NSTX

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XP Proposal for NSTX FY2011-12

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NSTX Research Forum
B233, PPPL
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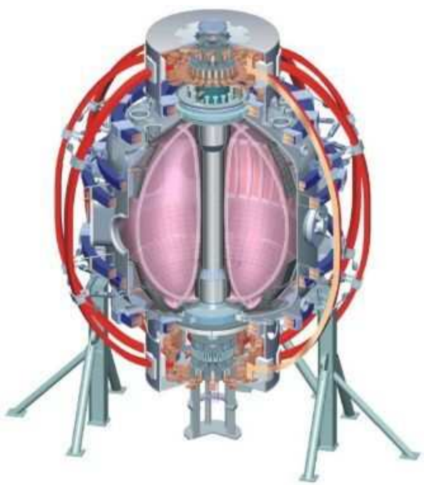

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Tangential FIDA commissioning XMP

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- New tangential FIDA view is being installed on NSTX and will be operational during FY11/12 run
- Radial/Time/Energy resolution as vertical FIDA (5cm / 10ms / 10keV)
- View geometry optimizes **sensitivity to passing ions** (co going)
- Important to address phenomena that affect fast ion distribution function in phase space (RF coupling, interaction with MHD instabilities,…)
- Need to acquire confidence on diagnostic operation: e.g. subtraction background components, impurity lines

XMP Goals:

1. to characterize the diagnostic performance under different NB injection schemes
2. compare the response of ***vertical*** and ***tangential*** systems in a controlled experiment, e.g. over basic plasmas with different passing/trapped fraction

Tangential FIDA commissioning XMP (2)

- Basic plasma scenario to avoid perturbation from MHD or ELMs. Target discharge: L-mode, limited on central stack
- B_t~5kG, I_p~900kA (e.g. 141715 or 127042 from former XMP54 - vertical FIDA checkout)

  – **Phase 1 [0.5 run days]**. Repeat with different NB injection waveforms, to provide single and double source measurements at Eb = 90/65keV. Ensure beam notches at different times for background assessment throughout the discharge

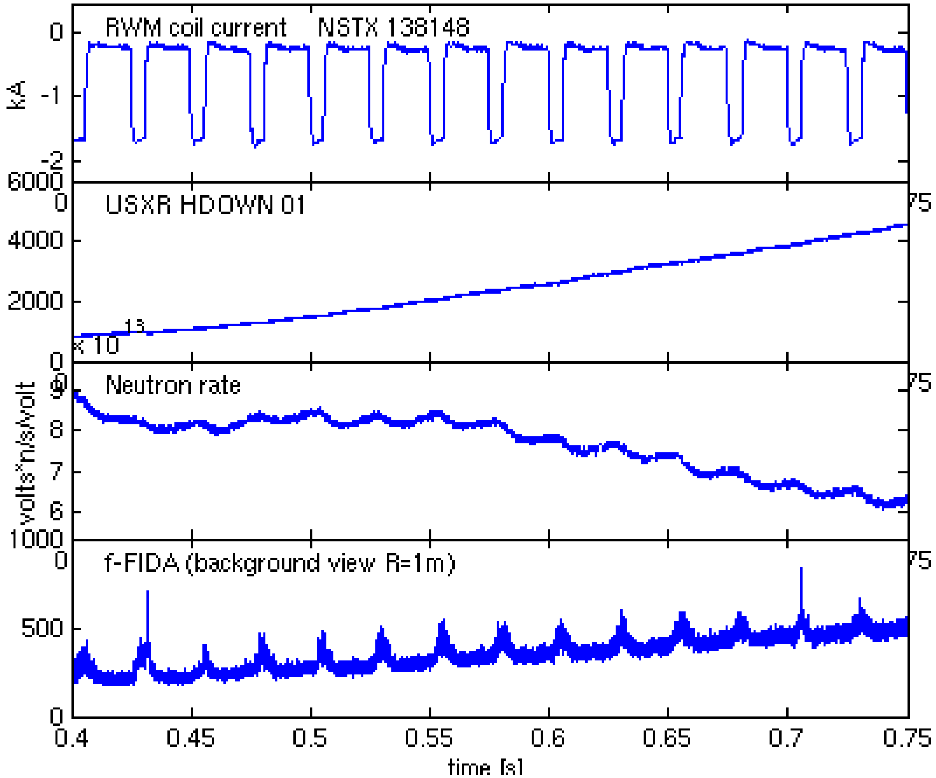
  – **Phase 2 [0.5 run days]**. Set heating to sources A(90kV), B(65kV). Vary Ip, Bt in steps to measure reference discharges at different passing/trapped fraction. Use beam modulation to validate background subtraction.

- Low levels of impurities required for FIDA measurement. One or two weeks of operation before the XP are preferable
- Results may be used for the validation of SPIRAL and FIDASIM codes in the NSTX

Effect of Applied 3D fields on Fast Ion Confinement

Effect of induced 3D fields on Fast Ion confinement

Goal: To investigate how externally imposed 3D fields may affect the fast ion population



- Losses are expected
- Resonances between orbits and perturbation determine which particles are affected (E,pitch)… FIDA!

- No clear evidence during FY2010
- 3D fields used for ELM triggering, fast modulation, high density, background light contamination
- Need for a dedicate approach: FIDA friendly scenario, low density, MHD/ELM “free”

Contributes to **ITPA EP-6**: *Fast ion losses and associated heat load from edge perturbations (ELMs and RMPs)*

Effect of induced 3D fields on Fast Ion confinement (2)

Target discharge: H-mode, ELM-free, P_{NB}=3-4 MW (AB).
Time window (~100 ms) with low MHD after begin of current flat top.
Error field correction only. Start from NSTX 142314, I_p~800kA, B_t~4kG.

- Phase 1 [0.75 run days] Apply n=3 perturbation (peripheral)
  - Extended period (t>200ms), starting in quiescent window
  - Repeat with increasing amplitude, until ELM appear
  - On positive vary sources combination AB->BC to vary trapped/passing
- Phase 2 [0.75 run days] Apply n=1 rotating perturbation (deep)
  - Monitor fast signals (f-FIDA, NPA, ssNPA, FILD) looking for signatures at the frequency of field rotation
  - Repeat increasing perturbation amplitude until n=1 kink is destabilized or coil current limit is reached

- If an effect is observed, repeat with NB notch to validate background subtraction: the goal is the spectral in formation
- Rotation may play a role: coupling could change with plasma braking
- Pre simulation (SPIRAL) may help refining the scenario

Effect of low frequency MHD on Fast Ion confinement

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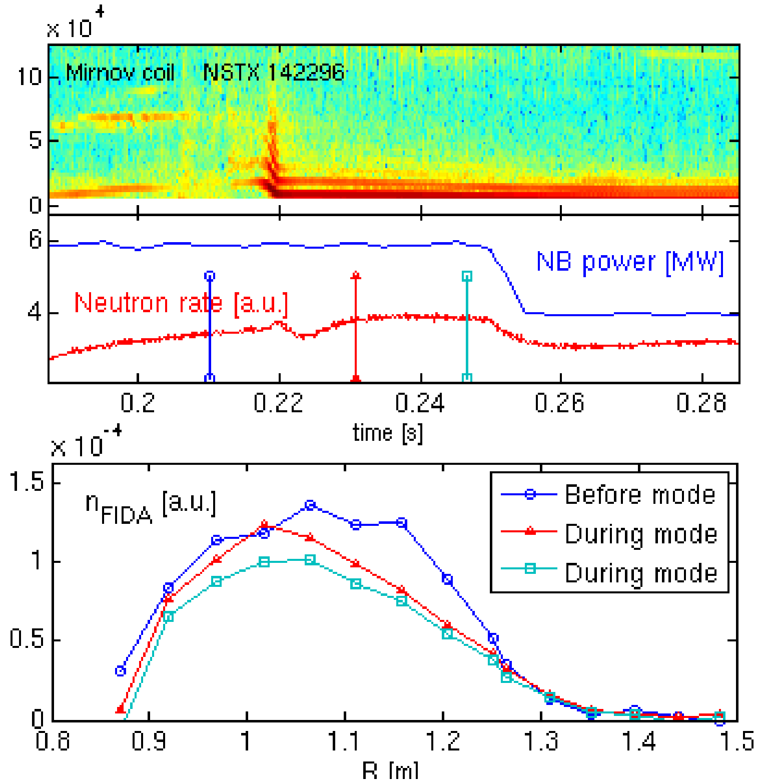


- Low frequency, low n continuous MHD modes often present in NSTX plasmas
- Tearing modes, n=1 non resonant kink, or both coupled are observed to induce losses of fast ion (trapped? passing?)
- FIDA is well placed for studying the interaction between LF MHD and Fast Ions
- Dedicated XP required to provide
  - 'isolated mode' observations (minimize High Frequency MHD activity)
  - Scenario optimized for simultaneous FIDA and reflectometer measurement (e.g. low monotonic Ne profile)

Goal (1): to understand how continuous LF MHD modes (tearing *and* non resonant kink) redistribute fast ion in real and phase space

Goal (2): to validate ***SPIRAL, M3D-K*** *and* ***FIDASIM*** codes on the case of LF MHD modes

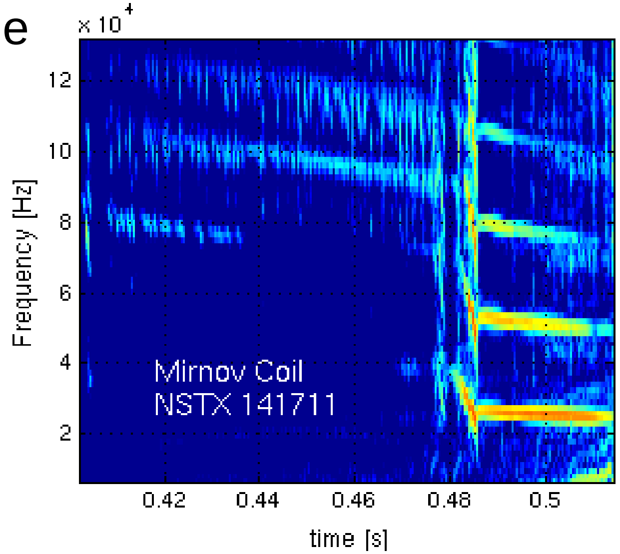
Milestone IR(12-2): *Assess predictive capability of mode-induced fast-ion transport*

Effect of low frequency MHD on Fast Ion confinement (2)

Two phases, to address the 'isolated' kink and tearing mode separately

- **Phase 1 [0.5 run days]** Establish discharge featuring 'isolated' tearing mode H-mode, ELM-free, PNB=3-4 MW. Minimal HF MHD
  - Start from 142293 I_p=900kA, B_t=3.5kG
  - Adjust startup and ramp up parameters (I_p, NB waveforms) to obtain a quiescent phase before the onset of an isolated tearing mode.
  - Repeat with different beam energies, I_p, B_t to observe behavior at different passing/trapped ratio, possibly island width.

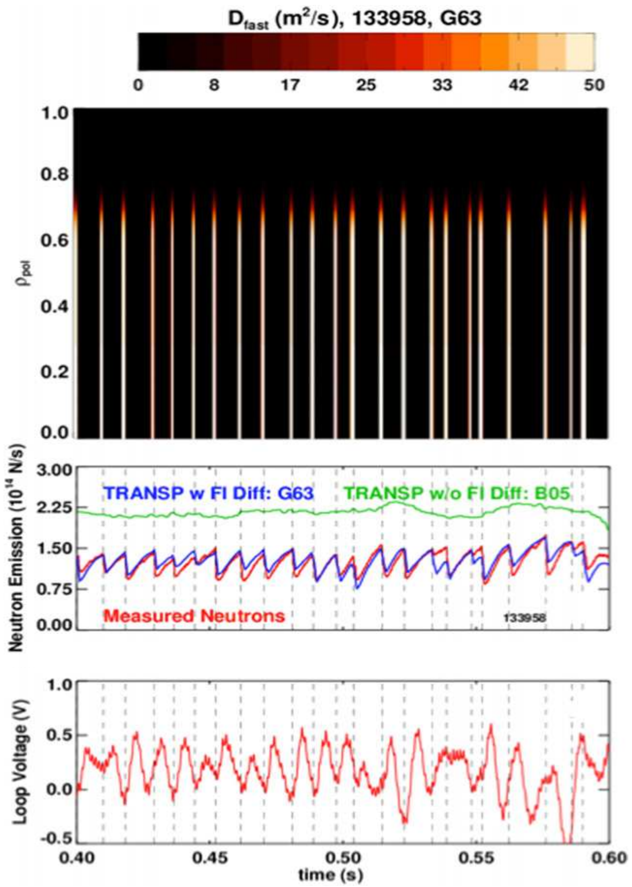
- **Phase 2 [0.5 run days]** Reproduce target discharge featuring 'isolated' continuous n=1 kink
  - Start from 141711 (I_p=900kA, B_t=500kG, excellent reflectometer coverage
  - Reduce density or anticipate mode onset to optimize FIDA measurement
  - Vary trapped/passing fraction selecting different NB sources (AB-BC) and/or varying I_p/B_t.



Effect of HF modes on NBI current drive efficiency

Effect of HF modes on NBI current drive efficiency

- MHD bursts EPM/TAE have been observed to affect significantly the current evolution profile in high CD fraction NSTX discharges
  - current redistribution
  - higher flux consumption
  - transient reduction of fast ion driven current
- The effect has been described by a bursting effective fast ion diffusivity (Gerhardt et al NF 51, 2010)
  - High non inductive fraction (~50%, f_{NB}~15%)
  - D~50 m^2/s across plasma core, during burst
  - Figure of merit is neutron rate drop
- Tangential FIDA suitable to investigate the interaction between the **passing fast ions** and TAE/EPM modes, to acquire confidence of current profile predictive capability.



Goal: to characterize the interplay between energetic particles, MHD bursting modes (TAE/EPM) and NBI current drive efficiency, in high non inductive fraction discharges

Effect of HF modes on NBI current drive efficiency (2)

Revisit plasma scenario with high non inductive CD and bursting mode:

- H-mode, ELM-free, I_p=700kA, B_t=0.78 T, P_{NB}= 6MW, non Inductive fraction ~50%
- Adjust density/current/shape/Lithium coating to increase the period between bursts, and allow t-FIDA and MSE measurement before and after burst.
- Repeat to increase statistics of events suitable for analysis (~10)
- If time allows, repeat at different I_p, B_t to observe behavior at different passing/trapped ratio

[0.5 run days]

Note: FIDA measurement is challenging at the density of the original target discharges. The XP would benefit on density control strategies developed during the run.