

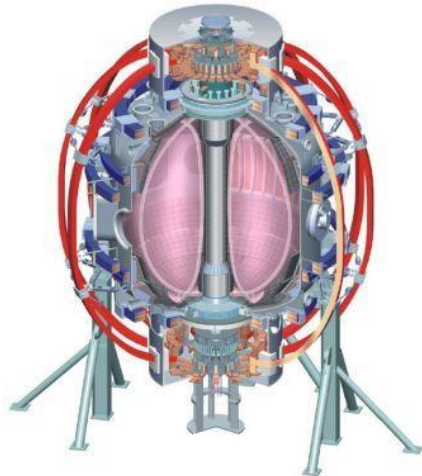
Lithium effects on the current profile in NSTX

Howard Yuh, Nova Photonics

M.G. Bell¹, S.M. Kaye¹, H.W. Kugel¹,
F.M. Levinton², R. Maingi³, V. Soukhanovskii⁴
¹PPPL ²Nova Photonics ³ORNL ⁴LLNL

Work supported by US DOE contract nos. DE-AC02-09CH11466 & DE-FG02-99ER54520

**52nd APS DPP Conference
Chicago, Illinois
November 8th, 2010**



College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Washington
U Wisconsin

Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITY
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

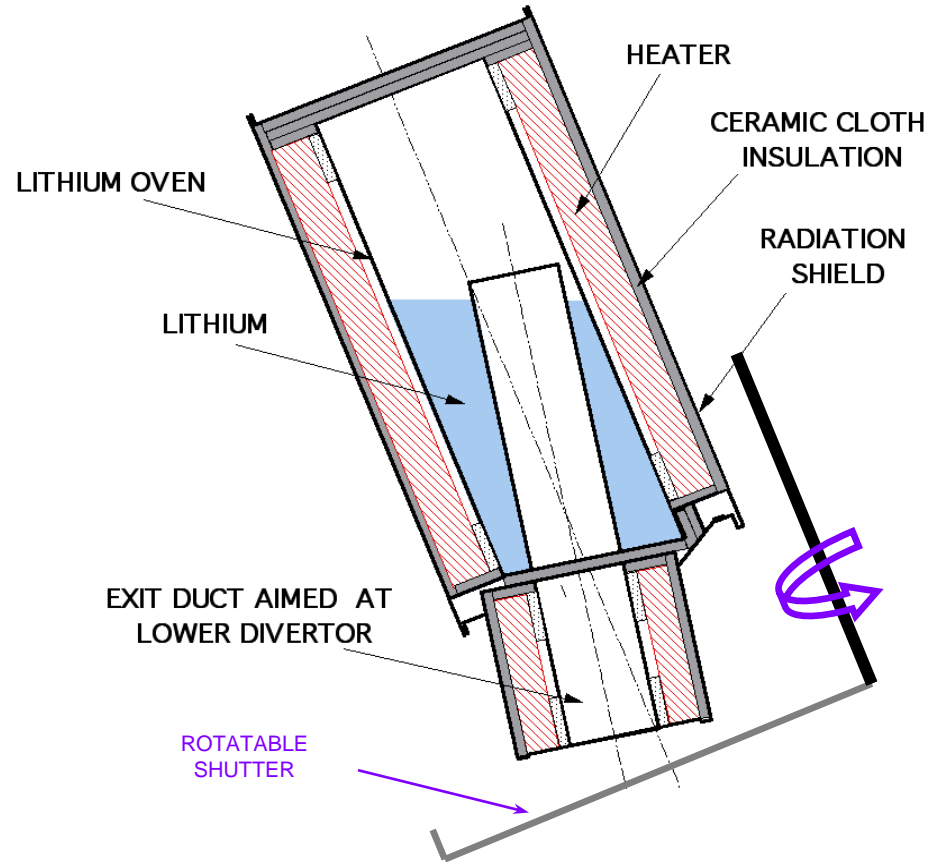
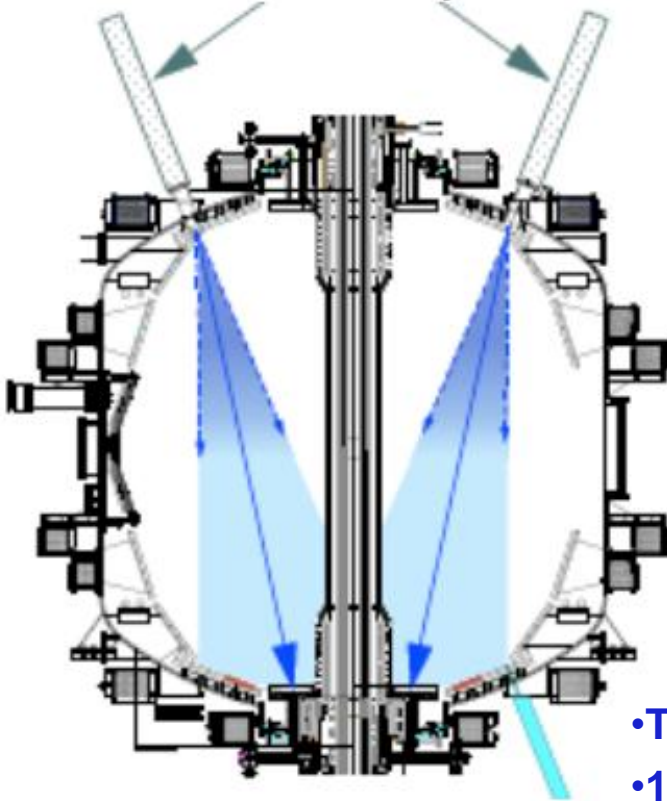
Abstract

Lithium coating of the plasma facing surfaces has been used extensively in NSTX, both on the carbon tiles and now on a **Liquid Lithium Divertor**. Improvements in electron confinement have been observed at mid-radii in the profiles for some lithiated plasma discharges. The effects of lithium on the current, q , and magnetic shear profiles are examined and correlated to these changes in transport and will be compared for discharges run with solid and liquid lithium on the divertor. The analyses of NSTX plasma equilibria use data from the upgraded 18 channel Motional Stark Effect (MSE) diagnostic. Issues that should be considered in this analysis include changes in impurity profiles and pedestal characteristics.

Supported by US DOE contracts DE-FG02-99ER54520 and DE-AC02-09CH11466.

NSTX wall conditioning is now exclusively lithium

Dual Liquid Lithium Evaporator
For Li wall coatings
Now routinely used



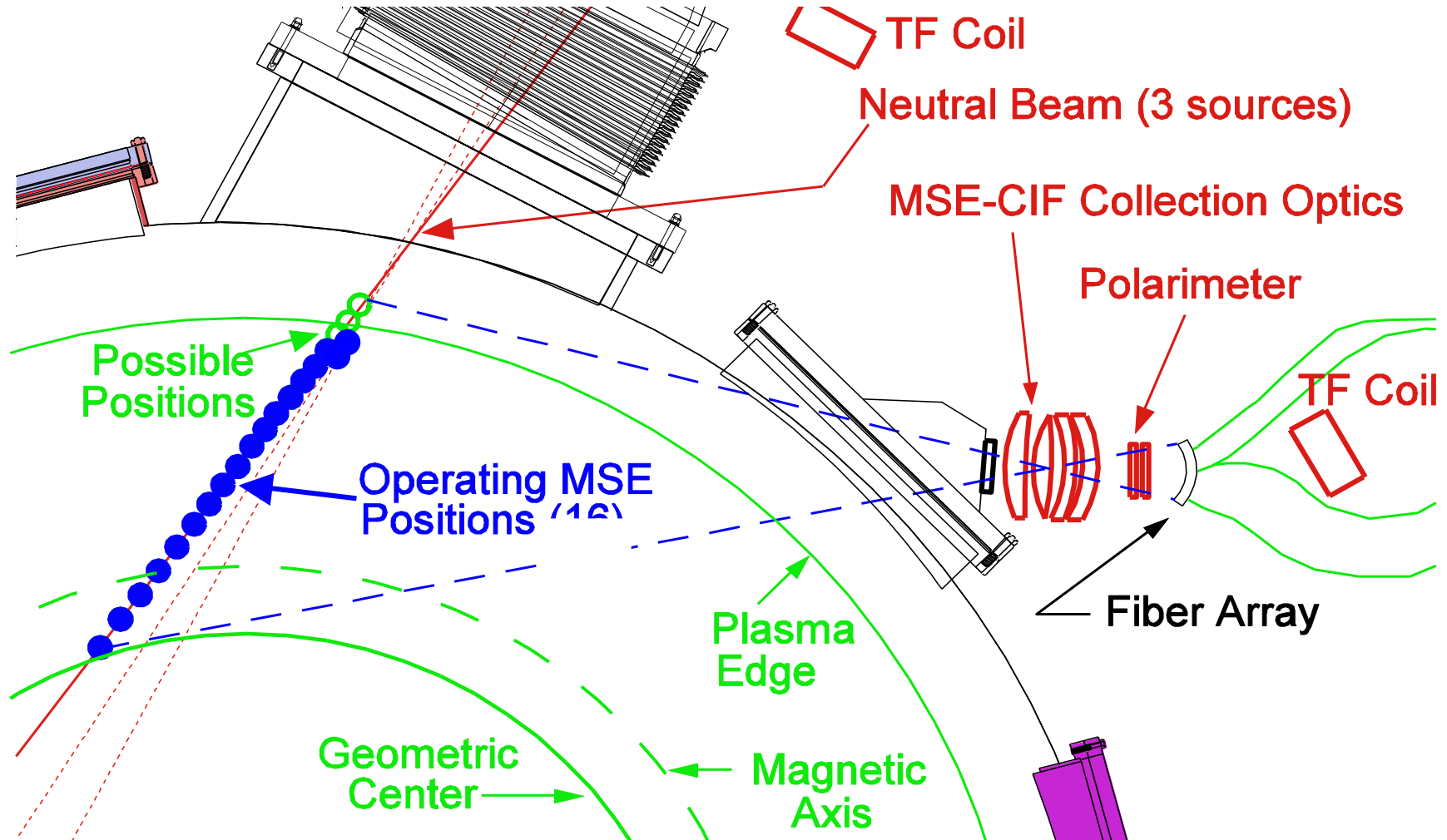
- Typically 50 to 300mg now deposited between shots
- 120g deposited into NSTX in 2008
- 320g deposited into NSTX in 2009
- 846g deposited into NSTX in 2010

H.W. Kugel

"...I used ta do a little but a little wouldn't do...So the little got more and more..." G'n'R, Mr. Brownstone

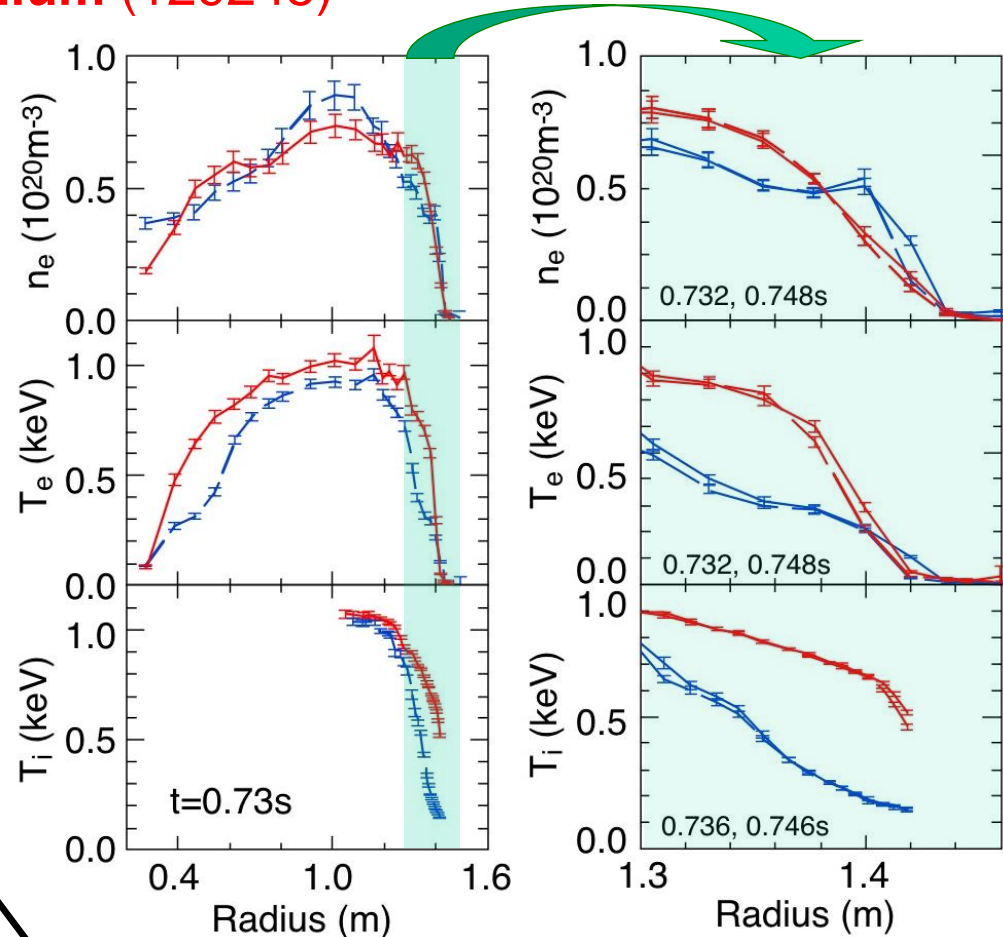
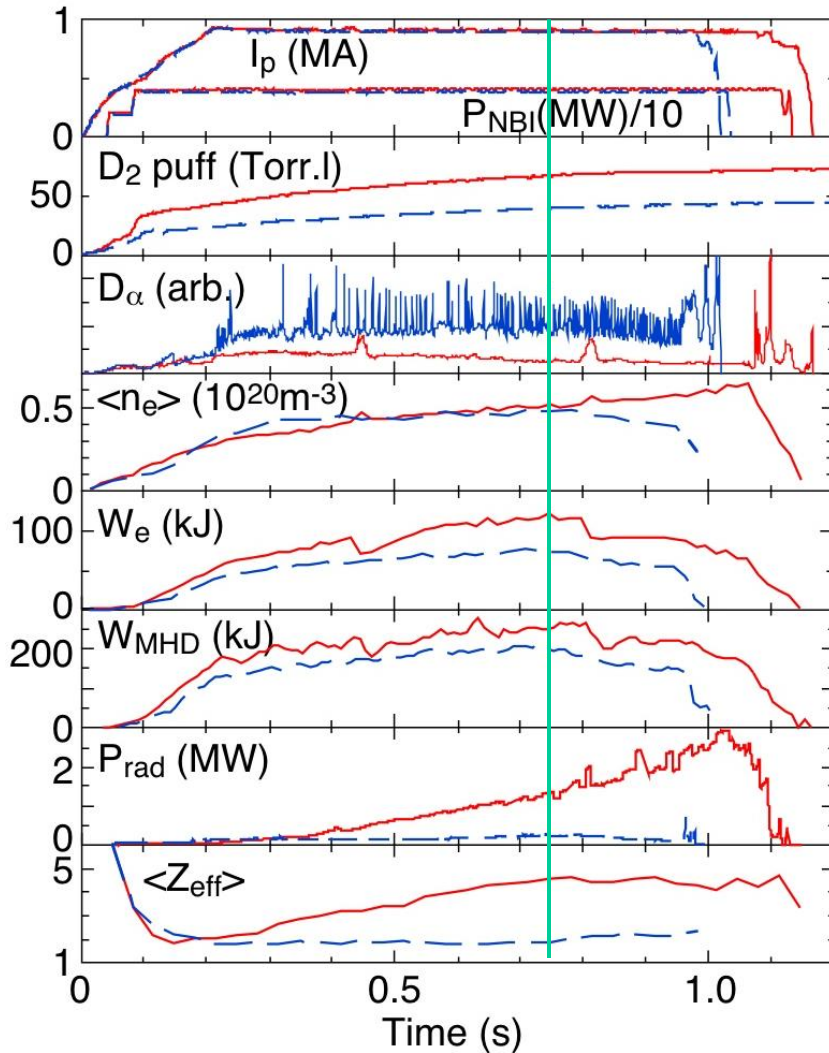
18 channel **M**otional **S**tark **E**ffect (**MSE**) diagnostic measures internal magnetic pitch angles

- Lyot filter based MSE system provides 5-10ms resolution at $\leq 0.35T$
- Provides full coverage from edge to past magnetic axis, all channels filled
- Diagnoses nearly all NSTX plasmas with beam heating or beam blips



Lithium coating reduces deuterium recycling, suppresses ELMs, improves confinement

No lithium (129239); **260mg lithium (129245)**

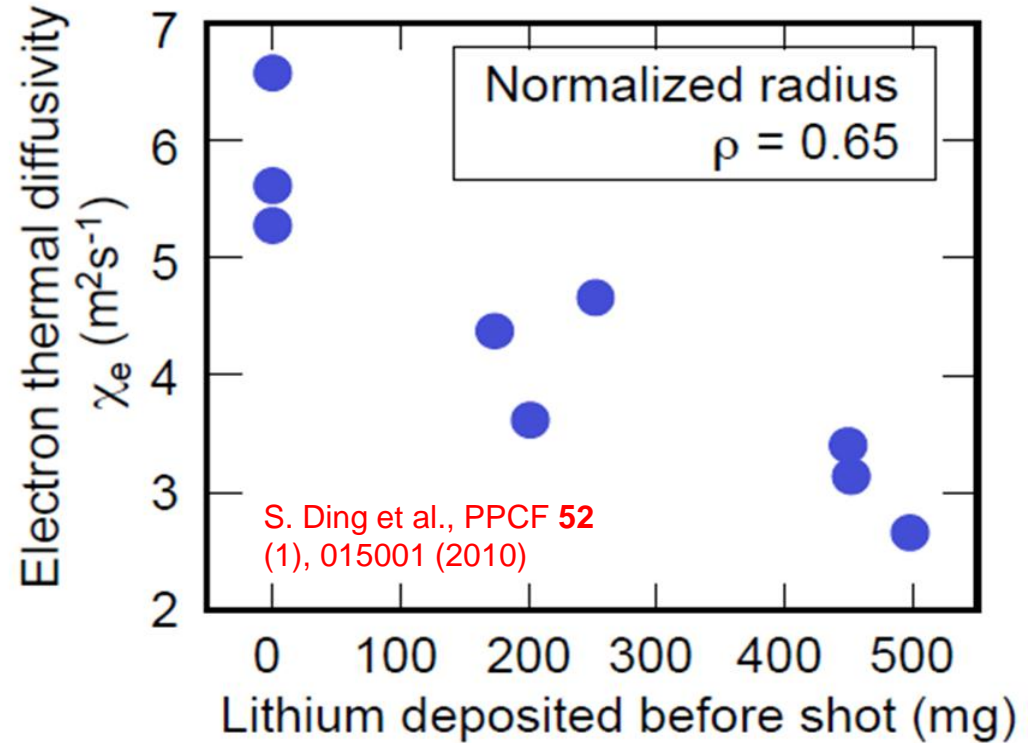


Without ELMs, impurity accumulation increases radiated power and Z_{eff}

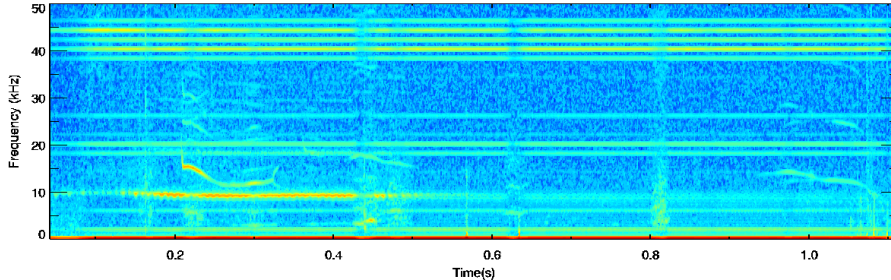
H. Kugel, B. LeBlanc, R.E. Bell, M. Bell

Improved electron confinement from lithium wall coating at mid-radius

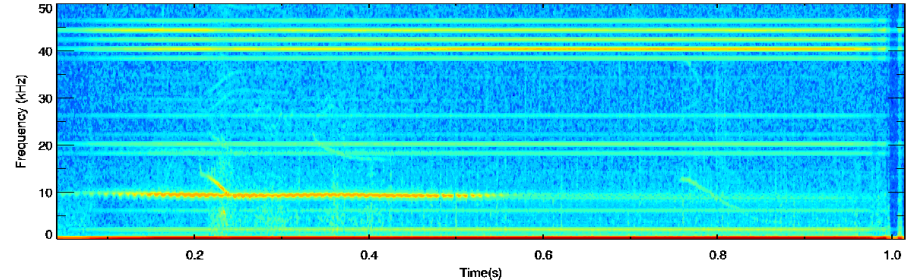
- TRANSP analysis confirms electron thermal transport in outer region reduced by lithium coating
- Thermal ion confinement remains close to neoclassical
- Relatively MHD quiescent



MSE-CIF FFT-Mag Radius: 1.39 Sightline: 14, , 129245

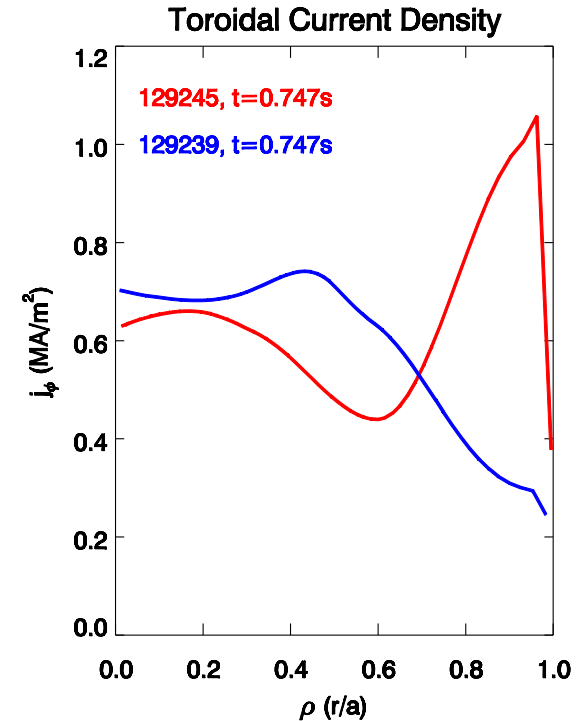
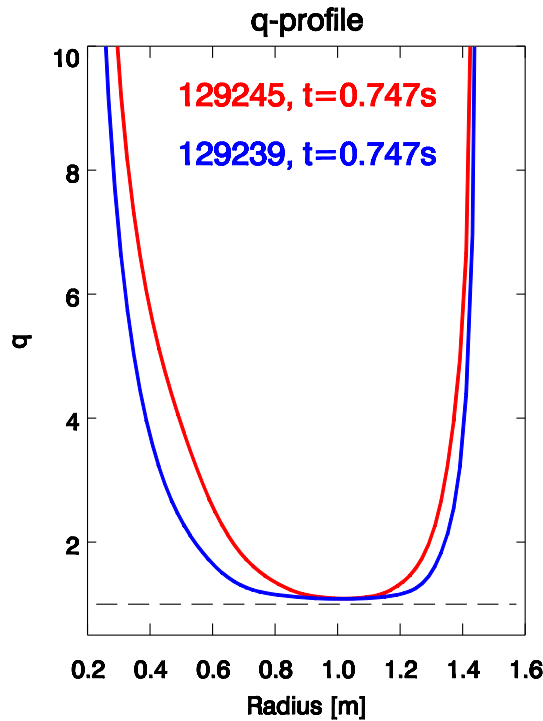
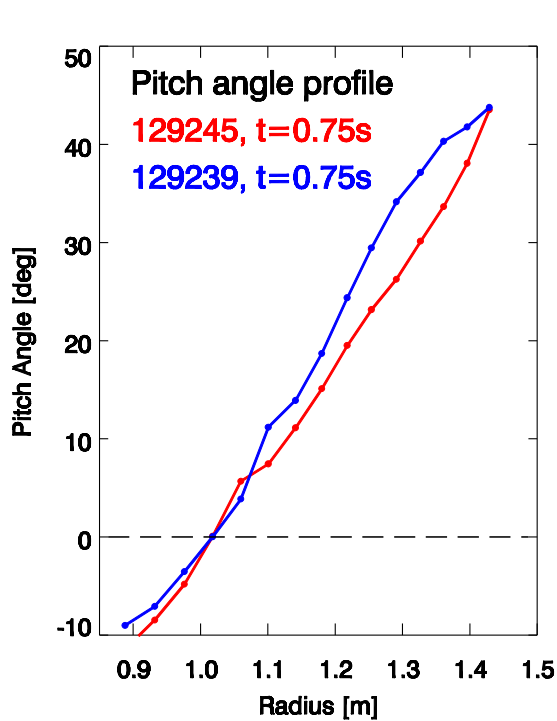


MSE-CIF FFT-Mag Radius: 1.39 Sightline: 14, , 129239

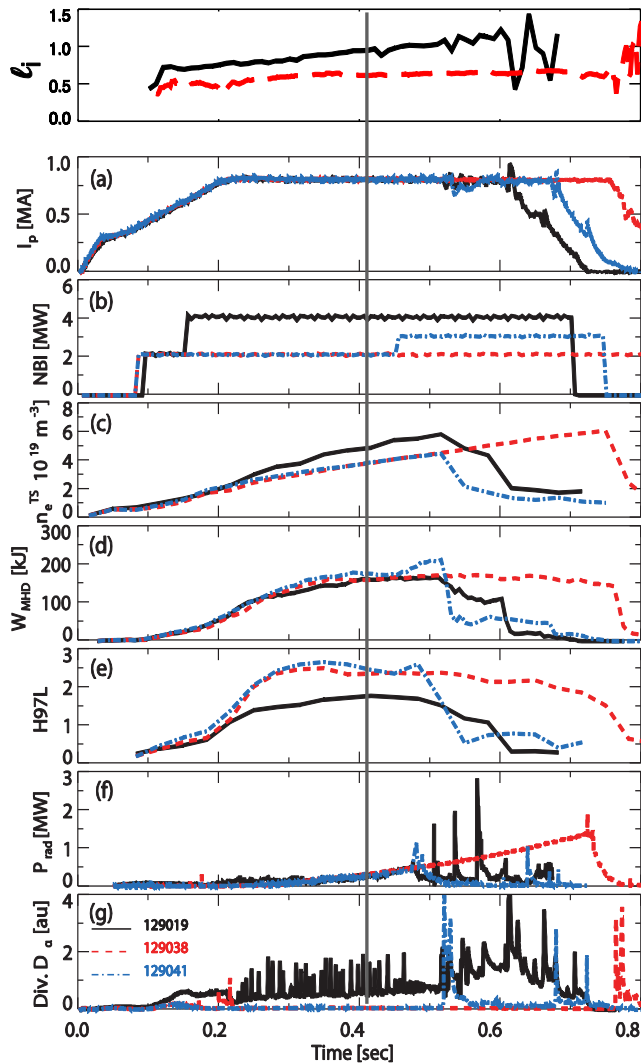


Improved Electron Confinement are observed with increased edge current density

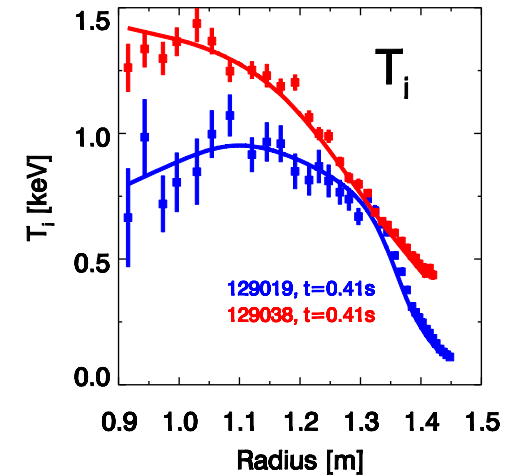
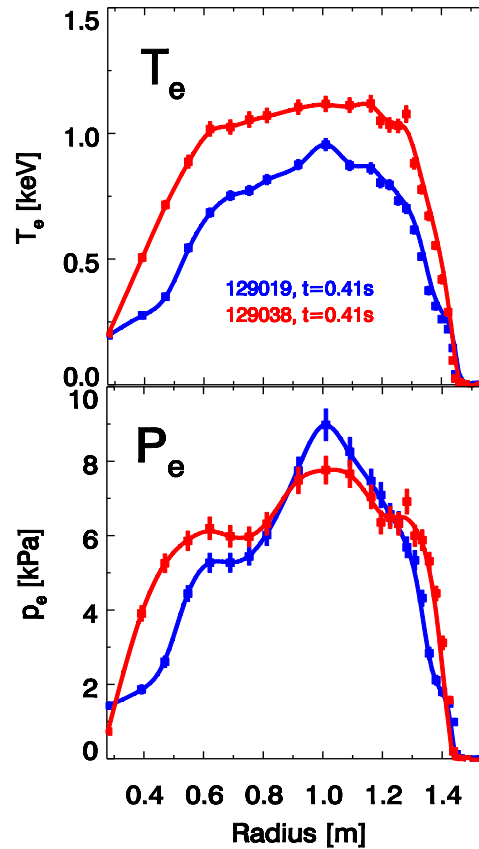
- Increase in edge current density observed in region of improved confinement
- Bootstrap can only explain a fraction of the increased current



ELMs suppressed with lithium coating, increased edge temperatures

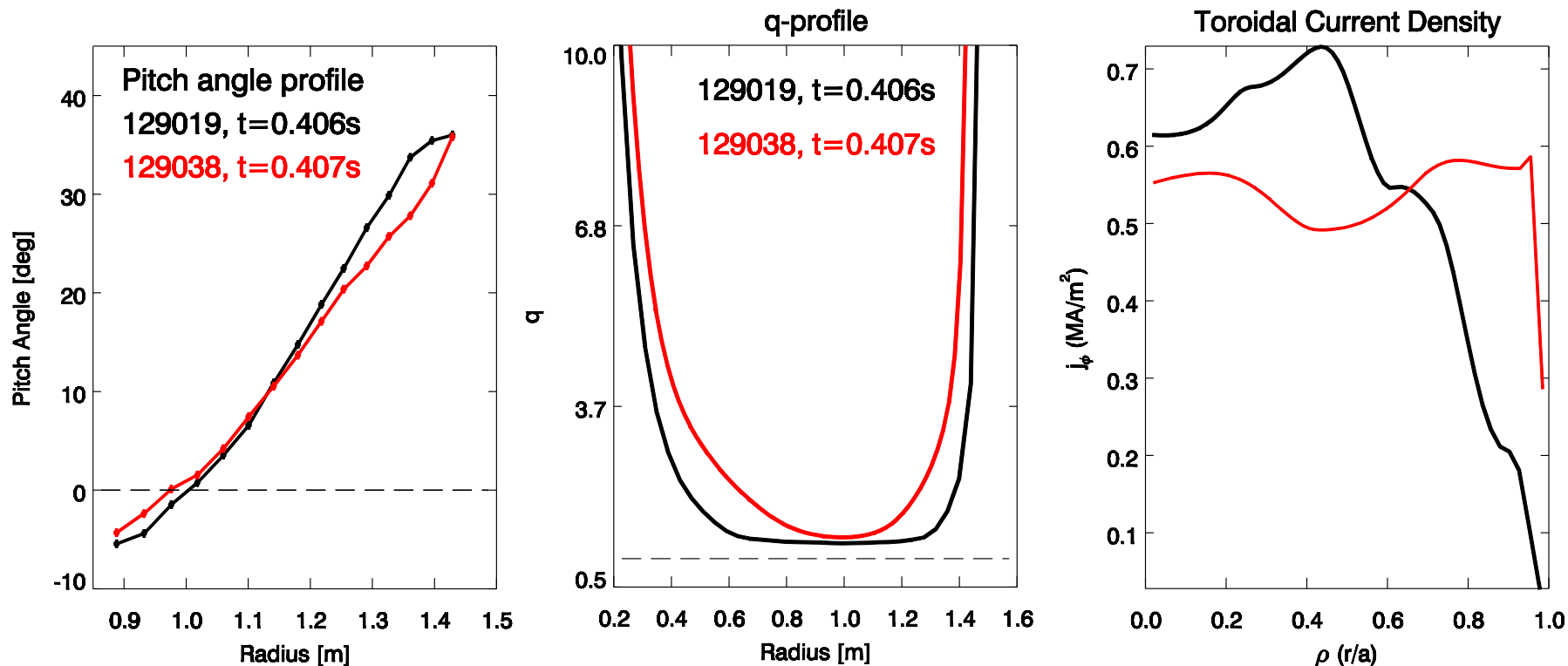


Maingi et al., PRL 103, 075001 (2009)



- LITER deposition suppressed ELMs
- Edge pressures and temperatures increased

Edge current density increases, ℓ_i is reduced

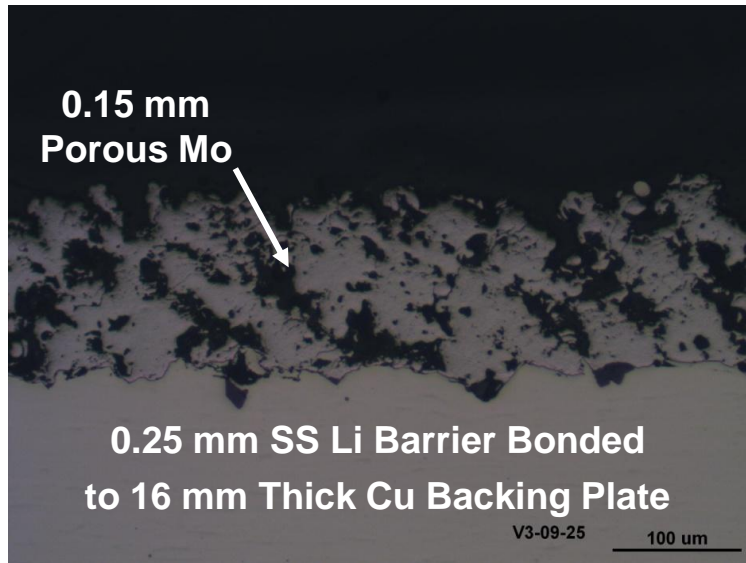


- Increase in edge current density
- Need higher resolution, E_r corrected $j_{pedestal}$ measurement

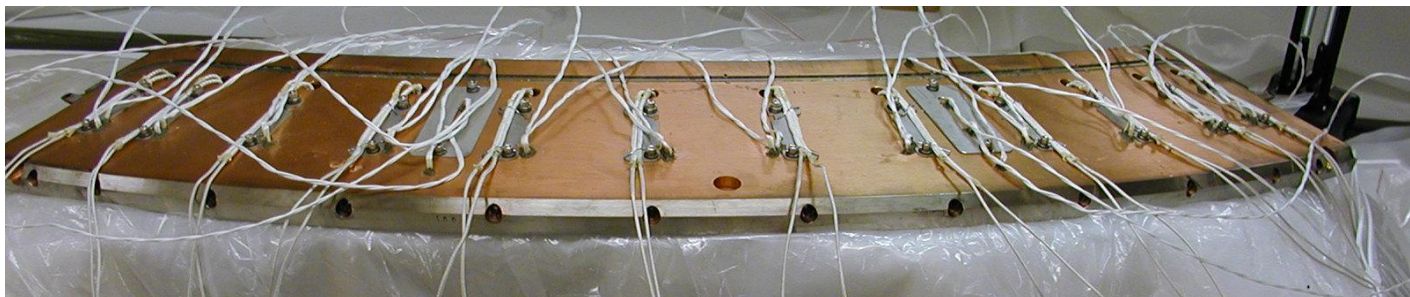
The LLD Plates, surface structure

Installed January, 2010

Micrograph of porous Mo layer



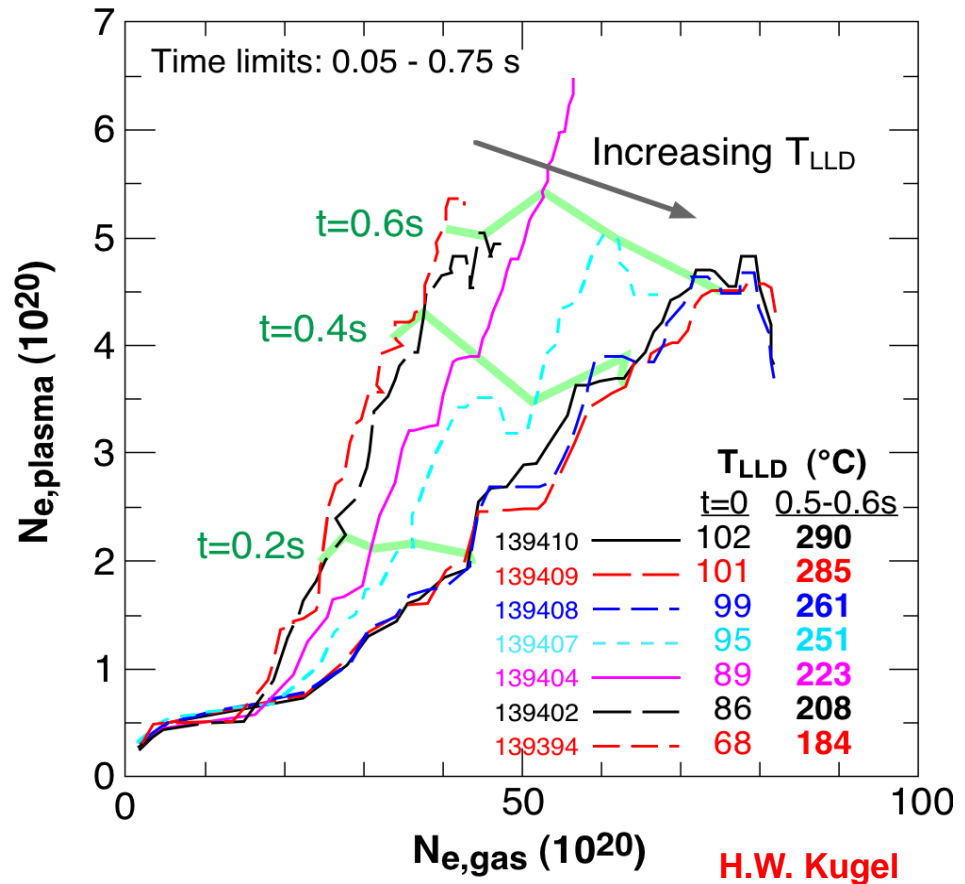
Back side of plate with heaters and thermocouples installed



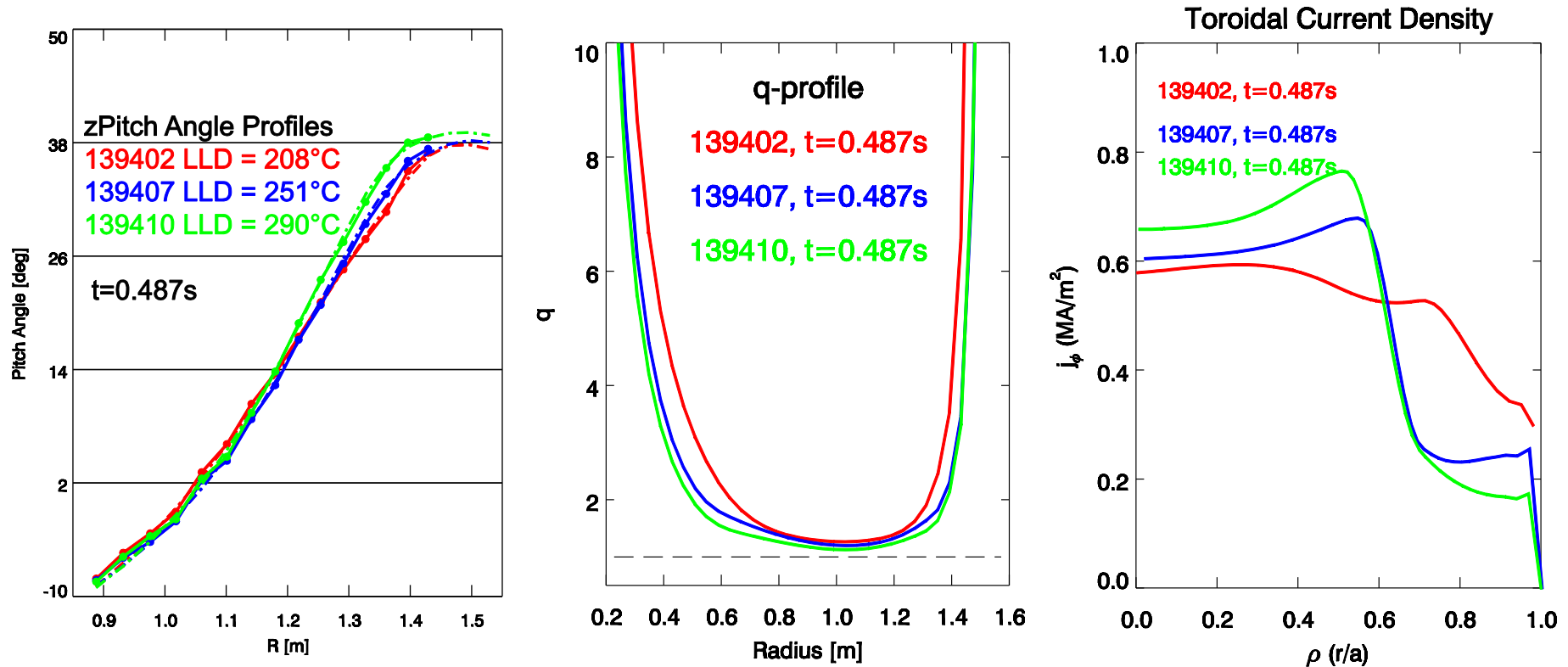
H. Kugel, R. Nygren (SNL), S. O'Dell (PPI), E. Starkman, M. Bell

Liquid Lithium Divertor (LLD)

- Observed preliminary indications of D pumping when surface heating by plasma liquefies lithium coating on LLD
 - Lower single null divertor plasmas with outer strike point on LLD raise peak surface temperature to $\sim 300^\circ\text{C}$
- Increased gas fueling did not increase plasma density proportionally



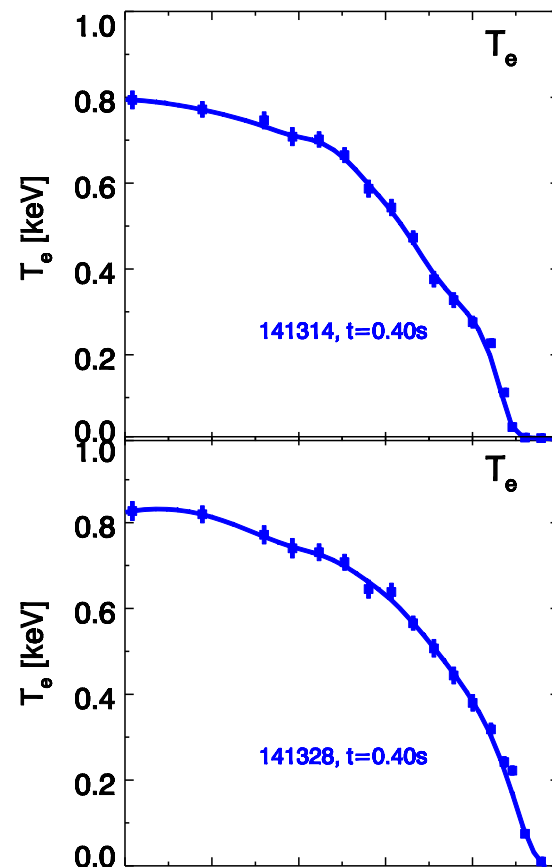
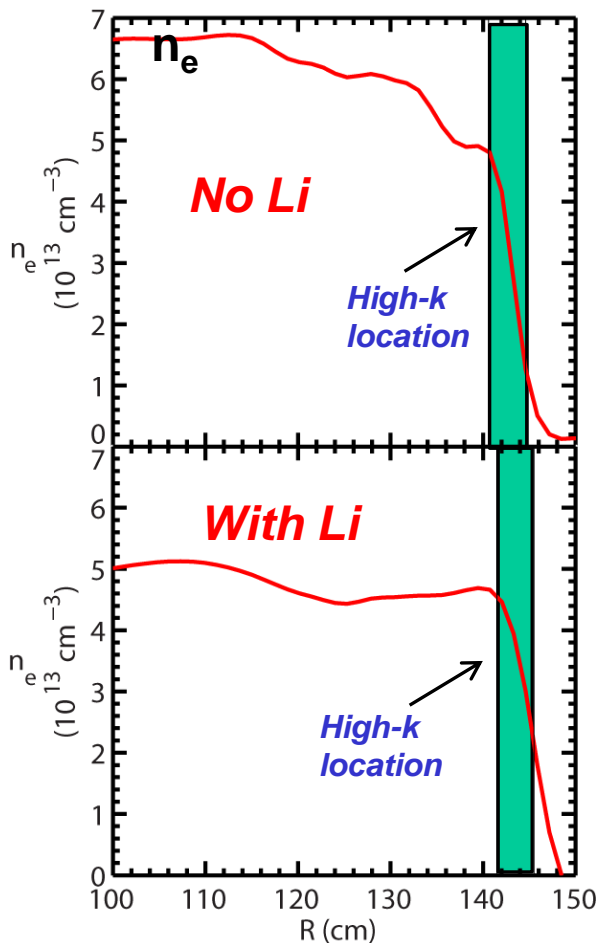
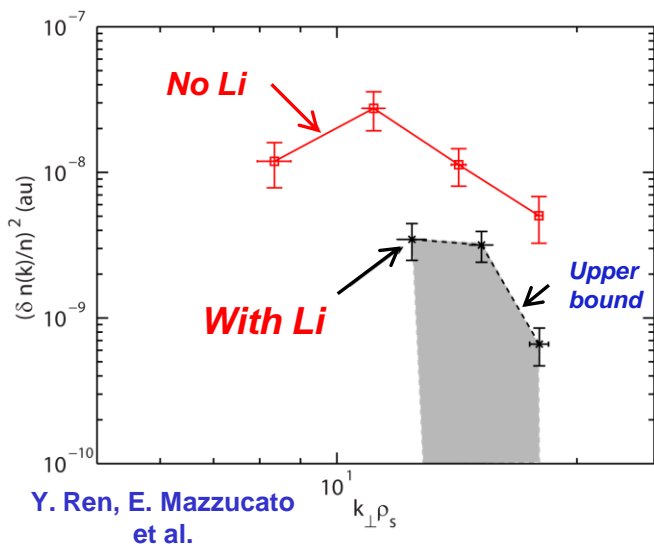
Liquefying LLD via plasma heating increased c



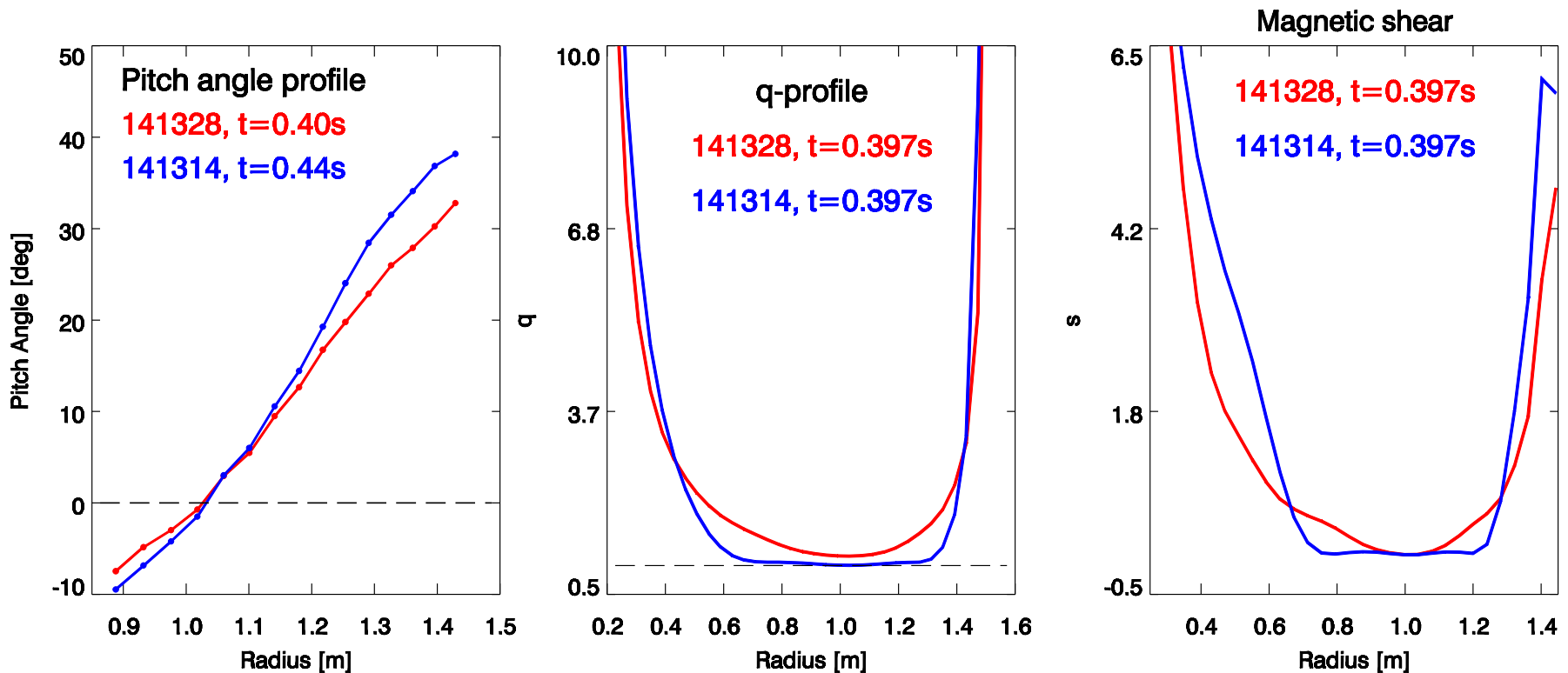
- Lithium is heated past melting temperature by setting plasma strike point on LLD
- Significantly more gas is injected to allow discharge to proceed
- Plasma tended to have more peaked current profile in this case

Electron gyro-scale turbulence in edge can be reduced with lithium

- k spectra of normalized density fluctuations
- Reduction of high-k turbulence power is observed in the pedestal region as lithium evaporation is increased from 3 mg/min to 30 mg/min

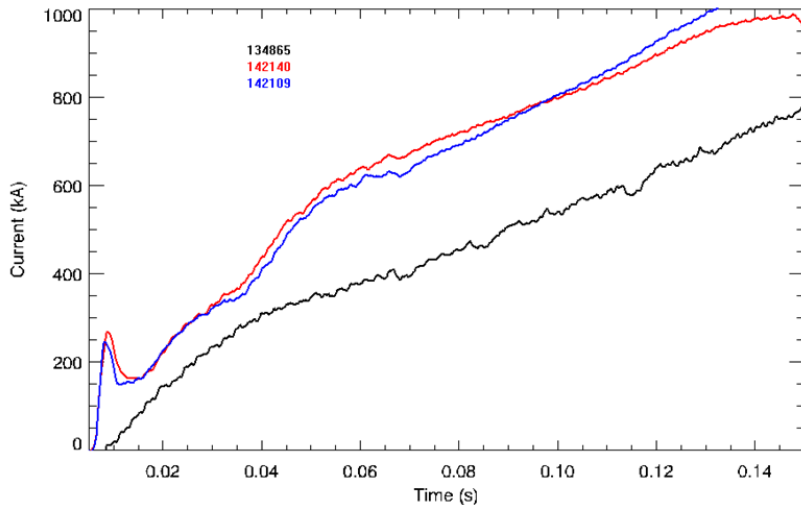
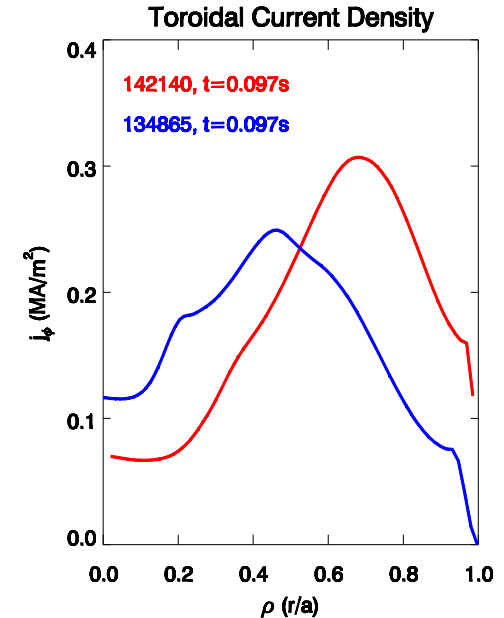
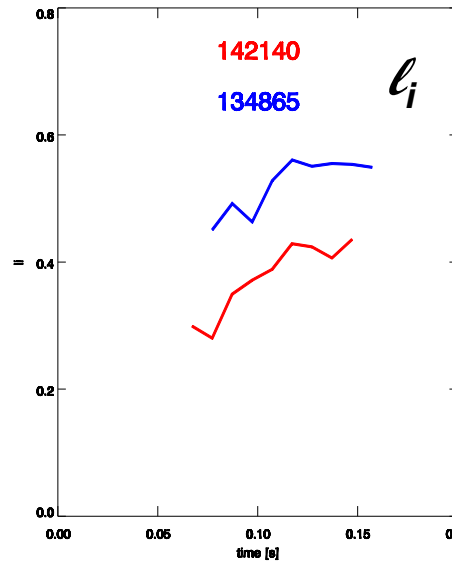
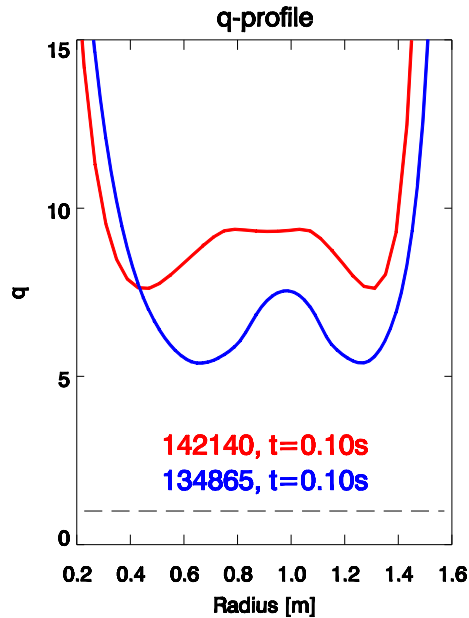


Increasing lithium evaporation rate can modify q-profile



- Increasing lithium evaporation rate modifies q-profile
- Statistical effect need to be considered, multiple changing factors makes lithium effects on transport difficult to isolate
 - ELMs, *AE modes, collisionality, pedestal changes, neutral density profile

CHI to OH coupled startup can now be reconstructed



- Reference Inductive discharge:
 - Uses 396mWb to get to 1MA
- CHI started discharge:
 - Uses 258 mWb to get to 1MA (53% less flux)

See R. Raman's Invited talk,
DI3.00004 (Monday, 4:30PM)

Conclusions & Future Work

- Evaporated lithium coatings can reduce ℓ_i
- Robust ELM suppression coincident with large increases in edge current density
 - Cause/effect with respect to ELM suppression?
- Heated LLD, while shown to pump D, has so far not produced the same current profile modifications as seen in previous years with LITER alone
 - increased gas input necessary to avoid MHD in front end negating effect?
- Some is good, is more better?