Status Report of SECRAL II Ion Source Development

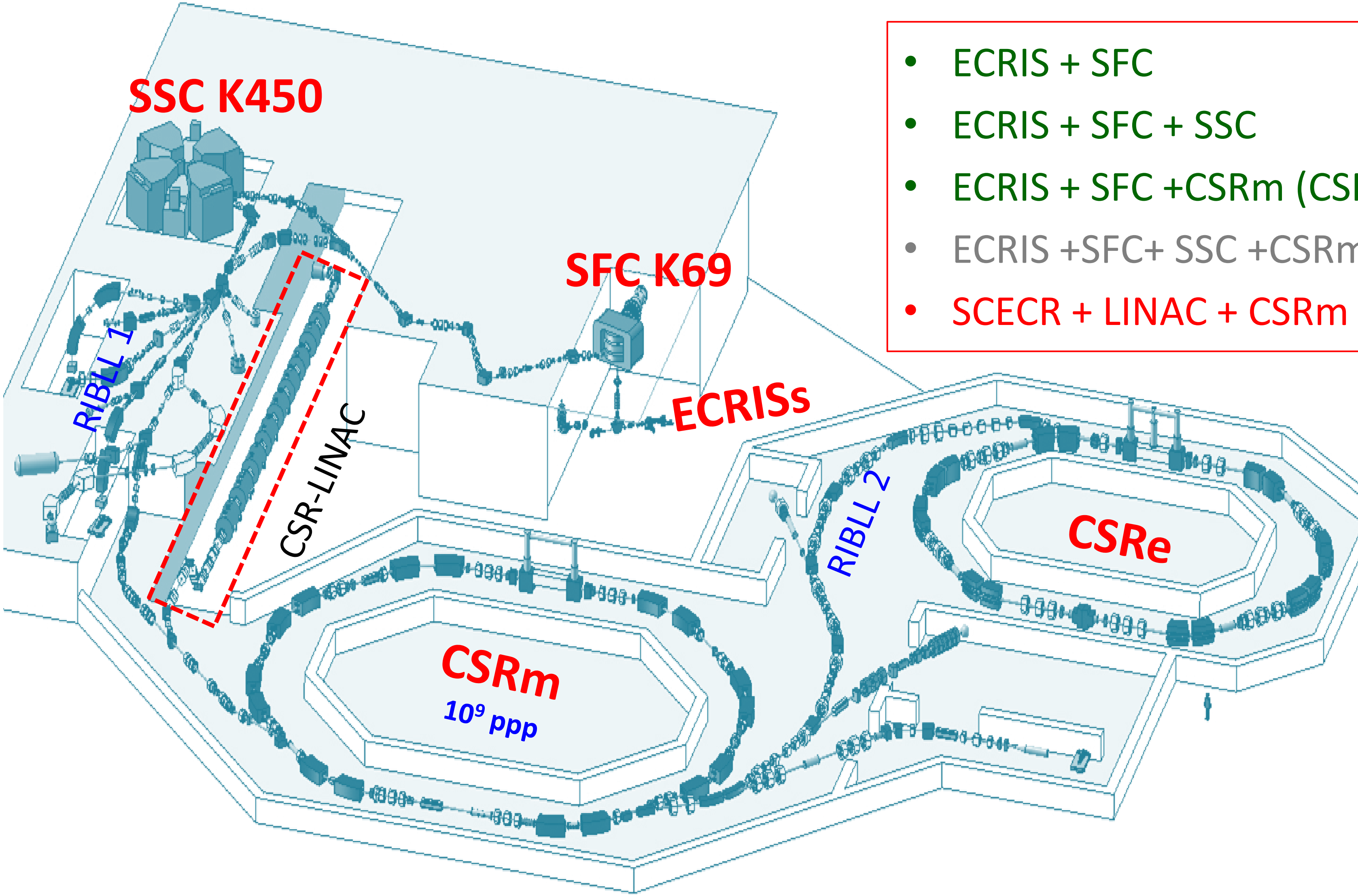
L. Sun

Institute of Modern Physics, CAS

Outline

- Motivation of SECRAL II
- Perspectives of SECRAL II
  - Latest Performance of SECRAL I
  - SECRAL II design
- SECRAL II Magnet Status
- Summary

HIRFL Operation Scheme

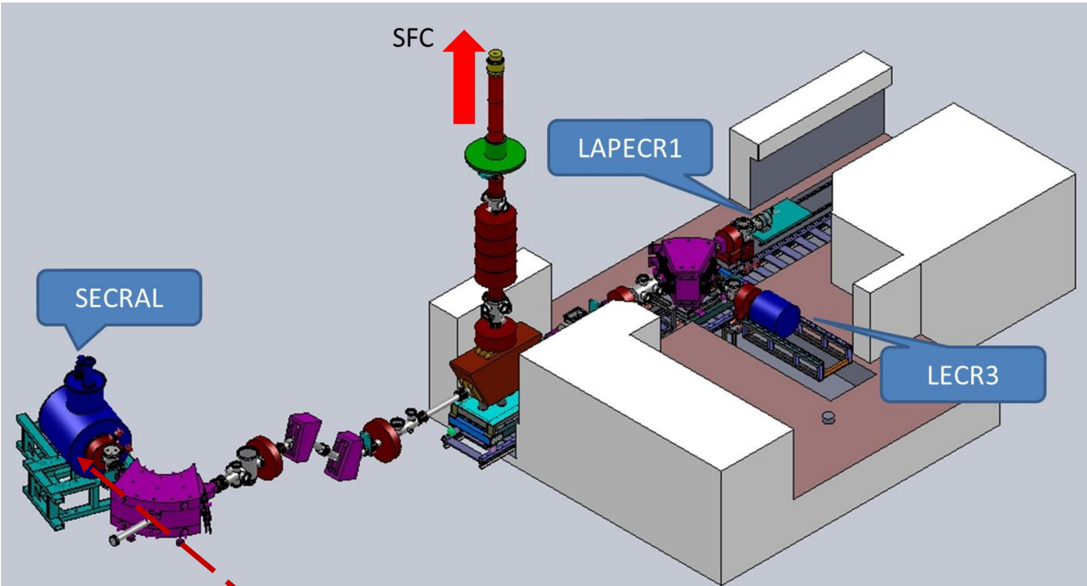


- ECRIS + SFC
- ECRIS + SFC + SSC
- ECRIS + SFC +CSRm (CSRe)
- ECRIS +SFC+ SSC +CSRm
- SCECR + LINAC + CSRm

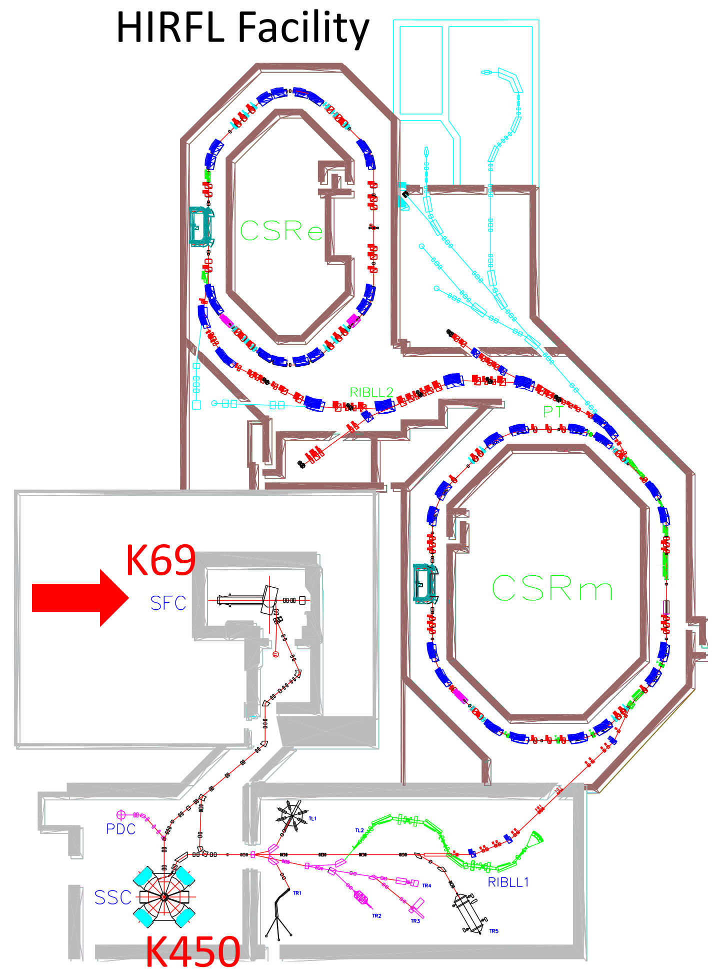
CSR-LINAC Project

A/q	3~7 ($^{238}U^{34+}$)
Frequency	108.48/216.96/(325.44) MHz
Kinetic energy	7(14) MeV/u
Pulsed Beam current	>1puA→ECR >2 puA
Beam repetition rate	1~30 Hz
Beam pulse duration	0.1~3 ms

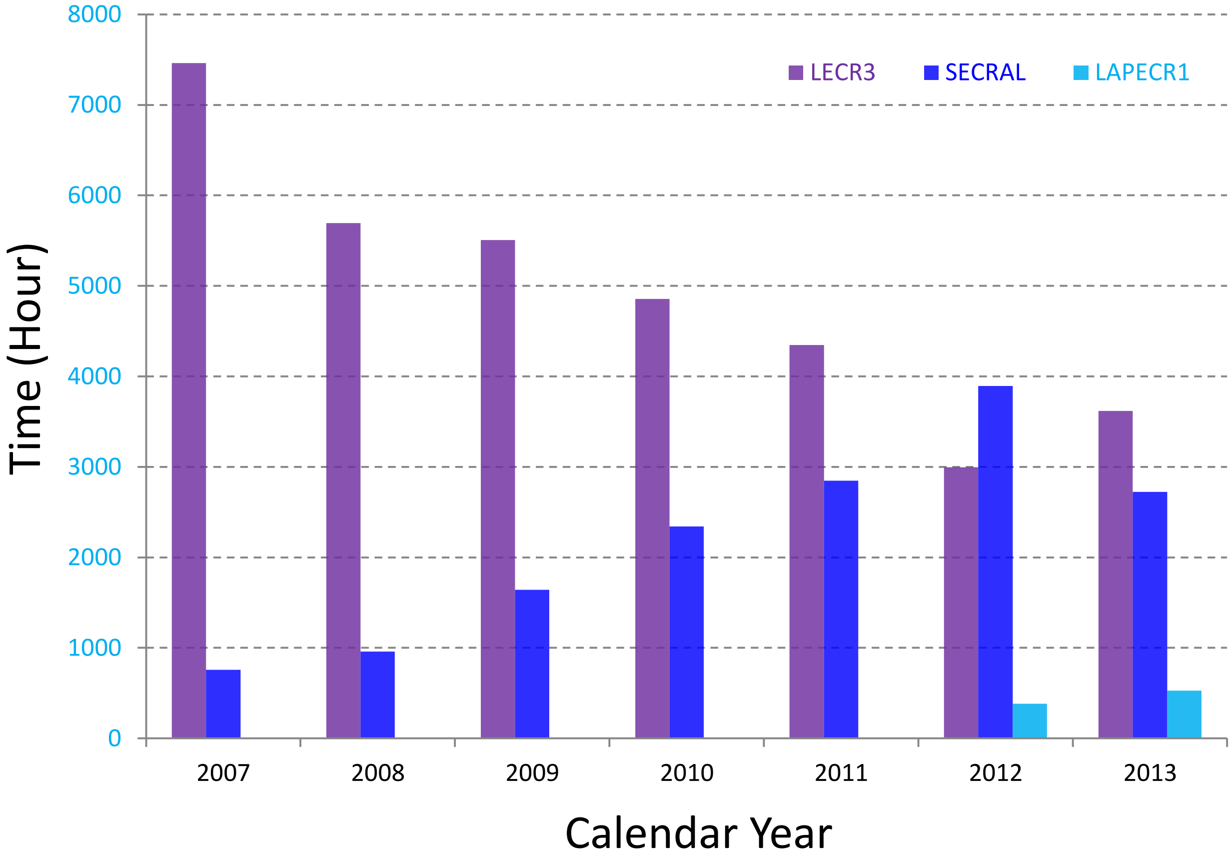
Backup of SECRAL



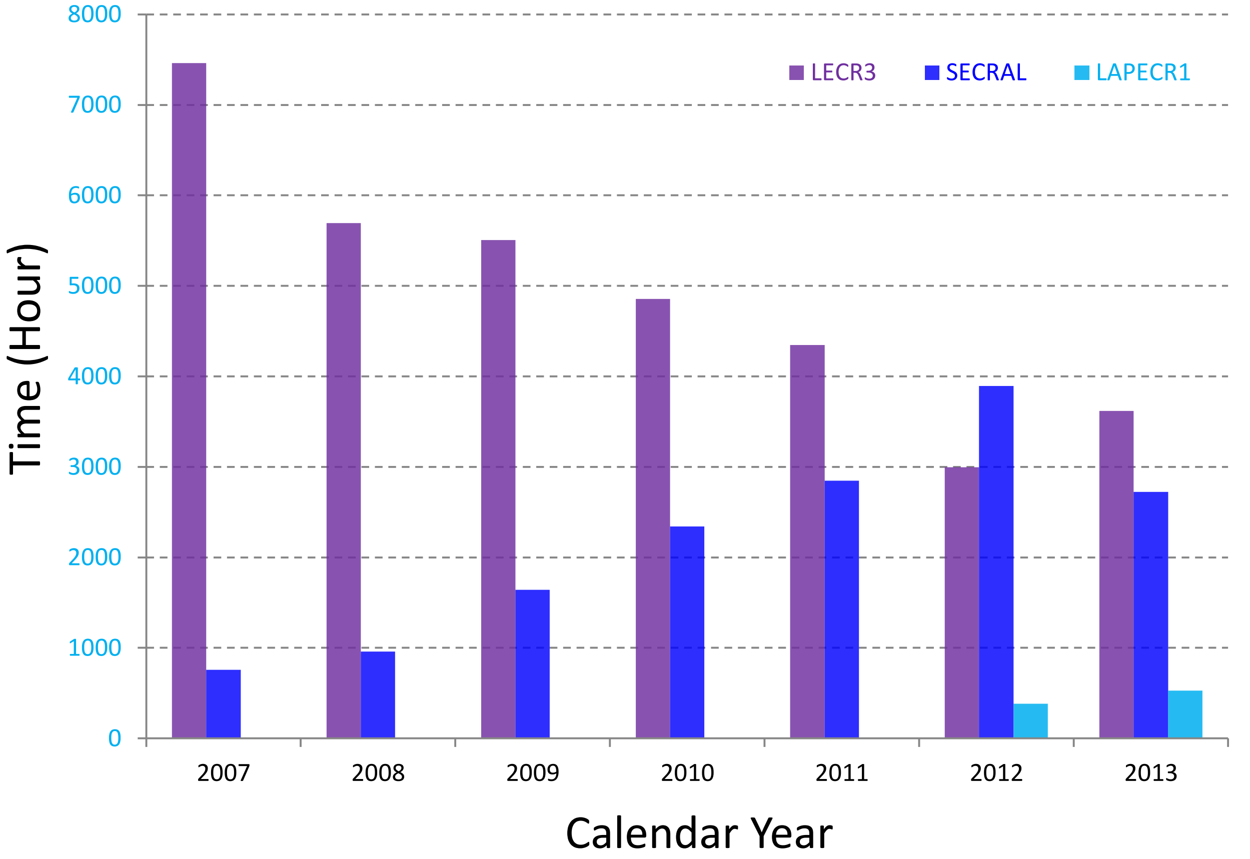
SECRAL: Highly charged ion beams heavier than Ar



Operation of SECRAL I

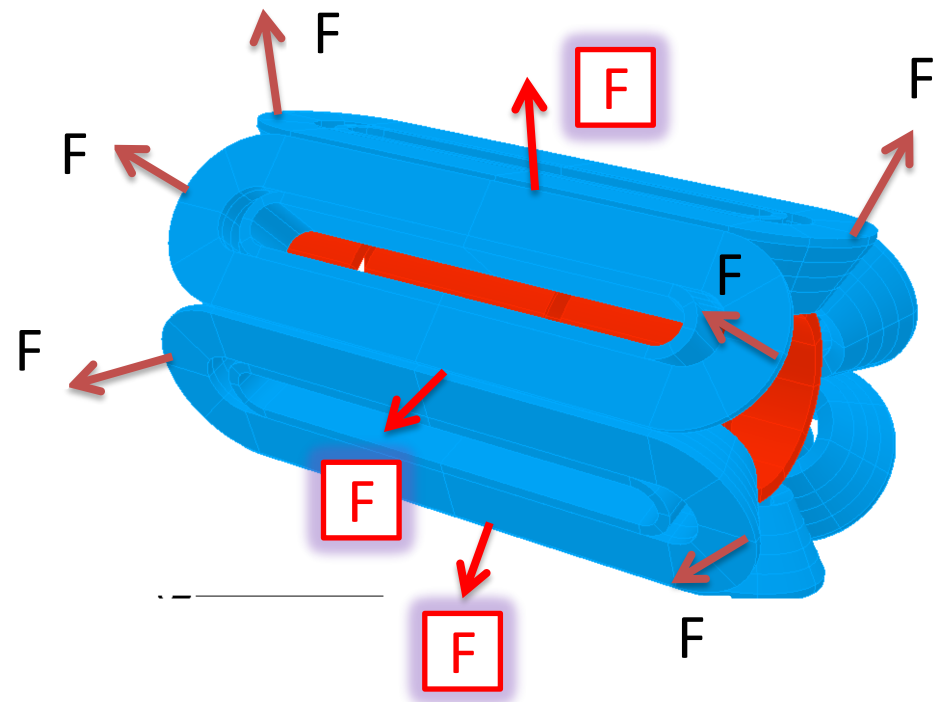


Operation of SECRAL I



Need contingency plan if SECRAL might fail to work

SECRAL Magnet



Pros

- Lower/simpler interaction forces;
- Smaller magnet size and cryostat;
- Simpler fabrication and somewhat a bit lower cost.

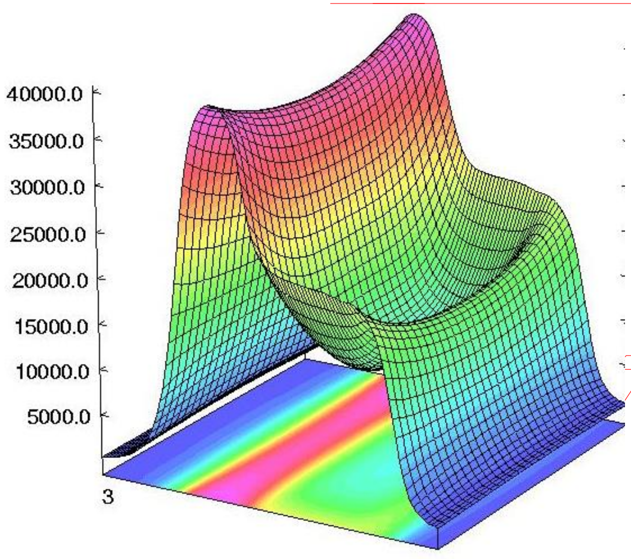
Con

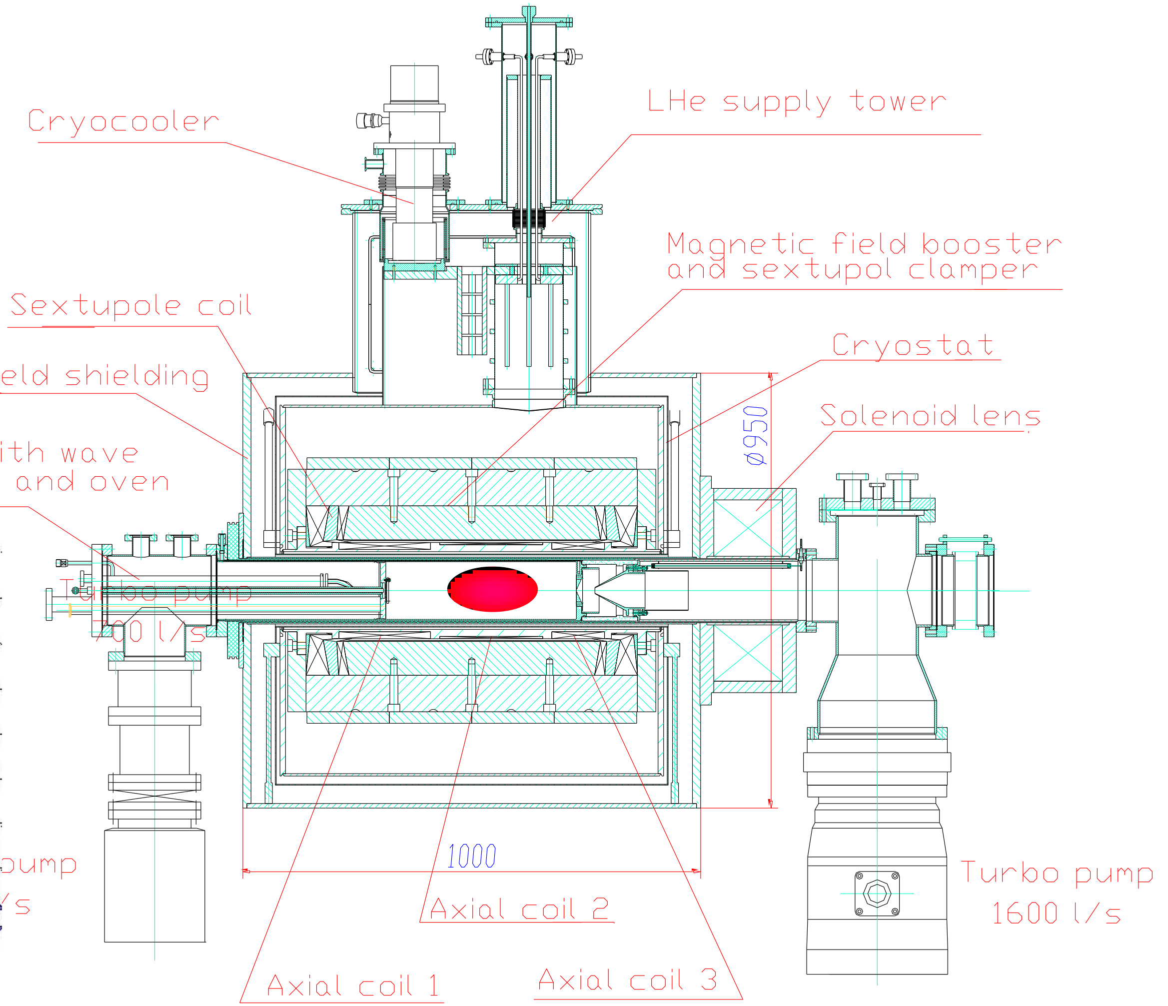
Inefficient utilization of the radial field.

Courtesy of D. Xie

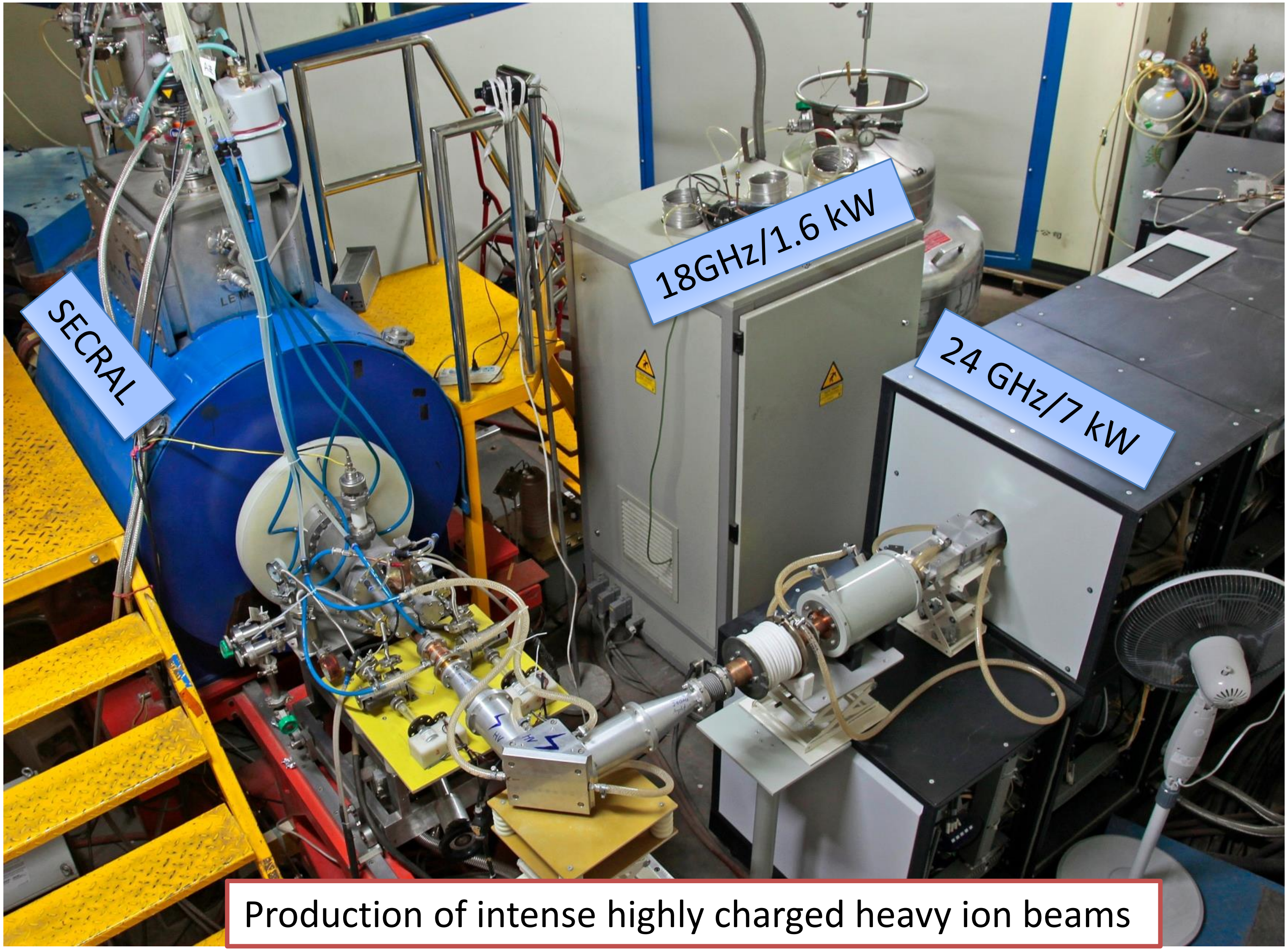
SECRAL I

Fully superconducting magnet
Axial field: 3.7, 2.2T
Sextupole Field at the wall: 2.0 T
RF frequency: 18-24 GHz
Warm bore: Ø140 mm
Extraction voltage: 25 kV



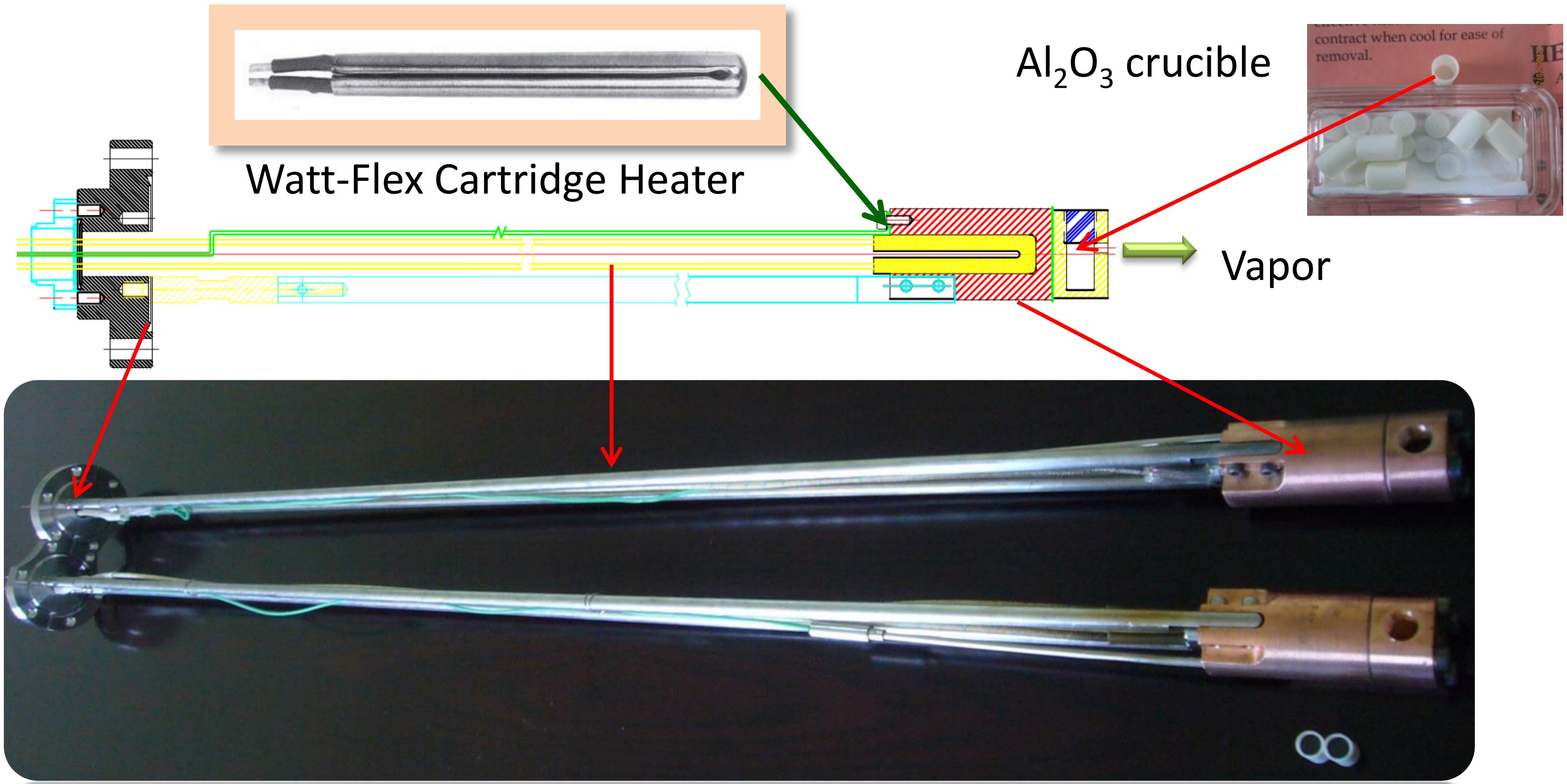


SECRAL I



Production of intense highly charged heavy ion beams

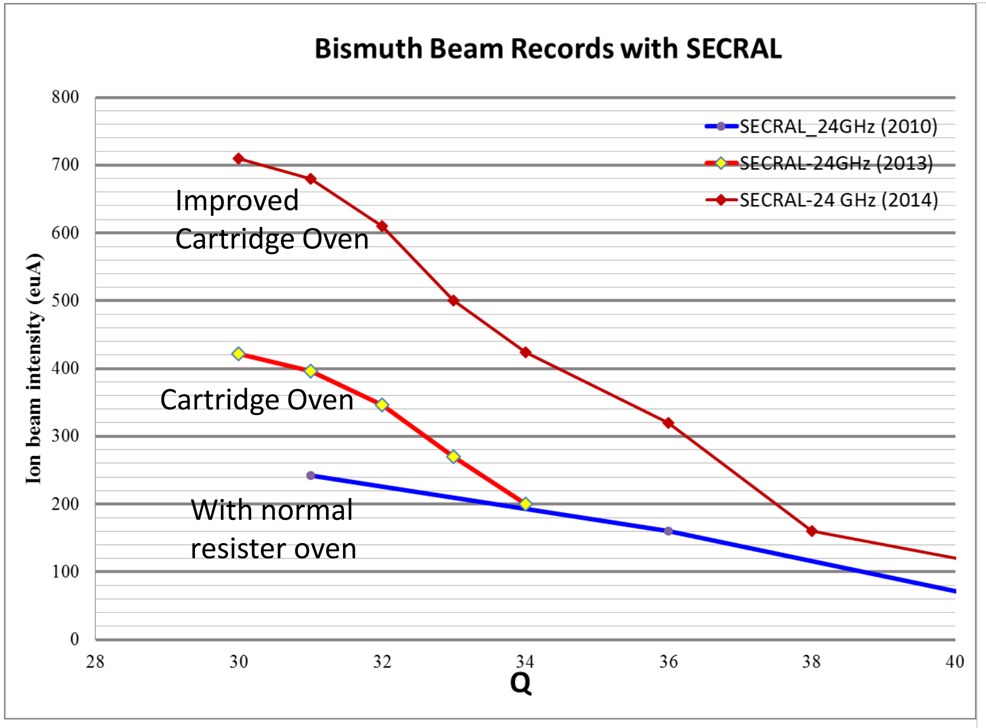
Improved Oven Tech.

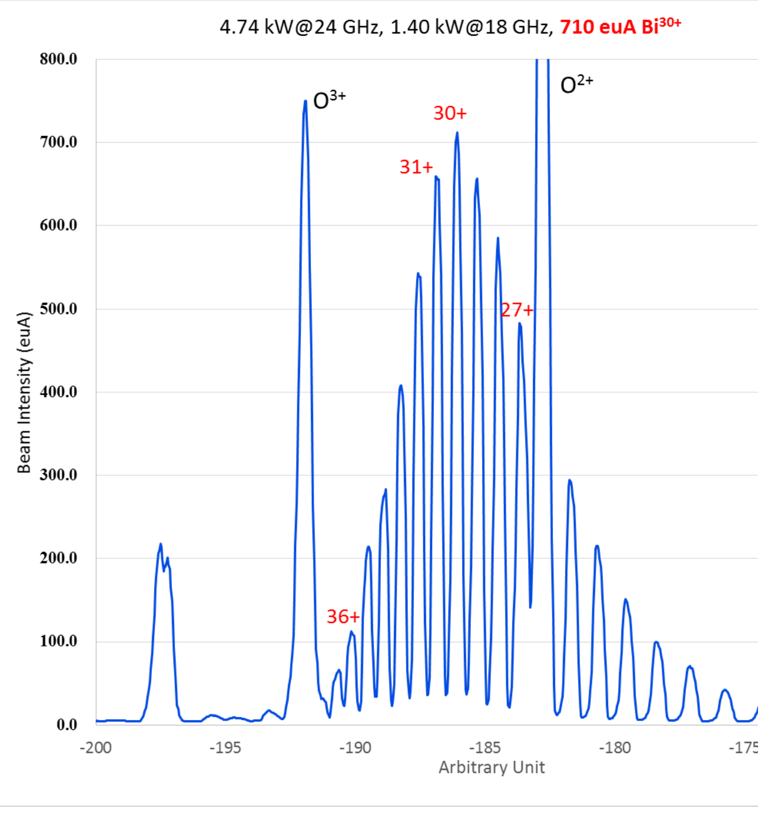


- Temp.: 650^0C Max., continuous control
- Capacity: Ø 7mmX12 mm crucible→>2 g Max. for Bi grains
- No liquid metal spilling

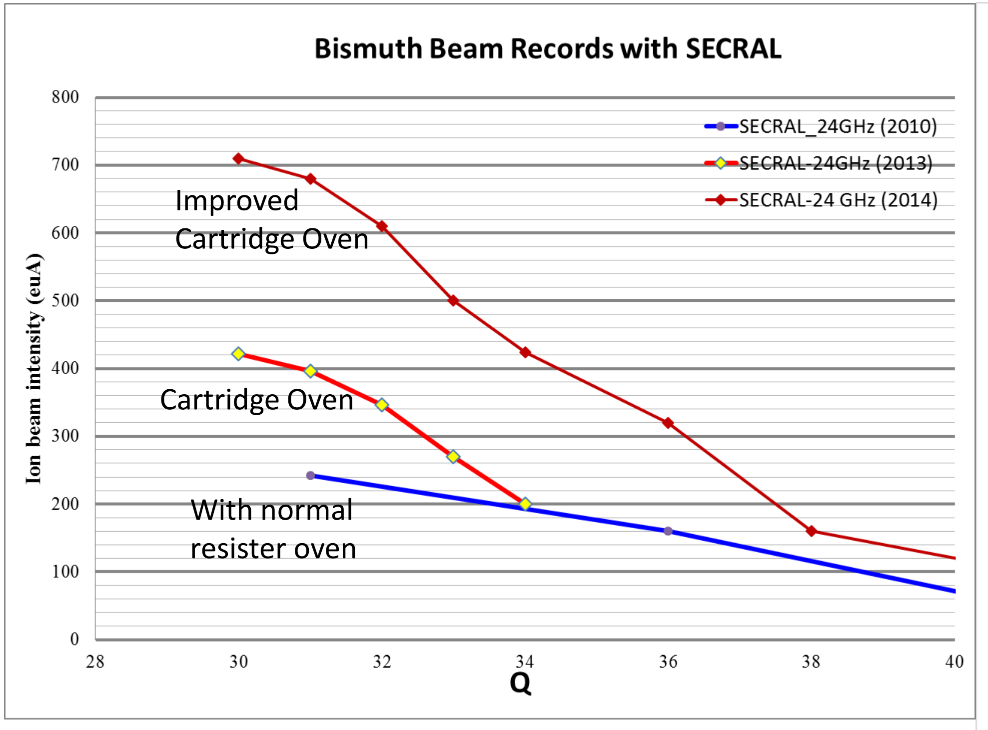
Tech. idea from LBNL

Intense Bi Beam Production

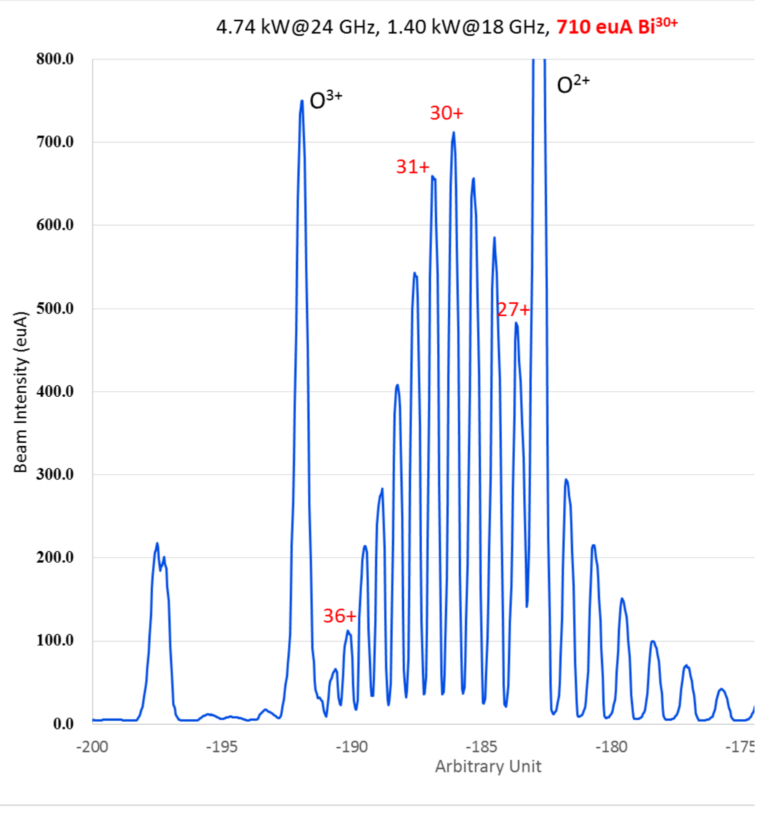




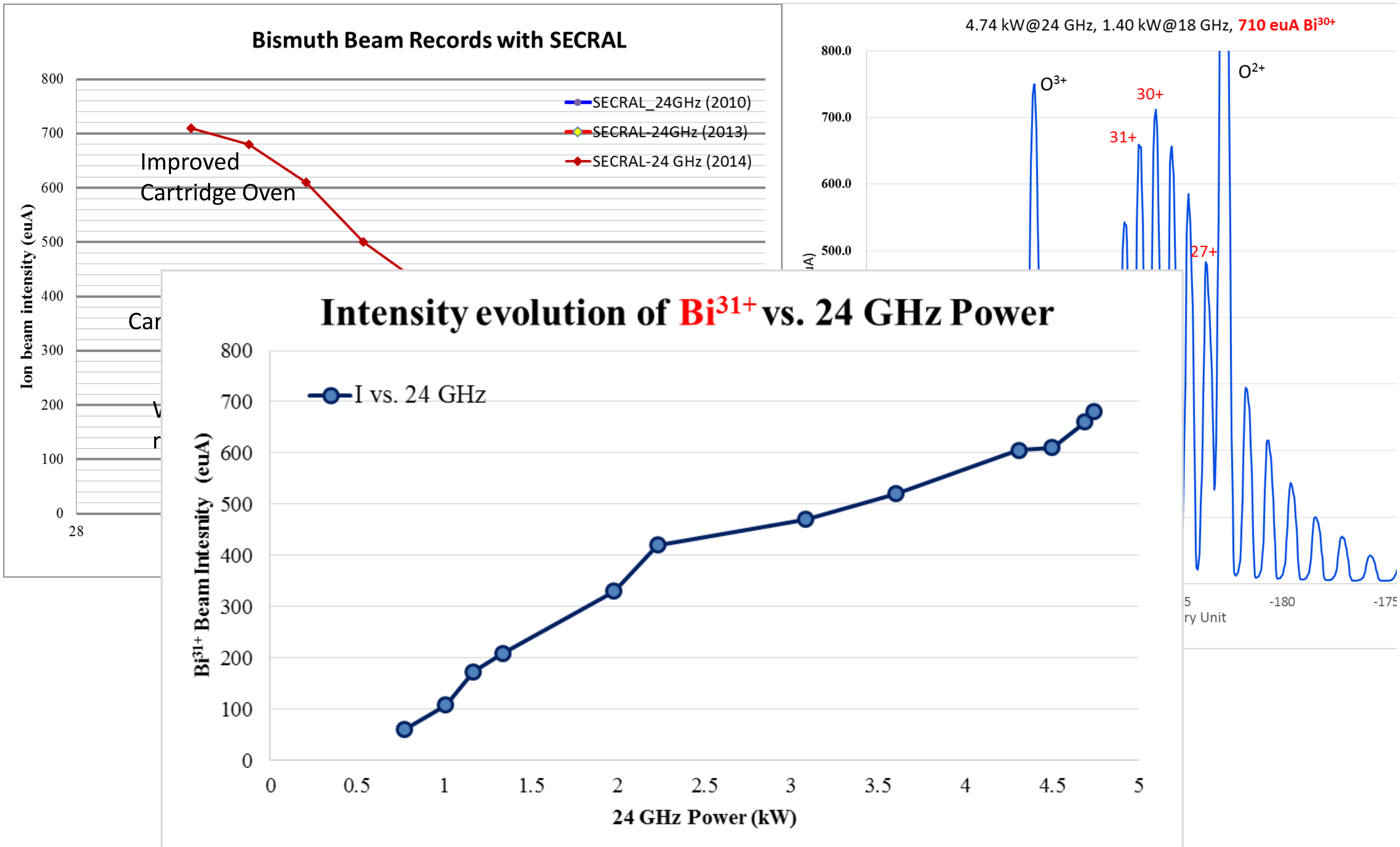
Intense Bi Beam Production



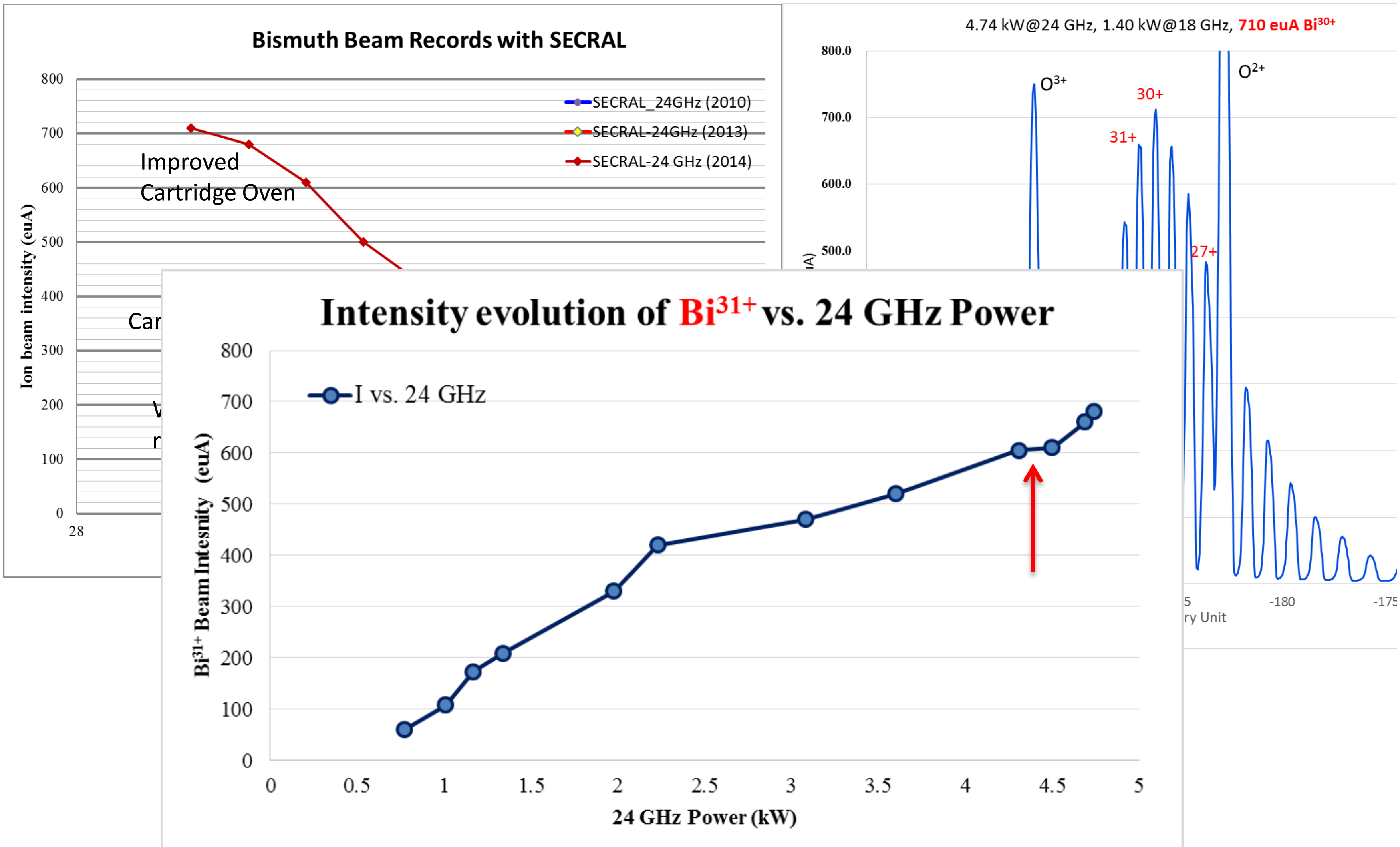
400 eμA Bi^{31+}@10.91 mg/hr



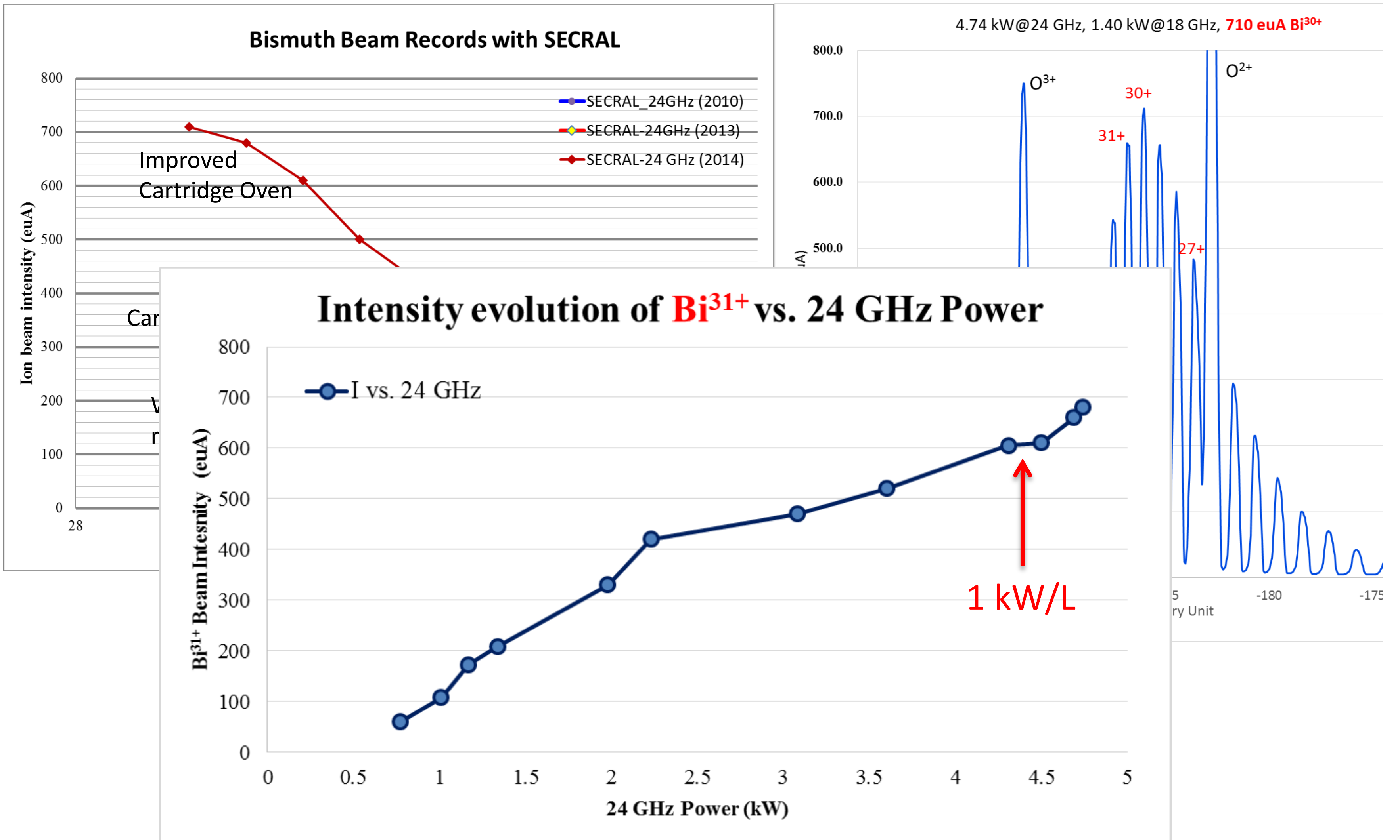
Intense Bi Beam Production



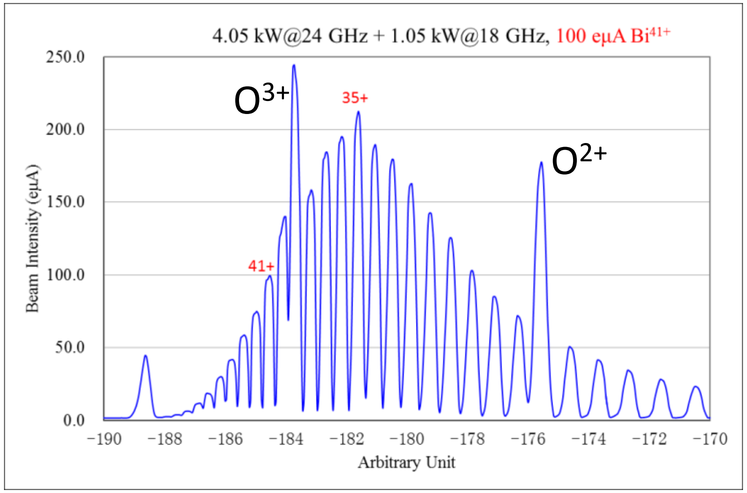
Intense Bi Beam Production

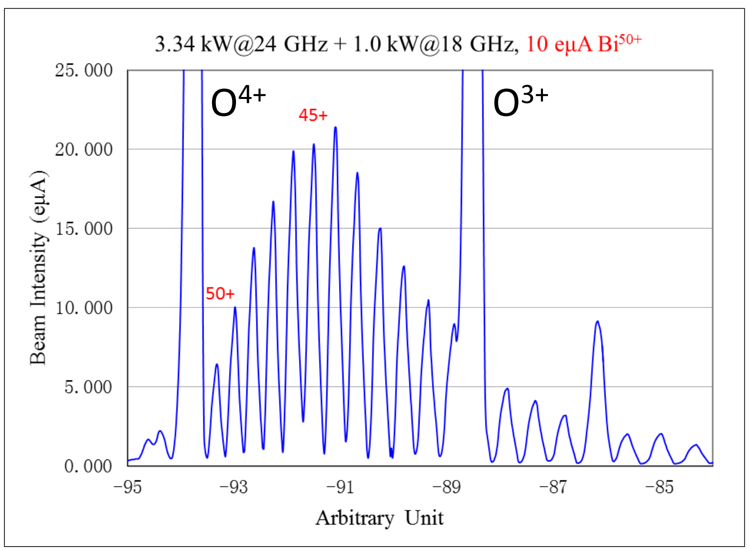


Intense Bi Beam Production



Production of HCIs

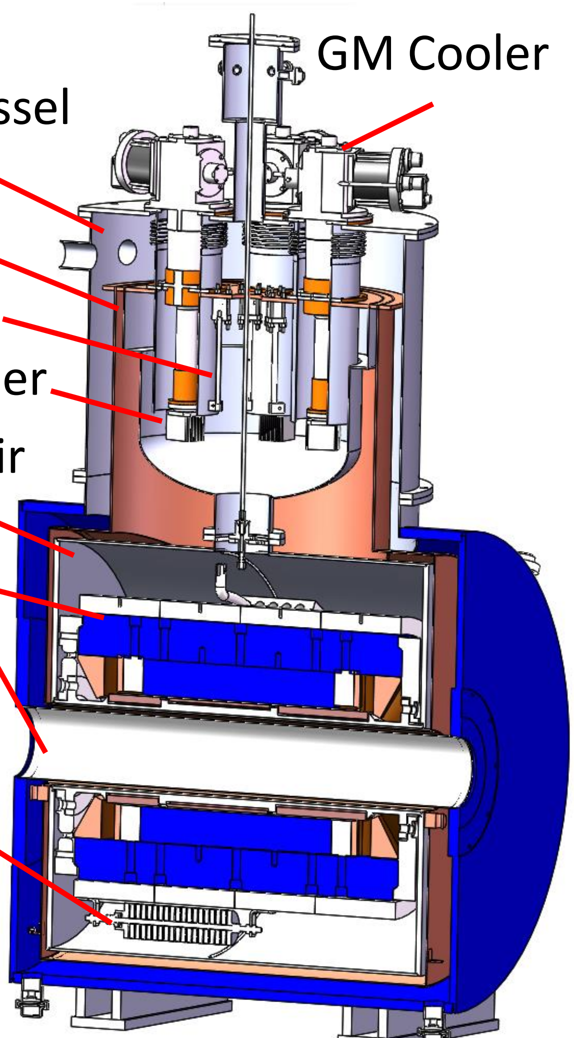




SECRAL I-24 GHz Bi results-2014

Q	Iq (eμA)
30	710
31	680
32	610
33	500
34	424
36	320
45	49
50	10.7
54	3.4
55	1.5
56	0.4
57	0.05

SECRAL II



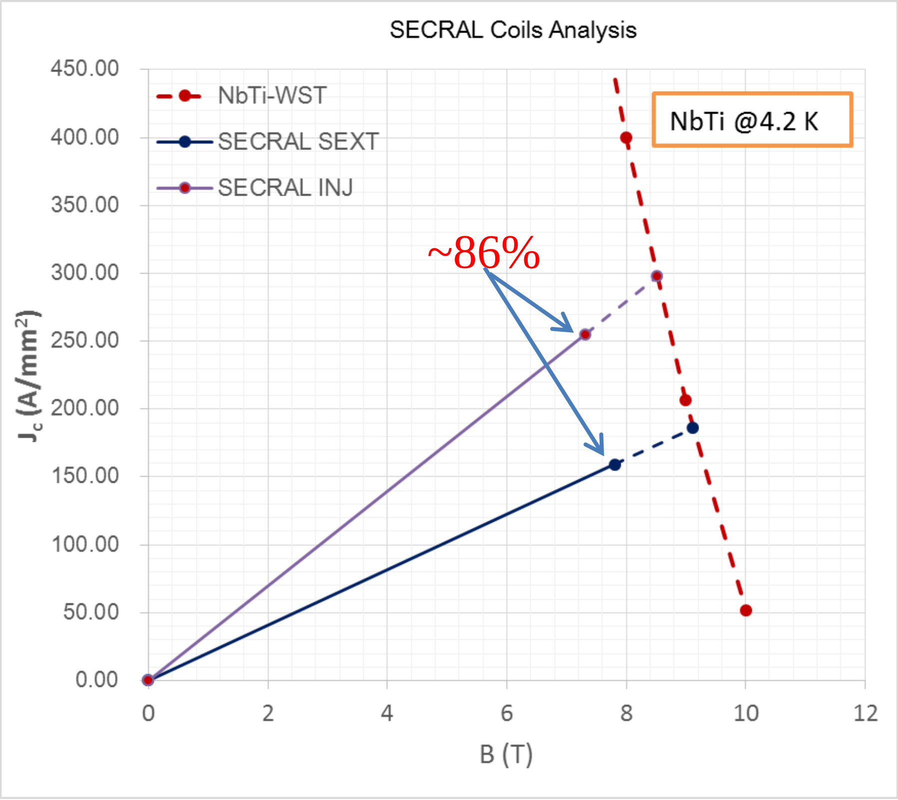
Parameters	Value
ω_{rf} (GHz)	18-28
Axial Field Peaks (T)	3.7 (Inj.), 2.2 (Ext.)
Mirror Length (mm)	420 mm
No. of Axial SNs	3
B_r at Chamber Inner Wall (T)	2.0
Coldmass Length (mm)	~810
SC-material	NbTi
Magnet Cooling	LHe bathing
Warmbore ID (mm)	~142
Chamber ID (mm)	~126
Dynamic cooling power (W)	~5

NbTi Wire

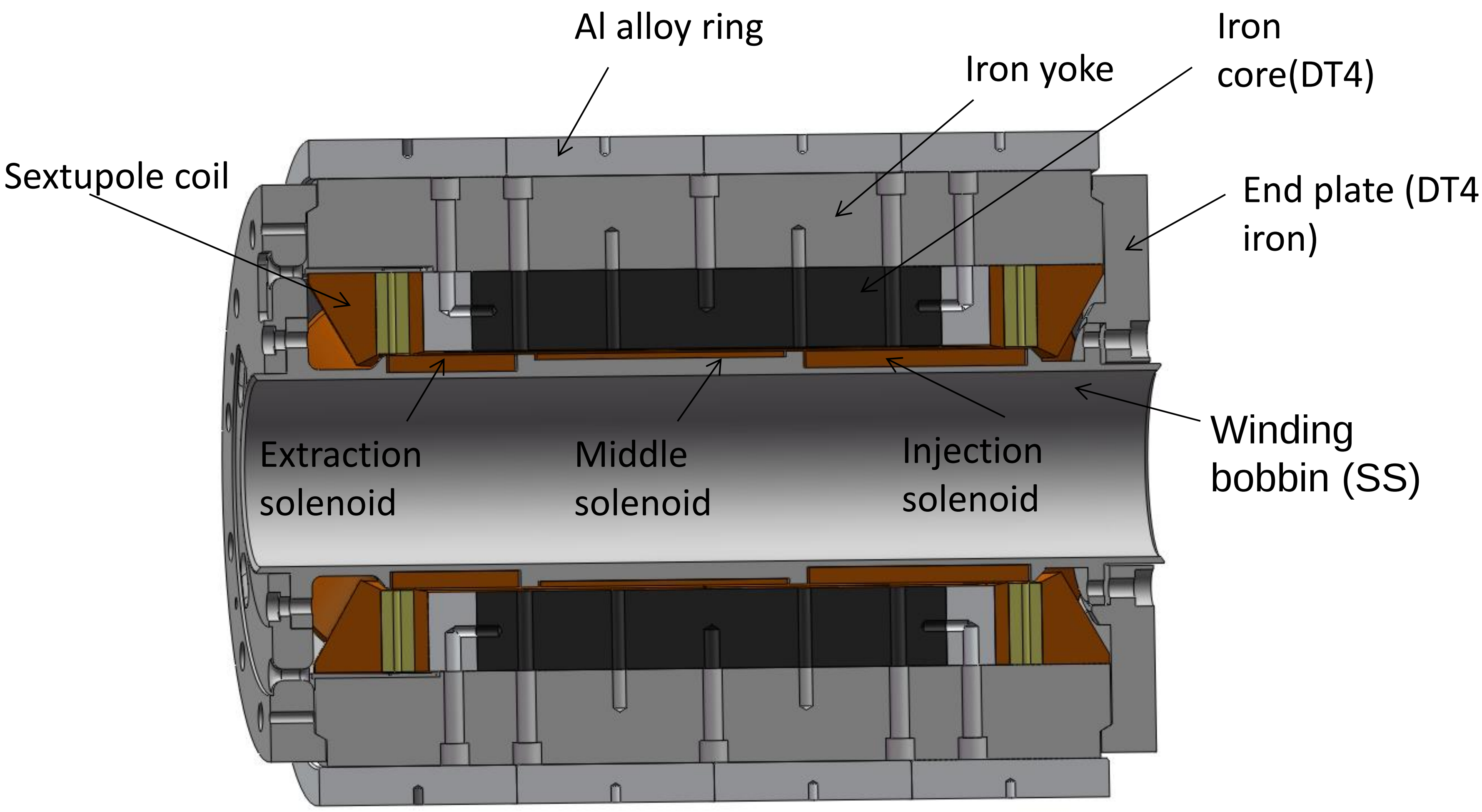
Rectangular wire from WST Co. Ltd

Item	Specs.
Type	Monolith
Insulation	Formvar
Bare size (mm^2)	1.20 × 0.75
Insulated size (mm^2)	1.28× 0.83
Cu/Sc ratio	1.3:1
RRR	>100
No. of Filaments	630
Filament size (μm)	27.6
Pitch size (mm)	15

Loading factor analysis chart



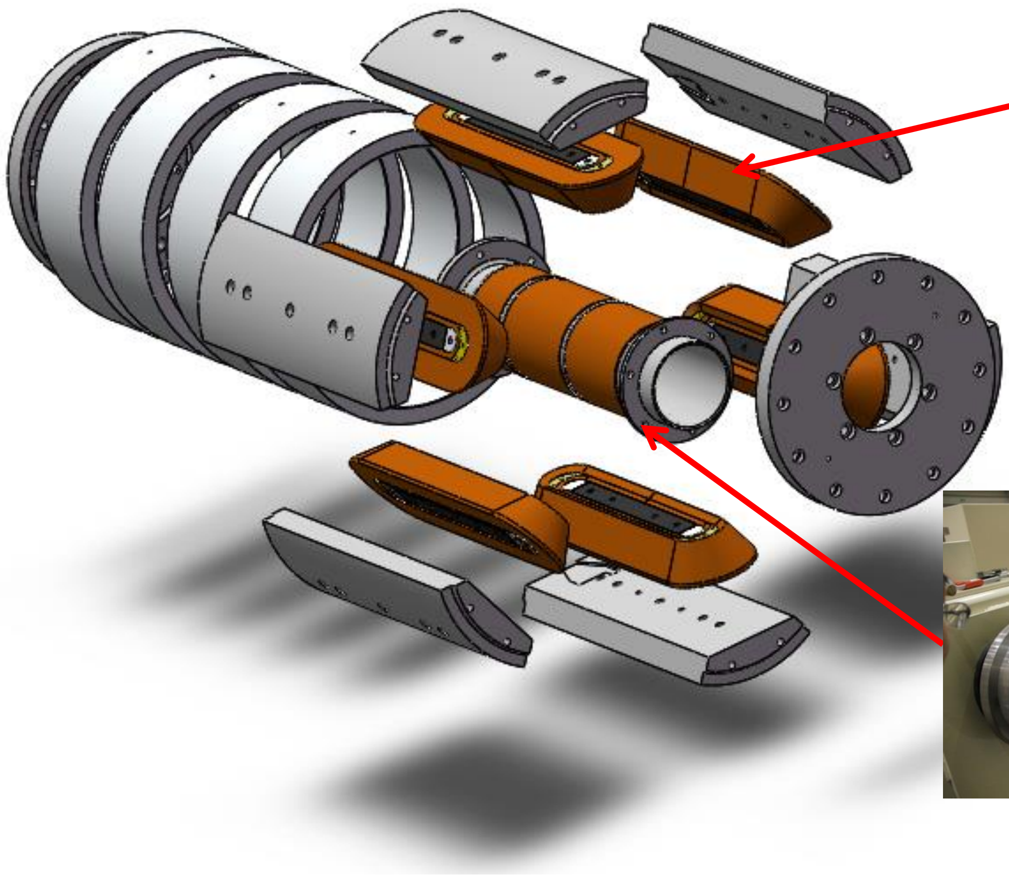
Cold Mass

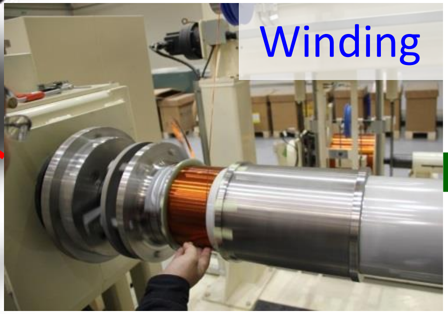


Al alloy ring
Iron yoke
Iron core(DT4)
Sextupole coil
End plate (DT4 iron)
Winding bobbin (SS)
Extraction solenoid
Middle solenoid
Injection solenoid

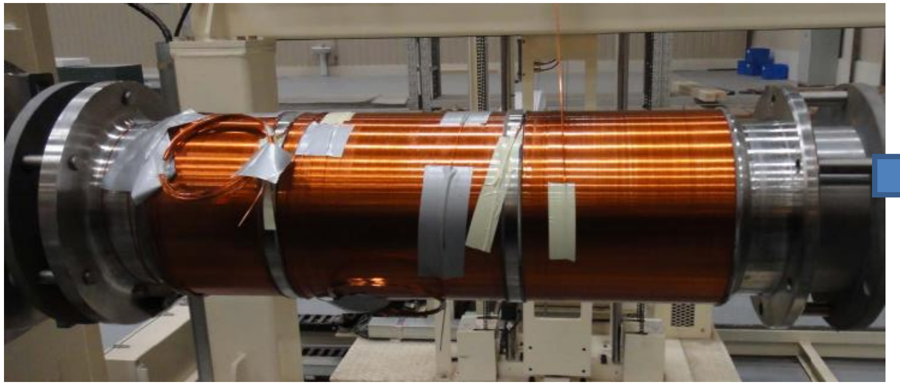
Cold Mass Structure

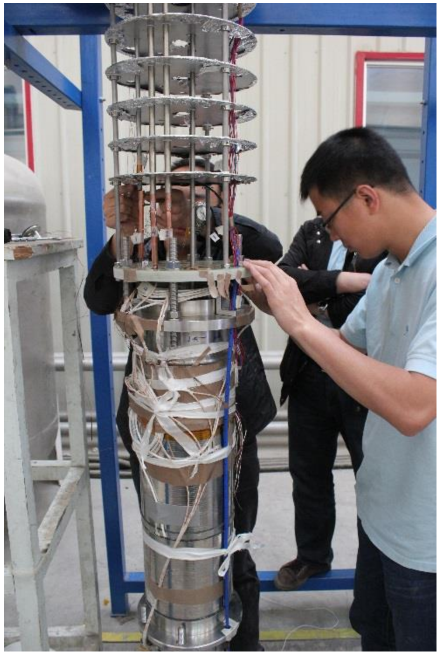
SECRAL II Coldmass





Solenoids

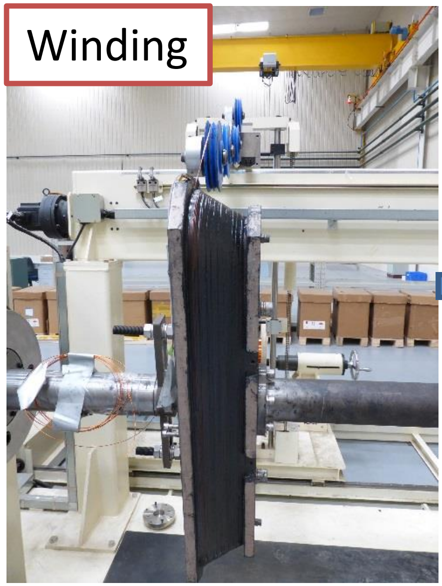




SNs ramped to 115% of designed currents without any quenches

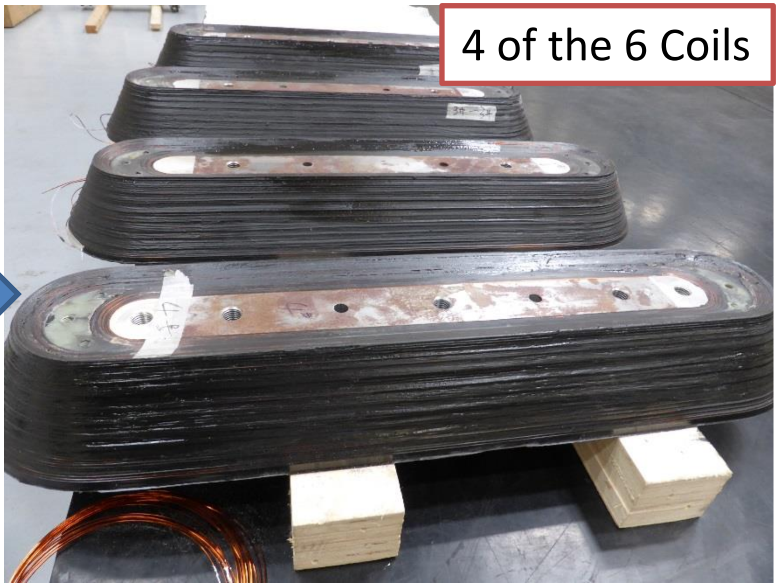
Sextupole Coils

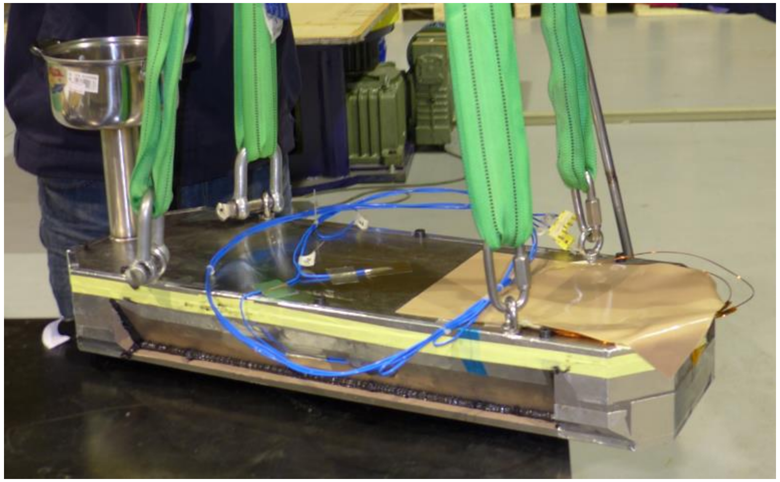
Winding



Single Coil

4 of the 6 Coils





Prepare for vacuum impregnation

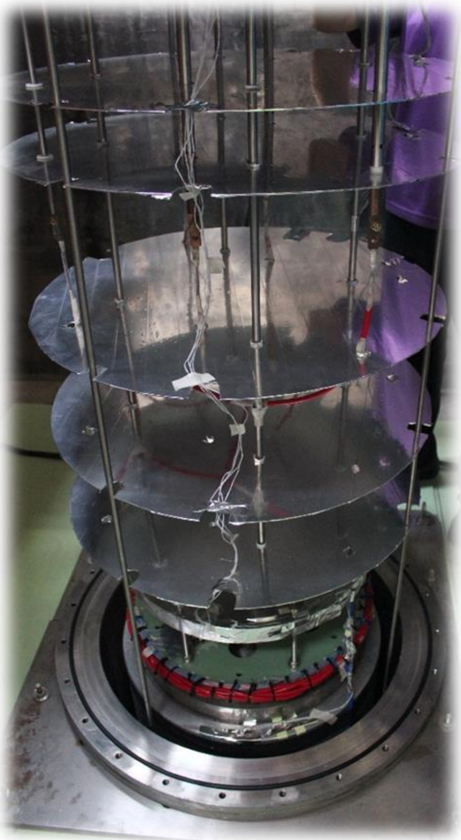
Assembly

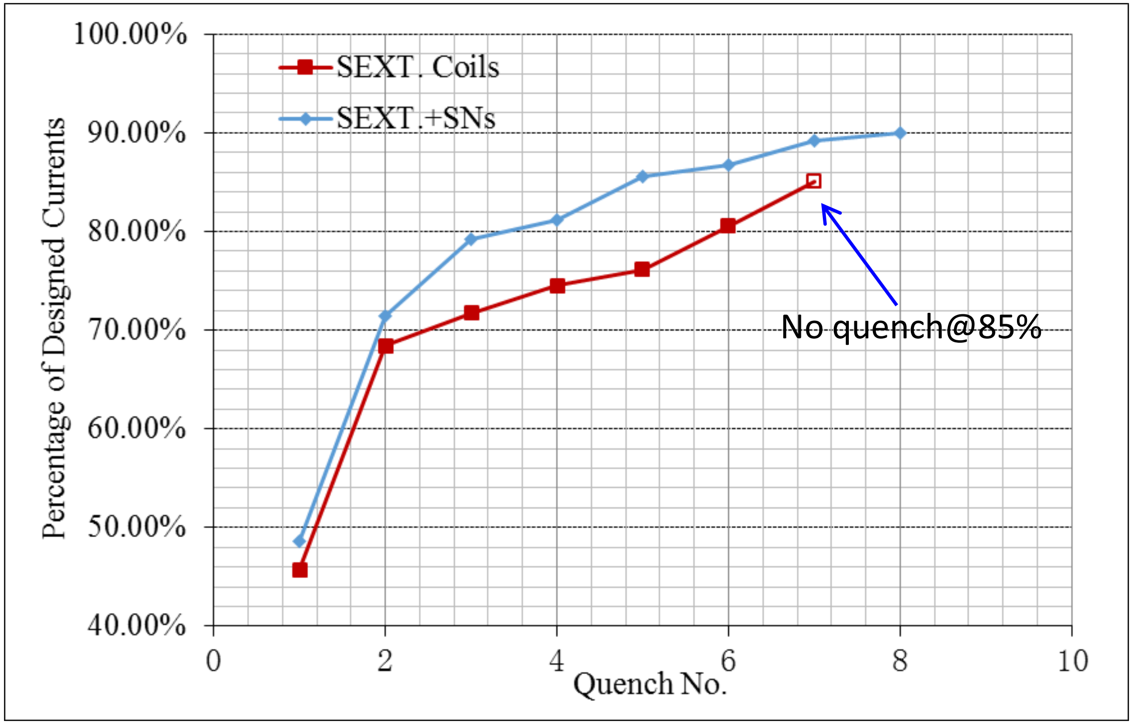
Sextupole Coils Pre-assembly

Finished Assembly

Finished with Al Clamping

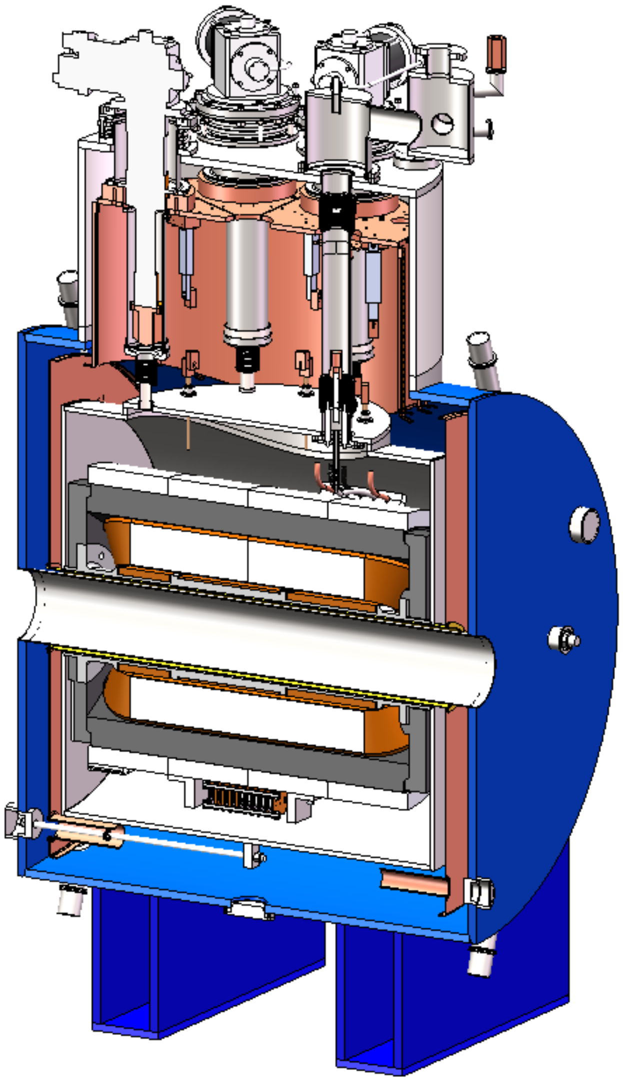
Cold Mass Test@4.2 K





- Sextupole coils ramped to 85% with 6 quenches
- All coils ramped together to 90% with 8 quenches

Status of Magnet Fabrication

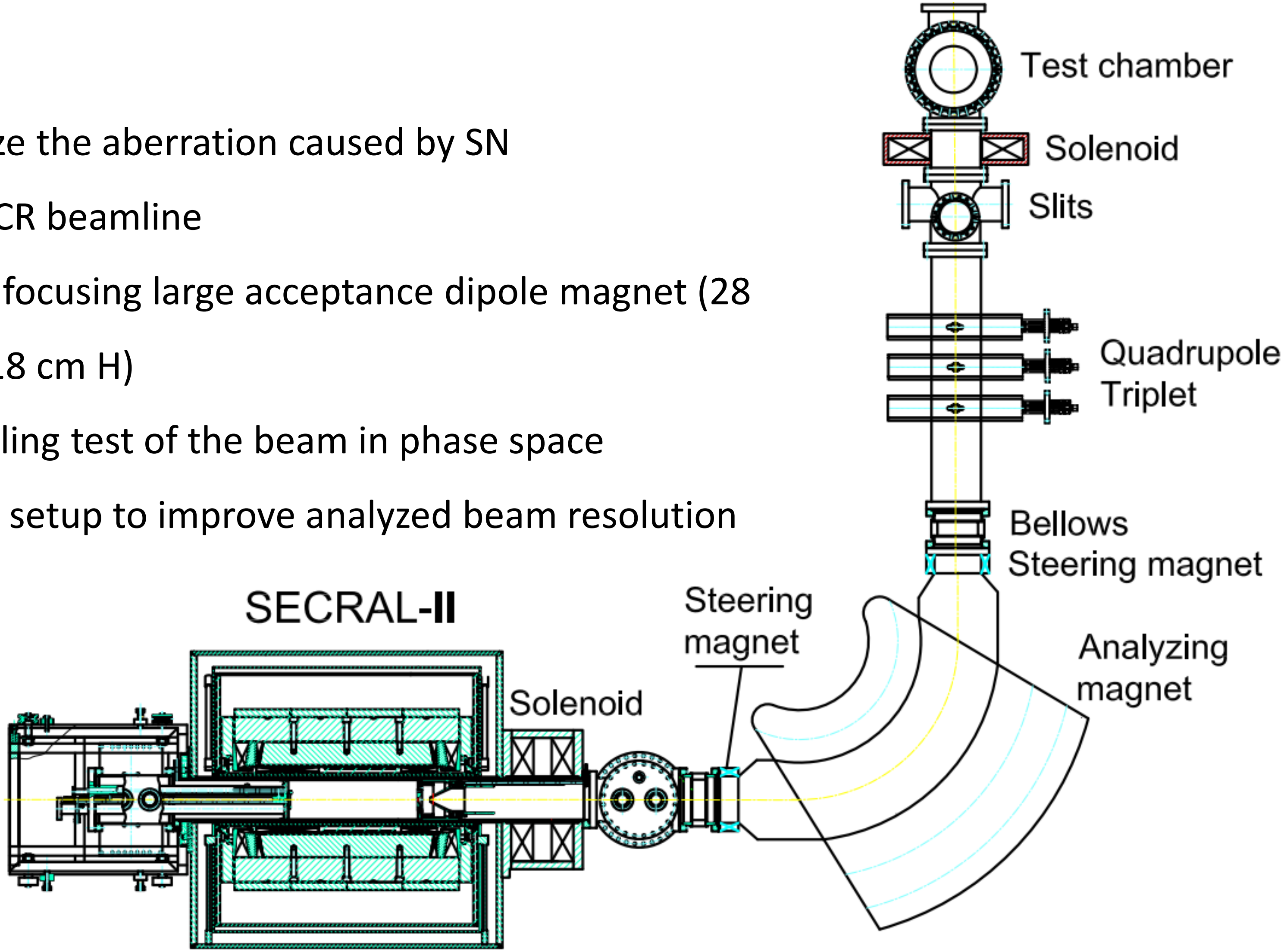


- Engineering design finished, and ready for factory fabrication
- Sumitomo GM coolers are ready to be delivered
- Cryogenics power supplies are to be delivered
- Total assembly is expected to be completed in Jan. 2015

Test Bench Setup

Features:

- Minimize the aberration caused by SN
- Short ECR beamline
- Double focusing large acceptance dipole magnet (28 cm W/18 cm H)
- Decoupling test of the beam in phase space
- Flexible setup to improve analyzed beam resolution



Summary

- 3rd G. ECRISs have been developed for more than 10 years, but still have great potentials
- Metal vapor supply is essential for a high performance ECRIS
- SECRAL II magnet cold mass fabricated successfully

Acknowledgement

Ion Source Group

W. Lu, Y. Yang, Y. C. Feng, W. H. Zhang, X. Z. Zhang, H. W. Zhao

Magnet Group

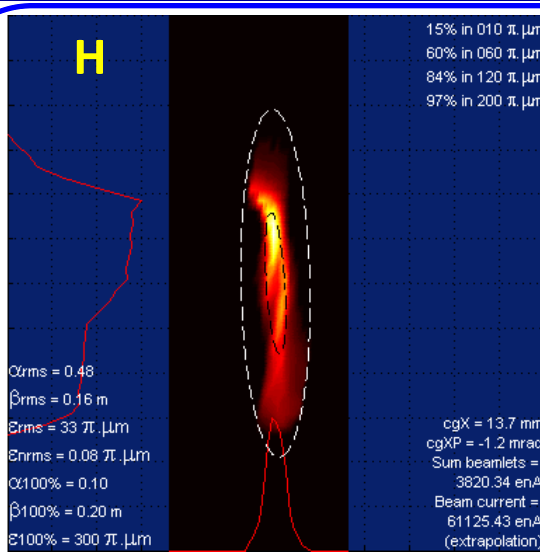
W. Wu, T. J. Yang, D. S. Ni, S. J .Zheng, B. M. Wu, E. M. Mei, B. Zhao, L. Zhu, L. Z. Ma

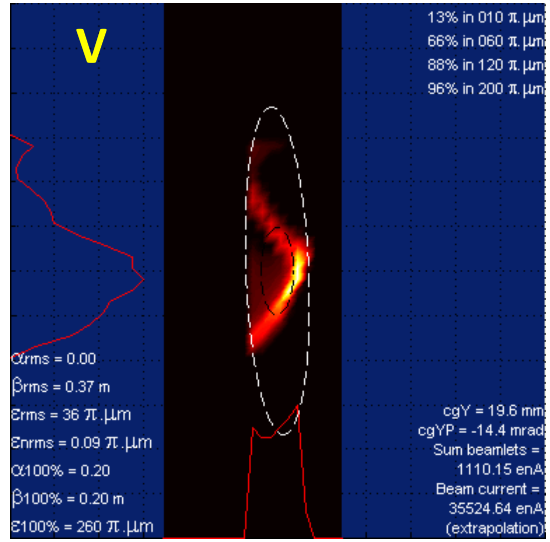
Xi’an Superconducting Magnet Technology (XSMT) Inc.

Thanks !!

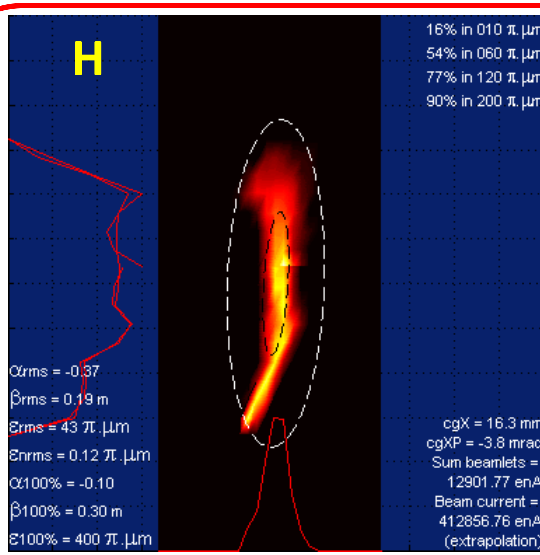
Backup Slides

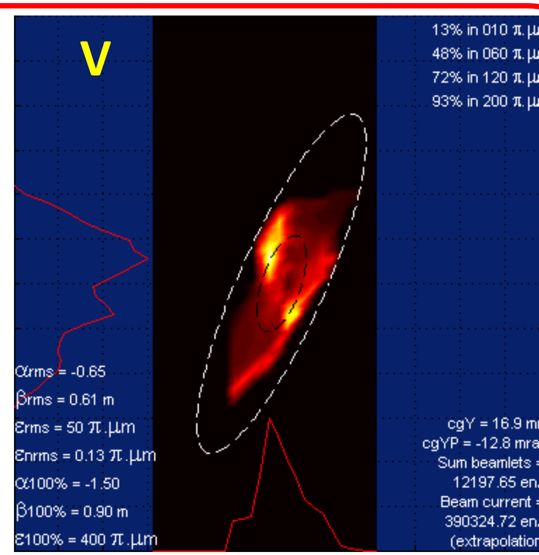
100 eμA



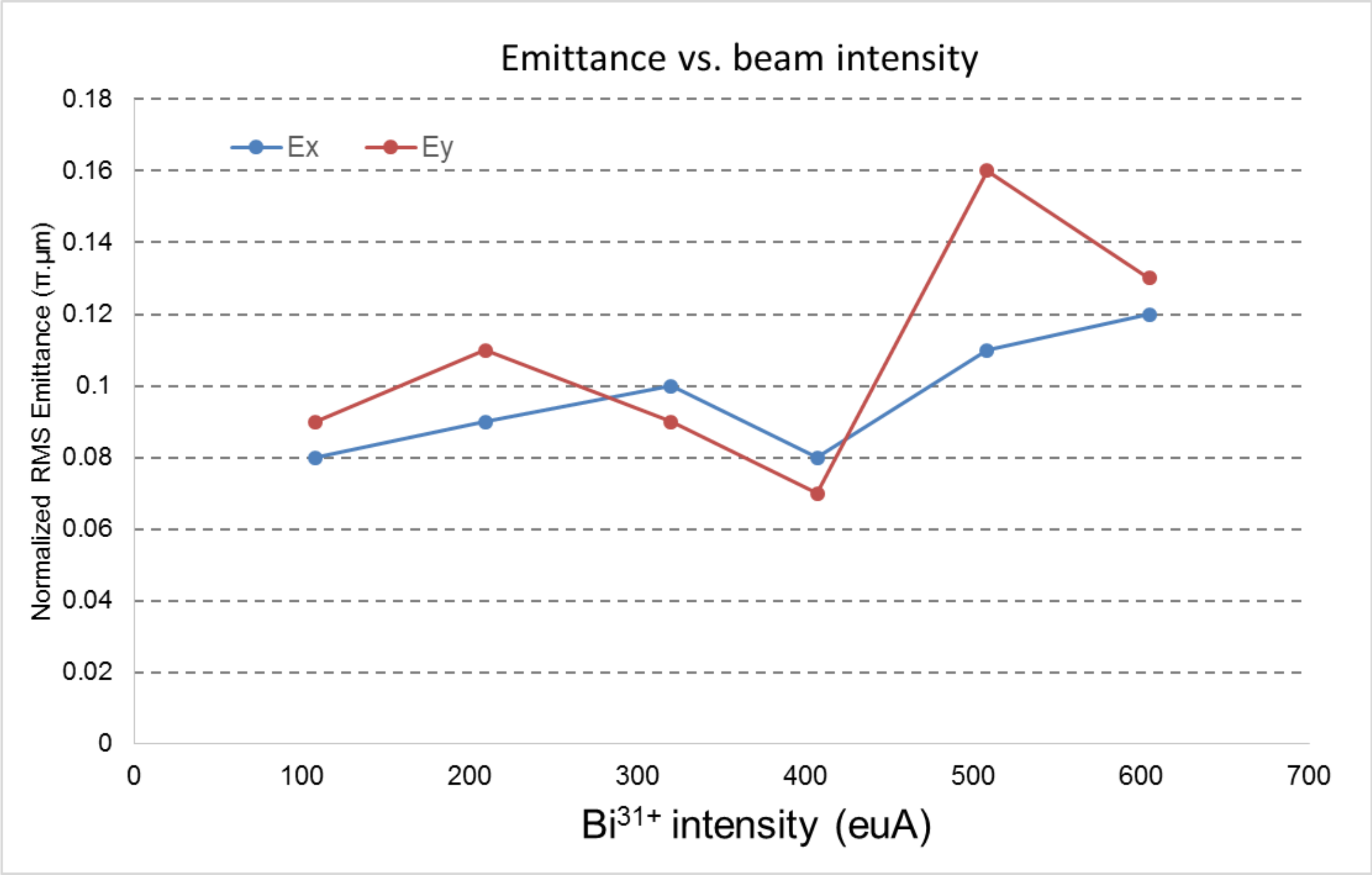


600 eμA

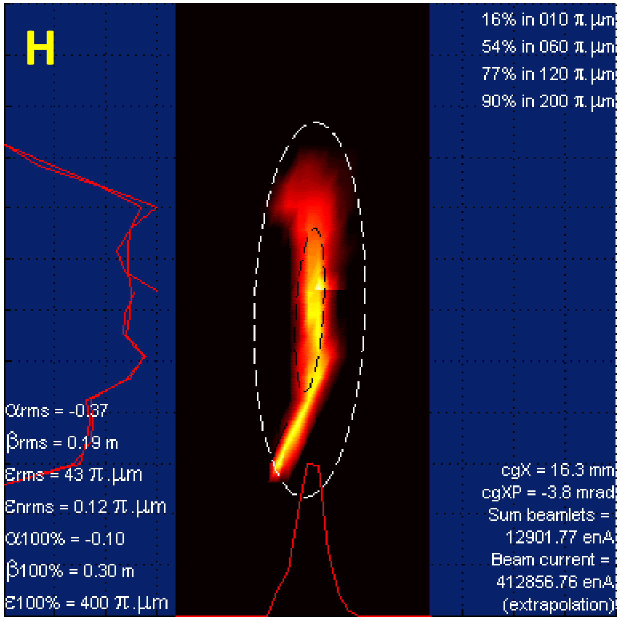


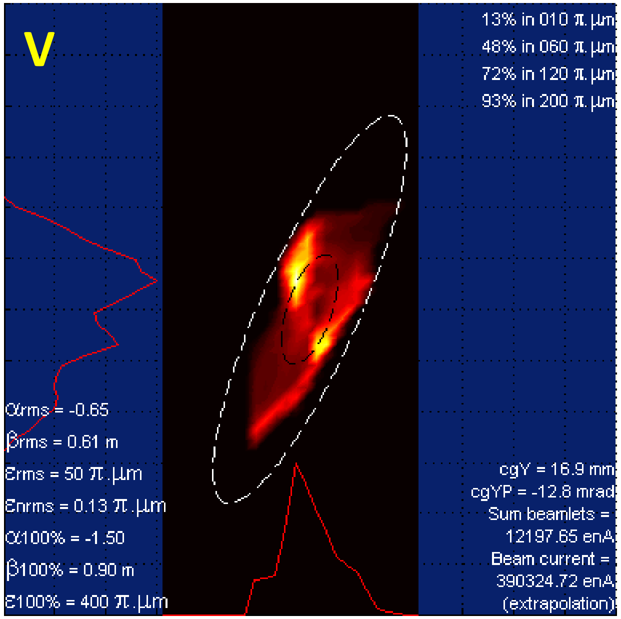


Emittance vs. Intensity



24 GHz, Bi^{31+}, Emittance ~600euA





24 GHz, Bi^{31+}, Emittance ~500euA