Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: Te gradient and magnetic shear effects on core transport		
OP-XP-734	**Revision:** *2007*	Effective Date: *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

Te gradient and magnetic shear effects on core transport **OP-XP-734**

1. Overview of planned experiment

This experiment seeks to modify and diagnose core transport as a results varying the power input into reversed shear plasmas. Previous work (Levinton XP522 & XP610, Hosea, XP617, LeBlanc XP538) have explored, respectively, RS discharges, HHFW heating, and injection of HHFW into RS discharges. The goal of this experiment is to combine and continue these effort at high field (5.5 kG).

By changing the injected power using a combination of NBI and HHFW into RS high core confinement plasmas, we would either affect T_e gradients or transport amplitude (unless MHD is responsible for transport). Critical T_e gradients necessary to drive ETG/microtearing may or may not have been reached in prior experiments, and it is hoped that increasing levels of turbulence will be diagnosed with increasing ∇Te. MSE, high-k, reflectometers, and both poloidal and tangential two color soft X-ray arrays will be used to diagnose the fluctuations.

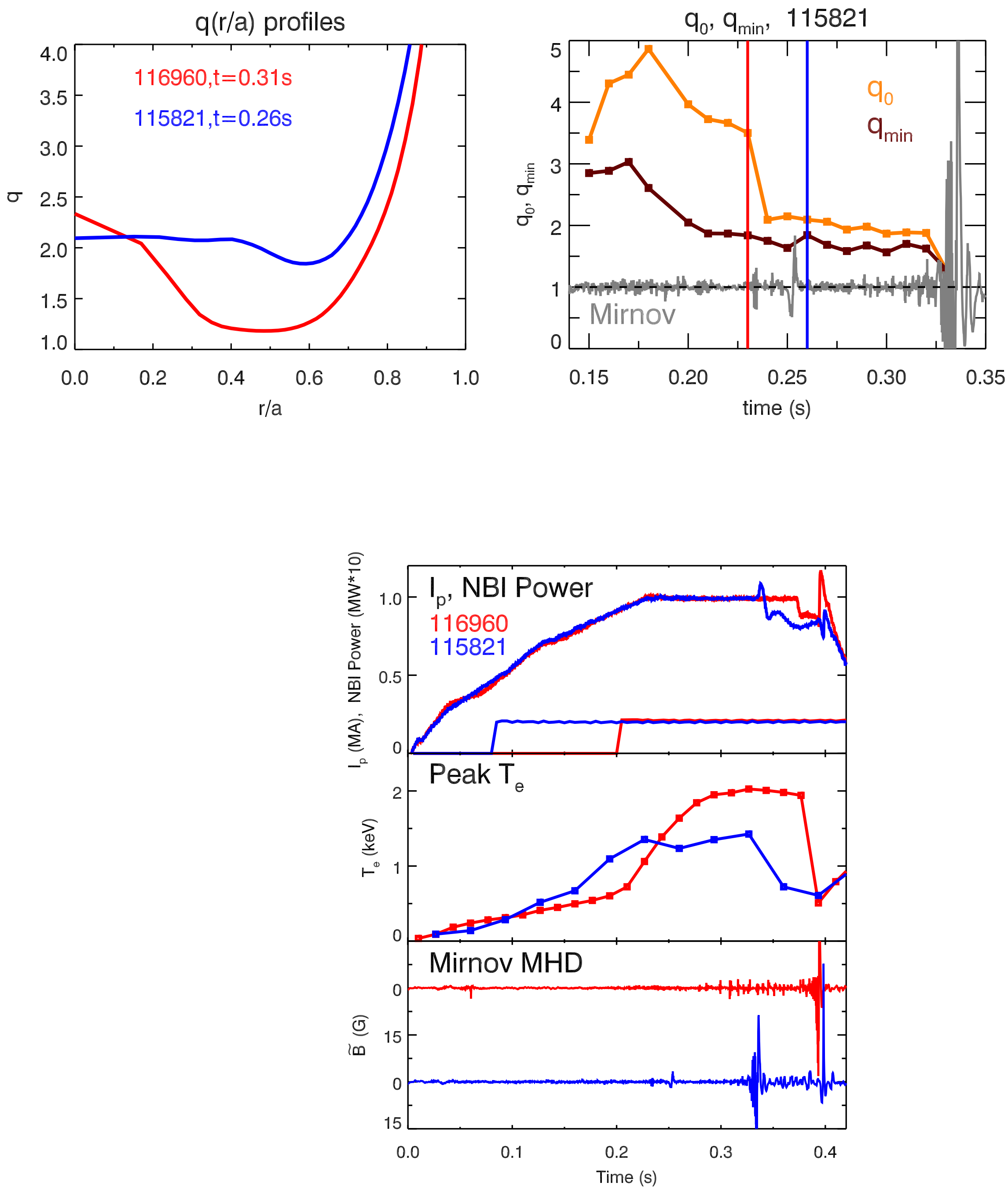
2. Theoretical/ empirical justification

The previous works had the discharge conditions (best shots) summarized as:

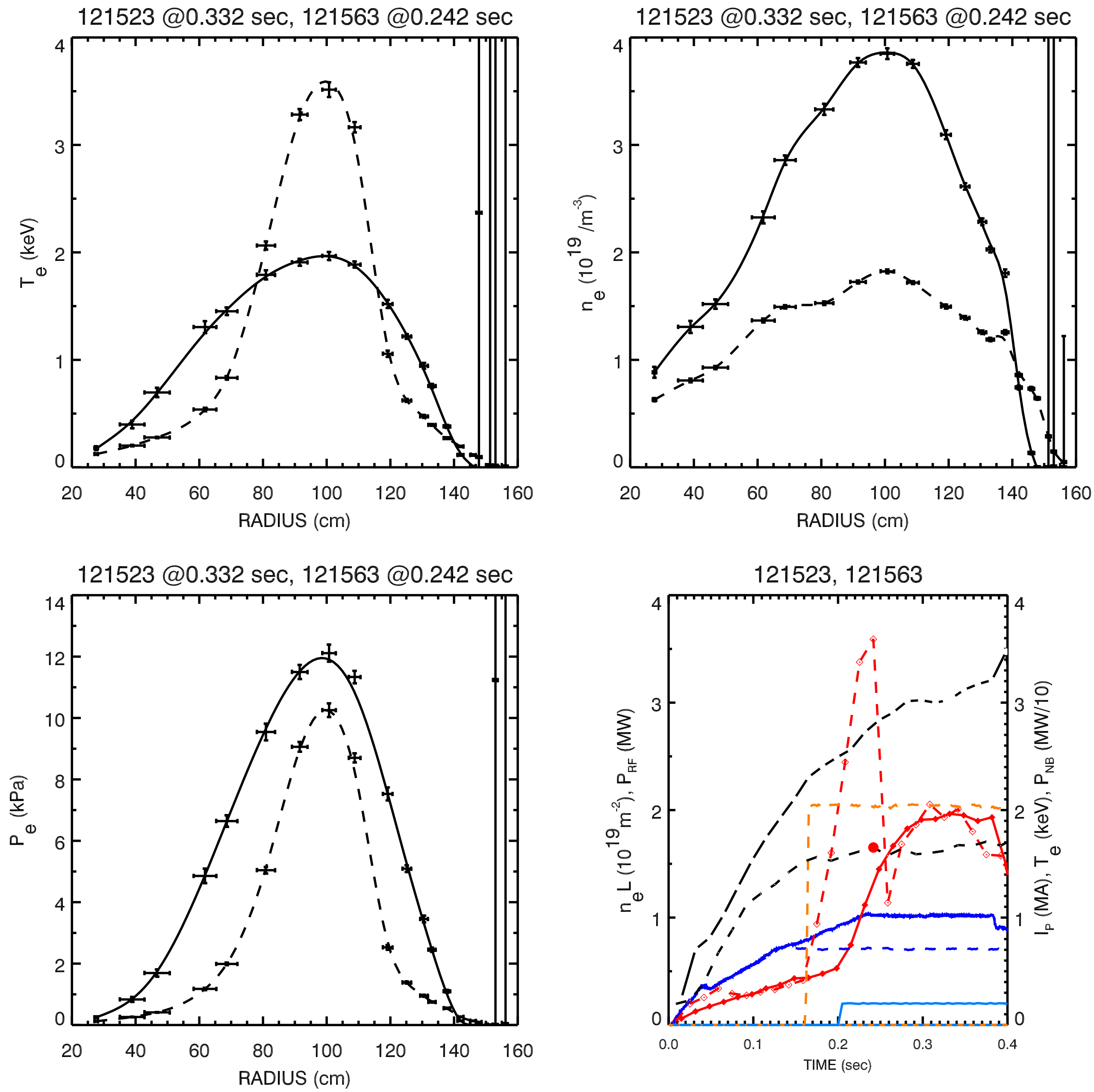
XP 610	L-Mode	RS	D	4.5kG	1.0MA	2MW SrcA	No RF	4.0×10^{19} m^{-3}	2.0 keV
XP 538	L-Mode	RS	D	4.5kG	0.9MA	2MW SrcA	0.7 MW RF	3.4×10^{19} m^{-3}	2.2 keV
XP 617	L-Mode	??	He	5.5kG	0.7MA	No NBI	2 MW RF	1.8×10^{19}m^{-3}	3.7 keV
XP 734	*L-Mode*	*RS*	*He*	*5.5kG*	*1.0MA*	*2-4 MW NBI*	*0-2 MW RF*	$1.3\times10^{19}m^{-3}$	?

Although the high T_e discharges in XP 617 did not have MSE and could not be confirmed as reversed-shear, they are suspected to be RS due their high core confinement.

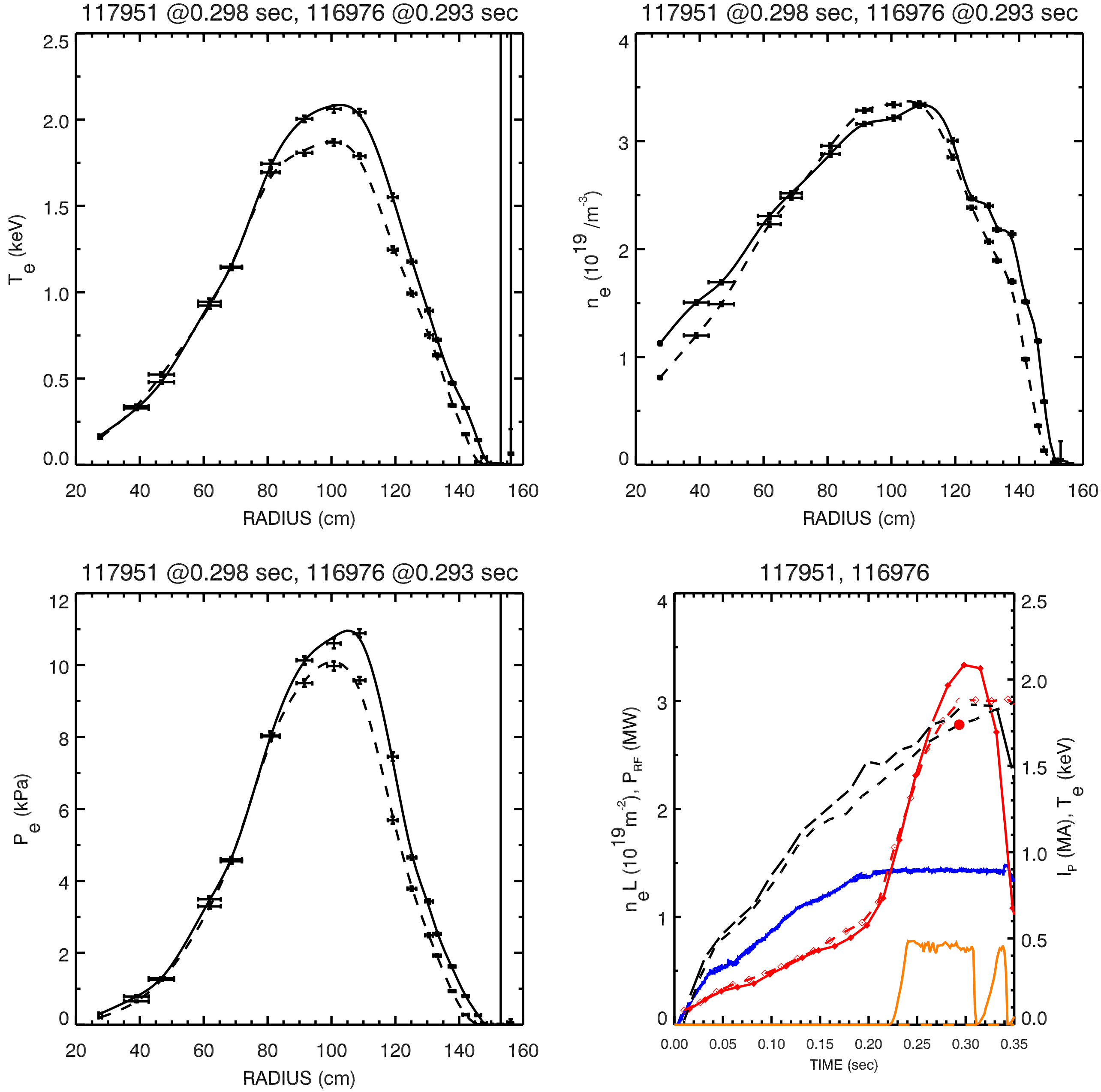
Previous experiments have confirmed the improvement of core electron transport for reversed-shear q-profile plasmas. High-k measurements were made more difficult due in part to MHD activity, particularly for the monotonic q-profile discharges. Heating power and timing will be varied to achieve various ∇T_e and q-profiles. Critical gradients in HHFW and NBI heated plasmas will be compared.



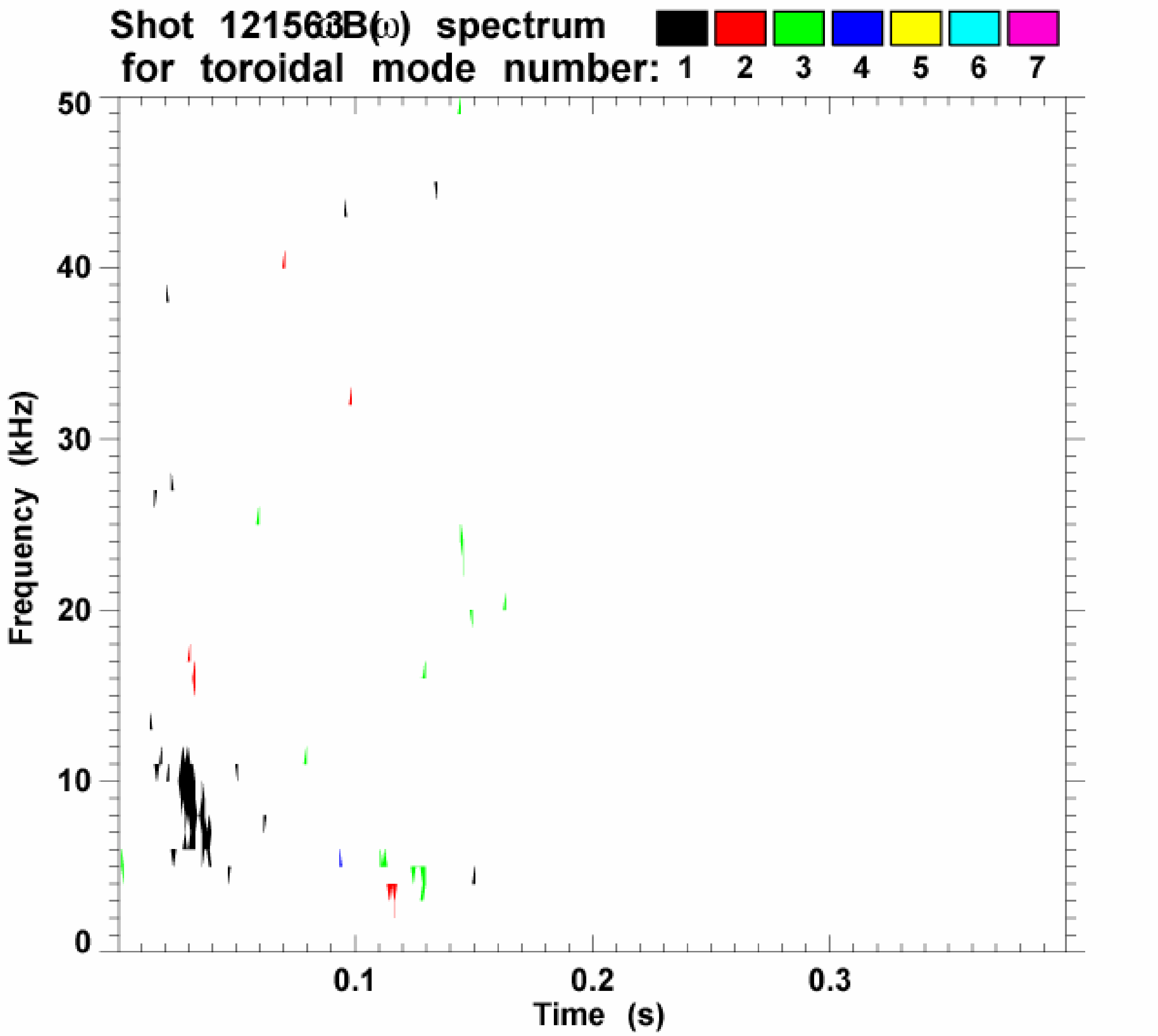
Results from XP 522 & 610 comparing reversed shear vs. flat core q-profiles. Note that beam timing was the primary input difference between the two discharges.



Comparison of profiles and peak trajectories for a good RS shot from XP 610 (RS) and a good shot from XP 617 (HHFW). While the RS shot achieved higher pressures due to density, the HHFW discharge reached higher T_e with sharper core T_e gradients with stationary n_e profiles. To diagnose fluctuations with correlation and profile reflectometers, the n_e profile must be monotonic (L-mode), with the peak lower than $2{\times}10^{19}$ m^{-3}.



Comparison between shots from B. LeBlanc's XP 538 (RS with HHFW at 4.5kG) and its reference shot from XP 522 (RS). About 700kW of HHFW was injected (best shot). Locked modes were an issue and RF coupling was an issue. Nonetheless, somewhat higher temperatures than the reference shot were reached.



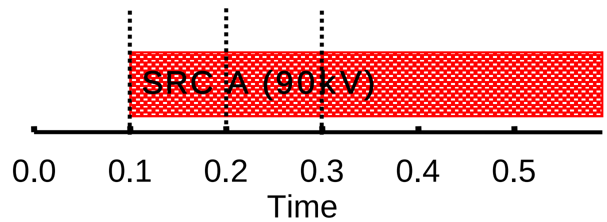
The HHFW shot 121563 appears to be relatively MHD quiescent.

3. Experimental run plan

A. Establish 3 q-profiles at different shear using heating timing. Using 121563 but at 1MA as the reference shot. Minimize density while avoiding locked modes. Modify current ramp to be the same as 116960 (2 ramp rates) or change to be constant rate throughout ramp.

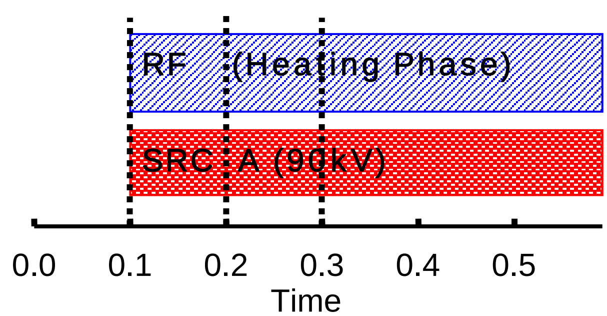
High-k set to observe at R=115cm.

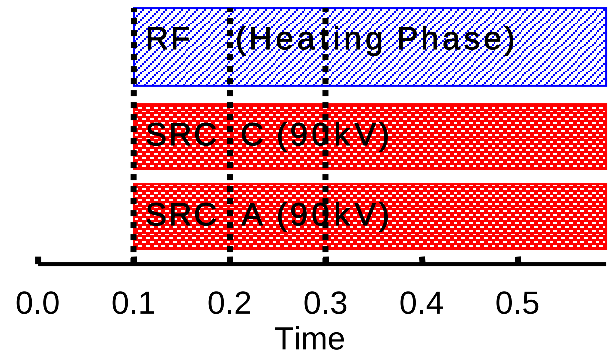
Shot Description	NBI	HHFW
5.5 kG NBI	2MW (100ms, Src A)	None
5.5 kG NBI	2MW (200ms, Src A)	None
5.5 kG NBI	2MW (300ms, Src A)	None



B. Add additional power in RF and NBI

Shot Description	NBI	HHFW
5.5 kG NBI	2MW (100ms, Src A)	2MW (100ms)
5.5 kG NBI	2MW (200ms, Src A)	2MW (200ms)
5.5 kG NBI	2MW (300ms, Src A)	2MW (300ms)
5.5 kG NBI	4MW (100ms, Srcs A,C)	2MW (100ms)
5.5 kG NBI	4MW (200ms, Srcs A,C)	2MW (200ms)
5.5 kG NBI	4MW (300ms, Srcs A,C)	2MW (300ms)





Decision point. If neither A or B works. Stop to consider options.

C. Take most successful RS profile shot(s) from Part B and change RF phasing to co-current and observe effects on core q evolution.

Shot Description	NBI	HHFW
5.5 kG NBI	2MW (Src A)	2MW+ (100ms), Co
5.5 kG NBI	4MW (Src A)	2MW+ (100ms), Co

Cell access for high-k to switch to 130cm and **repeat most successful shot set** for high-k at R=130cm.

D. Switch to deuterium and run best shots from parts A,B,C.

4. Required machine, NBI, RF, CHI and diagnostic capabilities

The 2007 HHFW XPs or XP 735 should be run first. Out of the results from that day, we will have the closest reference to create the discharge needed in this XP.
Plasmas seem to hit β limits in the RS discharges. It is hoped that increasing B_t relative to XP610 and increasing I_p relative to XP617 will allow for somewhat higher β limits. A reduction in density would also serve to postpone reaching the β limit. Locked modes were a major issue in XP 538 at low densities, but does not seem to be an issue during XP617. A density even lower than that in XP 617 would be preferred ($1.3\text{-}1.5 \times 10^{-19}$). If locked modes are an issue, is it possible to use the RWM coils to compensate for the error fields?

We will be running He plasmas with a possibility of switching to deuterium for comparison. He plasmas exhibit better density control important to avoid the β limit and allow reflectometers to measure fluctuations. These plasmas should not dither into H-mode. However, a clean transition into H-mode while maintaining the improved core confinement would be very interesting and was Part C of XP 610.

5. Planned analysis

LRDFIT/EFIT will be used to reconstruct q-profile. TRANSP will be used to calculate transport coefficients. Relative turbulent fluctuation amplitudes measured with the reflectometer and high-k (possible growth rates) can be compared with analytic theory. Hopefully, turbulence simulation codes will have matured sufficiently to be able to compare trends in measured and simulated fluctuation amplitudes with varying shear and ∇Te.

6. Planned publication of results

Successful results will be submitted to a suitable journal such as PoP or PRL.

PHYSICS OPERATIONS REQUEST

Te gradient and magnetic shear effects on core transport **OP-XP-734**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **5.5 kG** Flattop start/stop (s):

I_P (MA): **1.0 MA** Flattop start/stop (s): _____/_____

Configuration: **Same as 121563 OR newer XP 735 2007 HHFW discharge**

Outer gap (m): _____, Inner gap (m): _____

Elongation κ: _____, Triangularity δ: _____

Z position (m): **0.00**

Gas Species: He, Injector: **Midplane / Inner wall / Lower Dome**

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): **90(A),70-90(B,C)** Duration (s):

ICRF – Power (MW): **2MW**, Phasing: **Heating / CD**, Duration (s): _____

CHI: **Off**

Either: List previous shot numbers for setup: **121563**

Or: Sketch the desired time profiles, including inner and outer gaps, κ, δ, heating, fuelling, etc. as appropriate. Accurately label the sketch with times and values.

DIAGNOSTIC CHECKLIST

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Diagnostic	Need	Desire	Instructions
Bolometer - tangential array			
Bolometer array - divertor			
CHERS	✓		
Divertor fast camera			
Dust detector			
EBW radiometers			
Edge deposition monitor			
Edge pressure gauges			
Edge rotation spectroscopy			
Fast lost ion probes – IFLIP			
Fast lost ion probes – SFLIP			
Filtered 1D cameras			
Filterscopes			
FIReTIP	✓		
Gas puff imaging			
High-k scattering	✓		
Infrared cameras			
Interferometer – 1 mm			
Langmuir probes - PFC tiles			
Langmuir probes - RF antenna			
Magnetics – Diamagnetism			
Magnetics – Flux loops	✓		
Magnetics – Locked modes			
Magnetics – Pickup coils	✓		
Magnetics - Rogowski coils	✓		
Magnetics - RWM sensors			
Mirnov coils – high frequency	✓		
Mirnov coils – poloidal array			
Mirnov coils – toroidal array			
MSE	✓		
Neutral particle analyzer			
Neutron Rate (2 fission, 4 scint)			
Neutron collimator			
Plasma TV			
Reciprocating probe			
Reflectometer - FM/CW	✓		
Reflectometer - fixed frequency homodyne	✓		
Reflectometer - homodyne correlation	✓		
Reflectometer - HHFW/SOL	✓		
RF antenna camera			
RF antenna probe	✓		
Solid State NPA			
SPRED			
Thomson scattering - 20 channel			
Thomson scattering - 30 channel	✓		
Ultrasoft X-ray arrays	✓		
Ultrasoft X-ray arrays - 2 color	✓		
Visible bremsstrahlung det.			
Visible spectrometers (VIPS)			
X-ray crystal spectrometer - H			
X-ray crystal spectrometer - V			
X-ray PIXCS (GEM) camera			
X-ray pinhole camera			
X-ray TG spectrometer			