**Princeton Plasma Physics Laboratory**

# NSTX Experimental Proposal

Title: **Application of early error field correction to advanced scenarios**

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|---|---|---|
| **OP-XP-1004** | Revision: | Effective Date: **3/22/2010**<br>*(Approval date unless otherwise stipulated)*<br>Expiration Date: **3/22/2012**<br>*(2 yrs. unless otherwise stipulated)* |

## PROPOSAL APPROVALS

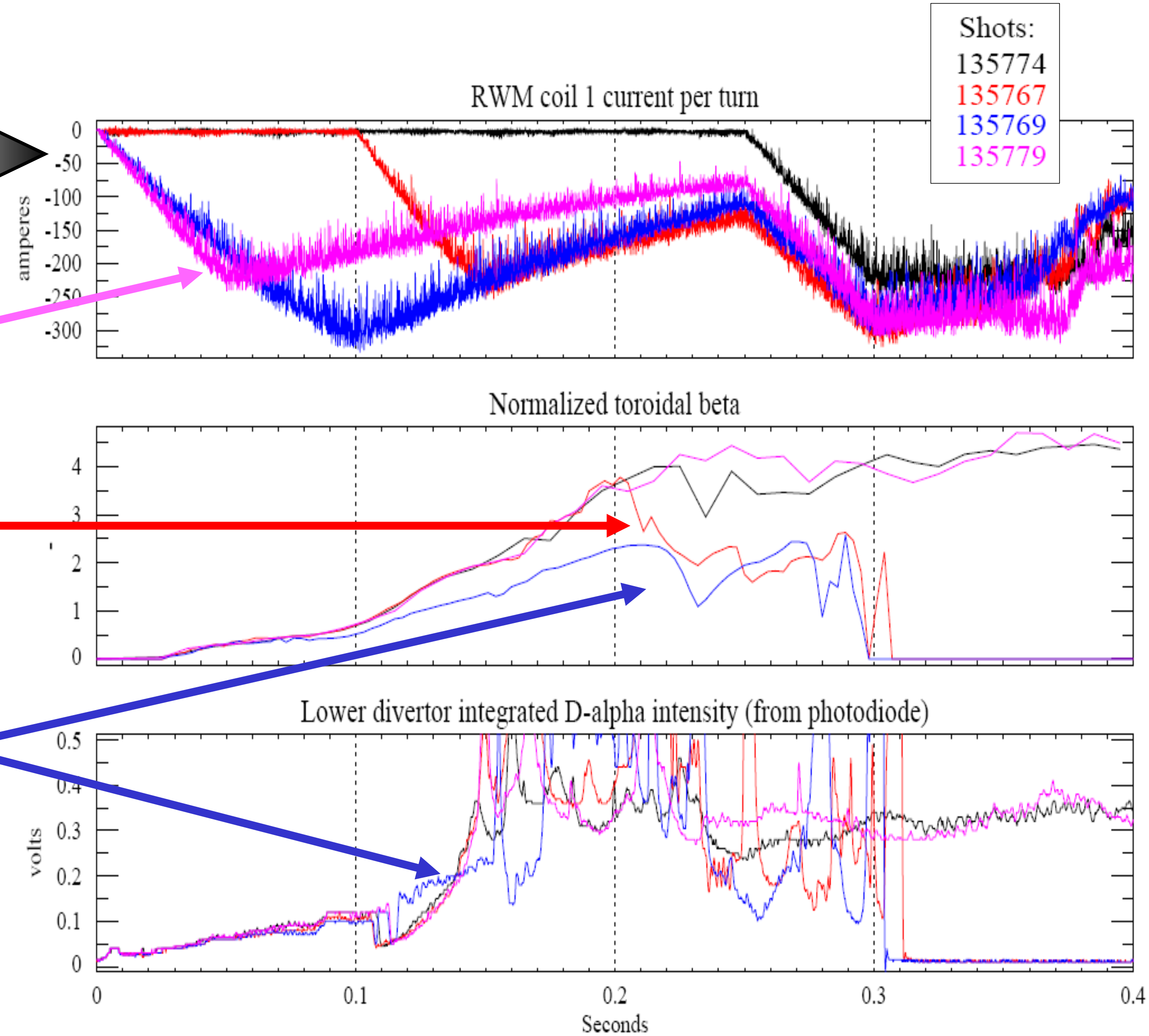
| | |
|---|---|
| **Responsible Author: J. Menard** | Date **3/22/2010** |
| **ATI – ET Group Leader: S. Gerhardt** | Date |
| **RLM - Run Coordinator: E. Fredrickson** | Date |
| **Responsible Division: Experimental Research Operations** | |

## RESTRICTIONS or MINOR MODIFICATIONS

(Approved by Experimental Research Operations)

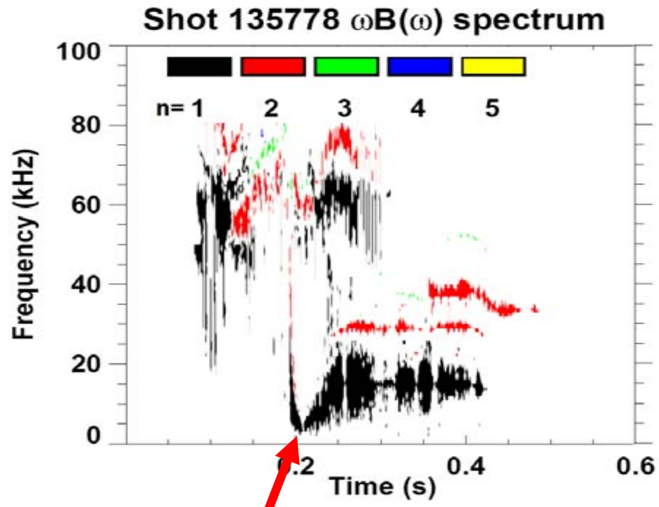
# Early n=1 EFC using OH×TF EF compensation algorithm has significant impact on early plasma stability

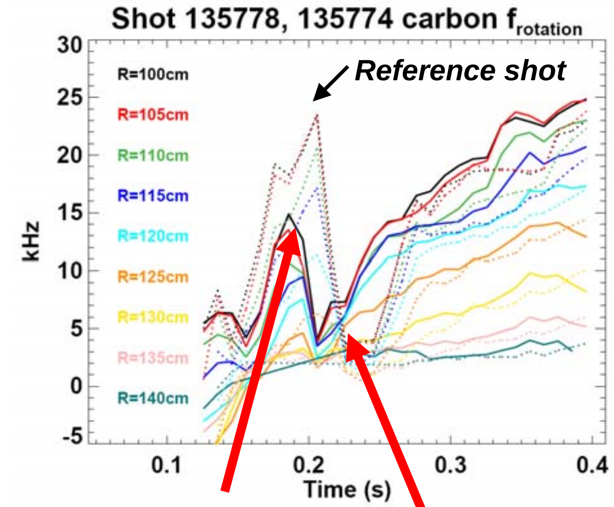
- **Timing and amplitude scan for early OH×TF n=1 EF correction**
  - Optimal correction
- EFC over-compensation can lead to β collapse
- Larger n=1 EFC over-compensation eliminates H-mode access



# Optimal early n=1 EFC reduces early locking tendency of n=1 tearing mode and substantially increases early rotation

- **Anti-corrective n=1 field (135778) vs. reference (135774)**




- *n=1 tearing mode nearly locks*
- *Rotation reduced 30-40%*
- *n=1 TM flattens rotation to low $f_\phi$=3-4kHz*

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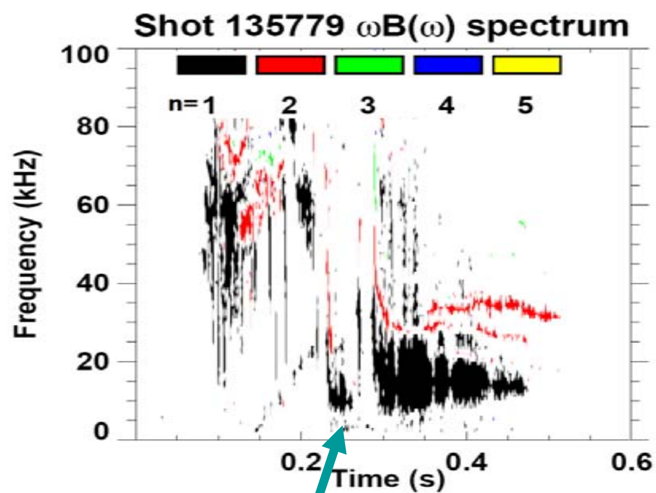
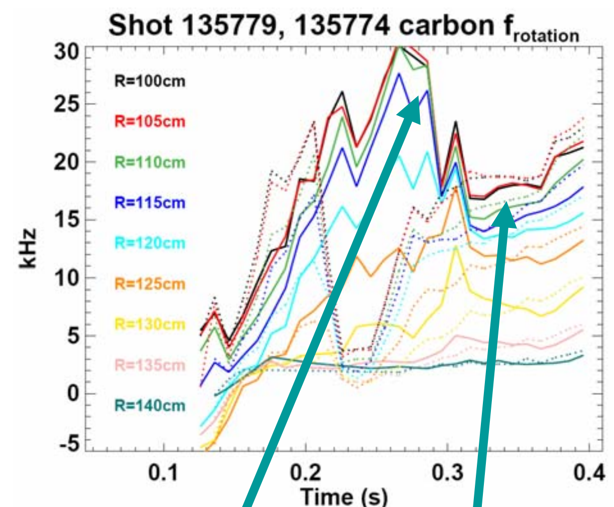
- **Optimal corrective n=1 field (135779) vs. reference (135774)**




- *n=1 tearing delayed, no locking, duration shortened*
- *Rotation increased 30%*
- *Core rotation maintained above 15kHz*

# NSTX EXPERIMENTAL PROPOSAL

TITLE: **Application of early error field correction to advanced scenarios** No. **OP-XP-1004**

AUTHORS: **J.E. Menard** DATE: **3/22/1010**

## 1. Overview of planned experiment

The goal of the proposed experiment is to further optimize early n=1 error-field correction for range of plasma density and flat-top current values. Scans of the time, amplitude, and toroidal phase of the applied early error field correction will be performed to minimize the plasma rotation damping and reduce and/or eliminate the early onset of tearing modes and mode locking.

## 2. Theoretical/ empirical justification

Previous operation with LITER has shown that low plasma density early in the discharge (first 200ms) can lead to locked tearing modes and disruptions. In 2009, reduction of the OH×TF error field early in the current ramp-up resulted in increased plasma rotation and reduced duration of early tearing modes. Additional optimization of correction is needed to maximize plasma rotation and reduce mode locking. Such correction could be important for reduced density advanced scenarios expected with the LLD.

## 3. Experimental run plan

A. Reproduce increase in rotation with n=1 early EFC using 700kA shot 135779 or similar (4 shots)

B. Scan EFC turn-on time, amplitude, phase to optimize EFC

  a. Timing scan: -30, -20, -10, 0, +20, +40ms (5-7 shots)

  b. Amplitude scan: ×0.6, 0.8, 1, 1.2, 1.4 (4-6 shots)

  c. Phasing scan: -30, -15, 0, 15, 30° (4-6 shots)

C. Assess stability at low density with and without optimized n=1 EFC

  a. Reduce density in 20% steps until LM disruption with n=1 EFC (8 shots)

D. Increase flat-top $I_P$ and assess/optimize n=1 EFC

  a. Scan EFC amplitude: ×0.8, 1.2, etc. for 0.9MA, 1.1MA (6-8 shots)

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

See Physics Operations Request

## 5. Planned analysis

MSE LRDFIT + TRANSP + IPEC analysis to understand EF penetration, locking, rotation damping.

## 6. Planned publication of results

Results will be published in Physics of Plasmas or Nuclear Fusion or similar within 1 year.

# PHYSICS OPERATIONS REQUEST

TITLE: **Application of early error field correction to advanced scenarios** No. **OP-XP-1004**

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**Brief description of the most important operational plasma conditions required:**

Reproducible 700kA NBI discharge (or best available fiducial) with early H-mode.

**Previous shot(s) which can be repeated:** **135779 or 135774 or fiducial**

**Previous shot(s) which can be modified:** **(see above)**

**Machine conditions** *(specify ranges as appropriate, strike out inapplicable cases)*

$I_{TF}$ (kA): **45kA** Flattop start/stop (s): **-0.040/1.75s**

$I_P$ (MA): **0.7MA** Flattop start/stop (s): **0.15-1.5s**

Configuration: **LSN/DND**

Equilibrium Control: **Isoflux** (rtEFIT)

Outer gap (m): **see reference** Inner gap (m): Z position (m):

Elongation: Triangularity (U/L): OSP radius (m):

Gas Species: **D** Injector(s): **see reference shot**

**NBI** Species: **D** Voltage (kV) **A: 90** **B: 90** **C:** 70 Duration (s): **1.5s**

**ICRF** Power (MW): **0** Phase between straps (°): Duration (s):

**CHI**: **Off** Bank capacitance (mF):

**LITERs: On** Total deposition rate (mg/min): **20mg/min**

**LLD:** Temperature (°C): **warm (if warm LLD provides reproducible pumping)**

**EFC coils: On** Configuration: **Odd**

# DIAGNOSTIC CHECKLIST

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AUTHORS: **J.E. Menard** DATE: **3/22/2010**

*Note special diagnostic requirements in Sec. 4*

| **Diagnostic** | **Need** | **Want** |
|---|---|---|
| Beam Emission Spectroscopy | | **X** |
| Bolometer – divertor | | **X** |
| Bolometer – midplane array | | **X** |
| CHERS – poloidal | | **X** |
| CHERS – toroidal | **X** | |
| Dust detector | | **X** |
| Edge deposition monitors | | **X** |
| Edge neutral density diag. | | **X** |
| Edge pressure gauges | | **X** |
| Edge rotation diagnostic | | **X** |
| Fast cameras – divertor/LLD | **X** | |
| Fast ion D_alpha - FIDA | | **X** |
| Fast lost ion probes - IFLIP | | **X** |
| Fast lost ion probes - SFLIP | | **X** |
| Filterscopes | **X** | |
| FIReTIP | | **X** |
| Gas puff imaging – divertor | | **X** |
| Gas puff imaging – midplane | | **X** |
| H$\alpha$ camera - 1D | | **X** |
| High-k scattering | | **X** |
| Infrared cameras | | **X** |
| Interferometer - 1 mm | | **X** |
| Langmuir probes – divertor | | **X** |
| Langmuir probes – LLD | | **X** |
| Langmuir probes – bias tile | | **X** |
| Langmuir probes – RF ant. | | **X** |
| Magnetics – B coils | **X** | |
| Magnetics – Diamagnetism | | **X** |
| Magnetics – Flux loops | **X** | |
| Magnetics – Locked modes | **X** | |
| Magnetics – Rogowski coils | **X** | |
| Magnetics – Halo currents | | **X** |
| Magnetics – RWM sensors | **X** | |
| Mirnov coils – high f. | | **X** |
| Mirnov coils – poloidal array | | **X** |
| Mirnov coils – toroidal array | **X** | |
| Mirnov coils – 3-axis proto. | | **X** |

*Note special diagnostic requirements in Sec. 4*

| **Diagnostic** | **Need** | **Want** |
|---|---|---|
| MSE | | **X** |
| NPA – E\|\|B scanning | | **X** |
| NPA – solid state | | **X** |
| Neutron detectors | **X** | |
| Plasma TV | **X** | |
| Reflectometer – 65GHz | | **X** |
| Reflectometer – correlation | | **X** |
| Reflectometer – FM/CW | | **X** |
| Reflectometer – fixed f | | **X** |
| Reflectometer – SOL | | **X** |
| RF edge probes | | **X** |
| Spectrometer – divertor | | **X** |
| Spectrometer – SPRED | | **X** |
| Spectrometer – VIPS | | **X** |
| Spectrometer – LOWEUS | | **X** |
| Spectrometer – XEUS | | **X** |
| SWIFT – 2D flow | | **X** |
| Thomson scattering | **X** | |
| Ultrasoft X-ray – pol. arrays | | **X** |
| Ultrasoft X-rays – bicolor | | **X** |
| Ultrasoft X-rays – TG spectr. | | **X** |
| Visible bremsstrahlung det. | | **X** |
| X-ray crystal spectrom. - H | | **X** |
| X-ray crystal spectrom. - V | | **X** |
| X-ray tang. pinhole camera | | **X** |