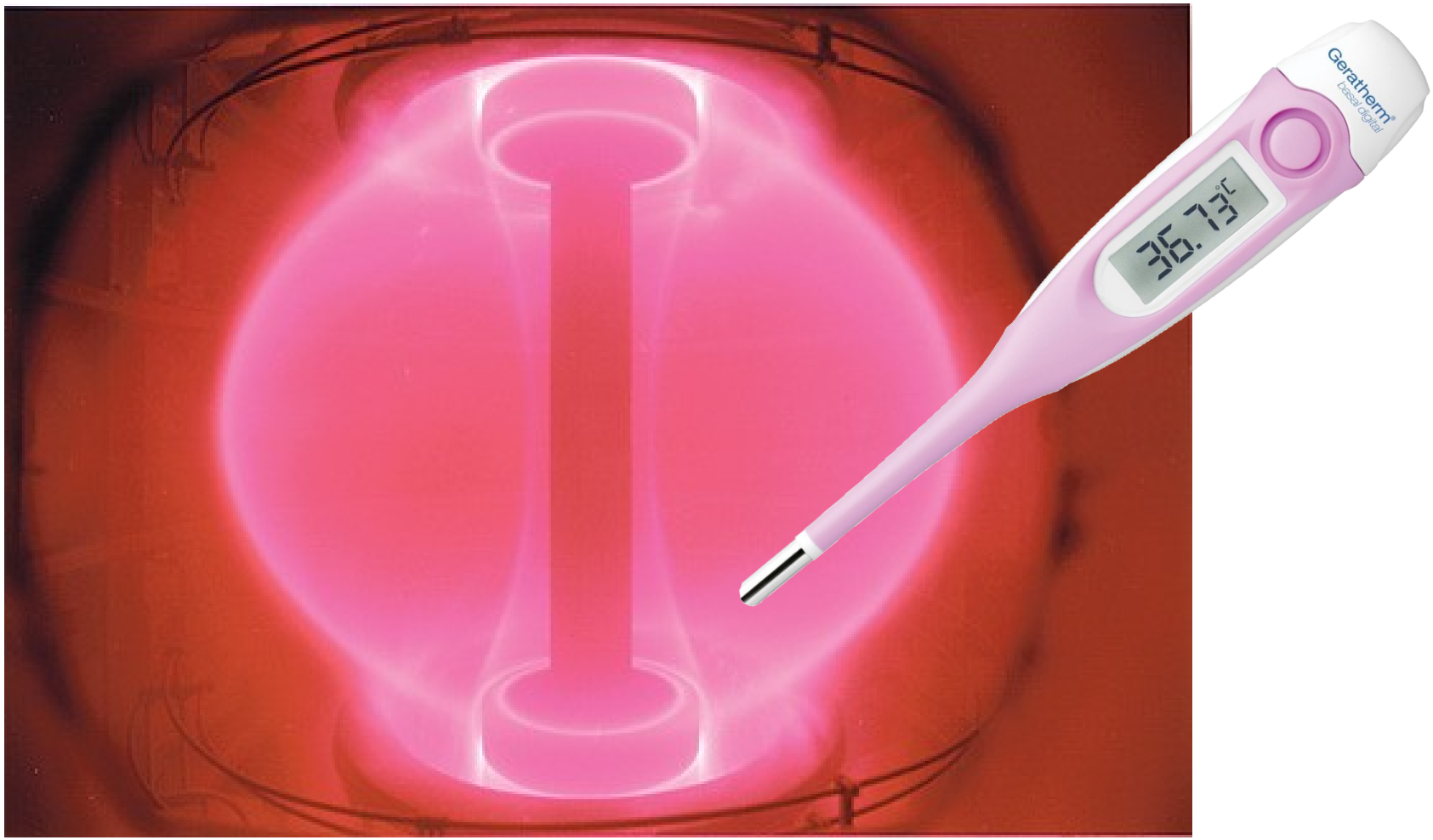
Probe measurements at GOLEM



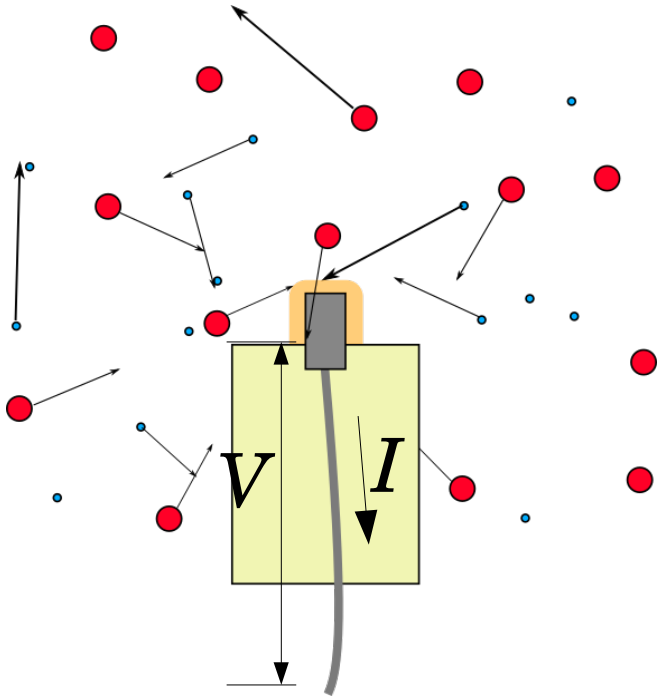
Probe measurements for fusion

- plasma physics in tokamaks is complicated

  → we rely in part on empirical laws
- reliable diagnostics needed for data on the design and operation of fusion reactors
- probes – a type of edge diagnostics
  - edge transport barrier
  - divertor detachment
  - turbulent transport

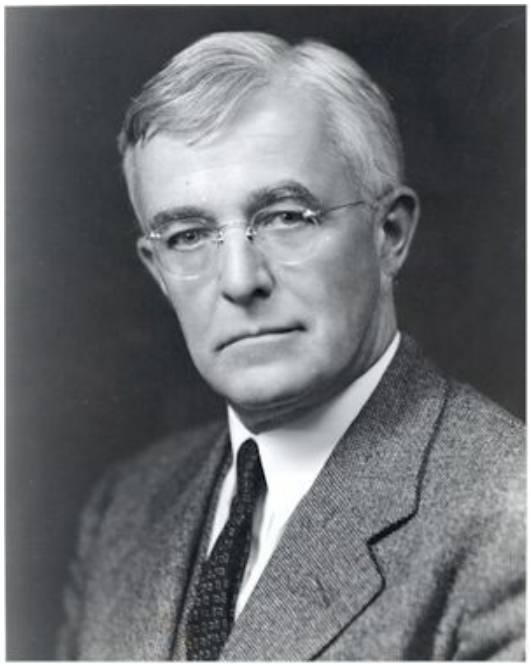
Probes

- probes = diagnostics measuring in direct contact with the edge plasma
- made of conductor
  - graphite, SS, tungsten...
- we measure probe voltage V and current I
- many probe shapes and forms



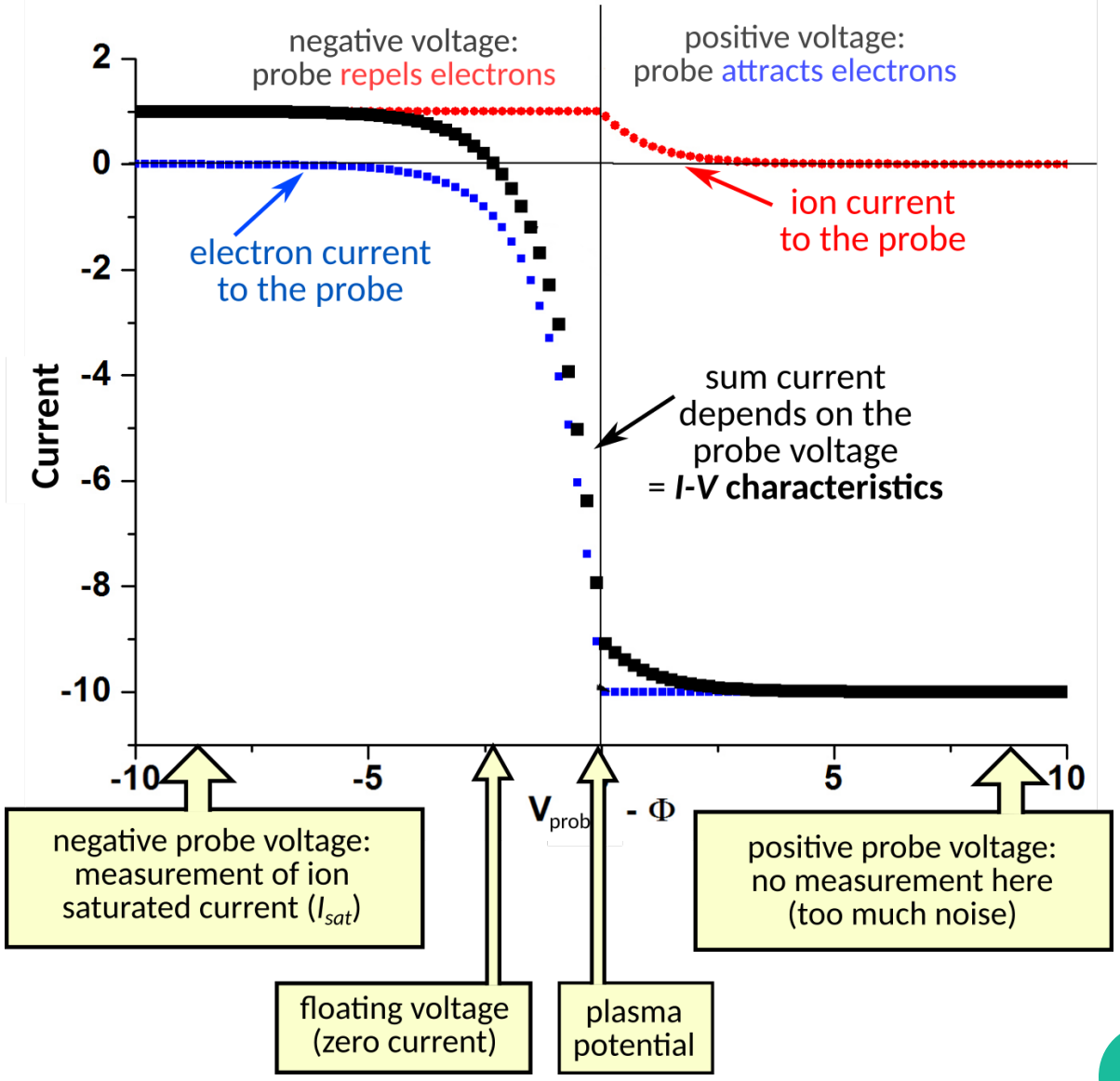
Basic probe operation.

Langmuir probe



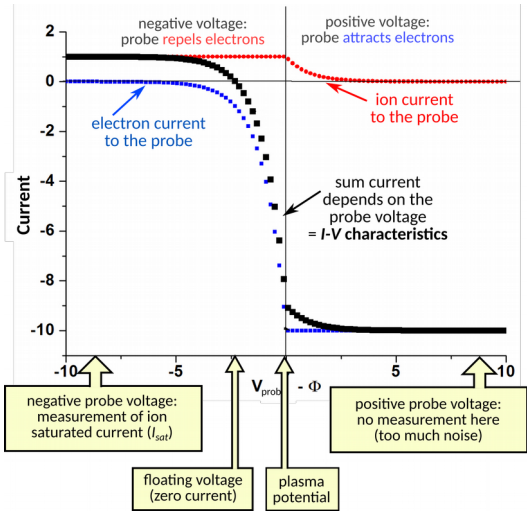
Irving Langmuir.

Langmuir probe I-V characteristics.



Measuring regimes

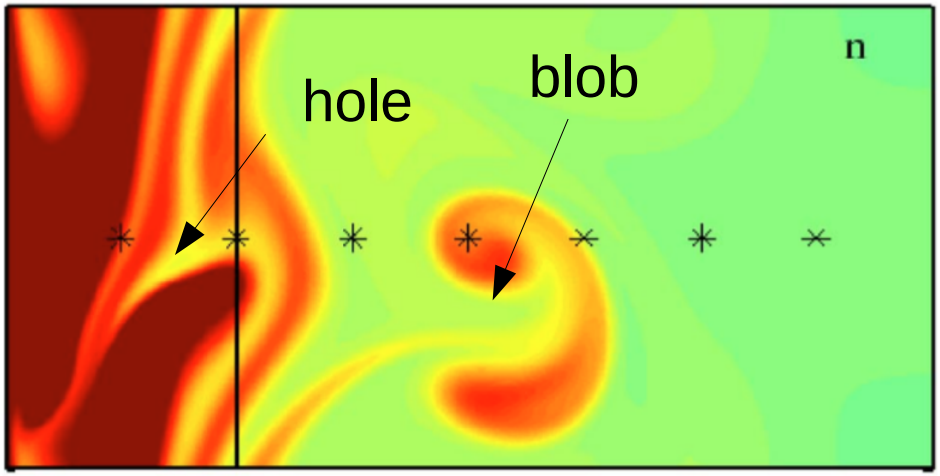
- V_{bias} ≈ -100 V: I_{sat} measurement
  - high temporal resolution
  - turbulence properties
- probe floating: V_{fl} measurement
  - high temporal resolution
  - approximation for plasma potential
- swept voltage: I_{sat}, T_e, V_{fl}, f_e, Φ...
  - lower temporal resolution



Double rake probe

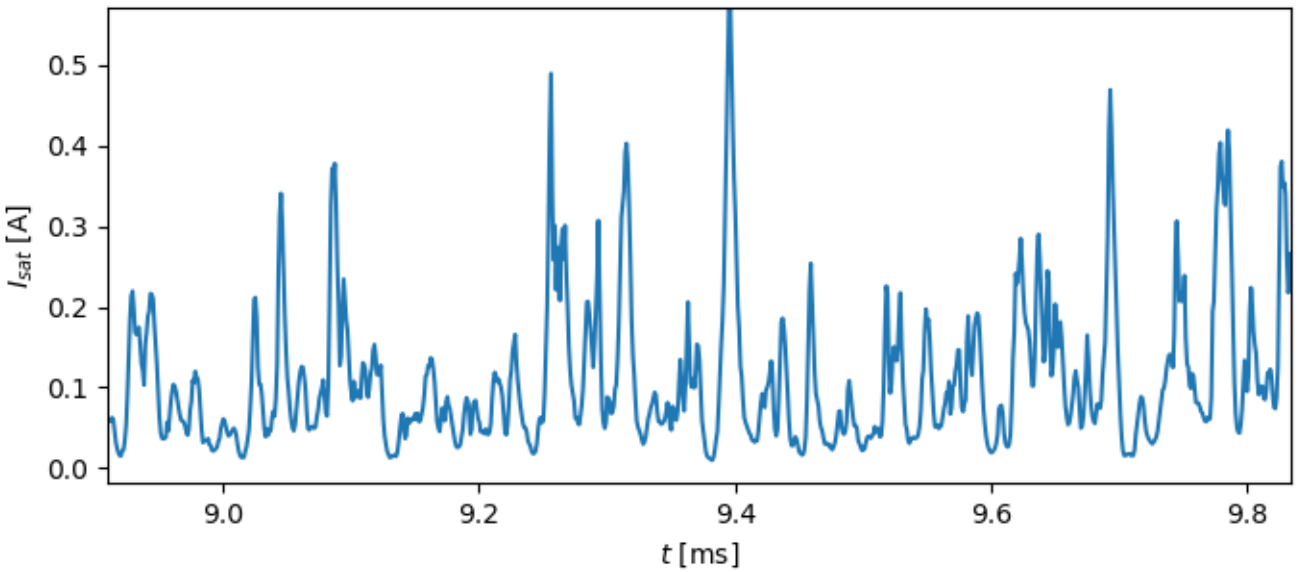
- 2 rows of independent Langmuir pins
- allows for radial profile measurement
  - plus on “shot-to-shot basis”

Plasma fluctuation studies



Turbulence simulation
(code ESEL).

$$I_{sat} \propto n_e \sqrt{T_e}$$

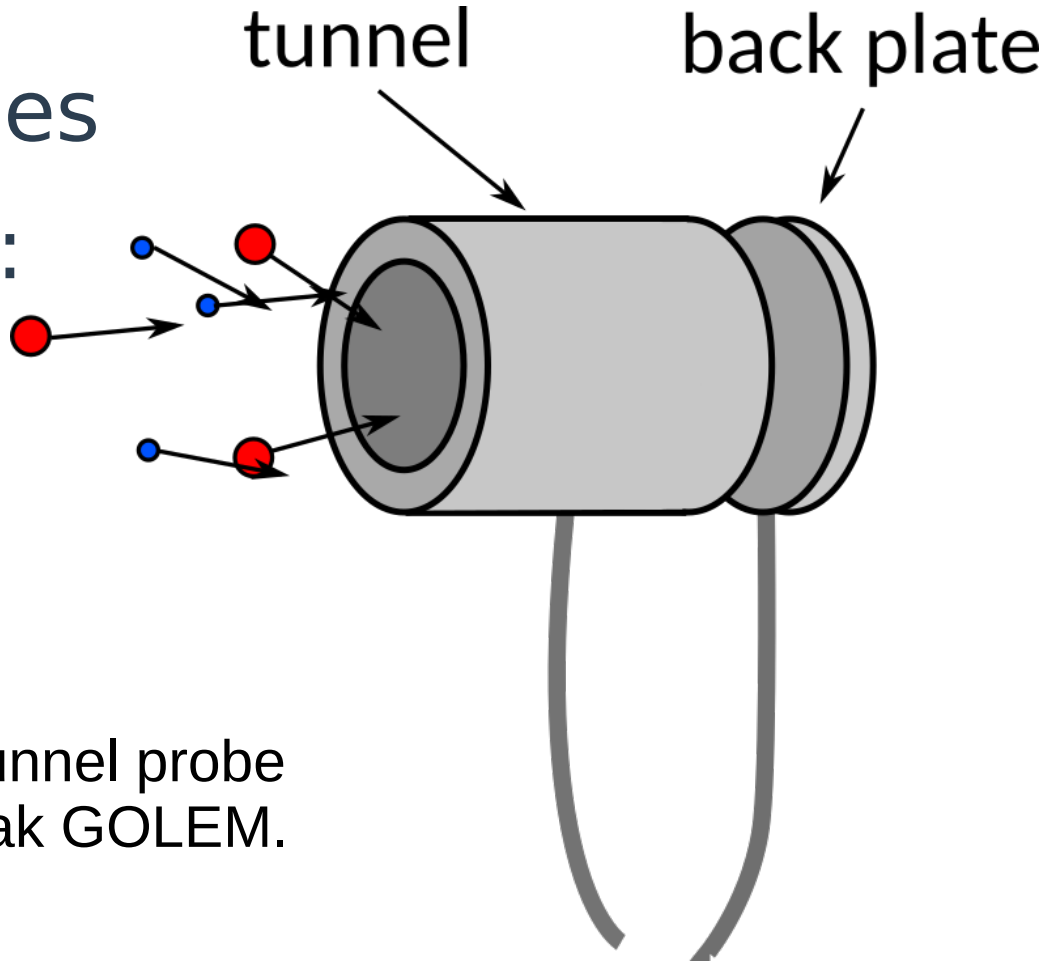


I_{sat} fluctuations
(GOLEM double rake probe,
discharge #29677).

Tunnel probe

- two shaped electrodes
- double tunnel probe: Mach number (I_{sat})

Double tunnel probe at tokamak GOLEM.



Tunnel probe scheme.

Conclusion of probes

- old and extensively researched
- “the easier it is to build, the harder it is to find out what it actually measures”