Association of Universities
for Research in Astronomy

WFMOS PROJECT

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Version: 1

Miyazaki's May '08 WFMOS Meeting Presentation

Reference Document

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	Gemini Engineering:	

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Revision: 1, Scot Kleinman, 17May08. Presented by Satoshi Miyazaki at the Cosmology Near and Far: Science with WFMOS workshop, 21May08.

Hyper Suprime-Cam

Satoshi Miyazaki

National Astronomical Observatory of Japan

2008/05/21

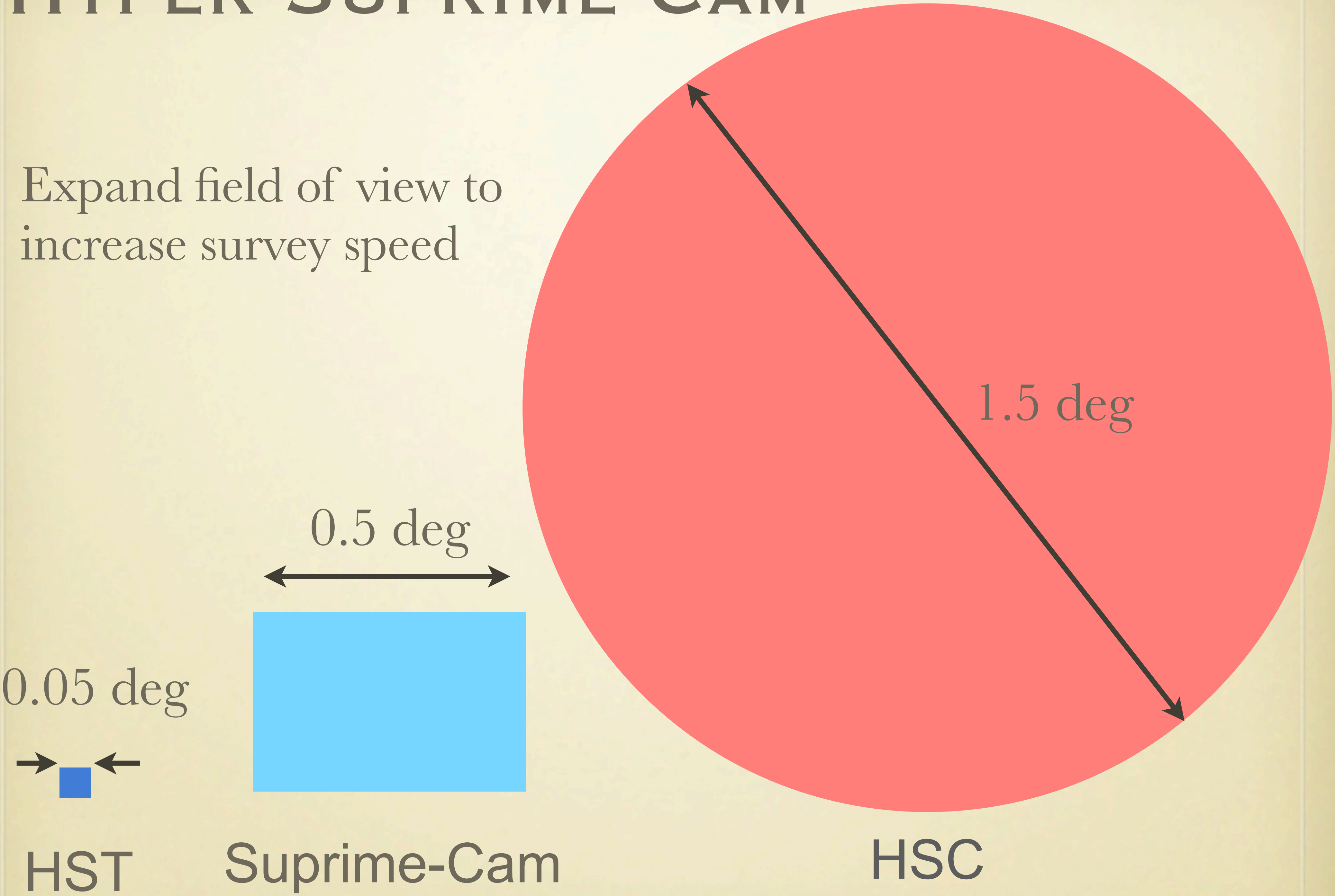
"Cosmology Near and Far: Science with WFMOS"
Waikoloa, Hawaii, May 2008

Introduction

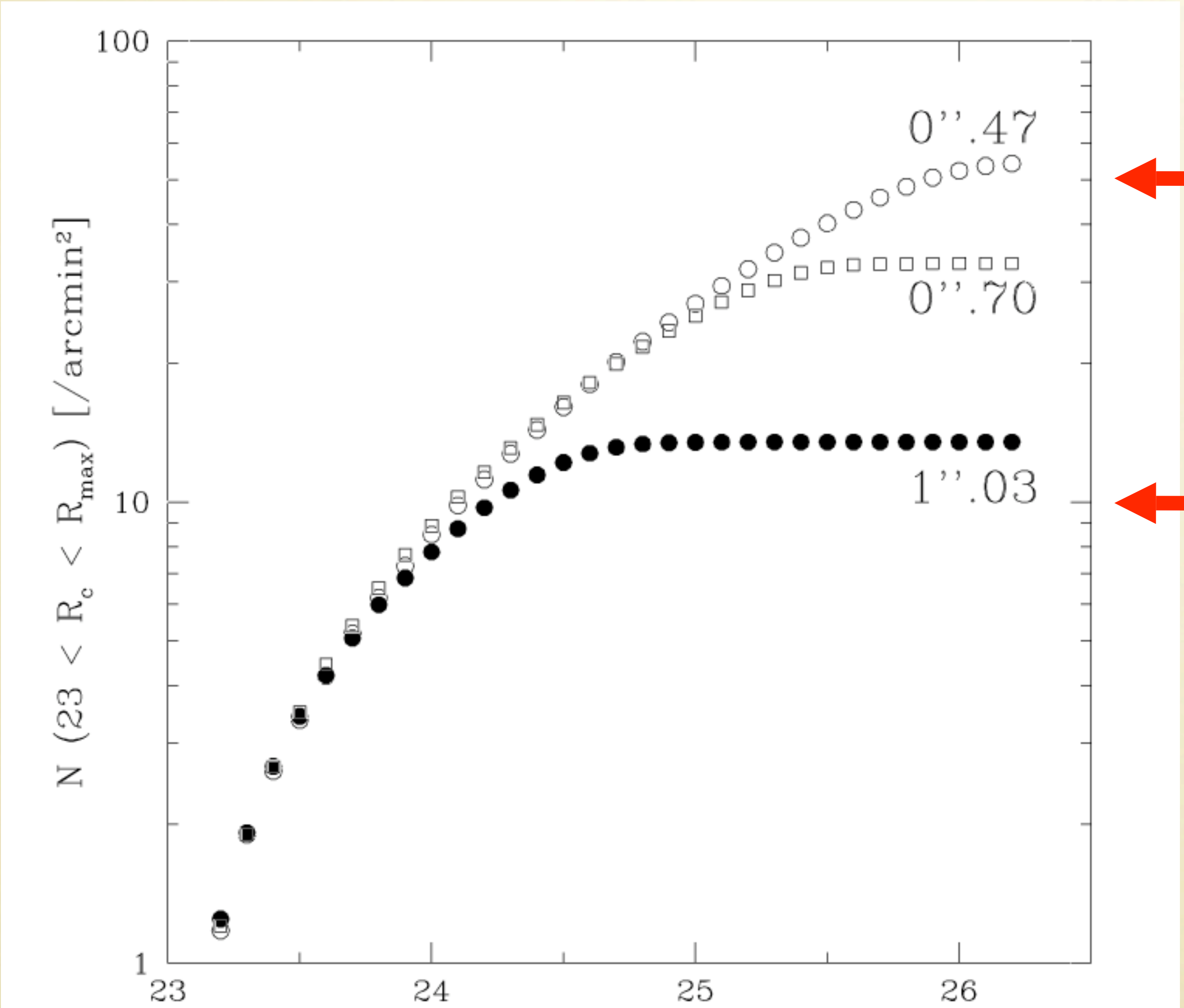
What is Hyper Suprime-Cam ?

Hyper Suprime-Cam

Expand field of view to increase survey speed



Surface Number Density of faint galaxies used for weak lensing anaysis



Miyazaki et al. 2007

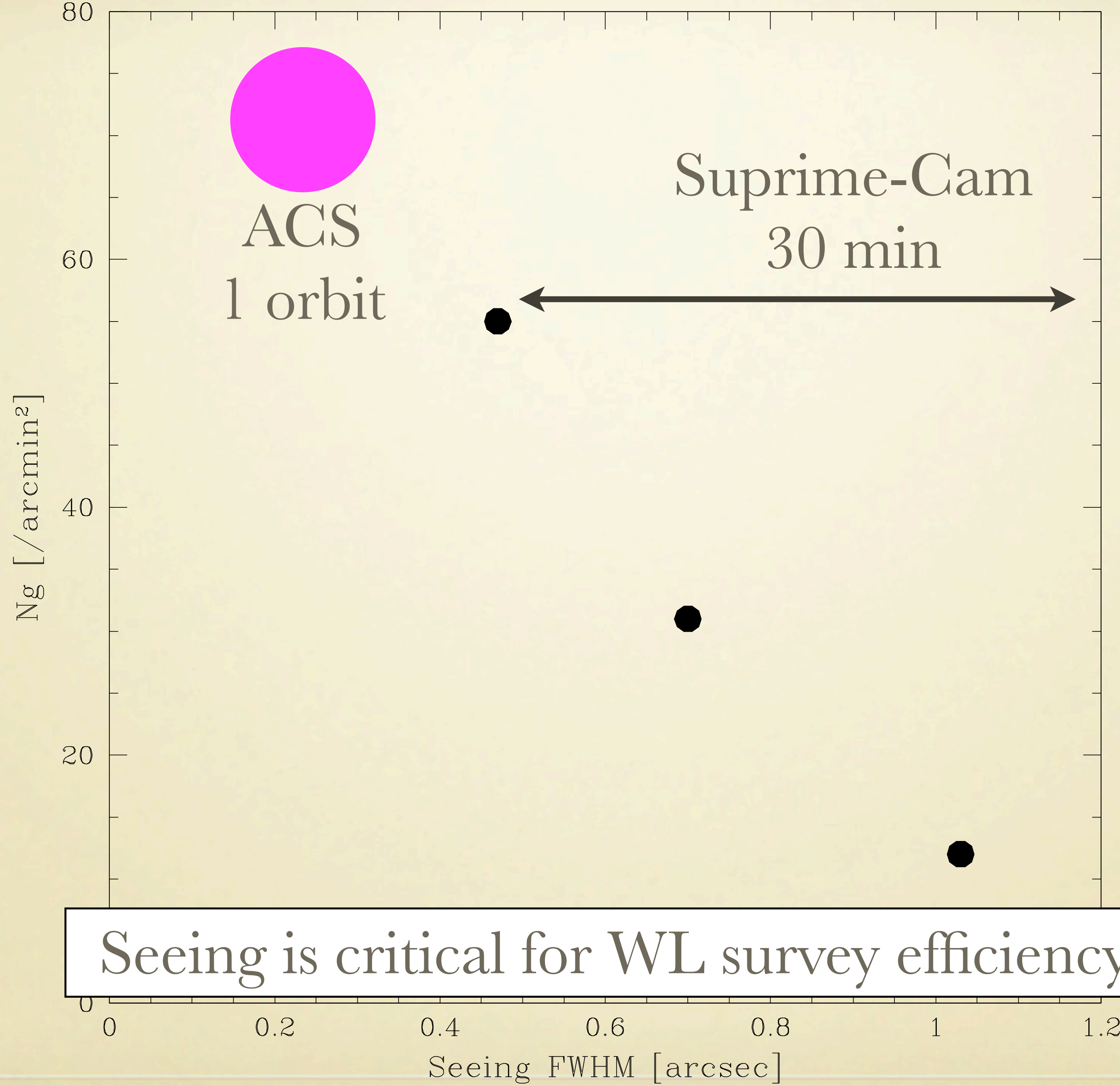
50

10

Galaxy size lower limit

S > S* + 1 σ S*

S*: PSF size of stars



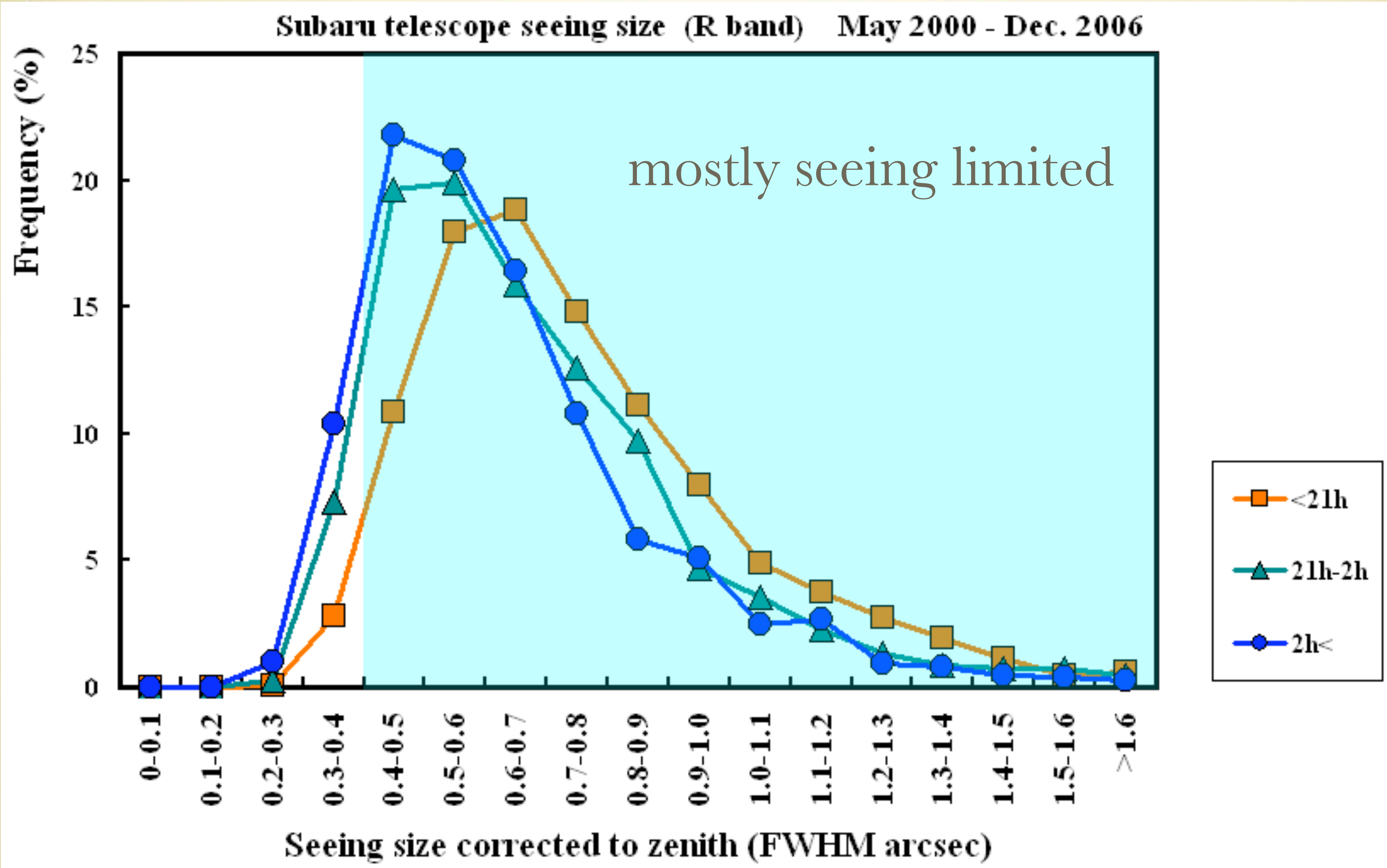
Seeing is critical for WL survey efficiency

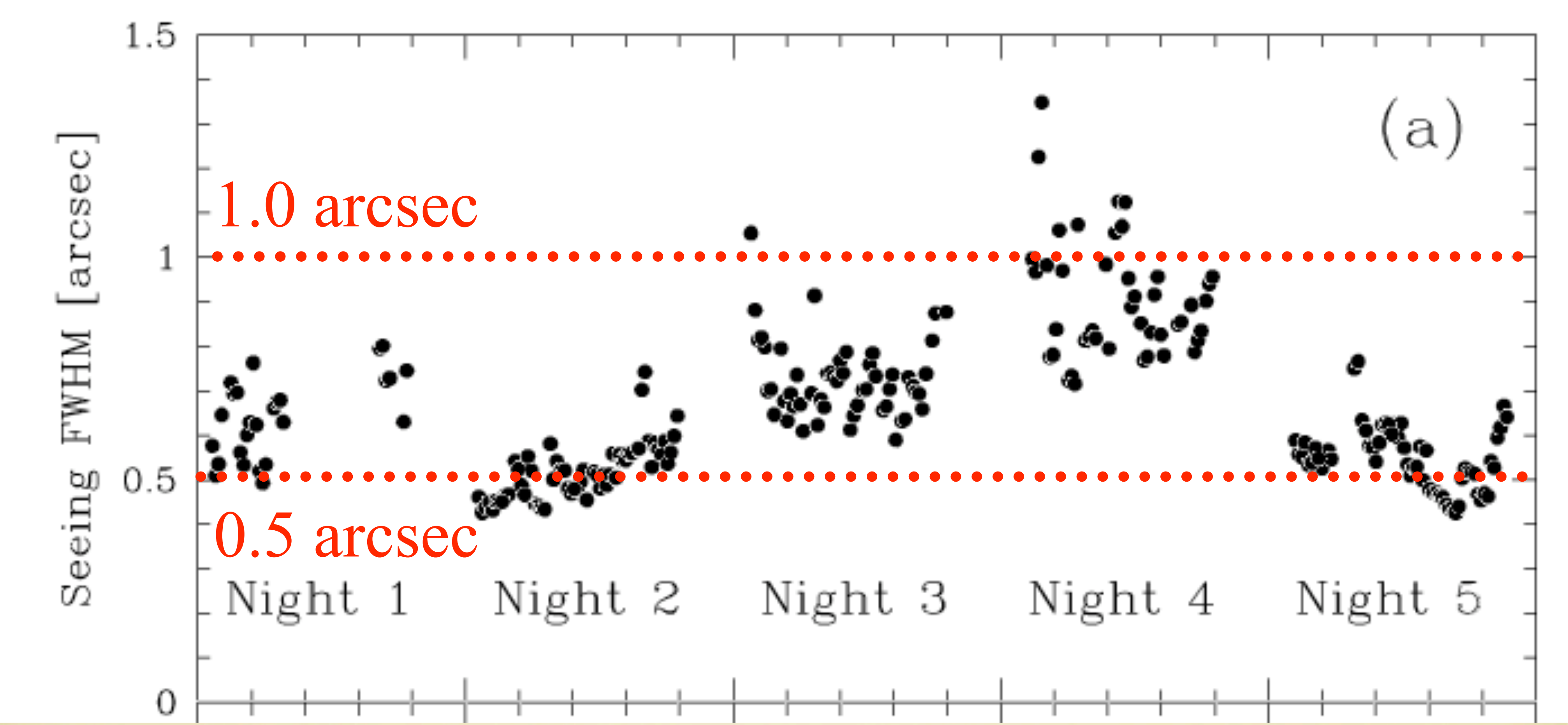
Hyper suprime-cam

Primary Technical Specifications

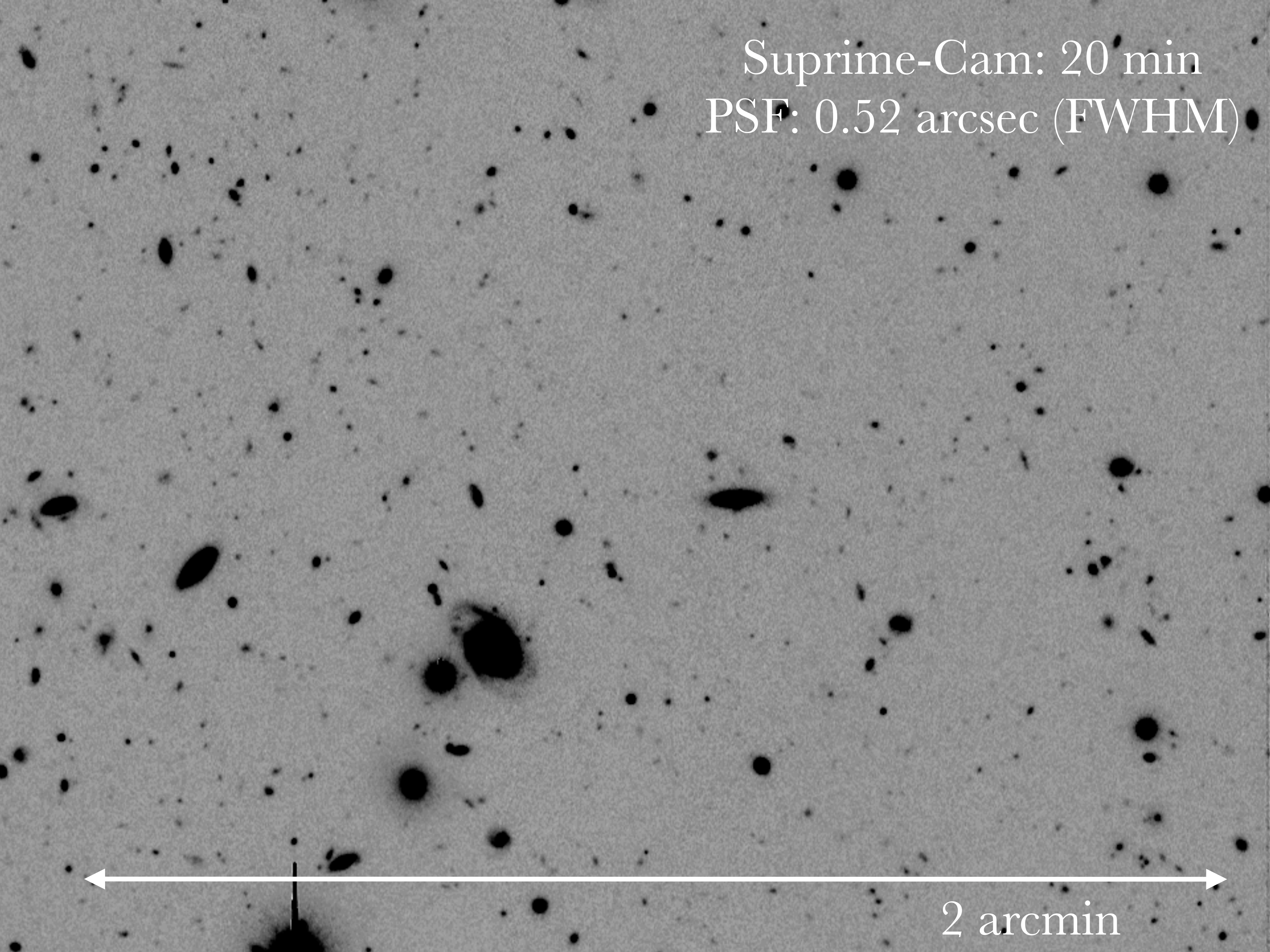
Field of View	1.5 degree diameter	Vignetting allowed up to 25 % at the edge Dead area (CCD gap) fraction ≤ 5 %
Instrument PSF size	$\leq$ 0".3 for r', i' $\leq$ 0".4 for g', Y	FWHM
Pixel scale	$\leq$ 0".2 /pix	
System Throughput	$\geq$ 50 % for g' $\geq$ 65 % for r' $\geq$ 65 % for i' $\geq$ 40 % for z' $\geq$ X % for Y	PM$\times$WFC$\times$Filter$\times$CCD at the center of the field
Minimum Shutter Speed	3 sec (1 sec goal)	Time accuracy $\leq \pm 1$ %
Min. interval of Exposures	20 sec (15 sec goal)	Including CCD readout and wipe pointing change

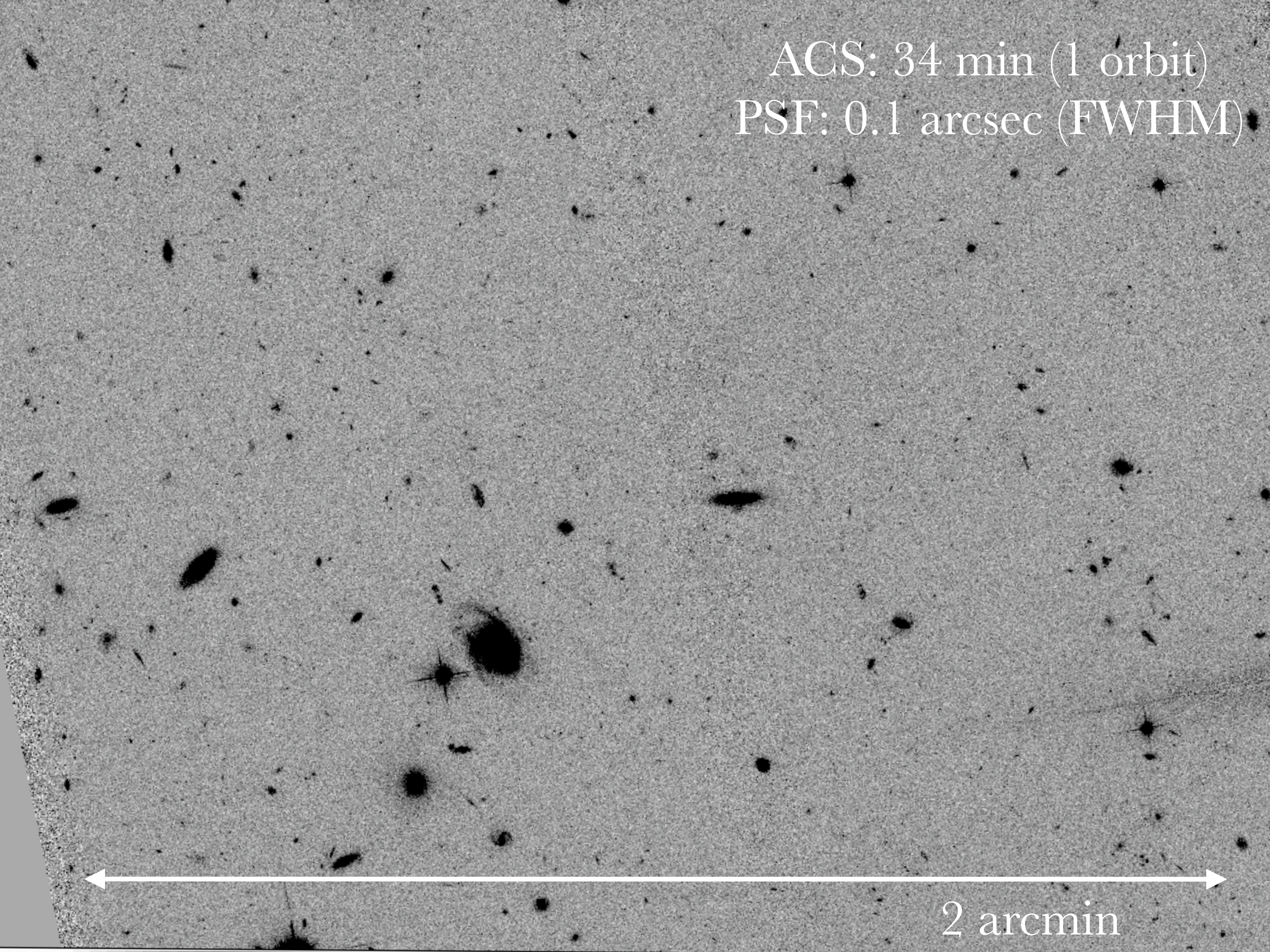
Subaru Seeing Statistics



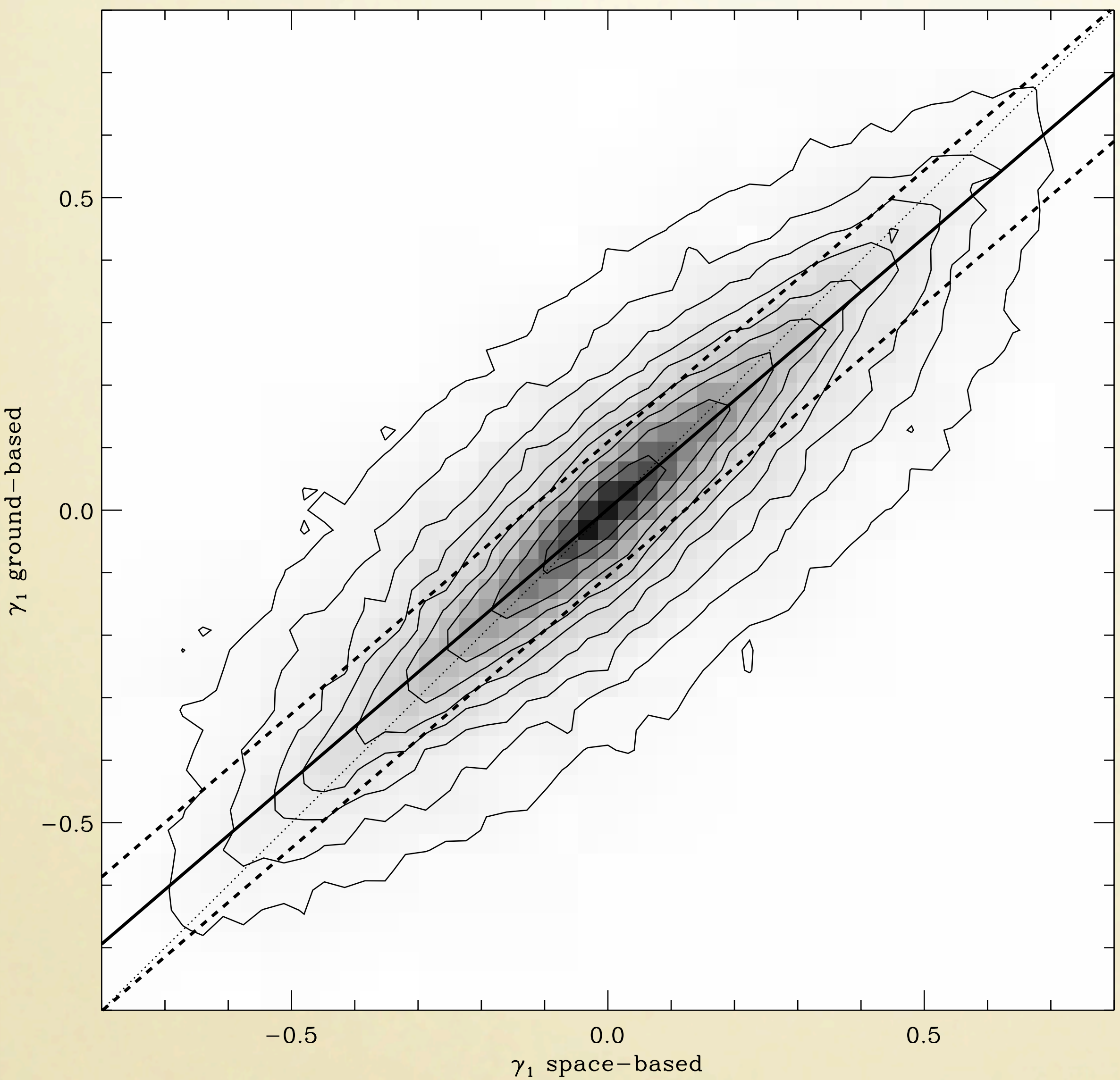


Seeing FWHM [arcsec]
1.5
1
0.5
0
(a)
1.0 arcsec
0.5 arcsec
Night 1
Night 2
Night 3
Night 4
Night 5


Suprime-Cam: 20 min
PSF: 0.52 arcsec (FWHM)
2 arcmin


ACS: 34 min (1 orbit)
PSF: 0.1 arcsec (FWHM)
2 arcmin

Ground vs space



Extracted Shear Comparison on COSMOS field

Kasliwal, Massey, Ellis, Miyazaki, Rhodes 2008 in press

Hyper Suprime-Cam is an upgrade of Suprime-Cam. It has almost 10 times field of view while maintaing equivalent image quality necessary for weak lensing survey.

Instrumentation

HSC Components

- HSC Mechanics (telescope interface)
- Wide Field Corrector
- HSC Camera Mechanics
  - Dewar
  - Shutter
  - Filter Exchanger
- Sensor
  - CCD
  - Electronics
- Filter
- SH (mirror analysis) & Guider
- Data management

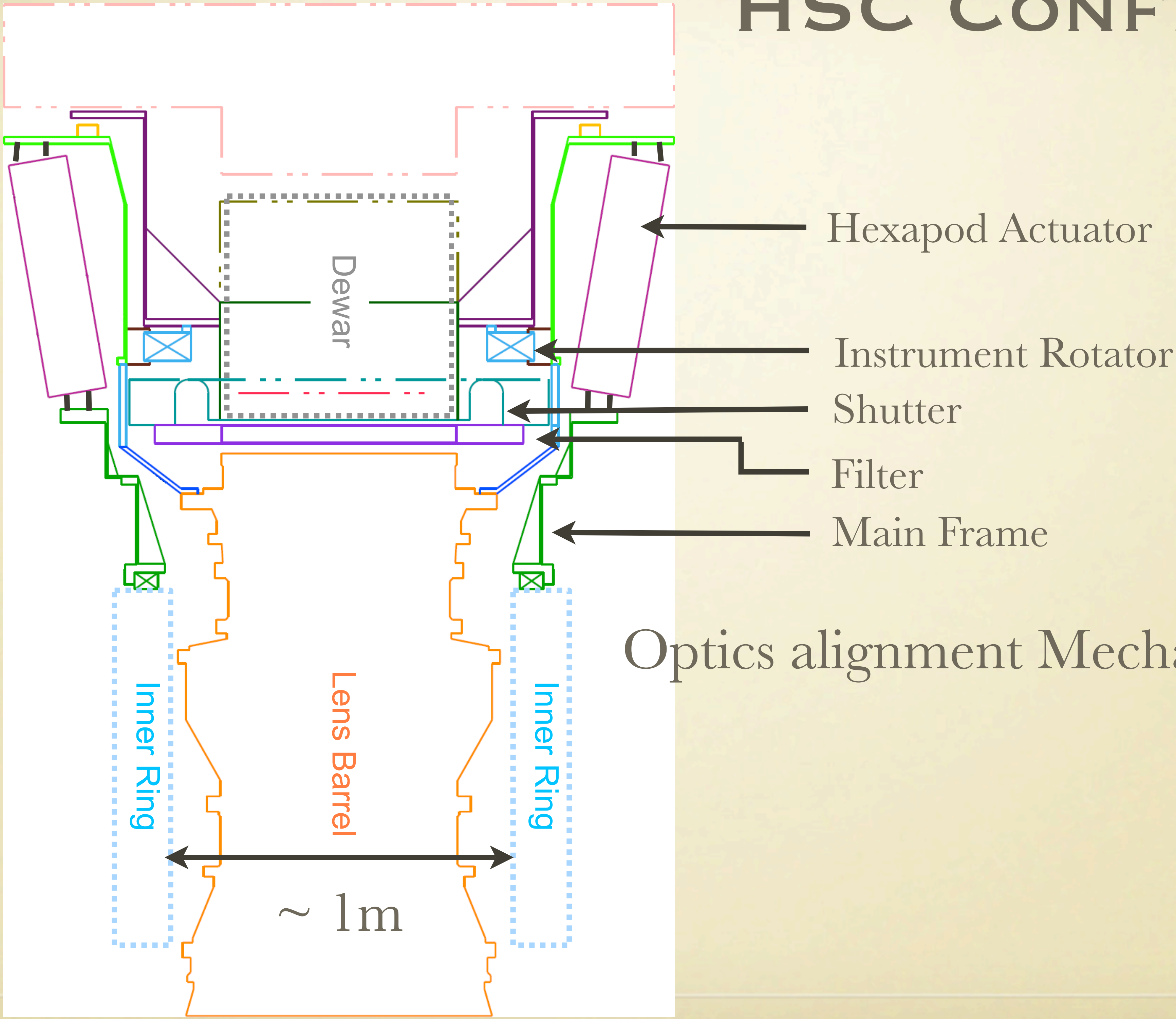
Mitsubishi

Canon

NAOJ
U-Tokyo
KEK
Princeton
ASIAA

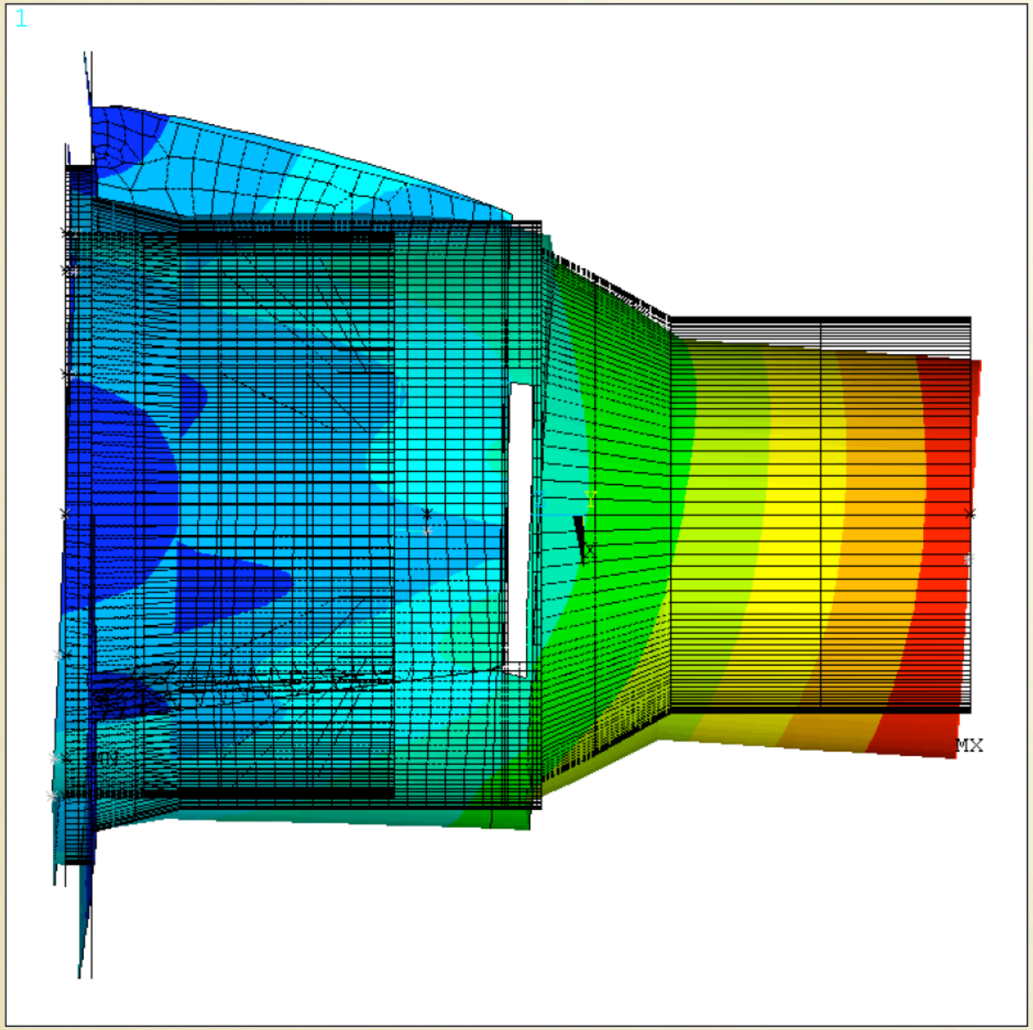
Komiyama's talk

HSC Config.



Optics alignment Mechanism

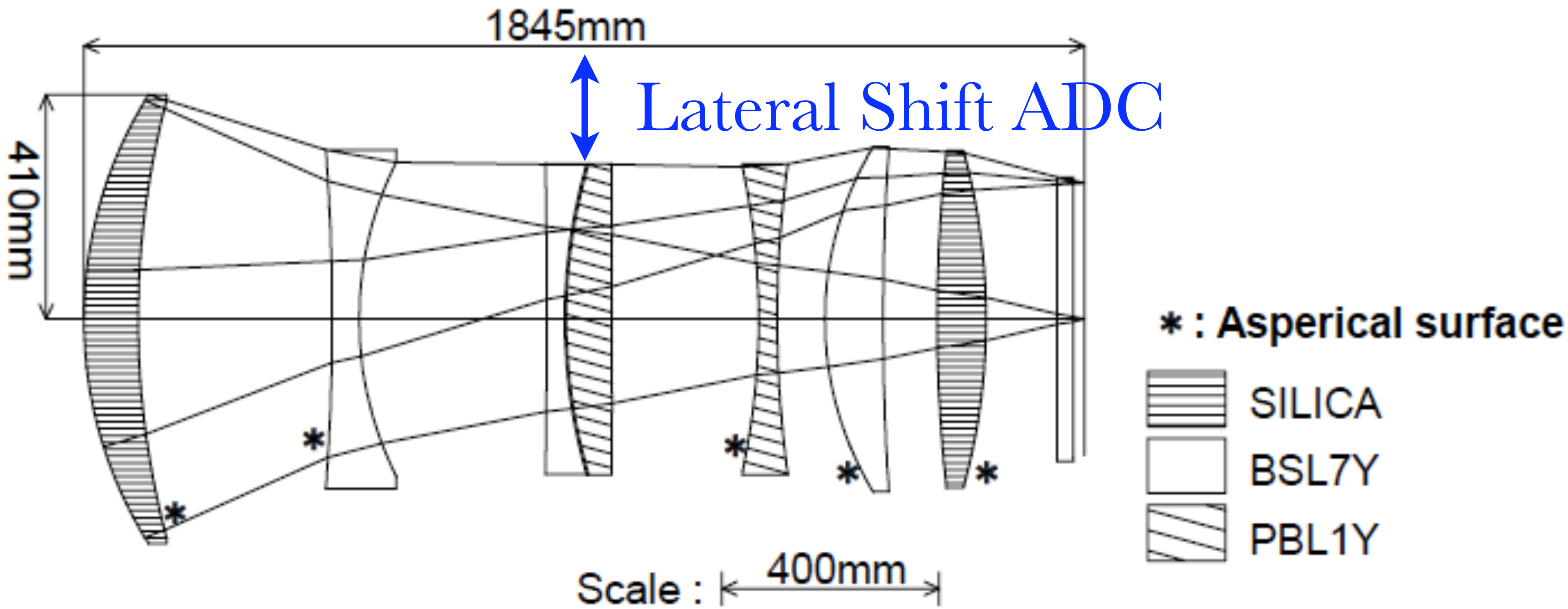
FEM Analysis



Structure and mechanics must be designed to meet the tolerance specification (0.17 arcsec) (in progress)

Wide Field Corrector

Wide Field Corrector



General Lens Data

Focal length	18416[mm]
image scale	0.0893[mm/arcsec]
image size	ϕ 498[mm]

0.17 arcsec/pix
(15 um pix)

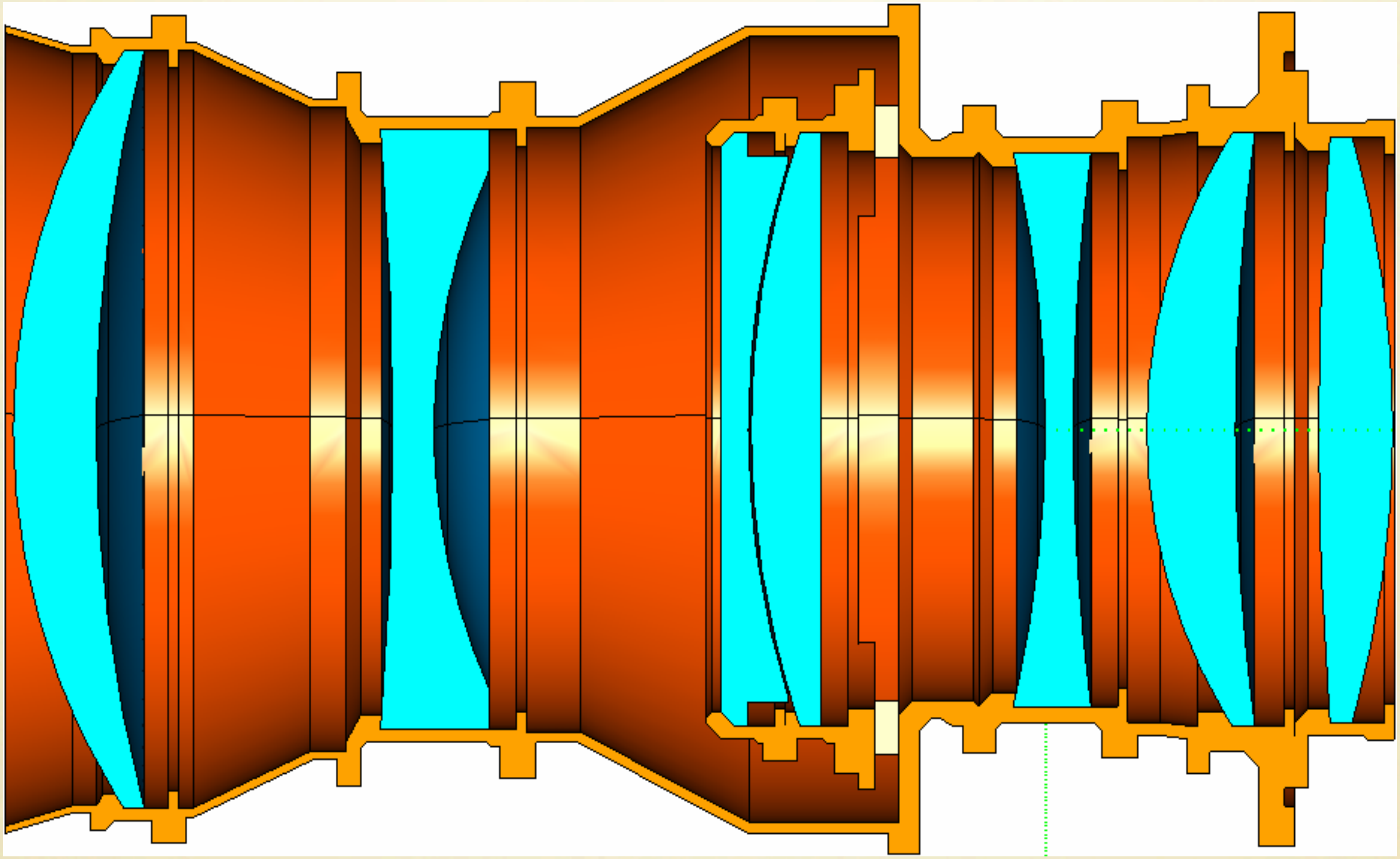
Optics Design Performance

Worst case value (FWHM arcsec)

EL=90	g'	0.12	u 0.45
	i'	0.08	
	y	0.10	
EL=30	g'	0.18	0.70
	i'	0.13	
	y	0.13	

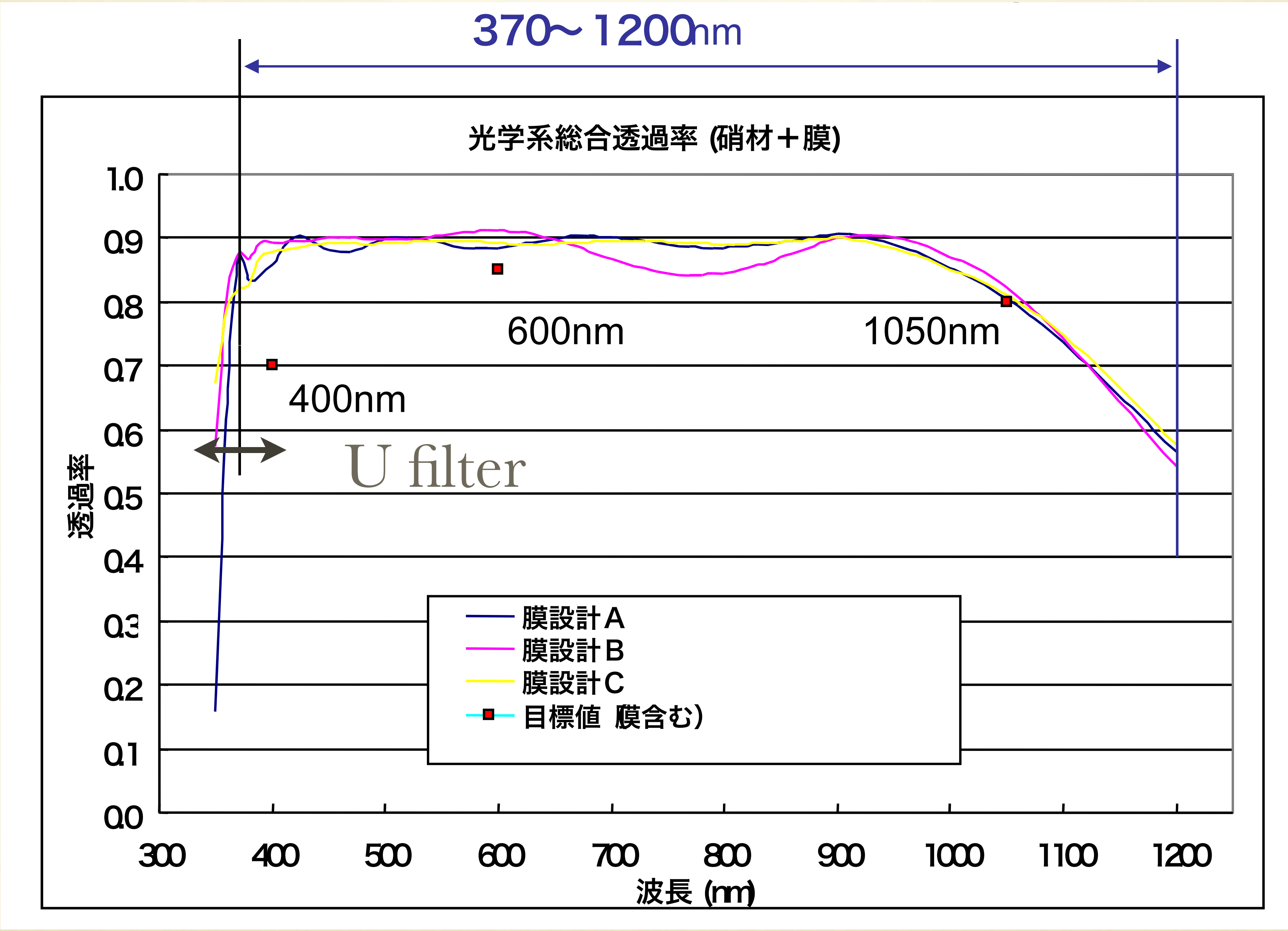
The rest of the error budget is spent for manufacturing error and lens barrel flexure.

Lens Barrel Design



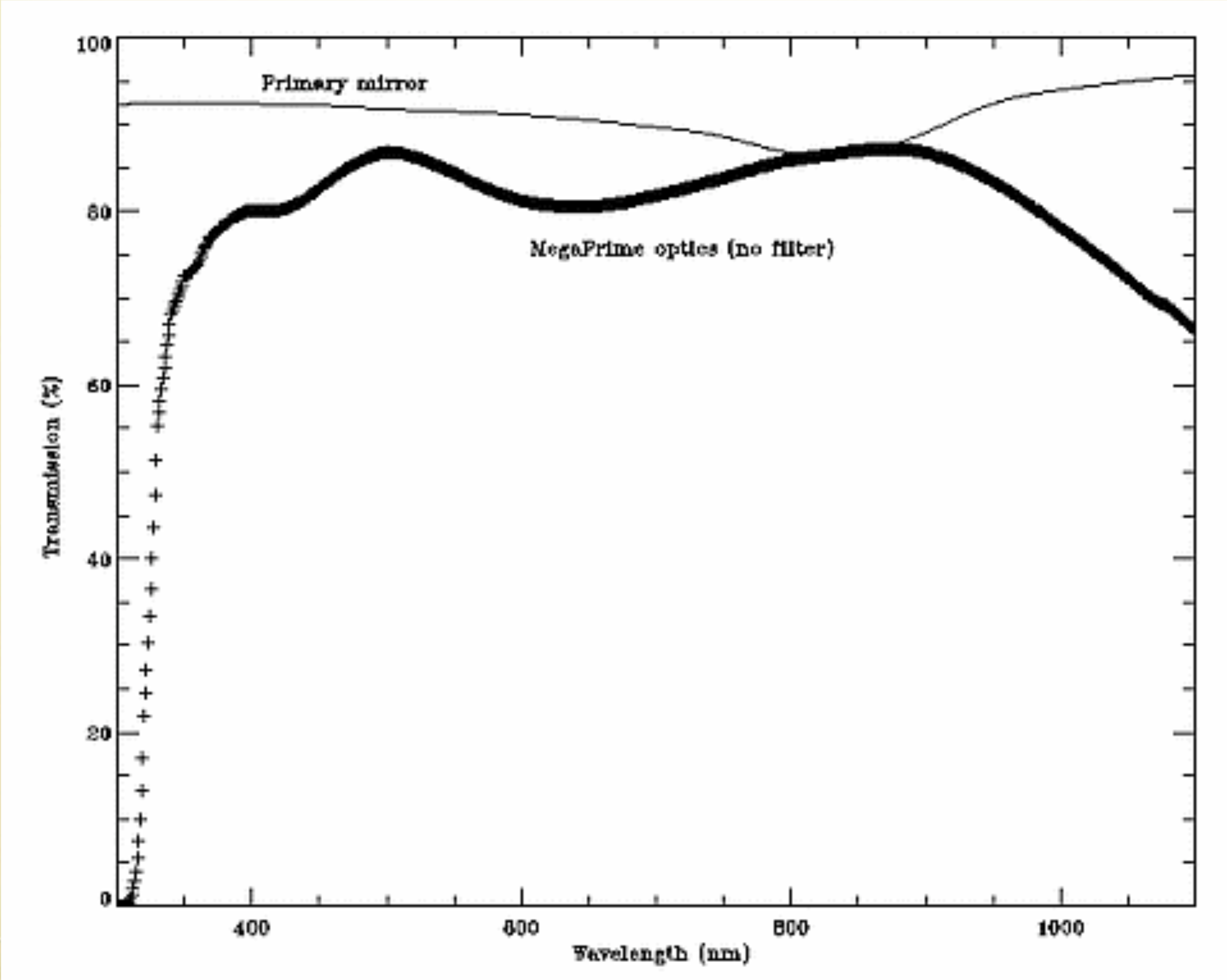
Low CTE (< 0.1 ppm)ceramic: Cordierite
High young modulus 140 pa
similar mass density with glass

Optics Transmission



Glass absorption and coating considered

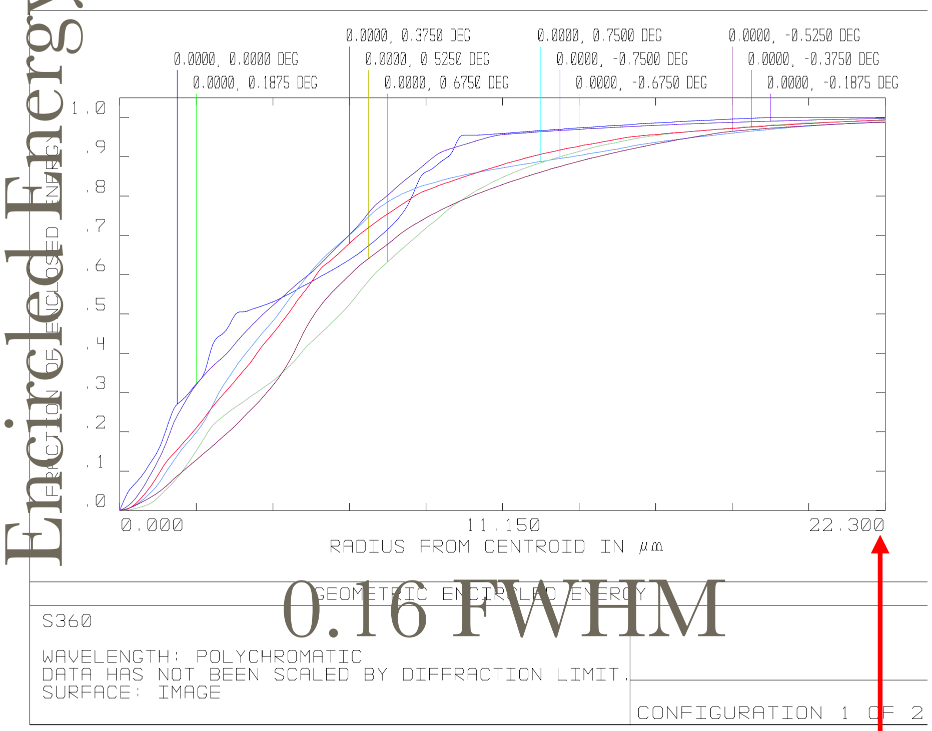
MegaPrime Transmission



Optics Design Performance for WFMOS

Wavelength= WFMOS / EL= 90degree
(390nm+460nm+560nm+700nm+1000 nm)

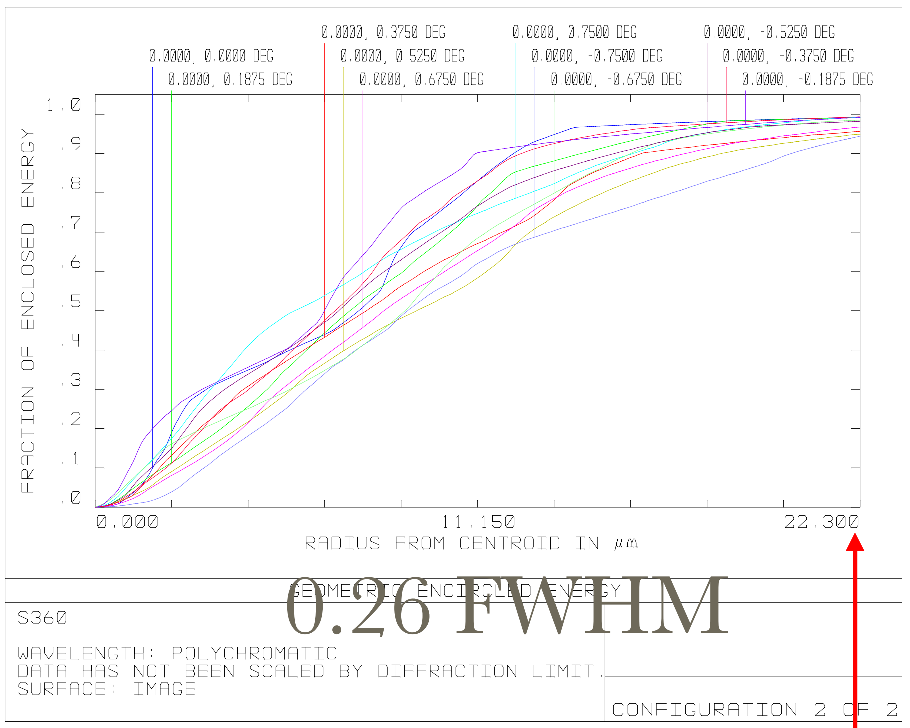
Encircled Energy



0.16 FWHM

D=0.5 arcsec

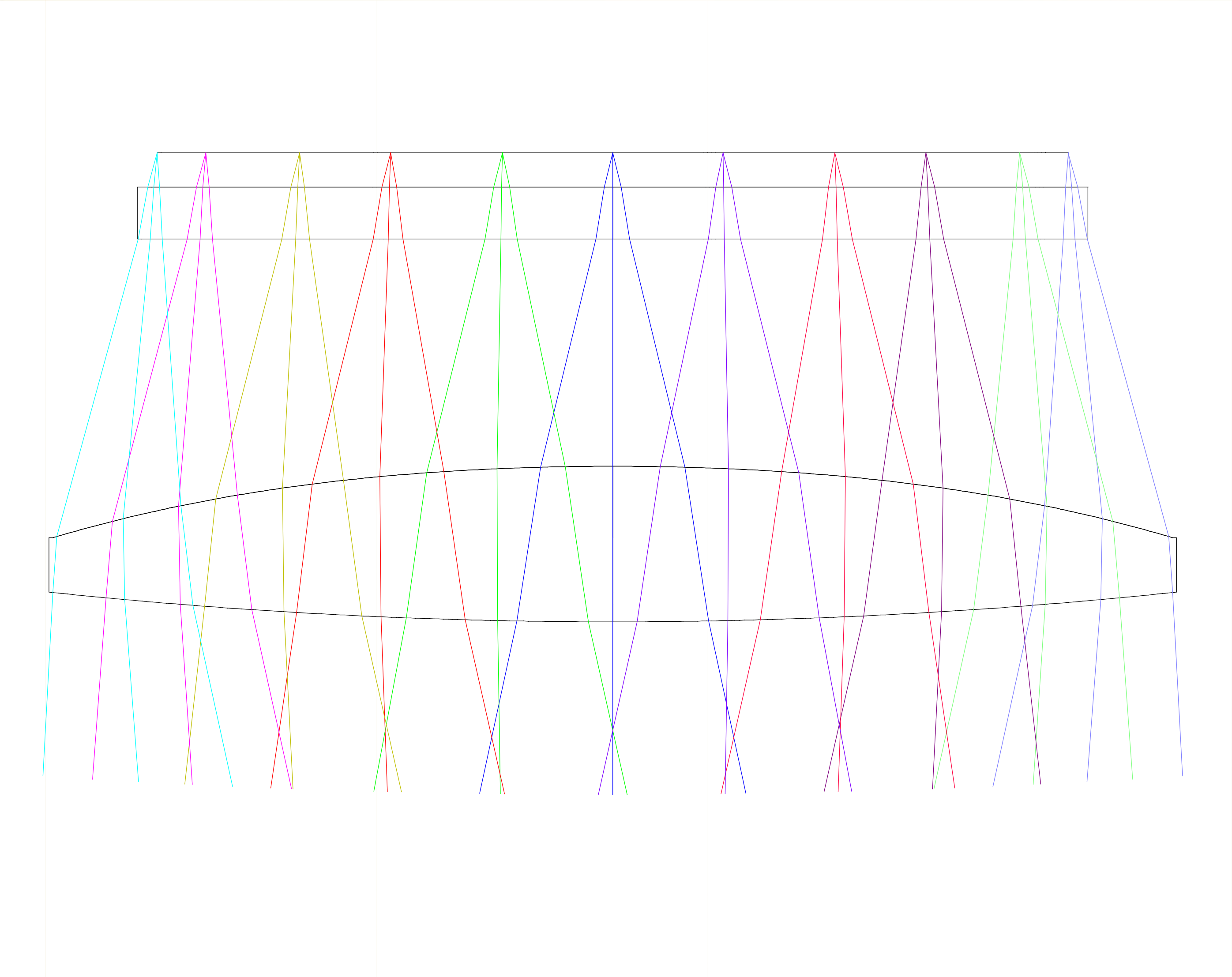
Wavelength= WFMOS / EL= 30degree
(390nm+460nm+560nm+700nm+1000 nm)



0.26 FWHM

D=0.5 arcsec

Non Telecentricity



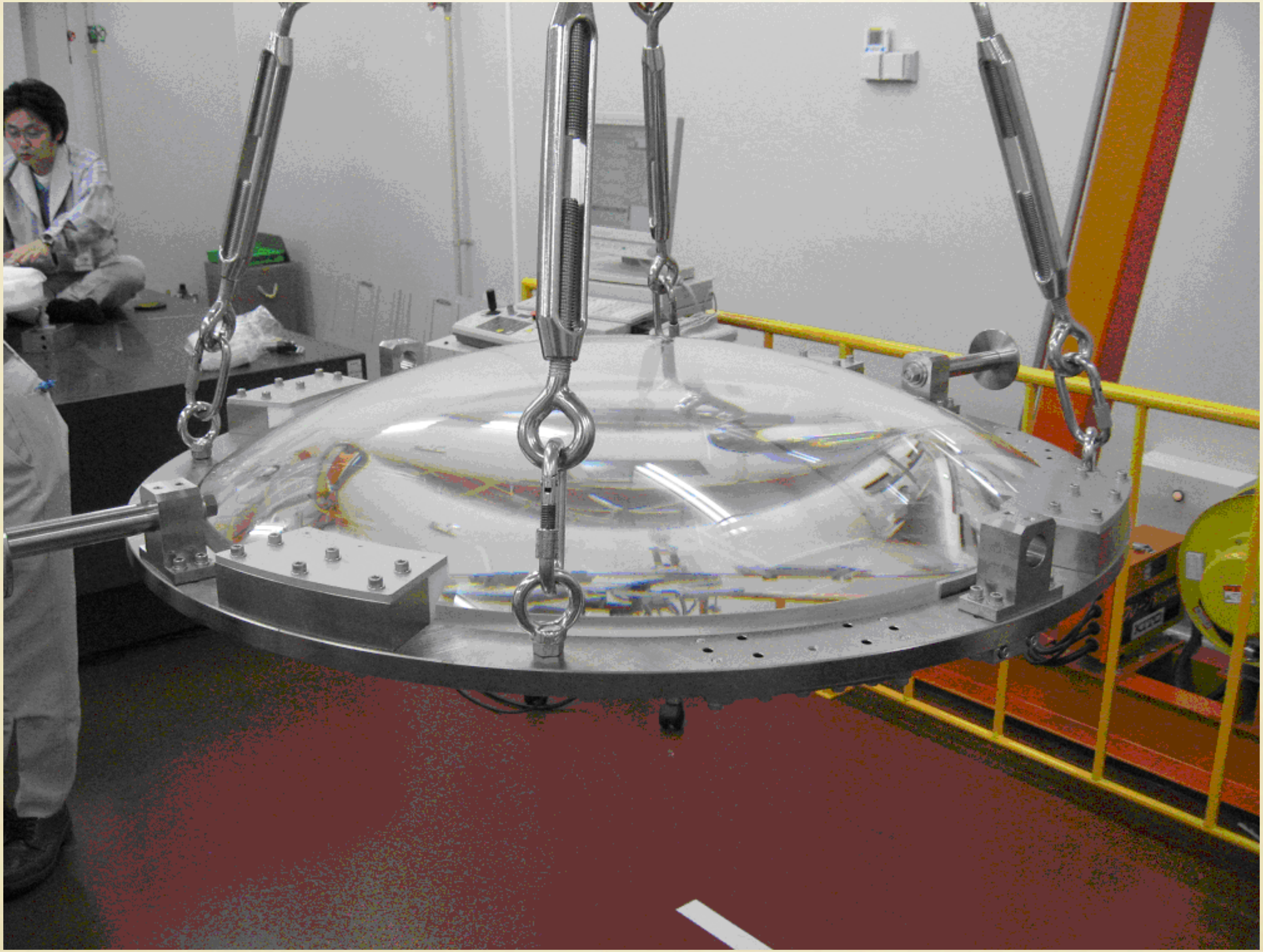
Inclination angle of the chief ray ~ 8 deg

causes light loss at the entrance into the fibers

because of the mismatch of NA

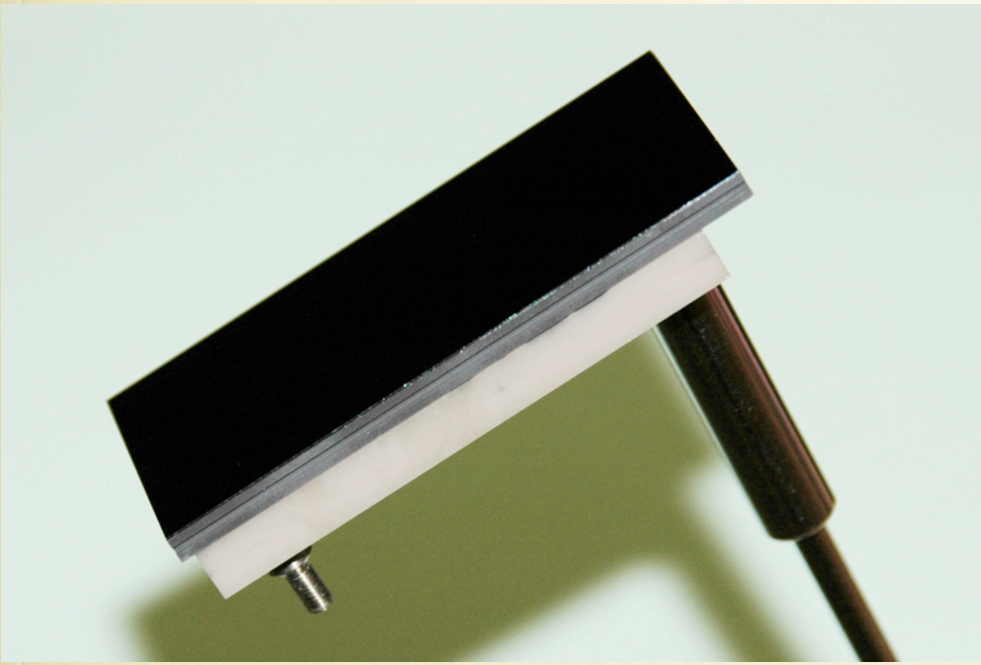
Solution: Tilt fiber slightly at the edge

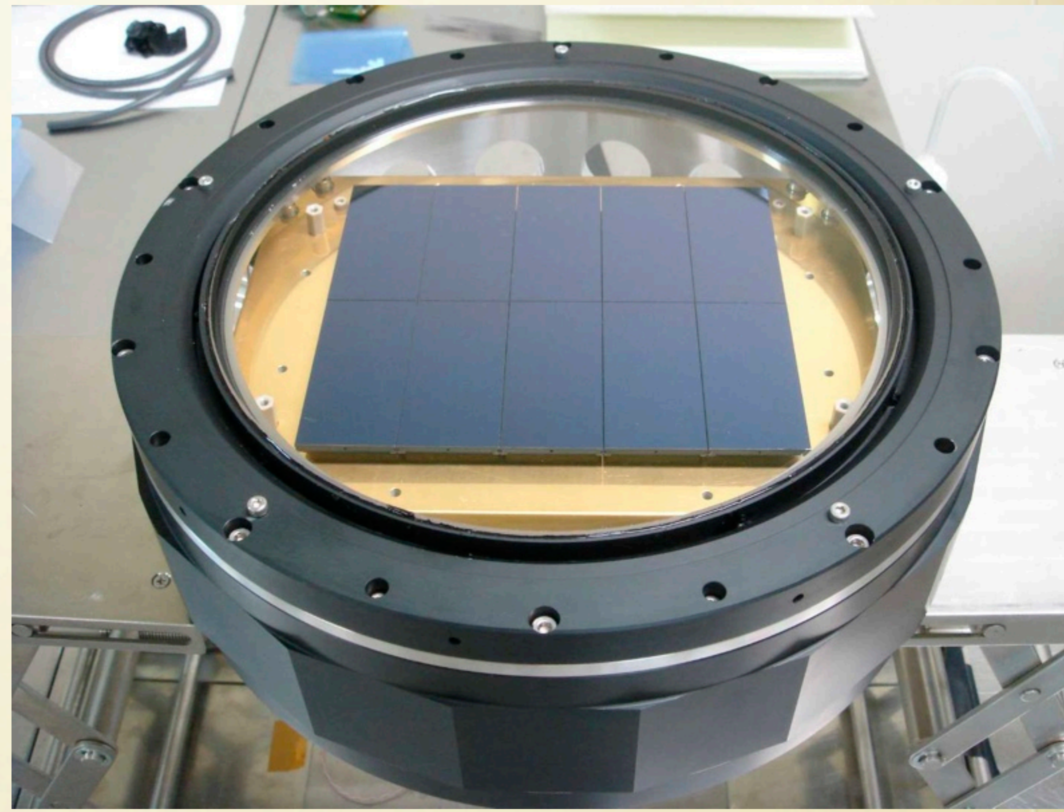
HSC WFC G1 Prototype



CCD

Hamamatsu CCD





2048 x 4096 15 micron
four side buttable

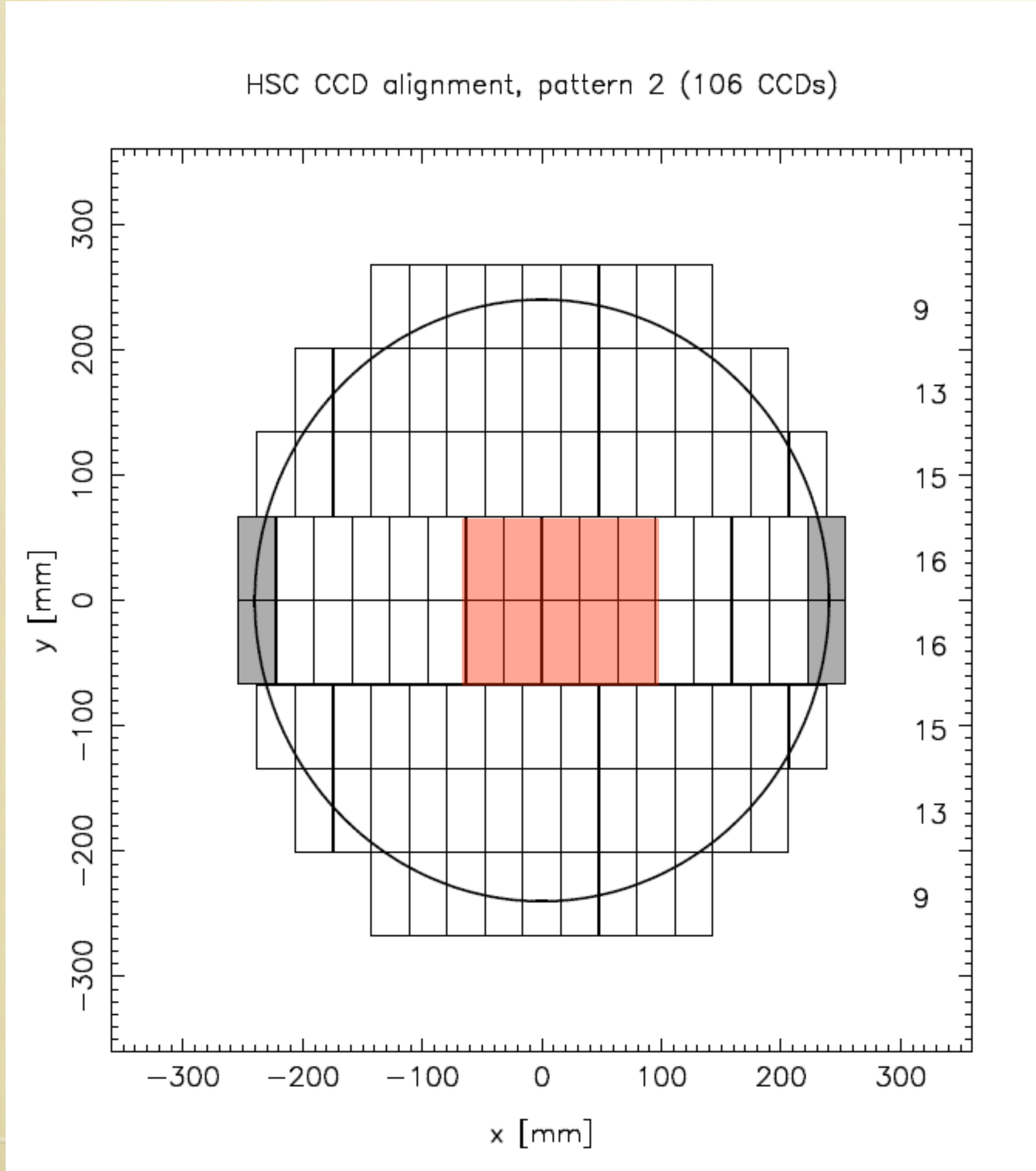
Suprime-Cam CCDs will be replaced and the commissioning run 2008/07

FDCCD Characterization

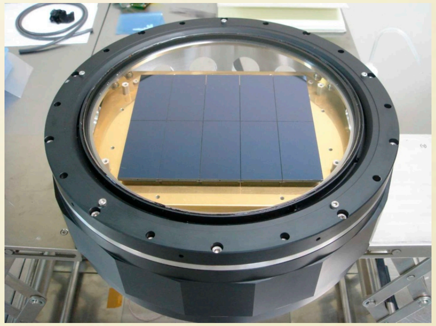
Parallel CTE	0.999995
Serial CTE	0.999995
Quantumn Efficeincy	40 % (400 nm)
	90 % (650 nm)
	40 % (10000 nm)
Thickness	$\geq$ 150 [μm]
Dark Current	1.4 [e/hour/pixel]
Full Well	180,000 [e]
Amplifier Responsivity	5.8 [μV/e]
Read Noise	4.4 e at 150 kHz reaout

$$T_{CCD} = -100^{\circ}C$$

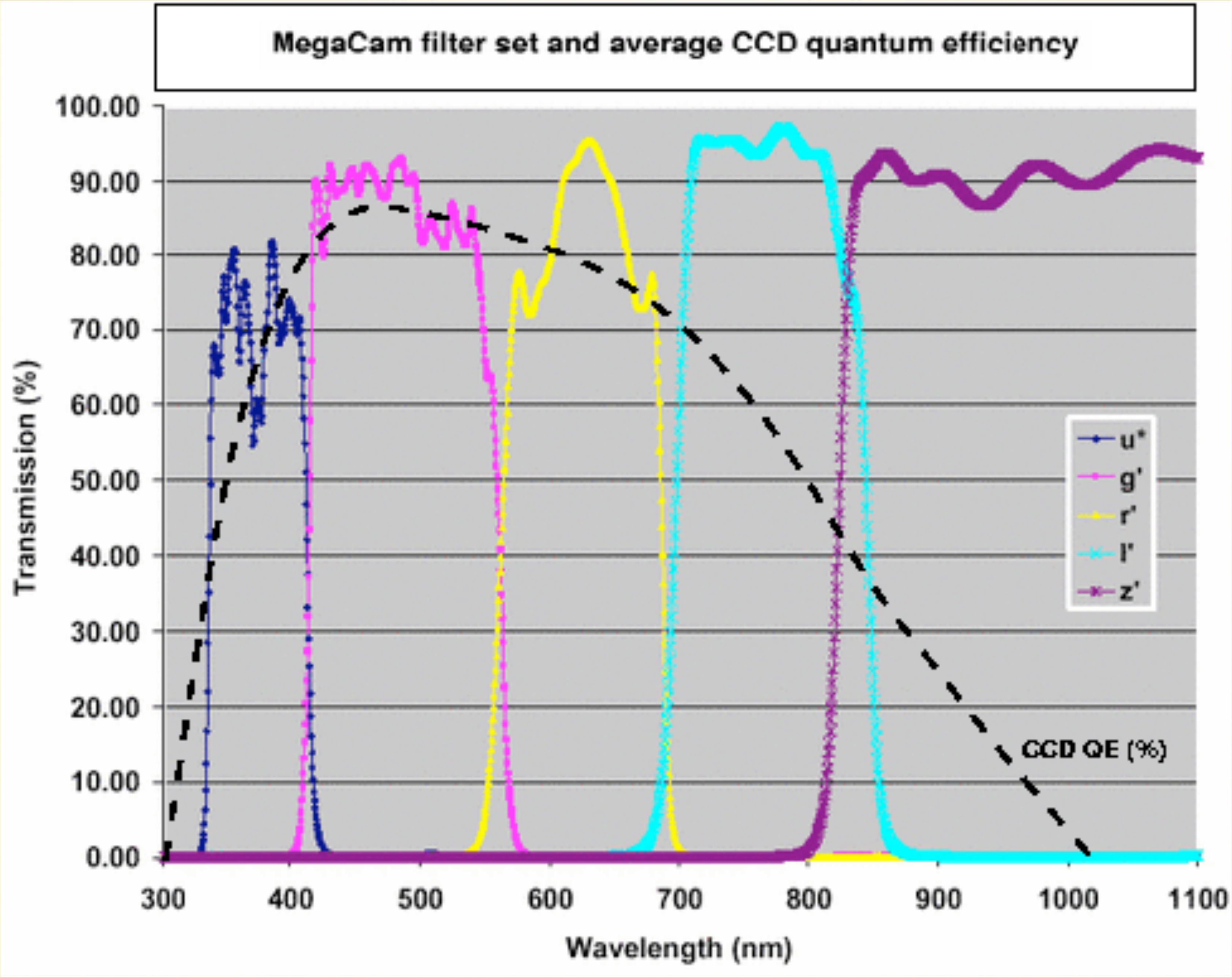
HSC: Focal Plane



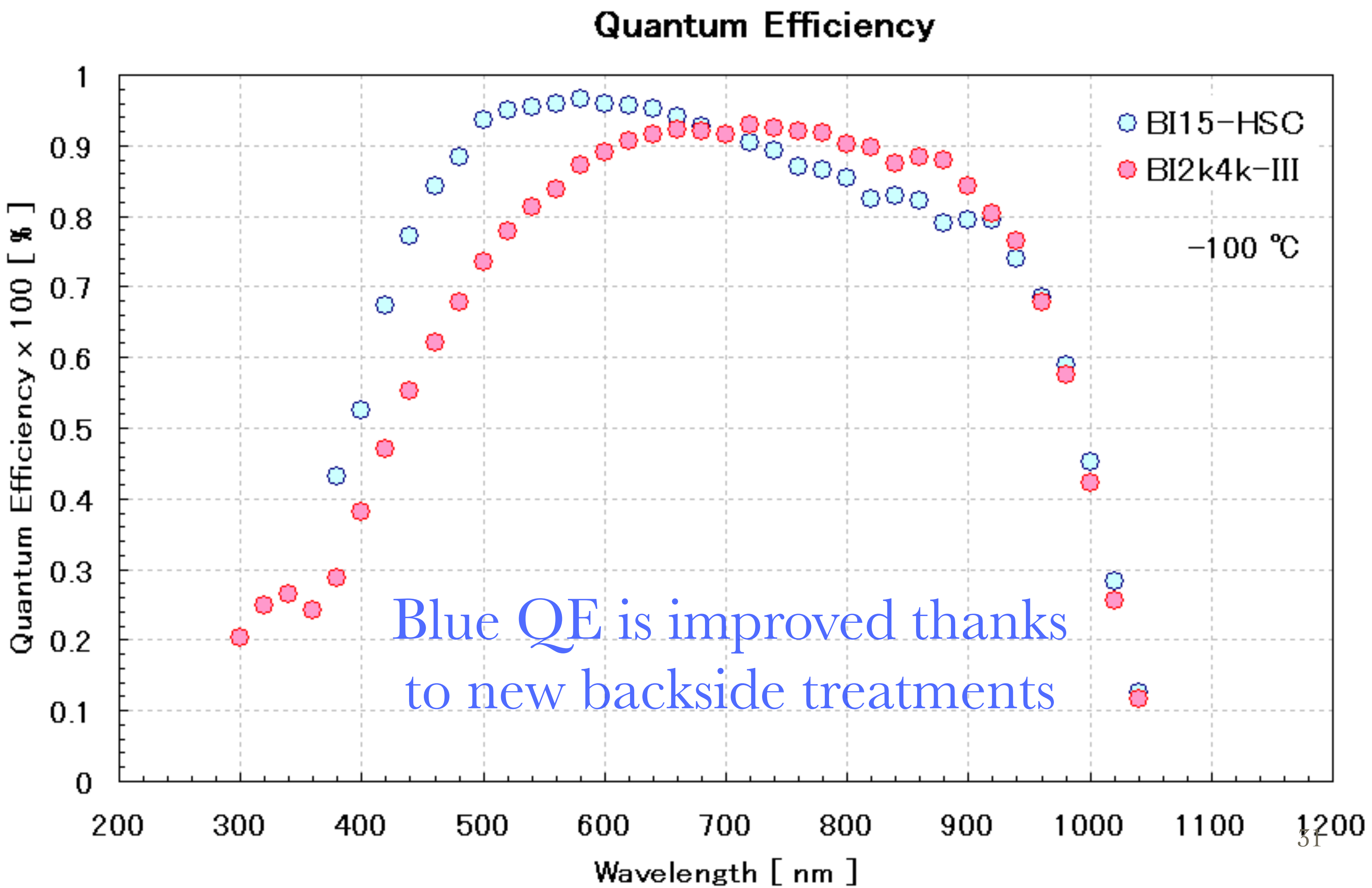
106 2k4kFDCCD



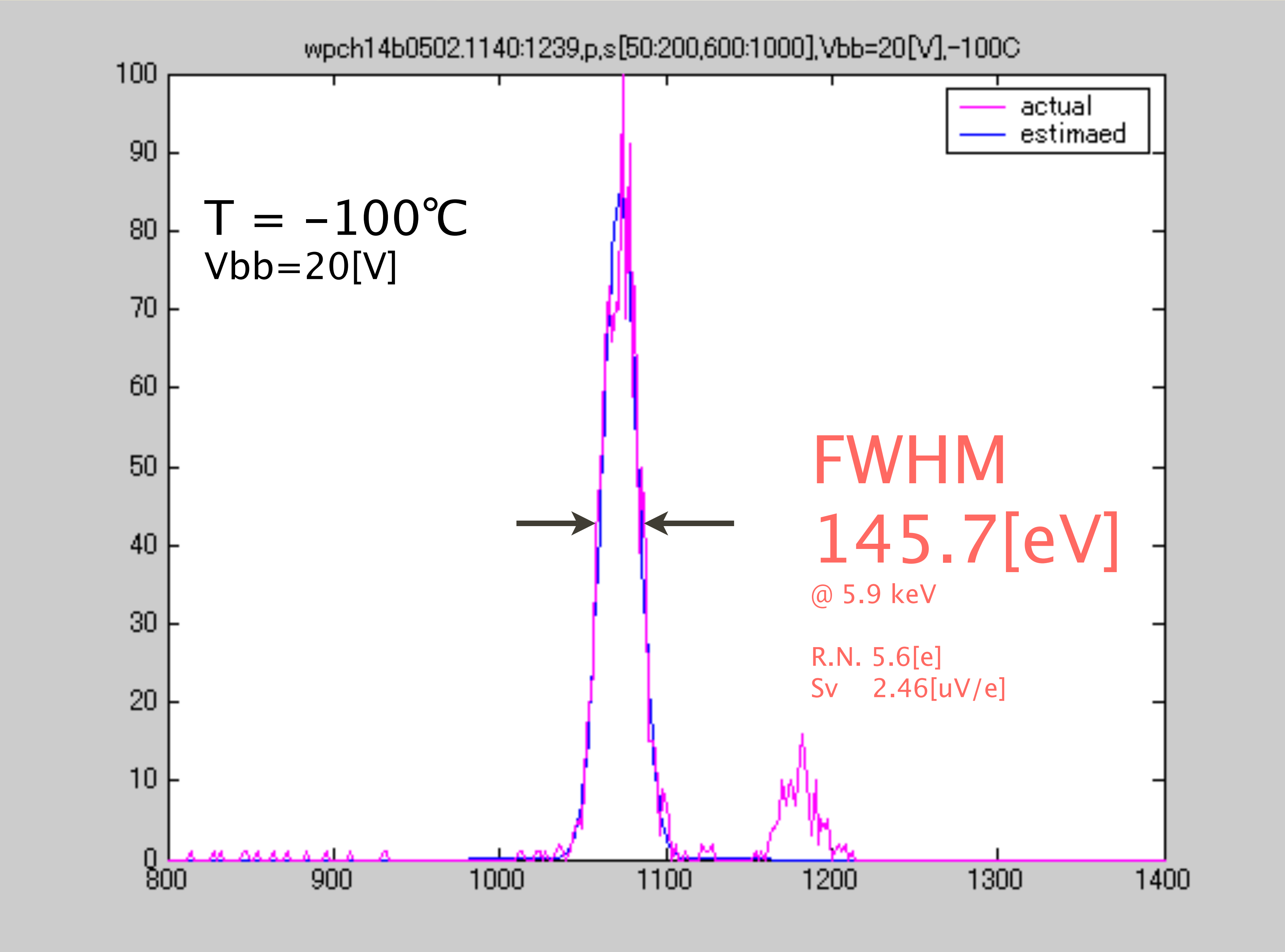
MegaCam CCD & Filter



FDCCD for HSC



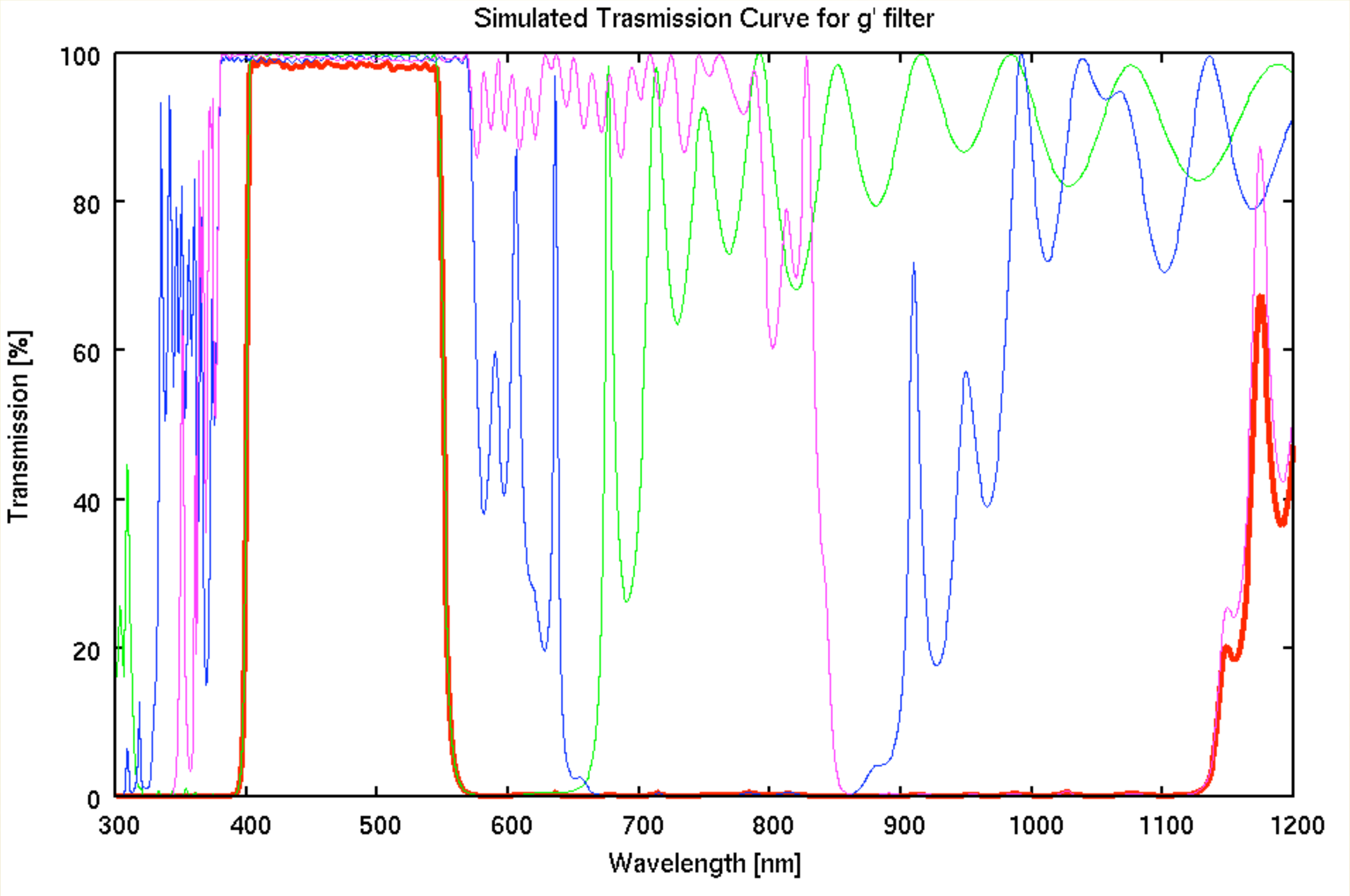
X-ray Energy Resolution



Filter

Interference Filter

g' (400 - 550 nm) Design

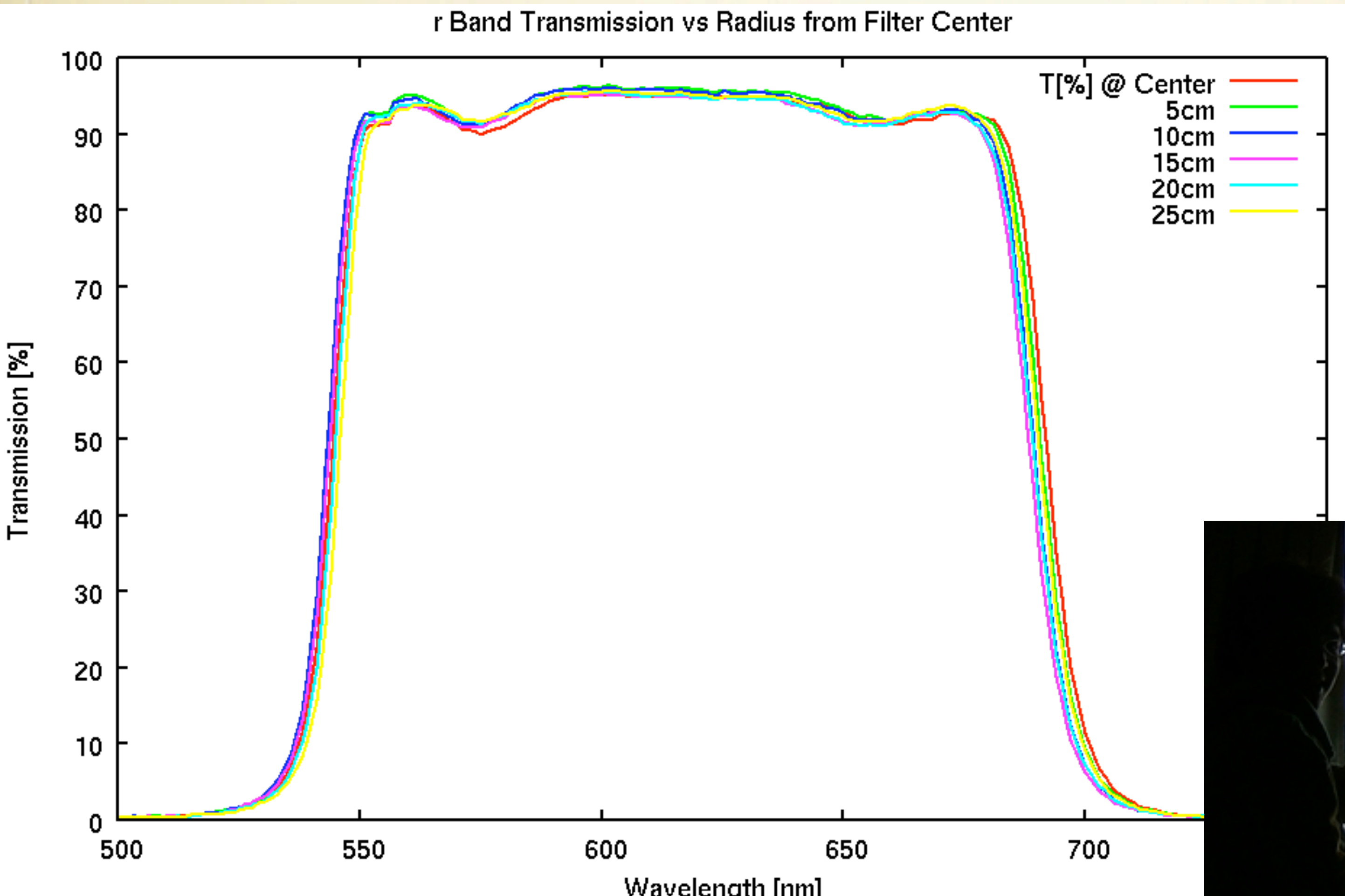


1 band select layer + 3 blocking layers

Broad band Filter

Prototype delivered on 2008/02/29

Prototype Filter Transmission Curve

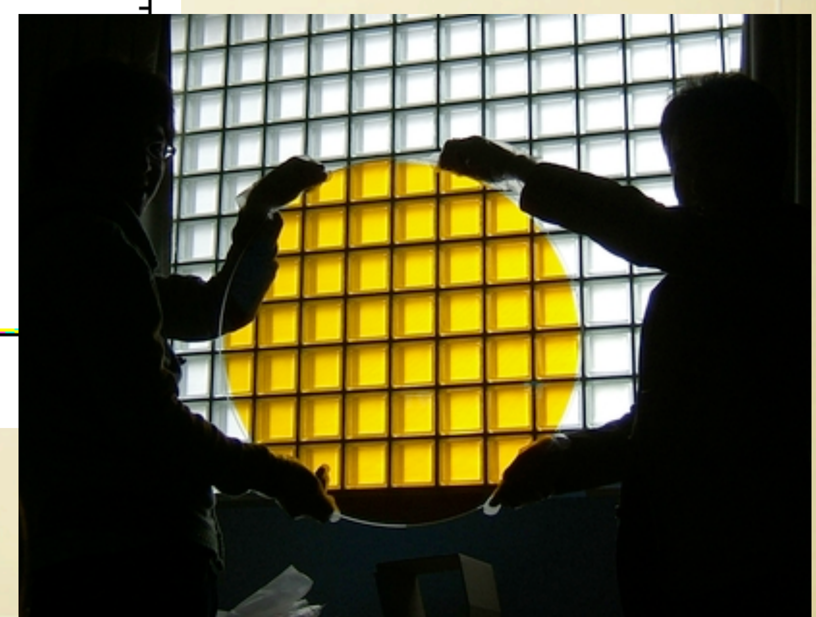


All the spec met at high level

Uniformity:

cutoff 3 nm

transmission 2-3 %



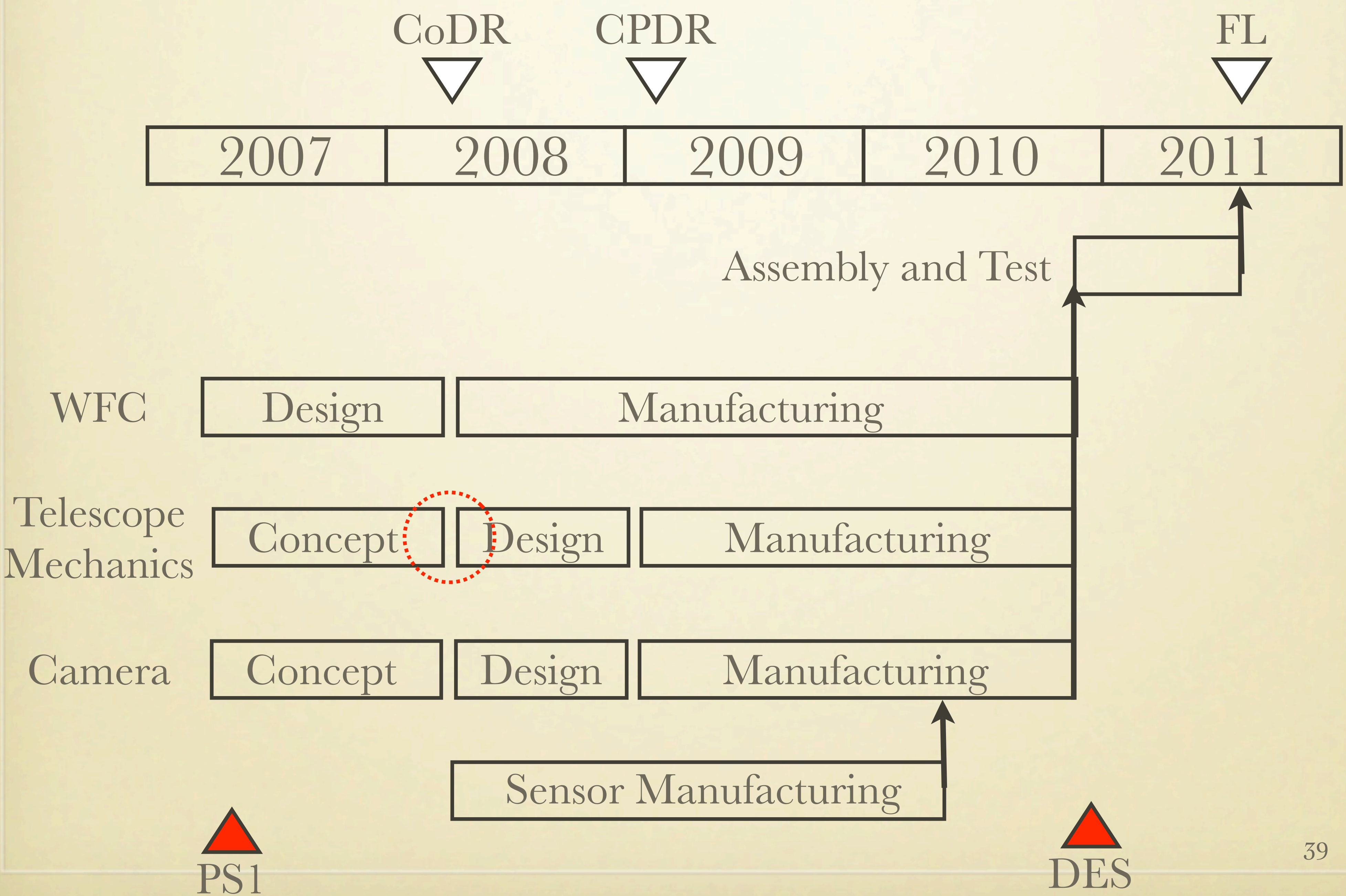
Narrow Band Filter

- More layers are needed to realize NBF (~ 10 nm)
    - High cutoff uniformity is crucial (< 1 nm)
- We must wait for the establishment of "Magnetron Sputtering Method" which is being developed by Asahi Spectra, Japan.
- We will see the feasibility report by March 2009.

Sensor readout electronics
Auto guider
SH sensor
Telescope Modification
IR emission suppression
Data Management
....

SPIE papers are being prepared

HSC Schedule



Hyper Suprime-Cam

Instrument	Hyper Suprime-Cam	DES
Aperture D[m]	8.2	4.0
Field Size D [deg]	1.5	2.0
Inst. PSF [arcsec]	0.3	0.6
Median Site Seeing [arcsec]	0.6	0.8 ?

Small Instrument PSF is crucial for HSC in order to be competitive with others.

Working with WFMOS study teams

- WFC
  - Non-telecentricity workaround
- Packaging
  - Space Constraint
  - Weight Constraint

We promise you to provide with these information as quickly as possible once the design works of HSC are settled.

Thank You