



# Results and Analysis of XP-229

## Pulse-length limits of NBI-heated LSN H-mode plasmas

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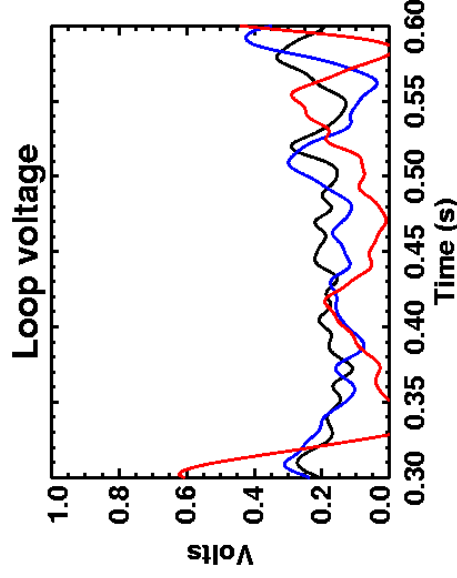
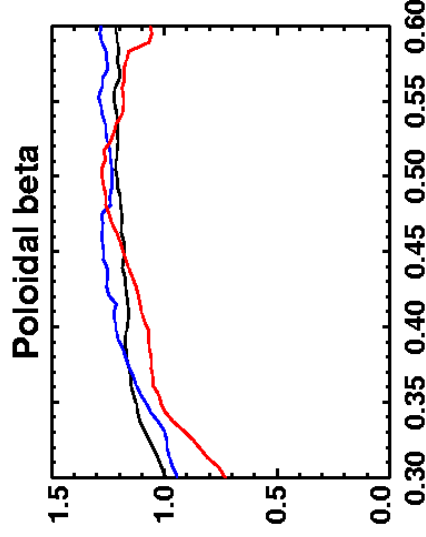
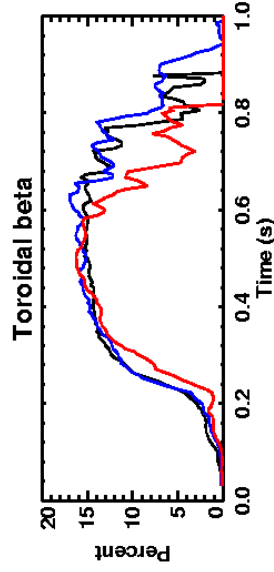
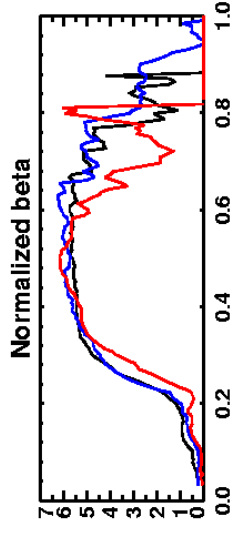
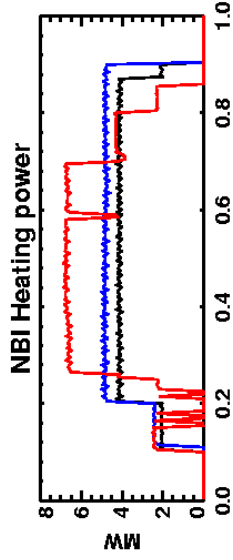
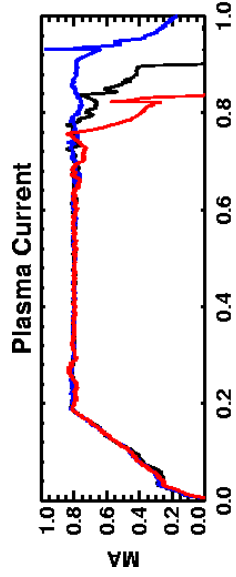
NSTX FY02 Results Review

Monday, September 09, 2002

# Achieved 1s pulse with 700ms, 800kA flat-top



108731  
109063  
109071



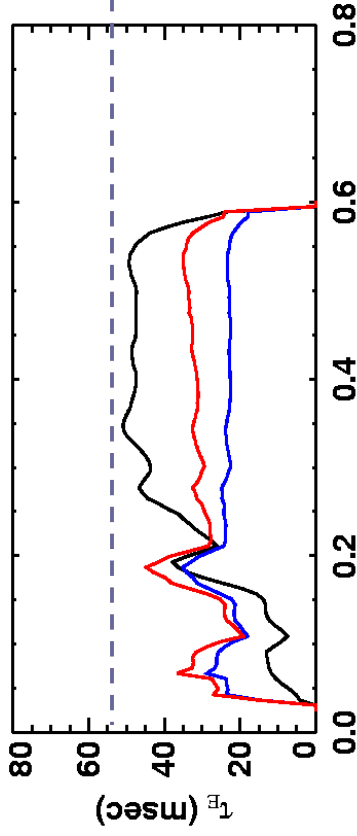
- 5kG out to  $t=950\text{ms}$
- 100kV A, B results:
  - Extra CD helpful
  - 4.8MW no more disruptive than 4MW
- A+B+C results:
  - Mean  $V_{\text{LOOP}} = 100\text{mV}$  from 350-550ms
  - Brief periods of negative loop voltage
- No shots sustained  $W_{\text{TOT}}$  past 750ms
- Initial disruption still largely internal

# Confinement improved at higher $V_{\text{NBI}}$ , TF



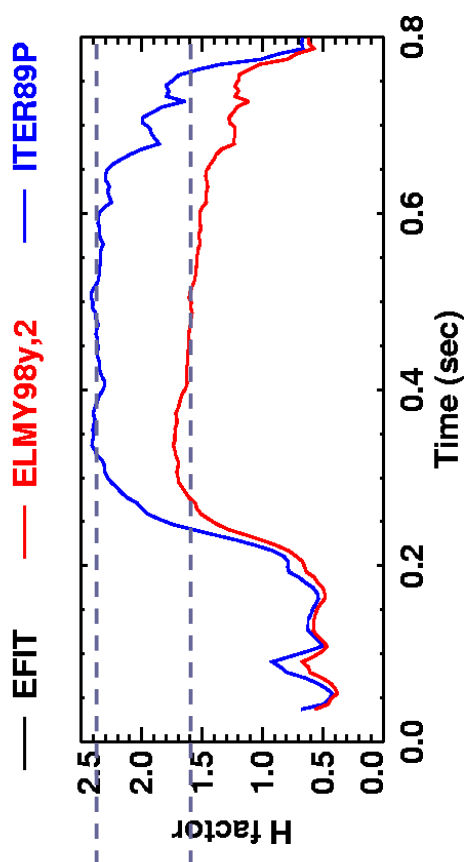
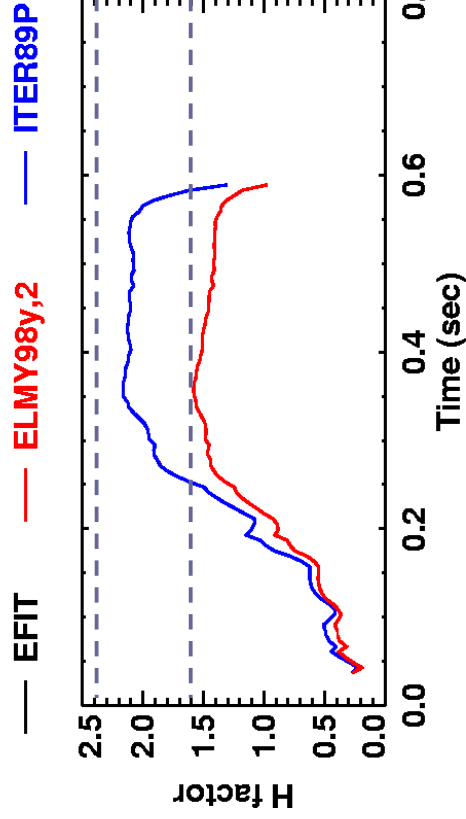
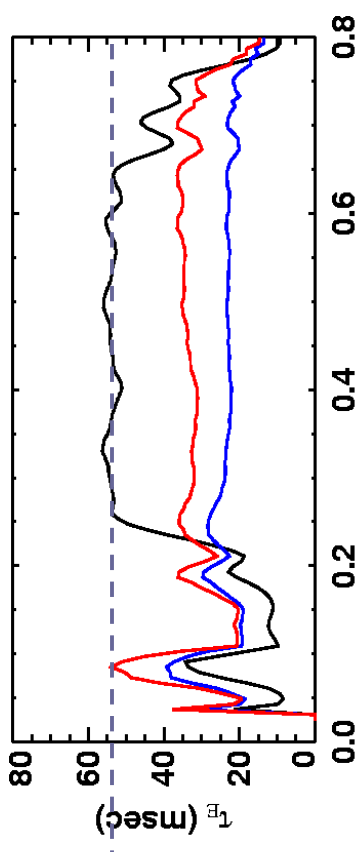
**A+B at 80kV, 3.2MW, 4.5kG**

**NSTX shot 107796**



**A+B at 90kV, 4.0MW, 5.0kG**

**NSTX shot 108731**

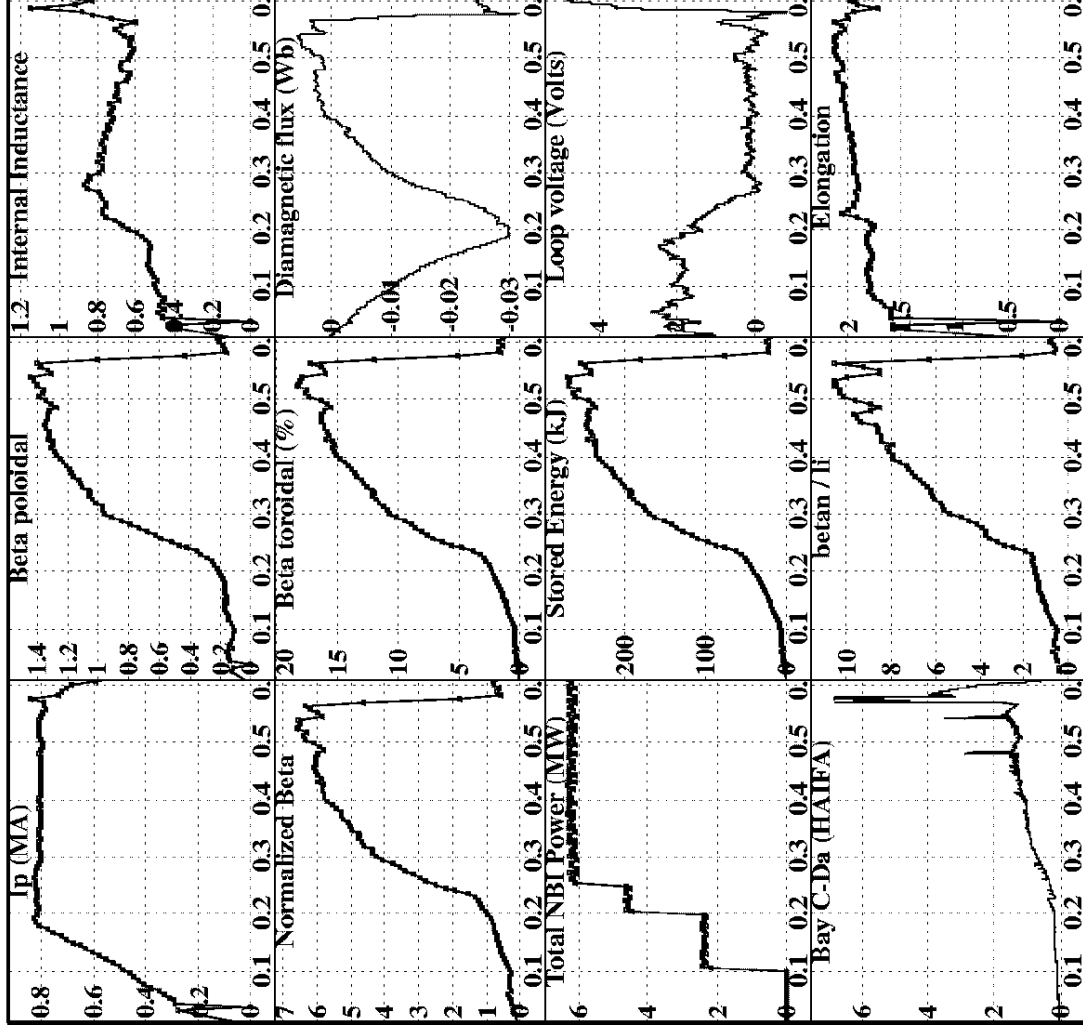


**A+B 100kV H-factors similar to 90kV at 5kG**

# Created diamagnetic plasma with high $\beta_N/\text{li}$ ratio




High beta-poloidal data for shot 109070



- Reached  $\beta_p = 1.4$  and  $\Phi = +5\text{mWb}$
- Standard EFIT fails due to “strong” diamagnetism
- Partial kinetic EFIT (preliminary) finds
  - $\beta_N = 6.2$
  - $\beta_N/\text{li} = 10$
- $V_{\text{LOOP}} = 100\text{mV}$  for 300ms (260-560ms)

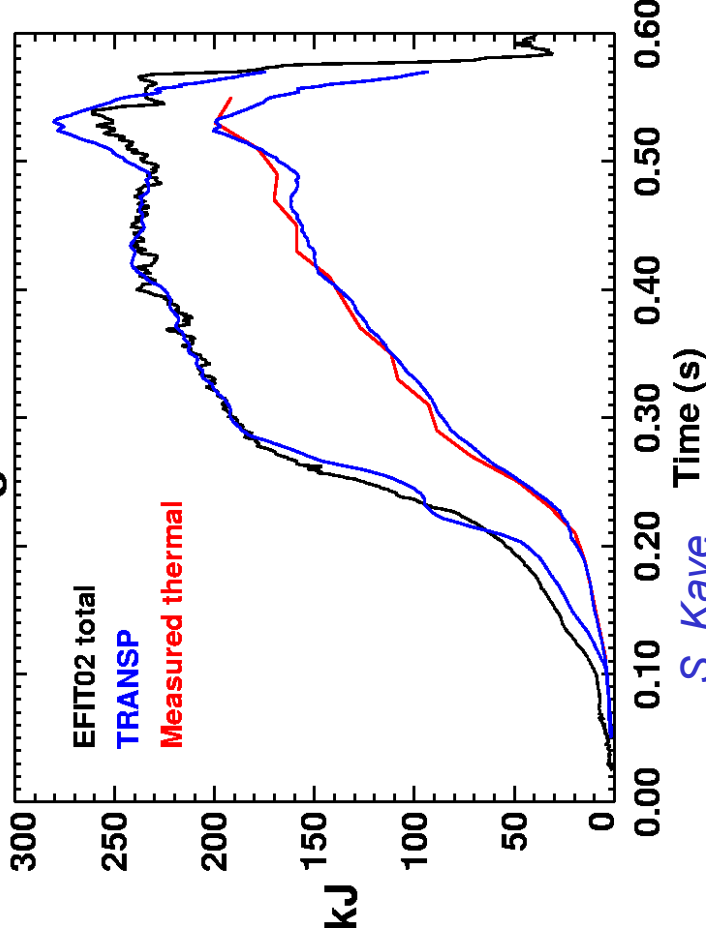
# TRANSP agrees with EFIT02 $W_{TOT}$ , $\Phi_{DIA}$

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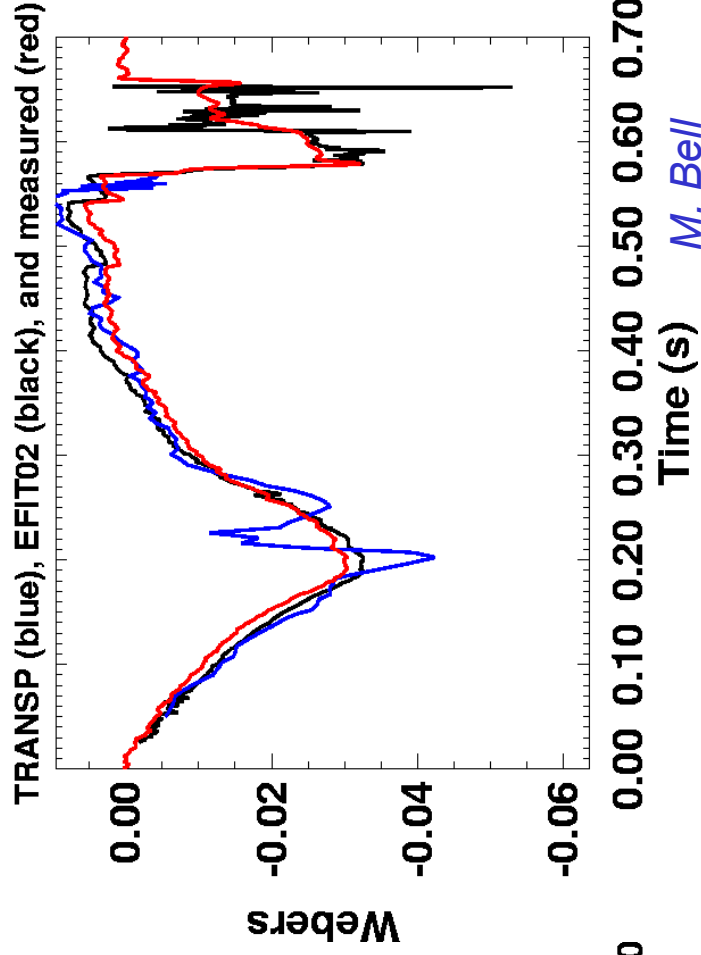
- Kinetic Diagnostics:
  - 20pt MPTS  $n_e$  &  $T_e$ ,  $T_i$  from CHERs, line-average  $Z_{eff}$
- Confirms plasma is slightly diamagnetic

Stored energies for 109070A22



S. Kaye

Diamagnetic flux for 109070A22



M. Bell

# TRANSP $\Rightarrow$ long-pulses have 50-60% NICD?

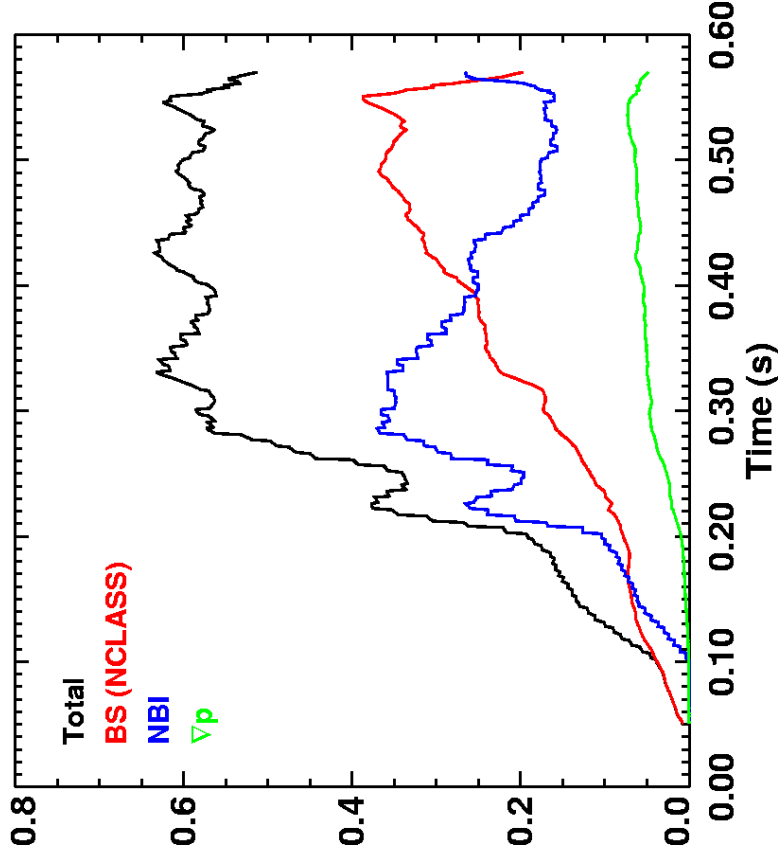


- Remaining uncertainties:  $Z_{\text{eff}}$ , neoclassical  $\sigma$

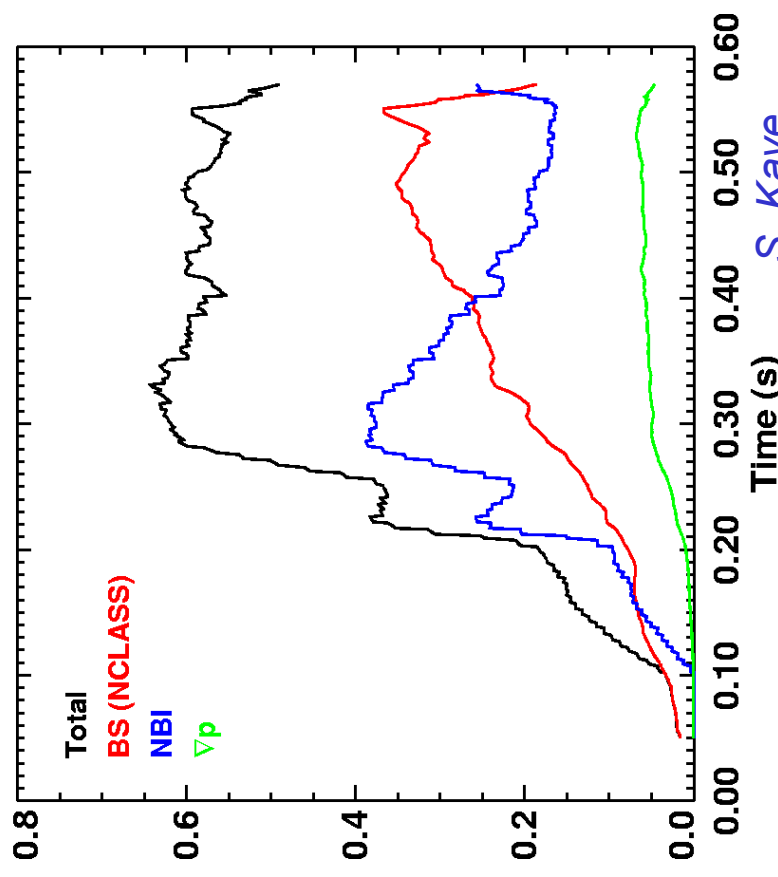
*Using EFIT02 q-profile*

*q-profile evolved from  $\sigma_{\text{neo}}$*

TRANSP non-inductive current fractions for NSTX shot 109070A22



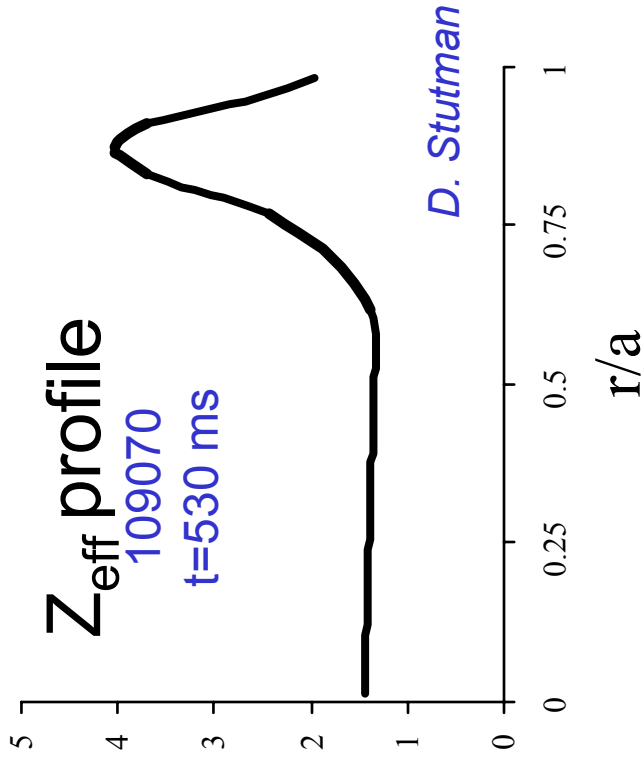
TRANSP non-inductive current fractions for NSTX shot 109070A19



# $Z_{\text{eff}}$ profile from USXR not flat



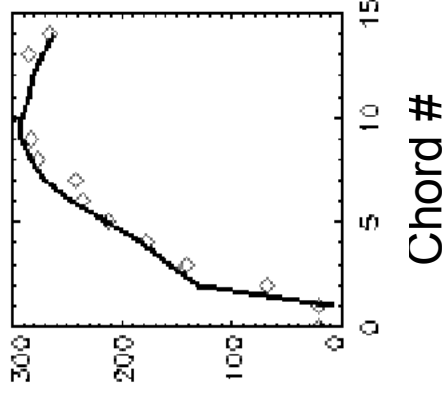
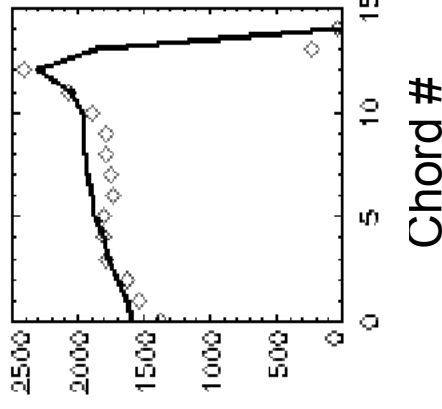
NSTX



USXR Diode signals

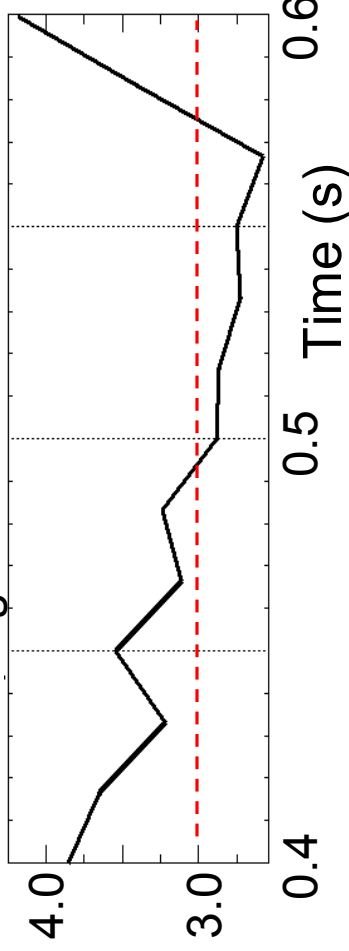
H up Be 10

H down Be 100



- C accumulation in H-mode ear
- Nearly pure D in core?
- Reasonable agreement with VB

Line-average  $Z_{\text{eff}}$  from VB and MPTS



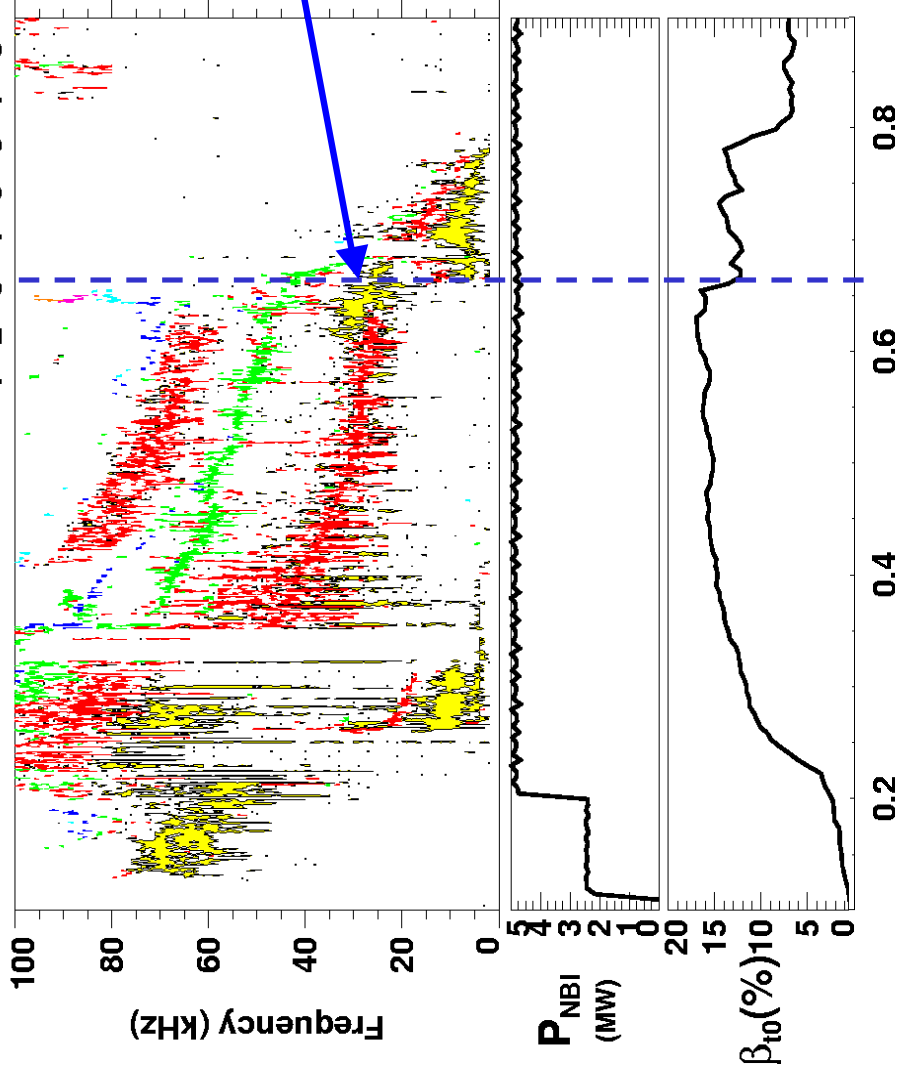
*V. Soukhanovskii*

# MHD: $n=1$ collapse precursor typical



NSTX Shot 109063

Toroidal Mode Number:



- $n=2,3$  active present prior to 1<sup>st</sup> collapse

- Rapid transition to  $n=1,3$  ( $n=1$  largest)

- $f$  matches core

rotation frequency:  
 $f=25-30\text{kHz}$

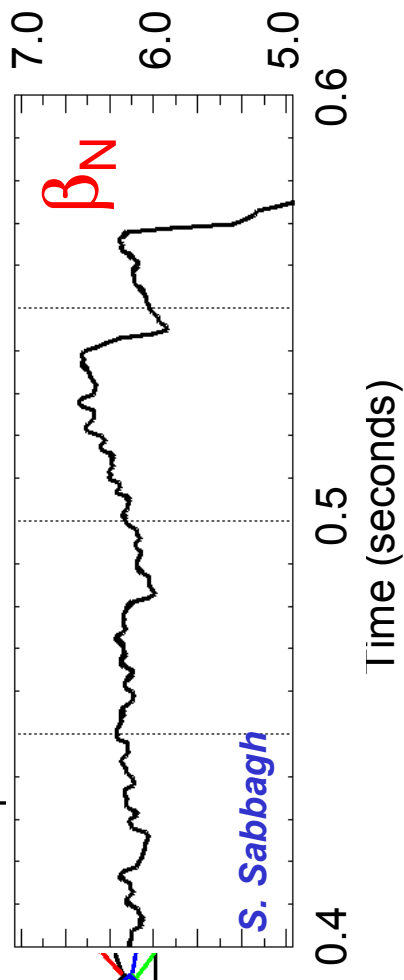
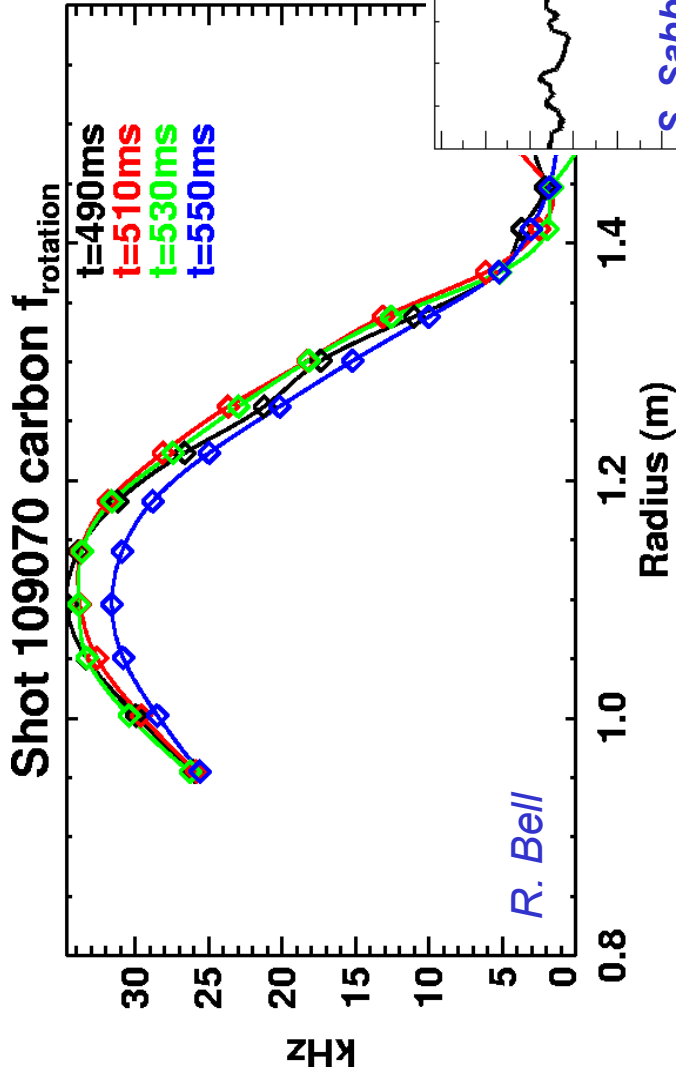
- TAE, TM, or kink?



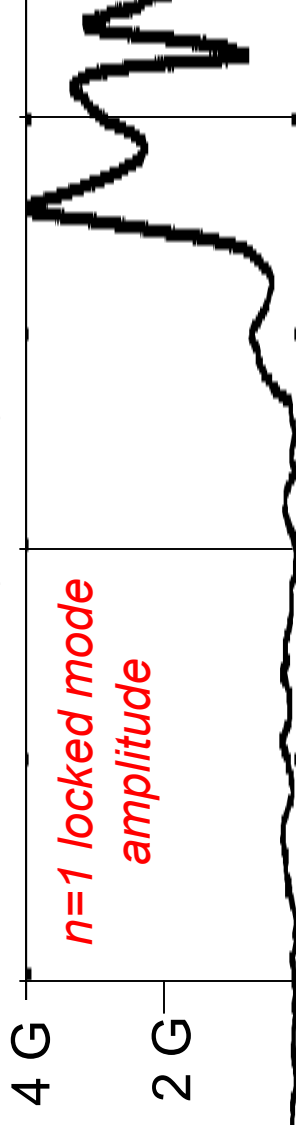
# Rotation damping weak prior to collapse



NSTX



Consistent with  $< 0.5\text{G}$   
 $n=1$  locked mode  
signal until  $t=0.58\text{s}$



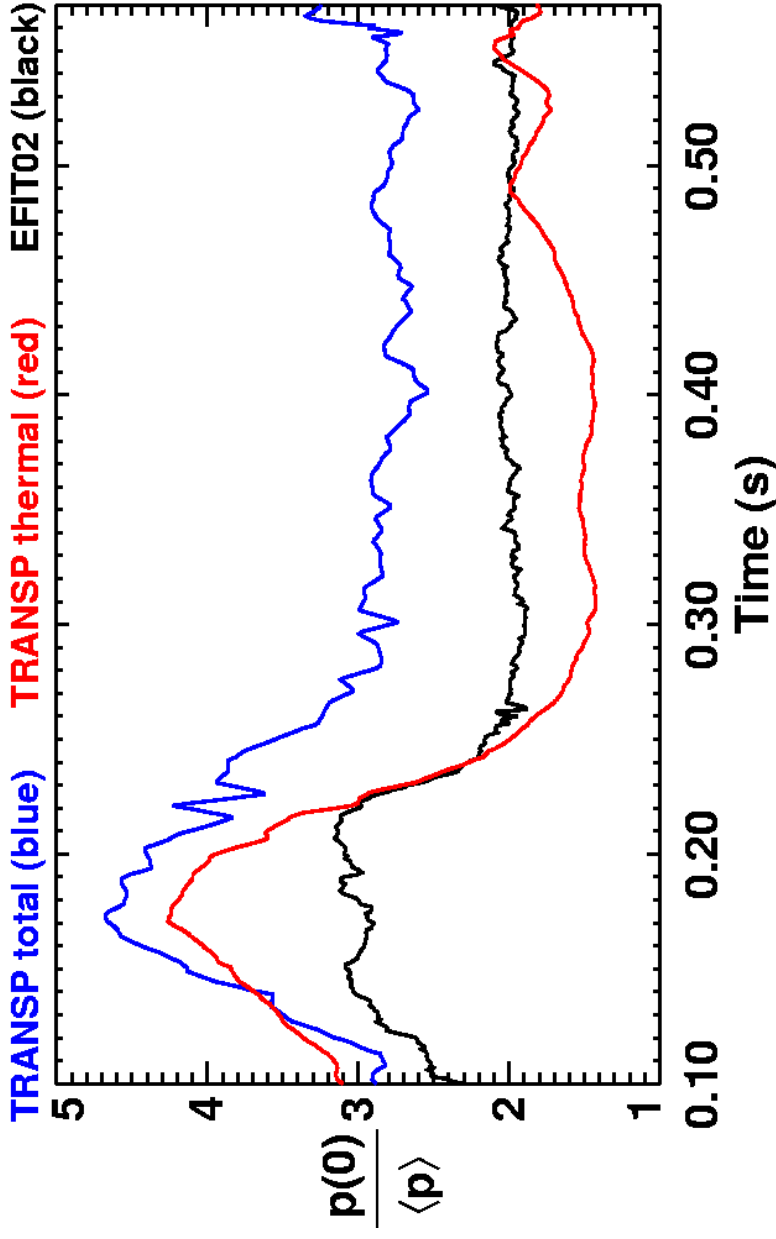
TRANSP  $p(\psi)$  peaking  $\approx 1.4 \times$  EFIT02 value

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- TRANSP pressure peaking factor = 2.5-3 late in shot
- EFIT02 closer to 2  $\Rightarrow$  *impact on equilibrium, stability?*

### Pressure peaking factors for 109070A22



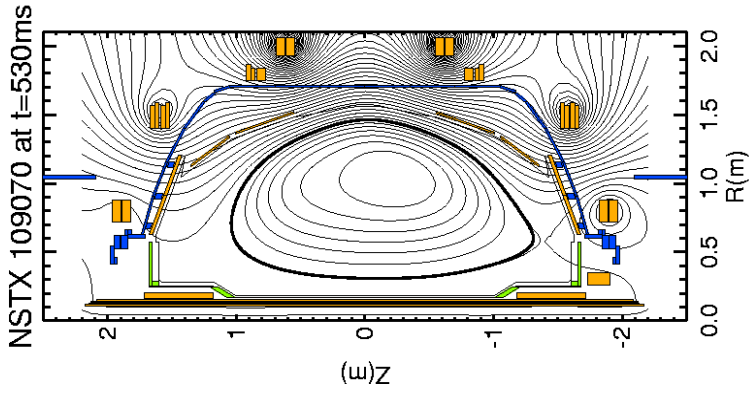
# EFIT02 yields monotonic $q(\psi)$



$\langle J_{\parallel} \rangle (\psi)$  using EFIT  $q(\psi)$  and:

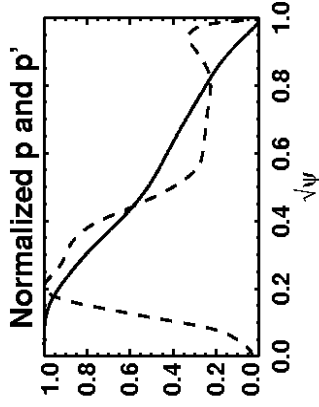
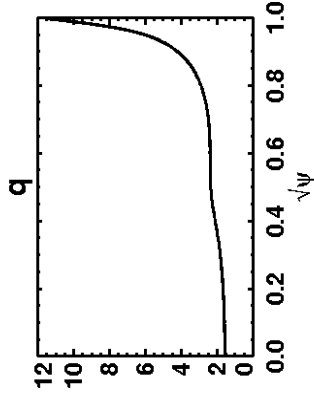
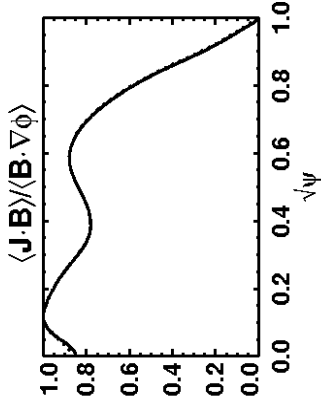
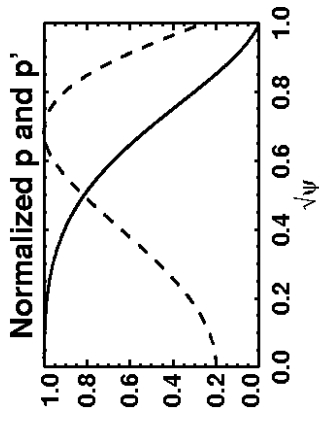
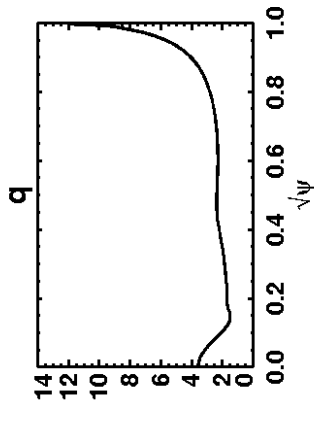
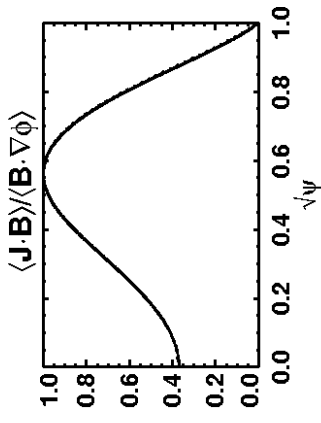
TRANSP  $p(\psi)$

EFIT  $p(\psi)$



JSOLVER ID: Nea-07wa

$I_p = 0.778\text{MA}$   
 $I_{\parallel} = 0.641$   
 $q_0 = 1.56$   
 $q_{\min} = 1.56$   
 $q_a = 11.4$   
 $\beta_t = 17.0\% (6.84\%)$   
 $\beta_N = 6.06 (2.42)$   
 $p'_{\text{ave}} < p = 2.80$

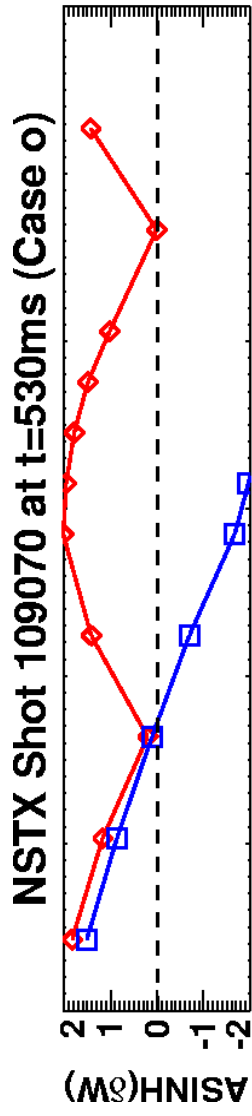


# $n=1$ stability variation with profiles:

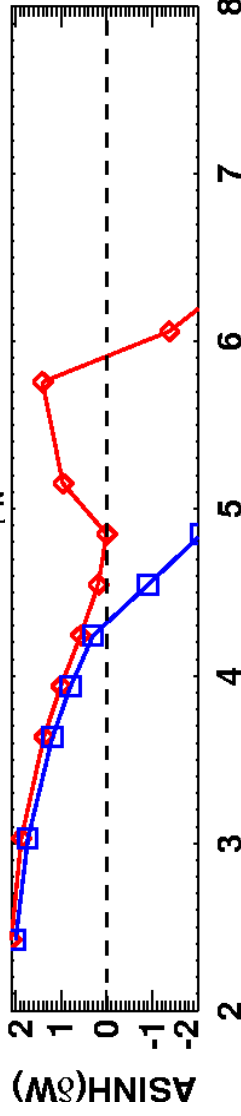


- Higher  $p(0)/\langle p \rangle$  lowers with-wall limit
- Higher  $p(0)/\langle p \rangle$  raises no-wall limit

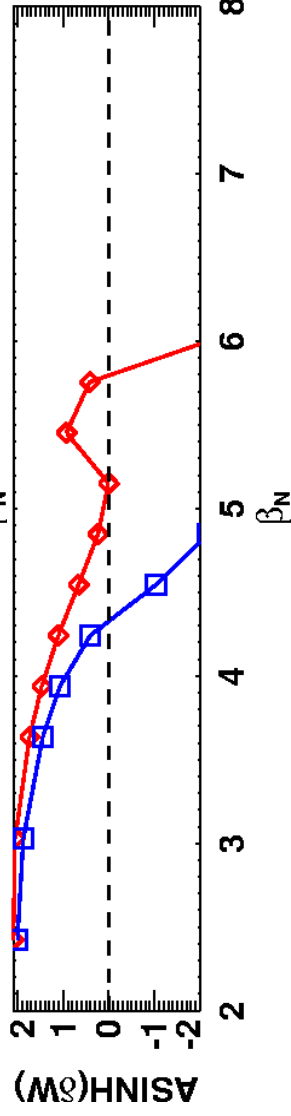
Profile choice:



EFIT q  
EFIT p



EFIT q  
TRANSP p



monotonic  $\langle J_{||} \rangle(\psi)$   
TRANSP p

# Summary



- LSN long-pulse XP achieved  $\approx 1$  s discharges
  - Shape, current, TF, NBI voltage all optimized
  - H-mode yields  $H_{89p}=2-2.5$ ,  $H_{98y,2}=1.4-1.6$
- Initial TRANSPs agree with magnetics
  - Indicate 50-60% NICD fractions in best shots
  - Zeff profile needed for more detailed analysis
- Discharges appear to routinely run above the no-wall limit, but eventually disrupt
  - Locked mode precursor & rotation damping both weak
- TRANSP pressure profile more peaked than EFIT02
  - Higher peaking can lower with-wall limit to  $\beta_N = 5.7-6$  (from DCON)
  - Peaking = possible explanation for “internal” collapses?
- Presently working on PEST-2 to get n=1 mode structure