

# **Global gyrokinetic simulation of ETG turbulence and transport in NSTX plasmas and development of synthetic diagnostic**

**Stéphane Ethier, Weixing Wang (PPPL), Francesca Poli (U of Warwick)**

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NSTX Results and Theory Review  
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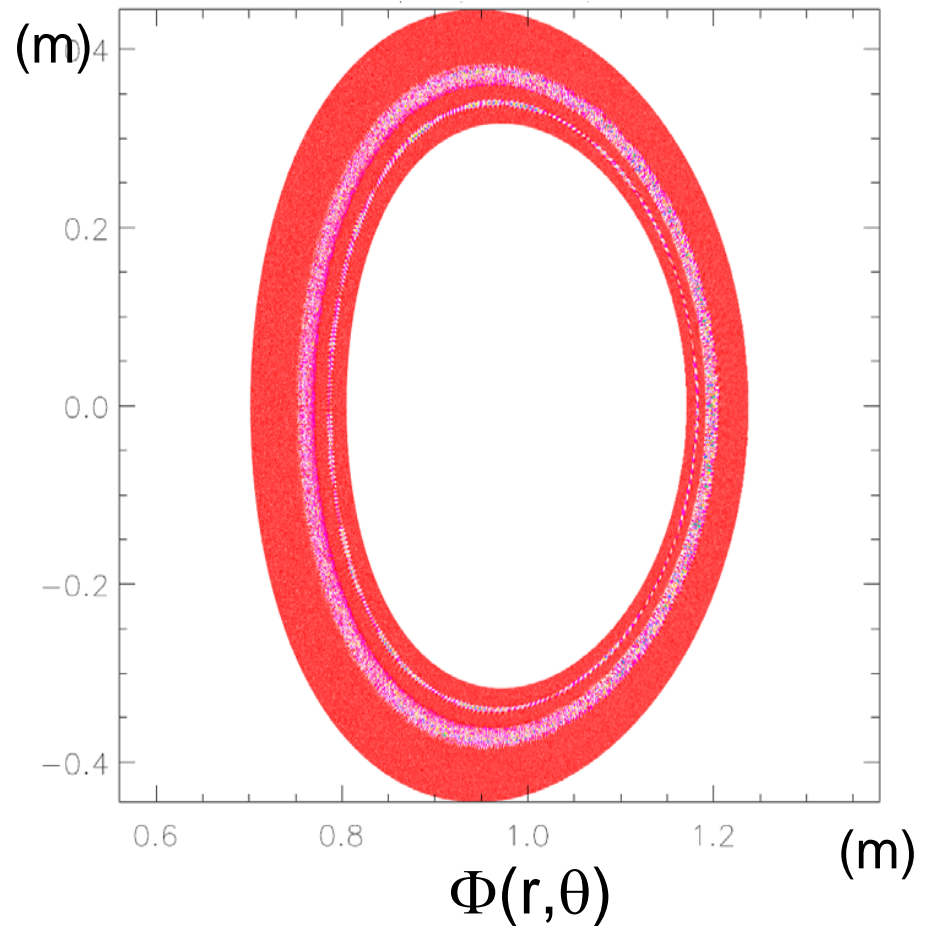
# Large-scale ETG simulation of NSTX shot 124901 with GTS code

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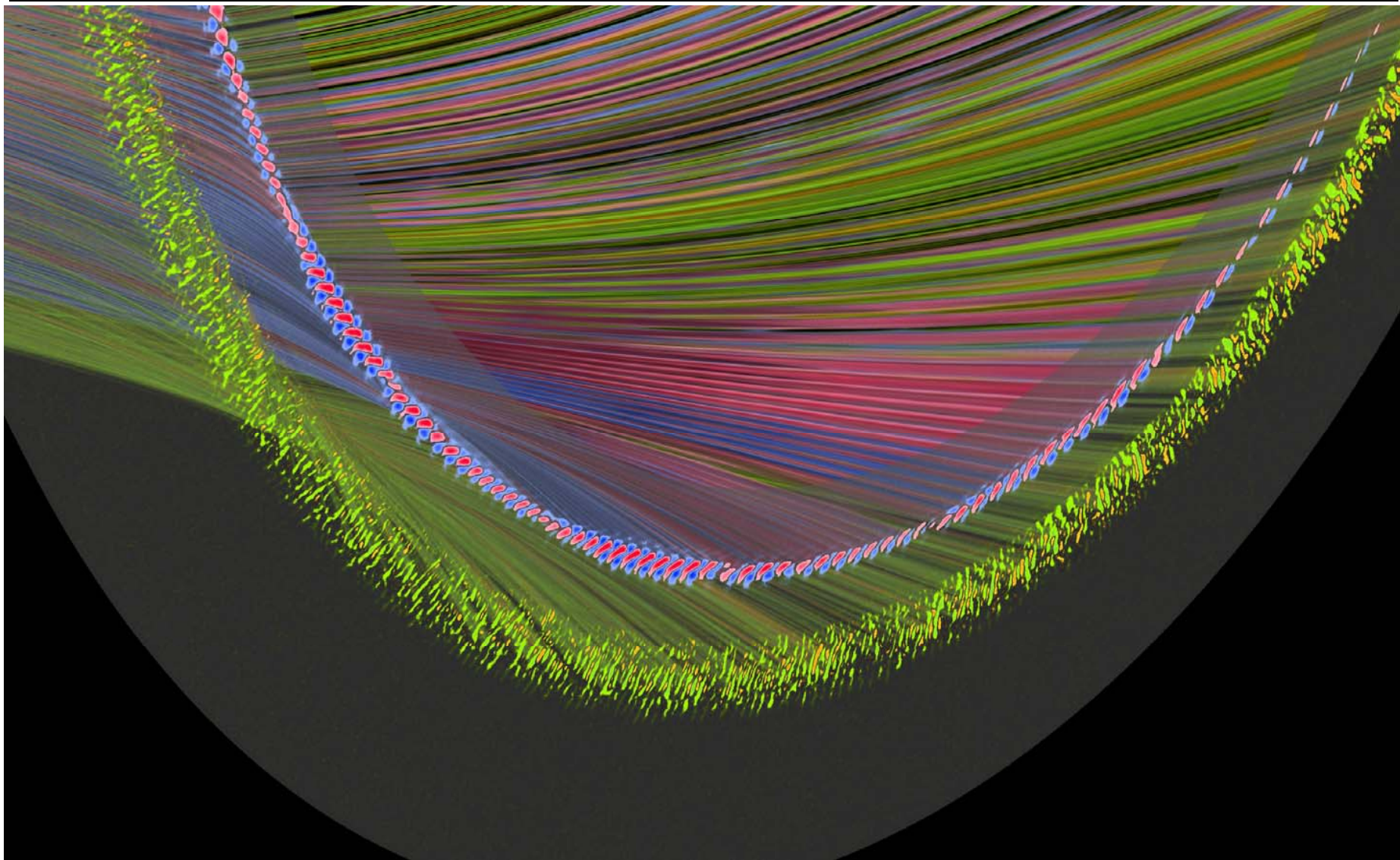
- GTS is a global, gyrokinetic PIC code developed at PPPL by Weixing Wang:
  - Handles general geometry (strongly shaped plasmas)
  - Inputs profiles and magnetic equilibria from experiments (from TRANSP runs)
  - Fully non-linear
- The goal is to carry out a direct comparison between ETG simulation results and high-k coherent electromagnetic scattering measurements.
- Global ETG simulations are very expensive though
  - ~ 4 million CPU-hours each
  - Require 400 million grid points and 23 billion particles

# NSTX shot 124901 at 0.3 sec

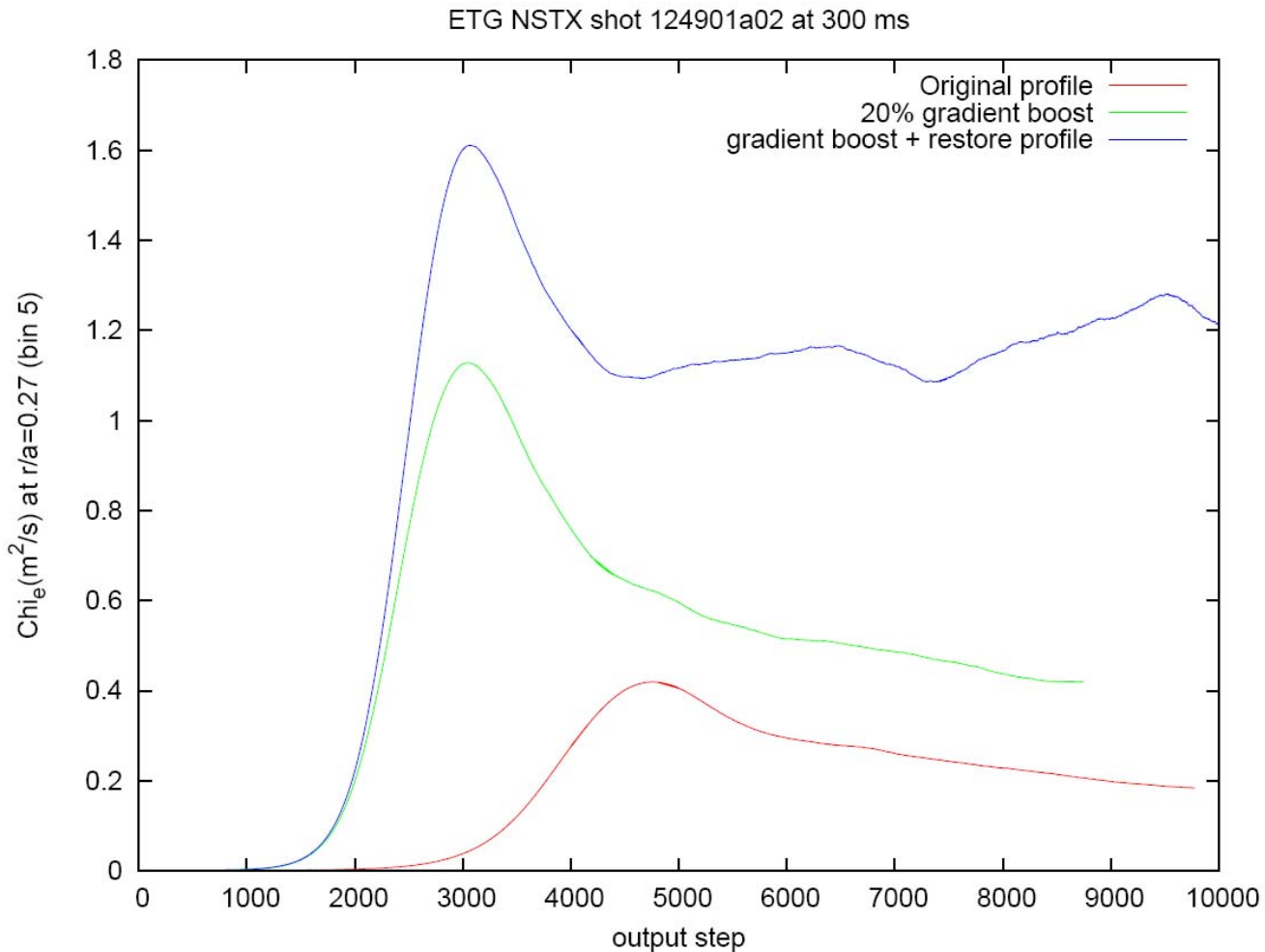
- Full poloidal variation
- 64 poloidal planes with field-line following grid
- Helium shot
- $Z_{\text{eff}} = 2$
- Radial variation of temperature and density profiles
- Electro gyroradius resolution grid



# Fully resolved electron-scale fluctuations



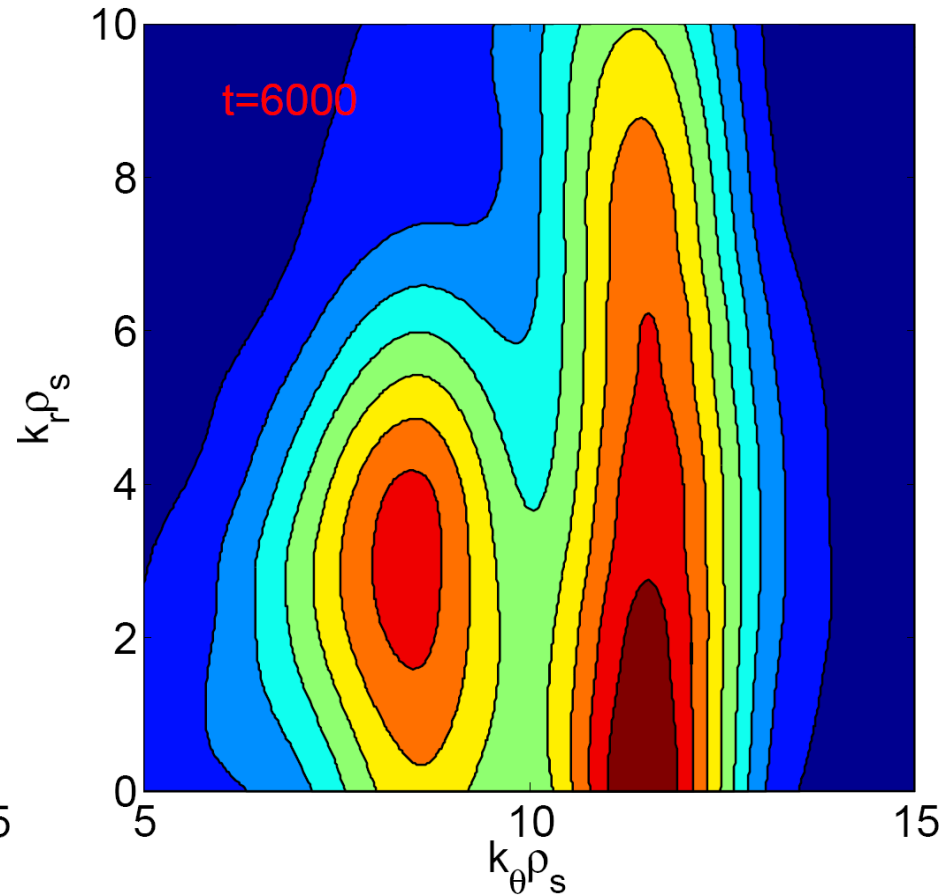
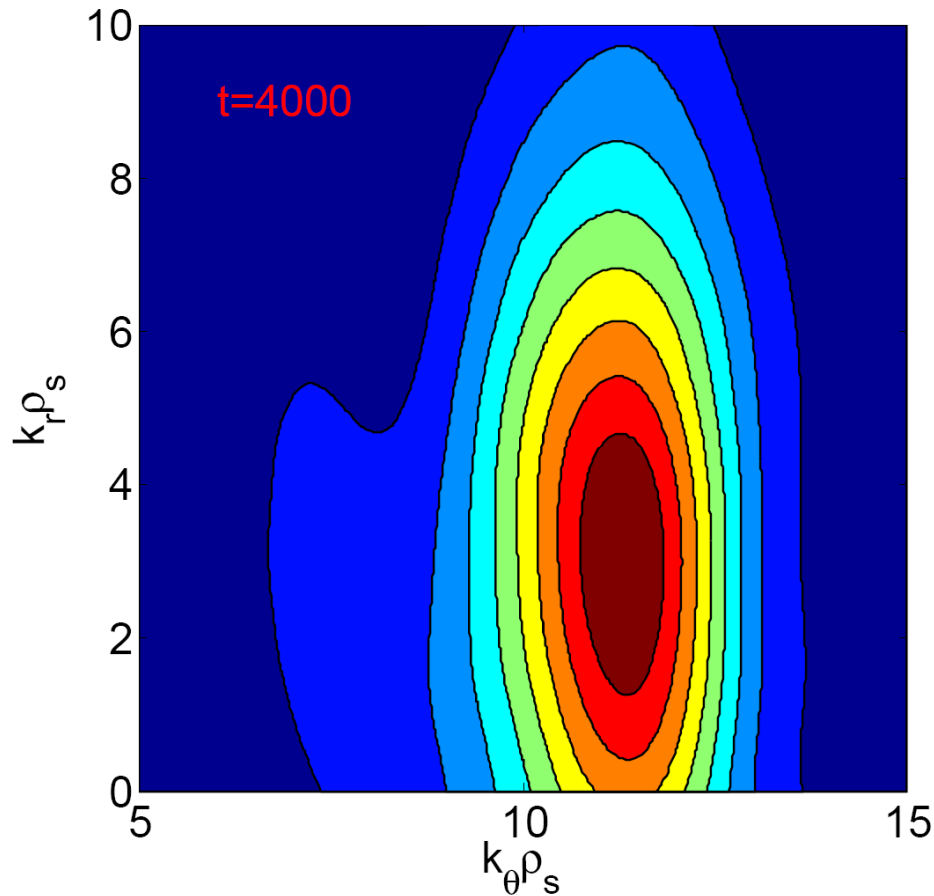
# Temporal evolution of $\chi_e$



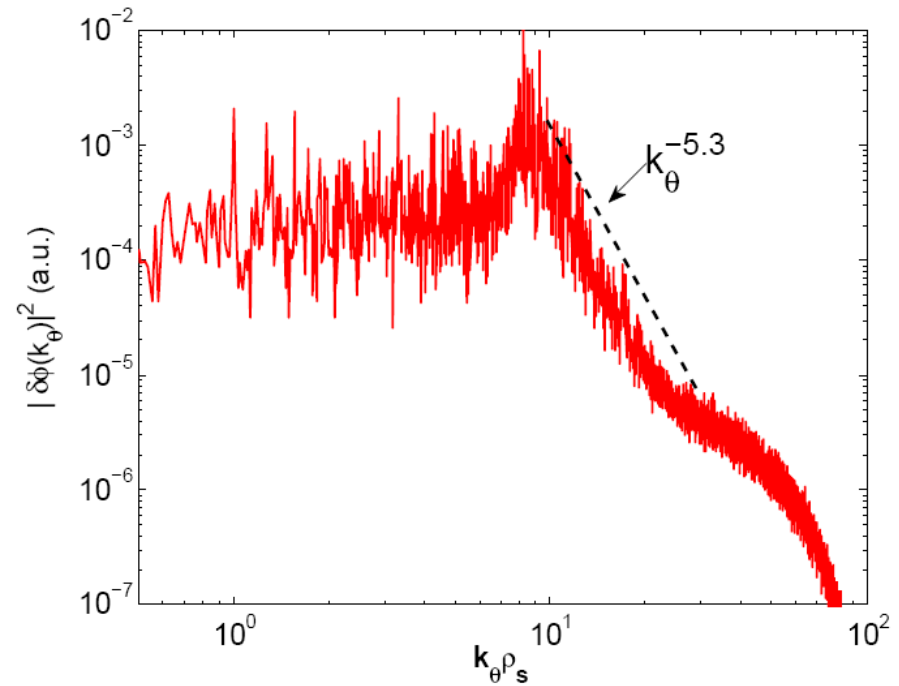
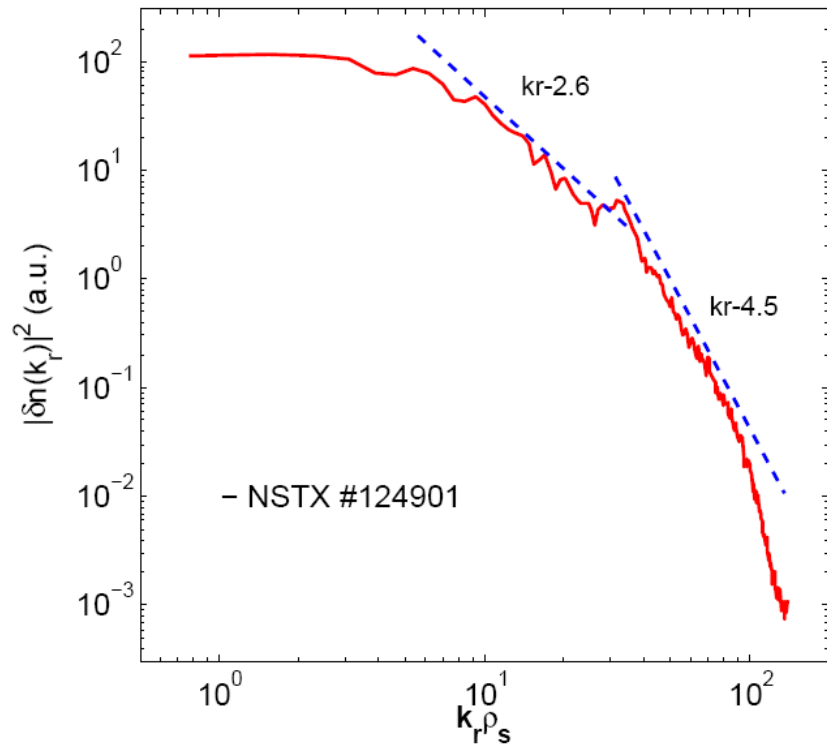
Increased gradient by 20% at every point to scan experimental uncertainty on temperature profile and Zeff.

# “Raw” k-spectra around scattering region

Window =  $2\pi/100$  centered around the mid-plane

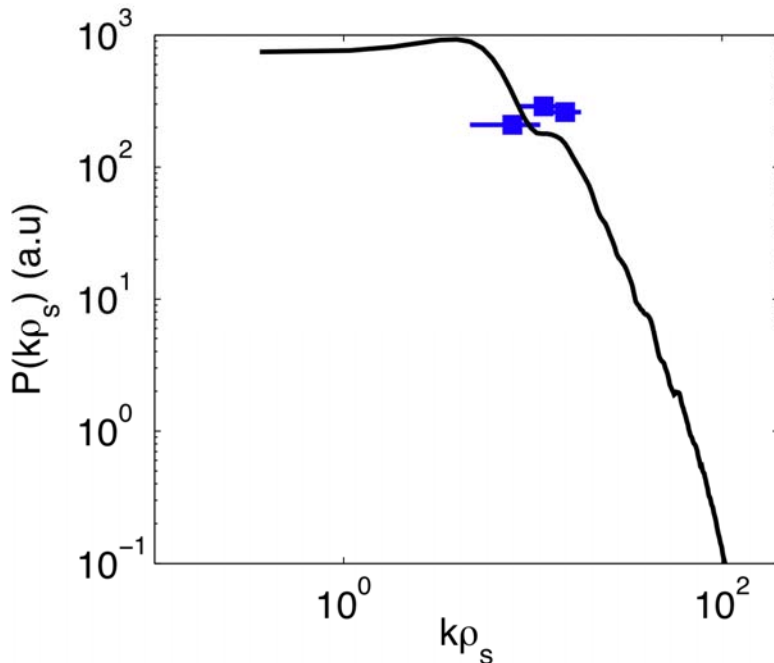
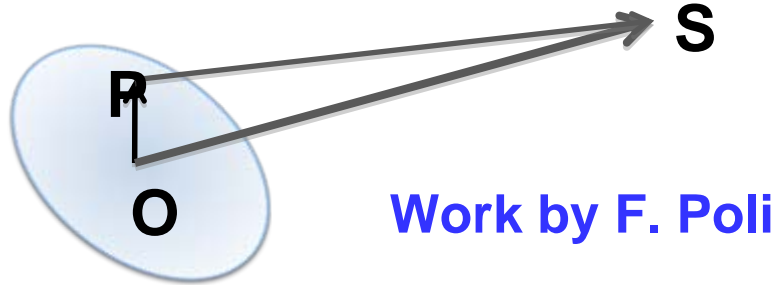


# First attempt at comparison between calculated and measured k-spectra



- Exponential power -2.6 (in  $k_r$  spectrum) and -5.3 (in  $k_\theta$  spectrum) in simulation compared to -2.8 (L-mode) and -4.5 (H-mode) of  $k_\perp$  (?) spectrum in experiments.

# Need for comprehensive synthetic diagnostic of coherent electromagnetic scattering

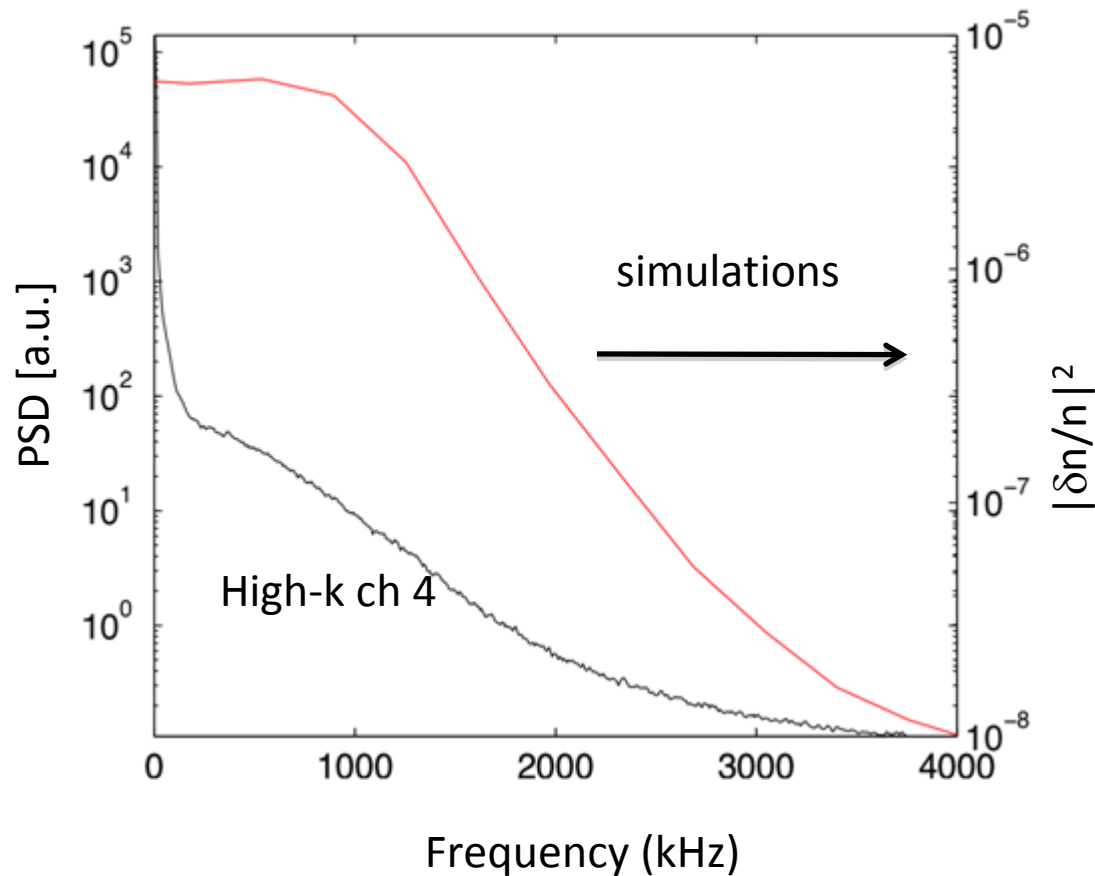


- Not enough experimental points in a small range of  $\mathbf{k}$
- Only 3 channels with good sensitivity for this shot
- Synthetic diagnostic to include:
  - Ray tracing
  - Instrument selectivity function
  - Mapping of  $\mathbf{k}$  onto receivers
- Will need to simulate several other shots



# Current state of synthetic frequency spectrum

- Need to include neoclassical  $E_r$  field in simulations



# Ongoing work

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- Synthetic diagnosis – compare apple to apple
- Comparison of density fluctuations  $\delta n_e/n_0$
- Central question: is ETG relevant to electron transport?
- $\chi_e \sim 0.3 \text{ m}^2/\text{sec}$  (too low?), but simulations also suggest strong dependence of ETG driven  $\chi_e$  on plasma parameters such as  $(T_e/T_i)Z_{\text{eff}}$
- Sensitivity studies: q profile,  $Z_{\text{eff}}$ , ...