

Application of a Near-Infrared Camera on the EAST Tokamak

Wenxue Fu, Dahuan Zhu, Binfu Gao, Yang Wang, Chuannan Xuan, Chunyu He, Junling Chen, Rui Ding, and EAST team

Institute of Plasma Physics, Chinese Academy of Sciences

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Contents



Background and motivation



System Design



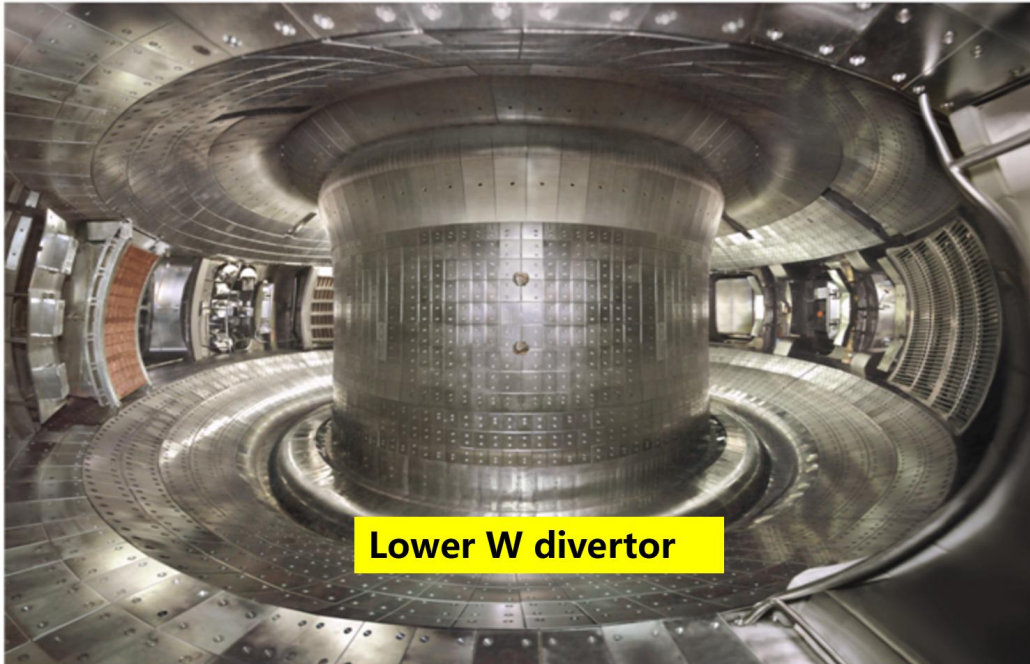
Assembly and Testing



Summary and Outlook

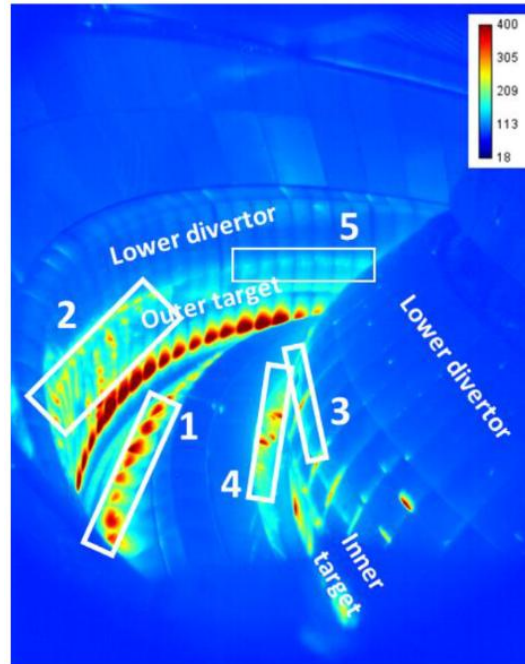
Background and Motivation

EAST Tokamak



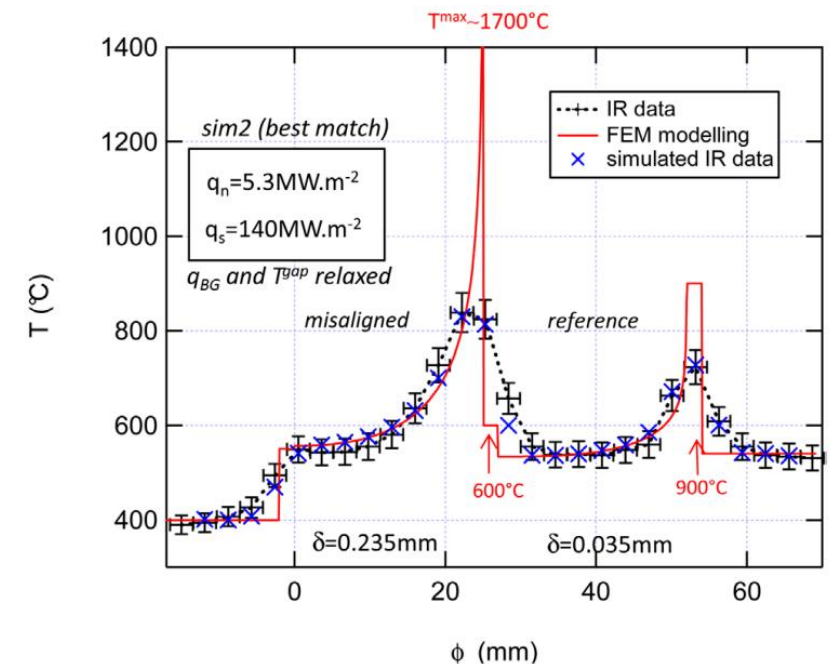
Long-pulse superconducting tokamak

Wide-field IR thermography



Global divertor temperature monitoring

Localized temperature structures



Narrow temperature peaks
can be underestimated

- ❑ Limited spatial sampling
Wide-field IR: ~ 3 mm/pixel

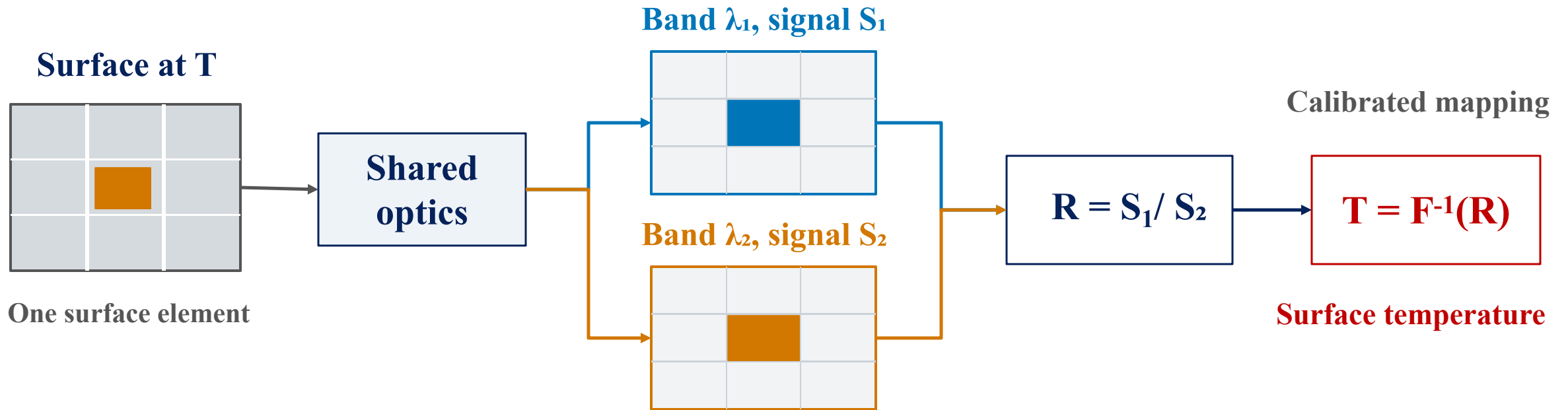
- ❑ Localized temperature peaks
Difficult to resolve accurately

- ❑ Emissivity uncertainty
Surface condition / coatings

- Need: High-resolution **two-color near-infrared** thermography
- Target spatial sampling: **~ 0.5 mm/pixel**

Two-Color Thermometry Principle

The ratio compares matched pixels at the same time

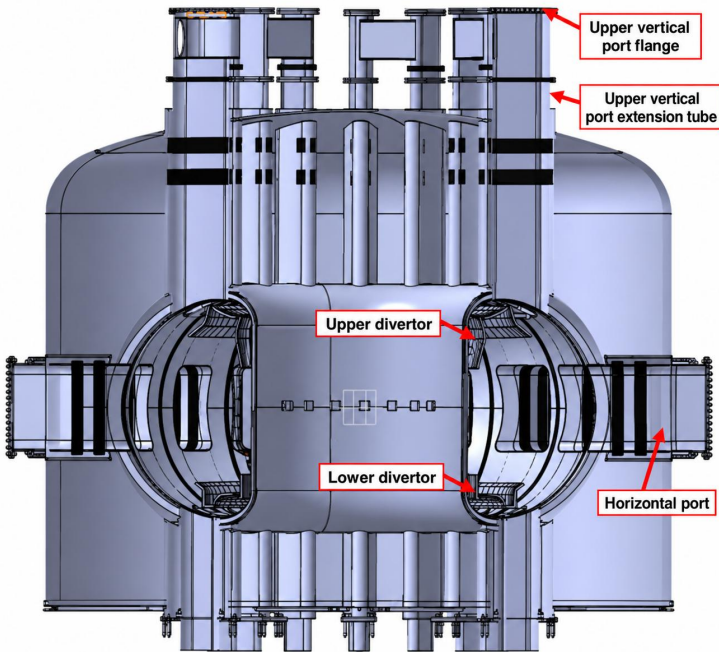


$$R \approx (G_1/G_2) (\epsilon_1/\epsilon_2) B(\lambda_1, T)/B(\lambda_2, T)$$

B: Planck radiance G: instrument response

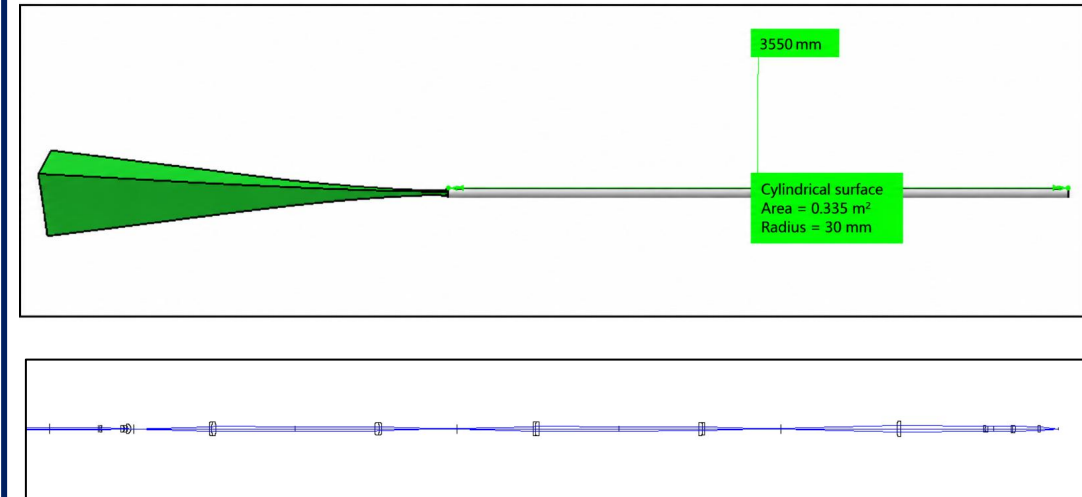
Blackbody calibration sets the response. The emissivity ratio ϵ_1/ϵ_2 still matters.

Optical Design and Parameters



Parameter	Design
Wavelength	1.5 μm
Optical length	3550 mm
Working distance	2332.8 mm
FOV	216 $\times$ 103 mm ²
Spatial sampling	0.3125 mm/pixel
F#	6

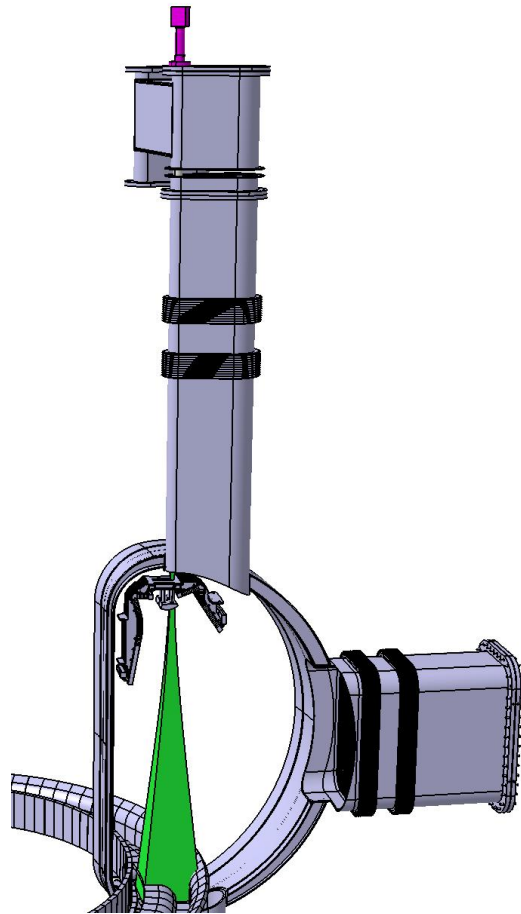
Long-distance endoscopic optics



- Restricted port access requires long-distance relay imaging.
- A 3.55 m coaxial relay transfers the lower-divertor image to the external camera system.

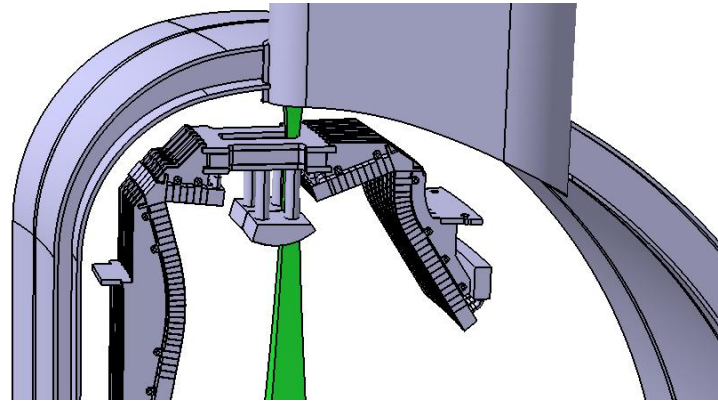
EAST Integration Design

H upper vertical port views the lower divertor

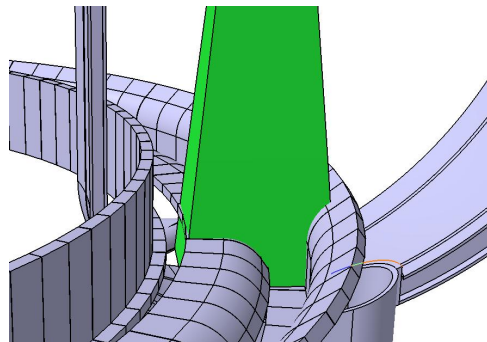


Proposed viewing path

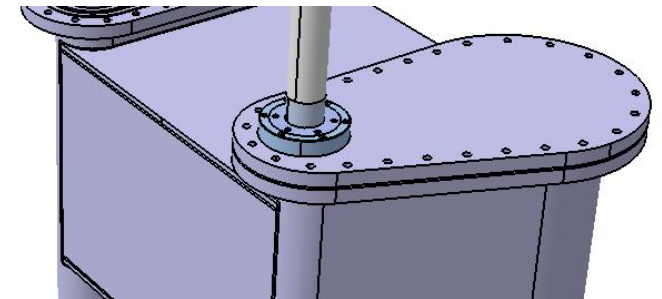
Clear the DOME aperture



View lower horizontal targets



Mount and seal at the port



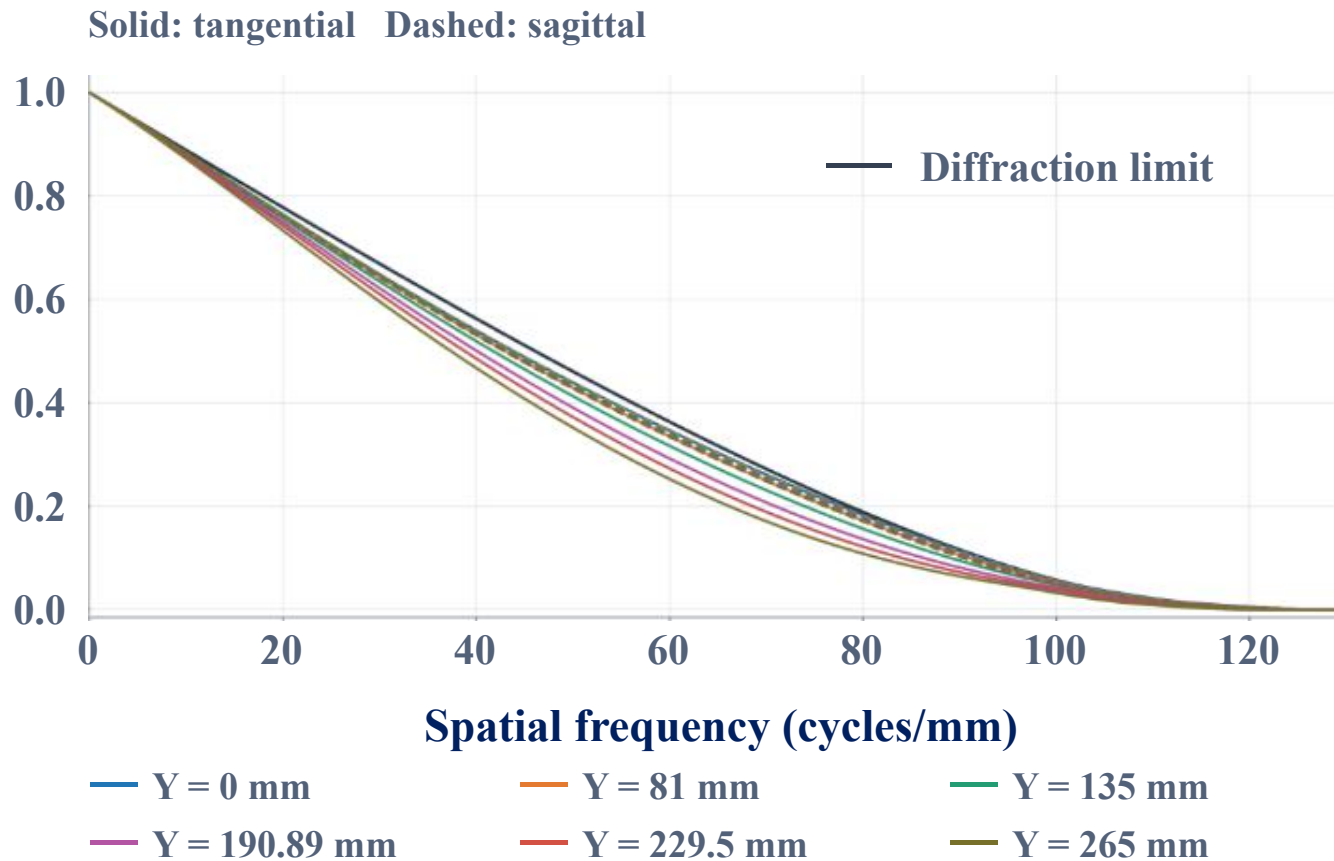
**Fused-quartz window
and fluoroelastomer O-rings**

**Vent grooves between
the lens groups**

Simulated Optical Performance

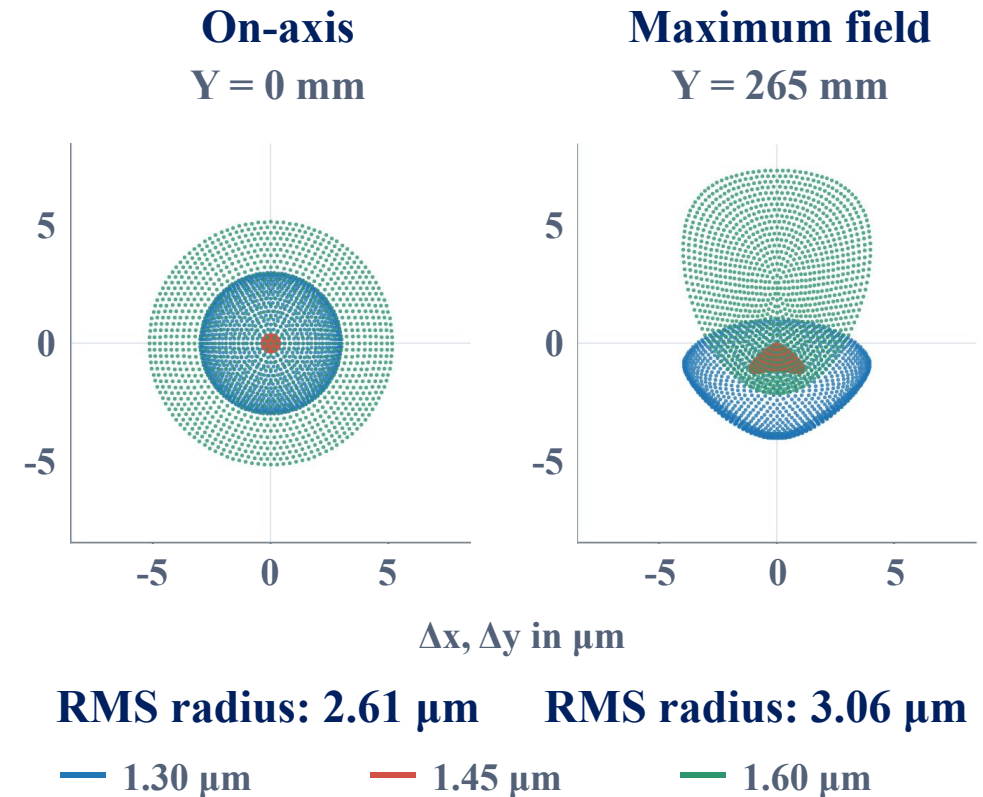
Nominal design at F/6 $\lambda = 1.30, 1.45, 1.60 \mu\text{m}$

MTF across six fields



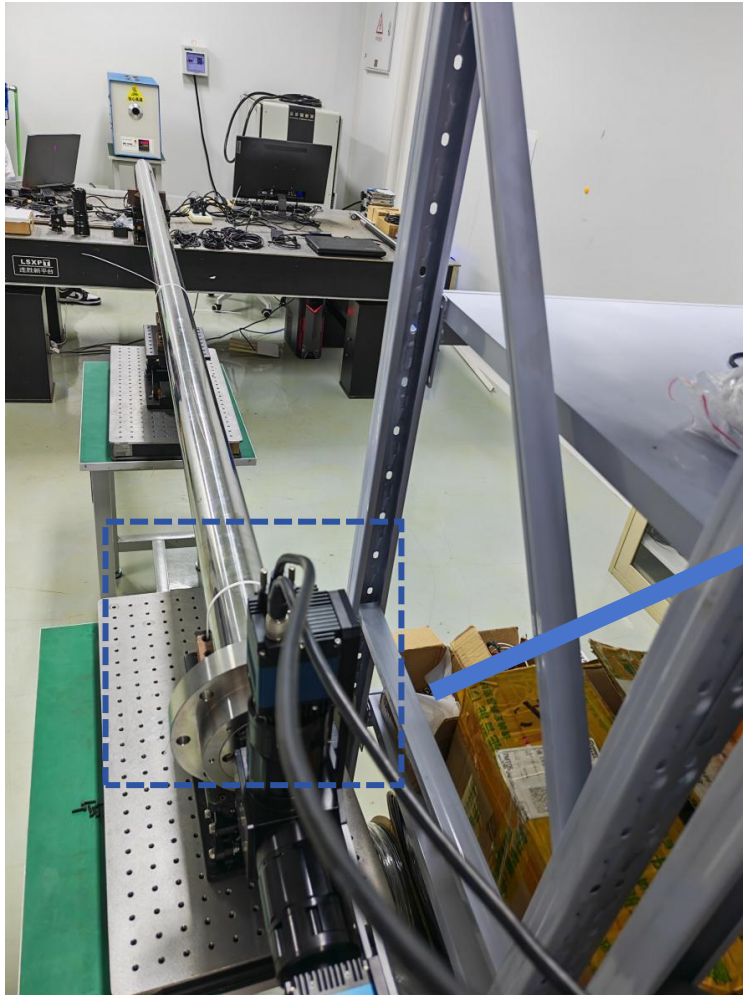
Representative spot diagrams

Same scale, relative to each field centroid



Simulated distortion $\approx 3\%$ at Y = 265 mm

Diagnostic Hardware Realization



Optical probe assembly

Two SWIR camera channels



Camera 1 (λ_1)

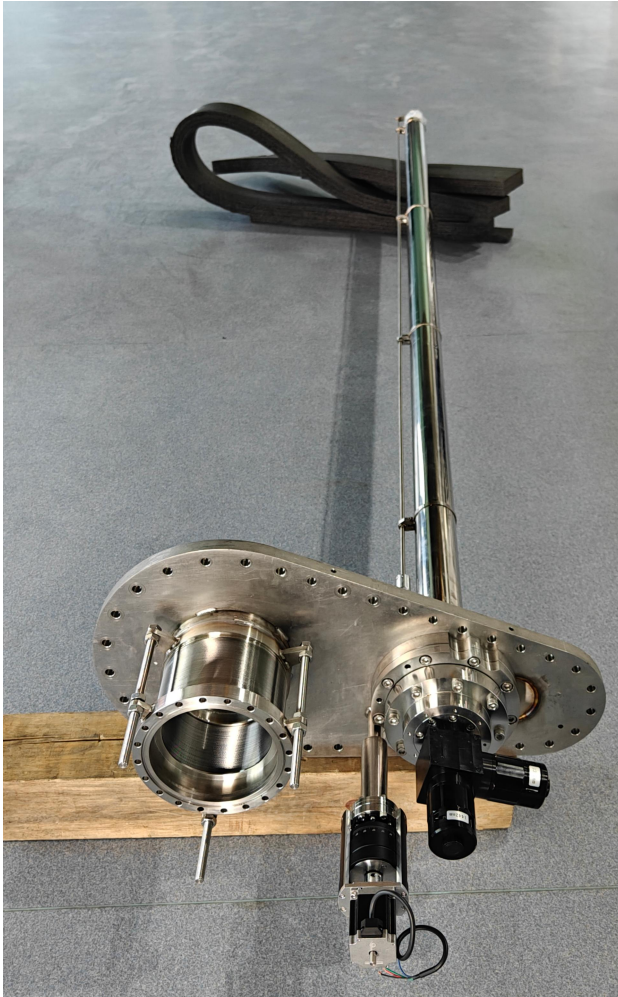
Camera 2 (λ_2)

1280×1024 pixels . $5 \mu\text{m}$ detector pitch

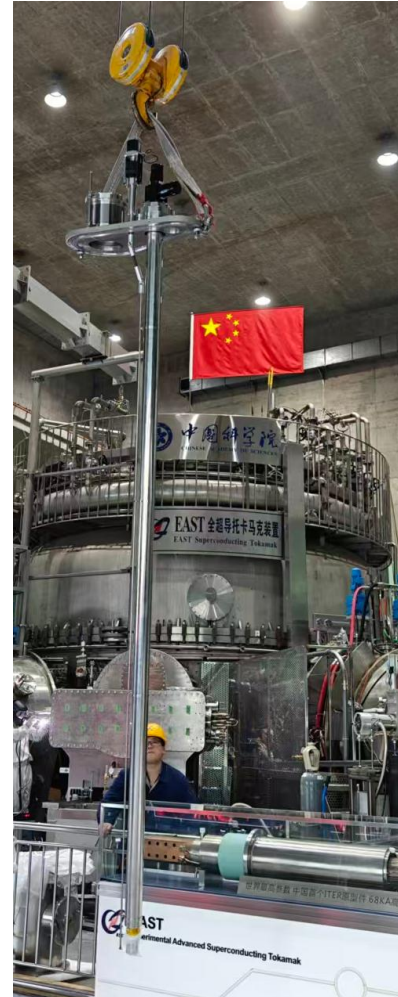
Dual SWIR cameras

- Simultaneous dual-channel acquisition enables two-color temperature measurement.

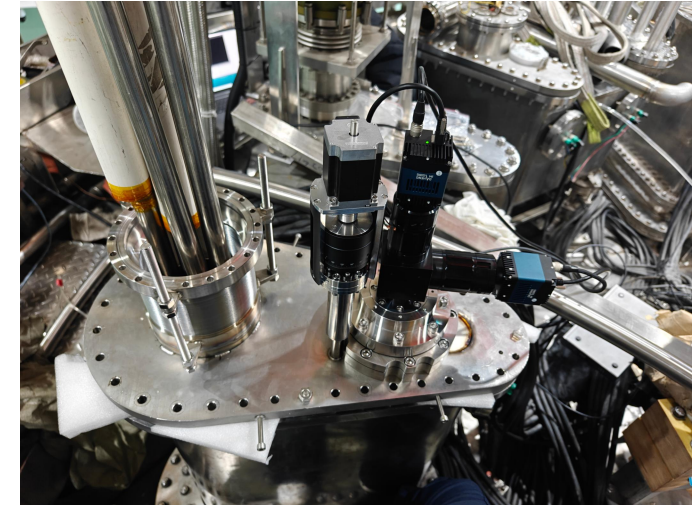
On-site Integration on EAST



Integrated diagnostic assembly



Hoisting and
installation on EAST

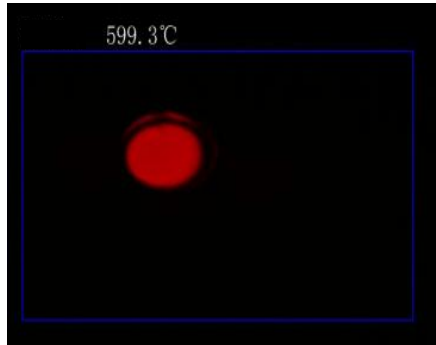


Final installed configuration at the H port

- The diagnostic system was successfully installed and integrated on EAST through the H upper vertical port.

Bench Test Results

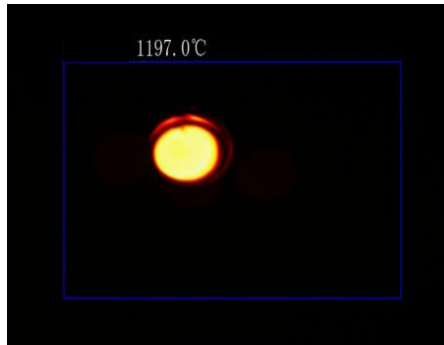
Blackbody thermometry



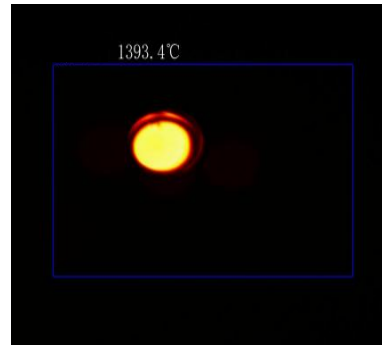
600 °C / 599.3 °C



800 °C / 797.4 °C



1200 °C / 1197.0 °C

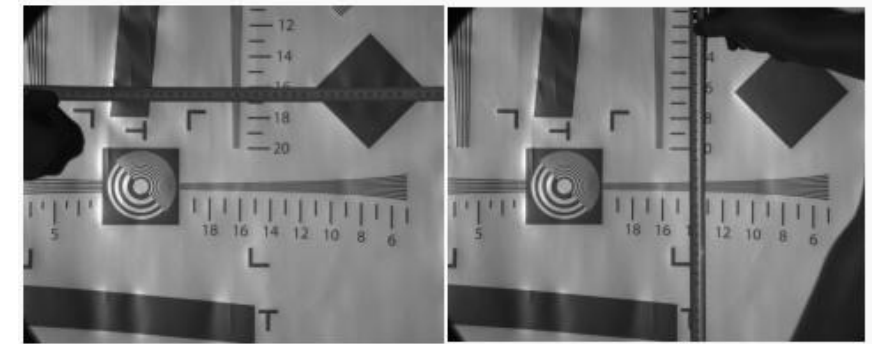


1400 °C / 1393.4 °C

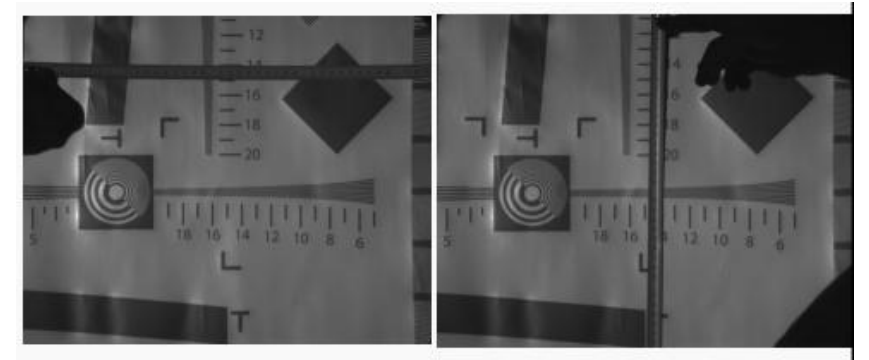
Setpoint / reading

Two-channel field of view

Transmitted channel



Reflected channel



Summary and Outlook

What we have built

✓ Two-color surface thermography

A 3.55 m relay optical system
installed on EAST

✓ Optical and blackbody tests

Two imaging channels, each with 14° FOV
Maximum absolute deviation: 6.6 °C
at the reported blackbody test points

Next: measurements on EAST

□ Acquire the first EAST dataset

Record dual-channel images during
plasma discharges

□ Measure divertor surface temperature

Obtain temperature distributions and observe
localized heating

THANKS FOR YOUR ATTENTION!

