A Baffled-Probe Technique for Real-Time Edge Diagnostics and Its Possible Applications on NSTX

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Proposal: floating, cold, fast and simple probe

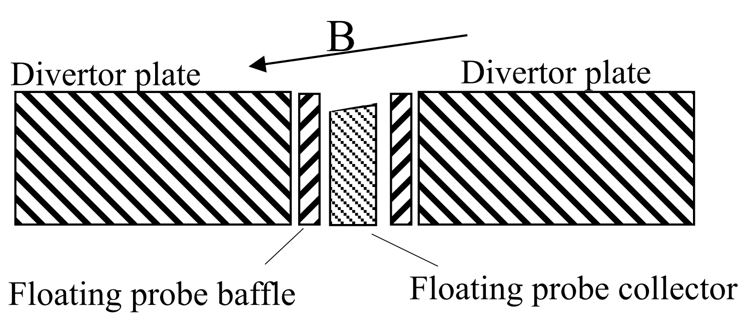
Goal: Simultaneous measurements of steady-state and fluctuating values of Plasma Potential, Electron and **ION** Temperatures in the divertor, SOL, near RF-antennas,….

Approach:

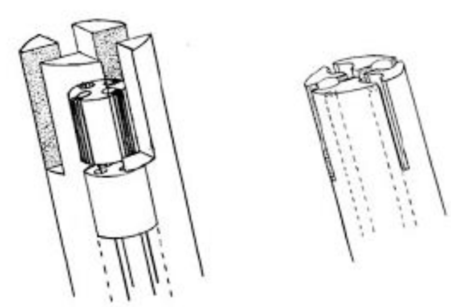
Ideal scenario: to build an array of simple, compact, and inexpensive flush-mounted baffled-probes on the divertor plate.

Practical scenario: to build and install probe/s on BEaP holder

Flush-mounted floating baffled-probe for divertor



Multi-baffled probe design



Note: Probe dimensions can be comparable with existing divertor probes on NSTX.

Why baffled-probe?

The principle of operation is based on the dependence of the sheath potential on the local direction of the magnetic field.

Compared to conventional electrostatic probes, the baffled-probe offers the advantages of direct measurements of plasma properties, while being non-emitting and floating:

- No probe-induced perturbation of the plasma due to probe bias or emitted electrons (i.e. no electron depletion, no plasma cooling, no impurities from hot probe etc).

- Simple design and electric circuitry (no bias).

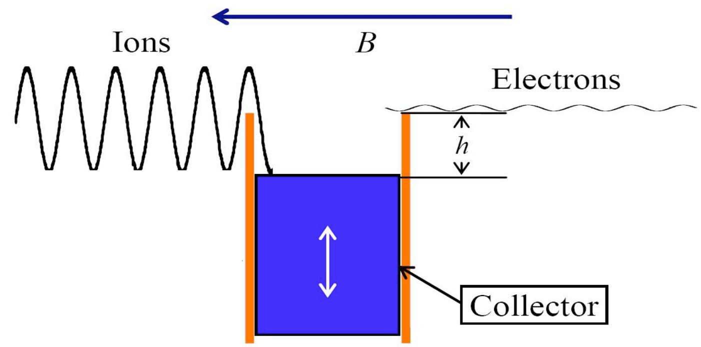
- No need in a complex data signal processing of a large data stream.

- Standard materials.

Related probe designs and applications

• Concept evolved from Katsumata design, which was proposed to measure ion energy distribution function.

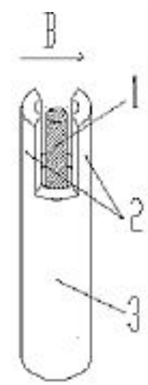
I. Katsumata, Contrib. Plasma Phys. 36S, 73 (1996).

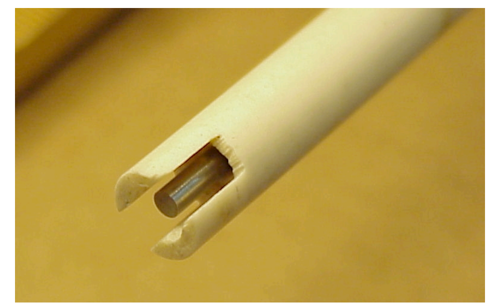


• Plug, rotating baffled and multi-baffled probes to measure ϕ, T_e, T_i.

Measurements on Q-machine at West Virginia and HSX of Wisconsin

V. I. Demidov et al., Rev. Sci. Instrum. 70, 4266 (1999).
V. I. Demidov et al., Contrib. Plasma Physics 44, 689 (2004).

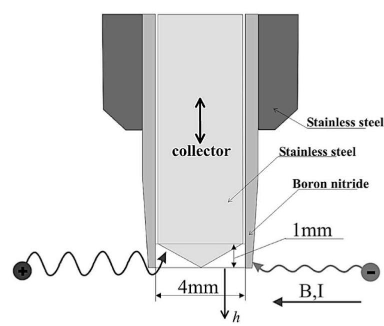




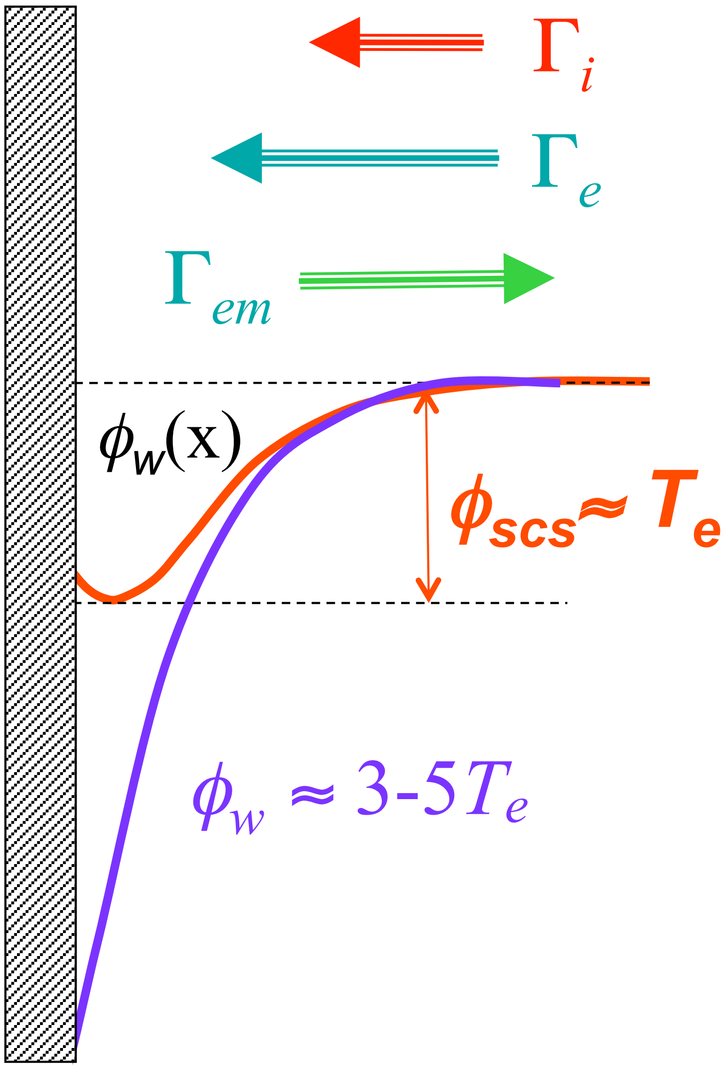
• Ball-pen probe.

Measurements on CASTOR tokamak

R. Schrittwieser et al., Rom. J. Phys. 50, 723 (2005).



Basic idea of ion-sensitive probe operation



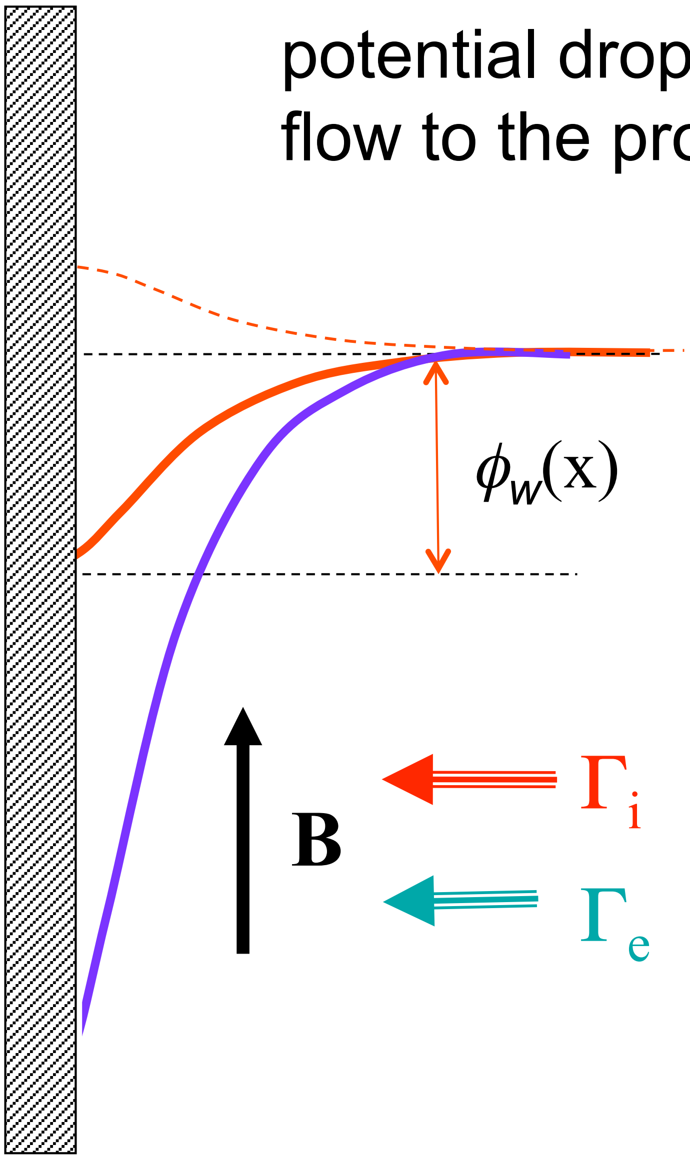
For a Maxwellian plasma and the probe potential less than plasma potential, the probe floating potential:

$$\phi_{fl} = \phi_{pl} - \underbrace{\frac{T_e}{e} ln\left(\frac{I_e^{sat}}{I_i^{sat} + I_{em}} \right)}_{\phi_w}$$

Electron emission, I_{em}, from the hot probe reduces the sheath potential.

Principle of operation of the baffled probe

In the baffled-probe, $\rho_{Le} << d \leq \rho_{Li}$, the sheath potential drop reduces by suppressing the electron flow to the probe across the magnetic field.



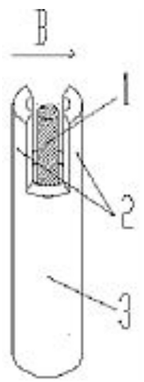
- When $\Gamma_e^{th} = \Gamma_i$, the floating probe measures the plasma potential.

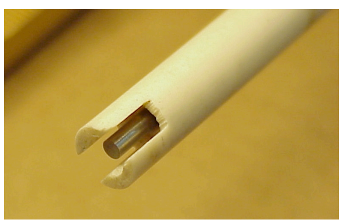
Without heating and emission!

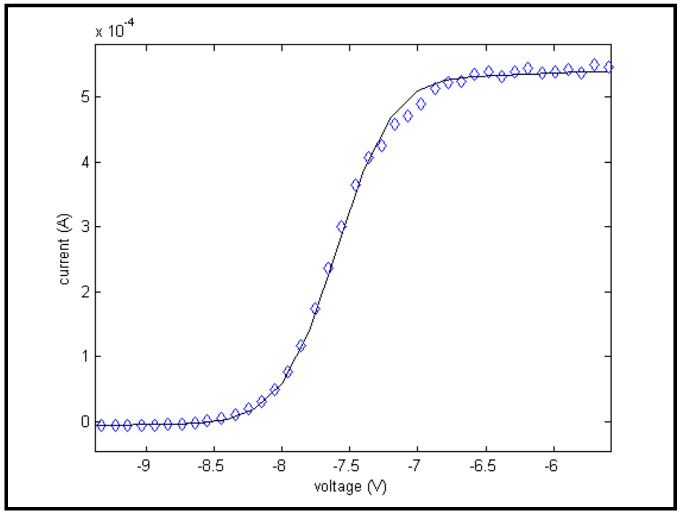
- When $\Gamma_e^{th} < \Gamma_i$, the floating probe provides a real time measure of the ion temperature.

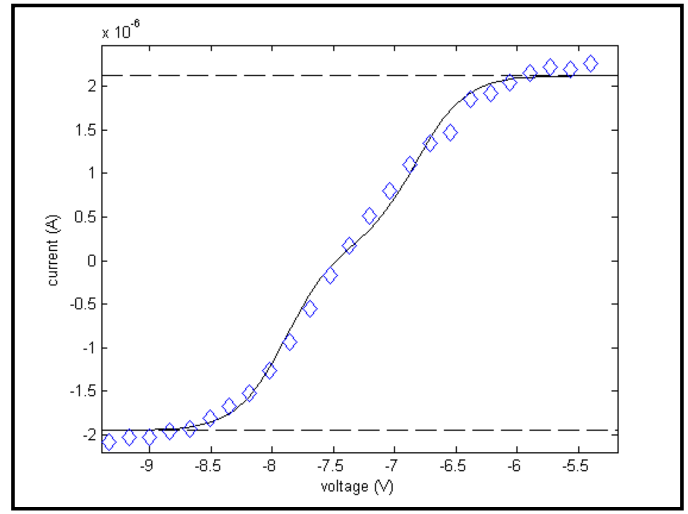
$$\phi_{fl} = \phi_{pl} + \frac{T_i}{e} ln\left(\frac{I_e^{sat}}{I_i^{sat}}\right)$$

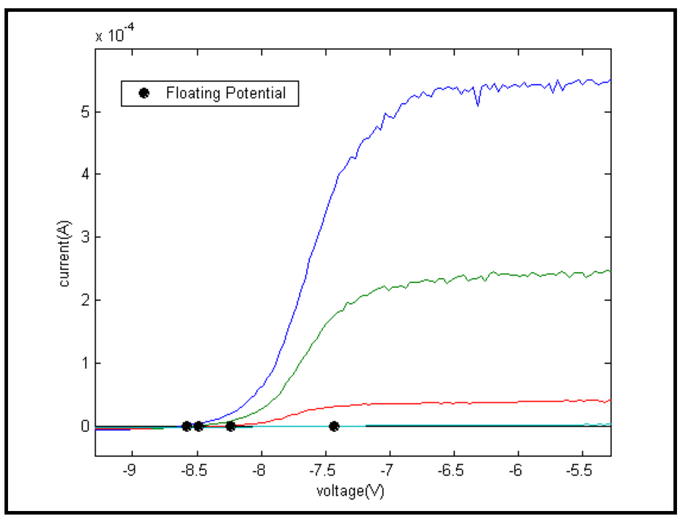
Measurements on Q-Machine at WVU: Baffled-probe floats at the plasma potential

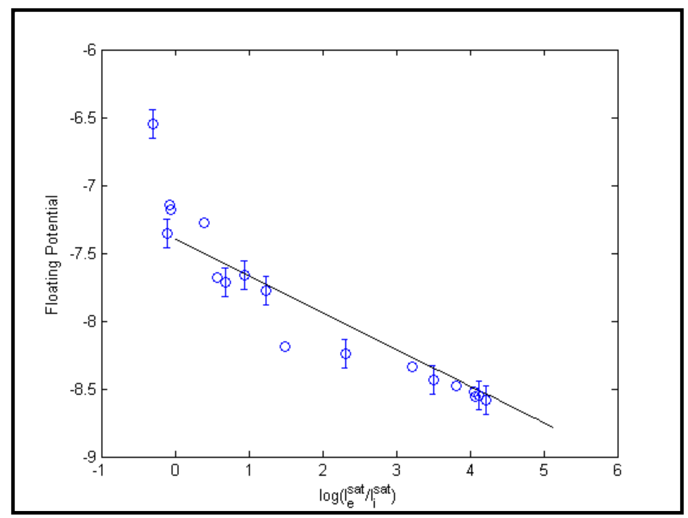




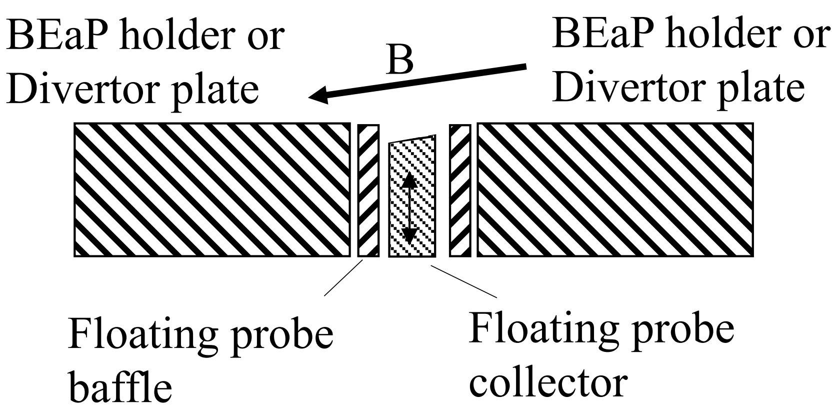




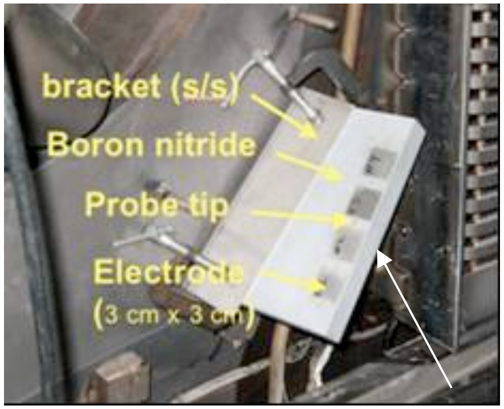




Flush-mounted baffled-probe for NSTX



Biased Electron Experiment



Possible probe position

• Flush-mounted probe can be placed on the outer side of BEaP holder where B is parallel to the surface.

• Collector is screened from the electron flow, while baffle is not. They float at different potentials.

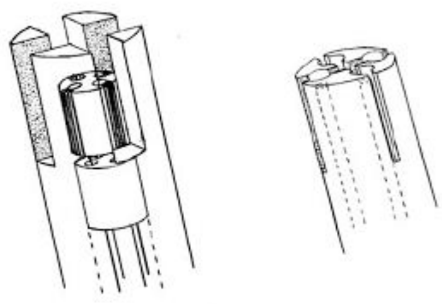
• Deduce plasma potential and electron temperature from measured floating potentials of collector and baffle (2 wires per probe).

• By making several probes with different collector positions, monitoring of ion temperature oscillations can be possible.

• Bias can be applied to the collector in order corroborate floating measurements.

Multi-baffled probe for NSTX

Multi-baffled probe design



[*] V. I. Demidov et al., Rev. Sci. Instrum. 74 4558 (2003)

Time response: $\tau \sim d/V_{ion}$ [sec],

where d~0.1-1 cm probe dimension
V_{ion} is the ion velocity [cm/sec]

- Each of the four collection surfaces is electrically isolated from the others.
- Two probe tips are un-baffled and two are baffled. The design enables one tip to be baffled more than the other.
- From the oscillations measured with each of the collection surfaces, we can determine

  Space potential fluctuations
  Electron temperature fluctuations
  Ion temperature fluctuations

Summary

✓ Baffled probe can be used for simultaneous measurements of Plasma Potential, Electron and ION Temperatures

✓ Proposed probe design is straightforward with simple circuitry and data processing, suitable for steady state and high frequency (~ 0.1-1 MHz) measurements.

✓ Proposed NSTX application: on BEaP for measurements of plasma parameters in SOL.

✓ Other potential applications: divertor and near rf-antenna.

✓ Probe modeling can be accomplished to help in analysis .