

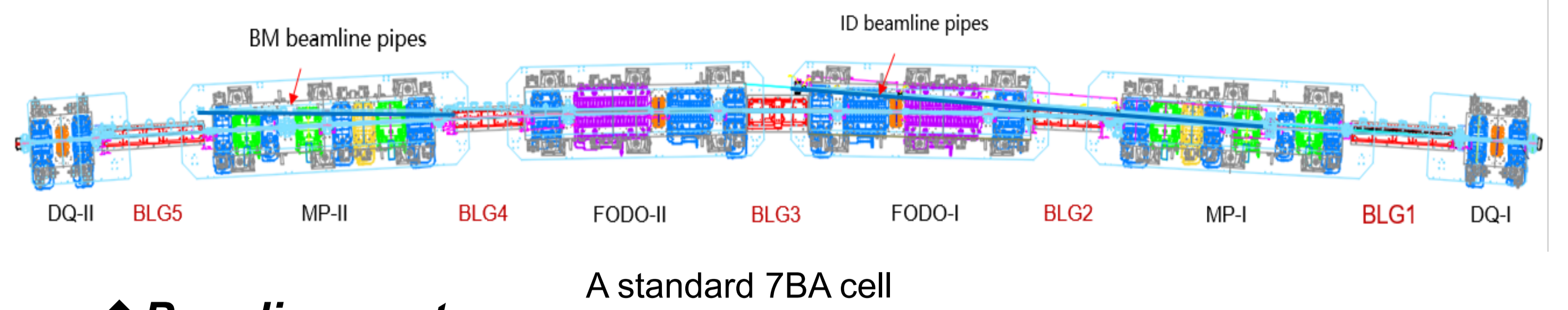


# INSTALLATION PROCESS EXPERIMENT OF HEPS STORAGE RING EQUIPMENT

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HEPS is a new generation synchrotron radiation source under construction in China. In order to complete high-precision installation of the 1.4km storage ring within a limited construction period, it is necessary to identify and solve potential issues in various aspects, including operation space, installation process, alignment scheme, and unit transportation, prior to the regular batch installation. Therefore, a full-process installation experiment was performed and the feasibility of relevant schemes are verified. Batch installation is currently in progress based on the experimental experience.

- HEPS storage ring circumference : 1360.4m, 7BA achromats.
- Experiment Aim: To identify and solve potential issues before the regular installation in batches.
- Experiment Object: A standard 7BA cell,
  - ◆ 6 pre-alignment units, 5 BLG magnets, 1 ID beamline, and 1 BM beamline



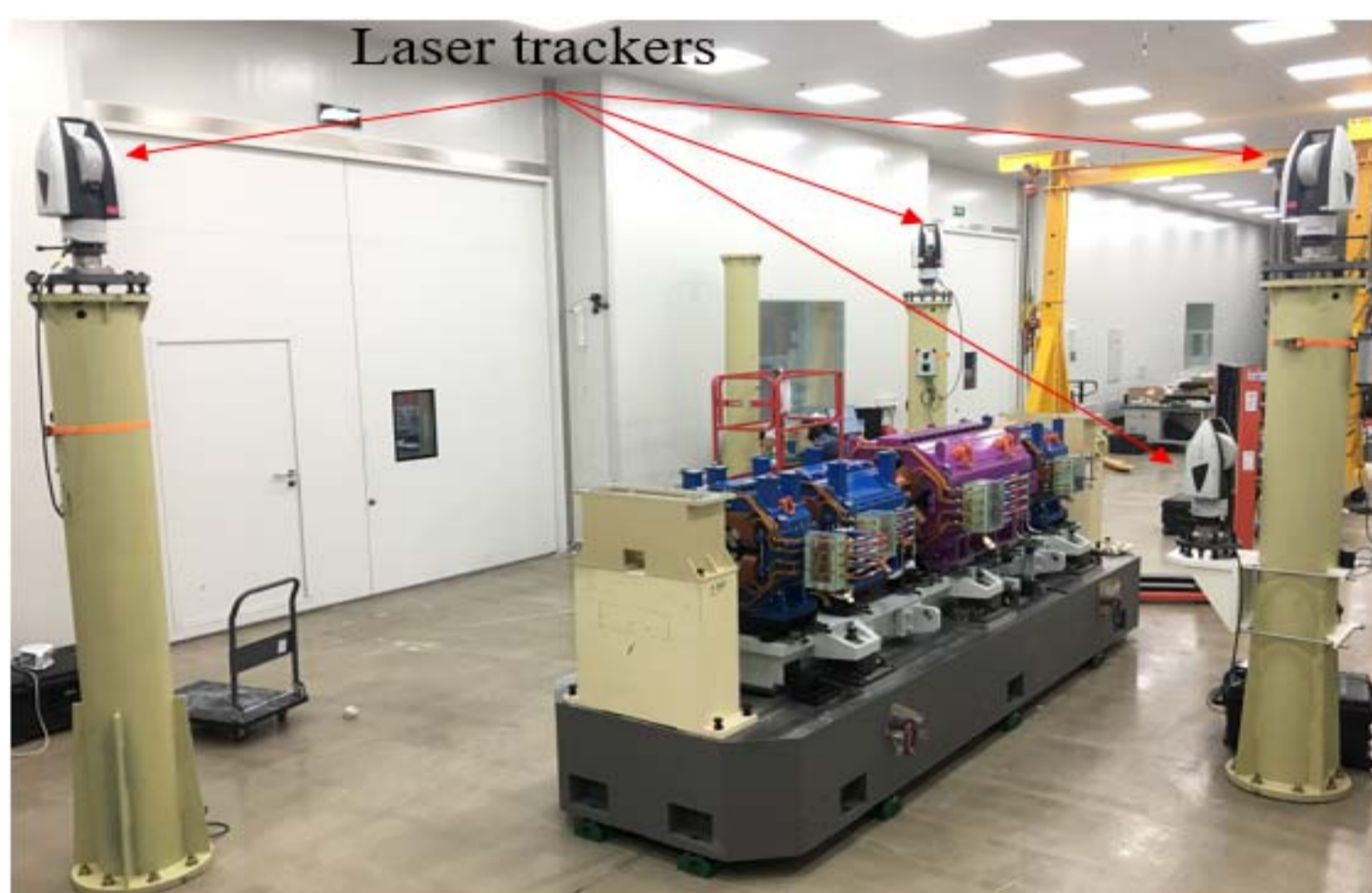
## PRE-ALIGNMENT SCHEME

### ◆ Requirements

- Pre-alignment error :  $\pm 0.03\text{mm}$
- Positioning deviation:  $\pm 0.01\text{mm}$

### ◆ Measuring accuracy

- Instrument : Laser tracking interferometer system, self-developed.
- Principle : Multi-lateration measurement
  - Four laser trackers in 3-high 1-low layout, measure a target point simultaneously with a Super-Cat's Eye reflector.
  - Only distance parameters are used for the target coordinate calculation, without introducing the angle measurement errors.
- Real-time coordinates measurement of spatial targets with laser tracking function and accuracy of  $6\mu\text{m}$  achieved.



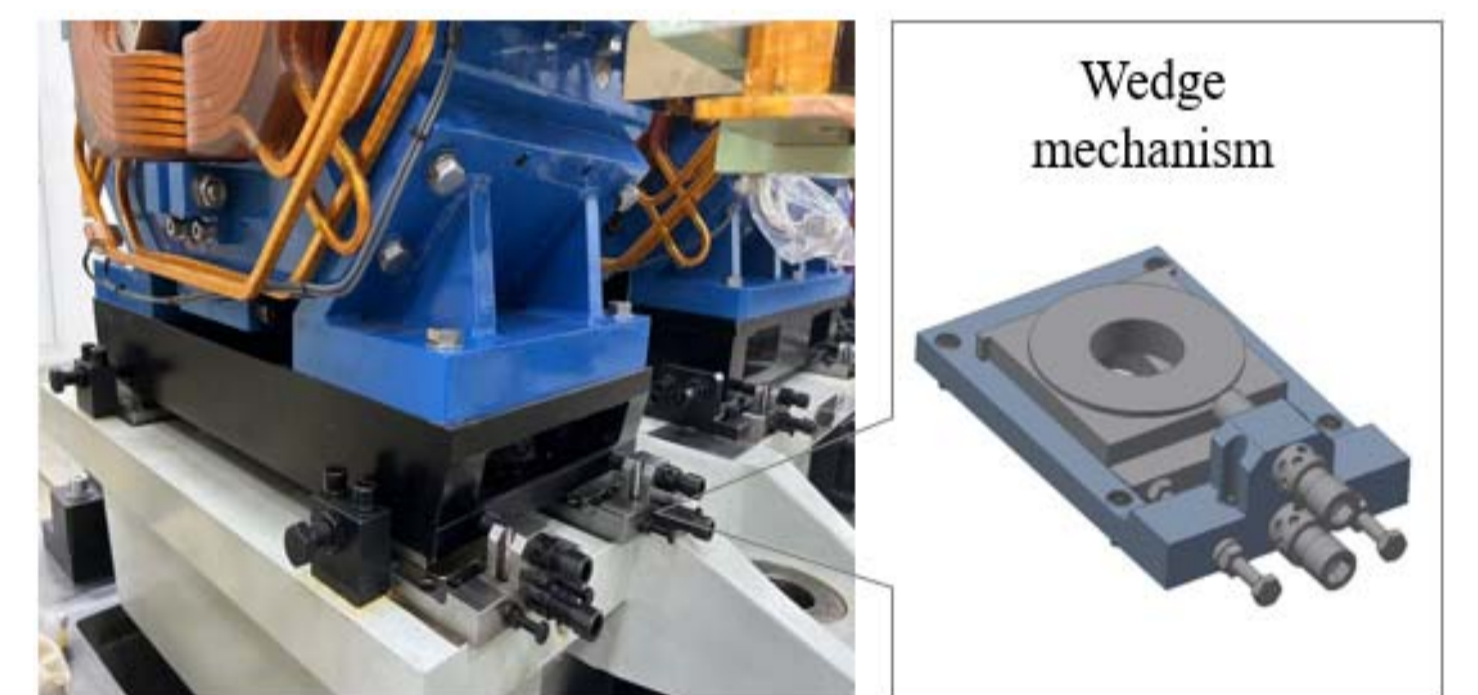
Laser tracking interferometer system

### ◆ Pre-alignment process

- Assembly and thermal stabilization of the Pre-Alignment.
- Establishment of a coordinate system based on the girder.
- Measurement of each magnet to determine the adjustment amount.
- Adjustment of each magnet one by one.
- Overall measurement to verify and evaluate the accuracy of the alignment.

### ◆ Magnets position adjusting

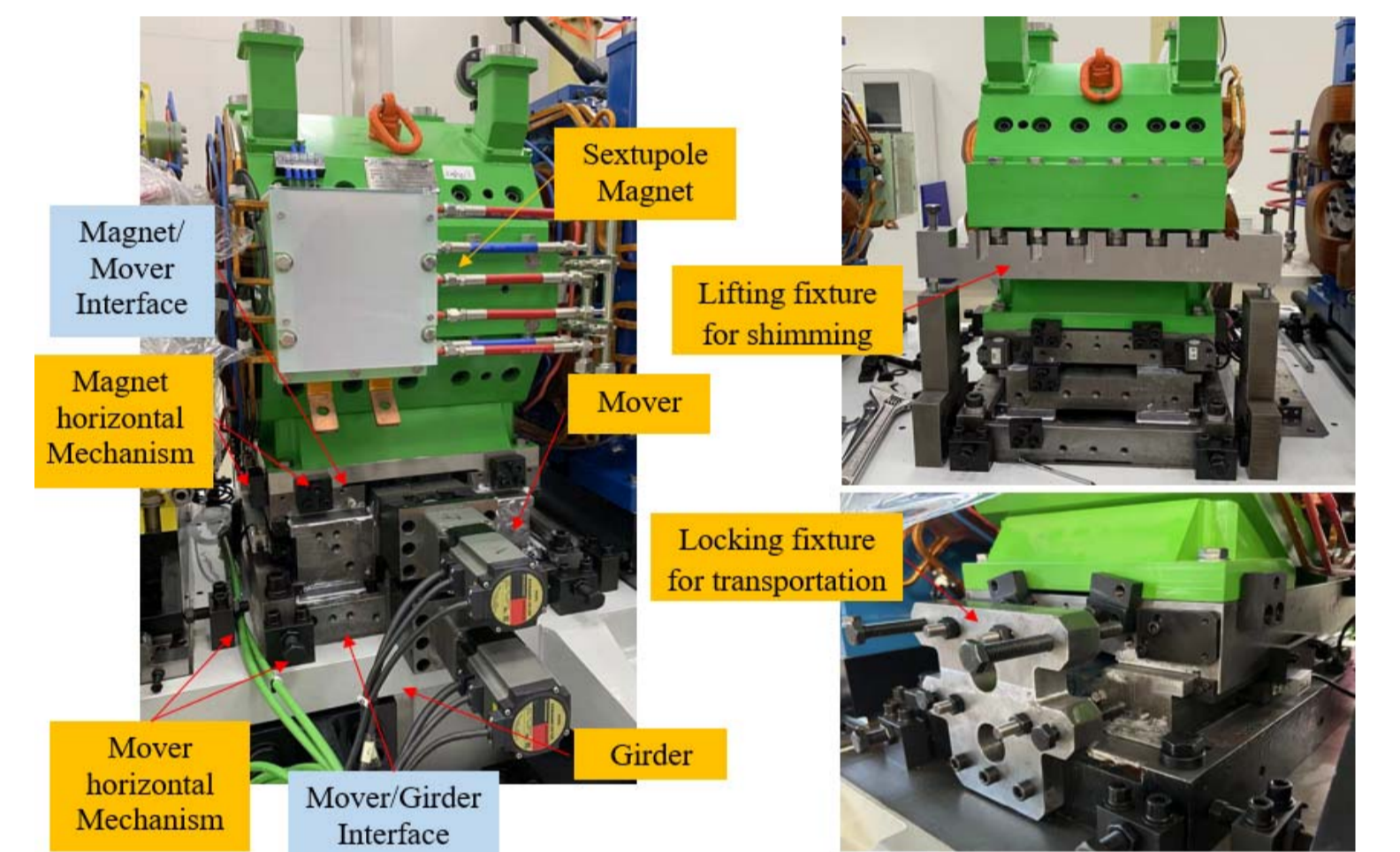
- Mechanism :
  - Vertical: wedge jack, range of  $\pm 1\text{mm}$
  - Horizontal: Fine screw, range of  $\pm 4\text{mm}$
- Positioning deviation:  $0.01\text{mm}$
- Tightening in-place :  $130\text{N}\cdot\text{m}$ 
  - Reduce internal stress to keep the position unchanged in a long time.



Magnet alignment mechanism

### ◆ Alignment of Sextupoles and Movers

- Movers are developed to do BBA, for beam optics correction.
  - Should be aligned on the girder properly to ensure online motion accuracy of  $5\mu\text{m}$ .
  - Positioning accuracy and efficiency are both concerned.
    - Mover-Girder: Tighten directly
    - Magnet-Mover: Shimming, special lifting fixture
    - Mover alignment mechanism & Operating the Mover.
  - Position stability : Lock the Mover slides by a fixture before transportation and restore the grating readings in the tunnel.



Installation of the sextupole & Mover

## REPEATABILITY OF MAGNET OPENING/CLOSING

- To make sure the alignment accuracy meeting the requirements after vacuum chambers installed.
  - Repeatability error:  $0.01\text{mm}$ ; Deviation from theoretical value:  $0.021\text{mm}$
  - Pins and consistent torques are the methods for repeatability.
  - MP & FD units are tested. Most magnets meet the requirements;
  - BD1/2 & ABF2/3 exceed  $0.01\text{mm}$  on repeatability at the first time, then keep stable at  $6\mu\text{m}$ .
- More experiments are performed The magnets shape is monitored during the opening/closing process and target coordinates changes are observed.
- The release of the internal stress is the most likely cause.
- Relevant procedures in the batch installation have been taken accordingly.



## TRANSPORTATION RELIABILITY

- ◆ Measures to ensure minimal change in magnet positions:
  - A self-levelling & vibration-reducing transport platform maintains the magnet level while up and down slopes.
  - The 6 girder supports should maintain the force balance in the whole transportation process.
  - A constant speed of 10-20 km/h of the truck should be secured.
- ◆ Magnet positions deviation after transportation is less than  $0.01\text{mm}$ , meeting the requirements of  $0.015\text{mm}$ .



Self-levelling platform

FD Unit lifted onto the truck

## MOCKUP EXPERIMENT

- ◆ A 7BA section mockup is built in the experiment hall.
  - 6 pre-alignment units, 5 Dipoles, 12 BPMs, & 18 vacuum chambers.
- ◆ installatin process is tested
  - Coarse installion, alignment and vacuum seal proceed through a flow process.
  - Exposure time of the vacuum chambers with NEG film to the atmosphere should be as less as possible.
- Operation space is checked.
  - Magnet opening /closing,
  - Vacuum elements alignment,
  - Vacuum connection,
- Special tools are used a lot in the critical places.



## CONCLUSION

- ◆ A full-process installation experiment was performed, the feasibility of relevant schemes are verified, and the required specifications in each process are met.
- ◆ Batch installation is currently in progress.