HSCの開発ステータス、フィルターの開発方針

宮崎　聡

国立天文台

Subru User's Meeting

2009/01/16

Hyper Suprime-Cam

- FOV: 1.5 deg in diameter
  - ~ 10 times faster Survey speed than Sprime-Cam
- Image quality: Instrument PSF < 0.3 (FWHM)
  - Equivalent with SC in r, i, z, Y band:

HyperSuprime
Feasibility Studyの現状

宮崎聡　小宮山裕

国立天文台ハワイ観測所

2005.8.25

すばる小委員会シンポ　２０１０年代のすばるを考える

国立天文台　三鷹

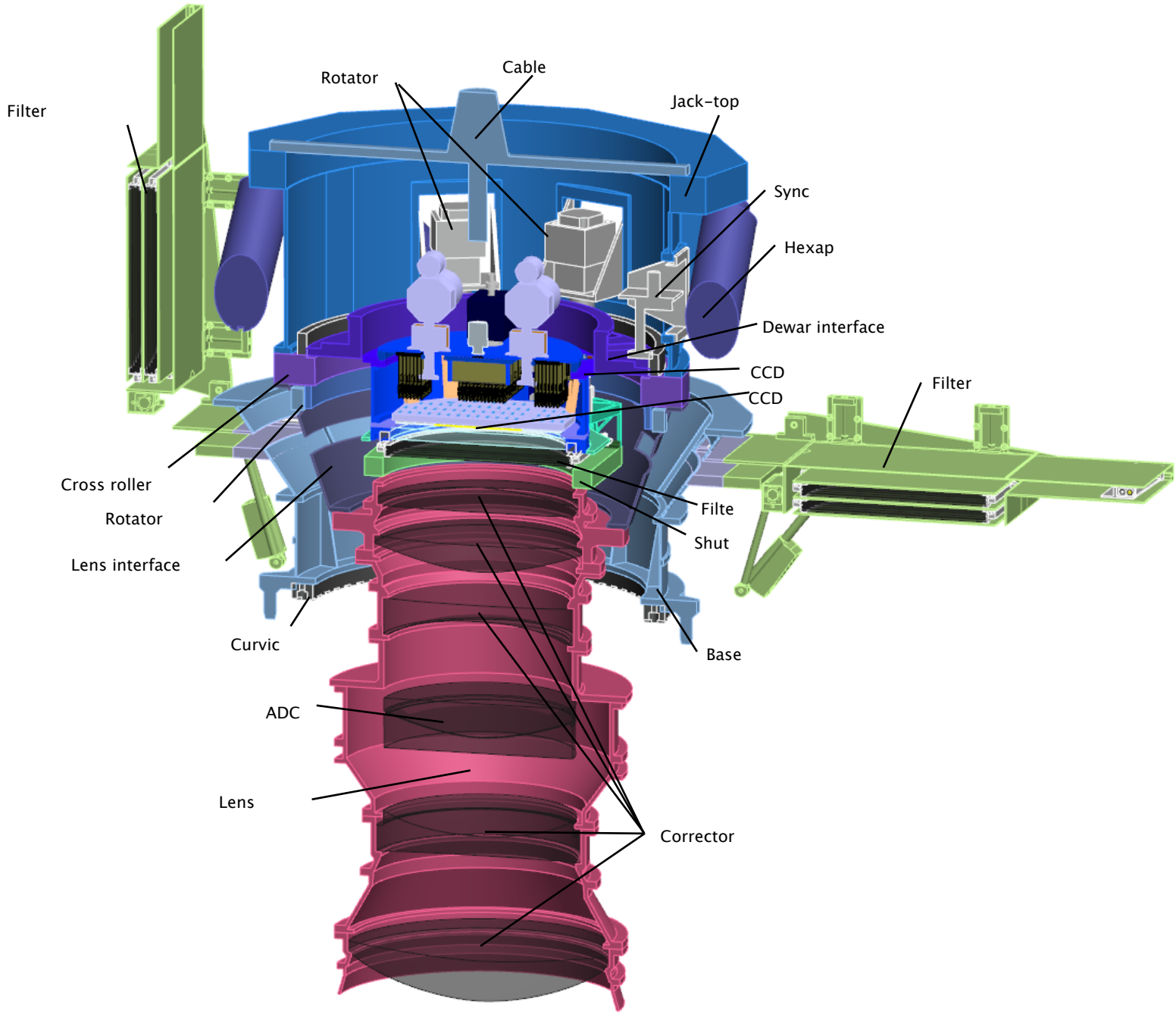
HSC Collaboration

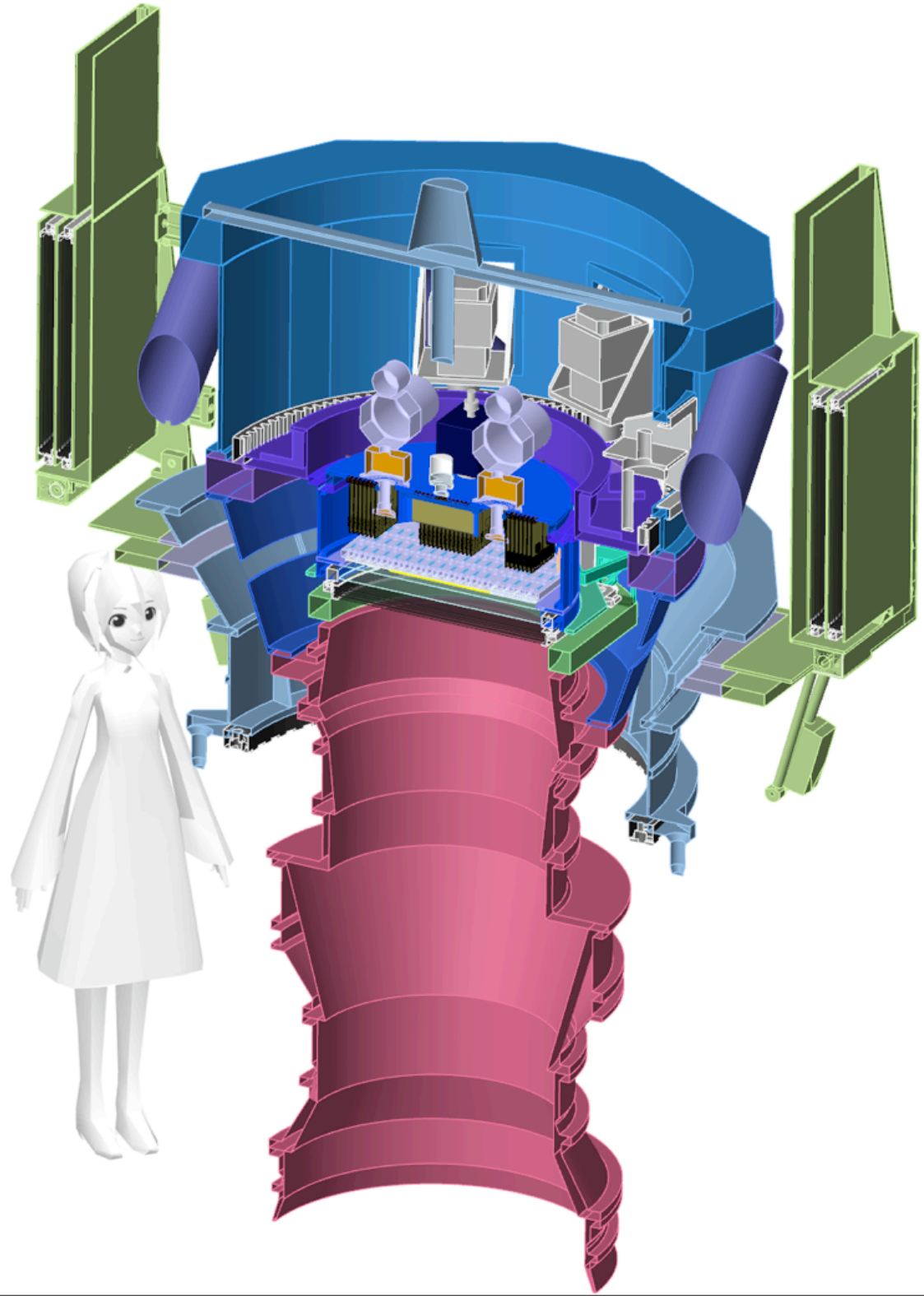
1. Camera Mechanics
   - Dewar, Shutter, Filter Exchanger
2. PFU Mechanics
   - Telescope I/F, Attitude Control, InR
3. Optics
   - Wide Field Corrector
   - Filter
4. Sensor
   - CCD
   - Readout electronics
5. Data Management
6. Project Management
   - Schedule, Budget

HSC Collaboration

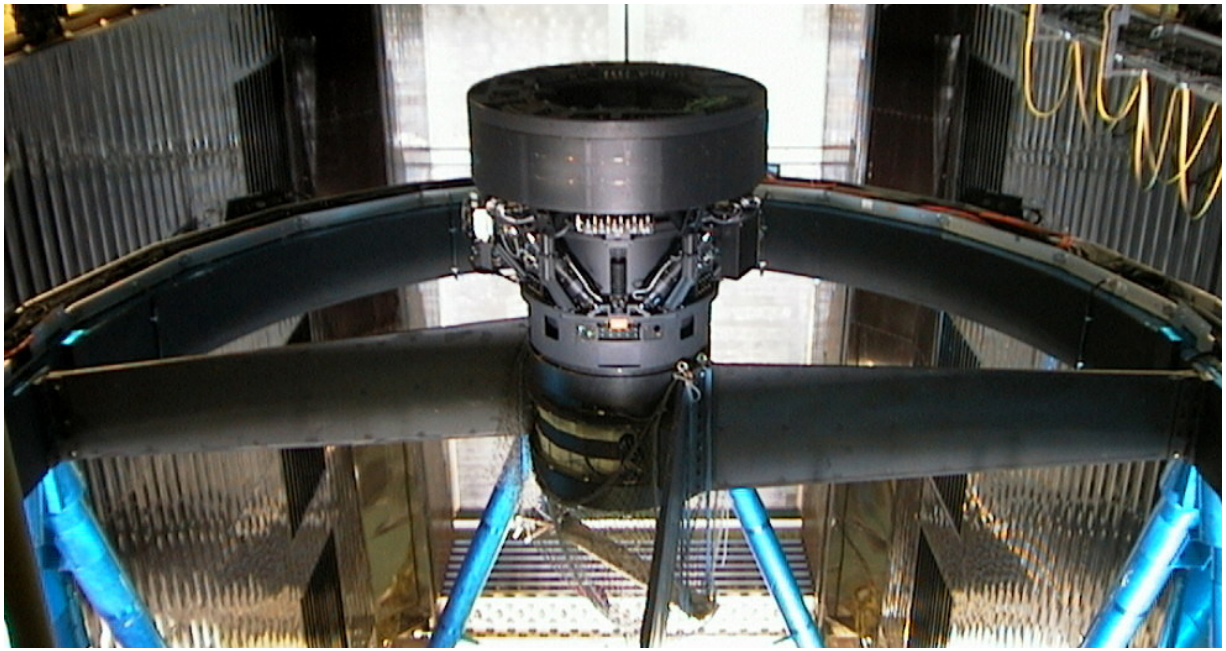
1. Camera Mechanics	NAOJ/IAA
- Dewar, Shutter, Filter Exchanger	
2. PFU Mechanics	Mitsubishi
- Telescope I/F, Attitude Control, InR	
3. Optics	
- Wide Field Corrector	Canon
- Filter	NAOJ
4. Sensor	
- CCD	Hamamatsu
- Readout electronics	N/UT/KEK
5. Data Management	N/UT/KEK/P
6. Project Management	NAOJ
- Schedule, Budget	

HSC Overview



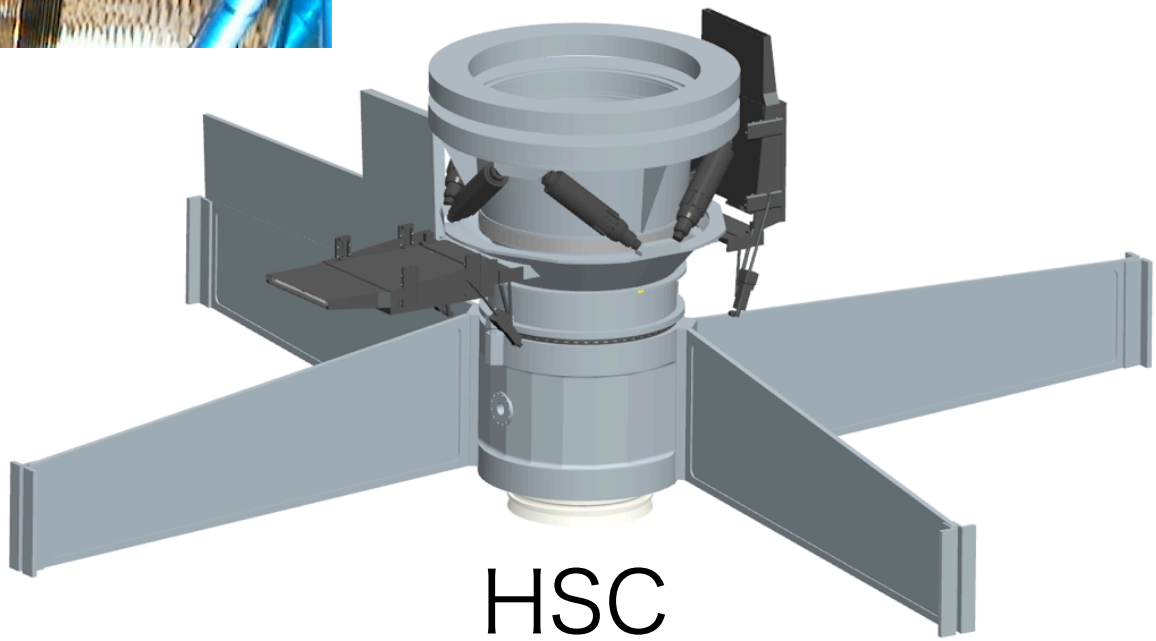


SC and HSC



SC

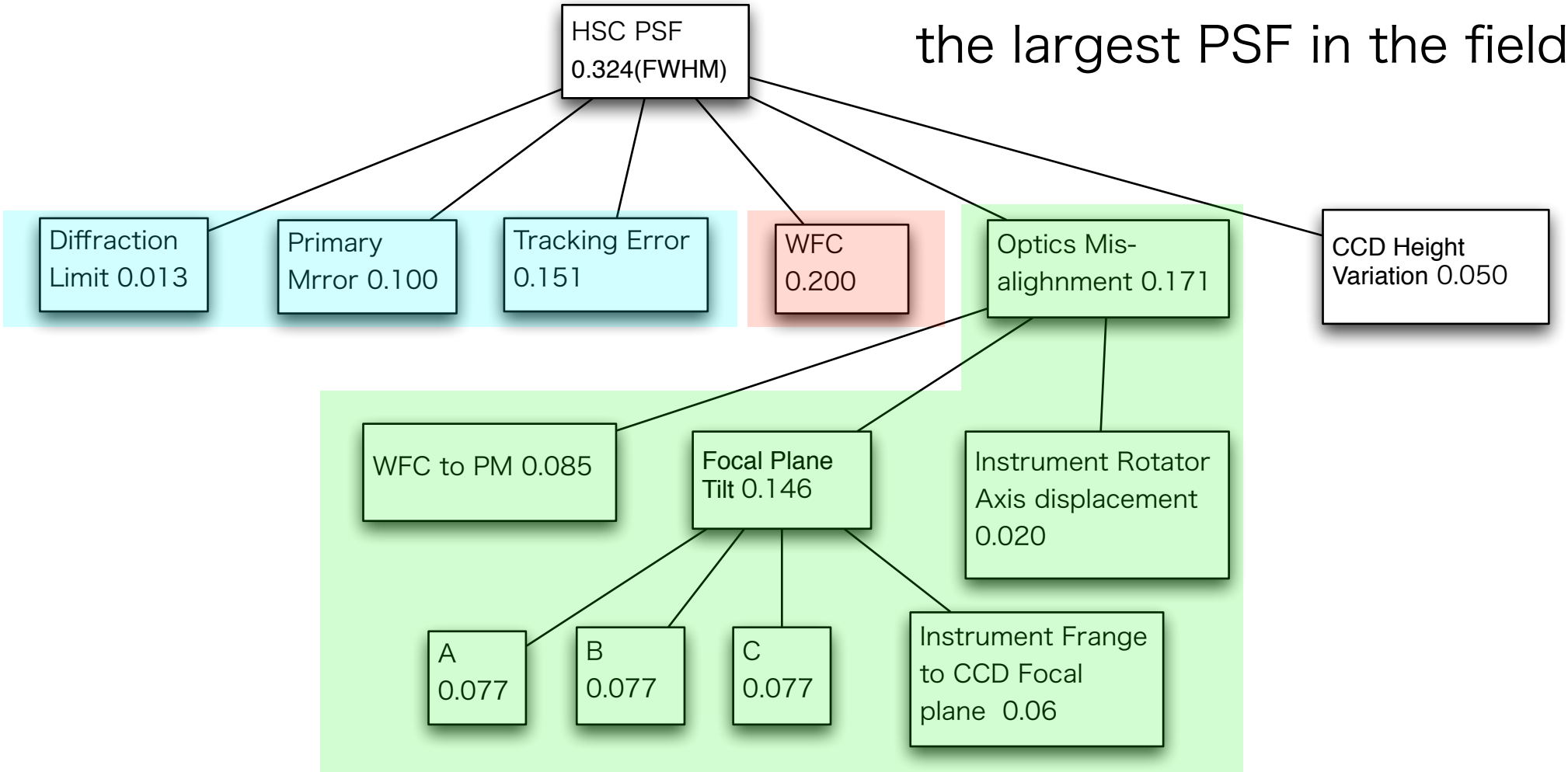
SC is already very large.



HSC

HSC System Design

the largest PSF in the field



Error budget Distribution

Frame FEM Analysis

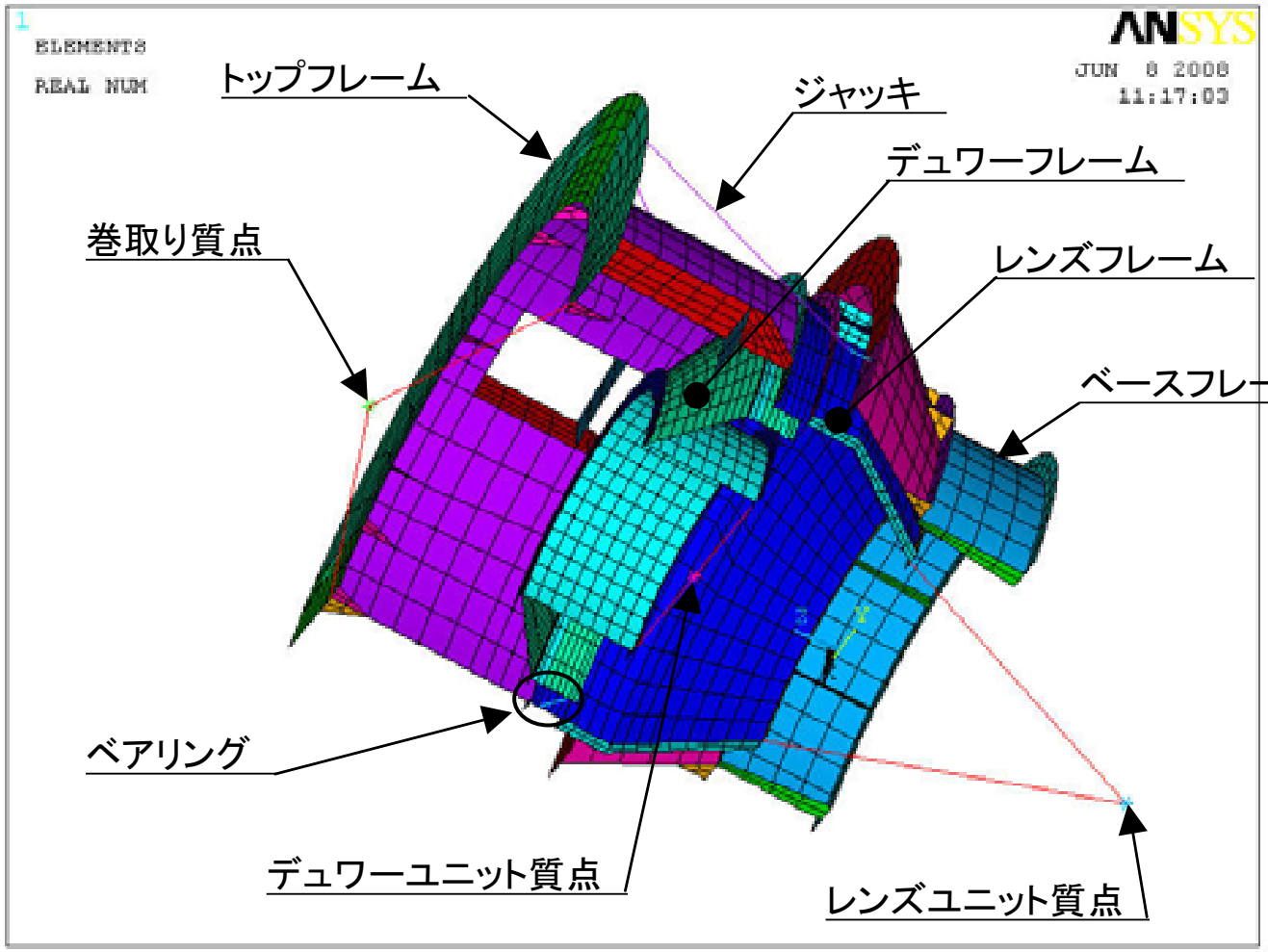


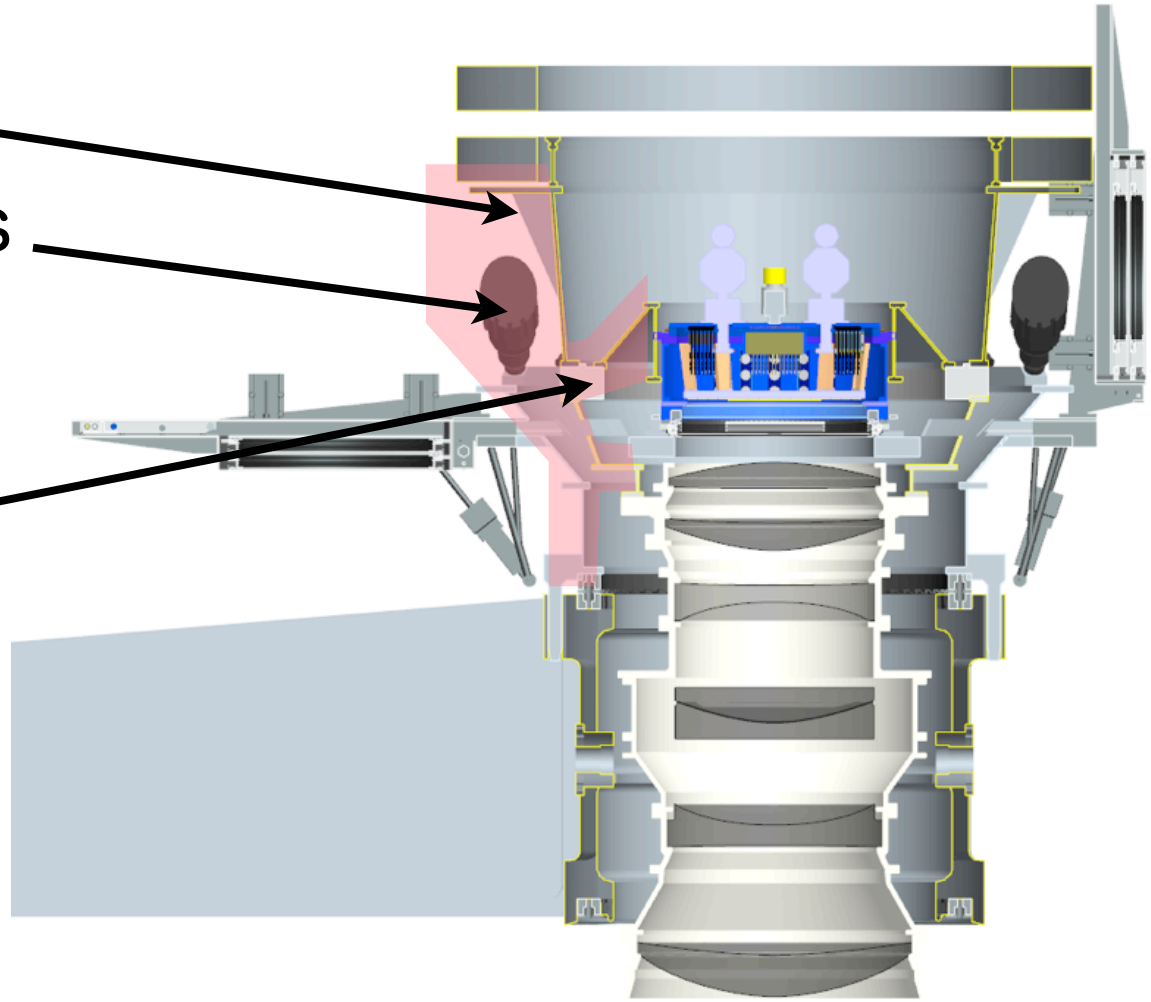
図 2-2　解析モデル断面斜視図

Flexure is allowed but tuned by design and additional manufacturing

Alignment between Dewar and Lens is crucial.

PFU Mechanics Design

- Defining Specifications of
  - Frame
  - Hexapod Actuators (steward platform)
  - Instrument rotator



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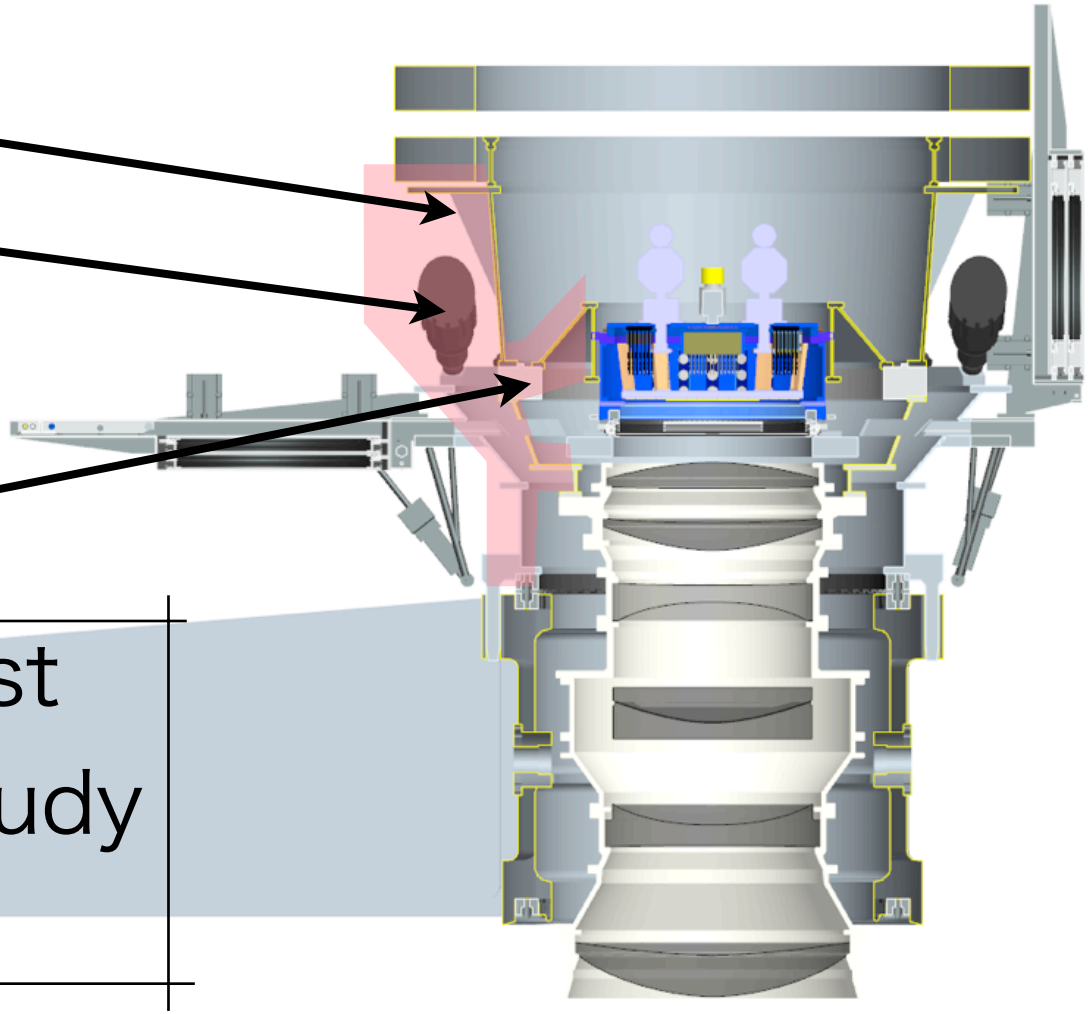


Mitsubishi has almost finished this design study just recently

Camera Mechanics

(a) CCD Dewar

Scale up of Suprime-Cam's

48 W(173K) Pulse Tube Cooler X 2

(b) Shutter

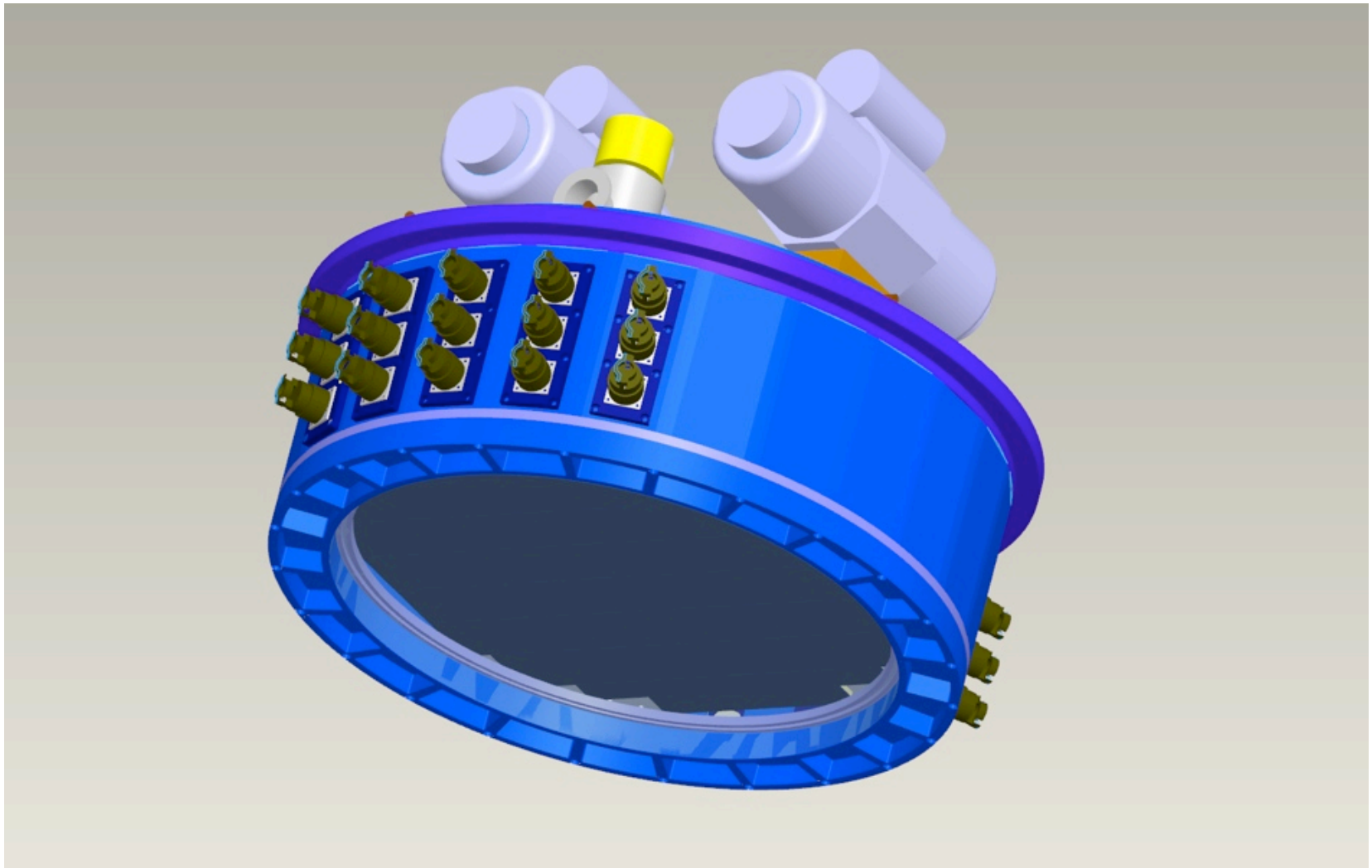
Prototype built

(c) Filter Exchanger

ASIAA Contribution, under design

Wang's talk

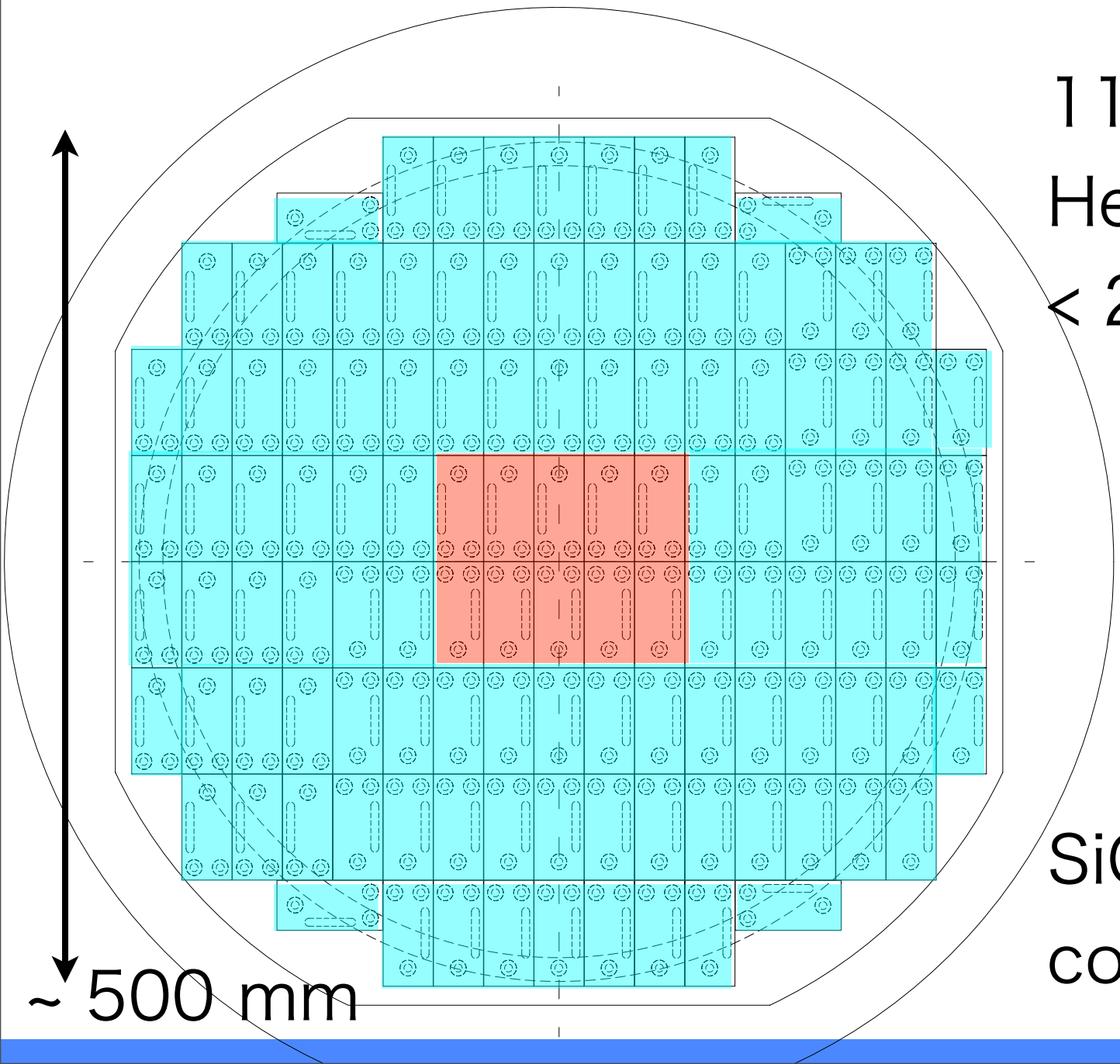
HSC Dewar



Mechanical and thermal design completed

Prototype being built this spring

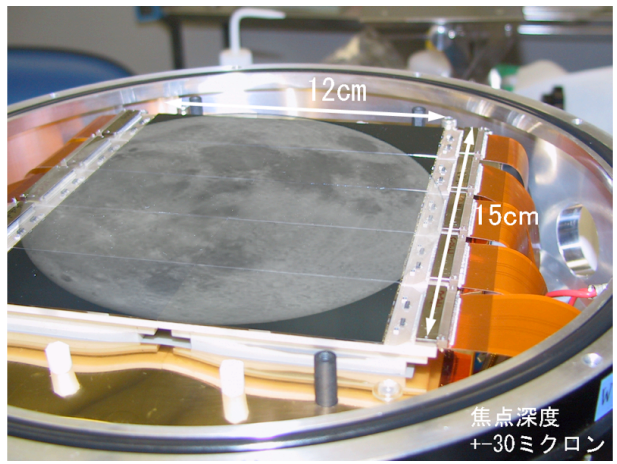
CCD Mosaic



116 CCDs

Height variation

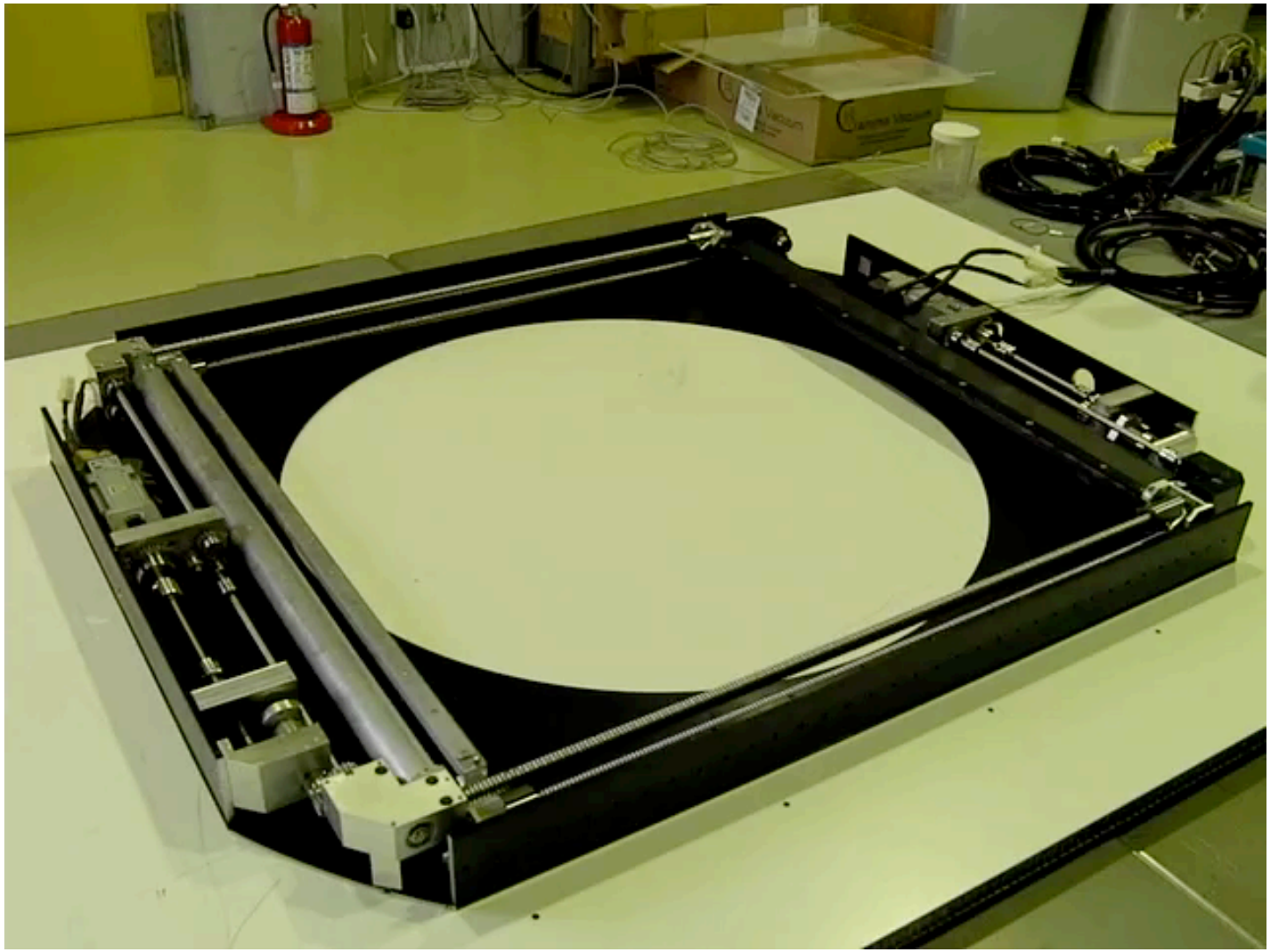
< 25 micron(p-v)



SiC monolithic cold plate

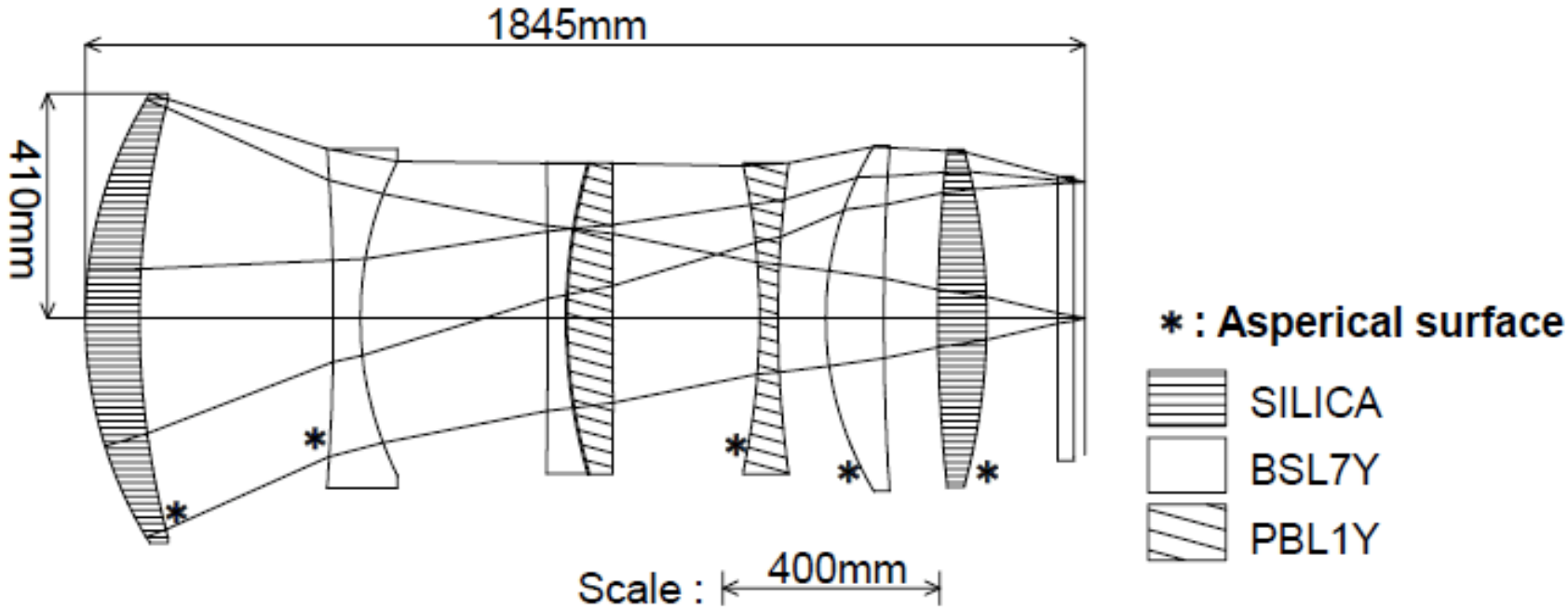
Shutter Prototype

- Goal 10 second exposure with 1 % precision



Optics (WFC)

Designed Image quality : FWHM << 0.2 arcsec



General Lens Data

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

Convex Aspheric lens is feasible only at few optics firms including Canon

0.17 arcsec/pix (15 um pix)

Designed Image quality

	0	0.125	0.25	0.5	0.75	[deg]
g	1.0	2.7	3.6			
(0.49)	5.8	5.5	6.3	9.2	5.2	
r	1.9	3.0	4.2			
(0.63)	1.3	1.5	3.4	4.0	4.5	
i	3.1	3.8	5.7			
(0.77)	2.8	3.8	5.1	5.3	4.4	
z	3.8	4.3	6.7			
(0.90)	2.8	4.1	5.0	6.3	4.6	

RMS spot radius (micron)

upper:SC, lower:HSC

Designed Image quality

	0	0.125	0.25	0.5	0.75	[deg]
g	1.0	2.7	3.6			
(0.49)	5.8	5.5	6.3	9.2	5.2	
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i	3.1	3.8	5.7			
(0.77)	2.8	3.8	5.1	5.3	4.4	
z	3.8	4.3	6.7			
(0.90)	2.8	4.1	5.0	6.3	4.6	

0.12” (FWHM)

RMS spot radius (micron)

upper:SC, lower:HSC

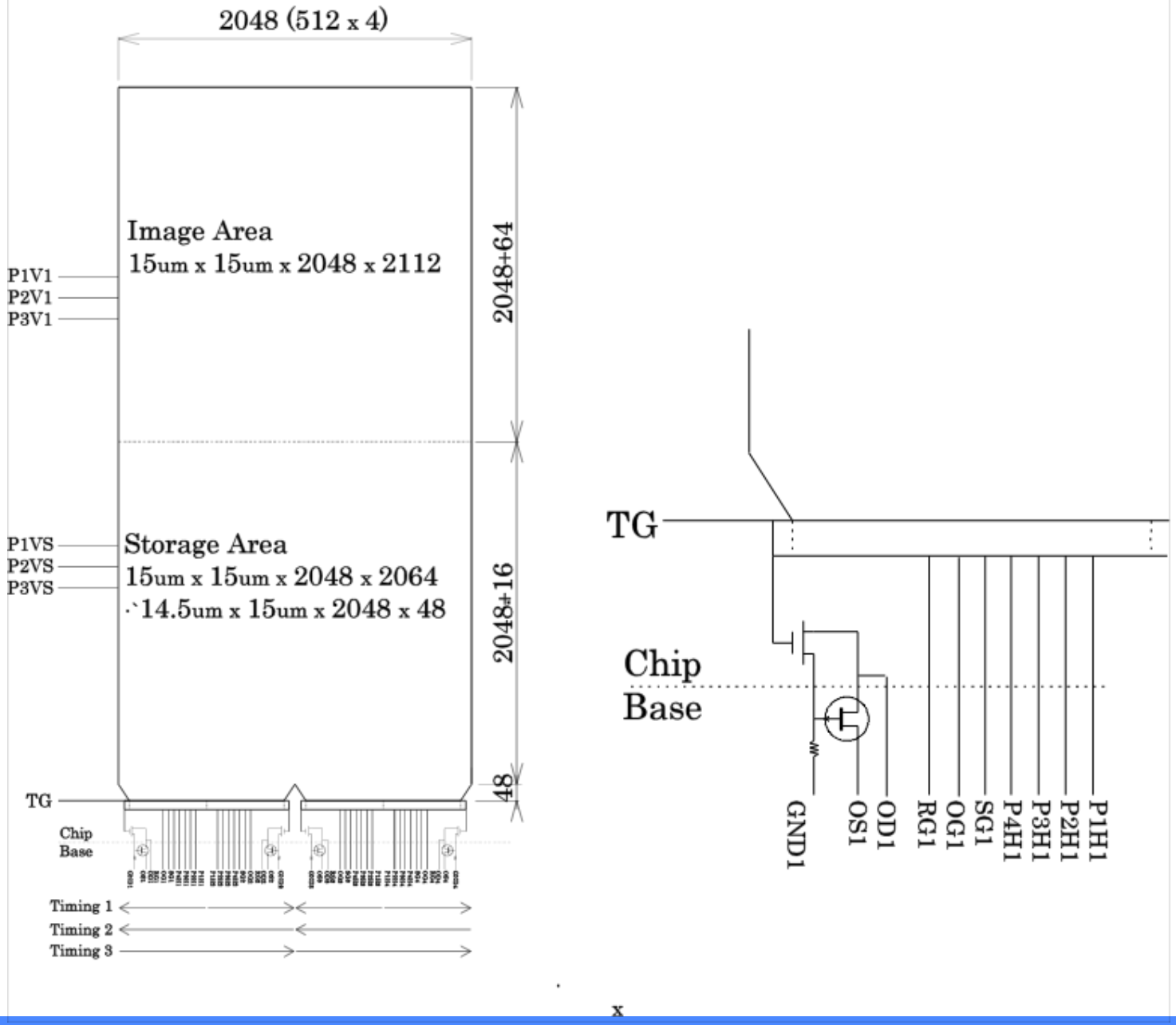
4. Sensor CCD

Hamamatsu (HPK) Fully Depleted CCD

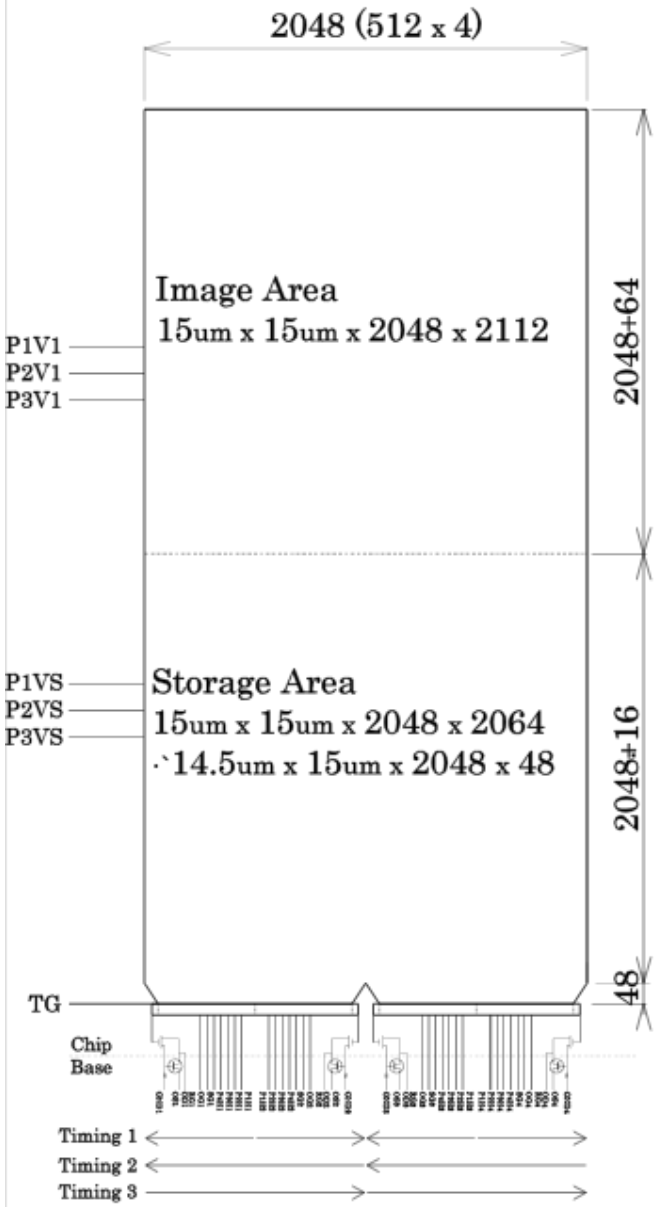
Product of long term (10 years) NAOJ-HPK Collaboration

HSC is a primary motivation of the development (upgrade of Suprime-Cam)

HPK FDCCD


2048 (512 x 4)
Image Area
15um x 15um x 2048 x 2112
2048+64
P1V1
P2V1
P3V1
P1VS
P2VS
P3VS
Storage Area
15um x 15um x 2048 x 2064
14.5um x 15um x 2048 x 48
2048+16
48
TG
Chip
Base
Timing 1
Timing 2
Timing 3
TG
Chip
Base
GND1
OS1
OD1
RG1
OG1
SG1
P4H1
P3H1
P2H1
P1H1

HPK FDCCD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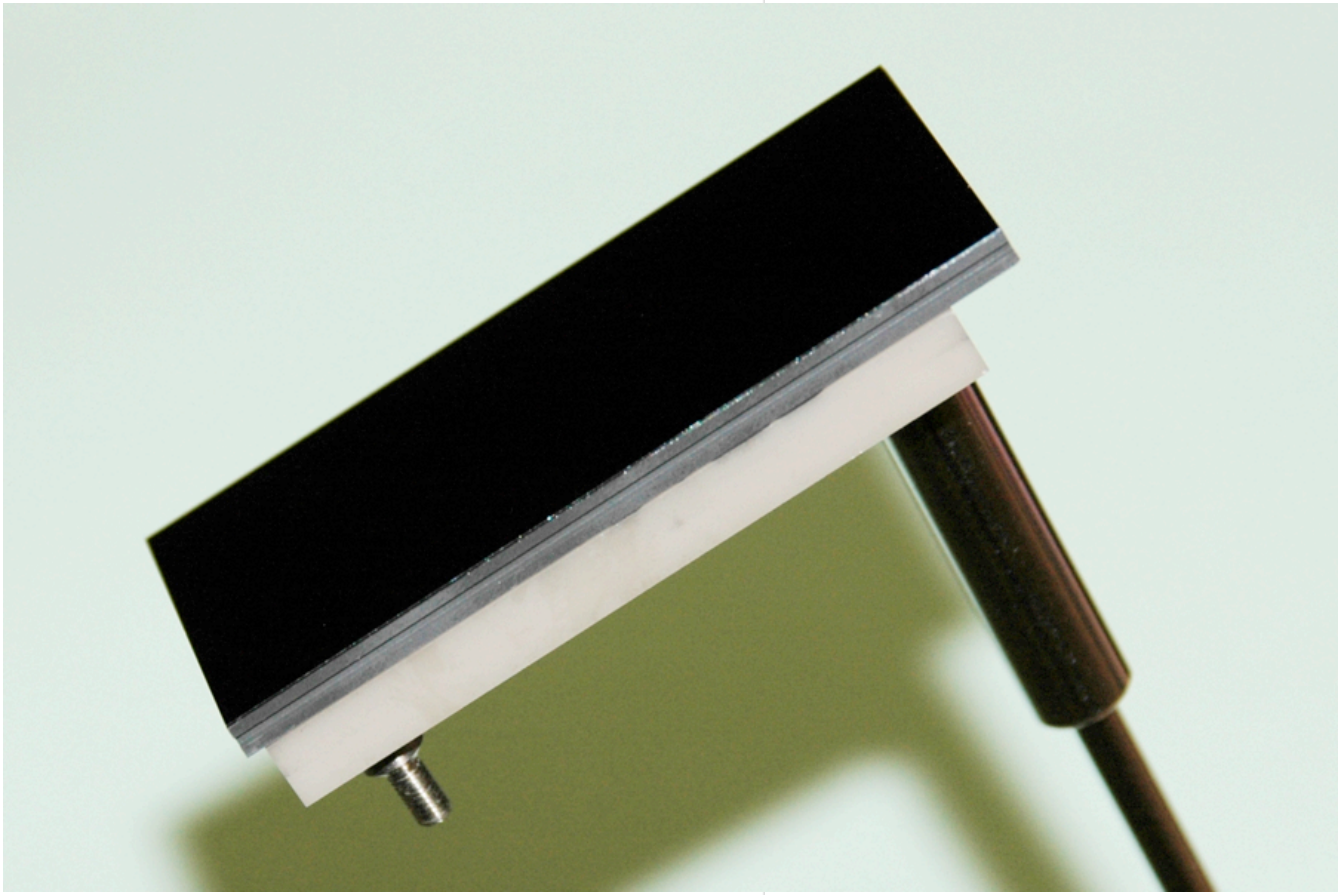
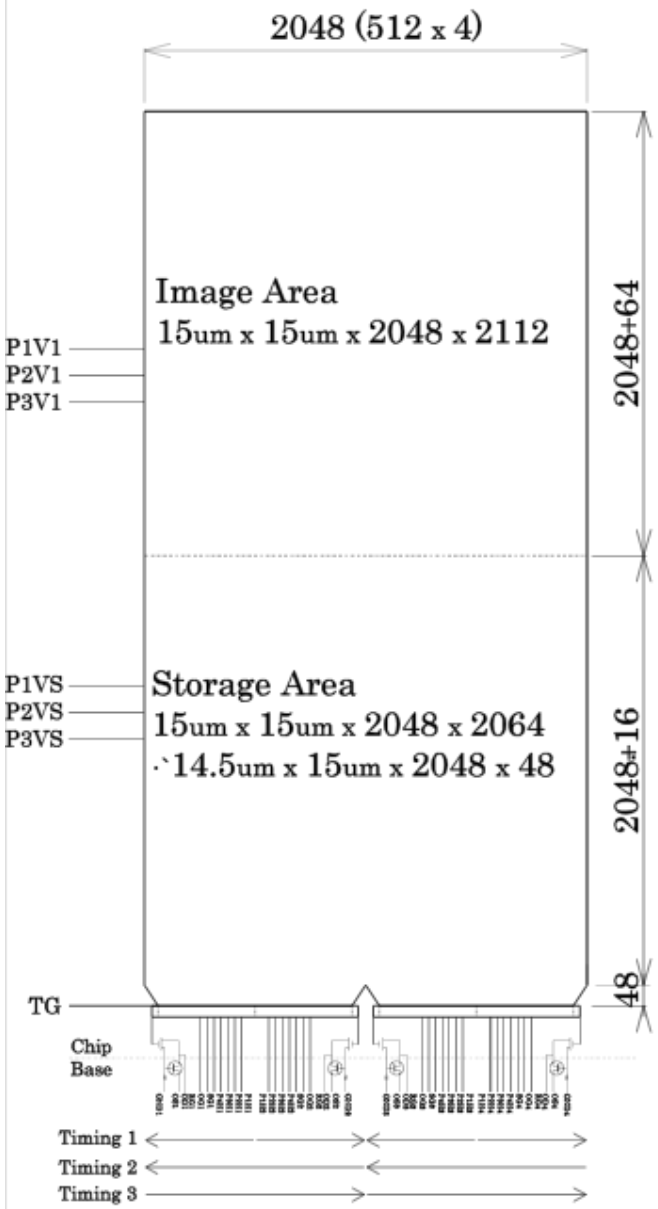
P3VS
Storage Area
15um x 15um x 2048 x 2064
14.5um x 15um x 2048 x 48
2048+16
48
TG
Chip
Base
Timing 1
Timing 2
Timing 3



HPK FDCCD


2048 (512 x 4)
Image Area
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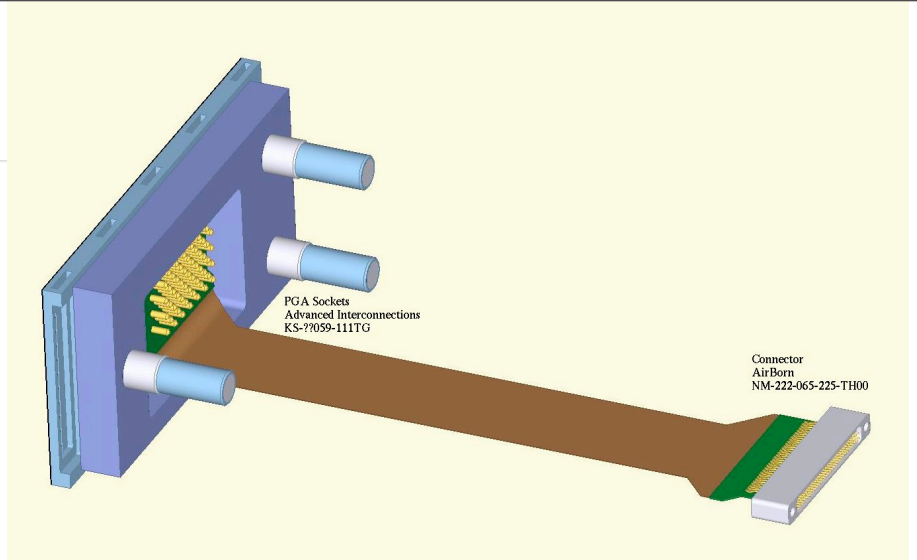
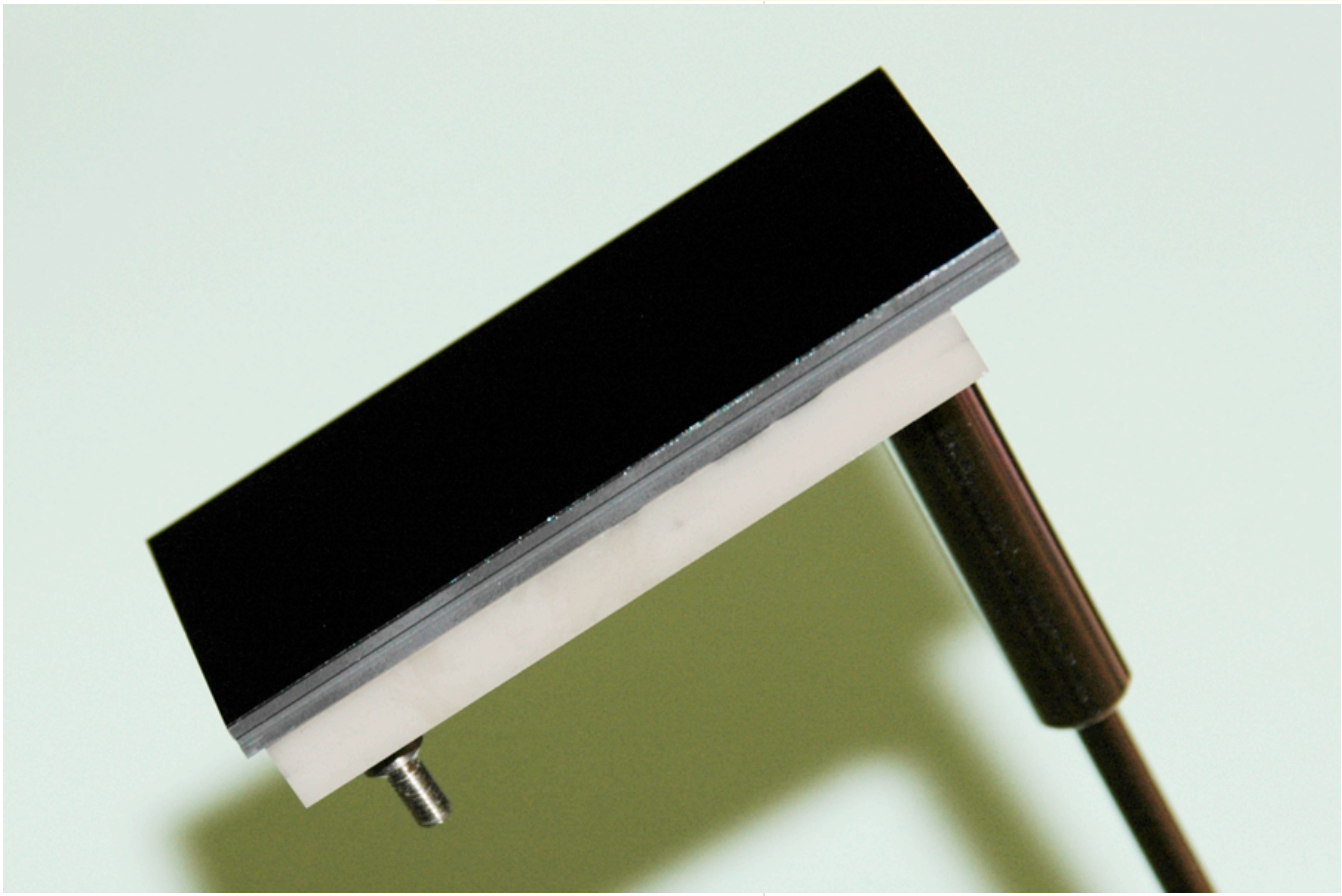
Timing 2
Timing 3


PGA Sockets
Advanced Interconnections
KS-??059-111TG
Connector
AirBorn
NM-222-065-225-TH00

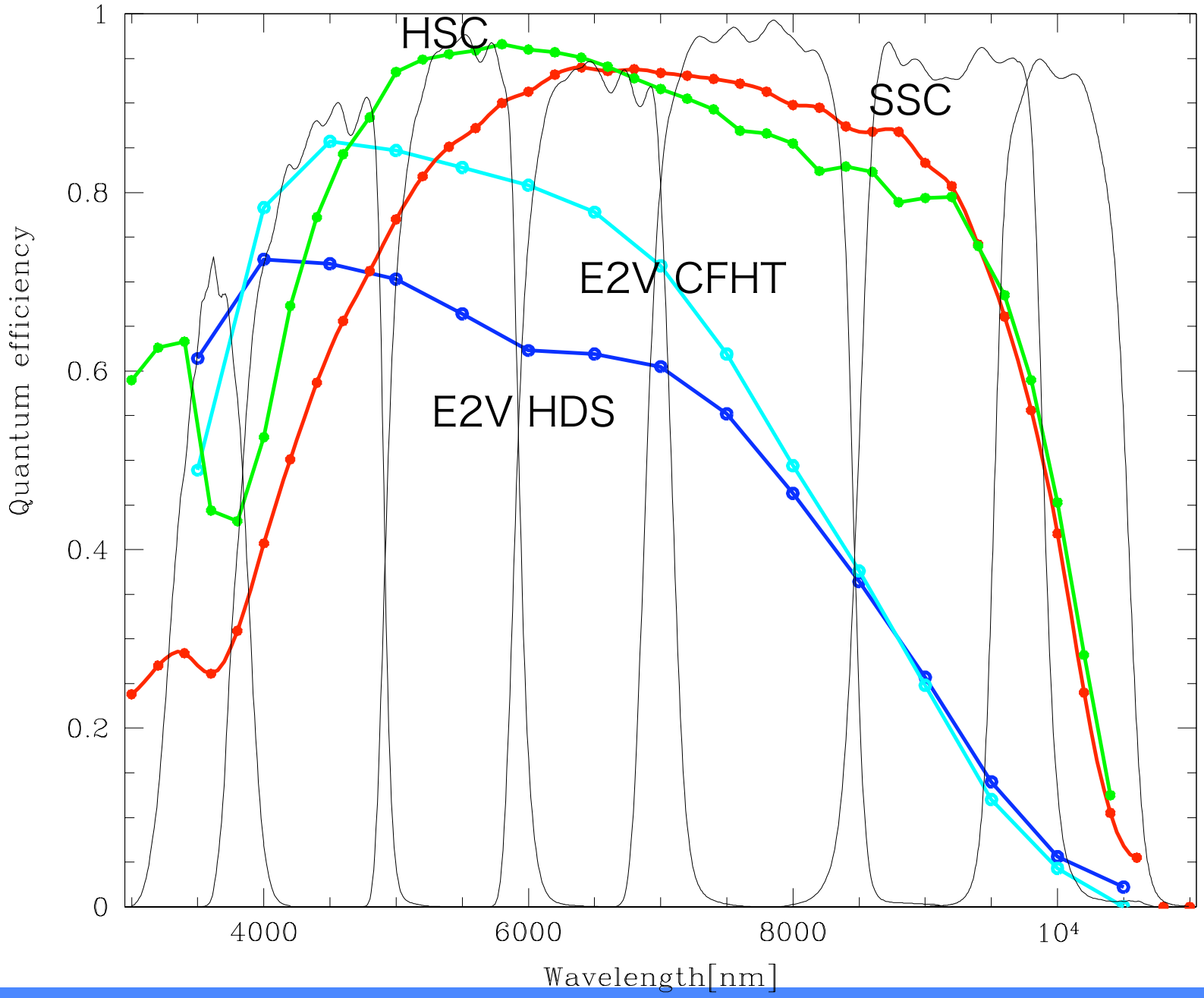


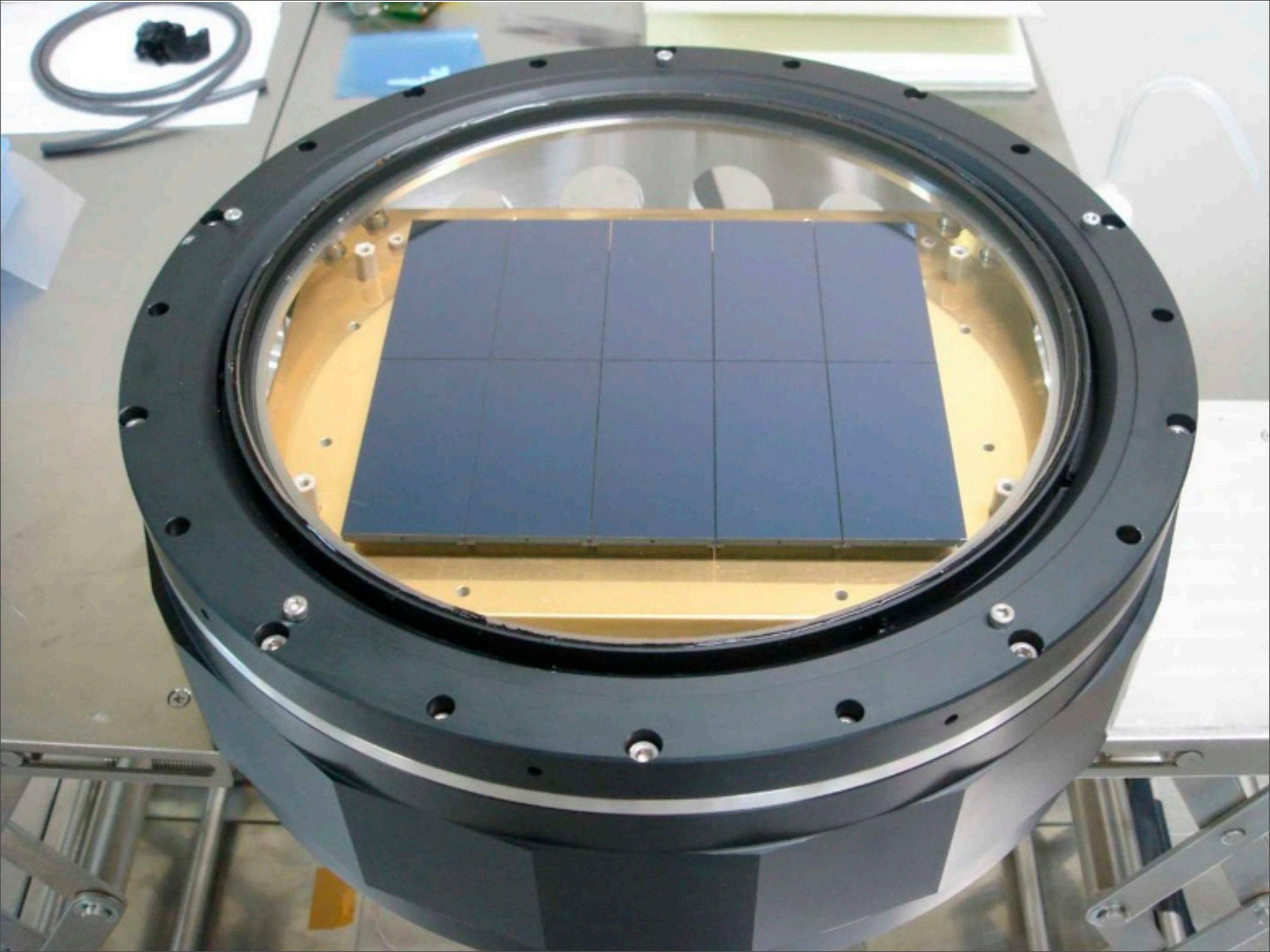
FDCCD Characterization

Parallel CTE	0.999995
Serial CTE	0.999995
Quantumn Efficeincy	40 % (400 nm)
	90 % (650 nm)
	40 % (10000 nm)
Thickness	200μm
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

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

QE Comparison





Super Suprime-Cam

- Prototype of Hyper Suprime-Cam
- Offered to general observers (shared risk basis) since August, 2008
- 40 % QE increase in z' confirmed

Super Suprime-Cam

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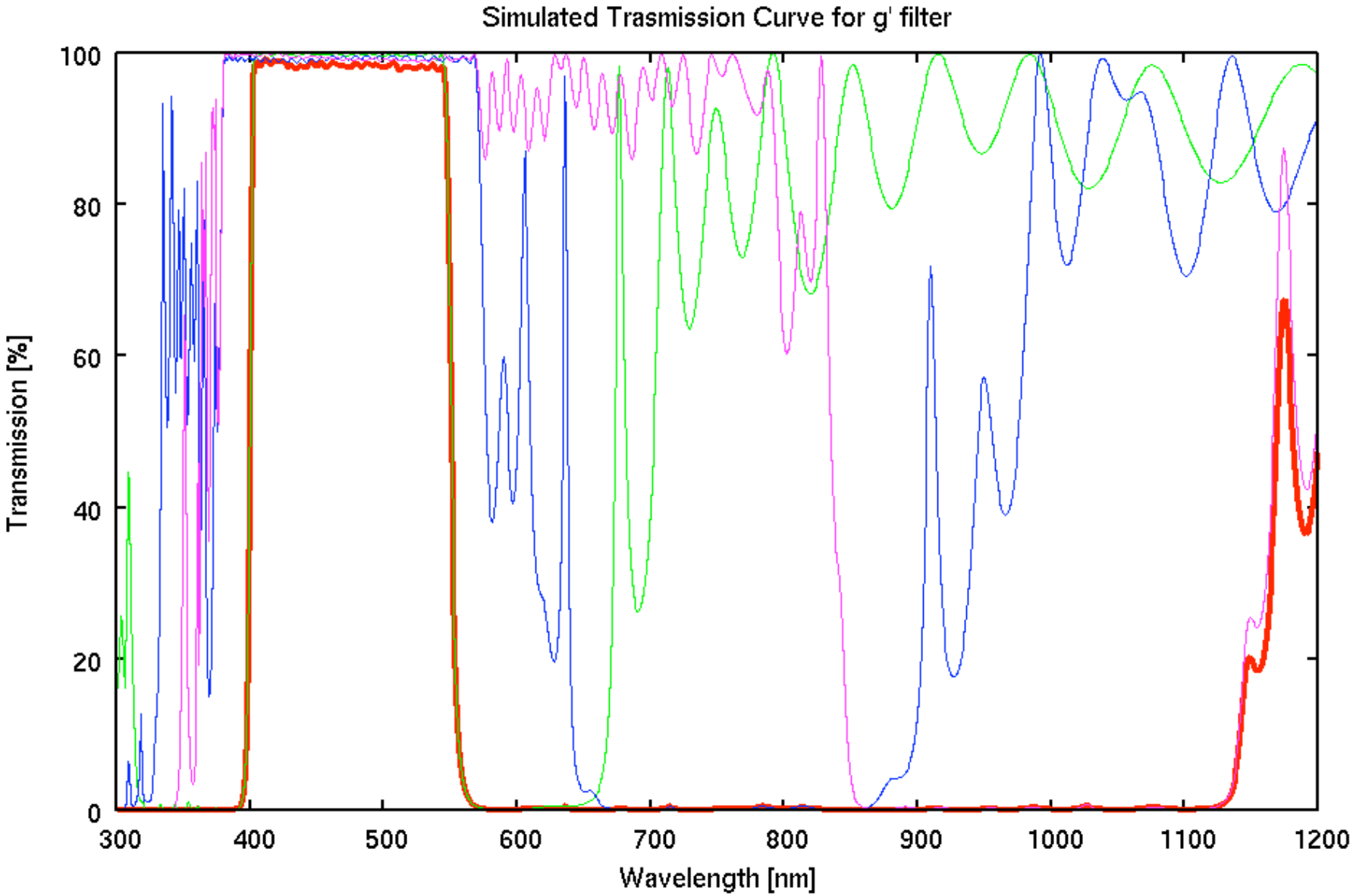
- 40 % QE increase in z' confirmed

No observer's complaint so far.


M17 B Rc z'

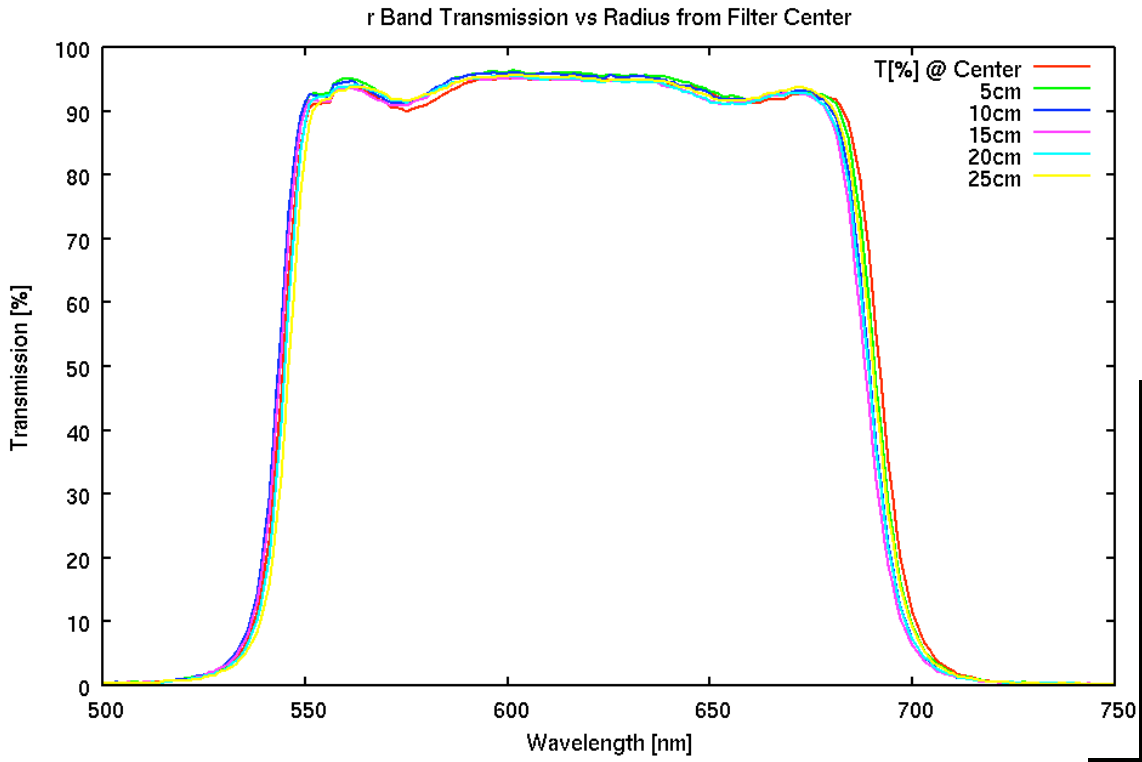
Filter

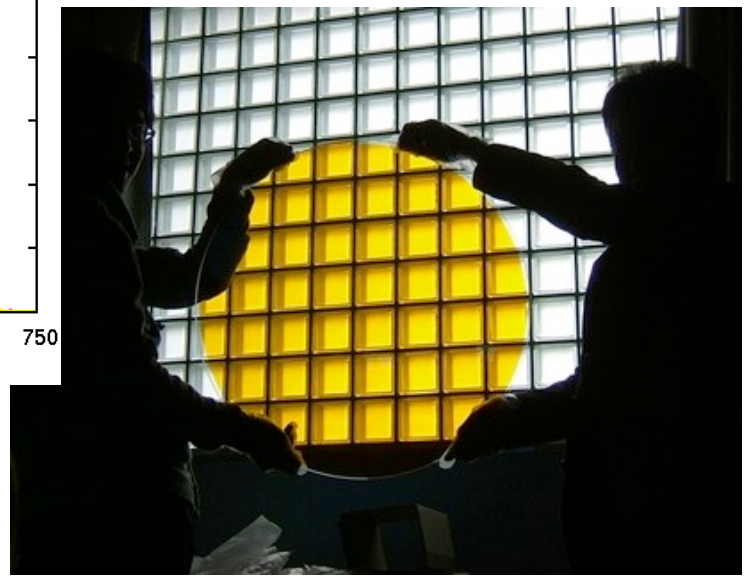
Designing Interference Filter



Filter Prototype

- Standard Evaporation method
- 60 cm phi

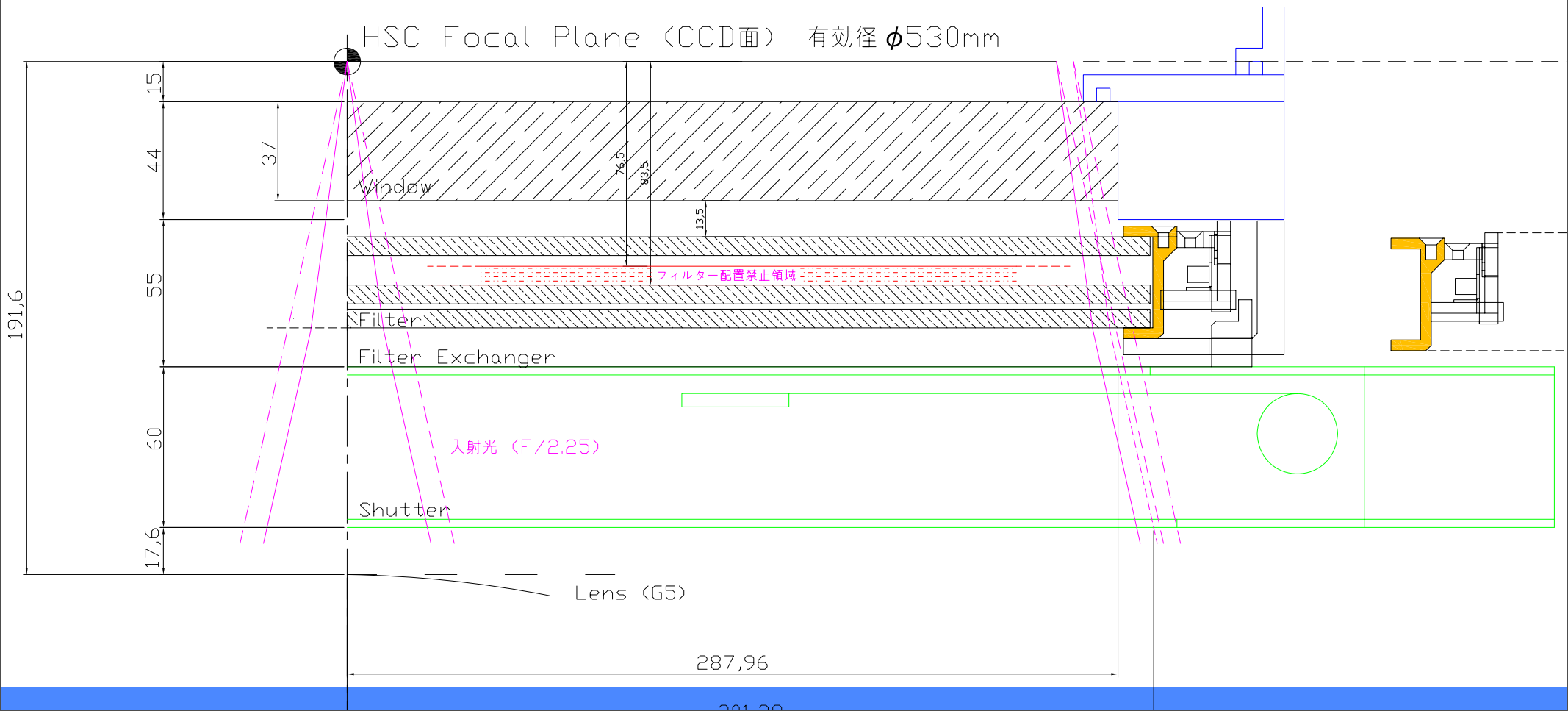




All specs are met
including the uniformity

Filter Structure

- 6 glass surface is required because the film built by the standard evaporation is porous



Sputtering deposition

- A way to obtain dense film
- We need to explore this option to make things simpler
- Possible vendors
  - Asahi Spectra
  - Barr Associate

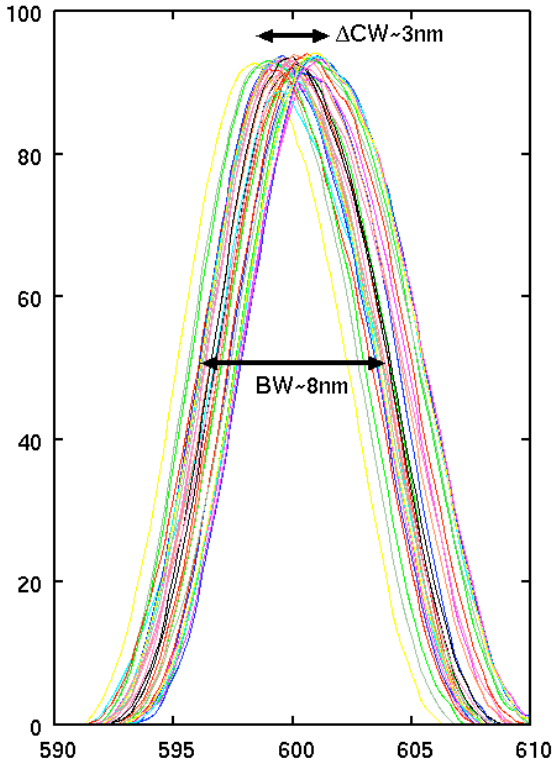
Narrow band Filter

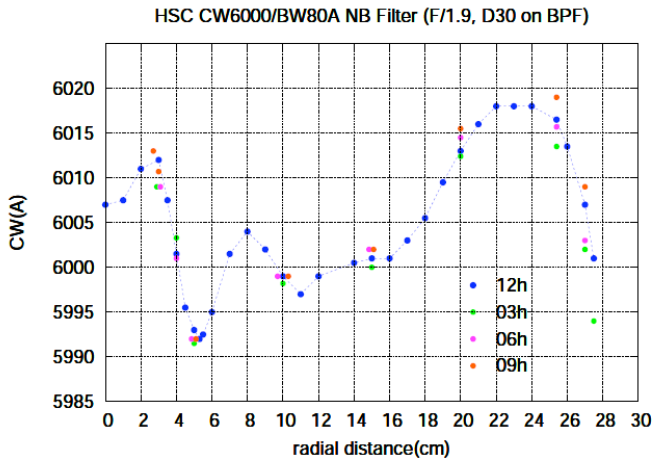
- Prototyping at Barr Associates through Hayashino-san

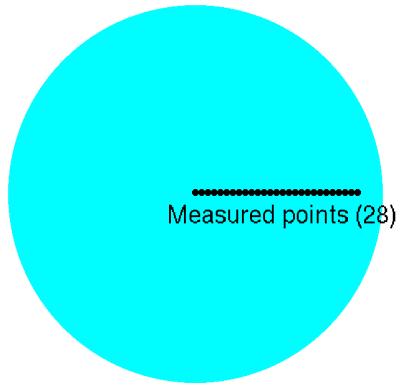
- Spec. for prototype filter
  - Dimension : D=600mm, t=15mm
  - Substrate : Schott B270
  - Central Wavelength(CW) : 6000Å
    - ΔCW : 17Å (r < 200mm), 30Å (200mm < r < 250mm)
  - Pass-band width(BW) : 80Å
    - ΔBW : 15Å (r < 200mm), 20Å (200mm < r < 250mm)
  - No blocking layer

Narrow band Filter

- Result
  - BW and CW meet the spec.
  - ΔBW and ΔCW meet the spec.
    - Unexpexted CW gradient in a few cm scale is detected
  - Overall, the prototype filter is a promising one.







Narrow Band Filter

- Asahi Spectra's effort
  - Building new sputtering facility
  - Goal of cut off wavelength uniformity
    - < 10 A

Both Asahi and Barr are possible options.

Project Milestones

Constraint

- Dark Energy Survey (2011/01 Survey start)
- Grant-in-Aid ends (2012/03)

2009/03	Design Review
2010/12	Assembly Completed at Mitaka
2011/1	Ship to Hawaii
2011/6	Engineering First Light
2011/9	Science Observations starts

フィルター持ち込みポリシー

- 必要性
  - Suprime-Camでは、ポリシーが不明確だったため、運用現場が混乱してしまった。
  - HSCはよりフィルターはより高価になる（SCの最低10倍）

ポリシーの決め方

T副観測所長の提案

1. 観測所、HSC製作組でたたき台を作成
2. 科学的、運用面を含め多角的に検討
   (SAC + 観測所で検討WG ?)
3. 観測所長が決定
4. 予算申請等を開始

ポリシーたたき台

- 現場レベルで検討中
- 基本的な考え方
  - フィルターを観測所に引き渡した時点で、制作者にはその所有権を放棄してもらう
  - 観測所は受け入れ後、一般公開を行う

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  - 観測所は受け入れ後、一般公開を行う

フィルター製作はコミュニティーへの貢献

HSC Project Status

	Design completed by 2009/1	Risk
1. Camera Mechanics	80 %	
2. PFU Mechanics	70 %	→
3. Optics		
- Wide field Corrector	95 %	
- Filter	60 %	
4. Sensor		
- CCD	95 %	
- Readout electronics	60 %	
5. Data Management	40 %	
6. Project Management		
- Schedule		
- Budget		

Summary

HSC design and prototyping is underway almost on schedule.

Design Review is scheduled on March 2, 2009