NSTX-U

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NSTX-U Collaboration Status and Plans for the UCLA Plasma Diagnostic group

Principal Investigator, Tony Peebles

Contributing researchers,

Neal Crocker, Shige Kubota,

Troy Carter, Jie Zhang (Graduated Student)

NSTX-U Collaborator Research Plan Meetings
PPPL – LSB B318
April / May 2014

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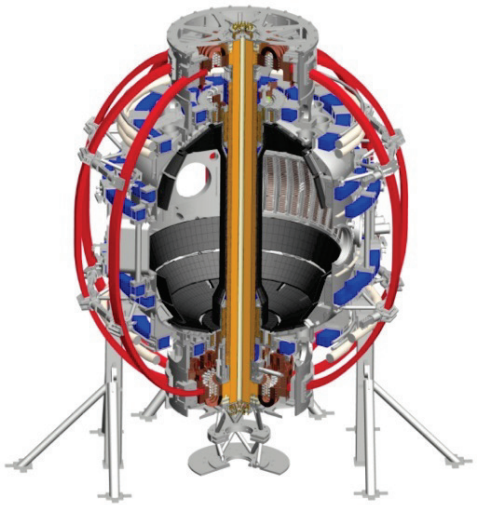

Culham Sci Ctr
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Chonbuk Natl U
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Seoul Natl U
ASIPP
CIEMAT
FOM Inst DIFFER
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

FY 14 status in preparation for NSTX-U operations in FY2015

- Multi-channel (16) reflectometry installation
  - Required new antenna interface shipped to PPPL for vacuum check and installation
  - Equipment rack relocation
    - After vacuum interface installed and rack position confirmed, UCLA will then ship millimeter-wave systems to PPPL for installation in rack
    - At this time custom waveguide runs will have to be fabricated and installed – ideally need to have CAD drawing indicating obstacles/access
    - Data Acquisition will also require re-installation and test
- 288GHz mid-plane polarimeter - status
  - Originally planned as NSTX student thesis (Jie Zhang)
    - Relocated to DIII-D due to early NSTX termination. Jie Zhang graduated December 2013 with multiple publications.
    - System was irradiated at DIII-D and remained “radioactive” until recently
    - System now at UCLA. Plan to upgrade and test prior to shipping to PPPL.

Research Plans for FY2015 and FY2016

- Multi-channel reflectometry will be fully operational for first NSTX-U plasma
  - Due to prior budget reductions system will likely not access core plasma for **high performance** plasmas ($n_{max} < 7x10^{19}$ m^{-3})
    - Full access to core plasma requires higher frequencies
    - Well-suited for edge/pedestal regions
    - In L-mode, core coverage possible for study of fast-ion driven modes
- Mid-plane polarimetry likely not available for first plasma
  - For reliability and S/N improvement, existing detectors will have to be replaced and system re-optimized at UCLA.
  - Installation onto NSTX-U non-trivial due to quasi-optical nature of system and uncertainties re physical access
    - Design of structural support requires more detail re restrictions in the pit prior to installation
    - Note that the system can also operate (alternatively) as a a mid-plane interferometer

Ideas to enhance participation in NSTX-U research/program by U.S. Universities, early-career researchers, and students

- Hundreds of University researchers are involved in fusion research
  - Current DoE solicitations for early career researchers **EXCLUDE** University researchers – only cover tenure track faculty.
    - National Laboratory researchers can write proposals for up to **$500k/yr**.
    - Tenure track professors can write proposals for up to **$150k/yr**.
- University Researchers can respond to most DoE solicitations, but NOT the early career solicitations
  - **This is definitely NOT motivational !!**
  - University Faculty need research staff to broaden research, supervise students, etc. Most encourage researchers to be Principal Investigators
  - Universities and DoE both need researchers, and need to **attract the very best talent**.
  - **An Early Career Program for University researchers achieves this.**
  - **Would allows proposals to be written for NSTX-U research**

Ideas to enhance participation in NSTX-U research/program by U.S. Universities - - - continued

- PPPL could also increase outreach to Universities by
  - Increasing University Researcher participation in Joint Proposals
  - Actively encouraging proposals from University Researchers to DoE, NSF, etc. that **directly benefit NSTX-U** – such encouragement could also target other activities at PPPL
  - Direct PPPL funding of small, targeted 1-year NSTX-U subcontracts with University Researchers
    - This would directly benefit Researchers by raising their stature, both within and outside of the University, while also providing exposure to increased opportunities
    - Also such contracts can act as a stepping stone to full DoE Grants
  - Allocation of space for a "diagnostic test laboratory" similar to that in existence at DIII-D

Highest-priority incremental measurement capability

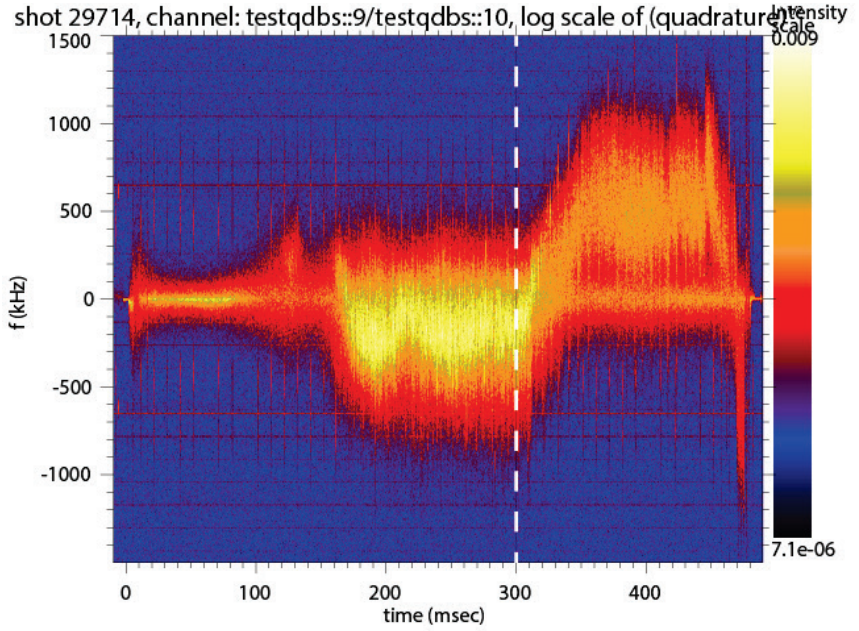
- Three possible incremental levels for UCLA PDG
  - Short time-scale (< 1year), modest cost: **upgrade REFLECTOMETER**
    - Add **four high frequency** channels to 16 channel reflectometer array to improve core access in high performance plasmas**. Allows access to density cutoffs up to 1x10^{14} cm^{-3}**
  - Moderate time-scale (2 years), moderate cost : **DBS**
    - Introduce Doppler Backscattering into NSTX-U
    - **Recently demonstrated using via collaboration between UCLA and CCFE on MAST**
      - Measured plasma flow in core, Alfvenic instabilities, intermediate k turbulence, GAMs, etc.
    - Ideally requires increased port access (large window - >15cm)
  - Longer timescale, significant cost : **Magnetic fluctuations via CPS**
    - **C**ross **P**olarization **S**cattering under development on DIII-D
      - Terry Rhodes, Principal Investigator
      - Ideally, requires multiple views to provide **localized**, k-resolved measurement
    - **Potentially VERY powerful diagnostic for NSTX-U high beta plasmas**

DBS data from MAST using NSTX Hardware

Jon Hillesheim (CulhamCentre for Fusion Energy) :

Invited Talk at upcoming HTPD Conference - also presented at 2014 EPS Conference

- Collaboration (UCLA-CCFE). NSTX 16 channel reflectometer hardware shipped to MAST
  - DBS on MAST requires toroidal and poloidal steering
  - Lot of data gathered re fast-ion driven modes, edge pedestal, intrinsic plasma rotation, GAM activity, etc.
  - Example; Core rotation in Ohmic plasma changes by ~10 km/s with ~20% change in density
    - Thought to be related to collisionality dependence of turbulent momentum transport (e.g. Barnes PRL 2013)



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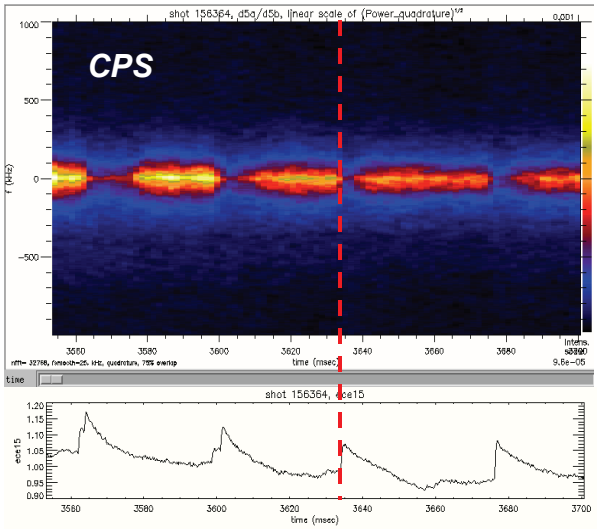
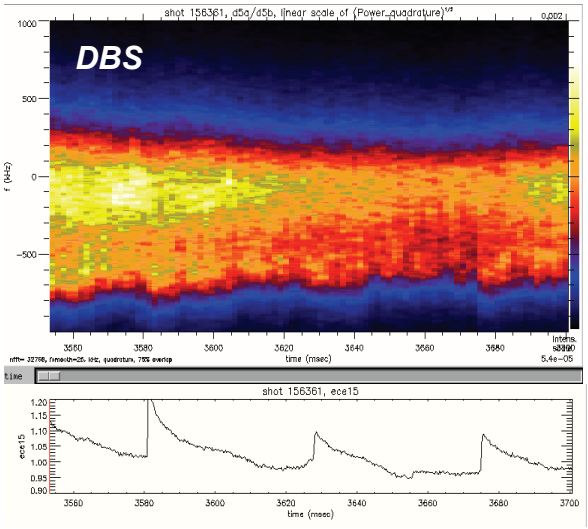
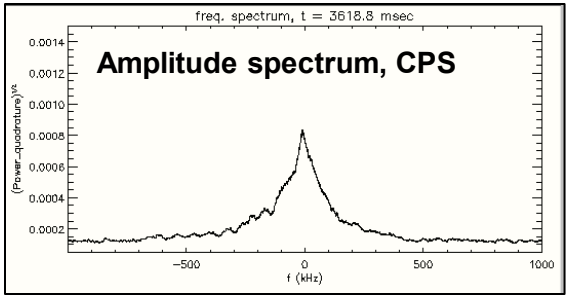
Preliminary CPS (magnetic fluctuations) data from DIII-D

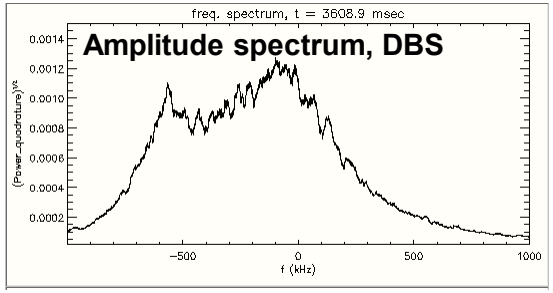
DoE Plasma Diagnostic Development Grant : Terry Rhodes, PI

DBS and CPS data were obtained on virtually identical, sequential sawtoothing L-mode discharges.
As can be seen the evolution and spectra of the CPS and DBS data are quite different









- Sequential L-mode shots with near identical sawteeth
- CPS indicates low frequency fluctuations up to the sawtooth crash (see ECE signal)
- **Contrasts with steadier, higher freq. DBS spectra from intermediate k density turbulence**

J. Zhang (UCLA Graduated Student) Major Publications

- "Interaction between Faraday rotation and Cotton–Mouton effects in polarimetry modeling for NSTX", **J. Zhang**, N. A. Crocker, T. A. Carter, S. Kubota, and W. A. Peebles, Review of Scientific Instruments, **81**, 10D519 2010

- "Design of a millimeter-wave polarimeter for NSTX-Upgrade and initial test on DIII-D", **J. Zhang**, W. A. Peebles, T. A. Carter, N. A. Crocker, E. J. Doyle, S. Kubota, X. Nguyen, T. L. Rhodes, C. Wannberg, and L. Zeng, Review of Scientific Instruments, **83**, 10E321 2012

- "Simulation of microtearing turbulence in national spherical torus experiment", W. Guttenfelder, J. Candy,S. M. Kaye,W. M. Nevins,E. Wang, **J. Zhang**, R. E. Bell, N. A. Crocker, G. W. Hammett, B. P. LeBlanc, D. R. Mikkelsen,Y. Ren, and H. Yuh, Phys. Plasmas,**19**, 056119 (2012)

- "A sensitivity assessment of millimeter-wave polarimetry for measurement of magnetic fluctuations associated with microtearing modes in NSTX-U", **J Zhang**, N A Crocker, WA Peebles, T A Carter and W Guttenfelder, Plasma Phys. Control. Fusion, **55**, 2013, 045011

- "Experimental validation of Mueller-Stokes theory and investigation of the influence of the Cotton-Mouton effect on polarimetry in a magnetized fusion plasma" **J. Zhang**, W. A. Peebles, N. A. Crocker, T. A. Carter, E. J. Doyle, A. W. Hyatt, T. L. Rhodes, G. Wang, and L. Zeng, Phys. Plasmas, **20**, 102519 2013

- "Growth and decay of runaway electrons above the critical electric field under quiescent conditions", C. Paz-Soldan, N. W. Eidietis, R. Granetz, E. M. Hollmann, R. A. Moyer, J. C. Wesley, **J. Zhang**, M. E. Austin, N. A. Crocker, Wingen, and Y. Zhu, Phys.Plasmas **21**, 022514 (2014)