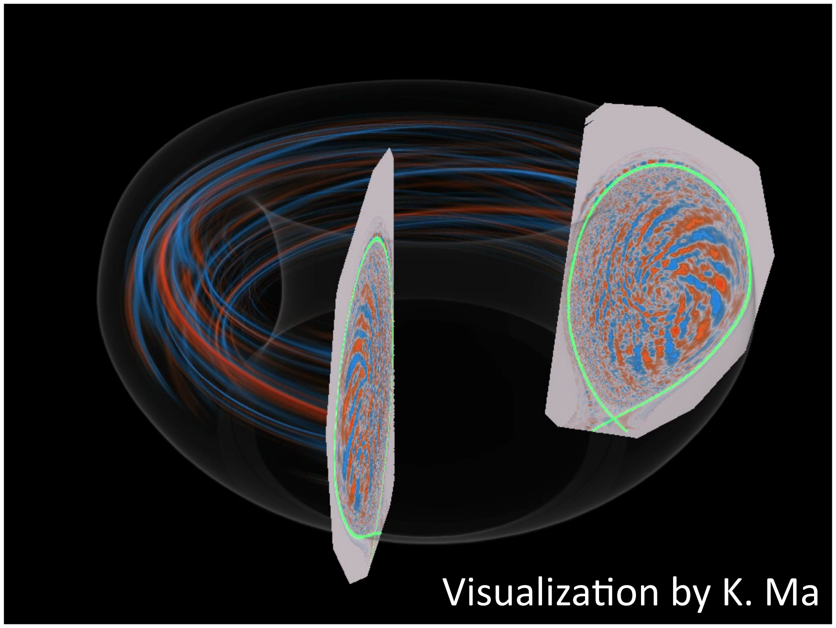
Li transport study in XGC0 and XGC1 (C.S. Chang, et al)

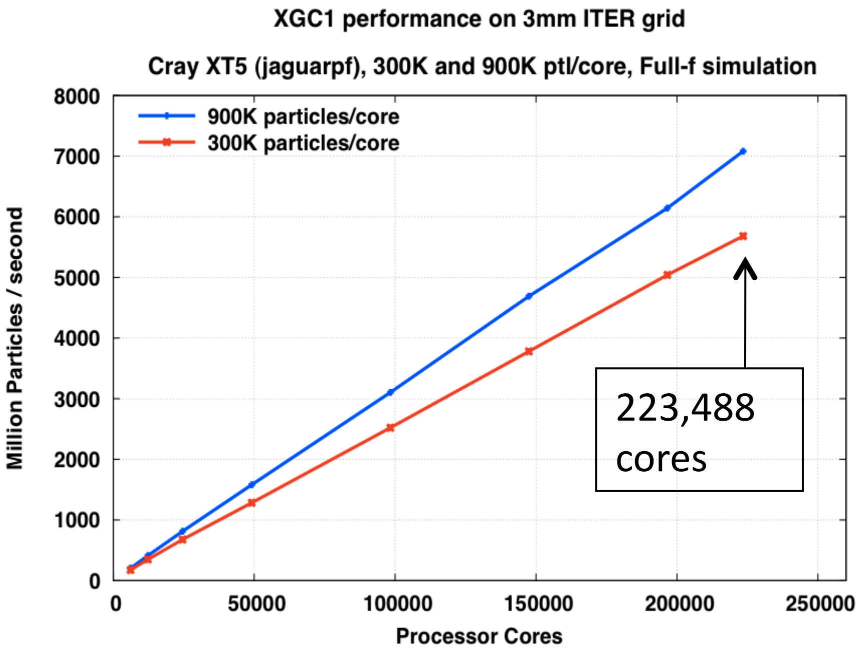
- Simulation: as much first-principles as possible, diverted geometry
  - XGC0: Neoclassical guiding center, not simulating turbulence, but modeling in the anomalous transport
  - XGC1: gyrokinetic neoclassical and turbulence
  - Both XGC0 and XGC1 will include Li and impurities, neutral transport with atomic physics, wall interaction coefficients, and radiation
  - Li effect on ELM stability boundary, in coupling with M3D-C1 and Elite
  - Li effect on the core plasma and impurity transport
  - Li effect on divertor heat load width will also be studied simultaneously
- Diagnostics
  - Measure Li and impurity profile time-dependence at all radii, 2D preferred
- Code development
  - Move Li and impurity particle routine from XGC0 to XGC1
  - Add poloidal electric field routine to XGC0
  - Couple M3D-C1 and XGC1 into EFFIS framework
  - Complete the kinetic electron capability to XGC1 across separatrix (discussed elsewhere)

Comprehensive gyrokinetic code XGC1
(Unique in the world fusion program)

- Diverted magnetic field geometry with material wall BD condition
- Includes magnetic axis: wall-to-wall simulation
  - Lagragian operation (particle time-advance) in cylindrical coordinates
  - Eulerian operation (field solver) in field-following coordinates
- Wall-recycling of neutral particle with atomic physics
- Multiscale simulation of neoclassical, turbulence, neutral particle, and atomic physics
- Aim for 24 hour simulation by utilizing HPC

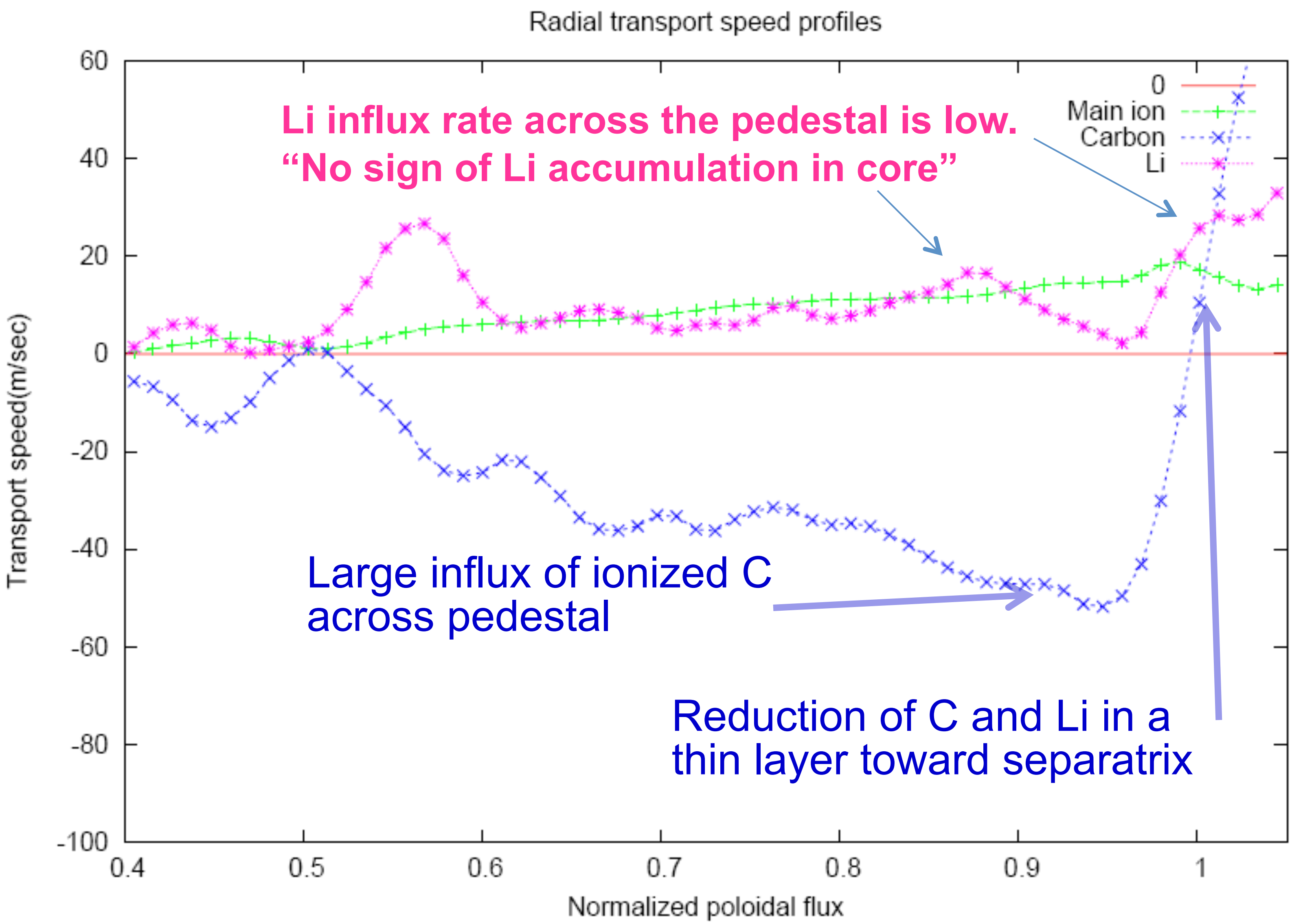


Ion turbulence fills the whole volume, but is confined by magnetic separatrix surface (green curve). DIII-D geometry is used.



XGC1 scales efficiently all the way to the maximal Jaguarpf capability, with MPI+ OpenMP. Routinely uses >70% capability.

XGC0 says, at n_C/n_e=10%, Li moves outward while C^{+6} moves in at ψ_N<1.

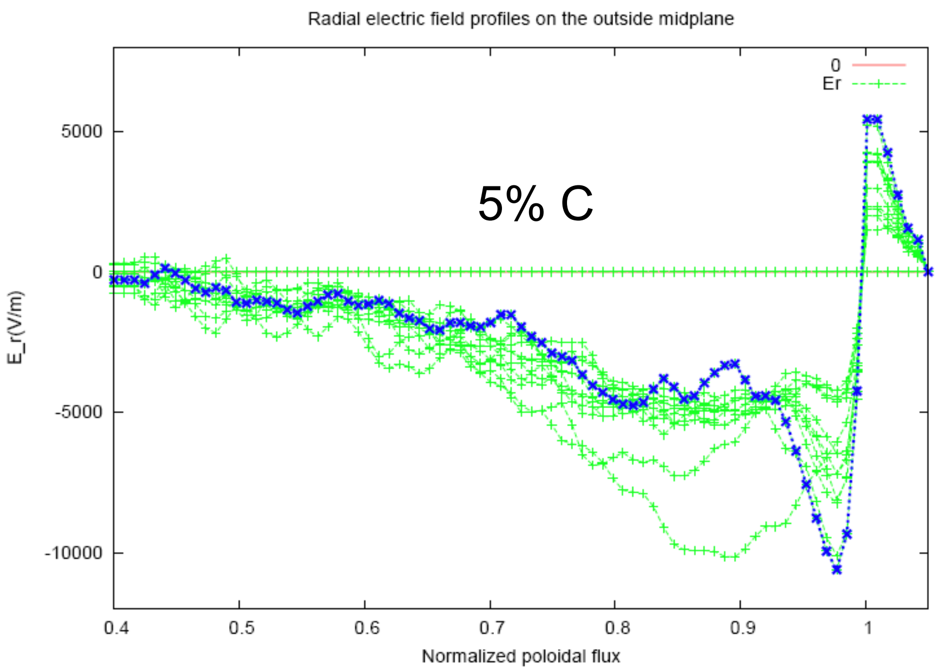


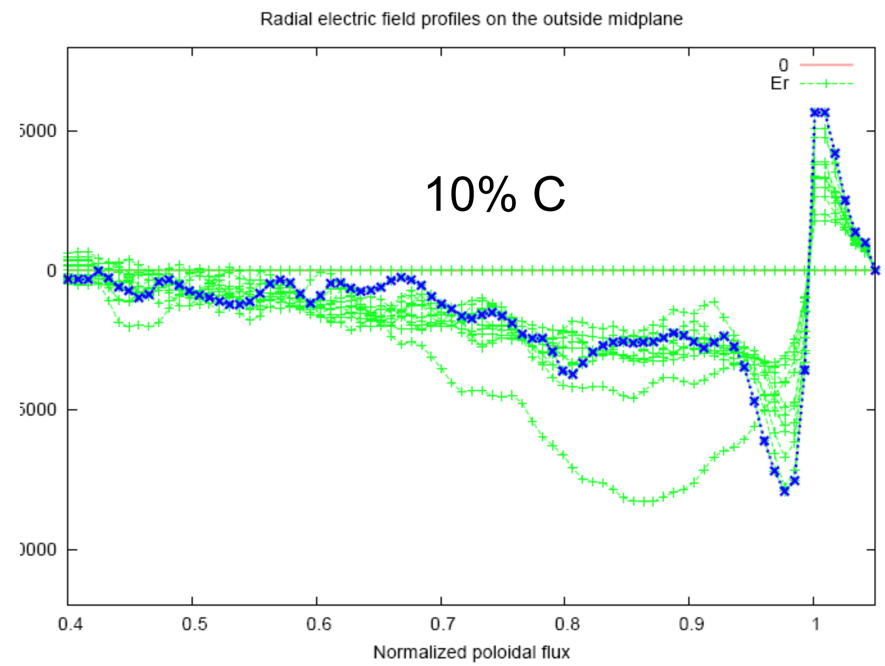
Carbon depletion from pedestal strengthens ExB shearing

E_r-well depth/width at n_C/n_e=5% is stronger than at 10%

Weaker X-loss effect by C in pedestal

$V_{\nabla B} \propto 1/Z$, $v_{||} \propto 1/m^{1/2}$: Thus, $V_{\nabla B}/ v_{||} \propto m^{1/2} / Z$: where Z_C/Z_D=6, $(m_C/m_d)^{1/2}$=**$6^{1/2}$**





Conjecture: Reduction of P_{L-H} with abundance of Li in the scrape-off layer:

- XGC0 observation: reduction in C^{+6} in the pedestal by high Li population in scrape-off layer (C^{+6} screening, but C^0 can still penetrate)
- Momentum conservation is not a constraint in scrape-off: Collisional transport yields Γ_C>0 just outside separatrix. → higher C collisionality by abundant Li, → higher Γ_C>0 just outside separatrix → more C depletion in pedestal → Increased ExB shearing rate.in pedestal

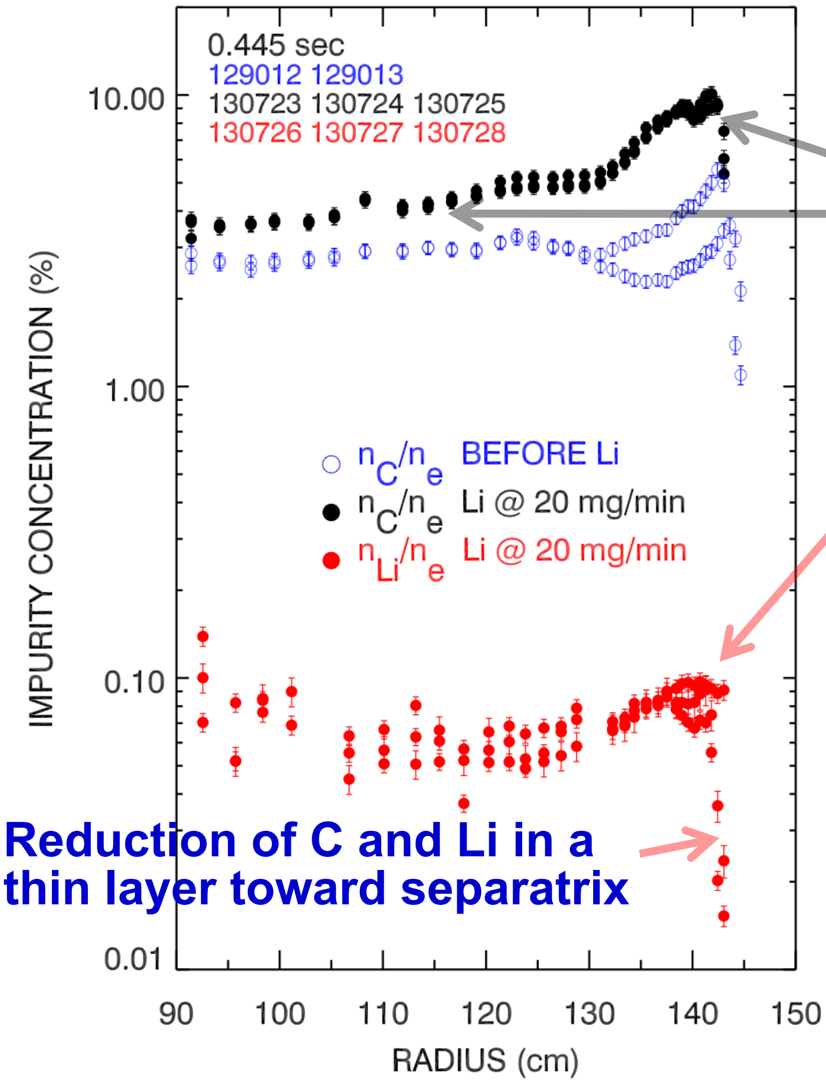
Conclusion and Discussion, from Li Symposium 2011

- **It appears that many of the Li behaviors and its influence on plasma in the H-mode, as seen in NSTX, could be related to neoclassical physics**
  - Blockage of Li influx, except in the early low-carbon stage, following the L-H transition
  - Enhanced flux of ionized C into core throughout H-discharge period
  - Reduction of C and Li in a thin layer toward separatrix
  - Lower $P_{L\text{-}H}$ with Li evaporation
  - Broadening n_e pedestal
- The initial large drop of C into hollow profile appears to be outside of neoclassical physics: A transient turbulence-neoclassical effect is suspected

  → **to be investigated from XGC1 gyrokinetic edge turbulence-neoclassical code**
- **A more realistic plasma "simulation," as opposed to the "academic" study, is needed**
- **Divertor heat load scaling with Li is to be studied. ADAS data to be used, in collaboration with the Auburn group.**

New Lithium Density Measurements in H-mode

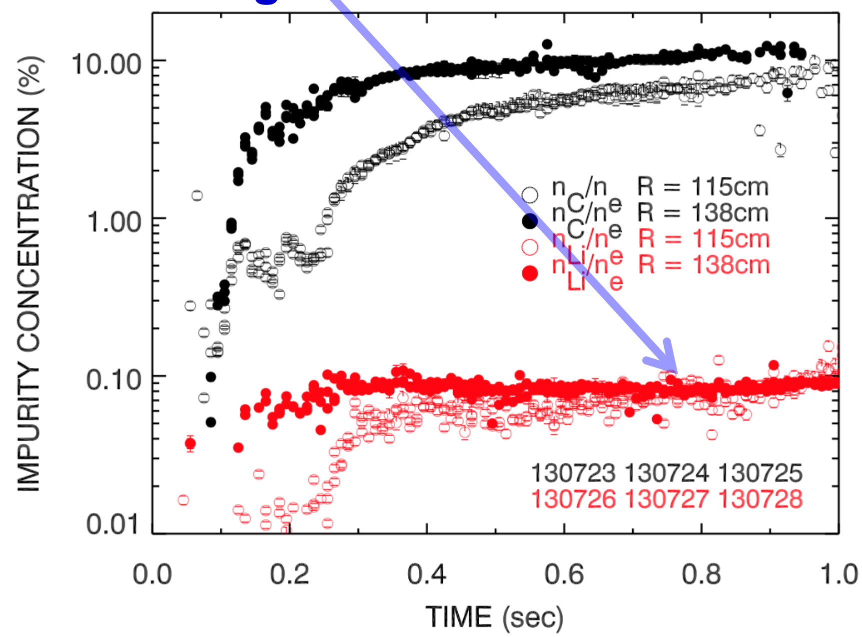
(We will try to connect the blue items with XGC0 simulation results.)



- Large drop of n_C at L-H transition into hollow profile → Probably a transient, nonlocal turbulence effect
- **Carbon increases with Li evaporation**
  - **C influx rate across pedestal is high**
  - **C accumulation in core**
- **Li screening at later time, but not earlier**
- **P_{LH} goes down with Li**

Li influx rate across the pedestal is low

"No sign of Li accumulation in core"



Reduction of C and Li in a thin layer toward separatrix

Figures are from R. E. Bell.