Measuring the electron distribution function in the edge of tokamak plasmas using Langmuir probes

By

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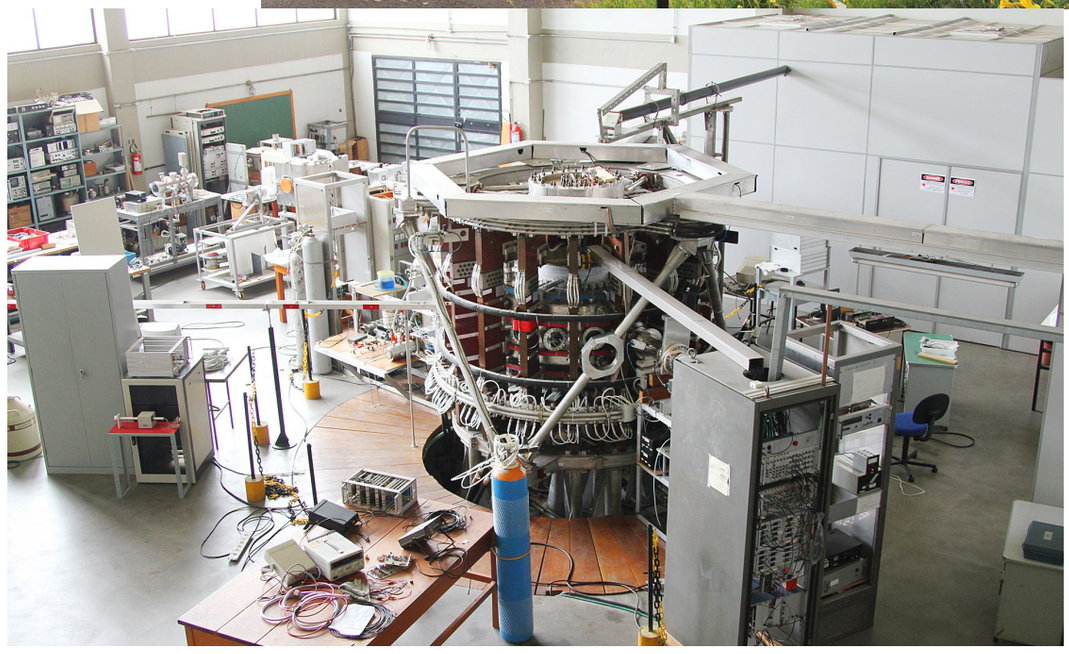

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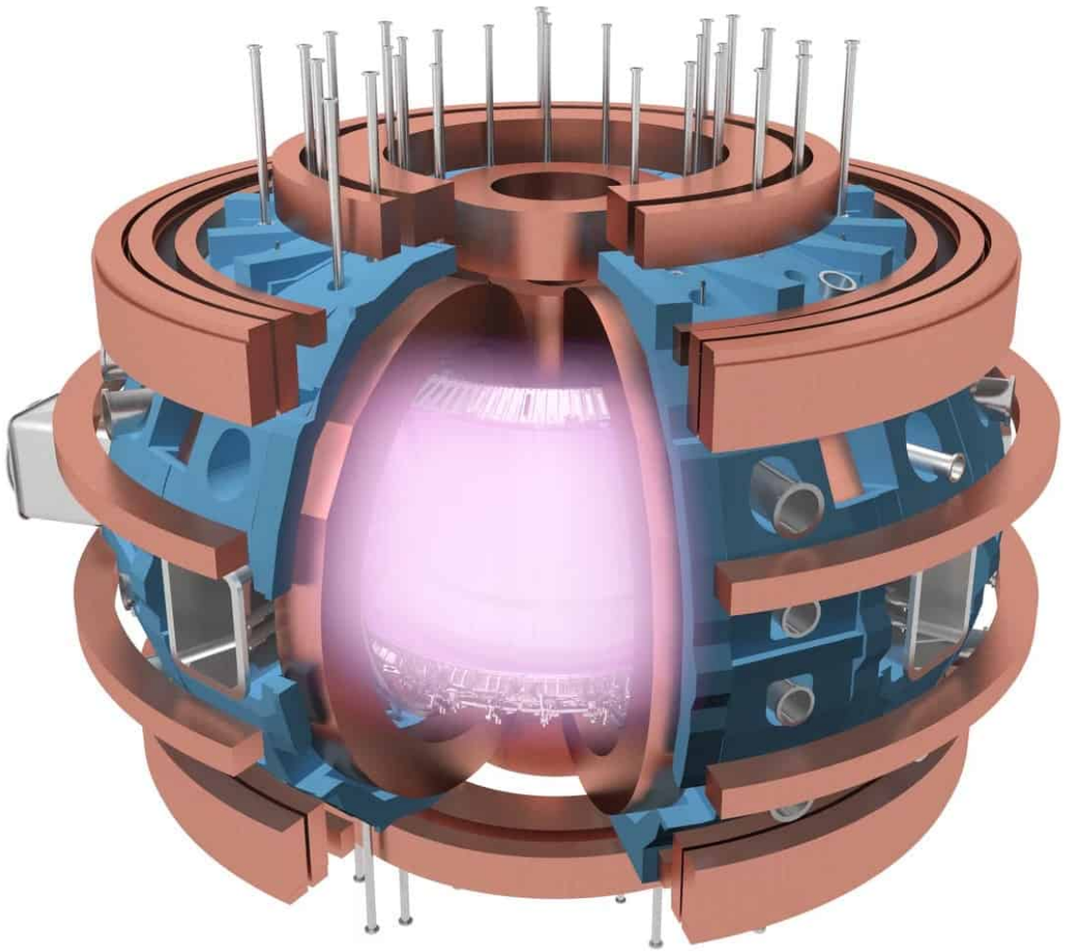
Tokamaks are machines developed to confine hot plasmas using strong magnetic fields aiming at producing energy via nuclear fusion

- **The word tokamak is a Russian acronym from** *toroidalnaja kamera s magnitnymi katushkami*, **which can be translated as toroidal chamber with magnetic coils**

- **Energy production via nuclear fusion requires relatively high temperatures**

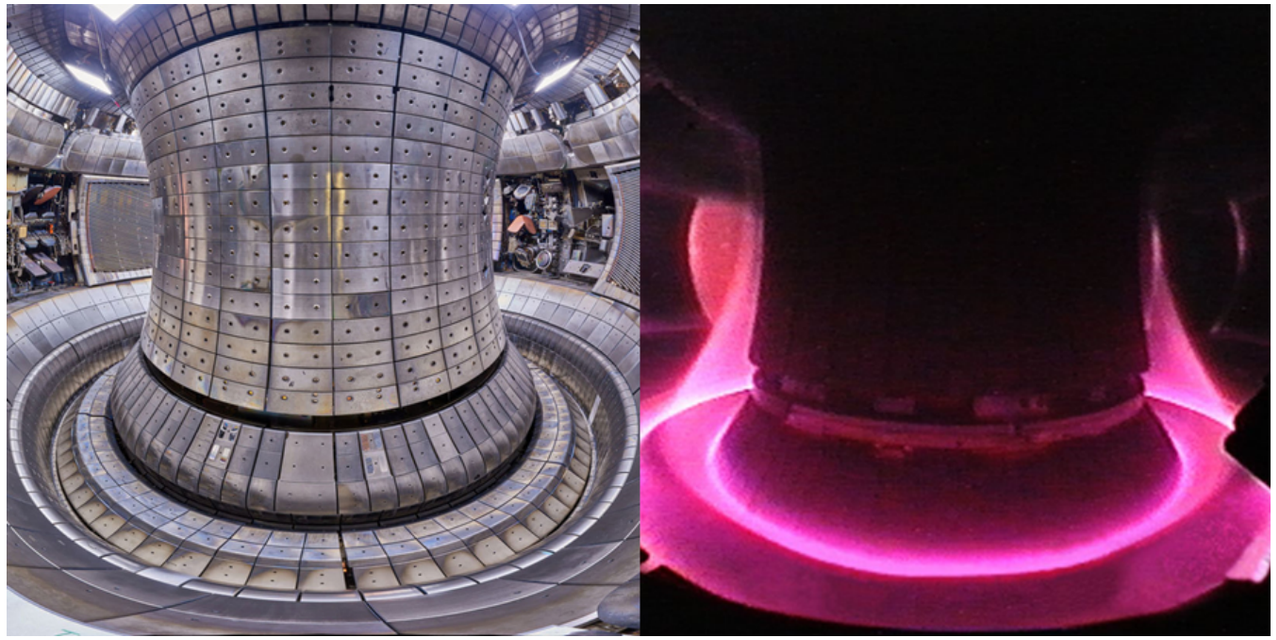
- **Tokamaks use a set of magnetic coils to produce strong magnetic fields that are needed to confine high temperature plasmas (~150 million Kelvin)**

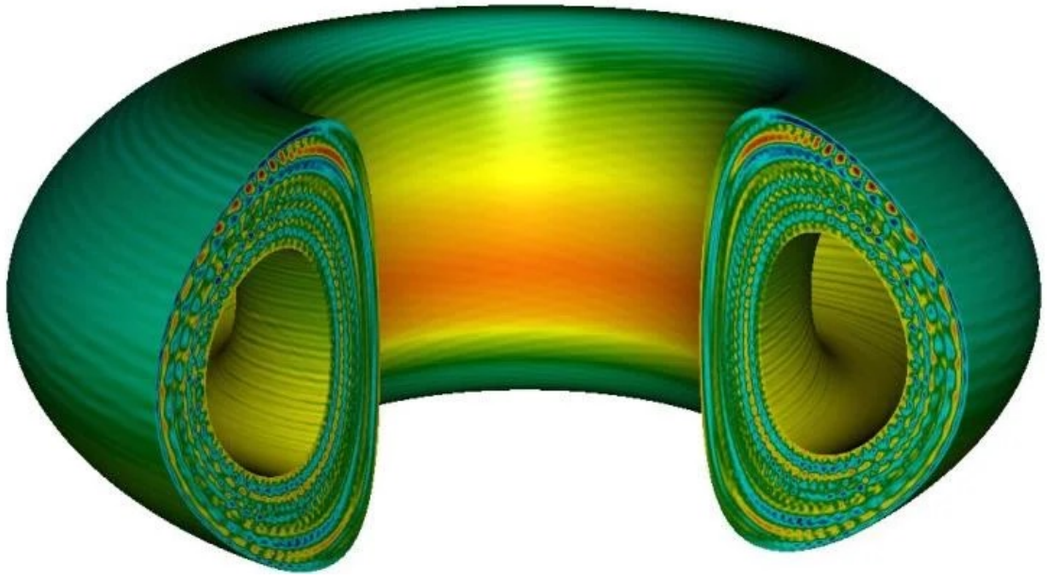
- **How do we diagnose such hot plasmas?**



Several passive and active plasma diagnostics are used to provide information about the plasma behavior

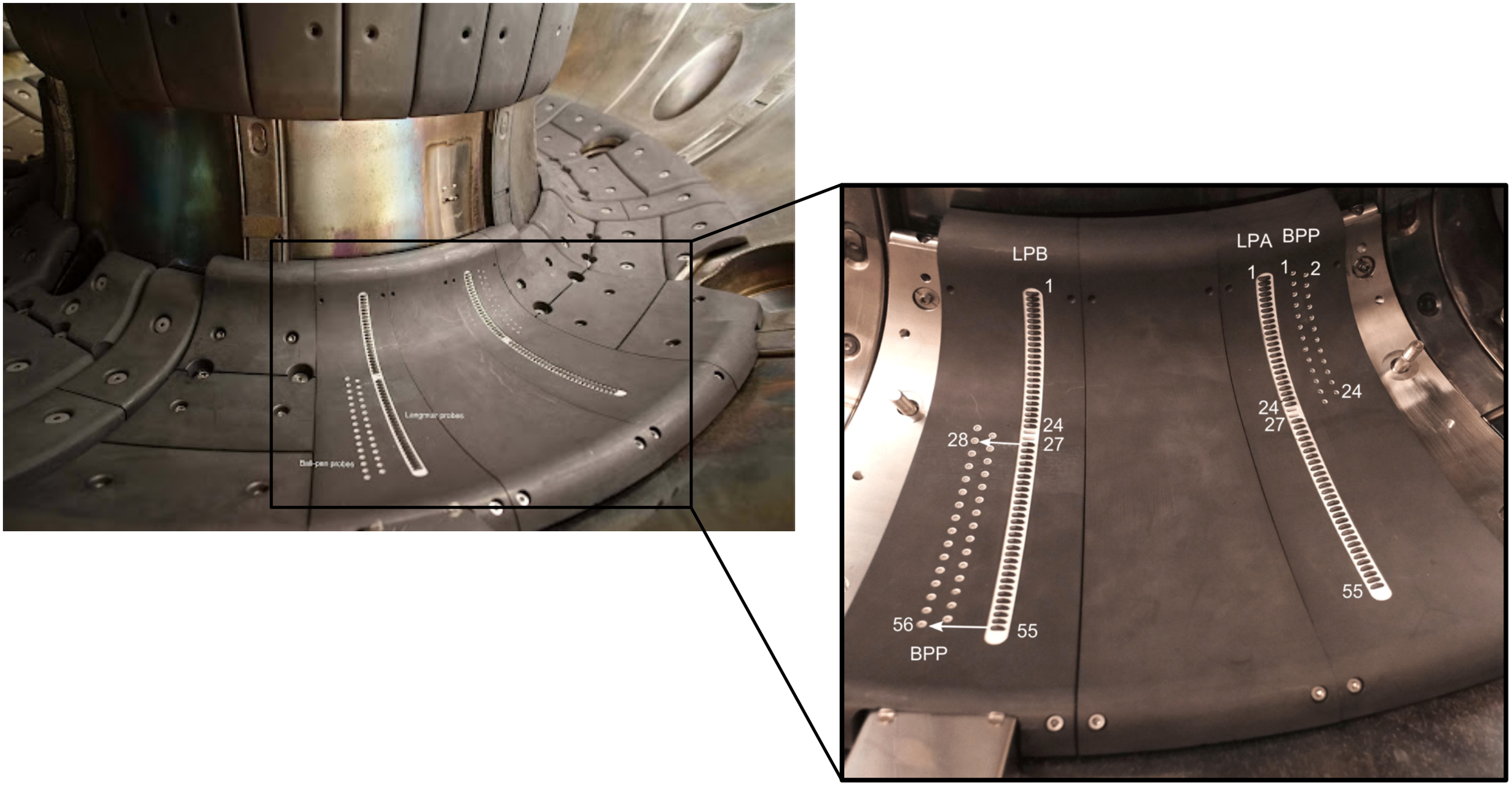
- **Different sets of plasma diagnostic are used in tokamaks**
  - *Magnetic sensors*
    - *Examples: Rogowski coils, Mirnov coils, flux loops, diamagnetic loops etc.*
  - *Optical diagnostics*
    - *Examples: Thomson scattering, reflectometry, spectroscopy, visible imaging etc.*
  - *Electrostatic probes*
    - *Examples: Ball-pen probes, Mach probe, Faraday cup, Langmuir probes etc.*





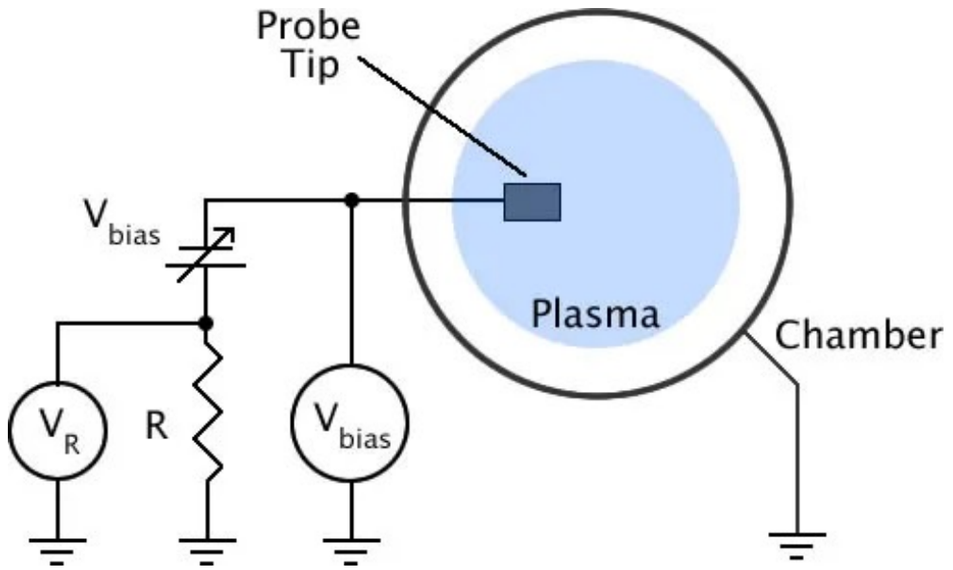
Example of tile embedded Langmuir probes

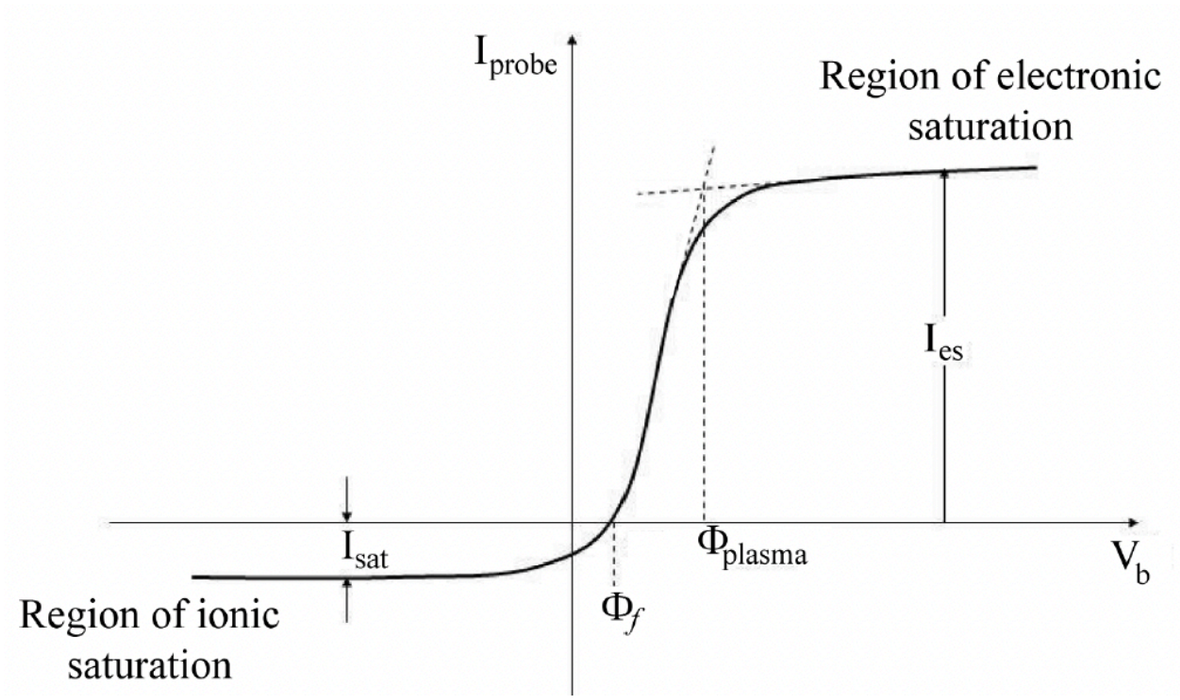
- **Tile embedded Langmuir probes are very frequently used in several tokamaks to diagnose the plasma-wall interaction**



Langmuir probes can provide information about the local electron density and temperature

- **Langmuir probes are just a simple electrode inserted into the plasma and polarized using a power supply.**





- *The ion saturation current is related to* n_e
- *The exponential part of the I-V characteristic is related to* T_e
- *The electron energy distribution is related to the second derivative of* $I_e(V)$

$$I_{\text{probe}} = I_{\text{es}} \left\{ \exp\left[\frac{e(V_b - \Phi_f)}{k_B T_e} \right] - 1 \right\} \qquad I_{\text{is}} = 0.6\, n_e\, e \sqrt{\frac{k_B T_e}{m_i}} \qquad g_e(V) = \frac{2m}{e^2 A} \left(\frac{2eV}{m} \right)^{1/2} \frac{d^2 I_e}{dV^2}$$

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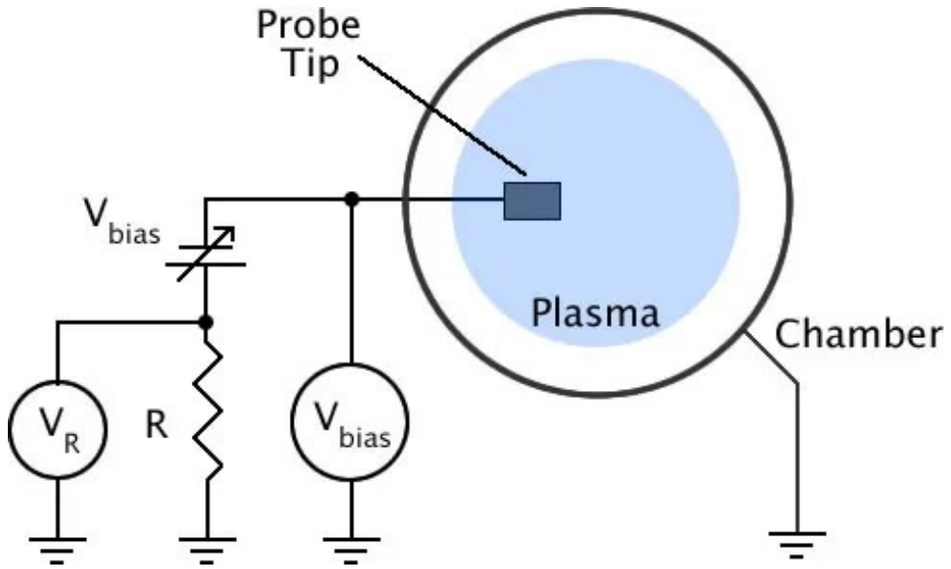

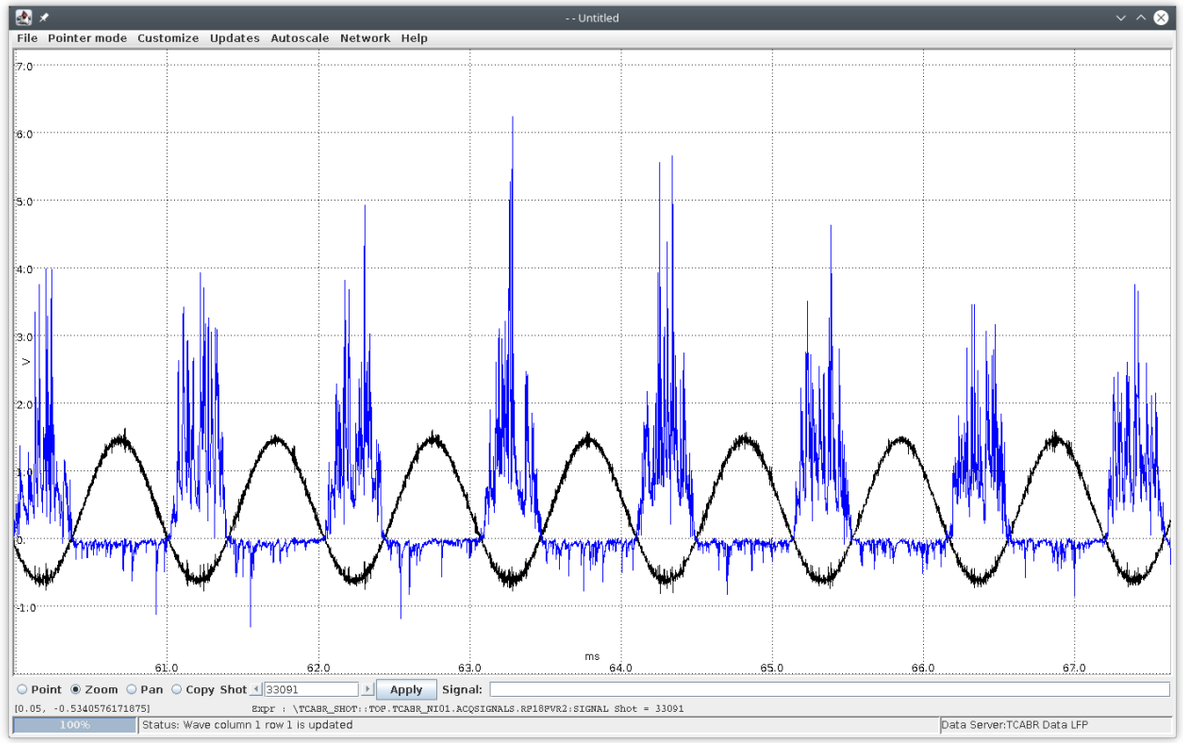

Typical Langmuir time traces

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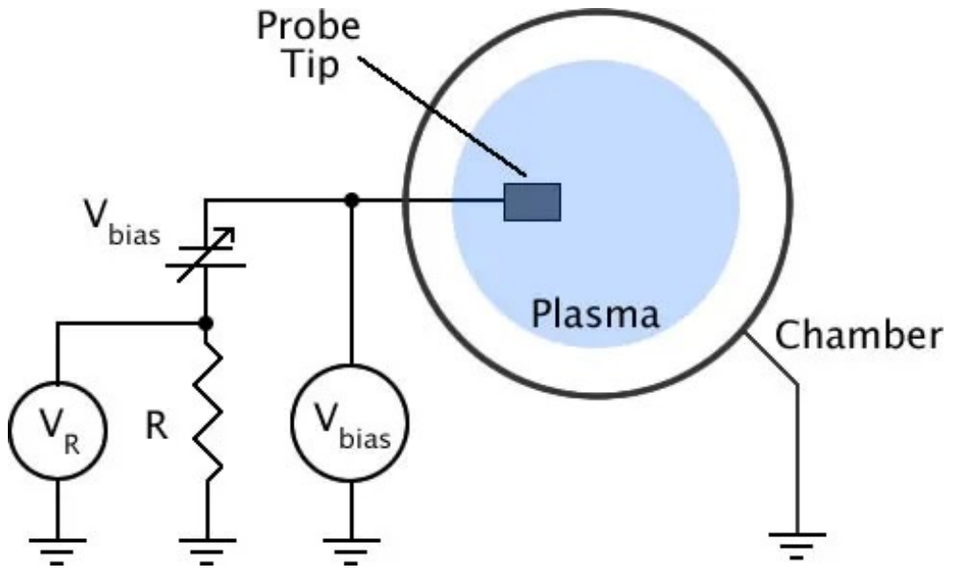

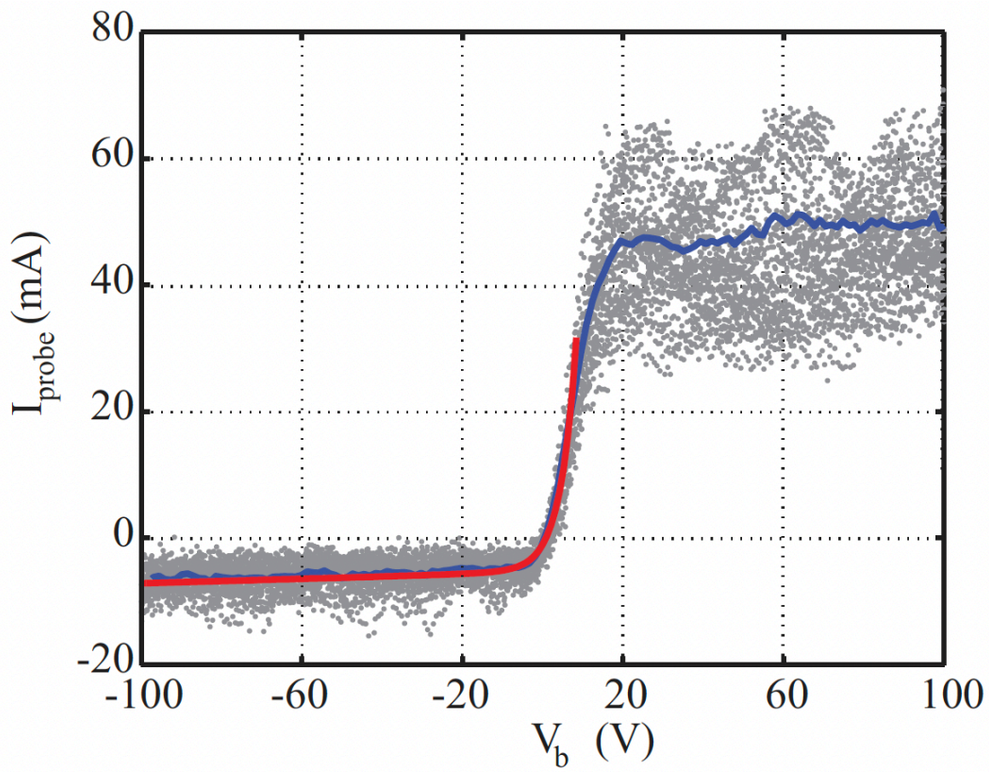

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