Fast Ion Loss on NSTX

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NSTX Results Review
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<u>Conclusion:</u> Beam ion loss measurements not understood as yet; different measurements don’t agree and some don’t agree with model

Motivations for measuring fast ion loss

- Loss rate affects plasma heating efficiency
- Wall heated by loss, could be damaged in extreme cases
- Serves as benchmark for numerical loss models
- Aids in determining mechanisms of loss
- Neutral beam (NB) ion loss serves as model system for αs in DT plasma (dimensionless parameters quite close)

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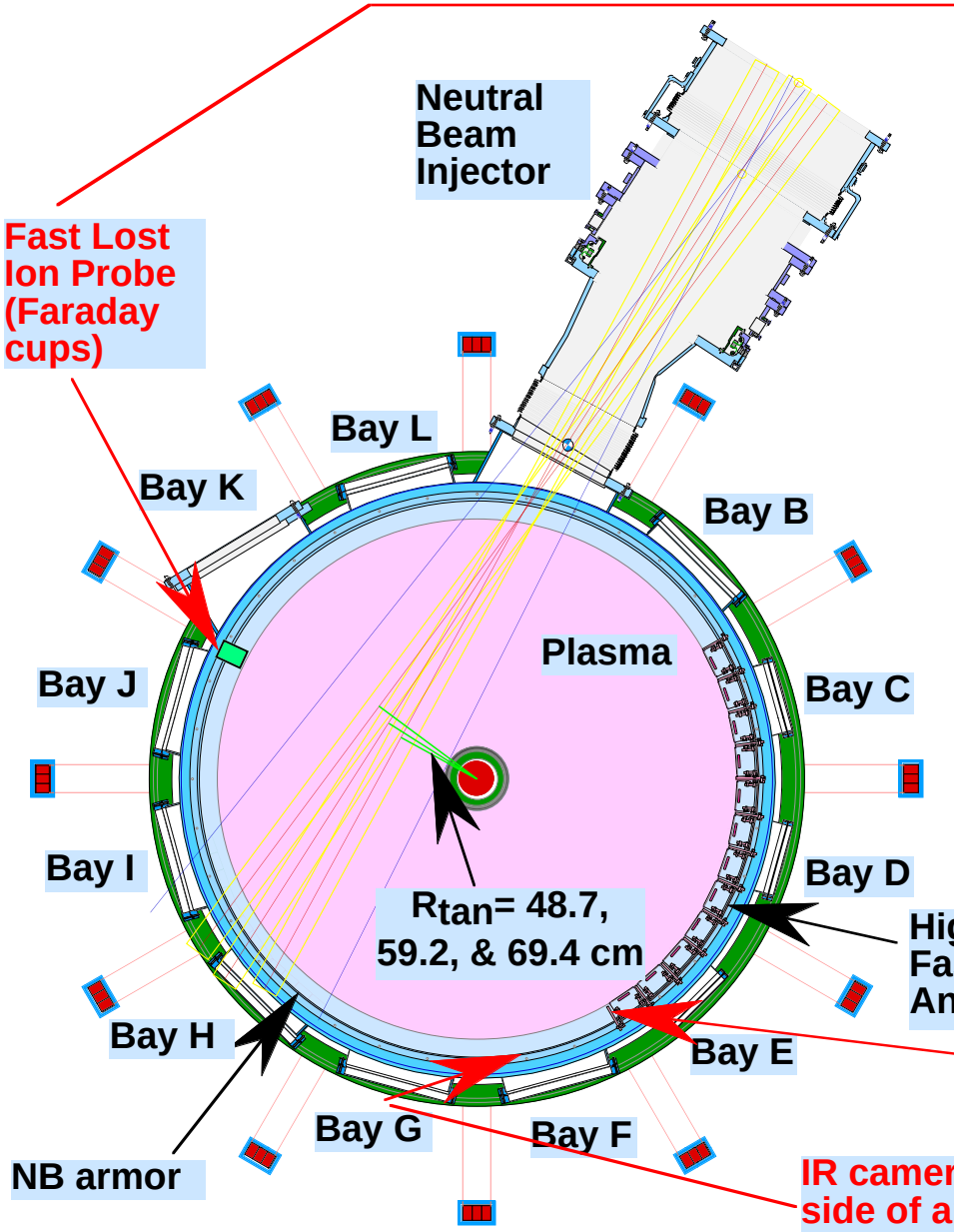
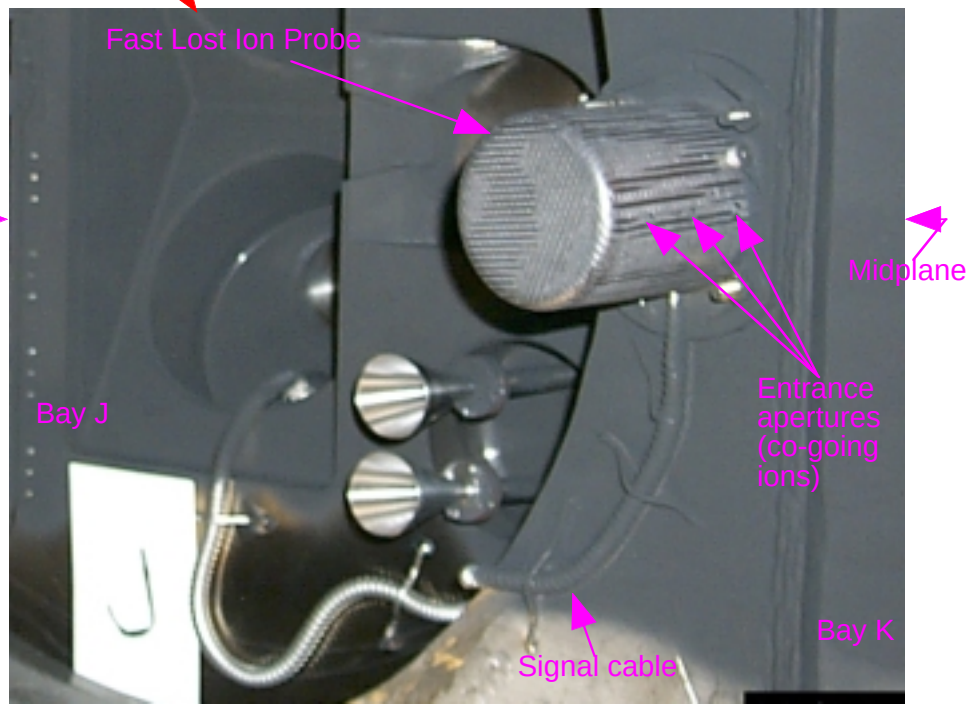
NSTX beam geometry and loss diagnostics

- NSTX NBI: 3 sources, 80 keV D, 5 MW total
- Plasmas typically have 90 cm ≤ R_{axis} ≤ 110 cm





- Measure losses as current in probe or as ΔT in antenna

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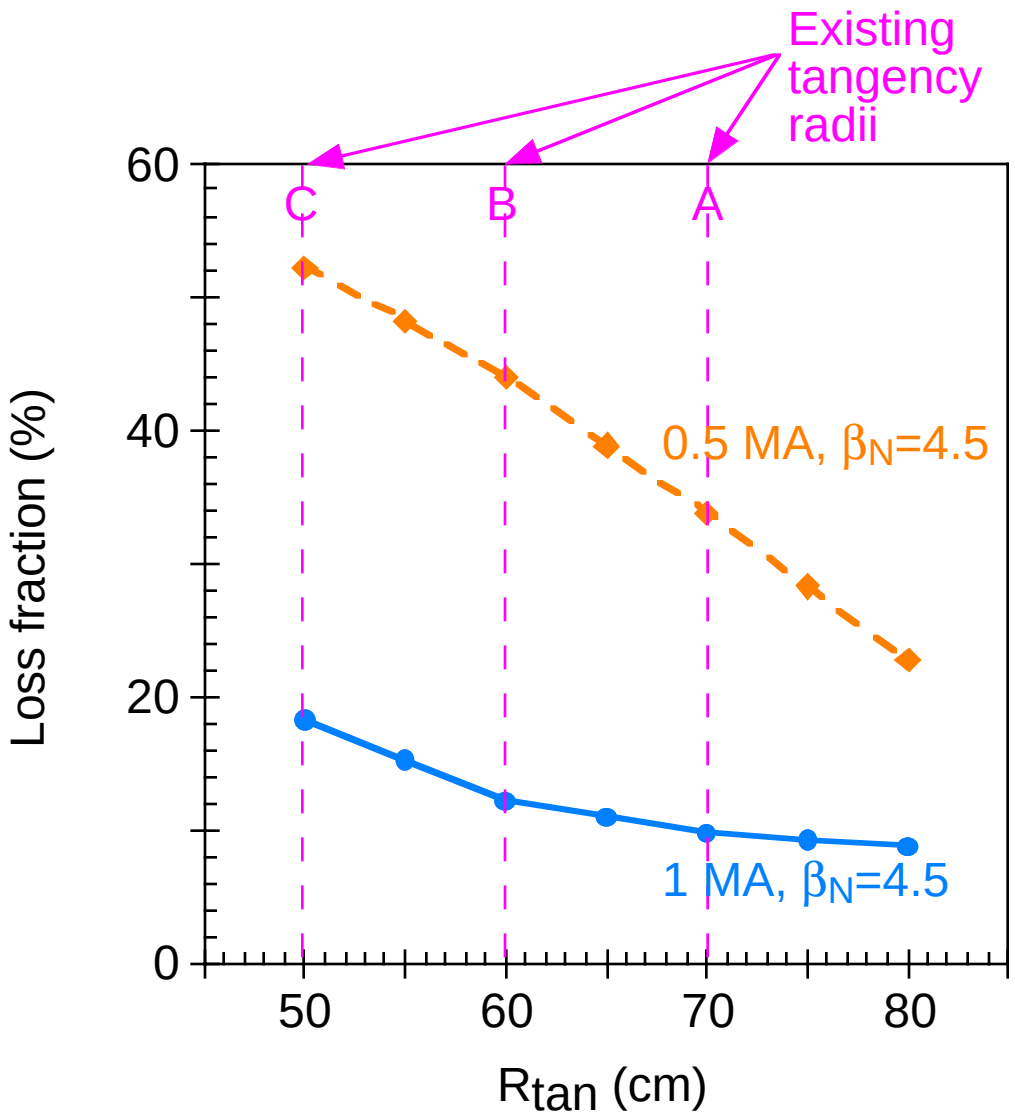
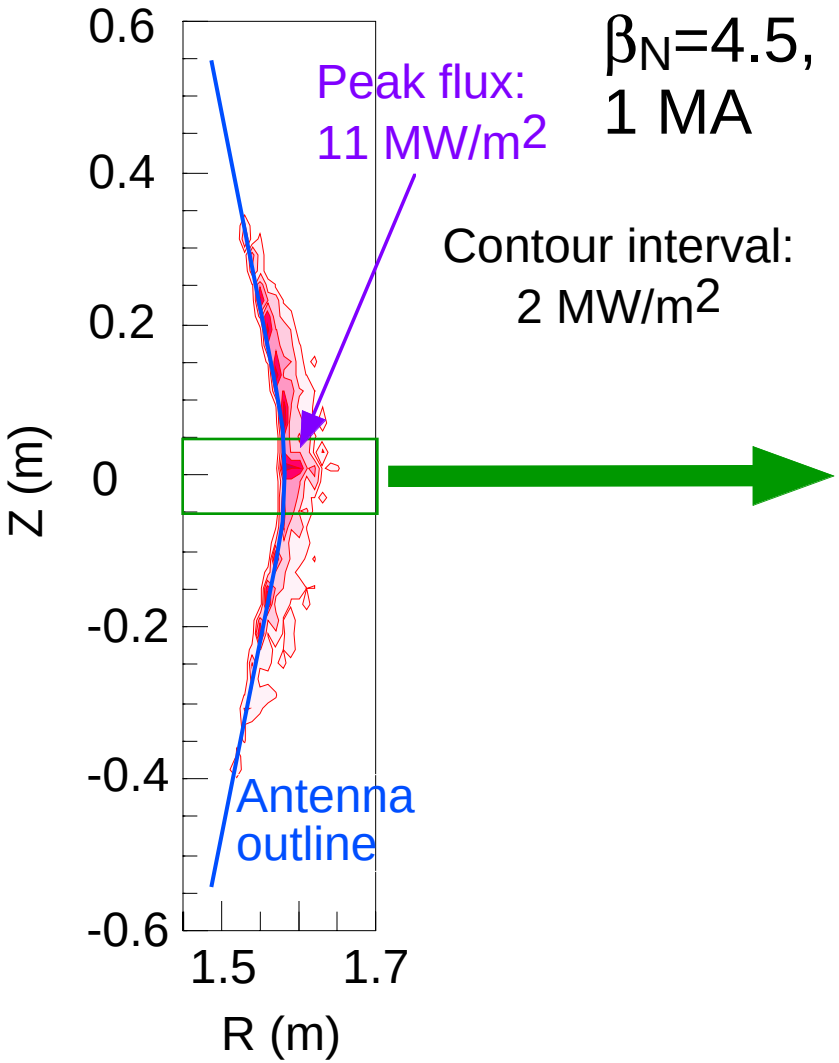
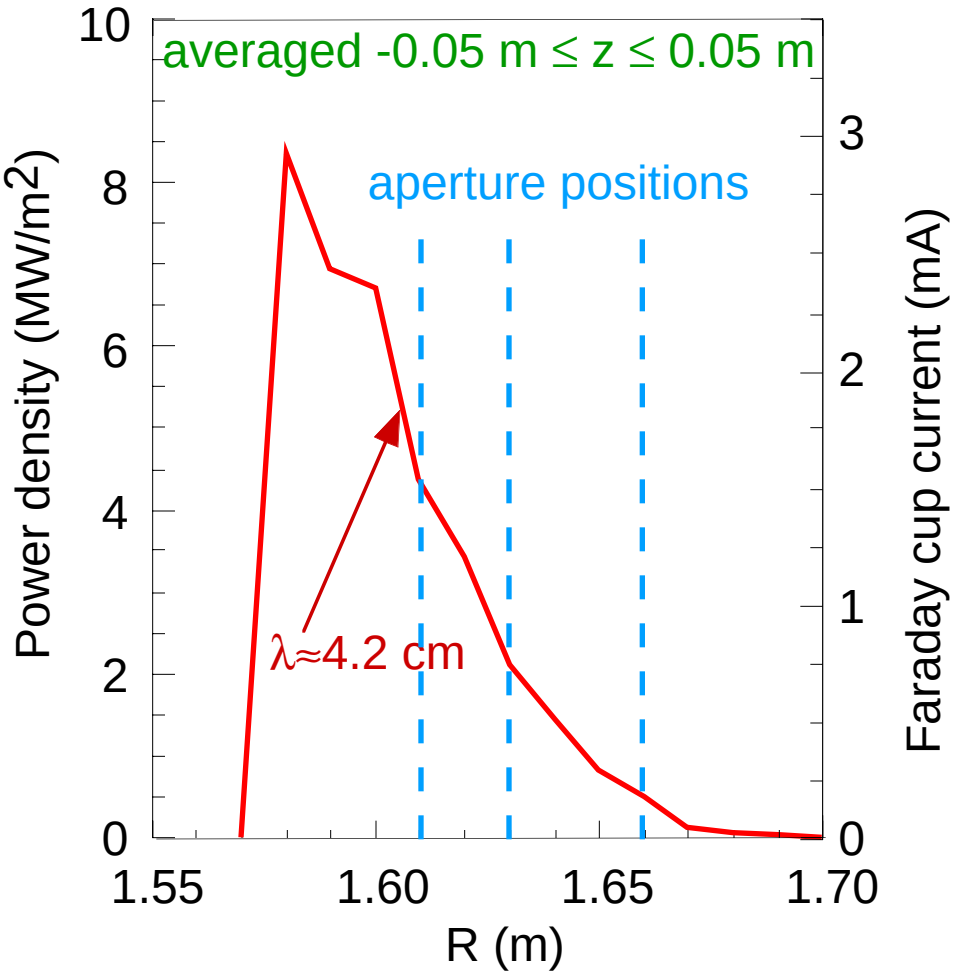
Beam ion loss rate model shows strong dependence on I_p and R_{tan} of beamline



- Beamline with largest R_{tan} (A) is best confined

Power density on side of HHFW antenna greatly exceeds that on front





- ΔT ~ 20° C for 0.5 s, 5 MW pulse (0-D estimate)
- Faraday cup currents predicted: 0.1-2 mA (at 5 MW)

Thermocouple measurements indicate heating of side of HHFW antenna during NBI shots

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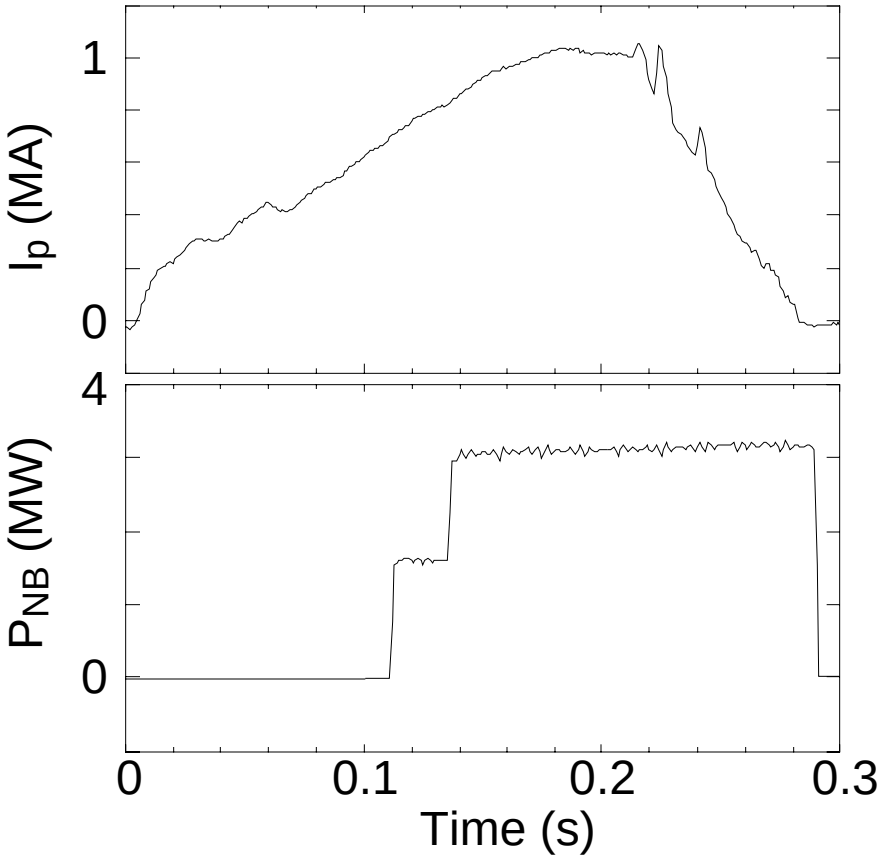
- Thermocouple measurements have been made
- Ohmic shots show no measurable ΔT
- Clear temperature rise observed for NBI shots; example: 103815



- Modeling for 1 MA shot predicted ΔT=20 °C for 5 MW injection, 0.5 s pulse length
- Shot 103815 had 3 MW for 0.17 s, giving measured ΔT=3.5 °C; Scaling from modeling results predicts ΔT=4 °C—good agreement

J. R. Wilson

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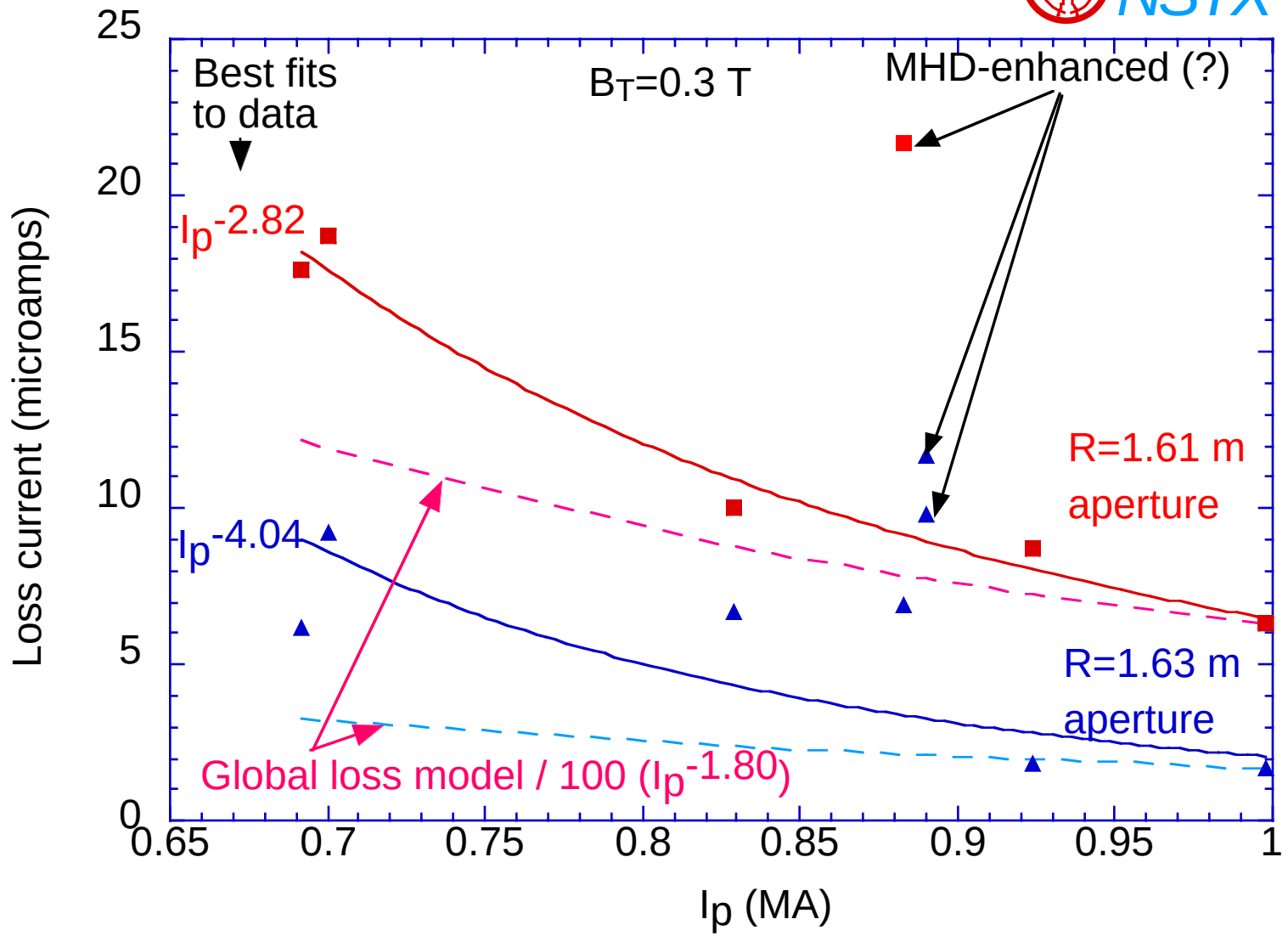
Faraday cup current much smaller than model predicts; varies with I_p in direction expected



- Measured loss ~10x smaller than model
- Difficult to get MHD-free signals, esp. at low I_p

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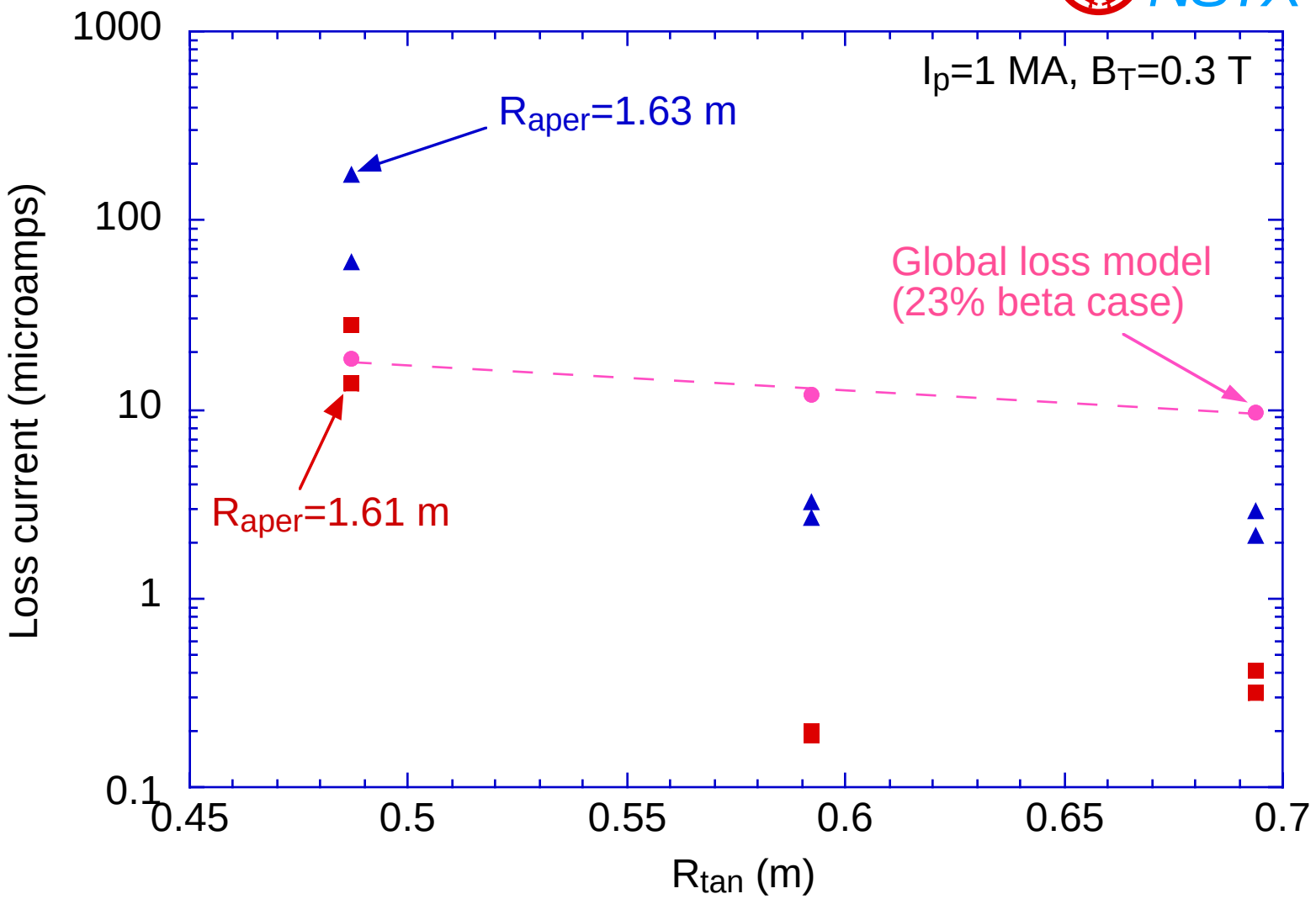
Loss varies with beam tangency radius more strongly than model predicts



- Variation of local loss could differ from global prediction
- Global prediction not for same equilibrium & $n_e(\psi)$

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Short scrape off length is possible source of variability of measurements

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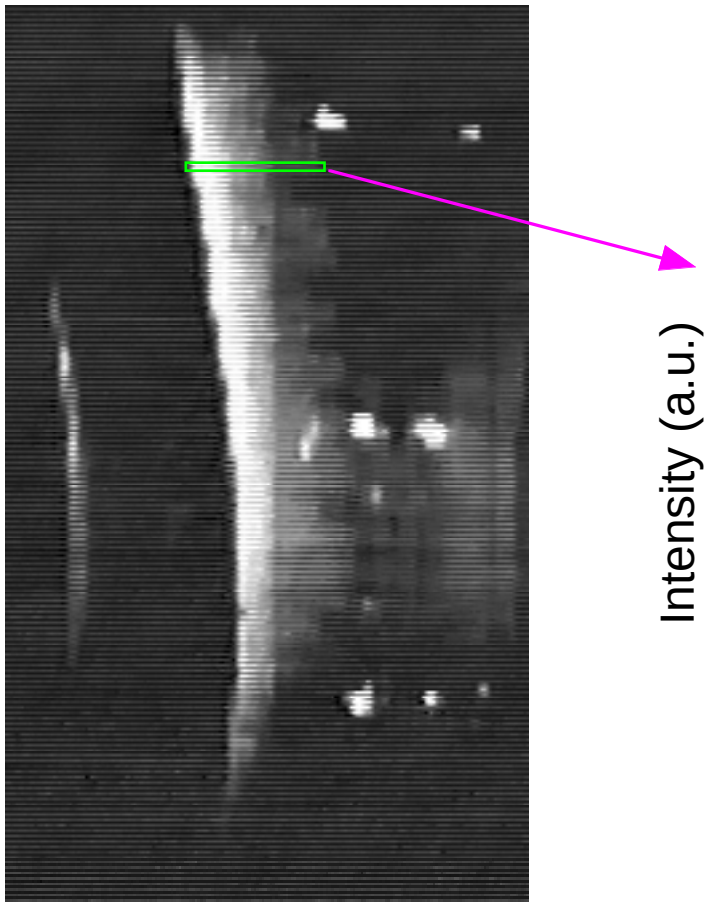
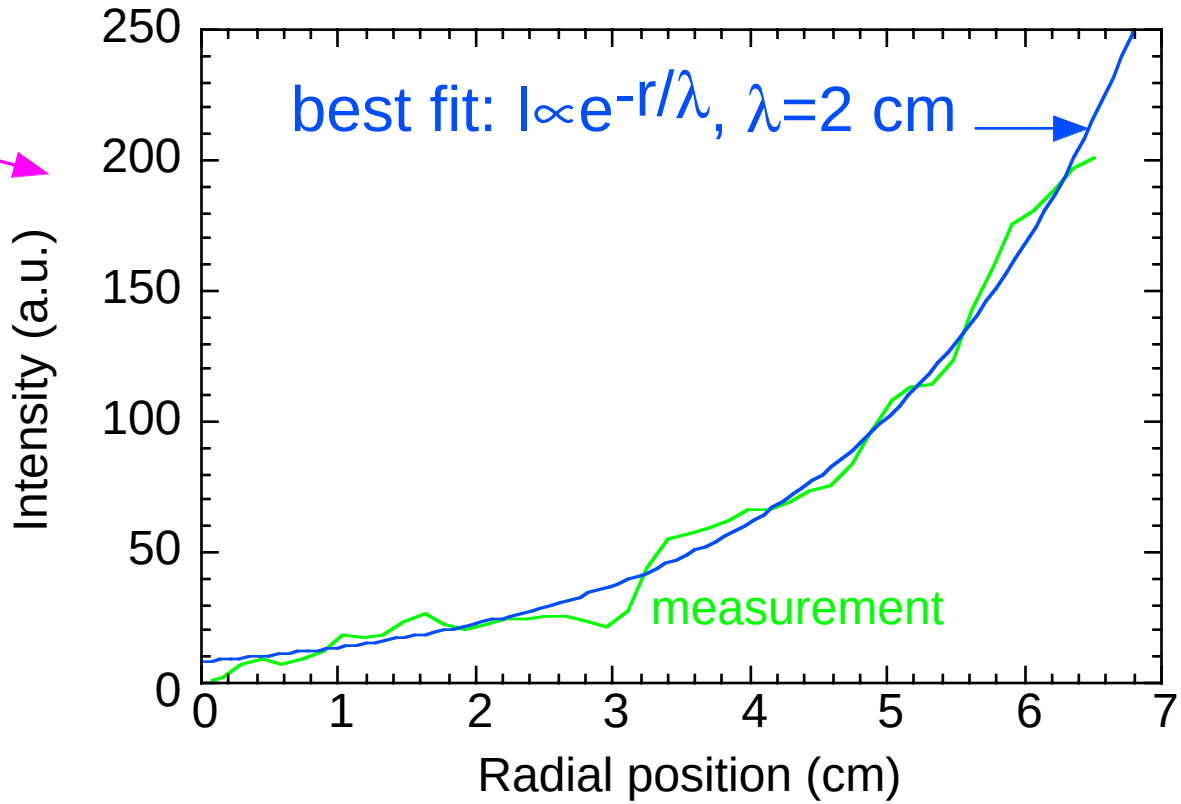


IR camera image
(shot 103336)



- Plasma outer gap frequently varies by ~10 cm–would give large variability in loss signal

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Conclusions

- Thermocouple data indicates loss to side of HHFW antenna that is around level predicted by model for the few shots studied
- IR camera shows ~2 cm scrape off length for beam ions
- Faraday cups measures loss rate ~10x smaller than modeled rate; origin of discrepancy may be short scrape-off length plus variability of plasma outer gap
- Loss rate varies with I_p more strongly than predicted by model
- Expected R_{tan} dependence of loss seen in FLIP data: loss from source C > that from source B, but ratios not in agreement with model

Future work

- Probe to measure energy & pitch angle of lost ions is being built
- Modeling needs to be upgraded to focus on orbits accepted by probe & made parallel to permit analysis of numerous experimental cases within a reasonable amount of time (now: 20 hours per condition)
- Short scrape-off length implies need for specific modeling of each shot of interest with actual measured equilibria and $n_e(\psi)$