P16

Hyper Suprime-Cam Medium Band Filter Survey

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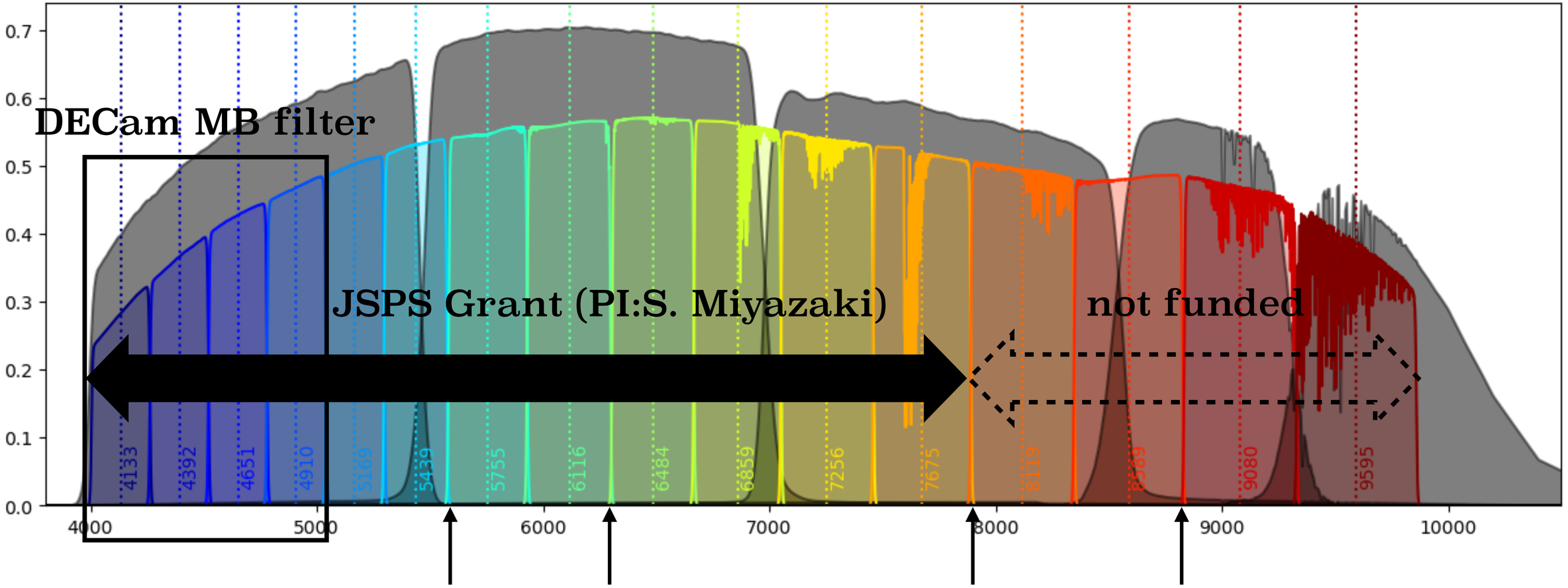
HSC MB filter working group

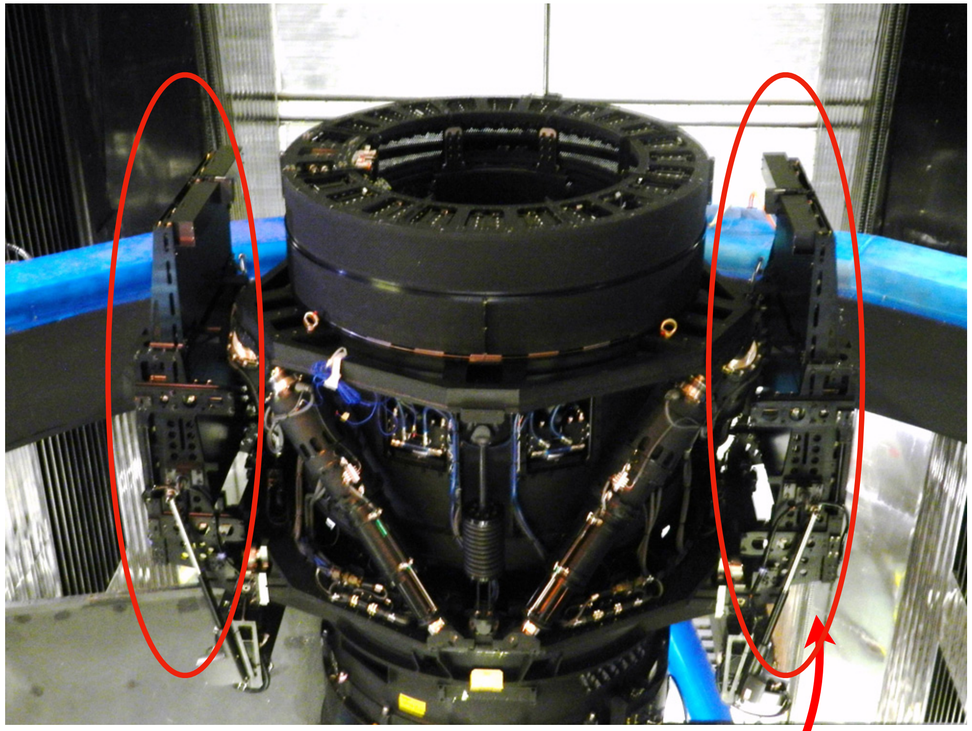
Jan. 28-30, 2025,
Subaru UM @ Mitaka

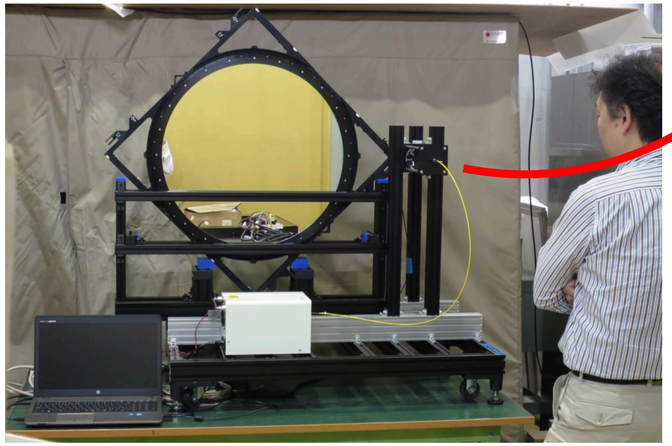
MB Filter transmission



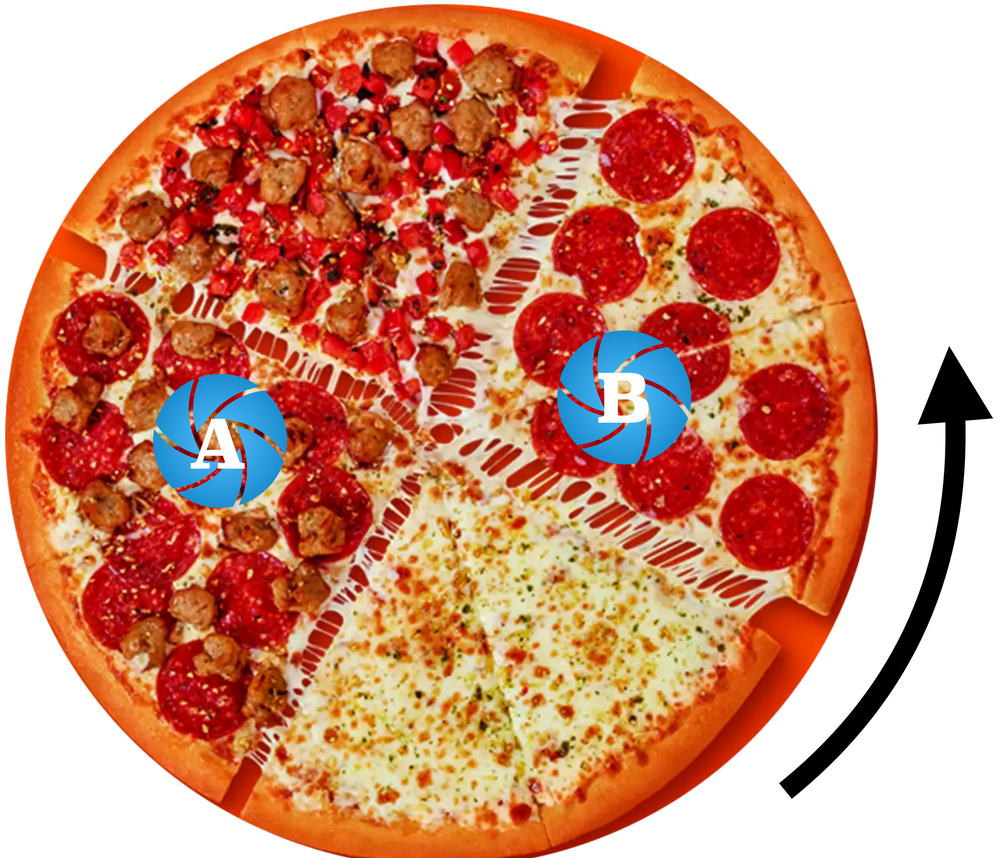
- 4 Blue bands : same as the DECam MB filters for the coordinated observation
- 5th to 16th bands : Bluer bands are relatively narrower than redder bands.
- Avoid any of the strong sky emission lines (they drop in between the filters)
- reddest 4 bands (8k-10k Å) are not yet funded

Filter Fabrication -mechanical design-





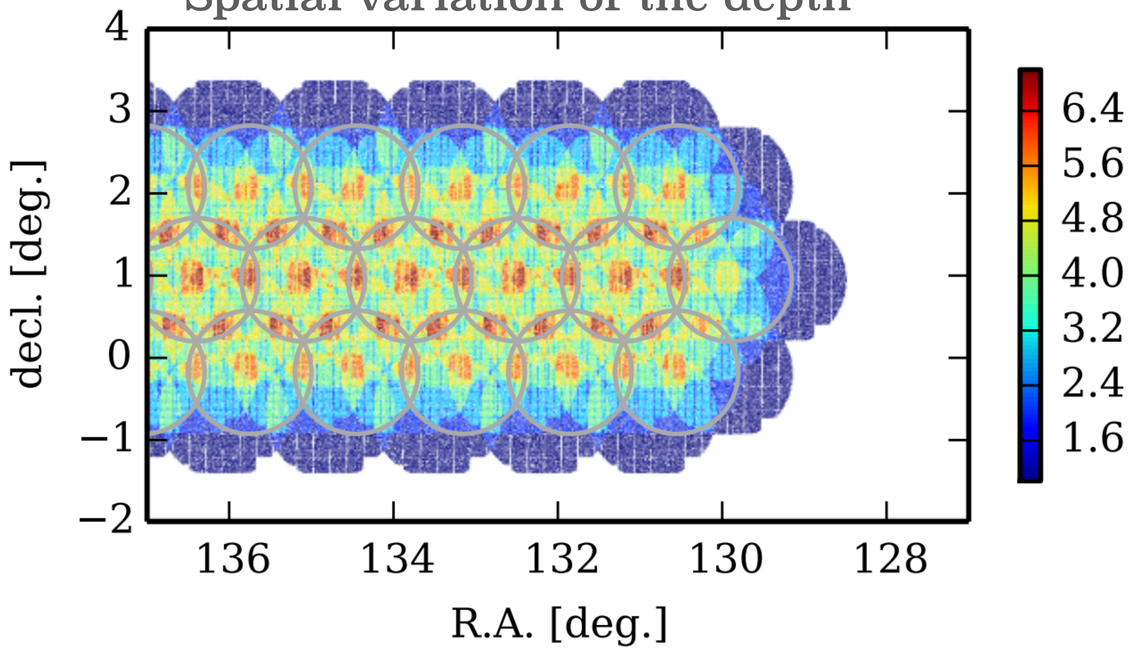
- HSC has a filter exchange unit (FEU) on both sides of the camera
- Each FEU has 3 slots of filters (6 in total)
- During the obs. run (~14 days in gray/dark nights), only 6 filters are available to observe.
- it takes 30 min. for filter exchange (among 6, chose 1 filter)

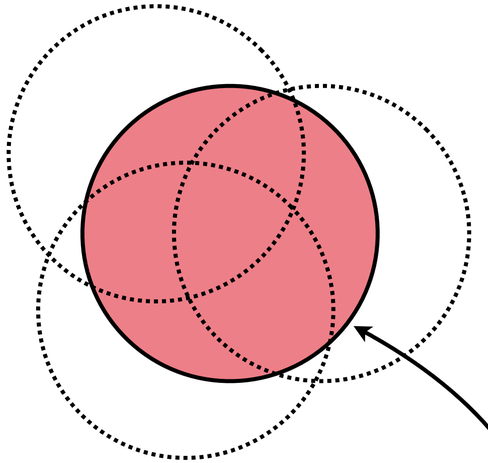


Subaru MB survey : dithering/tiling strategy

- 80% area for clear focus
- dithering steps should fill the gaps between the CCDs and cross-shaped frame
- Honeycomb shape should be the most efficient way to fill the sky with the circular FoV.

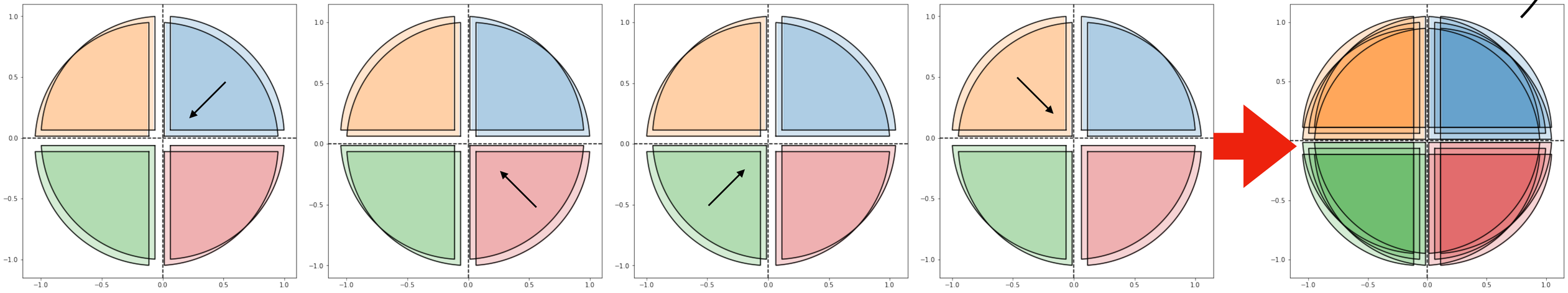
Spatial variation of the depth



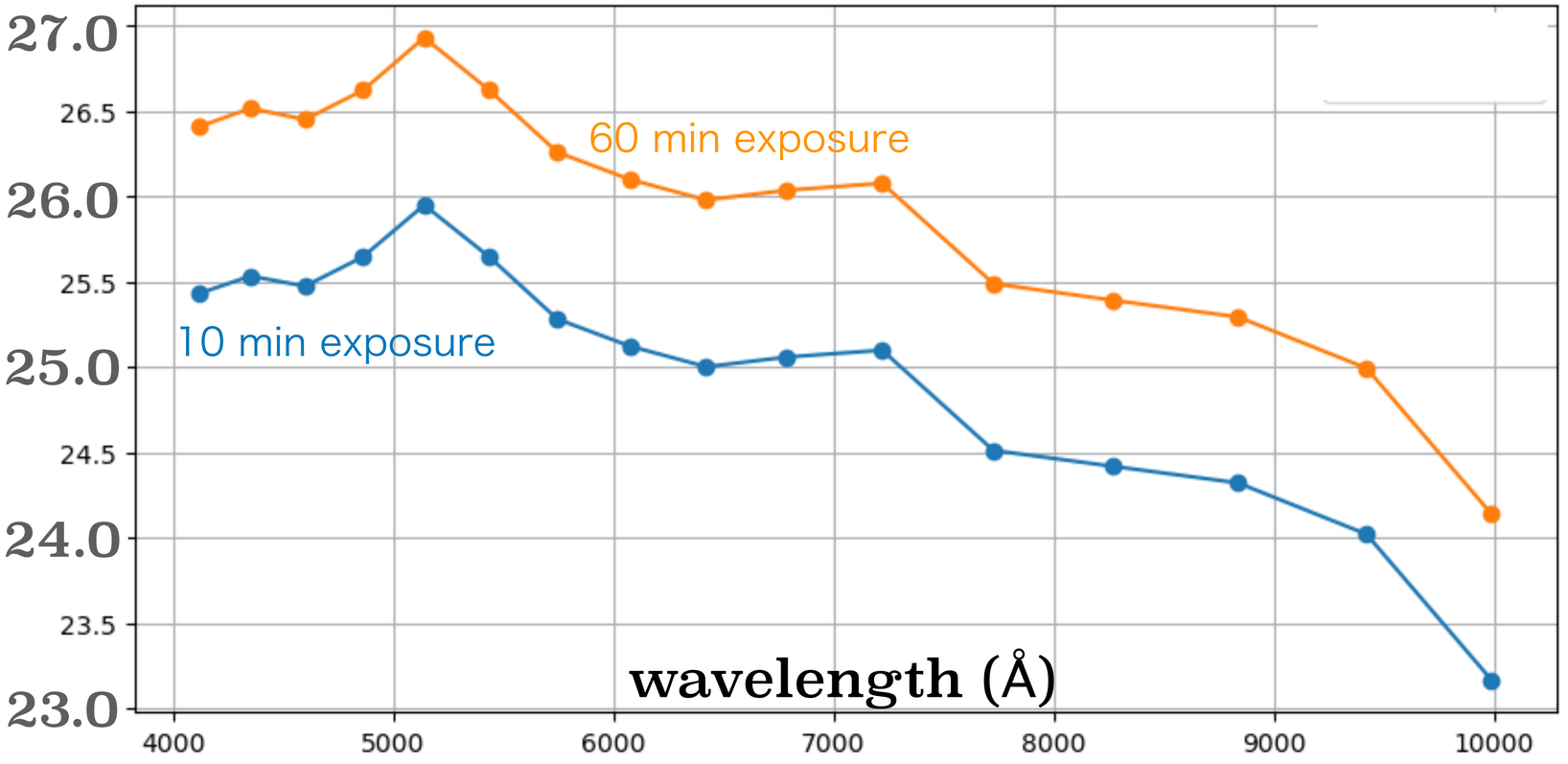


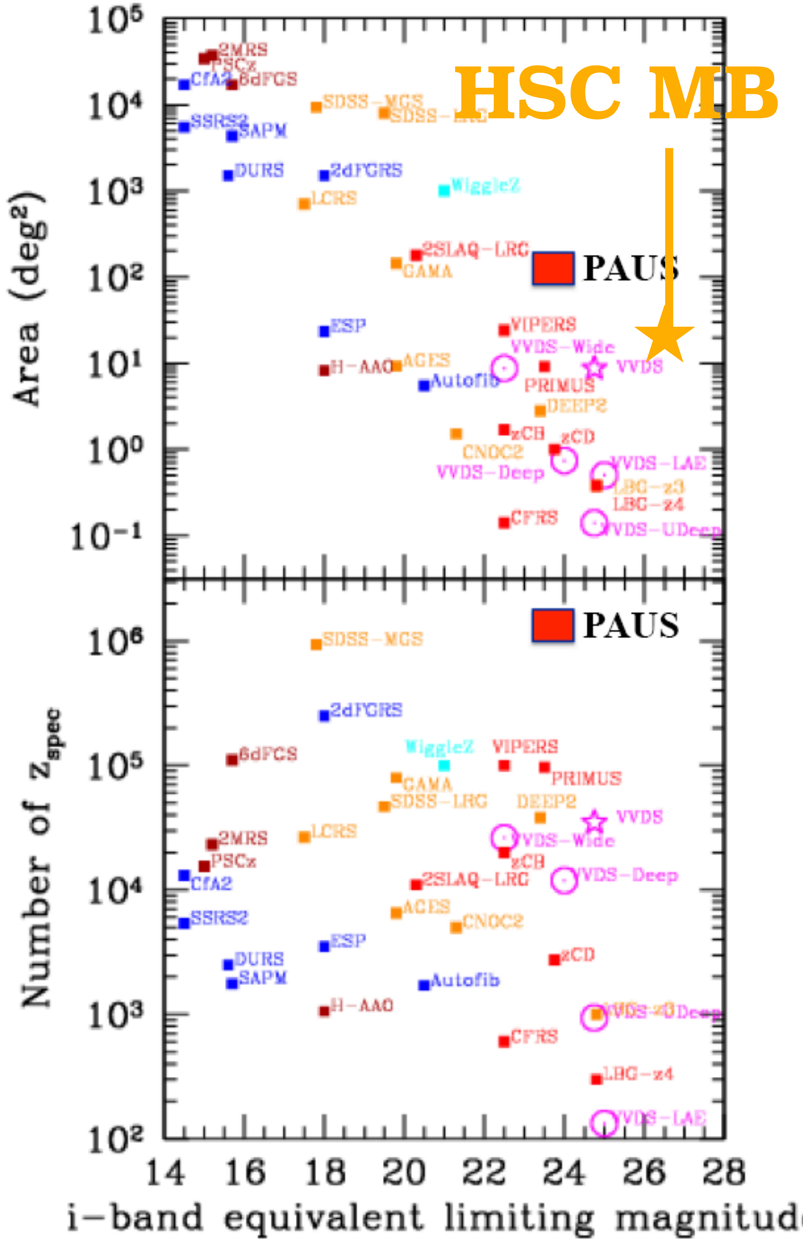
large step dithers for uniform depth across the field (HSC SSP)

small step dithers to fill the gap due to the cross-shaped frame



Subaru MB survey : Exposure Time Calculator





In 28 nights/HSC queue, we can observe either

Deep: 60 min. exposure
-> 26.5 mag@450nm
30 deg^2 for 16 filters

Wide: 10 min. exposure
-> 25.5 mag@450nm
150 deg^2 for 16 filters

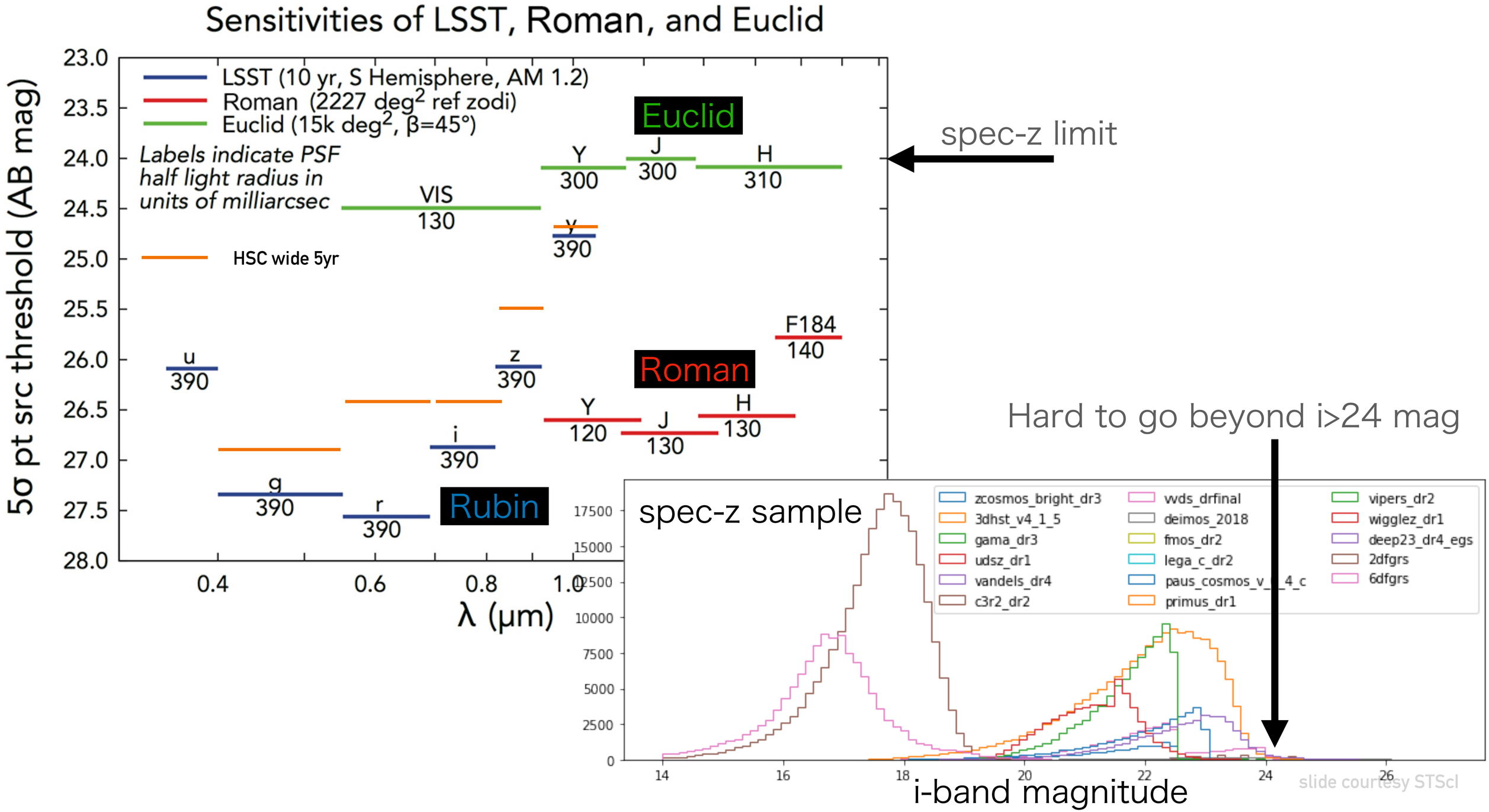
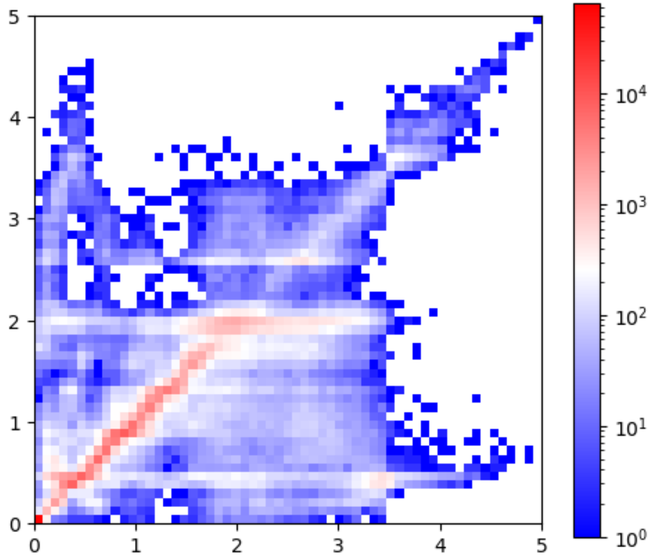
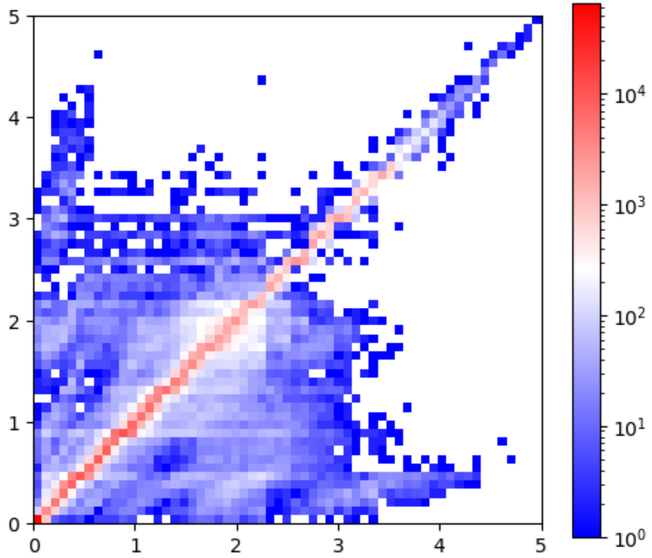

Sensitivities of LSST, Roman, and Euclid
LSST (10 yr, S Hemisphere, AM 1.2)
Roman (2227 deg² ref zodi)
Euclid (15k deg², β=45°)
Labels indicate PSF half light radius in units of milliarcsec
HSC wide 5yr
Euclid
Y 300
J 300
H 310
VIS 130
y 390
F184 140
Roman
Y 120
J 130
H 130
u 390
z 390
i 390
g 390
r 390
Rubin
5σ pt src threshold (AB mag)
λ (μm)
spec-z limit
Hard to go beyond i>24 mag
spec-z sample
zcosmos_bright_dr3
3dhst_v4_1_5
gama_dr3
udsz_dr1
vandels_dr4
c3r2_dr2
vvds_drfinal
deimos_2018
fmos_dr2
lega_c_dr2
primus_dr1
vipers_dr2
wigglez_dr1
deep23_dr4_egs
2dfgrs
6dfgrs
i-band magnitude
slide courtesy STScI

photo-z improvement : BB -> BB+MB

HSC 5 BB only



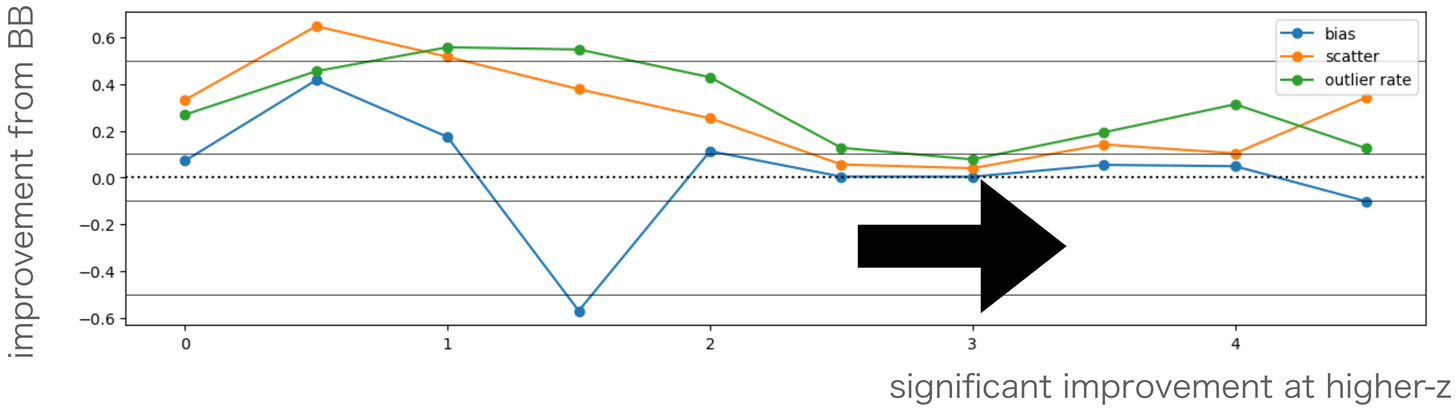
HSC 5 BB + 16MB



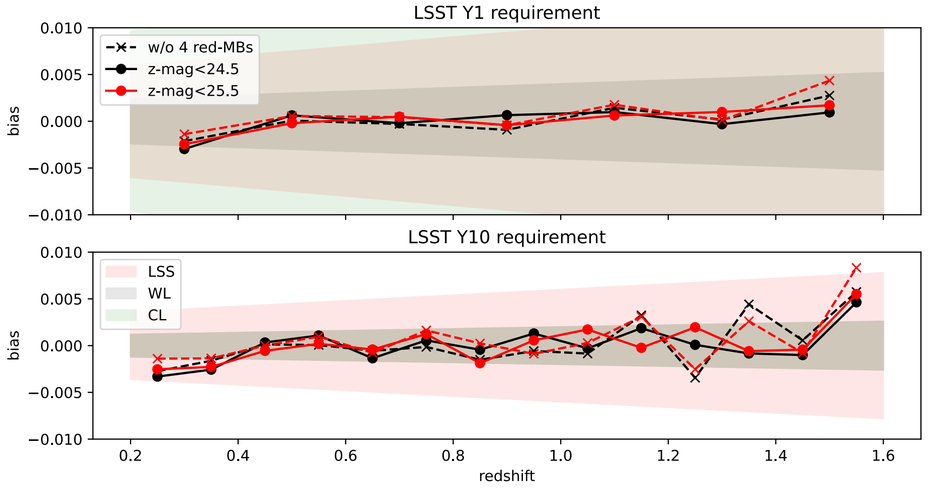
- EL-COSMOS synthetic spectra (w/ emission lines)
- convolve MB filters
- add noise (w/ 60 min. exposures)

- use flux only
- comparison to cosmos2020
- will meet the requirement for LSST-Y1 WL/LSS/ cluster cosmology
- will also meet the requirement for LSST-Y10 LSS. (partly for WL/clusters)

X_{5BB+16MB} / X_{5BB}

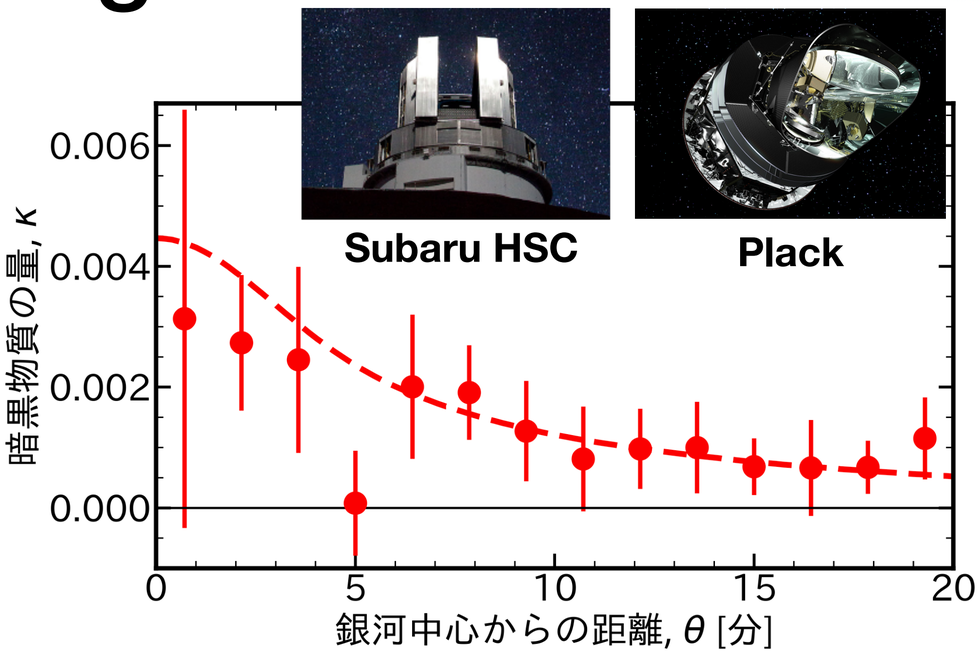


significant improvement at higher-z

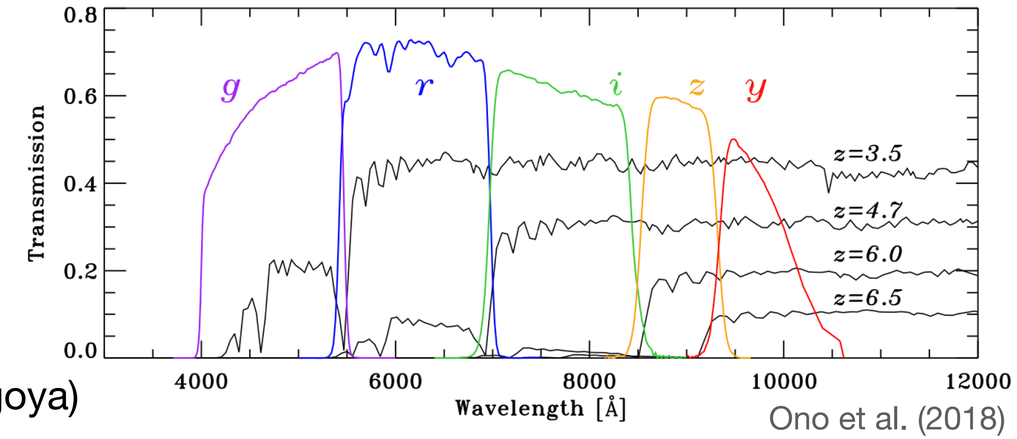


LSS measurement at high-z using CMBLens

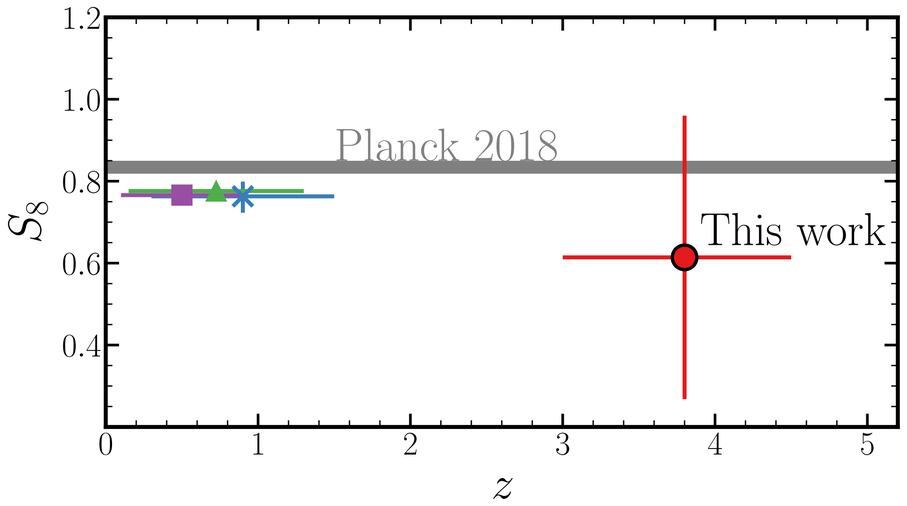
- We measure DM distribution around **Lyman Break Galaxies(LBG; 150M; Harikane+, 2022)** at z~4 with HSC for the first time
- Challenges
  - Need better statistics (# of obj.)
  - contamination of low-z galaxies due to the broad band LBG selection



H. Miyatake (Nagoya)



Ono et al. (2018)



Miyatake et al. (PRL, 2022a)

Colab w/ DESI-2

Can we coordinate the observation w/ HSC MB and DECam MB surveys for DESI-2 target selection?

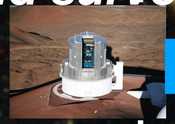
Great minds think alike.

D. Schlegel (LBNL)

2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2035 2036 2037

galaxy survey

Medium band surveys



HSC MB Survey

HSC MB-2

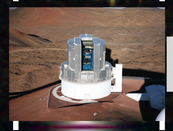
high-z cosmology

DECam MB Survey

Large LAE sample

Subaru 3

galaxy redshift survey



Subaru PFS (1,100deg^2; z<2.5)

PFS-2

Large LAE spec-z sample

DESI (14,000deg^2; z<2.5)

DESI-2 (5,000deg^2; 2.5<z<3.2)

CMB exp.

Simons Observatory

neutrino

LiteBIRD

Credit: NAOJ, NOIRLab, NSF, DOE, JAXA

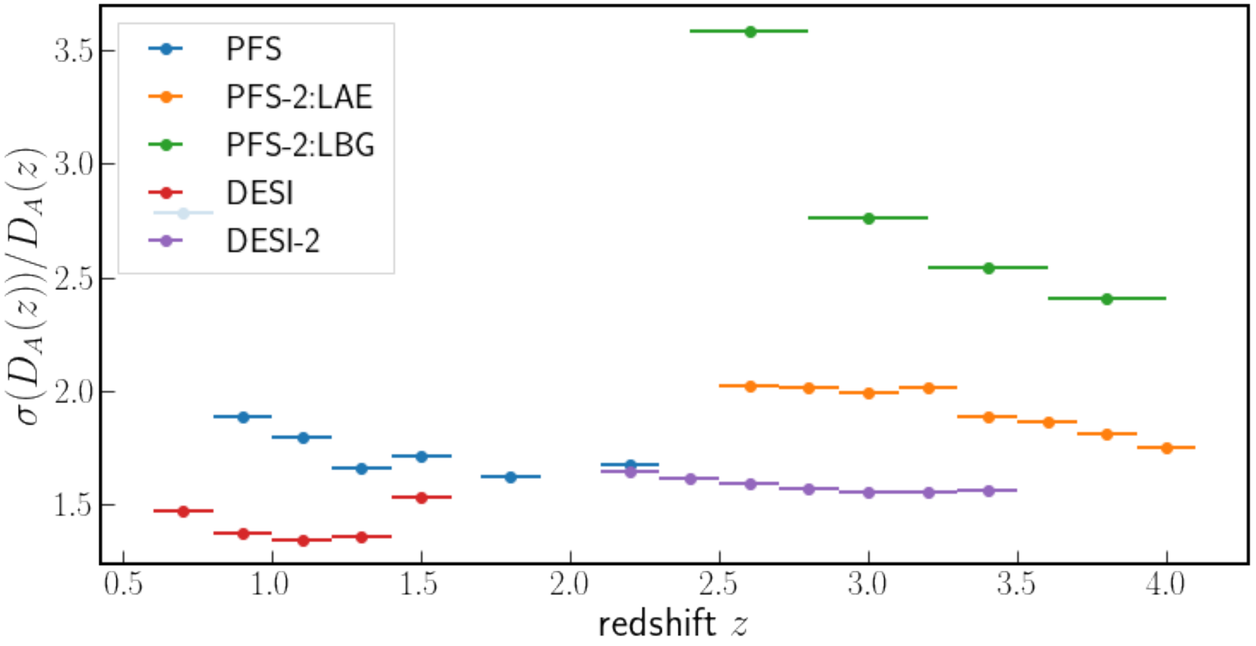
HSC-MD w/ PFS-2

T. Sunayama
(ASIAA)

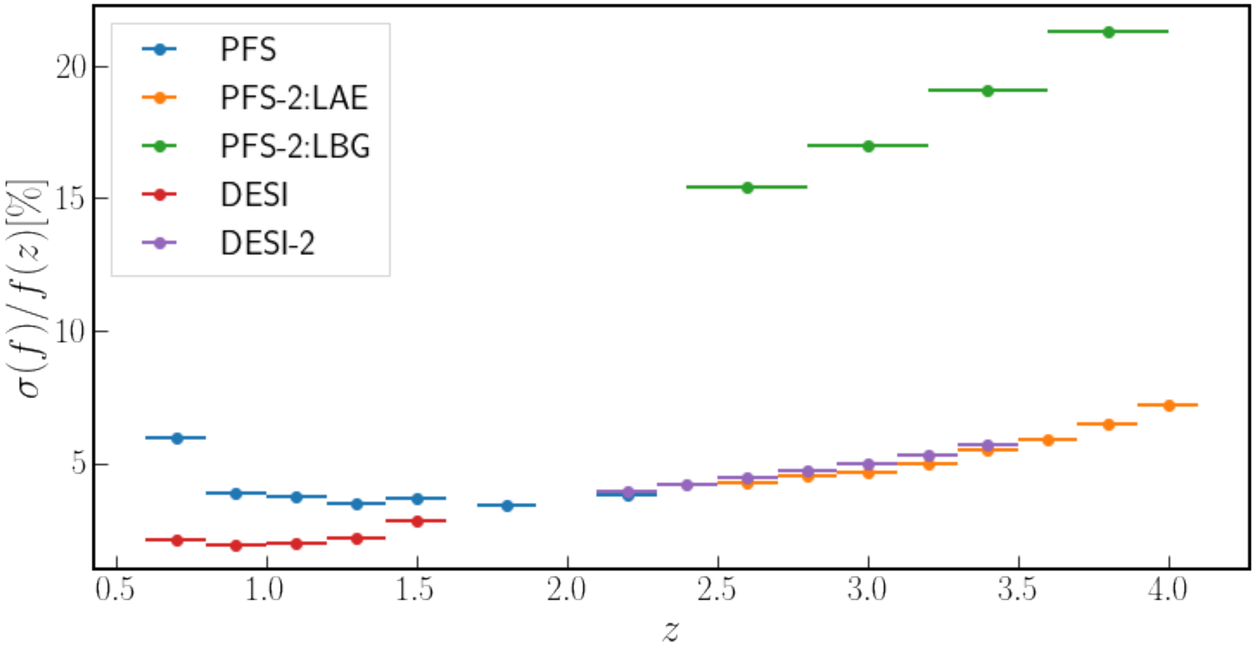
HSC-MB : LAE/LBG selection for 2,000 sq. deg in 110 nights (incl. bad weather)
PFS-2 : follow-up spec-z observations in 220 nights
-> **LBG/LAE sample down to 25.5 mag at 3.2<z<4.0 over 2,000 sq. deg.**

- BAO is already CV limited, PFS-2 is not as powerful as DESI-2 (5,000 sq. deg.)
- RSD is more suitable for PFS-2 (RSD is more sensitive to the galaxy # density)
- PFS-2 can go beyond z>3.5

BAO

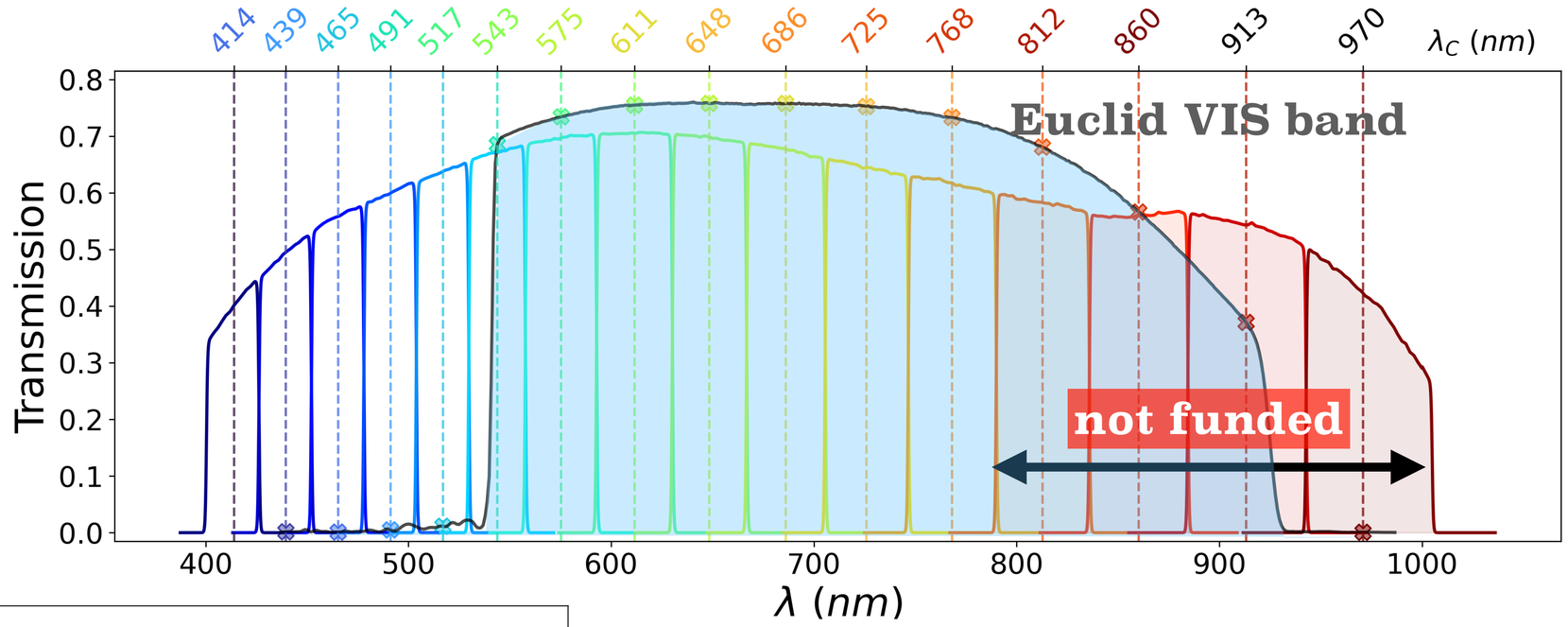


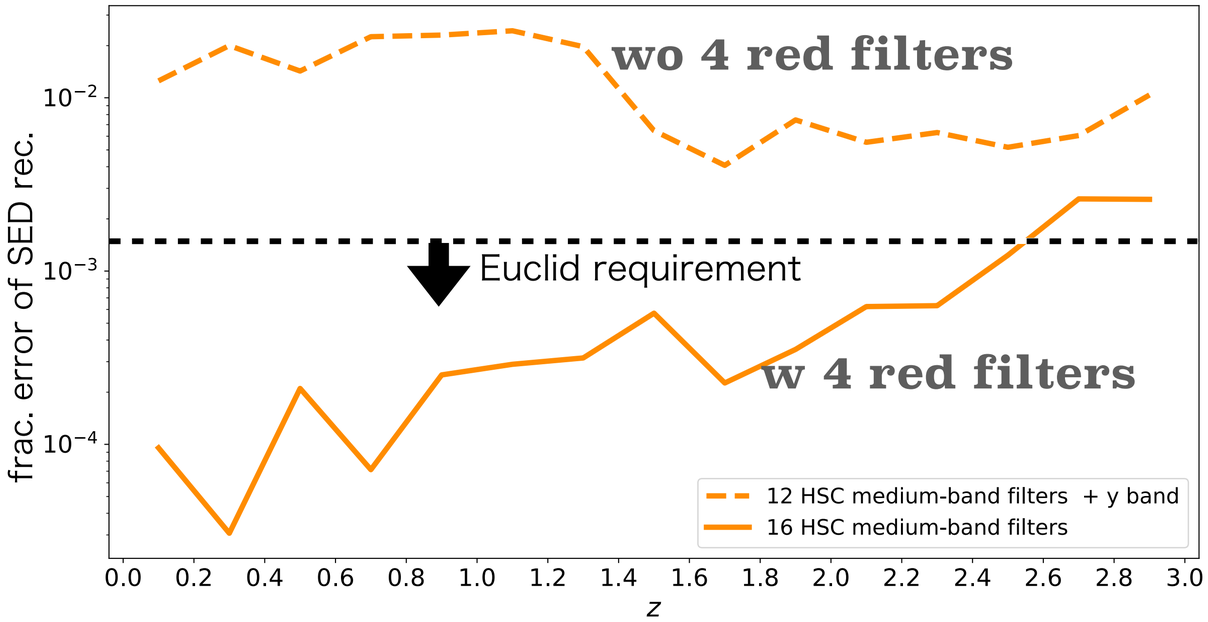
RSD



SED reconstruction for Euclid

F. Tarsitano (Geneva)





- Euclid will measure the galaxy shape with VIS-band (550-920nm)
- SED is reconstructed via GP w/ expected photometric errors
- wo 4 red filters, Euclid cannot meet the requirement (additive bias on gamma)

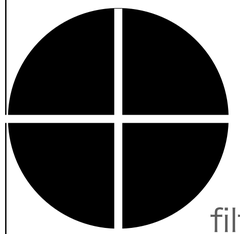
HSC MB workshop @ Nagoya, 2023 Sep. 1

HSC MB workshop @ Nagoya, 2024 Nov. 27, 28

Timeline

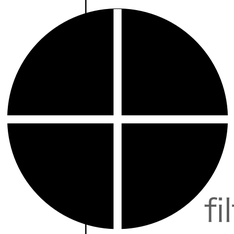
2024.8	2025.2	2025.8	2026.2	2026.8	2027.2	2027.8	2028.2	2028.8
24B	25A	25B	26A	26B	27A	27B	28A	28B

filter delivered 2025.2



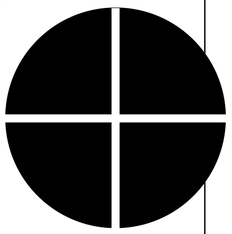
intensive

filter delivered 2025. 06

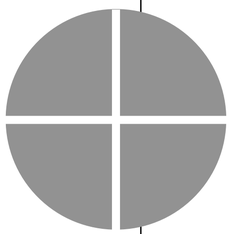


Subaru_x_Roman
(100 nights)

filter delivered 2025. 10



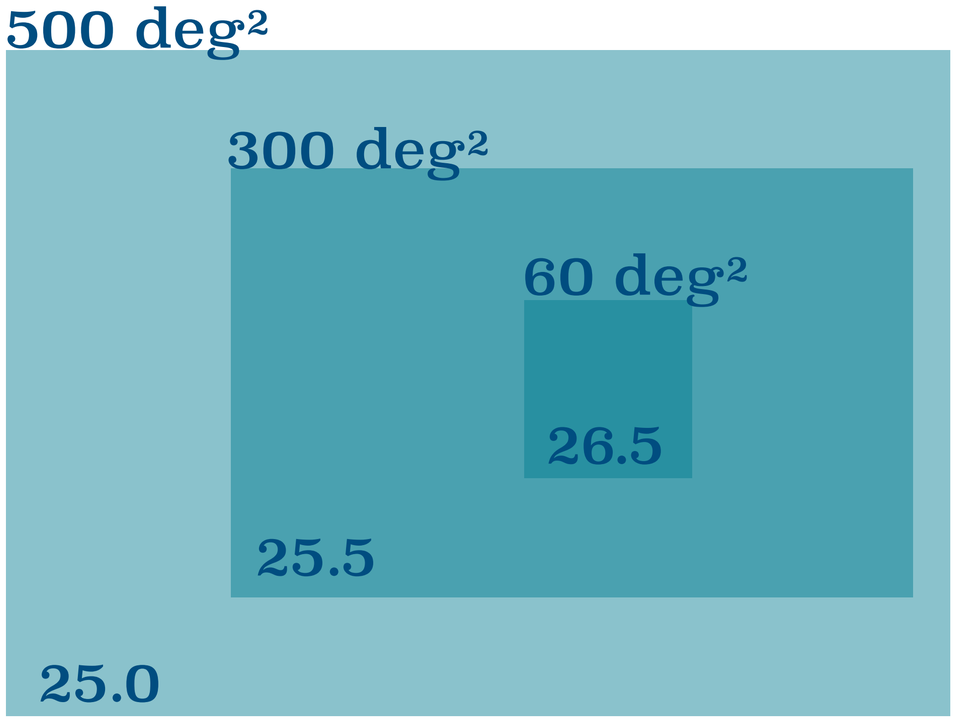
(filter delivered 2026~)



(intensive)

preparing S26A intensive proposal

- filter set : four bluest bands (414, 439, 465, 491 nm, delta=24nm)
- survey depths
  - ultra-wide (~25.0 mag@5min. ~ 500sq. deg)
  - wide (~25.5 mag@10min. ~300 sq. deg.)
  - deep (~26.5 mag@60min. ~60 sq. deg.)
- To observe LBGs/LAEs
- To improve the photo-z
- Welcome other science cases



- DECam survey will cover 1,000 deg² @ 25mag (target 2<z<3.5 LBGs/LAEs)
- DESI-2 will follow-up the spec-z for the candidates

summary

- We plan to have 16 medium band filters on Subaru HSC
- 12 MB filters are already funded and the first set will be delivered 2024 Dec.
- MB filters will have a legacy value for training/calibrating the photo-z for upcoming deep imaging surveys by 2030.
- Not only the photo-z training/calibration, lots of sciences will be possible.
- If you are interested in joining the HSC-MB survey, please feel free to let us know.
- We target S25B intensive program, (w/ 14 nights)
  - Deep Survey : 60 deg^2 down to r<26.5 mag
  - Wide Survey : 300 deg^2 down to r<25.5 mag
  - Ultra-Wide Survey : 500 deg^2 down to r<25.0 mag
  - Or wedding cake style (?)