Baffled and non-baffled Super-X studies on TCV

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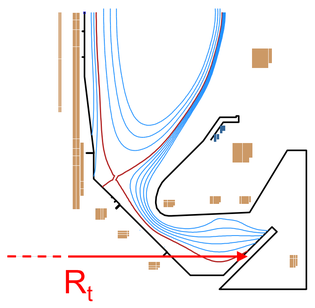
Background

- Total flux expansion (increasing R_t) in Super-X divertor is expected to **reduce the detachment threshold** and provide a **wider detachment window**
  - Modified 2pt. model prediction[1,2]:

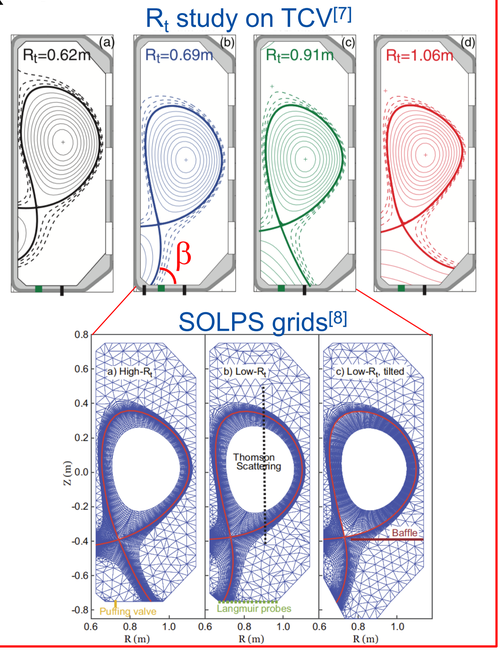
$$T_e^t \propto \frac{1}{R_t^2} \qquad n_e^t \propto R_t^2 \qquad n_e^u(T_e^t = const.) \propto \frac{1}{R_t}$$

  - Behavior confirmed by SOLPS in "box" divertor[3]
  - Wider detachment window expected from $q_{||} \propto 1/R$ dependence of parallel heat flux[4-6]

MAST-U implementation of a Super-X



R_t study on TCV[7]

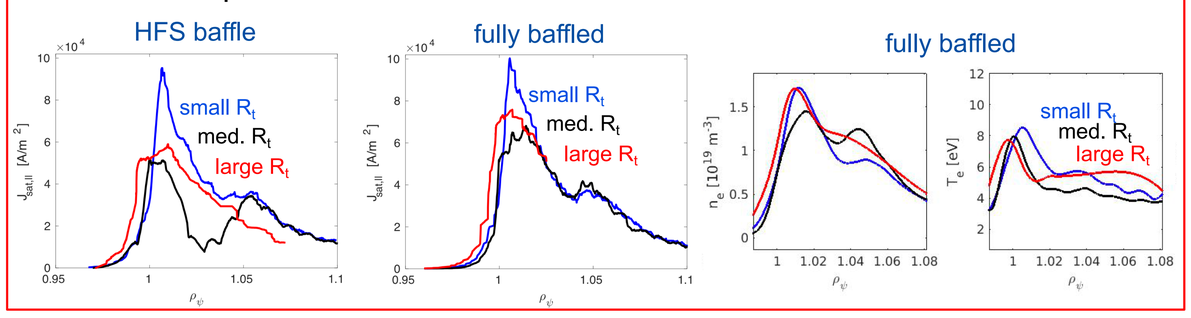


- Past density ramp experiments on TCV **did not show** expected benefits[7], despite 70% variation in R_t

- Recent SOLPS simulations[8] of intermediate R_t cases largely reproduce these experiments
  - ➢ R_t effect masked by **difference in neutral trapping**
  - ➢ Simulations predict R_t effect recovered if
  1. **Target poloidal incidence angle β matched**
  2. **Gas baffles added**

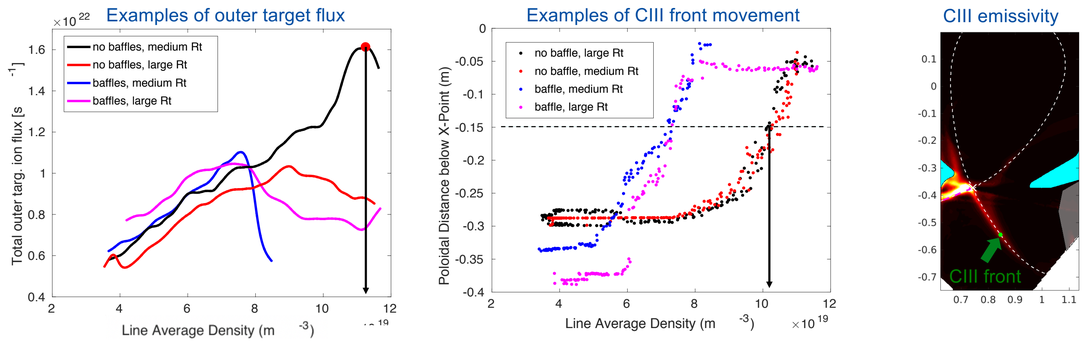
Target profiles vs R_t

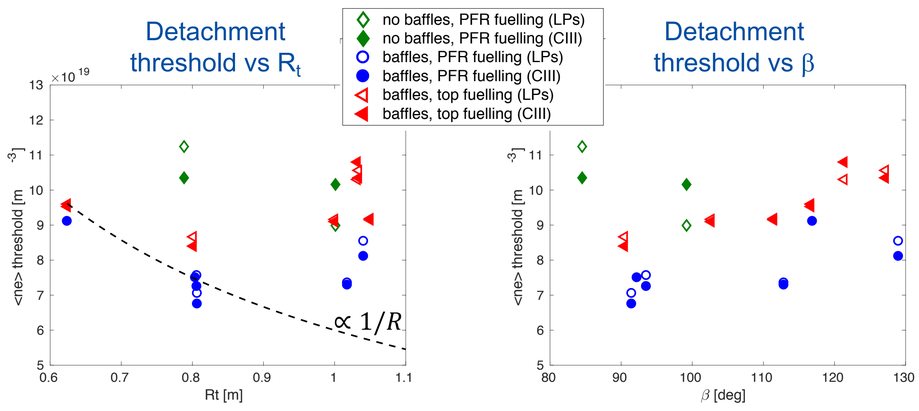
- ➢ $J_{sat,||}$ profile shape changes with R_t, especially without baffles. Changing SOL transport?
- ➢ n_e^t and T_e^t fairly independent of R_t



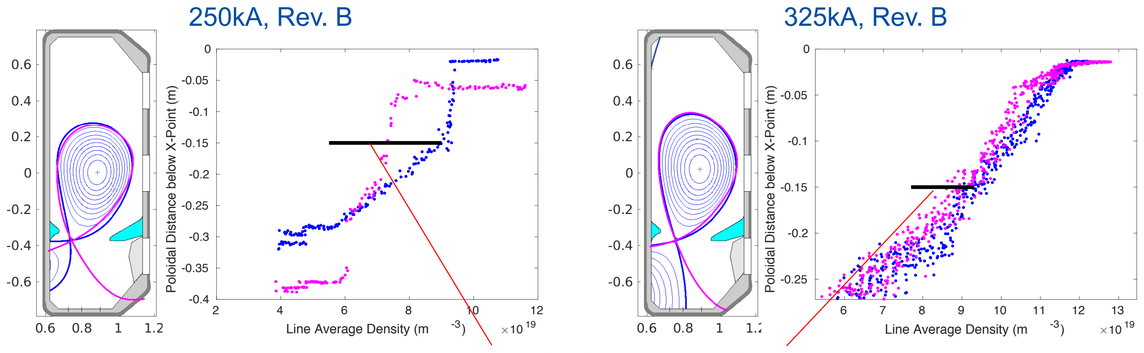
Detachment access

- Performed density ramps at different, fixed values of R_t
- Infer density threshold for detachment in two ways:
  1. integrated, outer target ion flux at maximum
  2. CIII emission front at 15 cm below X-point





- ➢ Detachment threshold from LPs and CIII front very similar (except for the two non-baffled shots)
- ➢ Threshold reduced with baffles, especially for PFR fueling
- ➢ For baffled shots, data better ordered by β than R_t
- ➢ A subset of shots with closely matched β for different R_t: shows threshold reduction*, but weaker than predicted:

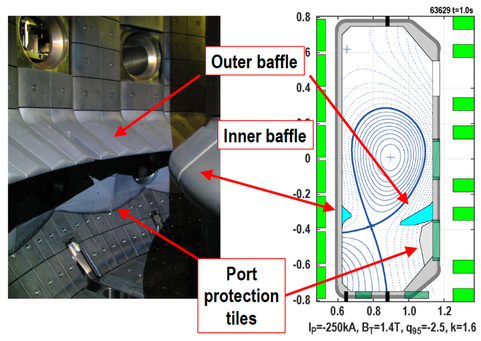


*Not in case of top fueling (not shown)

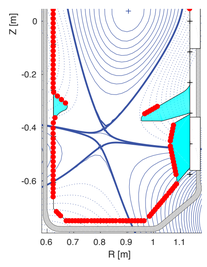
Goal of present work

Guided by the SOLPS simulations of [8], revisit the role of total flux expansion in the newly upgraded, baffled TCV tokamak

TCV's new divertor baffles[9,10]



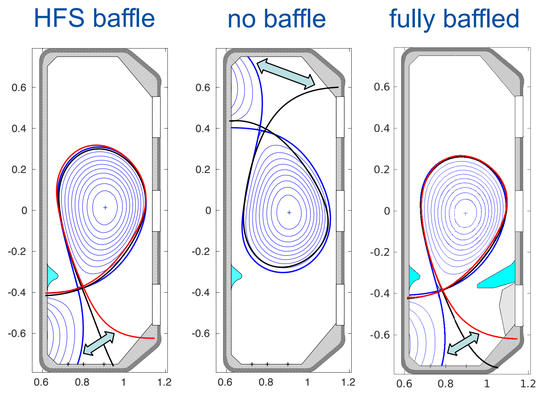
Improved wall LP coverage[11]

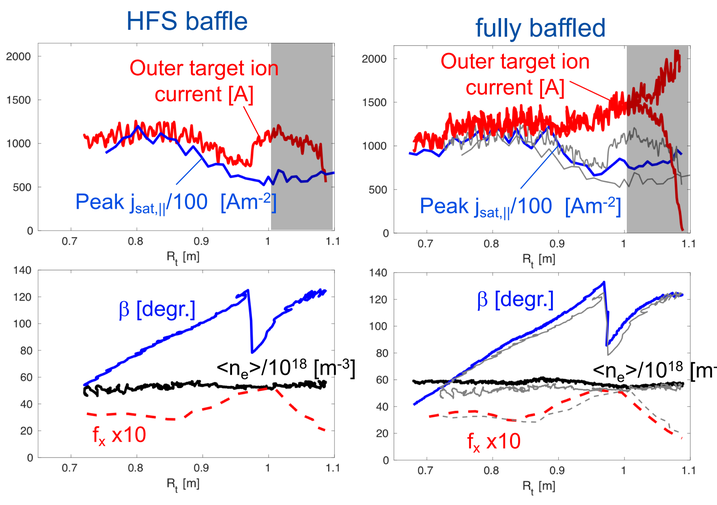


R_t scans, attached

Radial scan of outer target at constant density (250kA, Rev. B, attached)

2pt. model predicts
- $J_{sat,||}$ to scale as $\propto R_t$
- Total target ion current to scale as $\propto R_t^2$





- ➢ Peak $j_{sat,||}$ drops with R_t; slightly less so with baffles
- ➢ Total current increases only with baffles, but trend weaker than $\propto R_t^2$
- ➢ "HFS baffle" and "no baffle" cases show same behavior (not shown)

Conclusions

- Guided by SOLPS simulations[8], the R_t effect on target profiles and detachment onset have been revisited in TCV L-mode, rev. B plasmas
- In attached conditions, J_{sat} vs R_t does not follow the 2pt. model prediction; with baffles, agreement is better
- Consistent with SOLPS and SOLEDGE-2D simulations, baffles[8,12,13] and target angle β [8] are found to influence the detachment threshold
- With baffles and for constant β, limited dataset suggests that R_t effect on detachment is partly recovered
- Next: Extend dataset and pursue H-mode studies[14]

[1] Petrie *et al.*, NF **53**, 113024 (2013)
[2] Kotschenreuther *et al.*, NF **50** 035003 (2010)
[3] Moulton *et al.*, PPCF **59**, 065011 (2017)
[4] LaBombard *et al.*, NF **55**, 053020 (2015)
[5] Kotschenreuther *et al.*, PoP **20**, 102507 (2013)
[6] Lipschultz *et al.*, NF **56**, 056007 (2016)
[7] Theiler *et al.,* NF **57** 072008 (2017)
[8] A. Fil *et al.*, subm. to PPCF
[9] Reimerdes *et al.*, NME **12**, 1106 (2017)
[10] Fasoli *et al.*, NF, in press
[11] De Oliveira *et al.,* RSI **90**, 083502 (2019)
[12] Wensing *et al.*, PPCF **61**, 085029 (2019)
[13] Galassi *et al.*, this conference
[14] Harrison et al., PPCF **61**, 065024 (2019)

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Swiss Plasma Center

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