

# The North Galactic Cap Sky Survey from SCUSS to BASS

ZHOU Xu

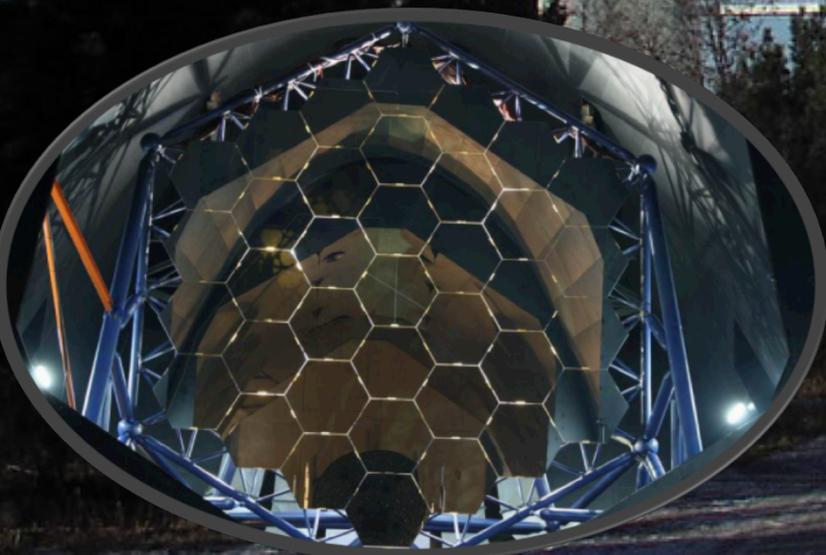
National Astronomical Observatories, CAS (NAOC)

The **South Galactic Cap U-band Sky Survey**  
(**SCUSS**)

The **North Galactic Cap g,r,z-band Sky Survey**

Beijing Arizona Sky Survey (**BASS**)

# The Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST)



**LAMOST Galactic and Extra-Galactic Research Group  
(2008-)**

# Scientific Goals

1. Supplying the input catalogue for LAMOST ;
2. Flux calibrations of the LAMOST spectra;
3. Scientific researches.



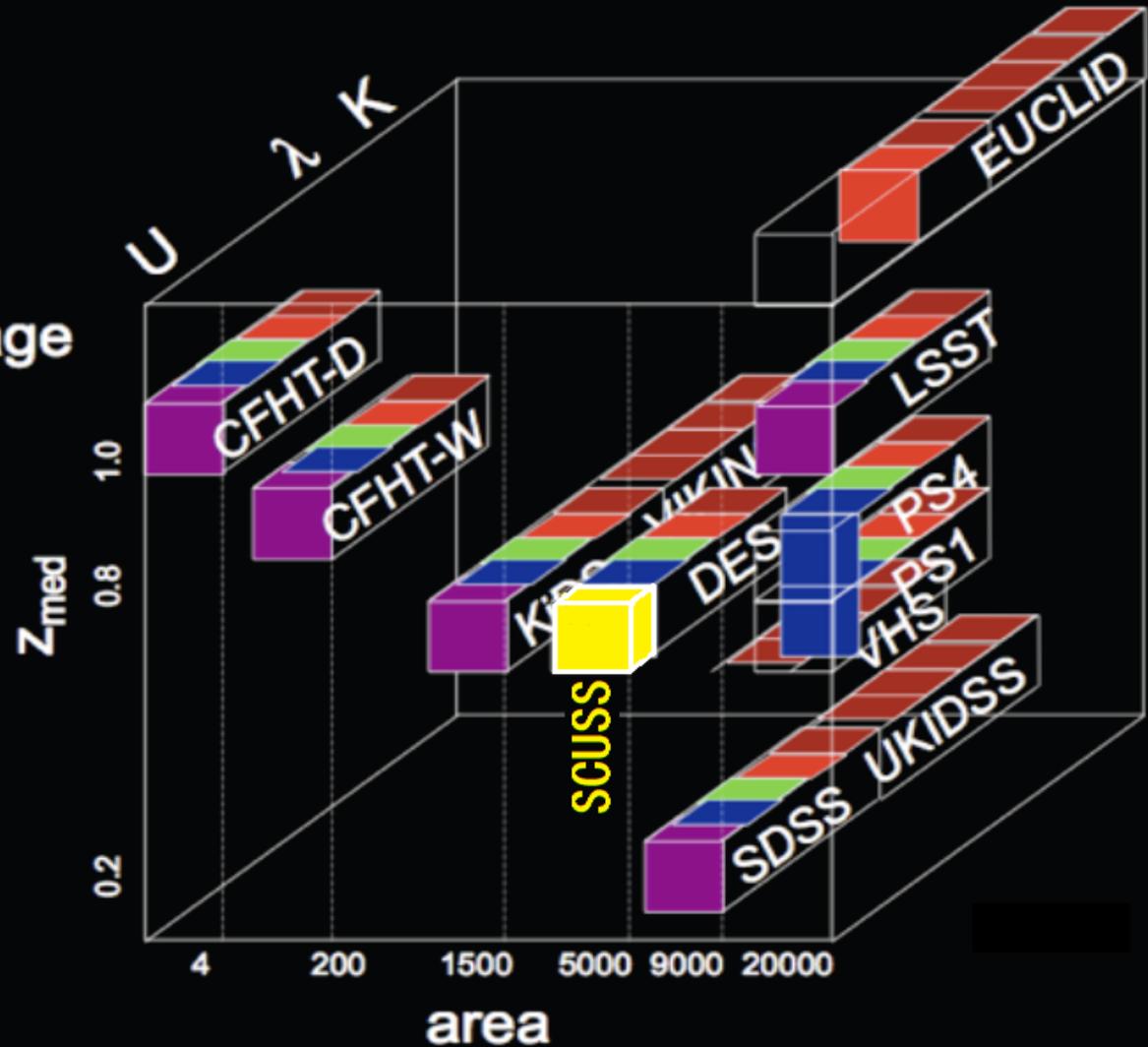
# The South Galactic Cap U-band Sky Survey (SCUSS)

This scope of work defines the 90Prime U-Band Survey Project to be undertaken by the National Astronomical Observatories of China (NAOC) in collaboration with the Steward Observatory (SO) of the University of Arizona (UA). This project will provide essential input data to the LAMOST project being carried out by NAOC. The U-band survey will utilize the 90Prime instrument with its 1-degree field at the prime focus of the SO/UA Bok 2.3 m telescope located on Kitt Peak, near Tucson, AZ. Funding will be provided by the NAOC to upgrade the 90Prime instrument to expedite the U-band survey and hence to address the LAMOST project needs. The SO/UA will participate in the U-band survey and provide telescope time and associated technical resources to support the observations.

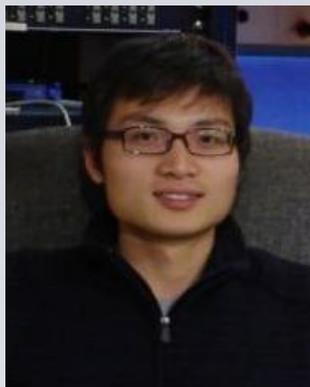
The scientific goal of the project is to undertake a U-band survey of a 3700 square degree region of the South Galactic Pole using 5 minutes exposures (to a limiting magnitude deeper than 22) and to complete the survey over an approximately three year time period. The technical goals of the upgrade project are to replace the existing focal plane with four blue-optimized CCDs, improve the controller readout electronics, and enhance the overall operation of the 90Prime system. Both NAOC and SO/UA scientists will have access to the data as they are taken. Final publication of the survey will be undertaken by NAOC with SO/UA participation.

# Survey parameters

- Area covered
- Median redshift
- Image quality
- Wavelength coverage



The position of SCUSS is added in diagram of N. Kaiser, 2011, NAOC.



范舟



邹虎



聂俊丹



张天萌

SCUSS  
Observers



马骏



钟靖



王嘉力



梁志雄

BASS  
Observers



蒋兆基



周志民



王松



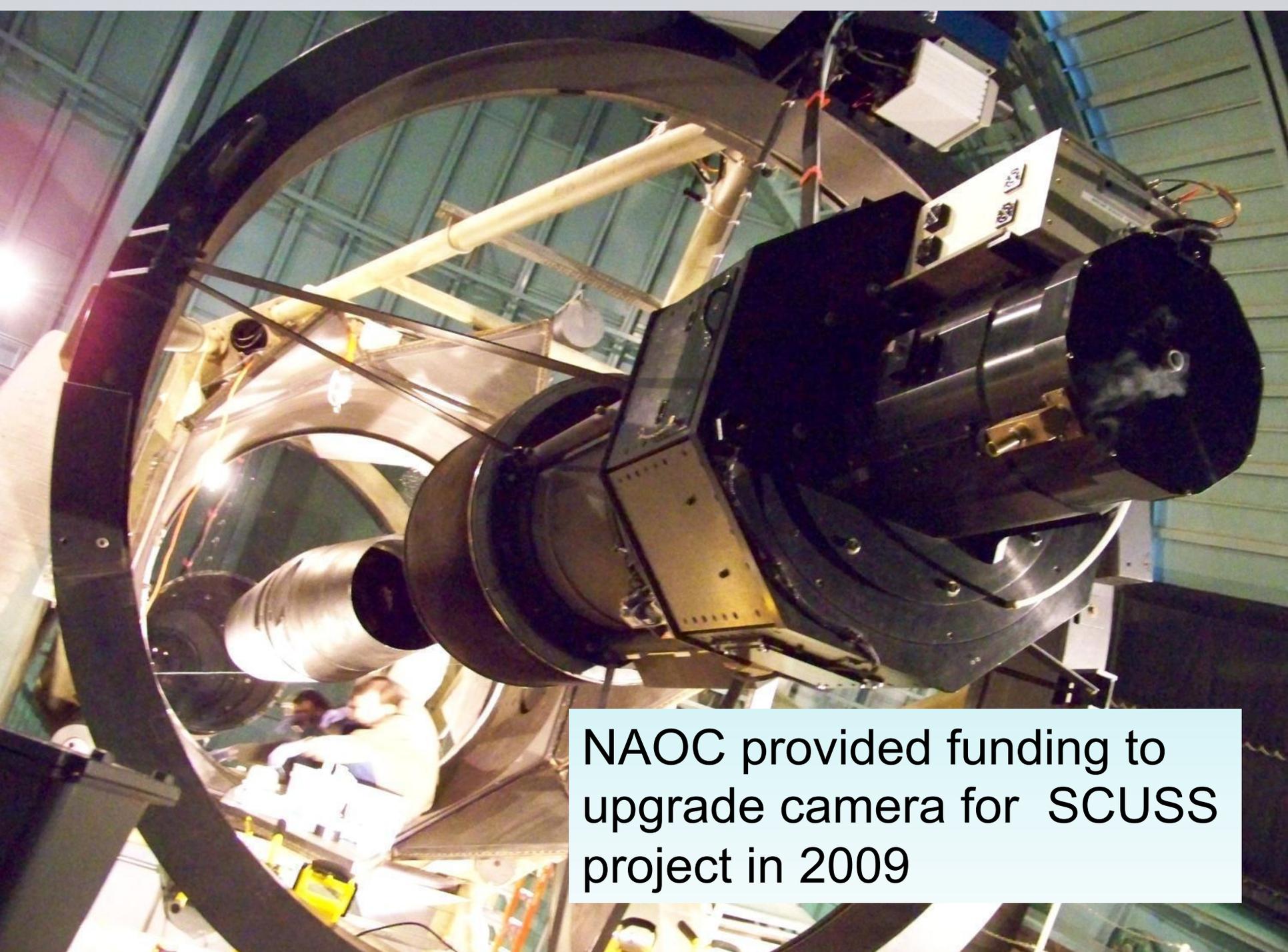
武振宇



周旭

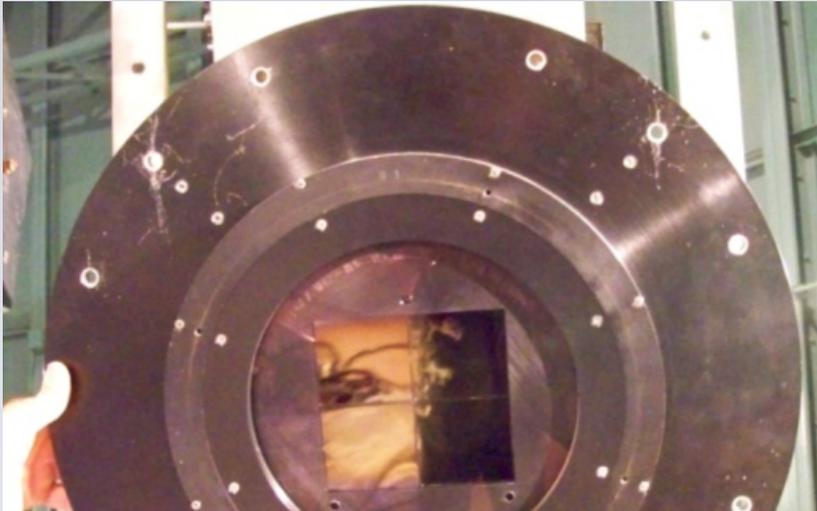


**2.3M BOK Telescope of Steward observatory on Kitt Peak**



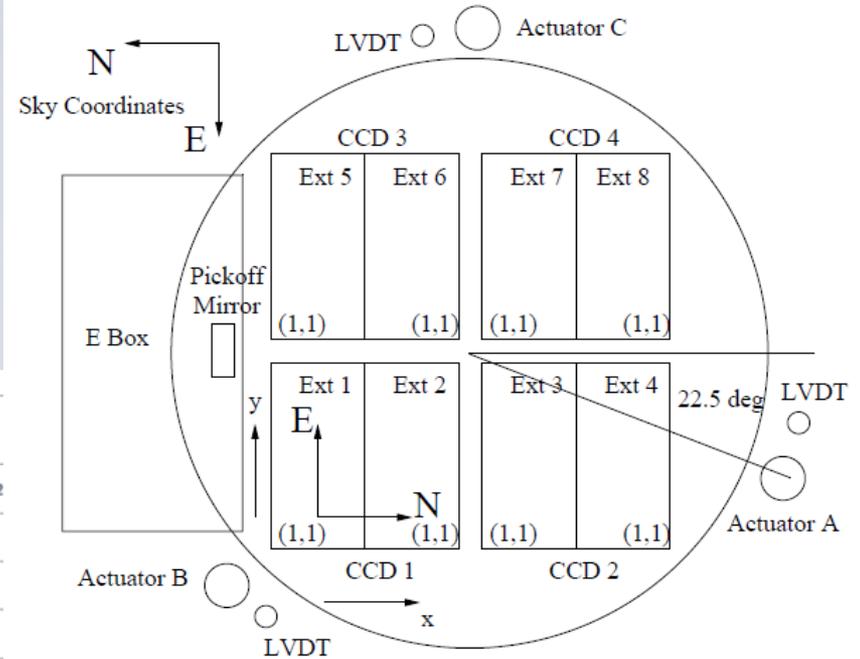
NAOC provided funding to upgrade camera for SCUSS project in 2009

# New camera with blue sensitive 4x4 CCD chips

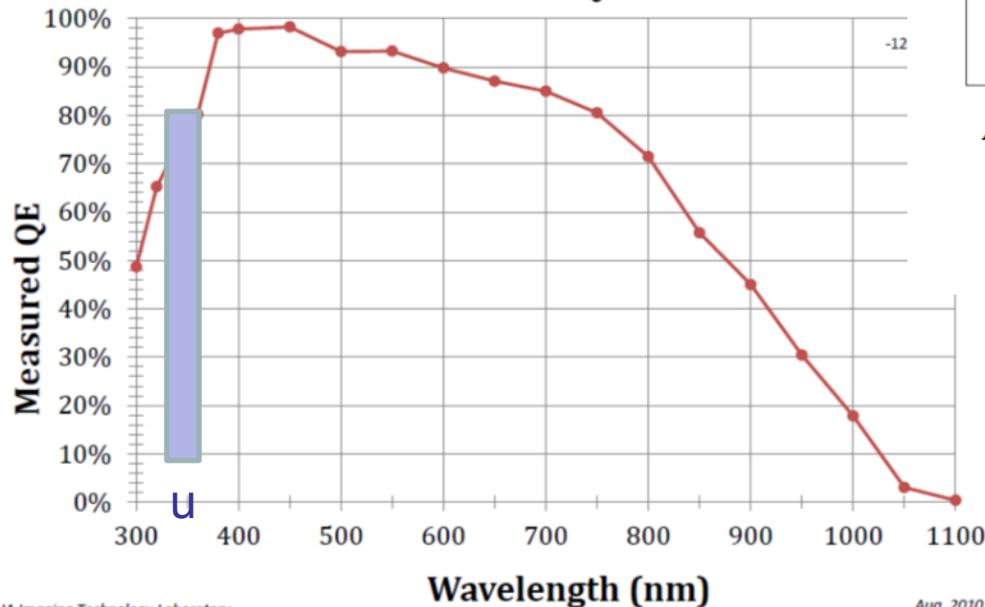


## 90prime CCD Configuration

### Physical Layout



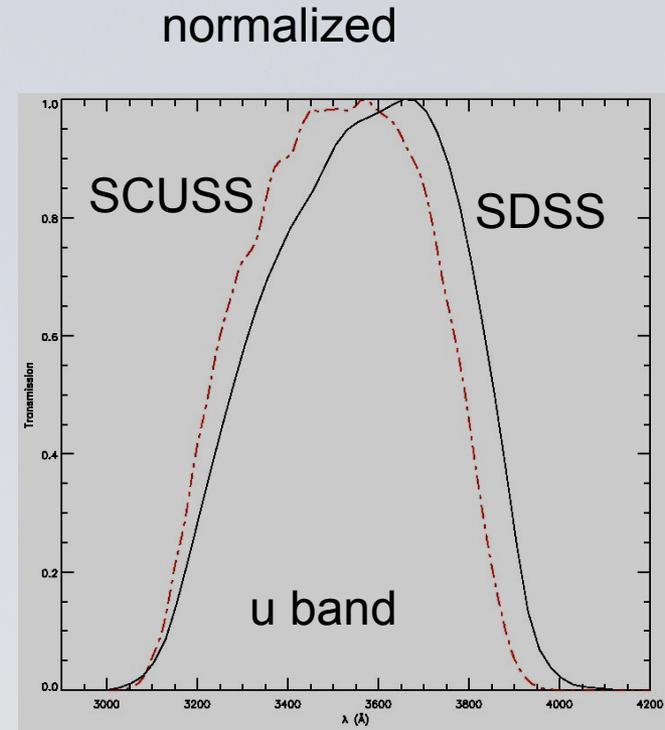
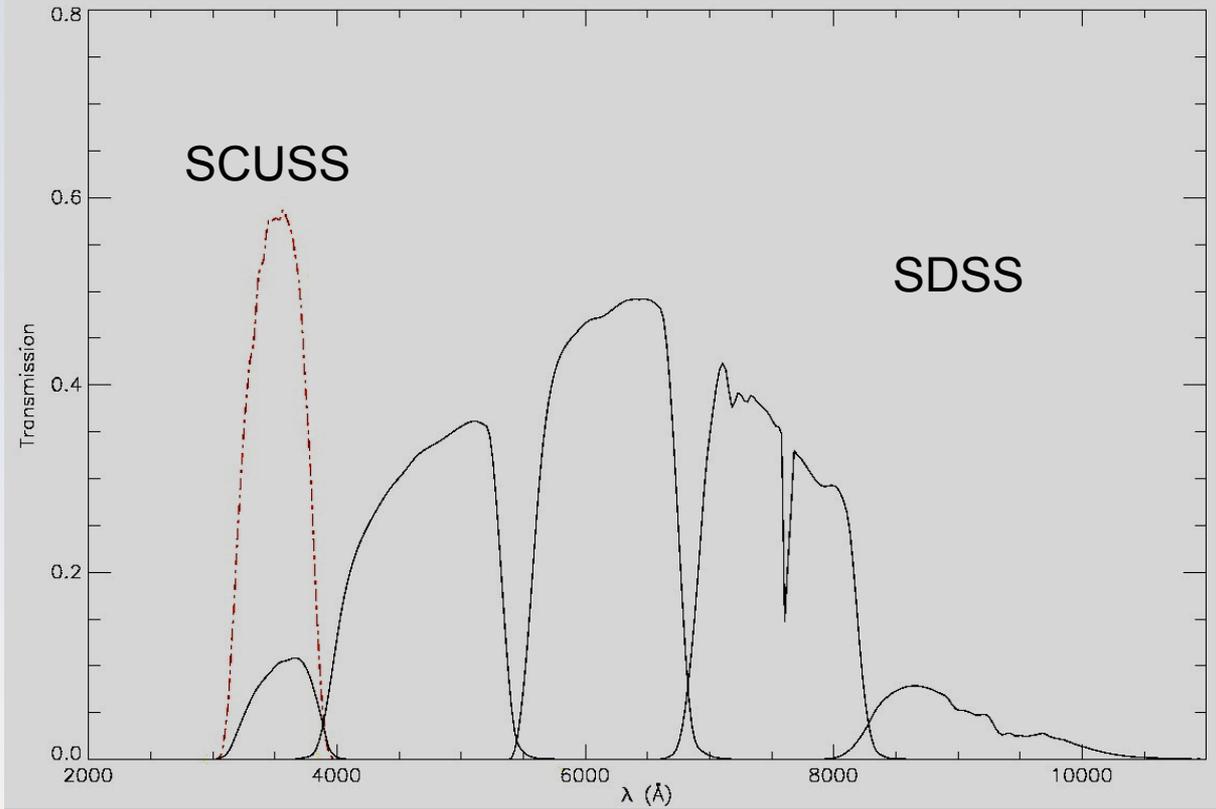
## 90Prime CCD QE



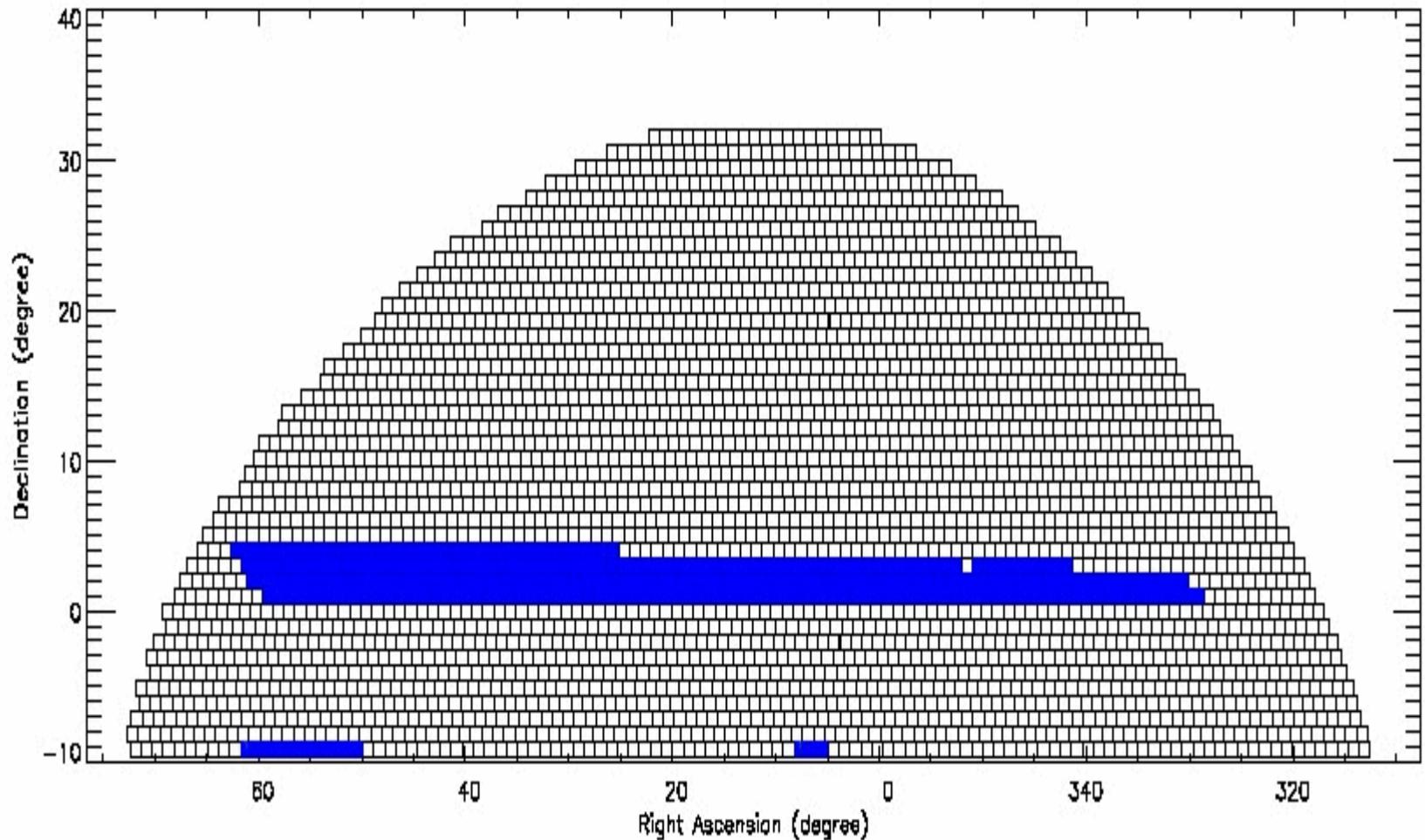
Looking into the dewar.



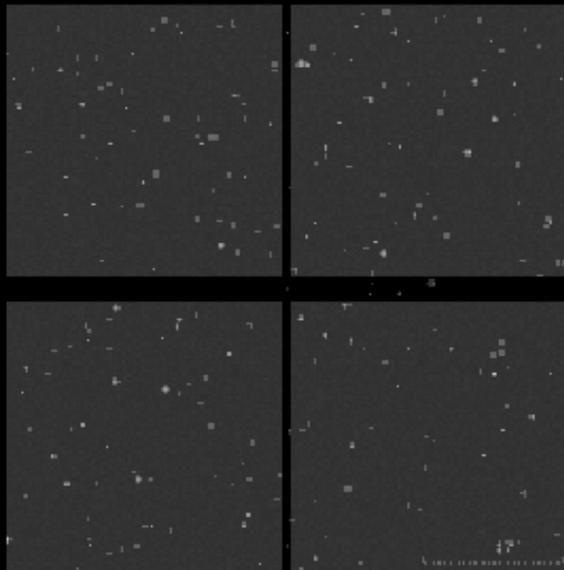
# Filter Transmission Curve



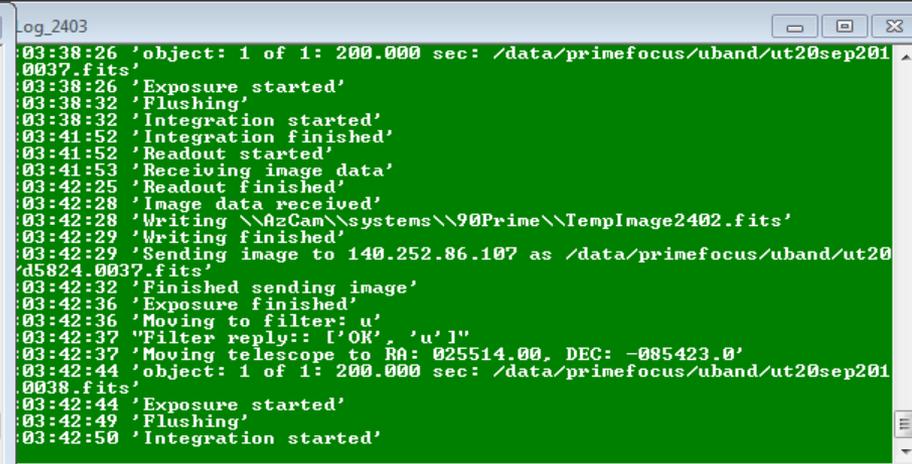
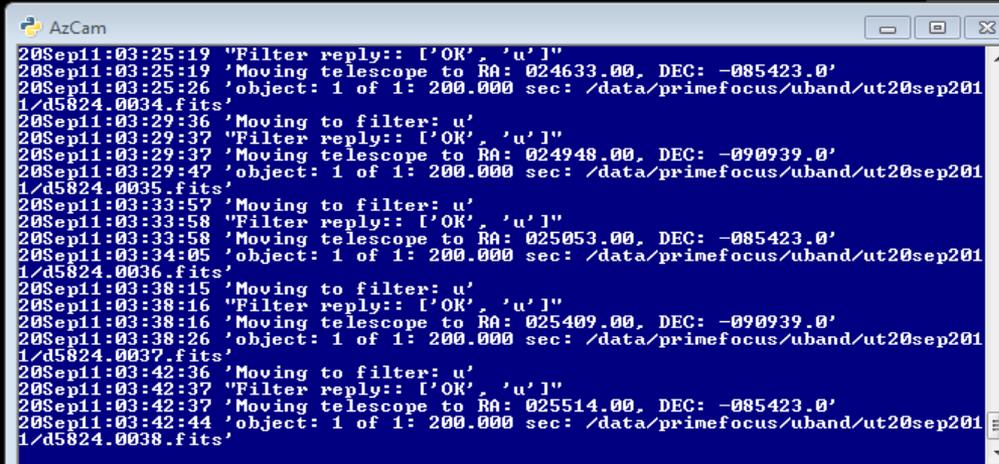
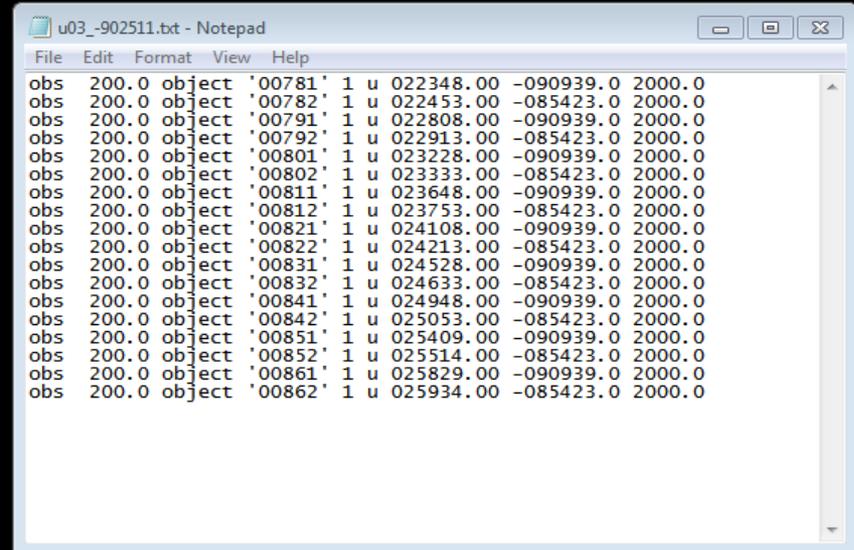
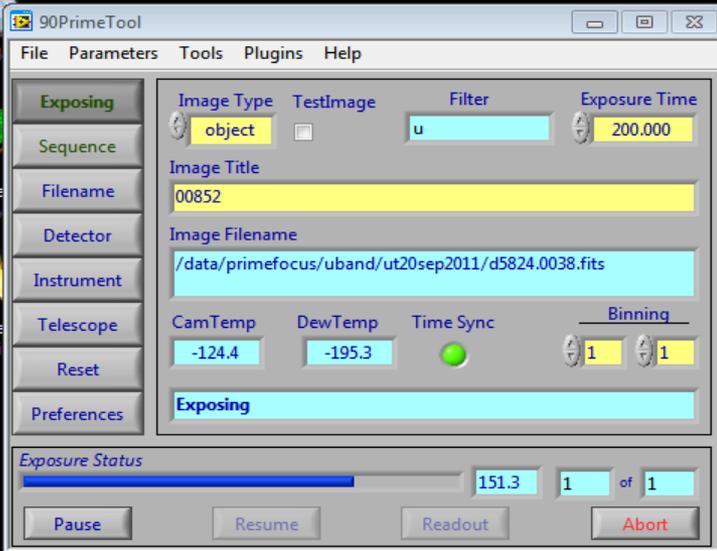
# SCUSS observation following the strategy & almost same as simulation



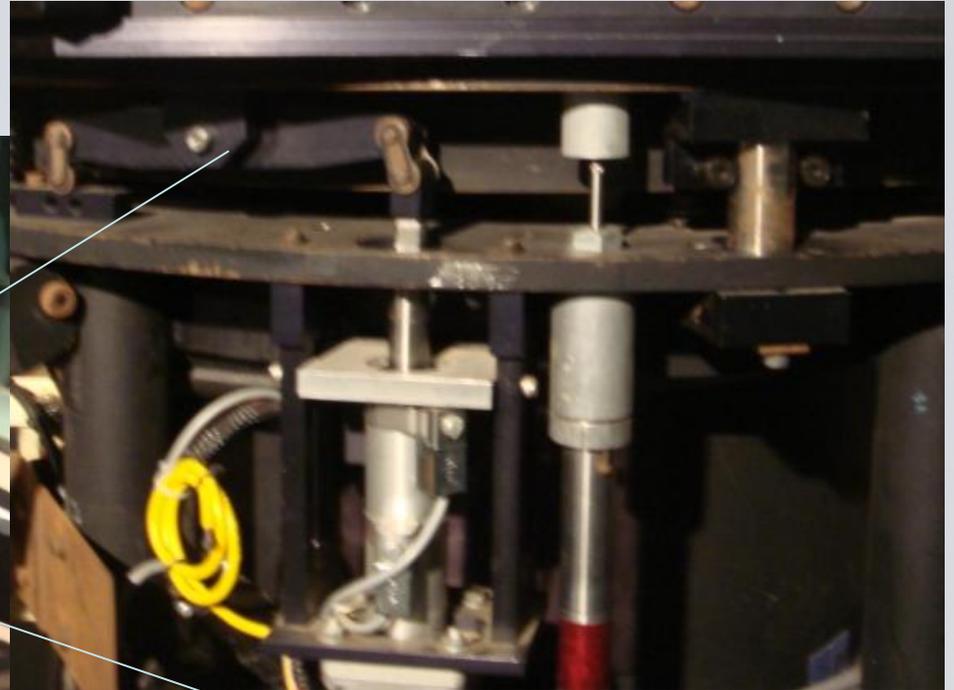
# The final scanning mode of SCUSS



# SCUSS Observation in Batch Mode



The focus plan is adjusted by 3 actuators



# Calculate the field center and initiate telescope

Image Edit view go help

Previous Next

530 x 512 pixels 91.5 KB 100% 1 / 8

3: 00:16:36.521 -08:56:28.47

OBS: 00:19:25.61 -08:49:26.0 (2000.0) 00:20:01.38 -08:45:32.4 (2011.7)

CAL: 00:17:44.36 -09:12:25.5 (2000.0) 00:18:20.14 -09:08:31.8 (2011.7)

101.25(1518.8)1379.5

[zhouxu@M81 tmp]\$ getcoord d5825.0003.fits

赤纬 (东)

00:19:25.367 -08:49:25.28 (2000.0) 4.4~17.0" 63'

Telescope coordinates

Real field center coordinate

The value for correction in

# Check image quality by observer

Image Edi

Previous

530 x 512 p

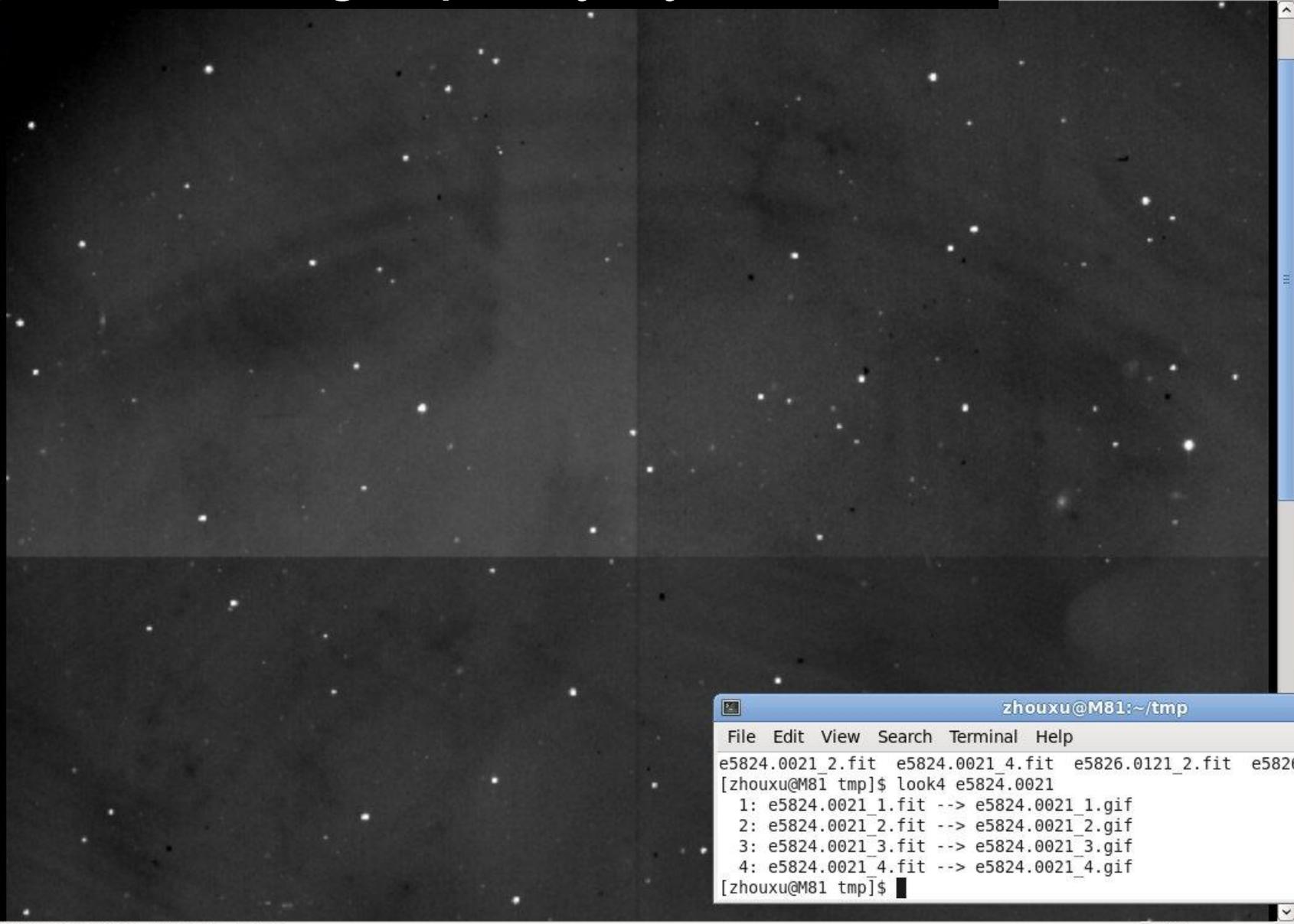
3: 00:16

-----

OBS: 00:

CAL: 00:

[zhouxu@M

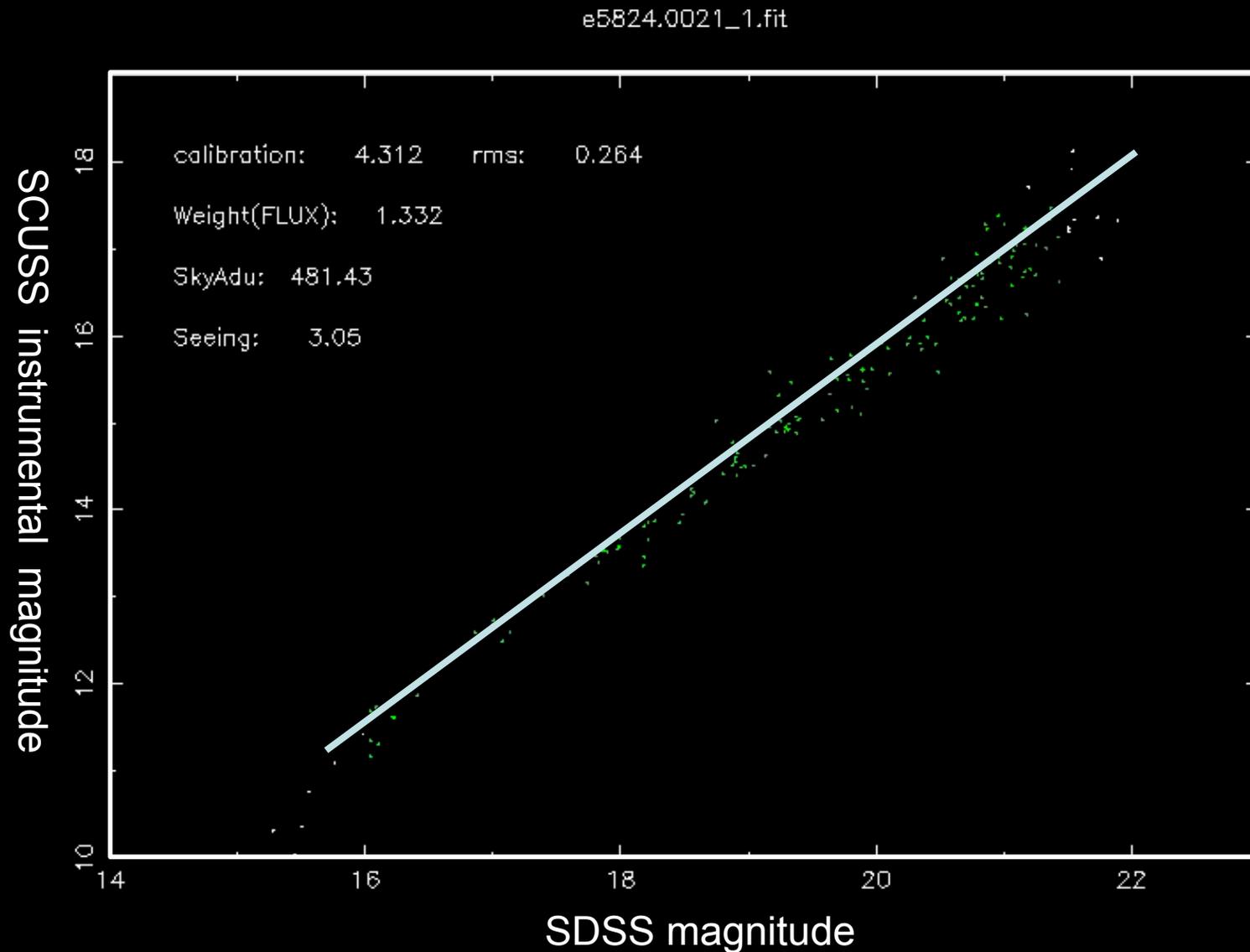


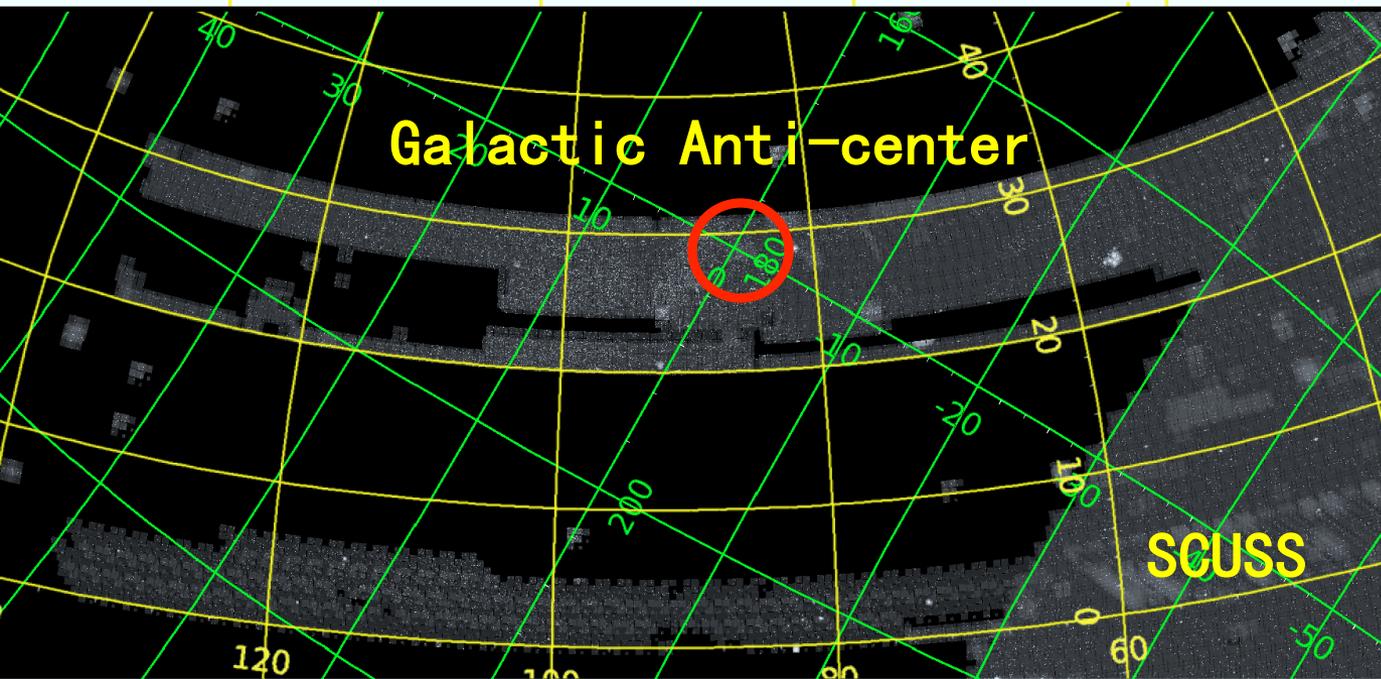
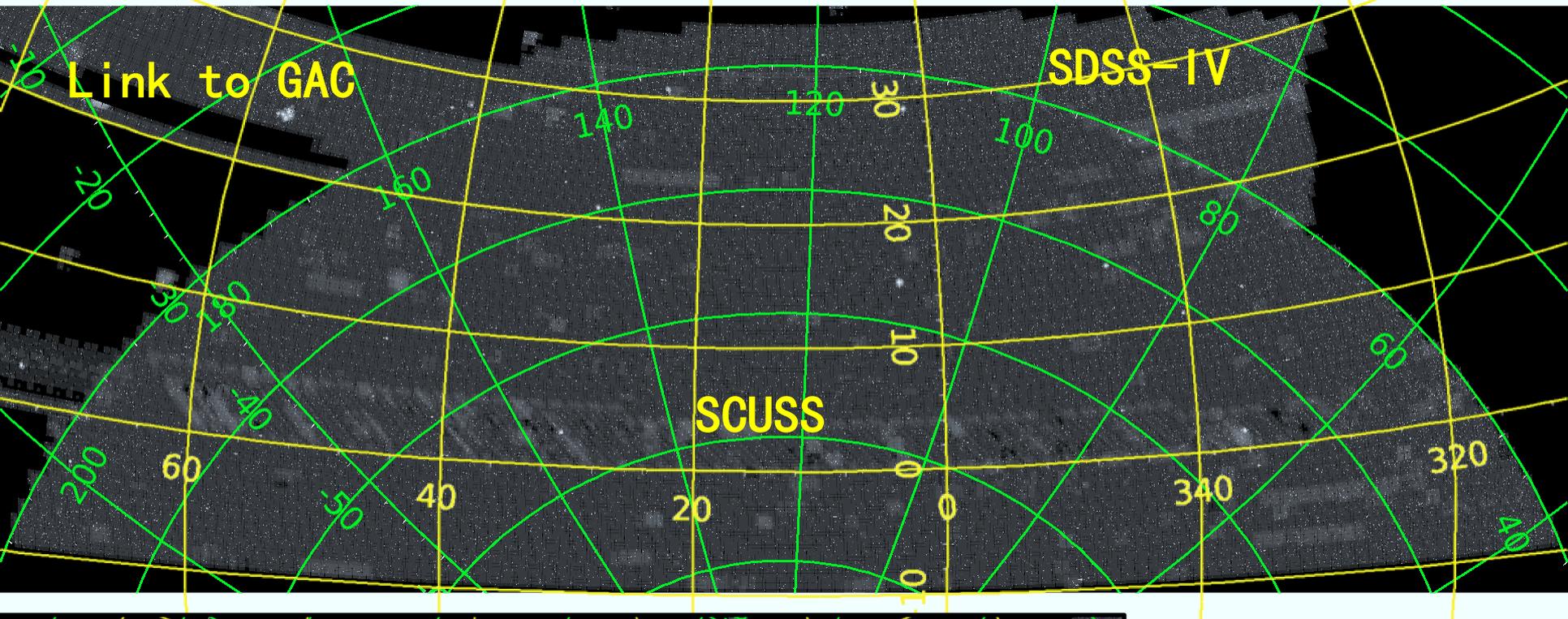
```

zhouxu@M81:~/tmp
File Edit View Search Terminal Help
e5824.0021_2.fit e5824.0021_4.fit e5826.0121_2.fit e5826.01
[zhouxu@M81 tmp]$ look4 e5824.0021
  1: e5824.0021 1.fit --> e5824.0021_1.gif
  2: e5824.0021 2.fit --> e5824.0021_2.gif
  3: e5824.0021 3.fit --> e5824.0021_3.gif
  4: e5824.0021 4.fit --> e5824.0021_4.gif
[zhouxu@M81 tmp]$

```

# Check image quality by observer





The total SCUSS observation area  $\sim 5000$  degree<sup>2</sup>

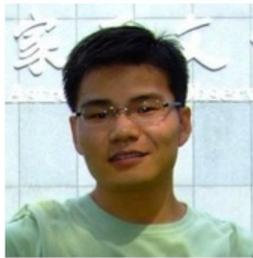
# Recall the SCUSS data reduction team



Zhaoji Jiang



X. Zhou



H. Zou



Z. Fan



Z. Y. Wu



J. D. Nie



C. Li



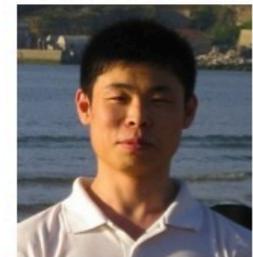
W. Zhang



J. Ma



I. M. Zhang



Z. M. Zhou

# DATA REDUCTION

BIAS Correction:

Overscan & Bias structure

Flat-Field Correction:

Super Sky Flats, Dome Flats & Twilight Flats

Astrometry:

UCAC4 catalogue

Flux calibration:

SDSS Dr9 & SCUSS internal self calibration

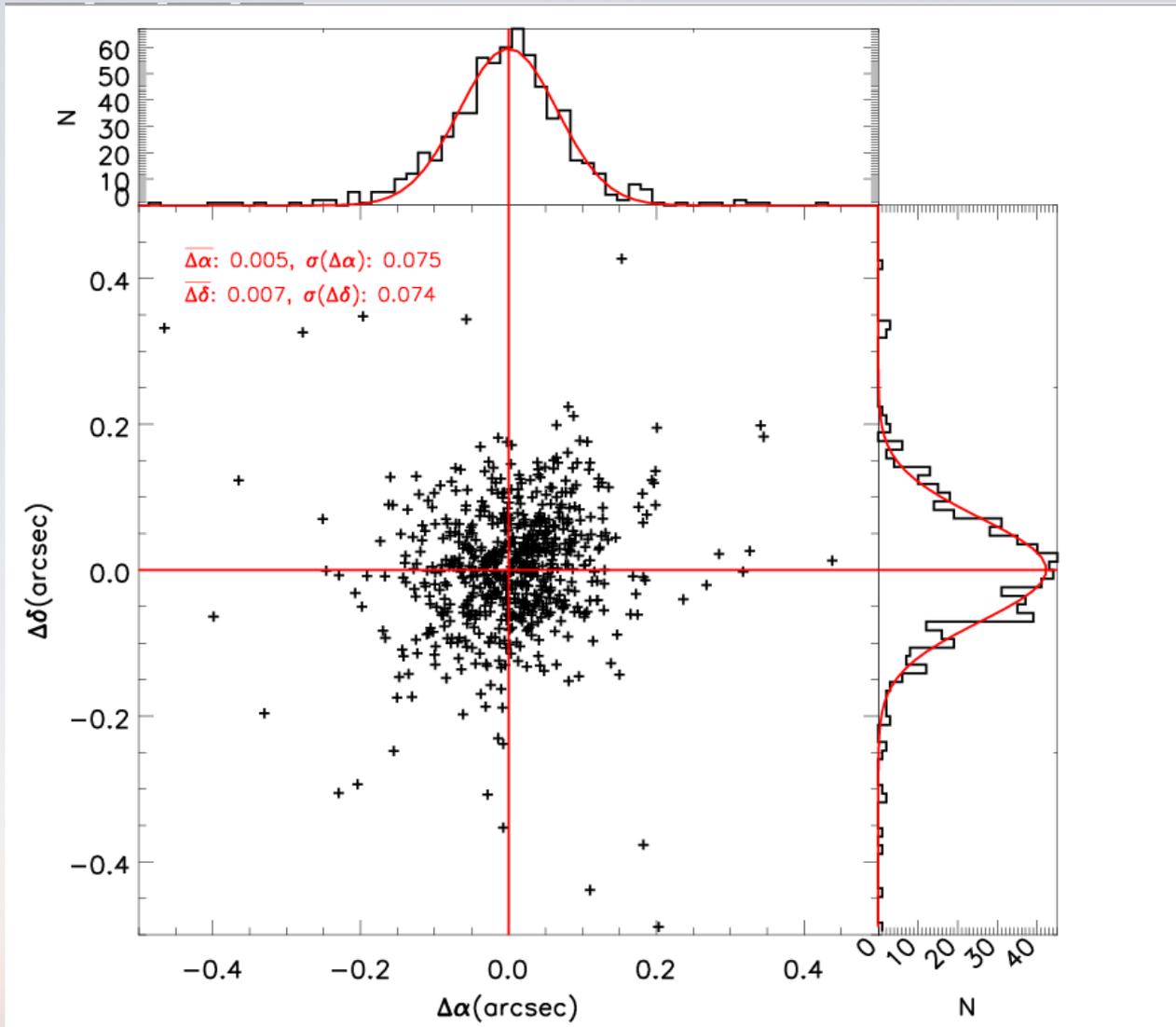
Image Combination:

Add images by weight of image qualities

Photometry:

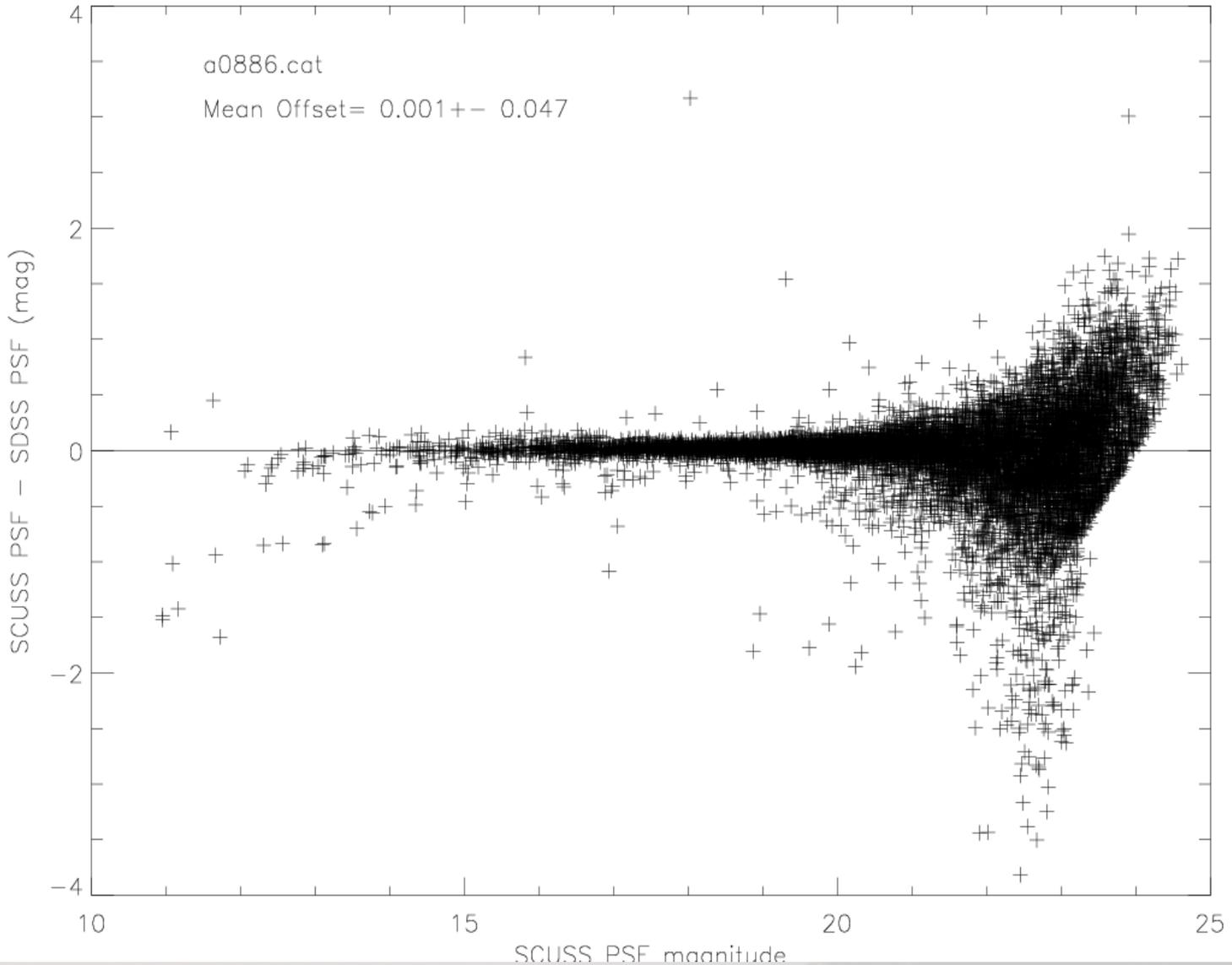
DAOPHOT, SEXtractor, (SDSS and LSST pipelines)

# The astrometry

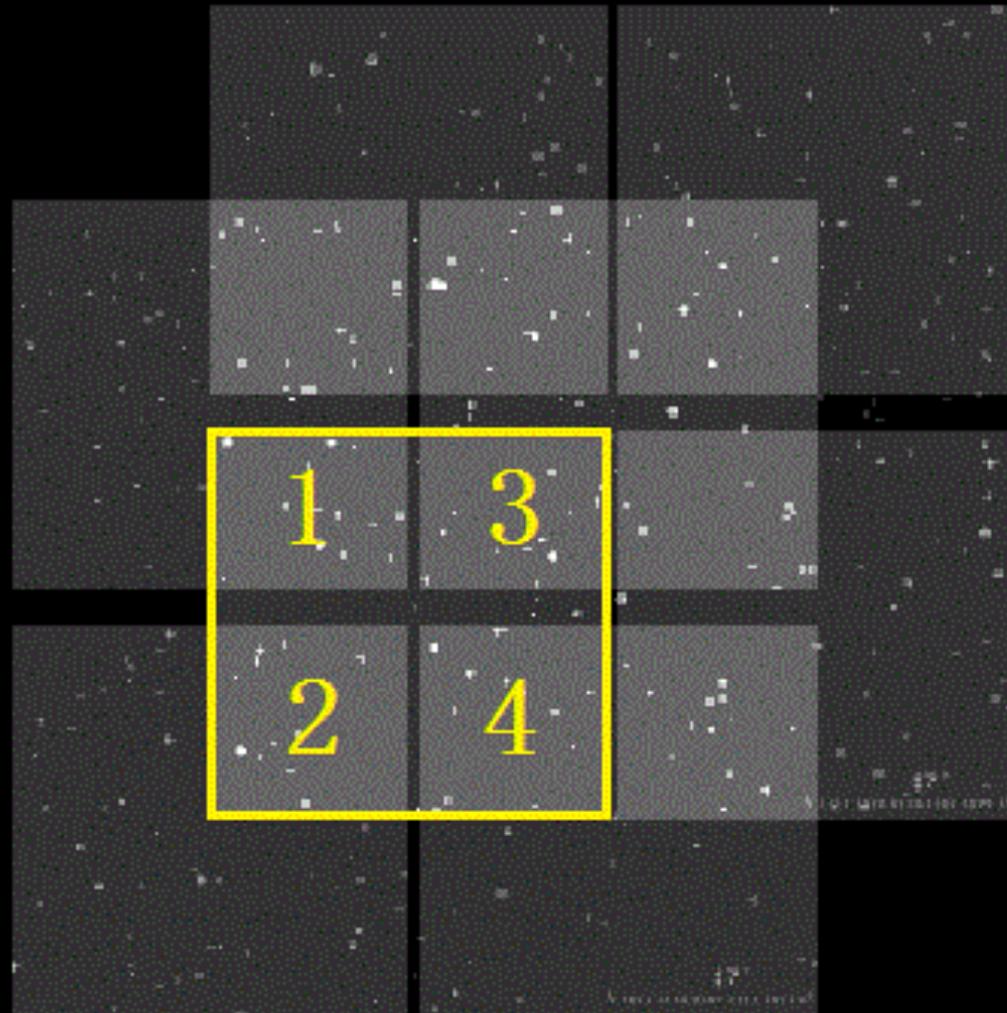


In comparison  
with UCAC4:  
0.15''

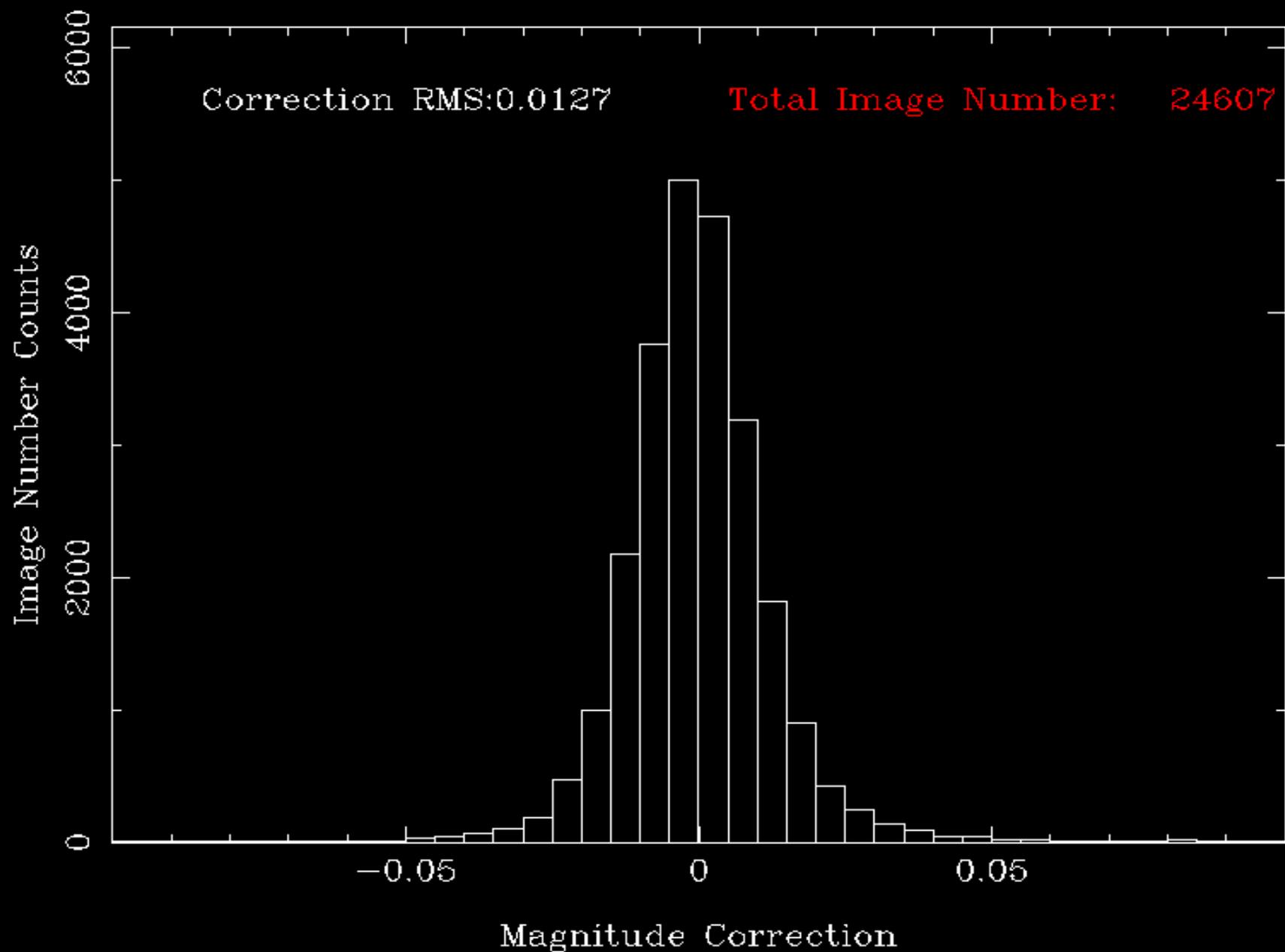
# SCUSS photometric measurement can be calibrated by SDSS catalogue



Each CCD frame can be calibrated by  
**4 previous exposure frames**

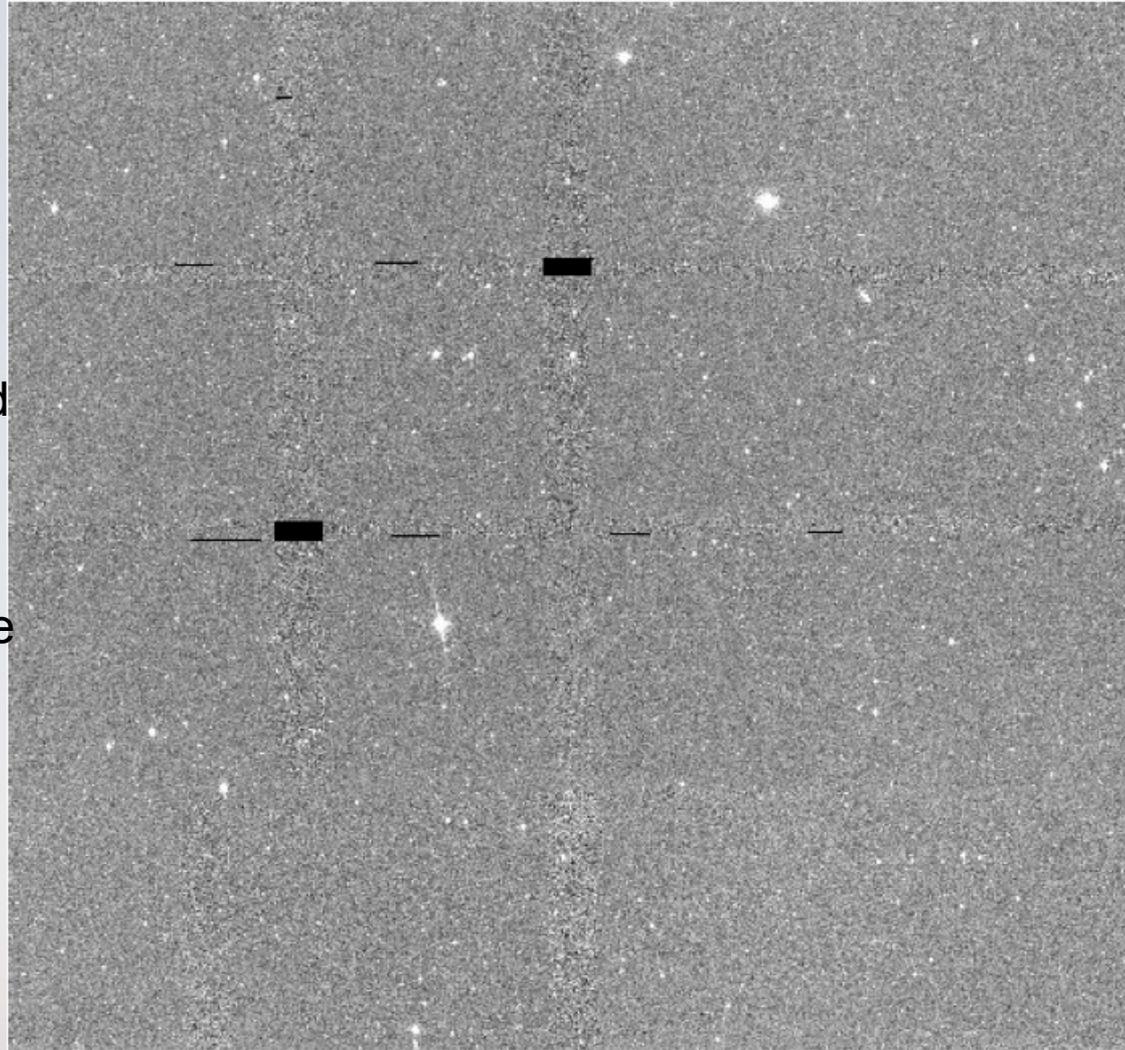


# SDSS calibration field

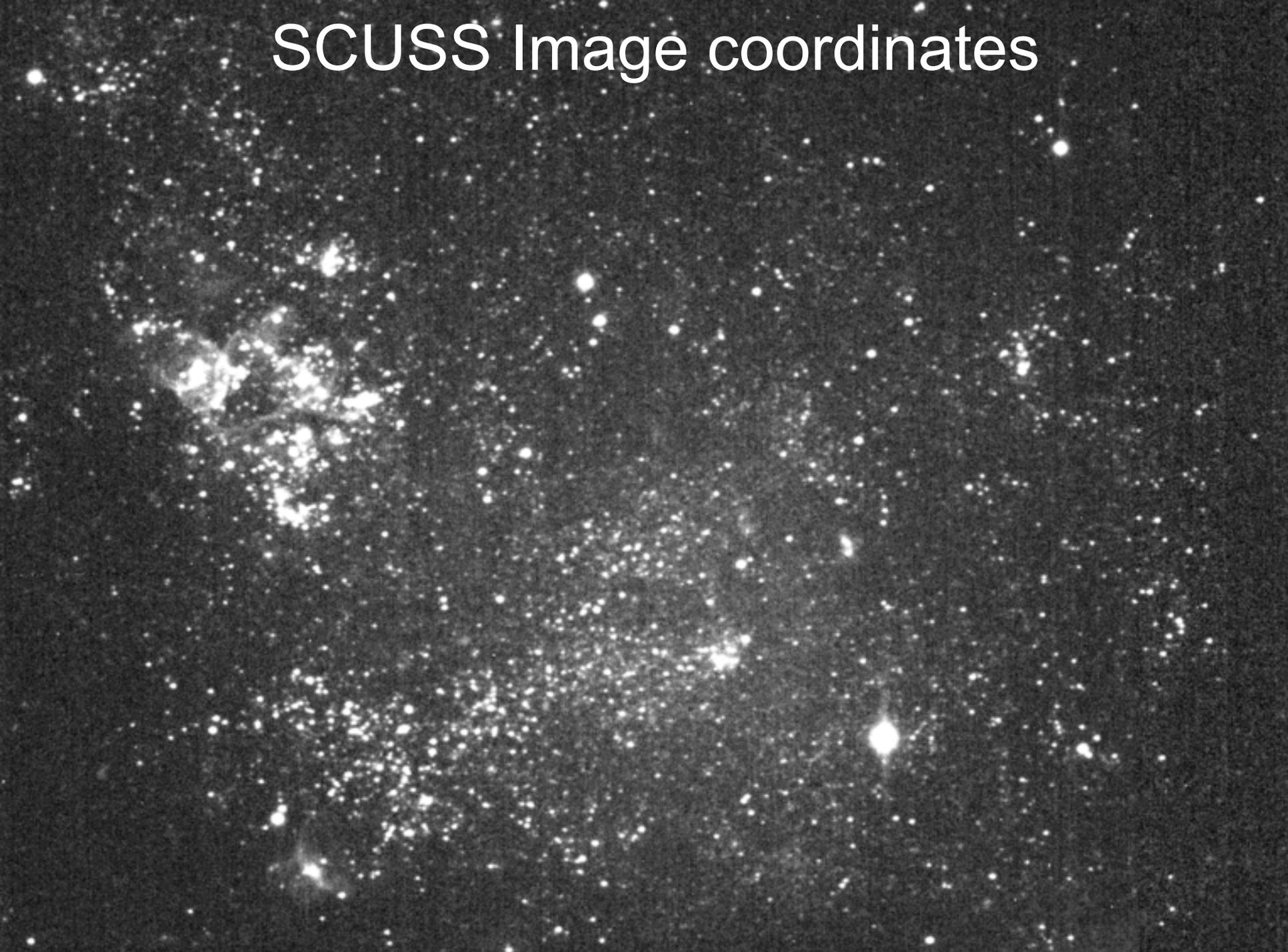


# Image combination

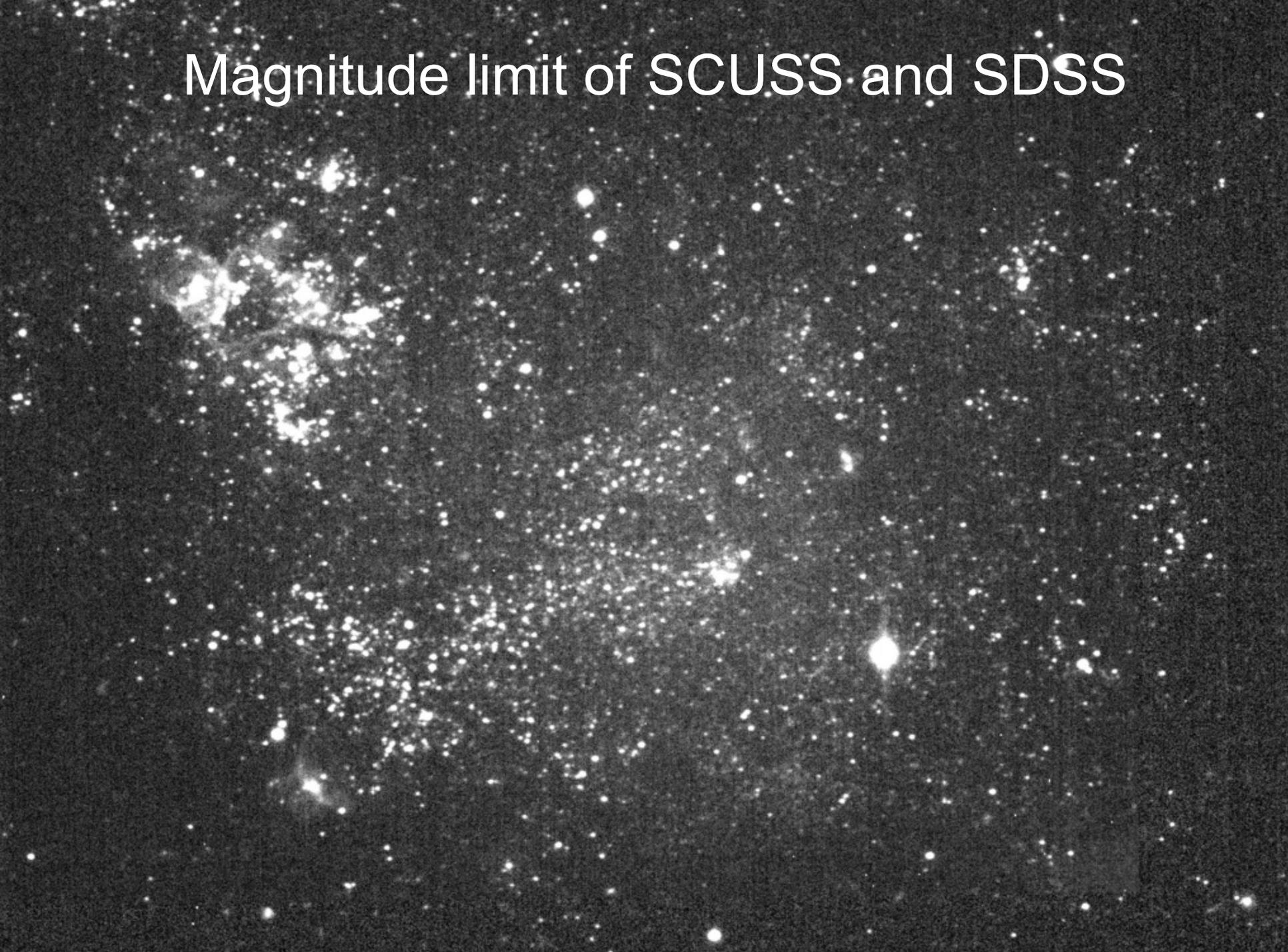
1. At present, the catalogs are generated based on combined images.
2. These combined images are one-degree size and created by stacking single exposures.



# SCUSS Image coordinates



# Magnitude limit of SCUSS and SDSS



# Download SCUSS calibrated image

← → <http://casdc.china-vo.org/ims/uband> 🔍 🗄️ ↻ ✕ 中 ba

★ 建议网站 ▾ 🌐 建议网站 ▾ 📄 获取更多附加模块 ▾ 📄 自定义链接 📄 获取更多附加模块 ▾

## Uband Image Server

Scale	<input type="text" value="0.454"/>	Generate	Reset
	arcsec/pixel (0.2~0.454~1.00), no limited. Uband CCD's platescale: 0.454 arcsec/pixel, recommend		
RA	<input type="text" value="1:00"/>		
	(2000.0)中心赤经, 格式: hh[:mm[:ss]]		
Dec	<input type="text" value="1:00"/>		
	(2000.0)中心赤纬, 格式: dd[:mm[:ss]]		
X	<input type="text" value="1000"/>		
	pixel, 13000 system limited		
Y	<input type="text" value="1000"/>		
	pixel, 13000 system limited		
Flux r	<input type="text" value="0.6"/>		
	less than it, not use; default use all		

### catalogbv1

Catalog, include SDSS DR8(Rows: 8402860)

### 输出选项

格式 HTML Table 数量 50

### 基本检索

天体  半径 10 arcsec

天体坐标 格式为deg或hh:mm:ss dd:mm:ss  
例如: 254.00002 -87.43165 或 16:56:00.004 -87:25:53.94

Search Reset All

### 完整检索

Show	Sort
<input checked="" type="checkbox"/>	<input type="checkbox"/>

The data is using for scientific research & SDSS IV eBOSS target selection

# SCUSS Research Team



# Nearby cluster of galaxy



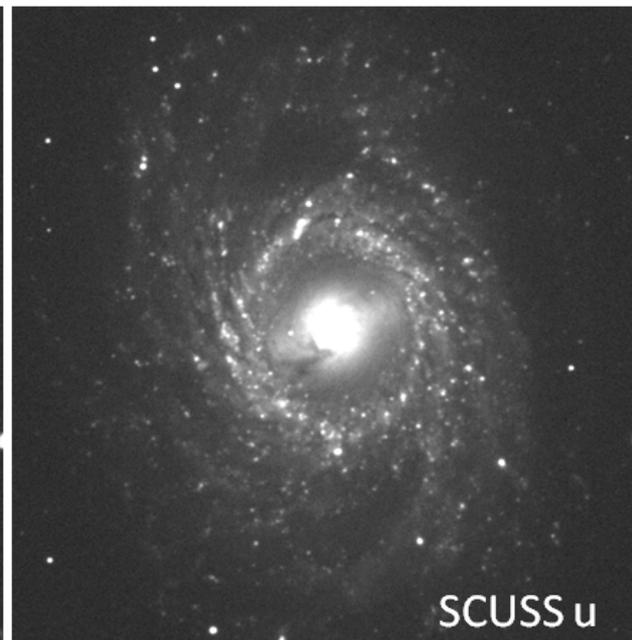
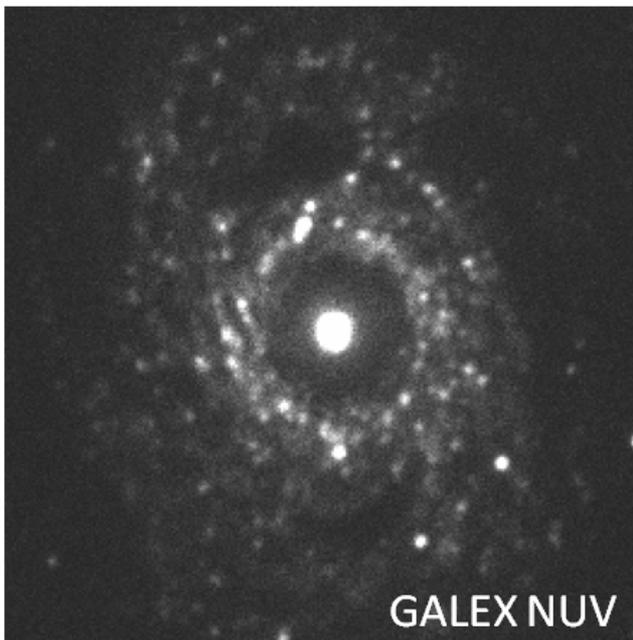
**Galaxy clusters of Abell 399 and Abell 401 in SCUSS u band image in field about 1x1 square degree and its sub field. The member galaxies fainter than 23 mag can be detected.**

## Nearby cluster of galaxy



**Galaxy clusters of Abell 399 and Abell 401 in SCUSS u band image in field about 1x1 square degree and its sub field. The member galaxies fainter than 23 mag can be detected.**

# Comparison of u band with UV and other optical bands



NGC3351

# Early type massive stars and star formation region



M33

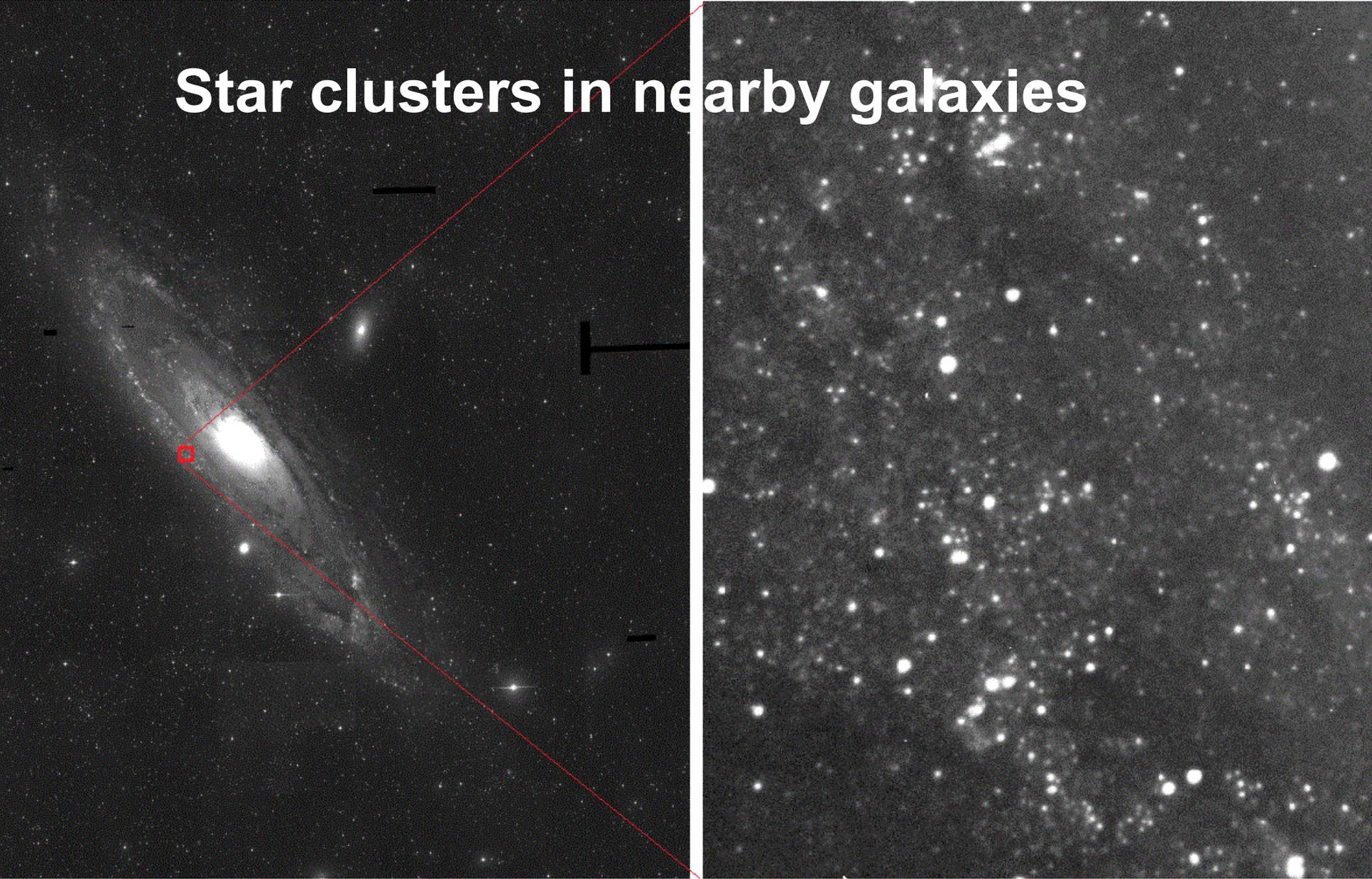
**SCUSS u Band image (3500A)**



**Fleming Astrophotography  
TMB203 F/7 RGB Ha, 36h Exposure**

In SCUSS image, the point sources are mainly the massive early type stars exist in star formation region. The Ha regions (pink) in color image are well associate with the massive early type stars (point sources) in SCUSS image.

# Star clusters in nearby galaxies



SCUSS M31 combined u band image of 3x3 square degree and its sub-image with FWHM=1.5".

## eBOSS Survey Plan

## ELGs

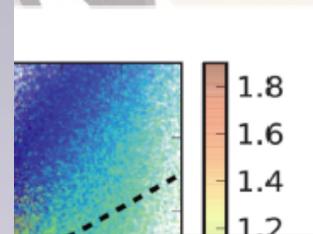
- Select  $\sim 180$   $0.6 < z < 1$  ELGs per sq deg
- Ancillary program of 3 plates in CFHT-LS (observe in 3 weeks)
  - complete to  $g = 22.8$  (470 per square degree)
  - 5 sigma detection thresholds of  $u = 23$ ,  $g = 24.4$ ,  $r = 24$ ,  $i = 23$ .
- Tests with previous ancillary program reveal mixed redshift success

## Clustering Quasars

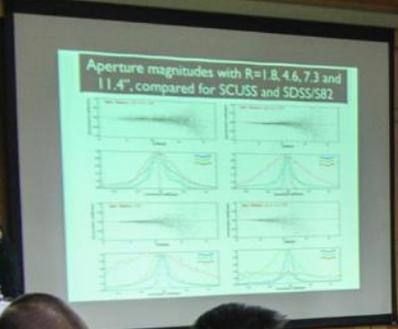
- $0.8 < z < 2$  quasars require homogeneity for LSS
- Impose photo-z priors on selection?
- Need targets as soon as possible (large area to tile)
- Selection from SDSS ugriz+(WIRO+SCUSS)+WISE
- TDSS+SPIDERS contribution?

to tile ELG?

data – drop homogeneity



Kyle Dawson – thoughts to consider



SCUSS Data is used in eBOSS target selection

# The Dark Energy Spectroscopic Instrument (DESI)

The DESI cosmology survey will be conducted from the Kitt Peak site over a 14,300 deg<sup>2</sup> extragalactic footprint. DESI will spectroscopically target 30 million objects from 3-band optical imaging combined with WISE imaging in the near infrared and GAIA astrometry. The four target categories are Luminous Red Galaxies (LRGs), Emission Line Galaxies (ELGs), quasar tracers, and Lyman-alpha forest quasars at  $z > 2.15$ .

The minimum footprint for the imaging survey to meet the DESI minimum science requirements is a 9,000 deg<sup>2</sup> survey in three optical bands to  $g = 24.0$ ,  $r = 23.6$  and  $z = 23.0$  with a fill factor of  $> 90\%$ .

# Beijing-Arizona Sky Survey

# BASS

## A New Legacy Survey of the Northern Galactic Cap

### Chinese Team:

- *NAOC*: **Xu Zhou (PI)**, **Hu Zou (Deputy PI)**, Zhaoji Jiang, Jun Ma, Tianmeng Zhang, Zhimin Zhou, Jundan Nie, Jiali Wang, Chao Liu
- *PKU*: Xuebing Wu, Ran Wang, Linhua Jiang
- *Tsinghua University*: Xiaofeng Wang

### US Team:

- **Xiaohui Fan (PI, Arizona)**, Ed Olszewski, Brenda Frye, Ian McGreer, Mike Lesser, Buell Jannuzi, Eduardo Rozo, Peter Nugent, David Schlegel, Dustin Lang, Arjun Dey

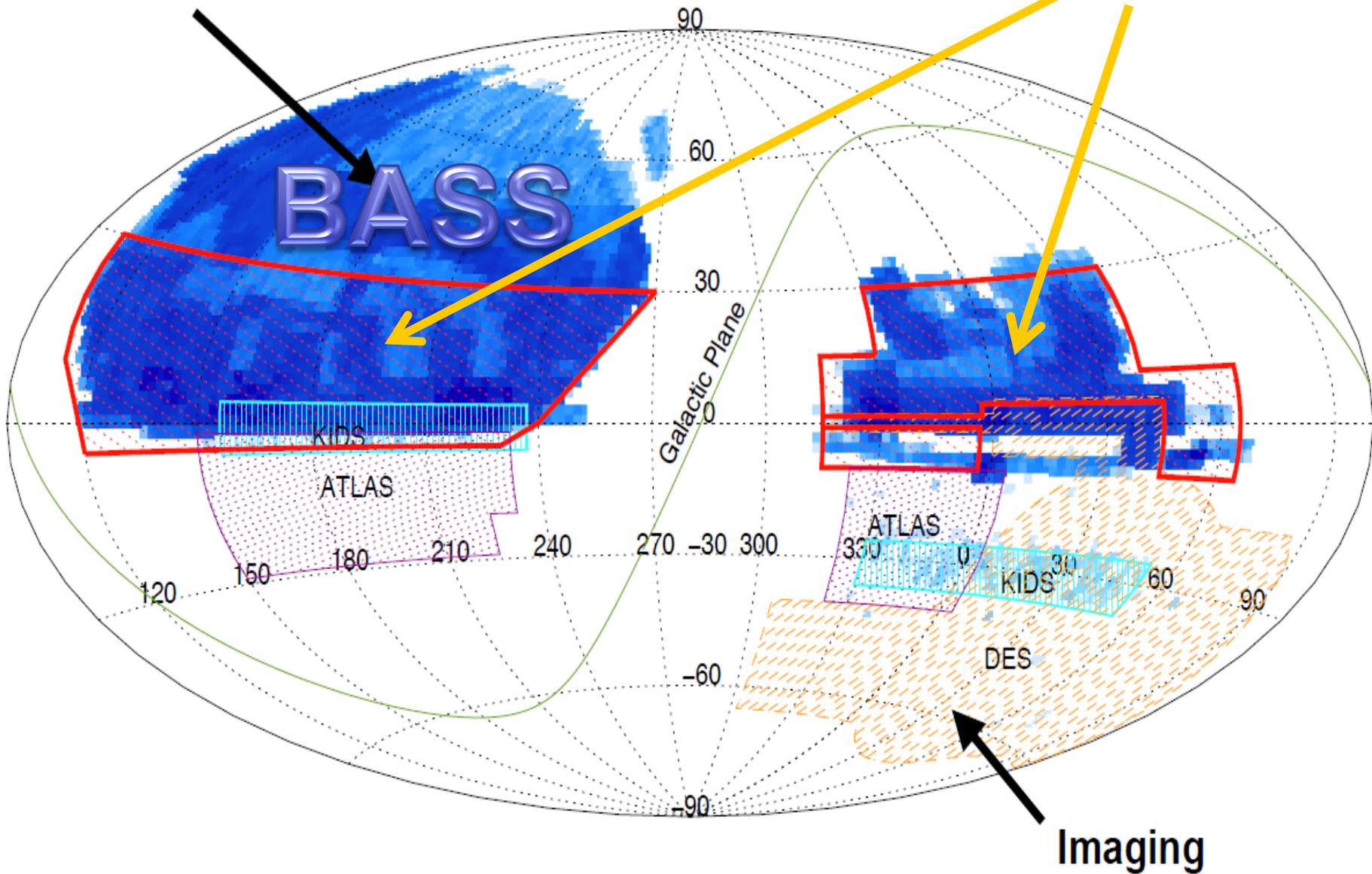
We propose to carry out the Beijing-Arizona Sky Survey (BASS), an ambitious wide-field multicolor survey of 5000 deg<sup>2</sup> of the Northern Galactic Cap using the 90prime imager on the 2.3m Bok Telescope at Kitt Peak, as a four-year collaboration between the Chinese team led by NAOC and the US team led by Steward Observatory, University of Arizona. The survey will use 400 nights, covering SDSS g, r, and z bands, reaching limiting AB magnitude of 24.4, 24.0 and 23.4, respectively. BASS will cover half of the SDSS extragalactic footprint at 1.2 to 2.9 magnitude deeper. ....

# Benefits to the Chinese Astronomical Community

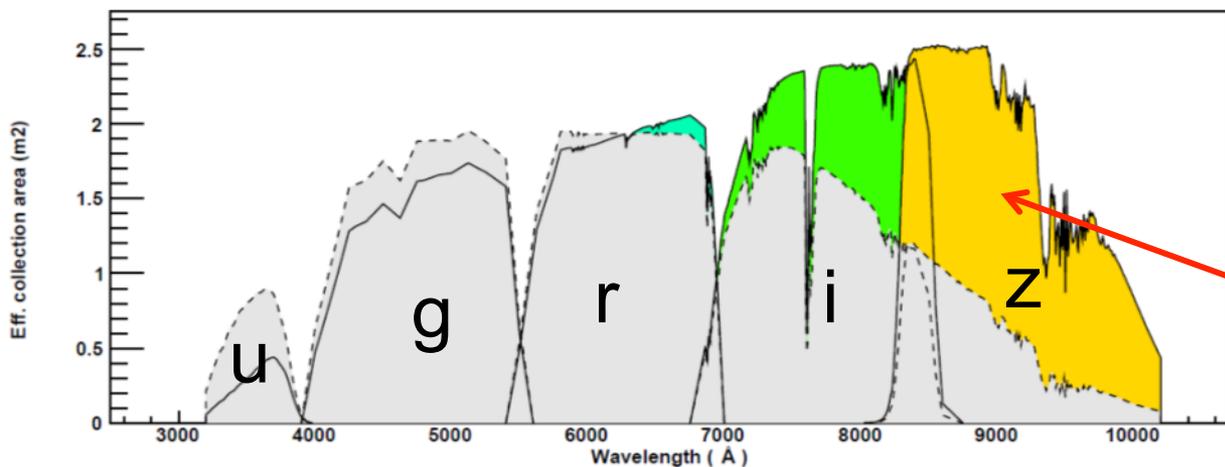
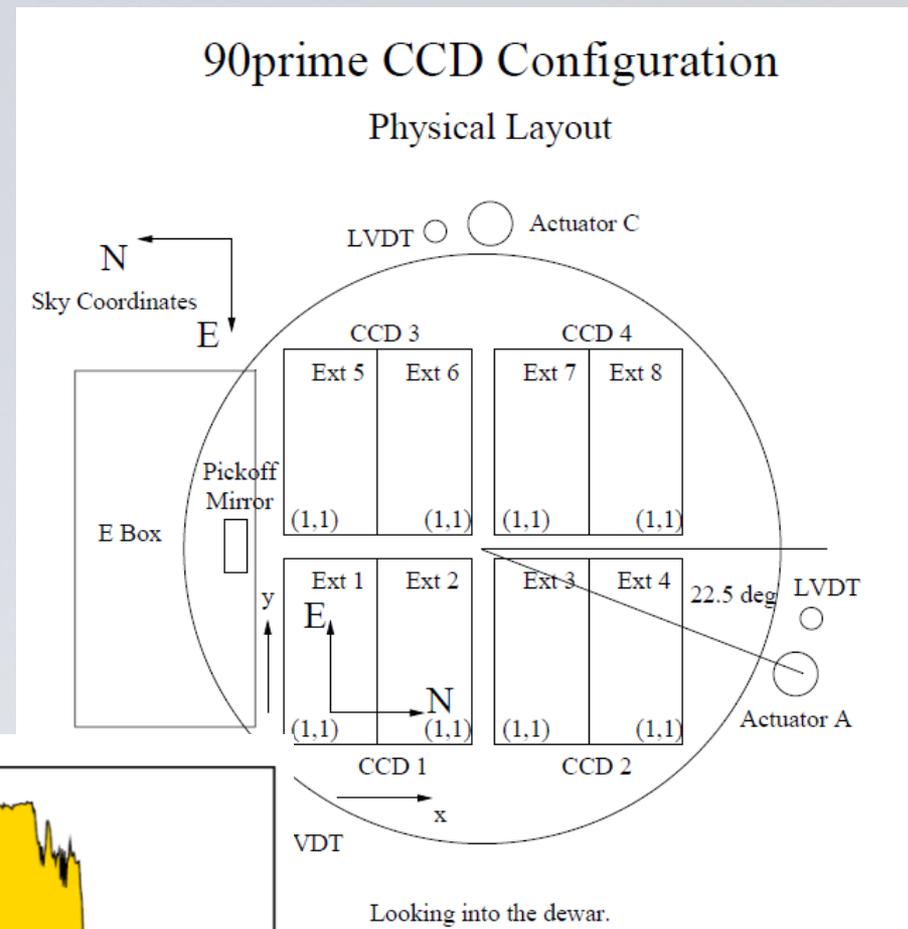
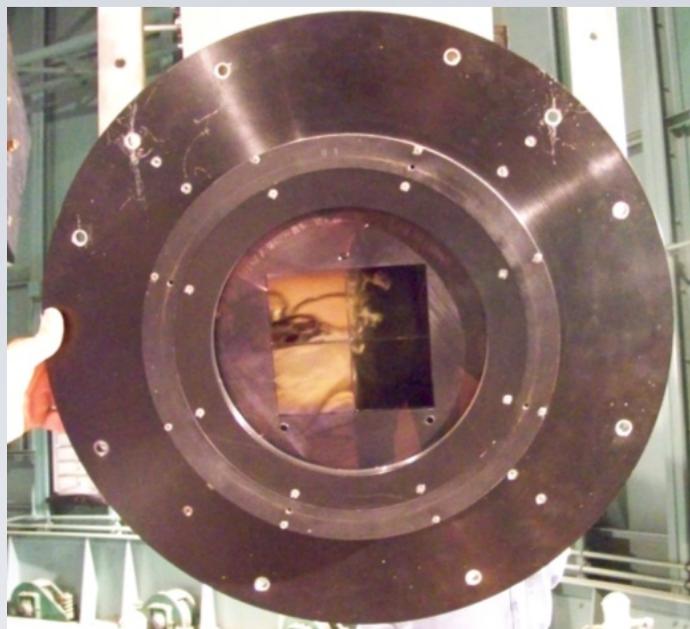
- Legacy data product with impact similar to that of SDSS imaging survey (1.5 mag deeper), raising the international profile of Chinese astronomy;
- Synergy with future wide-field survey projects in China, in particular the space station survey project and **Dome-A project**, in development of software, observing tools and training;
- China participate DESI project with \$100M contribution of BASS

Spectroscopy (SDSS)

DECam



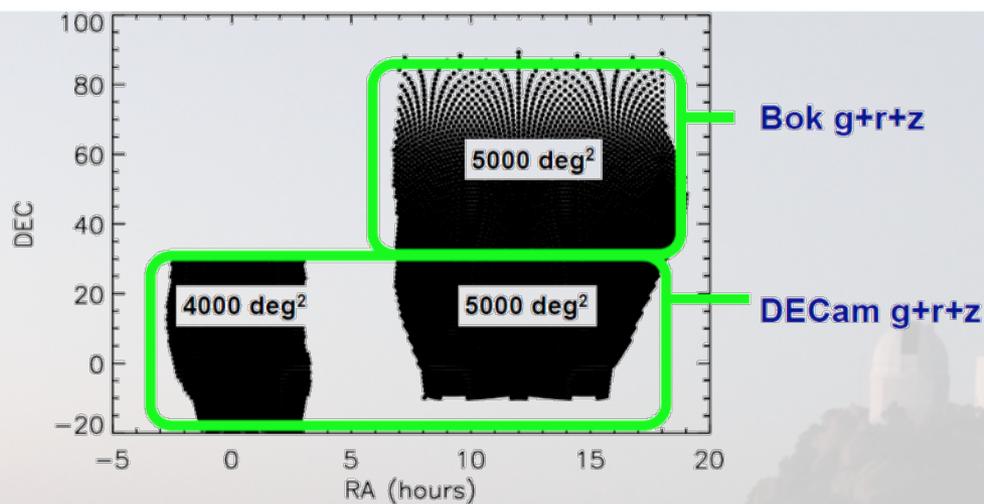
# The camera with blue sensitive 4 4Kx4K CCD chips



Efficiency of new z band

## Comparison to other surveys

Survey	Area (deg <sup>2</sup> )	Hemisphere	g	r	z
SDSS	11,000	North/Equ	23.0	22.8	20.5
Panstarrs	14,000	North/Equ	23.4	23.2	21.1
DES	5,000	South	25.1	24.3	23.4
KIDS/VST	1,500	Equ	25.4	25.2	--
SkyMapper	14,000	South/Equ	22.9	22.6	21.5
DECam	9,000	Equ	24.7	23.9	23.0
<b>BASS</b>	<b>5,000</b>	<b>North</b>	<b>24.4</b>	<b>24.0</b>	<b>23.4</b>



# BASS / Bok Legacy Survey

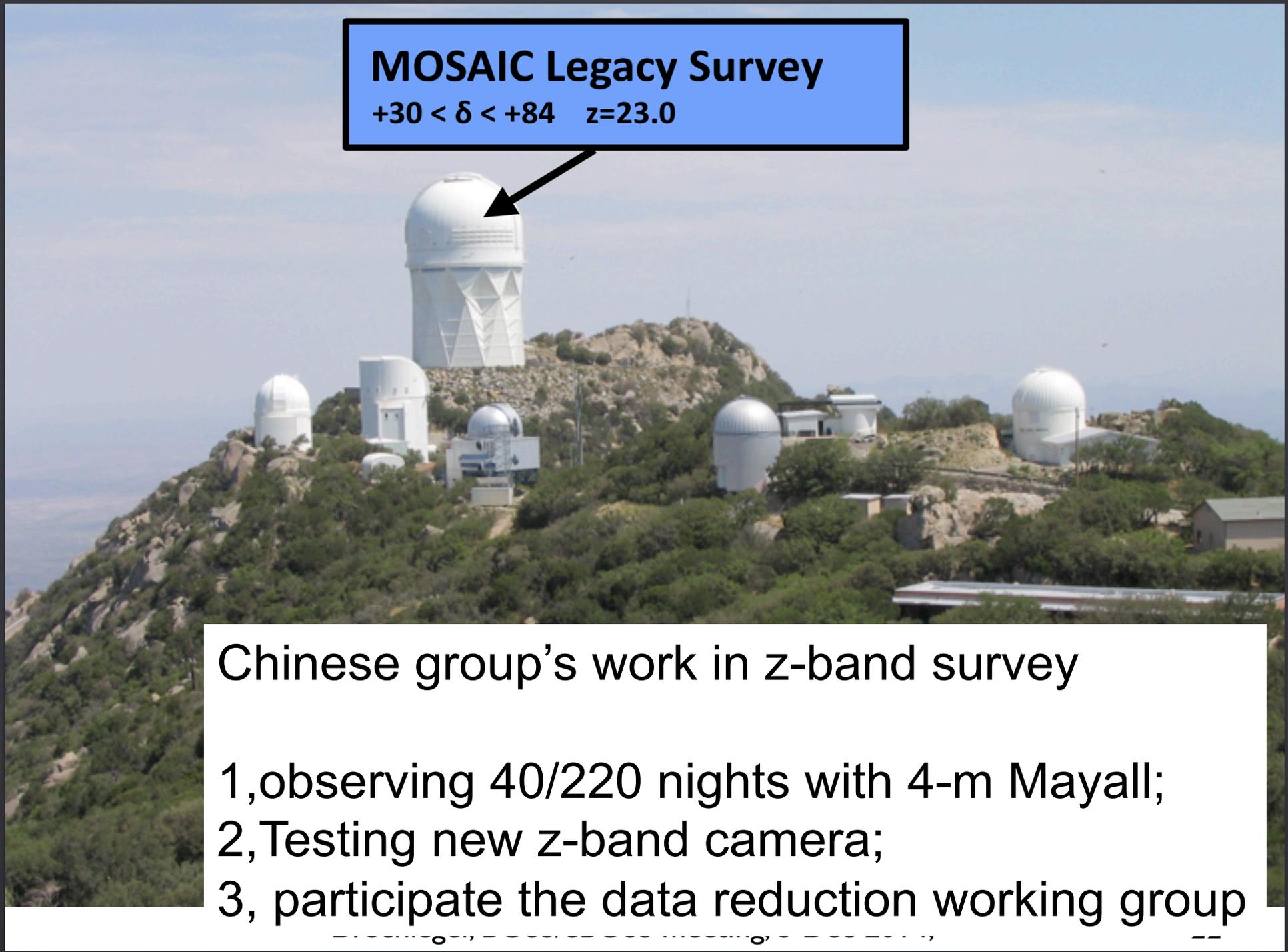
$+30 < \delta < +84$   $g=24.0, r=23.6$

Chinese group's work in g,r band survey

- 1, Observing 200 nights with 2.3-m BOK;
- 2, Developing new data reduction pipeline;
- 3, Co P.I. of the BASS project

# MOSAIC Legacy Survey

$+30 < \delta < +84$   $z=23.0$



Chinese group's work in z-band survey

- 1, observing 40/220 nights with 4-m Mayall;
- 2, Testing new z-band camera;
- 3, participate the data reduction working group

# No any Final MoUs are signed until now !

Because of long time discussion among different parts:

My group (BATC)

Chinese Pilot-B project

Chinese Community

Steward observatory / University of Arizona

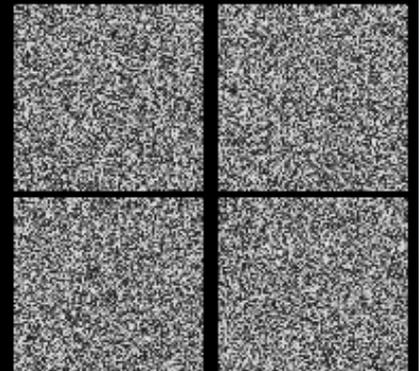
DESI project

NOAO

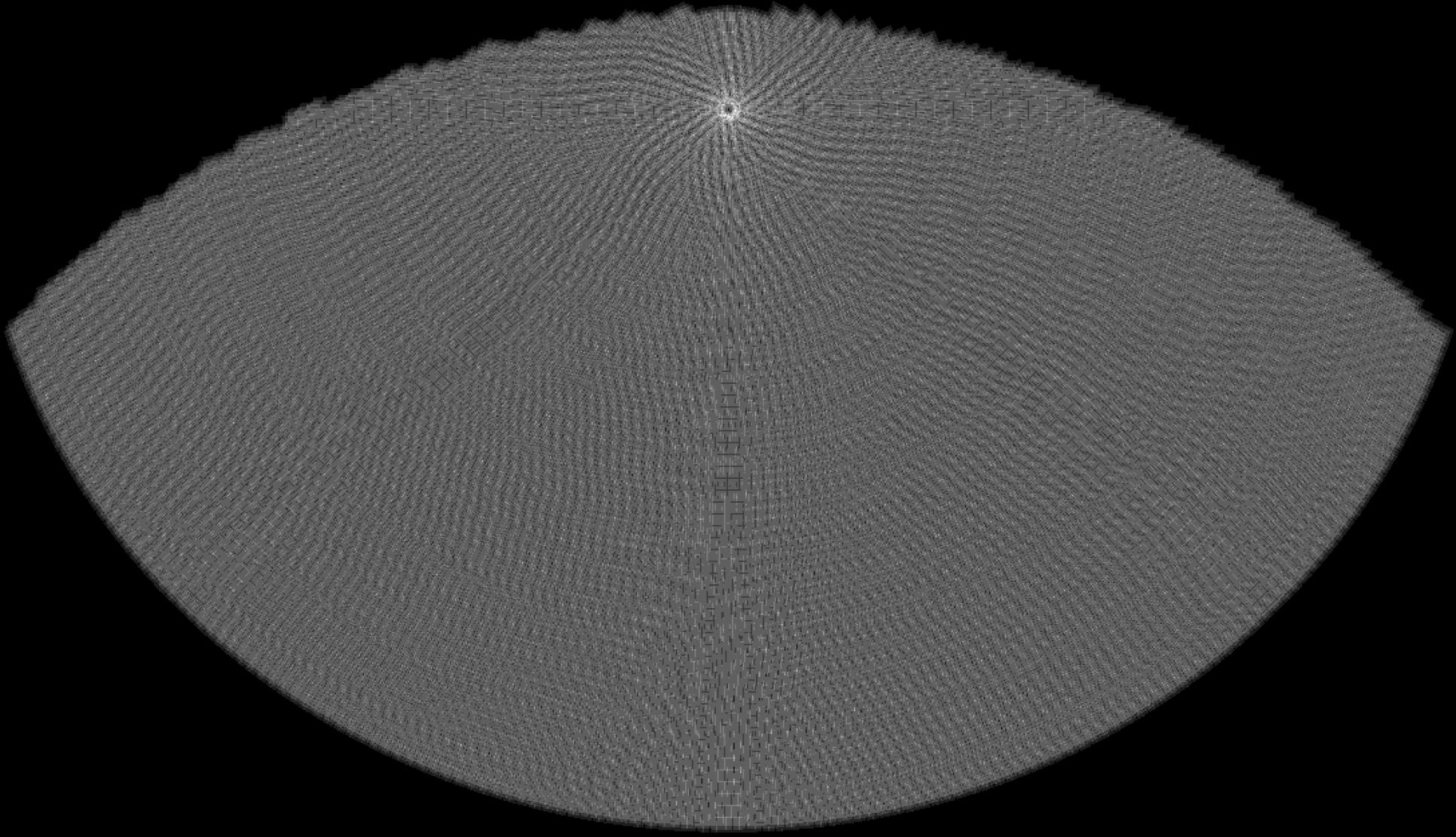
But Observation and data reduction already begin.



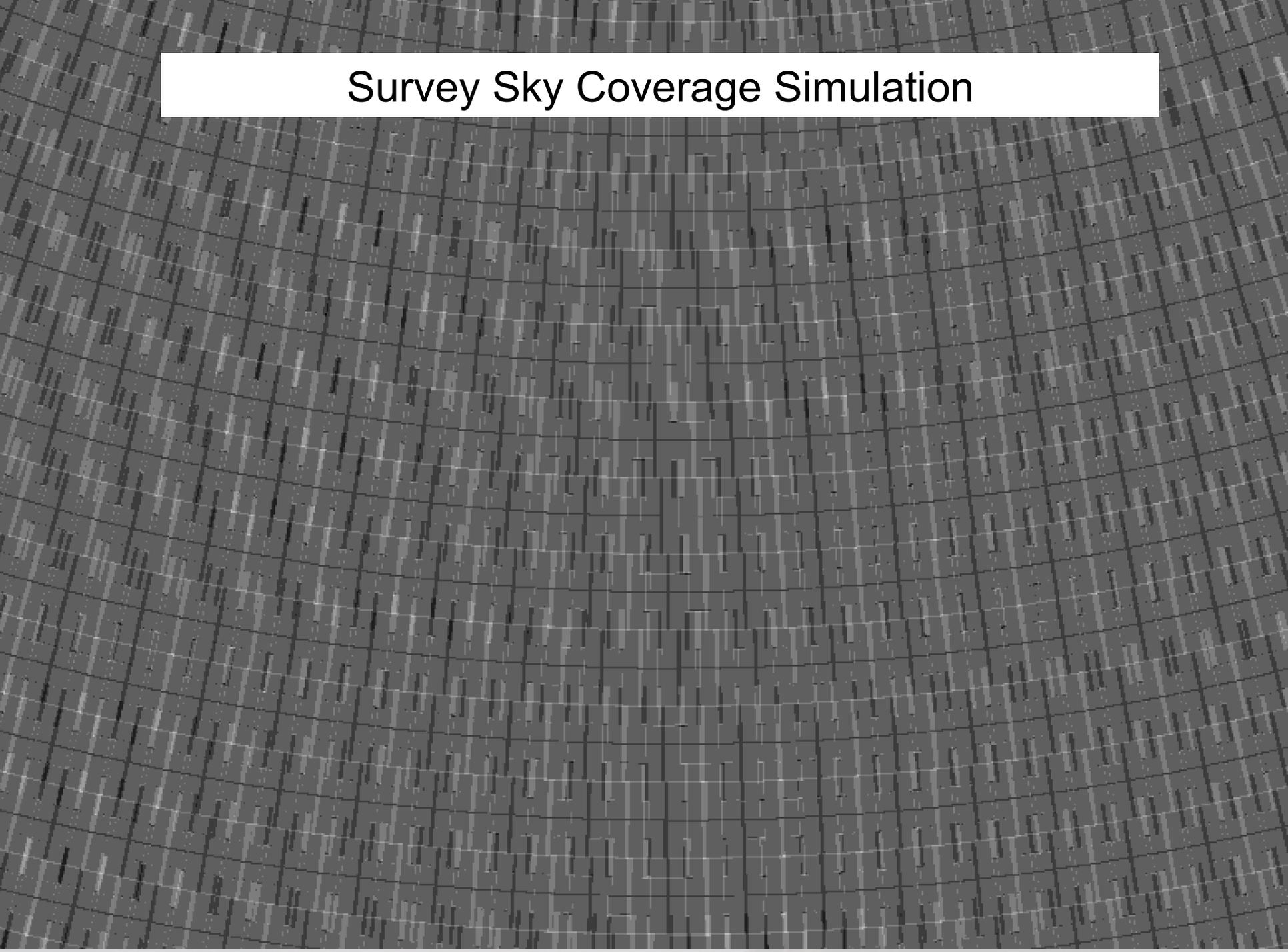
Sky Survey mode of the 3 exposure of each field



# Survey Sky Coverage Simulation

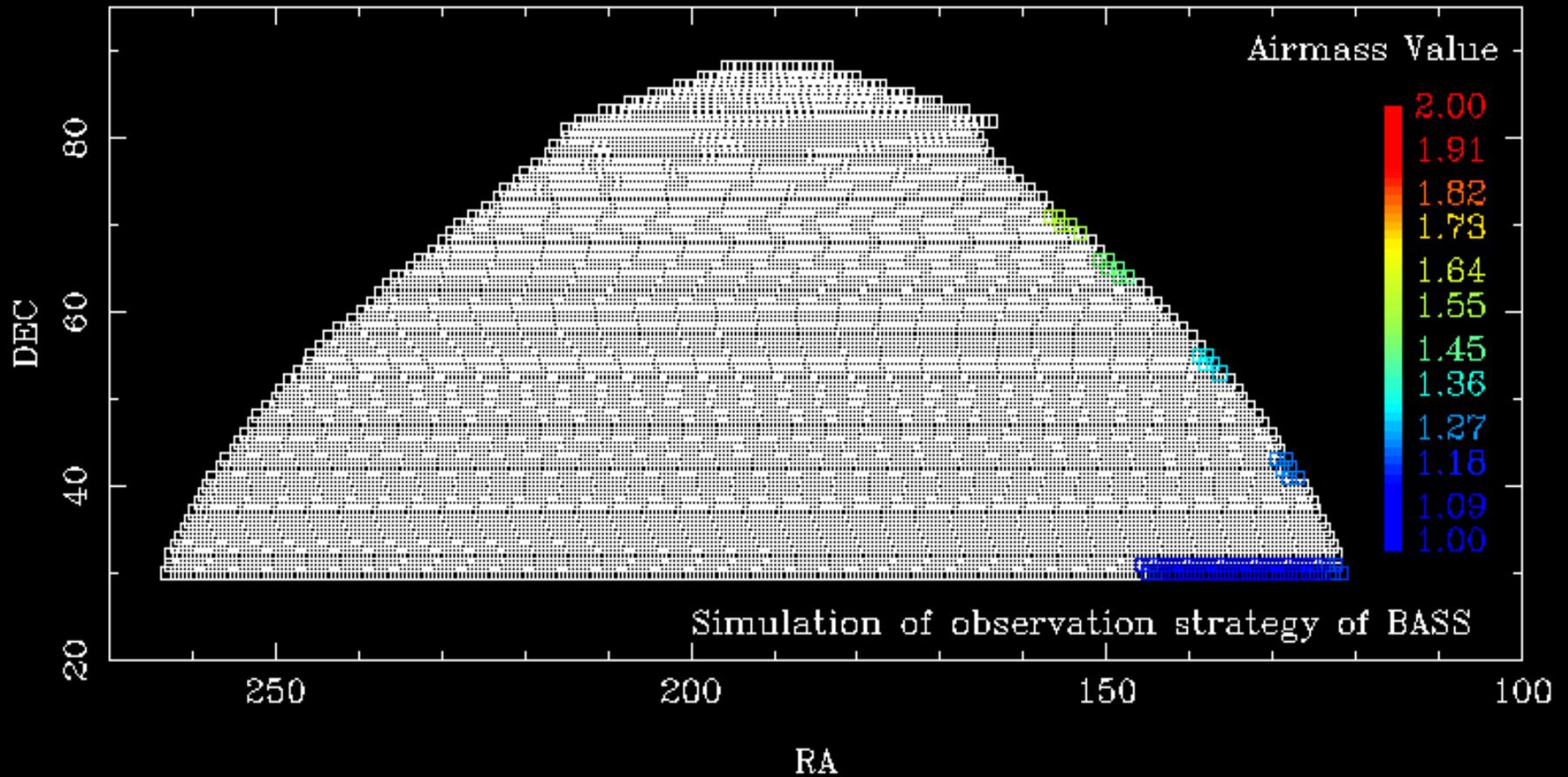


# Survey Sky Coverage Simulation

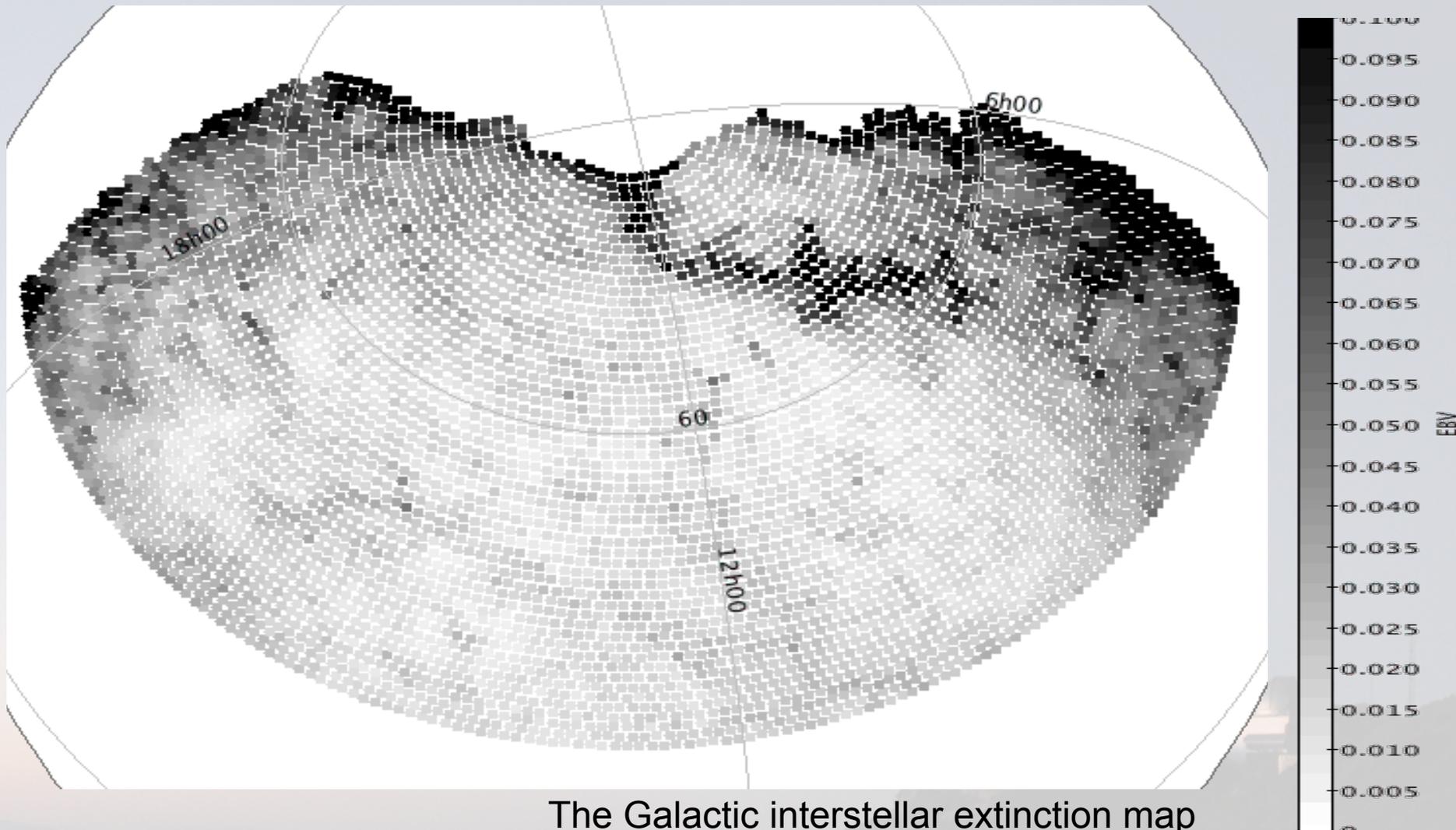
The background of the slide is a grayscale simulation of a survey sky coverage. It features a grid of small, light-colored rectangular markers arranged in a pattern that follows the curvature of a celestial sphere. The grid is composed of many small, light-colored rectangular markers arranged in a pattern that follows the curvature of a celestial sphere. The markers are arranged in a grid that is denser in the center and sparser towards the edges, suggesting a survey strategy that covers a large area of the sky. The overall appearance is that of a dense, regular sampling of the sky, with the grid lines curving to match the spherical geometry.

# Survey Sky Coverage Simulation

# Observation simulation of Air-Mass



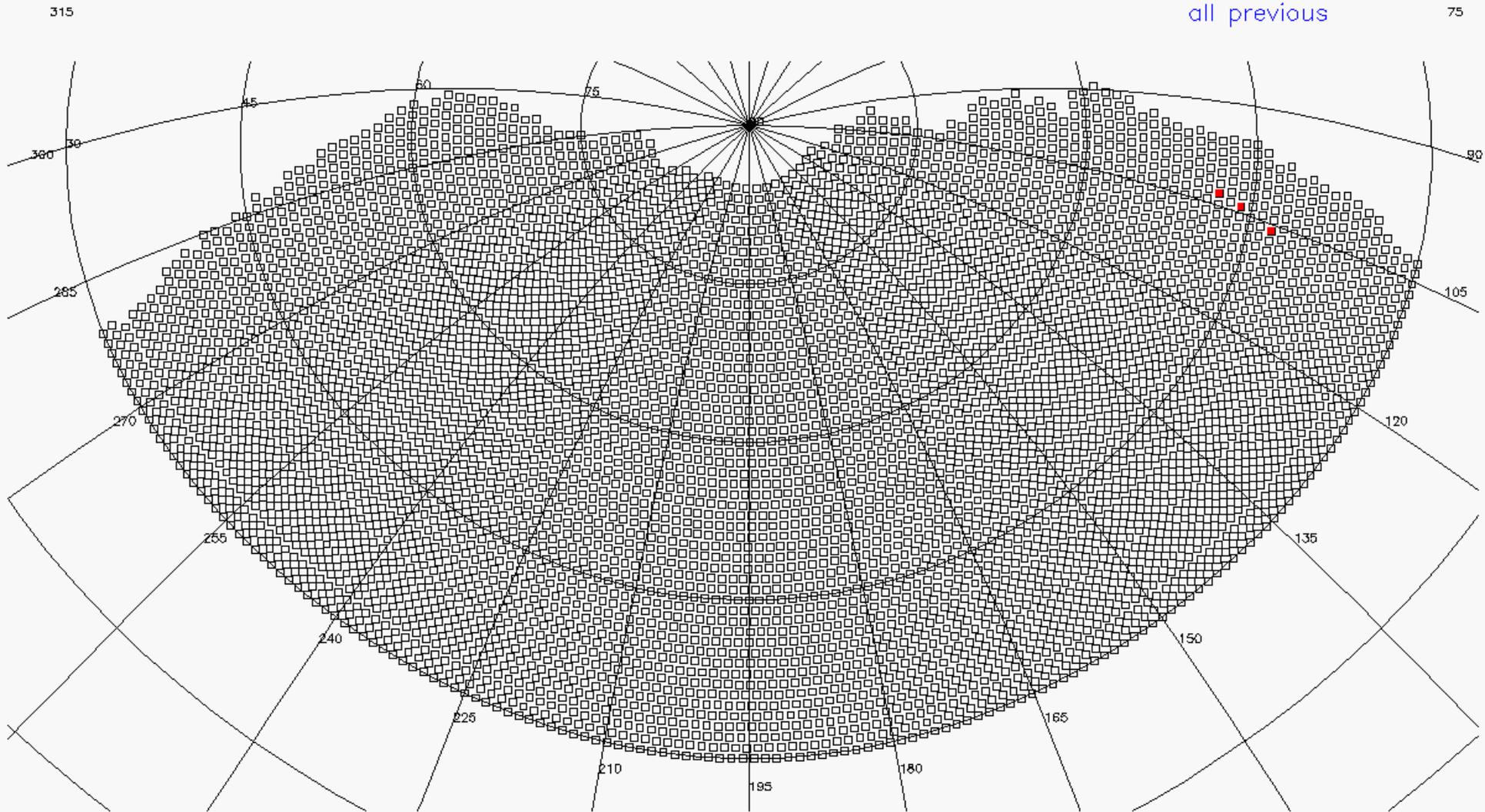
Exposure time depend on the galactic **interstellar extinction**, sky **background**, atmospheric **transparency** and **seeing** in real time



# The progress of observed fields

pass: 1, 2015-01-09 g, fields: 3, total: 3/5494 -> 0.1%

2015-01-09  
all previous



# The WIKI pages of the BASS project



## Beijing-Arizona Sky Survey (BASS)

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Large Visitor Globe

### Welcome to BASS



The [Beijing-Arizona Sky Survey \(BASS\)](#) is an ambitious wide-field multicolor survey of 5000 deg<sup>2</sup> of the Northern Galactic Cap using the 90prime imager on the 2.3m Bok Telescope at Kitt Peak, as a three to four-year collaboration between the Chinese team led by [NAOC](#) and the US team led by [Steward Observatory](#), University of Arizona. The survey will use 200 nights, covering SDSS g and r bands, reaching limiting AB magnitude of 24.4 and 24.0 (5 $\sigma$ ), respectively. The survey will follow the successful [SCUSS](#) model with strong participations and support from both China and US teams and produce high level science products for the general astronomical community. The survey data will allow effective target selection for the [DESI](#) dark energy spectroscopic survey project in the survey area.

[Survey Overview of the BASS survey](#)

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Future workgroup

# Remote Monitoring of the observation

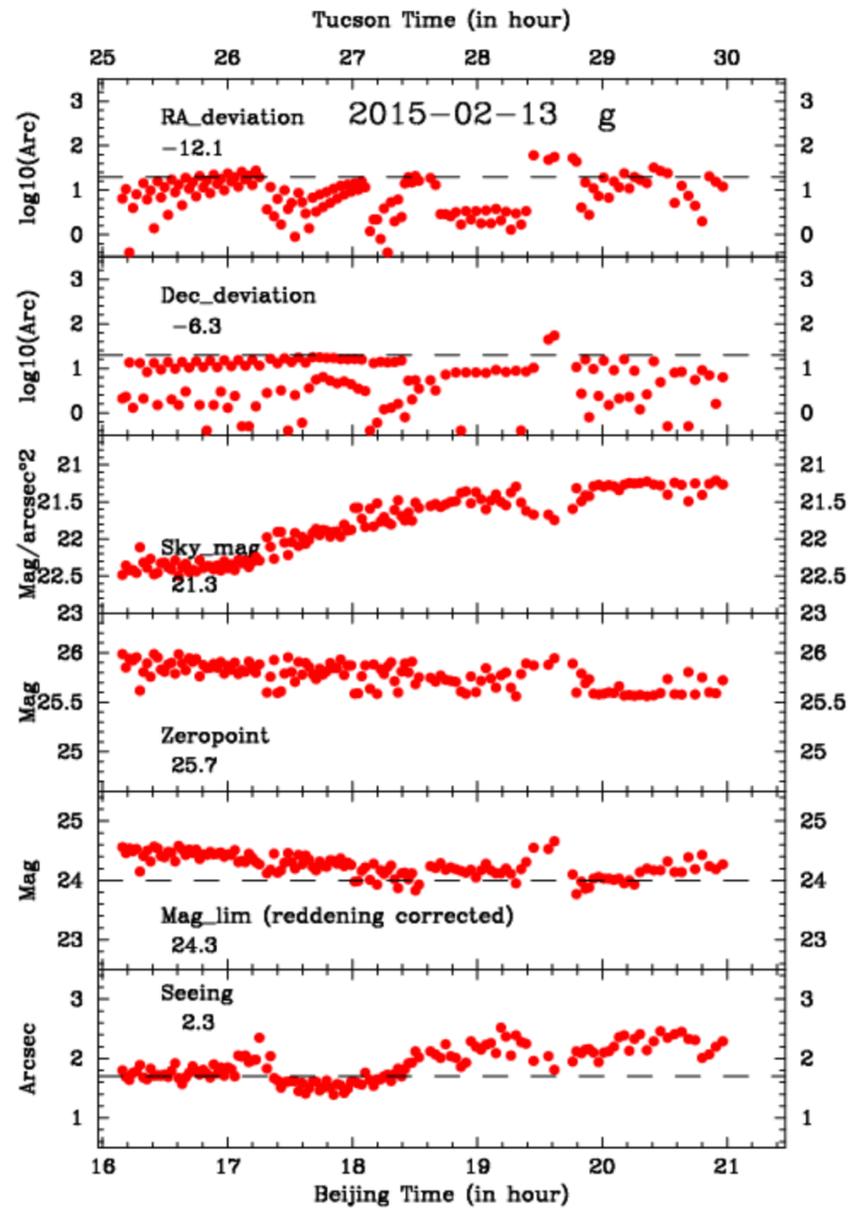
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Figure 1: Image quality of BASS observation



**BASS data and catalogues  
is open to public**

**All kind of collaboration  
are welcomed**