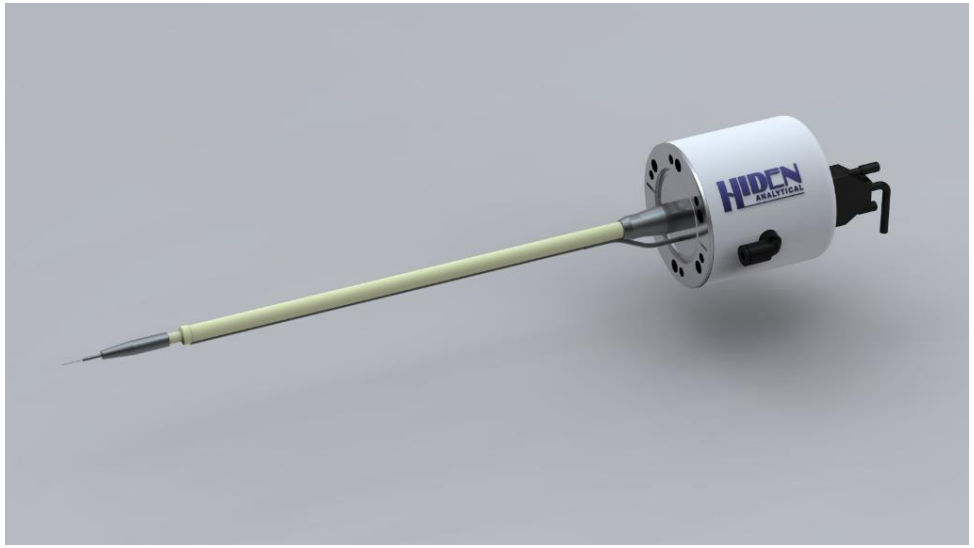
Hiden ESPion

Advanced Langmuir Probe for Plasma Diagnostics & Characterisation



Applications

- ESPion systems are offered with a range of standard plasma sampling options to provide a non invasive sampling interface for a broad range of plasma applications including:
- ECR- Electron Cyclotron Resonance
- HIPIMS
- Magnetron Discharge
- Helicon Source
- DC Glow Discharge Plasma
- Pulsed Plasma & Laser Ablation
- Parallel Plate - RF Plasma
- ICP- Inductively Coupled Plasma.

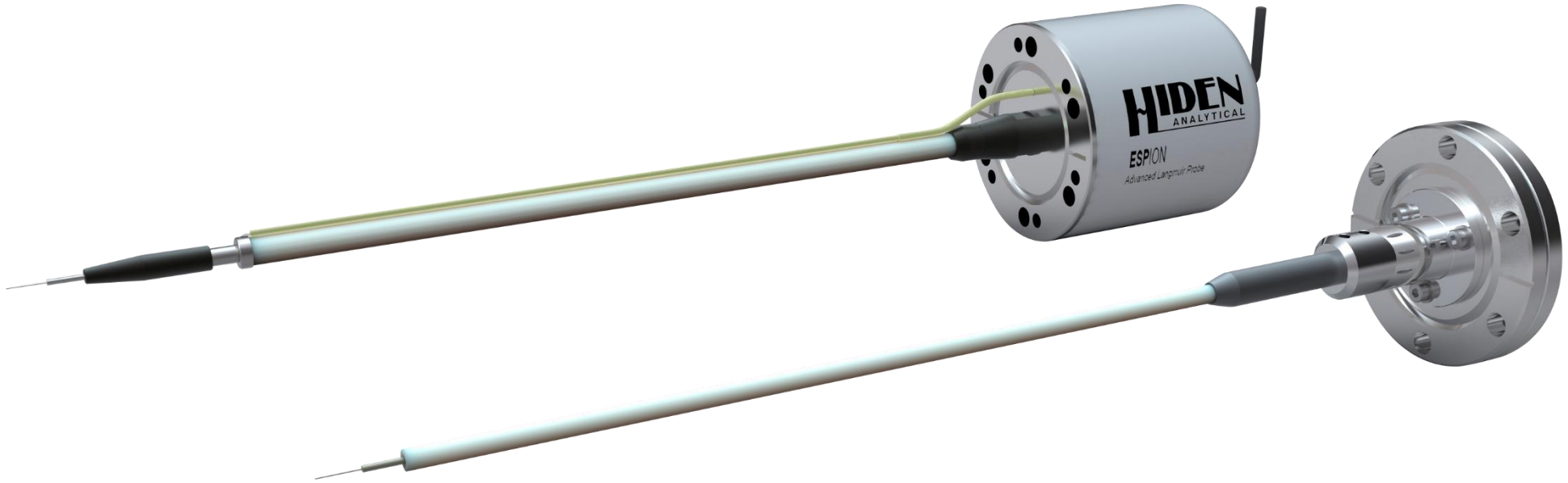
Data Available

- Floating Potential, V_f
- Plasma Potential, $V_{p.}$
- Electron Energy Distribution Function, EEDF.
- Debye length, $\lambda_{D.}$
- Ion Flux, Γ_i
- Ion density, N_i, and electron density, N_e, over the range 10^{14}-10^{19} m^{-3}
- Electron Temperature, Te, up to 10 eV.
- Orbital motion Limited (OML) and Allen Boy Reynolds (ABR)

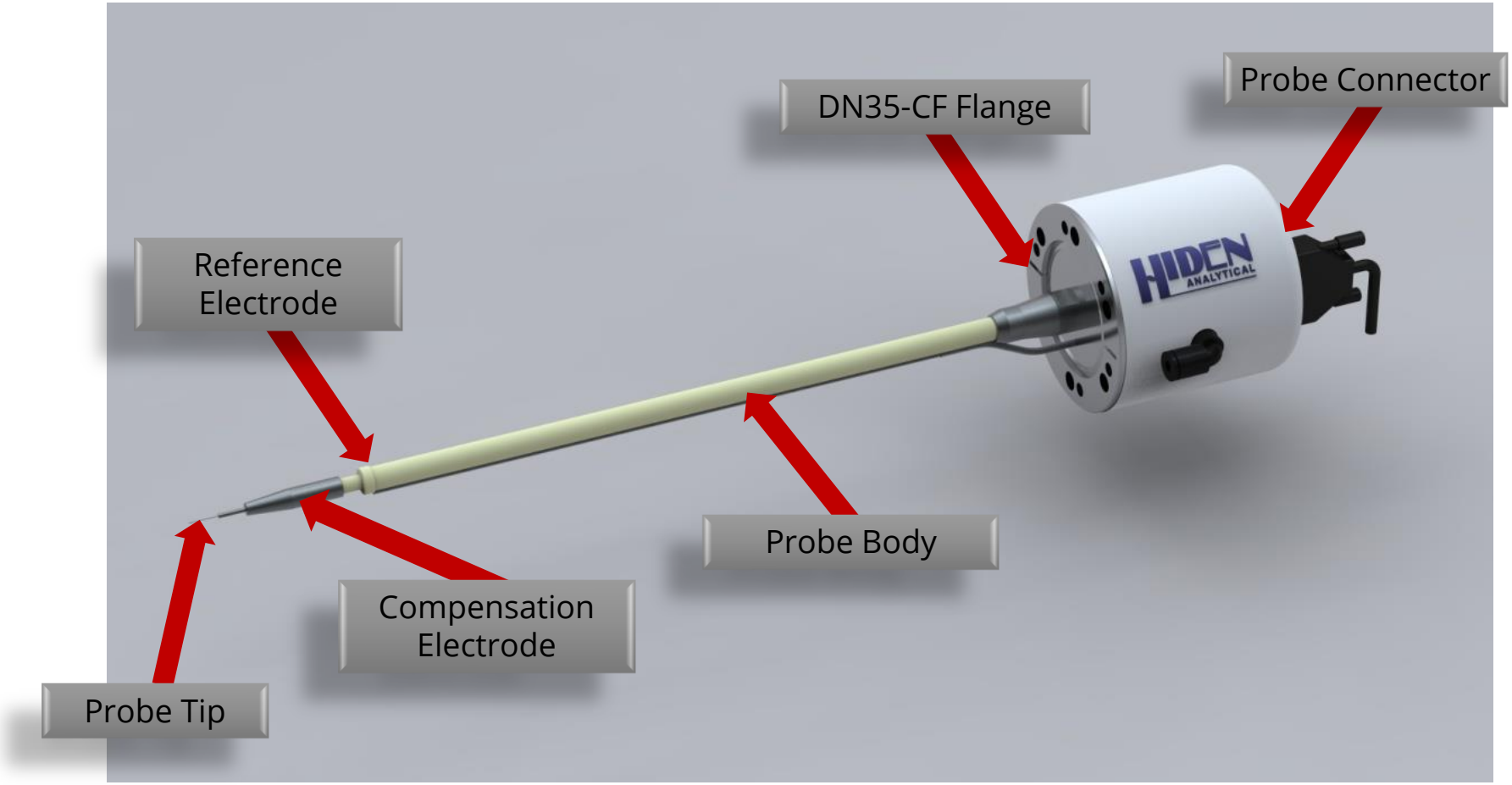
RF and DC Probes

- Probes available for both RF an DC plasmas.

- Two probe types available:
  - RF/DC for RF and DC Plasmas.
  - DCHT for DC and High Temperature Plasmas.



Configuration

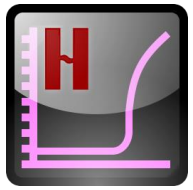


Probe Tips

Cylindrical Probe Tip

Planar Probe Tip

- More than 20 tip materials available, including Tungsten, Platinum, Molybdenum and Tantalum .
- Tip Types available:
  - Cylindrical
  - 90° for magnetically confined plasmas and plasma mapping.
  - Planar for Hall Thruster Discharges.
- Easily user replaceable.

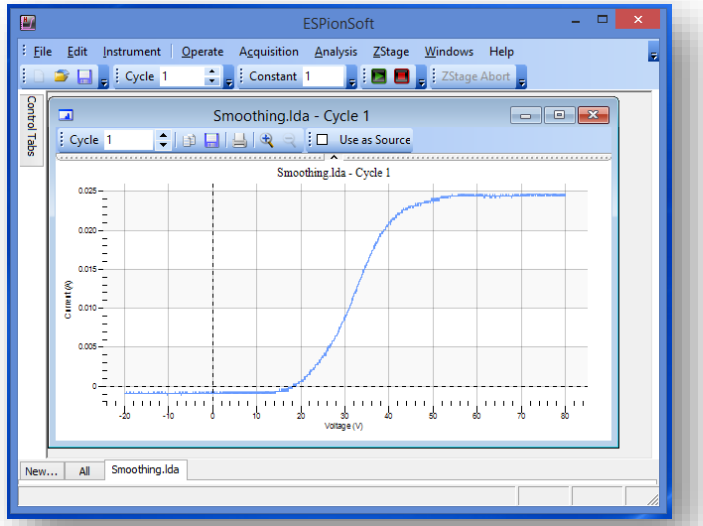


ESPionSoft Software

- Manual, semi-automatic and fully automatic data analysis data.
- Specific plasma probe data functions for the extraction of plasma parameters.
- Multiple graph displays and multiple files open simultaneously.
- Standard math operations on data curves (add, average, smooth, differentiate).
- Data curves may be combined mathematically, including a scan averaging feature.
- Per scan report of calculated plasma parameters including analysis statistics, slopes and intercepts.

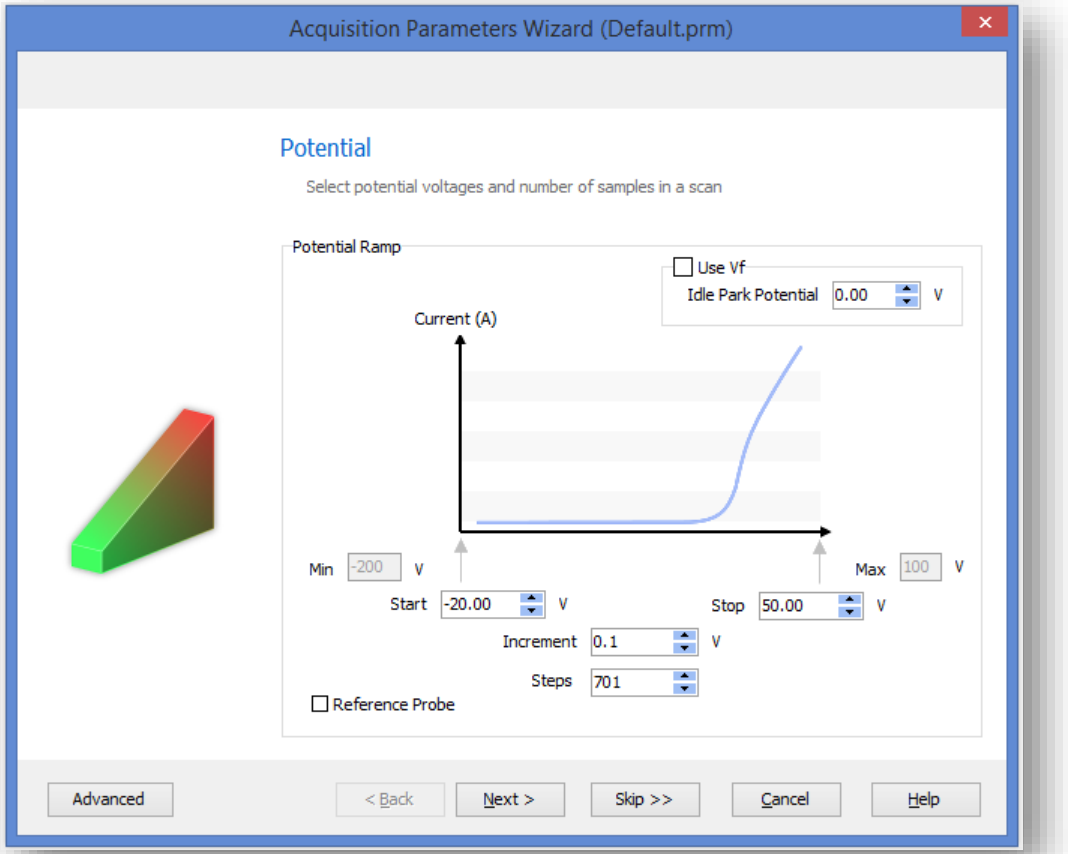
Scan Set up

- Intuitive setup using the ‘Setup Wizard’.
- A wide range of data acquisition parameters can be selected including:
  - Start/ stop potentials.
  - Data averaging and scan period.
  - Probe tip cleaning.
  - Automatic Z-motion steps and range.
  - Signal gating delay and increment timers.



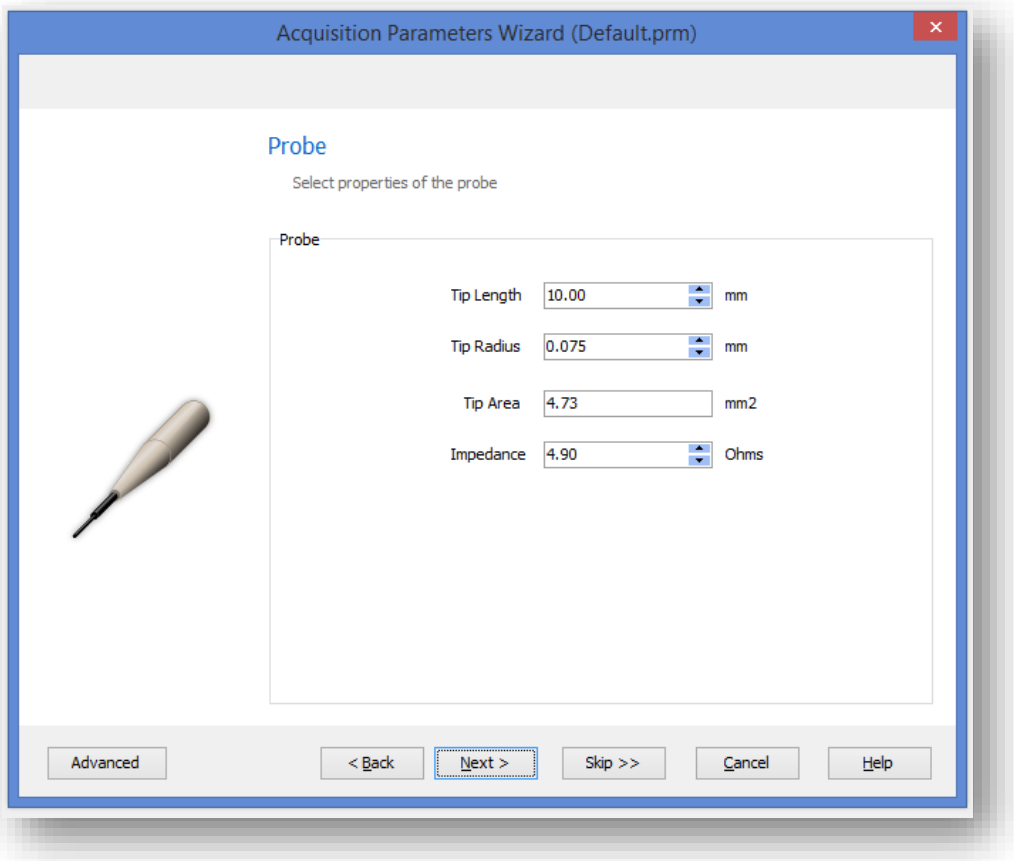
Acquisition Wizard

- Voltage range -200V to +100V, minimum increment 25mV.
- Current range 20μA to 1 A.



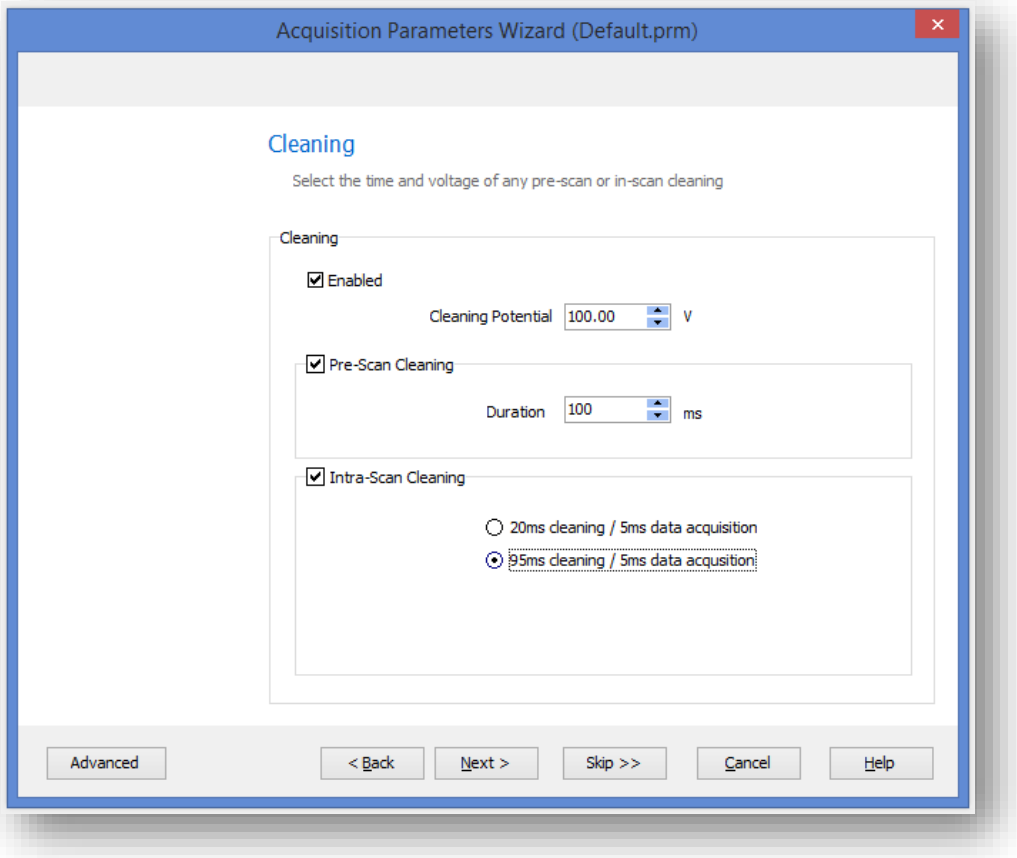
Tip Selection

- Parameters for tip geometry can be selected.
- Allows the use of a range of tip geometries.

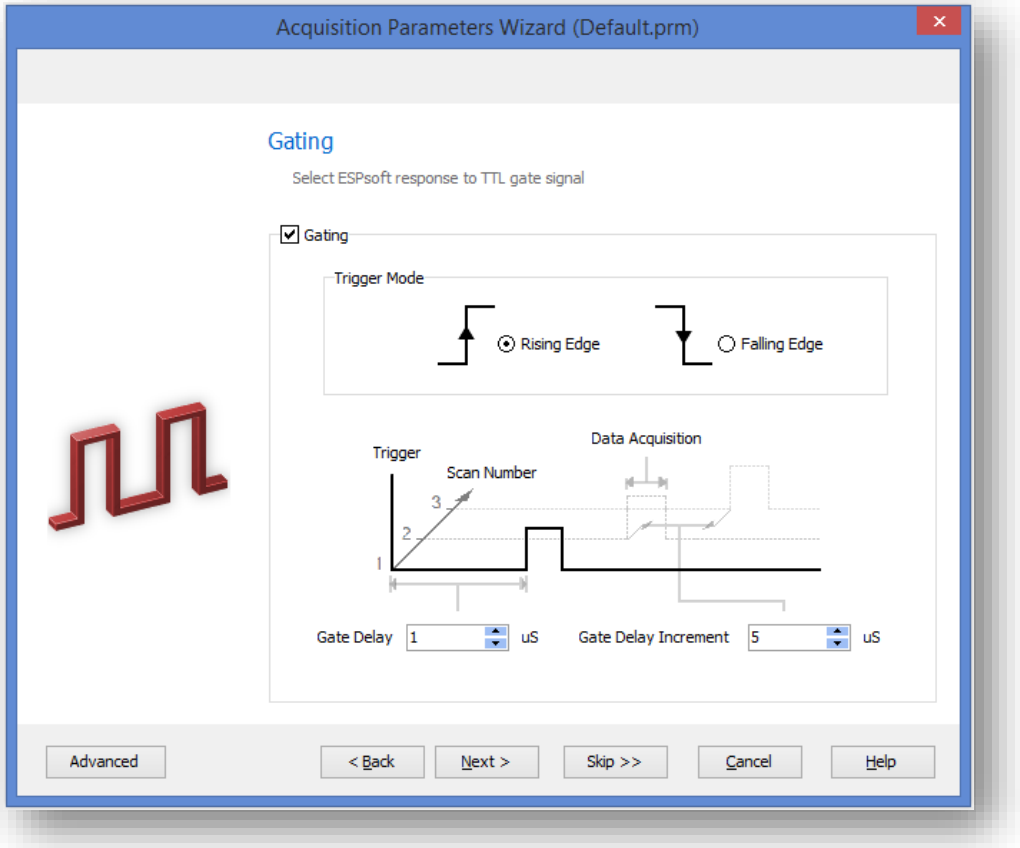


Automatic Tip Cleaning

- Cleaning potential from -200V to 100V.
- Inter-scan cleaning - variable 20ms cleaning and 5ms acquire for 25 ms cycle, or 100ms cleaning and 5ms acquire on 105ms cycle.

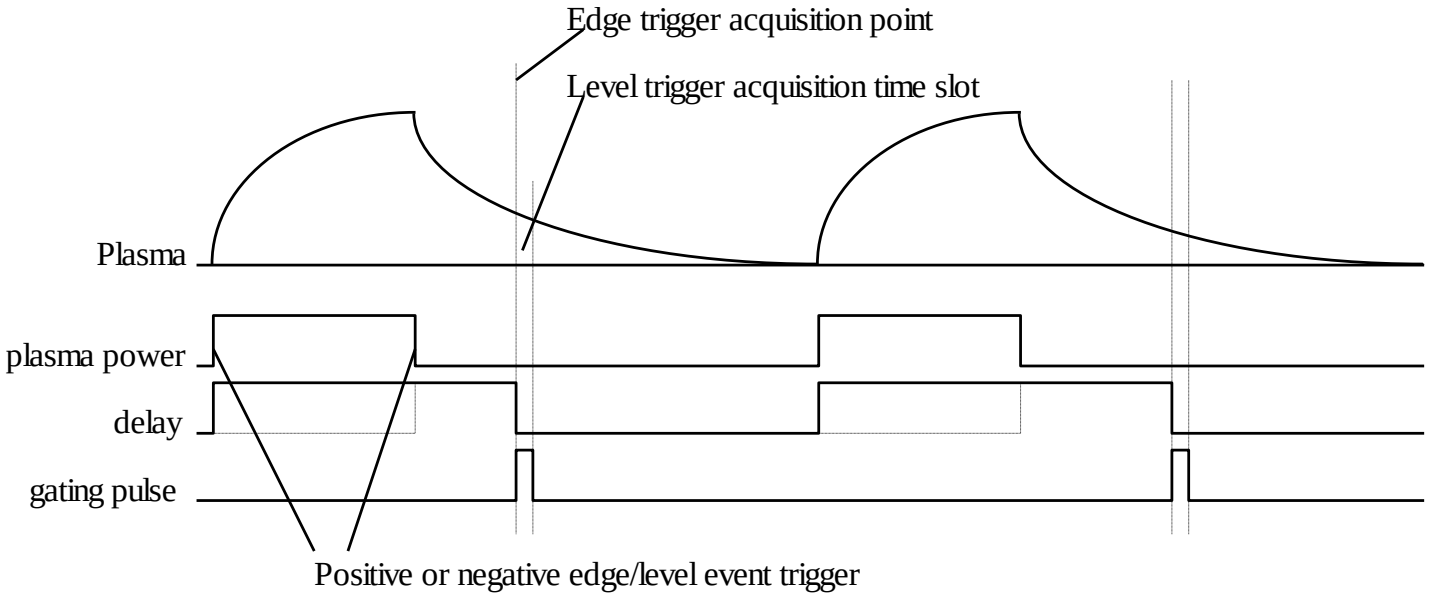


Signal Gating



- Signal gating to synchronise acquisition with a TTL signal.
- The acquisition window can be moved automatically through the pulse.
- Time resolved data is constructed over a number of scans.

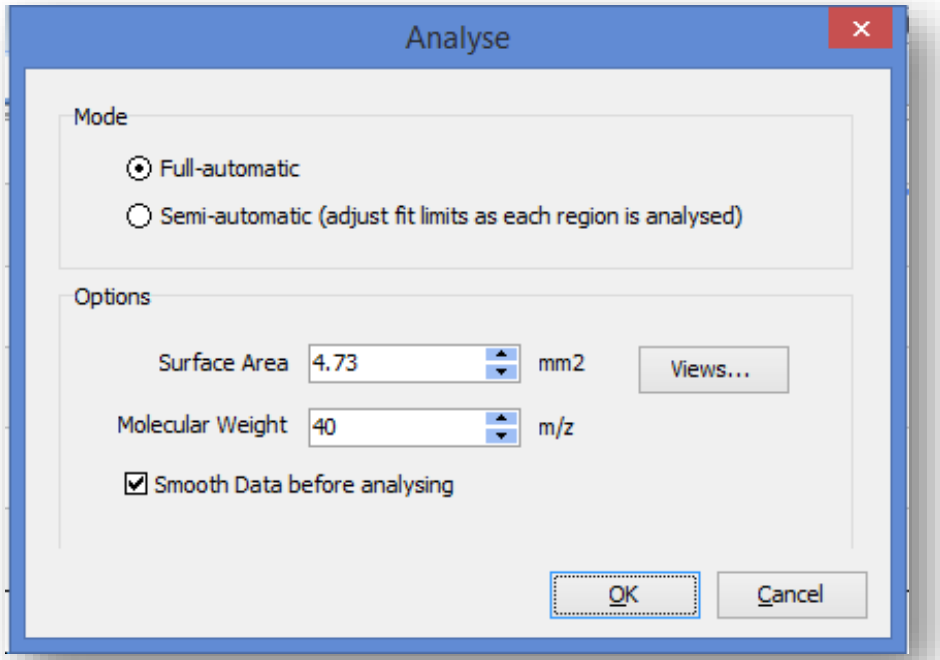
Signal Gating

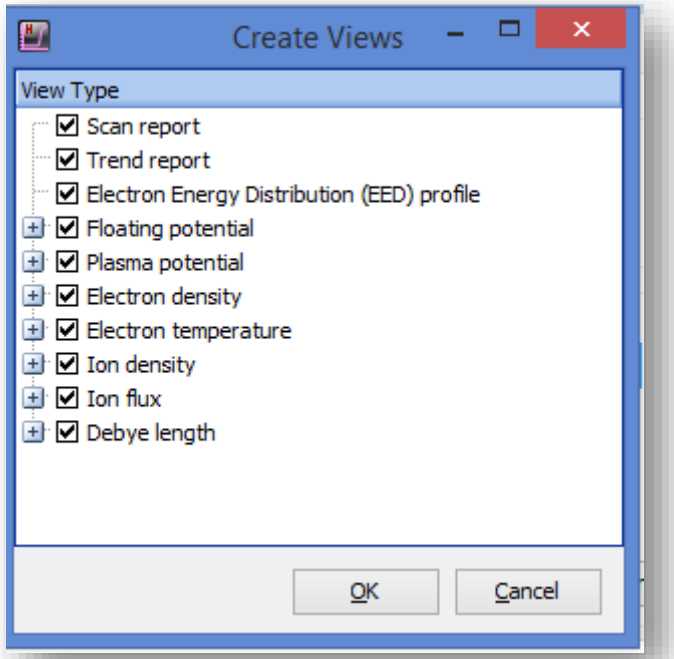


- I-V curve is constructed over many periods.
- By incrementing the delay, time resolved plasma parameters are obtained.

Data Analysis

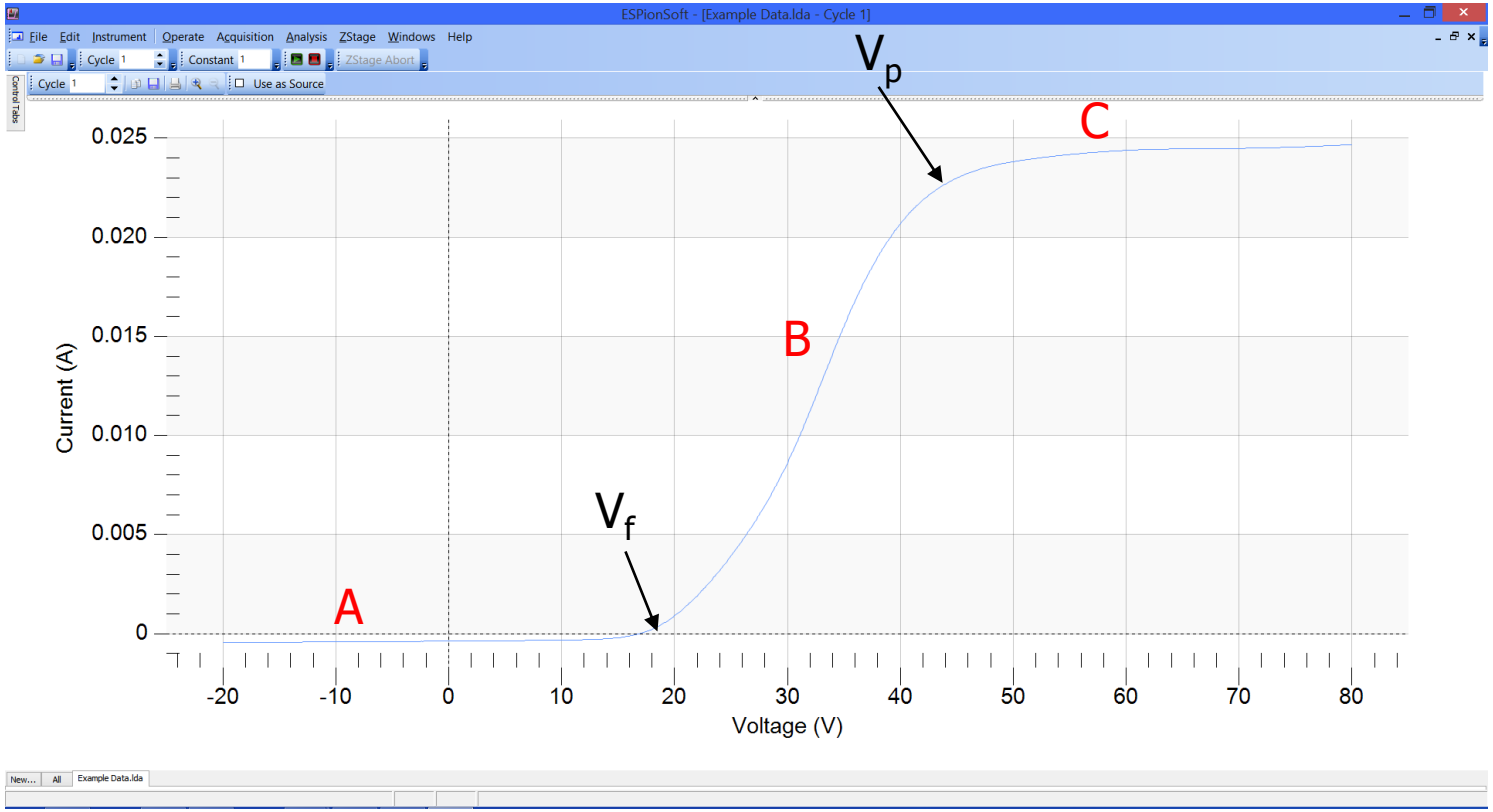
- Full and Semi-Automatic Analysis of measured parameters.
- Data can be shown as a report or analysis of individual parameters.





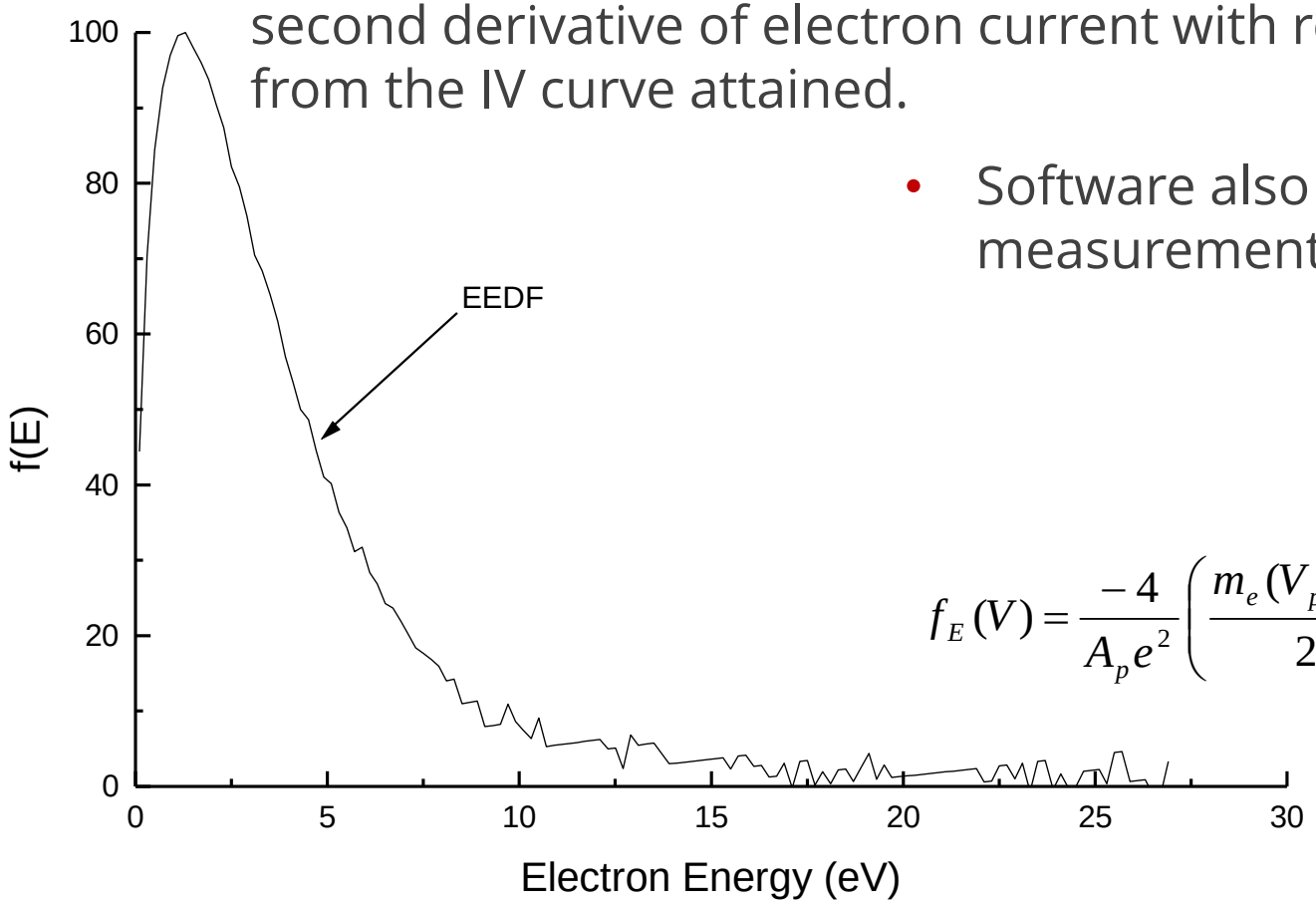
The I-V Curve

A. Ion collection
   (yields N_i & Γ_i "ion flux").
B. Electron retardation (yields T_e & EEDF).
C. Electron collection (yields N_e).



Electron Energy Distribution Function, EEDF

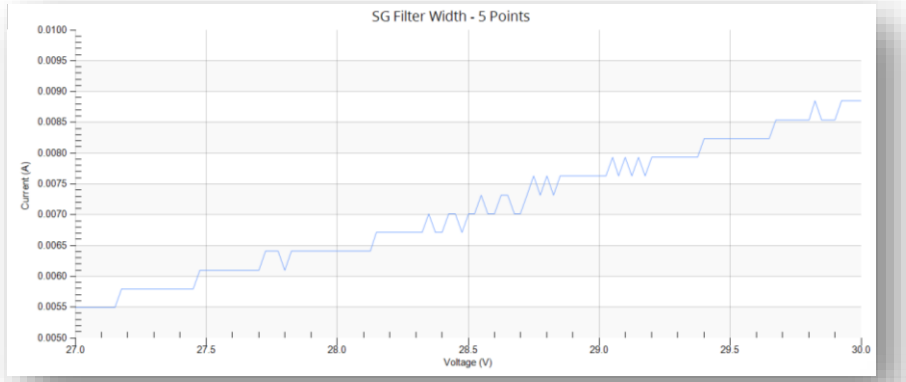
- EEDF is determined by the **Druyvestyn** method, using the second derivative of electron current with respect to voltage from the IV curve attained.



- Software also provides additional measurements of: T_e, N_e and EE.

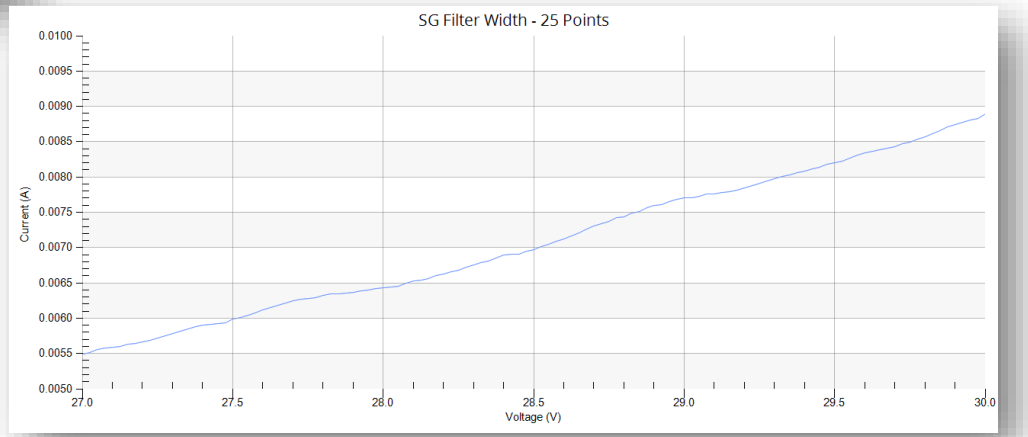
$$f_E(V) = \frac{-4}{A_p e^2}\left(\frac{m_e(V_p - V)}{2e}\right)^{1/2}\frac{d^2 I_e(V)}{dV^2}$$

Savitzky–Golay Filtering



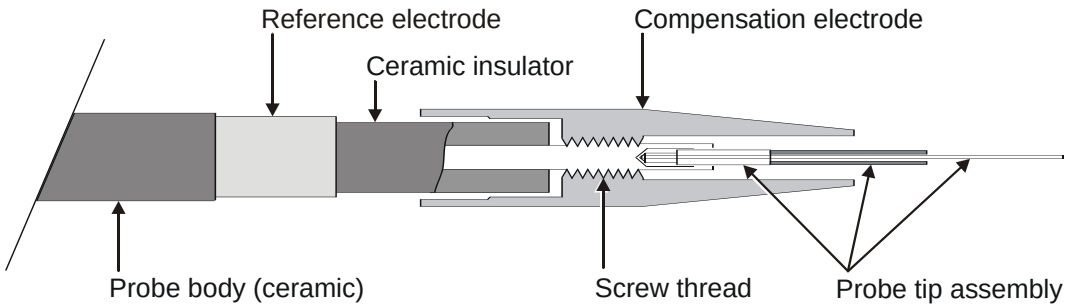
Typical scan with 5 point filter width.

Typical scan with 25 point filter width.



- The Savitzky-Golay Filter is used to digitally smooth data and improve the signal to noise ratio without greatly distorting the signal.

RF Compensation

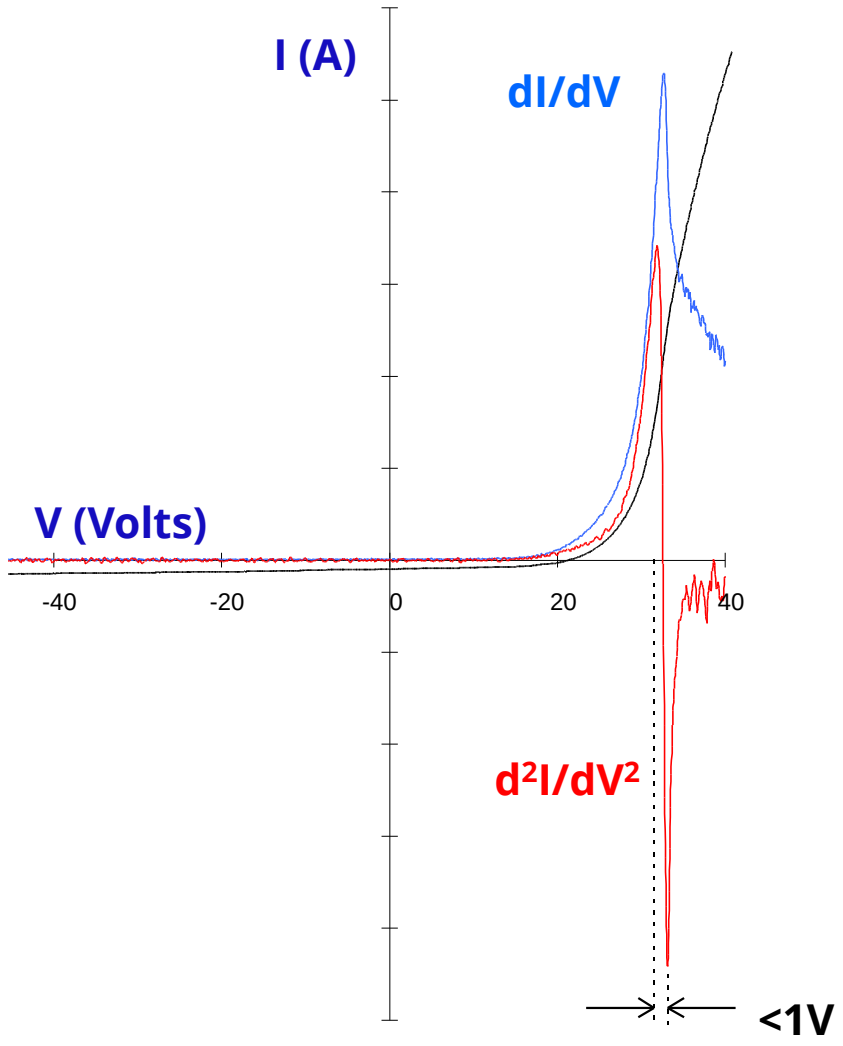


- Component of the RF driving voltage arises between plasma and probe tip distorting probe measurements.
- Removed by AC de-coupling the probe from the DC current measuring circuit and letting tip follow RF fluctuations.
- Hiden Analytical were the first to introduce passive compensation and ESPion has the highest blocking impedance of any commercially available Langmuir probe (wideband compensation).

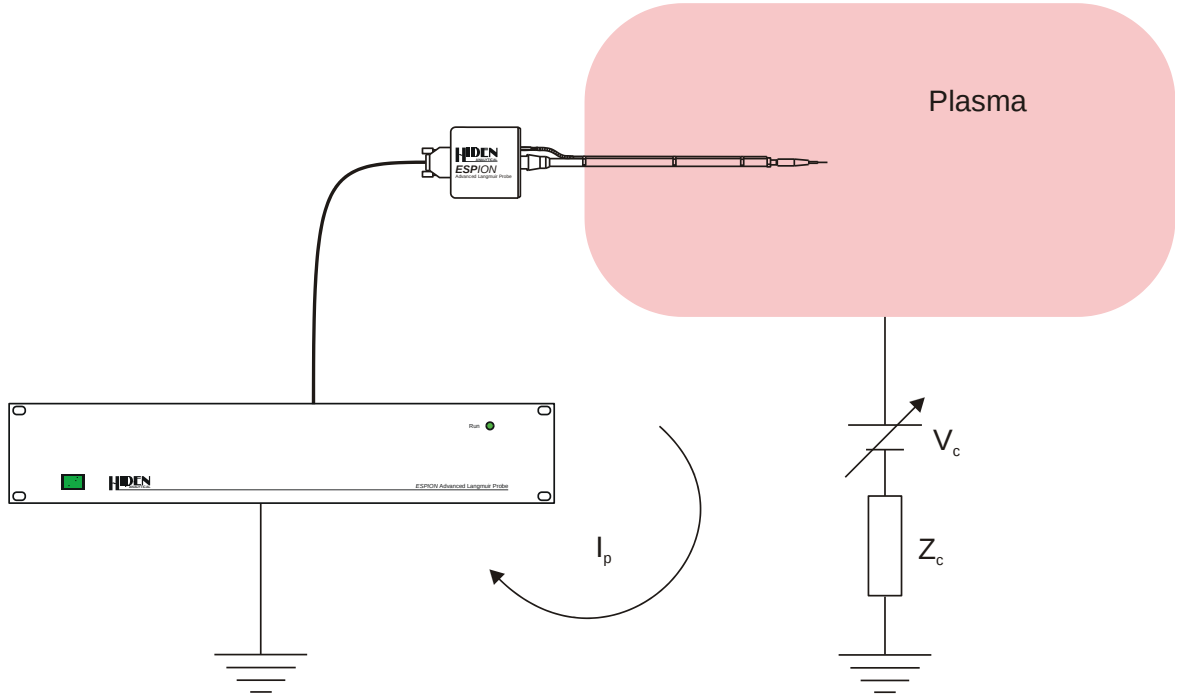
Chatterton, Rees and Al-Assadi, Vacuum ***42*** *(1991), 489*

RF Compensation

- Quality of rf compensation given by the peak separation of the second derivative, d^2I/dV^2, of the I-V characteristic
- Ideal case (perfect compensation) shows no displacement between the positive and negative peaks (both occurring at Vp) in d^2I/dV^2.
- As a practical limit, a difference below 1 Volt is considered excellent for a good rf compensation.

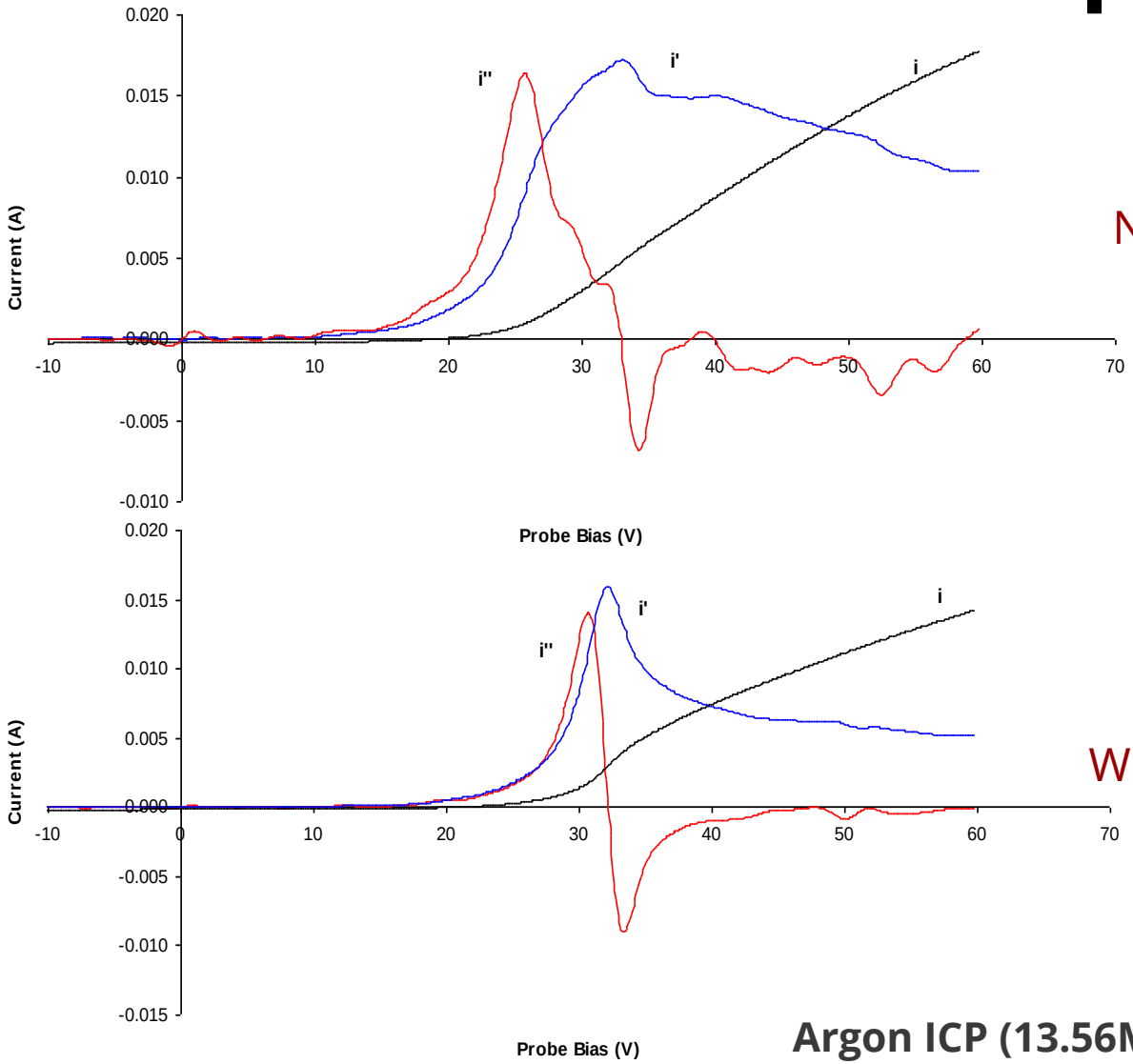


Low Frequency Reference Probe



- Reference probe compensates for low frequency effects:
  - Shift in the plasma potential (e.g. anodised chamber walls).
  - Noise (e.g. power supply).

Application Data - RF Compensation

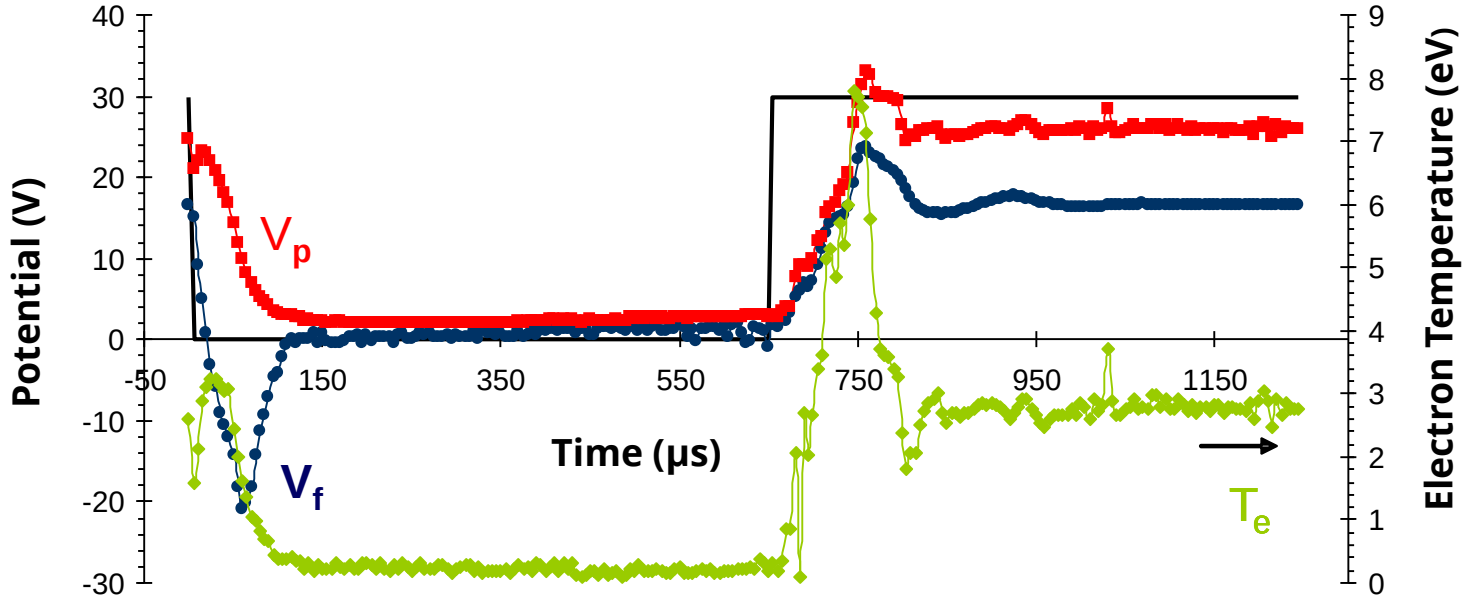


No RF compensation

With RF compensation.

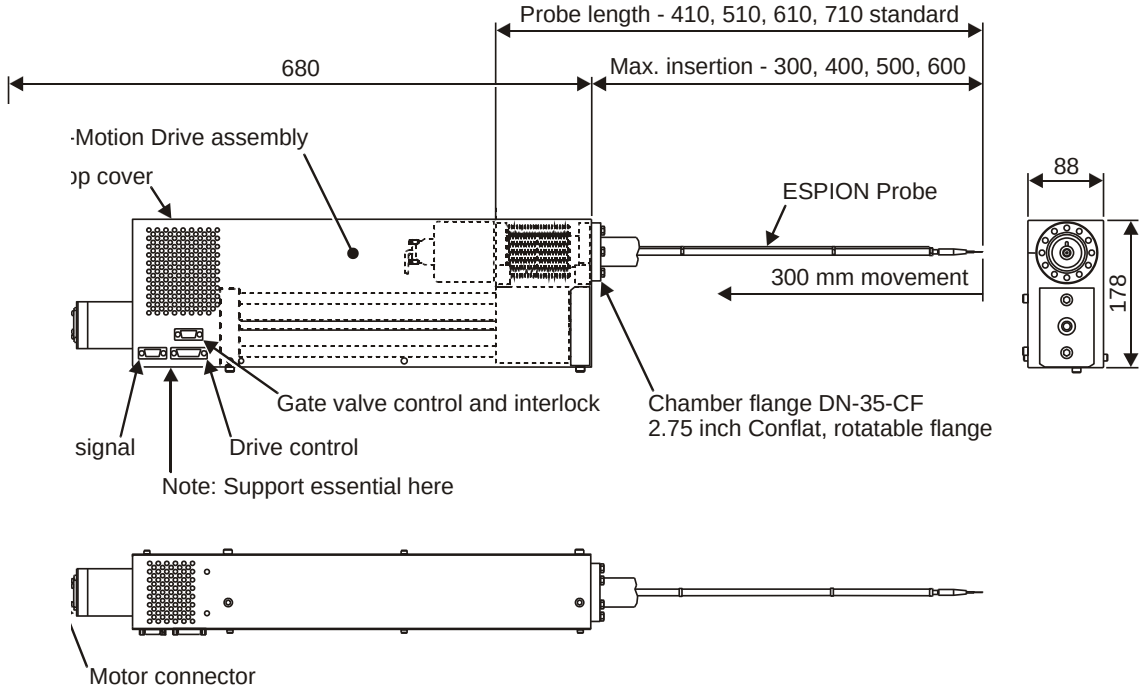
Argon ICP (13.56MHz), 30 mTorr, 50 W

Application data – Pulsed Plasma



- Gate delay resolution of 125 ns
- Time resolved plasma parameters in an Argon ICP discharge, 500 Hz modulation.

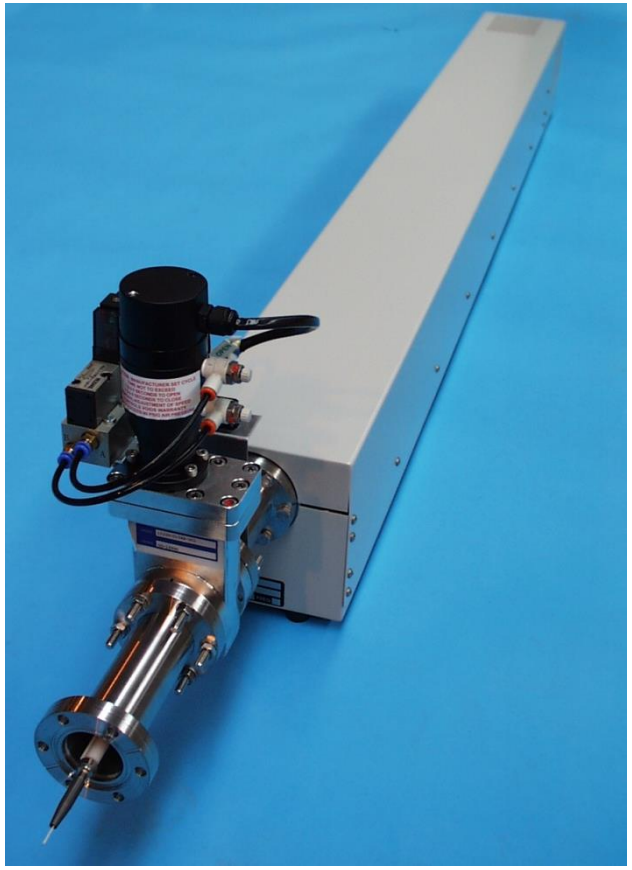
Custom Options



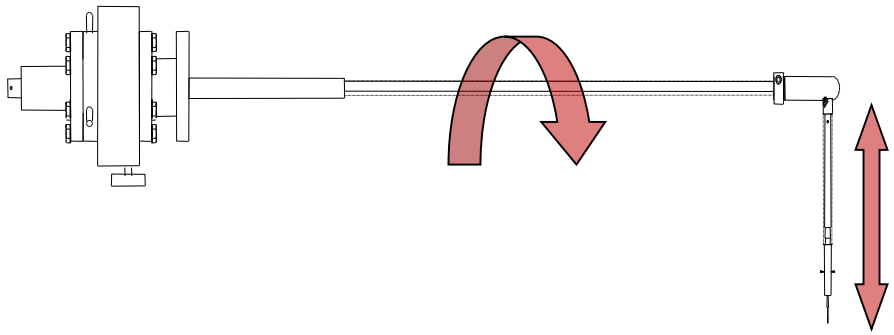
Automatic Z-Drive

- Stroke 300-900 mm
- Speed 12.7-25.0 mms^{-1}
- Manual option available

Custom Options



- 900 mm Auto Linear Drive fully interlocked pneumatic isolation valve.



- 90 degree probes
- Combined linear – rotary drives

Selected Users

USA	UK/Europe	Asia Pacific
Applied Materials	Bosch	Canon
Axelis	IMEC	Hitachi Fundamental Res.
CVC/Veeco	Motorola	Hyundai
DuPont	Nortel Networks	LG Electronics
IBM Research	Oxford Plasma Technology	NEC
LAM Research	Philips	Samsung
Lawrence Livermore	Rolls Royce	Sony Corporation
Motorola	SGS Thomson	TDK
NIST	Siemens	Tokyo Electron
Semetech	Surface Technology Systems	Toshiba