NSTX

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Transport and Turbulence TSG Results Review

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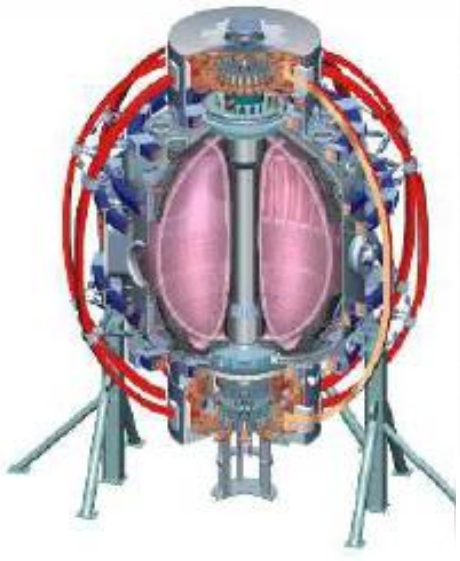
Howard Yuh, TSG Leader
Stan Kaye, TSG Deputy Leader
Taik-Soo Hahm, Theory & Modeling

FY10 NSTX Results Review
Sept 30, 2010



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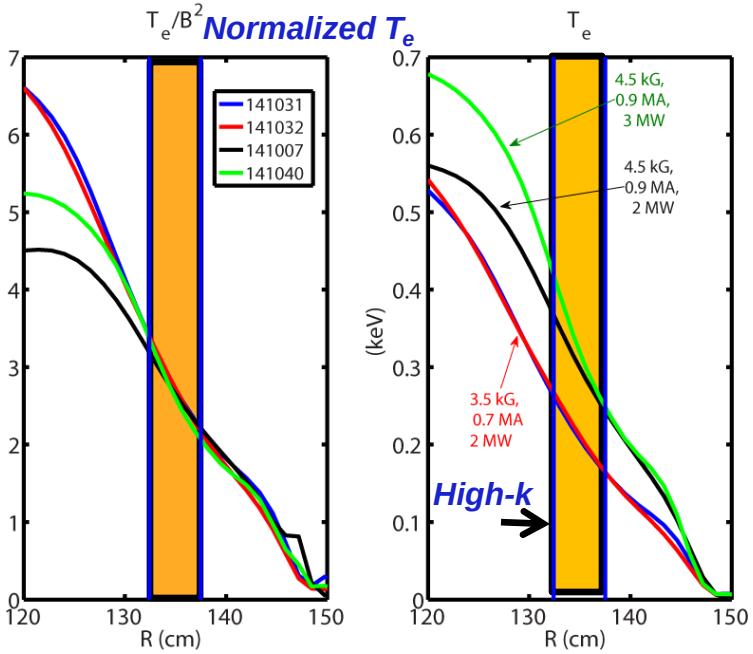
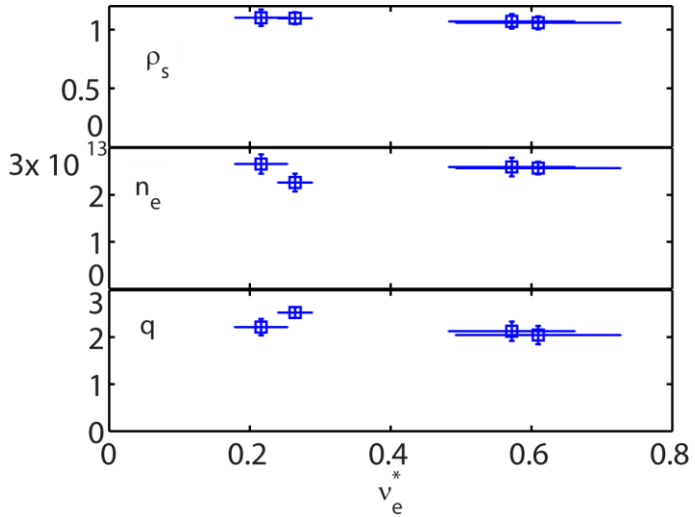
XP1037: Study of the Parametric Dependence of High-k Turbulence in NSTX (Y. Ren et. al.)



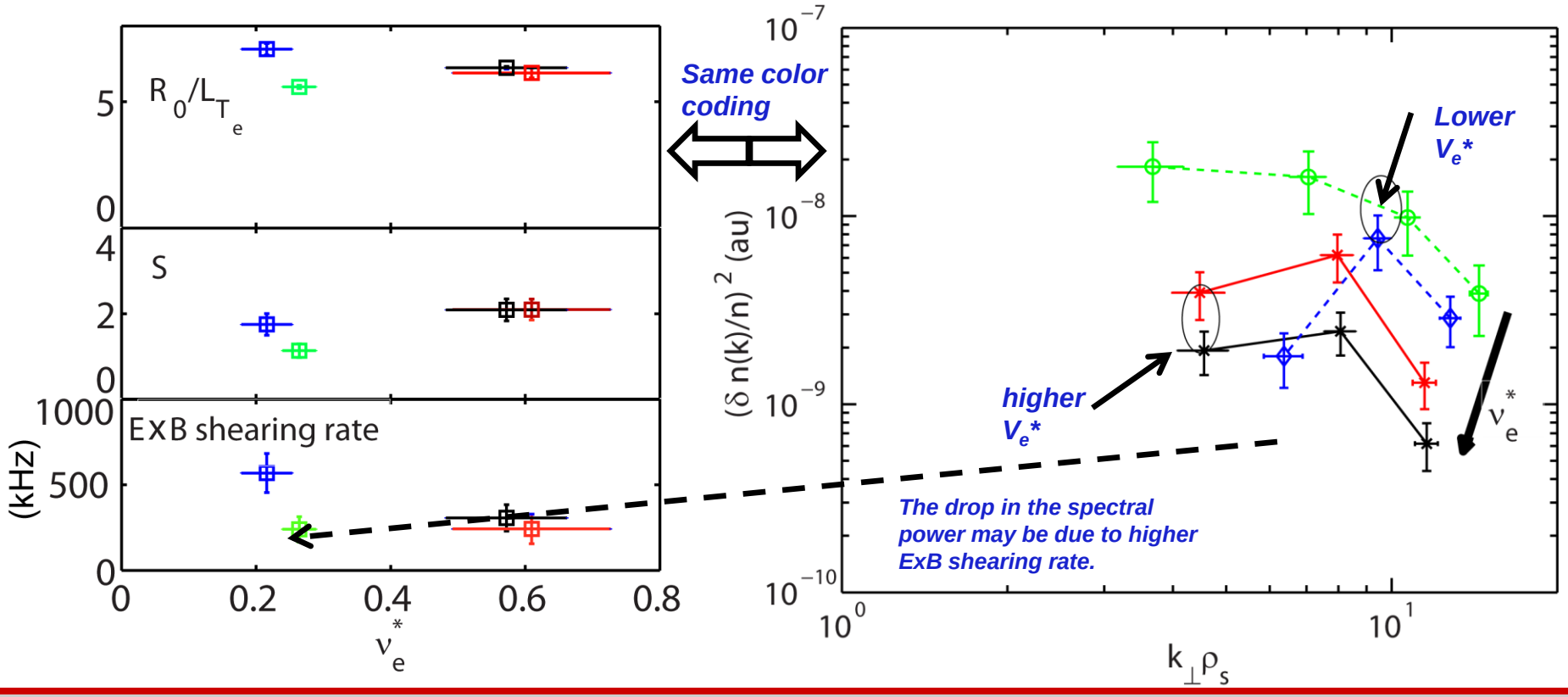


- **A Factor-of-Three Local Collisionality Scan Was Achieved**
- **T_e / B^2 was well maintained from R=130-145 cm: local v_{e*} was varied with constant ½$_e$ and $\bar{}_T$.**
- **I_p and B_T were varied with a constant ratio to keep constant q.**
- **Neutral beam power was adjusted to have a better match in T_e profile.**
- **The scan was carried out with (I_p(MA), B_T (kG))=(0.7,3.5), (0.9, 4.5) and (1.1, 5.5).**
- **(1.1 MA, 5.5 kG) shots have much high density and Z_{eff} and are not used.**
- **Factor of three change in v_{e*} is achieved.**
- **ρ_s , n_e and q have only small variations against v_{e*}.**

High-k Turbulence Power Seems to Increase as v_{e*} Decreases

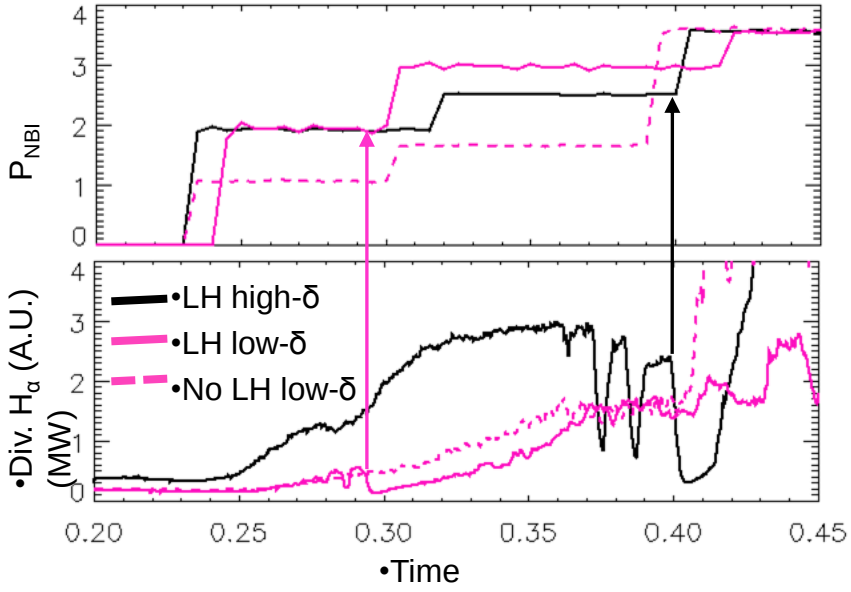
- T_e gradient variations are up to 30%.
- Variation in magnetic shear is larger, up to 90%.
- Variation in ExB shearing rate can be up to factor of two.

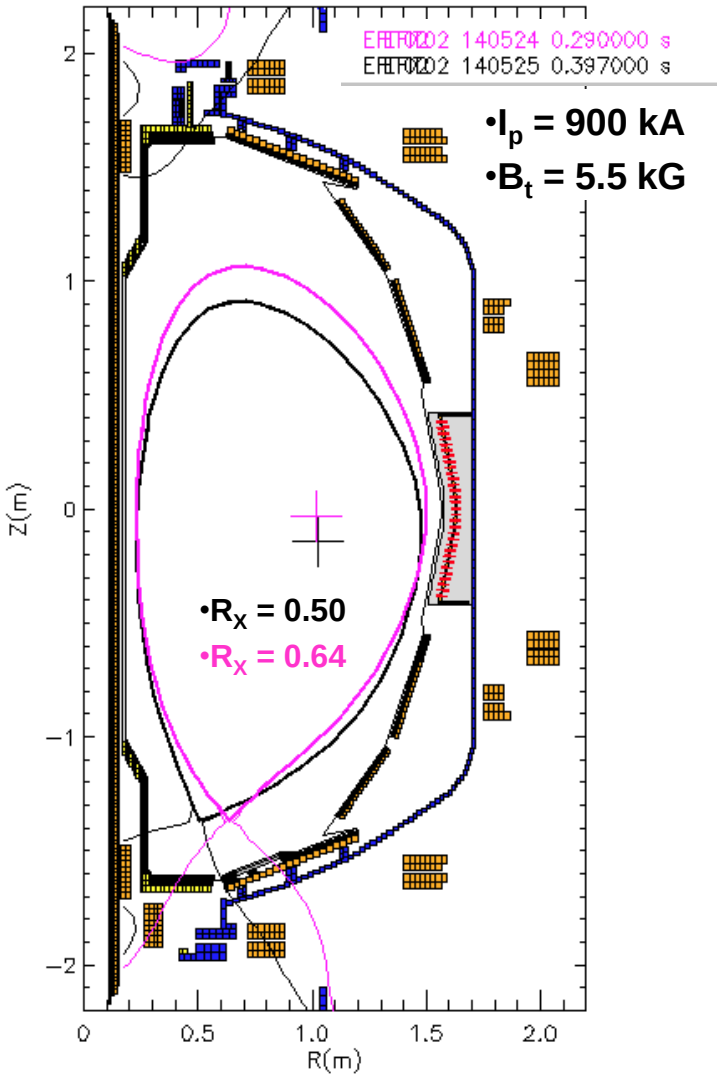
- High-k turbulence power appears to increase as v_{e*} decreases at $k_\perp \rho_s$ >9.
- Same relationship may hold for $k_\perp \rho_s$ <9 if ExB shearing stabilization is taken into account.
- Larger variation in v_{e*} is important to pin down the relationship.



XP1029: Dependence of P_{LH} on the X-point radius (D. Battaglia et.al.)

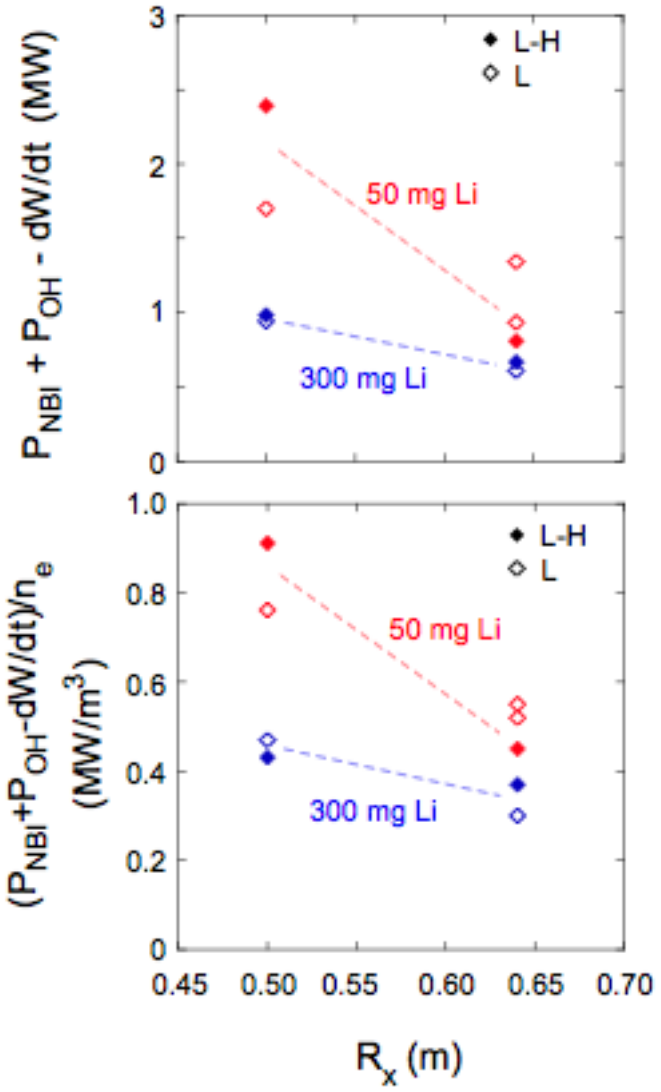
- XGC-0: thermal ion loss at the X-point increases with R_X
  - Increases E_r and E_r shear
  - May result in lower power threshold
- Two shapes reproduced with low and high lithium depositions
  - Measured P_{LH} vs R_X to compare to model





Initial results suggest dependence of P_{LH} on R_X

- Values computed using TRANSP
  - P_{OH} ~ 0.3 MW, dW/dt ~ 0.5 MW
  - P_{loss}/n_e approximate correction for P_{LH} density dependence
- R_X = 0.5 → 0.64 (22% reduction in B_t at X)
  - P_{loss}/n_e reduction of 38% w/ low lithium
  - P_{loss}/n_e reduction of 14% w/ high lithium
- Lithium = 50 mg → 200 mg
  - P_{loss}/n_e reduction of 47% for high-δ
    - Maximum lithium at outer strike point
  - P_{loss}/n_e reduction of 28% for low-δ
    - Maximum lithium in private flux region



XP1029 future plans and goals

- Higher time resolution equilibrium calculations underway
  - LRDFIT and/or EFIT02 at 1 ms resolution
  - Complete error analysis

- XGC calculations for high- and low-δ shapes at time of L-H

- **XP would benefit from additional ½ day of run time**
  - Repeat low-δ shape with low lithium for reference
  - Develop R_X = 0.42 shape for larger scan
  - Decrease B_t so it matches the value at X-point in the low-δ shape

- Planned publication of comparison XP and XGC0 results

XP1042 Mini-Results Review

Wayne Solomon, PPPL
and the NSTX Research Team

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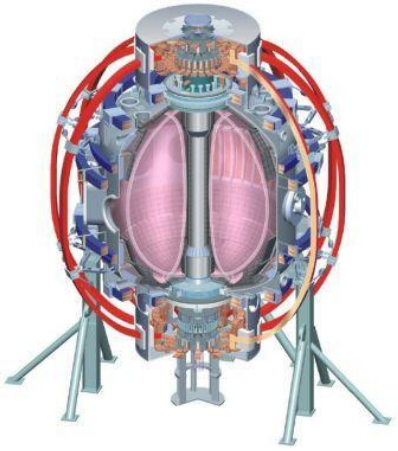

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ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

Characterization Of Intrinsic Rotation Drive Using Neutral Beam Torque Steps

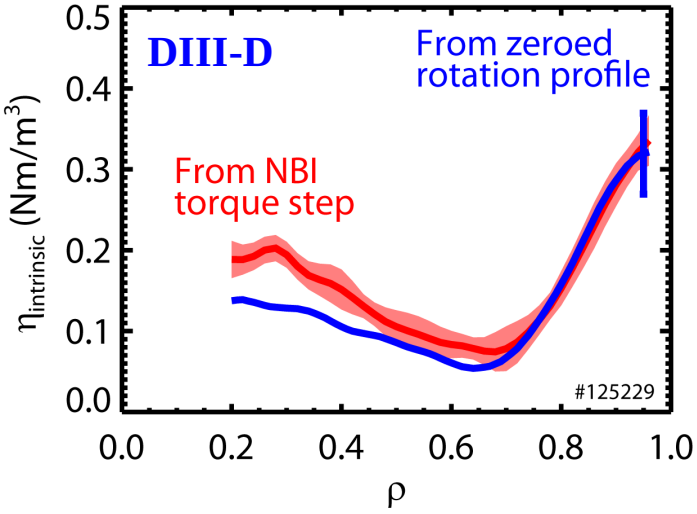
- Goal: Infer the effective torque profile associated with driving intrinsic rotation.

- Technique
  - Apply torque step and measure evolution of angular momentum

$$\frac{dL(\rho)}{dt} = T_{NBI}(\rho) + T_{intrinsic}(\rho) - \frac{L(\rho)}{\tau_\phi(\rho)} \quad \text{with} \quad L(\rho) = \int_0^\rho nmRV_\phi \; dV$$

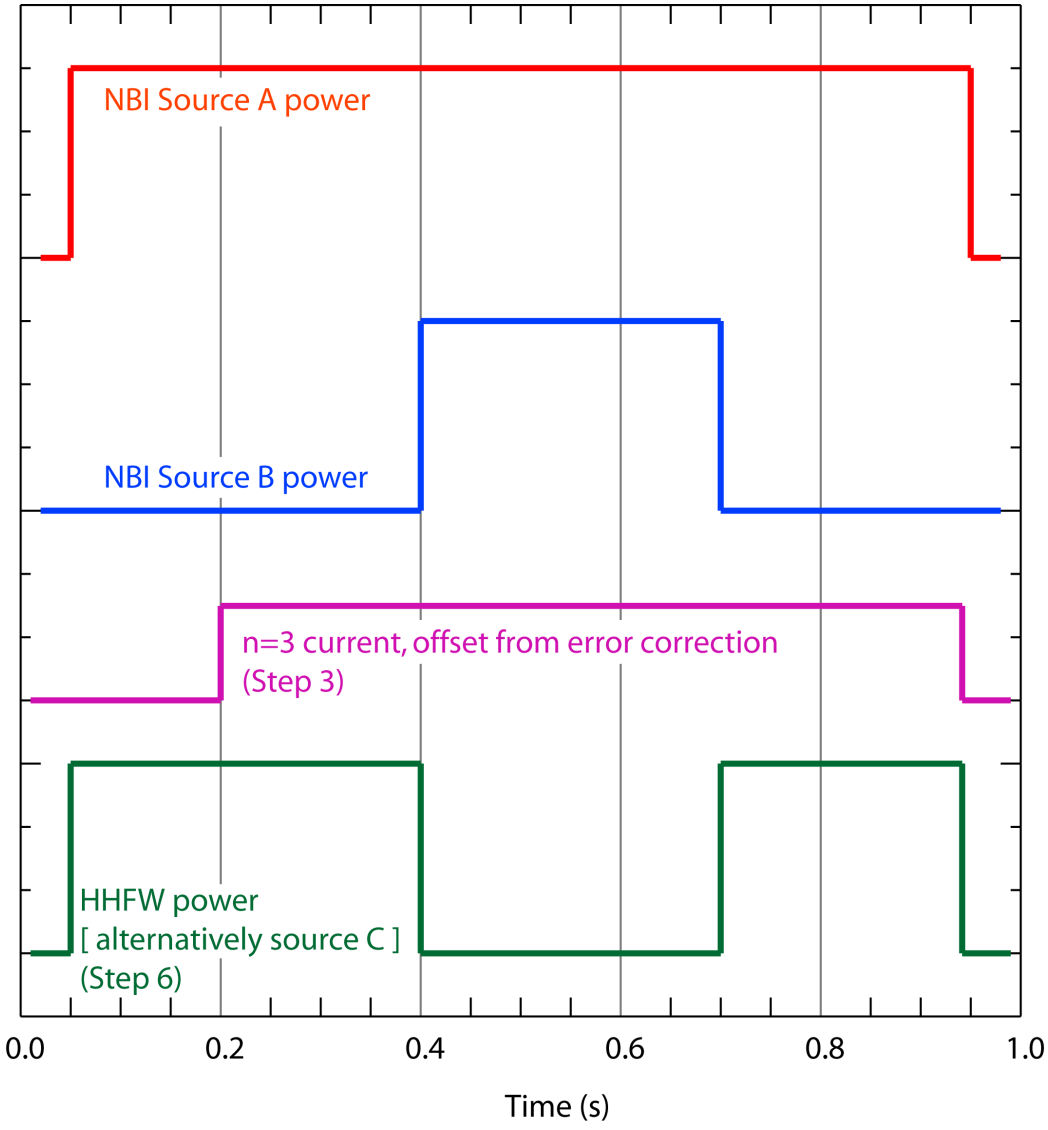
  - At each ρ, solve for two unknowns $T_{intrinsic}(\rho)$ and $\tau_\phi(\rho)$ from time history of data → highly overdetermined

  - Technique gives quantitatively similar result to measurement obtained by zeroing rotation



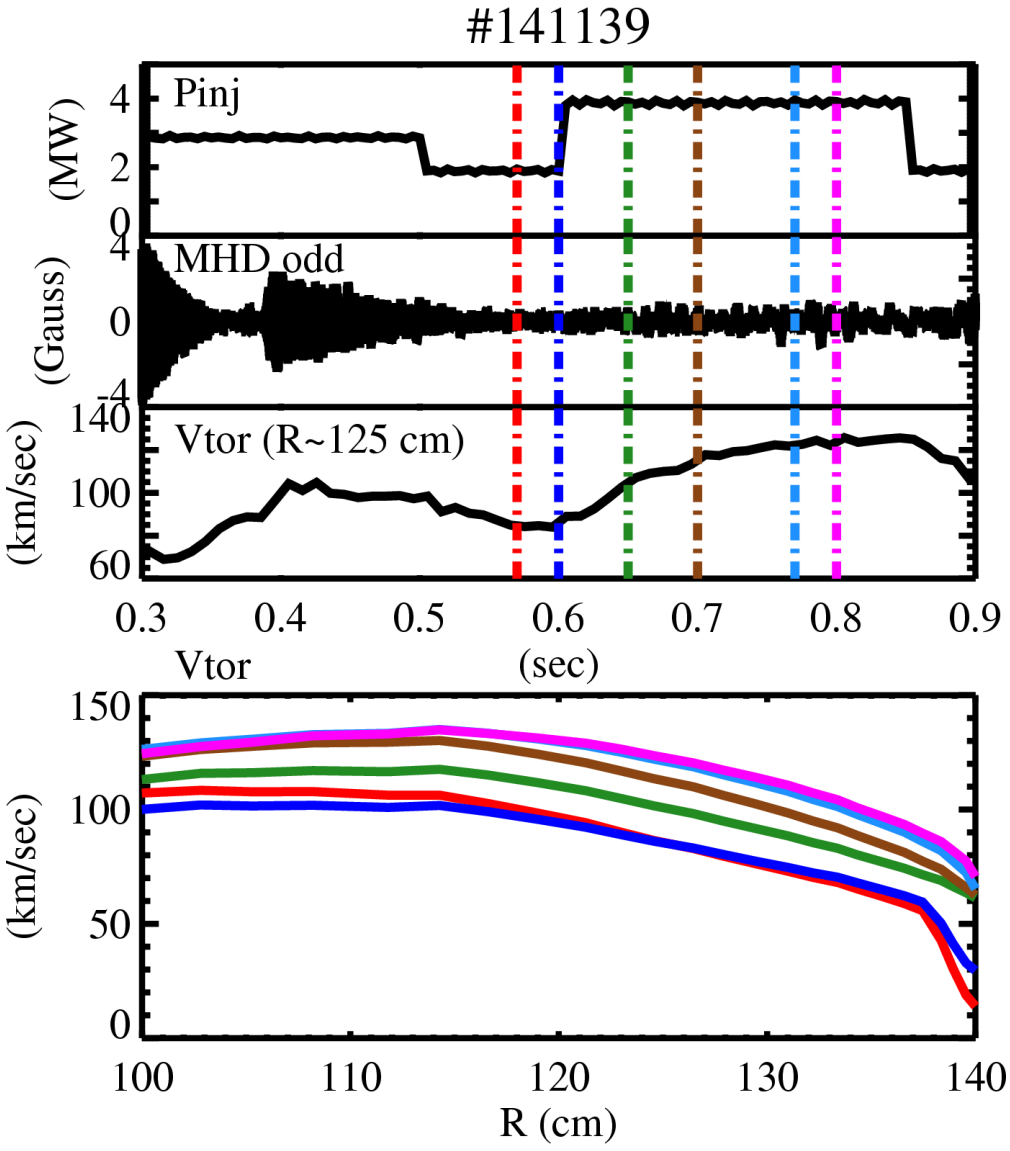
Major Part of Run Plan Completed

1. ✓ Establish baseline
2. ✓ Power scan
   - add source C, and then invert source B waveform
3. ✗ Interaction of intrinsic drive with n=3 fields
4. ✓ Ip scan
5. ✗ Couple 2 MW of HHFW
6. ✓ Torque perturbation at constant power
   - Switch between B&C sources
7. ✗ Use n=3 fields to apply torque step
   - Adjust dc bias to get rotation scan

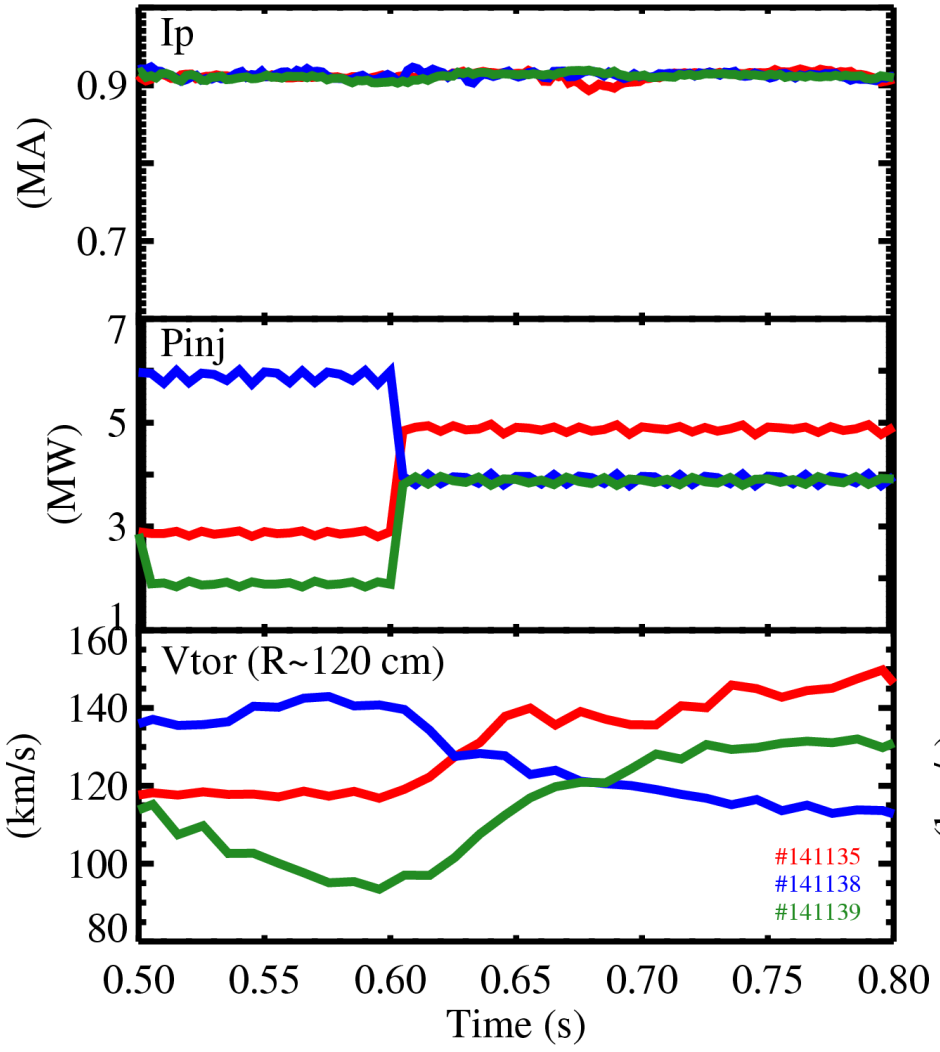


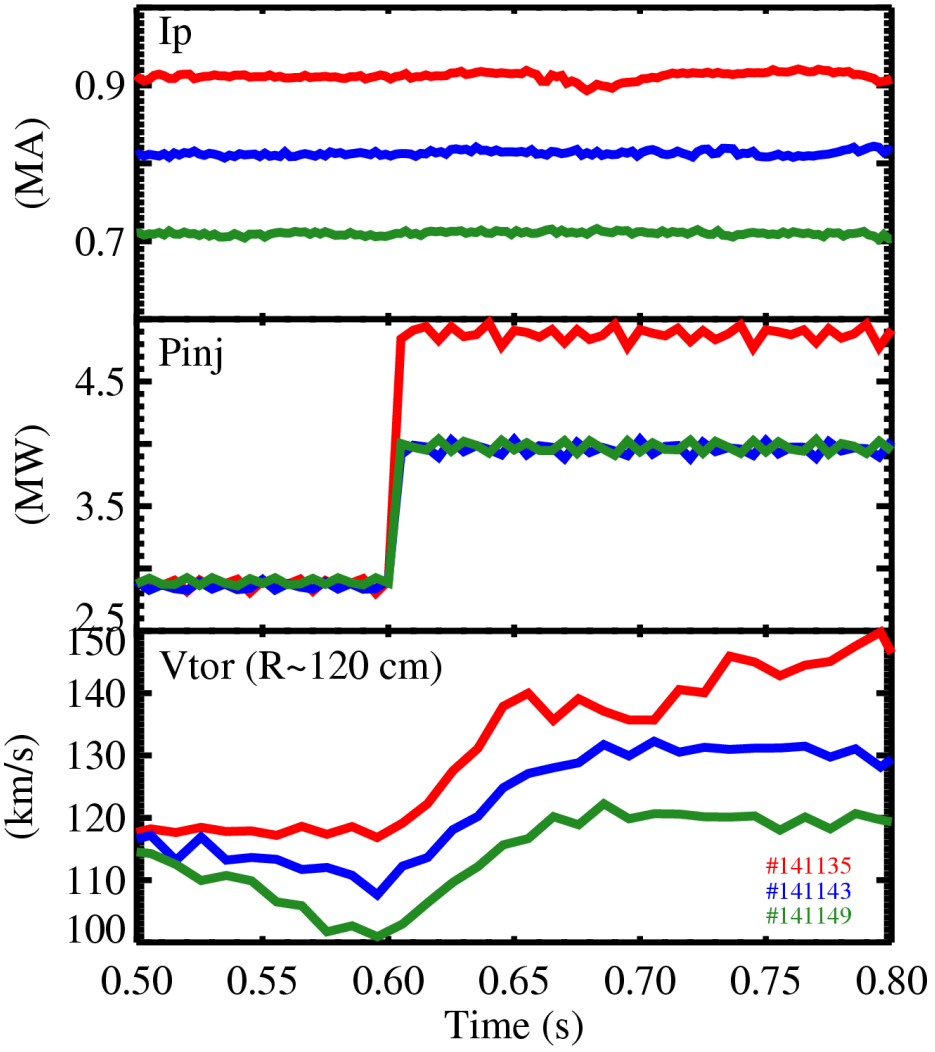
Acquired Good Rotation Data in Response to Torque Perturbation

- Rotation takes a long time to establish new steady state
  - Consistent with long momentum confinement time on NSTX
- Unfortunately, rotation is not quite stationary before beam step in most shots
  - But angular momentum may be better when factor in density change



Power and Ip Scans with Torque Perturbations Completed





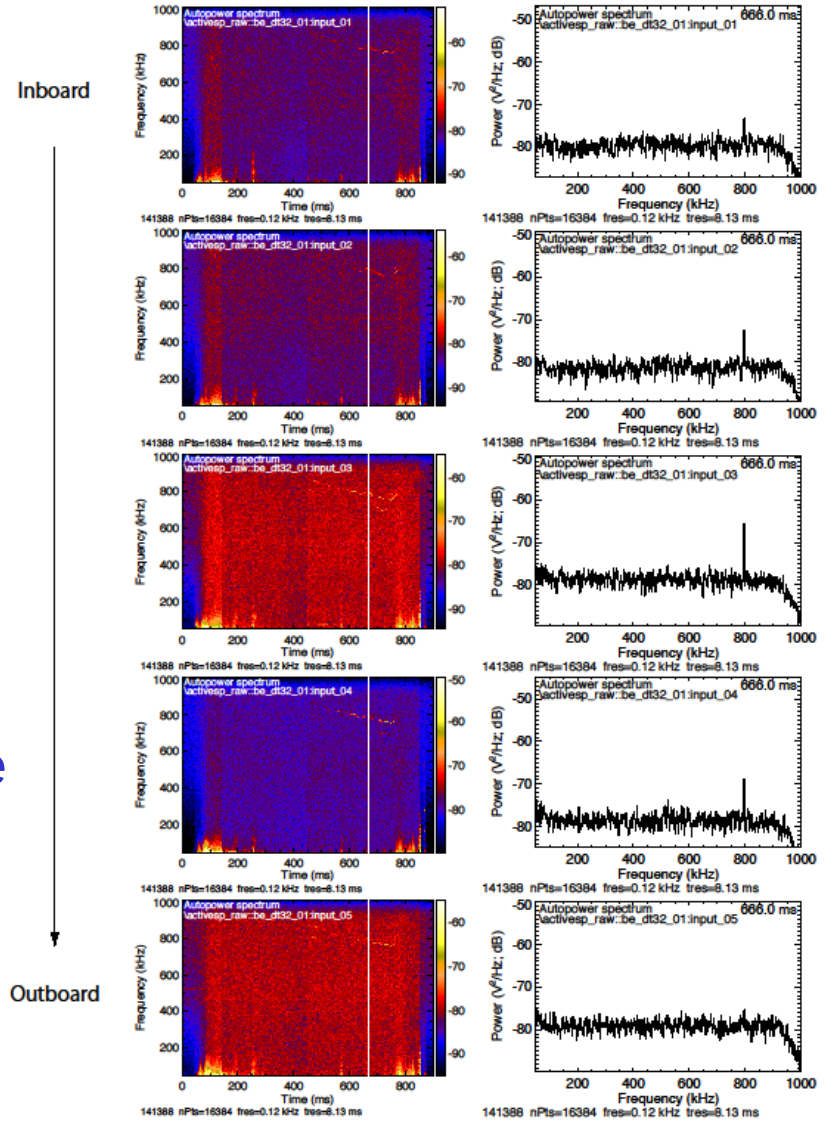
Still left…

- Missing data:
  - Interaction with n=3 and rotation scan (steps 3 & 7)

- Analysis:
  - TRANSP
  - Post-processing of TRANSP output to extract intrinsic drive
    - Tools have been tested on NSTX cases

BES measurements of GAE (XP 1013)

- **BES status**
  - 24 channels operational (6/2010) at outer view (0.5 < r/a < 1+)
  - 32 channels planned
  - Bay F LiTER found not to have LOS to R130, can operate concurrently
  - Inner view (~0.1 < r/a < ~0.8) R130 shutters unreliable, manual operation uncertain
- **BES has supported several XPs**
  - XP 936 (Rotation effect on turbulence & transport) (Kaye...)
  - XP 1013 (GAE e-transport) (Tritz... in WPI presentation)
  - XP1037 (High-k parametric dependece) (Ren...)

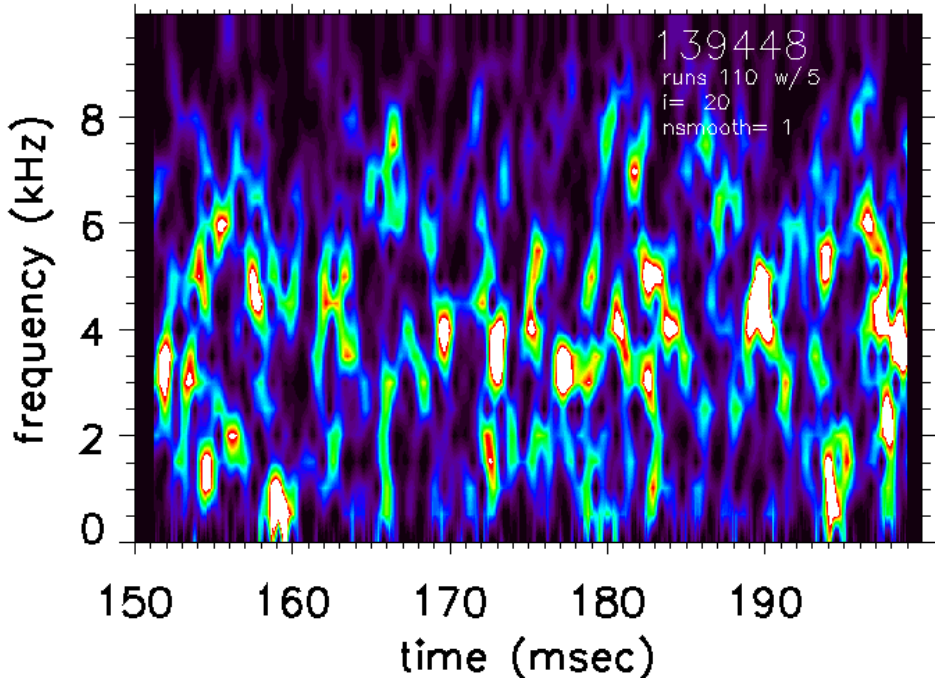


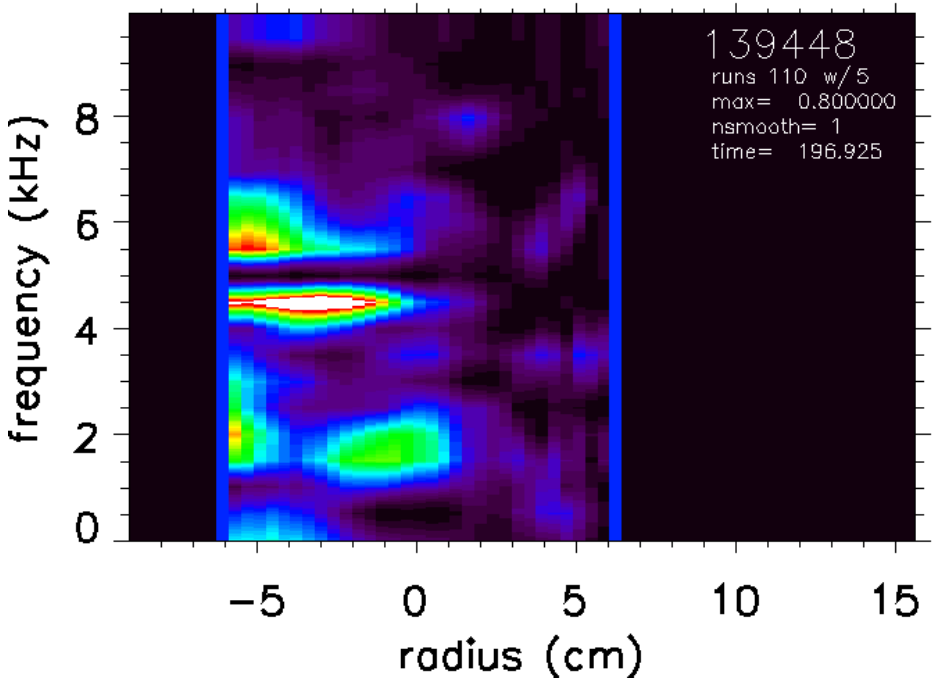
XP #1067: Edge Zonal Flows and Blob Formation

(S.J. Zweben, R. Maqueda, T. Munsat, Y. Sechrest, S.M. Kaye et al)

frequency spectrum of poloidal 'zonal flow' of turbulence can be complicated

radial distribution of poloidal 'zonal flow' of turbulence is peaked inside separatrix





- Analysis of 2-D flow profiles and attempt at 'scaling' with B/I are in progress
- Fluctuating poloidal flow of turbulence is larger than mean flow of turbulence

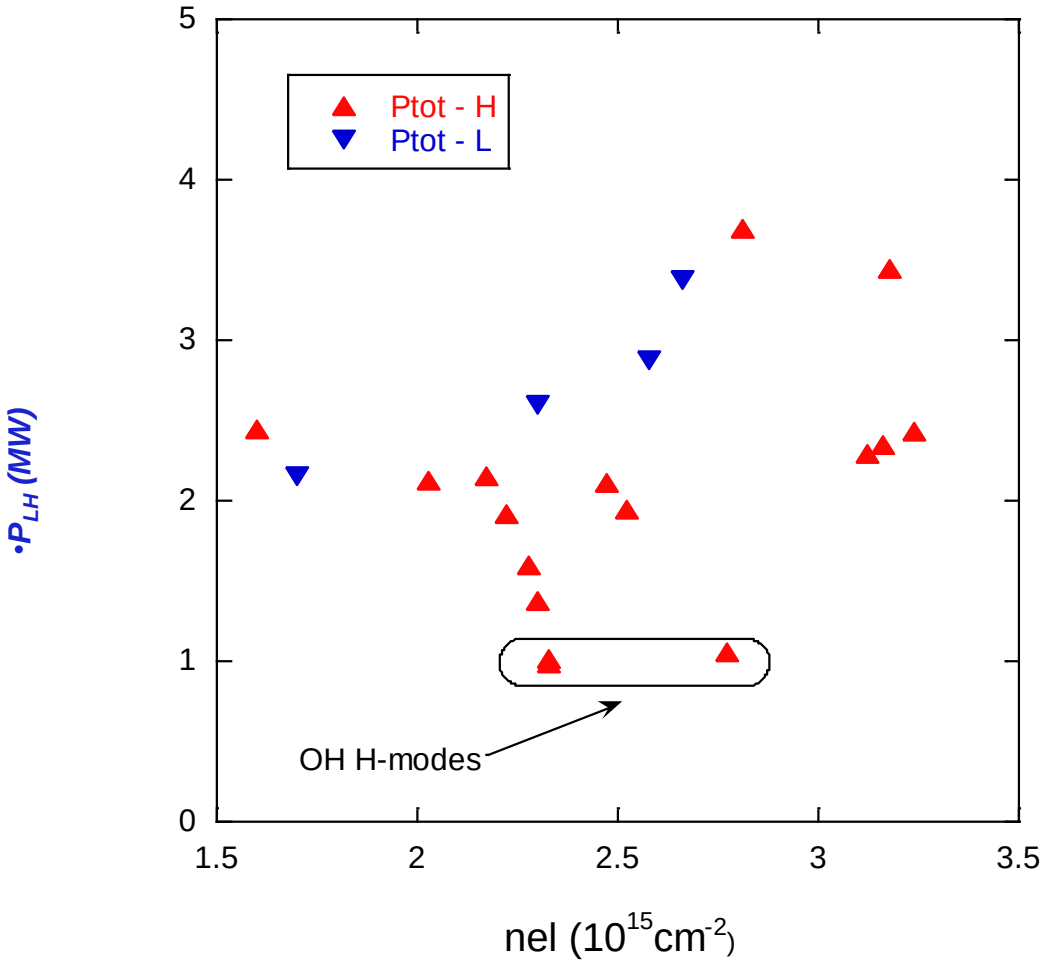
XP1041 (0.5+0.5) - Joint NSTX DIII-D poloidal rotation

(R.Bell)

- First attempt, Jun 29
  - XP compares measured and neoclassical poloidal velocities
  - Large but unknown amounts of nitrogen & argon present during 1st half day resulted in good measurements but neoclassical calculations are uncertain
- Second attempt, Sept 1
  - The first plasma condition could not be obtained due to trips in the PF3 coil current. Limits had been lowered after the PF4 ISTP.
  - The second plasma condition with higher Bt and lower Ip suffered from short plasmas, so previously obtained MHD quiet periods (occurring at later times) were not obtained.
  - No useable discharges.

XP1028 (0.5 ITER) - Density dependence of L-H threshold (Kaye...)

- Higher P_{LH} seems to increase with increasing n_e
- Non-reproducibility precludes definitive conclusions



XP922 & XP936 (Kaye...)

- XP922: Density dependence of L-H threshold
  - Could not set up a reproducible condition; abandoned XP after 1 ½ hrs
- XP936: Effect of rotation on energy confinement
  - Apply steady n=3 braking to establish range of rotational equilibria
  - Previous results doing this indicated increasing ion diffusivity (absolute and relative to neoclassical) as rotation/rotation shear decreased
  - Repeat experiment with BES to assess the change of low-k turbulence with decreasing rotation/rotation shear
  - Reproducible ELM-free condition difficult to obtain, but was able to get some range of powers and applied field amplitudes in ELM-free discharges; BES obtained
    - 0- to 400 – 1000 kA applied n=3 field
    - 1 to 4 MW

T&T Priority 1 XPs yet to run

XP1039 (0.5) - Comparison of turbulence in Ohmic H-mode (Kubota, Lee)

Fluctuation differences in L/H using correlation reflectometer, measure ion-neutral Renold's number

Requires: reflectometer, FIReTIP, GPI

Desireable: BES, high-k

XP1040 (0.5+0.5) - Sustained reversed shear ITBs at reduced power (Yuh)

Turbulence/transport evolution as smooth function in shear

Requires: RF (1-2MW), high-k.

Desirable: BES, reflectometer, FIReTIP

XP1036 (1.0) - P_{L-H} for D and He plasmas using RF (Battaglia, Zweben)

Requires: RF ramps (2+MW), GPI

Desirable: BES, reflectometer, FIReTIP

XP1038 (0.5+0.5) - Investigation of multi-scale turbulence (Smith, Kubota)

Parameter scan affecting low-k turbulence

Requires BES, reflectometer

Desirable: high-k, FIReTIP

T&T Priority 1 XPs requesting time to finish

XP1037 - Parametric Dependence of High-k Turbulence (Ren)

- High-k turbulence dependence on ν, B_t, I_p
- Full range of collisionality not yet achieved
- Inboard high-k radial position comparison

XP1042 - Intrinsic torque using torque transients (Solomon)

- Finish remaining XP with n=3 field interaction with intrinsic drive

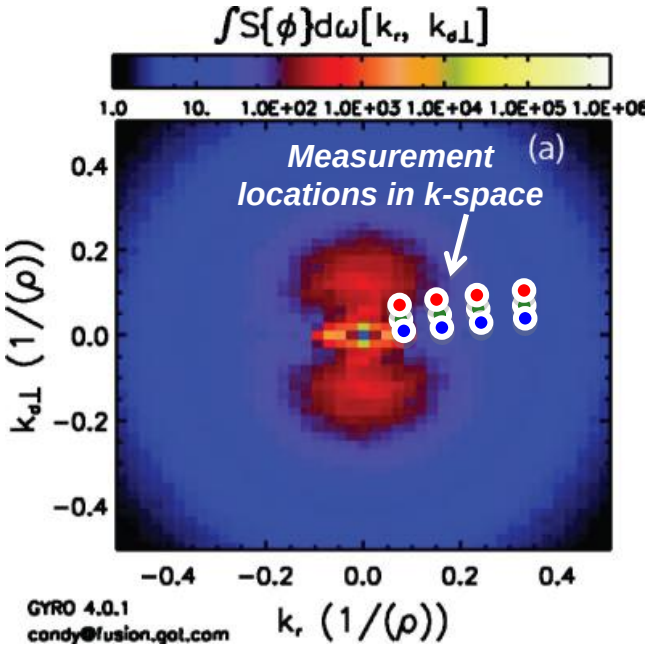
XP1041 - Joint NSTX DIII-D poloidal rotation experiment (R. Bell)

- Initial half day unsuccessful due to high impurities
- Both attempts suffered from machine conditions, Ar/N_2 on 1st attempt and PF3 trips on the 2nd.
- Low non-carbon impurity content with sufficiently

Additional T&T XP considerations

XP1070 - Investigation of ETG turbulence isotropy (Smith)

- Measurement of high-k fluctuations in k-space
- NSTX unique capability to measure different **k_θ/k_r ratios**,
- High-k gone after upgrade
- Fully reviewed, XP ready to run



XP(TBD) – Impurity Transport in the NSTX edge (r/a>0.8) (Clayton, Tritz)

- Short neon puffs and the high resolution ME-SXR
- High res ME-SRX, new postdoc