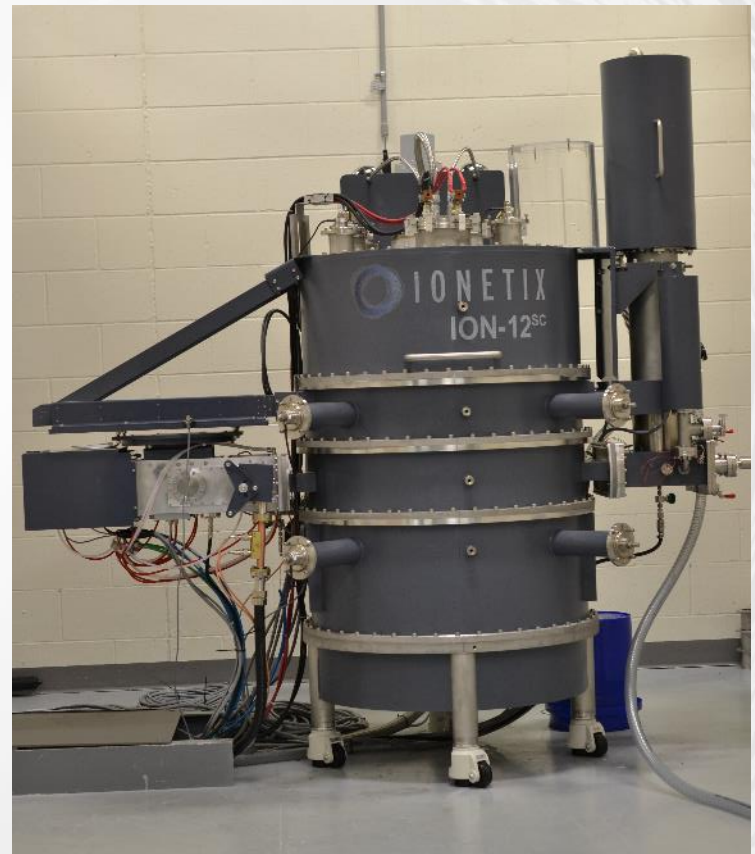




The ION-12SC Compact Superconducting Cyclotron for Production of Medical Isotopes

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Ionetix Corporation
Lansing, Michigan
USA



OUTLINE

- Scientific and physics design, beam dynamics simulations for Ion-12SC have been discussed previously
 - *V. Smirnov, S. Vorozhtsov, J. Vincent, “Design study of an ultra-compact superconducting cyclotron for isotope production”, Nuclear Instruments and Methods in Physics Research A 763 (2014) pp. 6-12*
- Engineering
- Manufacturing
- Accelerator system hardware
- Beam commissioning
- Experience at the 1st customer site

POSITRON EMISSION TOMOGRAPHY (PET)

PET imaging is an effective, non-invasive and painless diagnostic commonly used in oncology, cardiology and neurology diagnostics

- Radioisotope injected into patient
- PET scanner detects gamma rays produced by radioisotope as it decays
- Scanner measures amount of metabolic activity at the site in the body and translates signals into images
- Provides information about function and metabolism of body's organs (unlike CT or MRI)

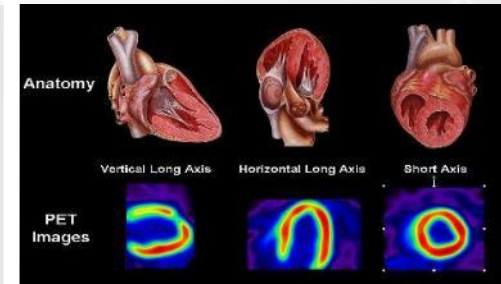


Image Source: ABC News and PET Solutions

STRONG DEMAND FOR SHORT LIVED PET RADIOISOTOPES

TWO MAJOR MARKETS

Emerging Markets (China/India)

^{18}F -FDG for oncology

- Demand will be driven by aging demographics, rising incidence of disease and increase in scanner installations
- Estimate oncology market opportunity by 2020: **>\$1.5 billion**

United States/Europe/Japan

^{13}N -ammonia for cardiology

- Demand will be driven by aging demographics, unstable supply of SPECT radiopharmaceuticals and superior imaging
- Estimated cardiac market opportunity by 2020: **>\$3 billion¹**

THE SOLUTION: ION-12SC SUPERCONDUCTING CYCLOTRON

Short lived PET radioisotopes have had limited adoption due to the size, weight, and cost of conventional cyclotrons



The ION-12SC is based on proprietary superconducting cyclotron technology

- Significantly smaller size, lighter weight and lower cost than conventional cyclotrons
- Lower power consumption and require less radiation shielding
- Significantly shorter installation time and simpler operations
- Compact size/weight allows for placement in hospital or clinic without special infrastructure.
- True dose-on-demand medical isotope production system

1st
OF ITS
KIND

ION-12SC COLLABORATORS

Ionetix Corporation, USA	J. Vincent, Ph.D.* G. Blosser* G. Horner* K. Stevens N. Usher* X. Wu, Ph.D.*
JINR, Dubna, Russia	S. Vorozhtsov, D. Sc. V. Smirnov, Ph.D.
Superconducting Systems Incorporated, USA	Prototype SC Magnet Engineering, Construction, & Development.
Tesla Engineering LTD, UK	Relocatable SC Magnet Design and Manufacturing
Technalogix Inc., Canada	Solid State RF Amplifier

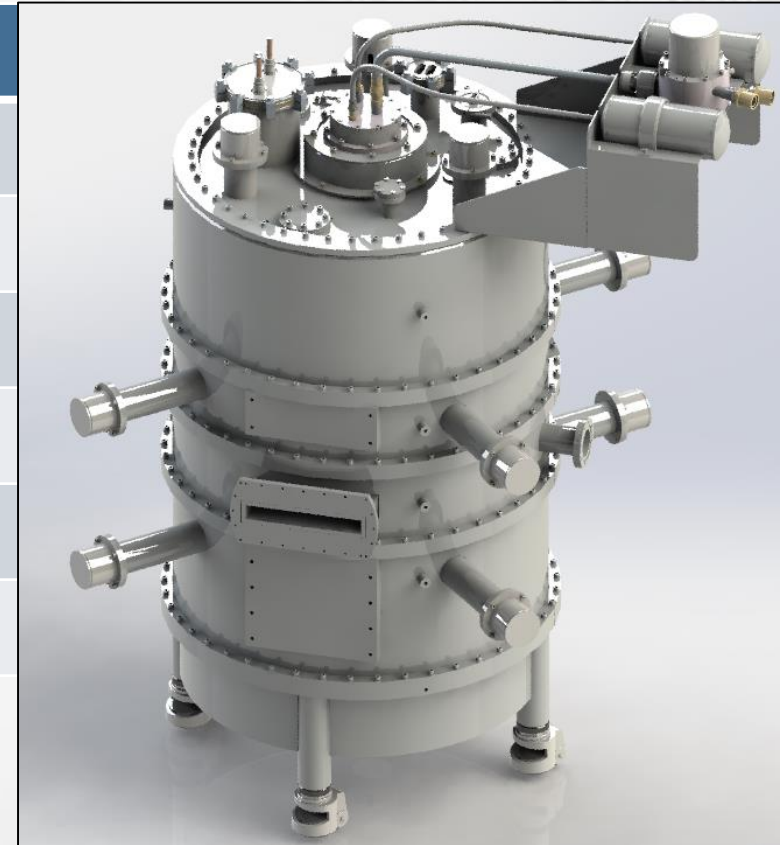
* Formally worked at National Superconducting Cyclotron Laboratory (NSCL), Michigan State University. Experienced in R&D for K500, K1200, CCP, K100, K250, and K250S superconducting cyclotrons.

ION-12SC CYCLOTRON MAIN PARAMETERS

Parameter	Value
Cyclotron type	Compact, Isochronous
Accelerated particle	Proton
Injection type	Internal PIG source
Magnet type	Superconducting
Central magnetic field	4.5 Tesla
Final beam energy	12.5 MeV
Max. Beam Intensity	~25 μ A

SIGNIFICANT REDUCTION IN SIZE AND WEIGHT

Parameter	Value
Final acceleration radius	115 mm
Target position radius	141 mm
Cyclotron diameter	884 mm
Cyclotron height	1955 mm
Magnet weight	~2041 kg
Cyclotron weight	~2268 kg

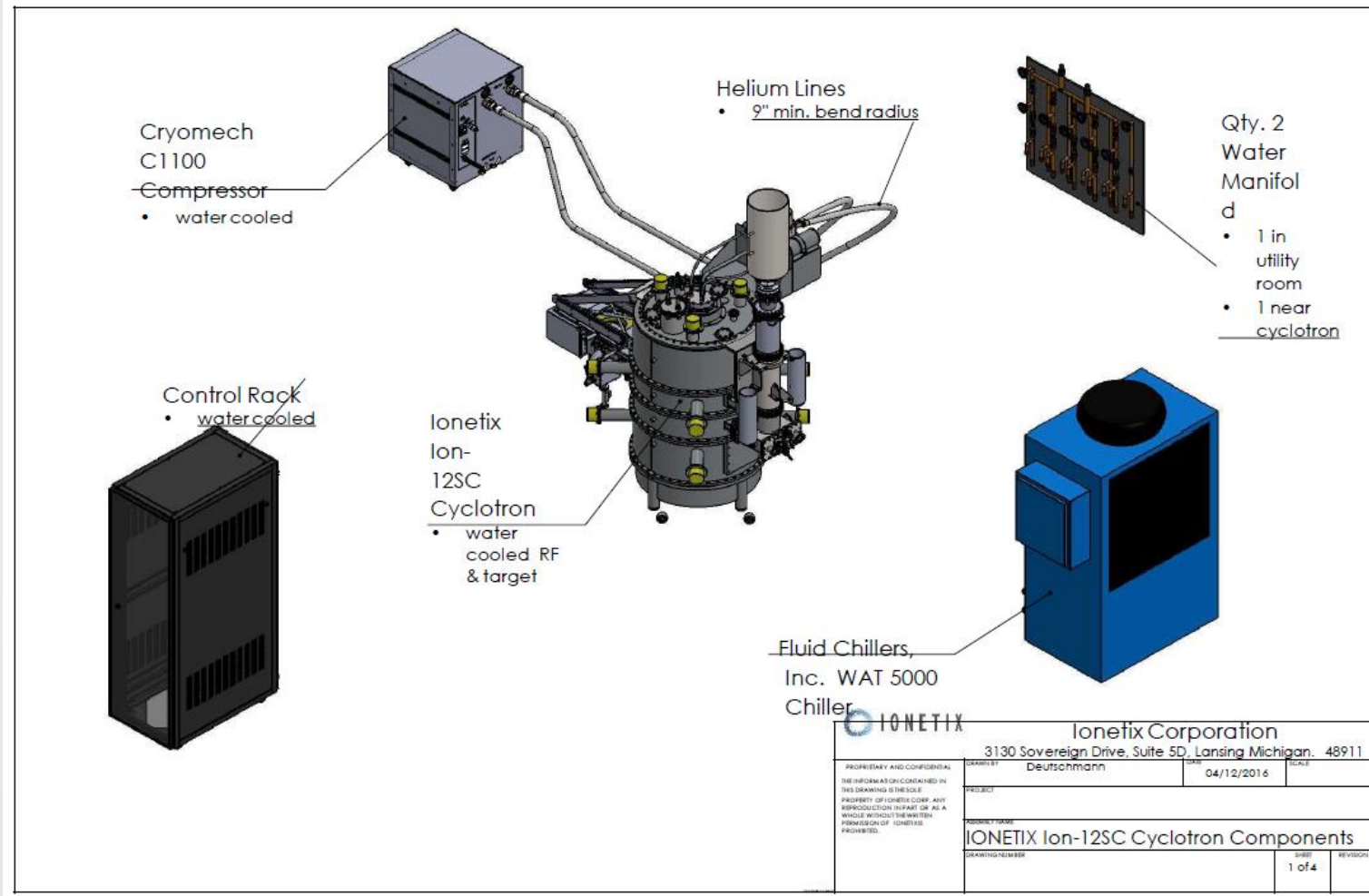


COMPARISON WITH EXISTING SYSTEMS



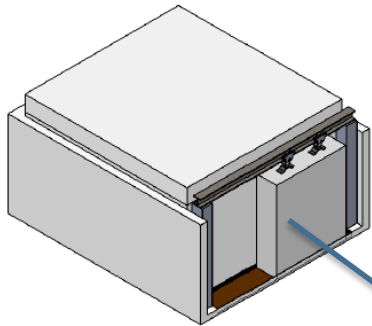
	Ionetix ION-12SC	Siemens Eclipse	GE PETtrace
Room Requirements	12' x 11'2"	22' x 26'	15' x 18'
Cyclotron Weight	2.3 tons	11 tons	22 tons
Shielding	Minimal	39 tons additional shielding	47 tons additional shielding
Price	~\$1.5mn (no special infrastructure required)	\$2.5mn (plus >\$7.5M infrastructure costs)	\$2.5mn (plus >\$7.5M infrastructure costs)
Staff Required	1	2-5	2-5
Power Requirement	34 kW	35 kW	70 kW

INTEGRATED ACCELERATOR SYSTEM

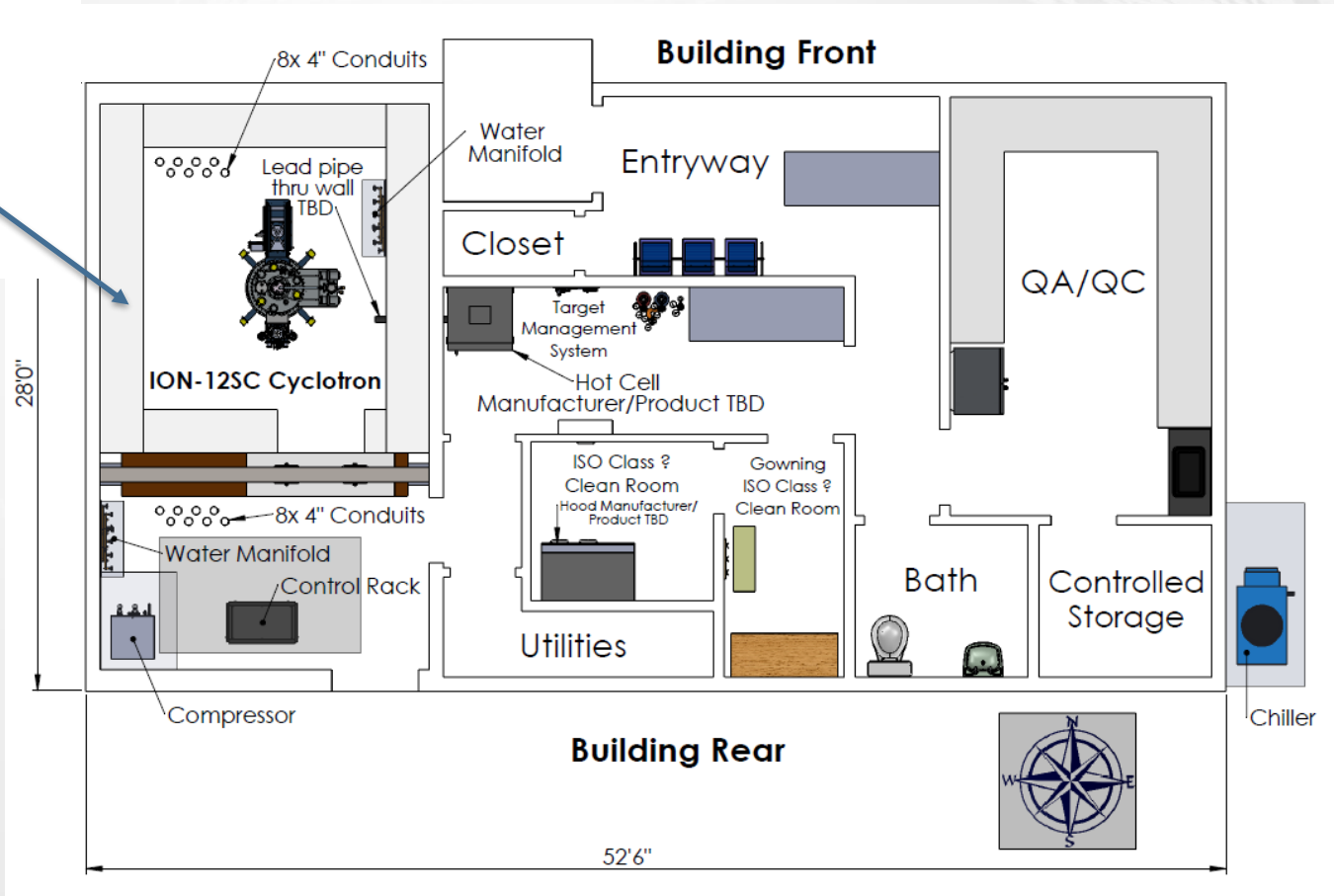


IONETIX			
Ionetix Corporation 3130 Sovereign Drive, Suite 5D, Lansing Michigan, 48911			
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PROJECT			
PROPERTY NO.			
IONETIX Ion-12SC Cyclotron Components			
DRAWING NUMBER	SHEET 1 of 4		REVISION

PLANNED IONETIX ISOTOPE PRODUCTION FACILITY, SARASOTA, FLORIDA (VAULT NEEDED FOR F18 PRODUCTION)



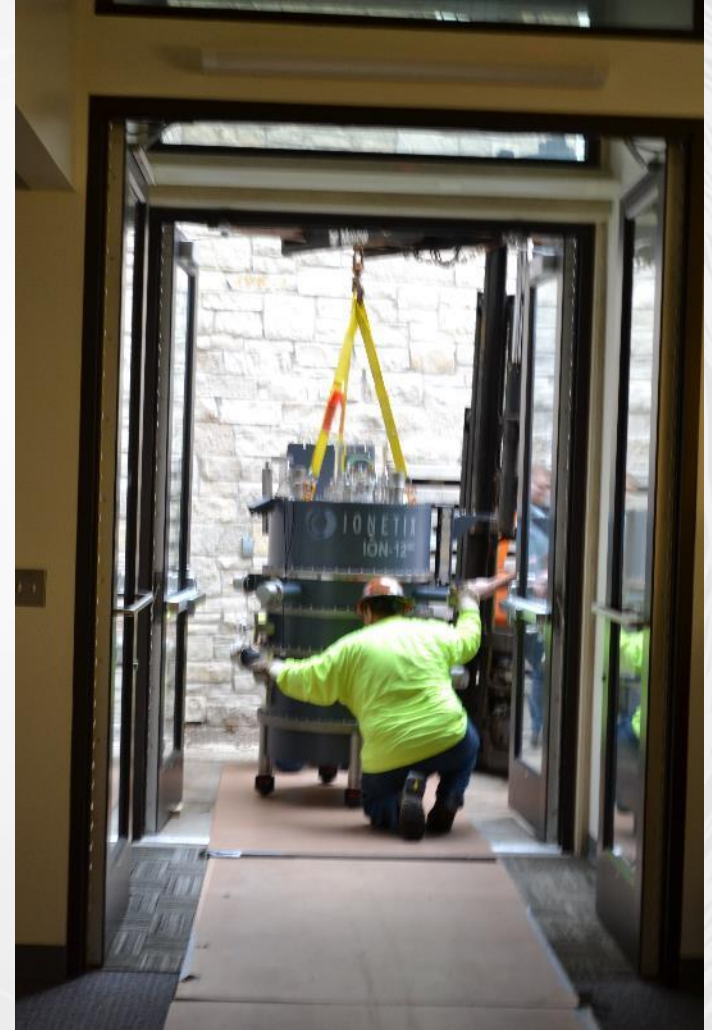
Cyclotron vault



BETA UNIT INSTALLATION AT UM JANUARY 2016



BETA UNIT INSTALLATION AT UM JANUARY 2016



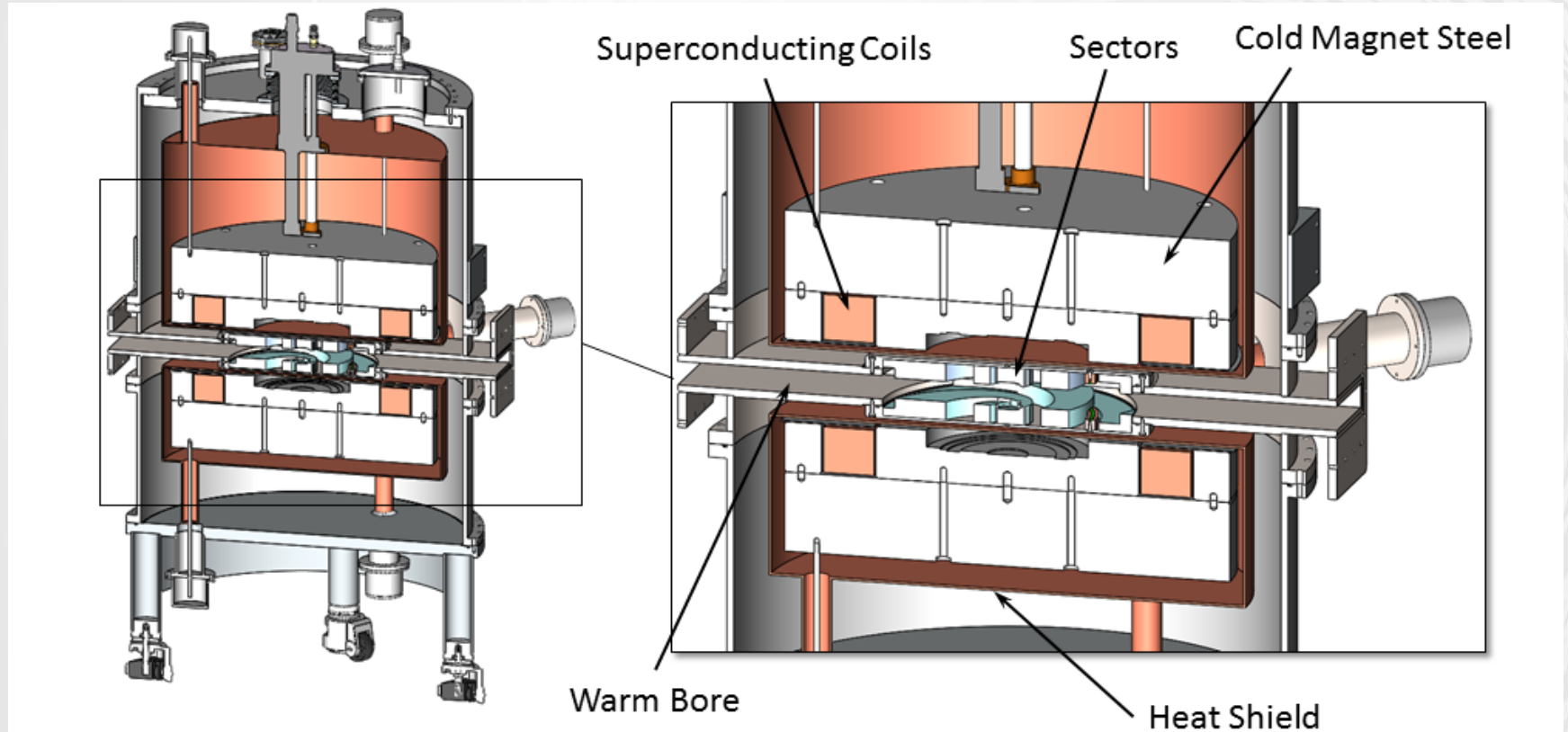
BETA UNIT INSTALLATION AT UM JANUARY 2016



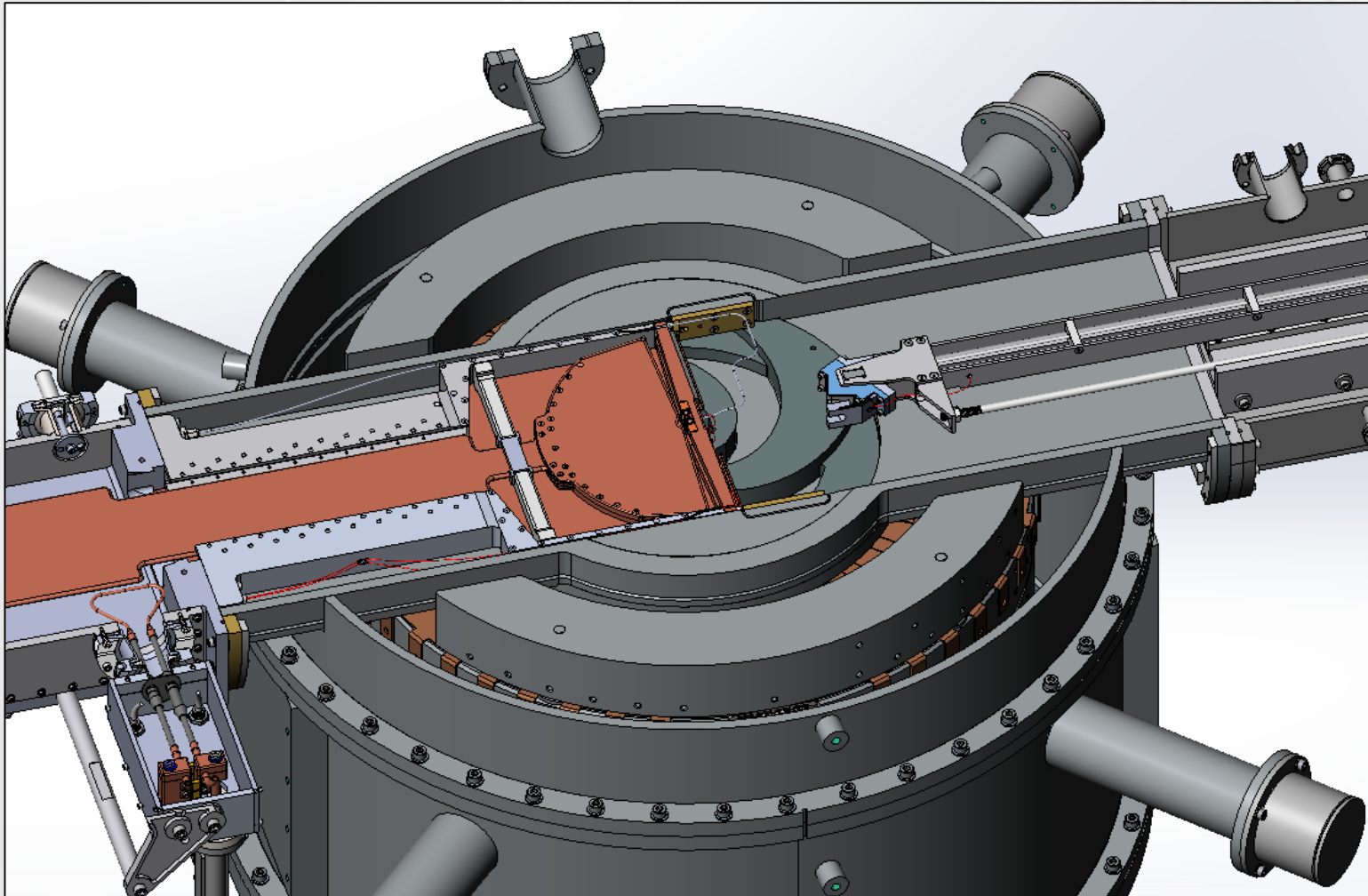
ION-12SC ACCELERATOR SYSTEM

- Superconducting magnet
- RF system
- Ion source
- Internal target and beam probe
- Controls & Instrumentation

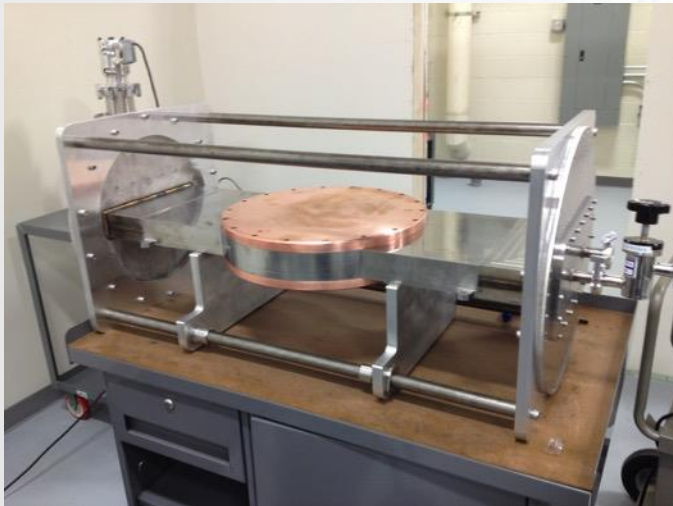
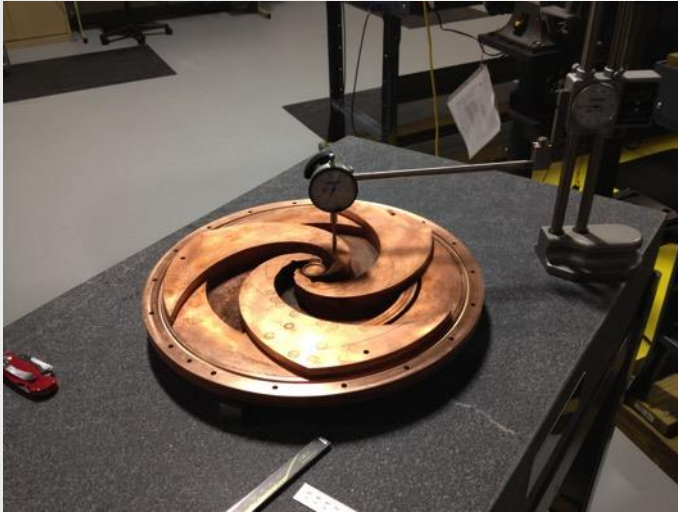
ION-12SC MAGNET SYSTEM



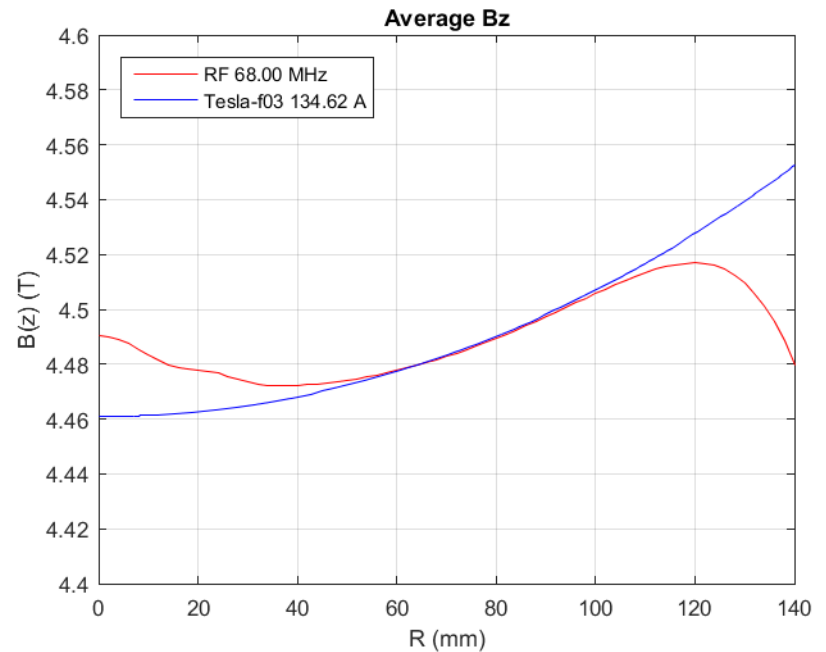
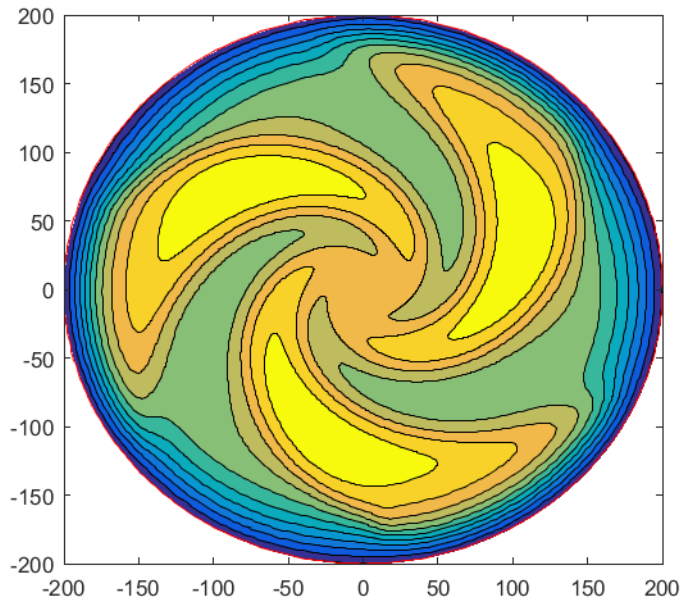
ION-12SC WARM BORE SECTORS, ION SOURCE, AND RF SYSTEM



WARM BORE SECTOR

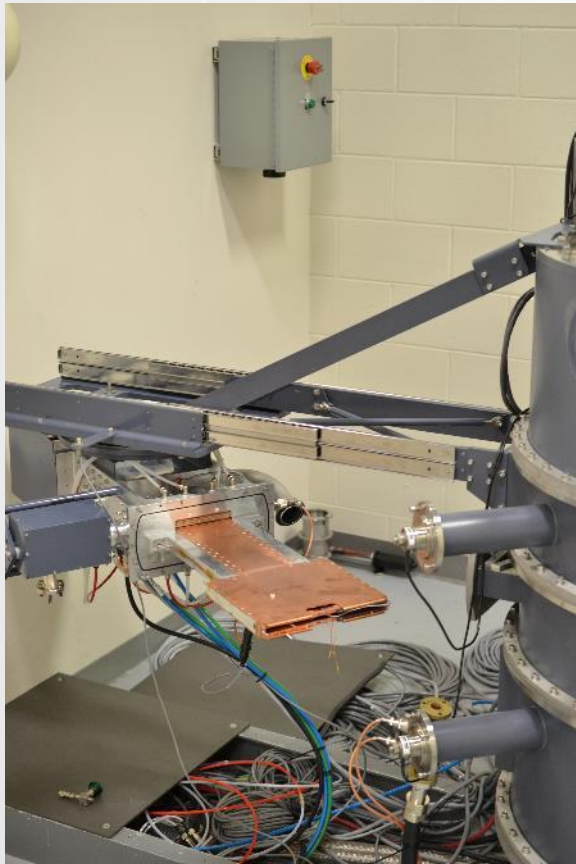


ION-12SC TESLA MAGNET: MAGNETIC FIELD



ION-12SC RF SYSTEM

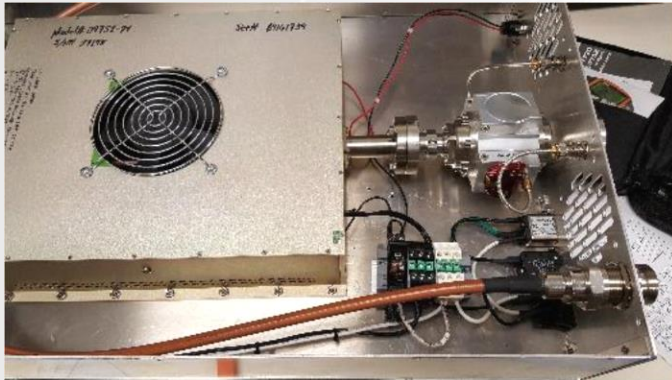
RF resonator



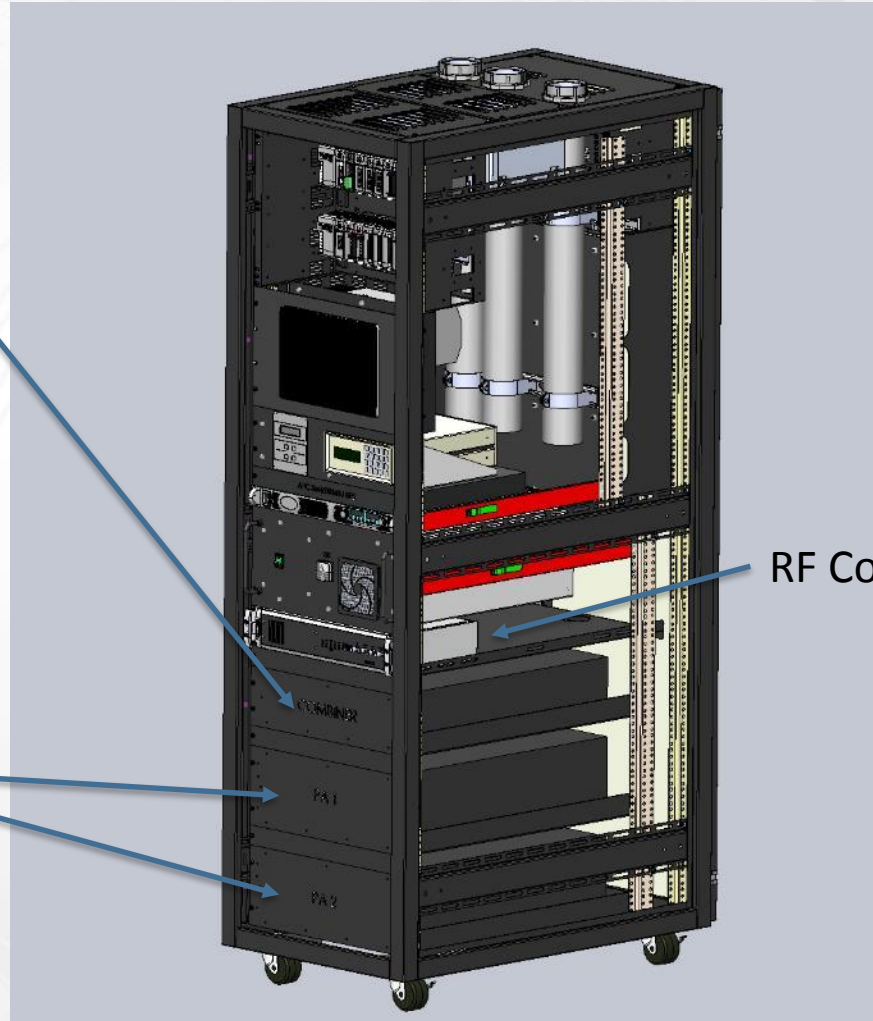
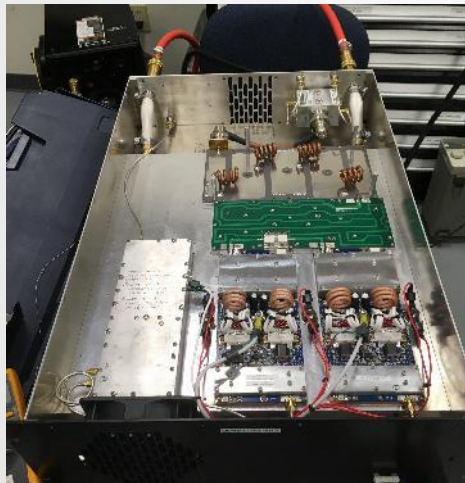
Parameter	Value
Drive Power	<6 kW
Nominal Impedance	50 Ohms
VSWR	<1.5
Tuning Range	66 -69 MHz
Water Cooling	4 GPM

ION-12SC RF SYSTEM

RF Combiner

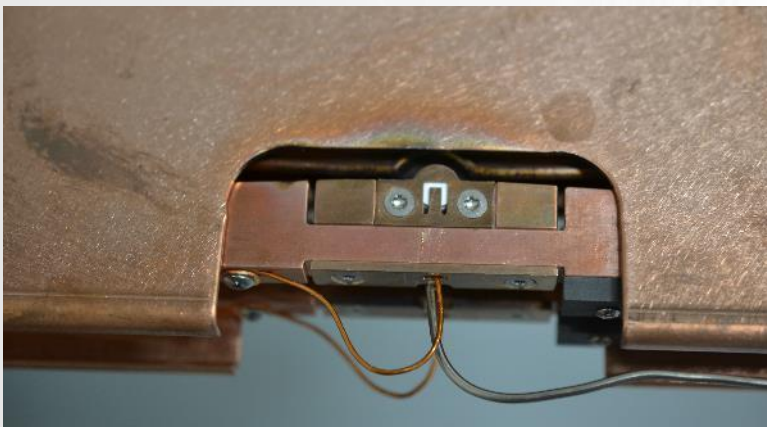


3kW RF amplifier



RF Controller

ION-12SC ION SOURCE



Parameter	Value
Ion Source Type	Cold cathode
Cathode Material	Tungsten
Chimney Diameter	2.0 mm
Slit Opening	2.0x0.5 mm 30 degree bevel
Current	0.1 - 15 mA
Voltage	0.6 - 1.6 kV
Gas Flow	0.1 – 1.0 sccm
Lifetime	>400 hours

ION-12SC INTERNAL TARGET AND BEAM PROBE



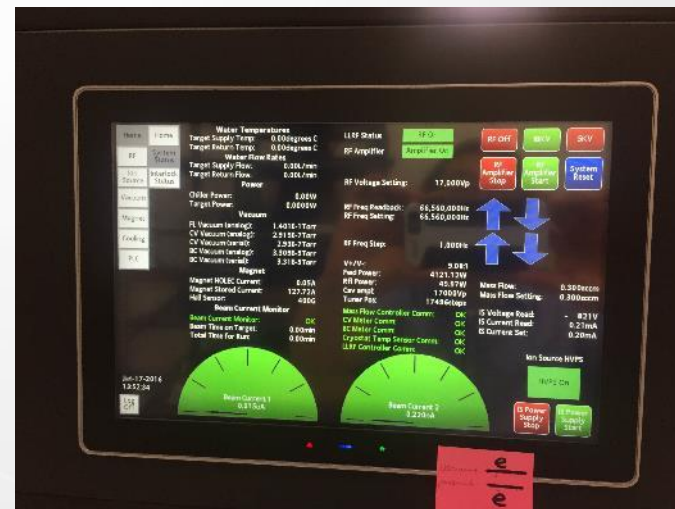
Parameter	Value
Target Type	Internal
Target Position	141 mm
Target Volume	3.0 ml
Target window	Aluminum (Graphene under development)
Probe Range	46 - 151 mm
Intensity Probe Head	Carbon
Energy Probe Head	Borosilicate Glass

ION-12SC CONTROLS & INSTRUMENTATION



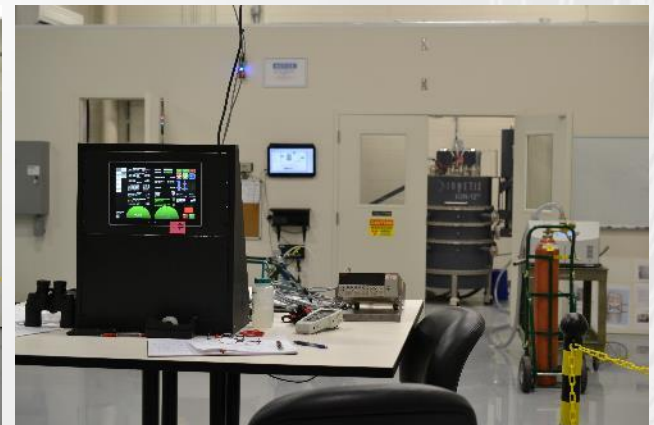
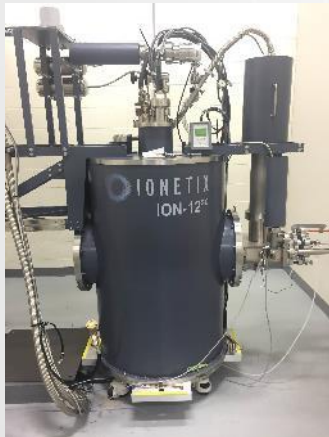
Standard 19" electronics rack

- RF amplifiers
- RF combiner
- RF controller (based on PLC and PCB)
- Magnet power supply
- Ion source power supply
- Cryogenics control
- Cooling water control

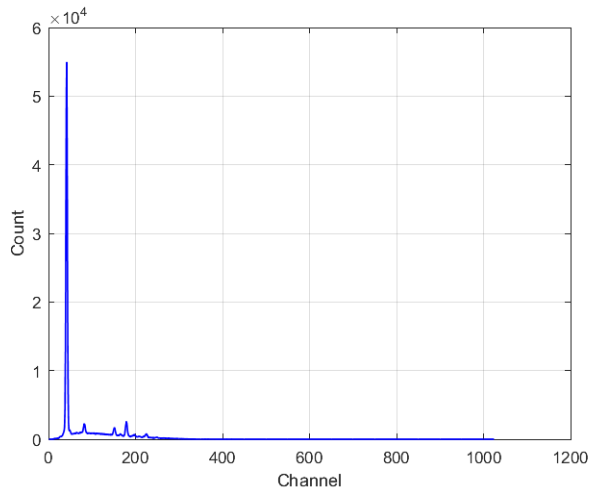


ION-12SC OPERATION EXPERIENCE

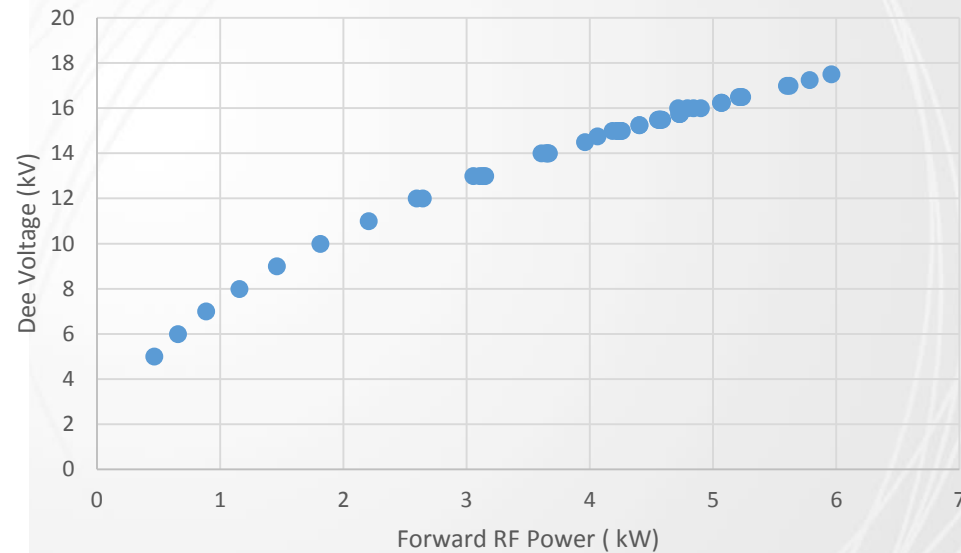
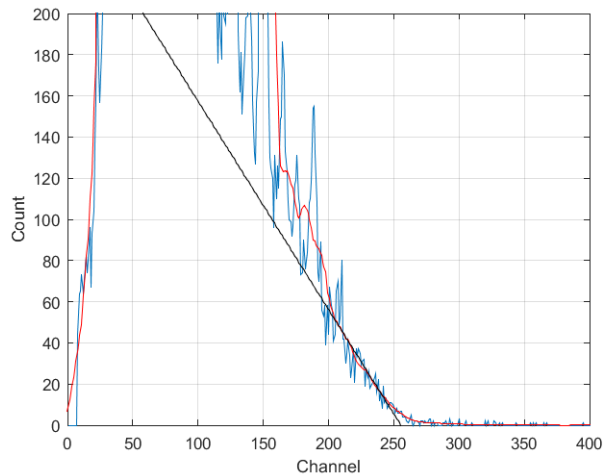
- Engineering prototype unit: July 2015 – September 2015
 - Ready to be shipped to MIT Nuclear Physics Department
- Manufacture unit #1: December 2015 – January 2016
 - Installed at the University of Michigan
- Manufacture unit #2: June 2016 - Now
 - The “Golden Master” of the Ionetix R&D facility



ION-12SC OPERATION EXPERIENCE – DEE VOLTAGE



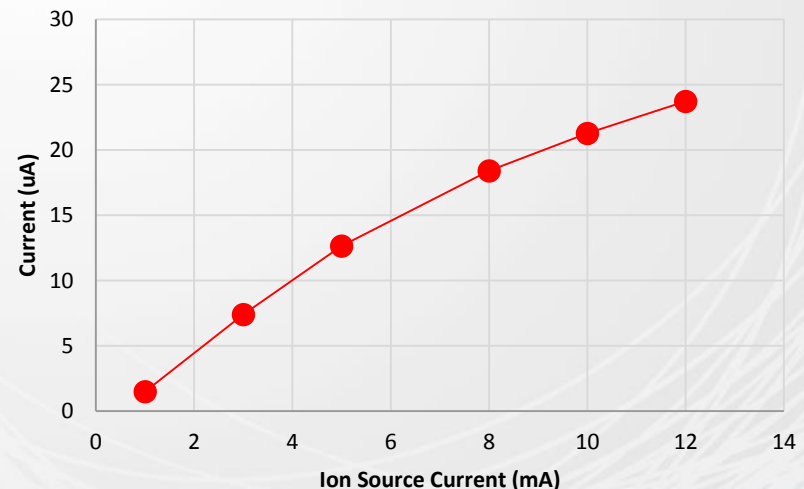
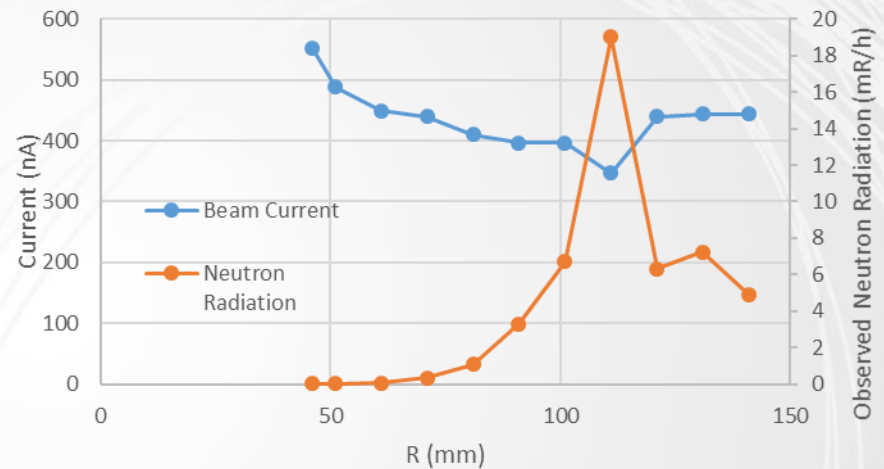
Measure cavity X-Ray spectrum to accurately determine Dee voltage



ION-12SC OPERATION EXPERIENCE – BEAM INTENSITY

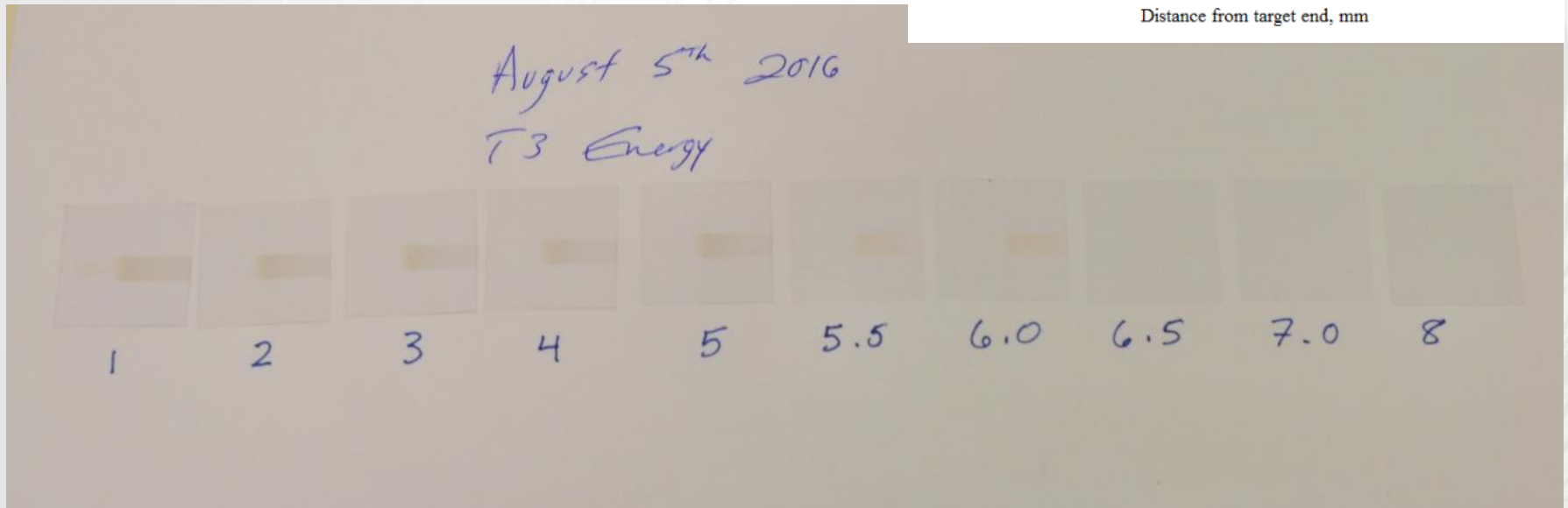
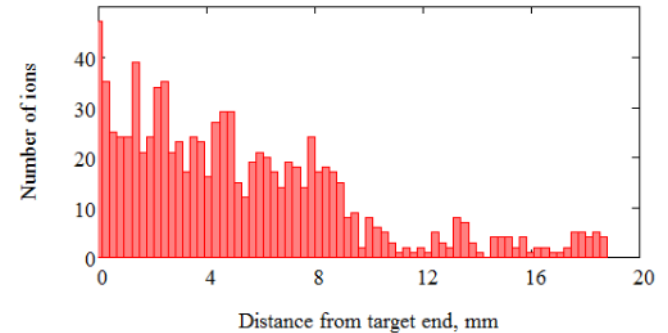
Operation Conditions

Magnet Current	129.2 A
Magnet Lateral Adjustment	0.619 mm
Magnet Vertical Adjustment	0.0 mm
Puller Gap	1.5 mm
Source Offset	2.0 mm
Source Gas	0.6 sccm
Source Aperture	0.635 mm x 2 mm with 30 degree bevel
RF Frequency	67.123 MHz
Dee Voltage	17.0 KV Peak



ION-12SC OPERATION EXPERIENCE – BEAM SPOT & ENERGY

Measured beam stopping distance
 Total thickness: 0.848 mm Borosilicate Glass
 Beam Energy: ~ 12.1 MeV SRIM calculation
 Slides 1 – 5 = 0.728 mm, 5.5 – 6 = 0.120 mm
 Beam spot radial width: ~ 12 mm



SUMMARY

- R&D and commissioning for the ION-12SC superconducting cyclotron for medical isotope production have been successfully completed
- ION-12SC have significant advantages over existing machines
 - Size and weight
 - Cost
 - Power consumption and shielding
 - Installation and operations
- Mass production at Ionetix soon to satisfy expected world demand.

THANK YOU

For more information please contact:

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