



ION SOURCE TEST FACILITY

PRODUCTS & SERVICES

WHAT WE DO



D-Pace

Dehnel – Particle Accelerator
Components & Engineering, Inc.



D-Pace, Inc. is part of the Buckley Systems group. Buckley Systems is a New Zealand manufacturer of precision electromagnets, ion beam physics hardware, and high vacuum equipment.

ABOUT

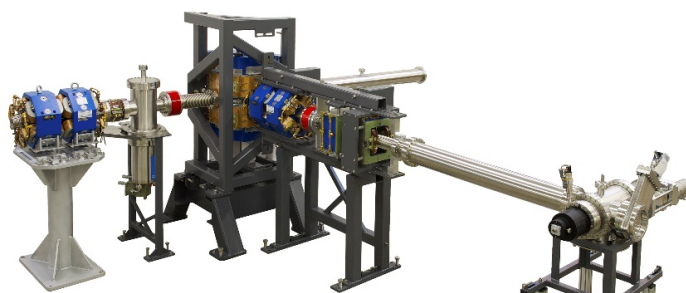
D-Pace supplies products and services to the international commercial accelerator industry. Our products and areas of expertise include beamline systems, beam diagnostic devices, and ion sources for research, industrial, and commercial accelerator systems. Our knowledgeable staff are well-versed in the special details associated with designing accelerator-related equipment. D-Pace works with experts worldwide to meet our customer's needs, and is committed to **innovation**, **quality** and **customer satisfaction**.

WE PROVIDE

- **Accelerator equipment** – accelerator sub-systems, industrial beamline systems, and individual components such as magnets, vacuum chambers, beam diagnostic devices, and electrostatic devices.
- **Ion-optical modeling, engineering, mechanical design, drafting and documentation services** – industrial beamline systems and components.
- **High performance, filament, and RF, DC volume-cusp H^- / D^- ion sources** – licensed and backed with TRIUMF support and with the University of Jyväskylä.

PRODUCT LIST

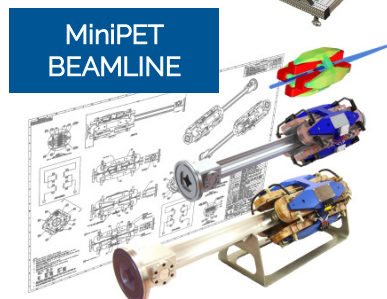
	NAME	MODEL
B.L.	MiniPET Beamline	MiniPET-30
	High Energy Beamline for BNCT	BNCT-50k
MAGNETS	1:500 Spectrometer, 90°	SPEC-500
	1:1500 Spectrometer, 90°	SPEC-1500
	1:100 Spectrometer, 45°	SPEC-100.45
	DC XY Steering Magnet	XY-85.184
	4-Port Target Selector	DM-14.4X18
	5-Port Target Selector	DM-14.5X13
	90° Bender Magnet	DM-54.90
	T-Magnet	DM-20.90.T
	90° Bender Magnet	DM-45.90
	TRIUMF/ISAC 22.5° Dipole	DM-50.22
	TRIUMF/ISAC 15° Dipole	DM-100.15
	3.25" Bore Quadrupole	QM-83.202
	Half Bunny Quadrupole	QM-103.186
	60 mm Bore Quadrupole	QM-60.100
	TRIUMF/ISAC BL2A Quadrupole	QM-BLA2
	Low Field Quadrupole	QM-38.80
	AC Scan Magnet	SM97-A
	400 G Solenoid	SOL-60.200
E.S.	Electrostatic Quadrupole Triplet	QE-3.50
	Einzel Lens	LE-25.15.45
DIAGNOSTICS	UniBEaM25 Optical Fiber Scanner	UniBEaM25
	UniBEaM75 Optical Fiber Scanner	UniBEaM75
	Oscillating Wire Scanner	OWS-30
	High Power Scintillator	BPV-100
	Beamline Quartz Scintillator	BPV-97.F
	Quartz Scintillator Target Insert	BPV-24.F
	Beam Stop, 10 kW	BS-40.10k
	Faraday Cup, 1 kW	FC-25.1k
	Faraday Cup, 3 kW	FC-25.3k
	Faraday Cup, Fixed, 600 W	FC-32.600.F
	Faraday Cup, 50 W	FC-50.50
	Precision Slits, 50 W	PS-50.50
	Emittance Scanner, 1.5 kW	ES-4
	Emittance Scanner, 10 kW	ES-100.10k
ION SOURCES	15 mA H ⁻ Filament Ion Source (Also D ⁻)	ISV.F-040
	7.5 mA H ⁻ RF Ion Source (Also D ⁻ , C ₂ ⁻ , C ₂ H ⁻ , C ₂ H ₂ ⁻)	ISV.RF-040



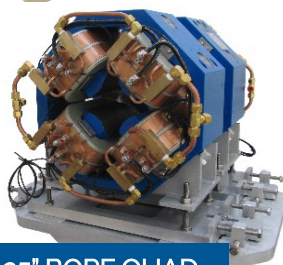
HIGH ENERGY BEAMLINE FOR BNCT



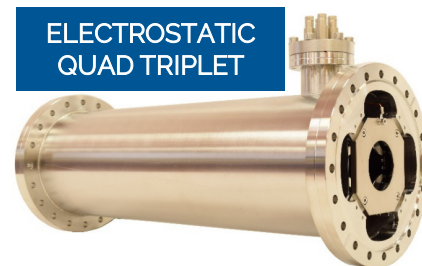
1:500 SPECTROMETER



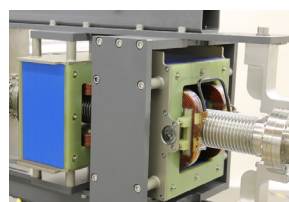
MiniPET BEAMLINE



3.25" BORE QUAD



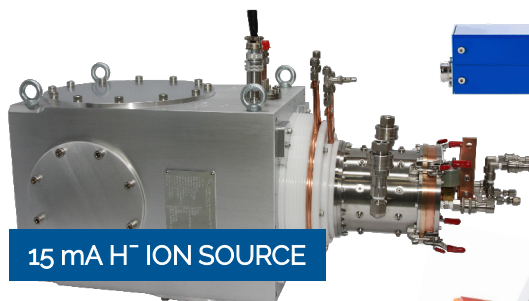
ELECTROSTATIC QUAD TRIPLET



AC SCAN MAGNET



DC-XY STEERING MAGNET



15 mA H⁻ ION SOURCE



UniBEaM25



EMITTANCE SCANNER

ENGINEERING SERVICES

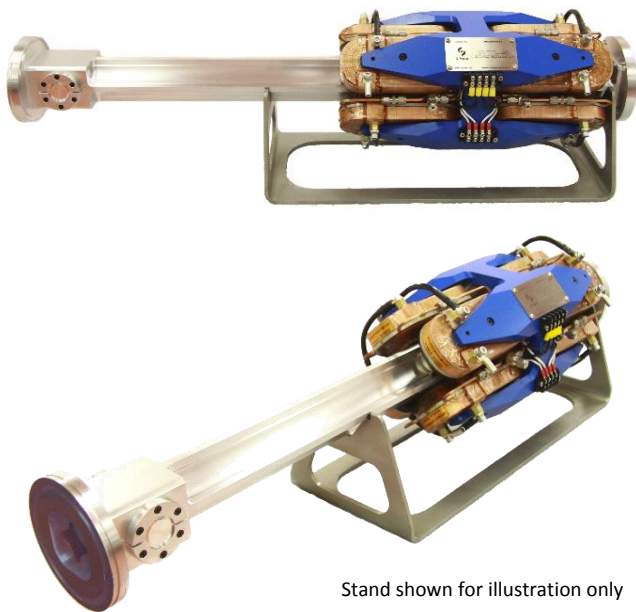
D-Pace also provides such services as:

- Beam measurement & characterization
- Custom engineering, design, & drafting
- Emittance scanning
- Training



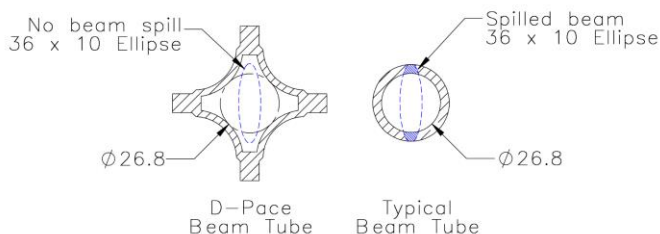
MiniPET-30 Beamline

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



Stand shown for illustration only

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.



- 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

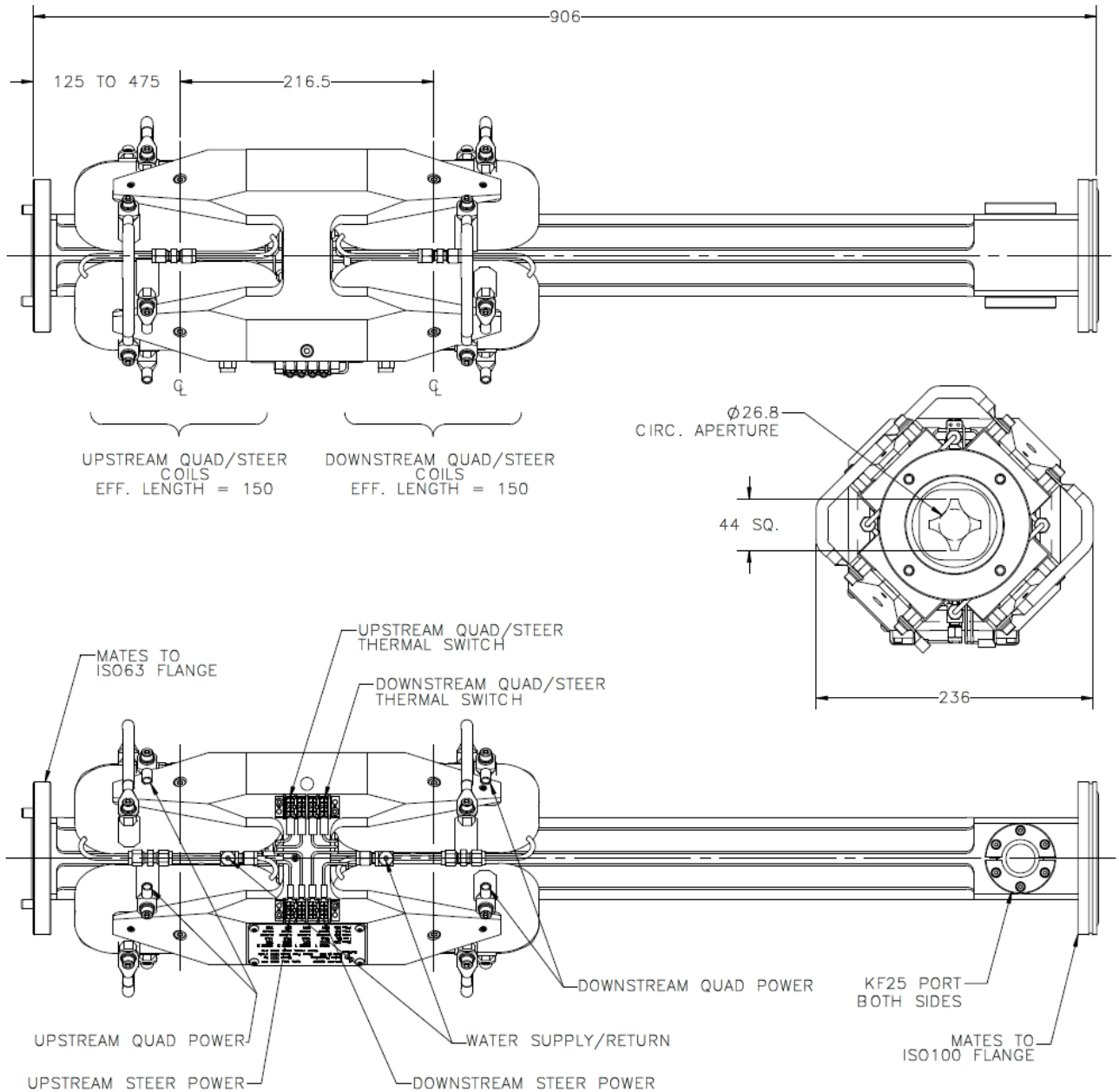
SPECIFICATIONS: *MiniPET-30* Beamline

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	0.25 Tesla
Quadrupole B/l	33 Gauss / A
Effective Length	150 mm
Max. Steering Angle	6.5 mrad at 12.6 MeV H ⁺
Cooling Water:	
Input	1 L/min, 20 °C
Connections	4 mm OD Tube Fitting
Thermal Switch:	One per coil
Trip Temperature	70 °C
Connection	#6 Screw Terminal
Power Supply Input (each, 4 supplies)	230 V AC, Single Phase, 50/60 Hz, 6 A Max.

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:	Quantity = 2	Quantity = 2
Output	0-75 A, 0-8 V, 600 W	± 10 A, ± 20 V, 200 W
Control	Analog 0 to 10 V	Analog -10 to $+10$ V

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

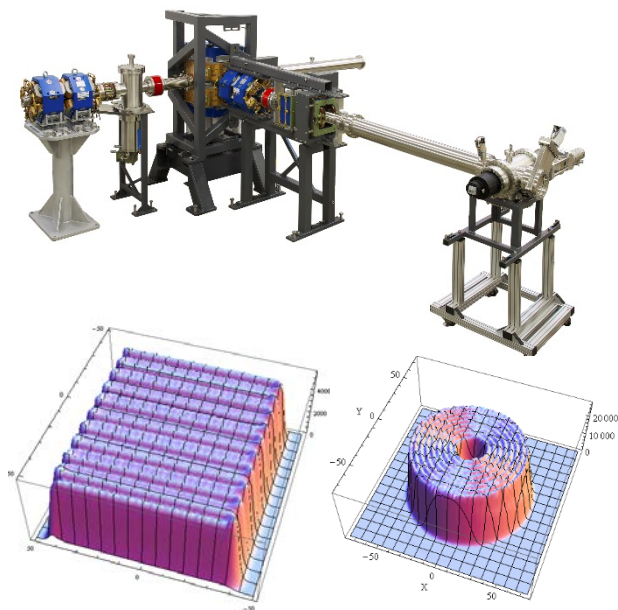
The *MiniPET-30* beamline includes power supplies to operate the four magnet functions: horizontal focusing, vertical focusing, horizontal steering, and vertical steering. A customized beam pipe can be provided to match the overall length and flange connections of existing installations. Additional KF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



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.

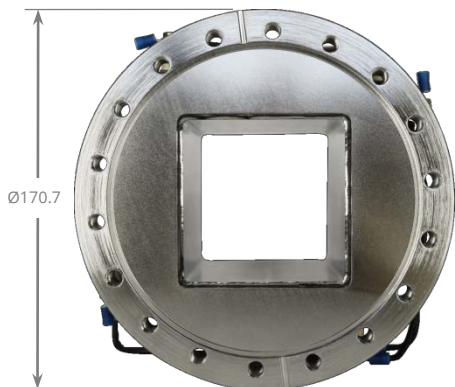
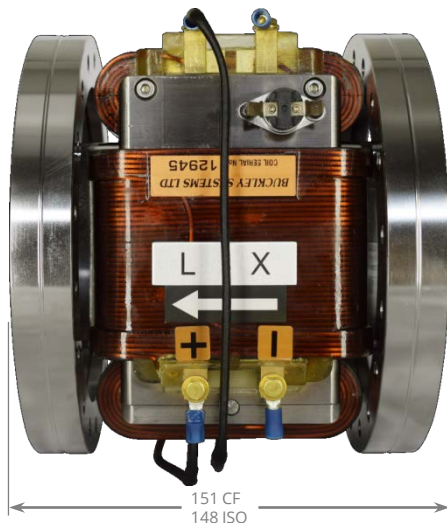
- Uniformly distribute beam on target with scan magnets.
- Beam Profile Monitor for low power beam scan visualization.
- Large acceptances for low transmission losses.
- Install in horizontal or vertical arrangement.
- Includes:
 - Magnets and stands.
 - Power supplies and cabinet.
 - Beam diagnostics.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

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	<ul style="list-style-type: none"> - Quadrupole Doublet (two pair) - DC XY Steering Magnet - 90° Bending Magnet - AC XY Scan Magnet Pair (with arbitrary function generators)
Diagnostics	<ul style="list-style-type: none"> - 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, $L_{\text{Eff}} = 202.3$ mm, $B_{\text{max}} = 0.4$ T
DC XY Magnet Specifications:	Iron Gap = 105 mm, $L_{\text{Eff}} = 184$ mm, $B_{\text{max}} = 0.01$ T
90° Bending Magnet Specifications:	Iron Gap = 52 mm, $L_{\text{Eff}} = 300$ mm, $B_{\text{max}} = 1.3$ T Pole-Face Entrance/Exit: Normal to beam
AC XY Scan Magnets (SM97-A spec. sheet)	

DC XY STEERING MAGNET

Dipole magnet provides steering in two directions

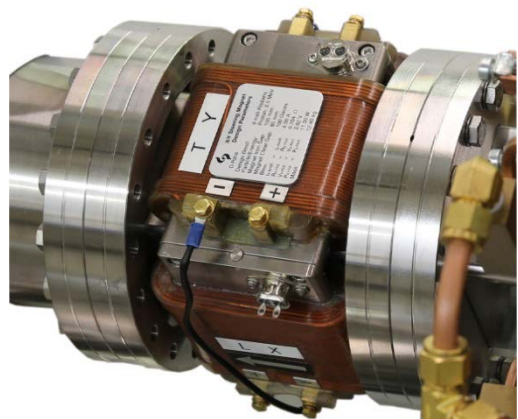


- Used to make small corrections to the charged particle beam direction
- Each steering direction operated by its own bipolar power supply
- No stand required. Supported from the flanges.
- Available with : 6-3/4" CF (DN125) flanges or ISO100 compatible flanges

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

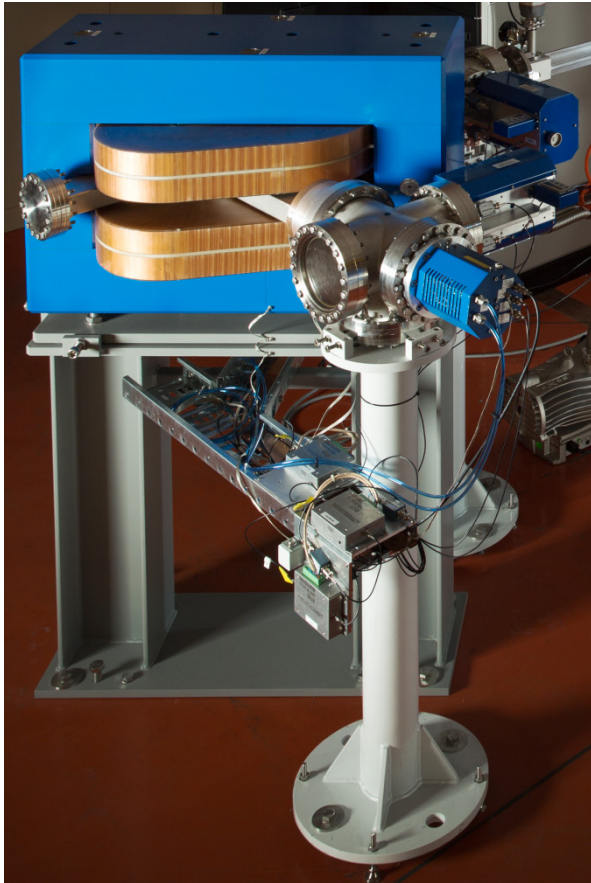


D-Pace reserves the right to update specifications as part of its ongoing product improvement program. Refer to D-Pace website for latest specifications.



1:500 MASS/ENERGY SPECTROMETER

Resolves ion beams to better than 1 part in 500.



The **D-Pace 1:500 Mass/Energy Spectrometer System** has been designed for resolving charged particle beams with $B\rho = 0.2196 \text{ T}\cdot\text{m}$ 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.

- 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:
 $T = 30 \text{ keV}$, $q = 1$, $M = 76 \text{ A.M.U.}$
- Magnet: 90° Dipole, $R = 191 \text{ mm}$, Mass = 2 Tonnes
- Upstream/Downstream Precision Slits:
 - 50 mm beam height
 - 0 - 20 mm manually adjustable gap, accurate to $\pm 0.05 \text{ mm}$

SPECIFICATIONS

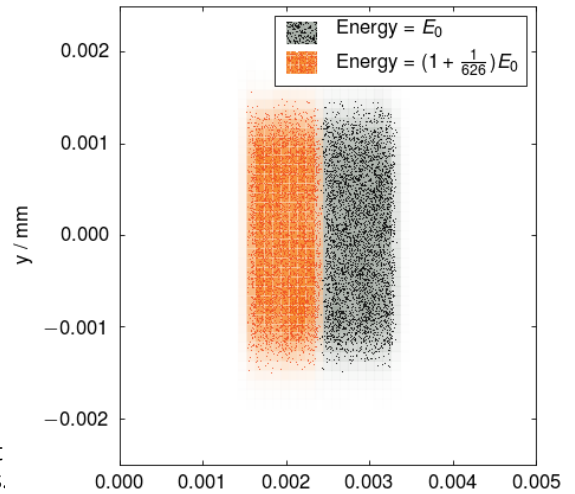
Mass (Weight)	~2200 kg
Bend Radius/ θ/B_{\max} $B\rho$	191 mm / 90° / 1.15 Tesla 0.2196 T·m
Ent./Exit Slit to Magnet Distance	500 mm / 615 mm
Vacuum Chamber	316 Stainless Steel, UHV
Magnet Gap	50 mm (V-Box Gap 42 mm)
Ent. & Exit Pole Angle	34.79°
Effective Length	300 mm
Beam Axis Height	1050 mm
Thermal 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 $\varnothing 10 \text{ mm}$ tube Fitting
Power Supply Output: Remote Control Current Control	100 A, 60 V, $\pm 10 \text{ ppm}$ RS232 1 – 100%
Power Supply Input (Other inputs possible)	400 VAC, Three Phase + neutral, 47/63 Hz

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

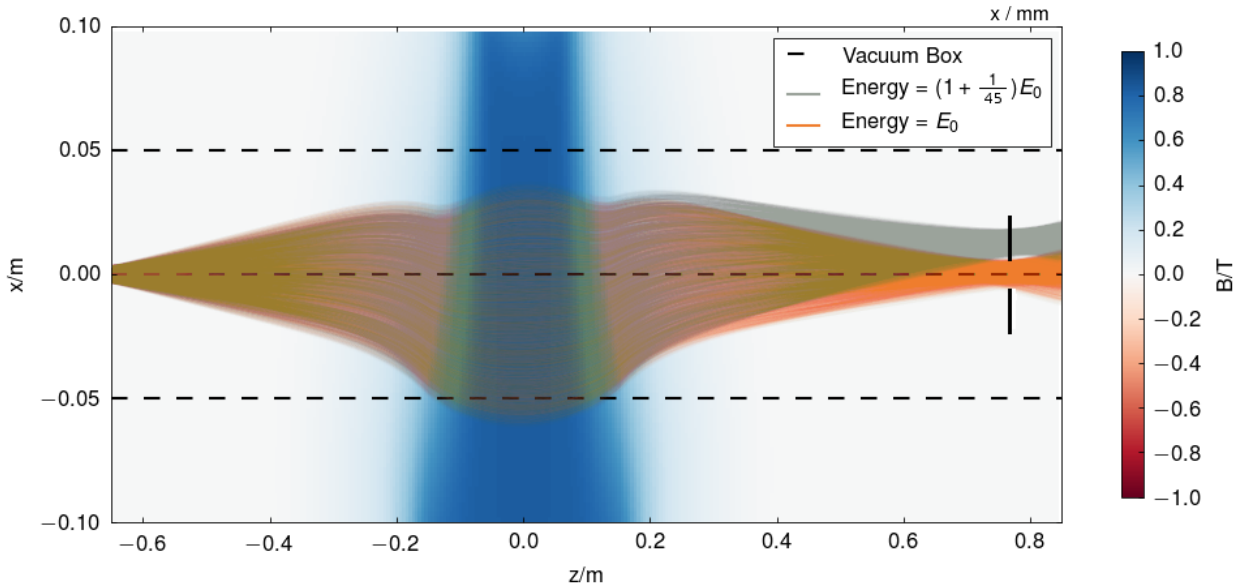
TABLE 1: Spectrometer resolving power as a function of accepted beam size in vacuum box for charged particle beams.

- 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.



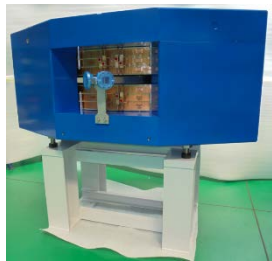
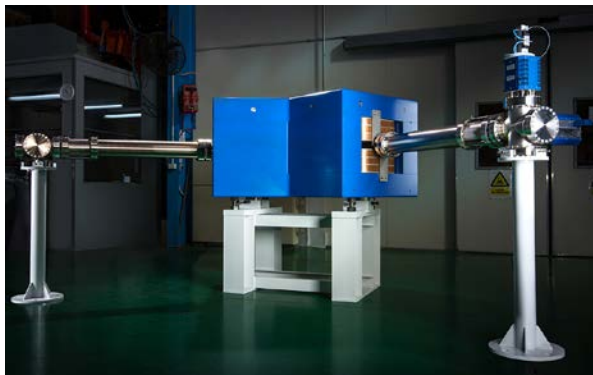
Beam-n5: Shows the n = 5 case from Table 1 (largest beam sizes in magnet) with two just-resolved beams.





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.

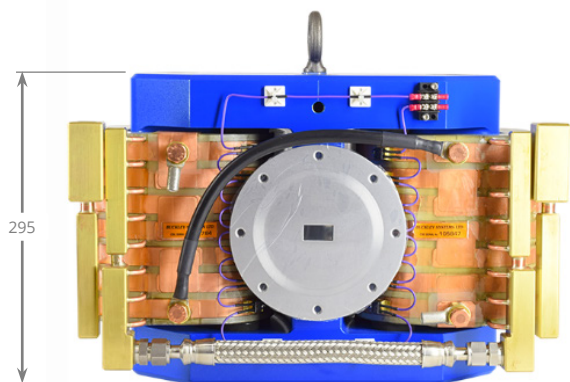
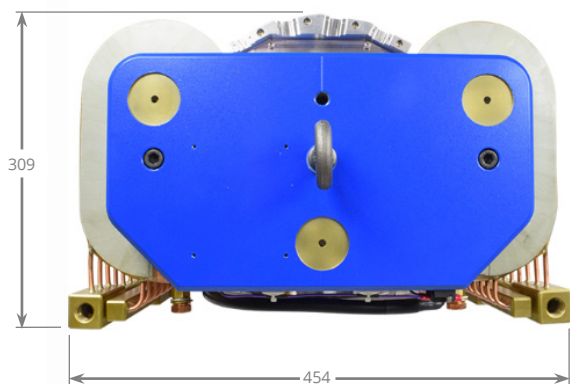
- Mass Resolution 1:1500 at 1.00 mm slit width
- Maximum Current, Energy, Mass: 1 mA, 50 keV, $q = 1+$, 1500 A.M.U.
- Magnet: 90° , $R = 1$ m, Mass = 10 Tonnes
- Upstream/Downstream High Resolution Slits:
 - 50 mm height
 - 0 - 20 mm Width accurate to ± 0.05 mm
- Pneumatic Faraday Cup with 50 mm Aperture

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 $\varnothing 12$ 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,

4-PORT TARGET SELECTOR

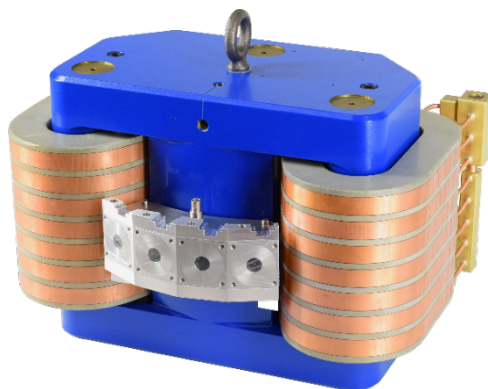
Magnetic target selector with 4 target ports, protection collimator and beam readback.



- 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	$\pm 9^\circ$, $\pm 27^\circ$
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

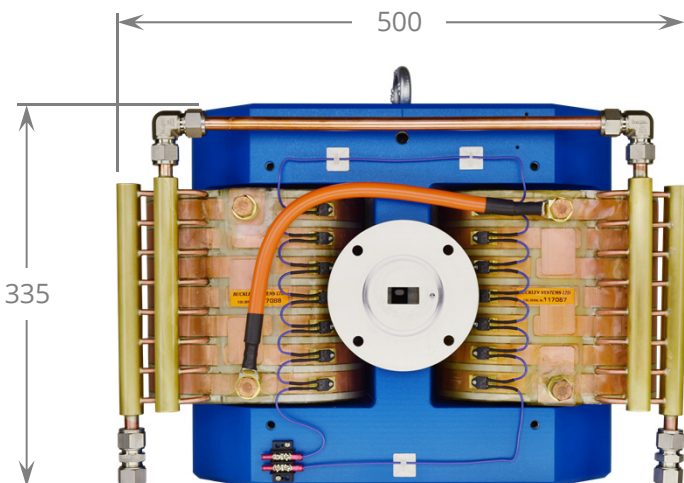
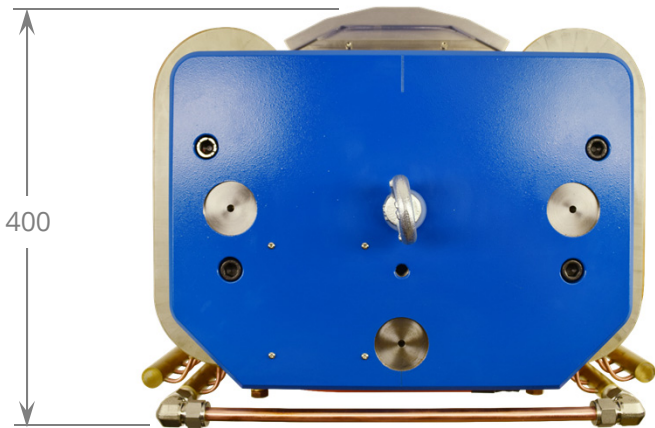
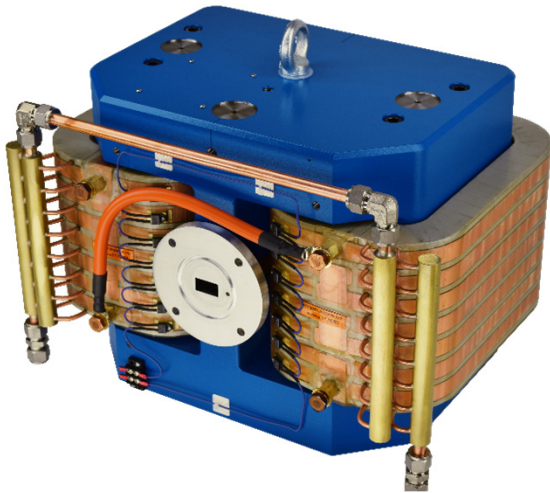




5-PORT TARGET SELECTOR

DM-14.5X13

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



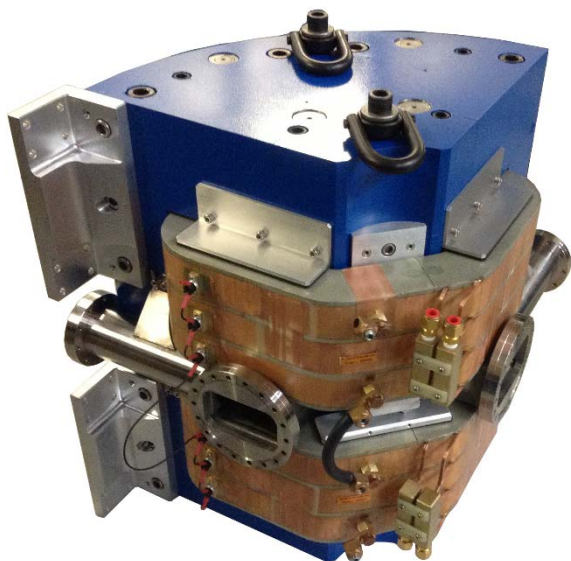
- Direct proton beams up to 18 MeV.
- Select from 1 of 5 target positions.
- Includes a protection collimator before targets, with beam current readback for safety interlocks.
- Coil and yoke design reduce irradiation of upstream equipment.
- Compact design ideal for use with MiniPET-30.

SPECIFICATION: DM-14.5X13

Mass (Weight):	278 kg
Target Angles:	$\pm 27^\circ$, $\pm 13.5^\circ$, 0°
Bend Radii:	636.6 mm, 1273.2 mm
Effective Length:	300 mm
Max. Field:	1.24 Tesla
Max. Current:	130 A
Max. Voltage:	31.3 V
Max. Resistance:	0.24 Ω
Max. Power:	4.07 kW
Gap (Vacuum Box)	14.5 mm
Exit Apertures:	$\varnothing 15$ mm
Coil Thermal Switches:	12 total (6 per coil)
Trip Temperature:	70°C
Cooling Water Flow:	> 3.0 L/min
Pressure Drop:	16.9 kPa
Inlet Temperature:	< 20 °C
Connections:	12 mm O.D. tube fittings
Vacuum Box:	Aluminum
Entrance Flange:	ISO100
Collimator Readback	BNC, grounded shield

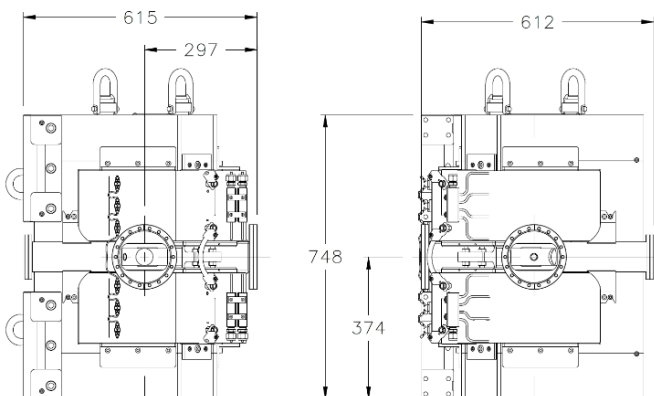
The **5-Port Target Selector** is a dipole magnet designed to direct a charged particle beam to one of five output directions. Intended for use with five targets, the device operates as a magnetic target selector. Included in the output of the vacuum chamber is a beam collimator, with a single beam current readback.

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



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



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

SPECIFICATIONS: DM-85.90

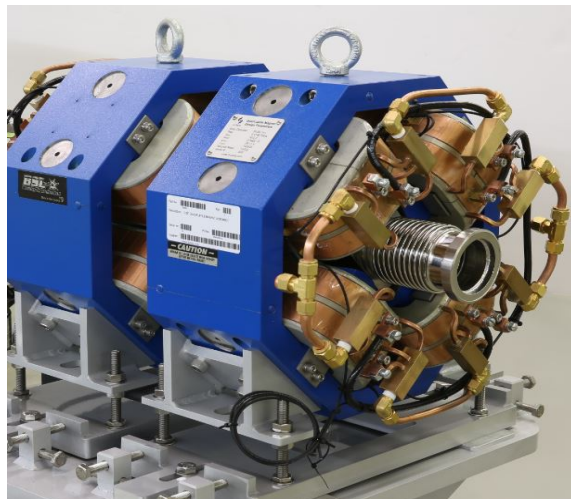
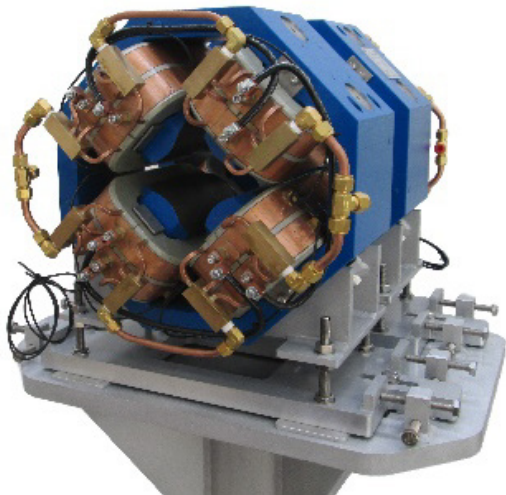
Mass (Weight)	1067 kg (magnet only)
Bend Angle	90°
Bend Radius	191 mm
Effective Length	300 mm
Max. Field	1.3 T
Max. Current/Voltage	125 A
Max. Voltage	33 V
Magnet Gap, Clear Gap Gap	54 mm, 49 mm
Thermal Switches Trip Temperature	3 per coil (1 per pancake) 70°C
Vacuum Chamber	316 SS (UHV)
Entrance/Exit 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" / 82.55 mm 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

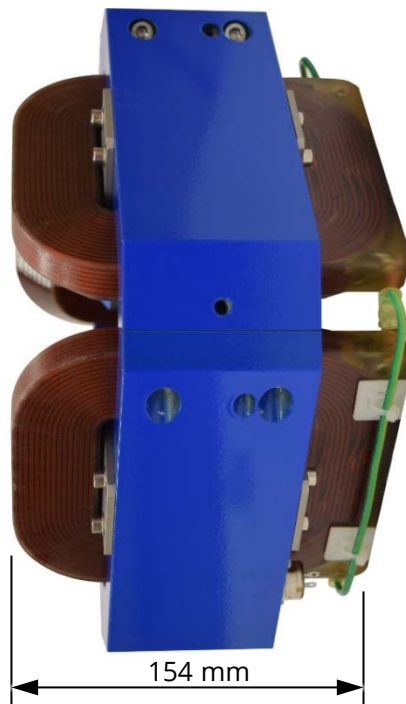
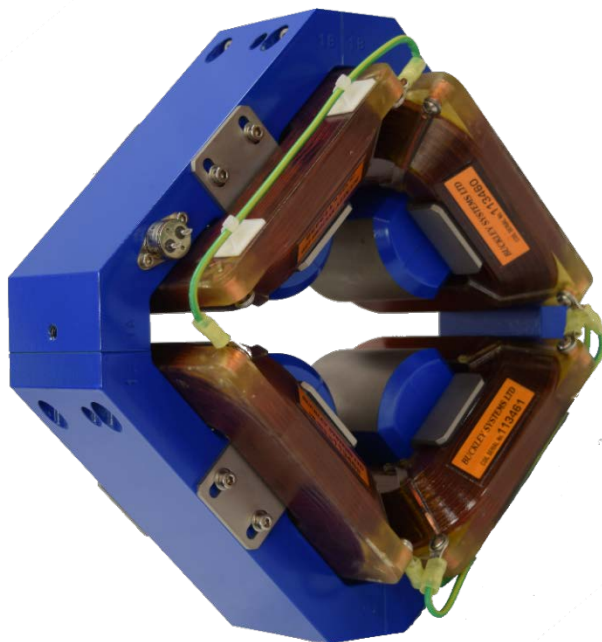


SPECIFICATION: QM-83.202

Magnet Type	Quadrupole
Bore Diameter	82.55 mm (3.25")
Iron Length	161 mm
Effective Length	202 mm
Mass	125 kg
Pole Tip Magnetic Field @ Max Current	0.42 T
Max Current	50 A
Max Voltage (Hot)	30 V
ΔT @ Max Current	$\sim 10^{\circ} \text{C}$
Cooling Water Flow	4 l/min
Inlet Pressure	~ 8.5 psi
ΔP	~ 3 psi
Thermal Switches Activation Temperature	70°C

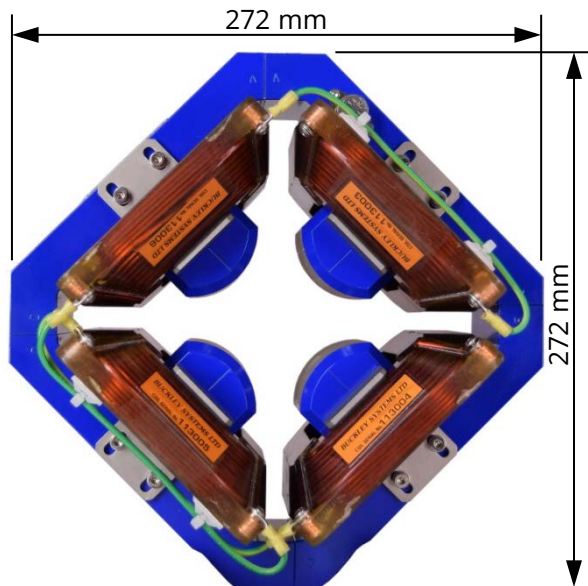
Ø60.0mm Bore Quadrupole Magnet

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



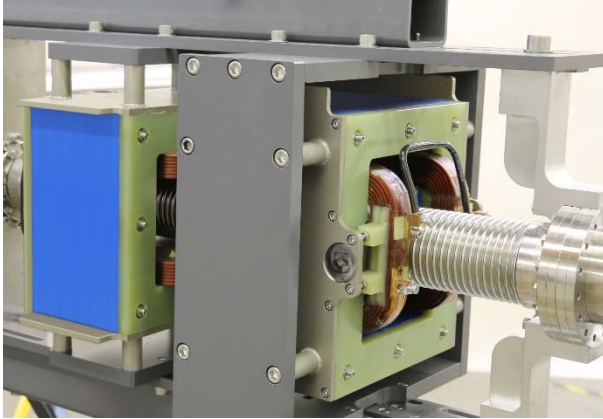
OVERVIEW:

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



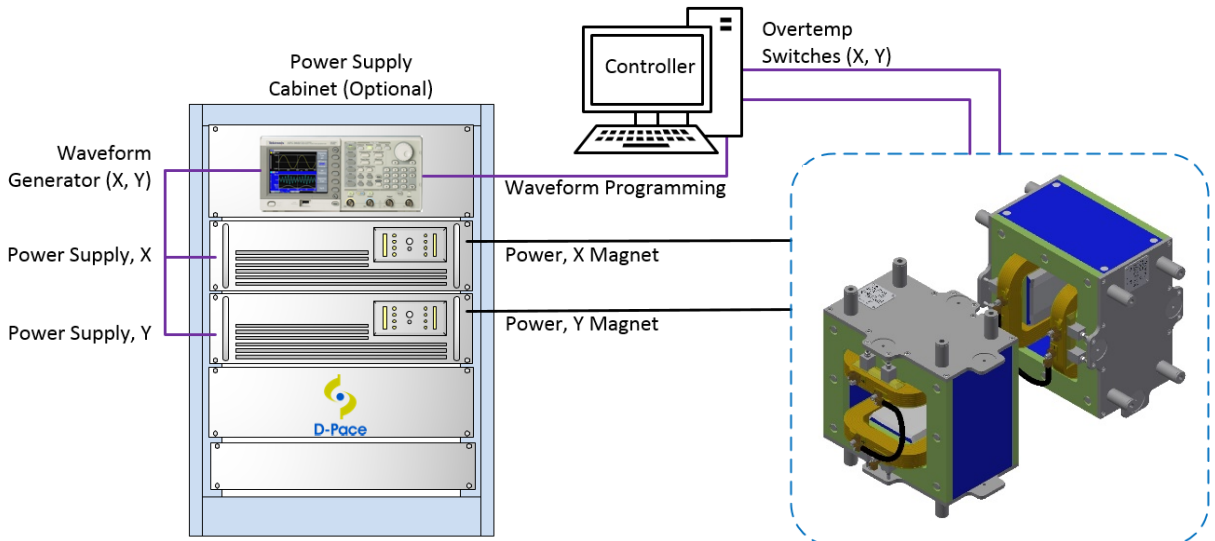
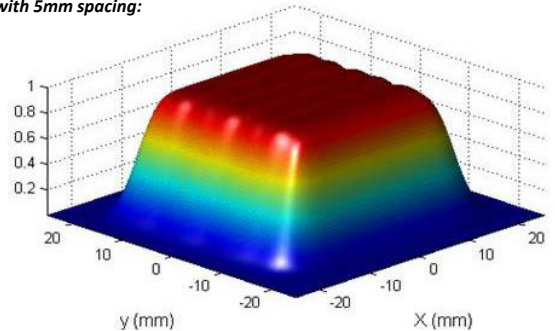
The **D-Pace Scanning Magnet System** is used to deflect a charged particle beam, usually for the purpose of managing power density on targets. Typically used in pairs (one to scan in the X plane, and one to scan in the Y plane) these AC magnets are driven by a dual-axis waveform generator and bi-polar 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 Gauss¹
- Scan frequencies up to 250 Hz²
- 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:

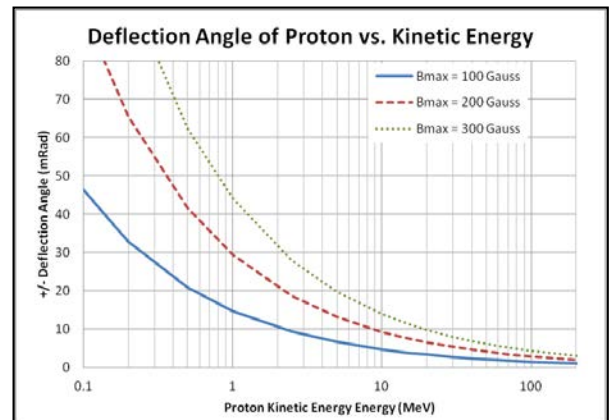
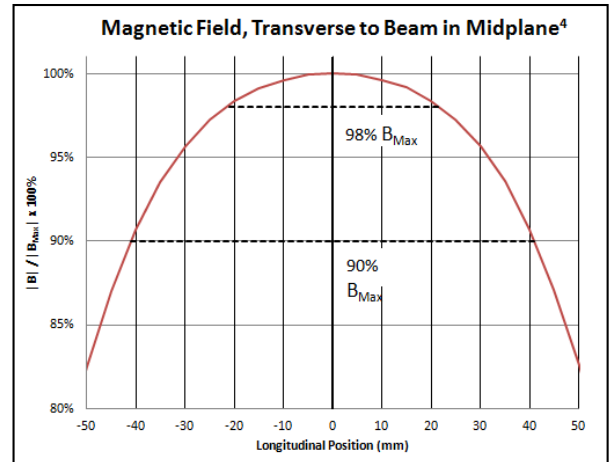
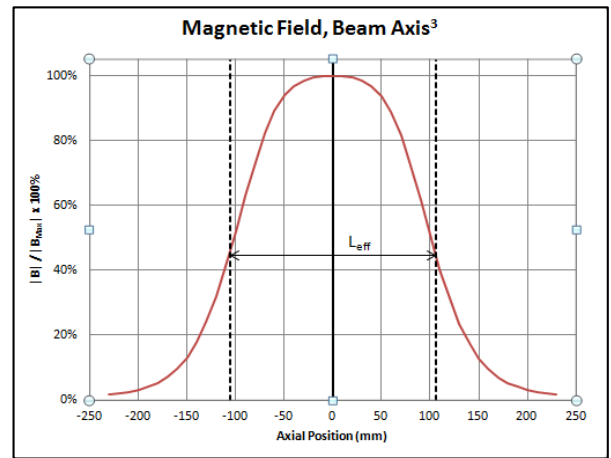
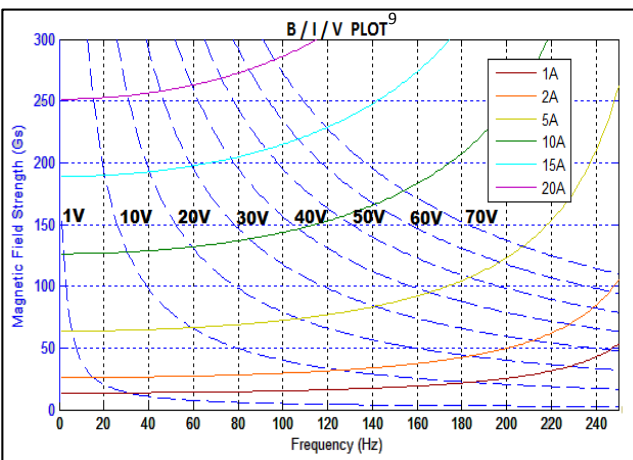


MAGNET SPECIFICATIONS

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 SPECIFICATIONS⁵

1) Power Supplies	Per Customer Requirements
2) Waveform Generator	2 Channels, 14 bits
3) Optional Cabinet (H x W x D)	16U Instrument rack 780 x 534 x 622mm
Mass (items 1, 2, 3)	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.

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 diameter² 25 mm
- Beam energy density³ 1 W/mm²
- No vacuum box required
- Insertion length⁴ 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

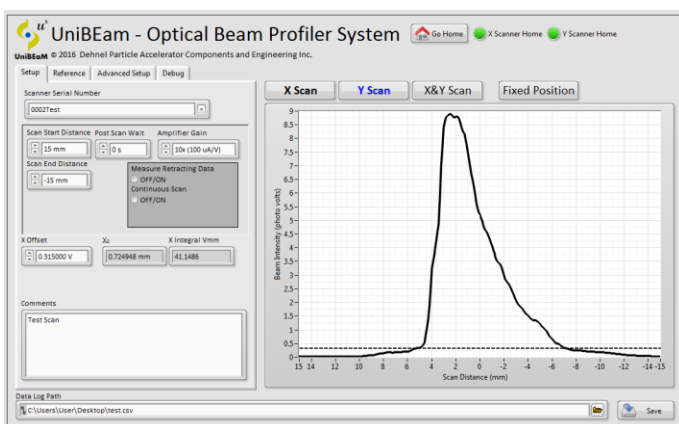
UniBEaM was conceived by the AEC-LHEP of the University of Bern¹ and commercialized by D-Pace. UniBEaM is a charged-particle beam profiling system - similar to a wire scanner except an optical sensor fiber is used instead of a metal wire. Ø50µm to 400µm sensing fibers scintillate in the visible spectrum 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.

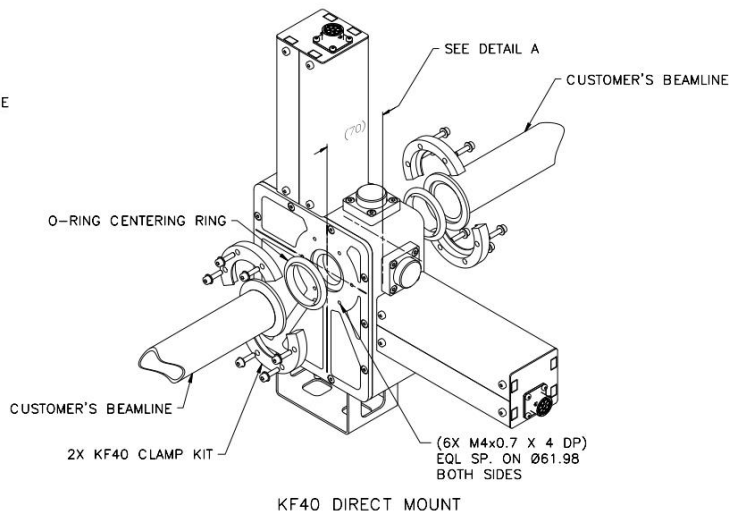
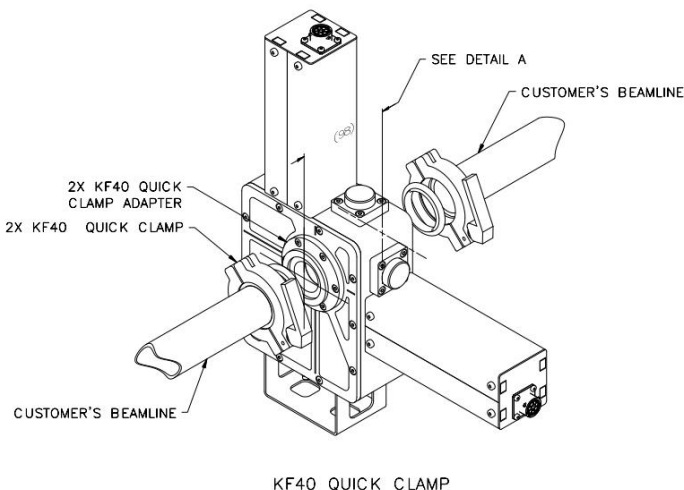
The probes are very compact, and require only 70mm along the beam axis⁴. X and Y scans can be conducted individually or concurrently.



Replaceable Sensor Fiber



Control & Analysis Software



SPECIFICATIONS: UniBEaM25-D

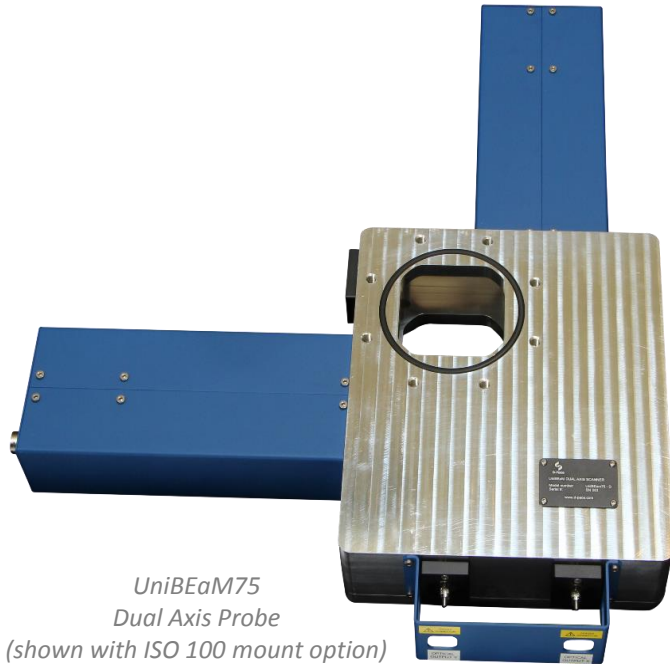
Max Beam Diameter ²	25mm
Particle Kinetic Energy	> keV
Sensitivity (Standard) ⁵	12pA @ 18MeV
Max Power Density ³	1 W/mm ²
Sensor Fibers	Doped Silica Ø200µm (Ø50µm to Ø600µm)
Position Resolution	0.025mm
Scan Speed	18mm/second
Probe Insertion Length ⁴	70mm
Flange Options	KF40 quick clamp or bulkhead CF40 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/mm².
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.

DUAL-AXIS BEAM PROFILER

UniBEaM75

Beam Profiler System Using Scintillating Fiber Sensor



- Measures beams from keV to GeV and pA to mA depending on the power density deposited
- Maximum beam diameter 75 mm
- Beam energy density² 10 W/cm²
- No vacuum box required
- Insertion length³ of just 82 mm
- 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 Bern¹ 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 600µm 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 82mm along the beam axis³. X and Y scans can be conducted individually or concurrently.

SPECIFICATION: UniBEaM75

Max Beam Diameter ²	75 mm
Particle Kinetic Energy	> keV
Sensitivity (Standard) ⁴	12pA @ 18 MeV (H ⁺)
Max Power Density ²	10 W/cm ²
Sensor Fibers	Doped Silica Ø600 µm
Position Resolution	200 µm
Scan Speed	26 mm/s @ step size 2.0 mm 20 mm/s @ step size 1.0 mm 15 mm/s @ step size 0.6 mm
Probe Insertion Length ³	82 mm
Flange Options	ISO 100-F CF 100 Conflat
Probe Mass	13 kg
Data File Format	CSV
Controller	19" Rack Mount, 2U
Input Power	100-240VAC 50/60Hz
Cable & Fiber Length	15 m (custom available)



OSCILLATING WIRE SCANNER PROBE MODEL OWS-30

TRIUMF-Licensed, Beam Profiler



The **D-Pace OWS-30 Oscillating Wire Scanner Probe** performs two orthogonal intensity scans of a beam in one scanning operation. A 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 $\pm 13^\circ$. 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.

- Measure low-energy charged-particle beam profiles (< 1 MeV)
- Simultaneous orthogonal scanning as a diagnostic tool for centering a beam
- Scan $\varnothing 30$ mm beam²
- Controllable scan speed
- Interchangeable $\varnothing 0.5$ mm tungsten wires
- Optional turnkey system and custom vacuum box
- TRIUMF-licensed technology³

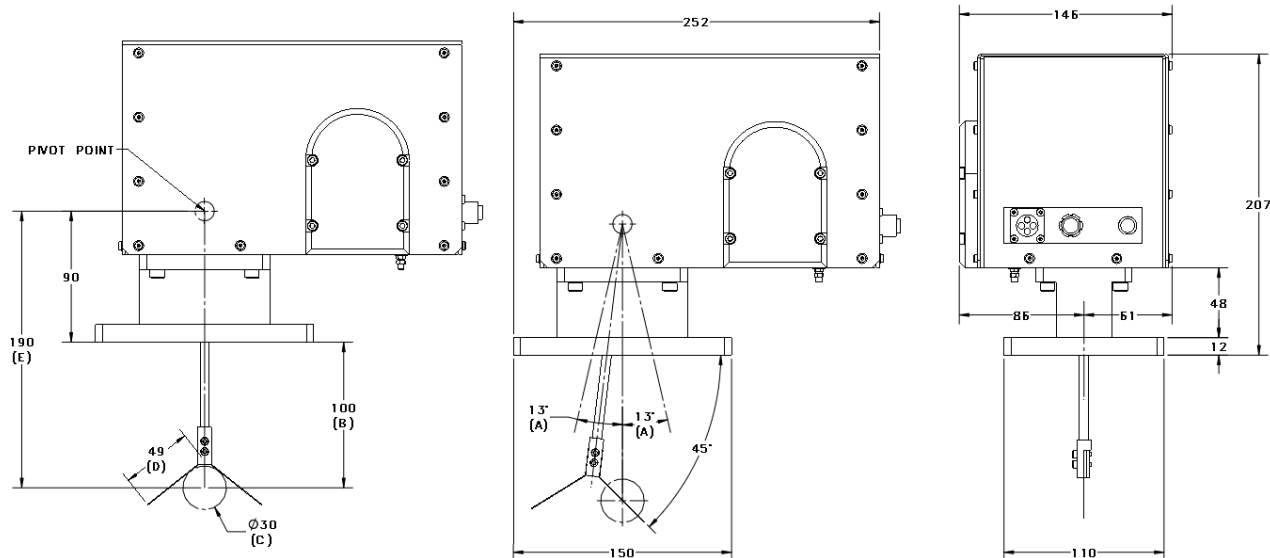
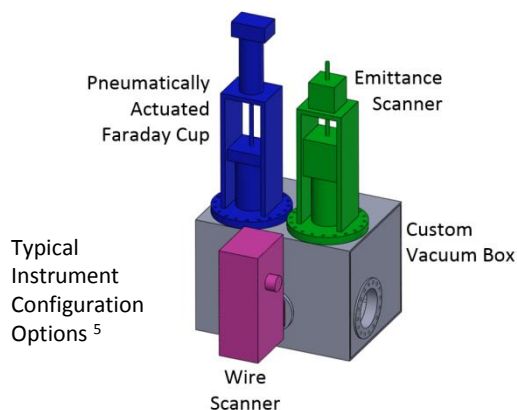
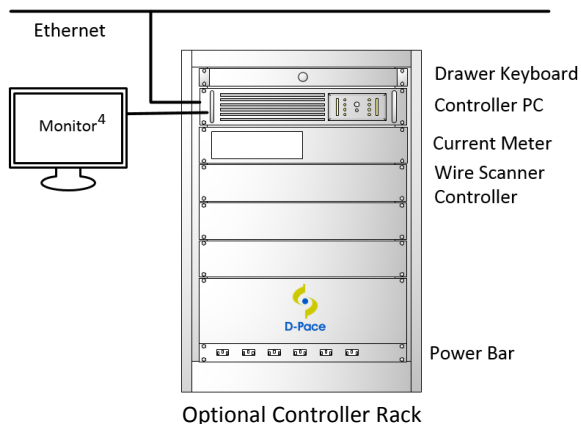
SPECIFICATIONS: OWS-30

Max Beam Diameter ²	30 mm
Min Oscillation Period	10 seconds/cycle
Max Oscillation Period	> 60 seconds/cycle
Maximum Beam Intensity	$1\text{W}/\text{mm}^2$
Wire	$\varnothing 0.5$ mm Tungsten
Bias voltage	None
Flange	Custom, O-ring
Mass	4 kg
Arm Scan Angle (A)	$\pm 13^\circ$
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.

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

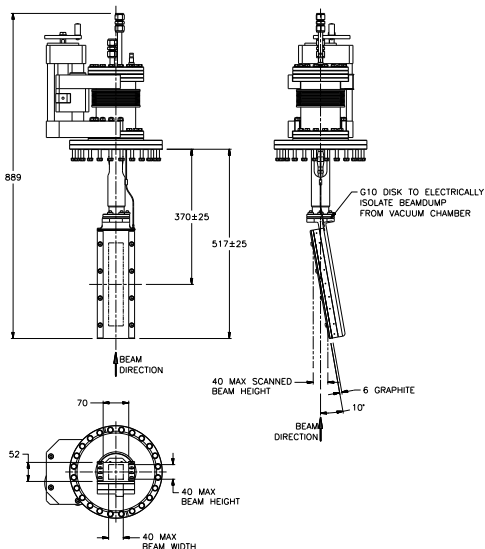


1. D-Pace can provide a custom vacuum box. Contact D-Pace with custom requirements for a quotation.
2. Wires tangent to beam diameter at maximum angle.
3. Technology licensed from TRIUMF for world-wide distribution.
4. Turnkey system with instrument rack option. Monitor not supplied.
5. Wire Scanner 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.



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	30 l/min
Inlet temperature	15°C (60°F)
Inlet connection	Ø12 mm Swagelok Tube fitting
Max inlet pressure	724 kPa (105 psi)
Pressure drop	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

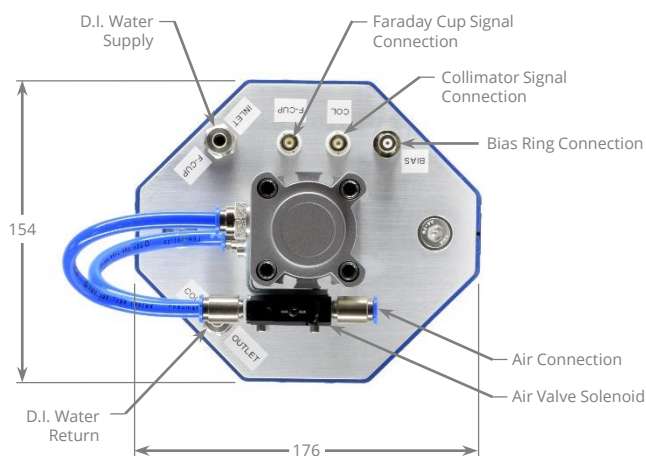
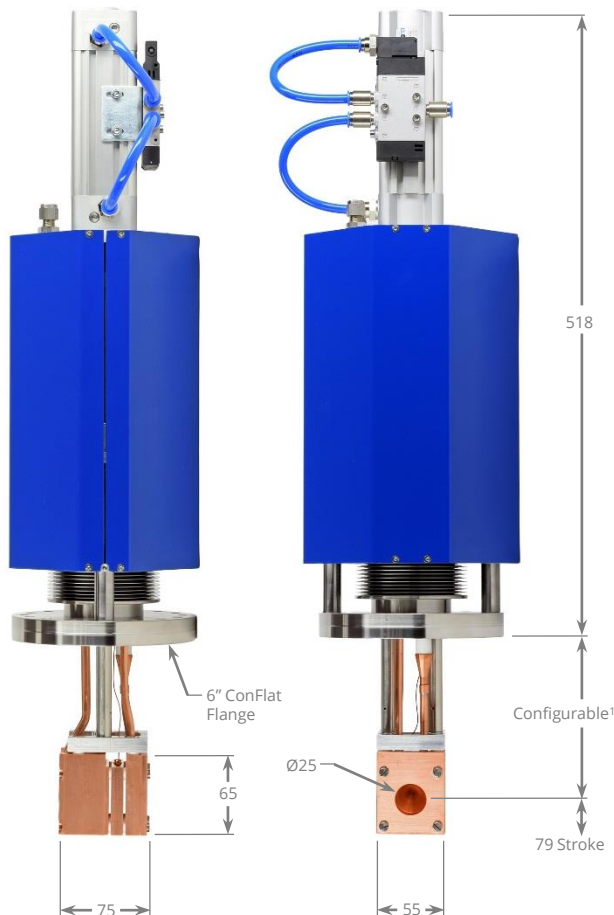
Notes:

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.

FARADAY CUP

FC-25.1K

Pneumatically-actuated, water-cooled, Faraday Cup for
Ø25 mm beams capable of 1 kW beam power



- Measure charged particle beams up to 1 kW beam power.
- 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

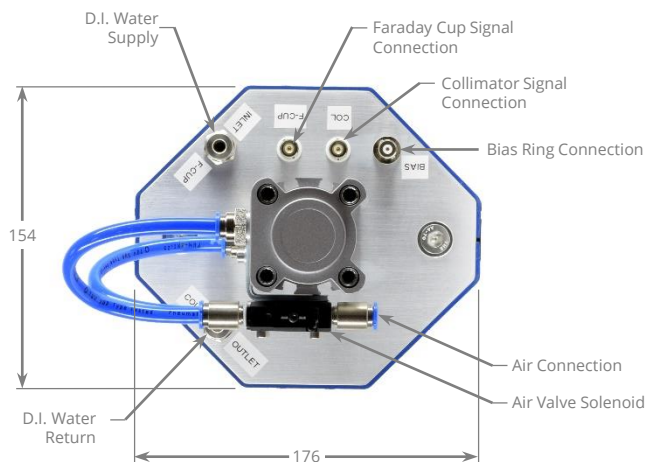
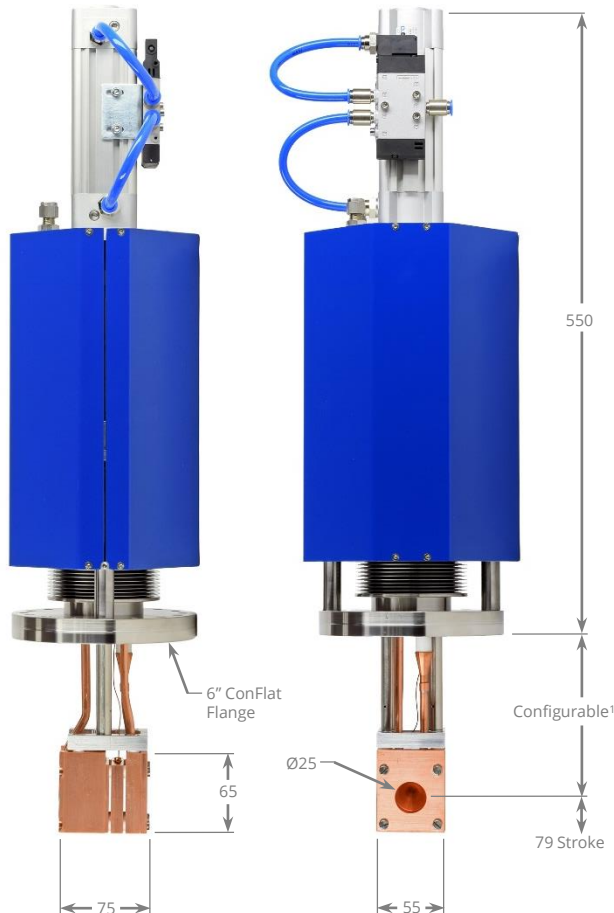
Max. Beam Power	1000 W (500W·cm ⁻²)
Collimator I.D.	Ø25 mm
Collimator Dimensions	55 mm × 65 mm
Cup/ Collimator Material	Copper ³
Flange	6" ConFlat (152 mm O.D.)
Max. Travel	79 mm
Pneumatic Operation Connections	24 V DC Solenoid Ø8 mm push tube fitting
Cooling Water	3 L/min De-ionized water only
Inlet Temperature Connections	< 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) ⁴ (Inserted & Retracted)	N/O reed switch, 2-wire, 5-30 V, 80 mA max.
Cylinder Speed Adjustments ⁴	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.
3. Tantalum plating option available.
4. Limit switches and cylinder speed adjustments not shown in images.

FARADAY CUP

FC-25.3K

Pneumatically-actuated, water-cooled, Faraday Cup for
Ø25 mm beams capable of 3 kW beam power



- Measure charged particle beams up to 3 kW beam power.
- 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 adjustment

SPECIFICATIONS: FC-25.3K

Max. Beam Power	3 kW (< 12 kW·cm ⁻²)
Collimator I.D.	Ø25 mm
Collimator Dimensions	55 mm × 65 mm
Cup/ Collimator Material	Copper ²
Flange	6" ConFlat (152 mm O.D.)
Max. Travel	79 mm
Pneumatic Operation Connections	24 V DC Solenoid Ø6 mm push tube fitting
Cooling Water	3 L/min De-ionized water only
Inlet Temperature Connections	< 20 °C Ø 1/2" (12.7 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) ³ (Inserted & Retracted)	N/O reed switch, 2-wire, 5-30 V, 80 mA max.
Cylinder Speed Adjustments ³	One-way flow control valves for exhaust air

1. Inserted length at retracted position configurable for customer's application. Stroke fixed.
2. Tantalum plating option available.
3. Limit switches and cylinder speed adjustments not shown in images.
4. D-Pace reserves the right to update specifications as part of its ongoing product improvement program. Refer to D-Pace website for latest specifications.



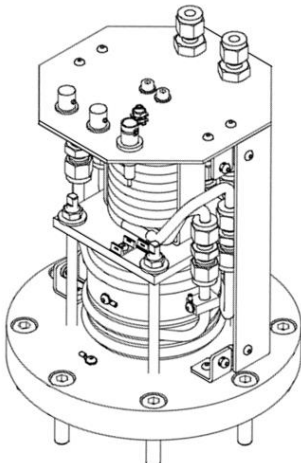
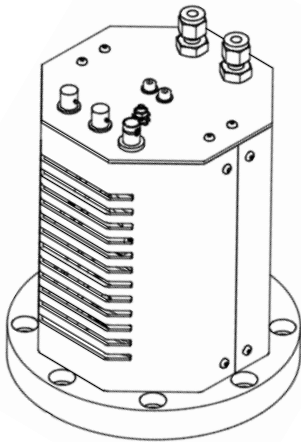
FARADAY CUP

FC-600-F

Stationary, water-cooled, Faraday Cup for
Ø32 mm beams capable of 600 W beam power



- Measures low-energy charged-particle beam currents 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

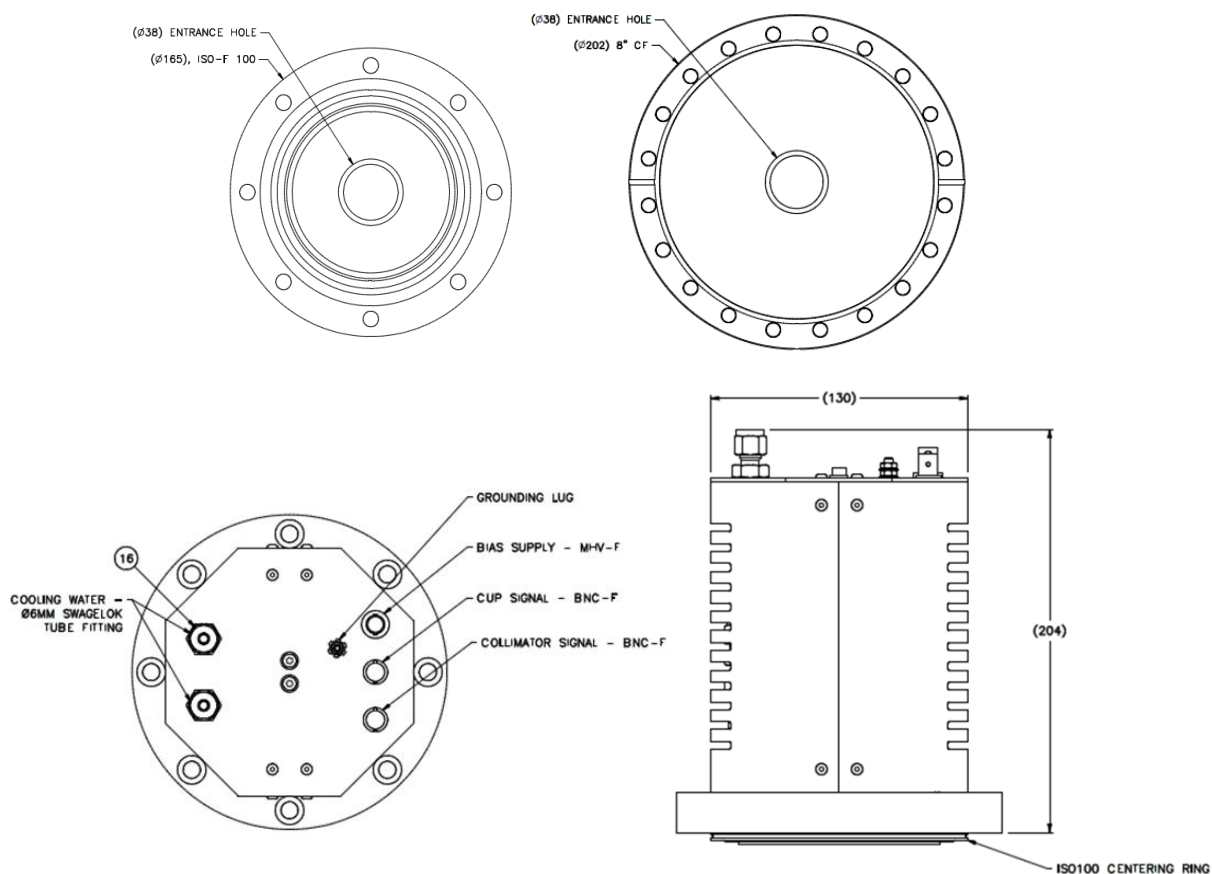
Beam Power, Max	600W
Collimator Diameter	32 mm
Bias Ring Diameter	32 mm
Faraday Cup Diameter	32 mm
Standard Flange	ISO 100F (O.D. 165mm)
Optional Flange	8" CF (O.D. 202mm)
Cooling	Water
Vacuum	HV (10^{-8} Torr) ¹

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.

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

FC-50

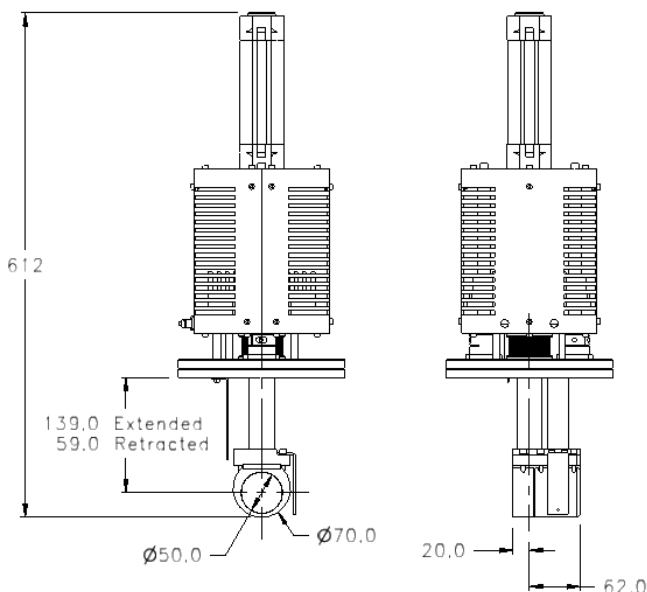
Pneumatically-actuated, water-cooled, for ultra high vacuum applications, capable of 50 W beam power



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

SPECIFICATIONS: 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
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.

PS-50 - PRECISION SLITS, 50W

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

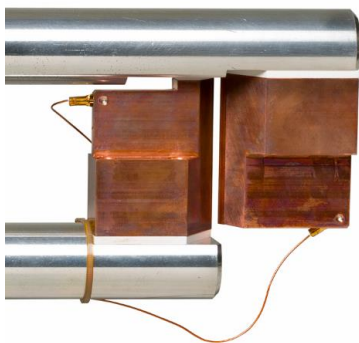


- High accuracy. Ideal for mass spectroscopy
- Measures low-energy charged-particle beam currents (< 1 MeV) up to 50W
- Ambient air cooled for simplicity
- Slit beam current read back³
- Designed for UHV vacuum

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



Manual adjustment with single knob



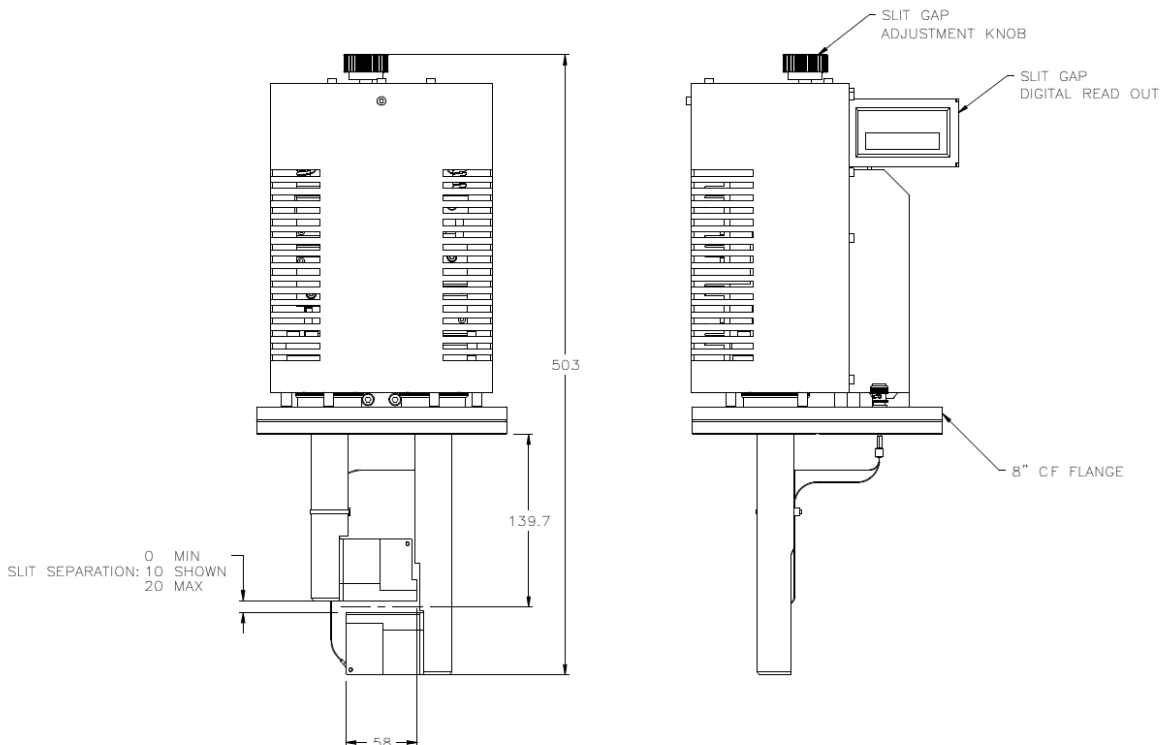
Digital readout of slit gap

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

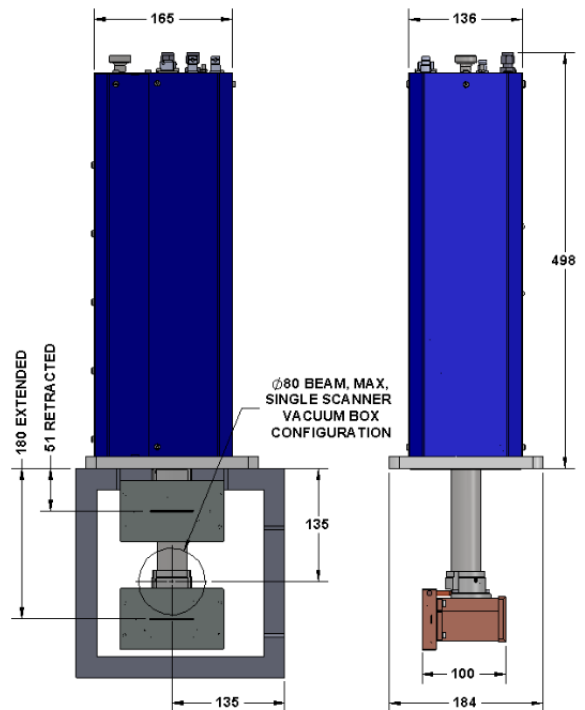
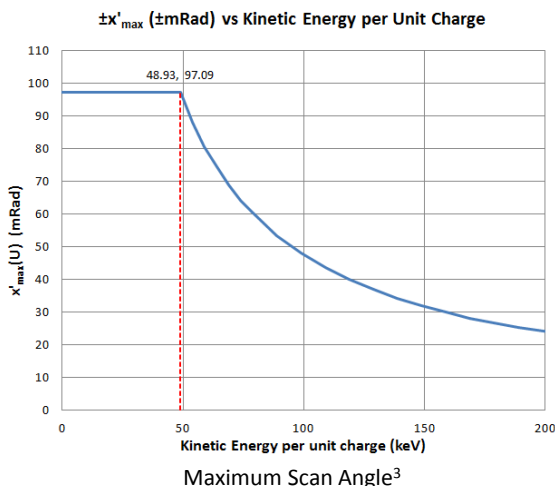
TRIUMF-Licensed Emittance & Phase Space Scanner Probe
With Turnkey Controller and Analysis Software



- Measure magnitude of emittance for low-energy charged particles (<1MeV)
- Water-cooled head for beam power up to 1500W and 500W/cm²
- 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-licensed technology¹

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.



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

SPECIFICATIONS - EMITTANCE PROBE	
Maximum Travel	130 mm
Distance, Slit to Flange	50 mm to 180 mm
Flange	Custom Rectangular, O-Ring
Y Resolution	100 μm (for $s = 100 \mu\text{m}$)
Y Step, Minimum	1 μm
Y' Max	$\pm 97 \text{ mRad}$ (for K.E. < 50keV, see plot)
Y' Resolution	1.3 mRad (for $s = 100\mu\text{m}$)
Y' Step, Minimum	16 bit resolution over +/- Y' Max
Sweep Voltage (V_{max})	+/-1000V
Slit width (s)	100 μm nominal Factory configurable 25 μm to 250 μm
Slit length (l)	50 mm
Beam \varnothing_{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, 1 \varnothing
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.

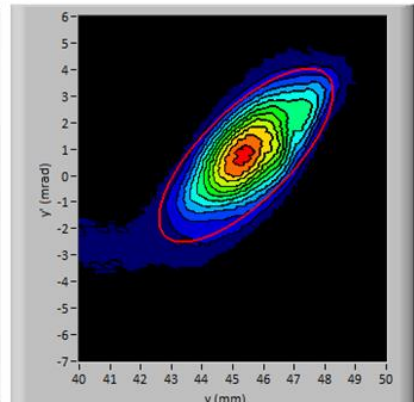
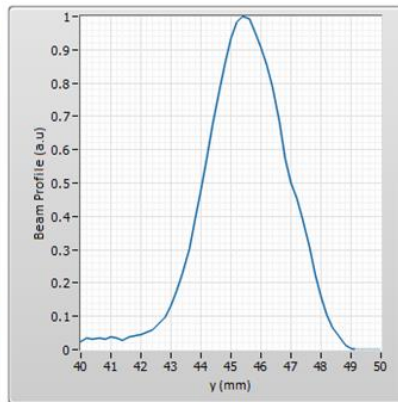


ES-4 Control Rack

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	45.422627 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

Ellipse Phase Space Area = πE
 $4 \cdot \epsilon_{\text{rms}}(\text{waist}) = (2 \cdot y_w \text{rms}) \cdot (2 \cdot y'_{\text{rms}})$



% Beam In Ellipse		% Beam Dimensions			Emittance		Transport Sigma Matrix		
%	n	y (mm)	y _w Waist (mm)	y' (mrad)	ϵ_N Normalized (mm*mrad)	ϵ Geometric (mm*mrad)	σ_{11} (mm ²)	$\sigma_{12}=\sigma_{21}$ (mm*mrad)	σ_{22} (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

D-Pace, Inc.

+1.250.352.5162

info@d-pace.com

www.d-pace.com

RF-POWERED TURNKEY NEGATIVE ION SOURCE SYSTEM

ISV.RF-040

TRIUMF & University of Jyväskylä licensed¹, volume-cusp

- Long intervals between maintenance² (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	BEAM CURRENT (mA)	BEAM ENERGY (keV)
H ⁻	0-7.5	20-30
D ⁻	0-3	20-30
C ₂ ⁻	0-0.05	20-30
C ₂ H ⁻	0-0.05	20-30
C ₂ H ₂ ⁻	0-0.05	20-30

Beam Intensities for Various Ions

SPECIFICATION: ISV.RF-040

ION SOURCE

Particle	H ⁻ , D ⁻ , C ₂ ⁻ , C ₂ H ⁻ , C ₂ H ₂ ⁻
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

Max Bias Supply	40 mA, 30 keV
RF Amplifier ^{5,6}	3 kW, 13.56 MHz
Plasma Lens	12 A, 70 V
Extraction Lens	60 mA, 5 kV
X & Y Steering Magnet	10 V, 10 A

VACUUM SYSTEM SPECIFICATIONS

Turbo Pumps, 1X Upstream & 1X Downstream	1700 l/s Flange ISO250F
Dry Scroll Roughing, 1X Upstream & 1X Downstream	35 m ³ /hr

GAS FLOW

Mass Flow Controller	11-30 sccm
----------------------	------------

CONTROLS

Control PLC	Phoenix Contact ILC, Ethernet
User Interface Options	D-Pace standalone or OPC command library for customer integration

COOLING WATER, DEIONIZED, 20°C (> 1.0 MOhm.cm)

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	5.0 LPM, 40 PSI (275 kPa)

TUNE DATA FOR MAXIMUM BEAM CURRENT:

	IONS				
	H ⁻	D ⁻	C ₂ ⁻	C ₂ H ⁻	C ₂ H ₂ ⁻
Max. Beam Current (mA)	8	3	0.05	0.05	0.02
Bias Supply (mA, kV)	11, 30	4.5, 30	0.68, 10	0.68, 10	0.68, 10
RF Power (kW)	3.1	2.6	0.5	0.5	0.5
Plasma Lens Supply (A,V)	5.9, 36	5.3, 50	1.0, 0	1.0, 0	1.0, 0
Extraction Lens Supply (mA, kV)	34, 3.0	39, 2.3	14, 1.2	14, 1.2	14, 1.2
Steering Magnet X (A)	0.5	3.0	0.0	0.0	0.0
Steering Magnet Y (A)	3.2	0.0	0.0	0.0	0.0
H ₂ (sccm)	16	9	30	30	30
Vacuum, Ion Source (Upstream) (10 ⁻⁴ Torr)	0.54	0.32	1.06	1.06	1.06
Vacuum, V-Box (Downstream) (10 ⁻⁵ Torr)	0.39	0.082	3.30	3.30	3.30
½ Beam Diameter at Waist (mm)	1.8	2.1	3.7	3.7	3.7
½ Beam Divergence at Waist (mrad)	37.8	53.3	41.7	41.7	41.7
Geometric 4rms Emittance (mm·mrad)	69	112	154	154	154
Normalized 4rms Emittance (mm·mrad)	0.89	0.89	0.71	0.71	0.71

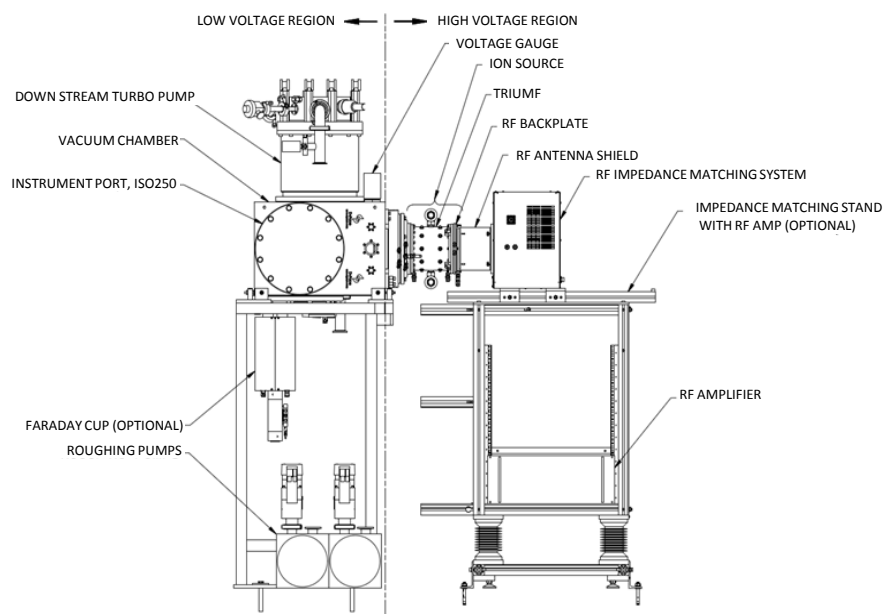
The ISV.RF-040 Ion Source system includes the following:

- Ion source & vacuum box
- Vacuum system & gauges
- Power supplies, PLC controls & software
- Low voltage and high voltage racks
- 40 kV isolation transformer
- Interlocks and HV grounding system
- User interface & Ethernet-based remote controls
- Ion source stand and RF stand
- Personnel access control interlocks
- Water flow gauges and interlocks
- Mass flow controller for feed gasses
- RF amplifier & impedance matching systems

Optional:

- High-voltage Faraday cage / enclosure
- Water de-ionization and cooling system
- Sliding Faraday cup
- UniBEaM fiber optic beam profile monitor
- TRIUMF-licensed emittance scanner
- 1:500 mass spectrometer with slits

Enquire about other negative and positive ion beams, and our Filament ion sources



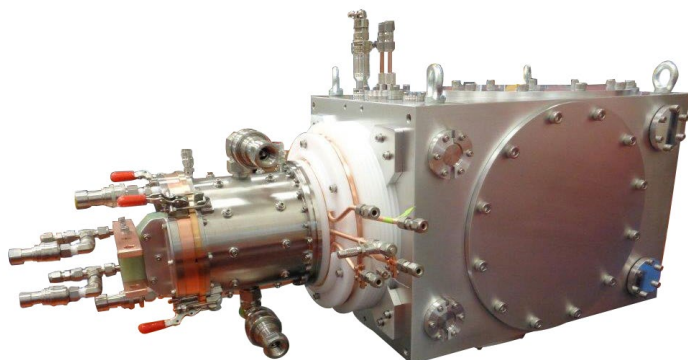
1. Ion Source licenced from TRIUMF. RF technology licenced from the University of Jyväskylä.
2. Estimates - testing in progress.
3. Window lifetime estimate based on 10% RF transmission degradation.
4. Suitable for installation of optional pneumatically-actuated Faraday cup and D-Pace ES-4 Allison type 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.

FILAMENT POWERED TURNKEY NEGATIVE ION SOURCE SYSTEM

ISV.F-040

TRIUMF-licensed, DC, volume-cusp

- Yields 15mA DC H⁻, and 5mA DC D⁻
- Low maintenance with long filament lifetime (> 5250 mA·hours)
- Negligible lens wear due to the optimized lens ion-optics, and low emittance
- Internal steering magnet enables beam alignment corrections
- Instrumentation options include Faraday cup, emittance scanner, beamlines, beam profiler and mass spectrometer



Ion Source with Vacuum Box

ION	Beam Current (mA)	Beam Energy (keV)
H ⁻	0-15	20-30
D ⁻	0-5	20-30

Beam Intensities for Various Ions

SPECIFICATION: ISV.F-040

ION SOURCE	
Particle Type	H ⁻ , D ⁻
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	
Max Bias Supply	40mA, 30 kV
Arc Supply	50 A, 200 V
Filament Supply	400 A, 10 V
Plasma Lens	42 A, 20 V
Extraction Lens	150 mA, 8 kV
X & Y Steering Magnet	10 V, 10 A
VACUUM SYSTEM SPECIFICATIONS	
Turbo Pumps, 1X Upstream & 1X Downstream	1700 l/s Flange ISO250F
Dry Scroll Roughing, 1X Upstream & 1X Downstream	35 m ³ /hr
GAS FLOW	
Mas Flow Controller	11-30 sccm
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)

Tune Data for Maximum Beam Current:		
	IONS	
	H ⁻	D ⁻
Max. Beam Current (mA)	18	6.0
Bias Supply (mA, kV)	25, 30	8.9, 30
Arc Supply (A,V)	48, 120	38, 120
Filament Supply (A,V)	35, 0.89	87, 158
Plasma Lens Supply (A,V)	21, 3.8	27, 5.7
Extraction Lens Supply (mA, kV)	130, 3.8	100, 2.7
Steering Magnet X (A)	0.82	3.50
Steering Magnet Y (A)	1.6	0.0
H ₂ (sccm)	20	15
Vacuum, Ion Source (Upstream) (10 ⁻⁵ Torr)	4.6	4.7
Vacuum, V-Box (Downstream) (10 ⁻⁶ Torr)	6.2	2.4
½ Beam Diameter at Waist (mm)	2.7	2.3
½ Beam Divergence at Waist (mrad)	34.4	49.4
Geometric 4rms Emittance (mm·mrad)	94	110
Normalized 4rms Emittance (mm·mrad)	0.75	0.90

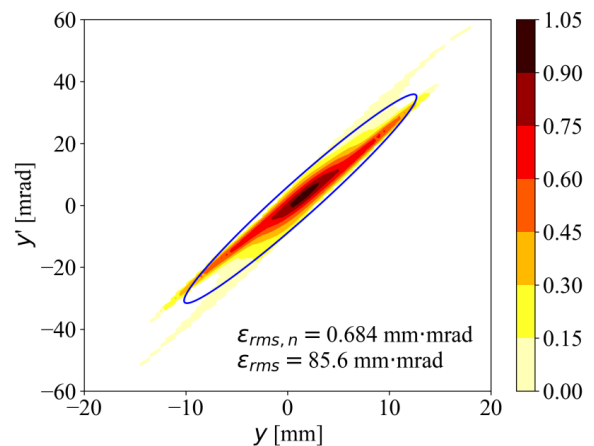
The ISV.F-040 Filament Ion Source system is a complete, turnkey ion source system including:

- Ion source & vacuum box
- Vacuum system & gauges
- Power supplies, PLC controls & software
- Low voltage and high voltage racks
- 40 kV isolation transformer
- Interlocks and HV grounding system
- User interface & Ethernet-based remote controls
- Ion source stand
- Personnel access control interlocks
- Water flow gauges and interlocks
- Mass flow controller for feed gasses

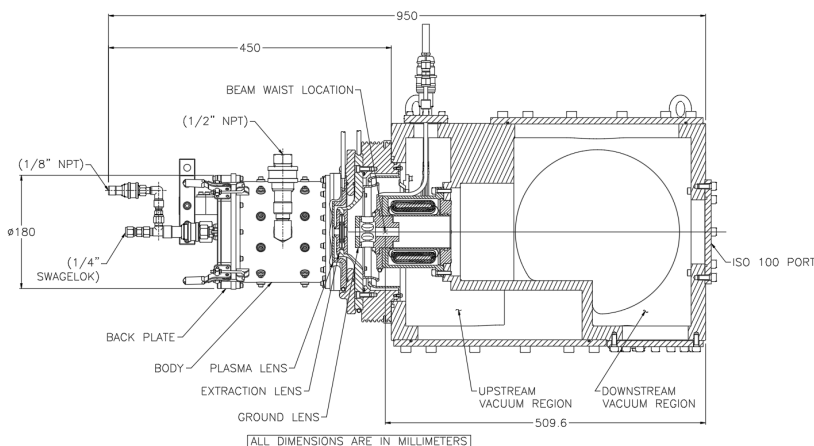
Optional:

- High-voltage Faraday cage/ enclosure
- Water de-ionization and cooling system
- Sliding Faraday cup
- UniBEaM fiber optic beam profile monitor
- TRIUMF-licensed emittance scanner
- 1:500 mass spectrometer with slits

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



Phase Space Plot, 18 mA H⁻ Tune



*Turnkey Filament-Powered Ion Source
Including Optional Beamline and Mass Spectrometer*

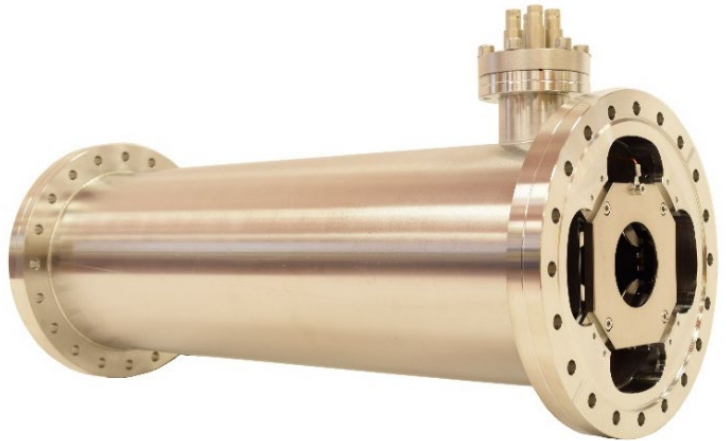
1. D-Pace reserves the right to update specifications as part of its ongoing product improvement program.



Electrostatic Quad Triplet, 50mm

Model QE 3.50

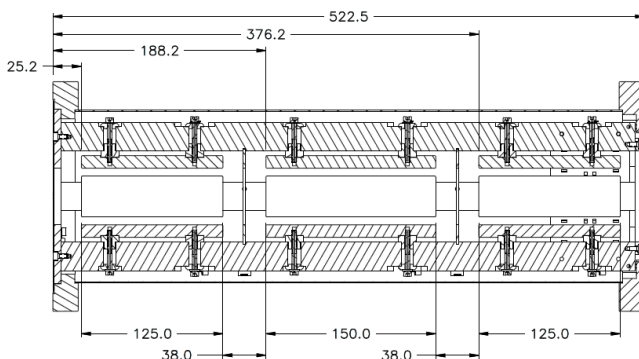
Aperture Ø50 mm, Maximum Pole Potential ± 1 kV



- Pole aperture 50mm
- Pole isolation from ground ± 1000 V (± 2000 V between opposite poles)
- Grounded collimators upstream from each quad (quantity 3)
- 8" CF Flanges
- Metal and ceramic seals (no elastomers)
- UHV options¹
- Optional power supply, with quantity 6 ± 1 kV 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 Aperture	Ø50.0 mm	
Collimator Aperture	Ø50.0 mm, Qty 3	
Overall Length	522.5 mm	
Flanges, Beam Pipe ¹	8" CF (DN160CF)	
Flanges, HV Feedthru	2-¾" CF (DN40CF)	
Vacuum	HV (10^{-9} Torr)	
HV Connectors	SHV (Qty 6)	
Isolation, Pole to Ground	± 1000 V	
Isolation, Pole to Pole	± 2000 V	
Mechanical Support	Flange supported ¹	



Notes:

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



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

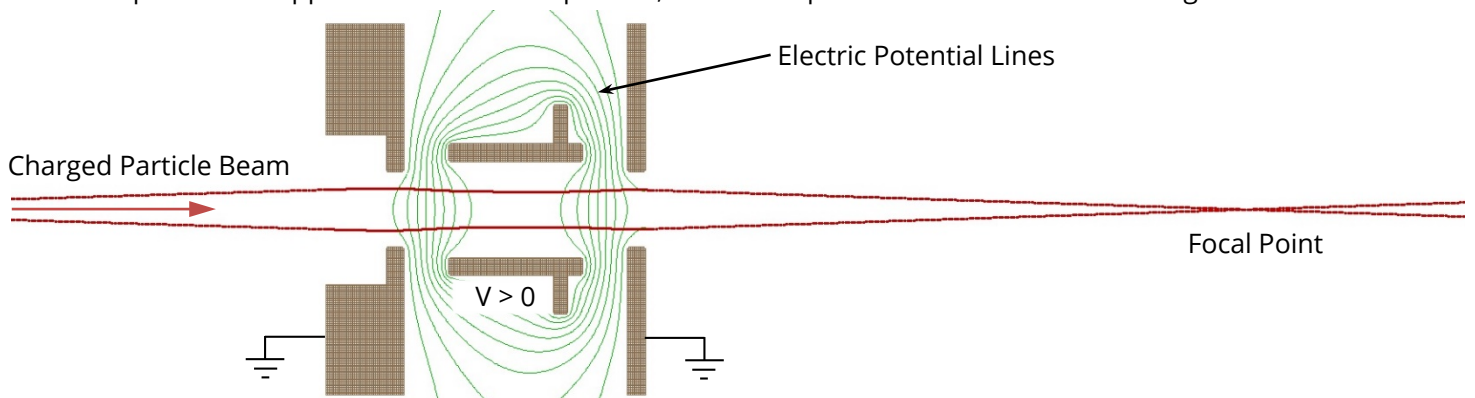
The D-Pace **LE-25.15.45 Einzel Lens** is a simple, robust way to achieve beam focusing with beams of 100 keV kinetic energy or less. It was designed for the D-Pace filament and RF ion sources, but can easily be incorporated into customer beamlines. This Einzel lens is an in-vacuum device, capable of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



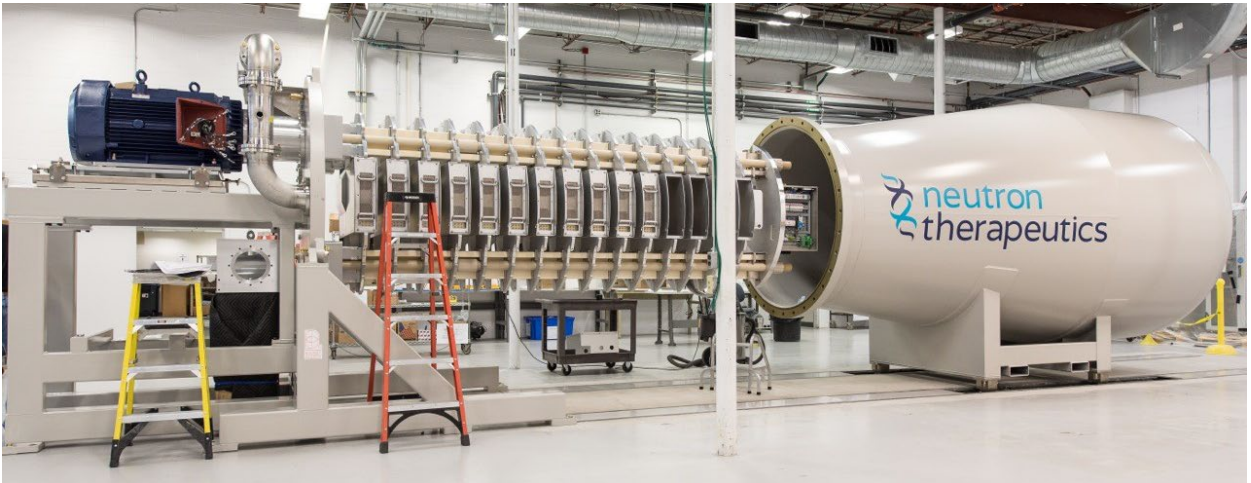
D-Pace Filament Ion Source

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 SF₆ 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%.

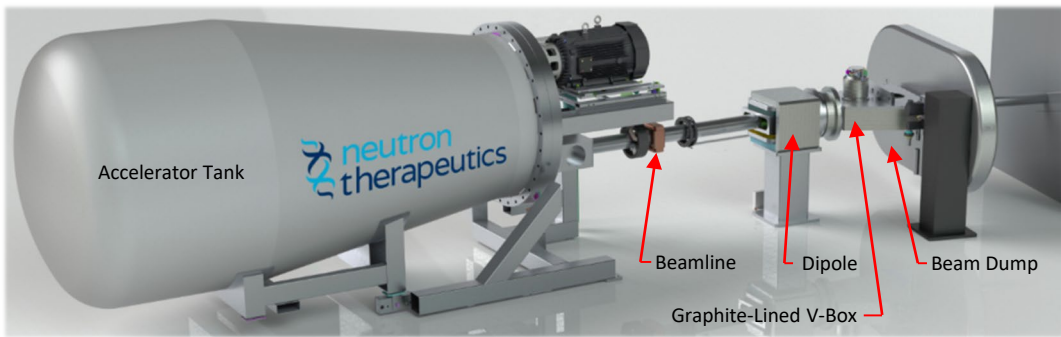
Complete support and maintenance service packages available, including consumables, replacement parts and quarterly/annual maintenance procedures.

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:
 - Physics & materials research
 - Non-medical applications
- 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 SF₆ (high-voltage isolation gas) handling system on a pallet. This ensures rapid SF₆ 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 \pm 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, \pm 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
---------------------------------------	------------------------

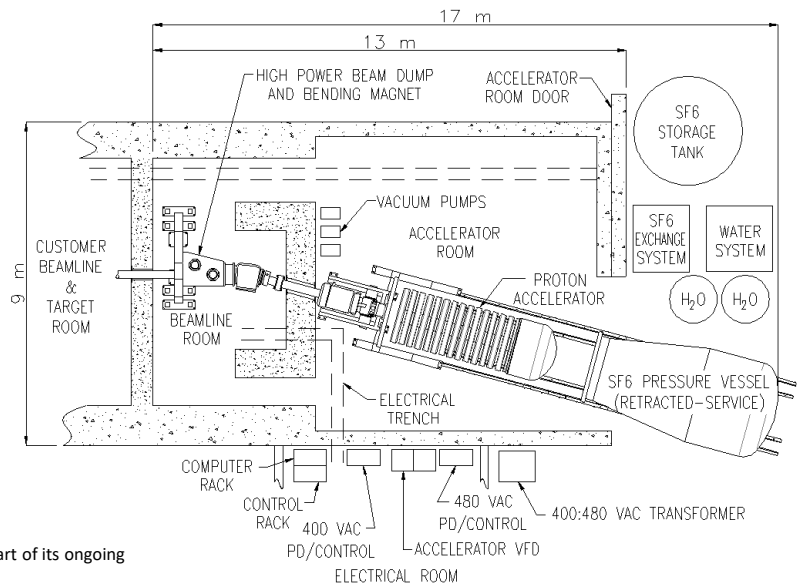
COMPRESSED DRY AIR

Pressure	7 bar (100 psi)
Flow, nominal / intermittent	9 m ³ /hr (5 cfm) / 43 m ³ /hr (25 cfm)



SF₆ Transfer System

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)



Facility Layout – Shielding shown for typical neutron application