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MHD-induced Energetic Ion Loss during H-mode Discharges in NSTX

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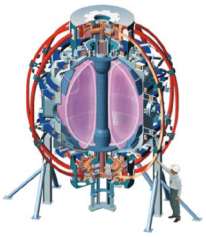
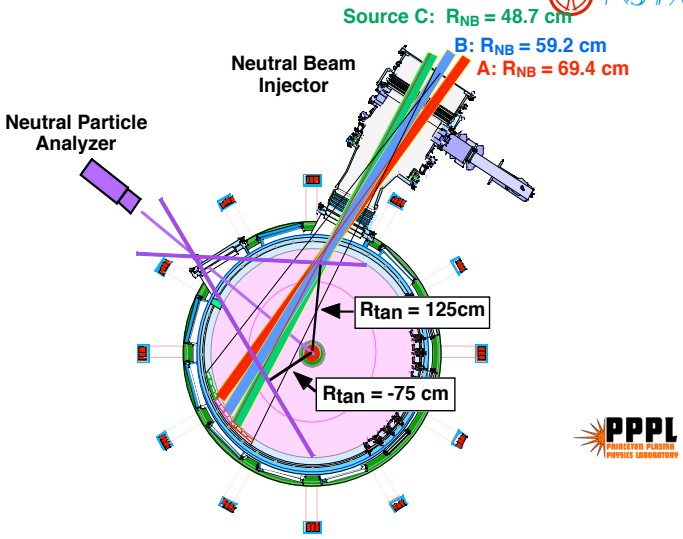


APS-DPP, 2005

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



- Positive NPA R_{tan} sightlines view co-going ions: negative R_{tan} view counter-going.

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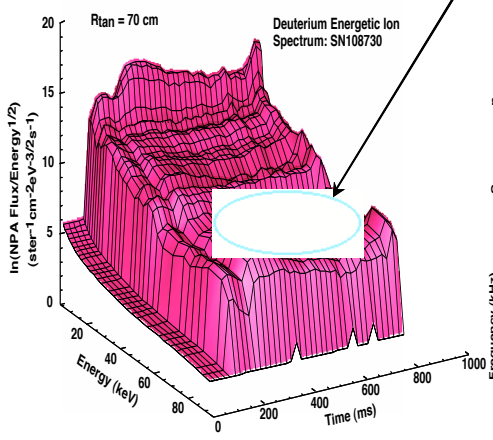
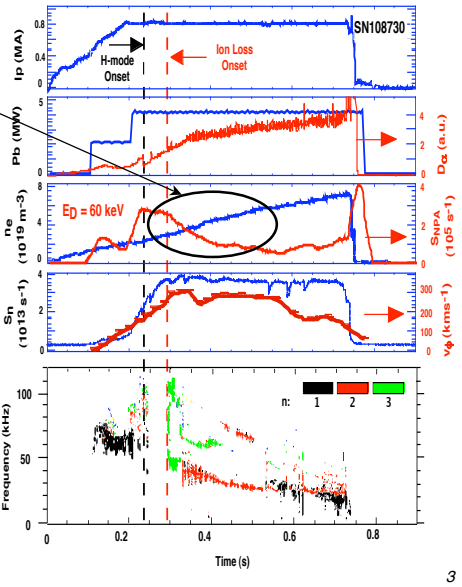
Illustration of MHD-induced Ion Loss during H-mode

B_T = 4.8 kG, I_p = 0.8 MA, Source A & B @ 90 keV, Low MCP Bias

NSTX

- **Following H-Mode onset at 230 ms, the NPA spectra show significant loss of energetic ions *only for E>E_b/2*.**





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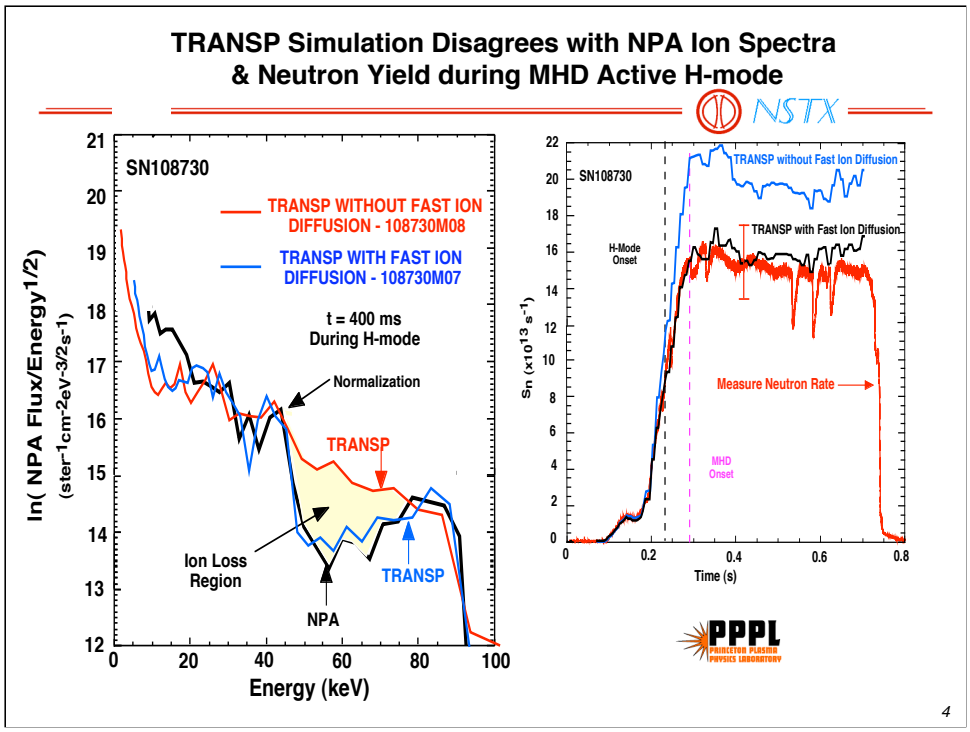
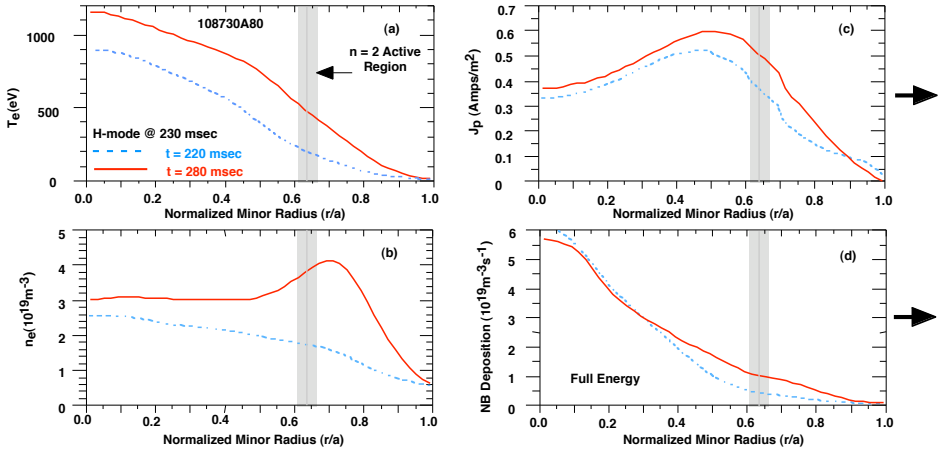


Lacking measurements to indicate otherwise, the applied anomalous diffusion was constant in minor radius. However, Gorelekov's QRBIT analysis indicated that the loss should be localized to ion orbits that intersect the MHD active region, which is localized off-axis. XP-504 is expected to provide experimental evidence of spatial localization.

Evolution of T_e, n_e (and hence Pressure) Profiles during H-mode Drives other Profile Changes

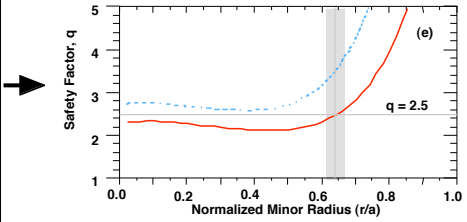
- Pressure profile evolution modifies I_p distribution, mainly by bootstrap driven current.

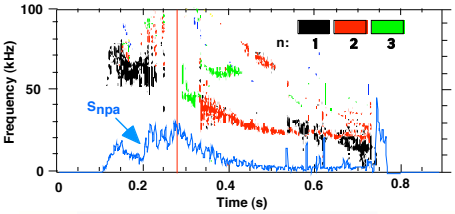


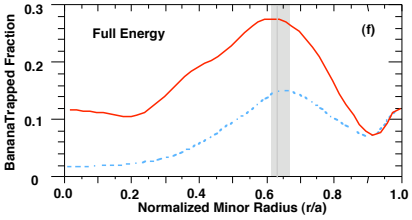
- Density profile evolution increases full energy NB deposition in outboard region.

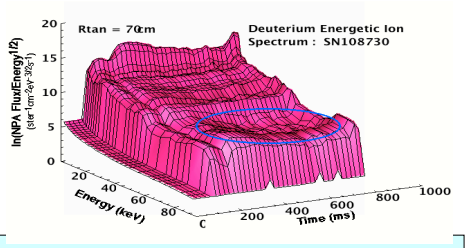
q-profile Evolution Introduces Low-n MHD activity: Elevated Trapped Ion Fraction Feeds Ion Loss

- I_p profile evolution modifies q profile, introducing q = 2.5 region around r/a ~ 0.63.

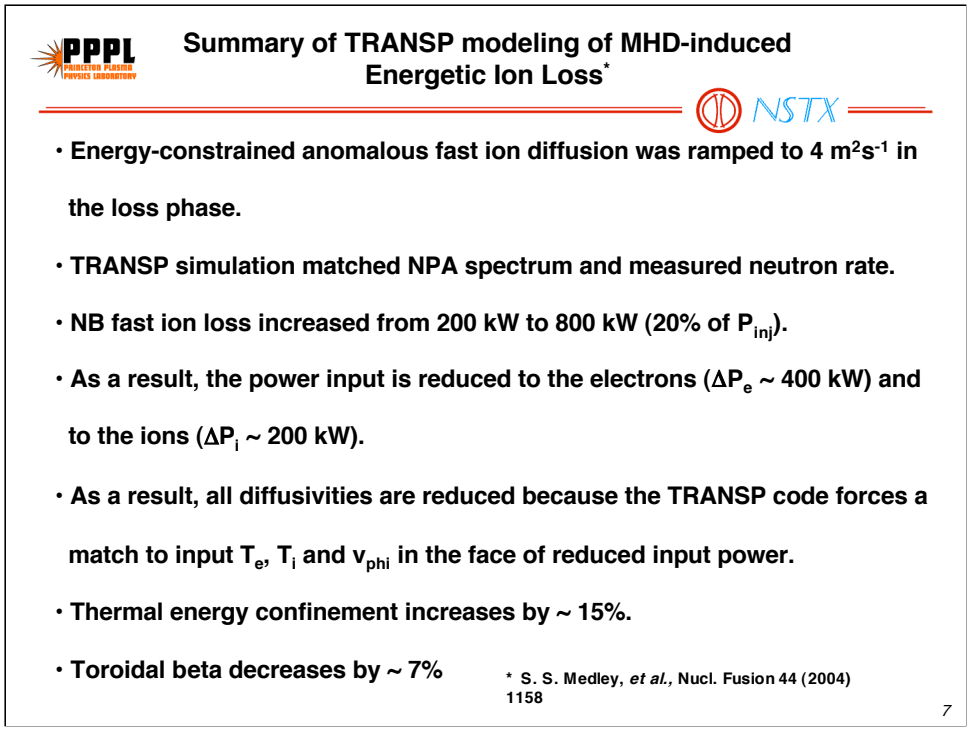






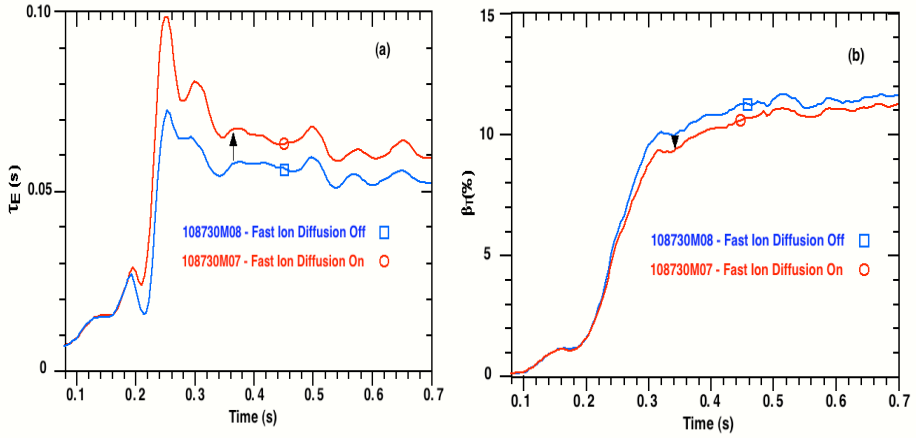


- Out-shifted NB deposition increases full E trapped ions in m/n = 5/2 MHD active region.



Preferentially reduced power to the electrons should have an impact on the Ti>Te anomaly.

TRANSP Analysis



- **TRANSP calculation of thermal energy confinement time (a) and toroidal beta (b) at t = 400 ms with and without fast ion diffusion for SN108730 is shown. For this case, accounting for fast ion loss increased the thermal energy confinement, τ_E, by ~ 15% but reduced the toroidal beta, β_T, by ~7%.**

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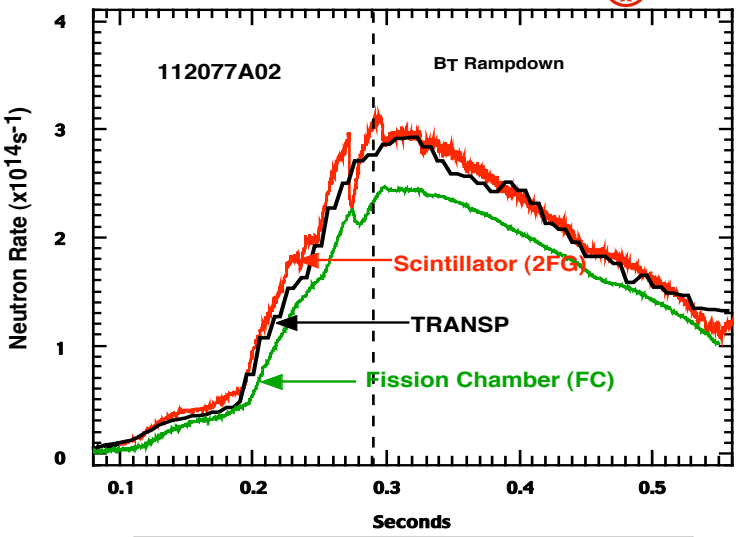
Neutron Conundrum #2: *Circa 2004*



• Ip = 0.8, B_T = 4.4 kG, P_{NB} = 6 MW, Sources A, B,C @ 90 keV

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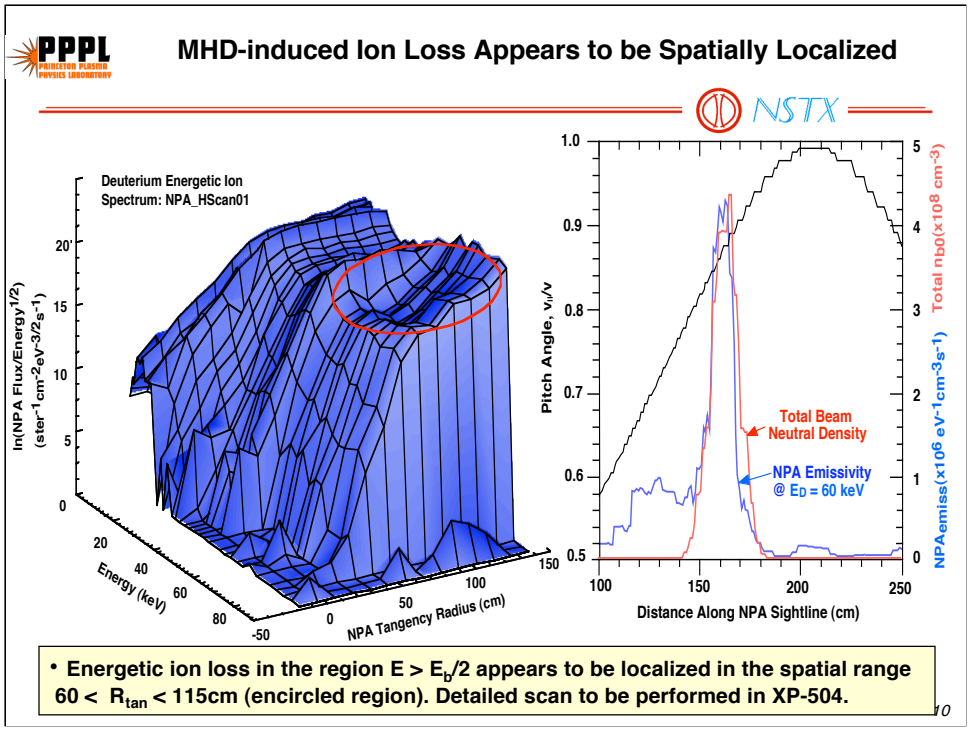
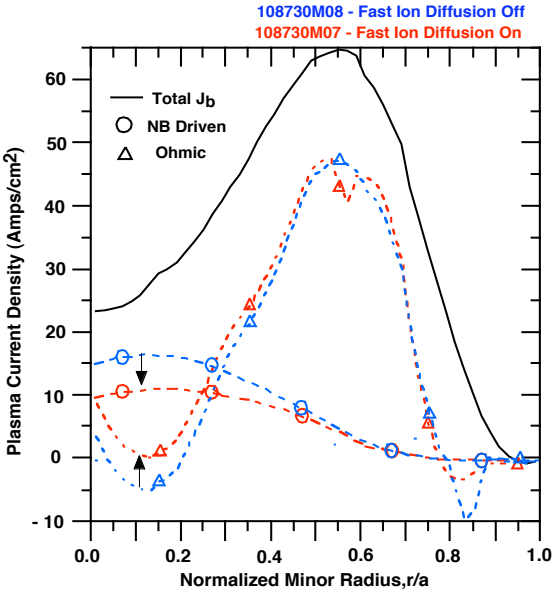


The combination of horizontal scanning and emissivity localization of the NPA flux along the sightline presents the possibility to define the volume of space affected by fast ion loss. This will reduce the neutron deficit maybe by ~ 50%. In fact, localization of the NPA observation could change the picture from one of ion loss to ion redistribution wherein core ions are redistributed radially outboard. This could have a beneficial effect in that core driven beam current would be moved off-axis which NSTX needs to maintain an elevated q(o). Also during this run the sFLIP diagnostic is available to help distinguish between the loss/redistribution scenarios.

Enhanced Fast Ion Diffusion Causes a Reduction of Beam-driven Current



- Enhanced fast ion diffusion causes the beam driven current in the core to decrease by ~ 30%.
- TRANSP increases the Ohmic current to force the total current to remain unchanged.

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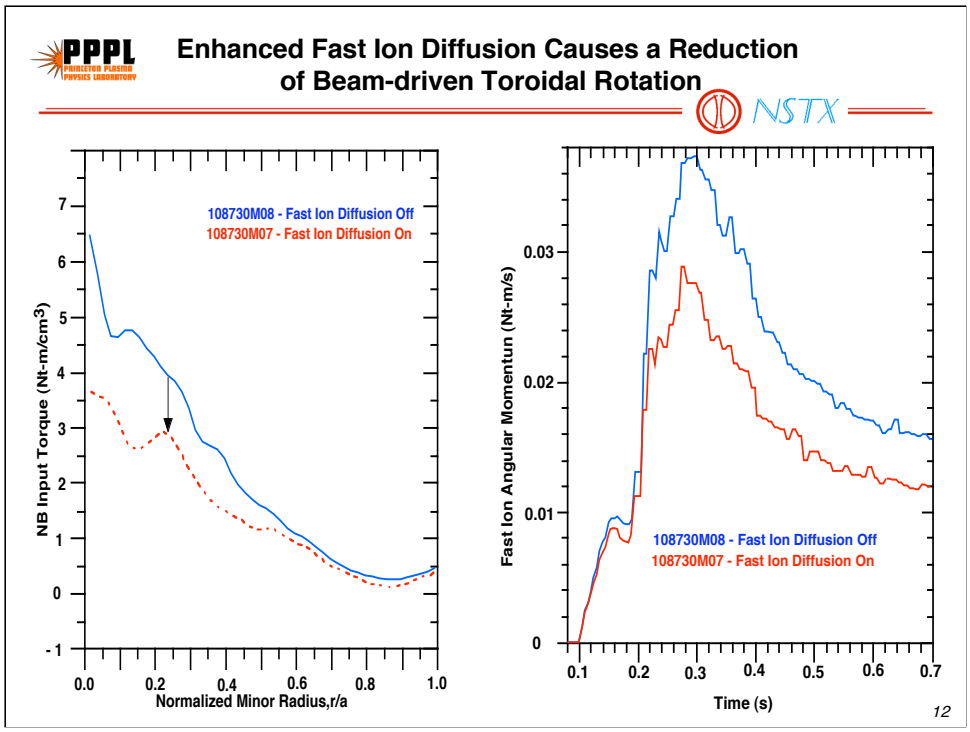
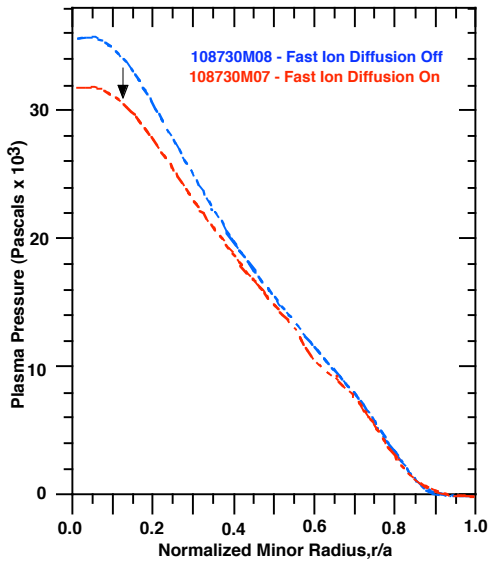


Fast ion diffusion does not affect the plasma toroidal velocity calculated by TRANSP. In response to changes in the fast ion momentum (velocity) arising from enhanced fast ion diffusion, TRANSP modifies the momentum diffusivity to enforce agreement of the calculated plasma rotation with the CHERS input data. This reduction in collisional torque should be at least partially offset by an increase in jxB due to the enhanced ion loss.

Enhanced Fast Ion Diffusion Causes a Modest Reduction of the Kinetic Pressure Profile



- These TRANSP simulations of the beam-driven current, input torque and kinetic pressure profile using flat fast ion diffusion will all be significantly modified by spatial localization of the MHD-induced energetic ion loss.

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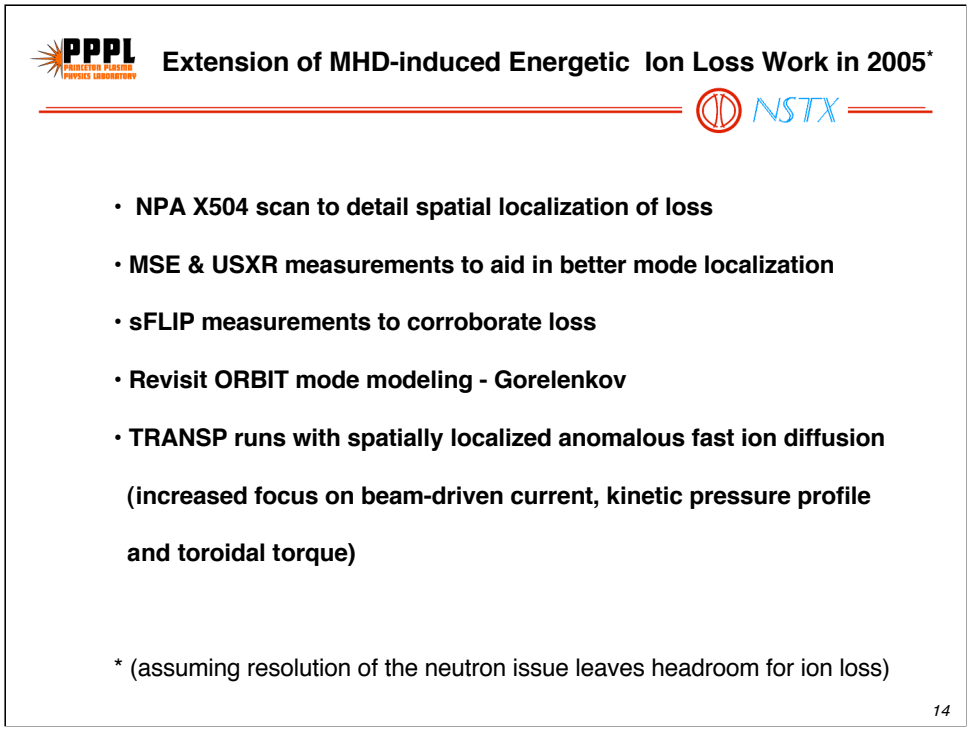
Kinetic pressure profile is thermal plus fast ions.



Kinetic pressure profile is thermal plus fast ions.