NSTX

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Shot spectrum for NSTX Upgrade

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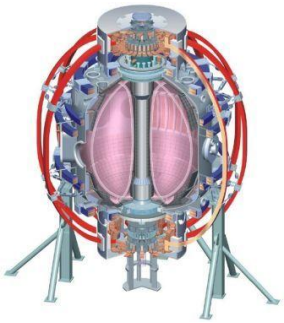
NSTX CS Upgrade Meeting
Engineering Conference Room
September 21, 2011



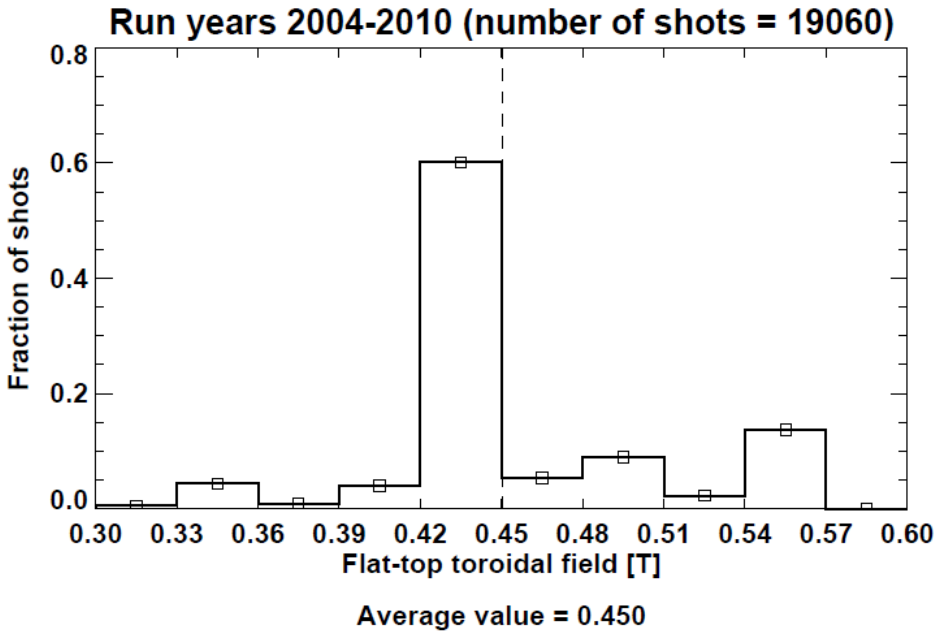
*This work supported by the US DOE Contract No. DE-AC02-09CH11466

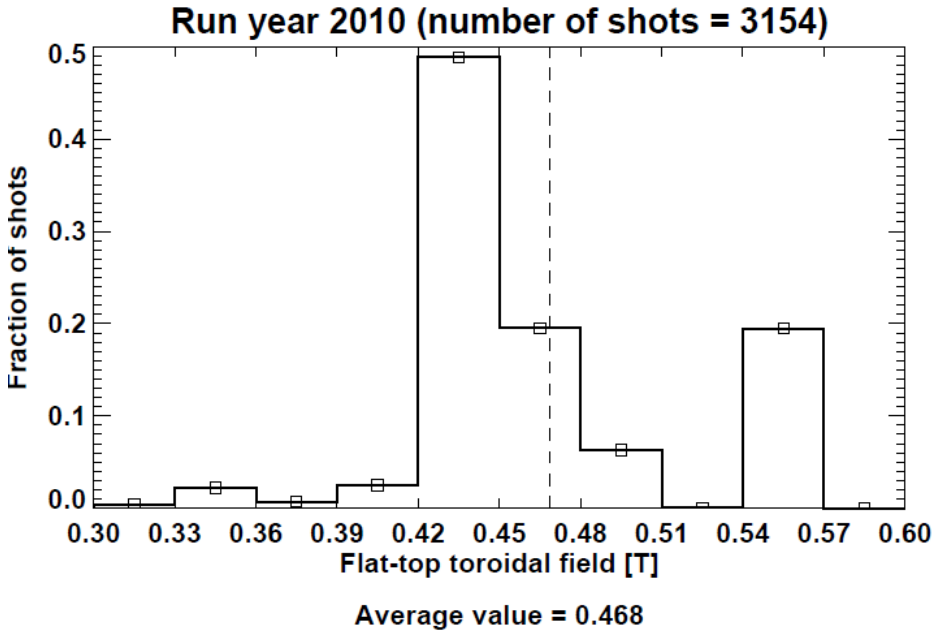
Shot spectrum considerations and assumptions

- Need 2x higher I_P, B_T and 5x longer pulses needed for physics studies → drives Upgrade design
- 20k shots needed for research program
- Assume 10 year operating life → 2k shots / year
  - Should be achievable with 14 run weeks / year
- Inter-shot period (magnet cool-down) = 12-20mins
  - Present NSTX is 10-12 minutes
  - Upgrade value is compromise between magnet capability and research program rep-rate requirements
- Base spectra of flat-top I_P and B_T, plasma pulse length, and TF $\int I^2 dt$ on recent NSTX ops (2010)

NSTX TF flat-top value spectrum

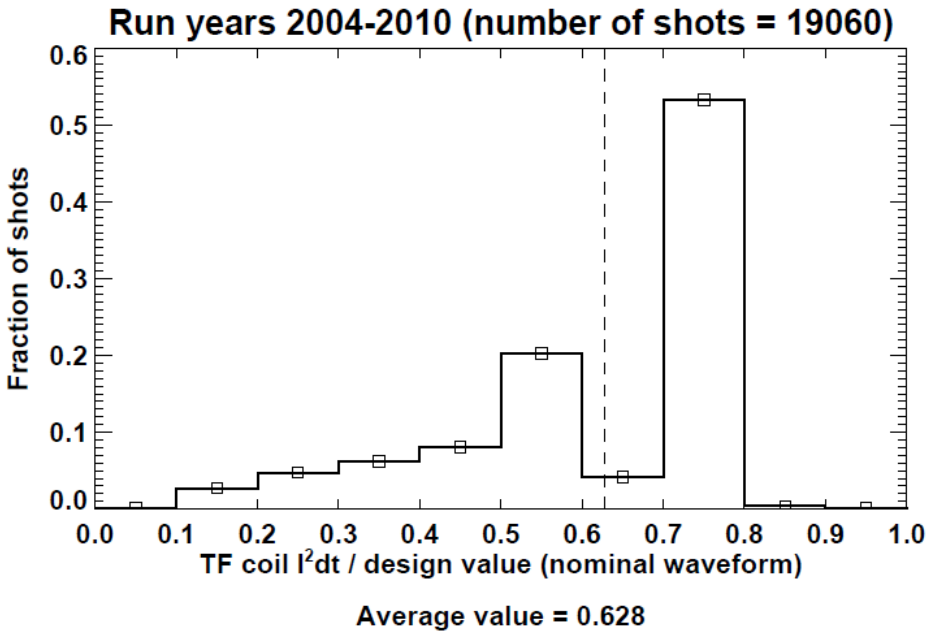
- 90-95% of shots run at ≥ 75% of max B_T (0.55T)
  - 50-60% at 0.42 – 0.45T
  - 15-25% at 0.45 – 0.54T
  - 15-20% at 0.55T

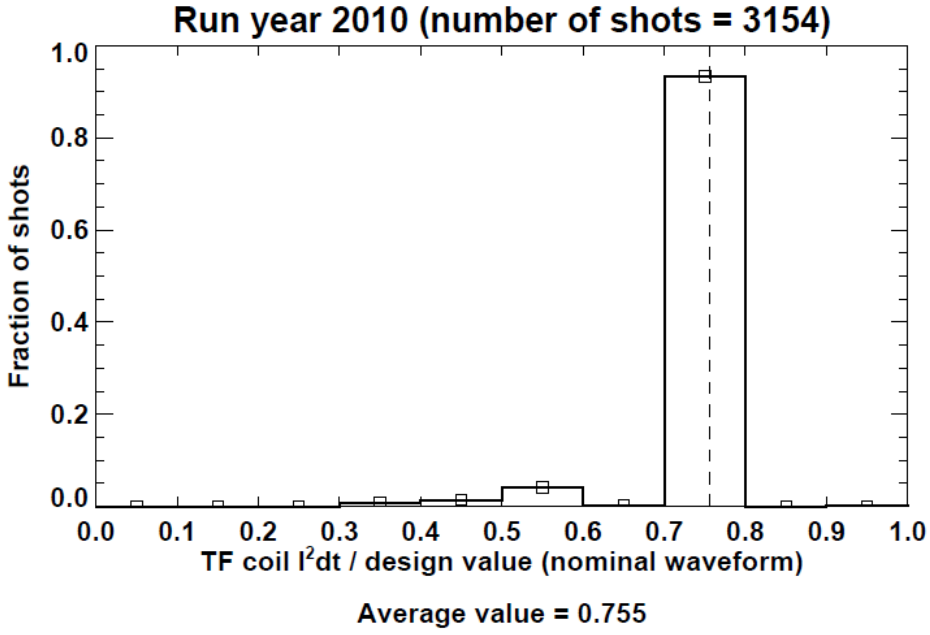




Majority of NSTX shots operated near TF $\int I^2dt$ limit

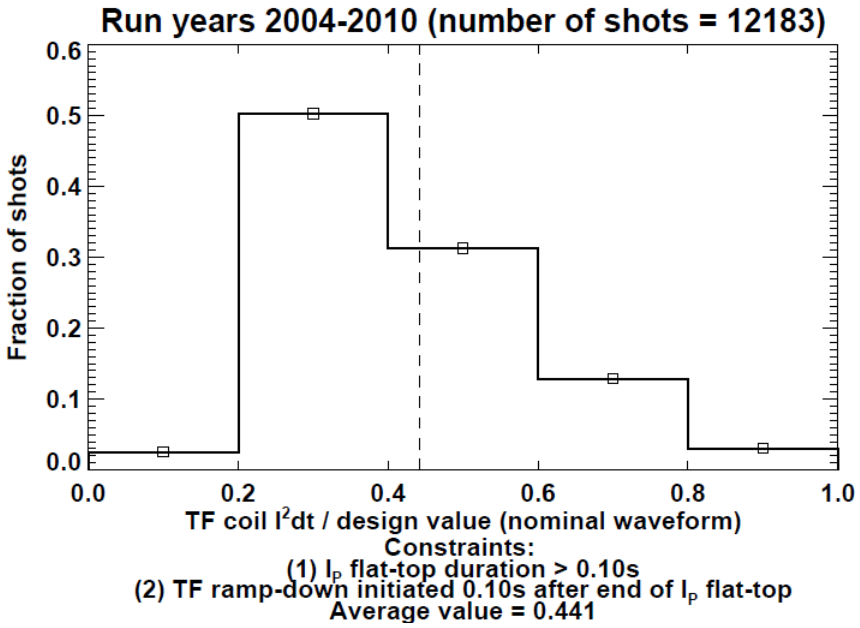
- More than 50% of NSTX shots operated at maximum allowed TF $\int I^2dt$ (set at ~75% of nominal waveform)
- NSTX TF pre-programmed → flat-top independent of I_P, I_{OH}
- Upgrade: TF thermal stress can in principle be reduced by turning off TF if full TF flat-top is not needed/utilized

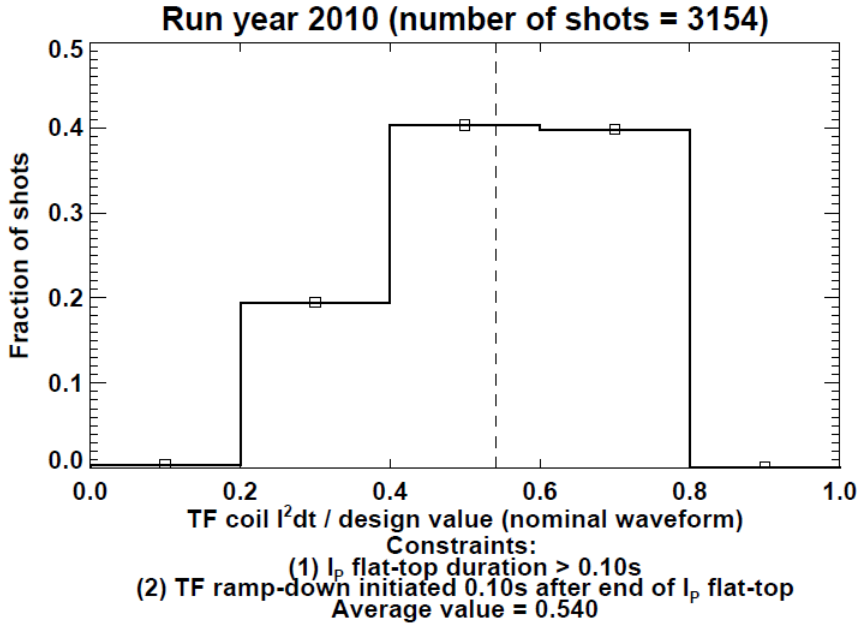




NSTX TF $\int I^2dt$ spectrum with 'smart' TF turn-off:

- If NSTX TF had been turned off 0.1s after end of I_P flat-top, the TF thermal stress would have been substantially reduced
  - 50% of all shots would have operated at 0.2-0.4 of nominal $\int I^2dt$
- However, substantial progress was made in lengthening I_P flat-top and TF utilization by end of 2010 (40% at 0.6-0.8)
- Upgrade: use $\int I^2dt$ spectrum similar to 2010 with TF turned off when not needed → need to implement in DCPS or PCS





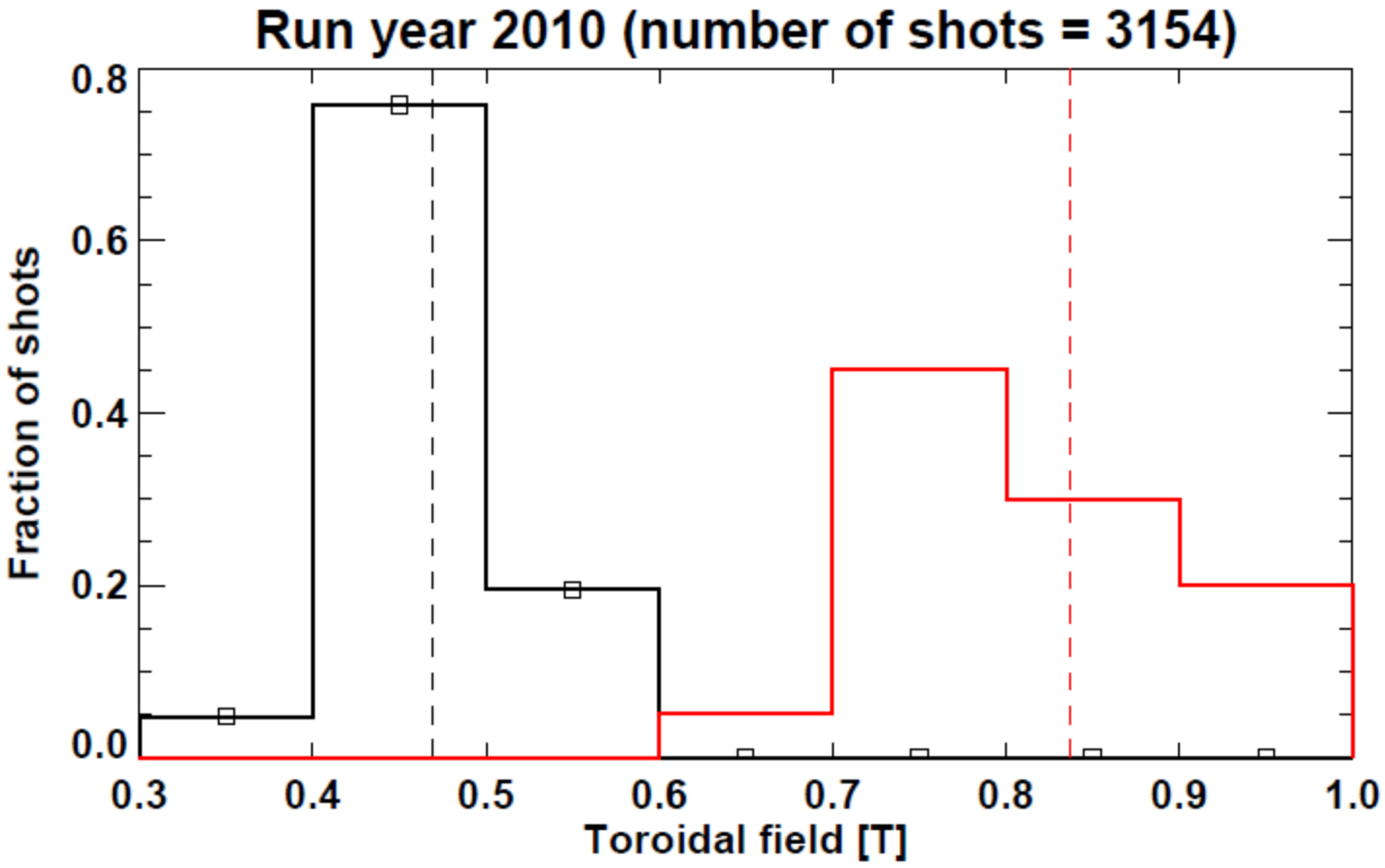
Proposed spectrum for CSU analysis and operation

Performance level	60%	75%	90%	100%	
B_T [T]	0.6	0.75	0.9	1	
I_P [MA]	1.2	1.5	1.8	2	
I_P flat-top duration [s]	Number of pulses				Total pulses
3	200	1800	1200	1000	4200
3.5	200	1800	1200	1000	4200
4	200	1800	1200	1000	4200
4.5	200	1800	1200	500	3700
5	200	1800	1200	500	3700
				Total	20000

Average TF cool-down time = 16 minutes

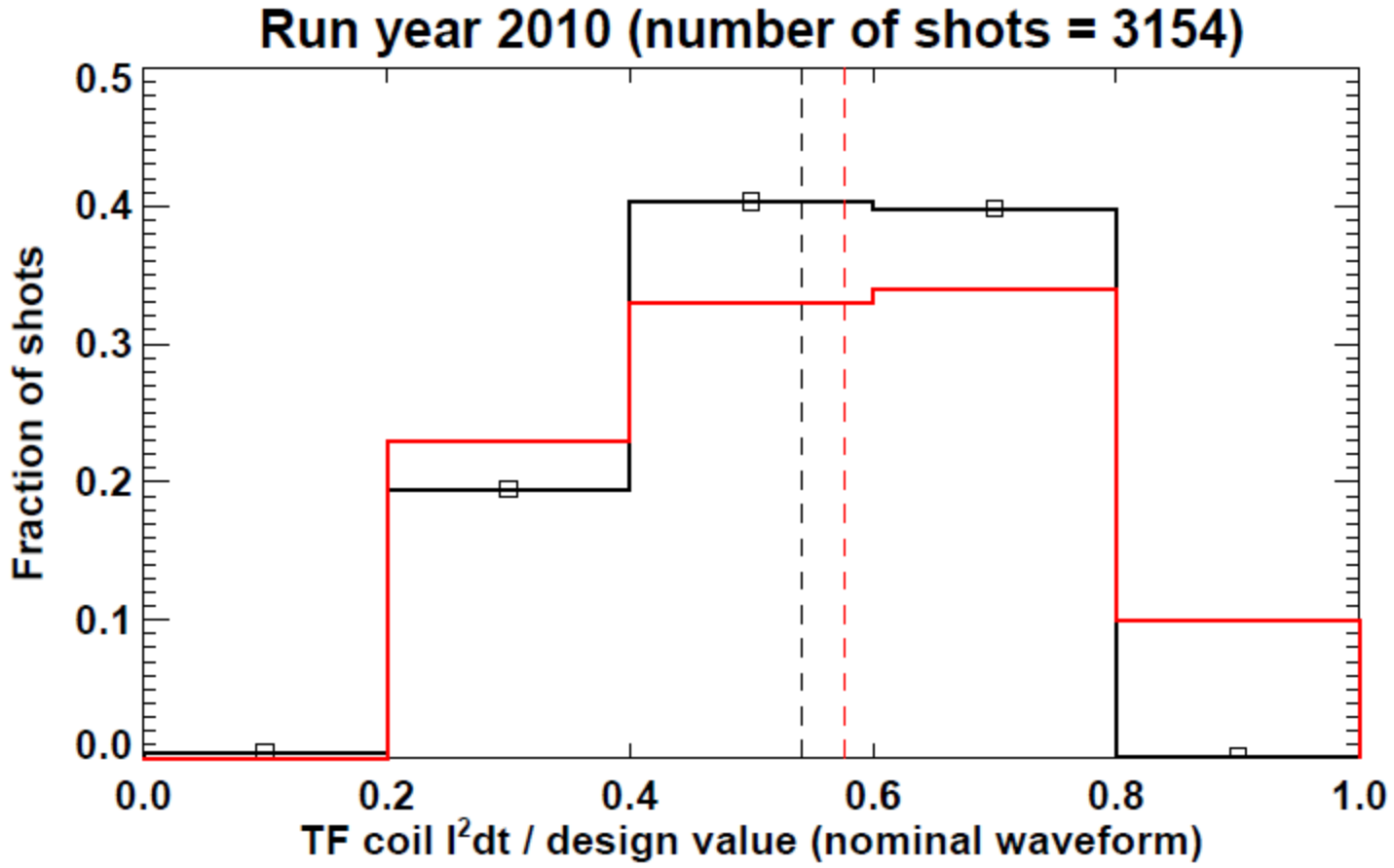
Flat-top toroidal field comparison

- NSTX (2010): 0.47T
- NSTX Upgrade: 0.84T → 2x higher at same R_0



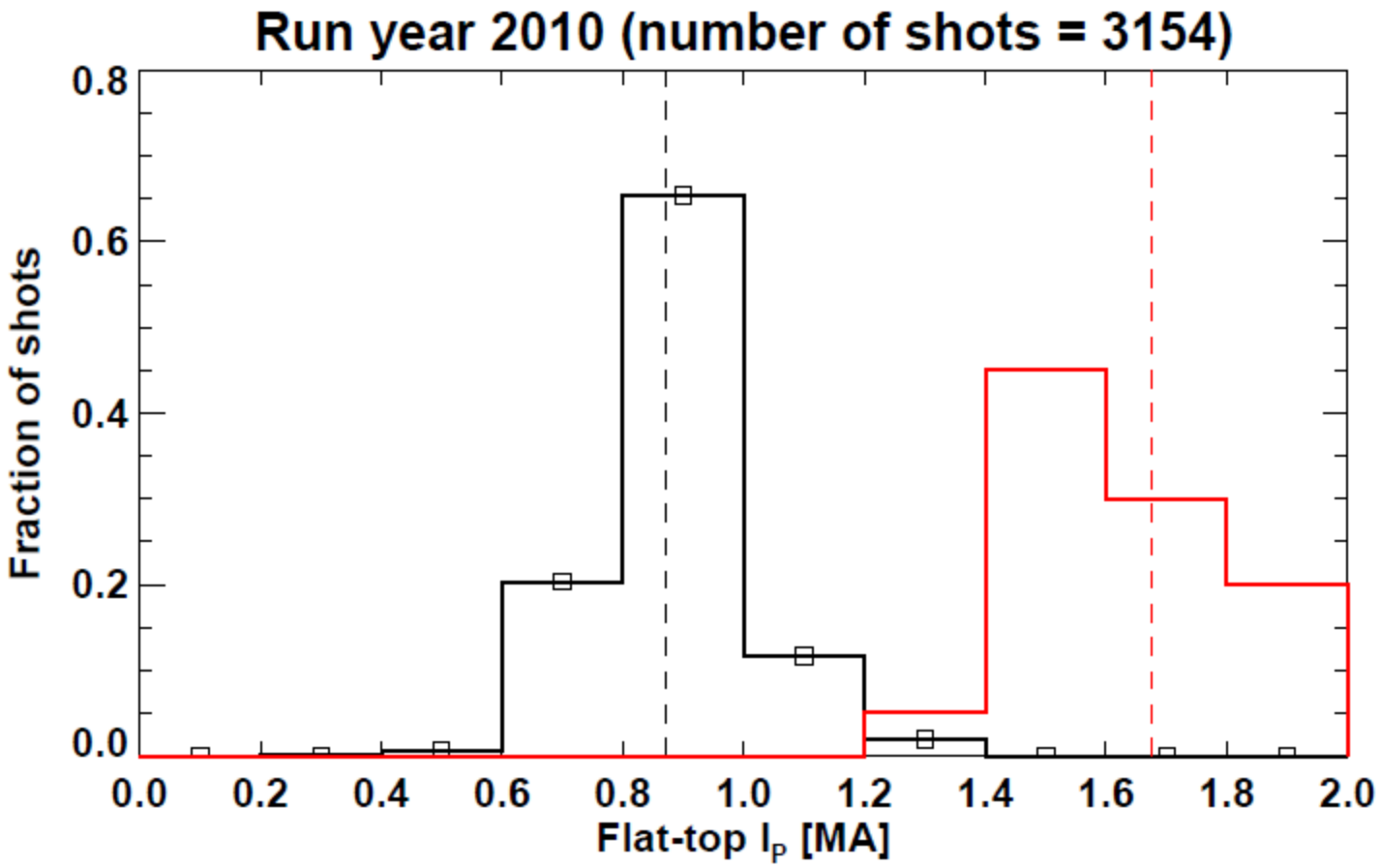
TF $\int I^2 dt$ comparison

- NSTX (2010): 0.54
- NSTX Upgrade: 0.58 (similar to NSTX 2010)



Plasma current flat-top value comparison

- NSTX (2010): 0.87MA
- NSTX Upgrade: 1.67MA → 2x higher



Plasma current flat-top duration comparison

- NSTX (2010): 0.64s
- NSTX Upgrade: 4s → 6x longer