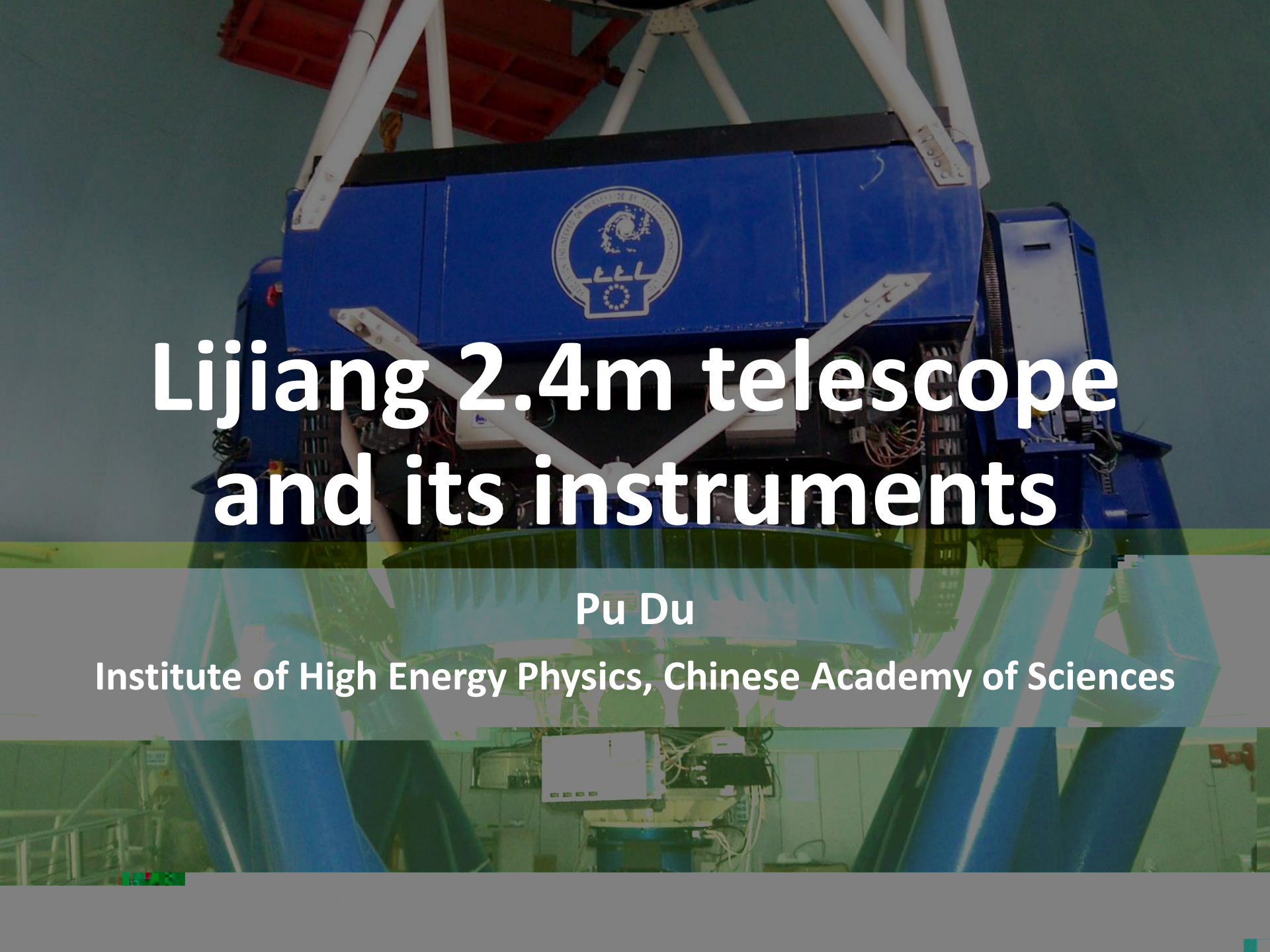
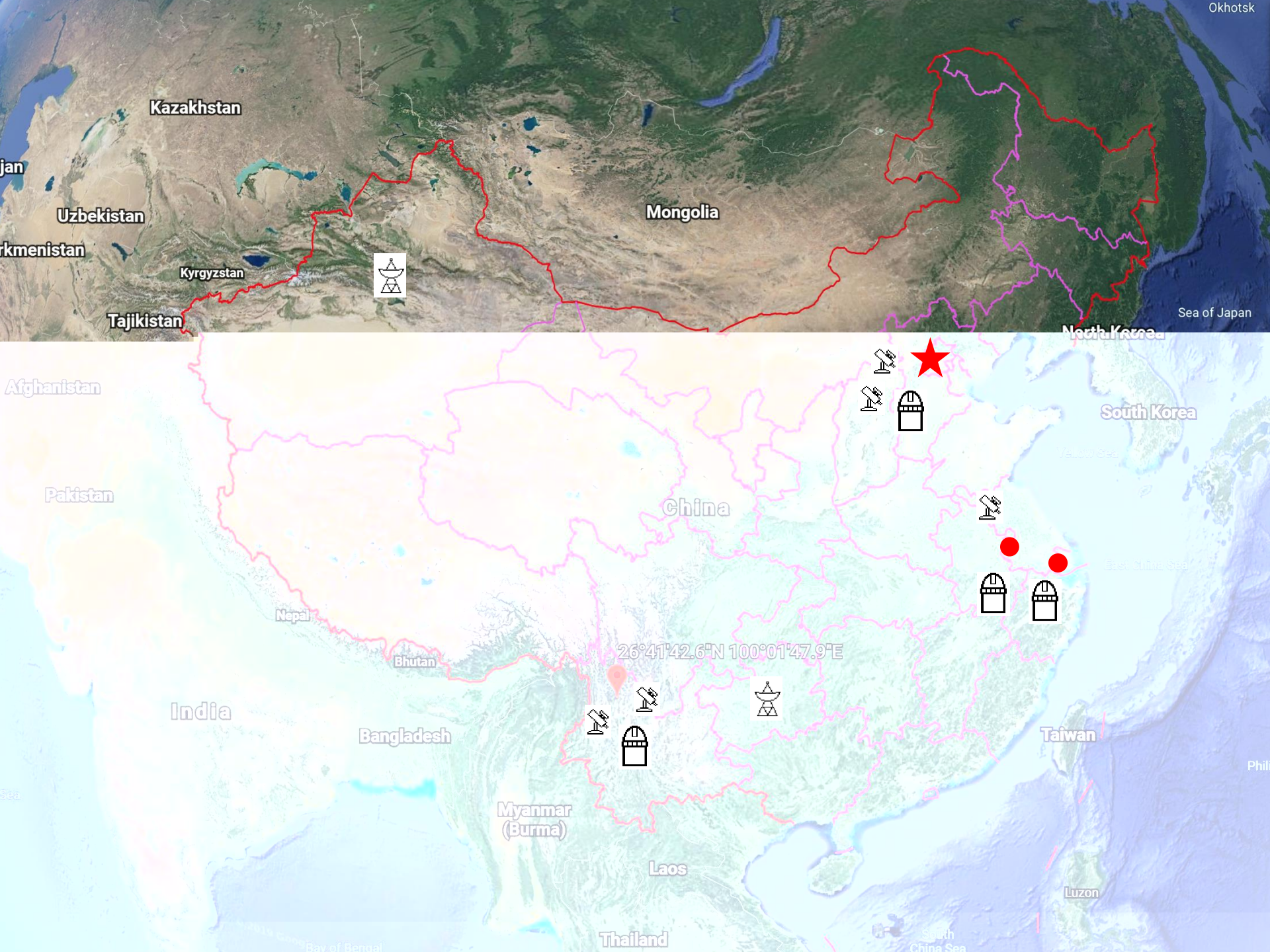


Lijiang 2.4m telescope and its instruments

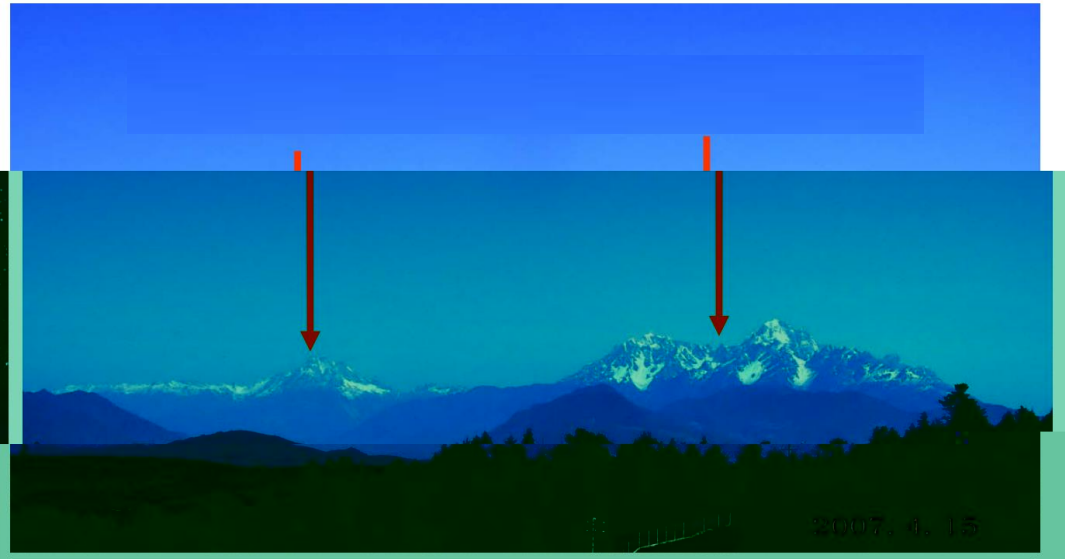
Pu Du

Institute of High Energy Physics, Chinese Academy of Sciences

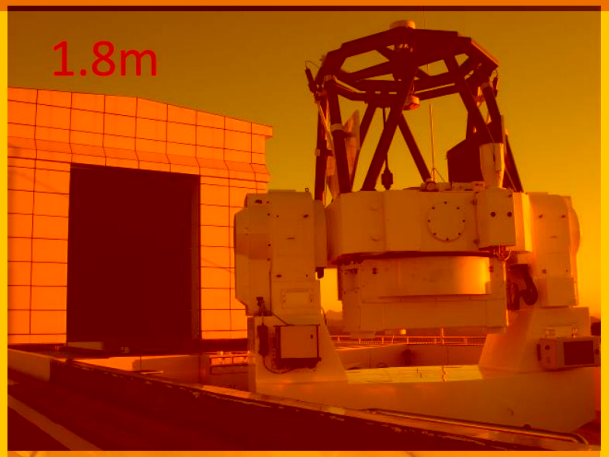

Okhotsk
Kazakhstan
Uzbekistan
Mongolia
Kyrgyzstan
Tajikistan
Sea of Japan
Afghanistan
Pakistan
China
South Korea
Nepal
Bhutan
26°41'42.6"N 100°01'47.9"E
India
Bangladesh
Taiwan
Myanmar
(Burma)
Laos
Thailand
Luzon

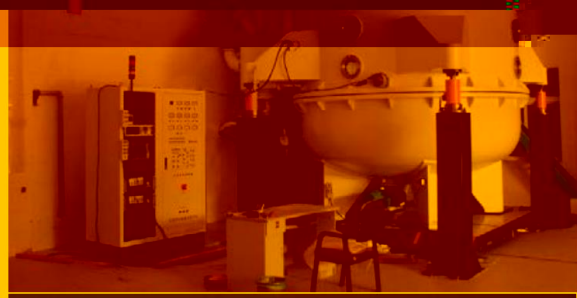

Belong to Yunnan Observatories, Chinese Academy of Sciences

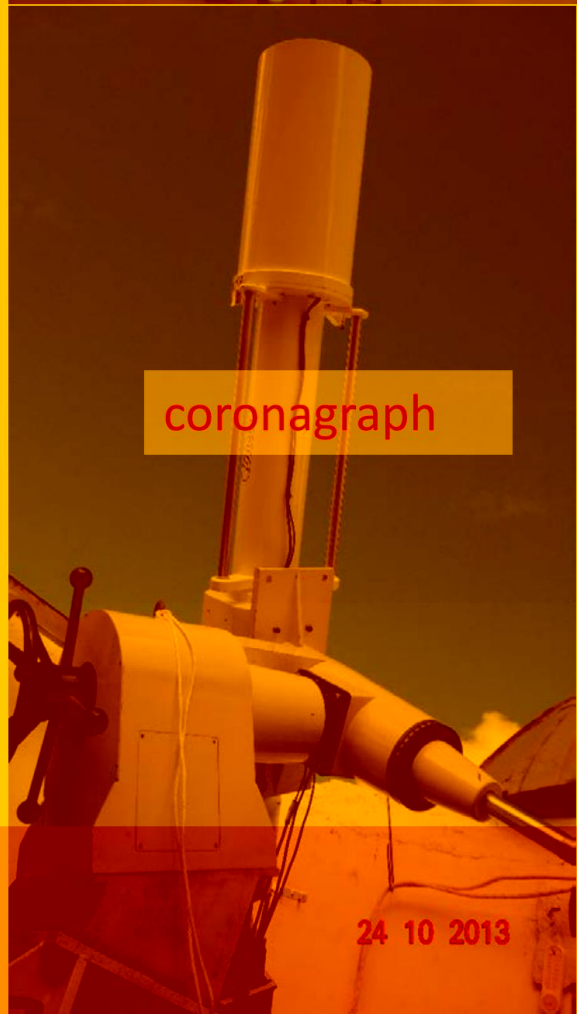
The astronomical conditions

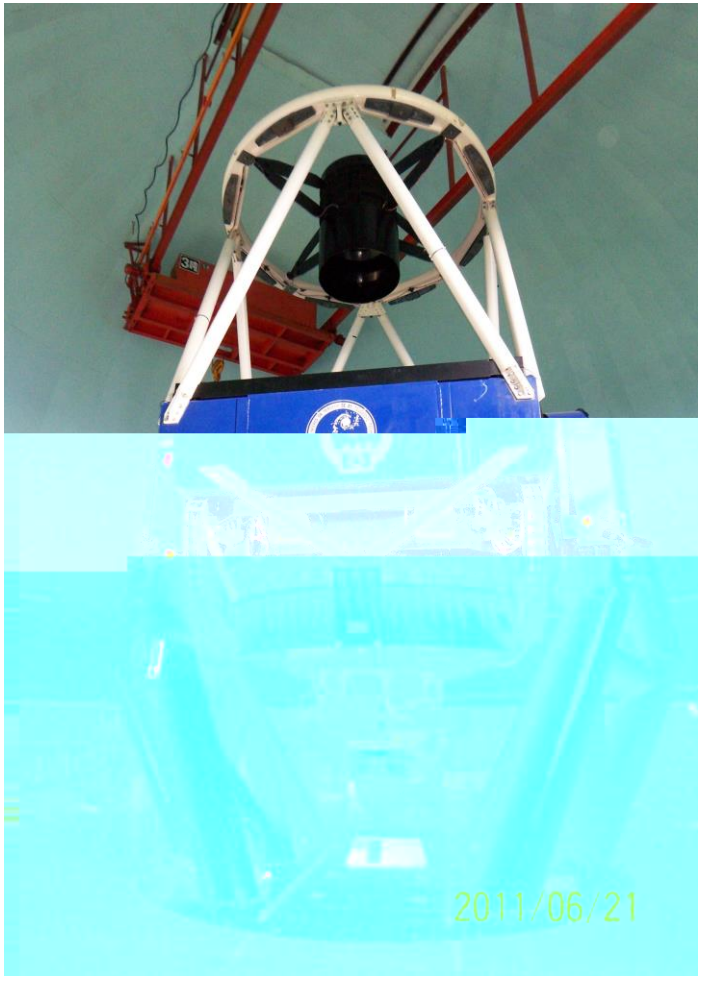


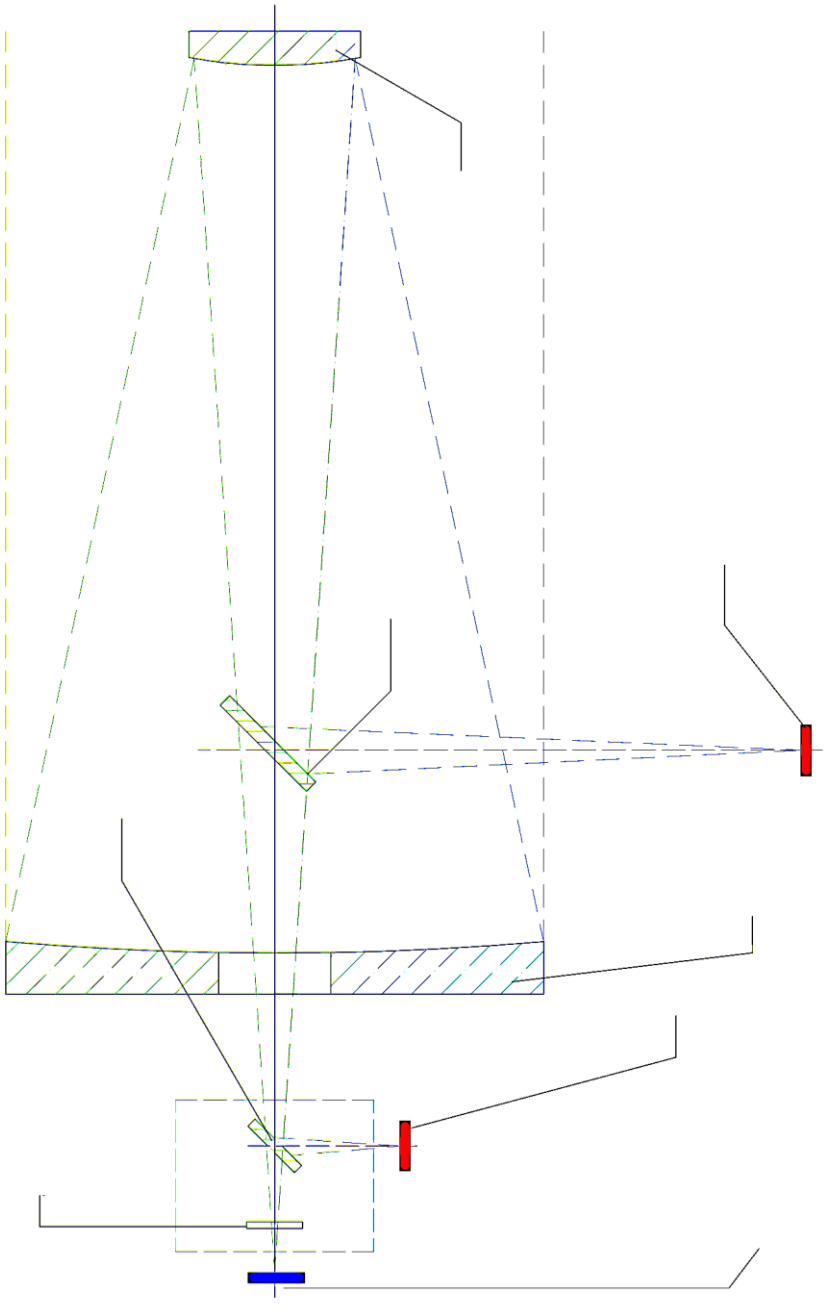
Telescopes at Lijiang Observatory



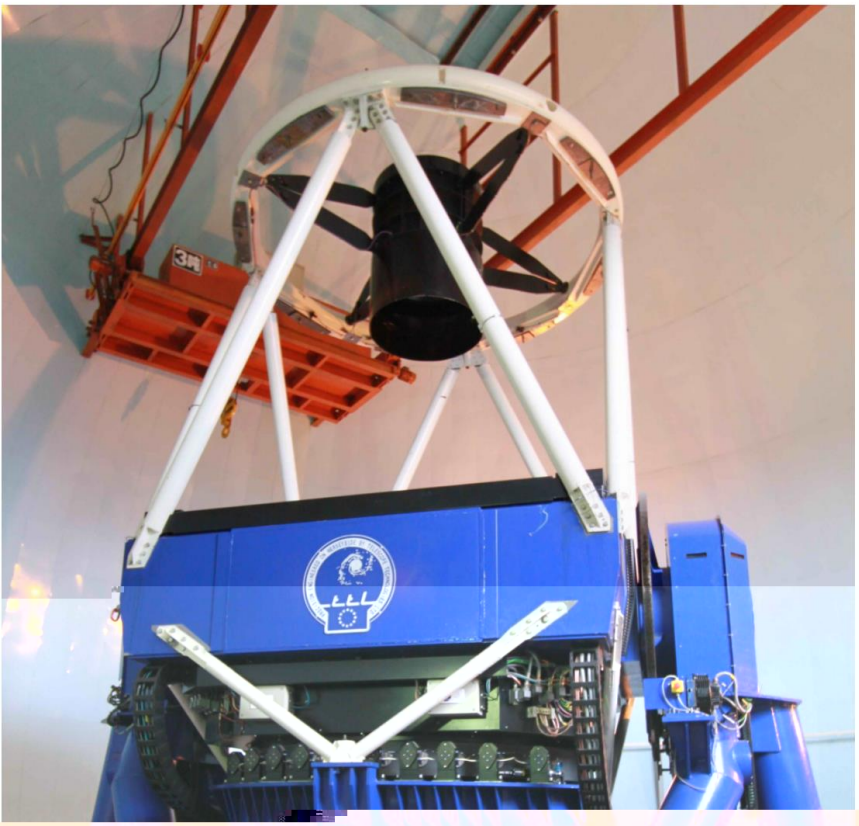


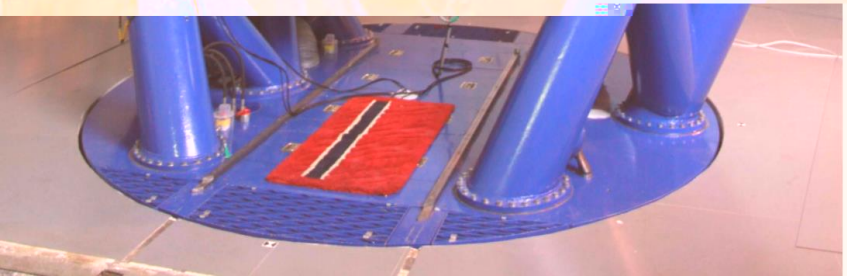


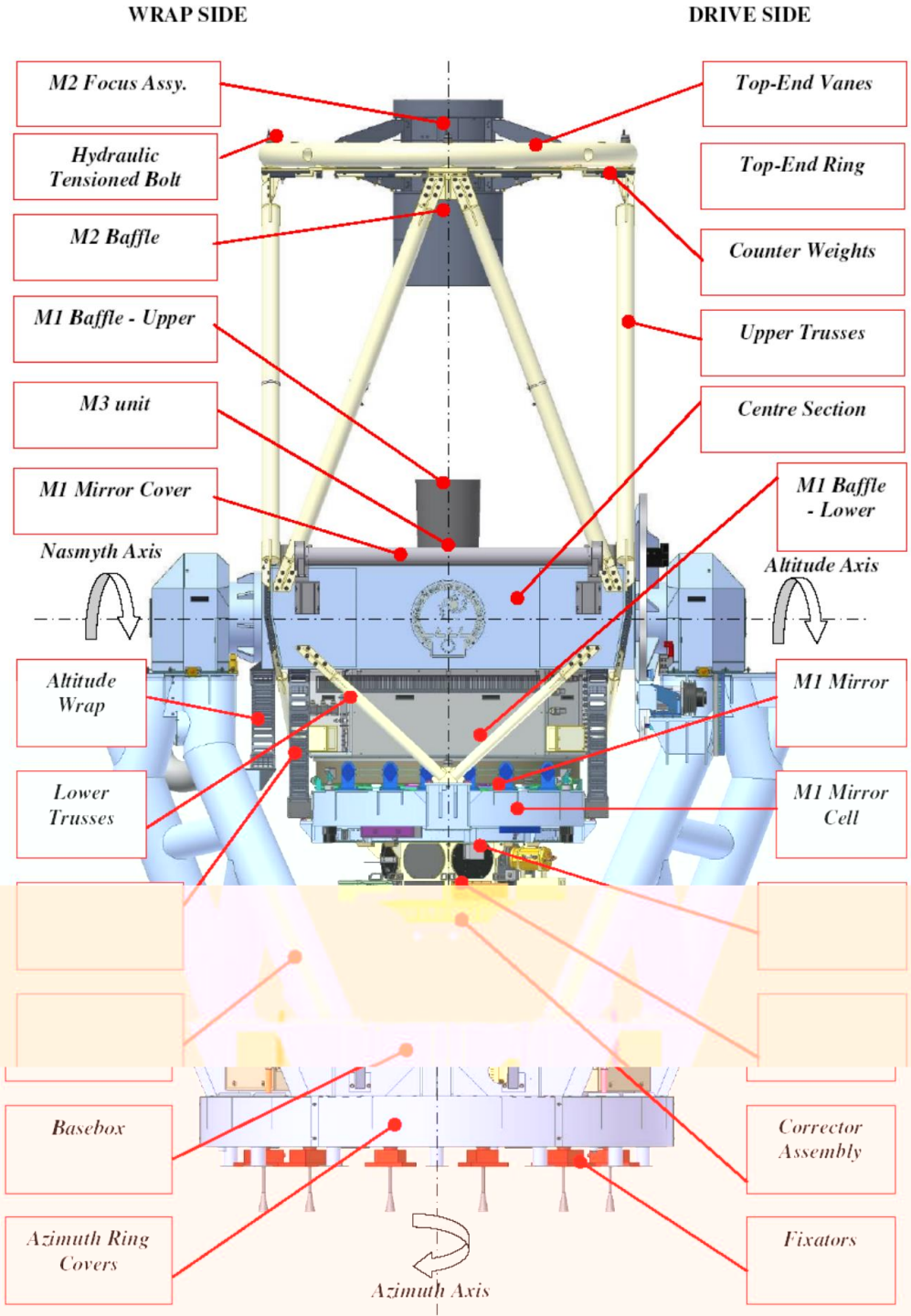

2011/06/21



The 2.4m Telescope



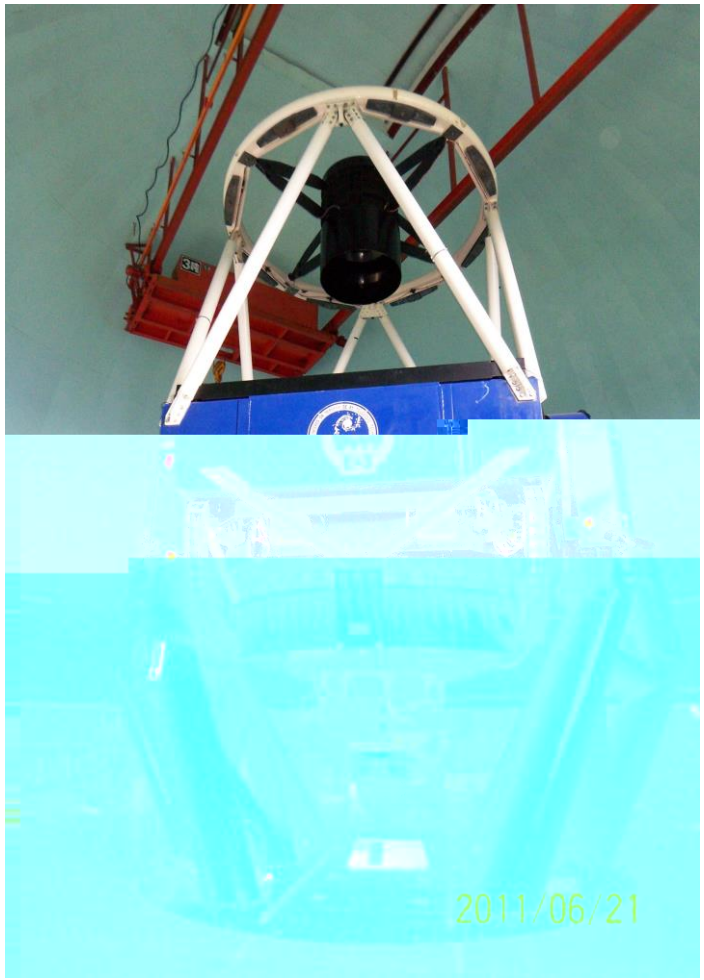




Specifications of the Telescope

- A-Z mount
- RC system, one Cassegrain focus, one Nasmyth platform
- Aperture: 2.4 meters
- Focal ratio: F/8
- Image quality: <0″.35 (on axis) & <0″.5 (FOV)

Telescope



Primary Mirror	Clear Aperture	2400mm
	Central Bore	500mm
	Focal Ratio	F/2.43
	Radius of Curvature	-11520mm
	Conic Constant	-1.073
Secondary Mirror	Clear Aperture	709mm
	Radius of Curvature	-4760.44mm
	Conic Constant	-4.187
	Distance to Primary Mirror	4094.114mm
	Distance to Focal Plane	[illegible]

F/8		Focal Ratio	
arc minutes	Cassegrain focus	FOV of Fold Port	8
arc minutes		FOV of Straight Port	10
arc minutes		Corrected FOV of Straight Port	40
F/8	Nasmyth focus	Focal Ratio	
arc minutes		FOV	8

Instruments

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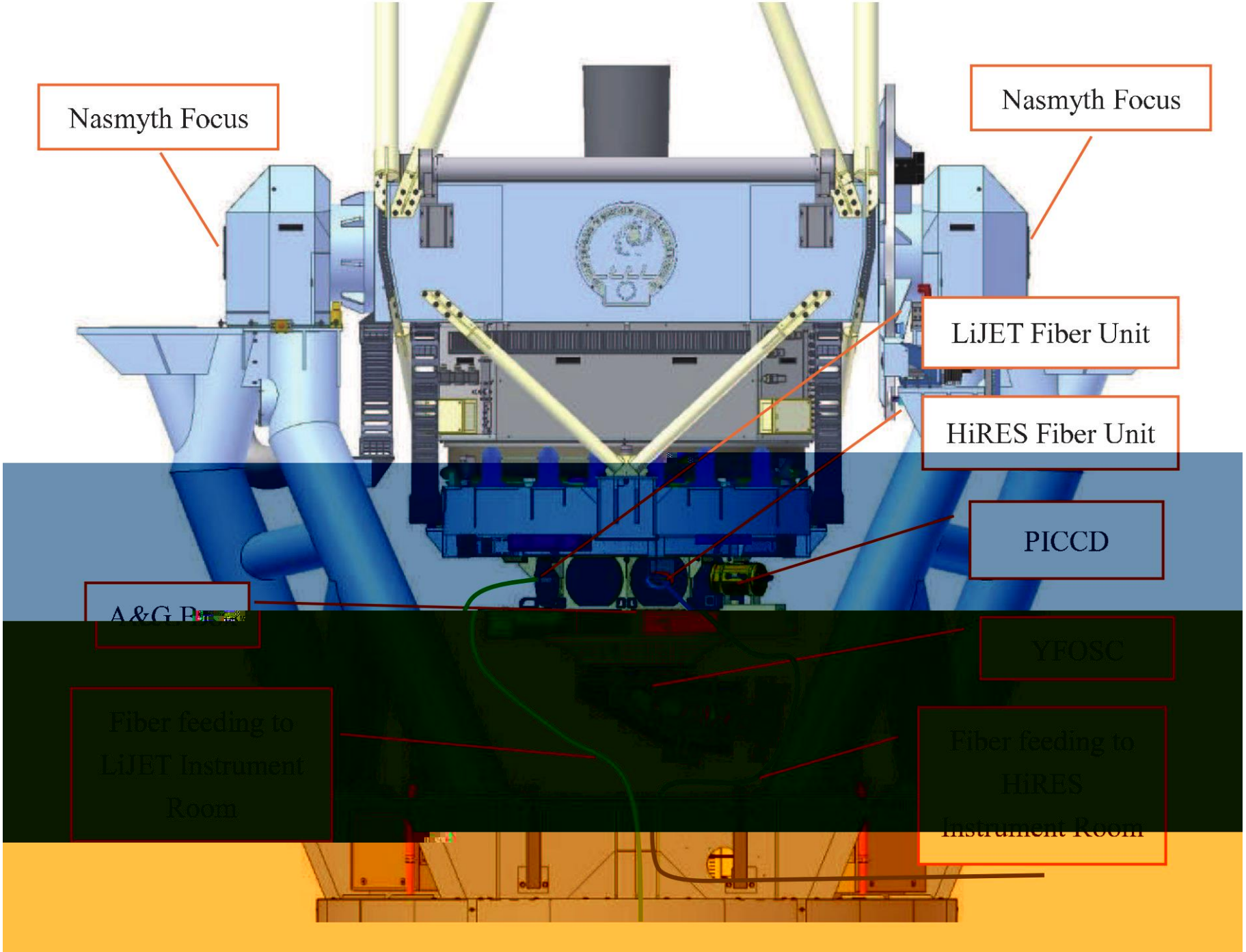
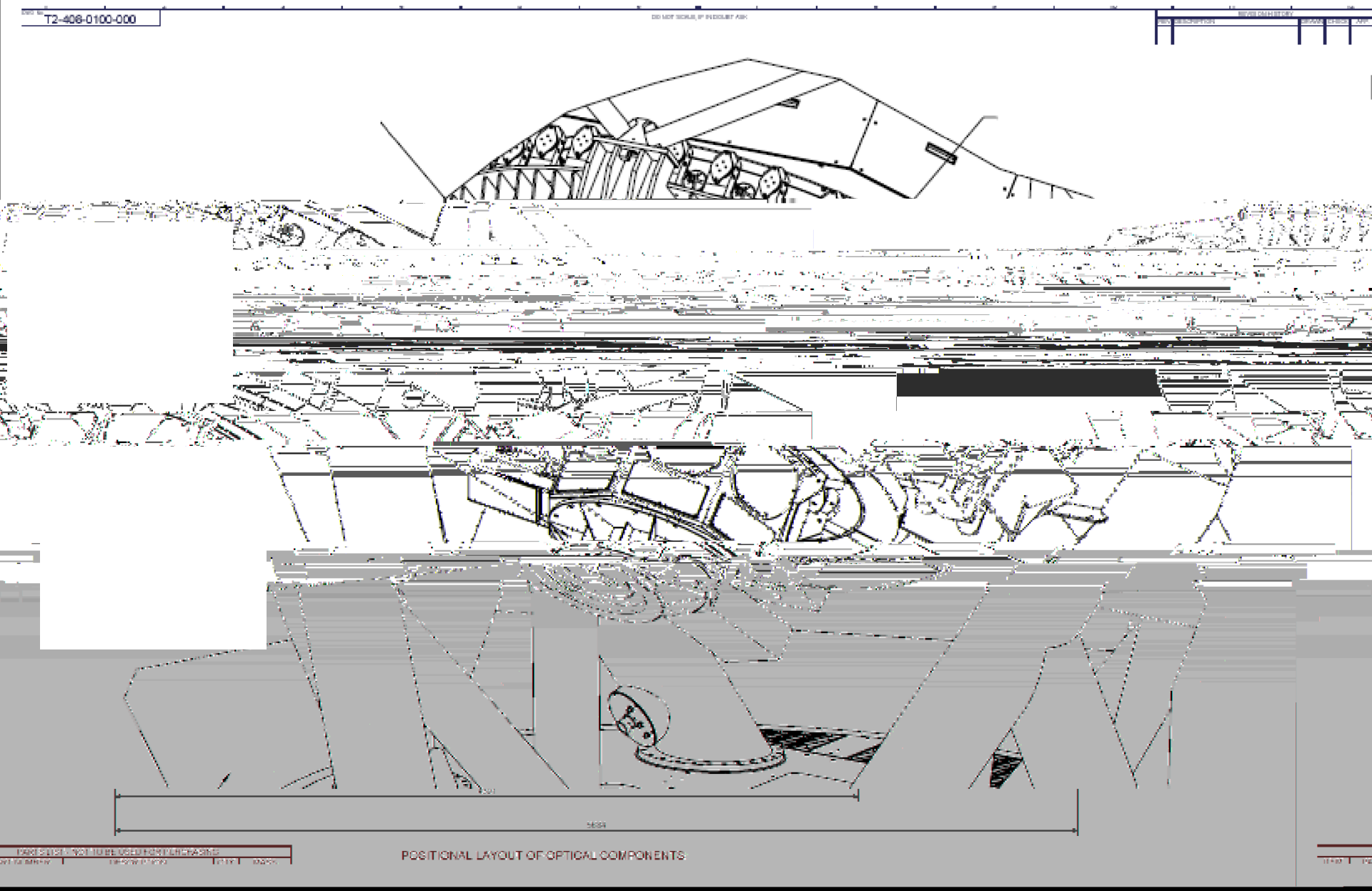
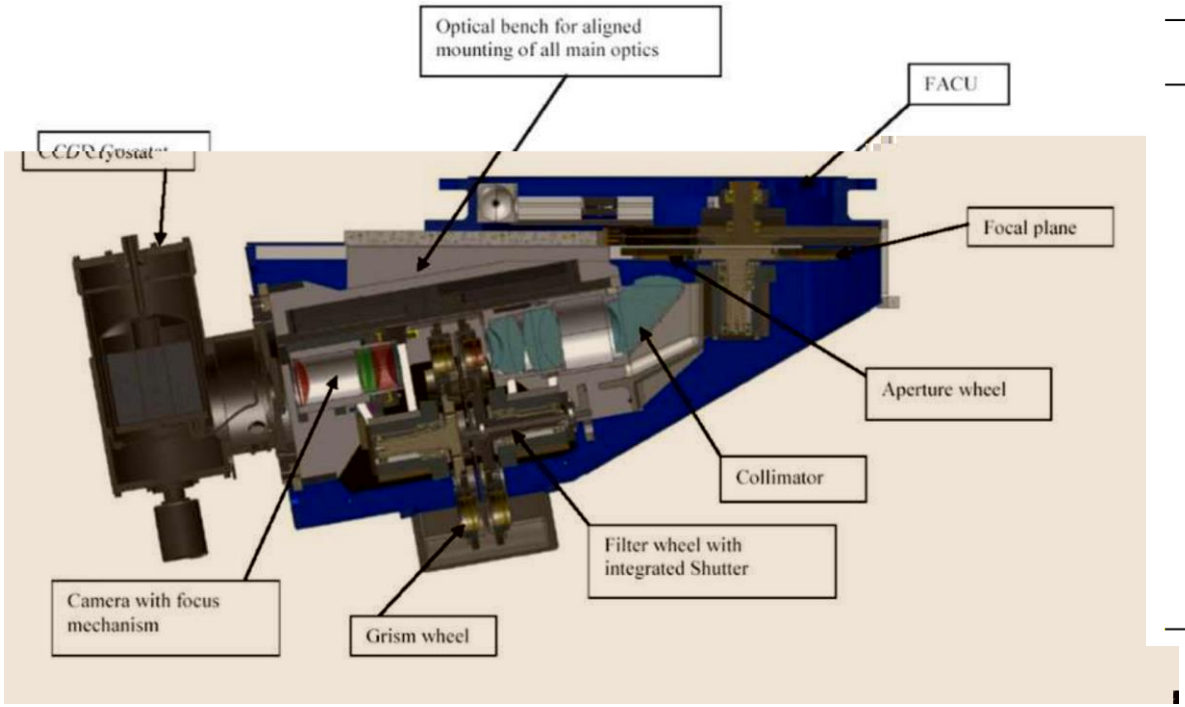

Nasmyth Focus
Nasmyth Focus
LiJET Fiber Unit
HiRES Fiber Unit
PICCD
YFOSC
Fiber feeding to LiJET Instrument Room
Fiber feeding to HiRES Instrument Room

The science folder

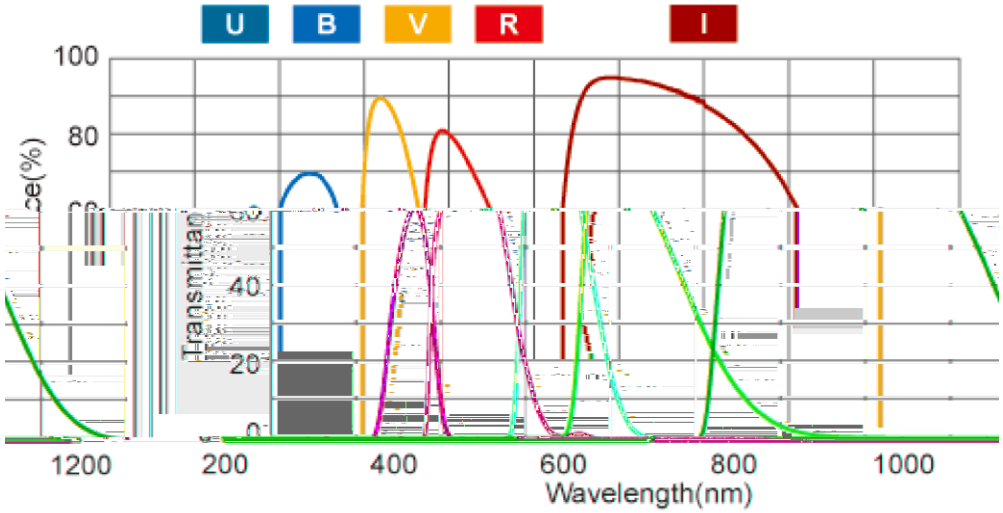


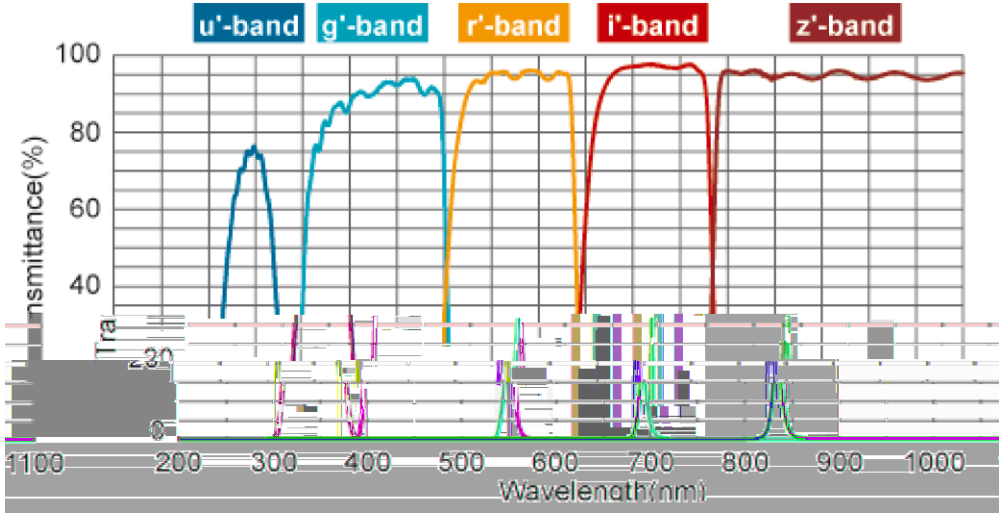
YFOSC



Parameter	Value
Pixels	2048×4608
Pixel Size	13.5um×13.5um
Image Area	27.6mm×62.2mm
Field of View	9.60'×9.60'
(Photometry)	(2K×2K)
Image Scale	0.283"/pixel
Cooling Mode	Liquid Nitrogen: -120°C
Gain	0.33e-
Readout Noise	6.3e-(Speed: 400kpixels/s)
	<5.0e-(Speed: 200kpixels/s)

Filters


U
B
V
R
I
100
80
40
20
1200
200
400
600
800
1000
Wavelength(nm)

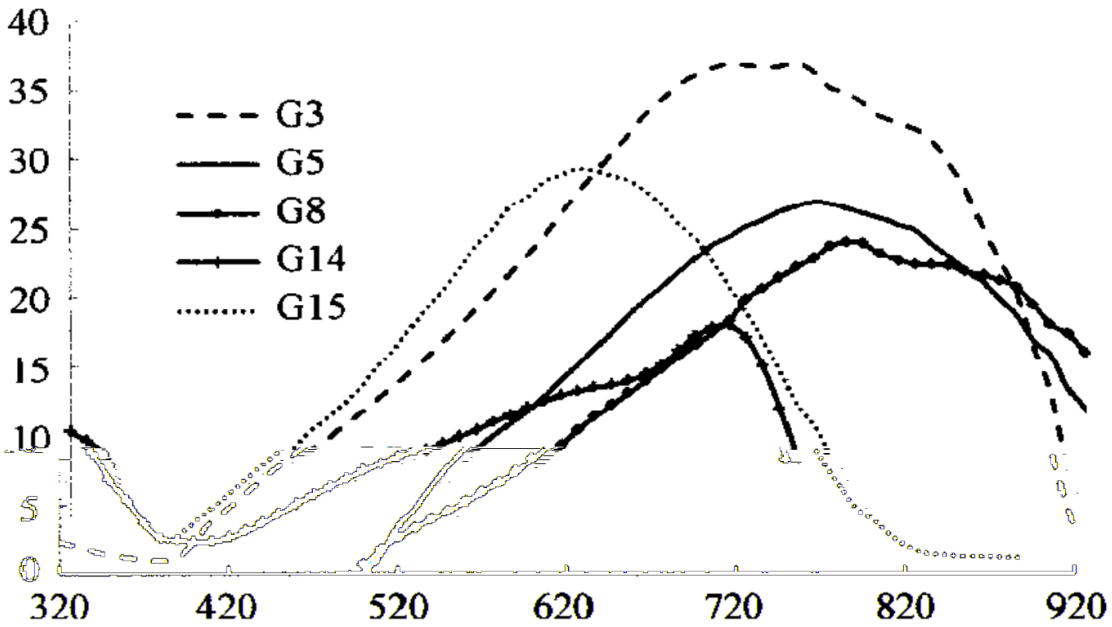

u'-band
g'-band
r'-band
i'-band
z'-band
100
80
60
40
200
300
400
500
600
700
800
900
1000
Wavelength(nm)

YFOSC

	Size (μm)	Sky angle (″)
Long Slit	54	0.58
	74	0.8
	93	1.0
	112	1.2
	140	1.5
	168	1.8
	233	2.5
	470	5.0
	940	10.0
Short Slit	54 ×500	0.58 ×5.37
	74 ×500	0.8 ×5.37
	100 ×500	1.07 ×5.37
	140 ×500	1.5 ×5.37
	460 ×500	4.94 ×5.37
	940 ×500	10.0 ×5.37

Grism No.	λc (nm)	λ Blaze (nm)	Grooves (nm/mm)	Dispersion (nm/pix)	Resolution (@600nm/pix)	Sp. Range (nm)	Order Range
12	730	700	75	1.1	545	520–980	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
980	1	15	586	527	300	0.39	1540	410–
980	1	5	650	700	300	0.46	1300	496–
746	1	14	463	428	600	0.17	3520	360–
960	1	8	650	700	600	0.15	4000	510–
980	3, 4, 5	13			316	0.06	10000	340–
980	7–23	9			79	0.06	10000	340–

YFOSC: Throughput



PI CCD camera

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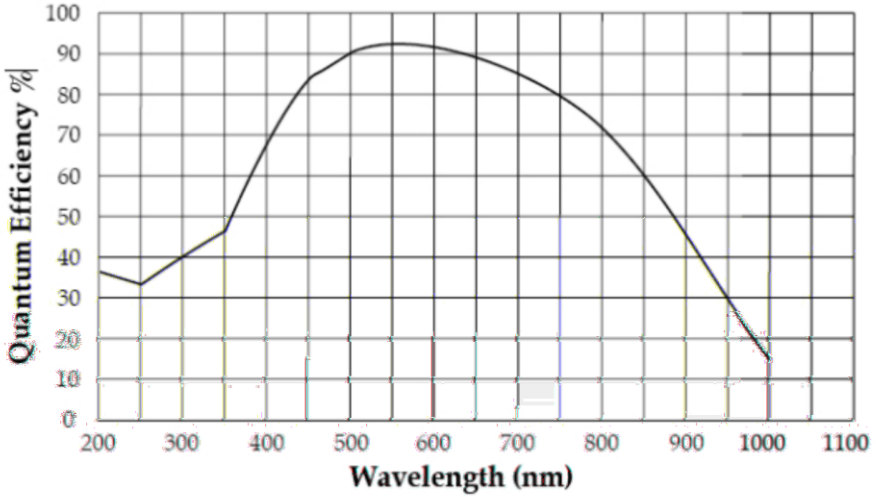
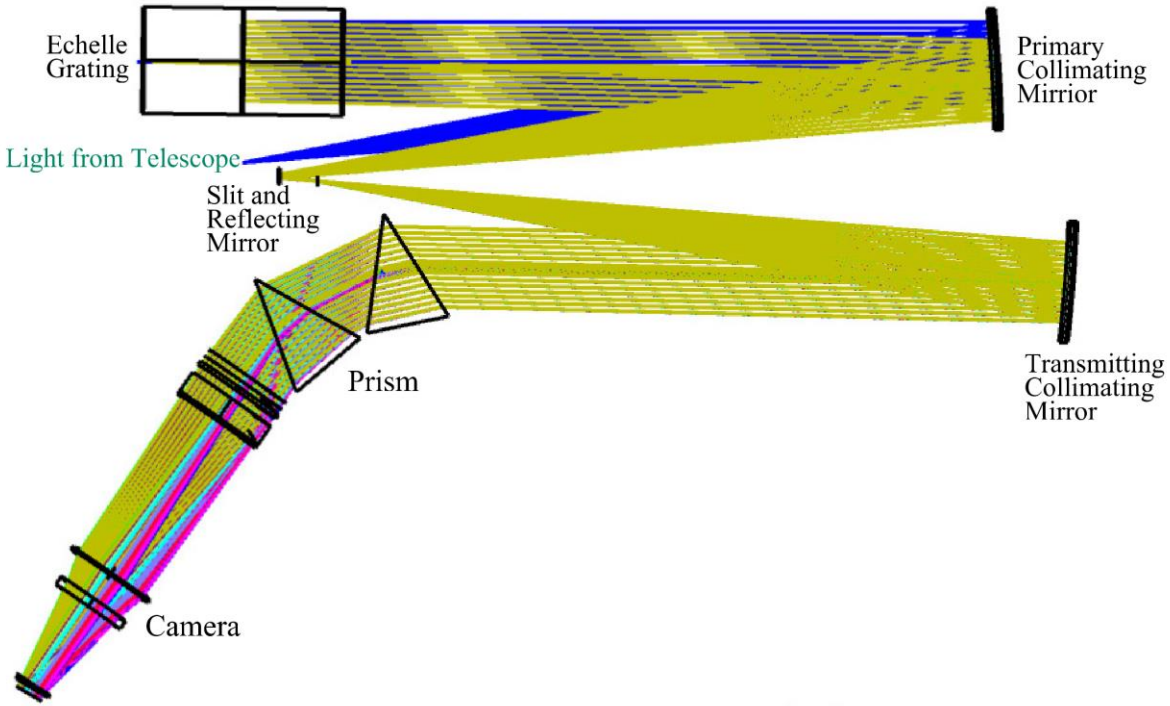
Parameter	Value
Pixels	1300×1340
Pixel Size	20 µm×20 µm
Image Area	26.0 mm×26.8 mm
FOV	4.40′×4.48′
Cooling Mode	Liquid Nitrogen:
	–70° C to –110° C, +/– 0.05° C
Linearity	< 1% (100 kHz), <2%(1 MHz)
Readout Noise	2.8e$^-$ (Low speed, Low gain mode)
	16.3e$^-$ (High speed, High gain mode)





Parameter	Value
Pixels	4096×4096
Pixel Size	12 μm×12 μm
Image Area	49.2 mm×49.2 mm
Cooling Mode	TEC semiconductor cooling: –90° C (With water cycle cooling)
Readout Noise	$<5.0e^-$ (Readout speed: 50 kHz) $<7.0e^-$ (Readout speed: 250 kHz)

HiRES

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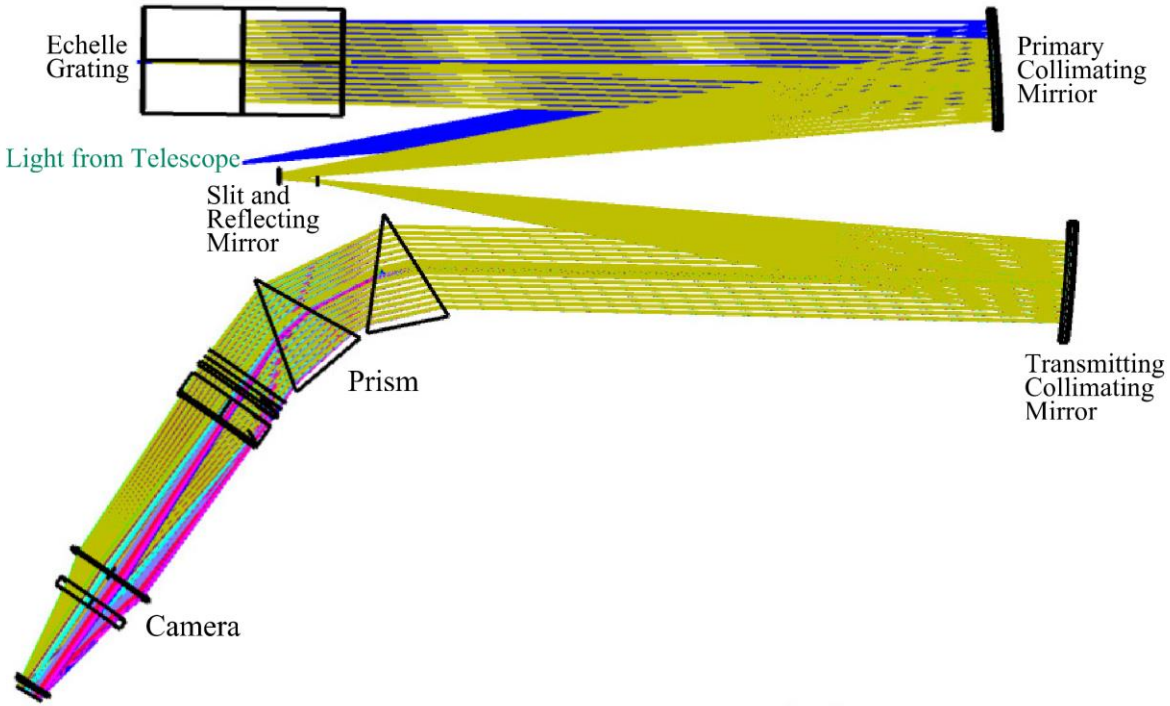
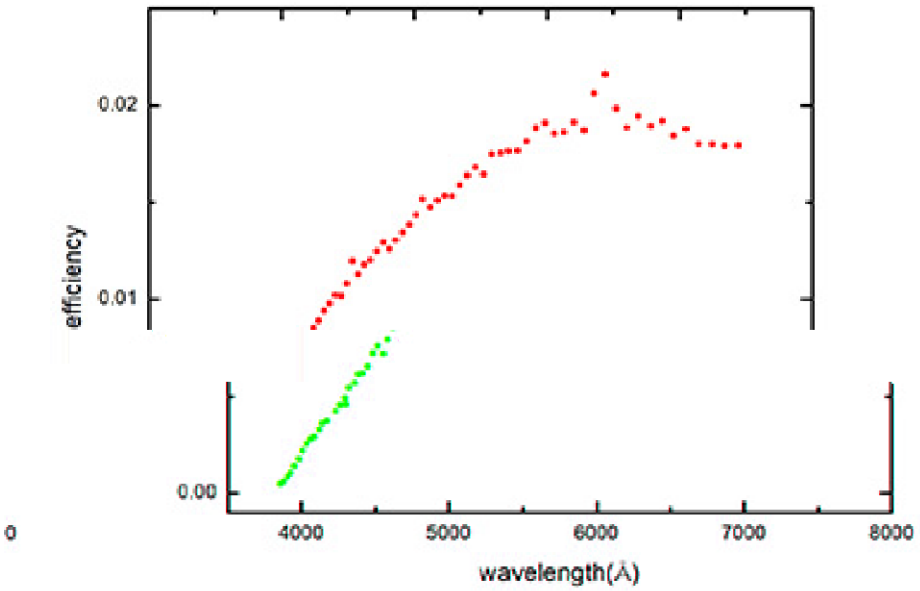
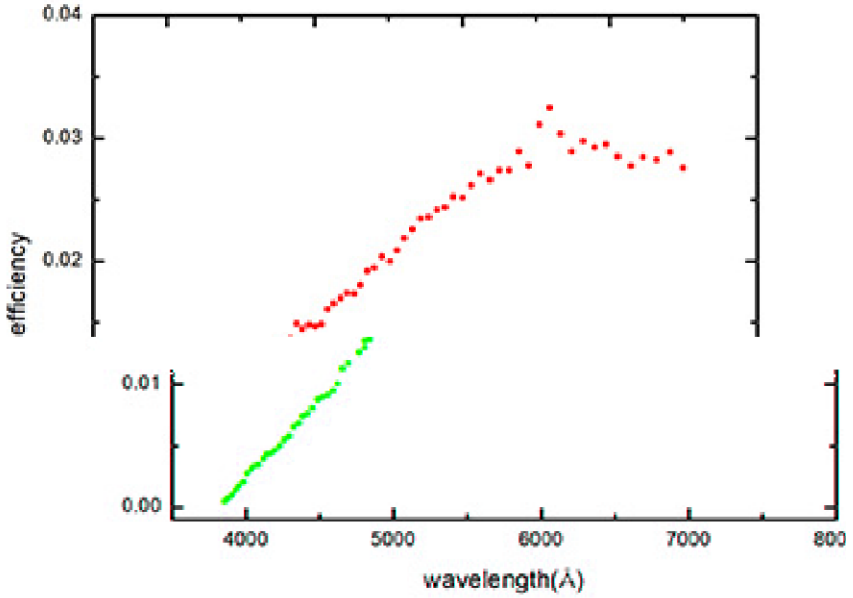
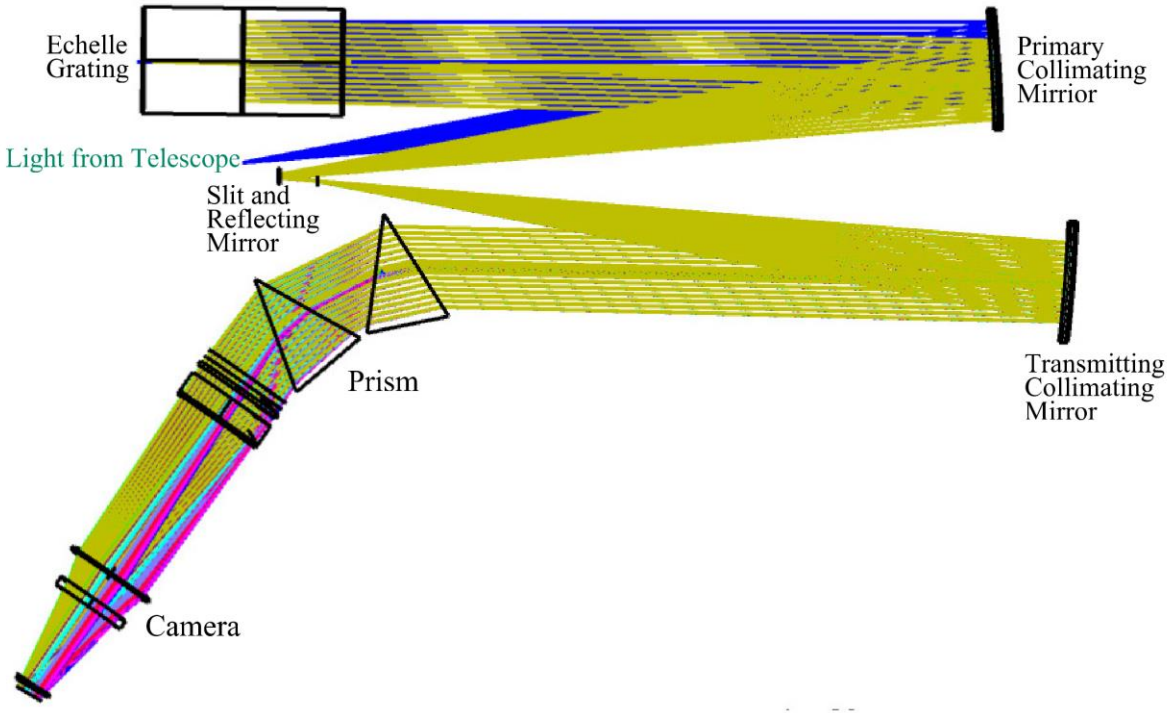


Parameter	Value
Pixels	4096×4096
Pixel Size	12 μm×12 μm
Image Area	49.2 mm×49.2 mm
Cooling Mode	TEC semiconductor cooling: –90° C (With water cycle cooling)
Readout Noise	<5.0e⁻ (Readout speed: 50 kHz) <7.0e⁻ (Readout speed: 250 kHz)

HiRES







Parameter	Value
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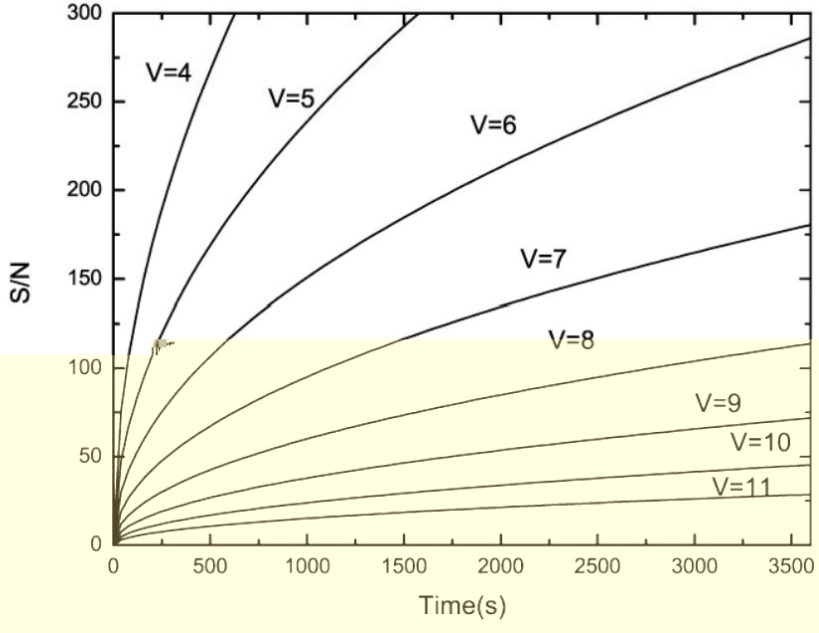
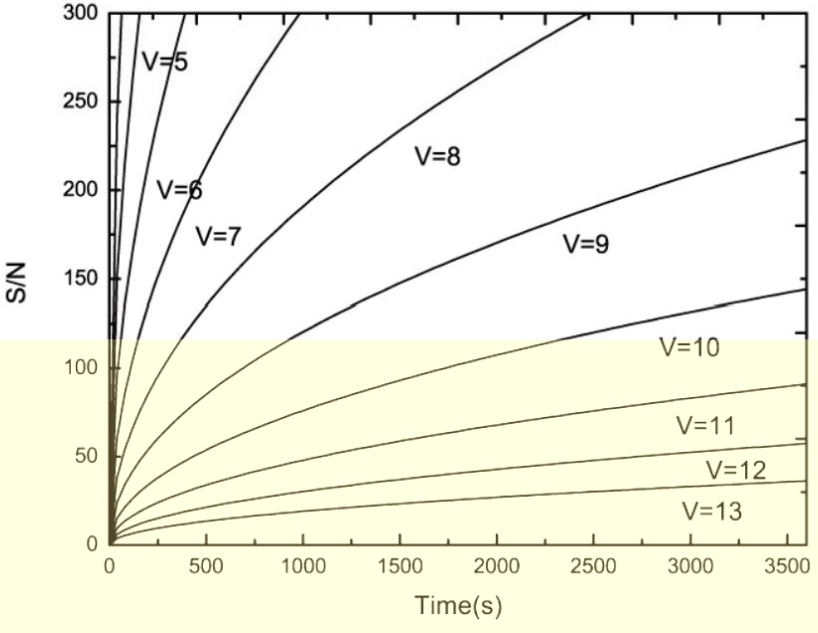
Cooling Mode	TEC semiconductor cooling: –90° C (With water cycle cooling)
Readout Noise	<5.0e⁻ (Readout speed: 50 kHz) <7.0e⁻ (Readout speed: 250 kHz)

HiRES





LiJET

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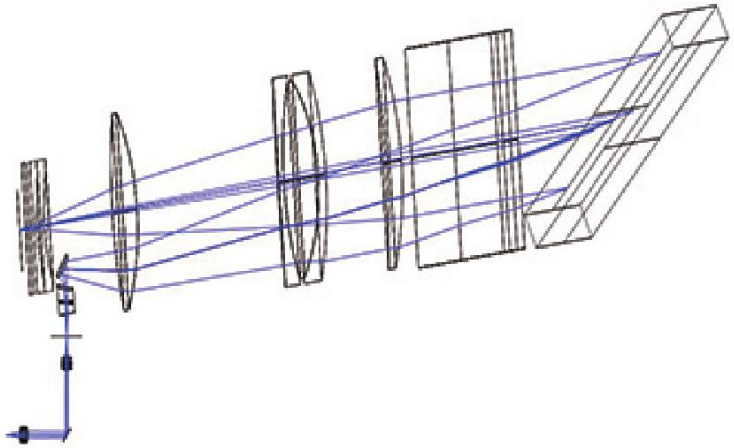

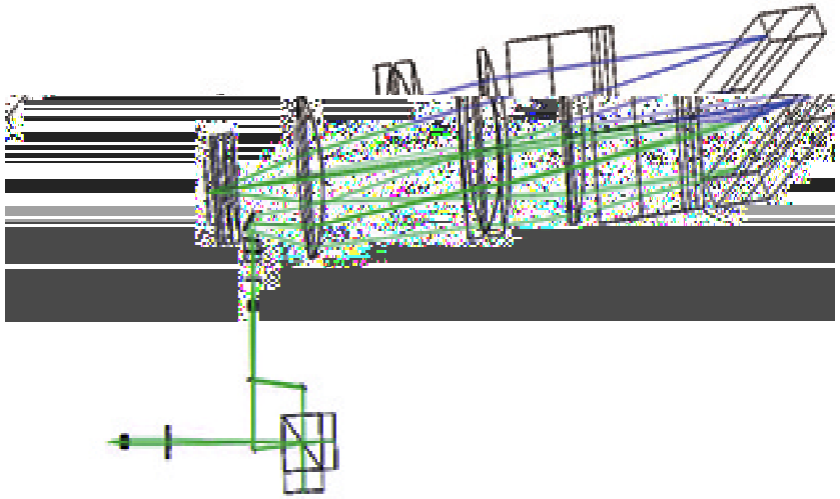

LiJET

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CHILI

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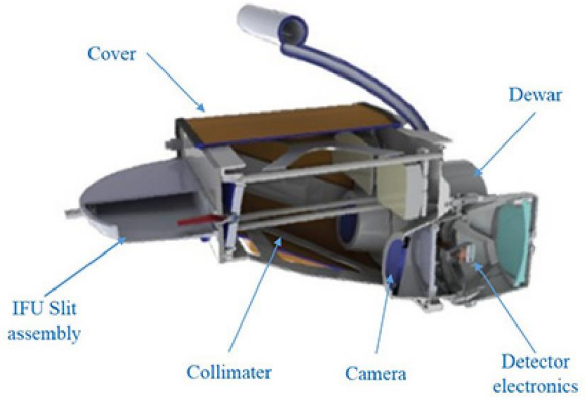
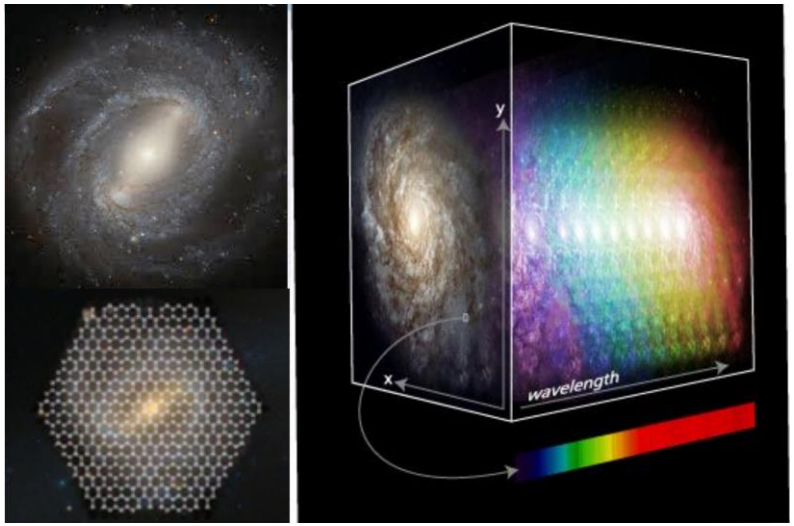
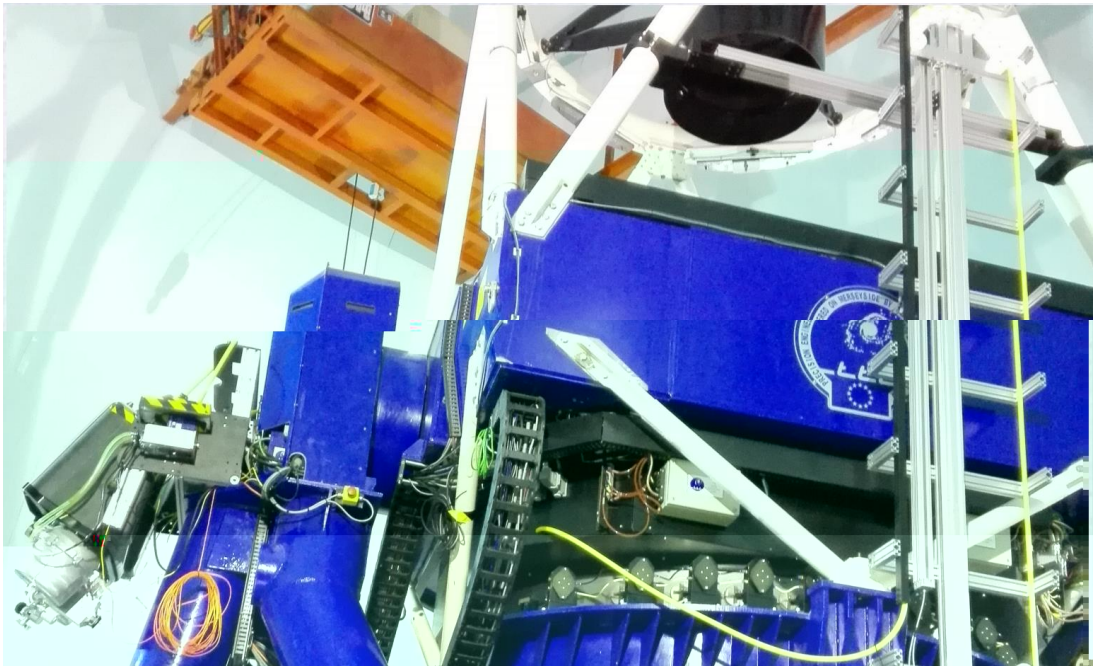
CCD	Number of Pixels	2048×2048
	Pixel Size	15 μm×15 μm
60 nm–720 nm)	Grating 2	Resolving Power 900 (4







Polarimeter

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Science @ YFOSC

- **Time-domain astronomy:**
  - **AGN Reverberation Mapping**
  - **Type-Ia Supernovae at early phase**

50% of total time

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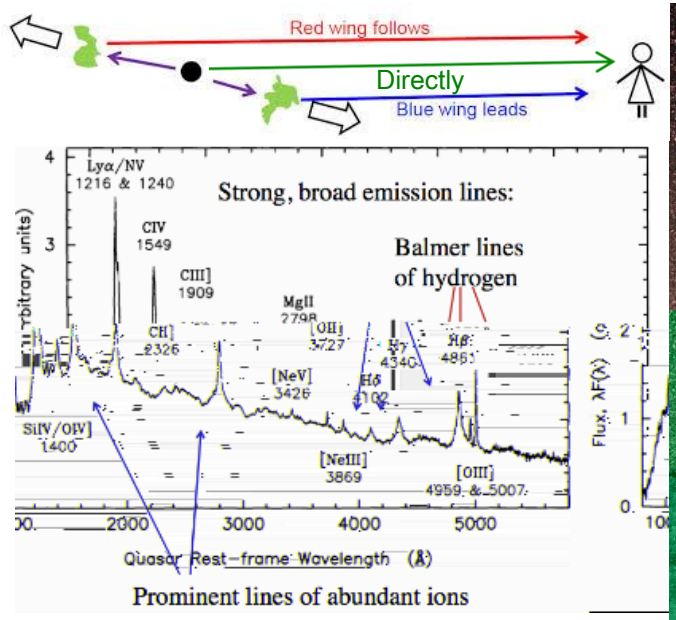
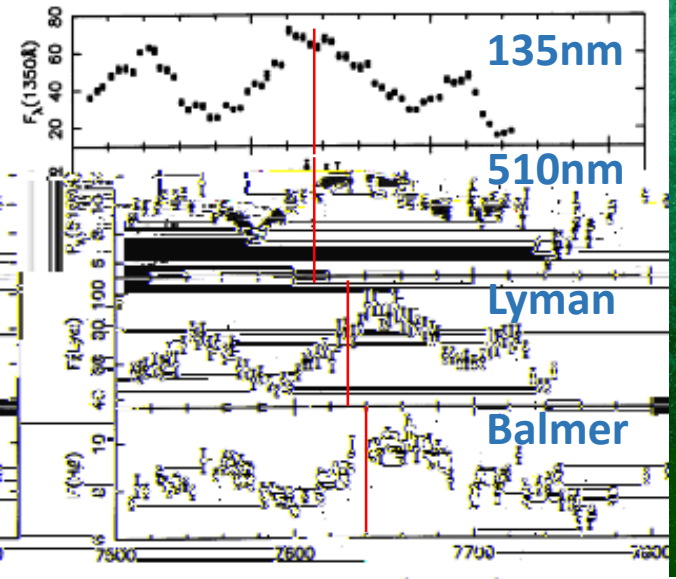
-
-

Reverberation Mapping

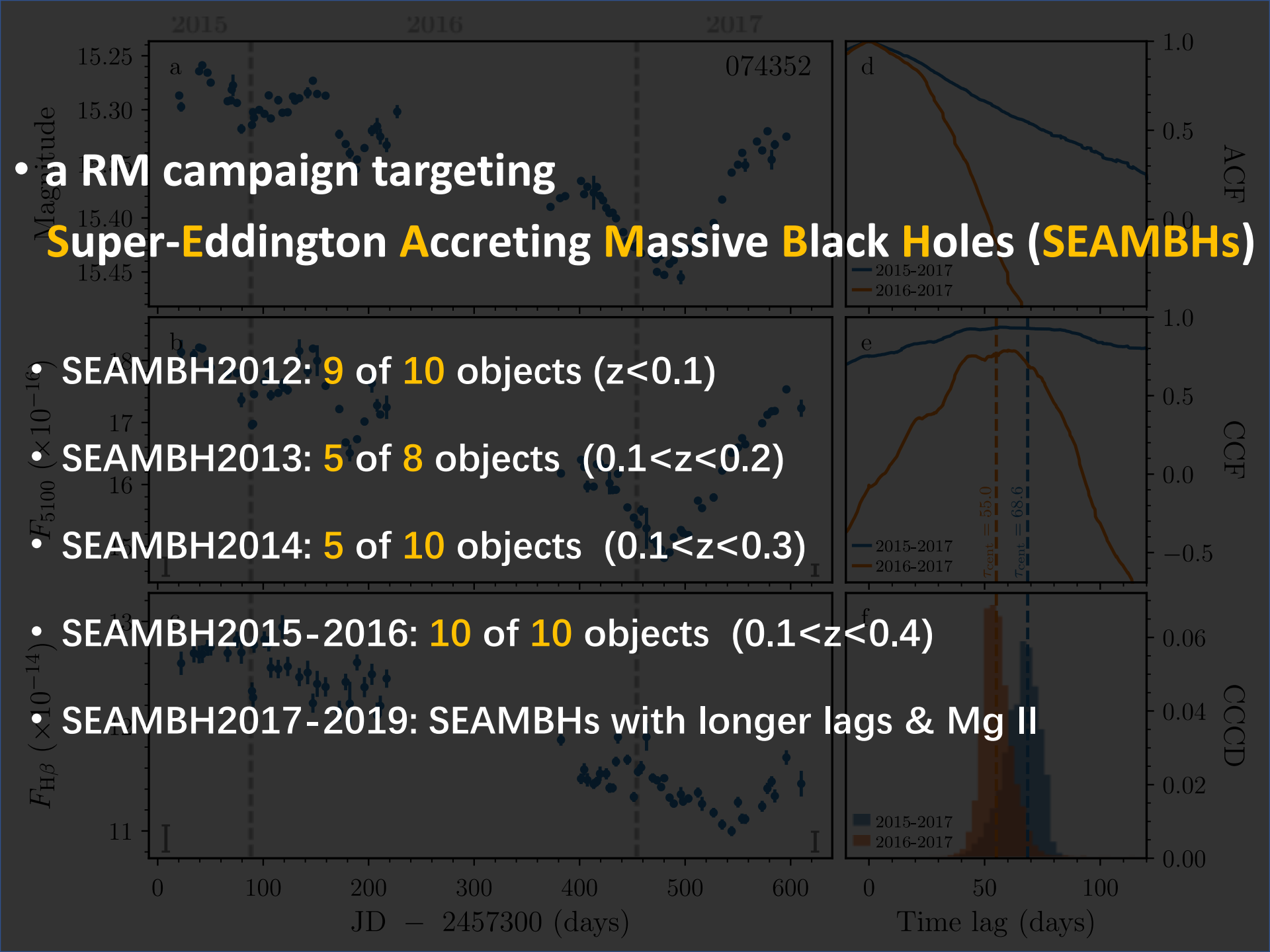




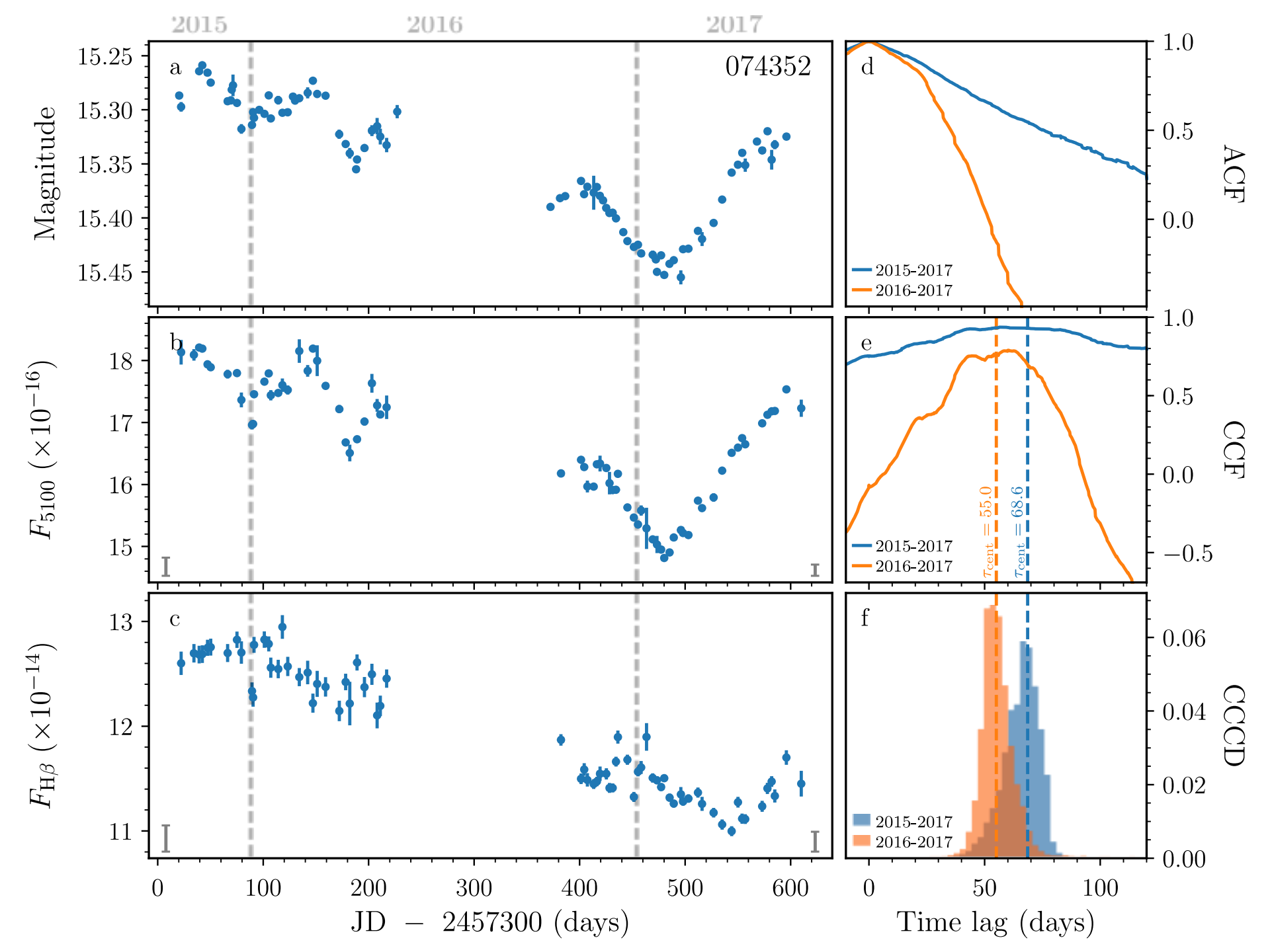
- BH mass
- Broad-line region
- Binary SMBHs
- Cosmology

Broad-line region

Accretion disk

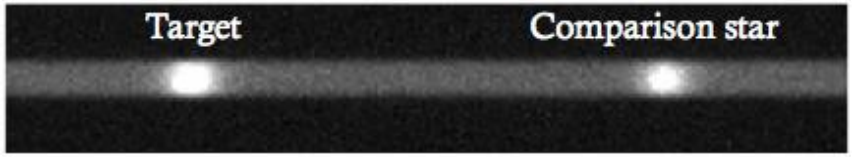


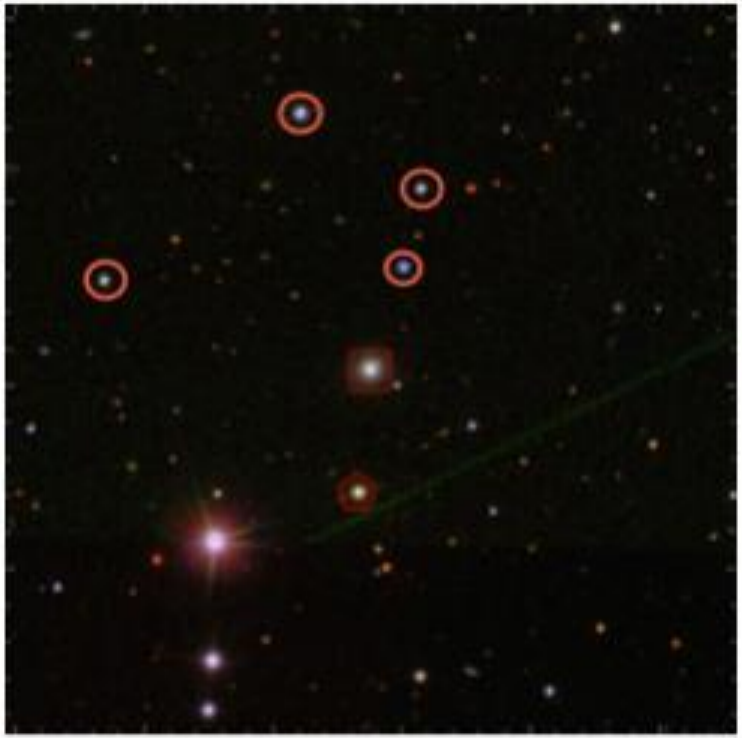
- a RM campaign targeting Super-Eddington Accreting Massive Black Holes (SEAMBHs)
  - SEAMBH2012: 9 of 10 objects (z<0.1)
  - SEAMBH2013: 5 of 8 objects (0.1<z<0.2)
  - SEAMBH2014: 5 of 10 objects (0.1<z<0.3)
  - SEAMBH2015-2016: 10 of 10 objects (0.1<z<0.4)
  - SEAMBH2017-2019: SEAMBHs with longer lags & Mg II


2015
2016
2017
a
074352
Magnitude
b
F_{5100} ($\times 10^{-16}$)
c
$F_{\mathrm{H}\beta}$ ($\times 10^{-14}$)
JD − 2457300 (days)
d
2015-2017
2016-2017
ACF
e
$\tau_{\mathrm{cent}} = 55.0$
$\tau_{\mathrm{cent}} = 68.6$
CCF
f
CCCD
Time lag (days)

Observing strategy

- **Observe a nearby comparison star along the slit simultaneously**
- **Photometry to test the variation**
- **[OIII] too weak!**





Calibration: pros and cons

- **[OIII]-based**

Pros:

no need to rotate the slit

Cons:

Spectral slope issue

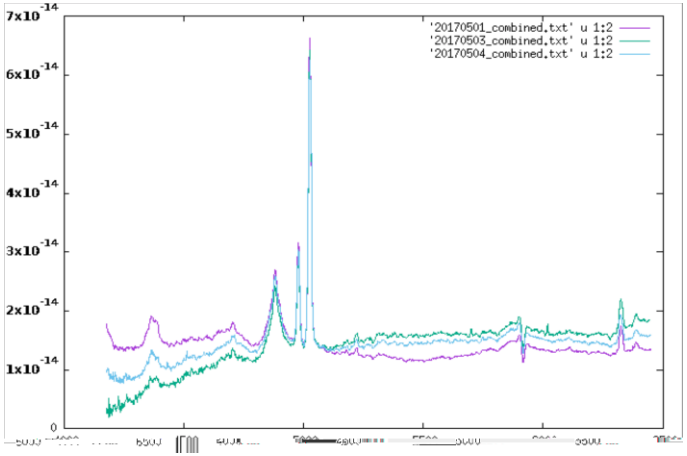
- **Comparison-star-based**

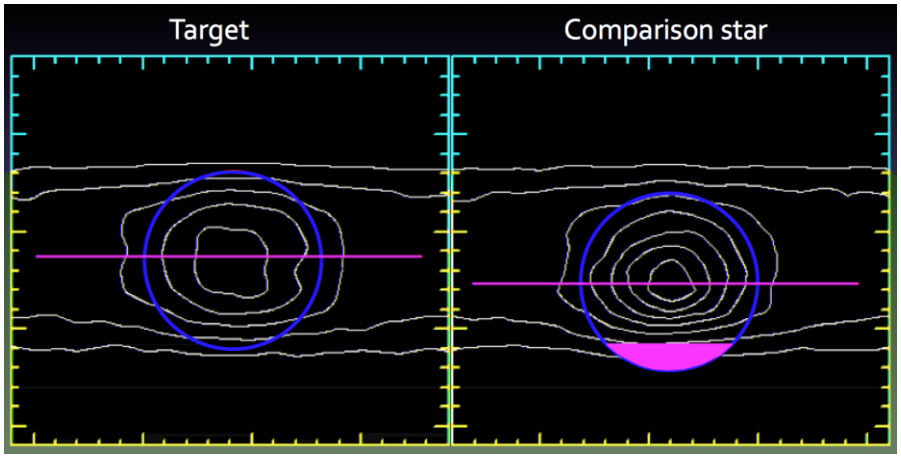
Pros:

Spectral slope calibration

Cons:

Inaccurate slit rotate -> calibration issue





Accuracy of the telescope

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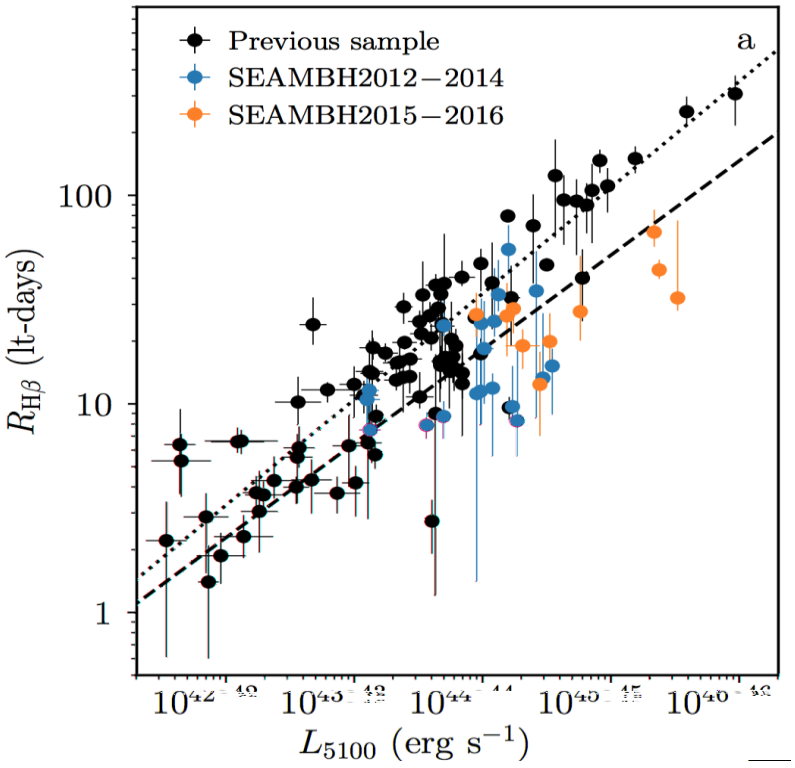
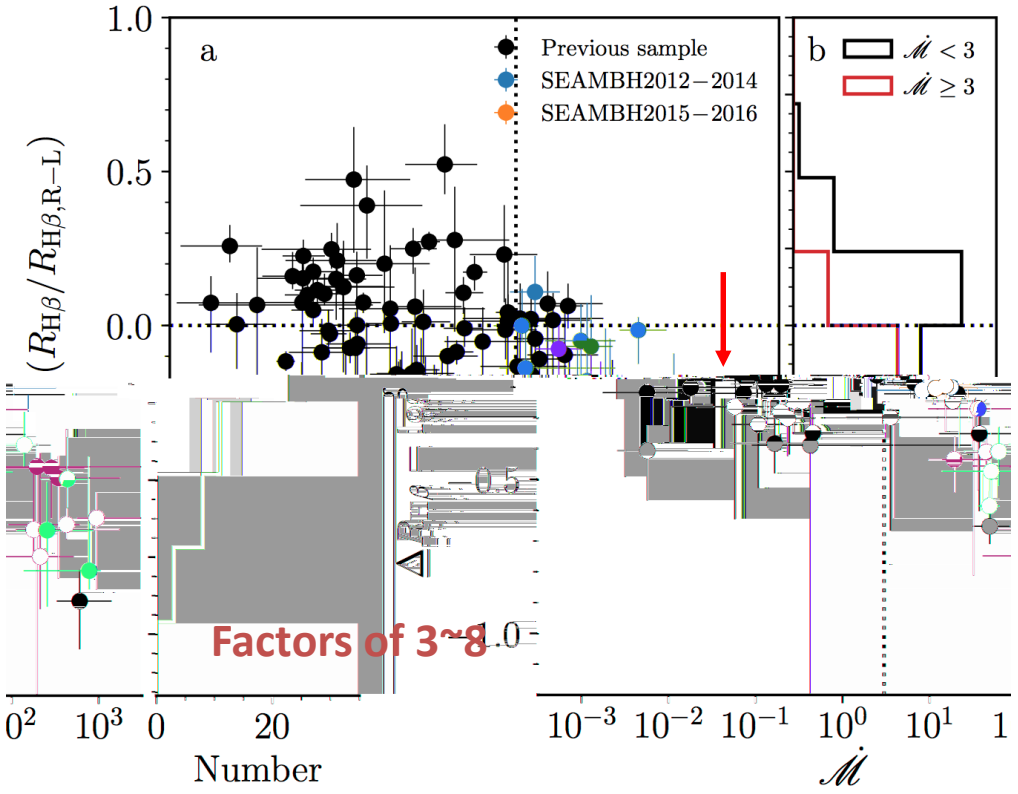
R-L relationship: shorter time lags

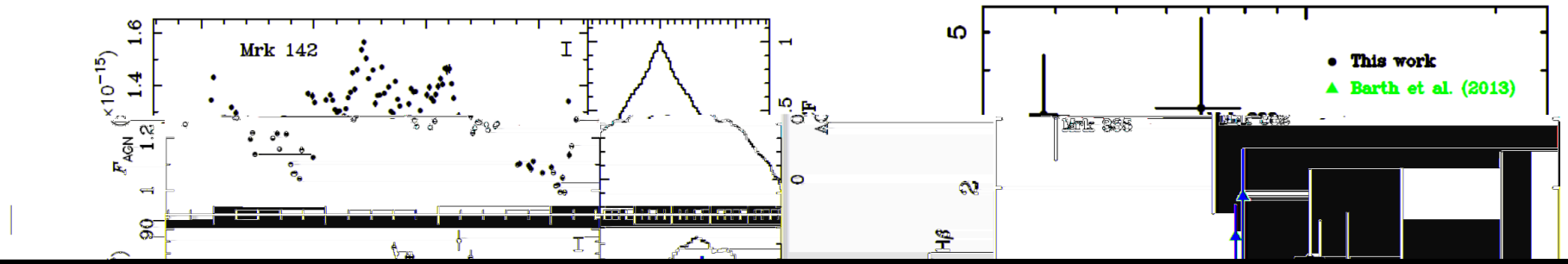


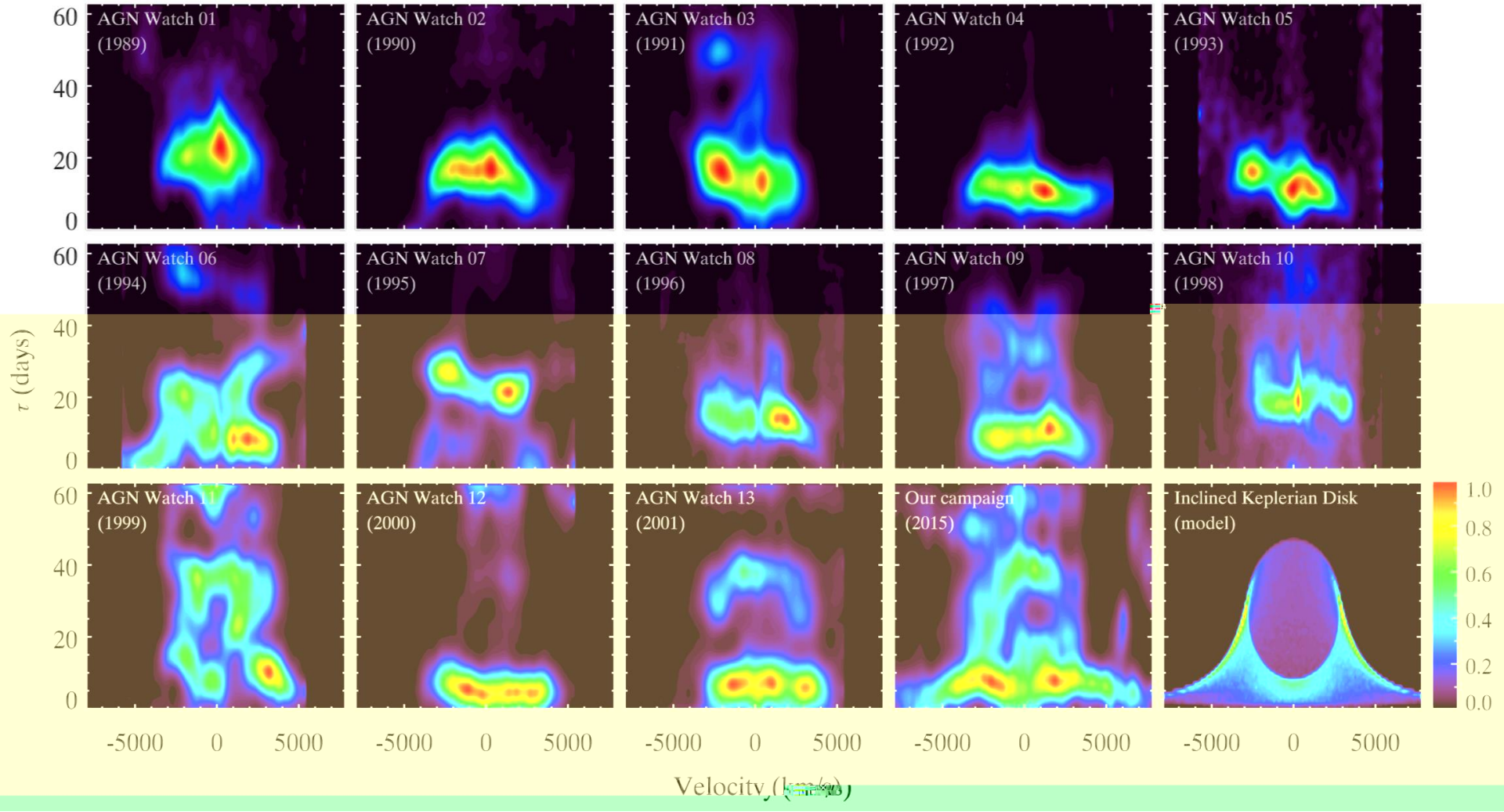


Du et al. (2014; 2015; 2016a; 2018),
Wang et al. (2014), Hu et al. (2015)

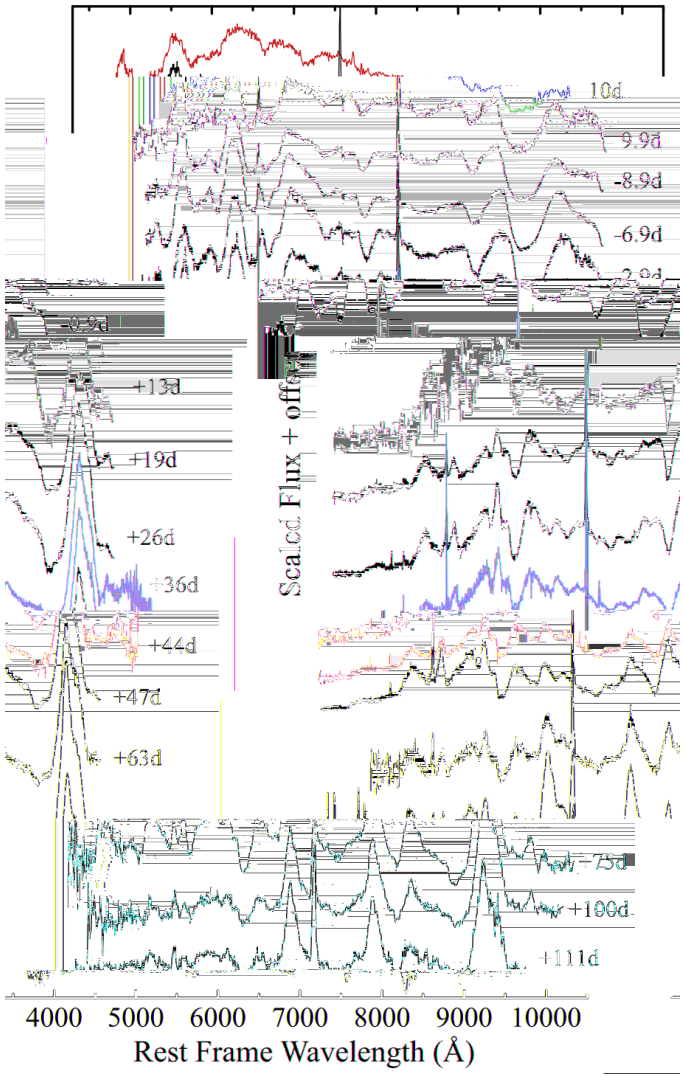
Optical iron Fe II: reverberations

- Fe II lines：eigenvector 1，a proxy of accretion rates or Eddington ratios
- Only 2 AGN measured：photoionized? Regions (accretion disk outer part)?




AGN Watch 01
(1989)
AGN Watch 02
(1990)
AGN Watch 03
(1991)
AGN Watch 04
(1992)
AGN Watch 05
(1993)
AGN Watch 06
(1994)
AGN Watch 07
(1995)
AGN Watch 08
(1996)
AGN Watch 09
(1997)
AGN Watch 10
(1998)
AGN Watch 11
(1999)
AGN Watch 12
(2000)
AGN Watch 13
(2001)
Our campaign
(2015)
Inclined Keplerian Disk
(model)
τ (days)
60
40
20
0
-5000
0
5000
1.0
0.8
0.6
0.4
0.2
0.0

Type-Ia Supernovae at early phase



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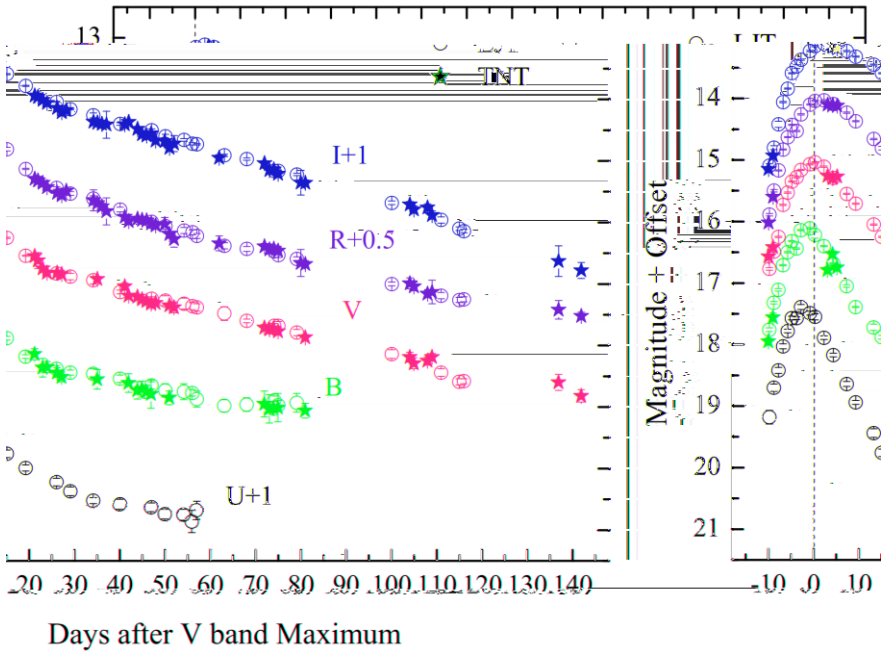

Other AGN researches

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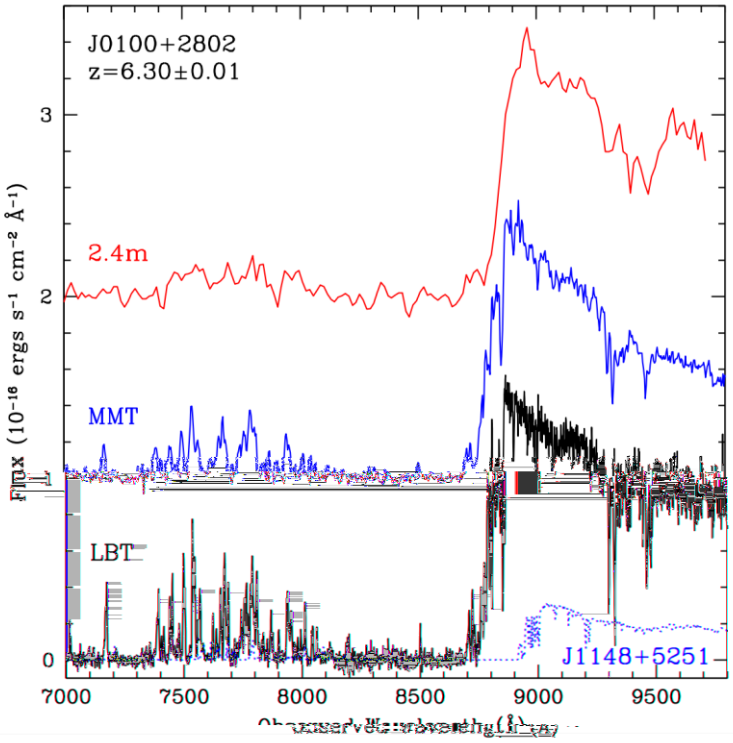

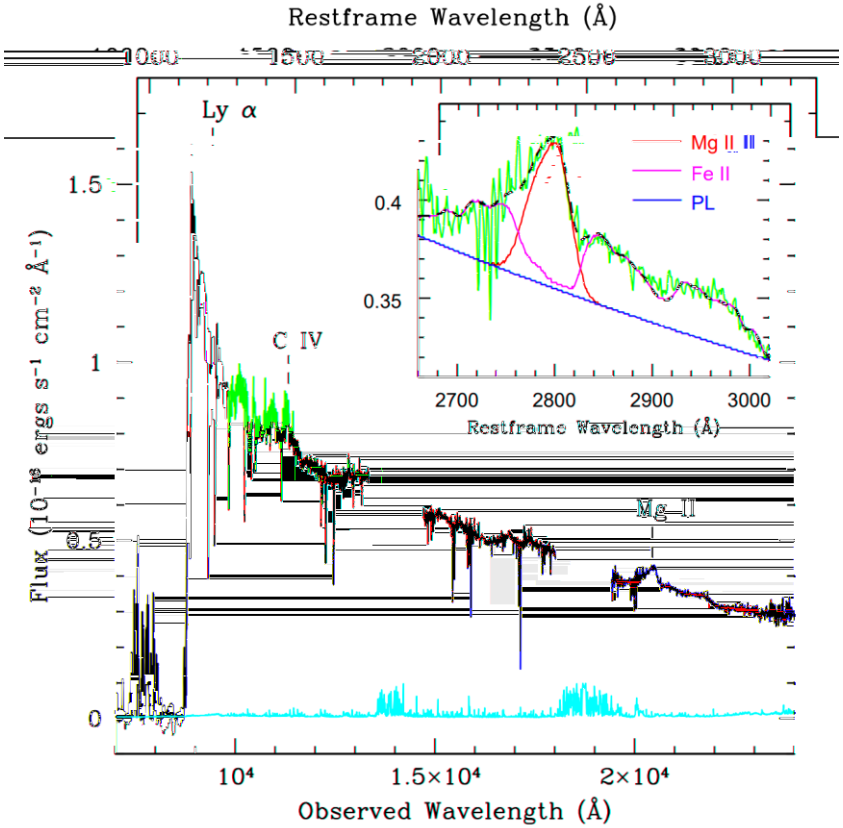

Other AGN researches

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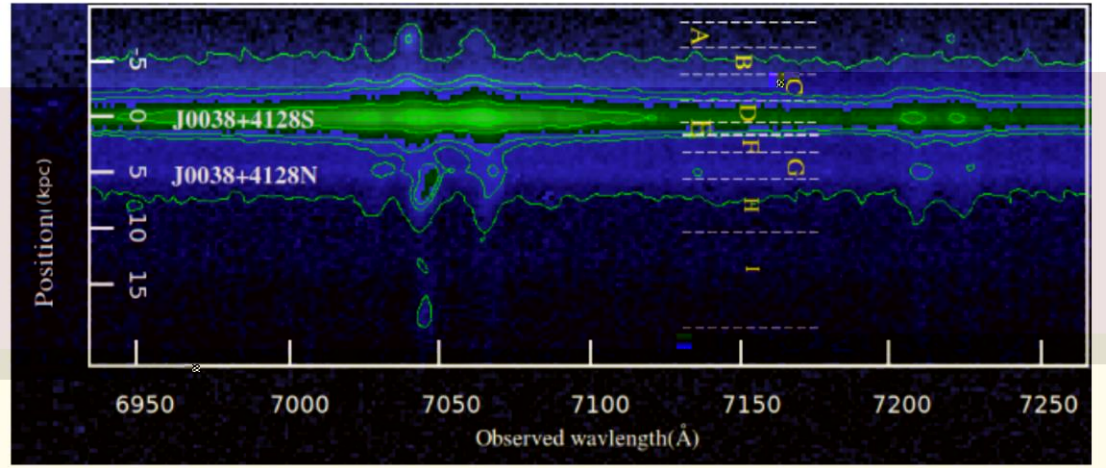

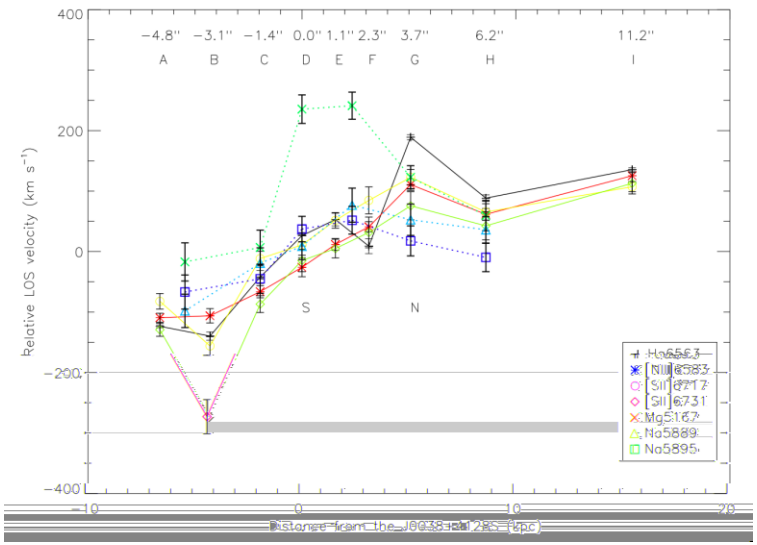

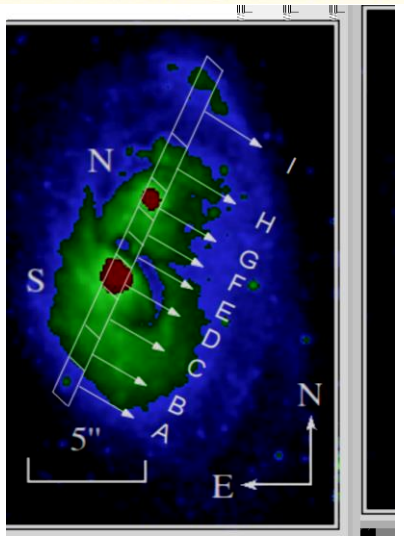

Summary

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