

# A new plate digitizer with air bearing platform

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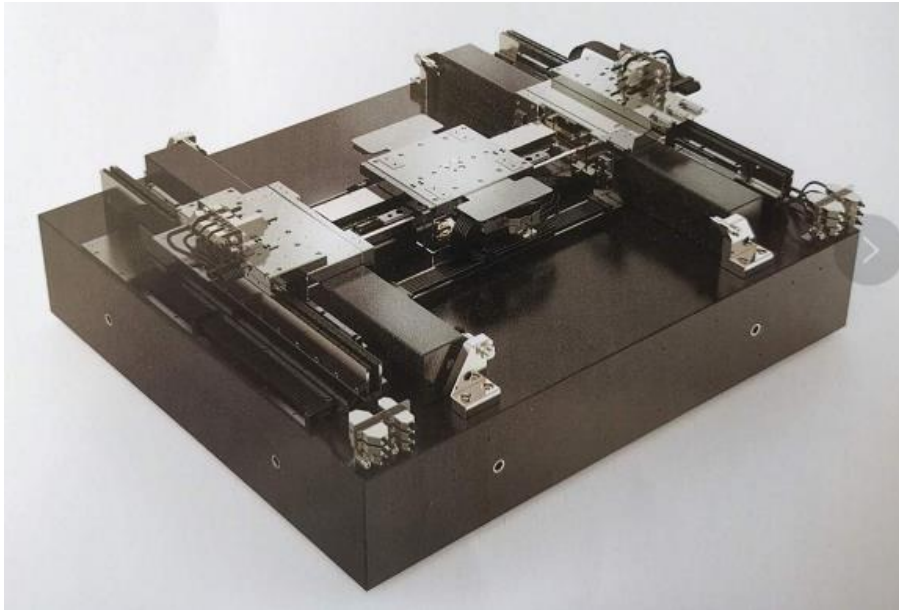
2021.9

# 1. Introduction

- Since 2000, IAU has set up a working group dedicated to the “Preservation and Digitization of Photographic Plates”, and has passed 2 Resolutions in 2000 and 2018 respectively to ask the observatories around the world to digitize astro-plates as soon as possible.
- During 2012~2015, a fast and precise plate digitizer was developed by SHAO and Nishimura Co. Ltd of Japan. During 2016~2017, the machine was used to digitize all Chinese plates (~30000).
- Based on the existing work, "Shanghai Photographic Plate Digitization Laboratory" was established in 2019, which plans to help the precise digitization of the astronomical plates around the world and establish the database shared by global astronomers.

The development of the new plate digitizer with air bearing platform is proposed!

## Key part: Air bearing platform – XVI VAG-1



Travel	Scan Axis	350 mm
	Step Axis	350 mm
Drive System		Linear Brushless Motor
Resolution		0.25 nm
Accuracy		$\pm 300$ nm
Repeatability ( choose linear driver )		$\pm 50$ nm
XYZ Position Stability ( Air On )		20 nm
Granite Bass Thickness		250 mm
Rated Payload(Maintaining Dynamic Specifications)		5 kg
Maximum Payload		30 kg
Maximum Velocity with Rated Payload	Scan & Step Axis	1000 mm/s
Peak Acceleration with Rated Payload	Scan & Step Axis	2 G (20 m/s <sup>2</sup> )
RMS Acceleration with Rated Load	Scan & Step Axis	1 G (10 m/s <sup>2</sup> )
Stiffness,First Natural Frequency with Rated Payload		>100 Hz
Pitch		2 arc sec
Roll		2 arc sec
Yaw		2 arc sec
XY straightness		0.5 $\mu$ m
XY Flatness		0.5 $\mu$ m
XY Orthogonality		<2 arc sec
Velocity ripple( sampled at 400mm/s)		0.1 %
MTBF		40,000 hours
Step and settle xx mm within $\pm$ xx nm		25mm step and settling into $\pm$ 100nm in 250ms

A sCMOS camera, doublesided telecentric lens and LED etc. are integrated and mounted on this air bearing platform to form a new plate digitizer.

## Main design indices of the new digitizer

No	parameter	Former digitizer	New digitizer
1	Scanning mode	line scanning	area scanning
2	Optical resolution	2540 DPI	>2000 DPI
3	Repeatability in position	0.5 $\mu\text{m}$	0.2 $\mu\text{m}$
4	Repeatability in brightness	0.02 mag	0.01mag
5	Accuracy in position	<1 $\mu\text{m}$	<0.5 $\mu\text{m}$
6	Optical dynamic range	3 OD	4 OD
7	Scanning area	300mm $\times$ 300mm	350mm $\times$ 350mm
8	Scanning time	<10 Min./plate	<5 Min./plate
9	Scanning function	monochrome, transmission	monochrome, transmission
10	Image format	16-bit fits	16-bit fits

## 2. Guarantee of basic conditions for the new digitizer

### (1) Reconstruction and decoration of the laboratory



Laboratory before decoration (2019)



Laboratory after decoration



(2) Plate storage warehouse with constant temperature and humidity



### (3) The Foundation pier for digitizer



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## 测试报告

TEST REPORT

报告编号: \*\*\*\*\*

Report No.

委托单位: 中科院上海天文台佘山站

Customer

委托单位地: 上海市松江区佘山国家森林公园内

Address of Customer

委托编号: \*\*\*\*\*

Order Number

工程名称: 上海天文台佘山站高精度扫描测量设备基础振动测试

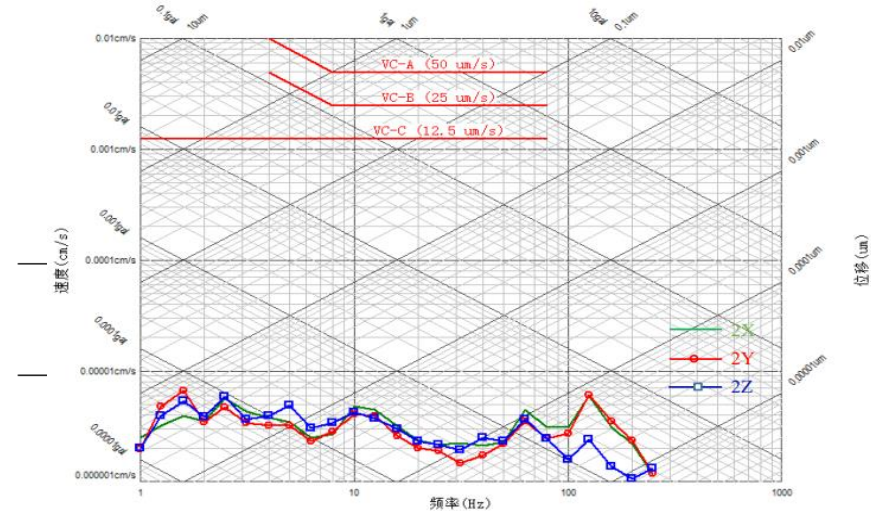
Project name

委托日期: 2020年7月15日

Date of Order

检测日期: 2020年7月21日

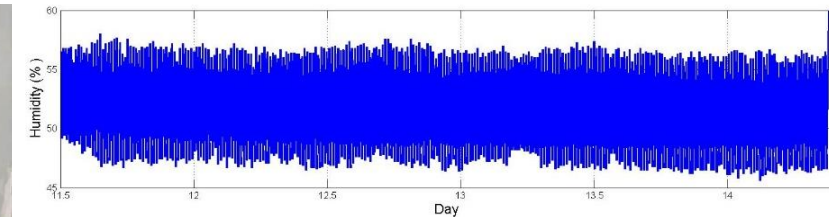
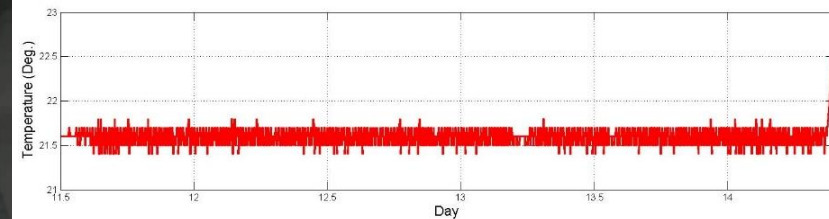
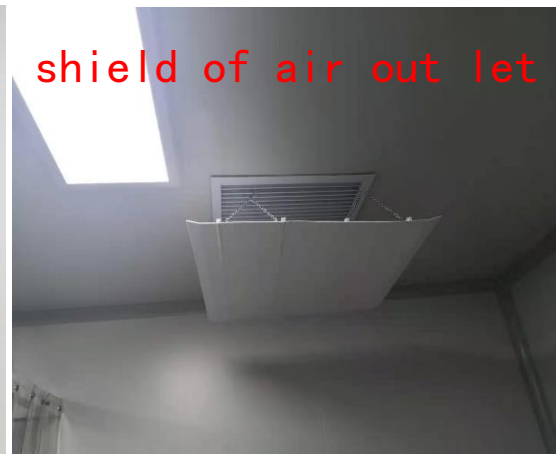
Date of Test



The anti-vibration on the foundation pier can meet the “vc-b” requirements of air bearing platform.



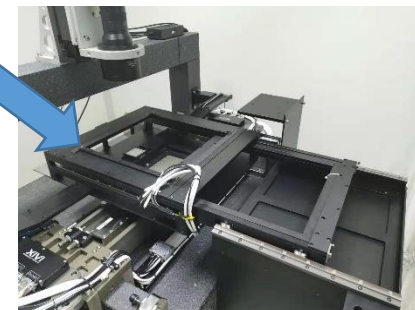
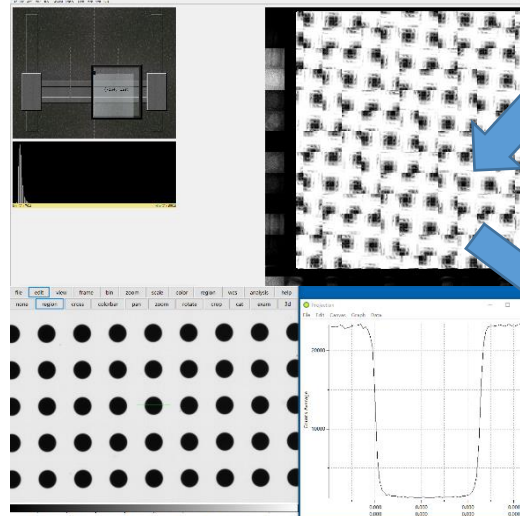
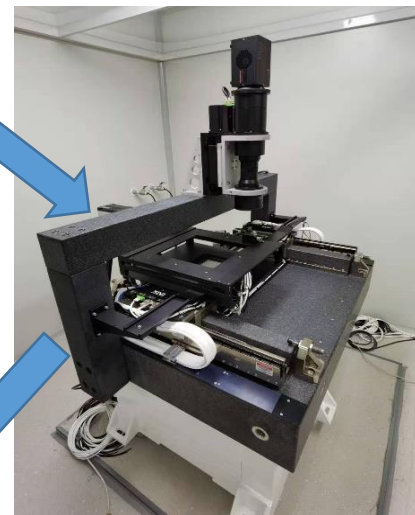
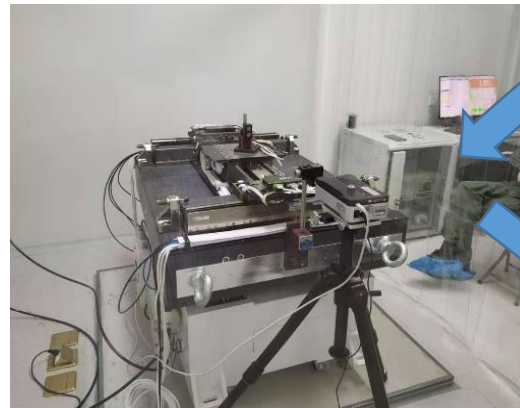
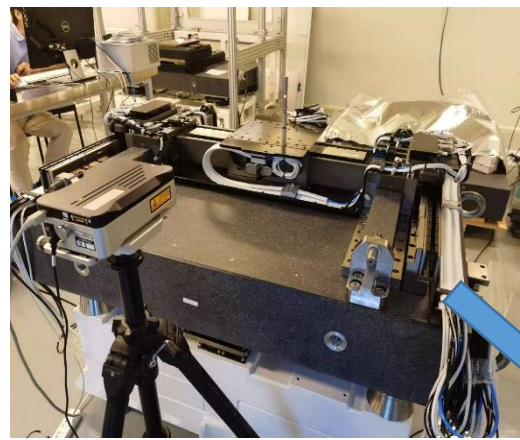
## (4) Temperature and humidity environment



The stability of temperature is better than  $\pm 0.5^{\circ}$  and humidity is than  $\pm 5\%$ .

### 3. Main time node of digitizer development

- Before 2020/7/1: reconstruction and decoration of laboratory
- 2020/7/13~15: test of air bearing platform in factory
- 2020/8/6: the platform arrived at Sheshan
- 2020/8/10~9/7: test of air bearing platform in laboratory
- 2020/9/17~9/25: Integration and adjustment of LED light, lens and plate carrier.
- 2020/10/9~12/31: performance test and optimization



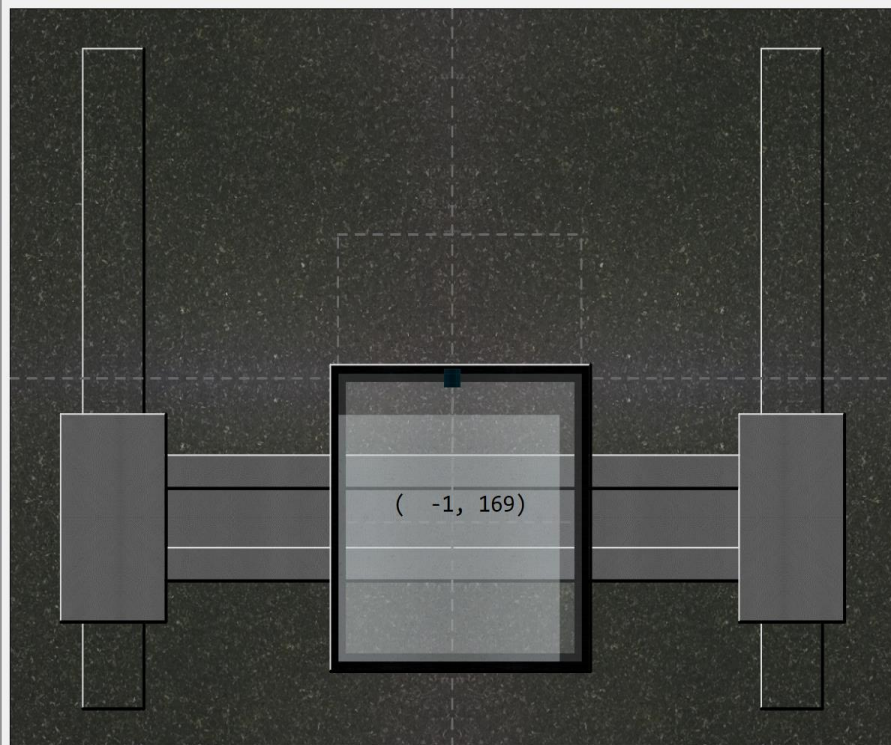




## Video of operating digitizer





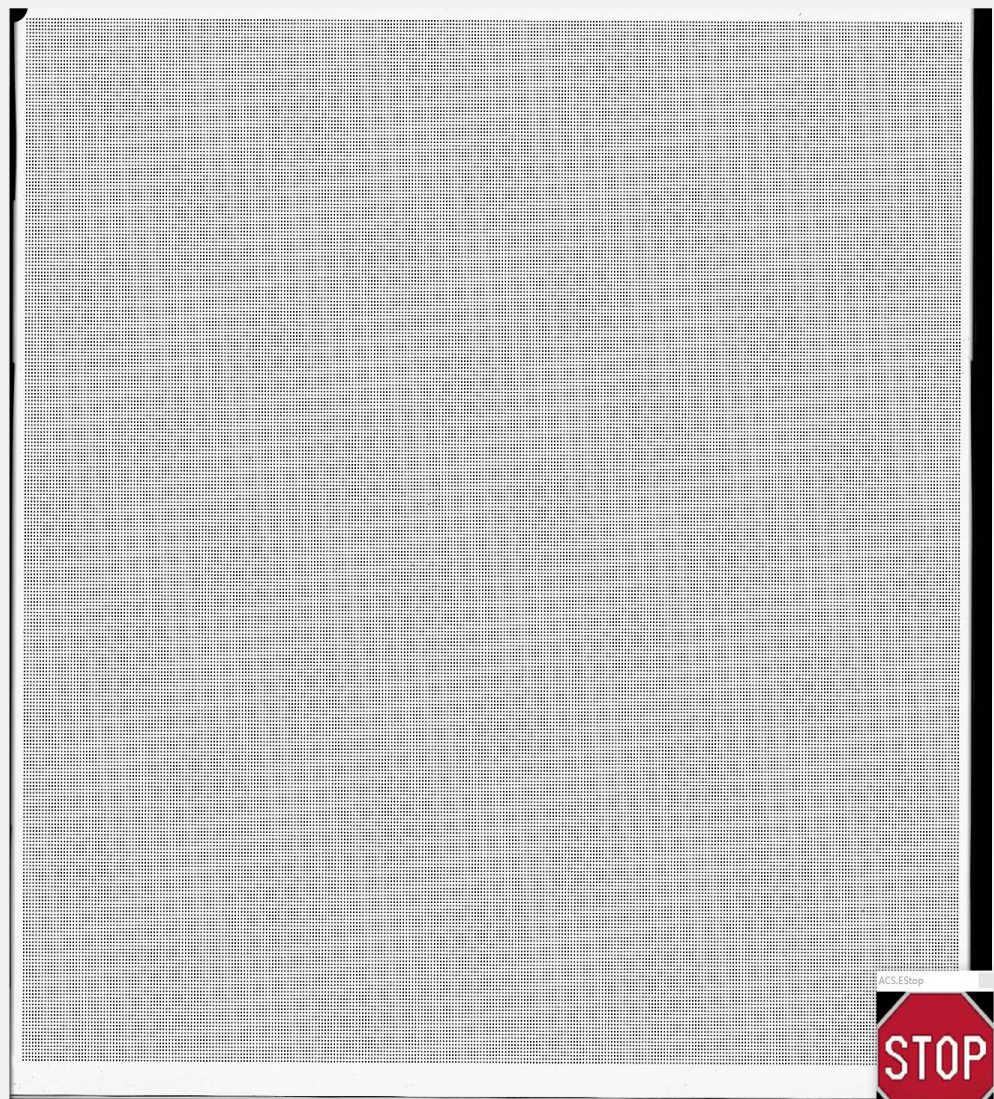


进仓异常 出仓异常 顶升异常 下降异常 进仓到位 允许进仓 允许出仓 仓盒到位



Min Val: 492.0

Max Val: 55132.0



Total: 115.0s, Step: 442.4ms, Camera: 141.2ms

Step = 80, x = 6816, y = 10904

Ready

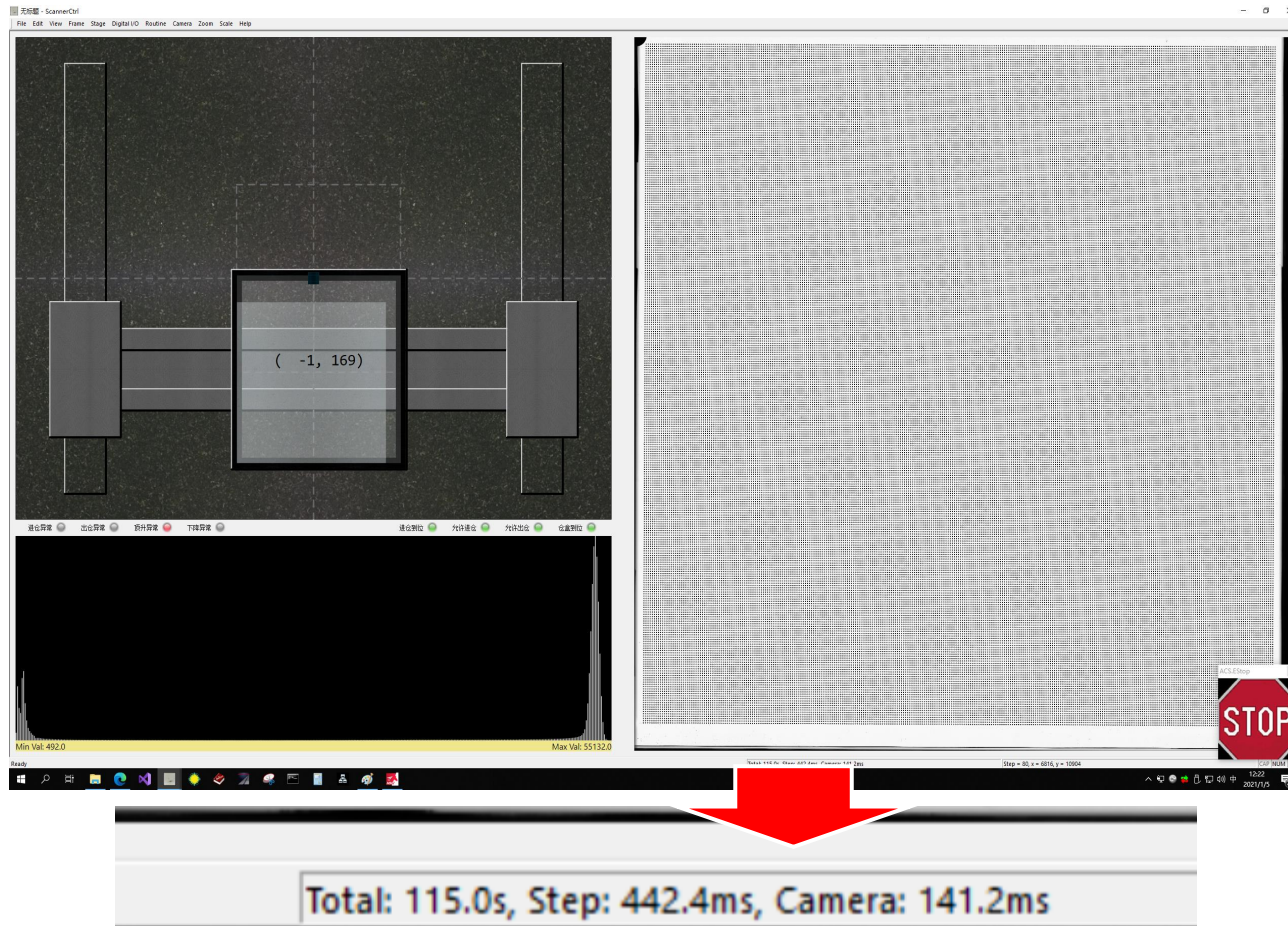
## 4. Basic performance of the new digitizer

- scanning area and time
- Scanning repeatability (position and brightness)
- Scanning optical dynamic range

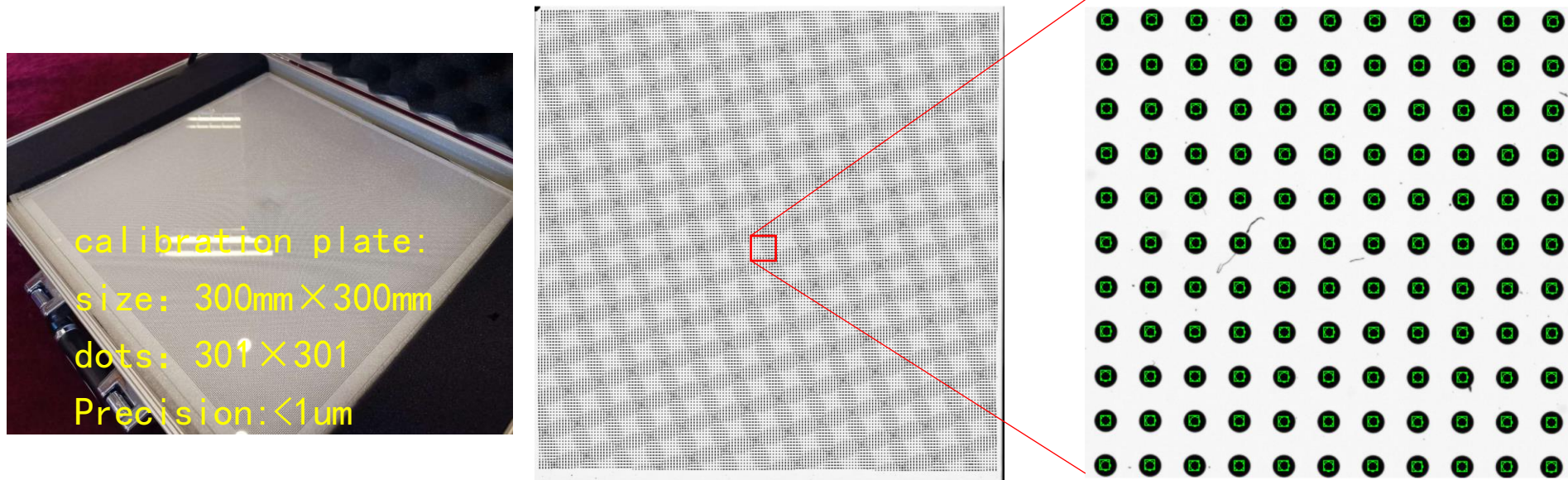


# (1) Basic performance - scanning area and time

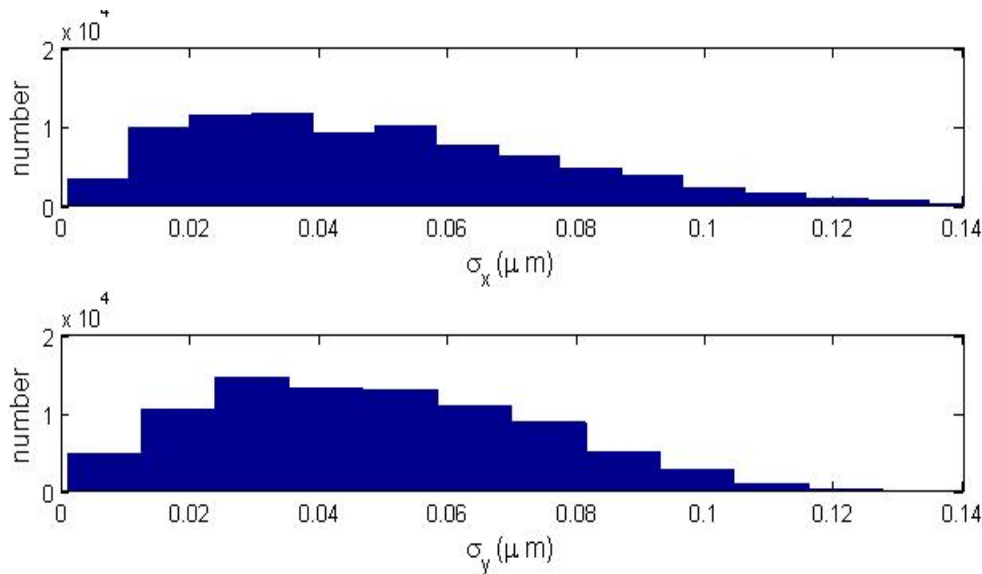
- Scanning mode: area + image mosaic;
- Size of one single block: 22mm×22mm (depends on sCMOS) ;
- For 300mm×300mm, 14\*14 blocks are taken and stitched into a whole image.
- It takes ~115s to complete the digitization of 300mm\*300mm region.



## (2) Basic performance - position repeatability



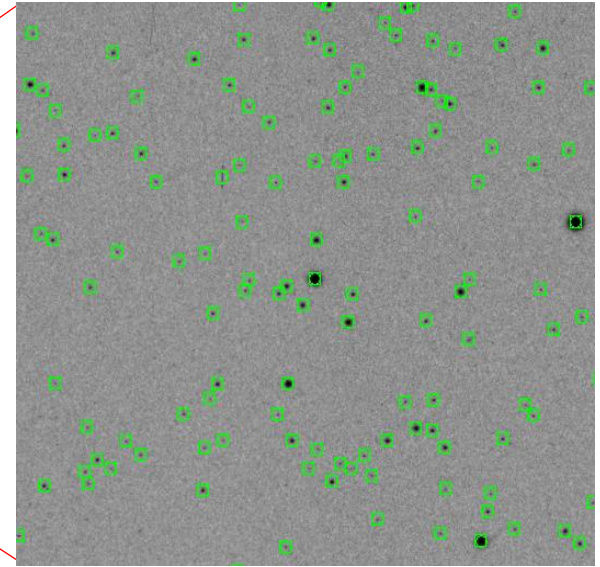
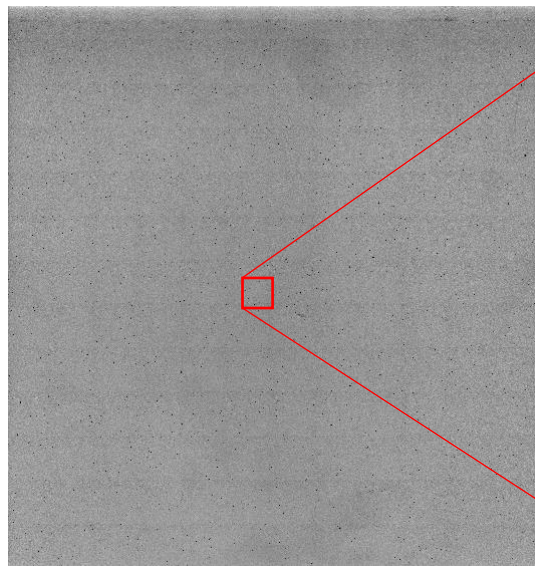
Digitize the calibration plate repeatedly and check the positions consistency of all dots, which reflects the internal accuracy of the equipment.



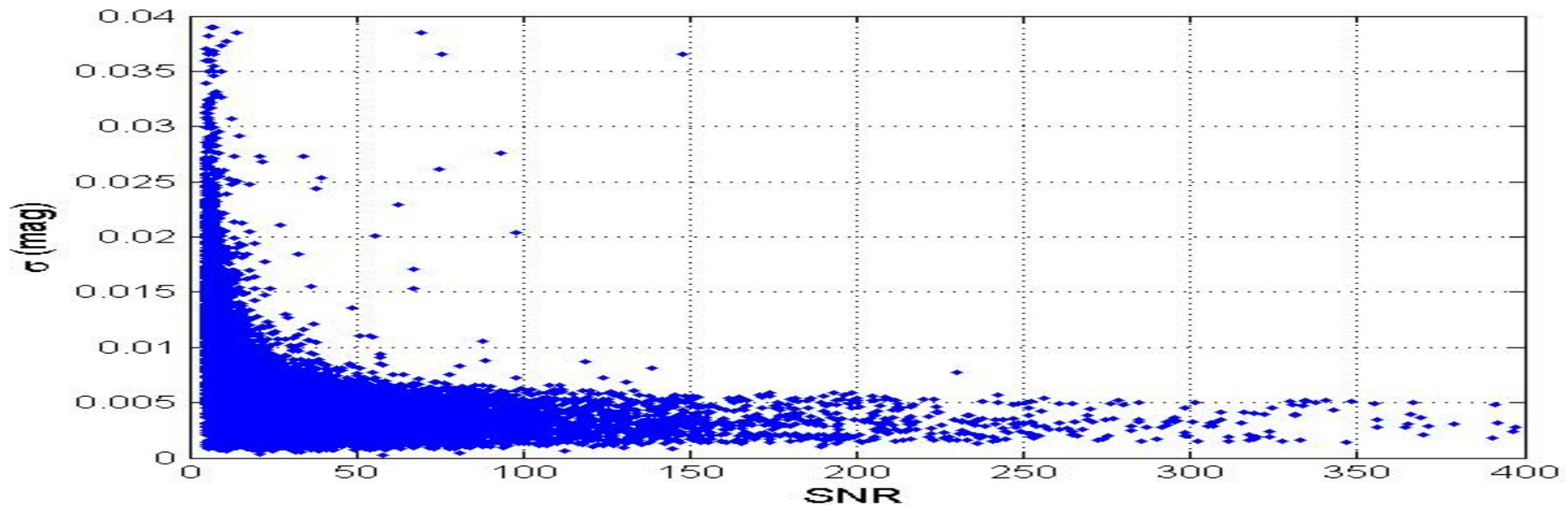
- ✓ The repeatability of positions is better than 0.1  $\mu\text{m}$  in X and Y;
- ✓ High repeatability can provide the conditions for the correction of systematic errors.



### (3) Basic performance - brightness repeatability



Digitize the astro-plate repeatedly and check the consistency of star brightness

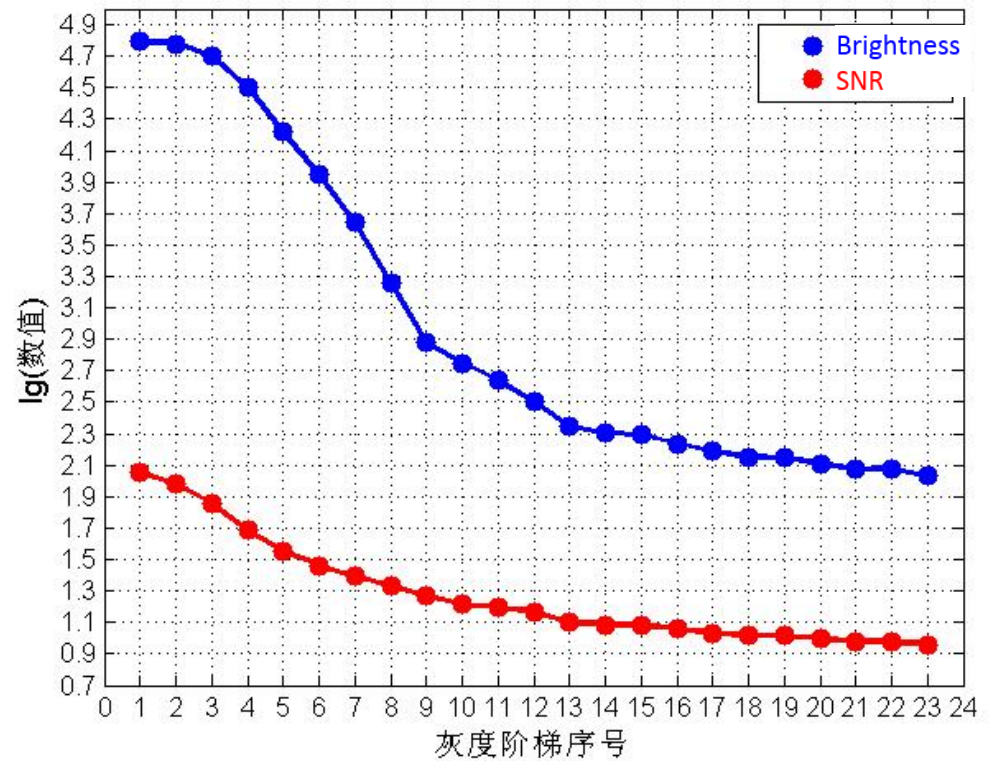
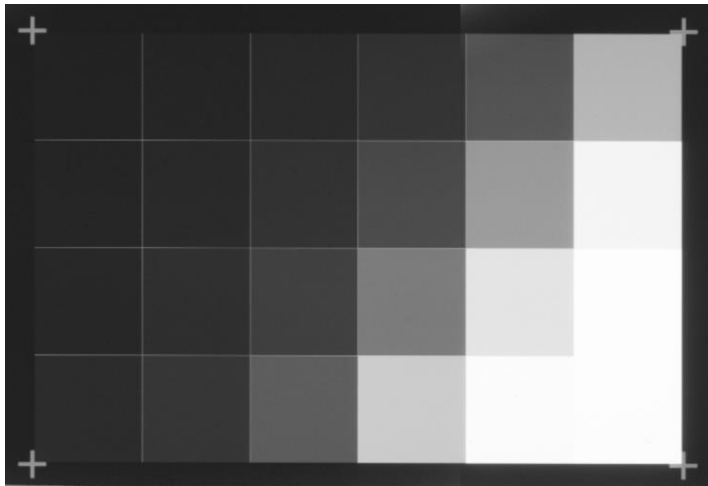


The repeatability of brightness is about 0.005 instrumental mag

## (4) Basic performance - optical dynamic range

Scan Edmund ISO-21550 Film (0.107 OD~4.028 OD) to check dynamic range

24	22	19	15	11	7
23	20	16	12	8	4
21	17	13	9	5	2
18	14	10	6	3	1



All the SNRs are higher than 8→  
the dynamic range is over 3.9 OD.

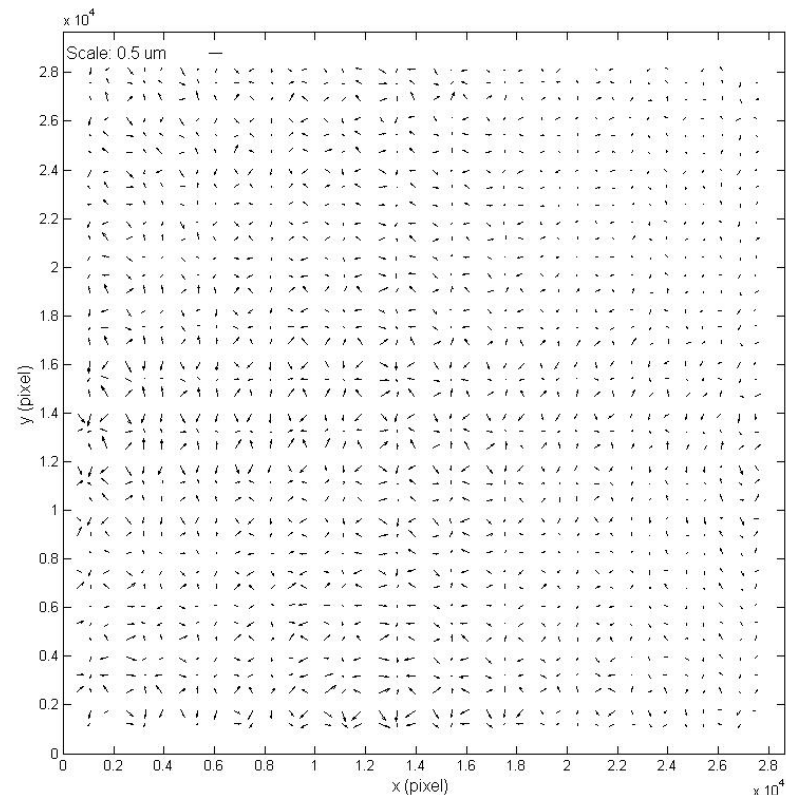
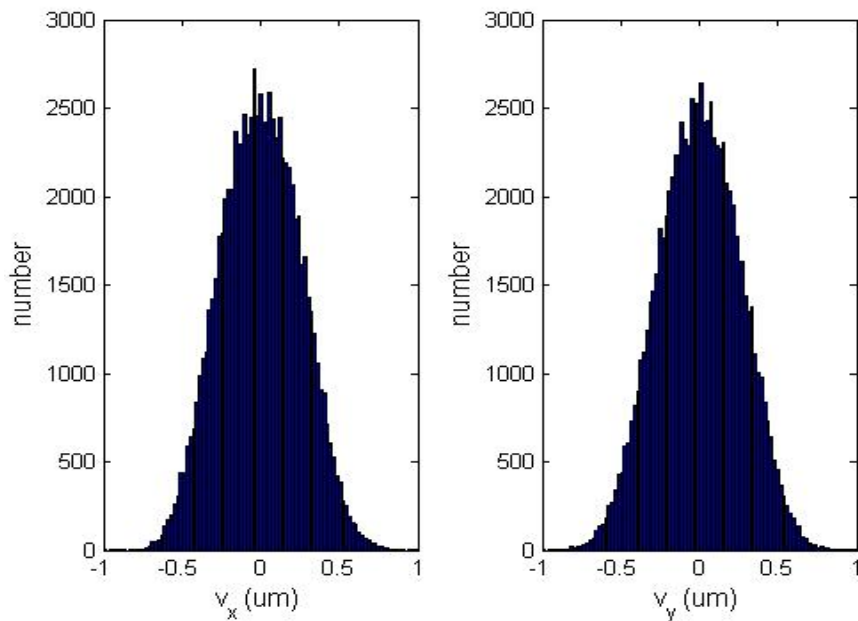
**5. On the basis of precise hardware design and processing, there would be some systematic errors:**

- Lens pointing deviation
- Lens optical distortion
- Imaging scale
- Non-orthogonality between platform motion direction and camera
- Splicing error

- We use the calibration plate to detect these systematic errors, compensate or eliminate them, and improve accuracy further .

- Overall accuracy

After correct systematic errors, scan the calibration plate and check the difference between scanning positions and theoretical positions of the standard dots.



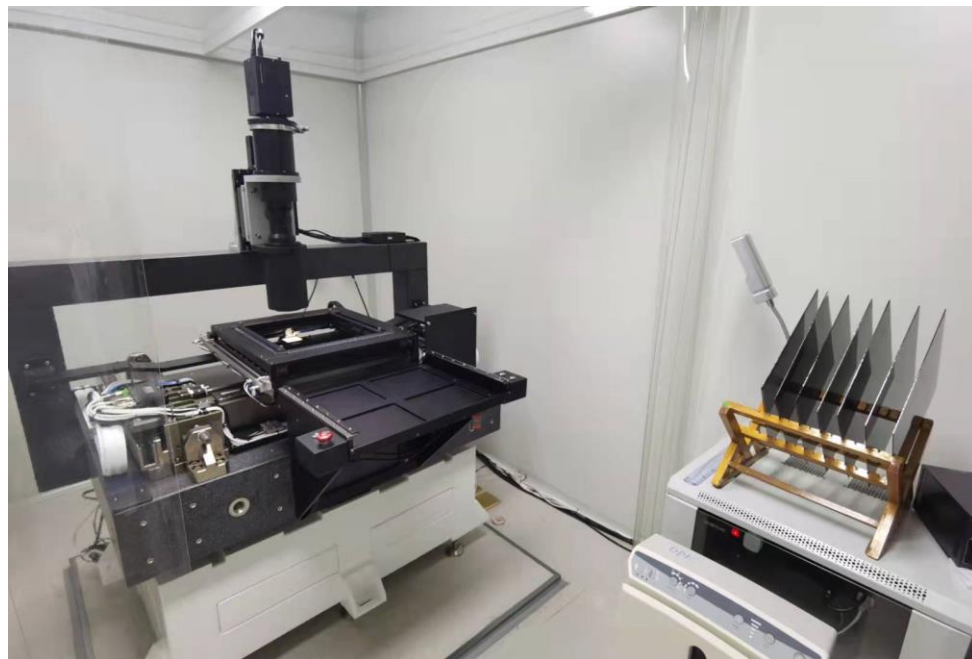
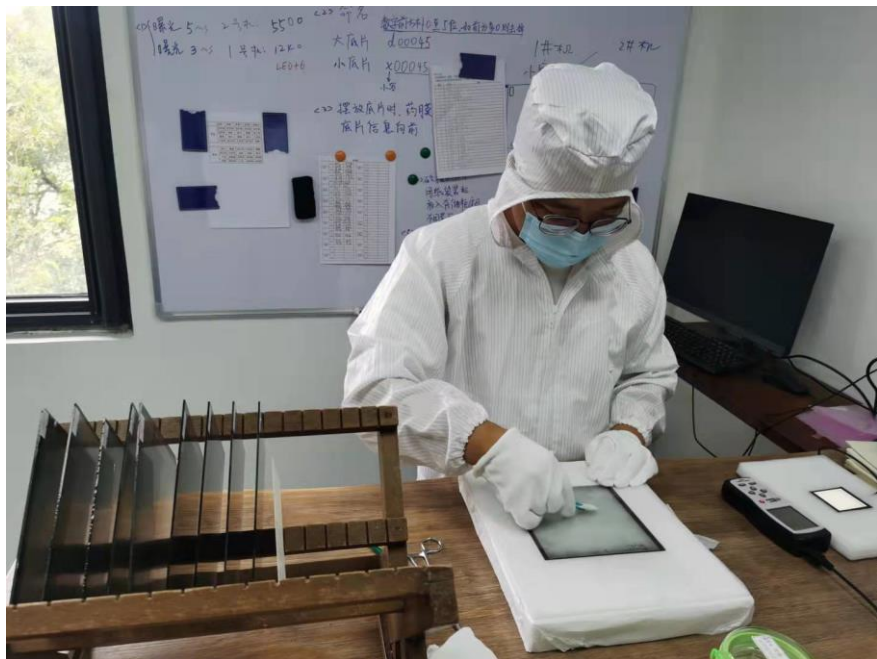
Standard deviation of the residuals is about 0.3 um



## 6. Current Work

In the last two months, ~10000 plates of Ulugh Beg Astronomical Institute and Torino Astronomical Observatory were transported to Shanghai and are being digitized.





*Thanks for attention !*

*Looking forward to close cooperation in astro-plate digitization.*