Initial Measurements of Beam Ion Confinement on NSTX-U

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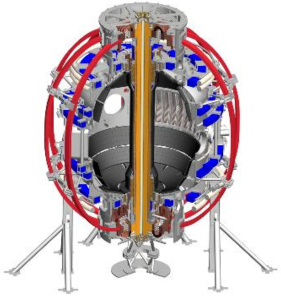
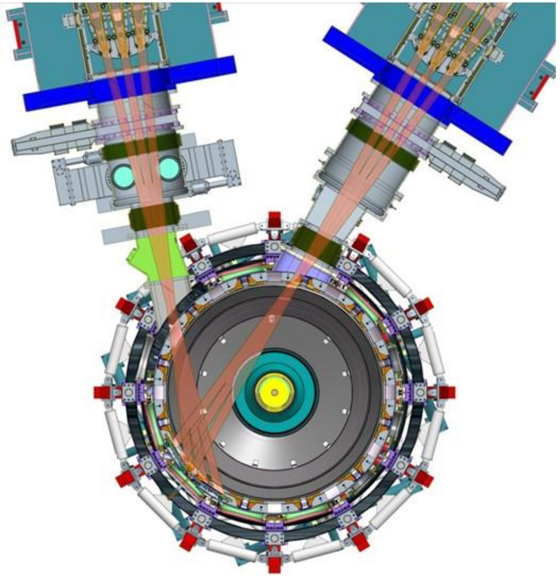


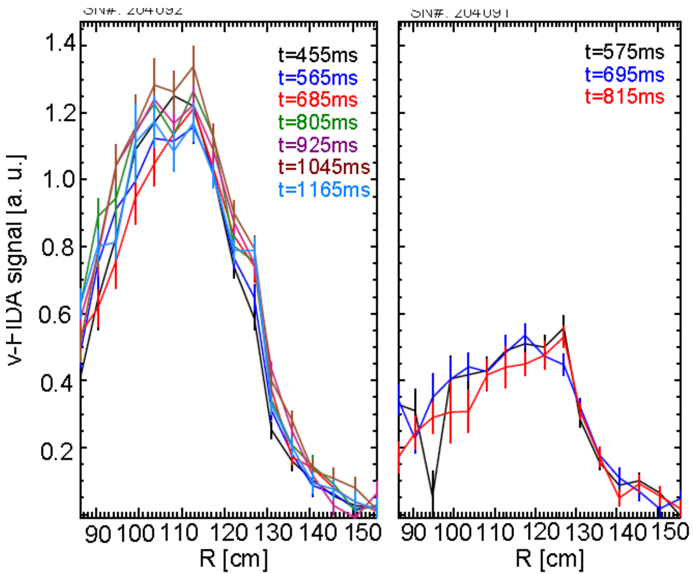
Motivation: Neutral Beam Checkout and NUBEAM Validation

NB #2 NB #1



1C (R_{tan}=50cm) 2A (R_{tan}=130cm)

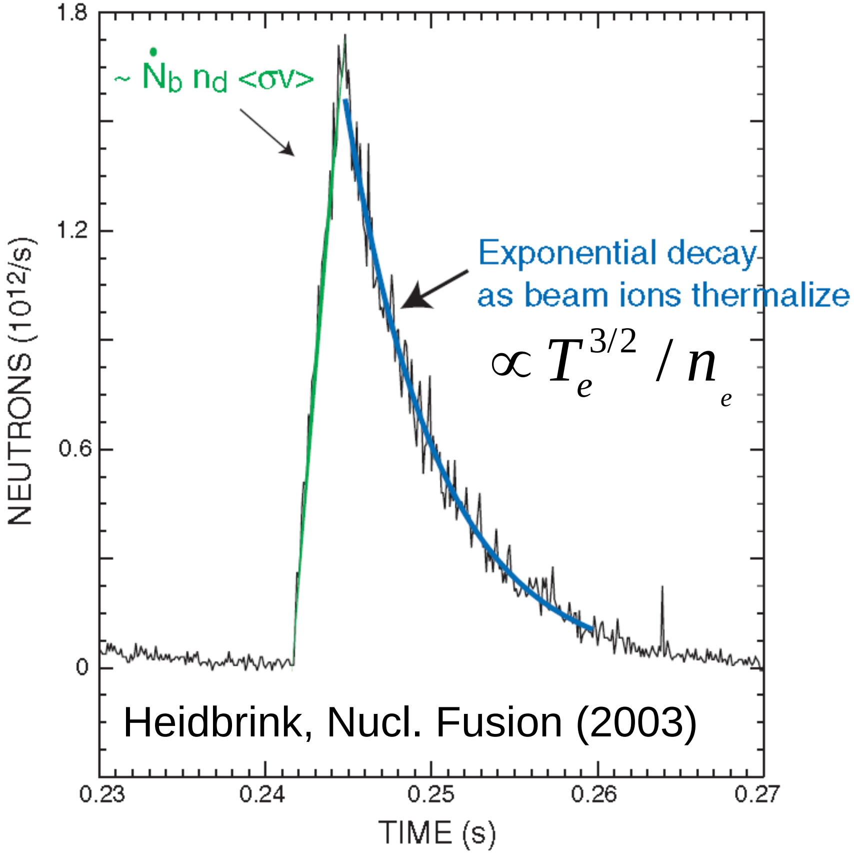
v-FIDA signal



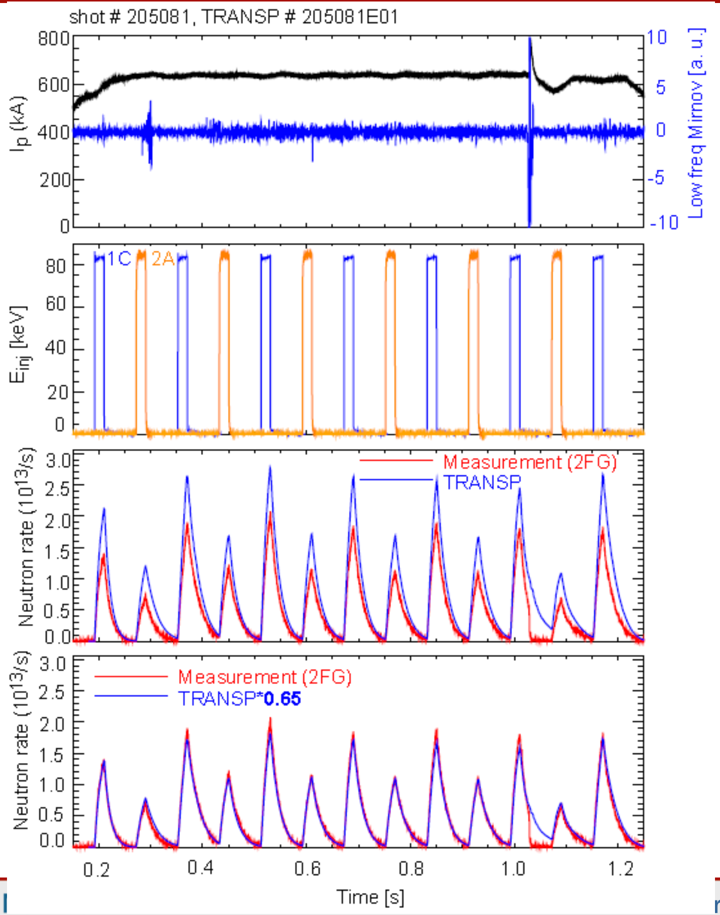
- NB line #2 is added to improve NBCD efficiency and provide more flexibility in current/q profile control. Good fast ion confinement is essential.
- Initial assessment of beam ion confinement in a diagnostic checkout experiment.

Beam Blips Injected into Low n_e, L-Mode Plasmas

- Plasma conditions
  - Center-stack limited, n_e~1-3x$10^{13}$$cm^{-3}$, B_t=0.65T, I_p~0.7MA
  - $S_{neutron}$ dominated by beam-plasma reaction
- Beam blips (~20ms pulses)
  - $S_{neutron}$ rise depends on number of confined beam ions injected
  - $S_{neutron}$ decay depends on slowing down and losses on $t_{slowing-down}$
  - E_{inj}=85keV and E_{inj}=65keV
  - Infer confinement time from decay process
    - Limited diagnostics, large uncertainties in Z_{eff}, T_i, equilibrium, edge neutral density



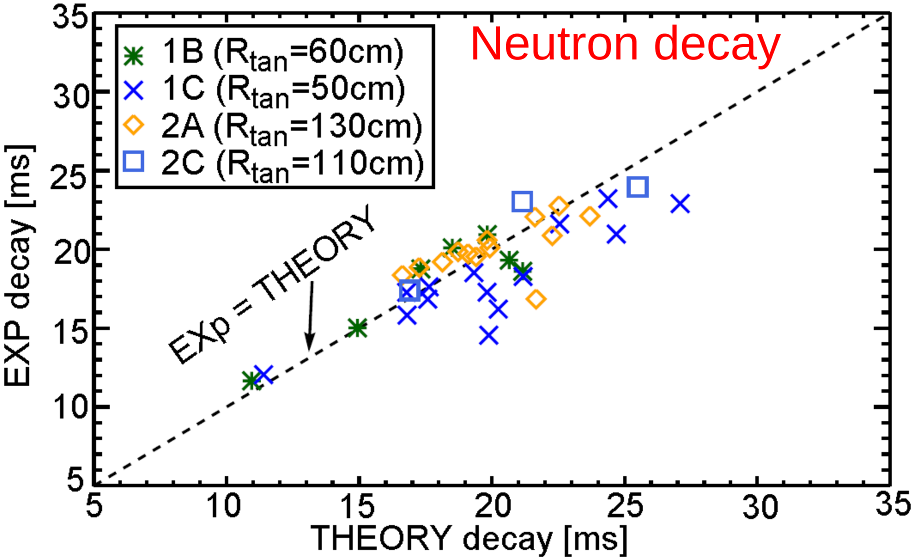
At E_{inj}=85keV, Neutron Decay Time Agrees with TRANSP Modelling, but Rise is ~65% of Prediction (1/2)

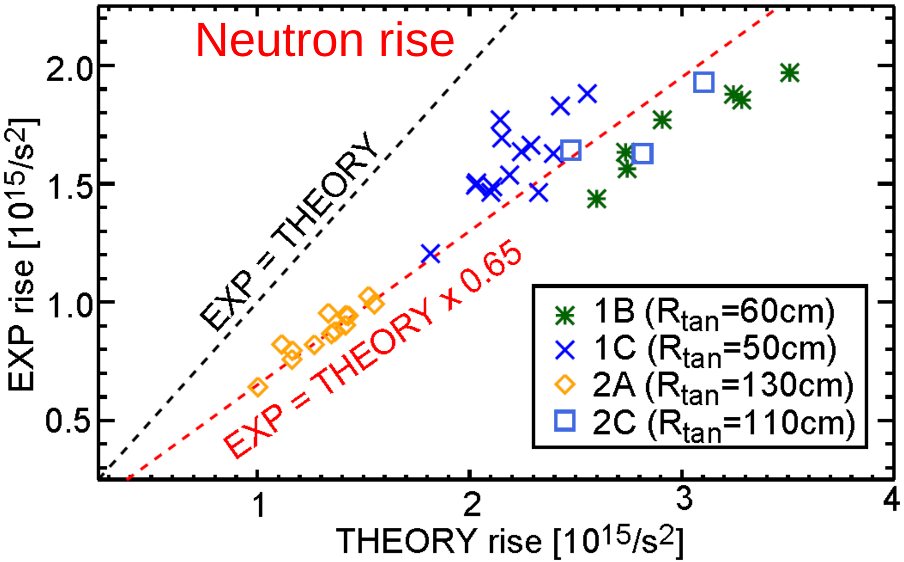


- Exclude bad blips with strong MHD
- TRANSP: Classical, flat Z_{eff}=1.5
- Use "2FG" scintillator neutron signal, cross calibrated to fission detector

Source (E_{inj}=85keV)	Neutron Rise (Exp/TRANSP)	Neutron Decay (Exp/TRANSP)
1B (R_{tan} 60cm)	0.58 +/- 0.02	1.02 +/- 0.08
1C (R_{tan} 50cm)	0.72 +/- 0.05	0.92 +/- 0.09
2A (R_{tan} 130cm)	0.66 +/- 0.03	1.01 +/- 0.09
2C (R_{tan} 110cm)	0.62 +/- 0.04	1.02 +/- 0.08

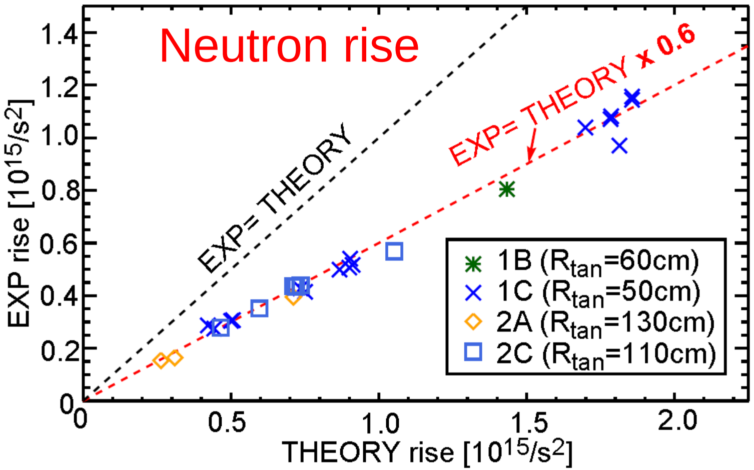
At E_{inj}=85keV, Neutron Decay Time Agrees with TRANSP Modelling, but Rise is ~65% of Prediction (2/2)

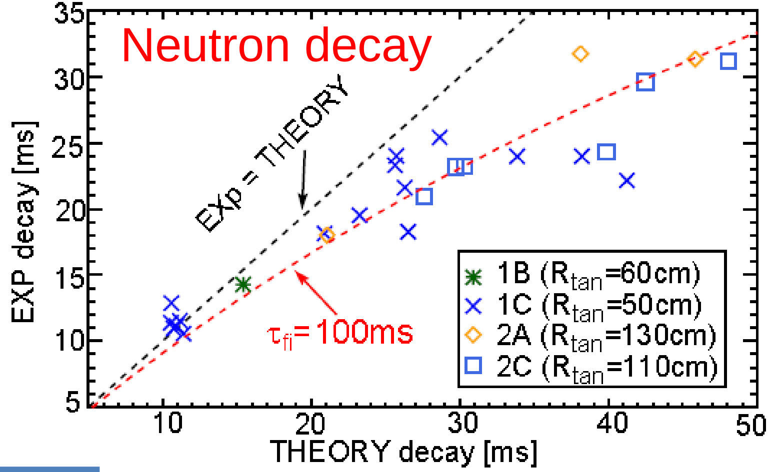




- Good agreement on neutron decay time indicates fast ions are well confined
- ~35% discrepancy in neutron rise (and absolute neutron rate) could be induced by uncertainties in neutron rate calibration, Z_{eff} & beam species mix

At E_{inj}=65keV, Relatively Large Discrepancy between Measurements and TRANSP Modelling (1/2)

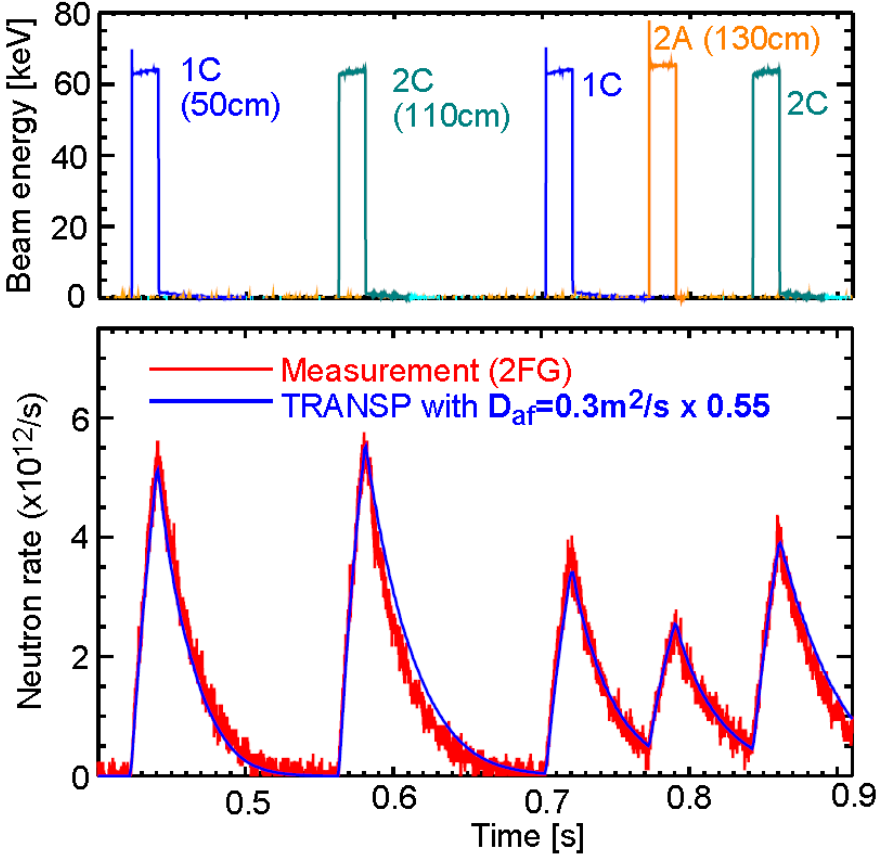




Source (E_{inj}=65keV)	Neutron Rise (Exp/TRANSP)	Neutron Decay (Exp/TRANSP)
1B (R_{tan} 60cm)	0.56	0.93
1C (R_{tan} 50cm)	0.60 +/- 0.03	0.88 +/- 0.18
2A (R_{tan} 130cm)	0.56 +/- 0.03	0.79 +/- 0.09
2C (R_{tan} 110cm)	0.59 +/- 0.03	0.71 +/- 0.07

Beam ion confinement time is estimated ~100ms

At E_{inj}=65keV, Relatively Large Discrepancy between Measurements and TRANSP Modelling (2/2)



TRANSP decay time gets reasonable agreement with data when a small anomalous fast ion diffusivity (D_{af}=0.3m^2/s) is used.

→ Beam ion behavior is still close to classical theory

Possible Reasons for Discrepancies in Neutron Decay and Neutron Rise

- **Reasons for neutron decay discrepancy in E_{inj}=65keV case**
  - Fast-ion Losses on 10 ms timescale
    - likely, huge edge/background neutral density, error fields, MHD
    - blips with E_{inj}=65keV on March 30, blips with E_{inj}=85keV on June 28
    - discrepancies of 2A/2C are slightly larger than 1B/1C
- **Reasons for neuron rise (and absolute neutron rate) discrepancy**
  - Z_{eff}: likely, currently Z_{eff} =1.5, need to increase Z_{eff} to ~3.5 in TRANSP
  - Neutron calibration uncertainties: possible, absolute error ~20%
  - Beam species mix: possible, E_{full} in TRANSP is ~15% higher than the estimation from beam-into-gas shots for E_{inj}=65keV case
  - Equilibrium: maybe, different equilibrium reconstructions lead to a 10% difference

Conclusions

- The behavior of NB line #2 is similar to NB line #1 for E_{inj}=85keV and 65keV.
- Based on neutron decay time after beam turn-off, beam ions are well confined when E_{inj}=85keV. The confinement at E_{inj}=65keV is slightly less than classical theory, but still ~100ms.
- The measured neutron rise and absolute neutron magnitude are only 60%-70% of TRANSP predictions.
  - Likely because of large uncertainties in Z_{eff}, E_{full} fraction, neutron calibration or edge/background neutral density.

More data on fast ion confinement and transport see poster ***NP10.00016*** *G. Z. Hao*