NSTX PPPL PRINCETON PLASMA PHYSICS LABORATORY Supported by U.S. DEPARTMENT OF ENERGY Office of Science

WPI Topical Science Group

Group discussion on status and plans for short-term EP activities

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

M. Podestà
G. Taylor, N. Gorelenkov

PPPL LSB-252

December 15th, 2010

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
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Do we have enough data/resources to make good progress in EP-related projects?

Two main areas:

- Measurements and modeling of High Frequency *AEs
  - Characterization of **GAEs/CAEs**
  - Impact on fast ion population still unclear
  - Good progress on studying effects on *thermal* transport (with T&T)

- Measurements and modeling of Low Frequency *AEs
  - Mainly targeting **TAEs/EPMs** and associated fast ion loss
  - Good case(s) identified for extensive theory/experiment comparison

Info will be useful to prepare WPI-EP overview

for next NSTX PAC meeting (Jan. 26-28, 2011)

Measurements/modeling of high frequency *AEs

Measurements/modeling of <u>high frequency</u> *AEs

- Characterization of **GAEs/CAEs**
  - Extensive set of data
  - Limited by uncertainties in **mode structure**, **polarization**?
    - Is information from updated reflectometers & BES enough?
    - Comparison with HYM predictions needs more resources?

Measurements/modeling of high frequency *AEs

- Characterization of **GAEs/CAEs**
  - Extensive set of data
  - Limited by uncertainties in **mode structure**, **polarization**?
    - Is information from updated reflectometers & BES enough?
    - Comparison with HYM predictions needs more resources?

- Impact on fast ion population
  - No clear signatures of fast ion losses
  - Indirect evidence of redistribution
    - Correlation between GAE/TAE avalanches, HEF on NPA, ...
  - Are there possible improvements in analysis of NPA, sFLIP, FIDA, ect. ?

Measurements/modeling of <u>high frequency</u> *AEs

- Characterization of **GAEs/CAEs**
  - Extensive set of data
  - Limited by uncertainties in **mode structure**, **polarization**?
    - Is information from updated reflectometers & BES enough?
    - Comparison with HYM predictions needs more resources?

- Impact on fast ion population
  - No clear signatures of fast ion losses
  - Indirect evidence of redistribution
    - Correlation between GAE/TAE avalanches, HEF on NPA, ...
  - Are there possible improvements in analysis of NPA, sFLIP, FIDA, ect. ?

- Effects of GAEs on *thermal* transport
  - Good synergy with T&T on analysis
  - Promising comparison with ORBIT, HYM. Alternative models proposed (e.g. *Kolesnichenko et al.*)
  - New data from BES/Reflectometers available
  - Future directions? Is there anything missing?

Measurements/modeling of low frequency *AEs

Measurements/modeling of low frequency *AEs

- At present, we are mainly targeting **TAEs** and **EPMs**
  - Should we include other low-frequency modes?
    - Low-*f* modes "triggered" by TAE avalanches
    - Large MHD modes causing depletion of FIDA profiles
    - 3D fields (!), see recent PPPL meeting and ITPA task

Measurements/modeling of low frequency *AEs

- At present, we are mainly targeting **TAEs** and **EPMs**
  - Should we include other low-frequency modes?
    - Low-*f* modes "triggered" by TAE avalanches
    - Large MHD modes causing depletion of FIDA profiles
    - 3D fields (!), see recent PPPL meeting

- Good scenario identified for extensive experimental characterization
  - L-mode case, excellent diagnostic coverage (see Backup Slides)
    - Profiles (including MSE), fast ion diagnostics, *mode structure*
      - Good initial results from reflectometers
      - Will BES data be available on ~3 months time scale?

Measurements/modeling of <u>low frequency</u> *AEs

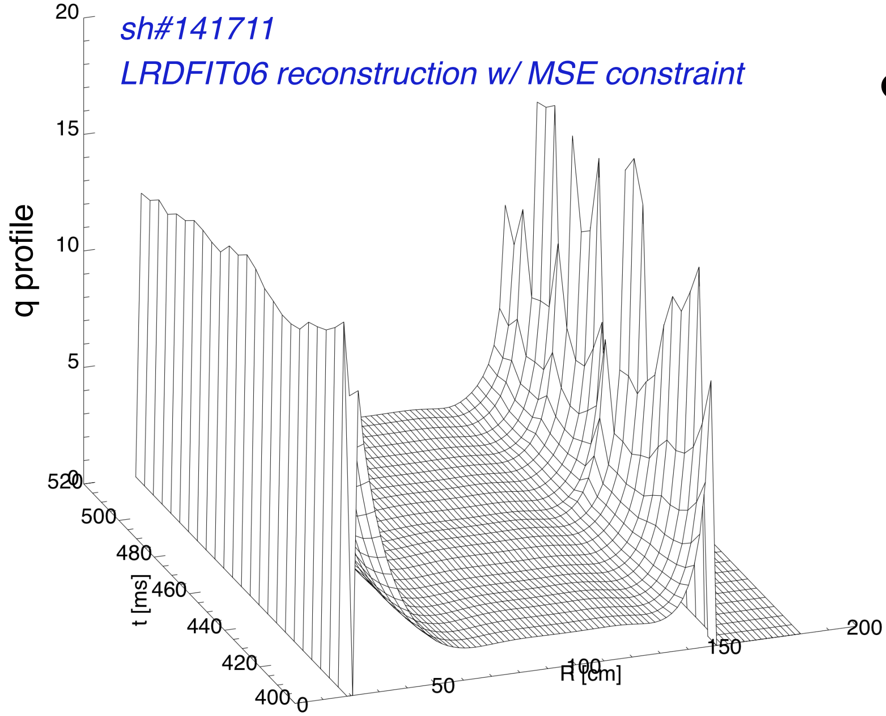
- At present, we are mainly targeting **TAEs** and **EPMs**
  - Should we include other low-frequency modes?
    - Low-*f* modes “triggered” by TAE avalanches
    - Large MHD modes causing depletion of FIDA profiles
    - 3D fields (!), see recent PPPL meeting

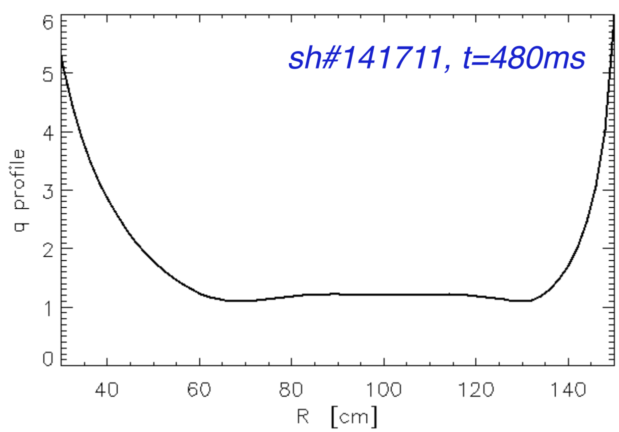
- Good scenario identified for extensive experimental characterization
  - L-mode case, excellent diagnostic coverage (see Backup Slides)
    - Profiles (including MSE), fast ion diagnostics, <u>*mode structure*</u>
      - Good initial results from reflectometers
      - Will BES data be available on ~3 months time scale?

- Plan to compare expt’s with M3D-K, SPIRAL (NOVA-K, ORBIT?)
  - TRANSP analysis under way
  - Anything else required?
  - Include other codes/analyses in the comparison?
  - Expected timeline for initial results?

Backup slides

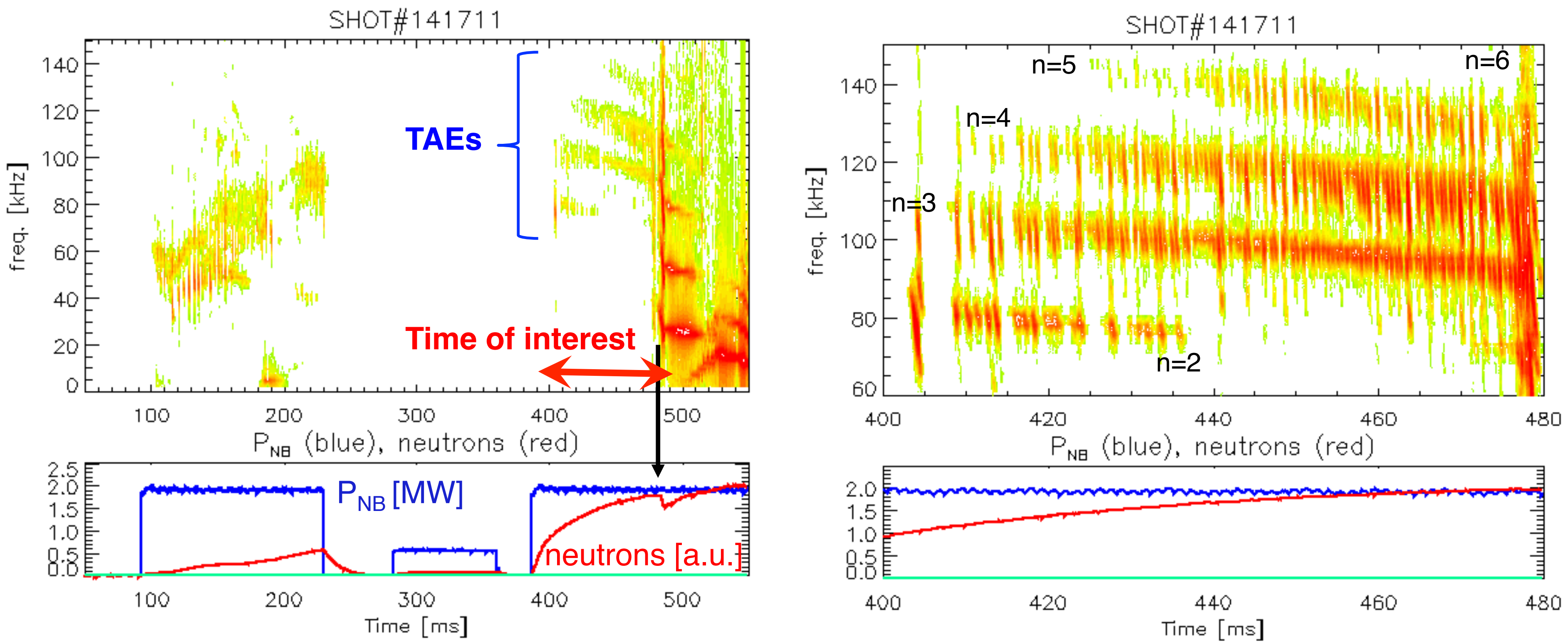
Experimental scenario : P_{NB}<3MW, $n_e \sim 3x10^{19} m^{-3}$, $T_i \sim T_e$=1-1.5keV





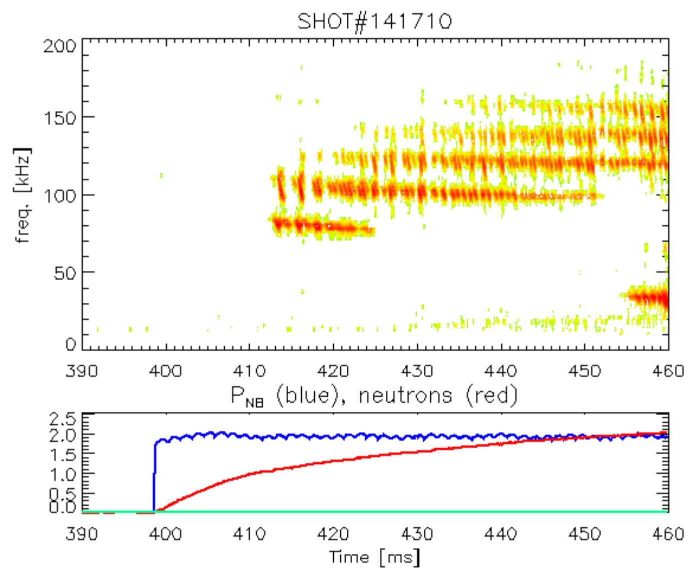
- NB-heated, L-mode plasmas
  - Plasma limited on center-stack
  - NB power and timing varied to affect mode stability
  - Plasma profiles slowly evolving in time
  - Slightly reversed *q* profile
  - Safety factor evolution reconstructed through `LRDFIT` code constrained by MSE data

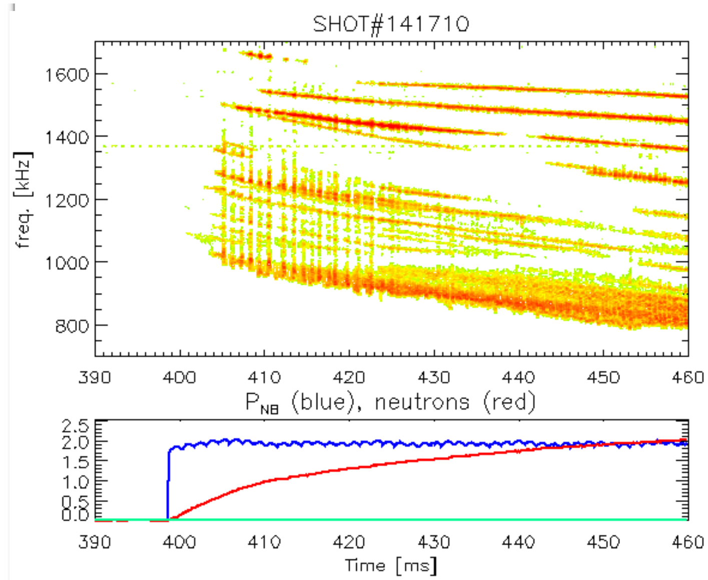
TAEs with low toroidal mode number (n=2→6) are observed, with dominant n=2-4 modes

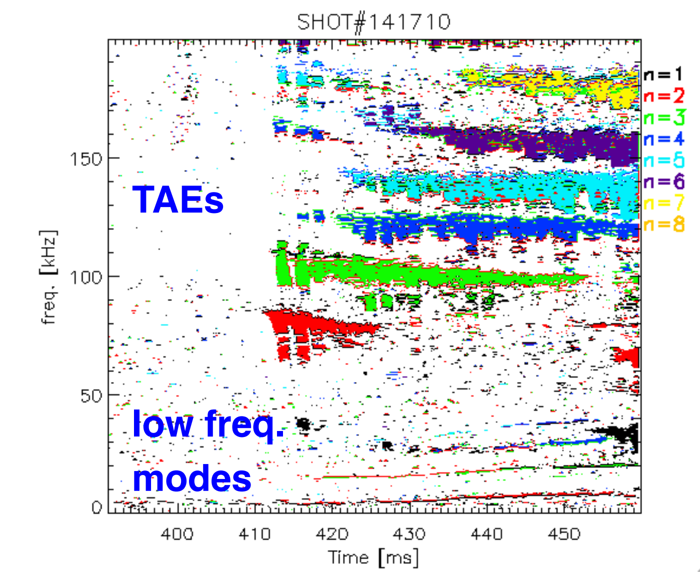


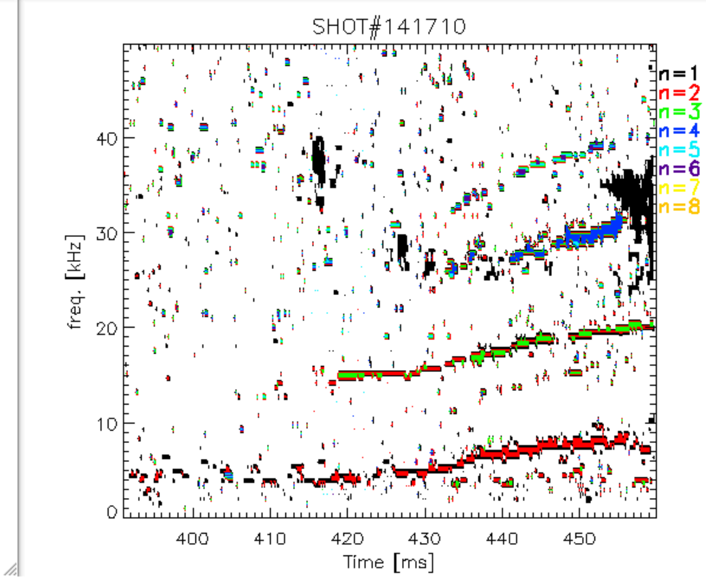
- TAEs observed in 60-150 kHz range
- Similar to previous experiments: bursting/chirping TAEs and occasional avalanches, leading to fast ion losses

TAE activity accompanied by GAEs (?) and other modes at much lower frequency



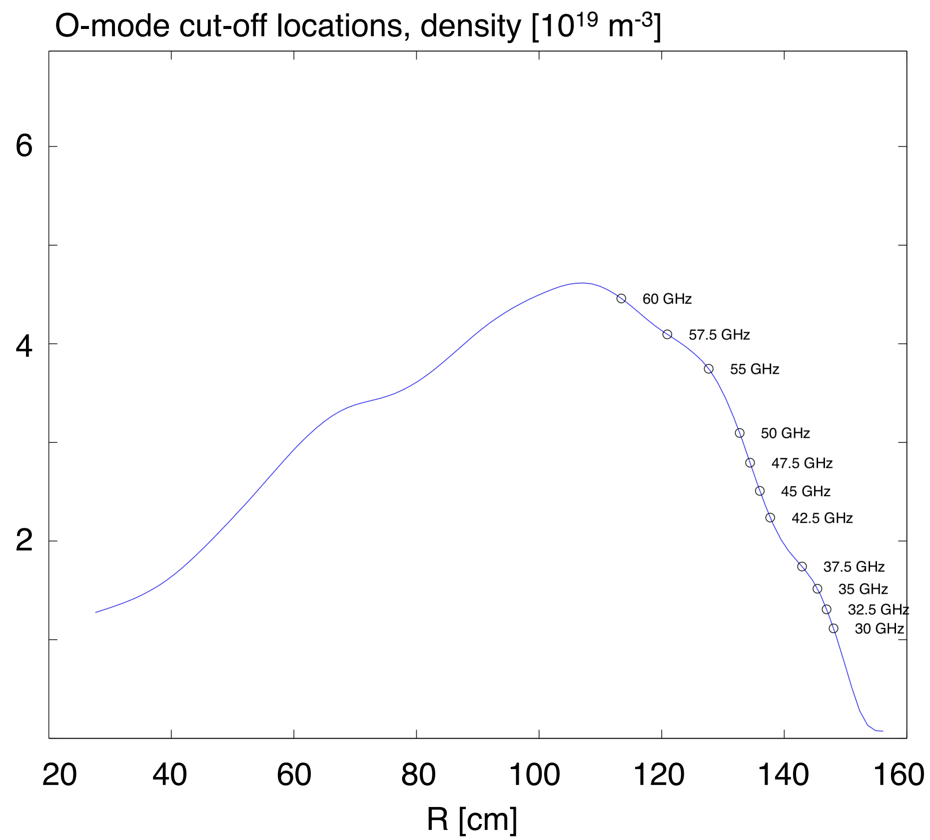


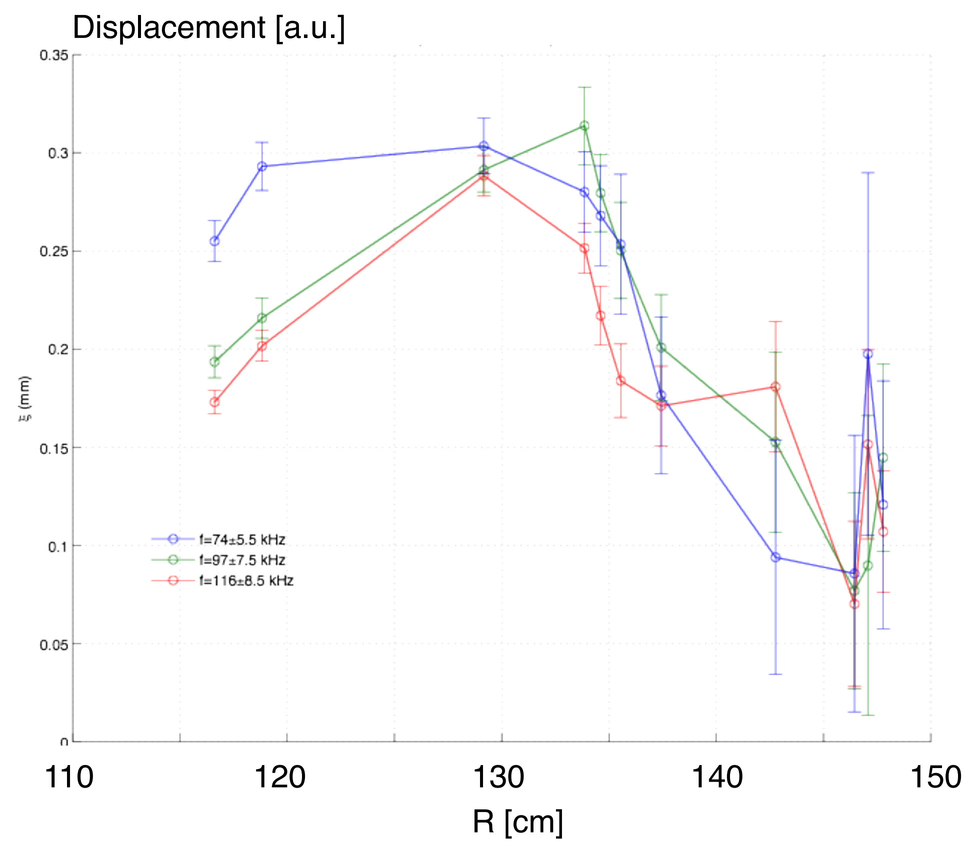




Upgraded UCLA reflectometer gives accurate measurements of TAE mode structure

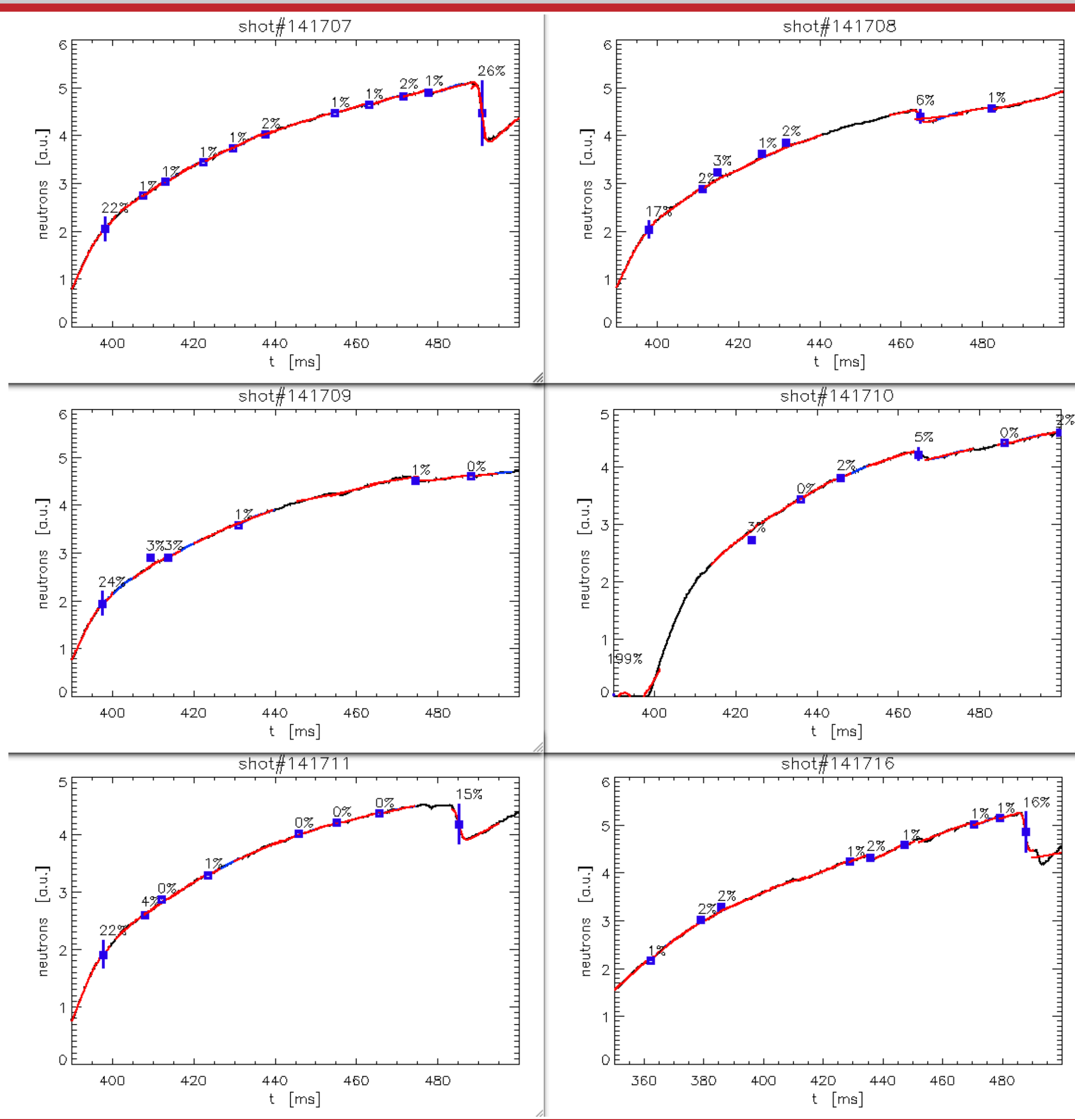
sh#141707, t=463ms





N. Crocker, S. Kubota - UCLA

Several good shots provide rich database on TAE-induced fast ion losses



IR(12-2): Assess predictive capability of mode-induced fast-ion transport

Good confinement of fast-ions from neutral beam injection and thermonuclear fusion reactions is essential for the successful operation of ST-CTF, ITER, and future reactors. Significant progress has been made in identifying the Alfvénic modes (AEs) driven unstable by fast ions, and in measuring the impact of these modes on the transport of fast ions. However, theories and numerical codes that can quantitatively predict fast ion transport have not yet been validated against a sufficiently broad range of experiments. To assess the capability of existing theories and codes for predicting AE-induced fast ion transport, NSTX experiments will aim at improved measurements of the mode eigenfunction structure utilizing a new Beam Emission Spectroscopy (BES) diagnostic and enhanced spatial resolution of the UCLA Multi-Channel Reflectometer. Improved measurements of the fast-ion distribution function will be available utilizing a tangentially viewing Fast-Ion D-alpha (FIDA) diagnostic. In order to broaden the range of discharge conditions studied to those relevant to future devices, experiments will be conducted for both L-mode and H-mode scenarios. Specific targets for the experiment-theory comparison are those between the measured and calculated frequency spectra, spatial structure and induced fast ion transport. Both linear (e.g., NOVA-K, ORBIT) and non-linear (e.g., M3D-K, HYM) codes will be used in the analysis. In addition, the newly developed full-orbit particle-following code SPIRAL will be adapted to the NSTX geometry and used to model fast ion losses by Alfvénic modes.