Fiber Positioning System for LAMOST and BigBOSS

Jiaru Chu, Professor

University of Science and Technology of China

Outline

- Brief introduction to the LAMOST
- Fiber positioning system of LAMOST
- Progress of positioner for BigBOSS

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Key Team Members for LAMOST fiber positioning system

- **Prof. Jiaru Chu,** the team leader for developing the 4000 robot unit LAMOST optical fiber positioning system;
- **Prof. Hongzhuan Hu ,** chief mechanical engineer, in charge of design and manufacturing technology for the positioning robot units;
- **Prof. Chao Zhai,** chief electronic engineer, in charge of system electronic control ;2
- **Prof. Jianping Wang,** chief manufacturing engineer, in charge of focal plane plate technology and manufacturing of fiber positioning robots;
- **Prof. Zhigang Liu,** chief software engineer, in charge of software development for fiber motion control and fiber position measurements.

The LAMOST Project

Large Sky Area Multi-Object Fiber Spectroscopic Telescope

- **A quasi-meridian reflecting Schmidt telescope**
- **The Chinese National Major Science Project**
- **Location： Xinglong Station, National Astronomical Observatories, Chinese Academy of Sciences**
- **Construction Period: 7 years (Sept.2001~Oct.2008)**

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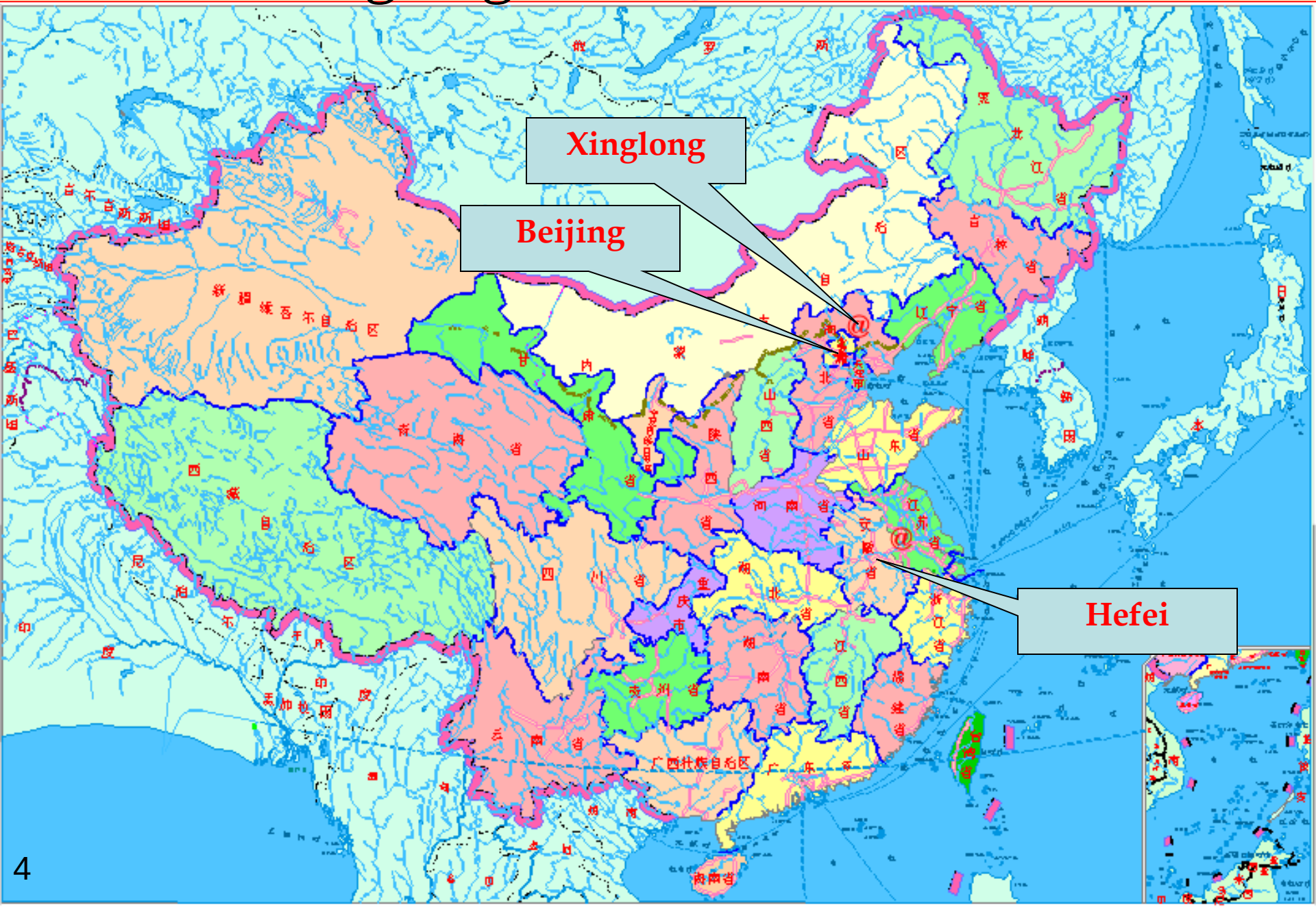
Where is Xinglong-LAMOST site



- Main features:

Aperture	focal plane diameter	spherical radius	Field of View	N. of Fibers	N. of Spectra
4 meters	1.75 meters	20meters	5 degrees	4000	10^7 (Galaxy)

- Performance:
  - 20.5 magnitude
    - 1 nm spectral resolution
    - 1.5 hours exposure
  - highest spectrum acquiring rate
    - 4000 spectra of objects

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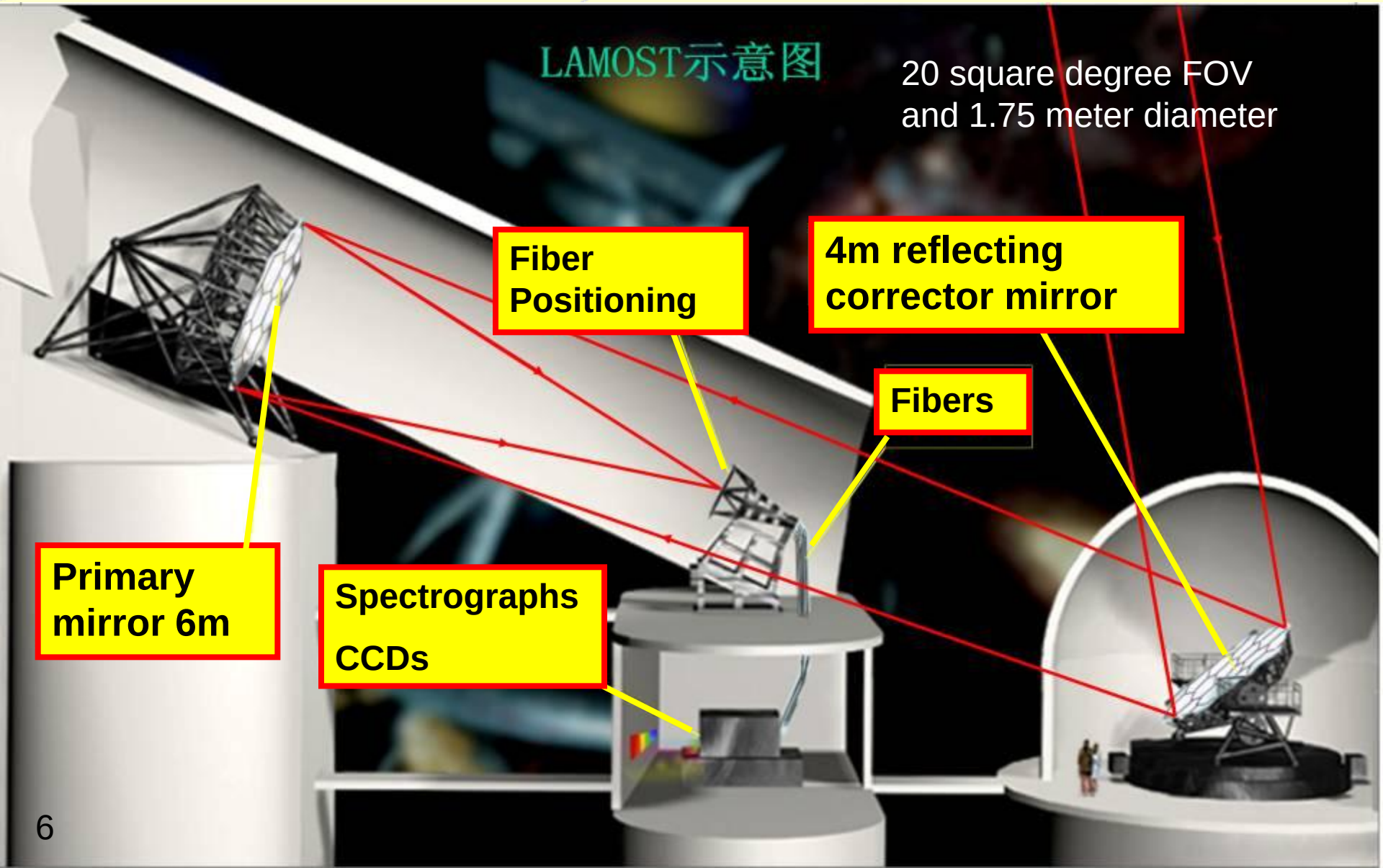
LAMOST concept

Originated by Prof Wang, S. & Prof Su, D.
refer to Wang, S., et al.
Applied Optics, Sept.1996



- Sub-systems of LAMOST

Science Division
- Observatory Control & Data Processing System
- Input Catalogue & Observing Strategy

Engineering Division
- Enclosure
- Instruments
  - fibers
  - fiber positioning
  - spectroscopes
  - CCDs
- Telescope Control System
- Mounting & Tracking System
- Active Optics & Mirror Support System
- Optical System

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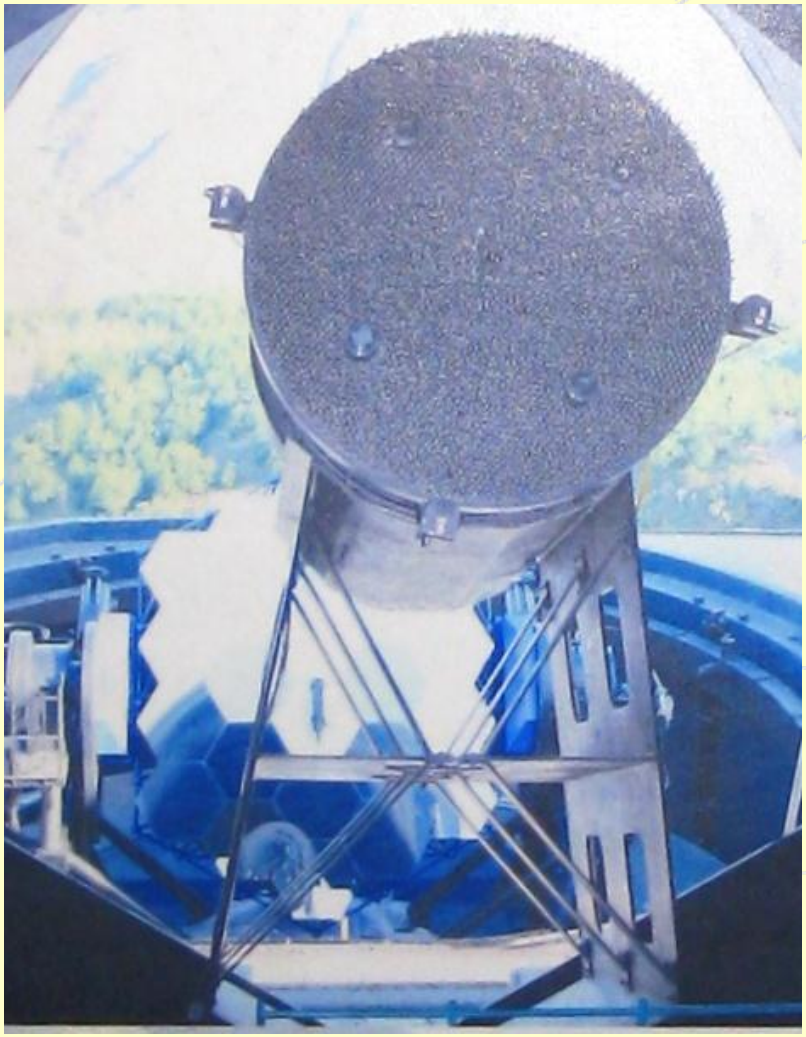
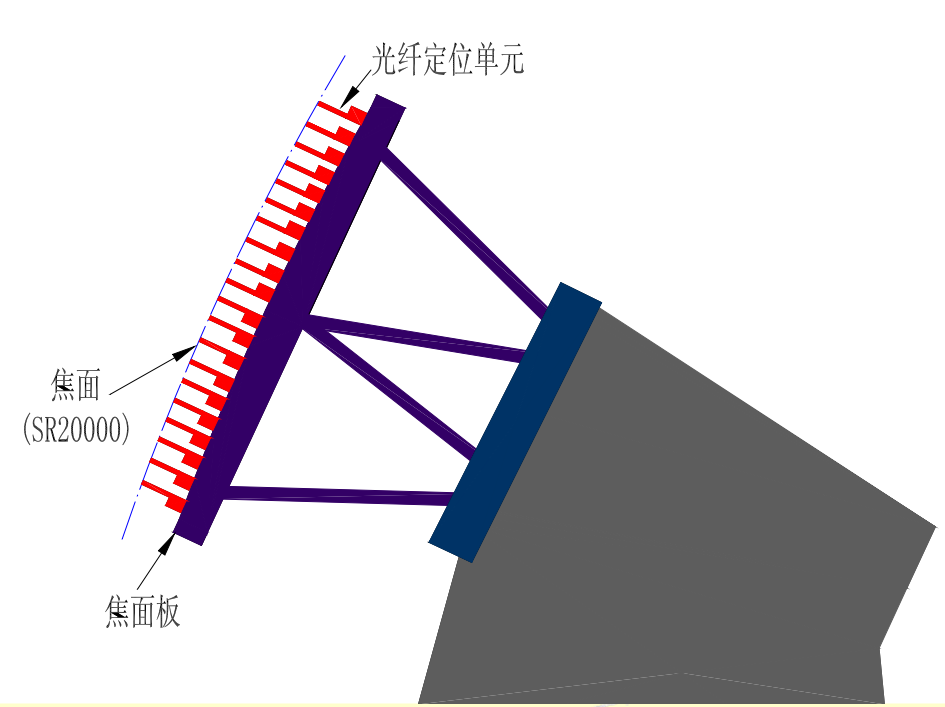
LAMOST
Optical Fiber Positioning System





- **4000fibers were uniformly distributed in the focal plane**

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Research of fiber positioner

- 1：Mechanics of fiber positioner
- 2：Control system
- 3：Focal plate
- 4: Mesurement and the testing system

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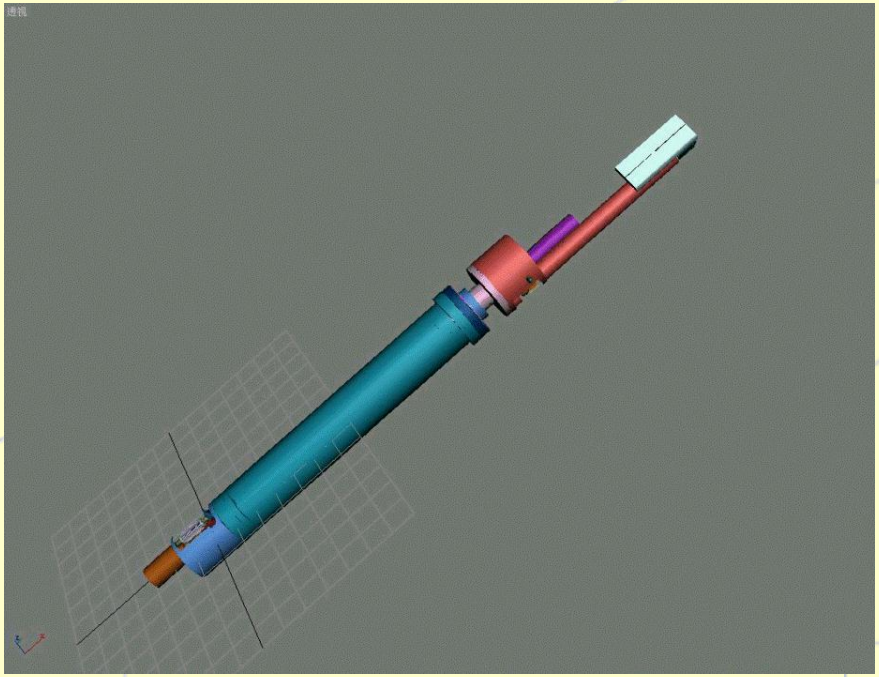
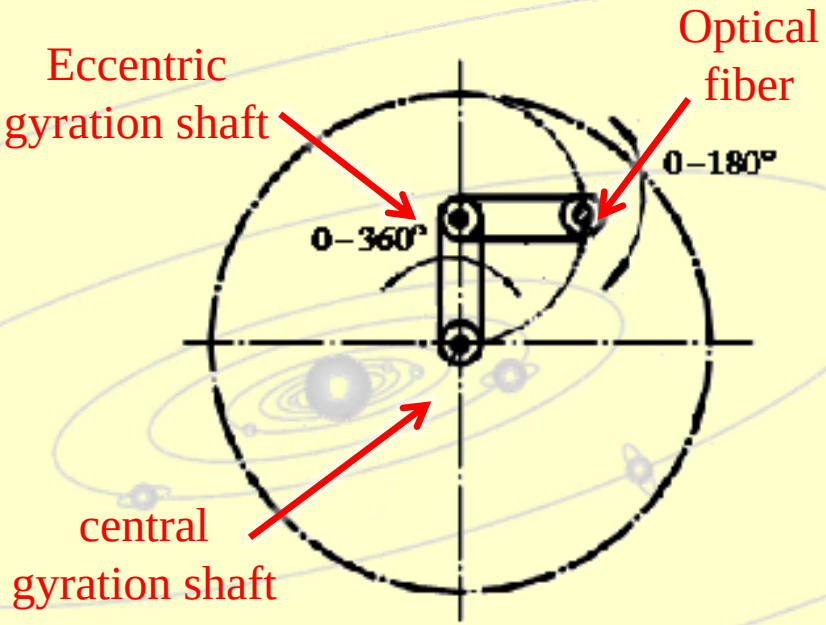
LAMOST
Fiber positioning robot





Double-gyration device → Central gyration
Double-gyration device → Eccentric gyration

Worm gearing ← Stepping motor

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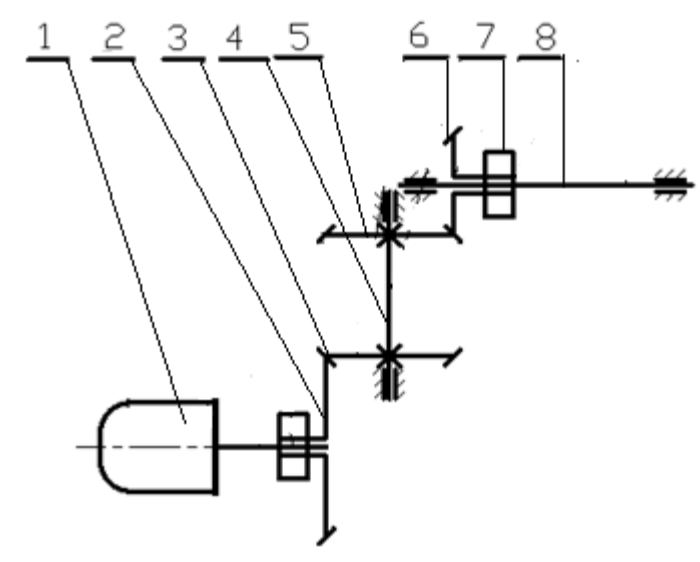
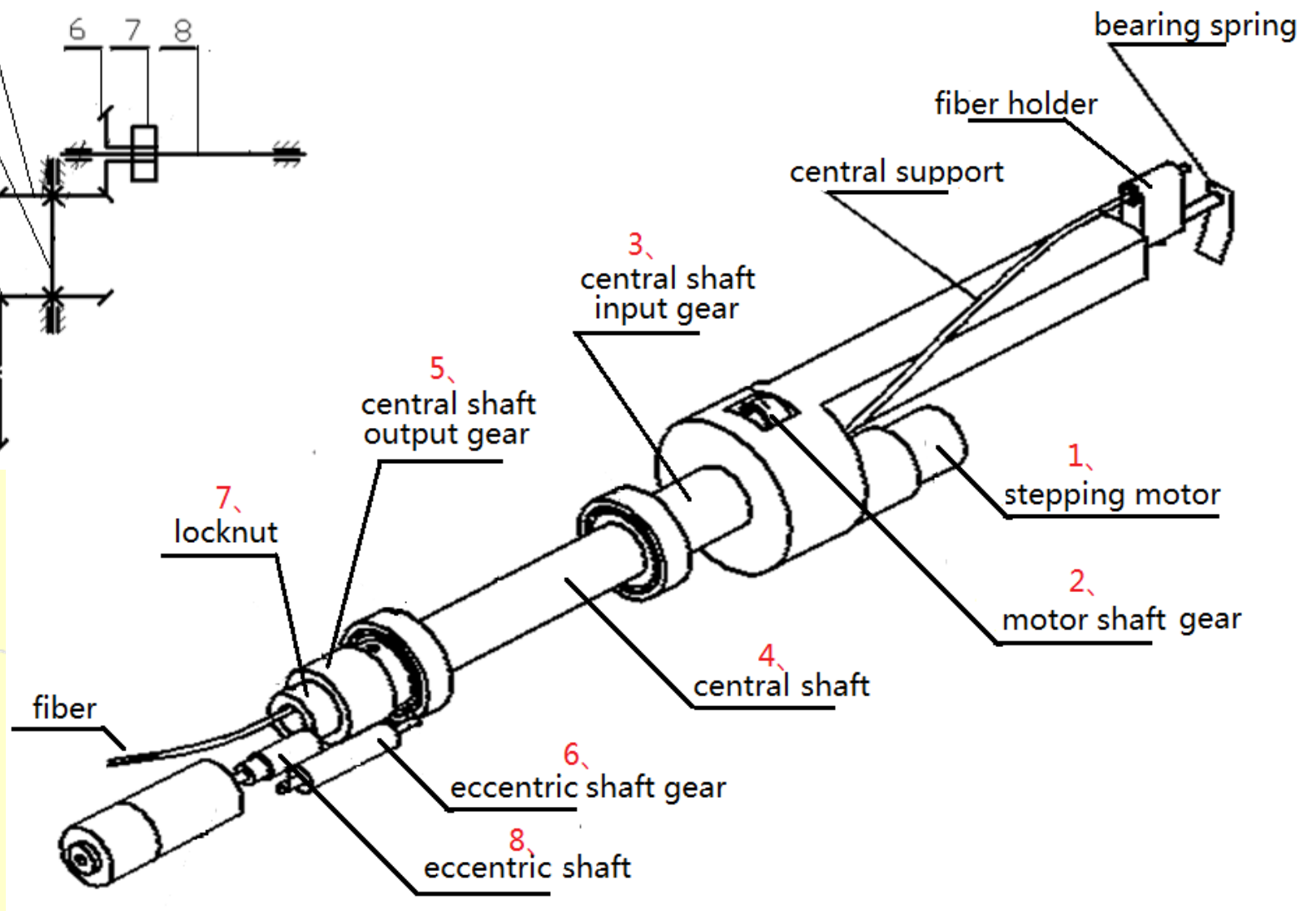
LAMOST

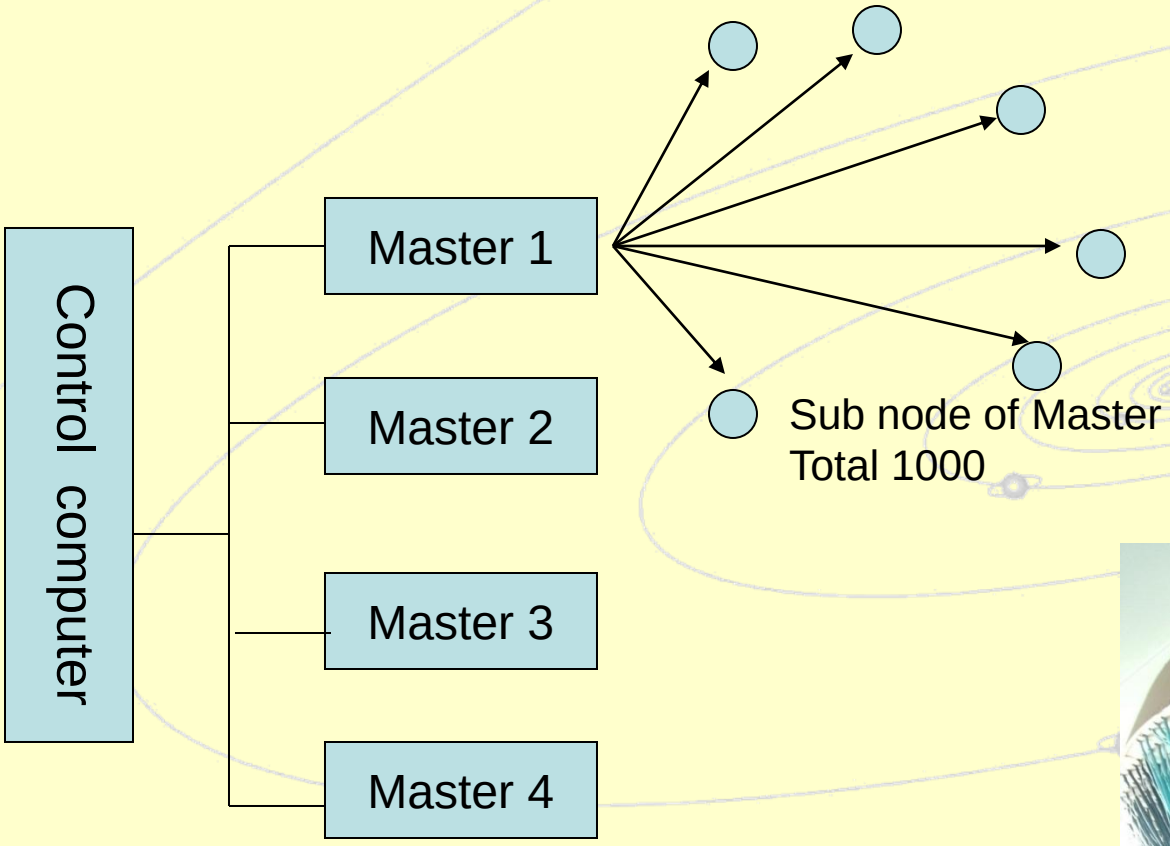
Moving transfer chain of the robot



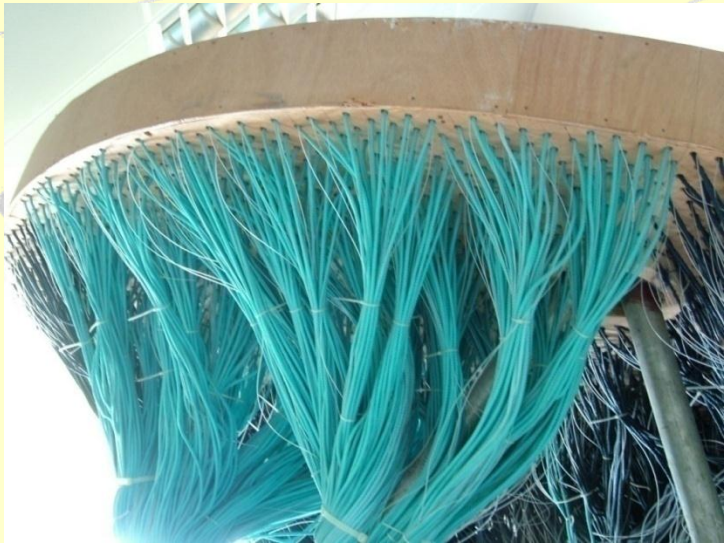


Control system

Two kinds of control system was made for LAMOST(Wire and wireless control)

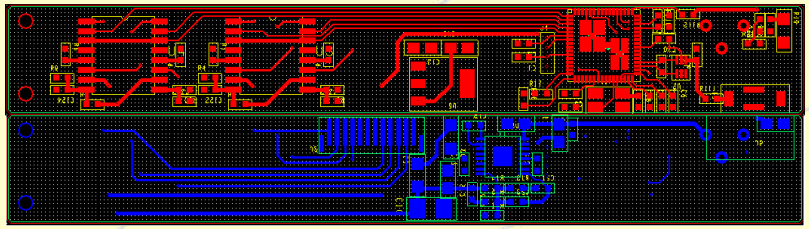


Model of focal plate with wire control system

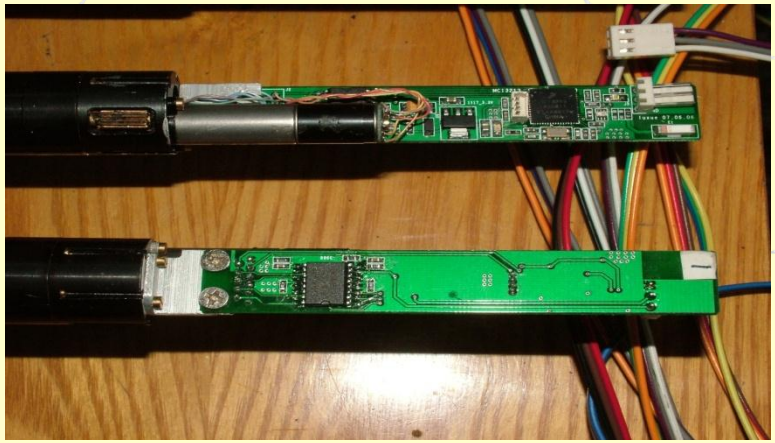


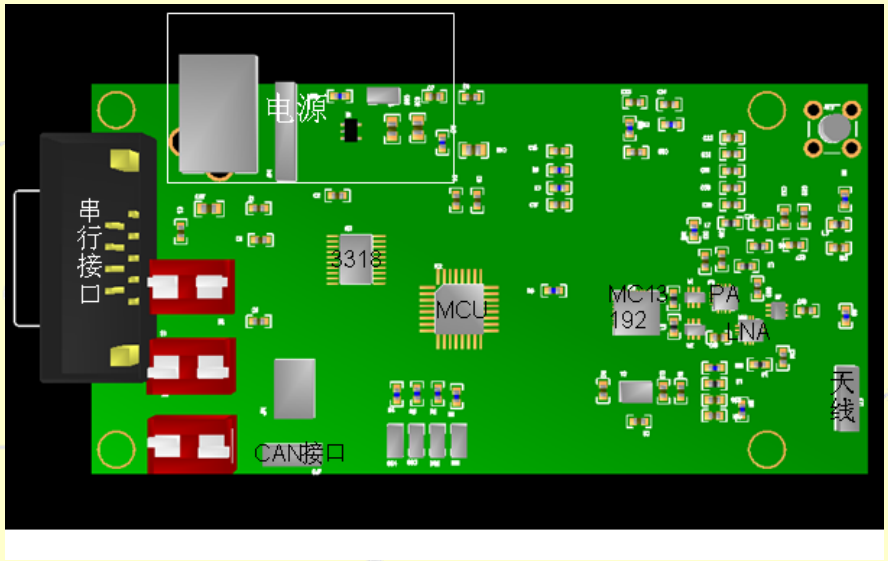
Wireless control system--Zigbee

Wireless control system—design of master and subnode



- Sub node
  Size:15mm*100mm





Master

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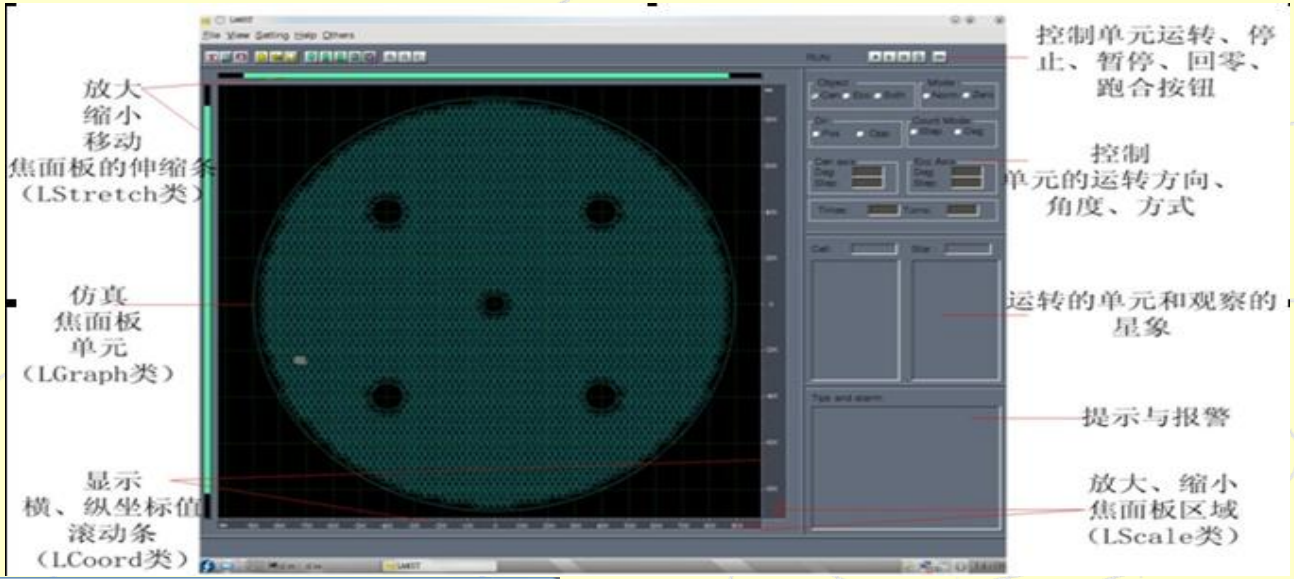
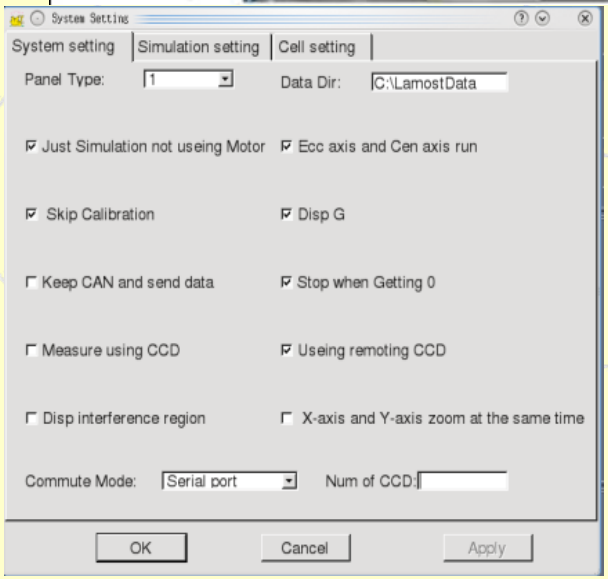
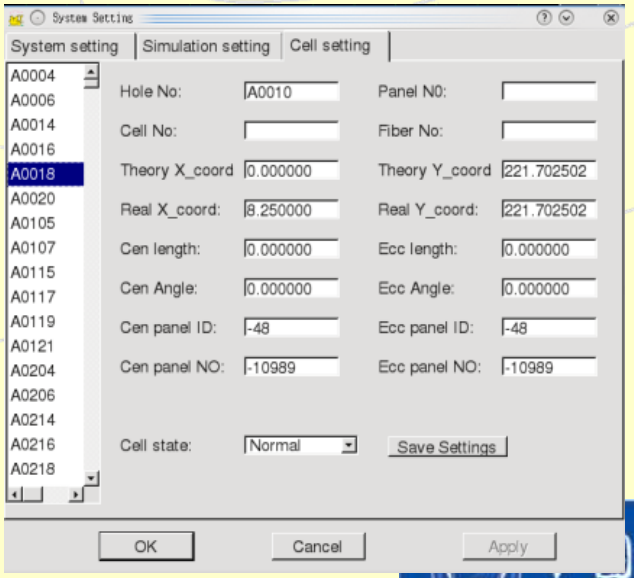
Wireless control system--Software







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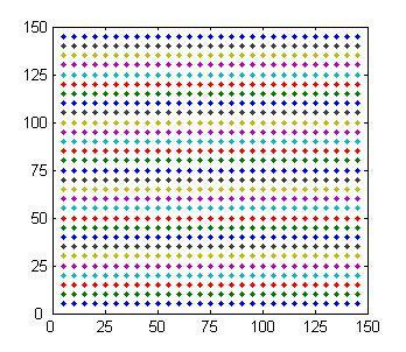
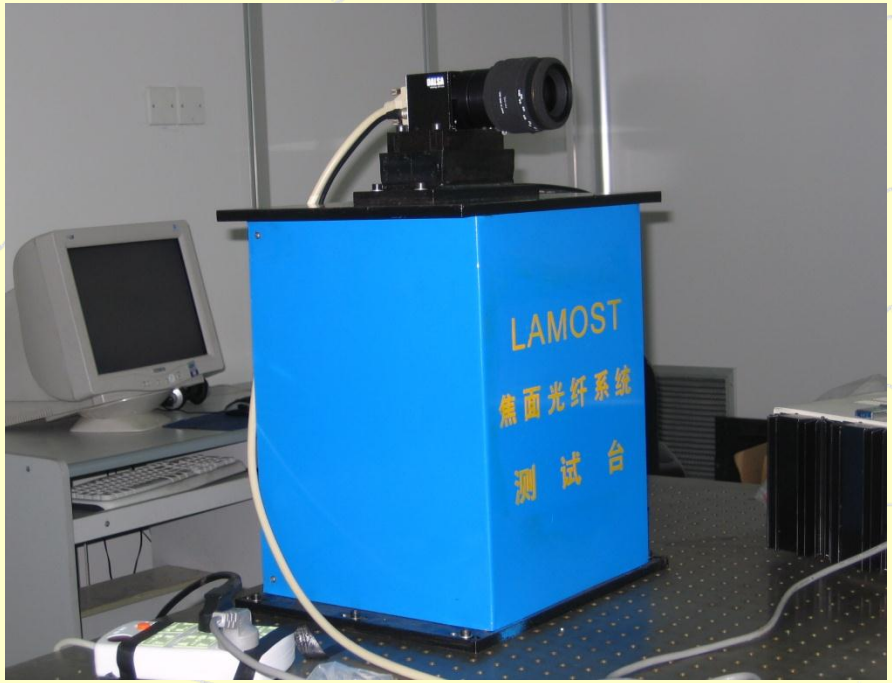
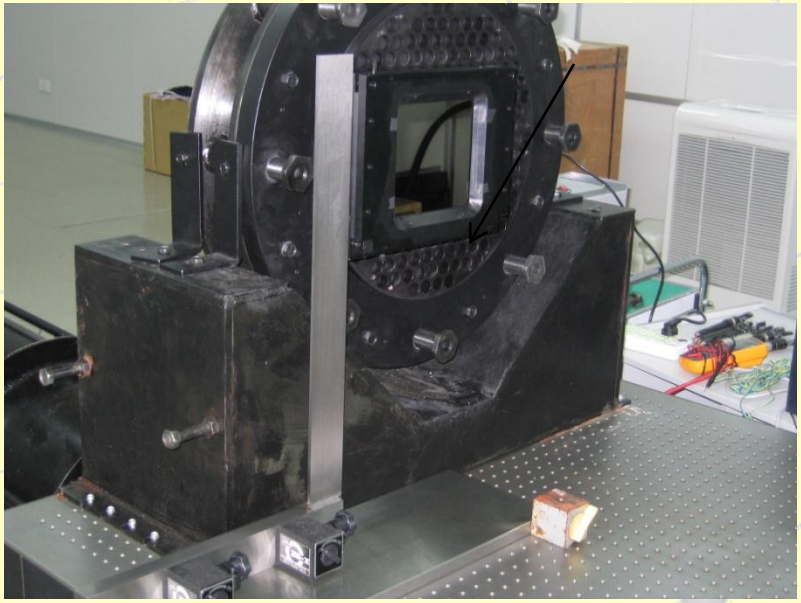
Measurement and testing







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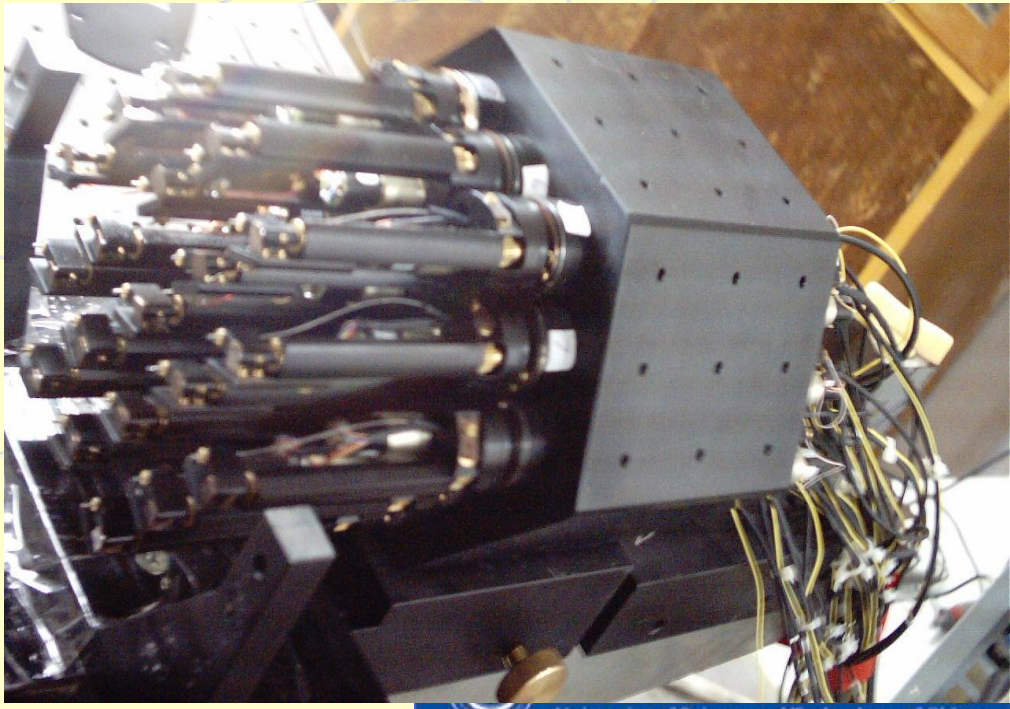
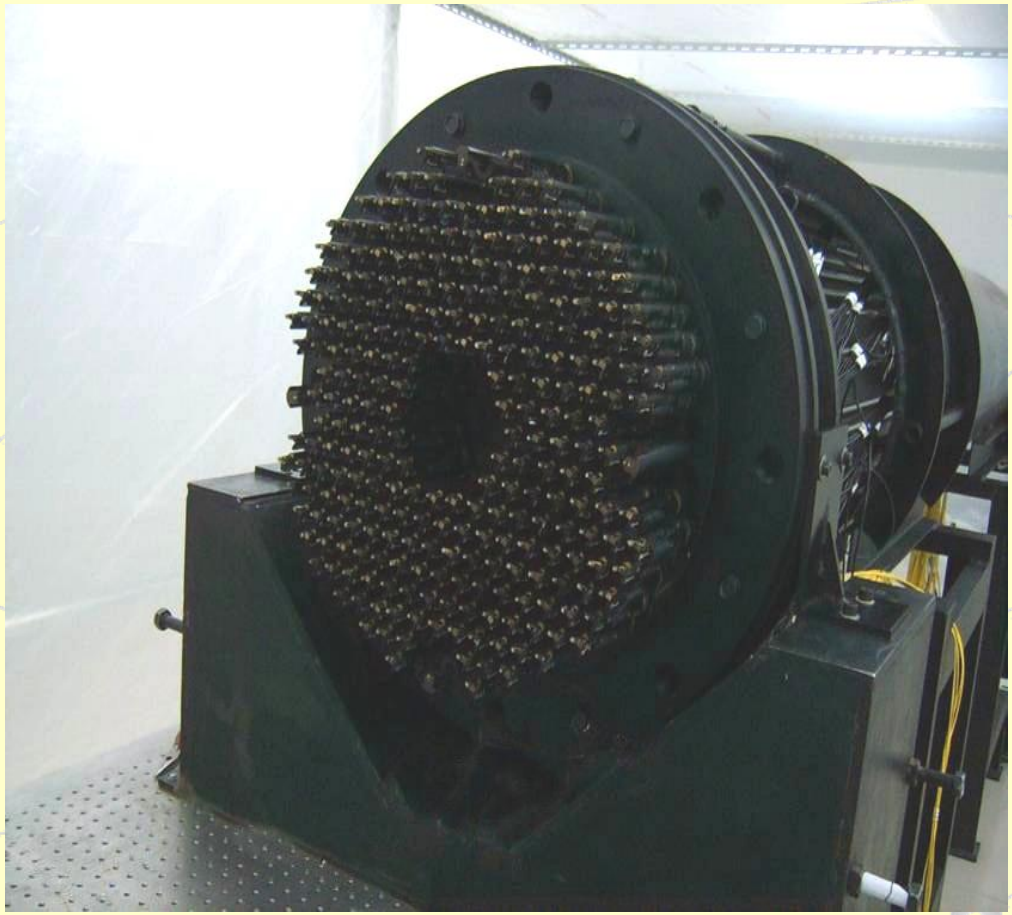
Progress of Fiber positioner in LAMOST

- 2000, single fiber positioner successful at Univ. of Sci. & Tech. of China
- 2003, Oct.,19-Fiber-positioner successful at USTC



Progress of Fiber positioner in LAMOST

- January 2005,fiber positioner system began
- Auguest 2006 ,small system with 256 positioner finished and assembled at Xinglong



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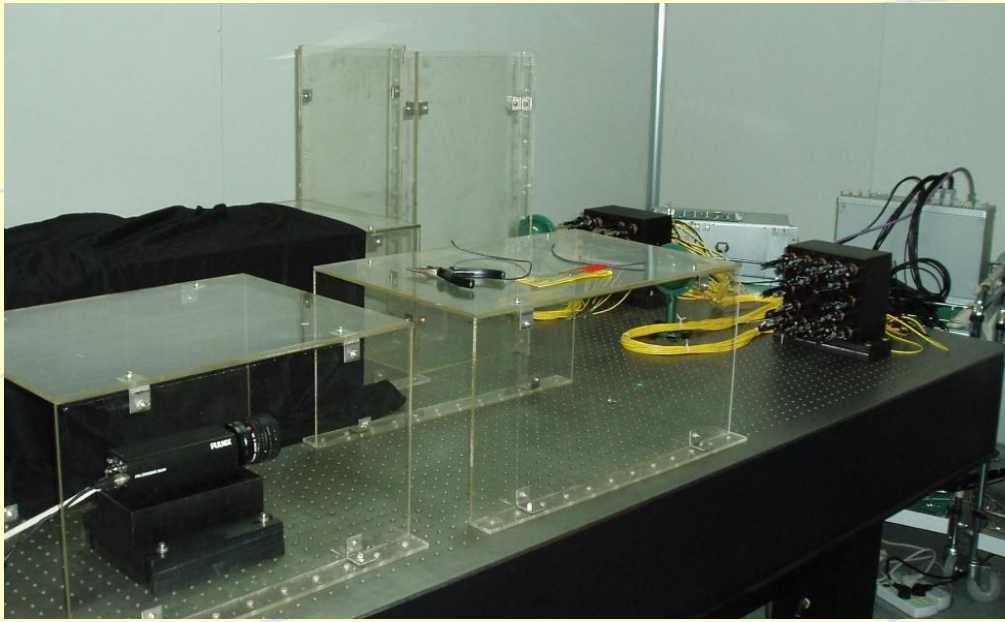
Progress of Fiber positioner in LAMOST

Running in factory



Calibration of positioner in lab

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Progress of Fiber positioner in LAMOST

Focal plate in factory

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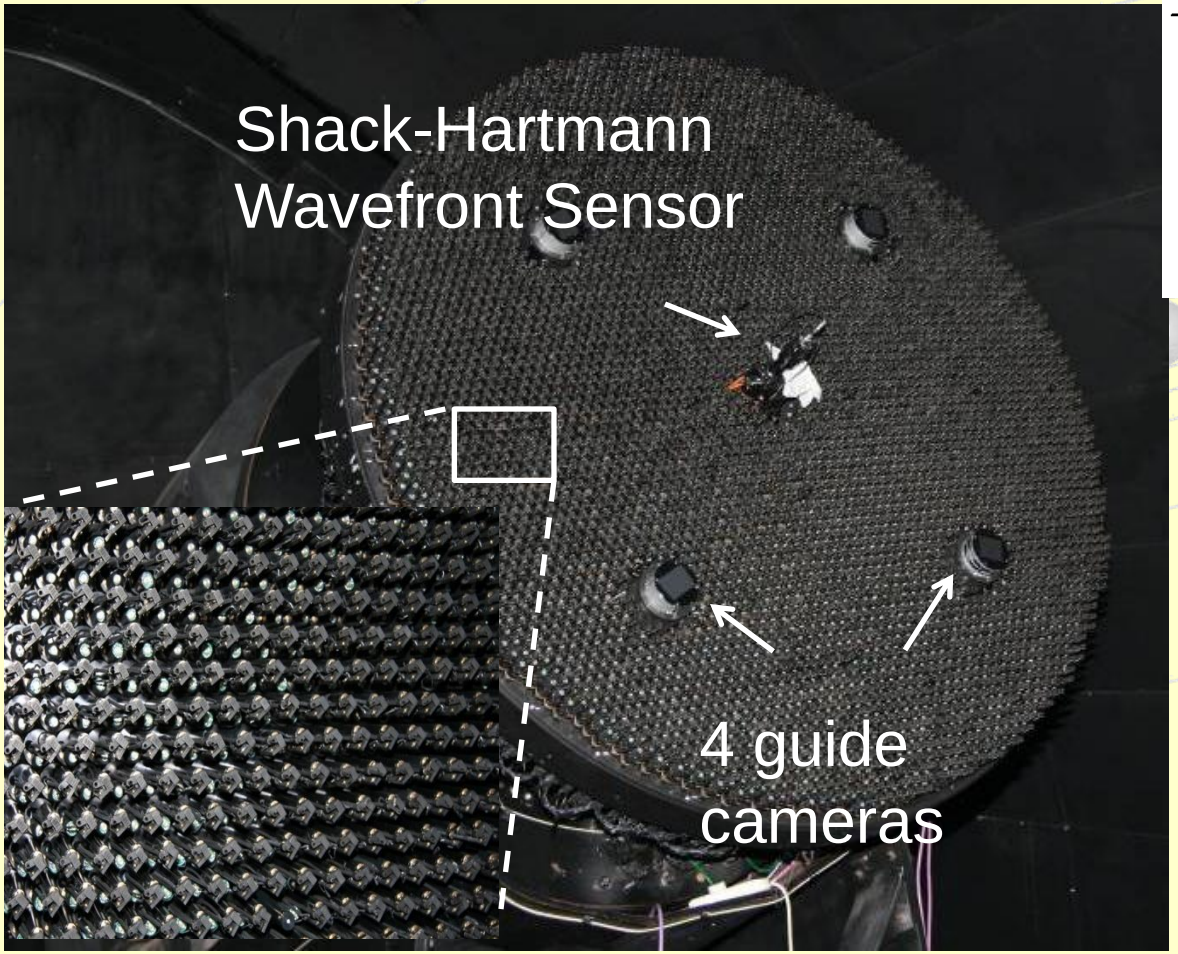
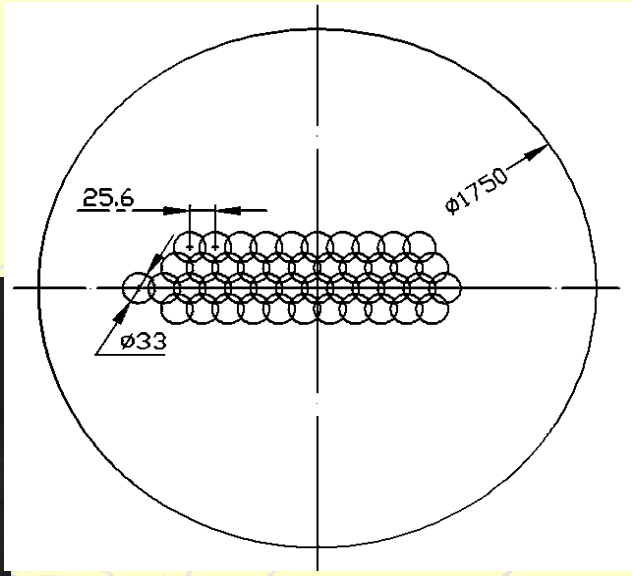
LAMOST 4000 fiber positioning units on a curved focal plane





Distributive parallel-controllable optical fiber positioning system (DPFP)

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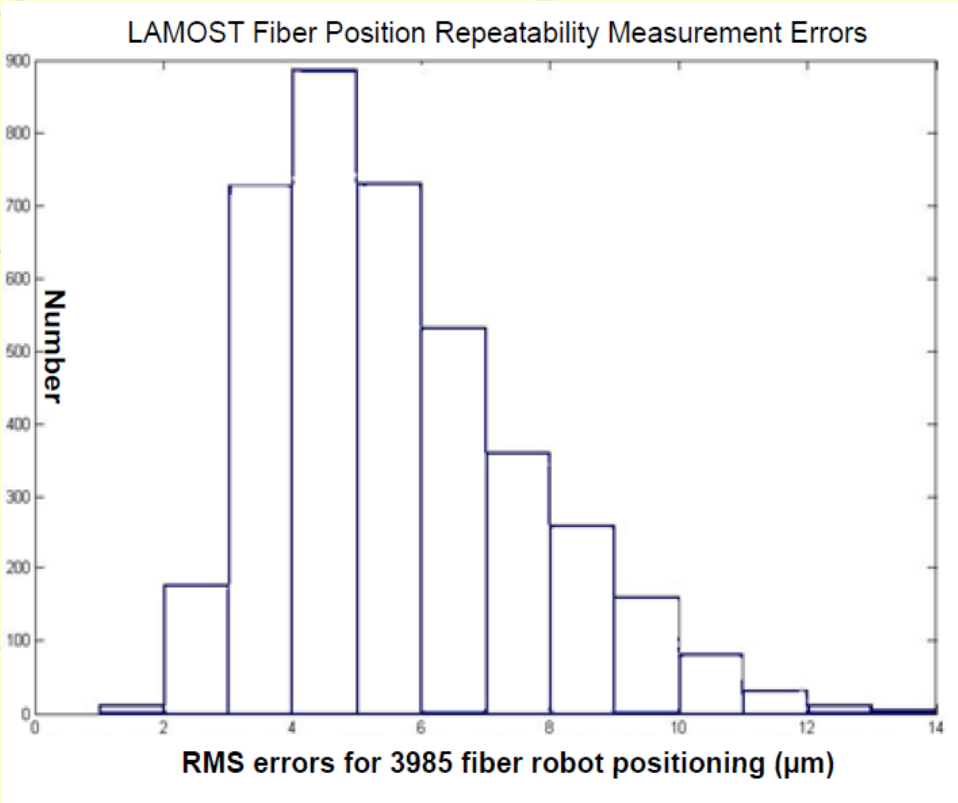
LAMOST fiber positioning accuracy

<8 μm repeatability error



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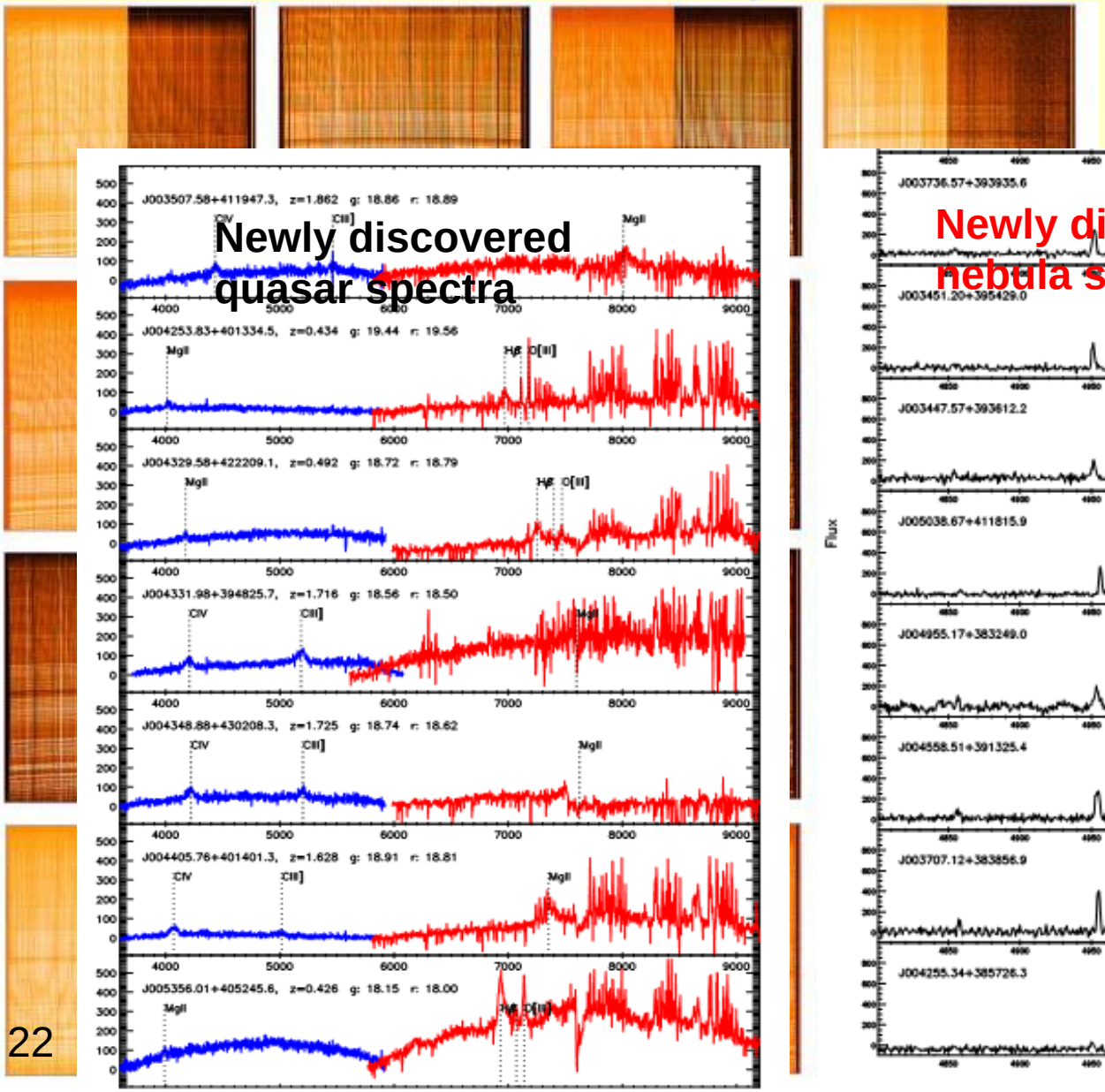
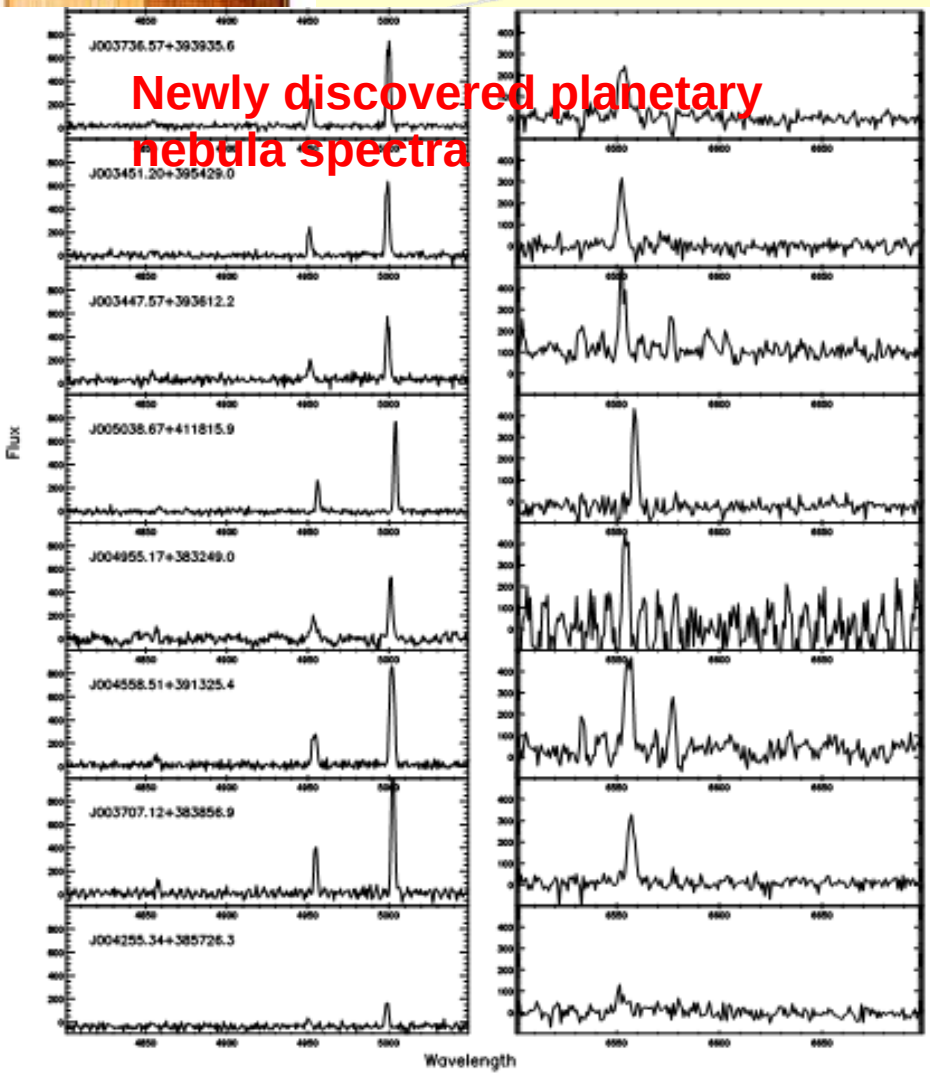
LAMOST spectra from M31 field, Oct. 26, 2009





Past development time for LAMOST 4000 fiber positioning system excluding R&D

PDR+CDR:60 days

Fabrication, construction and integration: 364 Days

Testing and calibration :93 days

(Total development time:517 days)

Operation and maintenance issues:

- **During the operation of LAMOST fiber positioner in 2008-2010, the fiber unit failure rate < 0.5% per year**
- **The failed unit is largely due to the wireless card failure, replacing wireless card is a easy to do in day time maintenance job.**

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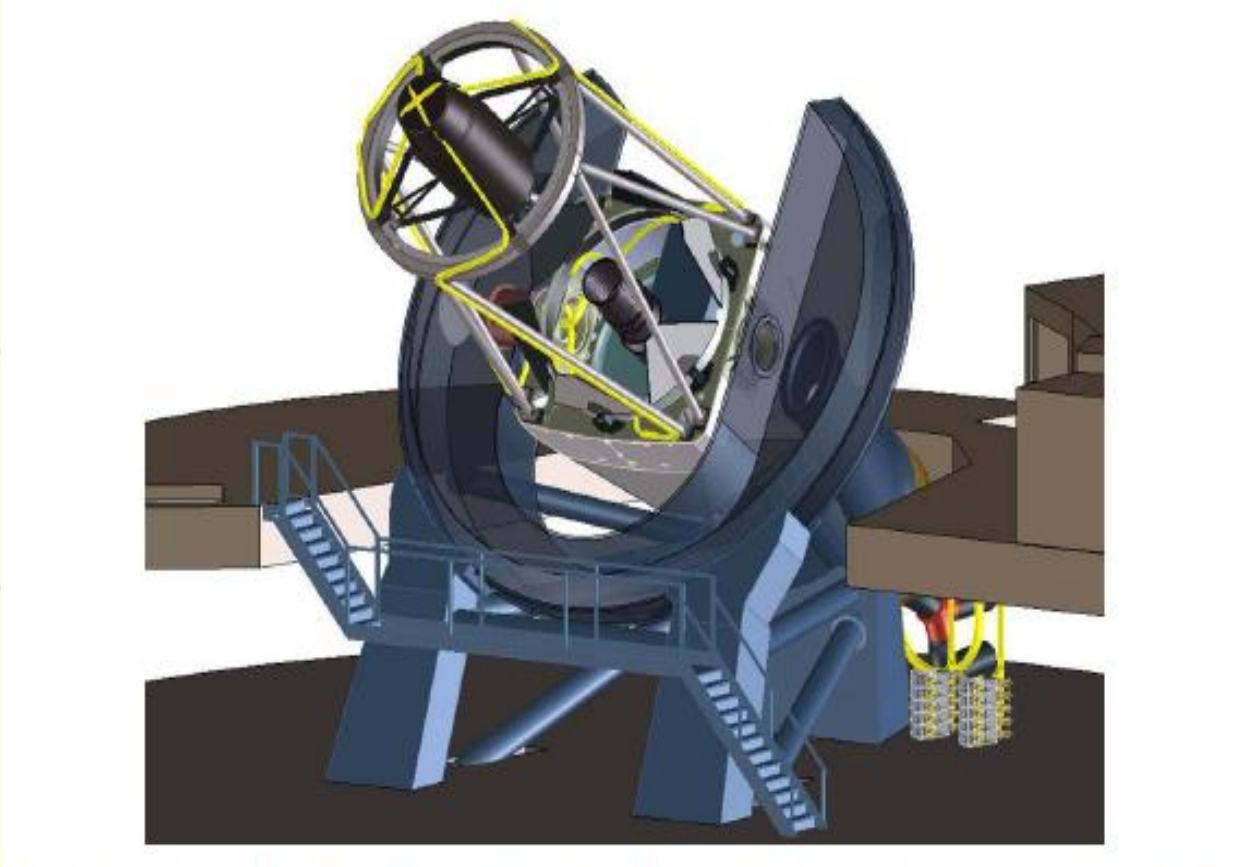
Progress of fiber positioner for BigBOSS



The BigBOSS instrument installed at the Mayall 4-m telescope. A new corrector lens assembly and robotic positioner and fiber optic focal plane are mounted at the prime focus. The spectrographs are adjacent to the telescope base at the end of the fiber runs.

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The main difference between fiber positioner systems of LAMOST and BigBOSS

- Size of positioner: 25.6mm—12mm
- Size and style of focal plate:

  Φ1.75m and spherical surface—Φ1m and plain surface.
- Number of positioner: 4000--5000

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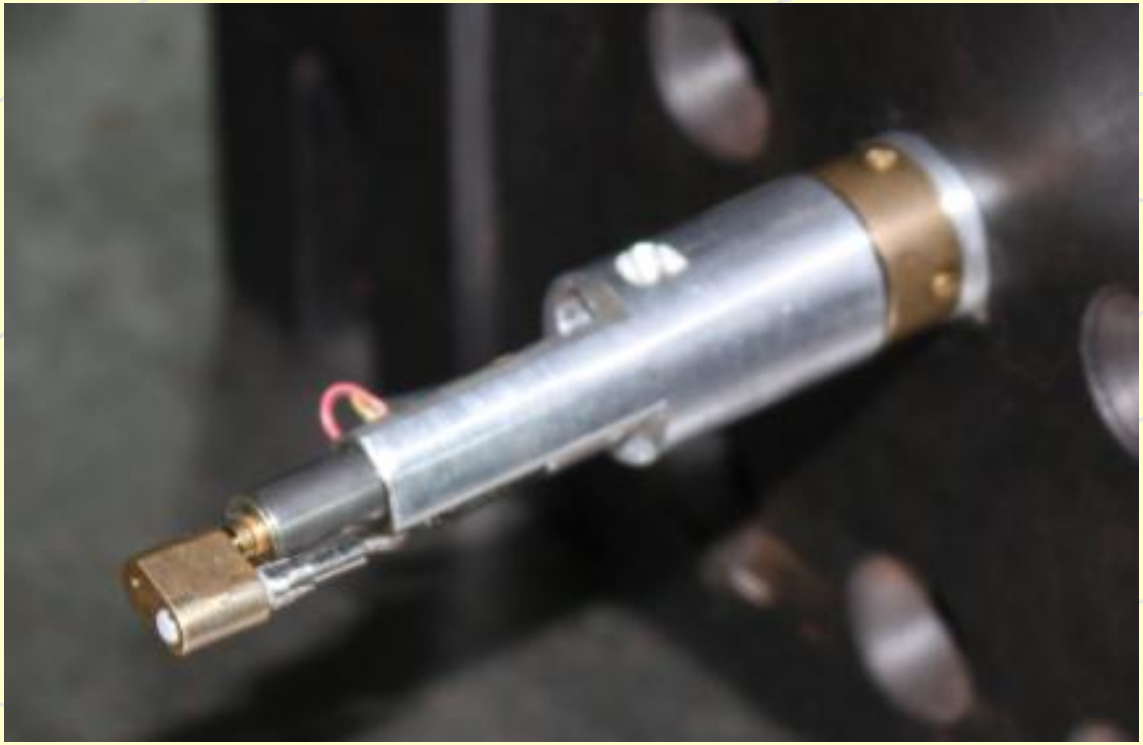
Progress of fiber positioner for Bigboss—15mm positioner



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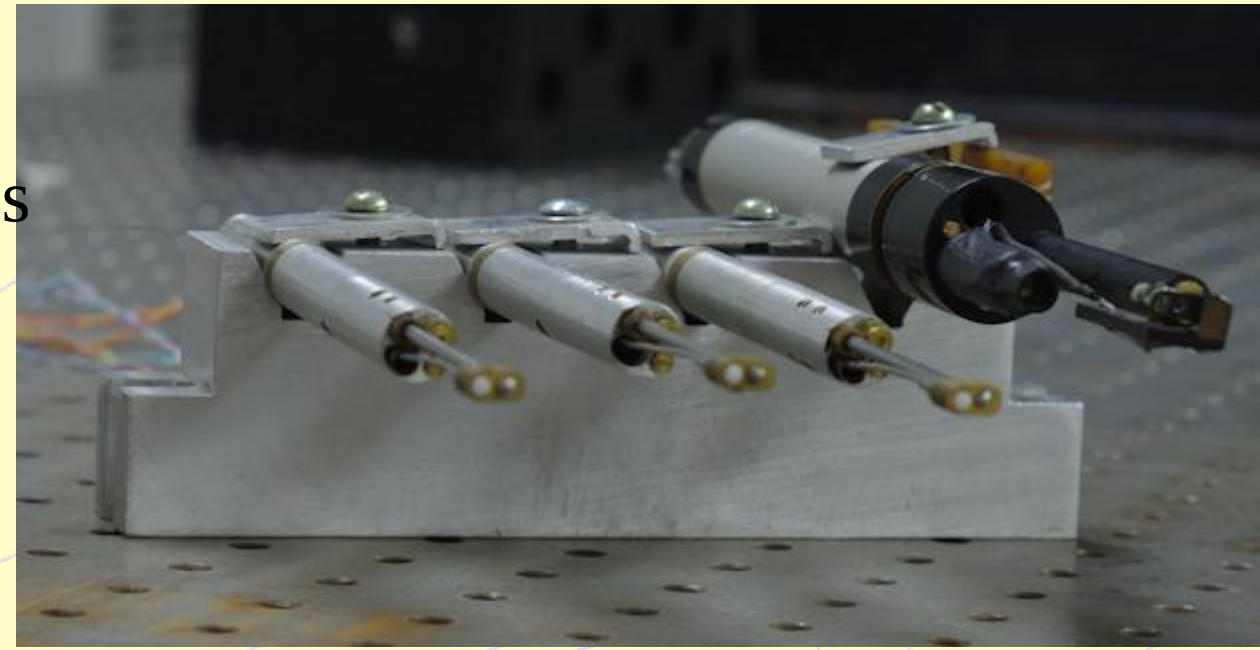
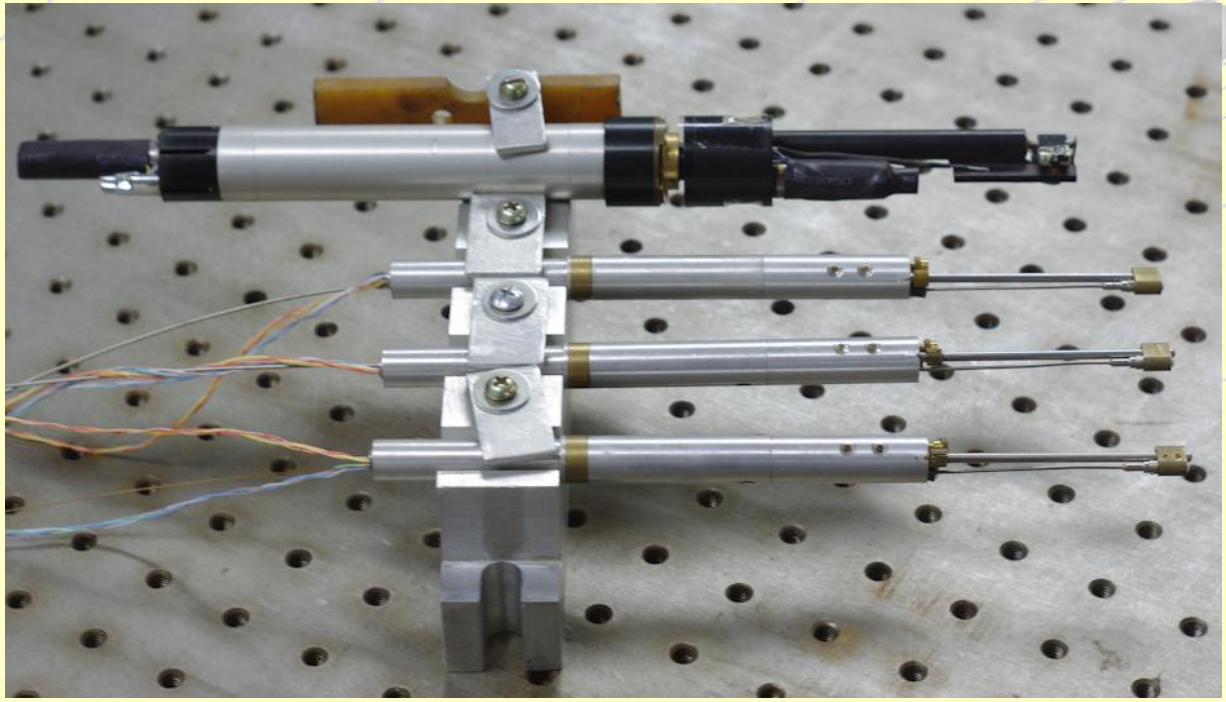
Progress of fiber positioner for Bigboss —12mm positioner





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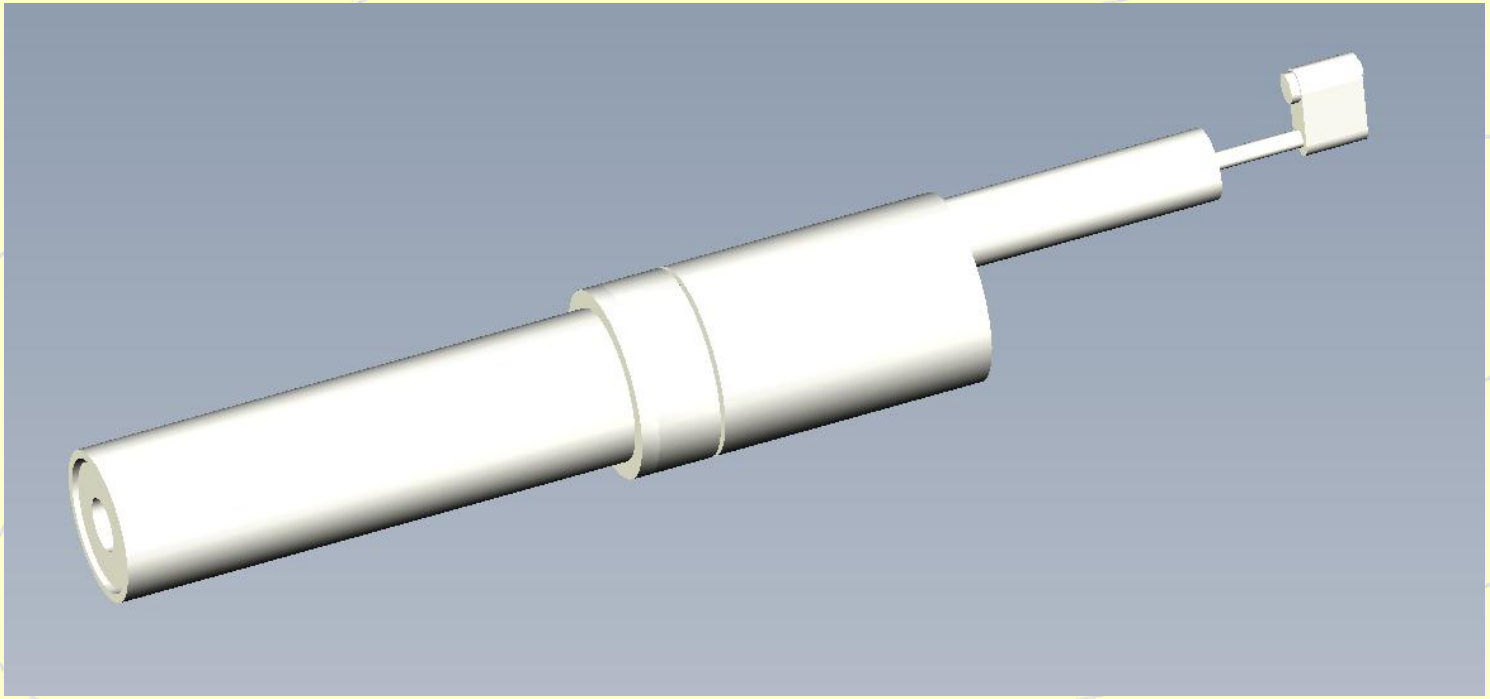
Structurer of the 12mm positioner



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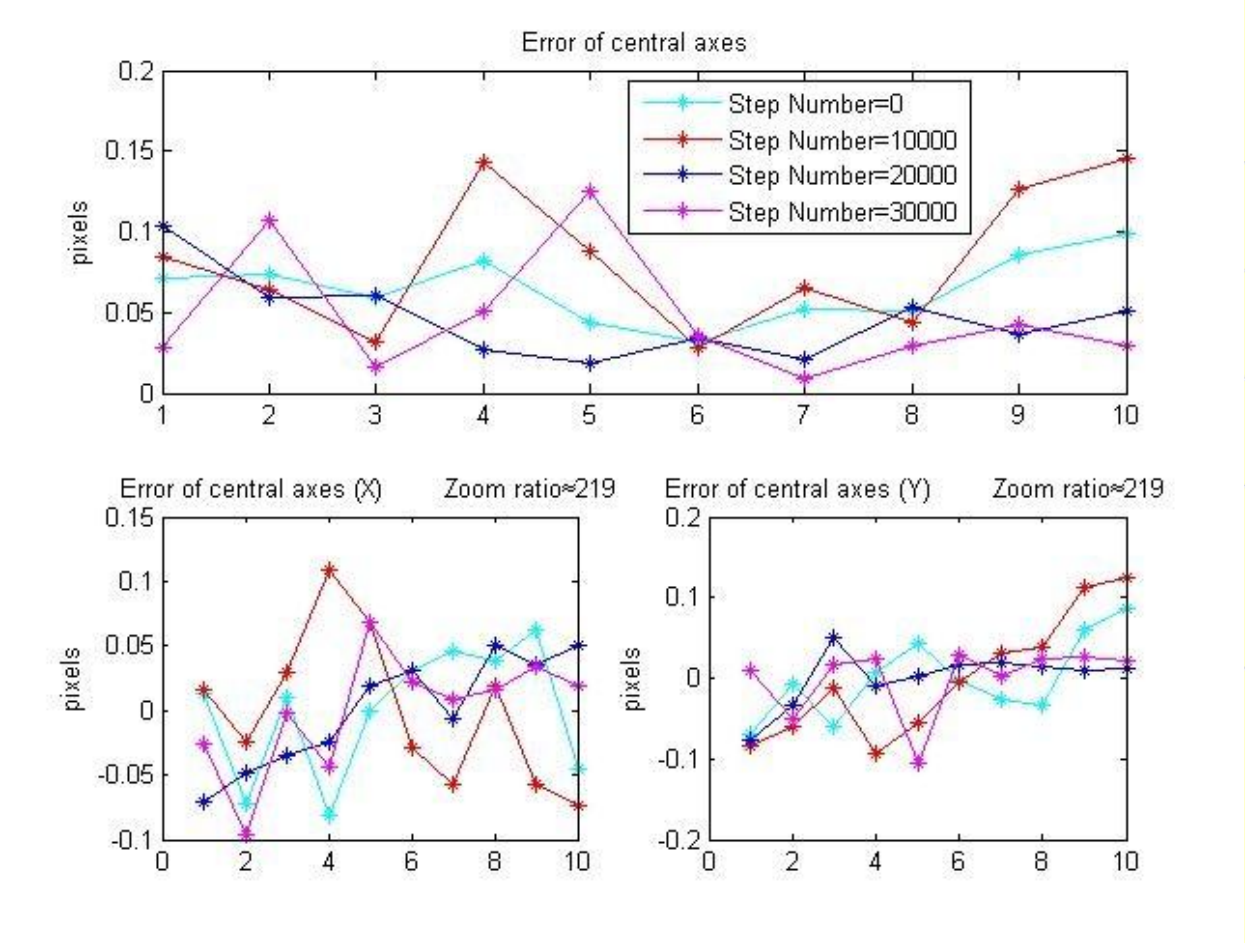
Progress of fiber positioner for Bigboss—Precision



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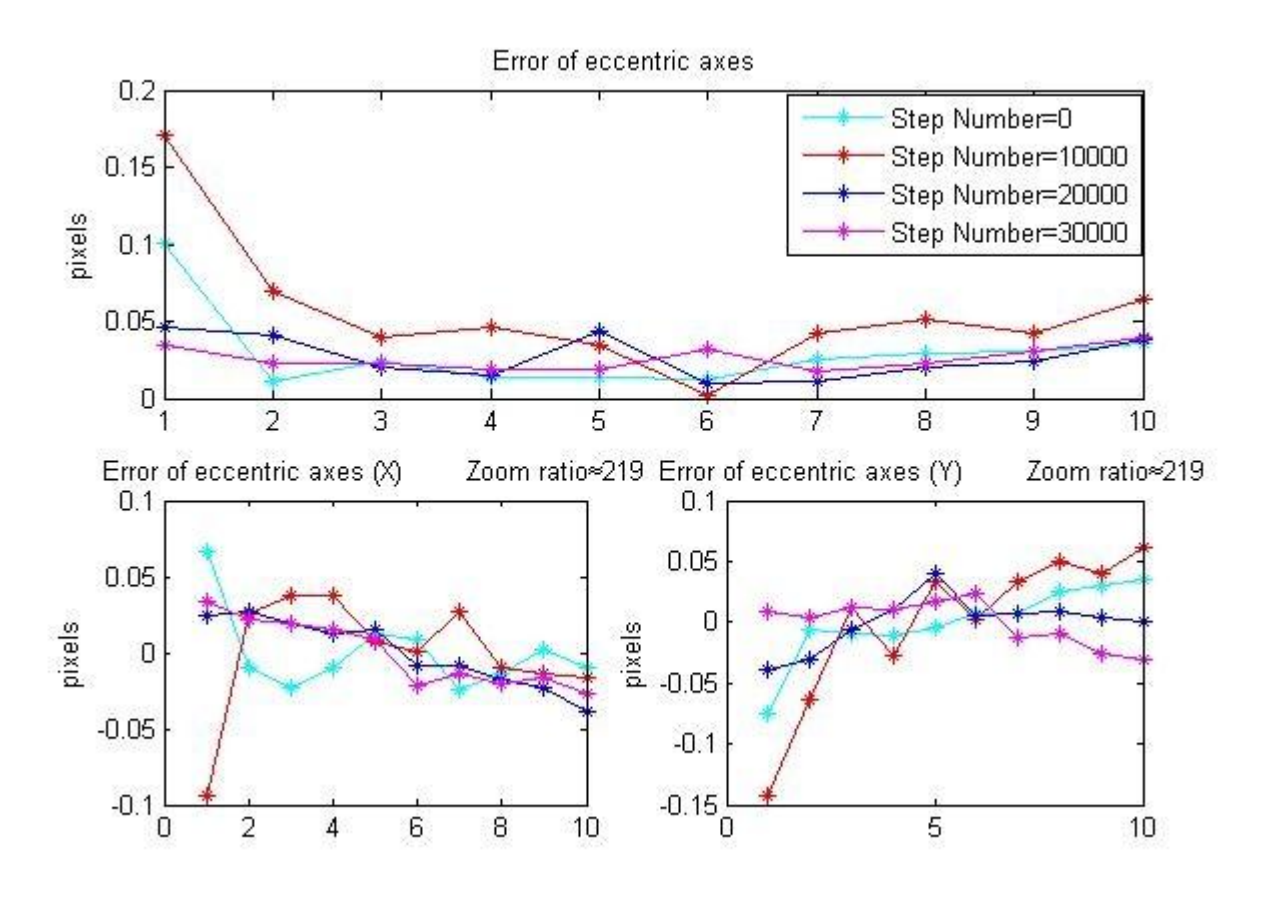
Progress of fiber positioner for Bigboss—Precision



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Summary

- **LAMOST 4000 fiber positioner system has helped to deliver early science with the LAMOST commissioning observations.**

- **LAMOST fiber system is quite reliable and easy to maintain.**

- **Funds are available to work for BigBOSS on positioner designing and prototyping immediately to help to move fabrication and construction time ahead of schedule to reduce the project schedule risk!**

Thank you for
your attention!