NSTX-U

Supported by

U.S. DEPARTMENT OF ENERGY | Office of Science

# Real-time Error Field Compensation in NSTX-U using Extremum Seeking Control

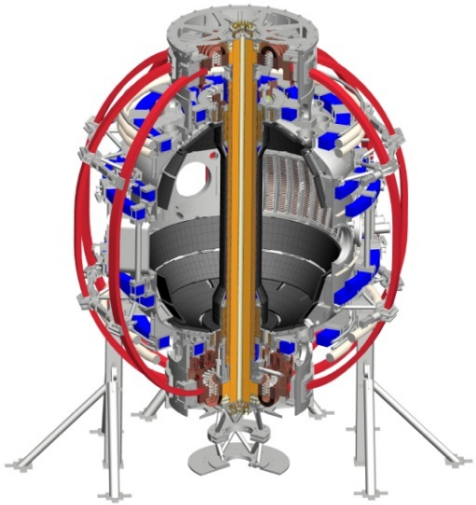

**Matthew J. Lanctot (GA)**

*with D. Boyer, D. Humphreys, R. La Haye, E. Olofsson, J.-K. Park, S.A. Sabbagh*


**NSTXU 2015 Research Forum**
**PPPL**
**February 24, 2015**


Coll of Wm & Mary
Columbia U
CompX
General Atomics
FIU
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Lehigh U
Nova Photonics
ORNL
PPPL
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Tennessee
U Tulsa
U Washington
U Wisconsin
X Science LLC

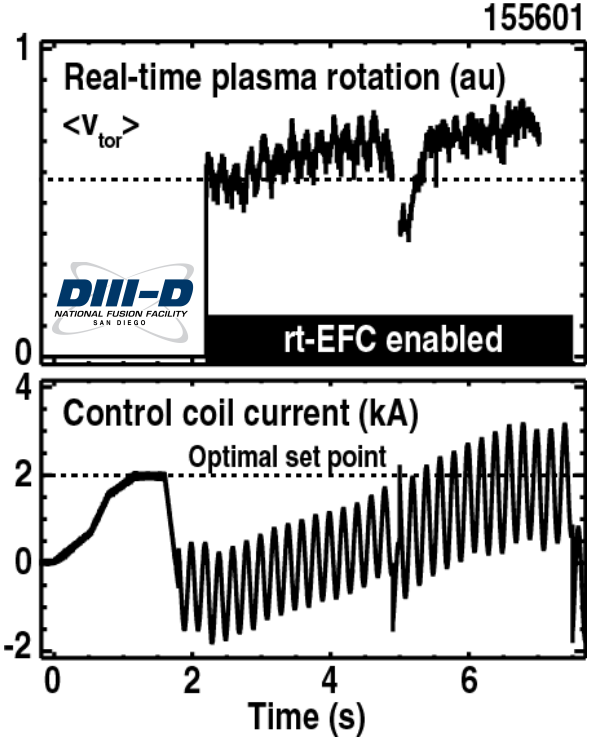
Culham Sci Ctr
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Inst for Nucl Res, Kiev
Ioffe Inst
TRINITI
Chonbuk Natl U
NFRI
KAIST
POSTECH
Seoul Natl U
ASIPP
CIEMAT
FOM Inst DIFFER
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

# A new real-time error field control algorithm based on extremum seeking control has been demonstrated on DIII-D

- **Issue: Disruption-free error field optimization techniques needed for present and future devices**

- **Requirements/constraints**
  - Track potentially time varying error fields and changing plasma conditions
  - Optimize multi-harmonic fields (n's & m's) using multiple coil sets




- **Extremum seeking control techniques are effective on DIII-D**
  - Use n=1 low frequency dither to probe plasma rotation response
  - Signal processing of rotation measurements extracts optimal coil currents that maximize rotation (agrees with other methods)
  - Present work: Improve convergence, reduce dither amplitude

# Long-term goal is to qualify extremum seeking error field control for ITER & compare against other techniques

- **Near-term goal:** Generalize algorithm to multi-harmonic fields and multiple coil sets & demonstrate on multiple devices
  (supports ITPA MHD Joint experiment on error field control)

- **Advantages**
  - Algorithm optimizes an n=0 performance metric (not n>1)
  - Requires no complex system model, allows rapid development
    - Commissioned on DIII-D <2 hours
  - Plasma response measurements obtained in parallel & can be used to track global plasma stability, control NBI power, ect.

- **Proposed Effort** (#3 can be combined with other efforts)
  1) Implement in NSTX-U PCS: ~ 1 month + offline simserver testing
  2) Commission algorithm: piggyback + >0.25 days experiment
  3) Use algorithm to attack high beta & low collisionality: 0.5-1 day