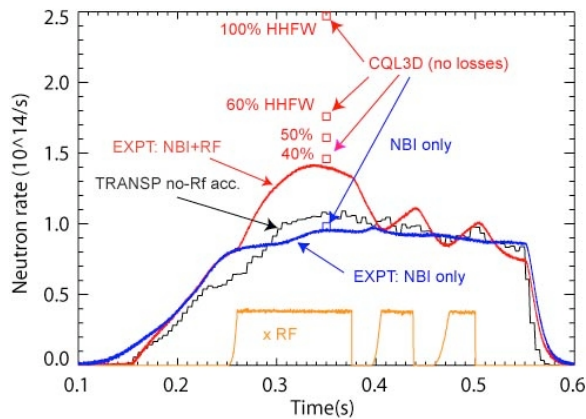# Computational Modeling Comparisons with NSTX
(Cql3d/Genray/DC/Aorsa for HHFW/NBI/CD, Finite-Orbit_width Effects, Synthetic Diagnostics)

R. Harvey, Yu. Petrov (CompX) working with F. Jaeger(ORNL),
C. Phillips, G. Taylor, J. Hosea, B. LeBlanc, D. McCune, K. Indireshkumar (PPPL)
Deyong Liu, Bill Heidbrink (UCI), D. Smithe (Tech-X)
Research Forum, PPPL, Dec. 1-3, 2009

Recent Work:

- CQL3D + GENRAY (for rays) gives estimate of HHFW absorption, including NBI,
 and provides nonthermal D$^+$ distributions for calculation of FIDA, NPA and dN_n/dt:

#130608, GENRAY+CQL3D, NBI & NBI+HHFW

B. LeBlanc, APS'09, Good agreement with
NBI, but need losses (finite-orbit) with HHFW.

#130608, Maxwellian damping: AORSA,GENRAY,TORIC

Code	Power to:	CHERS $T_i(0)\sim2$ keV	4 X CHERS $T_i(0)\sim2$ keV
AORSA	e	94	41.2
	D	.21	22.9
	H	5.8	35.9
GENRAY	e	96	39.2
	D	0.2	30.3
	H	3.3	28.5
	C	0.5	2.0
TORIC	e	88.9	26
	D	0.4	41.6
	H	10.7	32.4

C.K. Phillips, APS'09, Reasonable
agreement with some differences in detail.

#128739, FIDA from HHFI modeling
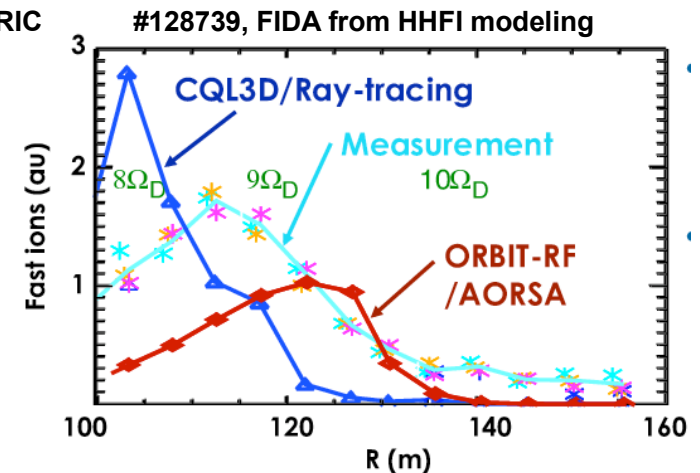
M. Choi, APS'09, Measured FI profile
intermediate between CQL3D and ORBIT-RF

In Progress and Planned Modeling:

- Collaboration with Kumar in coupling genray/cql3d to TRANSP.
- Finite-orbit-width corrections, and a full finite-orbit CQL3D are in progress.
  NSTX is the most clear application for this work.
- Edge modeling of electron heating in NSTX HHFW near-fields (from D. Smithe)
  is planned (using DC modification).

Finite-Width- (Lorentz-) Orbit Diffusion Coefficient Calculation with DC

DC appropriately averages over ~10^6 Lorentz orbit coordinate "kicks" per radius after one (or more) poloidal turns, in combined equilibrium+AORSA HHFW fields
**==>**
RF bounce-averaged diffusion coeffs including finite-orbit-width effect and multiple gyroharmonic interactions at each gyro-period.

Has been incorporated in CQL3D for tighter orbit machines and is work in progress for NSTX. It leads to substantial variations from QL theory, as distribution anisotropy evolves after RF turn-on.
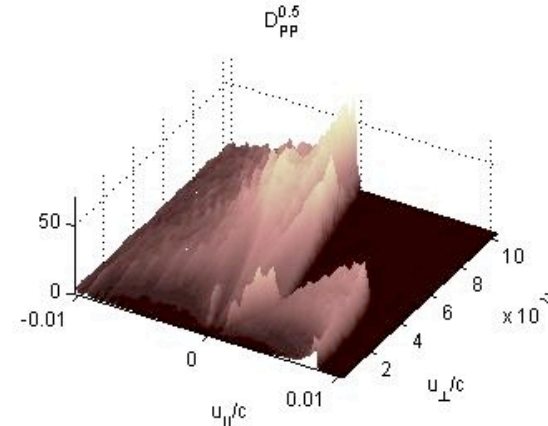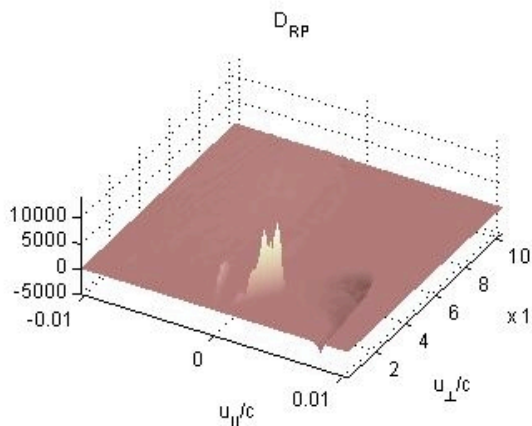
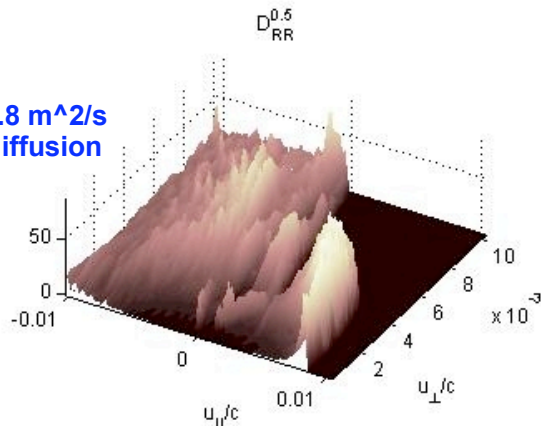**Research Plan: -Apply DC to NSTX, incl radial diffusion and orbit losses.**
-Consider application to Gorelenkov AE modes.

Comparison of Lorentz, gyro-avg, and guiding-center Orbits. Various pitch angles, at 100 keV. #108251

u=p/m,p=pitch angle, R=major radius.
Lorentz diffusion coefficients at rho~0.4
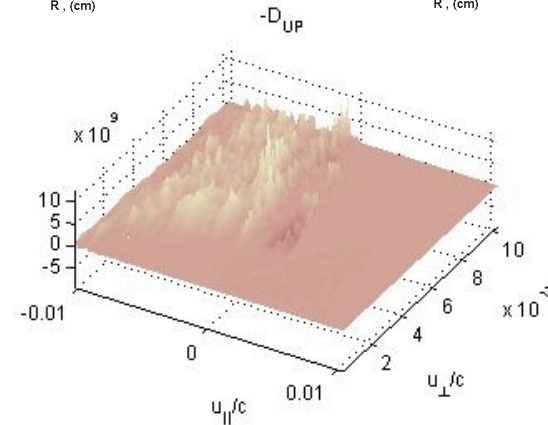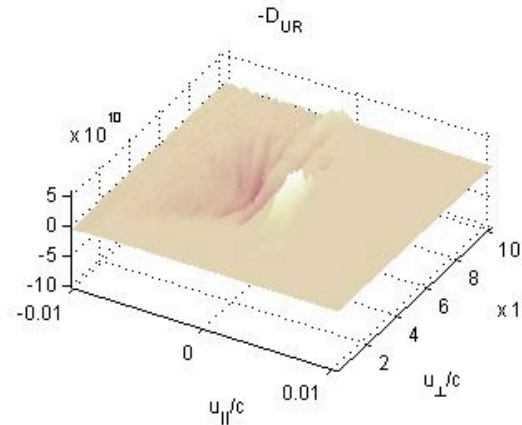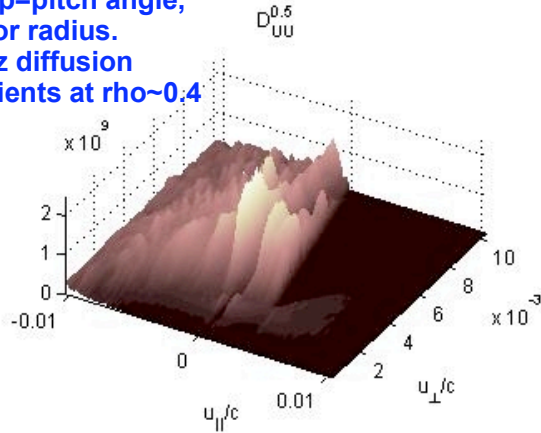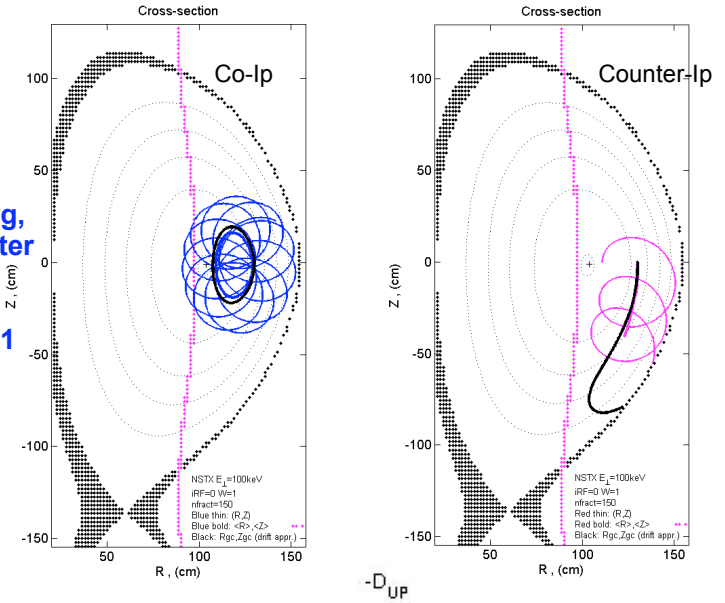
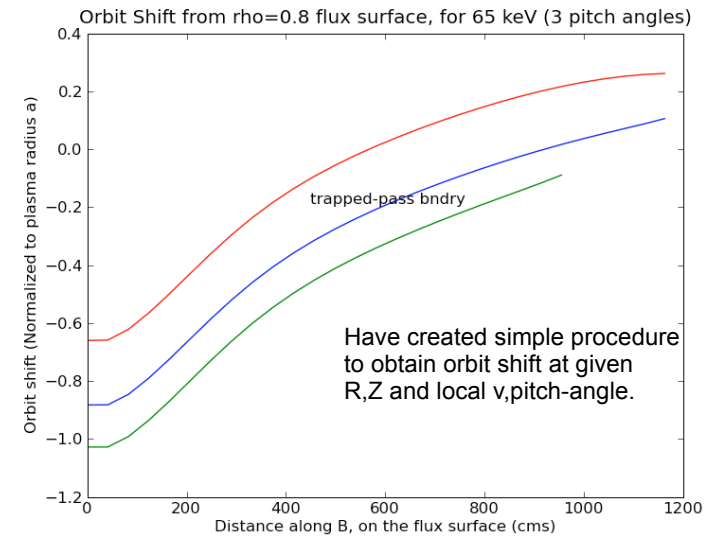**Up to 0.8 m^2/s radial diffusion**

Finite-Orbit-Width in CQL3D

•**A first-order orbit-width calculation has been added to the otherwise zero-orbit-width CQL3D and is being used to attribute FI distributions in the outer plasma to CQL3D distributions with BA position towards the plasma magnetic axis. Corrections to Dql/ NBI source are in progress. (With Heidbrink/Liu).**

•**Full finite-orbit guiding-center version of of CQL3D is also expected to begin this FY.**

Orbit Shift from rho=0.8 flux surface, for 65 keV (3 pitch angles)

trapped-pass bndry

Have created simple procedure to obtain orbit shift at given R,Z and local v,pitch-angle.

Orbit shift (Normalized to plasma radius a)

Distance along B, on the flux surface (cms)

Edge Plasma Studies with Realistic Antenna Fields

•**Object is to examine nonlinear edge electron acceleration in near-antenna HHFW fields, as an possible explanation of observed field-aligned heating.**

•**Dave Smithe (Tech-X) has coupled a CAD-file representation of the NSTX antenna (APS'09) to the VORPAL time-domain plasma model, and will shortly provide RF fields in front of the antenna up to slightly inside the LCFS.**

•**These will be used in a adaption of DC to obtain NL coupling of RF to electrons (trapping, Fermi acceleration, ponderomotive forces).**