# OPTIMIZATION OF THERMAL DEFORMATION OF A HORIZONTALLY DEFLECTING HIGH-HEAT-LOAD MIRROR BASED ON EINGA BATH COOLING


Jie Chen#, Xuwei Du, Zimeng Wang, Minghao Lin, Qiuping Wang

National Synchrotron Radiation Laboratory,

University of Science and Technology of China, 230029, Hefei, Anhui, P. R. China

Email: jiechen9@ustc.edu.cn


MEDSI 2023 Beijing — Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation

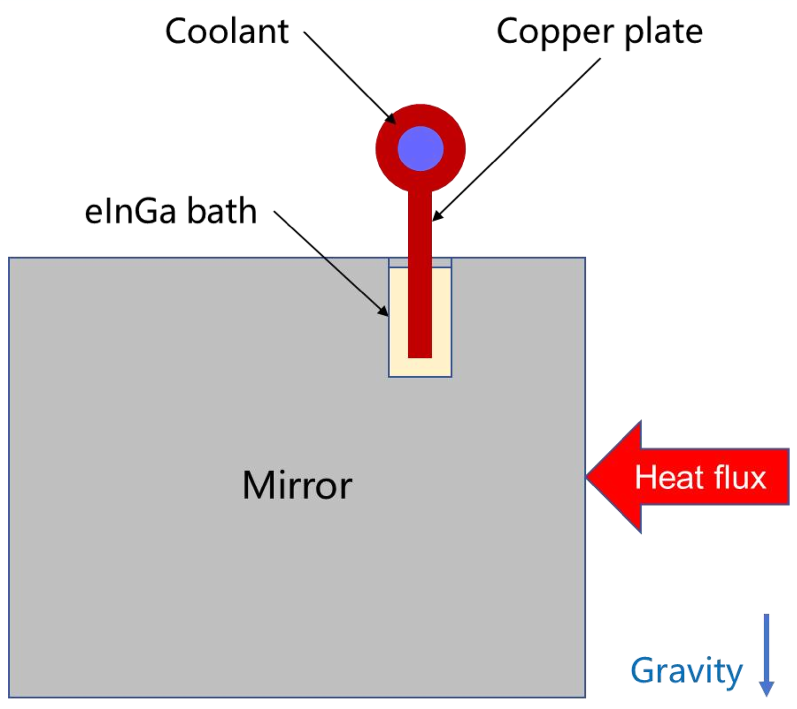
## INTRODUCTION

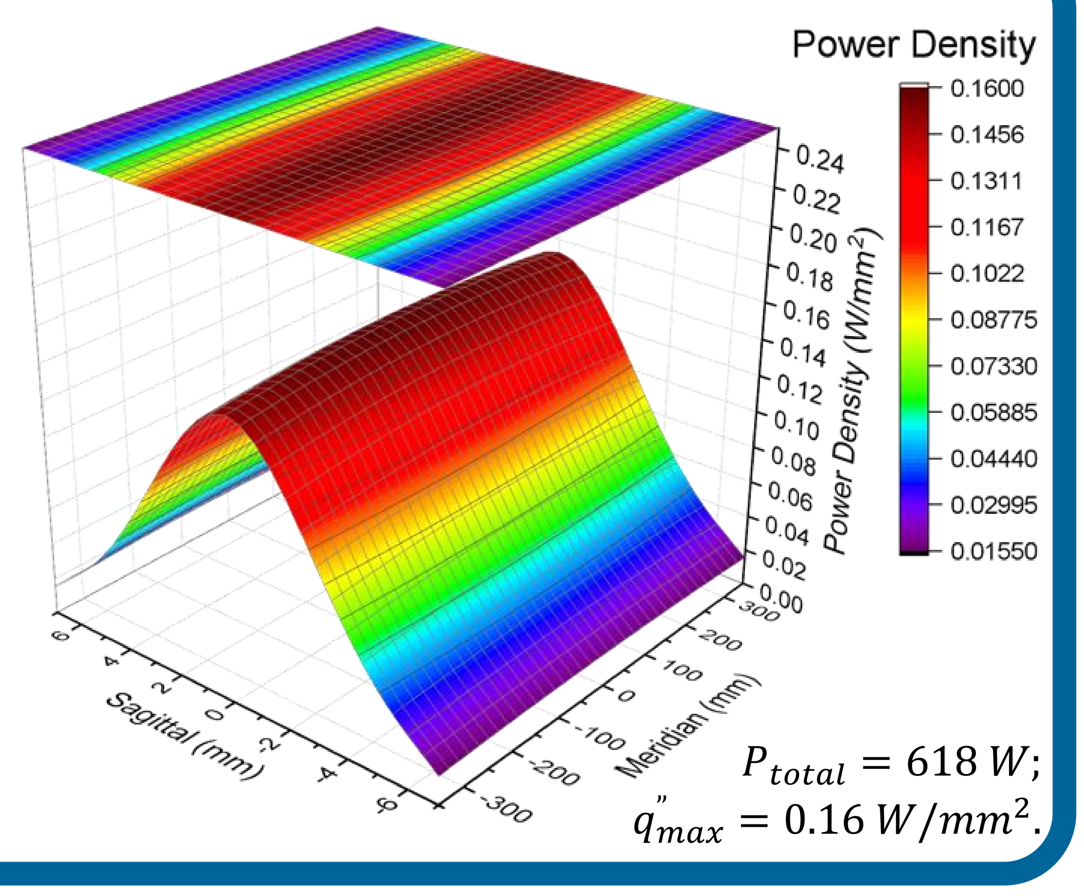
The synchrotron facility are developing towards higher brightness, lower divergence, narrower pulse, higher stability, etc. Therefore, the requirements of the first mirror of the beamline, who bear high-heat-load, are also upgraded, and the performances of the mirror become affected easily by other factors, such as **flow induced vibration**, **clamping force**, etc. Indirect water cooling based on eInGa bath is regarded as an effective mean to solve these thorny problems in designing of the first mirror cooling. However, for the case a horizontal deflection mirror, **the unilateral cooling** method is usually adopted, resulting in some **changes in the structure of the mirror**. In this paper, a first mirror horizontally deflecting of Hefei advanced light source (HALF) are taken as a example to introduce the optimization method to achieve ultra-low slope error in the meridian direction The results show that this optimization method provides a rapid design process to design the cooling scheme of the horizontally deflecting mirror based on the eInGa bath.

## LIMITATION FOR INDIRECT COOLING OF THE FIRST MIRROR

For the first mirror of horizontal deflection, the eInGa groove can only be applied on the top surface of the mirror, as shown in right figure. This cooling structure is very different from the vertical deflection mirror who has a bilateral eInGa bath for cooling:

1) The reduced cooling efficiency is prone to high temperature risk;
2) Deeper notch to generate larger reverse thermal moment.;
3) Thicker mirror to generate larger reverse thermal moment.

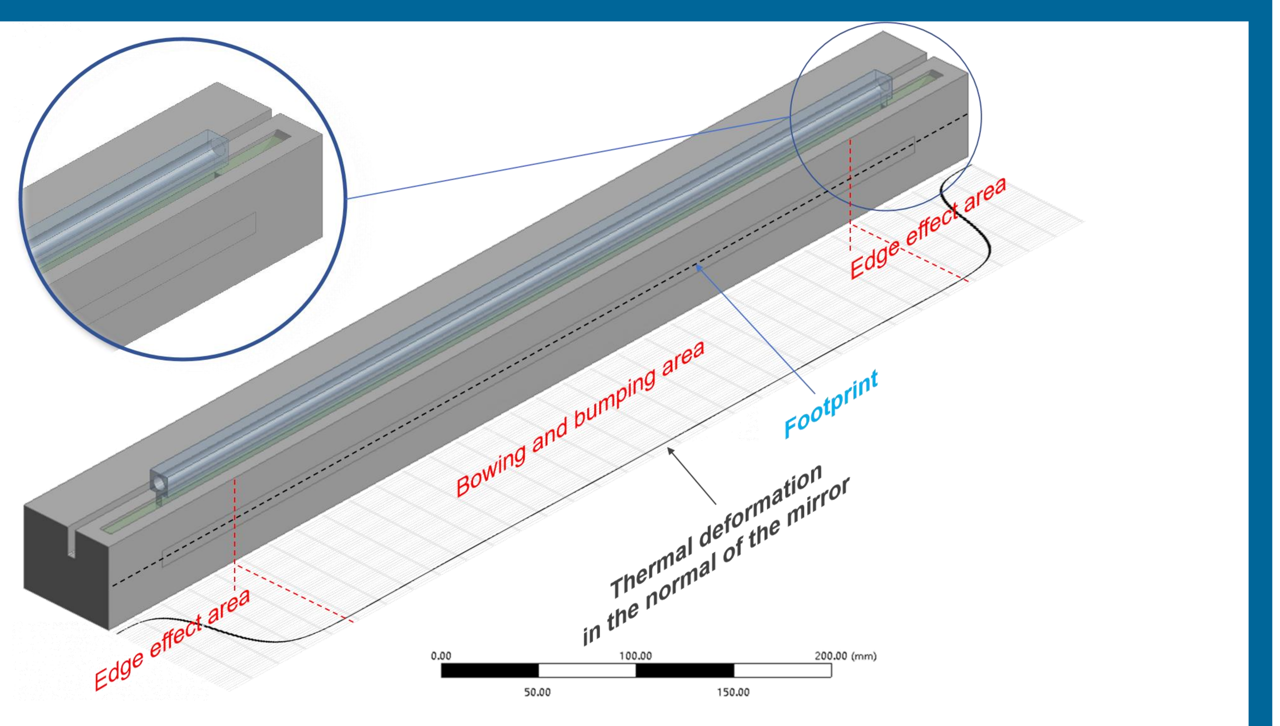


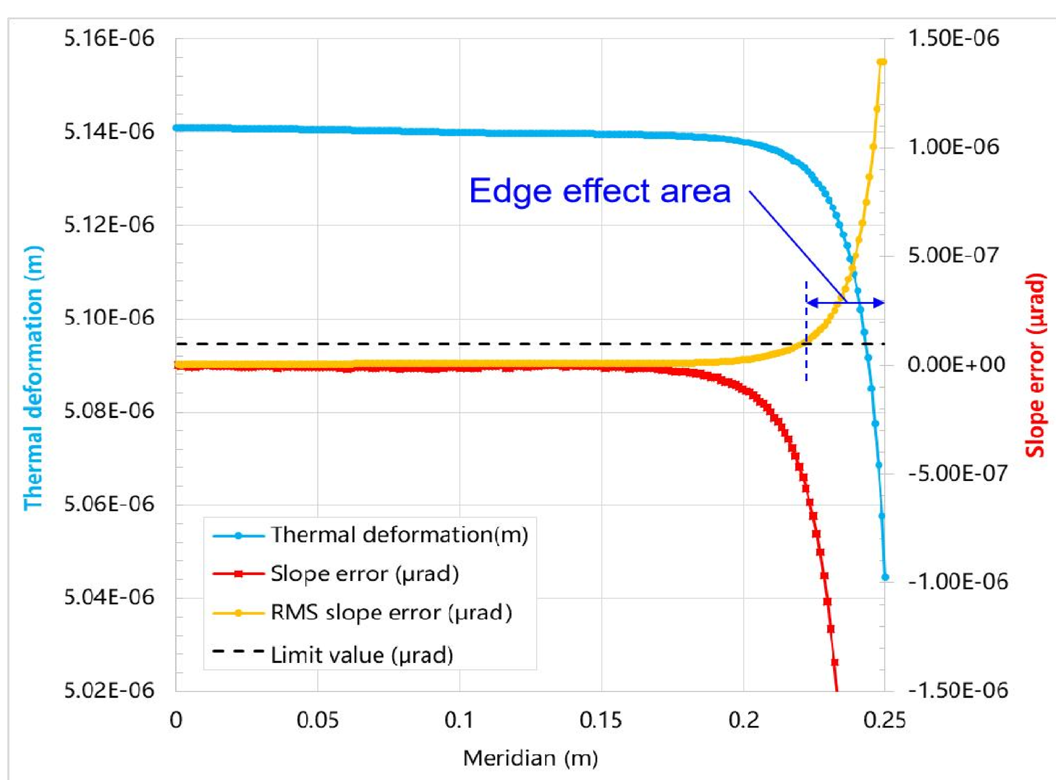

$P_{total} = 618\,W$; $q''_{max} = 0.16\,W/mm^2$.

## OPTIMIZATIONS FOR THE UNILATERAL COOLING BASED ON EINGA BATH

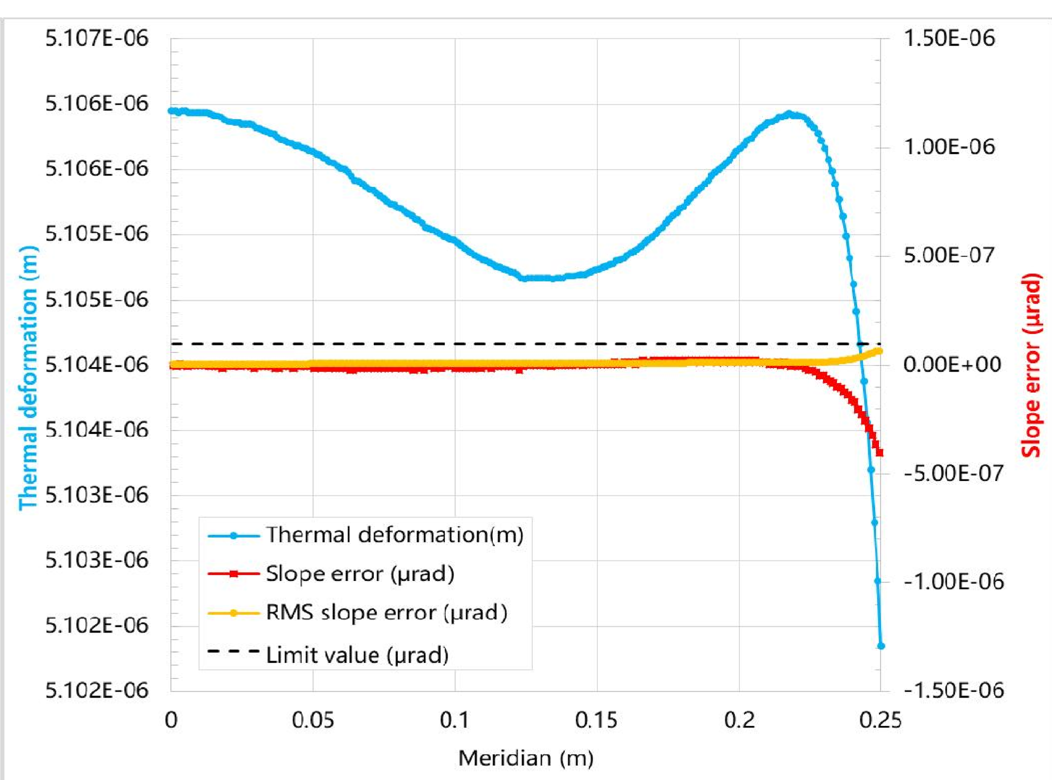
After the limit factors of the first mirror for horizontal deflection being settled, the mirror and its cooling structure are determined (right figure) except for the over irradiated size. For this module, the thermal deformation in the meridian direction of the incident surface of the mirror can be treated as the **superposition** of three effects, namely, **bowing**, **bumping** and **edge effect**.The thermal deformation of bowing and bumping derives from the total heat load and power density distribution respectively. And the edge effect derives from the changes in heat load conditions and cooling efficiency at both ends of the spot, featured with a sharp thermal deformation change in these areas.




$$(Over\ irradiation\ region) \geq (Central\ area) + 2 \times (Edge\ effect)$$




(a)




(b)

When evaluating the region of the edge effect, a slope error limit should be specified, such as **100nrad**. Then, according to the RMS slope error and slope error limit in Fig a, the **edge effect** region value is got, **29mm**. According to the above formula, the length of the **over irradiation area** of the mirror is determined to be 558mm. The original slope error RMS of the area (500mm) is 62 nrad in Fig b, the residual slope error RMS is 59 nrad, and the fitting circle radius is 4542.8 km.

## CONCLUSIONS

- ✓ The **curvature transition point** of the meridian thermal deformation provides a judgement to the notch optimization for eInGa bath cooling.
- ✓ Combined with **tuning of notch depth** and **evaluating of edge effect's region**, a horizontally deflecting mirror based on eInGa bath cooling can achieve a slope error RMS of **sub-hundred nano rad** in meridian directon.