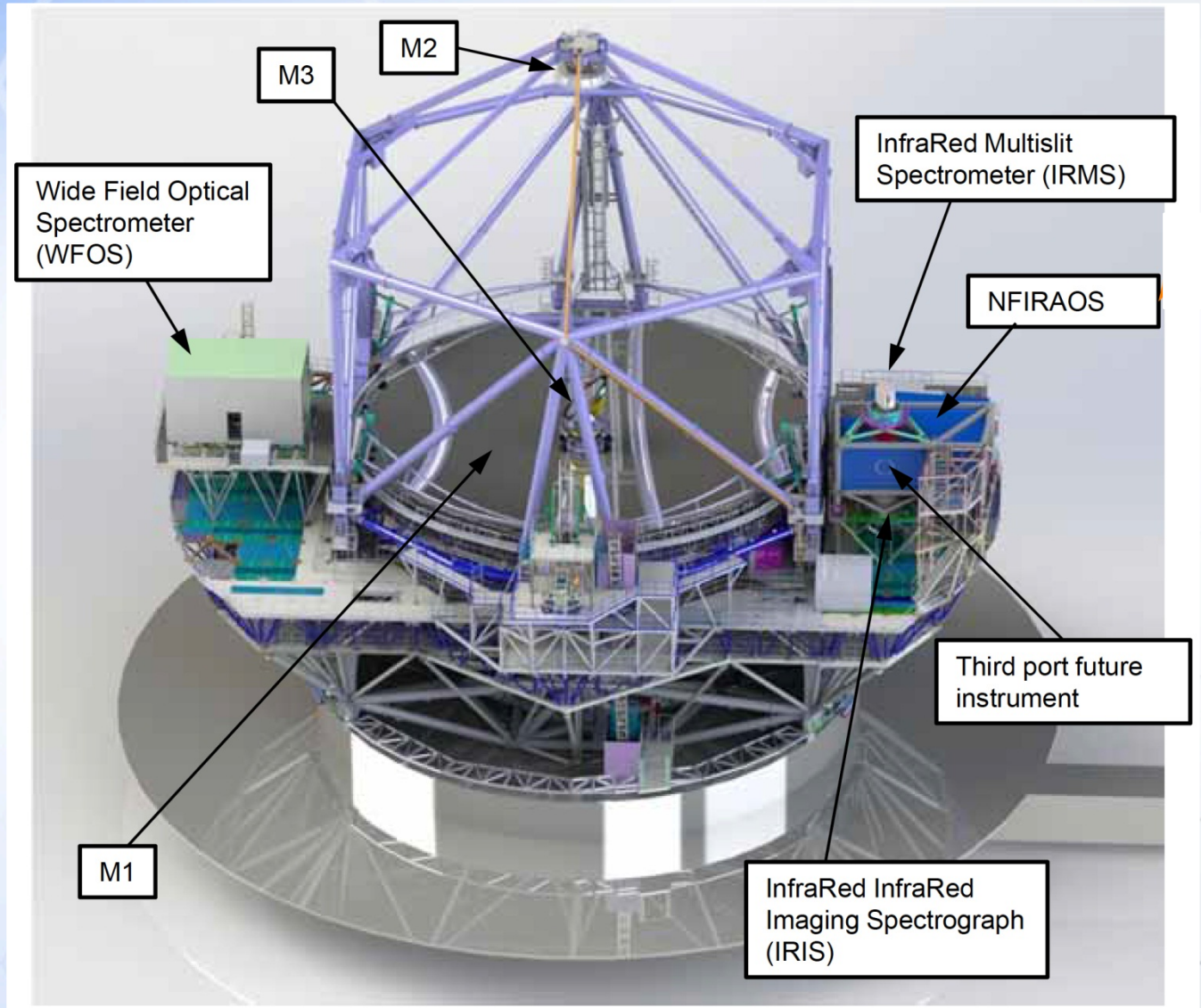
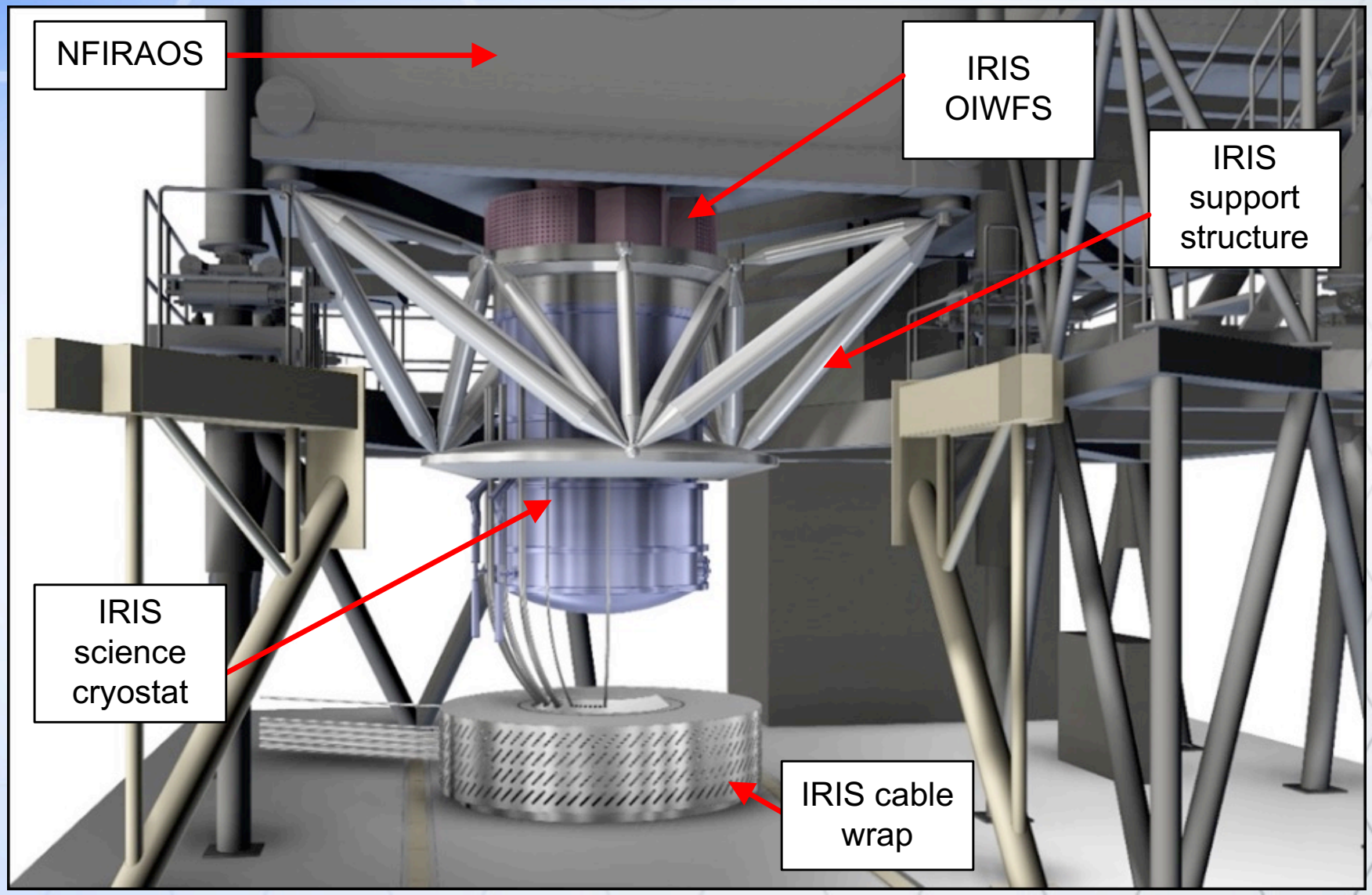
TMT/IRISのマイクロレンズアレイ及びスライサーIFU

国立天文台
早野　裕

TMT/IRIS

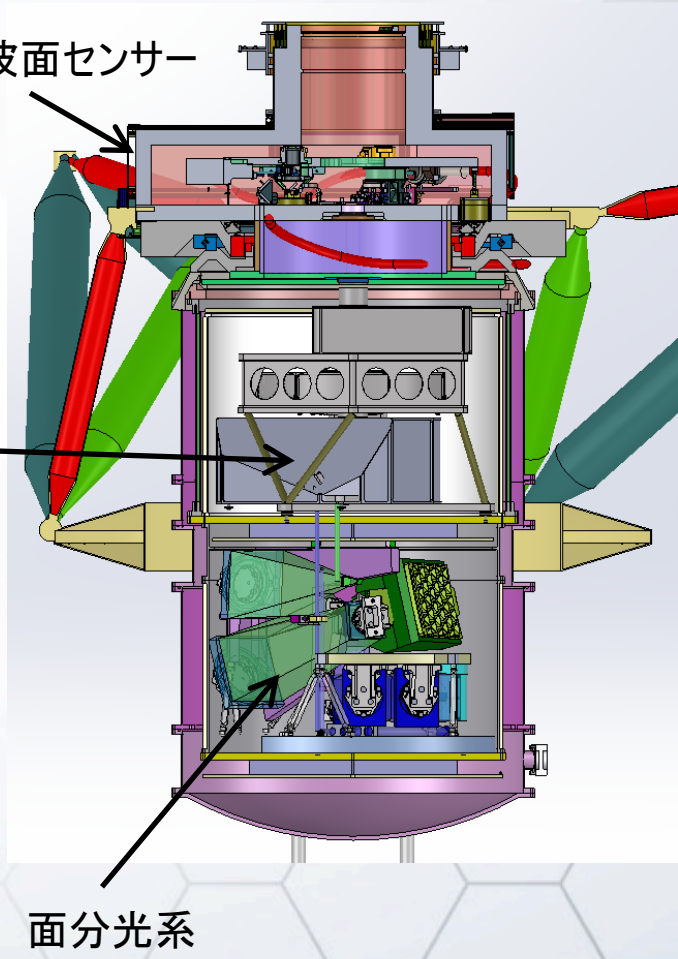

M2
M3
InfraRed Multislit Spectrometer (IRMS)
Wide Field Optical Spectrometer (WFOS)
NFIRAOS
Third port future instrument
M1
InfraRed InfraRed Imaging Spectrograph (IRIS)

IRIS hung under NFIRAOS

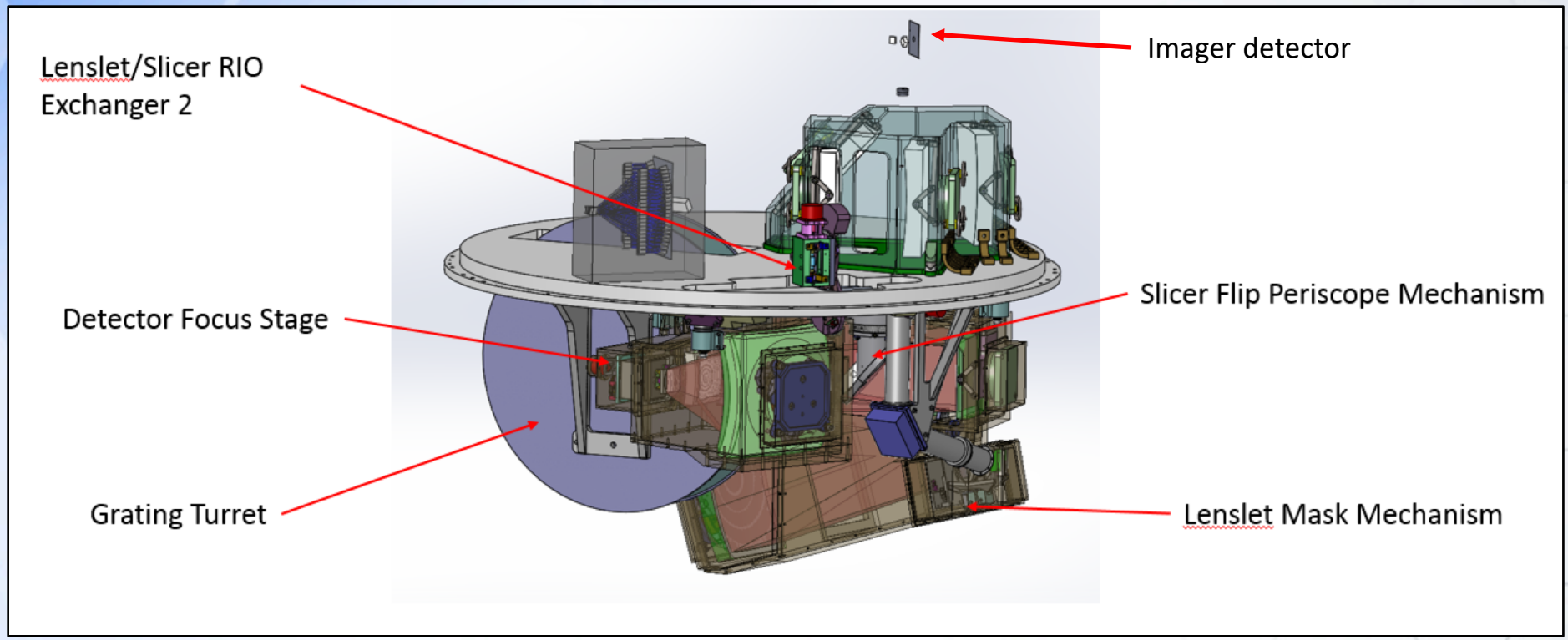


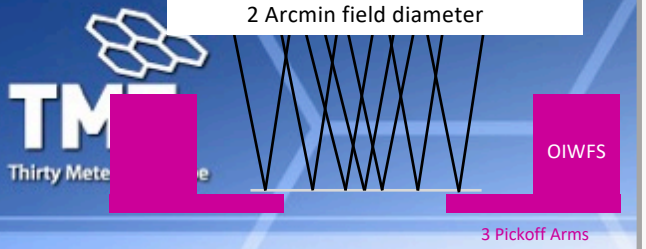
IRIS Capabilities

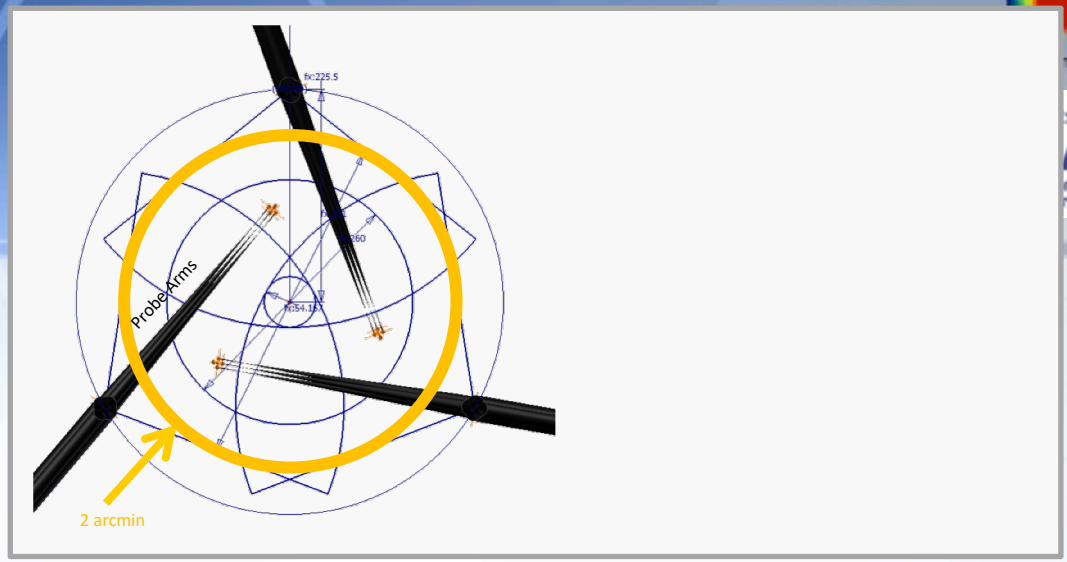
- First Light Imager and Spectrograph working in parallel at the diffraction limit of the Thirty Meter Telescope.
  - NGSAO and LGS MCAO with NFIRAOS
  - Wavelength Range 0.84-2.4 microns
  - RMS Wavefront Error < 40 nm in fine scales
  - High Order Atmospheric Dispersion Correction
- On-Instrument wavefront sensors (OIWFS).
  - Three sensors to measure tip/tilt, focus and distortion across field.
  - Near infrared sensors to gain from NFIRAOS AO correction.
- “Wide-Field” Imager
  - 34 arcsec field of view (2x2 grid of H4RG-10 Teledyne Detectors)
  - 4 mas plate scale (Nyquist @ 1.15 μm)
- Integral Field Spectrograph (H4RG-15 Teledyne Detector)
  - IFS with Four Plate Scales (4, 9, 25 and 50 mas per sample)
    - Up to 14,378 individual, simultaneous spectra.
  - Spectral Resolutions of 4000, 8000 and few exotic modes



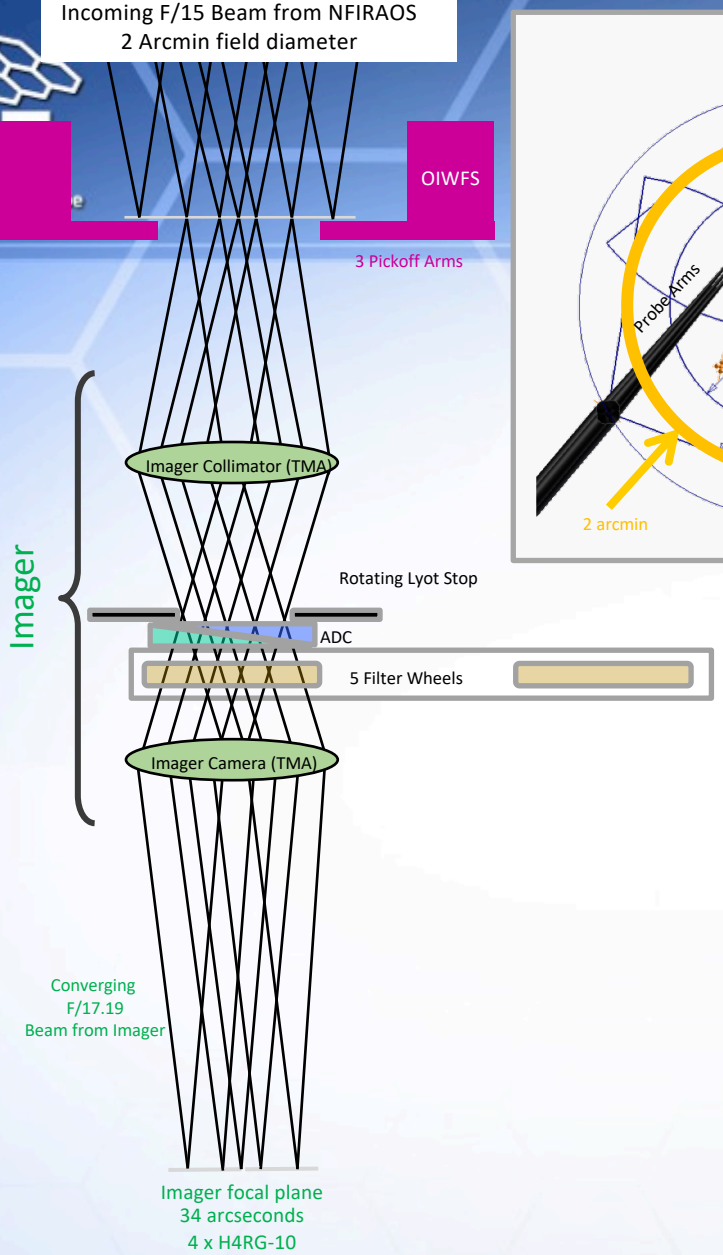
Integral Field Spectrograph Optomechanical

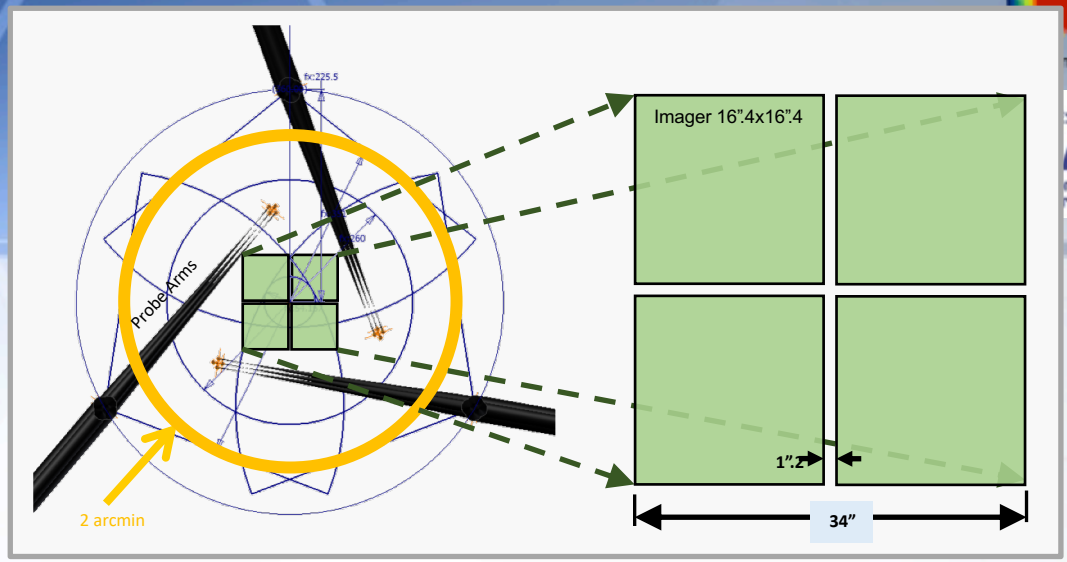






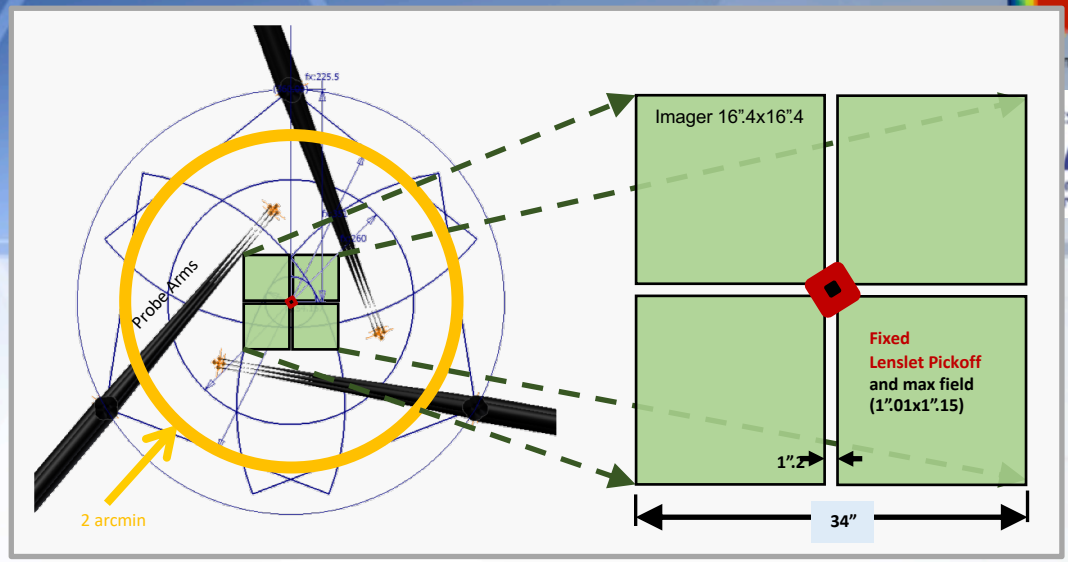
Three OIWFS Arms patrol 2 arcminute NFIRAOS output field.

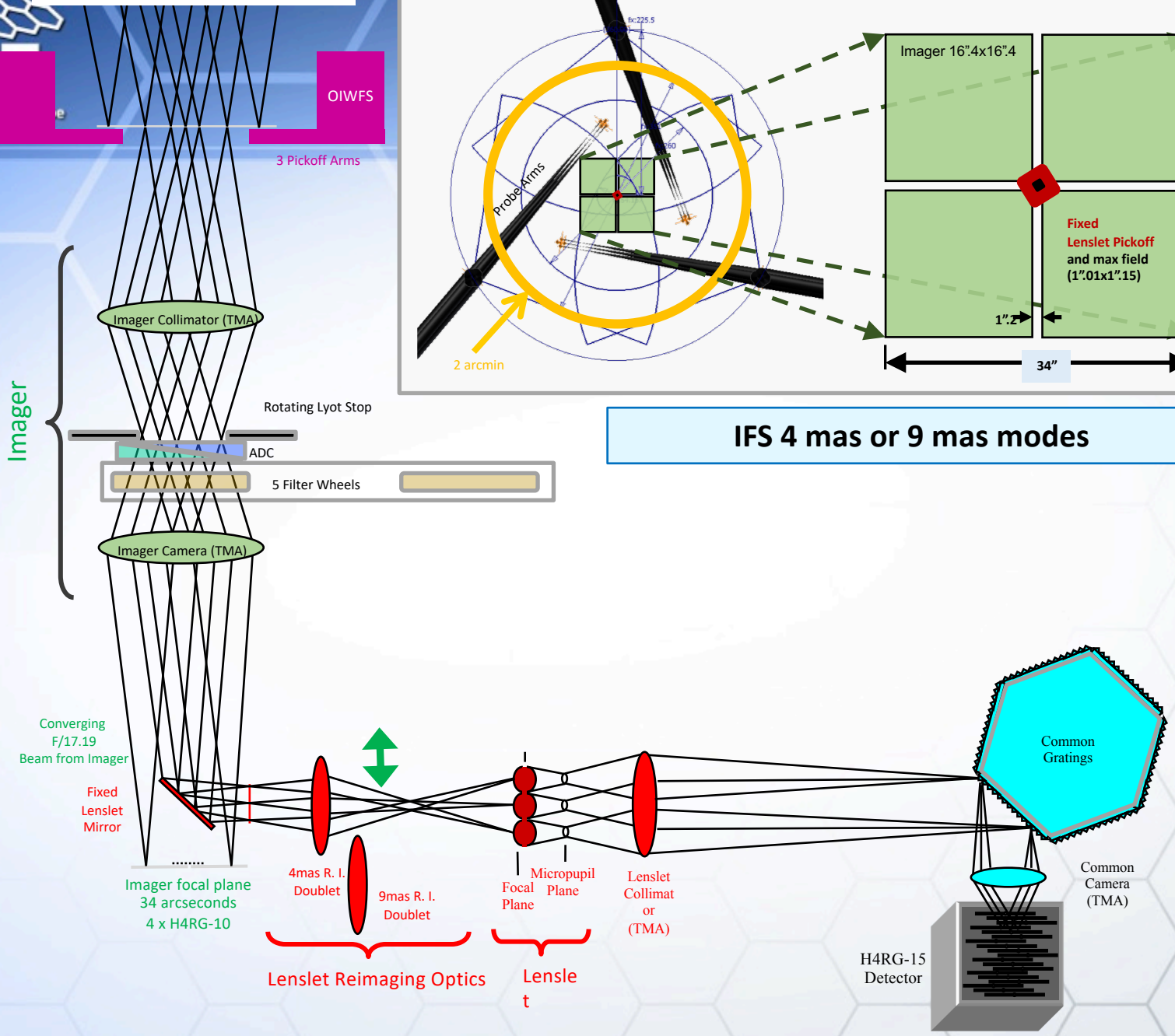




Imager with 4mas pixels
~34 arcsec field.

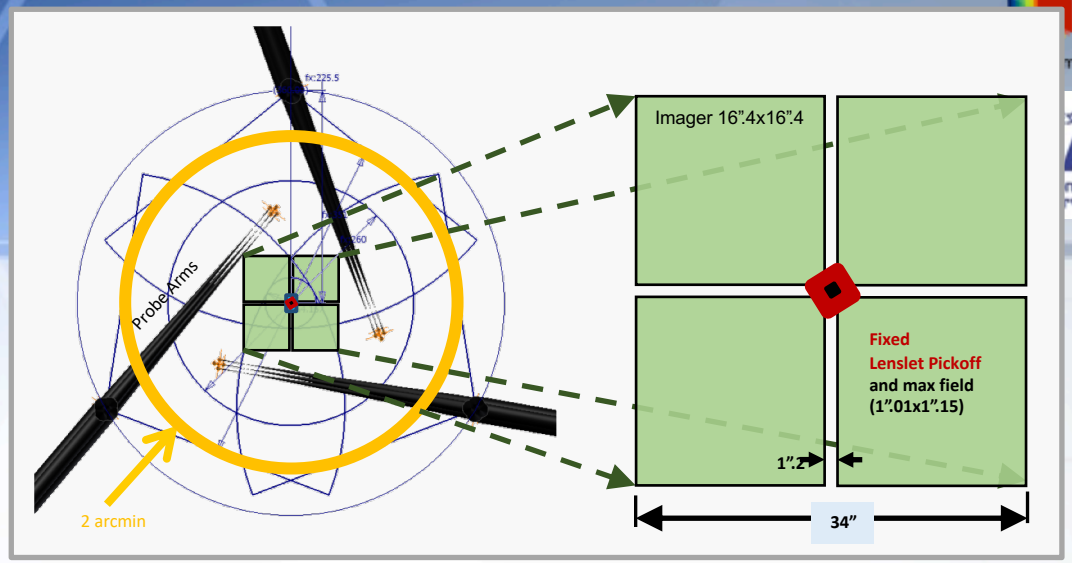
Incoming F/15 Beam from NFIRAOS
2 Arcmin field diameter



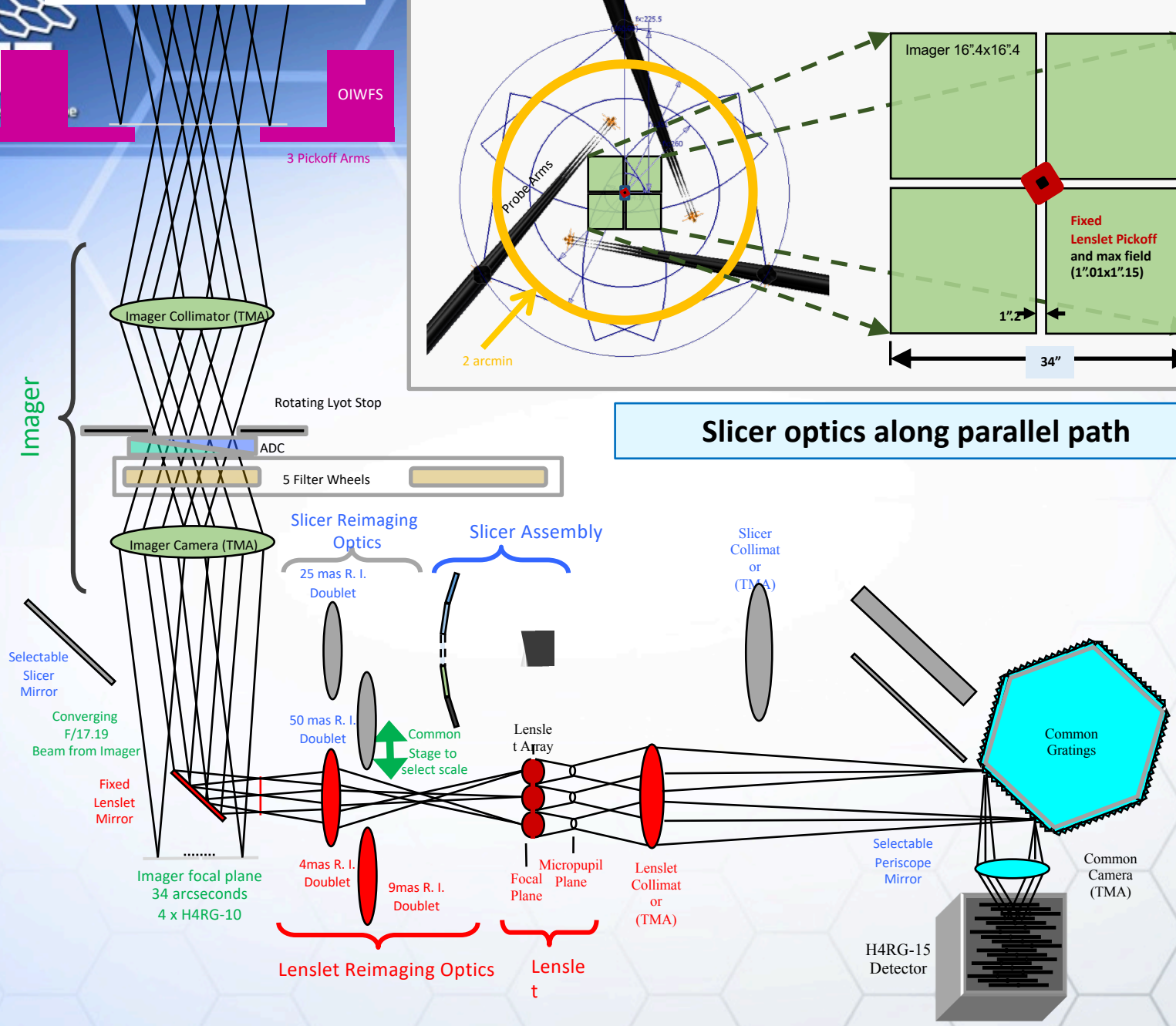


IFS 4 mas or 9 mas modes

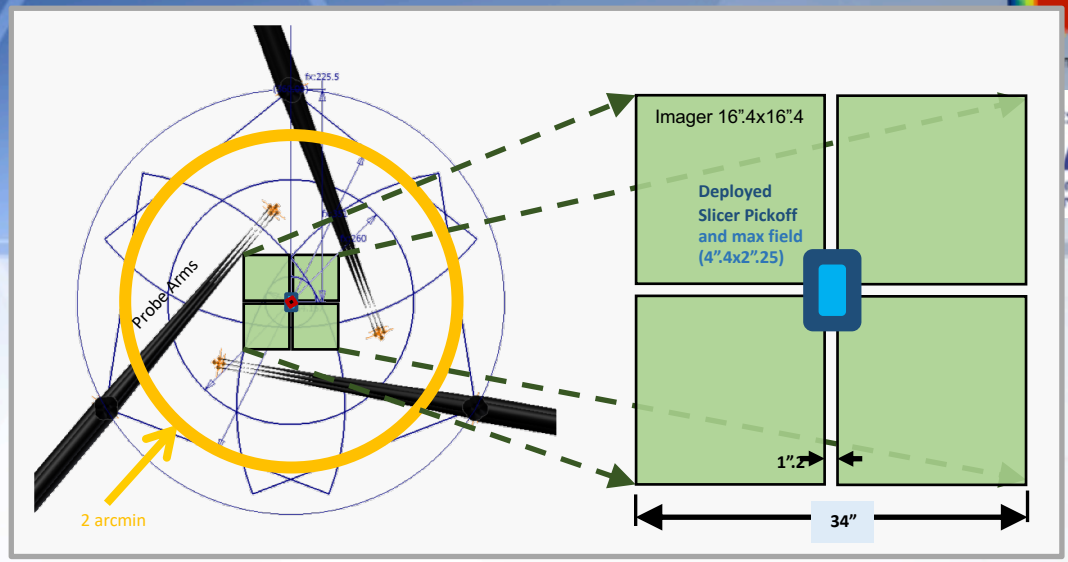
Incoming F/15 Beam from NFIRAOS
2 Arcmin field diameter



Slicer optics along parallel path



Incoming F/15 Beam from NFIRAOS
2 Arcmin field diameter



50 mas mode

OIWFS

3 Pickoff Arms

Imager

Imager Collimator (TMA)

Rotating Lyot Stop

ADC

5 Filter Wheels

25 mas R. I. Doublet

Imager Camera (TMA)

Slicer Assembly

Slicer Collimator (TMA)

Selectable Slicer Mirror

50 mas R. I. Doublet

Converging F/17.19 Beam from Imager

Common Stage to select scale

Lenslet Array

Fixed Lenslet Mirror

4mas R. I. Doublet

9mas R. I. Doublet

Common Gratings

Imager focal plane
34 arcseconds
4 x H4RG-10

Focal Plane

Micropupil Plane

Lenslet Collimator (TMA)

Selectable Periscope Mirror

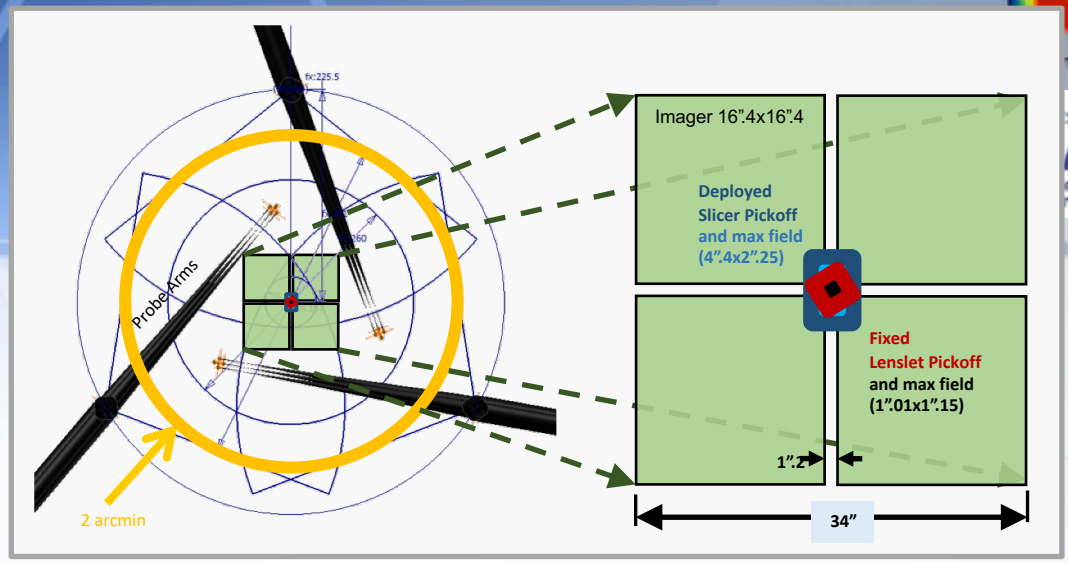
Common Camera (TMA)

H4RG-15 Detector

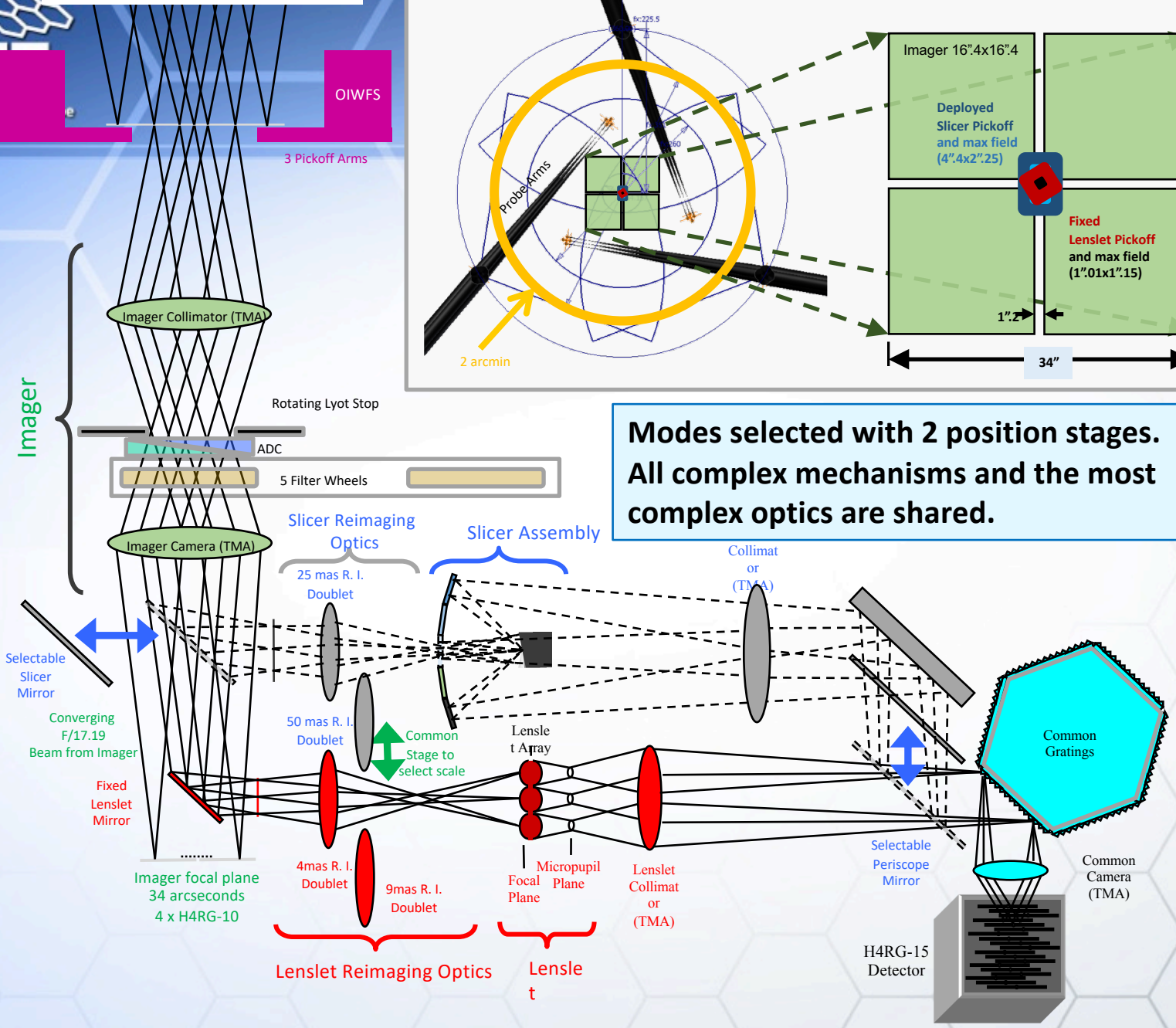
Lenslet Reimaging Optics

Lenslet

Incoming F/15 Beam from NFIRAOS
2 Arcmin field diameter



Modes selected with 2 position stages. All complex mechanisms and the most complex optics are shared.



SLICER SPECTROGRAPH

- Coarse platescales/ Wide FOV
- Slicer has 88 units rearranged into 2 pseudoslits, each with 2x22 “brick wall” pattern
  - 1.125”x2.2” @ 0.025” scale
  - 2.25”x4.4” @ 0.050” scale
    - Data Product: 45 x 88 x 1600(λ) elements

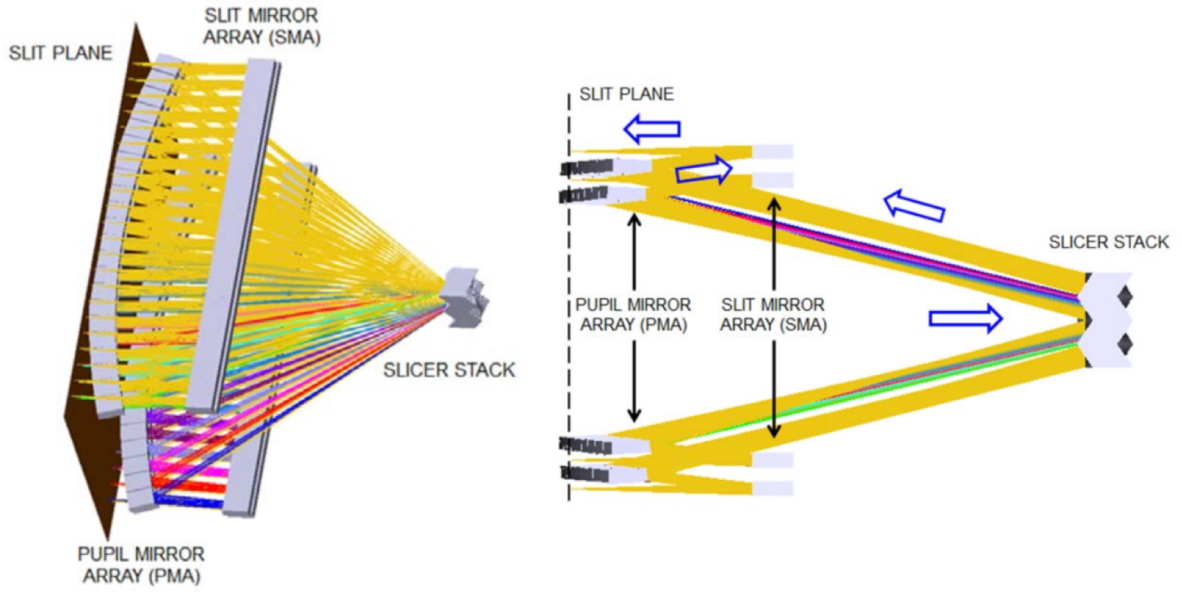


Figure 60 - CAD model of the IRIS image slicer shown (left) in isometric and (right) side view. All 88 channels are shown. The trace begins at the slicer stack and ends at the slicer long slit plane. Note that the IFU is shown here

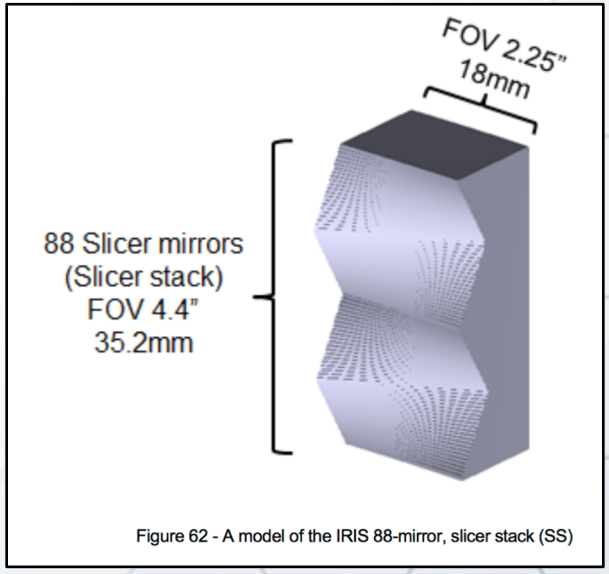
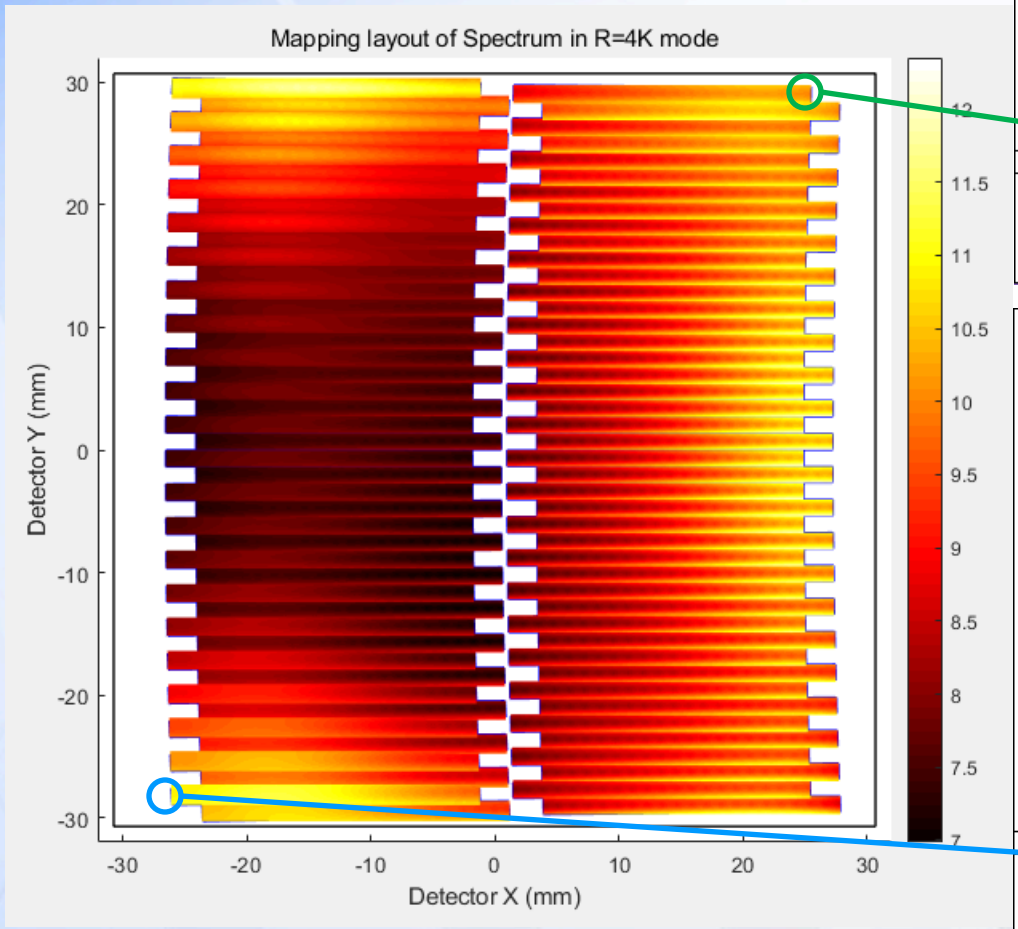
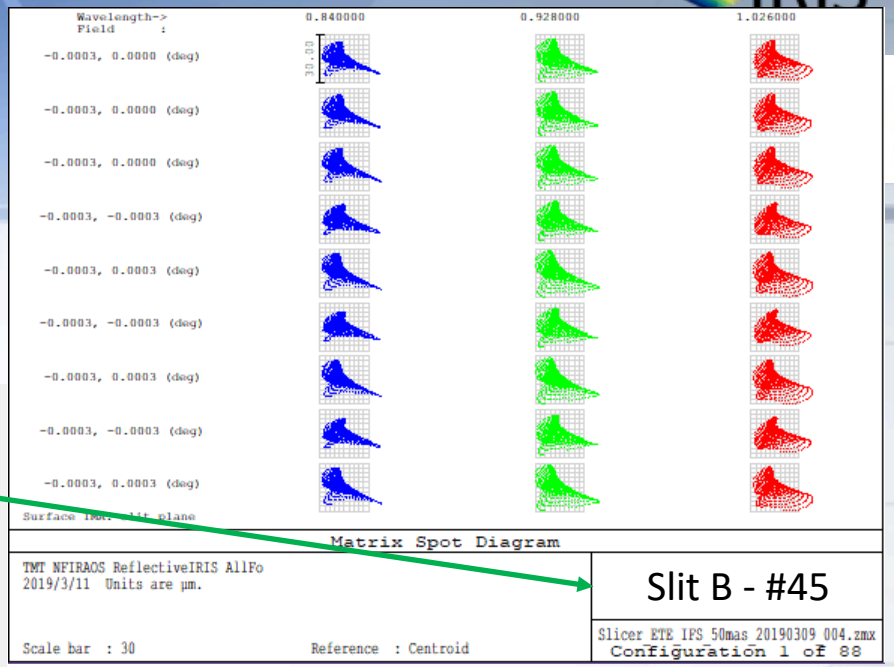


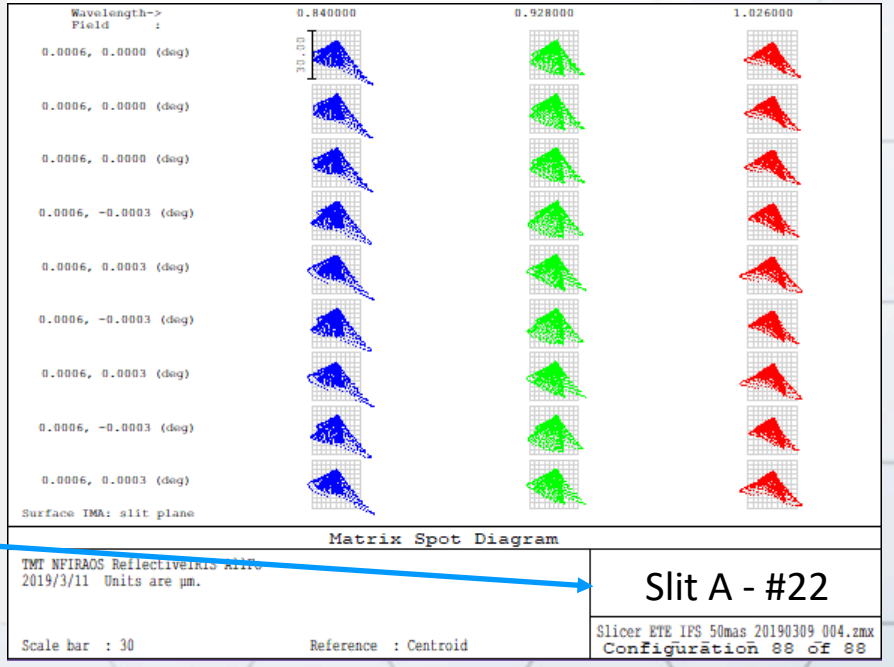
Figure 62 - A model of the IRIS 88-mirror, slicer stack (SS)

Image Quality

- Spot radius RMS distribution

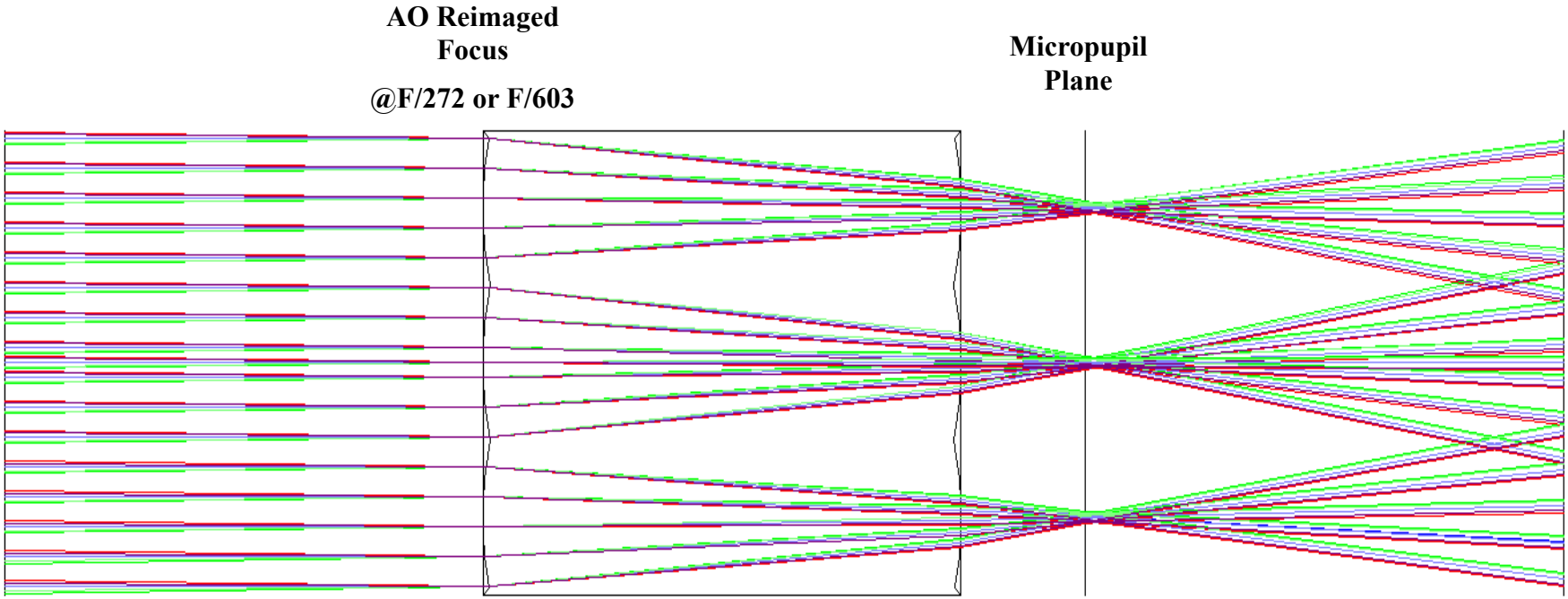




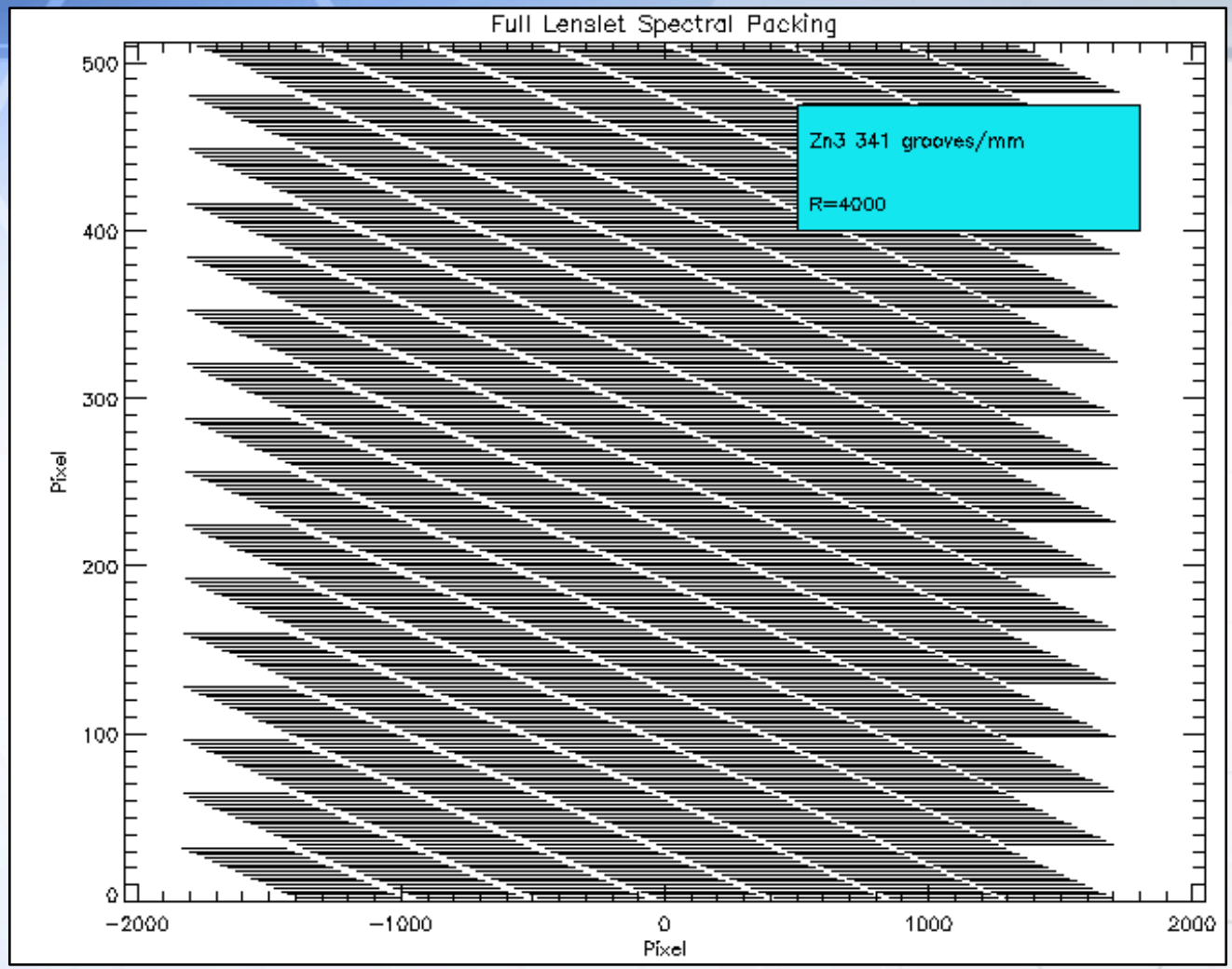


LENSLET ARRAY

- 112 x 128 elements each with 500 spectral elements
  - 0.45”x0.51” @ 0.004” scale
  - 1.01”x1.15” @ 0.009” scale
- Spot sizes set primarily by diffraction



Simulated Spectra



Stretched vertically to show individual spectra (only lower 512 rows)

IRIS Imager/IFS capabilities

Table 2: A top-level summary of IRIS capabilities with an R=4,000 spectral resolution requirement and a higher spectral resolution R=8,000 and 10,000 as an instrument goal. Both the grating and filter selection have been prioritized by the science team.

Capability mode	*Spatial sampling (mas)*	*Field of View (arcsec)*	*Resolution ($\lambda/d\lambda$)*	*Min/Max wavelength (μm)*	*Bandpass[3]*
Imager	4 mas	34 x 34	Set by filter	0.84-2.4	60 filters BB[1] and NB[2]
Slicer IFS					
88x45 Spaxels	50 mas	4.4 x 2.25	4,000, 8,000	0.84-2.4	20%,5%
	25 mas	2.2 x 1.125	4,000, 8,000	0.84-2.4	20%,5%
Slicer IFS					
44 x 45 Spaxels	50 mas	2.2 x 2.25	4,000, 8,000	0.84-2.4	20%,5%, H+K
	25 mas	1.1 x 1.125	4,000, 8,000	0.84-2.4	20%,5%, H+K
Lenslet IFS					
112x128 Spaxels	9 mas	1.01 x 1.15	4,000	0.84-2.4	5%
	4 mas	0.45 x 0.51	4,000	0.84-2.4	5%
Lenslet IFS					
16x128 Spaxels	9 mas	0.144 x 1.15	4,000, 8,000	0.84-2.4	20%, H+K
	4 mas	0.064 x 0.51		0.84-2.4	20%, H+K

IRIS gratings (2017/3/15)

#	NAME	Grooves (per mm)	Blaze angle	Filters	Field mode	Resolution	4mas	9mas	25mas	50mas
1	Z4000	341	9.86	Zbb	Slicer	4000			1.125"x2.25"	2.25"x4.5"
				Zn1-Zn4	Lenslet 112x128	4000	0.448"x0.512"	1.008"x1.152"		
2	Y4000	290	9.86	Ybb	Slicer	4000			1.125"x2.25"	2.25"x4.5"
				Yn1-Yn4	Lenslet 112x128	4000	0.448"x0.512"	1.008"x1.152"		
3	J4000	249	9.86	Jbb	Slicer	4000			1.125"x2.25"	2.25"x4.5"
				Jn1-Jn4	Lenslet 112x128	4000	0.448"x0.512"	1.008"x1.152"		
4	H4000	194	9.86	Hbb	Slicer	4000			1.125"x2.25"	2.25"x4.5"
				Hn1-Hn5	Lenslet 112x128	4000	0.448"x0.512"	1.008"x1.152"		
5	K4000	145	9.86	Kbb	Slicer	4000			1.125"x2.25"	2.25"x4.5"
				Kn1-Kn5	Lenslet 112x128	4000	0.448"x0.512"	1.008"x1.152"		
6	HK4000	167	9.86	H+K	Lenslet 16x128	4000	0.064"x0.512"	0.144"x1.152"		
7	Z8000	709	20.54	Zn1-Zn4	Slicer	8000			1.125"x2.25"	2.25"x4.5"
				Zbb	Lenslet 16x128	8000	0.064"x0.512"	0.144"x1.152"		
8	Y8000	606	20.54	Yn1-Yn4	Slicer	8000			1.125"x2.25"	2.25"x4.5"
				Ybb	Lenslet 16x128	8000	0.064"x0.512"	0.144"x1.152"		
9	J8000	516	20.54	Jn1-Jn4	Slicer	8000			1.125"x2.25"	2.25"x4.5"
				Jbb	Lenslet 16x128	8000	0.064"x0.512"	0.144"x1.152"		
10	H8000	398	20.54	Hn1-Hn5	Slicer	8000			1.125"x2.25"	2.25"x4.5"
				Hbb	Lenslet 16x128	8000	0.064"x0.512"	0.144"x1.152"		
11	K8000	310	20.54	Kn1-Kn3	Slicer	8000			1.125"x2.25"	2.25"x4.5"
12		282	20.54	Kn4-Kn5	Slicer	8000			1.125"x2.25"	2.25"x4.5"
13		296	20.54	Kbb	Lenslet 16x128	8000	0.064"x0.512"	0.144"x1.152"		
14	Z10000	872	26	Zbb	Lenslet 16x128	10,000	0.064"x0.512"	0.144"x1.152"		
15	Y10000	741	26	Ybb	Lenslet 16x128	10,000	0.064"x0.512"	0.144"x1.152"		
16	J10000	637	26	Jbb	Lenslet 16x128	10,000	0.064"x0.512"	0.144"x1.152"		
17	H10000	497	26	Hbb	Lenslet 16x128	10,000	0.064"x0.512"	0.144"x1.152"		
18	K10000	371	26	Kbb	Lenslet 16x128	10,000	0.064"x0.512"	0.144"x1.152"		

Grating Rankings (2018/5/3)

	ISDT RANKING (Weighted Ranks)		IRIS Science Team RANKING (Weighted Ranks)		IRIS Science Team + ISDT RANKING (Weighted Ranks)
H4000	6.82	K4000	9.72	K4000	8.33
K4000	6.59	H4000	8.61	H4000	8.18
J4000	6.38	J4000	8.33	J4000	7.68
H8000	5.97	HK4000	6.83	HK4000	6.46
J8000	5.74	Z4000	6.33	Z4000	6.04
K10000	5.67	Y4000	6.06	H8000	5.89
HK4000	5.54	K8000 (Kn1-Kn3)	5.28	Y4000	5.75
Z4000	5.36	K8000 (Kn4-Kn5)	5.22	K8000 (Kn1-Kn3)	5.74
H10000	5.36	H8000	4.33	J8000	5.63
K8000 (Kn1-Kn3)	5.26	K8000 (Kbb)	4.28	K8000 (Kn4-Kn5)	5.30
Y4000	5.13	J8000	4.00	K10000	5.11
K8000 (Kbb)	4.82	Z8000	3.78	K8000 (Kbb)	4.95
K8000 (Kn4-Kn5)	4.64	H10000	3.67	H10000	4.95
J10000	4.46	K10000	3.61	Z8000	4.37
Z8000	4.36	Y8000	3.11	J10000	4.07
Y8000	4.28	J10000	2.83	Y8000	3.93
Z10000	4.13	Z10000	2.67	Z10000	3.47
Y10000	3.69	Y10000	2.17	Y10000	2.88

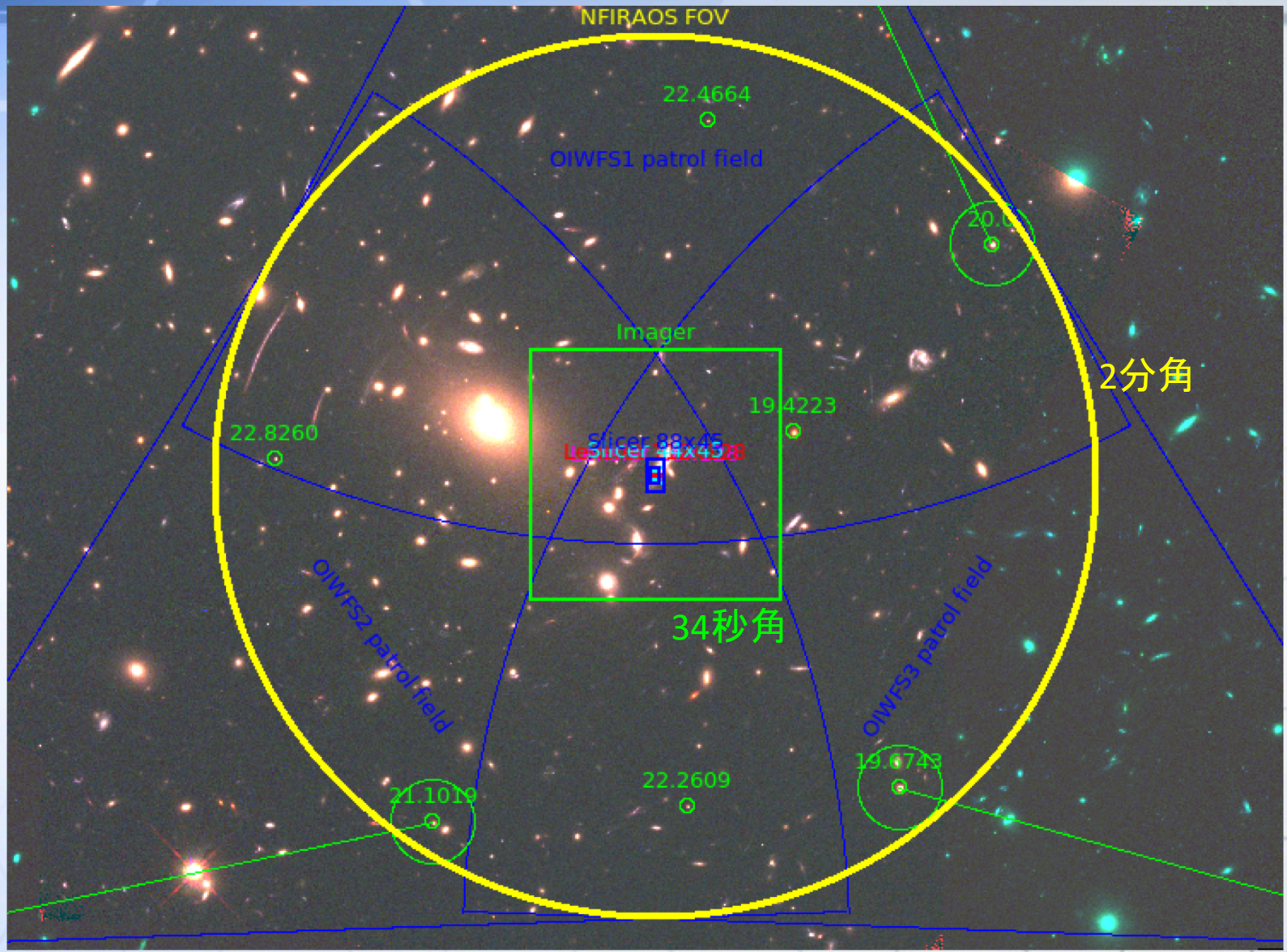
14 gratings

IFS Saturation—1 second integration

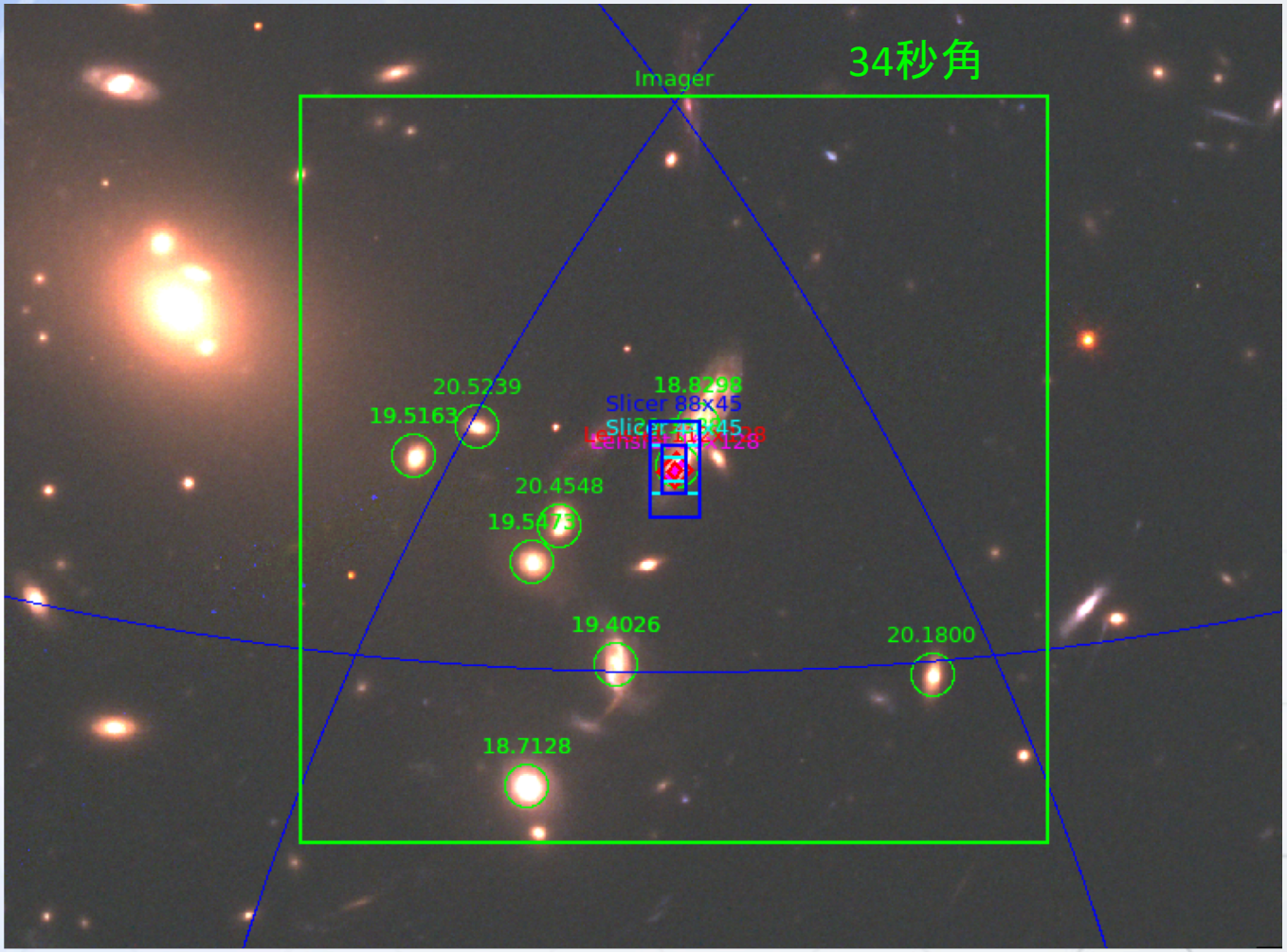
	4 mas Vega (mag)	9 mas Vega (mag)	25 mas Vega (mag)	50 mas Vega (mag)
Zbb	< 8.7	< 10.0	< 11.2	< 11.0
Ybb	< 8.5	< 9.9	< 10.9	< 10.9
Jbb	< 8.1	< 9.6	< 10.5	< 10.6
Hbb	< 7.6	< 9.1	< 10.2	< 10.4
Kbb	< 6.3	< 7.9	< 9.2	< 9.5

Assuming 90% non-linearity at 90,000 e-

Field setup on gravitationally-lensed field with OIWFS, Imager, & IFS

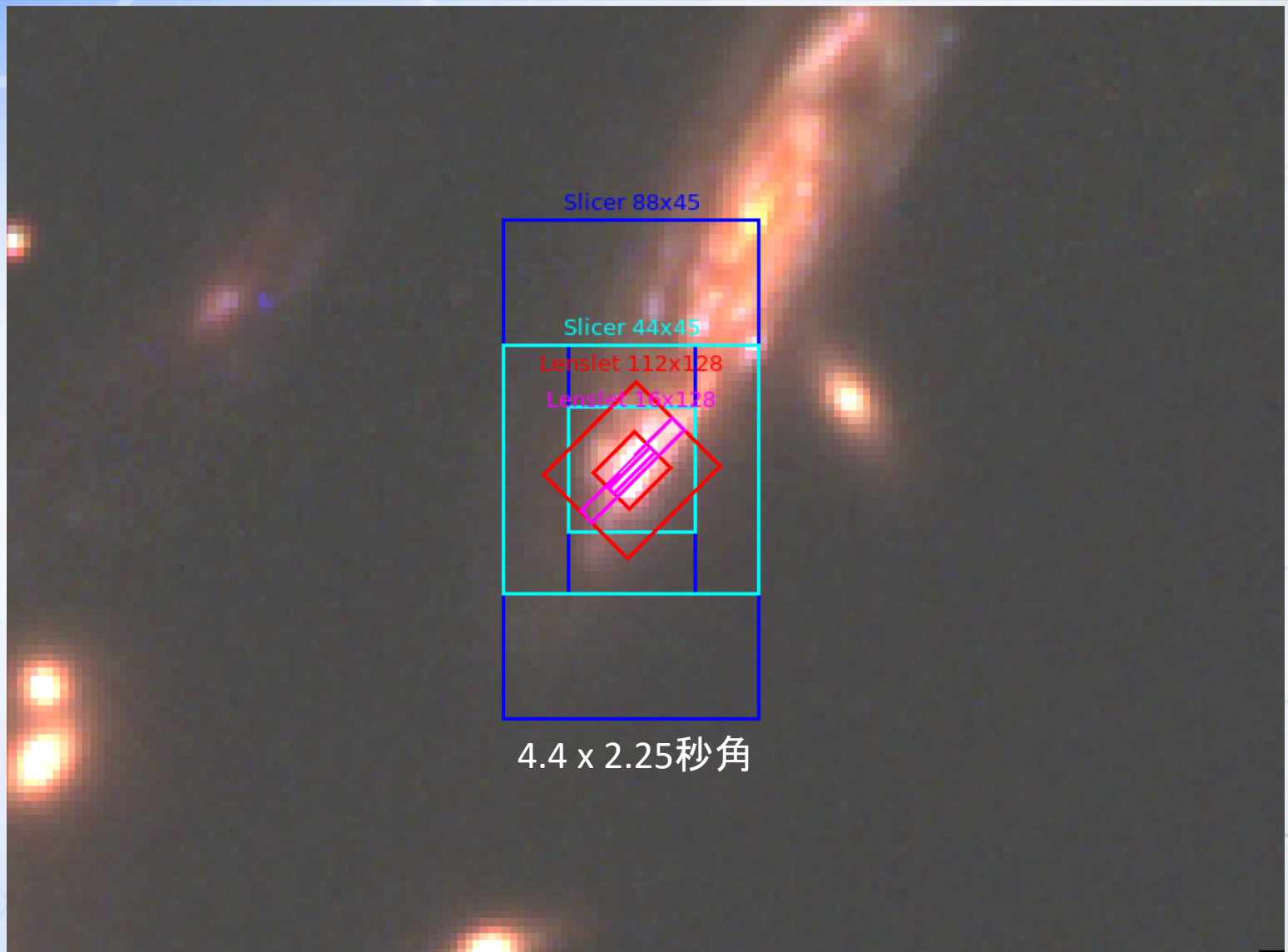


Issues of saturation: IRIS imager 60 second integrations



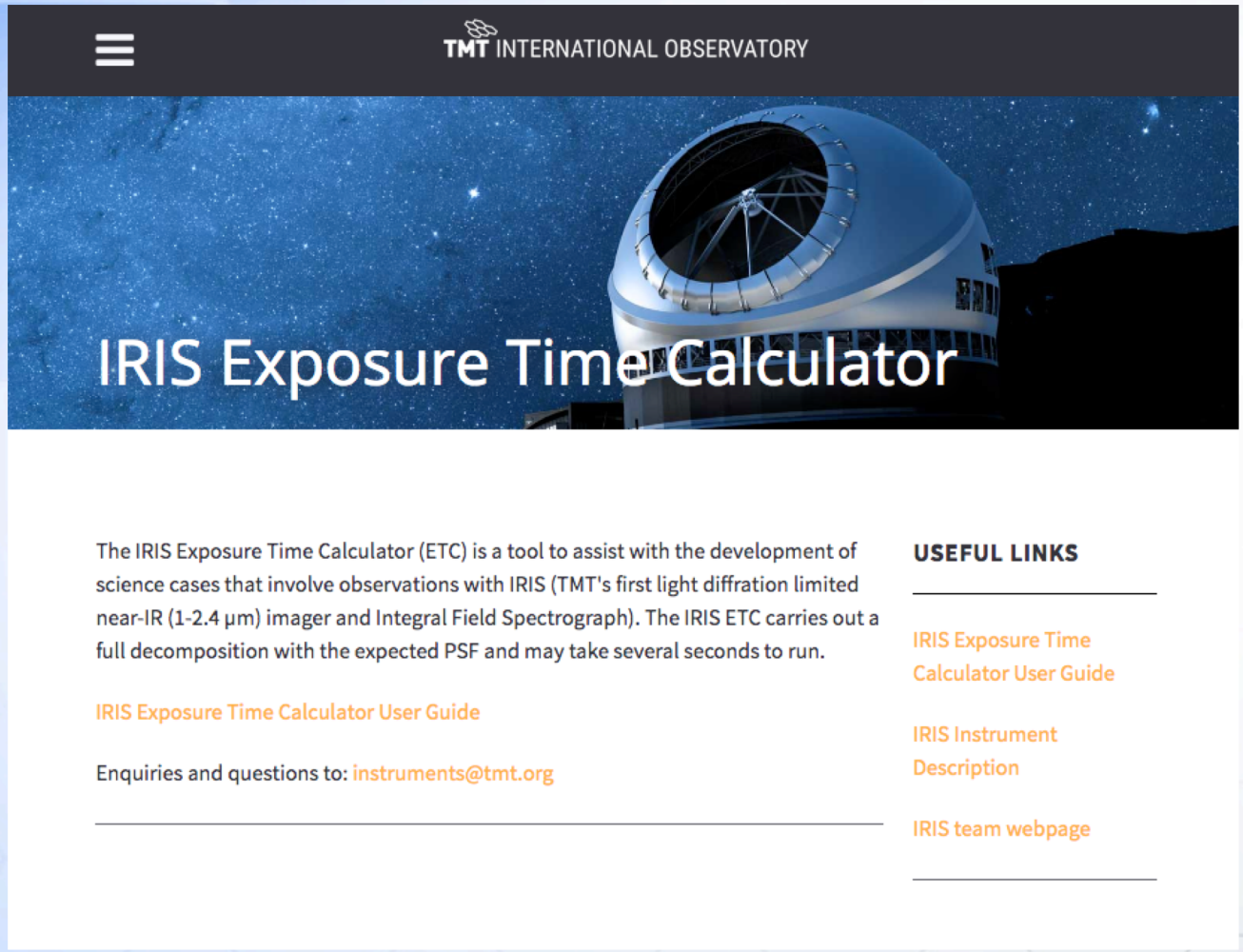
All green highlighted sources will saturate given exposure time

IRIS IFS field of view



IRIS Exposure Time Calculator

https://www.tmt.org/etc/iris



開発途中です。User Guideも含め、バグや不具合、不明な点などのフィードバックを歓迎します。