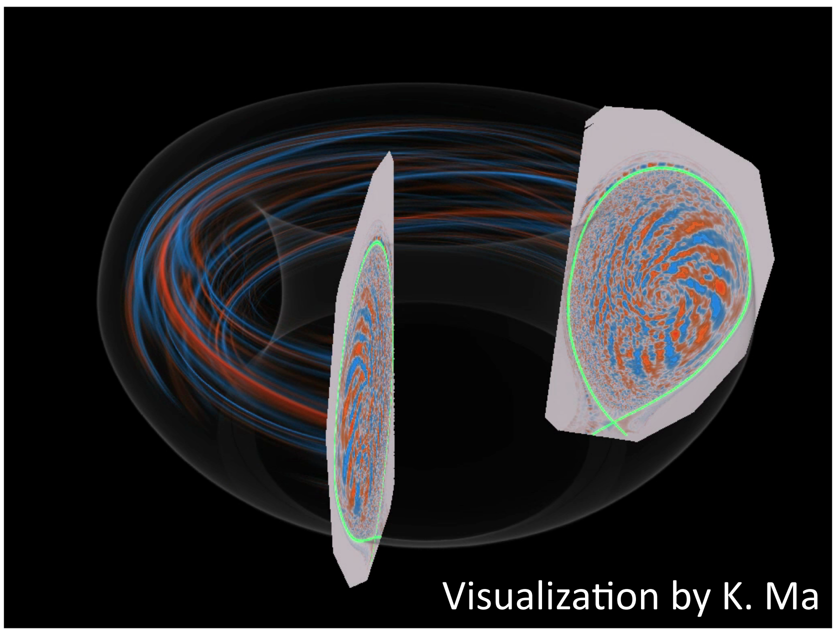
Study of H-mode pedestal in full-f GK XGC1 (Chang, et al)

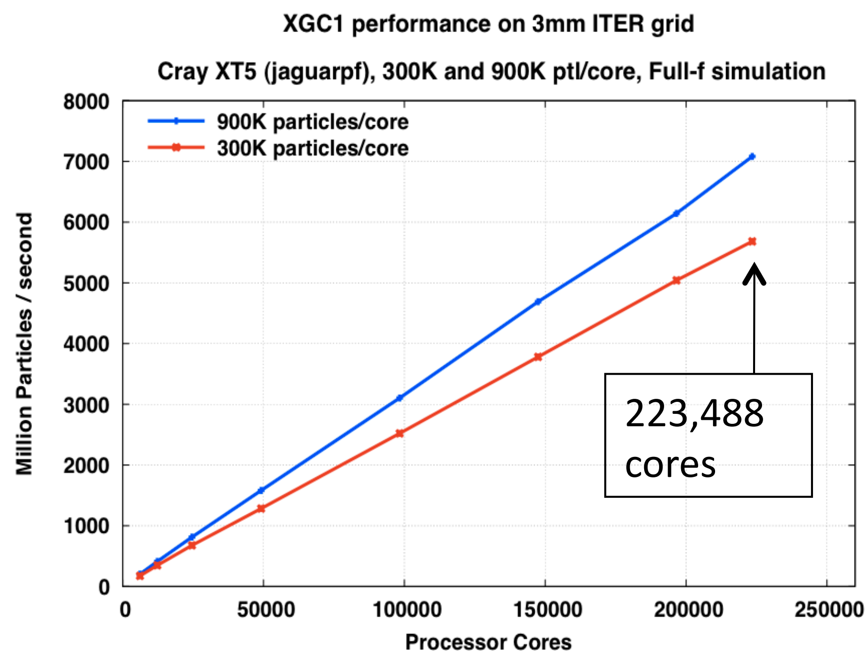
- **Simulation: first principles approach in diverted geometry**
  - **Nonlocal pedestal simulation, in self-consistent interaction with flux-driven core, SOL, and wall recycling**
  - **Multi-physics: Neoclassical, turbulence, impurities, neutrals, atomic physics**
    - Turbulence will include all the important electromagnetic modes (ETG will be handled on localized adaptive grids)
  - **Heat and particle sources, heat sink from atomic process in the pedestal and wall loss**
- **Diagnostics**
  - **Radially distributed turbulence property: δn, δT, k, ω, V'_{ExB}, correlations**
  - **Neutral density and temperature profiles, radiative loss measurement**
- **Code development**
  - **Present capability:**
    - ITG + neoclassical + neutrals in diverted geometry
    - Full-f electrostatic kinetic electron turbulence in non-diverted geometry
    - Delta-f electromagnetic turbulence in non-diverted geometry
  - **Near Future (~1 year)**: E&M turbulence + neoclassical + neutrals + RMP + impurities
  - **When NSTX-U is operational: ETG, NBI**

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

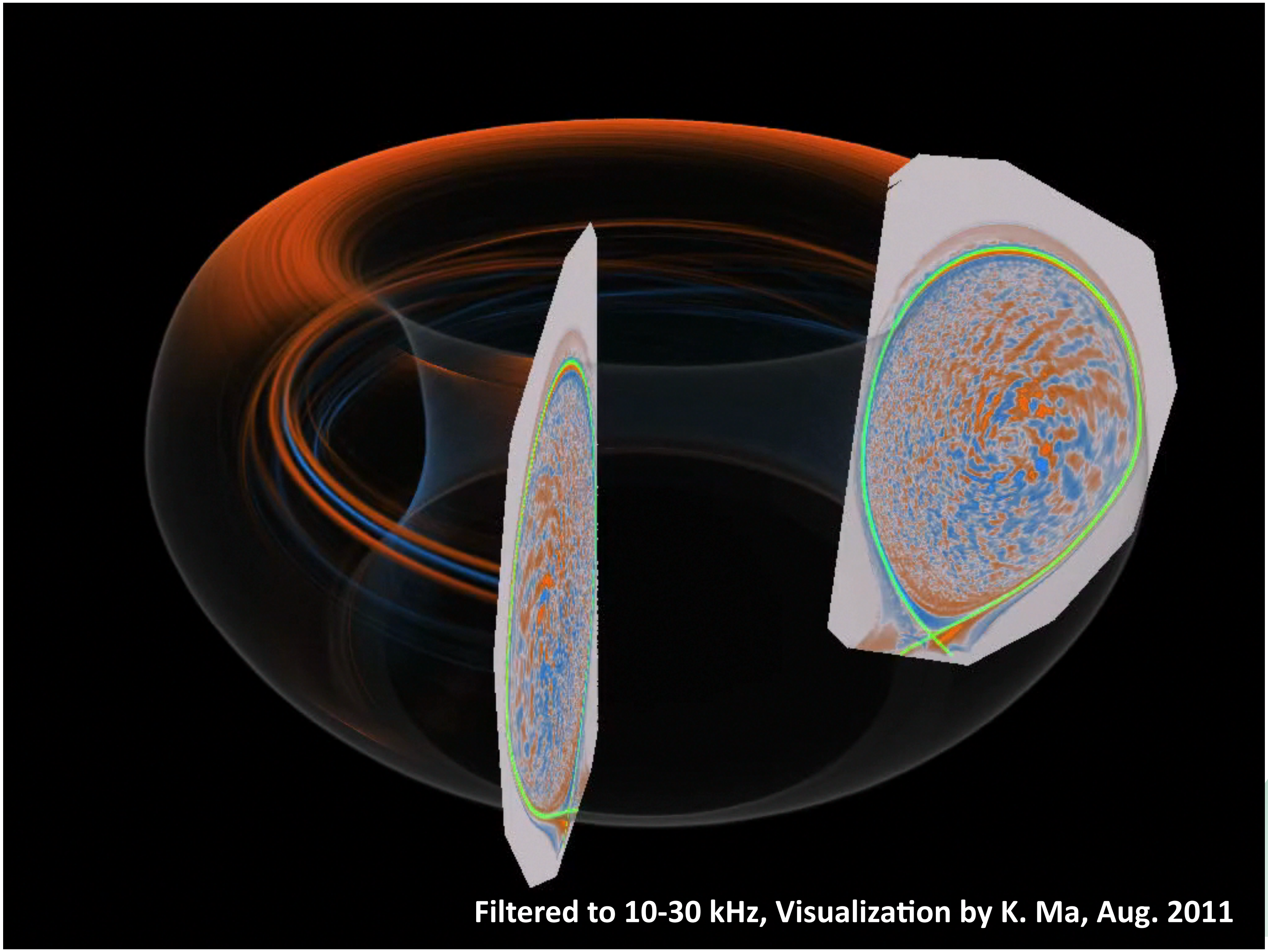


Ion turbulence fills the whole volume, but is confined by magnetic separatrix surface (green curve). DIII-D geometry is used.

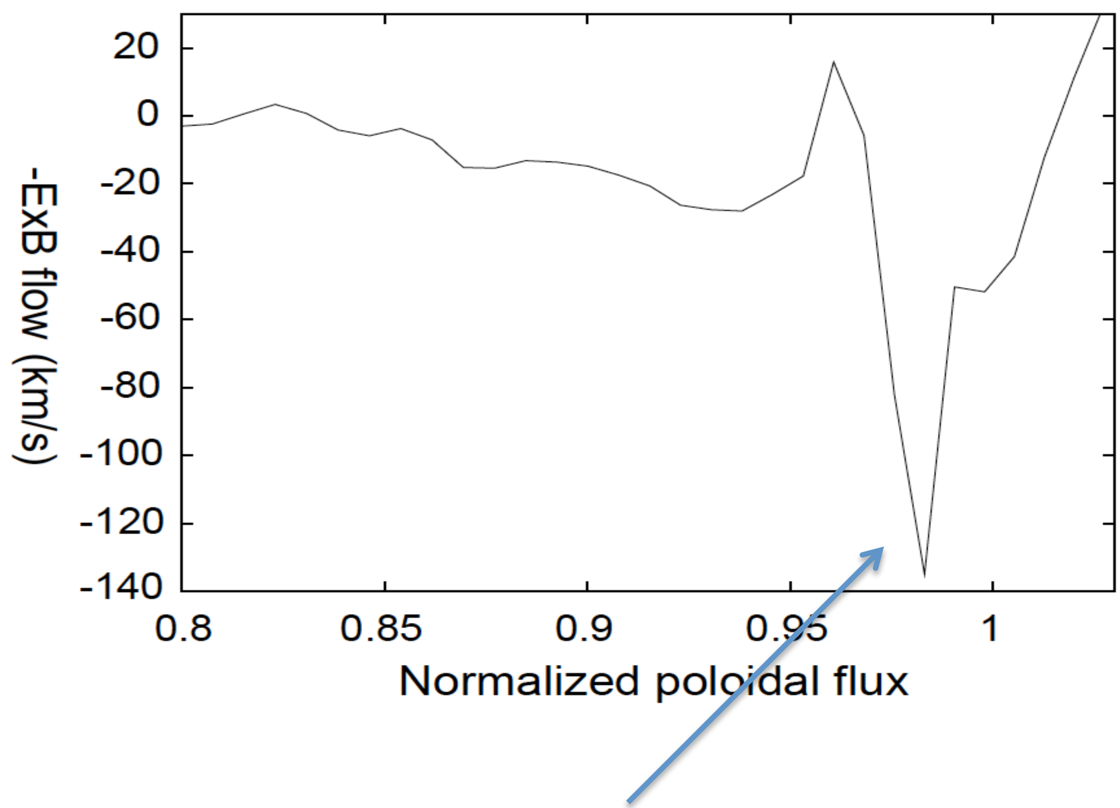


XGC1 scales efficiently all the way to the maximal Jaguarpf capability, with MPI+ OpenMP. Routinely uses >70% capability.

Ion turbulence fills up the whole volume including central core, but is confined by magnetic separatrix surface (green curve). DIII-D geometry is used with monotonic q>1.



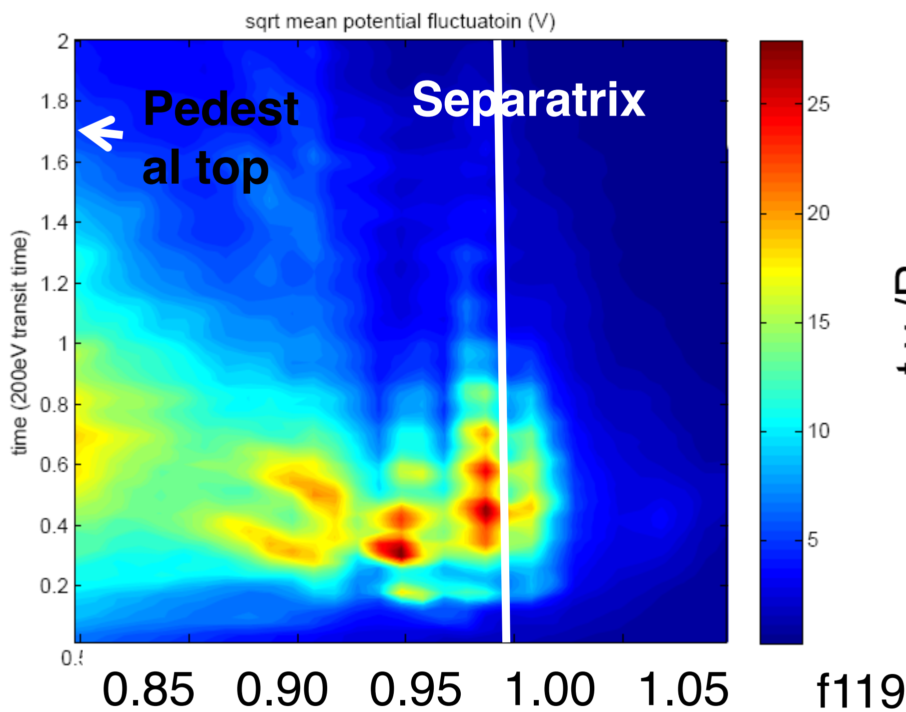
ExB flow in the edge region, from neoclassical X-transport and ITG turbulence physics, shows a negative E_r-well as seen in experiments.



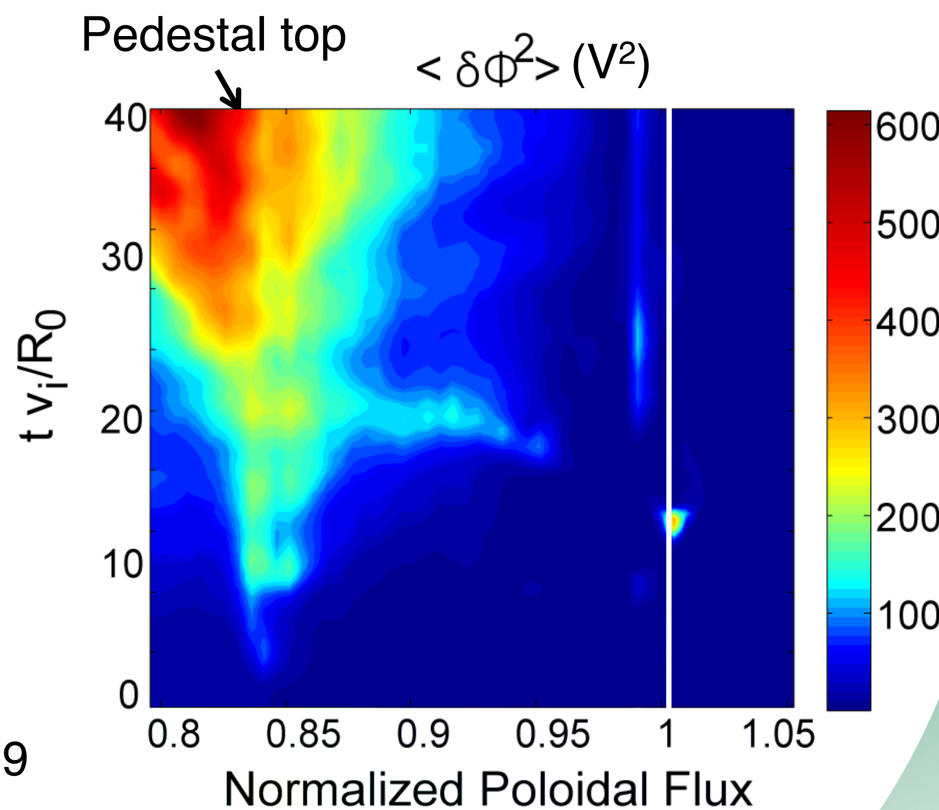
The E_r-well formation is robust, from the separatrix effect (X-Transport, Chang, Phys. Plasmas, 2004 and 2009)

ITG turbulence spreads into pedestal, combines with local electron turbulences, and yields residual turbulence

Artificial core-edge boundary distorts edge turbulence solution
→ ITG grid in the whole core is preferred while the edge grid is refined for smaller scale turbulence



Edge only simulation with a core-edge boundary



Edge ITG solution without an artificial core-edge boundary in a whole-volume simulation

Fully nonlinear collision operation

- We have both linear-based Monte Carlo operator and fully non-linear Fokker-Planck operator, at work in XGC0
- Chang-Hinton has been reproduced from nonlinear collisions within <20%