



# Overview of the Installation & Alignment of HEPS SR

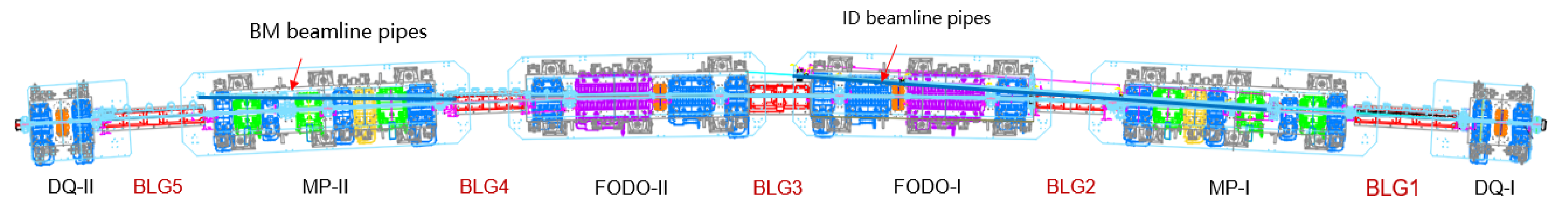
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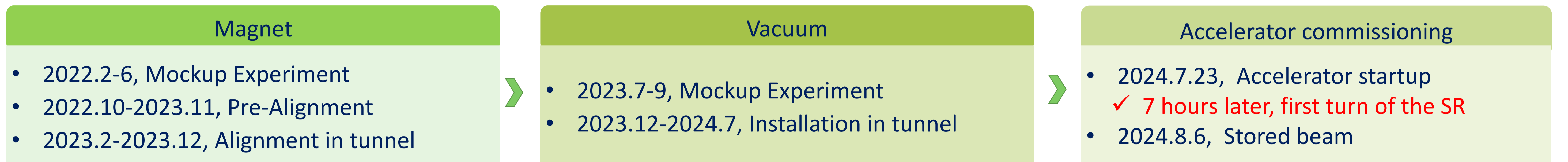
The High Energy Photon Source (HEPS) has been under construction since 2019. It is designed to be the first high-energy diffraction-limited synchrotron light source in China. To achieve an ultra-low emittance of less than 60pm.rad, substantial efforts have been invested in the alignment process of the SR. This involves thousands of elements being arranged in a very tight space. To fulfill such a heavy task, not only the accuracy, but also the efficiency has been taken into account. A mockup experiment has been performed firstly to verify the installation process and resolve the emerging and potential issues, paving the way of the mass installation. The progress of the accelerator commissioning indicates the satisfactory achievement of the alignment work.

## HEPS storage ring :

- 6GeV, 60pm.rad
- 1360.4m, 48-7BA achromats.
- Each arc section ~22m, 37magnets



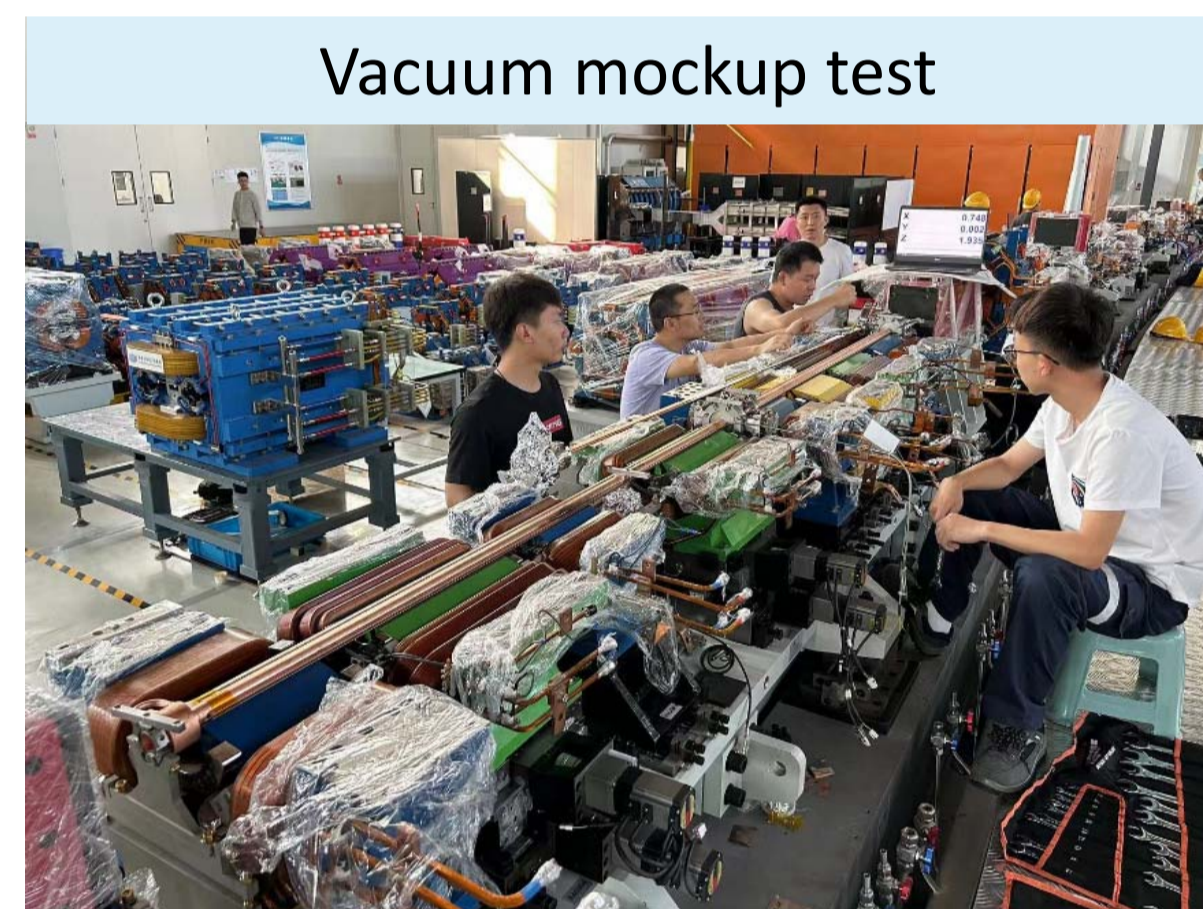
## Installation timeline:



## MOCKUP EXPERIMENT

- ◆ A 7BA section mockup is built in the experiment hall.
  - Divided into two stages, due to the delay in vacuum chamber supply.
- ◆ To verify the alignment accuracy, and check the operation space.
  - Measuring accuracy better than 6μm, deviation less than 10 μm after aligned.
  - Repeatability of the magnet opening /closing better than 10 μm.
  - Transportation variation less than 0.015mm.

- ◆ Most of the issues are resolved, ensuring the smooth progress of mass installation.
  - Two Longer-sized Magnets exceed 10μm at the first time, then keep stable at 6μm.
  - Internal stress should be the most primary cause, measures are taken in the mass installation.
    - At least 1 month of natural aging after manufacturing.
    - One operation of opening & closing prior to the magnetic measurement.
  - Photon absorbers are prealigned in the vacuum chambers to make sure the position accuracy of both the PA and VC meets the requirement at the same time.
  - Special tools are used a lot due to the restricted operate space.



## MAGNET ALIGNMENT

- ◆ Three work stations for pre-alignment, to keep up with the schedule.
- ◆ Average pre-alignment speed of each type of unit:
  - FD unit : Totally 96, 2 days per unit.
  - MP unit : Totally 96, 4.5 days per unit.
  - DQ unit : Totally 96, 1.5 days per unit.
- ◆ The pre-aligned units are supported evenly during the entire storage and transportation process.
- ◆ The concrete plinth aligned and grouted in the tunnel firstly.
  - Radial error: 2mm, Vertical error:1mm

Storage of the pre-alignment units



Installation of the pre-alignment units



## VACUUM INSTALLATION

- ◆ Vacuum elements are installed and aligned in the tunnel after the semi-precision alignment of the magnet units .
  - To avoid the difficulty of large deviation adjustment with vacuum connected.
- ◆ Vacuum chamber : long and thin→ easy to deform
  - For safety considerations with synchrotron light power.
    - Errors of chamber flanges: 0.3mm→where masks located
    - Errors of the aperture of the light beam: 0.2~1mm
      - Lots of auxiliary supports are installed.
- ◆ Stream line process : 3 cells/week
  - Open the top half of the magnets of a whole cell.
  - Install the vacuum chamber, and then do alignment.
  - Vacuum connection and vacuum leak detection.
  - Comprehensive measurement of the VC position.
  - Close the top half of the magnets .
  - Vacuum baking.

