Supported by

Office of Science

NSTX

XP-823: Robustness of improved error field suppression in long-pulse discharges

College W&M
Colorado Sch Mines
Columbia U
Comp-X
FIU
General Atomics
INL
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

Jon Menard, PPPL

NSTX Physics Meeting
PPPL
May 19, 2008

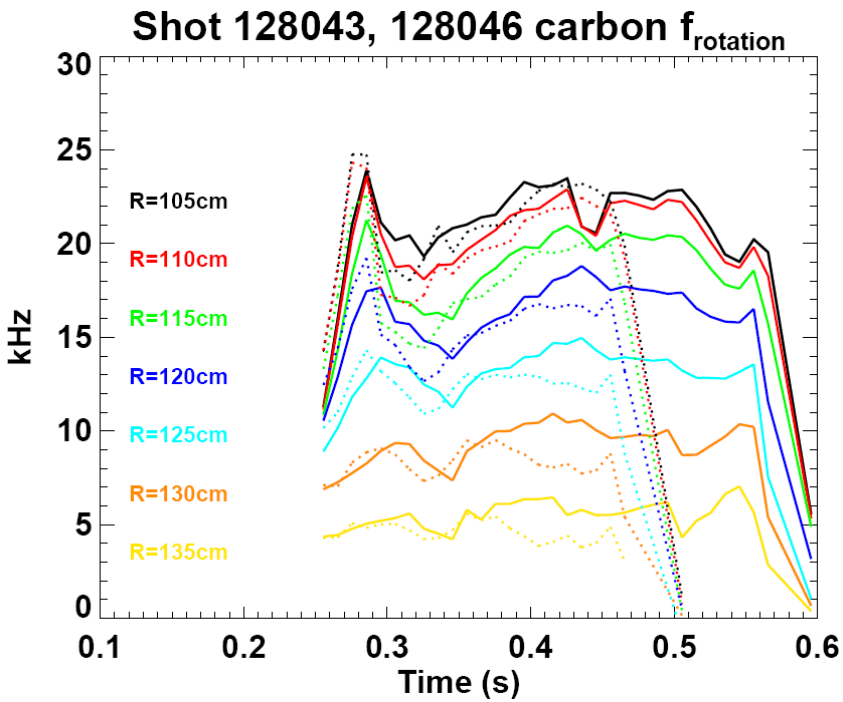
Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
IPP AS CR
U Quebec

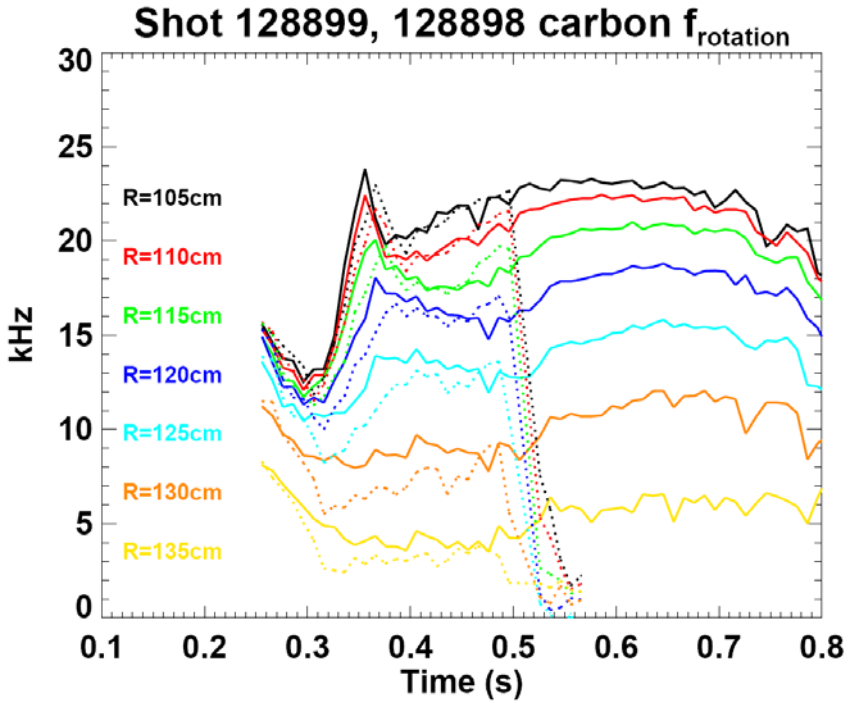
n=3 error field measured at 0.75MA and 1.1MA

Expands 2007 data set obtained at 900kA

n=3 field applied at t=0.25s

Corrective = solid
Anti-corrective = dashed





- 750kA: optimal $I_{SPA\text{-}n=3}$ = 300-400A
- 1.1MA: optimal $I_{SPA\text{-}n=3}$ = 500-600A
  - Corrective field (roughly) proportional to PF5 and plasma current
    - No measurable n=2 EF (S. Gerhardt)

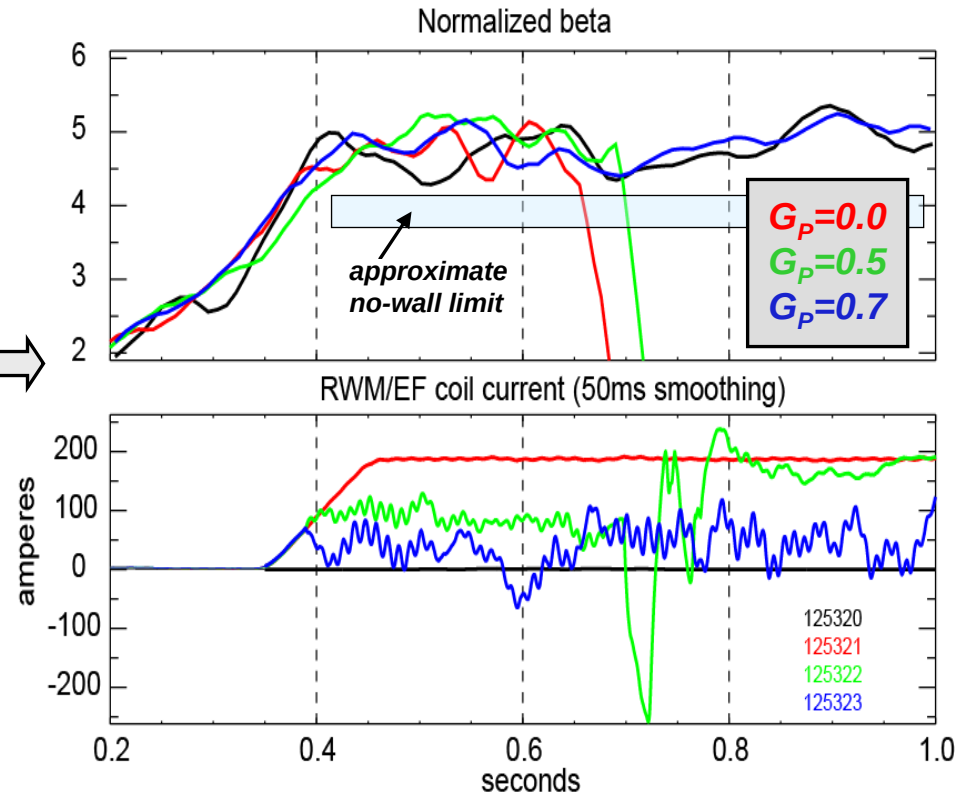
    → n=3 EF most likely due to PF5 coil, which is known to have n=3 asymmetry

In 2007, using optimized B_P sensors in control system allowed feedback to provide most/all n=1 error field correction at high β

- **Previous n=1 EF correction required a priori estimate of intrinsic EF**
- Additional sensors → detect modes with RWM helicity → increased signal to noise
- Improved detection → higher gain → **EF correction using *only feedback on RFA***

EFC algorithm developed in FY07:

- Use time *with minimal intrinsic EF* and RWM stabilized by rotation
- Intrinsic Ω_ϕ collapse absent in 2007 **→ purposely apply n=1 EF to reduce rotation, destabilize RWM**
- Find corrective feedback phase that reduces applied EF currents
- Increase gain until applied EF currents are nearly completely nulled and plasma stability restored
- **Then turn off applied error field (!)**



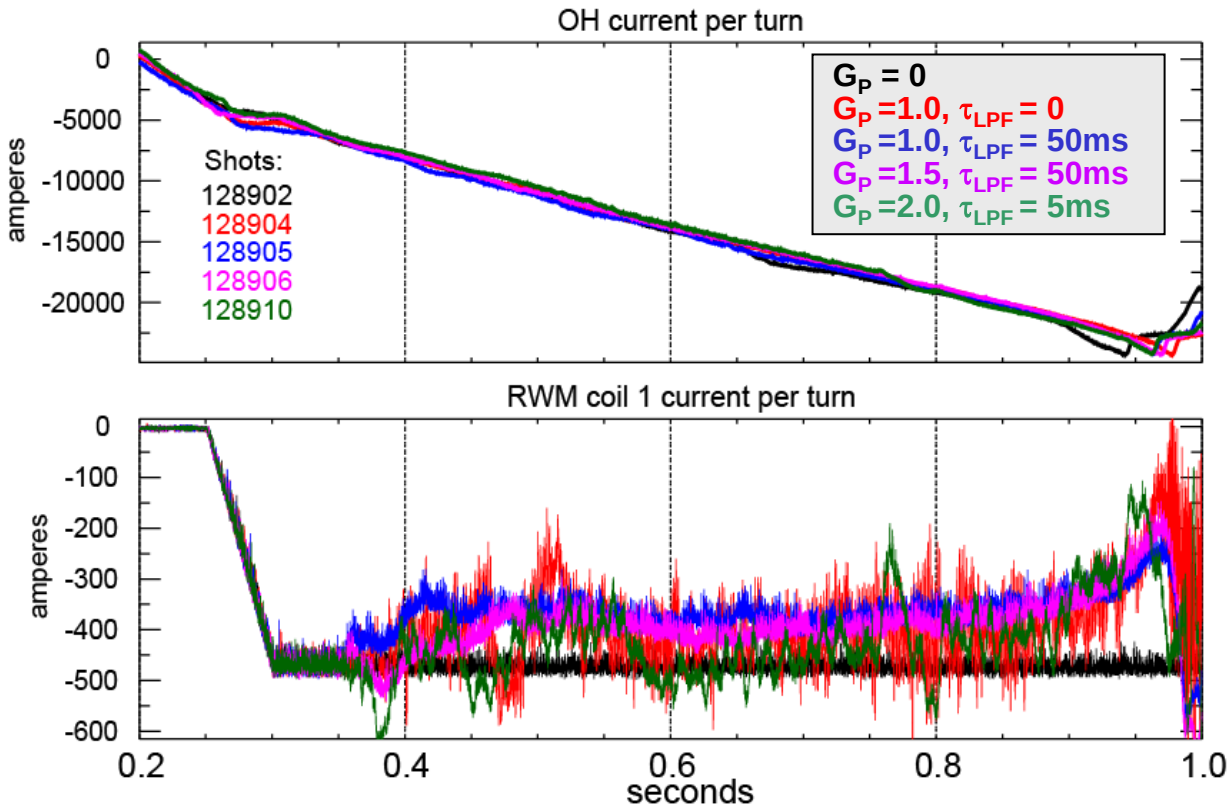
→ *Use same gain/phase settings to suppress RFA from intrinsic EF **and** any unstable RWMs*

n=1 feedback gain, LP filter optimized for I_P= 1.1MA

Expands 2007 data set at 900kA

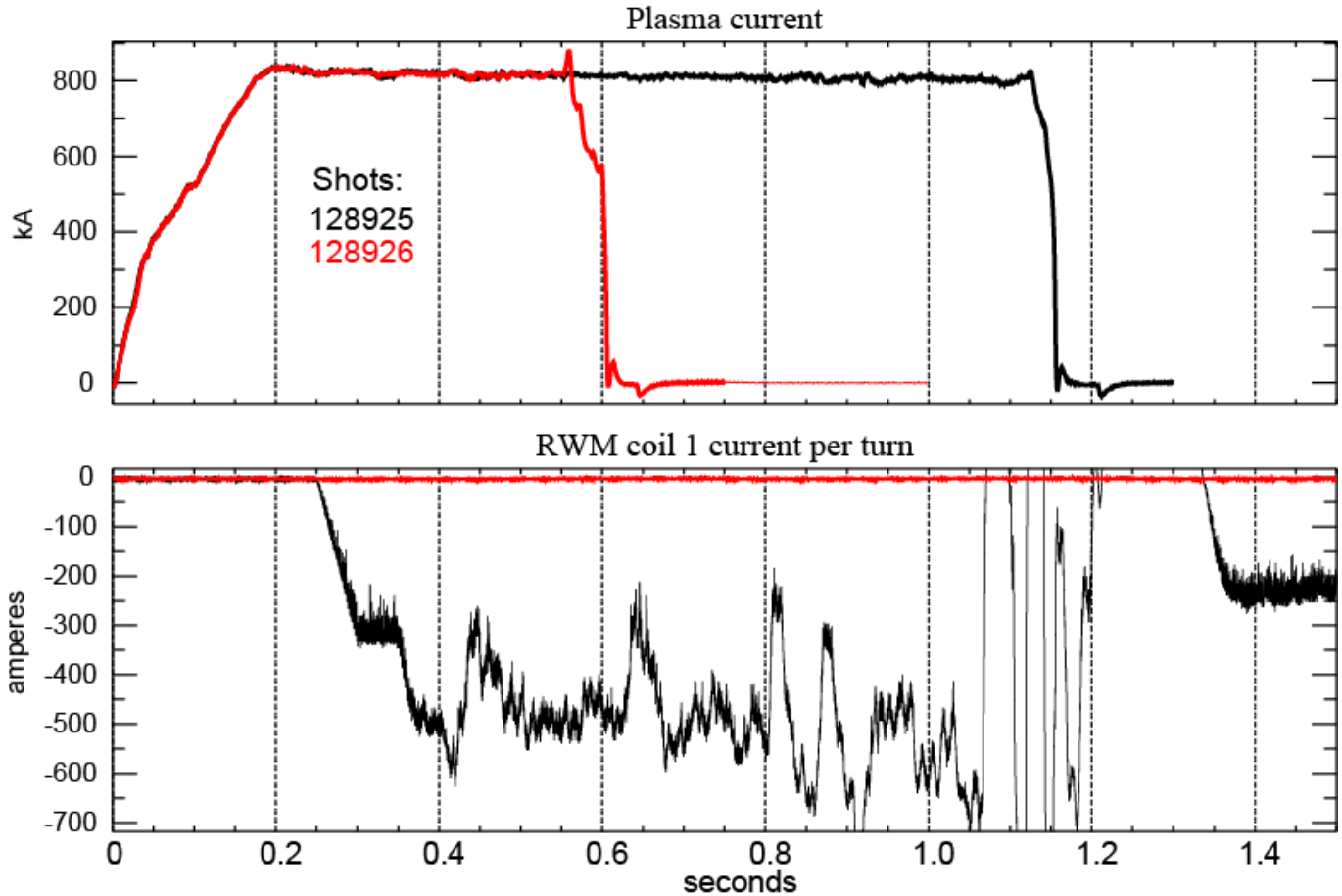
- Instead of applying known n=1 EF, used OHxTF EF (1.1MA uses full OH swing)
- Used B_P U/L averaging from 2007, included n=3 EFC (new for 2008)
- Increased gain scan by factor of 3: 0.7 in 2007 → up to 2 in 2008
  - Response to n=1 RFA from OHxTF error field changes little for $G_P > 1$
  - System marginally stable at $G_P = 2$ for τ_{LPF} as low as 1-2ms

→ **Optimal control parameters: G_P = 1-1.5, τ_{LPF} = 2-5ms**



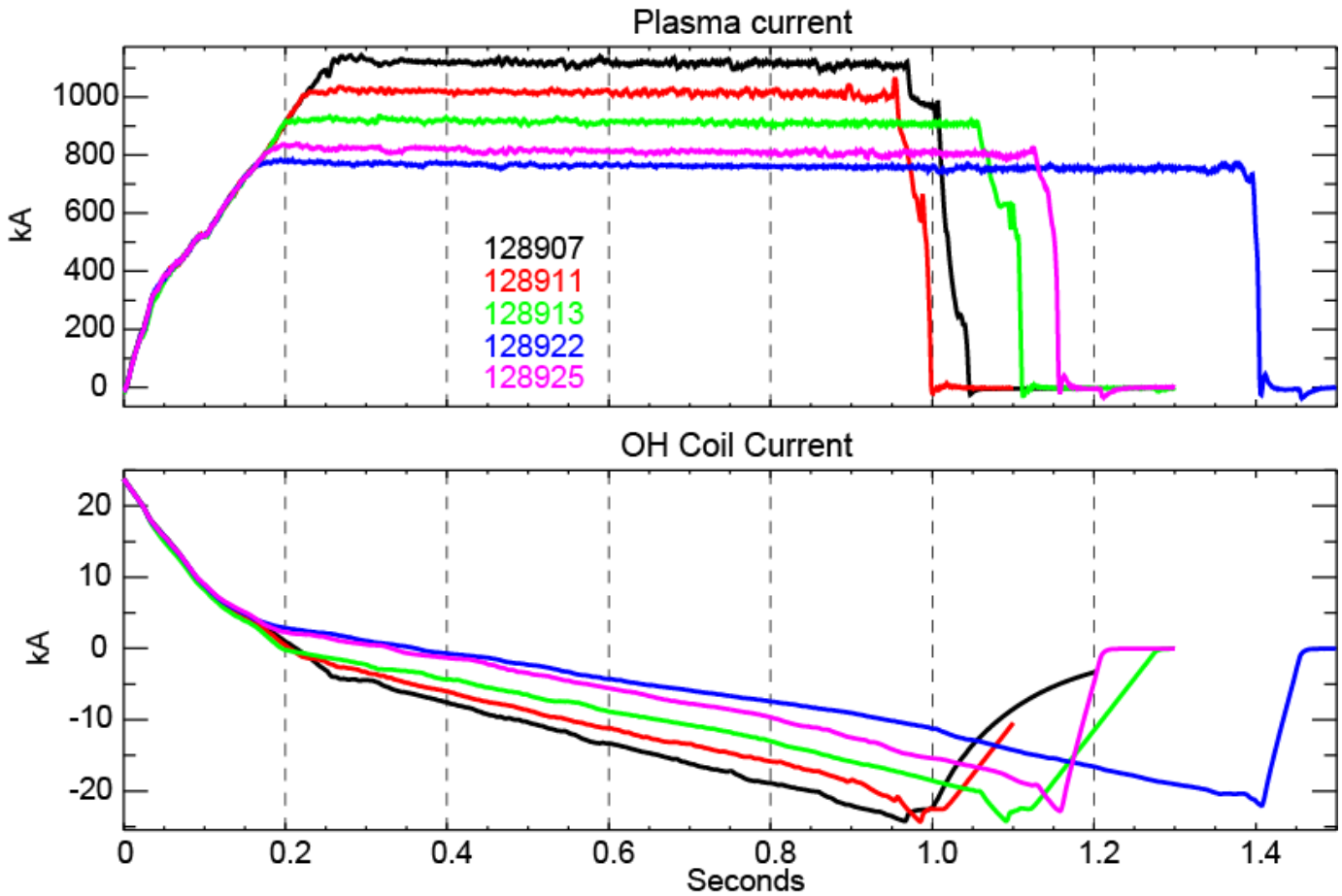
n=3 EFC + n=1 feedback important at lower current (< 900kA) for extending pulse lengths

- Pulses commonly disrupt near ~ 0.6s w/o mode control
  - At high beam power (high β_N = 5.5→ 6), mode control insufficient to avoid disruption (not shown)



n=3 EFC + n=1 feedback was successfully applied to wide range of plasma current = 0.75-1.1MA

- Pulses run reliably until nearly all OH flux is consumed



Optimized mode control + Lithium → record NSTX pulse-lengths

- Flux consumption reduced following LITER experiments
  - Lower V_{LOOP} at lower P_{NBI}

- Li + optimized EFC →
  - Avoid late n=1 rotating mode
  - rotation sustained
  - $\beta_N \geq 5$ sustained 3-4 τ_{CR}
  - record pulse-length = 1.8s