SINGLETRON ACCELERATOR SYSTEMS

COAXIAL AND IN-LINE POSITIVE ION ACCELERATORS 0.1 - 6.0 MV

HIGH VOLTAGE ENGINEERING

Particle Accelerator Systems for the scientific, educational and industrial research communities

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Introduction

The HVE Singletrons are reliable, compact and versatile -state of the art- single ended accelerator systems designed to produce a variety of highly stable ion beams for material modification and analysis.

The HVE Singletrons are designed to operate in a normal laboratory environment and fit in a single room laboratory of the type found in normal analytical facilities.

A built-in magnetic suppression system to reduce energy gain of back streaming electrons ensures a virtually X-ray free operation.

The clever concept permits straight forward set-up and operation of the system with little operator training needed.

A wide range of analyzing/switching magnets, beamlines and end stations is available to suit various applications including:

- Rutherford Backscattering Spectroscopy (RBS)
- Particle Induced X-ray Emission (PIXE)
- Particle Induced Gamma-ray Emission (PIGE)
- Nuclear Reaction Analysis (NRA)
- Micro- and nano-beam applications
- Ion beam modification
- Ion beam mixing

A modular design allows customized systems from standard components and makes system extensions possible with minimal changes and costs.

Basic concept

The HVE Singletrons are single ended accelerator systems with an all-solid-state HV power supply as successfully applied for many years in the HVE Tandetron tandem accelerator systems.

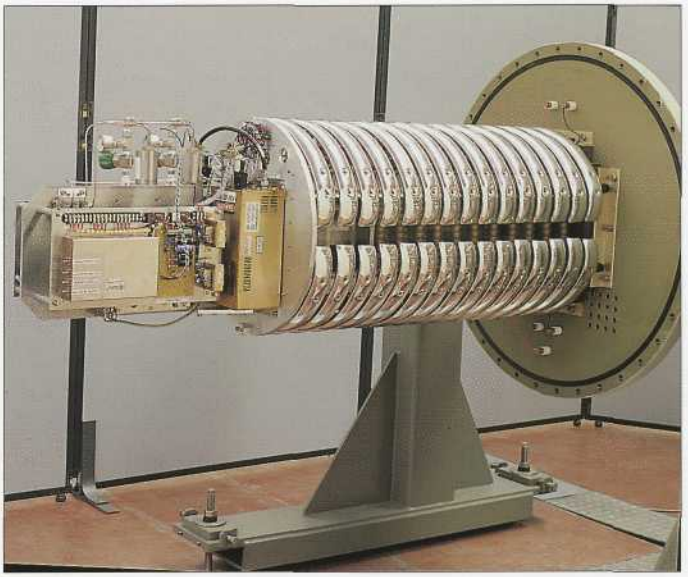
State of the art HV-power generation

The central feature of the HVE Singletron concept is a -state of the art- SF6 insulated, parallel fed, capacitively coupled Cockroft-Walton type HV power supply characterized by high reliability, extreme low noise level, high terminal voltage stability and low terminal voltage ripple.

Because the Singletron HV power supply is a voltage rather than a current source corona stabilization, to accommodate differences in beam- and charging-currents, is not required and the response to changes in beam loads is extremely fast.

As a result, the beam energy resolution of the Singletron is superior compared to other types of single ended accelerators.

Moreover, since the Singletron HV power supply is a purely electronic power supply, it has the advantage that it has no moving parts. As a result there are no vibrations, which might result in terminal voltage fluctuations, and ripple & stability values and dynamic behavior are stable over many years of operation whereby maintenance of the components in the pressure tank is seldom, if ever, needed.

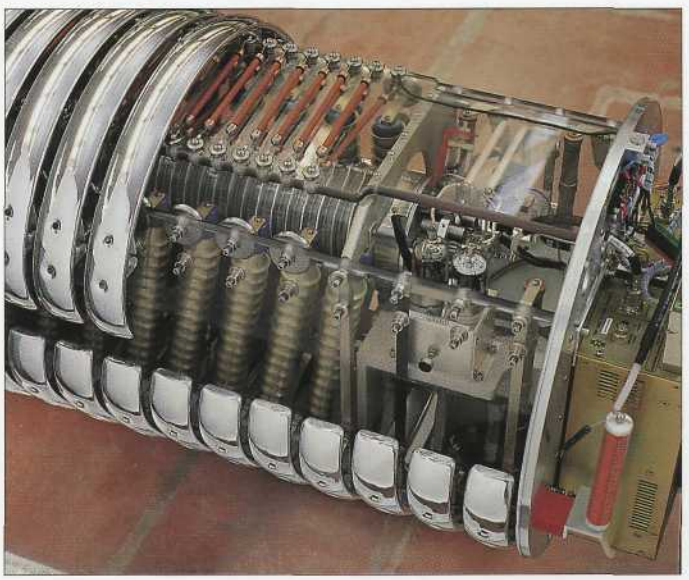


Coaxial Singletrons

HVE Singletron accelerators are, depending on their application(s) available in two versions: as Coaxial and as In-line Singletrons.

Coaxial Singletrons are the most compact and most cost effective Singletrons. With coaxial Singletrons the HV power supply is build around the acceleration stage.

To minimize terminal voltage fluctuations in case of transients in the acceleration stage, the HV power supply is mechanically separated from the acceleration stage and ion source. Both assemblies are self-supporting and are suspended from one common base end of the pressure tank.



In-line Singletrons

For applications where ripple specifications are of paramount importance In-line Singletrons are the preferred choice.

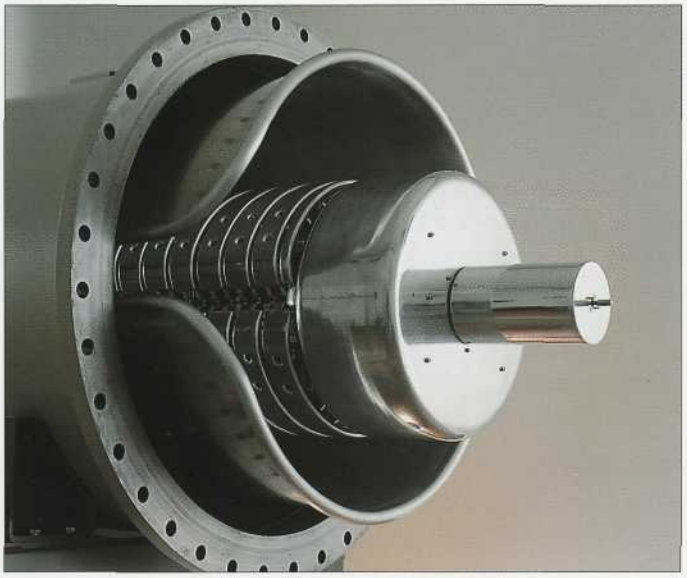
With the smaller versions of the in-line Singletrons the tank is split into two sections and the HV power supply is a separate self-supporting assembly suspended from the base of one of the pressure tank sections.

The acceleration stage too is a separate self-supporting assembly and is suspended from the base of the other pressure tank section

Because of a larger mechanical separation capacitive coupling between HV power supply and acceleration stage of in-line Singletrons is much lower than that of coaxial Singletrons. This in combination with additional RC-filtering makes in-line Singletrons superior in terminal voltage ripple.

Although somewhat longer than the coaxial Singletrons in-line Singletrons need approximately the same space for servicing as compared to coaxial Singletrons. By moving the HV power supply tank side wards after slightly retracting it is possible to service the accelerator interior in the available free space beside the machine for passage.

With the larger versions of the in-line Singletron the pressure tank is made out of one piece and the HV power supply is, to be able to carry the weight, supported by a structure that is suspended from both ends of the tank.



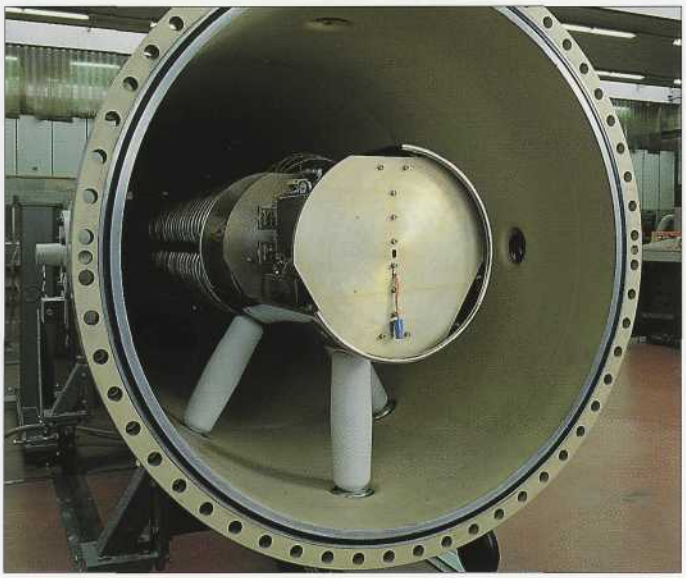
The acceleration stage and ion source remains to be a separate self-supporting assembly and is suspended from one end of the pressure tank.

The generator that supplies electrical power to the components in the HV terminal is mechanically isolated from the acceleration stage and ion source to avoid that the generator vibrations are transmitted to the HV terminal and or the ion source.

Ion species

Both coaxial and in-line Singletrons are equipped with a spacious HV terminal that provides room for an ion source, all solid state power supplies and up to four source feed gas systems.

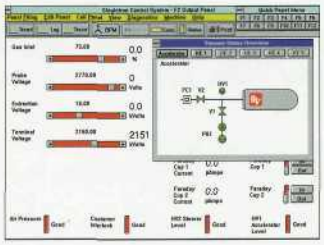
In the standard configuration the Singletrons are equipped with a Radio Frequency (RF) ion source that is able to produce a large variety of gaseous ions and is characterized by high reliability, low gas consumption and is easy to operate by means of only one parameter.



RF ion sources are available in two versions, with a short bottle (standard) and with a long bottle (optional). The long bottle version delivers approximately twice the beam current obtainable with a short bottle RF ion source.

Moreover a filament free Duoplasmatron ion source is optionally available and is recommended for micro- and nano-beam applications because of its superior brightness.

Depending on the application(s), other more suitable ion sources may be (-come) available and HVE is most willing to consider incorporation of such ion sources.

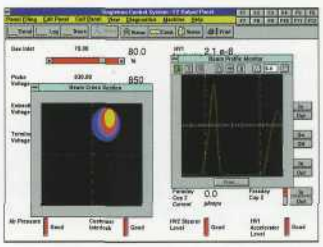
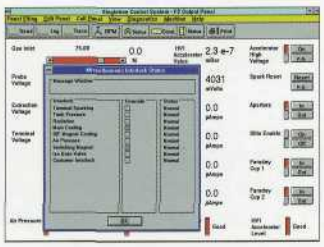



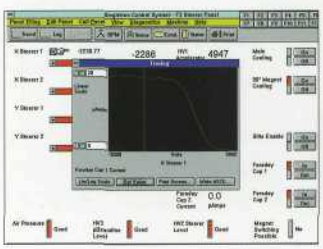
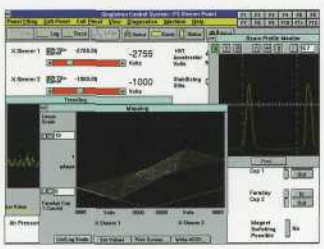
Full control automation

The HVE Singletrons use modern automation techniques to achieve maximal use and optimal performance on a day-to-day and month-to-month basis.

A dedicated Microsoft Windows™ based software program, developed in-house at HVE, running on an industrial personal computer provides user friendly interfaces and allows automatic start up & shut down and automated tuning, control & monitoring of the entire accelerator system.

All system parameters can be controlled using a mouse and/or keyboard whereby the actual readings are shown in an interactive sequential format or in a graphic format simultaneously as a function of time without the need for additional conventional control knobs, read outs or oscilloscopes.

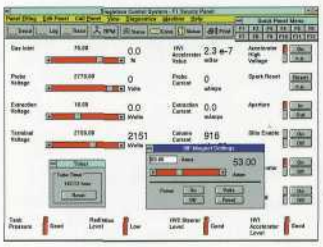
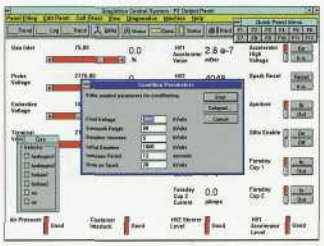



Auto tuning

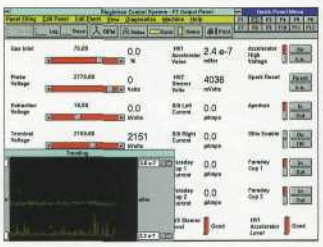
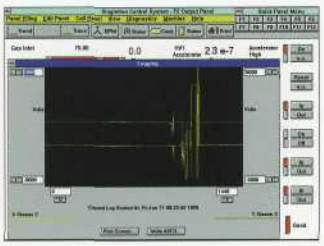
For automated tuning and optimizing of system parameters various subroutines are included such as:

- Automatic setting of magnet currents based on the entry of ion mass in AMU
- Direct entry of required dose in ions/cm^2
- Tracing & Mapping for optimizing of parameters, one respectively two (dependent) parameters simultaneously
- Teach & Playback capability for recall of parameters based on previous runs
- Display on the computer screen of an image of the scanned target area and beam profiles & cross sections at various locations throughout the system.

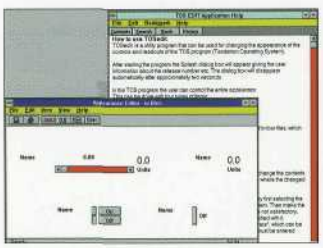
Auto start up

Automatic (unattended) system self start up and shut down allows maximal use of the accelerator system and includes control and monitoring of among others: ion source, vacuum system, terminal voltage conditioning and target heaters.

Auto beam tracking

Beam tracking is included for automatic adjustment of Einzellenses, steerers, Q-poles, beam scanners, electrostatic deflectors, magnets, etc. when changing the beam energy.
Moreover automatic beam energy stepping is available for automated thick layer implants and for automated nuclear reaction and resonance scattering analysis.




Complete system diagnostics

Misoperation of the critical parameters is protected. Subroutines such as Trending, Data Logging & Reports are available for system diagnostics.

HIGH VOLTAGE ENGINEERING EUROPA B.V.

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Specifications

Terminal voltage range	MV	0.1 - 0.5	0.1 - 1.0	0.1 - 2.0	0.2 - 3.0	0.2 - 3.5	0.3 - 5.0	0.3 - 6.0
Terminal voltage stability								
• standard system (GVM)*	$^{+}/_{-}$V	75	150	200	300	350	500	600
• with slit stabilisation**	$^{+}/_{-}$V	30	30	30	30	30	30	30
Terminal voltage ripple*								
- Coaxial Singletron								
• standard system	V_{pp}	150	200	400	600	700	1000	1200
• with de-rippling kit	V_{pp}	50	80	150	200	250	350	400
- In-line Singletron								
• standard system	V_{pp}	100	150	200	250	300	400	500
• with de-rippling kit	V_{pp}	10	20	25	30	35	50	60
X-ray level***	µSv/hr	<2	<2	<2	<2	<2	<2	<2
Beam currents****	eµA							
- Short bottle RF ion source	$^{1}H^{+}$	100	100	100	100	100	100	100
	$^{4}H^{+}$	60	60	60	60	60	60	60
- Long bottle RF ion source	$^{1}H^{+}$	200	200	200	200	200	200	200
	$^{4}He^{+}$	125	125	125	125	125	125	125

* measured over one hour, after one hour of warming up, at 75% of maximum terminal voltage.

** measured over one hour, after one hour of warming up, at the exit of a HVEE 90° 1500mm radius analyzing magnet, by means of:
- $^{7}Li(p,n)$ reaction at 1.881MeV for Singletron's with maximum terminal voltage >= 2MV
- $^{27}Al(p,\gamma)$ reaction at 992keV for Singletron with maximum terminal voltage = 1MV
- $^{27}Al(p,\gamma)$ reaction at 327keV for Singletron with maximum terminal voltage = 0,5MV

*** measured at 1mtr from the tankwall, running a 1µA He^{+} beam at maximum terminal voltage

**** measured at maximum terminal voltage in a Faraday cup after the high energy switching magnet