An Overview of the Survey Space Telescope of China Manned Space Program (CSST)

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ISSI-BJ CSST-Euclid Strong Lensing Discussion
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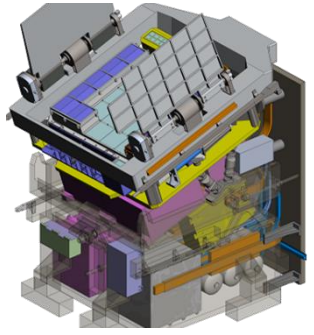
Introduction

A 2m space telescope in the same orbit as the China Manned Space Station, serviceable while docking with the station.

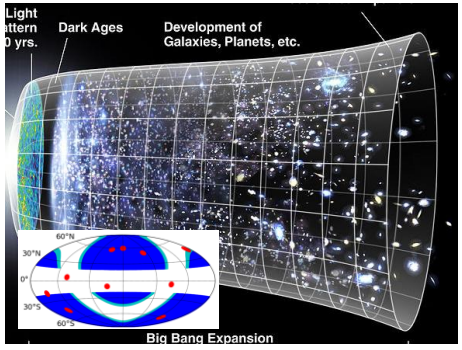
Instruments: Survey Camera (SC), Terahertz Receiver (THz), Multichannel Imager (MCI), Integral Field Spectrograph (IFS), Cool-Planet Imaging Coronagraph (CPIC).

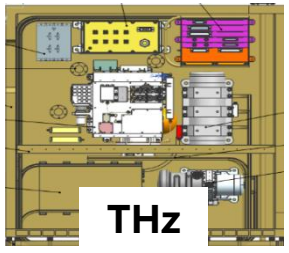
Mission: wide-area multiband imaging & slitless spectroscopic survey (7yr); other key programs & GO programs (2+yr).

CSST (~2024)

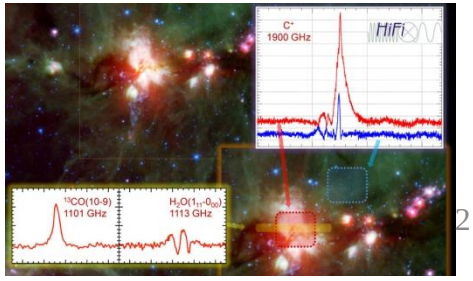


Survey Cam





THz



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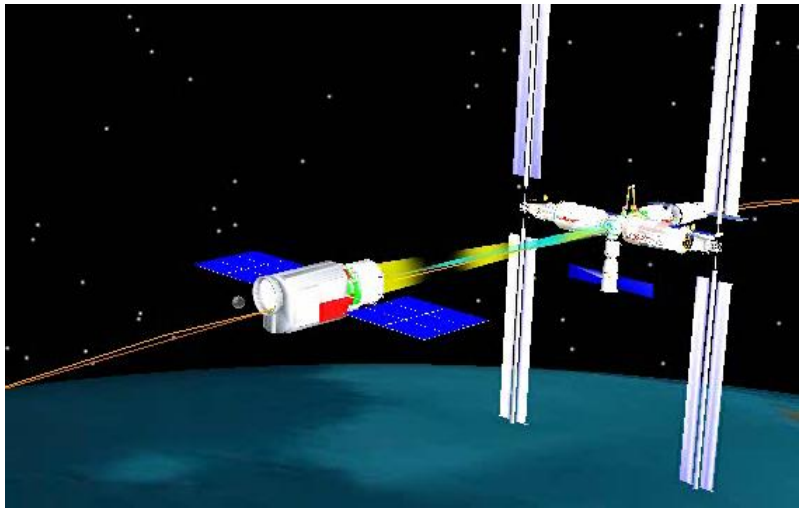
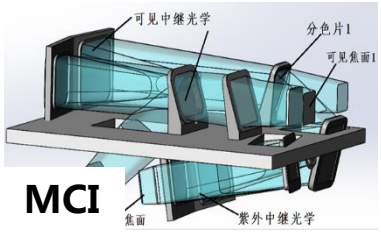
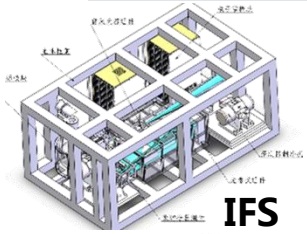


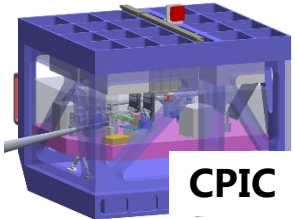
CSST & Space Station



MCI



IFS



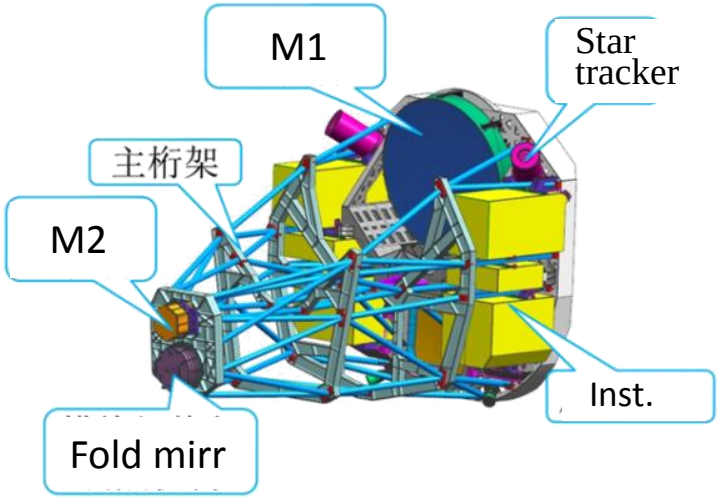
CPIC

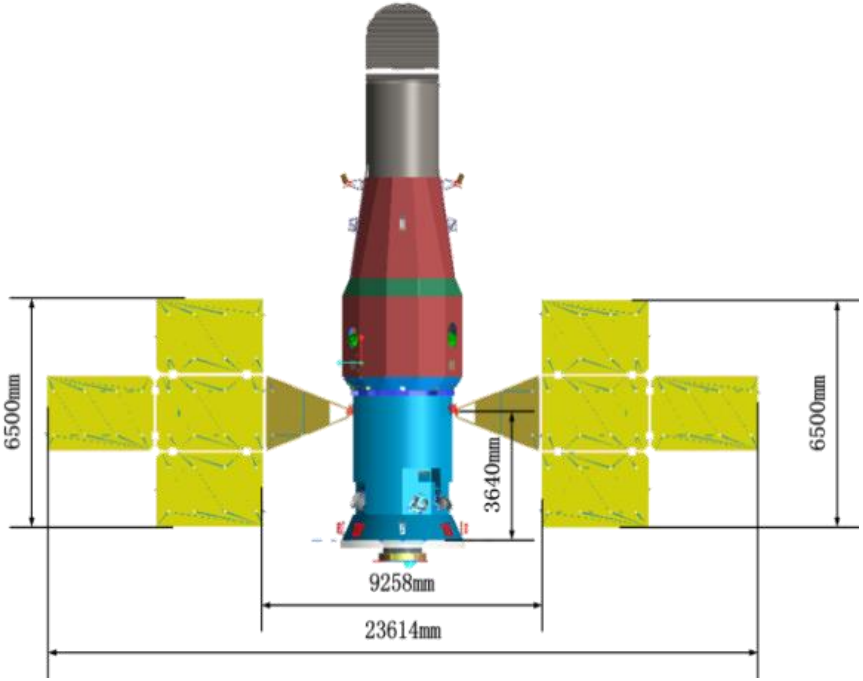
Telescope Specs

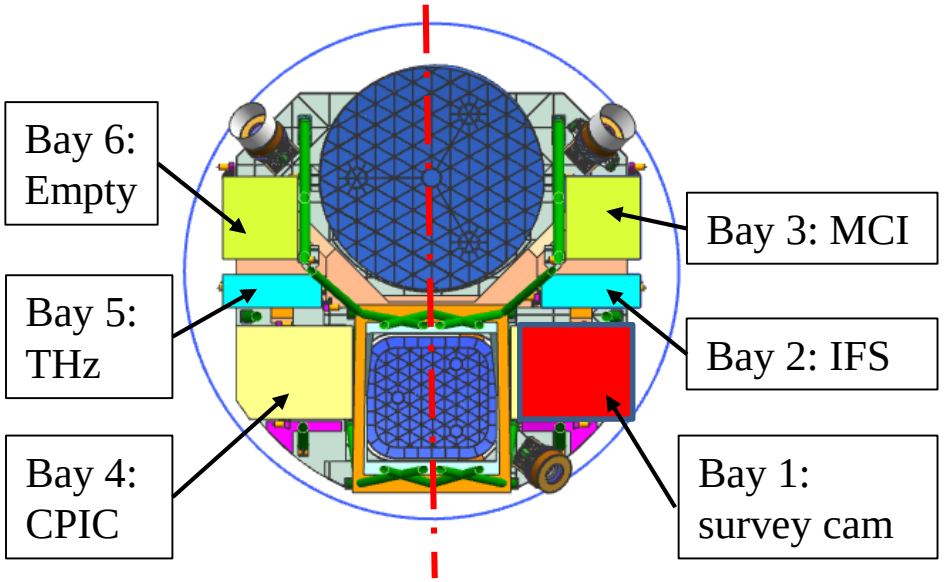
Aperture	≮2m
Focal length	28m
Field of view	≮1.7□° (≮1.1□° for survey)
Wavelength	0.255-1μm, 0.9-1.7μm, 0.41-0.51GHz
Image quality	optics: R_{EE80}≯0.13", full system R_{EE80}≯0.15" e_{avg}≤0.05, e_{max}≤0.15 (λ=0.6328μm, within ≮1.1□°)
Throughput	≮0.65 (NUV-Vis-NIR average, optics only)
Pointing accuracy	LOS: ≯5" (w/ guide star), 10" (w/o GS) Roll: ≯10" (w/o GS)
Stability (≮300s)	LOS: ≯0.05" (3σ, w/ GS), ≯9" (w/o GS) Roll: ≯1.5" (w/o GS)
Jitter	≯0.01" (3σ)
Slew	1°/50s, 20°/100s, 45°/150s; max 0.35°/s

System Design

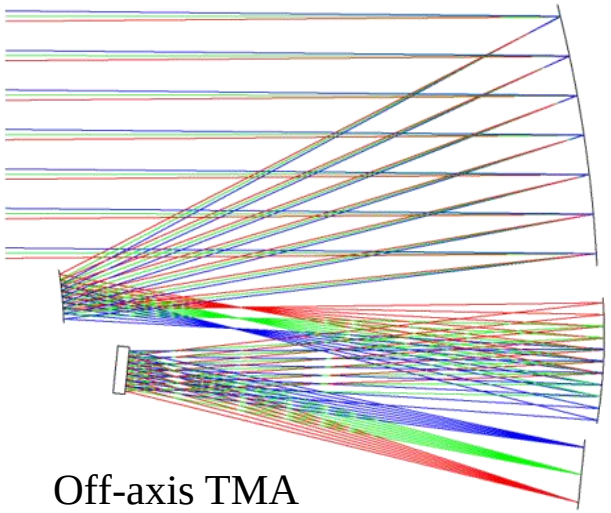
- Off-axis TMA (Cook)
- Serviceable by the CSS
- Slew & LOS/roll: control-momentum gyro + Stewart platform + fast steering mirror (fold mirr) + vib control
- Bay 2&3 can observe in parallel







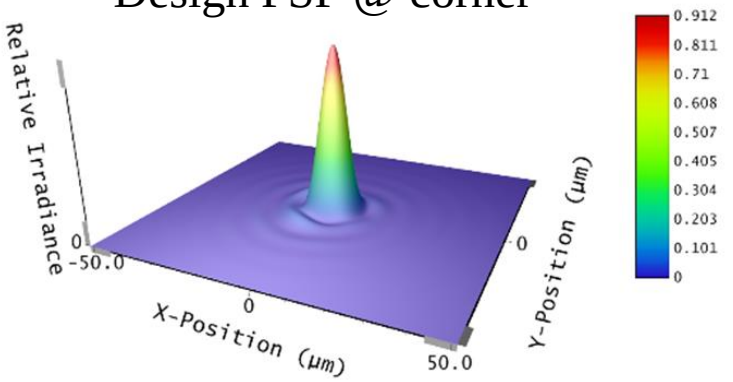
Optical Design



Off-axis TMA

Φ2m
SiC mirror
in figuring

Design PSF @ corner



Requirements

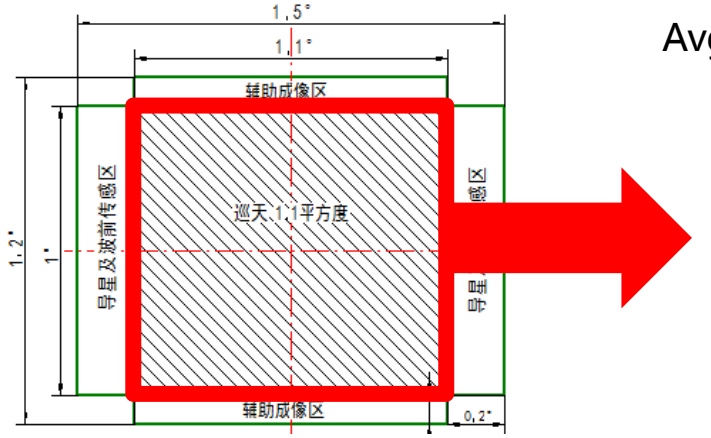
$R_{EE80} \leq 0.15$" @ 632.8nm

$e_{avg} \leq 0.05$, $e_{max} \leq 0.15$

PSF + jitter sim

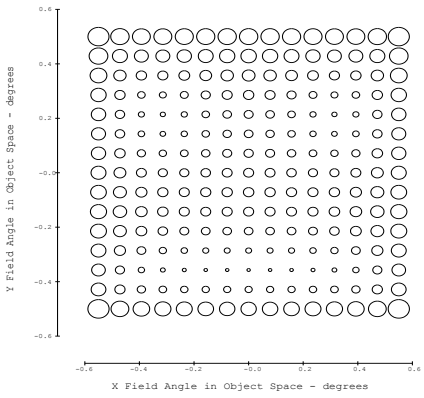
$R_{EE80} < 0.13$"

Pixel size 0.074"



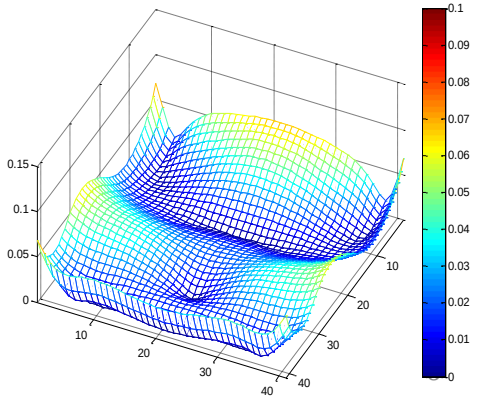
WFE

Avg 0.027λ(18nm), max 0.052λ

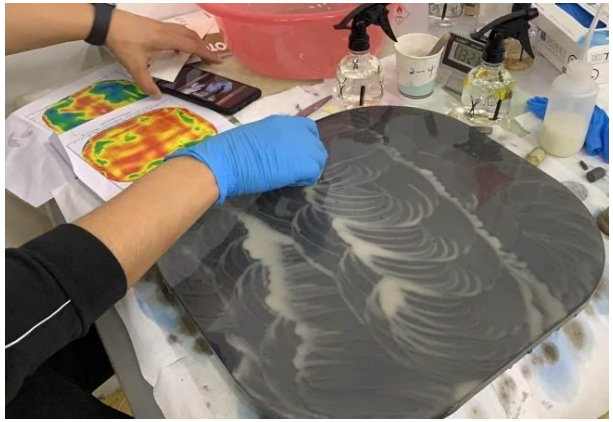


Ellipticity

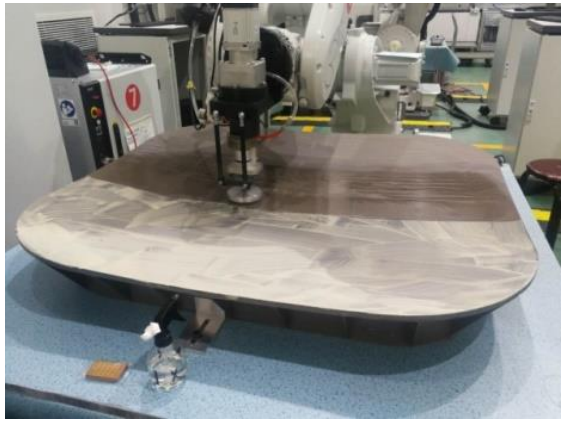
Avg 0.0263, max 0.087



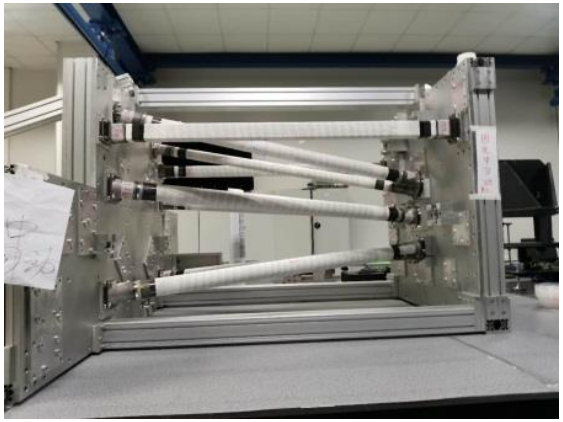
Building A Qualification Model



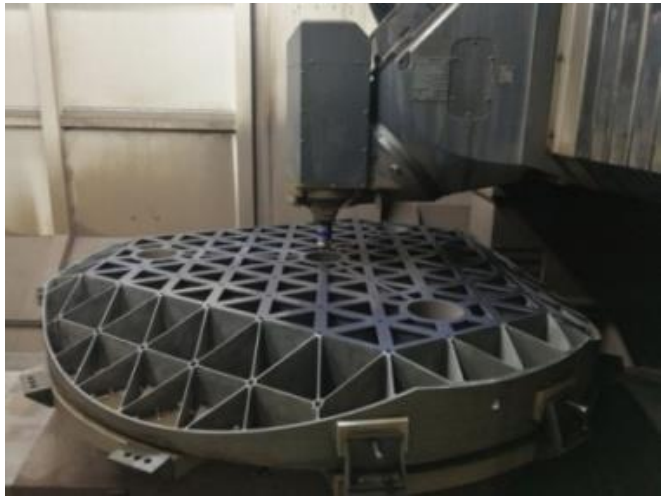
Secondary mirror



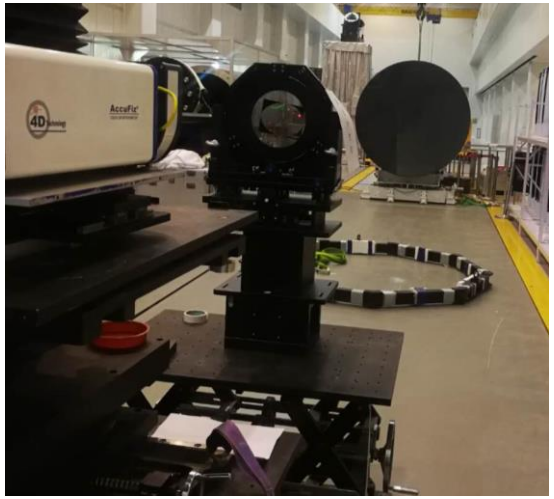
Tertiary mirror



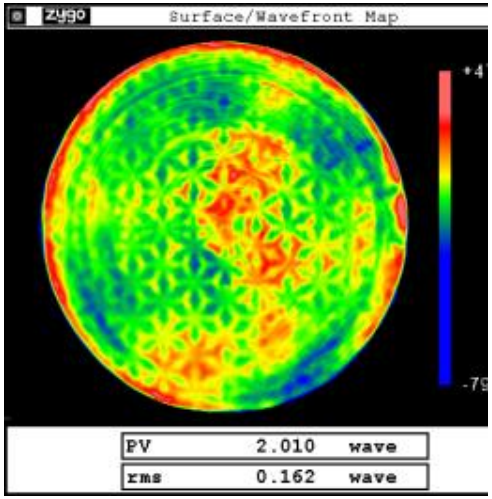
Truss



Primary mirror

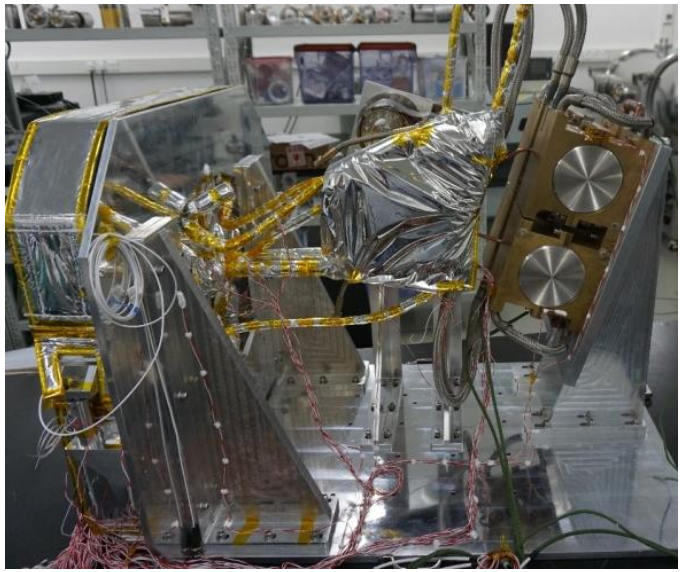


PM under test

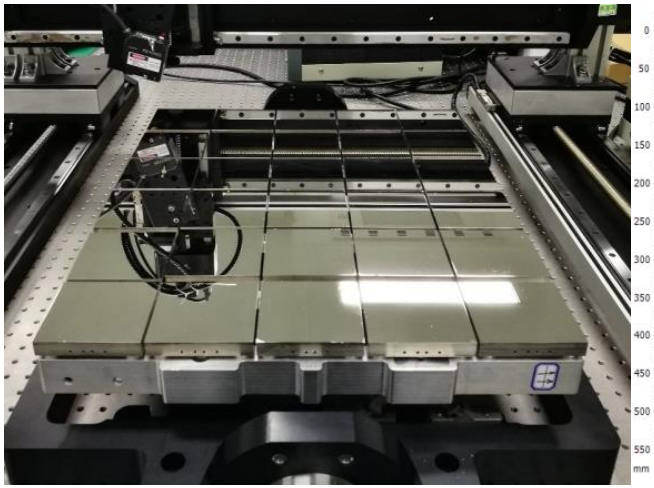


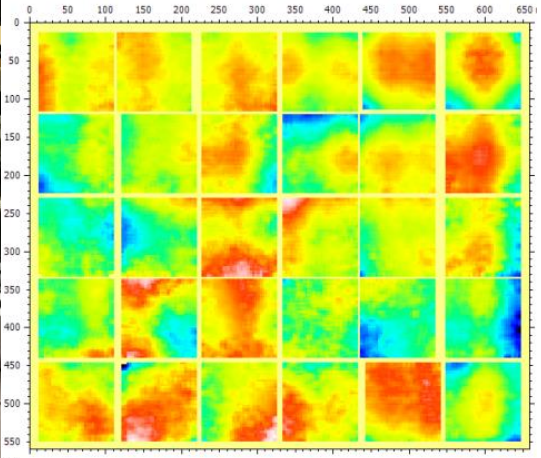
PM WFE (λ/5)
before fine polishing

Building A Qualification Model

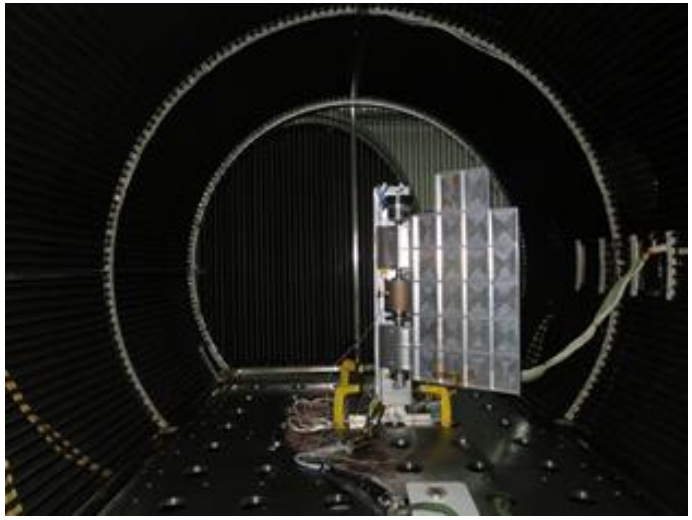


Cryo test model

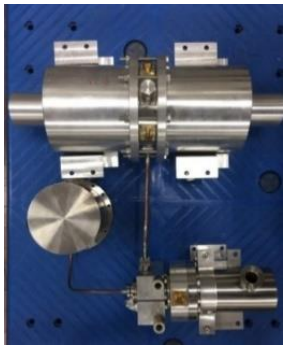




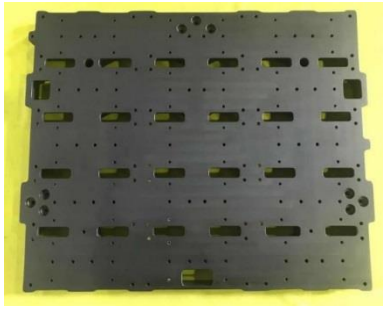
Mock focal plane, flatness: 31µm (PV)

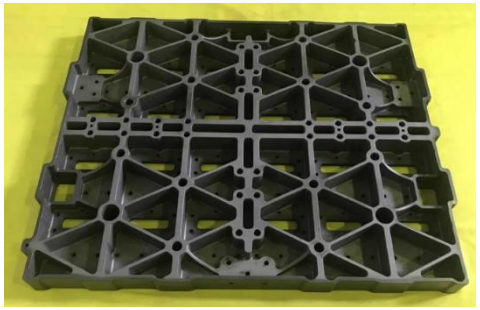


Shutter (1.3M+ ops tested)

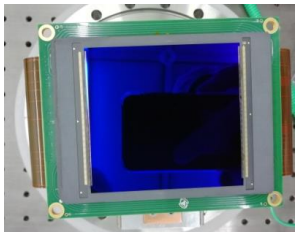


cryocooler

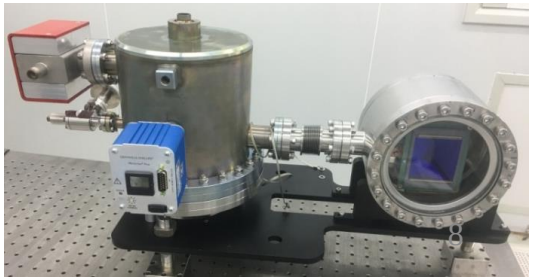




SiC mounting plate for detectors

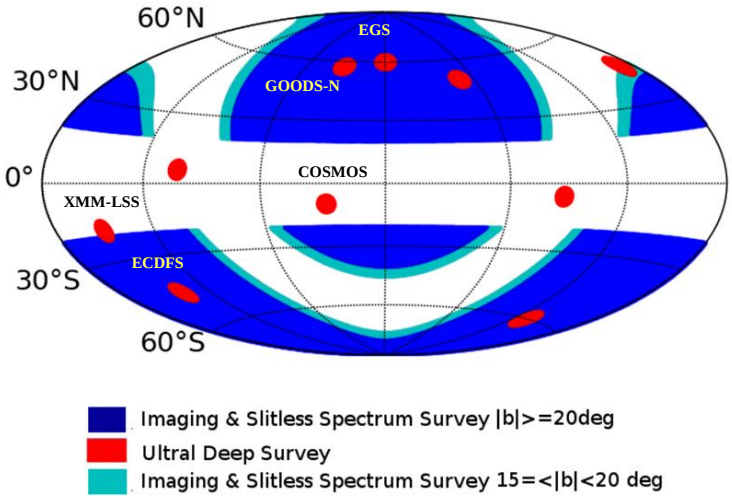


Detectors tested



Survey Specs

- **17500□° imaging : 255-1000nm, ≥6 filters, avg ≥25.5^{m} (5σ, point source, AB mag);**
- **17500□° slitless spect: 255-1000nm, R≥200, ≥22-23^{m};**
- **400□° deep imaging & spect: at least 1^{m} deeper.**



Ecliptic Coord.

Deep fields will be finalized later; sim results for demo only.

Science

Cosmology: dark energy, dark matter, gravity, large-scale structure, neutrinos, primordial non-Gaussianity…

AGNs: high-z AGNs, clustering, dual AGNs, variability, UV excess, host galaxies…

Galaxies: formation & evolution, mergers, high-zs, dwarfs, LSBs, near field, halos properties…

Milky Way: structure, satellites, dust, extinction…

Stellar science: formation, dwarfs, metal poor…

Solar system (high inclination): TNO、NEA…

Astrometry: reference frame, star clusters…

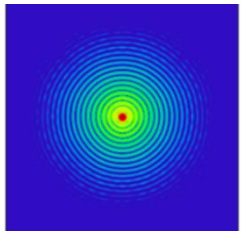
Comparison with Other Surveys

Project	Site/ orbit	Launch /op	FoV	R_{EE80}	Num pixels	Area	Wavelength	Num Filters	Spect
			deg^2	″	10^9	deg^2	nm		
CSS-OS	LEO	~2024	**1.1**	**0.15** 0.074/pix	**2.5**	**17500**	**255**—1000	≥6	yes
Euclid	L2	~2022	0.56 0.55	>0.2 pix lmt	0.6 0.07	15000	550—920 1000—2000	1 3	no yes
WFIRST	L2	>2025	0.28	>0.2	0.3	~2000	927—2000	4	yes
LSST	Chile	2023	9.6	~0.54	3.2	18000	320—1050	6	no

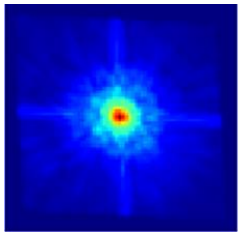
R_{EE80}: radius encircling 80% energy

	CSS-OS	HST/ACS WFC	Euclid VIS	WFIRST J
R_{EE50}	0.1"	0.06"	0.13"	0.12"
R_{EE80}	0.15"	0.12"	~0.23"	~0.24"

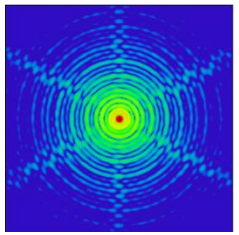
Dynamic sims: R_{EE80} ~0.13”



CSS-OS

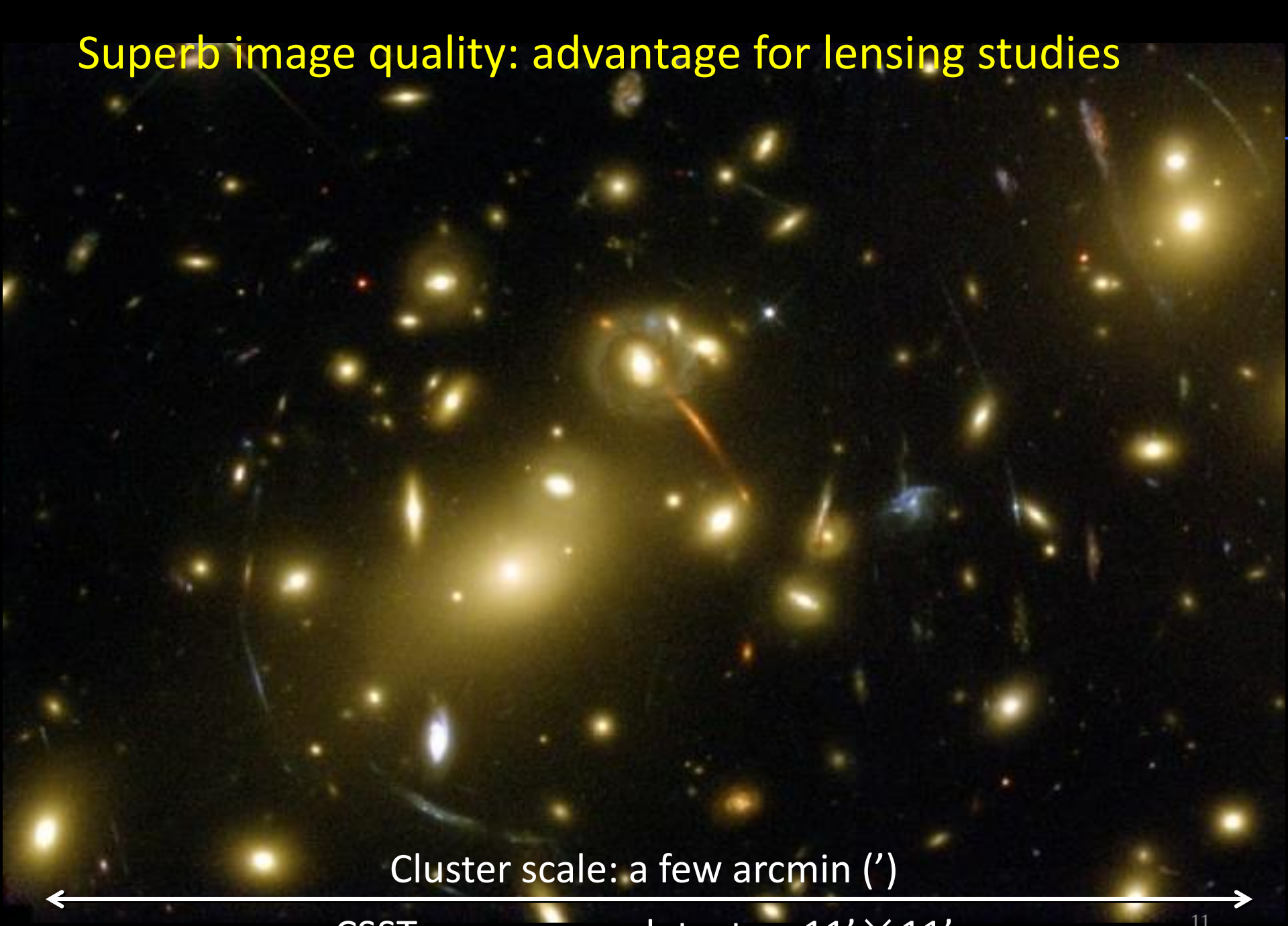


HST



Euclid

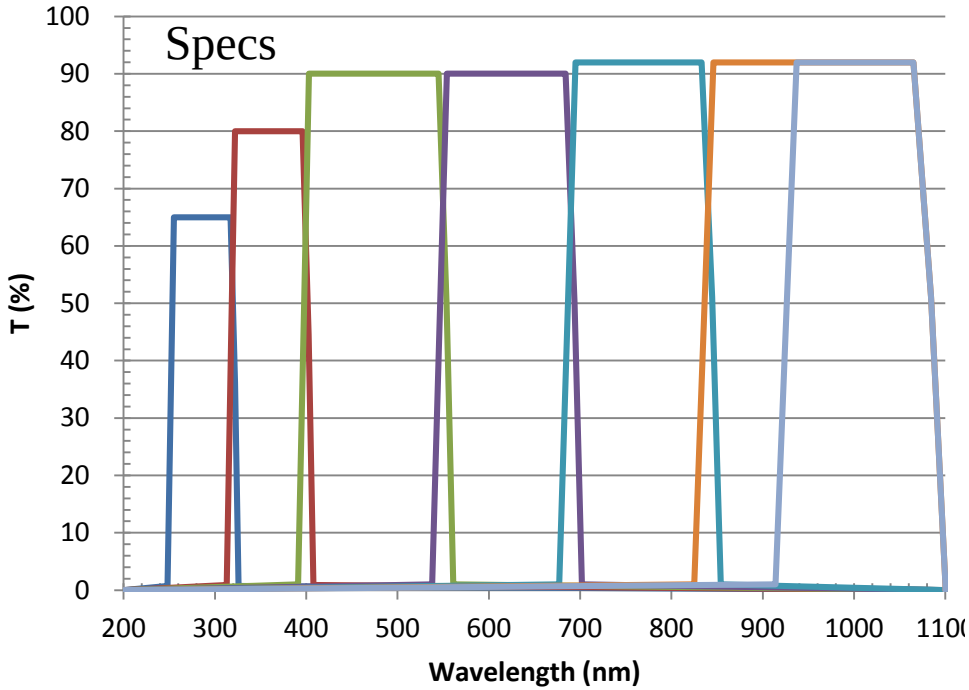
Superb image quality: advantage for lensing studies

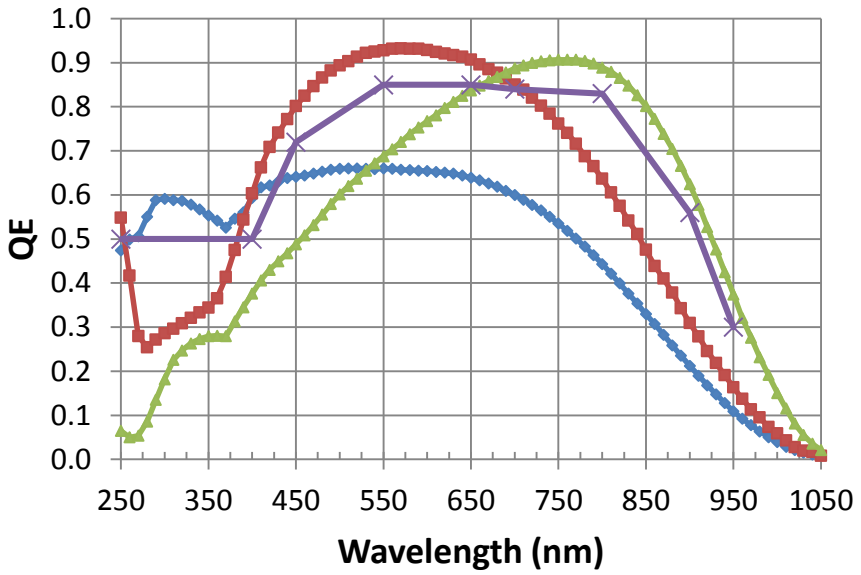


Cluster scale: a few arcmin (’)

CSST survey cam detector: 11’×11’

Filters & Limiting Mags





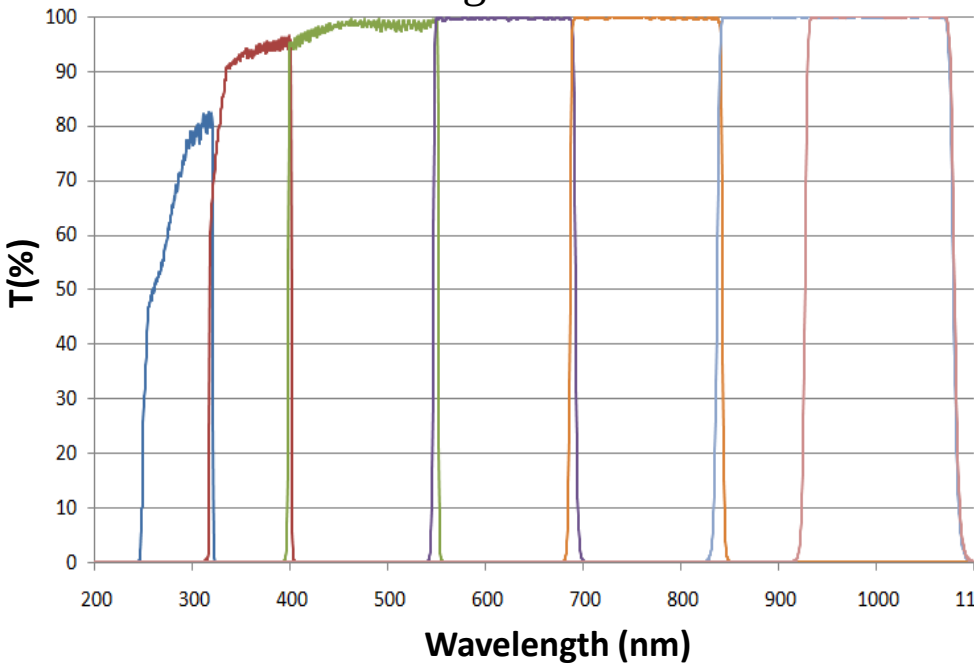
	t_{exp}	NUV*	u	g	r	i	z	y*
17500□°	2×150s	25.4	25.4	26.2	25.9	25.8	25.2	24.5
400□°	8×250s	26.7	26.7	27.4	27.1	26.9	26.4	25.7

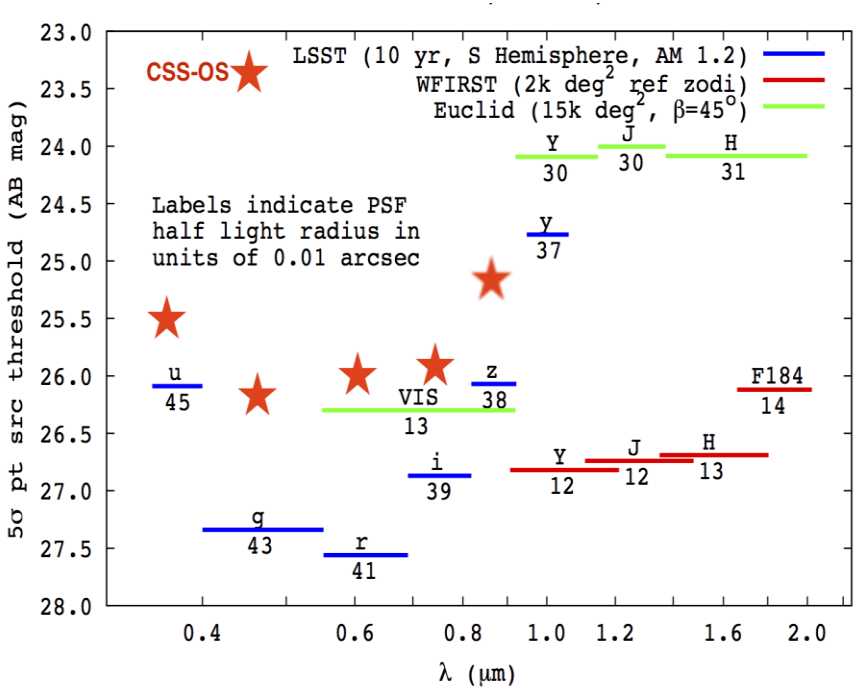
*NUV & y: 4×150s

w/ ~0.2^{m} margin from design

Filters & Limiting Mags

Vender designed filter curves





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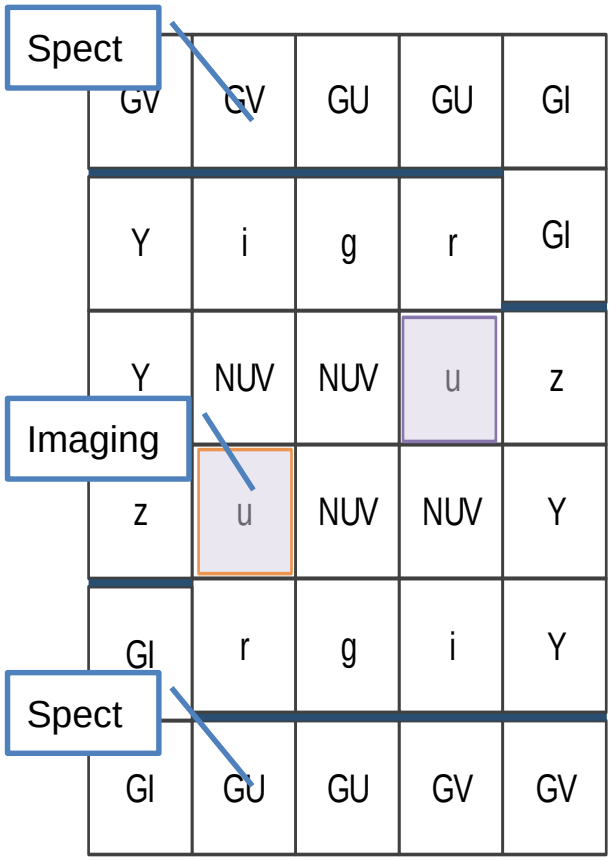
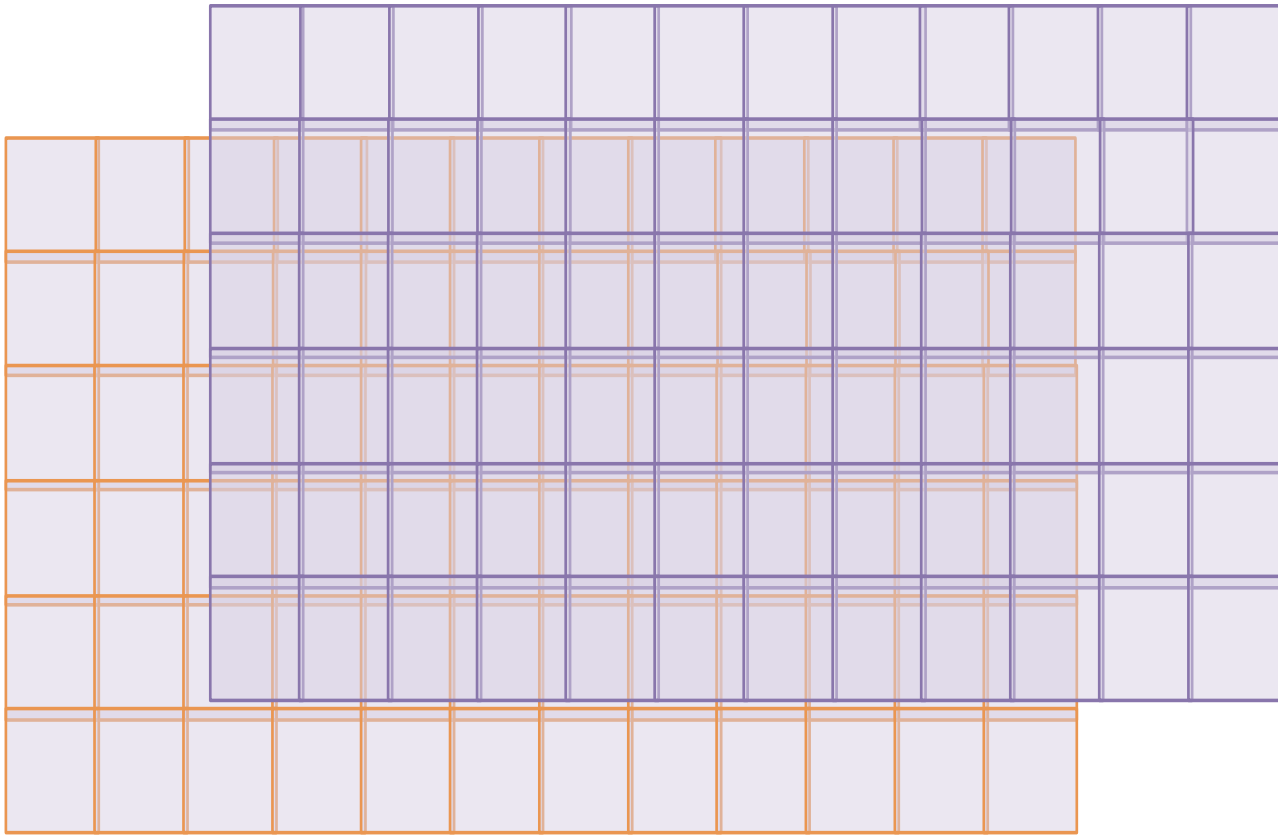
w/ ~0.2^{m} margin from design

Tiling of the Sky

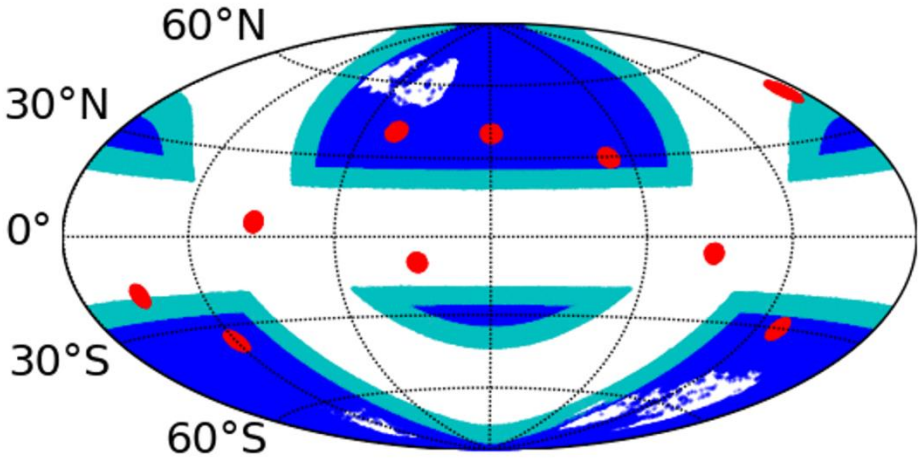


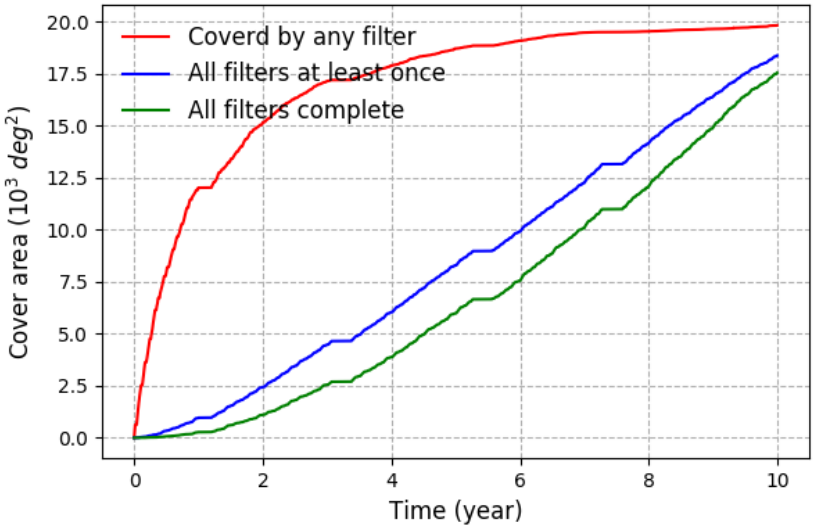


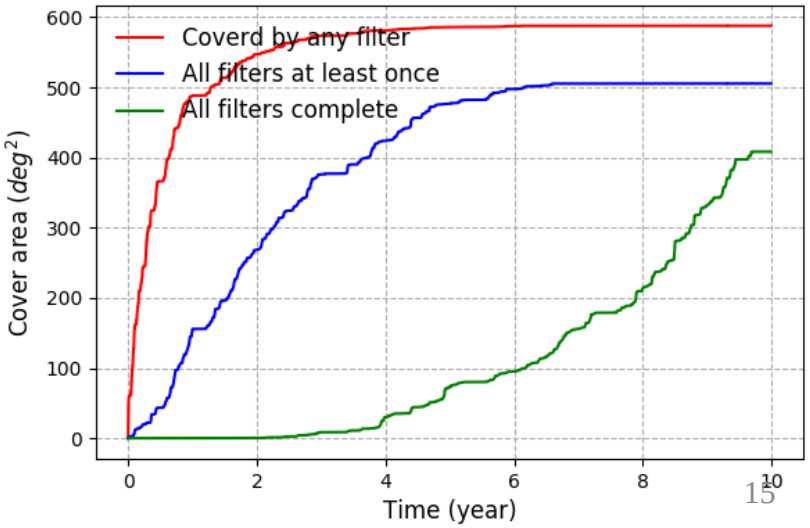
- 10” overlap b/w fields of each chip
- If one chip covers the whole sky, all other chips will also cover the whole sky.
- # of same-type filters = # of visits

Operations Simulations

Baseline 64% orbital time for survey (requesting 70%)

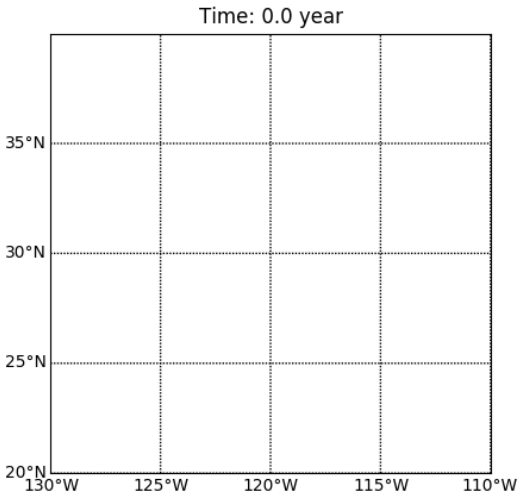


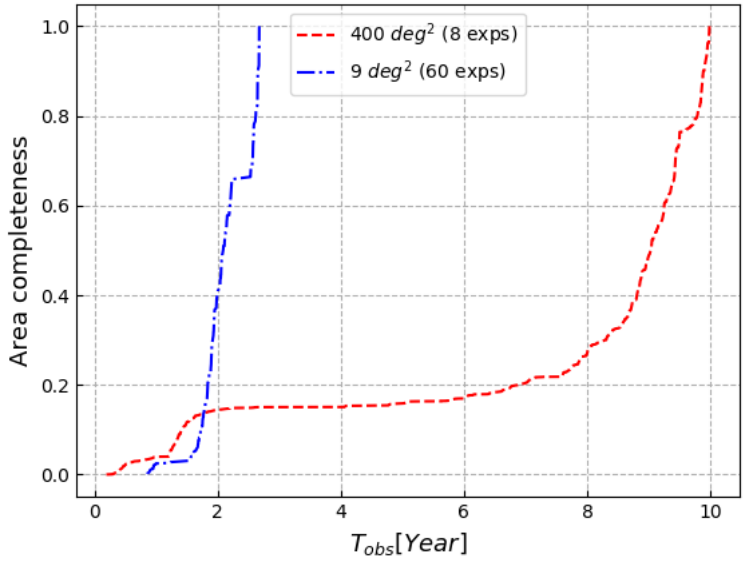


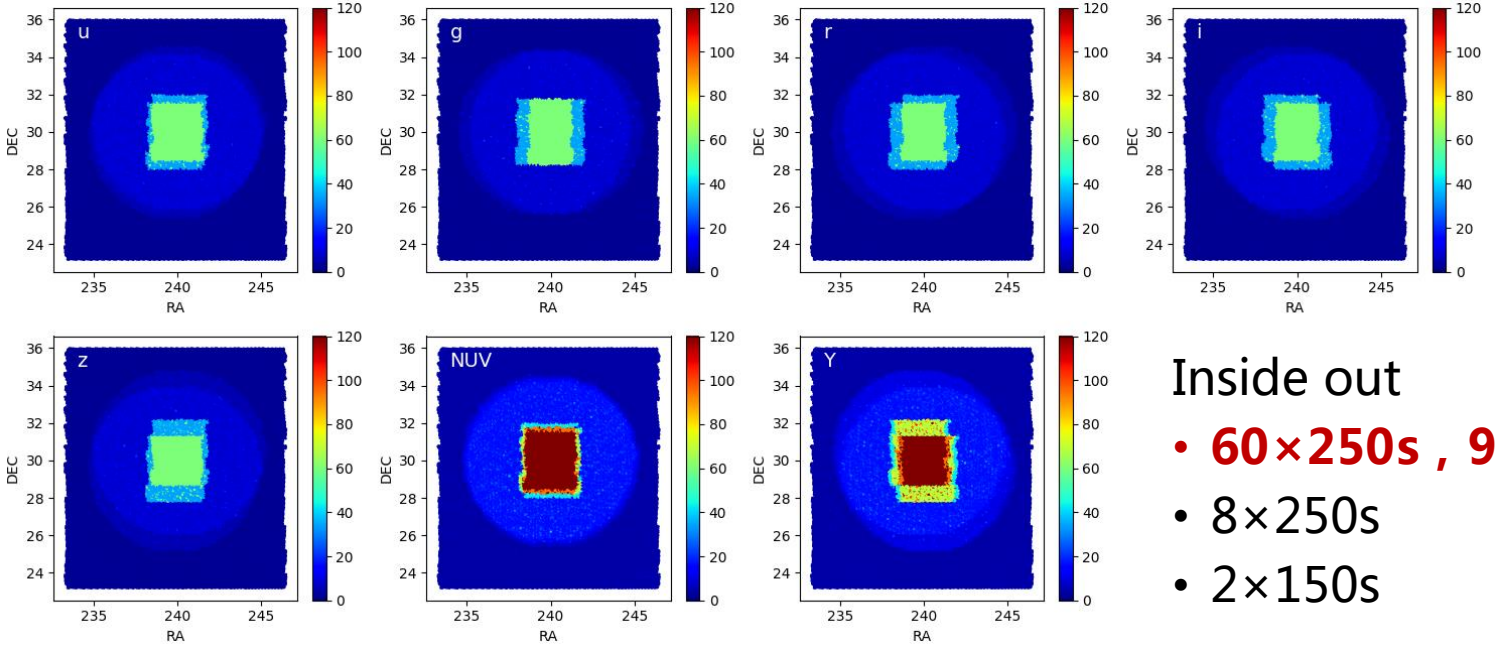


- 10-year coverage in simulation
  Wide field: 17540 deg^2
  Deep fields: 408 deg^2
- Most constraining factors: Sun & Earth
- Galactic plane & ecliptic plane can be observed

Ultradeep Field (Demo)







Inside out

- **60×250s , 9□°**
- 8×250s
- 2×150s


Thank you!
Looking forward to a fruitful collaboration with Euclid!