Characterization of Fast Ion Power Absorption of HHFW in NSTX

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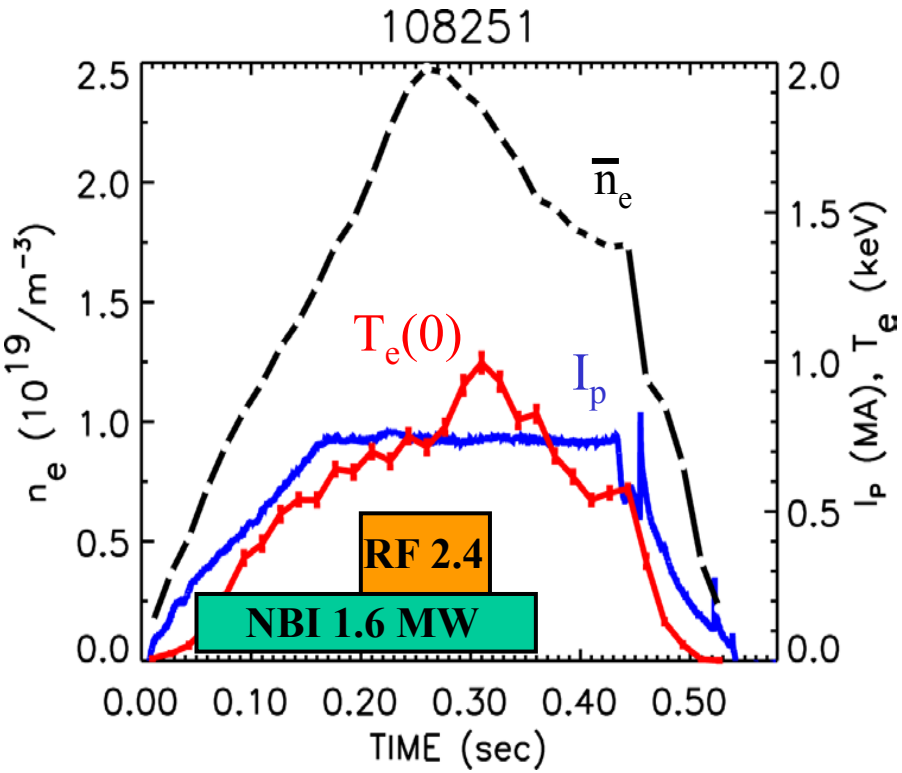
Introduction and Motivation

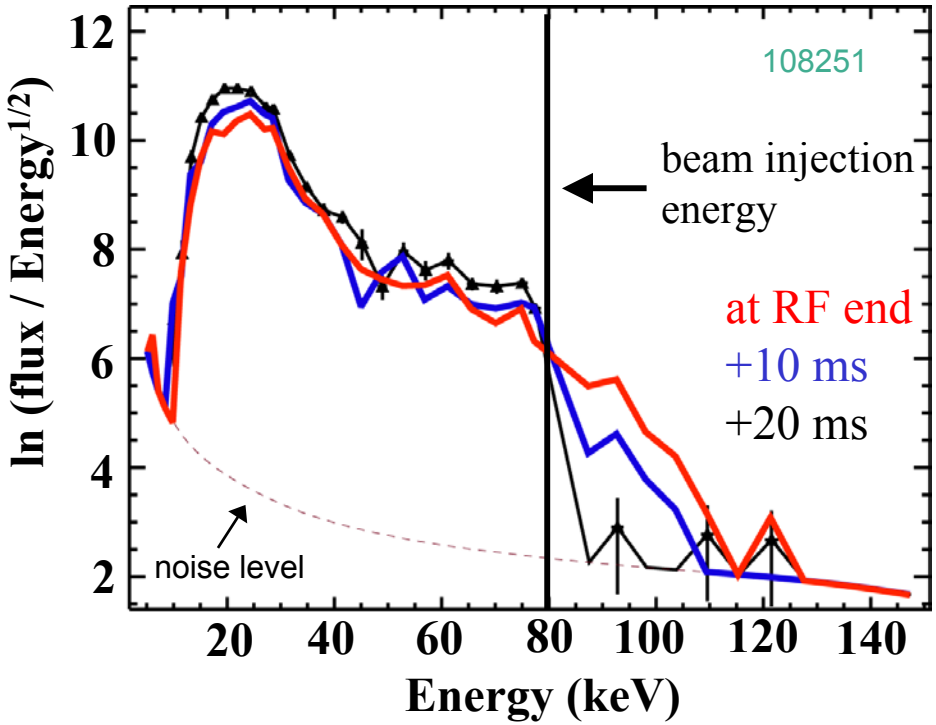
- Ion absorption critically important to assessing viability of HHFW to heat and drive current in STs
- Experimental evidence of HHFW interaction with NBI
  - Neutral Particle Analyzer (NPA) scannable at midplane
  - neutron rates, Fast Lost Ion probes
- Thompson scattering measures T_e, n_e profiles
  - X-ray Crystal Spectroscopy measures peak T_i
- Computational evidence
  - HPRT, TRANSP, CURRAY, AORSA, METS

HHFW can generate a fast ion tail with NBI

- Typical shot

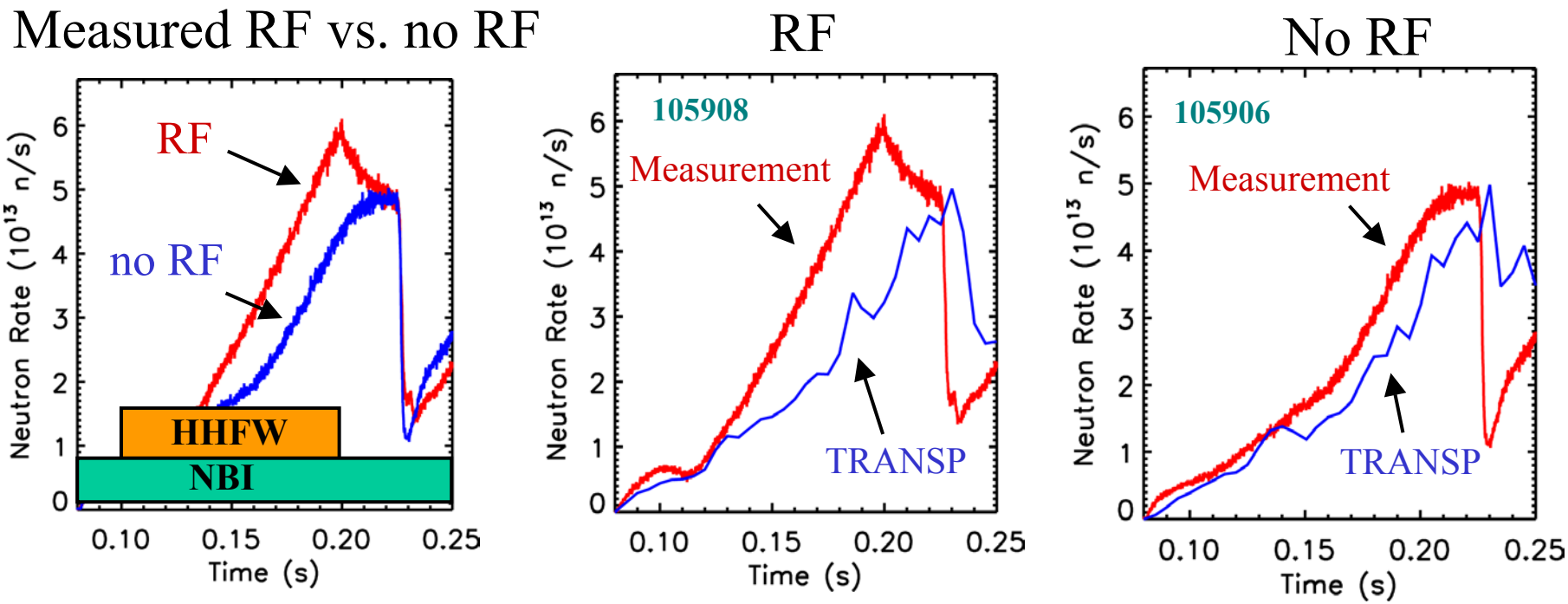


- D^+ tail extends to 130 keV
- Tail saturates in time during HHFW



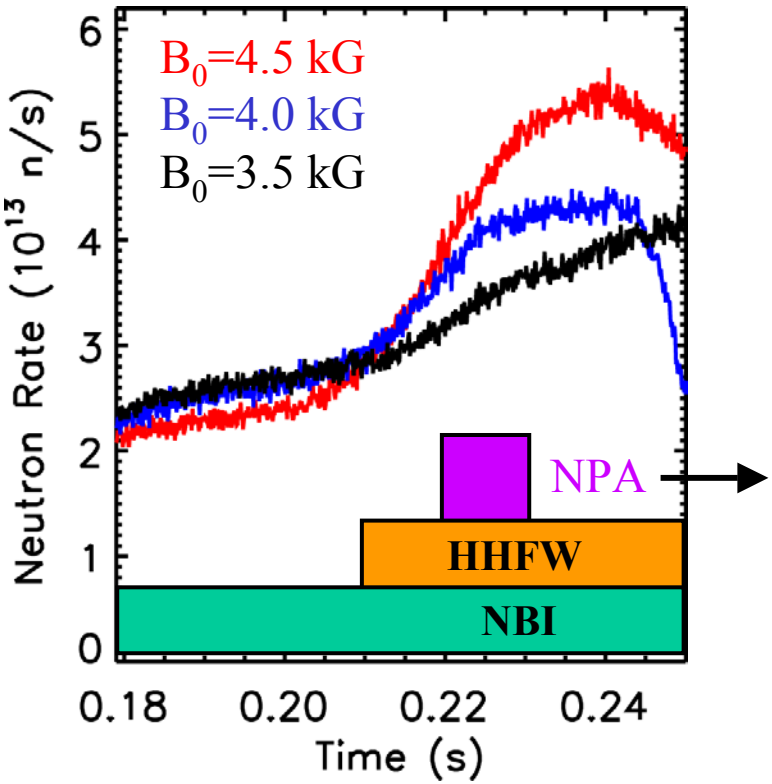
- Tail decays on collisional time scale

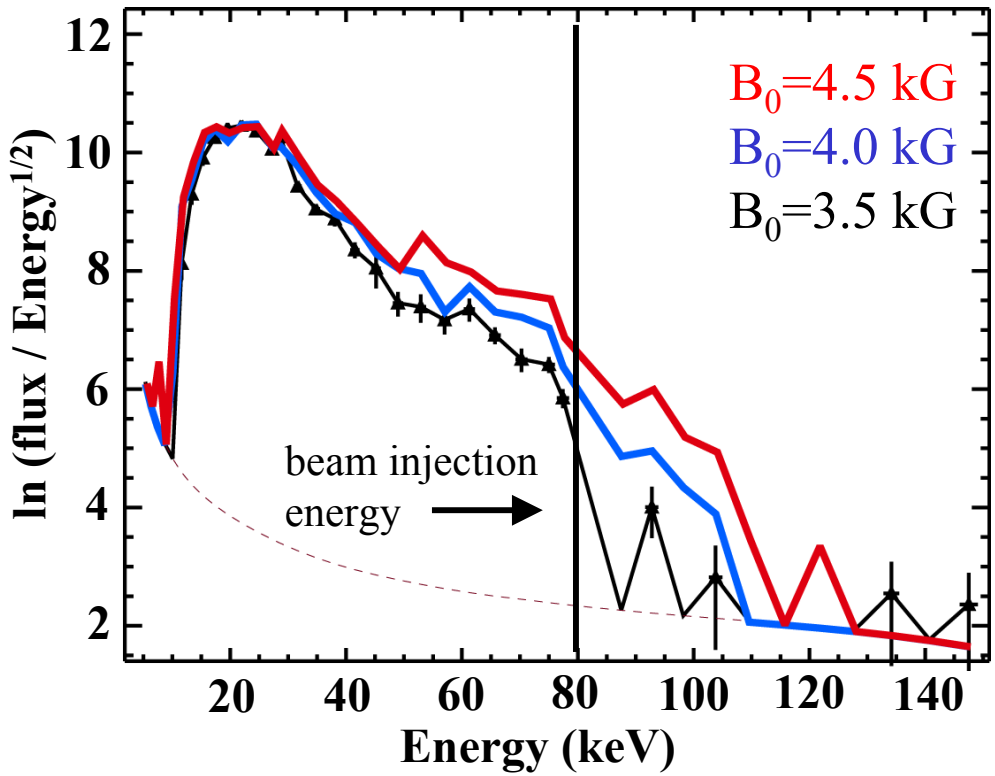
HHFW enhances neutron rate



- After RF turnoff, rate decays close to measured and predicted no RF value
- TRANSP neutron rate predictions without RF input fall shorter than measured rate for RF shot

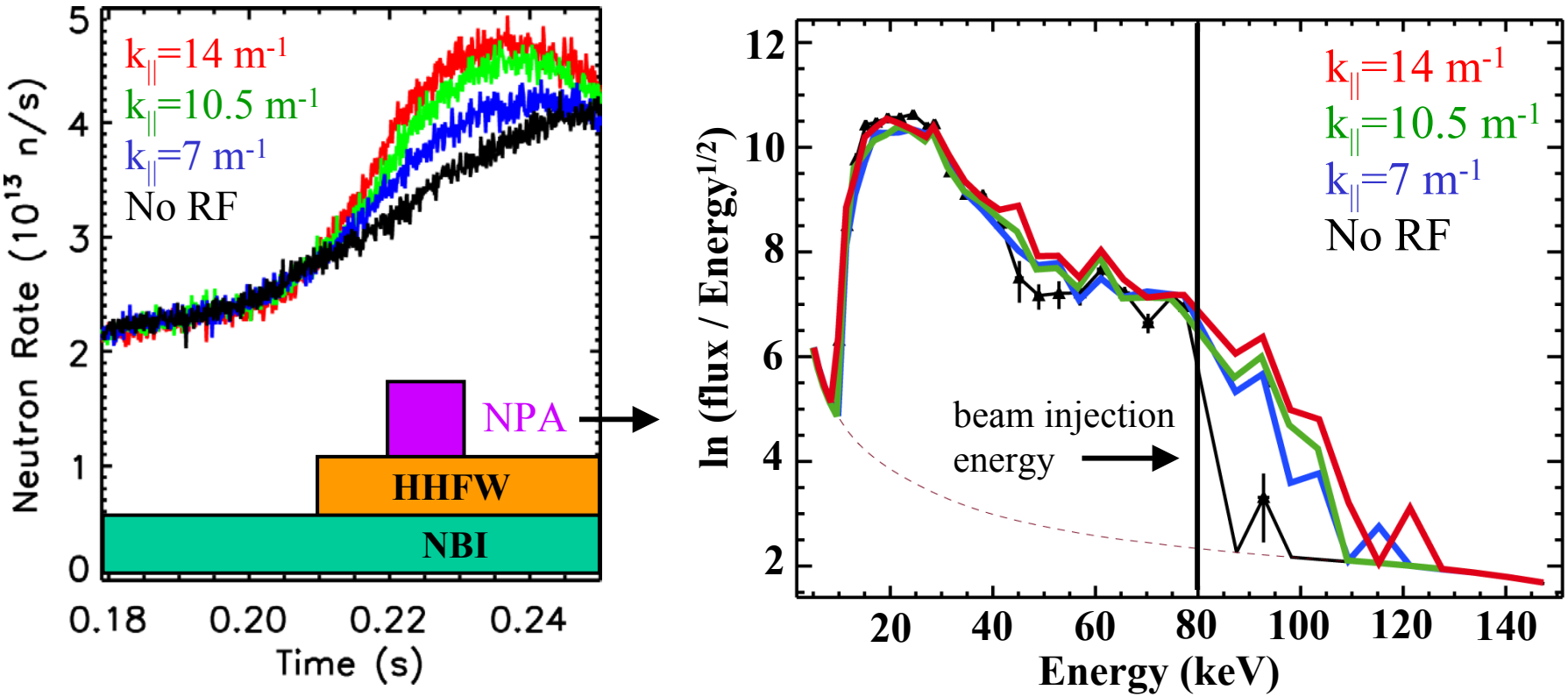
Tail reduced with lower B-field, higher β_t





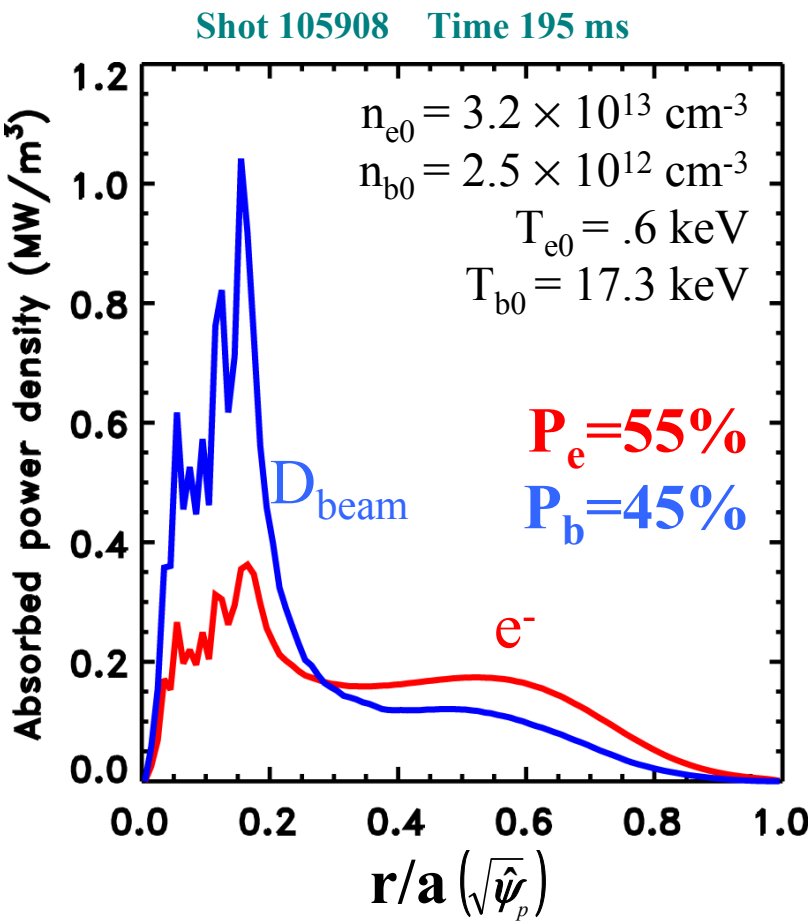
- Larger β_t promotes greater off-axis electron absorption reducing power available to centralized fast ion population

$k_{||}$ has little observed effect on fast ions



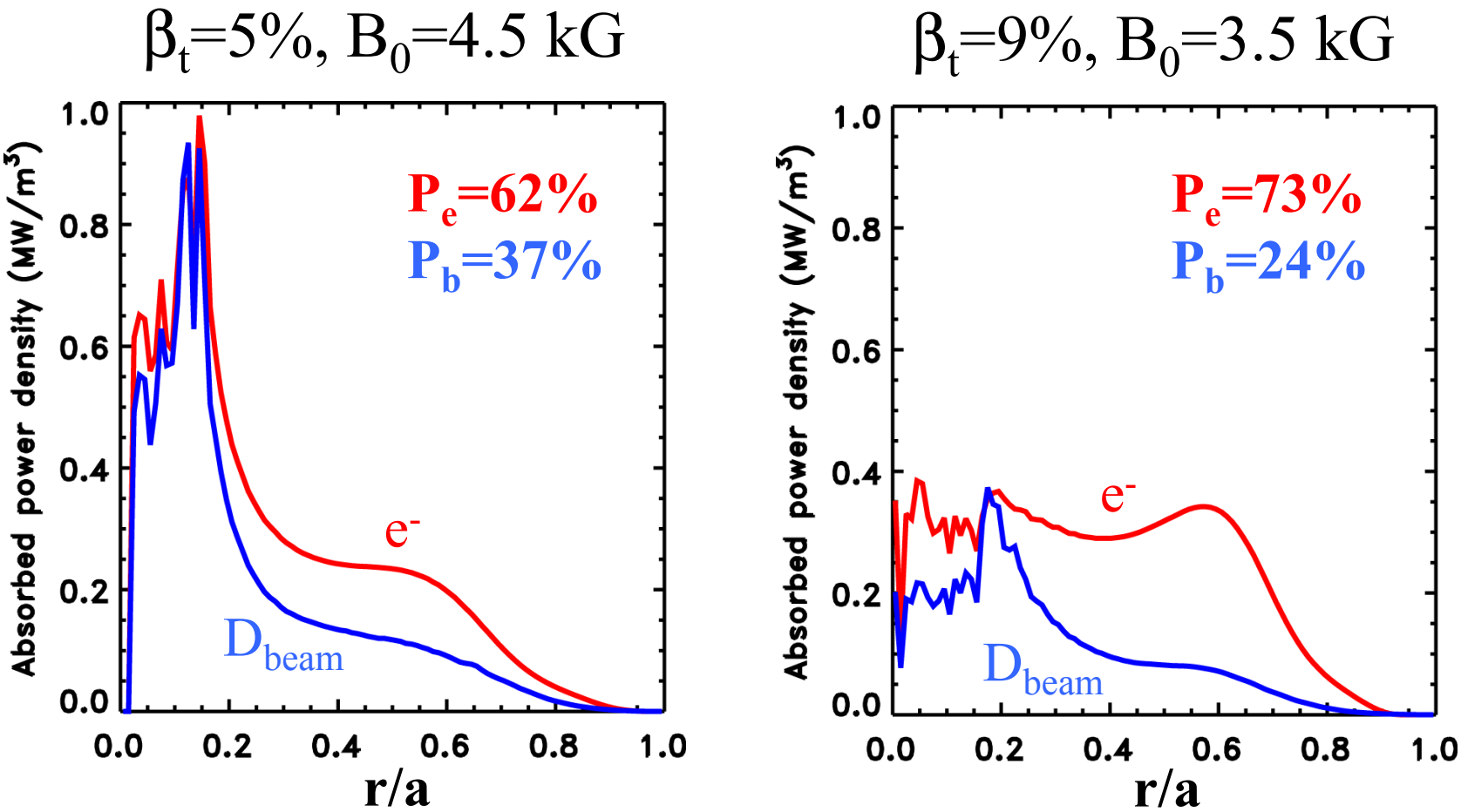
- Greater ion absorption predicted with lower $k_{||}$, but surprisingly little variation in tail, small neutron enhancement with higher $k_{||}$

Ray tracing predicts fast ion absorption competitive with electrons



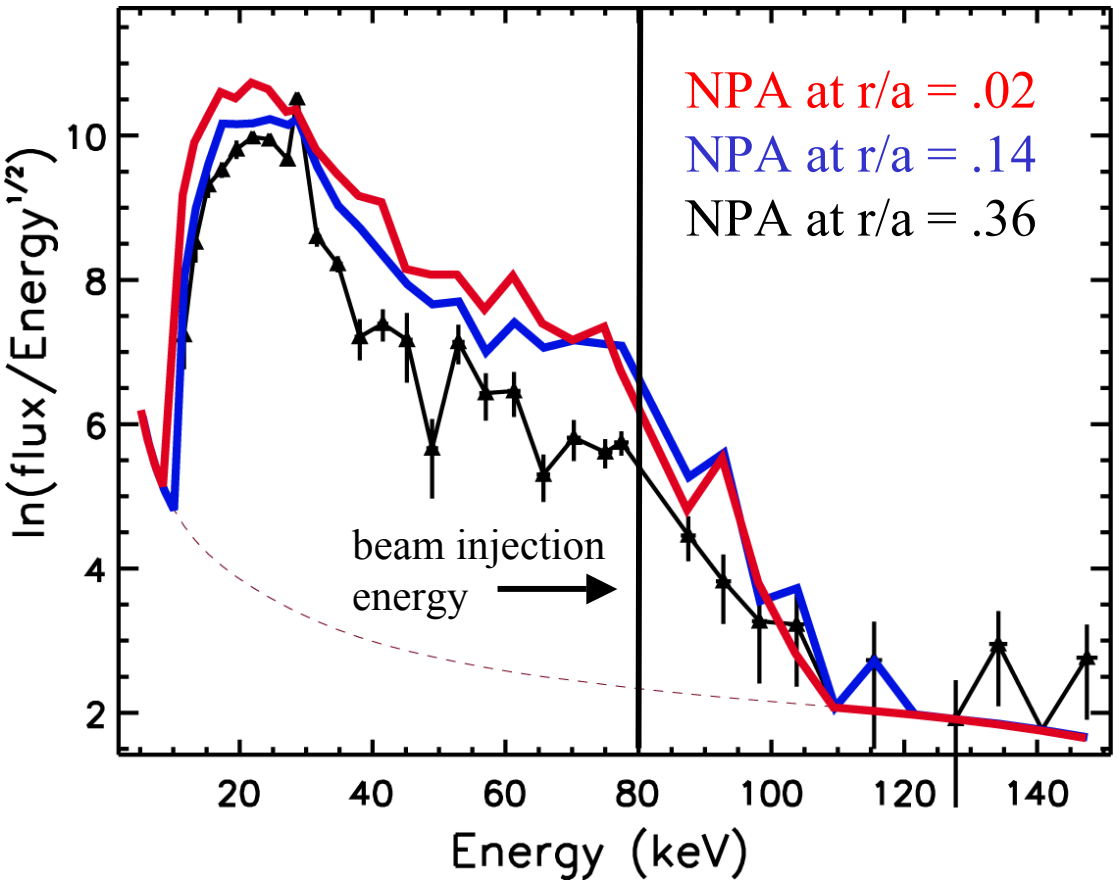
- HPRT computes hot plasma absorption over cold ion/hot electron ray path
- 25 rays used
- TRANSP output used as input for fast ion temp and density distribution
- Fast ions dominate central absorption, electrons further off-axis
- $T_{i,th} = 2\ T_e$ (XCS), no thermal ion absorption

Observation of less fast ion absorption at higher β_t consistent with theory



- Lower on-axis absorption for lower B, higher β_t predicted

NPA scan indicates induced tail well off-axis



- Depletion in particle flux with NPA R_{tan} further off-axis
- Tail extends to same energy range

Analysis Status and Plans

- Currently in the process of interfacing HPRT ray-tracer with the METS 1D full wave code
  - METS handles FLR and mode conversion correctly
  - Capability for METS to compute absorption with arbitrary distribution function recently added (Dumont BP1.080)
  - HPRT computes ray paths, passes relevant parameters along paths to METS
  - Fast ion dist. fcn. is pulled from TRANSP and converted to the appropriate form for METS
  - Allows better absorption profile comparisons between a 2D ray-tracer and a 1D full wave code

Summary

- Clear RF-induced fast ion tail observed with NBI
- Neutron rate and modeling support interaction
- Tail formation suppressed with higher β_t
- Little effect with $k_{||}$ observed
- Scans in I_p and beam energy also performed
- Tail observed up to 40% off-axis in r/a