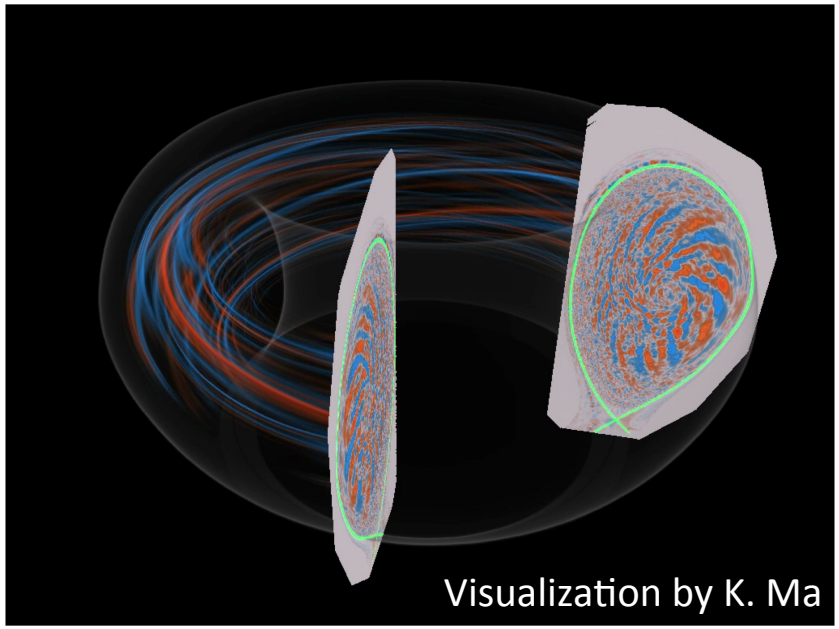
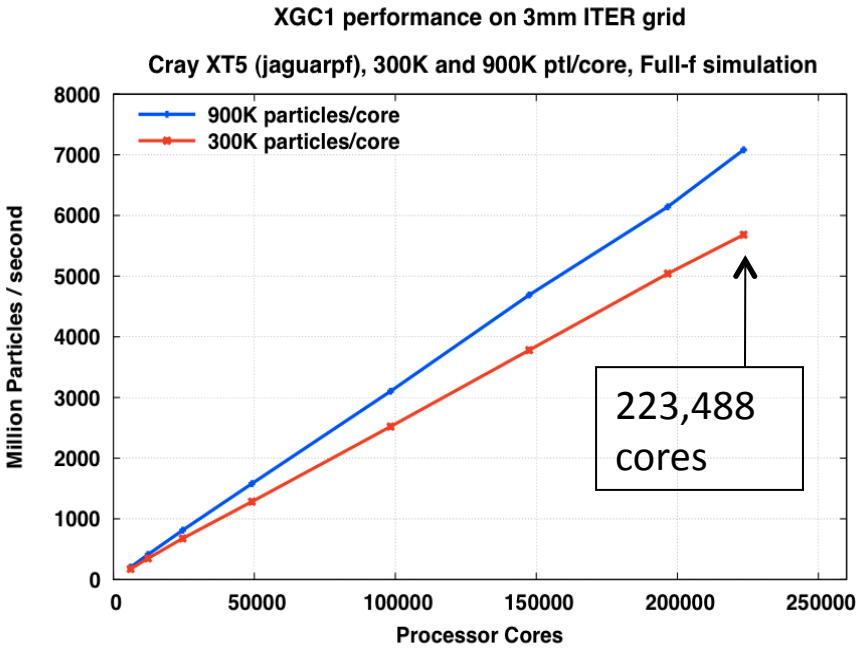
Comprehensive gyrokinetic code XGC1
(XGC0 is an axisymmetric version of XGC1: much faster)

- 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.

Pedestal-ELM cycle study in coupled XGC0, XGC1, M3D-C1

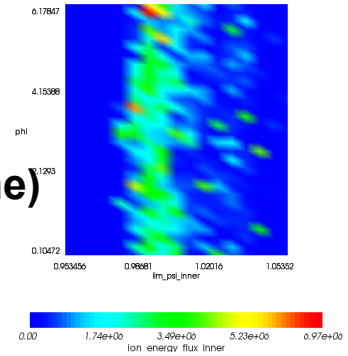
- **Simulation: as much first-principles as possible, diverted geometry**
  - **XGC, M3D_omp, Elite, M3D_mpp have been integrated in automated EFFIS (End-to-end Framework for Fusion Integrated Simulation)**
  - **Kinetic pedestal buildup in XGC0, with turbulence information from XGC1**
  - **MHD ELM instability in M3D-C1**
  - **XGC1 will also study "gyrokinetic ELMs"**
  - **Divertor heat load width will also be studied simultaneously**
  - **XGC0 and XGC1 will contain Li effects**
- **Diagnostics**
  - **Radially distributed fluctuation properties micro and MHD scale: δn, δT, k, ω, V'_{ExB}, correlations**
  - **Detailed particle and heat load profiles on both outer and inner leg plates**
- **Code development**
  - **Present XGC1 capability:**
    - ITG + neoclassical + neutral in diverted geometry
    - E&M turbulence in non-diverted geometry
  - **Present XGC0: In production use. Lacks poloidal electric field**
  - **Near Future (~1 year) XGC1**: E&M turbulence + neoclassical + neutrals + impurities
  - **Near Future XGC0: Add poloidal electric field**
  - **Longer Term XGC1: ETG, NBI**
  - **Add M3D-C1 and XGC1 into EFFIS**

Kinetic-MHD coupled simulation for pedestal-ELM cycle in automated EFFIS framework

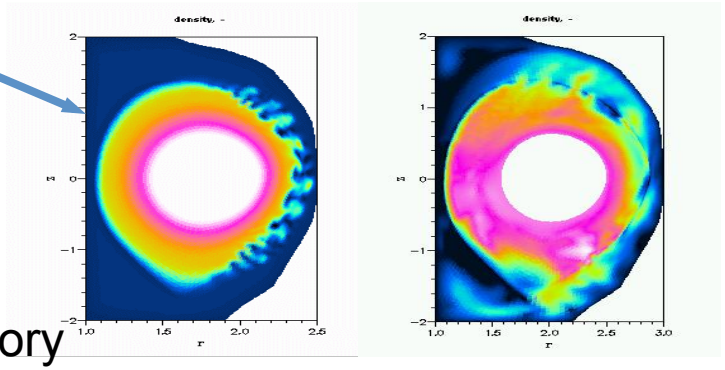
Linear stability check (Binary **Elite**)

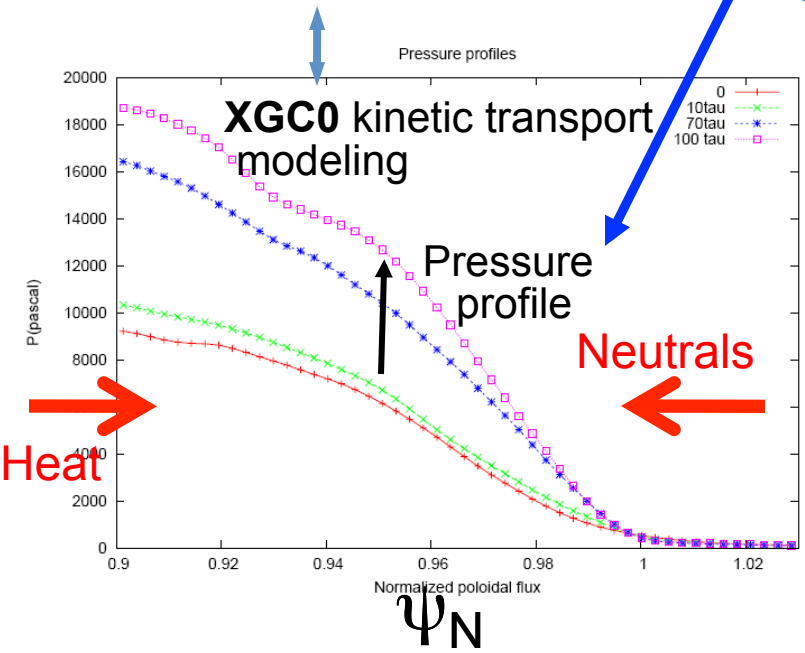
B-reconstruction and mesh interpolation by **M3D-OMP**

Divertor Heat Load
(2010 OFES Milestone)



ELM crash in extended **M3D-MPP**



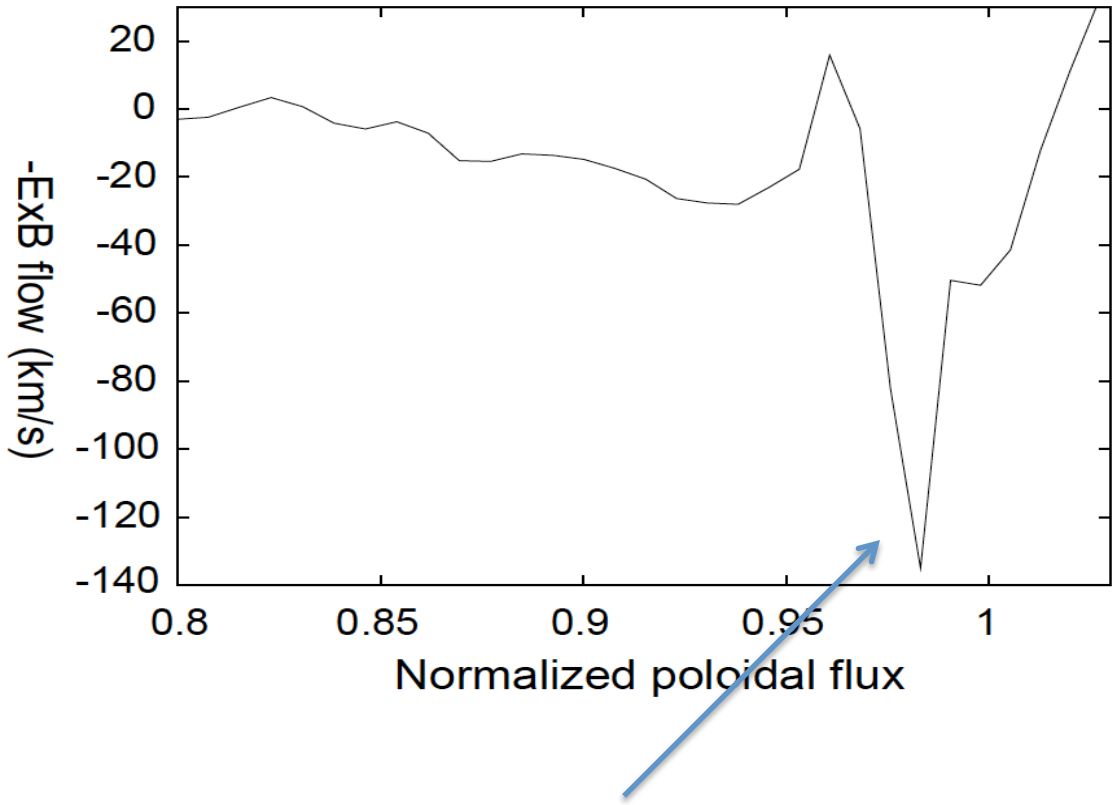


mxn Memory coupling of MHD turbulence

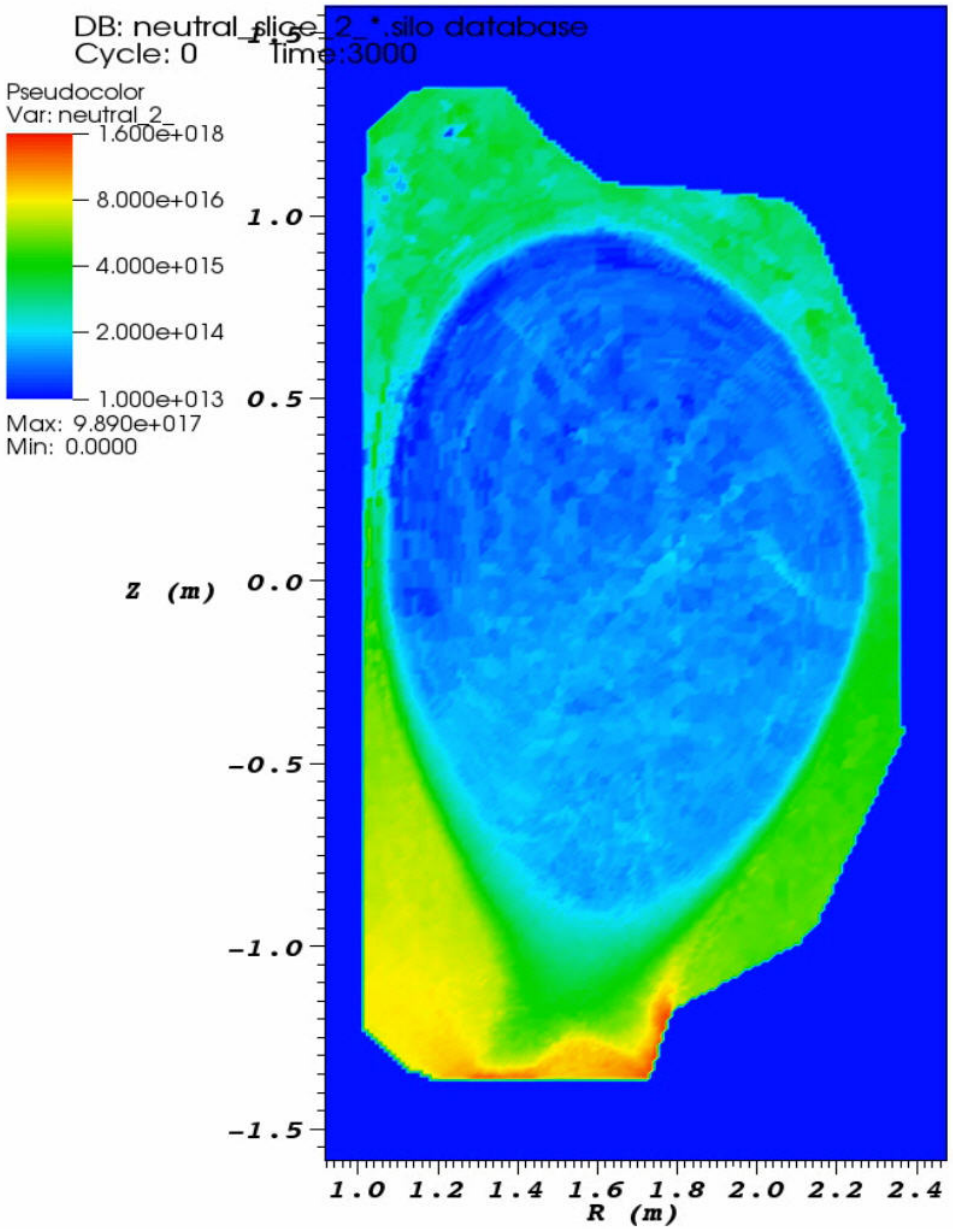
T=76
saturation

T = 496
relaxation

ExB flow in the edge region, from neoclassical X-transport and ITG turbulence physics, shows a negative E_r-well as seen in experiments.



The E_r-well formation is robust, from the separatrix effect (X-Transport, Chang, Phys. Plasmas, 2004 and 2009)



Neutral particle density distribution in realistic DIII-D edge geometry from XGC [simulation by D. Stotler].

Neutral particles interact with plasma in XGC0 and XGC1

- Monte Carlo transport
- Wall recycling
- Ionization
- Charge exchange