On the Energetic Particle Experimental Goals for 2010 run

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Attacking EP research in “ITER era”

Recent DOE initiatives

1) FSP planning phase (see today's FSP PPPL meeting 4:00pm)

EP studies are expected to be an essential part

2) Renew #3 thrust elements

- **Simulation/theory**
  - Improve stability threshold predictions
  - Identify stable regimes for ignited plasmas
  - Nonlinear consequences: when are alpha-driven instabilities tolerable?
- **Advanced diagnostics**
  - Direct measurements of mode structure, energetic particle profiles, escaping fast ions
  - Potential PPPL initiative: ICE-CAE for alphas diagnostic – natural for NSTX – active antenna experiments
- **Control techniques**
  - alpha fluctuations
  - heating profile, currents, flows
  - direct energy (alpha) channeling to fuel ions – active antenna experiments
- These goals will encompass both ITER/DEMO as well as interim non-ignited devices (DIII-D, CMOD, NSTX, JET, etc.)

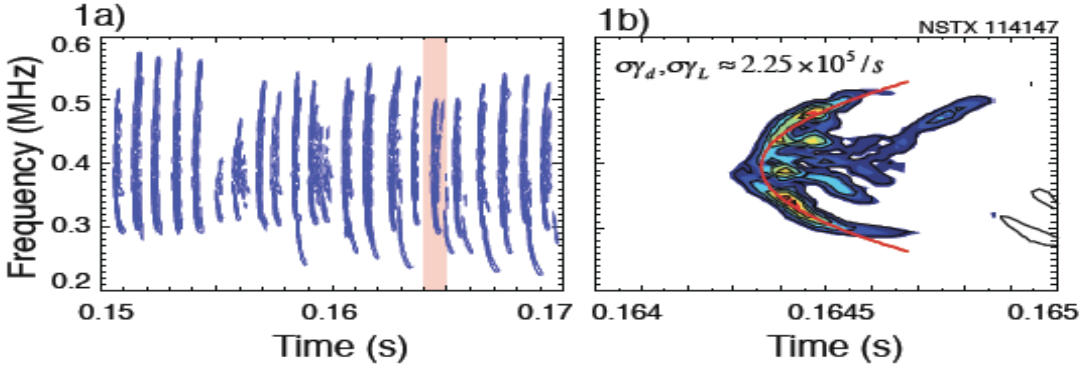
Priorities for FY2010

- *Milestone:*

Develop a predictive capability for the transport of fast-ions by super-Alfvenic-ion driven modes

- *ITPA joint tasks/experiments:*
  - *EP-1 Measurement of damping rate of intermediate toroidal mode-n AEs*
  - *EP-2 FI losses and redisctribution from localized Aes*
  - *New ## drag effect on TAE saturation*
  - *New ## fast ion transport by plasma turbulence*

XP for 2010: High frequency, GAE/CAE, effects on fast ion and electron confinement are too important



Coherant interaction with EPs! What are these modes?

- Potential effects on plasma/EP due to high-f modes
  - e-transport, help to make future projections
  - i-stochastic heating (alpha channeling)
  - can explain HEF, validate theory, codes
- Active excitation is important for mode control, alpha channeling
  - ICE studies – diagnostic for ITER, cyclotron resonances
  - Mode identification, structure; two types of modes (shear and compressional)
  - coherent structures in the phase space => elucidate particle transport in the phase space - HEF

Backup slides

Simulation/theory thrust component

- **Nonlinear energetic instability models**: can alpha transport in unstable regimes be tolerated?
  - Larger number of interacting modes than current experiments
  - Coupling of *meso*- to *micro*- scale dynamics
  - Avalanche modes or profile relaxation?
  - Accessible regions of phase space that an unstable alpha distribution can relax to
  - Effect of 3D equilibrium fields on alpha transport (ripple, ferritic materials, RWM/ELM coils)
  - Is a steady-state alpha heating profile possible?
  - **A range of simulation methods needed:**
    - fully gyrokinetic (GTC, Irvine - Scidac),
    - hybrid MHD (GKM, PPPL – FSP???),
    - reduced and
    - quasi-linear models (Gorelenkov, Berk, Ghantos, PPPL)

Thank you!!

Simulation/theory thrust component (cont.)

- Coupling with thermal plasma MHD, multi-physics
  - Sawteeth instabilities
    - Trigger for Alfvén avalanches
    - Will energetic particle stabilization allow core gradients to build up to levels that are unsustainable -> relaxation oscillations
    - Compatible with steady-state operation?
  - Fishbone instabilities – rapid alpha ejection?
  - Neoclassical tearing instabilities, RWM, ELMs – will they cause enhanced alpha losses?
  - Alpha transport driven by core micro-turbulence

Controls for alpha effects will be essential for optimized fusion performance

- Previous two elements (simulation, diagnostics) fundamental to developing successful control methods
- Density profile, magnetic shear, pellets, flow shear
- Suppression of Alfvén instabilities by focused ECH observed on DIII-D
- Alfvén stability control from beat waves between two ICRF frequencies
- Damping on other fast particle populations (beams, ICRF)
  - ITER could use positive NBI near edge to enhance Landau damping- also could help to drive plasma rotation
- Enhanced loss regions (stochastic resonances)
  - Ash removal, burn control
- Alpha channeling effects
  - decrease effective slowing-down time, reduce instability drive
  - Improved fusion reactivity, hot-ion mode
- Mitigation methods
  - Use ECE diagnostic coupled with match-filter method or neural networks to identify fault conditions