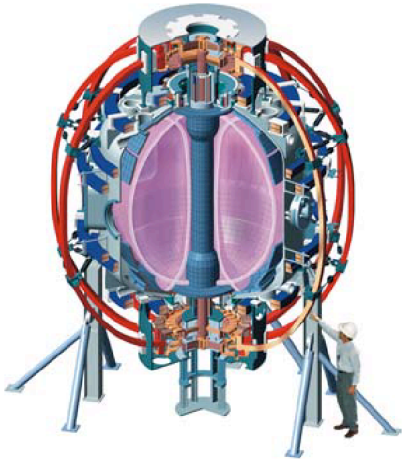
Supported by

Status of the Investigation of Fast-ion Redistribution or Loss due to MHD Modes and Alfvén Instabilities in NSTX

S. S. Medley, D. S. Darrow, E. D. Fredrickson, J. Menard and the NSTX Team

Princeton Plasma Physics Laboratory, PO Box 451, Princeton, NJ 08543 USA

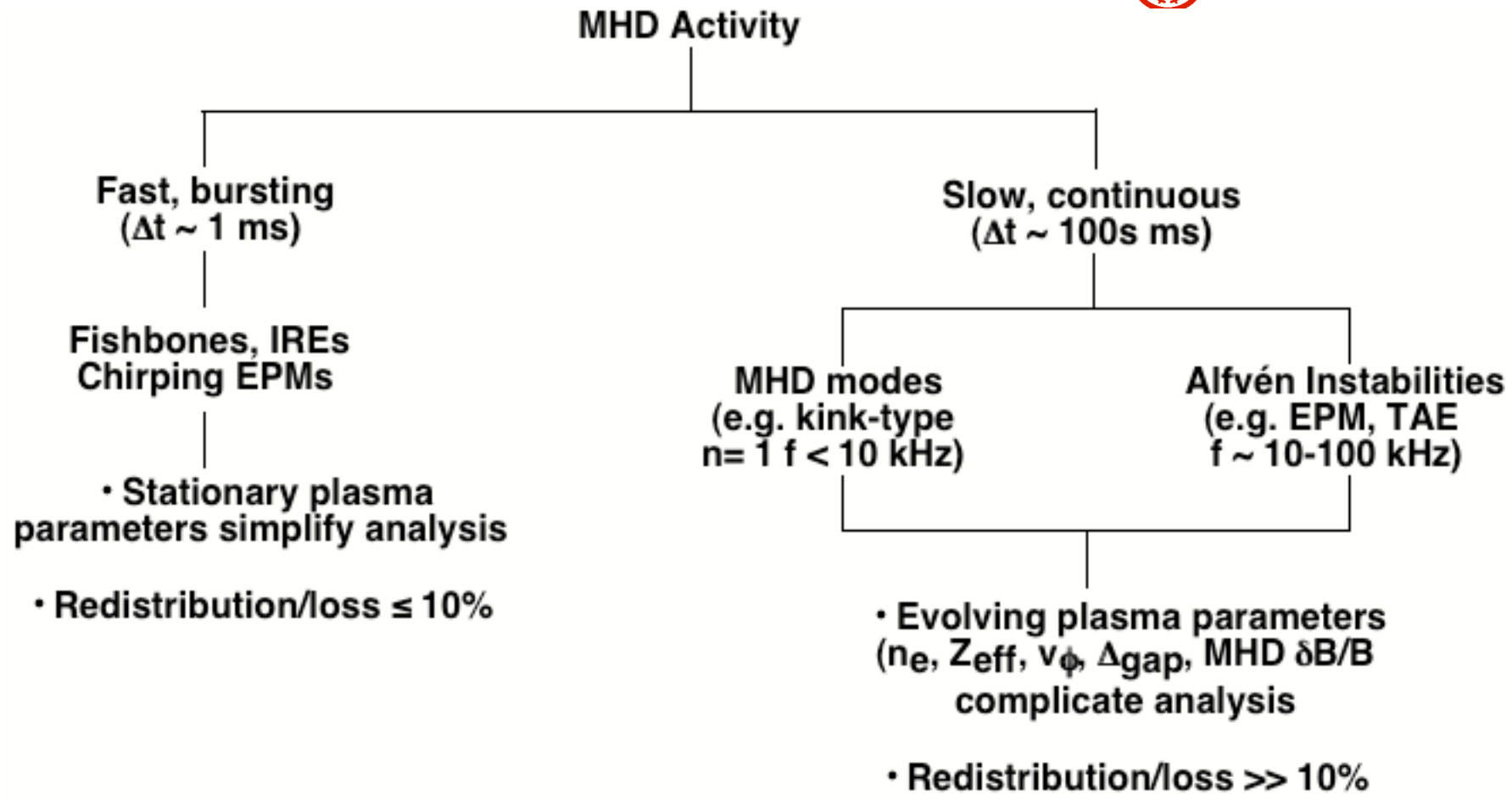


NSTX Results/Theory Review

PPPL July 26 - 28, 2006

Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
NYU
ORNL
PPPL
PSI
SNL
UC Davis
UC Irvine
UCLA
UCSD
U Maryland
U New Mexico
U Rochester
U Washington
U Wisconsin
Culham Sci Ctr
Hiroshima U
HIST
Kyushu Tokai U
Niigata U
Tsukuba U
U Tokyo
JAERI
Ioffe Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
U Quebec

Categories of MHD-induced Redistribution/Loss of Energetic Ions



- **Magnitude of the MHD-induced redistribution/loss has been based almost entirely on volume-integrated neutron yield measurements.**

Expanded Diagnostics for Evaluation of MHD-induced Energetic Ion Redistribution/Loss

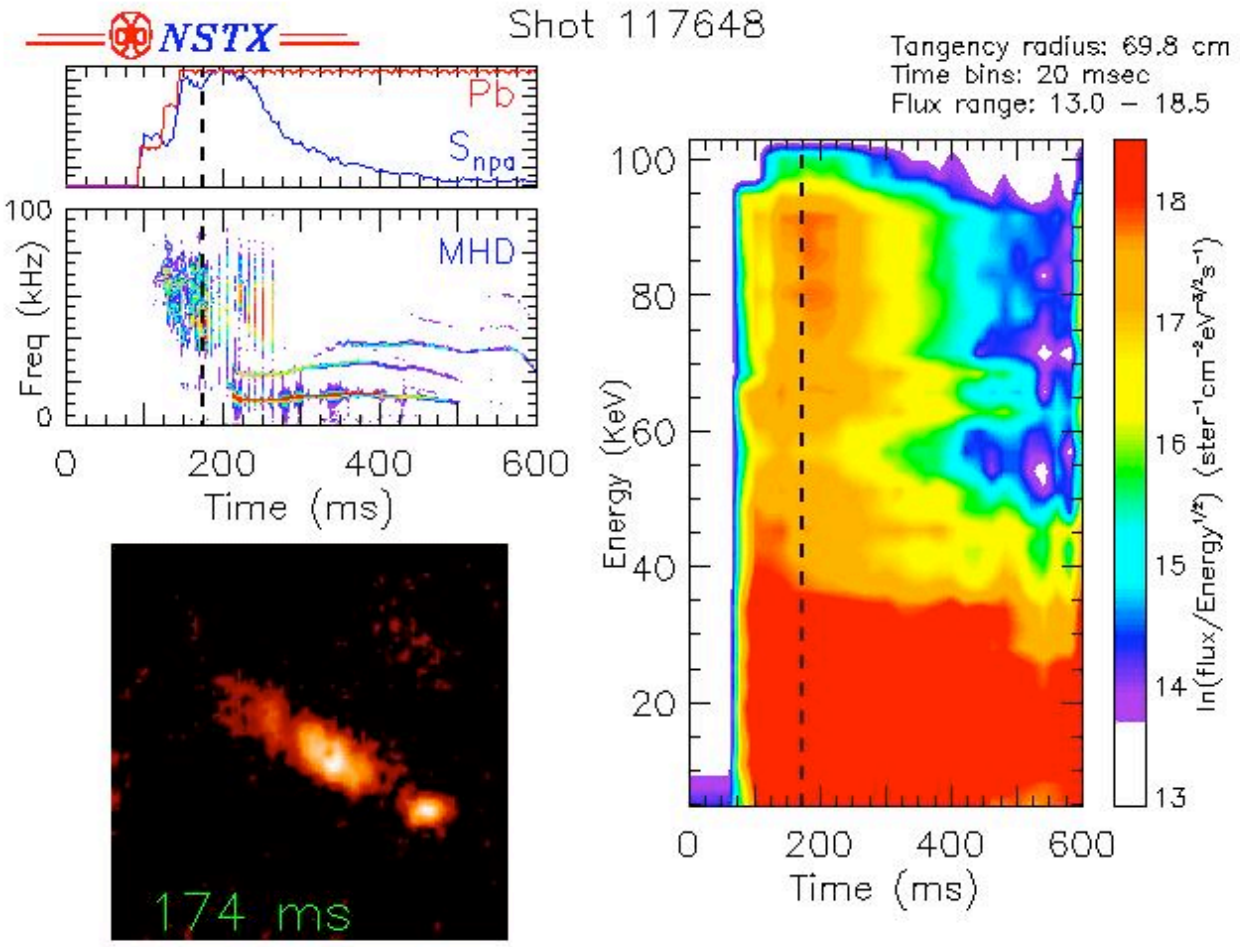
- Mirnov, USXR, FireTip…characterize MHD activity (mode, amplitude, localization)
- $S_n(t)$…volume-averaged neutron rate
- $S_{npa}(E, t, R_{tan})$…line-integrated charge exchange neutral efflux

> - Both the volume-averaged $S_n(t)$ and line-averaged $S_{npa}(E, t, R_{ta})$ show MHD-induced fast ion depletion, but cannot distinguish between redistribution and loss effects .

- sFLIP Imaging (Darrow)…identifies energetic ion loss to the outer wall
- MSE (Levinton) + LRDFIT (Menard)…identifies redistribution because outward displacement of the core-peaked energetic beam ions modifies the beam-driven current profile and hence the core q-profile [1]

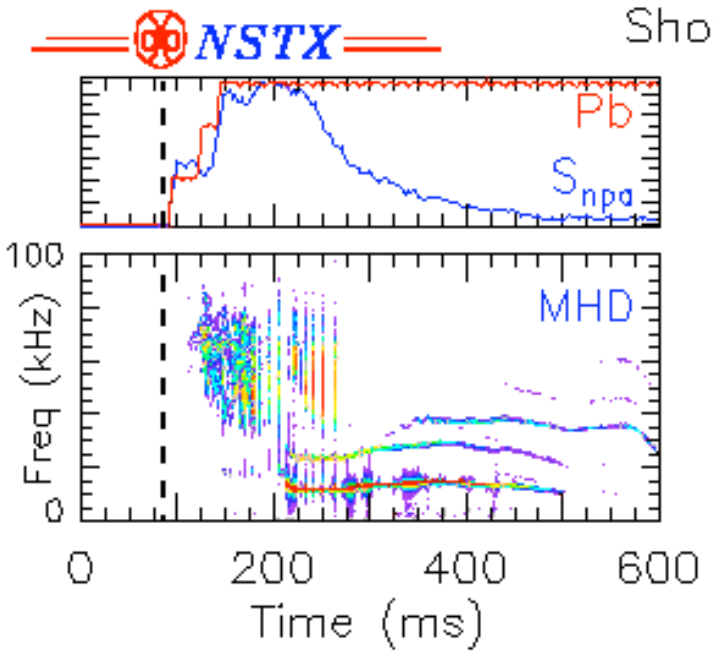
[1] "Observation of Instability-induced Current Redistribution in a Spherical Torus Experiment," J. E. Menard, *et al.* PPPL-4160 (May, 2006). Submitted to PRL

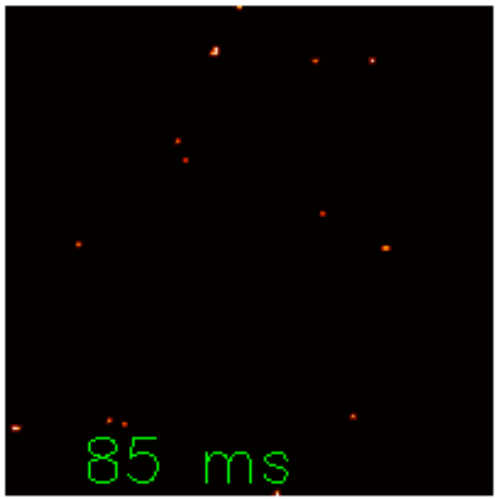
New Tool Enables Correlation of Energetic Ion Flux with sFLIP and Mirnov Data

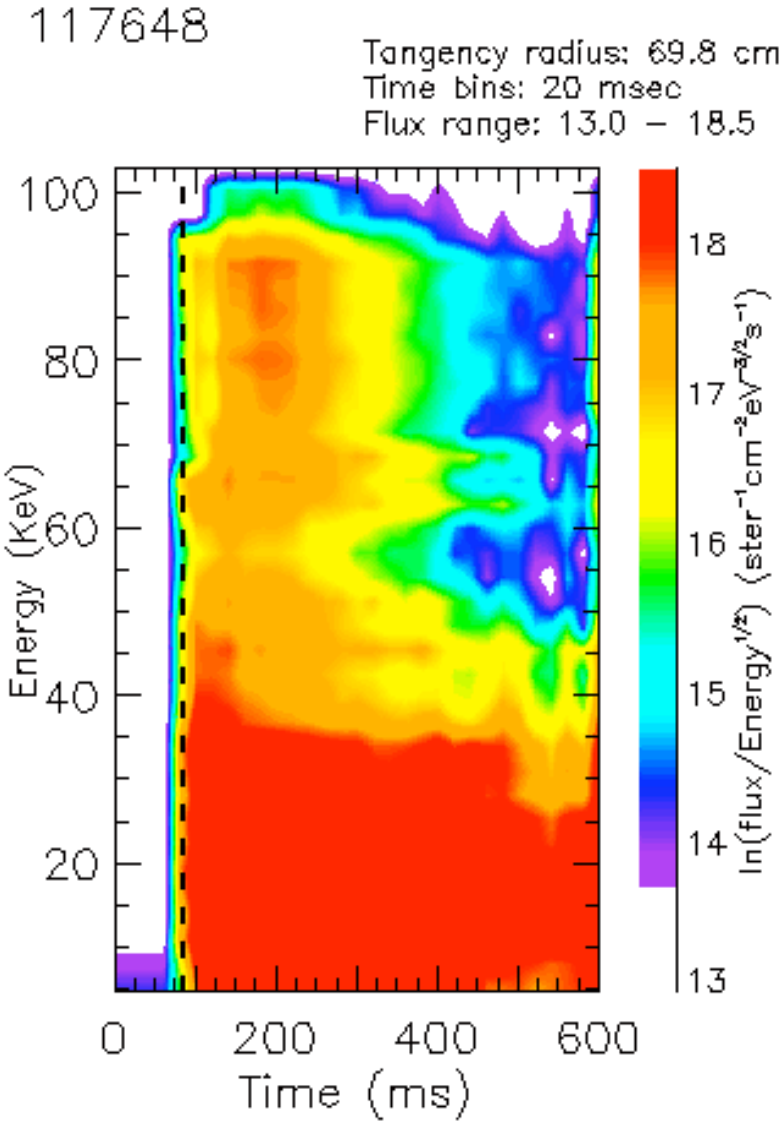


- **D. Darrow is preparing an sFLIP image overlay to quantify gyroradius centroid (energy) and pitch angle of the energetic ion loss.**

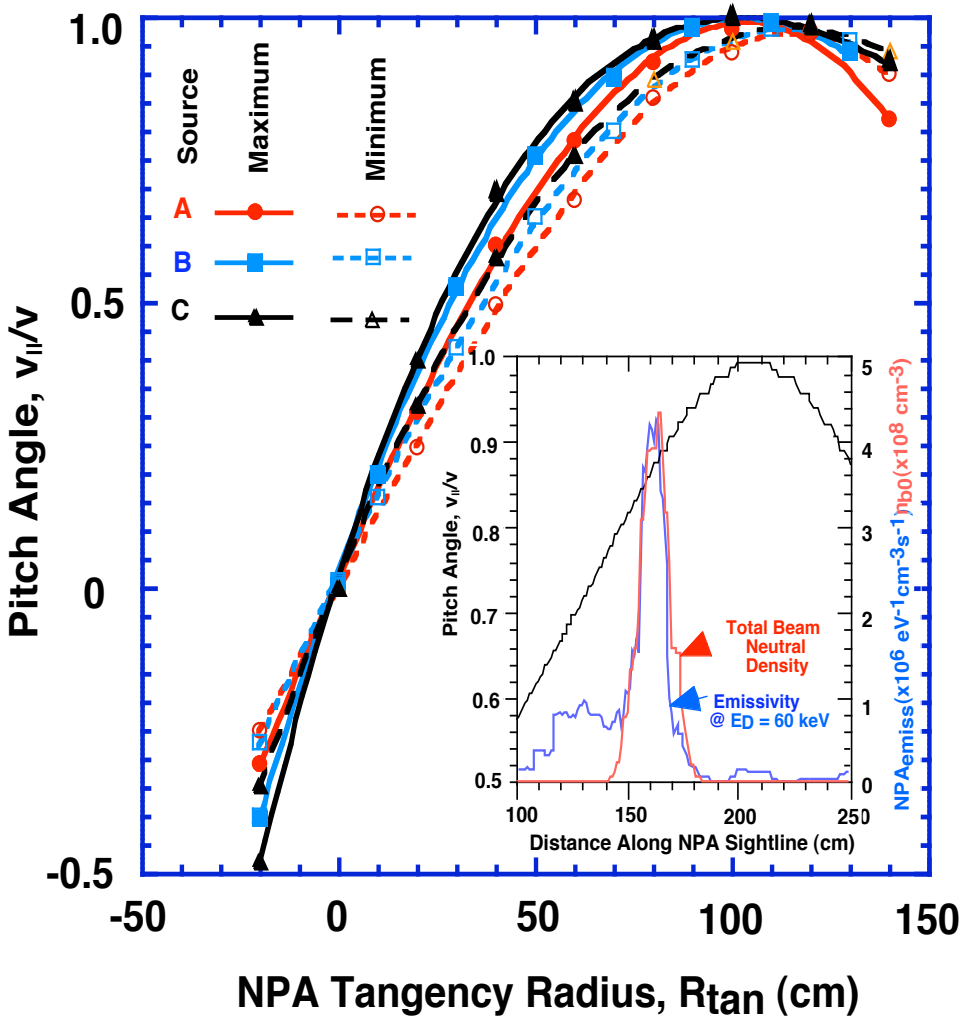
Correlation of NPA Energetic CX Flux with sFLIP and Mirnov Data

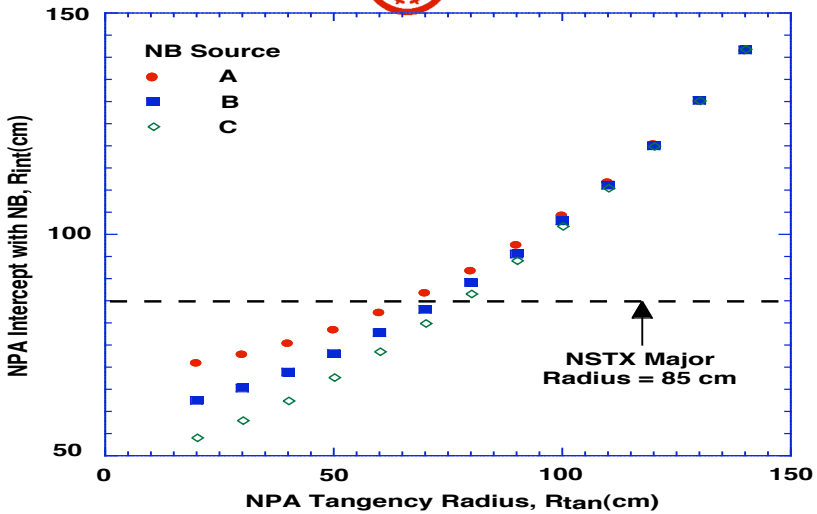


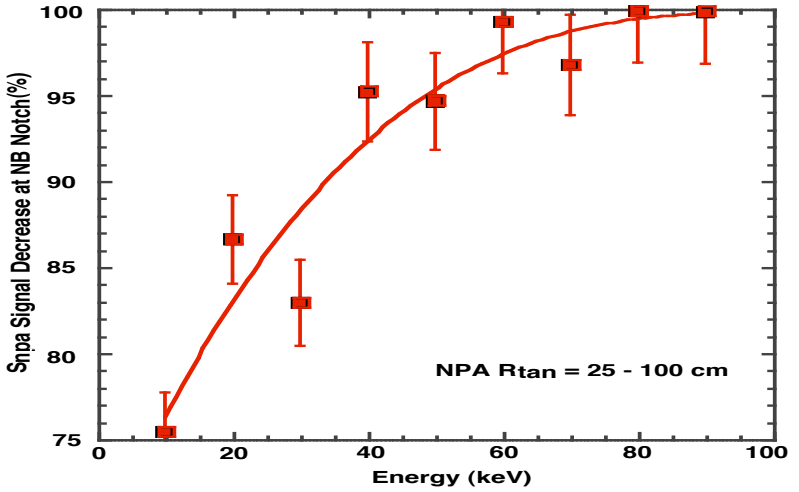




NPA Measurements are Localized in Pitch and Space by Beam Injected Neutrals



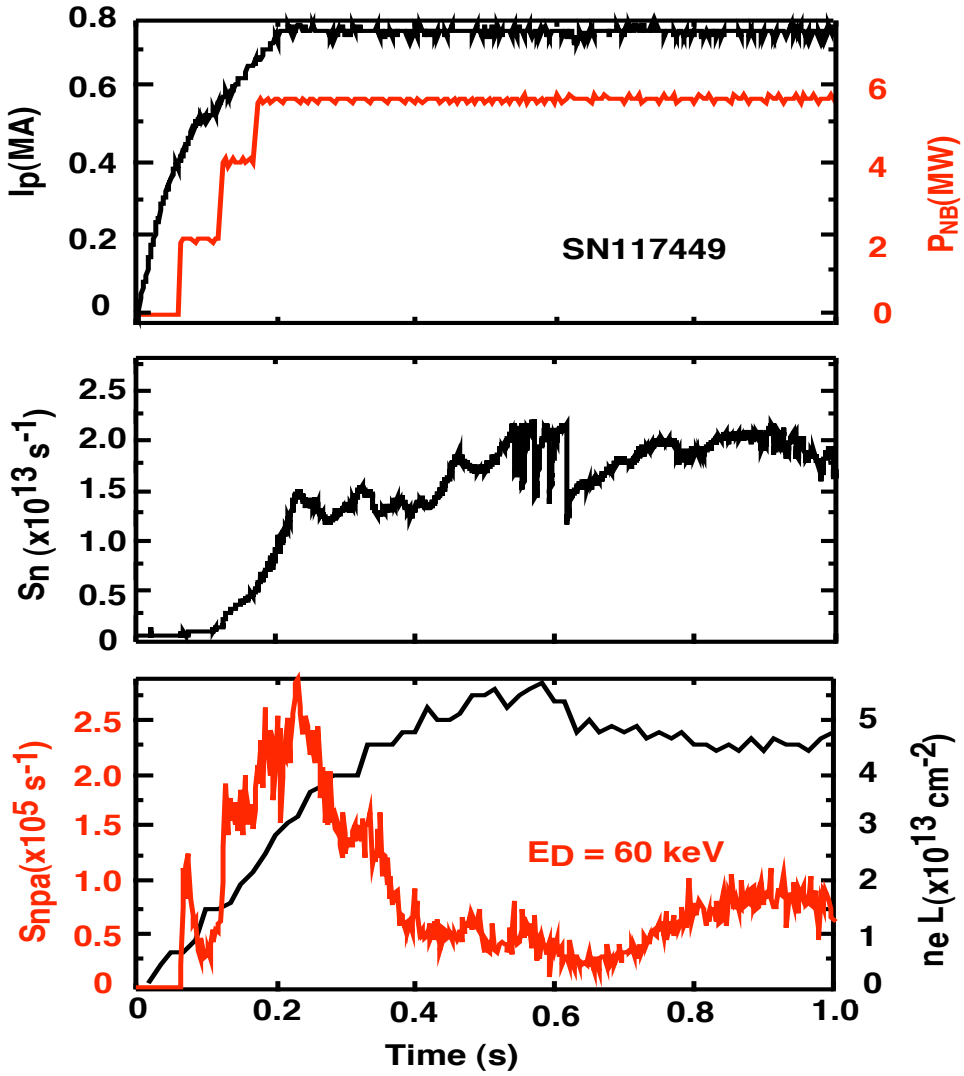


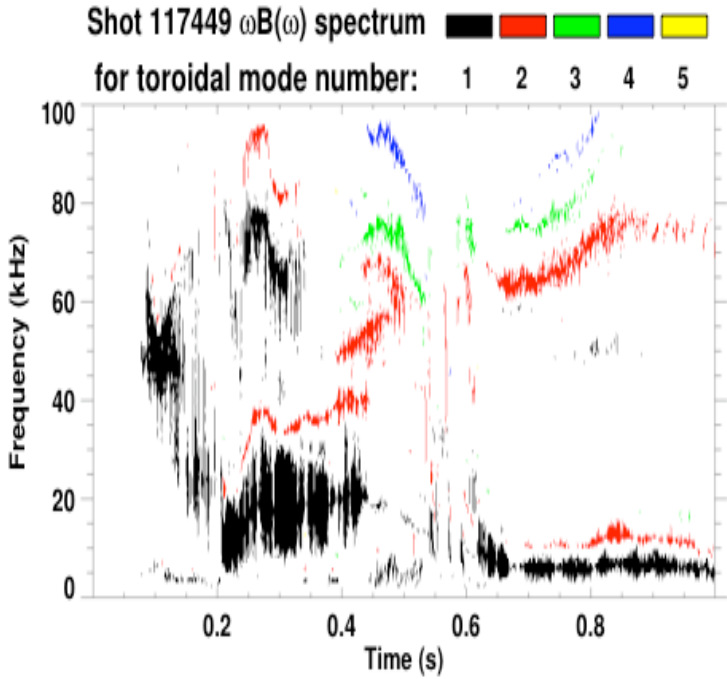


- **Dominance of charge exchange emissivity by beam neutrals results in both field pitch and spatial localization of NPA measurements.**

SN117449 Waveforms

I_p=0.75 MA, B_T=4.5 kG, A&B@90 keV, C@80 keV

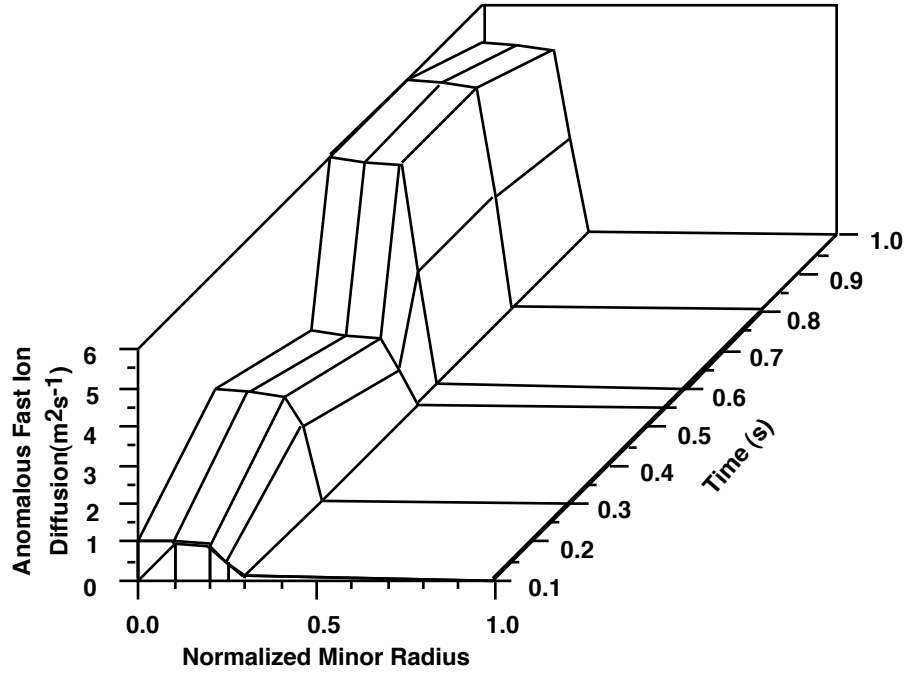


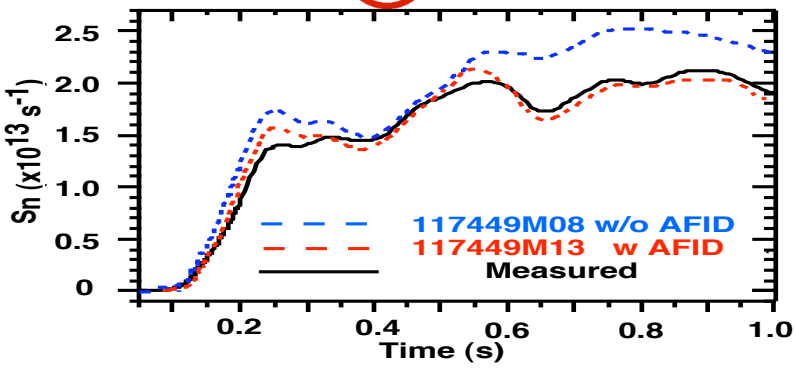


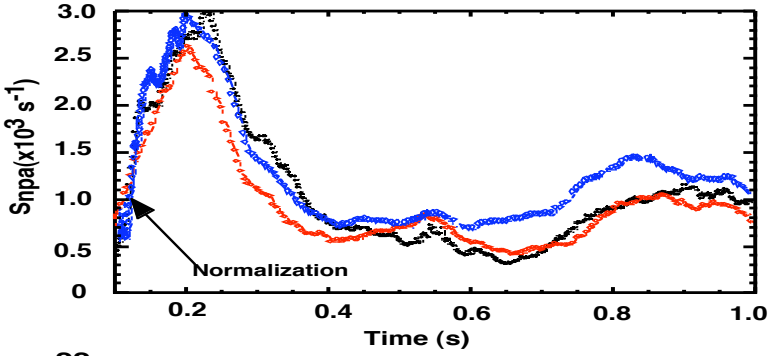
- S_{npa} depletion during n_e rise (t = 0.2-0.6 s) is due to combined effects of CX emissivity & Alfvén instabilities.
- TOI for TRANSP analysis is t = 0.6-1.0 s during an n=1, f<10 kHz kink-type MHD mode.

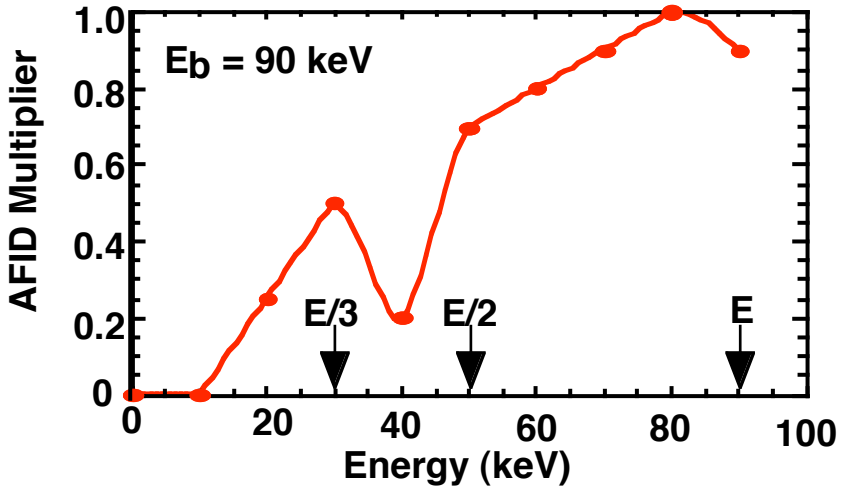
TRANSP Anomalous Fast Ion Diffusion (AFID) Model

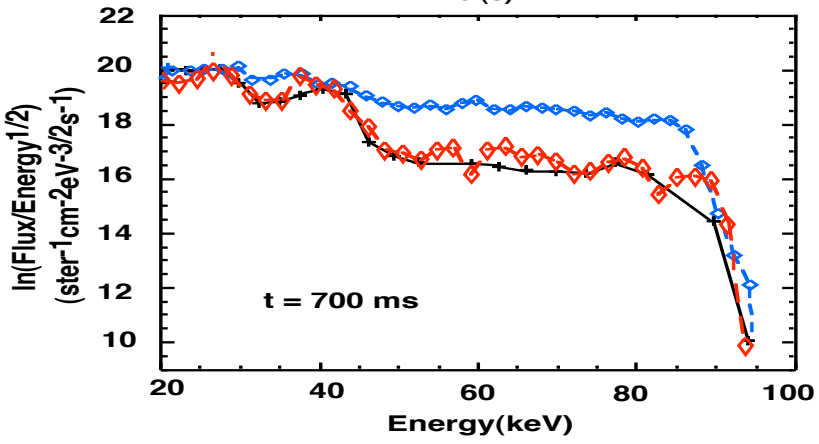
I_p=0.75 MA, B_T=4.5 kG, A&B@90 keV, C@80 keV









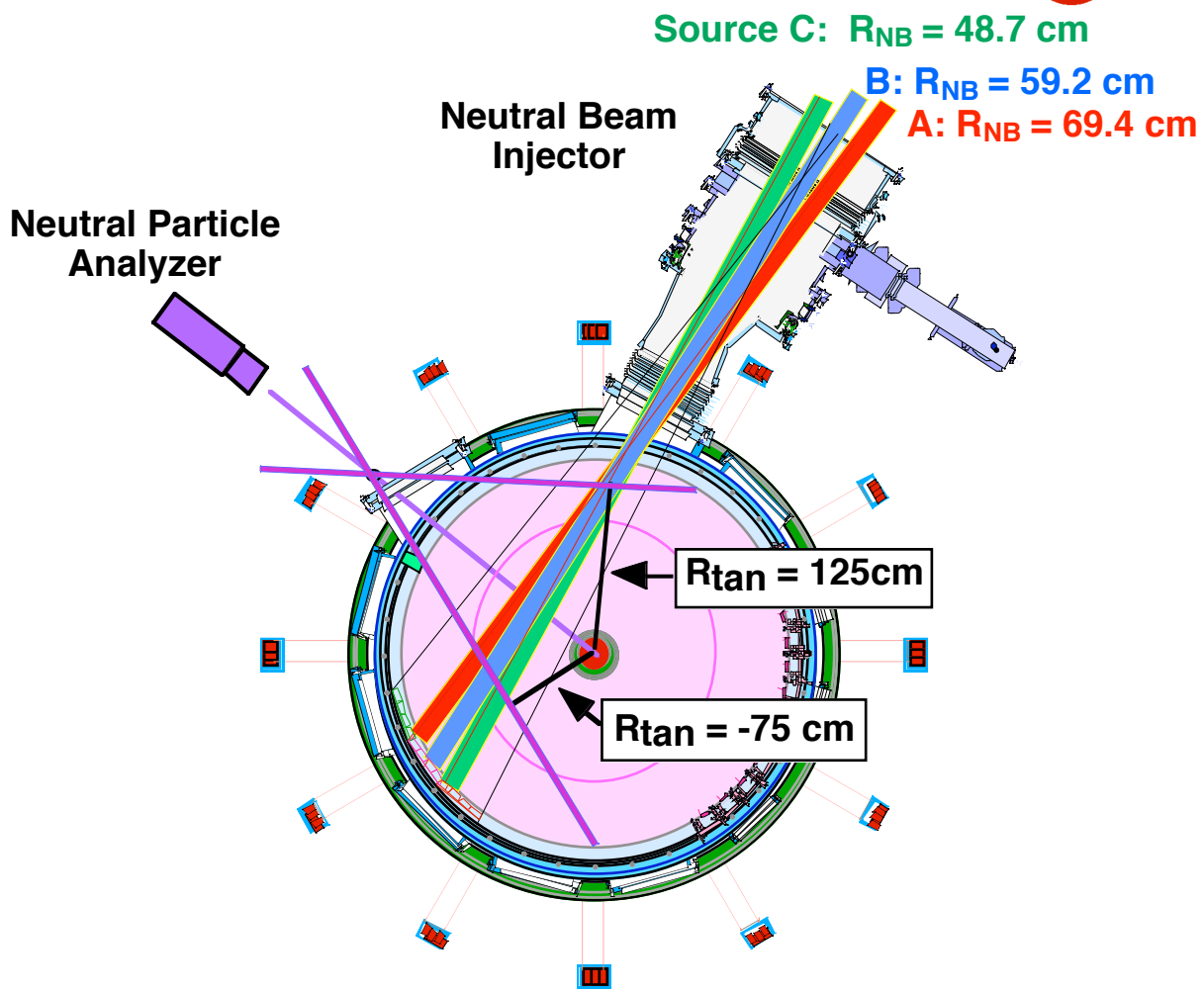


Summary

- Data mining for fast ion loss effects is complete for 2005 and in progress for 2006.
- MSE/LRDFIT and sFLIP are being utilized to distinguish between energetic ion redistribution and loss effects, respectively.
- Both CX emissivity and MHD instability effects contribute to depletion of the S_{npa}.
- Volume averaging of NB halo neutrals in TRANSP compromises analysis to separate the CX emissivity and MHD instability effects.
- R. Akers is applying the LOCUST code (that has proper halo neutral modeling) to quantify the effect of halo neutrals on S_{npa} amplitude and time evolution.
- If halo neutrals affect the evolution of S_{npa}, progress in the investigation reported here will be severely impacted: options are to upgrade TRANSP or import LOCUST, both requiring ~ 0.5-1.0 MY of manpower.

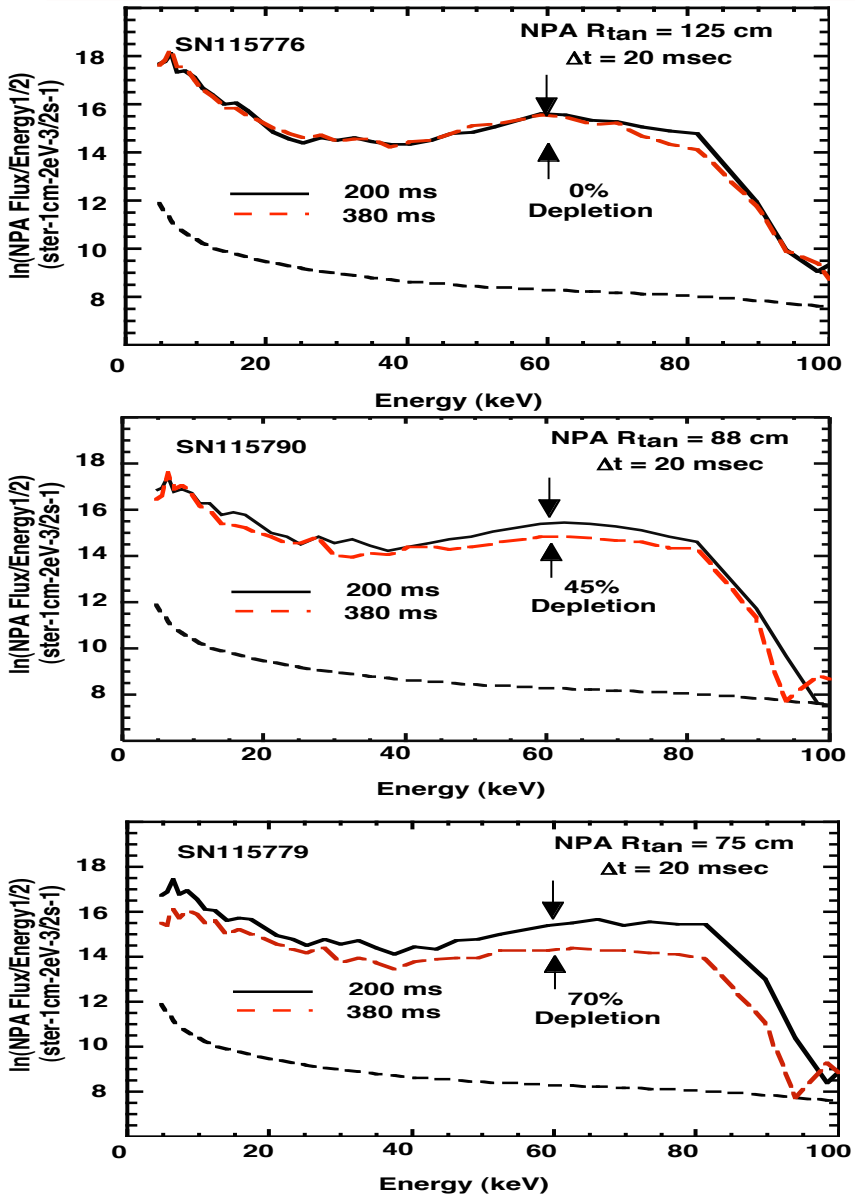
Backup

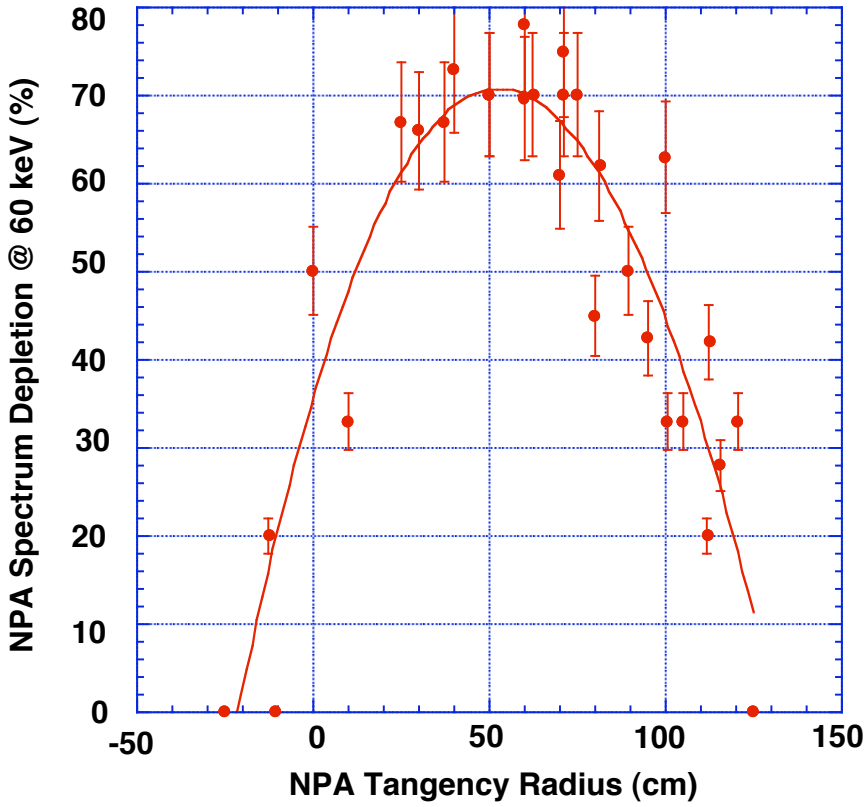
The Neutral Particle Analyzer (NPA) on NSTX Scans Horizontally Over a Wide Range of Tangency Angles on a Shot-to-Shot Basis



- Covers Thermal (0.1 - 20 keV) and Energetic Ion (≤ 150 keV) Ranges

Depletion of the NPA Energetic Ion Spectra Exhibits a Spatial Dependence





- The left panels show spectra at various R_{tan} preceeding (t = 200 ms) and following (t = 380 ms) H-mode onset.
- The right panel shows the spatial dependence of the depletion at E = 60 keV.