Characterization of Fast Ion Power Absorption of HHFW in NSTX

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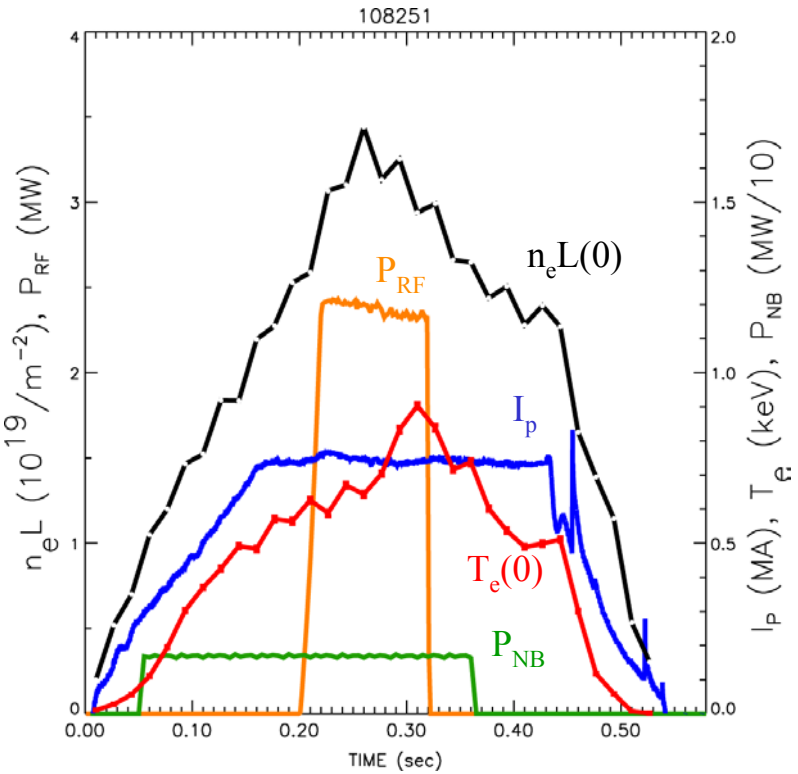
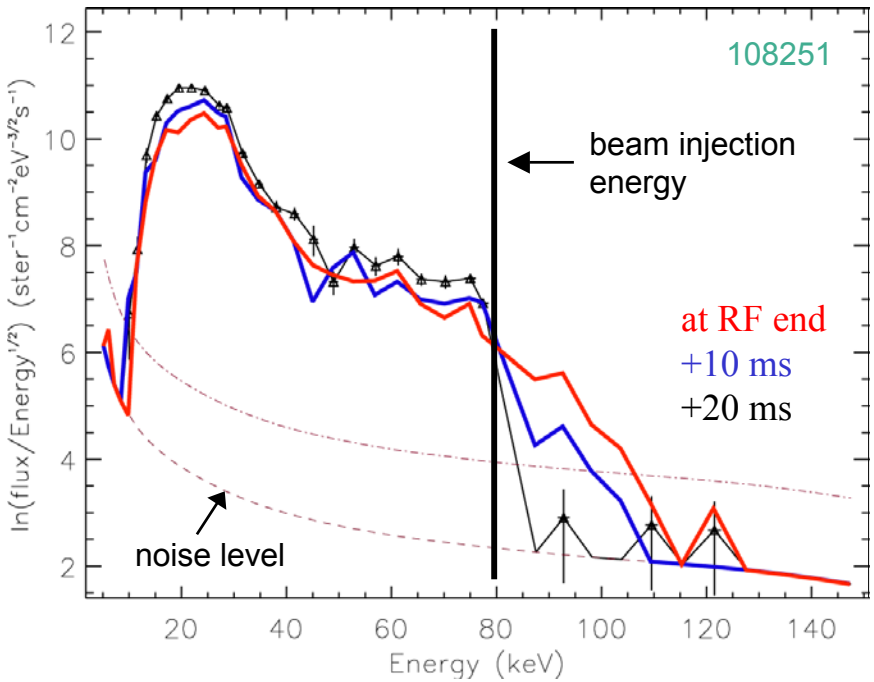
NPA shows fast ion tail build-up and decay

- HHFW turns off at t=320ms
- NBI Source A on throughout



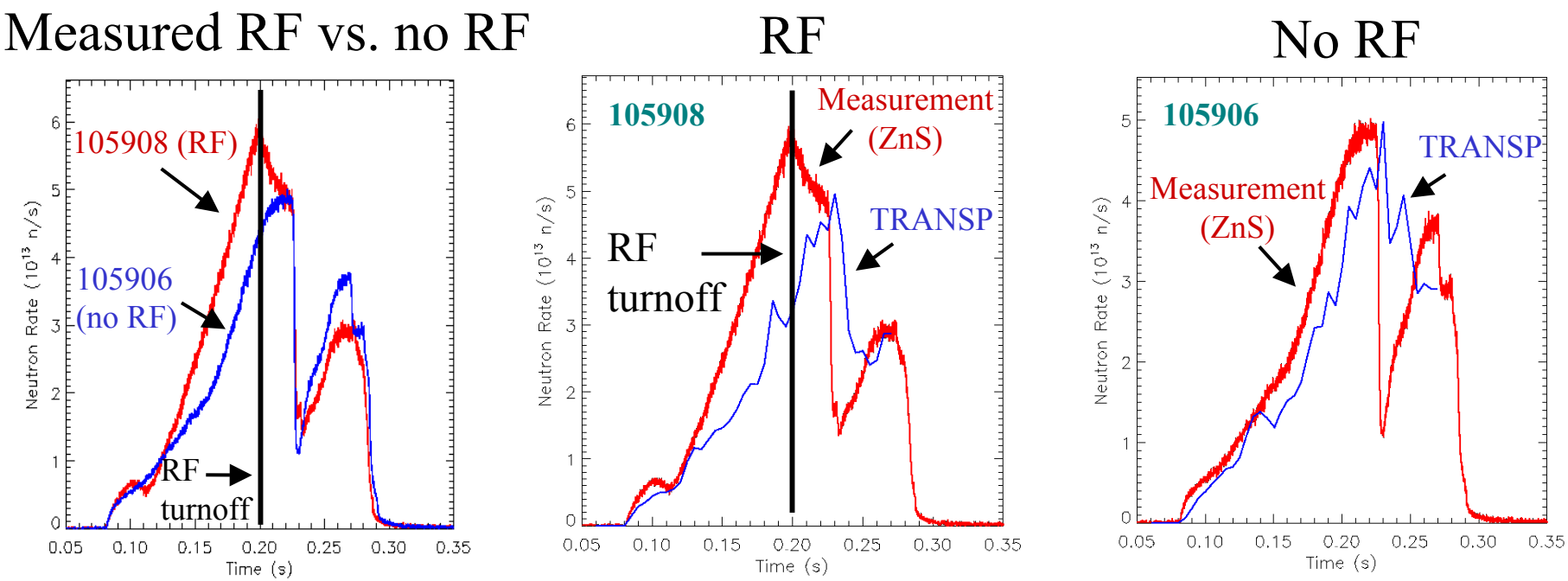
- typical shot traces in 1082xx series

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



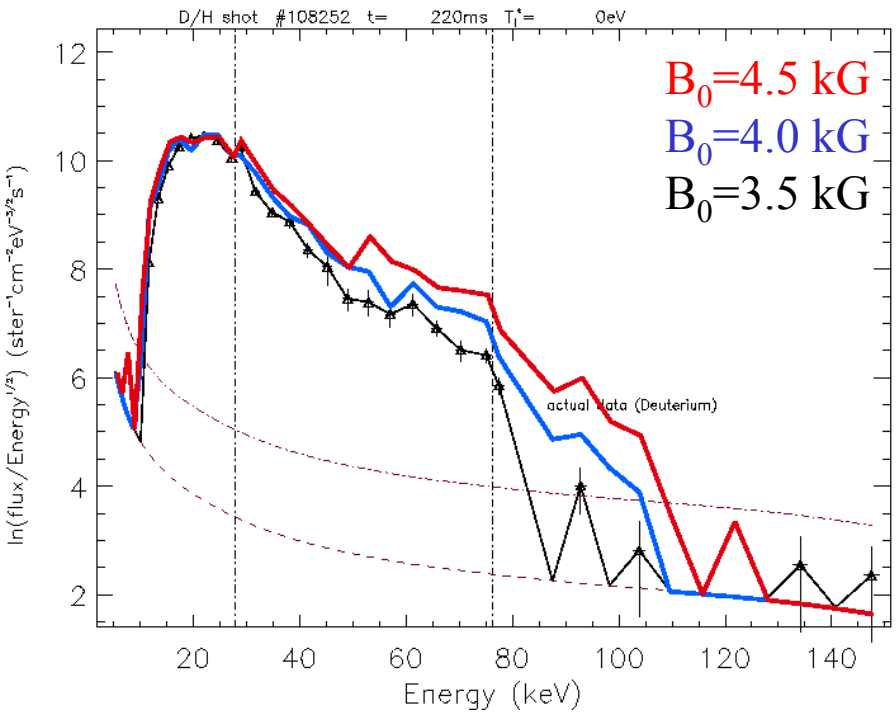
- Tail decays on collisional time scale

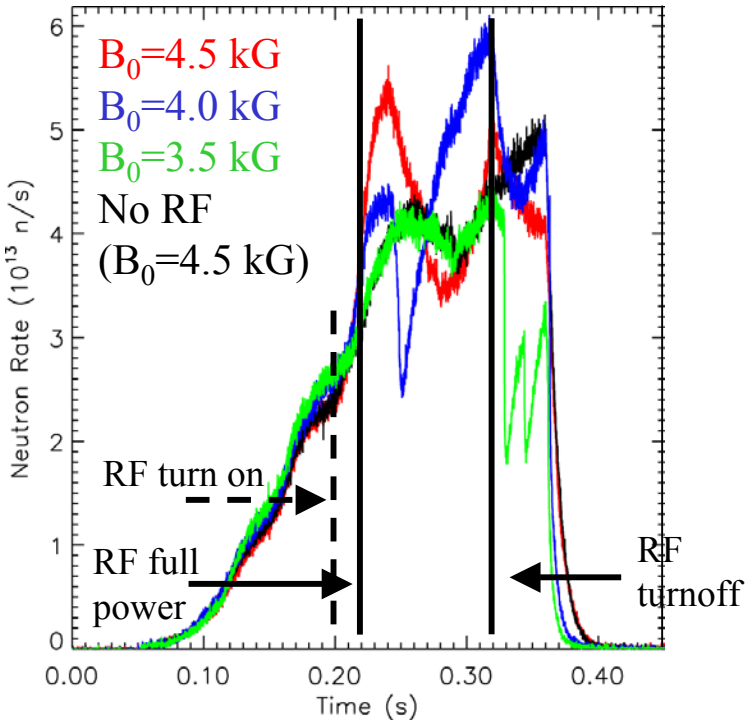
Measured neutron rate exceeds prediction w/ RF on



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

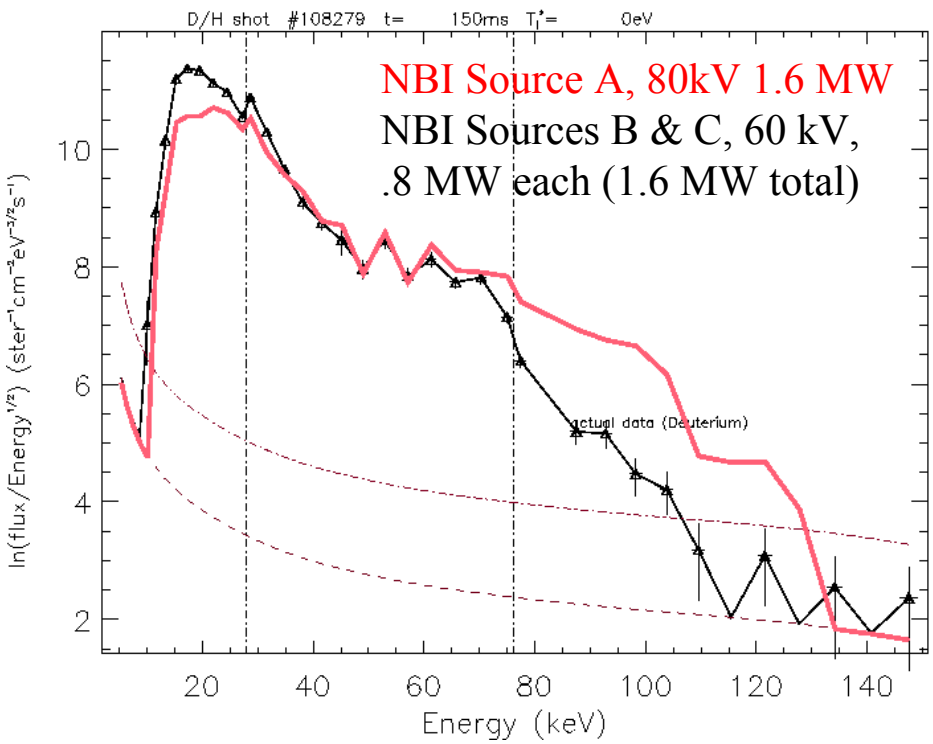
Stronger tail with higher B-field

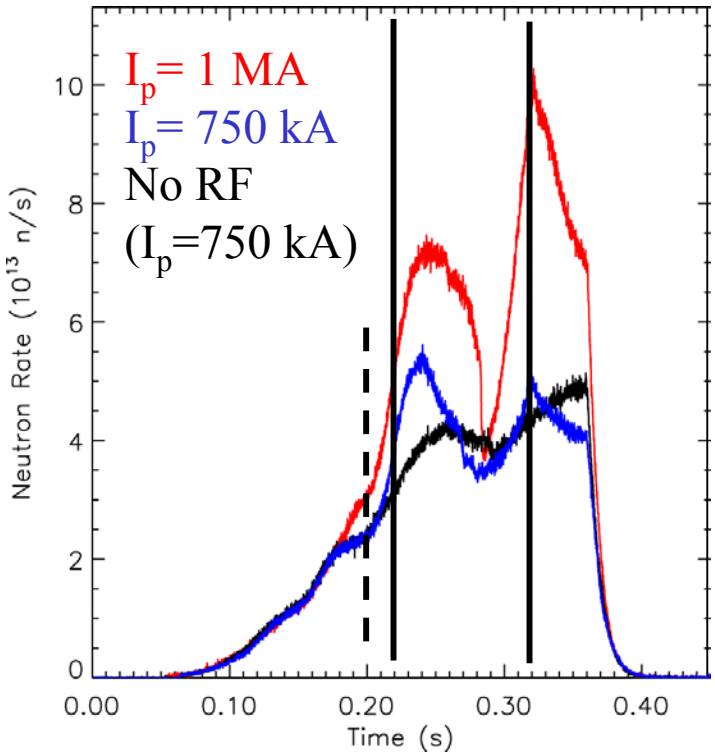




- As B_0 increases, the NPA sees a larger tail
- Enhanced neutron rate with higher B_0 until MHD ~240 ms
- Likely due to larger β with lower B, which promotes greater off-axis absorption where fast ion population is small

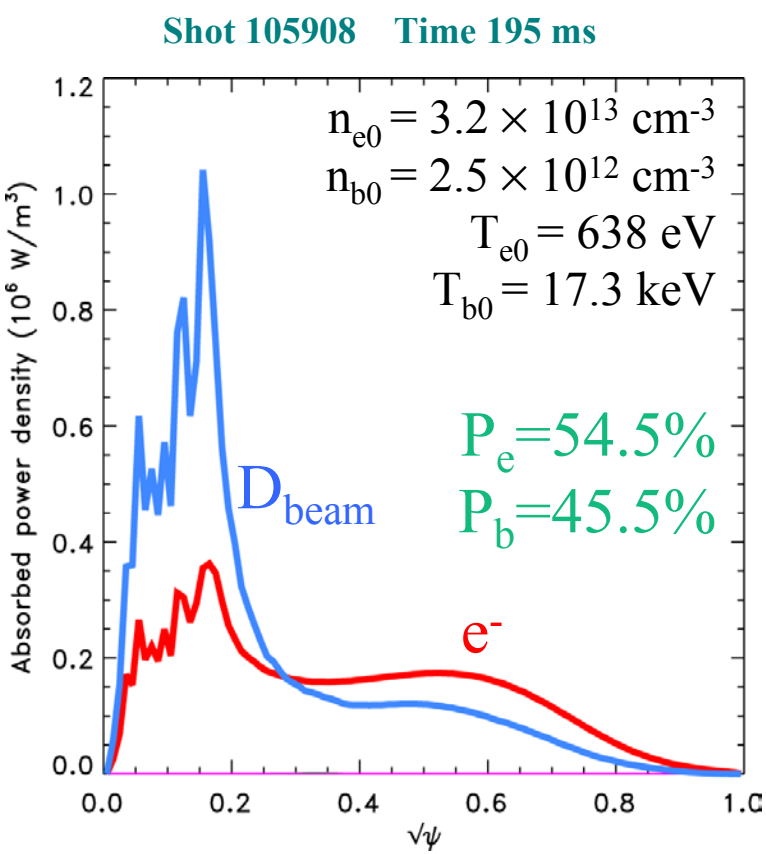
Beam energy, I_p, $k_{||}$ scans





- Larger tail observed with greater total beam energy, fixing power
- Tail of low vs. high I_p similar, but neutron rate greater enhanced
- Greater ion absorption predicted with lower $k_{||}$, but surprisingly little variation in tail, small neutron enhancement with higher $k_{||}$

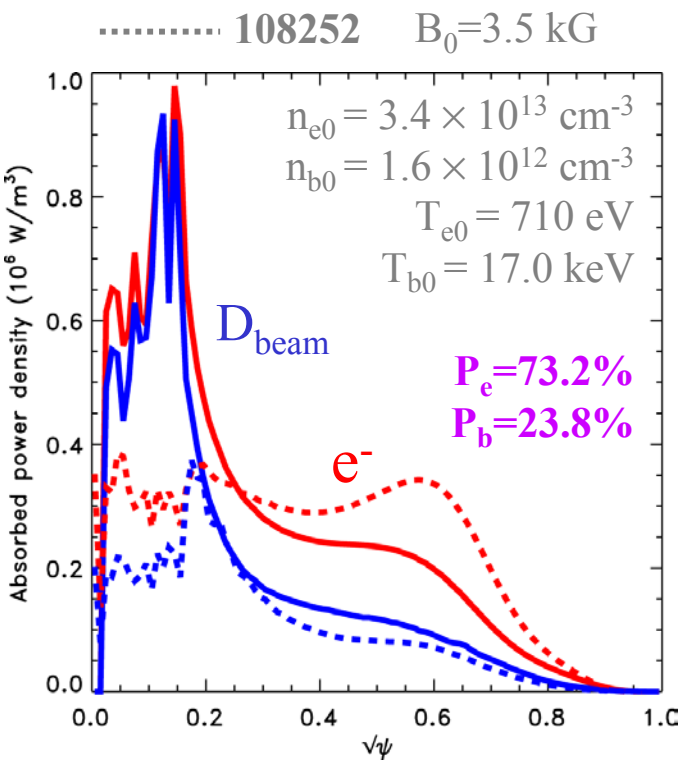
Ray tracing predicts significant fast ion absorption

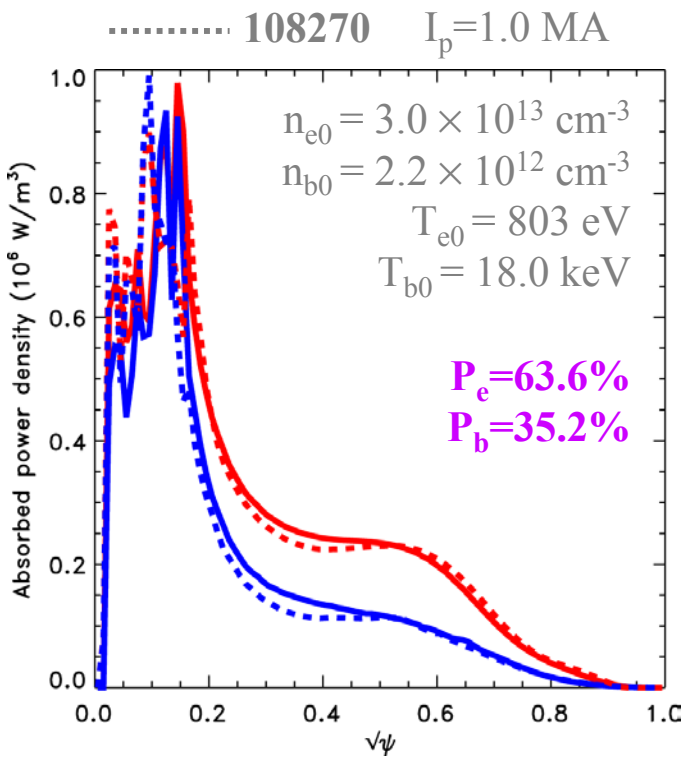


- HPRT computes hot plasma absorption over cold ion/hot electron ray path
- 25 rays used
- TRANSP output used as input for fast ion temp and density distribution
- Total power evenly split
- Fast ions dominate central absorption
- Electrons dominate further off-axis

Modeling agreement

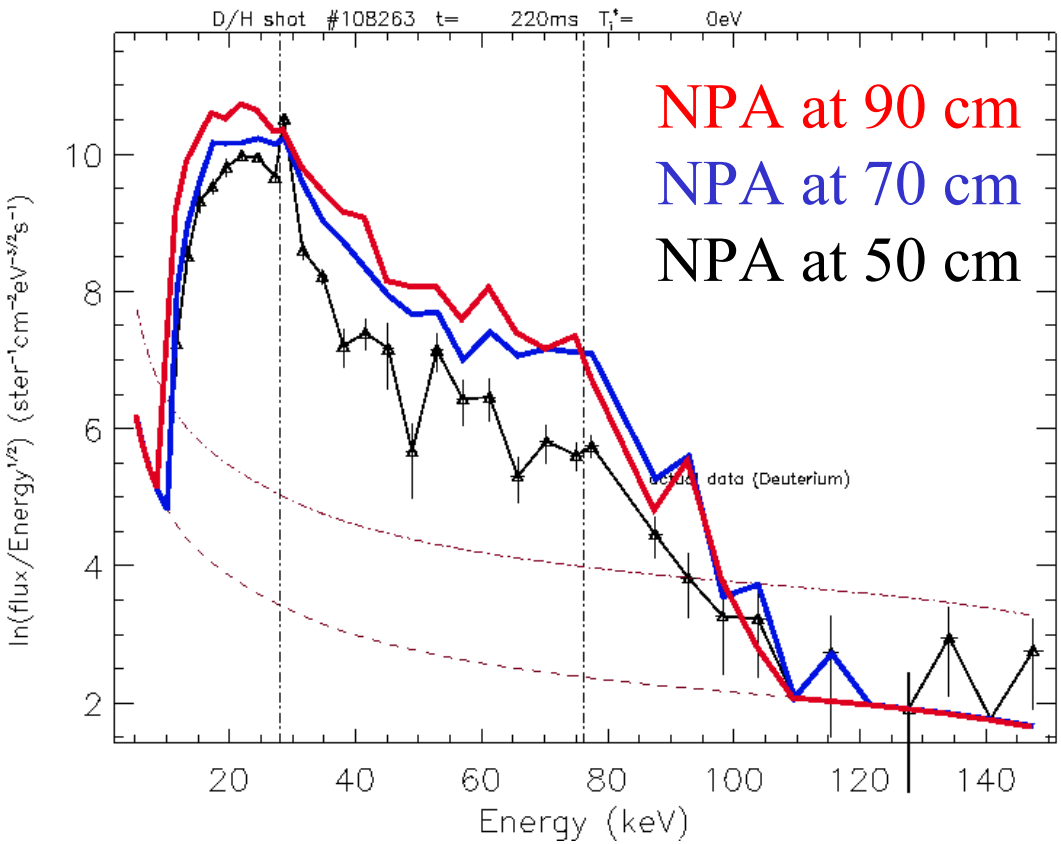
Shot 108250: $B_0 = 4.5$ kG, $I_p = 750$ kA, $n_{e0} = 2.8 \times 10^{13}$ cm^{-3}, $n_{b0} = 2.0 \times 10^{12}$ cm^{-3}, $T_{e0} = 769$ eV, $T_{b0} = 17.2$ keV, **$P_e = 62.3\%$**, **$P_{fast} = 36.8\%$**





- Higher off-axis absorption for lower B predicted and observed
- Little absorption profile change at higher I_p, little change in tail

NPA scan, $k_{||}$= 7 m^{-1}, B_0=4.5 kG



- 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 full wave code
  - Remi Dumont has added capability for METS to compute absorption with arbitrary distribution function
  - 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
- Stronger tail with higher B_0 and beam energy
- Higher neutron rate, similar tail with larger I_p
- Little effect with $k_{||}$ observed
- Tail energy range constant up to 40 cm off-axis