Recent THE RIKEN 28GHz SC-ECRIS Result

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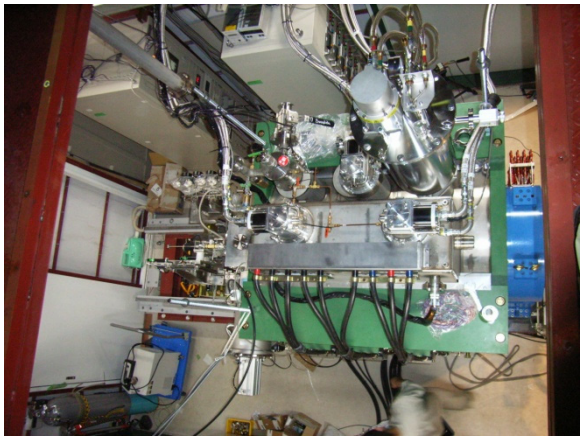
M. Kidera, M. Komiyama and O. Kamigaito, RIKEN
T. Aihara, M. Tamura, A Uchiyama, SHI

Milestone

2007 Design start
2008 Construction start
2009 First beam with 18GHz
2010 Test experiment with 18GHz
Install the ion source in the new IS room for new injector system
2011 Installation of 28GHz gyrotron
First beam with 28GHz



Production of Xe and U beam with 28GHz at the RF power <2kW

m

Contents of presentation

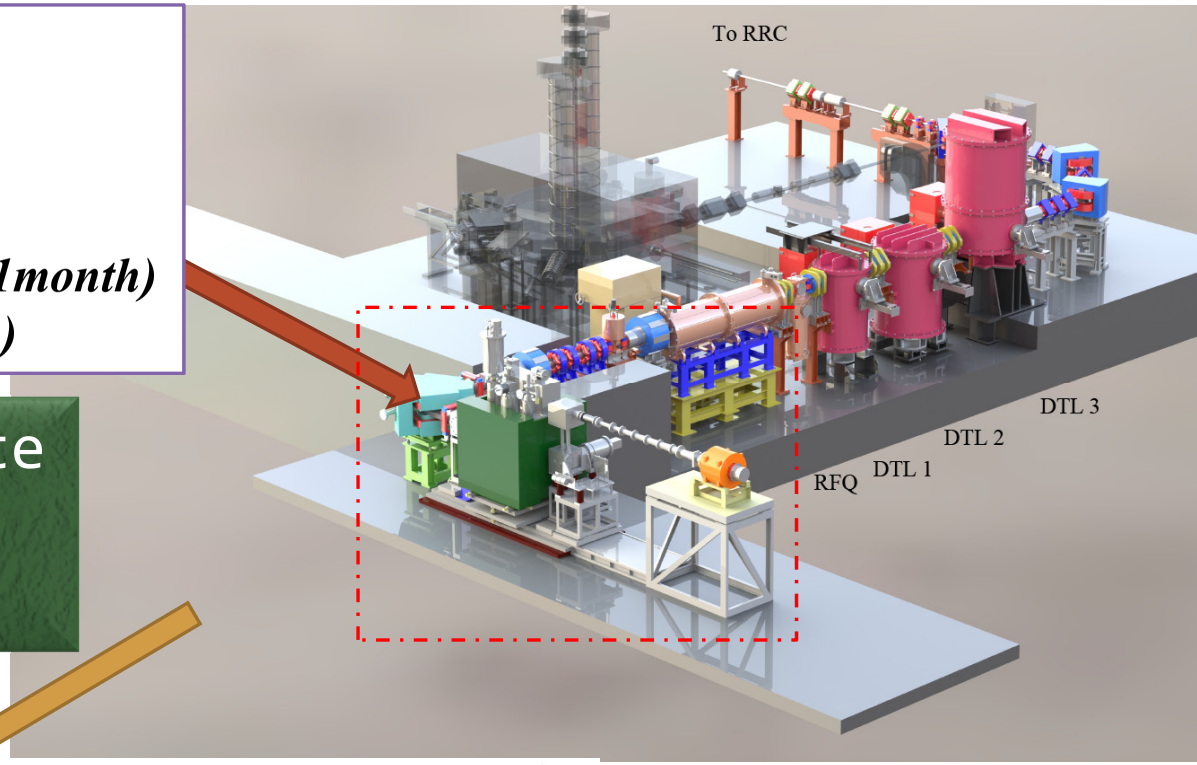
- Introduction
- Heat load problem (GM-JT)
- Gyrotron and its stabilization.
- Beam production
  (Xe U intensity emittance)
- Conclusion and future plan.

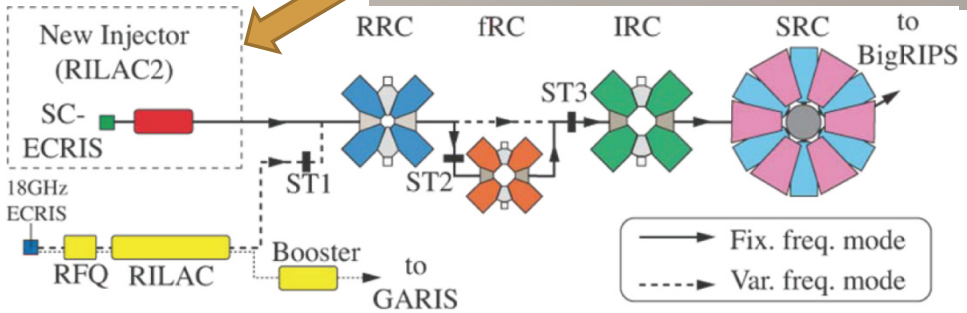
New injector system RILAC2

New injector system (2010~)

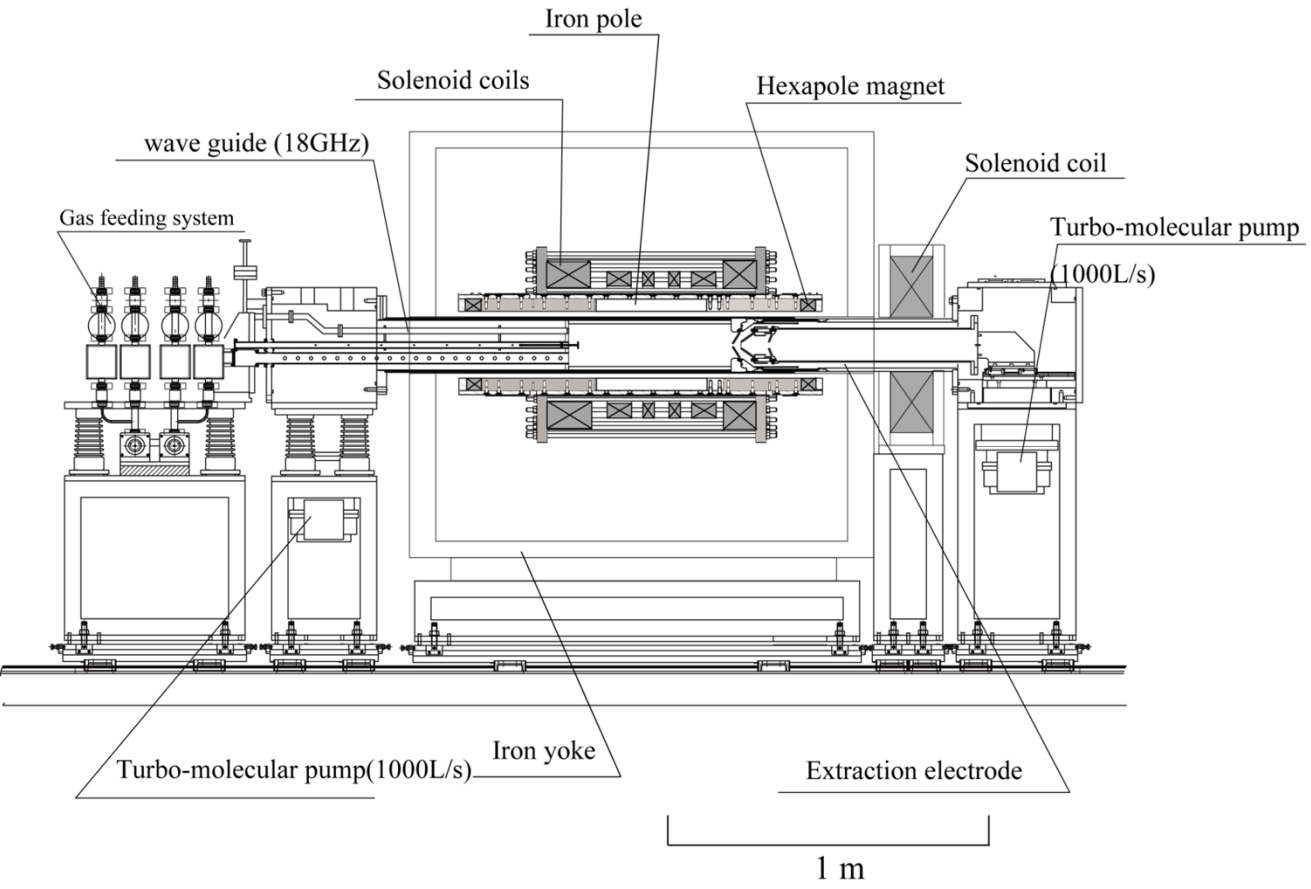
Requirement (FY2012)
U^{35+} beam production
Sputtering method
1.5pμA
long term operation(> 1month)
~100πmm mrad (~90%)

Required charge state
$^{238}U^{35+}$
$^{136}Xe^{20+}$





RIKEN 28 GHz SC-ECRIS

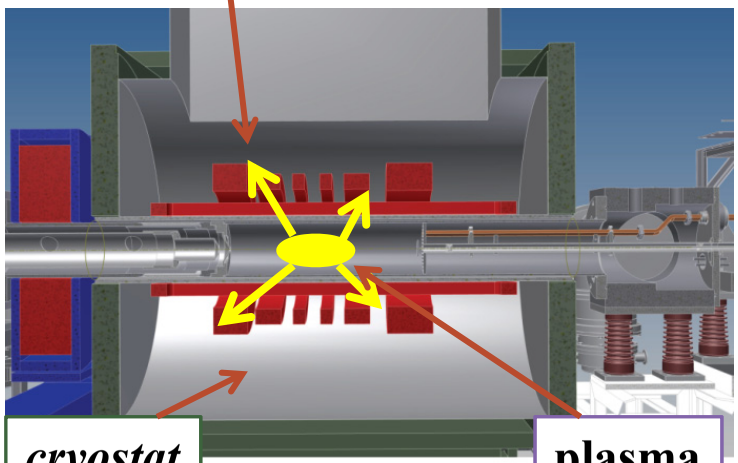


- Binj ~3.8T
- Bmin < 1T
- Bext ~2.3T
- Br ~2.1T
- Chamber ϕ150 length 525mm
- Vext 40kV max
- Micro wave
  18GHz 1.5kW
  28GHz 10kW

Flat Bmin G. D. Alton, et al RSI 65(1994)775

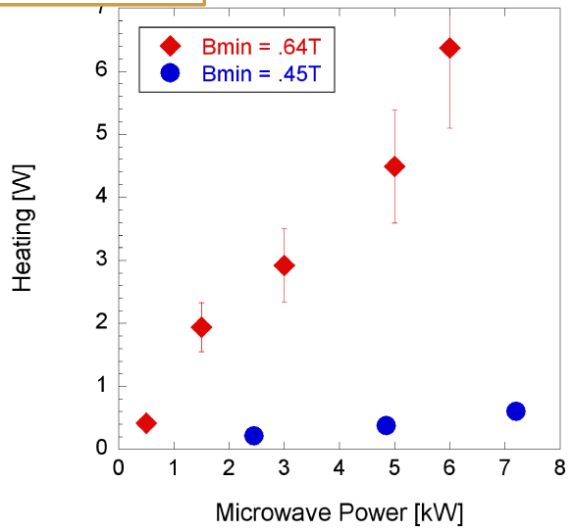
Heat load problem

High energy x-ray (>several 100keV)

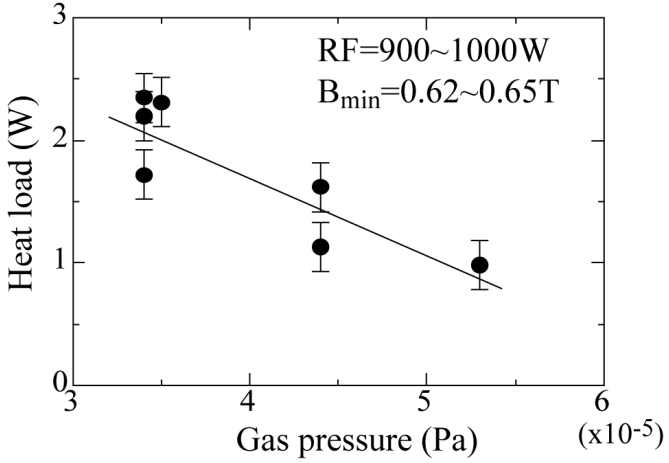


VENUS 28GHz

D. Leitner et al, RSI 79(79)033302



RIKEN SC-ECRIS 28GHz

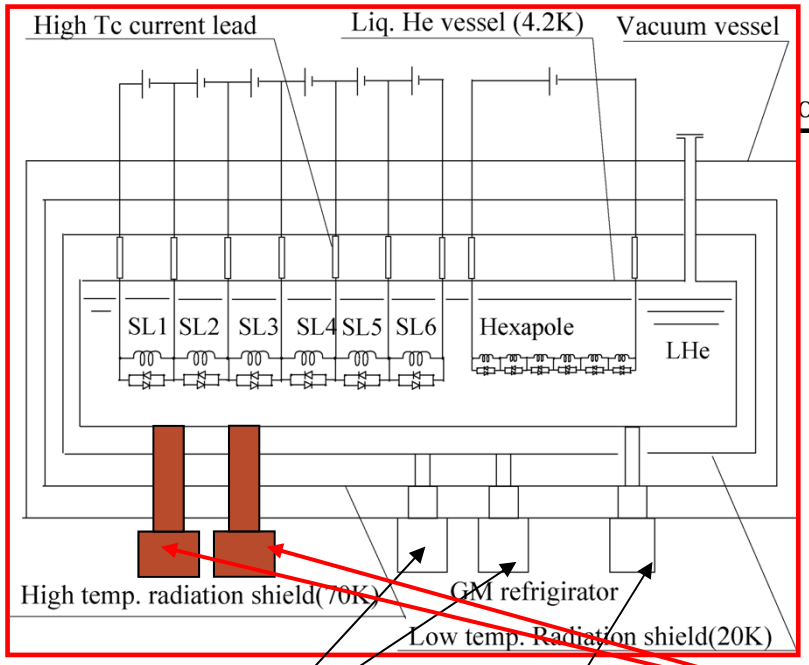


Y. Higurashi et al, RSI 83,02A308(2012)

Cryostat

(W)

Item	Helium vessel	Low temp. radiation shield	High temp. radiation shield
Design temp.	4.2 K	20 K	70K
Radiation	0.005	5.5	40
Conduction			
Support	0.005	0.3	4
Port	0.06	1.5	20
Current lead	0.07	10	64
otal heat load	0.14	17.3	128



GM refrig. 35W(45K), 6.3W(10K)

GM. Refrig. 50W(43K), 1.0W(4.2K)

2009.2

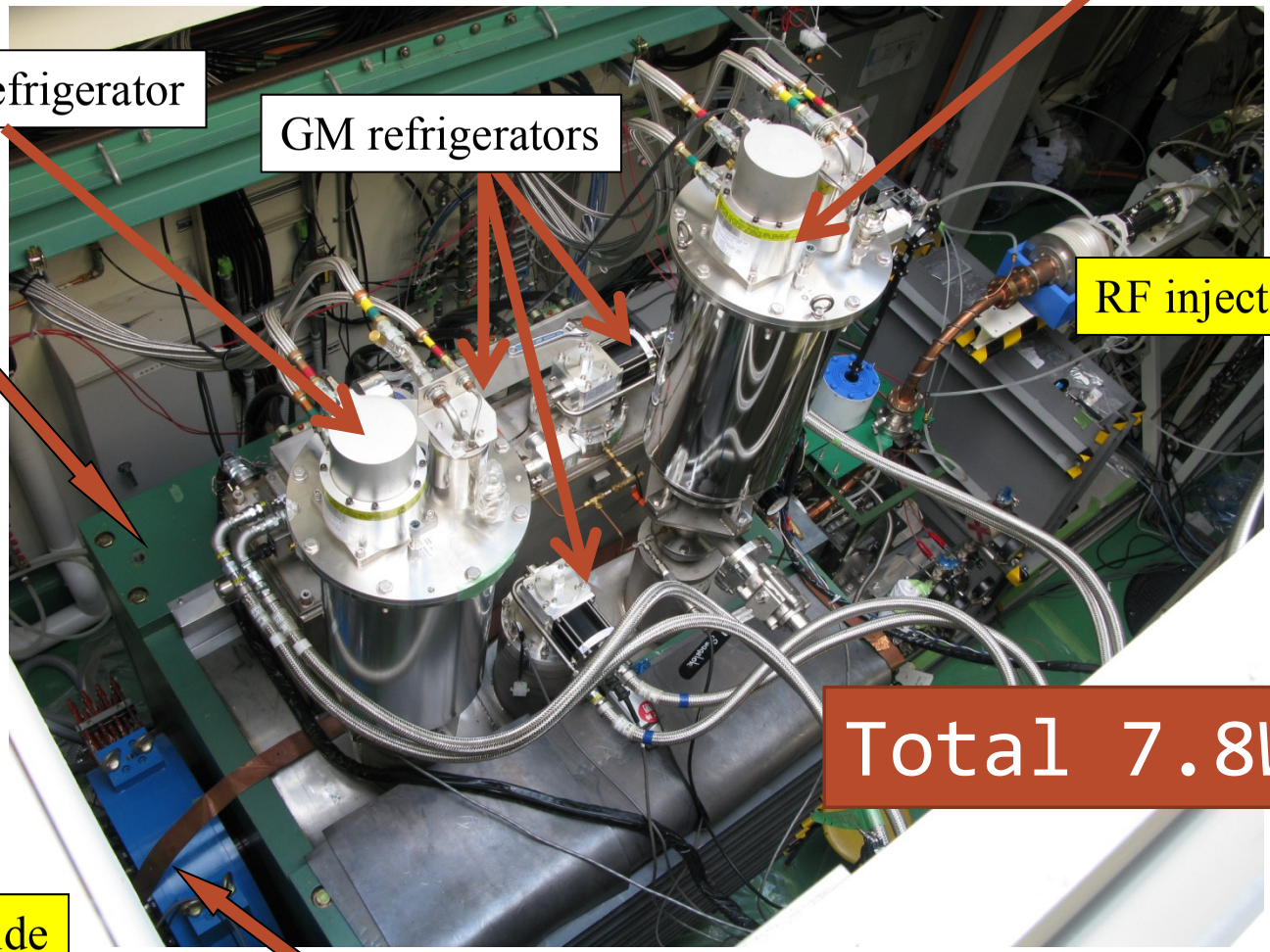
2012.4

CG310SC(SUMITOMO)***(GM-JT refrig.)***

Cooling capacity
4.2W/5.0W@4.2K(50/60Hz)
Electric power consump. 5.1/6.1kW(50/60Hz)

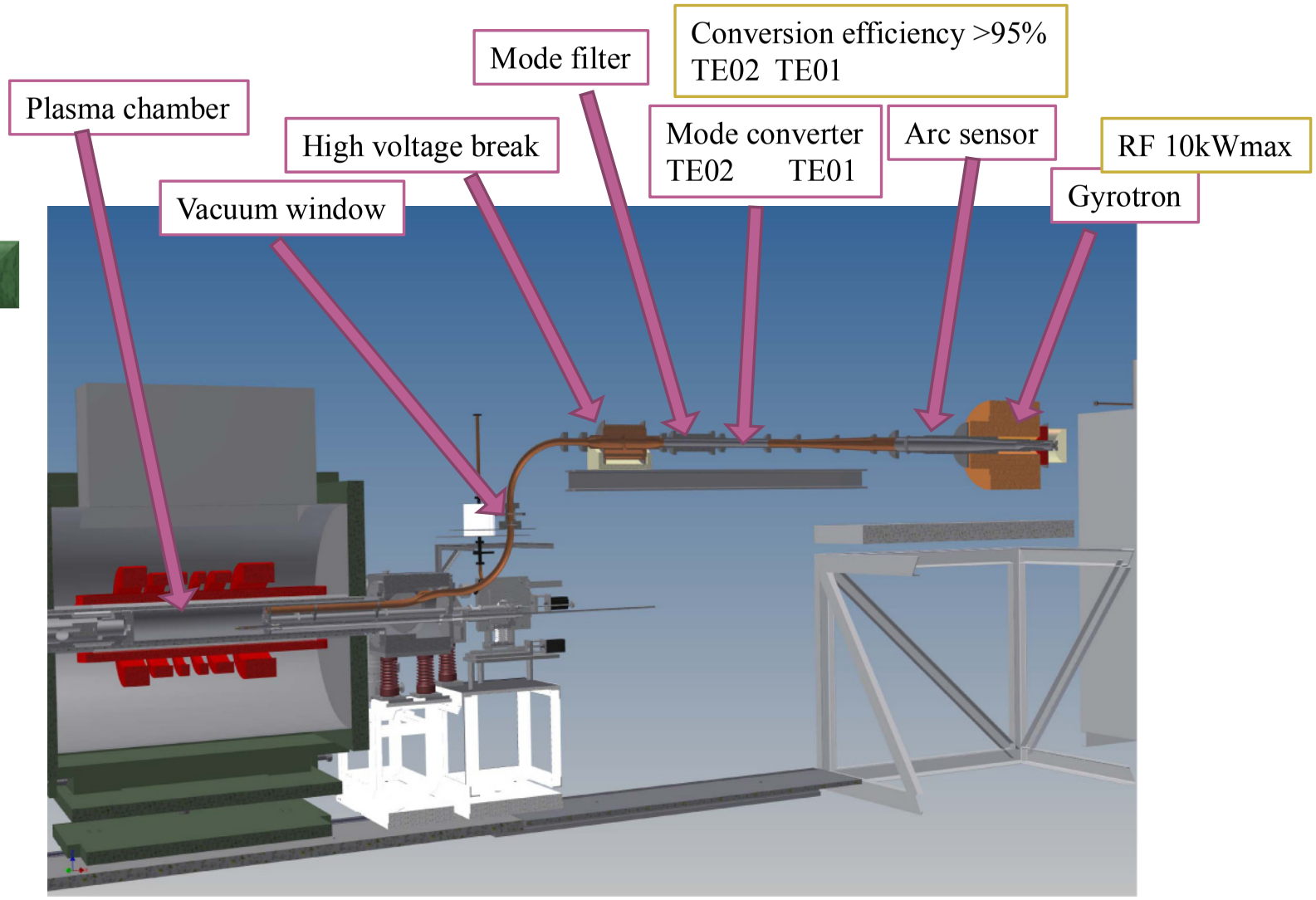
Electric power	AC200V 3 phase
Weight	~220kgr
Dimension	700Wx520Dx1095H

New GM-JT

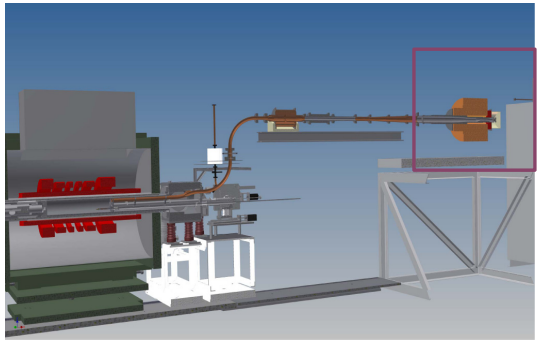

NEW GM-JT 4W@4K
GM-JT refrigerator
GM refrigerators
Iron yoke
RF injection side
Total 7.8W@4K
Beam extraction side
Solenoid coil

28GHz ECRIS + Gyrotron

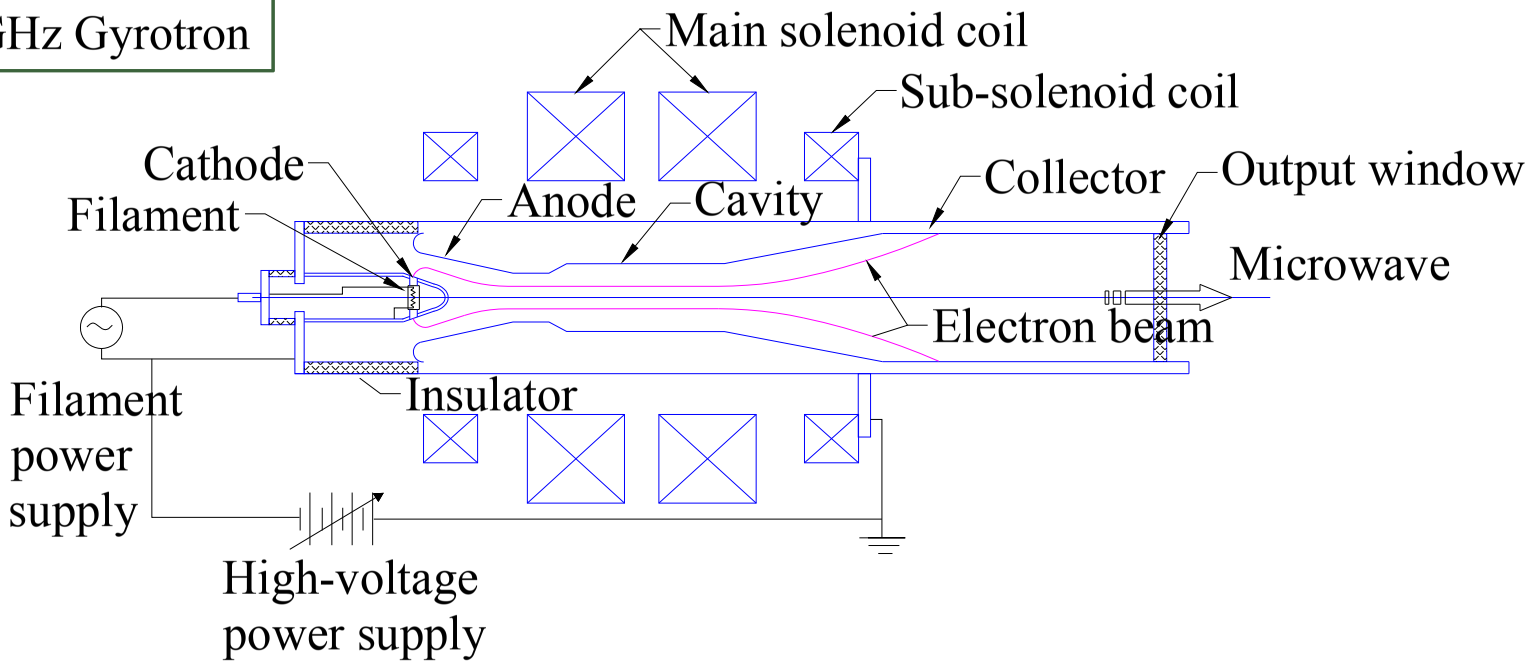
From 2011



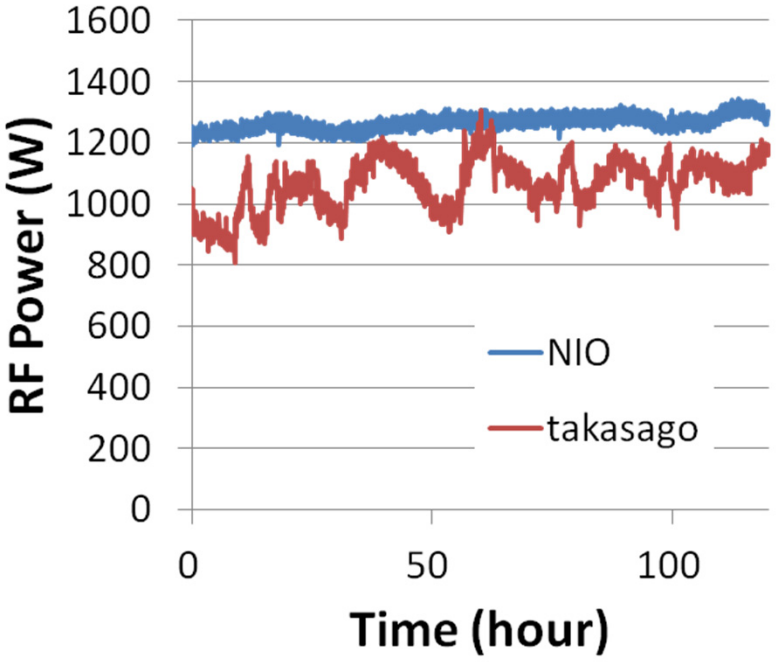
Gyrotron

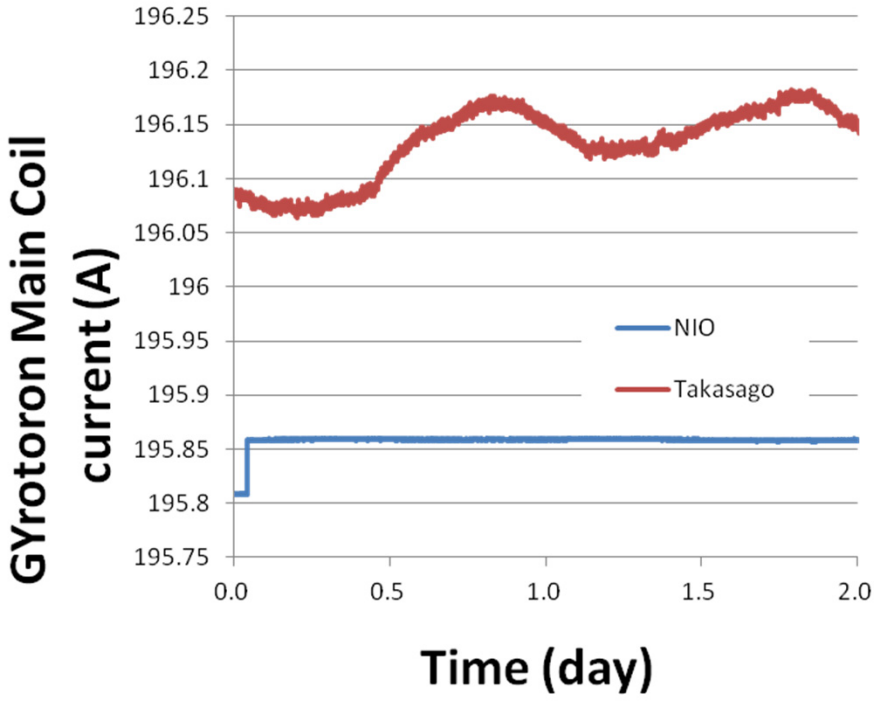


28GHz Gyrotron



Gyrotron Stability

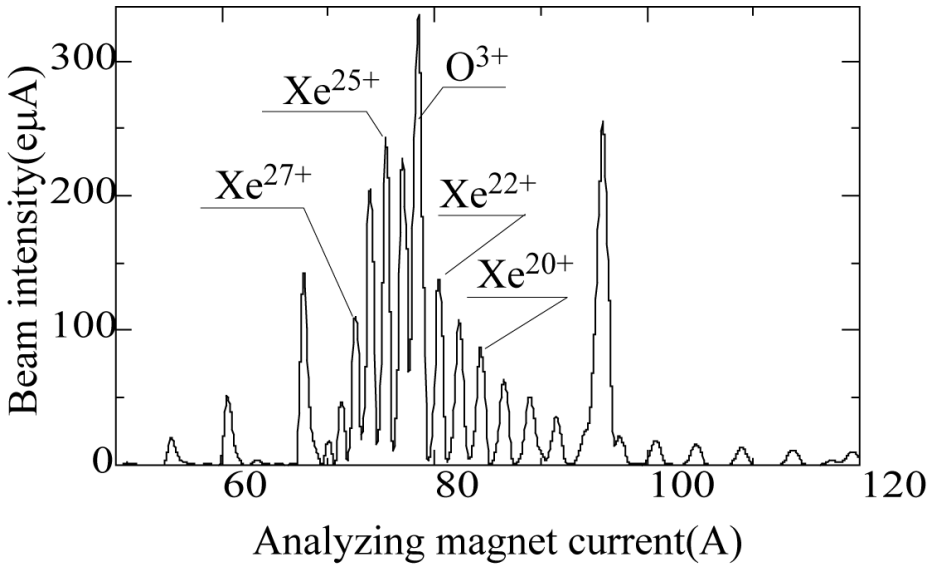


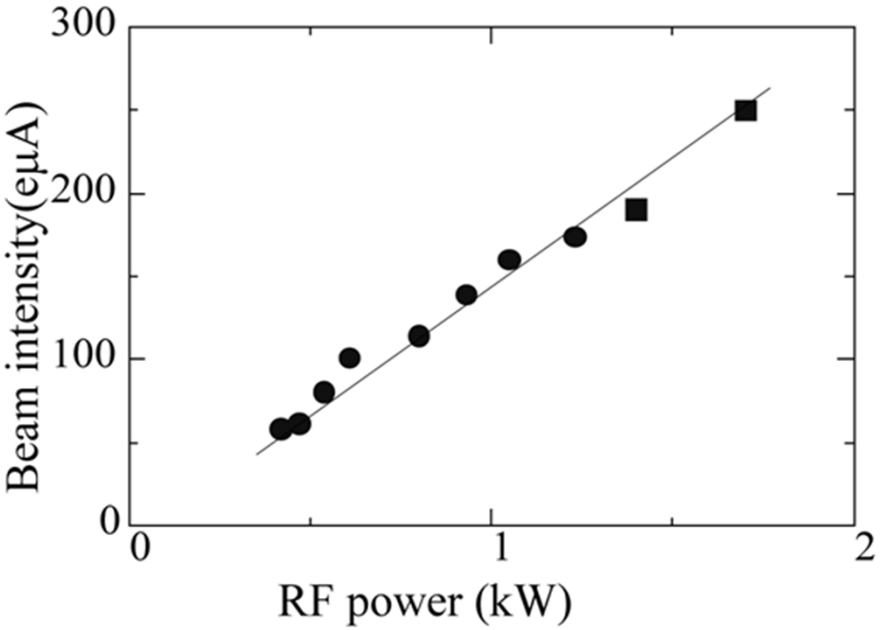


Main Coil P.S.	Current stability	RF power stability
NIO	10ppm/day	7~8% @1.5kW
Takasago	500ppm/day	20~30% @1.5kW

J. Ohnishi et al., Poster TUPP17

^{124}Xe beam





Xe^{25+} 250eμA @1.7kW(28GHz)

B_{inj} 3.2T

B_{min} 0.65T

B_r 1.85T

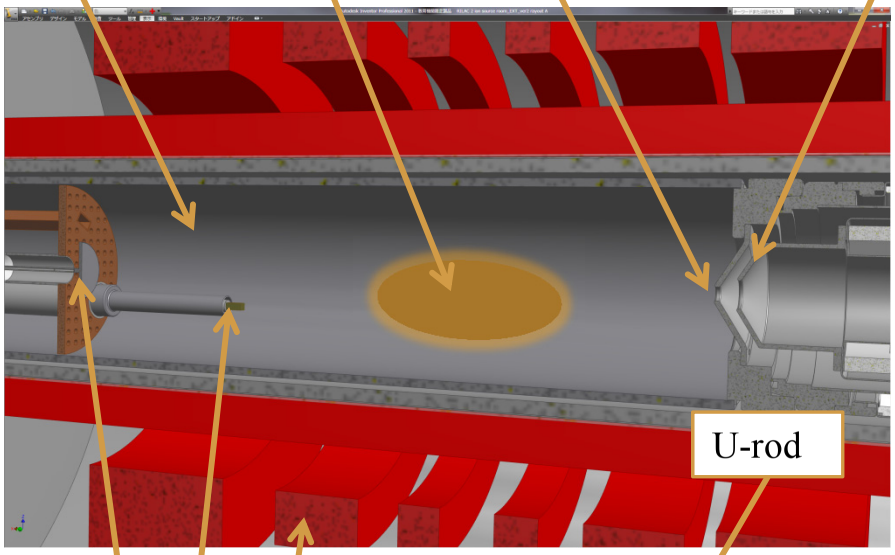
B_{ext} 1.8T

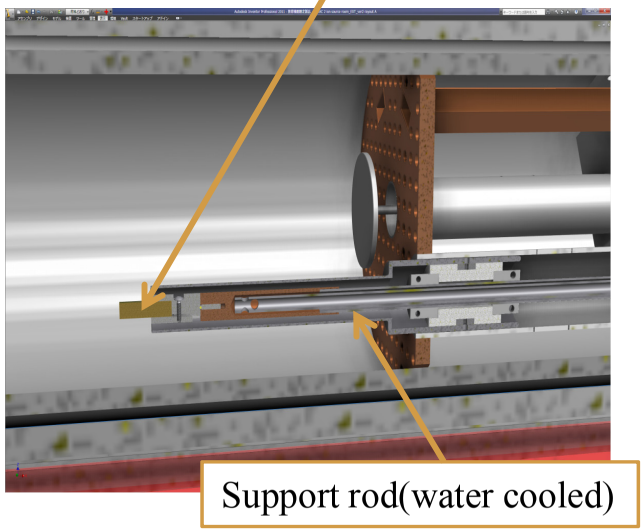
The extraction voltage 22 kV

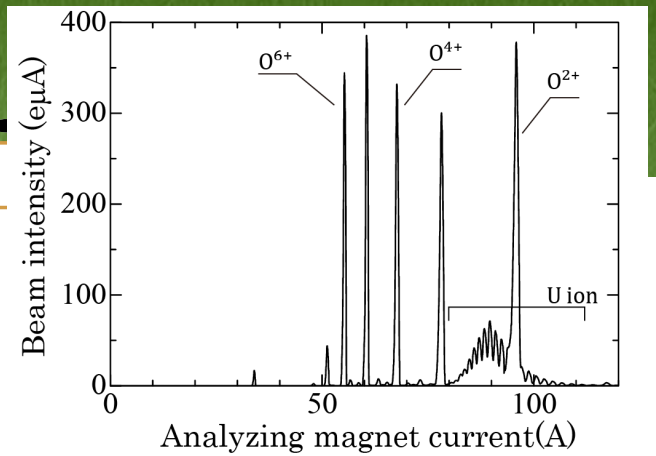
The typical gas pressure

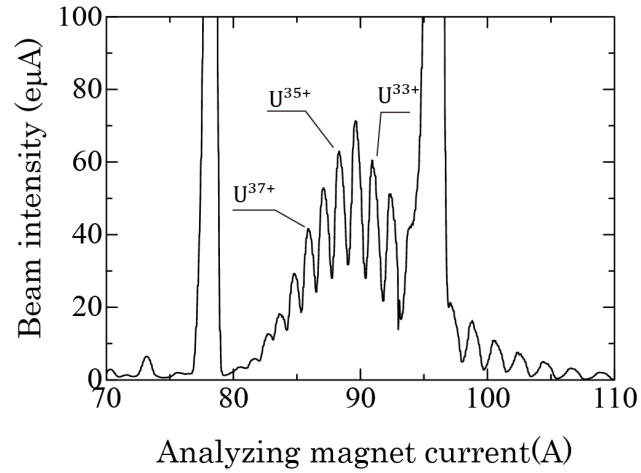
~5 x10^{-5} Pa

U beam









U^{35+} 60eμA @2kW(28GHz)

B_{inj} 3.1T B_{min} 0.65T

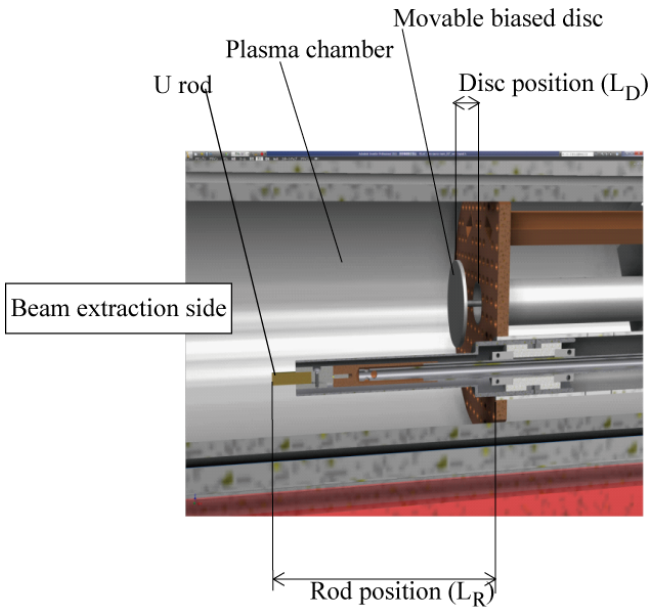
B_r 1.85T B_{ext} 1.8T

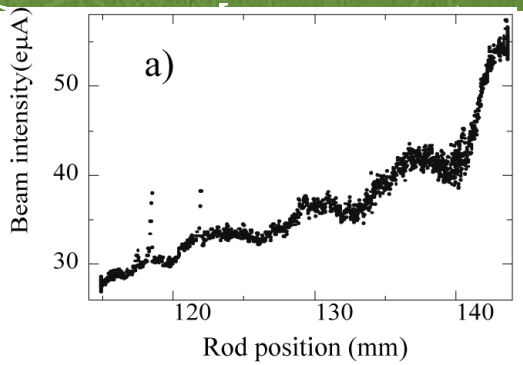
The extraction voltage 22 kV.

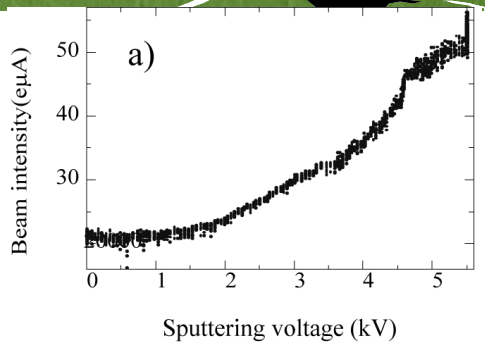
3~5 x10^{-5} Pa.

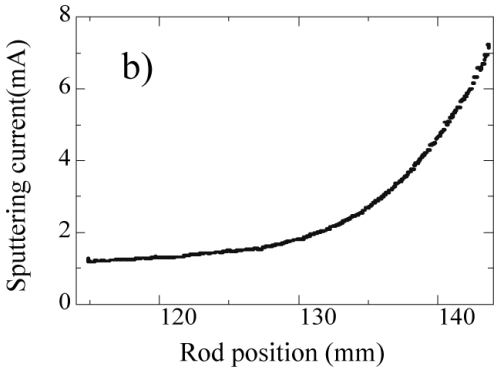
(U^{33+} 80eμA@2kW)

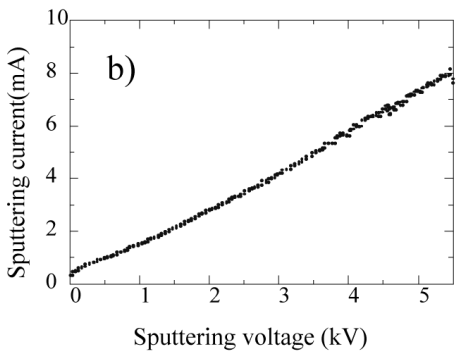
Sputtering rod position and Voltage

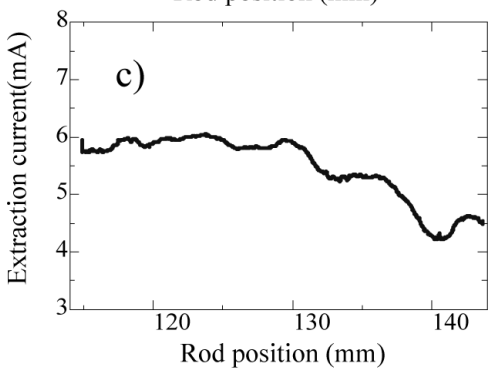


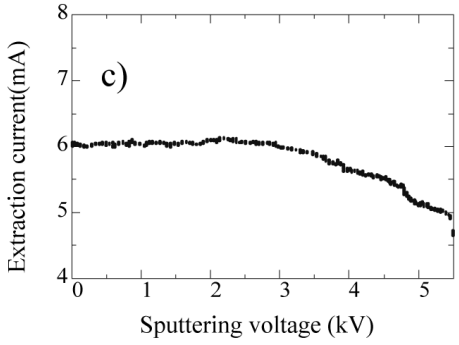






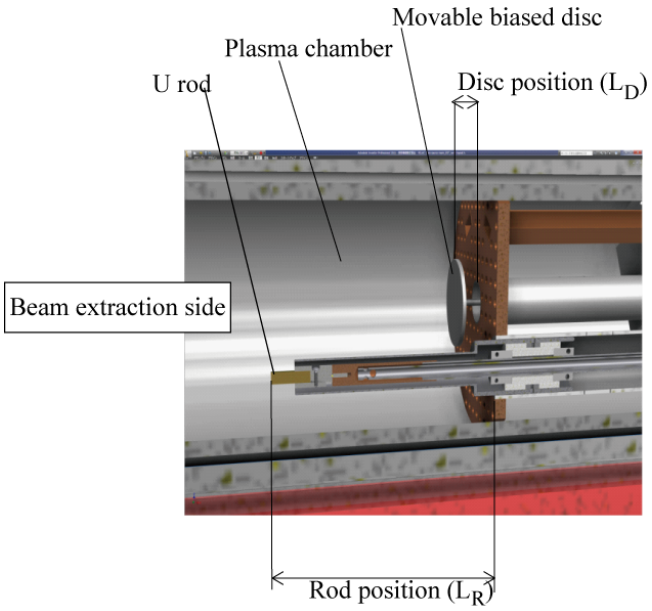


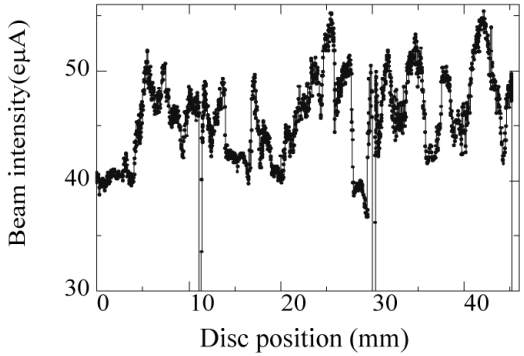


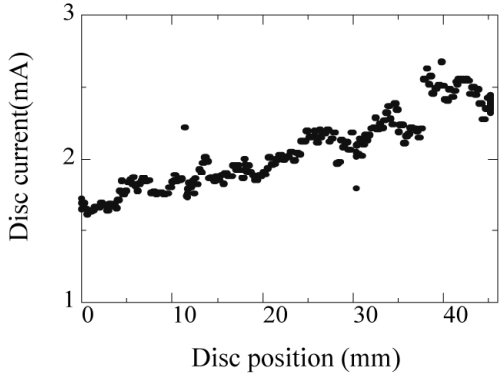


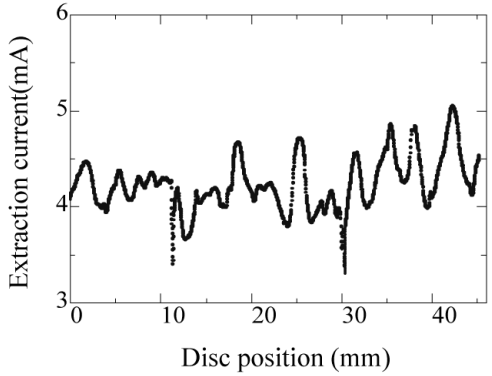
Bias disk position effect

201201231602

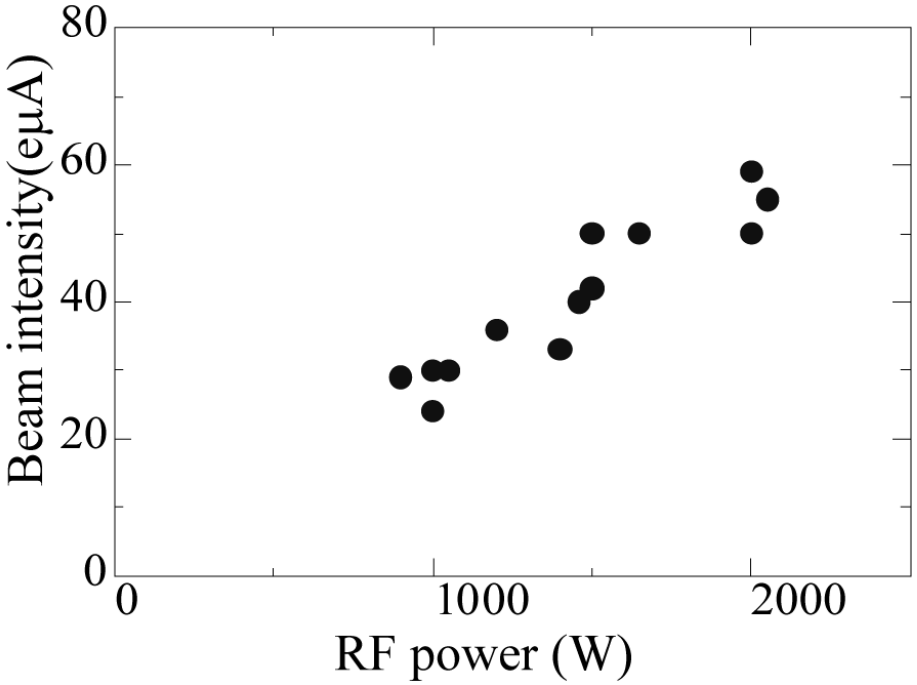




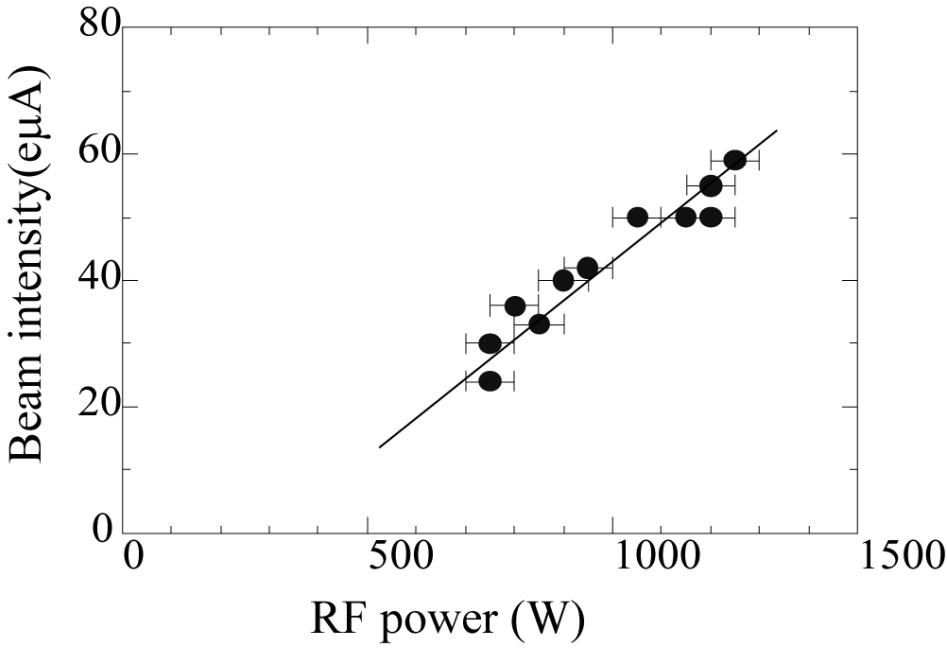




U^{35+} beam intensity VS RF power



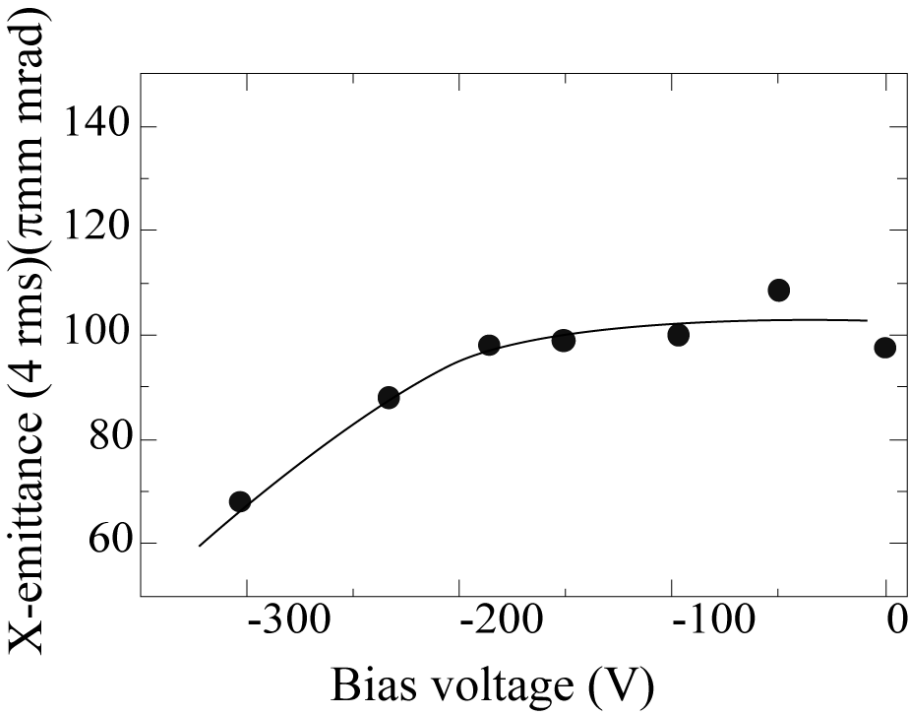
Diode output



Calculate from plasma chamber cooling water tempreture

Injected RF power efficiency to Plasma chamber is about 60~70%

Emittance



U^{35+} X-emittance as a function of Bias disk voltage

- U^{35+} beam emittance ~100π mm mrad

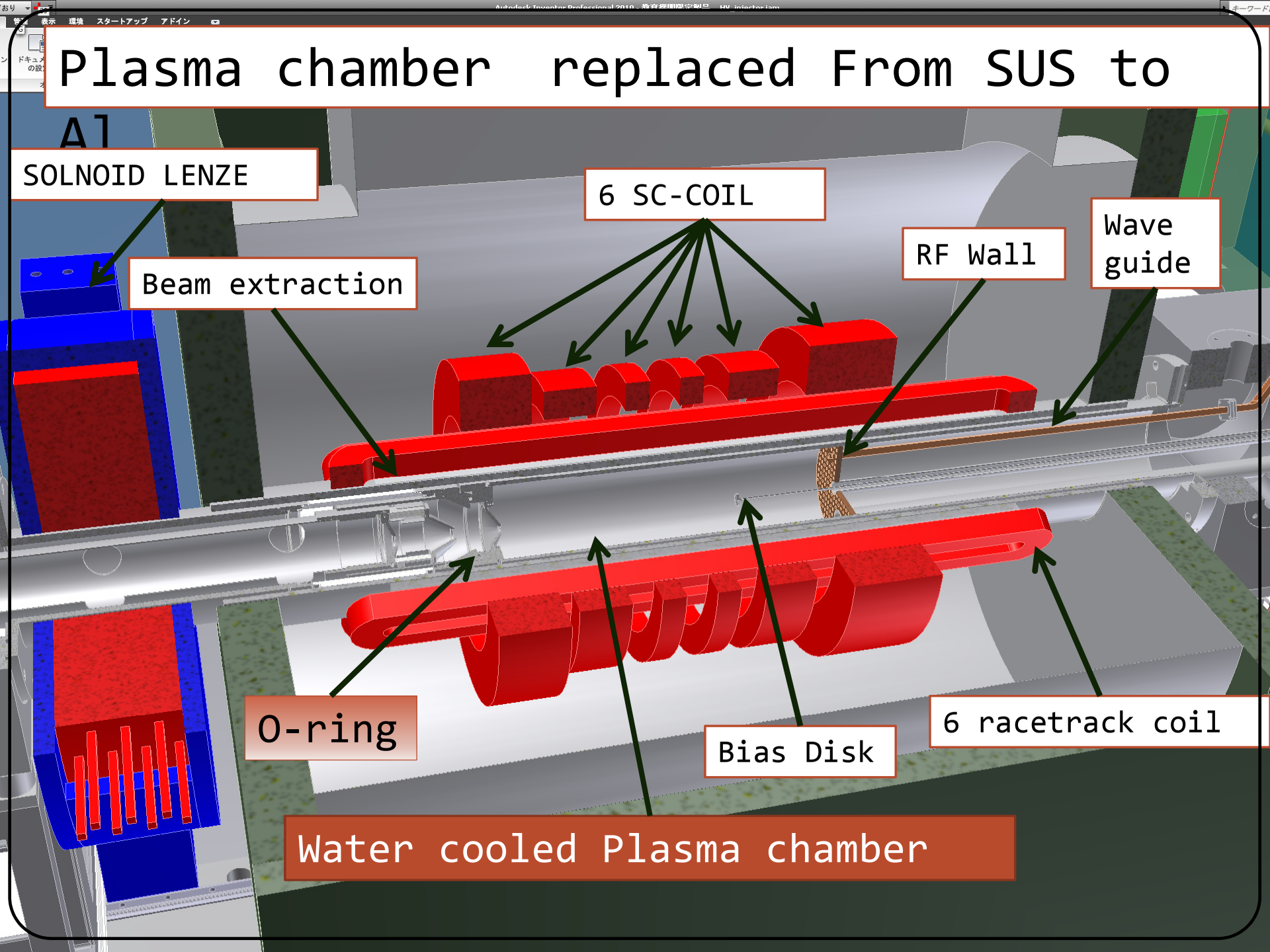
K. Ozeki et al., Poster WEPP08

Summary (Xe and U ion beam)

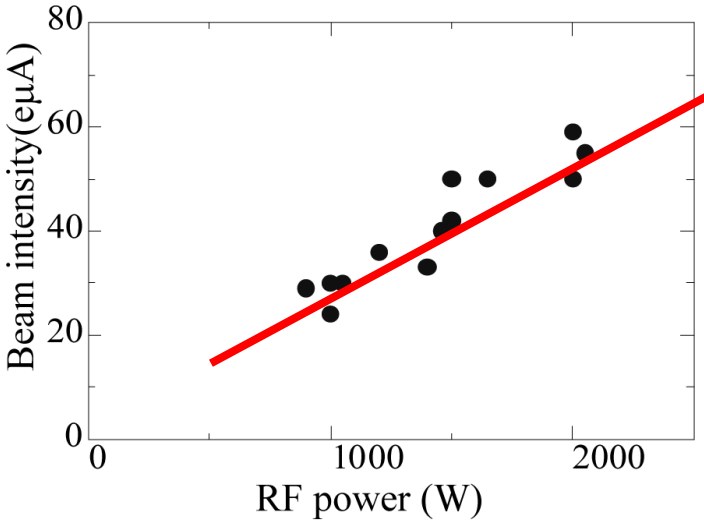
Beam intensity

- Xe^{25+} 250eμA @1.7kW(28GHz)
- U^{35+} 60eμA @ 2 kW(28GHz)
  U^{33+} 80eμA @ 2 kW(28GHz)
  (20 times from RIKEN 18GHz ECRIS)
  - Emittance ~100π mm mrad

Plasma chamber replaced From SUS to Al



High temperature oven

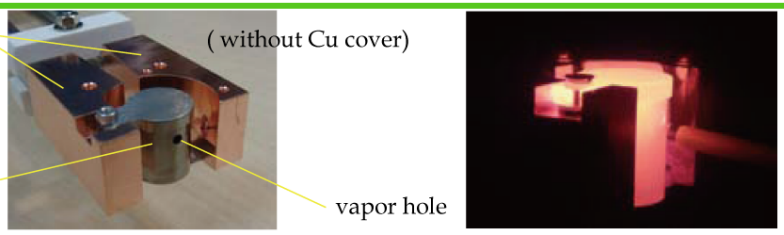


RF power >6kW

U^{35+}~200eμA

using High temp. Oven

more U vapour



- Power consumption for the oven was improved about 80 % (1.6 [kW] → 350 [W]) by using a method of a connection by the different kind metal
- Non-trouble during about 270 hours at 1800 ~2000 ℃ (without sample)
- Long-term stability, durability, control, and reproducibility were confirmed.

D. Leitner et al, RSI 79(2008)02C710

Conclusion and future plan

- Now Al Plasma chamber is under commissioning. High RF power result will be coming soon.
- To produce U vapour, we will make a test experiment with high temperature oven.
- More Optimization of the Magnetic field distribution.

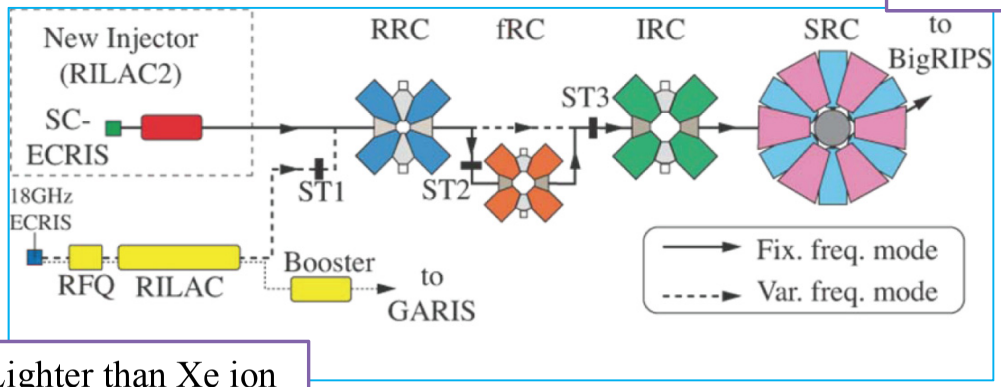
Final goal is U^{35+} >200eμA


Thank you for your attention

RIKEN RIBF

Heavier than Xe ion

~345MeV/u



Lighter than Xe ion

18GHz ECR ion source

RILAC

RRC

28GHZ SC-ECRIS

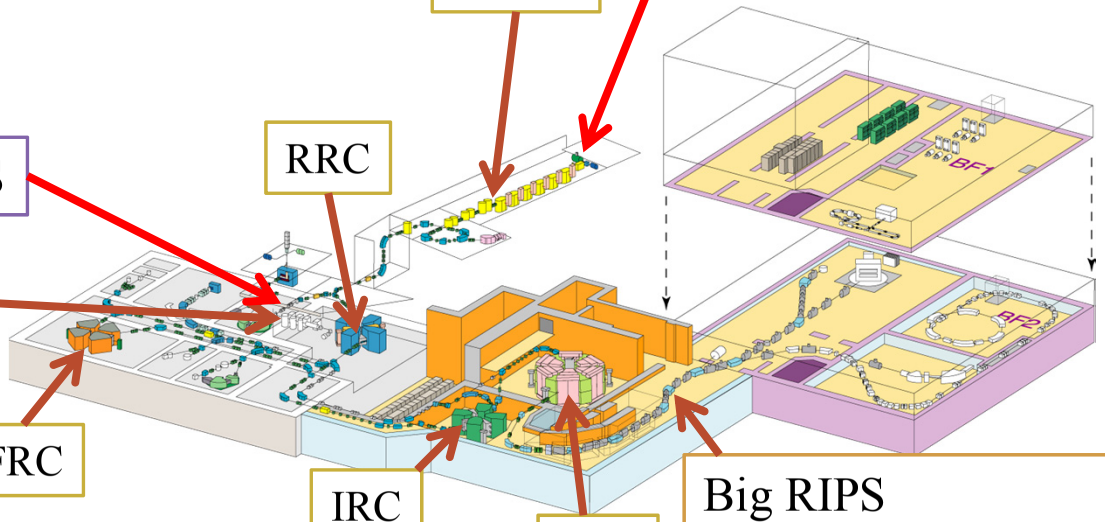
RILAC II

FRC

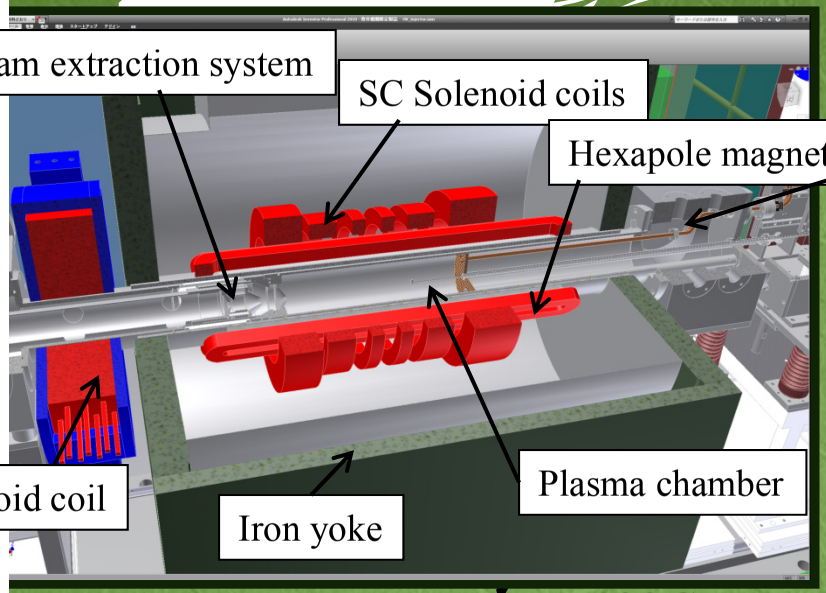
IRC

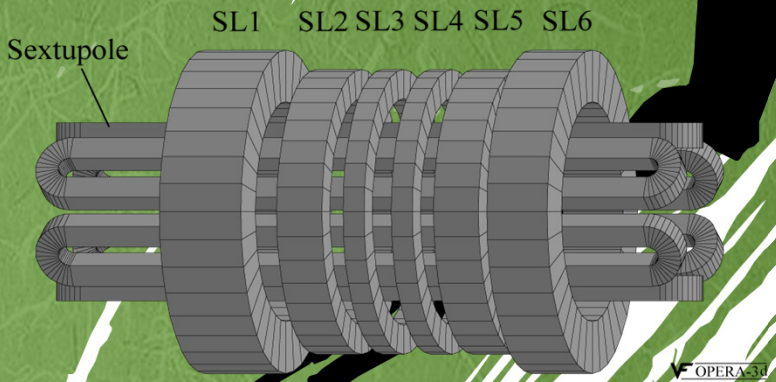
SRC

Big RIPS
(fragment separator)



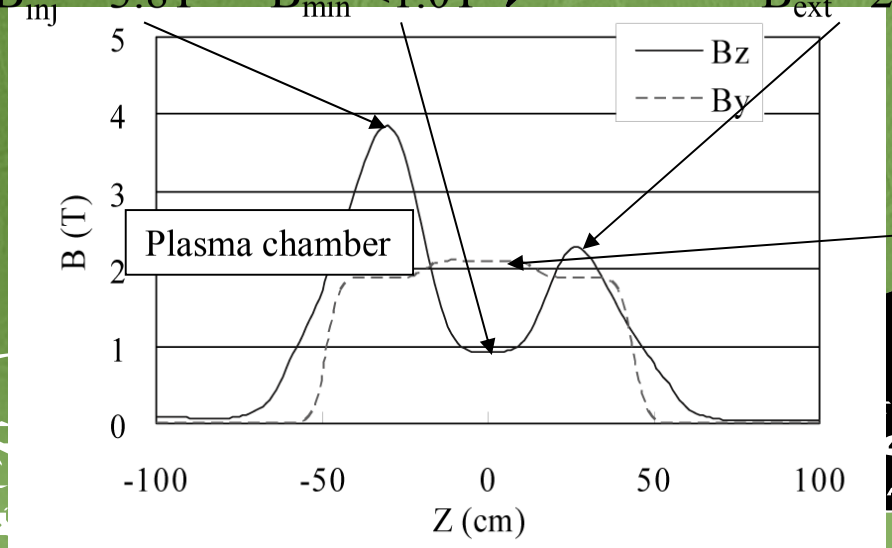
RIEN 28GHz SC-ECR ion source





For 28GHz operations

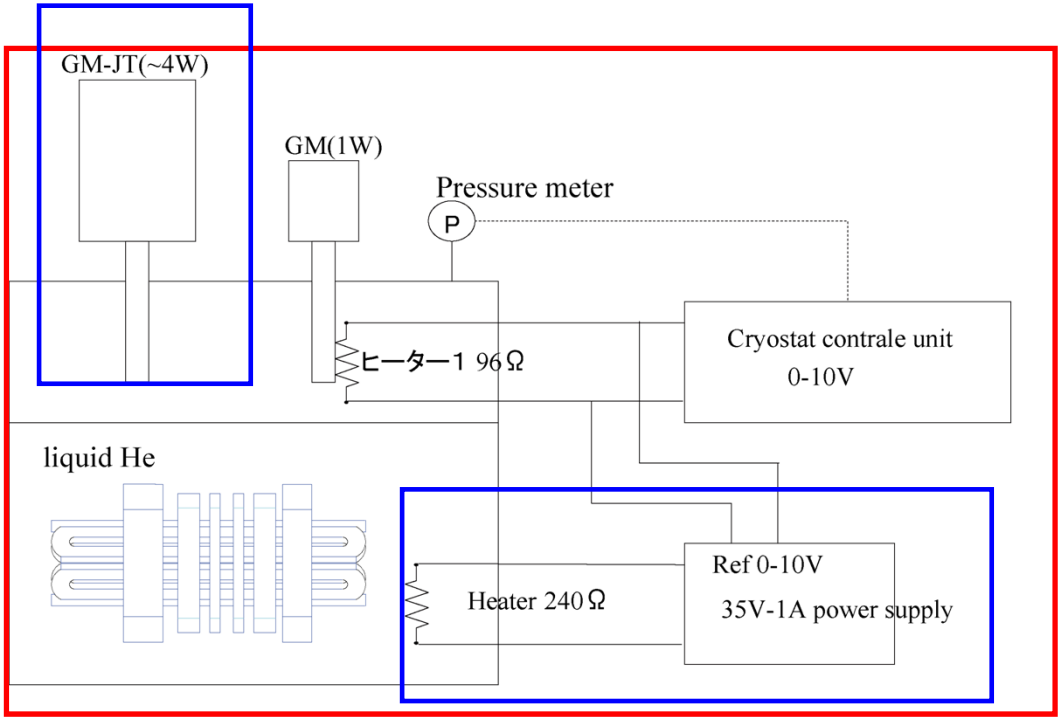
B_{inj} ~3.8T B_{min} <1.0T B_{ext} ~2.3T

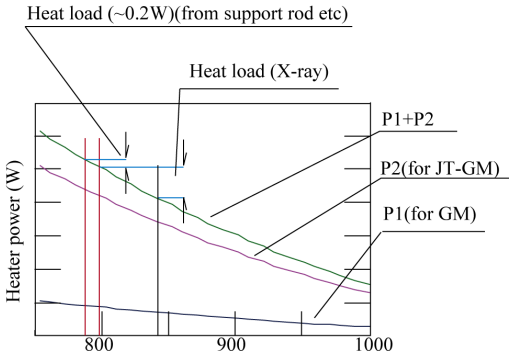


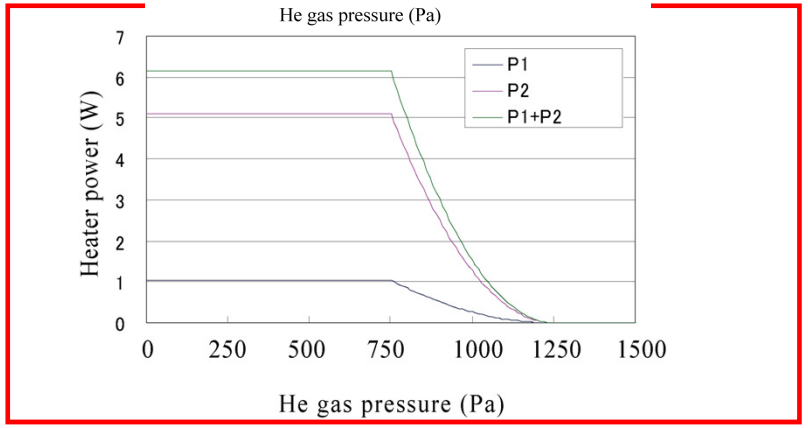
~2.1T

High energy Physics and Nuclear Physics 31(2007)37
J. Ohnishi et al,

Cryostat II


GM-JT(~4W)
GM(1W)
Pressure meter
P
ヒーター1 96Ω
Cryostat contrale unit
0-10V
liquid He
Heater 240Ω
Ref 0-10V
35V-1A power supply


Heat load (~0.2W)(from support rod etc)
Heat load (X-ray)
P1+P2
P2(for JT-GM)
P1(for GM)
Heater power (W)
800
900
1000


He gas pressure (Pa)
P1
P2
P1+P2
Heater power (W)
0
1
2
3
4
5
6
7
0
250
500
750
1000
1250
1500
He gas pressure (Pa)

Sputtering Voltage