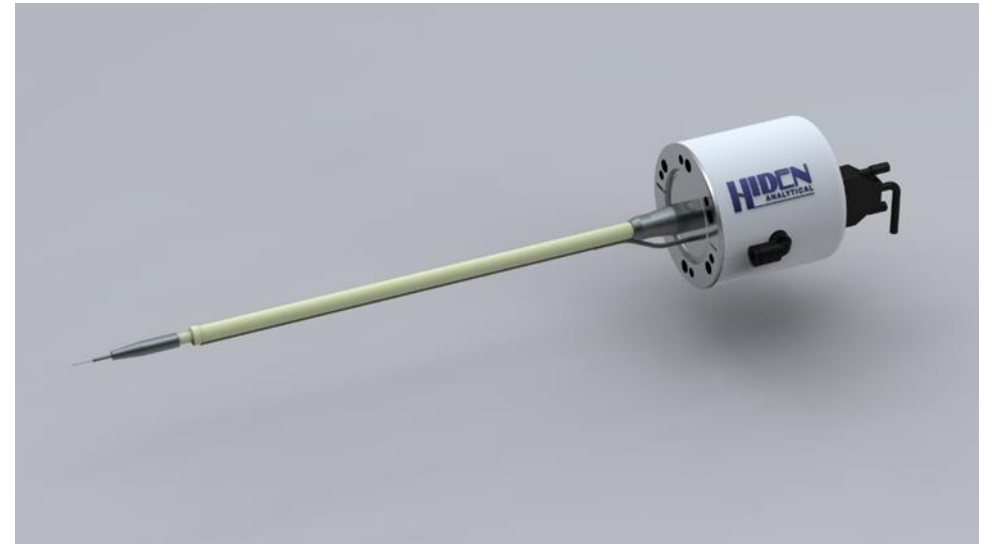


Hidden ESPion

Advanced Langmuir Probe for Plasma Diagnostics &
Characterisation

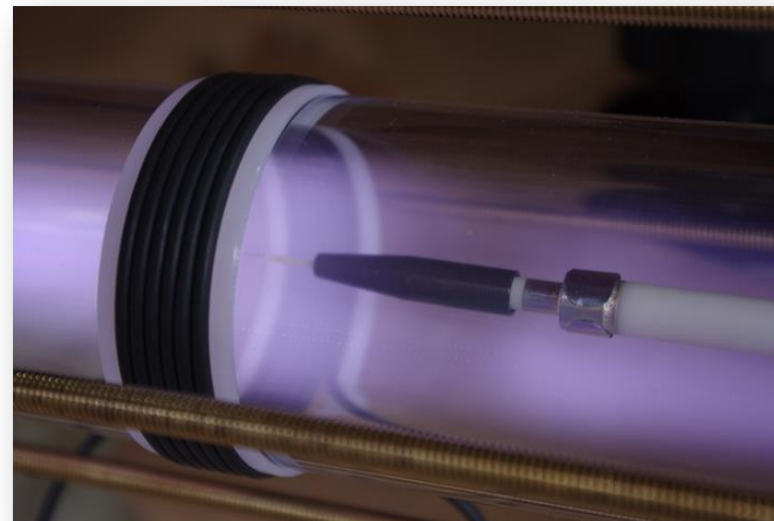
Applications

- 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.



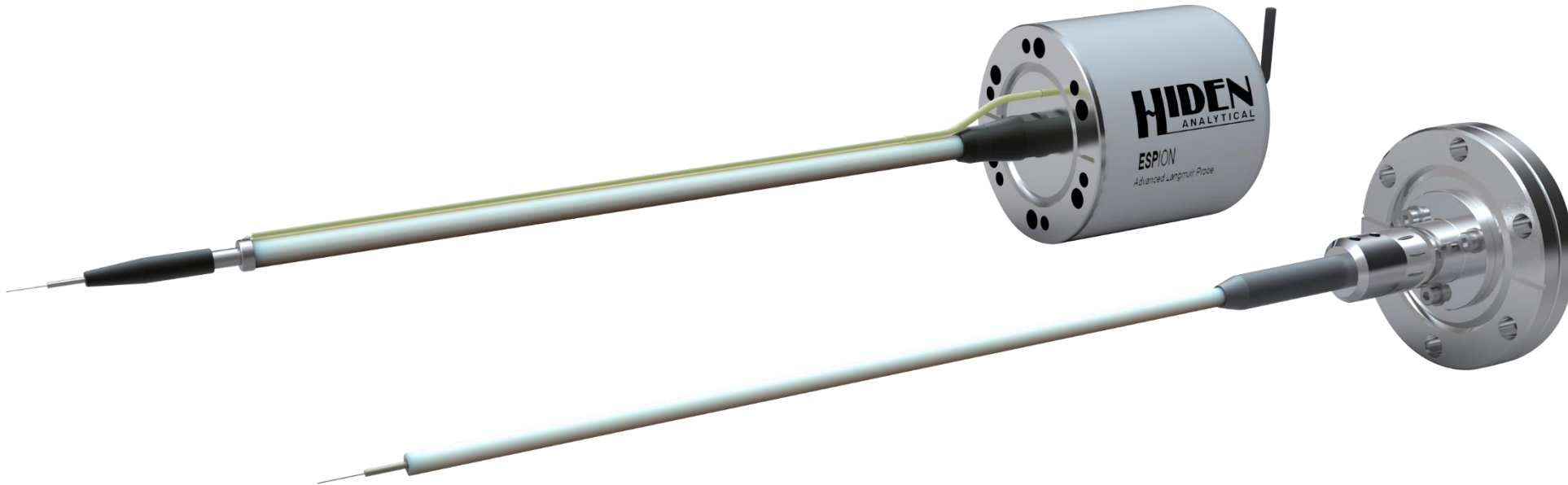
Data Available

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

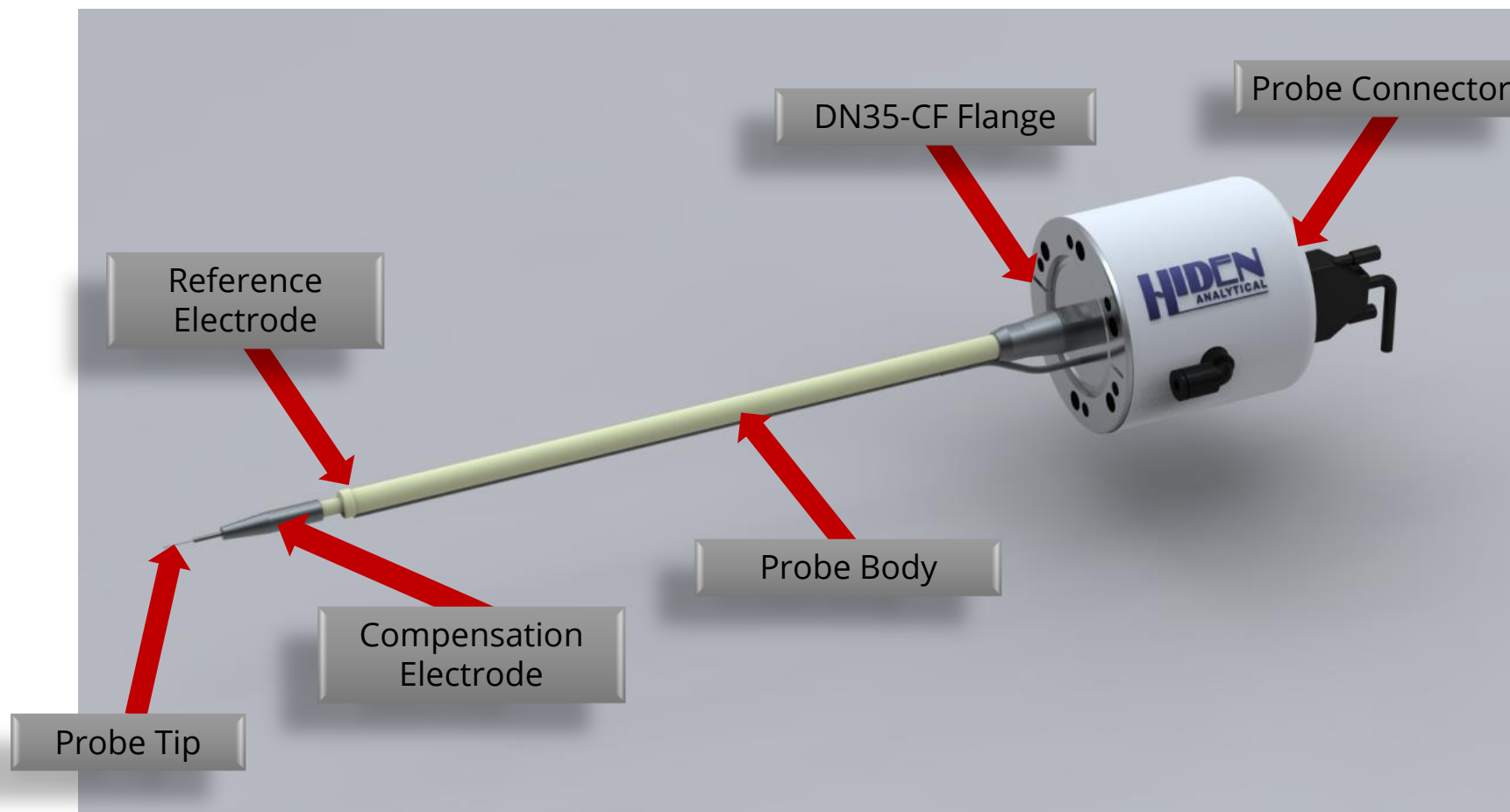


RF and DC Probes

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



Configuration



Probe Tips

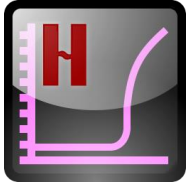


Cylindrical Probe Tip



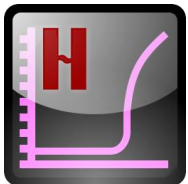
Planar Probe Tip

- 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.



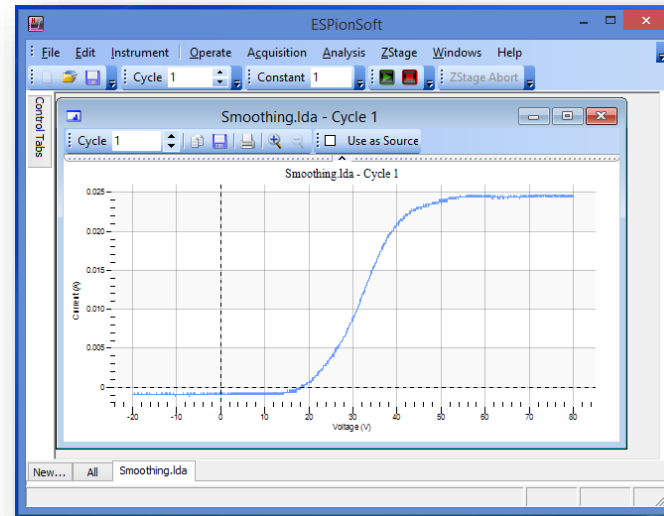
ESPionSoft Software

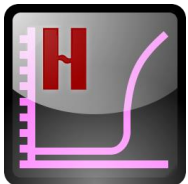
- Manual, semi-automatic and fully automatic data analysis data.
- Specific plasma probe data functions for the extraction of plasma parameters.
- Multiple graph displays and multiple files open simultaneously.
- Standard math operations on data curves (add, average, smooth, differentiate).
- Data curves 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

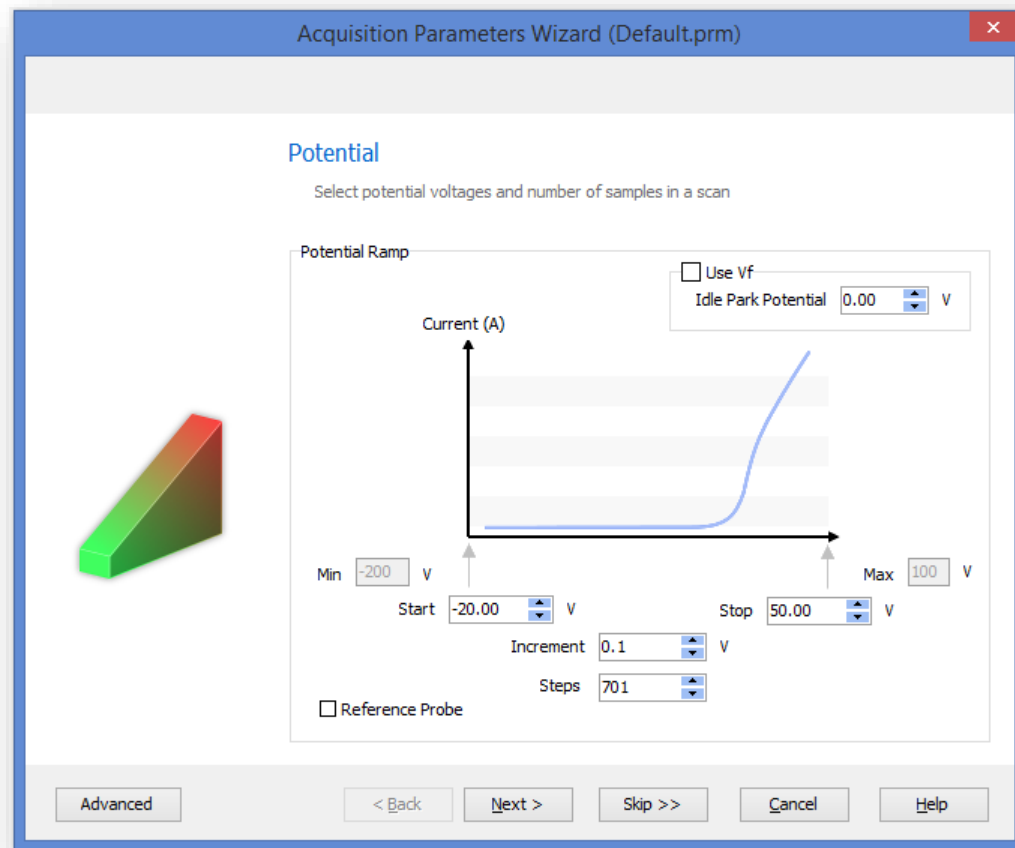
- Intuitive setup using the 'Setup Wizard'.
- A wide range of data acquisition parameters can be selected including:
 - Start/ stop potentials.
 - Data averaging and scan period.
 - Probe tip cleaning.
 - Automatic Z-motion steps and range.
 - Signal gating delay and increment timers.

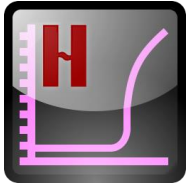




Acquisition Wizard

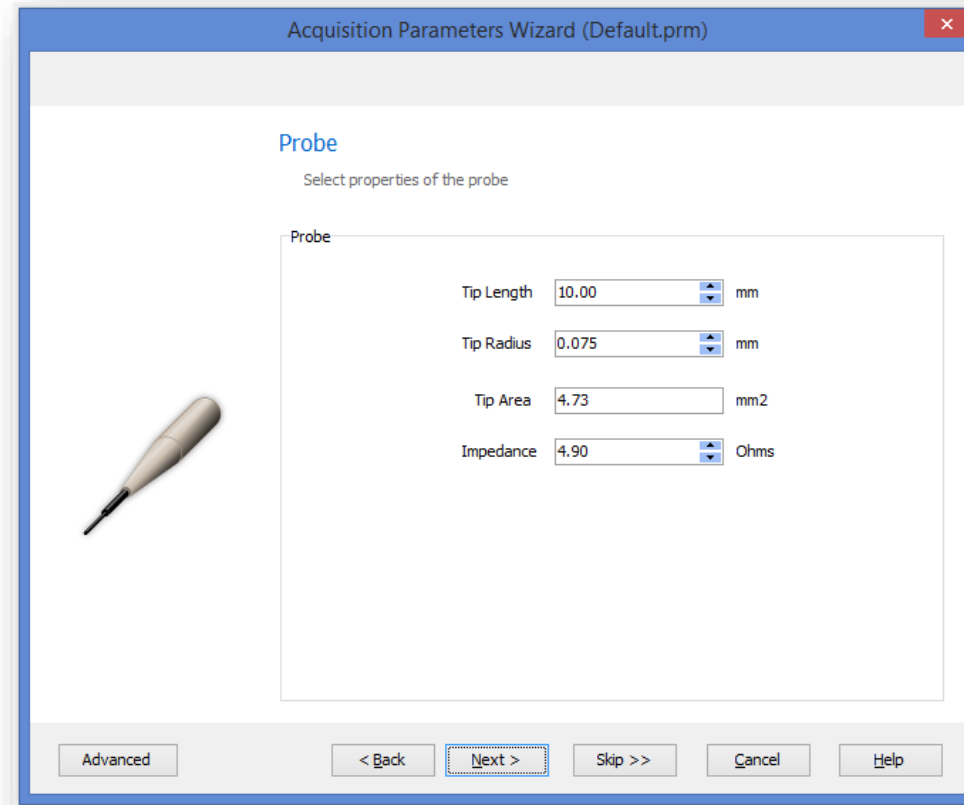
- Voltage range -200V to +100V, minimum increment 25mV.
- Current range 20 μ A to 1 A.

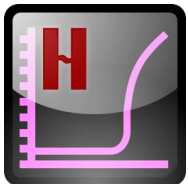




Tip Selection

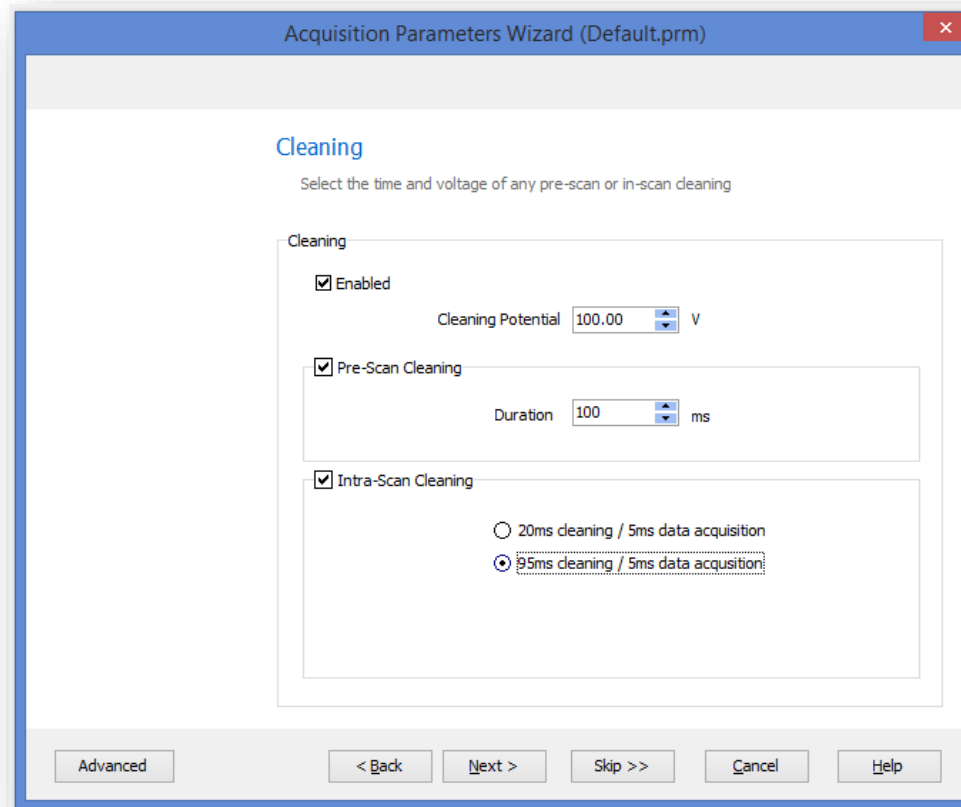
- Parameters for tip geometry can be selected.
- Allows the use of a range of tip geometries.

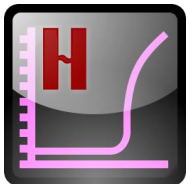




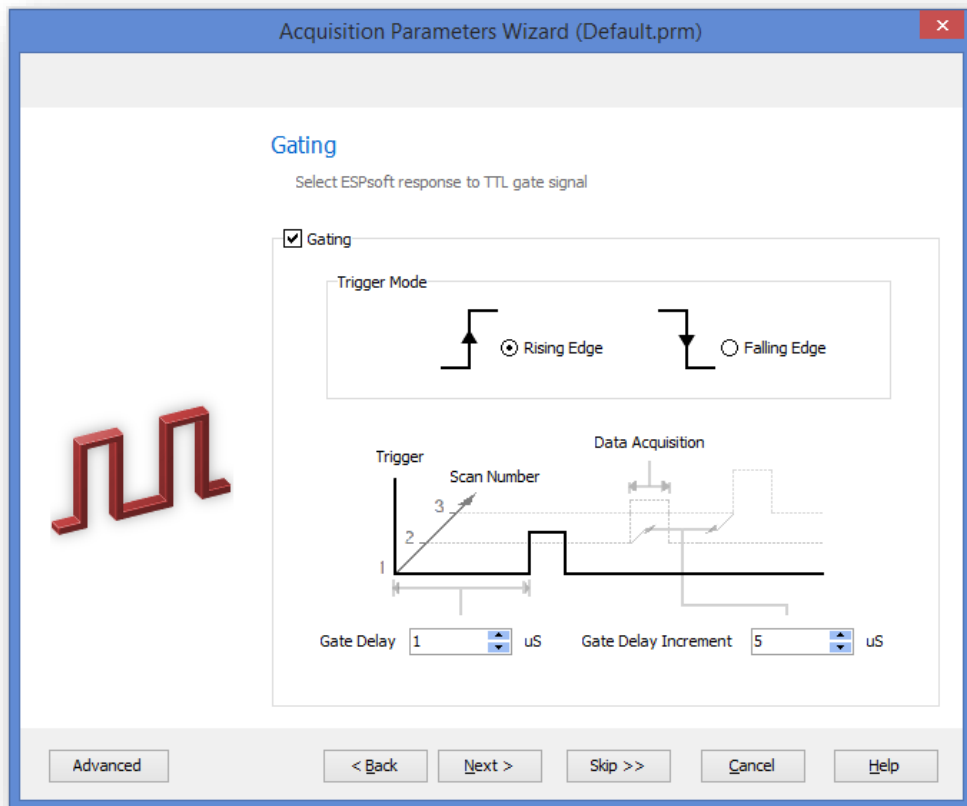
Automatic Tip Cleaning

- 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.

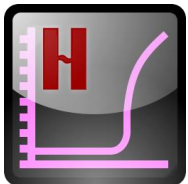




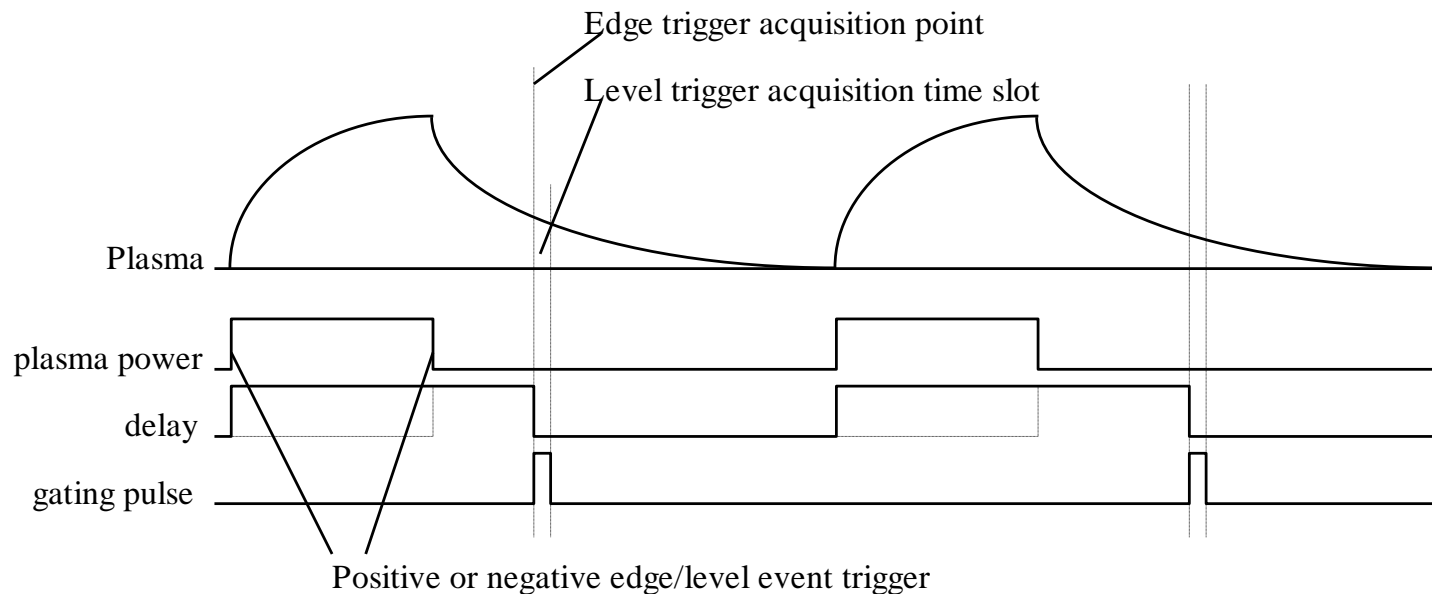
Signal Gating



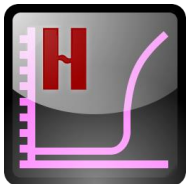
- Signal gating to synchronise acquisition with a **TTL signal**.
- The acquisition window can be moved **automatically** through the pulse.
- **Time resolved data** is constructed over a number of scans.



Signal Gating

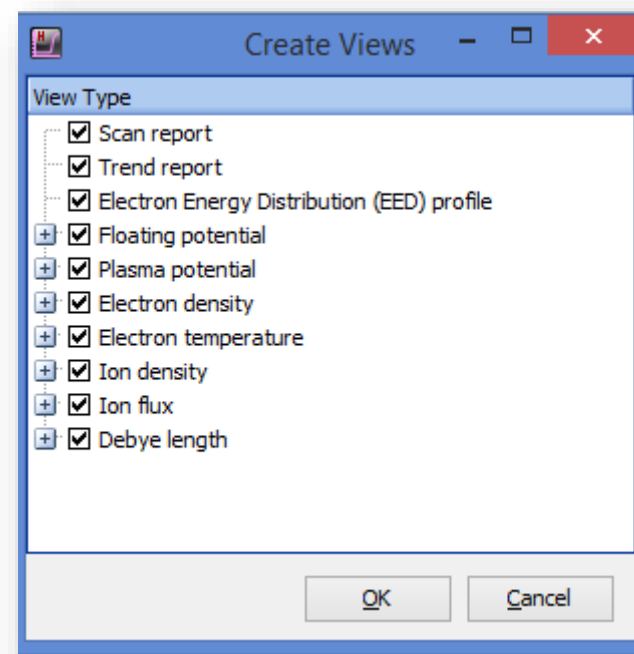
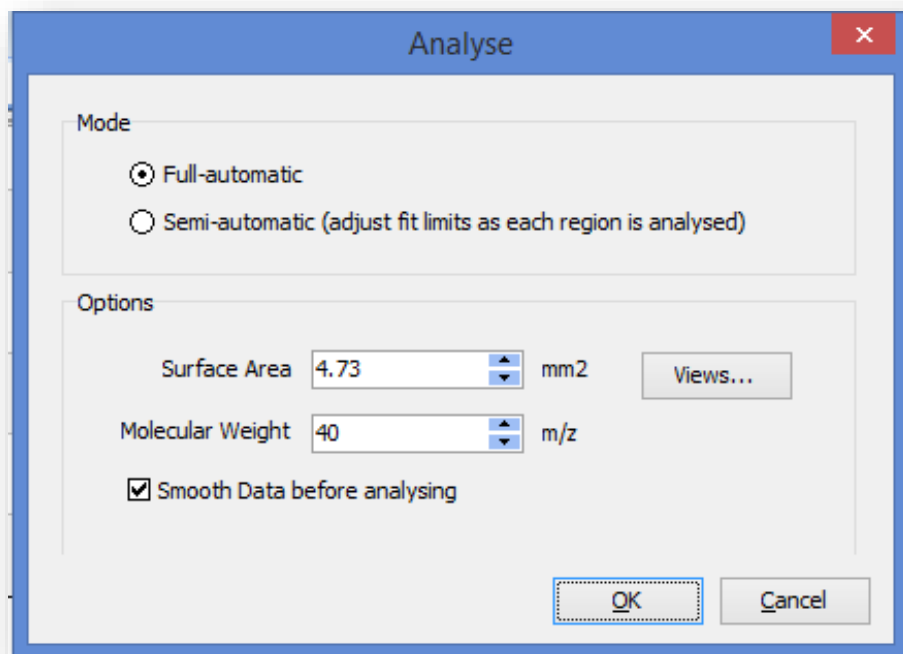


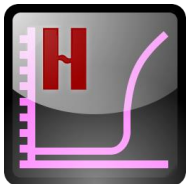
- I-V curve is constructed over many periods.
- By incrementing the delay, time resolved plasma parameters are obtained.



Data Analysis

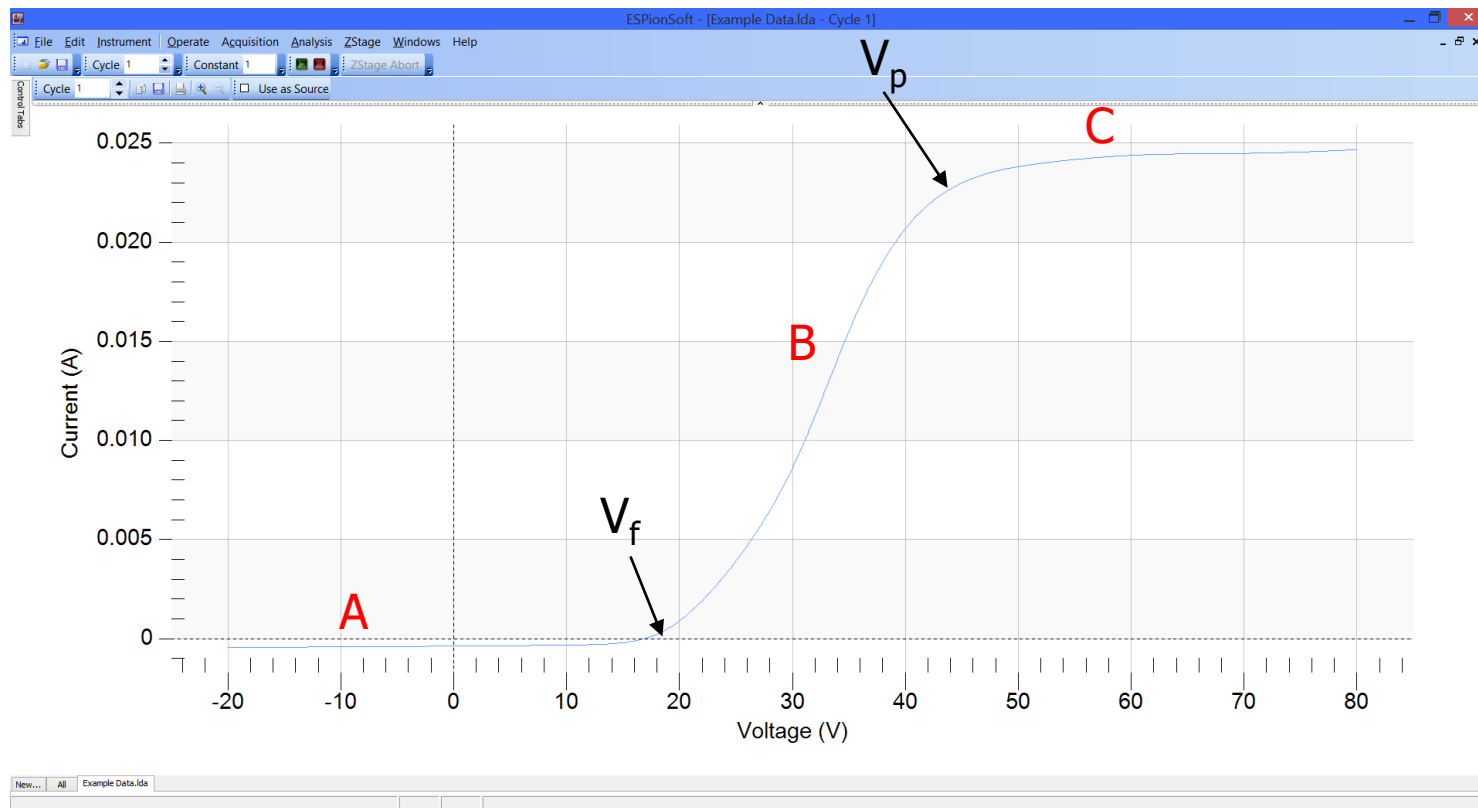
- Full and Semi-Automatic Analysis of measured parameters.
- Data can be shown as a report or analysis of individual parameters.

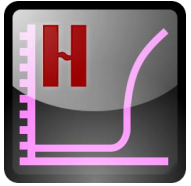




The I-V Curve

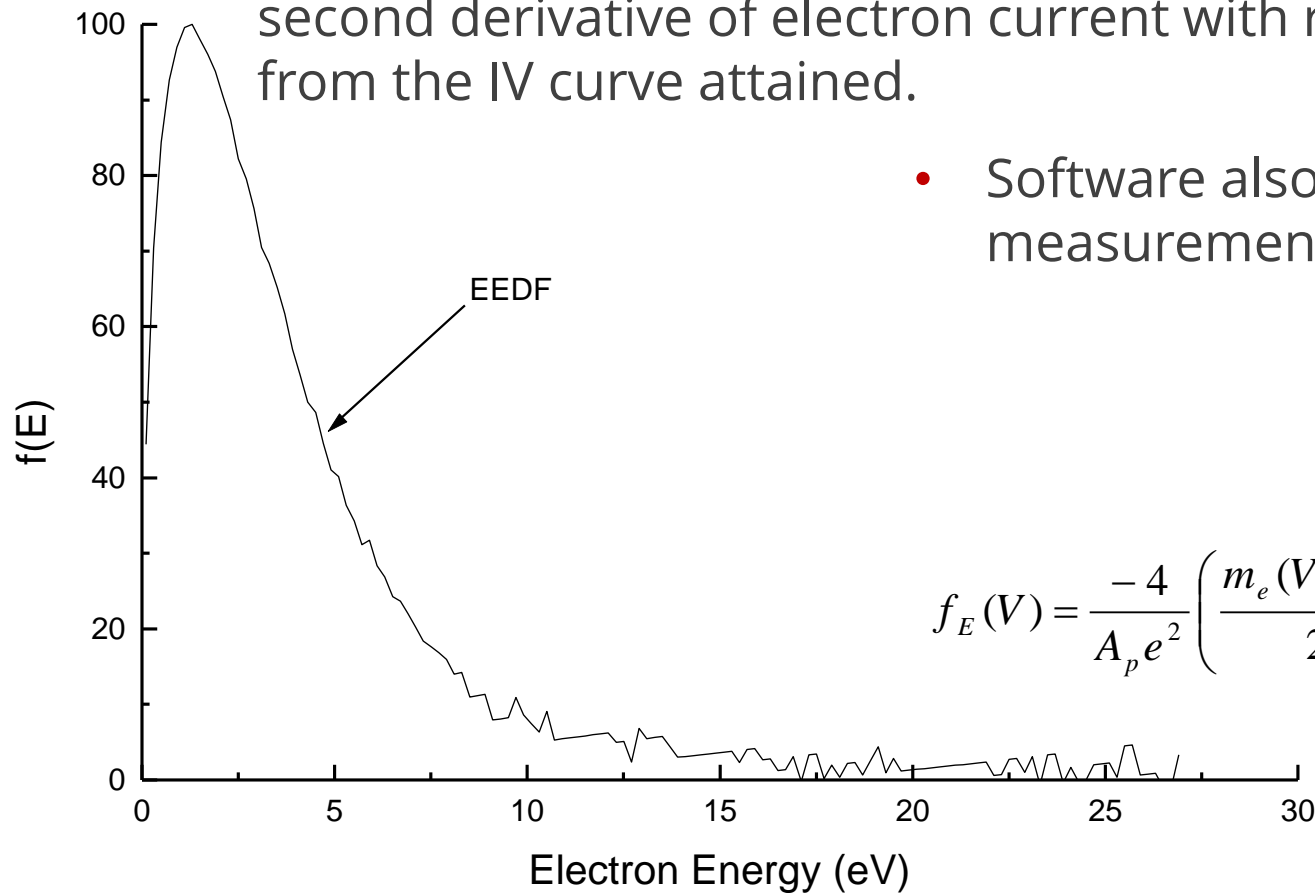
- A. Ion collection (yields N_i & Γ_i "ion flux").
- B. Electron retardation (yields T_e & EEDF).
- C. Electron collection (yields N_e).





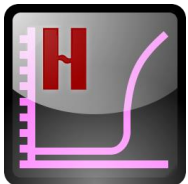
Electron Energy Distribution Function, EEDF

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

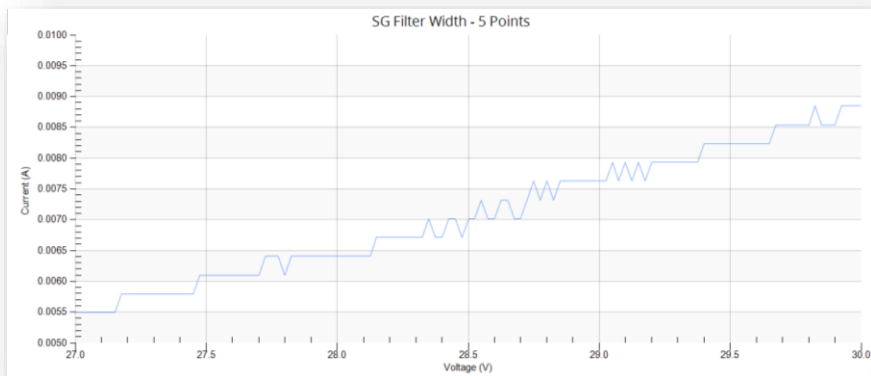


- Software also provides additional measurements of: T_e , N_e and EE .

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

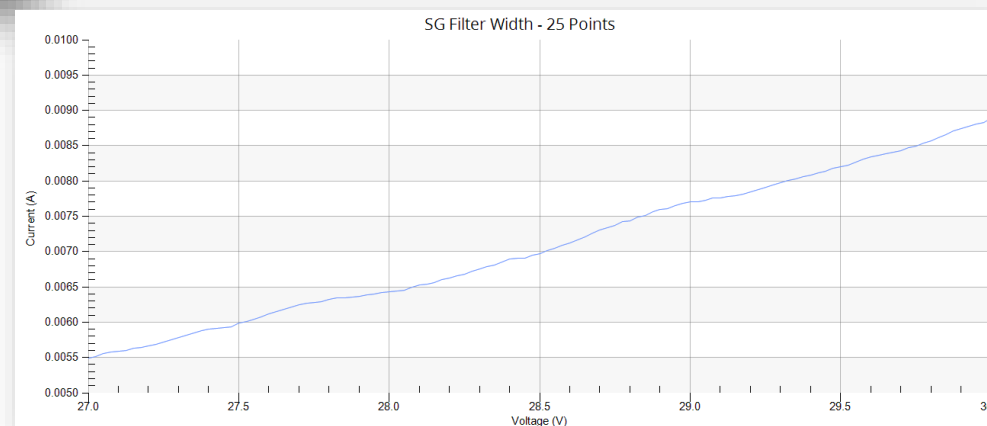


Savitzky-Golay Filtering



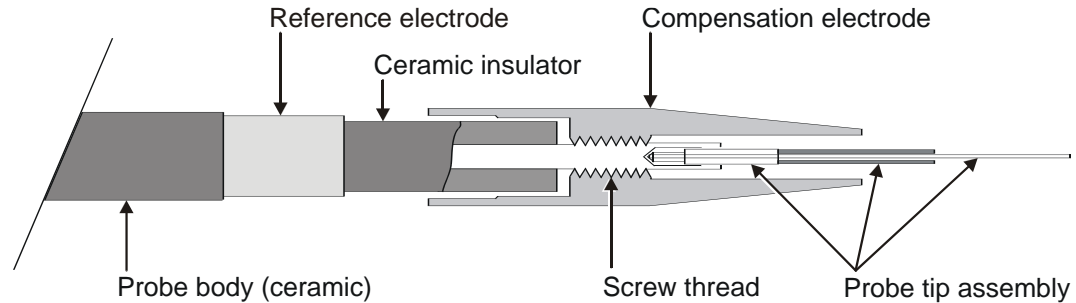
Typical scan with **5 point** filter width.

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

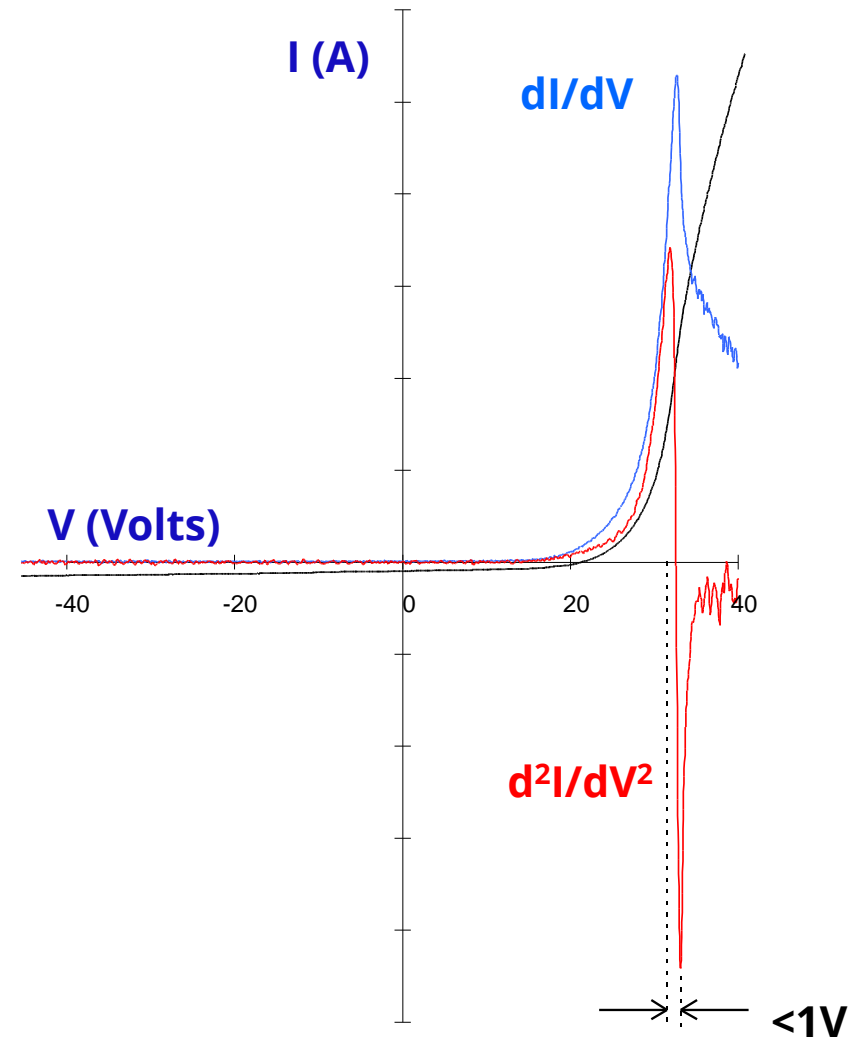


- Component of the RF driving voltage arises between plasma and probe tip distorting probe measurements.
- Removed by **AC de-coupling** the probe from the DC current measuring circuit and letting tip follow RF fluctuations.
- Hiden Analytical were the **first** to introduce passive compensation and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

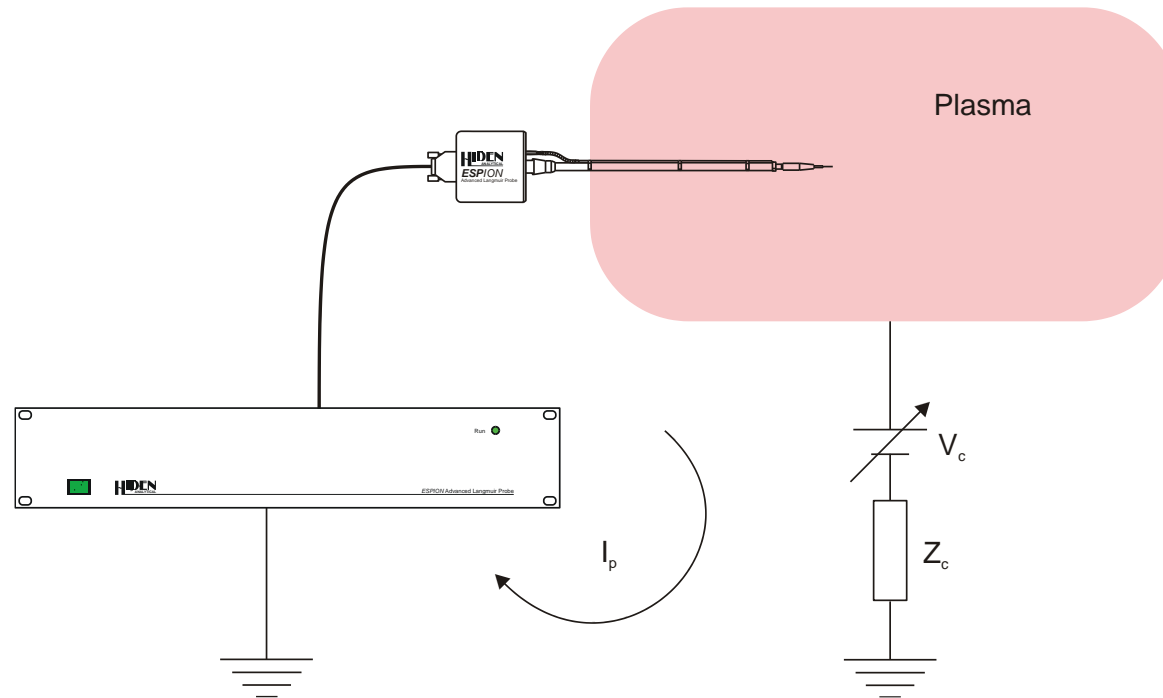
Chatterton, Rees and Al-Assadi, Vacuum 42 (1991), 489

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 V_p) in d^2I/dV^2 .
- As a practical limit, a difference below **1 Volt** is considered excellent for a good rf compensation.

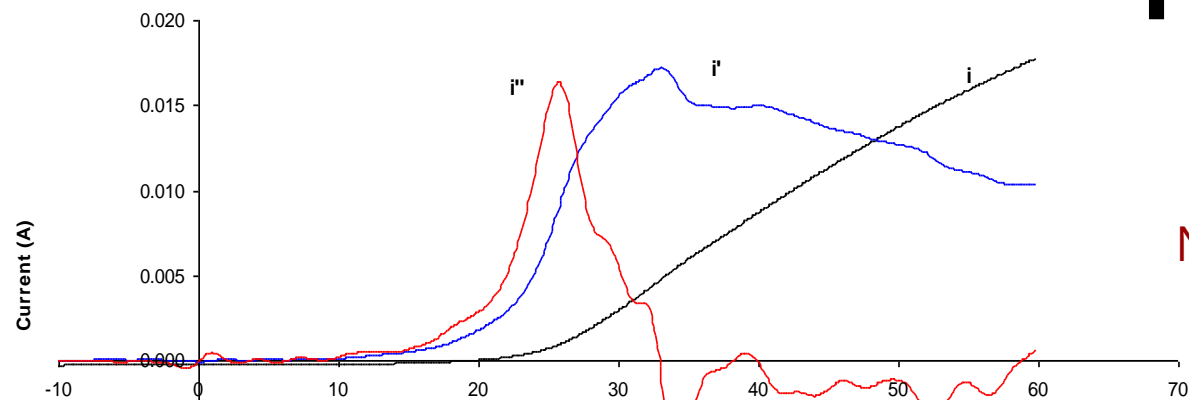


Low Frequency Reference Probe

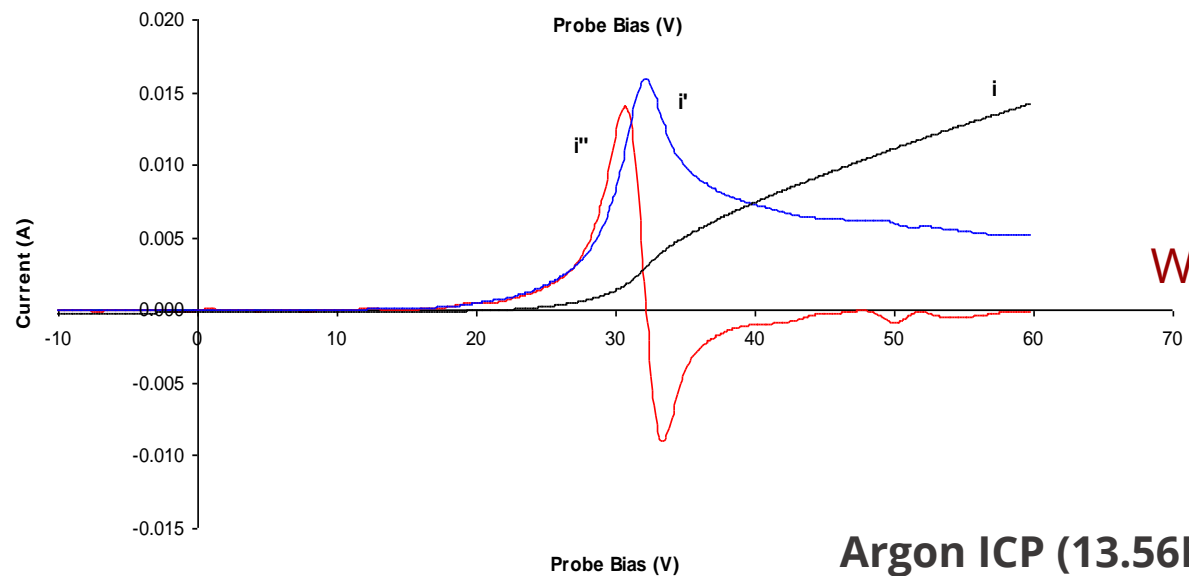


- Reference probe compensates for low frequency effects:
 - Shift in the plasma potential (e.g. anodised chamber walls).
 - Noise (e.g. power supply).

Application Data - RF Compensation



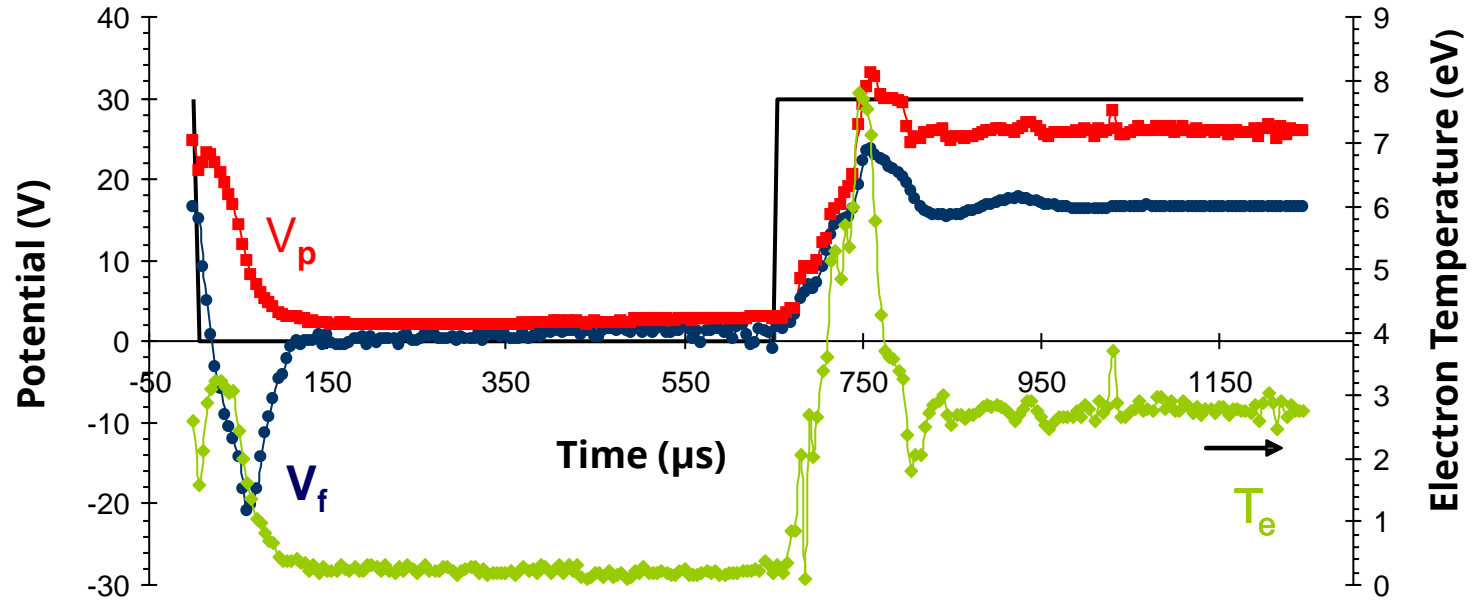
No RF compensation



With RF compensation.

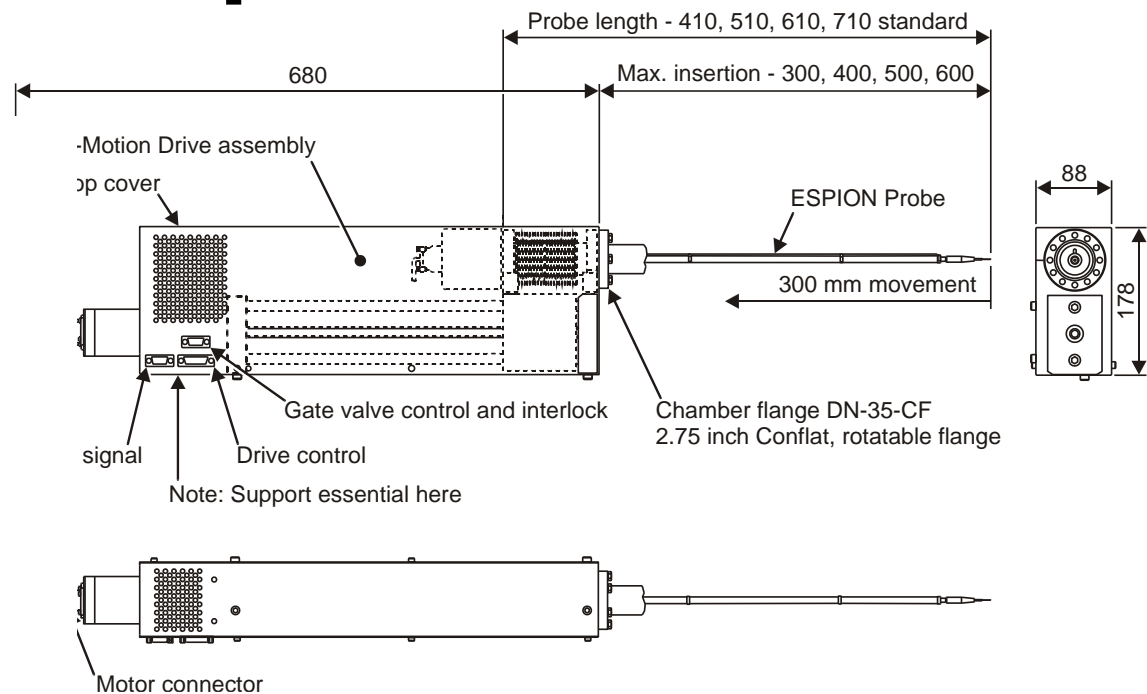
Argon ICP (13.56MHz), 30 mTorr, 50 W

Application data - Pulsed Plasma



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

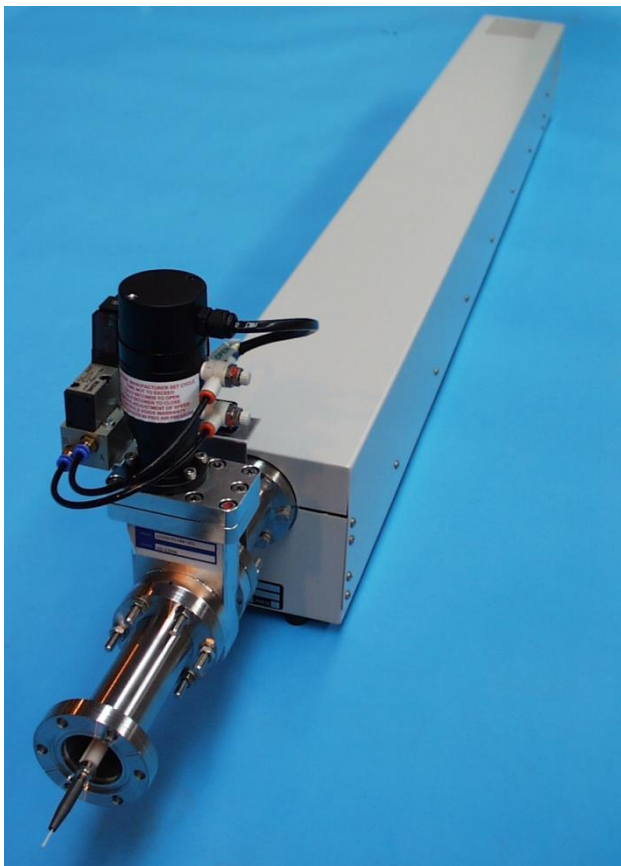
Custom Options



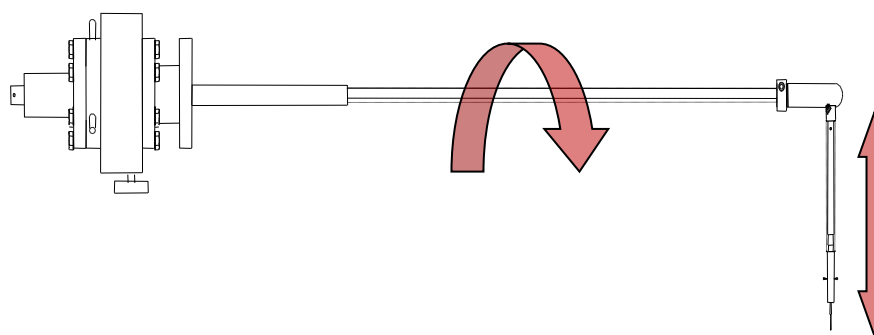
Automatic Z-Drive

- 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

Applied Materials

Axelis

CVC/Veeco

DuPont

IBM Research

LAM Research

Lawrence Livermore

Motorola

NIST

Semtech

UK/Europe

Bosch

IMEC

Motorola

Nortel Networks

Oxford Plasma Technology

Philips

Rolls Royce

SGS Thomson

Siemens

Surface Technology
Systems

Asia Pacific

Canon

Hitachi Fundamental
Res.

Hyundai

LG Electronics

NEC

Samsung

Sony Corporation

TDK

Tokyo Electron

Toshiba



HYUNDAI



MOTOROLA

- 
- A photograph of a modern, two-story office building with a grey facade and large glass windows. The building has a prominent "HIDEN ANALYTICAL" sign on its side. The sky is clear blue, and there are green trees and bushes in the foreground. A large, semi-transparent white circle is overlaid on the left side of the image, containing a bulleted list.
- www.HidenAnalytical.com
 - The Hiden website is an excellent resource with product pages, brochures, catalogues, product pages with some application notes, presentation and other information.
 - Contact +44 1925 445225 for direct support.