Imaging Simulation of Chinese Space Station Telescope(CSST)
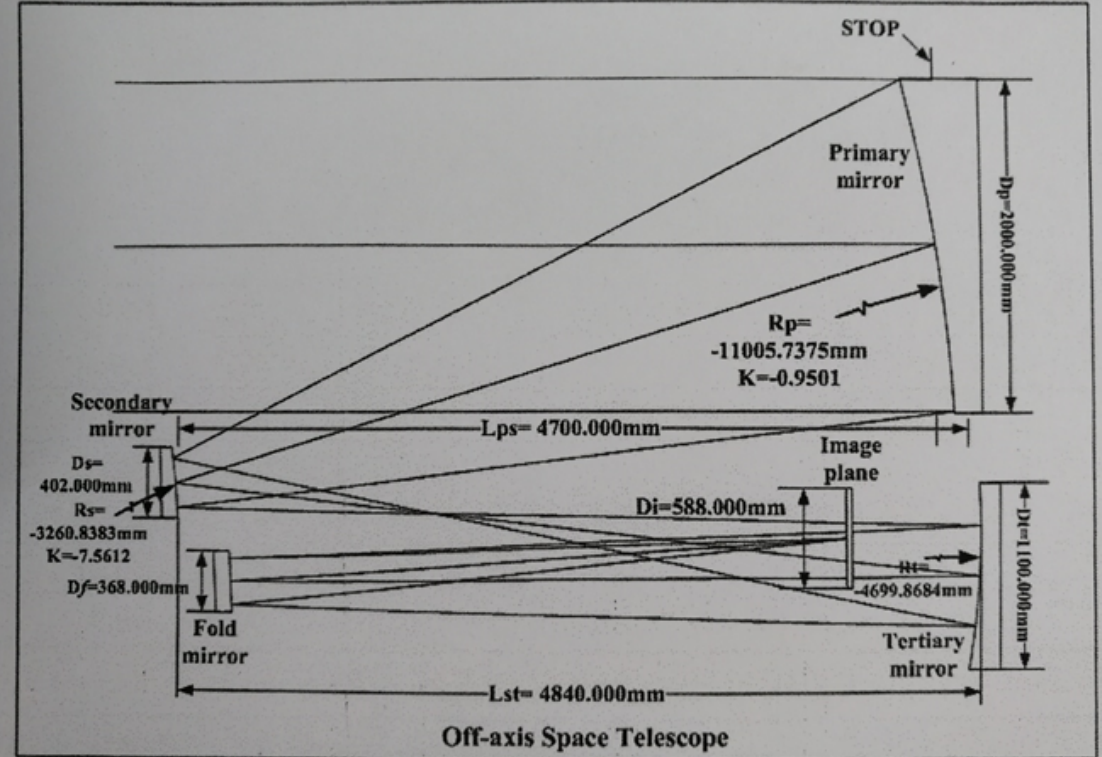
Guoliang Li on behalf of
Chao liu, Xianmin Meng, Xin Zhang, Ran Li
Dezi Liu,
Chengliang Wei, Yu Luo
Xiaobo Li、 Zhang Ban and etc.

Beijing， 2019.11.06

Outline

- Introduction
- Progress
- Phosim
- Outlook

What does CSST look like?

STOP

Primary mirror

$Dp=2000.000mm$

$Rp=$ -11005.7375mm
$K=-0.9501$

Secondary mirror

$Lps= 4700.000mm$

Image plane

$Ds=$ 402.000mm
$Rs=$ -3260.8383mm
$K=-7.5612$
$Df=368.000mm$

$Di=588.000mm$

$Dt=1100.000mm$

$Ht=$ -4699.8684mm

Fold mirror

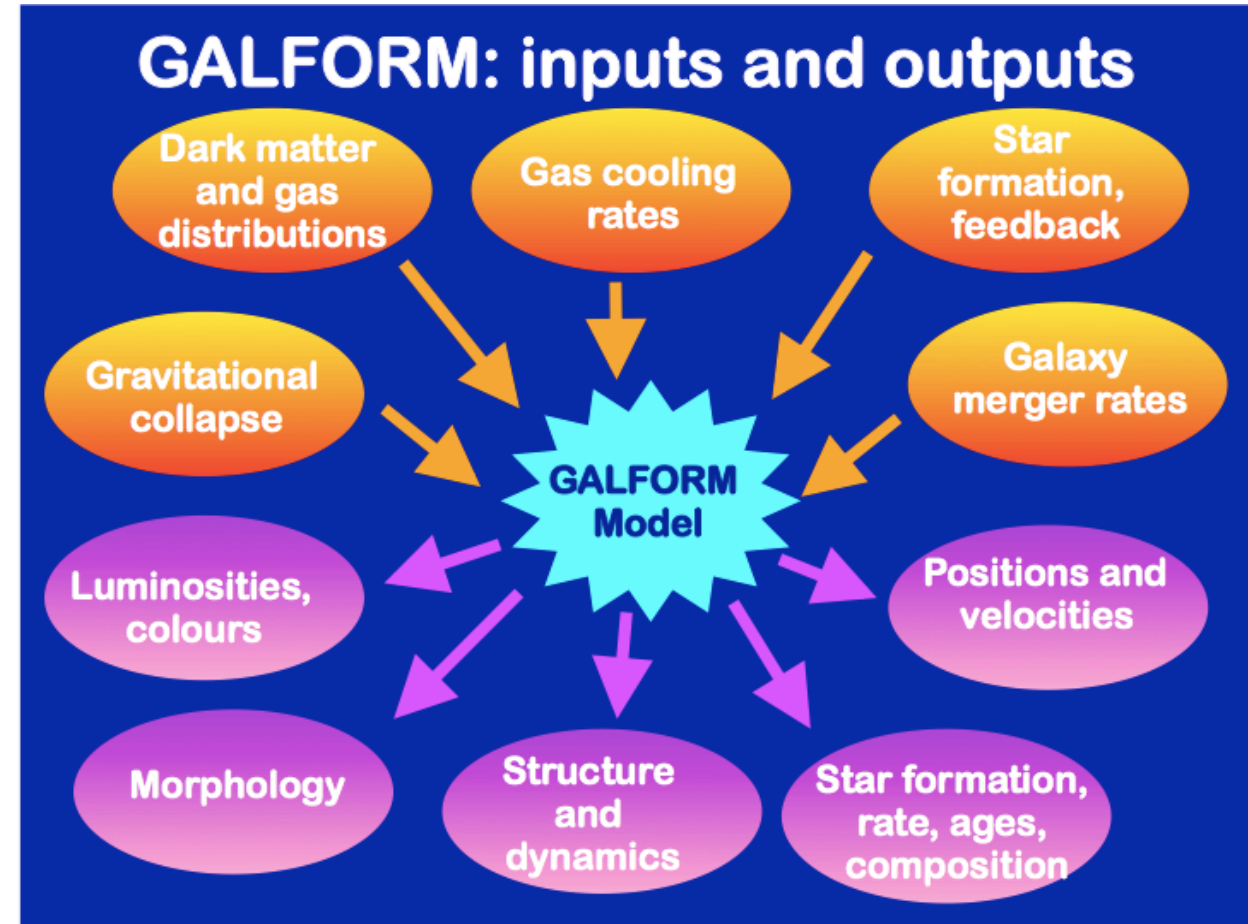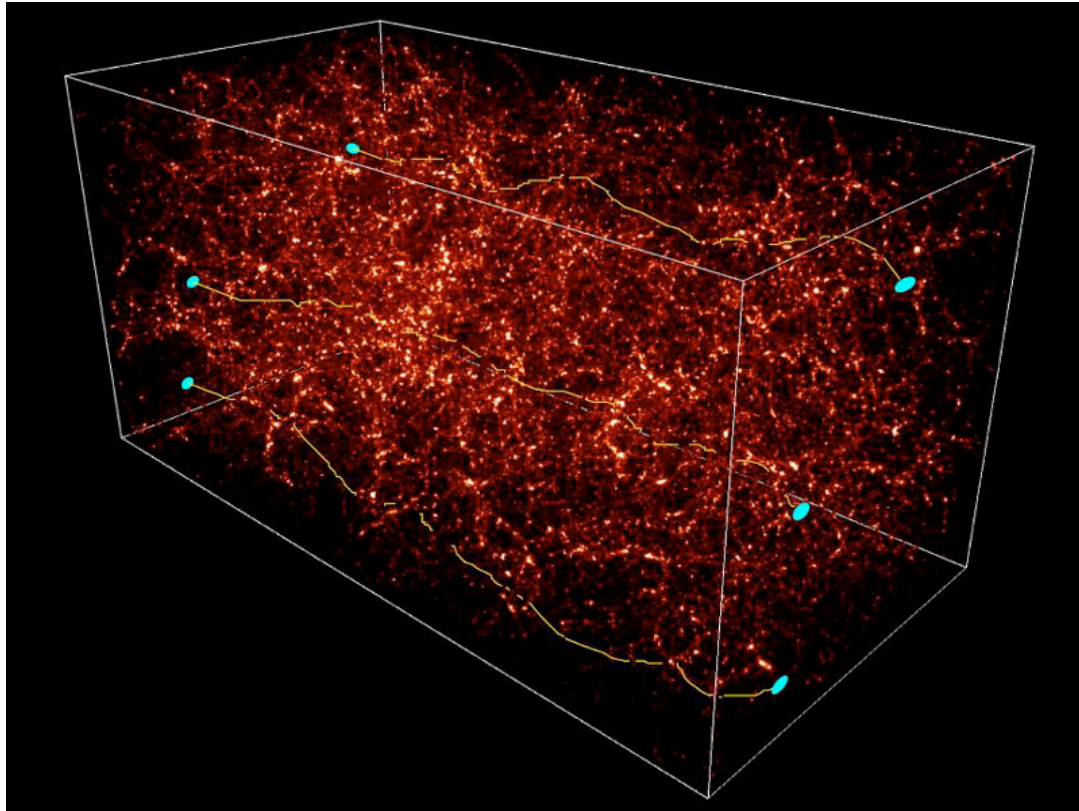Tertiary mirror

$Lst= 4840.000mm$

Off-axis Space Telescope

Lps : Distance between the primary and the secondary mirror
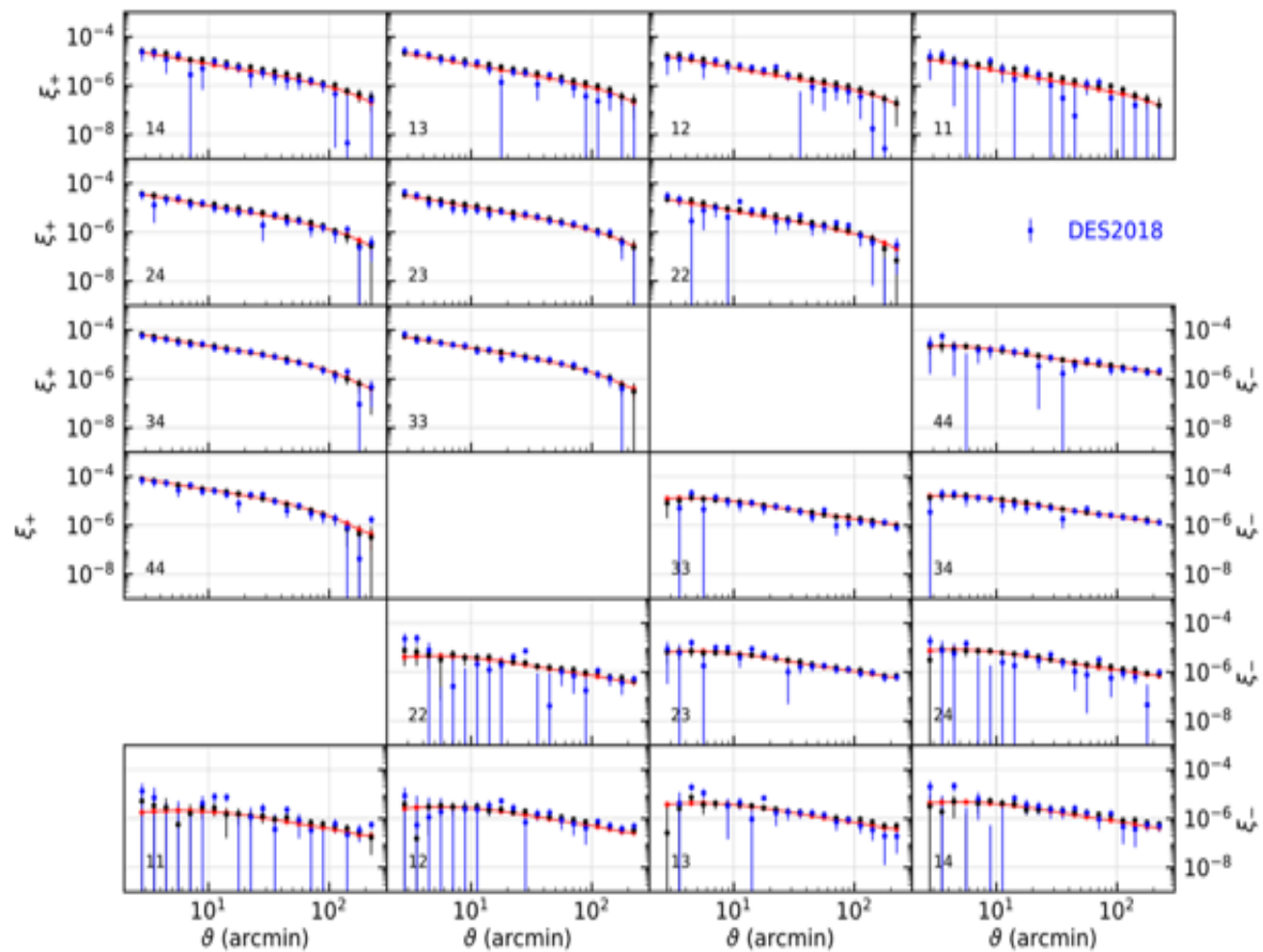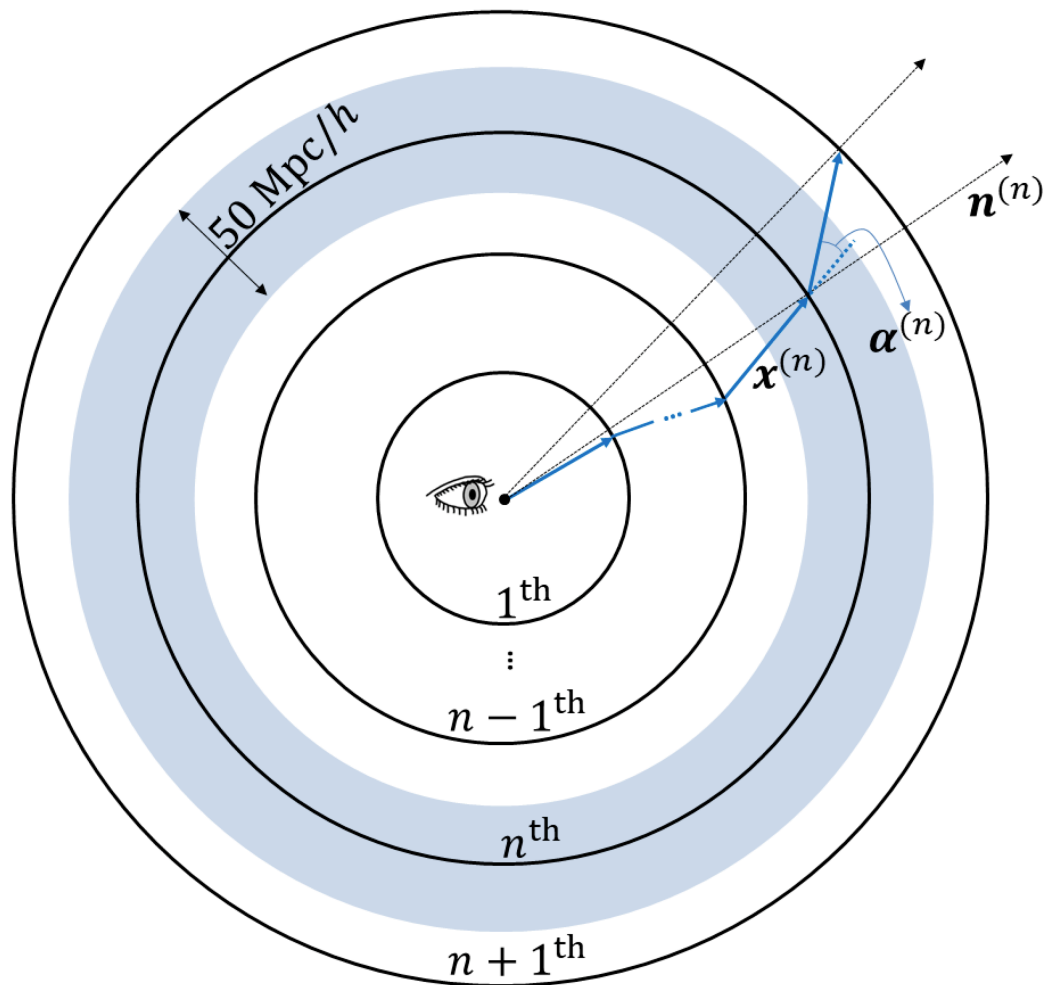Lst : Distance between the secondary and the third mirror

Imaging Simulation
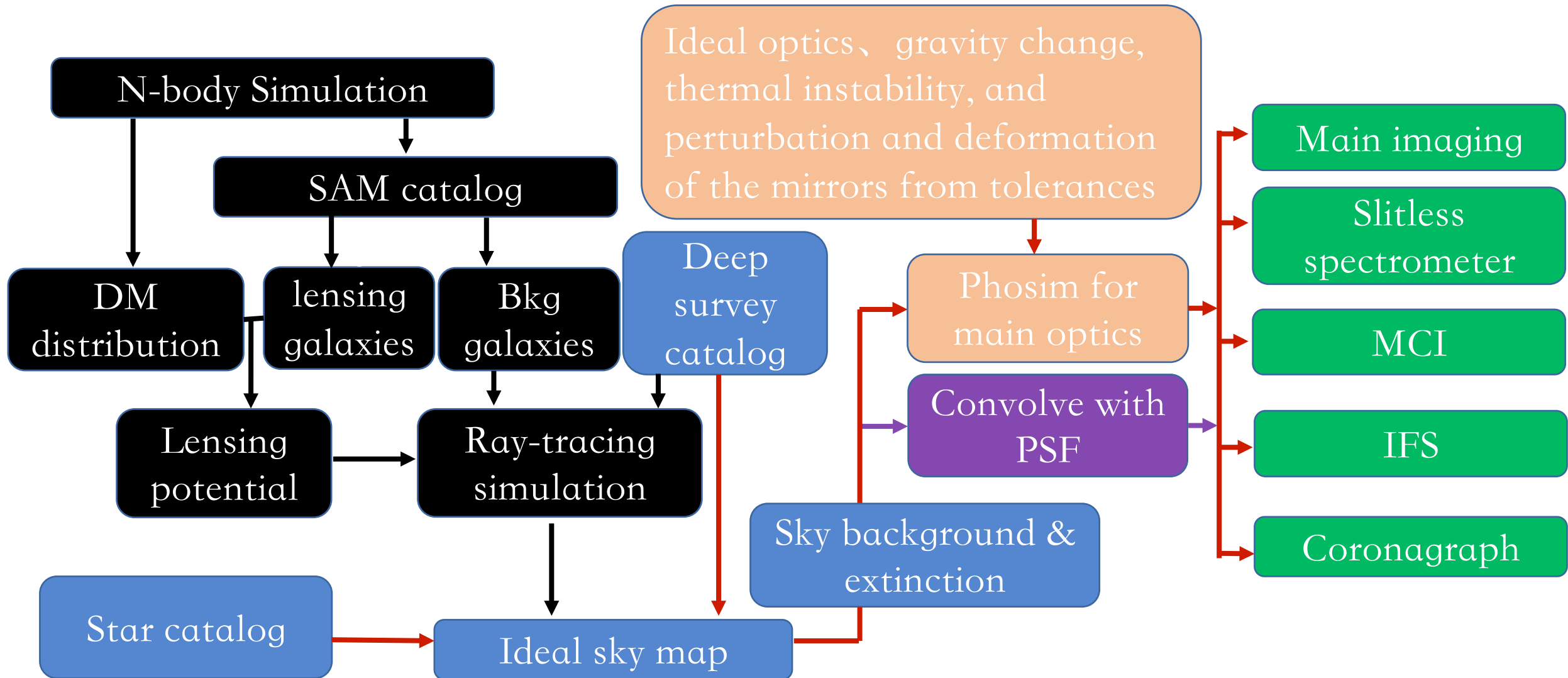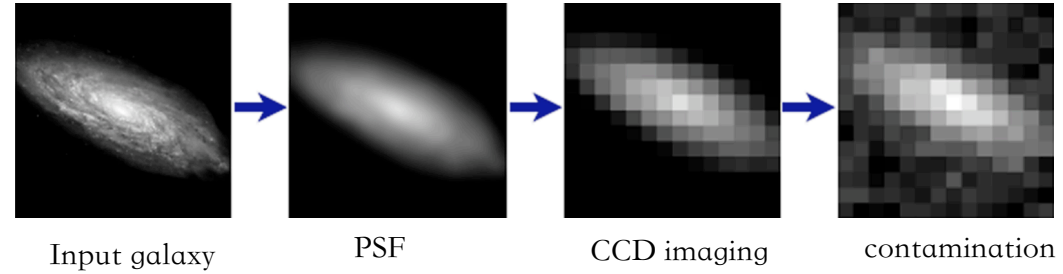
Progress—Cosmology Simulation & Semi-analytical model

Progress– weak lensing simulation

Progress —CCD imaging

Input galaxy   PSF   CCD imaging   contamination

Galsim creates images by using input:

1.Catalog：galaxy types，magnitude，positions， shape， size，extinction， redshift，SED, star catalog, objects in our solar system and etc。

3. PSF：ideal model，vibration、rotation、 thermal breathing、brighter-and-fatter、field distortion and etc.

4. Contamination：white noise，dark current、bad pixels、 hot pixels、cosmic rays and etc.
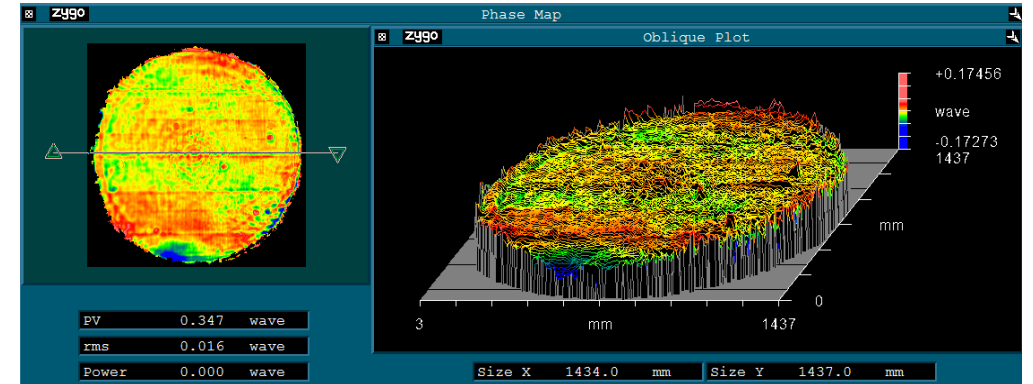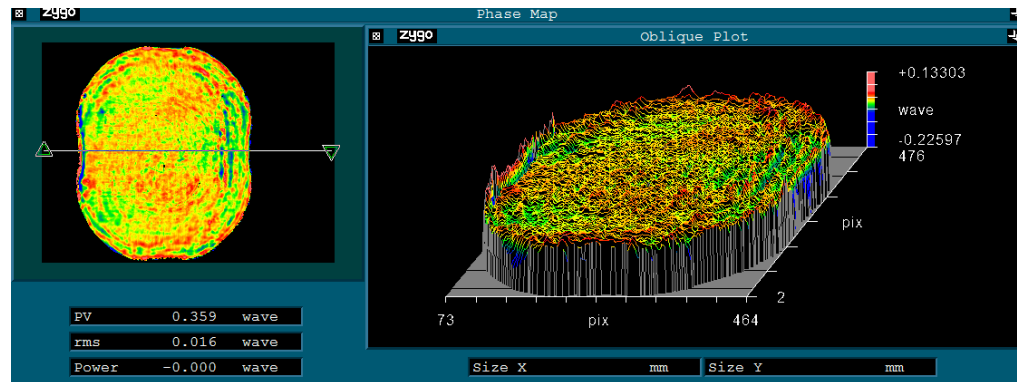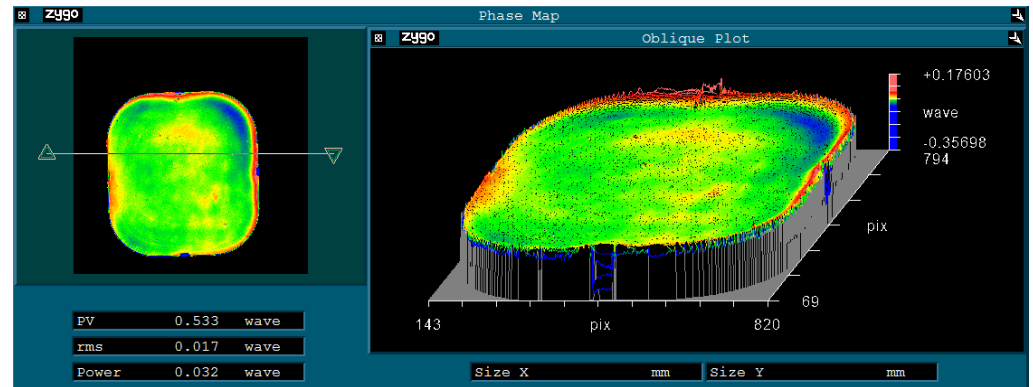
5. Survey strategy。

Progress—slitless spectrometer


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┌─────────────────────────────────────────────────┐
│  Objects(morphology, brightness and spectrum)    │
└─────────────────────────────────────────────────┘
                        │
                        ▼
┌──────────────────┐        ┌──────────────────┐
│   Extinction     │  ⊗     │   Optics PSF     │
└──────────────────┘        └──────────────────┘
                              ⊗
                    ┌──────────────────────┐
                    │  Spectrometer model  │
                    └──────────────────────┘
                              ⊗
                    ┌──────────────────────┐
                    │      CCD PSF         │
                    └──────────────────────┘
                              │
                              ▼
┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐
│  Sky background  │→ │   CCD effects    │ ←│   Cosmic ray     │
└──────────────────┘  └──────────────────┘  └──────────────────┘
                              │
                              ▼
                    ┌──────────────────────┐
                    │      2D image        │
                    └──────────────────────┘
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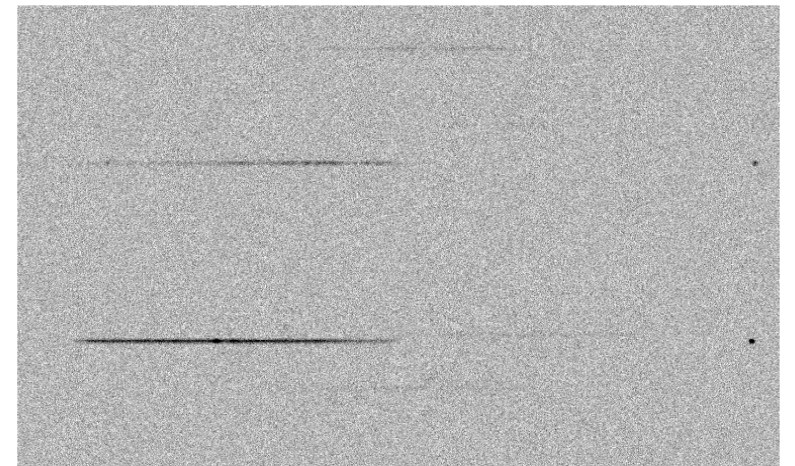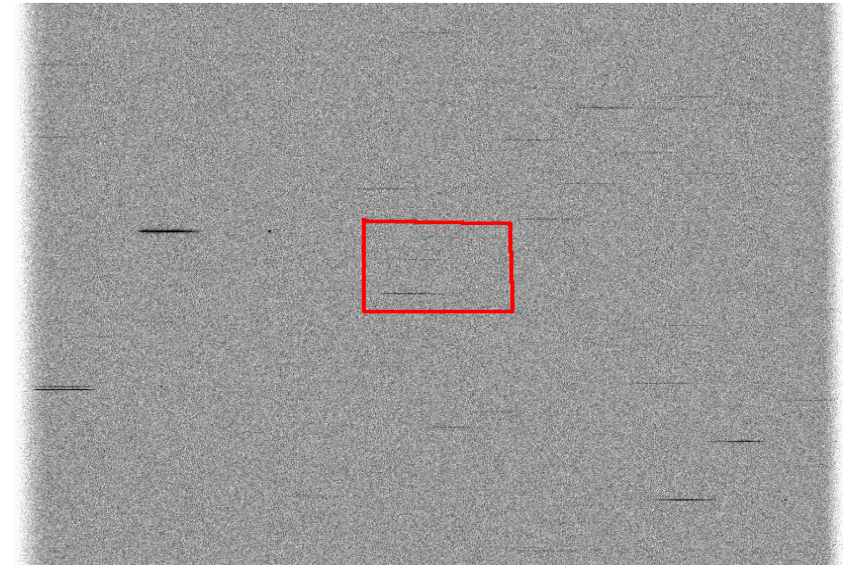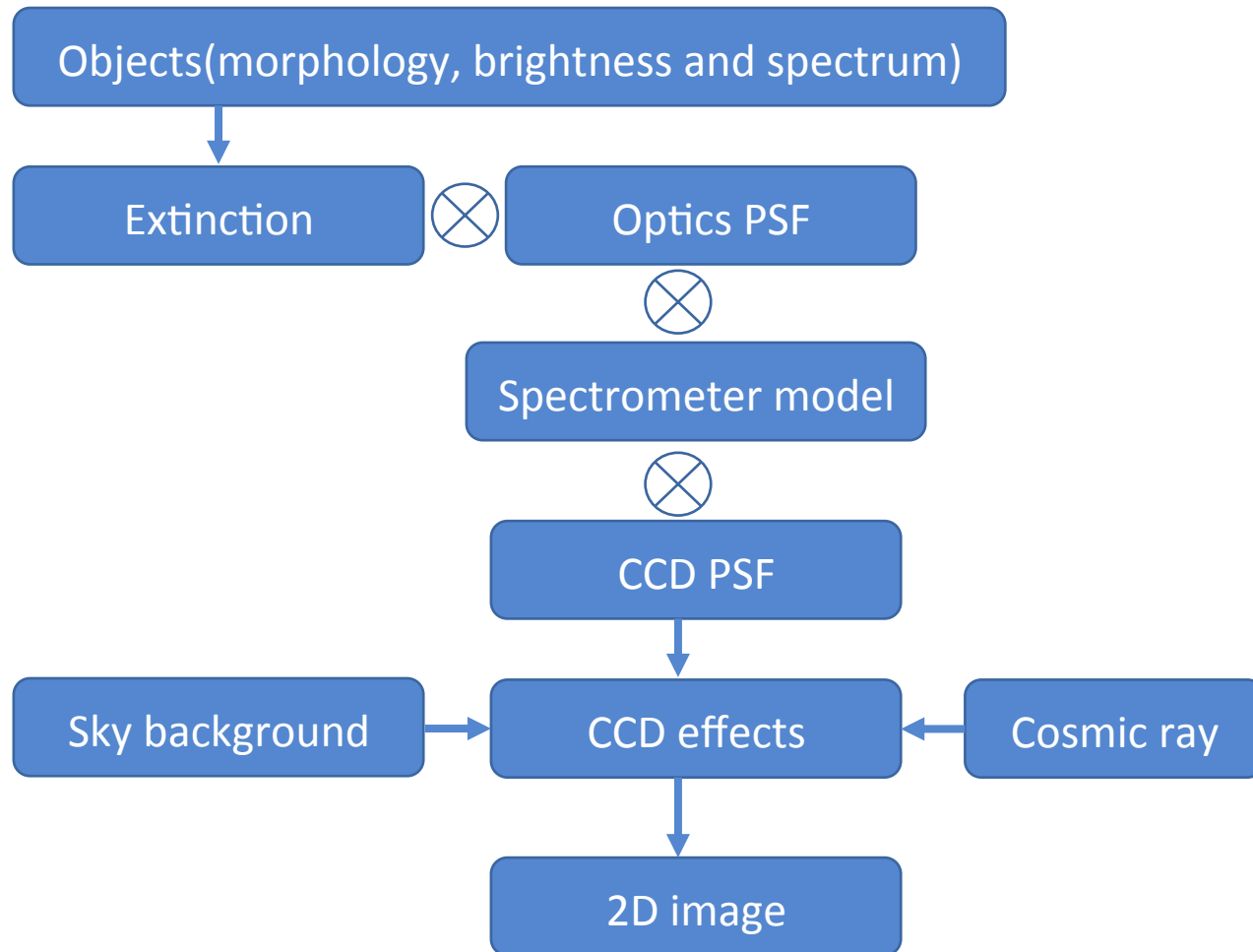
Progress—optics--mirrors
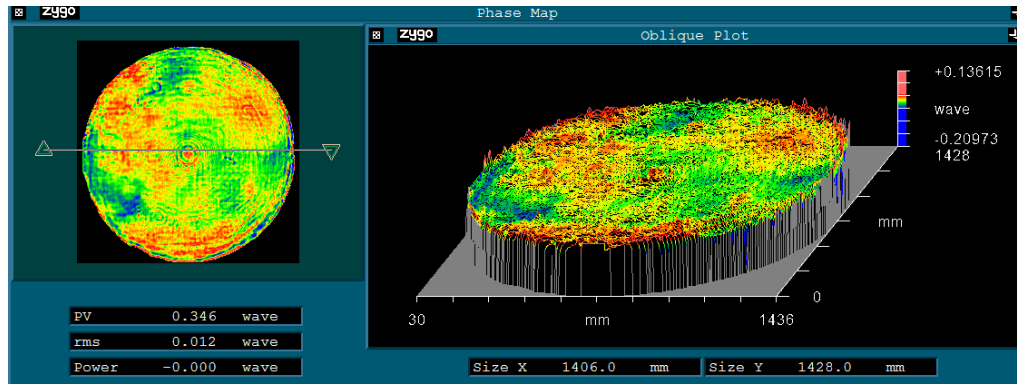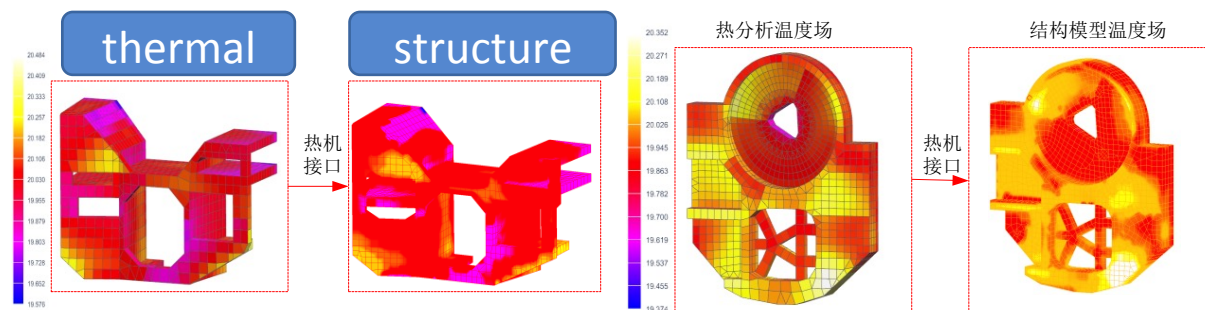

Fluctuation on the primary mirror

Tertiary

mirrors	Primary	Secondary	Tertiary	Fold
rms	0.0125λ	0.01λ	0.009λ	0.009λ

λ=632.8nm

Progress—optics--alignment tolerances

镜面调整项		偏心（mm）		倾斜（"）		间隔（mm）	
		X	Y	绕X轴	绕Y轴		
装调公差	主镜	主镜作为基准				主三镜间隔	2.5
	三镜	0.3	0.3	60	60		
补偿器	次镜	0.3	0.6	18	57	2.8	
	像面	—	—	293	360	33	
波差下降量		~0.013λ(各视场RMS)					

Progress—optics—thermal instability

热分析温度场

结构模型温度场

thermal → structure

热机接口

热机接口

光机热集成仿真方案

热分析 UG/TMG → XXXX 热仿真模型 → 热分析 → XXXX 温度场 → 温度场映射 | 热-机接口 Matlab

结构分析 Nastran → XXXX 结构仿真模型 → 热弹性分析 → 光学表面节点位移 → 光学表面位移拟合 | 光-机接口 Matlab/ Sigfit

像质分析 Code V → 光学表面波前误差刚体位移 → 光学设计文件 → 系统波前误差系统传函 → 热控指标

设计优化

RMS=5.7nm/PV=44.02nm

RM and PV in Primary

RMS=1.14nm/PV=7.32nm

Secondary

RMS=3.39nm/PV=23.52nm

Tertiary

RMS=2.3nm/PV=13.13nm
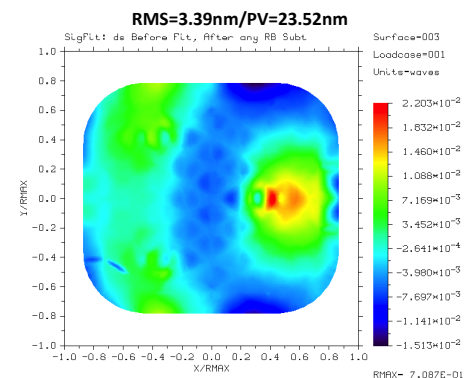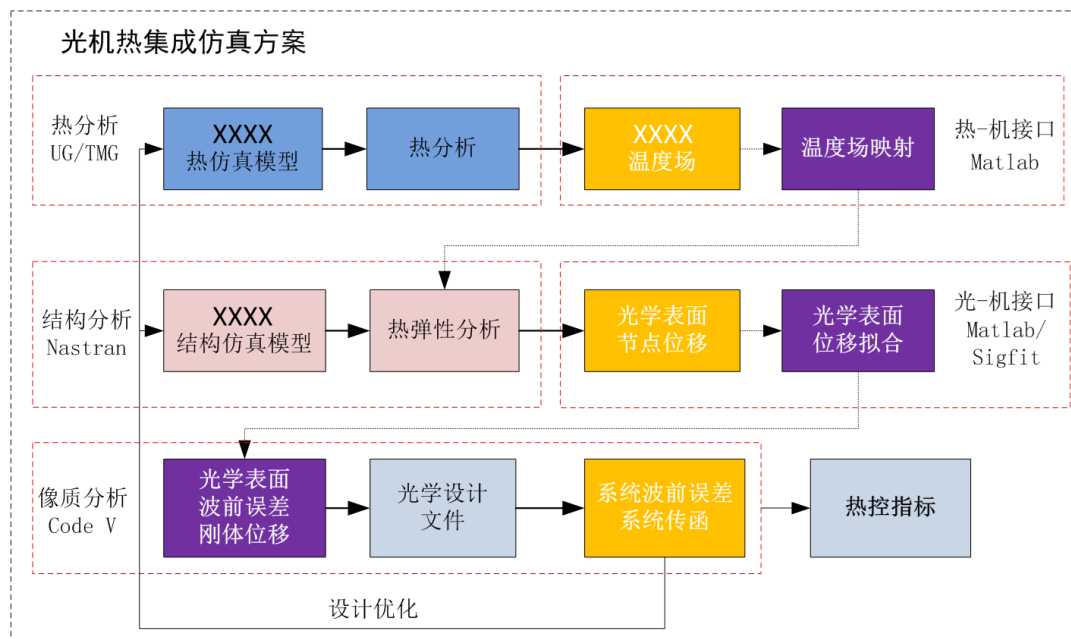
Fold

Progress—optics—gravity change

RMS=5.89nm/PV=56.6nm

RM and PV in Primary

RMS=2.46nm/PV=11.93nm

Secondary

RMS=3.24nm/PV=25.5nm

Tertiary

RMS=6.53nm/PV=51.32nm
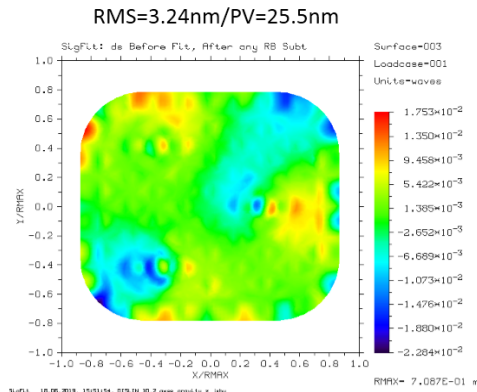
Fold

	X (μm)	Y (μm)	Z (μm)	RX (″)	RY (″)	RZ (″)
Primary	-21.02	2.4	0.26	0.62	0.48	0.34
Secondary	-144.5	-26.2	0.33	-1.44	10.6	8.45
Tertiary	-14.61	0.78	2.96	0.07	0.2	-1.74
Fold	-171	-22.2	18.4	0.36	19.1	7.06
FP	-26.70	-4.93	7.76	-0.39	-4.31	1.84

Maximum changes in position and position angle

Off-axis Space Telescope

Lps : Distance between the primary and the secondary mirror
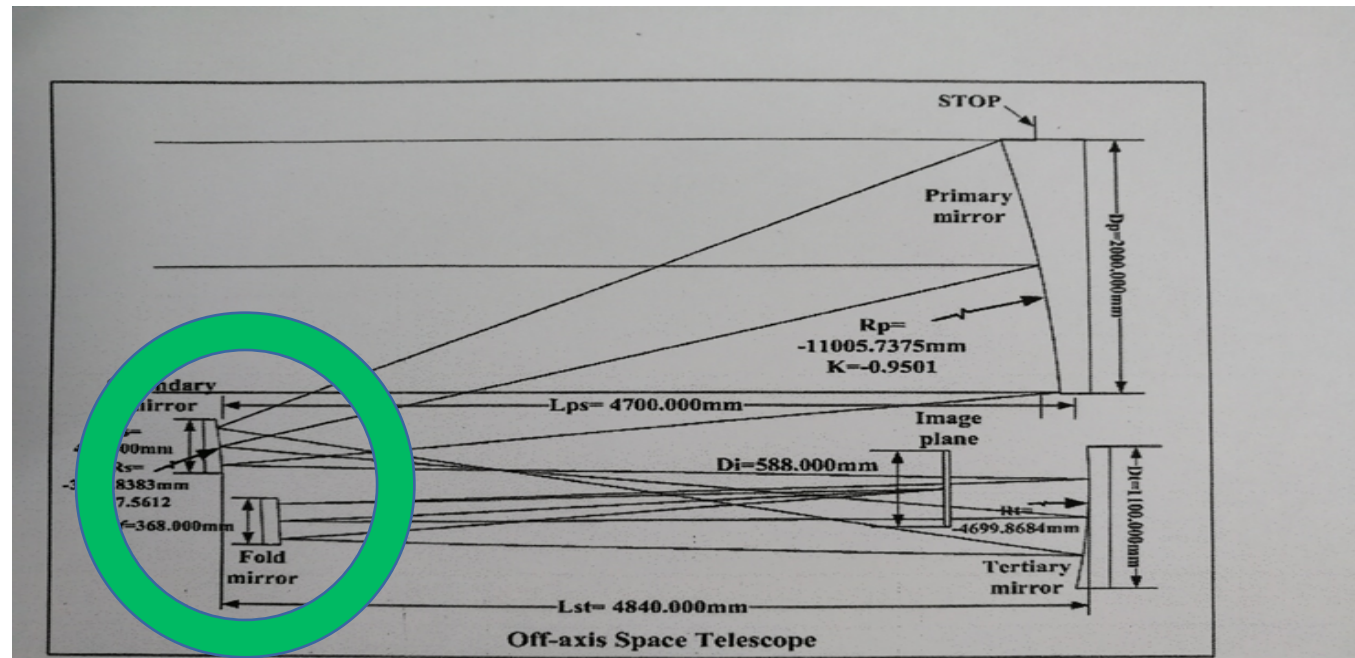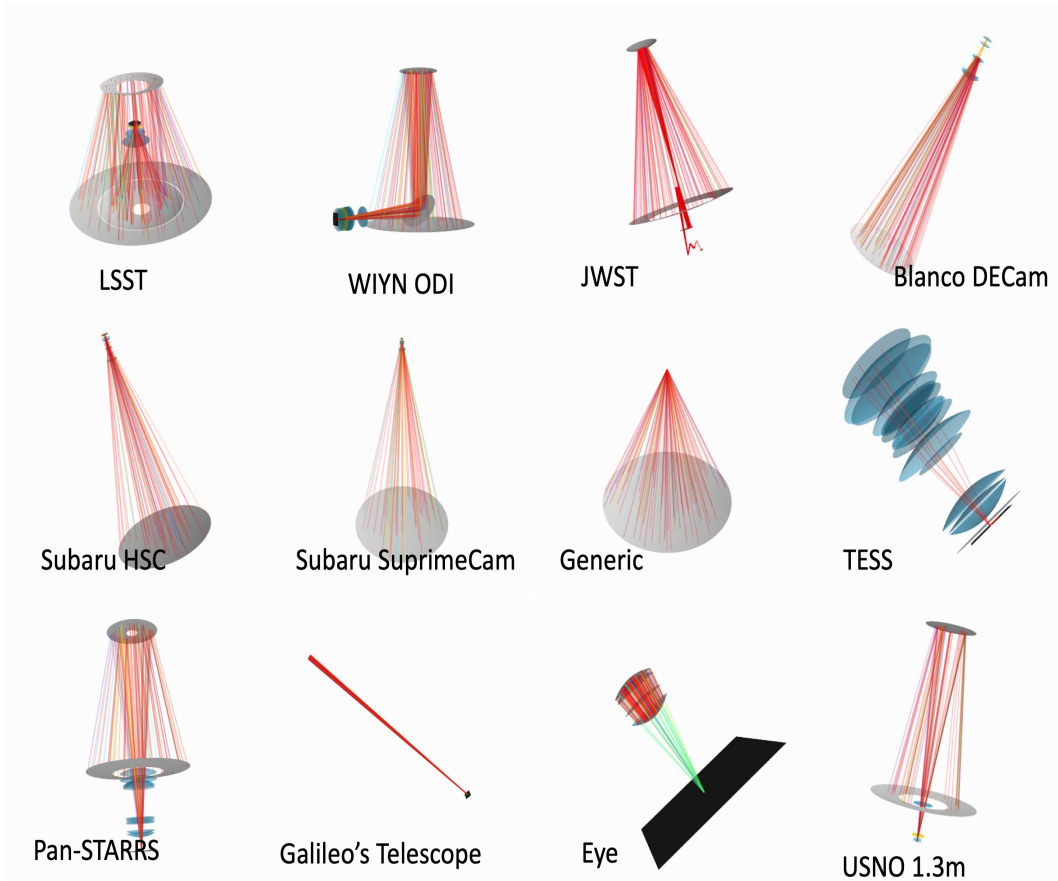
Progress—optics—vibration
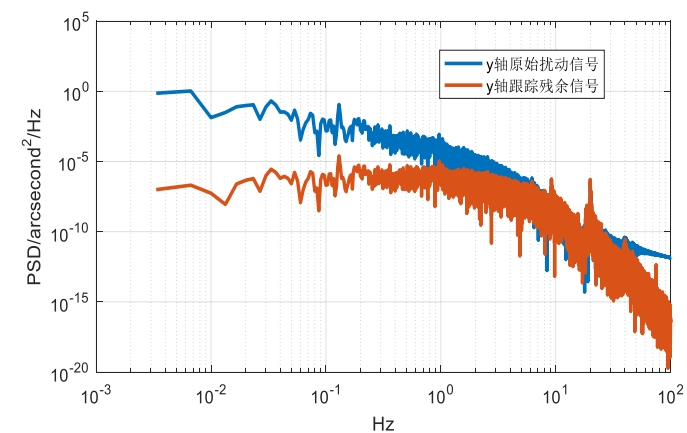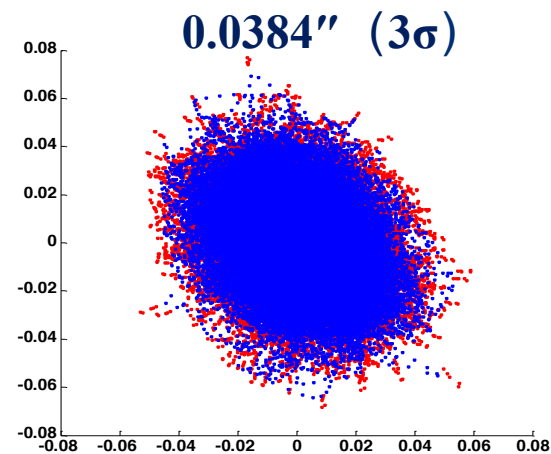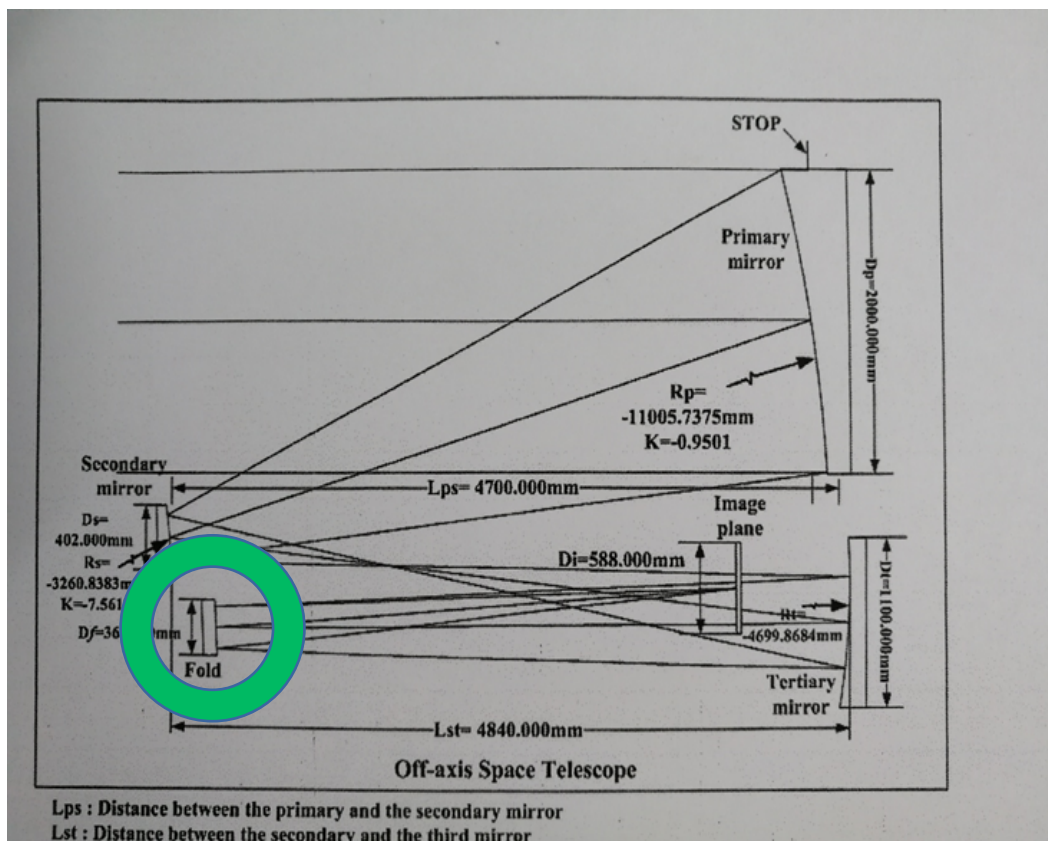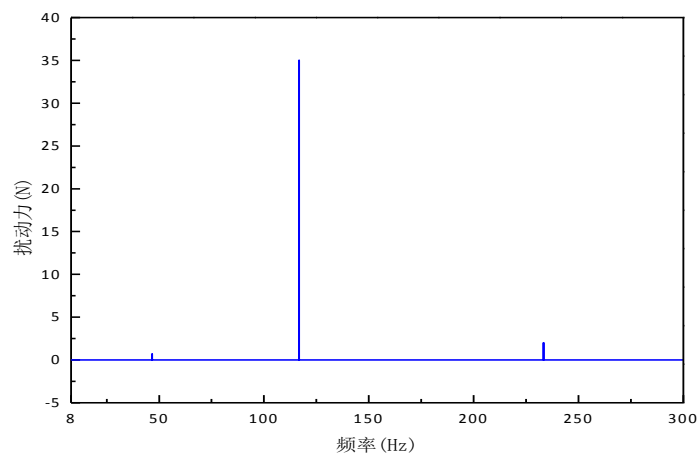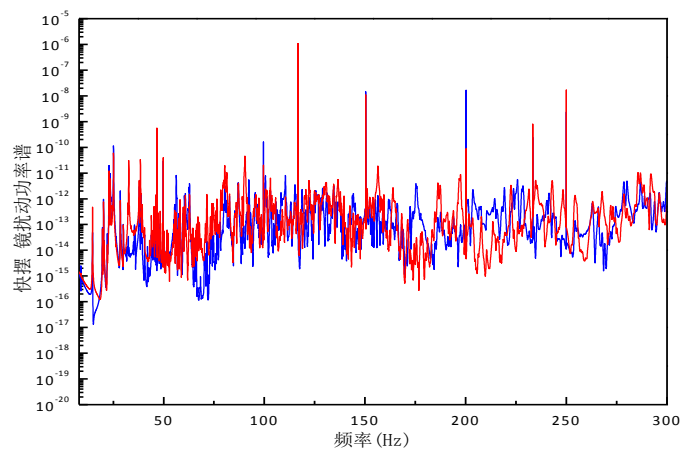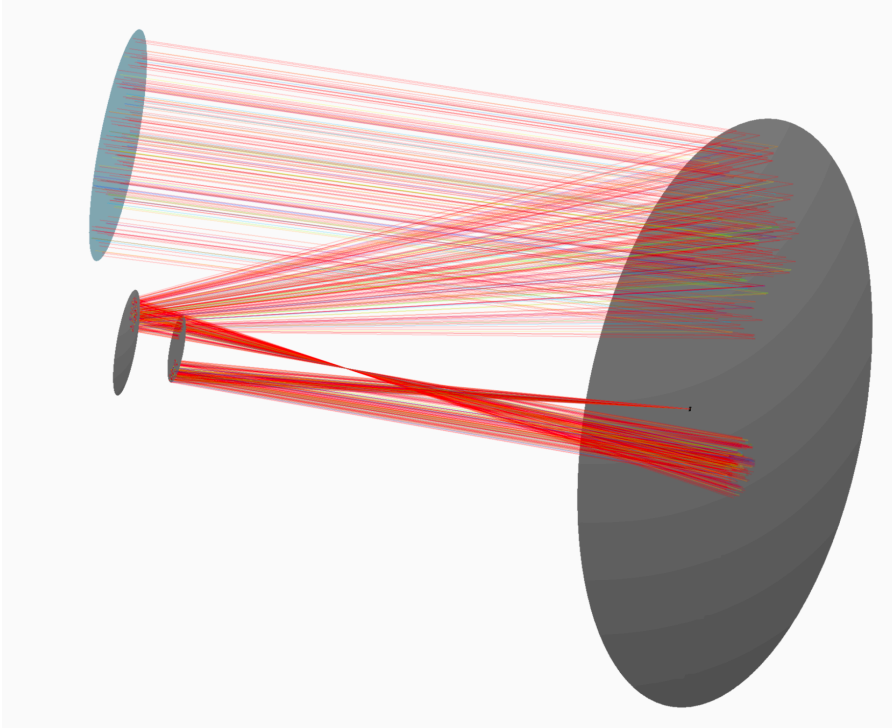
Progress—update requirement

- The speed of simulation

- The more realistic PSF and PSF field

- The synthetic effects of the optics and CCD

- An integrated simulator···

Phosim

--by John Peterson

LSST

WIYN ODI

JWST

Blanco DECam

Subaru HSC

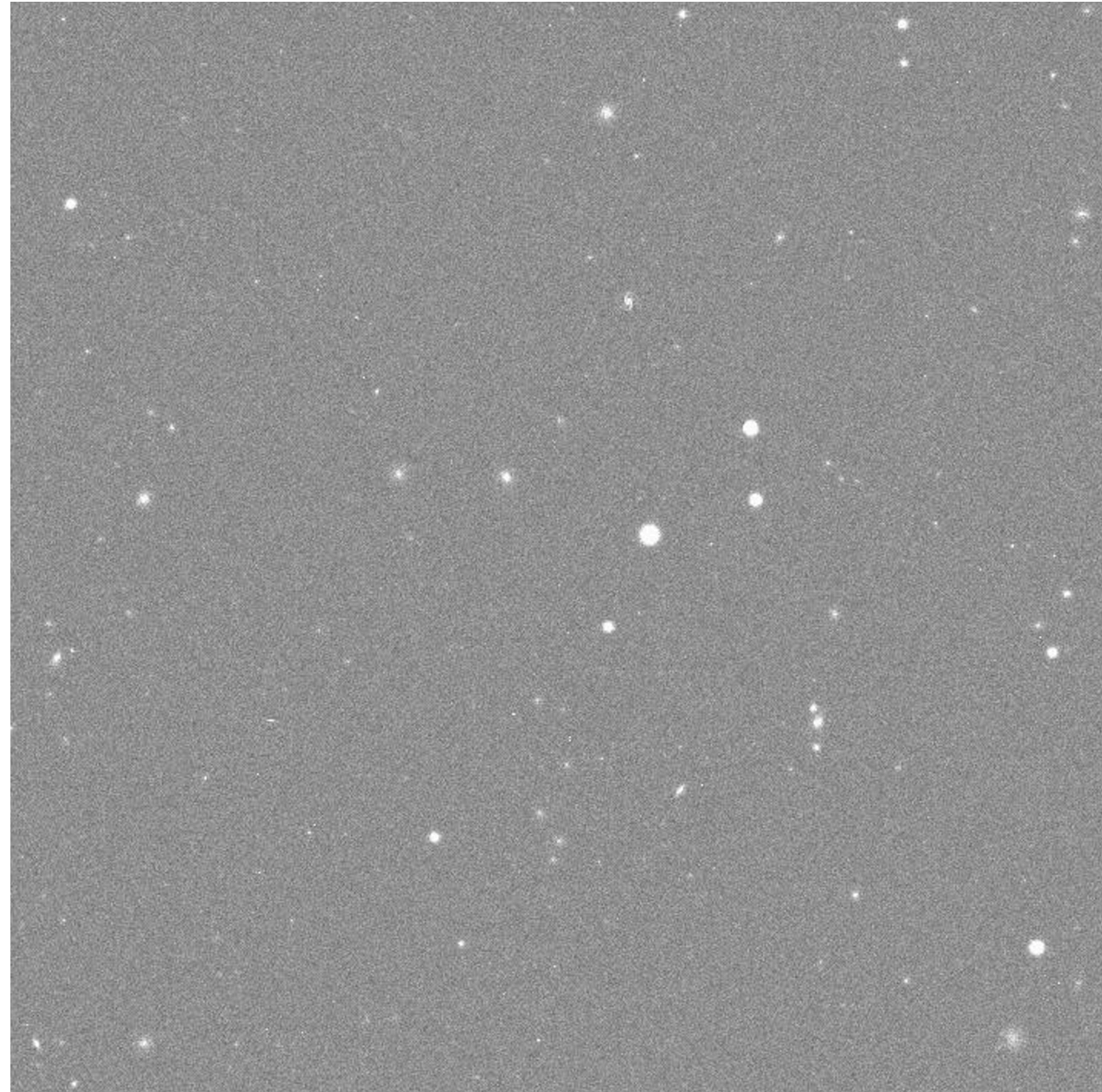Subaru SuprimeCam

Generic

TESS

Pan-STARRS

Galileo's Telescope

Eye

USNO 1.3m

Phosim

1. Fast，100 times faster than Zemax.
2. Integral simulation，mimics a lot of effects.
3. Each effect can be turn on/off individually.

In the future

- N-body simulation with box size of 1.5Gpc/h and 8000^3 particles
- More sophisticated catalogs
- Focus on Phosim
- Slitless spectrophotometer
- CCD/CMOS simulation

项目	EE80角半径	衰减量占比分析	EE80角半径	衰减量占比分析
ideal	0.0673"	0	0.0673"	0
gravity+设计值	0.0768"	14.1%	0.0768"	14.1%
Fluctuation on mirrors+设计值	0.0813"	20.8%	0.0902"	34.0%
thermal+设计值	0.0852"	26.6%	0.0852"	26.6%
强制位移+设计值	0.0708"	5.2%	0.0708"	5.2%
结果（RSS）	0.0922"	37.0%	0.0995"	47.9%