LAMOST Experiment for Galactic Understanding and Exporation (LEGUE)

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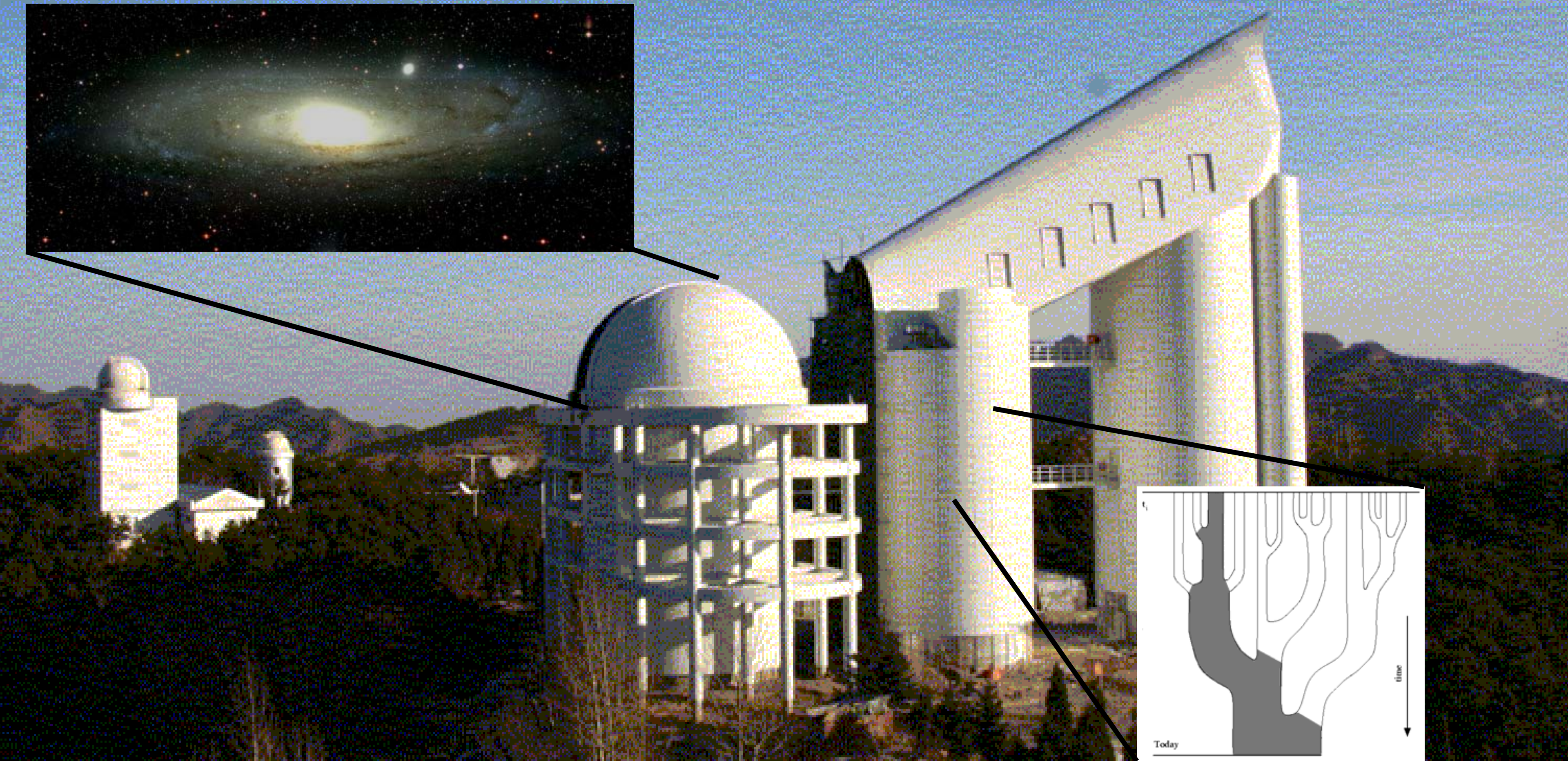
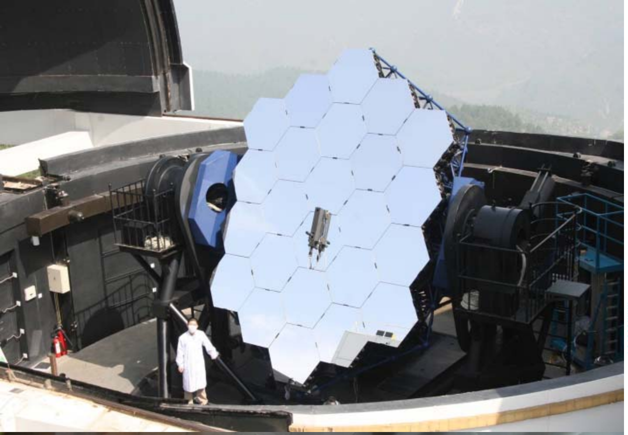
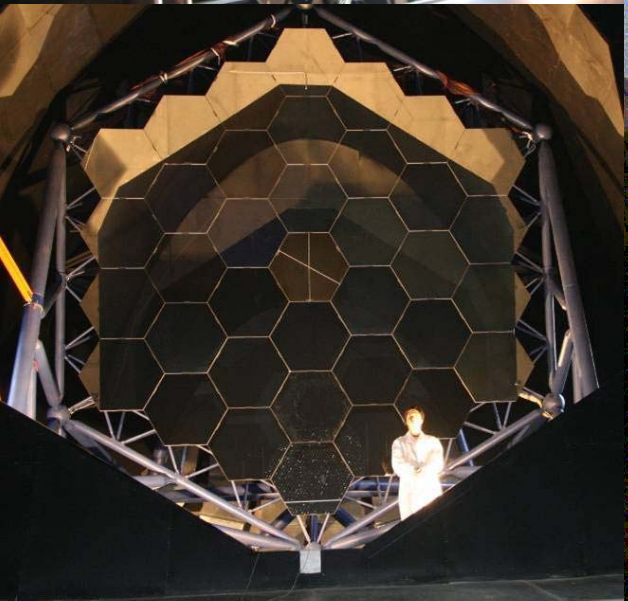


LAMOST Experiment for Galactic Understanding and Exploration (LEGUE)

Science Goals

(1) Discovery of spheroid substructure
(2) Constrain Galactic potential
(3) Disk/spheroid interface near Galactic anticenter
(4) Search for extremely metal poor stars
(5) Identify smooth component of spheroid
(6) Structure of thin/thick disks, including chemical abundance and kinematics
(7) Search for hypervelocity stars
(8) Survey OB stars and 3D extinction in Galaxy
(9) Globular cluster environments
(10) Properties of open clusters
(11) Complete census of young stellar objects across the Galactic plane



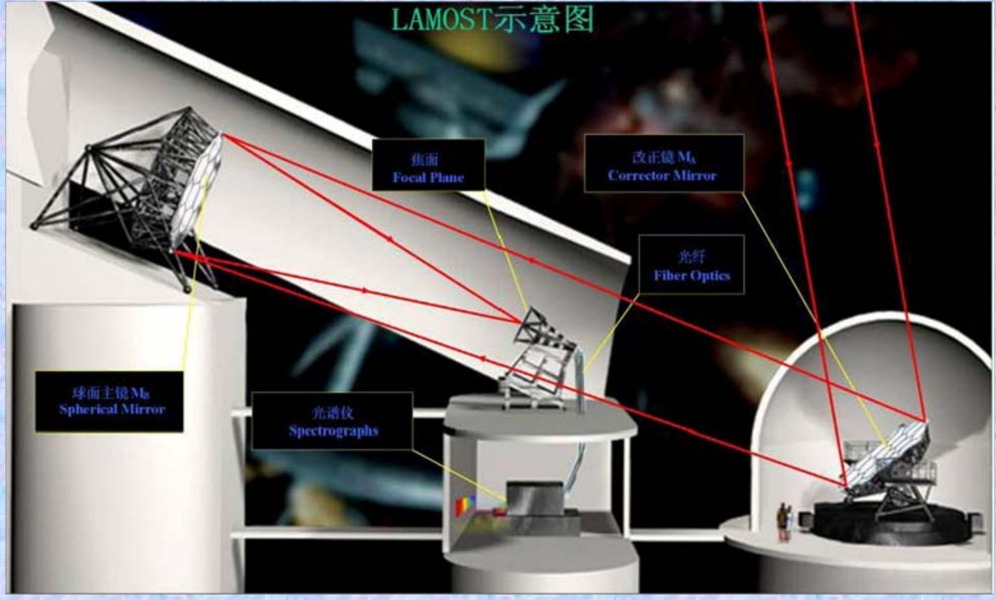


4 meter telescope
4000 fiber spectrograph

Operations in 2009/2010

Xinglong Observing Station, 3hr north of Beijing

Optical System



M_A is the Schmidt corrector, 5.72m x 4.40m, with 24 hexagonal plane sub-mirrors, each with 1.1m diagonal and 2.5 cm thickness.

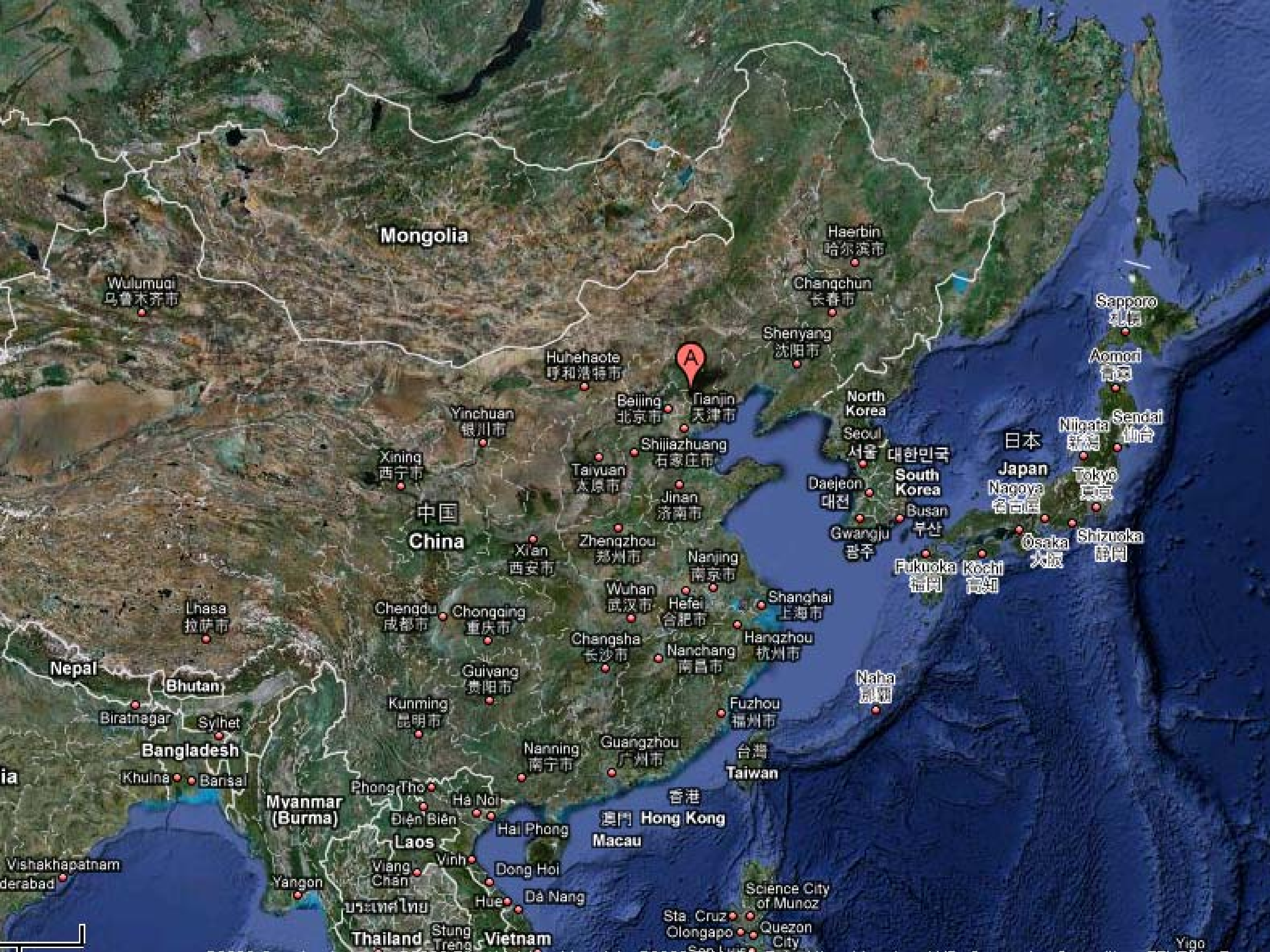
M_B is the spherical primary, 6.67m x 6.05m, with a radius of curvature of 40m, 37 hexagonal spherical sub-mirrors, each with 1.1m diagonal and 7.4 cm thickness.

Active control for aspheric shape of corrector (34 force actuators plus 3 mount points per submirror). Optimal shape changes with declination and hour angle.

Active control for M_B is just 3 mount points plus three actuators per submirror.

Optical axis is 25° from horizontal.

The focal plane has a radius of curvature of 20m.



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Shenyang
沈阳市
Huhehaote
呼和浩特市
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Beijing
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天津市
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银川市
Shijiazhuang
石家庄市
Seoul
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대한민국
Xining
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Taiyuan
太原市
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Sendai
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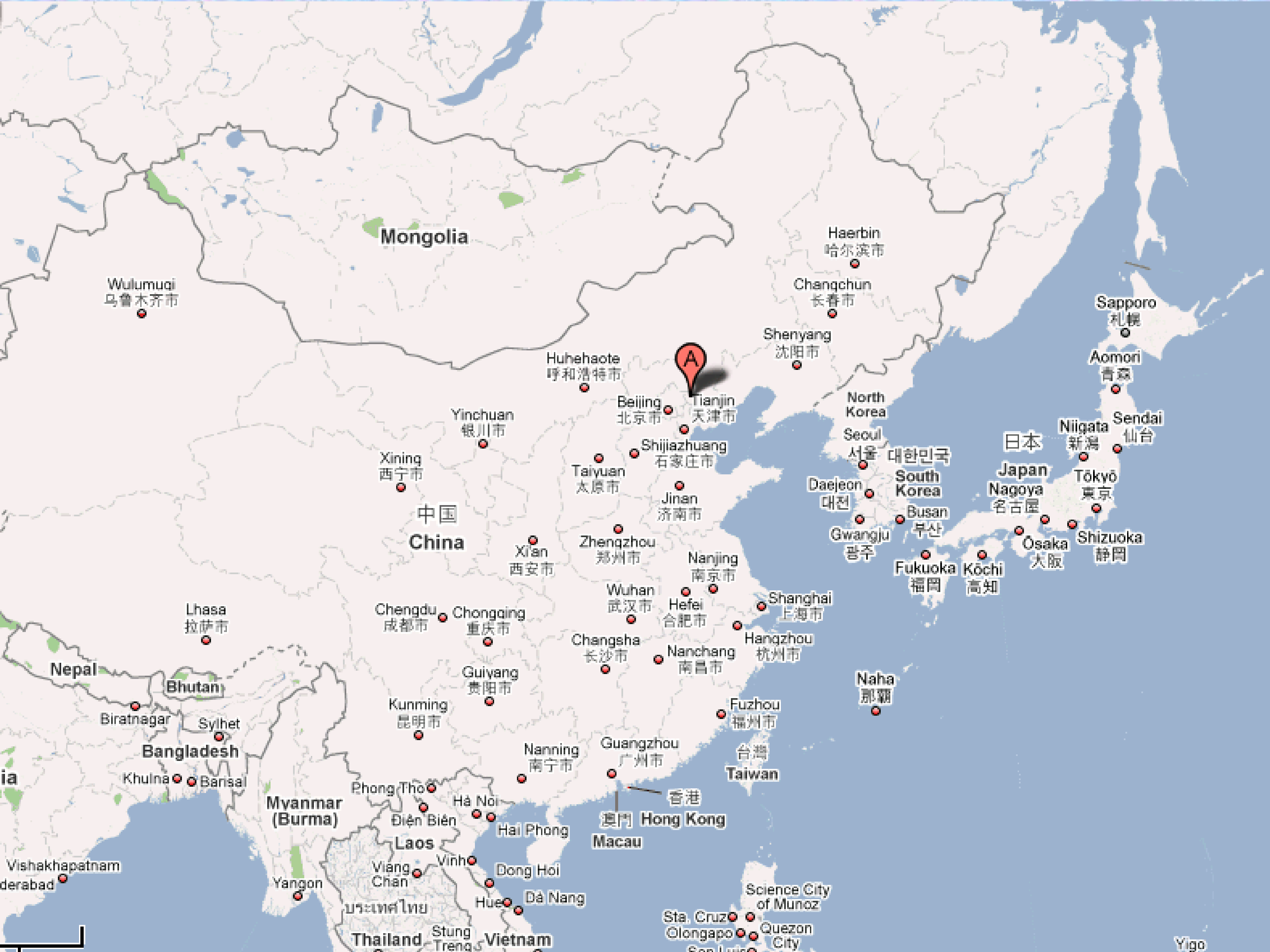
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Hà Nội
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Điện Biên
Hai Phong
澳門
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Laos
Vishakhapatnam
Vinh
Dong Hoi
Viang Chan
Yangon
Science City of Munoz
Huế
Đà Nẵng
Sta. Cruz
Olongapo
Quezon City
Thailand
Stung Treng
Vietnam
Yigo

The Promise of LAMOST

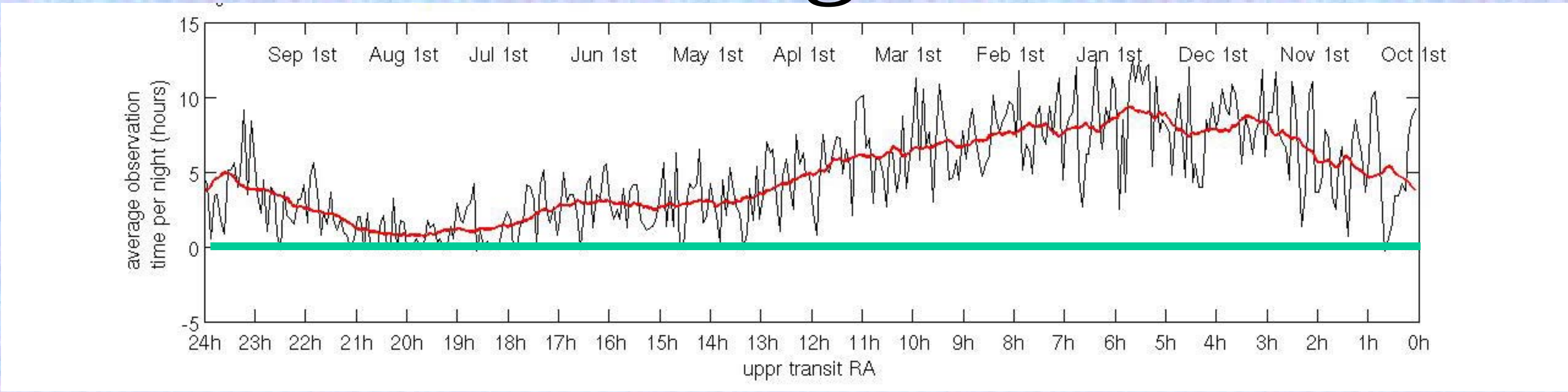
4000 fibers, 4 meter telescope, first light was December 8, 2008. R=1000/2000, maybe 5000/10,000 gratings in the future.

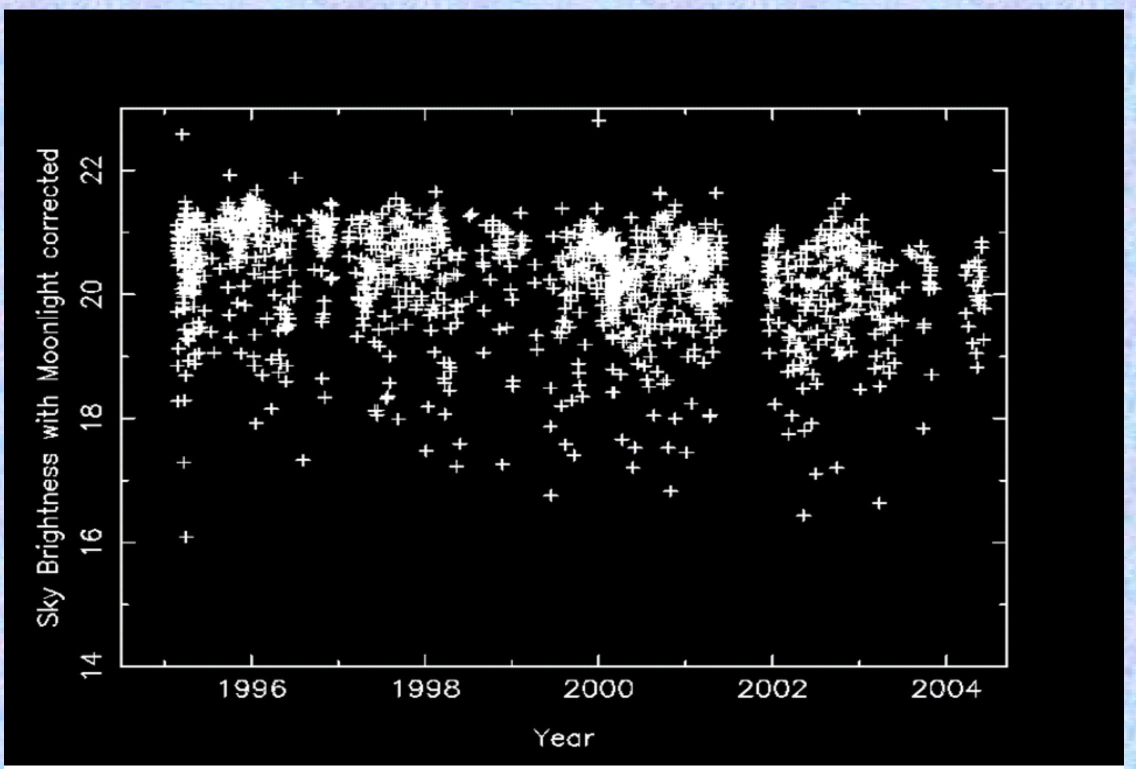
Two million spectra per year.

Because I believe that LAMOST has the best potential for unraveling the formation history and dark matter potential of the Milky Way galaxy, I will traveled 12 time zones more than 8 times in two years, committed my sabbatical last year to LAMOST survey planning and design, and started learning Chinese. I will go to Beijing for 6 weeks this summer, and take my younger kids with me.

The has NSF funded a US-China partnership that will support US Galactic astronomers for form collaborations with Chinese astronomers to support the spectroscopic survey and analyze the data.

The Challenge of LAMOST



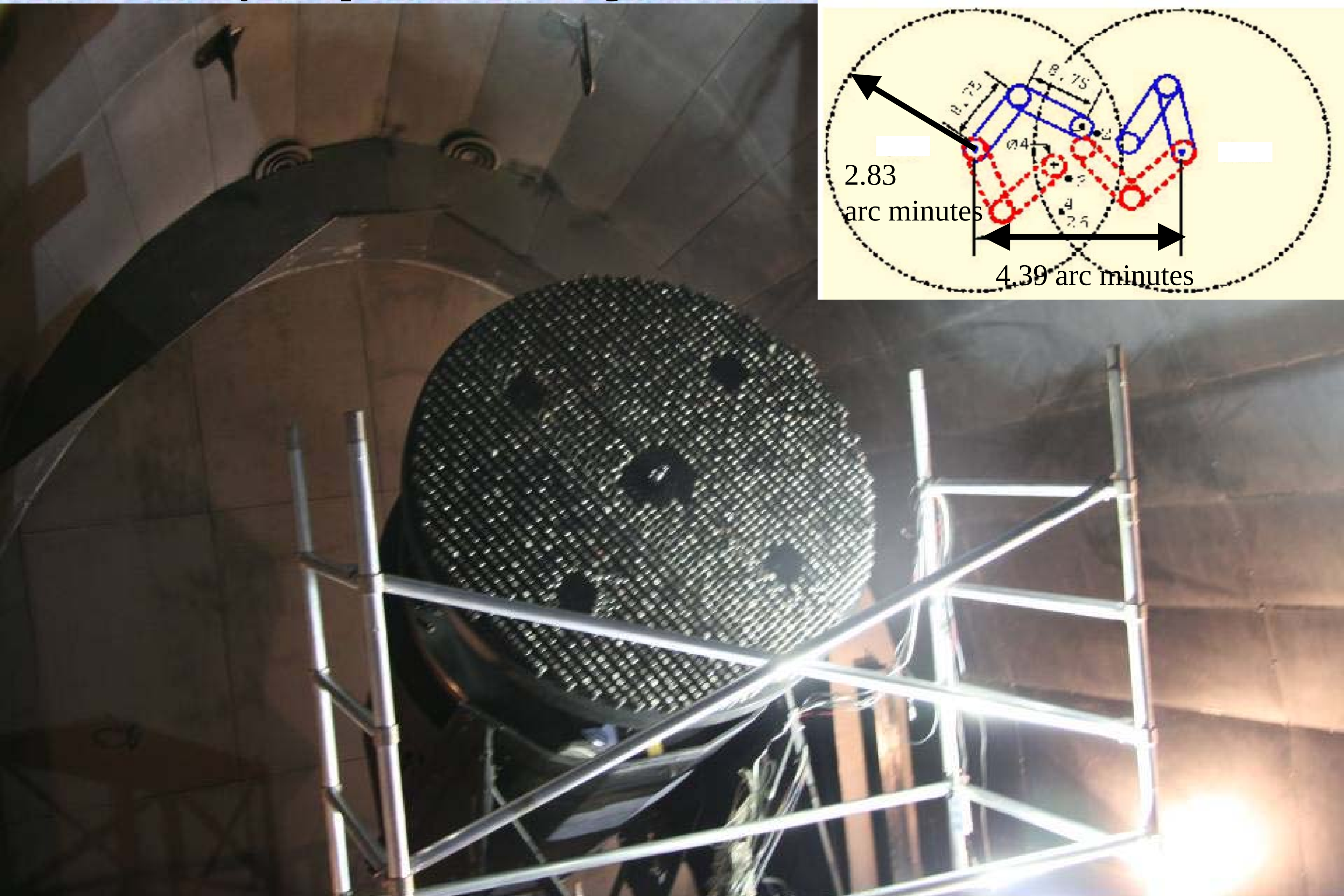


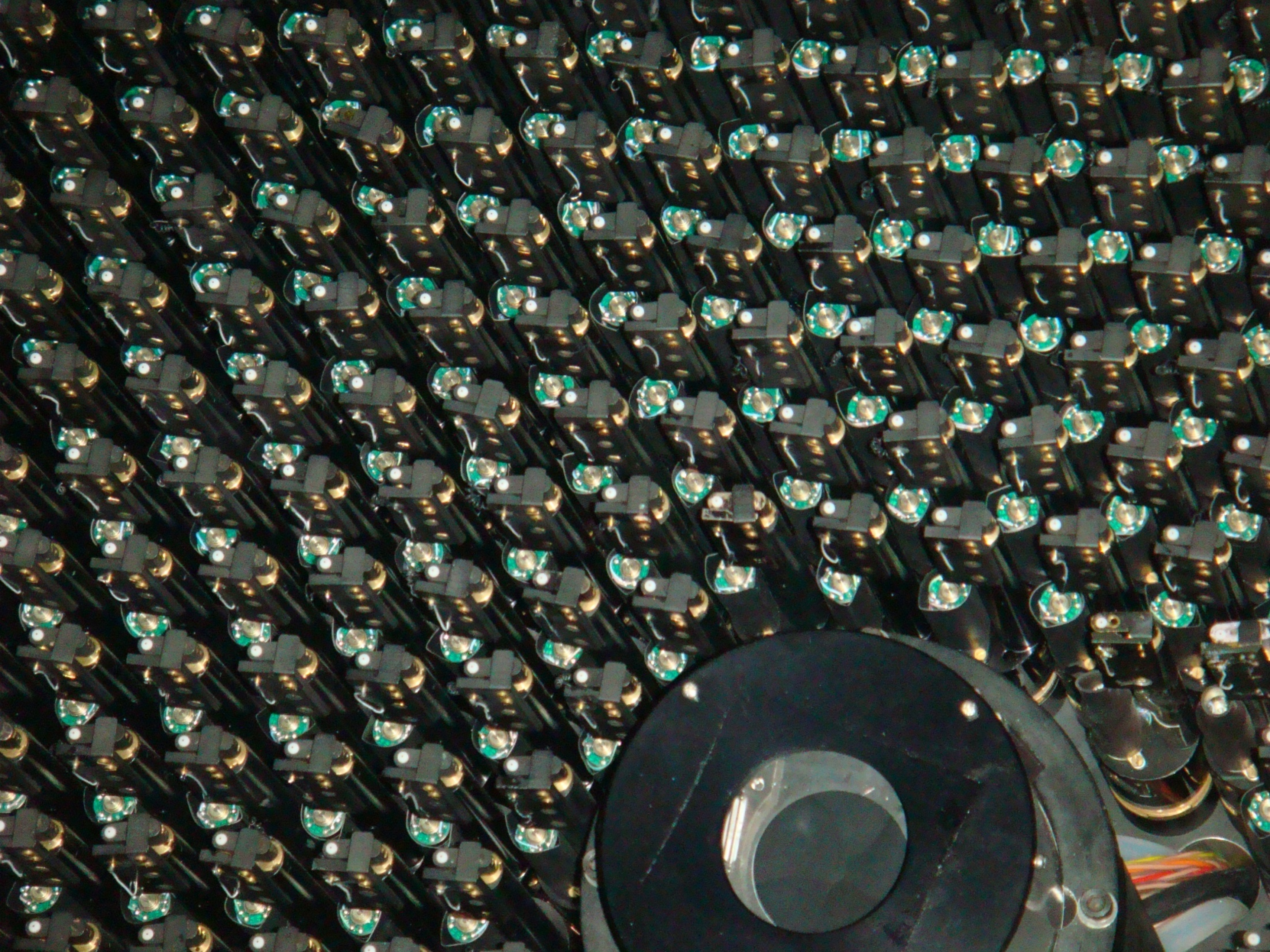
The variation of sky brightness from 1995 to 2004

Worries:

Sky brightness
Scattered light
Dust pollution
Temperature controll
Calibration
Cultural issues

The field of view is 5 degrees diamter. Atmospheric refraction can move an object up to 1.7” during an observation.





LAMOST Timeline

Original proposal: November 1996
Approved: April 1997
Preliminary design approved: June 1999
Detailed design competed, construction begins: September 2001
"First Light" with partial mirrors, weird focal plane instrument: May 2007
All parts on mountaintop: August 2008
Real first light & start of commisioning: October 2008
Dedication: October 2008
Engineering commissioning: Jan. 2009
Survey operations: beginning of 2011? Maybe 2012?

LAMOST Experiment for Galactic Understanding and Exploration (LEGUE)

Survey Strategy (five years)

Three subsets:

(1) Spheroid (|b|>20°) portion will survey at least *2.5 million* objects at R=2000, with 90 minute exposures, during dark/grey time, reaching g_0=20 with S/N=10.

(2) Anticenter (|b|<30°, 150°<l<210°) portion will survey about *3 million* objects at R=2000 with 40 minute exposures, during bright time (and some dark/grey time), reaching J=15.8 with S/N=20.

(3) Disk (|b|<20°, 20°<l<230°) and will survey about 3 *million* objects at R=2000 or R=5000, with 10 or 30 minute exposures, respectively, during bright time, reaching g_0=16 with S/N=20

Spheroid Survey

Use SDSS, our own, PanSTARRS, or SuperCOSMOS photometry, in that order, as available.

(1) Select as many $0.1<(g-r)_0<1.0$, $g_0<17$ stars as possible (a nearly complete sample where surveyed, except below b=40°, randomly sample to $g_0<18$

(2) Randomly sample stars with $(g-r)_0<0.4$ in the magnitude range $17<g_0<20$

If *u*-band photometry is available, we will deselect QSOs. The subsampling will be about one in two or one in three at higher latitudes.

Smaller subsets with special selection:

- We will observe a sample of high proper motion stars with colors of M dwarfs in the magnitude range $16<g_0<20$ (local spheroid stars)
- If *u*-band available, subsample K and M giant candidates with $17<g_0<20$
- Within 3 tidal radii of 40 selected GCs, we will use a completely different selection algorithm to select stars with color/magnitude of the GC stars
- We will include bright (V<12) K and M stars from the Tycho-2 catalog, without regard to their proper motion.

Anticenter Survey

In the region |b|<30°, 150°<l<210°:

(1) We will use a weighted, random, magnitude-limited selection of stellar objects. Proper motion and color may be used in the weighted selection. About one in five objects will be observed (the exact number depends on the magnitude limit), making sure that each population of stellar type is well sampled statistically. Originally, we planned to use J<15.8 and select from 2MASS, but now we have other options for optical selection.

The goals of the anticenter survey are to study the composition, kinematics and structure of the thin and thick disks and their interface with the halo; and to study disk substructure (including streams). F main sequence stars will be observed to six kiloparsecs from the Sun (fourteen kpc from the Galactic center).

Disk Survey

Select bright stars (V<16) from GSC II, with positions from 2MASS and proper motions from UCAC3. We will not use dereddened magnitudes for bright stars near the Galactic plane. Note that very bright stars in GSC II overlap with the Tycho 2 catalog, which will supply position and proper motions without additional cross-matching.

In the region $|b|<20°$, $20°<l<230°$ (but little data for $l<80°$):

(1) Select all bright O, B, T Tauri, and HH stars from a special list of known objects.

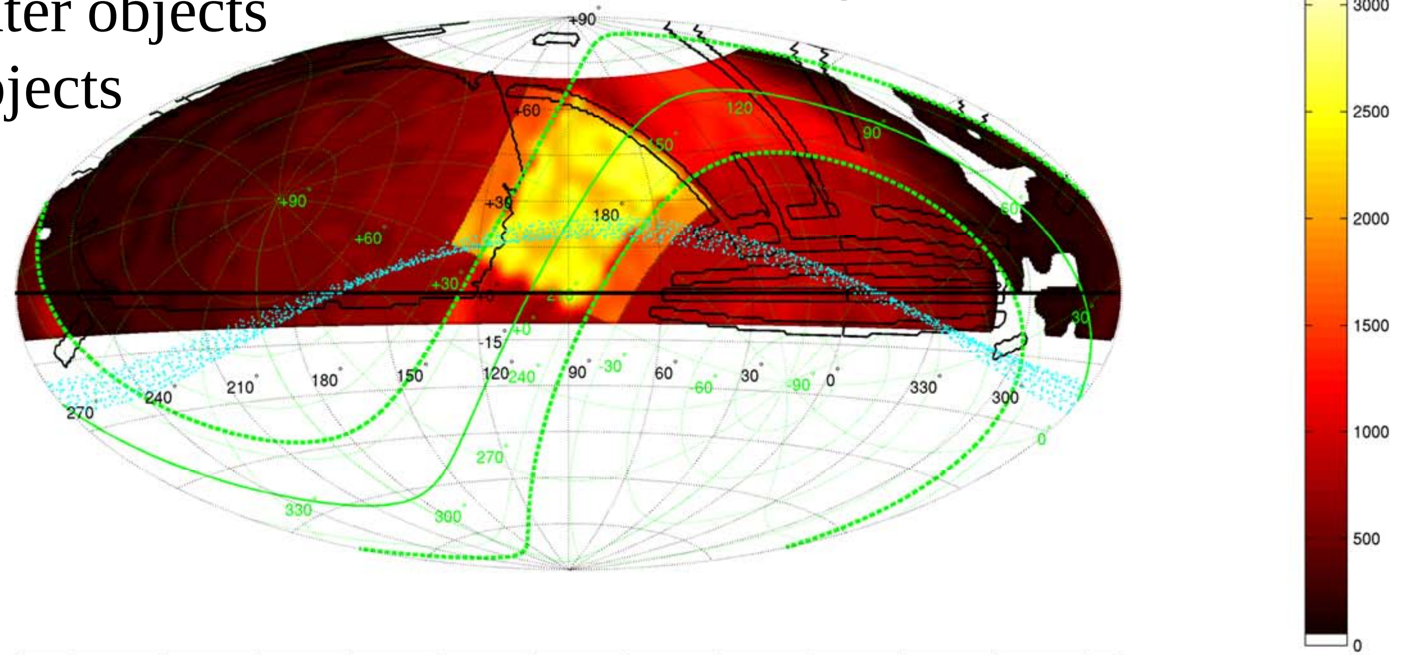
(2) Within 0.5° radius of any open cluster, select only stars with proper motion, color, magnitude consistent with cluster membership (these object lists may be generated from separate special catalogs).

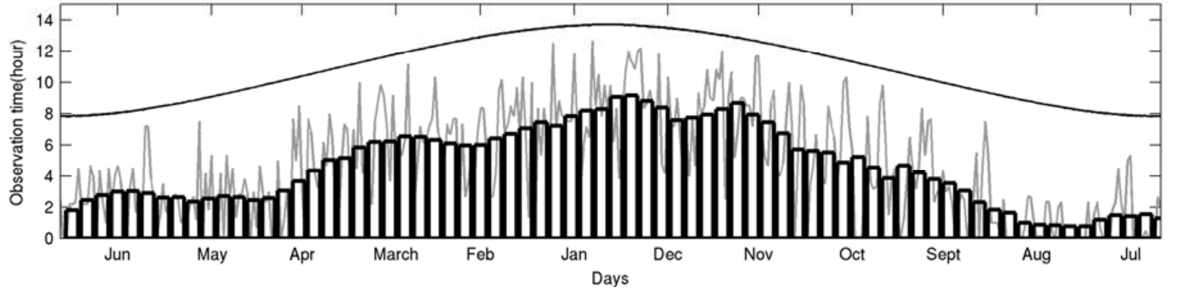
(3) Observe bright (V<12) K and M stars from the Tycho 2 catalog.

(4) Randomly select stars from the magnitude-limited sample.

7.5 M halo objects
5 M anticenter objects
3 M disk objects

Deng Licai, Liu Chao





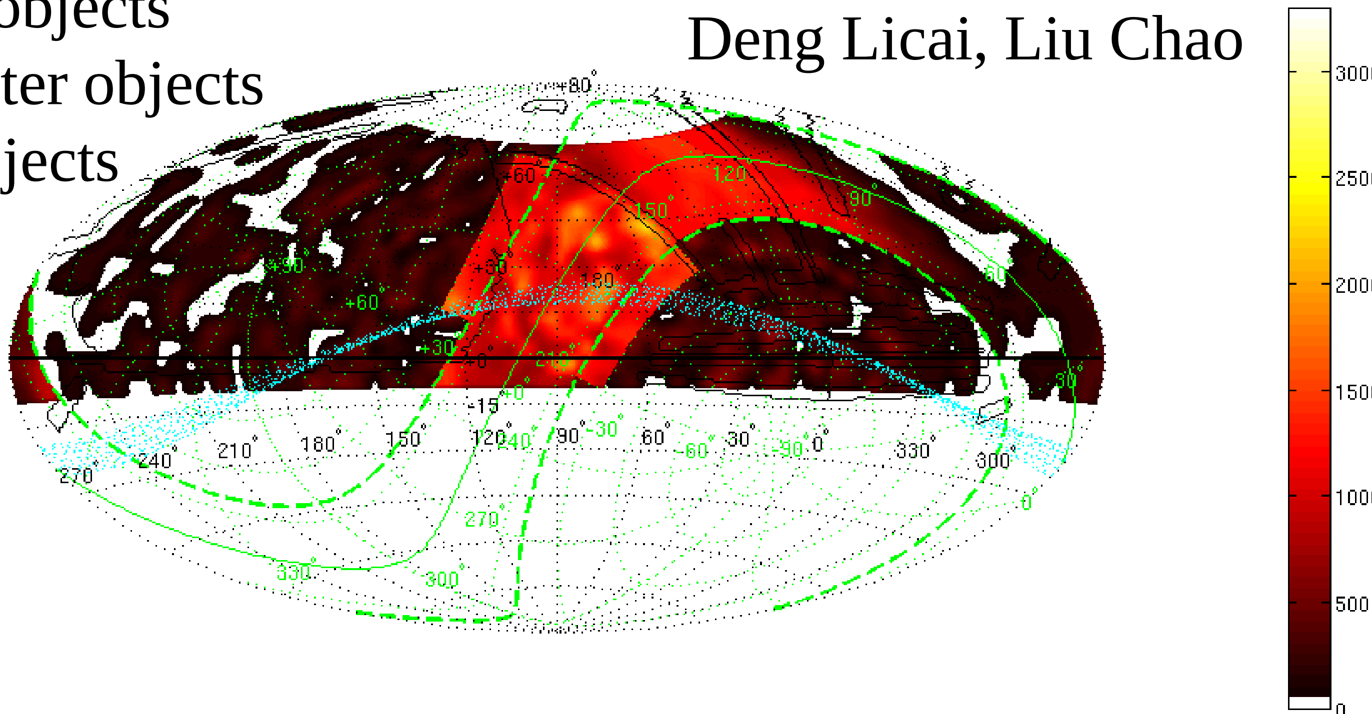
Sample survey coverage in fibers per square degree, shown as an Aitoff projection in Equatorial coordinates (Galactic coordinates shown in blue). The survey simulation was done assuming all of the time for a five year period, including moon and likely weather conditions as a function of season.

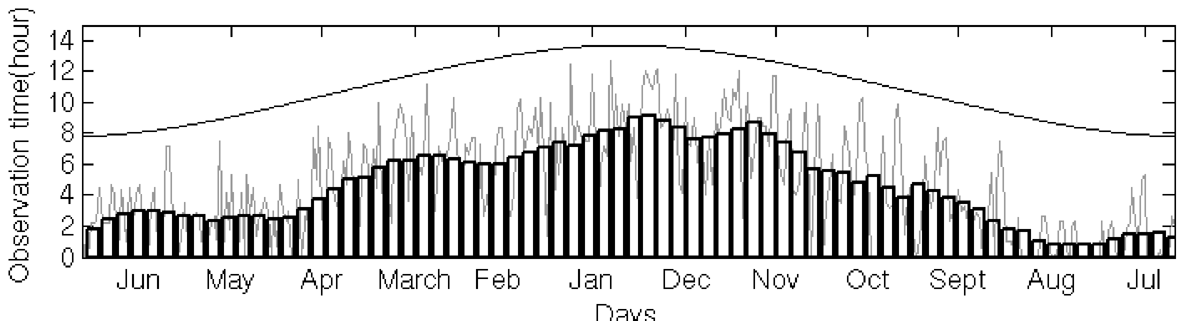
2.5 M halo objects

3 M anticenter objects

3 M disk objects

Deng Licai, Liu Chao





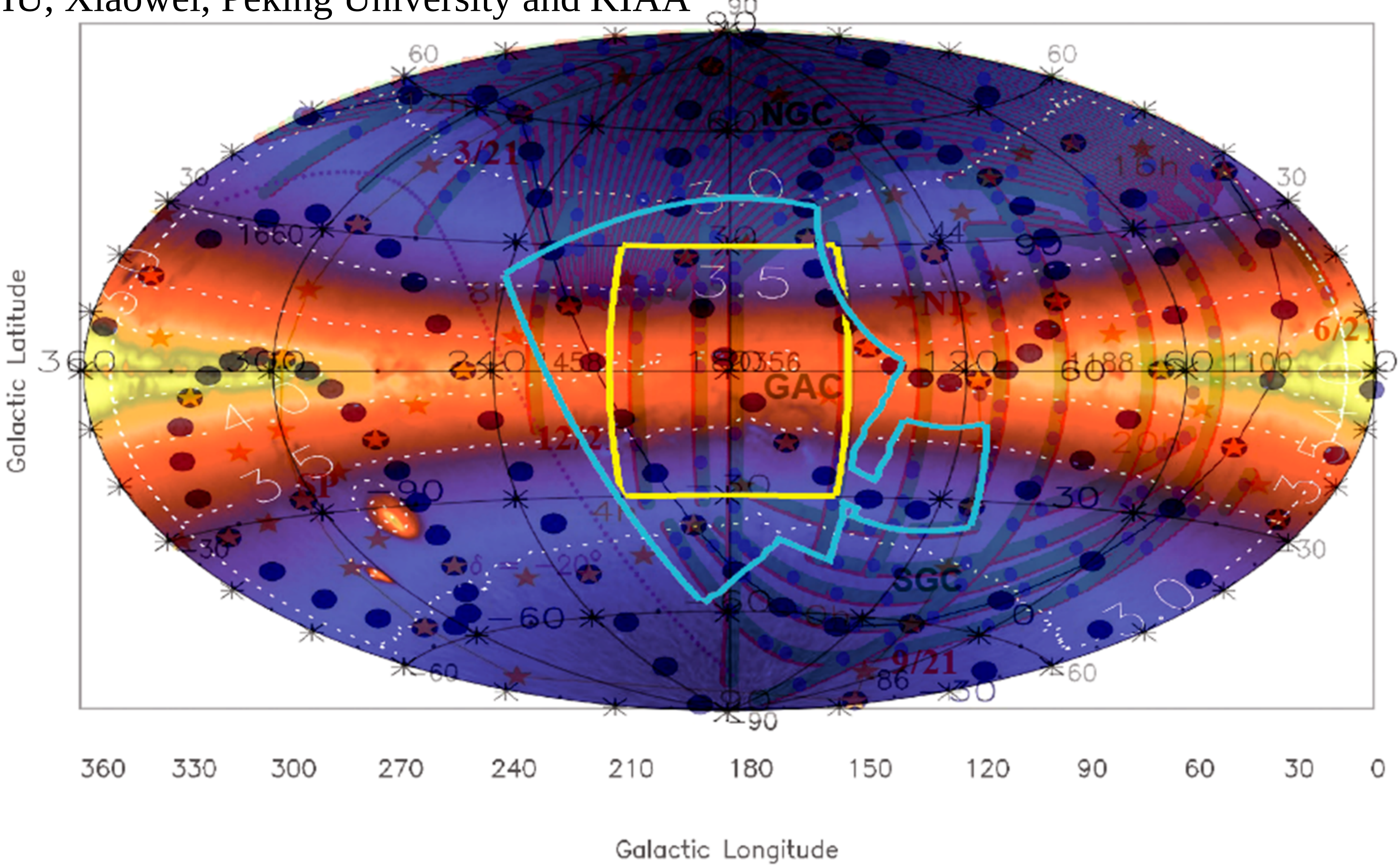
Sample survey coverage in fibers per square degree, shown as an Aitoff projection in Equatorial coordinates (Galactic coordinates shown in blue). The survey simulation was done assuming 1/3 of the dark/grey time and all of the bright time for a five year period, including moon and likely weather conditions as a function of season.

The Xuyi Galactic Anticenter Imaging Survey (XGAIS) for LEGUE

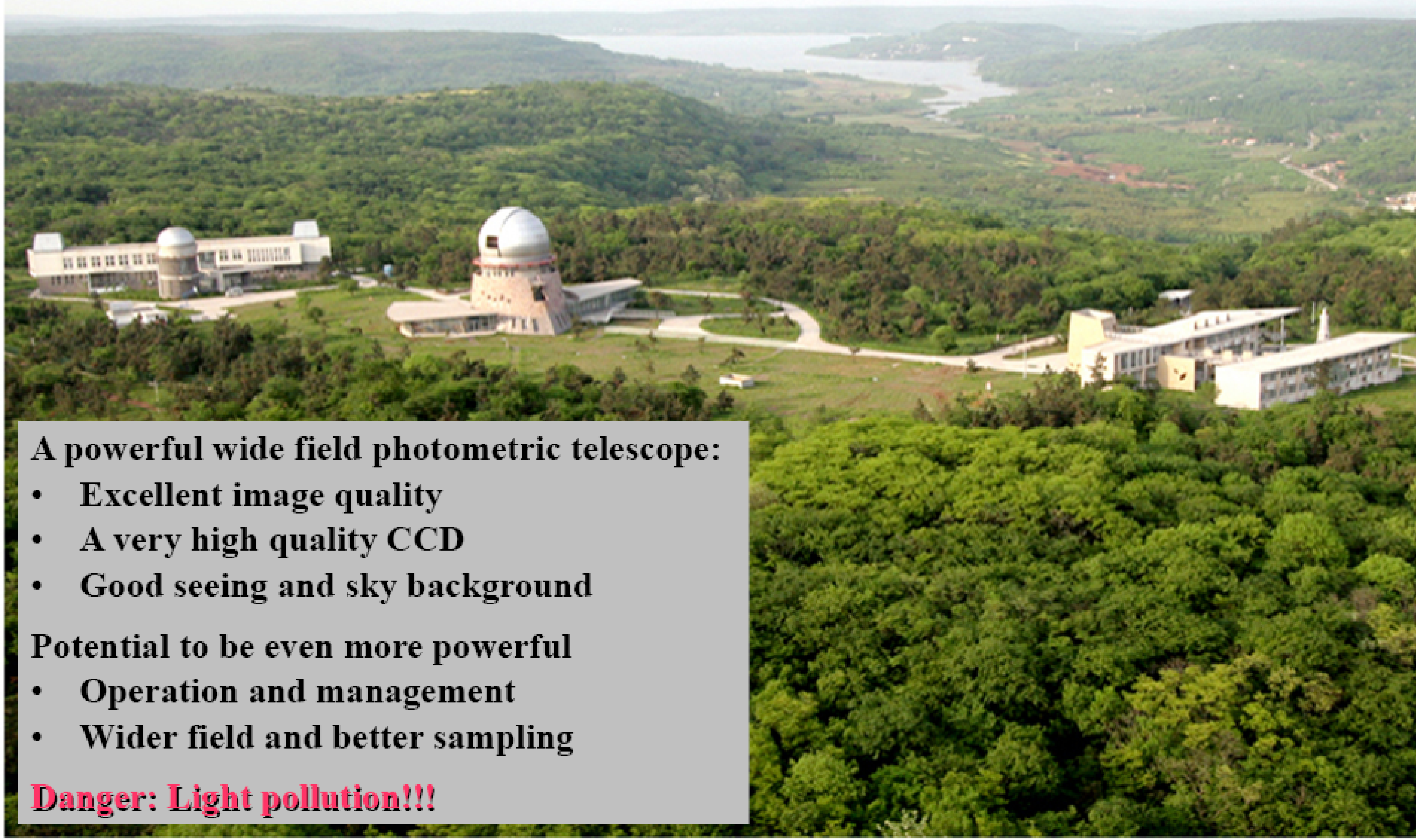
SDSS g,i filters

$\alpha = 05^h45^m37^s.20$
$\delta = 28°56'10.2''$

LIU, Xiaowei, Peking University and KIAA



Xuyi 1.0/1.2m Schmidt Telescope



A powerful wide field photometric telescope:

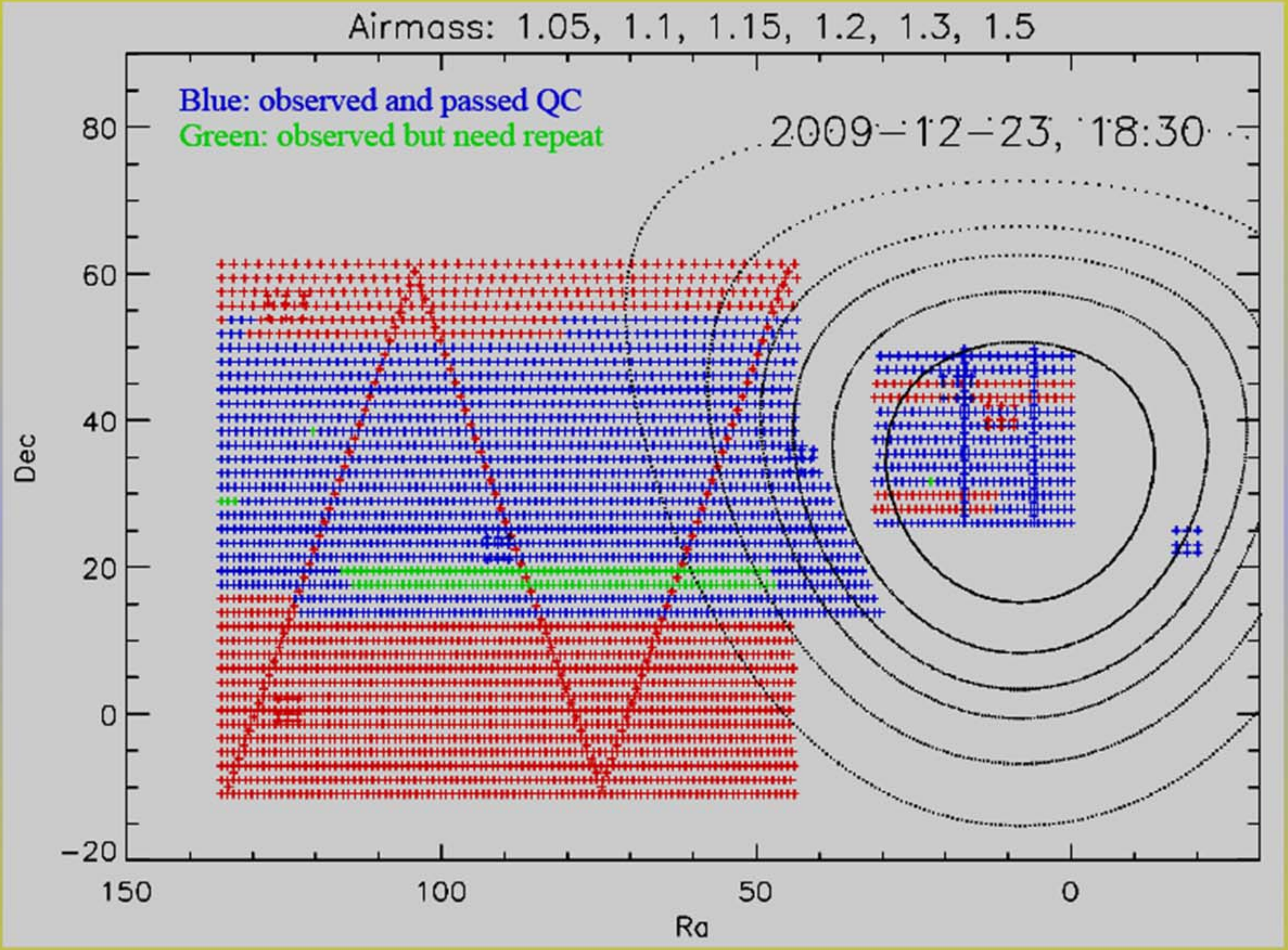
- Excellent image quality
- A very high quality CCD
- Good seeing and sky background

Potential to be even more powerful

- Operation and management
- Wider field and better sampling

Danger: Light pollution!!!

Survey progress (as of 2009/11/24)



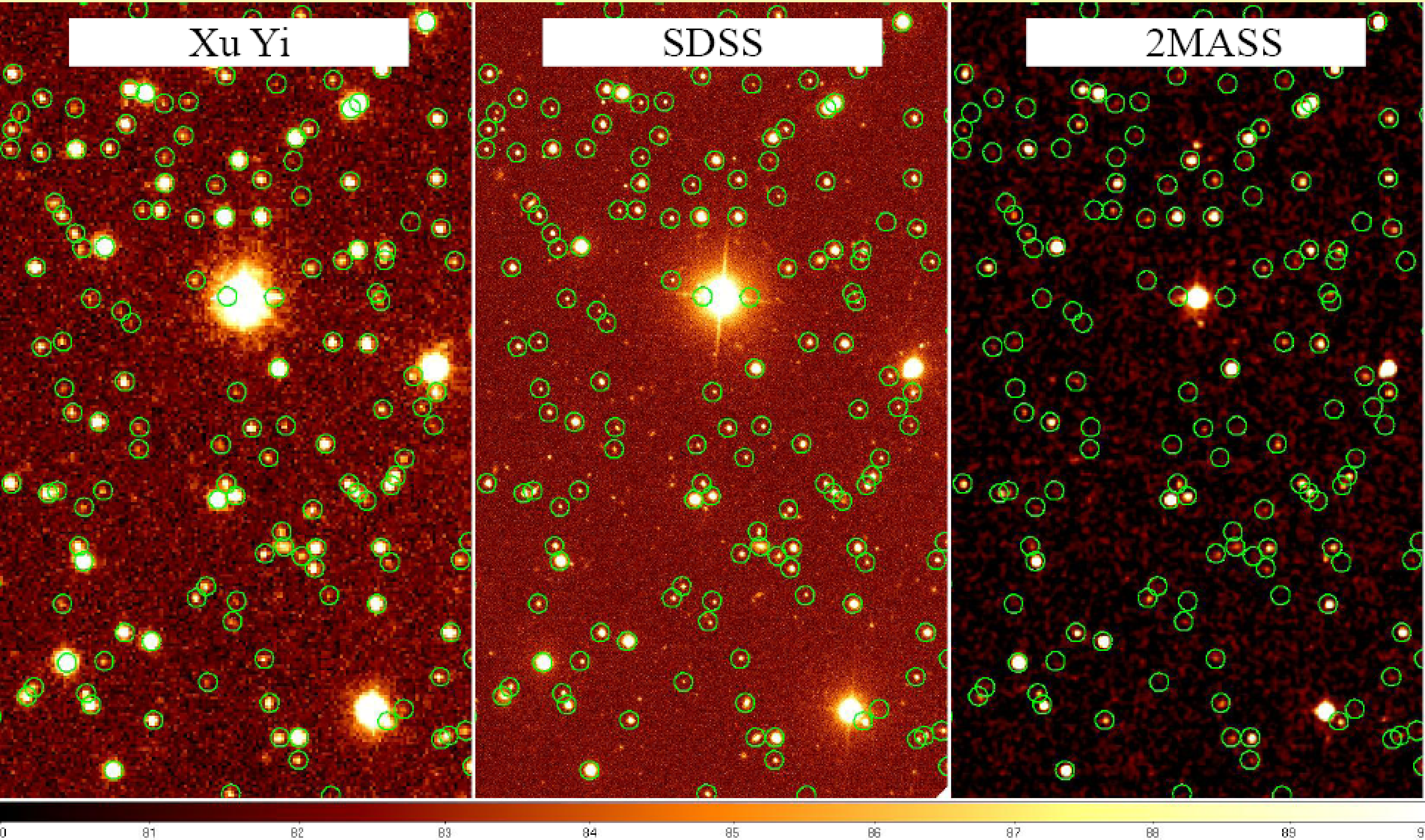
Airmass < 1.15 (zenith distance < 30 deg) except for fields with Dec < 3 deg

北京大学天文学系
Department of Astronomy, Peking University

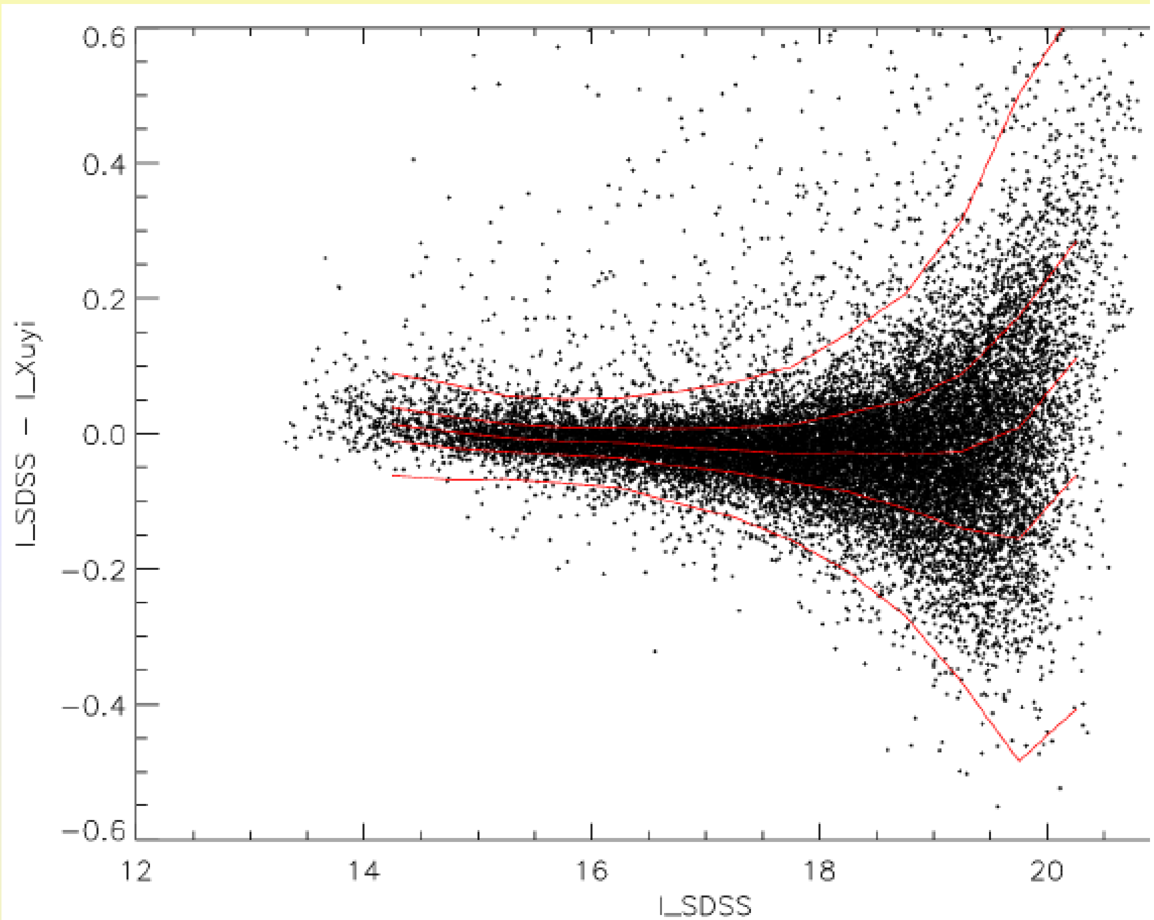
Comparison of Xuyi, SDSS and 2MASS data

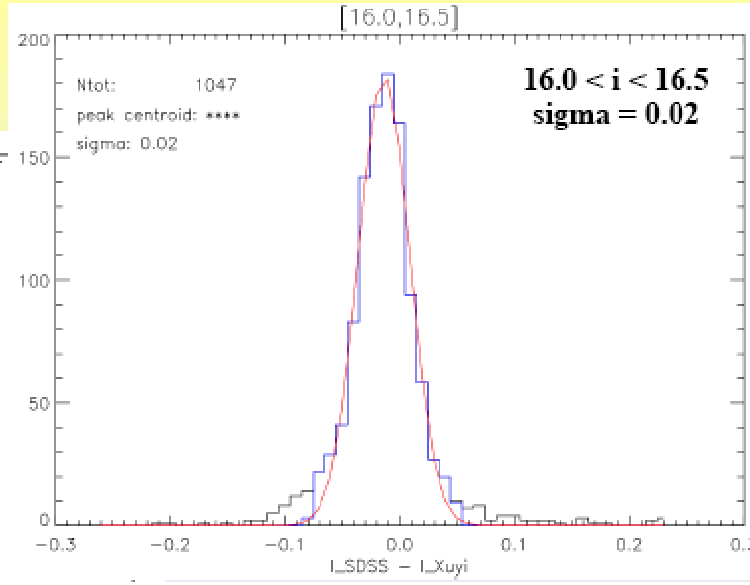
RA = 01:12:15, Dec = +44:46:02 20091017_l02s5_i_90s_0001

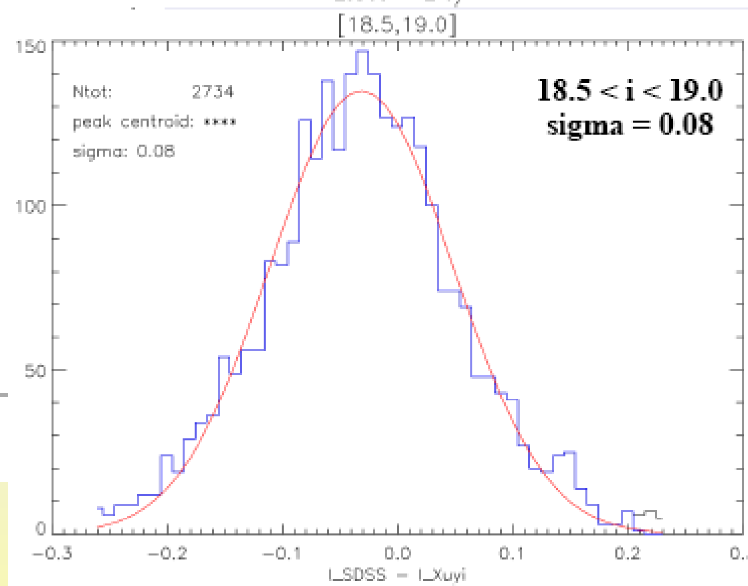
Circles are sources detected by Xuyi Telescope (3 sigmas)



p20091023_073011+4024_90s_i.fit (whole frame)







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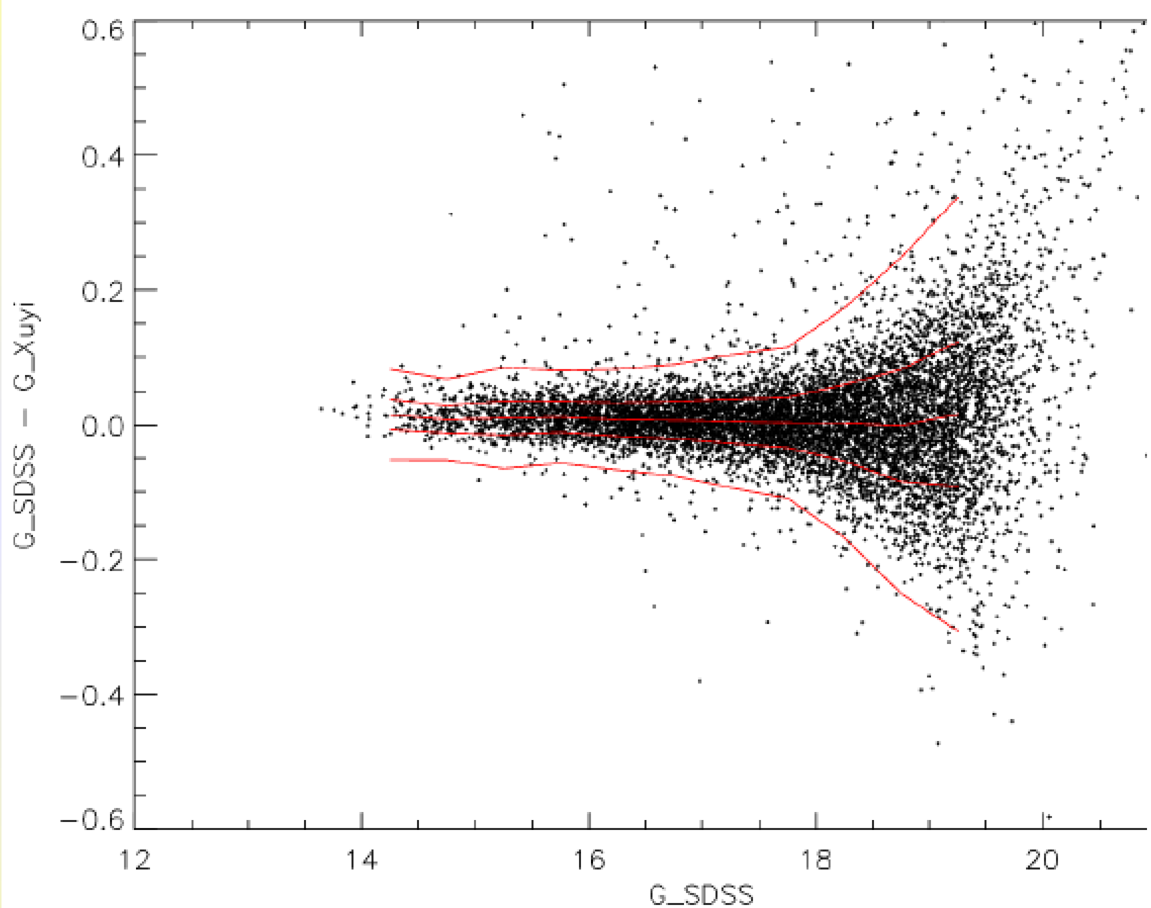
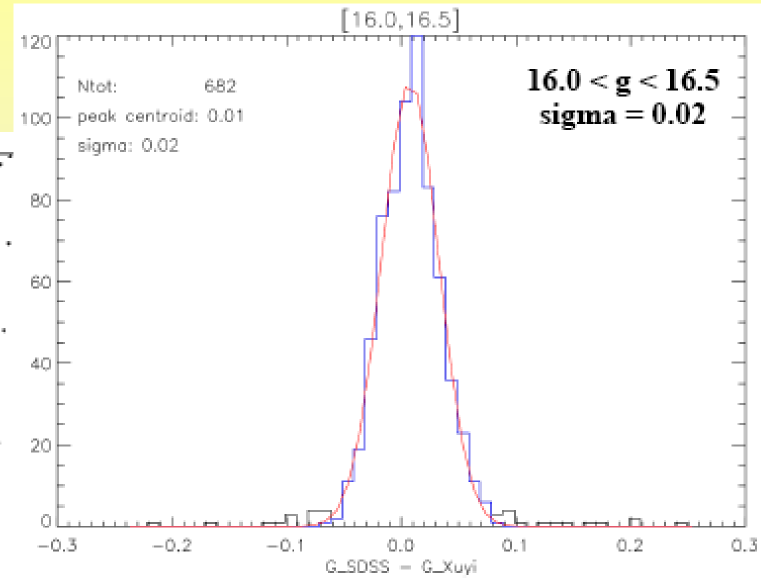
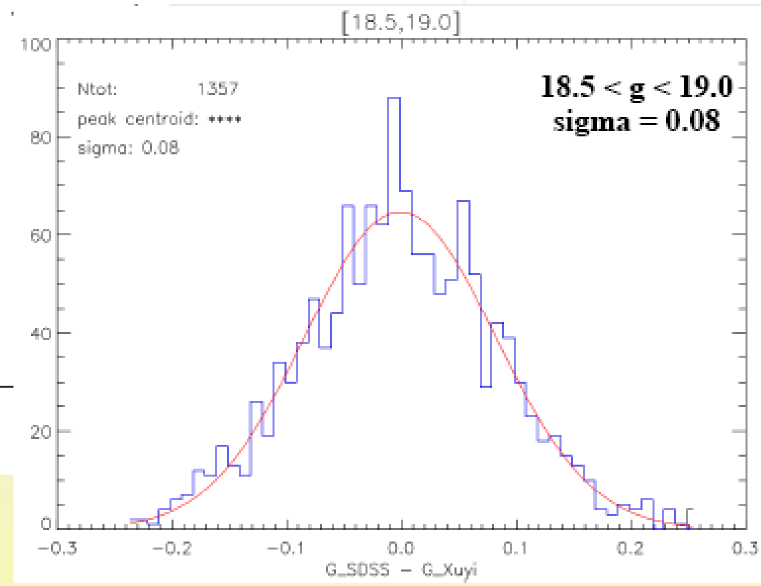




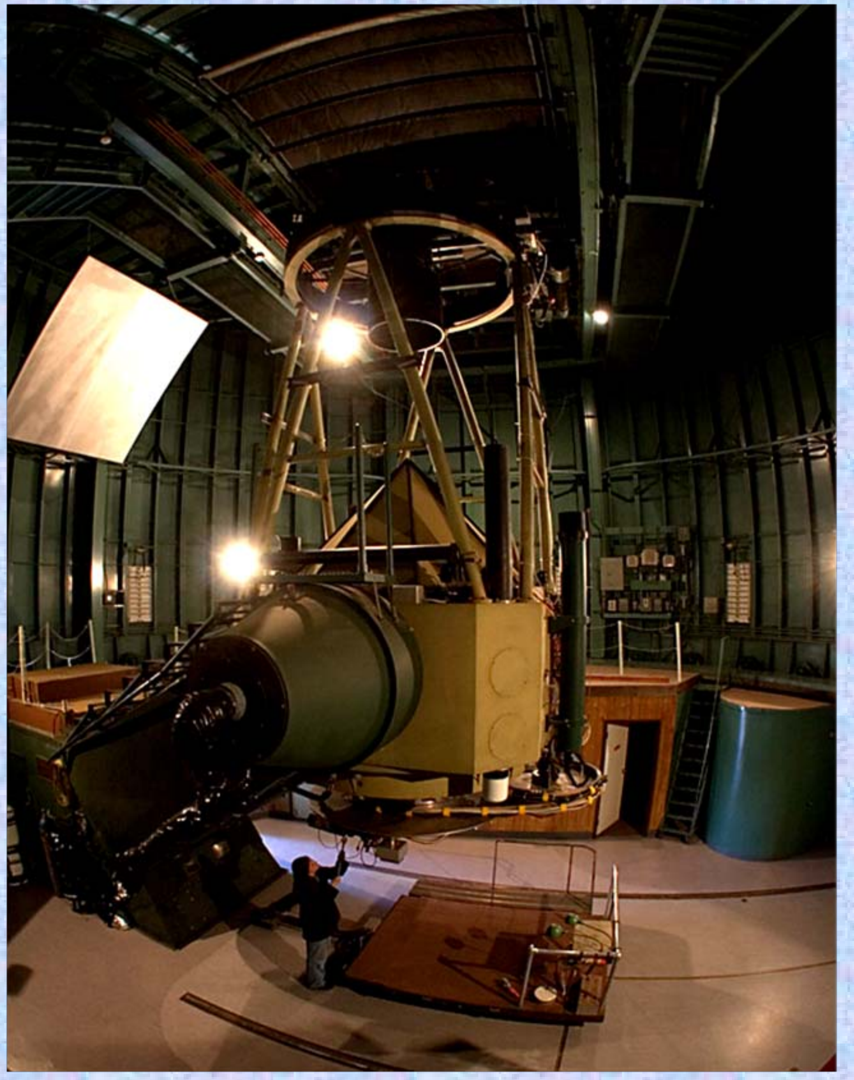


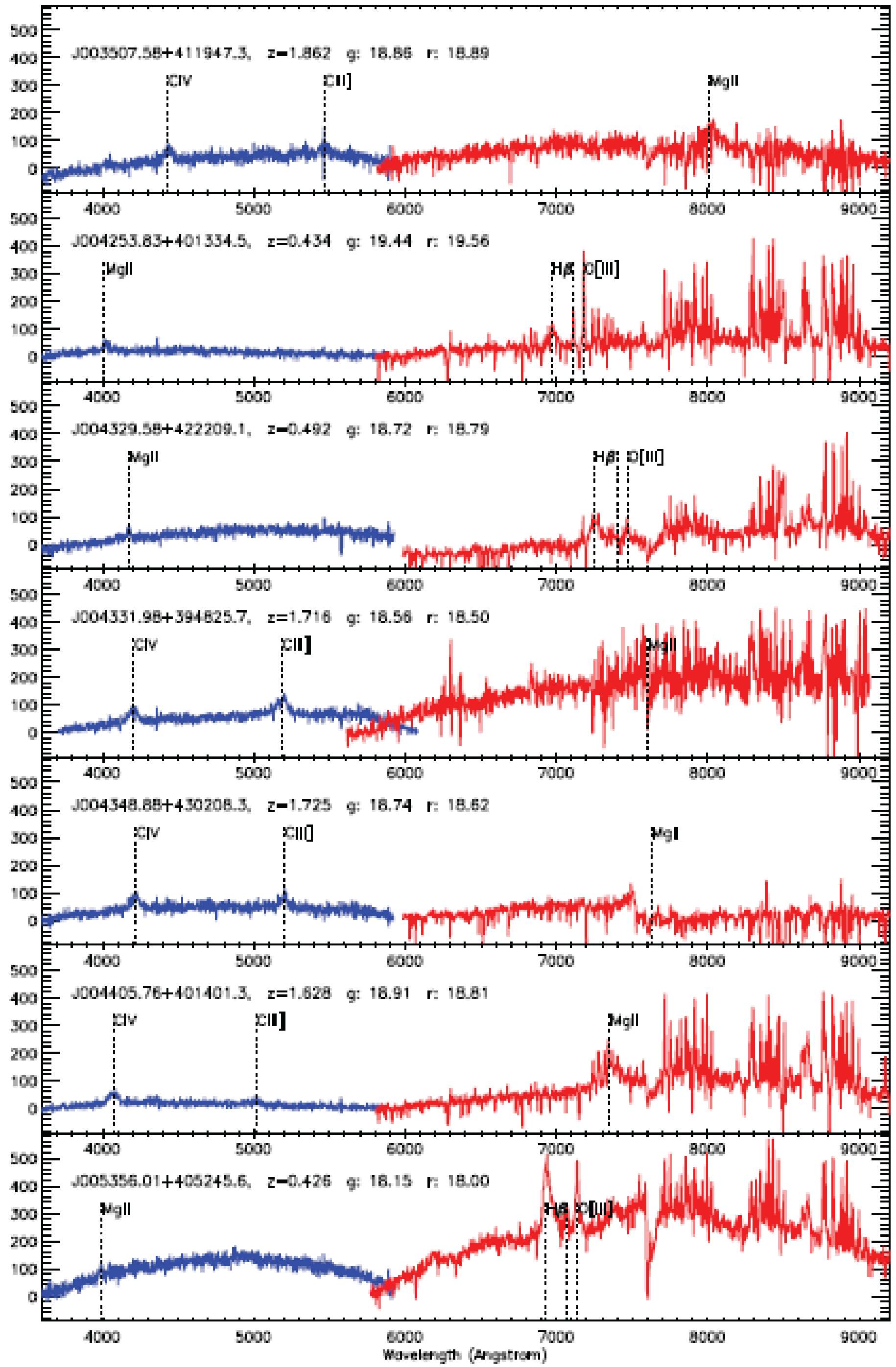
Photometric accuracy: %2 (~ SDSS)
Limiting magnitudes (g, i): 19 (10)

u-band survey on 2.3 meter Bok telescope

3 years, 60 nights/year
Arizona’s Steward Obs.
Starting September 2010
3700 sq. deg.

Primarily run by extragalactic working group, and I am not certain of the footprint. Maybe South Galactic Cap?





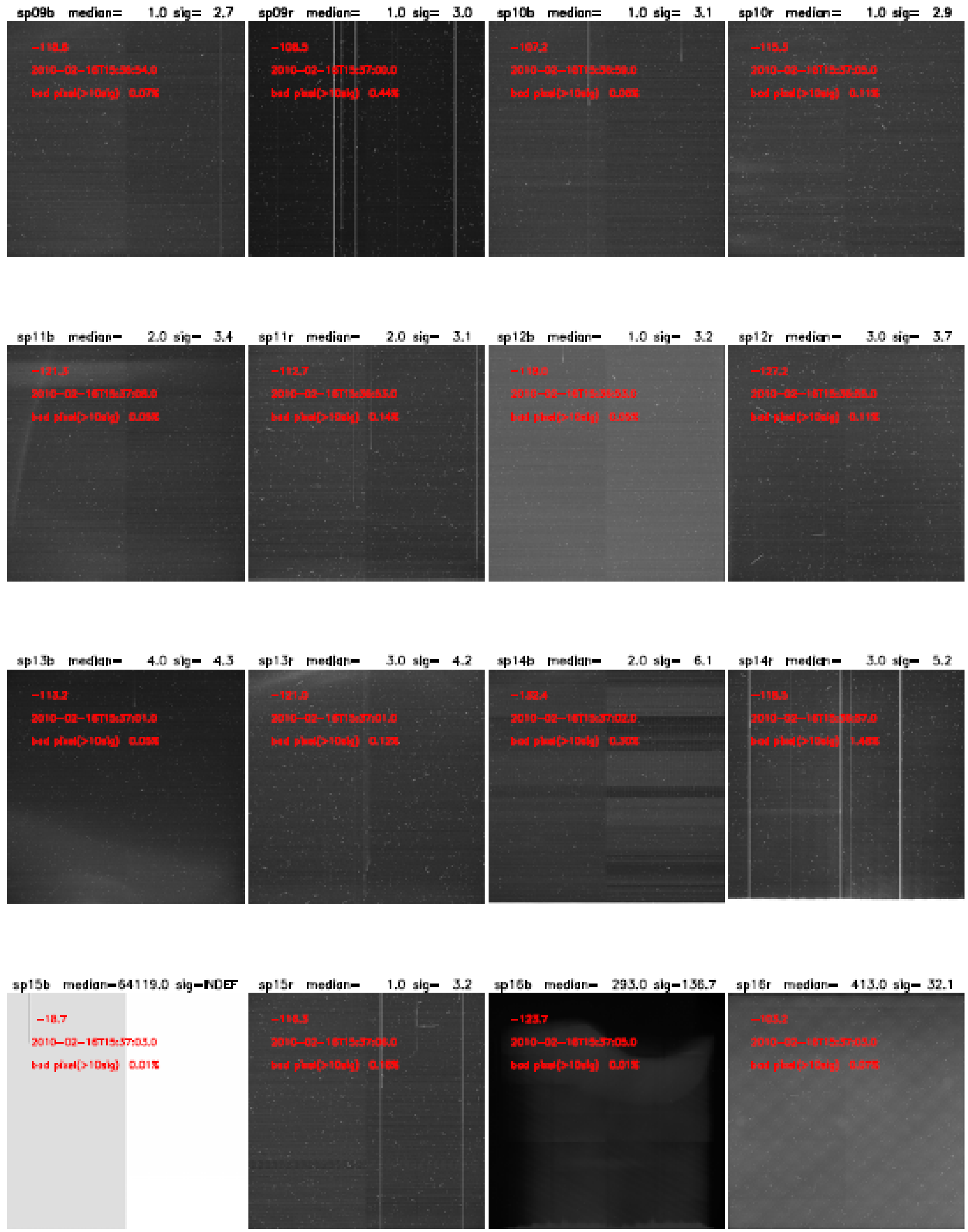
Newly discovered QSOs in LAMOST commissioning data

Every piece of hardware and software needs to be aligned, calibrated, tuned, or perfected in some way, but all of the components function at some level.

Current Issues

- Automatic dewar filling sometimes fails
- Noise in CCD readout
- Spectrograph optics not well aligned (this causes many data problems)
- Fiber mapping not ideal
- Fibers not well aligned with slit
- Need additional light baffling
- Performance as a function of sky position poorly understood
- Light leaks in dark frames
- Sky too variable for software pipelines
- Temperature control required for spectrograph room, focal plane
- System efficiency should be 8-10%, but recent tests indicate more like 1%
- Management needs to coordinate scientists and engineers

LAMOST bias frames



Next Steps for LAMOST

(1) Estimate capabilities of LAMOST using calculations and data.

(2) Merge Galactic and extragalactic surveys into one survey plan.

(3) Final negotiations for PLUS-LAMOST partnership.

(4) Design and carry out pilot survey.

Participants in LAMOST, US (PLUS)

Heidi Newberg (Rensselaer), Timothy Beers (Michigan State), Carl Grillmair (IPAC), Raja Guhathakurta (Santa Cruz), Sebastien Lepine (AMNH), Brian O'Shea (MSU), Jordan Raddick (education, Johns Hopkins), Jerry Sellwood (Rutgers), Brian Yanny (FNAL), and Zheng Zheng (IAS), Heather Morrison (Case Western), Evan Kirby (CalTech).

The collaborating group of Chinese astronomers, under the leadership of Licai Deng(NAOC), includes: Yuqin Chen, Jingyao Hu, Huoming Shi, Yan Xu, Haotong Zhang, Gang Zhao, Xu Zhou (NAOC); Zhanwen Han, Shengbang Qian (Yunnan, NAOC); Yaoquan Chu (USTC); Li Chen, Jinliang Hou (SHAO); Xiaowei Liu, Huawei Zhang (PKU); and Biwei Jiang (BNU).

An NSF grant that would fund the PLUS partnership with LAMOST has been funded. US Galactic astronomers are welcome to join PLUS if they are interested in an active collaboration with Chinese scientists.

For more information: http://lamost.us