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High Intense Vanadium-Beam Production to Search for New Super-Heavy Element with Z = 119

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Abstract

We have begun synthesizing a new super-heavy element (SHE) with an atomic number, Z, of 119 using a very powerful vanadium-beam (V-beam) to overcome the very small production cross section. We investigated the correlation of the V-beam intensity, the total power of 18- and 28-GHz microwaves, and the consumption rate of metallic V powder that was proportional to the amount of the vapor in the plasma chamber. Consequently, we obtained approximately 600 eμA at a microwave power of 2.9 kW and a consumption rate of 24 mg/h. In addition, we found that the position of the crucible used as an evaporator of the V sample and the strength of the mirror field at the extraction side B_{ext} from 1.34 to 1.51 T did not have a significant effect on the beam intensity.

Introduction

New project of synthesis of super heavy element (SHE)
with atomic number $Z = 119$, since FY 2016

$_{23}V + _{96}Cm \rightarrow _{119}SHE$

Requirements
1) **Higher acceleration energy** than before
2) **High Intensity** vanadium-ion (V-ion) beam
3) **About 1-month stable beam supply** without interruption

1) → SRILAC with 10-superconducting (SC) cavities in Fig. 1.

Emerging issue in SRILAC operation

The **accelerating voltage** in the SC cavity is **seriously reduced** by the adsorbed **particulate matters** that is generated by **beam loss** (sputtering).

→ **Emittance Limitation** using **"Slit Triplet" of LEBT** in Fig. 1.

↳ The intensity was reduced to ~30 % of that of analyzed beam.

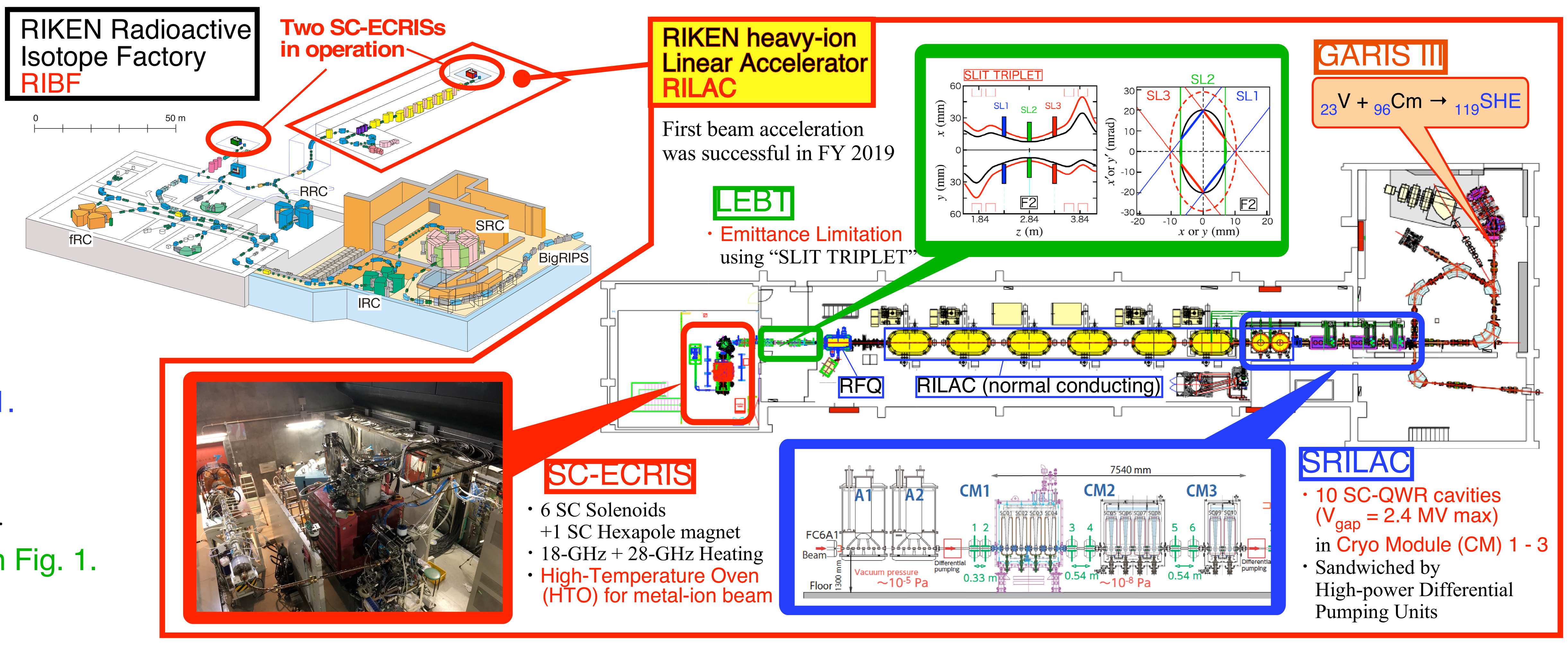

Figure 1: Bird view of RIBF and upgraded RILAC

To meet the requests 2) and 3)

a) Investigate Optimum Parameters, the V-vapor amount and the microwave power

b) Develop Large-capacity High Temperature Oven system (HTO).

Experimental

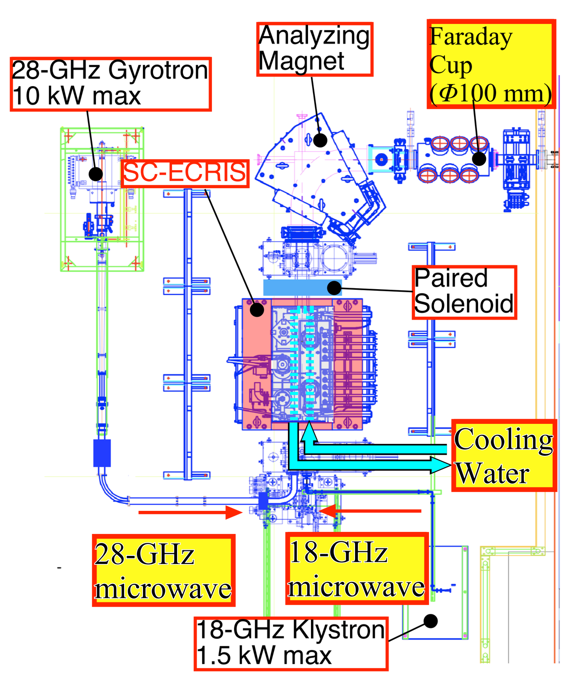

Figure 2: Experimental setup

a) Optimization of the V-ion-beam intensity

- **Total microwave power** (18 and 28GHz)
- **V-vapor amount**

→ **V-beam intensity**

- **V-ion-beam Intensity** was measured by the Faraday cup in Fig. 2
- **Total microwave power** was estimated from the temperature reise and flow rate of cooling water in Fig. 2 flowing though the plasma chamber.
- **The V-vapor amount** is equivalent to the **V-sample consumption rate**.

b) Large capacity HTO

- A crucible is heated by the Joule heating (DC current).
- **Two Crucibles** were equipped as shown in Fig. 3.
  → **4.4 g** of granular V sample is available.

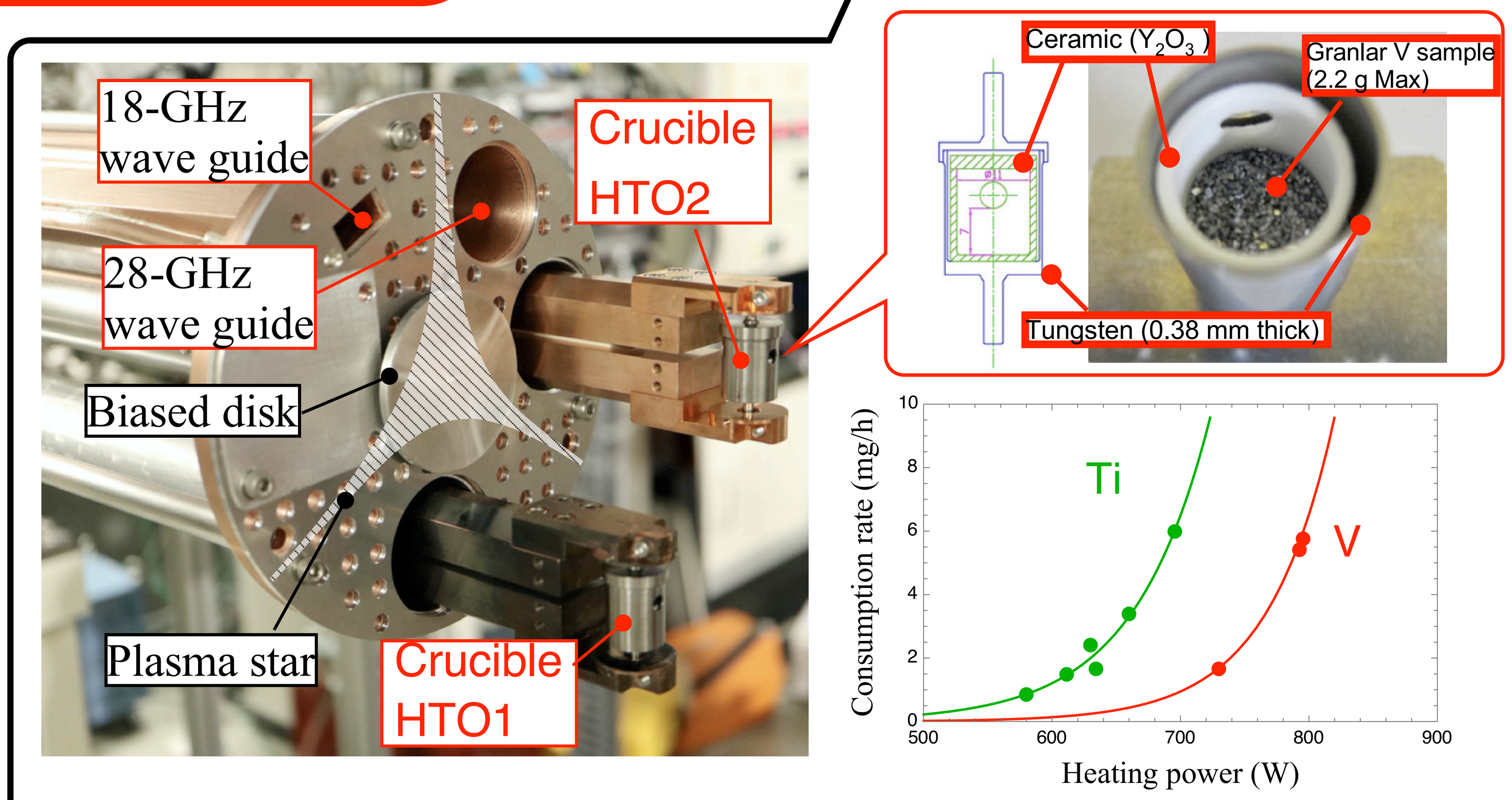

Figure 3: Developed doble HTO system, and the consumption rate of Ti and V samples as afunction of the heating power of each crucible.

Results and Discussions

Is there difference in the intensity between the different positions of HTO1 and 2 ?

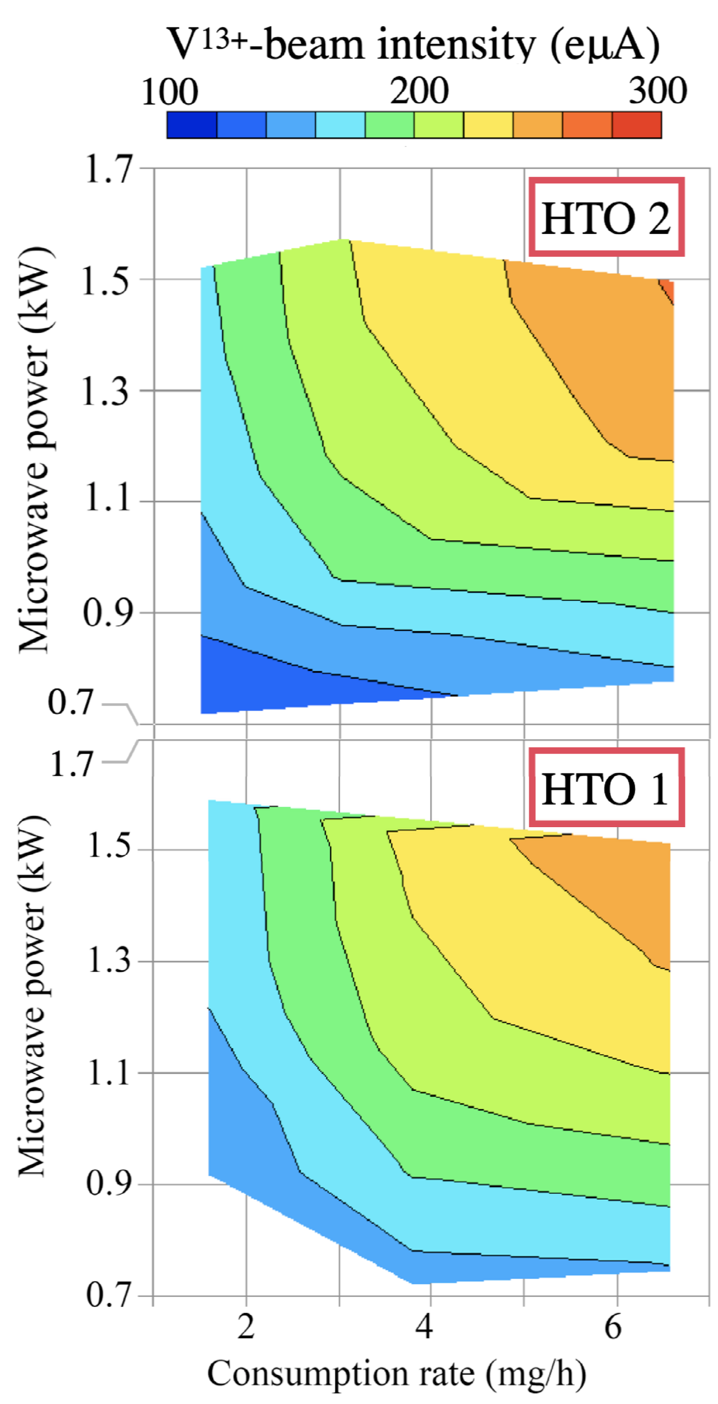

Figure 4: Contour plots of beam intensity as function of the consumption rate and the microwave power for HTO 1 and 2.

No significant difference between the positions of HTOs in the faraday cup measurement.

Simultaneously using HTO 1 and HTO 2

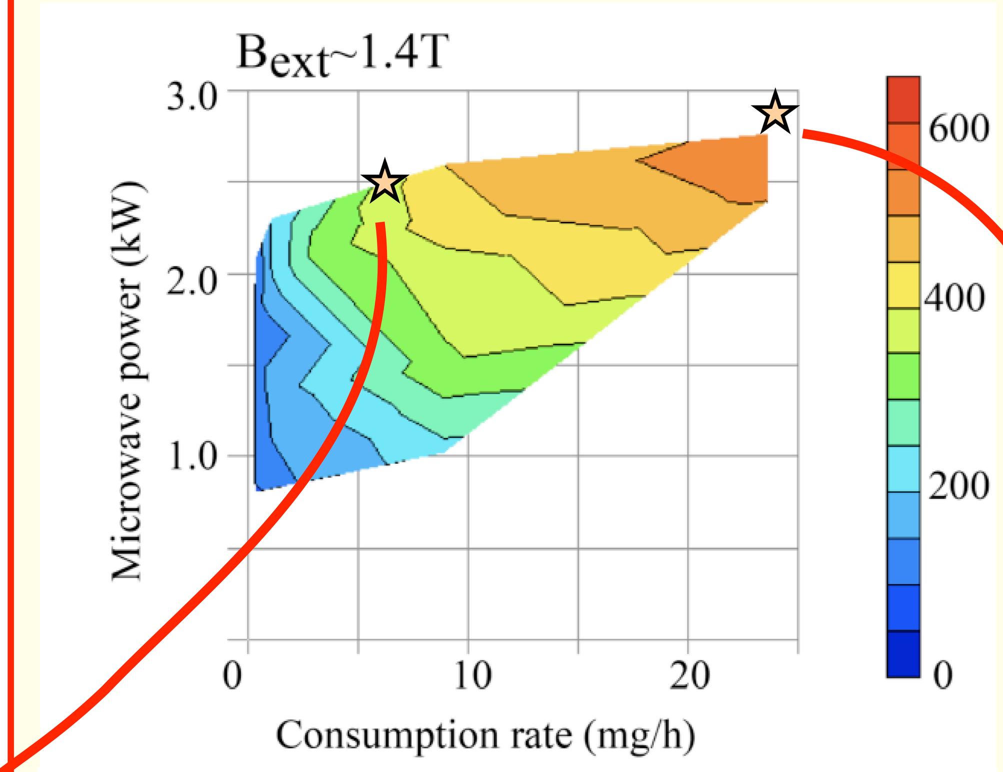

Figure 5: Contour Plots simultaneously using HTO 1 and 2.

400 eμA with ~ 6 mg/h and 2.5 kW

↓ *4.4-g V sample is available.*

~ 1 month beam supply is available!!

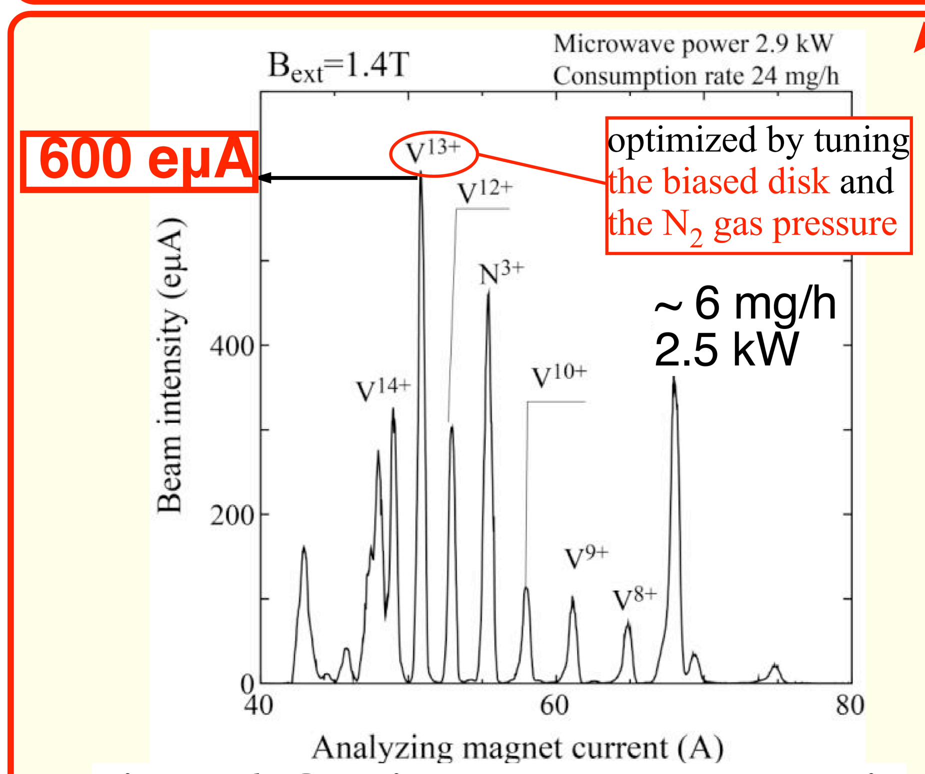

Figure 6: Obtained mass-to-charge ratio spectrum with the N_2 support gas.

~ 1 week extra-high beam intensity

→ the **production target development**

Is there difference in the intensity between the different mirror field around the extraction region B_{ext}?

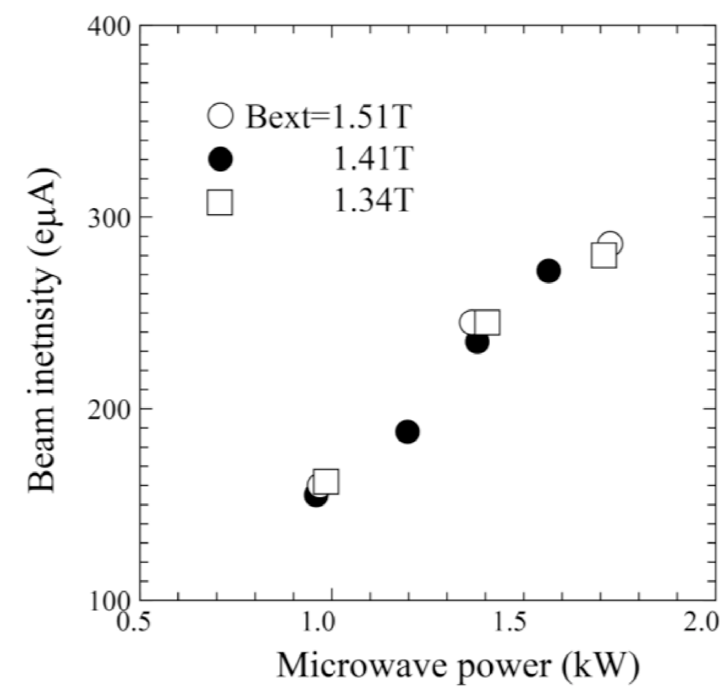

Figure 7: The V^{13+}-ion beam intensity obtained as a function of the microwave power when the the B_{ext} is changed from 1.34 to 1.51 T.

No significant difference between B_{ext} of 1.34 to 1.51 T

Conclusions

1) We measured **the beam intensity of V^{13+}** as a function of both the **consumption rate** of the vanadium sample and **the microwave power**.

- *The optimized beam intensity was plotted as the two-dimensional contour plot.*
- *The V^{13+}-beam intensity of 400 eμA at a consumption rate of ~ 6 mg/h and a microwave power of 2.5 kW.*
  → Simultaneously using both HTO crucibles allows us to execute SHE synthesis, which lasts ~ 1 month without interruption.
- *The V^{13+}-beam intensity of 600 eμA at a consumption rate of 24 mg/h and a microwave power of 2.9 kW.*
  →The extra-high-intensity beam lasts for one week, for the essential development of the production target.

2) On the other hand, **significant effects by changing the oven position and varying B_{ext} between 1.34 and 1.51 T** on the beam intensity were **not observed** within the scope of the simple measurement using only a Faraday cup.