Readout Electronics for Hyper Suprime-Cam

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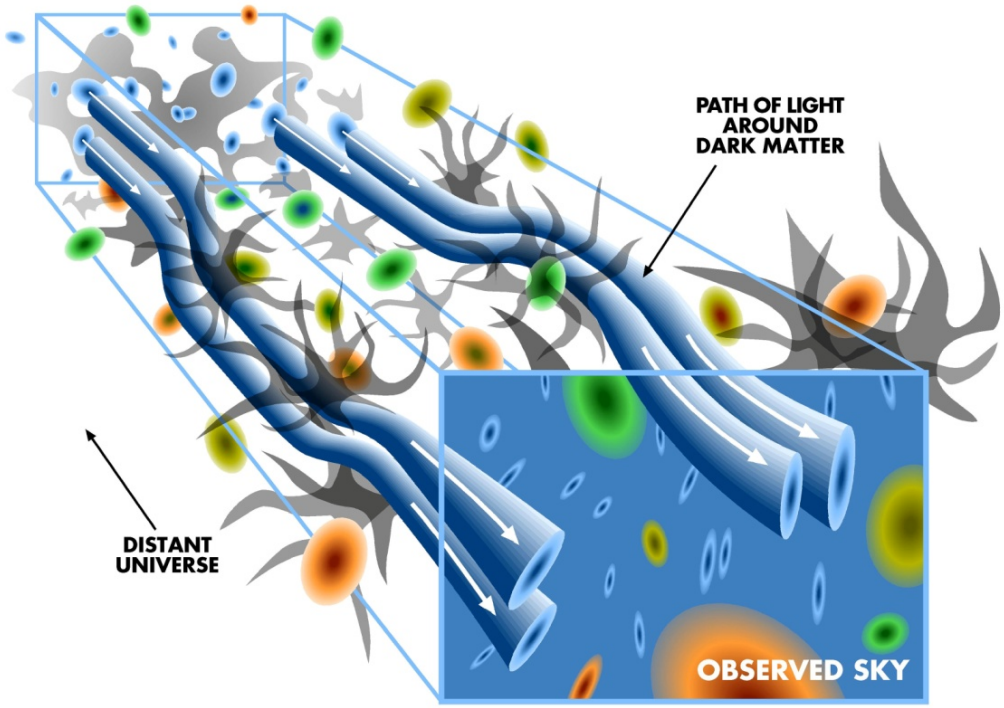
Outline

- Introduction
  - Weak lensing as a probe of dark energy
- Overview of Hyper Suprime-Cam
- Readout Electronics of Hyper Suprime-Cam
  - CCD, FEE, and **BEE**
  - BEE: Multi-channel, high speed, and low noise readout electronics
- Summary

Weak Lensing (WL) as a Probe of Dark Energy

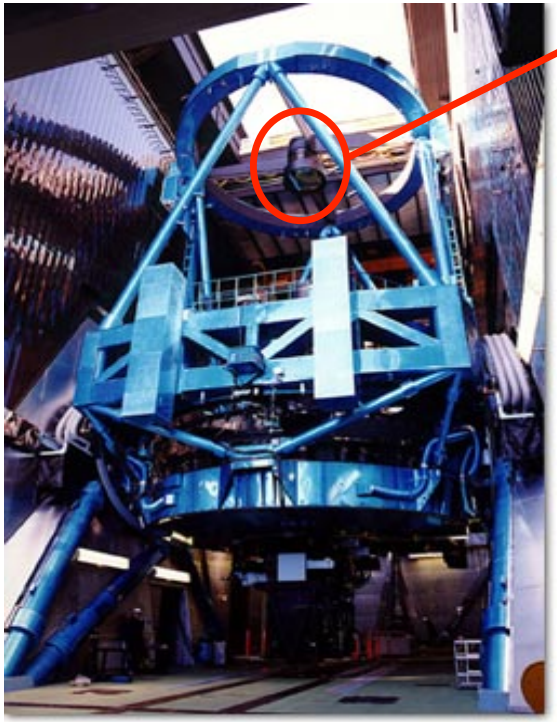


3D mapping of WL signals of faint galaxies
→ cosmological structure and its evolution
→ information about dark energy (Ω_{de}, w).

Requirements
✓Wide Survey
✓Deep Survey
} Statistics
✓Good Image Quality
⟶ Systematic

Upgrade the existing prime focus camera of Subaru Telescope

Hyper Suprime-Cam (HSC)



Prime Focus

0.25deg^2

Suprime-Cam

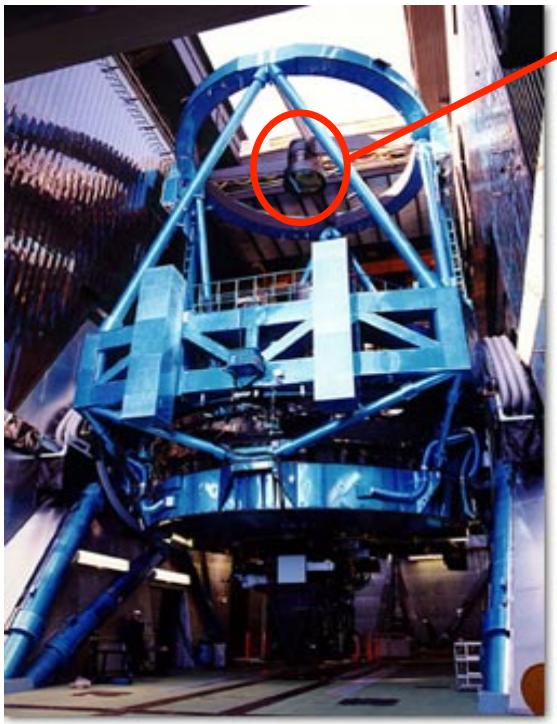
10 CCDs(2k x 4k, ~170MB)

☹ Not So Wide

☺ Deep
(25.5[AB mag] @i’,
15min)

☺ Good Image Quality
(FWHM 0.7’’)

Hyper Suprime-Cam (HSC)



Prime Focus

0.25deg^2

Suprime-Cam

10 CCDs(2k x 4k, ~170MB)

☹ Not So Wide

☺ Deep
(25.5[AB mag] @i', 15min)

☺ Good Image Quality
(FWHM 0.7'')

1.8deg^2

Hyper Suprime-Cam

112 CCDs (2k x 4k, ~>**2GB**)

First Light: early 2012

☺ Wide

☺ Deep
(25.8[AB mag] @i', 15min)

☺ Good Image Quality
(FWHM 0.7'')

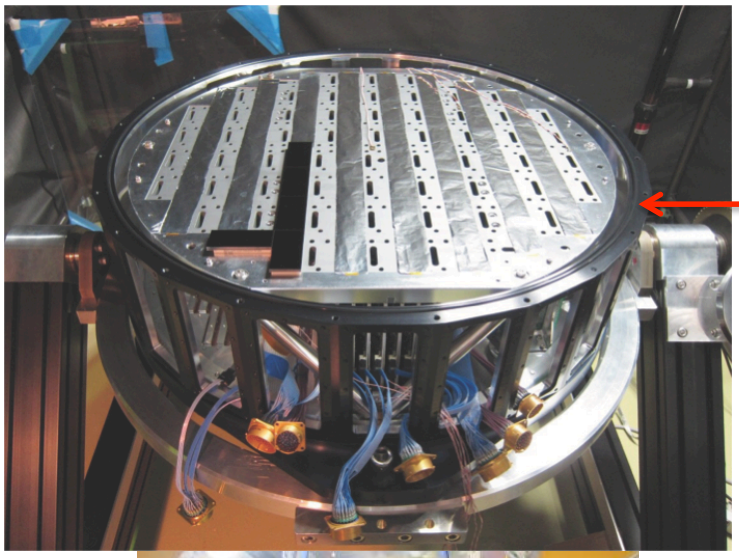
HSC will enlarge the field of view by ~7 times!

Comparison with Other WL Surveys

Survey	Area [deg^2]	FOV [deg^2]	Mirror Diameter [m]	Start
HSC	2000	1.8	8.2	2012
DES	5000	3	4.0	2012
LSST	20000	9.6	8.4	2020?

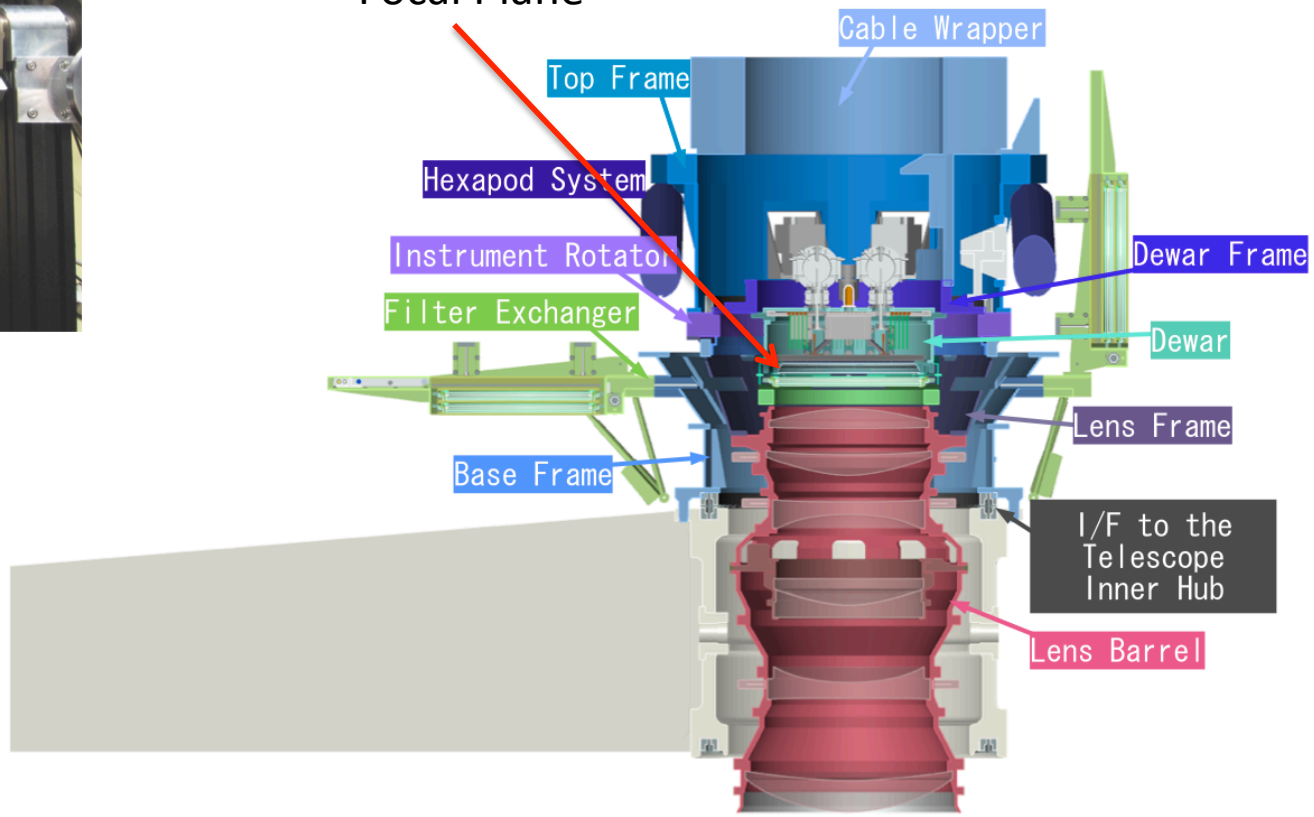
HSC Assembly

Dewar

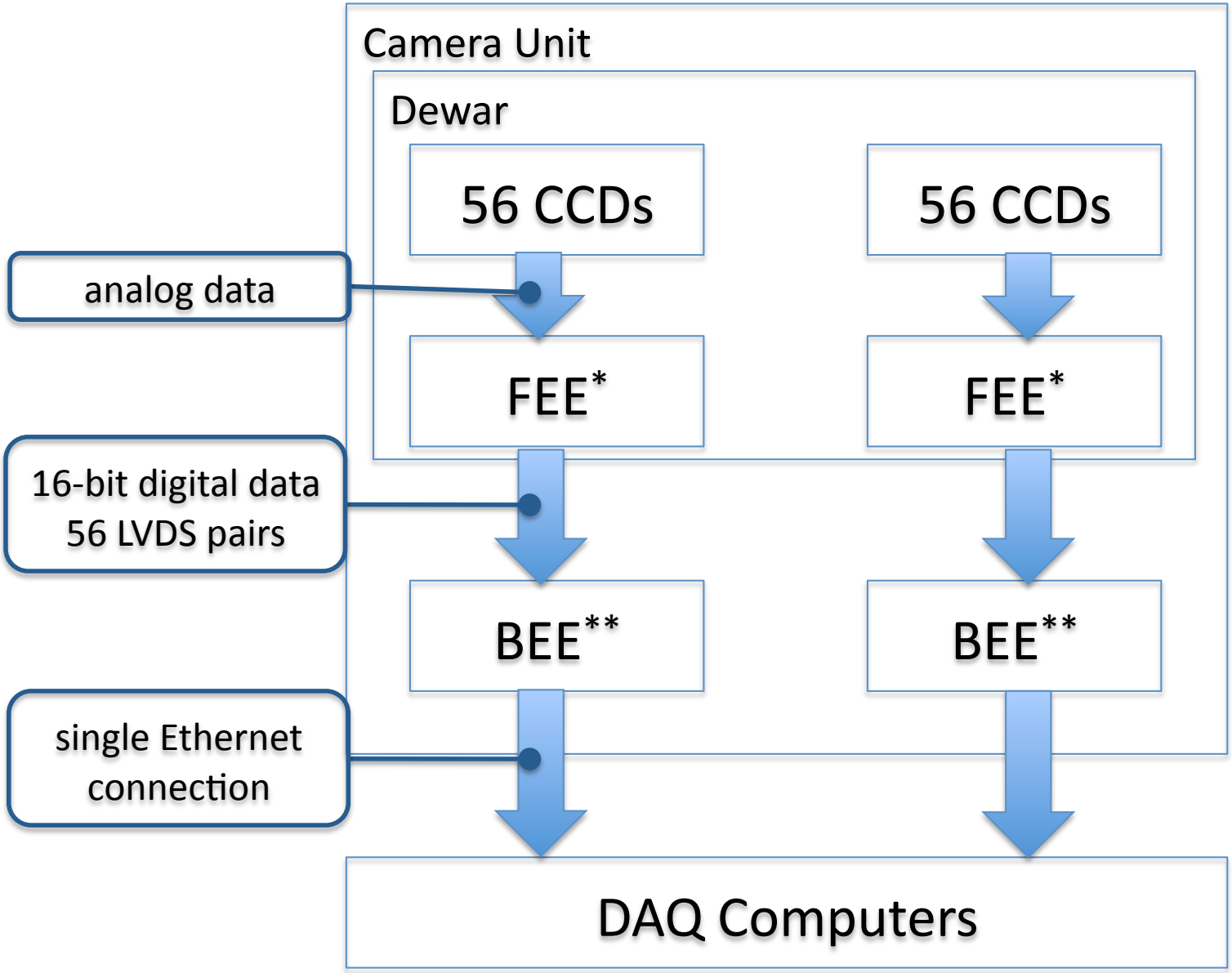


Lens Barrel

Focal Plane



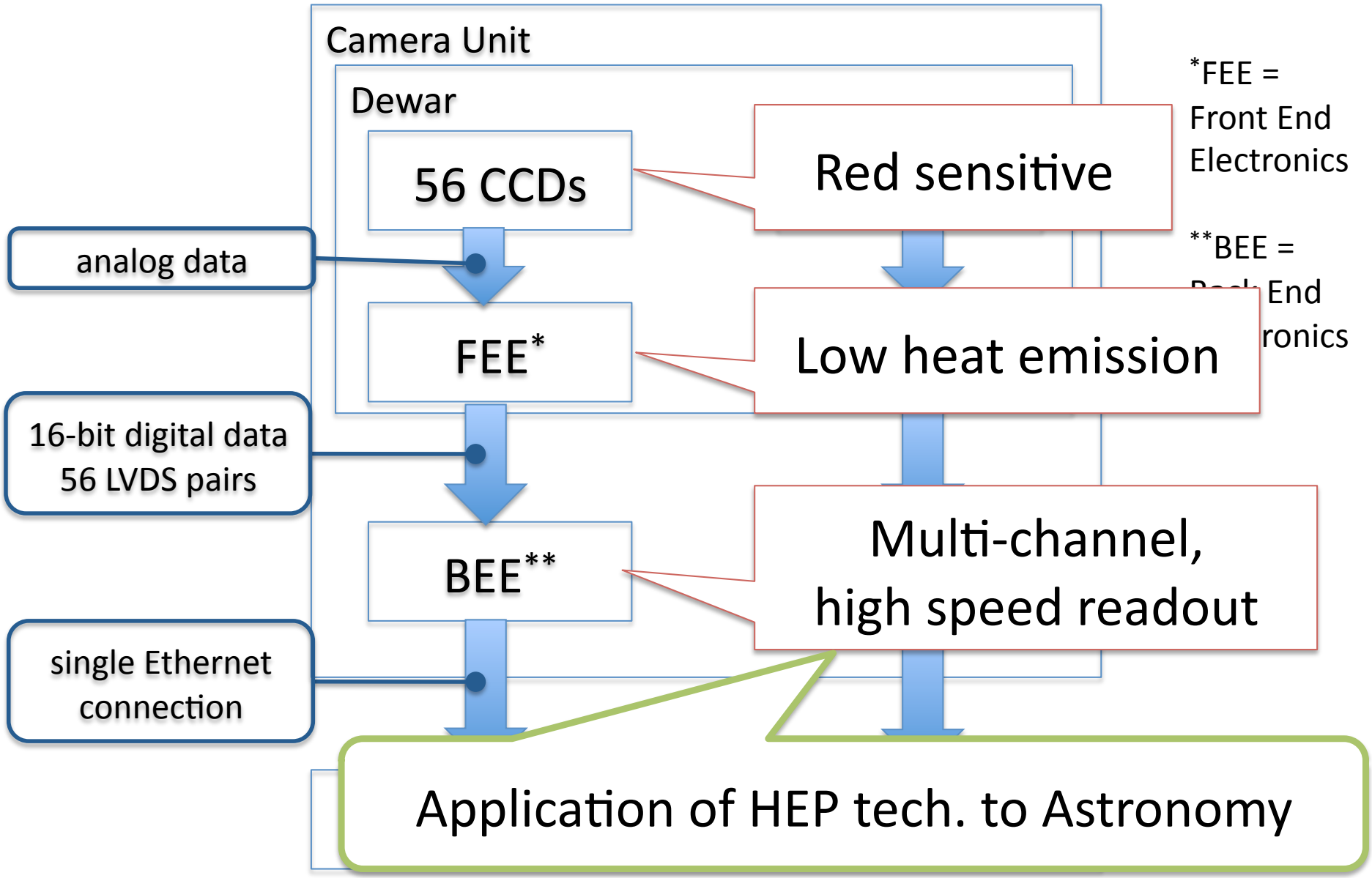
Detector + Readout Electronics



*FEE = Front End Electronics

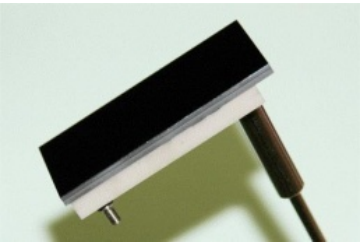
**BEE = Back End Electronics

Detector + Readout Electronics

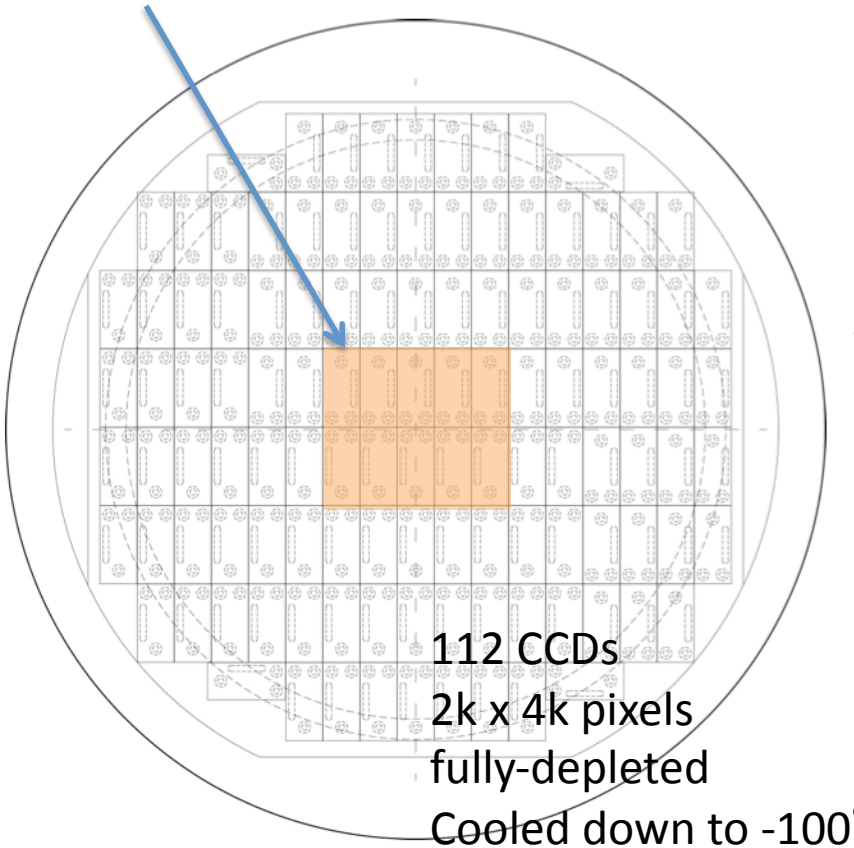


CCDs

Hamamatsu &
NAOJ

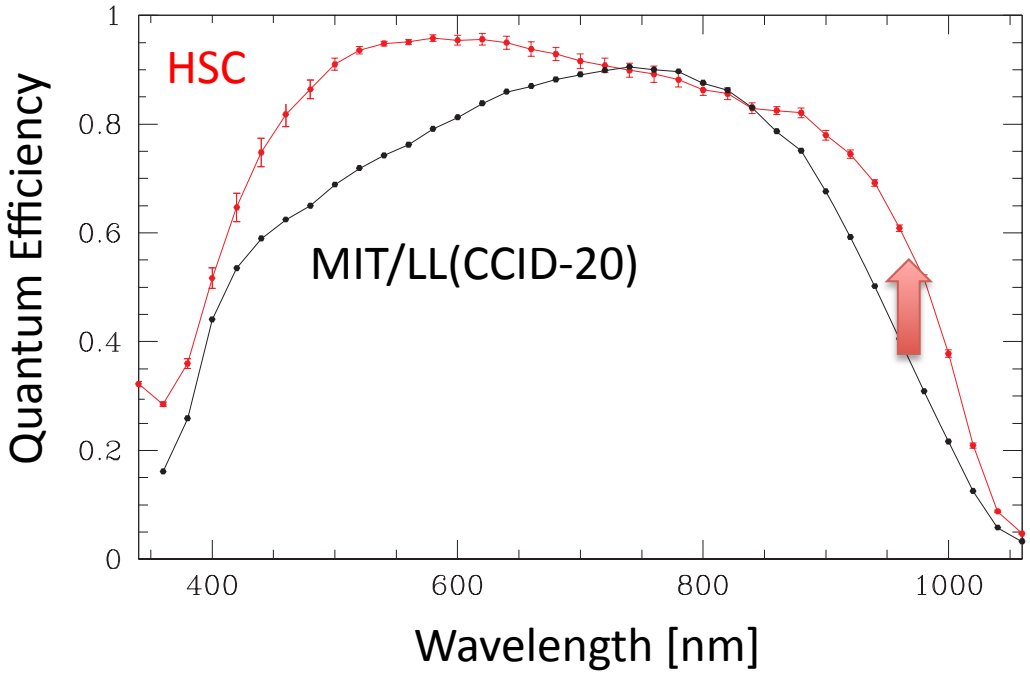


Suprime-Cam FOV



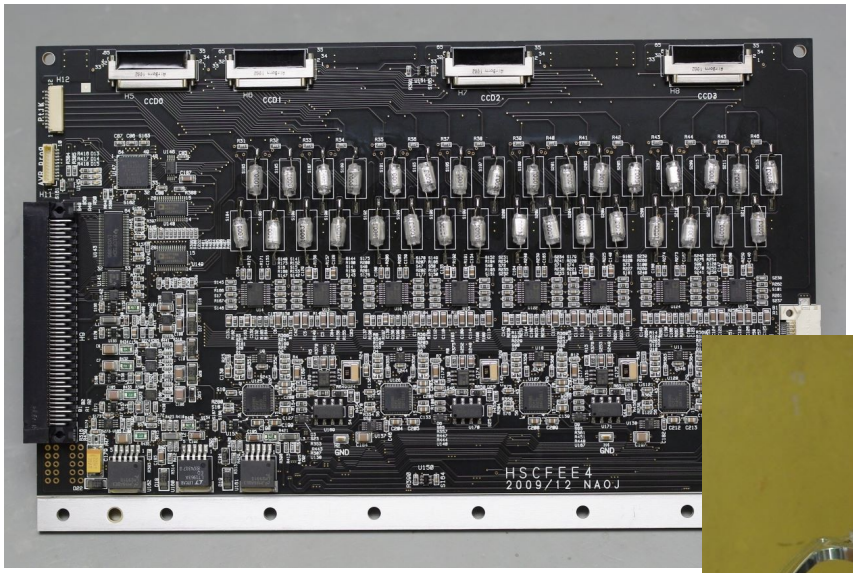
112 CCDs
2k x 4k pixels
fully-depleted
Cooled down to -100℃

Kamata, et al., Proc. SPIE 7742, 774229 (2010)



High QE at longer wavelength
→ make use of high-redshift objects

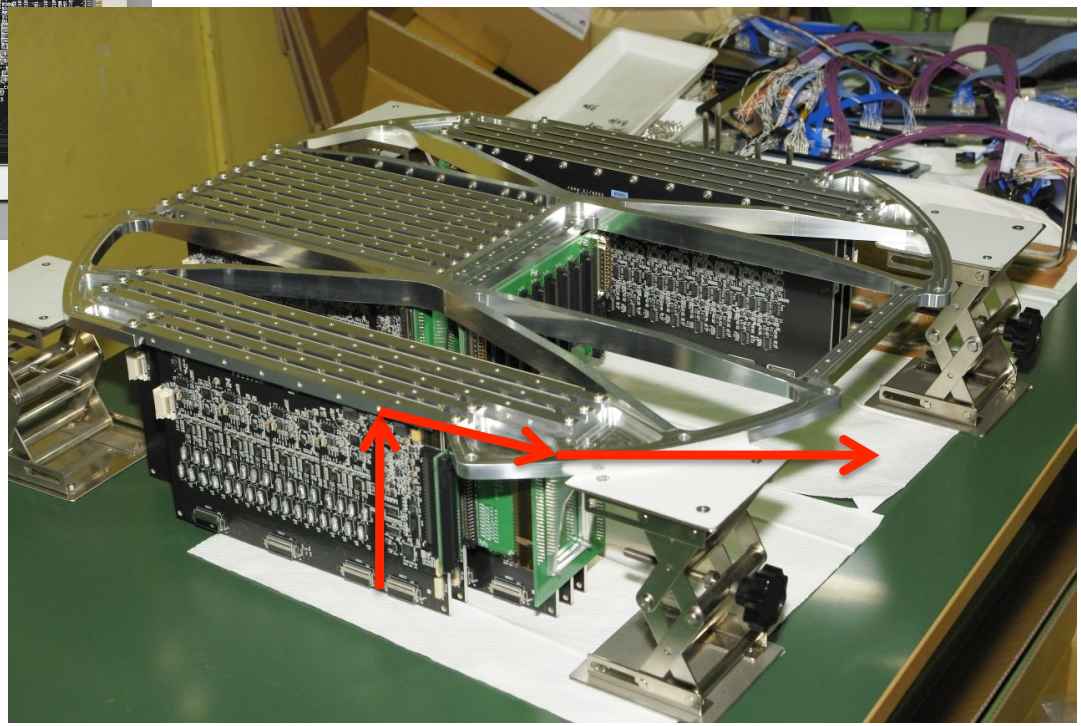
Front-end Electronics (FEE)



- Cooled down together with CCDs.
- Heat is released to the outside of dewar through aluminum core PCB, dewar frame, and dewar wall.

- Clock drivers
- Pre-amp, bias voltage generators, CDS*, 16-bit ADC
- 28 FEE boards are used.

*Correlated double sampling



FEE boards mounted on the dewar frame

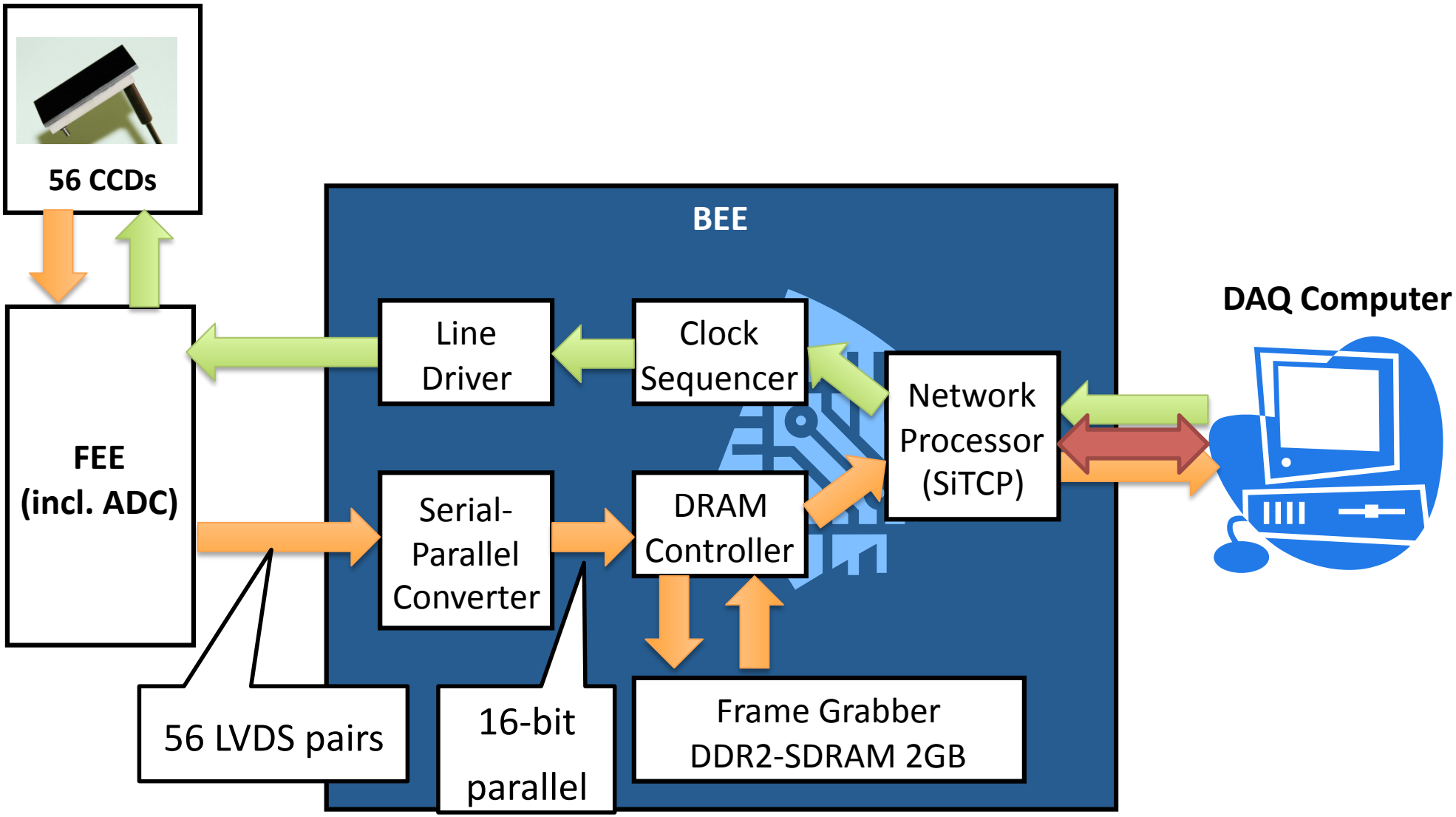
Back-end Electronics (BEE)

Requirements

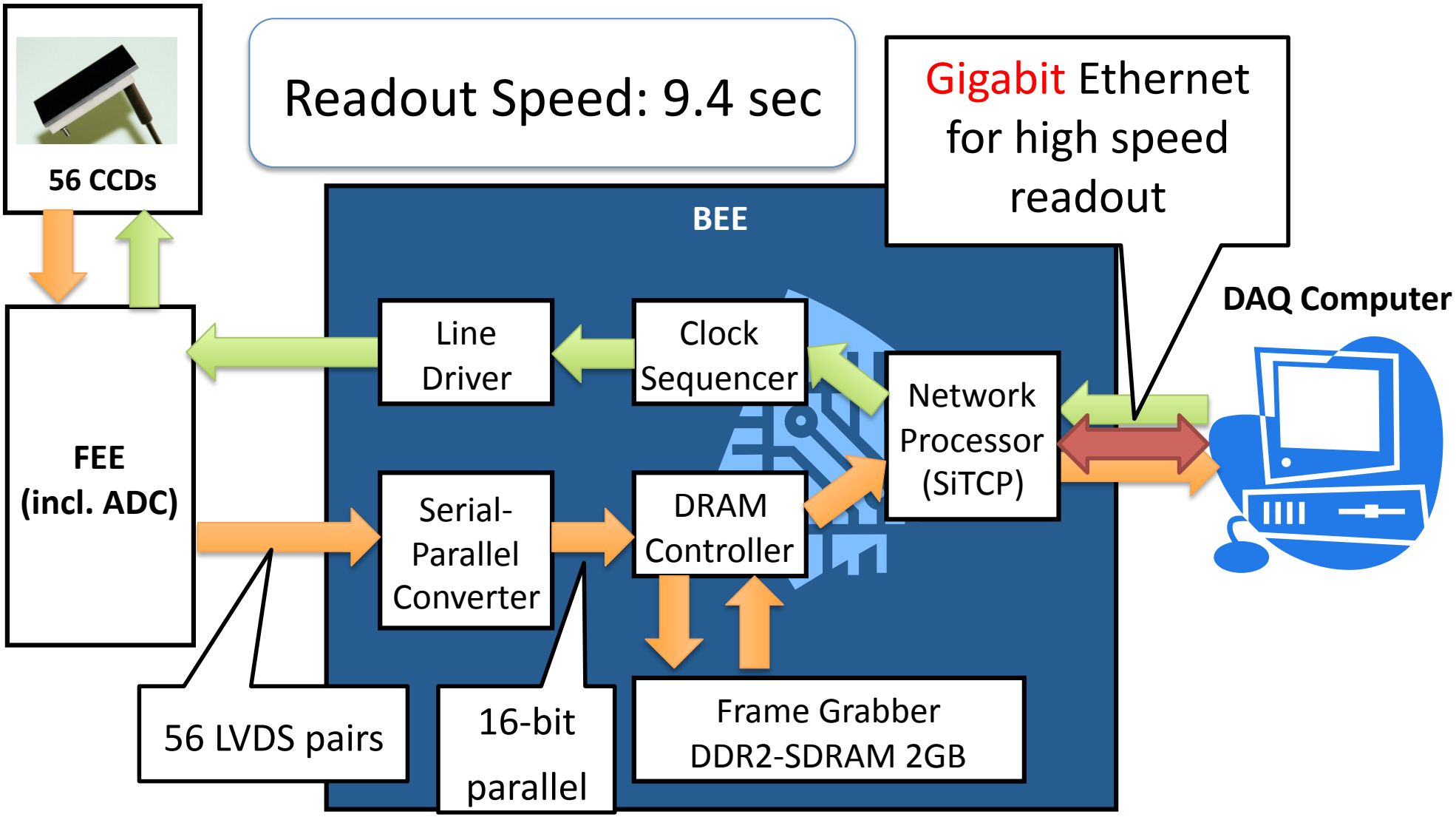
1. Multi-channel, high speed readout: a single image (~2GB) within 10 sec
2. No major noise contribution
3. Small, light and low power consumption

- 3U Euro-card System (7 slots)
- 140mm x 180mm x 130mm
- Power consumption:~10W

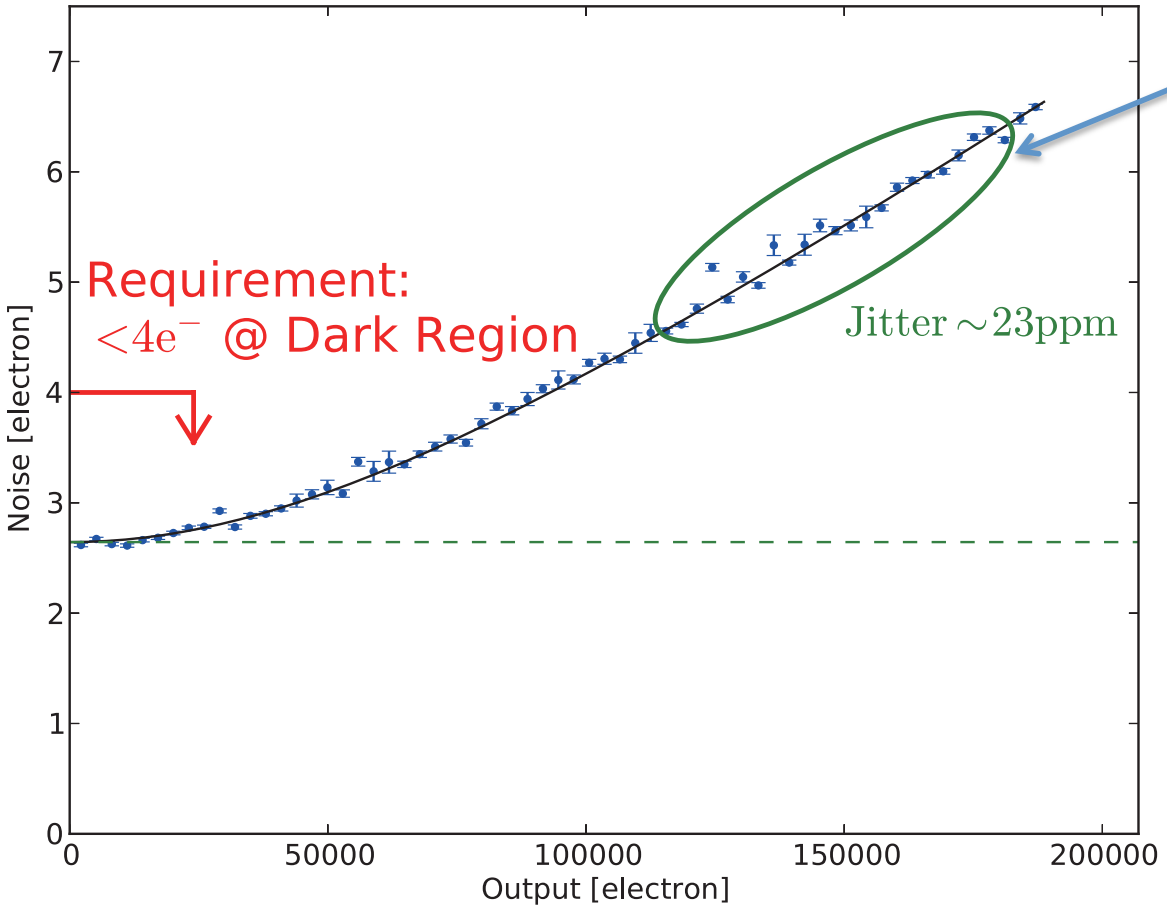
Signal Flow of BEE



Signal Flow of BEE

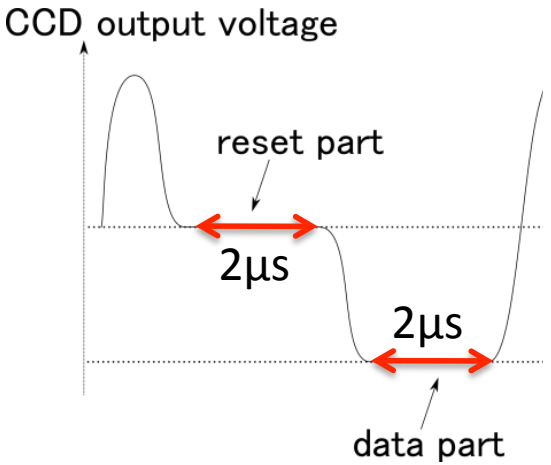


Noise Measurement

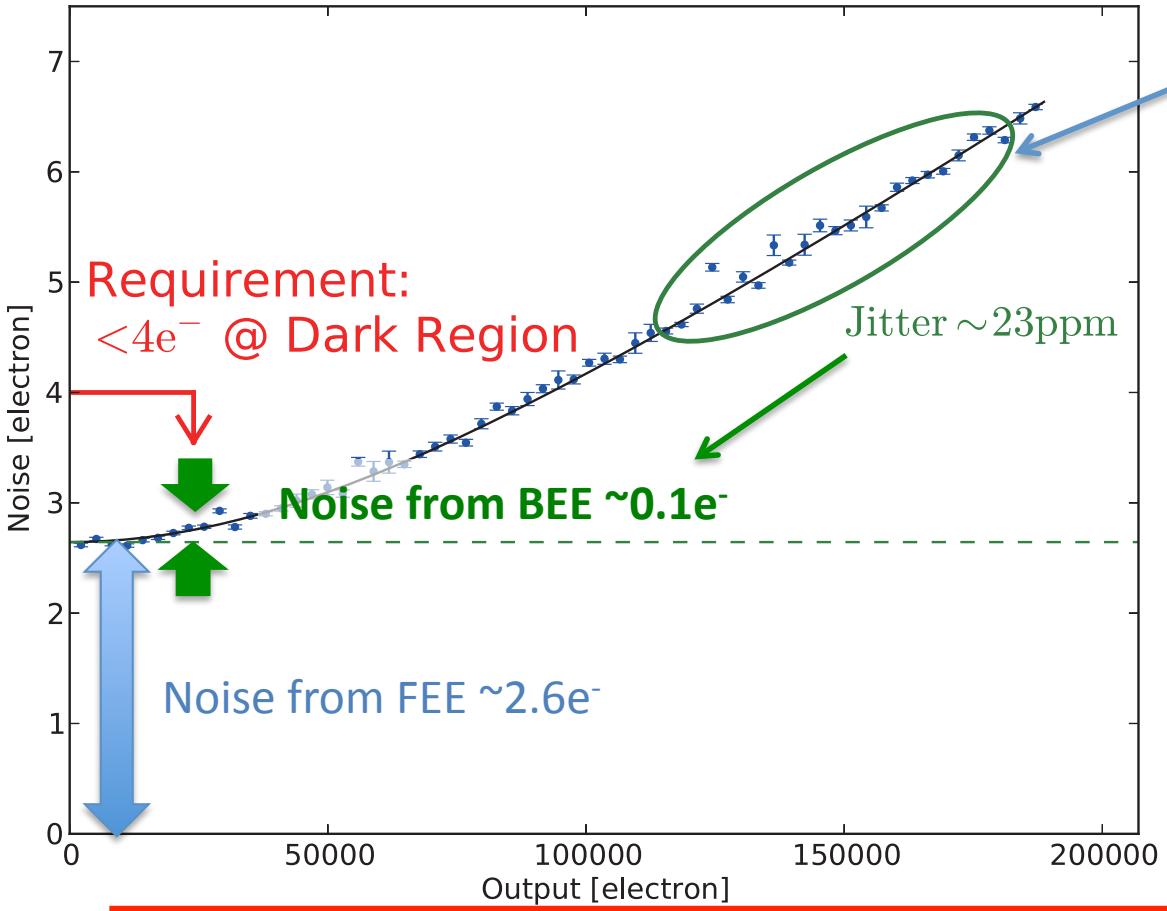


$$V_{out} \times \frac{\delta T}{T}$$

Jitter of CDS gate signal generated by **BEE**

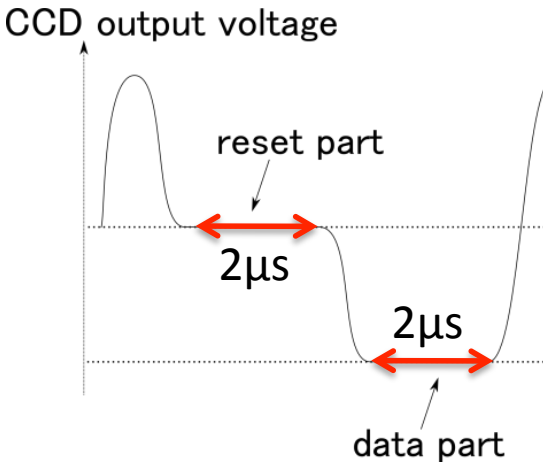


Noise Measurement



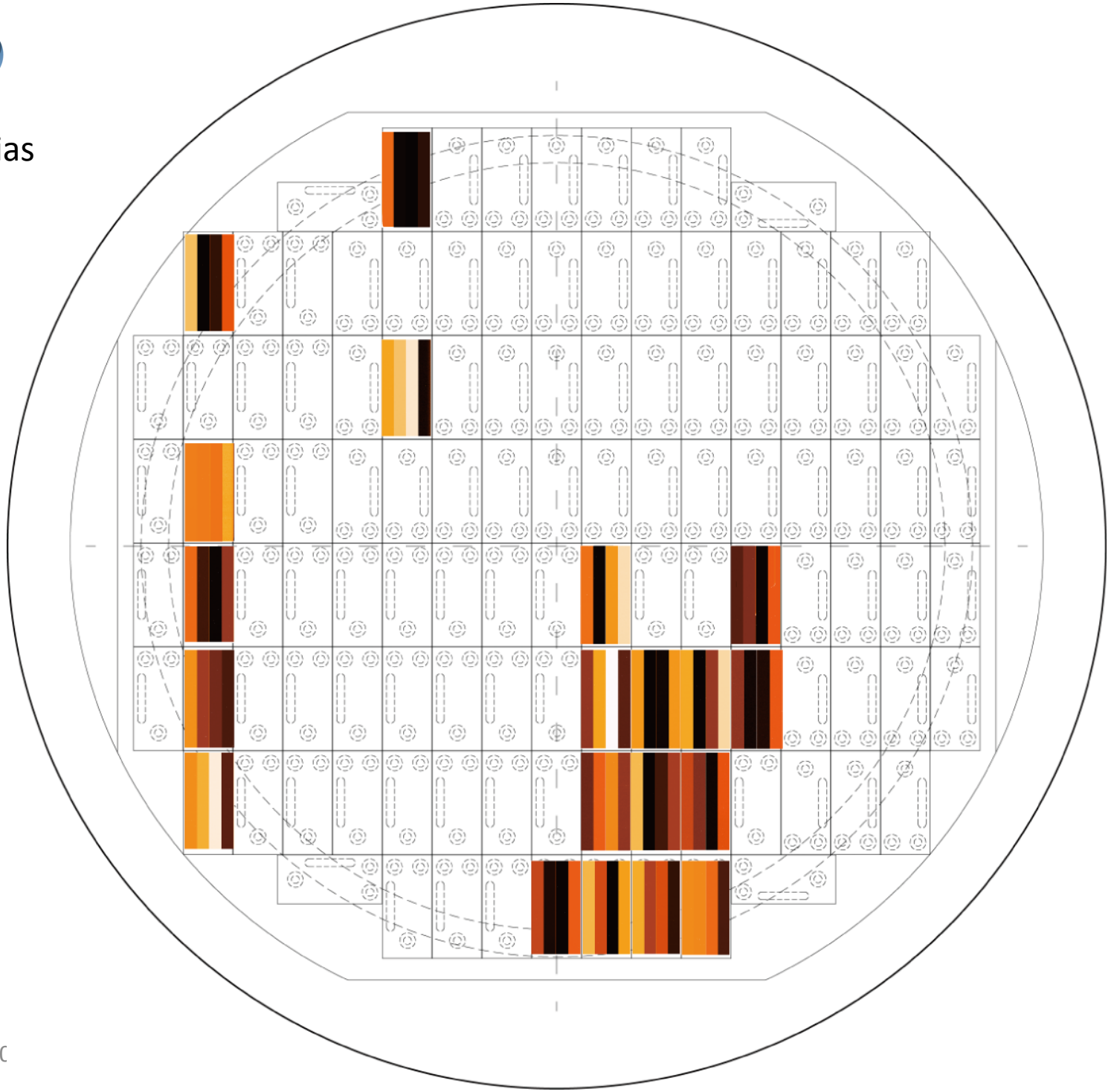
$$V_{out} \times \frac{\delta T}{T}$$

Jitter of CDS gate signal generated by **BEE**



Contribution from BEE ~ 0.1e- @ dark region

CCD bias



Summary

- HSC is the next generation prime focus camera for Subaru Telescope
  - Main science: explore dark energy via weak lensing
- We developed BEE for HSC
  - Application of HEP tech. to astronomy
  - High speed readout (9.4 sec for an image)
  - No major noise contribution (~0.1e^-)

First light in early 2012!