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Limiter and Emissive Electrode Biasing Experiments on the Tokamak ISTTOK

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- Experimental Setup
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- Emissive electrode bias
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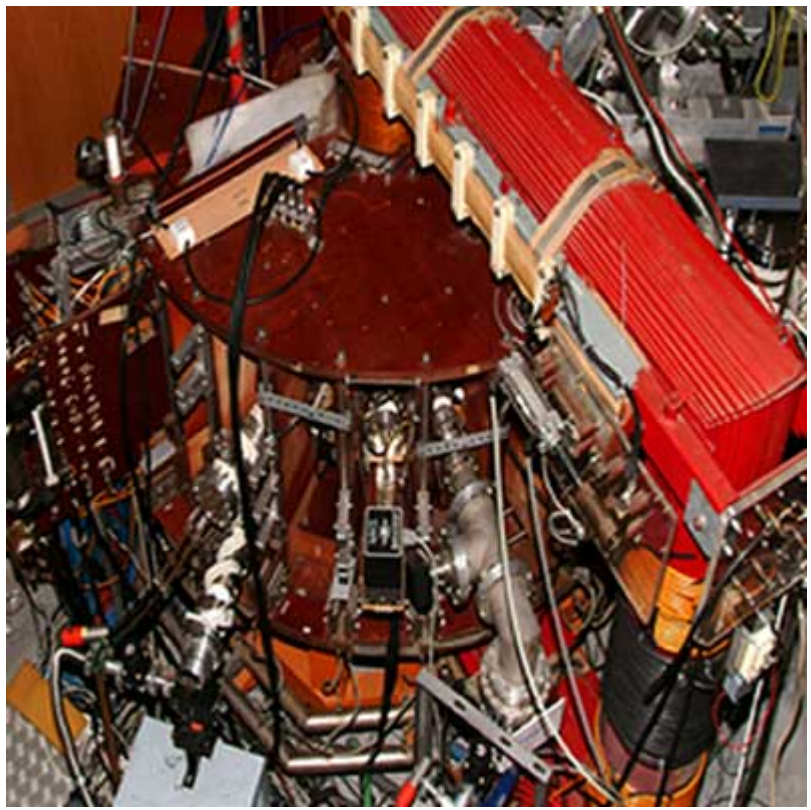
Tokamak ISTTOK



Circular cross-section

Poloidal graphite limiter

R = 46 cm

a = 7.8 cm, r_{vess}= 10 cm

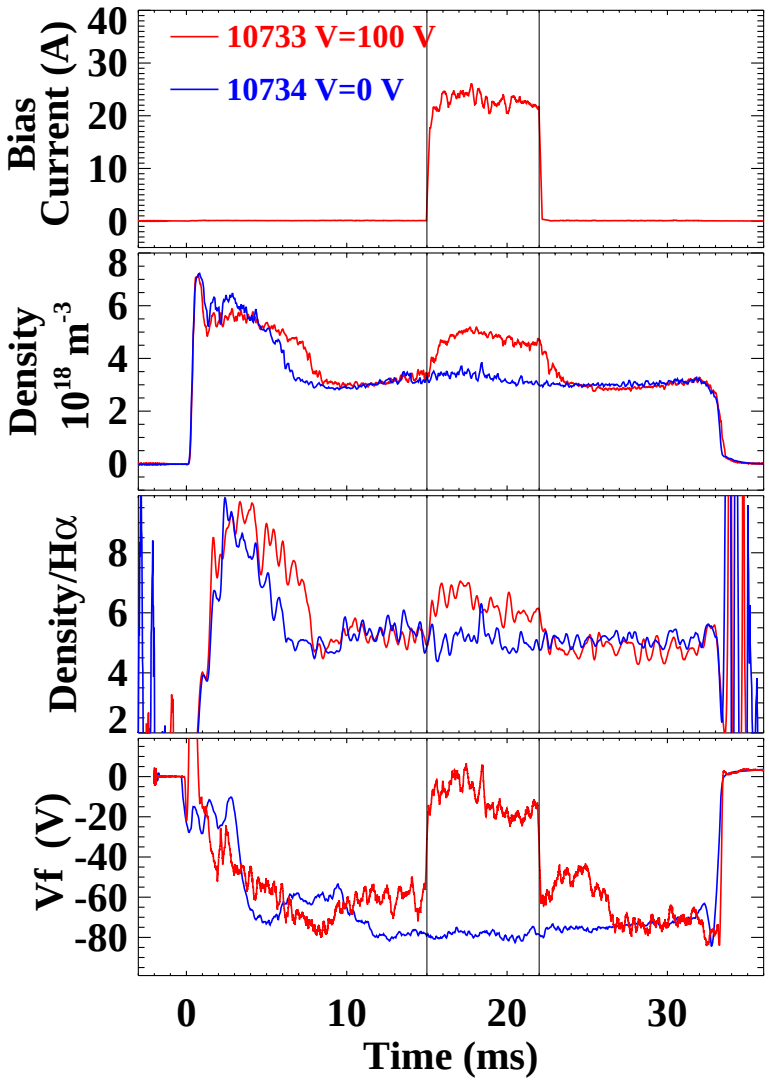
B_T = 0.3-0.6 T

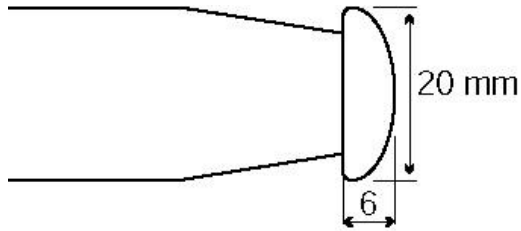
I_p = 4-8 kA

$\langle n_e \rangle = 3\text{-}6 \times 10^{18}\ m^{-3}$

τ_D = 40 ms

Previous results - Electrode bias





Electrode 1.5 cm inside LCFS

Positive bias

- Large increase in density
- Improvement of particle confinement
- Large increase in Er (up to 8 kV/m)

Negative bias (-250<V<0 V)

- No effects either global or local parameters (collect current ~1 A)

C. Silva, PPCF 04

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Motivation

Negative bias does not modify the Er due to the low collected current (1 A, up to 50 A for positive bias).

Aim: *Obtain the larger current necessary to modify confinement at negative bias*

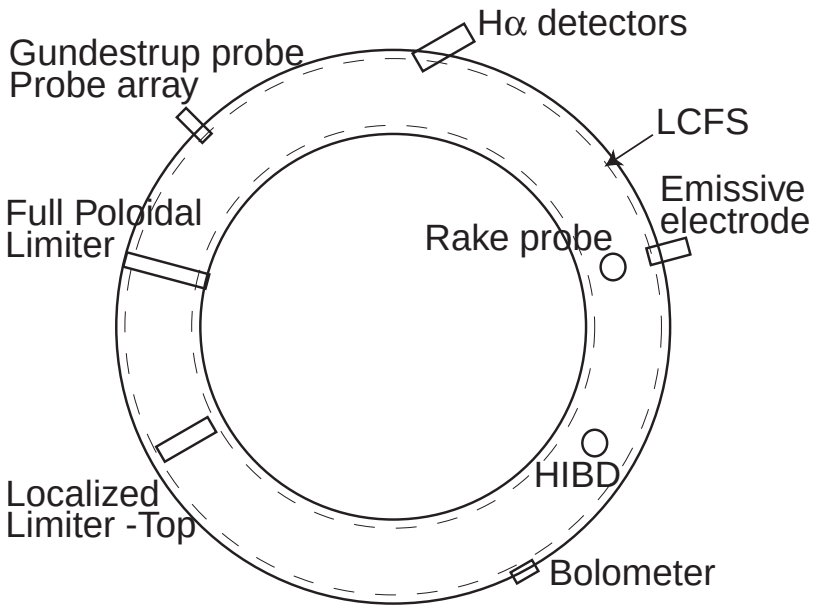
- **Limiter Bias:** small limiter inserted inside the main limiter radius

- **Emissive electrode bias:** small LaB_6 (Lanthanum Hexaboride) emitter, current up to 30 A

The behavior of the plasma under both emissive electrode and localized limiter bias will be compared

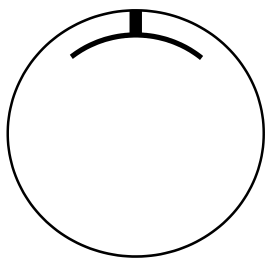
Experimental Setup

ISTTOK top view



Localized limiter

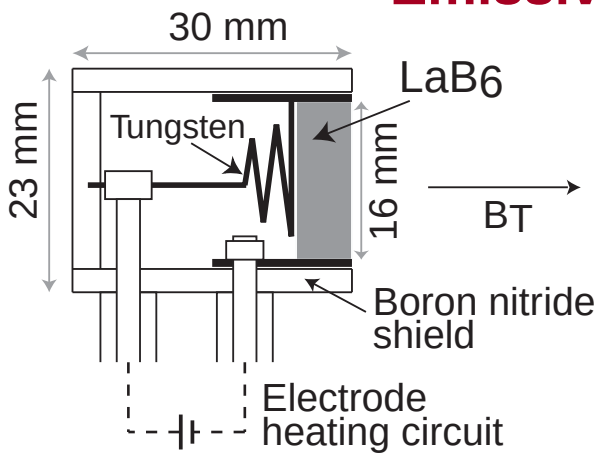
$-18 < r_{Lim} - r_{MainL} < 0$ mm



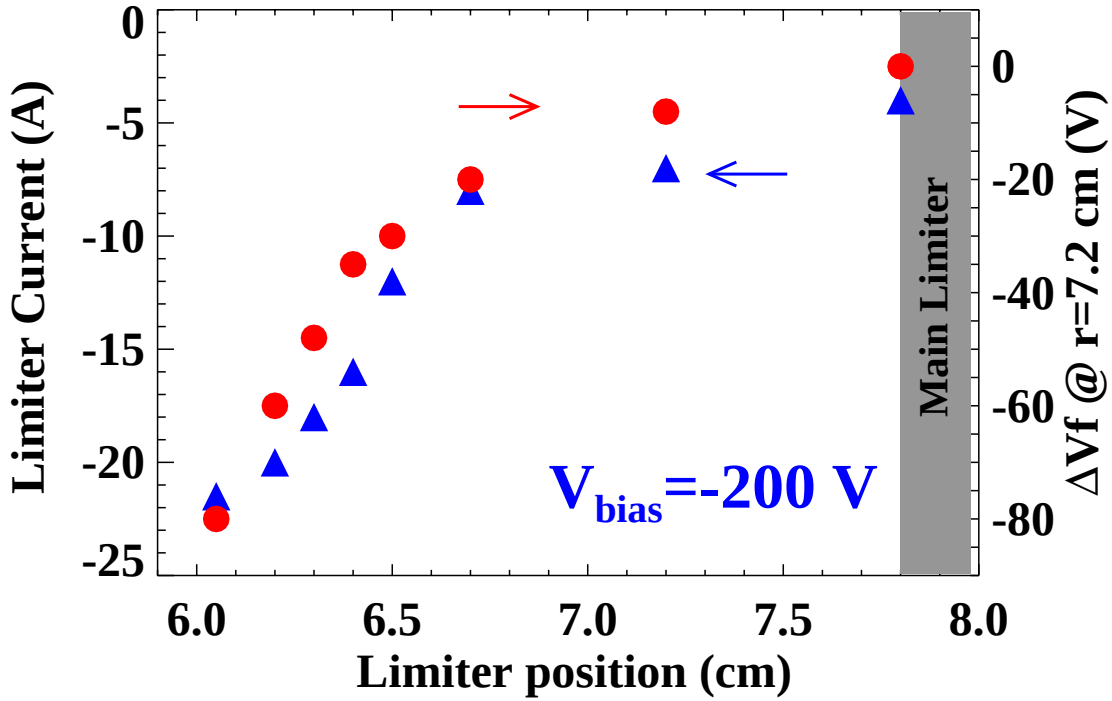
Relevant features

- Localized limiter (90º)
- Fully poloidal limiter
- Rake probe (4 mm radial resolution)
- Gundestrup probe
- Emissive electrode ($j=20A/cm^2$)

Emissive Electrode

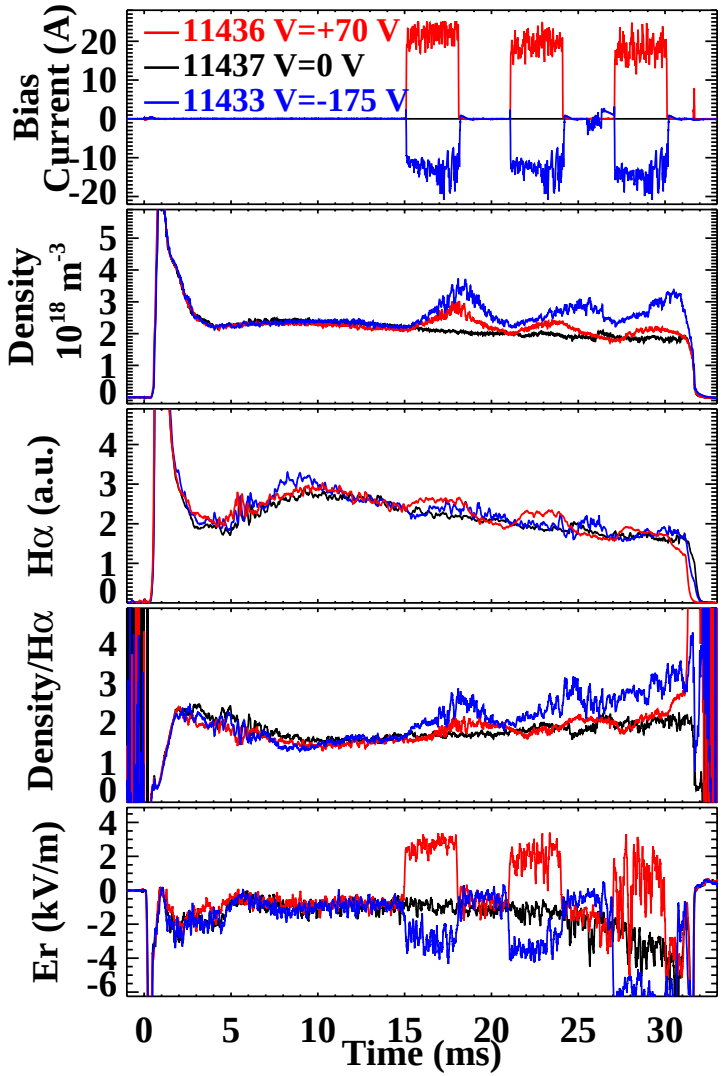


Limiter bias - Effect limiter position



- Both the limiter current and the ΔVf increase as the limiter is inserted into the plasma.
- Clear modification in Vf profile observed for negative bias (contrary to electrode)
- There is a linear relation between Er and the collected current
- However, localized limiter perturbs plasma for r_{lim}<6.7 cm

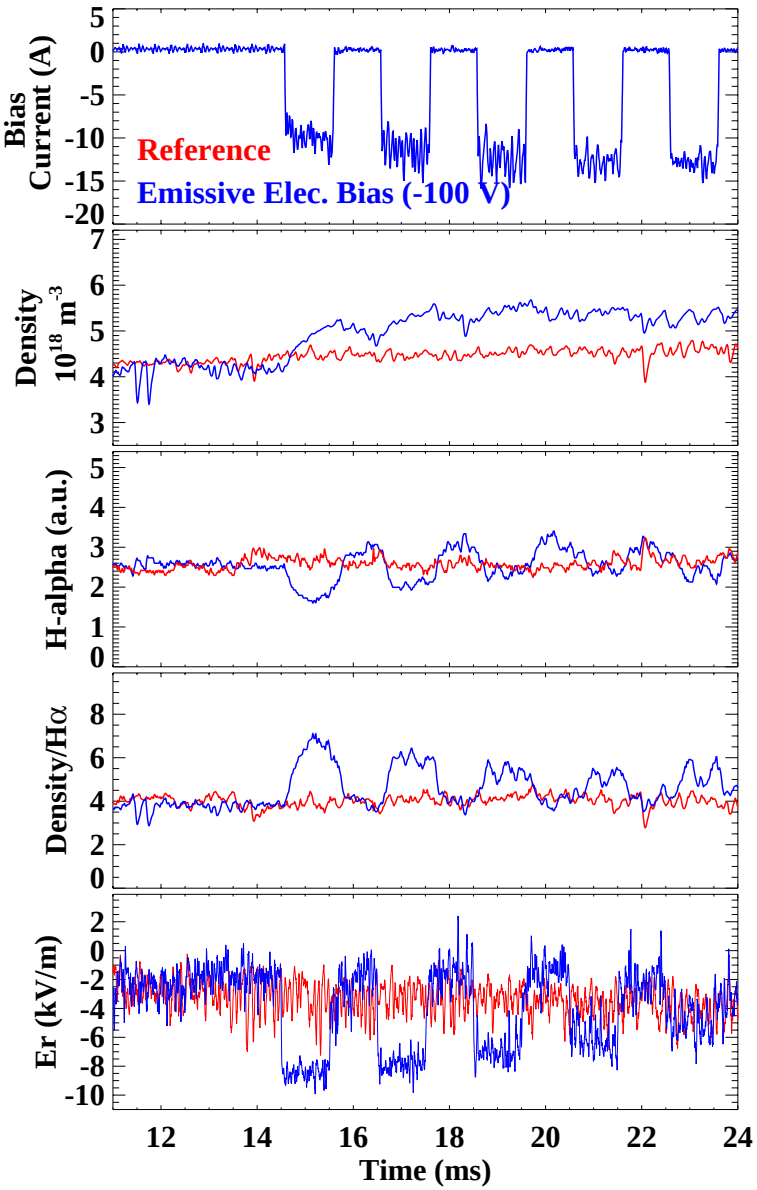
Limiter bias: Positive vs negative bias



Small Limiter 1.4 cm inside main limiter position

- Collected current for positive (negative) 20A (-15 A)
- Increase in density for both polarities
- Improvement in particle confinement larger for negative bias
- Positive bias increases recycling
- Er modified in a short time scale (<50 μs).
- Although plasma perturbed by the limiter, LB allows control of Er

Emissive Electrode bias



Electrode 1.0 cm inside LCFS

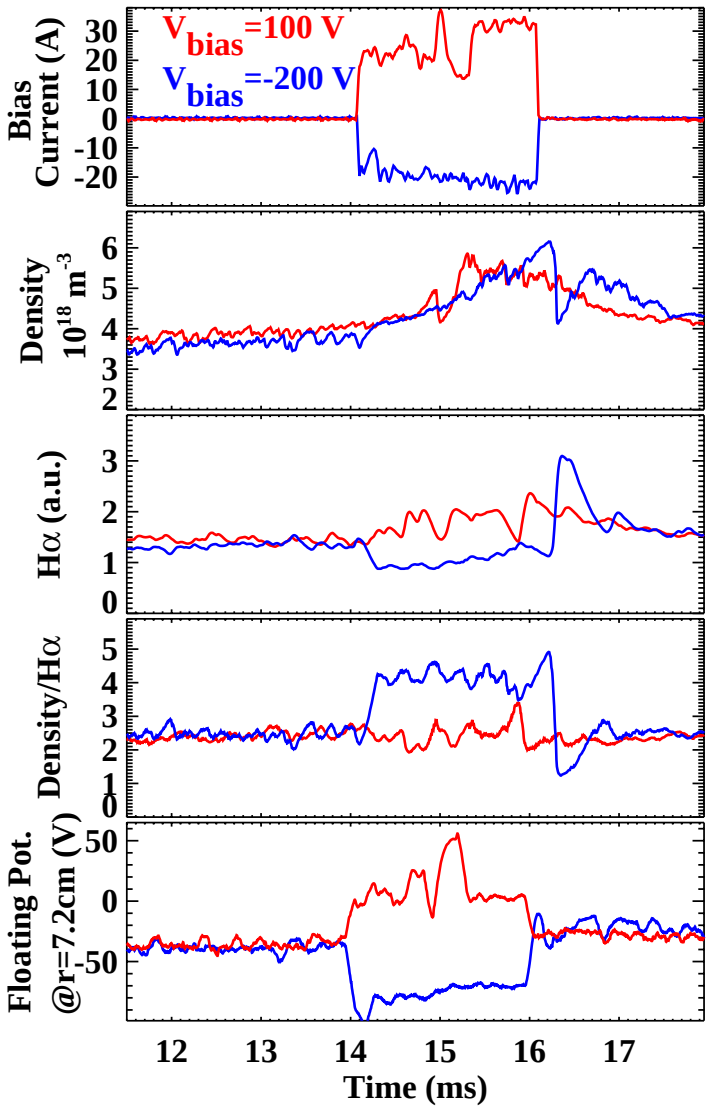
V_{bias}=-100 V

- Large collected current (10-15 A) >> Isat cold electrode
- Clear increase in density and decrease in the Hα radiation

  $\Rightarrow$ large improvement in particle confinement
- Er modified in a short time scale (<50 μs).

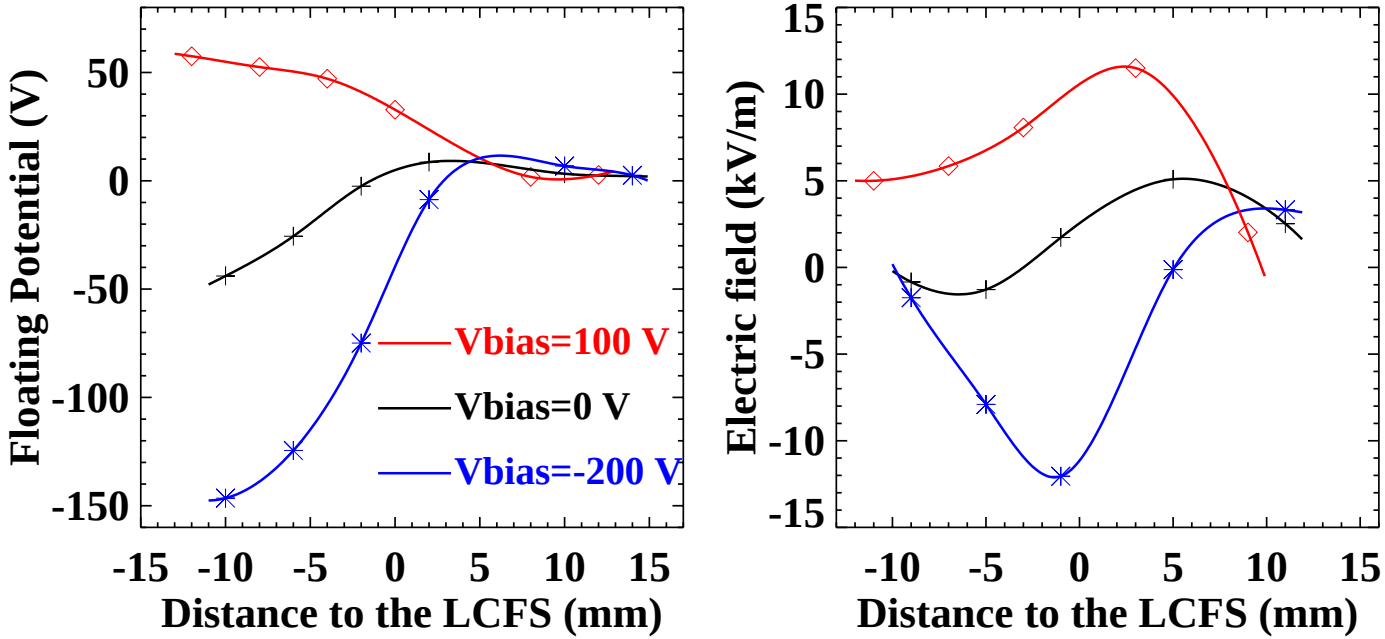
Emissive electrode allows the control of Er at negative bias

Emissive Electrode: Positive vs negative bias



- Positive bias: V_{bias}>50 V behaves as non-emissive
- Up to 30 A collected current (both polarities)
- Clear improvement in particle confinement for negative bias
- Positive bias increases recycling
- Floating potential modified for both polarities!

Emissive Electrode bias



- Radial electric field (up to 12 kV/m) for both polarities
- Emissive Electrode: Robust tool to control the edge Er and transport.

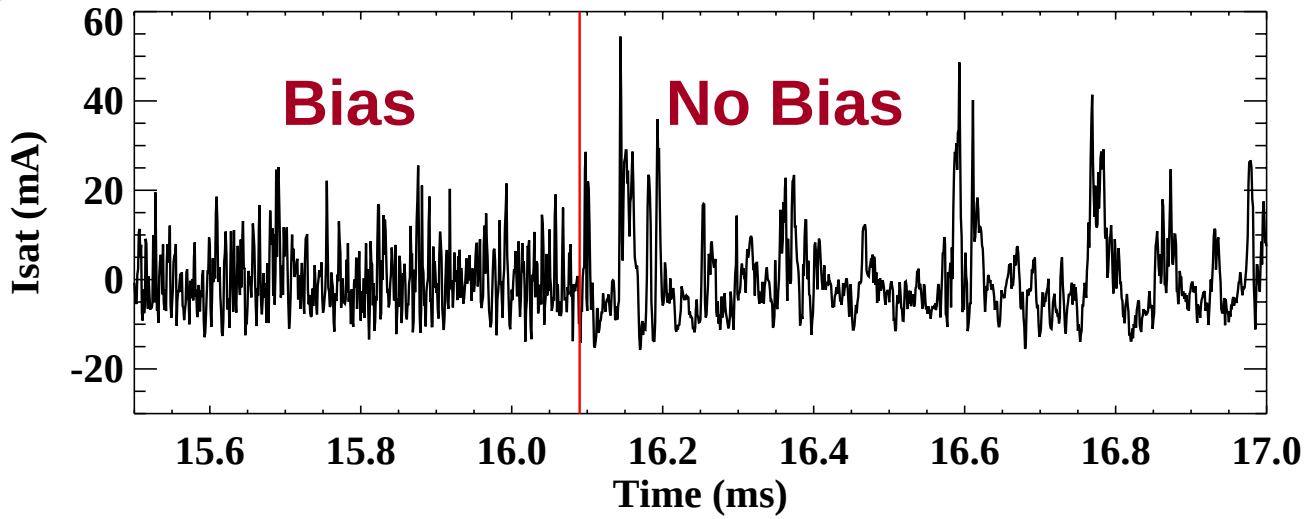
Comparison with negative Limiter Bias

- Emissive electrode perturbs significantly less the plasma
- Leads to larger Er and improvement in particle confinement

Bias effect on edge fluctuations

Large ExB shear is induced for both polarities, but the improvement in confinement is only observed for negative bias.

Negative emissive electrode bias



- Contrary to the observed for positive bias, negative bias suppresses the intermittent transport.
- Different behavior of the particle confinement may be related with the edge turbulent transport.

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Summary and conclusions

- In small tokamaks the current collected by negative biased cold electrodes is not sufficient to modify Er → **Emissive electrodes** produce a larger current density (x20)

- Large currents can be drawn at negative V_{bias} by both localized limiter and emissive electrode bias, leading to significant modifications in the edge Er profile and to an improvement in particle confinement.

- Compared with the localized limiter, the emissive electrode has the advantage of perturbing significantly less the plasma, leads to stronger Er and to a larger improvement in confinement.

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Summary and conclusions

- A significant increase in the plasma density is observed for both polarities but the improvement in particle confinement is larger for negative bias.

- The intermittent events are only suppressed for negative bias, suggesting that the different behavior of the particle confinement for positive and negative bias may be related with the edge turbulent transport.

- The emissive electrode proved to be a valuable tool on the control of the edge Er, allowing a detailed investigation of its importance in transport.