Multi-scale drift turbulence dynamics in an Ohmic discharge as measured at the FT-2 tokamak and modelled by full-f gyrokinetic ELMFIRE-code

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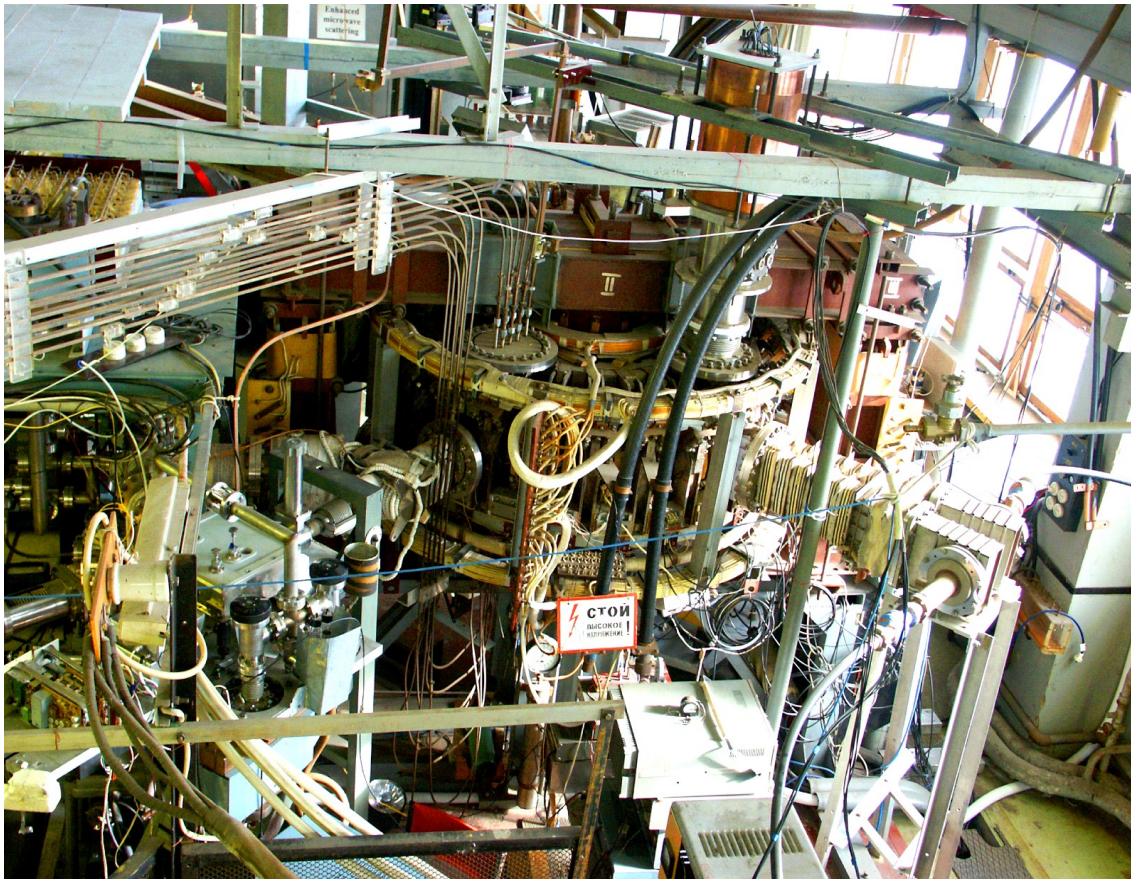
Association
Euratom-Tekes

Contents of this talk

FT-2 tokamak (Ioffe Institute)



$R_0 = 55$ cm

$a = 8$ cm

$B_t < 2.7$ T

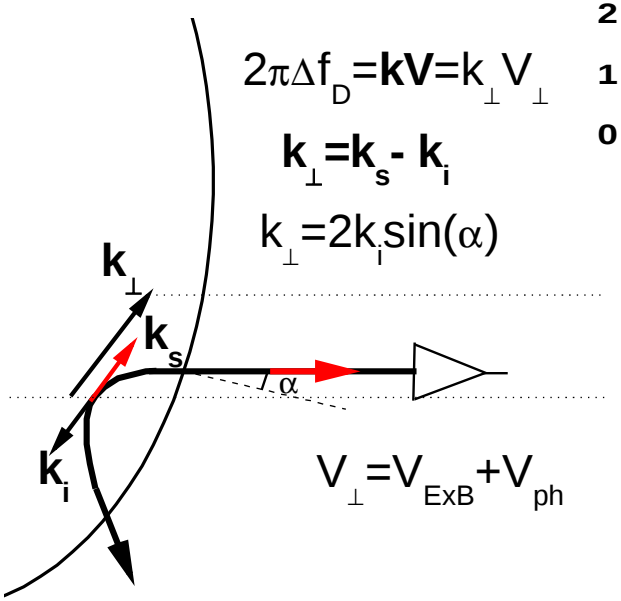
$I_p < 50$ kA

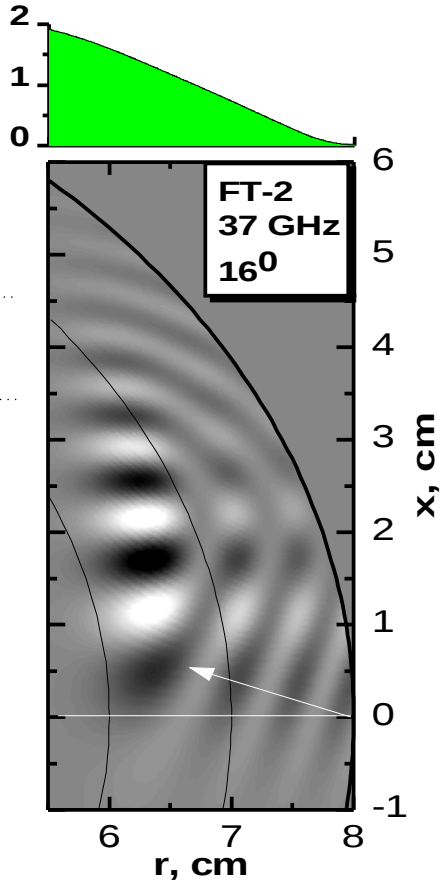
$N_e < 7 \cdot 10^{19}$ m^{-3}

$T_e < 1.0$ keV

$T_i < 0.4$ keV

Microwave Doppler reflectometry





Synthetic diagnostic

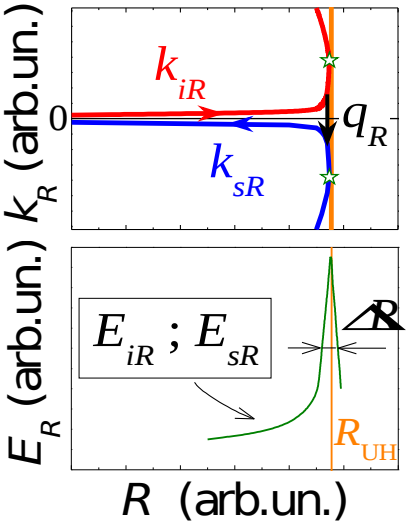
$$I(t)=\int w(r,\theta)\,\delta n(r,\theta,t)\,r\,dr\,d\theta$$

$$W(r,\theta)=w\cos+i*w\sin$$

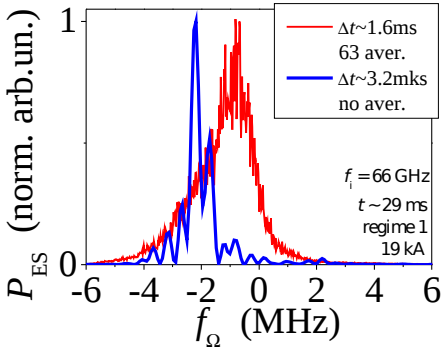
The synthetic diagnostic is constructed using the complex instrumental DR weighting function.

(S.Leerink CPP'10 **50**)

Microwave Enhanced scattering in UHR

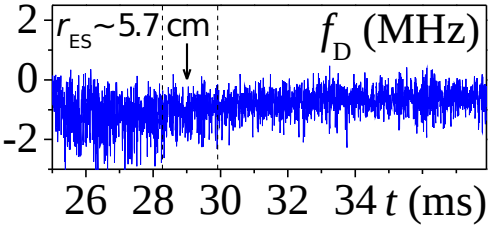


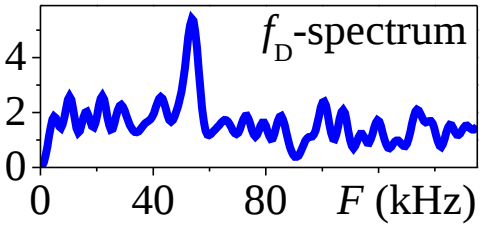
ES spectrum

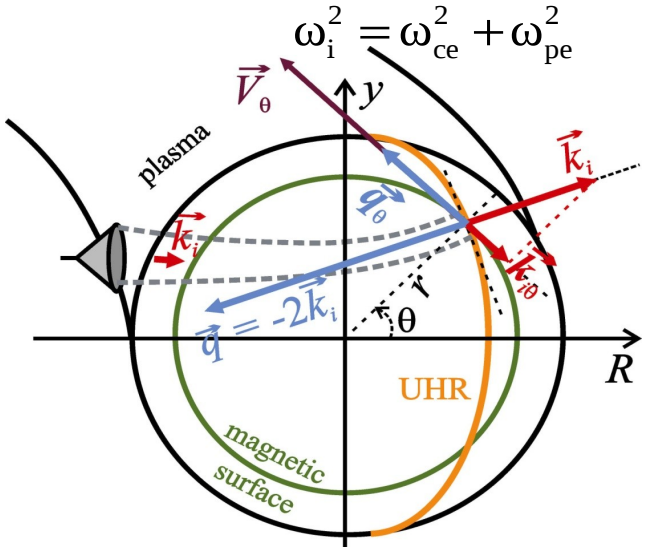


Doppler frequency shift

$$f_D = \frac{\int_\Omega f_\Omega |P(f_\Omega)|\, df_\Omega}{\int_\Omega |P(f_\Omega)|\, df_\Omega}$$







$$2\pi f_D = q_\theta V_\theta \qquad f_\Omega = f_s - f_i$$

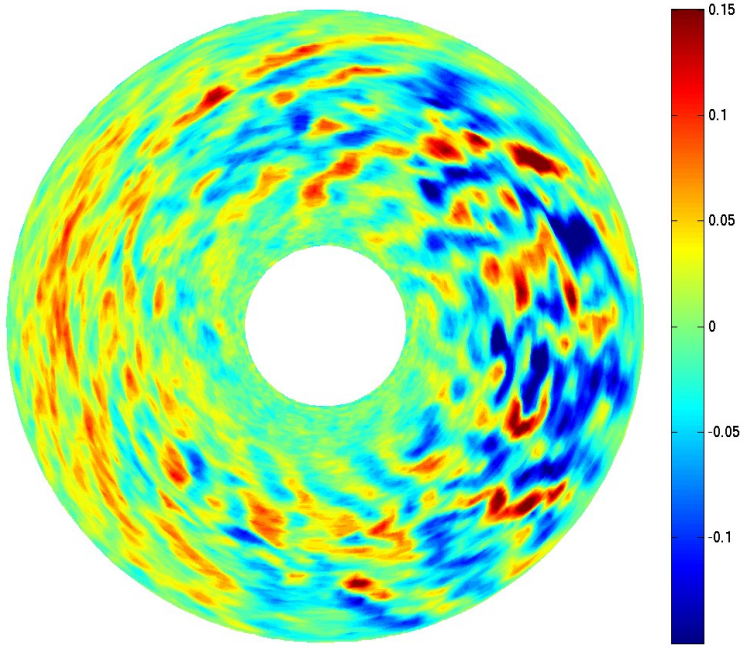
Gusakov et al. PPCF'06 **48**
Gurchenko et al. PPCF'10 **52**

Gyrokinetic full-f code: ELMFIRE

ELMFIRE properties:

- Gyrokinetic electrostatic 5D full-f particle code.
- Species: e,i, impurity.
- Binary collision model.
- Quasineutrality enforced through polarization drift and electron parallel non-linearity.
- Applicable for kinetic analysis of neo-classical physics and microturbulence.

Heikkinen et al. JCP '08 & '11, PoP'10



Instantaneous density fluctuation normalized to flux-surface averaged density, poloidal section.

Profiles and transport results

t ~ 28.3-29.9 ms

I_p ~ 19 kA

B_T ~ 2.2 T

ν^* ~ 10-25

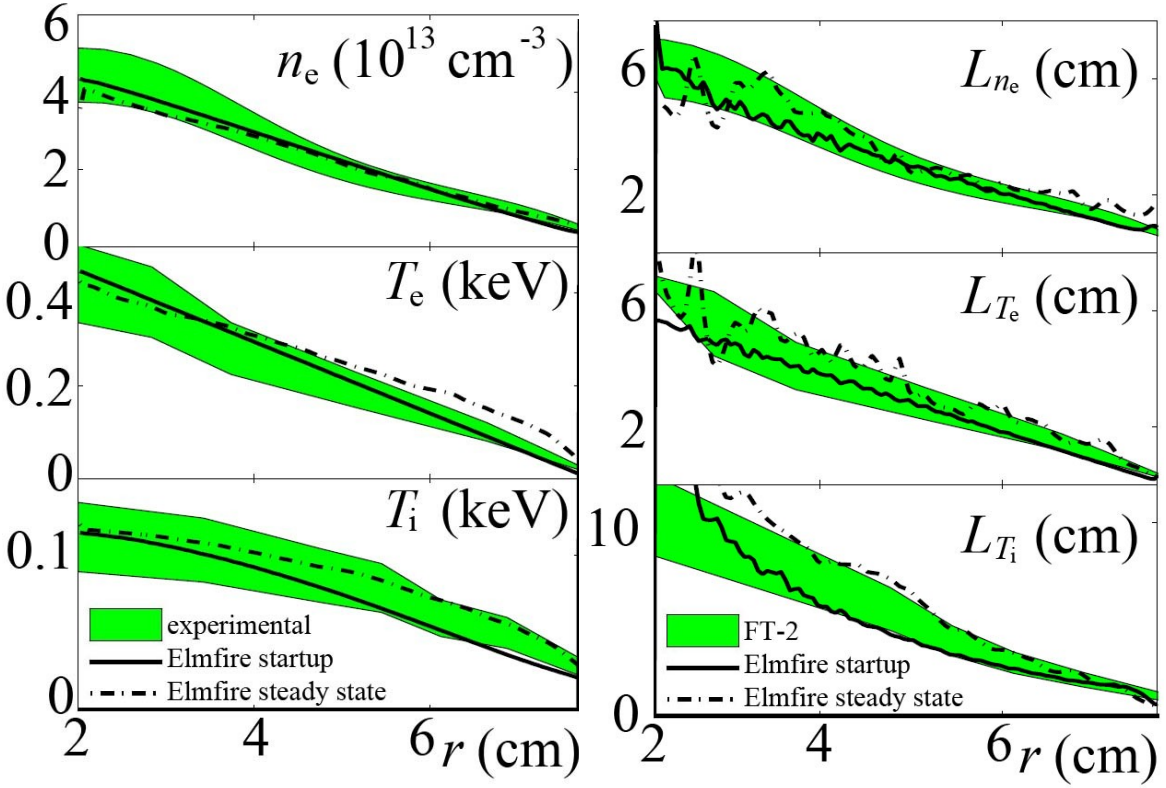
τ_E ~ 1 ms

hydrogen plasma

main impurity: oxygen O^{+6}

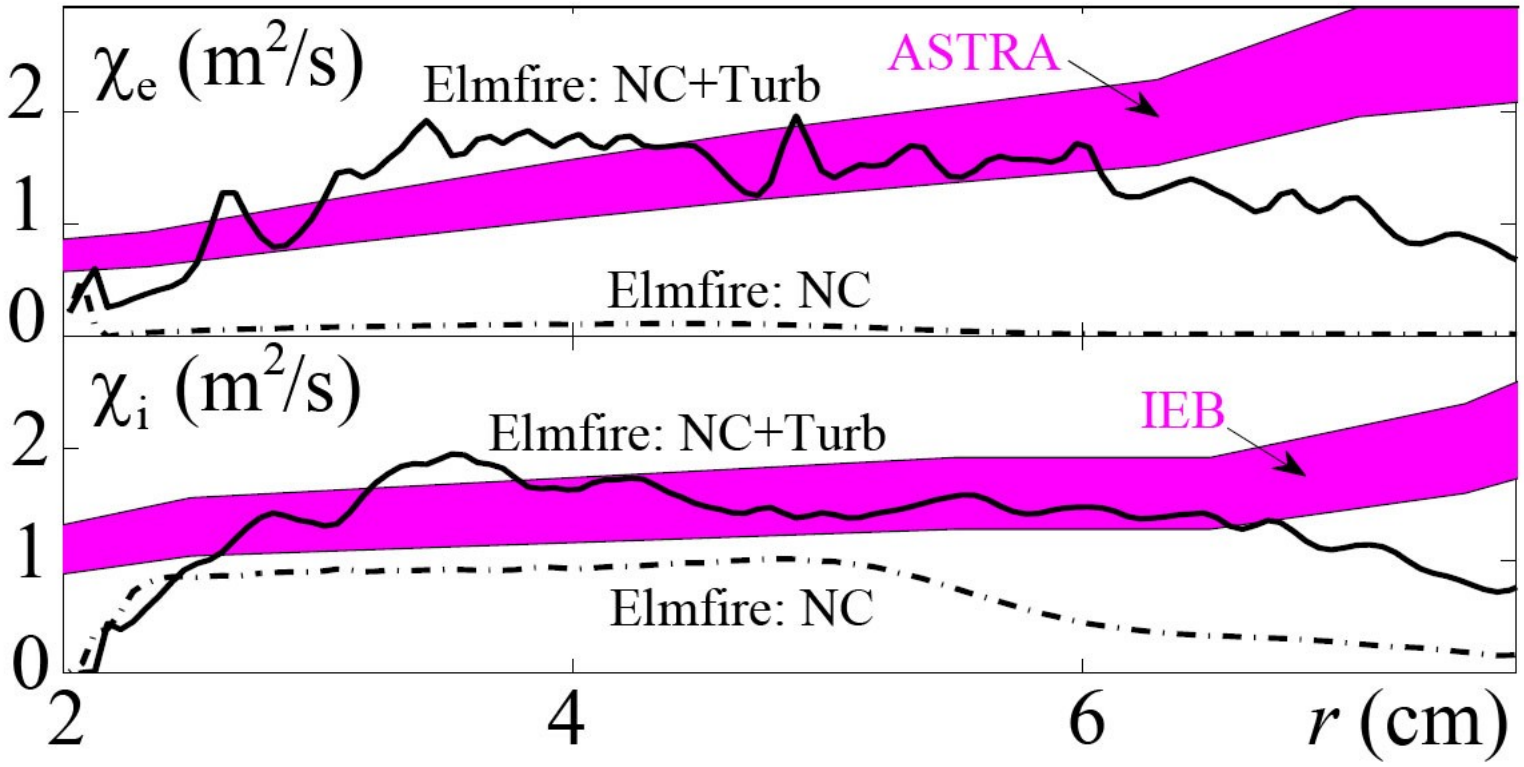
Z_{eff} ~ 3.1

$T_{H+} = T_{O+6}$ assumed



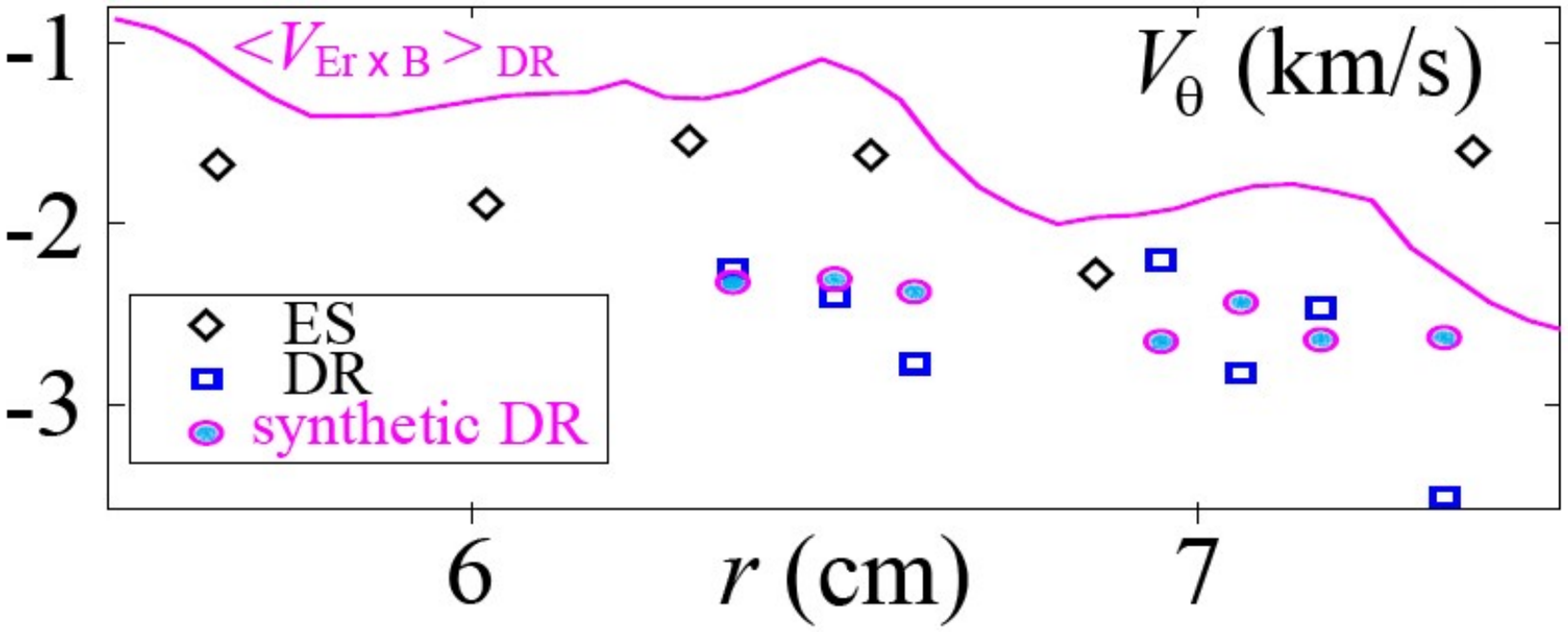
Profiles and transport results (ctd)

ASTRA modeling: G.V. Pereverzev and P.N. Yushmanov, preprint IPP 5/98 Garching



Poloidal rotation profiles compared

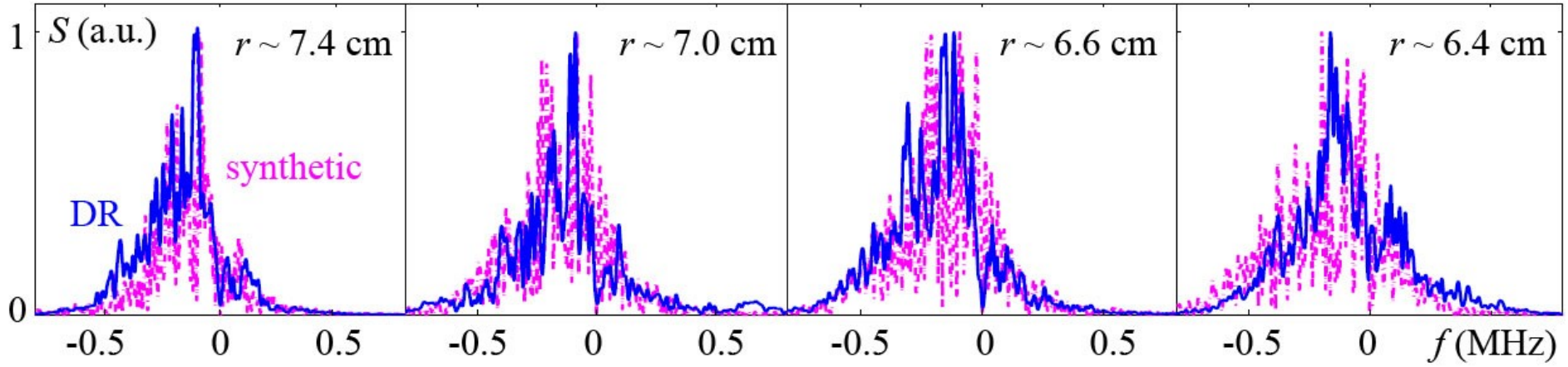
Poloidal rotation profiles were measured with Enhanced Scattering, Doppler Reflectometry and from ELMFIRE.



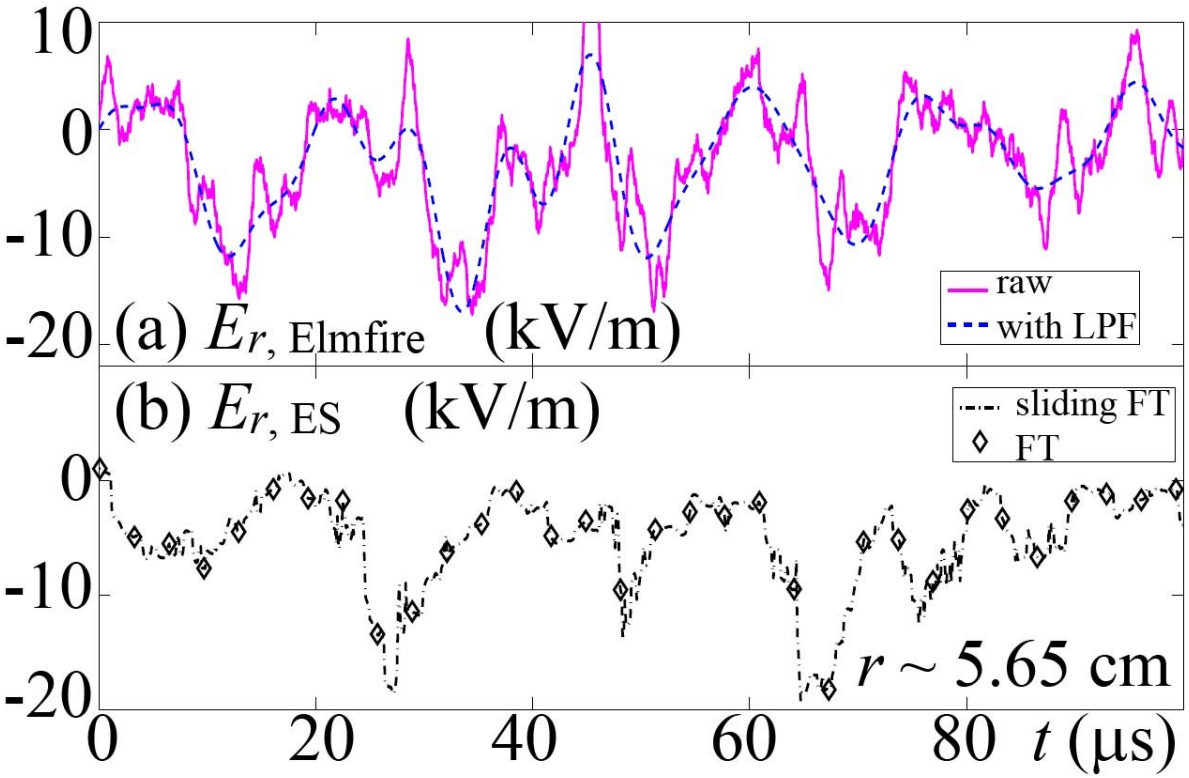
Doppler reflectometry spectra

DR spectra were compared to the synthetic diagnostic. Shift, width and shape reproduced.

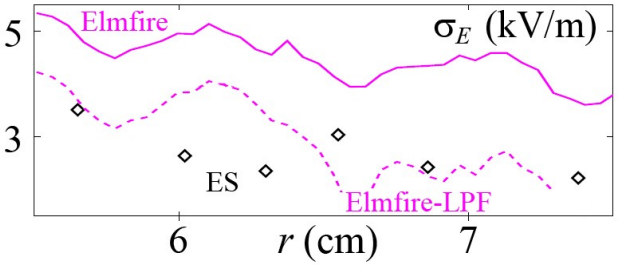
S.Leerink et al. PRL'12, accepted for publication



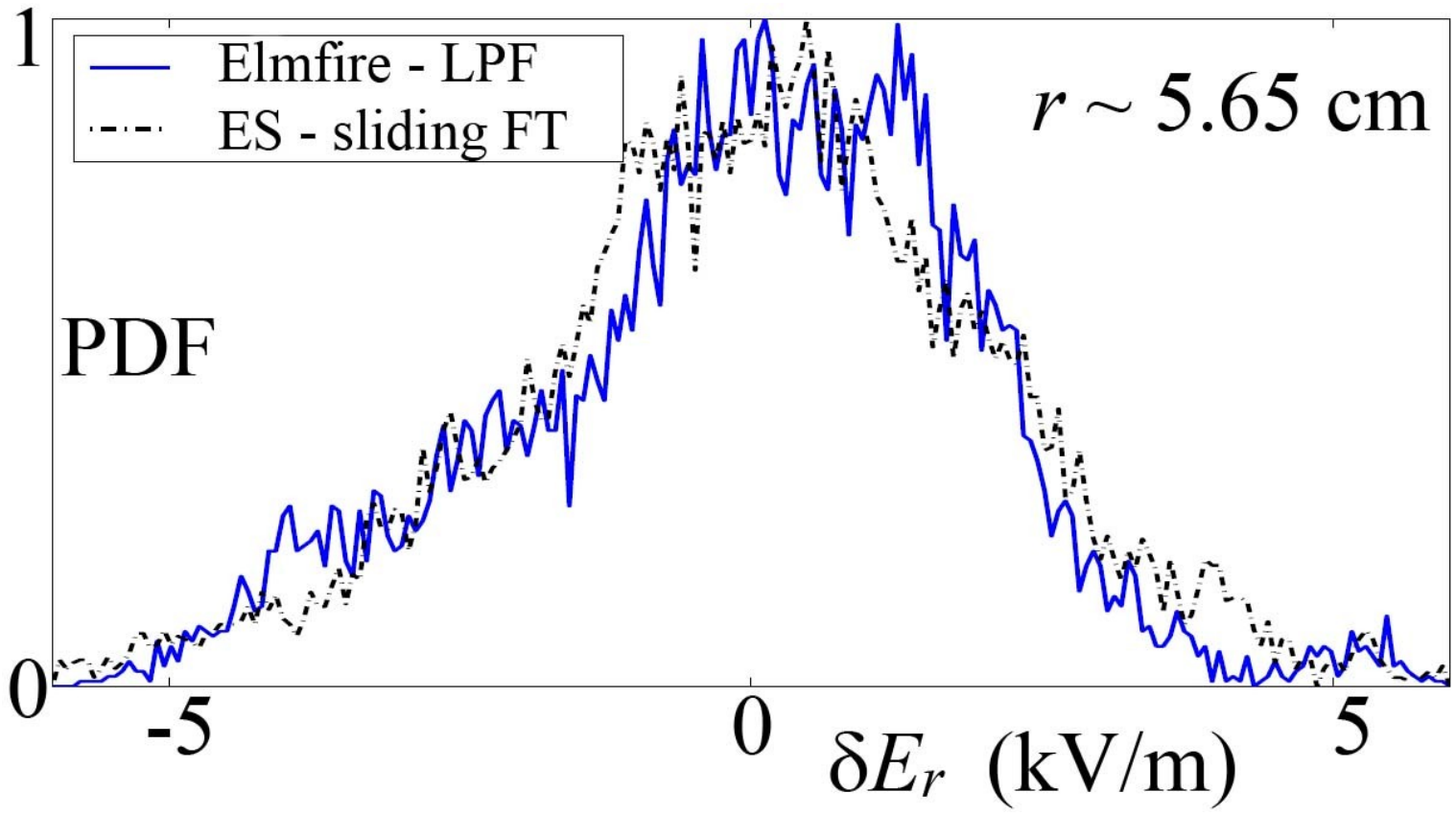
E_r evolution in time



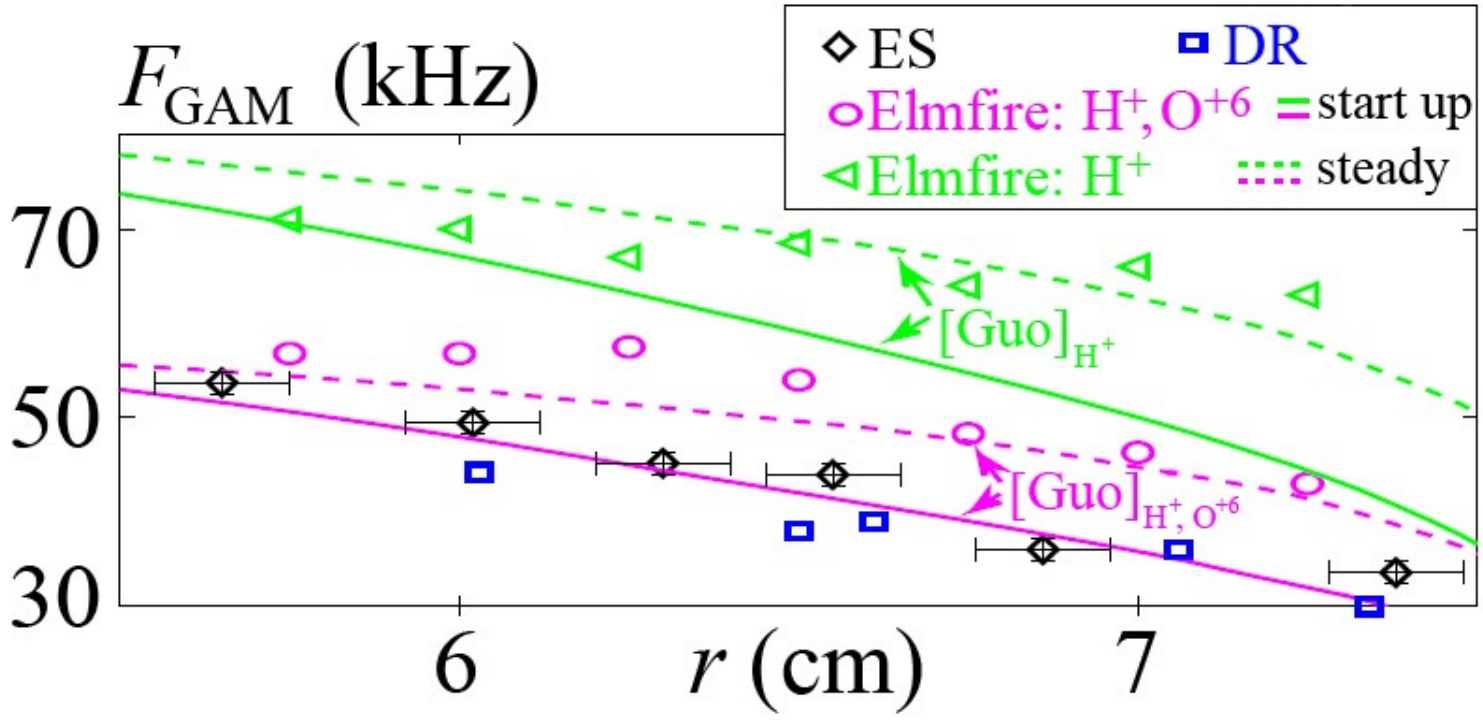
The experimental signal is low-pass filtered with a Nyquist frequency of F_N = 156.25 kHz. This has to be taken into account in analysis of simulation data.



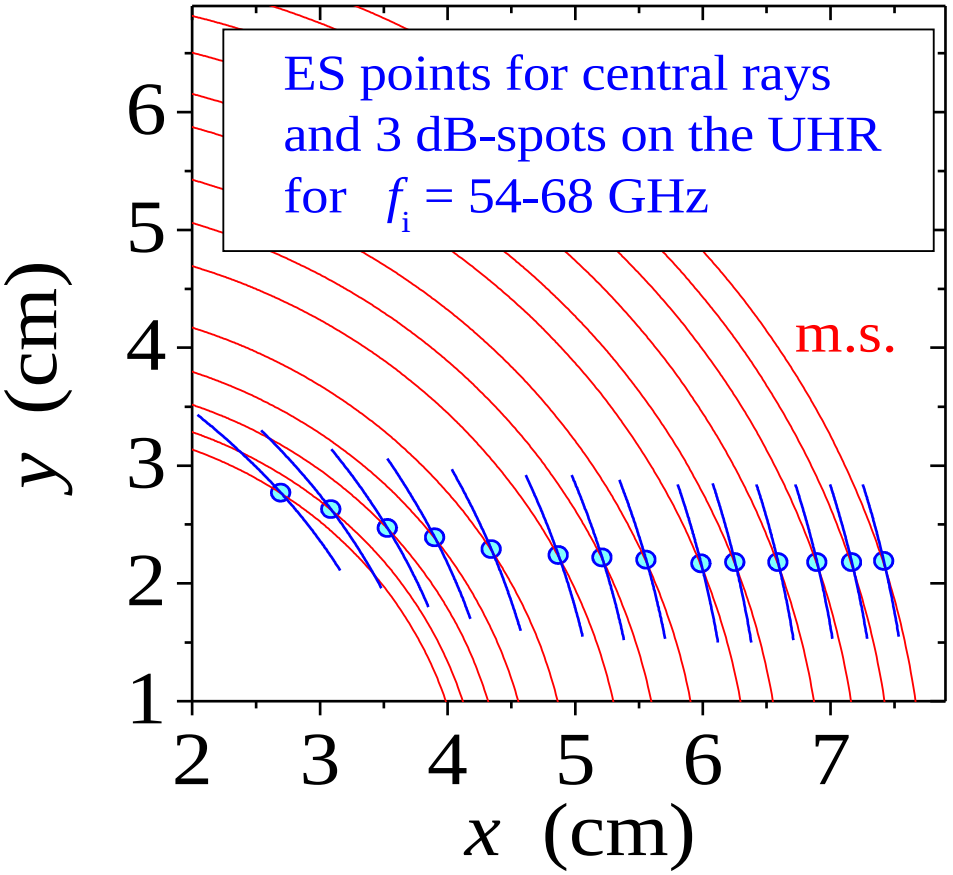
E_r fluctuation statistics



Comparison of GAM frequencies



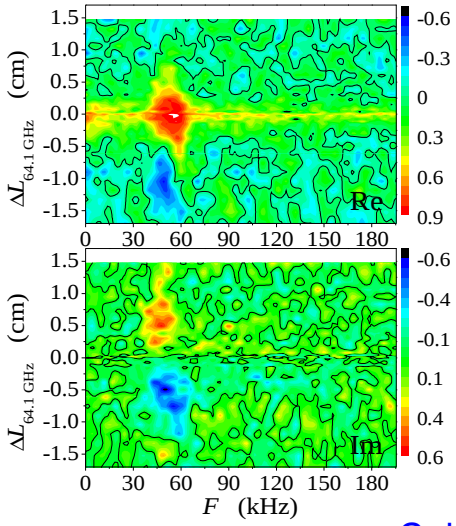
GAM correlation measurements with ES



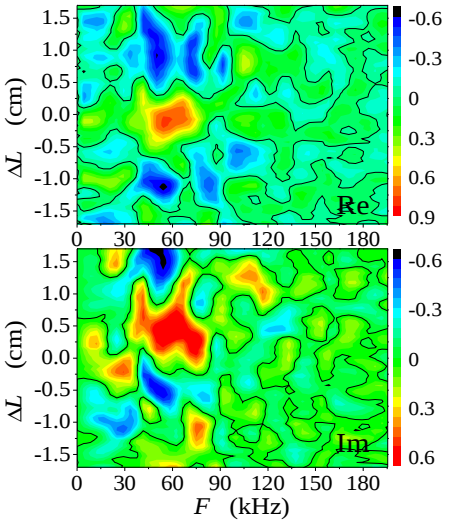
Enhanced scattering allows correlation measurements if two signals are measured,
$| f_2 - f_1 | < 4$ GHz corresponds to
$|\Delta L| < 2$ cm in plasma

GAM correlation measurements with ES

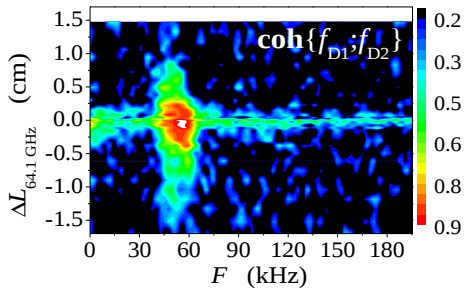
ES: two f_D-signals

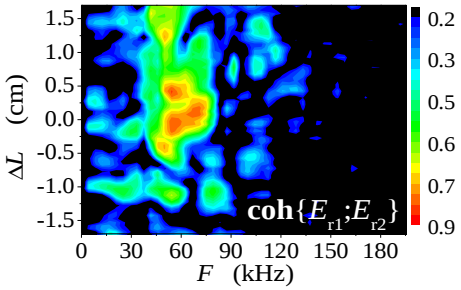


Elmfire: E_{r1} & E_{r2}

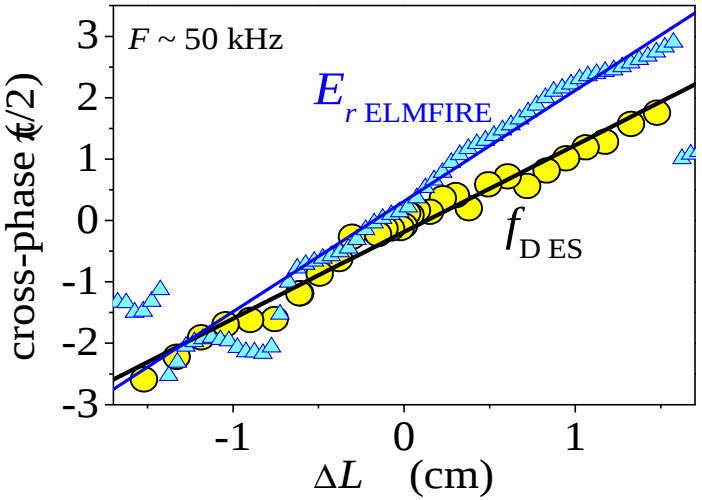


Coherence:





V_r direction: radially outwards



Conclusions

Good correspondence between experimental and simulation data have been obtained:

- For transport properties.
- Doppler reflectometry, and ES measurements of
  - Mean E×B flows.
  - DR spectra.
  - Oscillations in zonal flows.
  - GAM spatial correlation properties.
- Clear influence of an impurity species is observed.

Acknowledgements

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