# Progress and plans with modeling of edge turbulence in NSTX

**M.V. Umansky**

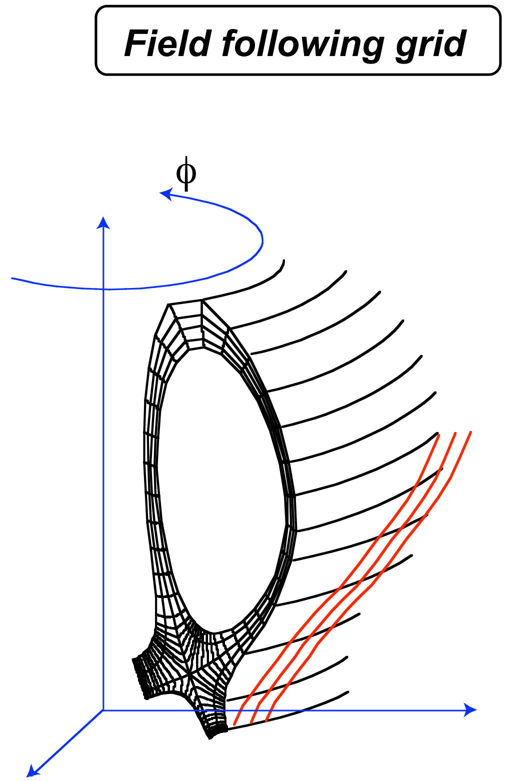
**LLNL**

**Presentation at**
**NSTX Boundary Physics 5-year plan meeting**

**Feb. 12, 2007**

# BOUT (BOUndary Turbulence) is a unique modeling tool for tokamak edge plasma turbulence*

- **Fluid equations based on Braginskii equations for $N_i$, $T_e$, $T_i$, $V_{||e}$, $V_{||i}$, and $\varpi$**
- **Spatial discretization on 3D mesh in real geometry**
- **Time integration by implicit ODE solver PVODE**
- **Parallel implementation with MPI**




---

*Xu et al, Contrib. Plasma Phys. 38, 158 (1998)*

# BOUT code has been recently improved and tested

- **A new version of the code, BOUT-06, is a substantial redesign emphasizing improved general structure**

- **The code has been verified on a number of linear and nonlinear test problems:**

  **- interchange instability, drift instability, acoustic waves**

  **- coupling between the Alfvenic dynamics and electron pressure (suggested by Dr. B.D. Scott, IPP)**

  **- real tokamak geometry benchmarked with UEDGE**

- **BOUT-06 passes all these tests; at this point there is virtually no doubt the code is solving the equations correctly, as long as the solution is resolved on the grid**

# BOUT-06 is showing encouraging results for NSTX

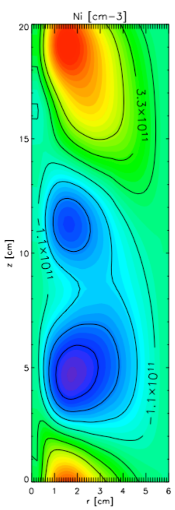
- Using a "4-field model" based on equations for $N_i$, $V_{e||}$, $V_{i||}$, $\varpi$ - a subset of full-blown BOUT model - with $T_{e,i}$ fluctuations set to zero.
- The full model is completely functional, however the reduced model is faster, more convenient for experimentation
- Main parameters of saturated turbulence obtained so far
  - $L_{rad}$ ~ 5 cm OK
  - $L_{pol}$ ~ 5 cm OK
  - $\delta N/N$ ~ 10 % OK
  - $\tau$ ~ 5-10 $\mu$S ??? - Experimental $\tau$~25-30 $\mu$S
- Work in progress on resolving of the time scale issue

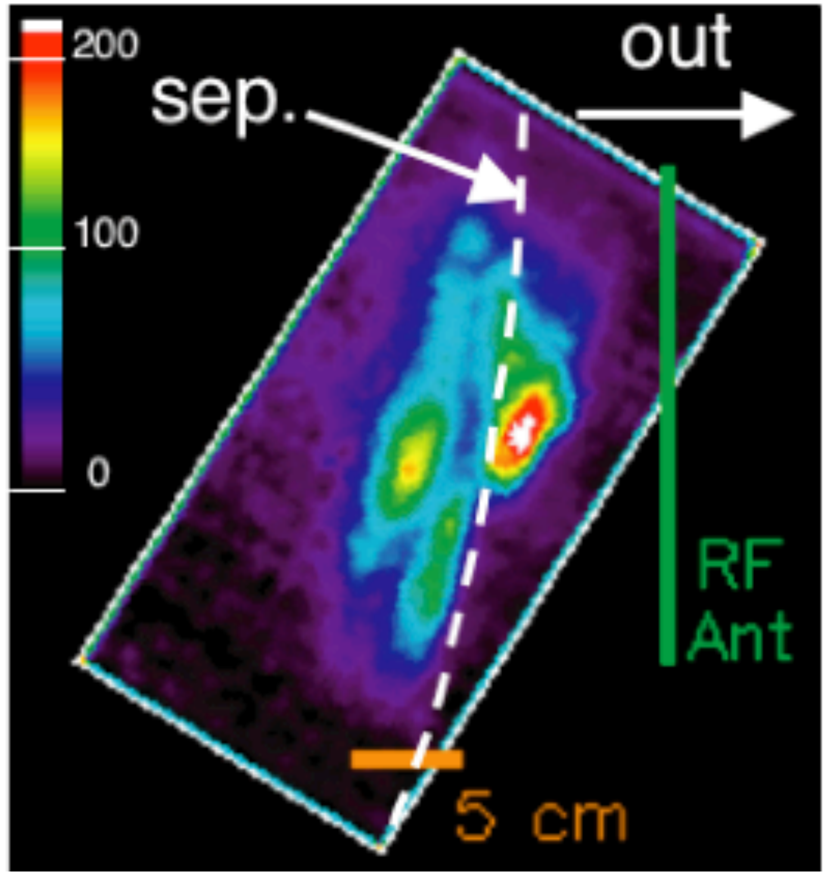
# BOUT results and GPI data seem to have similar cross-field spatial scale ~5 cm

**On same scale**

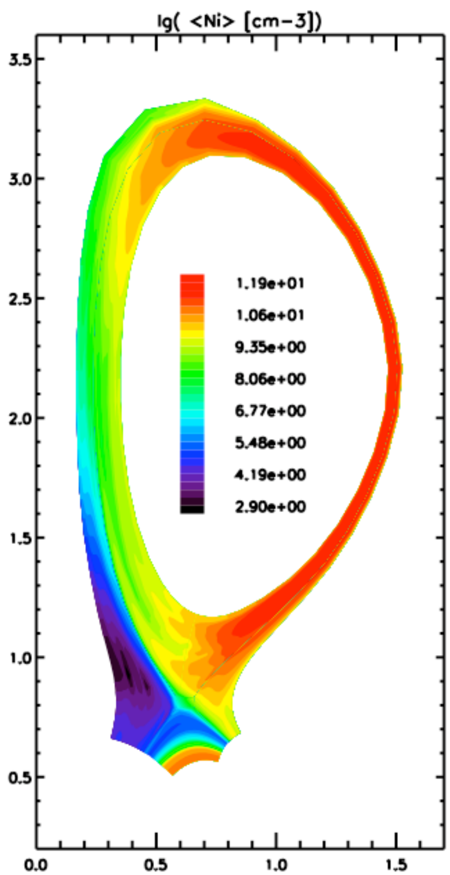
**BOUT and GPI data ⇒**

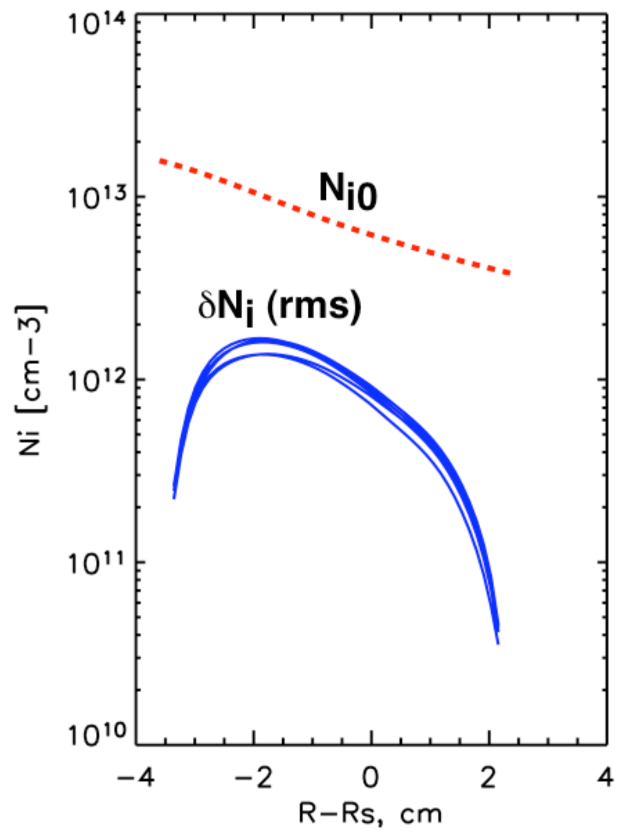
⇓



# Spatial distribution and magnitude of calculated rms <$N_i$> look reasonable



# Issues and tasks for the near term, ~1-2 years

- **Investigate the discrepancy in the time scales**
- **Investigate the radial electric field and flow shear**
- **Investigate the effect of nonzero $\delta T_{ei}$**
- **Investigate the effect of radial boundary conditions; try double-null geometry**

# Issues and tasks for the longer term, ~2-5 years

- **Try to understand the physics of transport, formation and dynamics of density blobs**
- **Try to understand the physics of L-H transition and H-mode pedestal**
- **Try to understand the physics of ELM instability/evolution**
- **Engage NSTX scientists in using BOUT, make it a community code**

# Summary

- BOUT has been redesigned and thoroughly tested on a suite of verification test problems
- BOUT-06 shows encouraging results for NSTX
- We have outlined a set of tasks for BOUT for near term and longer term - lots of work but doable
- The good ties between LLNL and NSTX will promote progress in this area