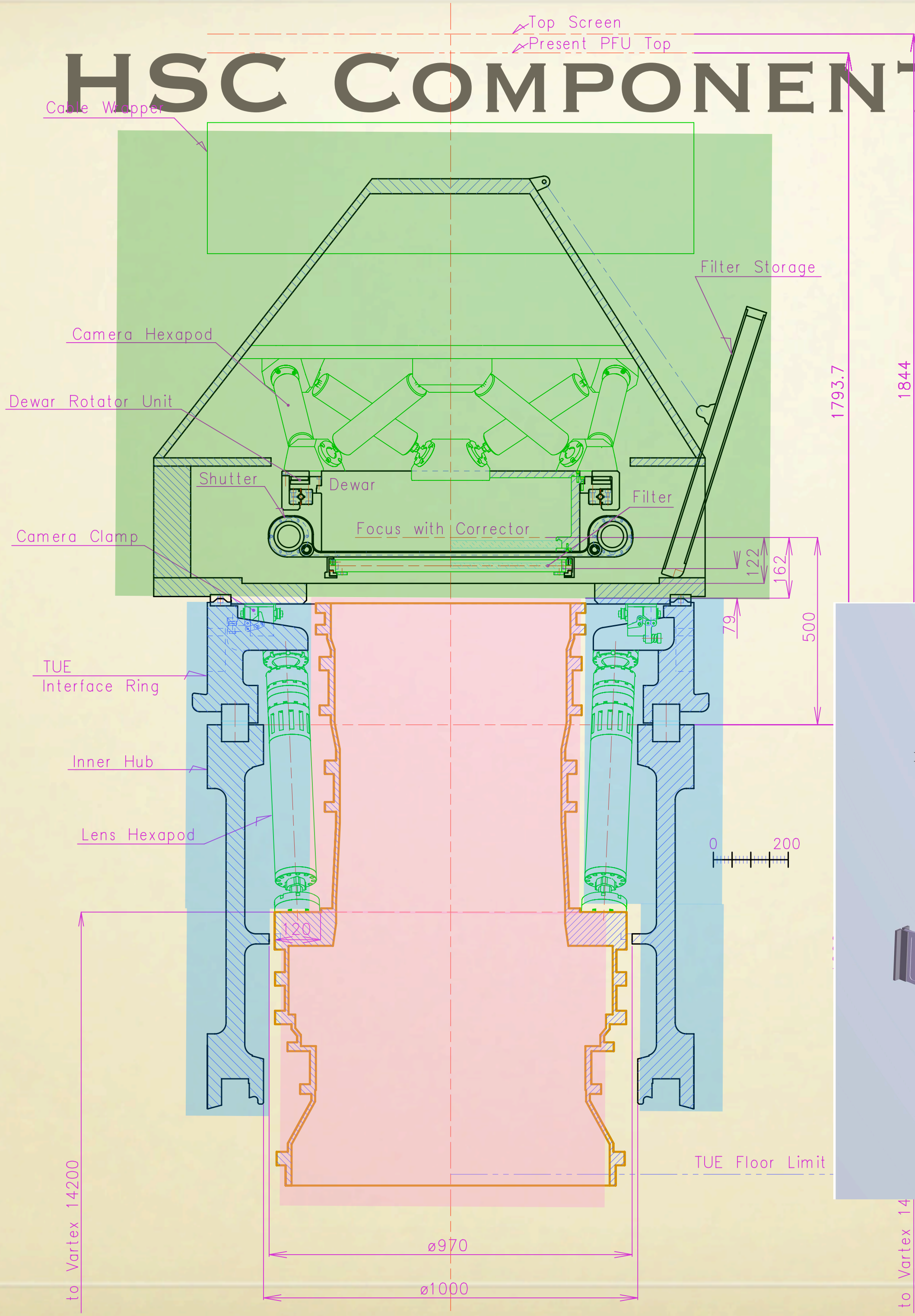
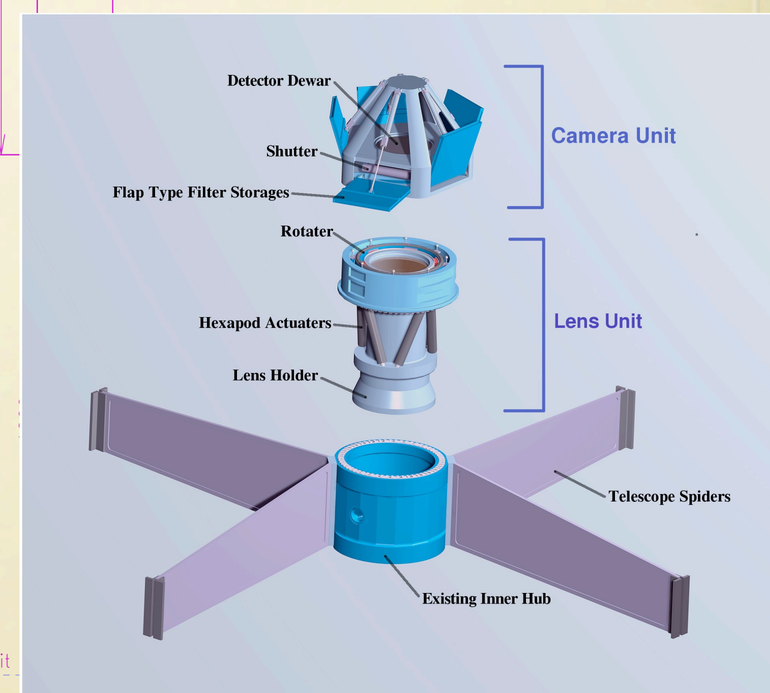
# Hyper Suprime-Cam
## Project Status update

Satoshi Miyazaki
NAOJ

2008/01/29
Subaru TAC User's Meeting

# HSC Components



# 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
ASIAA

# Talk Outline

- HSC Mechanics (telescope interface)
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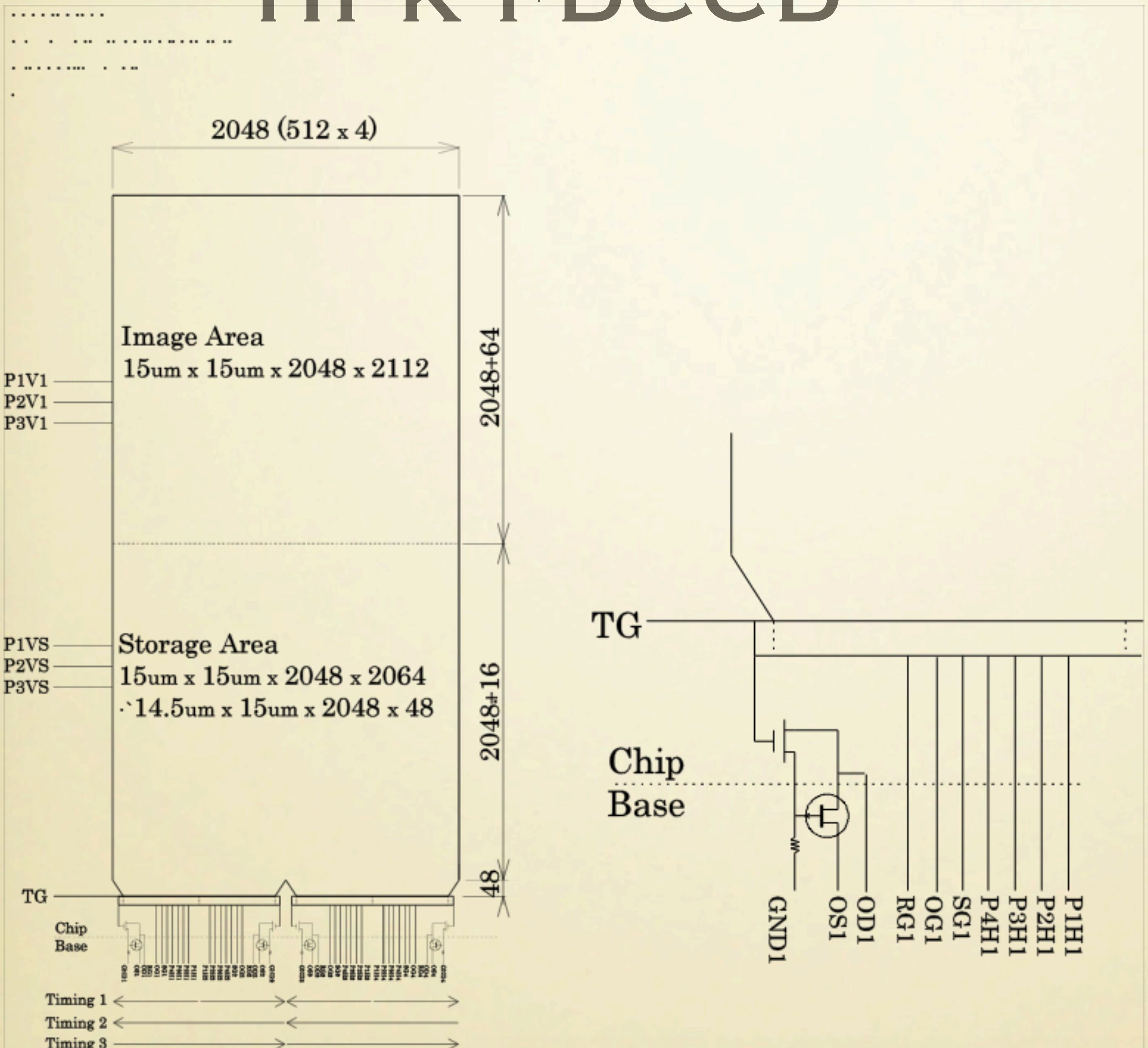
Wang

Furusawa

# HPK FDCCD




4 output amp. 4 side buttable

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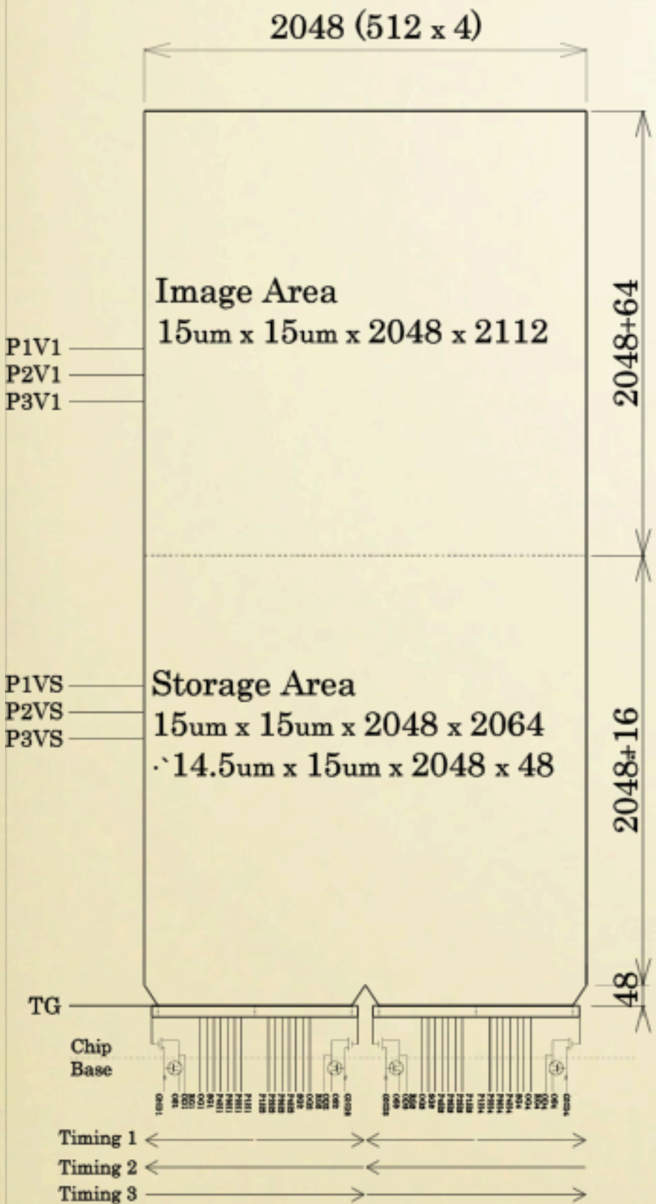


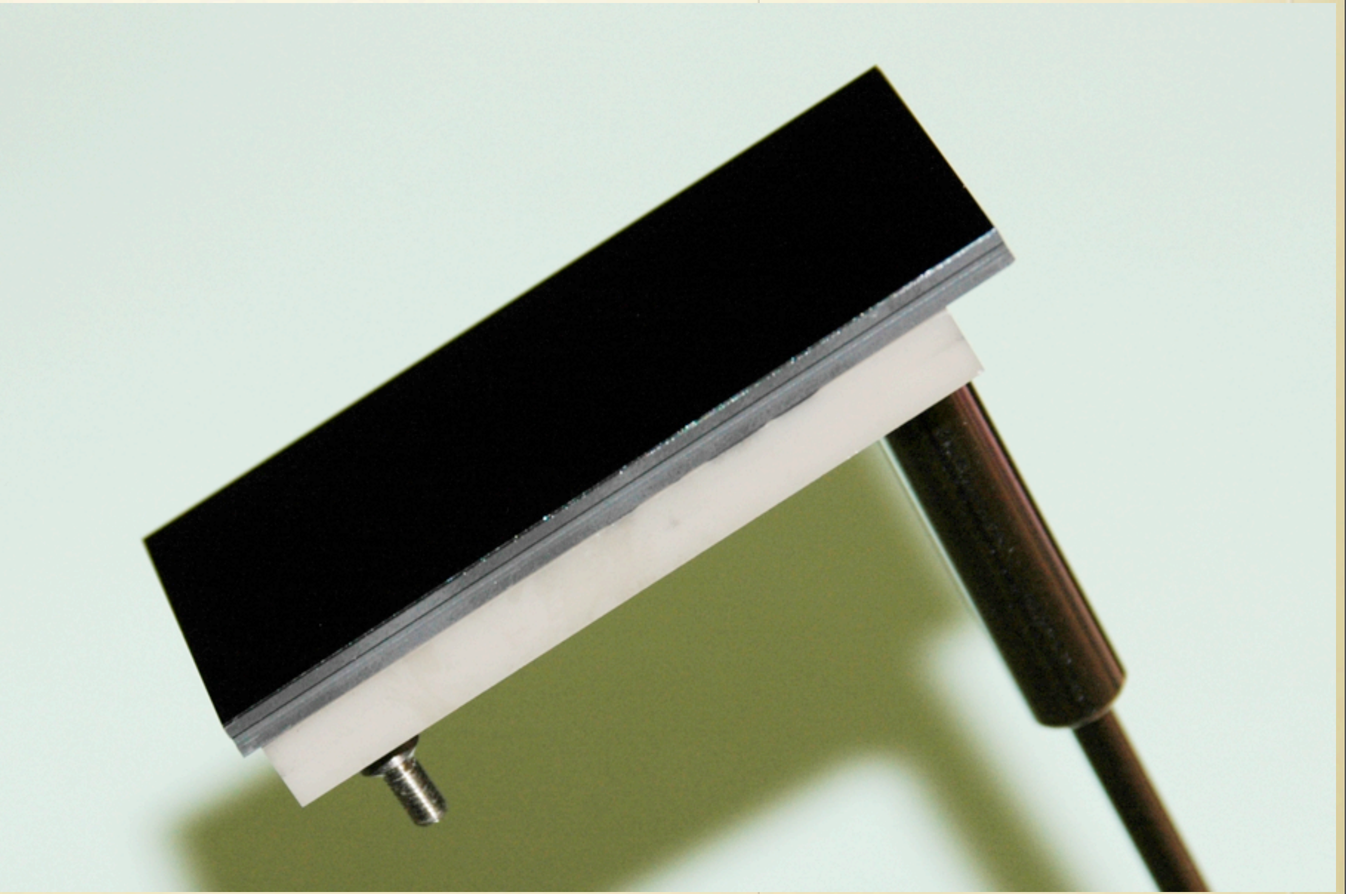

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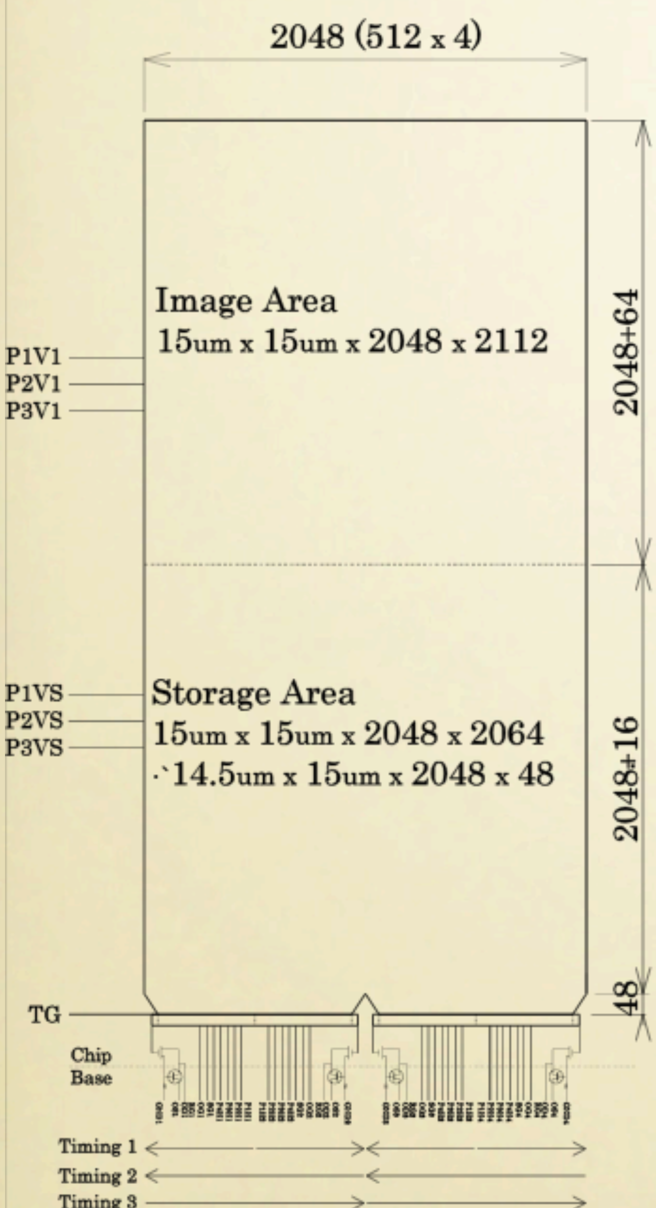


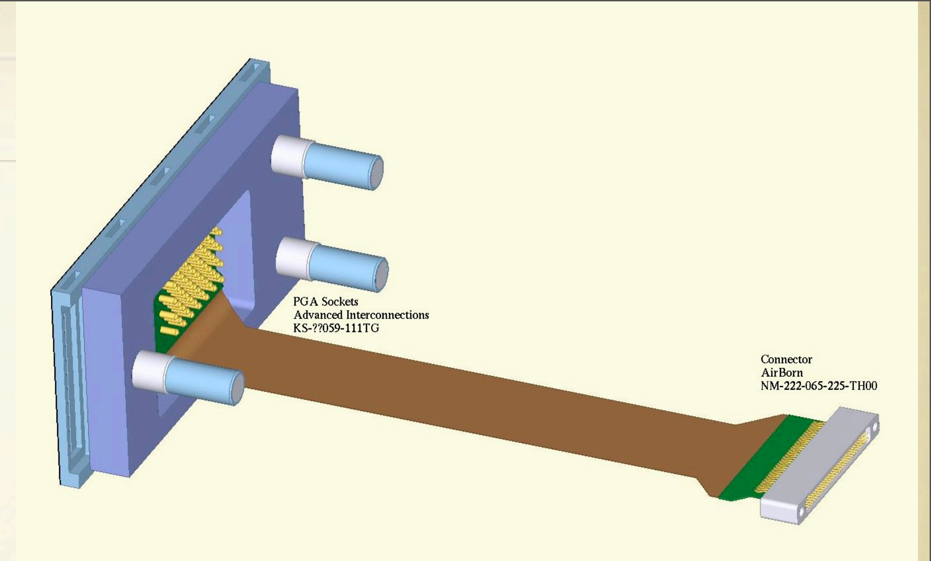


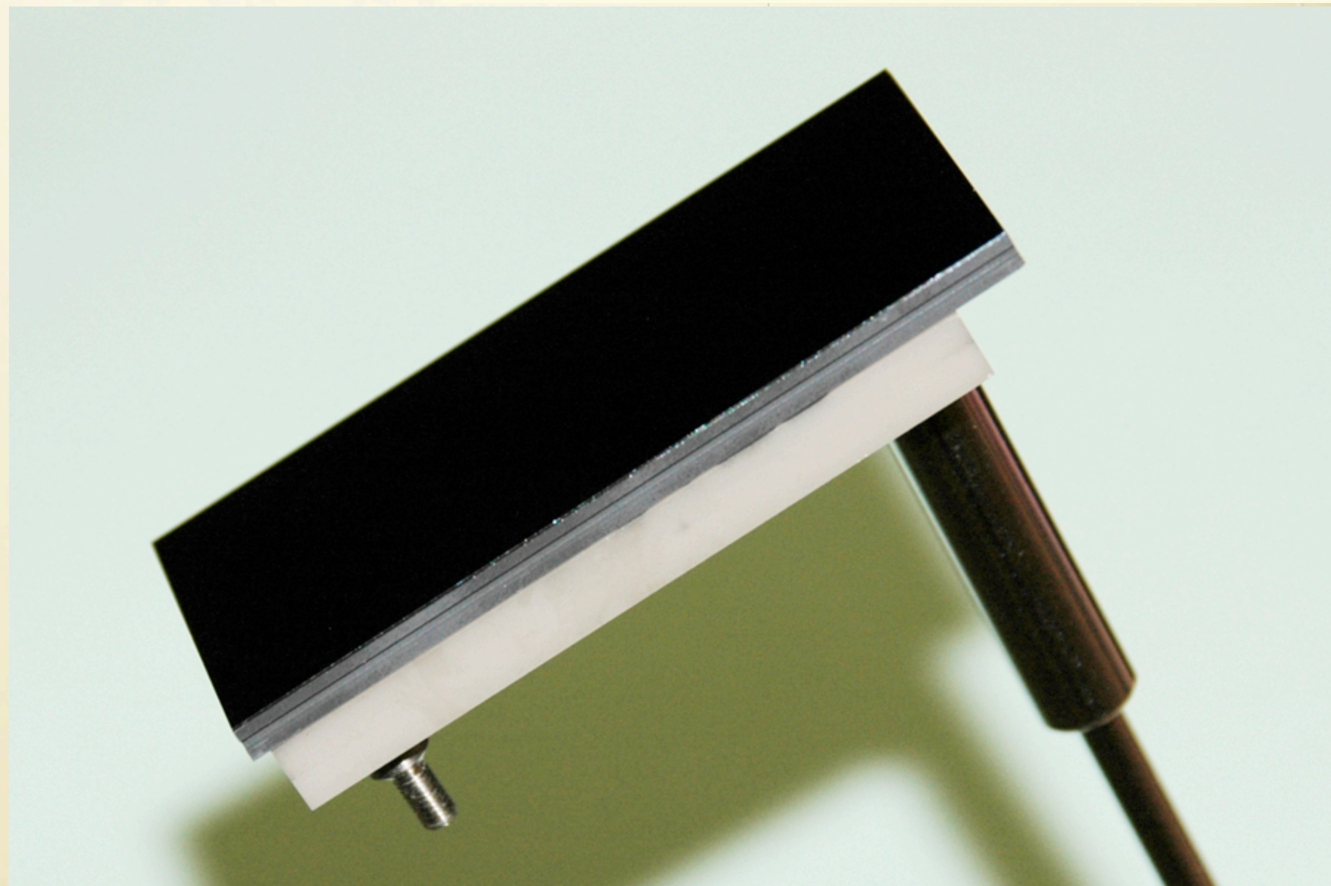

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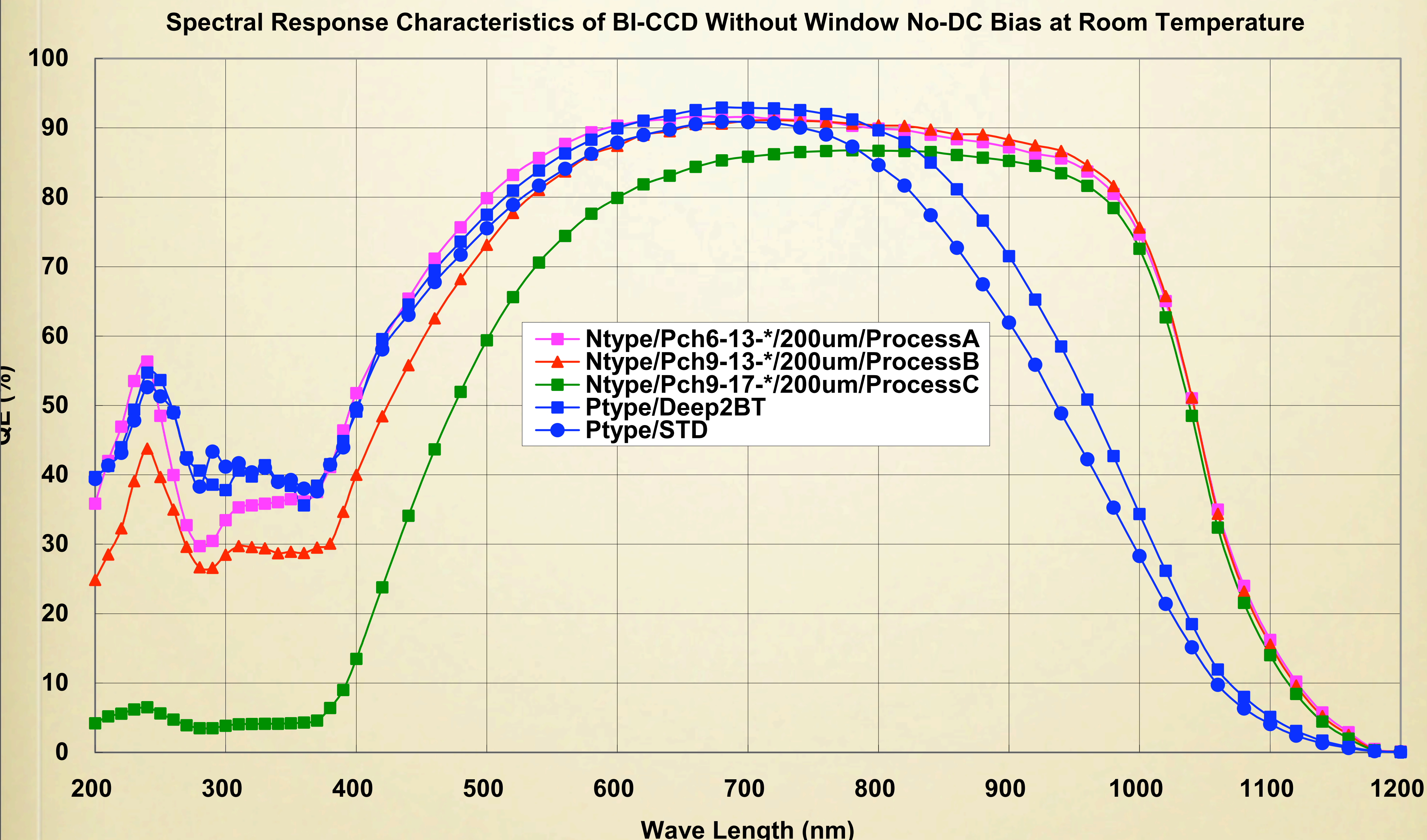
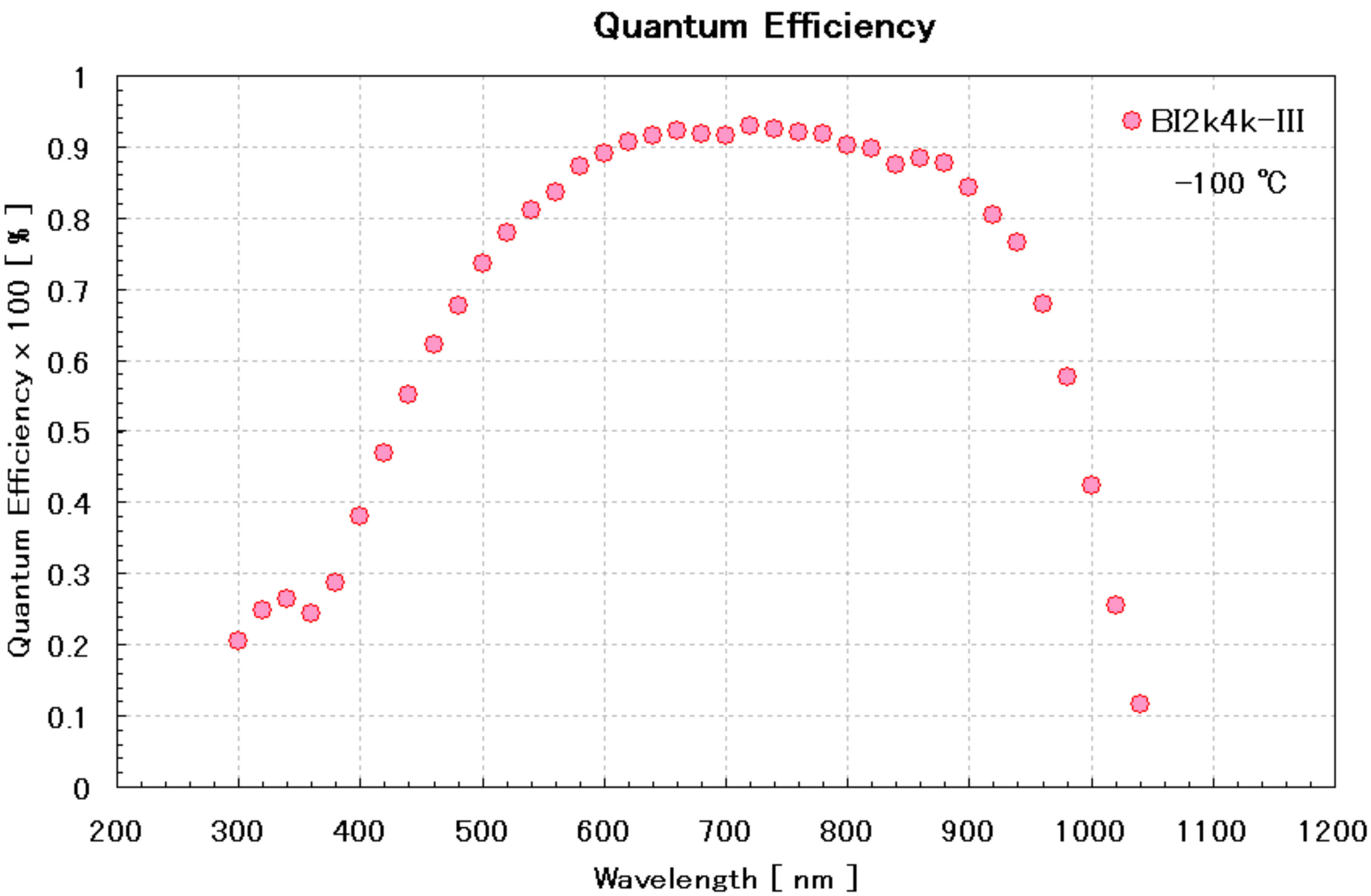
# FDCCD QE at Room Temp.



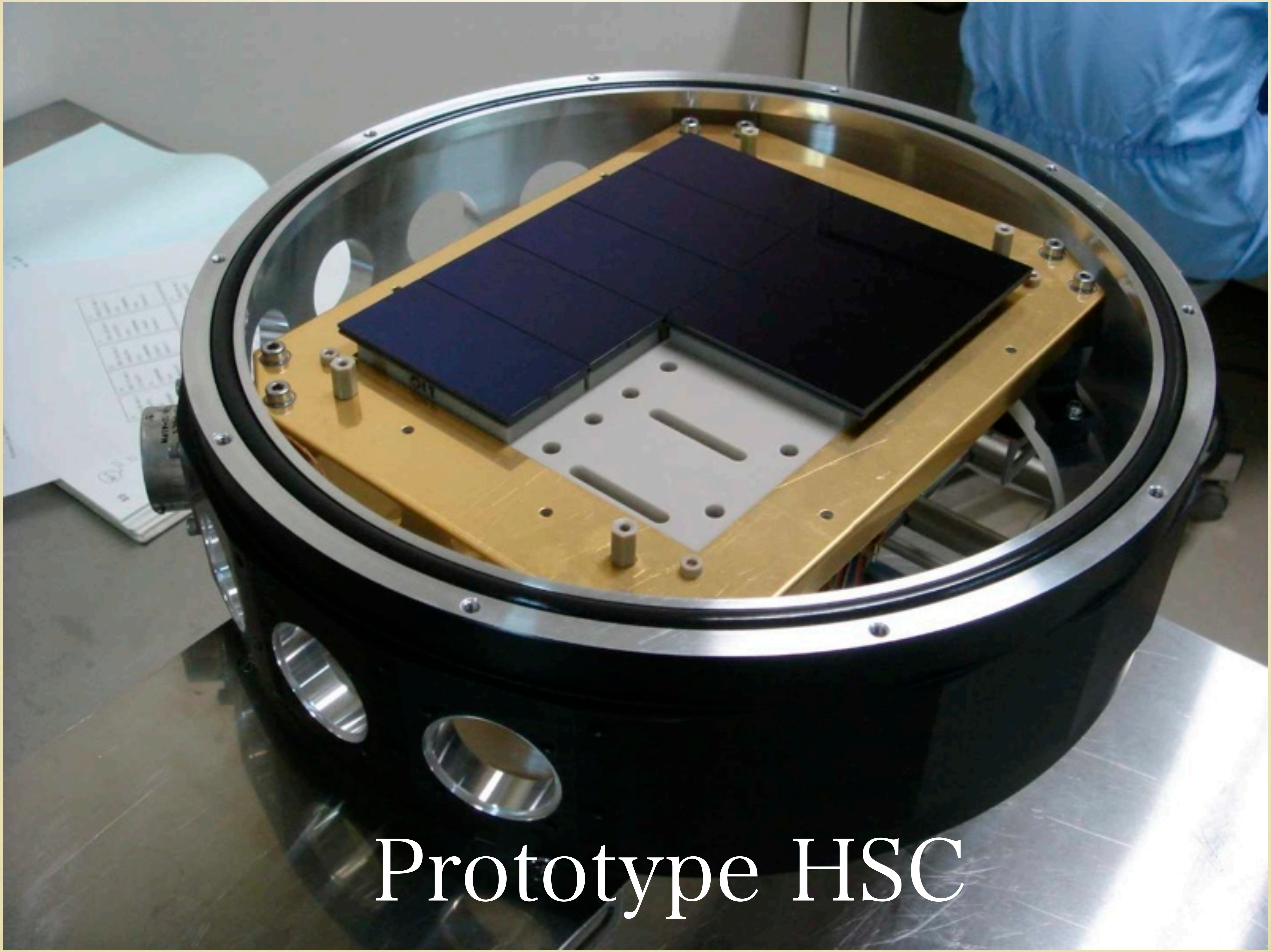
# QE at operation Temp.



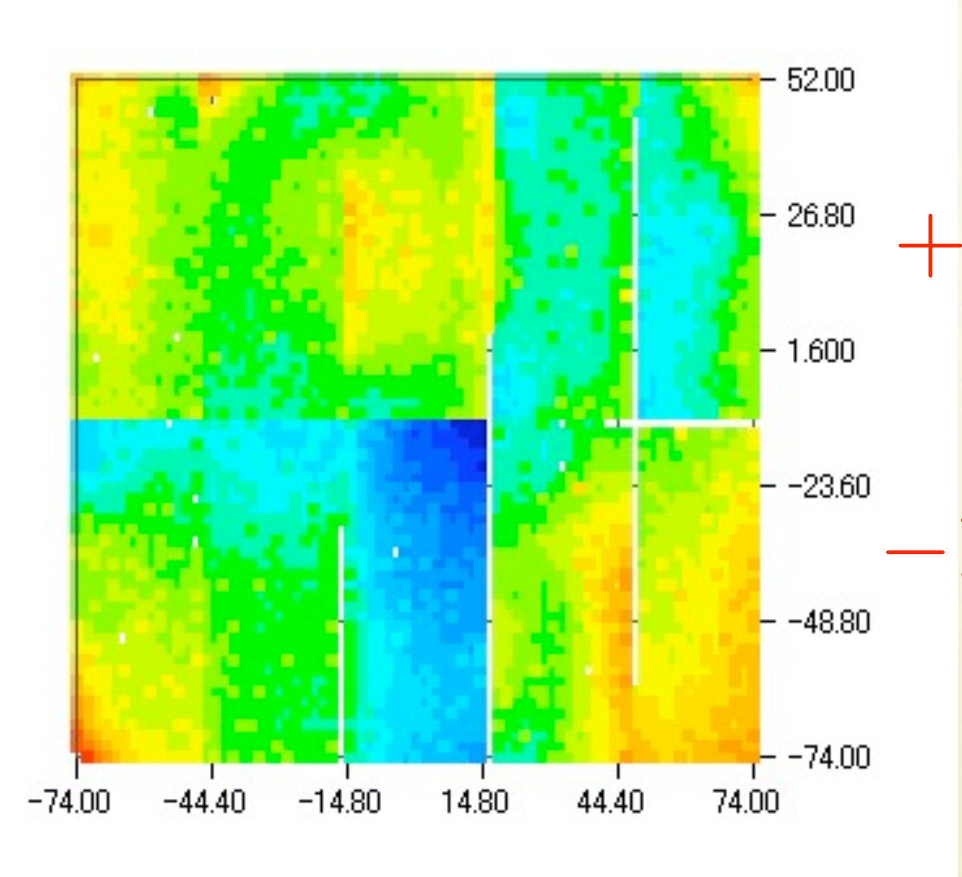
# FDCCD Characterization

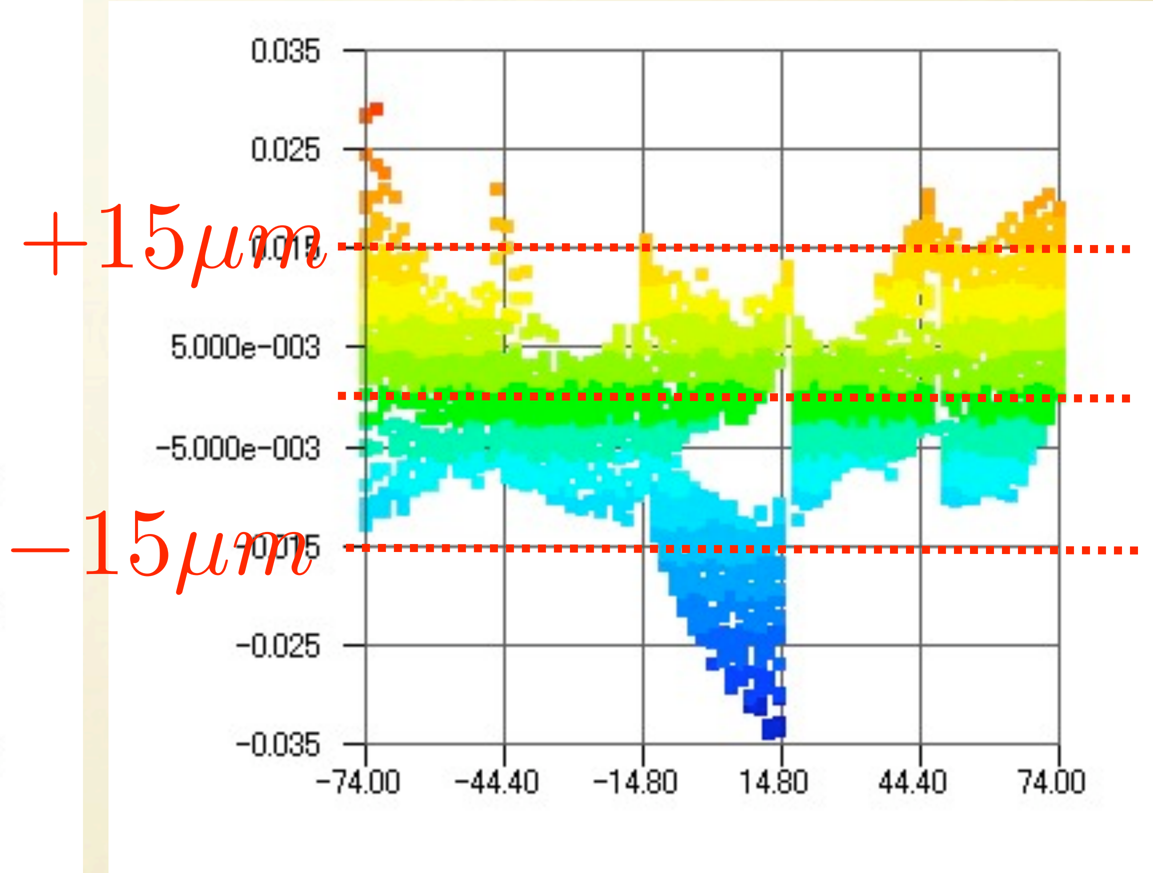
| | |
|---|---|
| Parallel CTE | 0.999995 |
| Serial CTE | 0.999995 |
| Quantumn Efficeincy | 40 % (400 nm) |
| | 90 % (650 nm) |
| | 40 % (10000 nm) |
| Thickness | $\geq$ 150 [$\mu$m] |
| Dark Current | 1.4 [e/hour/pixel] |
| Full Well | 180,000 [e] |
| Amplifier Responsivity | 5.8 [$\mu$V/e] |
| Read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

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


Prototype HSC

# Height Variation

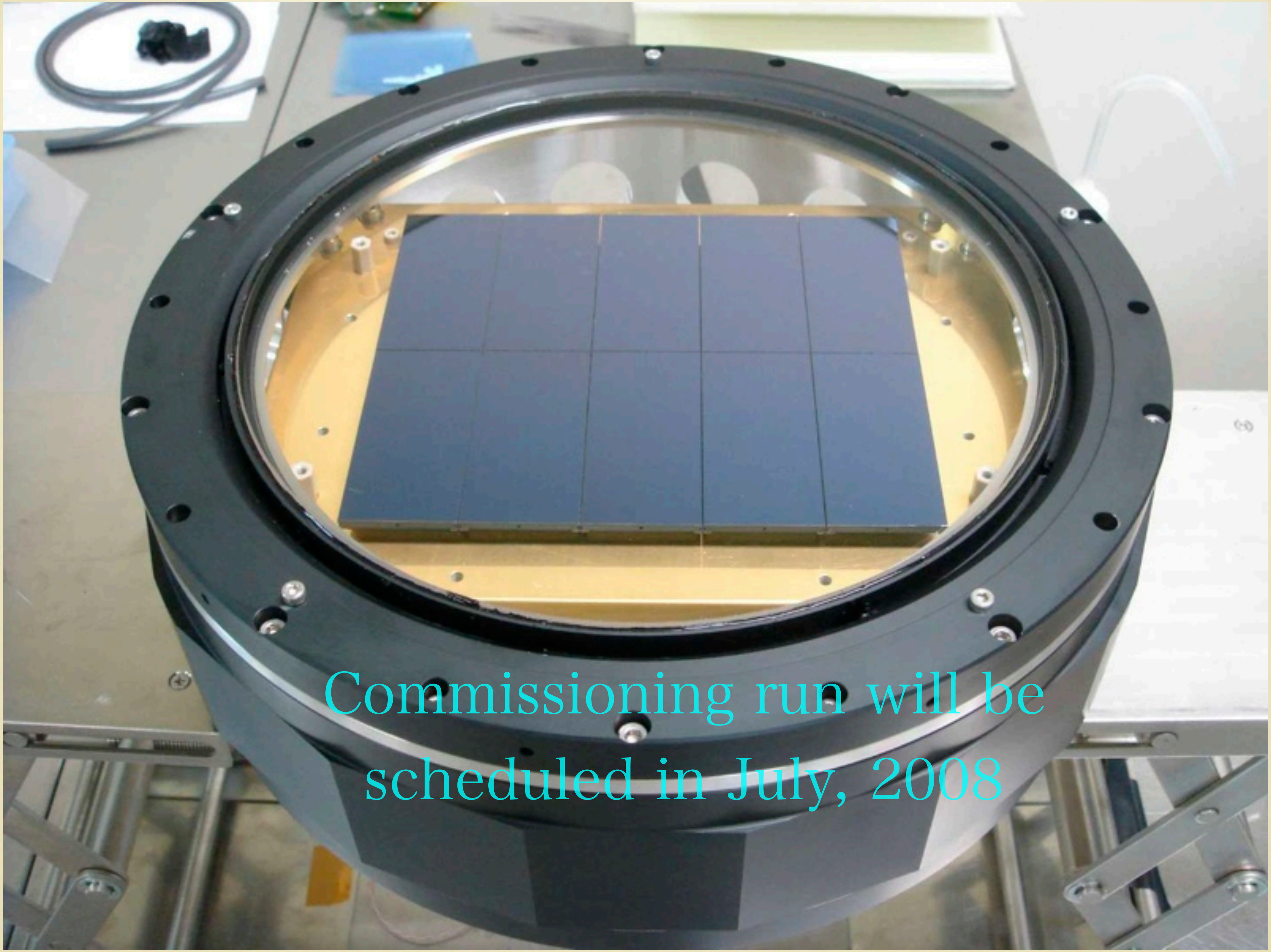


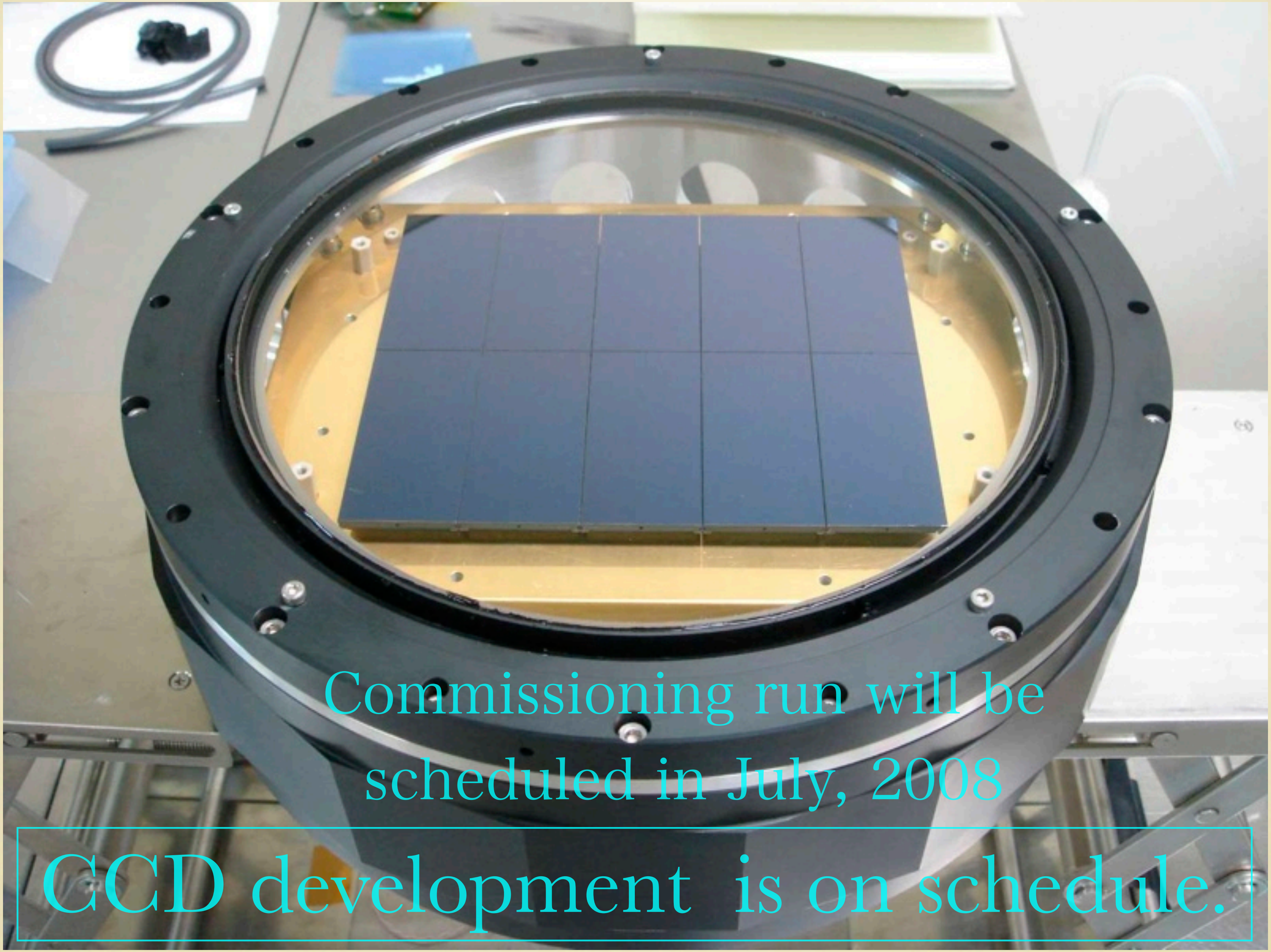




One device is out of spec. Need to be replaced

Height measurement system of assembling line seems to have been unstable temporarily

- Fixed


Commissioning run will be
scheduled in July, 2008



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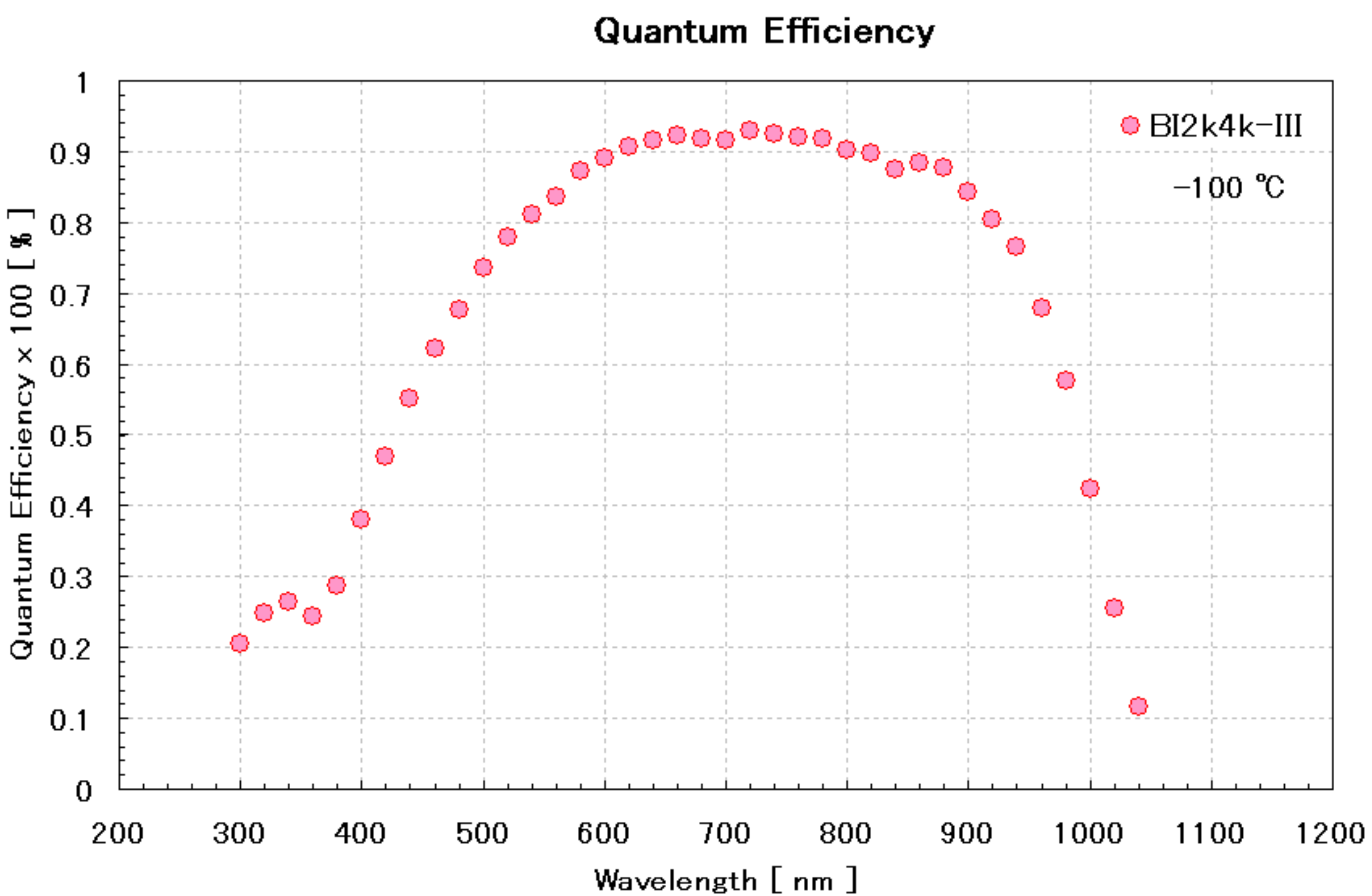
CCD development is on schedule.

# FDCCD for HSC



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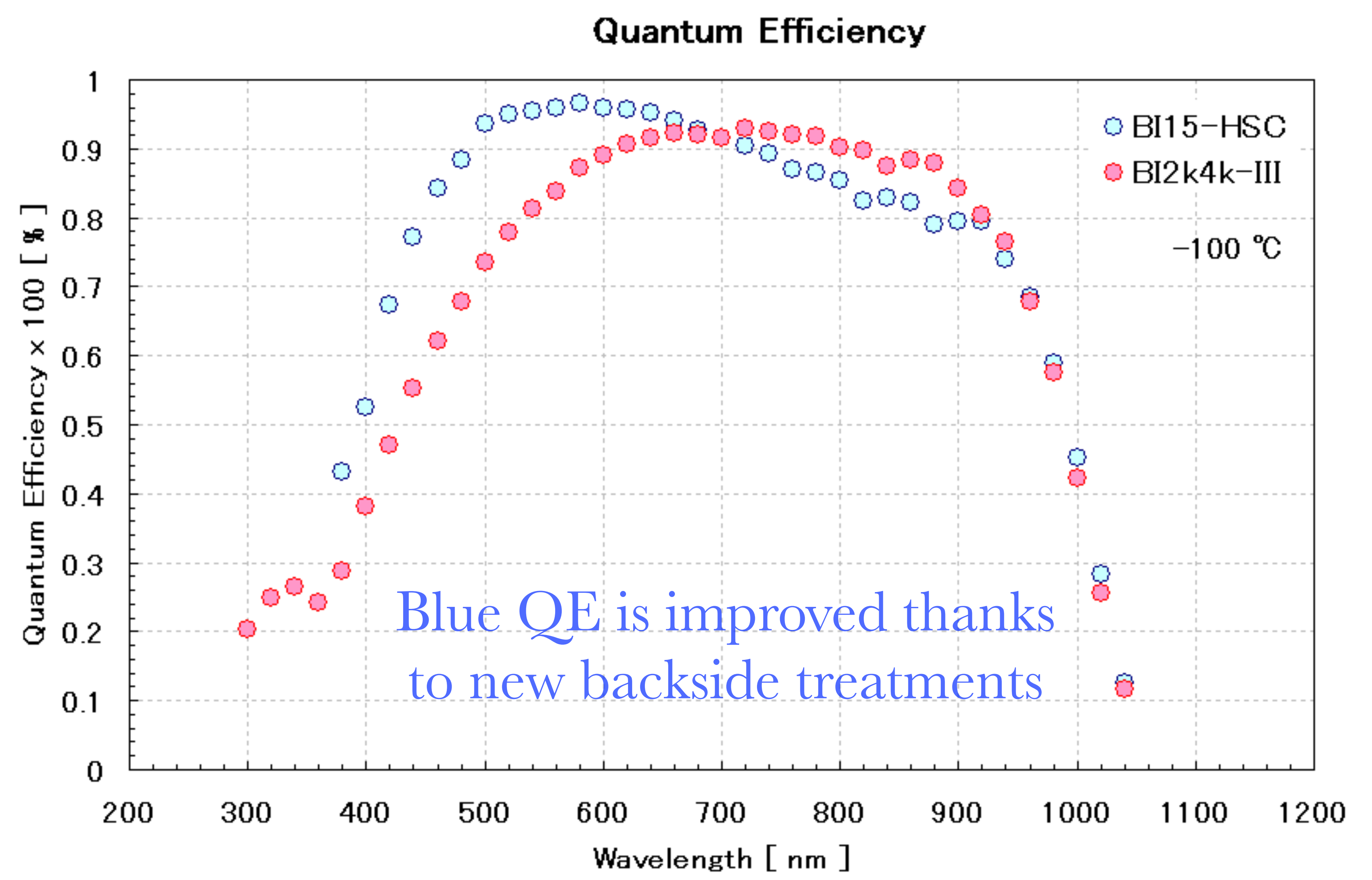


# Thickness Control(Aside)

- Thickness of the depletion layer can be accurately controlled.
  - Mechanical polishing
- Prototyping of Thinner & Thicker CCD is underway

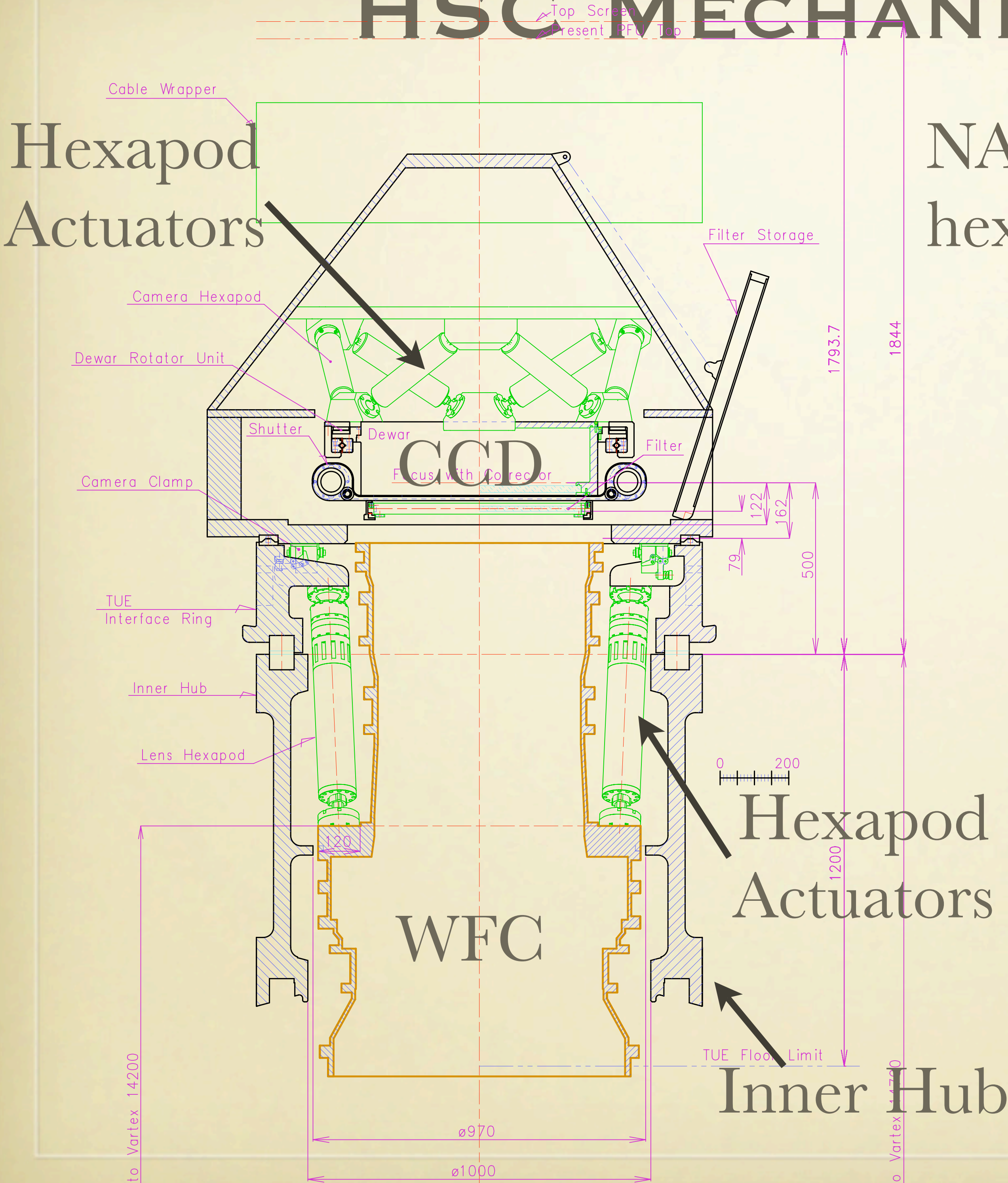
| | | |
|---|---|---|
| $100\mu m$ | $\uparrow$ harder to handle | SNAP and LSST |
| $200\mu m$ | | HSC |
| $300\mu m$ | | FOCAS |

# HSC Mechanics

- Telescope Interface
  - Unit exchange
  - Clipping
- Attitude Control (Hexapod actuators)
- Instrument Rotator

Basic structural design
Foundation of HSC

# HSC Mechanics




NAOJ designed the dual hexapod type

2007/10

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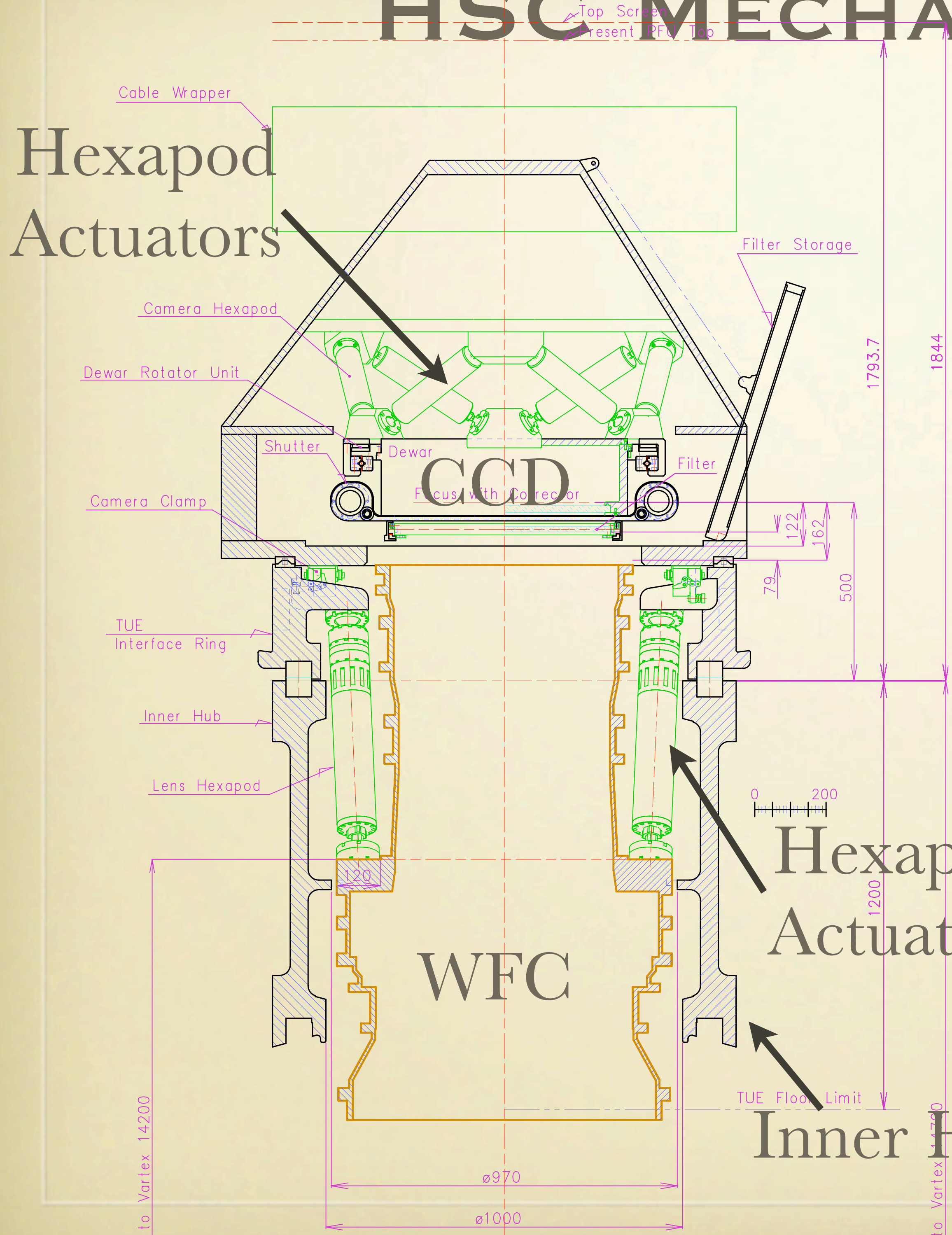


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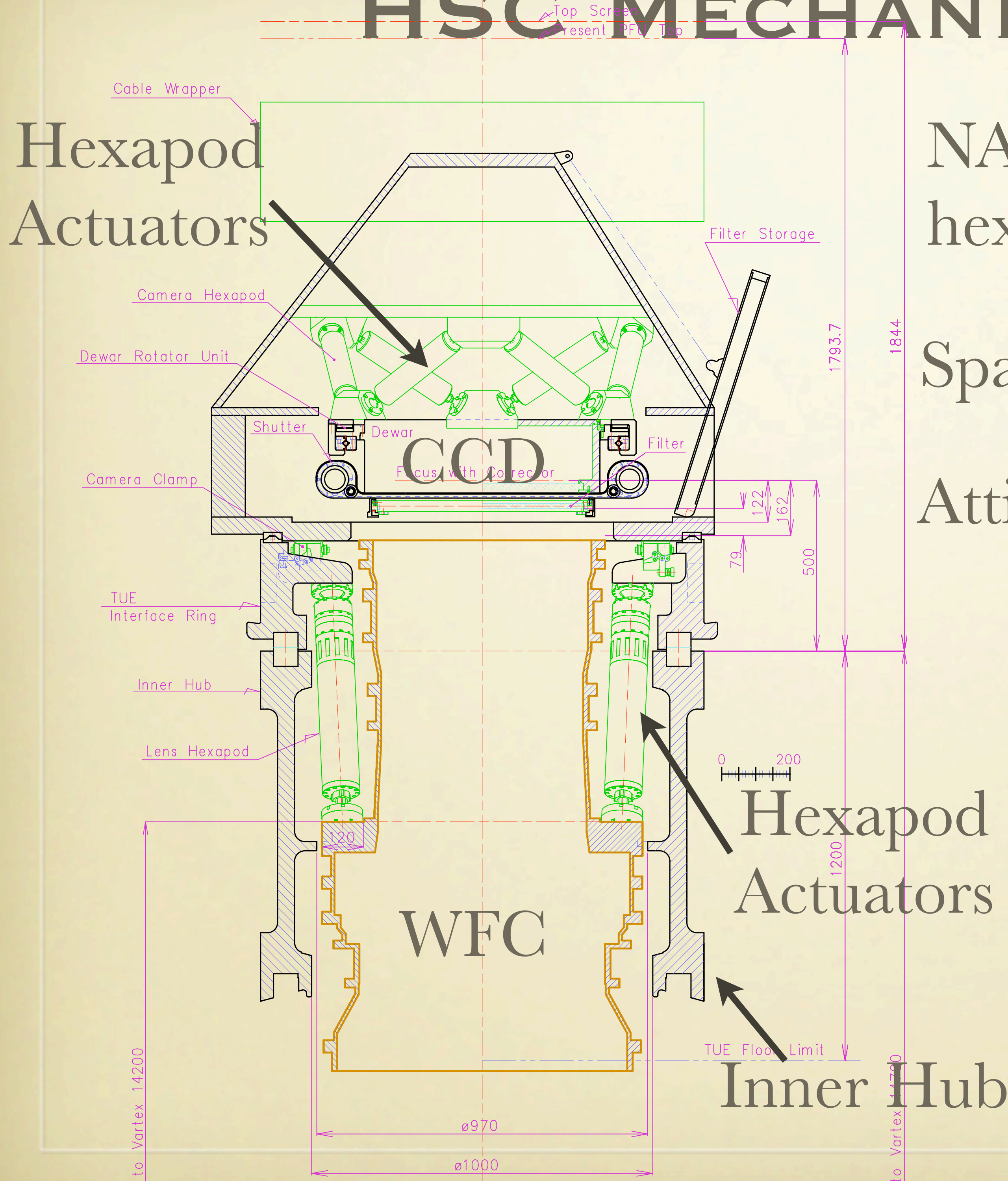


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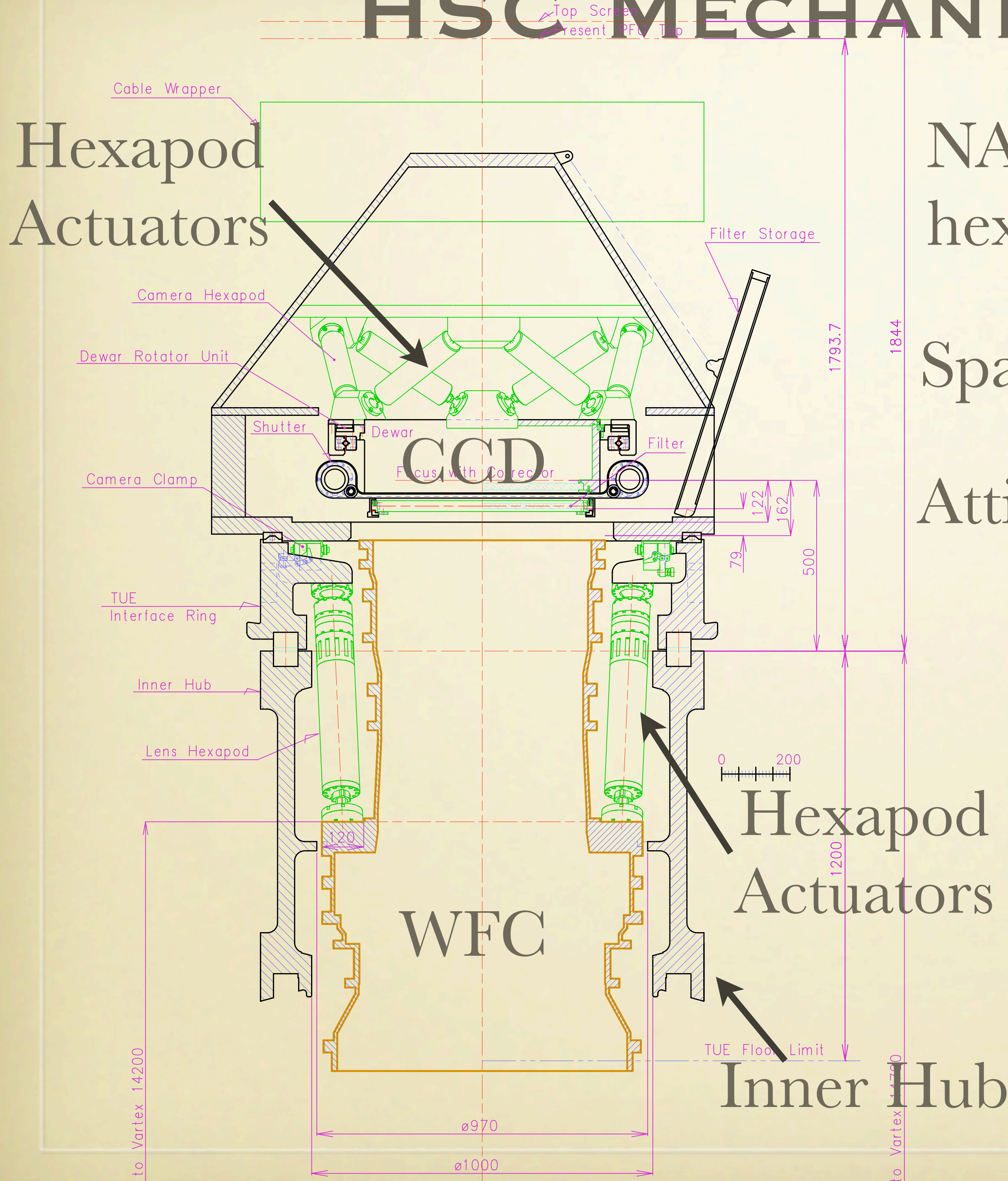


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Completely new actuators must be developed to realize 1.5 deg.

2007/10

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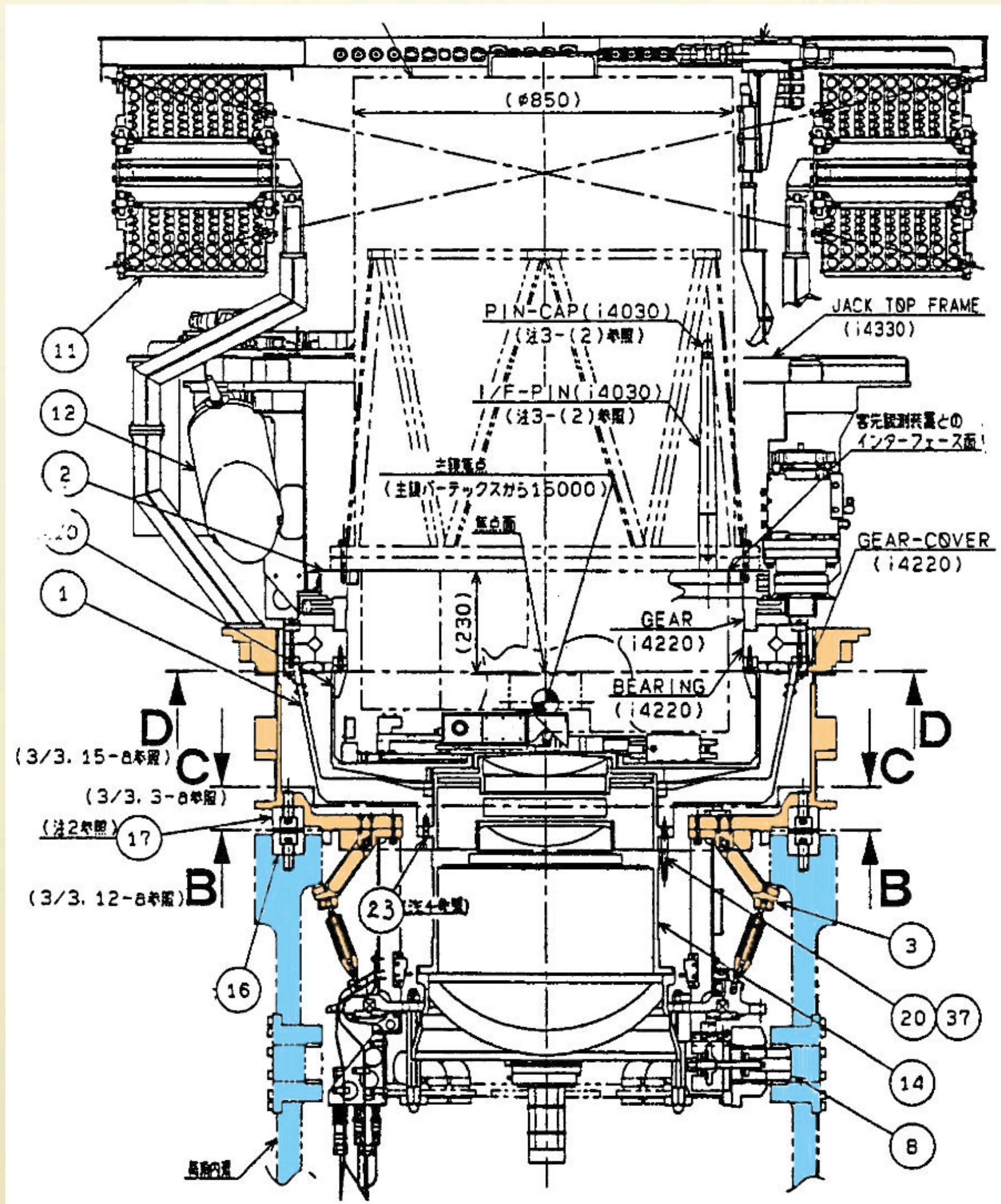
- New development of actuators will be risky judging from their experiences.
- They proposed to adopt existing Subaru actuators (PFU and secondary mirrors use) but it is large.
- In order to realize 1.5 deg, we have to change the HSC mechanics configuration significantly.

# Proposal of Mitsubishi



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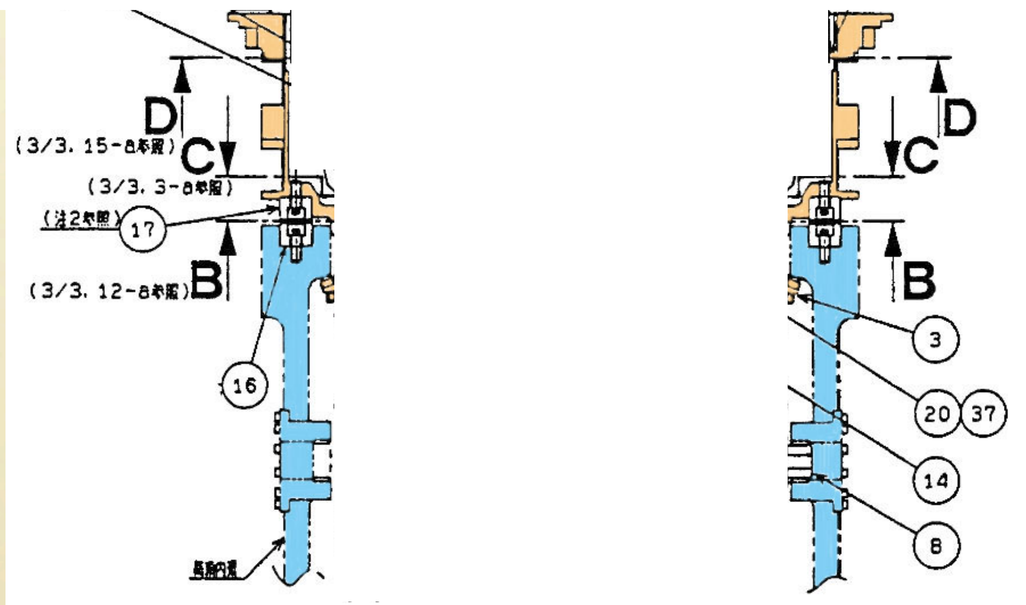

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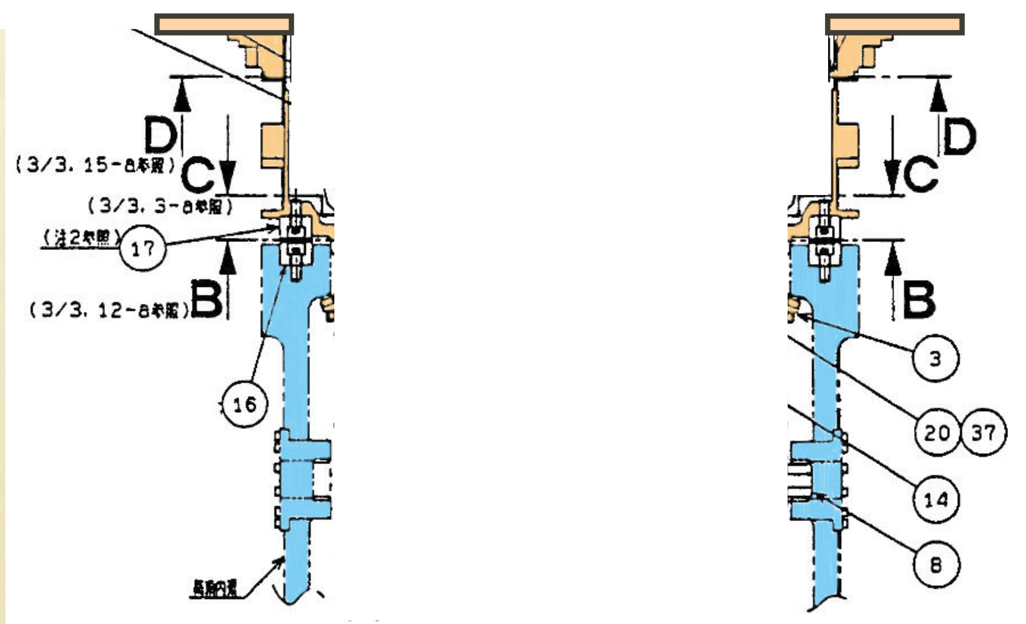

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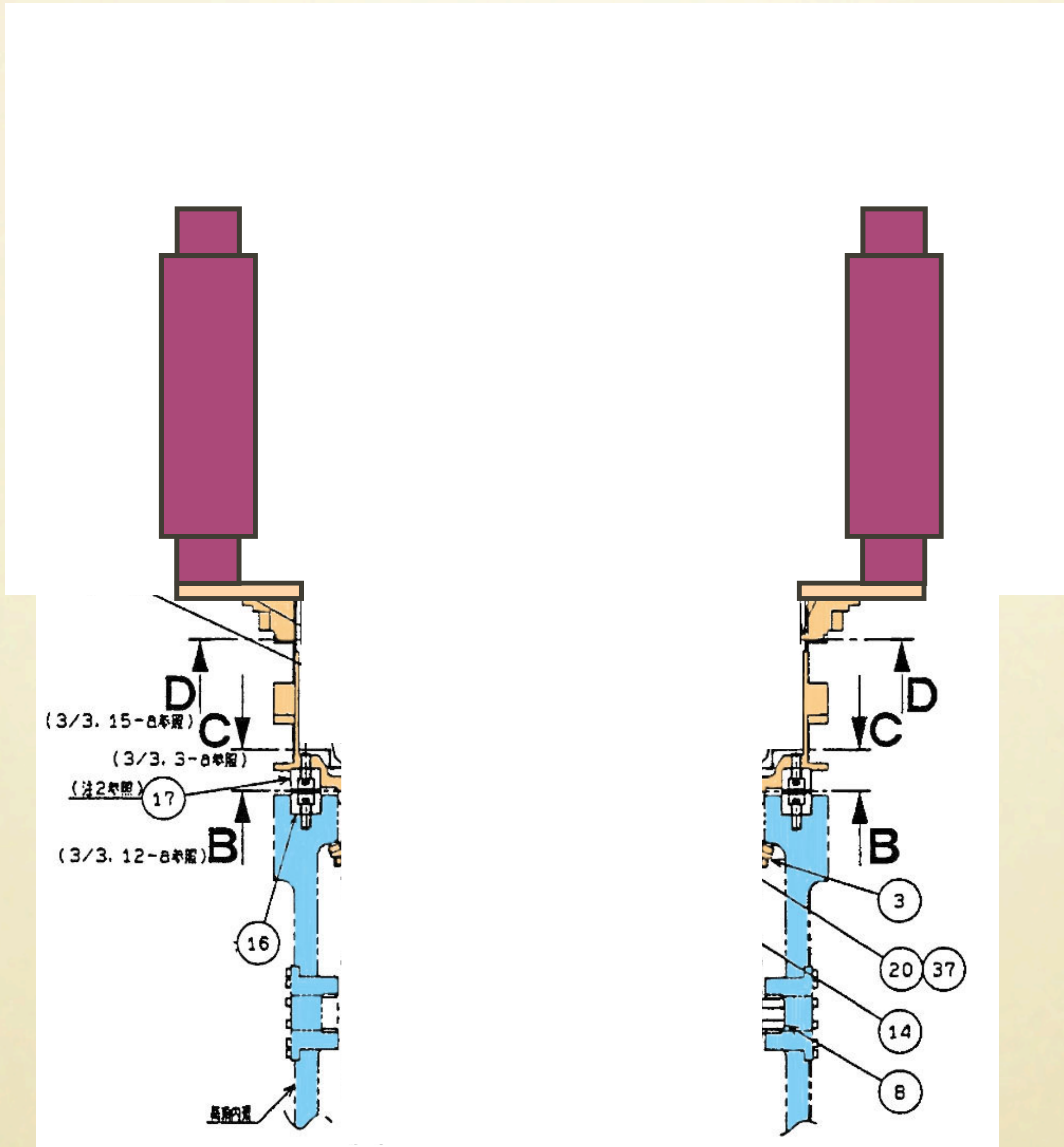

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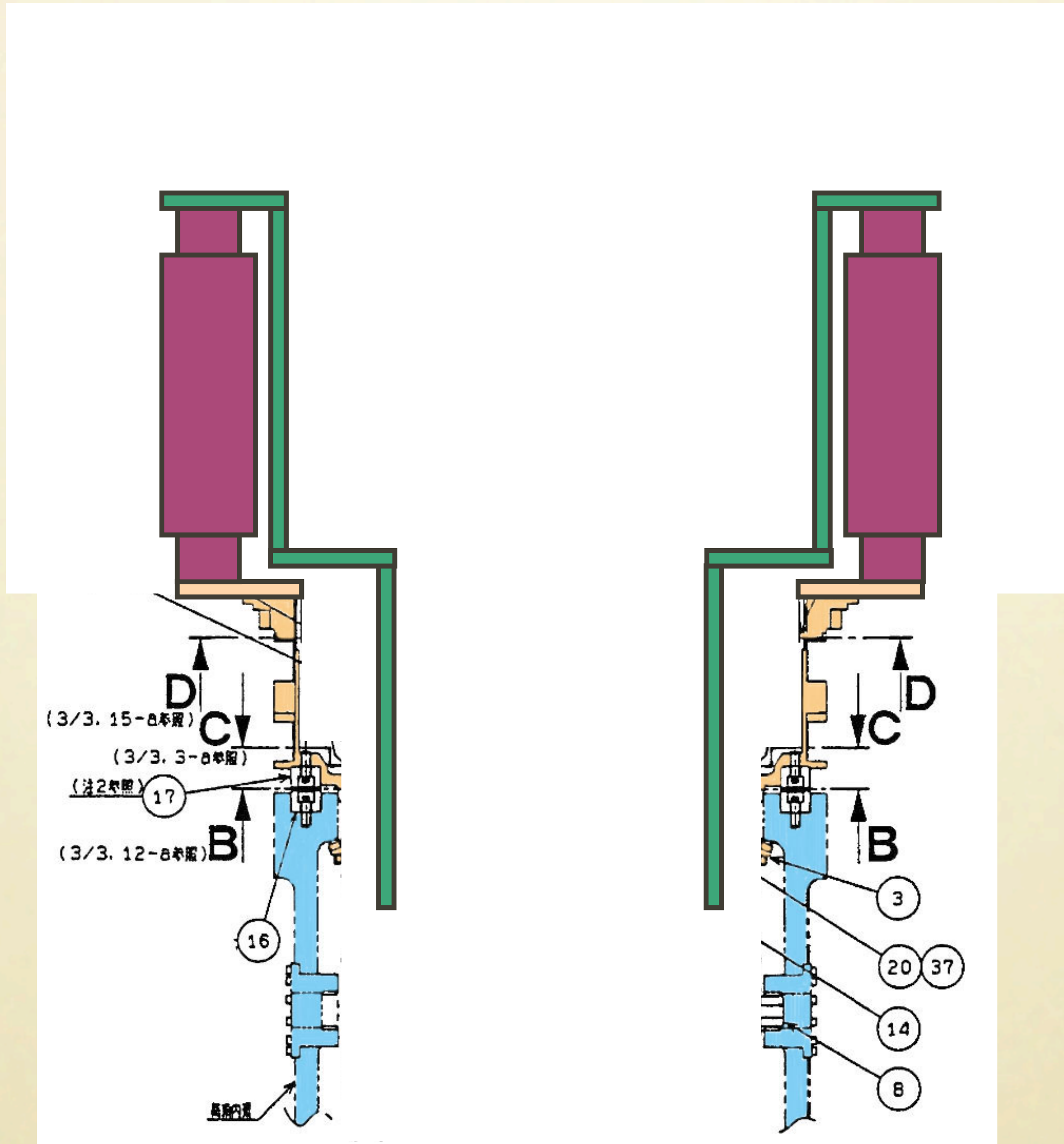

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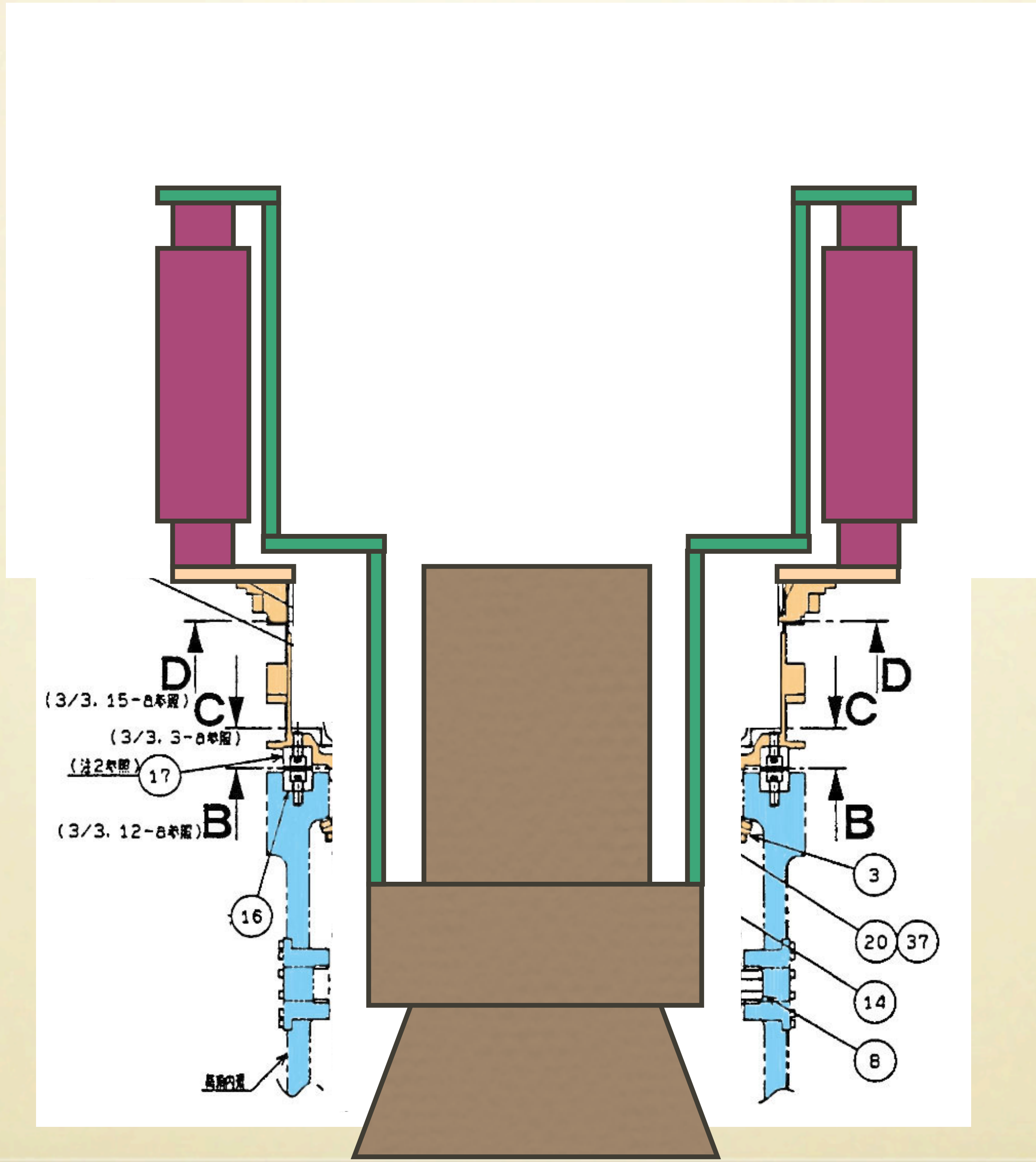

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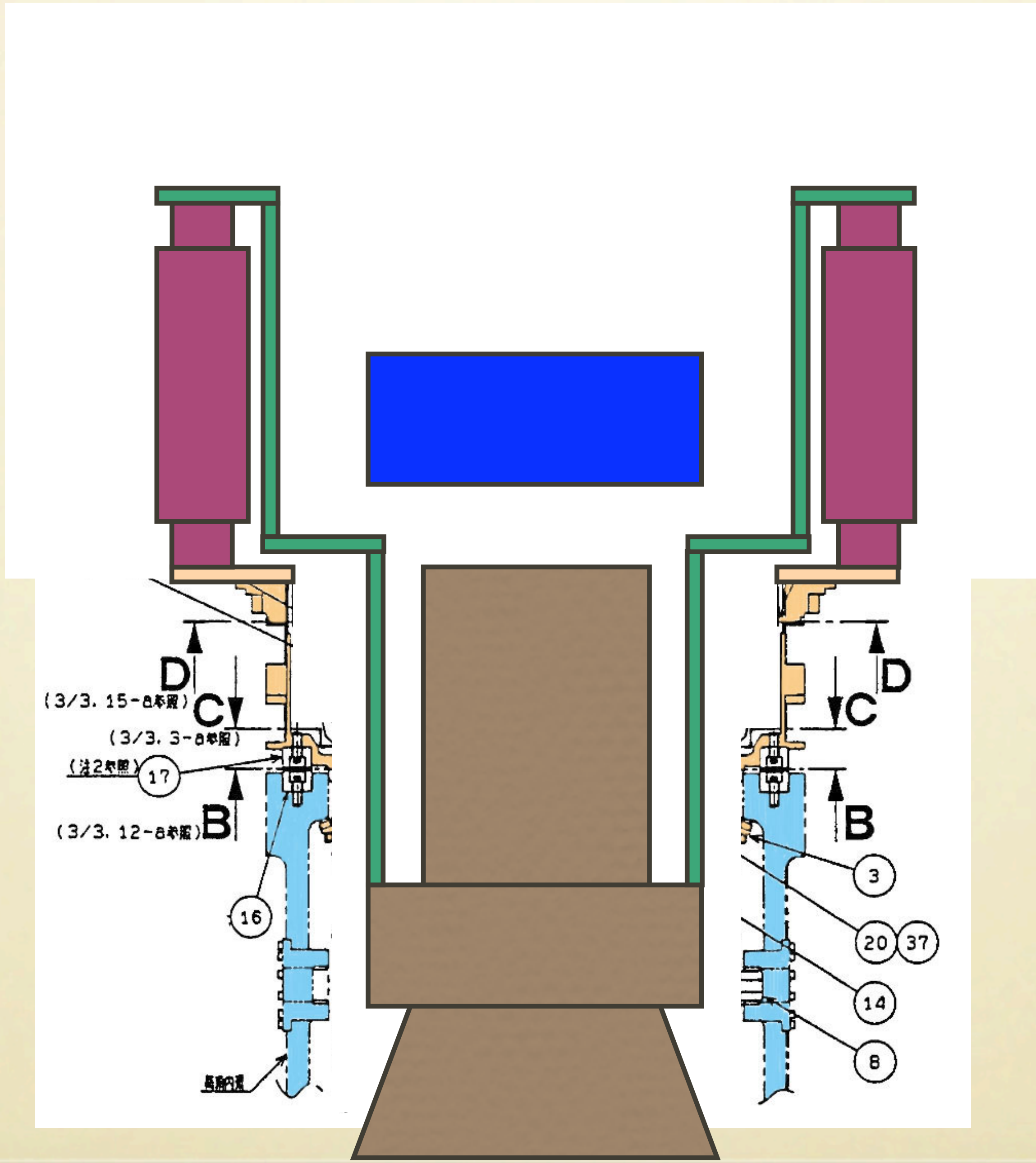

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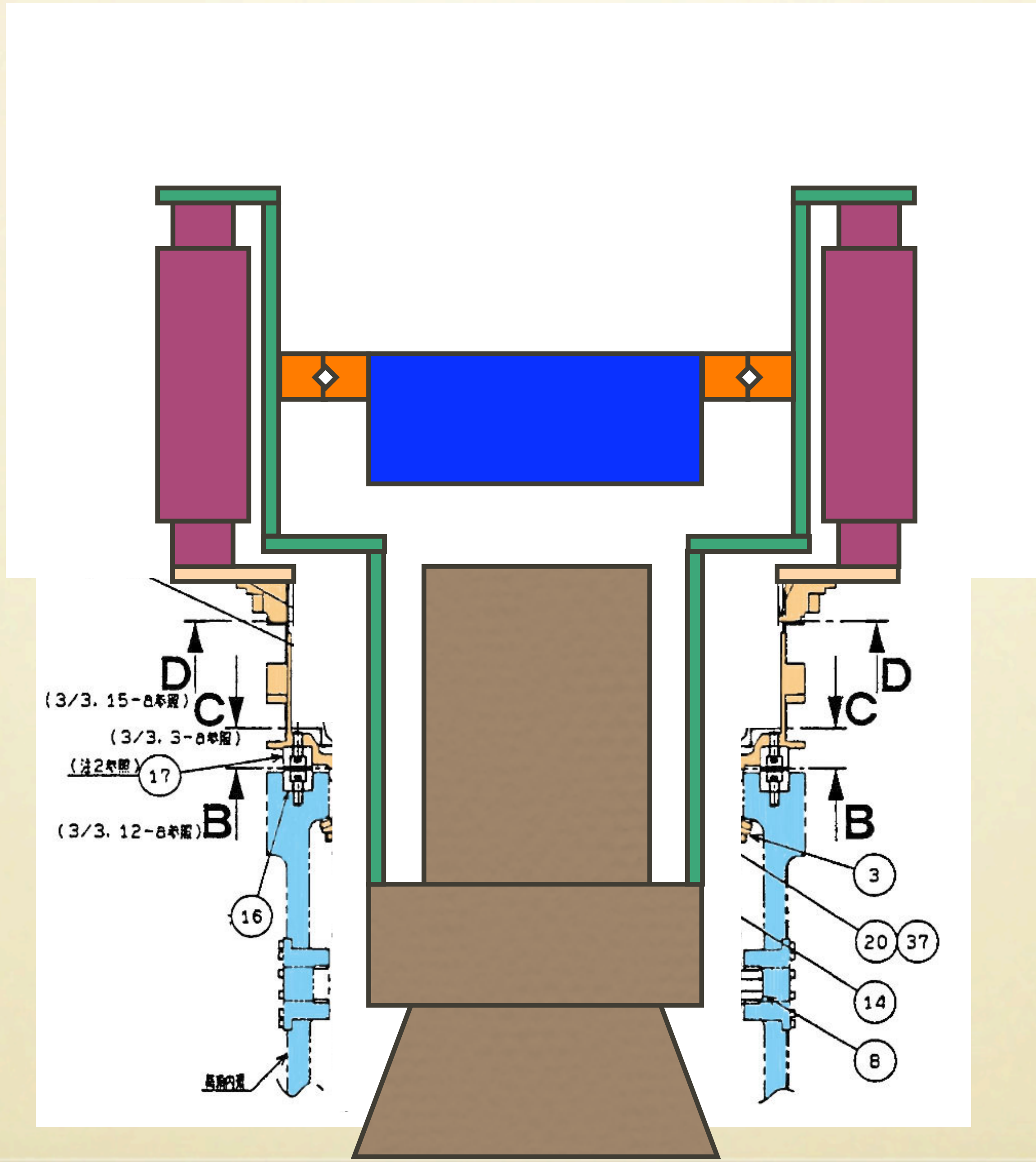

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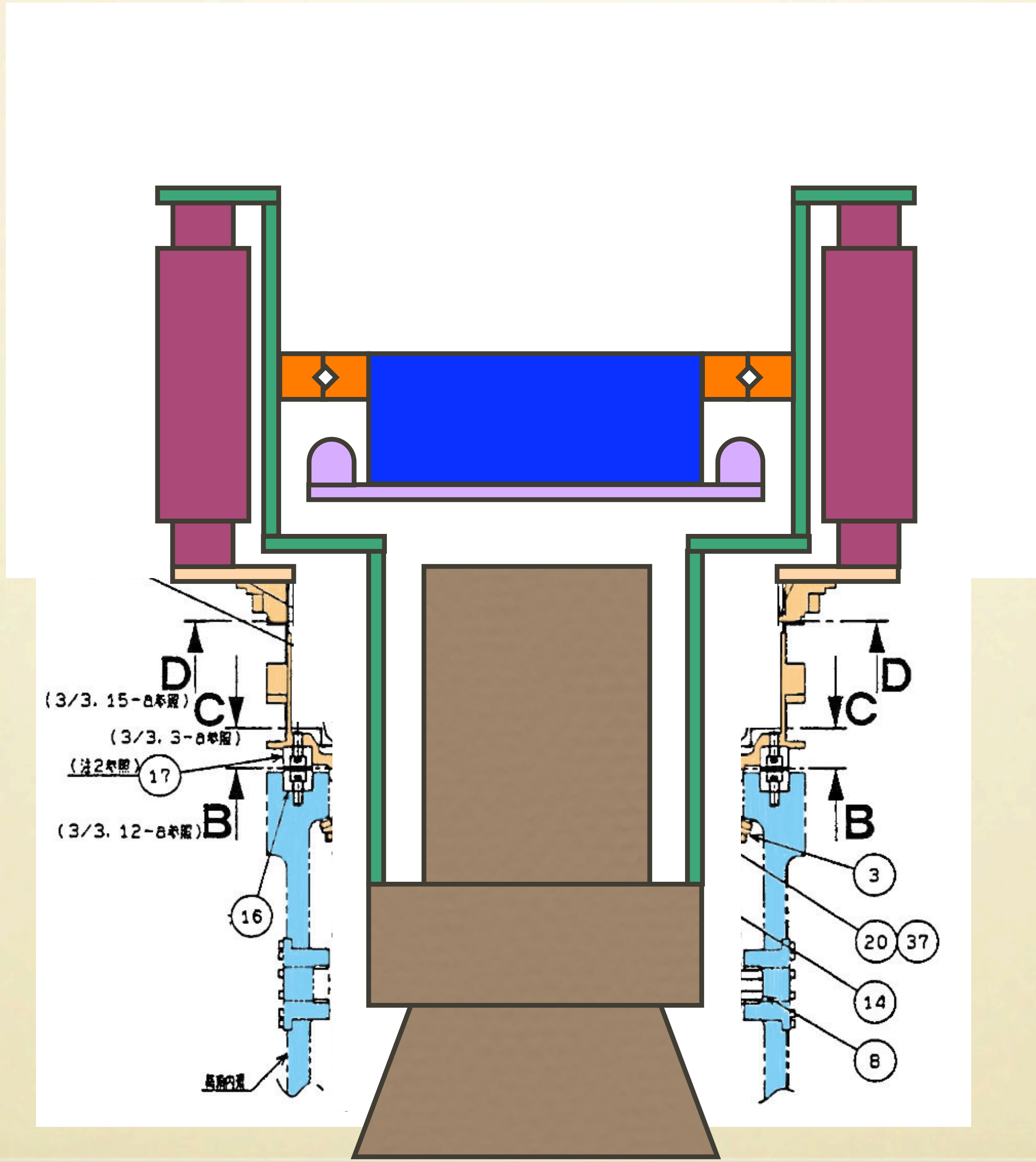

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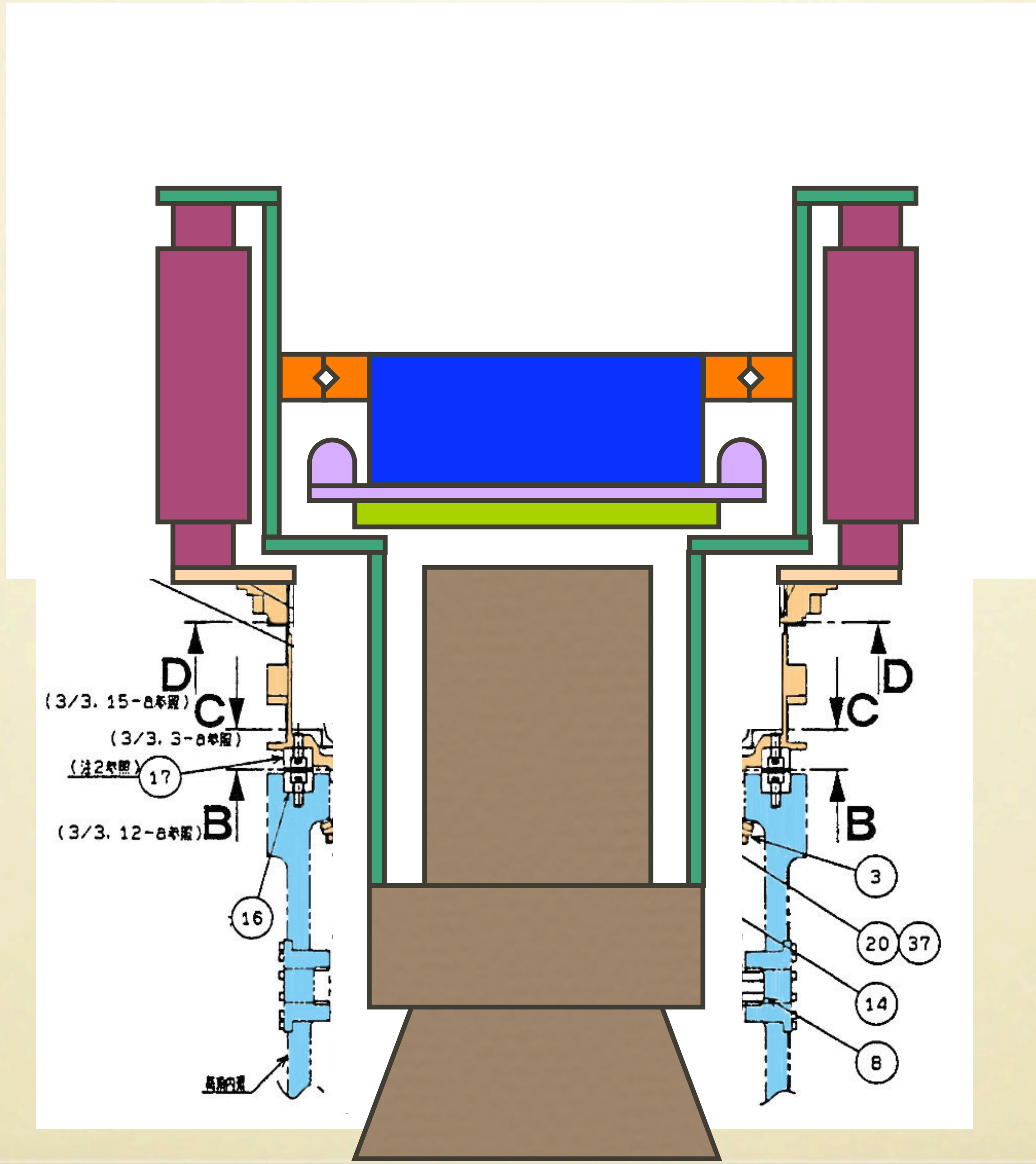

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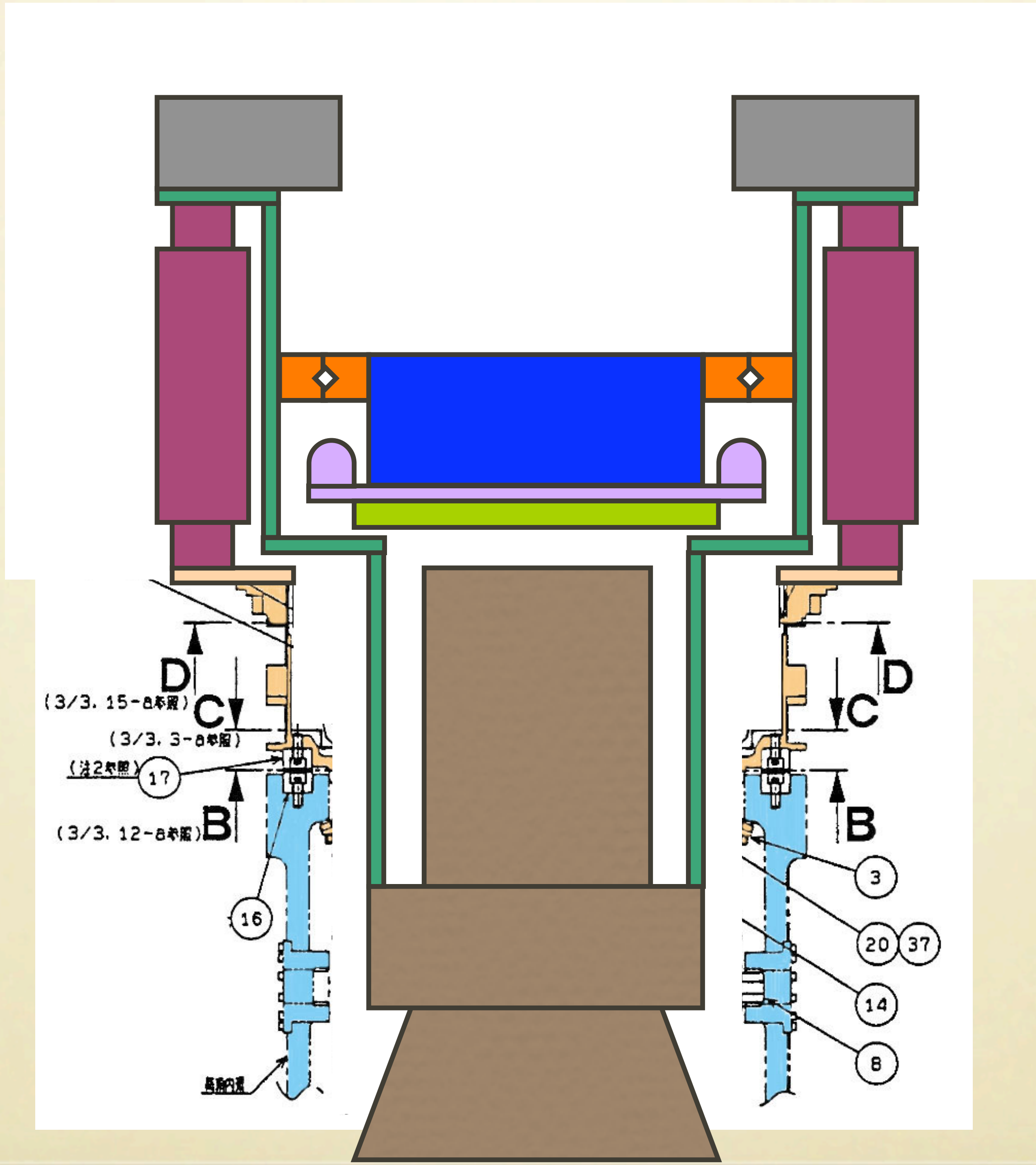

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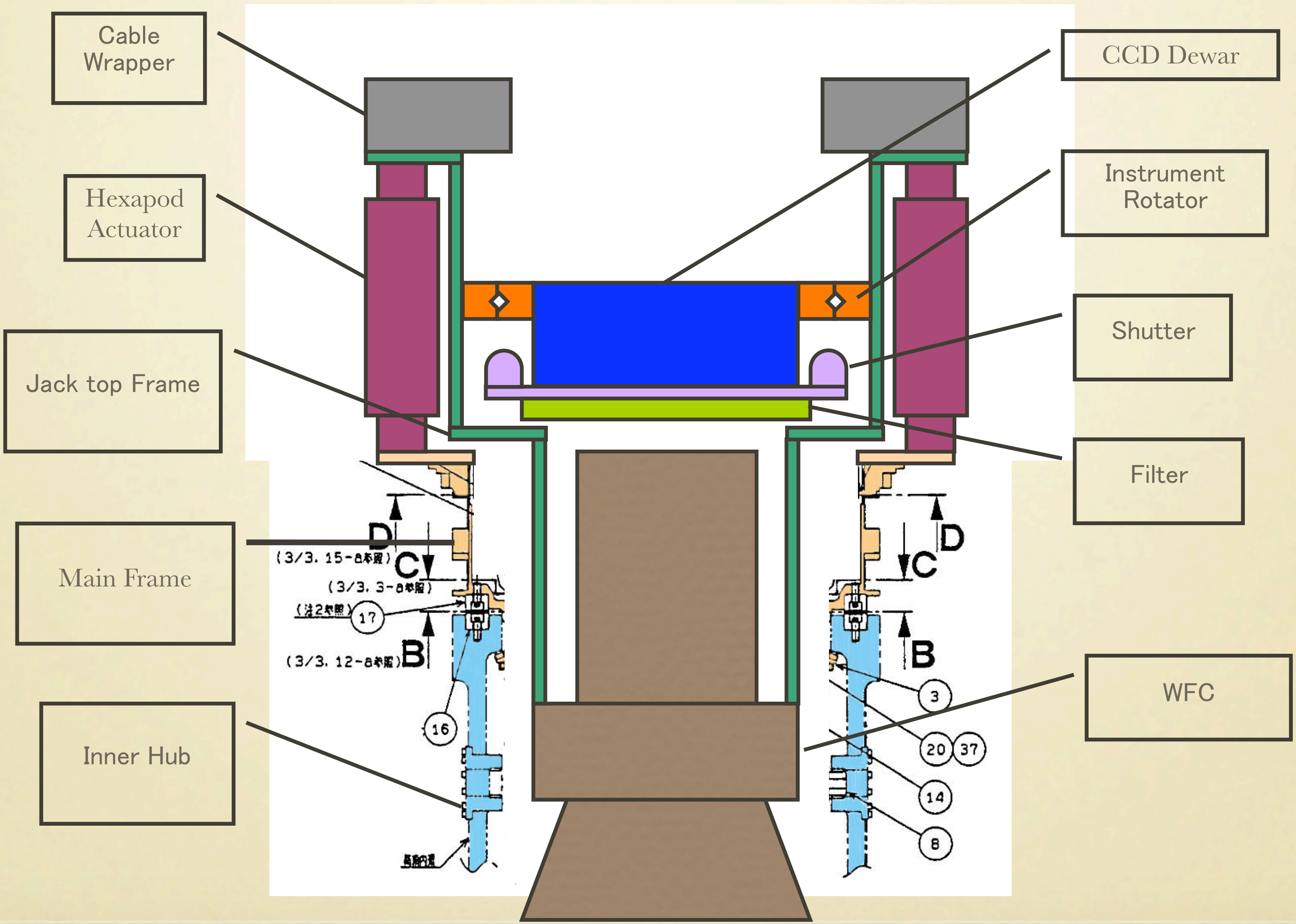

# Mitsubishi Design Issues

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- Total Weight
- Flexure of Jack Top Frame
- Loading of Filters
  - Filter must be loaded through the insertion slot of the Jack Top Frame
  - Automatic filter loading system is hard to implement because of space constraint. (TUE handling space.)

# Filter Exchanger

- FE must be totally re-designed.
- External Filter Loader must be adopted
    - Manual
        - Simpler but it takes at least ~1 hour to change
    - Automatic
        - Convenient (3-4 filters loaded) but extensive design study is needed to satisfy weight/space constraints

# HSC Mechanics

- Basic conceptual studies of HSC mechanical configuration are underway.
    - FEM study of the structure.
    - Choice of material (CFRP, Ti)
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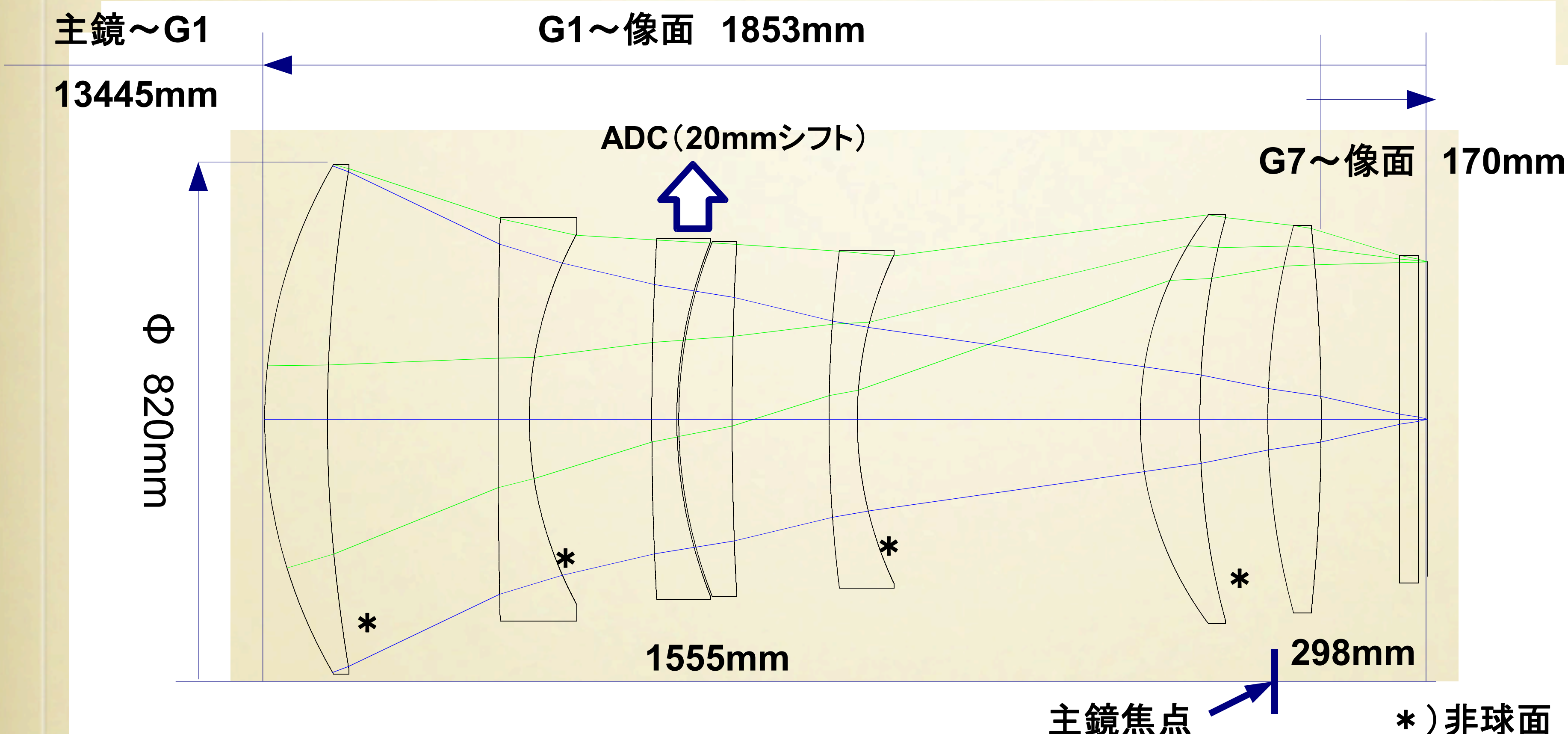
HSC Mechanics design is behind schedule.
(~ 6 month)

# Wide Field Corrector

- WFC design is optimized for the new configuration.




設計性能

| | | g | r | i | z |
|---|---|---|---|---|---|
| EL=90 | D80 | 0.254 | 0.205 | 0.219 | 0.232 |
| | | | | | |
| EL=30 | D80 | 0.290 | 0.219 | 0.223 | 0.232 |
| | | | | | |

| WFMOS | EL=90 | EL=30 |
|---|---|---|
| D80 | 0.335 | 0.413 |
| D90 | 0.375 | 0.524 |
| D95 | 0.482 | 0.602 |
| | | |

IQ equivalent with SC

重量：有効径で約378kg（フィルタ含まず）

- More space is allowed which results in performance improvement.

# Wide Field Corrector

- Some more refinement of the design is necessary but not so critical.
- G1 glass will be placed an order soon.
- Prototyping of Lens barrel is underway
    - Cordierite is adopted.

      $Mg_2A\ell_4Si_5O_{18}$

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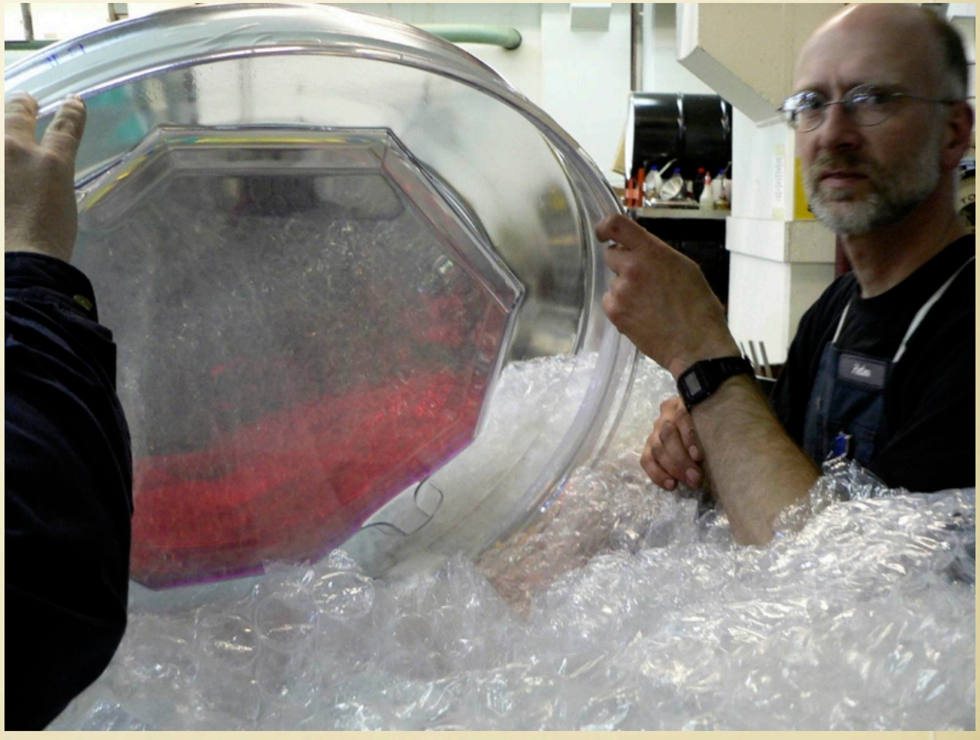
WFC design and development is on schedule.

# Broad Band Filter

- Large aperture (> 250mm) colored glass filter is not available.
- Promising solution for > 500mm dia. : Interference filter

Pan-STARRS Filter by Barr Associate

- 500mm dia.
- uniformity
  - transmission : 5-10% difference
  - cut-off : ~15nm

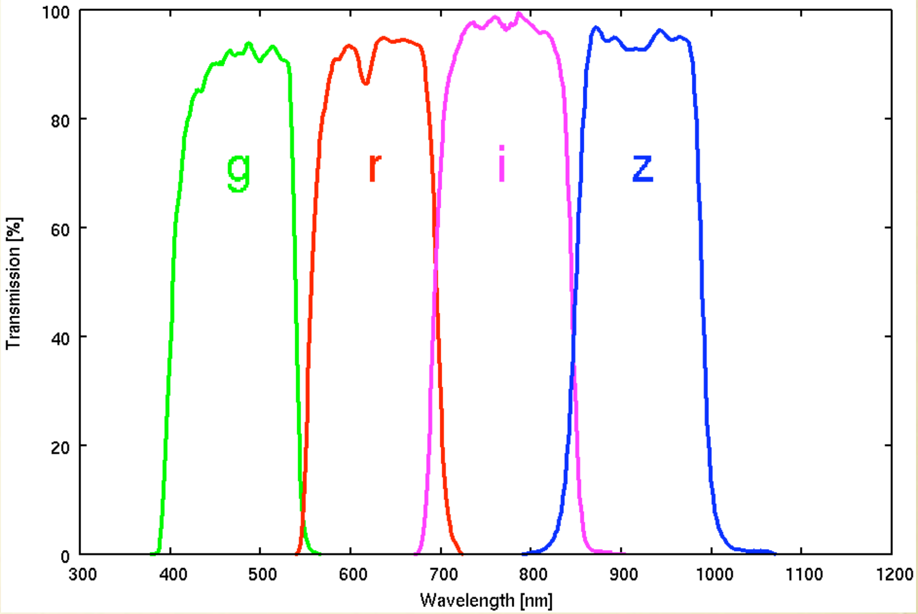


# Broad Band Filter

## Specifications for broad band filters

- synthetic fused silica base, interference type filter
- diameter > 580mm, thickness < 30mm
- peak transmission > 90%
- 50% transmission wavelength
  - g 400-550 nm
  - r 550-695 nm
  - i 695-845 nm
  - z 850-925 nm
  - Y 960-1070 nm
- uniformity
  - 3nm in wavelength, 2% in transmission
- leakage < 0.1%

SuprimeCam filter

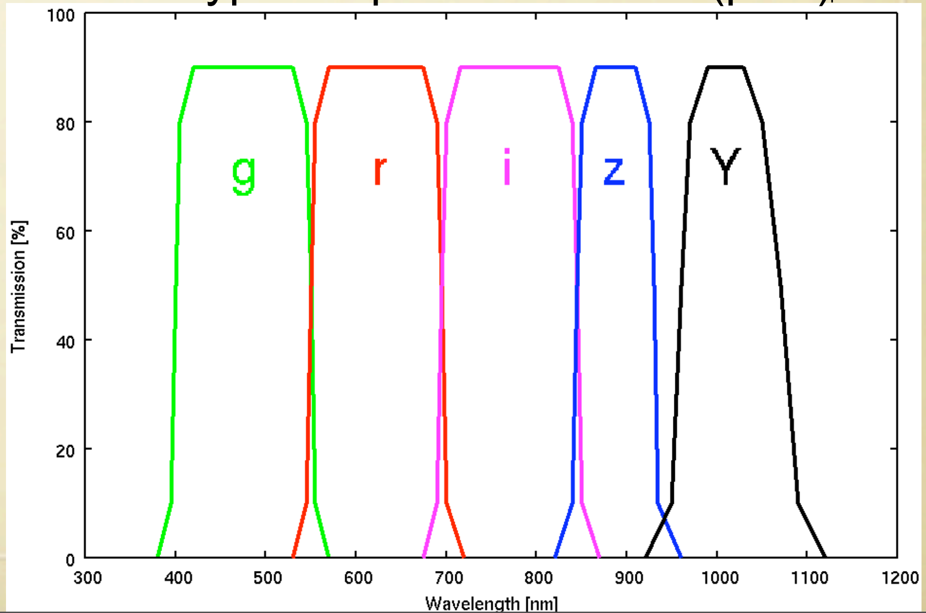



## Prototyping

Optical Coatings Japan, Inc.
Spec. compromised for now

- r-band equivalent w/o leak cut surface
- d=600mm (580mm effective), t=10mm
- TEMPAX base
- cutoff wavelength error ~ 8nm
- uniformity ~ 2% in wavelength (N/A in transmission)
- schedule
  - Dec. 2007 start manufacturing
  - Feb. 2008 finish manufacturing

Hyper SuprimeCam filter (plan)



# Narrow Band Filter

R&D : lead by Hayashino, Tomoki (Tohoku University)

**Prototyping**

Assumption : Band Width(BW) ~ 8nm, Central Wavelength(CW) ~ 450-600nm

Expected specifications for the moment

- BW error : 1.3nm(r < 200mm), 2.0nm(200 < r < 250mm)
- CW error : 1.5nm(r < 200mm), 3.0nm(200 < r < 250mm)
- $T_{peak}$ : > 70%(r < 200mm), >65%(200 < r < 250mm)

(600mm dia. is not guaranteed by manufacturer.)

Schedule

- Specification: until Apr. 2008
- Order : May 2008
- Deliver : Sep. 2008?

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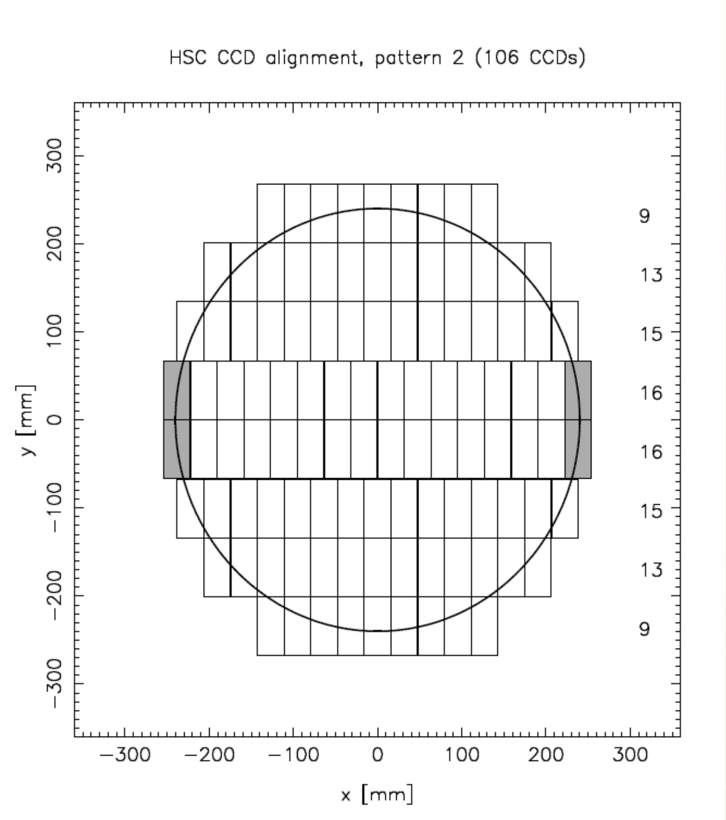
Several prototyping and evaluation cycles seems crucial to meet the spec.

# Autoguider

- Science CCDs are used.
- ~1-3 sec exposure (~3-5 sec cycle) for $m_{AB}$<14 mag provides enough photons for auto-guiding even in narrow bands under bad conditions.
- number density of $m_{AB}$<14 mag stars → area of 2 2kx4k CCDs necessary.
- CCD exposed while reading out -> But the Image deformation is negligible.

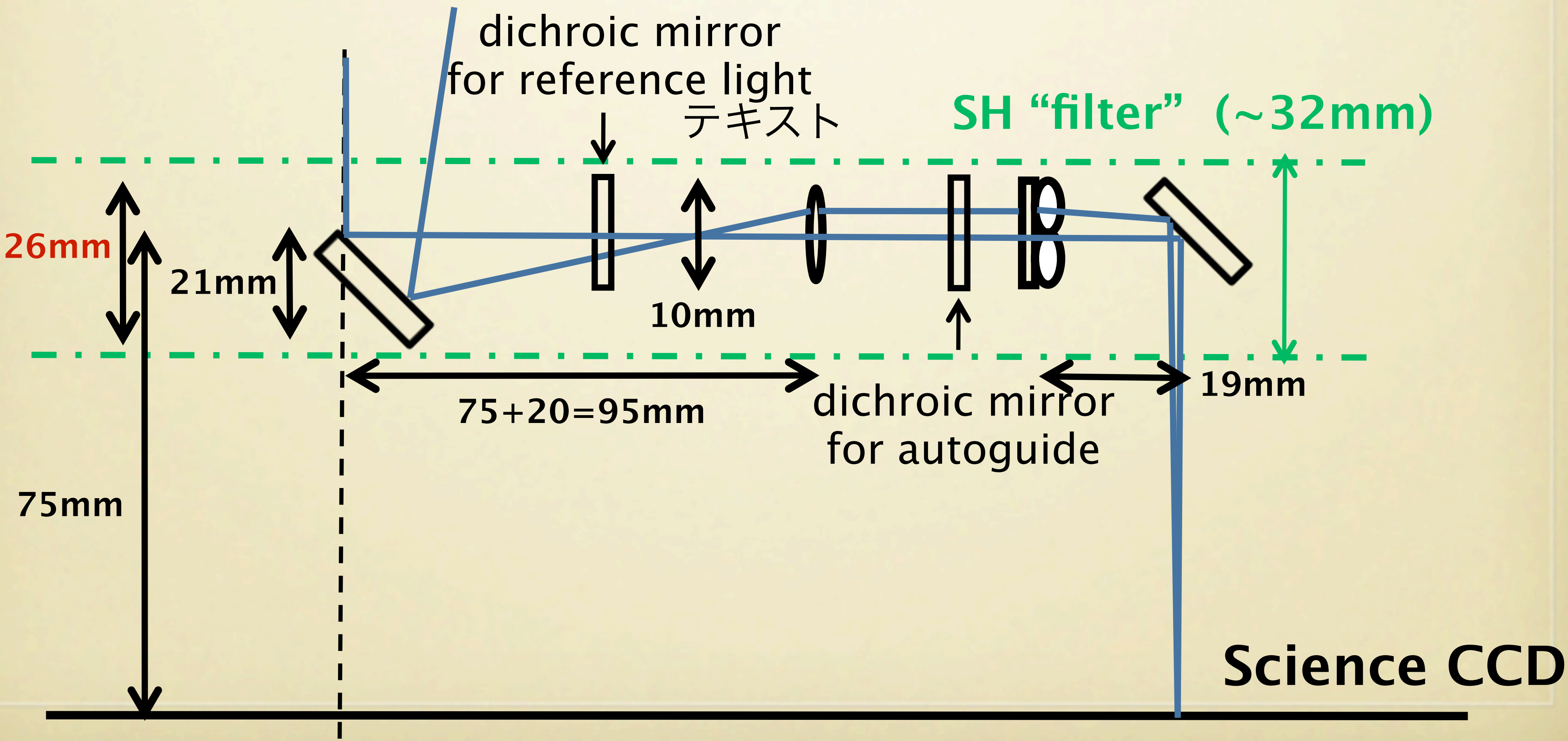



Special electronics are prepared for guide CCD.

# Shack-Hartmann

**<u>SH “filter”</u>**

• installed as a “filter”.
• stellar images are formed on the science CCDs.
• almost the same resolution and dynamic range of wavefront error measurements as the current PF SH.
• reasonable size.
• AG camera (used only for SH): uncooled video camera (proven for FMOS)



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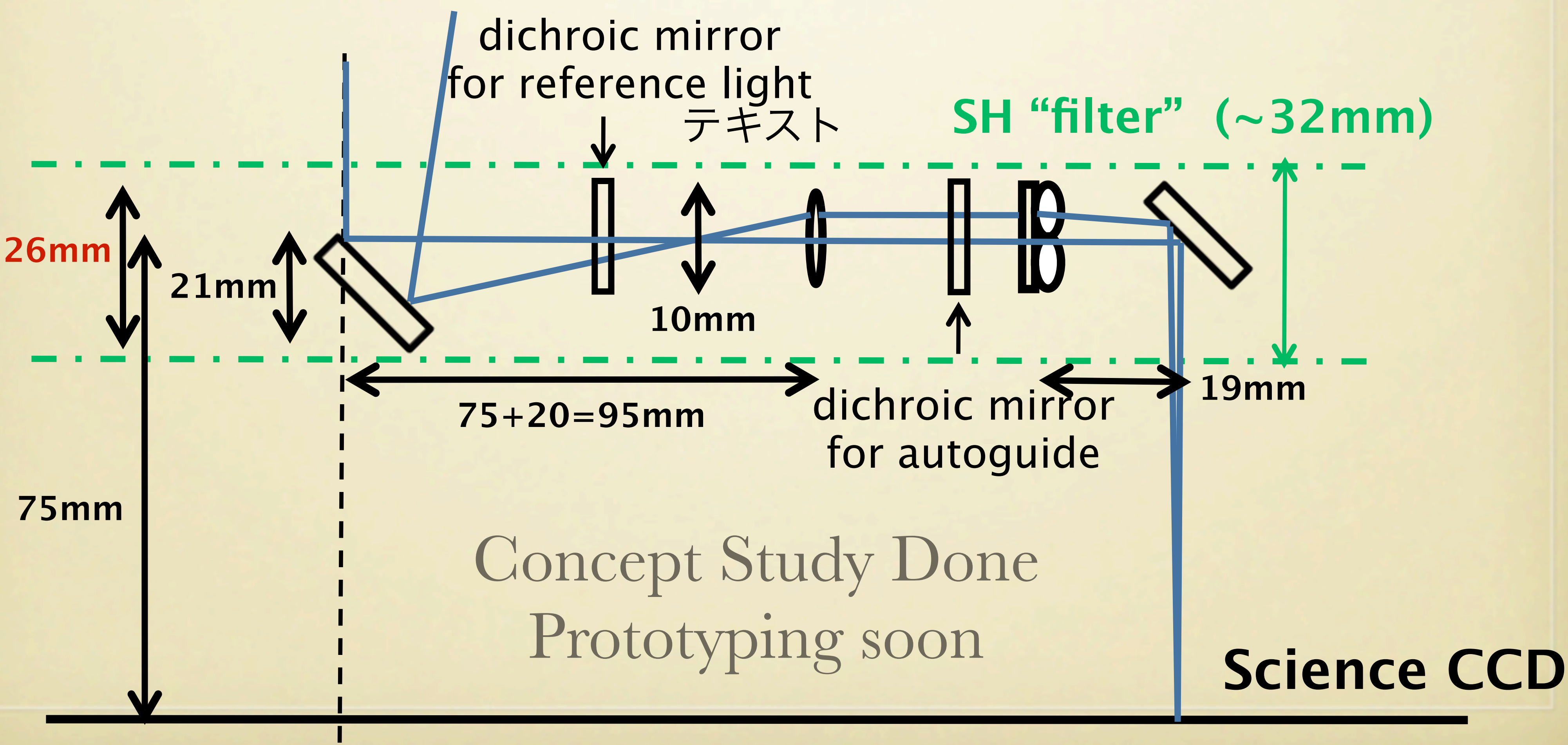

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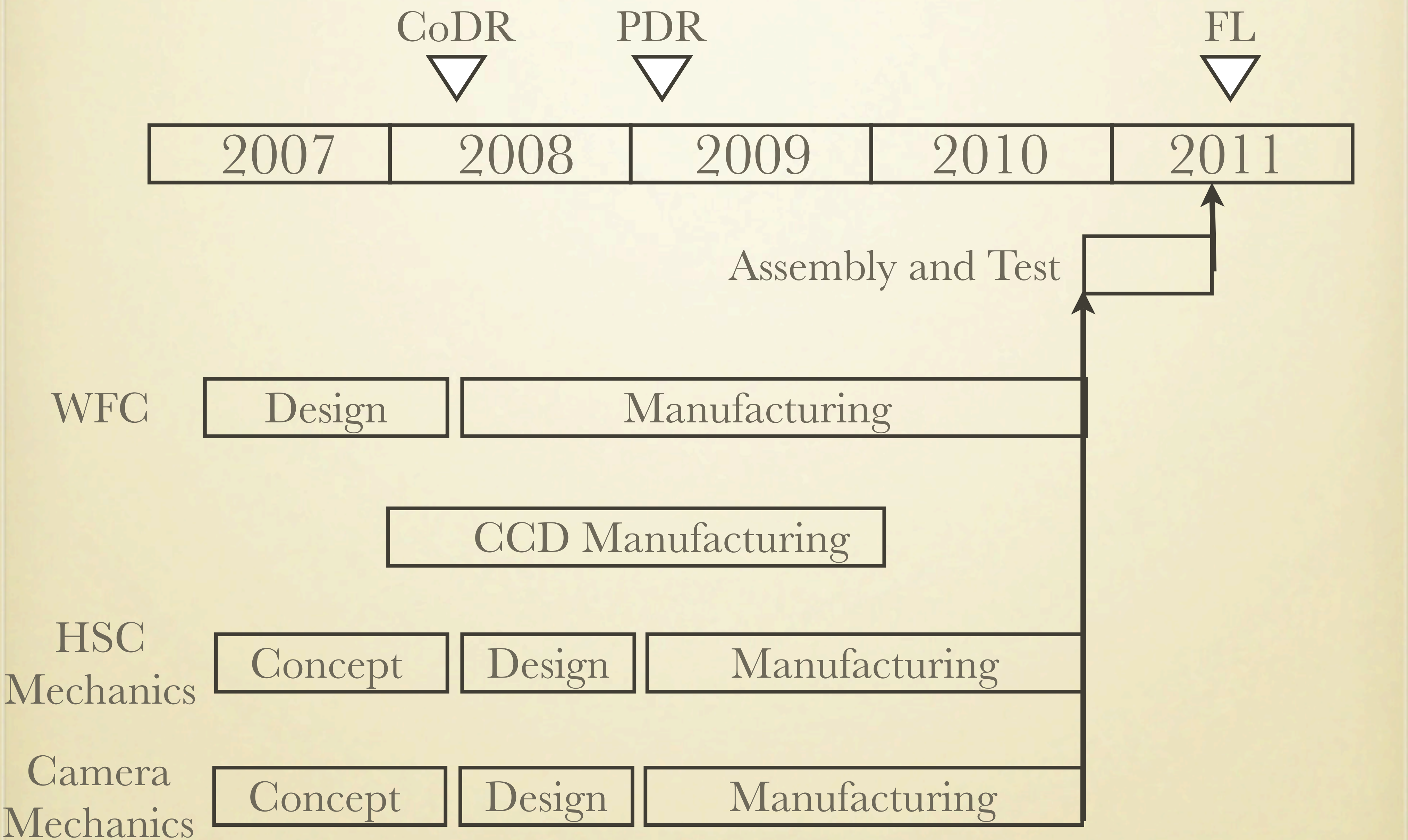

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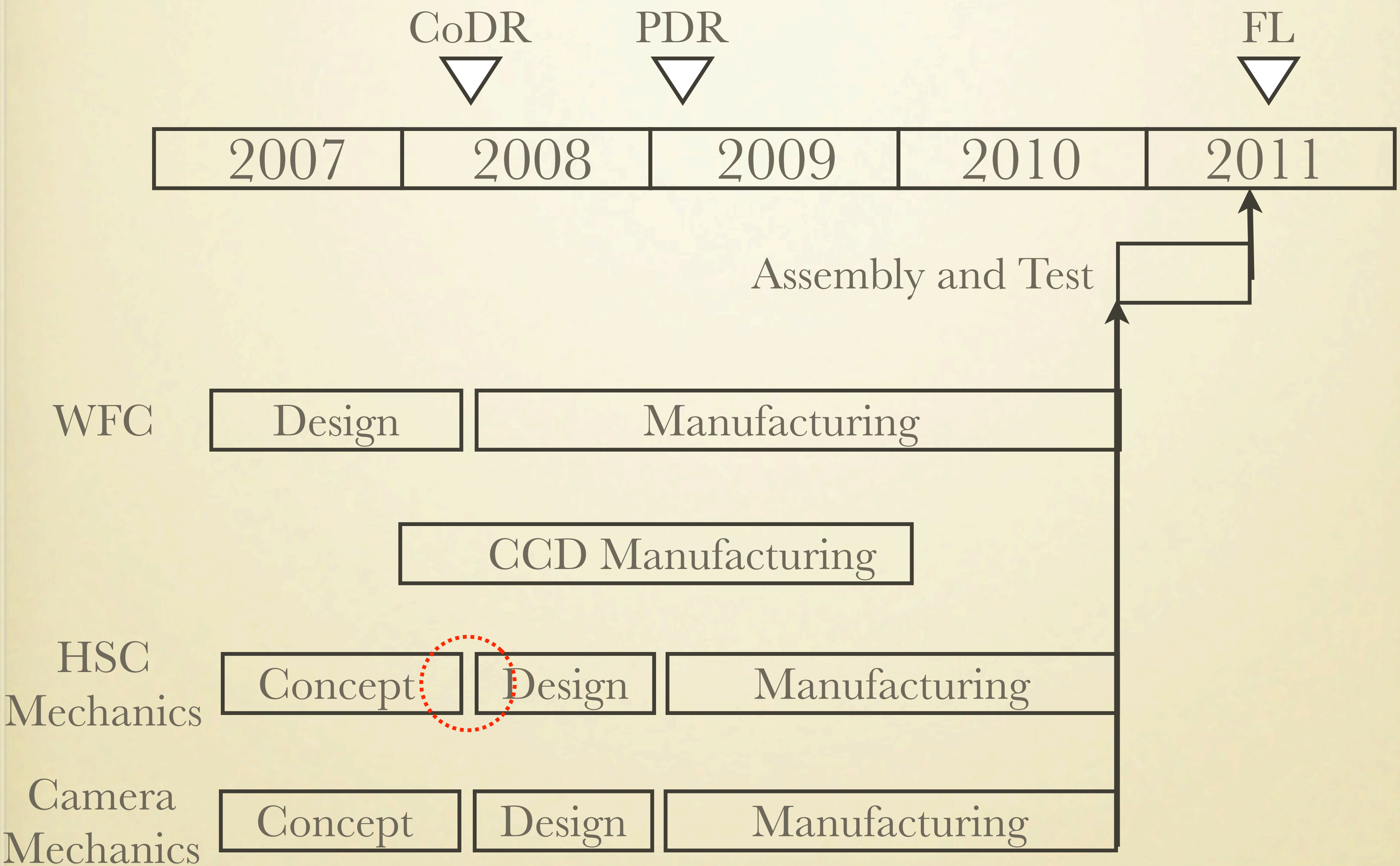

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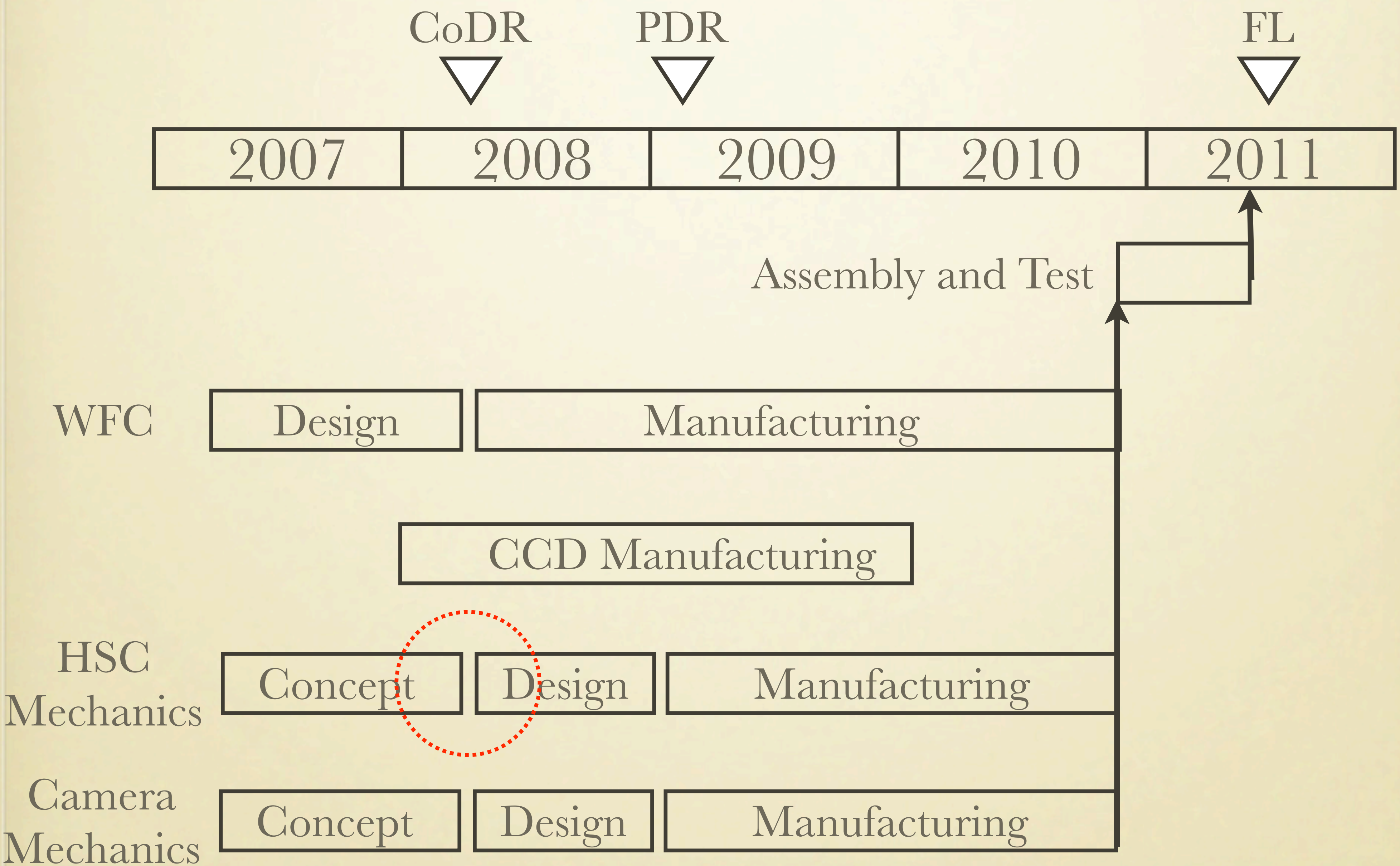

# Summary

- CCD and WFC development is on schedule.
- Conceptual study of HSC mechanics is behind schedule by ~ 6 month because of the significant change of the configuration.
    - Filter exchange time might be long up to 1 hour.
- Prototyping of the filters are underway. Final spec. depends on the result of prototyping.

Thank You