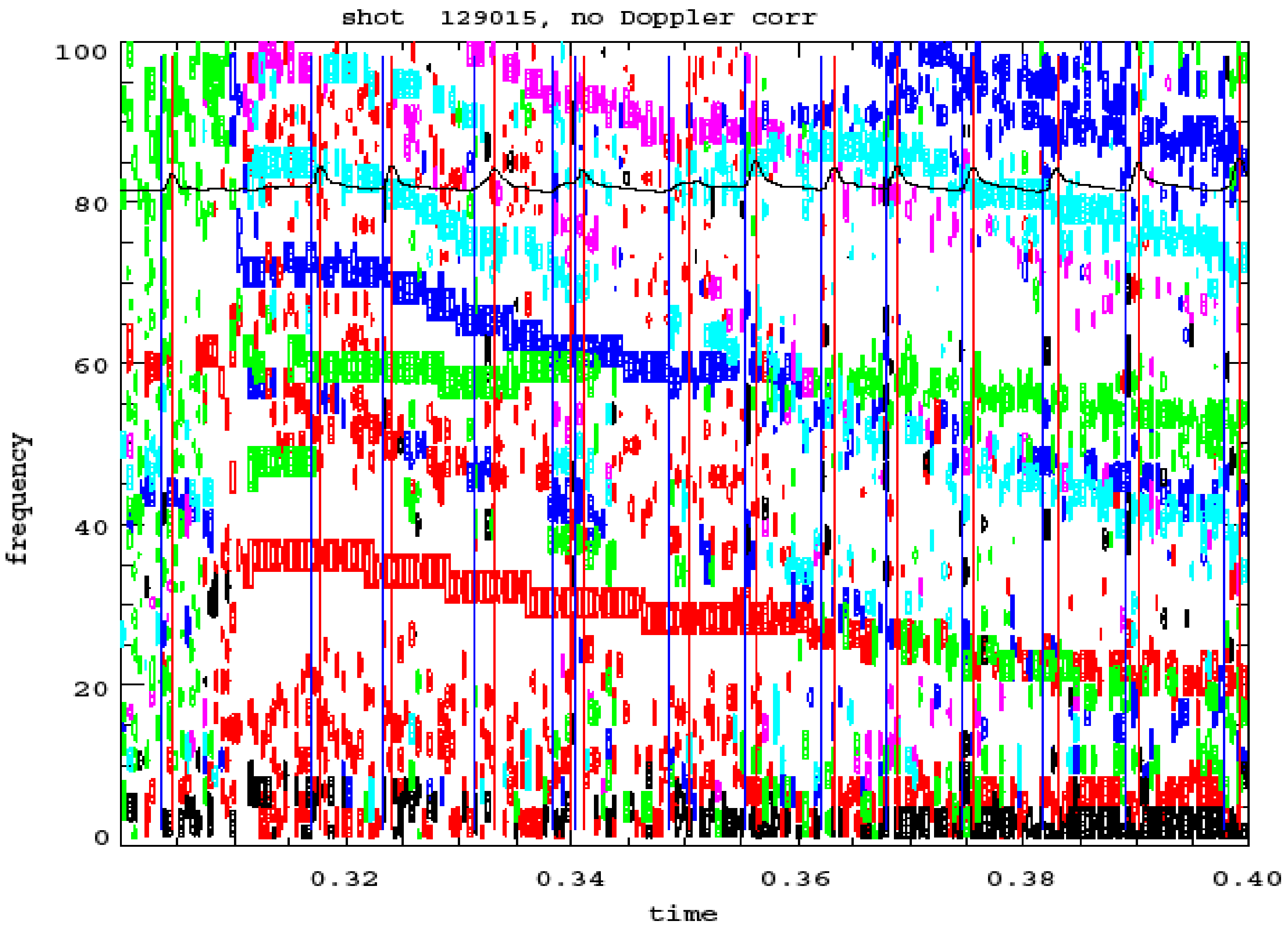
NSTX

Time domain

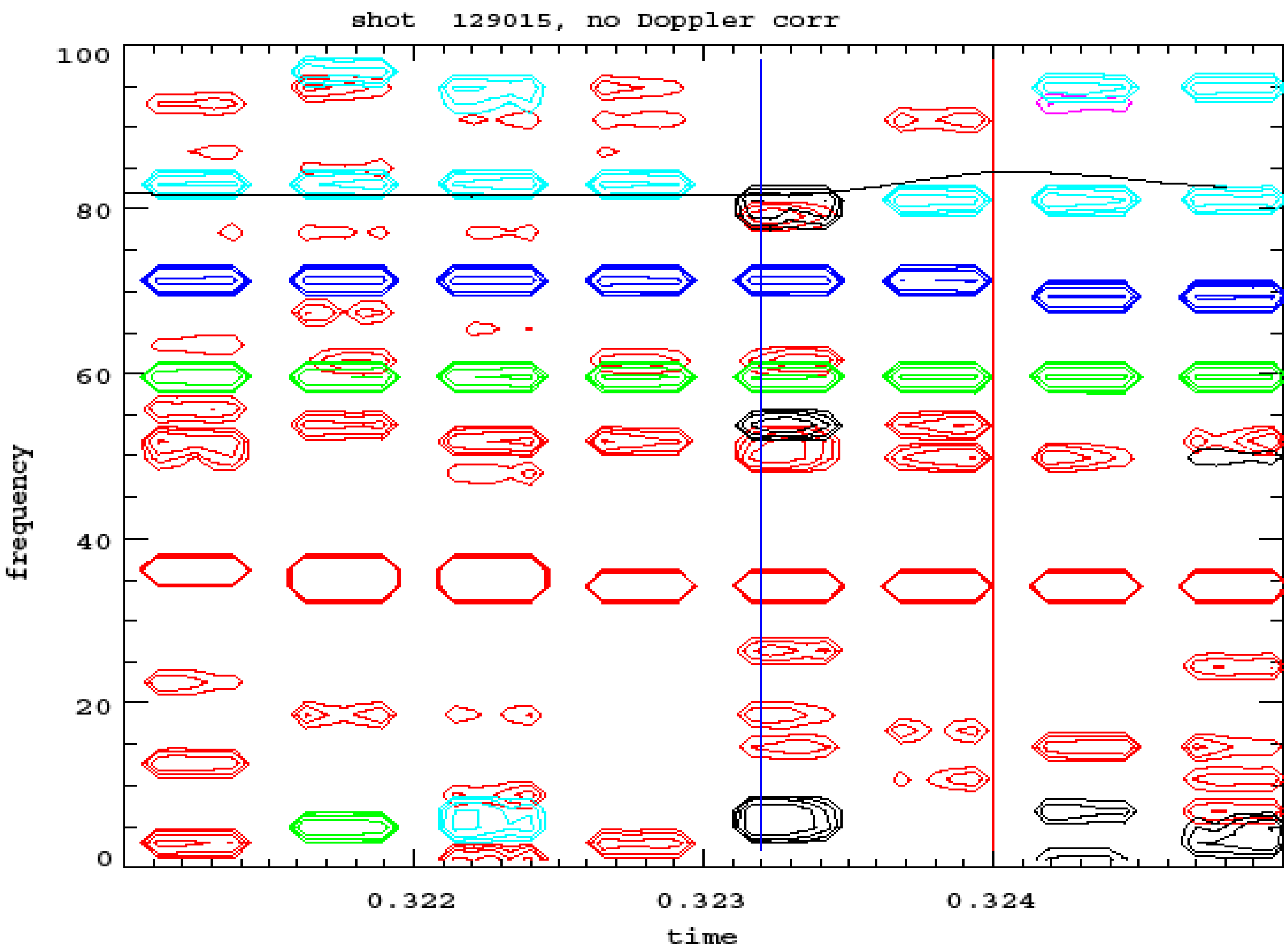


NSTX 129015 - without lithium

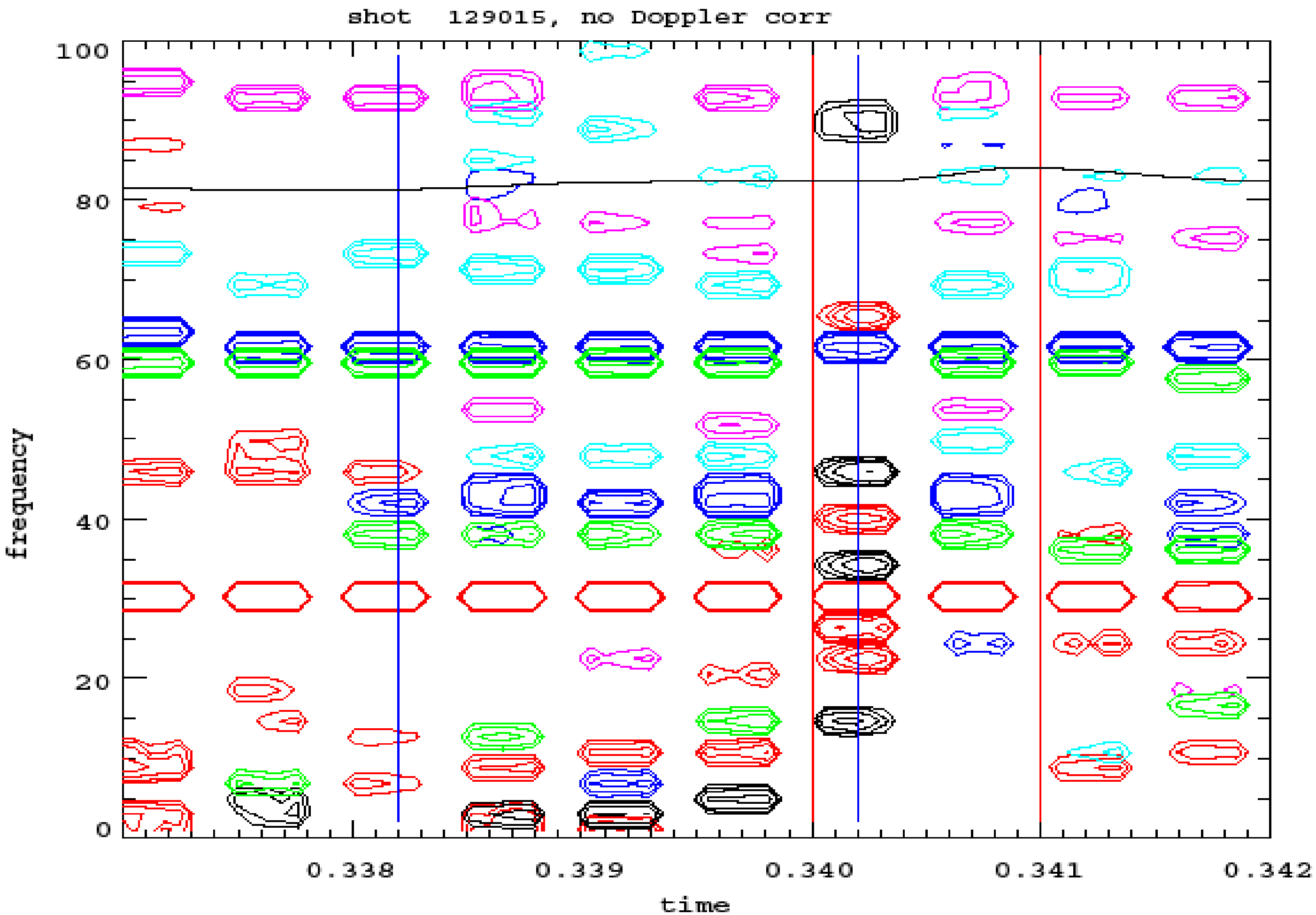
Spectrogram



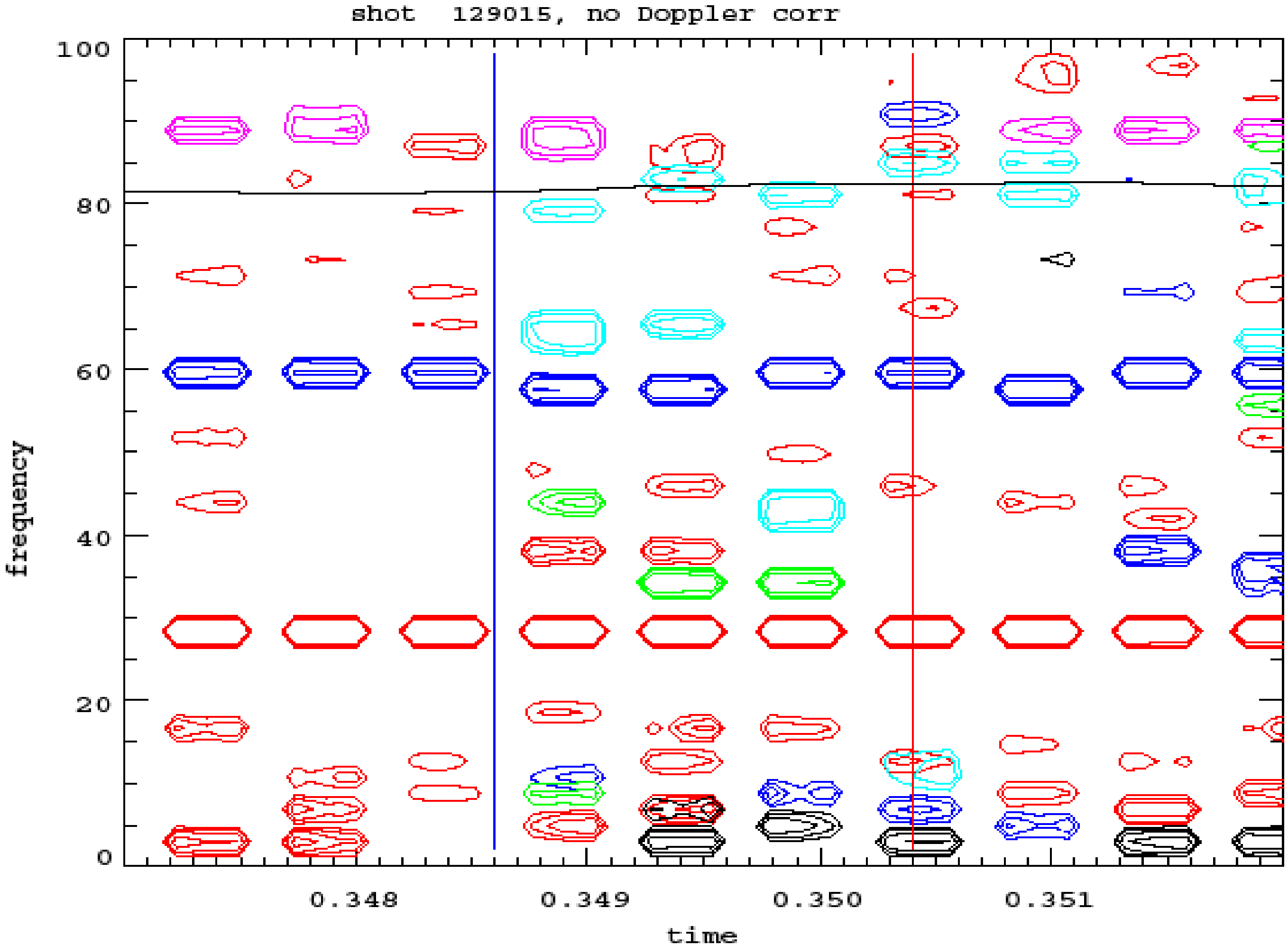
NSTX 129015 - ELM at 0.3240 s



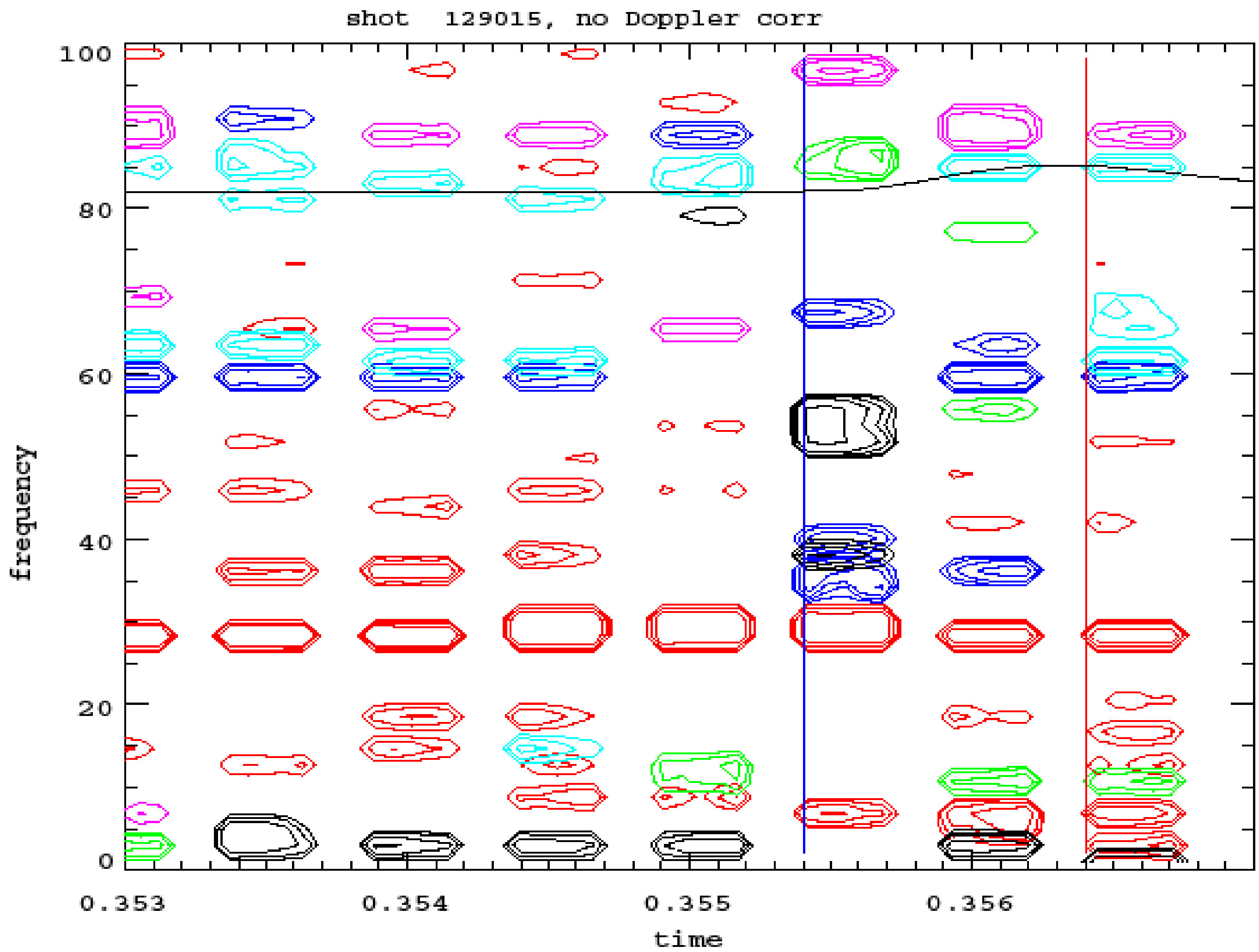
NSTX 129015 - ELM at 0.3410 s



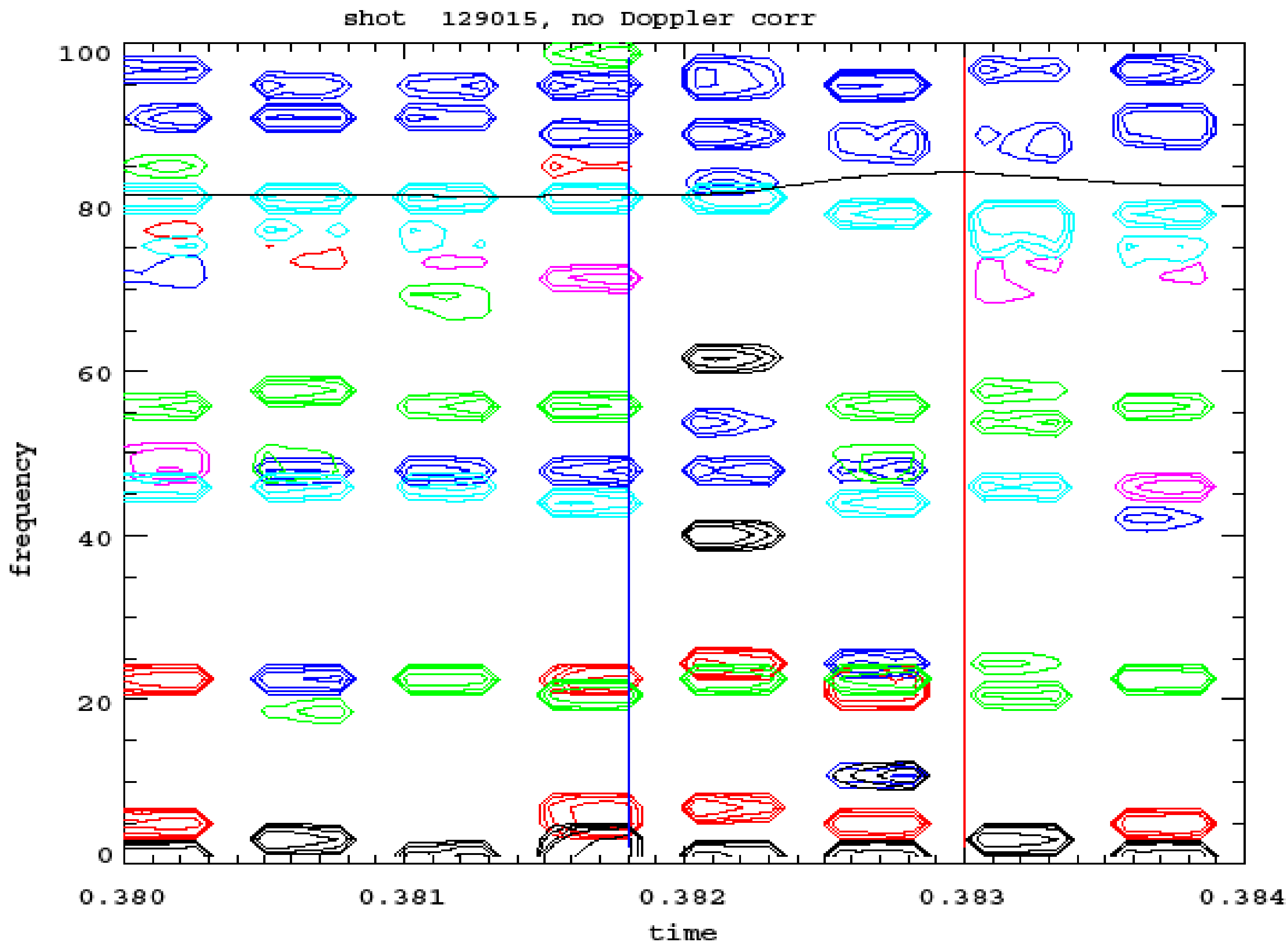
NSTX 129015 - ELM at 0.3512 s



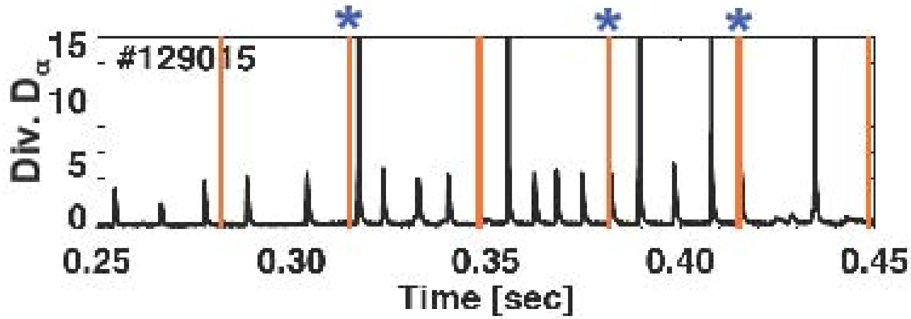
NSTX 129015 - ELM at 0.3564 s

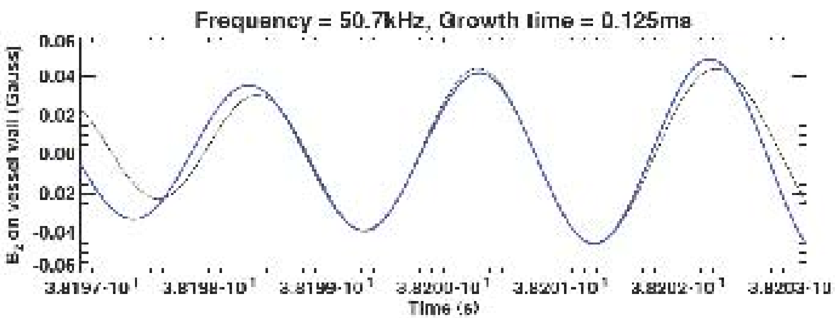


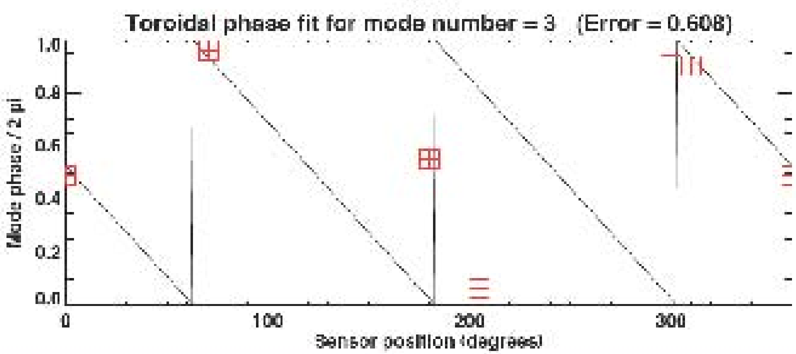
NSTX 129015 - ELM at 0.3830 s



Low-n ELM precursor observed in magnetics

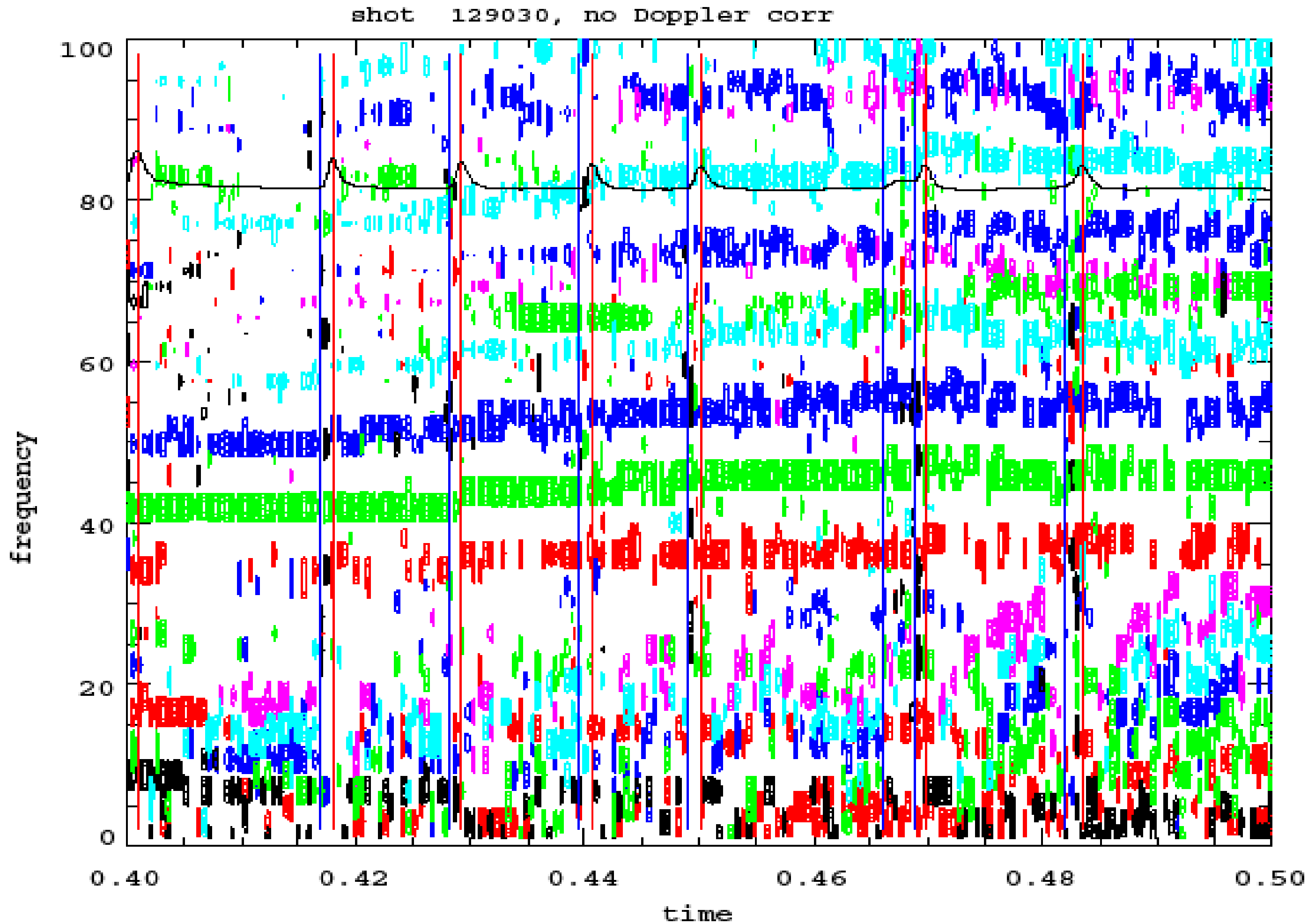




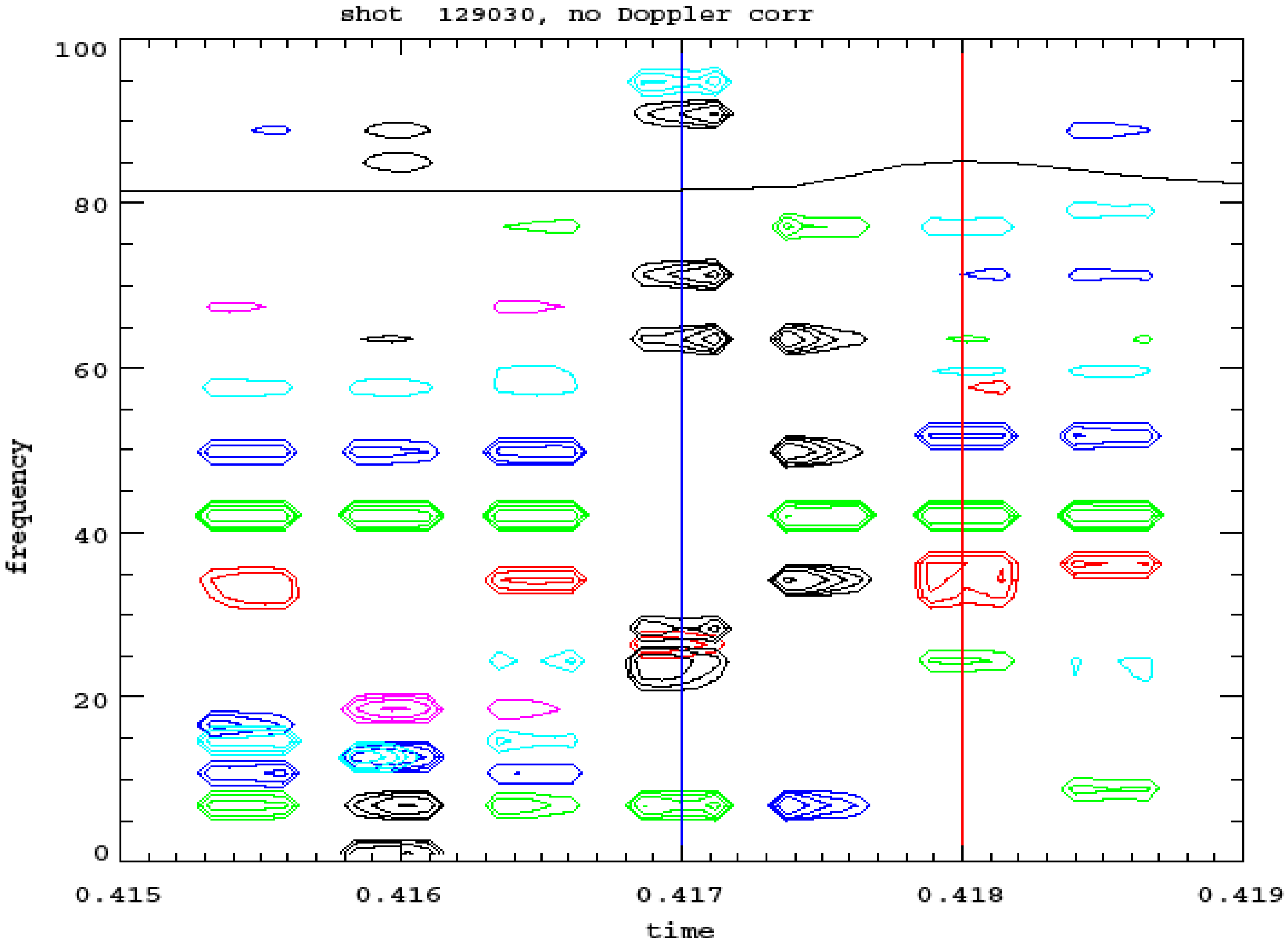


- Discharge with optimal ELM timing relative to Thomson pulses chosen for stability analysis
  - 3 ELMs in last 20% of ELM cycle
- Magnetic fluctuation spectrum from 40-60kHz analyzed near ELM at t=0.382s sec
- n=3 pre-cursor oscillation shown here
  - Other ELMs: n=2-5

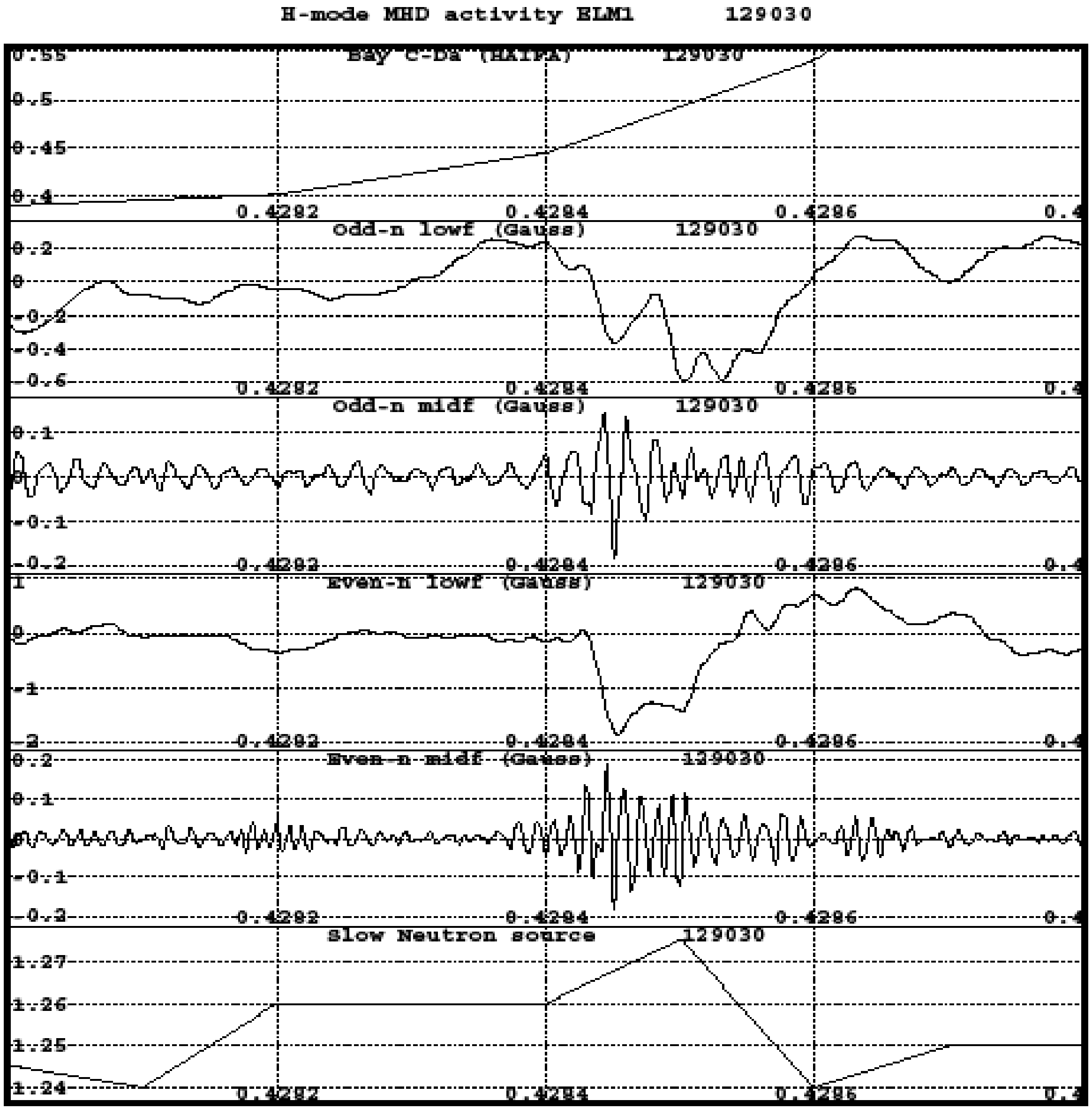
NSTX 129030 - with lithium



NSTX 129030 - ELM at 0.4180 s



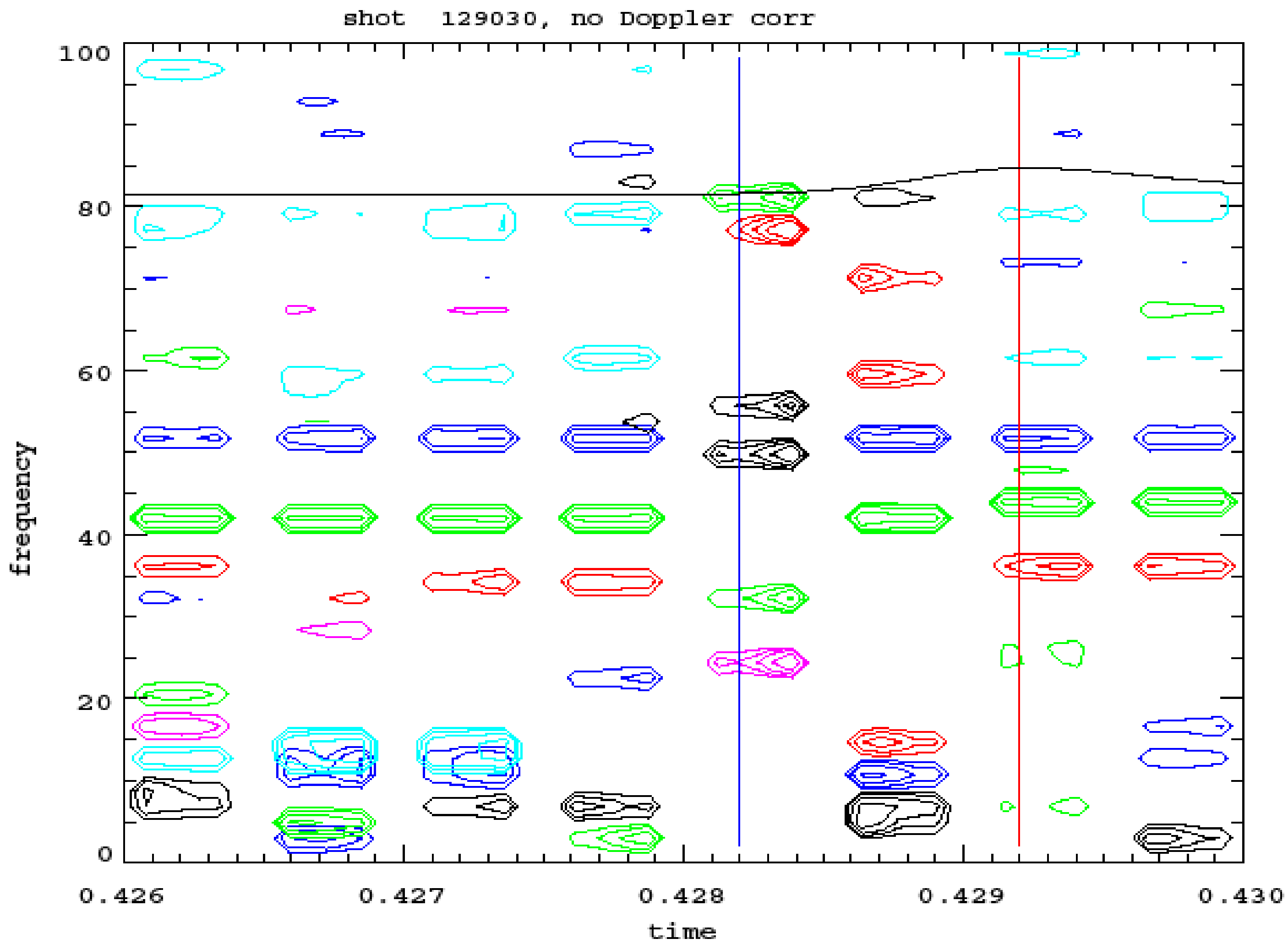
NSTX 129030 - ELM precursors in time domain



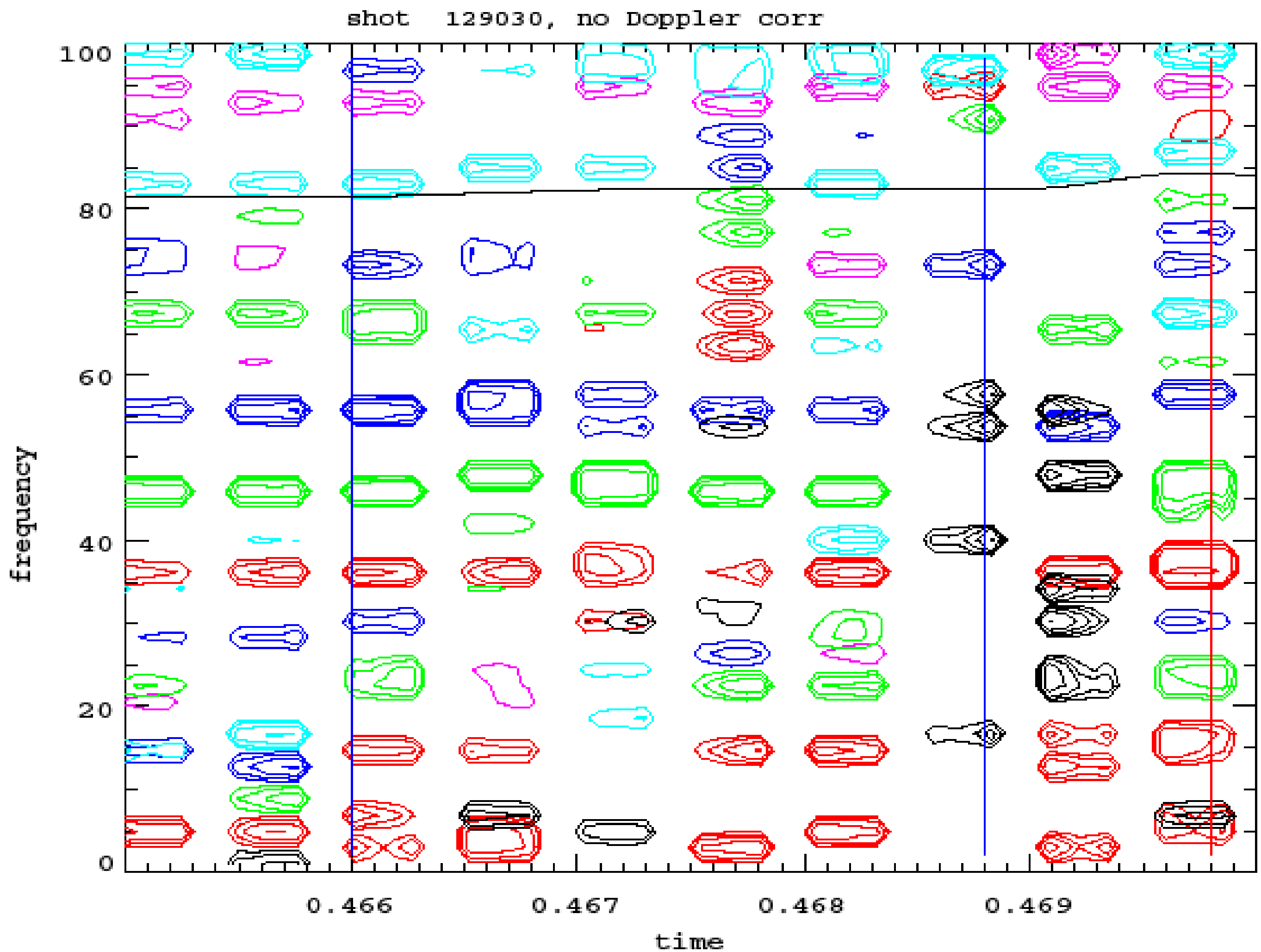
n =1
~ 50 kHz

n = 2
~ 75 kHz

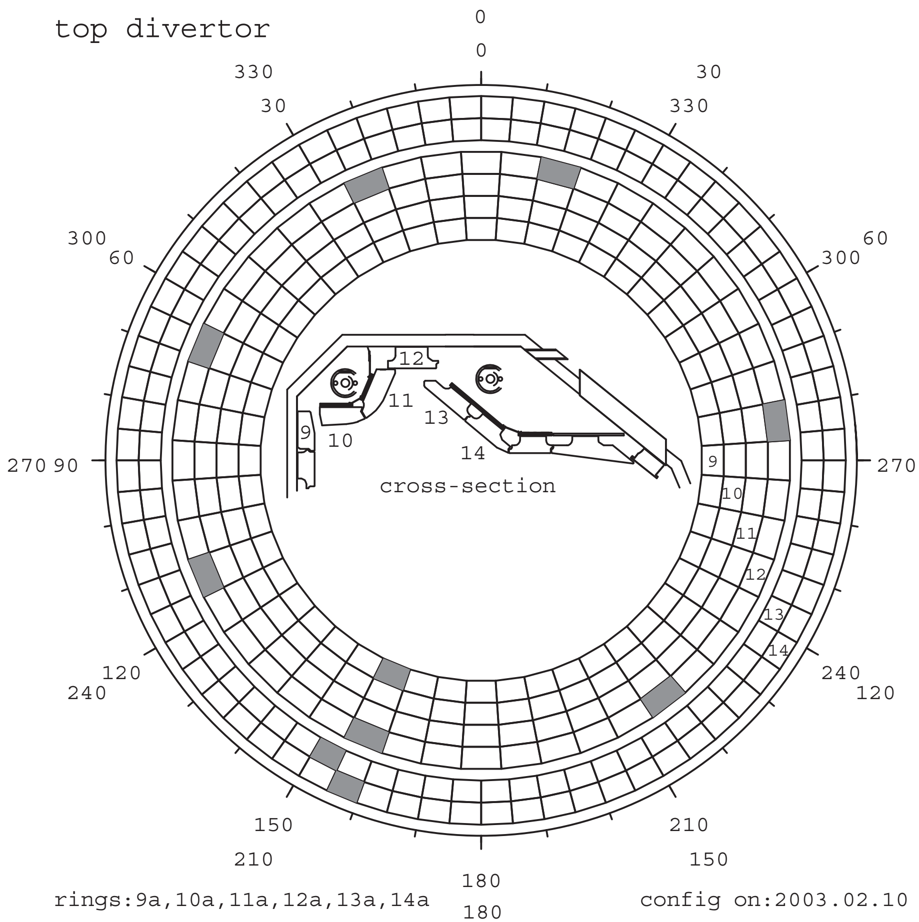
NSTX 129030 - ELM at 0.4292 s

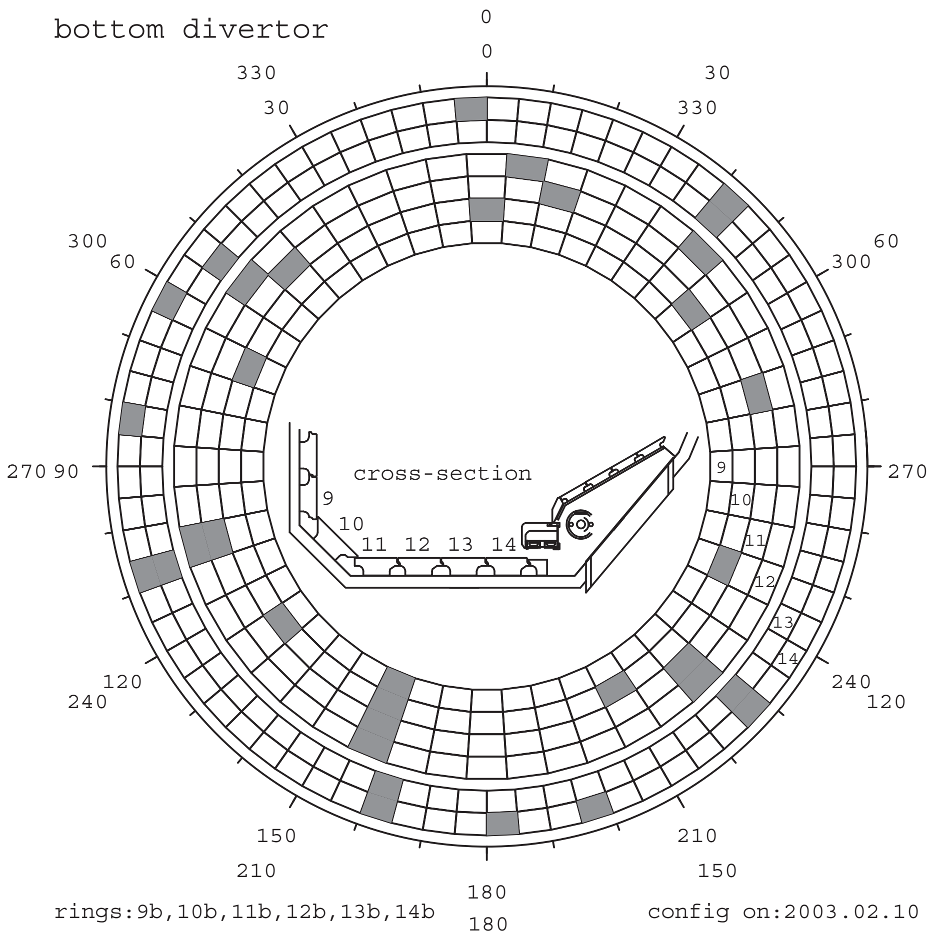


NSTX 129030 - ELM at 0.4698 s

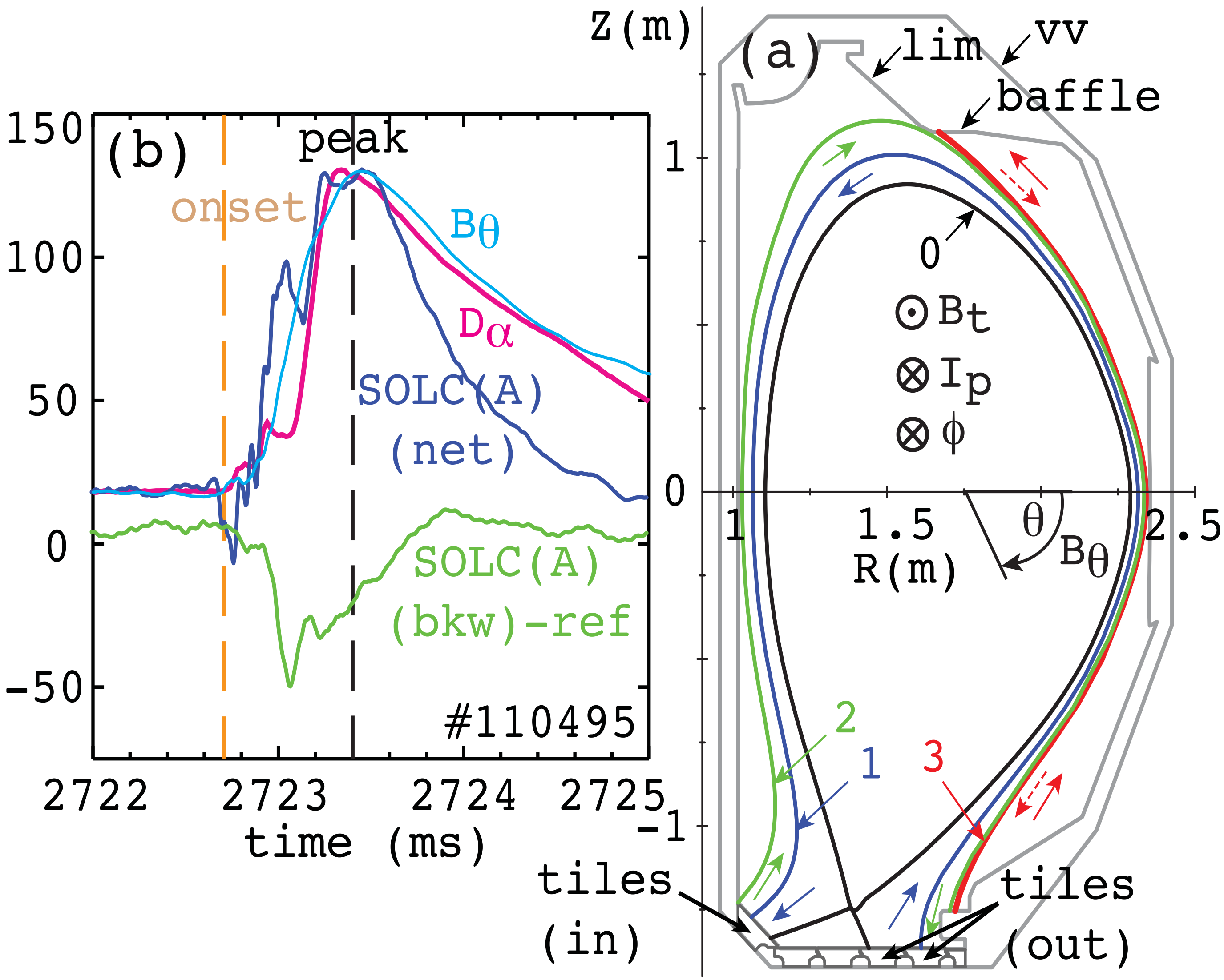


SOL currents observed in DIII-D: Takahashi et al

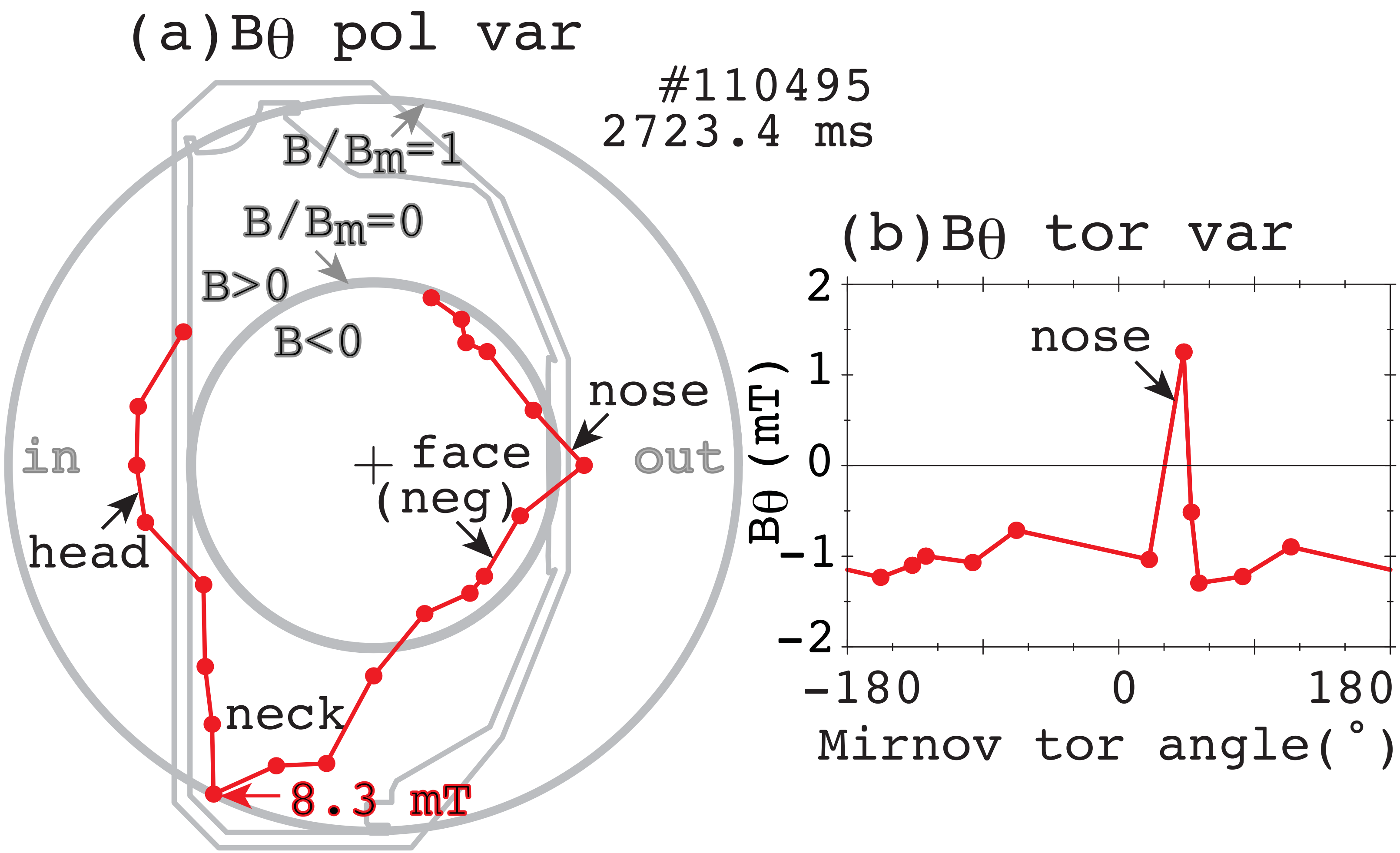




SOLC correlated with ELMs in DIII-D



B_θ has anti-ballooning character in DIII-D



Homoclinic tangle contact with PFC -> radiative condensation

NSTX

Drake[4] found the MARFE to be a radiative condensation instability governed by

parallel and perpendicular conduction   radiative condensation

$$\frac{5}{2}n\gamma\tilde{T} + k_{\|}^{2}\kappa_{\|}\tilde{T} - \kappa_{\perp}\frac{\partial^{2}\tilde{T}}{\partial r^{2}} = nn_{z}\left(\frac{2L_{z}}{T} - \frac{\partial L_{z}}{\partial T}\right)\tilde{T} \qquad (1)$$

Wesson and Hender[5] observed that the most unstable mode $\tilde{T}$ varies as cos θ and wave number $k_{\|} = 1/qR$

$$\kappa_{\perp}\frac{\partial^{2}\tilde{T}}{\partial r^{2}} - k_{\|}^{2}\kappa_{\|}\tilde{T} = nn_{z}T^{2}\frac{\partial}{\partial T}\left(\frac{L_{z}(T)}{T^{2}}\right)\tilde{T} \qquad (2)$$

[4] Drake, PF **30** (1987) 2429.
[5] Wesson and Hender, NF **33** (1993) 1019.

Discussion of Results

n = 2,3,4,5,6 modes appear to slowly growing with limited contribution to D signal -> not 'explosive'

n = 1 modes appear to be necessary for 'explosive growth'

SOL currents in DIII-D maybe likely candidates for n= 1 modes

Homoclinic tangles making contact with material surfaces may drive thermo-electric currents and/or radiation condensation events

Conclusions

Since they can produce non-axisymmetric current and error fields, maybe useful to actively control SOL currents to stabilize edge to ELMs and other modes.

Need to look for evidence of anti-ballooning character of ELMs in NSTX