XP 931: Effect of the active stabilization of RWMs on the background plasma

L. Delgado-Aparicio[1], S. A. Sabbagh[2], S. P. Gerhardt[3], R. Bell[3], D. Stutman[1], K. Tritz[1], J. Berkekey[2], J. Bialek[2], W. Blanchard[2], M. Finkenthal[1], B. LeBlanc[3], J. Levesque[2], and J. Manickam[3]

[1]The Johns Hopkins University

[2]Columbia University

[3]Princeton Plasma Physics Laboratory

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Motivation

Address the 2009 research milestone of understanding the physics of RWM stabilization and control, especially on the effects of the actively stabilized RWMs on the background plasma

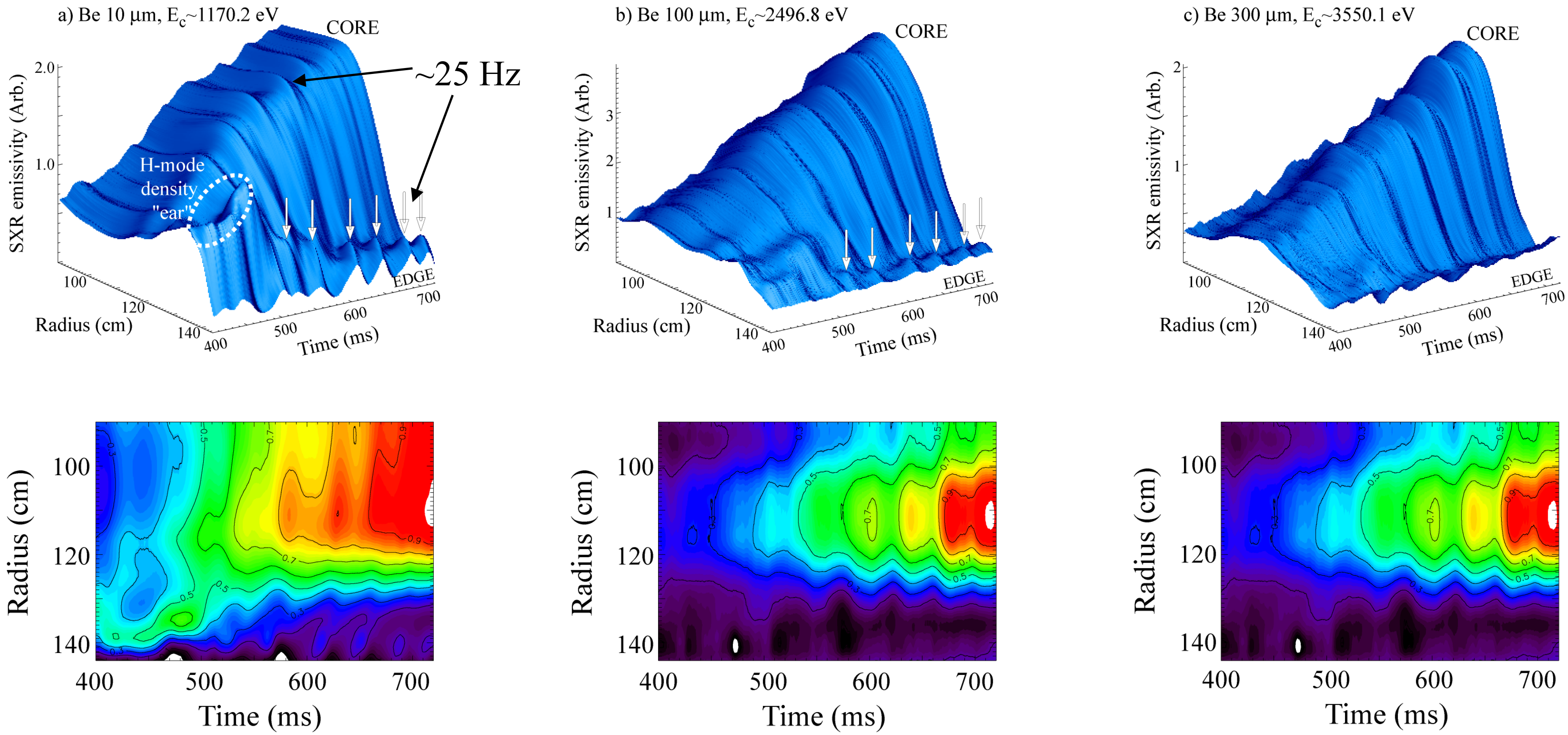
a) Modification of kinetic profiles (T_e, n_e & n_Z)

b) T_e and $n_e n_Z$ fluctuations.

Observations in NSTX, DIII-D and JT-60:

1. Multi-energy SXR characterization of actively stabilized resistive wall modes in NSTX. [L. Delgado-Aparicio, APS-DPP-2008].
2. Investigation of Resistive Wall Mode Internal Structure (work done at DIII-D). [I. N. Bogatu, APS-DPP-2006].
3. Dynamics and Stability of Resistive Wall Mode in the JT-60U High-β Plasmas. [Matsunaga, 22nd IAEA-2008].

Multi-energy SXR reconstructions of actively stabilized RWMs



Delgado-Aparicio, PoP letter, to be submitted, (2009).

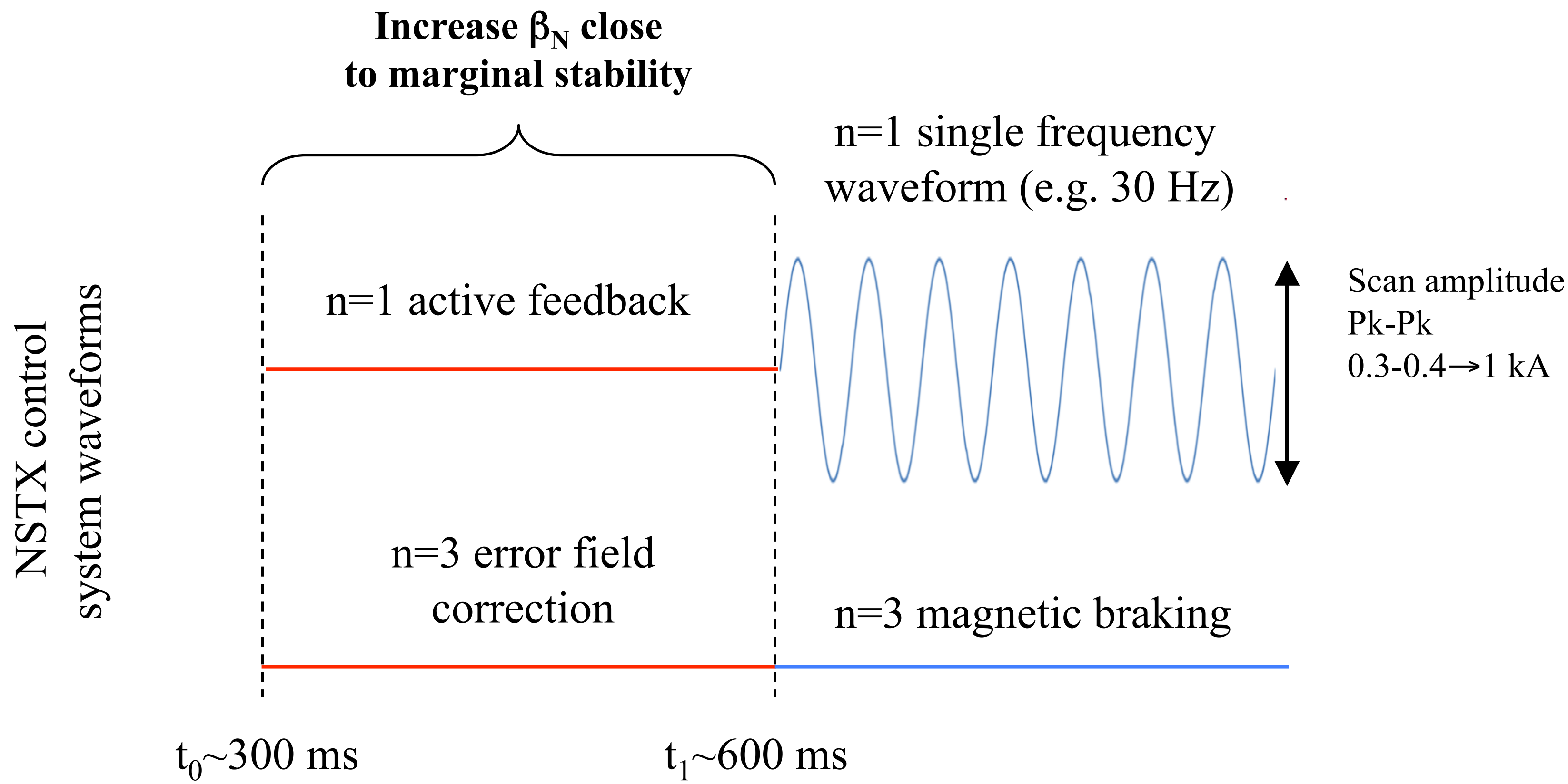
- $n=3$ braking and $n=1$ stabilizing fields modified kinetic profiles at early times.
- Are the RMPs taking out the H-mode density "ears"?
- Increased edge n_Z blobs during stabilization; good correlation with drops in $\boldsymbol{T_{e0}}$ & S_n.
- ***May have identified a stable RWM near the natural RFA resonance***.

Research targets

a) the role of the resonant field amplification and its kinetic response near the marginal stability and,

b) the modification of the kinetic plasma profiles by the use of the ($n=3$ braking and the $n=1$ active feedback) external fields .

1^{st} part: Role of RFA near marginal stability



- Scan t_1 to avoid getting "that" close to marginal stability (~2-3 shots).
- Scan *n*=1 amplitude to look for ***kinetic response*** of RFA (~2×3=6 shots).
- Inject neon for the *n*=1 amplitudes selected (~ 3 shots).
- Time: ½ day.

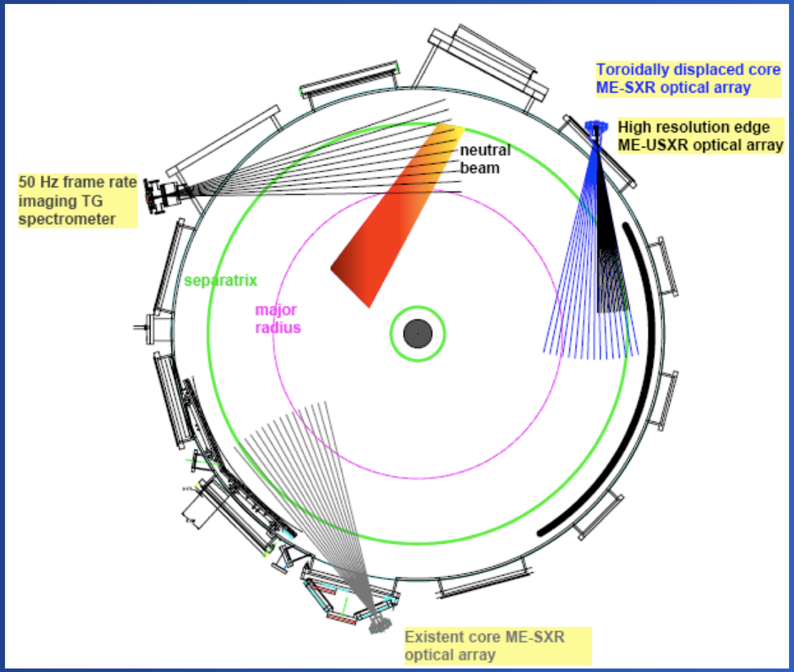
2^{nd} part: *Effects of applied external fields on plasma profiles*

n=3 magnetic braking

n=1 active feedback	***OFF***	***ON***
OFF	w/o Neon (2 discharges)	w/o Neon (2 discharges)
ON	w/o Neon (2 discharges)	w/o Neon (2 discharges)

- One more discharge per condition for contingency (background or Neon doped).
- Inject neon at @ 1.5 Torr·*l*/s (or less) for a time window ∈ [350-400] ms
- Total = 12 successful H-modes.
- Apply *n=3* braking and *n=1* active stabilization @ 450 ms like in 120041-44-47, 120717.
- Time: ½ day

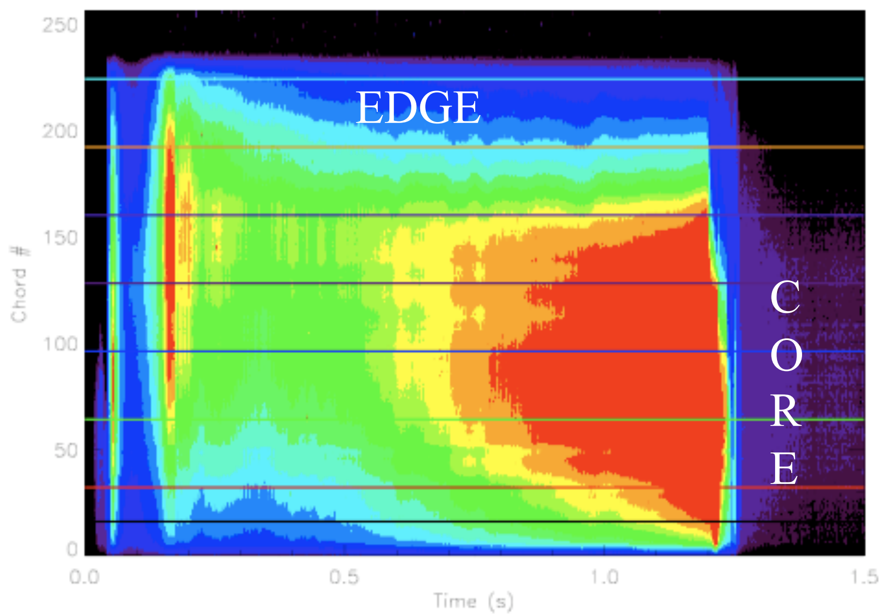
Combining existent diagnostic with new edge ME-SXR array at a different toroidal location enables probing new physics:



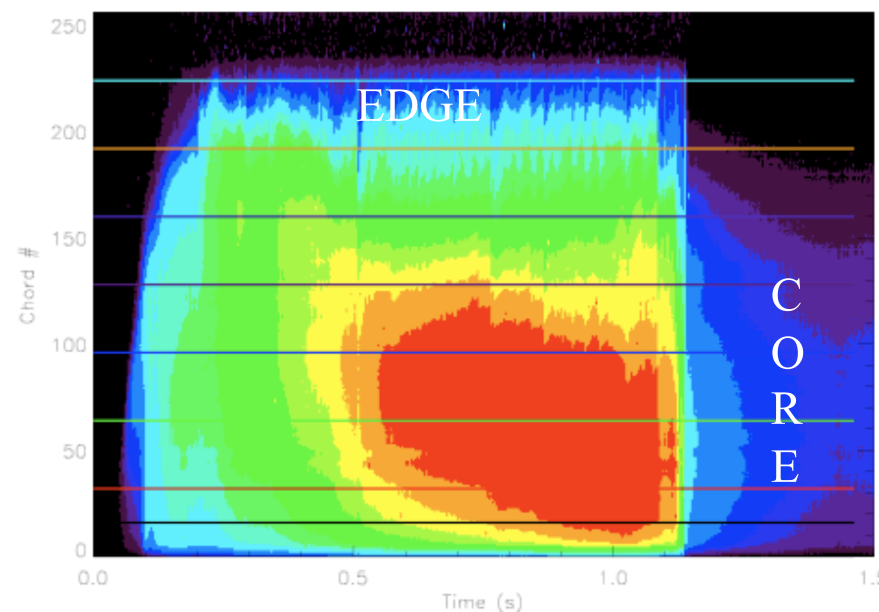
a) accurate n=1 identification
b) hot ion stabilization mechanism
c) possible multi-mode RWM components

Continuous coverage with high resolution at the edge

Ti 0.3 μm



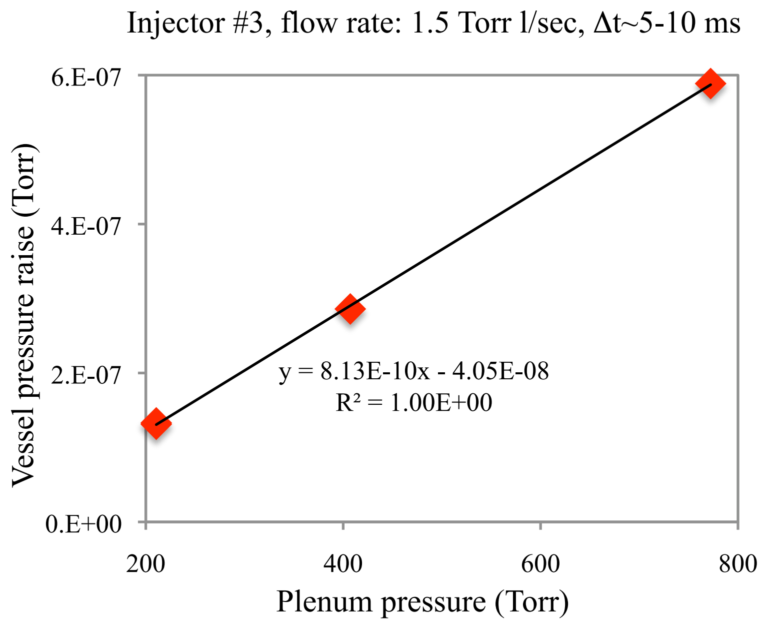
Be 10 μm

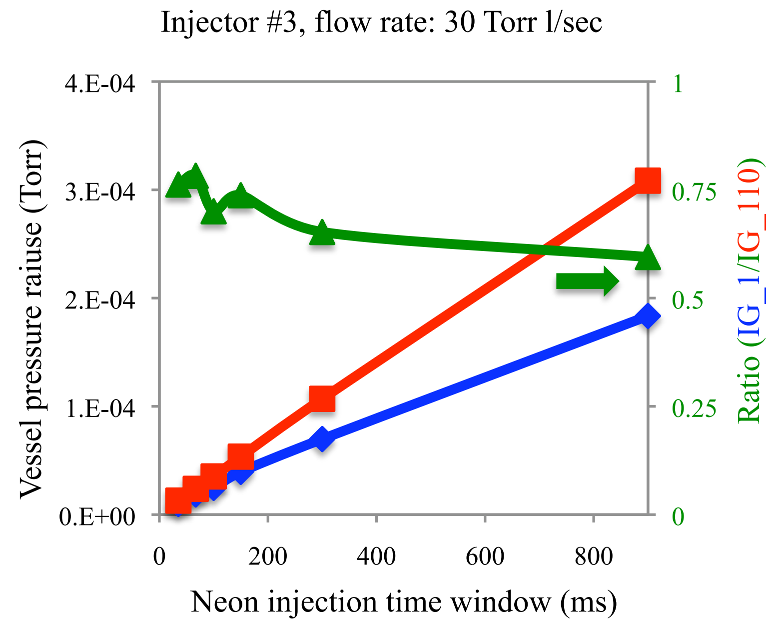


- EDGE ME-SXR array.
- Continuous coverage with ***~1 cm spatial resolution*** (oversampling).
- **GOAL: sub-cm resolution**.

- Scintillator + image intensifier + fiber-bundle + fast camera
- Use of Ti 0.3 and Be 10 μm foils.
- Capable of observing NBI induced CX-emission.

Prescription for Neon injection worked





- Use of injector #3 for neon injection.
- Linear response of gas injection at 1.5 Torr•*l*/s for 5-10 ms.
- Ion gauge calibration at increased flow rates for different time windows.
- The neon gauge factors are: IG_110 = 3.30 & IG_1 = 4.27
- ***Shot # 133125 (P_{plenum}~210 Torr): 6.3 $\times 10^{17}$ neon atoms***

… and was used in 6 experimental proposals

a) XP931 on the Effect of the active stabilization of RWMs on the background plasma. (**Macroscopic Stability TSG**).

b) XP932 on the Influence of Hot Ions on Resistive Wall Mode Stability (**Macroscopic Stability TSG**).

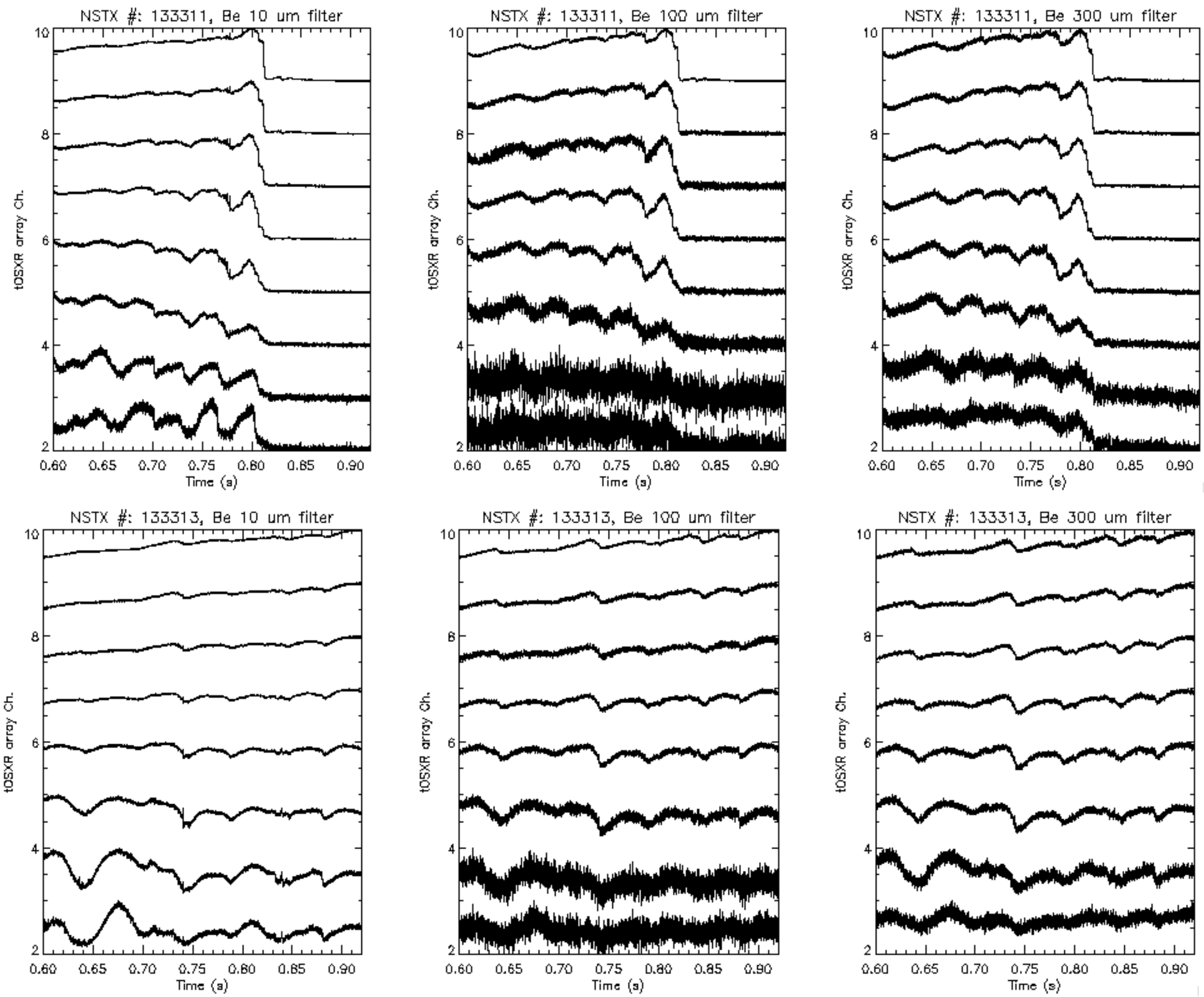
c) XP935 on the Search for multiple RWM behavior at high β_N (**Macroscopic Stability TSG**).

d) XP918 on the Effect of Impurities and Wall Conditioning on NTMs (**Macroscopic Stability TSG**).

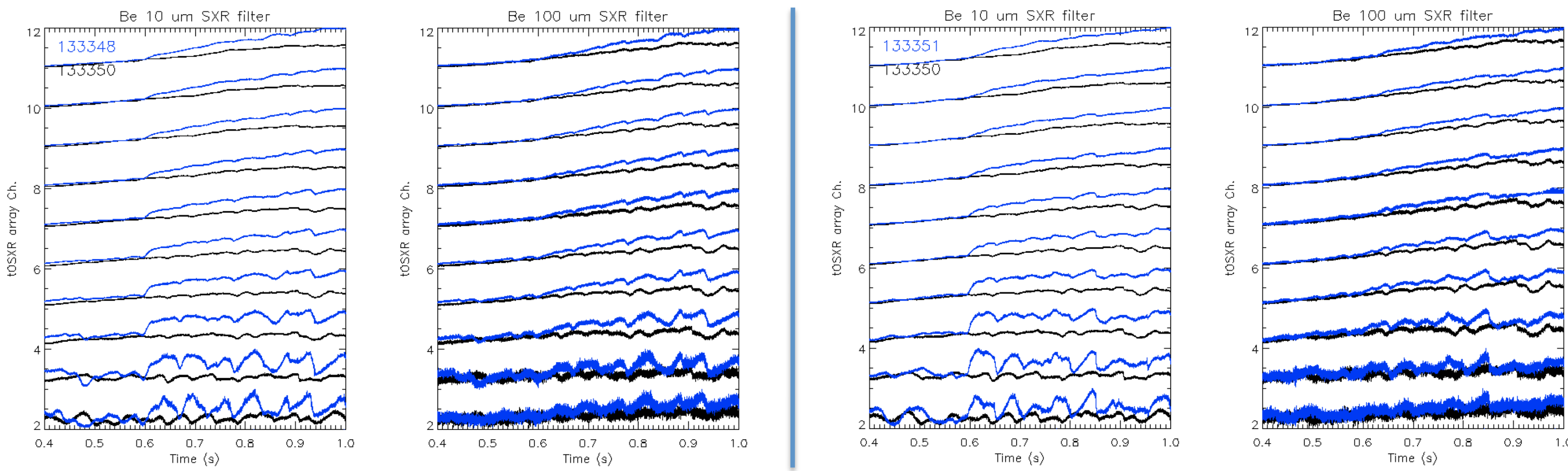
e) XP921 on the Characterization of GAE modes & their effect on electron thermal transport (T&T and WP TSGs).

f) XP908 on the Dependence of momentum and particle pinch on collisionality (T&T TSG).

Probing the RFA using an *n=1* single frequency traveling waveform (e.g. 30 Hz)



MHD & transport studies using Neon injection in actively stabilized RWMs



- Good Ne injections time @ ~ 600 ms.

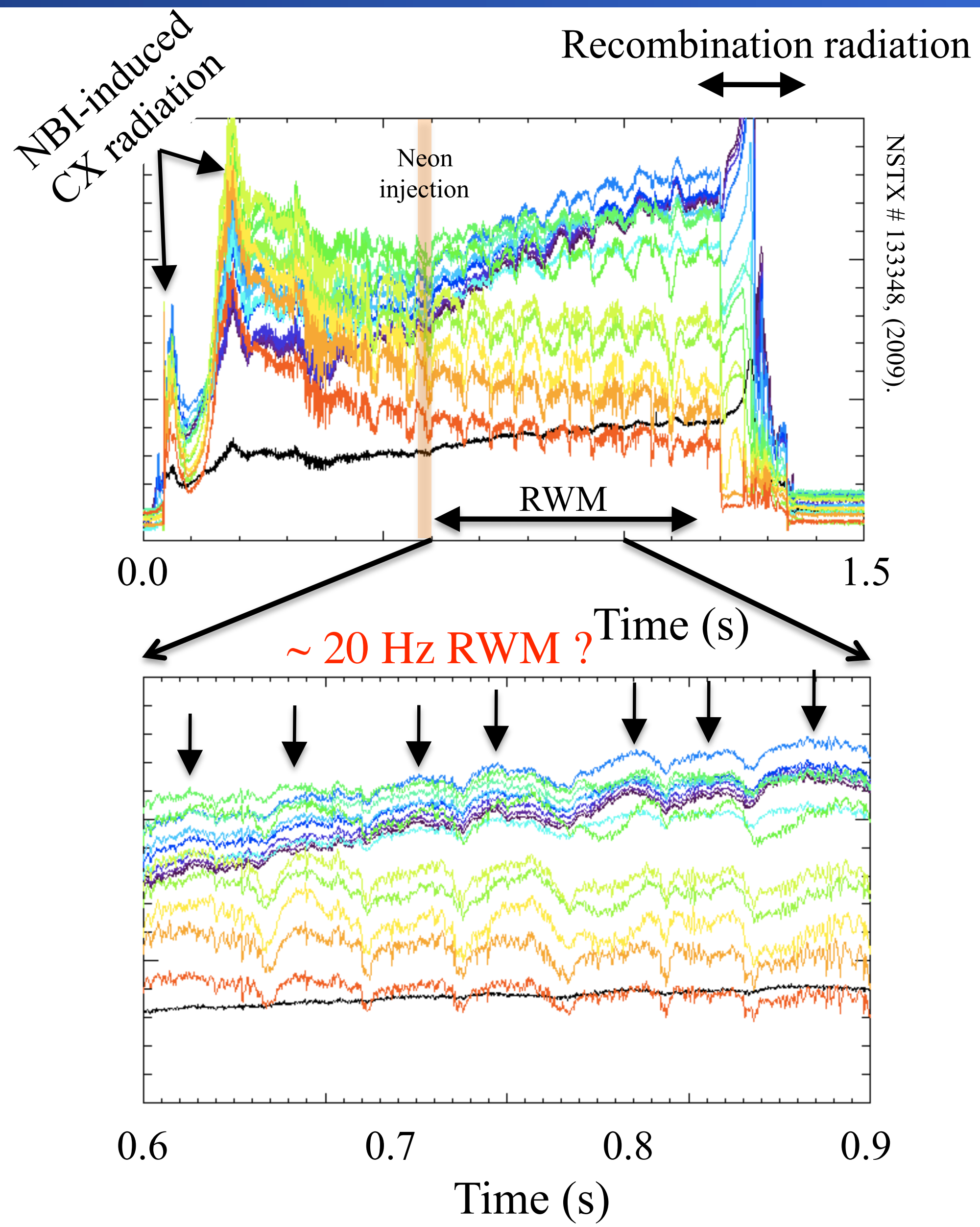
- Inject neon at @ 1.5 Torr·*l*/s (or less) for a time window ∈ [600-610] ms.

- Very reproducible effect (NSTX #s 133348 and 133351 vs background 133350).

- Data with the high-energy Be 300 μm foil is also available.

- Neon emission sheds light into the RWM identification as well as in the problem of changing particle transport.

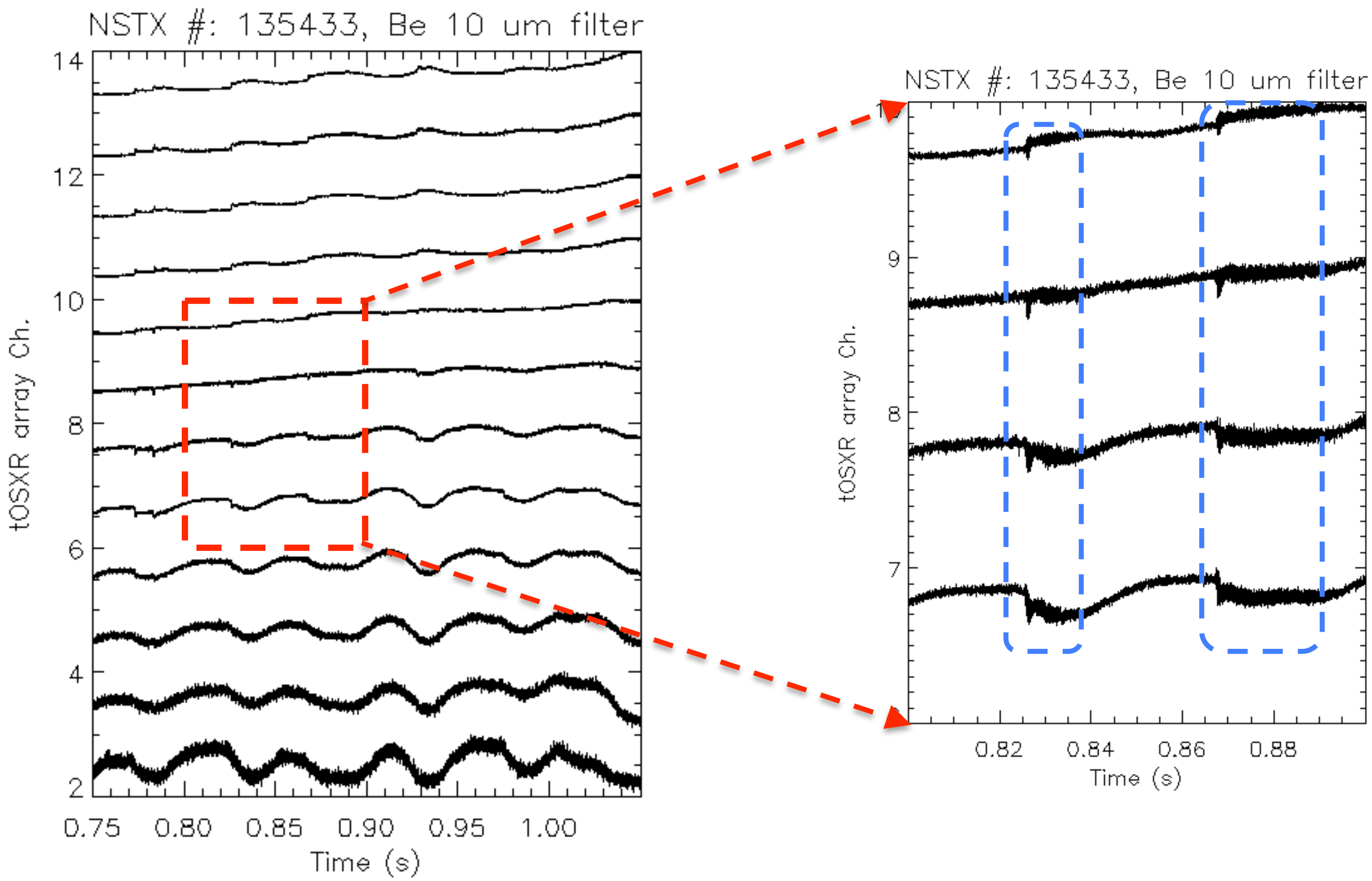
New high spatial resolution diagnostic capability for NSTX



- EDGE ME-SXR array.
- 16 discrete channels with ~1 cm spatial resolution.
- Scintillator + image intensifier + 16-ch diode array + TIA amplifiers
- Use of Ti 0.3 and Be 10 μm foils.
- Capable of observing NBI induced CX-emission.
- Use of Ne-puff to shed light into RWM stabilization mechanisms.
- Effect of impurity penetration will also be decoupled.

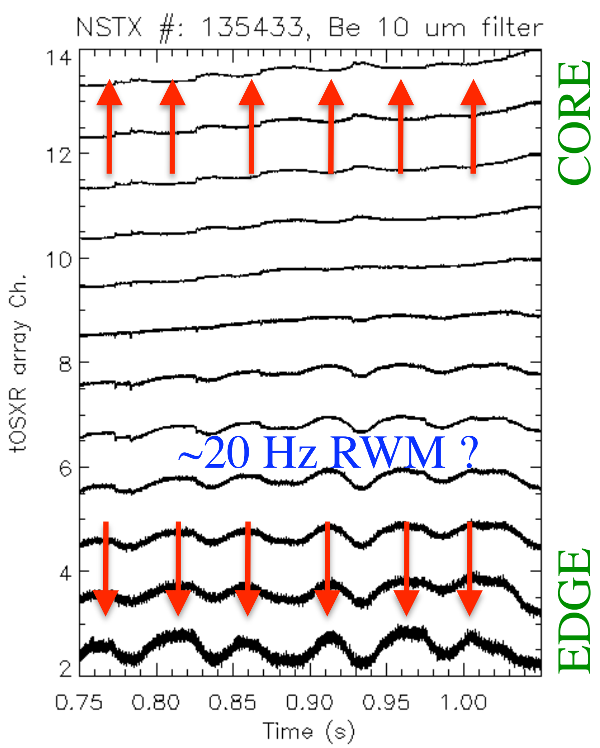
Preliminary data mining for RWM shots (I)

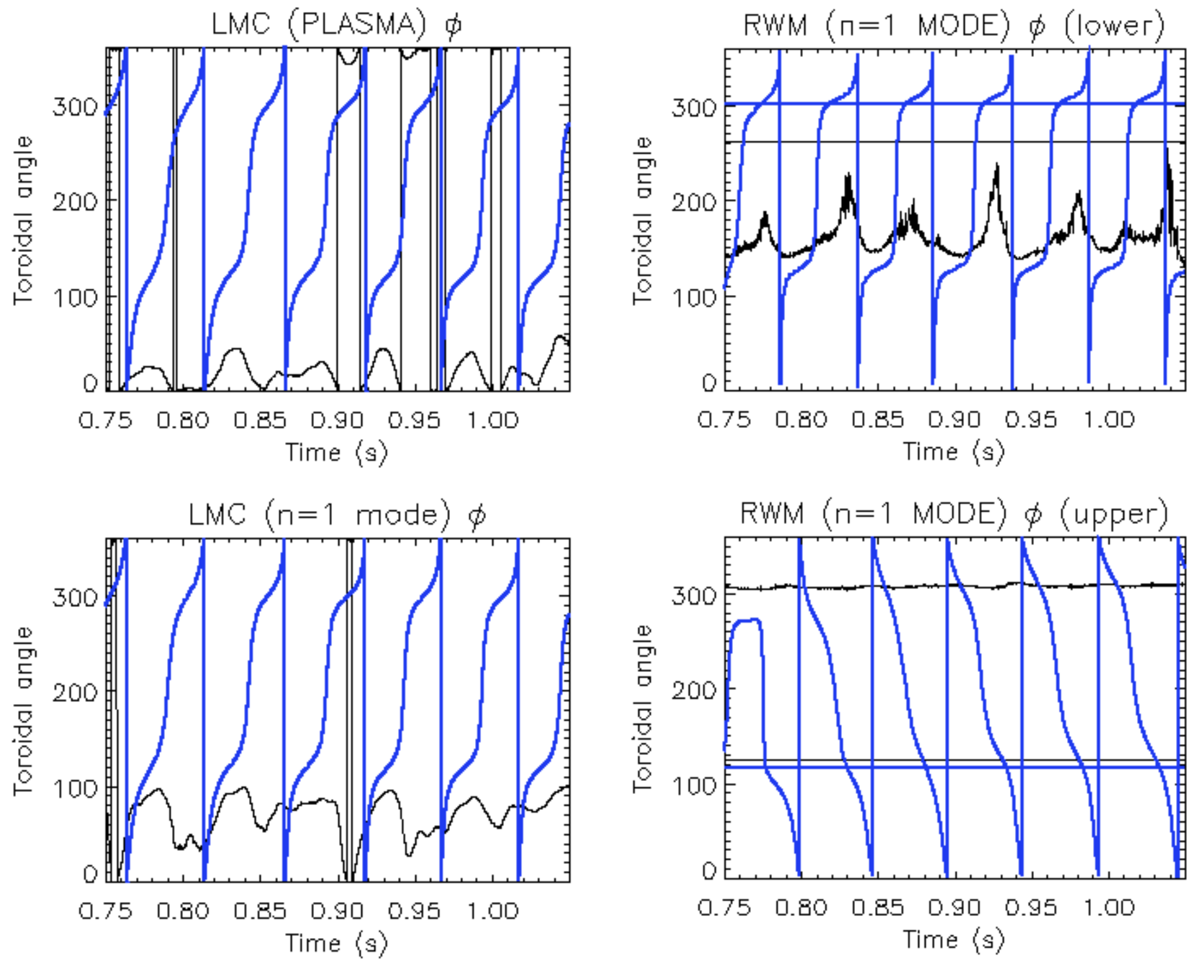
NSTX # 135433
RWM + ~20 kHz fishbones (?)



Good correlation between SXR & magnetics

Data from the low-energy ME-tOSXR array using a Be 10mm

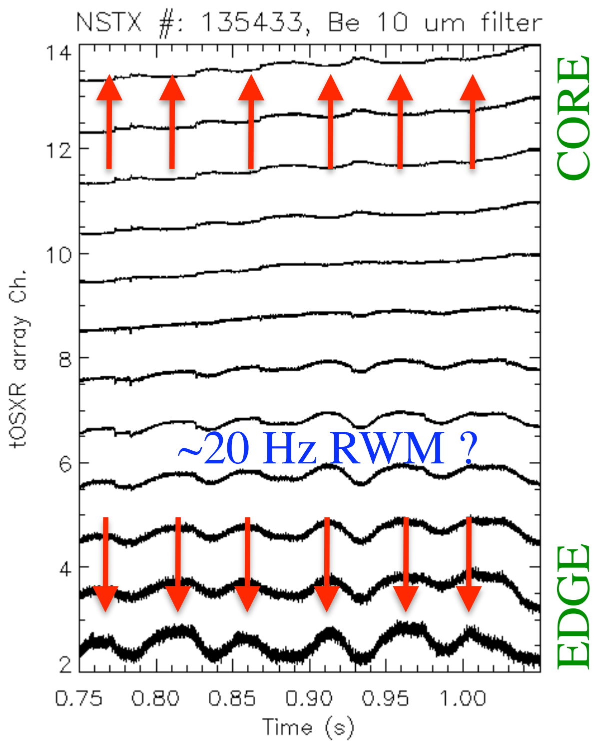


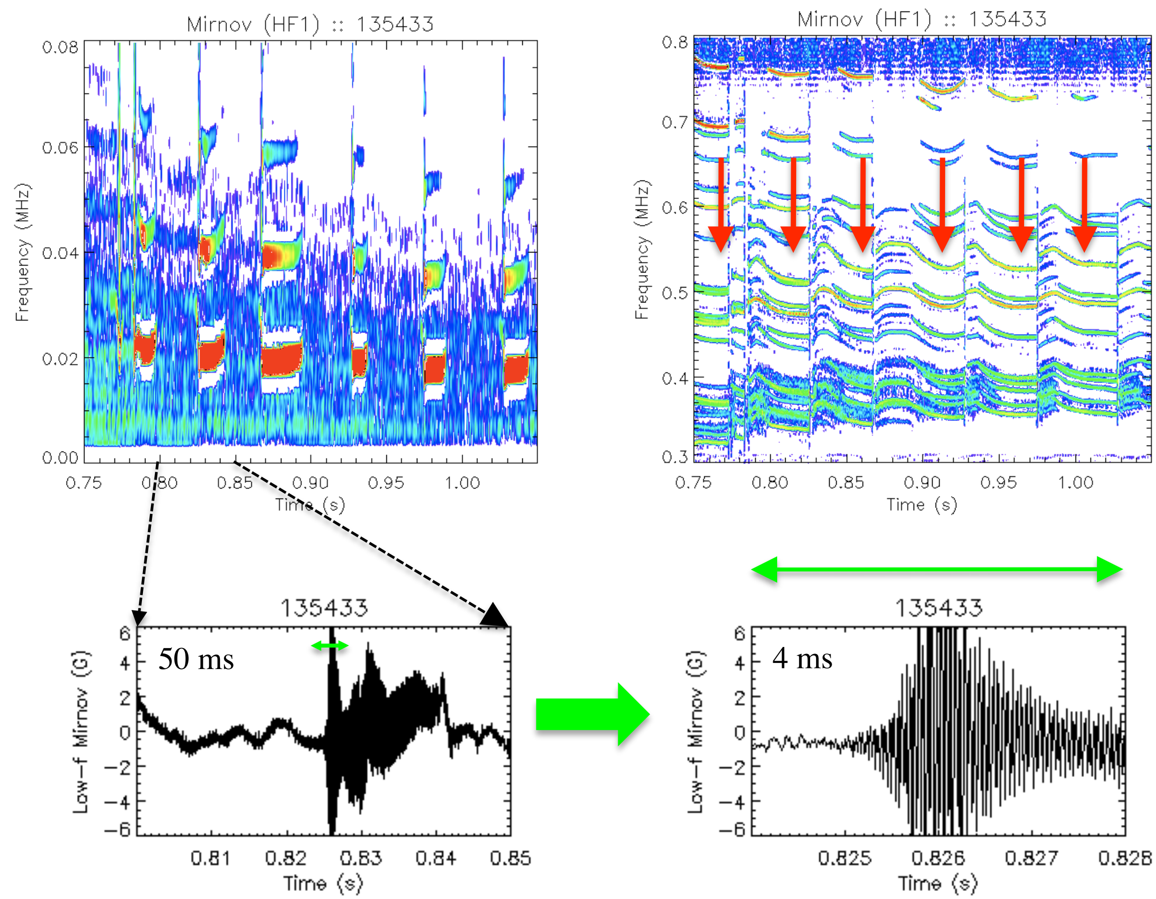


- Good correlation between low-, medium and high-energy SXR and magnetics (LMC and RWM B_r & B_ϕ).
- SXR indicates typical edge density (n_e, n_Z) and core T_e fluctuations as reported before (rotating ~20 Hz *n=1* RWM).

Low and *high-f* MHD activity during stabilized RWM

Data from the low-energy ME-tOSXR array using a Be 10mm

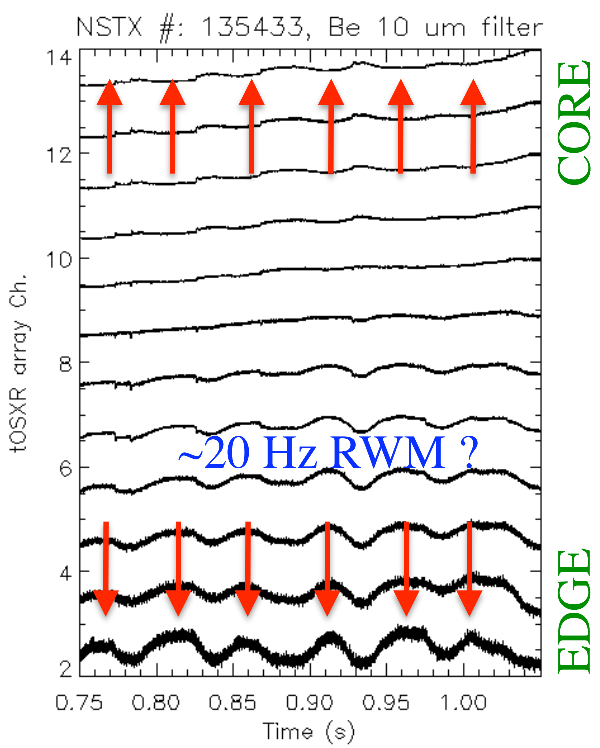




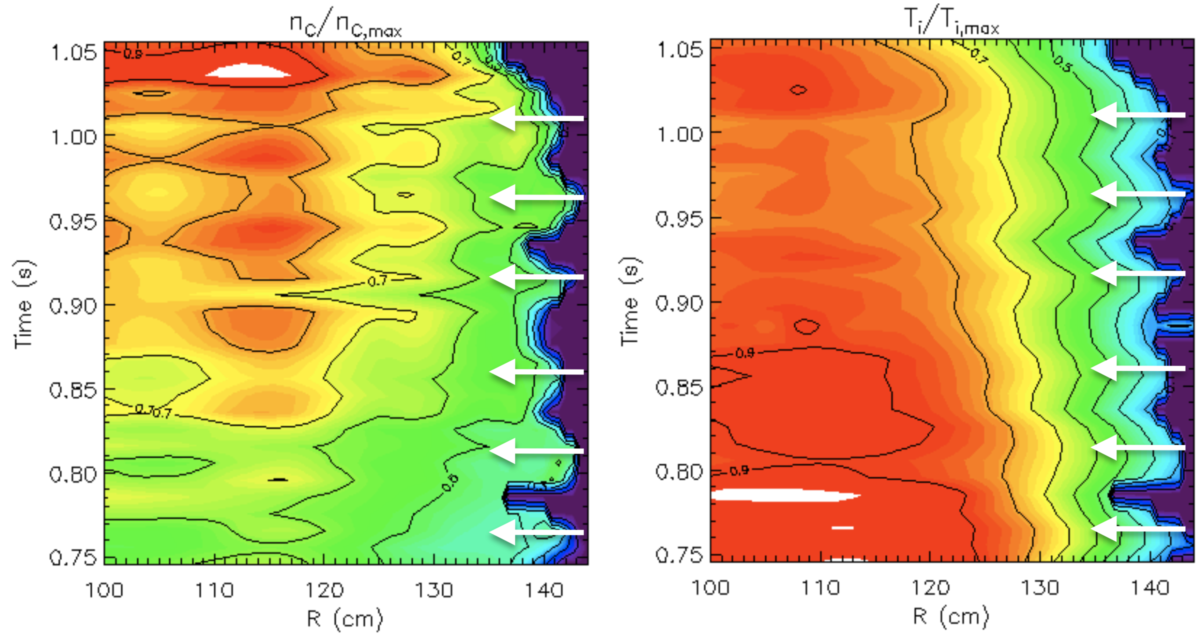
- Is the fishbone-like MHD destabilizing the plasma?
- ME-tOSXR array also observed this early (~30→20 kHz) fishbone-like + (~20 kHz) modes.
- Good correlation also with D_α, CHERS, neutrons, bolometer, and β_t and $W_{MHD\text{-}EFIT}$.

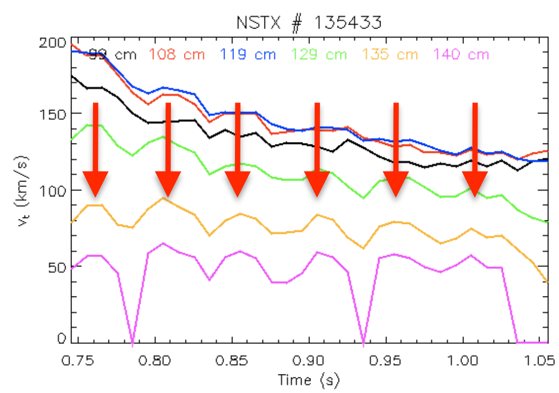
CHERS indicates activity during stab. RWM

Data from the low-energy ME-tOSXR array using a Be 10mm



Normalized carbon density, ion temperature and toroidal velocity from CHERS

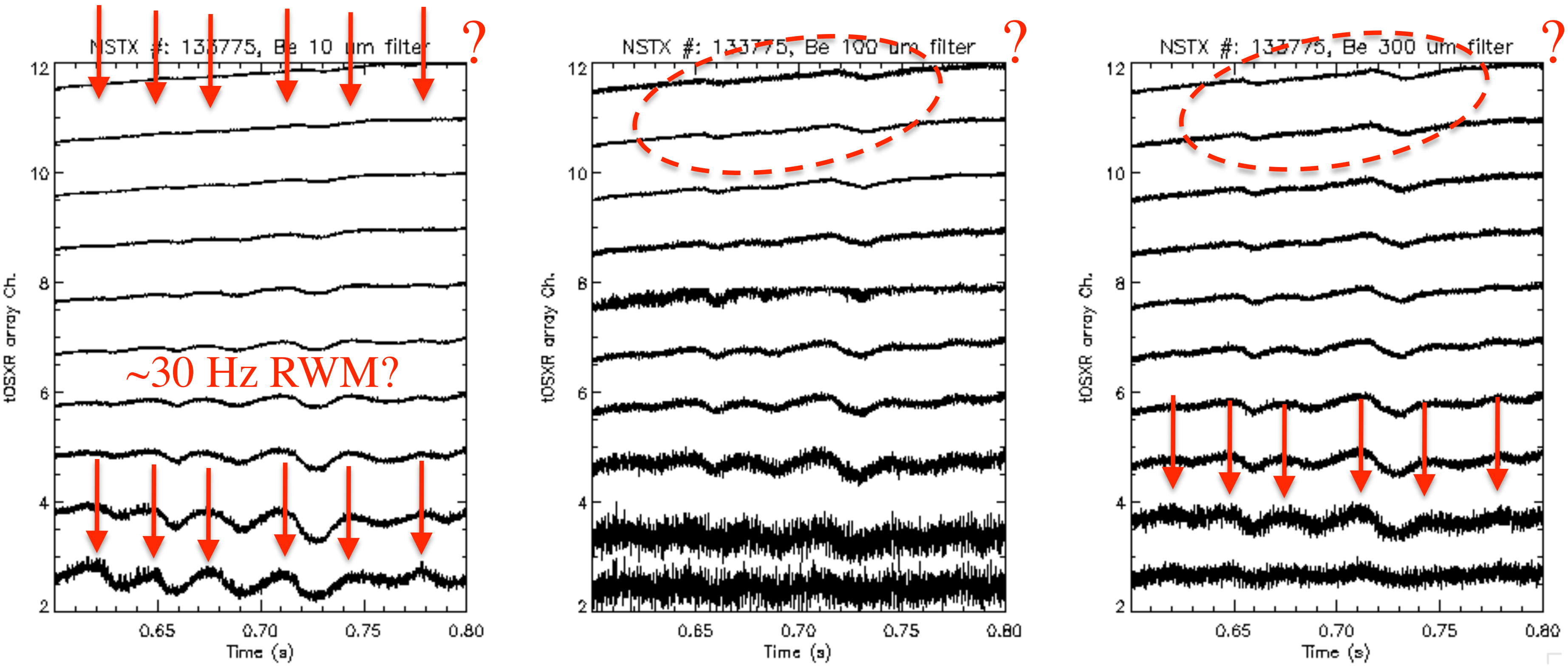




- CHERS data also indicated presence of ~20 Hz n=1 RWM.
- n_C and T_i at the edge are correlated.
- n_C at the edge and core appear to have an offset.

Preliminary data mining for RWM shots (II)

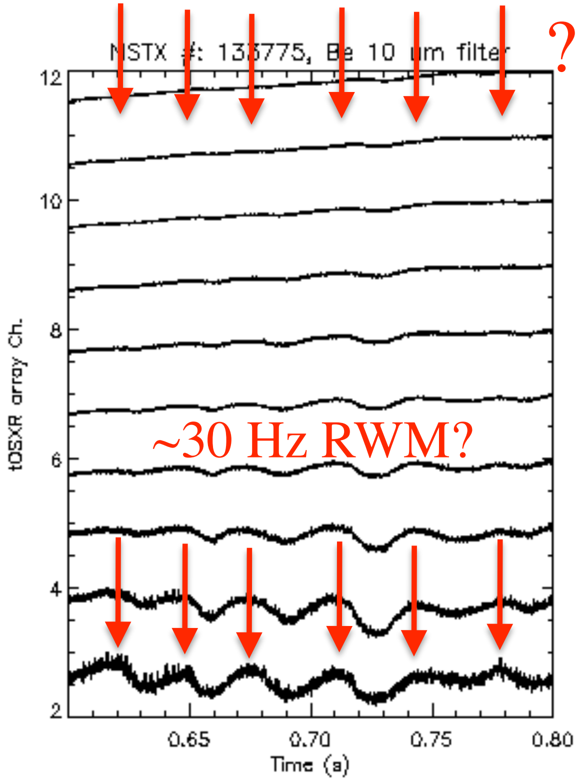
NSTX # 133775: ~30 Hz *low-f* activity observed with the ME-SXR array



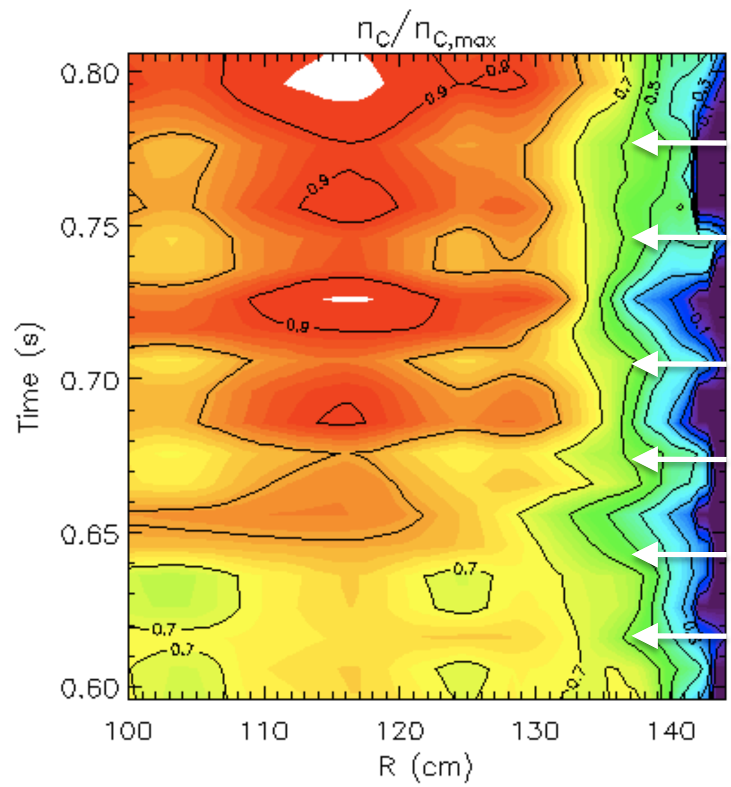
- The ~30 Hz *n=1* activity is observed at the edge.
- Is the *low-f* ~30 Hz activity lost in the core?

CHERS also observes ~30 Hz activity

Data from the low-energy ME-tOSXR array

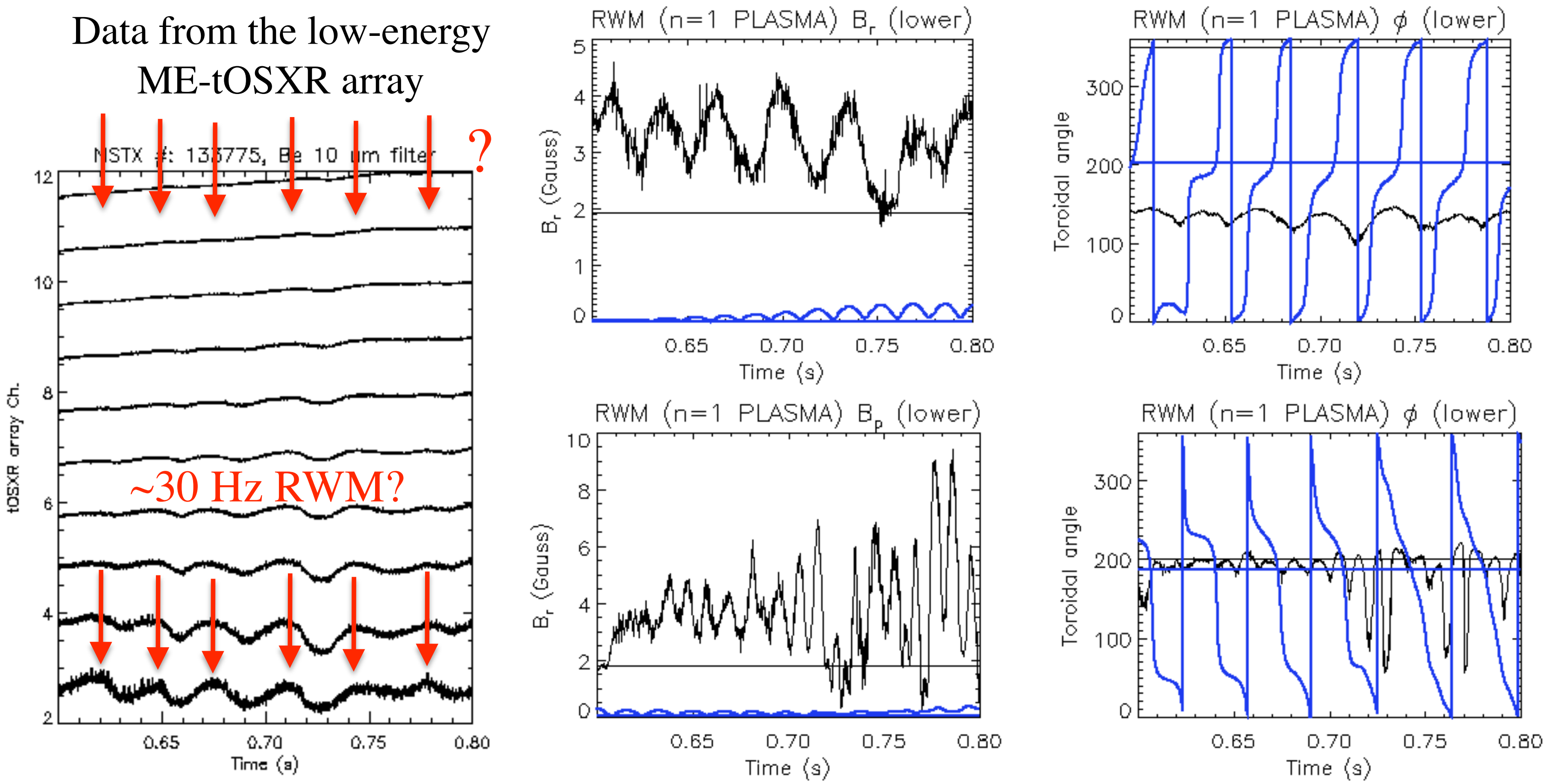


Normalized carbon density from CHERS



- CHERS data also indicated presence of ~30 Hz n=1.
- n_C and T_i at the edge are correlated.
- n_C at the edge and core appear to have an offset.
- Appear to be ***smaller*** perturbations than the observed ~20 Hz n=1 RWM. Need to quantify!

Good correlation between SXR and magnetics



- RWM coils also indicated presence of ~30 Hz *n*=1.
- Invert the data ⇒need to quantify with respect to the observed ~20 Hz RWM.
- Why are the toroidal phases different?
- Does the fluid displacement has an offset (π) with respect to the magnetic phase?
- Run DCON!!!

Summary