# Simulations to optimize thermal shields of thermal ion source for Radioactive Ion Beam (RIB) production

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## Introduction

A radioactive ion beam (RIB) facility is being planned at BARC, Vizag using ISOL method [1]. The Target Ion Source System (TISS), involving the production and ionization of radioactive elements, is one of the crucial components of the RIB facility. The present study follows the basic design of SPES [2] and includes a target assembly and an ion source. A thermal/surface ion source is proposed to ionize the radioactive fission fragments produced and extracted from $UC_x$ target disks contained inside a Graphite cylinder which is surrounded by a Ta tube. A proton beam strikes the $UC_x$ target, producing neutron-rich radioactive isotopes that are extracted via the Effusion-Diffusion method. High temperatures with lower gradients in the target disks are preferred for higher production rates and efficient diffusion of radioactive elements from the target disks. The ionizer, a thin Ta tube, then ionizes neutral radioactive isotopes through surface ionization at high temperatures.

Temperature profile of the target assembly was studied by thermal simulations and reported in [3]. The results showed that with a 1100 A current, the maximum temperatures in the Ta tube, graphite cover, and target disks were 2150°C, 1105°C, and 928°C, respectively. The disk temperature could not be increased further due to the Ta sublimation point of 2200°C at a vacuum of $10^{-5}$ mbar. Modifying the Ta wing geometry could raise the maximum disk temperature to 1148°C.

To counter this heat loss by better containing the generated heat, thermal shieldings around the Ta tube were proposed (as shown in FIG.1) and were optimized for performance.

## Thermal Analysis

This study, conducted using COMSOL software,

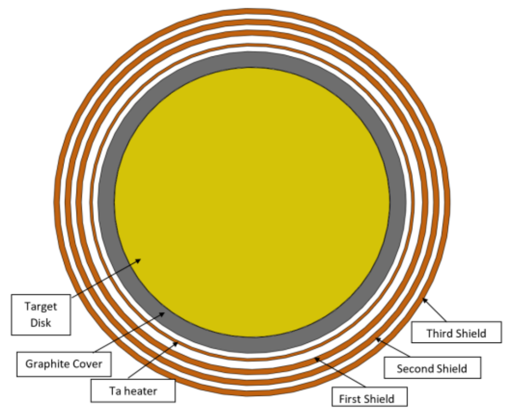


FIG. 1: Schematic cross-sectional view of the target disk surrounded by graphite cover which is kept inside Ta heater. Three shields are shown outside the Ta heater target assembly (Not to scale)

focuses on thermal shielding simulations of a Ta heating source. Electrical and thermal boundary conditions were consistent with those in [3]. Thermal properties—thermal conductivity, specific heat, and emissivity—of $UC_x$, Ta, Graphite, and Al were also unchanged. Various numbers of concentric Ta cylindrical shields with different thicknesses and diameters were considered to optimize the temperature profile in seven $UC_x$ target disks. The simulations aimed to optimize: a) the number of shields, b) the thickness of each cylindrical shield, and c) the gap between shields.

## Results & Discussion

*Diameter Optimization for Single screen:* The first cover's inner diameter was varied from 52 mm to 69 mm, with a fixed thickness of 1 mm. FIG.2 shows the temperature profiles across seven UCx disks for various inner diameter of

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single Ta shield. The 54 mm diameter gave the best temperature profile.

### *Thickness optimization for single screen:*

The diameter of the first cover was set as 54 mm and the thickness of the cover was then varied from 0.2 mm to 1 mm in steps of 0.2 mm. 1 mm thickness provided slightly better results as compared to others. Hence this thickness was chosen for all further analyses.

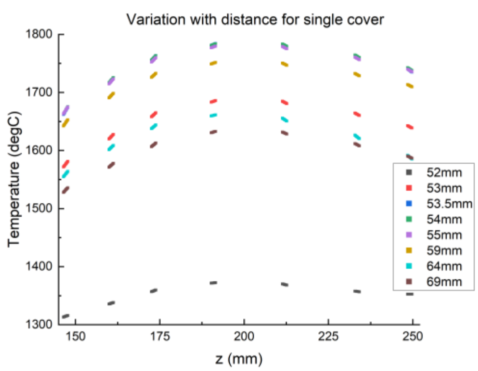


FIG. 2**:** Temperature profile across seven disks for various inner diameters of single Ta shield with 1mm thickness

### *Diameter optimization of various thermal shields:*

With one 1mm thick Ta shield at 54 mm, a second Ta shield cover of 1 mm thickness was added with the inner diameter varying from 57 mm to 59 mm, 61 mm and 64 mm. The 57 mm diameter was found to be optimal for the second cover. The maximum disk temperatures reached close to 1975 °C (as shown in FIG. 3) .

Now a third Ta shield of 1 mm thickness was added keeping the first two covers at 54 mm & 57 mm. Its diameter was varied from 60 mm to 62 mm. The temperature profile was almost similar for the third cover at both 60 mm & 62 mm inner diameter as shown in & the disk temperature reached a maximum of about 2100°C.

### *Shielded vs Unshielded configuration:*

The 54 mm and 57 mm diameter two-cover setup was compared to the unshielded setup. At 500 A, the shielded configuration achieved better temperature levels than the unshielded one at around 1100 A (see FIG.4), thus significantly reducing current requirements.

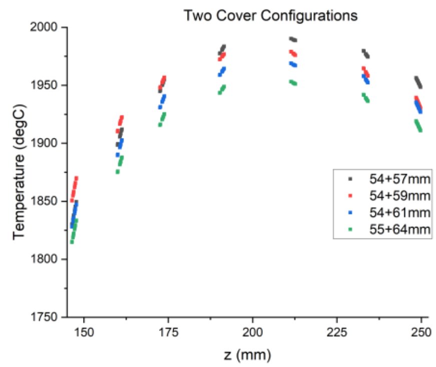


FIG. 3**:** Target disks temperature profile for various thicknesses of single Ta shield of 54 mm diameter

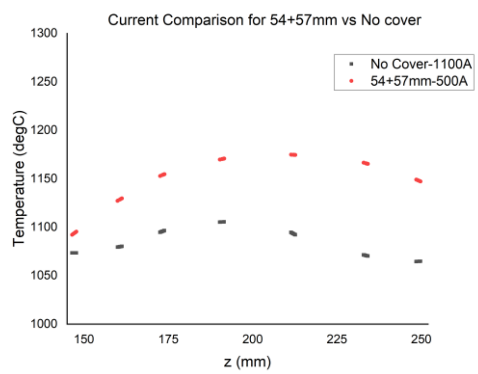


FIG. 4**:** Shielded vs Unshielded configurations

## Conclusion & Remarks

The study shows that the thickness of the thermal shields did not have much impact on temperature profile. It also showed that thermal shielding could reduce current requirements by almost a factor of half and achieve much higher disk temperatures. Further plans include studying the effect of such high temperatures on the mechanical stability & stress tolerance of the $UC_x$ target disks.

## References

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