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**Flux driven pedestal formation above a certain source
Flux driven pedestal formation in tokamaks: Turbulence
simulations validated against the isotope effect**

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Ingredients for realistic L mode edge modelling

Key players for realistic L mode edge [Bourdelle NF2020]:

- Turbulence drive resistive Drift Waves on which larger β has a destabilizing impact [Bonanomi NF2019, De Dominicis NF2019]

- $\vec{E} \times \vec{B}$ shear, key in formation of the edge transport barrier [Burrell PoP 2020], incl. neoclassical friction and realistic SOL E_r or at least realistic LCFS value for E_r

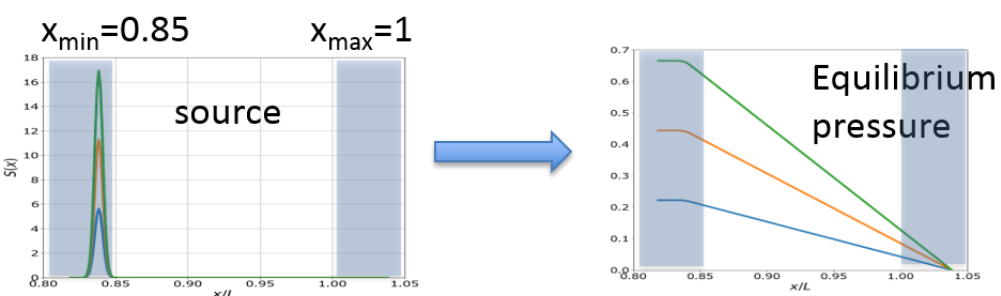
First self-consistent pedestal formation in 3D non-linear fluid flux-driven simulation including the following critical physical ingredients:

- 1) resistive electromagnetic Drift Waves and ballooning modes
- 2) E_r accounting for neoclassical friction on $V_\theta(v^*)$ with realistic L mode edge v^* from banana to Pfirsch-Schlüter regimes

As in experiments, the pedestal forms above a certain power threshold. As in experiments, this power threshold is lower for Tritium plasmas than for Deuterium plasmas.

So far, flux driven pedestal formation in electrostatic: EMEDGE3D [Chôné PoP2014] and BOUT++ [Park PoP2015] and here electromagnetic EMEDGE3D [DeDominici, ArXiv2019]. **More flux driven fluid codes should explore!!**

Fluid flux driven concentric circular torii without SOL



EMEDGE 3D [Fuhr PRL2008, De Dominicis NF 2019]

Charge and energy conservation,

Pressure $\propto T$, i.e. iso-density

Ohm's law

including electromagnetic and diamagnetic effects

E_r such that 0 at LCFS and with neoclassical friction on V_θ

E_r force balance, role of V_θ in L mode edge

Example at JET [Hillensheim PRL 2016]

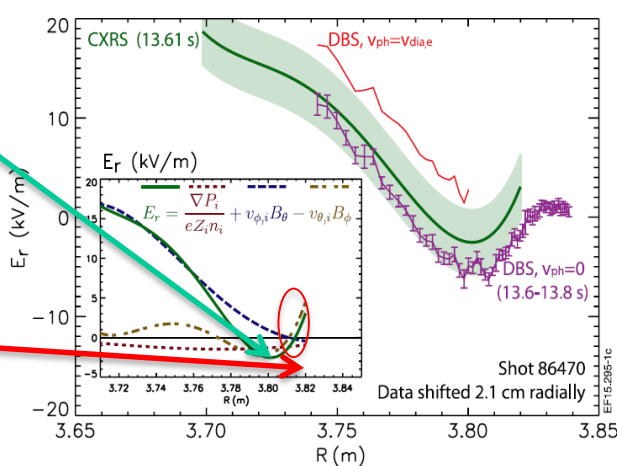
$\frac{\nabla P_i}{Z_i n_i}$ a good proxy for $\min(E_r)$ see AUG

[CavedonNF2020]

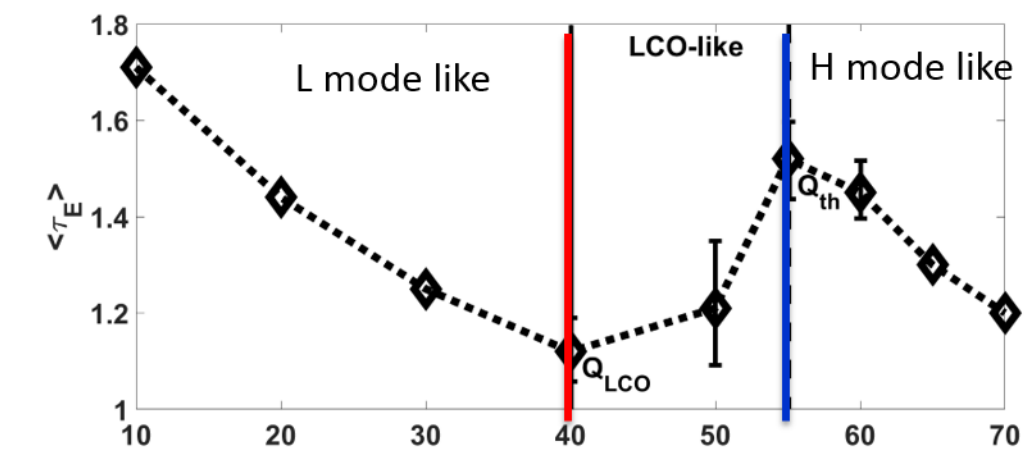
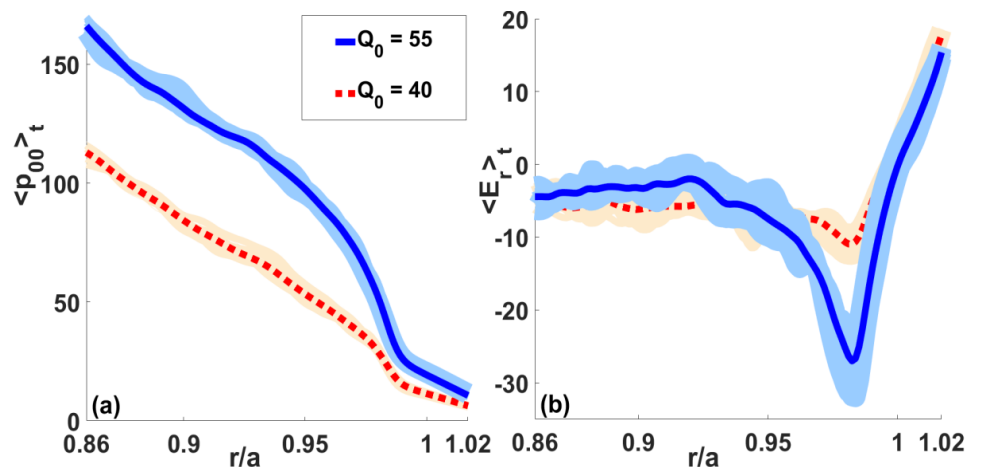
But... from $\min(E_r)$ to the LCFS $V_\theta(v^*)$ with v^* from banana to P-S!

$$v_{\theta i} = k_i \frac{\nabla_r T_i}{e B_\phi}$$

$$k_i = \left(\frac{1.17 - 0.35 v_{i*}^{1/2}}{1 + 0.7 v_{i*}^{1/2}} - 2.1 v_{i*}^2 \epsilon^3 \right) \frac{1}{1 + v_{i*}^2 \epsilon^3}$$



Flux driven pedestal formation above a certain source



In nonlinear simulation:

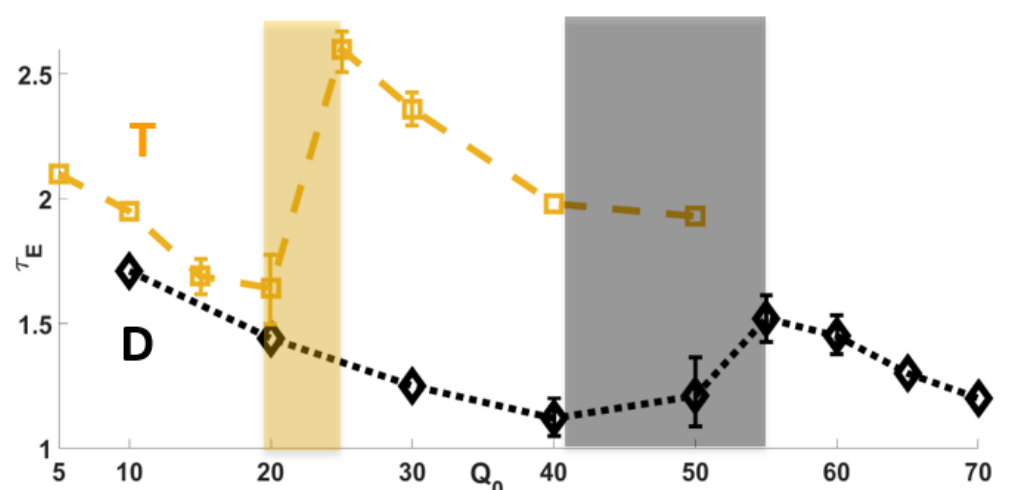
$\tau_{E \times B} > \tau_{turb}$ i.e. $\gamma_E < \gamma_{turb}$

$\gamma_E > \gamma_{turb}$

T_{e0} (eV)	n_0 (m^{-3})	B_0 (T)	$\frac{R}{L_p}$	q
50	$2.5 \cdot 10^{19}$	1	58	$2.5 \rightarrow 3.5$

[DeDominici, ArXiv2019]

flux driven pedestal formation captures isotopic effect



A lower power threshold in T compared to D

$$Q_{th} \sim \frac{1}{A^\alpha} \text{ with } \alpha \approx 1.8 \pm 0.6$$

[DeDominici, ArXiv2019]

D to T: correlation length λ_{turb} similar

Correlation time

τ_{turb} higher in T vs D

due to higher mass

Hence weaker

turbulence drive in T

