

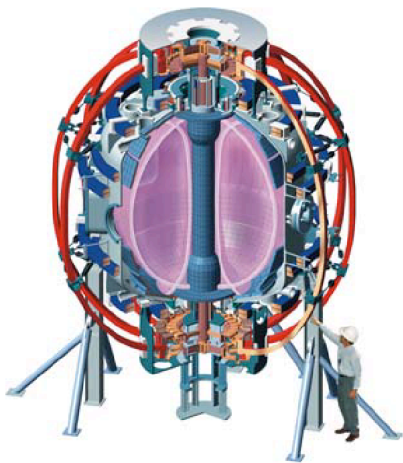
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Spatially Resolved Measurements of Neutral Beam Energetic Ion Distributions in NSTX: XP-504

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NSTX Results Review 2005

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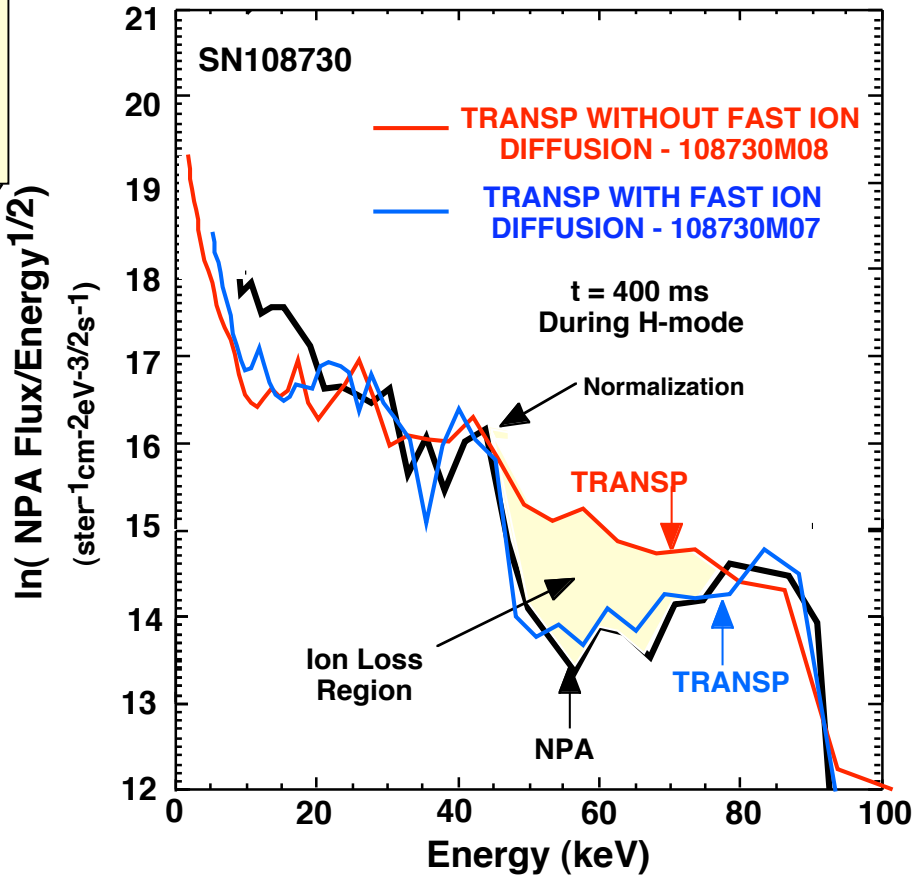
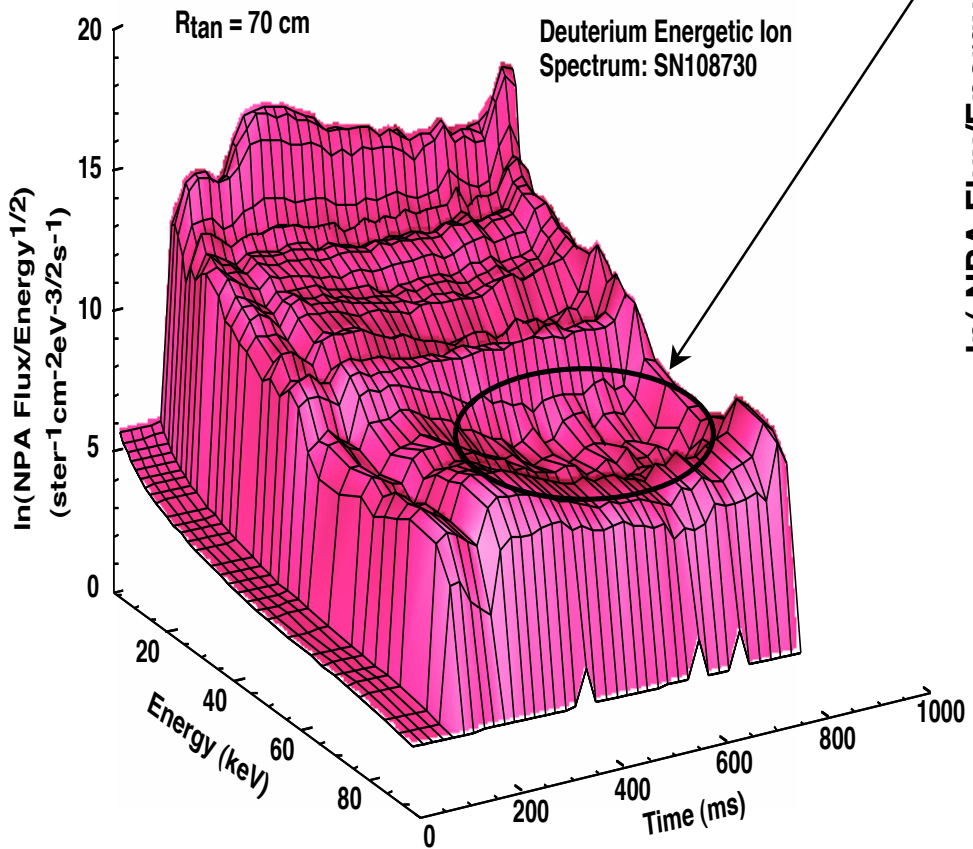
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Example of CX Neutral Flux Depletion during H-mode

S. S. Medley, *et al.* Nucl. Fusion 44, 1158 (2004)

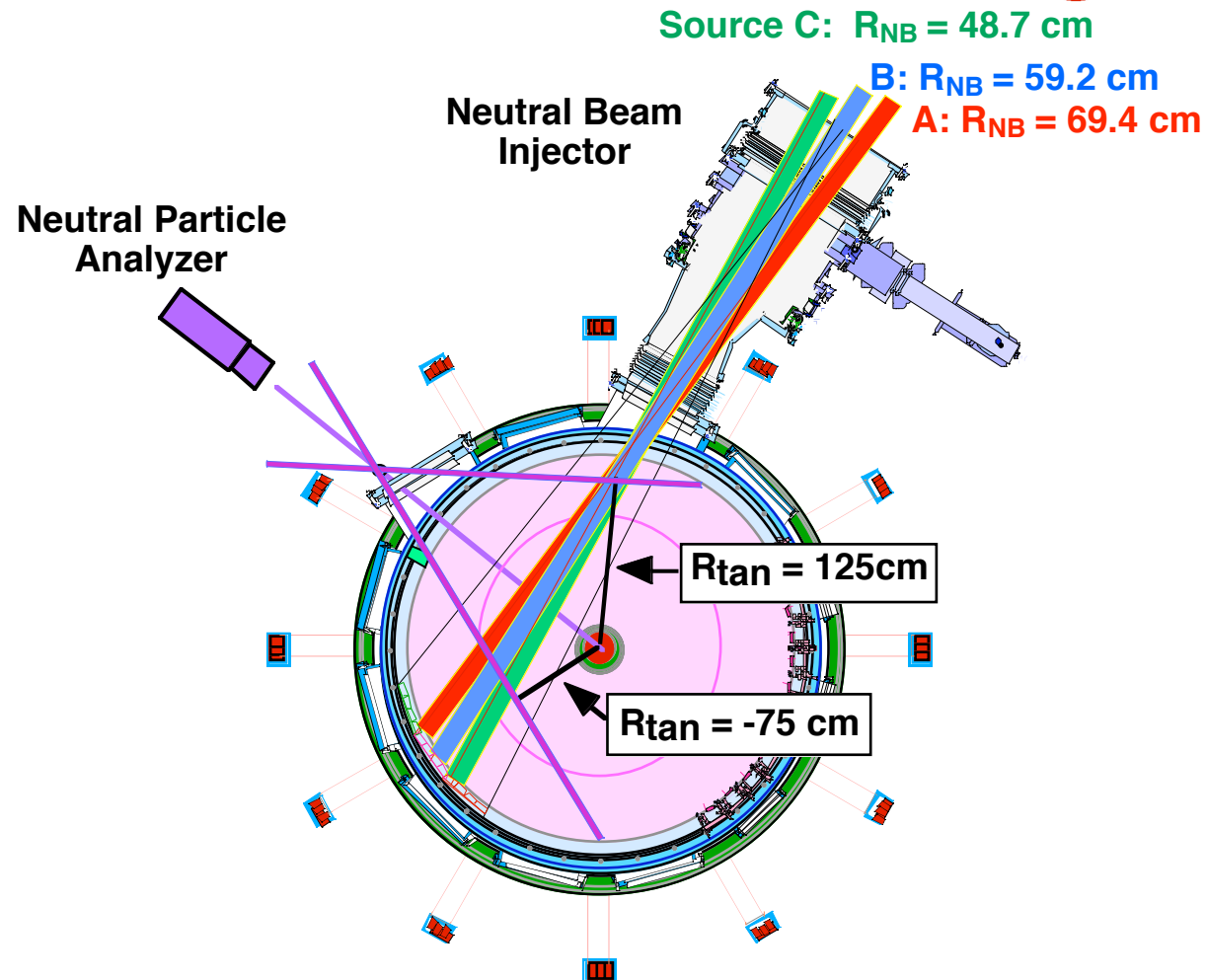


• Following H-Mode onset, the NPA spectra show significant depletion of energetic ions *only for $E > E_p/2$* .



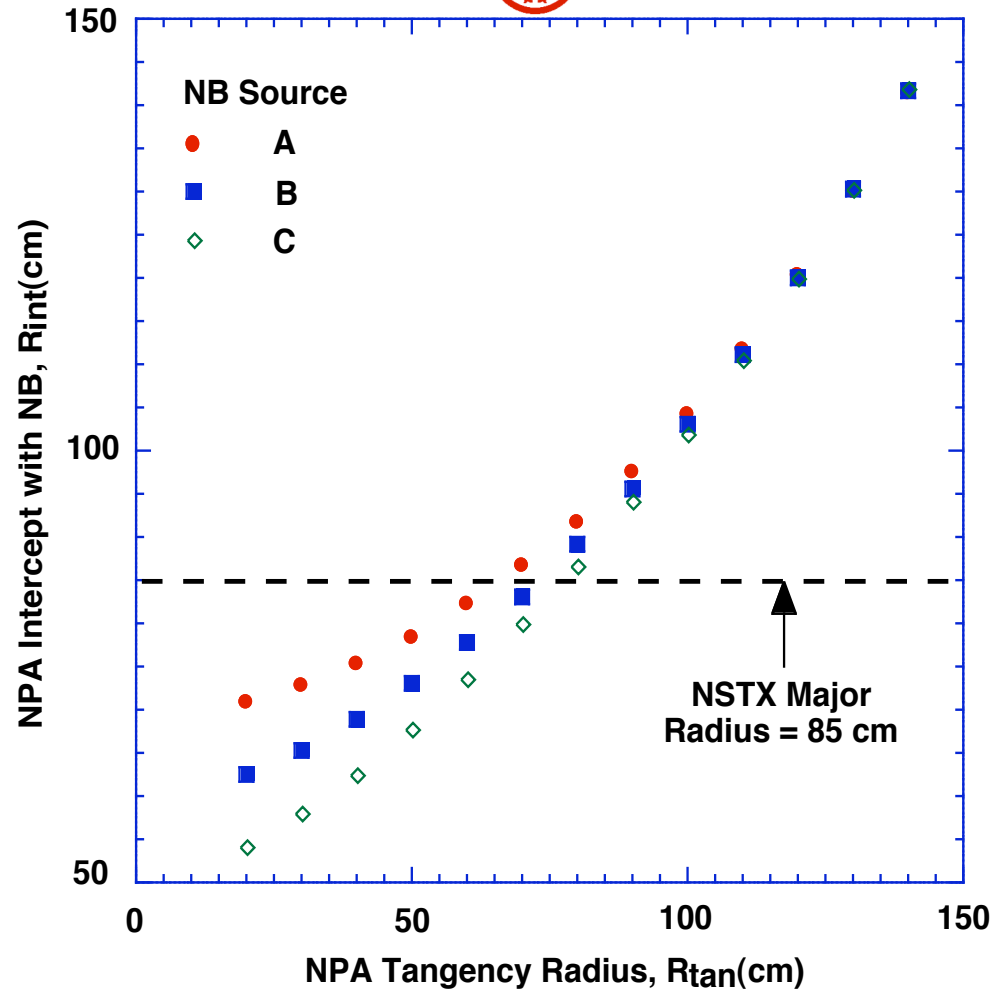
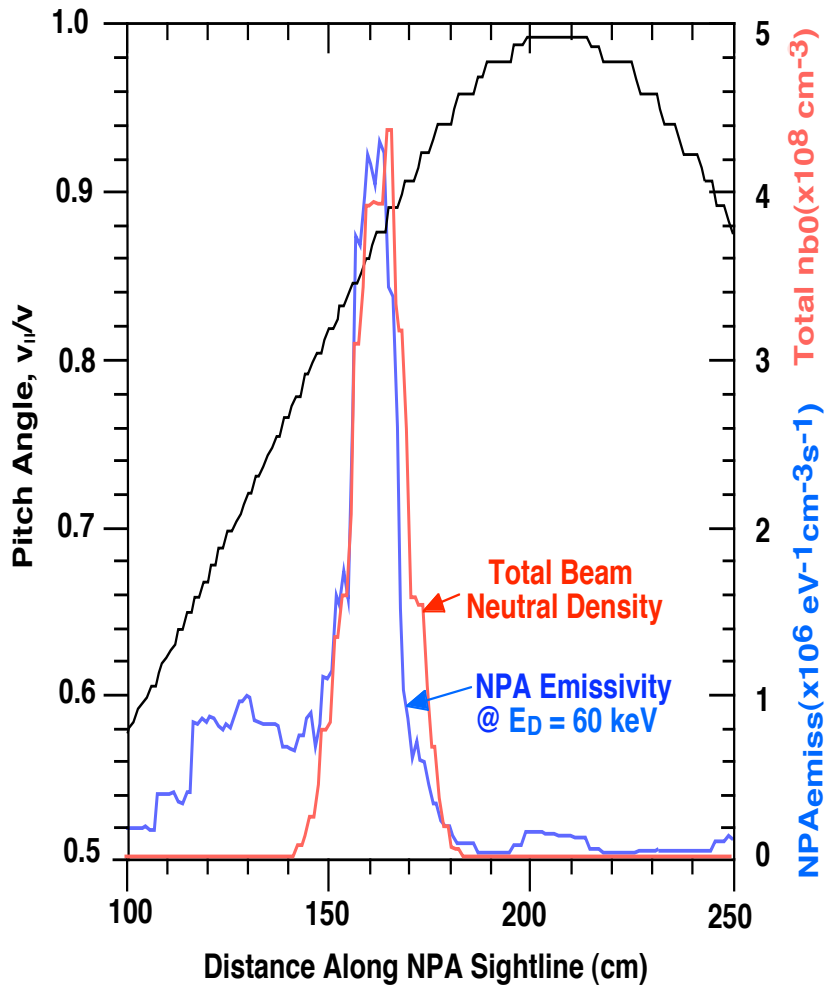
• TRANSP simulation of the NPA measurements required using a time and energy dependent anomalous ion diffusion ($\sim 4 \text{ m}^2/\text{s}$).

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



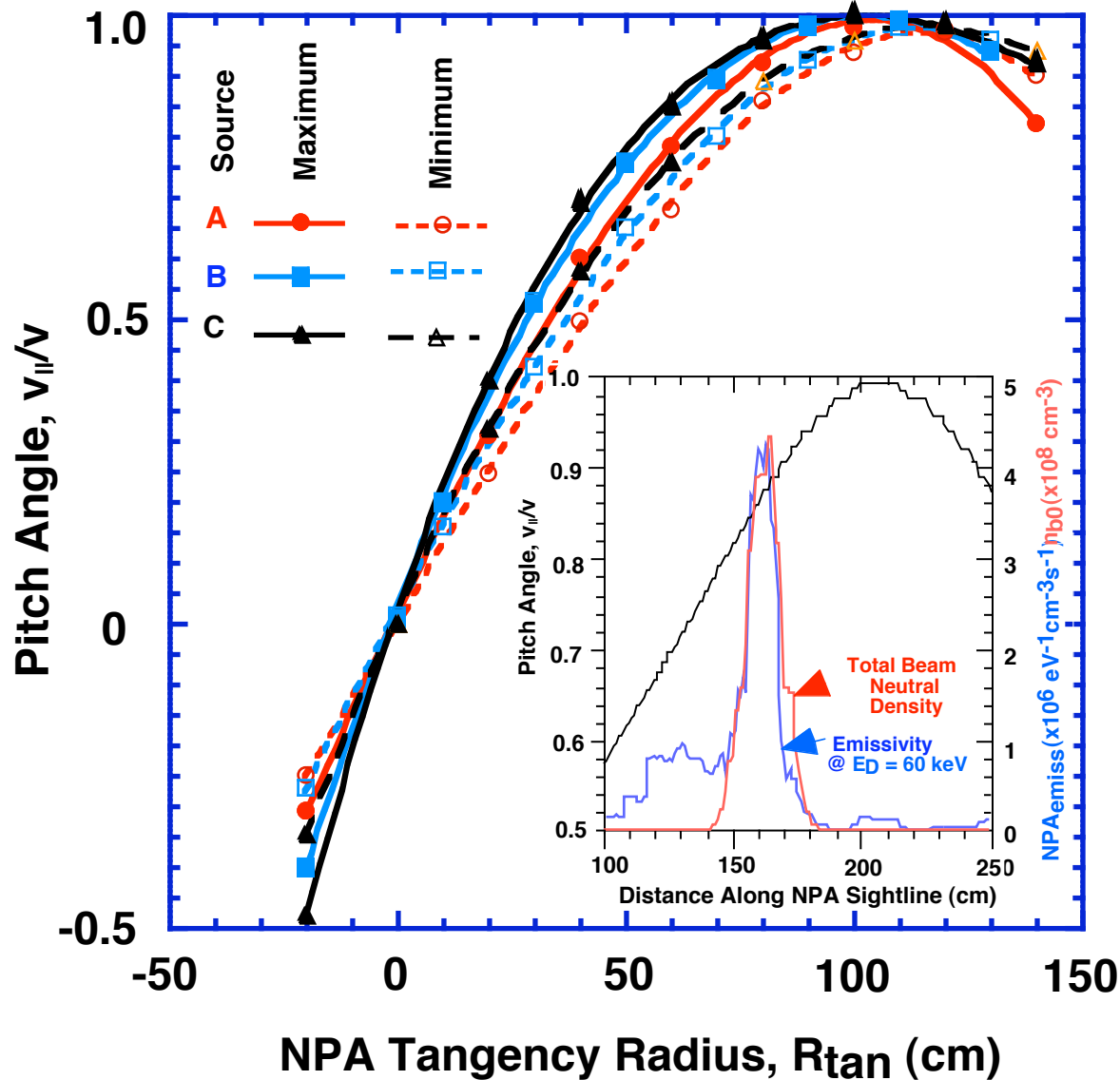
- Covers Thermal (0.1 - 20 keV) and Energetic Ion (≤ 150 keV) Ranges

NPA Measurements are Spatially Localized by Beam Injected Neutrals



- Up to 2/3 of the line-integrated flux can originate in the intersection region of the NPA sightline with the NB.

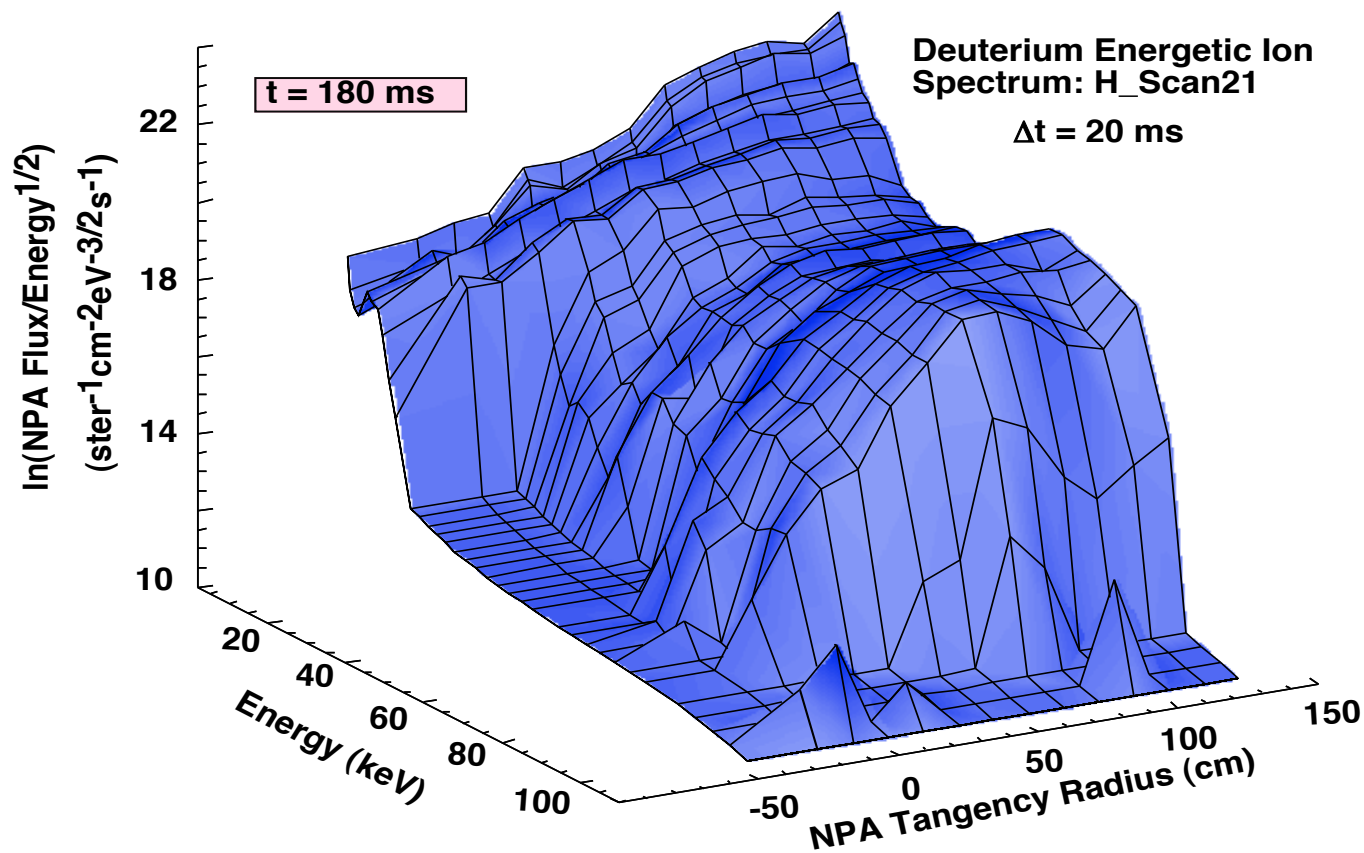
NPA Measurements are Localized in Pitch Angle by Beam Injected Neutrals



- The beam injected neutrals spatially localize the NPA signal (insert).
- This spatial localization also constrains the range of pitch angles viewed by the NPA (main panel).
- The spatial localization weakens with increasing NB penetration distance (due to attenuation of the beam neutrals) and increasing n_e .

NPA Horizontal Scan at 180 ms

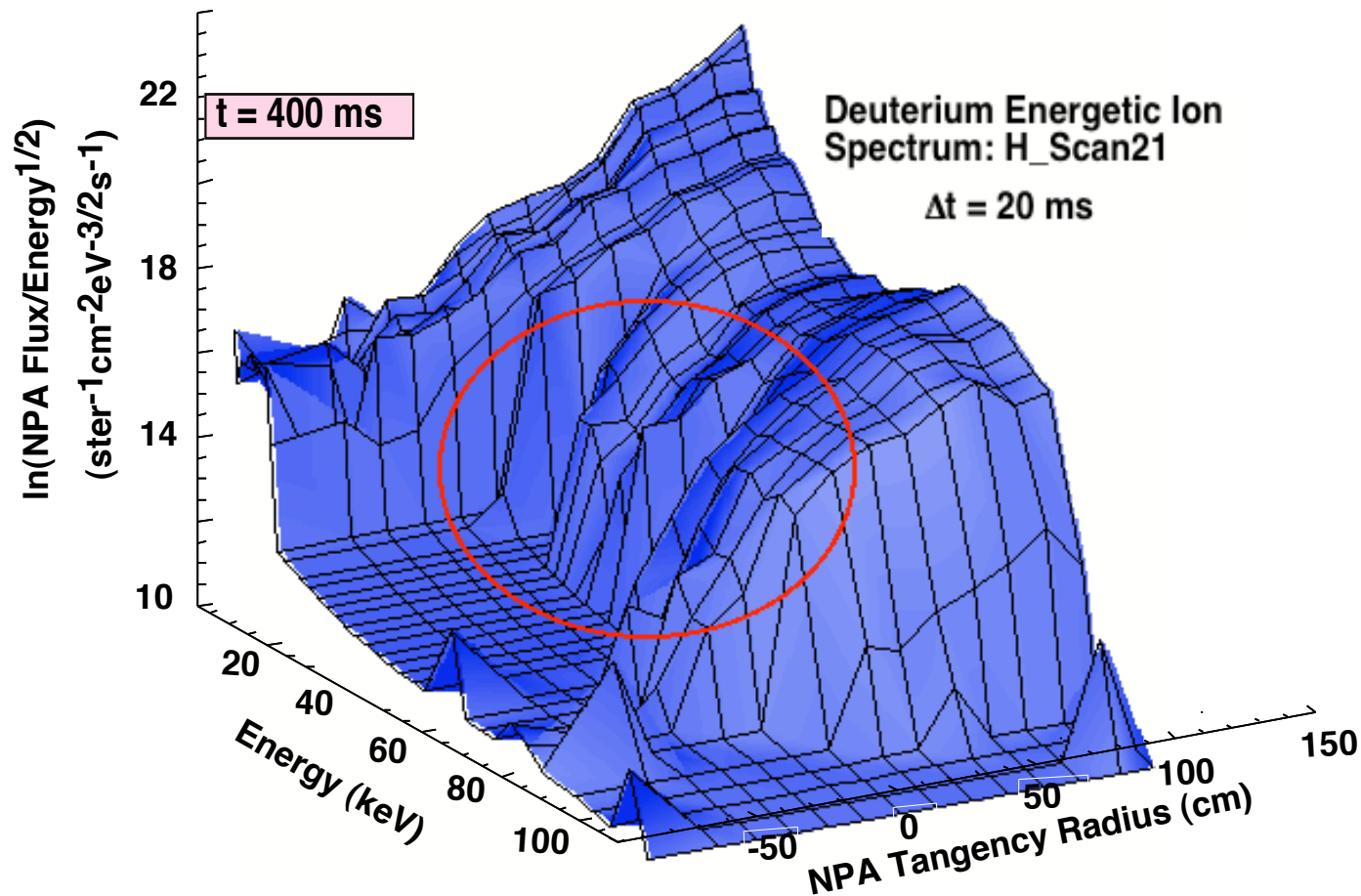
Preceding H-mode Onset: No Spectrum Depletion



- The spectra at small tangency radii drop off naturally because this region corresponds to trapped orbits not populated by tangential NB injection in NSTX.

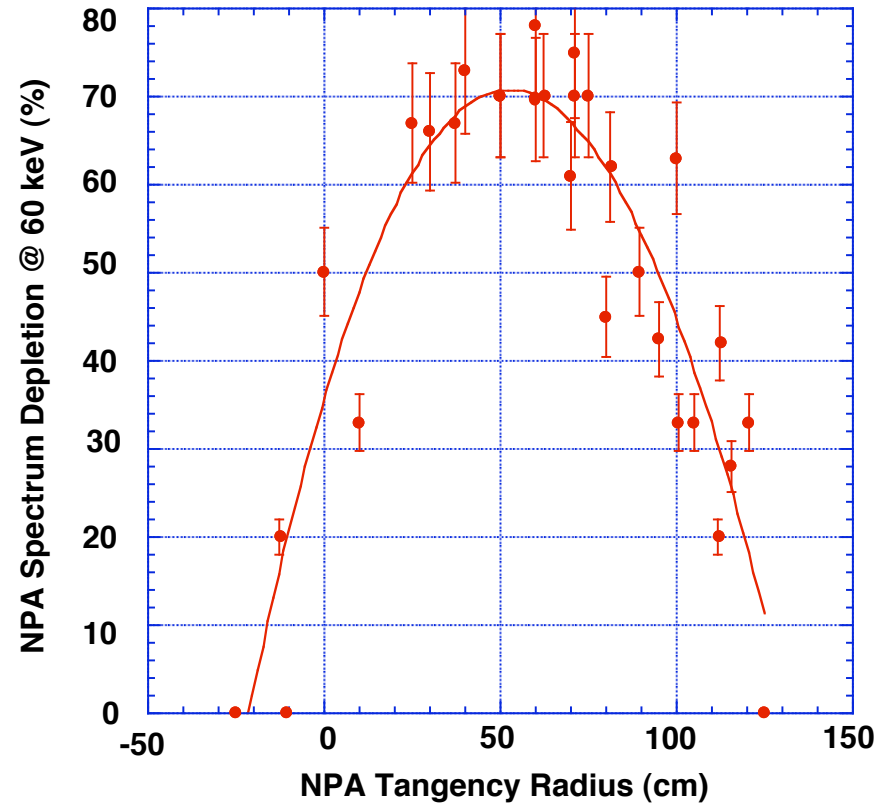
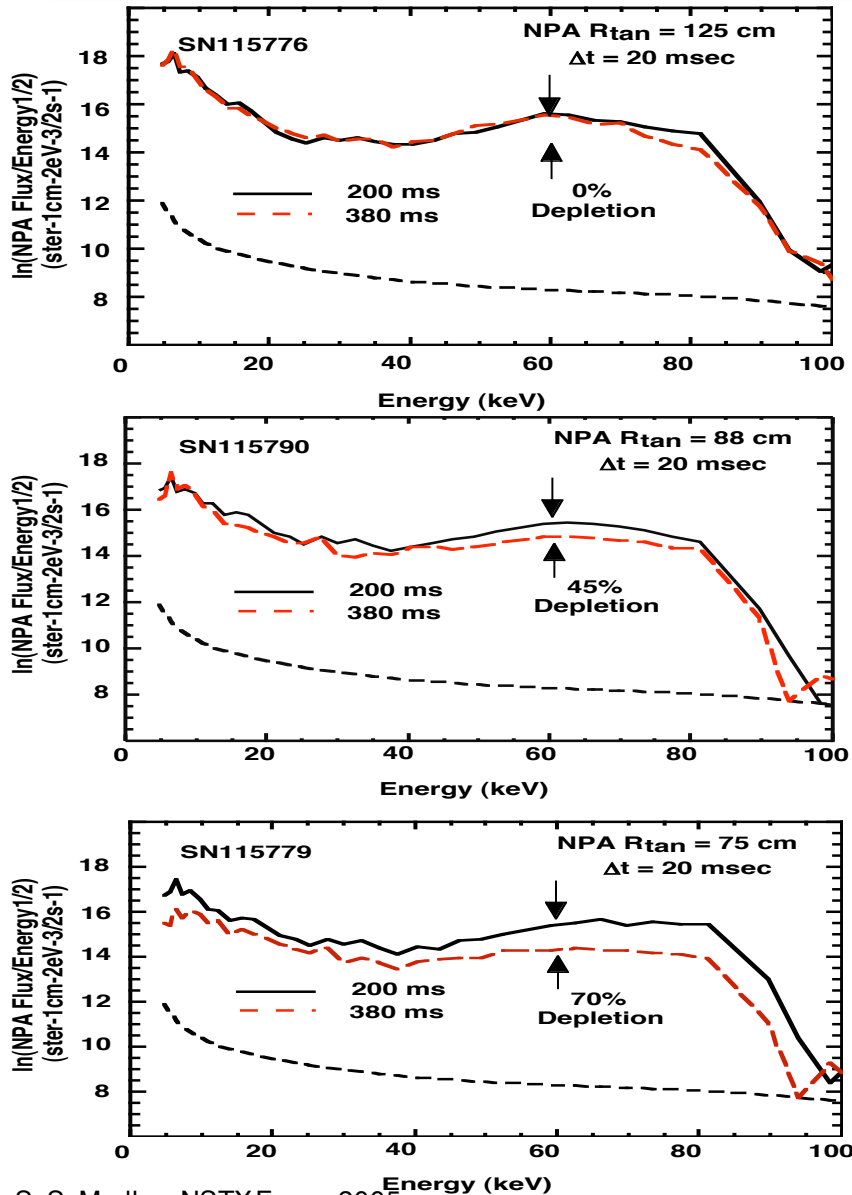
NPA Horizontal Scan at 400 ms

Following H-mode Onset: Spectrum Depletion



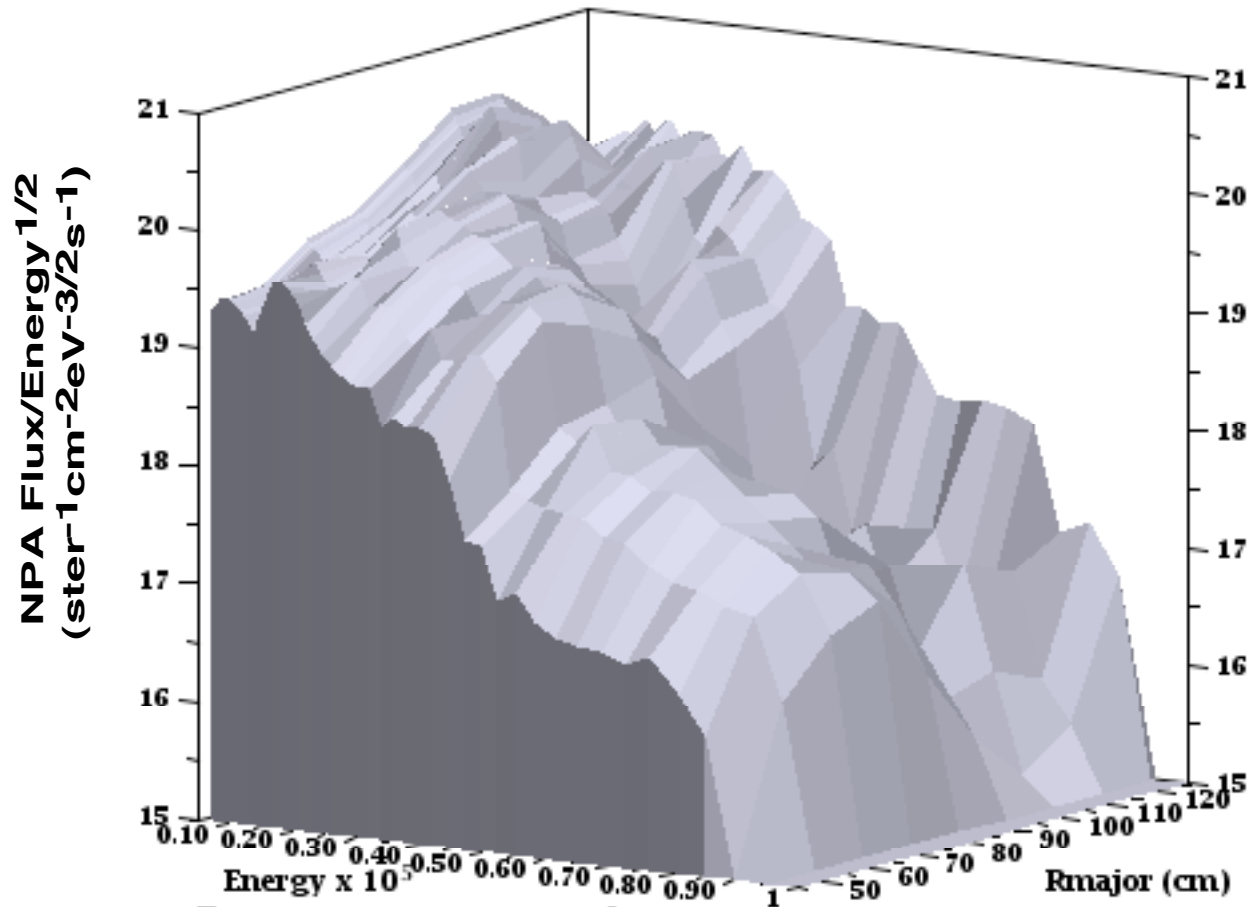
- Following H-mode onset, a clear depletion of the NPA horizontal scan spectrum is observed at $E > E_b/3$ and $R_{tan} < 50$ cm (encircled region).

Depletion of the NPA Energetic Ion Spectra Exhibits a Spatial Dependence



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

TRANSP Analysis of the Energetic Ion Spatial Distribution



- TRANSP simulation of NPA spectra exhibits some similarities to measured spectra. The increase of the spectrum at $R_{\text{tan}} = 125$ cm is likely due to an issue in the TRANSP modeling of edge neutral density.

Various Mechanisms Can Produce Energetic Ion Depletion Observed by the NPA Diagnostic



✓ MHD Effects

- Strong $n=1$ or $n=2$ mode activity and reconnection events [1]
- Fishbones [2]

✓ Plasma Opacity Effects

- Outer gap width (i.e. plasma radius)
- High density, broad $n_e(r)$ profiles

✓ H-Mode Effects

- MHD-induced ion loss is observed during H-mode operation due to high, broad density profile effects [3].

• Data mining and TRANSP analysis of the 2005 run is in progress to investigate the above effects, particularly the role of EPM/TAE/CAE MHD activity in depletion of the energetic ion distribution.

[1] "Neutral Particle Analyzer Measurements of Ion Behavior in NSTX," S. S. Medley, *et al.* PPPL-3668 (February, 2002)

[2] "Wave Driven Fast Ion Loss in the National Spherical Torus Experiment," E.D. Fredrickson, *et al.* Phys. Plasmas 10, 2852 (2003)

[3] "MHD-induced Energetic Ion Loss during H-mode Discharges in the National Spherical Torus Experiment," S. S. Medley, *et al.* Nucl. Fusion 44, 1158 (2004)

- For H-mode discharges, measured NPA energetic ion spectra exhibit energetic ion depletion primarily for $E > E_p/3$.
- The measured spectrum depletion exhibits a spatial dependence, peaking around $R_{\text{tan}} \sim 50 \pm 10$ cm and vanishing at larger R_{tan} .
- TRANSP modeling exhibits some features similar to the measurements, but the energy dependence of the depletion is different (depletion increases with decreasing E).
- Charge exchange emissivity effects can account for part, but not all, of the observed energetic ion depletion behavior.
- During the 2006 run, counter-injection experiments are expected to significantly expand understanding of the energetic ion depletion phenomena.