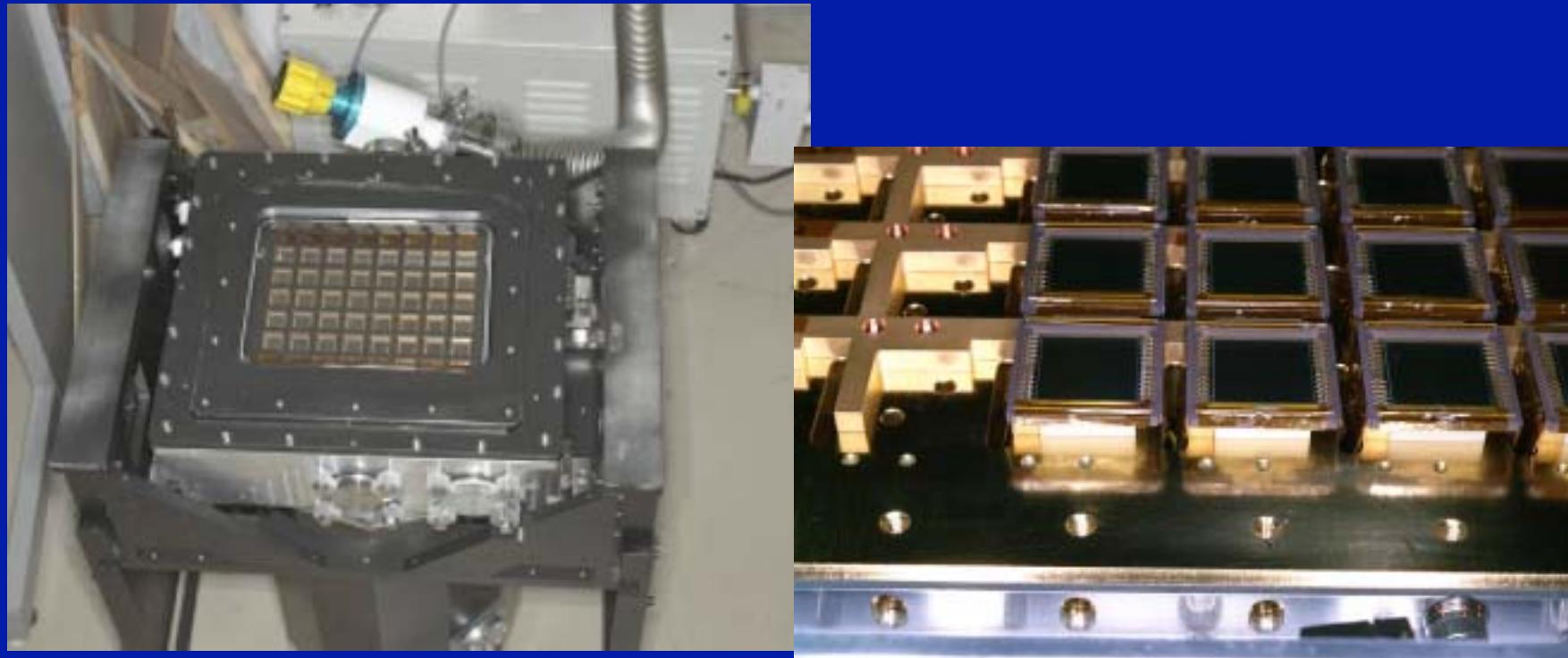


Hyper Suprime-Cam HSC

Satoshi Miyazaki
NAOJ ATC/Subaru

NAO-UT Mosaic Camera

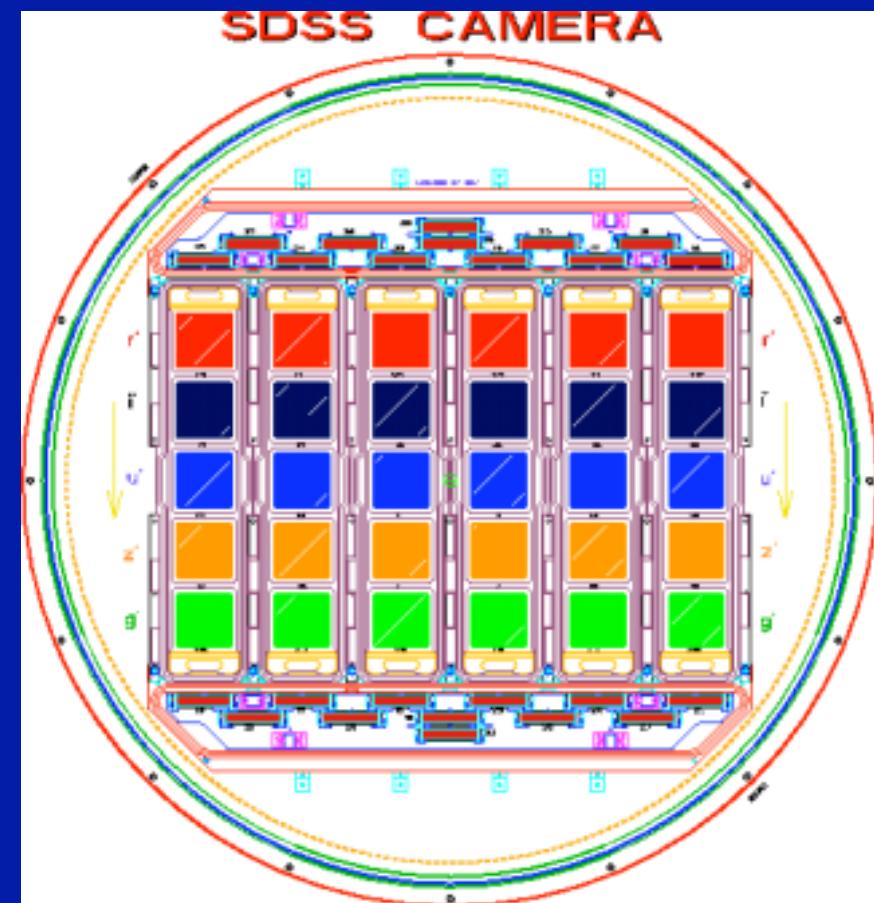
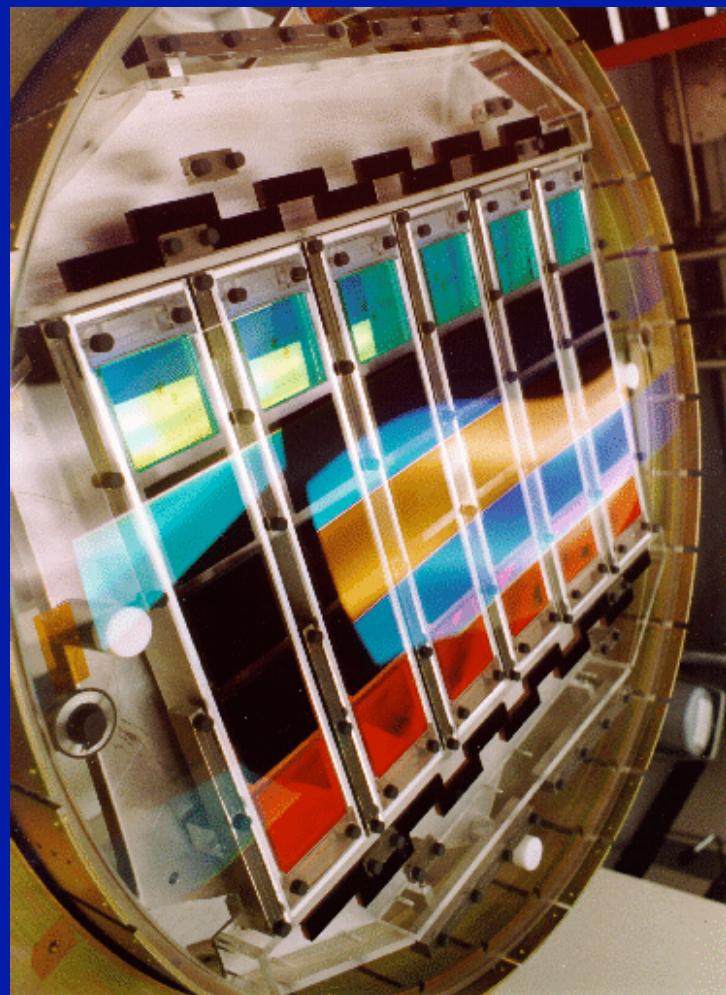
Sekiguchi Iwashita Doi Kashikawa Okamura (1992)



Mosaic of TI 1cm x 1cm CCDs
The world largest focal plane while
large format CCD was not available

SDSS Photometric Camera

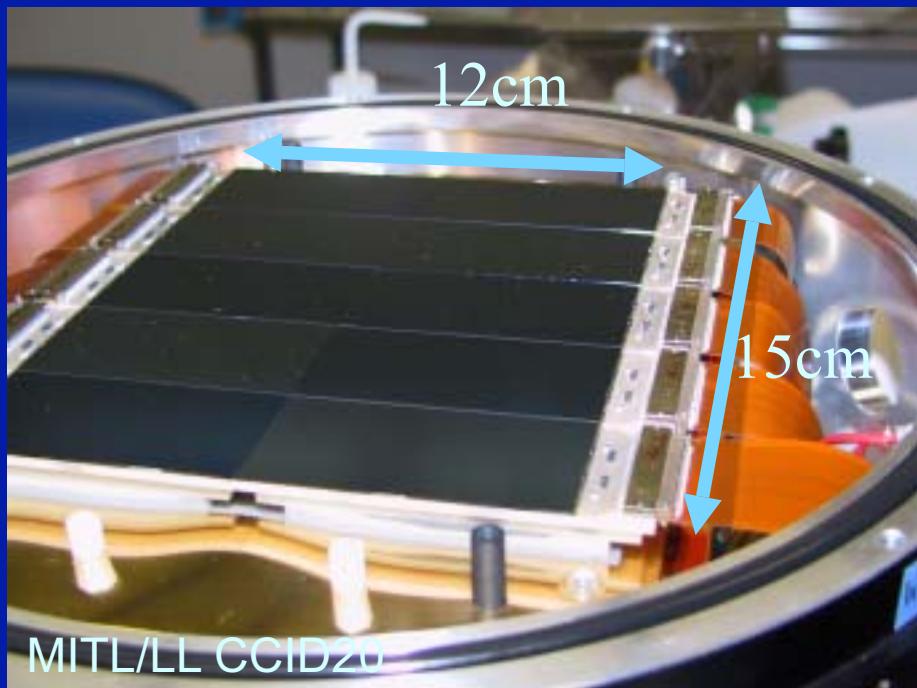
Gunn Carr Rockosi Sekiguchi et al. (1998)



2007/03/16

VHEPA-6 HSC Miyazaki

Subaru Prime Focus Camera



FOV 34 arcmin x 27 arcmin
10 MIT/LL CCID20

Based on experiences
accumulated through
NAO-UT mosaic and SDSS
cameras.

Canon : Optics
Mitsubishi : Mechanics

The decision to build the
prime focus on 8 m Subaru
made by **Kodaira** and
Okamura was farsighted.

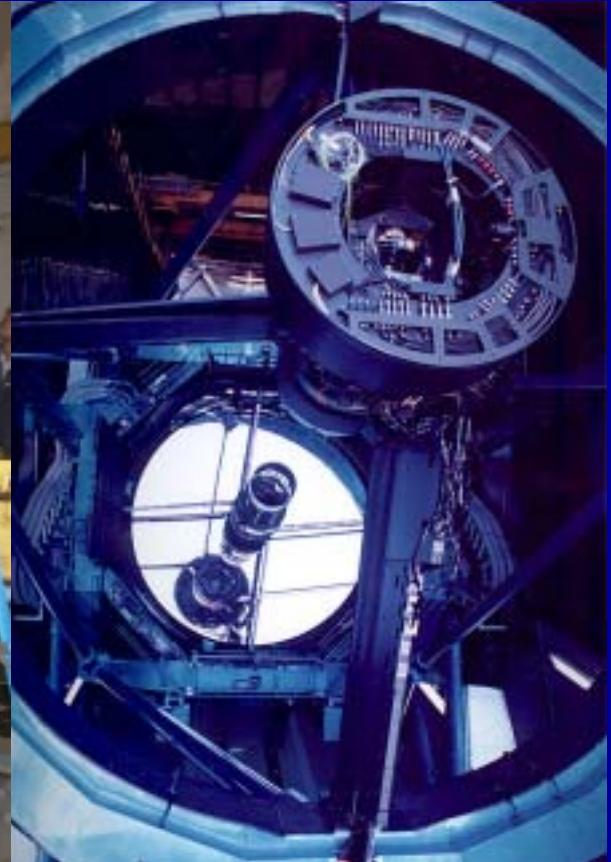


Cano

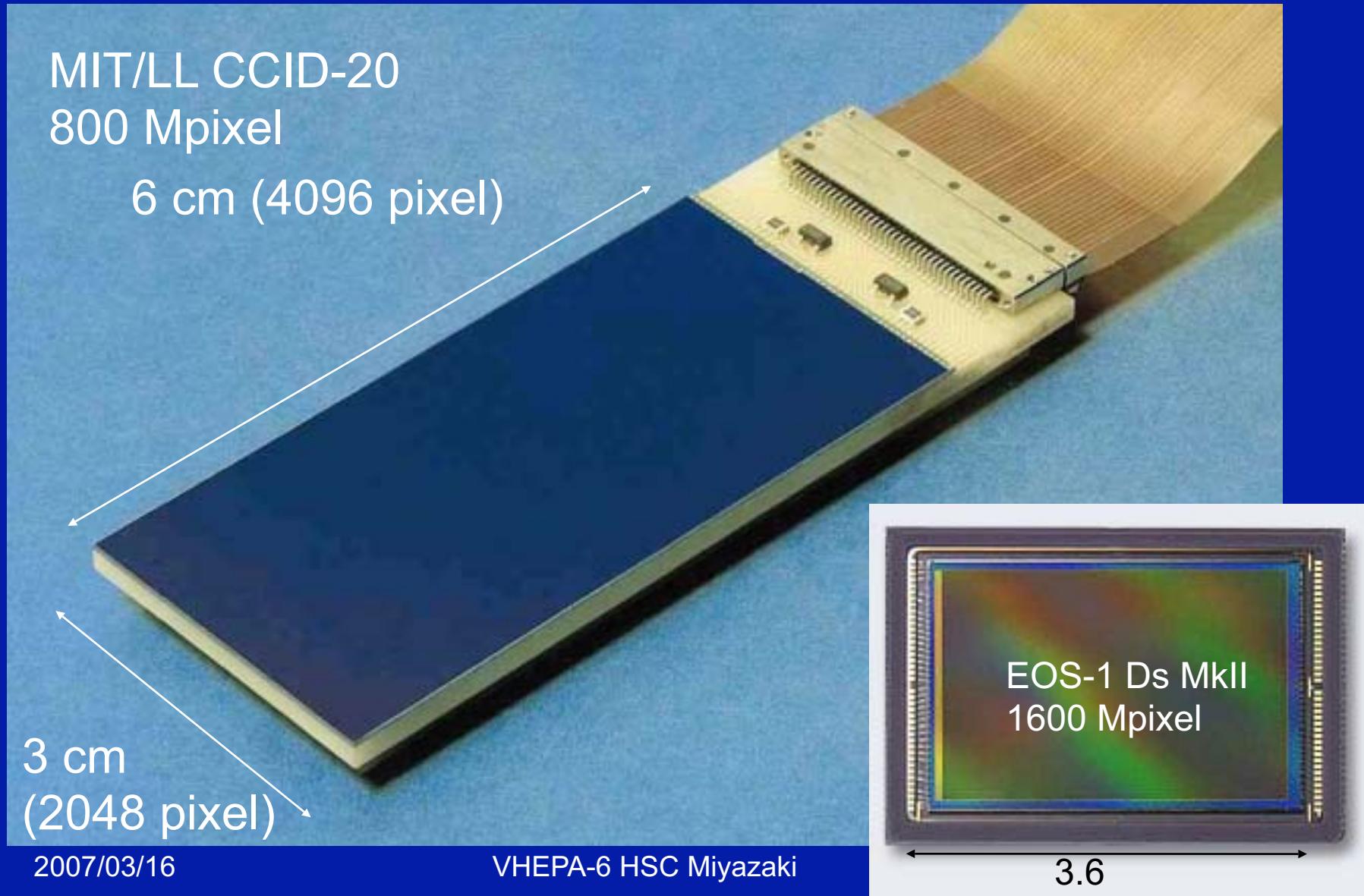


Mitsubishi

Suprime-Cam



Suprime-Cam CCD



Strength of Suprime-Cam 1

- High Red QE in red band (MIT/LL CCD)
 - less fringing

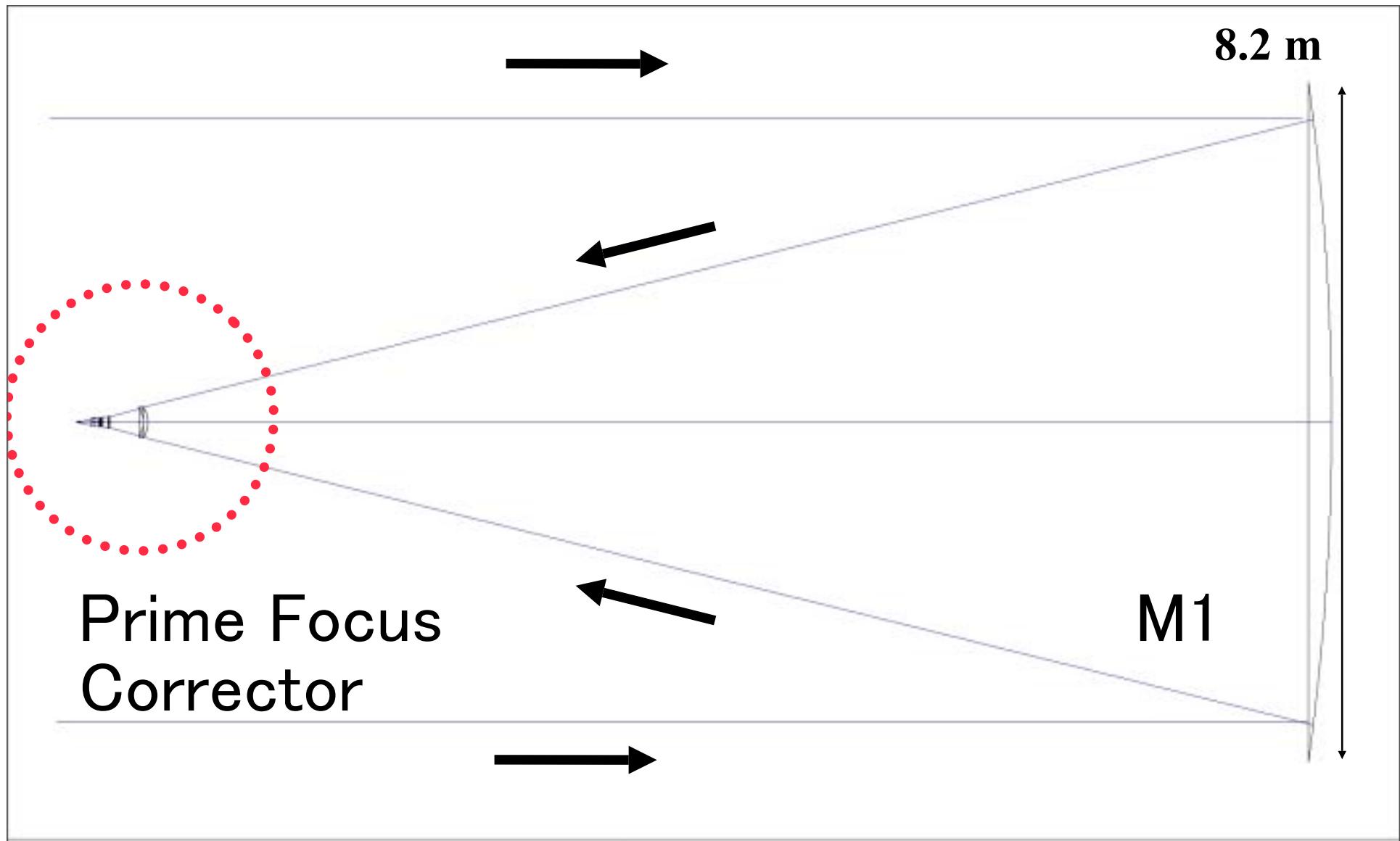
Table 1: The most distant galaxies with measured redshift (as of Sep.14, 2006).

Rank	Identification	Coordinates	Redshift	Distance [#]	Paper	Publishing date
1	IOK-1	J132359.8+272456	6.964	12.8826	Iye et al.	Sep. 14, 2006
2	SDF ID1004	J132522.3+273520	6.597	12.8250	Taniguchi et al.	Feb. 25, 2005
3	SDF ID1018	J132520.4+273459	6.596	12.8248	Kashikawa et al.	Apr. 25, 2006
4	SDF ID1030	J132357.1+272448	6.589	12.8238	Kashikawa et al.	Apr. 25, 2006
5	SDF ID1007	J132432.5+271647	6.580	12.8222	Taniguchi et al.	Feb. 25, 2005
6	SDF ID1008	J132518.8+273043	6.578	12.8219	Taniguchi et al.	Feb. 25, 2005
6	SDF ID1001	J132418.3+271455	6.578	12.8219	Kodaira et al.	Apr. 25, 2003
8*	HCM-6A	J023954.7-013332	6.560	12.8189	Hu et al.	Apr. 1, 2002
9	SDF ID1059	J132432.9+273124	6.557	12.8184	Kashikawa et al.	Apr. 25, 2006
10	SDF ID1003	J132408.3+271543	6.554	12.8178	Taniguchi et al.	Feb. 25, 2005

[#] Distance in billion light years calculated for a model of the Universe that has an age 13.66 billion years.

* This object was discovered by Keck telescope. All the rest were discovered by Subaru Telescope in the Subaru Deep Field.

c.f. MegaCam: EEV
NOAO Mosaic: SITE



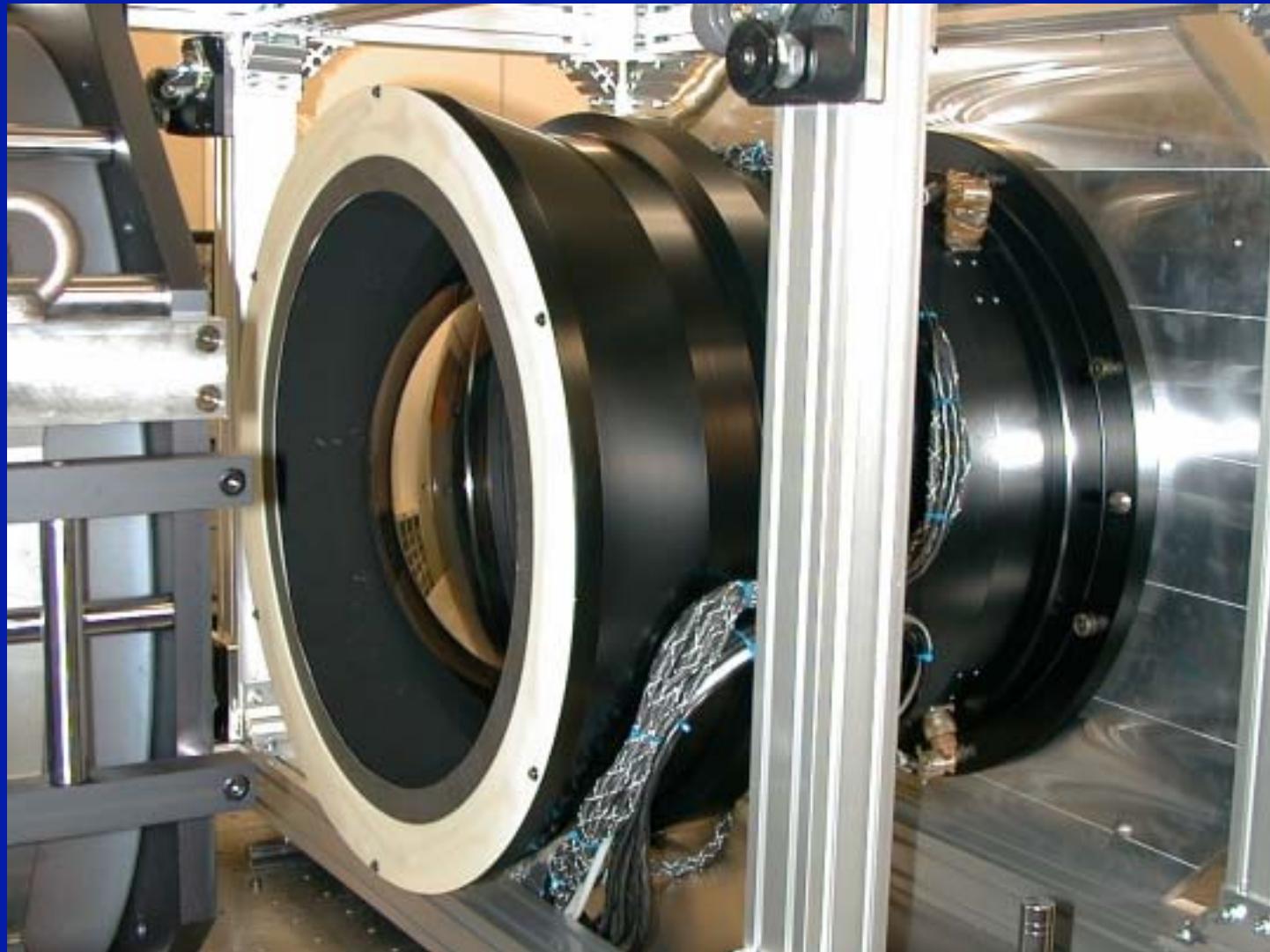
Prime Focus
Corrector

M1

3D LAYOUT

SUPRIM CAM
FRI JUL 1 2005

SUBARU TELESCOPE
650 N ROHOKU PLACE
HILO HI96720
TEST.ZMX
CONFIGURATION 1 OF 1



Canon Suprime-Cam Corrector

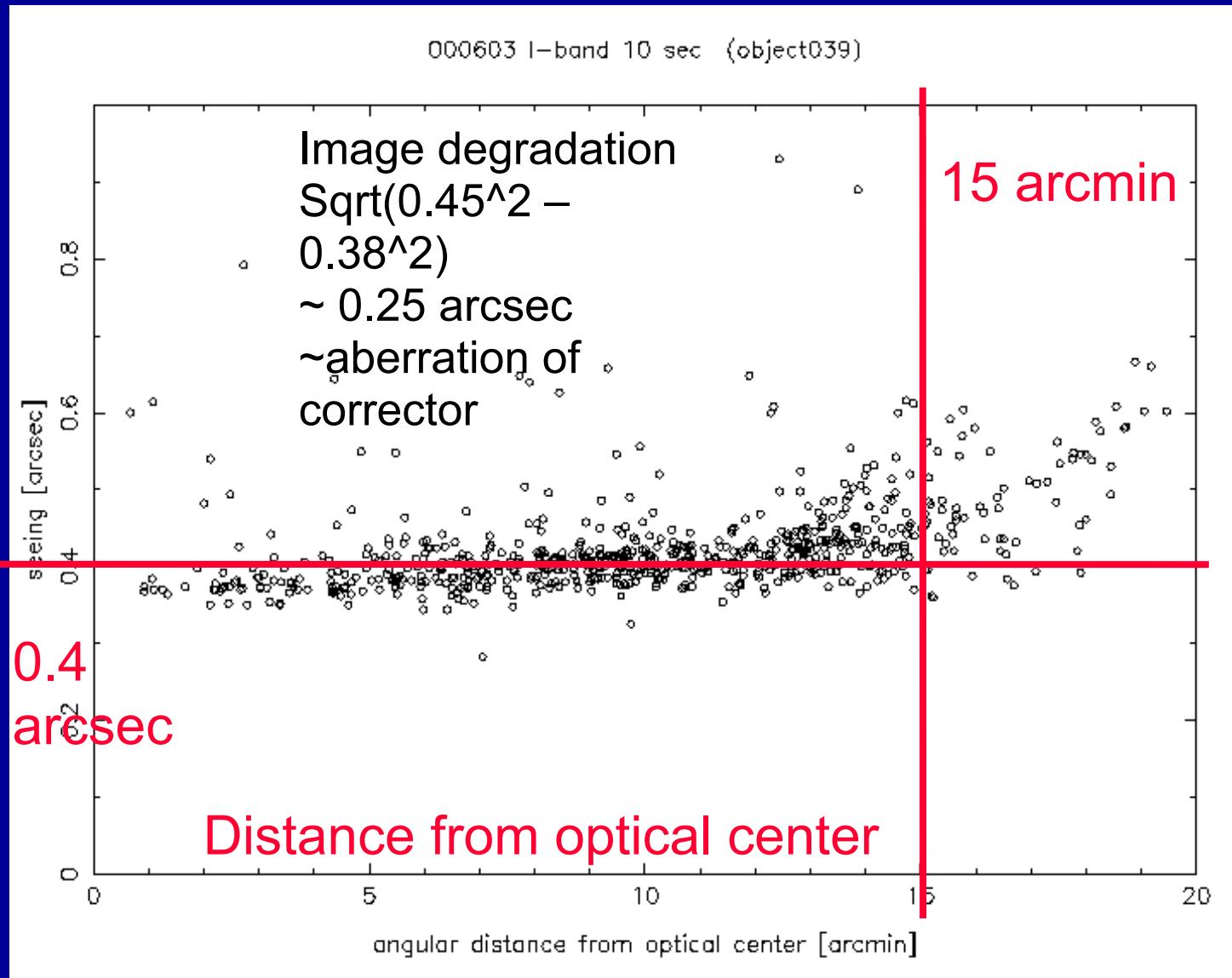
2007/03/16

VHEPA-6 HSC Miyazaki

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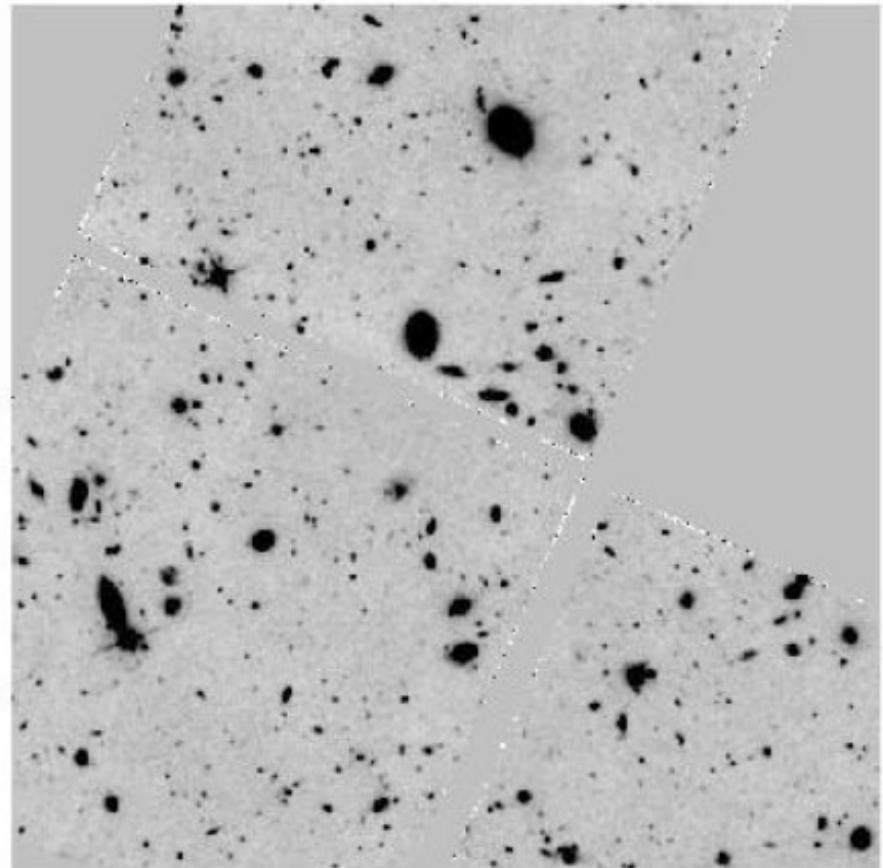
Image Quality of Suprime

Image Size of stellar objects (FWHM)

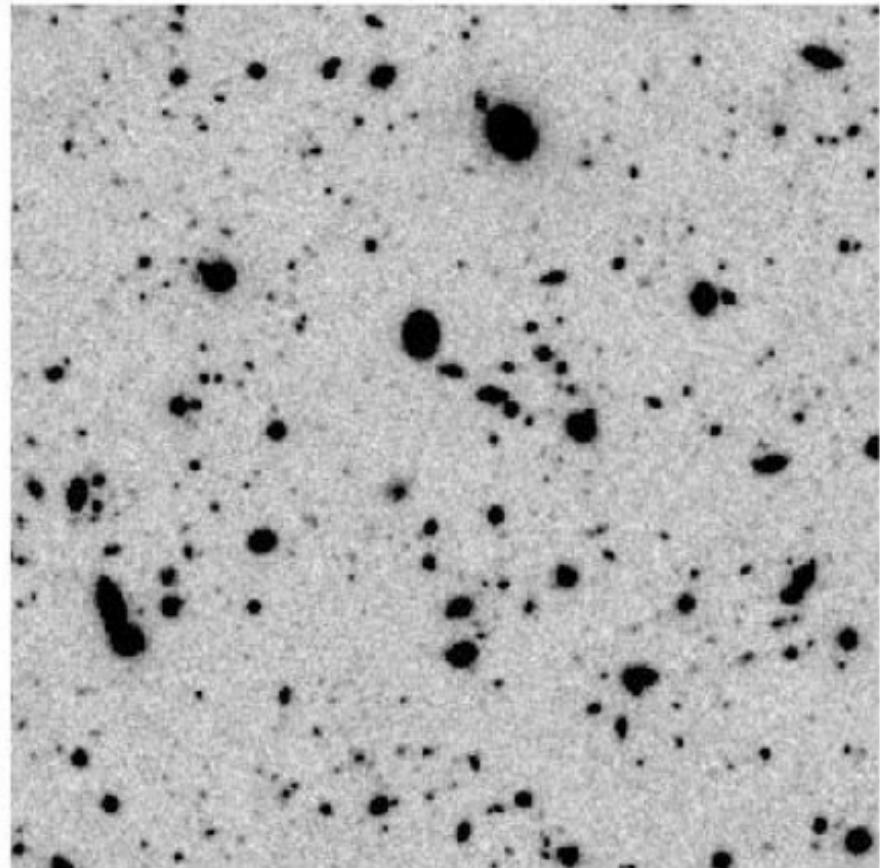


Strength of Suprime-Cam 2

Hu & Cowie 2006 Nature

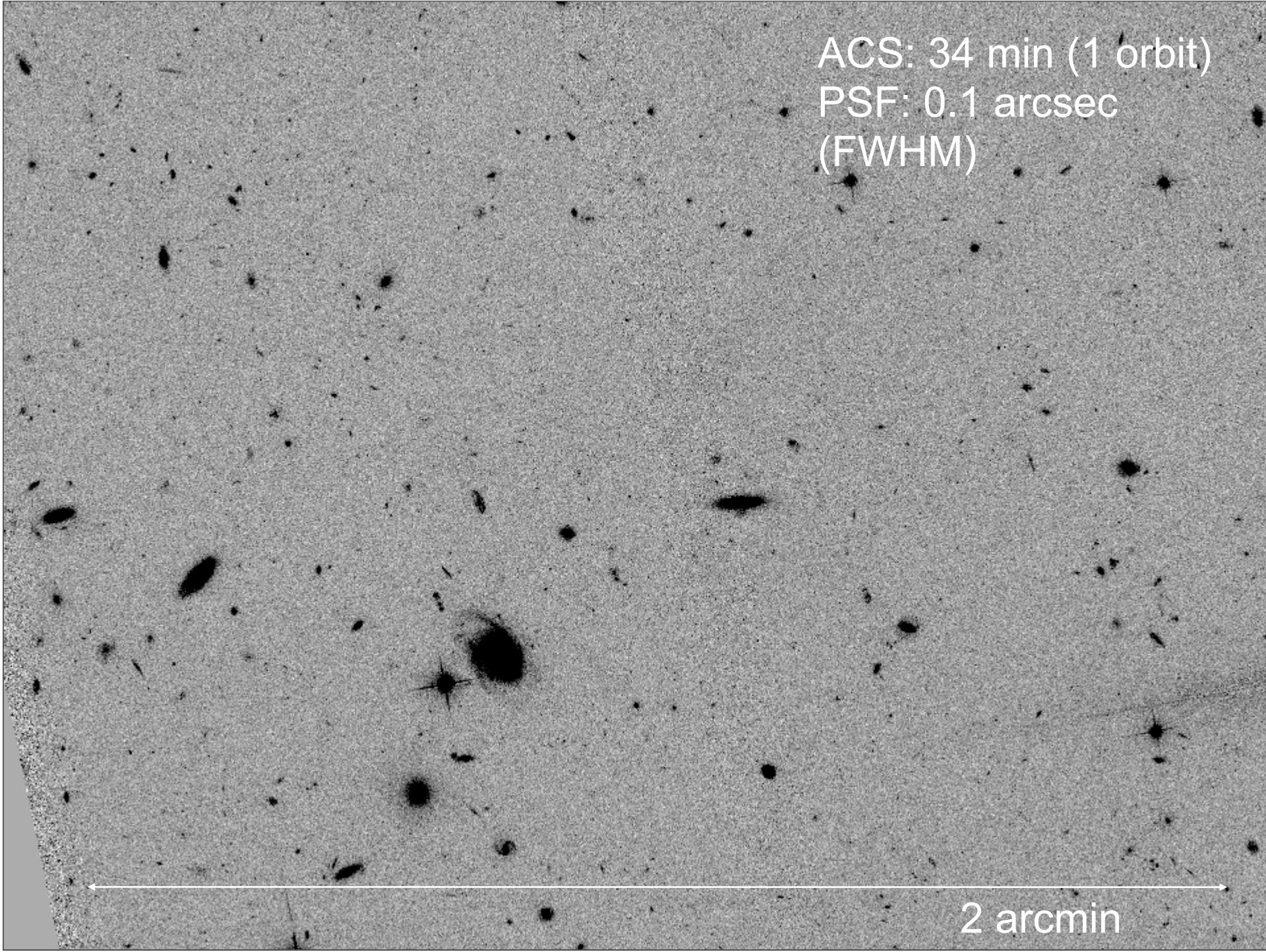


HST 'wide-I' continuum



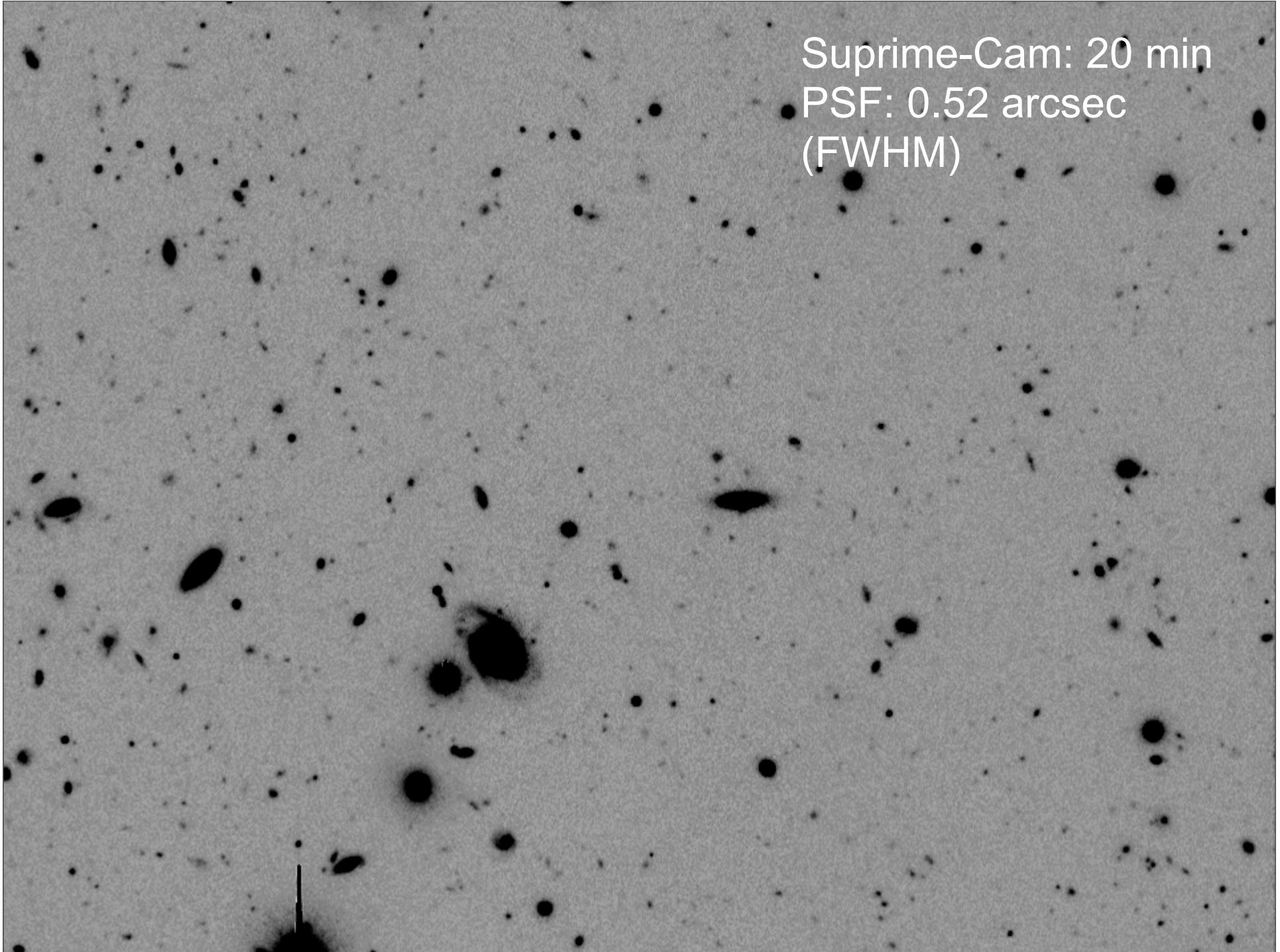
NB816 narrowband

Good Image Quality and FOV X100 larger



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

2 arcmin

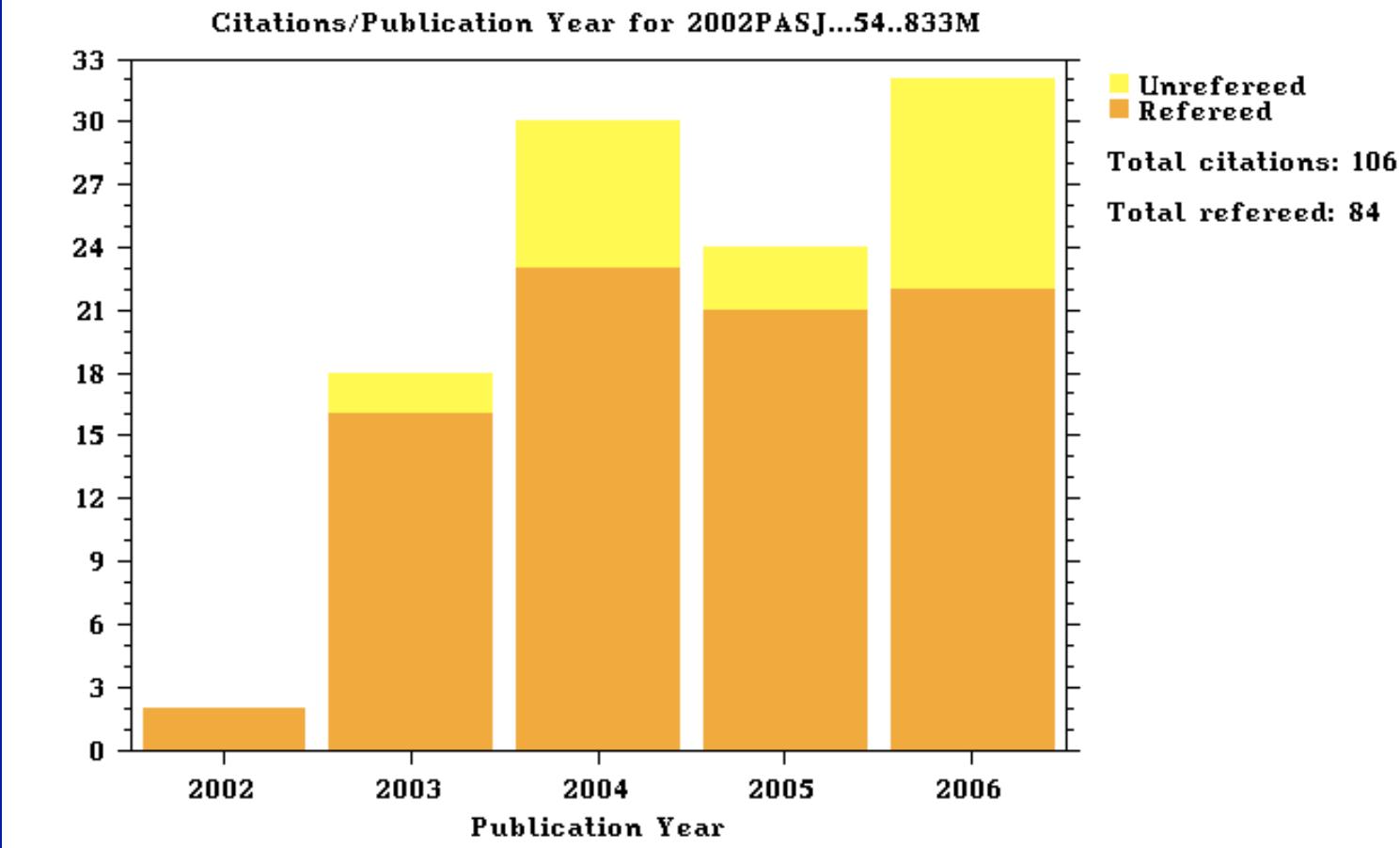


Suprime-Cam: 20 min
PSF: 0.52 arcsec
(FWHM)

Popularity of Supreme-Cam

Citations history for [2002PASJ...54..833M](#) from the ADS Databases

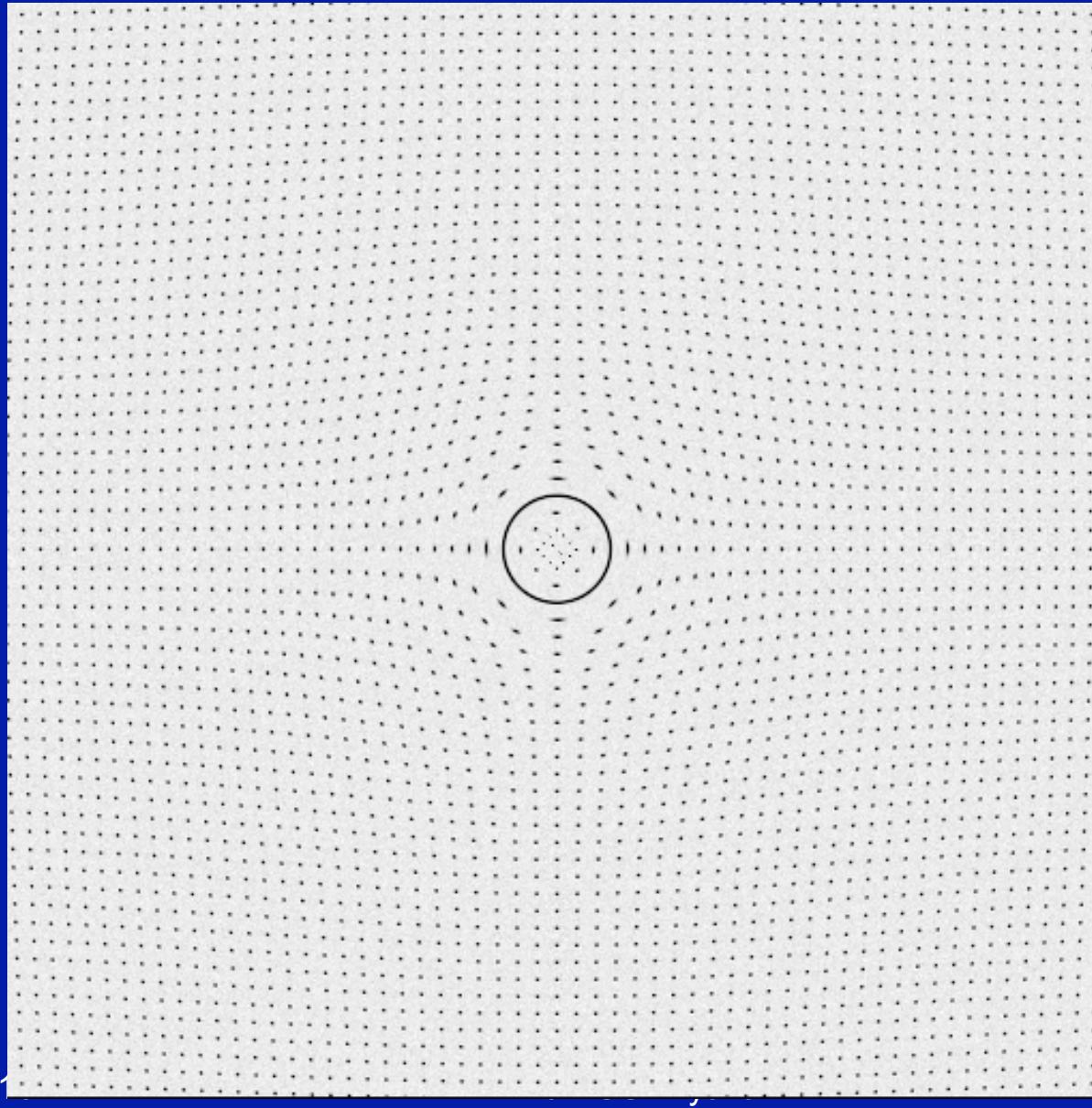
The Citation database in the ADS is NOT complete. Please keep this in mind when using the [ADS Citation lists](#).

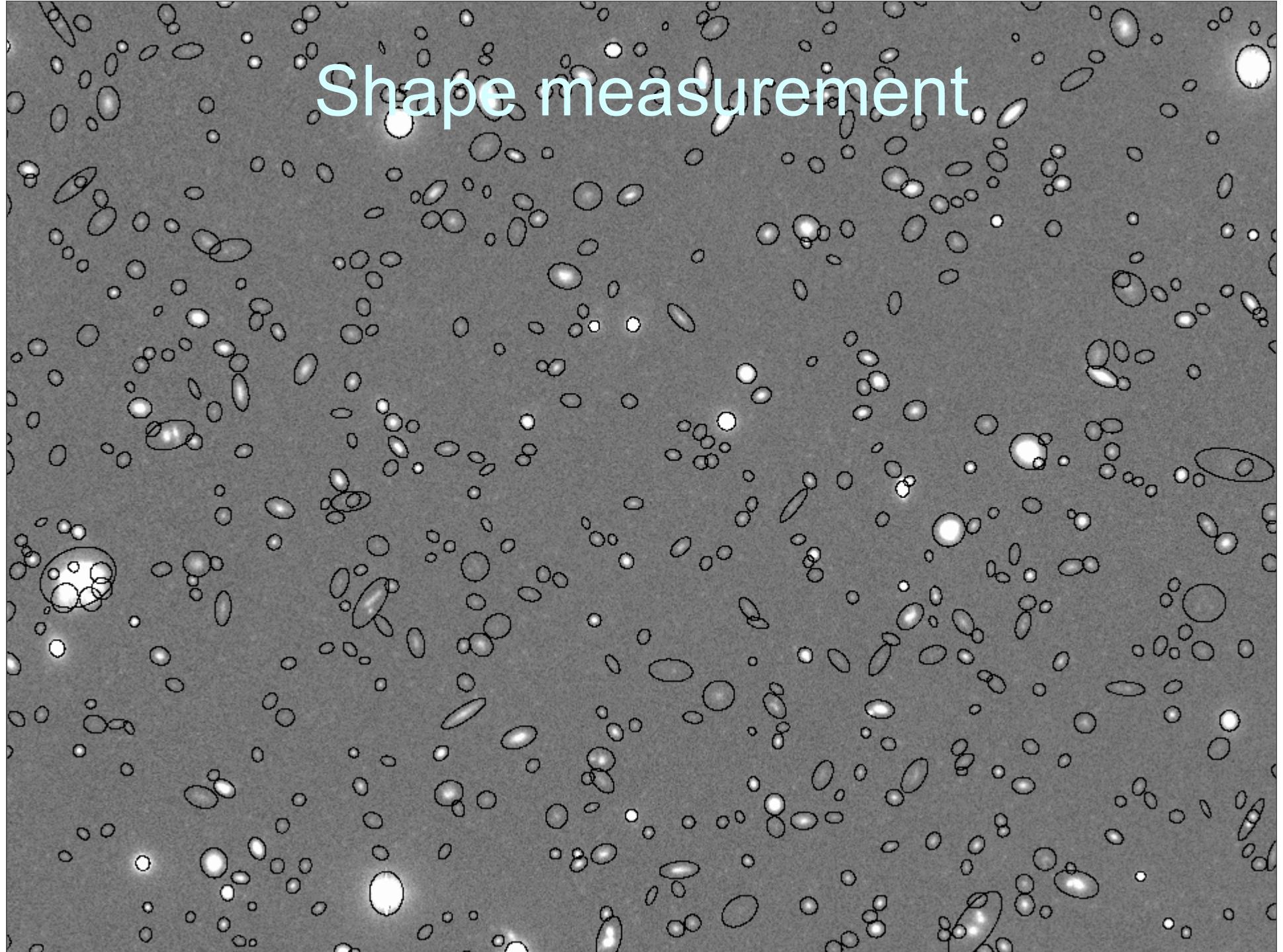


Application

Weak Lensing Survey

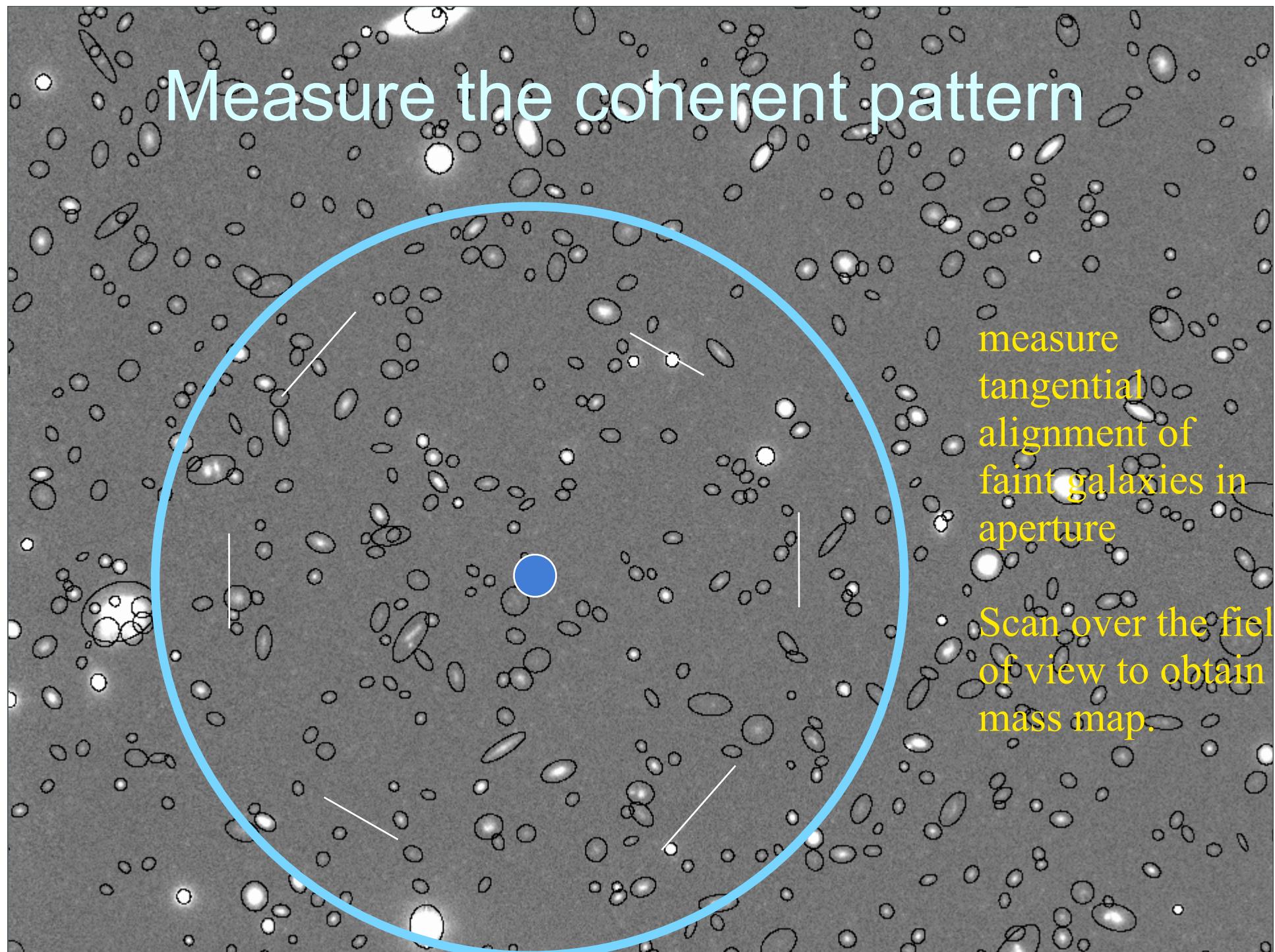
Shear



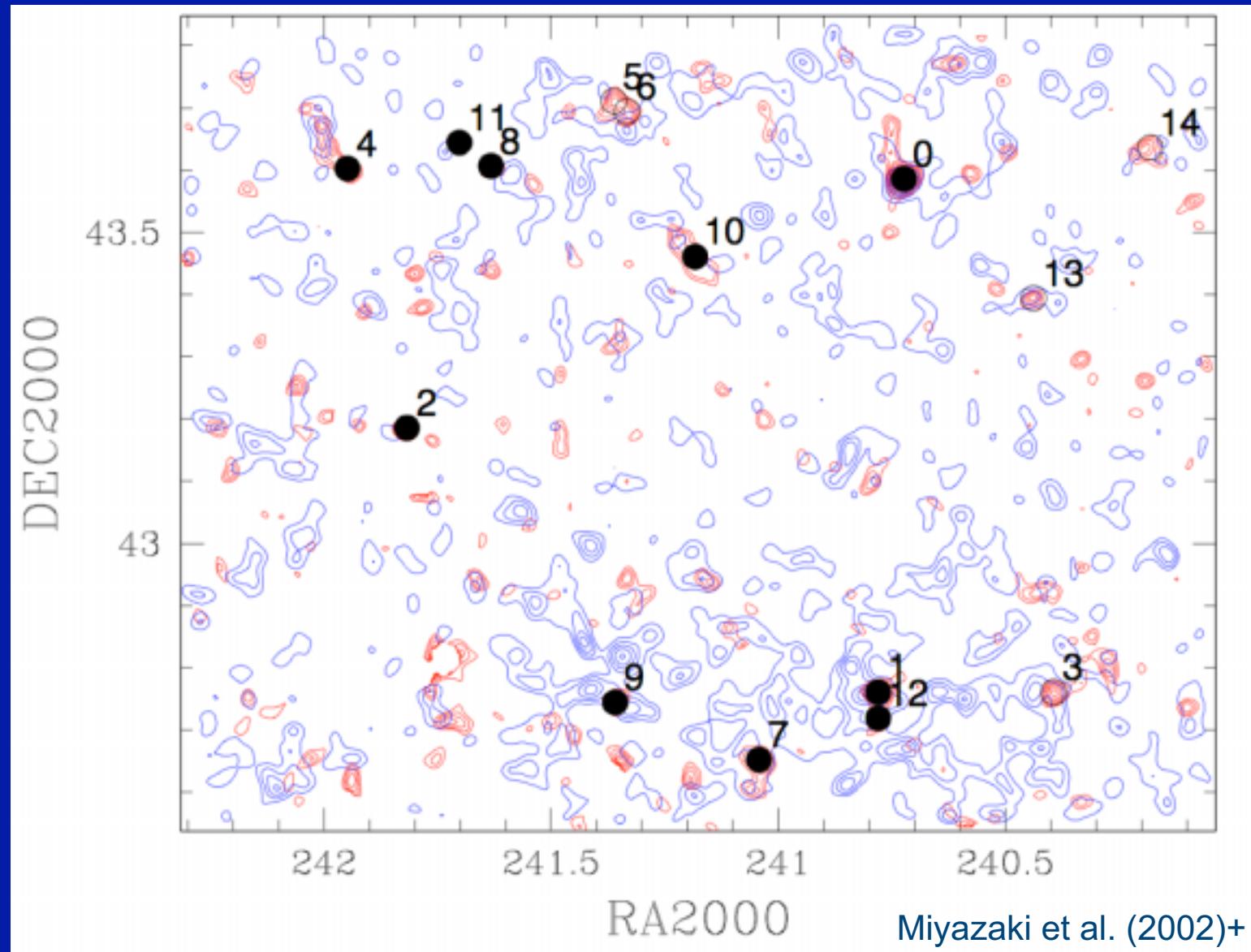


Shape measurement

Measure the coherent pattern

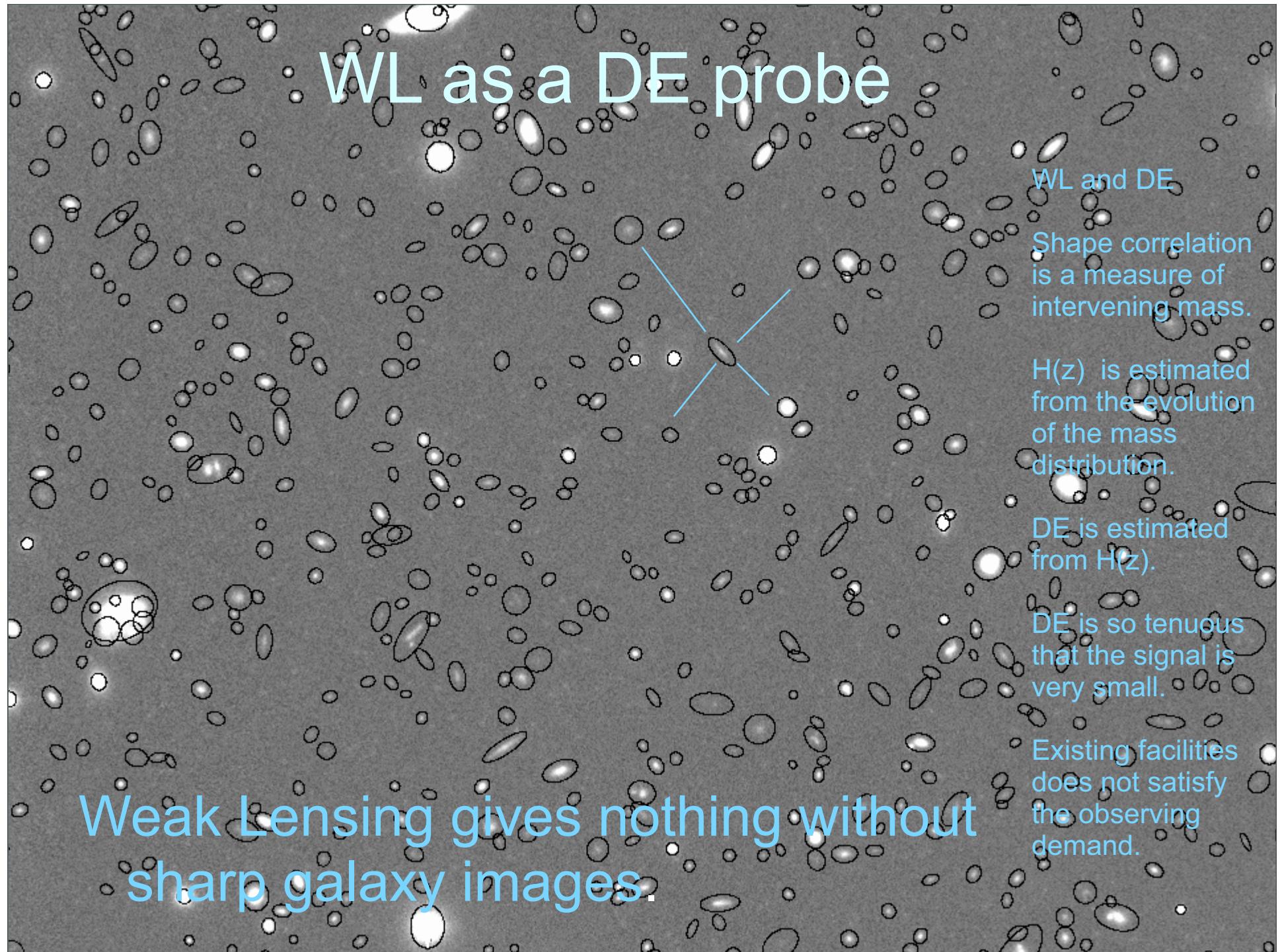


Weak Lensing Survey



3×3
Suprime
Field



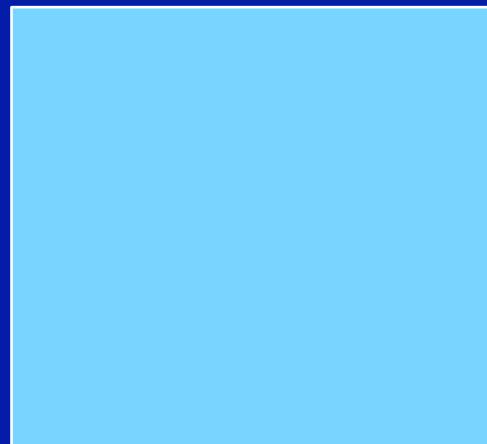


Survey Speed

Camera	A [m ²]	Ω [deg ²]	A Ω	First Light
SDSS	3.83	6.0	22.99	May-98
UH8K	9.59	0.25	2.40	Sep-95
CFH12K	9.59	0.375	3.60	Jan-99
Suprime	51.65	0.256	13.17	Jul-99
MegaCam	9.59	1.0	9.59	Jan-03

Two key concepts

- Expanding the field of view by 10 times while keeping the same resolution
- Even higher QE in red

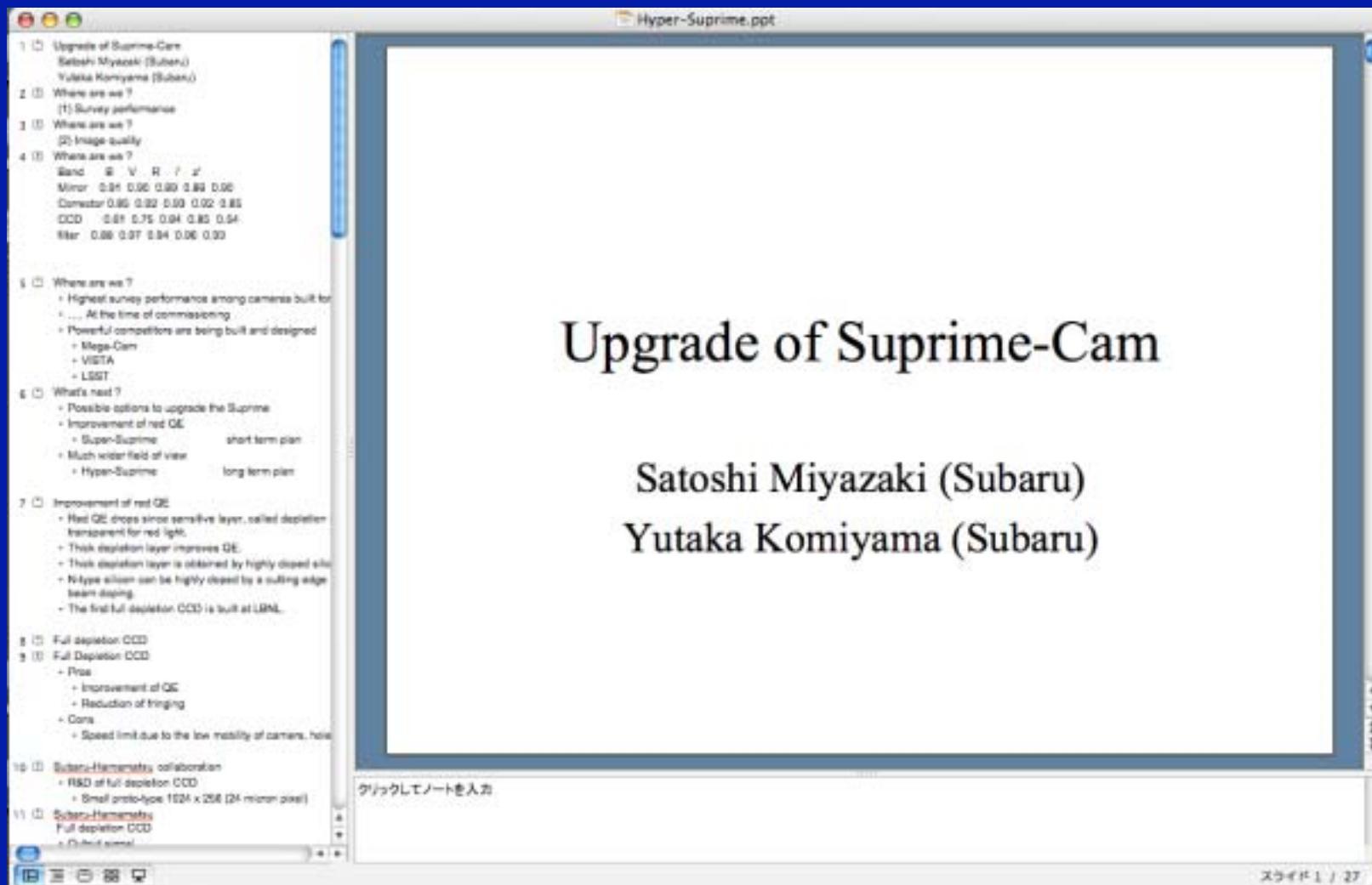


HST Suprime-Cam

because DE is so
tenuous

HSC

Subaru Future Workshop 2002



First presentation was made on 2002/07.

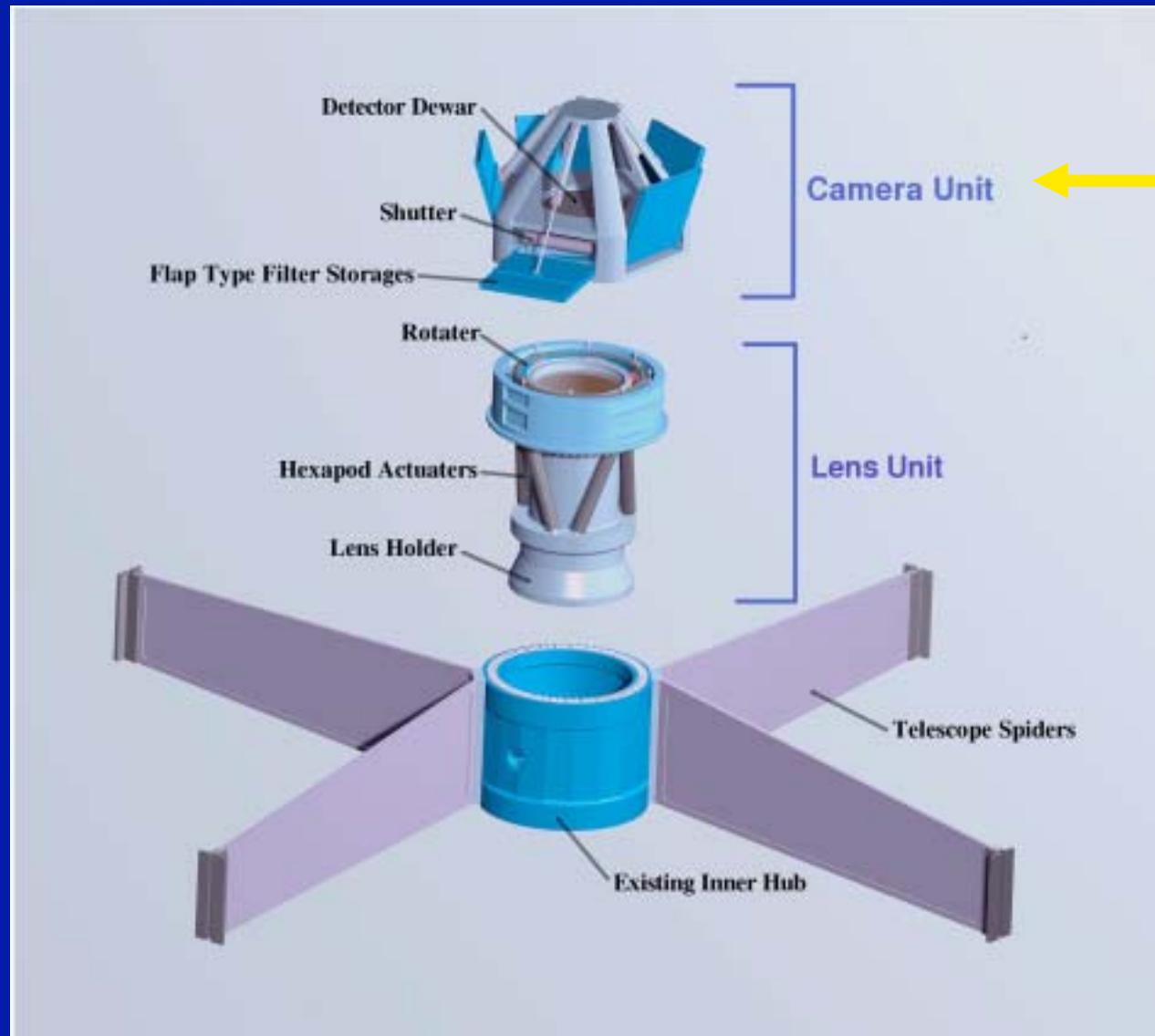
HSC: Specification

- FOV: 2.0 deg (1.4 Gpixel)
 - 1.5 deg option considered
- D80: < 0.3 arcsec ($\lambda > 600$ nm)
< 0.4 arcsec ($\lambda < 600$ nm)
- Readout time: $<\sim 20$ sec
- Weight: < 3 - 3.5 t (including lens)

HSC Design Constraints

- Subaru is a general purpose telescope.
- Minimize impacts on telescope operations
 - Down time
 - Instrument exchange
- Minimize IR emissivity
 - MOIRCS builder, Ichikawa, joined our team
- Detail Discussions with Mitsubishi is crucial.
 - Being delayed due to ALMA and the recent earthquake

HSC: Mechanical Design

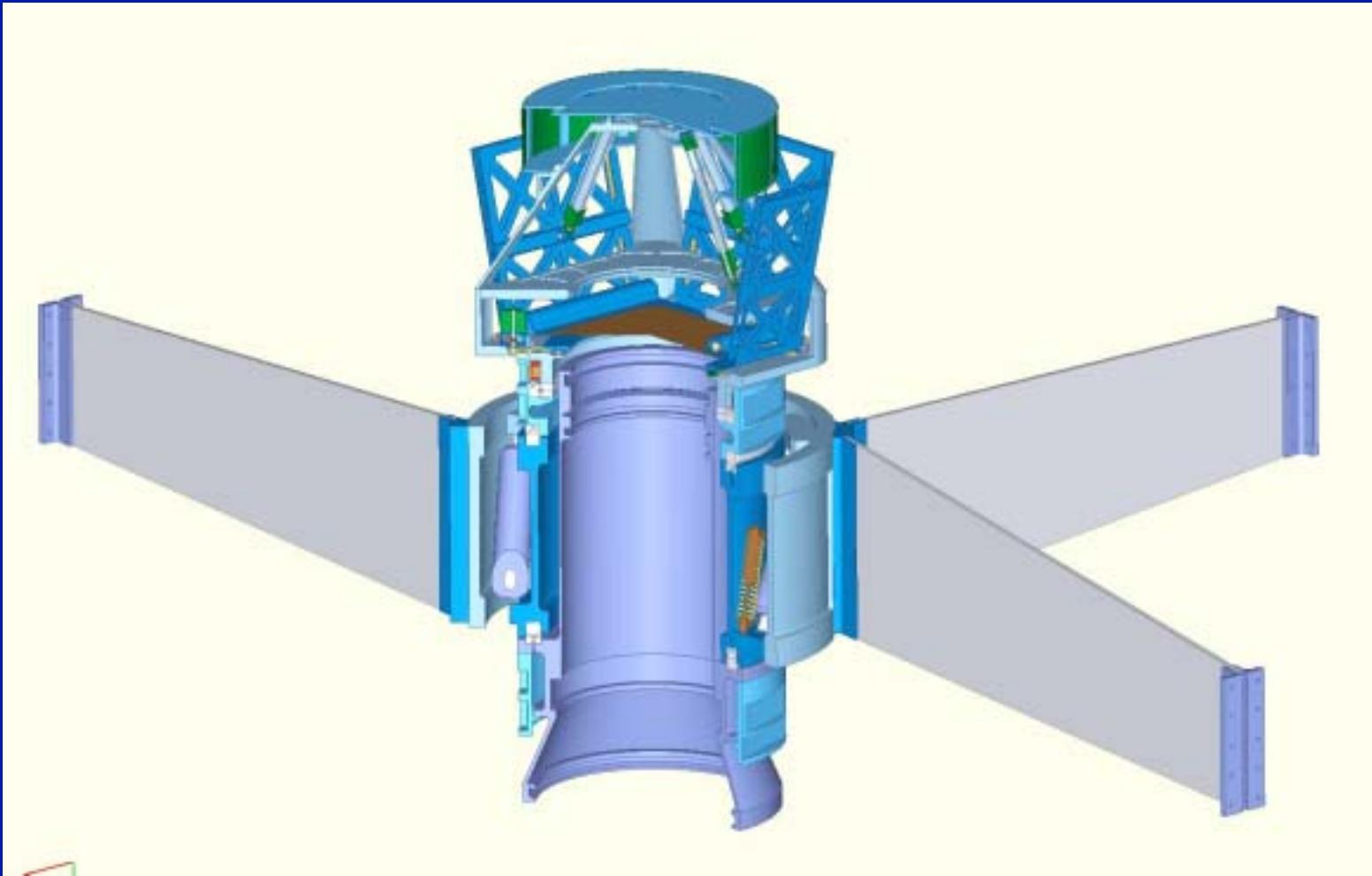


Interchan-
geable
with
WFMOS.

1.5 deg
option is
shown.

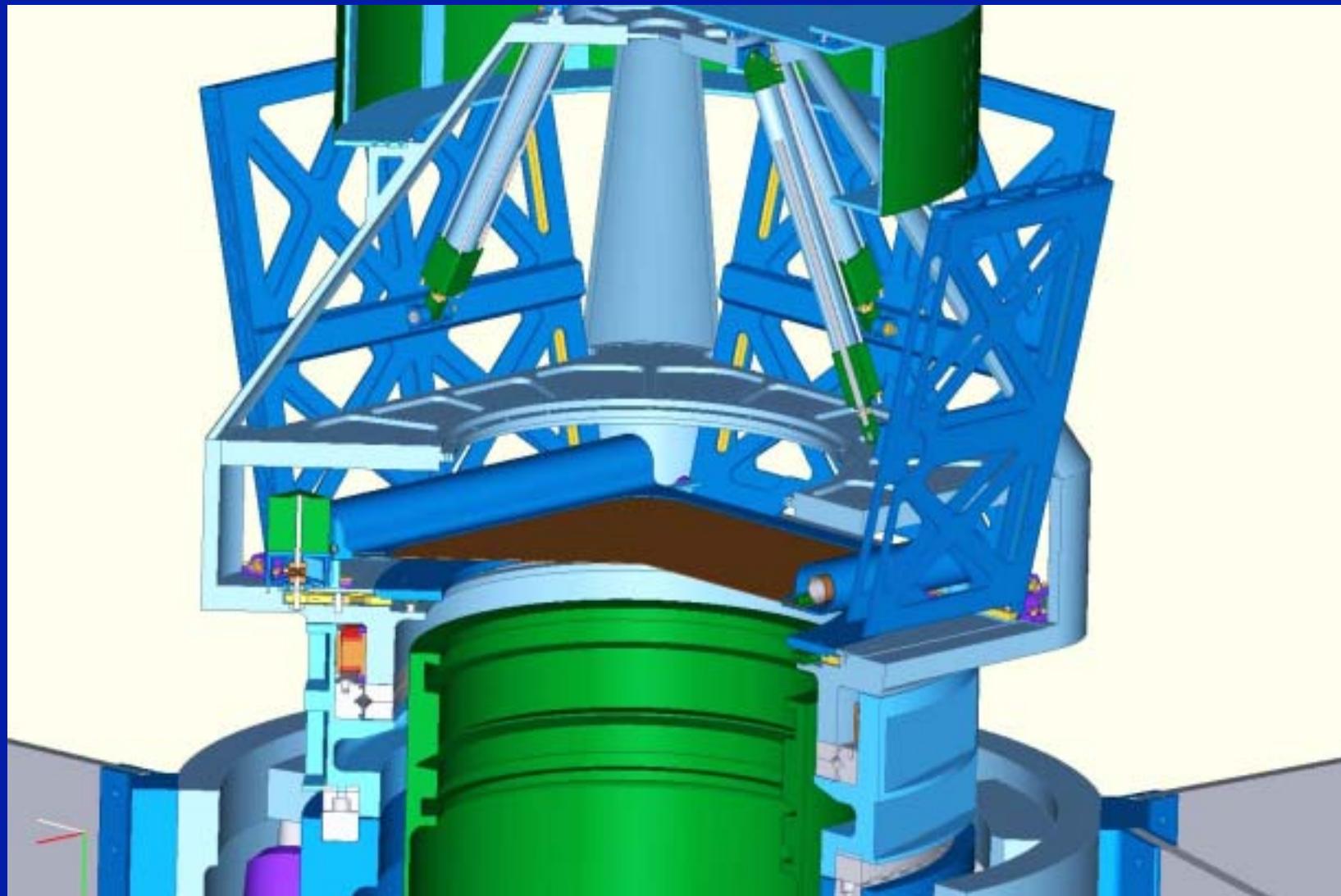
Refer to
Doi et al.
6269-130

2 deg Configuration

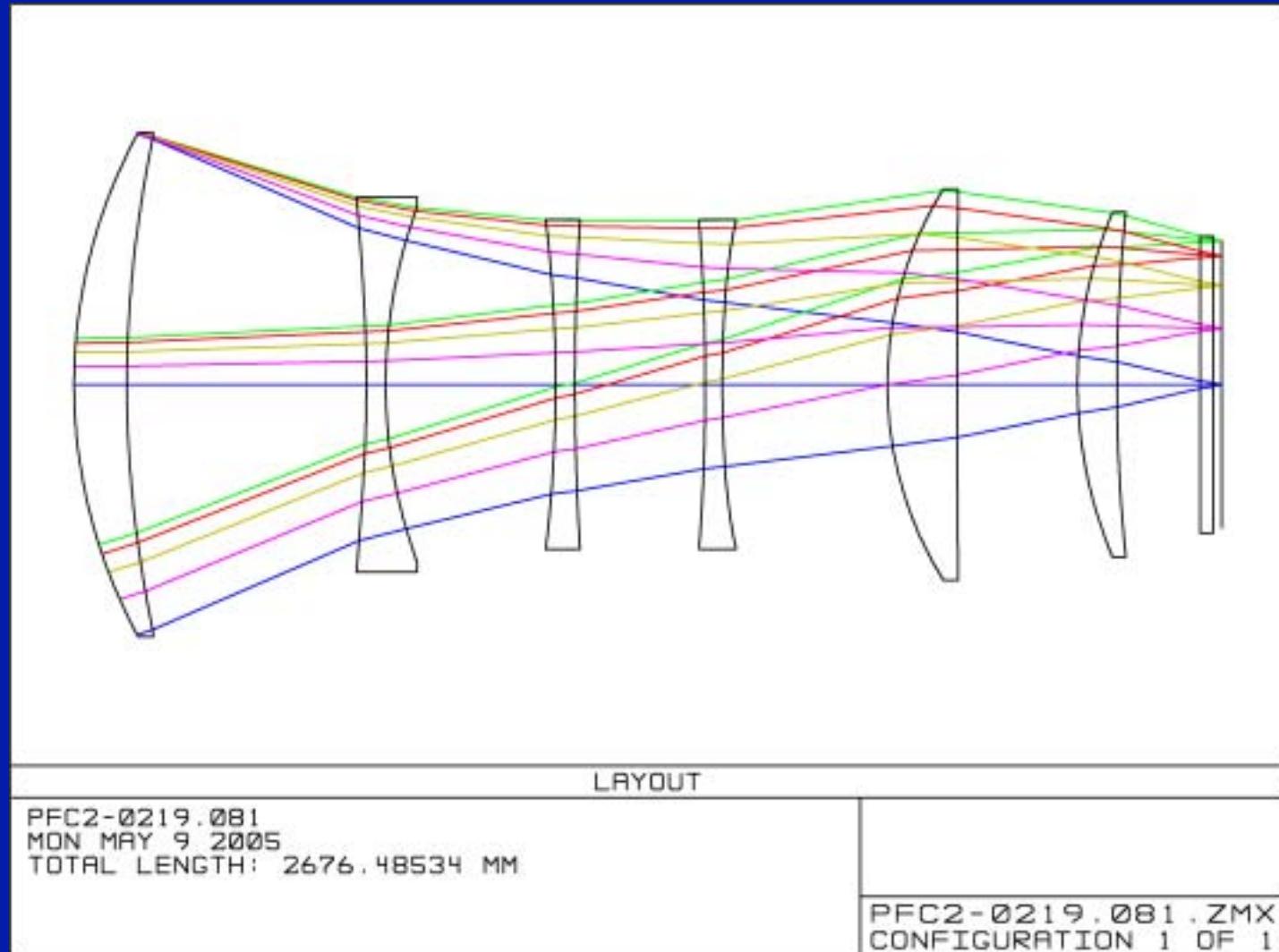


Inner hub should be replaced to have actuators

Filter Ex. and Shutter



Optics: 2 deg option



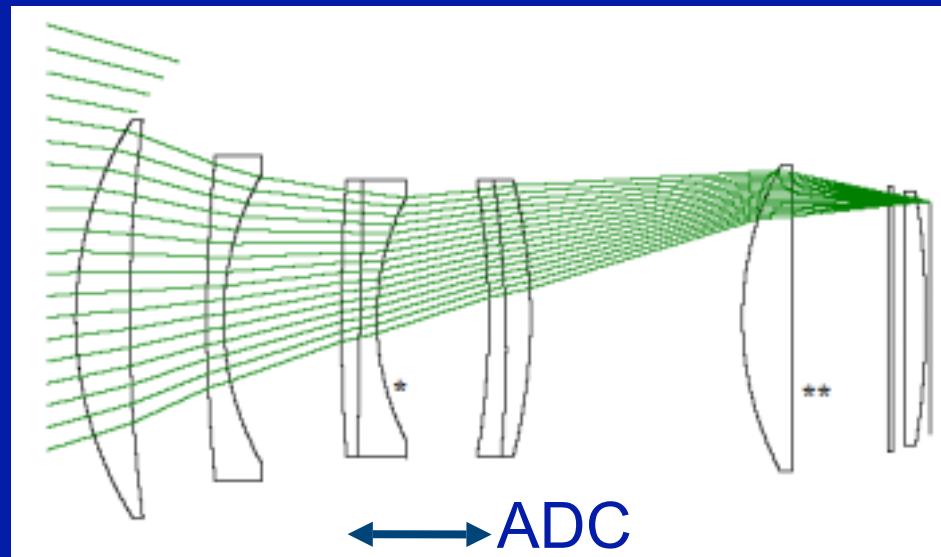
Dr. Takeshi
design

1.2 m dia.
All Silica
except one

Refer to
Komiyama
et al.
6269-125

Optics: 1.5 deg option

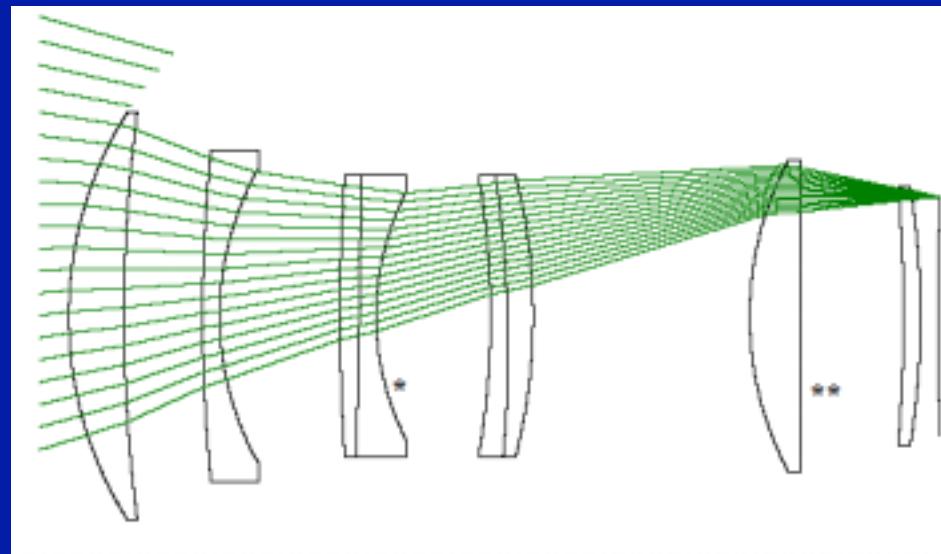
HSC



P. Gillingham
design

0.9 m dia.
Mostly Silica
ADC installed

WFMOS



Aspheric 2 surf.
(conic)

D80:1.5 deg option

	At ZD = 0					At ZD = 65				
	WFMOS		HS			WFMOS		HS		
	g	r	I	z		g	r	I	z	
config:	1	3	5	7	9	2	4	6	8	10
r80 μm	14.3	13.7	8.4	7.2	7.9	20.2	15.1	9.3	9.5	9.0
r90 μm	18.7	16.5	10.1	9.5	10.7	25.6	18.0	11.2	11.7	12.0
r95 μm	21.6	20.9	14.0	13.9	16.3	31.1	24.0	14.7	15.5	16.8
d80 arcsec	0.30	0.29	0.18	0.15	0.16	0.42	0.31	0.19	0.20	0.19
d90 arcsec	0.39	0.34	0.21	0.20	0.22	0.53	0.38	0.23	0.24	0.25
d95 arcsec	0.45	0.44	0.29	0.29	0.34	0.65	0.50	0.31	0.32	0.35

D80 < 0.3 arcsec for 400 < lambda < 1100

Risks in HSC Project

1. Fabrication of Large Corrector
Large Filters
CCDs
2. Telescope modification
3. Obtaining telescope time

Large Optics Fabrication



SAGEM-REOSC

LBT
D=80 cm
Lens



LBT Prime Focus Camera



F/1.45
30 arcmin

Canon



HSC Optics design study
approved by CEO & COO

EOS 20Da
夜空の表現者たちへ
より美しく、より快適な天体撮影を可能にする
カスタムモデル、EOS 20Da誕生。

The advertisement features a large image of a telescope dome at night, with the Canon EOS 20Da camera lens prominently displayed in the foreground. The text highlights the camera's suitability for astrophotography.

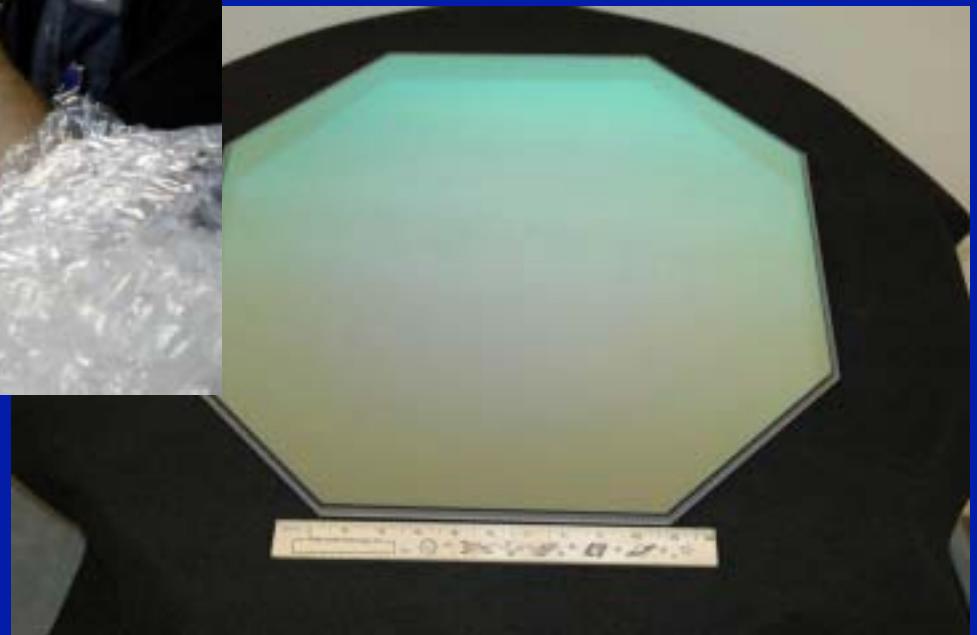


Large Filter

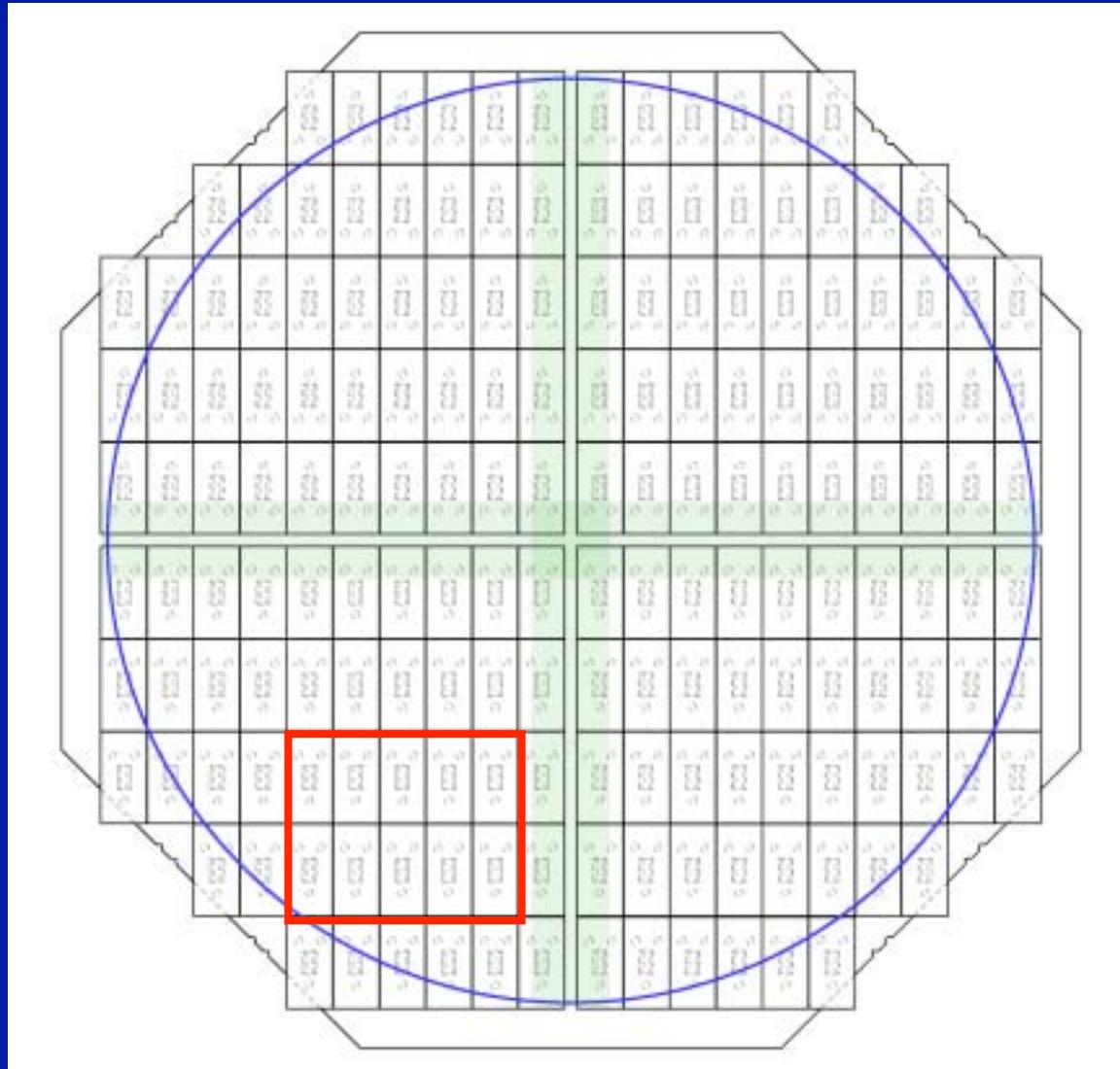


no color glass
Interference coat

Pan-STARRS
D=50 cm Filter
Barr Associate



Focal Plane of HSC

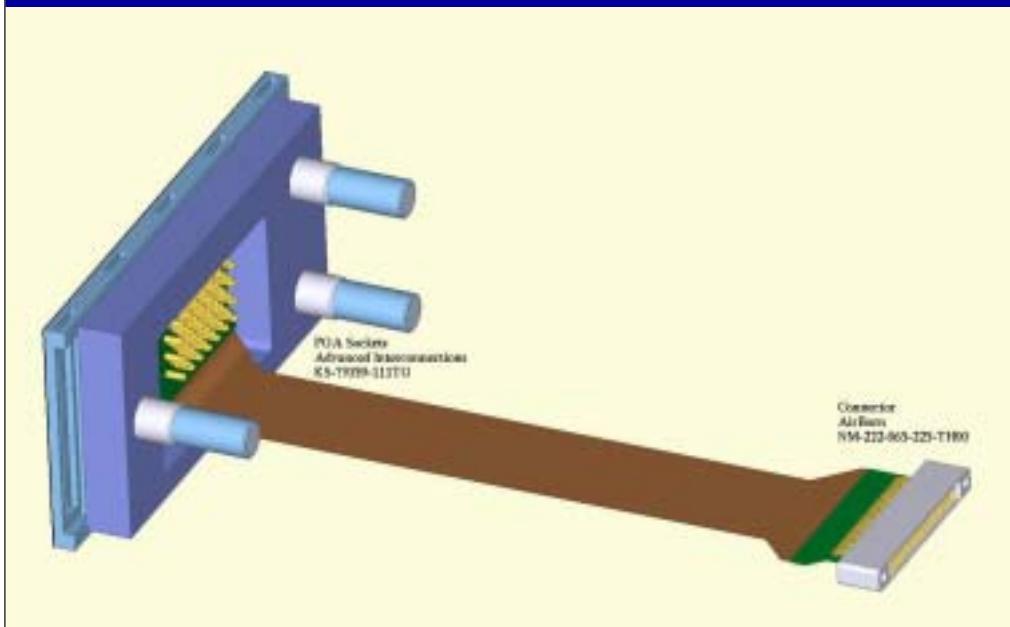
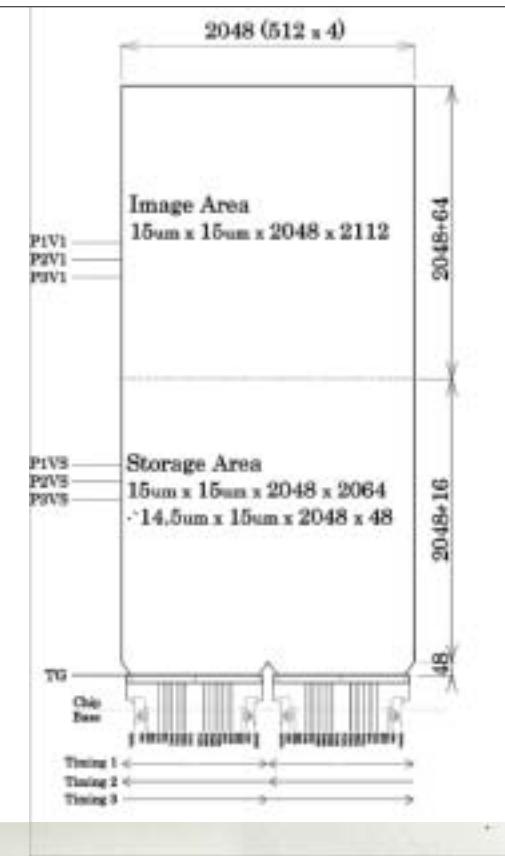


2 degree
60 cm

168 2k4k
CCDs

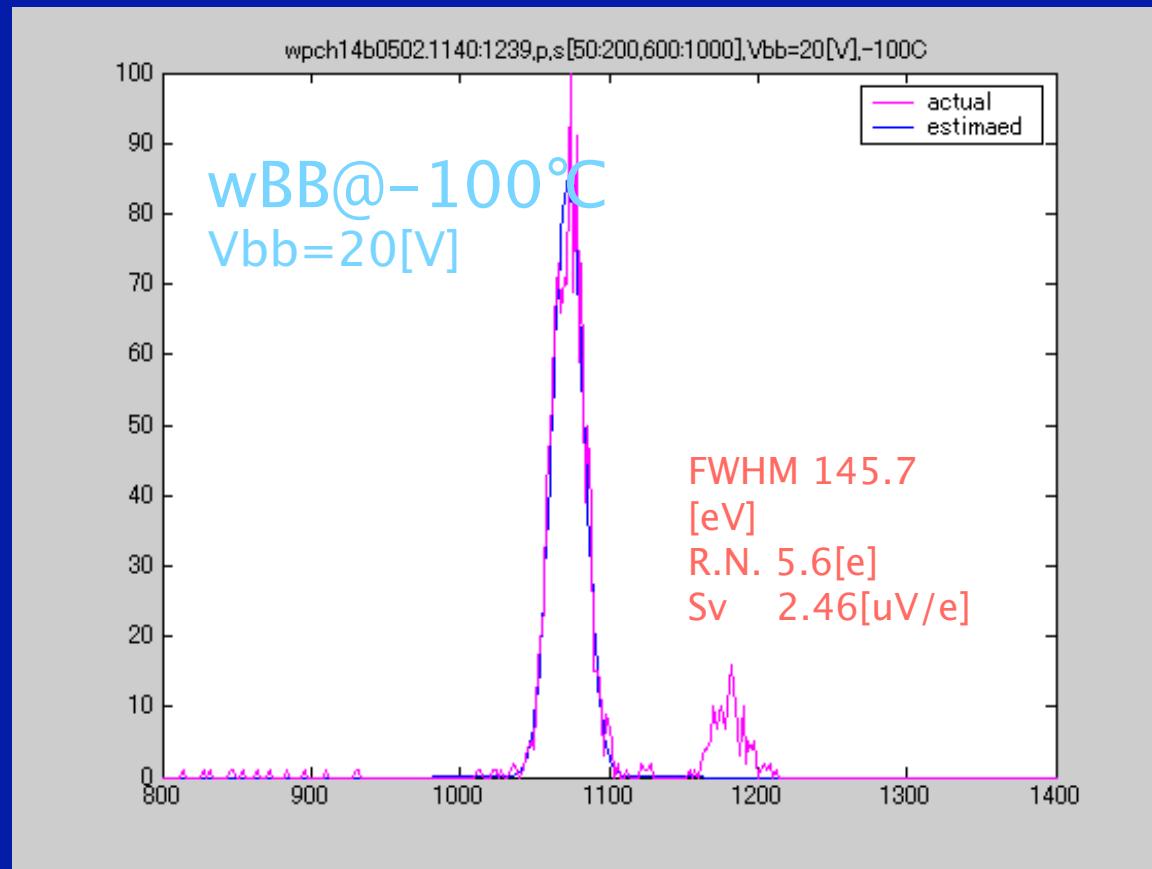
CCD

- Hamamatsu (n-type silicon)
2k4k (15 μ m) 4 side buttable
4 output amplifier
200 μ m fully depleted



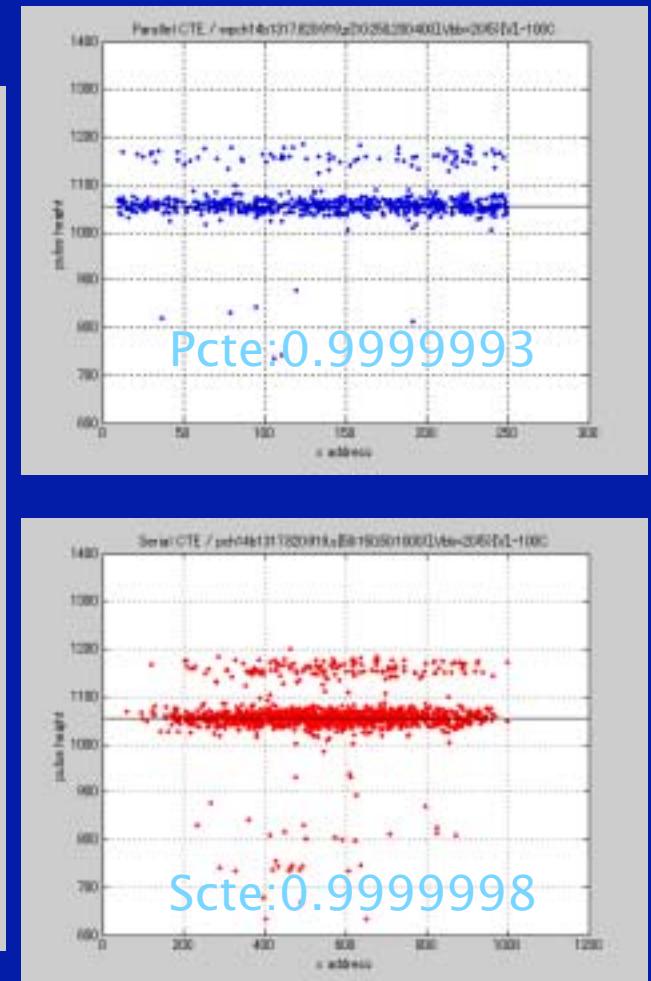
Test Device X-ray test

Energy Spectrum of X-ray



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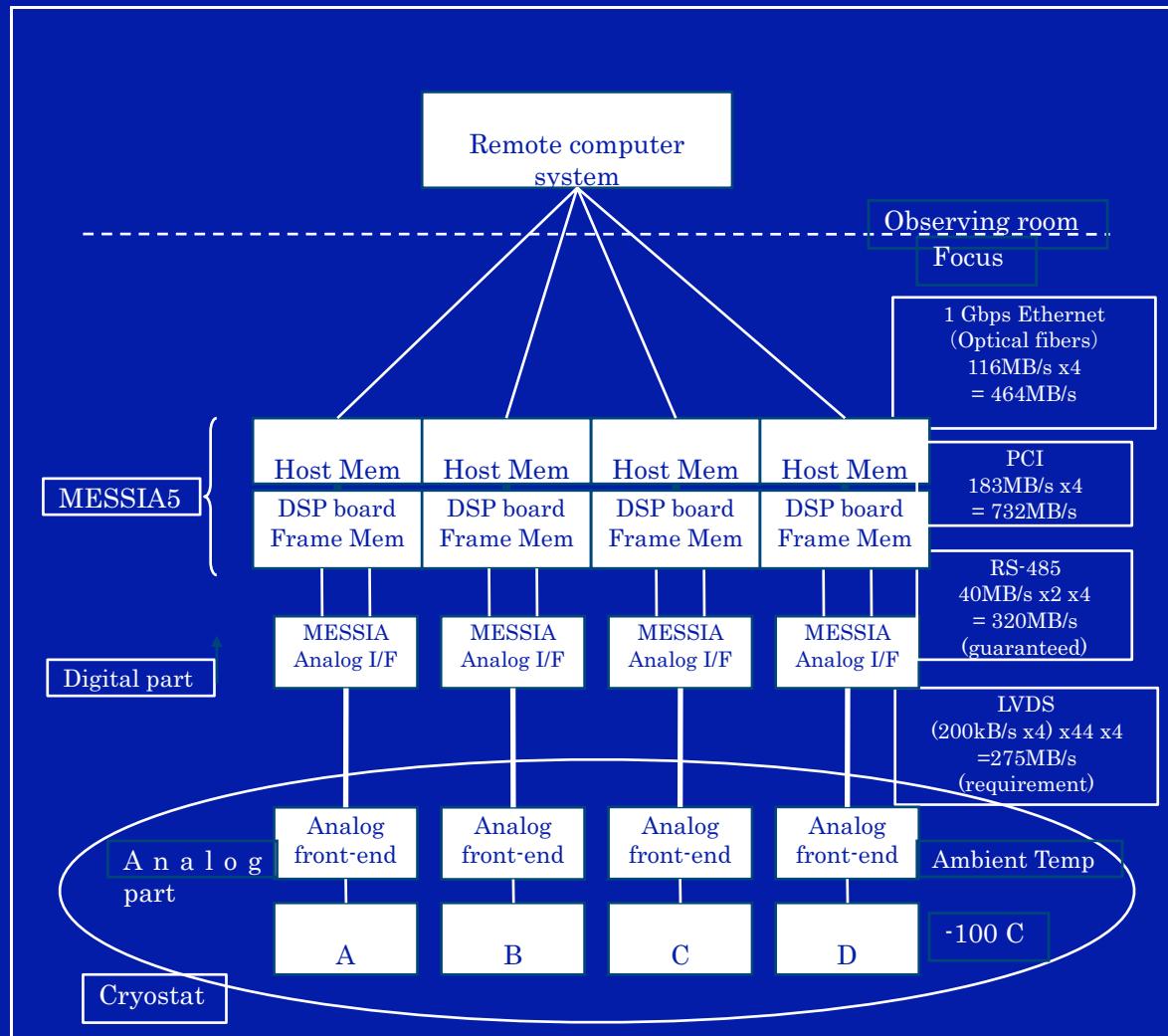
40

Performance Improvement

- CTE 0.9999 \rightarrow 0.999995
- Responsivity 0.2 μ V/e \rightarrow 5 μ V/e
- Full well 20,000 e \rightarrow 100,000 e
- Dark current 100e/h/pix \rightarrow a few e/h/pix
(-100C)

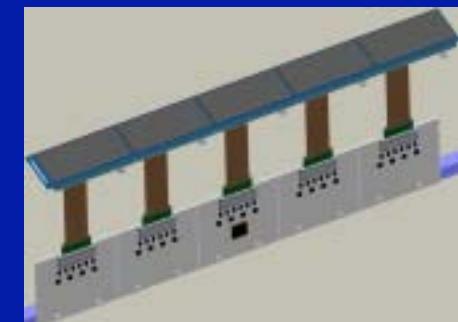
Refer to Kamata et al.
6267-73

Electronics



10~20 sec readout

Standard Subaru
D-electronics:
Messia5



Refer to
Nakaya et al. 6269-127

Telescope Modification

- Inner Hub
- Cramping Mechanism
- Instrument exchange Mechanism



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Risks Reduction Studies

underway in collaboration with ...

Large Corrector

Canon

Large Filters



CCDs

HAMAMATSU

Japan

Telescope modification



Comparison

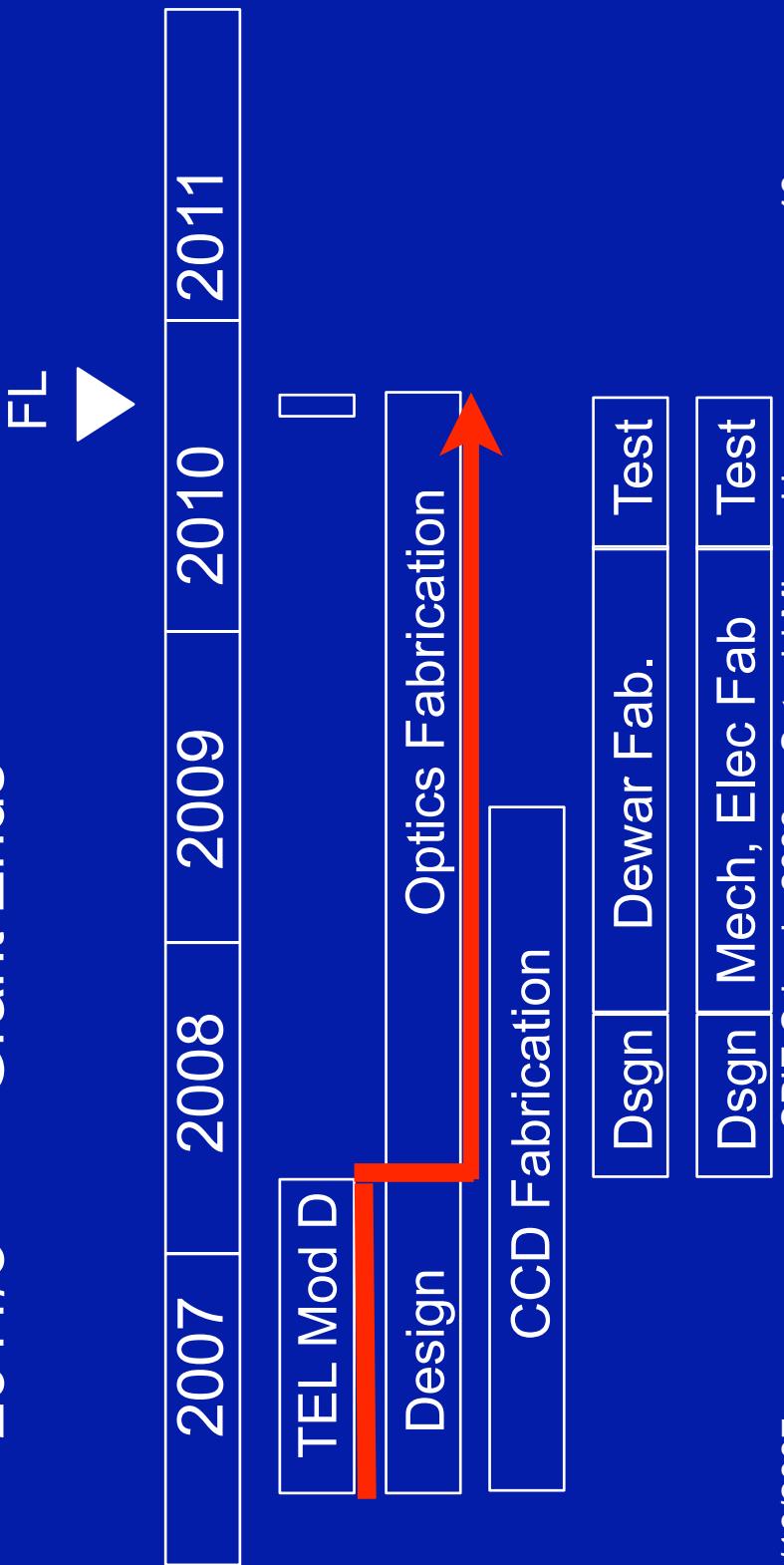
Project	AΩ	\$\$\$ [M]	Note
DES	37	~ 30 ?	4 m (CTIO)
Pan-STARRS	13.4x4	> 50 ?	1.8m x 4 New Tel.
HSC	162 (91)	~ 20-25	8.3 m (Subaru)
LSST	329	~ 300?	6.5 m eq. New Tel. c.f. Suprime-Cam ~ 10

Pre-cursor of LSST

High image quality is crucial for all the projects.
Only Subaru has a demonstrated performance.

Schedule

- 2008/3 HSC International Review (NAOJ HQ)
- Instrument
 - Science cases
- 2011/3 Grant Ends



2007/03/16

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Thank You