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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  $\beta$  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  $E_r$

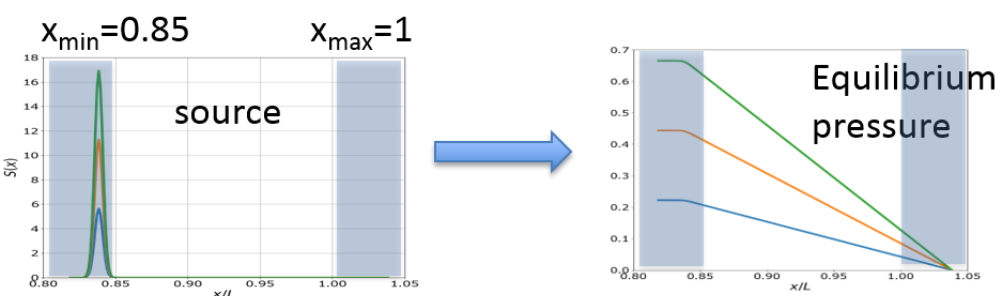
**First self-consistent pedestal formation in 3D non-linear fluid flux-driven simulation** including the following critical physical ingredients:

- 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  $V_\theta$

## $E_r$ force balance, role of $V_\theta$ in L mode edge

Example at JET [Hillensheim PRL 2016]

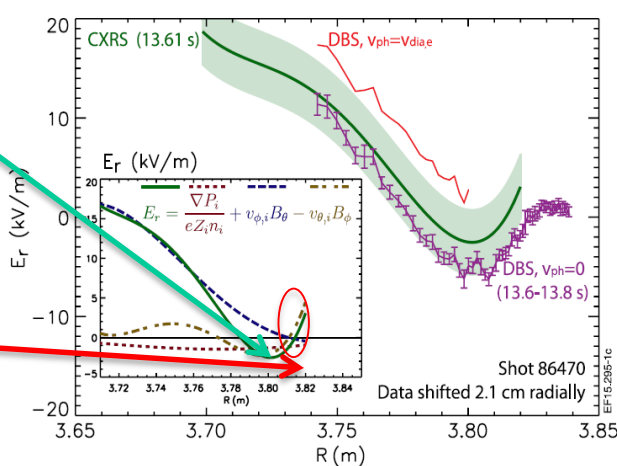
$\frac{\nabla P_i}{Z_i n_i}$  a good proxy for  $\min(E_r)$  see AUG

[CavedonNF2020]

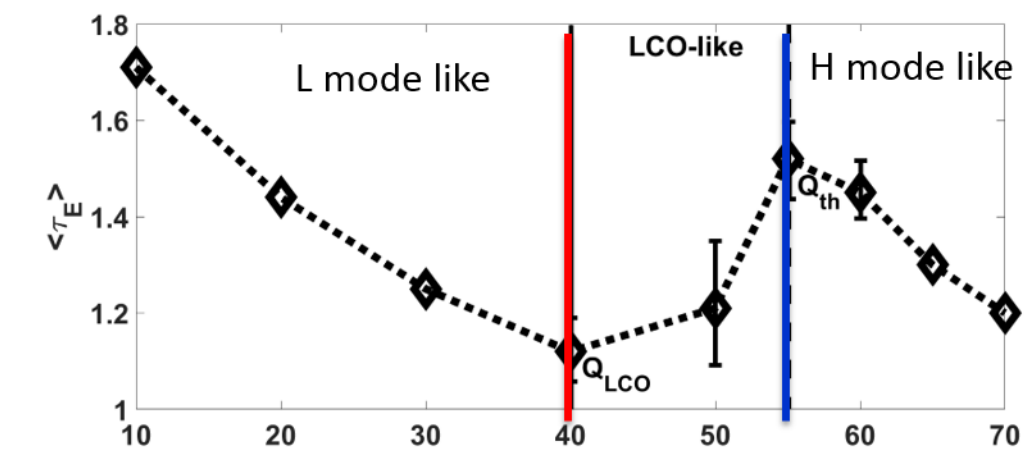
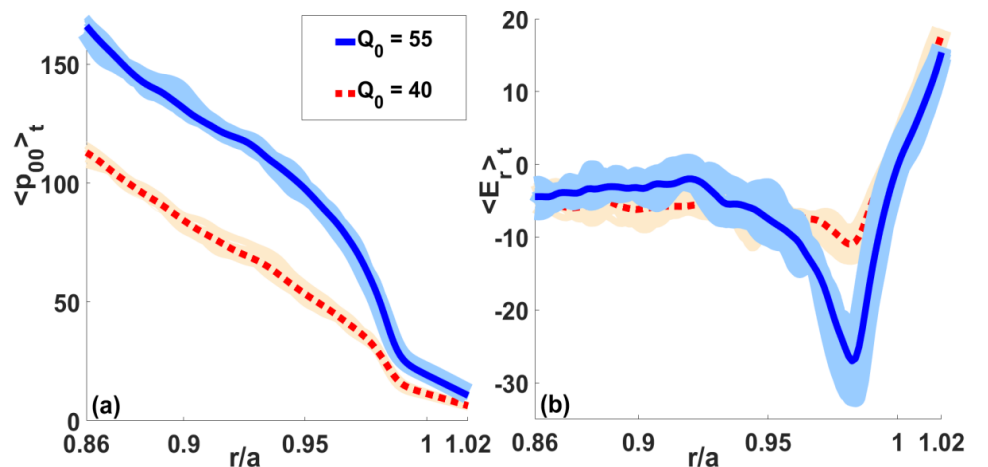
But... from  $\min(E_r)$  to the LCFS  $V_\theta(v^*)$  with  $v^*$  from banana to P-S!

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

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



## Flux driven pedestal formation above a certain source



In nonlinear simulation:

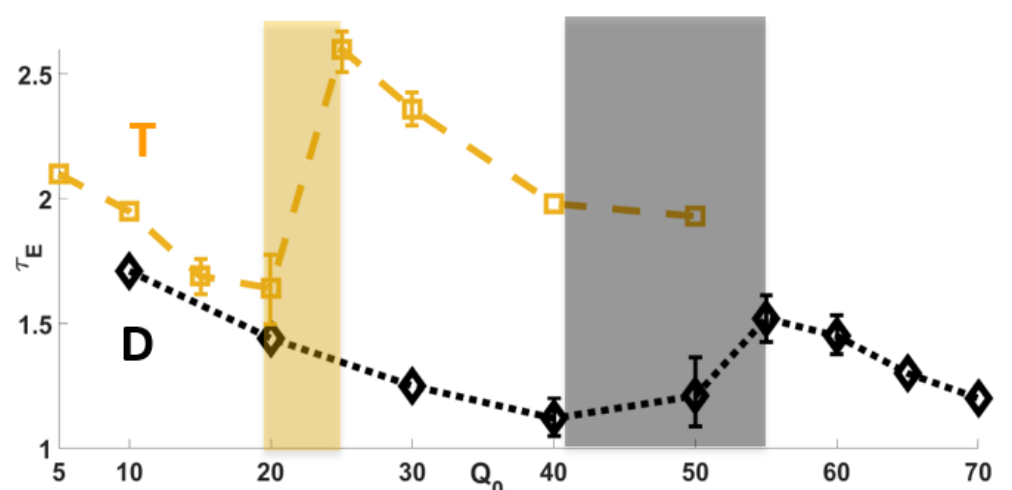
$$\tau_{E \times B} > \tau_{turb} \text{ i.e. } \gamma_E < \gamma_{turb}$$

$$\gamma_E > \gamma_{turb}$$

| $T_{e0}$ (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  $\lambda_{turb}$  similar

Correlation time

$\tau_{turb}$  higher in T vs D

due to higher mass

Hence weaker

turbulence drive in T

