Weak Lensing using Subaru and Future Prospects

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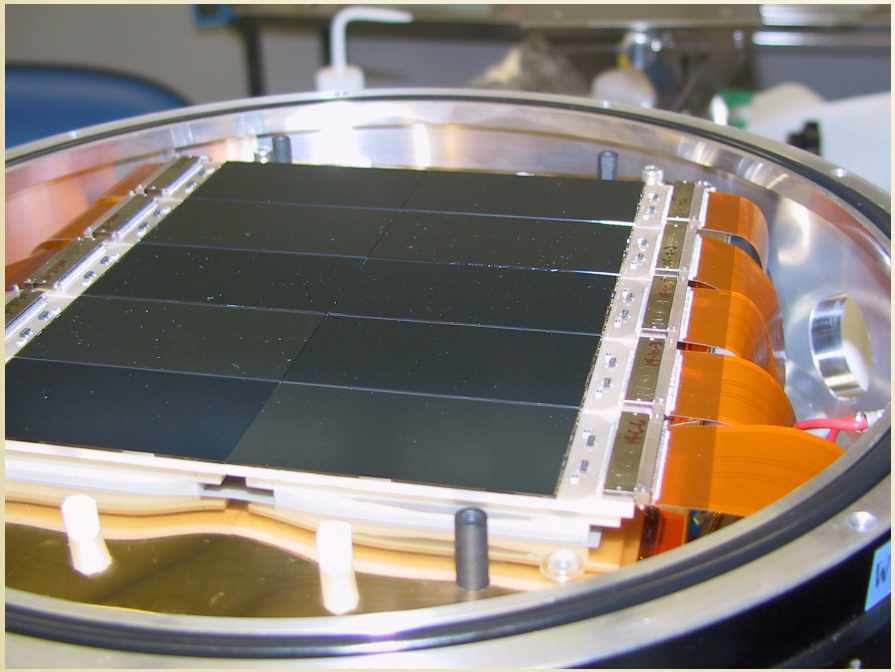
Talk Outline

- Weak Lensing Observations Using Subaru
  - Suprime-Cam (Miyazaki et al 2002a)
  - Cosmic shear (Hamana et al. 2003)
  - Cluster Survey (Miyazaki et al. 2002b, 2007 submitted)
- Future Prospect
  - Hyper Suprime-Cam

Suprime-cam

- 34 arcmin x 27 arcmin uniquely on 8 m telescope $\frac{1}{4}\mathrm{deg}^2$
- Survey Speed (AOmega) ~ CFHT MegaCam
- Median Seeing = 0.6 - 0.7 arcsec in i' (~ MegaCam)



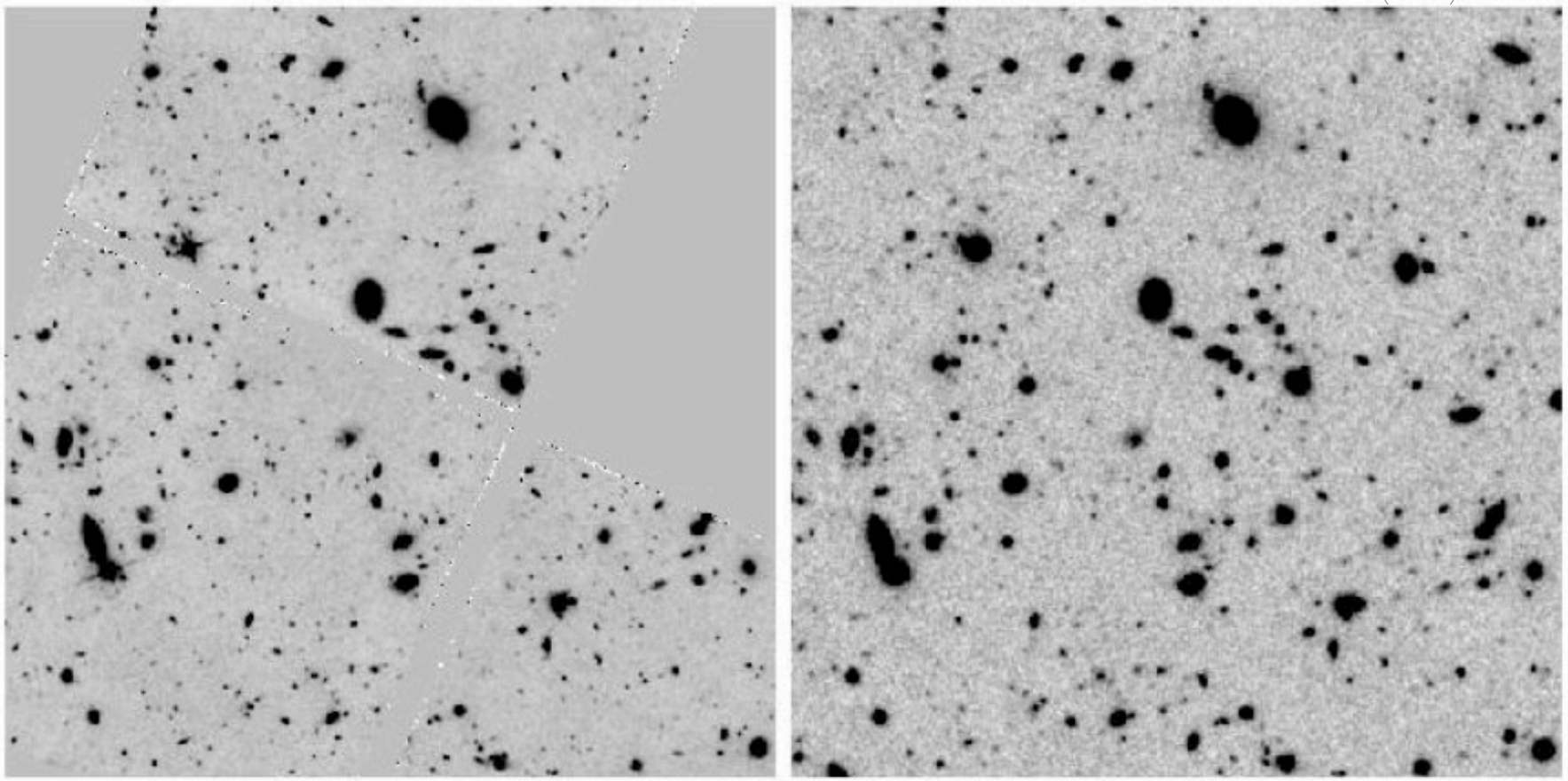
Miyazaki et al. (2002)

An obvious advantage over MegaCam is high QE in red and less fringing. (MIT/LL > E2V)

->Efficient survey of high z galaxies (LBG, LAE)

Good Image Quality

Hu & Cowie (2006) Nature



HST 'wide-I' continuum

NB816 narrowband

HST

Suprime-Cam

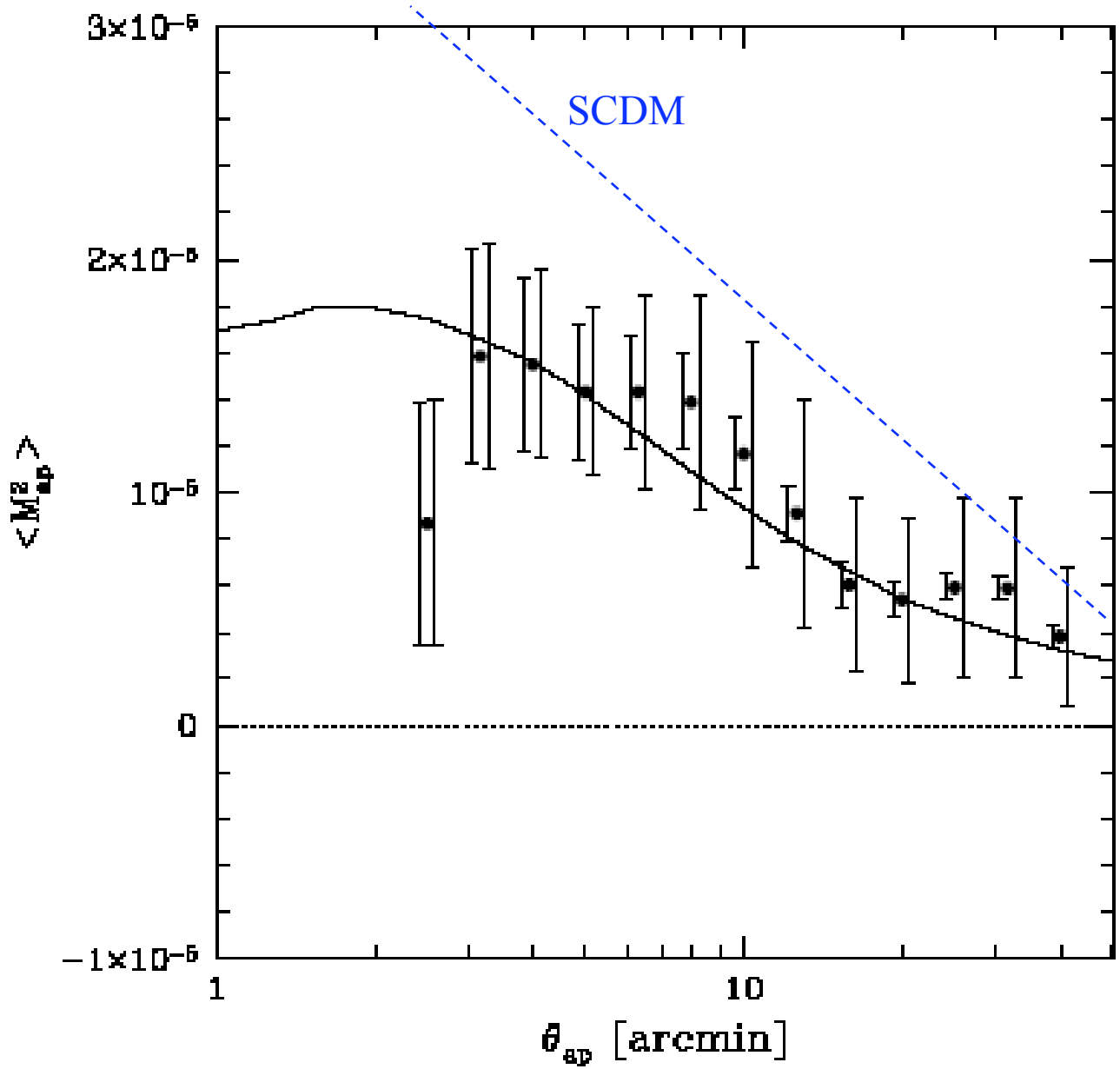
~ 100 times larger FOV

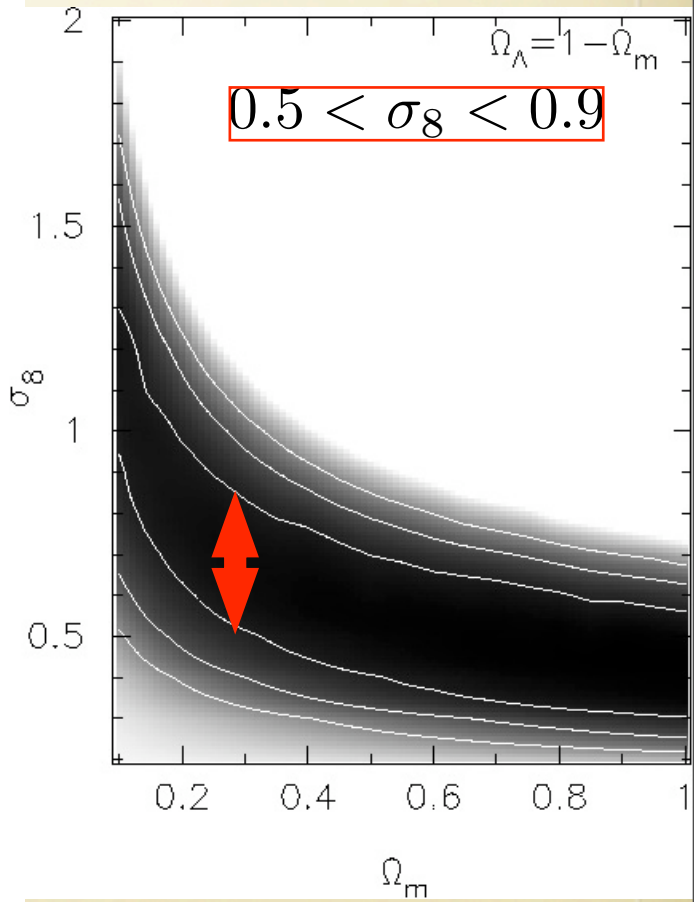
Disadvantage of Subaru

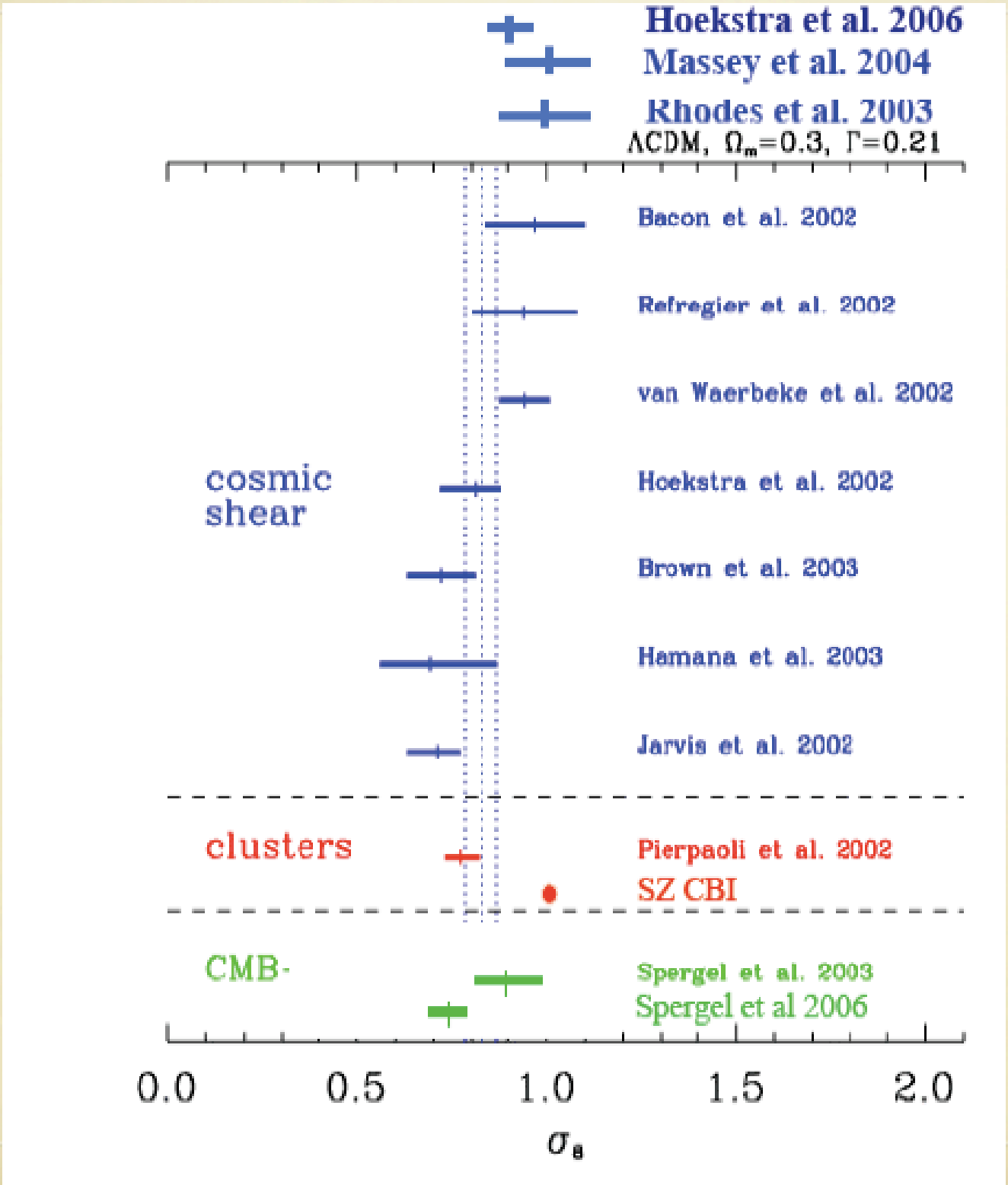
- The only one telescope for Japanese community
  - Fairly oversubscribed (4-5 times)
- Extremely large survey (eg CFHLS) is not feasible.

A motivation to build even larger
field size camera ...
Hyper Suprime-Cam (HSC)

Cosmic Shear on 2 sqdeg





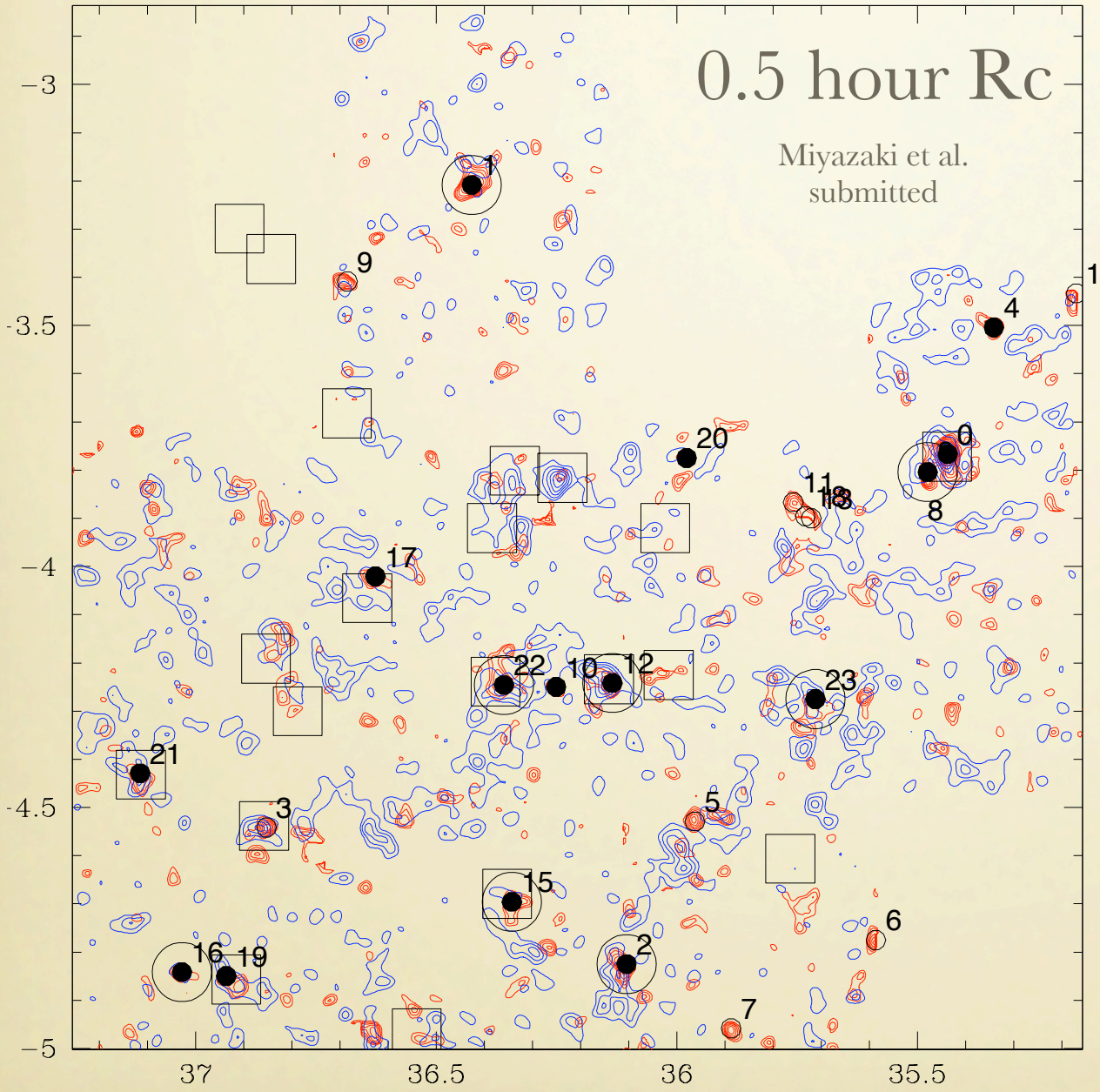

Hoekstra et al. 2006
Massey et al. 2004
Rhodes et al. 2003
ΛCDM, Ω_m=0.3, Γ=0.21
Bacon et al. 2002
Refregier et al. 2002
van Waerbeke et al. 2002
cosmic shear
Hoekstra et al. 2002
Brown et al. 2003
Hamana et al. 2003
Jarvis et al. 2002
clusters
Pierpaoli et al. 2002
SZ CBI
CMB
Spergel et al. 2003
Spergel et al 2006
0.0
0.5
1.0
1.5
2.0
σ_8

WL Cluster Survey

- Use Kappa S/N map to select cluster candidate
    - to reduce contamination
- Spectroscopic follow-up by multi object spectrographs (FOCAS)
    - to identify superposition of small systems
- ~ 20 square degree: 100 clusters candidates

- Hamana, Ellis, Kashikawa, Massey, Refregier, J.Tayler

Cluster Identification



n: peaks in SN map

● secure halos (15)

□ X-ray clusters

○ This work follow-up

XMM-LSS
10 ks

Blind Cluster Survey

Field	n	ID	RA	DEC	κS/N	κ	N_g [a]	FOCAS [b]	Known[c]	NEDG[d]	Note
XMM-Wide	00	SL J0221.7-0345	35.44	-3.77	8.15	0.156	72	-	0.43	-	XLSSC 006
	01	SL J0225.7-0312	36.43	-3.21	5.72	0.108	41	0.14	-	-	LRIS z = 0.14
	02	SL J0224.4-0449	36.10	-4.82	5.06	0.074	40	0.49	-	-	
	04	-	35.34	-3.50	4.91	0.082	21	-	-	-	
	08	SL J0222.3-0446	35.48	-3.80	4.33	0.081	29	-	-	-	LRIS z = 0.41
	10	-	36.25	-4.25	4.20	0.062	23	-	-	-	
	12	SL J0224.5-0414	36.13	-4.24	4.06	0.057	70	0.26	-	-	LRIS z = 0.26
	15	SL J0225.3-0441	36.34	-4.70	3.94	0.091	34	0.26	-	-	
	16	SL J0228.1-0450	37.03	-4.84	3.94	0.072	31	0.29	-	-	
	17	SL J0226.5-0401	36.63	-4.02	3.90	0.079	37	-	0.34	-	XLSSC 014
	19	SL J0227.7-0450	36.94	-4.85	3.81	0.064	43	-	0.29	-	Pierre et al. (2006
	20	-	35.98	-3.77	3.81	0.048	20	-	-	-	
	21	SL J0228.4-0425	37.12	-4.43	3.80	0.055	49	-	0.43	-	XLSSC 012
	22	SL J0225.4-0414	36.36	-4.25	3.72	0.073	43	0.14	-	-	
	23	SL J0222.8-0416	35.71	-4.27	3.69	0.049	52	0.43,0.19,0.23	-	-	

Miyazaki et al. submitted

12/15 (= 80 %) is identified as clusters (S/N > 3.69)

WL Cluster survey is feasible

(3 unidentified halos have not yet been observed spectroscopically.)

Comparison at CFHLS D1

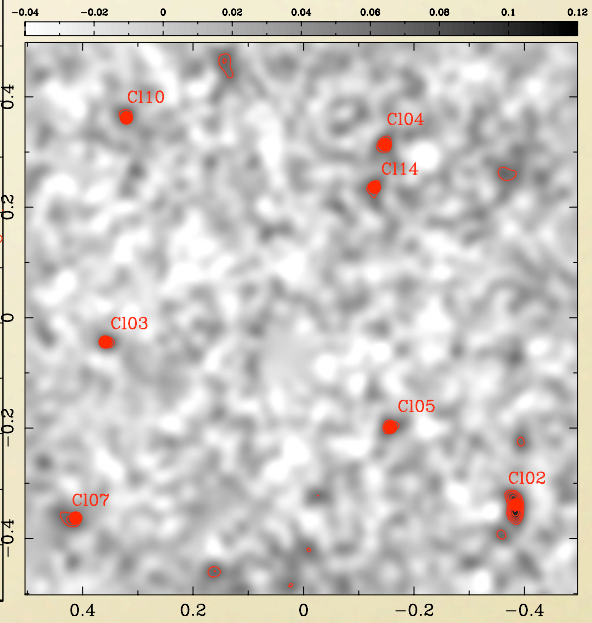
Miyazaki et al. submitted

Rc: 0.5 hour x 13

30-40 gals/arcmin2

tens of hours i'

T00003 DR



Gavazzi & Soucail (2007)

Efficiency of WL cluster survey

- 2.2 square degree (XMM-Wide)
- 15 Shear selected clusters found : 8 hr observing time
- 8 X-ray clusters missed

$$\frac{15}{15+8} = 65\%$$ is not bad for the price we paid

(~ $80k: Subaru 1 night)

Summary of Suprime33 Paper1

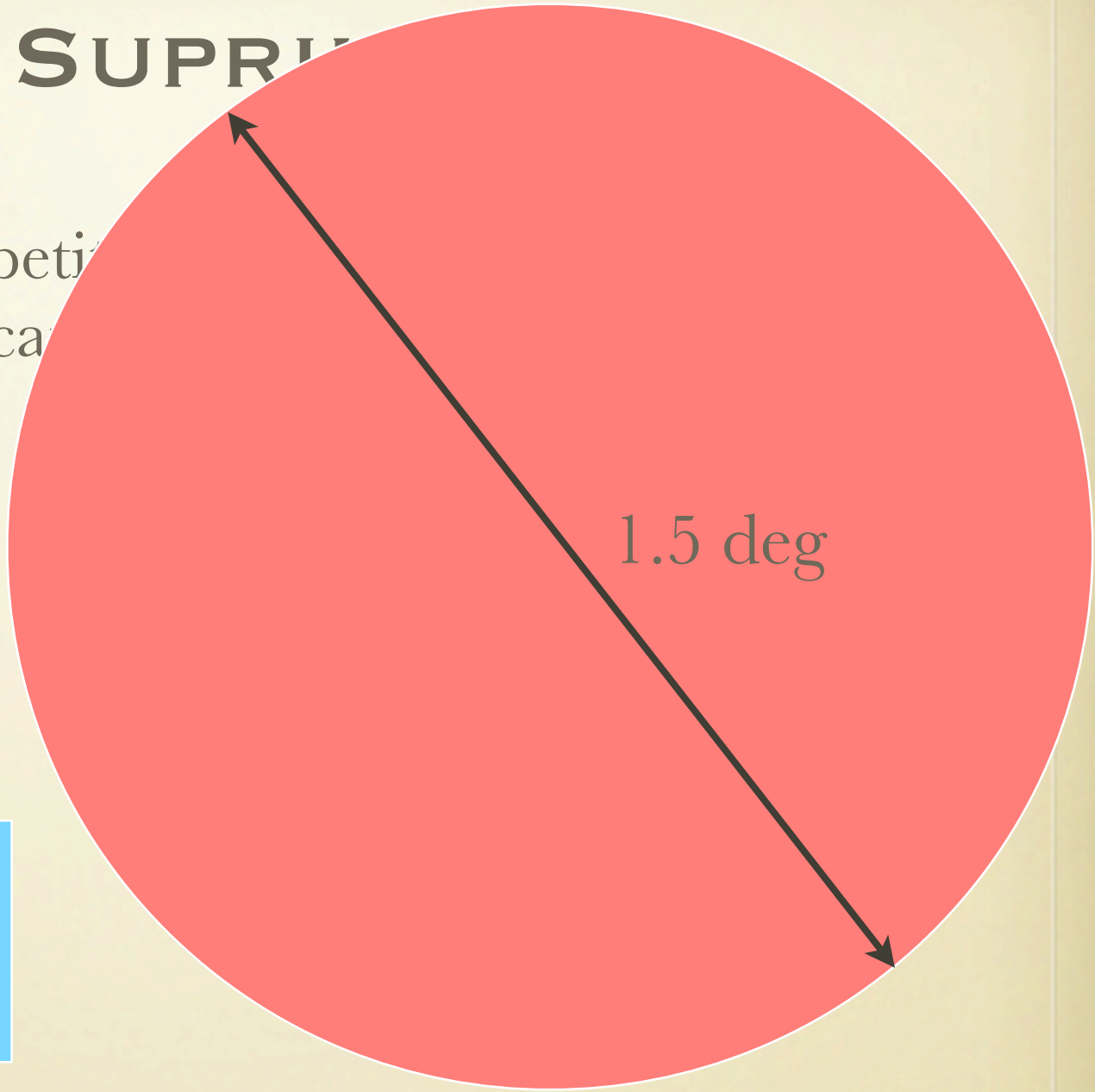
Miyazaki et al. submitted

- 17 square degree secure area (out of 22 sqdeg observed)
- 100 halos identified with S/N > 3.69
- 26 halos followed up by FOCAS MOS
  - All confirmed as clusters (including superposition)
- 41 halos have reliable redshift (LRIS, literature)

Spectroscopic follow-up is still on-going using FOCAS (Hamana et al. in prep. 9 more including less significant but interesting) and Keck LRIS (Green et al. in prep. (20+) more)

Hyper Suprime-Cam

- In order to be competi
  need even a larger ca

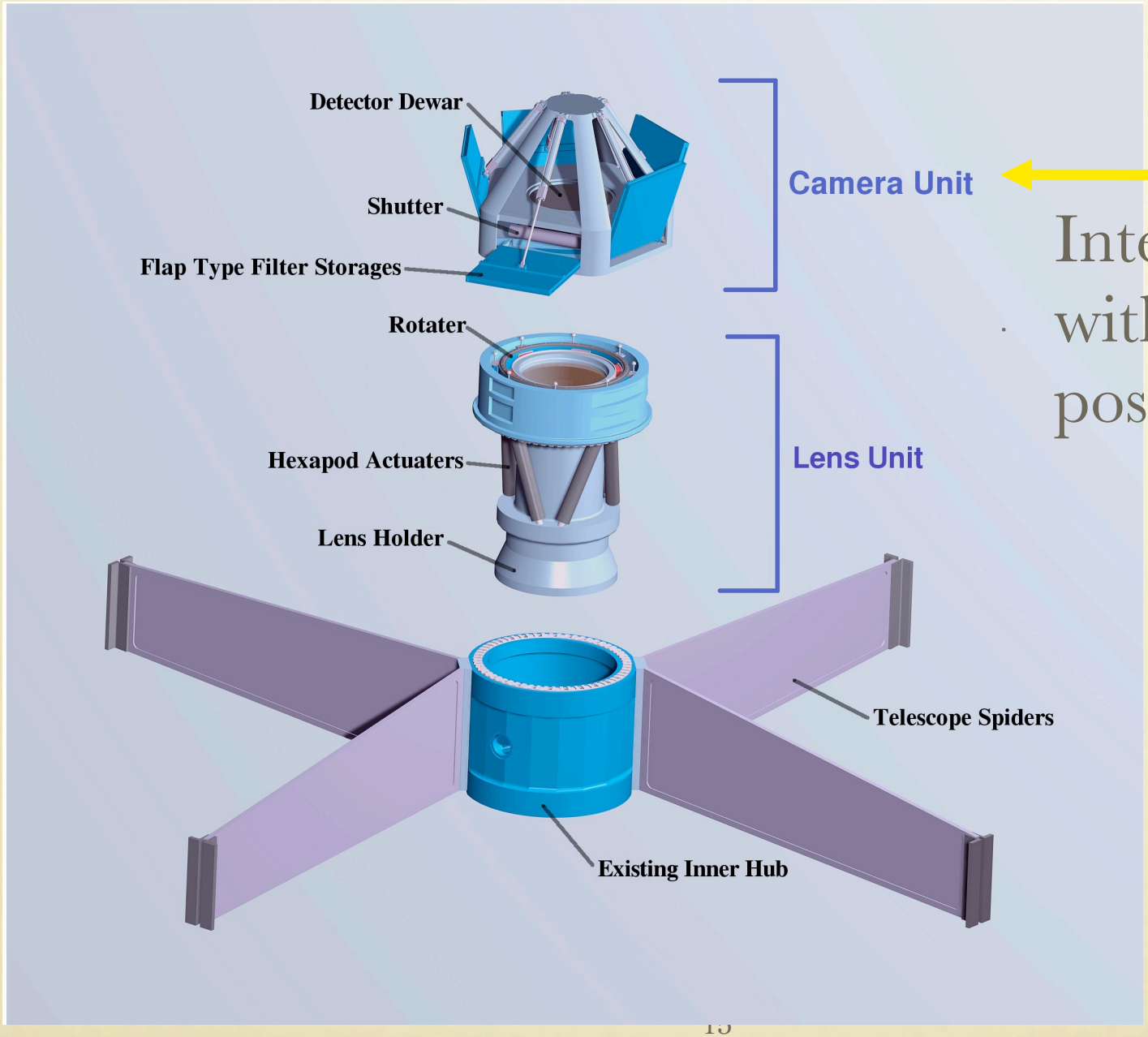


HST

Suprime-Cam

HSC

HSC: Mechanical Design

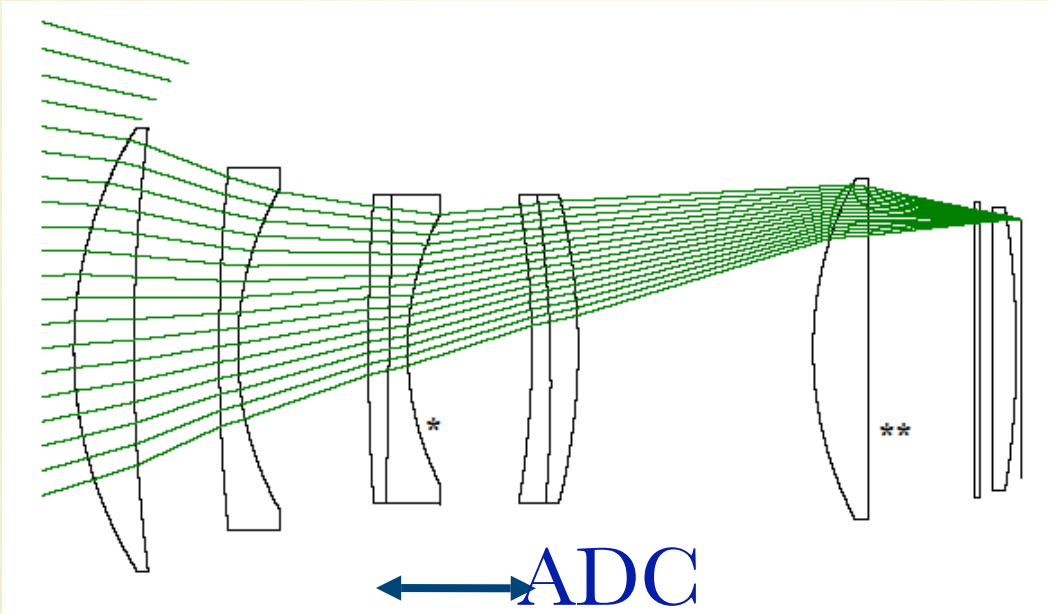


Interchangeable with WFMOS positioner

WFMOS: 4000 fiber spectrograph proposed by Gemini

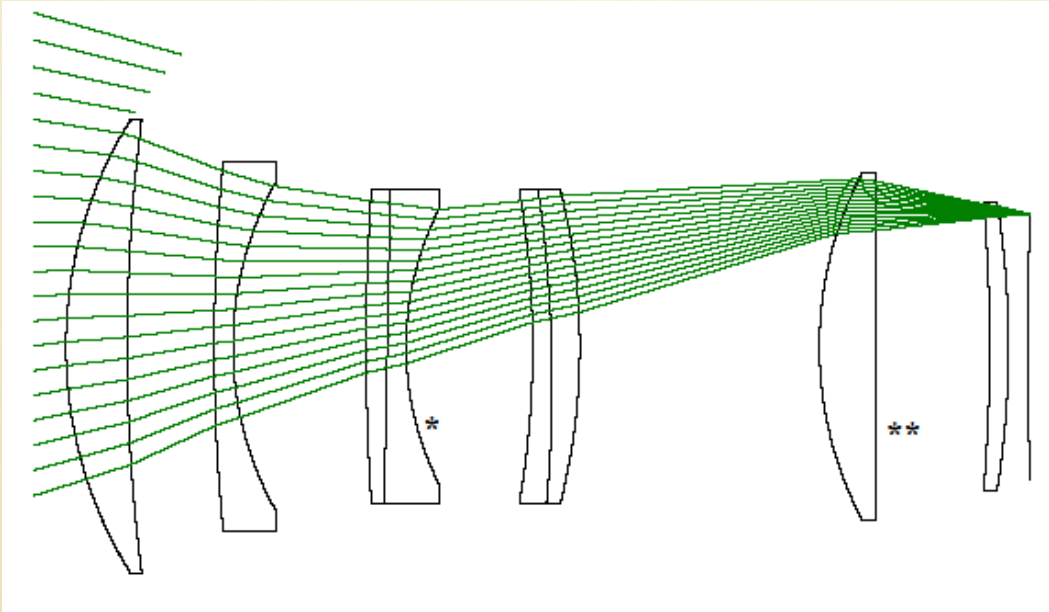
Optics: 1.5 deg option

HSC



0.9 m dia.
Mostly Silica
ADC installed

WFMOS

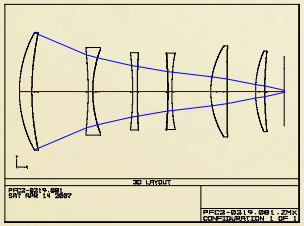
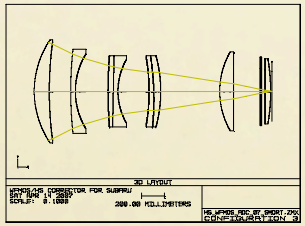
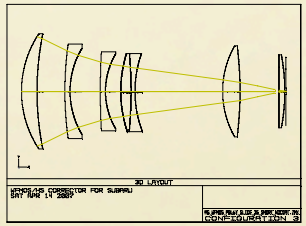
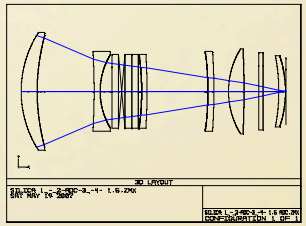
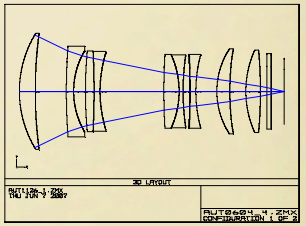


Aspheric 2 surf.
(conic)

Large Optics

- Design Varieties
  - FOV　2 deg, 1.5 deg
  - ADC　rotation prism, lateral shift

	武士氏2degADCなし	Peter氏1.5deg回転式ADC	Peter氏1.5degシフト式AD	成合氏1.5degPrism式ADC	田中1.5degシフト式ADC
file name	PFC2-0219.081.ZMX	HS_WFMOS_ADC_07_short.ZMX	HS_WFMOS_PBL6Y_slide_25_short.ZMX	SILICA 1_-_2-ADC-3_-4-1.5.ZMX	
使用波長(nm)	400～1100	390～1000	390～1000	500～1100	420～1050
焦点距離(mm)	18693	19628	19916	19147	18665
構成枚数(F.Fを除く)	6群6枚	6群8枚	6群7枚	8群10枚	7群9枚
G1有効径(mm)	1180	880	880	873	880
使用非球面枚数	3面	2面	3面	3面	3面
非球面最大有効径(mm)	1161	662	856	839	645

Takeshi　Gillingham　Gillingham　Nariai　Tanaka

Optics Performance

- Specifications:
  - HSC: D80 < 0.3 arcsec in r, i, z, Y
  - WFMOS: D80 < 0.5 arcsec in 350 - 1000 nm

Design Performance (D80 in arcsec)

設計性能

		Z=0					Z=60			
	WFMOS	g	r	i	z	WFMOS	g	r	i	z
武士氏2degADCなし		0.4	0.26	0.24	0.26	--------	--------	--------	--------	--------
Peter氏1.5deg回転式ADC	0.39	0.36	0.27	0.26	0.26	0.44	0.35	0.28	0.27	0.27
Peter氏1.5degシフト式ADC	0.33	0.39	0.27	0.27	0.33	0.57	0.41	0.39	0.32	0.36
成相氏1.5degPrism式ADC	0.43	0.42	0.21	0.2	0.23	0.68	0.5	0.32	0.26	0.25
田中1.5degシフト式ADC	0.38	0.33	0.26	0.26	0.25	0.42	0.42	0.3	0.29	0.27

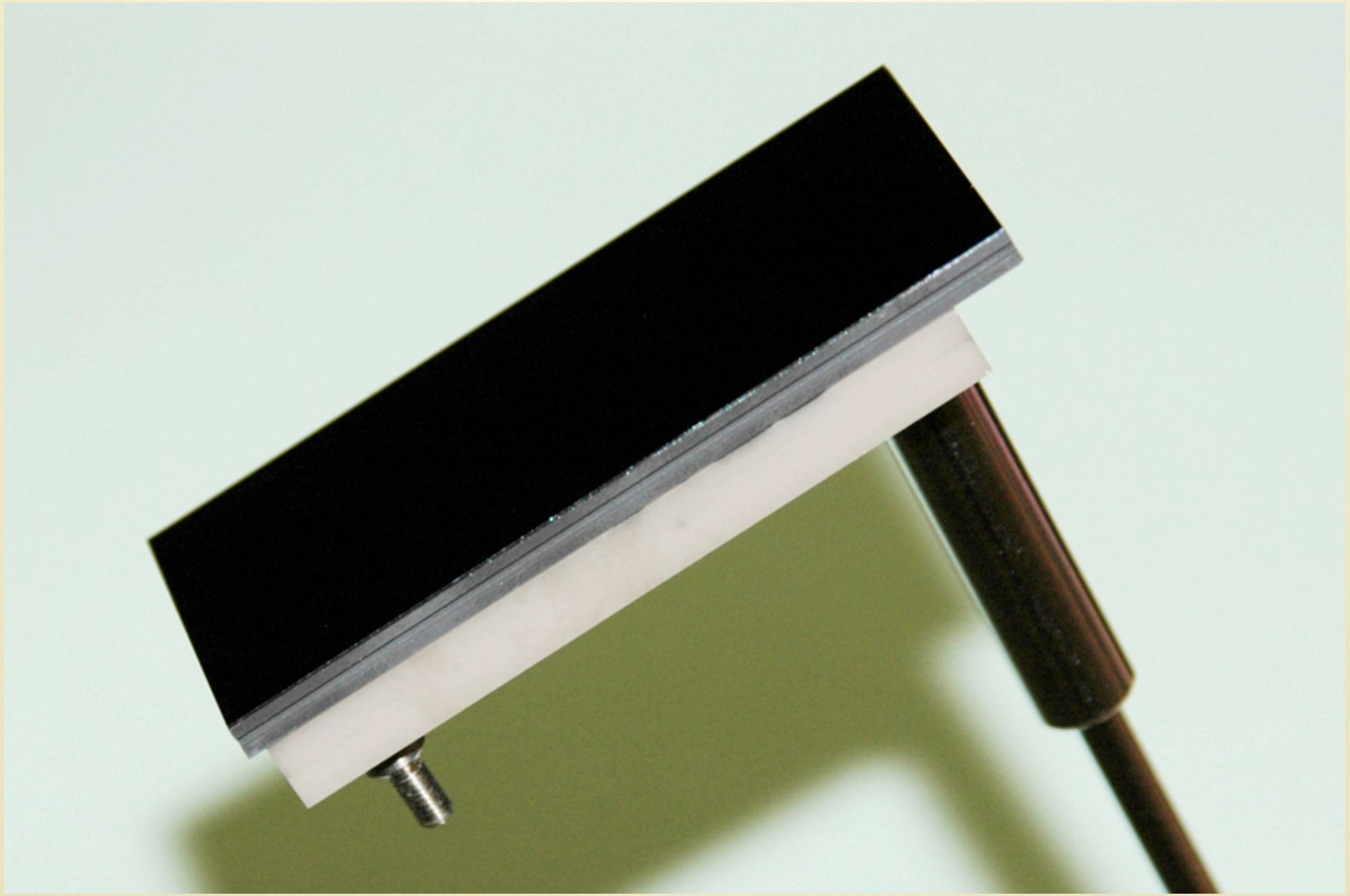
Specs are fully met.

Collaboration with Canon

- All the existing designs are provided to Canon.
- Canon is responsible for
  - Optimization of the designs based on:
    - detail tolerance analysis
    - manufacturability
  - Lens holder design

Mr.Mitarai Mr.Uchida

Focal Plane Array



Hamamatsu 4 side buttable FD CCD

Focal Plane Arrays

- 10 CCDs are ready to mount on Suprime-Cam.
- On telescope performance verification will be carried out in a year.
- Focal plane assembly method has yet been finalized.
    - Princeton experiences are invaluable.

Collaboration

Large Corrector

Large Filters

CCDs

Mechanics

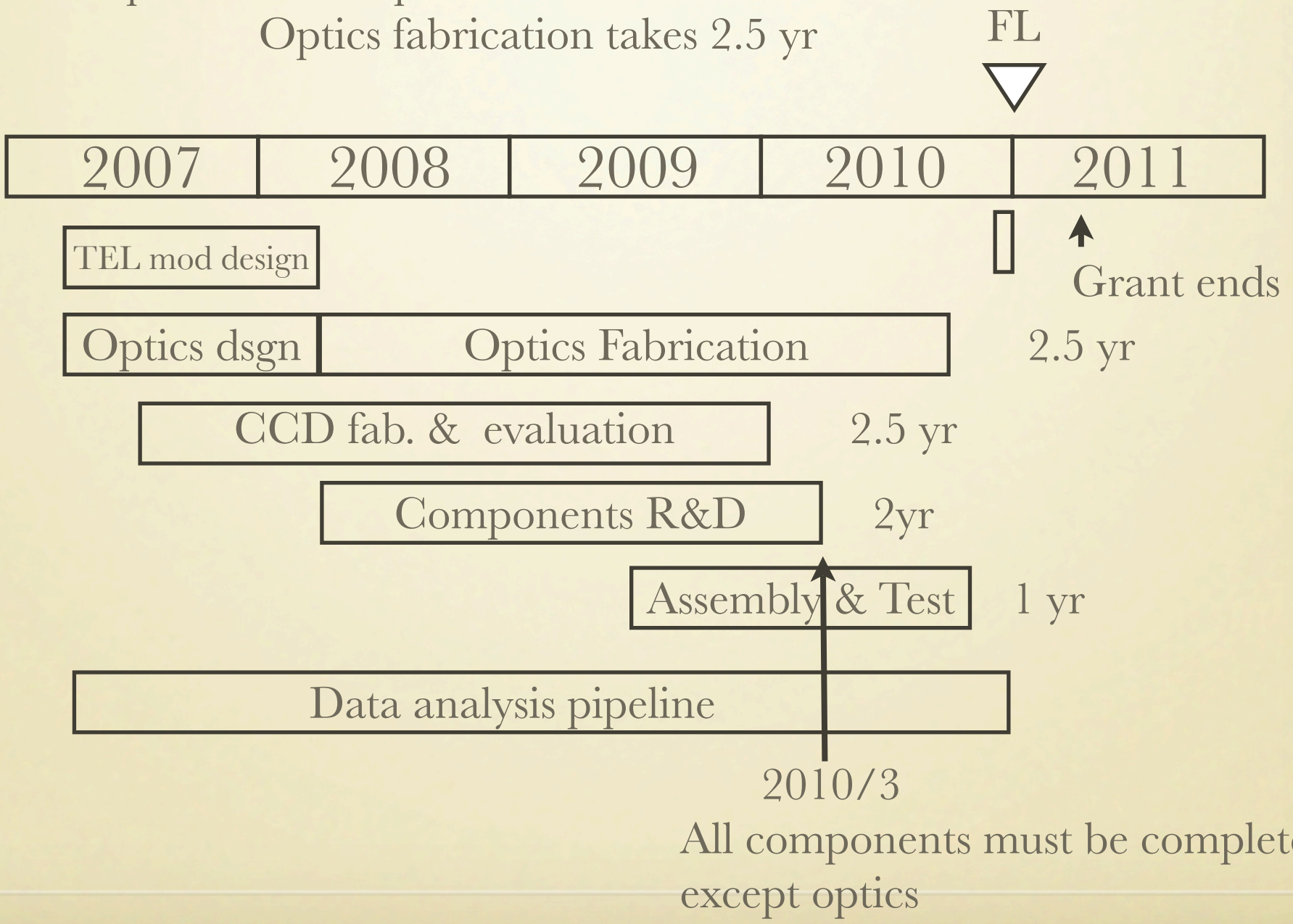
International Collaboration

- ASIAA, Taiwan
- Princeton University
- UC Davis, SLAC

Collaboration frameworks are being discussed.

DRAFT SCHEDULE

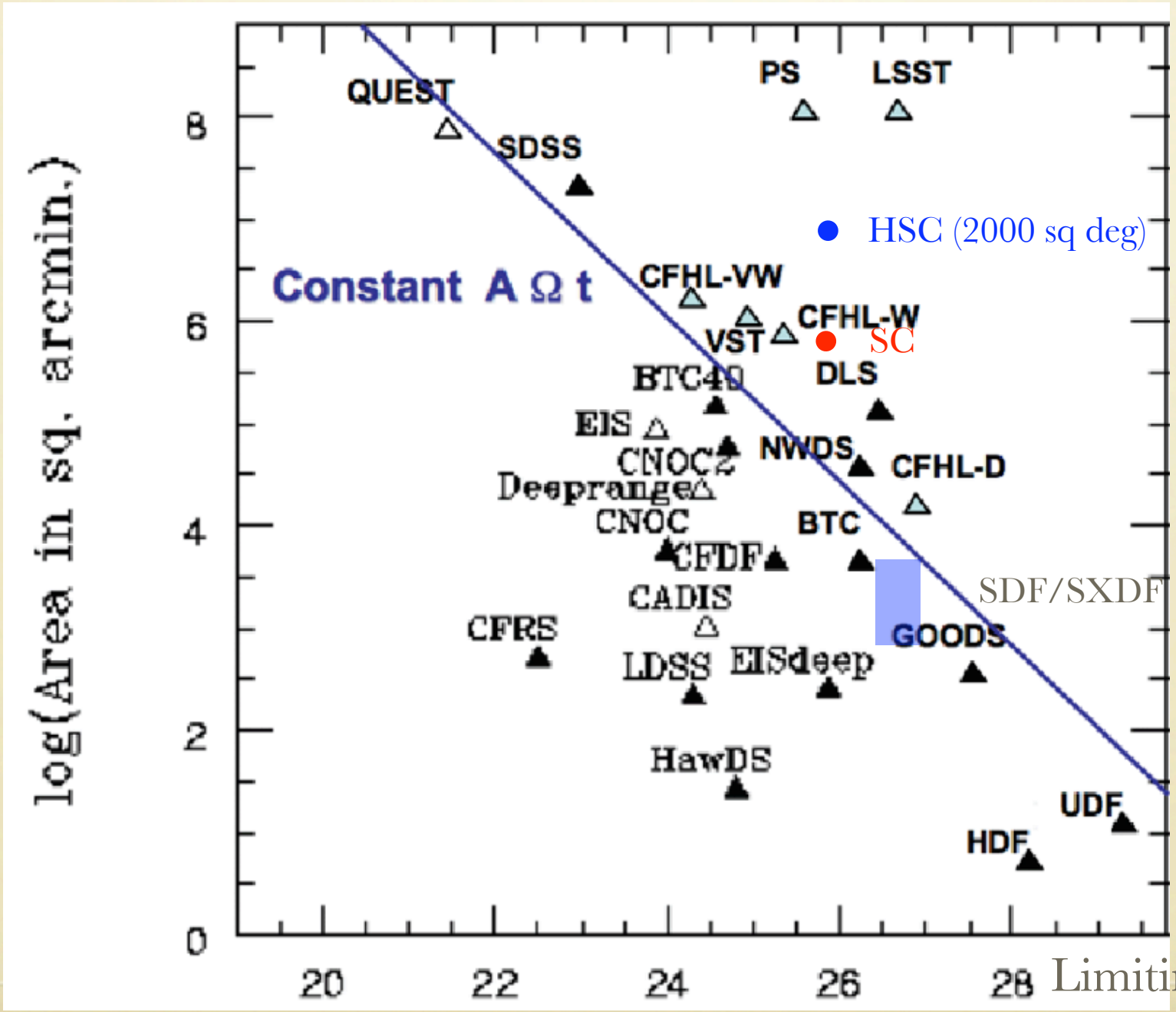
Assumptions: Final Spec. determined 2008/3
Optics fabrication takes 2.5 yr



HSC Survey Design

- Optimization of survey is under way.
- But preliminary numbers given are:
  - 200 - 300 nights over 5 years considered
  - 3 - 4 band

HSC Survey


log(Area in sq. arcmin.)
Limiting AB mag
Constant A Ω t
HSC (2000 sq deg)
SC
SDF/SXDF
QUEST
SDSS
PS
LSST
CFHL-VW
CFHL-W
VST
BTC40
DLS
EIS
CNOC2
NWDS
CFHL-D
Deeprange
CNOC
BTC
CFDF
CADIS
CFRS
GOODS
LDSS
EISdeep
HawDS
UDF
HDF
0
2
4
6
8
20
22
24
26
28

Thank You