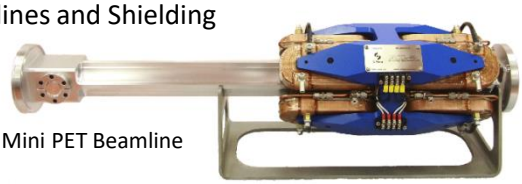
PRODUCT & SERVICE LIST

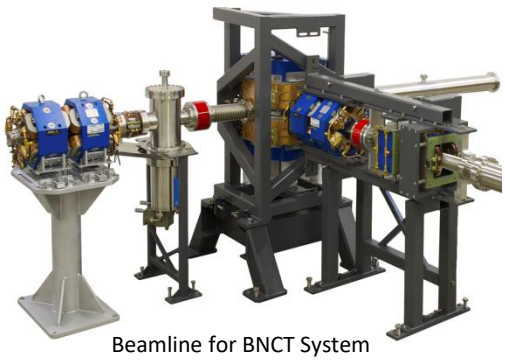
D-Pace supplies complete turnkey beamline systems, and beamline sub-components such as: magnets, beam diagnostics, vacuum chambers, supports and shielding to the international commercial accelerator industry. In addition D-Pace provides auxiliary ion source systems, and spectrometer and energy analysis systems.

Beamline Systems

- BNCT Beamlines
- Mini-Beamlines for PET
- Injection Beamlines
- Custom Beamlines and Shielding



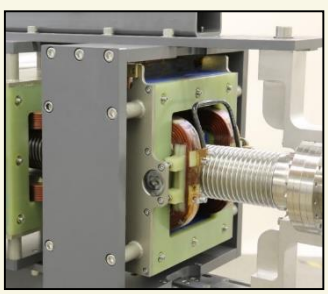
Mini PET Beamline



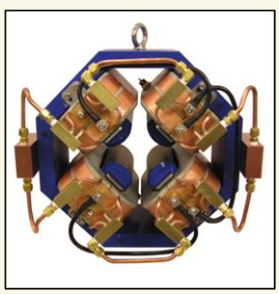
Beamline for BNCT System

Magnets

- AC Scanning Magnet for Beam Raster Scanning
- Quadrupole
- Dipole: Bender, Steerer, Analyzing
- Solenoid
- Custom Magnets Including Ion Optics Design



AC Scanning Magnet



Quadrupole Magnet

DC XY Steer Magnet

Turn-key Negative Ion Source Systems

- 30 keV, up to 15 mA H^- Volume-Cusp Filament Sources (TRIUMF Licensed)
- 20 keV, 1mA RF H^- source (University of Jyvaskyla License)
- Ion Source Replacement Parts (Maintenance and Consumables)

TRIUMF Licensed H^-/D^- Ion Source

Turn-key Positive Ion Source Systems

- D-Pace, Inc. is now representing Pantechnik's world-class ECR Ion Sources in North America (www.pantechnik.com)

PANTECHNIK

Pantechnik MONOGAN 1000

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PRODUCT & SERVICE LIST

(continued)

Beam Diagnostic Devices

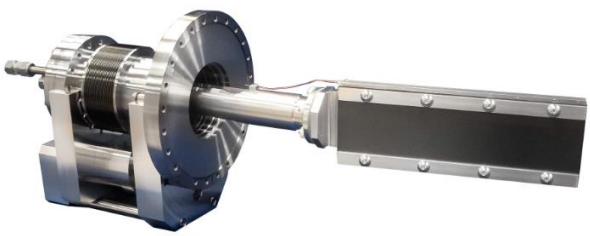
- Emittance Scanner Systems
- Pneumatically-Actuated Faraday Cups & Beam Stops
- Wire Scanner
- Mass Spectrometer and Energy Analysis Systems
- Slits and Collimators
- Beam Profile Monitors

PS-50 – Precision Slits, 50W

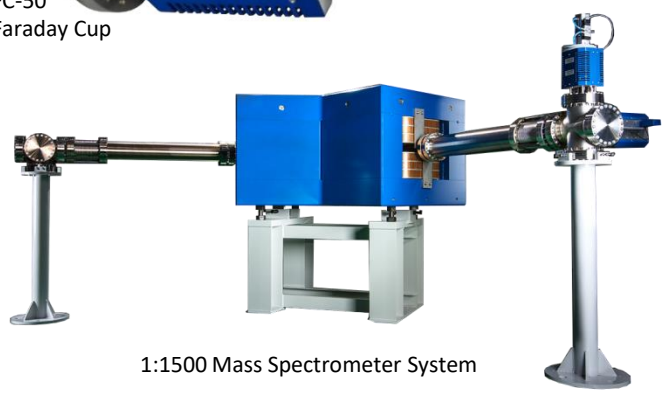
UniBEaM25-D
Dual Axis Probe
(shown with quick clamp option)

ES-4 Emittance Scanner

FC-50
Faraday Cup



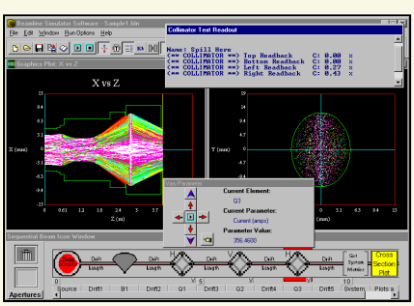
BS-10kW-1 10kW Beam Stop



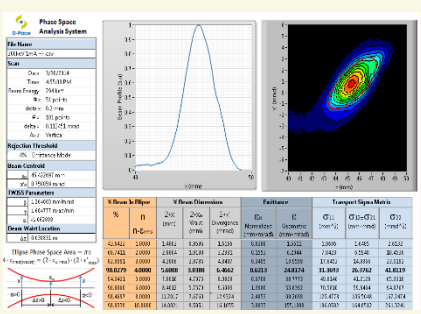
1:1500 Mass Spectrometer System

Software

- Beamline Simulator™ Software. Licensed to AccelSoft Inc. for world-wide marketing & sales rights (www.ghga.com/accelsoft)
- Diagnostic Instrument Software for Emittance & Phase Space Analysis, and other Diagnostic Products



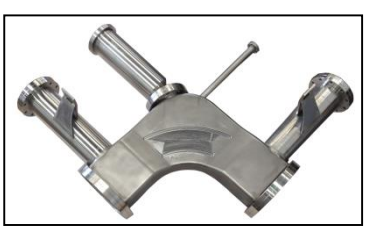
Beamline Simulator™



Phase Space Analysis Software

Other Products and Services

- Ion Optical System Design
- Magnet engineering and manufacture with ion-optical validation
- Custom Vacuum Chambers and Beam Pipes
- Radiation Shields
- Equipment Supports and Alignment Structures



Custom Vacuum Box

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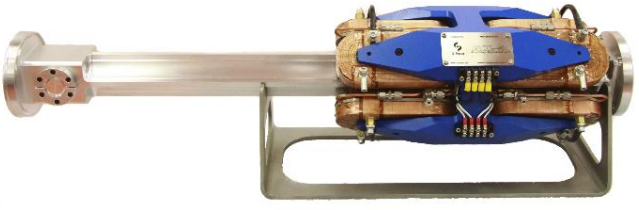
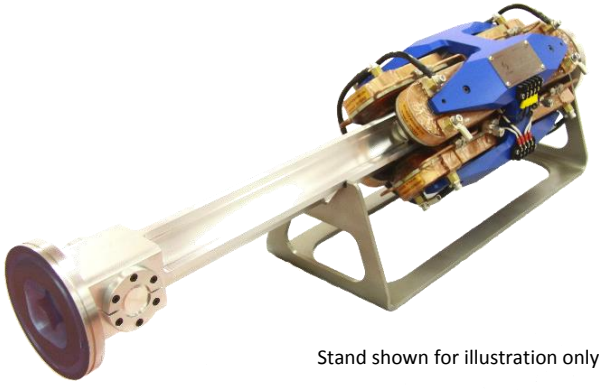
MiniPET-30 Beamline

Compact beamline for PET, with both Horizontal and Vertical Focusing and Steering to give Complete Beam Tuning

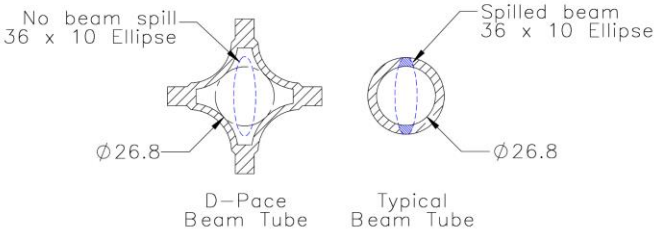




Stand shown for illustration only

- **Unique aluminum beam tube aperture for high beam transmission and low activation**
- **Combined quadrupole/steering doublet achieves focusing and steering in both horizontal and vertical directions, for optimized beam on target**
- **Ideal for use with 12-19 MeV proton beams for radioisotope production**
- **Light-weight, no dedicated support required**
- **Combined magnet self-aligns with beam tube**

The **D-Pace** ***MiniPET-30*** beamline performs both focusing and steering functions, through use of a combined quadrupole doublet and X and Y steering magnets. This allows for increased control of a proton beam for PET isotope production, which can greatly improve production rates. This compact and light-weight beamline uses low-activation materials and a unique, self-supporting beam pipe. The beamline is mounted directly to upstream and downstream elements, requiring no other support or dedicated stand. All water and electrical connections are made on a single side of the system for simple access and hose/cable routing. Two KF25 ports are included, for vacuum connection or other devices.



SPECIFICATIONS: *MiniPET-30* Beamline	
Mass (Weight)	54 kg
Dimensions (W x H x L)	236 x 236 x 908 mm
Circular Aperture	Ø26.8 mm
Beam Tube Material	Aluminum
Entrance / Exit Flange	ISO63 / ISO100
Vacuum Ports	2x KF25 (4x KF25 available)
Upstream Support	65 N.m bending
Downstream Support	18 N.m bending
Max. Quadrupole Field Quadrupole B/I Effective Length	0.25 Tesla 33 Gauss / A 150 mm
Max. Steering Angle	6.5 mrad at 12.6 MeV H+
Cooling Water: Input Connections	 1 L/min, 20 °C 4 mm OD Tube Fitting
Thermal Switch: Trip Temperature Connection	One per coil 70 °C #6 Screw Terminal
Power Supply Input (each, 4 supplies)	230 V AC, Single Phase, 50/60 Hz, 6 A Max.

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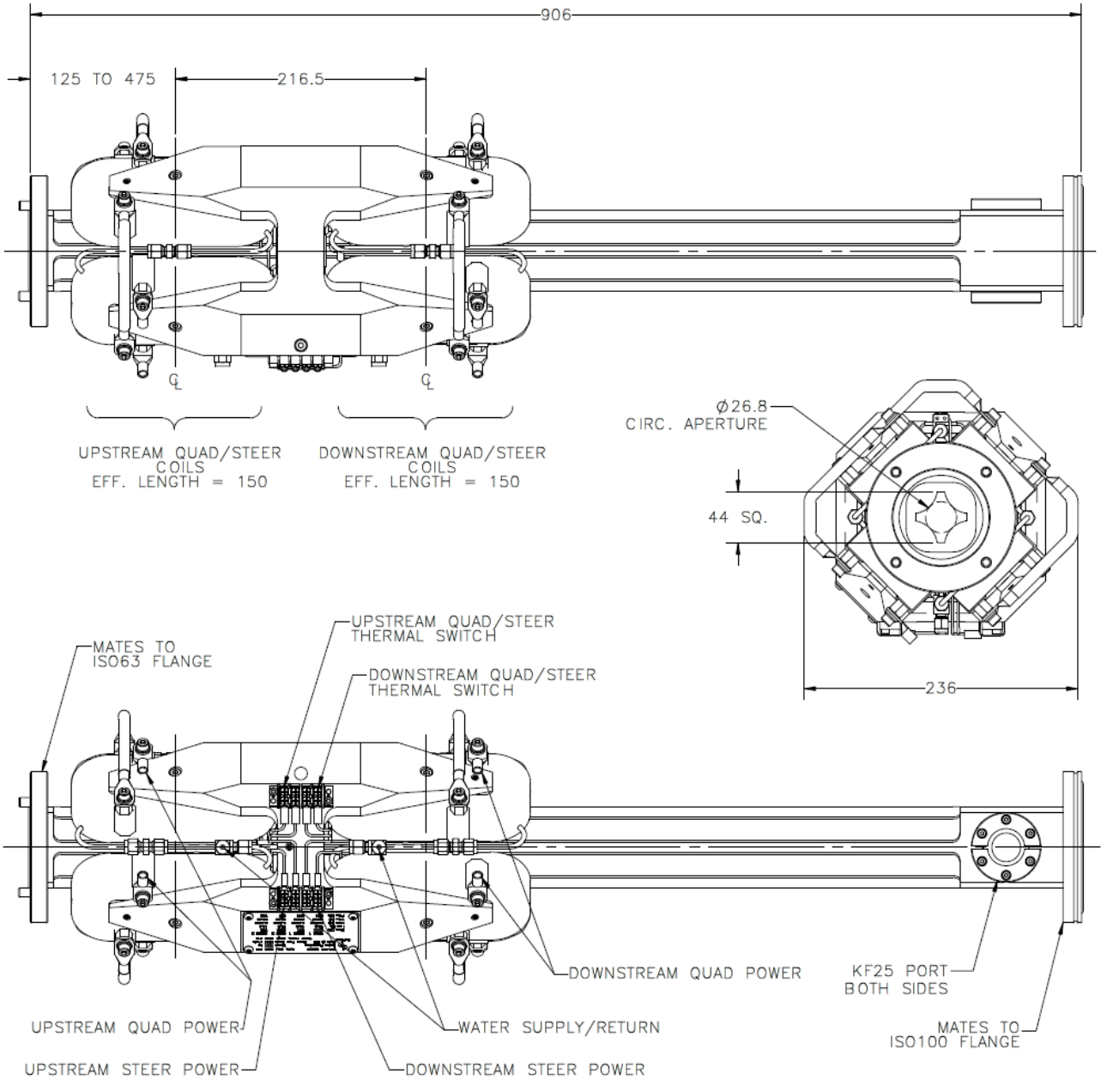
MiniPET-30 Magnet	Quadrupole	Steering
Upstream Coils	Horizontal Focusing	Vertical Steering
Downstream Coils	Vertical Focusing	Horizontal Steering
Connections	4 AWG Cable Lug	#6 Screw Terminal
Power Supply: Output Control	Quantity = 2 0-75 A, 0-8 V, 600 W Analog 0 to 10 V	Quantity = 2 ± 10 A, ± 20 V, 200 W Analog –10 to +10 V

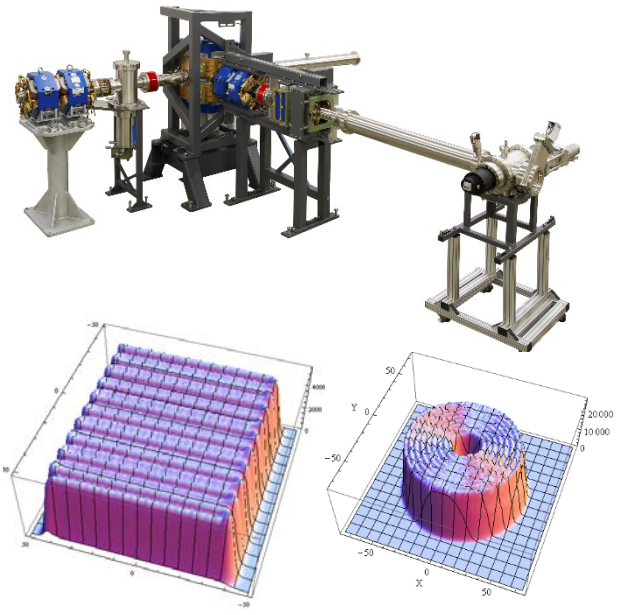
D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

The *MiniPET-30* beamline includes power supplies to operate the four magnet functions: horizontal focusing, vertical focusing, horizontal steering, and vertical steering. A customized beam pipe can be provided to match the overall length and flange connections of existing installations. Additional KF 25 ports can be provided upon request.



High Energy Beamline for BNCT

Transports 50 kW proton beams (20 mA, 2.5 MeV) from Accelerator to Target, for Boron Neutron Capture Therapy



- **Uniformly distribute beam on target with scan magnets.**
- **Beam Profile Monitor for low power beam scan visualization.**
- **Large acceptances for low transmission losses.**
- **Install in horizontal or vertical arrangement.**
- **Includes:**
  - **Magnets and stands.**
  - **Power supplies and cabinet.**
  - **Beam diagnostics.**
  - **Vacuum equipment, beampipes and chambers.**

The **D-Pace High Energy Beam Transport (HEBT)** beamline product has been designed for the transport of 50 kW proton beams (20 mA, 2.5 MeV) for Boron Neutron Capture Therapy (BNCT). Beams are transported with low losses due to large acceptance apertures throughout the system, and can be uniformly distributed on target to mitigate power density issues. The beamline consists of two sets of quadrupole doublets, a DC XY steering magnet, 90° bending dipole magnet, and one pair of AC XY scan magnets. Diagnostics include: two Bergoz NPCT beam current transformers; two graphite, water-cooled collimators with beam current readback; and a low power, pneumatic, beam profile monitor. The system comes complete with all stands, vacuum chambers, pumps, gauges, beampipes, bellows, power supplies, and scan function generators. Gate valves are provided at beamline entrance, exit, and thru-lines. Its 2 meter by 4 meter transport layout, with a 2.5 meter thru-line, can be set up in a horizontal or vertical arrangement. Installation, commissioning, and training services can be provided. Custom ion-optical and engineering modifications can also be undertaken to meet your particular beam energy, current, and power conditions.

SPECIFICATIONS: ***HEBT Beamline***	
Mass (Weight)	~2950 kg
Beamline Layout	2 m × 4 m, with 2.5 m thru
Beam Axis Height	1.25 m
Ion-Optical Elements - Quadrupole Doublet (two pair) - DC XY Steering Magnet - 90° Bending Magnet - AC XY Scan Magnet Pair (with arbitrary function generators)	
Diagnostics - Bergoz NPCT beam current monitor (two) - Beam Collimators (two) with current readback - Pneumatic Beam Profile Monitor (500 W)	
Quadrupole Magnet Specifications: Bore Dia. = 82.3 mm, L_{Eff} = 202.3 mm, B_{max} = 0.4 T	
DC XY Magnet Specifications: Iron Gap = 105 mm, L_{Eff} = 184 mm, B_{max} = 0.01 T	
90° Bending Magnet Specifications: Iron Gap = 52 mm, L_{Eff} = 300 mm, B_{max} = 1.3 T Pole-Face Entrance/Exit: Normal to beam	
AC XY Scan Magnets (SM97-A spec. sheet)	

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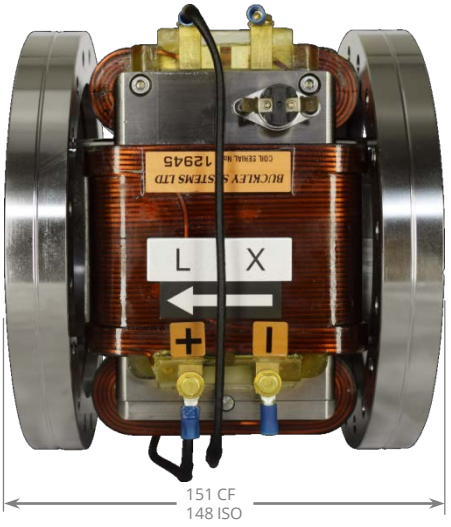
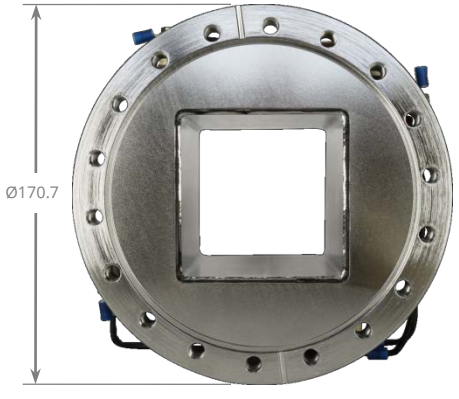
DC XY STEERING MAGNET

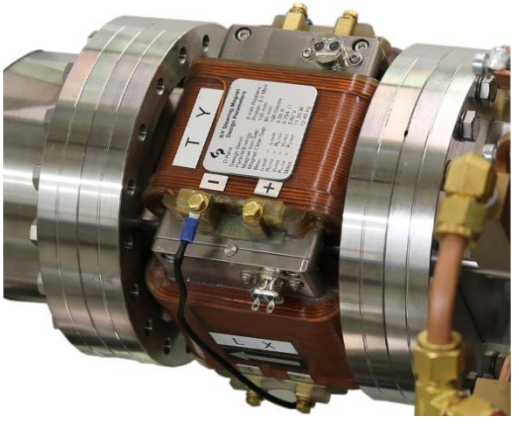
Dipole magnet provides steering in two directions





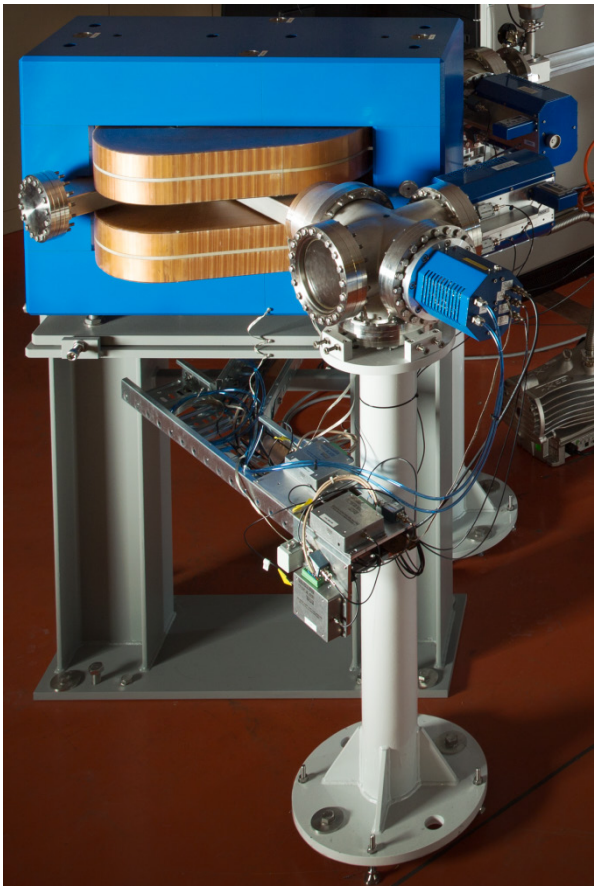
- Used to make small corrections to the charged particle beam direction
- Each steering direction operated by its own bipolar power supply
- No stand required. Supported from the flanges.
- Available with : 6-3/4" CF (DN125) flanges or ISO100 compatible flanges

SPECIFICATIONS:	Model #: XY-85.184
Mass (Weight)	12 kg (with vacuum tube)
Magnet Iron Gap	105 mm
Magnet Clear Gap	85 mm
Vacuum Tube Gap	74 mm x 74 mm
Iron Length	80 mm
Effective Length	184 mm
Pole Tip Max. Field	0.01 T(X), 0.01 T(Y)
Max. Current/Voltage	4 A(X), 4 A(Y) / 2.6 V(X), 2.6 V(Y)
Entrance/Exit Port	6-3/4" CF (DN125) or ISO100
Flange to Flange Insertion Length	151 mm CF 148mm ISO
Vacuum Chamber	Stainless Steel 304
Thermal Switches Trip Temperature	2 70°C
Cooling	Ambient Air



1:500 MASS/ENERGY SPECTROMETER

Resolves ion beams to better than 1 part in 500.



- Energy resolution 1:626 with 1 mm slit gap and small divergence beams, 1:45 with 5 mm slit gap and large divergence beams.
- Example Maximum Beam Energy & Particle Mass: T = 30 keV, q = 1, M = 76 A.M.U.
- Magnet: 90° Dipole, R = 191 mm, Mass = 2 Tonnes
- Upstream/Downstream Precision Slits:
  - 50 mm beam height
  - 0 - 20 mm manually adjustable gap, accurate to ± 0.05 mm

The **D-Pace 1:500 Mass/Energy Spectrometer System** has been designed for resolving charged particle beams with Bρ = 0.2196 T•m to better than 1 part in 500 in energy. The system comes complete with all stands, vacuum chambers, slits, Faraday cup, spectrometer magnet, power supply and control system. Installation, commissioning, and training can also be provided. Custom modifications can also be undertaken to meet your particular beam kinetic energy, charge state, particle mass, and beam current conditions.

SPECIFICATIONS	
Mass (Weight)	~2200 kg
Bend Radius/θ/B_{max} Bρ	191 mm / 90° / 1.15 Tesla 0.2196 T•m
Ent./Exit Slit to Magnet Distance	500 mm / 615 mm
Vacuum Chamber	316 Stainless Steel, UHV
Magnet Gap	50 mm (V-Box Gap 42 mm)
Ent. & Exit Pole Angle	34.79°
Effective Length	300 mm
Beam Axis Height	1050 mm
Thermal Switches: Trip Temperature:	One per coil strip (4 total) 70 °C
Qty 2 Slits Qty 1 Fixed F-Cup, or Qty 1 Actuated F-Cup	D-Pace Spec 2120017 D-Pace Spec 2120022 D-Pace Spec 2120011
Cooling Water Connections	2.6 L/min total @ 20 °C Ø10 mm tube Fitting
Power Supply Output: Remote Control Current Control	100 A, 60 V, ±10 ppm RS232 1 – 100%
Power Supply Input (Other inputs possible)	400 VAC, Three Phase + neutral, 47/63 Hz

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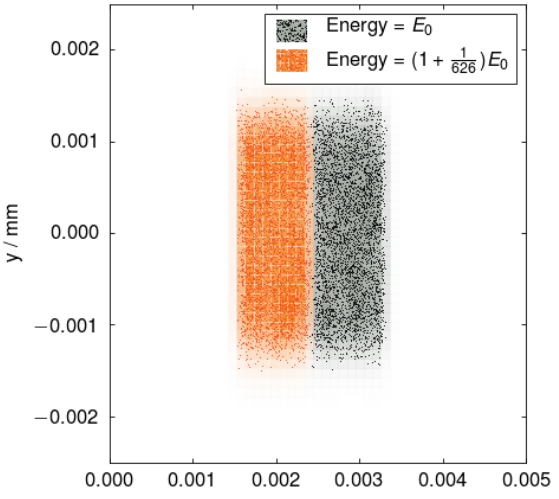
n	OBJECT SLIT				IN MAGNET		IMAGE SLIT	OPTICAL PARAMETERS		
	$\|x\|_{max}$ $[mm]$	$\|y\|_{max}$ $[mm]$	$\|x'\|_{max}$ $[mrad]$	$\|y'\|_{max}$ $[mrad]$	$\|x\|_{max}$ $[mm]$	$\|y\|_{max}$ $[mm]$	$\|x\|_{max}$ $[mm]$	M factor Magnification	D $[mm]$ Dispersion	Resolving Power $\frac{E}{\Delta E}$
1	0.5	1	4.4	4.4	3.2	2.8	0.4	0.9	570	626
2	3	5	35	26	24.4	15.8	3.2	1.1	550	83
3	3	5	69	33	48.3	19.5	4.6	1.5	630	68
4	5	5	35	24	27.0	14.6	4.8	1.0	570	58
5	5	5	66	33	47.5	19.2	5.9	1.2	570	45

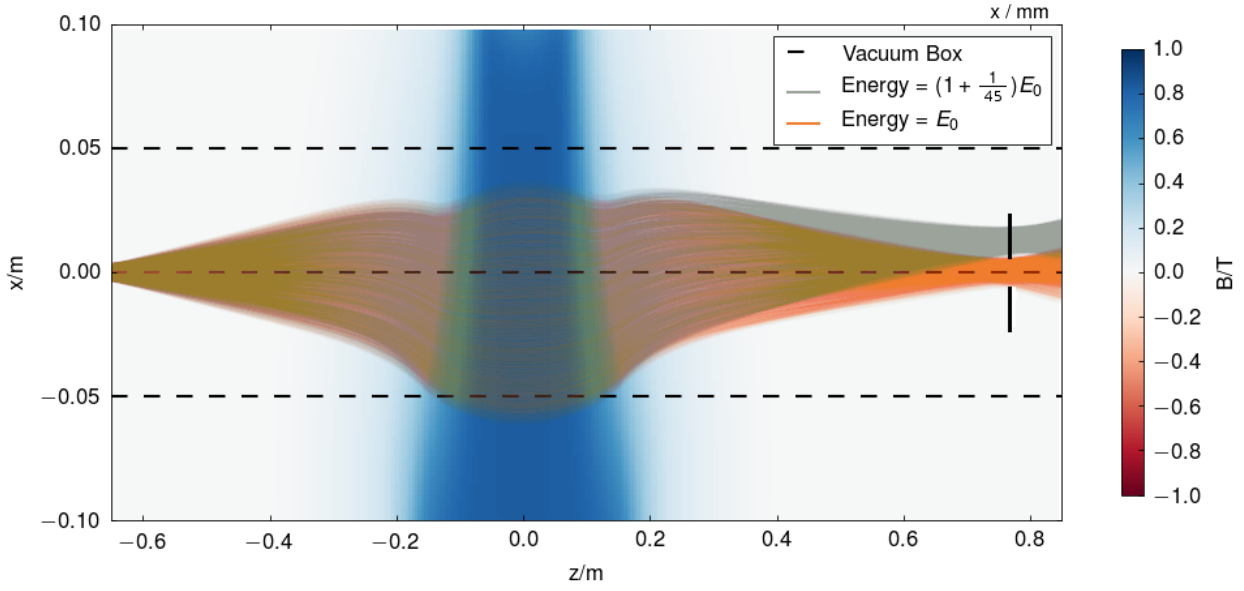
TABLE 1: Spectrometer resolving power as a function of accepted beam size in vacuum box for charged particle beams.

- All sizes are given as maximum dimension from a center point (half-widths and half-heights).
- The magnification (M factor) of the system is the width of the beam at the object slit divided by the width of the beam at the image slit.
- The resolving power of the system is related to the dispersion (D) and magnification (M) and half-width of the image slit (s) as: $R = D2Ms$
- For the case of unrestricted wide beams through the magnet, aberrations cause the effective resolving power to decrease.

Object-n1: Shows the beam density at the plane of the image slit, with particles colour-coded by energy for the n = 1 high resolution case from Table 1.



Beam-n5: Shows the n = 5 case from Table 1 (largest beam sizes in magnet) with two just-resolved beams.



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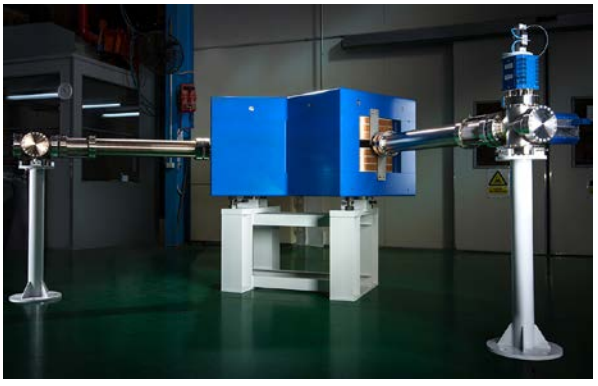
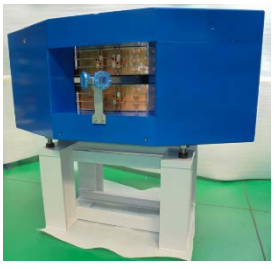
1:1500 Mass Spectrometer System

Resolves ion beams with kinetic energy to 50 keV, currents to 1 mA, and particle mass to 1500 A.M.U. to 1 part in 1500.





The **D-Pace 1:1500 Mass Spectrometer System** has been designed for resolving singly charged molecular beams with kinetic energy up to 50 keV and up to mass 1500 A.M.U. to 1 part in 1500 in mass. Beam currents up to 1 mA can be sustained by the slits and Faraday cup. The system comes complete with all stands, vacuum chambers, beampipe, bellows, magnet, slits, Faraday cup, spectrometer magnet, power supply and control system. Installation, commissioning, and training can also be provided. Custom modifications can also be undertaken to meet your particular beam kinetic energy, charge state, particle mass, and beam current conditions.

- **Mass Resolution 1:1500 at 1.00 mm slit width**
- **Maximum Current, Energy, Mass: 1 mA, 50 keV, q = 1+, 1500 A.M.U.**
- **Magnet: 90°, R = 1 m, Mass = 10 Tonnes**
- **Upstream/Downstream High Resolution Slits:**
  - **50 mm height**
  - **0 - 20 mm Width accurate to ±0.05 mm**
- **Pneumatic Faraday Cup with 50 mm Aperture**

SPECIFICATIONS: ***1:1500 Mass Spectrometer System***	
Mass (Weight)	~10 Tonnes
Bend Radius/Angle	1000 mm / 90°
Ent./Exit Slit - Magnet	1500 mm
Vacuum Chamber	316 Stainless Steel, UHV
Magnet Gap	50 mm, V-Box Gap 42 mm
Ent./Exit Pole Angle	18.435°
Maximum Flux Density	1.25 Tesla
Beam Axis Height	1300 mm
Thermal Switches: Trip Temperature	One per coil pancake 70 °C
Qty = 2 Slits Qty = 1 Faraday Cup	D-Pace Spec 2120017 D-Pace Spec 2120011
Cooling Water Connections	14 L/min total @ 20 °C Ø12 mm Swagelok Tube Fitting
Power Supply Output: Remote Control Current Control	200 A, 60 V, ±10 ppm RS232 1 – 100%
Power Supply Input	360-440 VAC, Three Phase + neutral, 47/63 Hz,

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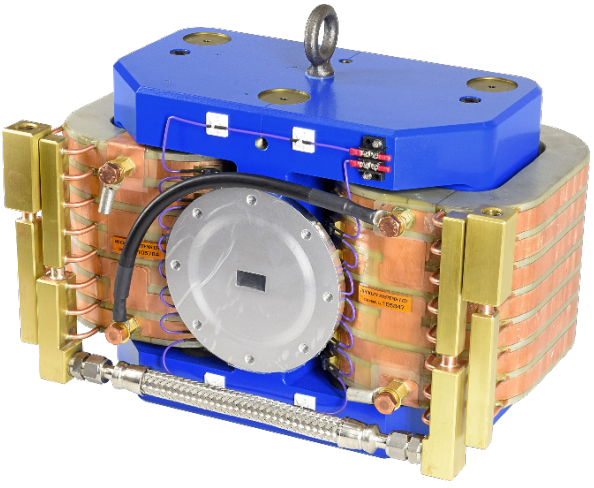
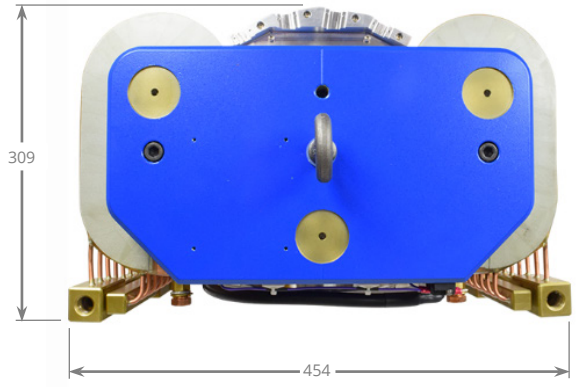
4-PORT TARGET SELECTOR

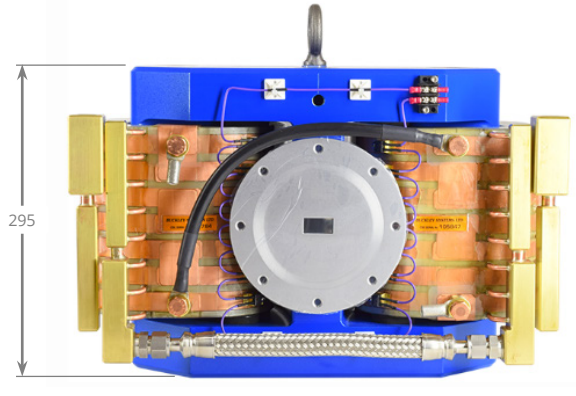
Magnetic target selector with 4 target ports, protection collimator and beam readback.

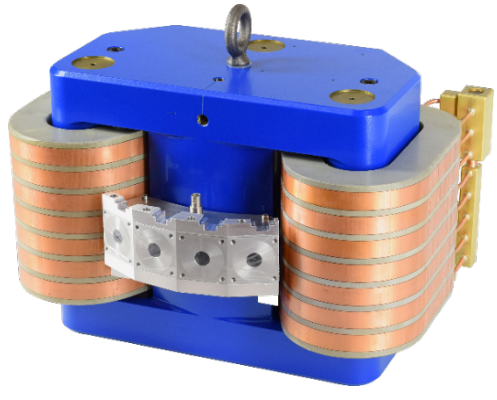


- **Select from 1 of 4 target positions.**
- **Includes a protection collimator before targets, with beam current readback for safety interlock.**
- **Coil and yoke design reduce irradiation of upstream equipment.**
- **Compact design ideal for use with D-Pace MiniPET-30.**



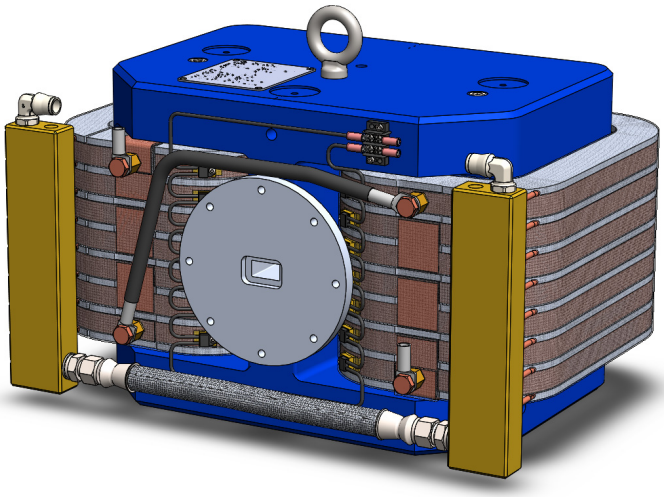
SPECIFICATIONS: DM-14.4X18	
Mass (Weight)	172 kg (magnet as shown)
Target Angles	±9°, ±27°
Bend Radii	466.9 mm, 1400.6 mm
Effective Length	220 mm
Max. Field	1.1 T
Max. Current/Voltage	130 A / 22.1 V
Gap (Vacuum Box)	14.5 mm
Entrance/Exit Port	ISO100 / Ø15 mm
Vacuum Chamber	Aluminum
Thermal Switches Trip Temperature	12 total (6 per coil) 70°C
Cooling Water Inlet Temperature Connections	3 L/min < 20°C Ø12 mm tube fittings
Collimator Readback	BNC, grounded shield



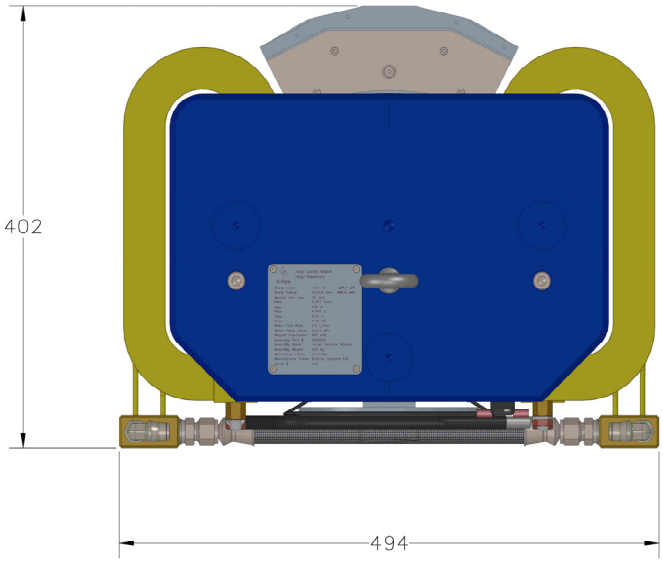


5-PORT TARGET SELECTOR

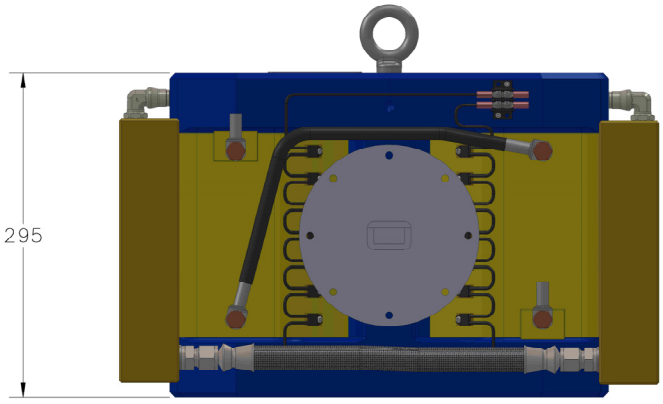
Magnetic target selector with 5 target ports, protection collimator and beam readback, for 18 MeV protons.

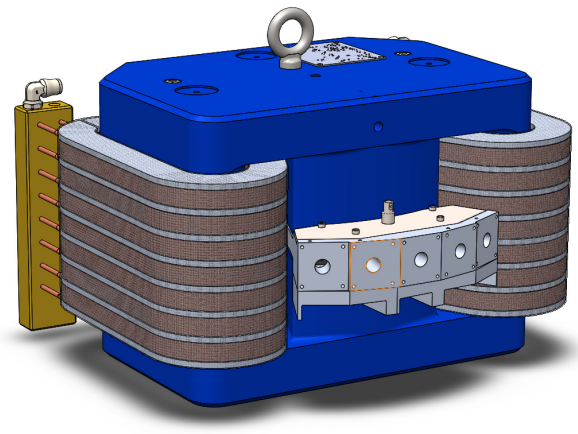


- **Direct proton beams up to 18 MeV.**
- **Select from 1 of 5 target positions.**
- **Includes a protection collimator before targets, with beam current readback for safety interlock.**
- **Coil and yoke design reduce irradiation of upstream equipment.**
- **Compact design ideal for use with D-Pace MiniPET-30.**



SPECIFICATIONS:	
Mass (Weight)	273 kg (magnet as shown)
Target Angles	±27˚, ±13.5˚, 0˚,
Bend Radii	636.6 mm, 1273.2 mm
Effective Length	300 mm
Max. Field	1.1 Tesla
Max. Current	130 A
Max Voltage	28 V
Gap (Vacuum Box)	14.5 mm
Exit Apertures	Ø15 mm
Thermal Switches Trip Temperature	12 total (6 per coil) 70˚C
Magnet Cooling Water Inlet Temperature Connection	3 L/min 20˚C Ø12 mm tube fitting
Vacuum Chamber	Aluminum
Entrance Flange	ISO100
Collimator Current Readback	BNC, grounded shield

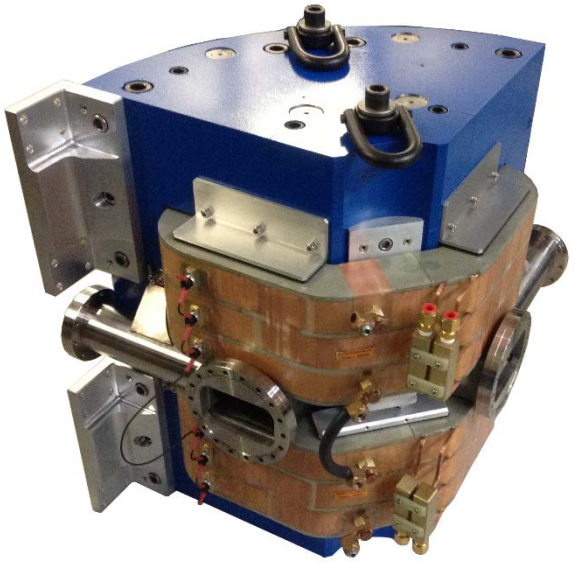




90° BENDER MAGNET

DM-54.90

90° dipole magnet, with entrance & exit collimators and beam spill readback

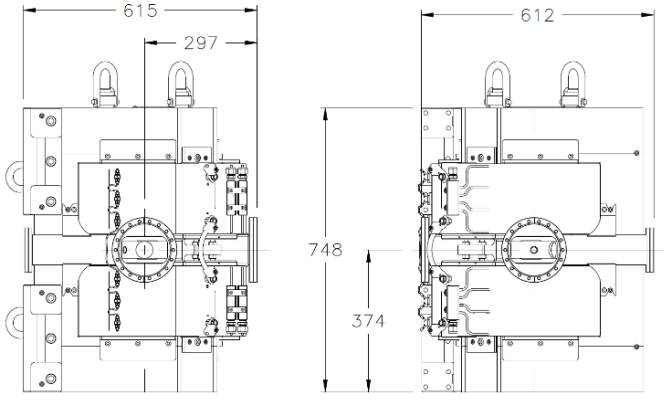


- Bend charged particle beams through 90°
- Entrance & exit beam collimators available, with current readback
- Horizontal and vertical mounting options available

The D-Pace 90° Bender Magnet can be purchased as:

- Magnet only
- Magnet with Vacuum box having thru-port, collimator mounting ports, and inspection port
- Magnet with vacuum box & entrance and exit collimators (collimator seen below)
- Above options with horizontal or vertical support stand

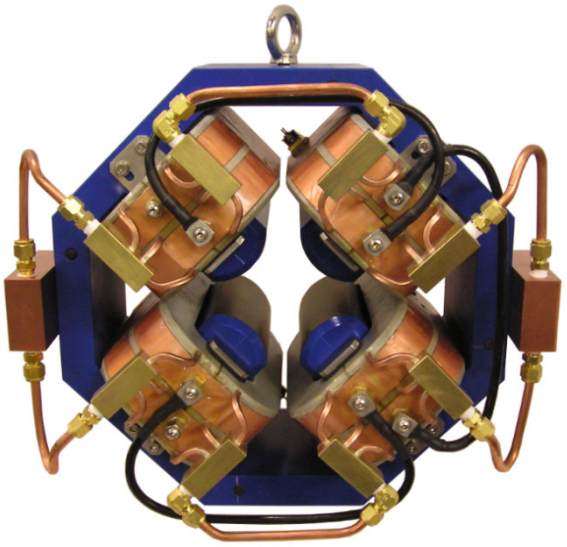
SPECIFICATIONS: DM-85.90	
Mass (Weight)	1067 kg (magnet only)
Bend Angle	90°
Bend Radius	191 mm
Effective Length	300 mm
Max. Field	1.3 T
Max. Current/Voltage	125 A
Max. Voltage	33 V
Magnet Gap, Clear Gap Gap	54 mm, 49 mm
Thermal Switches Trip Temperature	3 per coil (1 per pancake) 70°C
Vacuum Chamber	316 SS (UHV)
Entrance/Exit Port	DN 125 CF (6-3/4 in CF)
Thru-Port & Collimator	DN 63 CF (4-1/2 in CF)
Beam Collimators	Entrance & Exit available
Collimator I.D.	Ø46 mm
Cooling Water Flow	> 7 L/min (3.5 L/min/coil, parallel)
ΔT @ Max Current	~14°C
Inlet Pressure	~14.5 psi
Pressure Drop	~4 psi

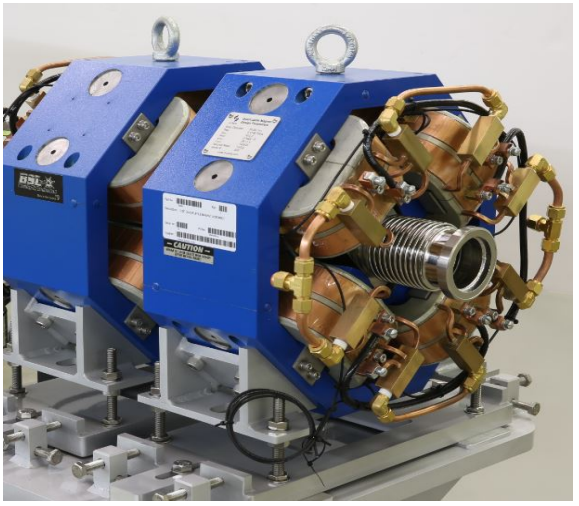


Entrance / Exit Collimator

3.25" Bore Quadrupole Magnet

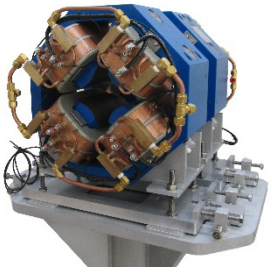
Model QM-83.202





The D-Pace standard 3.25" / 82.55mm bore diameter quadrupole magnet for charged particle focusing can be purchased as:

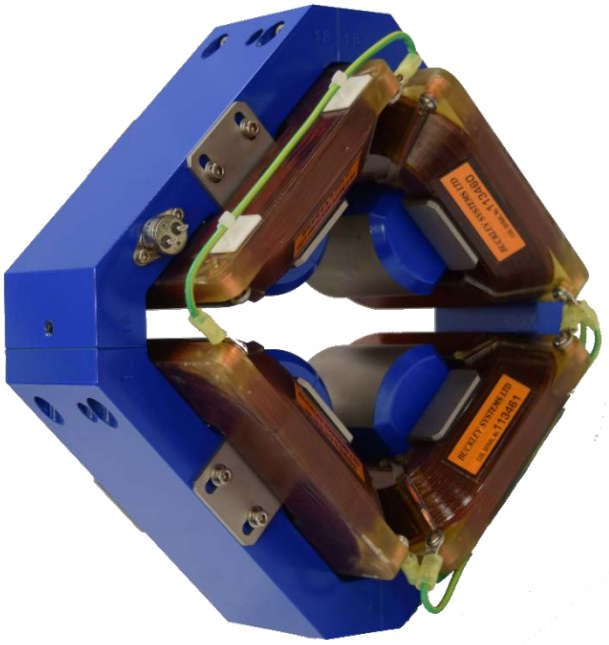
- Singlet, Doublet, or Triplet
- With or without beampipe included
- With or without power supplies

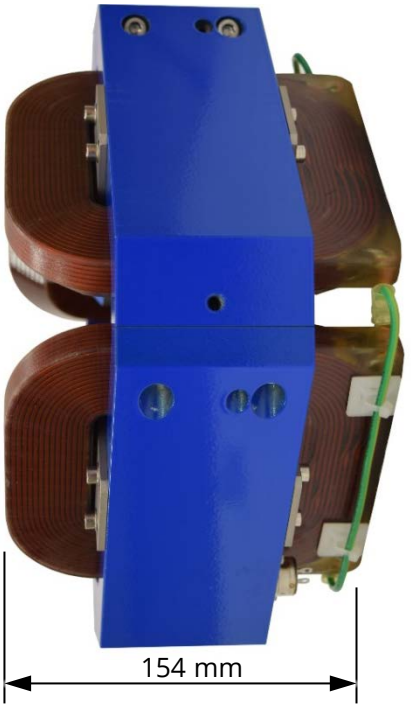


SPECIFICATION: QM-83.202	
Magnet Type	Quadrupole
Bore Diameter	82.55mm (3.25")
Iron Length	161mm
Effective Length	202mm
Mass	125kg
Pole Tip Magnetic Field @ Max Current	0.42 T
Max Current	50A
Max Voltage (Hot)	30V
ΔT @ Max Current	~10˚C
Cooling Water Flow	4 l/min
Inlet Pressure	˜8.5psi
ΔP	~3psi
Thermal Switches Activation Temperature	70˚C

Ø60.0mm Bore Quadrupole Magnet

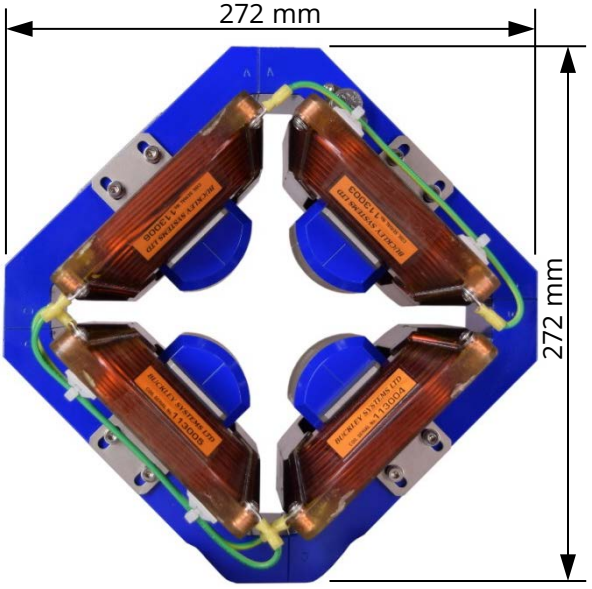
Model QM-60.100





The D-Pace standard Ø60.0mm bore quadrupole magnet for charged particle focusing can be purchased as:

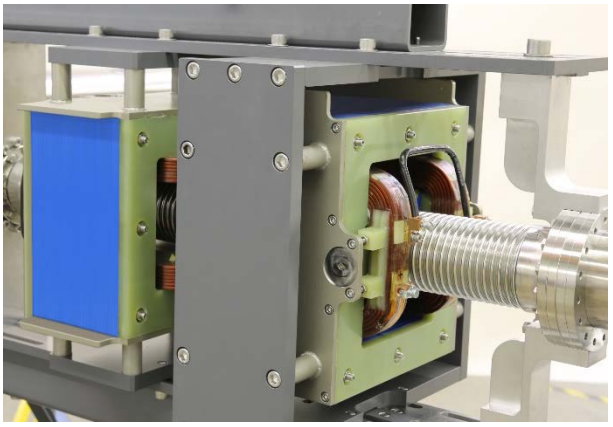
- Singlet • Doublet • Triplet
- With or without beampipe included
- With or without power supplies



OVERVIEW:	
Magnet Type	Quadrupole
Bore Diameter	60.0mm
Iron Length	70mm
Effective Length	100mm
Mass	25kg
Pole Tip Magnetic Field @ Nominal Current	0.1 T (1000 Gauss)
Nominal Current	6.86A
Nominal Voltage	8.55V
Cooling	Air
Thermal Switches Activation Temperature	82˚C

AC SCAN MAGNET SYSTEM, AIR-COOLED

Stand-alone AC Magnet or Turnkey System for Raster Scanning of Charged Particle Beams

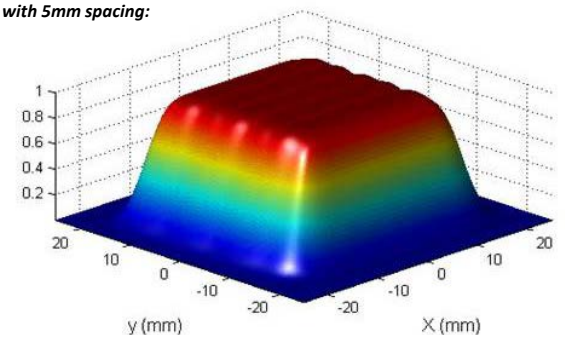


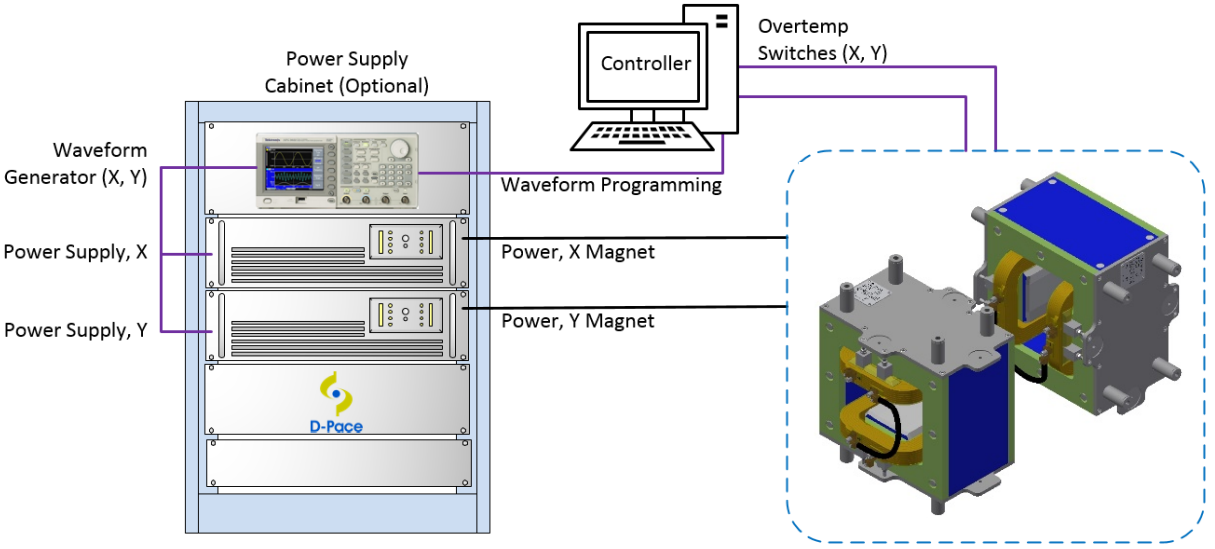
The **D-Pace Scanning Magnet System** is used to deflect a charged particle beam, usually for the purpose of managing power density on targets. Typically used in pairs (one to scan in the X plane, and one to scan in the Y plane) these AC magnets are driven by a dual-axis waveform generator and bi-polar power supplies, which D-Pace can provide in an optional 19" half-height cabinet. Standard patterns include Lissajous, circular, and square raster patterns. D-Pace can create new profiles for customers' specific requirements. Power distribution on the target determines the scanning pattern required. New profiles can be uploaded via USB from the customer's PC. D-Pace can also provide beam pipes or bellows with customer-specific flanges.

OVERVIEW: **Model #: SM97-A**

- Distribute beam power on targets
- Use standard or application-specific patterns
- Magnetic field strength up to 270 Gauss[1]
- Scan frequencies up to 250 Hz[2]
- Pole gap 97mm
- Compact laminated-core construction
- Magnets available individually or as turnkey system complete with power supplies, instrument rack and beampipe

Example: Beam intensity distribution for XY scan with Gaussian (0-2.5mm) beam, with 5mm spacing:





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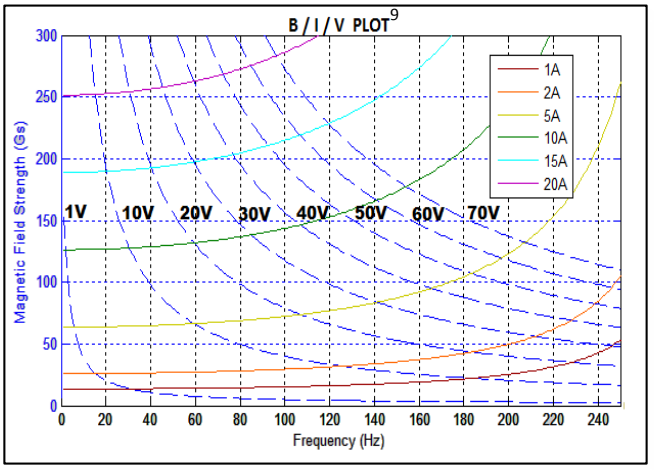
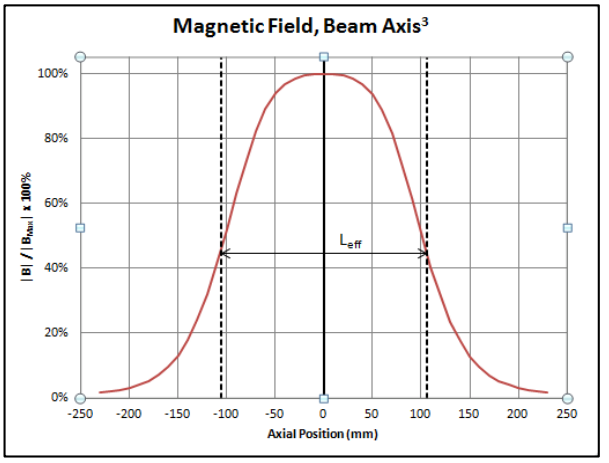
MAGNET SPECIFICATIONS

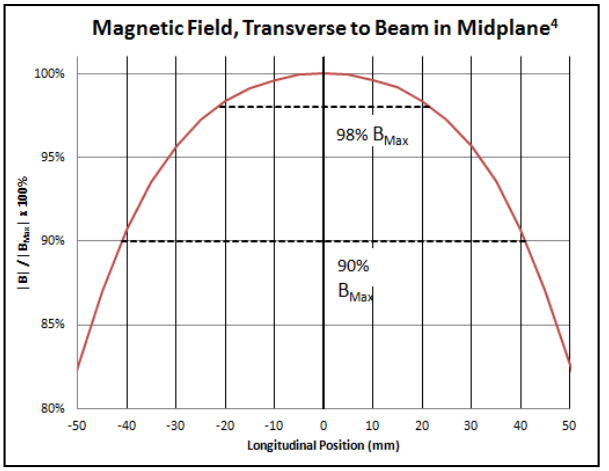
B/I	12.5 Gauss/Amp[6]
Inductance	5.13 mH
Coil Resistance	76 mΩ (DC)
Magnet gap	97mm
Effective length	212 mm
Field Flatness, Transverse	+/- 20mm off axis: 98% of B_{max} +/- 40mm off axis: 90% of B_{max}
Thermal protection	Resettable thermal switches, one per coil
Dimensions (L x W x H)	310mm x 340mm x 383mm See drawing: 1590277
Mass	85 kg
Power	4-8 AWG Screw Connector
Yoke Style	Non-opening
Alignment Features	6 Alignment fiducials 3 top, 3 bottom

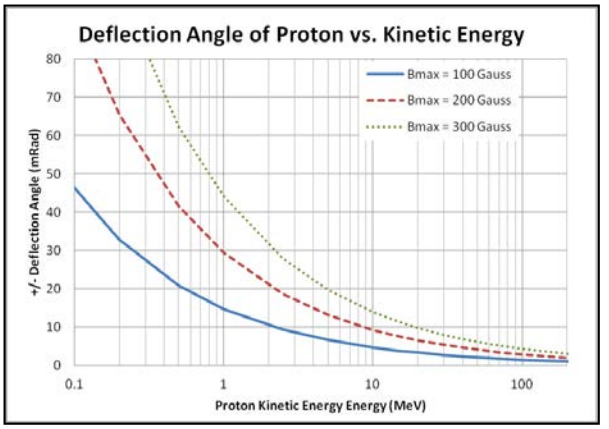
TURNKEY SYSTEM SPECIFICATIONS [5]

1) Power Supplies	Per Customer Requirements
2) Waveform Generator	2 Channels, 14 bits
3) Optional Cabinet (H x W x D) Mass (items 1, 2, 3)	16U Instrument rack 780 x 534 x622mm 70 kg (approx.)
4) Beam Pipe, Optional	Hydro-formed bellows Custom flanges





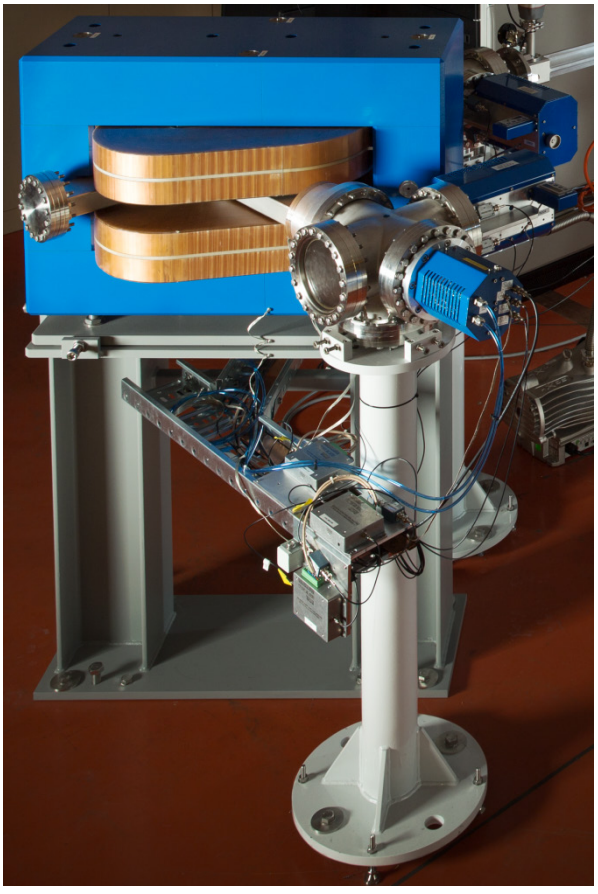




1. With power supply 20A, 50V, 70Hz maximum.
2. With 2A, 65V power supply (100 Gauss maximum).
3. Scan in magnetic mid-plane along beam axis.
4. Scan in magnetic mid-plane transverse to beam axis.
5. Contact D-Pace for turnkey system customization.
6. Centered, beampipe bellows.
7. See Design Note 2010067: Selecting Power Supplies.
8. See Design Note 2010069: Design of Scan Patterns.
9. Using power supply with shunt capacitance of 55µF.

1:500 MASS/ENERGY SPECTROMETER

Resolves ion beams to better than 1 part in 500.



- Energy resolution 1:626 with 1 mm slit gap and small divergence beams, 1:45 with 5 mm slit gap and large divergence beams.
- Example Maximum Beam Energy & Particle Mass: T = 30 keV, q = 1, M = 76 A.M.U.
- Magnet: 90° Dipole, R = 191 mm, Mass = 2 Tonnes
- Upstream/Downstream Precision Slits:
  - 50 mm beam height
  - 0 - 20 mm manually adjustable gap, accurate to ± 0.05 mm

The **D-Pace 1:500 Mass/Energy Spectrometer System** has been designed for resolving charged particle beams with Bρ = 0.2196 T•m to better than 1 part in 500 in energy. The system comes complete with all stands, vacuum chambers, slits, Faraday cup, spectrometer magnet, power supply and control system. Installation, commissioning, and training can also be provided. Custom modifications can also be undertaken to meet your particular beam kinetic energy, charge state, particle mass, and beam current conditions.

SPECIFICATIONS	
Mass (Weight)	~2200 kg
Bend Radius/θ/B_{max} Bρ	191 mm / 90° / 1.15 Tesla 0.2196 T•m
Ent./Exit Slit to Magnet Distance	500 mm / 615 mm
Vacuum Chamber	316 Stainless Steel, UHV
Magnet Gap	50 mm (V-Box Gap 42 mm)
Ent. & Exit Pole Angle	34.79°
Effective Length	300 mm
Beam Axis Height	1050 mm
Thermal Switches: Trip Temperature:	One per coil strip (4 total) 70 °C
Qty 2 Slits Qty 1 Fixed F-Cup, or Qty 1 Actuated F-Cup	D-Pace Spec 2120017 D-Pace Spec 2120022 D-Pace Spec 2120011
Cooling Water Connections	2.6 L/min total @ 20 °C Ø10 mm tube Fitting
Power Supply Output: Remote Control Current Control	100 A, 60 V, ±10 ppm RS232 1 – 100%
Power Supply Input (Other inputs possible)	400 VAC, Three Phase + neutral, 47/63 Hz

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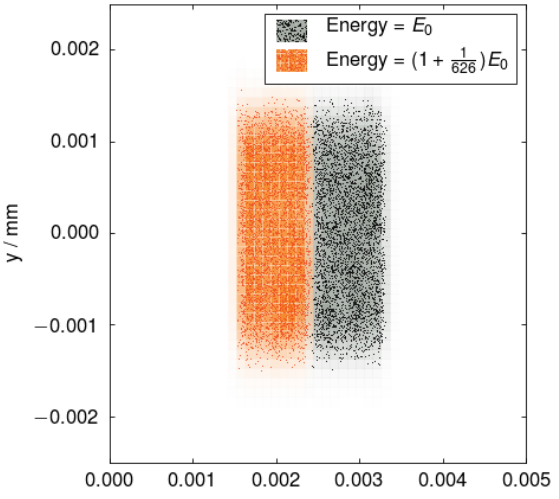
n	OBJECT SLIT				IN MAGNET		IMAGE SLIT	OPTICAL PARAMETERS		
	$\|x\|_{max}$ $[mm]$	$\|y\|_{max}$ $[mm]$	$\|x'\|_{max}$ $[mrad]$	$\|y'\|_{max}$ $[mrad]$	$\|x\|_{max}$ $[mm]$	$\|y\|_{max}$ $[mm]$	$\|x\|_{max}$ $[mm]$	M factor Magnification	D $[mm]$ Dispersion	Resolving Power $\frac{E}{\Delta E}$
1	0.5	1	4.4	4.4	3.2	2.8	0.4	0.9	570	626
2	3	5	35	26	24.4	15.8	3.2	1.1	550	83
3	3	5	69	33	48.3	19.5	4.6	1.5	630	68
4	5	5	35	24	27.0	14.6	4.8	1.0	570	58
5	5	5	66	33	47.5	19.2	5.9	1.2	570	45

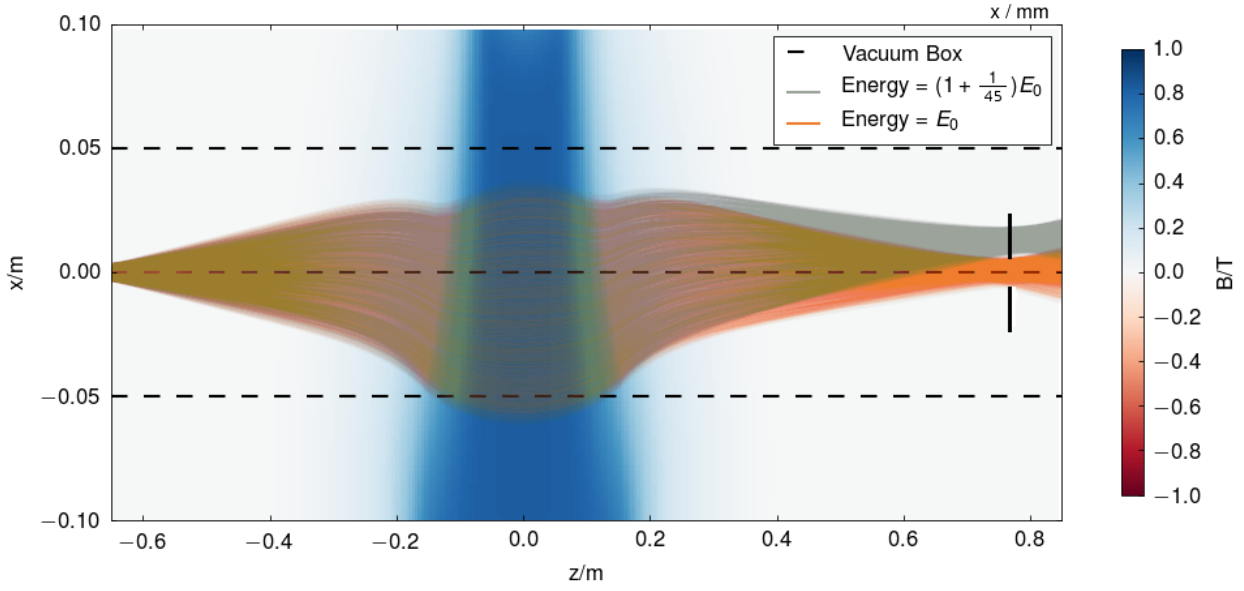
TABLE 1: Spectrometer resolving power as a function of accepted beam size in vacuum box for charged particle beams.

- All sizes are given as maximum dimension from a center point (half-widths and half-heights).
- The magnification (M factor) of the system is the width of the beam at the object slit divided by the width of the beam at the image slit.
- The resolving power of the system is related to the dispersion (D) and magnification (M) and half-width of the image slit (s) as: $R = D2Ms$
- For the case of unrestricted wide beams through the magnet, aberrations cause the effective resolving power to decrease.

Object-n1: Shows the beam density at the plane of the image slit, with particles colour-coded by energy for the n = 1 high resolution case from Table 1.



Beam-n5: Shows the n = 5 case from Table 1 (largest beam sizes in magnet) with two just-resolved beams.



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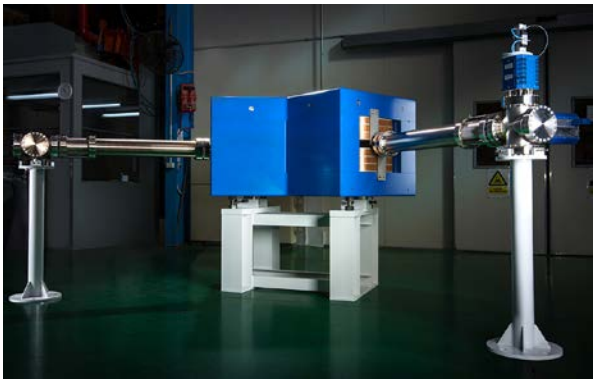
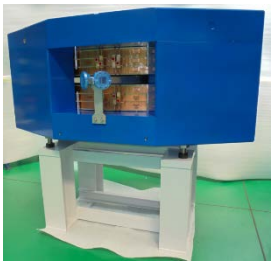
1:1500 Mass Spectrometer System

Resolves ion beams with kinetic energy to 50 keV, currents to 1 mA, and particle mass to 1500 A.M.U. to 1 part in 1500.





The **D-Pace 1:1500 Mass Spectrometer System** has been designed for resolving singly charged molecular beams with kinetic energy up to 50 keV and up to mass 1500 A.M.U. to 1 part in 1500 in mass. Beam currents up to 1 mA can be sustained by the slits and Faraday cup. The system comes complete with all stands, vacuum chambers, beampipe, bellows, magnet, slits, Faraday cup, spectrometer magnet, power supply and control system. Installation, commissioning, and training can also be provided. Custom modifications can also be undertaken to meet your particular beam kinetic energy, charge state, particle mass, and beam current conditions.

- **Mass Resolution 1:1500 at 1.00 mm slit width**
- **Maximum Current, Energy, Mass: 1 mA, 50 keV, q = 1+, 1500 A.M.U.**
- **Magnet: 90°, R = 1 m, Mass = 10 Tonnes**
- **Upstream/Downstream High Resolution Slits:**
  - **50 mm height**
  - **0 - 20 mm Width accurate to ±0.05 mm**
- **Pneumatic Faraday Cup with 50 mm Aperture**

SPECIFICATIONS: ***1:1500 Mass Spectrometer System***	
Mass (Weight)	~10 Tonnes
Bend Radius/Angle	1000 mm / 90°
Ent./Exit Slit - Magnet	1500 mm
Vacuum Chamber	316 Stainless Steel, UHV
Magnet Gap	50 mm, V-Box Gap 42 mm
Ent./Exit Pole Angle	18.435°
Maximum Flux Density	1.25 Tesla
Beam Axis Height	1300 mm
Thermal Switches: Trip Temperature	One per coil pancake 70 °C
Qty = 2 Slits Qty = 1 Faraday Cup	D-Pace Spec 2120017 D-Pace Spec 2120011
Cooling Water Connections	14 L/min total @ 20 °C Ø12 mm Swagelok Tube Fitting
Power Supply Output: Remote Control Current Control	200 A, 60 V, ±10 ppm RS232 1 – 100%
Power Supply Input	360-440 VAC, Three Phase + neutral, 47/63 Hz,

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UniBEaM25-D

Dual-Axis Ion Beam Profiler System Using Scintillating Fiber Sensor

UniBEaM25-D
Dual Axis Probe
(shown with quick clamp option)

Front

Back

UniBEaM25-D – Dual Axis Controller

- **Measures beams from keV to GeV and pA to mA depending on the power density deposited**
- **Maximum beam diameter[2] 25 mm**
- **Beam energy density[3] 1 W/mm²**
- **No vacuum box required**
- **Insertion length[4] of just 70mm**
- **Scintillating sensor fibers**
- **Dual X & Y axis profiles**
- **In-plane scanning**
- **Radiation resistant – no electronics in the probe**
- **Low electromagnetic susceptibility**
- **Complete turnkey system**

UniBEaM was conceived by the **AEC-LHEP** of the **University of Bern**[1] and commercialized by **D-Pace.** UniBEaM is a charged-particle beam profiling system - similar to a wire scanner except an optical sensor fiber is used instead of a metal wire. Ø50µm to 400µm sensing fibers scintillate in the visible spectrum as they pass through the beam. The scintillation light is transmitted through the short sensor fiber into a standard multimode optical fiber, which transmits the light long distances with minimal attenuation and no electromagnetic susceptibility. The light is converted by a high-sensitivity photo sensor located in the UniBEaM controller, amplified, digitized, and displayed on a monitor.

The system is a standalone device, requiring only the addition of a monitor and keyboard. A TCP/IP text-based command set is in development. This will allow UniBEaM to be used as a slave device to a higher-level controller or to interface with EPICS over Ethernet.

The probes are very compact, and require only 70mm along the beam axis[4]. X and Y scans can be conducted individually or concurrently.

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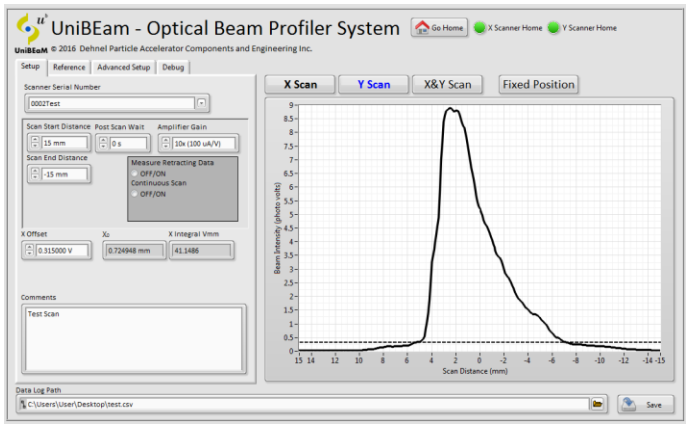
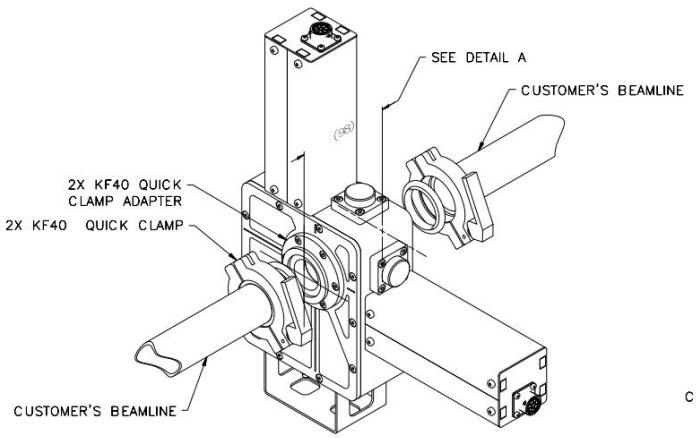
Replaceable Sensor Fiber



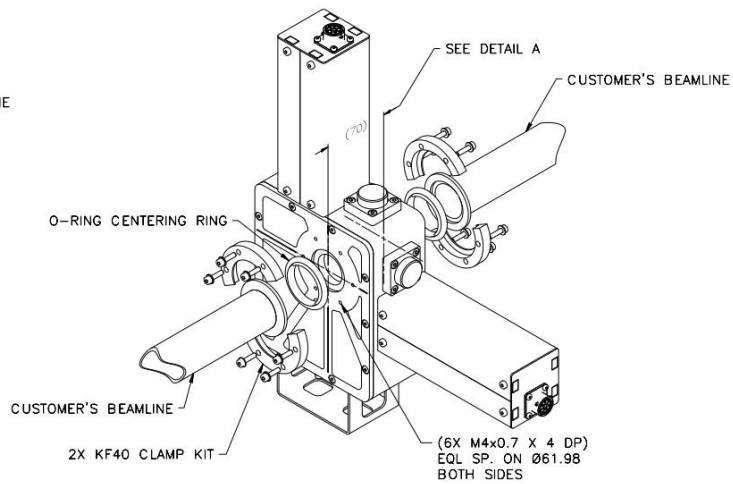
Control & Analysis Software

SPECIFICATIONS: UniBEaM25-D	
Max Beam Diameter[2]	25mm
Particle Kinetic Energy	> keV
Sensitivity (Standard)[5]	12pA @ 18MeV
Max Power Density[3]	1 W/mm^2
Sensor Fibers	Doped Silica Ø200µm (Ø50µm to Ø600µm)
Position Resolution	0.025mm
Scan Speed	18mm/second
Probe Insertion Length[4]	70mm
Flange Options	KF40 quick clamp or bulkhead CF40 flange
Probe Mass	7 kg
Data File Format	CSV with header
View port	KF16 quartz w/ cap
Controller	19" Rack Mount, 2U
Input Power	100-240VAC 50/60Hz
Cable & Fiber Length	15 meters (custom available)

1. UniBEaM is licensed from AEC-LHEP University of Bern to D-Pace Inc. for exclusive worldwide manufacturing, sales, and distribution.
2. UniBEaM50 (50mm) and UniBEaM100 (100mm) are in development.
3. Higher beam power densities possible for > 5MeV. At 18MeV, maximum beam power density is 18W/mm^2.
4. With QF40 bulkhead clamp (98mm with QF40 quick clamp option, 92mm for CF40 option - see D-Pace drawing 1590329).
5. For signal-to-noise of 2 for standard system at 18MeV H^+. Contact D-Pace for higher sensitivity systems.
6. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.



KF40 QUICK CLAMP



KF40 DIRECT MOUNT

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OSCILLATING WIRE SCANNER PROBE MODEL OWS-30

TRIUMF-Licenced, Beam Profiler

- Measure low-energy charged-particle beam profiles (< 1 MeV)
- Simultaneous orthogonal scanning as a diagnostic tool for centering a beam
- Scan Ø30 mm beam[2]
- Controllable scan speed
- Interchangeable Ø0.5mm tungsten wires
- Optional turnkey system and custom vacuum box
- TRIUMF-licenced technology[3]

The **D-Pace OWS-30 Oscillating Wire Scanner Probe** performs two orthogonal intensity scans of a beam in one scanning operation. An replaceable 0.5mm diameter tungsten wire with two legs is pivoted about an axis within the case of the instrument. A high-sensitivity ammeter is used to measure the intercepted beam current.

The wire crosses the beam in an arc of approximately ±13°. Each wire leg passes through the center of the beam at 45° relative to the flange. The oscillation speed is controlled by adjusting the motor voltage. Position feedback is output as an analog signal.

D-Pace can provide a custom vacuum box.[1]

The Wire Scanner Probe can be purchased separately, or D-Pace can provide a turnkey system, complete with the probe, controller, current meter, PC, software, cables, and optional instrument rack. The software displays 2D intensity distributions in real time as scans are performed, allowing the operator to tune and center beams. A single oscillation results in two passes of both legs of the scanning wire through the beam.

SPECIFICATIONS - EMITTANCE PROBE	
Max Beam Diameter[2]	30 mm
Min Oscillation Period	10 seconds/cycle
Max Oscillation Period	> 60 seconds/cycle
Maximum Beam Intensity	1W/mm^2
Wire	Ø0.5 mm Tungsten
Bias voltage	None
Flange	Custom, O-ring
Mass	4 kg
Arm Scan Angle (A)	± 13°
Flange to Beam Center (B)	100mm
Leg Wire Length (D)	49mm
Pivot Length (E)	190mm
Output	BNC Coax

The wire scanner can be factory configured for smaller beams by adjusting the scan angle. This allows the device to operate in smaller vacuum boxes.

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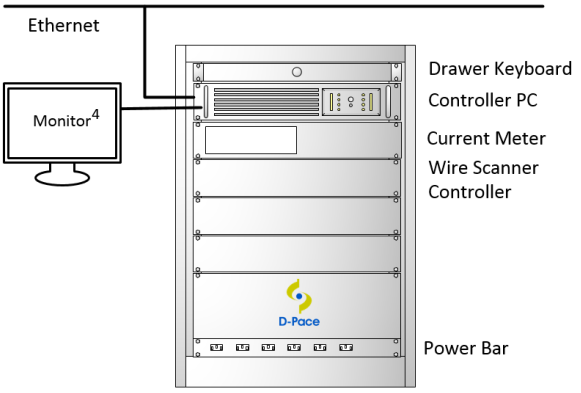
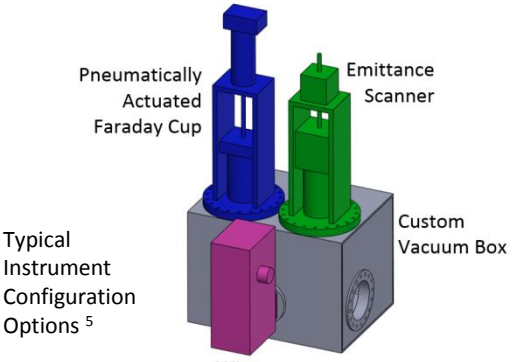
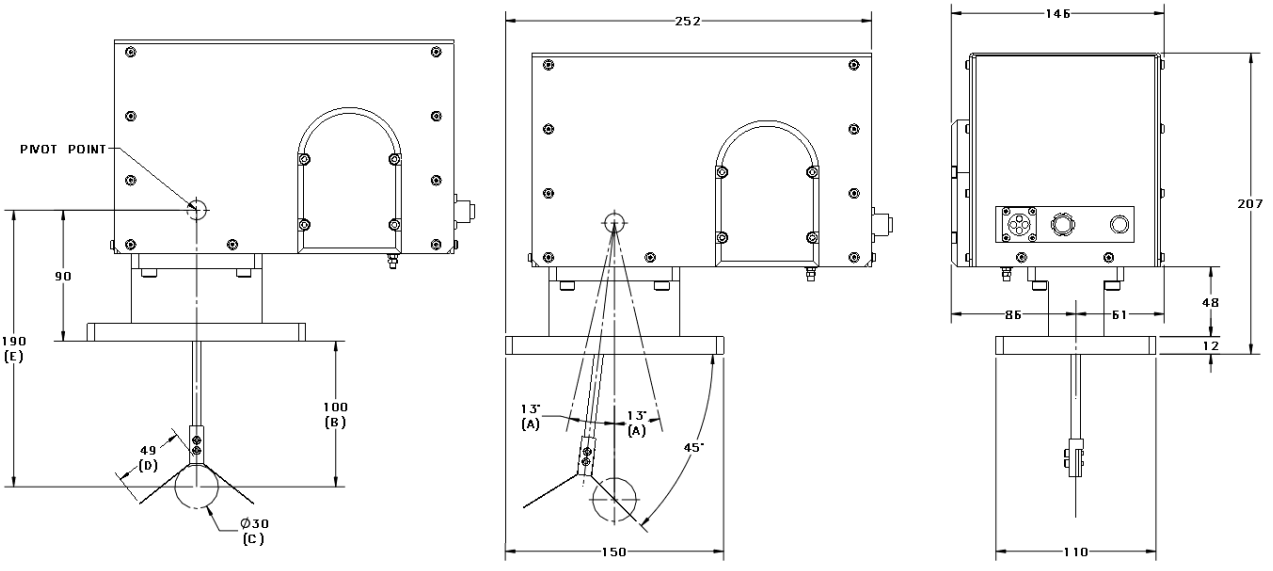
SPECIFICATION - TURNKEY SYSTEM OPTION [4]	
Turnkey System	Includes probe, computer, software, power supplies, instrumentation and cables
Instrument Rack Option	Optional 19” rack, keyboard and power distribution
Platform	Industrial PC / Windows™ OS
Control Options	Stand alone or Remote Ethernet control
Current Meter	2nA to 20mA (full scale) 10-100pA (typical noise floor)
Power	115 or 220 VAC (configured) 550 W, single phase
Data Plots & Visualization	2D orthogonal intensity distribution displayed in real time
File Export	CSV
Dimensions (W x D x H)	16U instrument rack 545 x 660 x 765 mm
Mass (approx.)	60 kg excluding probe



Optional Controller Rack



Typical Instrument Configuration Options [5]



1. D-Pace can provide a custom vacuum box. Contact D-Pace with custom requirements for a quotation.
2. Wires tangent to beam diameter at maximum angle.
3. Technology licensed from TRIUMF for world-wide distribution.
4. Turnkey system with instrument rack option. Monitor not supplied.
5. Wire Scanner can be combined with D-Pace’s Phase Space Emittance Scanner and Faraday Cup Probes.
6. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

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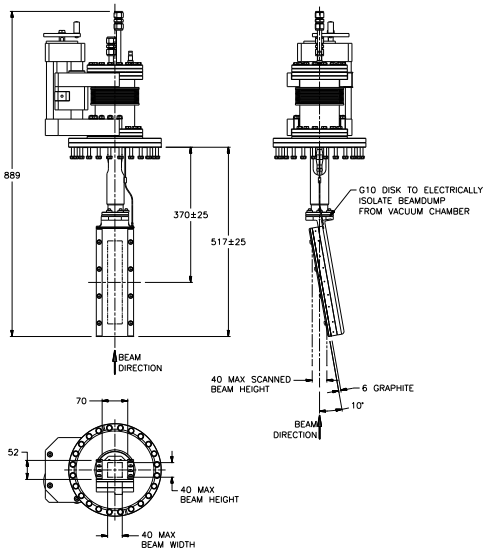
BEAMSTOP – MODEL BS-10kW-1

Position Adjustable High Power Beamstop For Ultra High Vacuum Applications



- Designed to stop 350µA, 30MeV proton beam
- Beam current read back
- CF flanges with aluminum gaskets and Kalrez o-ring for low maintenance in radiation environment

SPECIFICATIONS:	Beamstop, BS-10kW-1
Maximum beam power	10.5kW
Maximum beam intensity	2.0 W/mm^2
Maximum proton kinetic energy	30 MeV
Max beam size	40 mm X 40 mm
Cooling water: Flow rate Inlet temperature Inlet connection Max inlet pressure Pressure drop	 30 l/min 15°C (60°F) Ø12 mm Swagelok Tube fitting 724 kPa (105 psi) 372 kPa (54 psi)
Current read back	BNC Connector
Flange	DN 200CF (10”CF) (Ø203mm) Rotatable, with tapped M8 holes
Adjustment	±25 mm in beam direction, Manual hand wheel

Notes:

1. More detailed information available and dimensions on sketch 1590273.
2. D-Pace can provide a custom vacuum box.
3. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

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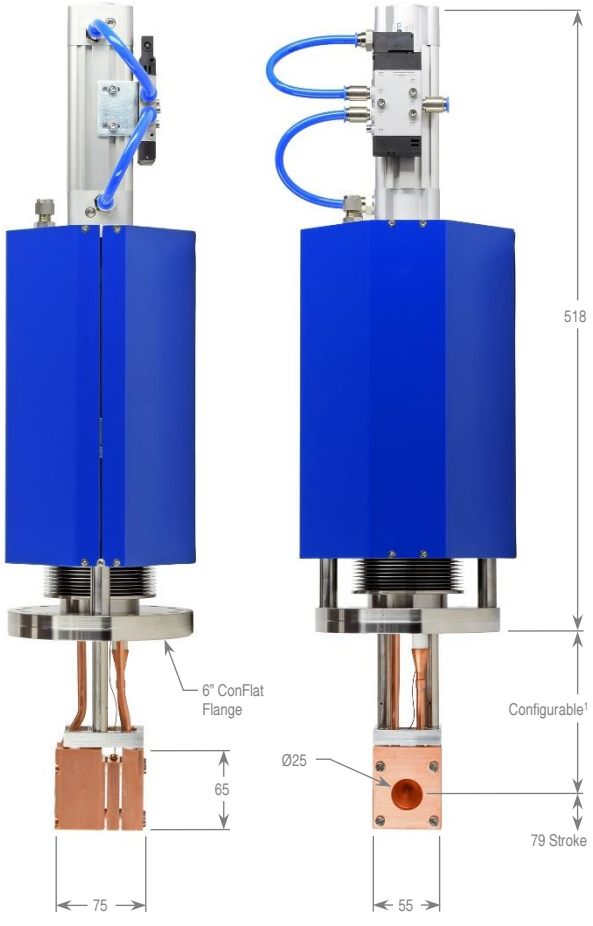
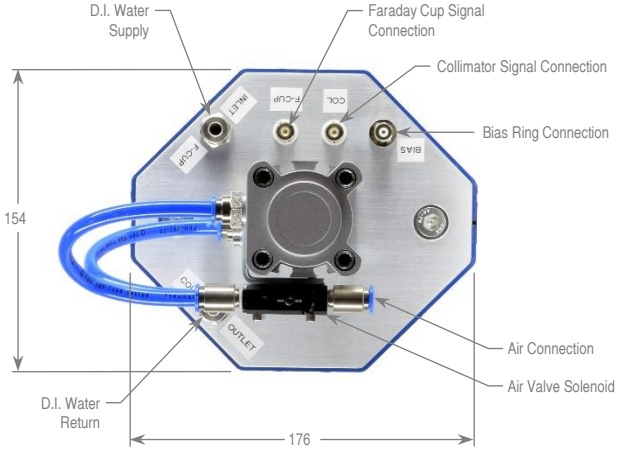
FARADAY CUP

FC-25.1K

Pneumatically-actuated, water-cooled, Faraday Cup for Ø25 mm beams capable of 1000 W beam power,





- Measure charged particle beams up to 1 kW beam power, with up to 1 MeV particle energy
- Secondary-electron suppression electrode
- Water-cooled (de-ionized water required)
- Beam current readback from both entrance collimator and Faraday Cup
- Ø25 mm aperture, Ø55 max. beam size
- Pneumatic actuation
- Reed limit switch feedback for device position
- Cylinder actuation speed adjustments

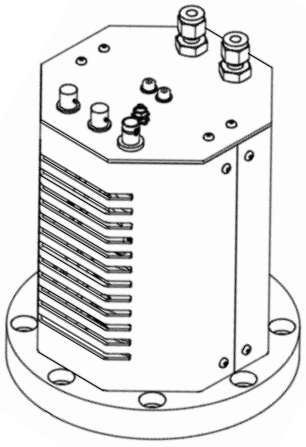
SPECIFICATIONS: FC-25.1K	
Max. Beam Power	1000 W (< 500W·cm^{-2})
Max. Particle Energy	1 MeV
Collimator I.D.	Ø25 mm
Collimator O.D.	55 mm × 65 mm
Flange	6" ConFlat (152 mm O.D.)
Max. Travel	79 mm
Pneumatic Operation Connections	24 V DC Solenoid Ø8 mm push tube fitting
Cooling Water Inlet Temperature Connections	1 L/min De-ionized water only < 20 °C Ø6 mm tube fittings
Current Readbacks: Faraday Cup Signal Collimator Signal	 Isolated BNC, female Isolated BNC, female
Bias Ring Connection Max. Bias Voltage	Grounded MHV, female 500 V
Limit Switches (Qty 2)* (Inserted & Retracted)	N/O reed switch, 2-wire, 5-30 V, 80 mA max.
Cylinder Speed Adjustments*	One-way flow control valves for exhaust air

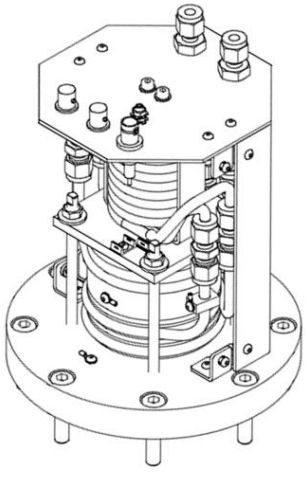
1. Inserted length at retracted position configurable for customer's application. Stroke fixed.
2. D-Pace reserves the right to update specifications as part of its ongoing product improvement program. Refer to D-Pace website for latest specifications.

* Limit switches and cylinder speed adjustments not shown in images.

FARADAY CUP, MODEL FC-600-F
600W STATIONARY

- Measures low-energy charged-particle beam currents (< 1 MeV) up to 600W
- Secondary-electron suppression electrode
- Water-cooled
- Beam current read back from both collimator and Faraday cup
- Polymer water tubing for electrical isolation within chassis for safety





SPECIFICATIONS: FC-600-F	
Beam Power, Max	600W
Collimator Diameter	32 mm
Bias Ring Diameter	32 mm
Faraday Cup Diameter	32 mm
Standard Flange	ISO 100F (O.D. 165mm)
Optional Flange	8” CF (O.D. 202mm)
Cooling	Water
Particle Kinetic Energy Range	< 1 MeV
Vacuum	HV (10^{-8} Torr)[1]

Notes:
1. FC-600-F design utilizes internal O-rings
2. Signal connector shells isolated from chassis, but grounded internally with a jumper wire to the ground post.
3. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

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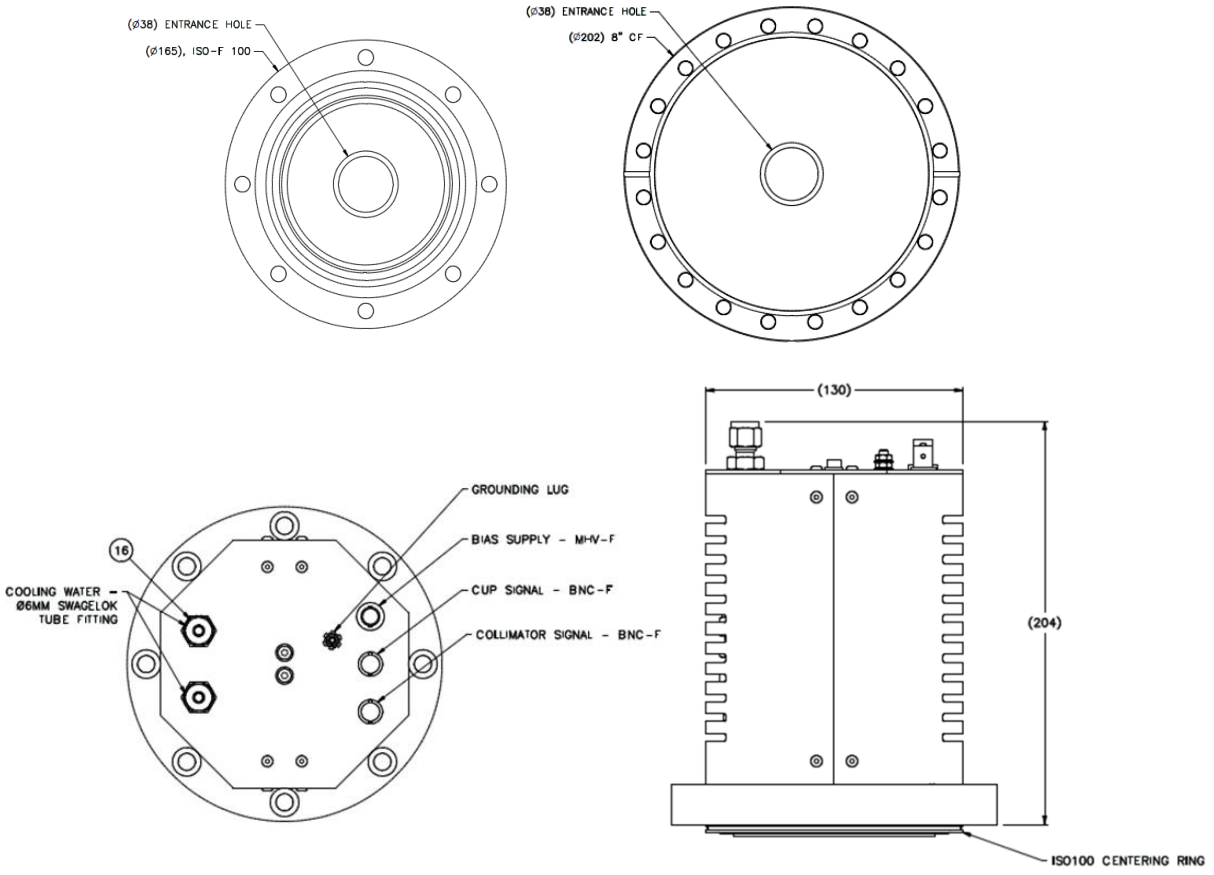
ISO 100 FLANGE (STANDARD) 8” CF FLANGE OPTION



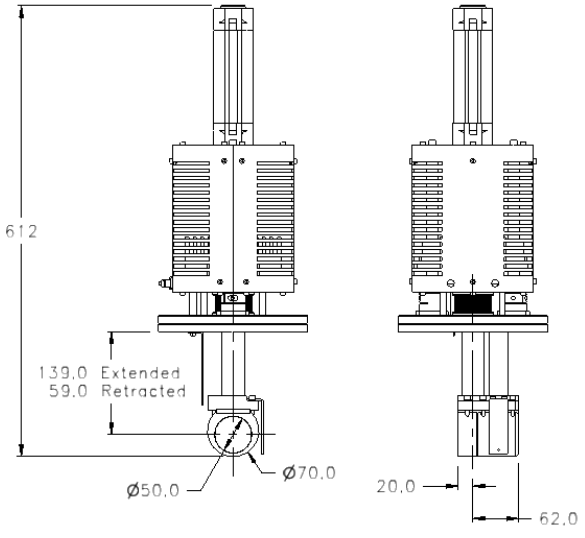
CONNECTORS AND COOLING: FC-600-F	
Connector, Faraday Cup Signal	Isolated BNC[3]
Connector, Collimator Signal	Isolated BNC[3]
Connector, Electron Suppression Bias	MHV, 500V Maximum
Cooling Water Connections Minimum flow Pressure, minimum Pressure, maximum	 6mm Swagelok Tube Fitting 1 liter/min 200 kPa (30psi) 620 kPa (90psi)
Water Tubing, Internal	Cup, bias ring and collimator cooling tubes connected in series with >100 cm of 4 mm I.D. polymer tubing between collimator and bias, and between signal and bias. This eliminates the need for external isolation water tubing.
Current Leakage, DI Water, 1MΩ/cm Water, 1kΩ/cm	Bias to Cup, Bias to Collimator < 200 nA < 200 µA
Grounding Lug	M4 Stud

FARADAY CUP – MODEL FC-50

Pneumatically-Actuated Faraday Cup
For Ultra High Vacuum Applications

- Measures low-energy charged-particle beam currents (< 1 MeV) up to 50W
- Secondary-electron suppression electrode
- Air-cooled for simplicity
- Beam current read back
- End stop limit switches

SPECIFICATIONS:	Faraday Cup, FC-50
Maximum Beam Power	50W
Maximum Travel	80 mm
Cup Inner Diameter	50 mm
Flange	DN 150CF (O.D. 203mm)
Electron Suppression	Bias Ring, 500V Max MHV Connector
Cooling	Air
Current Read back	BNC Connector
Particle Kinetic Energy Range	< 1 MeV
Pneumatic Control	3.5 – 7.0 Bar



Notes:

1. Expansion/retraction distance is configurable for customer's application.
2. D-Pace can provide a custom vacuum box.
3. D-Pace can provide a controller for current-to voltage conversion, limit-switch feedback, and pneumatic control.
4. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

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PS-50 - PRECISION SLITS, 50W

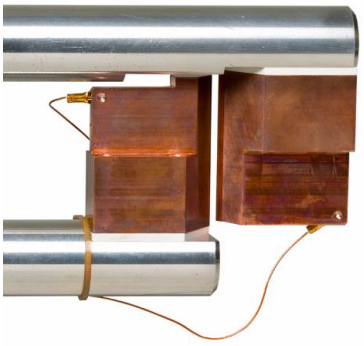
Manually-Actuated Slits for Ultra High Vacuum Where High Precision is Required

- High accuracy. Ideal for mass spectroscopy
- Measures low-energy charged-particle beam currents (< 1 MeV) up to 50W
- Ambient air cooled for simplicity
- Slit beam current read back[3]
- Designed for UHV vacuum

The **D-Pace 50W Precision Slits** were designed for mass spectroscopy. This device is manually actuated using a single knob, and has a convenient digital readout which indicates the slit separation distance. The slits are electrically isolated, allowing the current to be read from each slit independently through the BNC connectors on the flange. BNC shorting caps are provided if electrical isolation is not required.

The 50W Precision Slits are air-cooled, eliminating the need for water. This was accomplished with large cross section aluminum rods to conduct heat from the copper slits to heat sinks in ambient air within the device. Low-thermal-expansion Invar rods are used to compensate for high expansion rate materials used to conduct heat. The welded bellows design is UHV compatible and requires no O-rings.

D-Pace can also provide crosses, beamlines, spectrometer magnets, and control systems for a complete spectrometer system.



Electrically-Isolated Copper Slits

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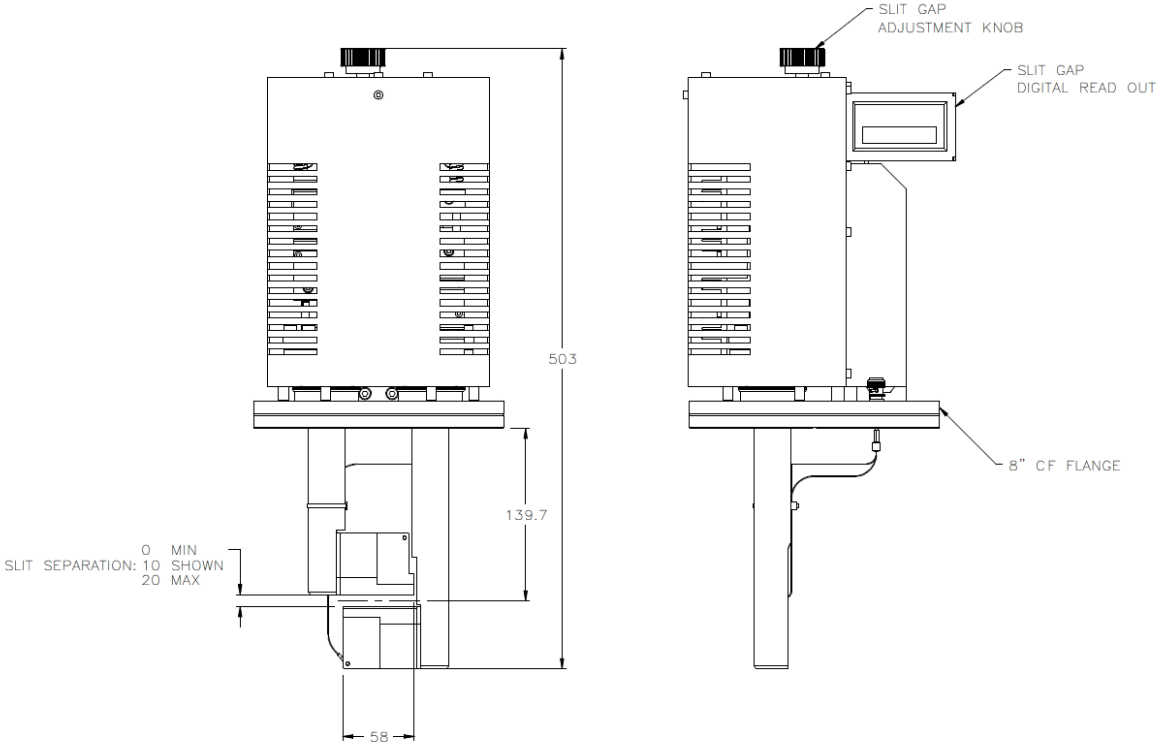
Manual adjustment with single knob

Digital readout of slit gap

SPECIFICATIONS: PS-50	
Maximum Beam Power	50W
Slit Adjustment	0.00 – 20.00mm
Slit Width	50 mm [1]
Flange	DN 150CF [2] (O.D. 203mm)
Cooling	Ambient Air
Current Read back	2 BNC Connectors [3]
Particle Kinetic Energy Range	< 1 MeV
Vacuum	UHV
Absolute Slit Position Relative to Flange	± 0.1mm
Position Resolution	0.05mm

Notes:

1. Plane transverse to slit motion.
2. Designed for use with standard cross with rotatable flange. Bolted from below.
3. Optional. BNC shorting caps are provided.
4. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.



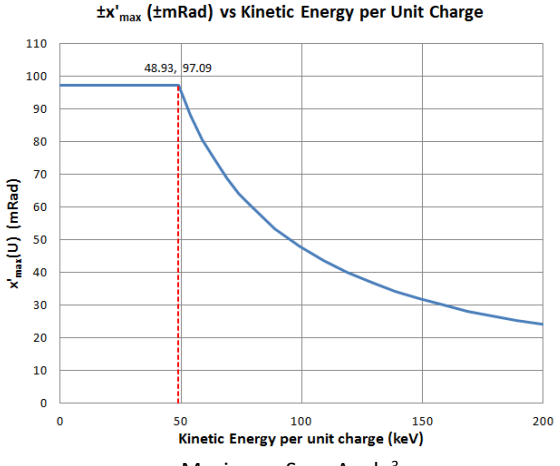
EMITTANCE SCANNER – MODEL ES-4

TRIUMF-Licenced Emittance & Phase Space Scanner Probe With Turnkey Controller and Analysis Software

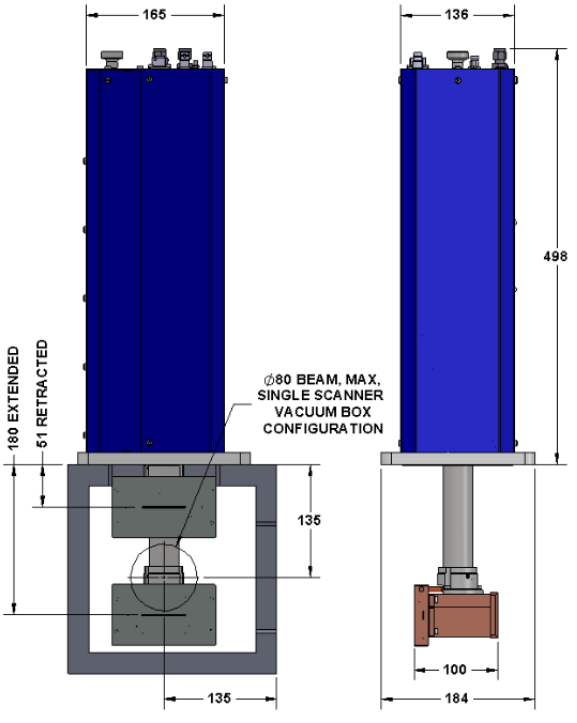
- Measure magnitude of emittance for low-energy charged particles (<1MeV)
- Water-cooled head for beam power up to 1500W and 500W/cm^2
- Determine phase space ellipses by percentage of total beam or by RMS emittance
- Use data for modelling beam transport in ion-optical analysis software
- TRIUMF-licenced technology[1]

The **D-Pace Emittance and Phase Space Scanner System** is an Allison-type emittance scanner, combining an electric trajectory sweep technique with a mechanical position beam sweep, enabling the simultaneous measurement of position (y) and angle (y'). Two probes can be used to scan horizontal and vertical plane phase spaces, or a single head can be used by re-mounting the head on a port 90° to the first. The system includes probe, computer, software, power supplies, and instrumentation.

D-Pace acquisition and analysis software enables the operator to optimize scans for resolution and scan time, and plot beam profiles, 2D and 3D contours with and without emittance ellipses. Data can be exported.



Maximum Scan Angle[3]



D-Pace can customize the Emittance Probe to customers' requirements. D-Pace provides custom vacuum boxes for single or dual scanners.[2]

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SPECIFICATIONS - EMITTANCE PROBE	
Maximum Travel	130 mm
Distance, Slit to Flange	50 mm to 180 mm
Flange	Custom Rectangular, O-Ring
Y Resolution Y Step, Minimum	100 µm (for s = 100 µm) 1 µm
Y' Max Y' Resolution Y' Step, Minimum	± 97 mRad (for K.E. < 50keV, see plot) 1.3 mRad (for s = 100µm) 16 bit resolution over +/- Y' Max
Sweep Voltage (V_{max})	+/-1000V
Slit width (s)	100 µm nominal Factory configurable 25µm to 250µm
Slit length (l)	50 mm
Beam $Ø_{max}$ (nominal)	40 mm
Bias Voltage	-100 Volts
Electrode gap (g)	4.0 mm
Electrode length (L_{eff})	76 mm
Mass	19 kg
Cooling Water	1.5 LPM Minimum MIN: 210 kPa (30 PSI) MAX: 620 kPa (90 PSI)
Max Beam Power[3]	1500 W
Max Beam Intensity[3]	500 W/cm^2
Cooling Plate	Molybdenum/Copper
Slits	Molybdenum (Front), Copper (Rear)

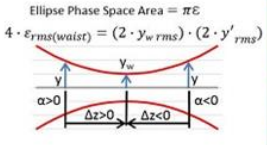
SPECIFICATIONS – TURNKEY CONTROL SYSTEM	
Instrument Rack	16U 19" rack, w/ keyboard, power bar
Platform	Industrial PC / Windows™ / LabView™
Typical Scan Time	< 1 minute for 30 step Y by 30 step Y' scan
Current Meter	2nA to 20mA (full scale) 5 pA (typical noise floor)
Power	115 or 220 VAC, 600 W, 1Ø
Data Plots & Analysis	2D & 3D phase-space intensity distributions, computed emittance, RMS ellipses, Twiss Parameters
File Export	CSV, PDF
Dim (W x D x H)	545mm x 660mm x 785mm
Mass (approx.)	70 kg excluding probe

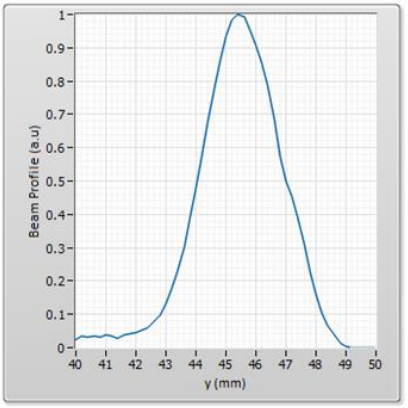
1. Licenced from TRIUMF for exclusive world-wide distribution.
2. Vacuum boxes available. Contact D-Pace.
3. Contact D-Pace with beam requirements.
4. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

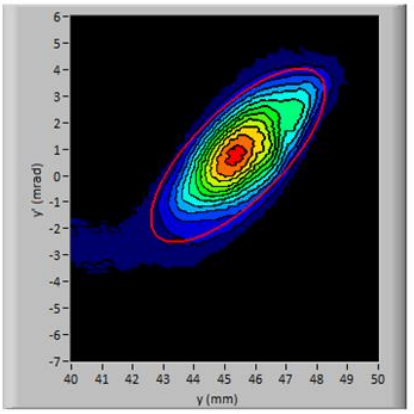
ES-4 Control Rack

Phase Space Analysis System 2.0

File Name	
300keV 1mA H- V20	
Scan	
Date:	3/30/2014
Time:	4:55:03 PM
Beam Energy:	294 keV
# y	51 points
delta y	0.2 mm
# y'	101 points
delta y'	0.113451 mrad
Axis:	Vertical Top
Rejection Threshold	
4%	Emittance Mode
Beam Centroid	
y	45.422697 mm
y'	0.750859 mrad
TWISS Parameters	
β	1.264003 mm/mrad
γ	1.684777 mrad/mm
α	-1.062809
Beam Waist Location	
Δz	-0.630831 m







% Beam In Ellipse		% Beam Dimensions			Emittance		Transport Sigma Matrix		
%	n n·εrms	y (mm)	yw Waist (mm)	y' (mrad)	εN Normalized (mm•mrad)	ε Geometric (mm•mrad)	σ11 (mm^2)	σ12=σ21 (mm•mrad)	σ22 (mrad^2)
38.7123	1	1.4002	0.9595	1.6166	0.0388	1.5511	1.9606	1.6485	2.6132
62.8932	2	1.9802	1.3569	2.2861	0.0777	3.1022	3.9212	3.2970	5.2265
78.4950	3	2.4252	1.6619	2.8000	0.1165	4.6533	5.8817	4.9455	7.8397
87.3408	**4**	**2.8004**	**1.9190**	**3.2331**	**0.1553**	**6.2044**	**7.8423**	**6.5940**	**10.4530**
92.7853	5	3.1310	2.1455	3.6147	0.1942	7.7555	9.8029	8.2426	13.0662
95.8613	6	3.4298	2.3503	3.9597	0.2330	9.3065	11.7635	9.8911	15.6794
98.2886	8	3.9604	2.7139	4.5723	0.3107	12.4087	15.6847	13.1881	20.9059
98.8053	10	4.4278	3.0342	5.1120	0.3883	15.5109	19.6058	16.4851	26.1324

Screen shot of ES-4 analysis software

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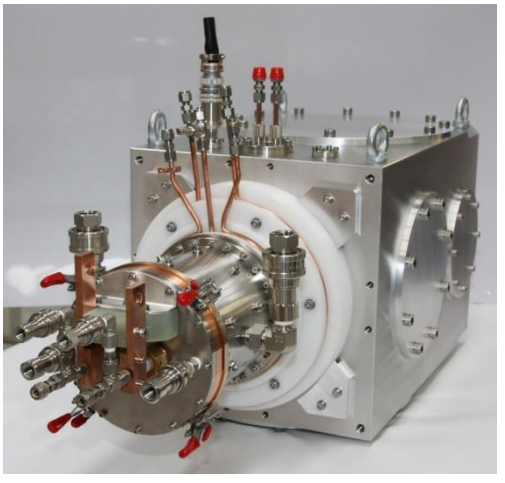
15 mA H^- Ion Source, Turnkey System

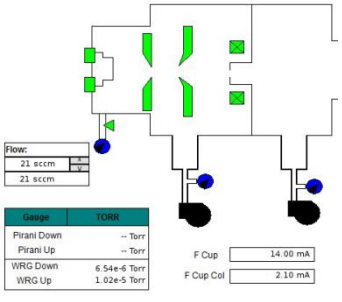
TRIUMF-Licensed Volume Cusp Ion Source System
Model F.H-15.30-SYS

Turnkey Ion Source
Including Optional Beamline and Mass Spectrometer

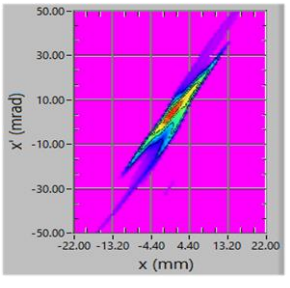


Ion Source with Vacuum Box

- Maximum H^- current >15 mA DC in 20 – 30 keV energy range
- Low maintenance with long filament lifetime (> 5250mA·hours)
- Negligible lens wear due to the optimized lens ion-optics, and low emittance
- Instrumentation options include Faraday cup, emittance scanner, beamlines, beam profiler and mass spectrometer
- Completely customizable
- TRIUMF-licensed technology



Portion of Controls Interface



Phase Space Plot, 15mA H^- Tune

Enquire about other negative and positive ion beams, and our RF-powered ion sources

The F.H-15.30.SYS Filament Ion Source system is a complete, turnkey ion source system including:

- Ion source & Vacuum box
- Vacuum system & gauges
- Power supplies, PLC controls & software
- User interface & Ethernet-based remote controls
- Low voltage and high voltage racks
- 40kV isolation transformer
- Interlocks and HV grounding system
- Personnel access control interlocks
- Water flow gauges and interlocks
- Mass flow controller for feed gasses
- Optional high-voltage Faraday cage
- Optional water de-ionization system
- Optional sliding Faraday cup
- Optional fiber optic beam profile monitor
- Optional TRIUMF-licensed emittance scanner
- Optional 1:500 mass spectrometer with slits

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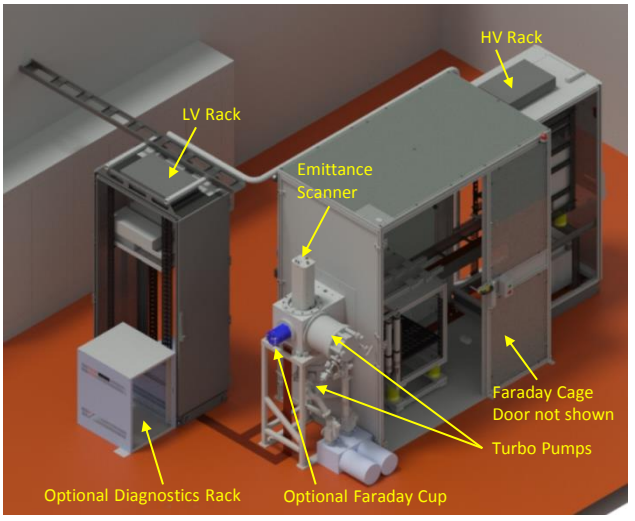
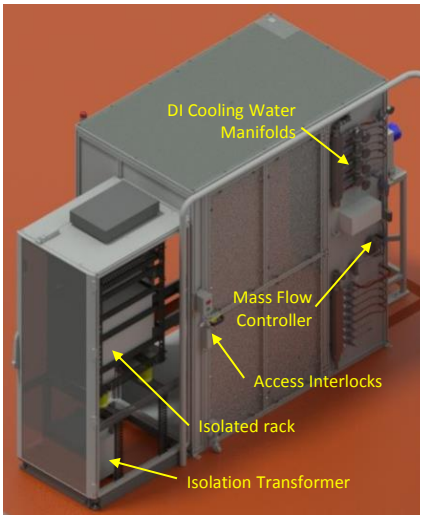




SPECIFICATIONS:	
ION SOURCE	
Particle Type	H^-
Beam Current	0 to 15 mA
Beam Kinetic Energy	20 to 30 keV
Normalized 4rms Emittance	< 1 mm·mrad
Beam Purity	> 99%
Filament Lifetime	> 5250 mA·hours
Beam Current Stability	± 1% over 24 hours
POWER SUPPLIES	
Bias Supply	40mA, 30 keV
Arc Supply	50 A, 200 V
Filament Supply	400 A, 10 V
Plasma Lens	42 A, 10 V
Extraction Lens	150 mA, 5 kV
X & Y Steer	10 V, 10 A
VACUUM PUMPING SPECIFICATIONS	
Turbo Pumps, 2X Upstream & Downstream	1700 liters/second H_2 Flange ISO250F
Dry Scroll Roughing, 2X Upstream & Downstream	35 m^3h^{-1}
GAS FLOW	
Mass Flow Controller	11-30 sccm H_2
CONTROLS	
Control PLC	Phoenix Contact ILC, Ethernet
User Interface Options	D-Pace standalone or OPC command library for customer integration
High Voltage Interlocks	HV grounding relay with access control locks
COOLING WATER, DEIONIZED, 20°C (>1.0 MOhm.cm)	
Source Body	8.0 LPM, 40 PSI (275 kPa)
Filament	1.0 LPM, 70 PSI (480 kPa)
Back Plate	1.5 LPM, 70 PSI (480 kPa)
Plasma Lens	1.5 LPM, 70 PSI (480 kPa)
Extraction Lens	1.5 LPM, 70 PSI (480 kPa)
XY Steering Magnet	1.0 LPM, 70 PSI (480 kPa)

1. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

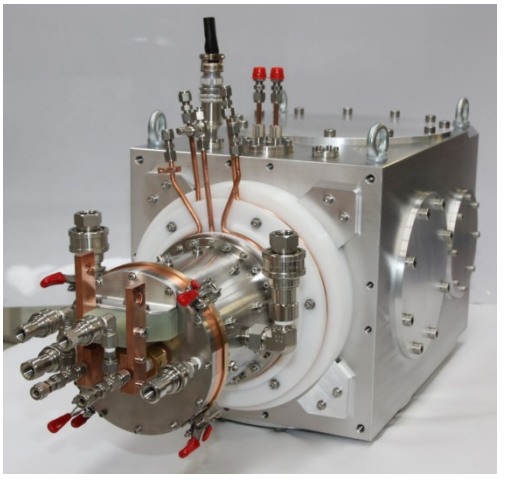
Sample Tune Data:

Beam Current H^- (mA)	Bias Supply (mA, kV)	Arc Supply (A,V)	Filament Supply (A,V)	Plasma Lens Supply (A,V)	Extraction Lens Supply (mA, kV)	Steering Magnet X (A,V)	Steering Magnet Y (A,V)	H_2 (sccm)	Vacuum, Ion Source (Upstream) (Torr)	Vacuum, V-Box (Downstream) (Torr)	½ Beam Diameter at Waist (mm)	½ Beam Divergence at Waist (mrad)	Geometric 4rms Emittance (mm·mrad)	Normalized 4rms Emittance (mm·mrad)
5.0	7.1, 30	8.8, 120	231, 3.43	4.2, 3.23	26.2, 2.12	0.00	0.00	10	3.59e-5	2.62e-6	2.01	45.4	91	0.73
10.0	13.5, 30	18.8, 120	204, 3.15	9.36, 3.99	33.9, 2.99	5.00	3.00	13	3.21e-5	3.52e-6	1.69	40.1	68	0.54
13.0	17.9, 30	26.8, 120	176, 2.74	12.5, 3.82	60.8, 3.45	1.00	1.64	15	4.65e-5	4.56e-6	2.21	41.05	91	0.73
15.0	20.4, 30	33.6, 120	143, 2.34	15.8, 3.94	71.2, 3.56	0.82	1.55	17	5.00e-5	5.19e-6	2.52	34.7	87	0.70
18.0	24.9, 30	47.5, 120	35, 0.89	21.2, 3.83	127, 3.80	0.82	1.55	20	4.65e-5	6.24e-6	2.72	34.4	94	0.75

5 mA D^- Ion Source, Turnkey System

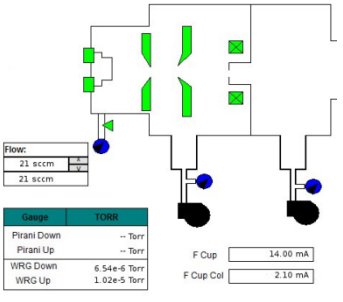
TRIUMF-Licensed Volume Cusp Ion Source System
Model F.D-5-30-SYS

Turnkey Ion Source
Including Optional Beamline and Mass Spectrometer



Ion Source with Vacuum Box

- Maximum D^- current > 5 mA DC in 20 – 30 keV energy range
- Low maintenance with long filament lifetime (> 5250mA·hours)
- Negligible lens wear due to the optimized lens ion-optics, and low emittance
- Instrumentation options include Faraday cup, emittance scanner, beamlines, beam profiler and mass spectrometer
- Completely customizable
- TRIUMF-licensed technology



Portion of Controls Interface

Enquire about other negative and positive ion beams, and our RF-powered ion sources

The F.D-5-30.SYS Filament Ion Source system is a complete, turnkey ion source system including:

- Ion source & Vacuum box
- Vacuum system & gauges
- Power supplies, PLC controls & software
- User interface & Ethernet-based remote controls
- Low voltage and high voltage racks
- 40kV isolation transformer
- Interlocks and HV grounding system
- Personnel access control interlocks
- Water flow gauges and interlocks
- Mass flow controller for feed gasses
- Optional high-voltage Faraday cage
- Optional water de-ionization system
- Optional sliding Faraday cup
- Optional fiber optic beam profile monitor
- Optional TRIUMF-licensed emittance scanner
- Optional 1:500 mass spectrometer with slits

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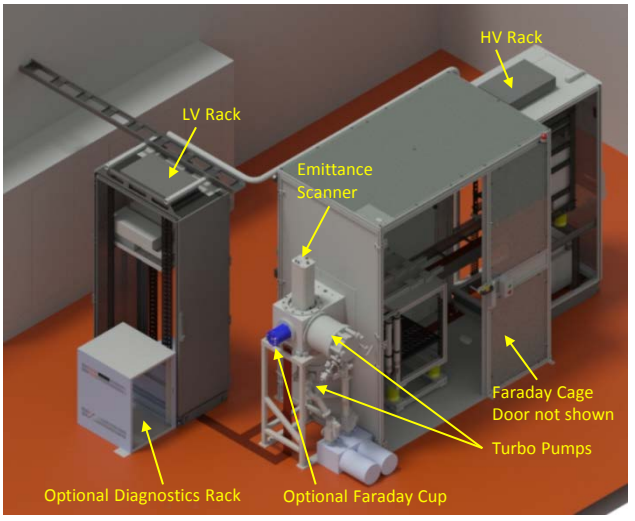
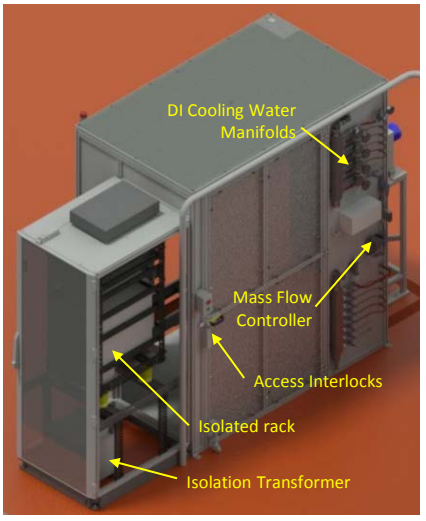




1. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

SPECIFICATIONS:	
ION SOURCE	
Particle Type	D^-
Beam Current	0 to 5 mA
Beam Kinetic Energy	20 to 30 keV
Normalized 4rms Emittance	< 1 mm·mrad
Beam Purity	> 99%
Filament Lifetime	> 5250 mA·hours
Beam Current Stability	± 1% over 24 hours
POWER SUPPLIES	
Bias Supply	20mA, 30 keV
Arc Supply	50 A, 200 V
Filament Supply	400 A, 10 V
Plasma Lens	42 A, 10 V
Extraction Lens	150 mA, 5 kV
X & Y Steer	10 V, 10 A
VACUUM PUMPING SPECIFICATIONS	
Turbo Pumps, 2X Upstream & Downstream	1700 liters/second H_2 Flange ISO250F
Dry Scroll Roughing, 2X Upstream & Downstream	35 m^3h^{-1}
GAS FLOW	
Mass Flow Controller	11-30 sccm H_2
CONTROLS	
Control PLC	Phoenix Contact ILC, Ethernet
User Interface Options	D-Pace standalone or OPC command library for customer integration
High Voltage Interlocks	HV grounding relay with access control locks
COOLING WATER, DEIONIZED, 20°C (>1.0 MOhm.cm)	
Source Body	8.0 LPM, 40 PSI (275 kPa)
Filament	1.0 LPM, 70 PSI (480 kPa)
Back Plate	1.5 LPM, 70 PSI (480 kPa)
Plasma Lens	1.5 LPM, 70 PSI (480 kPa)
Extraction Lens	1.5 LPM, 70 PSI (480 kPa)
XY Steering Magnet	1.0 LPM, 70 PSI (480 kPa)

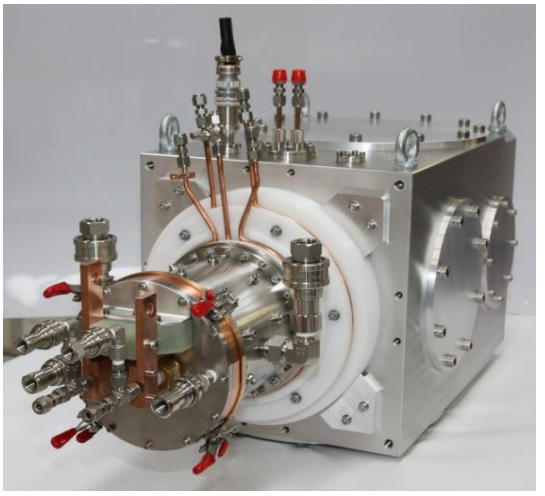
Sample Tune Data:

Beam Current D^- (mA)	Bias Supply (mA, kV)	Arc Supply (A,V)	Filament Supply (A,V)	Plasma Lens Supply (A,V)	Extraction Lens Supply (mA, kV)	Steering Magnet X (A)	Steering Magnet Y (A)	H_2 (sccm)	Vacuum, Ion Source (Upstream) (Torr)	Vacuum, V-Box (Downstream) (Torr)	½ Beam Diameter at Waist (mm)	½ Beam Divergence at Waist (mrad)	Geometric 4rms Emittance (mm·mrad)	Normalized 4rms Emittance (mm·mrad)
1.0	1.54, 30	3.20, 120	220, 3.23	2.20, 4.14	19.4, 1.07	0.0	3.0	5.0	1.92e-5	3.86e-7	1.59	49.9	79.3	0.63
2.0	2.92, 30	7.47, 120	217, 3.25	5.40, 4.97	23.5, 1.56	0.0	3.0	7.0	2.44e-5	1.06e-6	1.82	42.0	76.7	0.61
3.0	4.39, 30	11.9, 120	207, 3.17	7.68, 4.58	51.3, 1.94	0.0	3.5	9.0	3.09e-5	7.64e-7	1.54	50.1	77.3	0.62
4.0	6.10, 30	18.1, 120	183, 2.87	11.3, 4.62	76.4, 2.31	2.5	3.0	11	3.66e-5	1.01e-6	2.34	47.9	112	0.90
5.0	7.72, 30	24.4, 120	160, 2.53	14.5, 4.43	109, 2.56	3.5	0.0	14	4.39e-5	2.14e-6	2.30	45.5	105	0.84
6.0	8.94, 30	38.3, 120	87.0, 1.58	27.0, 5.74	103, 2.68	3.5	0.0	15	4.73e-5	2.43e-6	2.29	49.4	113	0.90

5 mA H^- Filament Ion Source, Turnkey System

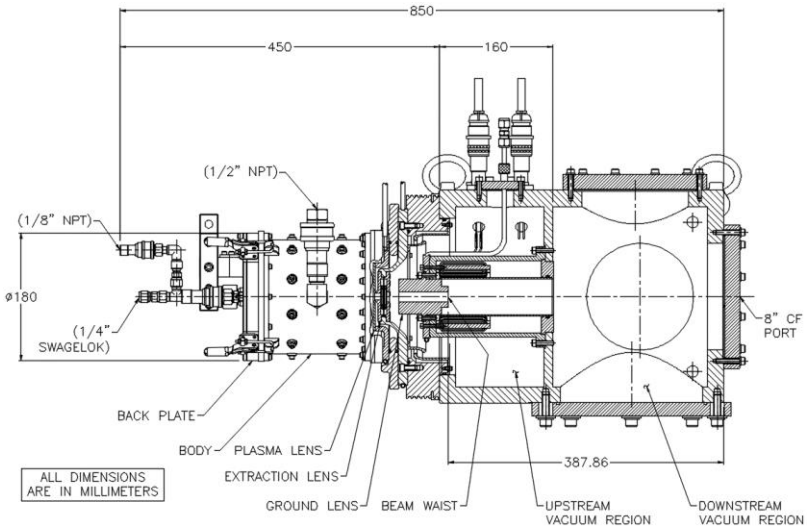
TRIUMF-Licensed Volume Cusp Ion Source System
Model F.H-5.30-SYS

Turnkey Ion Source with Optional Beamline & Mass Spectrometer



Ion Source with Vacuum Box

- Maximum H^- current >5 mA DC in 20 – 30 keV energy range
- Low maintenance with long filament lifetime (> 5250mA·hours)
- Negligible lens wear due to the optimized lens ion-optics, and low emittance
- Instrumentation options include Faraday cup, emittance scanner, beamlines, beam profiler and mass spectrometer
- Completely customizable
- TRIUMF-licensed technology



The F.H-5.30.SYS Filament Ion Source system is a complete, turnkey ion source system including:

- Ion Source & Vacuum Box
- Vacuum system & gauges
- Power supplies, PLC controls & software
- User interface & Ethernet-based remote controls
- Low voltage and high voltage racks
- 40kV isolation transformer
- Interlocks and HV grounding system
- Personnel access control interlocks
- Water flow gauges and interlocks
- Mass flow controller for feed gasses
- Optional high-voltage Faraday cage
- Optional water de-ionization system
- Optional sliding Faraday cup
- Optional fiber optic beam profile monitor
- Optional TRIUMF-licensed emittance scanner
- Optional 1:500 mass spectrometer with slits

Enquire about other negative & positive ion beams, and our RF-powered ion sources

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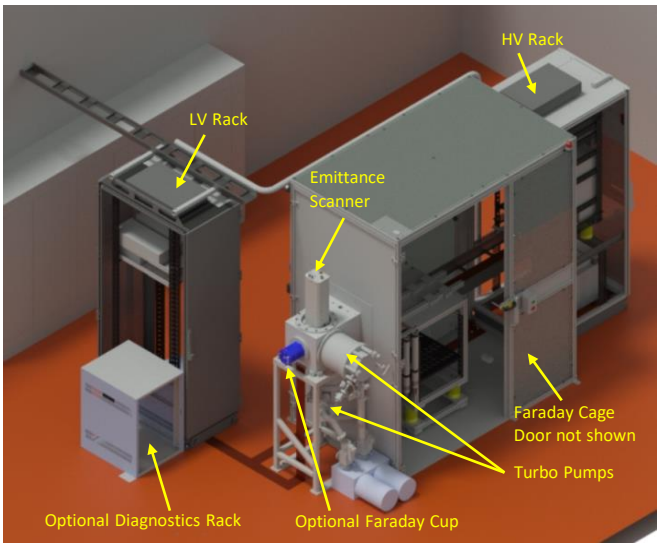
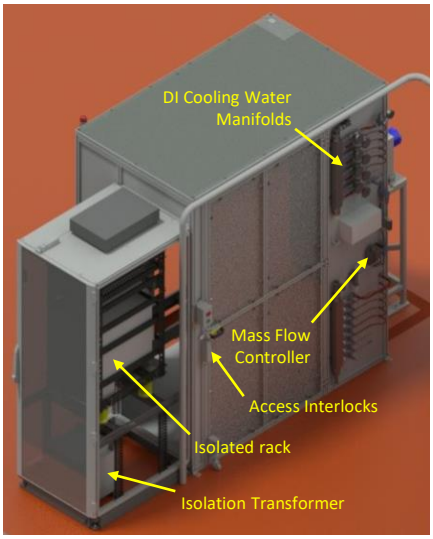




1. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

SPECIFICATIONS:

ION SOURCE	
Particle Type	H^-
Beam Current	0 to 5 mA
Beam Kinetic Energy	20 to 30 keV
Normalized 4rms Emittance	< 1 mm·mrad
Beam Purity	> 99%
Filament Lifetime	> 5250 mA·hours
Beam Current Stability	± 1% over 24 hours
POWER SUPPLIES	
Bias Supply	20mA, 30 keV
Arc Supply	26 A, 150 V
Filament Supply	200 A, 10 V
Plasma Lens	20 A, 10 V
Extraction Lens	75 mA, 5 kV
X & Y Steer	10 V, 10 A
VACUUM PUMPING SPECIFICATIONS	
Turbo Pumps, Upstream Downstream	450 liters/second H_2 1700 liters/second H_2
Dry Scroll Roughing, 2X Upstream & Downstream	35 m^3h^{-1}
GAS FLOW	
Mass Flow Controller	11-20 sccm H_2
CONTROLS	
Control PLC	Phoenix Contact ILC, Ethernet
User Interface Options	D-Pace standalone or OPC command library for customer integration
High Voltage Interlocks	HV grounding relay with access control locks
COOLING WATER, DEIONIZED, 20°C (>1.0 MOhm.cm)	
Source Body	8.0 LPM, 40 PSI (275 kPa)
Filament	1.0 LPM, 70 PSI (480 kPa)
Back Plate	1.5 LPM, 70 PSI (480 kPa)
Plasma Lens	1.5 LPM, 70 PSI (480 kPa)
Extraction Lens	1.5 LPM, 70 PSI (480 kPa)
XY Steering Magnet	1.0 LPM, 70 PSI (480 kPa)

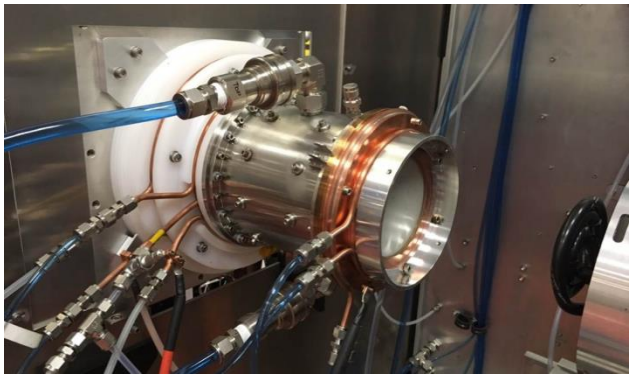
SAMPLE TUNE DATA:

Beam Current H^- (mA)	Bias Supply (mA, kV)	Arc Supply (A,V)	Filament Supply (A,V)	Plasma Lens Supply (A,V)	Extraction Lens Supply (mA, kV)	Steering Magnet X (A,V)	Steering Magnet Y (A,V)	H_2 (sccm)	Vacuum, Ion Source (Upstream) (Torr)	Vacuum, V-Box (Downstream) (Torr)	½ Beam Diameter at Waist (mm)	½ Beam Divergence at Waist (mrad)	Geometric 4rms Emittance (mm·mrad)	Normalized 4rms Emittance (mm·mrad)
1.2	4.5, 25	2.4, 101.7	172, 2.91	1.5, 2.0	6, 1.55	3.02	0.00	9.71	7.2×10^{-5}	1.0×10^{-6}	1.94	24.7	48.04	0.35
2.0	6.0, 25	4.8, 101.6	172, 2.93	3.0, 2.8	7, 1.8	3.43	0.00	15	1.0×10^{-4}	1.4×10^{-6}	2.28	21.5	48.96	0.36
3.0	9.0, 25	7.5, 101.6	174, 3.04	4.7, 3.1	12, 2.2	2.70	0.00	15	1.0×10^{-4}	1.5×10^{-6}	2.84	20.8	58.94	0.43
4.1	11.0, 25	12.2, 101.7	173, 3.11	8.2, 4.0	15, 2.4	2.72	0.00	15	1.0×10^{-4}	1.6×10^{-6}	3.18	23.0	73.16	0.53
5.1	13.0, 25	18.7, 101.5	168, 3.12	12.5, 4.4	31, 2.6	2.49	0.00	15	1.0×10^{-4}	1.6×10^{-6}	3.74	23.1	86.40	0.63

7.5 mA H^- RF Ion Source, Turnkey

Model RF.H-7.5-30-SYS Volume Cusp Ion Source System
TRIUMF & University of Jyväskylä Licensed[1]

- Maximum H^- current > 7.5 mA DC in 20 – 30 keV energy range
- Long intervals between maintenance[2] (1 year)– no filaments to replace
- RF powered - no metal sputtering due to filaments (important for ion implantation)
- Ability to pulse beam
- Extensive beam instrumentation options

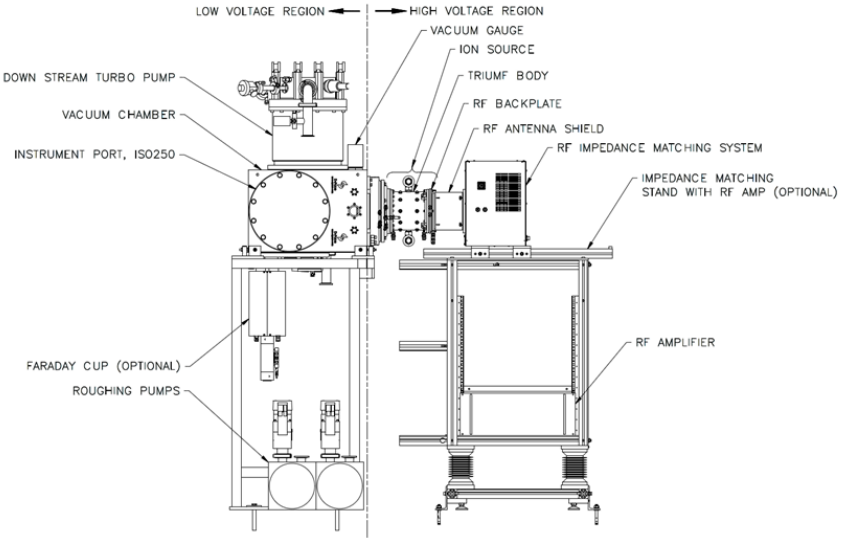


RF window (L) and antenna (R), shown separated

- Ion source & vacuum box
- Vacuum system & gauges
- Power supplies
- High voltage grounding & bleeder circuits
- RF amplifier & impedance matching systems
- PLC controls & software
- User interface & Ethernet-based remote controls
- Mass flow controller for feed gasses

Customizable with the following subsystems:

- Ion source stand and RF stand
- High-voltage Faraday cage / enclosure
- Low voltage and high voltage racks
- 40kV isolation transformer
- Personnel access control interlocks
- Water flow gauges and interlocks
- Water de-ionization system
- Sliding Faraday cup
- Fiber optic beam profile monitor
- TRIUMF-licensed emittance scanner



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SPECIFICATIONS:	
ION SOURCE	
Particle Type	H^-
Beam Current	0 to 8 mA
Beam Kinetic Energy	20 to 30 keV
Normalized 4rms Emittance	< 0.7 mm·mrad
Beam Purity	> 99%
RF Window Lifetime[2,3]	> 1 year
Beam Current Stability[2]	< ± 1% over 24 hours
Beamline Flange	ISO 100
Instrument Port[4]	ISO 250
POWER SUPPLIES	
Bias Supply	40mA, 30 keV
RF Amplifier[5,6]	3kW, 13.56 MHz
Plasma Lens	12 A, 70 V
Extraction Lens	60 mA, 5 kV
X & Y Steer	10 V, 10 A
VACUUM SYSTEM SPECIFICATIONS	
Turbo Pumps, 2X Upstream & Downstream	1700 liters/second H_2 Flange ISO250F
Dry Scroll Roughing, 2X Upstream & Downstream	35 m^3h^{-1}
GAS FLOW	
Mass Flow Controller	11-30 sccm H_2

CONTROLS	
Control PLC	Phoenix Contact ILC, Ethernet
User Interface Options	D-Pace standalone or OPC command library for customer integration
COOLING WATER, 20°C	
XY Steering Magnet	1.0 LPM, 70 PSI (480 kPa)
Turbo Pumps	2.0 LPM, 70 PSI (480 kPa)
COOLING WATER, DEIONIZED, 20°C (> 1.0 MOhm.cm)	
Source Body	5.0 LPM, 40 PSI (275 kPa)
RF Amplifier	5.0 LPM, 40 PSI (275 kPa)
RF Antenna	1.0 LPM, 70 PSI (480 kPa)
RF Window	1.5 LPM, 70 PSI (480 kPa)
Plasma Lens	1.5 LPM, 70 PSI (480 kPa)
Extraction Lens	1.5 LPM, 70 PSI (480 kPa)
Faraday Cup	1.5 LPM, 70 PSI (480 kPa)

D-Pace will work with customers to meet their requirements. PLC software can also be integrated on the customer's PLC. Code will be provided.

Custom enclosures or cages can be provided.

The system can be provided such that all active electronic assemblies are located remotely from the ion source.

Sample Tune Data:

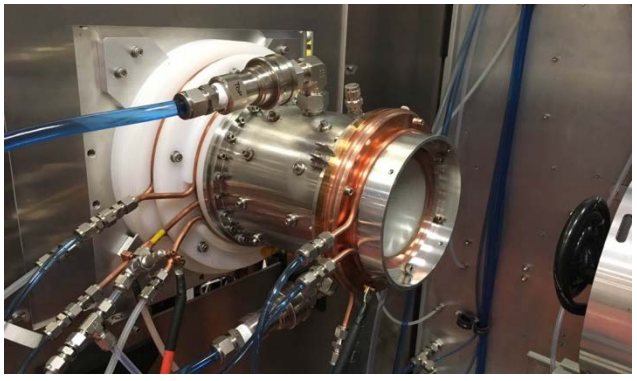
Beam Current H^- (mA)	Bias Supply (mA, kV)	RF Power (KW)	Plasma Lens Supply (A,V)	Extraction Lens Supply (mA, kV)	Steering Magnet X (A)	Steering Magnet Y (A)	H_2 (sccm)	Vacuum, Ion Source, Upstream (Torr)	Vacuum, V-Box, Downstream (Torr)	½ Beam Diameter at Waist (mm)	½ Beam Divergence at Waist (mrad)	Geometric 4rms Emittance (mm·mrad)	Normalized 4rms Emittance (mm·mrad)
1.0	1.6, 30	0.6	0.6, 16.3	5.5, 1.11	0.0	3.0	15	5.38e-5	3.27e-6	2.40	32.2	77.3	0.62
2.0	2.8, 30	0.8	1.3, 38.6	12.8, 1.45	0.5	3.2	11	3.79e-5	2.39E-6	1.80	41.7	75.1	0.60
3.0	4.4, 30	1.1	1.9, 30.7	17.7, 1.82	0.5	3.2	13	4.40e-5	2.98e-6	1.55	51.5	79.9	0.64
4.0	5.9, 30	1.5	3.1, 41.6	17.4, 2.08	0.5	3.2	14	4.73e-5	3.21e-6	1.53	49.8	76.0	0.61
5.0	7.3, 30	1.9	4.0, 39.6	30.3, 2.28	0.5	3.2	14	4.73e-5	3.27e-6	1.74	39.0	67.9	0.54
6.0	8.8, 30	2.4	5.2, 43.6	37.8, 2.58	0.5	3.2	14	4.73e-5	3.40e-6	1.78	38.3	68.0	0.54
7.0	10.4, 30	2.9	5.8, 36.6	36.1, 2.85	0.5	3.2	16	5.28e-5	3.86e-6	1.72	37.0	63.5	0.51
8.0	11.4, 30	3.1	5.9, 35.7	34.6, 2.98	0.5	3.2	16	5.38e-5	3.86e-6	1.81	37.8	68.6	0.55

1. Ion Source licenced from TRIUMF. RF technology licenced from the University of Jyväskylä.
2. Estimates - testing in progress.
3. Window lifetime estimate based on 10% RF transmission degradation.
4. Suitable for installation of optional pneumatically-actuated Faraday cup and D-Pace ES-4 Allison type emittance scanner.
5. 5kW amplifier recommended for beam currents > 5mA.
6. RF Amplifier can be installed in the RF as rack shown or installed remotely.
7. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

3 mA D^- RF Ion Source, Turnkey

Model RF.D-3-30-SYS Volume Cusp Ion Source System
TRIUMF & University of Jyväskylä Licensed[1]

- Maximum D^- current > 3 mA DC in 20 – 30 keV energy range
- Long intervals between maintenance[2] (1 year)– no filaments to replace
- RF powered - no metal sputtering due to filaments (important for ion implantation)
- Ability to pulse beam
- Extensive beam instrumentation options

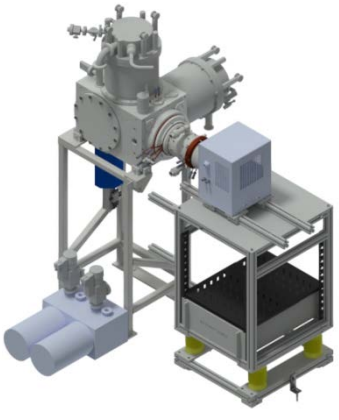


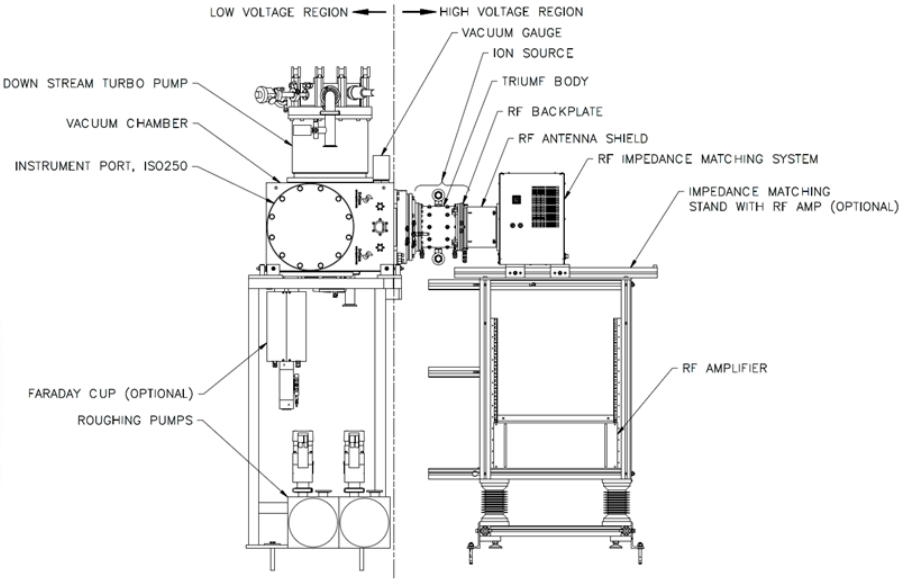
The RF.D-3.30-SYS Filament Ion Source system includes the following:

- Ion source & vacuum box
- Vacuum system & gauges
- Power supplies
- High voltage grounding & bleeder circuits
- RF amplifier & impedance matching systems
- PLC controls & software
- User interface & Ethernet-based remote controls
- Mass flow controller for feed gasses

Customizable with the following subsystems:

- Ion source stand and RF stand
- High-voltage Faraday cage / enclosure
- Low voltage and high voltage racks
- 40 kV isolation transformer
- Personnel access control interlocks
- Water flow gauges and interlocks
- Water de-ionization system
- Sliding Faraday cup
- Fiber optic beam profile monitor
- TRIUMF-licensed emittance scanner





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SPECIFICATIONS:	
ION SOURCE	
Particle Type	D^-
Beam Current	0 to 3 mA
Beam Kinetic Energy	20 to 30 keV
Normalized 4rms Emittance	< 1.1 mm·mrad
Beam Purity	> 99%
RF Window Lifetime[2,3]	> 1 year
Beam Current Stability[2]	< ± 1% over 24 hours
Beamline Flange	ISO 100
Instrument Port[4]	ISO 250
POWER SUPPLIES	
Bias Supply	10mA, 30 keV
RF Amplifier[5]	3kW, 13.56 MHz
Plasma Lens	12 A, 70 V
Extraction Lens	60 mA, 5 kV
X & Y Steer	10 V, 10 A
VACUUM SYSTEM SPECIFICATIONS	
Turbo Pumps, 2X Upstream & Downstream	1700 liters/second H_2 Flange ISO250F
Dry Scroll Roughing, 2X Upstream & Downstream	35 m^3h^{-1}
GAS FLOW	
Mass Flow Controller	3-10 sccm H_2

CONTROLS	
Control PLC	Phoenix Contact ILC, Ethernet
User Interface Options	D-Pace standalone or OPC command library for customer integration
COOLING WATER, 20°C	
XY Steering Magnet	1.0 LPM, 70 PSI (480 kPa)
Turbo Pumps	2.0 LPM, 70 PSI (480 kPa)
COOLING WATER, DEIONIZED, 20°C (> 1.0 MOhm.cm)	
Source Body	5.0 LPM, 40 PSI (275 kPa)
RF Amplifier	5.0 LPM, 40 PSI (275 kPa)
RF Antenna	1.0 LPM, 70 PSI (480 kPa)
RF Window	1.5 LPM, 70 PSI (480 kPa)
Plasma Lens	1.5 LPM, 70 PSI (480 kPa)
Extraction Lens	1.5 LPM, 70 PSI (480 kPa)
Faraday Cup	1.5 LPM, 70 PSI (480 kPa)

D-Pace will work with customers to meet their requirements. PLC software can also be integrated on the customer's PLC. Code will be provided.

Custom enclosures or cages can be provided.

The system can be provided such that all active electronic assemblies are located remotely from the ion source.

Sample Tune Data:

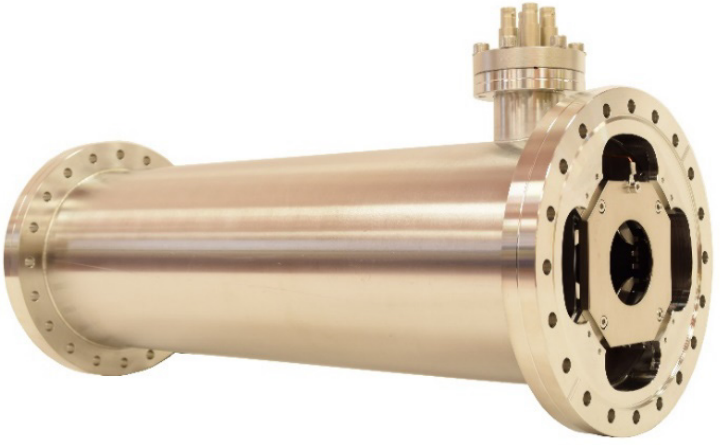
Beam Current D^- (mA)	Bias Supply (mA, kV)	RF Power (KW)	Plasma Lens Supply (A,V)	Extraction Lens Supply (mA, kV)	Steering Magnet X (A)	Steering Magnet Y (A)	H_2 (sccm)	Vacuum, Ion Source, Upstream (Torr)	Vacuum, V-Box, Downstream (Torr)	½ Beam Diameter at Waist (mm)	½ Beam Divergence at Waist (mrad)	Geometric 4rms Emittance (mm·mrad)	Normalized 4rms Emittance (mm·mrad)
0.5	0.9, 30	0.4	0.6, 27.7	15.4, 1.07	0.0	0.0	4.0	1.95e-5	4.23e-7	2.1	55.3	113	0.91
1.0	1.5, 30	0.6	1.1, 54.7	30.6, 1.56	2.0	0.0	4.5	2.10e-5	4.56e-7	1.9	48.2	93.7	0.75
1.5	2.2, 30	1.1	2.0, 59.5	17.0, 1.60	2.0	0.0	7.0	3.09e-5	6.59e-7	2.4	56.2	135	1.08
2.0	3.1, 30	1.6	3.0, 41.7	11.2, 1.93	3.0	0.0	7.0	2.93e-5	7.93e-7	2.1	54.7	112	0.90
2.5	3.7, 30	2.0	3.8, 47.7	63.0, 2.15	3.0	0.0	7.0	2.82e-5	6.59e-7	2.2	56.5	124	0.99
3.0	4.5, 30	2.6	5.28, 49.7	39.3, 2.33	3.0	0.0	8.5	3.21e-5	8.22e-7	2.1	53.3	112	0.89

1. Ion Source licenced from TRIUMF. RF technology licenced from the University of Jyväskylä.
2. Estimates - testing in progress.
3. Window lifetime estimate based on 10% RF transmission degradation.
4. Suitable for installation of optional pneumatically-actuated Faraday cup and D-Pace ES-4 Allison type emittance scanner.
5. RF Amplifier can be installed in the RF as rack shown or installed remotely.
6. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

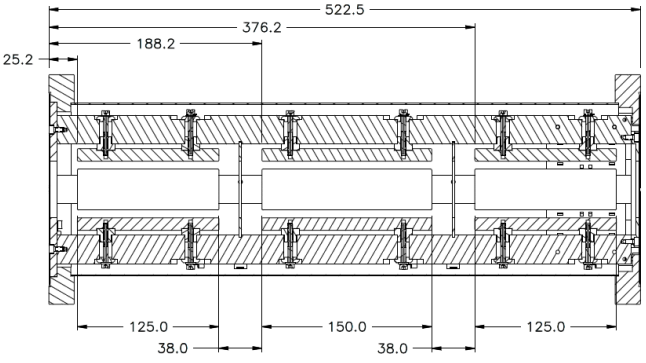
Electrostatic Quad Triplet, 50mm

Model QE 3.50

Aperture Ø50mm, Maximum Pole Potential +/-1kV



- Pole aperture 50mm
- Pole isolation from ground ±1000V (±2000V between opposite poles)
- Grounded collimators upstream from each quad (quantity 3)
- 8" CF Flanges
- Metal and ceramic seals
- UHV options 1
- Optional power supply, with quantity 6 +/-1kV bipolar outputs in single 2U 19" rack mount chassis



SPECIFICATION: QE 3.50		
	Pole Length (mm)	
	Physical	Effective
Quadrupole 1	125	150
Quadrupole 2	150	175
Quadrupole 3	125	150
Pole Spacing	91.5mm	66.5mm
Pole Aperture	Ø50.0 mm	
Collimator	Ø50.0 mm, Qty 3	
Overall Length	522.5 mm	
Flanges, Beam Pipe	8" CF	
Flanges, HV Feedthru	2-¾" CF	
Vacuum	HV (10-9 Torr)	
HV Connectors	SHV (Qty 6)	
Isolation, Pole to Ground	±1000	
Isolation, Pole to Pole	±2000	
Support	Flange supported 1	

Notes:
Contact D-Pace for customization options.
D-Pace reserves the right to update specifications as part of its ongoing product improvement program.

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EINZEL LENS

LE-25.15.45

D-Pace

For use with D-Pace ion sources and beams < 100 keV.

- **Able to focus beams of 100 keV or less.**
- **Mounts directly in D-Pace ion sources.**
- **Simple, robust design for beam focusing.**

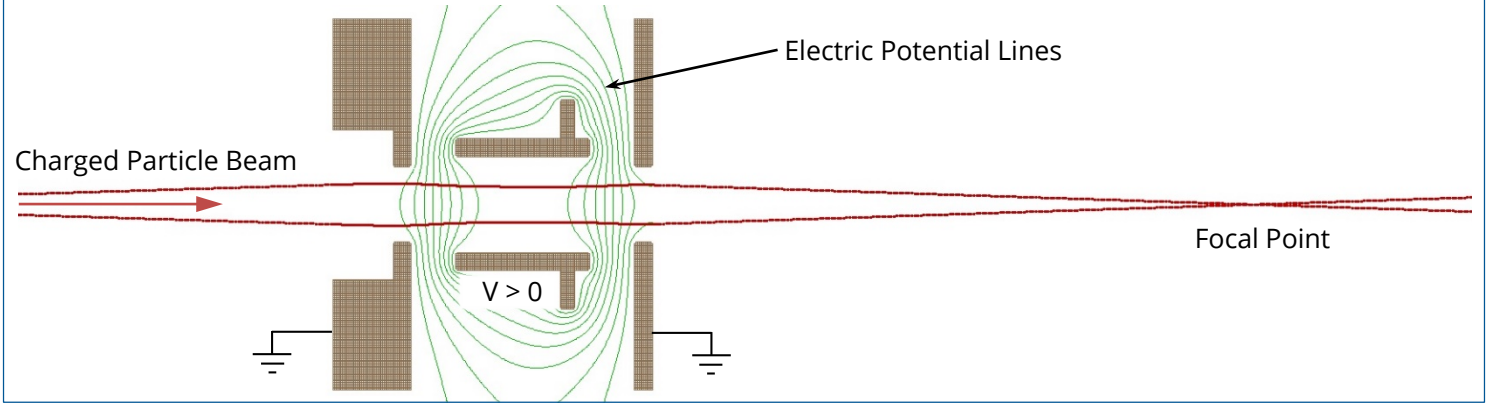
SPECIFICATION: LE-25.15.45	
Weight/Mass:	3.2 kg
Aperture:	Ø25 mm
Electrode Gaps:	15 mm
Electrode Length:	45 mm
Max. Voltage:	40 kV
Overall Dimensions:	Ø154 mm × 113 mm long
Vacuum Pressure Range:	1×10^{-4} to 1×10^{-9} torr
Cooling Method:	Radiant
Electrical Connection:	LGH Threaded connector, or Threaded Connector, or Push-Pin

The D-Pace **LE-25.15.45 Einzel Lens** is a simple, robust way to achieve beam focusing with beams of 100 keV kinetic energy or less. It was designed for the D-Pace filament and RF ion sources, but can easily be incorporated into customer beamlines. This Einzel lens is an in-vacuum device, capable of operating at 40 kV, and is constructed of metal and ceramic components, with PEEK insulated cable and attachments. A 40 kV electrical feedthough is provided with the Einzel lens.

The D-Pace LE-25.15.45 Einzel Lens is an effective addition to the D-Pace ion sources. When purchased with a D-Pace ion source, the Einzel lens can be delivered pre-installed. Visit www.d-pace.com to learn more about our sources, and explore other devices that can aid in beam shaping improvements.

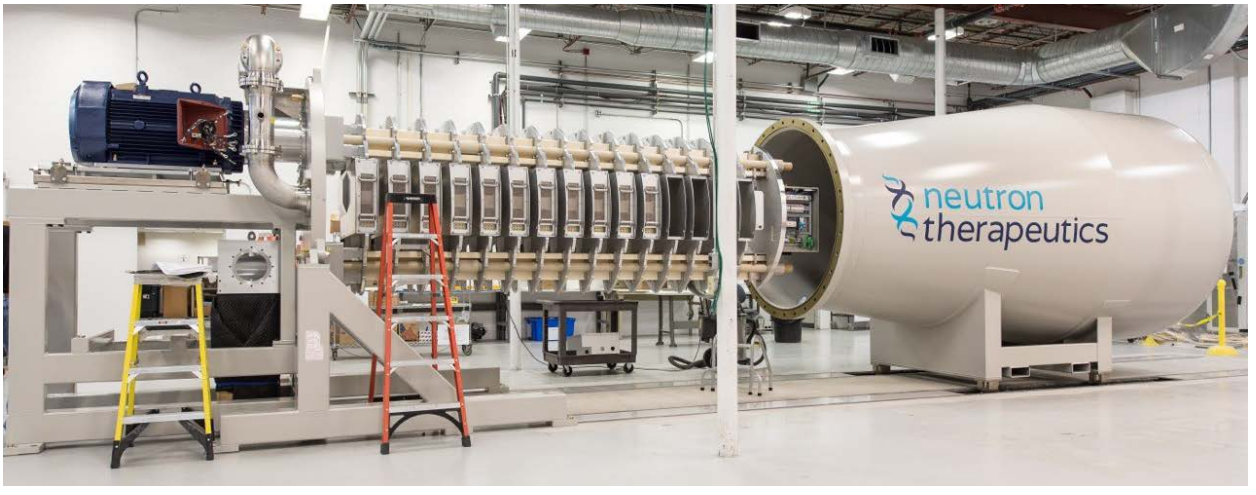
D-Pace Filament Ion Source

Einzel lenses are charged particle lenses that provide focusing without changing the resultant kinetic energy of the beam. They consist of three apertures along the beam axis, and focus the beam by creating an electric field in the path of the ions. This field is symmetric, so ions will regain their initial kinetic energy after exiting the lens. An electrical potential is applied to the middle aperture, while the upstream and downstream are grounded.



NT HIGH-CURRENT DC PROTON ACCELERATOR SYSTEM

Model: H+26.30



The NT 30 mA DC H^+ accelerator achieves proton energies of 1.85 – 2.6 MeV for research applications

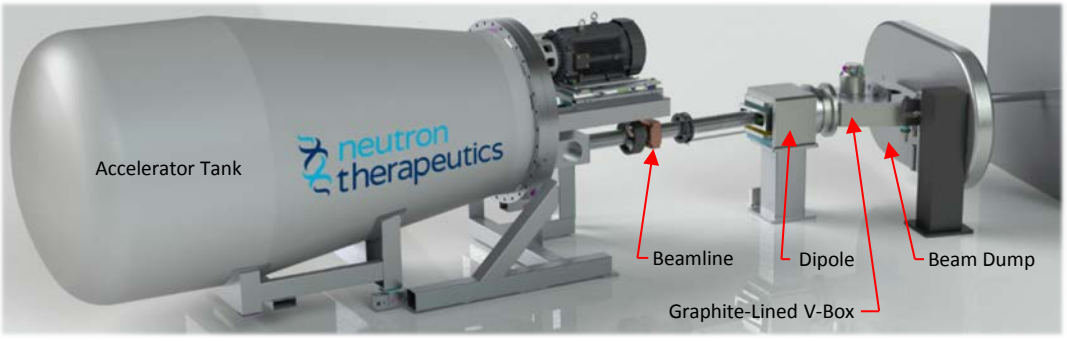
OVERVIEW:
High Current: Proton current 30+ mA DC, 2.6 MeV.
50% AC supply power to beam power efficiency.[2]
15° dipole for mass separation & elimination of neutron back streaming (when used for neutron production).
Economical footprint - compact design optimizes facility space requirements.
Less than 2 hour turn-around for routine maintenance, including SF_6 pump out and recharge time.
Modular accelerator structures. 15 identical accelerator stages with modular power supplies.
100kW beam dump for tuning at full beam current.
Customizable beamline to suit customer's application.
Proven reliability: Prototype system factory tested for 37,000 mA·hours at 30mA continuous beam, for > 100 hours/month over one year period. Designed for continuous operation with uptime > 98%.
Complete support and maintenance service packages available, including consumables, replacement parts and quarterly/annual maintenance procedures.

The NT Model H+26.30 is a comprehensive accelerator system for DC proton beam currents of 30+ mA at 2.6MeV.

Industrial and research applications including:

- Implantation
- Neutron applications:
  - BNCT R&D
  - Physics & materials research
- Silicon and sapphire exfoliation
- Contraband detection systems
- Materials surface modification

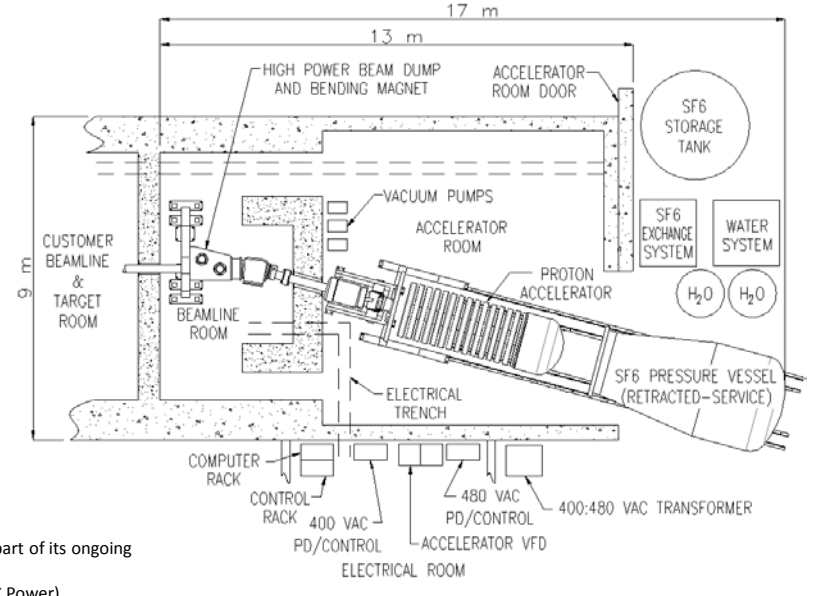
- The accelerator can be supplied with a lithium target for neutron production.
- The beamline incorporates three quadrupoles and two pairs of XY steering magnets.
- The system includes a complete SF_6 (high-voltage isolation gas) handling system on a pallet. This ensures rapid SF_6 gas containment for servicing the accelerator. It consists of a storage tank, pumps and a heat exchanger.
- The system includes a complete water cooling system (deionized & propylene glycol) on a pallet. This system requires just two connections to the customer-supplied water chiller.



ACCELERATOR SPECIFICATIONS:	
ACCELERATOR	
Proton Beam Current:	0 to 30+ mA DC
Proton Beam Kinetic Energy:	0.5 – 2.6 MeV ± 5 keV
Proton Beam: Gaussian beam profile. Adjustable spot size using supplied optics from 15 - 100mm 6σ width at typical target location, 4.4 m from dipole bending magnet center.	
Ion Source Type:	ECR, 2.45 GHz
Species:	H^+ (~90%), H_2^+ (~10%), Other (<1%) Beamline 15° dipole separation of H^+
Hydrogen Gas Flow Rate:	1 - 5 sccm
Hydrogen Bottle	566 litres, purity 99.99%
System Vacuum Level:	1 x 10^{-6} Torr Four turbo-molecular pumps
Electrical Isolation Gas	SF_6, 1090 kg, 99.95%
BEAMLINE	
Quadrupole Triplet	Qty 1
Dipoles, XY Steering	Qty 2, ± 1° max @ 2.8MeV
Dipole, High Power	Qty 1, 15° max @ 2.8MeV
V-Box	Graphite-lined alum, water-cooled
Beam Dump	100kW, water-cooled, graphite/alum
Beam Profiler	2D profiling beam dump

SITE REQUIREMENTS:	
ELECTRICAL POWER (Excluding Water Chiller)	
Panel Capacity:	400 VAC, 470 kVA, 50/60 Hz
Power Requirements:	288 kW (Full Load), 22 kW (Idle)
WATER CHILLER (Customer Supplied)	
Water Chiller Heat Capacity:	250 kW
Chiller Electrical Power	< 75kW
Flow Rate:	280 lpm max
AIR VENTILLATION	
Temperature / Dew point:	18°C - 25°C / 14°C max
Flow Rate, Accelerator Room	Per local building codes for air exchange of room volume - neutral heat load due to water cooling.
Flow Rate, Electrical Room	Per local building codes for air exchange of room volume + 24kW heat removal.
Emergency SF_6 Duct to O/S	Ø200mm, rated to 1 bar
COMPRESSED DRY AIR	
Pressure	7 bar (100 psi)
Flow, nominal / intermittent	9 m^3/hr (5 cfm) / 43 m^3/hr (25 cfm)

SF_6 Transfer System



Facility Layout – Shielding shown for typical neutron application

1. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.
2. Based on typical operation. (Beam Power)/(Motor AC Power)