Supported by Office of Science

XP802: Active RWM stabilization system optimization and ITER support

College W&M
Colorado Sch Mines
Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Maryland
U Rochester
U Washington
U Wisconsin

S.A. Sabbagh[1], R.E. Bell[2], S. Gerhardt[2], J.E. Menard[2], J.W. Berkery[1], J.M. Bialek[1], D.A. Gates[2], B. LeBlanc[2], F. Levinton[3], K. Tritz[4], H. Yu[3]

[1]*Department of Applied Physics, Columbia University*

[2]*Princeton Plasma Physics Laboratory*

[3]*Nova Photonics, Inc.*

[4]*Johns Hopkins University*

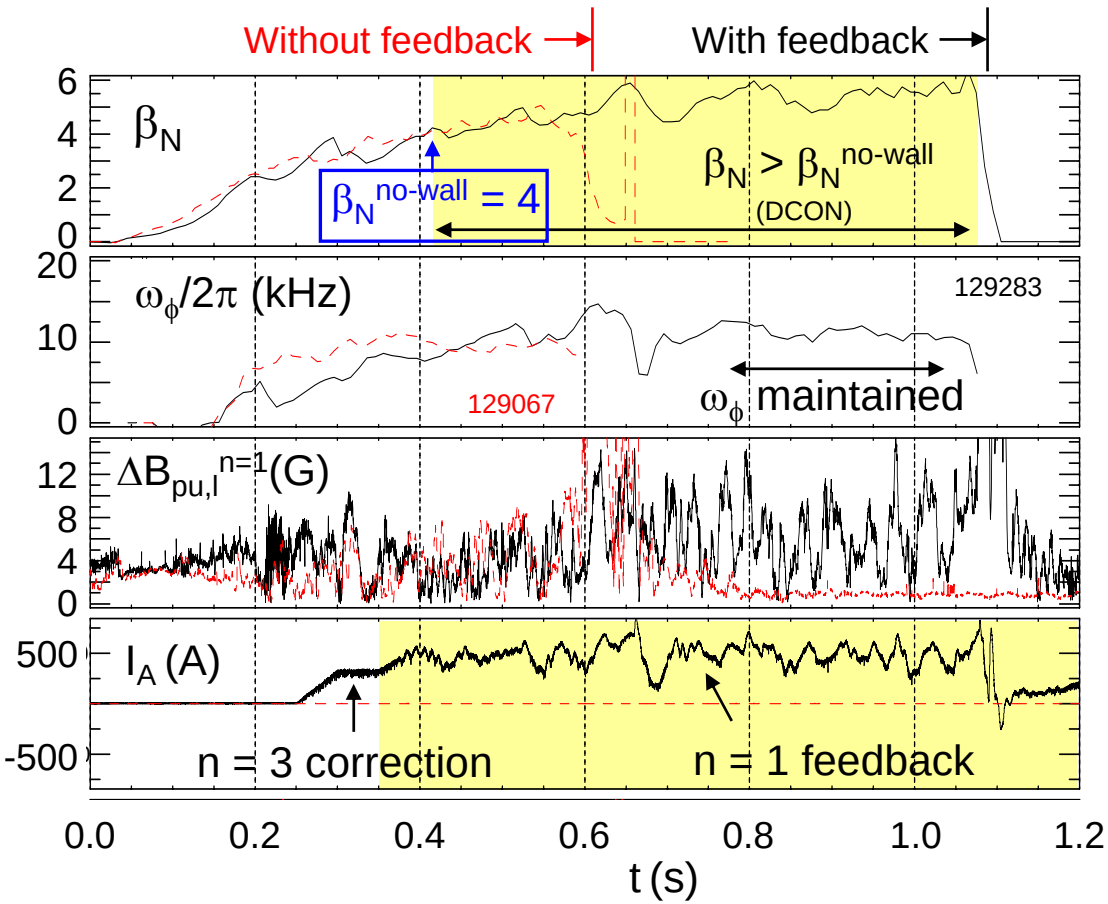
Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

NSTX Results Review
Princeton Plasma Physics Laboratory
August 7th, 2008

XP802: Active RWM stabilization system optimization and ITER support

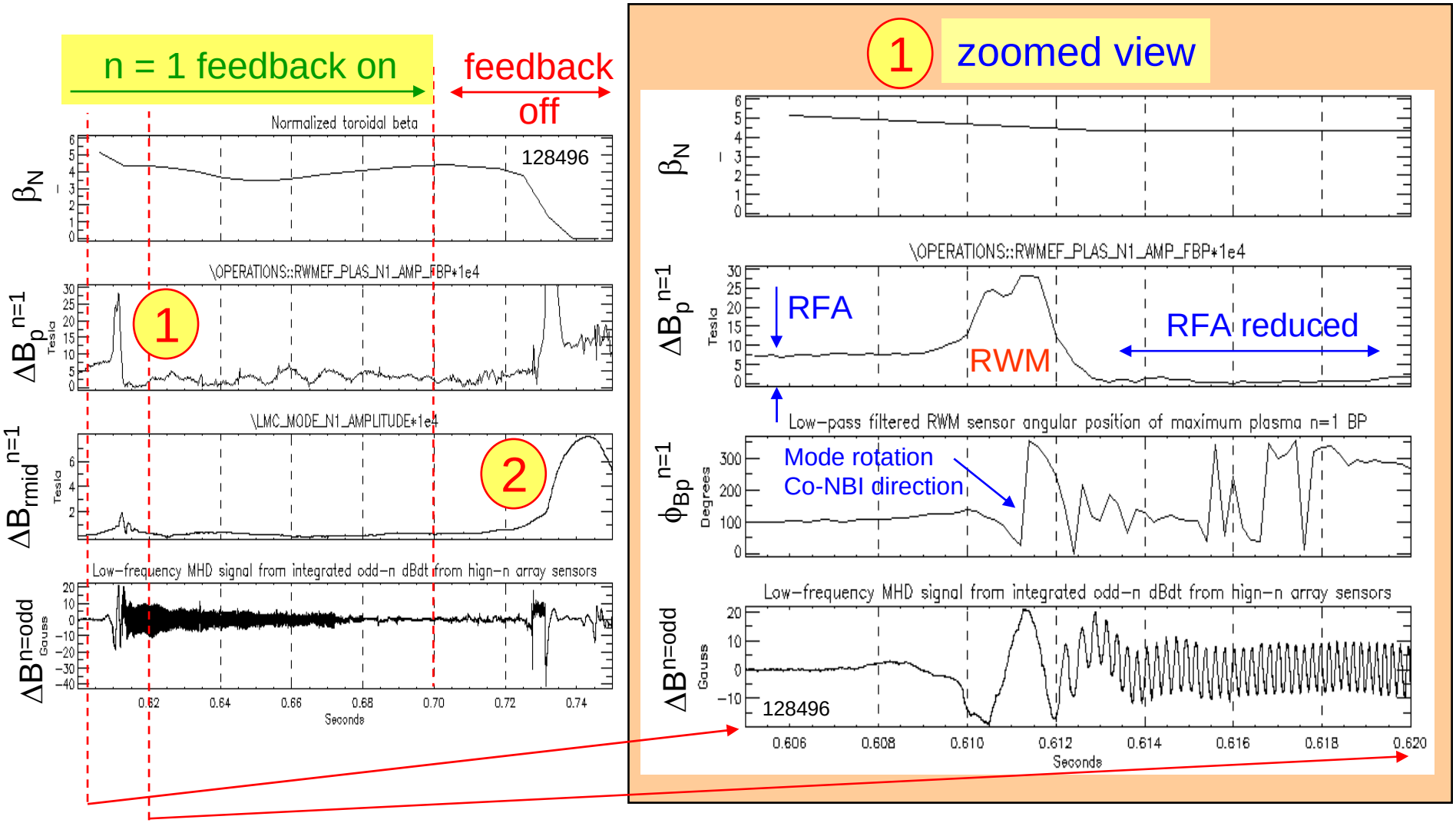
- Goals
  - Alter active control configuration to achieve highly reliable RWM stabilization at various plasma rotation, ω_ϕ
    - Upper/lower RWM B_r, B_p sensors, follow from best CY2007 feedback settings
    - B_r sensor feedback provides RFA correction, B_p provide RWM stabilization
    - Determine if stable, low $\omega_\phi < \omega_{*i}$ operation exists with feedback turned off
    - If achieved, control system open as a tool for all NSTX XPs as desired
  - Specific ITER support requests
    - Study effect of applied time delay on feedback (requires control system time delay capability)
    - Determine impact of a large toroidal gap on active RWM stabilization to simulate ITER port plug coil geometry (take out one of six control coils)
- Progress
  - B_r sensors used successfully with B_p sensors for n = 1 feedback control
  - n = 1 control system used as tool in many XPs; dynamics examined
  - ITER support requests examined with limited run time

Active RWM control and error field correction maintain high β_N plasma



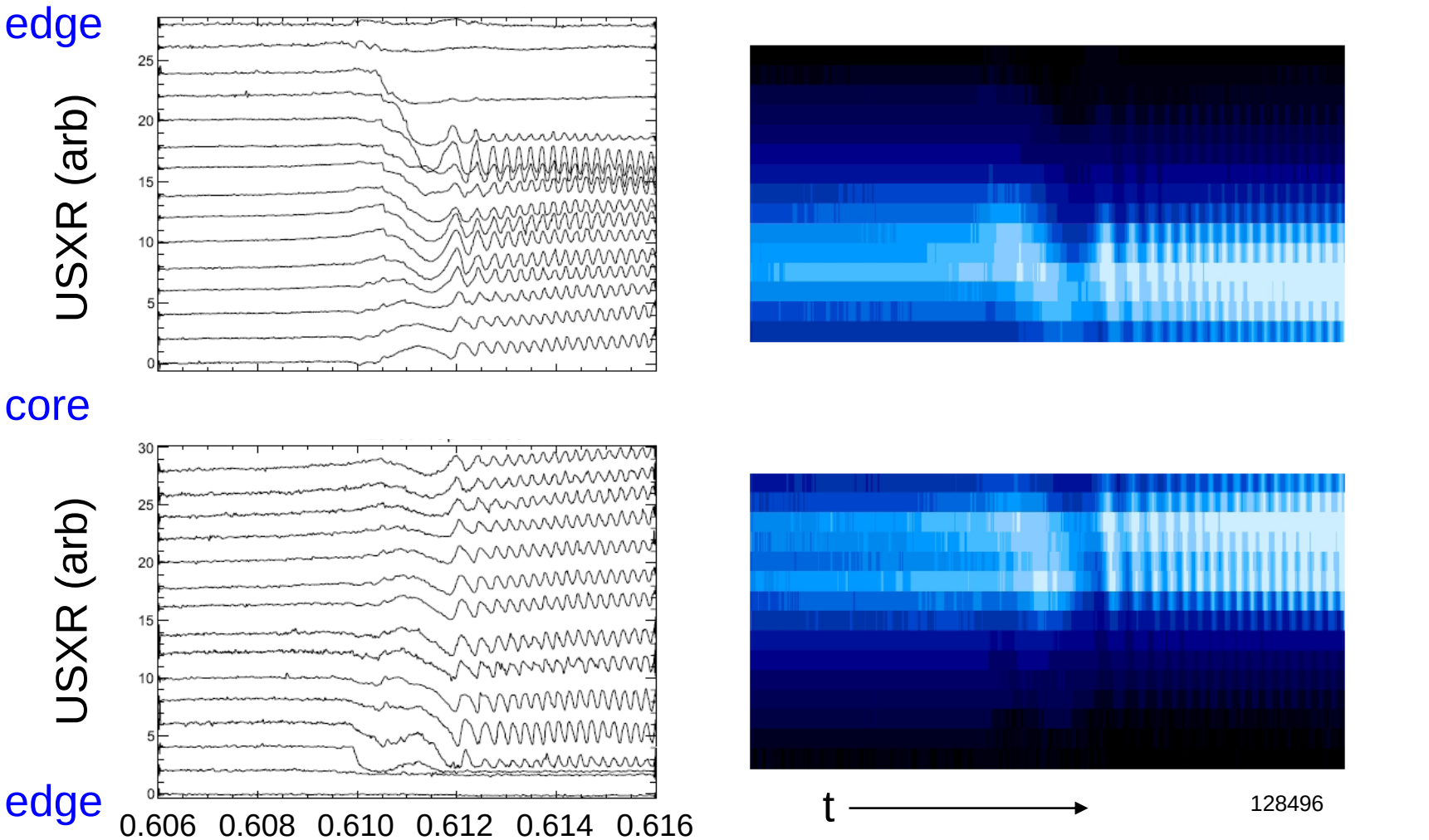
- n = 1 active control
  - Upper/lower B_p sensors
  - Favorable B_r feedback settings found in 2008
  - Fast response ~ 1 ms
- n = 3 DC field correction
  - best maintains ω_ϕ
  - but - RWMs observed w/o feedback at high ω_ϕ
- NSTX record pulse lengths
  - Up to 1.8s (shown previously)
- n = 1 feedback now being used as tool in many XPs
  - > 200 shots in 2008 with active feedback in 10 XPs
- Present goal to increase reliability, performance
  - Feedback success ~ 74%
    - RWM more likely when NTM stabilized (e.g. by lithium)
    - Poloidal deformation of mode

Initial RWM evolves into rotating global kink during n=1 feedback



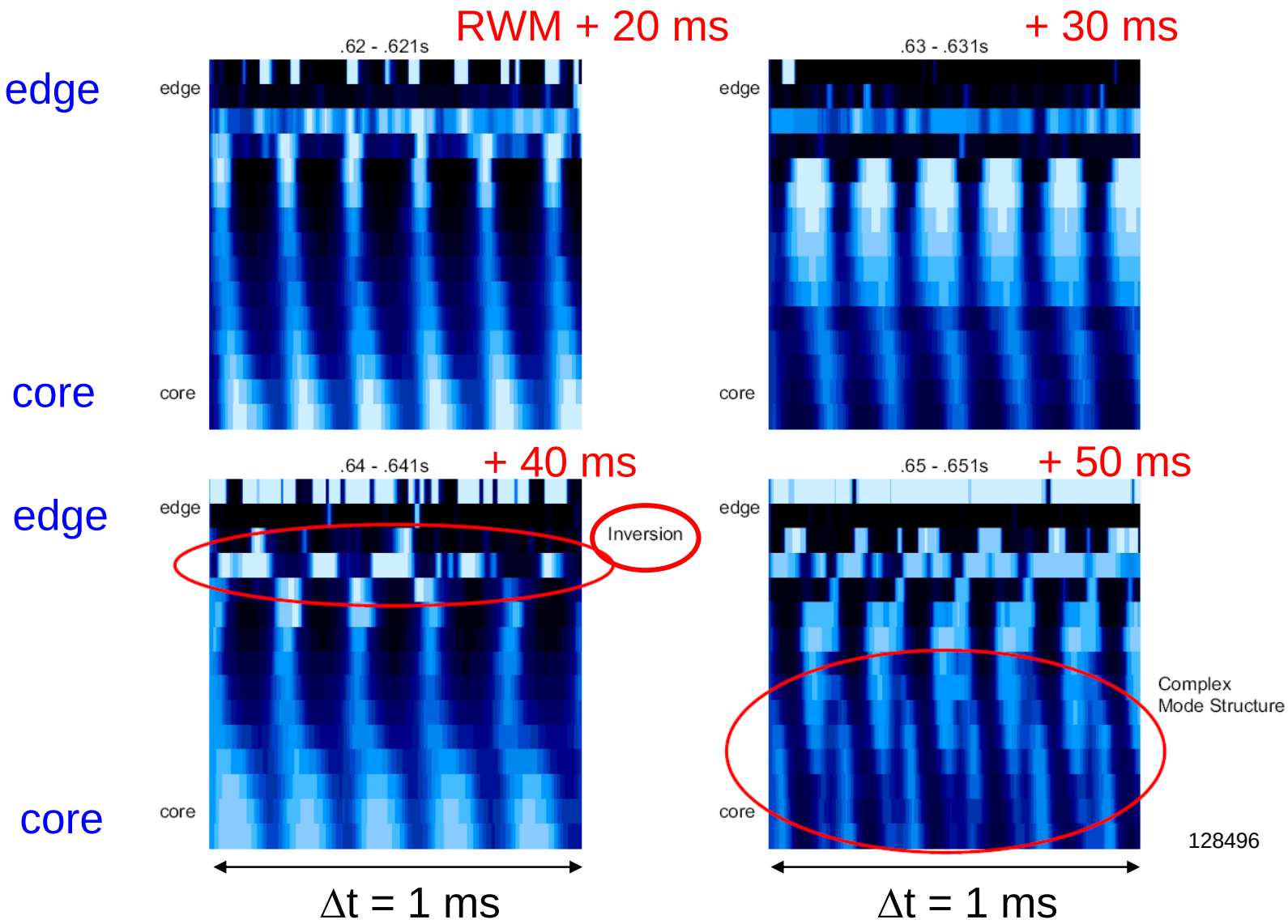
- Plasma suffers beta collapse 2 after feedback is turned off

1 Soft X-rays show transition from RWM to global kink

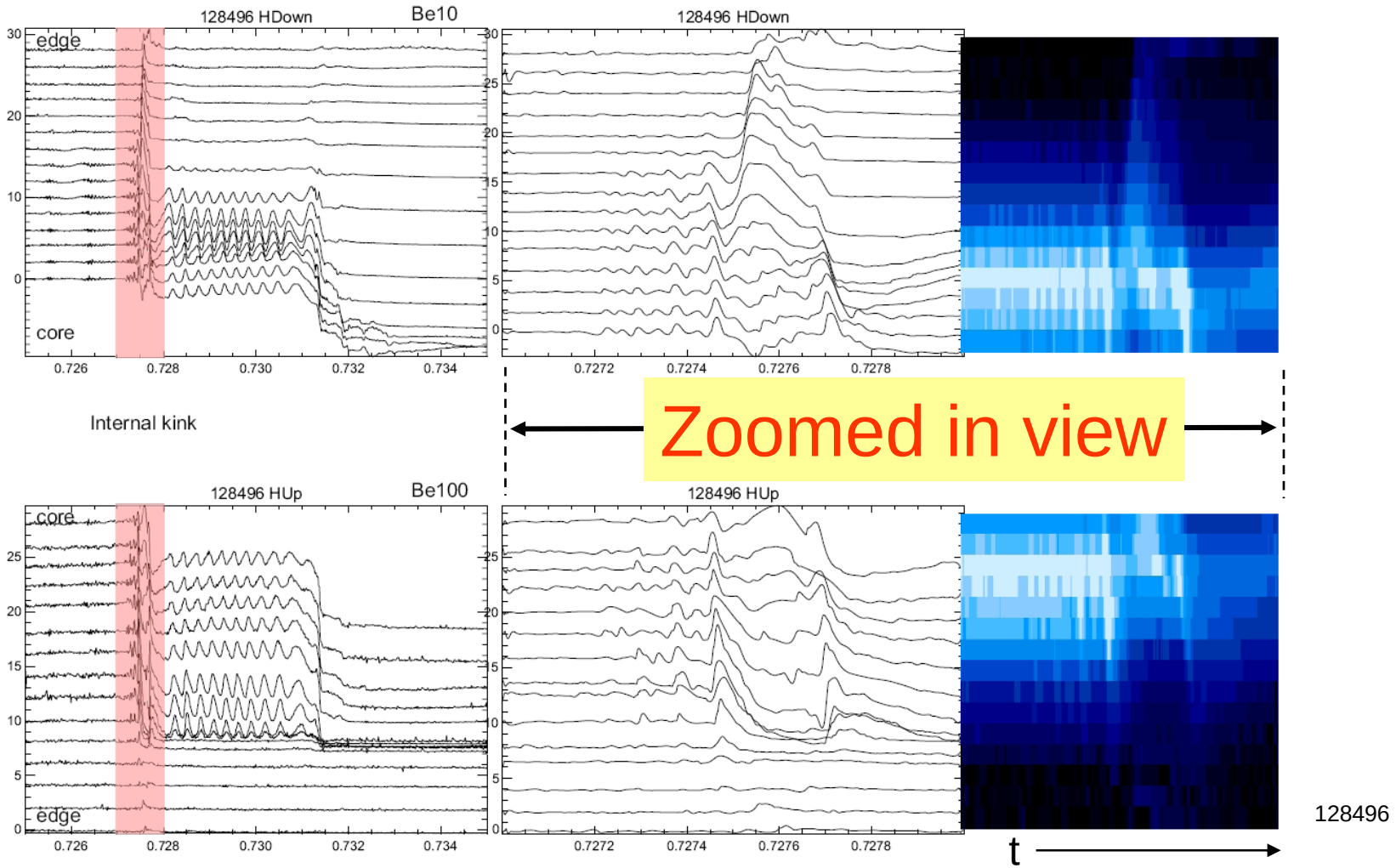


- Initial RWM locked signature spins up, amplitude dies away

Tearing mode appears significantly after global kink onset

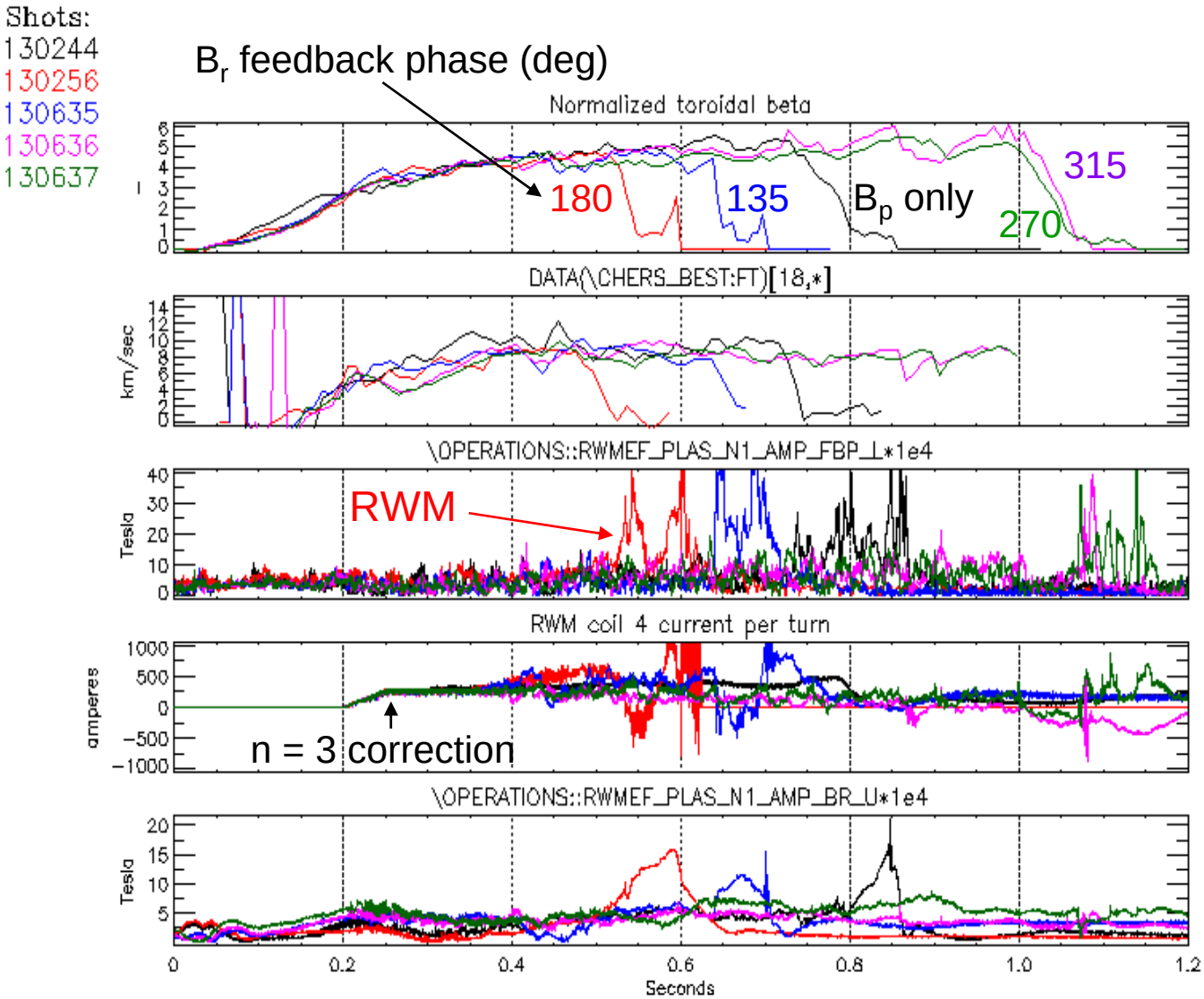


2 Terminating event appears to be an internal kink



- n = 1 LMD shows mode lock (RWM?) preceding/concurrent w/kink
- Internal kink more prominent in long pulse, lithium conditioned plasmas

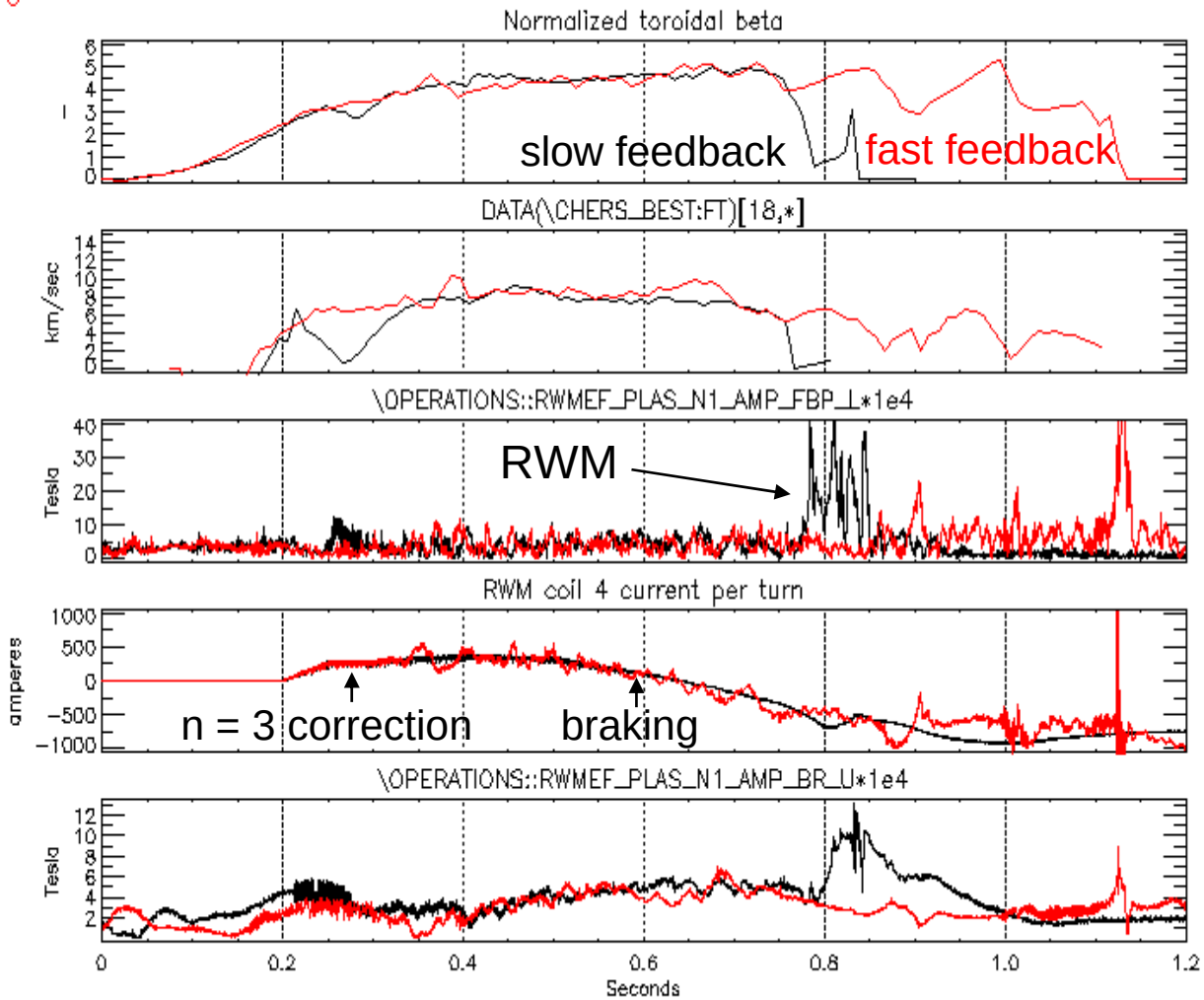
Favorable feedback settings found for B_p + B_r sensors



- Steady V_ϕ
  - N = 3 EFC + n = 1 feedback
- B_r feedback phase scan
  - All RWM sensors used
  - Favorable B_p feedback settings
  - B_r gain, phase varied to find best settings

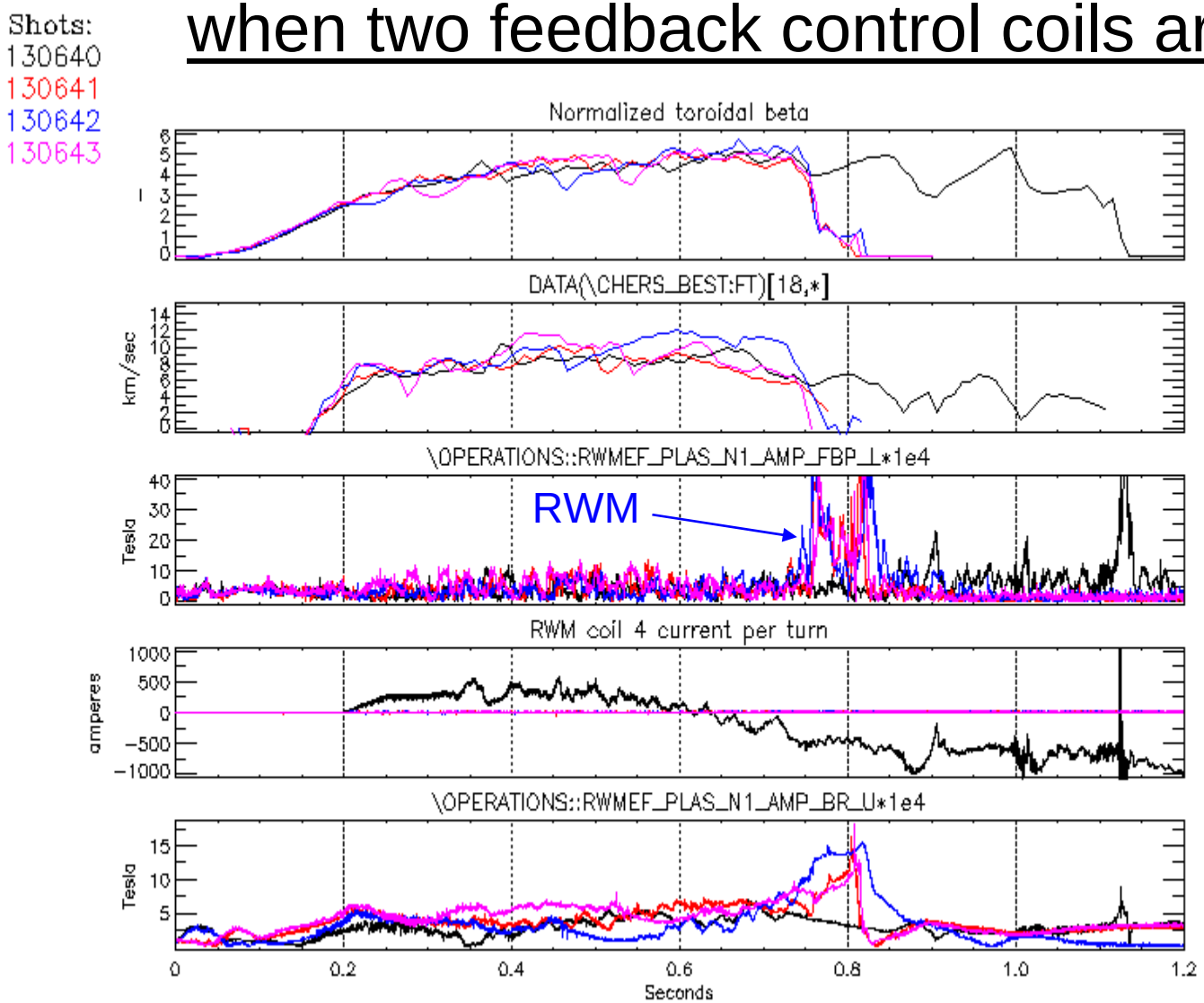
ITER support: Low V_ϕ, high β_N plasma not accessed when feedback response sufficiently slowed

Shots:
130639
130640



- Low V_ϕ access for ITER study
  - use n = 3 braking
- n = 1 feedback response speed significant
  - "fast" (unfiltered) n = 1 feedback allows access to low V_ϕ, high β_N
  - "slow" n = 1 "error field correction" (75ms smoothing of control coil current) suffers RWM at V_ϕ ~ 5kHz near q = 2

ITER support: Low V_ϕ, high β_N plasma not accessed when two feedback control coils are disabled



- Low V_ϕ access for ITER study
  - use n = 3 braking
- n = 1 feedback doesn't stabilize plasma with coils disabled
  - scenario to simulate failed coil set in ITER
  - Feedback phase varied, but no settings worked
  - RWM onset at identical time, plasma rotation
  - Will examine cause of control loss

XP802 results show RWM control details at various V_ϕ

- General conclusions (so far)
  - n = 1 feedback system has produced far greater reliability of discharge avoiding RWM
    - More detailed statistics being compiled
  - n = 1 feedback system does not insure stability against RWM
    - e.g. failures from fast mode growth, mode deformation
  - Mode characteristics appear to be RWM, not tearing
    - Unlike present observation/conclusion by DIII-D
    - Mode spin up, converts to global kink mode initially, tearing appears later
    - Feedback system might be easing transition to rotating kink by altering boundary condition
  - Full RWM sensor set used in feedback
  - Increased “latency” for control current activation reduces effectiveness of RWM control
  - Deactivating two diametrically opposed control coils defeats feedback
    - Further analysis to determine reason for feedback failure