Computational Study of Neoclassical Transport in NSTX using GTC-NEO

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Outline

- The National Spherical Torus Experiment
- Plasma Transport in NSTX
- GTC-NEO Simulation Results
- Conclusions / Future Work

National Spherical Torus Experiment*

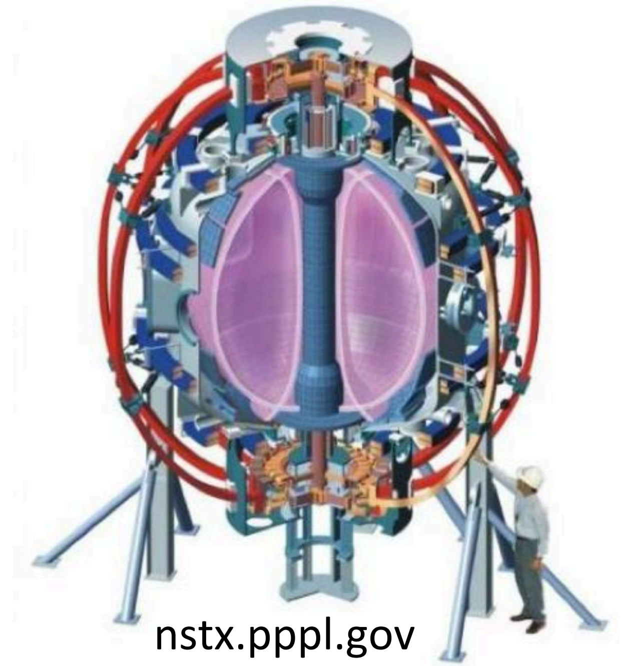
- Magnetic Confinement fusion device
- Low aspect ratio (“spherical”) $R_0/a > 1.26$
- Deuterium plasma with up to:

  1.3 MA plasma current

  7 MW Neutral Beam Heating

  6 MW Radio Frequency heating

  ~ 100 million degrees C



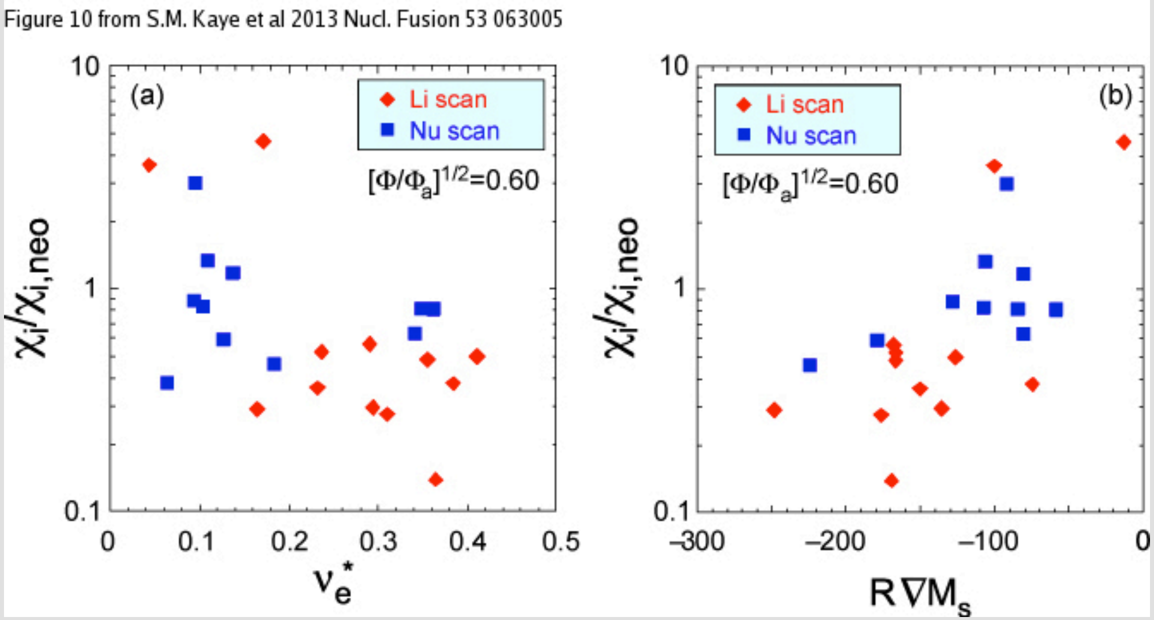
nstx.pppl.gov

Plasma Transport in NSTX

- Transport = motion of particles and energy
  - Classical = uniform E, B
  - Neoclassical = nonuniform E, B
    - Irreducible minimum
    - Gives drifts across B-field leading to trapped particle orbits
- In NSTX:
  - Ion thermal transport shows trend of increasing anomalous transport at lower collisionality*

$$q = -\chi n \text{ grad } T$$

Plasma Transport in NSTX



- In NSTX:
  - Ion thermal transport shows trend of increasing anomalous transport at lower collisionality*

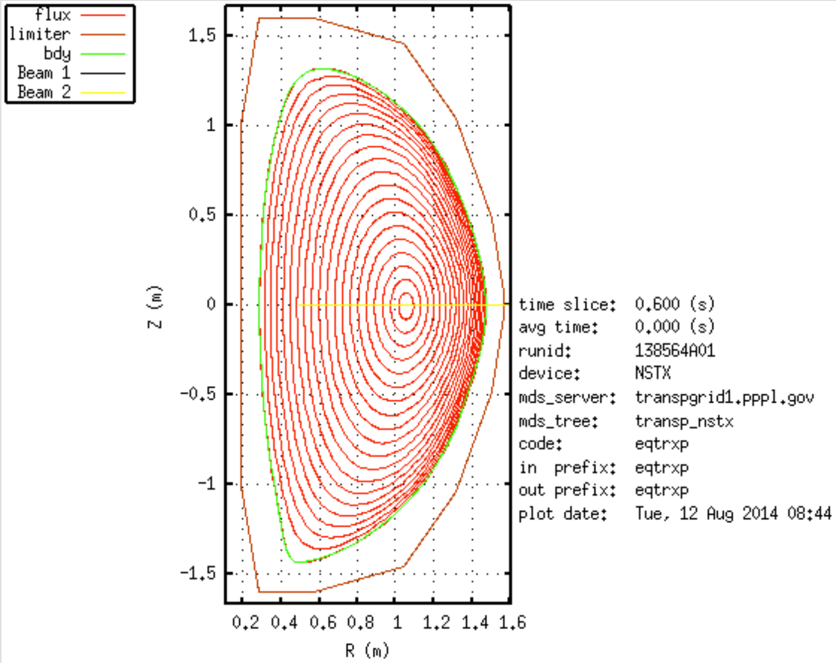
$$q = -\chi n \ \text{grad} \ T$$

Why GTC-NEO?

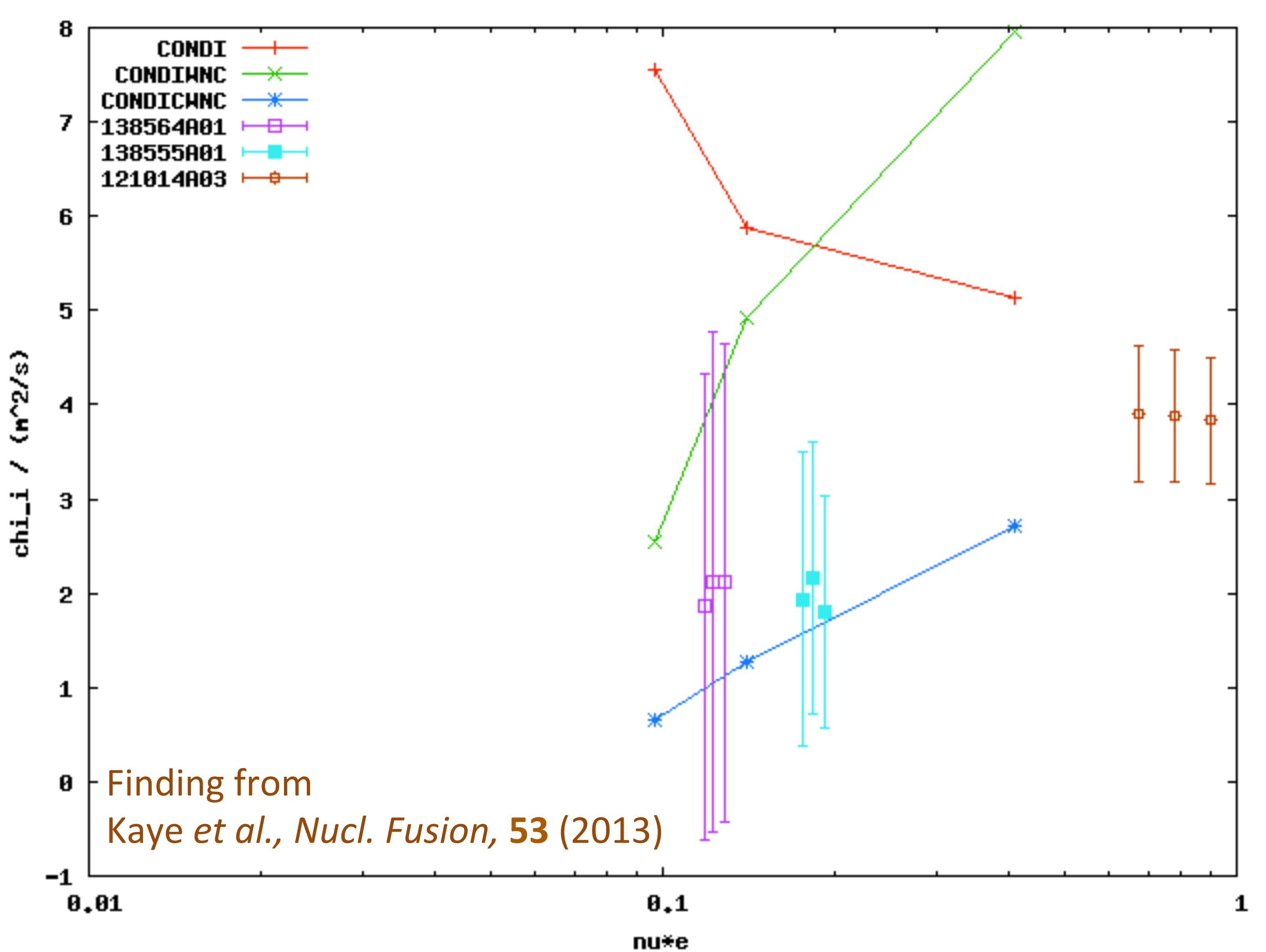
- Ion thermal transport trend identified by comparison to NCLASS* model
  - Neoclassical models assume small orbit widths for trapped particles, paths bound to flux surfaces
- **GTC-NEO simulates the motion of a plasma to calculate transport quantities
  - Intrinsically includes finite orbit (non-local) effects

Simulation Results of GTC-NEO

- Three H-mode shots, similar q and $\langle\beta_t\rangle$
  - $\langle\beta_t\rangle$ = plasma pressure / magnetic pressure
  - $q \approx rB_t / RB_p$
  - Data taken from TRANSP* interpretive analysis code using experimental diagnostic data



Example of TRANSP B-field reconstruction


CONDI
CONDIWNC
CONDICWNC
138564A01
138555A01
121014A03
chi_i / (m^2/s)
nu*e
8
7
6
5
4
3
2
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0
-1
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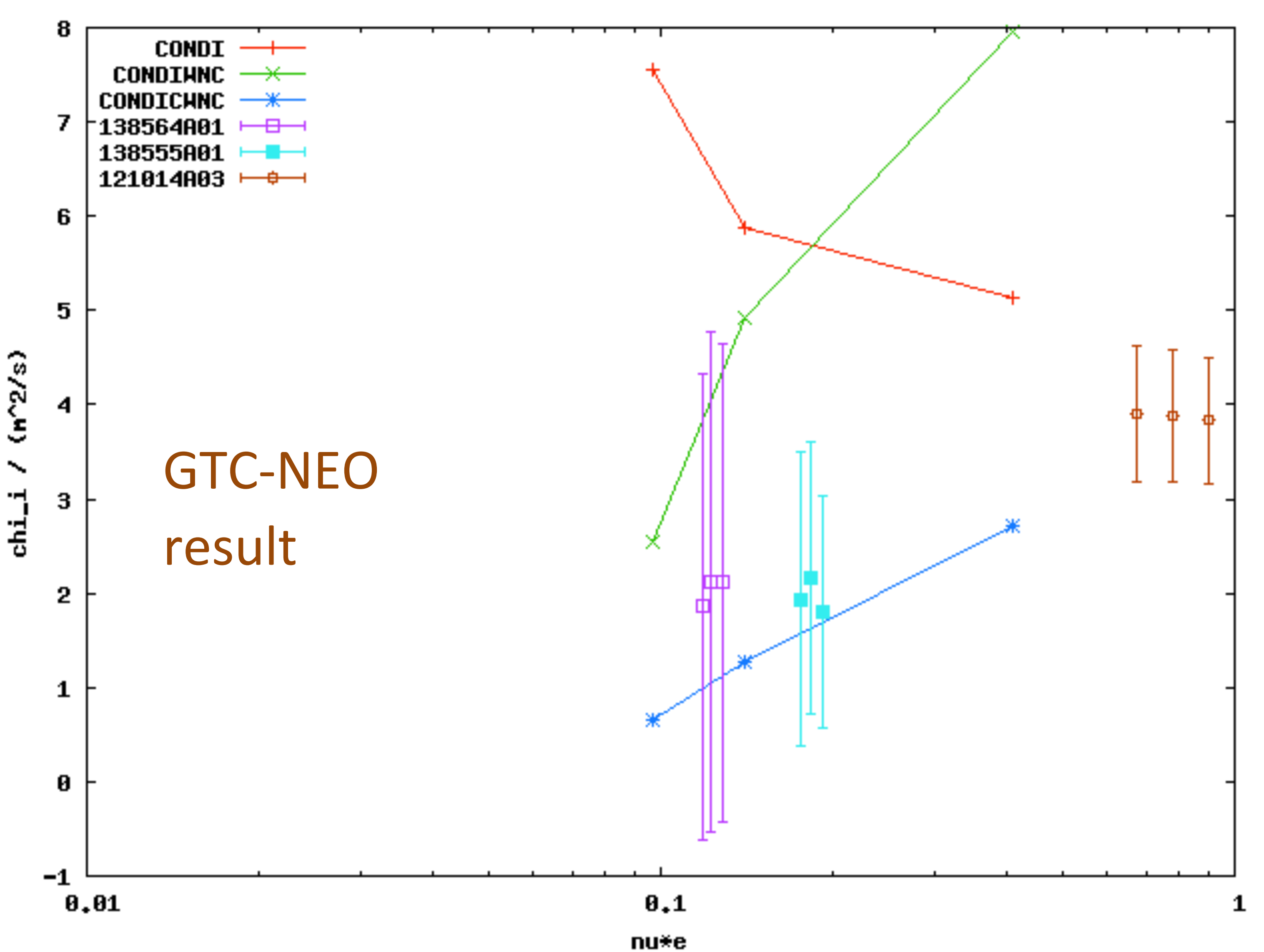
0.1
1
Finding from
Kaye *et al., Nucl. Fusion,* **53** (2013)


CONDI
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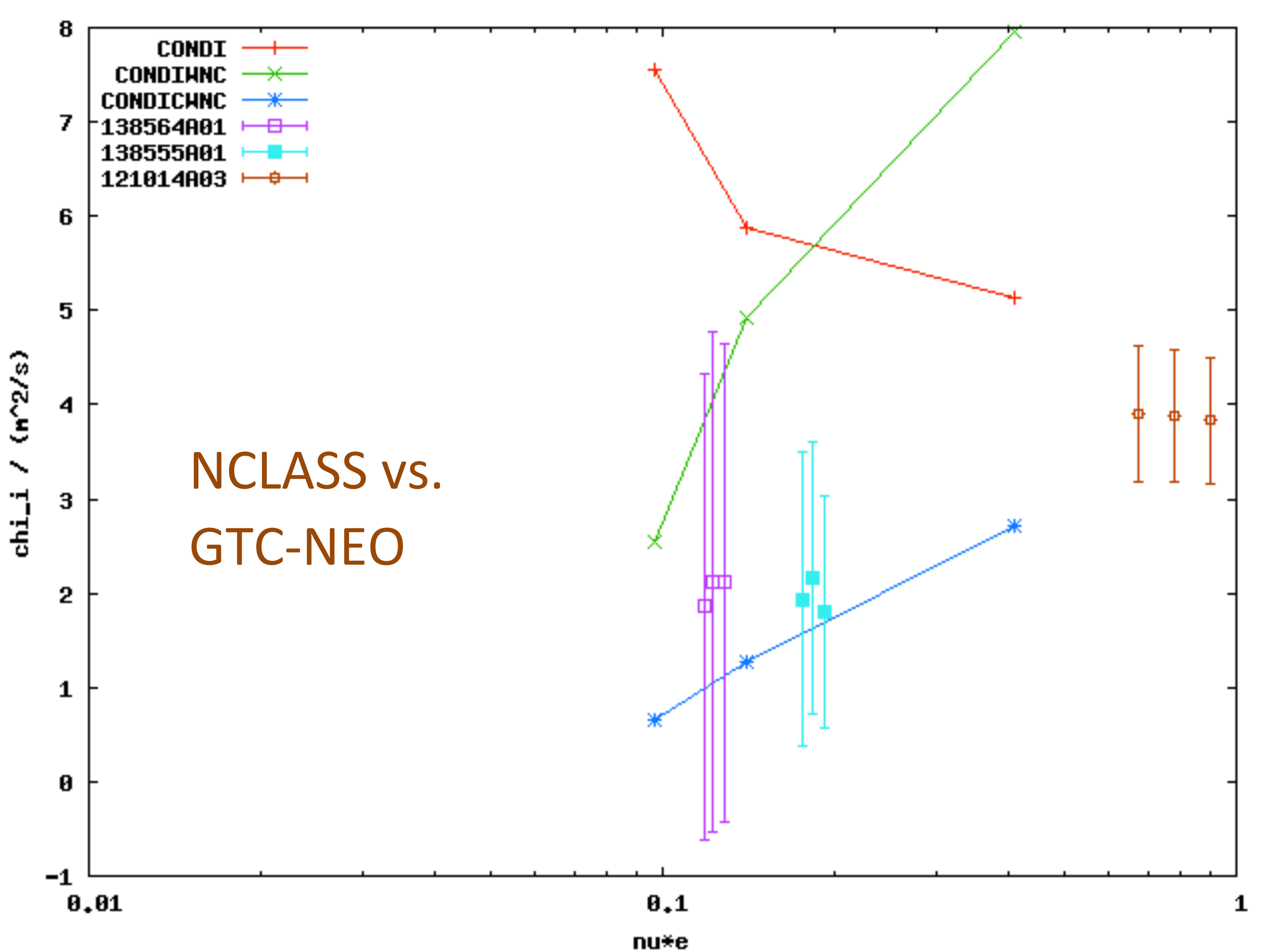
GTC-NEO
result


NCLASS vs.
GTC-NEO
CONDI
CONDIWNC
CONDICWNC
138564A01
138555A01
121014A03
chi_i / (m^2/s)
nu*e
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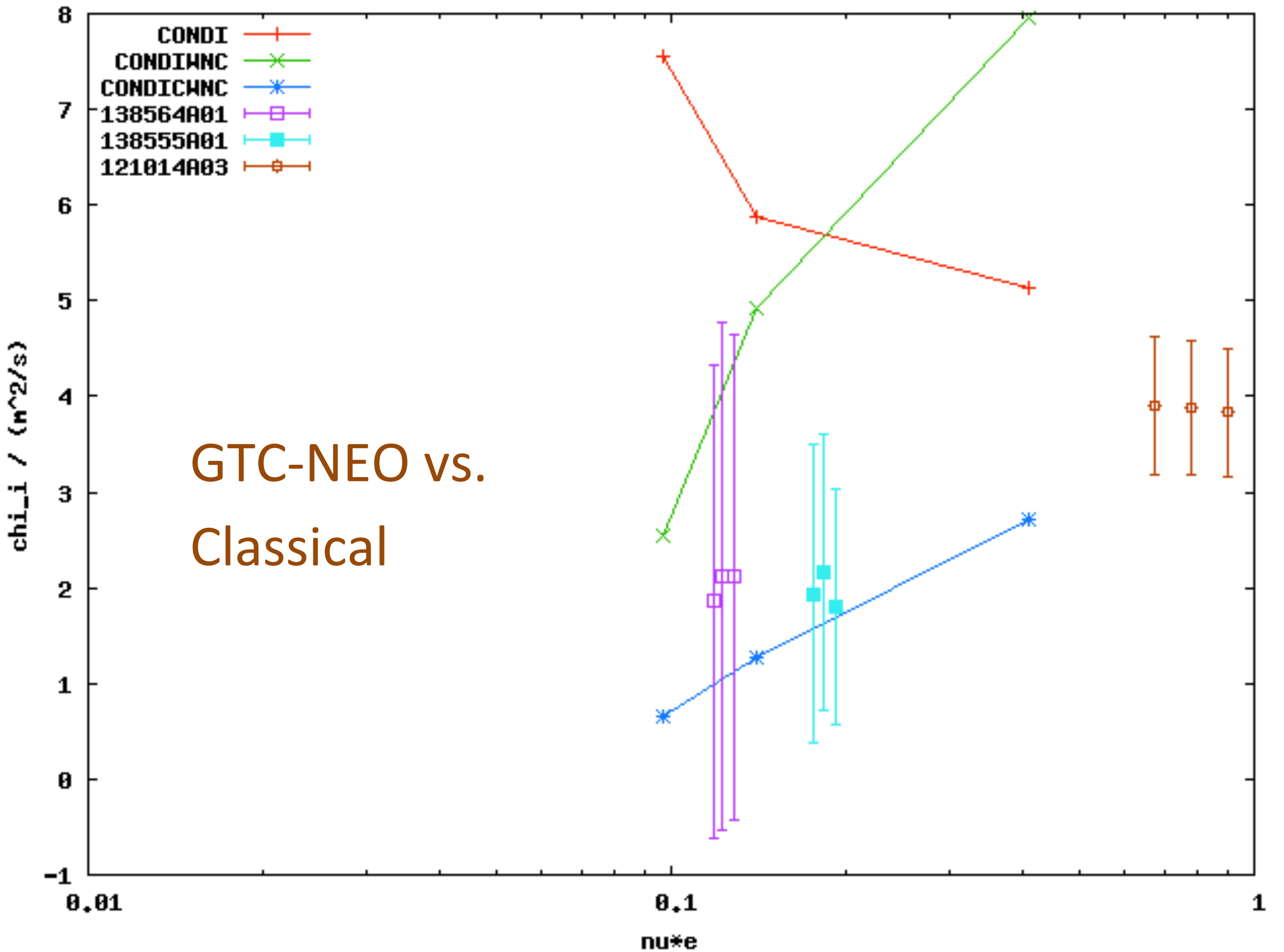

GTC-NEO vs. Classical

Conclusions / Future Work

- Rigorously confirmed the existence of anomalous ion thermal transport at low collisionality in NSTX
- NSTX transport approaches the neoclassical level at high collisionality

- Run a turbulence code (e.g. GTS) to try to identify possible modes causing this transport