Beam ion loss in TFTR reversed shear plasmas

E. Ruskov, R. Budny, S. S. Medley, M. Redi, S. Scott, E. Synakowski, S. VonGoeler, R. White and S. Zweben

Princeton Plasma Physics Laboratory

Summary

TRANSP code modeling of short T-beam pulses injected into TFTR RS plasmas indicates that ~40% beam power is lost on a time scale <<70ms

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MOTIVATION

- Fusion performance of reversed shear (RS) plasmas in TFTR has been below the expectations.

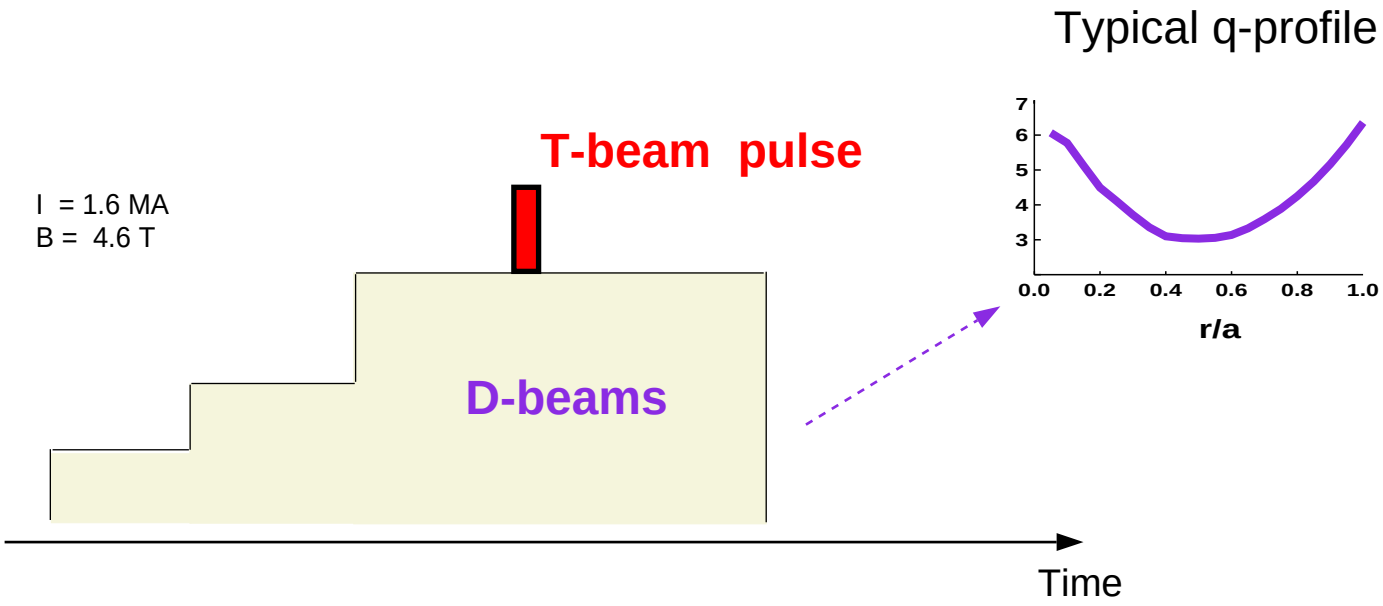
- H . Park: DT neutron emission in these plasmas is 35% lower than expected from discharges with monotonic q-profiles and similar density peekedness.

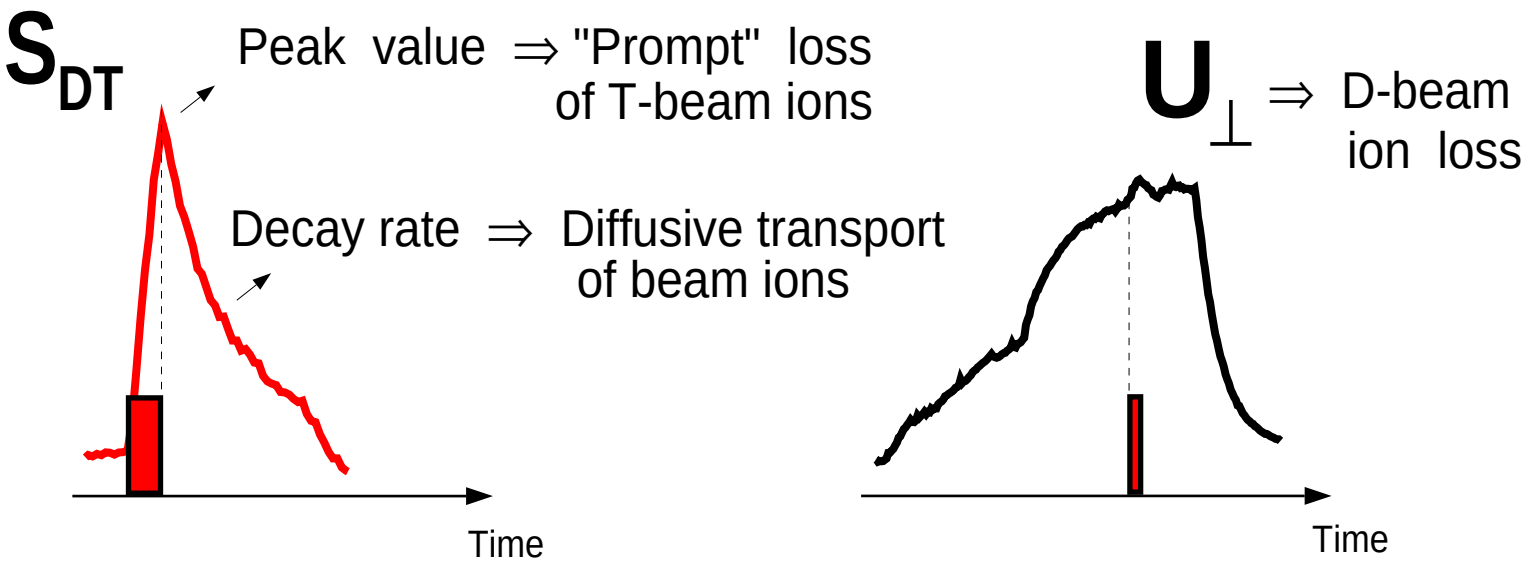
- Typical TRANSP overestimates of DT neutrons from RS plasmas fueled with D&T beams: 50-100%

- We suspected that beam ion loss is responsible for these observations.

- K. Tobita: Reversed shear in JT-60U degrades triton burnup.

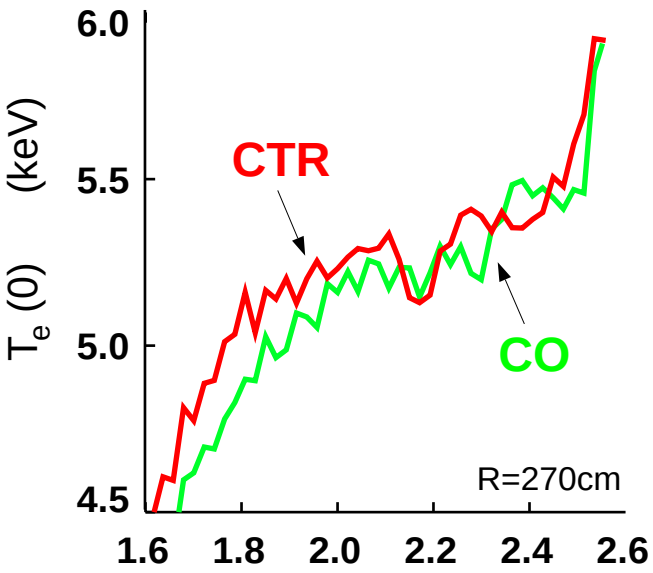
EXPERIMENT

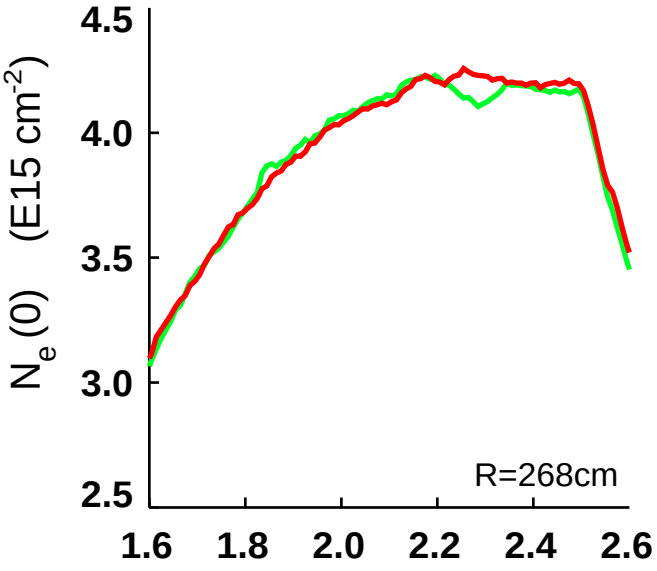


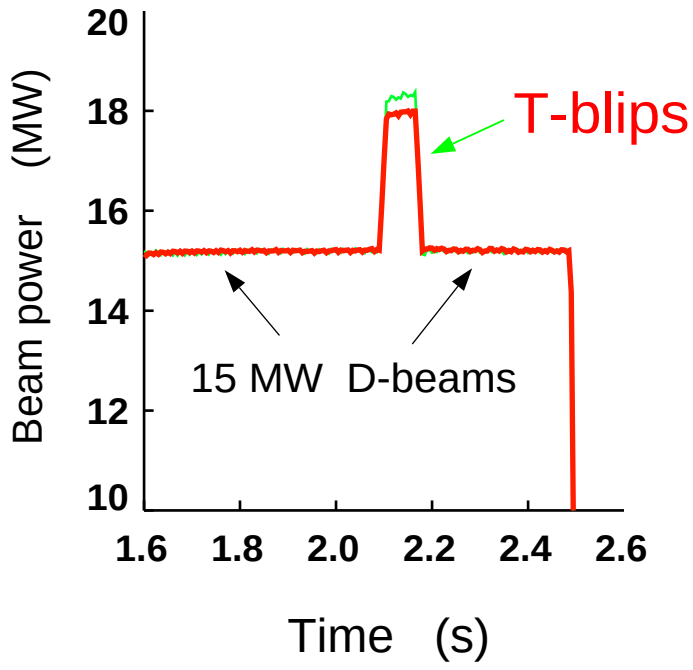


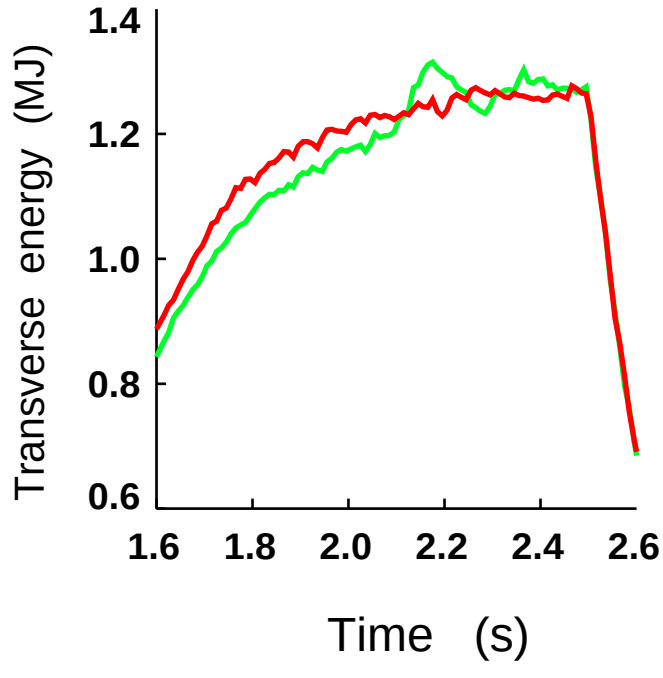
T-beam pulses were injected in CO and CTR direction.

The CO and CTR T-blip shots have nearly identical plasma conditions



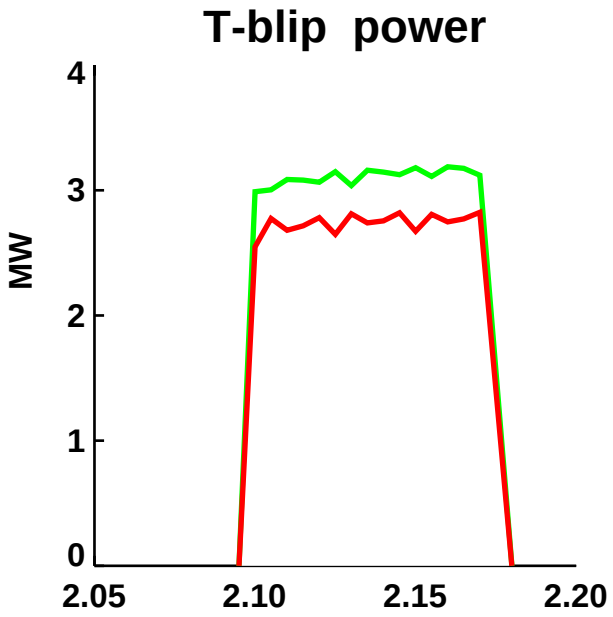


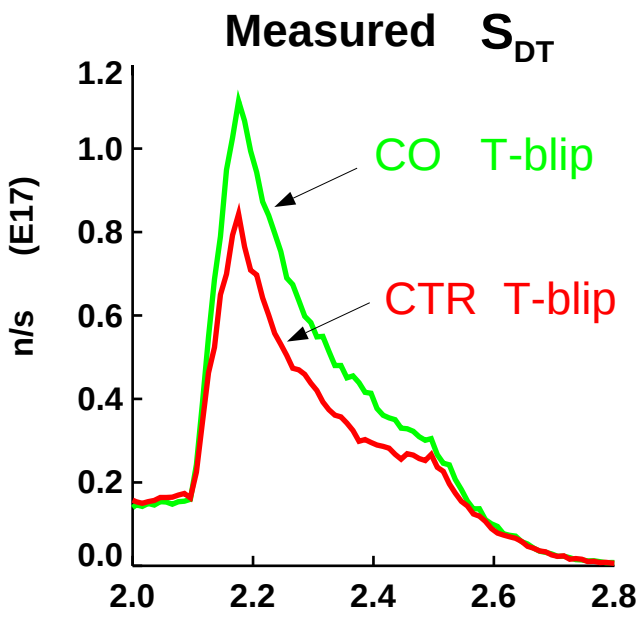


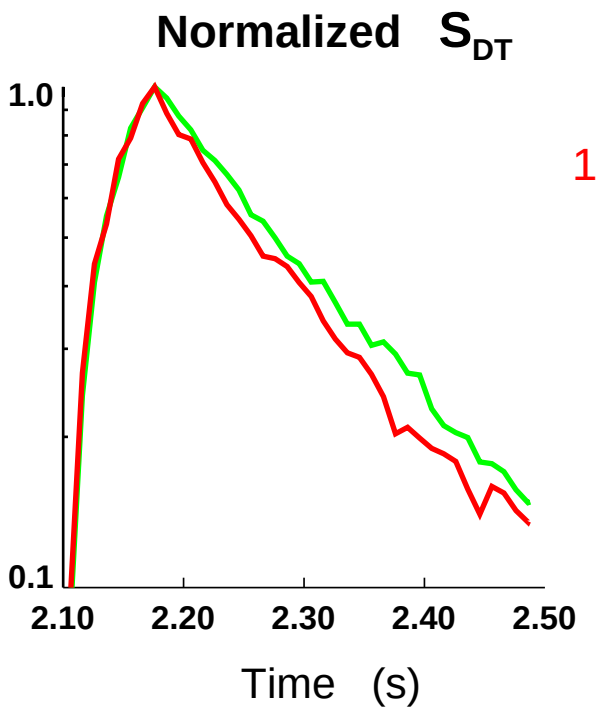


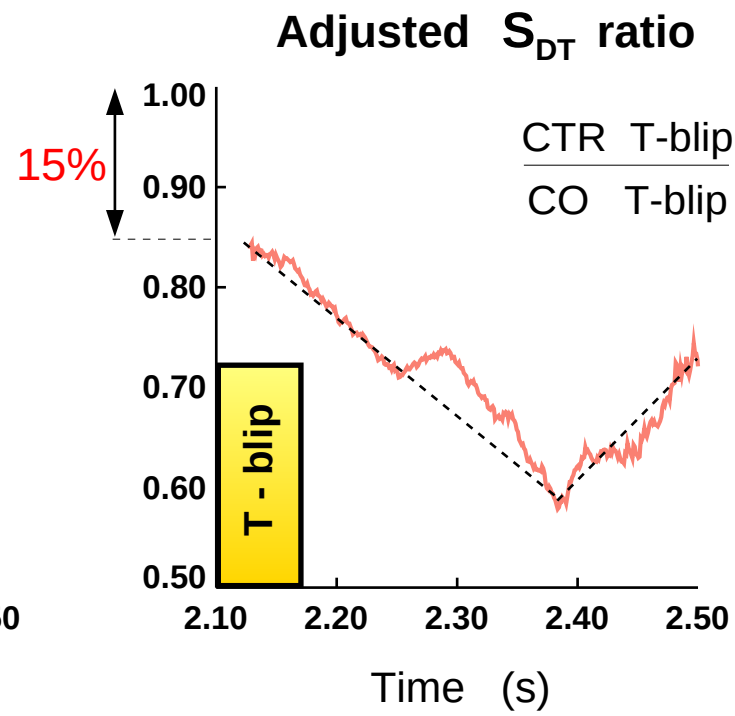
CTR T-beam ions have 15% higher first orbit loss than CO T-beam ions

TFTR





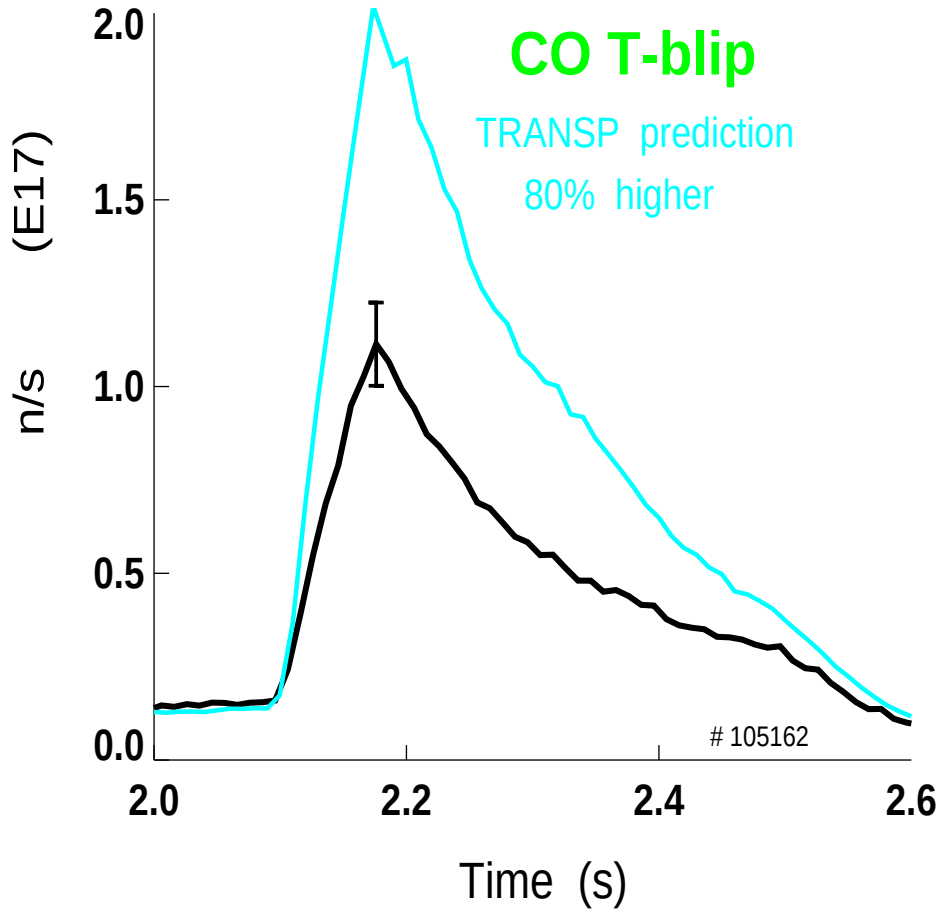


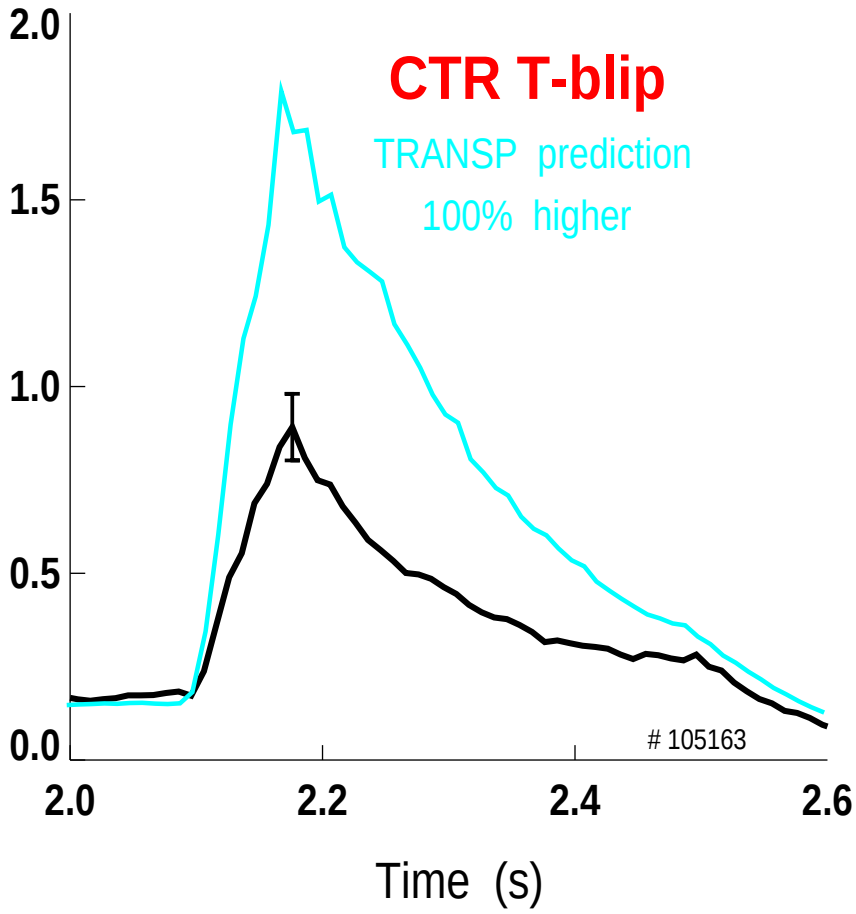


This result is in agreement with TRANSP and ORBIT code calculations.

TRANSP overestimates DT neutron rates by ~100%

TFTR





- Measured T_i and carbon impurity profiles
- First orbit loss <u>is</u> calculated ; no ripple loss

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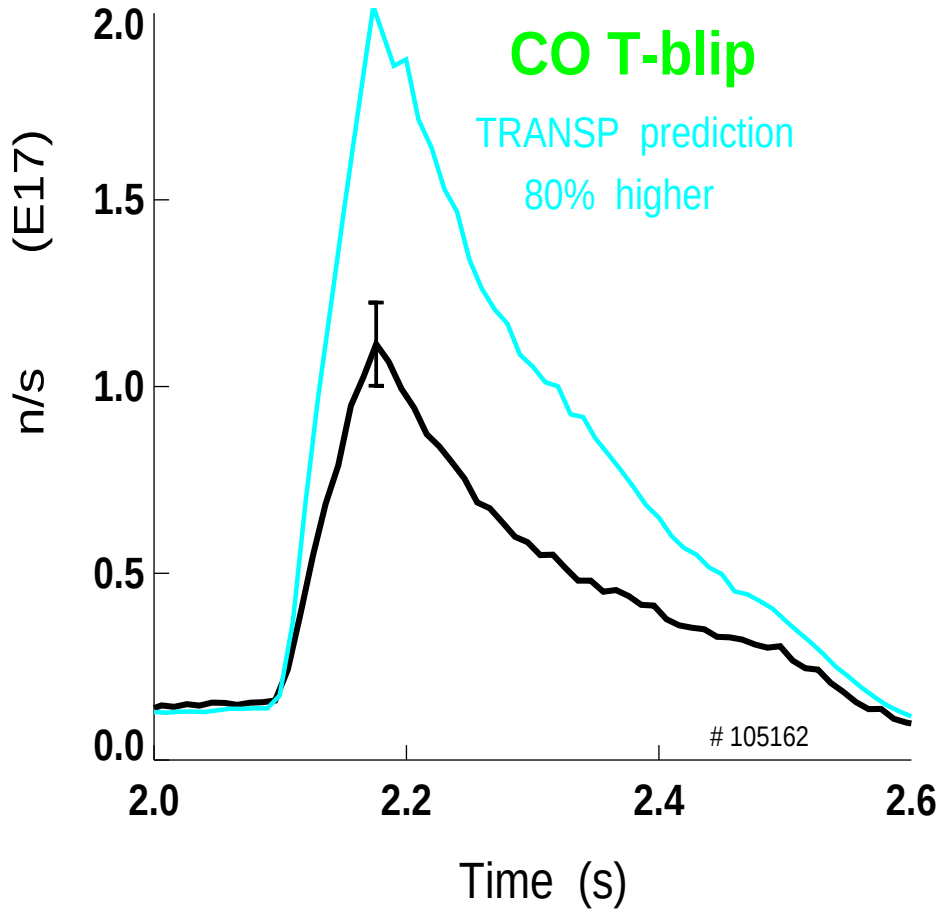
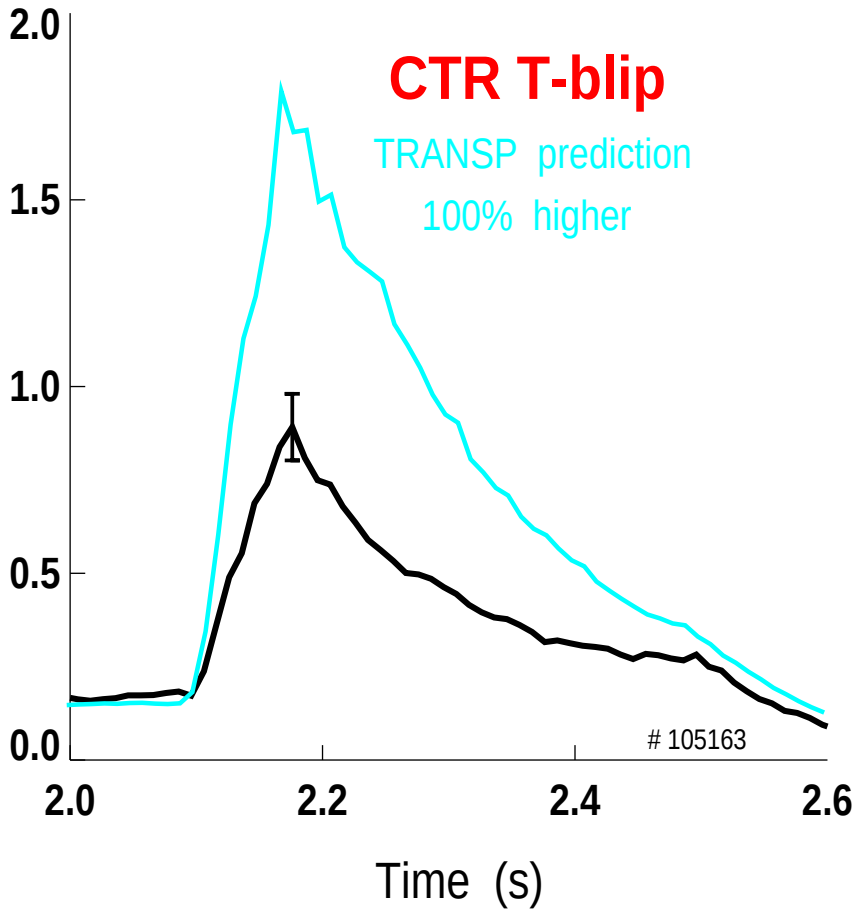
TFTR





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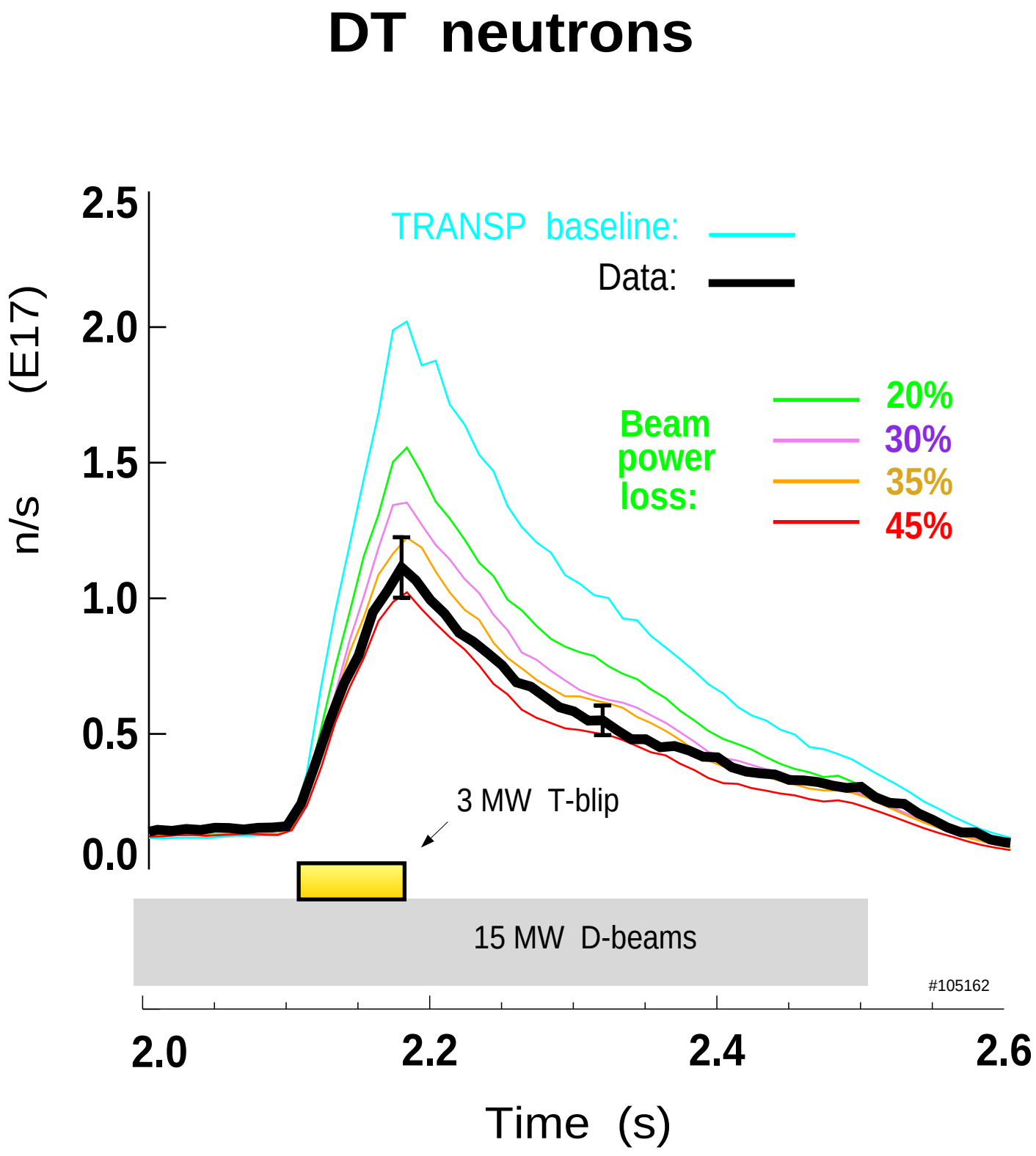
"REDUCED BEAM POWER" MODELS

- Examples of unsuccessful TRANSP models:
  - Scaled-up or modified Z_{eff} profiles
  - Scaled-up recycling
  - Anomalous beam ion diffusion
  - TRANSP ripple model

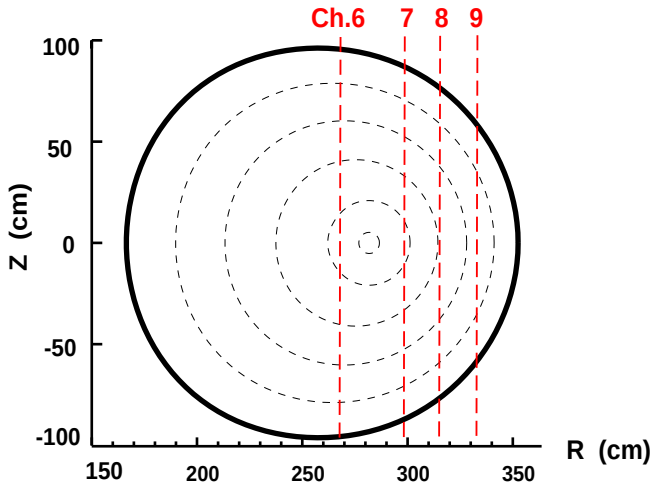
- After exhausting all relevant TRANSP modeling altarnatives, we decided to "reduce" (scale down) the beam power in the simulation:

  $\Rightarrow$ model for beam ion loss on a time scale much shorter than the beam ion slowing down time τ_s ~200ms

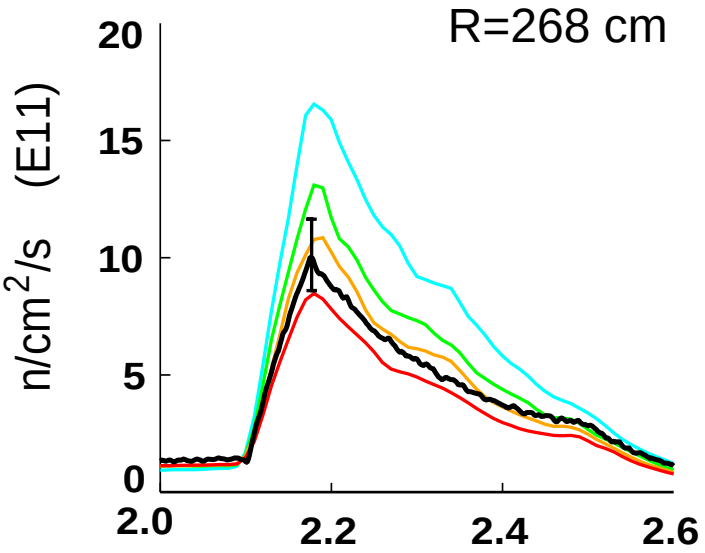
TRANSP modeling implies ~40% beam loss

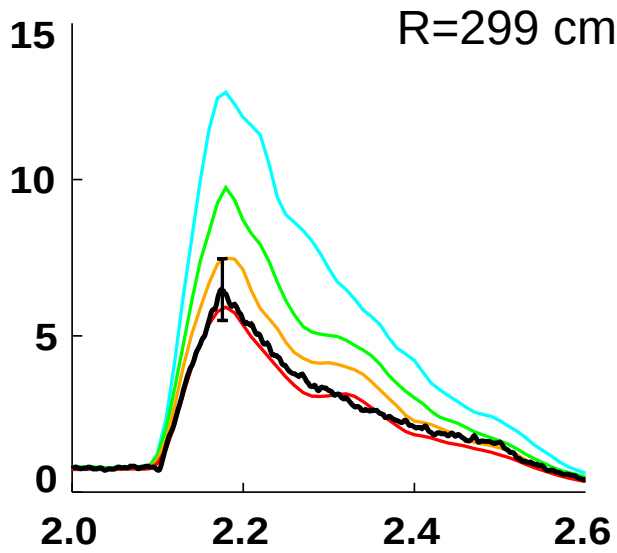


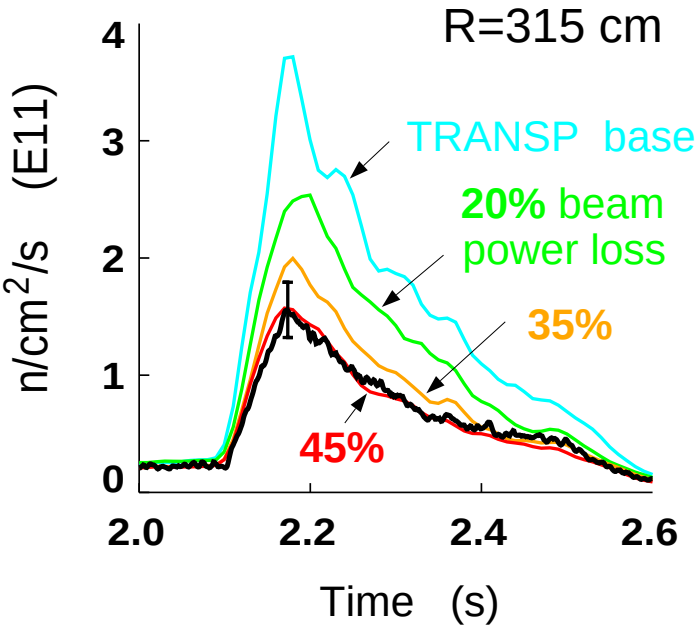
Neutron flux data confirms the ~40% beam power loss

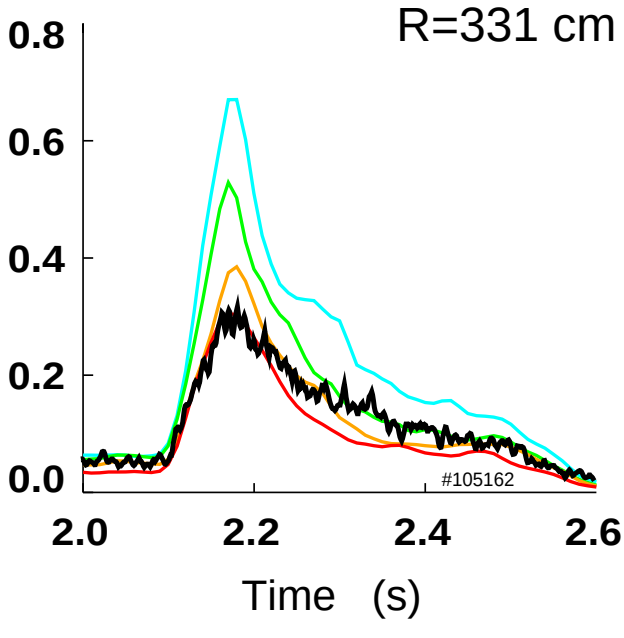


TFTR



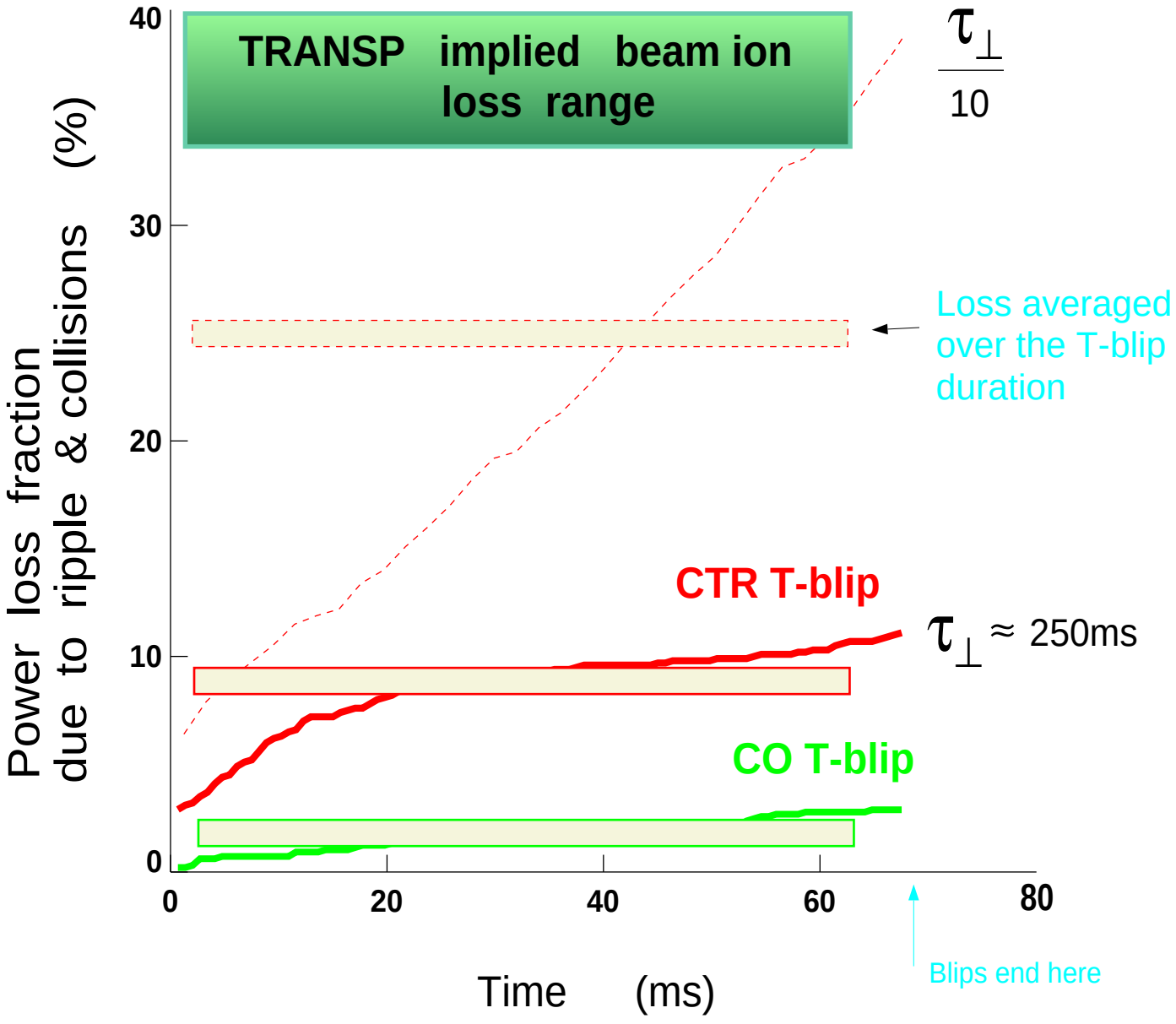






ORBIT code calculations of stochastic ripple diffusion can not explain the experiment

TFTR



CONCLUSIONS

- TRANSP simulations indicate that beam ions in TFTR RS plasmas exhibit ~40% power loss.
- This loss occurs on a time scale much shorter than the beam ion slowing down time.
- ORBIT code calculations of stochastic ripple diffusion can explain at most a third of the TRANSP modeling implied beam power loss.
- We do not understand the nature of this discrepancy. Is there any new physics involved?
- Fast ion confinement is a critical issue for advanced tokamaks. We have to validate the code(s) predictions with direct measurement of beam ion loss.