The 4th Workshop on Extra-Solar Planet Search with Precise Radial Velocity Measurements

Astronomy in China Today
- Large Astronomical Facilities in China

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National Astronomical Observatories
Chinese Academy of Sciences

2009-10-09 @ 北海道 (Hokkaido)

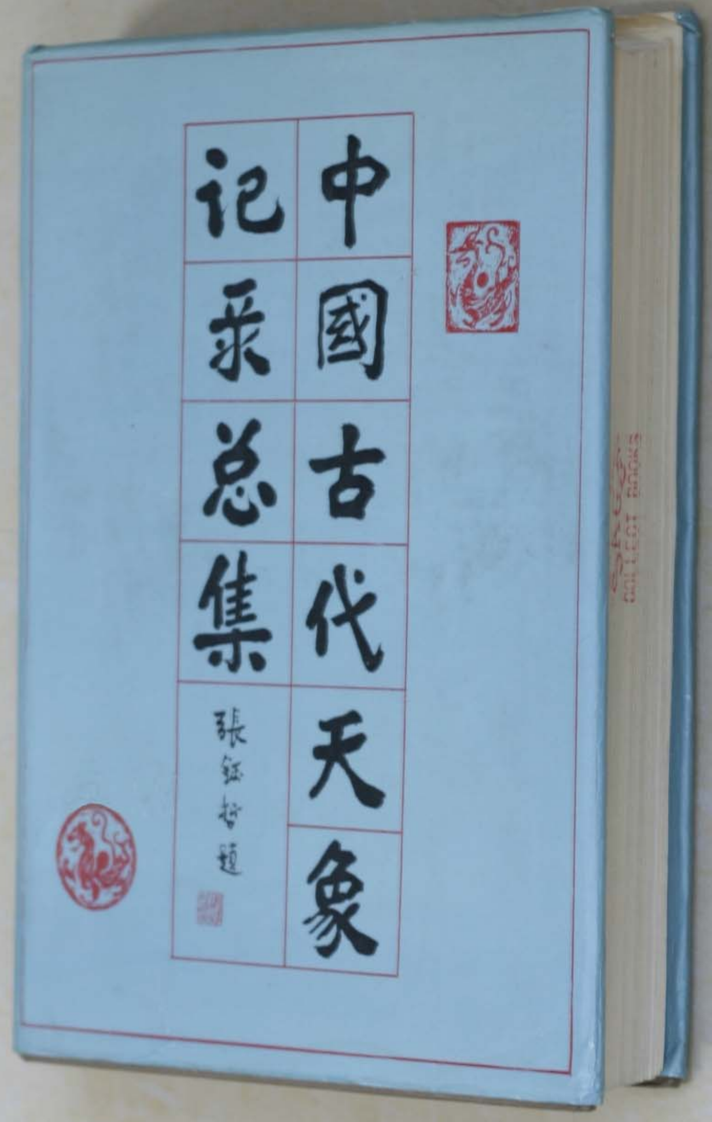
Outline

- **Brief introduction of Chinese astronomy**
- **Ground-based facilities**
- **Space missions**
- **Future projects of Chinese astronomy**
- **Brief summary**

Brief Introduction

- Glory of Chinese ancient astronomy

With over 4,000 years' development, the Chinese ancient astronomy experienced a lengthy period of spectacular prosperity. This precious history not only established a profound foundation for the development of Chinese astronomy and bequeathed to us as a priceless legacy, but also serves as an otherwise unavailable source of records for modern astronomical research.



<The collection of Chinese historical astronomical records>
1100 pages with 10000 records

Brief Introduction
- Growing community

- The past 30 years since the adoption of 'open door policy' have witnessed great advance in astronomical studies in China, especially in the last decade

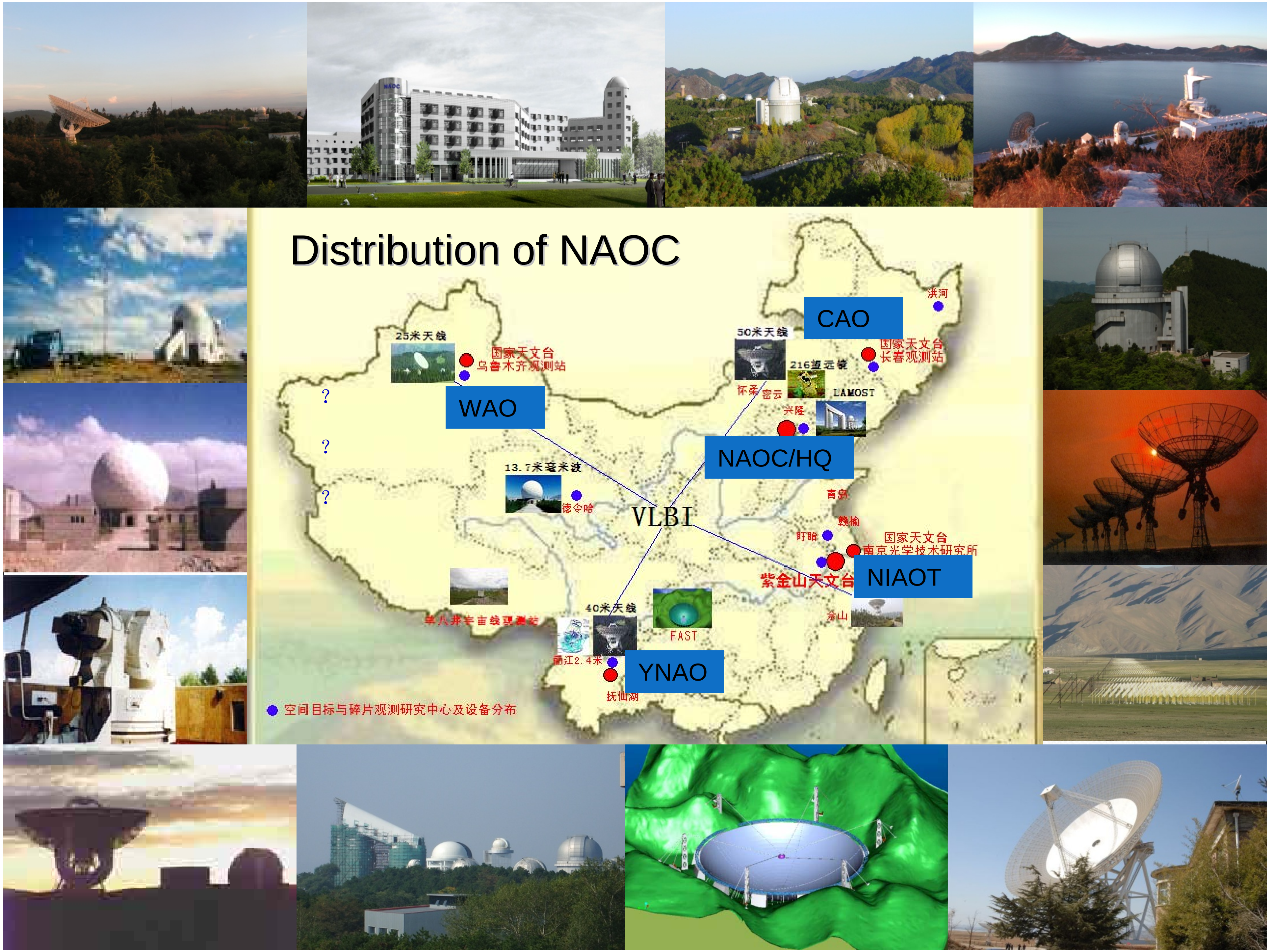
	1997	2007
Research funding	~3 Million $	~30 Million $
Faculty	~ 600	~ 900
Ph.D.	~ 12 per year	~ 80 per year
Journal papers	~150	~650

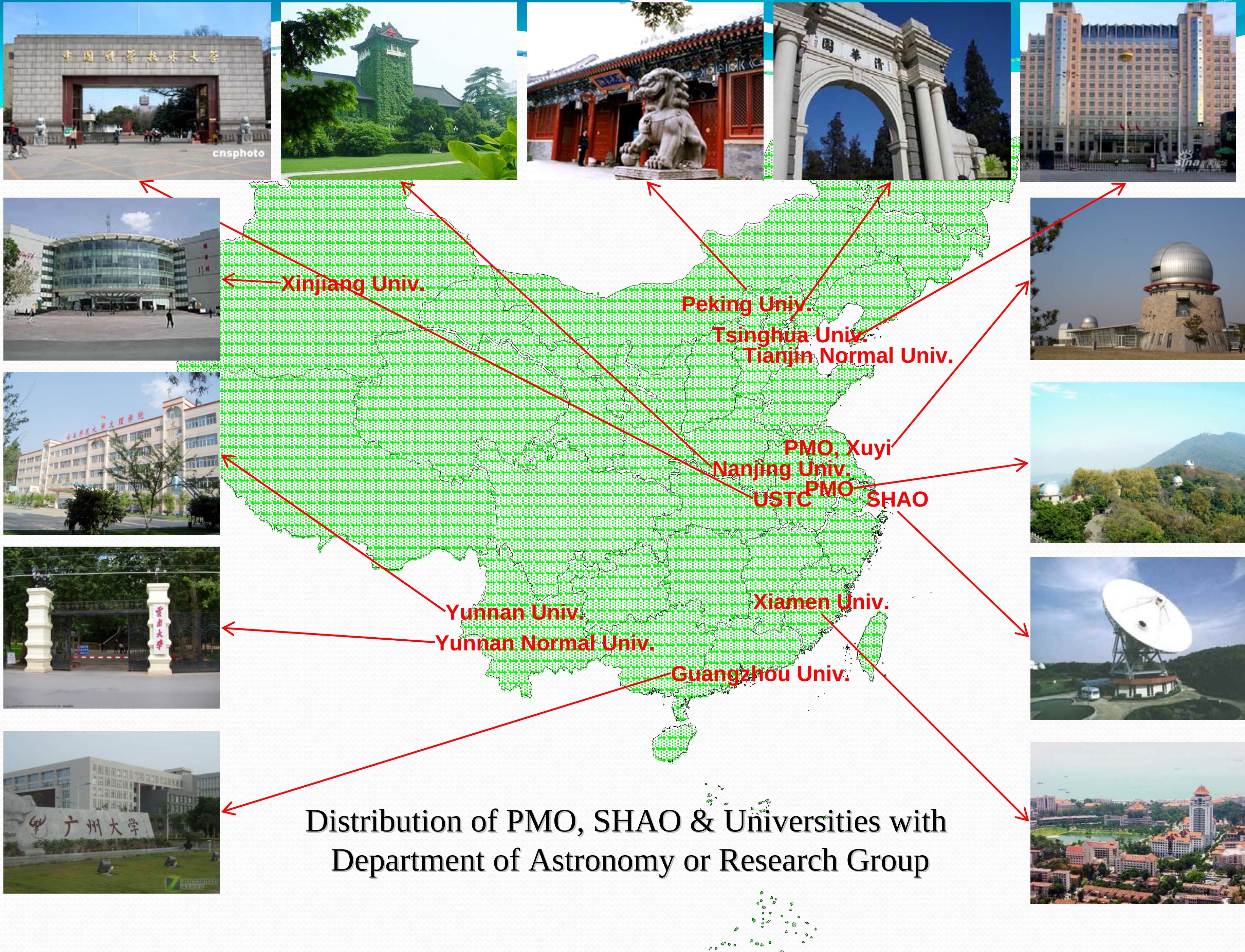
Brief Introduction

- Astronomical research institutions
  - Chinese Academy of Sciences (CAS)
    - National Astronomical Observatories
    - Purple Mountain Observatory
    - Shanghai Observatory
    - Univ. of S & T of China
  - Ministry of Education
    - Nanjing University
    - Peking University
    - Tsinghua University
    - Beijing Normal University
    - … …

National Astronomical Observatories

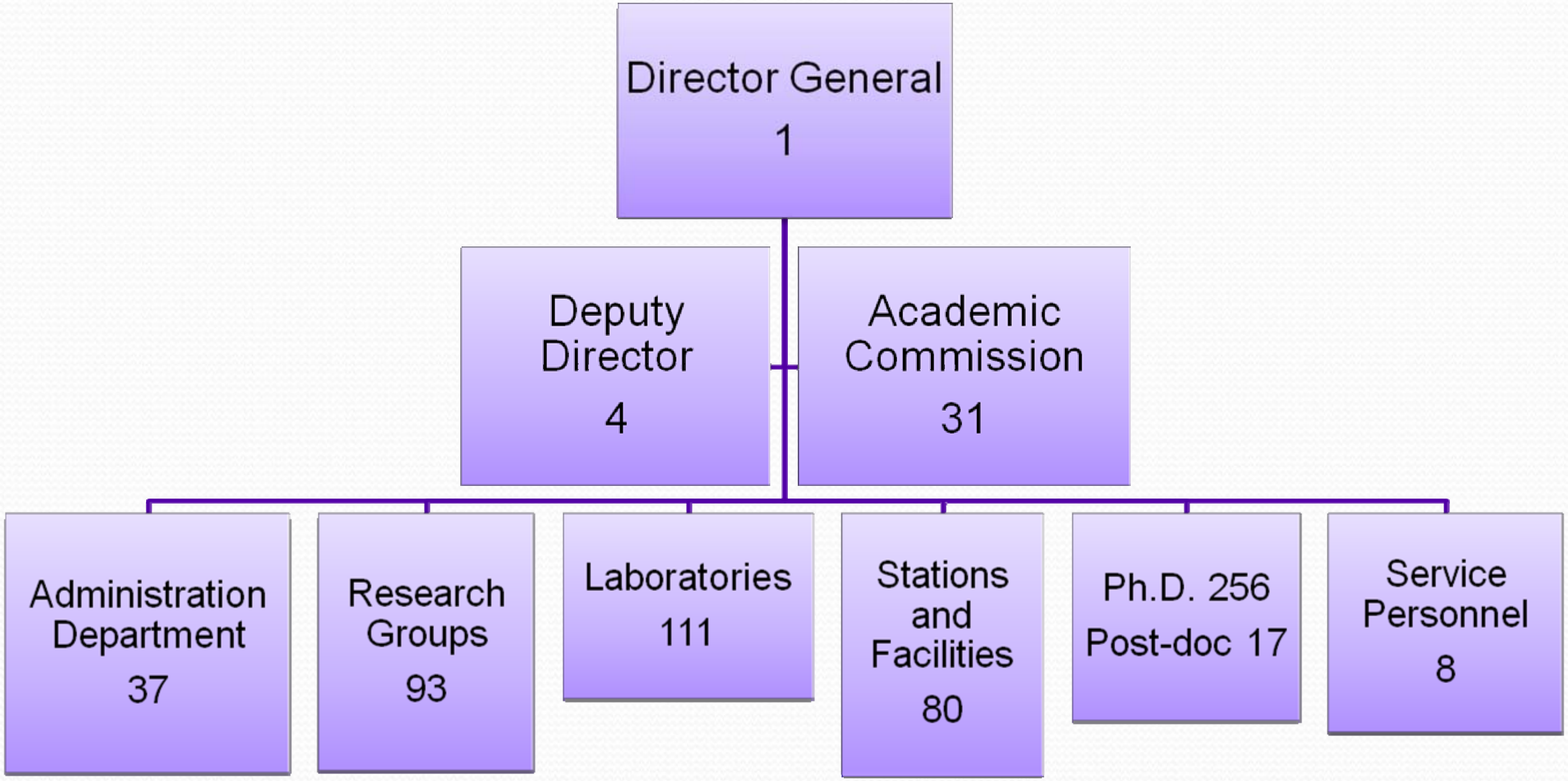
Nanjing University


Distribution of NAOC
25米天线
国家天文台
乌鲁木齐观测站
WAO
CAO
洪河
50米天线
国家天文台
长春观测站
216望远镜
怀柔
密云
LAMOST
兴隆
NAOC/HQ
13.7米毫米波
德令哈
VLBI
青岛
赣榆
盱眙
国家天文台
南京光学技术研究所
紫金山天文台
NIAOT
佘山
FAST
40米天线
丽江2.4米
YNAO
抚仙湖
空间目标与碎片观测研究中心及设备分布



Distribution of PMO, SHAO & Universities with Department of Astronomy or Research Group

Structure of NAOC (HQ)



Brief Introduction

- Astronomical journals

- Four professional journals
- Including one English journal
  - *Chinese Journal of Astronomy and Astrophysics*, ChJAA
  - *Research in Astronomy and Astrophysics* from 2009
- Two amateur astronomical magazines

Brief Introduction

- China has been playing a more and more important role in the international astronomical community
  - Wider international collaborations.
  - The 28th General Assembly of the International Astronomical Union (IAU GA) will be held in Beijing, China. This milestone event would promote China's international status and enhance its presence in the astronomical community.
  - China also hosts more and more international symposiums, workshops, conferences.

CNCC Panorama

Undertaking some renovations in late 2009 after Beijing Olympics

国家会议中心
CHINA NATIONAL CONVENTION CENTER

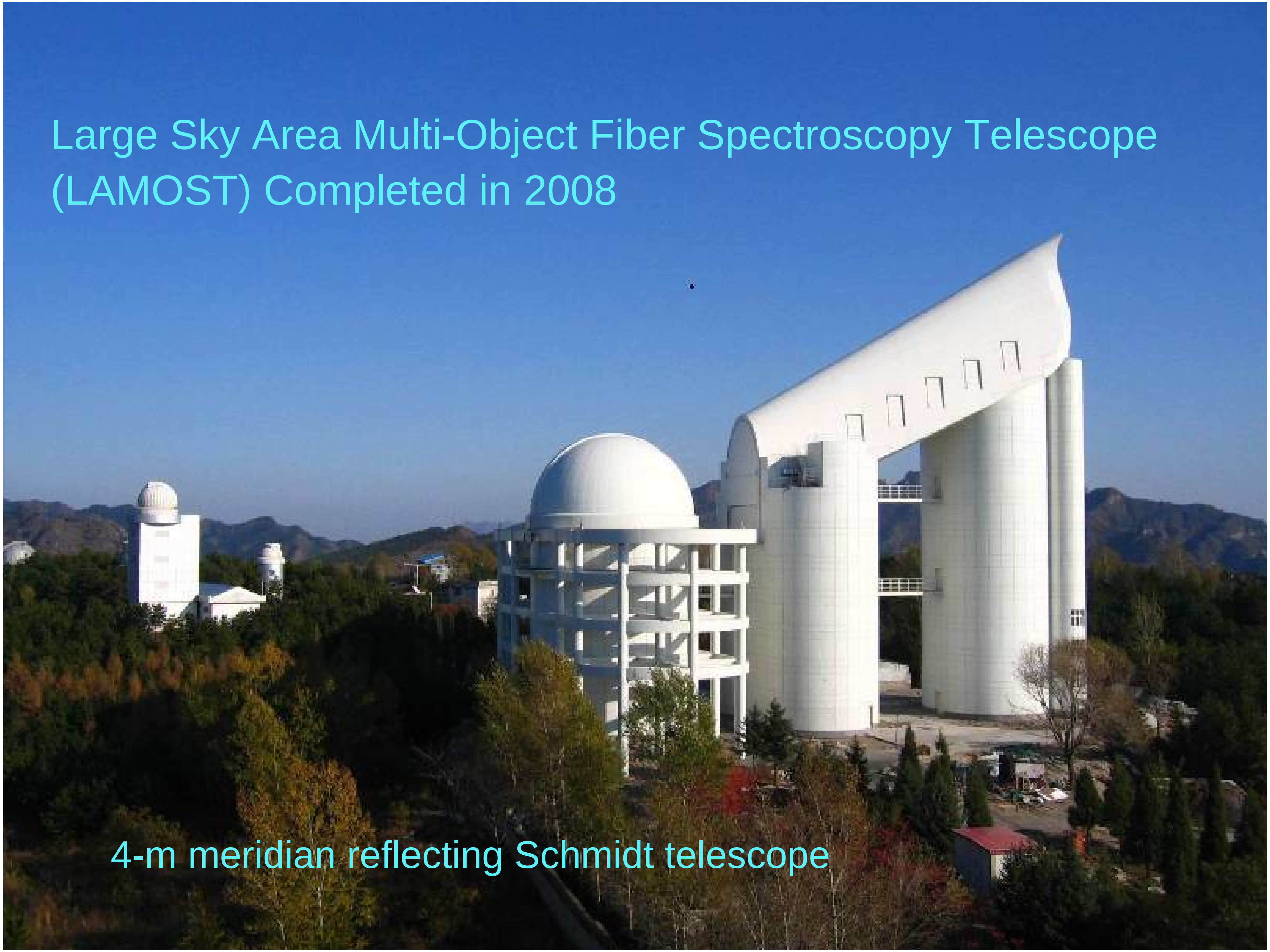
WWW.CNCCCHINA.COM

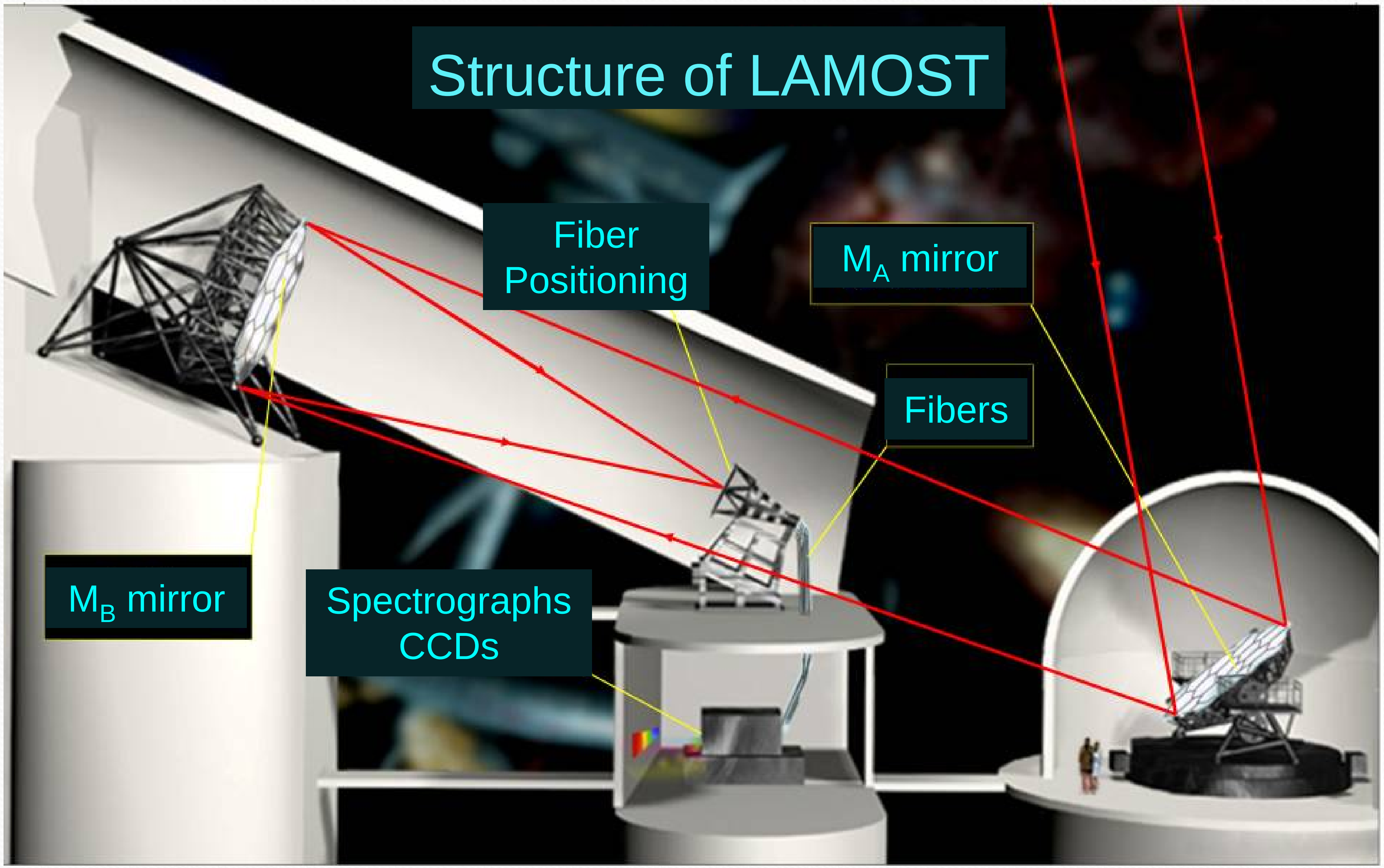
The largest convention hall covers an area as large as 6,400 square meters, with 6,000 seats that can be removed or relocated to meet any special requirements.

The grand banquet hall can accommodate 3,500 people with more than 4860 square meters in size and 10 meters ceiling height . The pillar-free design offers a versatile range of possibilities in function plan for the grand banquet hall.

Ground Based Astronomical Facilities

Progress of LAMOST, FAST, 21CMA, and CSRH

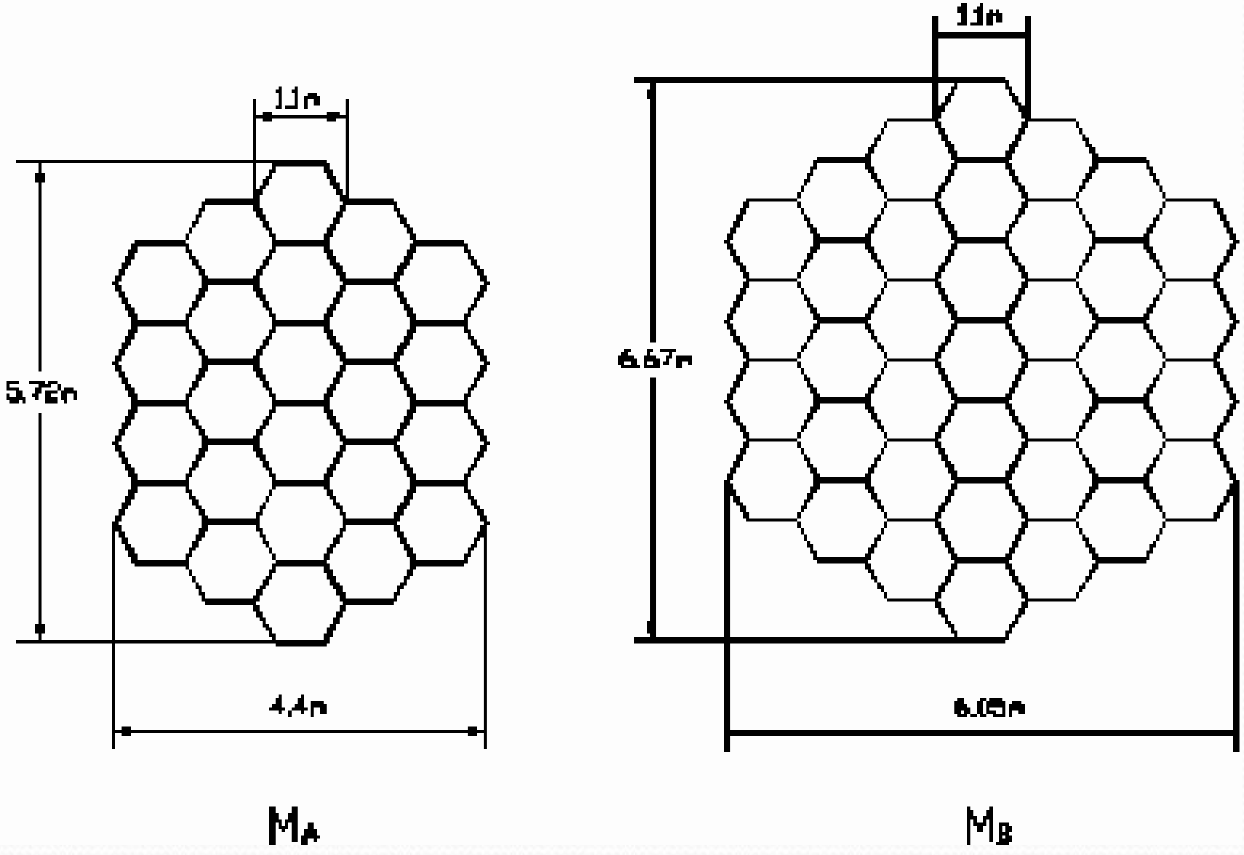

Large Sky Area Multi-Object Fiber Spectroscopy Telescope (LAMOST) Completed in 2008
4-m meridian reflecting Schmidt telescope


Structure of LAMOST
Fiber Positioning
M_A mirror
Fibers
M_B mirror
Spectrographs CCDs

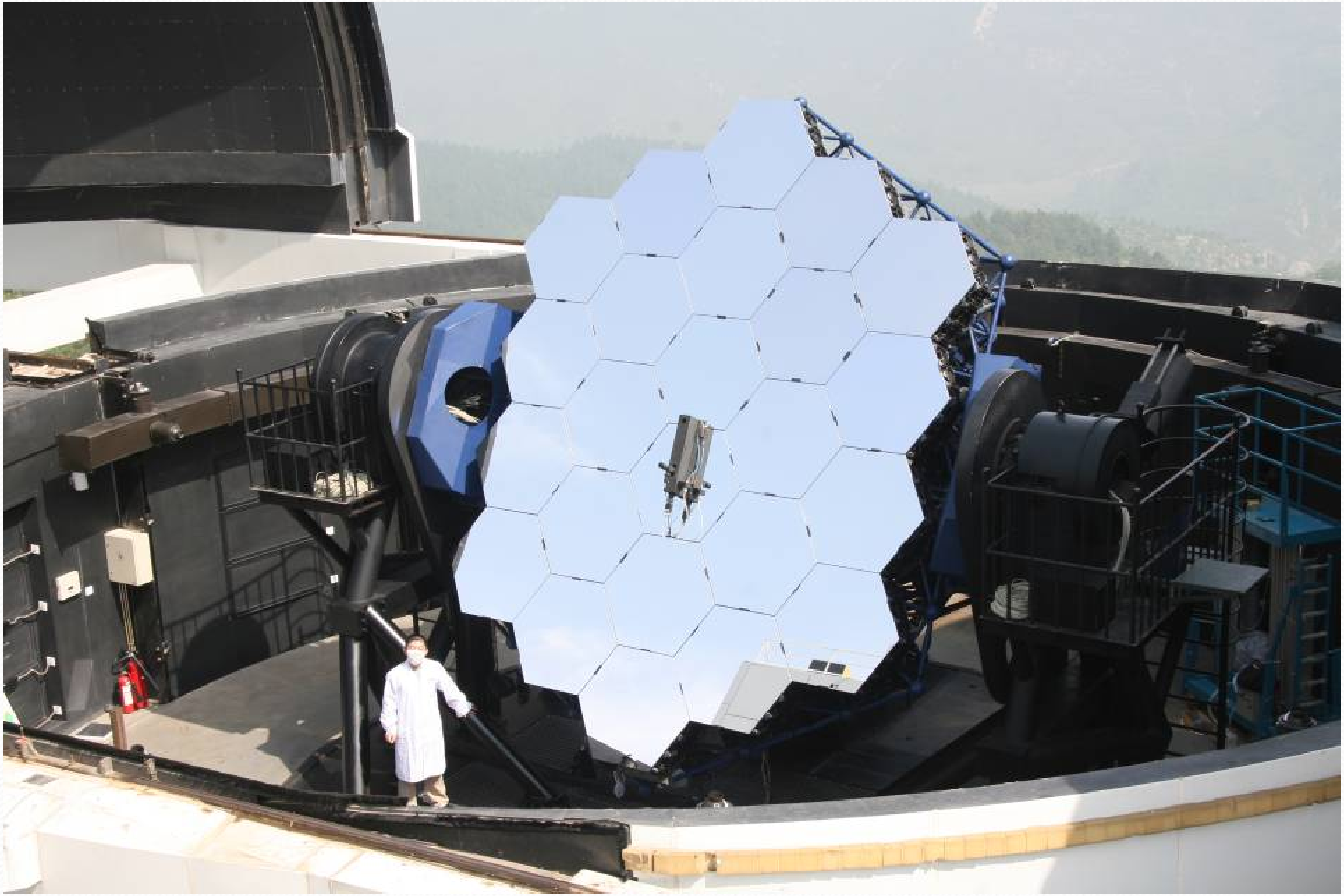
Basic parameters of LAMOST

- Schmidt telescope: 4.8m/6.1m
- Declination of observable sky area: -10° ~ +90°.
- FOV: 20 square degree
- Fibers: 4000
- Spectrum resolution:
  - VPH (Volume Phase Holographic) Grating
  - R = 1000/2000; 5000/10000

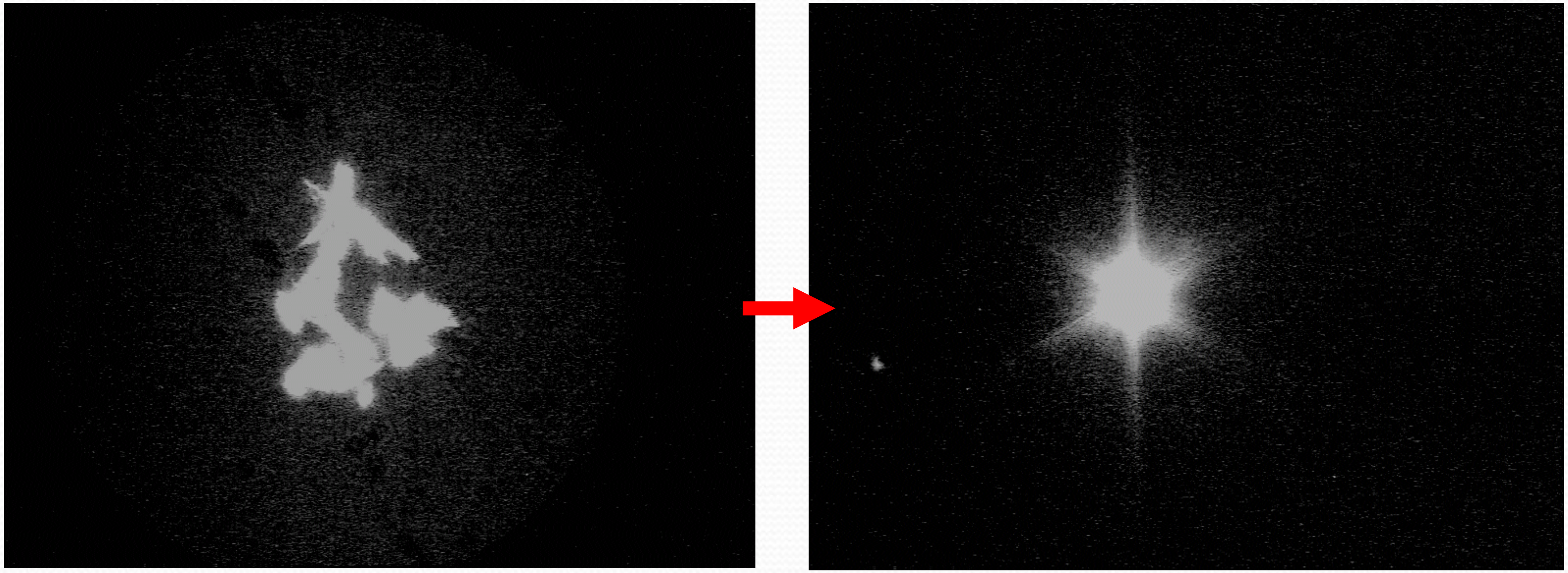
- Ma: reflecting corrector (24 sub-mirrors) ~ 4.8m
- Mb: spherical mirror (37 sub-mirrors) ~ 6.1m



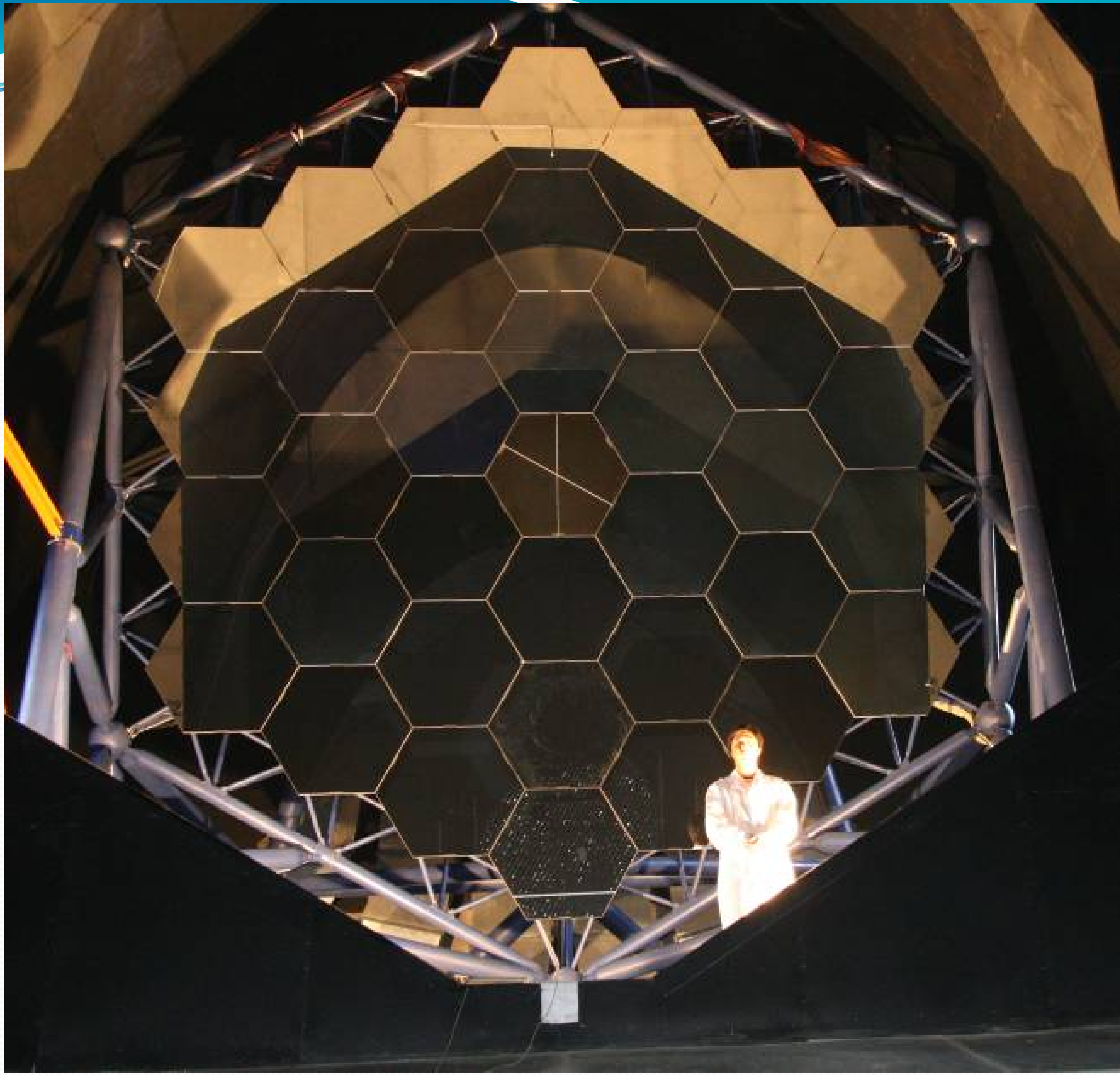
24 sub-mirrors of M_A



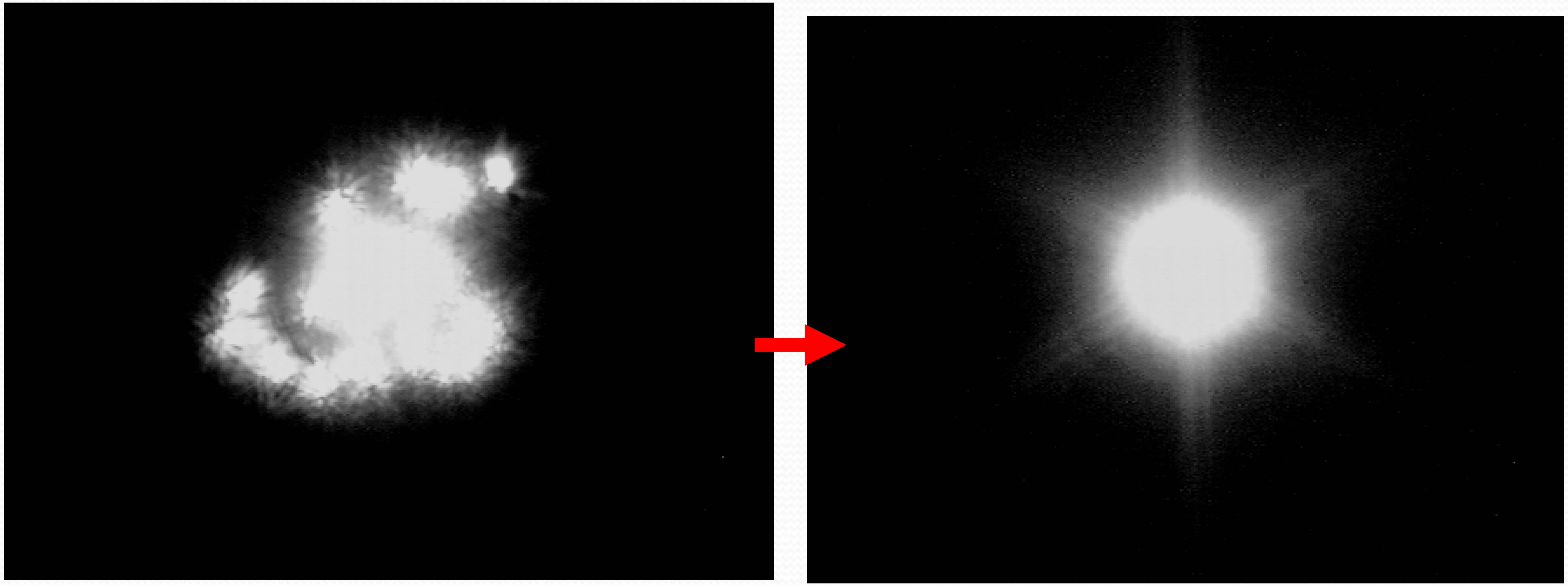
- 24 sub-mirrors of M_A （Sept. 10, 2008)

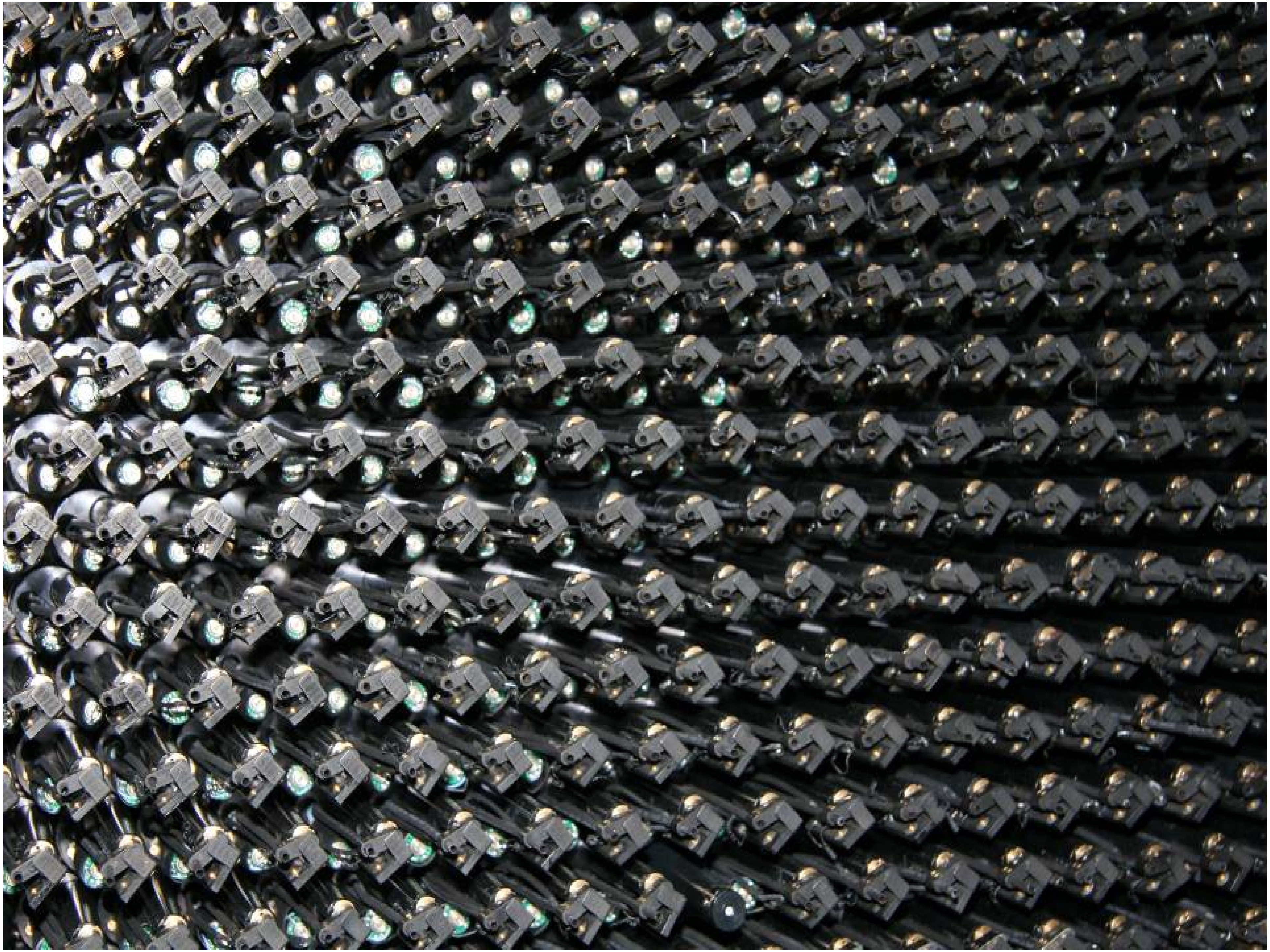


M_B

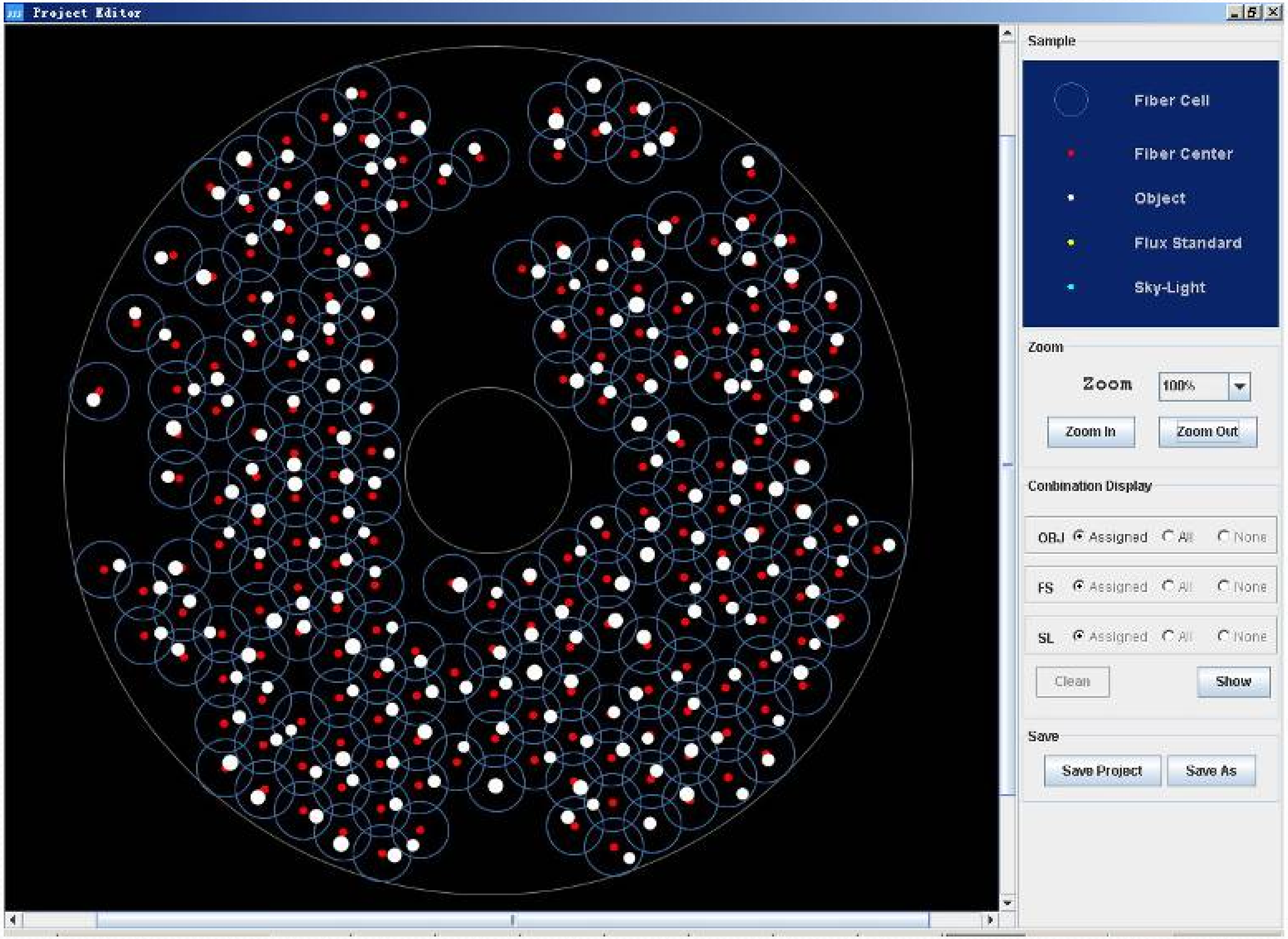


- 37 sub-mirrors of M_B （July 13, 2008)





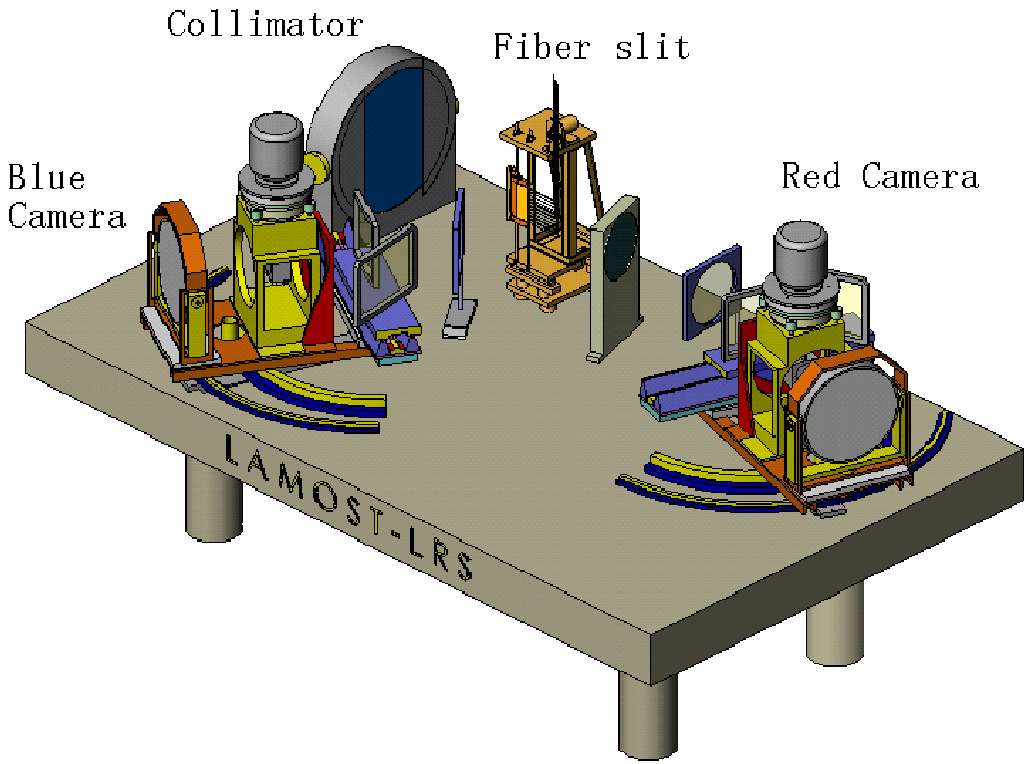
Select the targets

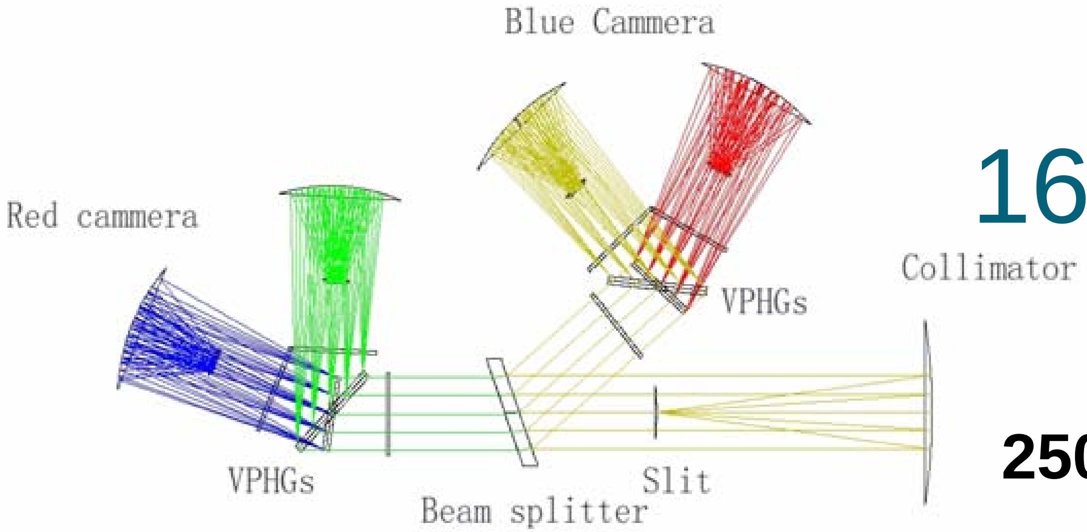


Spectrographs room

R_L = 1000/2000

R_M= 5000/10000





16 spectrographs

250 fibers per spectrograph

LAMOST Spectrographs (I)

Low Resolution Spectrographs (LRS)

	Blue Arm		Red Arm	
	R	wave.(nm)	R	wave.(nm)
full slit	1000	370-590	1000	570-900
1/2 slit	2000	370-590	2000	570-900

16 LRSs with two 4K x 4K CCD each

LAMOST Spectrographs (II)

Medium Resolution Spectrographs (MRS)

	Blue Arm		Red Arm	
	R	wave.(nm)	R	wave.(nm)
full slit	5000	510-550	5000	830-890
1/2 slit	10000	510-550	10000	830-890

* other wavelength ranges can be achieved by turning Volume Phase Holographic Grating

Technical Challenges

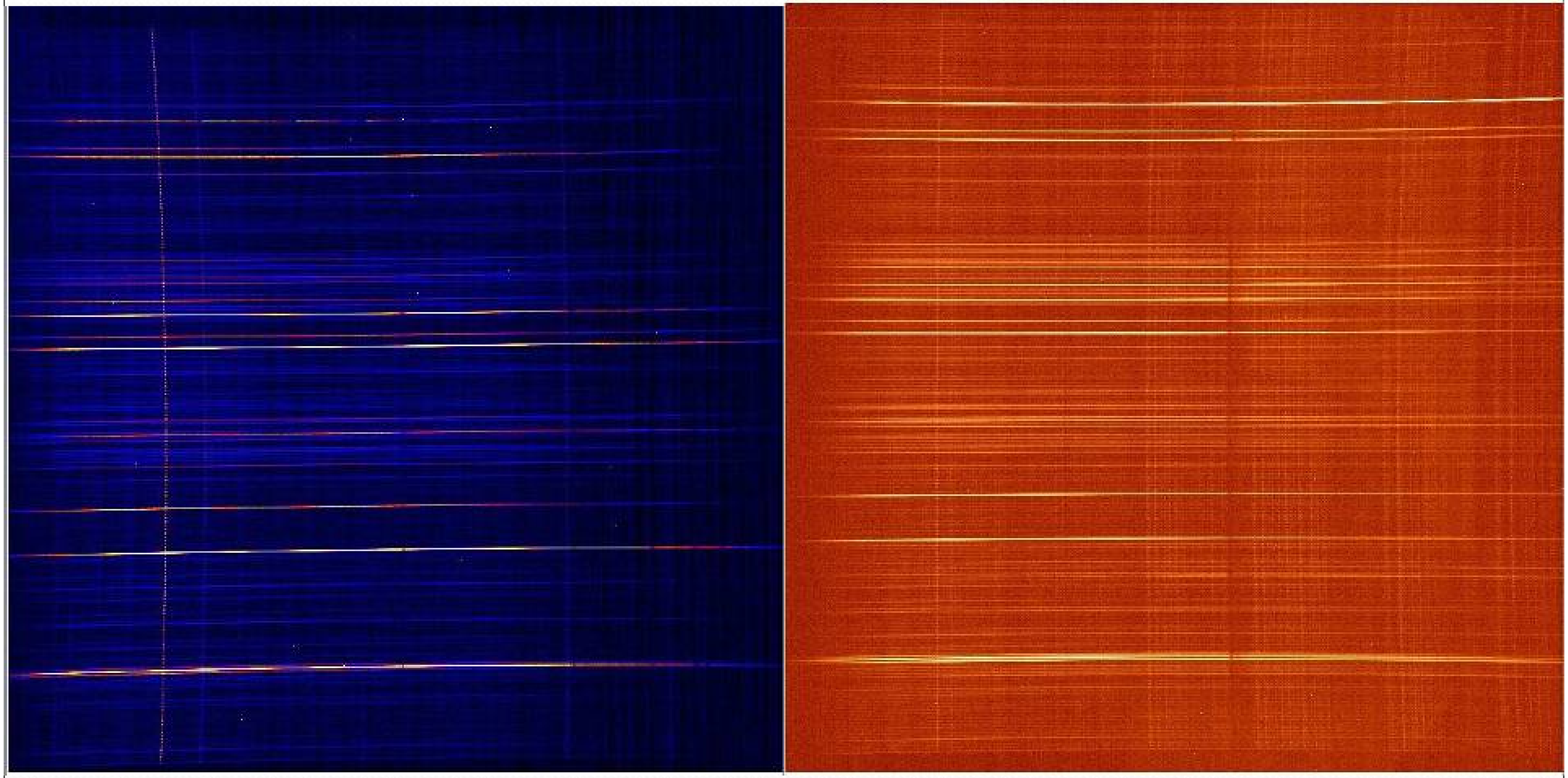
- Active optics
  - segmented thin mirror active optics in M_A
  - segmented mirror active optics in M_B
- Fiber positioning
  - LAMOST: 4000 fibers
  - SDSS: 640 fibers
  - 2dF: 400 fibers

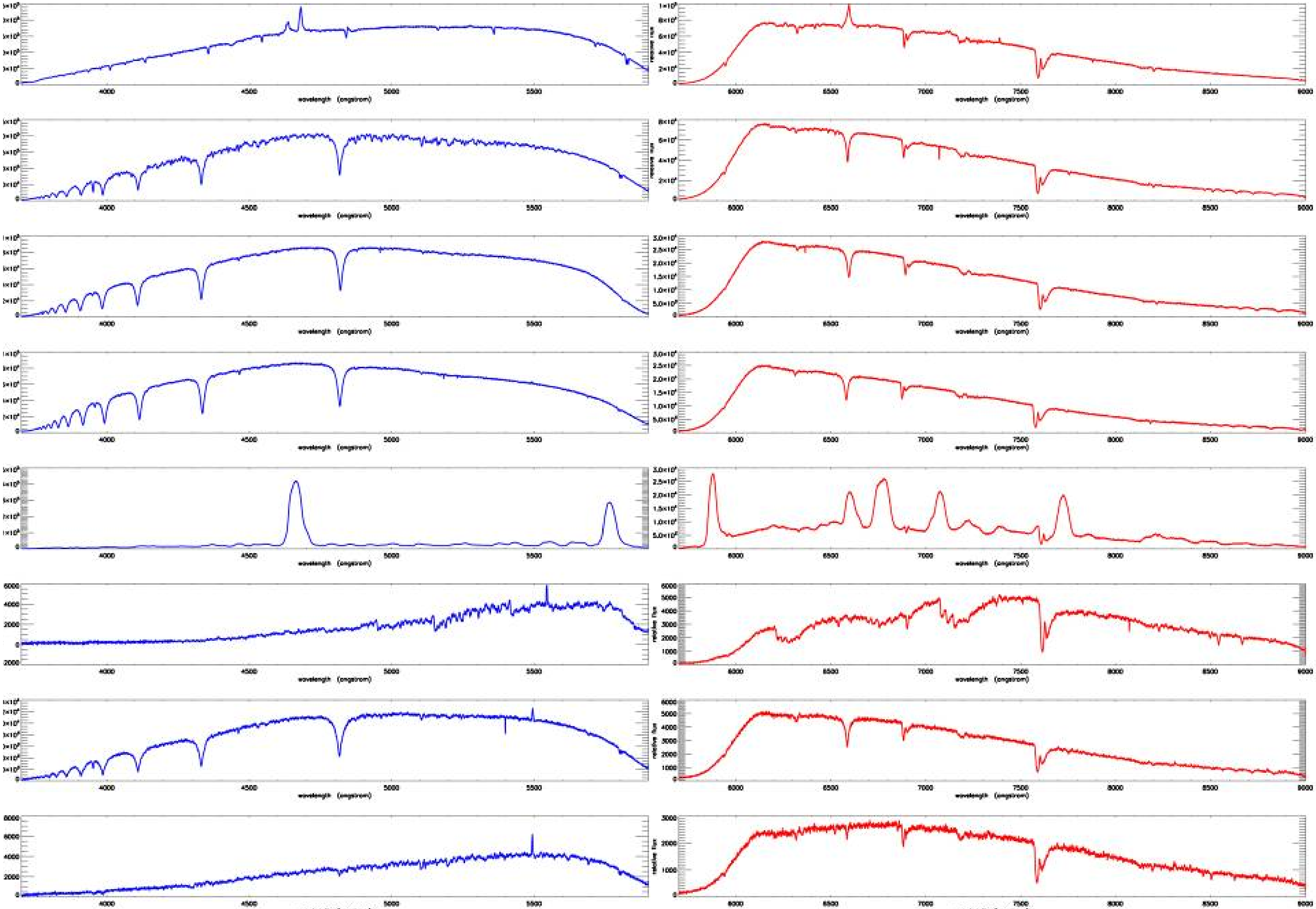
LAMOST milestones

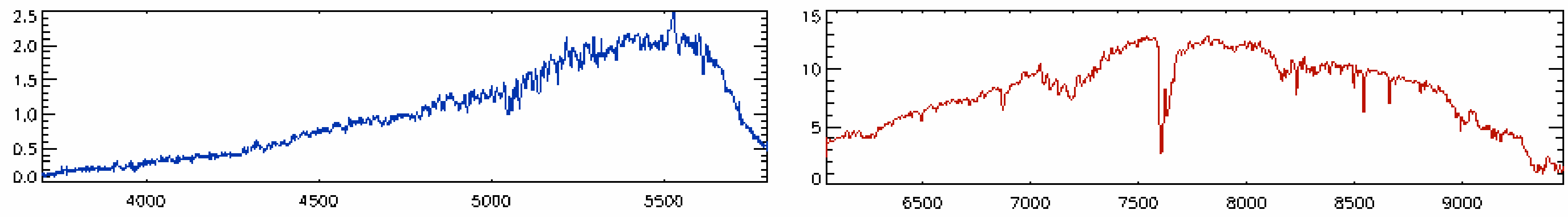
	reviewed	approved
Proposal	Nov. 1996	Apr. 1997
Feasibility Study	Jul. 1997	Aug. 1997
Preliminary Design	Apr.-May 1999	Jun. 1999
Detailed Design	Sep. 2001	
Construction	2001-2008	
First Light	May 20, 2008	
Completion	Oct. 2008	

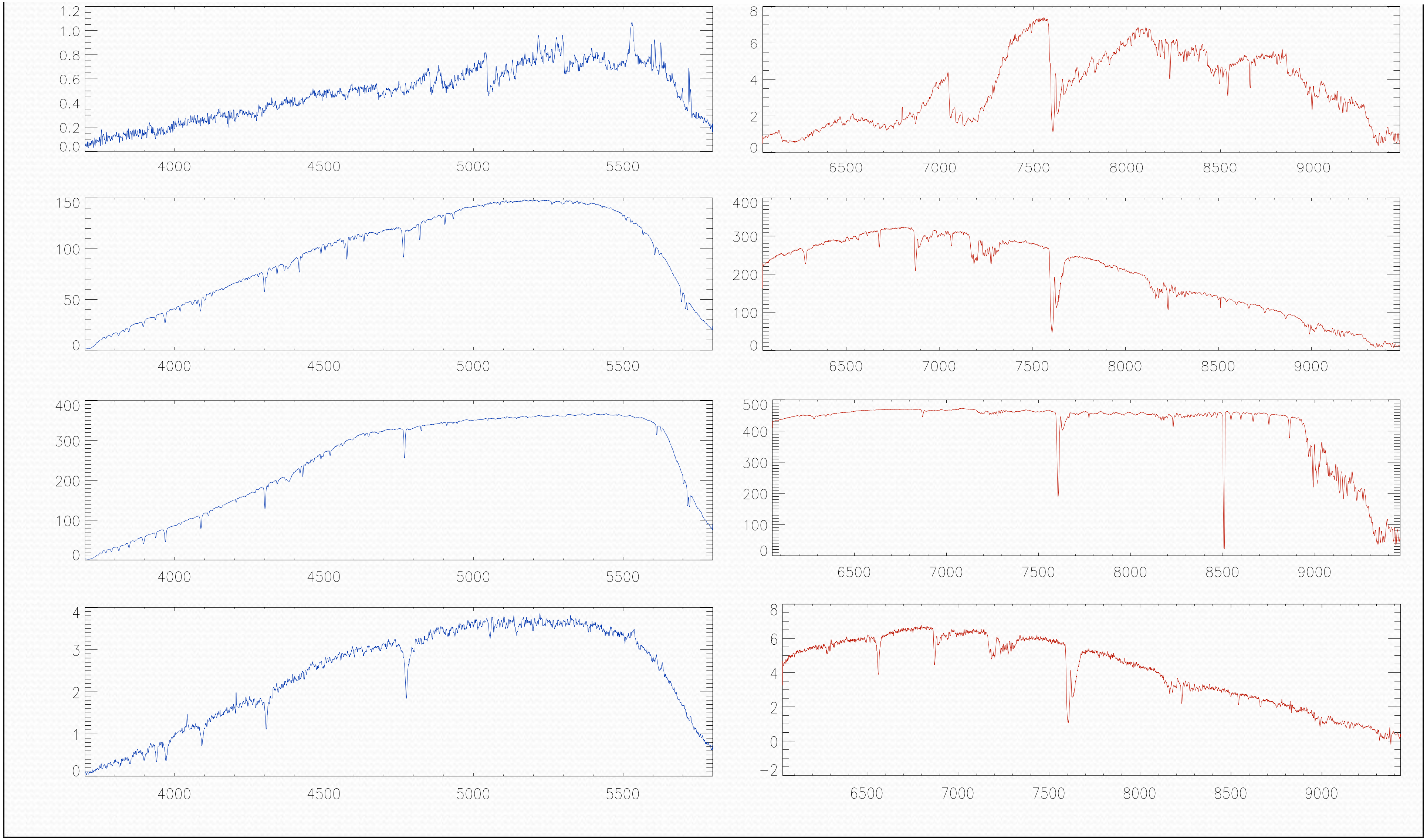
Inaugural of LAMOST completion
2008.10 @ Xinglong, China

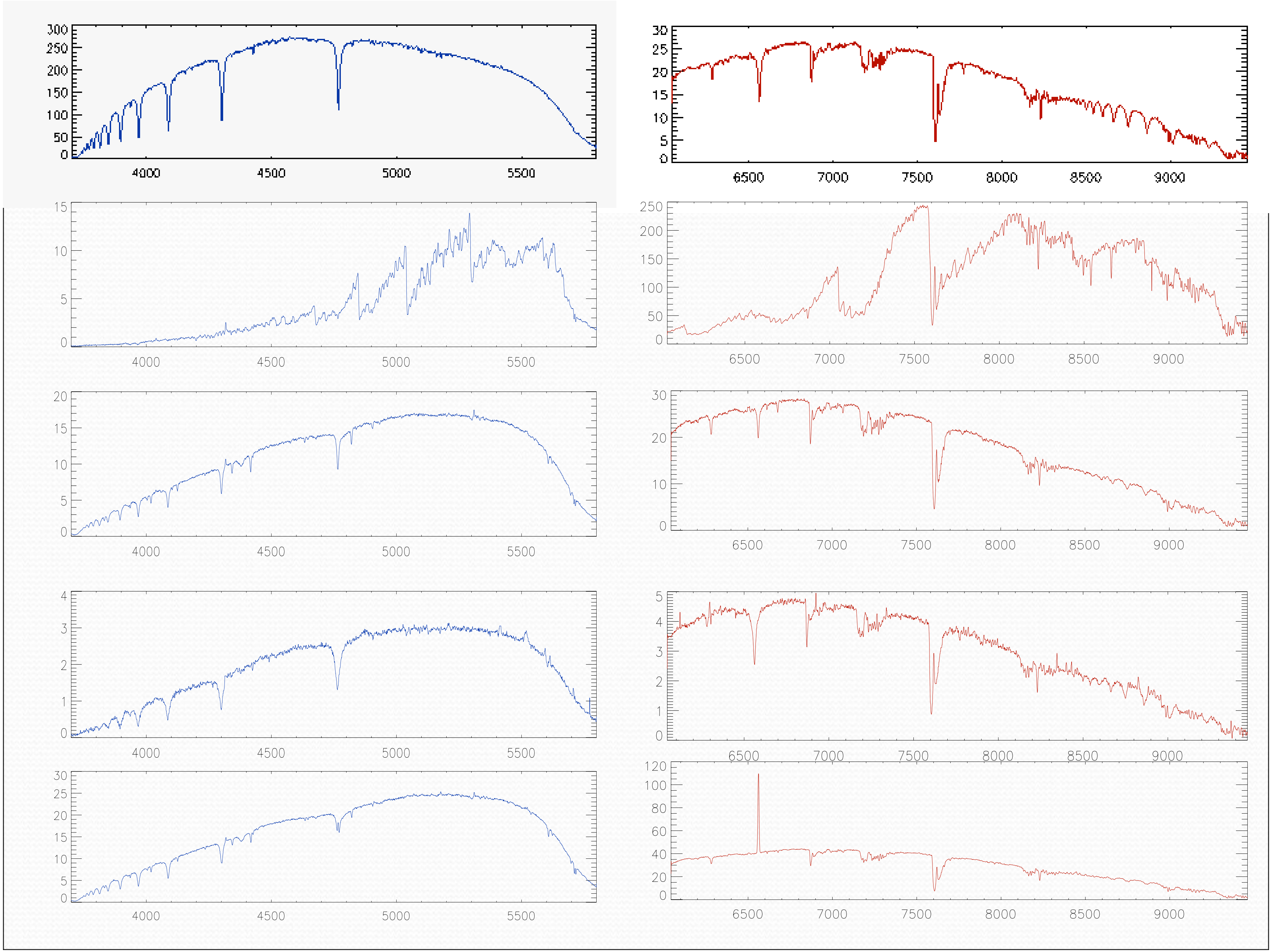
Stellar Spectra in Commission（Sep. 28, 2008）



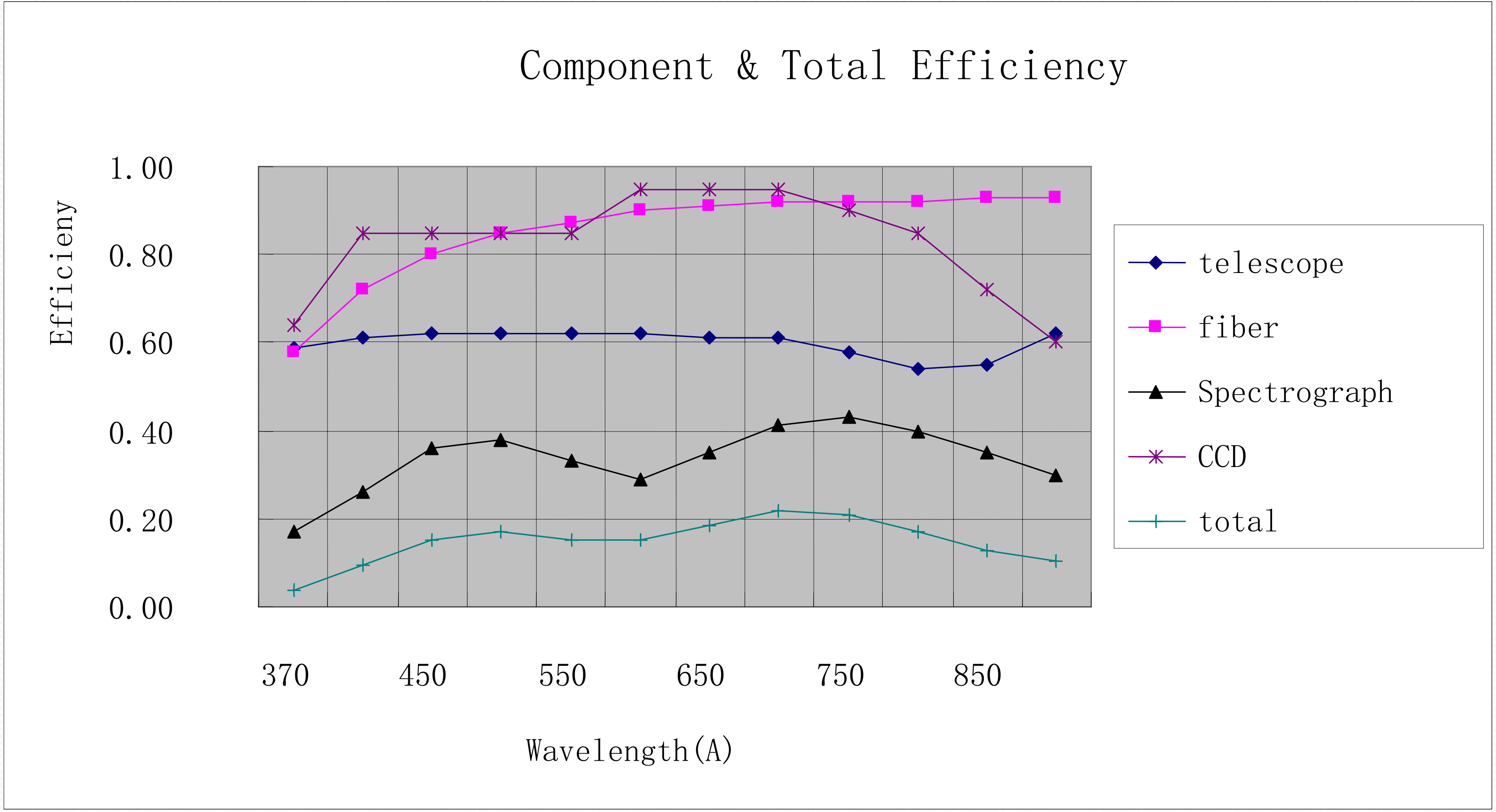

wavelength (angstrom)
relative flux
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000


2.5 2.0 1.5 1.0 0.5 0.0
4000 4500 5000 5500
15 10 5 0
6500 7000 7500 8000 8500 9000

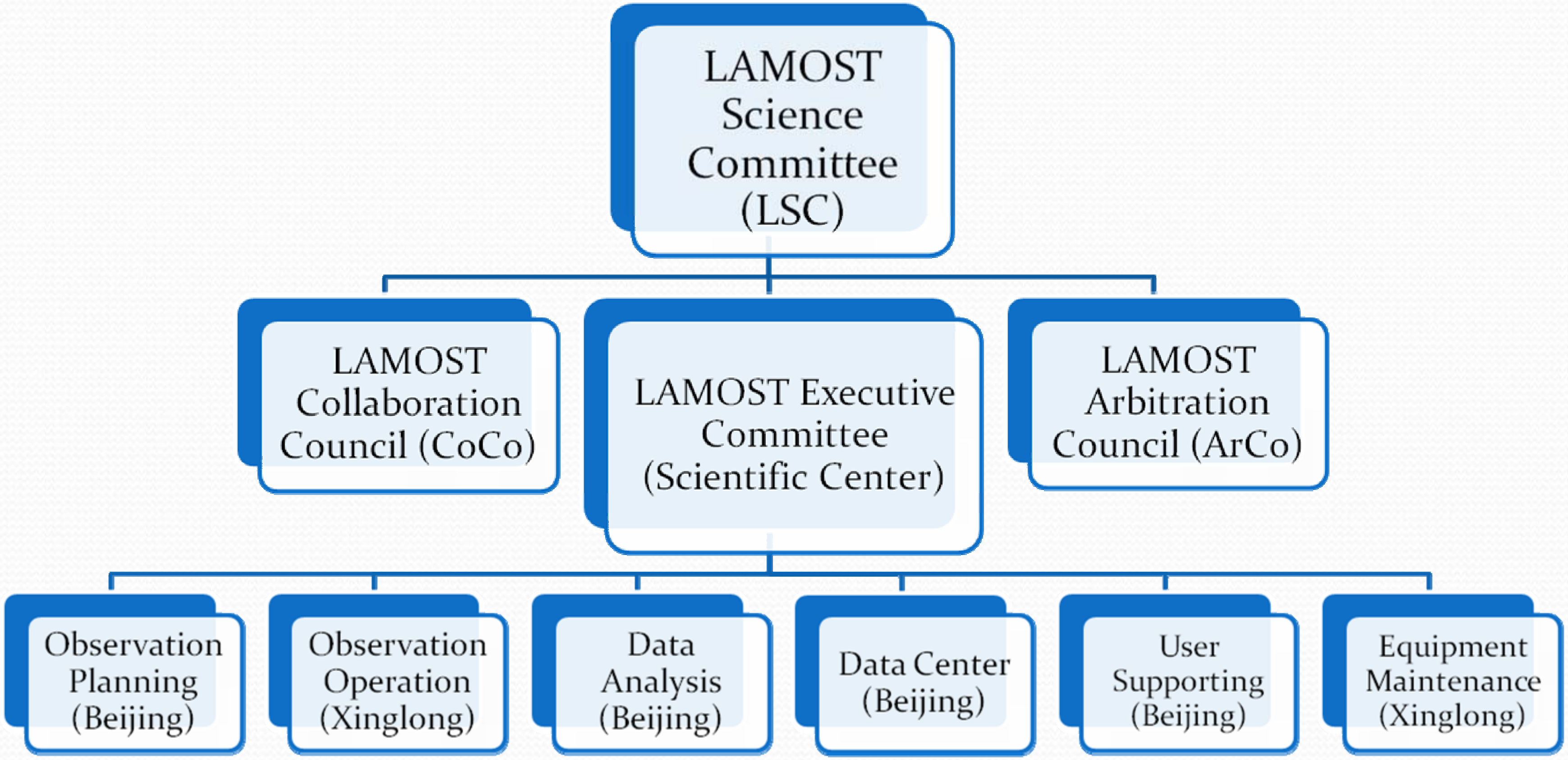

1.2 1.0 0.8 0.6 0.4 0.2 0.0
4000 4500 5000 5500
8 6 4 2 0
6500 7000 7500 8000 8500 9000
150 100 50 0
4000 4500 5000 5500
400 300 200 100 0
6500 7000 7500 8000 8500 9000
400 300 200 100 0
4000 4500 5000 5500
500 400 300 200 100 0
6500 7000 7500 8000 8500 9000
4 3 2 1 0
4000 4500 5000 5500
8 6 4 2 0 −2
6500 7000 7500 8000 8500 9000



300 250 200 150 100 50 0
4000 4500 5000 5500
30 25 20 15 10 5 0
6500 7000 7500 8000 8500 9000
15 10 5 0
4000 4500 5000 5500
250 200 150 100 50 0
6500 7000 7500 8000 8500 9000
20 15 10 5 0
4000 4500 5000 5500
30 20 10 0
6500 7000 7500 8000 8500 9000
4 3 2 1 0
4000 4500 5000 5500
5 4 3 2 1 0
6500 7000 7500 8000 8500 9000
30 25 20 15 10 5 0
4000 4500 5000 5500
120 100 80 60 40 20 0
6500 7000 7500 8000 8500 9000


Component & Total Efficiency
Efficieny
1.00
0.80
0.60
0.40
0.20
0.00
370
450
550
650
750
850
Wavelength(A)
telescope
fiber
Spectrograph
CCD
total

LAMOST Operation System



LAMOST Science Planning

- Aug, 2008 – Dec, 2009
  - LSC setup two working groups:
    - LEGAS - Extragalactic survey
    - LEGUE - Galactic survey
    - → Unique LAMOST spectroscopic survey
- May 28-31, 2009
  - International evaluation for LAMOST survey project proposed by working groups

LEGUE Science Working Group:

- PI: DENG Licai   Co-PI: HOU Jinliang

CHEN Yuqin, CHRISTLIEB Norbert, HAN Zhanwen,
LEE Hsu-Tai, LIU Xiaowei, NEWBERG Heidi,
PAN Kaike, WANG Hongchi, ZHU Zi

LEGAS Science Working Group:

- PI: JING Yipeng   Co-PI: ZHOU Xu

CHEN Xuelei, FAN Xiaohui, LI Cheng,
SHEN Shiyin, WANG Junxian, WU Hong,
WU Xuebing, ZHENG Xianzhong

Review Panel

- Respected experts from 7 countries and 10 world-known institutes or universities in astronomy and astrophysics

- Richard Ellis - Chair (CalTech)
- Jiansheng Chen (NAOC)
- Matthew Colless (AAO)
- Georges Comte (Obs. de Mars.)
- Carlos Frenk (Uni. Durham)
- Jingyao Hu (NAOC)
- Richard Kron (Uni. Chicago)
- Heather Morrison (Case Western Reserve Uni.)
- Timo Prusti (ESA)
- Hans-Walter Rix (MPIA)
- Nicholas Walton (Cambridge)
- Fred Watson (AAO)
- Don York (Uni. Chicago)

LAMOST Commission Period

- Sep.-Dec., 2008
  - Fiber positioning units
  - Spectroscopic calibration
  - Operation software
  - Pipelines for data processing
- 2009/2010:
  - Stability (Active optics, Dome seeing)
  - Efficiency (Fibers, Spectrographs, CCDs)
  - Scientific test observations
    - Open clusters, nearby galaxies, selected area survey, …

LAMOST Regular Survey

- 2011 – 2015/2016
  - Extra-galactic spectroscopic survey —

    Galaxy and QSO red shift survey

    (6.3 millions)
  - Stellar spectroscopic survey —

    Structure of the Galaxy, and so on

    (7.5 millions)

Test Observations

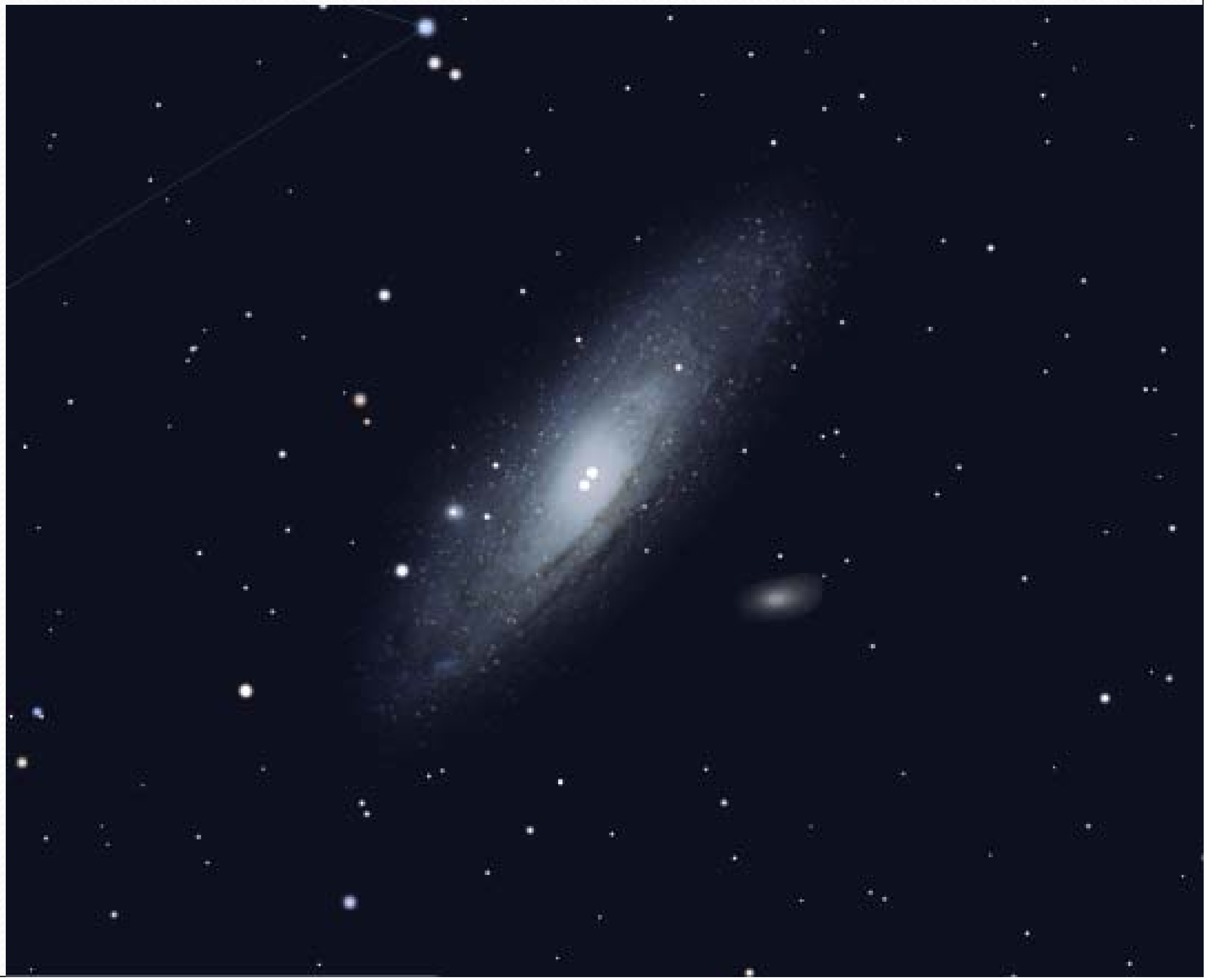
- Sept. 2008: bright stars (V<16)
- Dec. 2008: M31 Field
- Feb. 2009: open clusters, clusters of gal.
- Mar. 2009: SDSS spectra
- Apr. 2009: stars (V<19)

- Several dark nights in each month

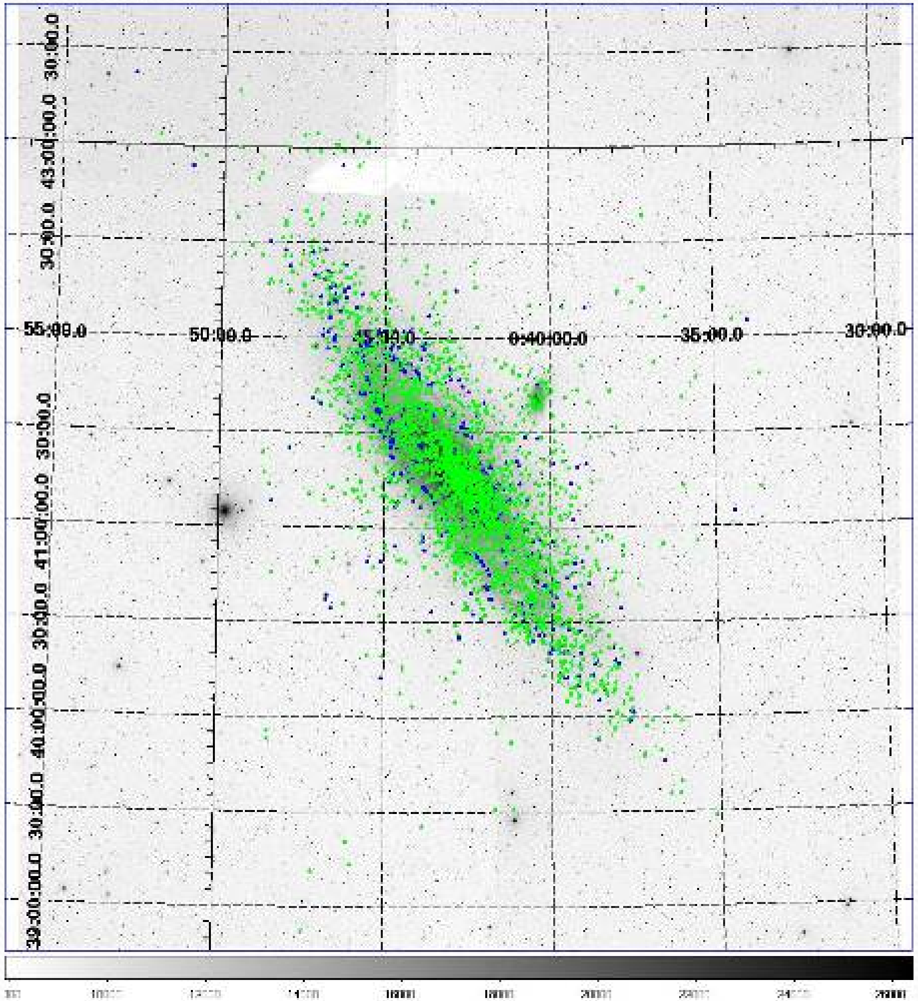
M31 Field

Dec. 27, 2008

- M31
  - Planetary nebula
  - Global clusters
- Others
  - Galaxies
  - Stars
- 1800s Exp.



5° x 5°



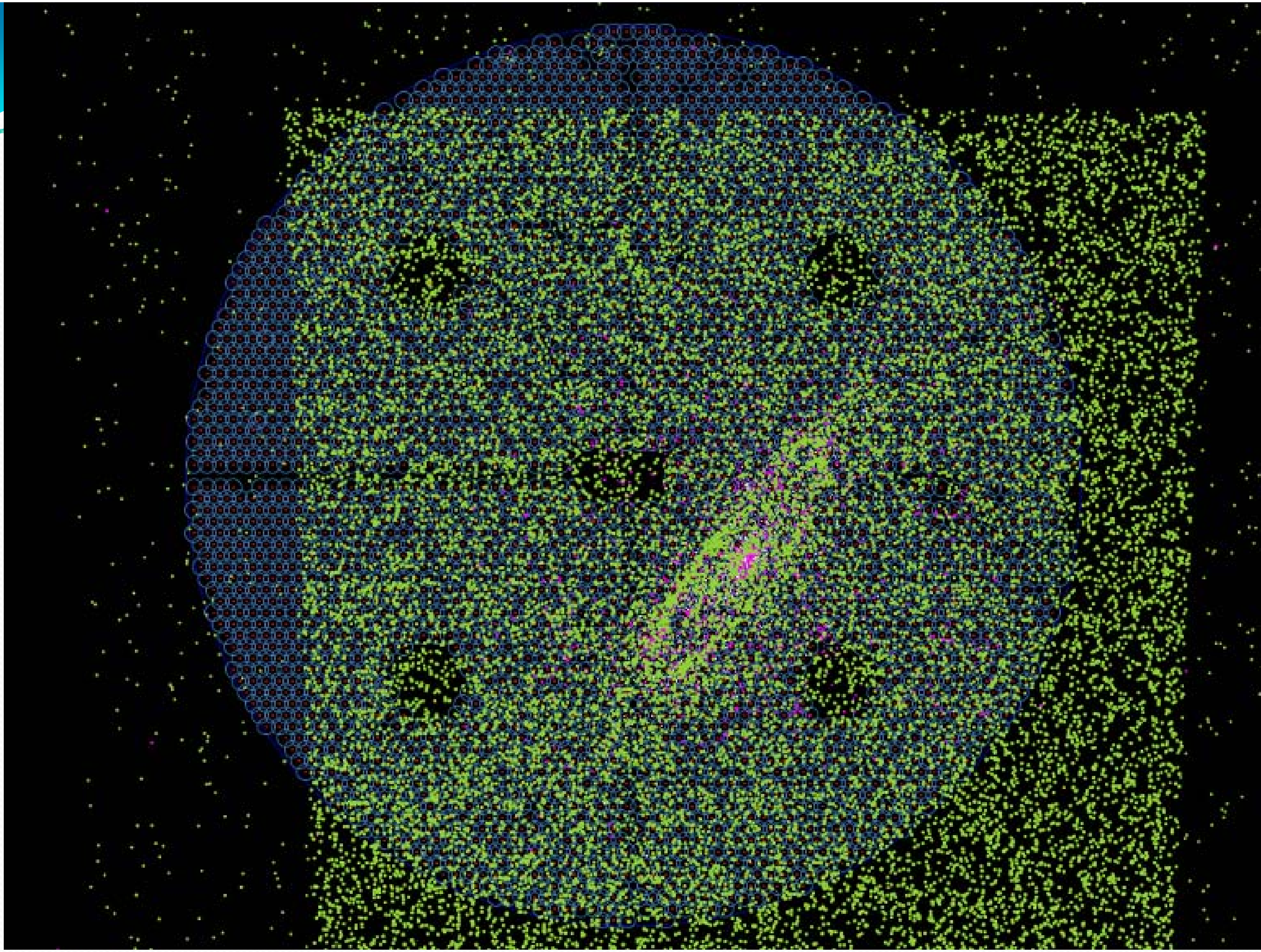
3300 emission line objects:

1) 2729 PNe
2) 571 compact H II regions

Position: ~0.2” – 0.3”
Radial velocity: ~15 – 20 km/s
[O III] 5007 flux: ~0.1 mag

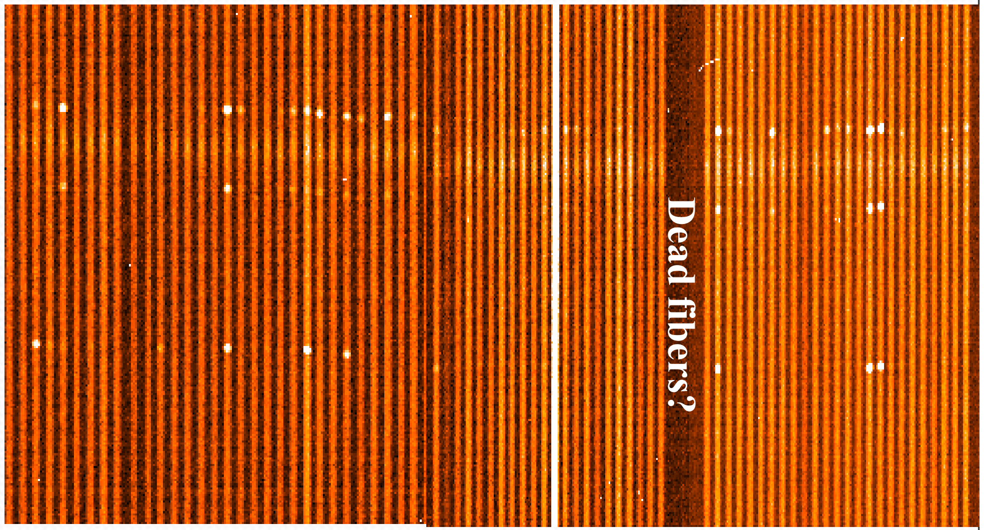
Complete to m_{5007} = 23.75

Merrett et al., 2006, MN, 369, 120



White: emission line object; Pink: GCs; Green: 2MASS objects

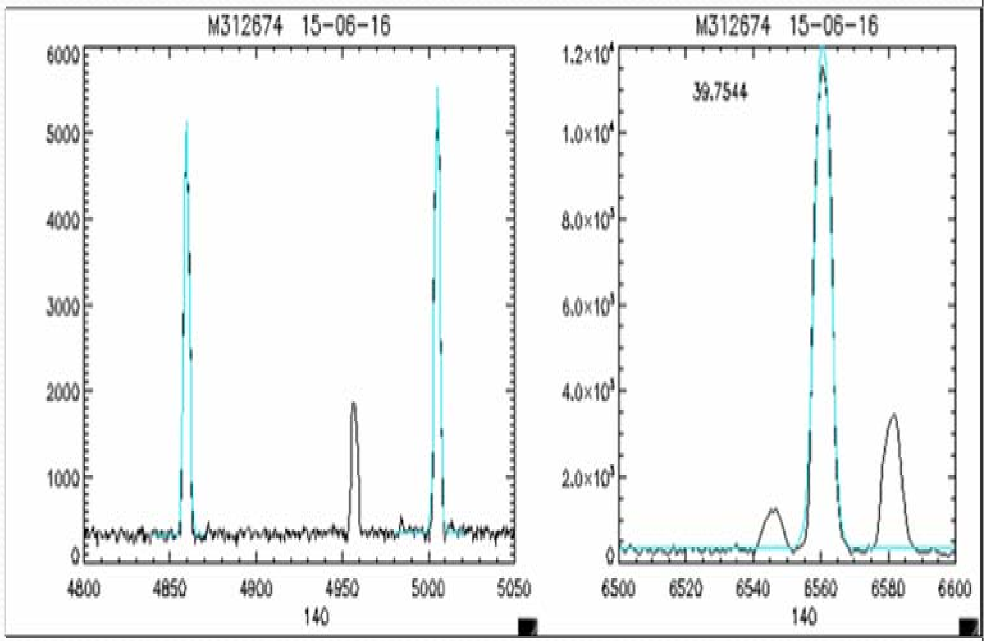
Result from spectra of 15th spectrograph



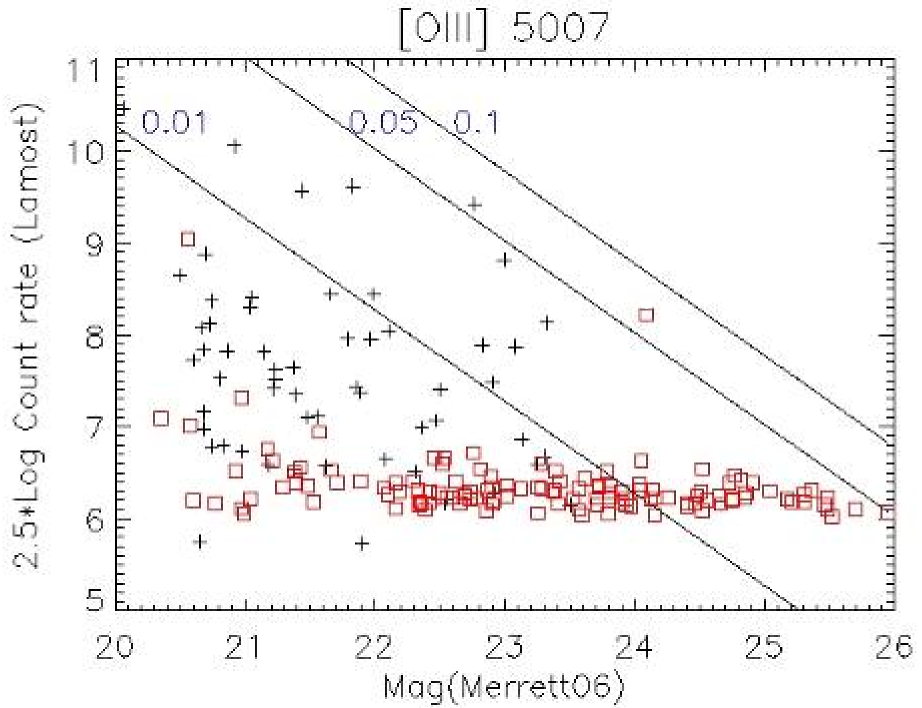
- Targets include:
  - 186 emission line objects, 50 of them detected
  - 31 GCs
  - 22 2mass objects
  - 1 galaxy

Compare H_β, [OIII] 5007 and H_α velocities measured by LAMOST with previous results:
==> wavelength calibration

Compare [OIII] 5007 fluxes with previous results:
==> efficiency & pointing accuracy



LAMOST efficiency



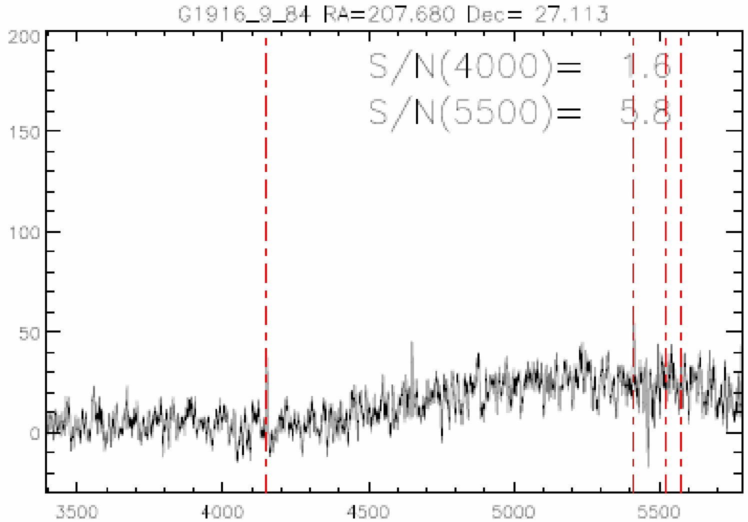
- 17 of 24 MA mirrors employed
- 30 minute exposure
- Gains:
  - – Blue: 0.89,0.88 e-/ADU
  - – Red: 1.19,1.18 e-/ADU

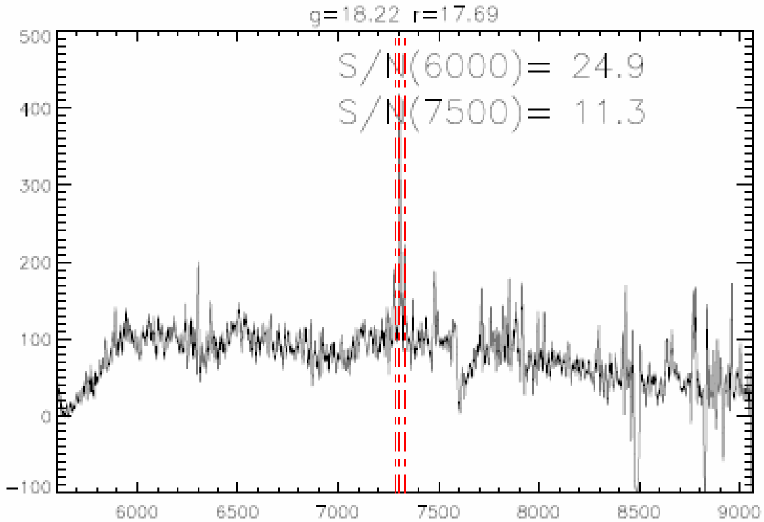
Target: optical throughput ~10%

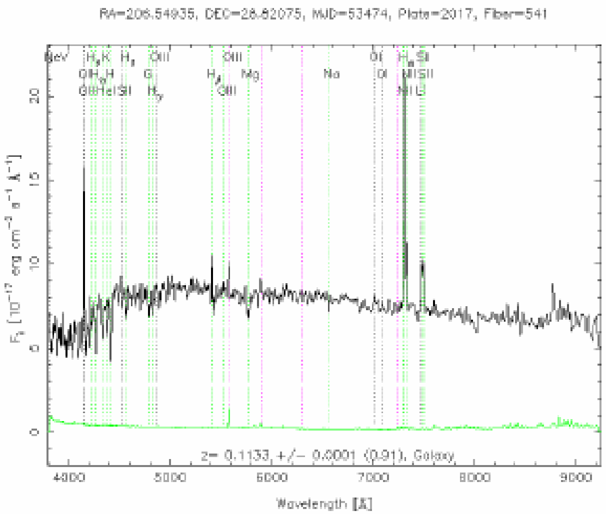
"□ "upper limits for non-detected objects
"+" : detected objects

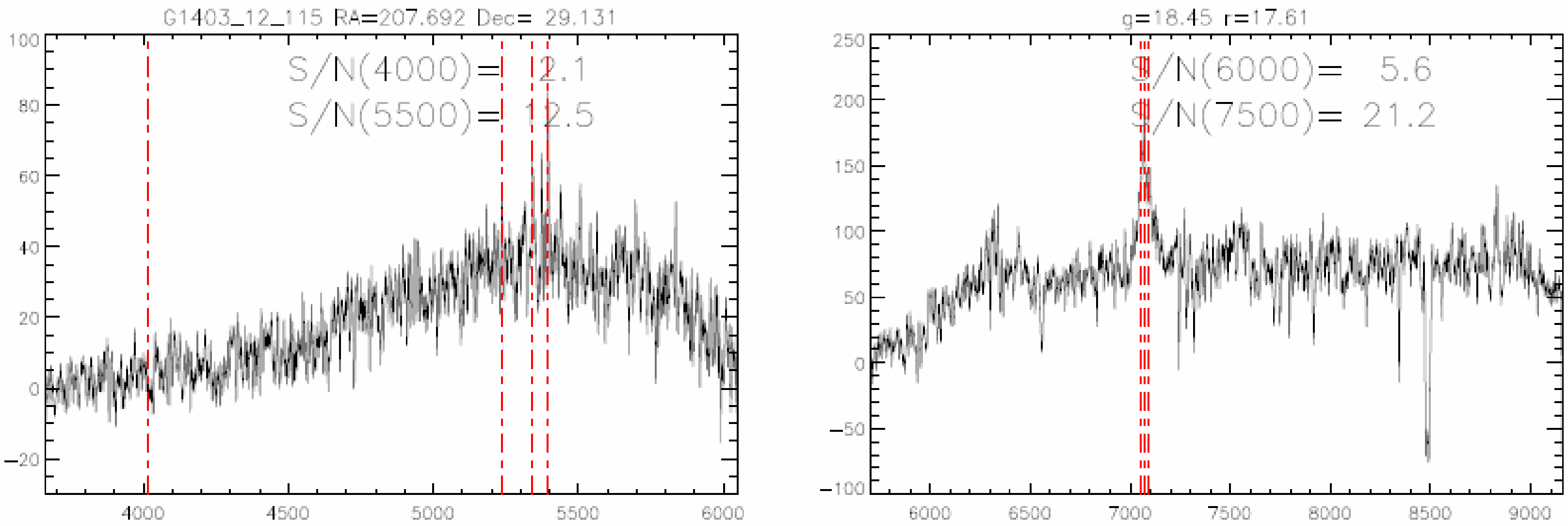
Test observation at the end Feb., 2009

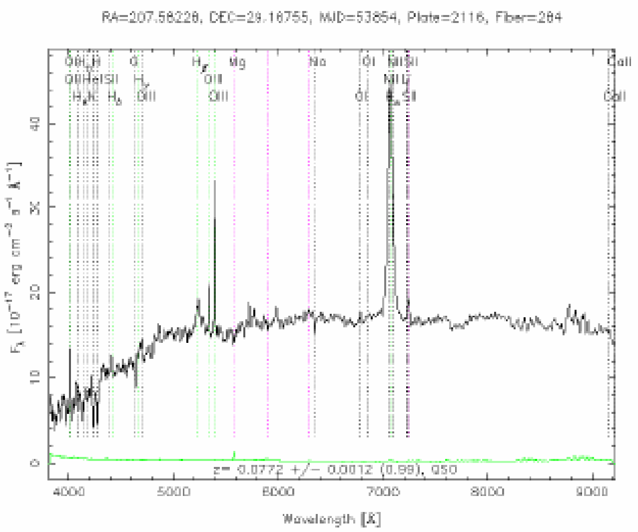
- NGC 2244
- M67
- A1775

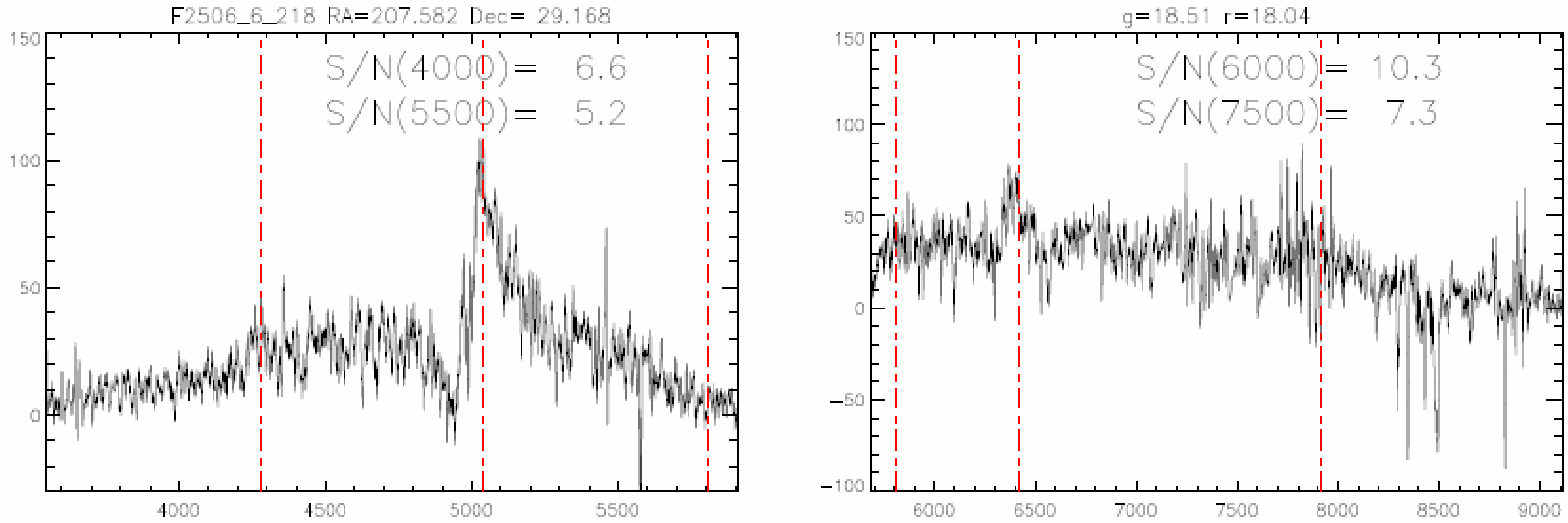

G1916_9_84 RA=207.680 Dec= 27.113
S/N(4000)= 1.6
S/N(5500)= 5.8


g=18.22 r=17.69
S/N(6000)= 24.9
S/N(7500)= 11.3

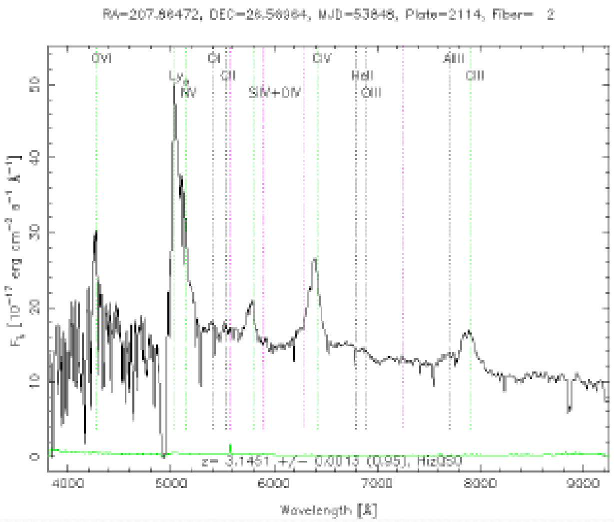

RA=206.54935, DEC=28.82075, MJD=53474, Plate=2017, Fiber=541
z= 0.1133 +/- 0.0001 (0.91), Galaxy
Wavelength [Å]


G1403_12_115 RA=207.692 Dec= 29.131
g=18.45 r=17.61
S/N(4000)= 2.1
S/N(5500)= 12.5
S/N(6000)= 5.6
S/N(7500)= 21.2

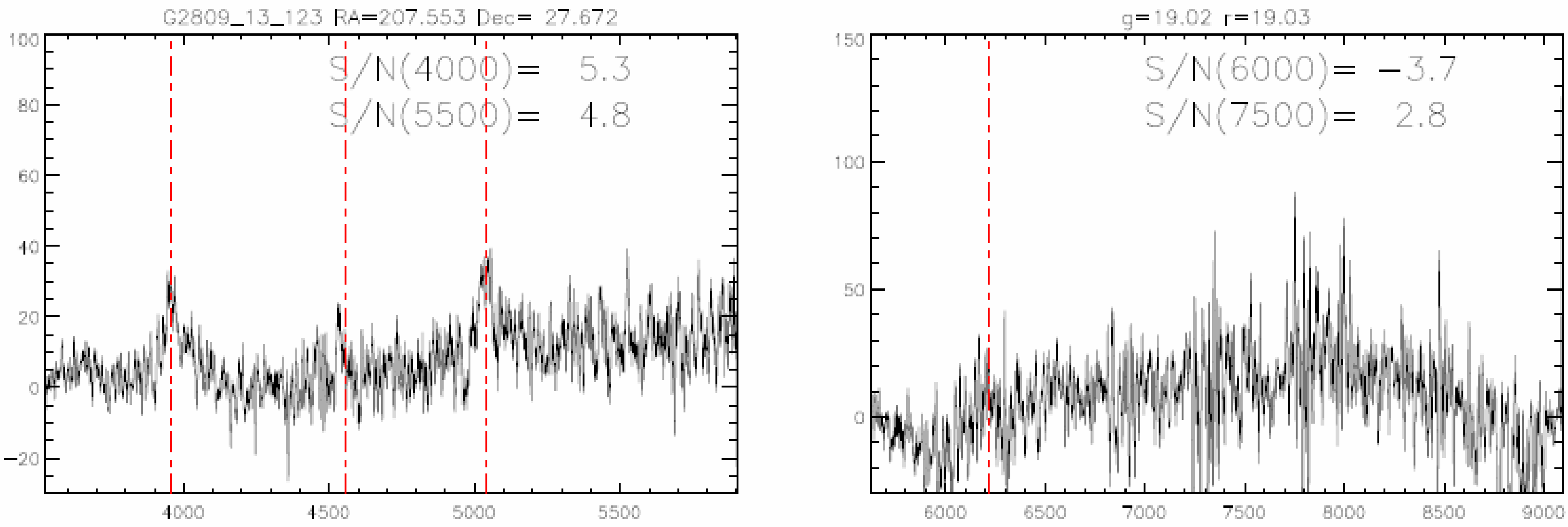

RA=207.58228, DEC=29.16755, MJD=53854, Plate=2116, Fiber=284
z= 0.0772 +/- 0.0012 (0.99), QSO
Wavelength [Å]



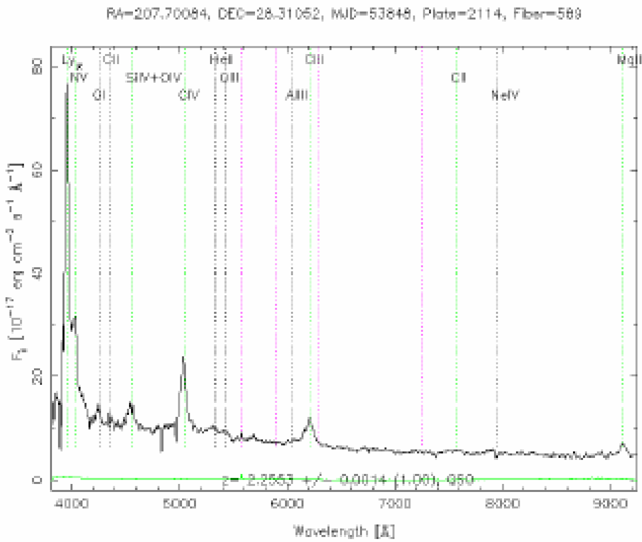
F2506_6_218 RA=207.582 Dec= 29.168
g=18.51 r=18.04
S/N(4000)= 6.6
S/N(5500)= 5.2
S/N(6000)= 10.3
S/N(7500)= 7.3



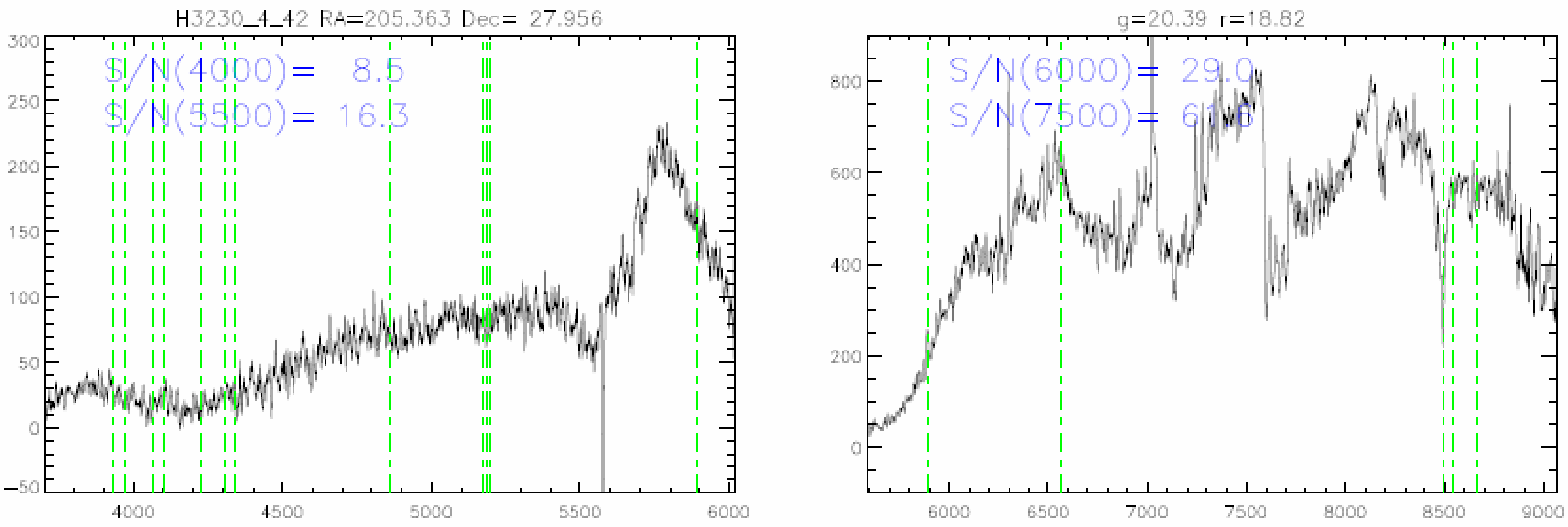
Plate=2114, Fiber= 2
OVI
Lyα
NV
OI
CII
SiIV+OIV
CIV
HeII
OIII
AlIII
CIII
z= 3.1451 +/- 0.0013 (0.95), HizQSO
Wavelength [Å]

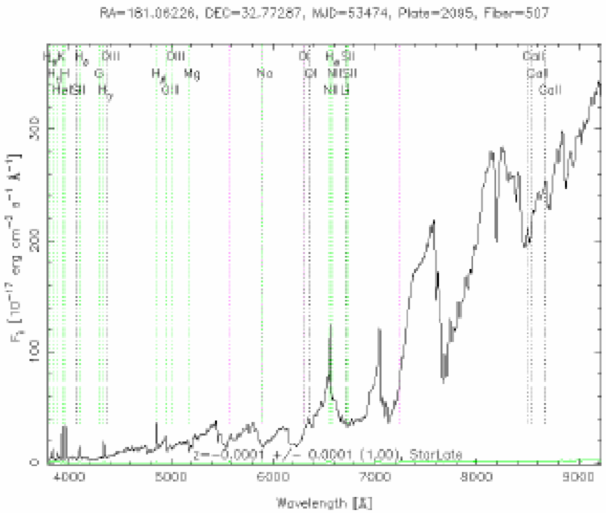


G2809_13_123 RA=207.553 Dec= 27.672
S/N(4000)= 5.3
S/N(5500)= 4.8
g=19.02 r=19.03
S/N(6000)= −3.7
S/N(7500)= 2.8



RA=207.70084, DEC=28.31062, MJD=53848, Plate=2114, Fiber=589
Lyα
NV
OI
CII
SiIV+OIV
CIV
HeII
OIII
AlIII
CIII
CII
NeIV
MgII
z= 2.2563 +/- 0.0014 (1.00), QSO
Wavelength [Å]

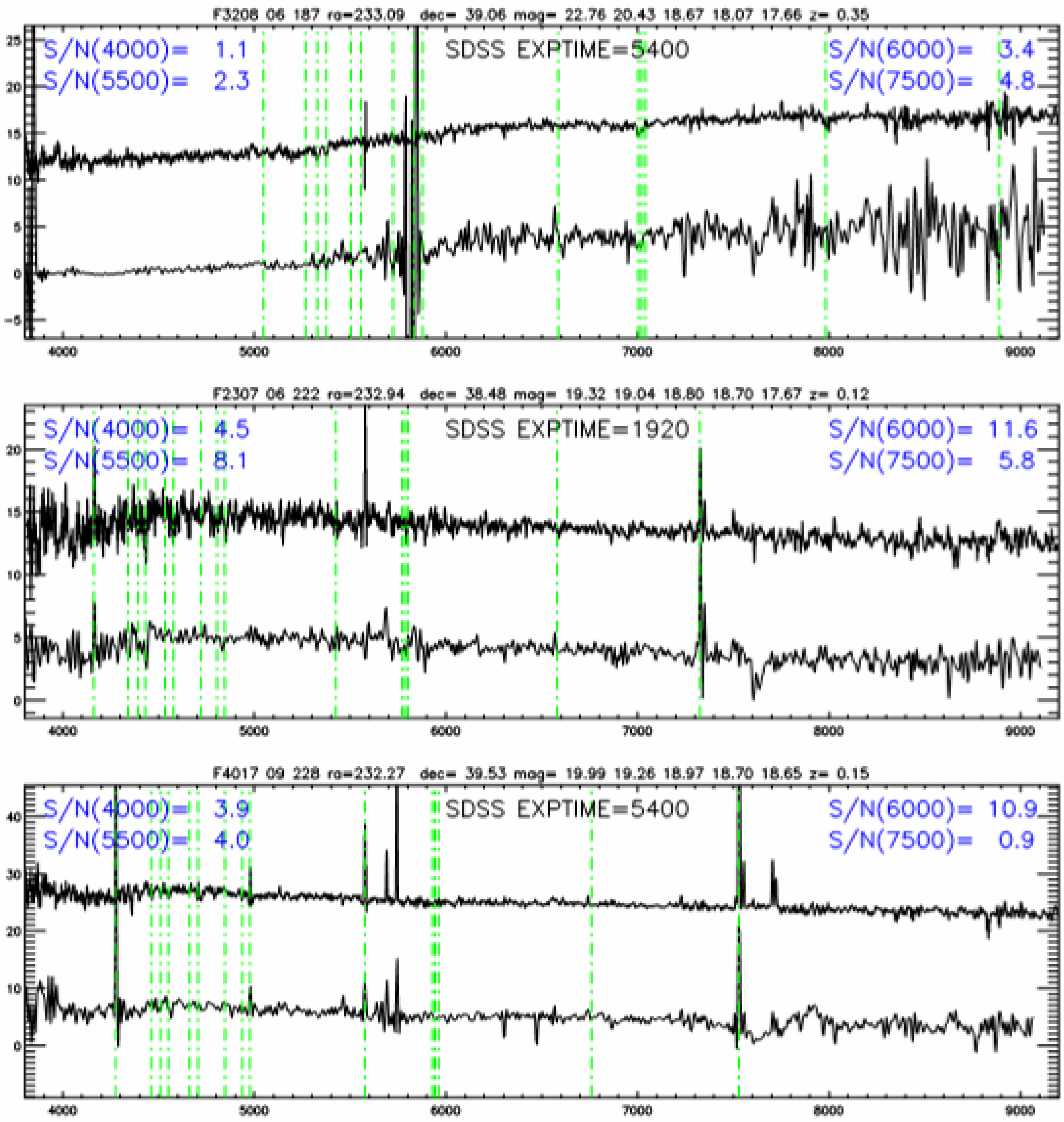

H3230_4_42 RA=205.363 Dec= 27.956
g=20.39 r=18.82
S/N(4000)= 8.5
S/N(5500)= 16.3
S/N(6000)= 29.0
S/N(7500)= 61.6


RA=181.06226, DEC=32.77287, MJD=53474, Plate=2095, Fiber=507
z=-0.0001 +/- 0.0001 (1.00), StarLate
Wavelength [Å]

Apr.1, 2009

Galaxies

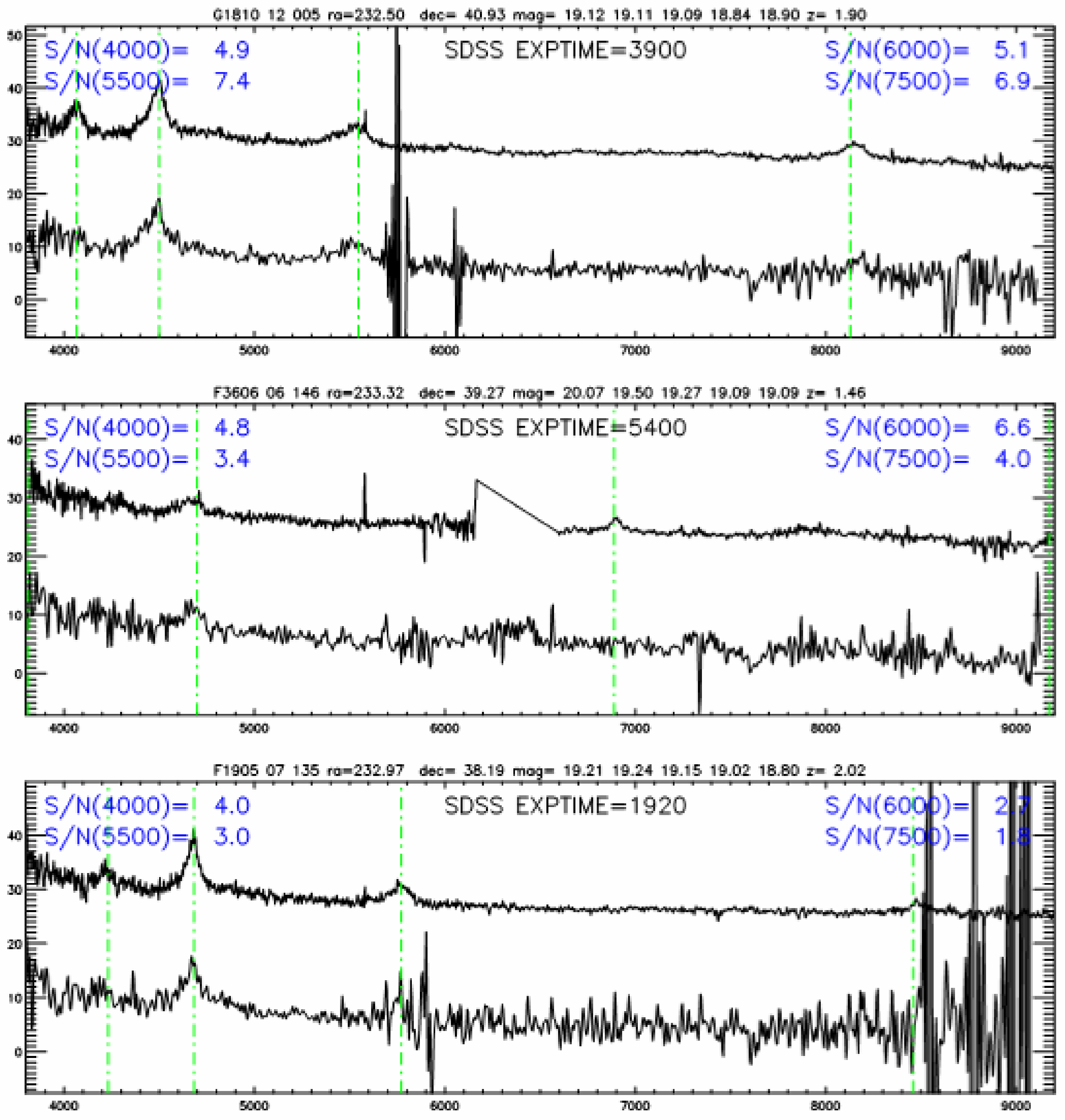
(g>19)

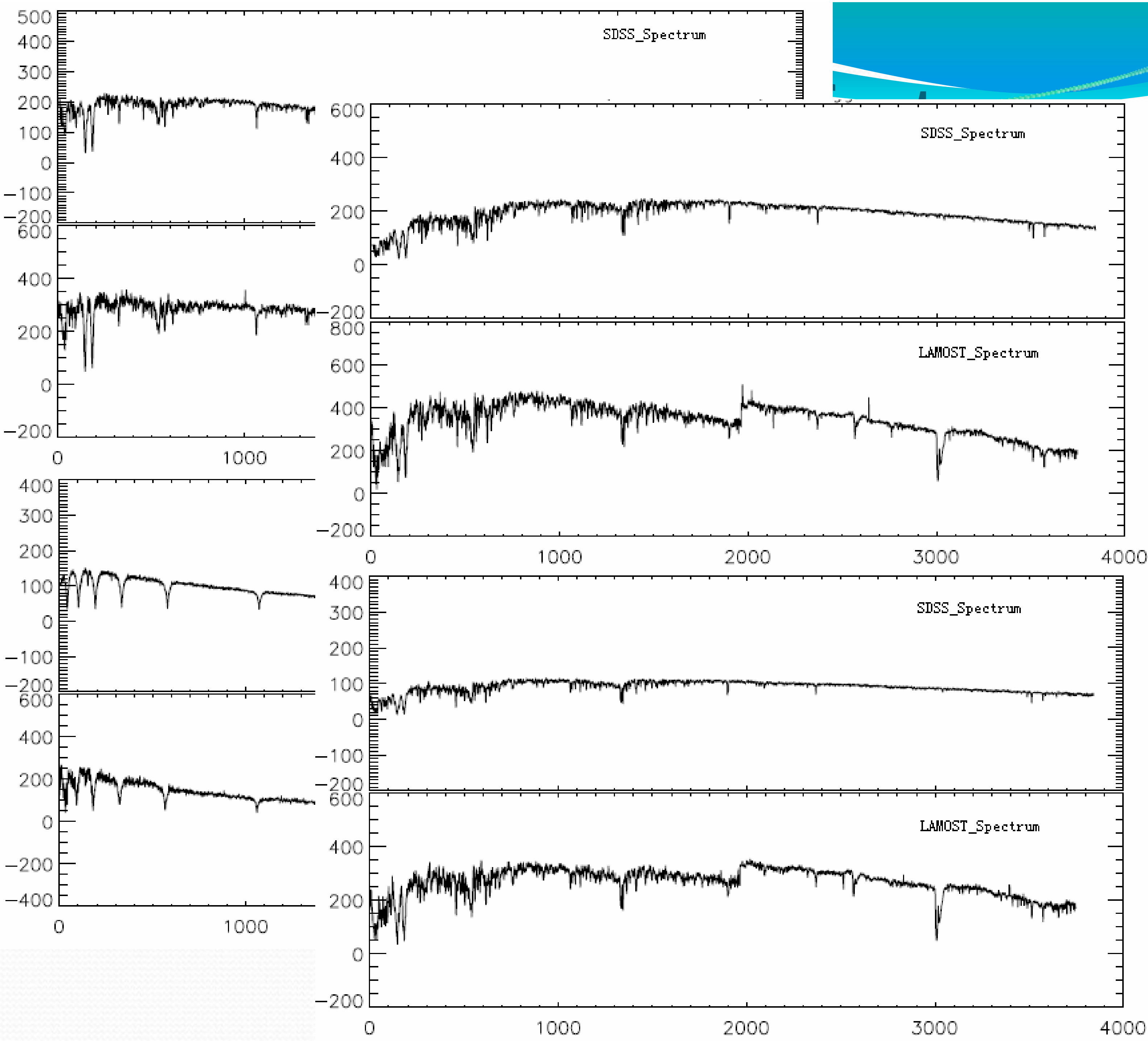


Apr.1, 2009

QSOs

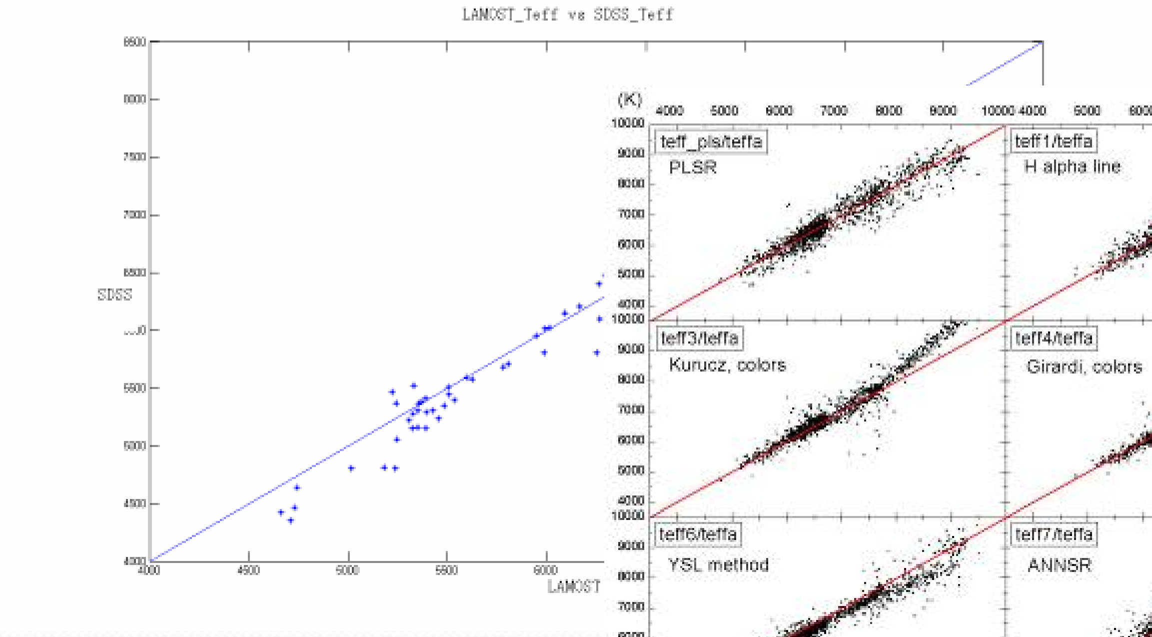
(g>19)

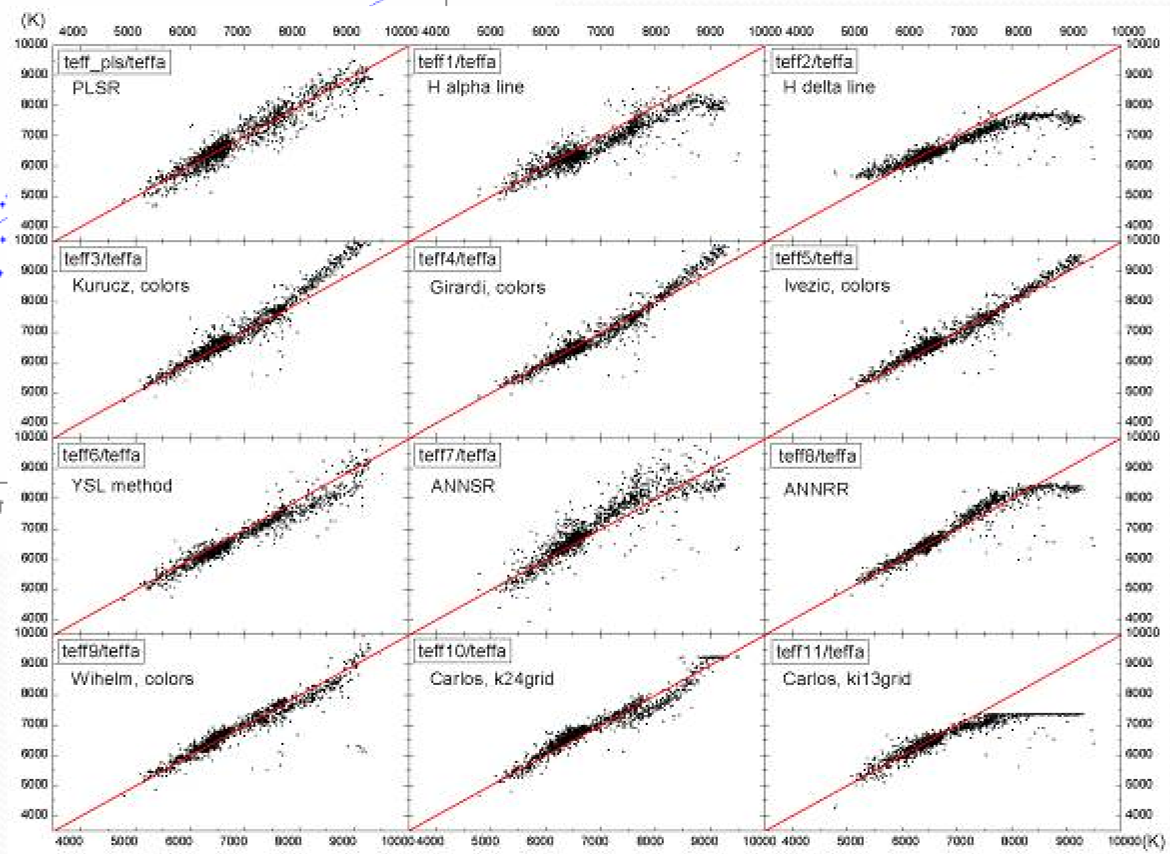


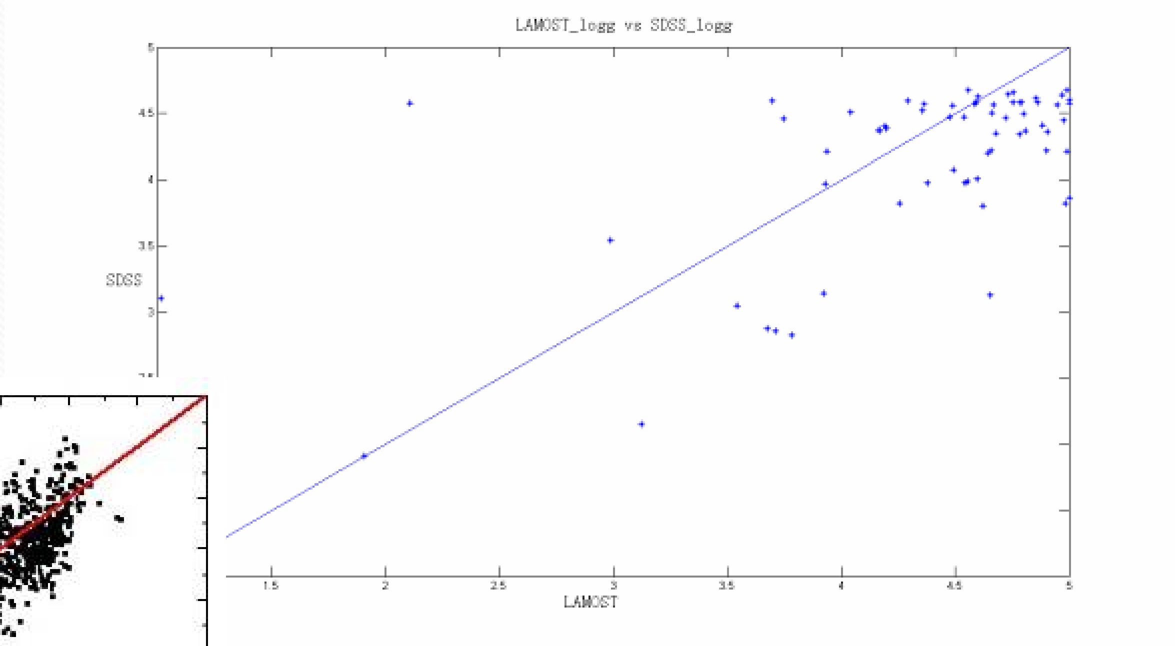


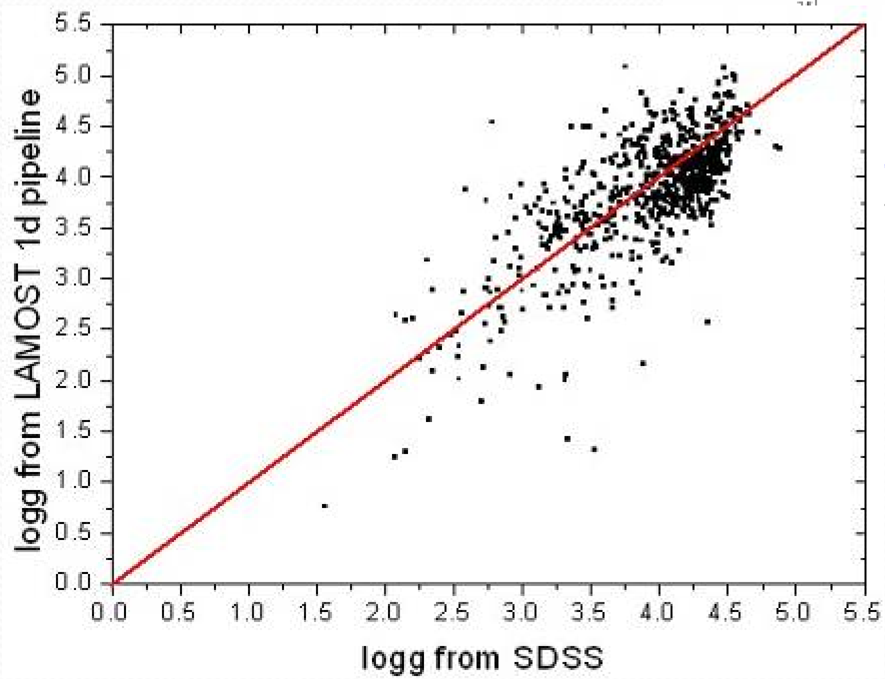
sdss	lamost
F5	F5
A0	B9
F9	G0
K1	F9
F9	F9
F5	F5
F9	F2
F5	F5
G0	F5
F9	G5
F9	F9
F9	F9
F9	F9
G0	O
G2	F5
F9	F9
A0	A0
K1	F9
K5	K5
F9	G2
F5	F5
M0	M0V

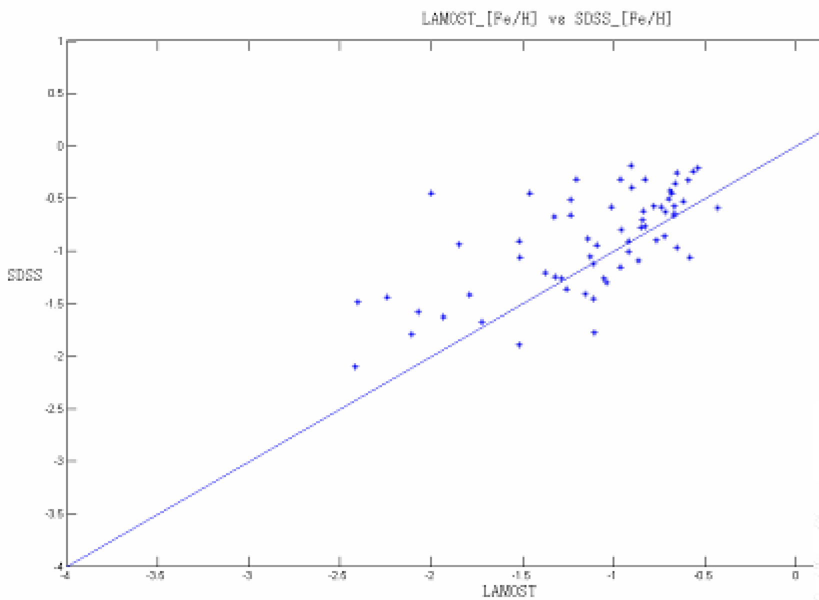
Determination of Stellar parameters Teff, log g, [Fe/H]

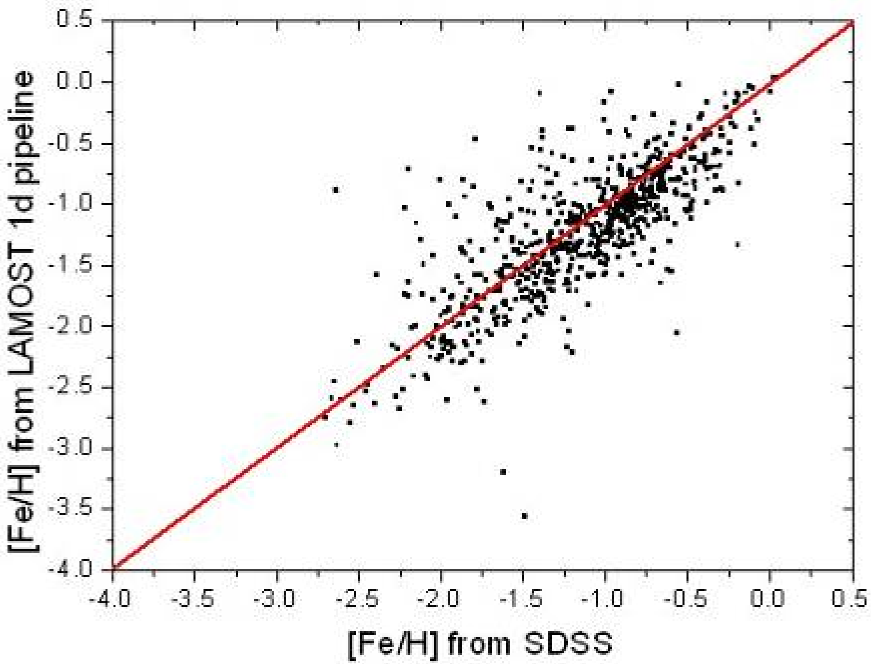





LAMOST_logg vs SDSS_logg
SDSS
LAMOST


logg from LAMOST 1d pipeline
logg from SDSS
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5

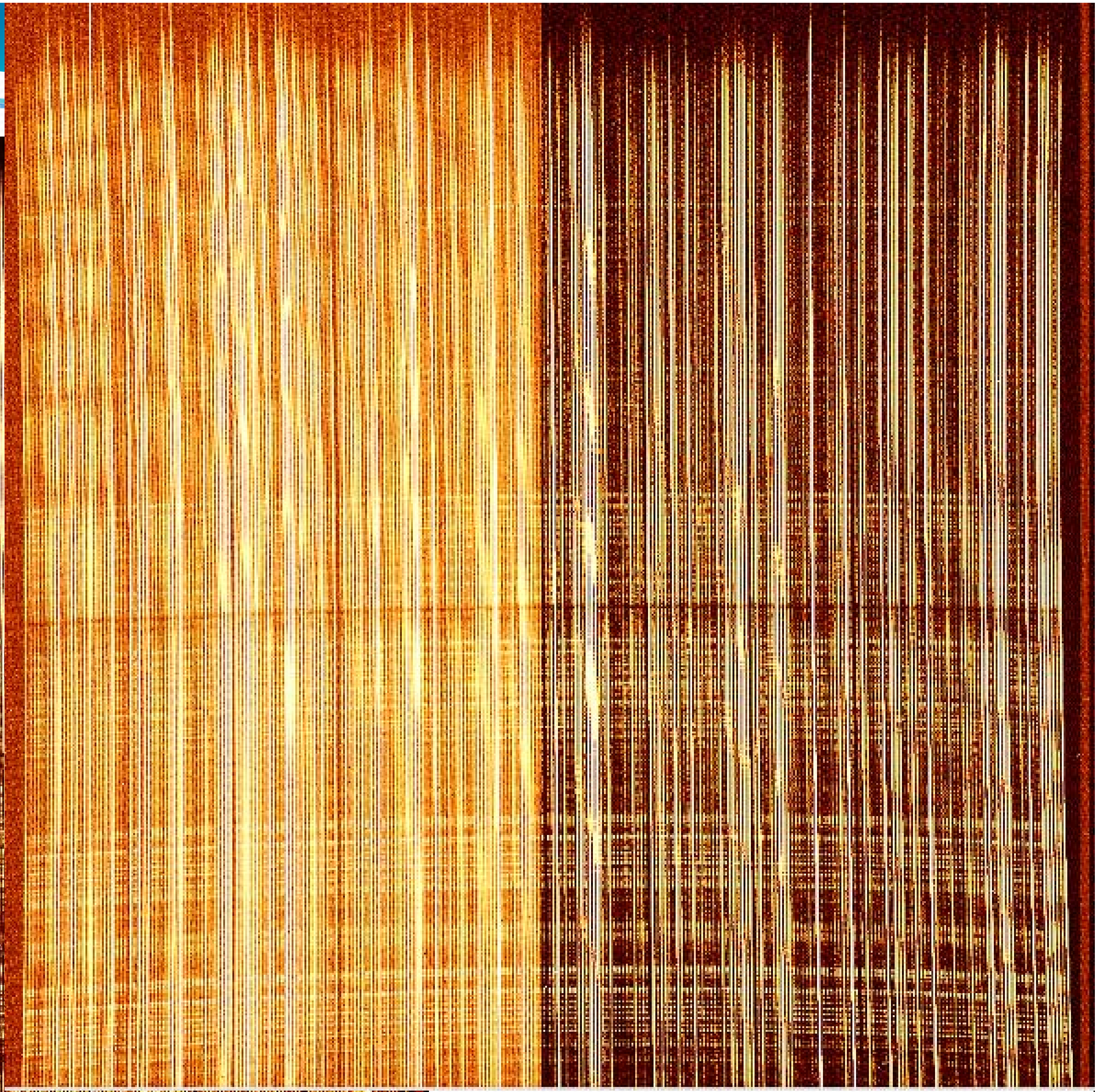

LAMOST_[Fe/H] vs SDSS_[Fe/H]
SDSS
LAMOST


[Fe/H] from LAMOST 1d pipeline
[Fe/H] from SDSS
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.0 0.5

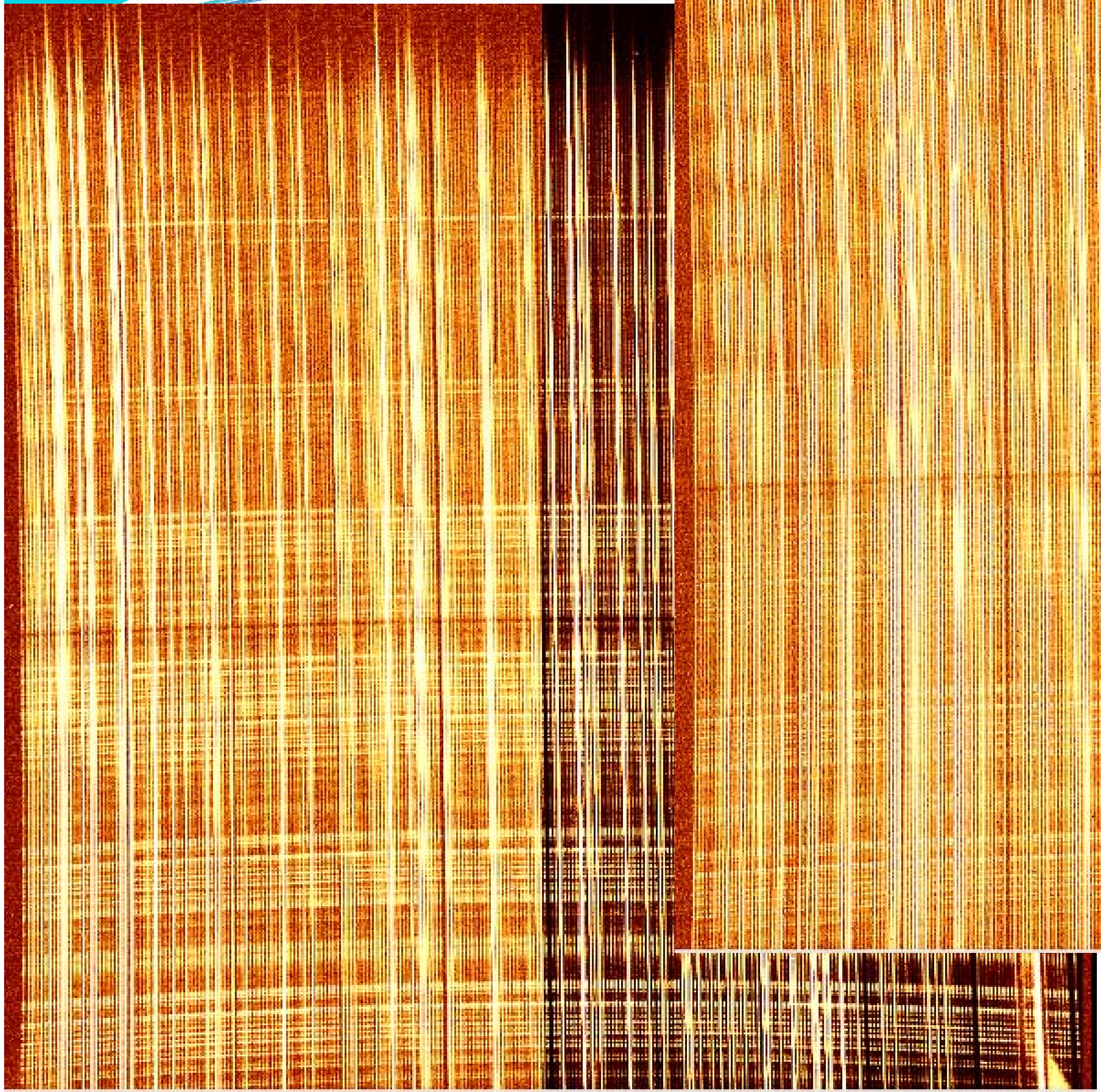
Apr. 26, 2009

- Stars (V<19)

- More than 3600 spectra got in one test observation (>90% of selected objects)



No.5: red



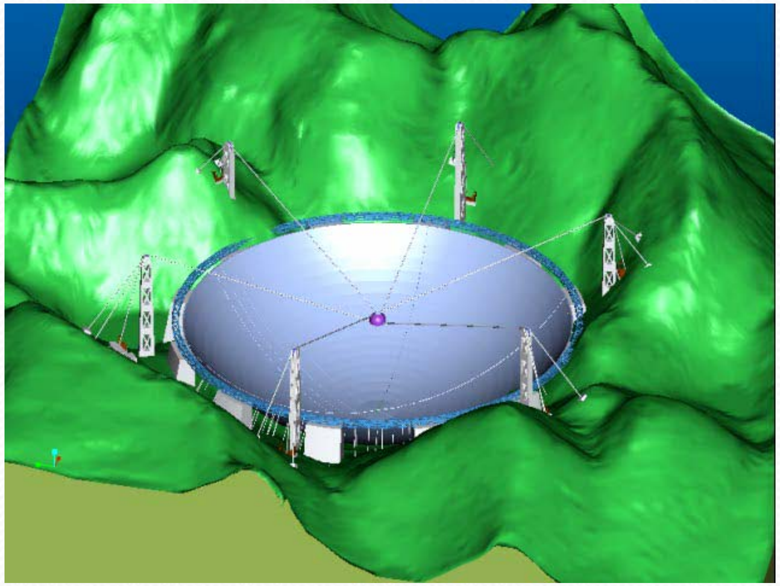
No.4: red

Preliminary Conclusion

- Whole system works well
- Get spectra of objects to g=20 now
- Further improvement
  - Accuracy of fiber positioning
  - Dome seeing
  - Optical throughput
  - Scattering light in dome and spectrographs
  - 2D & 1D pipeline
  - ……

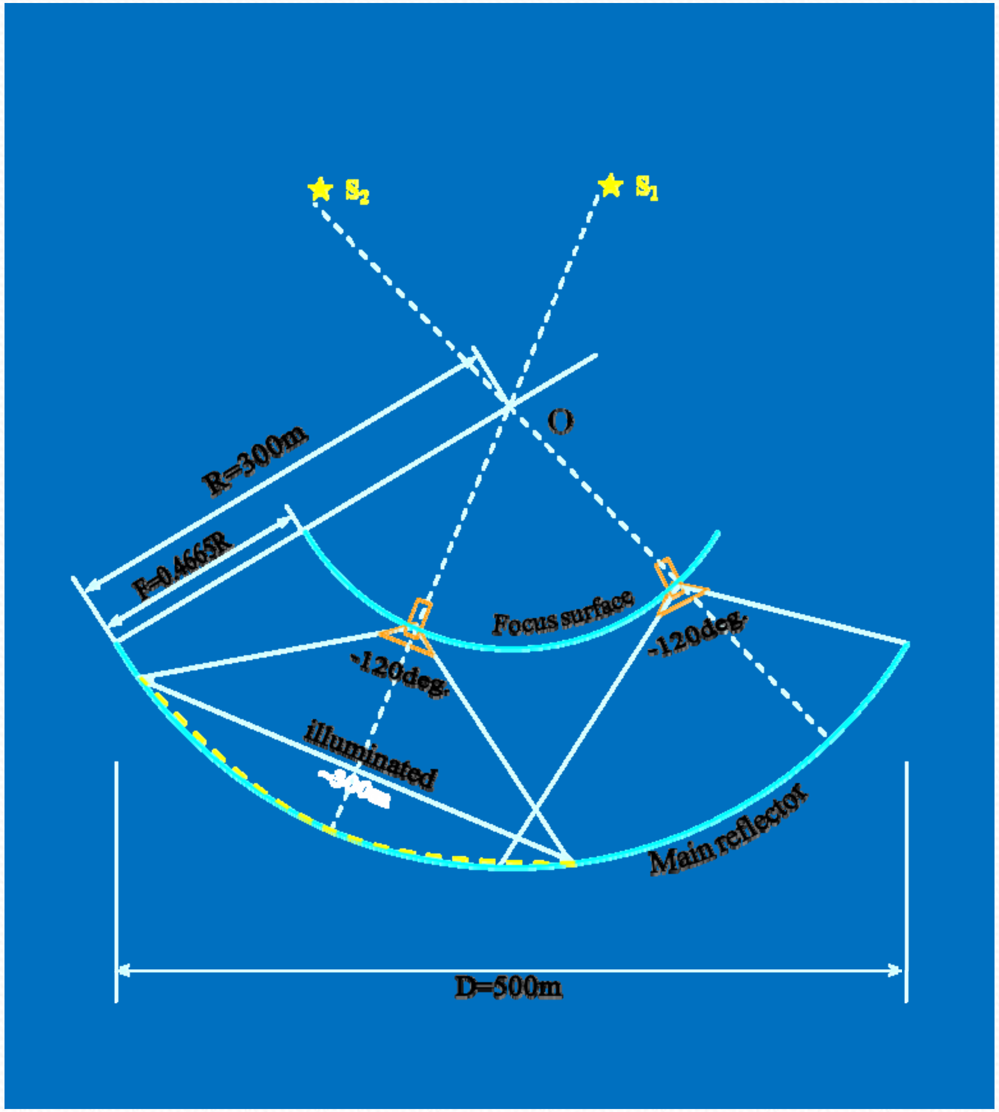
Five-hundred-meter Aperture Spherical Telescope - FAST

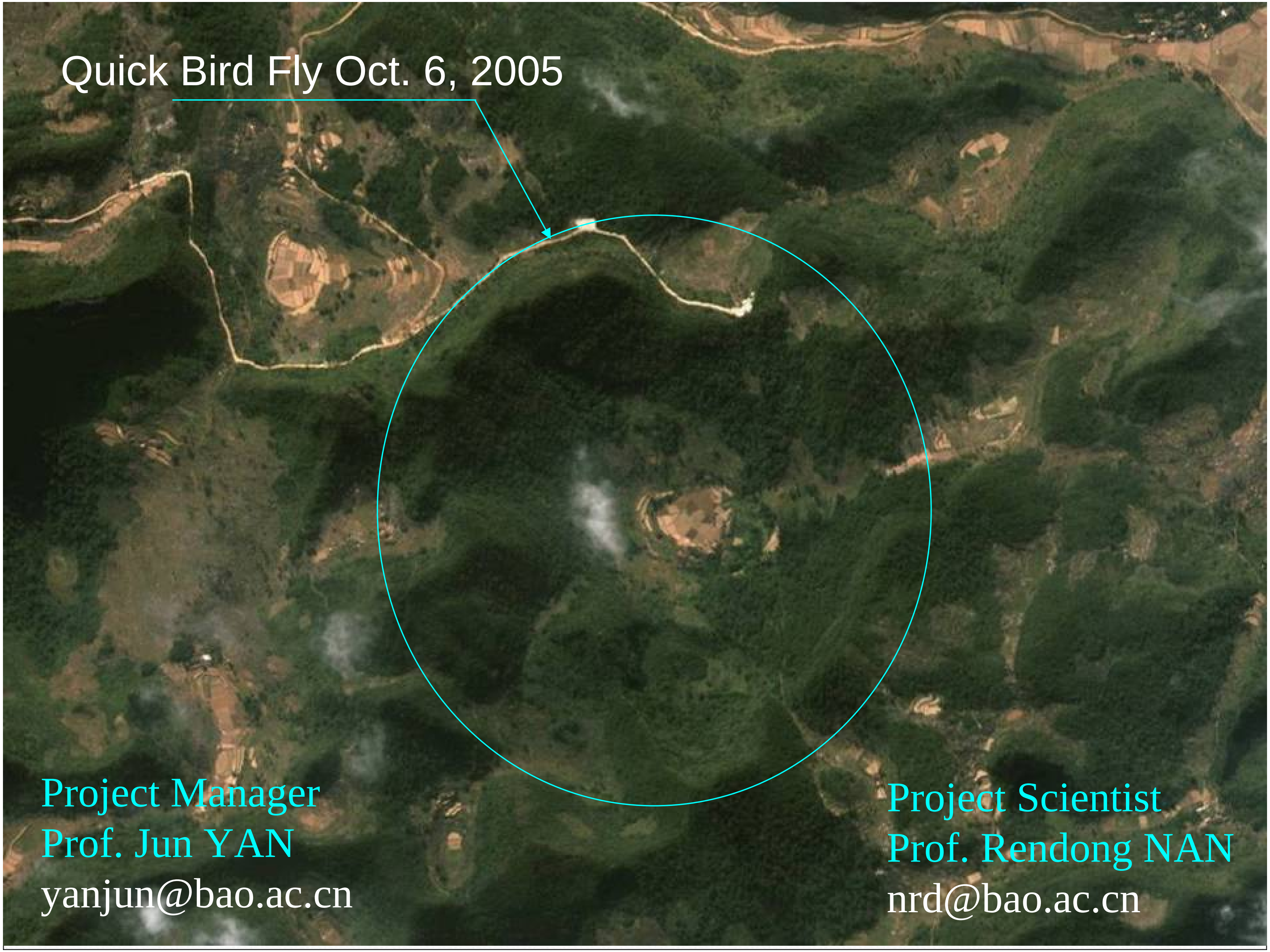
- Unique Karst depression as the site
- Active main reflector
- Cable - parallel robot feed support



Optical Geometry and Specs

- Reflector: R～300m, D～500m, opening angle: θ～110-120°
- Illuminated aperture: D_{eff}=300m
- Sky coverage: maximum zenith angle: 40°
- Working frequencies: 70MHz-3GHz, up to C-, X-band
- Sensitivity 2000 ㎡/K
- Resolution 2.9'
- Multibeam 19
- Pointing Accuracy：8″




Quick Bird Fly Oct. 6, 2005
Project Manager
Prof. Jun YAN
yanjun@bao.ac.cn
Project Scientist
Prof. Rendong NAN
nrd@bao.ac.cn

- Science Cases
  - HI surveys
  - Pulsar research
  - Hosting VLBI network
  - Molecular lines
  - SETI

- FAST milestones:
  - Concept born together with SKA, back to 1993
  - Funding Proposal approved on July 10, 2007
  - Feasibility Study approved on Oct. 31, 2008
  - Preliminary Design evaluated on Dec. 15, 2008
  - Opening Foundation held on Dec. 26, 2008

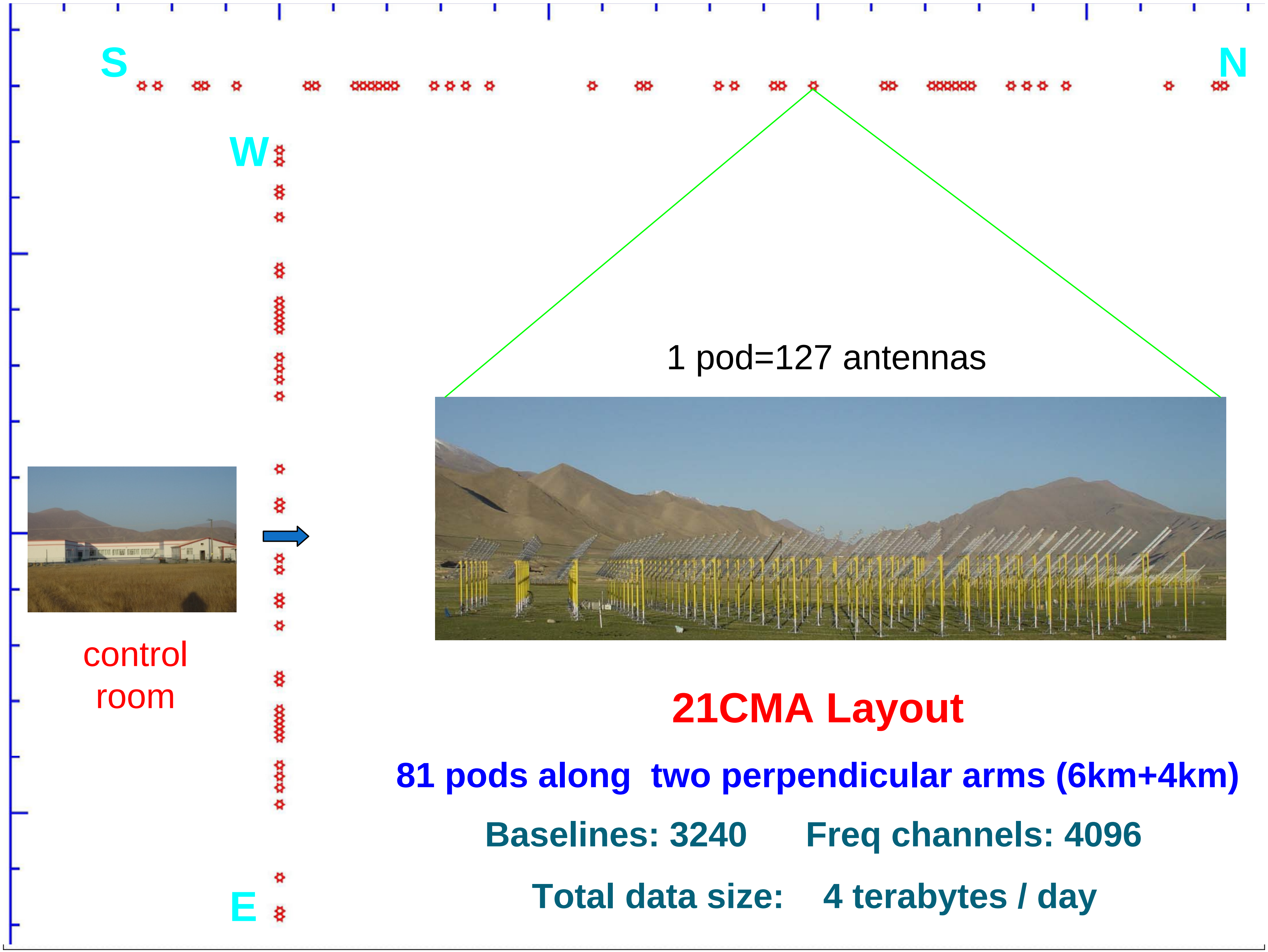
FAST Opening Foundation

21 Centimeter Array (21CMA)

Goal: Search for the Lights of First Stars at Epoch of Reionization

Physical Area: 50544m^2 Working Frequency: 70-200MHz
10287 antennas @ 4x6 km arms

Chief Scientist: Prof. Xiangping WU wxp@bao.ac.cn



21CMA Layout

81 pods along two perpendicular arms (6km+4km)

Baselines: 3240 Freq channels: 4096

Total data size: 4 terabytes / day

Characteristics of 21CMA

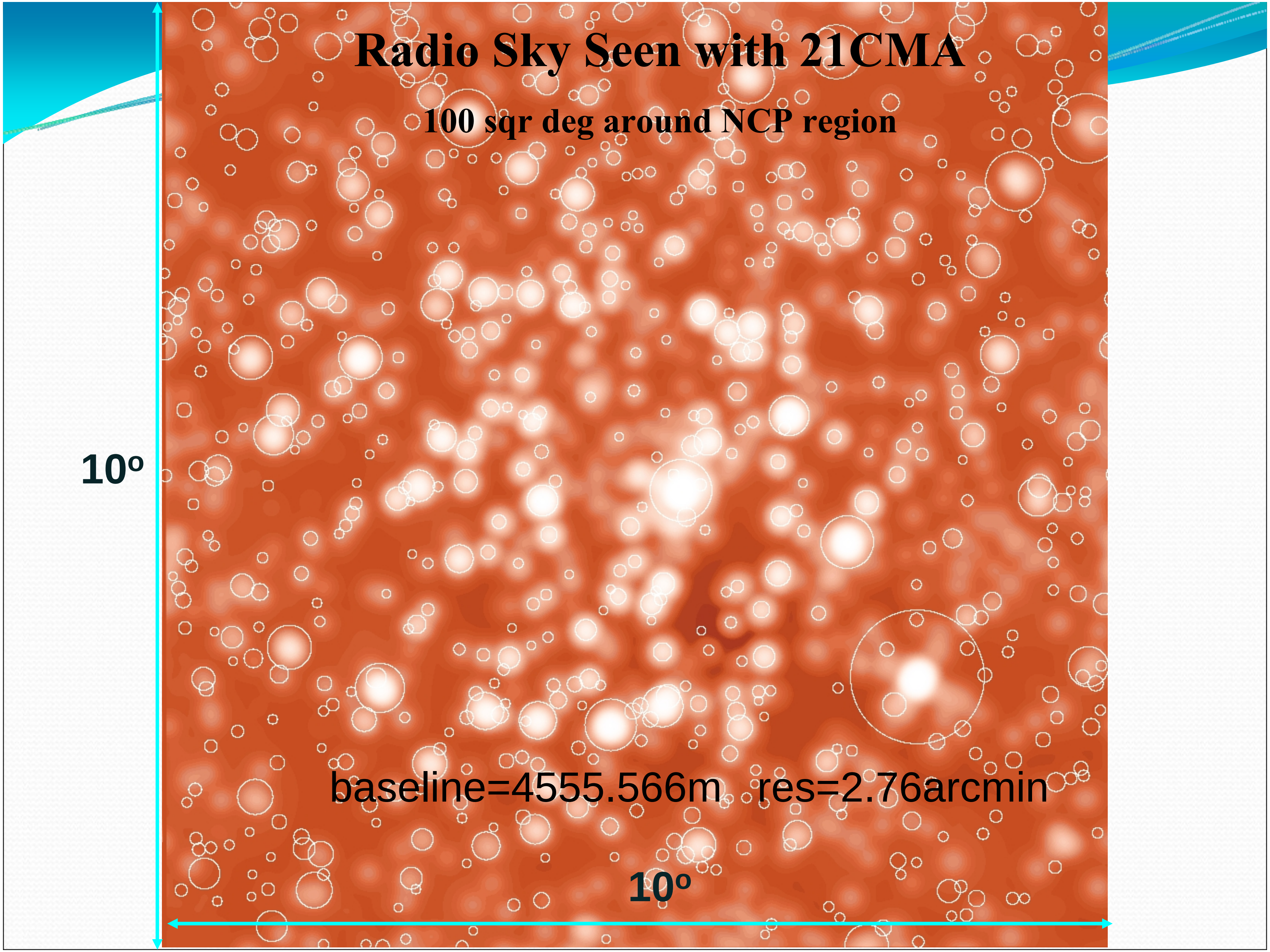
Frequency coverage:

70 - 200 MHz

Redshifted 21cm Line:

$$\lambda = 21\text{cm} \; (1 + z)$$

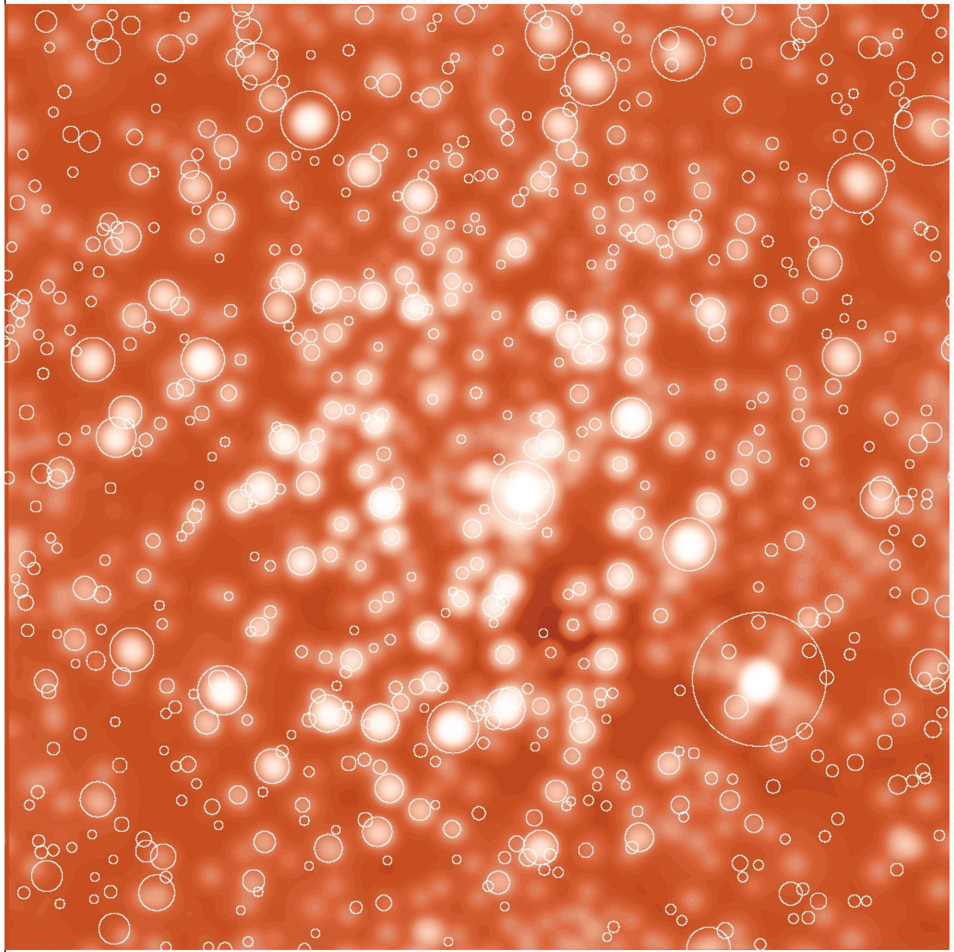
z	λ (cm)	ν (MHz)
6	147	200
10	246	130
20	441	68

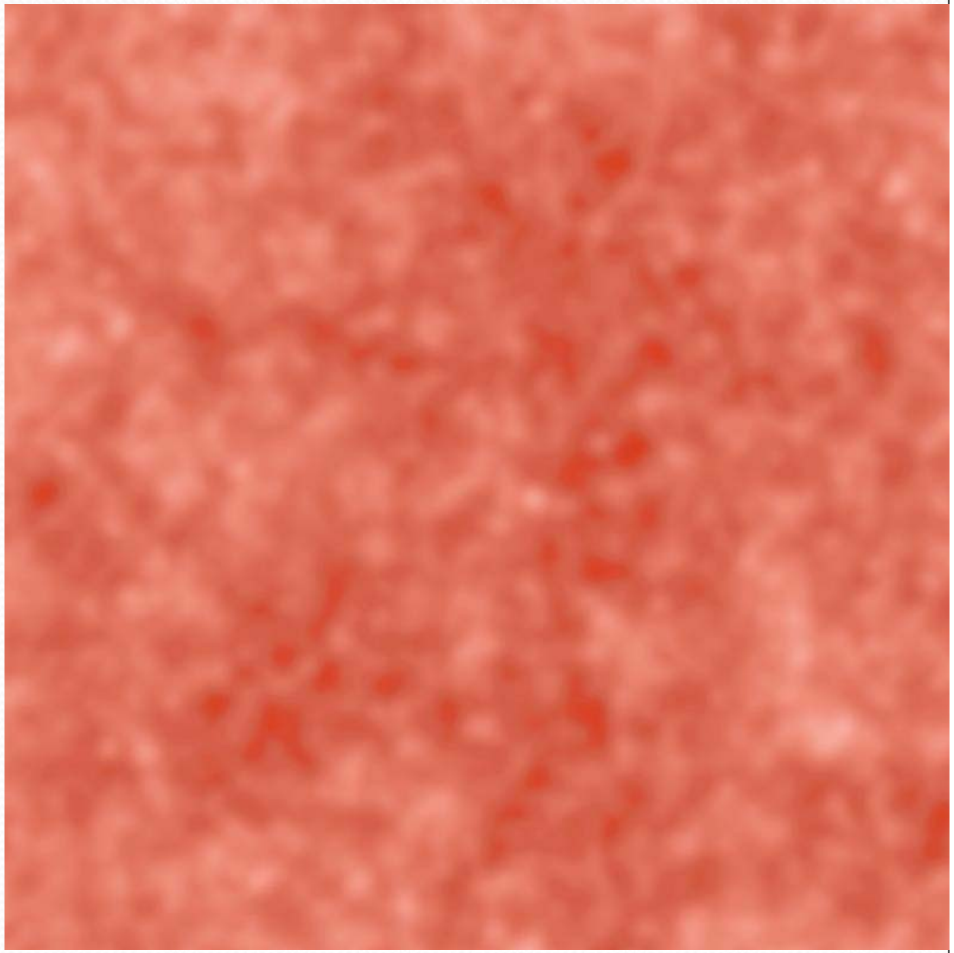


Radio Sky Seen with 21CMA
100 sqr deg around NCP region
10o
baseline=4555.566m res=2.76arcmin
10o

Strategy:

Remove foreground sources to “see” structures of reionization



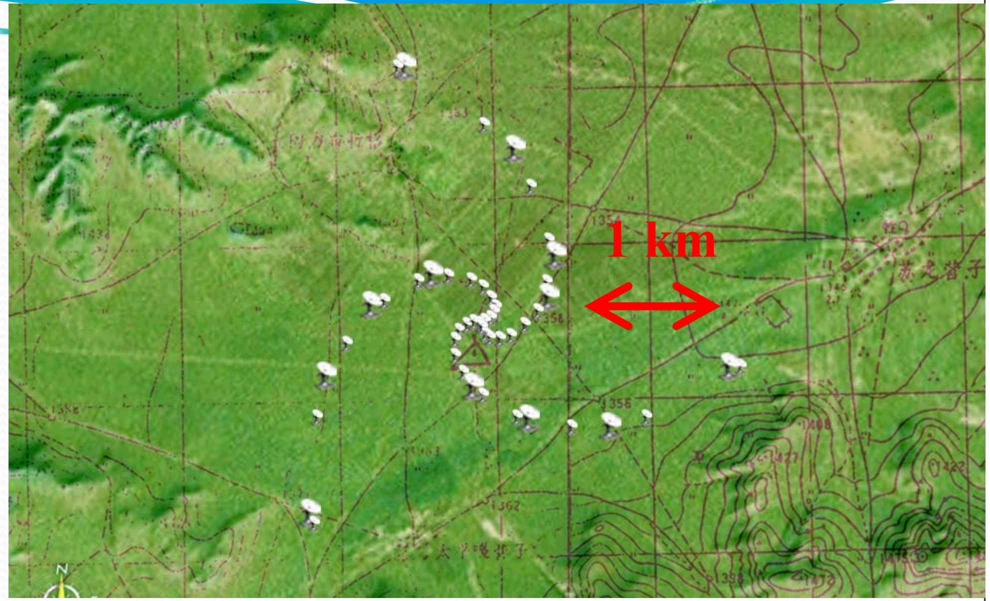


VHF Sky@21CMA

Residual Background

Chinese Radioheliograph Project (CSRH)

Imaging spectroscopy in dm-cm range, with high temporal, spatial, and spectral resolutions, is important for addressing fundamental problems of energy release, particle acceleration and particle transport



Array Configuration
Site: Inner Mongolia, China

Chief Scientist: Prof. Yihua YAN yyh@bao.ac.cn

Low frequency array: CSRH-I during 2008-2010

High frequency array: CSRH-II during 2011-2013

CSRH Specifications

Freq. Range: ~0.4–15 GHz （λ： ~75 –2 cm）

Frequency Res.: 64 or 128 chan （I: 0.4-2 GHz）

32 or 64 chan （II: 2-15 GHz）

Spatial Res.: 1.3”– 50”

Temporal Res.: ~<100 ms （0.4-15 GHz)

Dynamic Range: 25 dB （snapshot）

Polarizations: Dual circular L, R

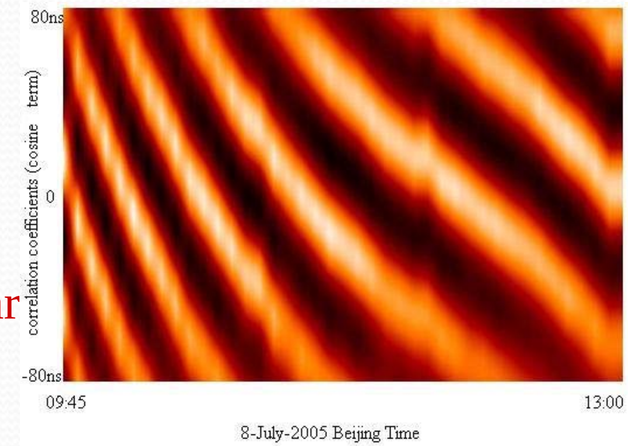
Array: I: 40×∅4.5m parabolic antennas

II: 60× ∅2m parabolic antennas

Max baseline: 3 km

Field of view: 0.6°– 7°

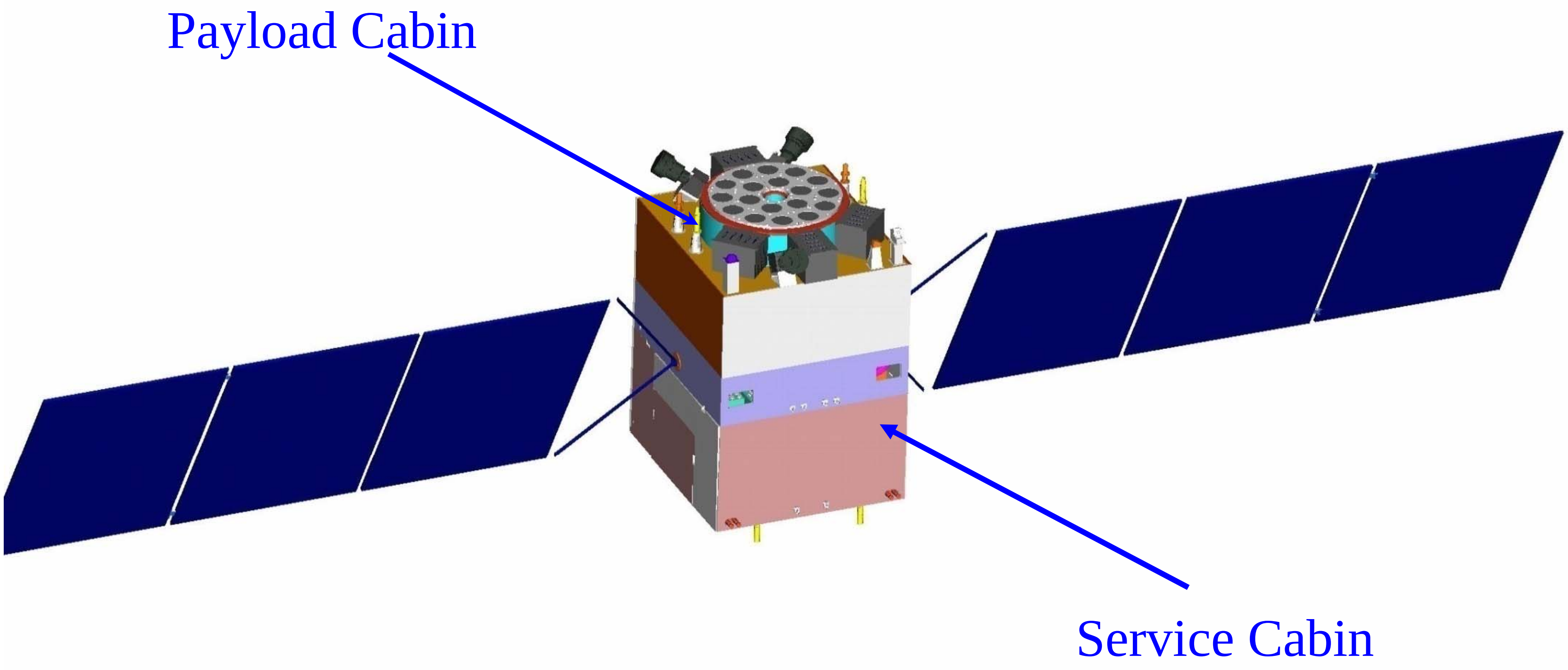
2-element prototype experiment in 2005 with Fringes of Solar Radio Signal at 1.6GHz for short baseline of 8 m →



Space Missions

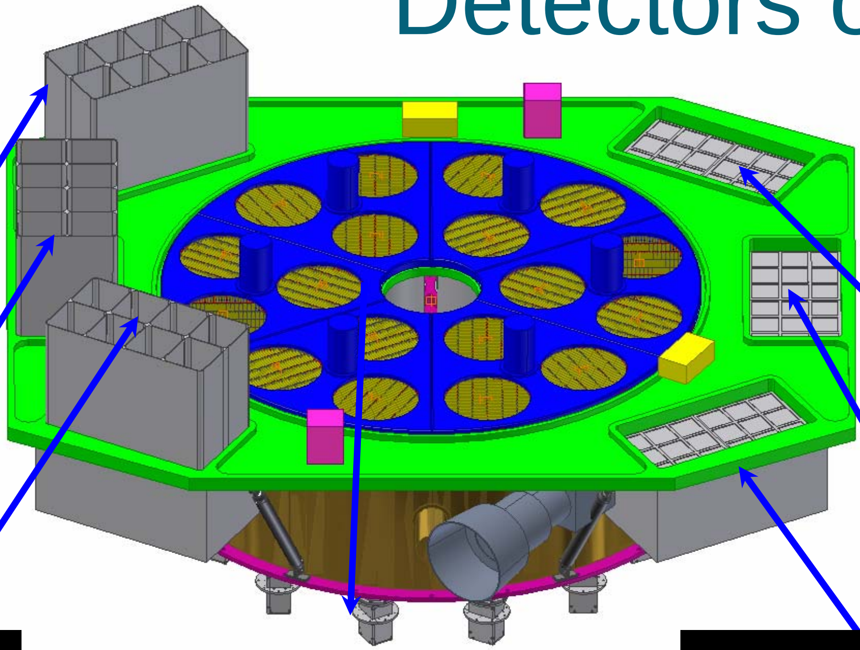
HXMT, SVOM, POLAR, WSO, SST, and SMESE

HXMT: planned for launch around 2011



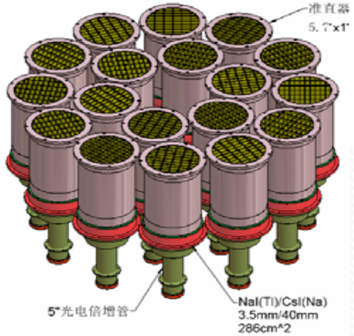
Hard X-ray Modulation Telescope

Detectors onboard



Low Energy X-ray Telescope (LE)
(1-15 keV)
SCD, 384 cm^2)

Medium Energy X-ray Telescope (ME)
(5-30 keV)
(SiPIN, 952 cm^2)



High Energy X-ray Telescope (HE)
(20-250 keV, 18 modules, 5000 cm^2)

Main science of HXMT

- Hard X-ray full sky survey with high sensitivity
  - Hard X-ray full sky map:
    - diffuse background and cosmic variance
  - Discover highly obscured supermassive BHs:
    - Galaxy formation and evolution
  - Discover new types of high energy objects:
    - usual surprises of new surveys

Main science of HXMT (cont.)

- Broad band and large collection area pointed observations of high energy objects
  - Space-time in strong gravitational field:
    - dynamics and radiation near BH horizons of stellar mass and supermassive BHs
  - High energy particle acceleration:
    - AGN, SNR, shock and relativistic jets
  - Large scale structure:
    - through hard X-ray detection of galaxy clusters

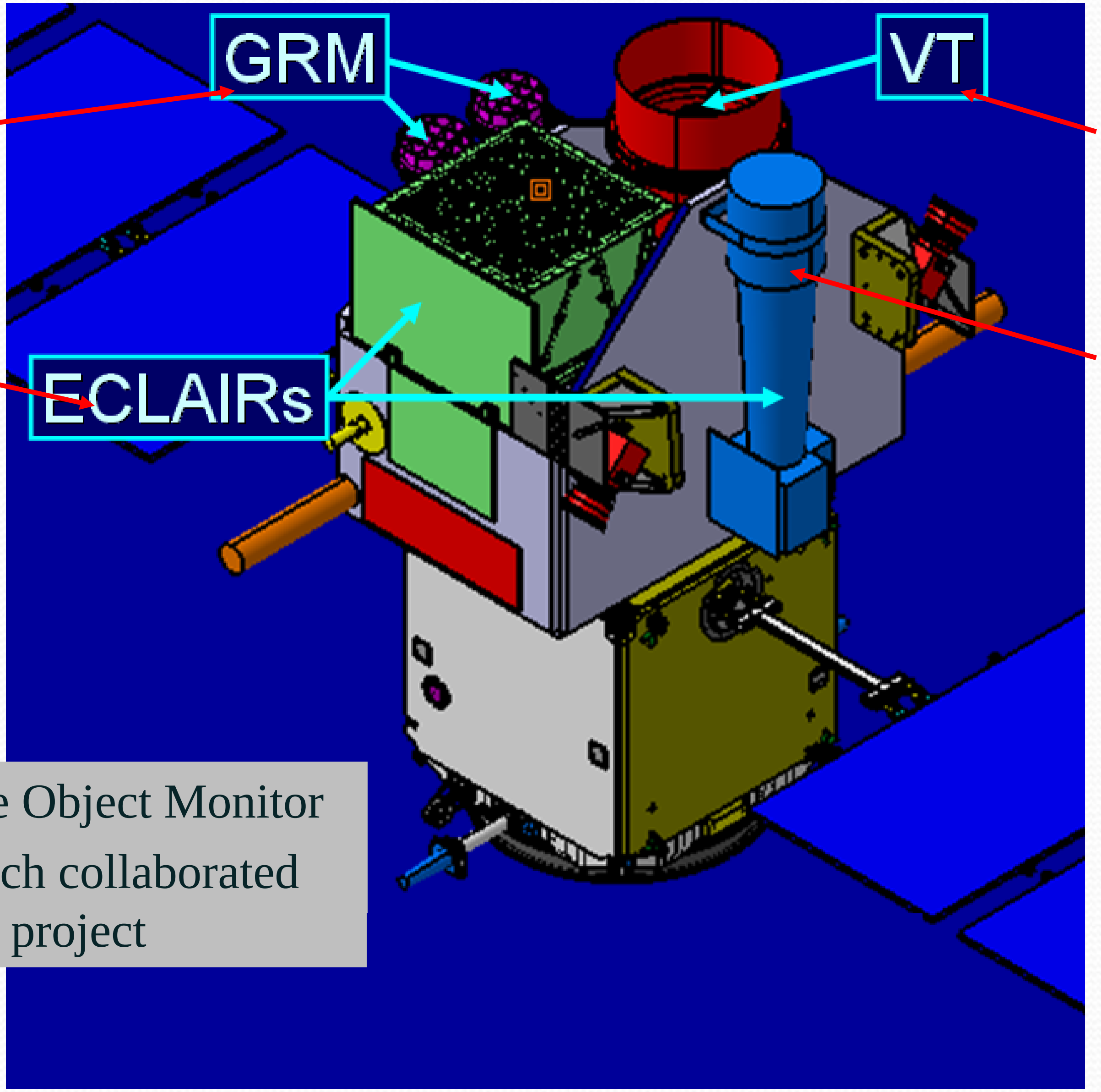
Project Scientists: Prof. Tipei LI litp@mail.ihep.ac.cn
Prof. Shuangnan ZHANG zhangsn@tsinghua.edu.cn

A multi- λ GRB project: SVOM

China:
30keV-5MeV

France:
4 -150keV

Launch time:
2012 - 2013



China: 45cm
diameter

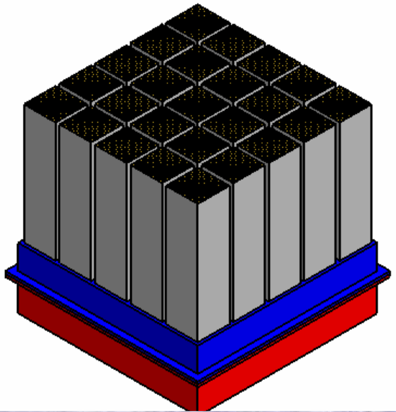
France:
0.5 - 10keV

Space Variable Object Monitor

Chinese-French collaborated space project

Gamma-ray burst polarization experiment onboard China's Spacelab: POLAR

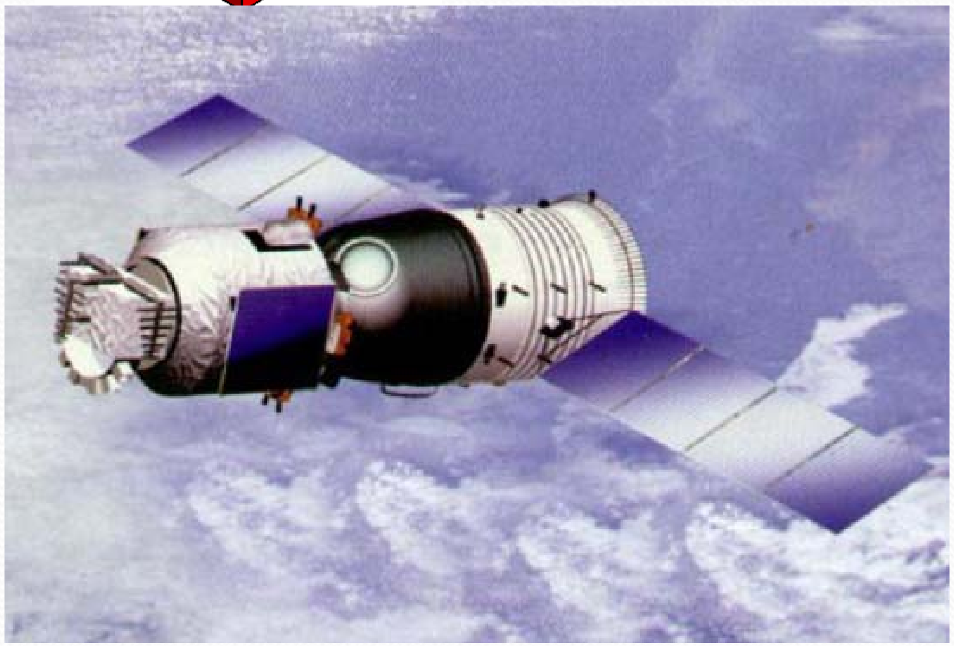
- Instrument concept proposed by N. Produit, et al., NIM (2005)
- Onboard China's spacelab TG-2: launch time 2011-12
- A China-led international collaboration
- FOV of POLAR: ~½ sky
- *Requires directionality and energy spectrum known after the fact*



Tian-Gong

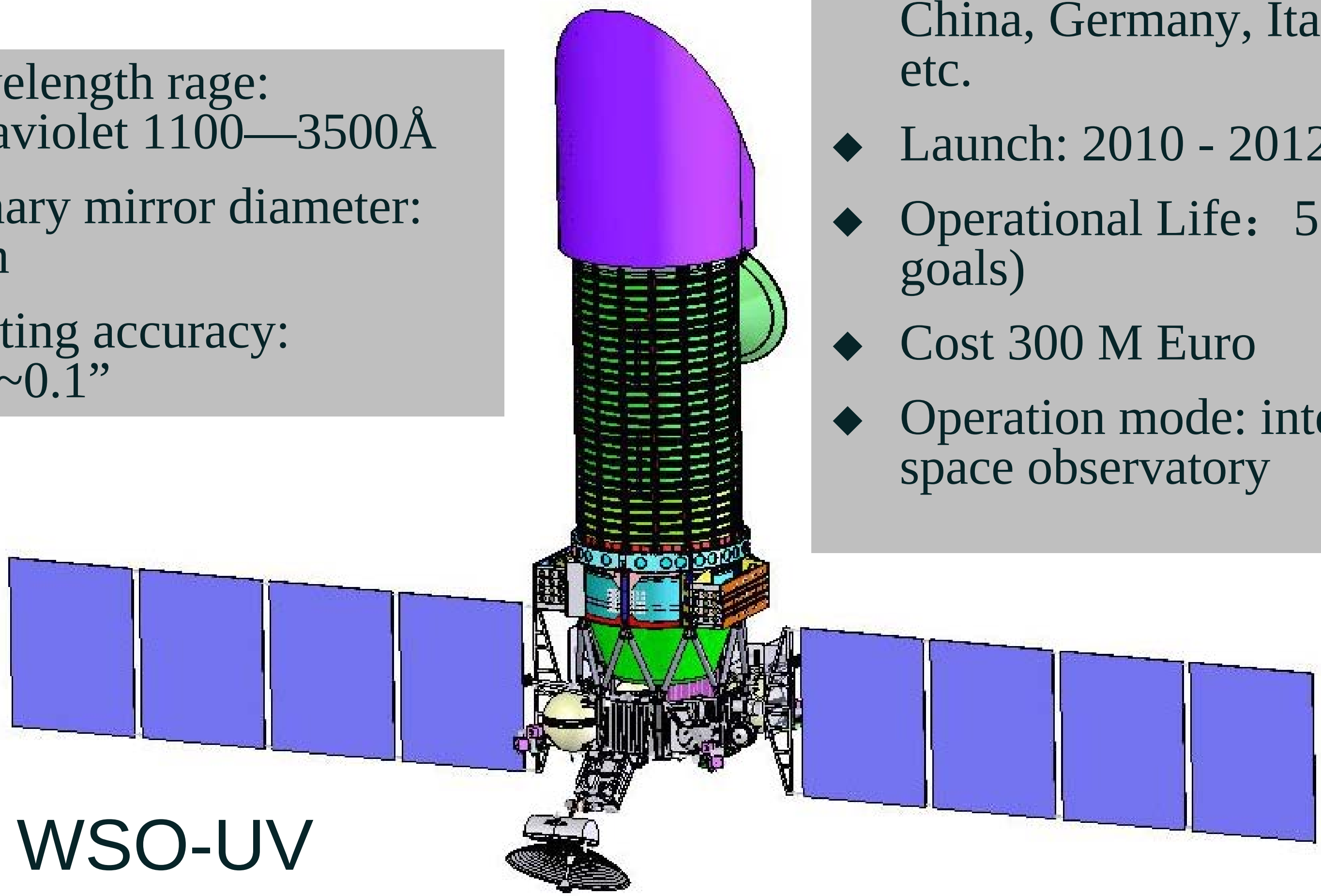
天宫

Palace in Heaven



World Space Observatory - Ultraviolet

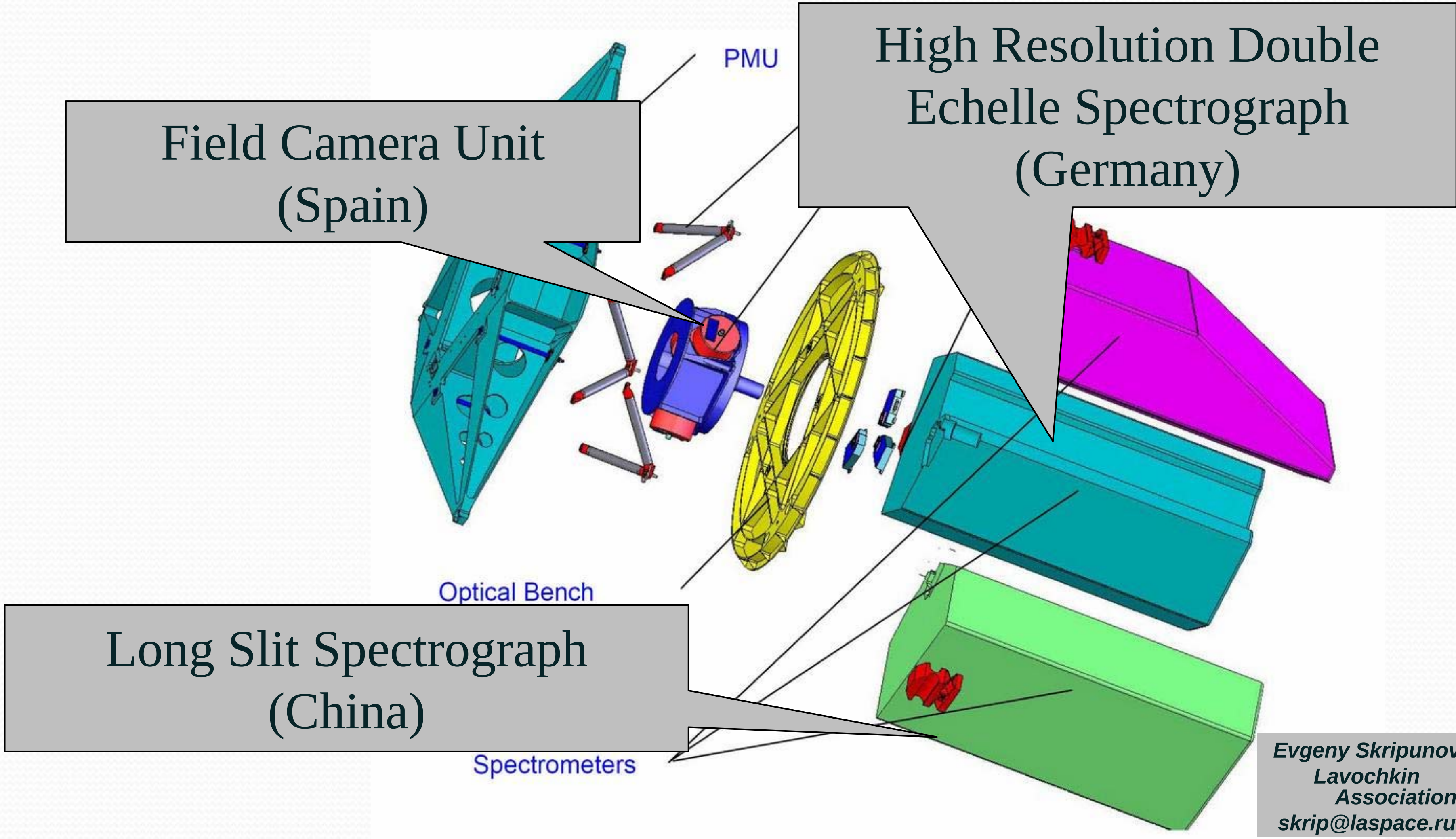
- Wavelength rage: Ultraviolet 1100—3500Å
- Primary mirror diameter: 1.7m
- Pointing accuracy: 0.05~0.1”



WSO-UV

- Led by Russia, participated by China, Germany, Italy, Spain, etc.
- Launch: 2010 - 2012
- Operational Life：5 years (10 goals)
- Cost 300 M Euro
- Operation mode: international space observatory

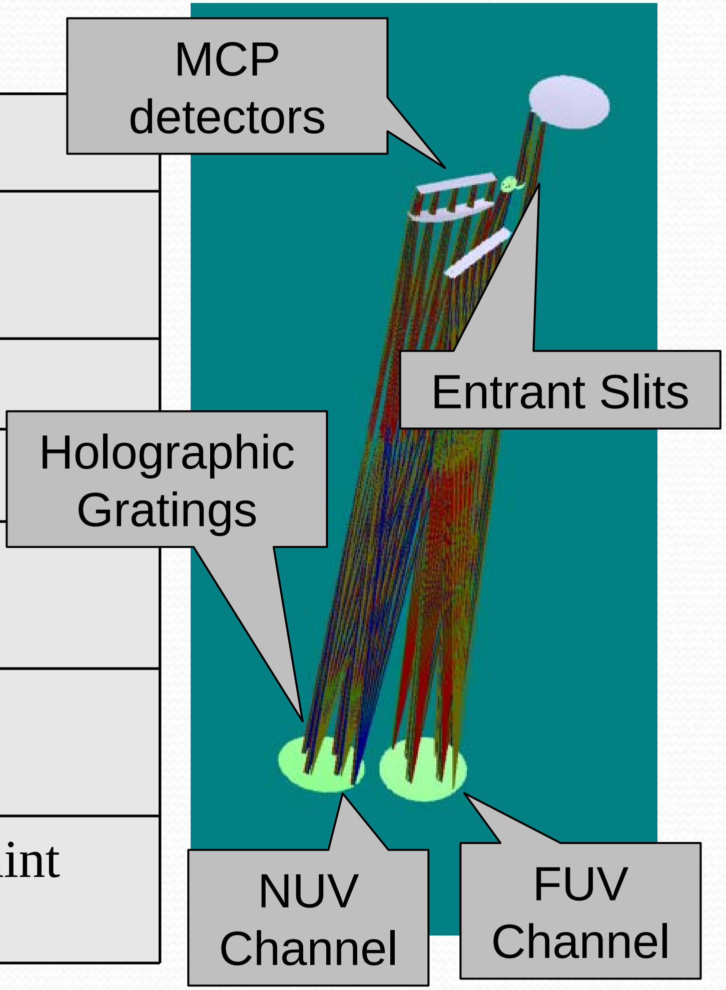
WSO-UV's Three Science Instruments



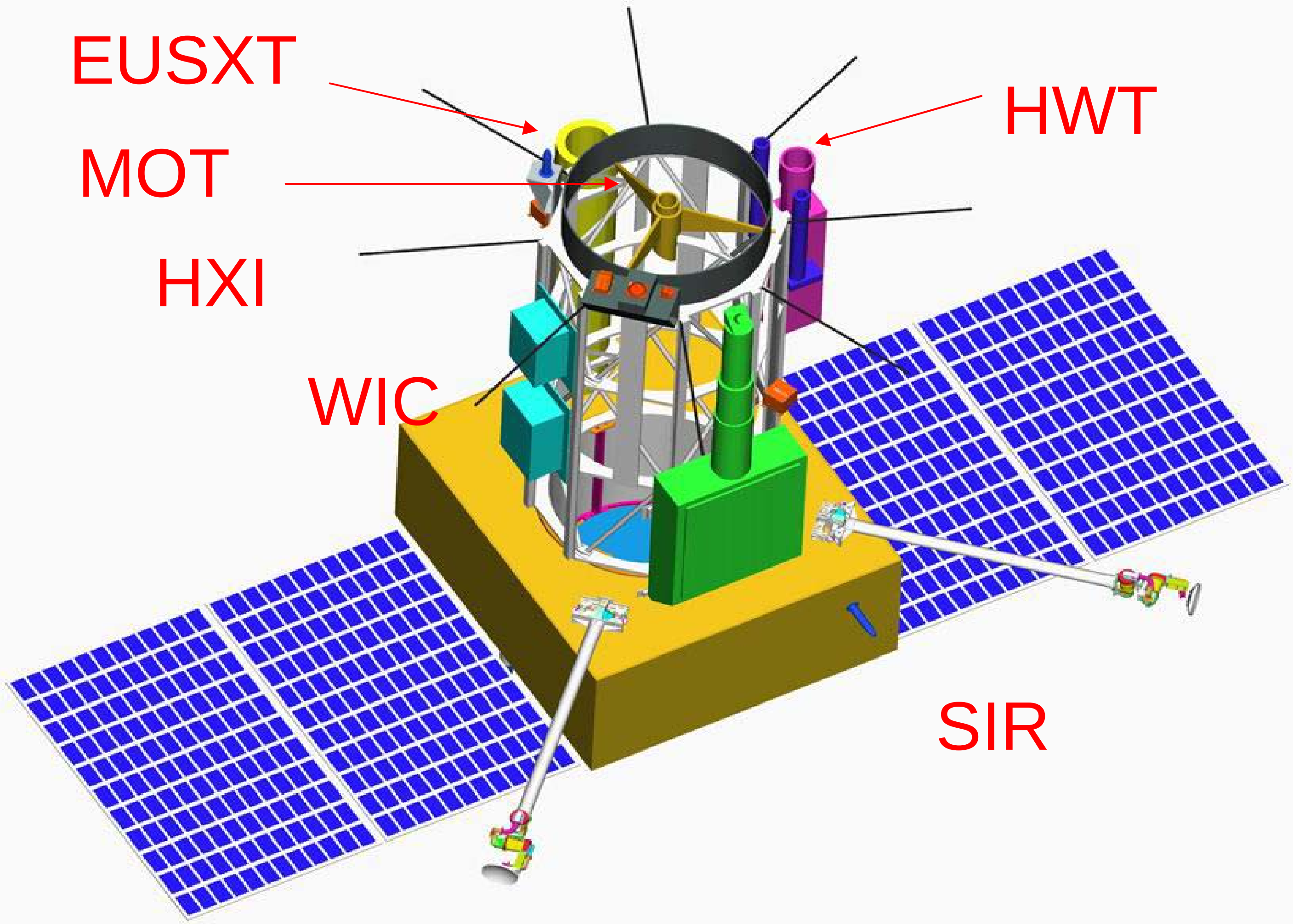
Evgeny Skripunov
Lavochkin Association
skrip@laspace.ru

China's Long Slit Spectrograph

Parameter	specification
Wavelength coverage	102~320 nm two-channel design
Width of slit	1″ ≈ 82 μm
Length of slit	75″ ≈ 6.2 mm
Spectral resolution	1500~2500
Spatial resolution	0.5”~1”
sensitivity	Optimized to observe faint sources



Space Solar Telescope (SST)



Payloads of SST

- MOT: Main Optic Telescope (1 Meter)
  - 0.1″, 2.8'×1.5', 8 channels, two lines
  - polarization measurement accuracy ~ 2×10^{-4}
- EUSXT: Extreme Ultraviolet and Soft X-ray Telescope
  - 0.8″, 7'×7', 2 EUV channels (19.5, 160 nm) + SXR
- WIC : White-light Inner-corona Coronagraph
- HXI : Hard X-ray Imager
- HWT: Hα and White Light Telescope
  - 1″, 0.7° × 0.7°, Full disk
- SIR: Solar & Interplanetary Radio Spectrometer
  - 2-50 MHz, 0.1s resolution

Scientific Objectives of SST

- Through coordinated, wide spectral coverage, high resolution and continuous observations
  - Study the evolution of multi-scale transients and various phenomena in the solar atmosphere
  - Investigate the heating mechanism of the chromosphere and the corona
  - Study the mechanism of the energy build-up and release in solar flares and CMEs

Project Scientist: Prof. Hongqi ZHANG
hzhang@bao.ac.cn

SMESE (SMall Explorer for Solar Eruptions)

Chinese-French Collaborated Space Project

Payloads：

- Ly α Imager (up to 1.15 $R_\odot$)
- EUV Imager (Fe XII 19.5 nm)
- Far IR Telescope (35 & 150 μm)
- Ly α Coronagraph (1.1-2.5 $R_\odot$)
- X-ray Spectrometer (10-300 keV)
- γ -ray spectrometer (0.2-600 MeV)

To detect solar flares and CMEs

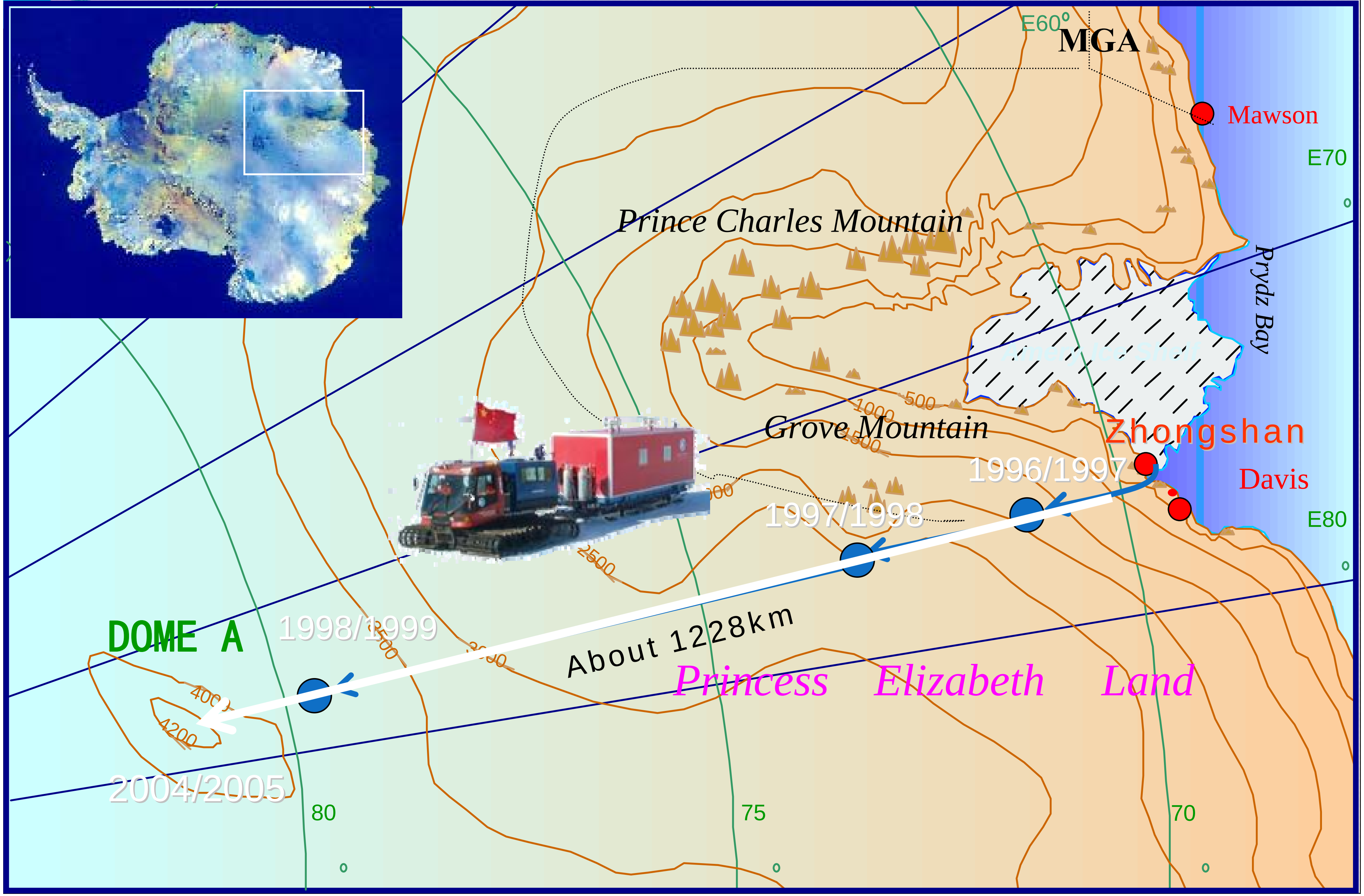
Expected to launch in 2012-2013

Project Scientist: Prof. Cheng FANG
fangc@nju.edu.cn

Future Projects of Chinese Astronomy

- Chinese Antarctic Observatory
- Participation in 30m Class Telescope Projects

Chinese Expedition in Antarctica



Chinese Center for Antarctic Astronomy

- On Jan. 18, 2005, led by Professor Yuansheng LI, Chinese group reached Dome A
- Dome A - the inland peak of the Antarctica
  - altitude of 4100m
  - 60km x 10km “drop” shape
- China’s aspiration to build the Antarctica station and carry out related scientific researches

First Chinese Observation in Dome A

NEWS NATURE|Vol 451|14 February 2008

Report from *Nature*

Chinese astronomers look to Antarctic

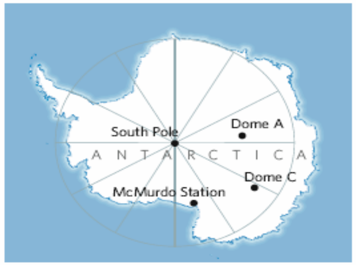
A Chinese expedition returned last week from a 14-day crawl across the East Antarctic ice sheet in cargo containers, pulled by tractors, that doubled as living quarters. The trip, sponsored by the Polar Research Institute of China, completes only the second traverse to Dome A — the highest point on the eastern ice cap and the place where China intends to start building a research base next year.

The team also set up a suite of research instruments to study the atmosphere and sky above Dome A, most notably a remotely operated observatory called PLATO, which will assess how good the skies are for astronomical 'seeing'. PLATO includes four 14.5-centimetre telescopes, built in China, that will take advantage of more than three straight months of darkness during the Antarctic winter. "We think Dome A is the best site on Earth for astronomy," says Xiangqun Cui of the Nanjing Institute of Astronomical Optics and Technology.

The hope is that the desolate plateau, which sits 4,100 metres above sea level, will boast conditions unrivalled elsewhere on the planet — even at the French/Italian base at Antarctica's Dome C, 1,200 kilometres away, which set up its own automated test observatory in 2003 and has since ramped up to larger projects.

Proponents of Antarctic astronomy have looked to Domes A and C as alternative sites to the South Pole, above which 300 metres of turbulent air cause observations of stars to jitter and blur[1]. Dome C, by contrast, has only additional 100 metres is very important because

Cold comfort: China has set up a remotely operated observatory on Dome A, the summit of East Antarctica's ice cap.



Such conditions make Dome A attractive to Chinese astronomers, who have begun work on a suite of three 0.5-metre telescopes that they hope to deploy at the site in 2009. They are also eyeing the location for a potential US$40-million, 4-metre infrared and optical telescope. A proposal on that may be submitted this summer to the Chinese Academy of Sciences.

The true potential of Dome A may lie in observations outside optical wavelengths. The efficiency of infrared astronomy is particularly sensitive to temperature, and winter nights that drop as low as −90 °C will eliminate much of the noise from the atmosphere and the telescope itself, researchers say.

Report from *Science*

SCIENCE & TECHNOLOGY, 2005

ites *Indicators* con-
prise that its author-
the volume, is that
exceedingly expen-
' he writes.

s to zoos; how math
ng fields and multi-

ning and employer

outside academia,
of S&E jobs.

China Reaches Dome A

BEIJING—A 17-person team led by the Polar Research Institute of China last week struck camp at the highest bulge on the East Antarctic Ice Sheet in search of the best astronomical viewing on Earth. The team is installing an automated suite of instruments to measure atmospheric turbulence, moisture, and other parameters and is setting up four 14.5-centimeter optical telescopes that will start snapping images after night falls in March. "Everything is going smoothly," says Cui Xiangqun, an astronomer at the Nanjing Institute of Astronomical Optics and Technology, which built the telescopes. China hopes to have a year-round base at Dome A up and running by 2010.

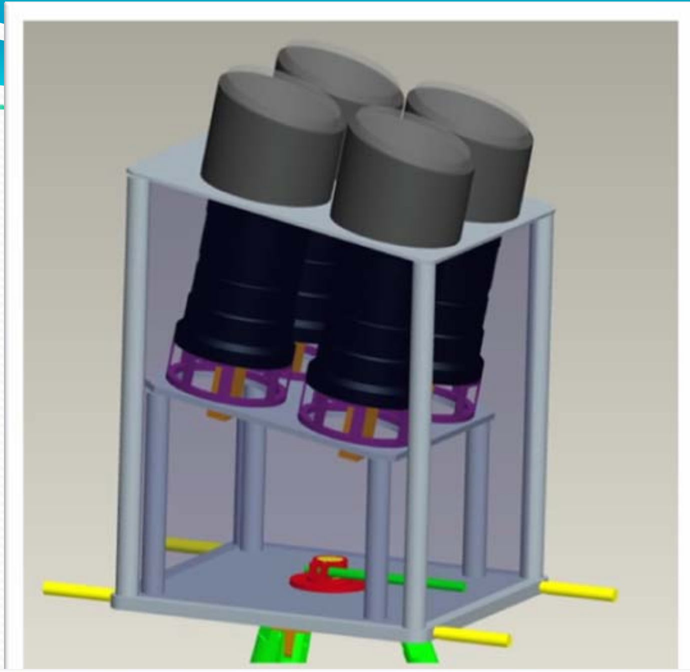
–RICHARD STONE

SCIENCE VOL 319 25 JANUARY 2008 399

Published by AAAS

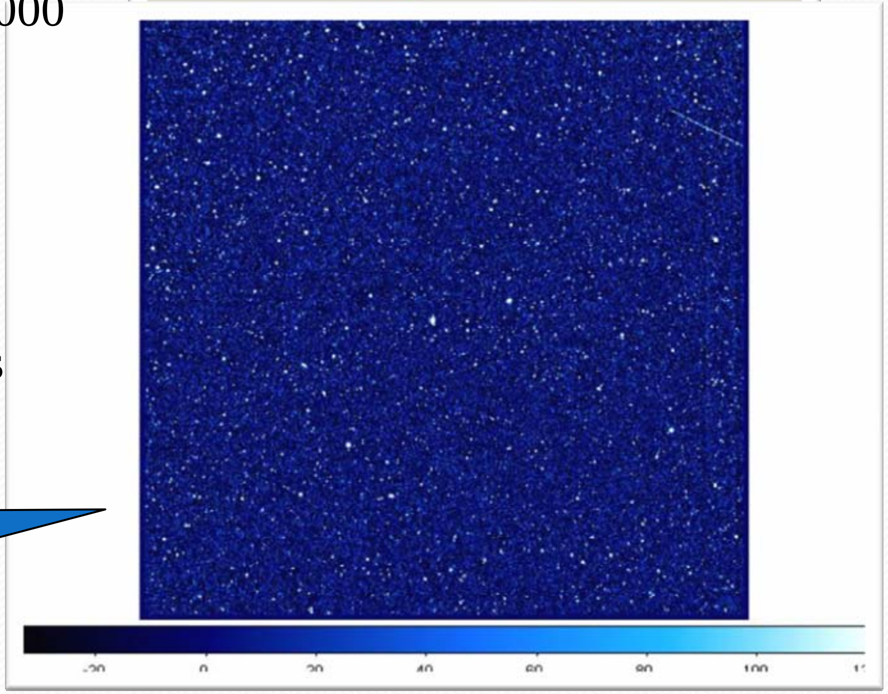
This astronomical investigation suggests that Dome A could be one of best astronomical sites in the world

CSTAR: 4 x 14.5cm telescope array



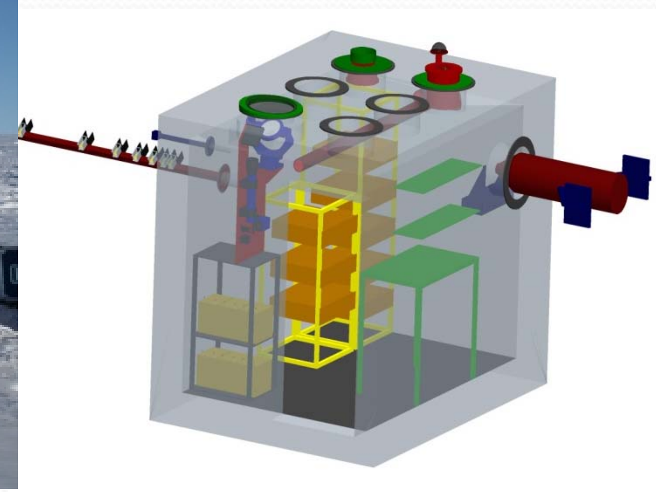
- To construct 4 CCD photometric telescope, with 4 colors, radius of 14.5cm and FOV ~ 20 deg^2
- Scientific goals:
  - Variance in luminosity and colors of ~8000 objects
  - To detect supernova, nova, etc.
  - To search for exo-planets
  - Light curves of variables
  - Statistical number of Antarctic variables
  - Site evaluation

The first star map of the southern sky observed by Chinese astronomers



PLATO (Plateau Observatory, collaboration with Australia and U.S.)

Facilities inside PLATO: MASS, Lunar SHABAR, SNODAR, Nigel, Gattini Dome A, Pre－HEAT, etc.



MASS, Lunar SHABAR and Nigel

- MASS (Multi-Aperture Scintillation Sensor): provided by UNSW and CTIO, to measure the 500 – 20000m atmosphere structure constant with star light
- Lunar SHABAR (SHAdow Band And Ranging): provided by UNSW and CTIO, to measure the 20 – 100m atmosphere structure constant with moon light
- Nigel: provided by UNSW, to take multi-fiber low dispersion spectra of polar lights to examine polar light background and its effect on astronomical observations, etc.

SNODAR

(Surface layer Non-Doppler Acoustic Radar)

provided by UNSW and CTIO, to measure the 5 – 100m atmosphere structure constant in high resolution (1m)

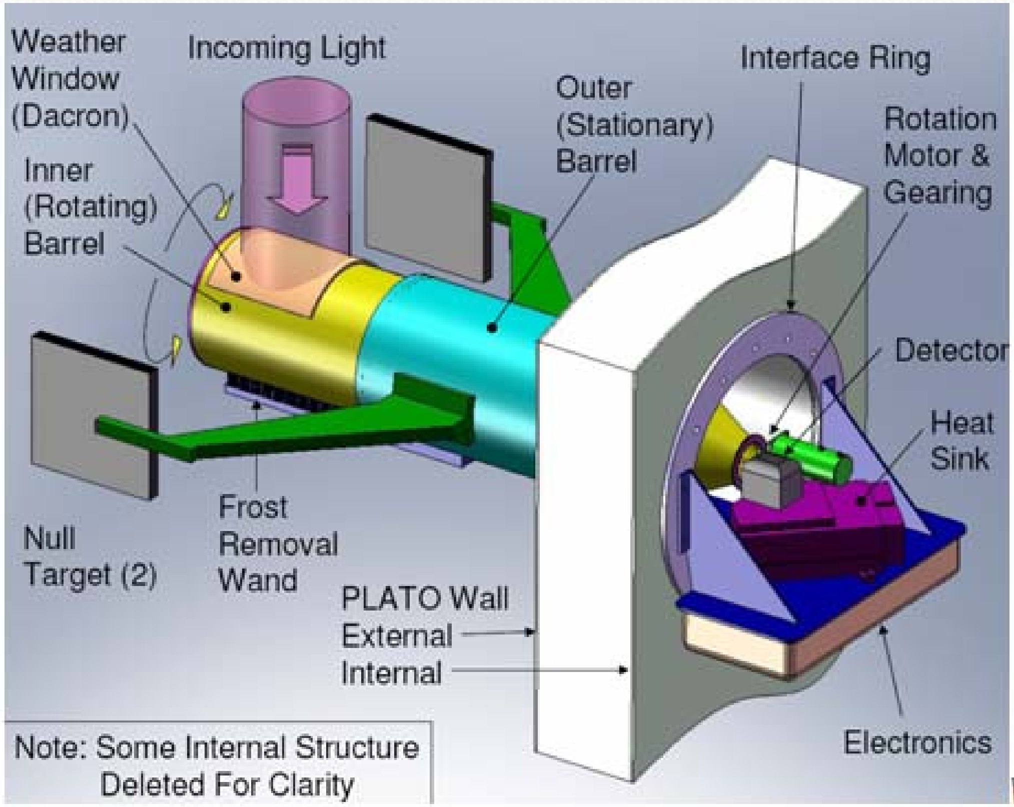
Gattini Dome A

provided by Caltech, two sky-imaging modes (different FOV) to investigate the cloud coverage, sky light background, atmospheric transparency, etc.

Pre – HEAT

(the High Elevation Antarctic Terahertz Telescope)

Provided by University of Arizona and collaborated with the Purple Mountain Observatory, to measure atmosphere opacity of millimeter and sub-millimeter wave, and imaging of Galactic emission lines



Scientific Strategy

- Comprehensive site evaluation of Dome A
- Establish observation platforms in optical/infrared, sub-millimeter/THz astronomy led by Chinese astronomers and with international collaborations
- Build optical/infrared wide field survey and sub-millimeter/THz telescopes
- Study the frontier of observational astronomy, including searching for exo-planets and supernova, monitoring transient objects, dark matter and dark energy, stellar and galactic formation and evolution, etc.

Road Map of Chinese Antarctic Observatory

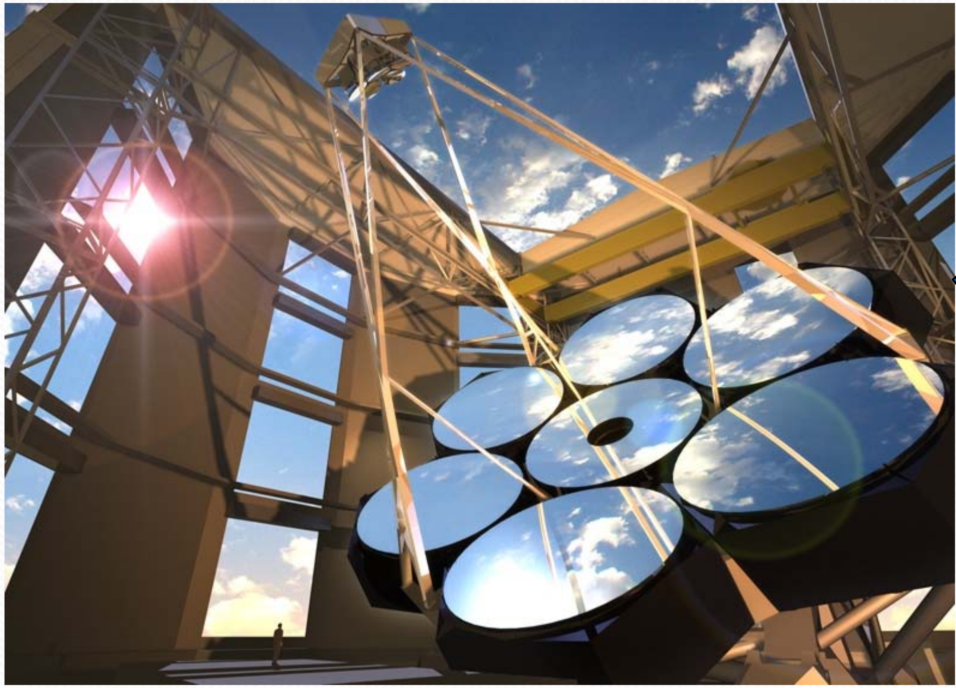
- 2006-2008:
  - site survey
  - preliminary observation – CSTAR, PLATO(Pre-HEAT(THz), SNODAR, etc)
- 2008-2012:
  - comprehensive site survey (accurate measurement of atmosphere turbulence, seeing, transparency, temperature, wind speed, etc.)
  - further observation – CSTAR, Pre-HEAT, HEAT, FTS, Antarctic Schmidt Telescope (AST3)

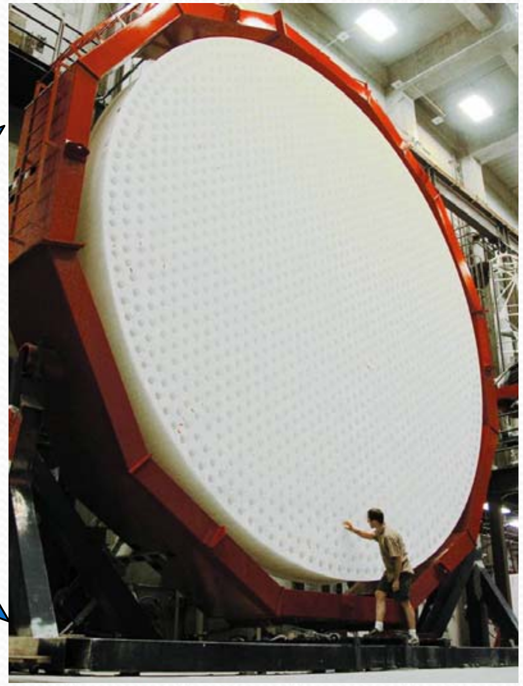
Road Map of Chinese Antarctic Observatory

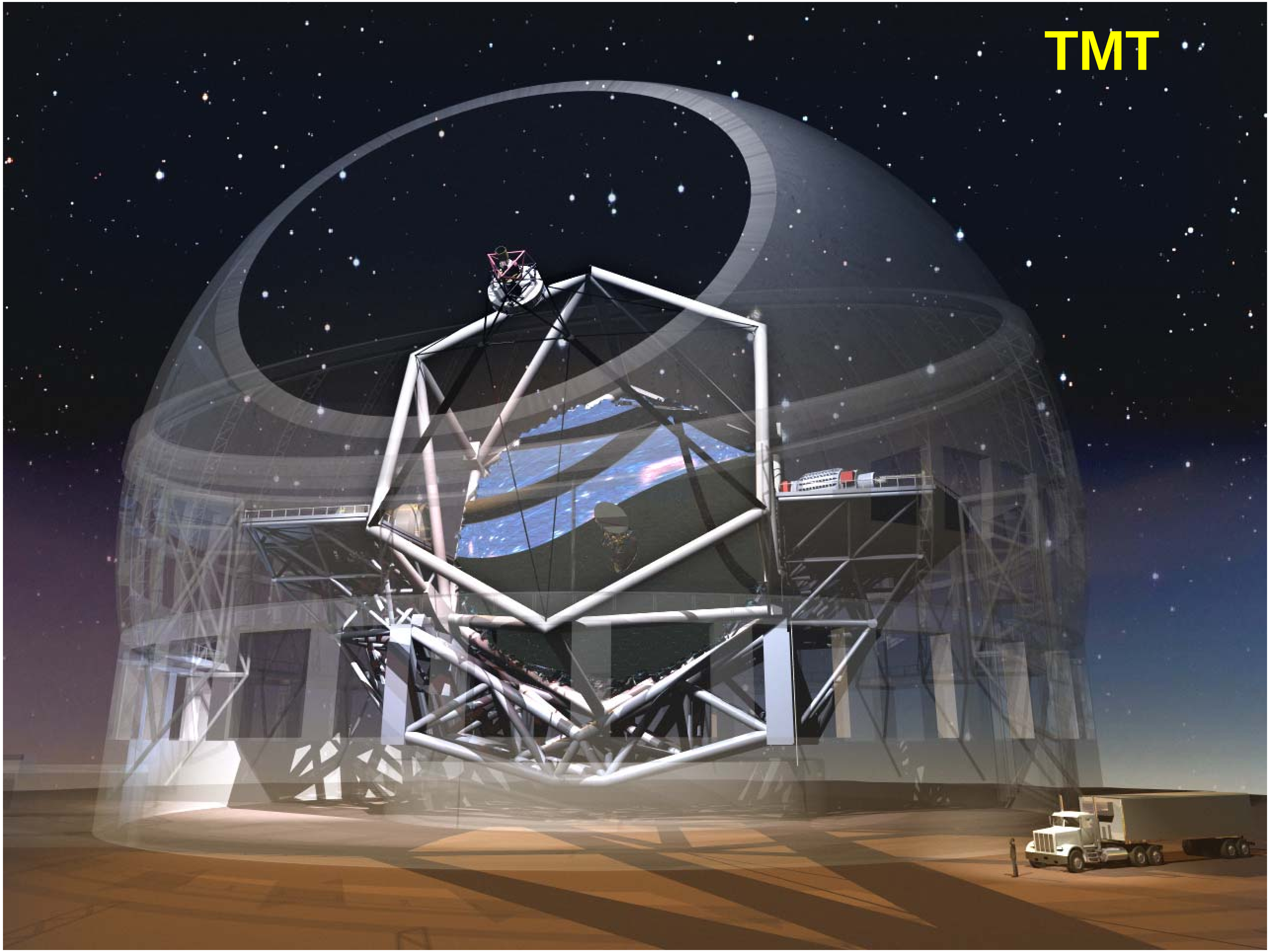
- 2011-2014:
  - 3-5m millimeter/THz telescope
- 2011-2016:
  - 4m wide field optical/infrared telescope
- 2015-2020:
  - 10-15m large THz/FIR telescope
  - 8-10m infrared spectroscopic survey telescope (super LAMOST) or optical/infrared telescope with superb imaging capability

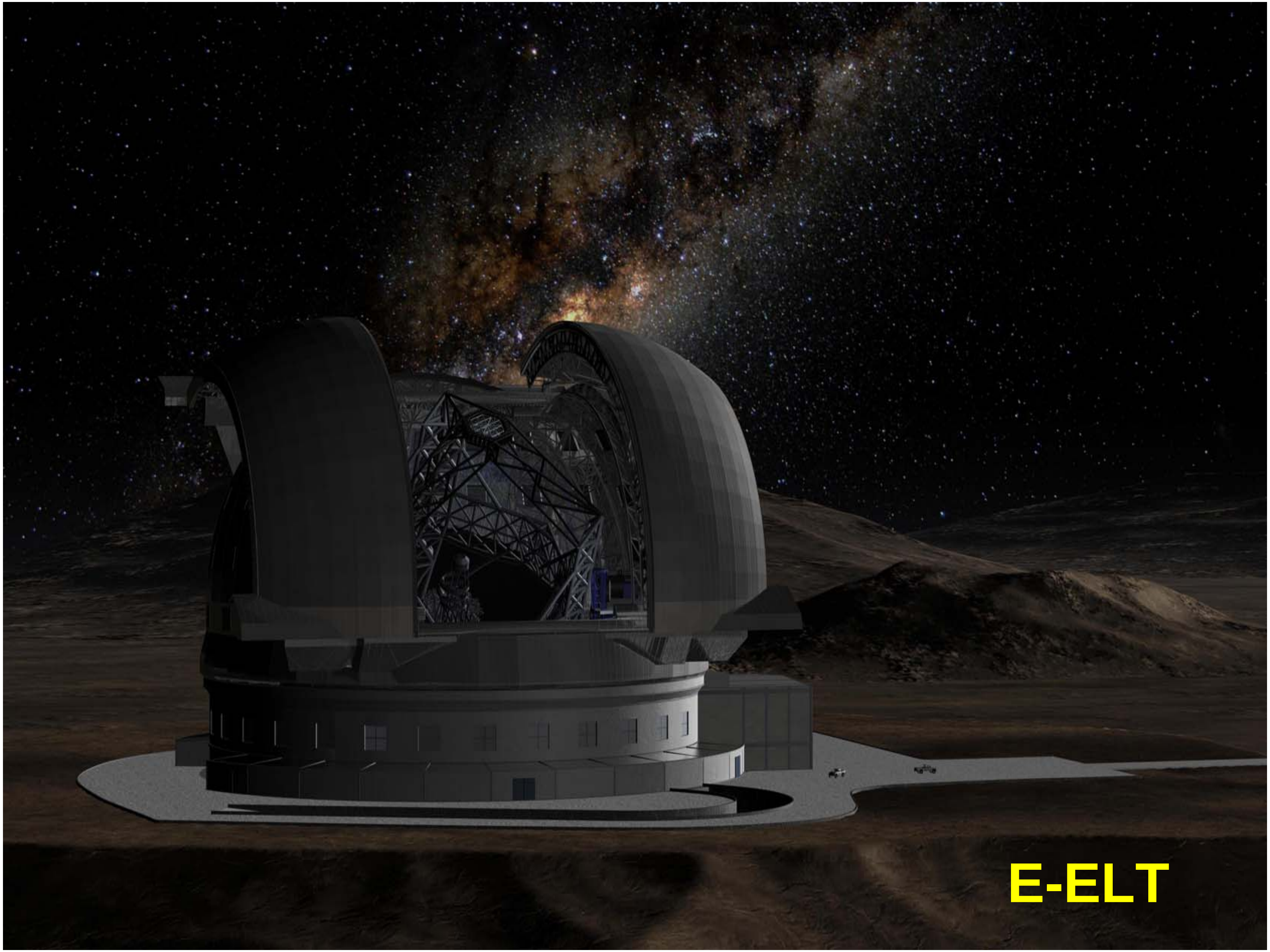
Participation in 30m Class Optical/Infrared Telescope Projects

GMT






TMT


E-ELT

Motivation and Strategy

- Promote Chinese astronomical scientific and technical research, comprehensively and effectively
- Achieve breakthrough in frontiers of modern astronomy
- Exploit the most advanced resources available
- Cultivation of the next generation of Chinese astronomers
- Complement with China's key astronomical projects
  - Large spectroscopic survey facility: LAMOST
  - Large radio telescope: FAST


TMT
THIRTY METER TELESCOPE

Thirty Meter Telescope

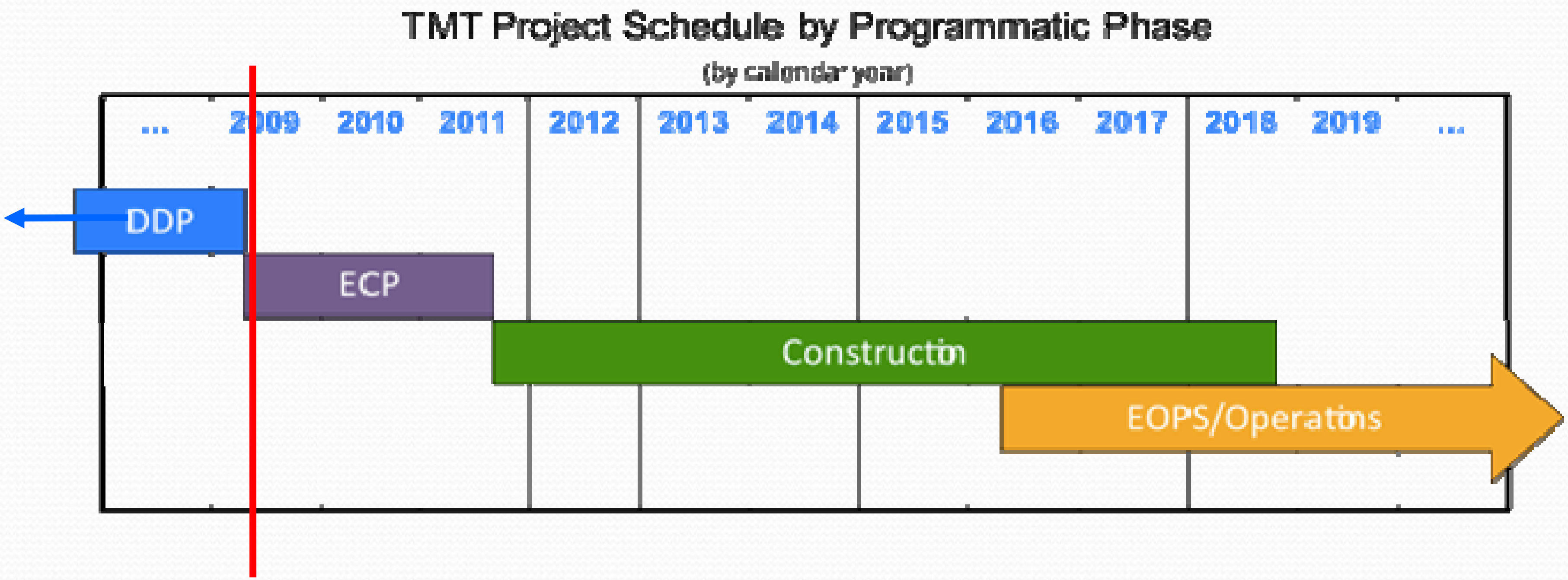
- 30m filled aperture, highly segmented
- Three mirror telescope
- f/1 primary
- Field of view 20 arcmin
- Elevation axis in front of the primary
- Wavelength 0.31 – 28 μm
- Operational 1° thru 65°
- Seeing-limited mode
- Adaptive optics mode


Summit ridge site
Mauna Kea
4210m
13 North Site

Summary of Estimate for Construction Phase

- **Budgeted Cost for TMT = $759.7 million (2009US$)**
- Contingency = $227.2 million at 29.9%
- **Total = $986.8 million (2009US$)**
- The cost estimate is continuously updated to reflect:
  - Changes in the project schedule
  - Updated supplier quotes
  - Design changes/optimizations
  - Other economic and external influences
- This estimate is under development
  - TMT Cost Review Fall 2009 following site selection

TMT Schedule by Program Phase



Progress and status of C-TMT

- Chinese delegation visited TMT in Jan. and June, 2009
  - Introduced the progress of researches
  - Discussed possible collaboration based on TMT
  - China will be involved in the TMT instrumental development
- In August 2009, NAOC Director General signed a letter of intention to TMT Board
- In September 2009, NAOC setup C-TMT structure:
  C-TMT Board, Science Advisory Committee,
  Project Office: Project Manager, Scientist, Engineer

Brief summary

- During the last decade, astronomy in China has experienced enormous advances, among which the most significant progress is reflected by the construction and development of large astronomical facilities.
- Ground-based and space facilities have been or are planned to be built in recent years, e.g., LAMOST, FAST, 21CMA, HXMT, WSO, SST and so on.
- Future large astronomical projects in China will put even more emphasis on international collaborations, and we are expecting invaluable perspective, advice and input from our international colleagues

Postface

- China is still a developing country; the Chinese astronomy is still under developing and has a long way to go
- With the rapid economic growth, China has the determination and is more capable to make significant contributions to astronomical development as we did in ancient history
- We look forward to wider and closer collaborations with astronomers worldwide

Thanks!

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