Modeling of NSTX Plasmas with the Tokamak Simulation Code (TSC)

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PPPL

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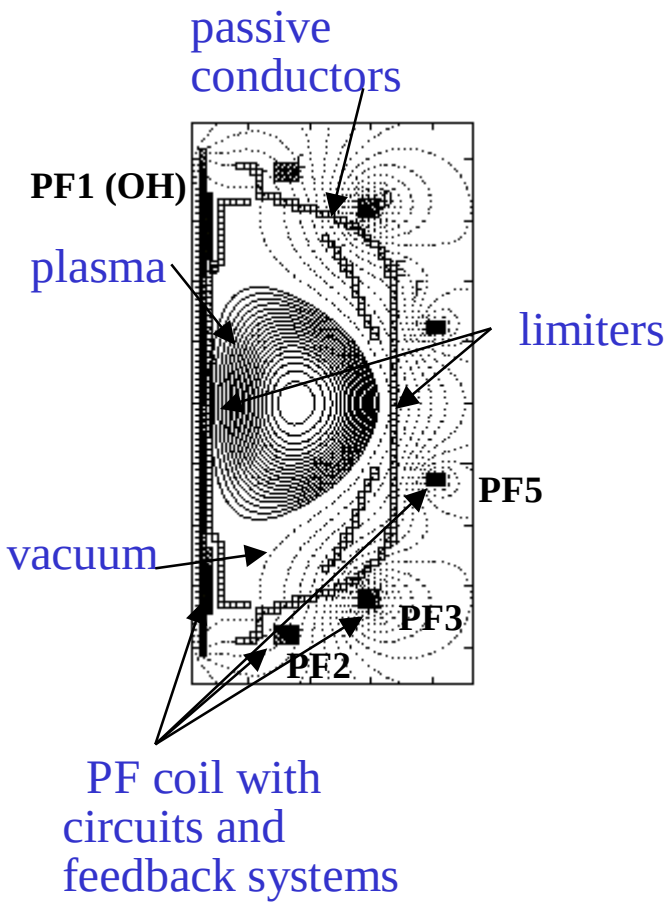
Summary and Overview

- The Tokamak Simulation Code (TSC) is widely used for the design of new experiments…in particular to predict flux requirements
- TSC can read a NSTX data file with coil currents, line averaged density, and magnetics measurements (Thanks to J. Menard) .
- Good agreement with magnetics data can be obtained, but this normally requires adjusting χ_e and/or χ_I multiplier in time.
- TSC has been coupled with a ballooning stability code and with DCON and PEST to provide stability predictions for NSTX operation
- TSC can also model CHI experiments where force-free current exits and enters vessel due to applied poloidal voltage..assumes 2D
- Some upgrades are in the works that should make TSC more useful as a tool for developing integrated scenarios

Tokamak Simulation Code (TSC)



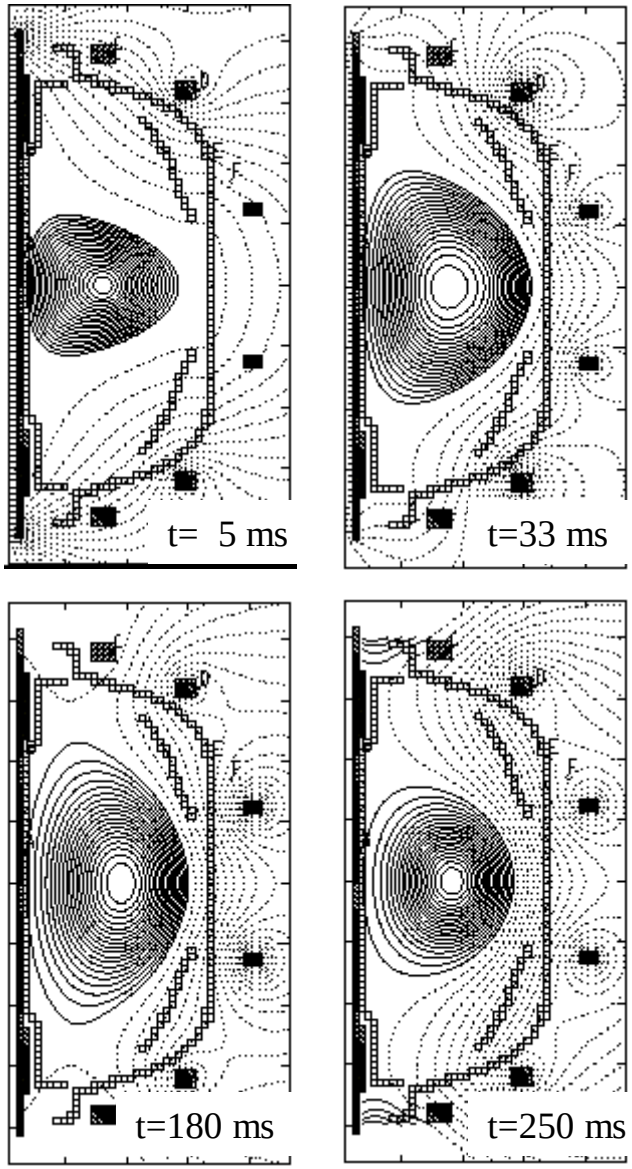
- TSC models the evolution of a free-boundary axisymmetric toroidal plasma on resistive and energy confinement time scales.
- The surface-averaged transport equations for the pressures and densities are solved in magnetic flux coordinates using matrix implicit method
- An arbitrary transport model can be used,
- Neoclassical-resistivity, bootstrap-current, auxiliary-heating, current-drive, alpha-heating, radiation, pellet-injection, sawtooth, and ballooning-mode transport models are all available.
- As an option, circuit equations are solved for all the poloidal field coil systems with the effects of induced currents in passive conductors included.
- Realistic feedback systems can be defined to control the time evolution of the plasma current, position, and shape.
- Open field lines can be included, and the halo current is computed as part of the calculation

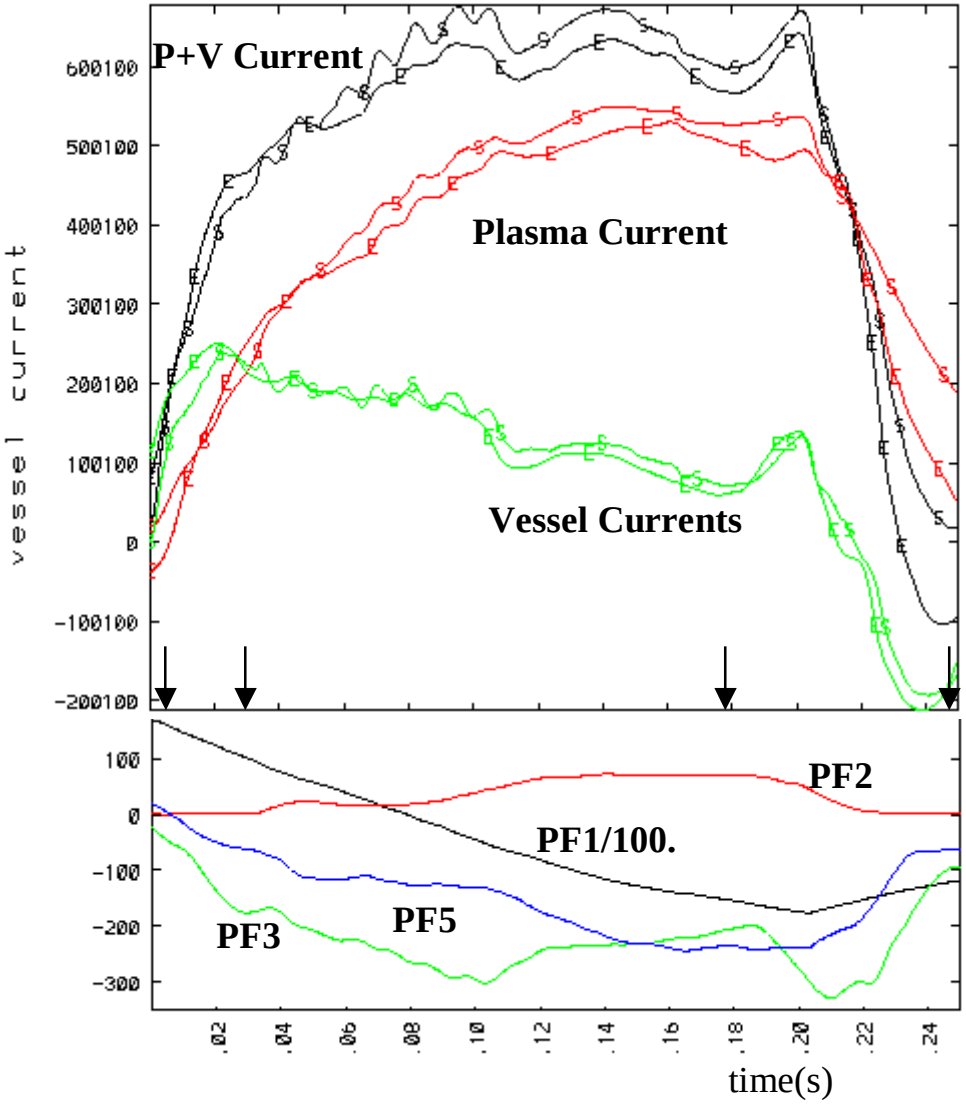
Comparison of TSC with Predictive Transp

Capability	PTRANSP	TSC
Te/Ti/Vφ, q prediction	yes	yes
Density prediction & pellets	no +2	yes
NBI heating and CD	yes	simple model*
ICRF high harmonic	no +3	no +3
Lower Hybrid	yes	yes
Impurity radiation	no +1	yes
GLF23 transport model	no +2	yes
Fixed boundary equilibrium	yes	no
Free boundary equilibrium	no	yes

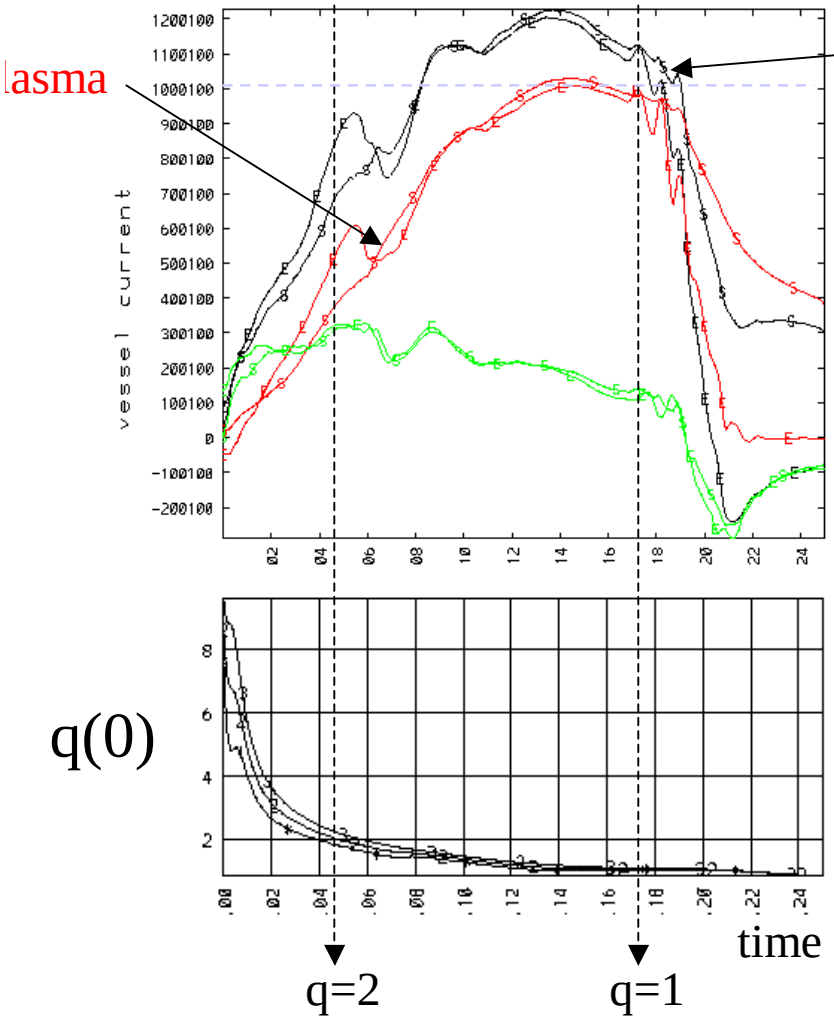
* Will upgrade to TRANSP beam package when it is available

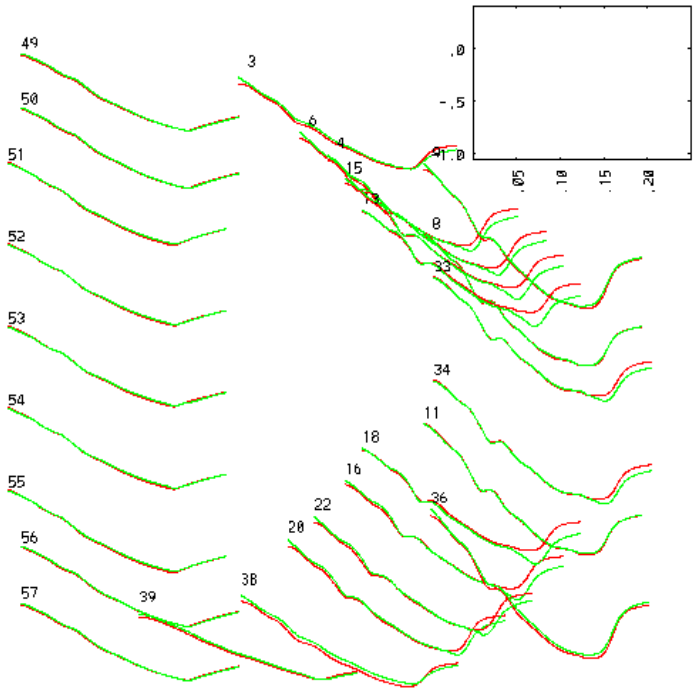
NSTX shot 100920 Predict plasma current using actual coil currents and standard transport model





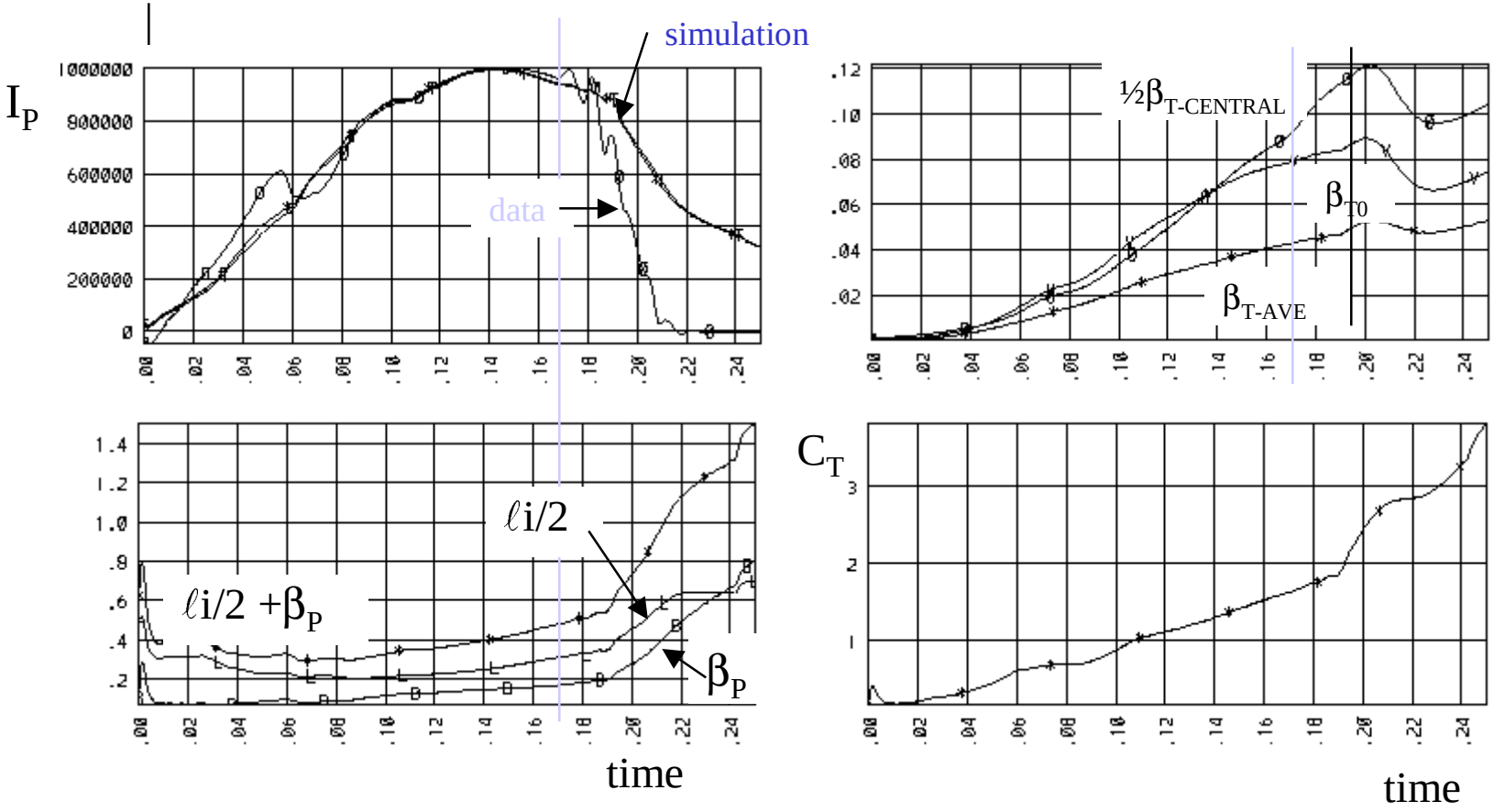
1MA ohmic shot 101522-- TSC results <u>using measured coil currents</u> vs data



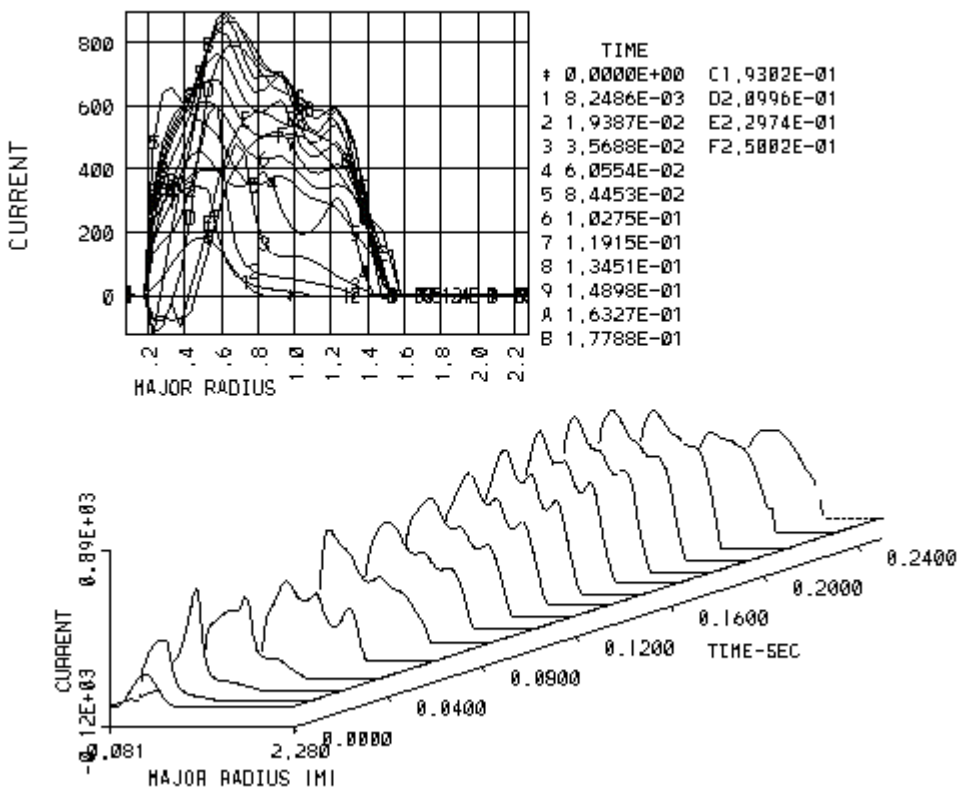


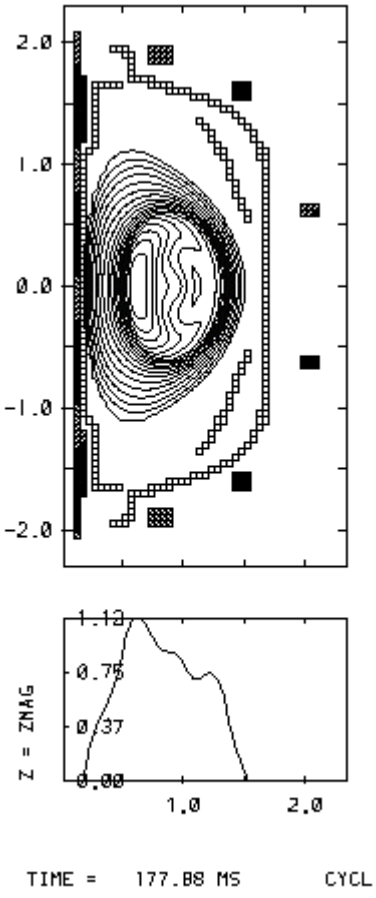
Comparison of flux loop values:
green…TSC simulation
red….Experiment

1MA ohmic shot 101522



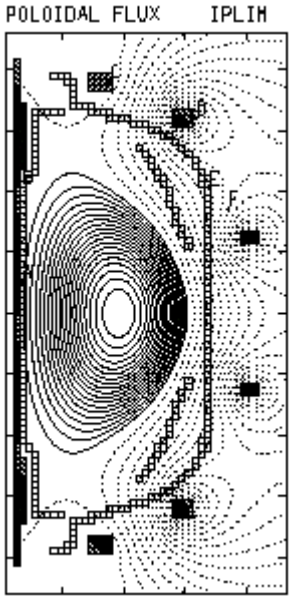
1 MA ohmic shot 101522



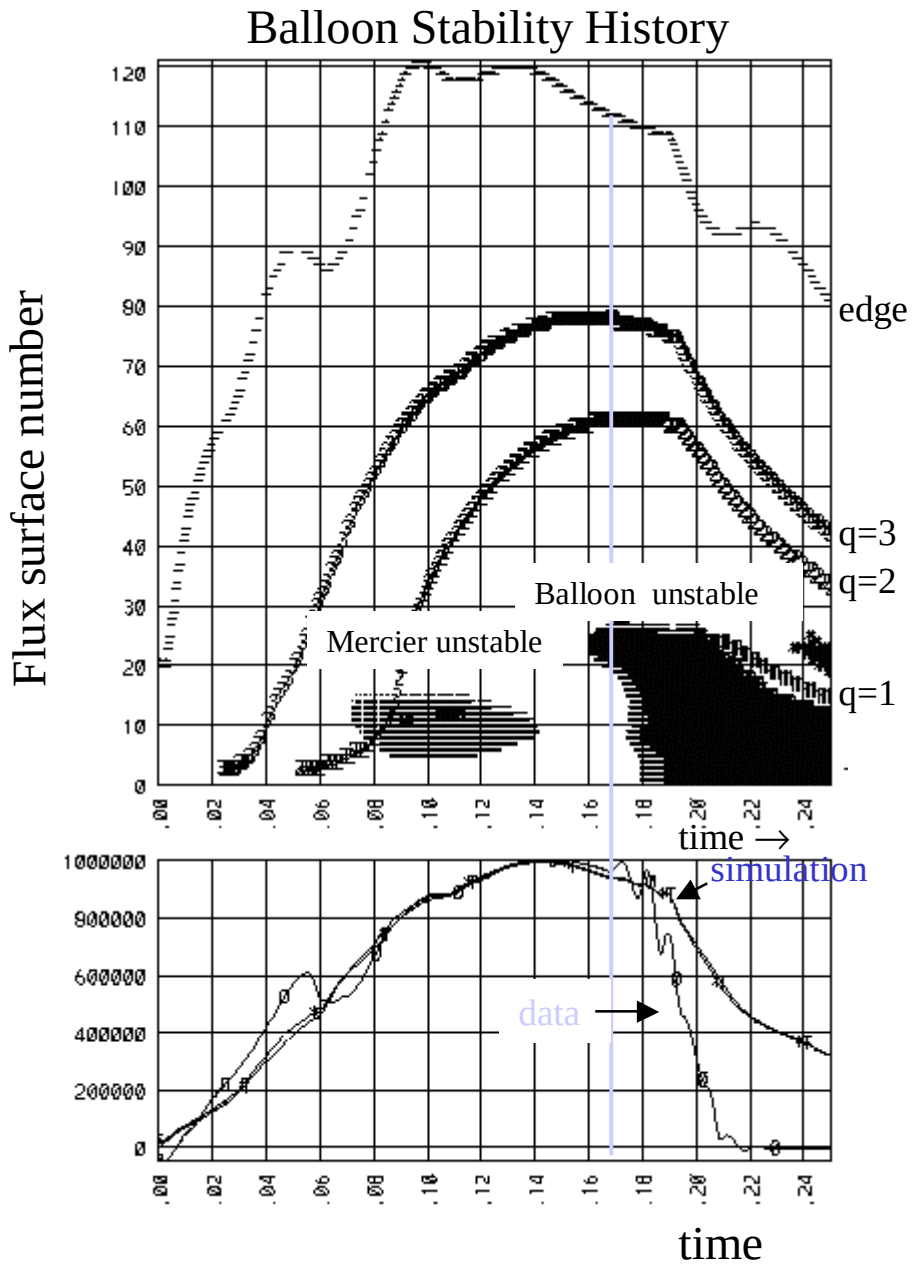


Note: plasma current not equilibrated

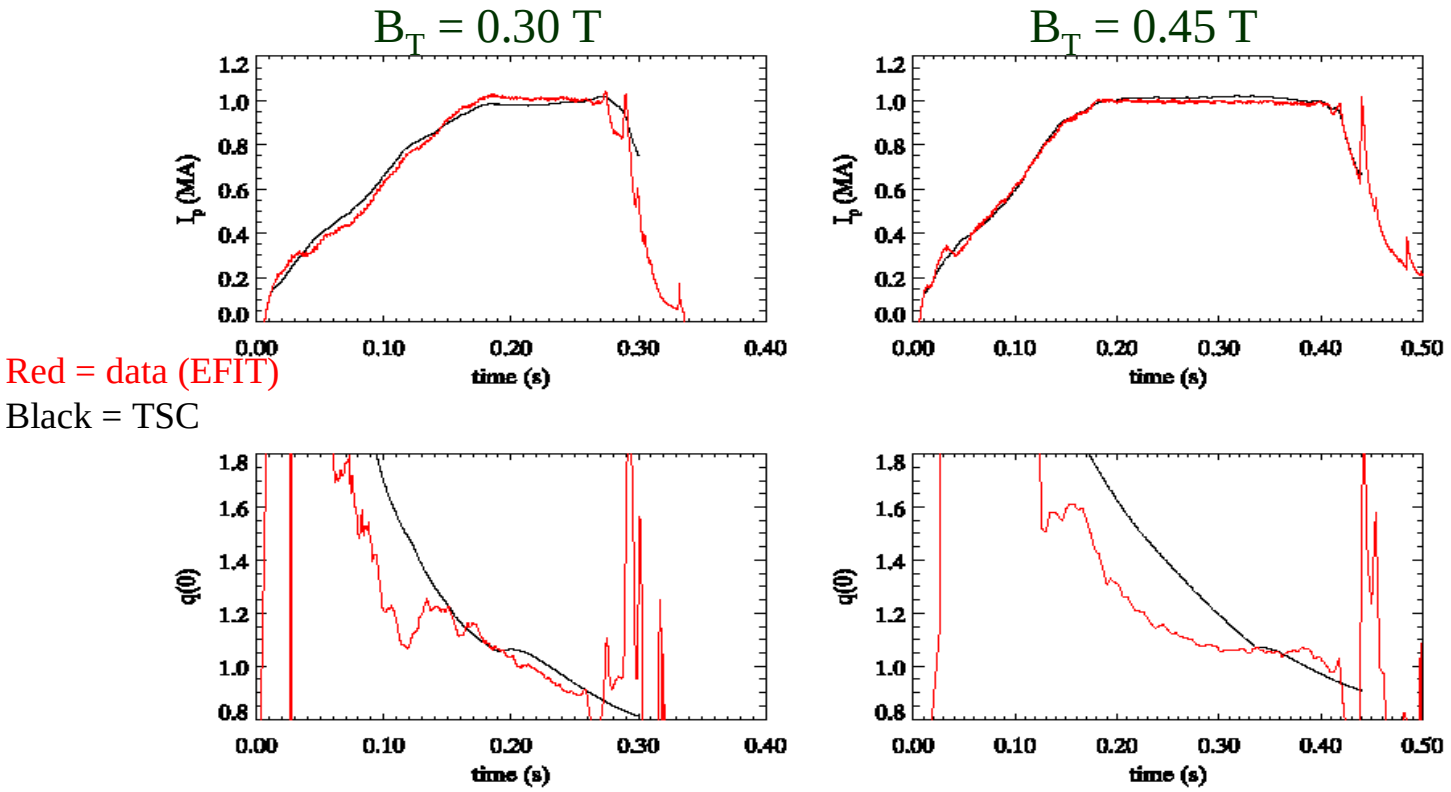
1 MA ohmic shot 101522



Large region of Balloon instability develops about time discharge “terminates”



TSC was used recently to model the NSTX current evolution for a Toroidal Field scan series with 1.5MW beams. (Gates, et al)

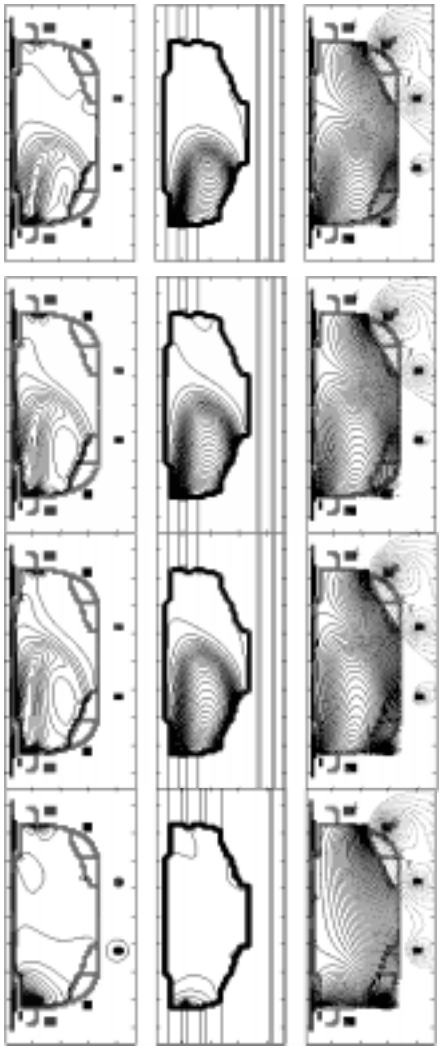


- TSC could reproduce the plasma current evolution using only the experimental values of the PF current trajectories. Everything else is predictive
- Supported the correlation between the q=1 surface and termination of the current

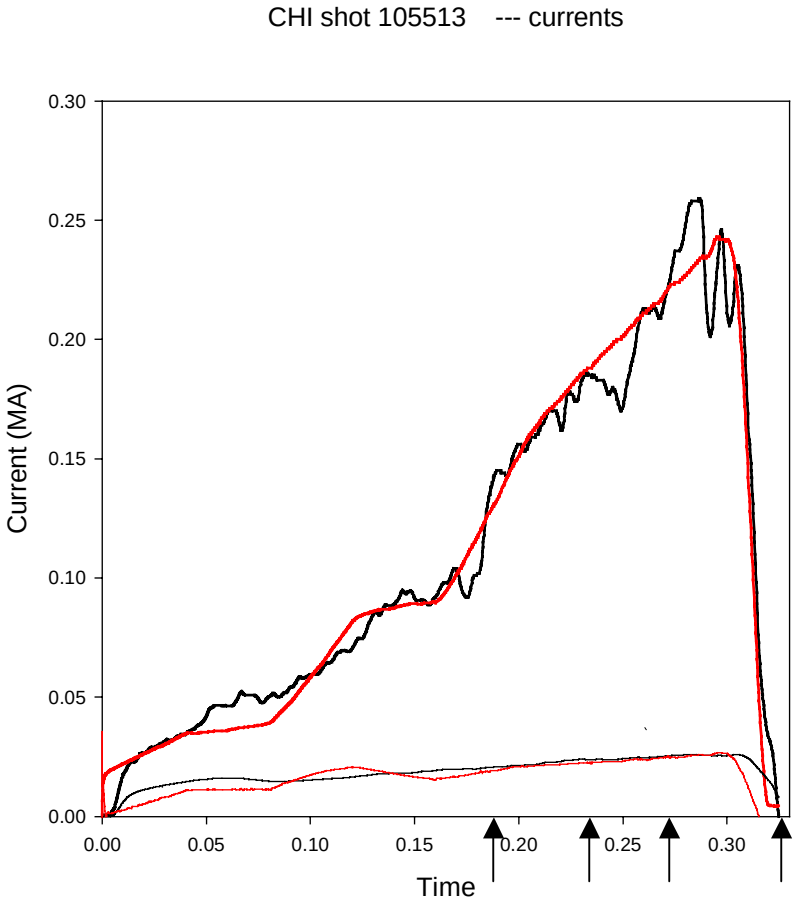
Toroidal current

poloidal current

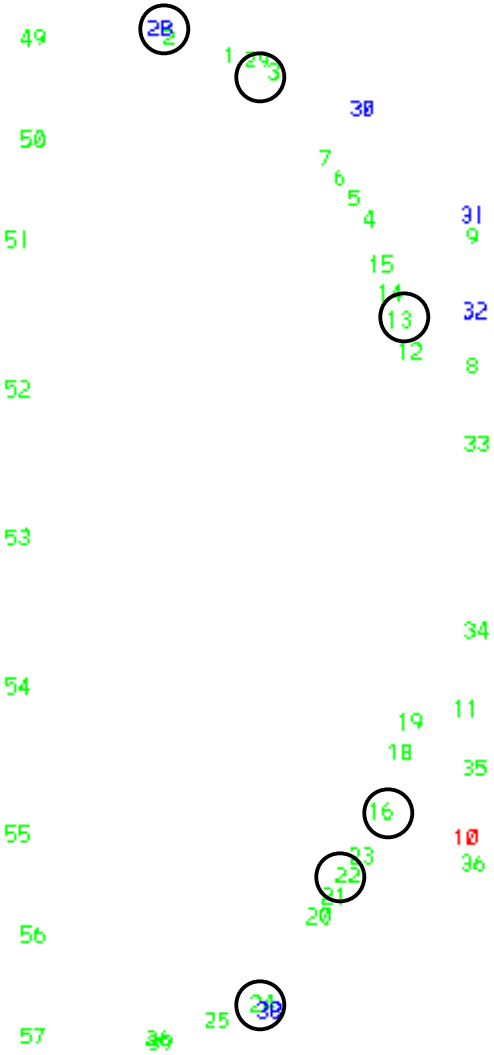
poloidal flux

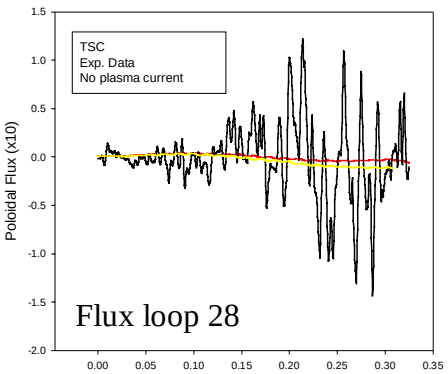


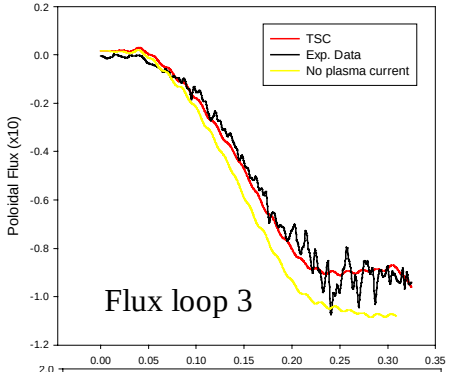
NSTX CHI shot 105513

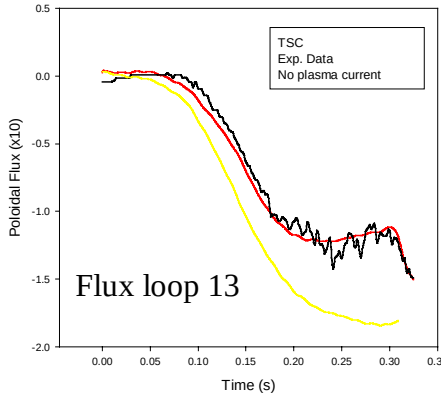


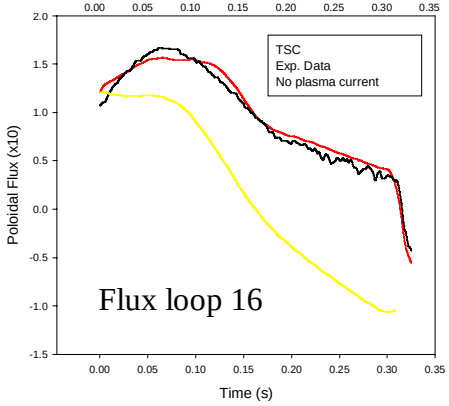
105513

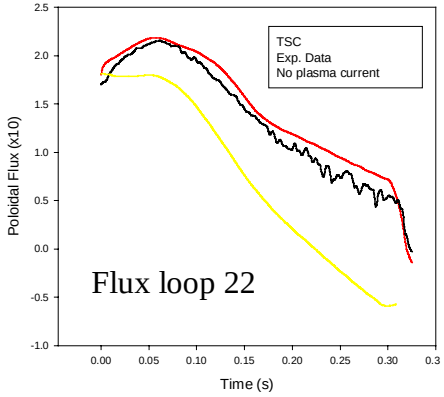


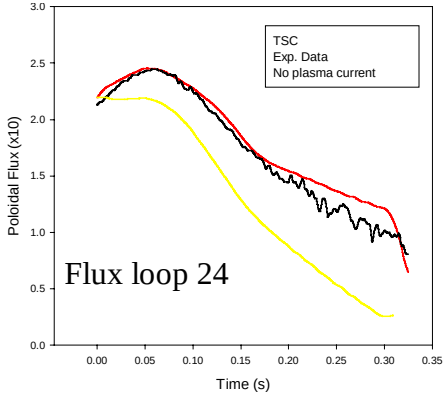

TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Flux loop 28

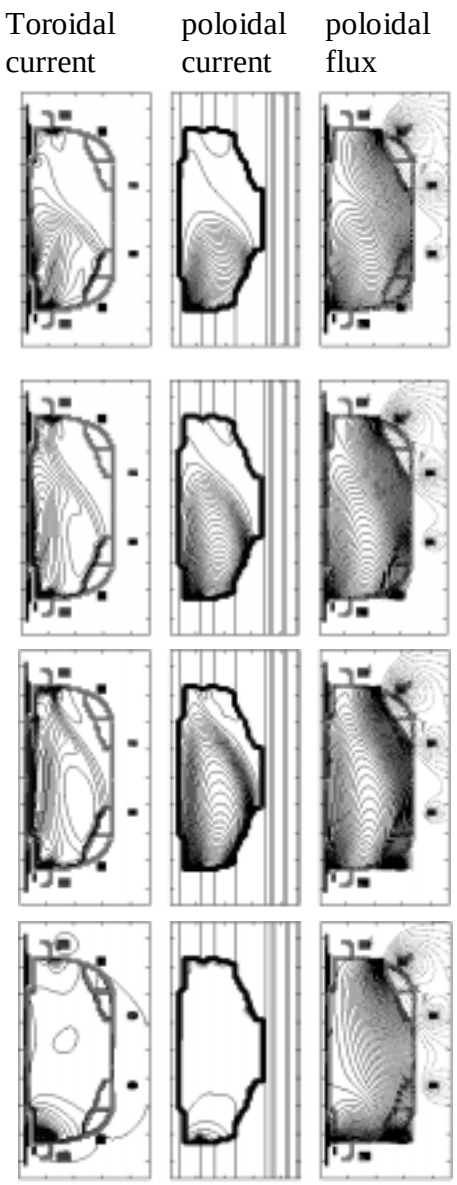

TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Flux loop 3


TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Flux loop 13

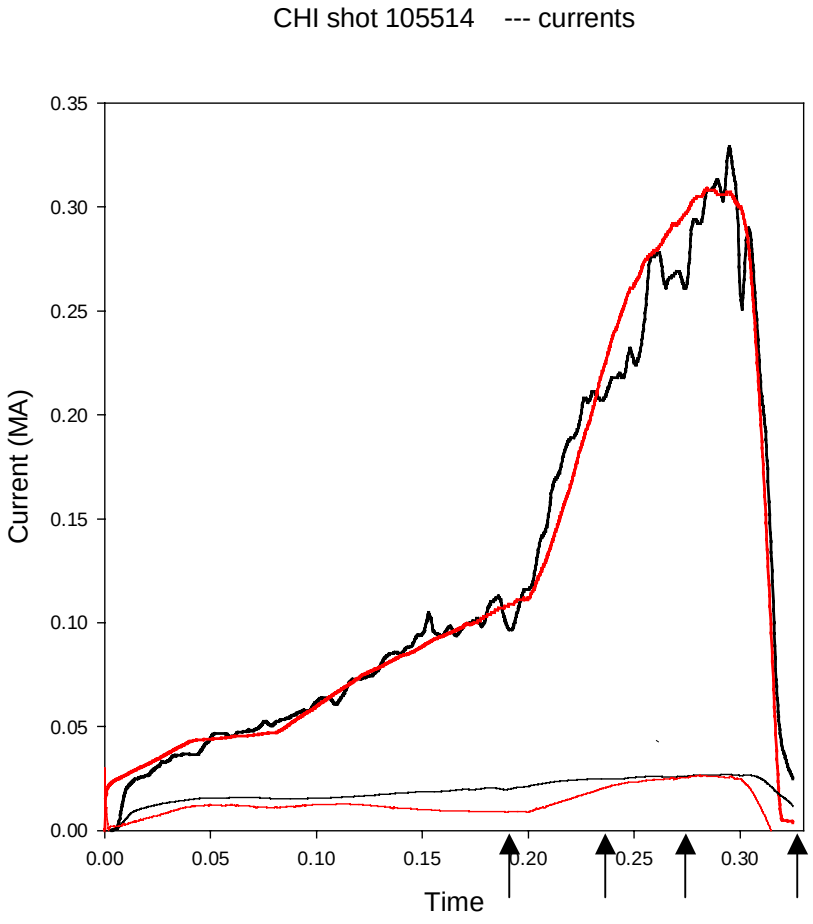

TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Flux loop 16
Time (s)


TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Flux loop 22
Time (s)

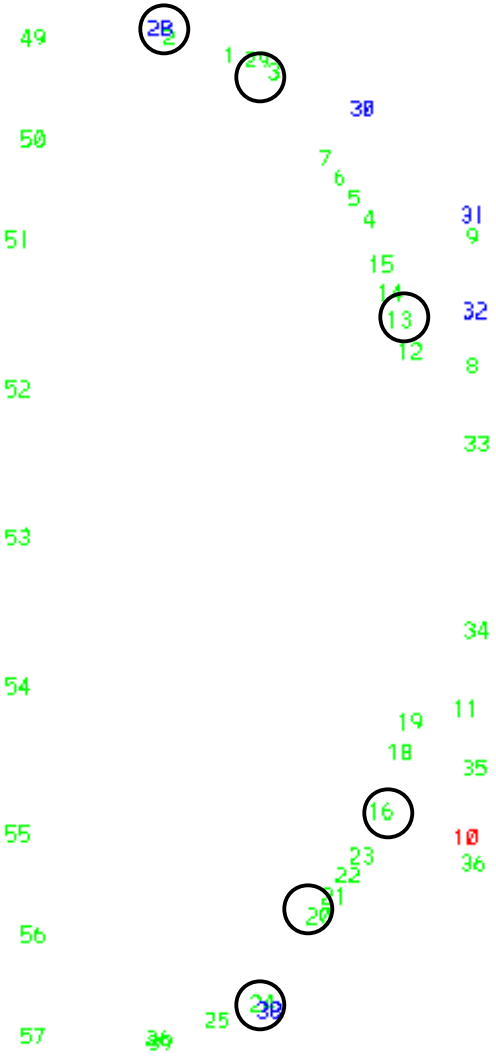

TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Flux loop 24
Time (s)

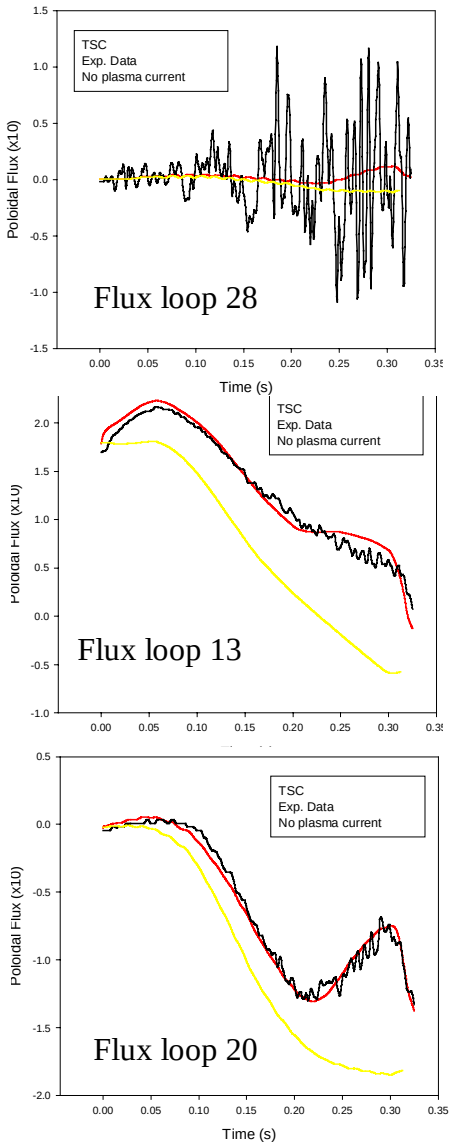


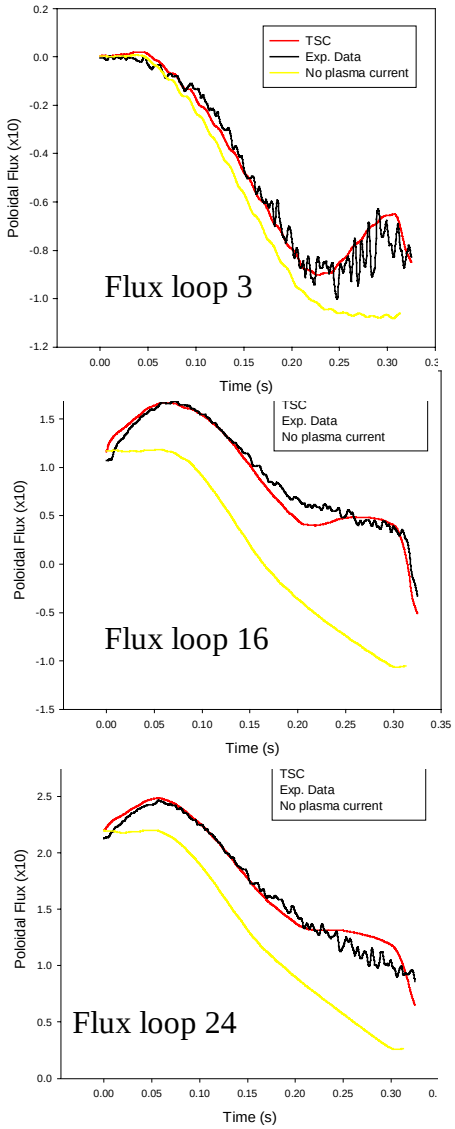
NSTX CHI shot 105514



105514




TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Time (s)
Flux loop 28
Flux loop 13
Flux loop 20


TSC
Exp. Data
No plasma current
Poloidal Flux (x10)
Time (s)
Flux loop 3
Flux loop 16
Flux loop 24

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