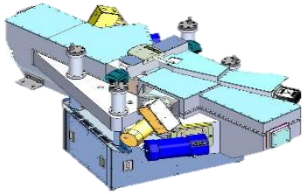
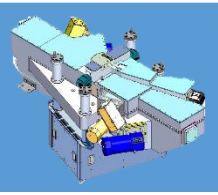


The current status of the Next Generation Palomar Spectrograph(NGPS) for Hale Telescope

报告人：季杭馨(hxji@niaot.ac.cn)
中国科学院南京天文光学技术研究所

2023.11.20-23



目 录

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Nanjing Institute of Astronomical Optics & Technology，CAS

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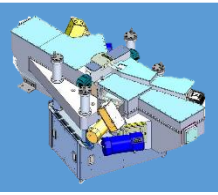
- ✓NGPS方案介绍

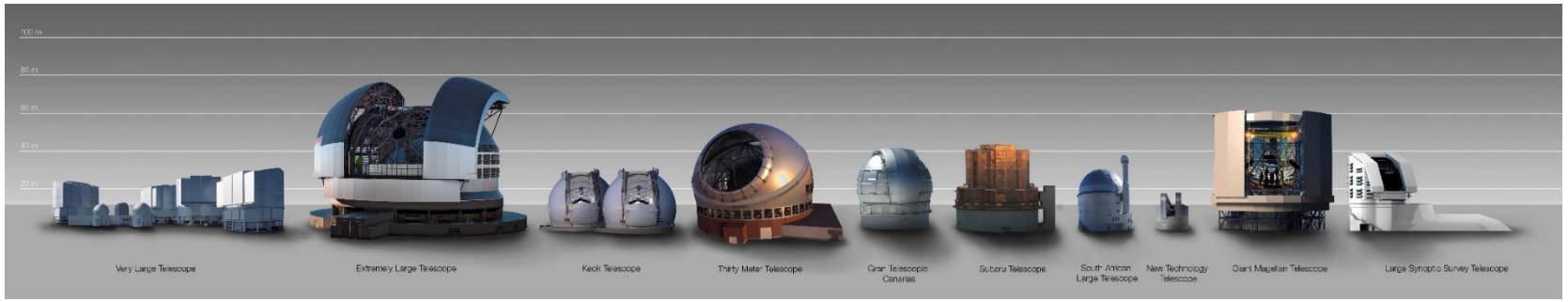


NGPS项目背景

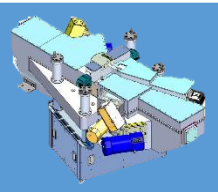
中国科学院南京天文光学技术研究所
Nanjing Institute of Astronomical Optics & Technology，CAS

✓天文学是观测驱动的科学

- 国际4-10米级中大型望远镜是目前主流研究成果最重要的来源



- 国内，只有2米级的精测光学望远镜，迫切需要中大型望远镜上的宽波段、高通量的光学光谱仪，开展对更多更暗目标的光学观测
- 国际，多个地基和空间大视场巡天项目的建设完成，需要大批量的光谱后随观测需求（iPTF，ZTF等等）



NGPS项目背景

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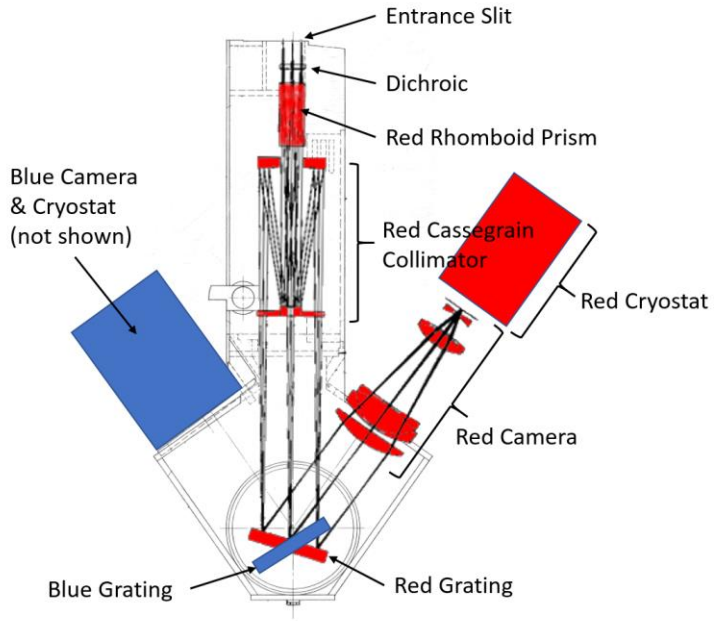
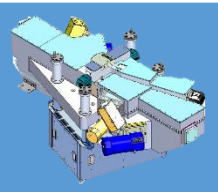
- ✓ **Palomar Double Spectrograph, DBSP**
- ✓ **Commission： 1982~至今**
  - ➢ Peak efficiency is about 15%
  - ➢ Two Channel & Resolution Mode exchange by manual
  - ➢ The operation efficiency is limited





NGPS项目背景

中国科学院南京天文光学技术研究所
Nanjing Institute of Astronomical Optics & Technology，CAS

✓科学需求

#	Project	Wavelength Range (nm)	Resolving Power (R)	Example Program
1	Transient follow-up	350-1050	1000	Classification of supernovae
2	Gaia follow-up	350-1050	2000-5000	Measure radial velocities of RR Lyrae with Gaia distances
3	Nebular line diagnostics of galaxies	350-1050	2000-5000	Measure strengths and profiles of nebular emission lines in nearby to moderate-redshift galaxies to diagnose the excitation, metallicity, extinction, and kinematics of ionized gas in galaxies Measure redshifts of Lyα emitters in the redshift range $1.9 < z < 7.6$
4	General stellar classification	350-1050	2000-5000	Measure strengths of emission lines or spectrophotometric indices in order to measure stellar temperatures, surface gravities, and abundances
5	Stellar diagnostics of galaxies			Stellar population and kinematics of bulges
6	Solar system objects	700-1050	1000-2000	Composition of asteroids
7	Cataclysmic variables	650-900	3000-5000	Magnetic field strength and mass ratio of AM CVn systems
8	Late-type dwarf stars	800-1050	~5000	Spectrally type brown dwarfs
9	IMF in elliptical galaxies	400-1050	3000-5000	Identify ratio of dwarfs to giants from the Na I doublet and the Wing-Ford FeH band

Table 2. Science capability summary for NGPS. Each line of this table represents a potential science program enabled by NGPS.

NGPS研制要求

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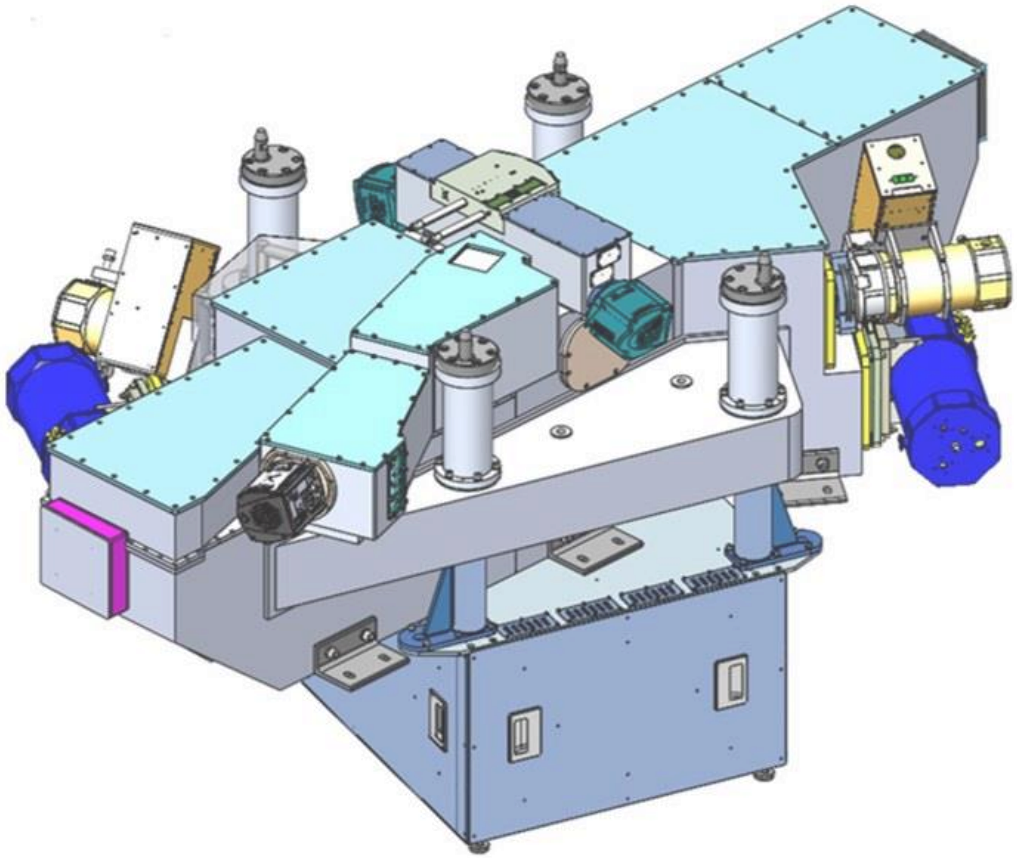
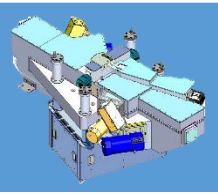
- ✓ 导星视场：2.5’ x 2.5’ (3’ x 3’ goal)
- ✓ 光谱仪视场：180×10 arcsec
- ✓ 工作波段：
  - U: 310-436nm
  - G: 417-590nm
  - R: 561-794nm
  - I: 756-1040nm
- ✓ 仪器效率：>65% (无狭缝损失)
- ✓ 光谱分辨率：R>1800 @ 0.5”, 最大可实现R>4500
- ✓ 采样大小：~2.7 pixels @ 0.5”
- ✓ 像质要求：
  - U≤0.3”;
  - G, R, I≤0.25”
- ✓ 工作温度：-10℃~30℃
- ✓ 需具备自动调焦功能和主动柔性补偿功能



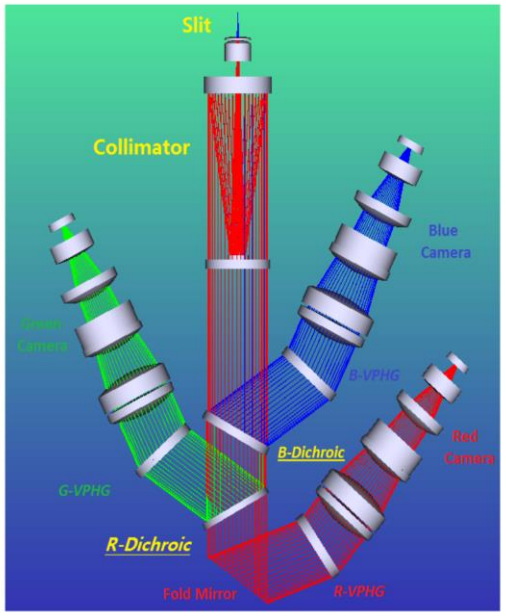


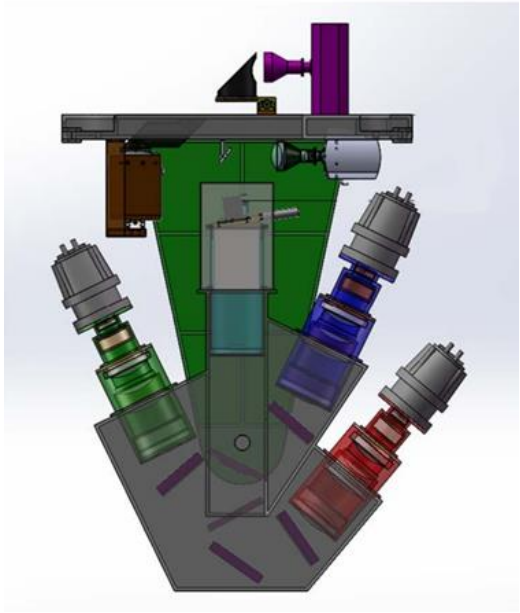
NGPS关键节点

中国科学院南京天文光学技术研究所
Nanjing Institute of Astronomical Optics & Technology，CAS

✓ Next Generation Palomar Spectrograph, NGPS

- 2015.1, NGPS 科学需求与仪器需求
- 2016.1, NIAOT 赴 P200讨论仪器接口
- 2016.6, NIAOT完成NGPS的概念设计
- 2016.11，与北大签署“新一代多功能光学光谱仪的研制”
- 2017.1, NGPS三通道初步设计评审





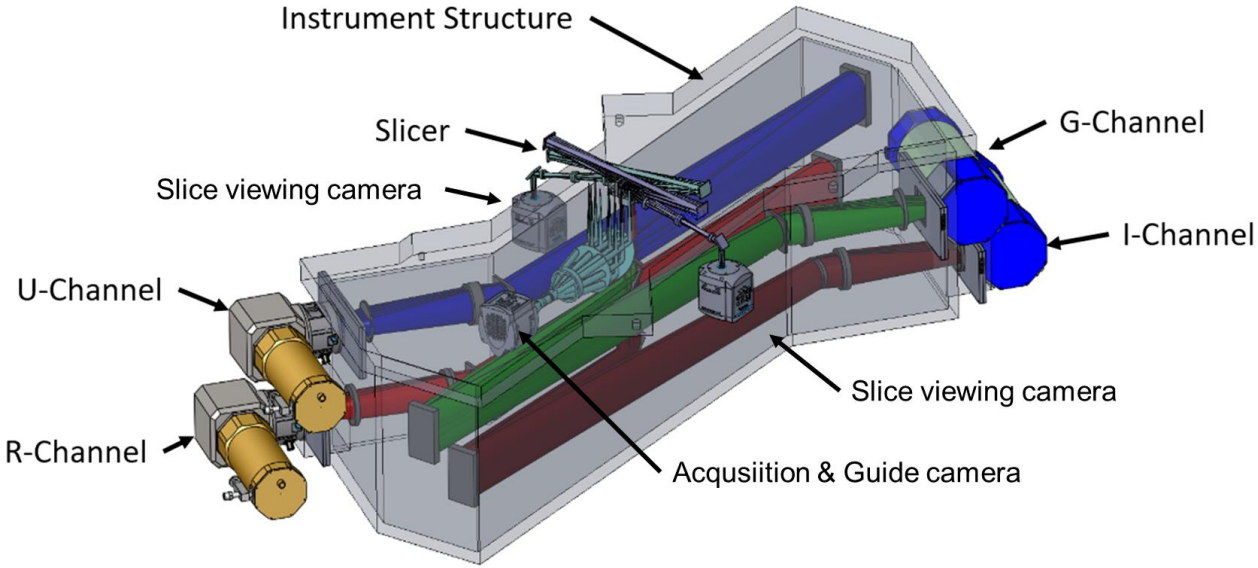
- R=370-1000nm
- R=1800@1.5”狭缝
- 峰值效率~35%
- 共用准直系统
- 准直口径150mm
- 7片透射式相机系统

NGPS关键节点

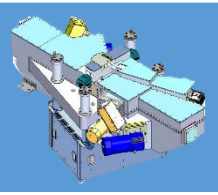
中国科学院南京天文光学技术研究所
Nanjing Institute of Astronomical Optics & Technology, CAS

✓ Next Generation Palomar Spectrograph, NGPS

- 2017.10, PKU、NAOC和CIT 签订MoU
- 2018.5, CIT技术团队加入
- 2019.2, PKU & NIAOT联合申请国家重大科研仪器研制项目
- 2019.5, CIT&NIAOT讨论四通道设计方案的可行性
- 2020~, NGPS正式改为四通道设计



- R=310-1040nm
- R=1800@0.5”狭缝
- 峰值效率~45%
- 可调整狭缝
- 独立的准直系统
- 准直口径~100mm
- 3切分像切分器



NGPS关键节点

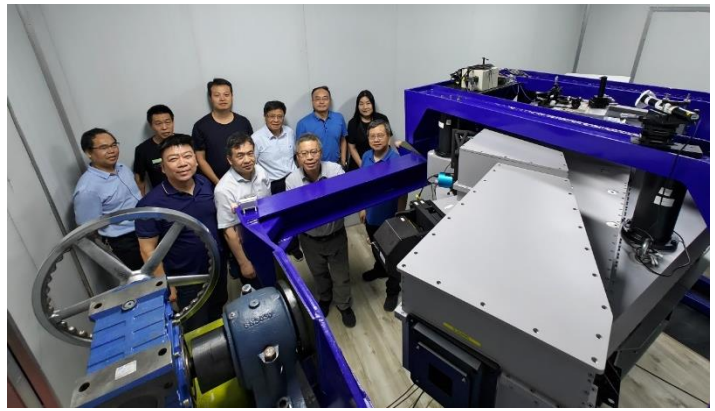
中国科学院南京天文光学技术研究所
Nanjing Institute of Astronomical Optics & Technology，CAS

✓ Next Generation Palomar Spectrograph, NGPS

➢ NGPS详细设计

- 2021.8， GRI通道光学设计MRR
- 2021.10, U通道光学设计MRR（透射式相机改为施密特相机）
- 2022.4， A&G光学MRR
- 2022.6, UGRI通道光机系统MRR, A&G光机系统MRR
- 2022.7, STR主体框架MRR
- 2023.3, NGPS-A&G导星系统初步
- 2023.7, NGPS国际评审、国内技术测试和验收评审
- 2023.9, NGPS运到CIT进行联调测试并初光

Pre-Ship Review



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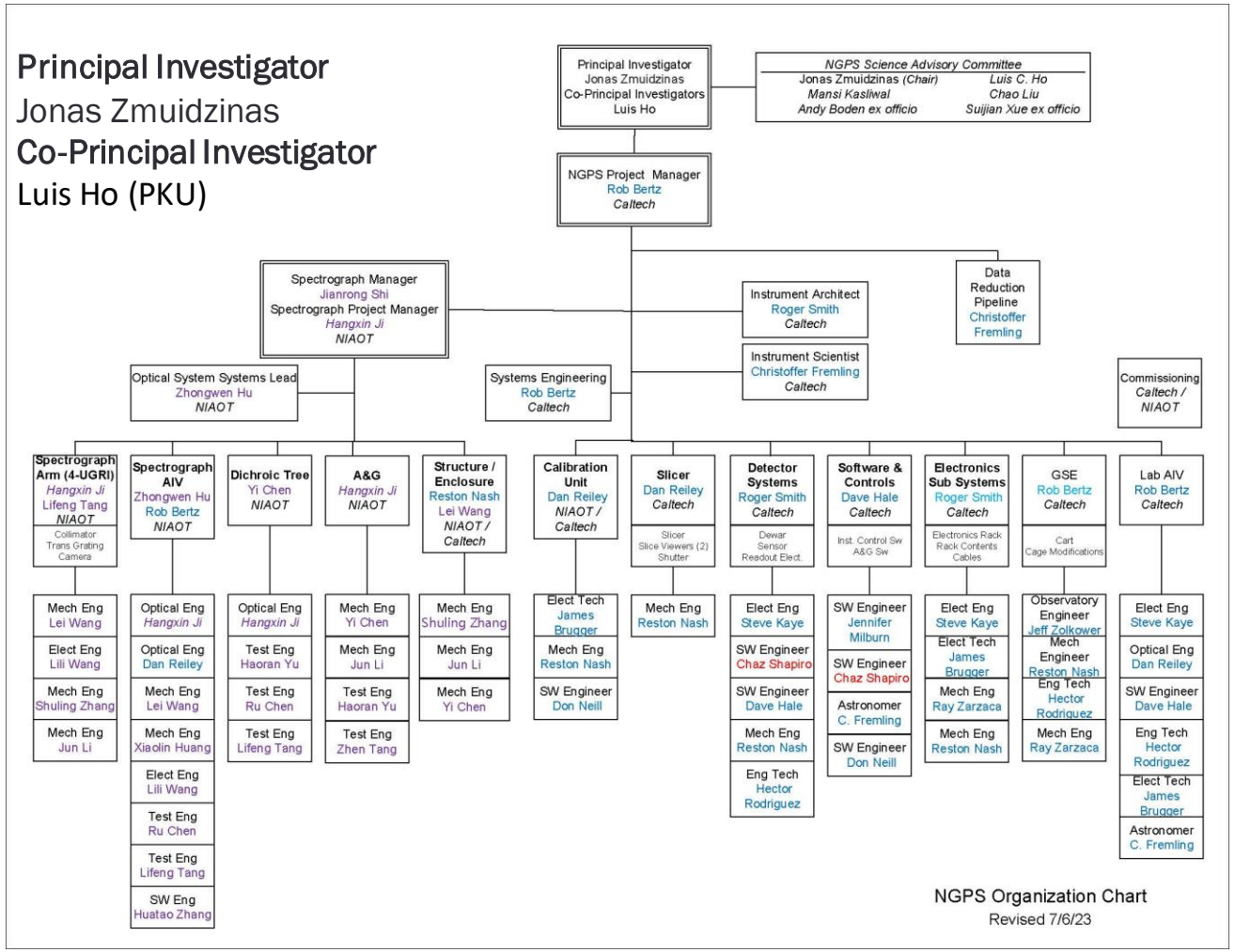
✓NGPS研制团队



技术团队

科学团队

中国科学院国家天文台
NATIONAL ASTRONOMICAL OBSERVATORIES
CHINESE ACADEMY OF SCIENCES

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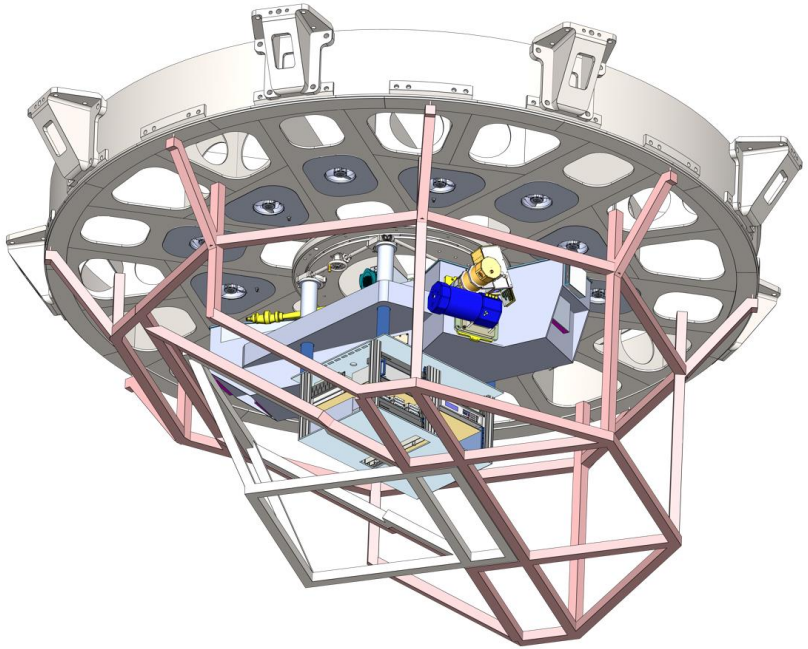
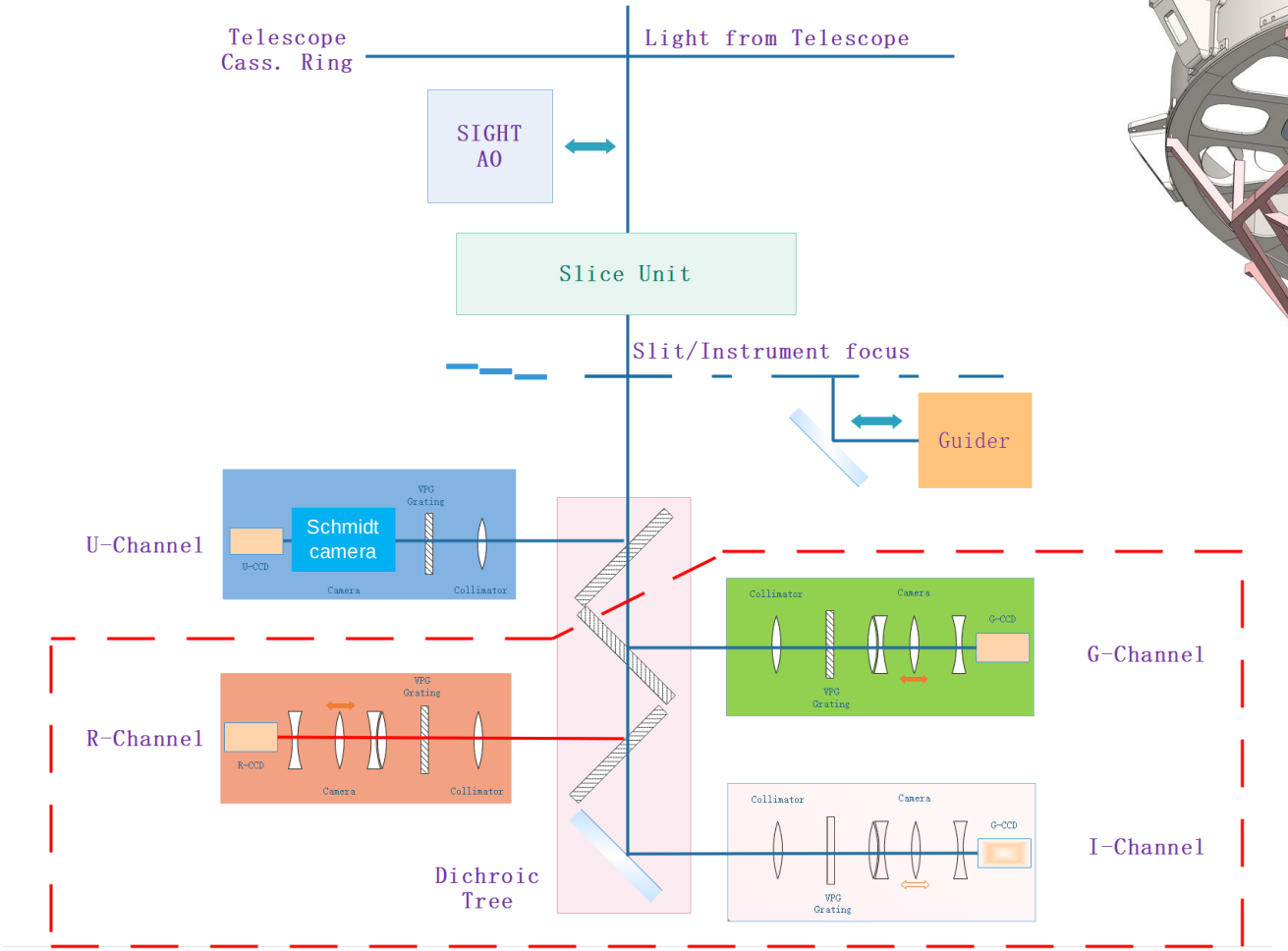
✓NGPS整体布局





NGPS方案介绍

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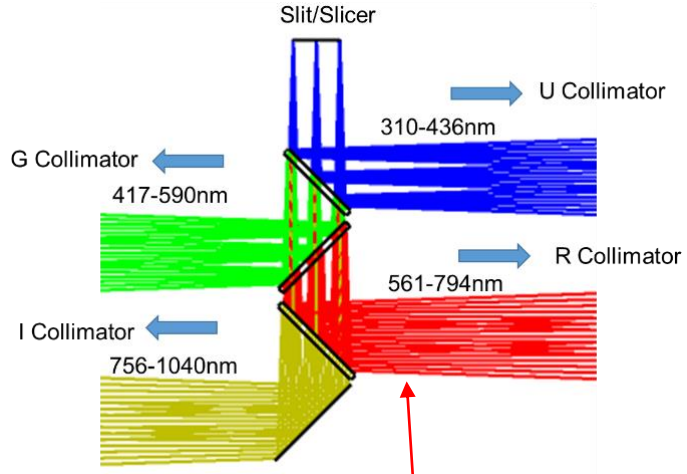
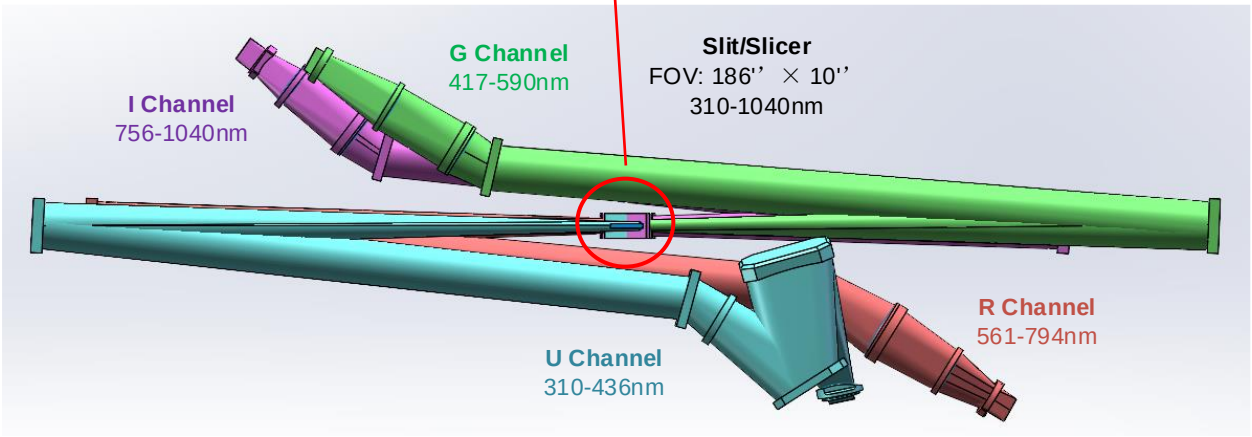
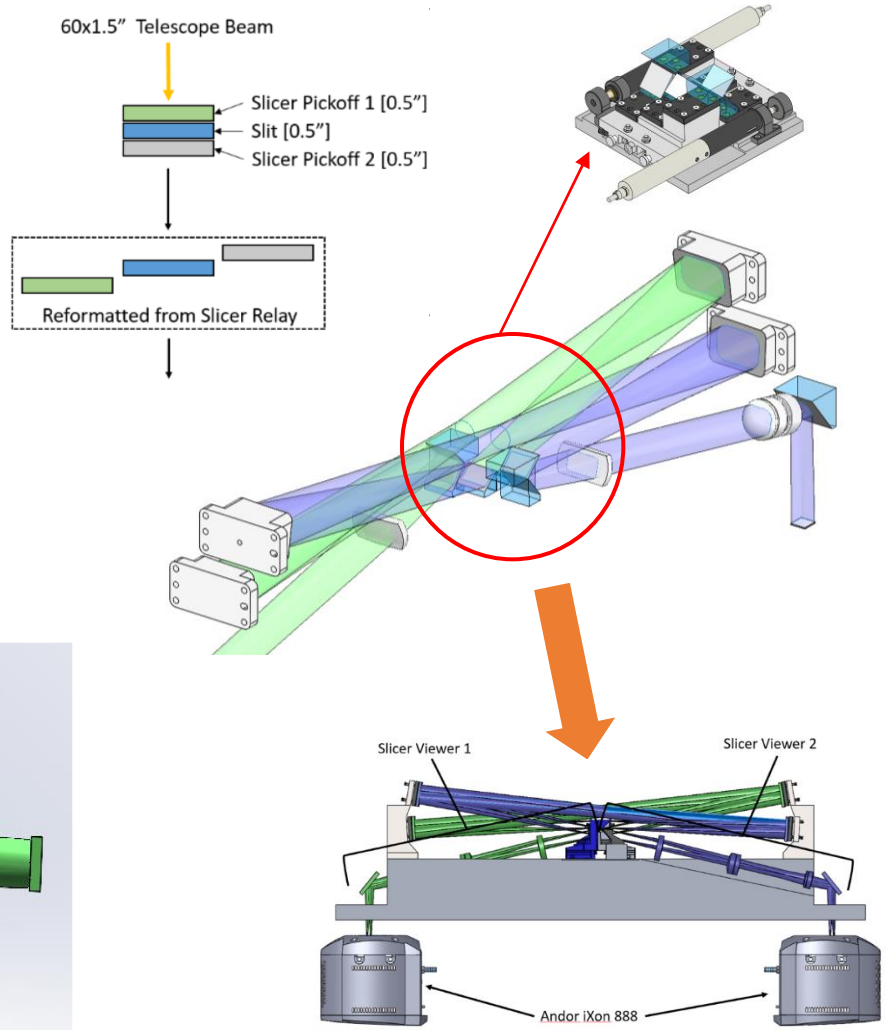
Nanjing Institute of Astronomical Optics & Technology，CAS

✓NGPS光学设计







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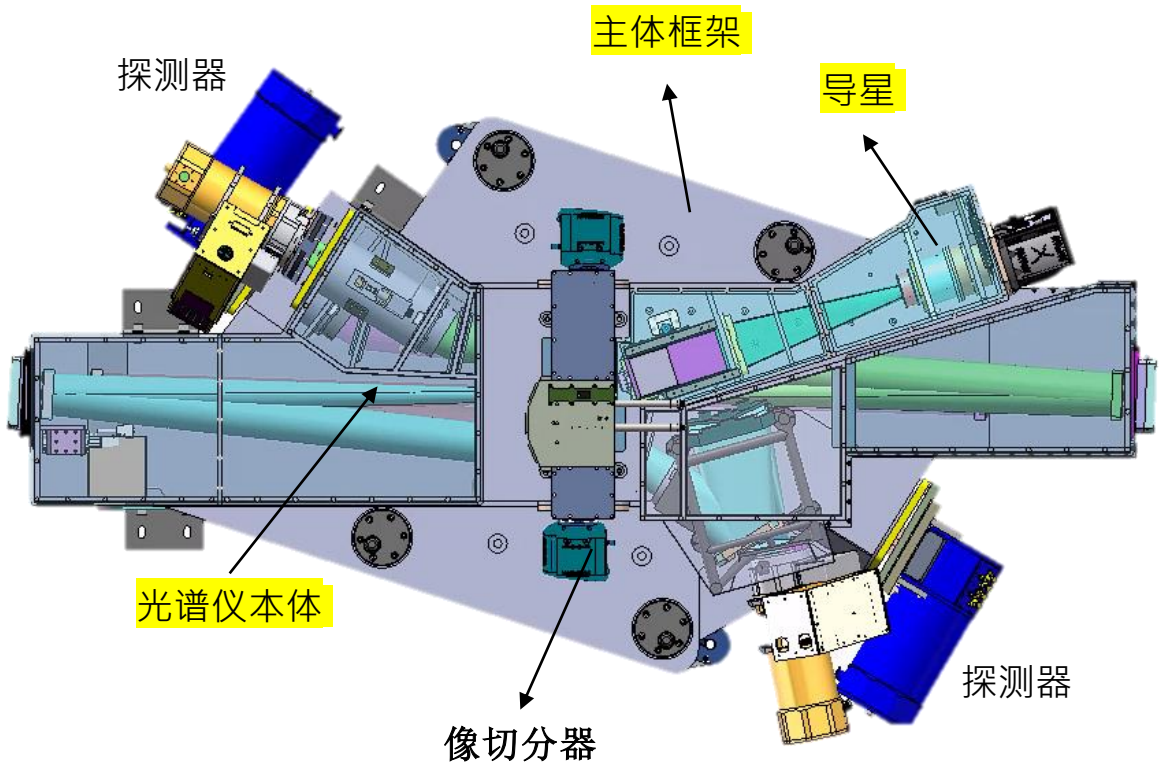
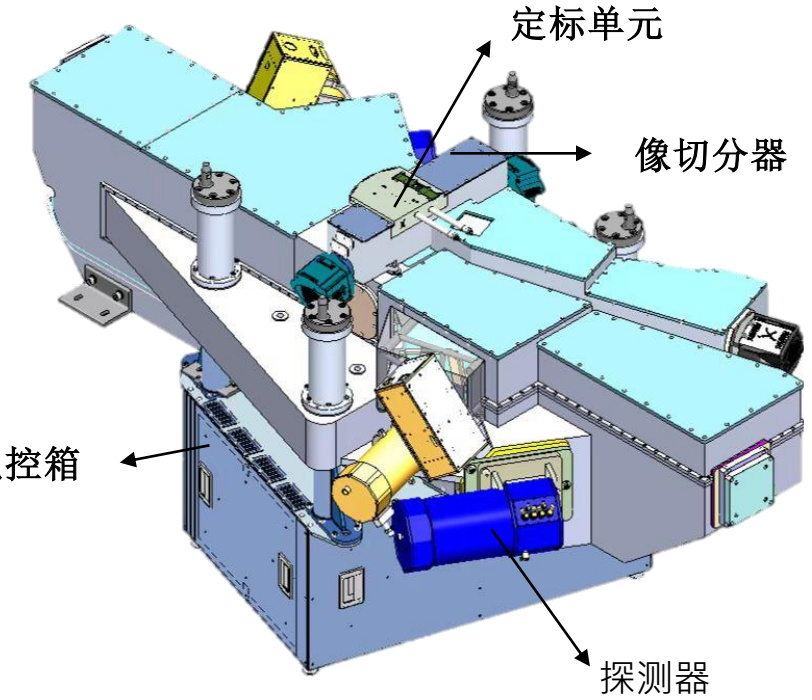
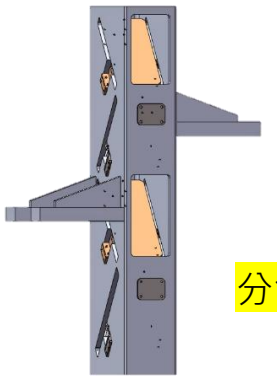
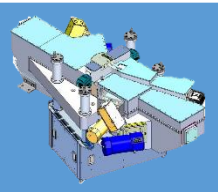
✓NGPS子系统组成









NGPS方案介绍

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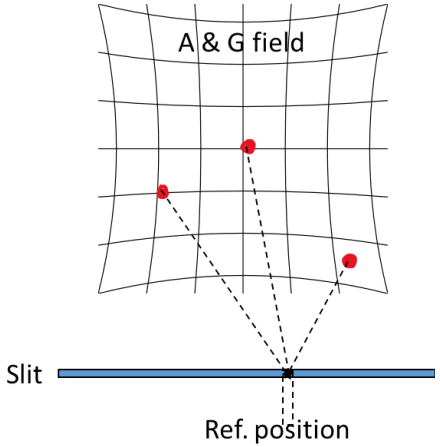
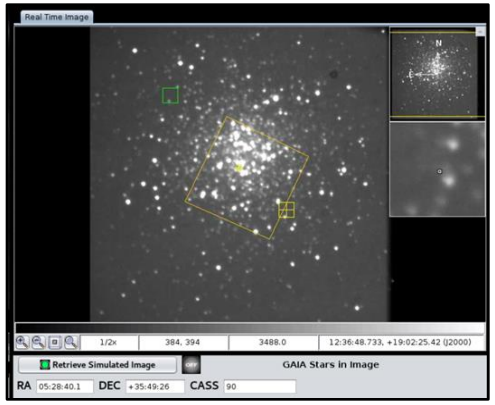
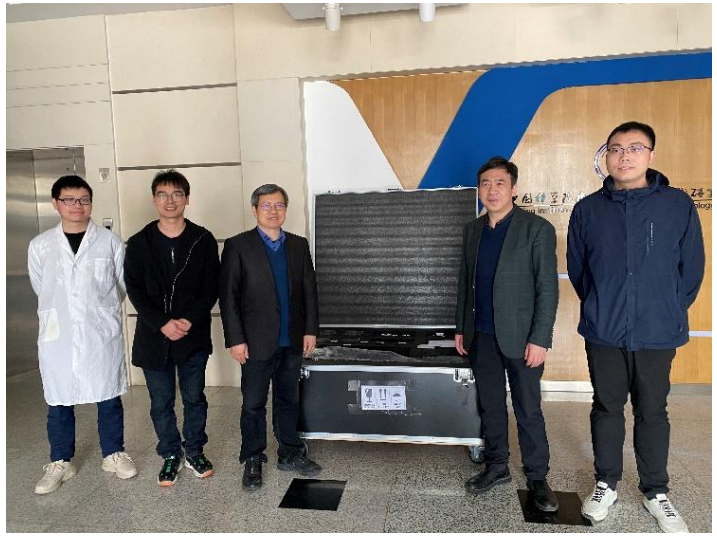
✓NGPS偏置导星(NIAOT)

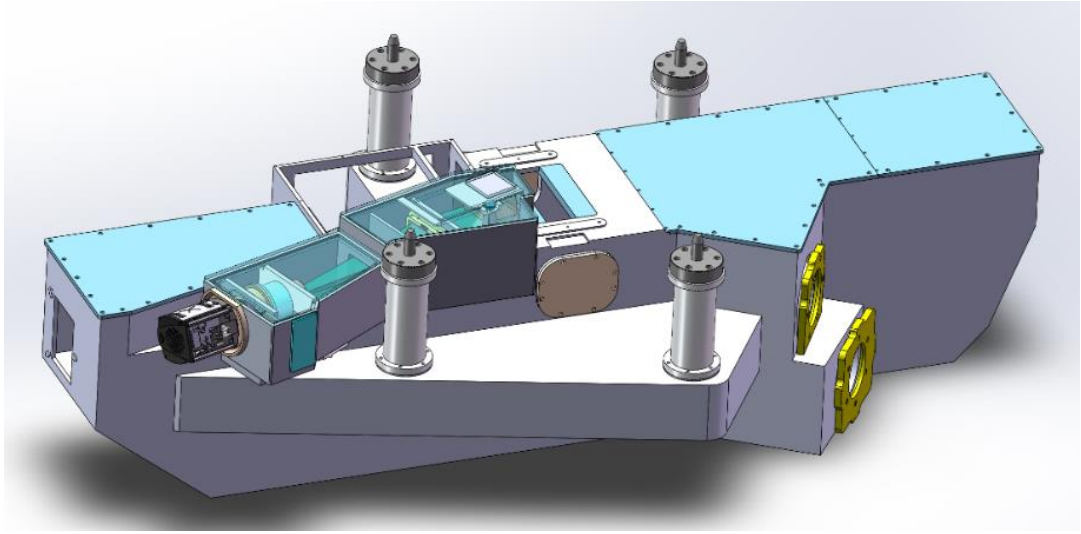
- **基本参数:**
  - 波长覆盖: 400-850nm
  - 视场: 4.35′x4.35′
  - EMCCD: 1024x1024@13um
  - 工作温度：-10℃~30℃
  - 具备测光功能

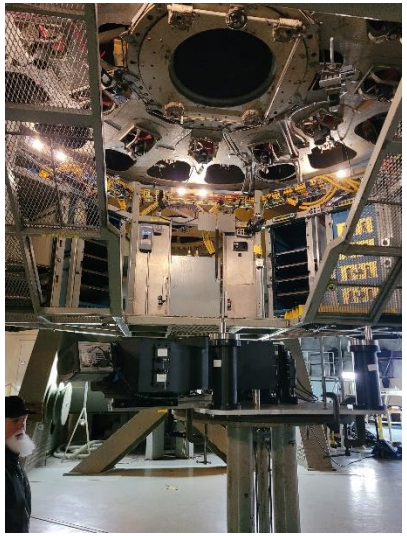




A&G 1st light







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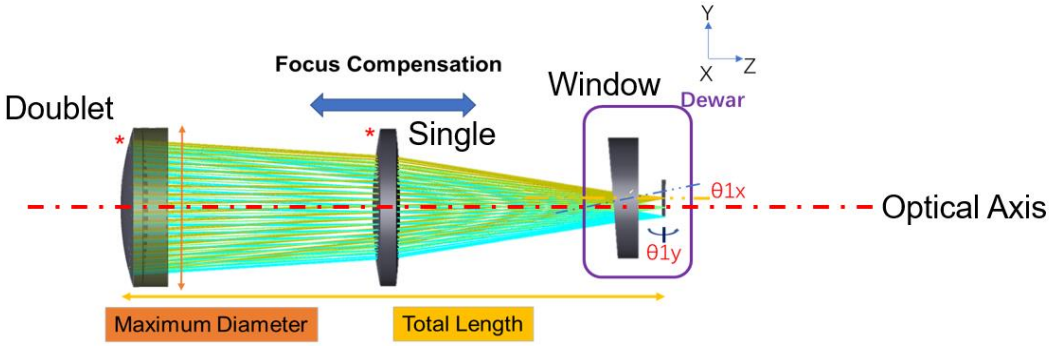
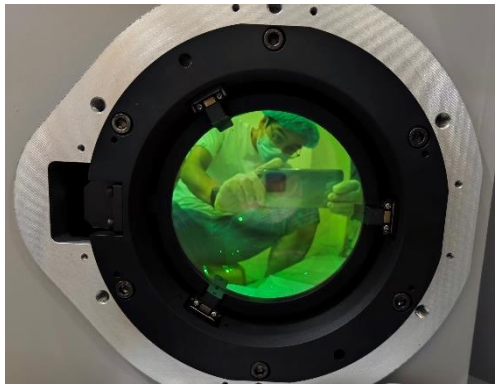
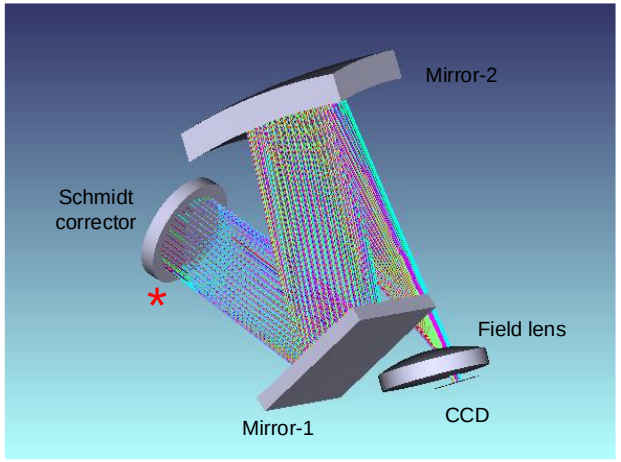
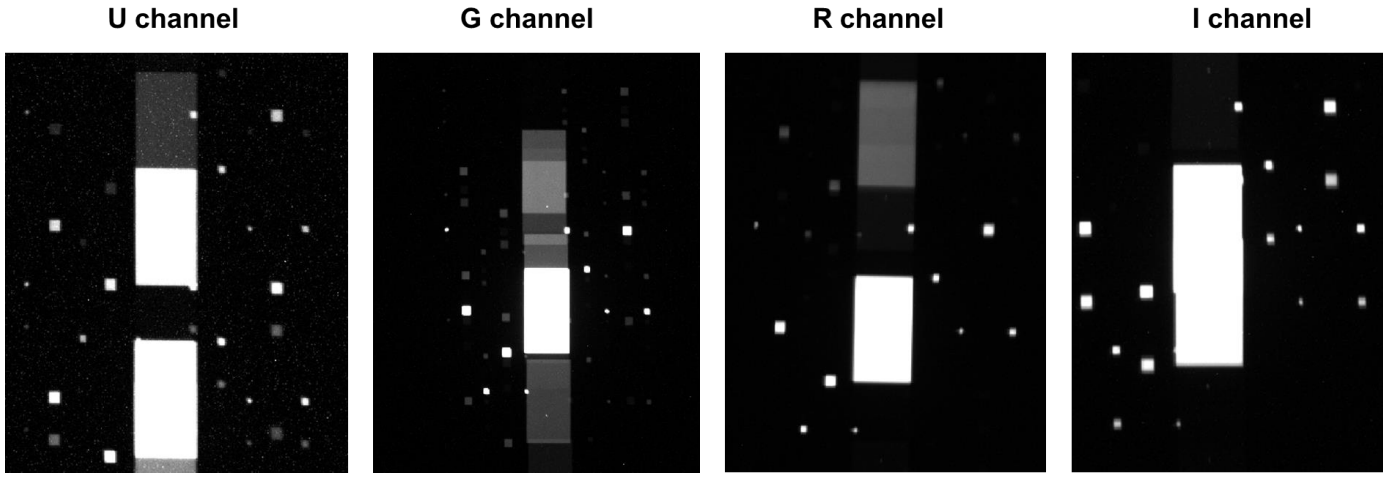
✓NGPS相机系统









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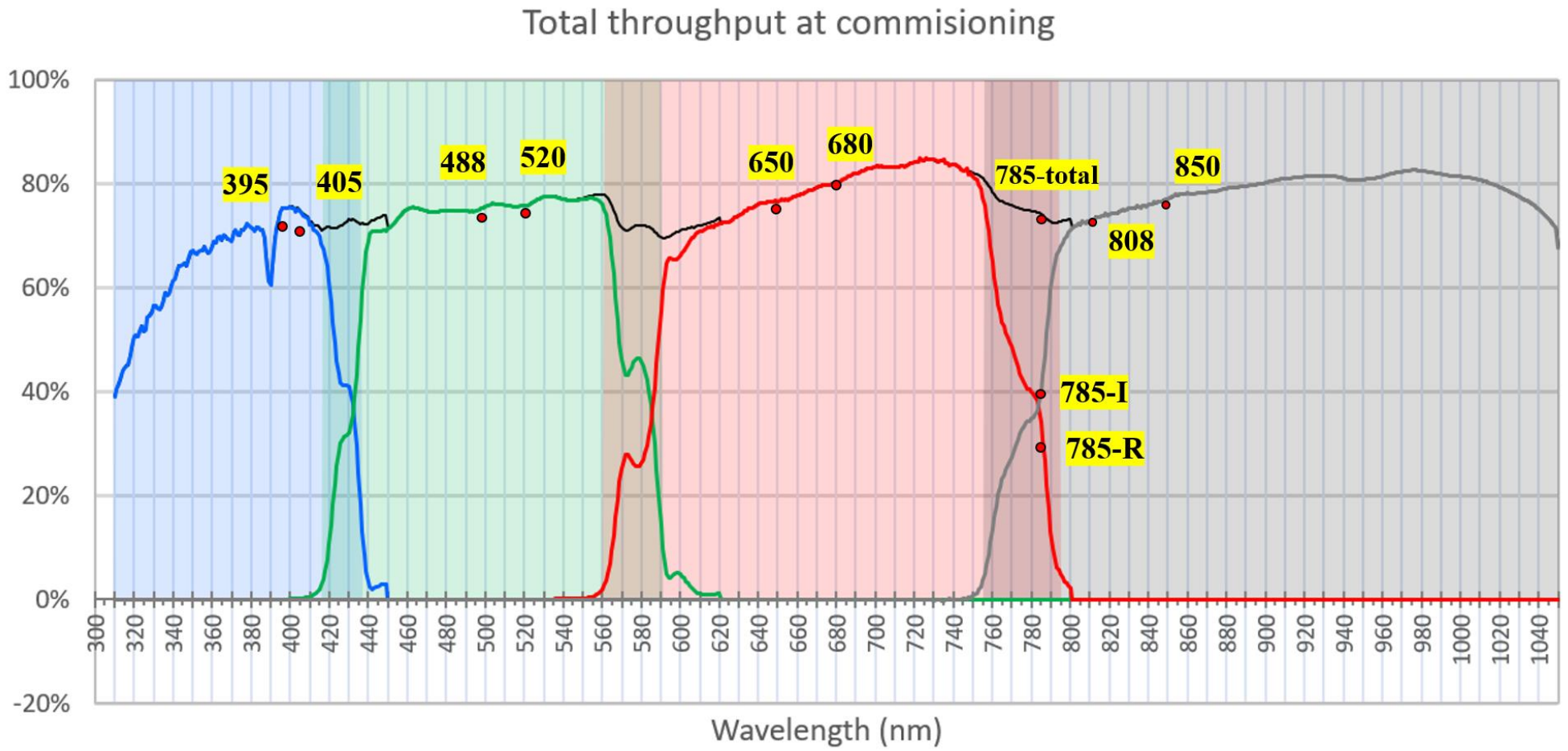
✓NGPS的仪器效率



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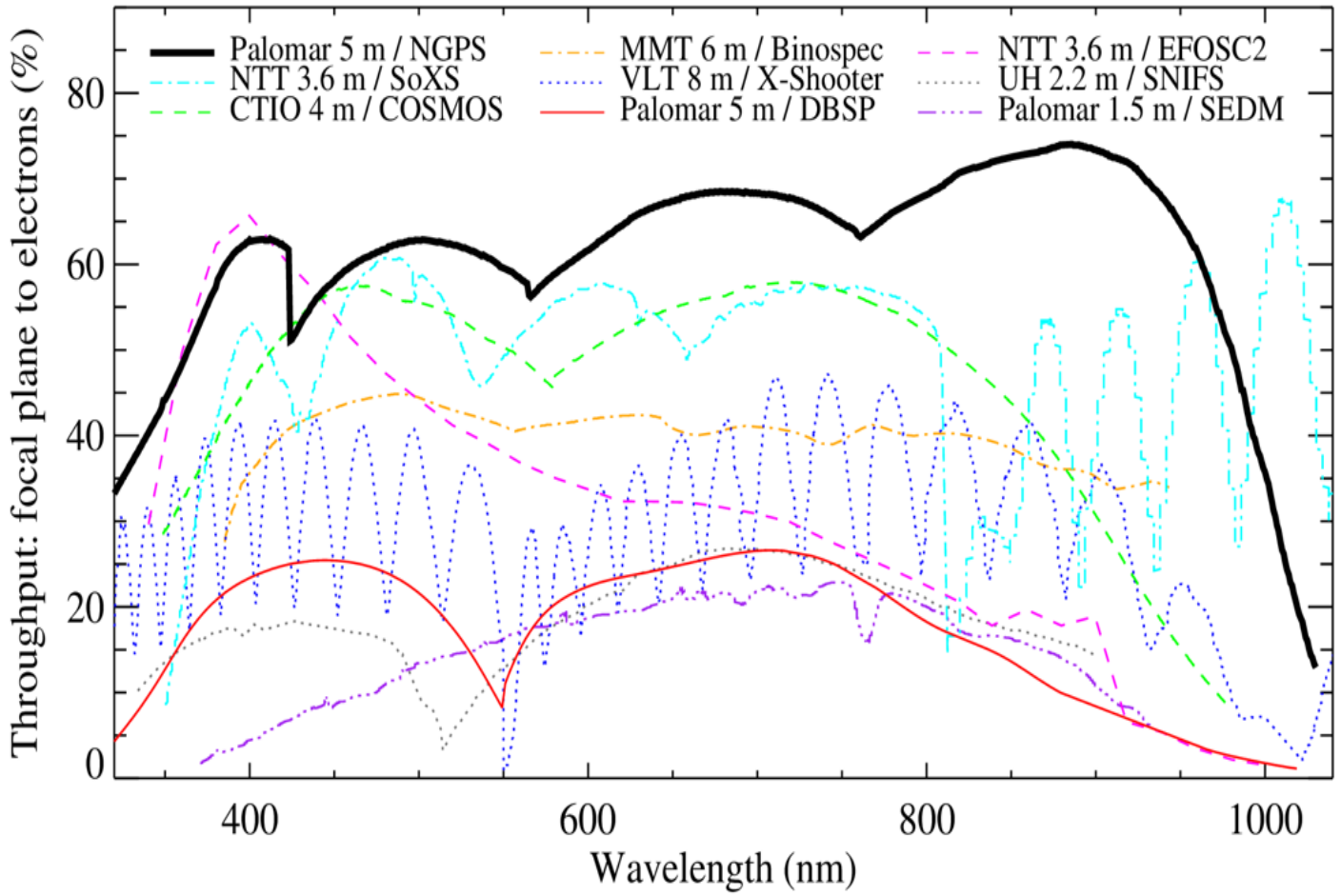
Nanjing Institute of Astronomical Optics & Technology，CAS

✓NGPS的仪器效率



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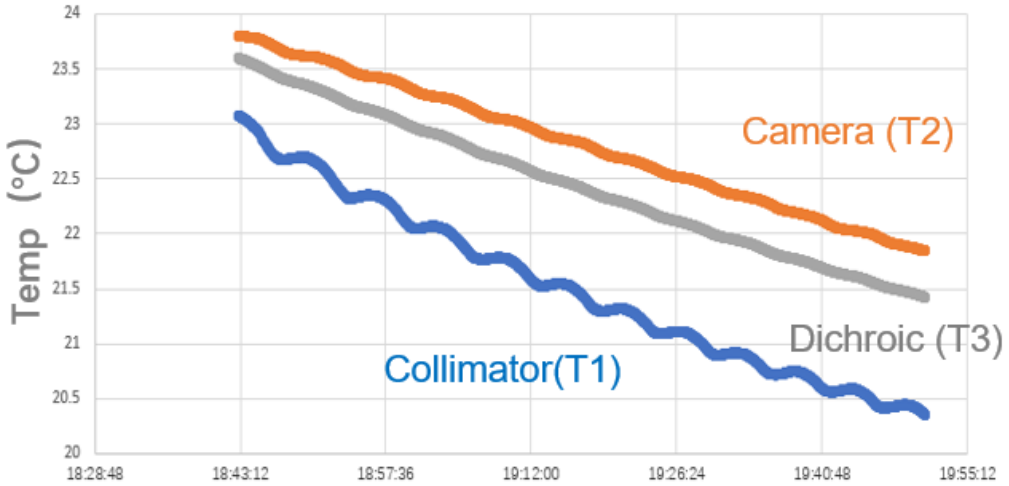
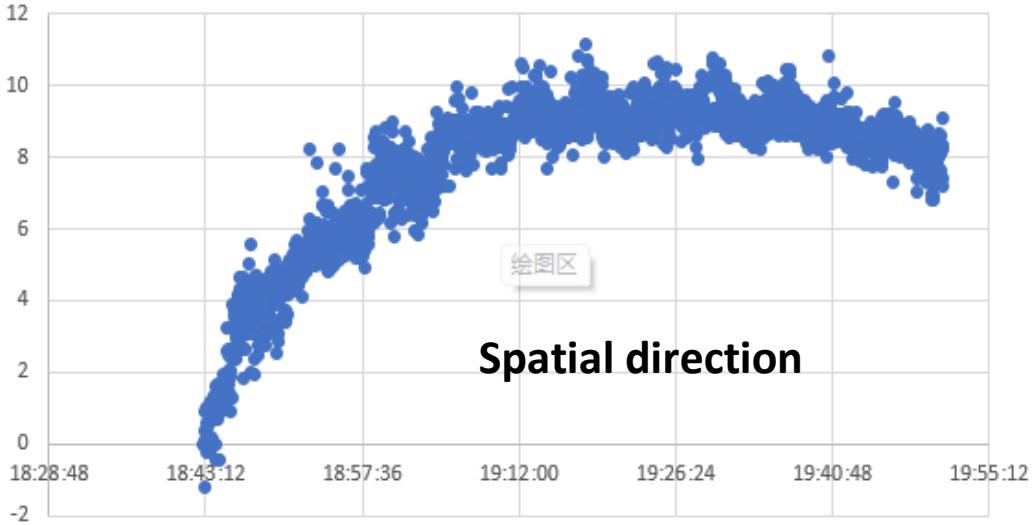
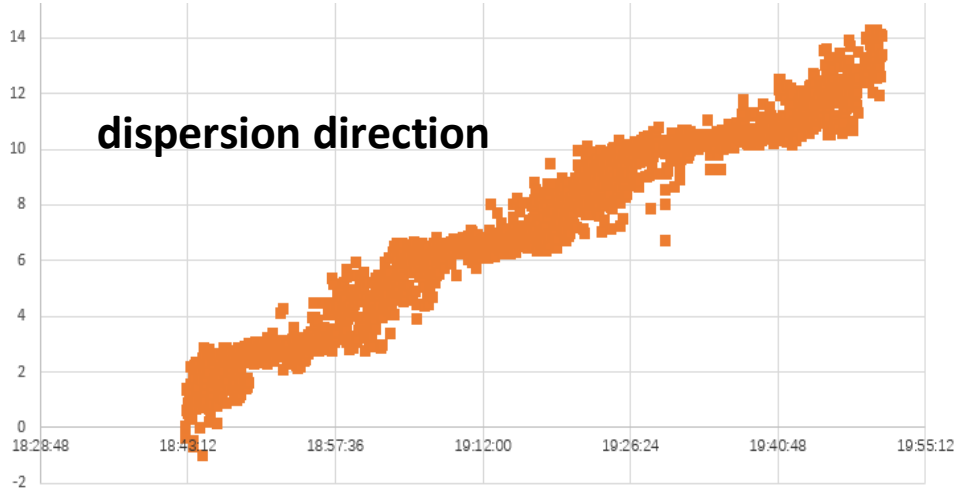
✓NGPS的图像漂移（温度）

- 两个方向漂移的相关系数分析
- 两个方向漂移与温度呈现负相关







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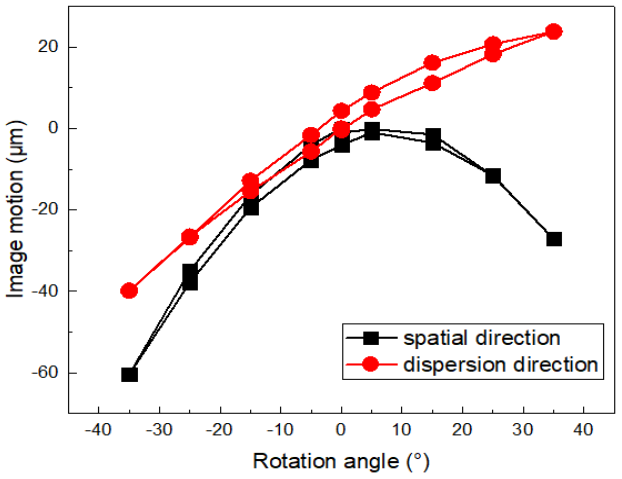
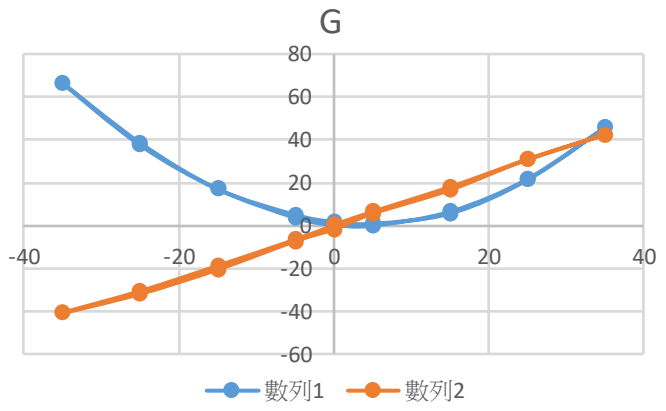
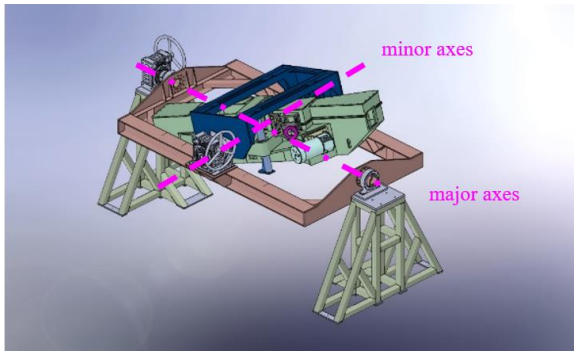
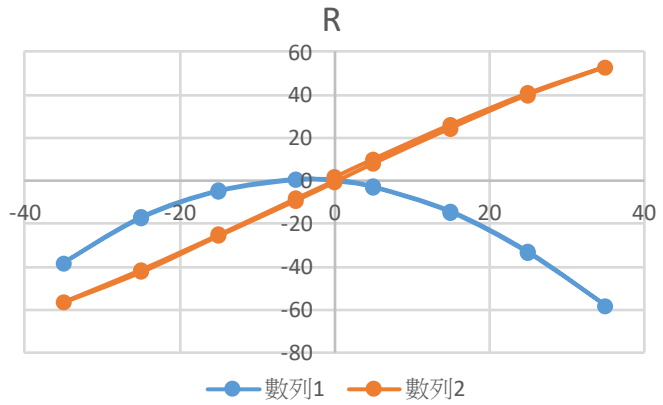
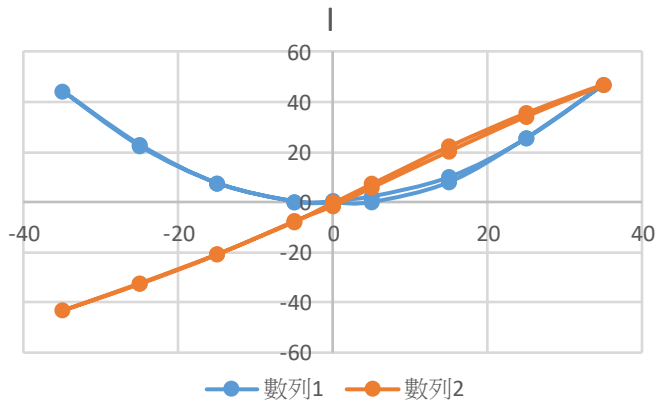
✓NGPS的图像漂移（重力-Minor）

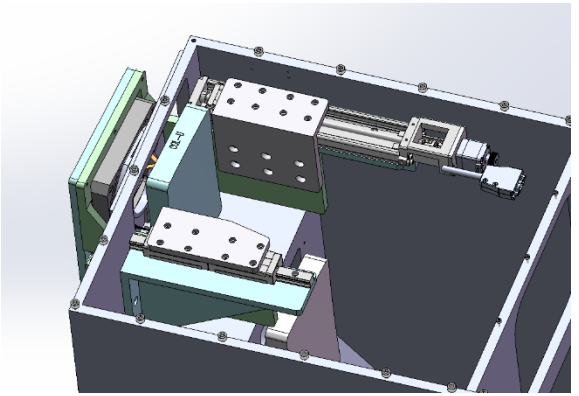












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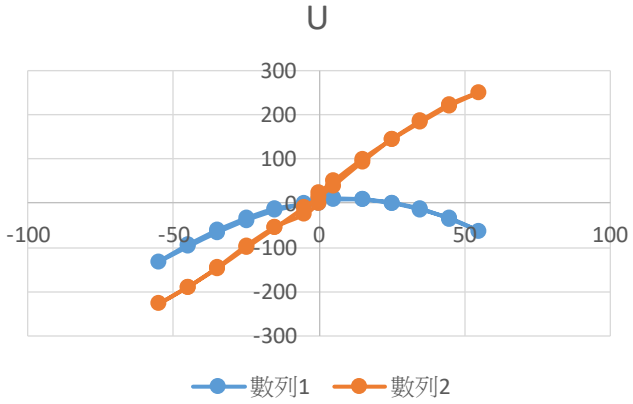
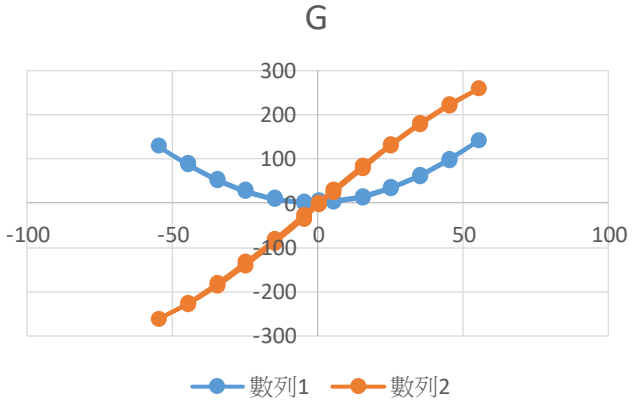
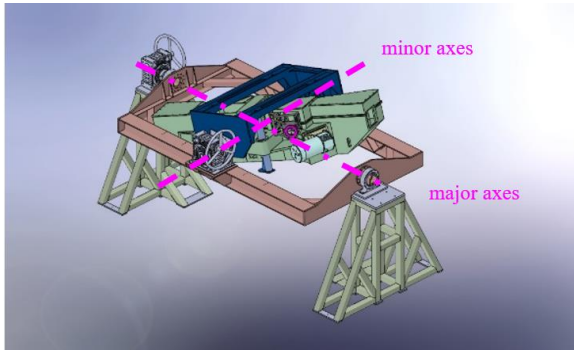
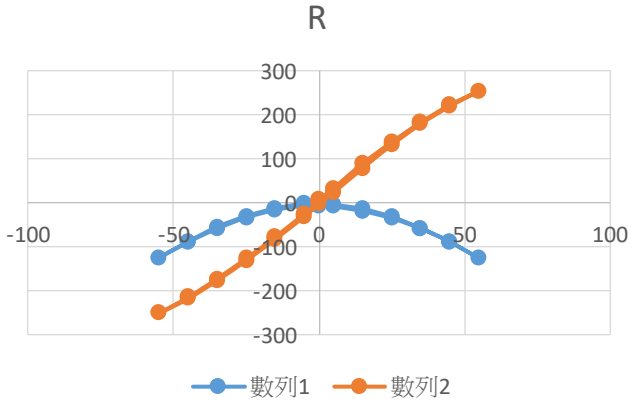
✓NGPS的图像漂移（重力-Major）

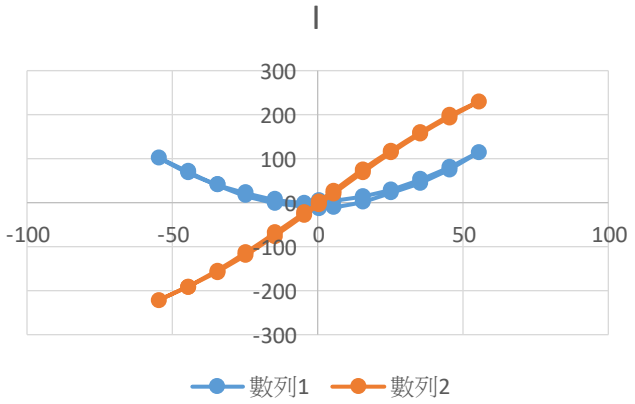
Spatial　Dispersion











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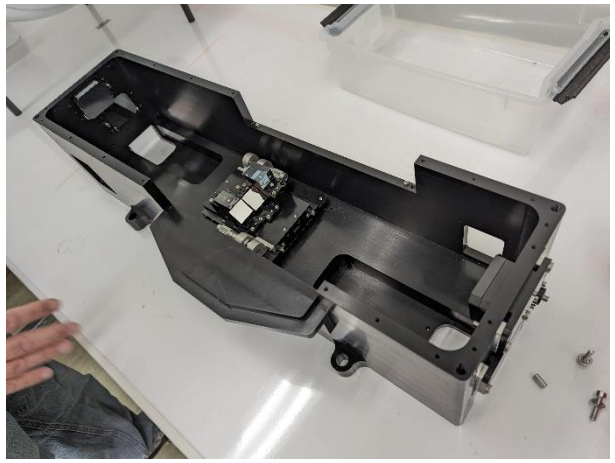
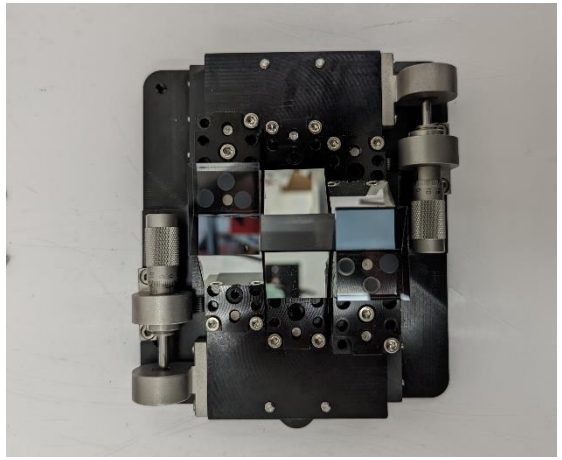
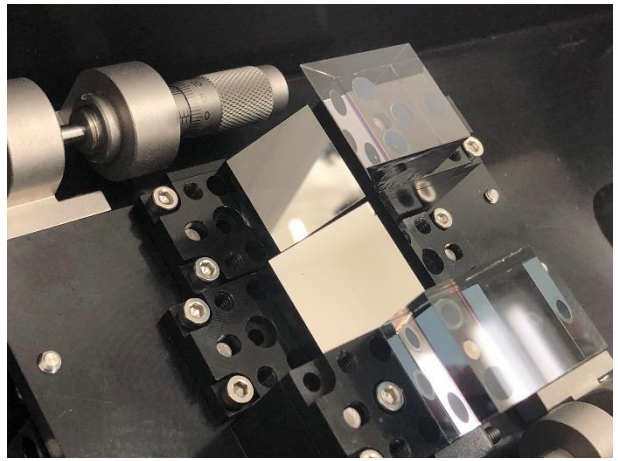
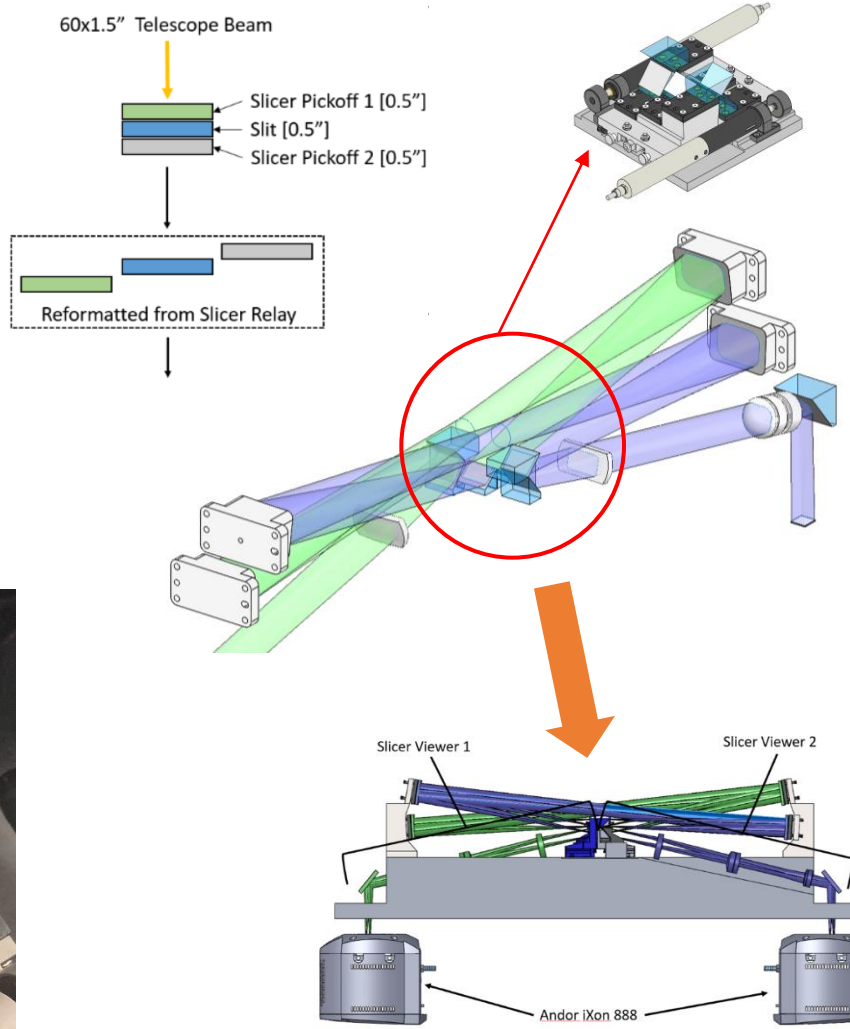
✓NGPS像切分器（CIT）









NGPS方案介绍

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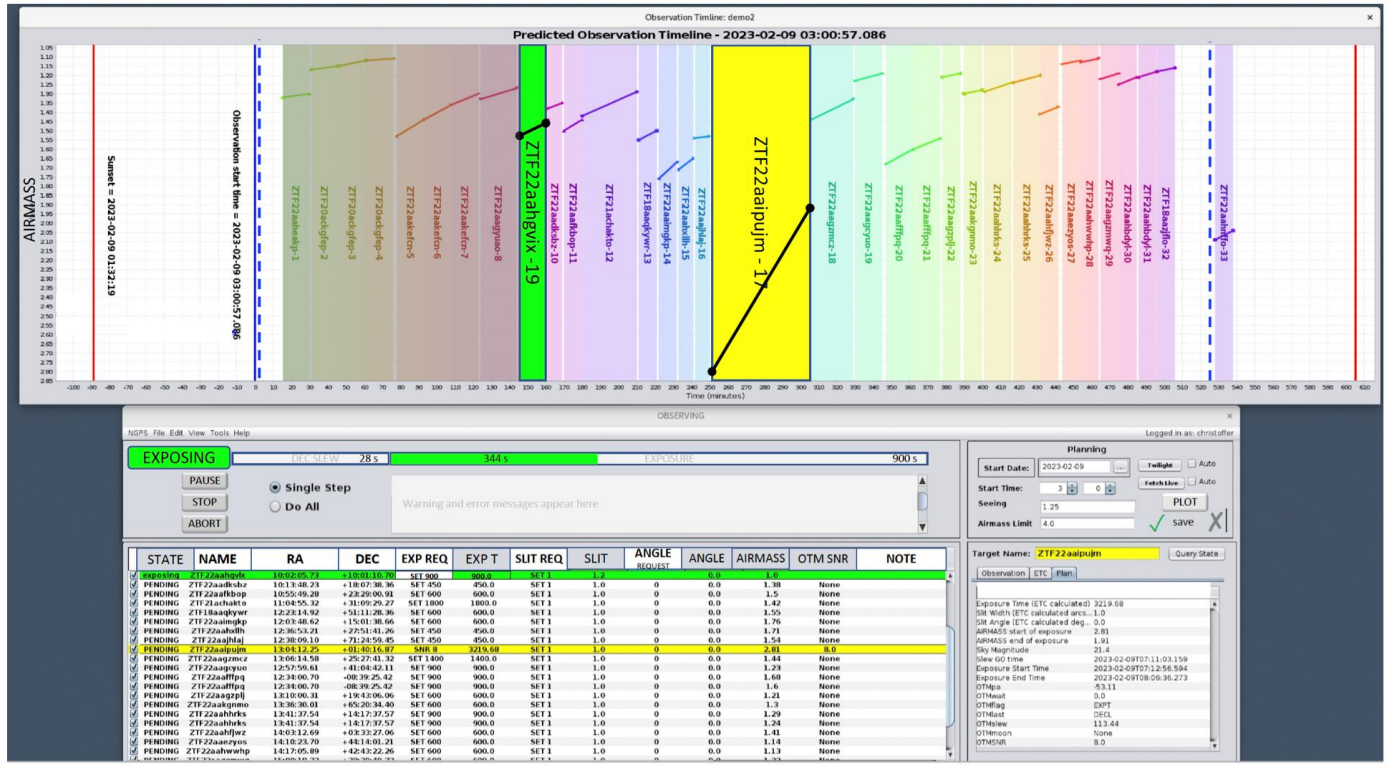
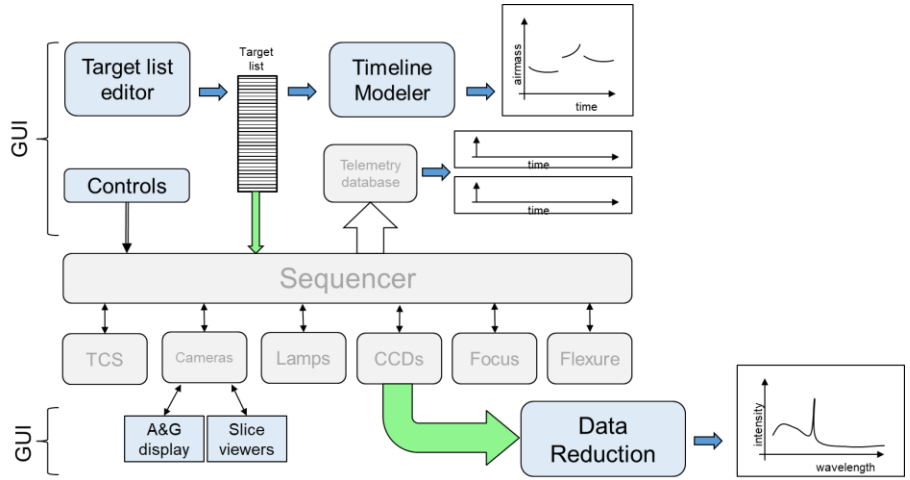
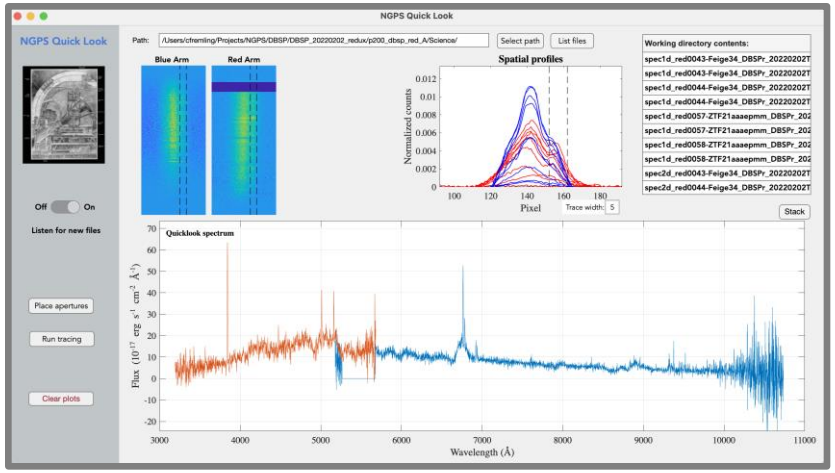
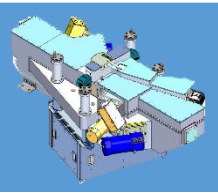
✓NGPS观测策略(CIT)









总结

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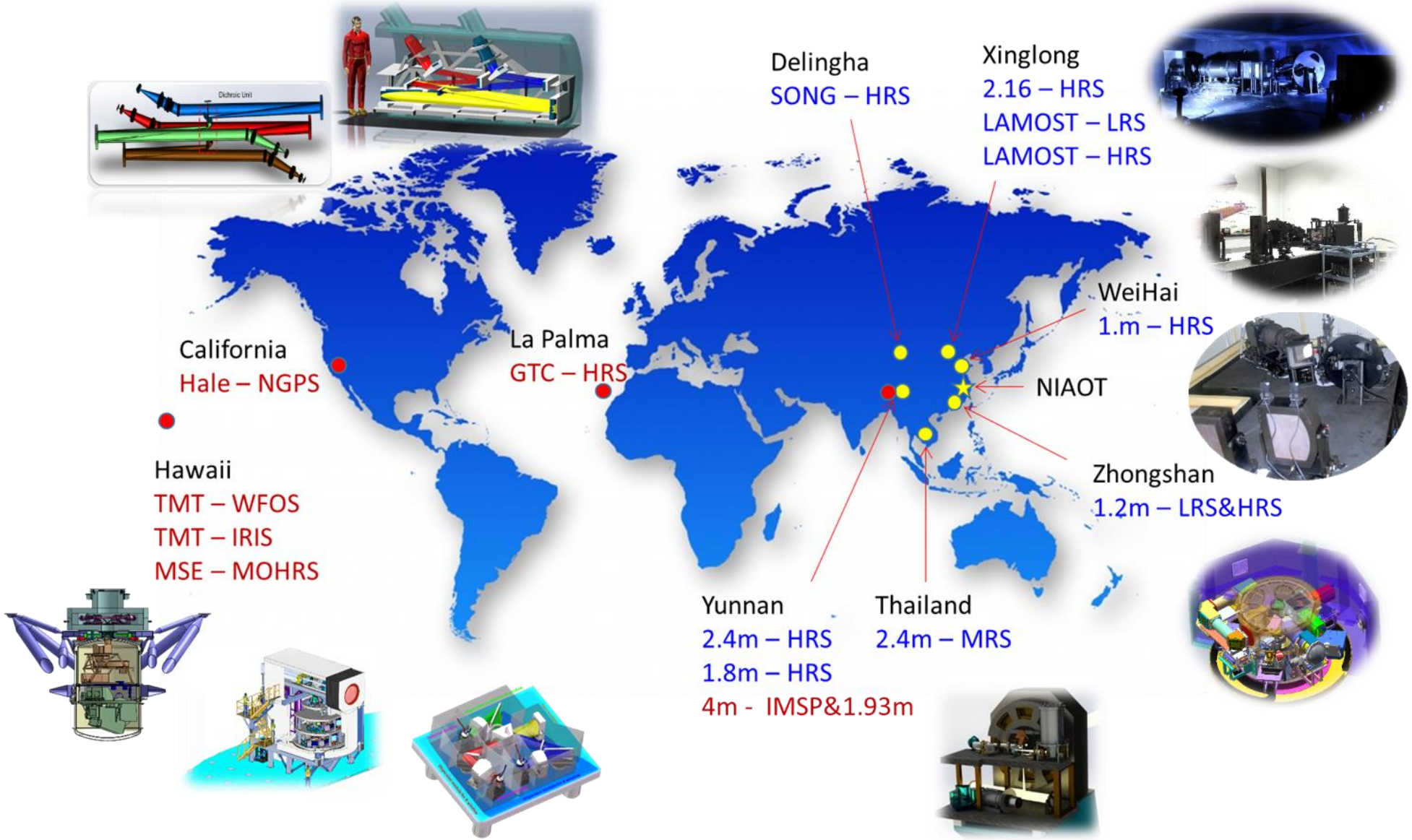
- ✓替代DBSP，成为海尔望远镜的主力设备
- ✓单次曝光可同时覆盖310-1040nm
- ✓在中等视宁度的情况下，分辨率可实现≥4500
- ✓提高仪器的效率
  - ➢ 4个通道，色散方向16K像素
  - ➢ 采用3切分像切分器，权衡狭缝损失和光谱效率
  - ➢ 360-1000nm仪器平均效率优于65%
- ✓提高仪器观测效率
  - ➢ 只需调整狭缝和曝光时间
  - ➢ 固定光栅
  - ➢ 重力和温度的主动柔性补偿
  - ➢ 自动补偿焦点漂移
  - ➢ 提供功能强大的GUI界面、自动化观测


Delingha
SONG – HRS
Xinglong
2.16 – HRS
LAMOST – LRS
LAMOST – HRS
WeiHai
1.m – HRS
NIAOT
Zhongshan
1.2m – LRS&HRS
California
Hale – NGPS
La Palma
GTC – HRS
Hawaii
TMT – WFOS
TMT – IRIS
MSE – MOHRS
Yunnan
2.4m – HRS
1.8m – HRS
4m - IMSP&1.93m
Thailand
2.4m – MRS