Proposals in this presentation

Proposals
Electron temperature gradient control with off-axis ECRH power density scans for TEM/ETG studies
The ITG-TEM transition and its dependence on collisionality
Stability survey of the density gradient driven TEM while holding collisionality
ECH density pump-out in W7-X and the ITG-TEM transition (pushed to Soeren?)
Configuration comparison high/low/negative mirror (with matched profiles)

Electron temperature gradient control with off-axis ECRH power density scans for TEM/ETG studies

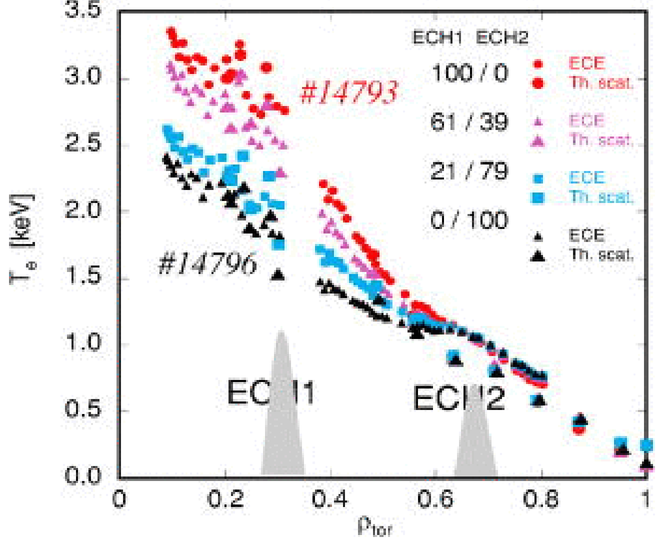
- ∇T_e can be controlled independently from the density profile and average electron temperature on a magnetic surface (across a radial range) by

→Varying the ratio of ECRH power density applied across a magnetic surface

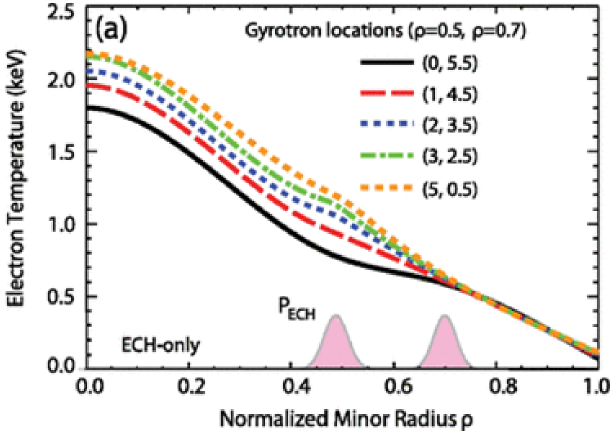
→ECRH modulation on inner source for heat pulse propagation experiments [eliminating possible non-linearity in stiffness measurements $\chi_e(\nabla T, \cancel{T}, \ldots)$]

$$\chi_e^{HP} = -\frac{\partial(q_e/n_e)}{\partial(\nabla T_e)} \qquad q_e/n_e = \int_0 -\chi_e^{HP}\, d(\nabla T_e)$$

AUG



DIII-D



DIII-D: J.C. Hillesheim *PoP* **20,** 056115 (2013) / PRL 110 045003 (2013); AUG: A.G. Peeters PoP **12**, 022505 (2005) / PRL

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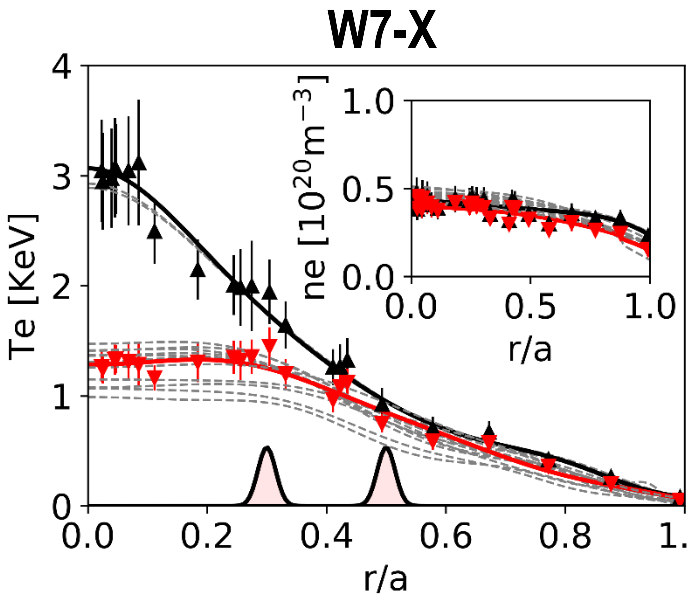
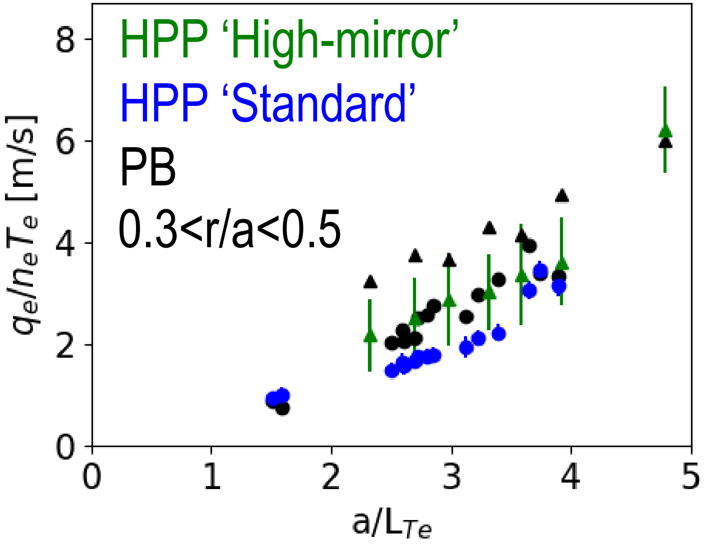
$$\chi_e^{HP} = -\frac{\partial(q_e/n_e)}{\partial(\nabla T_e)} \qquad q_e/n_e = \int_0 -\chi_e^{HP} d(\nabla T_e)$$

  - Highly sensitive to low-∇T_e (initial condition) and more precise than PB



- Methodology used on DIII-D and AUG to investigate ETG and ∇T-TEM driven turbulence and electron temperature profile stiffness.

→Tested in OP1.2b on W7-X. Tie-in to TG Profiles for profile control.



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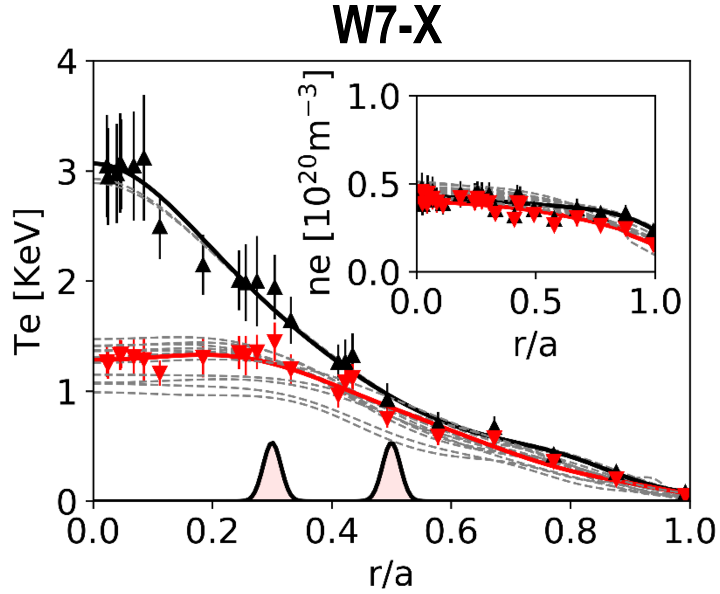
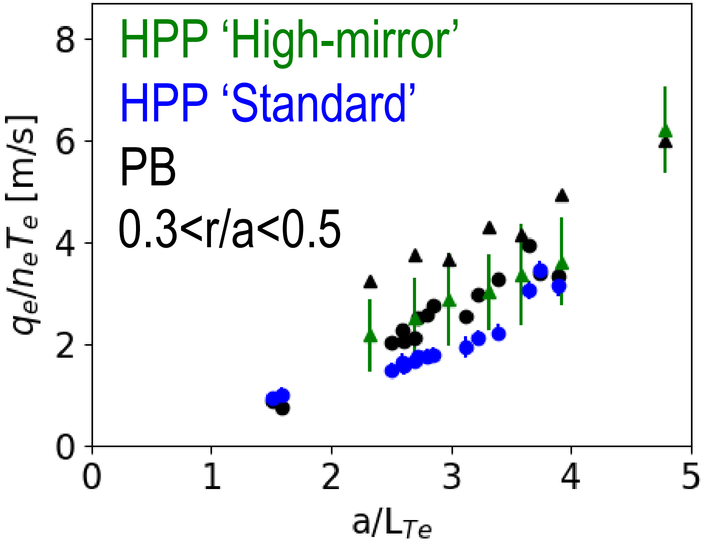
- Methodology used on DIII-D and AUG to investigate ETG and ∇T-TEM driven turbulence and electron temperature profile stiffness.

→Tested in OP1.2b on W7-X. Tie-in to TG Profiles for profile control.

Note: the achieved $T_e \sim \frac{1}{n_e}\sqrt{\frac{dP}{dV}}$ ... off-axis heating requires proportionally higher launched power to change ∇T and the T_e-profile





DIII-D: J.C. Hillesheim *PoP* **20,** 056115 (2013) / PRL 110 045003 (2013); AUG: A.G. Peeters PoP **12**, 022505 (2005) / PRL

Electron temperature gradient control with off-axis ECRH power density scans for TEM/ETG studies

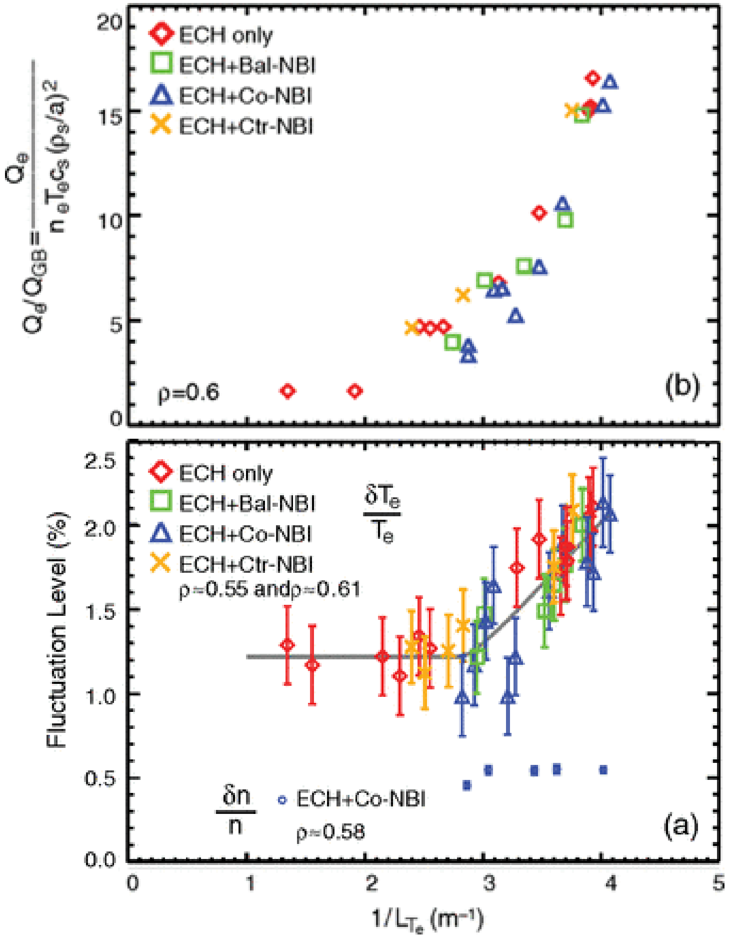
Required diagnostic / measurements:

- High-quality profile measurements (Thomson / XICS / CXRS)
- PCR measuring in U-band (w/in LCFS where n_e<4.5x10^{19}m^{-3})
- Steerable Doppler refl.: normal hopping
- CECE centered on ∇T –control surface

Experimental segments:

- Plasma start-up with on-axis ECRH
- “Steady-state” period (~1 s) with NBI blips (CXRS) and with LBO;
- Scan off-axis heating in ~4 discharges

DIII-D



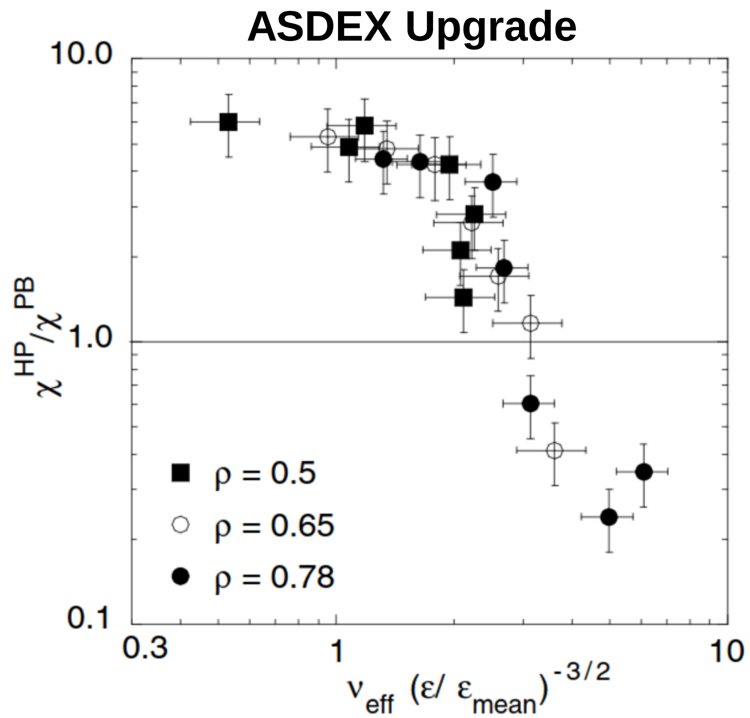
- Dedicated discharges: ~5 / configuration / density / surface -> 15 discharges [high-mirror, low-mirror, negative-mirror]

DIII-D: J.C. Hillesheim *PoP* **20,** 056115 (2013) / PRL 110 045003 (2013); AUG: A.G. Peeters PoP **12**, 022505 (2005) / PRL

The ITG-TEM transition and its dependence on collisionality

The ITG and TEM are coupled drift wave modes. The TEM is stabilized by collisional detrapping while the ITG mode is largely unaffected by collisions. Goal is to investigate the transition between ITG and TEM dominant transport in W7-X.

- Vary collisionality by changing plasma density and ECRH heating power



Required diagnostic / measurements:

- High-quality profile measurements (Thomson / XICS / CXRS)
- PCR measuring in U-band (within plasma LCFS)
- Steerable Doppler reflectometer: normal hopping at “low-k”
- “Steady-state” period (~1 s) with NBI blips (CXRS) and LBO + 17 Hz ECRH modulation period (~1 s)

Dedicated discharges: 5 / configuration -> 15 discharges [high-mirror, low-mirror, negative-mirror]

Similarities and tie-ins to proposal of same name presented by Carralero / **F. Ryter *et al.*, PRL 95 (2005)**

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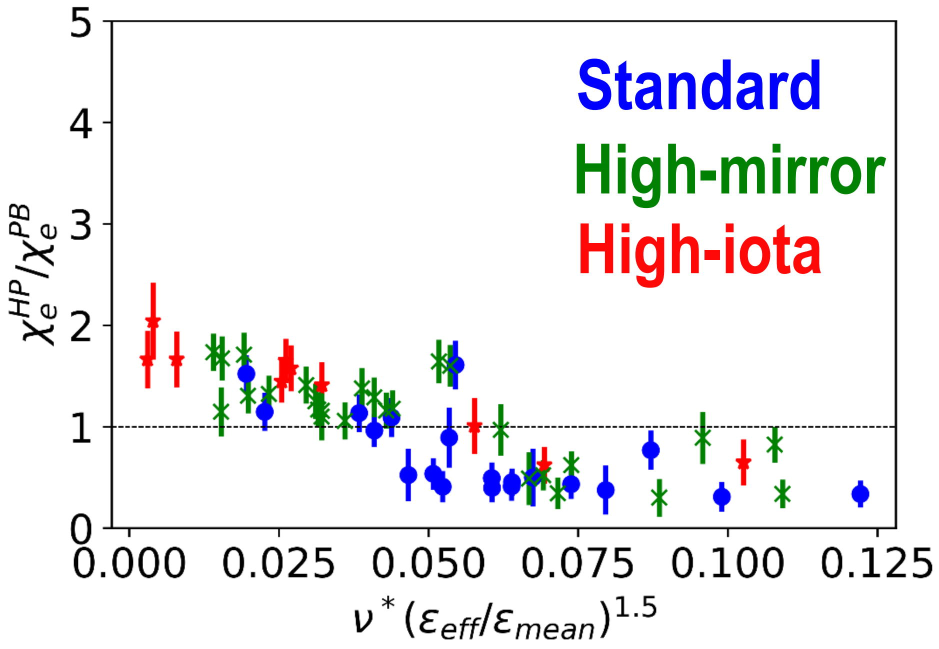

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  + 17 Hz ECRH modulation period (~1 s)

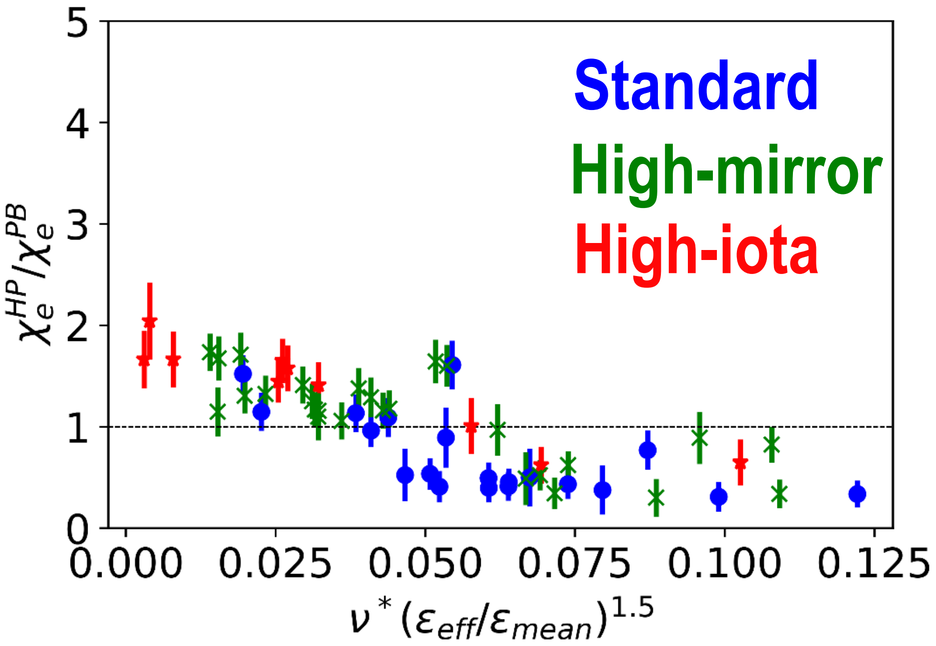
Dedicated discharges: 5 / configuration -> 15 discharges [high-mirror, low-mirror, negative-mirror]

Similarities and tie-ins to proposal of same name presented by Carralero / **G.M. Weir *et al.*, NF 61 (2021)**

Stability survey of the density gradient driven TEM while holding collisionality

The ITG and TEM are coupled drift wave modes. The TEM is stabilized by collisional detrapping while the ITG mode is largely unaffected by collisions. Goal is to investigate the transition between ITG and TEM dominant transport in W7-X.

- Attempt to hold collisionality constant by appropriately scaling the ECRH power while changing the plasma density



Required diagnostic / measurements:

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- PCR measuring in U-band (within plasma LCFS)
- Steerable Doppler reflectometer: normal hopping at “low-k”
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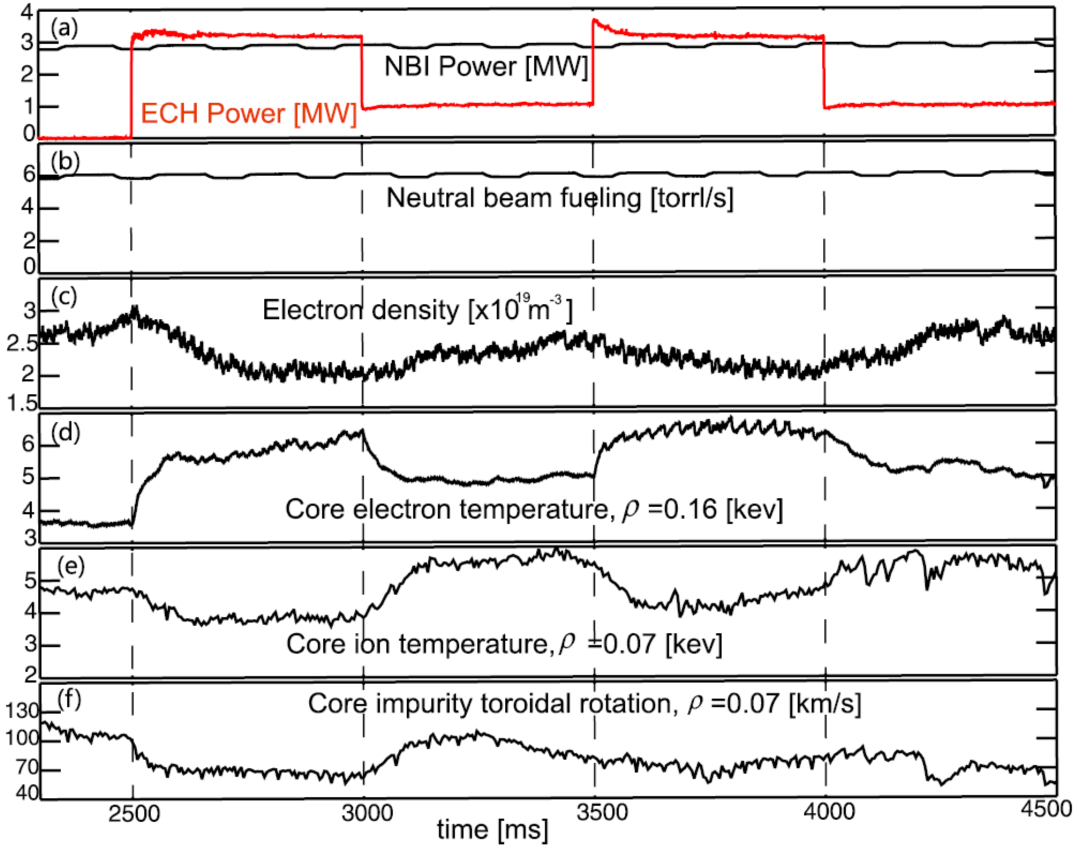
Dedicated discharges: 5 / configuration -> 15 discharges [high-mirror, low-mirror, negative-mirror]

Similarities and tie-ins to proposal of same name presented by Carralero / **G.M. Weir *et al.*, NF 61 (2021)**

ECH density pump-out in W7-X and the ITG-TEM transition

The ITG and TEM influence both the electron temperature and the plasma density profile shape through changes in the ECH driven flux as well as profile relaxation (temperature and density).

- Changes in Te/Ti can modify dominant turbulence drive (Te/Ti increases, ITG->TEM)
- Thermodiffusive pinch changes from inward (ITG) to outward (TEM)
- Strongly related to profile control (TG: Profiles)



Required diagnostic / measurements:

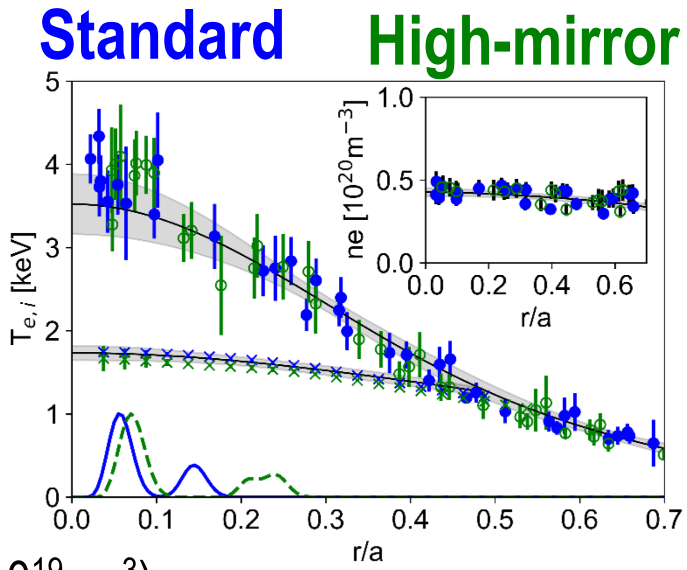
- High-quality profile measurements (Thomson / XICS / CXRS)
- PCR measuring within plasma LCFS (U-band operation)
- Steerable Doppler reflectometer: normal hopping at “low-k”
- Steady NBI / ECRH period + slow high power ECRH modulation (~2 s, ~70% depth, <~2 Hz)

Dedicated discharges: 1 / density (5) / configuration (3) -> 15 discharges [high-mirror, low-mirror, negative-mirror]

Tie-ins to collisionality / ITG-TEM proposals; strong relation to “Turbulence during power step-down-induced edge density gradients” based on **X. Wang NF 57, (2017)**

Configuration comparison high/low/negative mirror (with matched profiles)

- The differences in transport under matched kinetic profile conditions are directly dependent on the differences between magnetic configurations.



Required diagnostic / measurements:

- High-quality profile measurements (Thomson / XICS / CXRS)
- PCR measuring in U-band (w/in LCFS where n_e<4.5x10^{19}m^{-3})
- Steerable Doppler refl.: mirror angle scan for wavenumber meas.

Experimental segments (example):

- Vary plasma density between discharges over small range (ex// 4.0, 4.5, and 5.0 x 10^{19} m^{-3})
- Change on-axis ECRH heating power in ~3 steps; “Steady-state” period (~1 s) with NBI blips (CXRS) and with LBO; + 17 Hz on-axis ECRH modulation (67% duty cycle, ~30% depth)
- Use off-axis heating to change temperature gradient (if necessary) in follow-up

Dedicated discharges: ~5 / configuration -> 15 discharges [high-mirror, low-mirror, negative-mirror]

G.M. Weir et al., NF 61 (2021)

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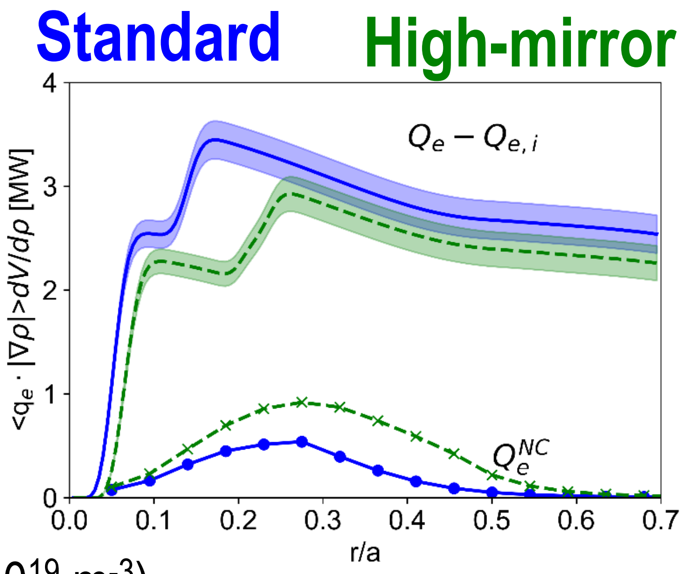
- The differences in transport under matched kinetic profile conditions are directly dependent on the differences between magnetic configurations.



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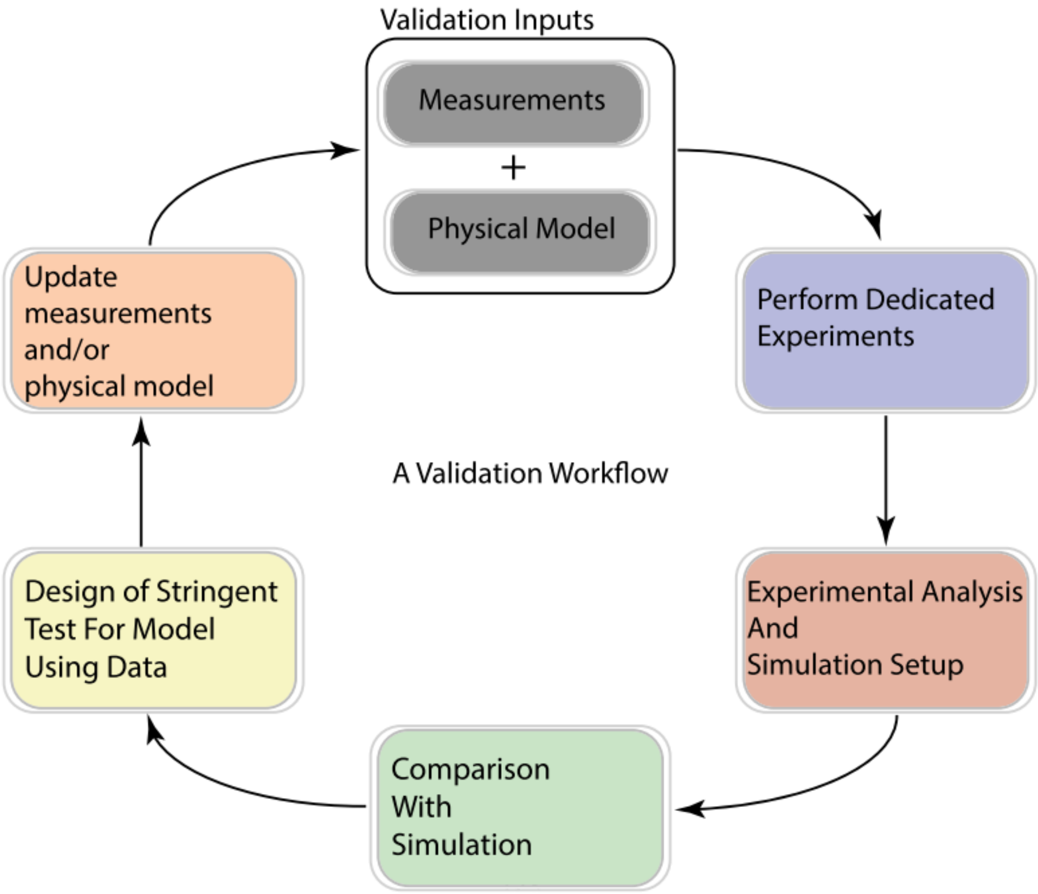
Dedicated discharges: ~5 / configuration -> 15 discharges [high-mirror, low-mirror, negative-mirror]

G.M. Weir et al., NF 61 (2021)

Matching physics parameters and fluxes to nonlinear gyrokinetic calculations at the ion-scale

- Validation of ionscale turbulence models in ECRH heated plasmas / CECE synthetic diagnostic development
  - Nonlinear gyrokinetic simulation in flux tube geometry at realistic exp. parameters (Ex// r/a~0.7, T_e/T_i=1.0, a/L_{ne}=0.7, a/L_{Te}~a/L_{Ti} ~2)
  - Experimental scan of ECRH power and density near op. point:

→ Can a *reduced model* based on subdominant modes reproduce the measured fluxes and cross-phases?



part of DOE grant: "Exploring ion heat transport during NBI heated plasmas at W7-X"

M.J. Pueschel PRL 116 (2016), C.C. Hegna PoP 25 (2018) / B. Faber J. Plasma Phys. 84, (2018), **A. White *J. Plasma Phys* 85 (2019)** / S.J. Freethy, *PoP* 25 (2018)

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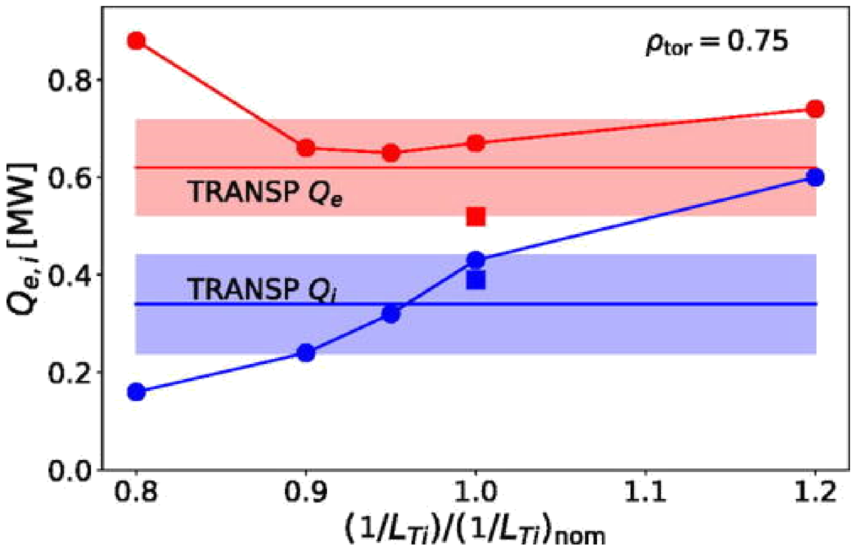
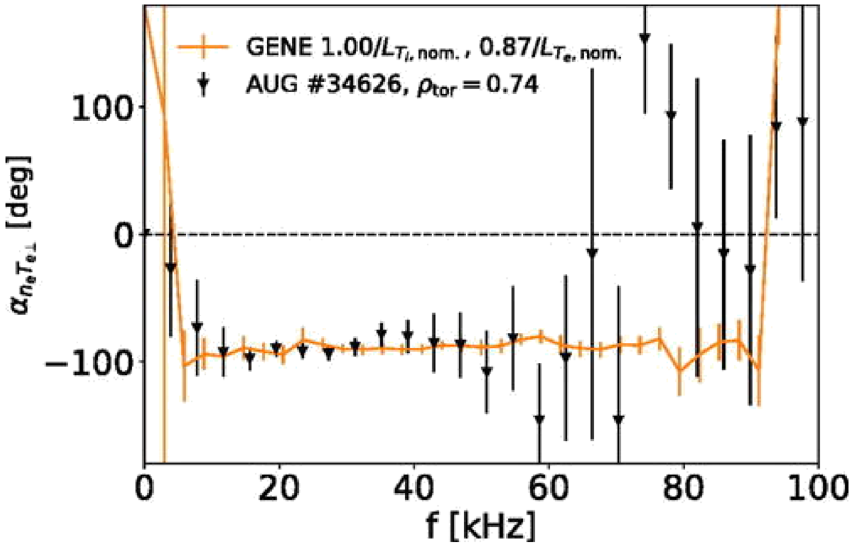
  - Experimental scan of ECRH power and density near op. point:

    → Can a *reduced model* based on subdominant modes reproduce the measured fluxes and cross-phases?

- Diagnostic methods:
  - Steerable Doppler reflectometer scan over wavenumber
  - NBI Blips for CXRS (high-quality profile measurements)
  - PCR measuring w/in the LCFS (U-band operation, ~5x10^{19} m^{-3})
  - CECE nT-crossphase measurements 0.7<r/a<0.9
  - ~1.0 s steady-state period (CECE); +~1.0 s of ECRH modulation (17 Hz, 67% duty cycle, 30% depth)
- Estimated # of dedicated discharges: 5





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Similar proposals

Proposal	**Proposals with similar aspects**
Electron temperature gradient control with off-axis ECRH power density scans for TEM/ETG studies	→ Profile control methodology (TG profiles)
“The ITG-TEM transition and its dependence on collisionality” and “Stability survey of the density gradient driven TEM while holding collisionality”	Similarities to proposal of same name presented by Carralero
	Complimentary to “ECH density pump-out in W7-X and the ITG-TEM transition”
	Possibly complimentary to “Turbulence during power step-down-induced edge density gradients”
ECH density pump-out in W7-X and the ITG-TEM transition	→Related to non-local transport and ECRH driven flux investigations. → Profile control aspects (TG profiles)
Configuration comparison high/low/negative mirror (with matched profiles)	Tie-ins to proposals from Jorge and also to ITG-TEM studies
Matching physics parameters. and fluxes to nonlinear GK calculations (and reduced models) at the ion-scale	Assessment of the relative weight of the different transport channels (i.e. neoclassical and turbulent) on particle Transport (García-Regaña)
	The ITG-TEM transition and its dependence on collisionality (Carralero): comparison to full surface GK simulations

Electron temperature gradient control with off-axis ECRH power density scans for TEM/ETG studies -> specific program description

Program A)

Time	1x on-axis	7x off-axis @ r/a~0.3	2x off-axis @ r/a~0.5
0.0-0.5s	1	0	0
0.5-1.7s	0	4 + 1 modul.	2
1.7-2.8s	0	5 + 1 modul.	1
2.8-4.0s	0	6 + 1 modul.	0

*modulation: 17 Hz, 25% depth, 1.2s

Program B)

Time	on-axis	4x off-axis @ r/a~0.3	5x off-axis @ r/a~0.5
0.0-0.5s	1	0	0
0.5-1.7s	0	1 + 1 modul.	5
1.7-2.8s	0	2 + 1 modul.	4
2.8-4.0s	0	3 + 1 modul.	3

*modulation: 17 Hz, 25% depth, 1.2s

r/a~0.3 at minimum power

Program C

Time	1x on-axis	7x off-axis @ r/a~0.6	2x off-axis @ r/a~0.7
0.0-0.5s	1	0	0
0.5-1.7s	0	4 + 1 modul.	2
1.7-2.8s	0	5 + 1 modul.	1
2.8-4.0s	0	6 + 1 modul.	0

*modulation: 17 Hz, 25% depth, 1.2s

Program D

Time	on-axis	4x off-axis @ r/a~0.6	5x off-axis @ r/a~0.7
0.0-0.5s	1	0	0
0.5-1.7s	0	1 + 1 modul.	5
1.7-2.8s	0	2 + 1 modul.	4
2.8-4.0s	0	3 + 1 modul.	3

*modulation: 17 Hz, 25% depth, 1.2s

r/a~0.6 at minimum power