Neutral Beam Ion Confinement & Loss from NSTX Plasmas

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Main Question: Can STs confine fast ions well?

Preliminary answer: Yes, if no strong MHD activity

Fast Ion Physics Issues

Parameters:

NSTX: R=86 cm, a=68 cm, κ=2, $I_p \leq 1$ MA, $B_T \sim 0.3$ T

NBI: 80 keV D, 5 MW total, 3 sources (R_{tan}=50, 60, & 70 cm)

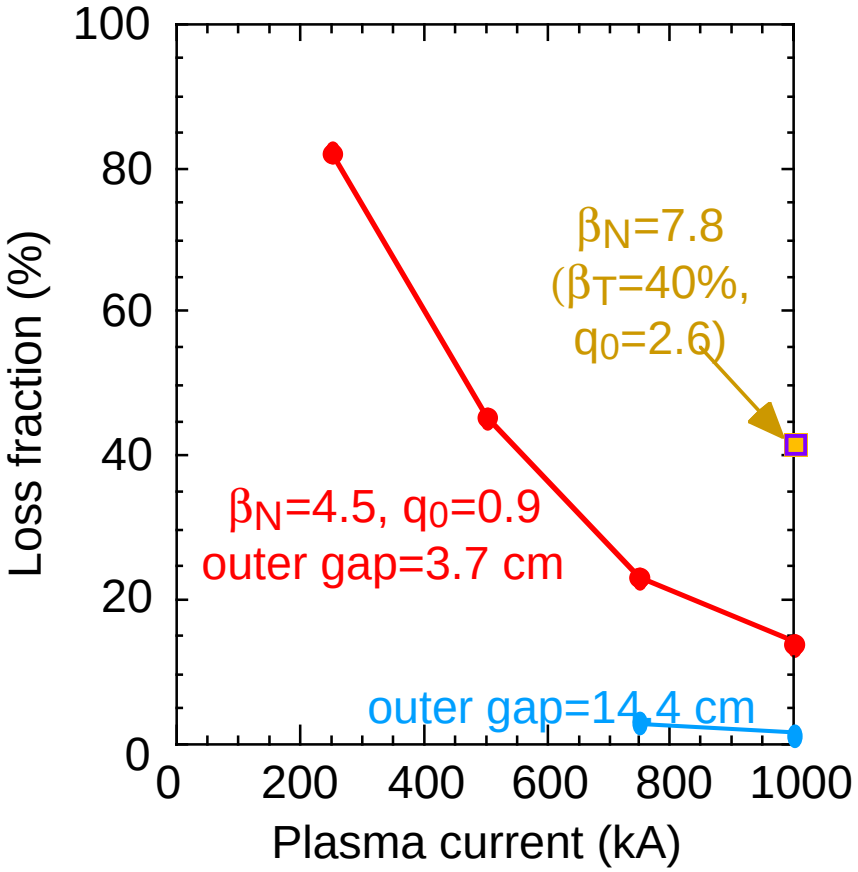
Covered today:

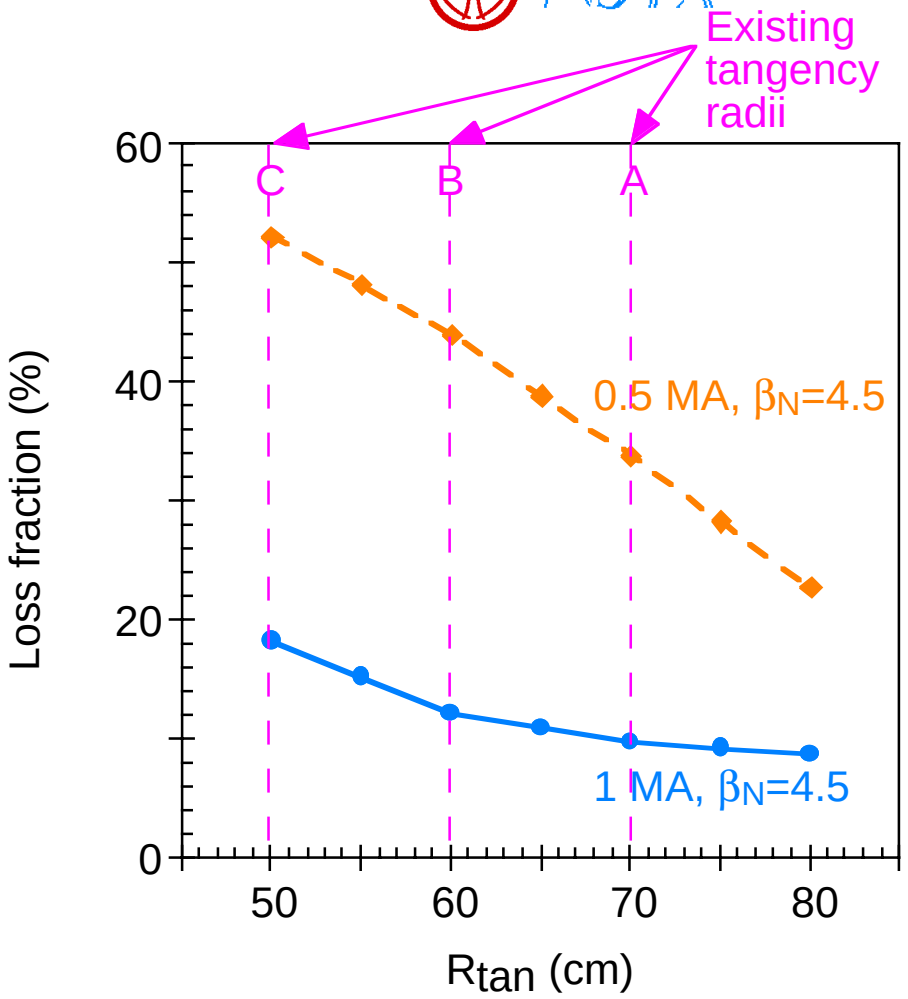
- Prompt orbit confinement
- MHD effects
- NBI + HHFW heating

Diagnostics:

Neutron detectors, fast ion loss probe, energetic neutral particle analyzer

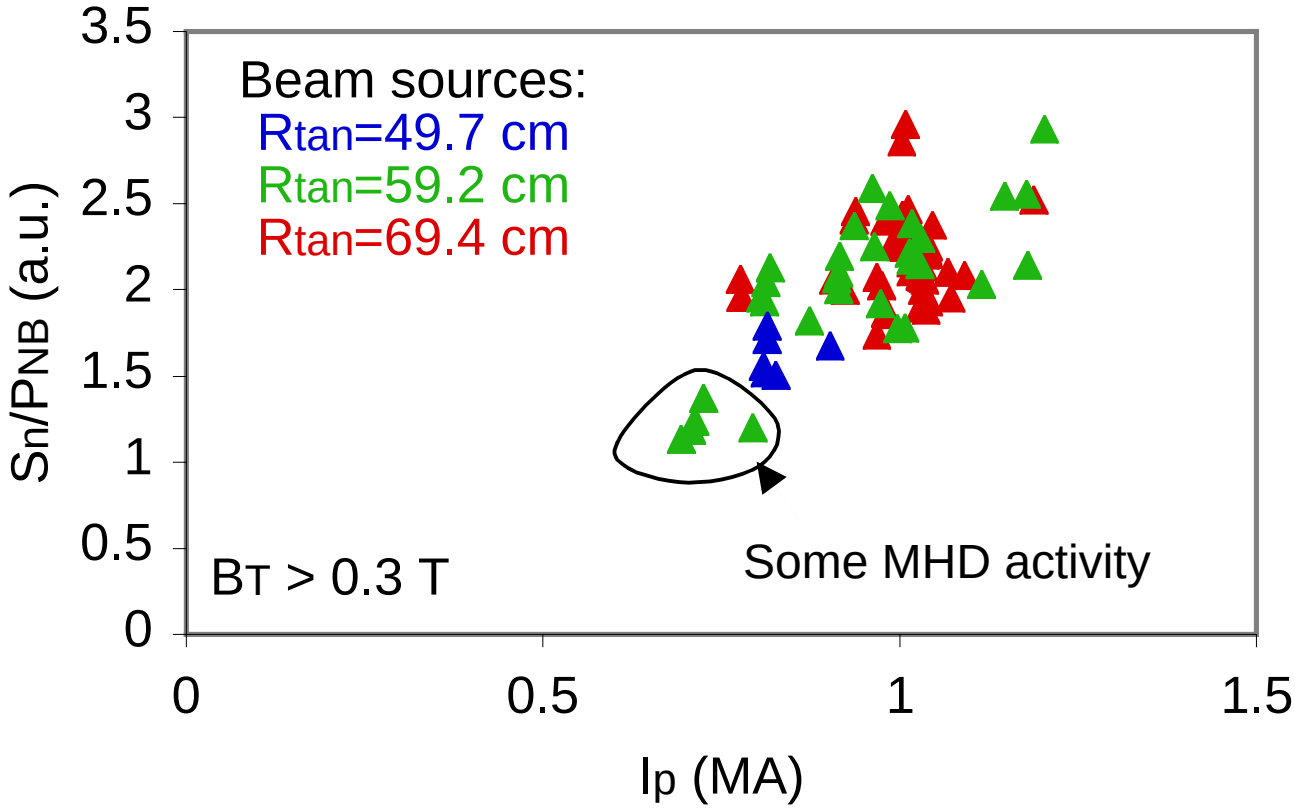
Modeling shows NBI loss fraction depends strongly on I_p, δ_{outer}, & R_{tan}





- EIGOL code results
- B_T not yet studied

Neutron emission increases with I_p, in accord with prompt loss model

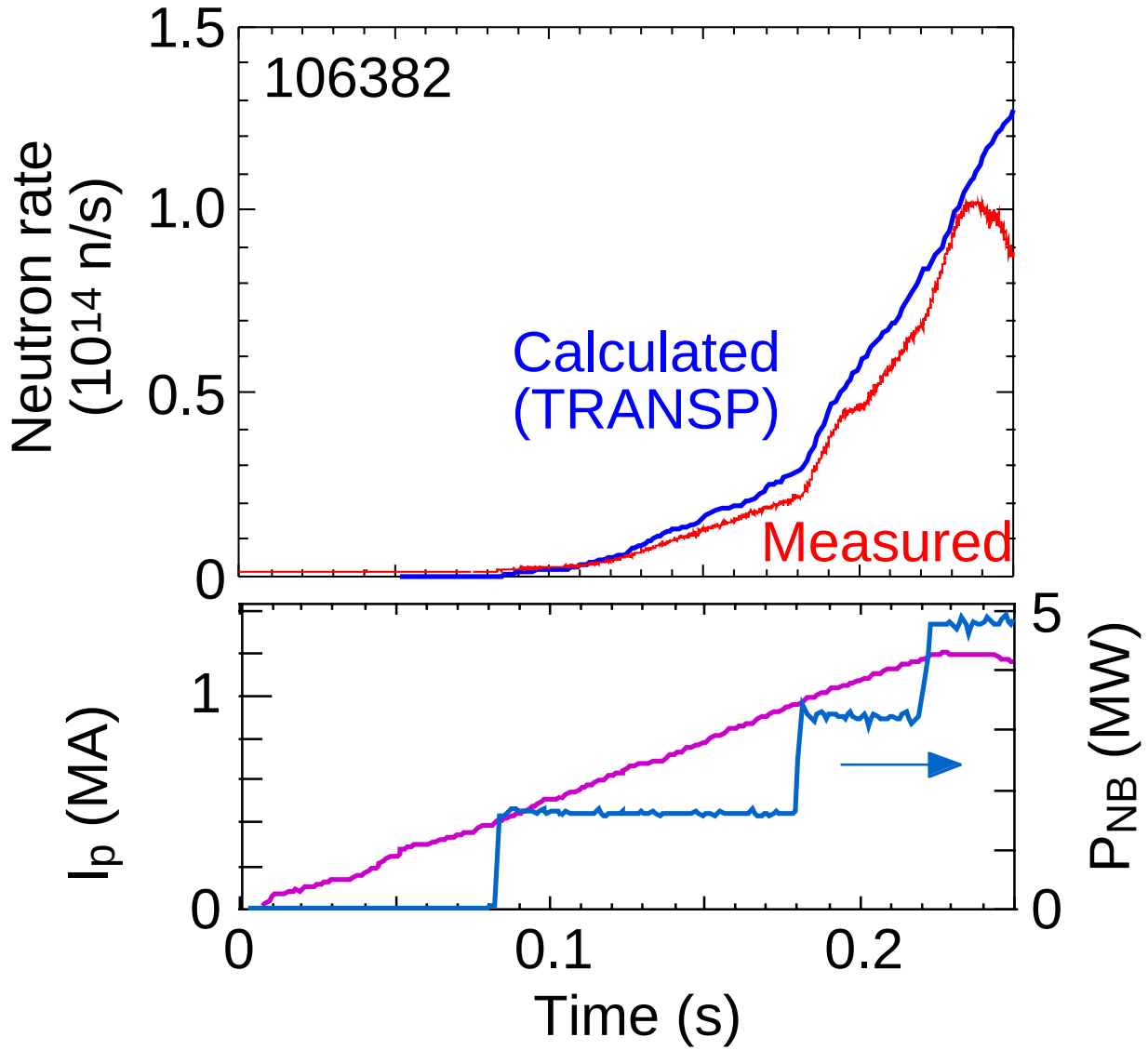


$t_{beam\text{-}on}$ > 30ms into I_p flat top only

Single beam source shots only

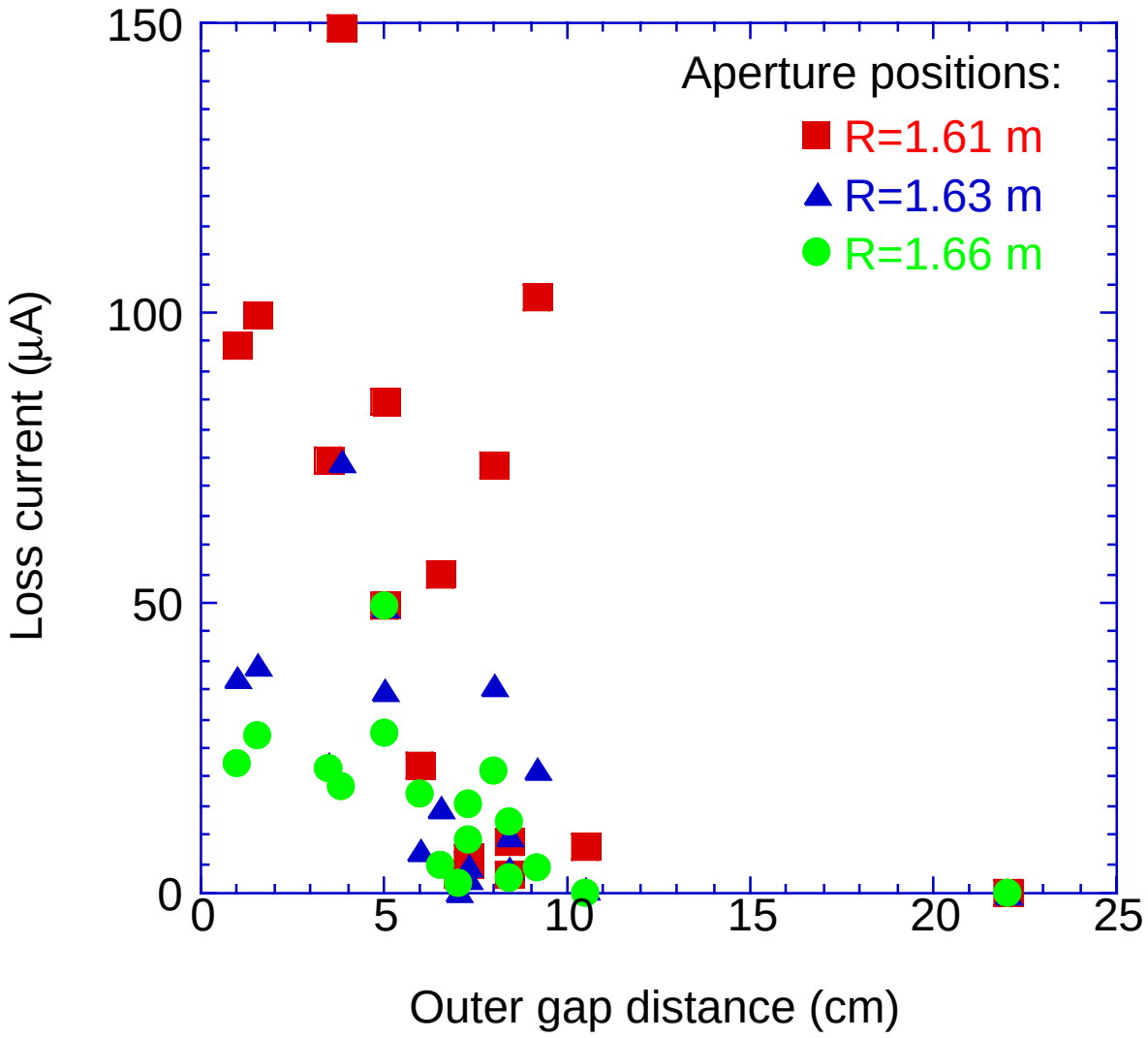
- Fast ions appear better confined at higher I_p
- **But**, MHD may mask the true correlation by causing early rollover in emission
- Dependence on source R_{tan} smaller than expected

TRANSP correctly predicts neutron rate, implying little non-classical loss



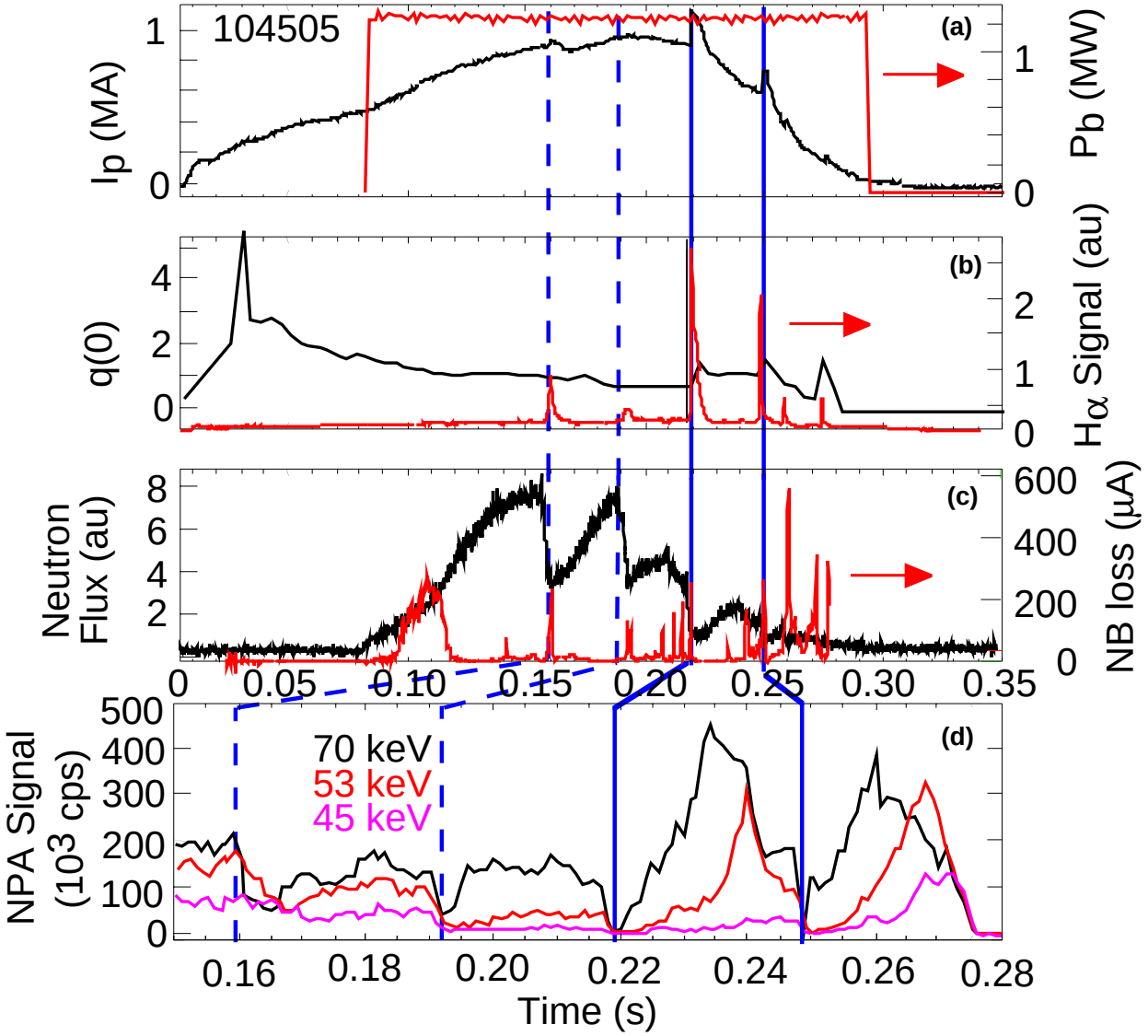
TRANSP includes only prompt loss of NB ions (classical loss)

Measured prompt loss rate varies strongly with δ_{outer}



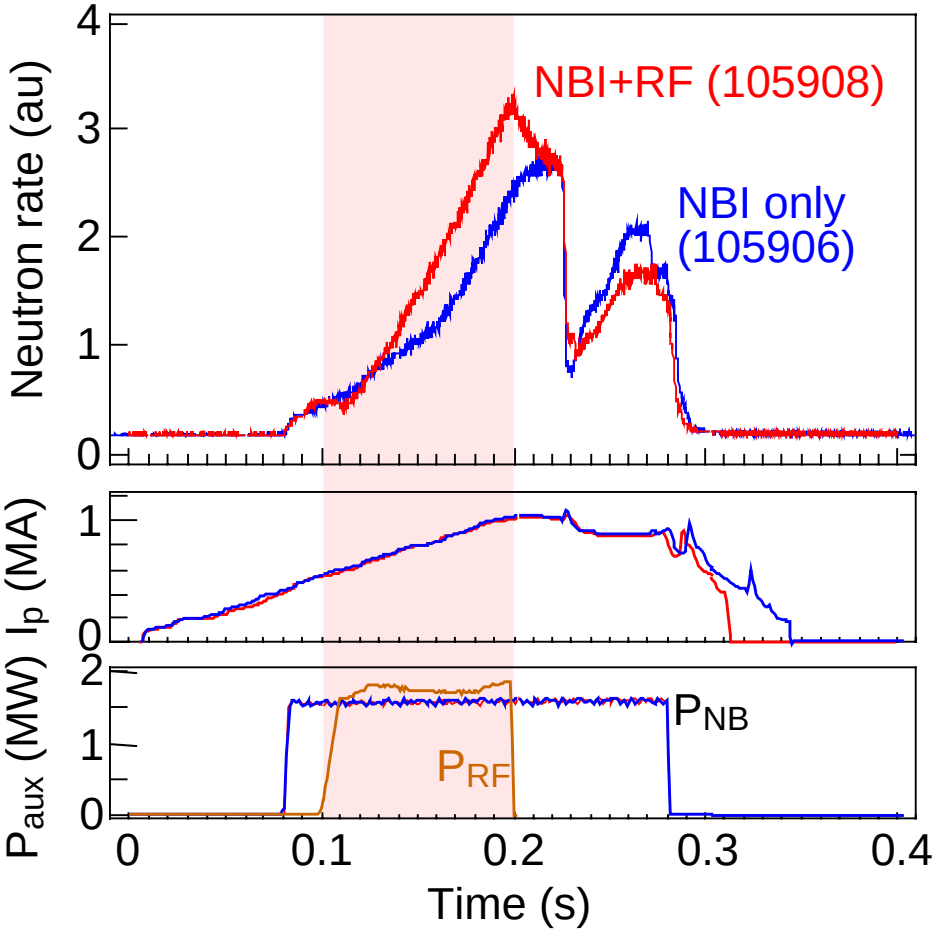
- Measured with Faraday cup probe
- Loss trend is in direction expected

Sawteeth & IREs cause large drop in S_n & NPA signal

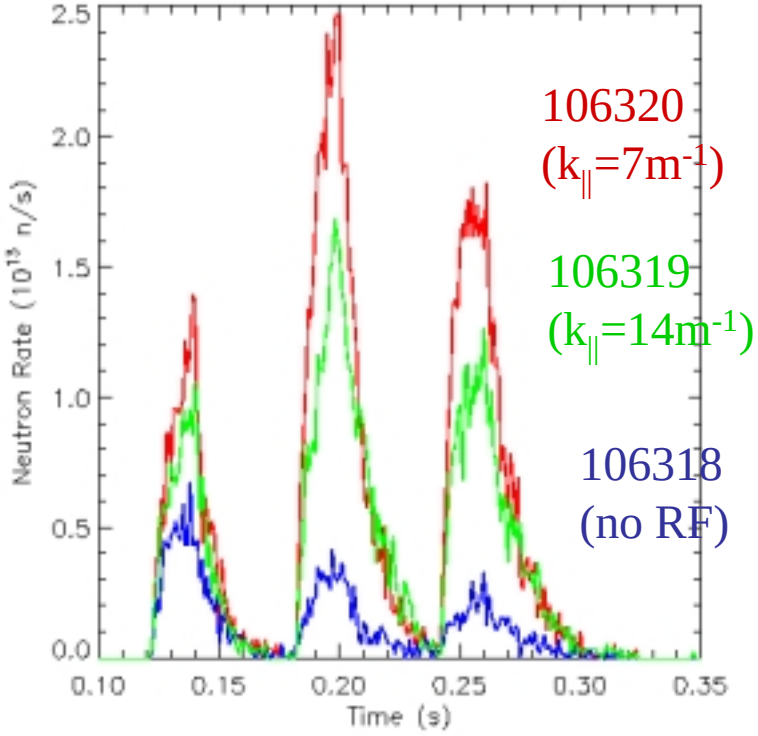


- Conjecture that large beam ion gyroradius + large q=1 surface cause large loss at IREs & sawteeth
- Smaller loss of NPA signal at lower energy

Neutron rate with NBI + RF gives higher neutron rate than NBI only, implying RF acceleration of NB ions



Steady RF + NBI blips



- Lower $k_{||}$ gives larger neutron enhancement
- Ion tail to 120 keV seen by NPA during RF+NBI

Summary

- Beam ion confinement dependence on I_p & δ_{outer} in accord with model, but only weak variation with R_{tan} observed
- Absolute S_n in good agreement with TRANSP, suggesting loss is principally prompt (classical)
- RF acceleration of NB ions results in enhanced neutron rate
- A variety of MHD instabilities substantially affect beam ion confinement

Invited talk (Wed. PM): Frederickson LI1.003-Beam modes

Posters (Thu. PM): Medley QP1.029, Roquemore QP1.031, Miah QP1.030, Rosenberg QP1.010