

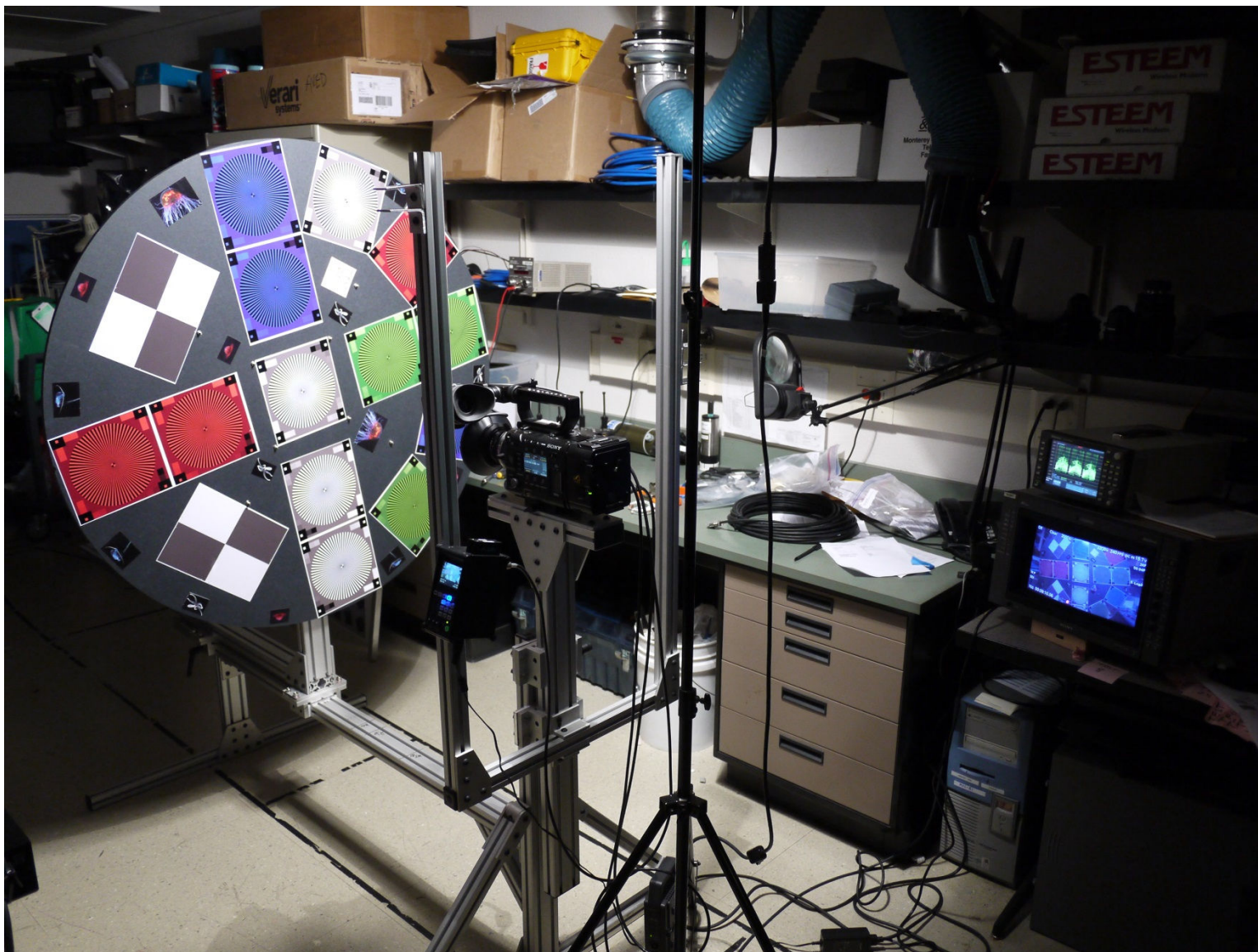
i2MAP Camera and Lens Testing

Mark Chaffey

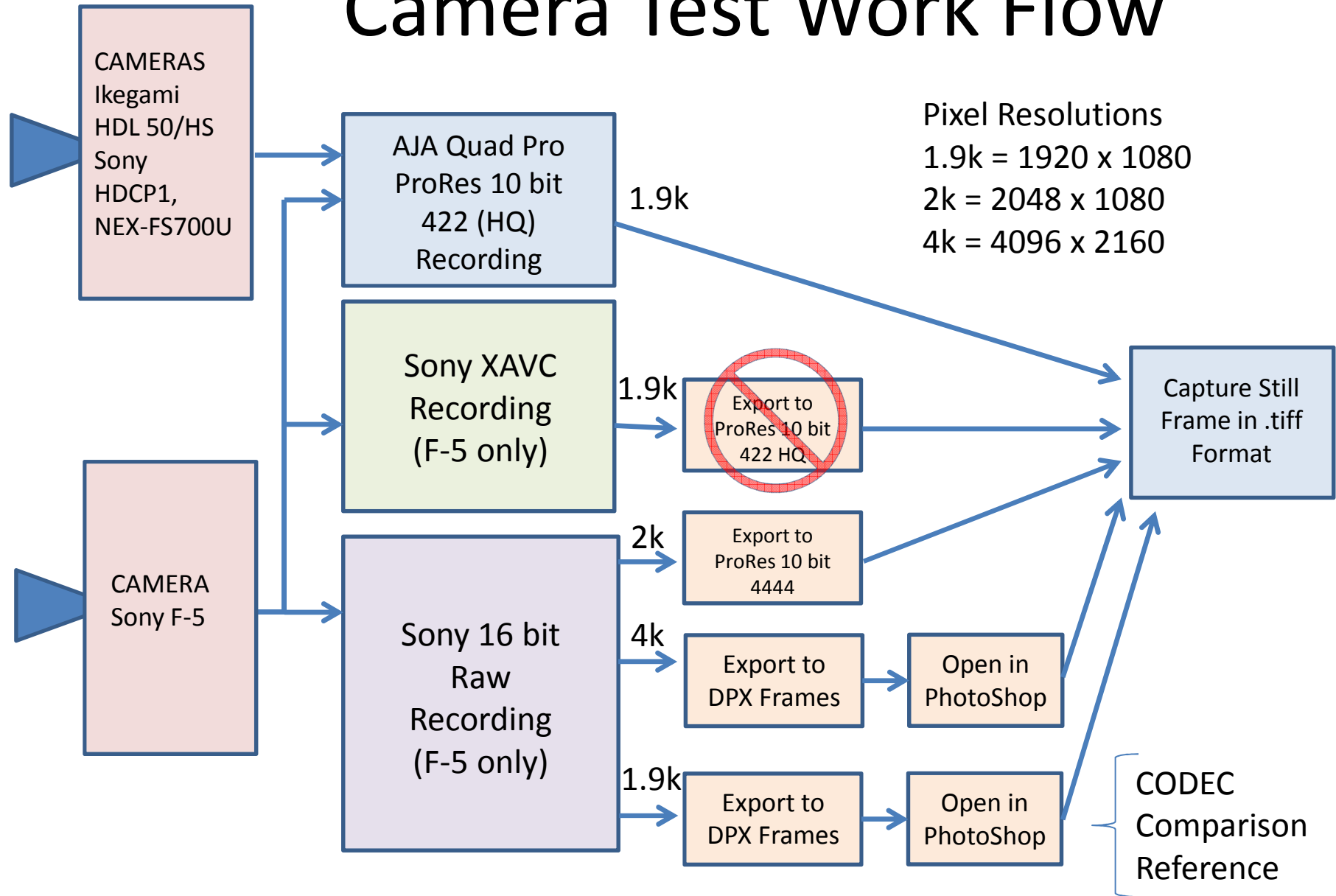
MBARI

chma@mbari.org

Camera Test Setup

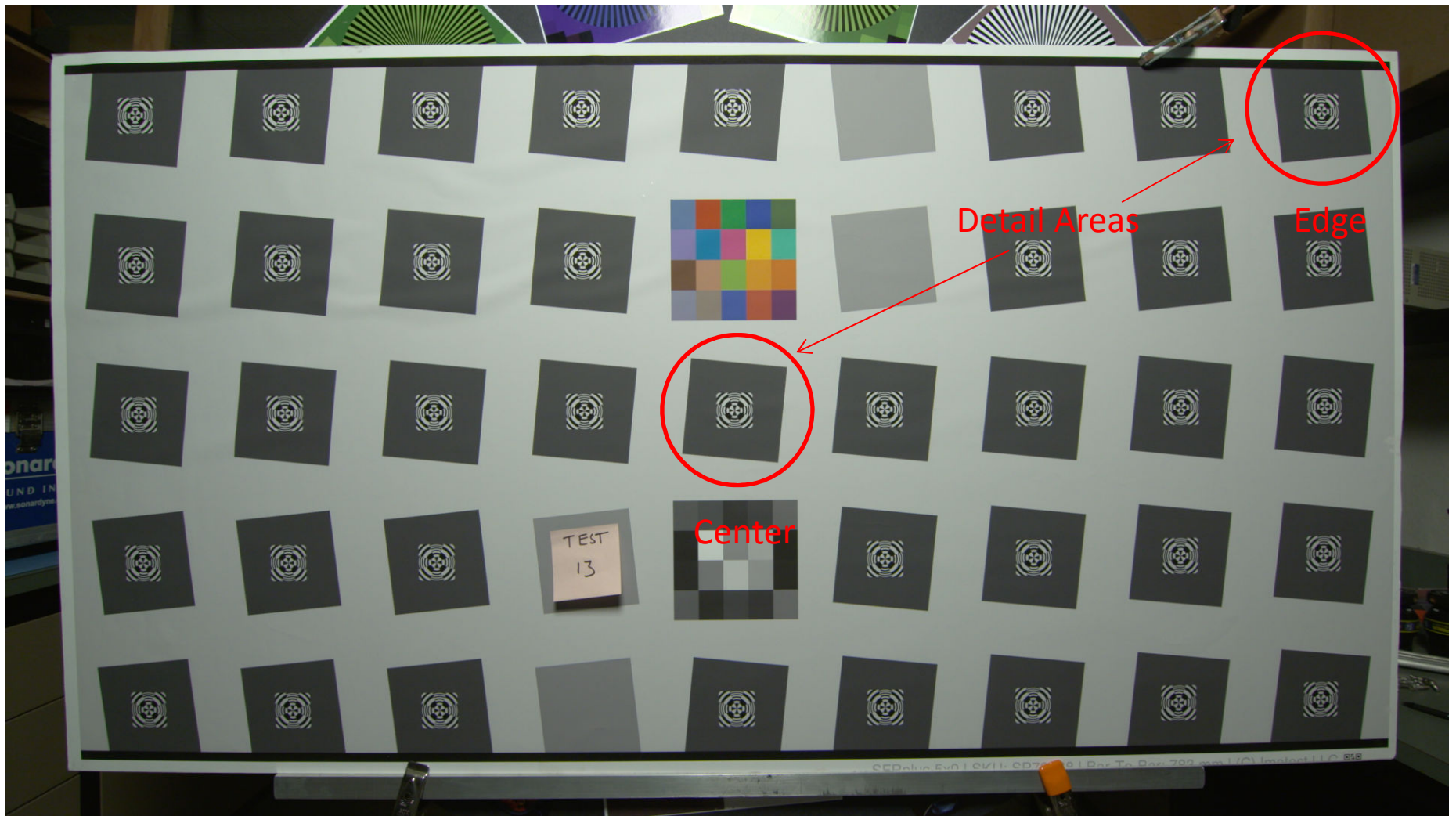


Camera Test Work Flow



Camera Detail Resolution Comparison Locations

Target Distance at "Sweet Spot" ~ 0.5 Meters From Dome



Sony F-5, SCL-P11X15 Lens, 400 lux, 70 IRE, Target 36 inches

2/3" Camera B4 Mount Lens Comparison

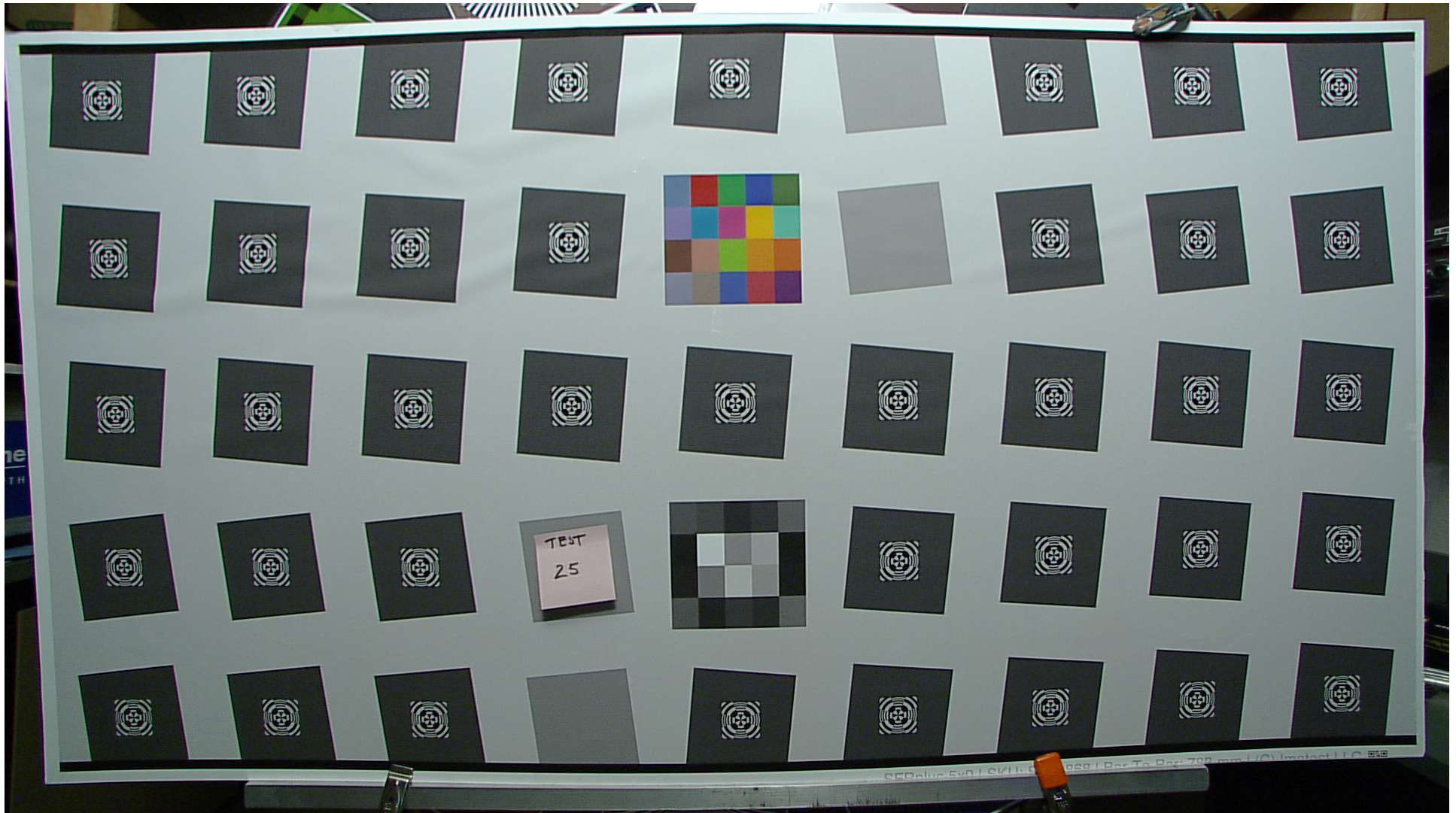
Fujinon HAeF5 5mm Prime

Vs

Zeiss Digi Prime T1,9 5mm

All Tests Done at 1920X1080 P60 Format
With ProRes 422(HQ) Codec

Ikegami HDL-50/HS and Fujinon HAeF5 5mm Lens



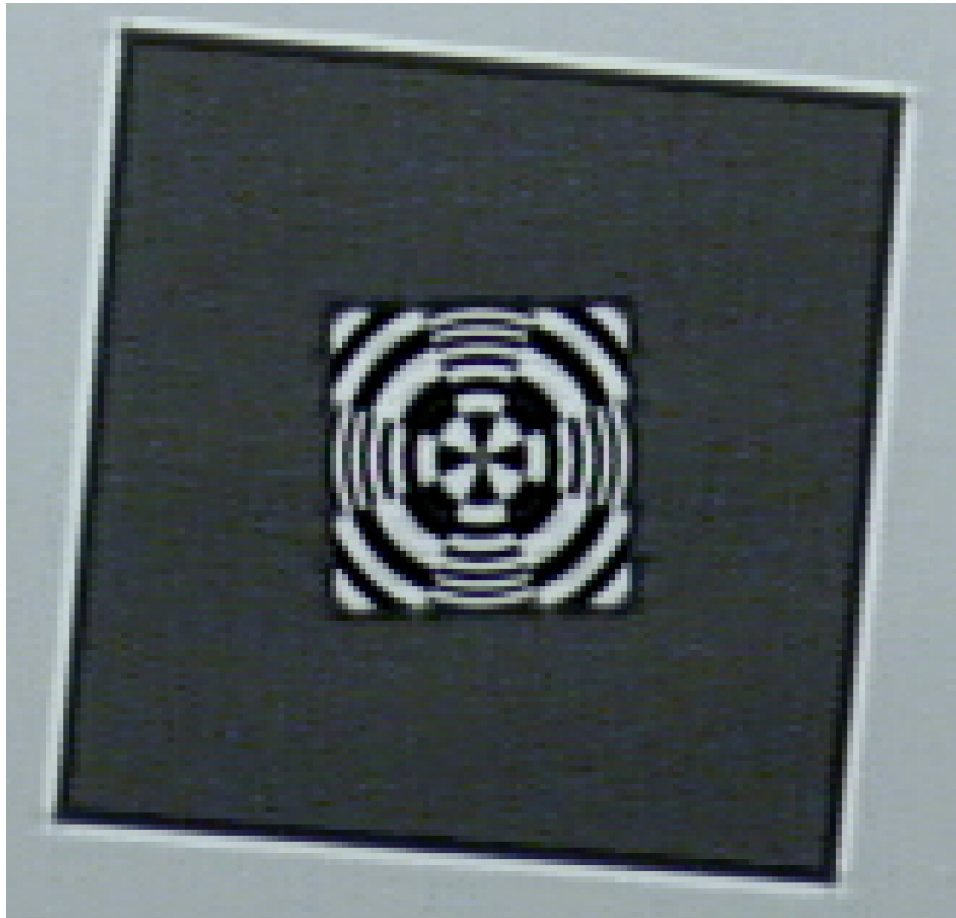
Ikegami HDL50/HS, 5mm Lens, 140 lux, 75 IRE, Target 38 inches File: Test_25.tiff

Ikegami HDL-50/H and Zeiss Digi Prime T1,9/5mm Lens



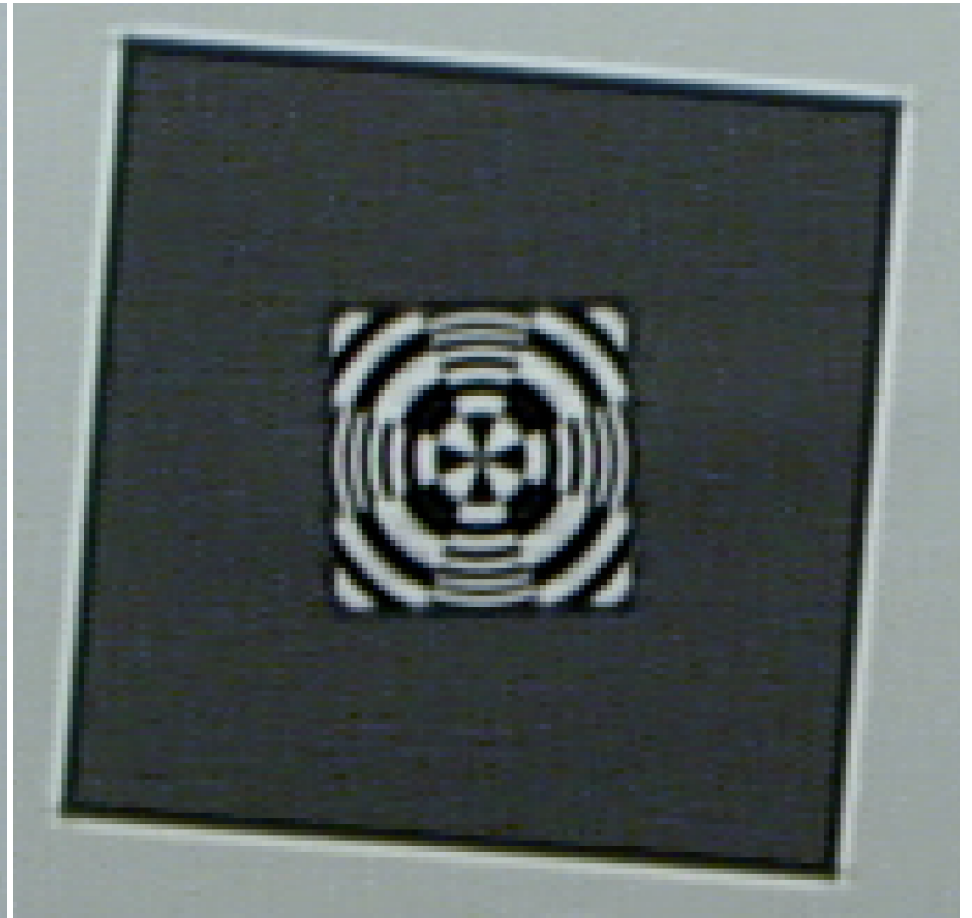
Ikegami HDL50/HS, 5mm Lens, 140 lux, 80 IRE, Target 39 inches File: Test_28.tiff

B4 Mount Lens Comparison - Center



Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches

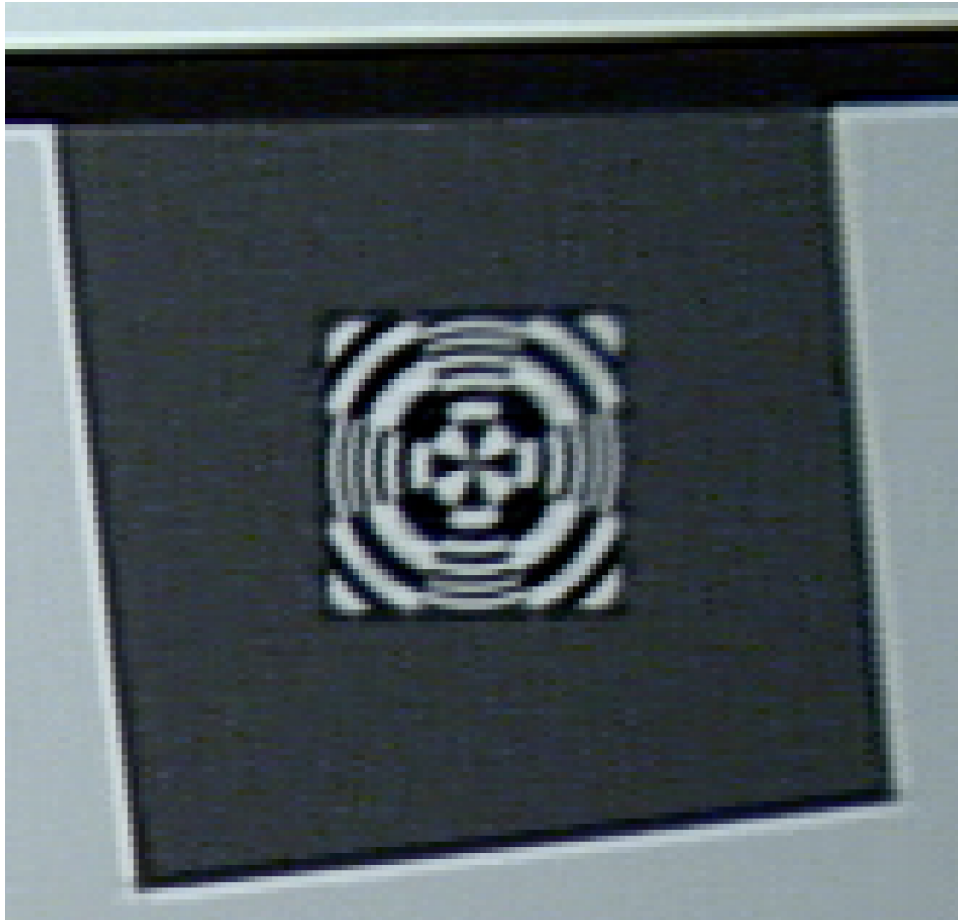
File: Test_28.tiff



Ikegami HDL-50/HS, Fujinon 5mm
Lens, 140 lux, 75 IRE, Target 38 inches

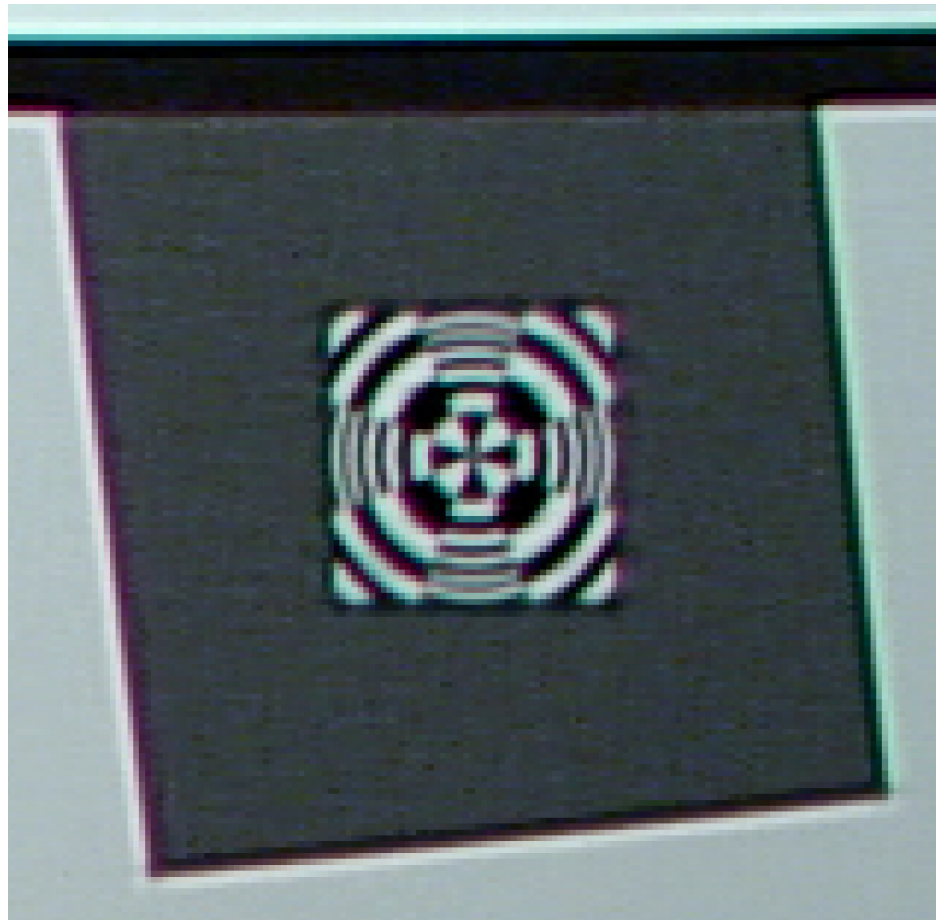
File: Test_25.tiff

B4 Mount Lens Comparison - Edge



Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches

File: Test_28.tiff



Ikegami HDL-50/HS, Fujinon 5mm
Lens, 140 lux, 75 IRE, Target 38 inches

File: Test_25.tiff

Camera Comparison

Sony HDCP1 vs. Ikegami HDL50/HS



The B4 Mount Lens Winner Was Used for The Camera Test
Zeiss Digi Prime T1,9/5mm

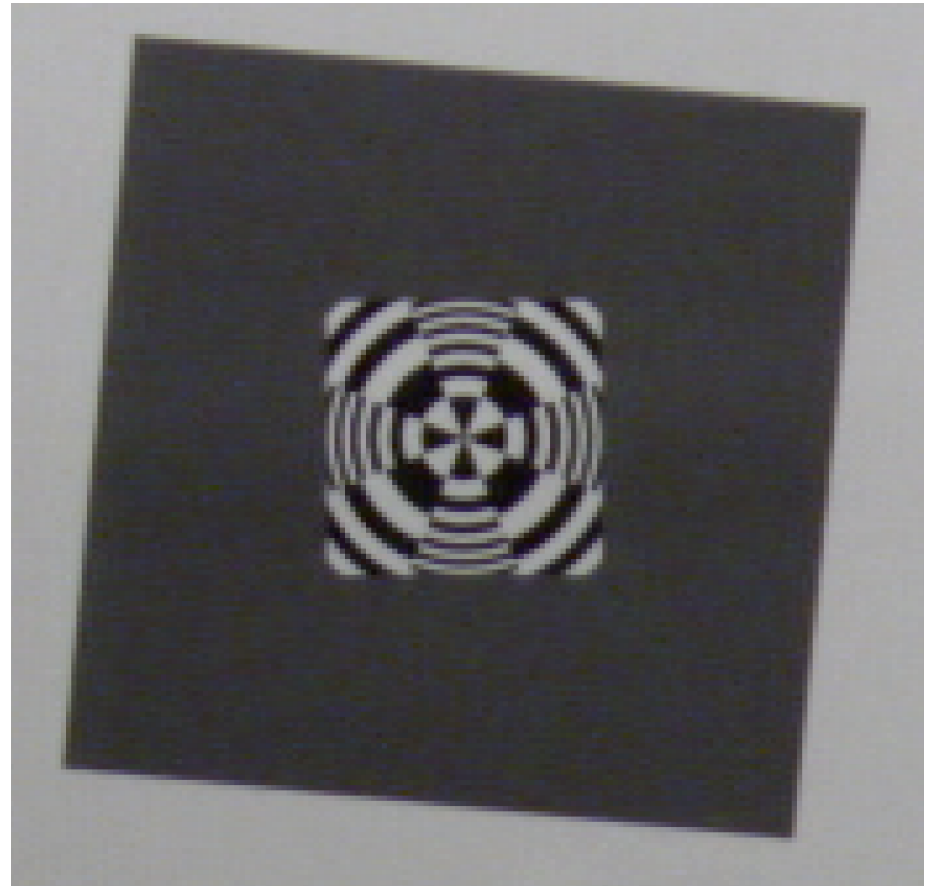
Sony HDCP1 vs. Ikegami HDL50/HS

Center Resolution



Sony HDCP1, Zeiss 5mm Lens, 160 lux, 85 IRE, Target 38 inches, detail ON (25)

File: Test_90.tiff



Ikegami HDL-50/HS, Zeiss 5mm Lens, 140 lux, 80 IRE, Target 38 inches detail OFF

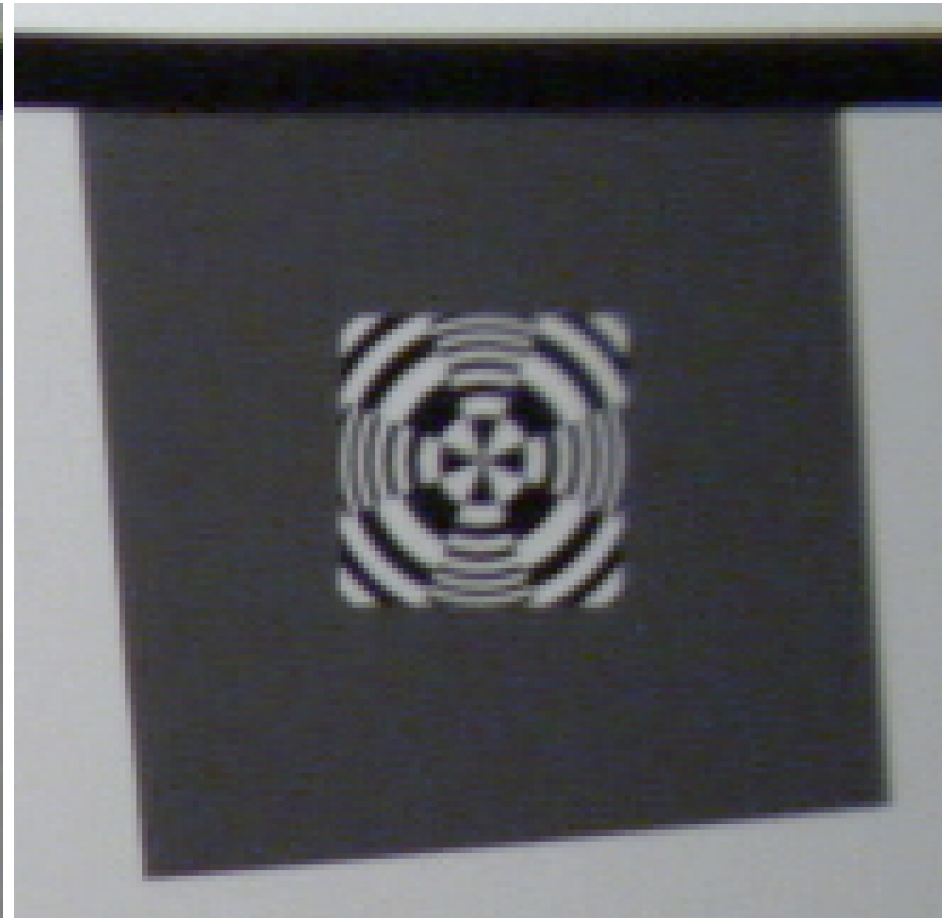
File: Test_77.tiff

Sony HDCP1 vs. Ikegami HDL50/HS

Edge Resolution



Sony HDCP1, Zeiss 5mm Lens, 160 lux, 85 IRE, Target 38 inches, detail ON (25)
File: Test_90.tiff



Ikegami HDL-50/HS, Zeiss 5mm Lens, 140 lux, 80 IRE, Target 38 inches
File: Test_77.tiff

Sony HDCP1 vs. Ikegami HDL50/HS

Color Reproduction (4:2:2 Format)

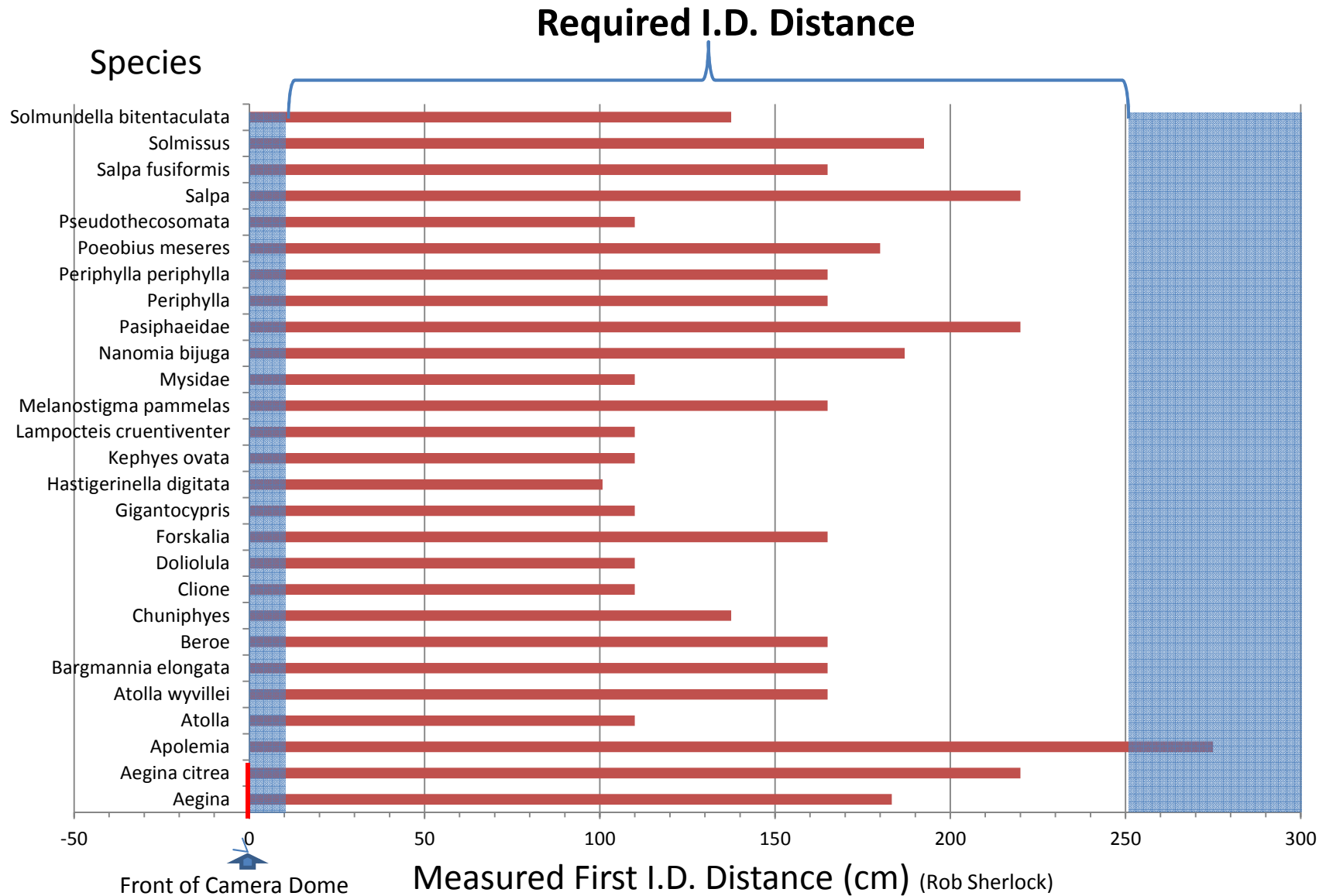


Sony HDCP1, Zeiss 5mm Lens, 160 lux,
85 IRE, Target 38 inches

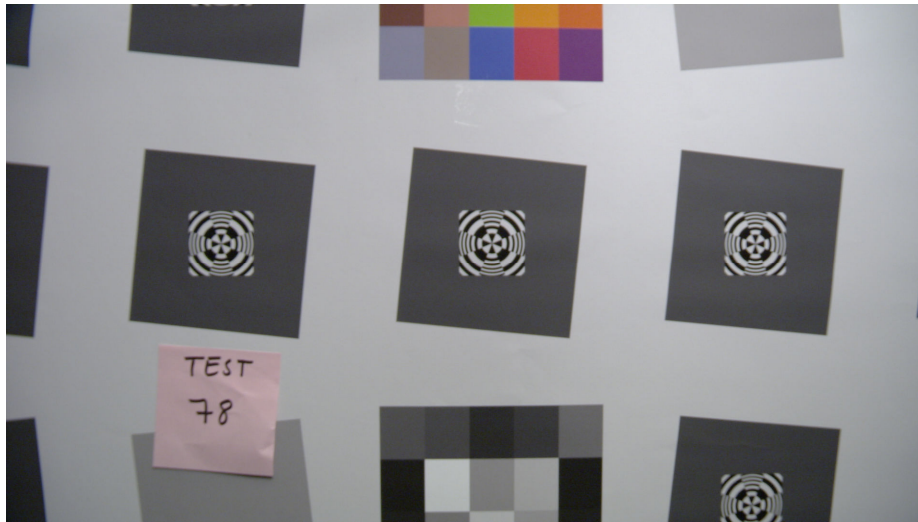


Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches

Distance Requirements for the Identification of Representative Organisms in the Camera Field-of View



Test Showing The Ikegami HDL-50/HS and Zeiss Digi Prime T1,9/5mm Lens Meets The i2MAP Depth of Field Requirements



Ikegami HDL-50/HS, Zeiss 5mm Lens, 170 lux, 80 IRE, Target 19.25 inches (10cm from dome equiv.), F 2.5, focus distance 35.5 inches
File: Test_78.tiff



Ikegami HDL-50/HS, Zeiss 5mm Lens, 170 lux, 80 IRE, Target 112 inches (2.5m from dome equiv.), F 2.5, focus distance 35.5 inches
File: Test_84.tiff

Super 35 Camera PL Mount Lens Comparison

Sony SCL-P11X15 Lens

Vs

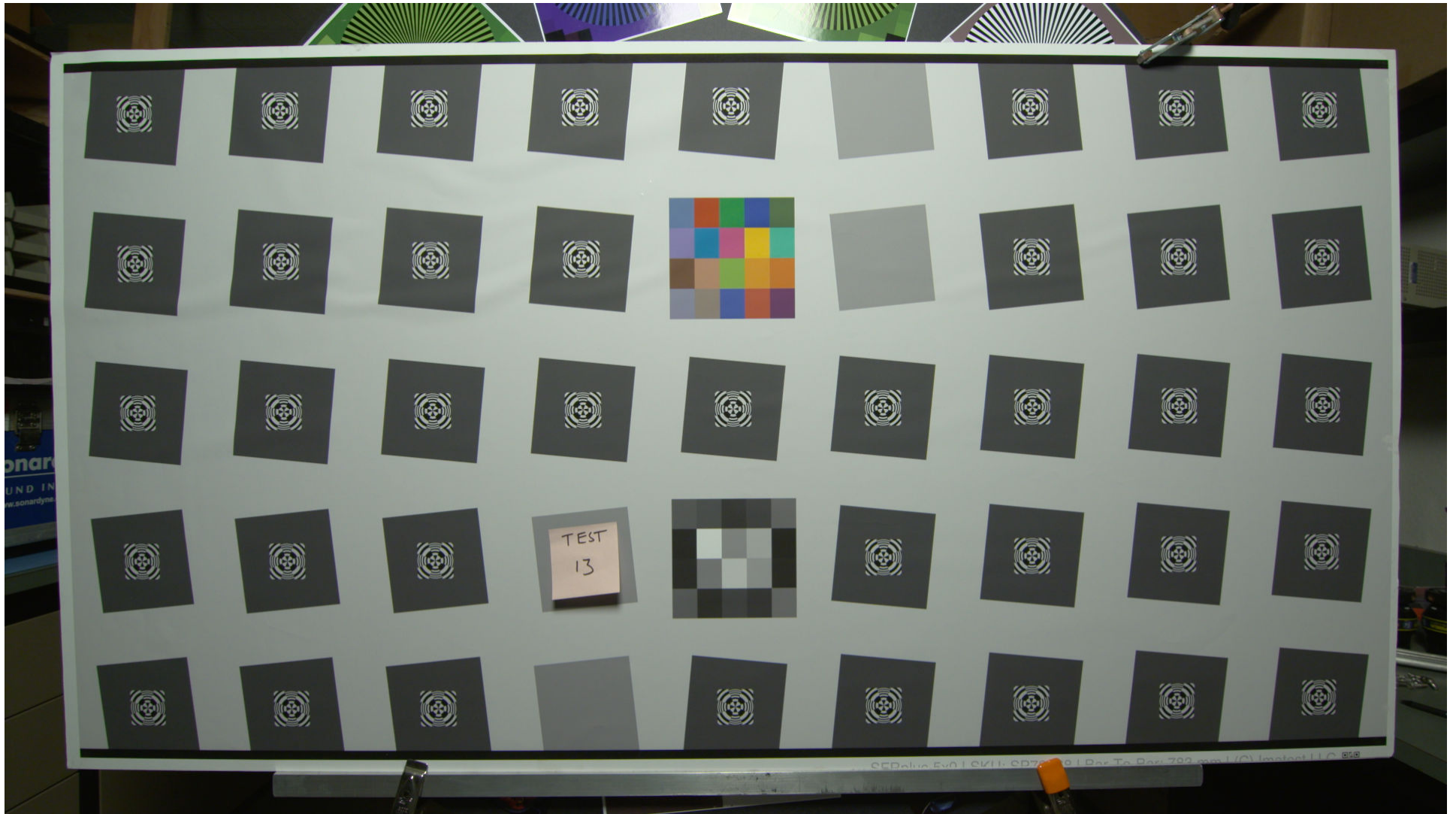
Optex/Zeiss Distagon 10.5mm Mk.2

Vs

Arri/Zeiss Distagon 12mm T2.1 Standard Prime

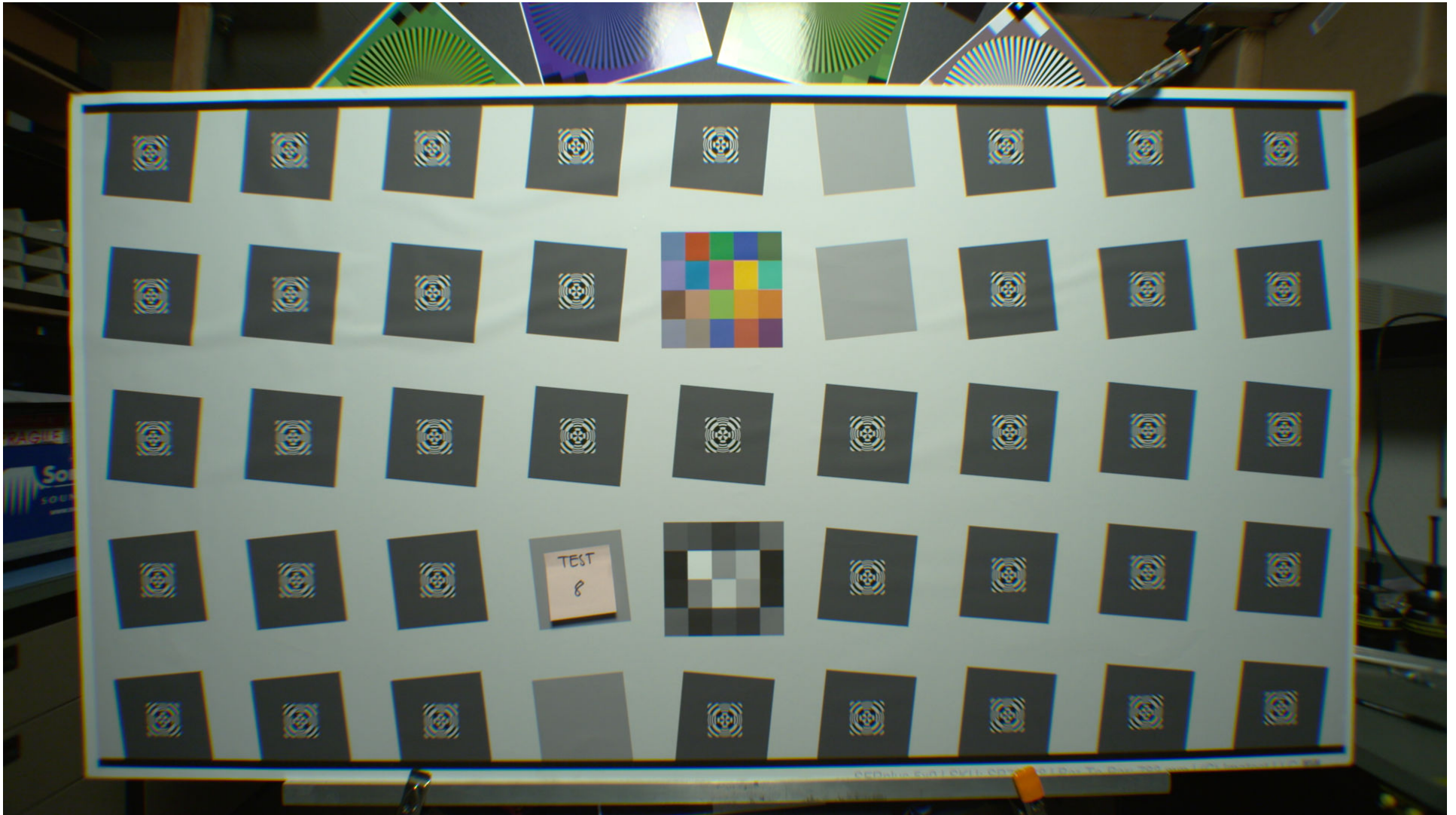
All Tests Done at 1920X1080 P60 Format
With ProRes 422(HQ) Codec

Sony F-5 and Sony SCL-P11X15 Lens



Sony F-5, SCL-P11X15 Lens, 400 lux, 70 IRE, Target 36 inches File: Test_13X.tiff

Sony F-5 and Optex/Zeiss Distagon 10.5mm Mk.2 Prime Lens



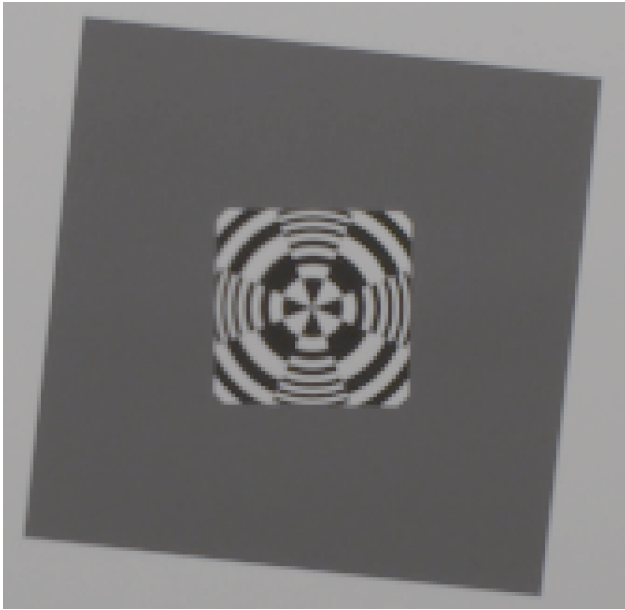
Sony F-5, Optex 10.5mm Lens, 400 lux, 80 IRE, Target 34 inches File: Test_8.tiff

Sony F-5 and Arri/Zeiss Distagon 12mm T2.1 Standard Prime Lens

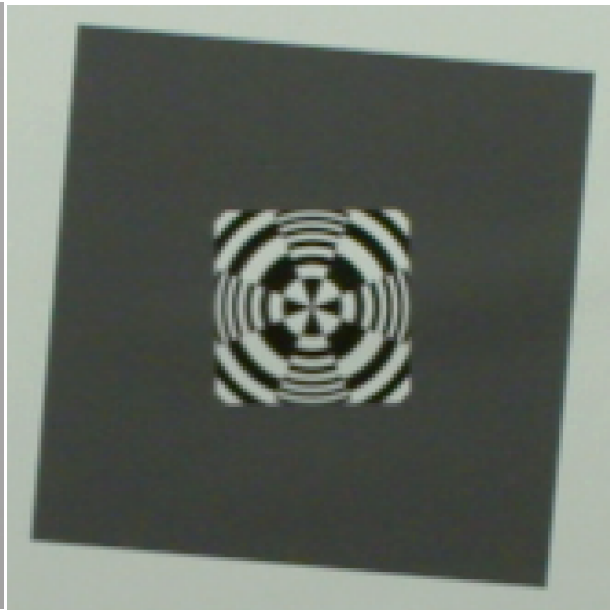


Sony F-5, Zeiss 12mm Lens, 520 lux, 70 IRE, Target 36 inches File: Test_12A.tiff

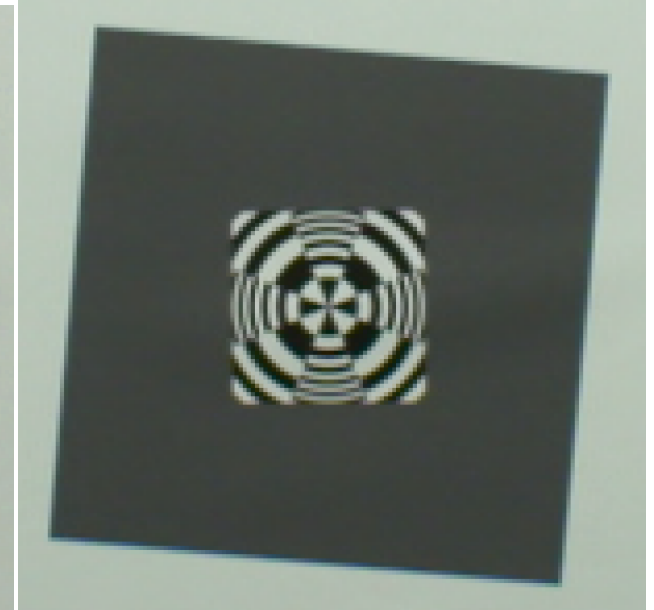
PL Mount Lens Comparison - Center



Sony F-5, SCL-P11X15 Lens,
400 lux, 70 IRE, Target 36
inches File: Test_13X.tiff

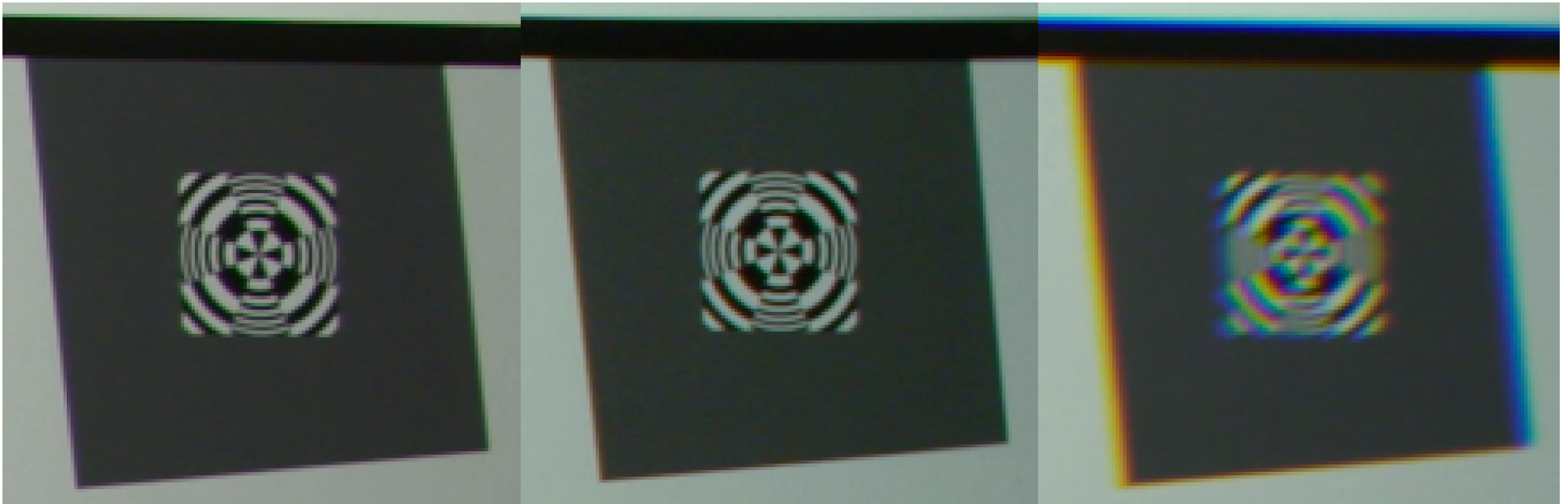


Sony F-5, Zeiss 12mm
Lens, 520 lux, 70 IRE,
Target 36 inches
File: Test_12A.tiff
(lightened 20%)



Sony F-5, Optex 12mm Lens,
400 lux, 80 IRE, Target 34
inches
File: Test_8.tiff

PL Mount Lens Comparison - Edge



Sony F-5, SCL-P11X15 Lens,
400 lux, 70 IRE, Target 36
inches File: Test_13X.tiff
(\$6000)

Sony F-5, Zeiss 12mm
Lens, 520 lux, 70 IRE,
Target 36 inches
File: Test_12A.tiff
(lightened 20%) (\$6,000
used, but no lens data)

Sony F-5, Optex 10.5mm
Lens, 400 lux, 80 IRE, Target
34 inches
File: Test_8.tiff (\$6500)

Camera Comparison

Sony NEX-FS700U vs. Ikegami HDL50/HS



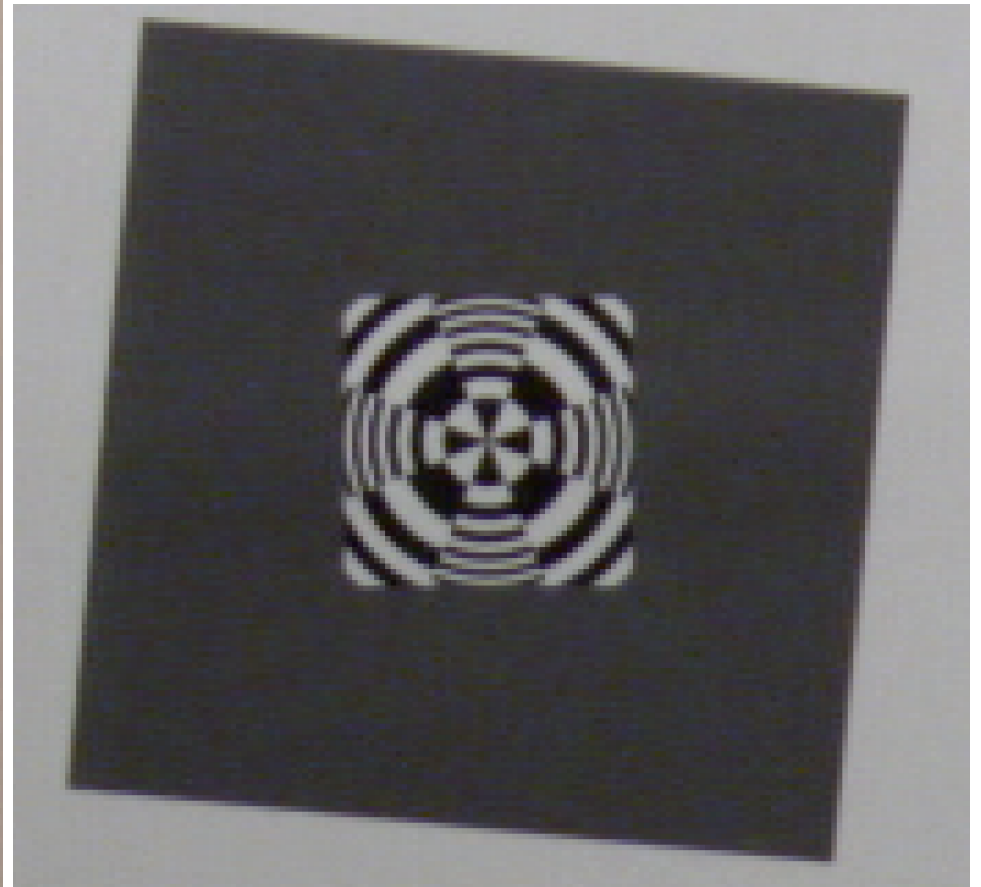
The PL and B4 mount Lens Winners Were Used for The Camera Test
Sony SCL-P11X15 Lens and Zeiss Digi Prime T1,9/5mm

Sony NEX-FS700U vs. Ikegami HDL50/HS

Center Resolution



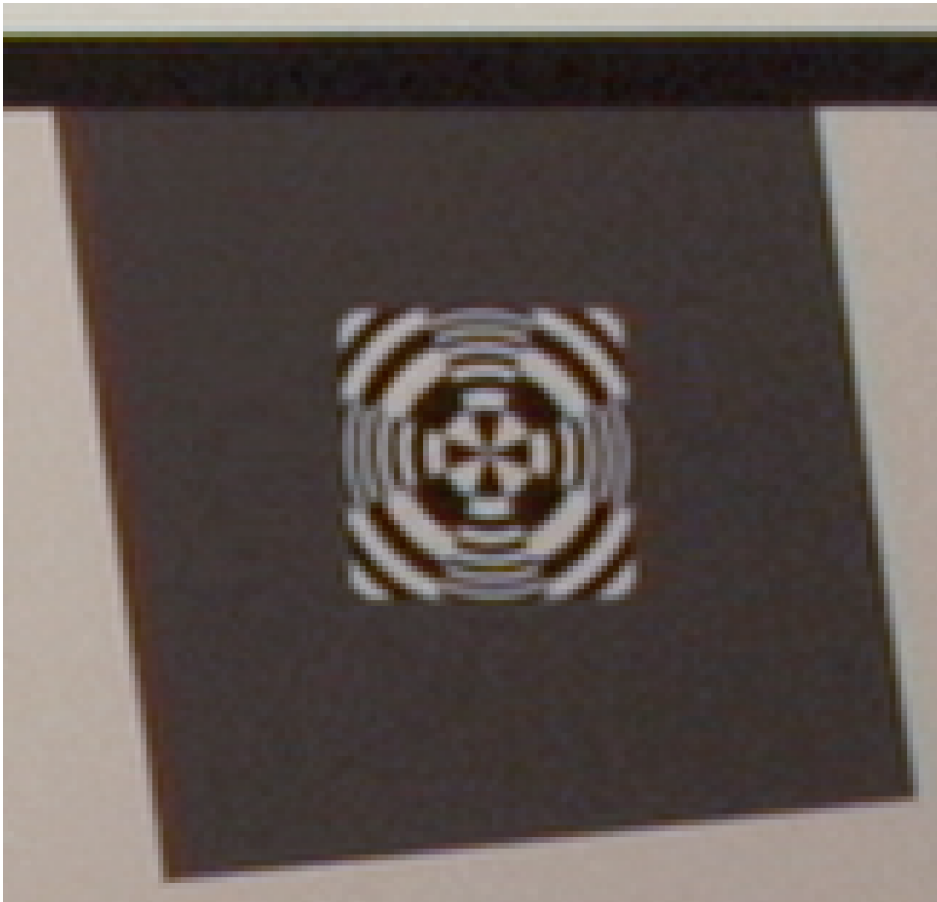
Sony NEX-FS700U, Sony 11mm Lens,
150 lux, ISO 2000, Target 34 inches,
(mild color correction) File: Test_33.tiff



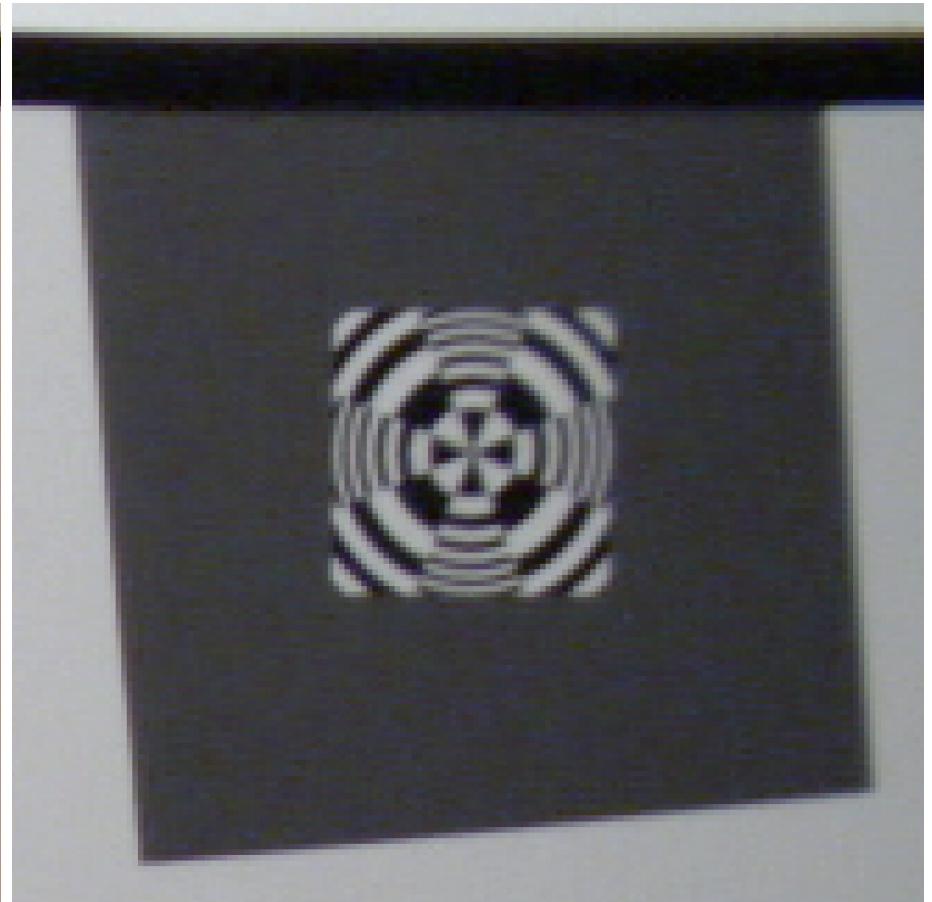
Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches
File: Test_77.tiff

Sony NEX-FS700U vs. Ikegami HDL50/HS

Edge Resolution



Sony NEX-FS700U, Sony 11mm Lens, 150 lux,
ISO 2000, Target 34 inches (mild color
correction) File: Test_33.tiff



Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches
File: Test_77.tiff

Sony NEX-FS700U vs. Ikegami HDL50/HS

Color Reproduction (4:2:2 Format)



Sony NEX-FS700U, Sony 11mm Lens,
150 lux, ISO 2000, Target 38 inches
(w/mild color correction)



Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches

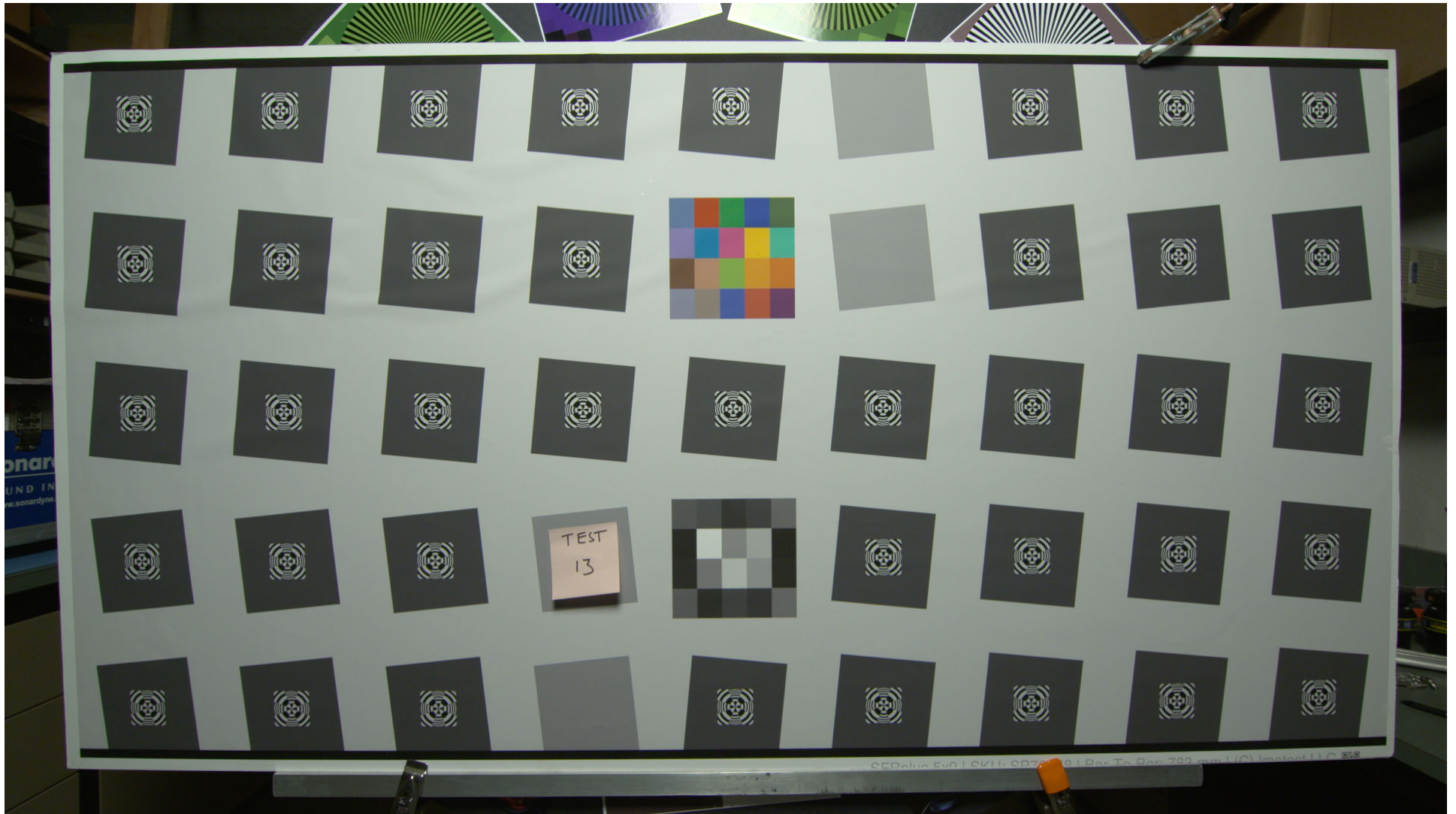
Camera Comparison

Sony F-5 vs. Ikegami HDL50/HS



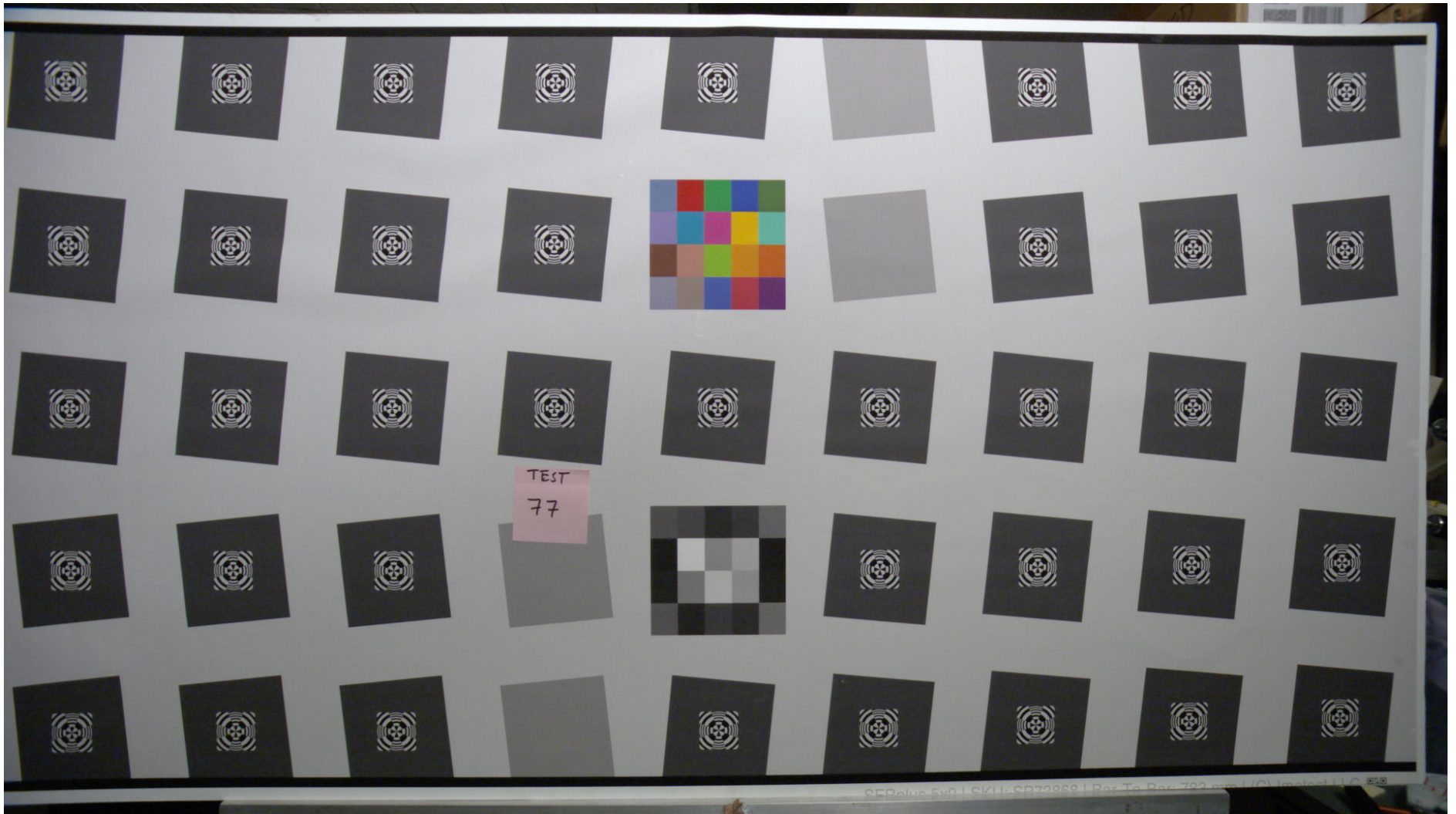
The PL and B4 mount Lens Winners Were Used for The Camera Test
Sony SCL-P11X15 Lens and Zeiss Digi Prime T1,9/5mm

Finalist #1 Sony F-5 and Sony SCL-P11X15 Lens



Sony F-5, SCL-P11X15 Lens, 400 lux, 70 IRE, Target 36 inches File: Test_13X.tiff

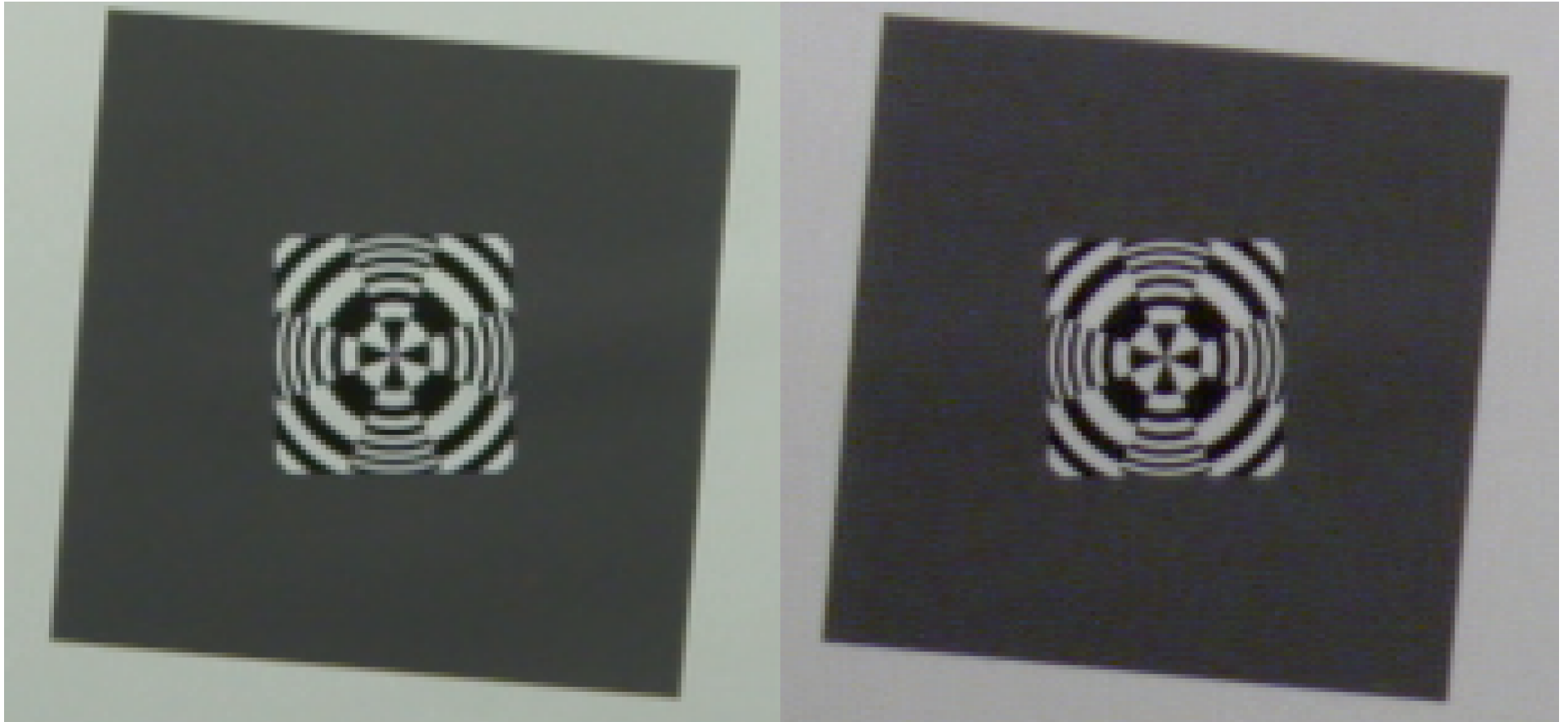
Finalist #2, Ikegami HDL-50/H and Zeiss Digi Prime T1,9/5mm Lens



Ikegami HDL50/HS, 5mm Lens, 140 lux, 80 IRE, Target 39 inches File: Test_77.tiff

Sony F-5 vs. Ikegami HDL50/HS

Center Resolution

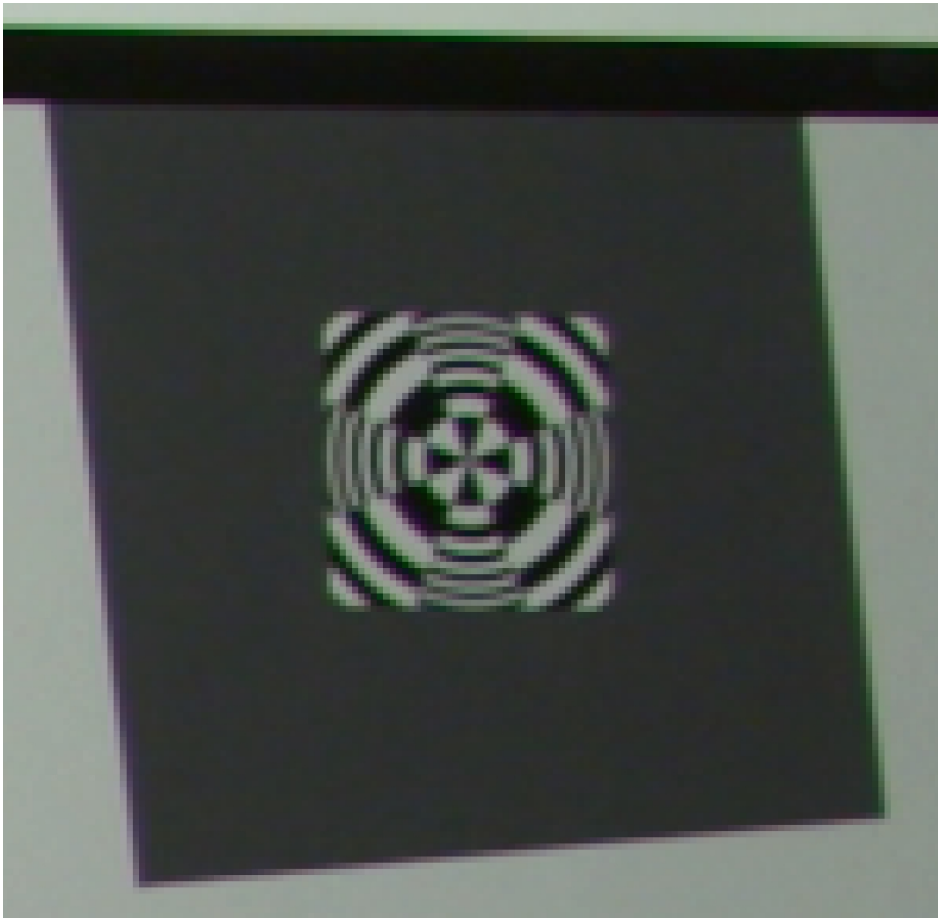


Sony F-5, Sony 11mm Lens, 400 lux,
ISO 800, Target 36 inches, 1920x 1080 P60
File: Test_13X.tiff

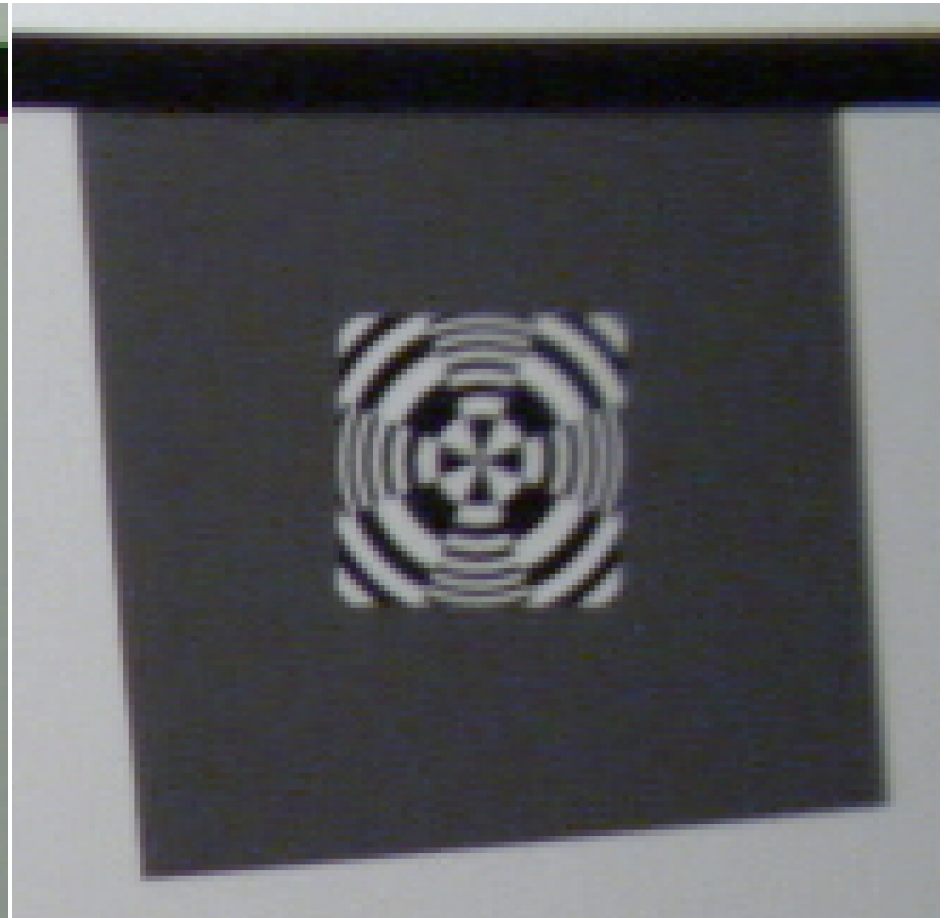
Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches
File: Test_77.tiff

Sony F-5 vs. Ikegami HDL50/HS

Edge Resolution



Sony F-5, Sony 11mm Lens, 400 lux,
ISO 800, Target 36 inches, 1920x 1080 P60
File: Test_13X.tiff



Ikegami HDL-50/HS, Zeiss 5mm Lens,
140 lux, 80 IRE, Target 38 inches
File: Test_77.tiff

Sony F-5 vs. Ikegami HDL50/HS

Color Reproduction (4:2:2 Format)

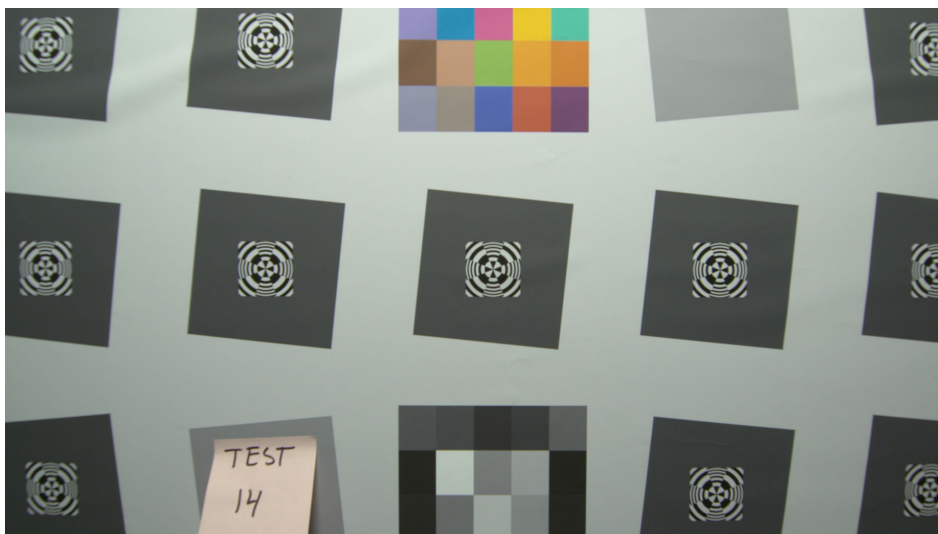


Sony F-5, Sony 11mm Lens, 400 lux, ISO 800, Target 36 inches, 1920x 1080 P60
(no color correction)



Ikegami HDL-50/HS, Zeiss 5mm Lens, 140 lux, 80 IRE, Target 38 inches
(no color correction)

Test Showing the Sony F-5 and the Sony SCL-P11X15 Lens Meets the i2MAP Depth of Field Requirements (at F 5.6)



Sony F-5, Sony SCL-P11X15 lens set to 11mm, 560 lux, 75 IRE, Target 18 inches (10cm from dome equiv.), F 5.6, focus distance 31.5 inches

File: Test_14.tiff



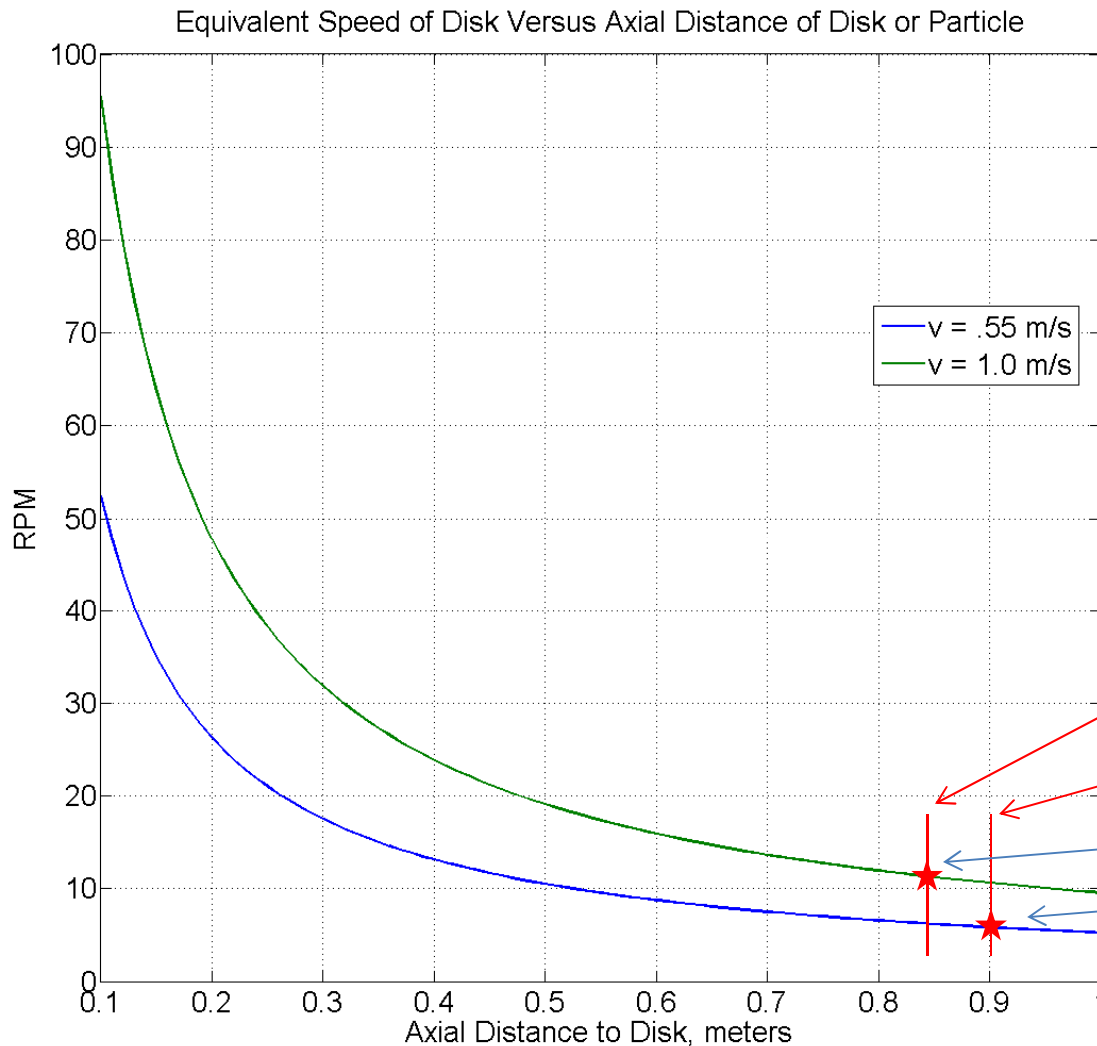
Sony F-5, Sony SCL-P11X15 lens set to 11mm, 560 lux, 75 IRE, Target 113 inches (2.5m from dome equiv.), F 5.6, focus distance 31.5 inches

File: Test_45.tiff

Temporal Resolution Testing

Rotating Test Target Reproduced Object Angular
Velocities Simulating AUV Speeds of 0.55 and
1.0 meters per second

Translation of Vehicle Motion to Focal-Plane



$$v^P = v^T \quad (1)$$

$$-f \frac{rv}{x_{3p}^2} = -f \frac{r}{x_{3t}} \omega \quad (2)$$

$$\omega = \frac{vx_{3t}}{x_{3p}^2} \quad (3)$$

$$\omega = \frac{v}{x_3} \quad (4)$$

x_{3p} – focal plane to particle

x_{3t} – focal plane to disk

Eqn. 3 $\Rightarrow$ 4 if they're equal.

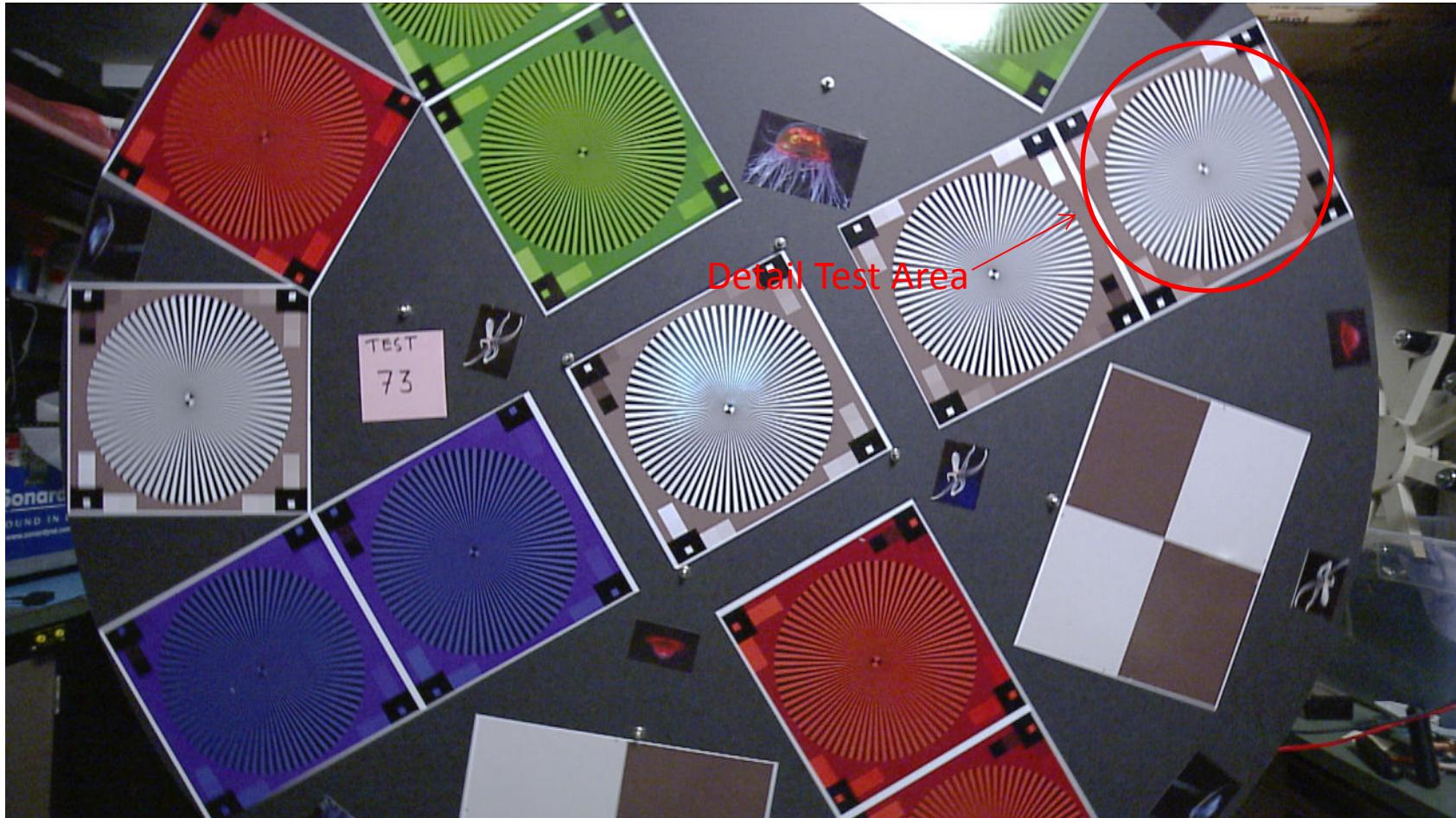
Super-35 Camera Distance
(adjusted for 0.5 meters from dome front)

2/3" Camera Distance

1.0 m/sec. = 11 RPM

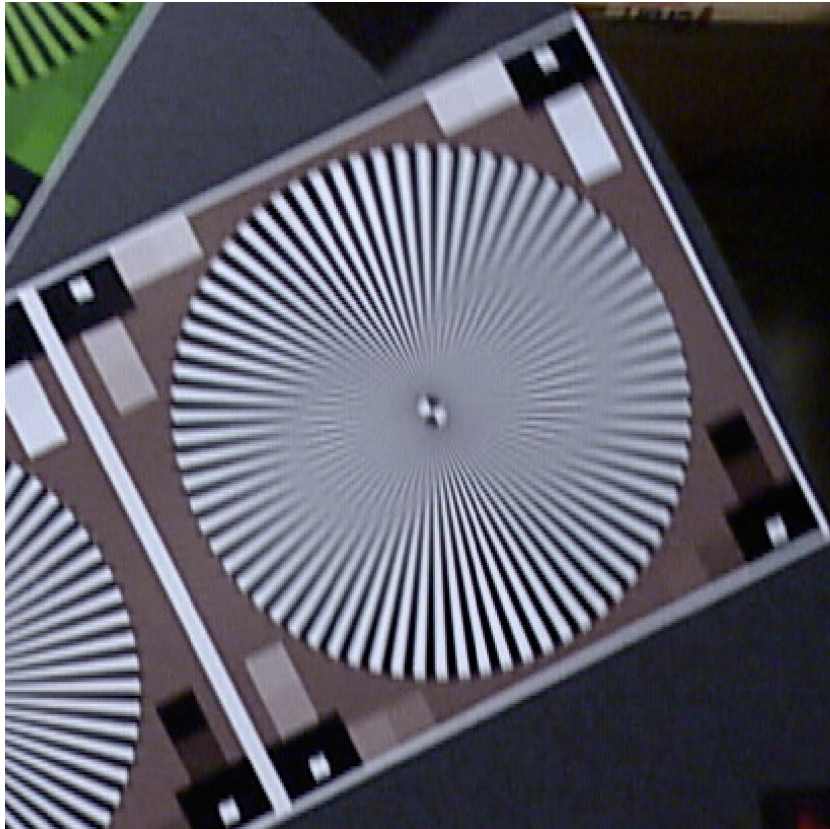
0.55 m/sec. = 6 RPM

Temporal Resolution, Can We Get Good Image Quality at 1 Meter Per Second? Enter The Wheel of Death

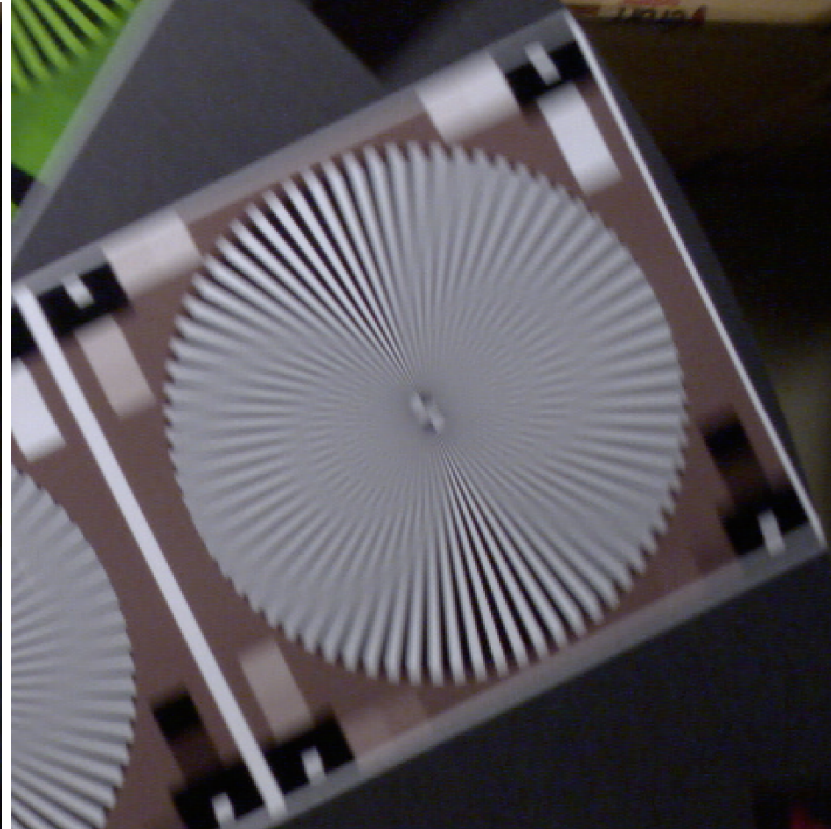


Ikegami HDL50/HS, Zeiss 5mm Lens, 100 lux, 1920x 1080i 30
Disk 6 RPM (~ 0.5 m/sec), File: Test_73_White.tiff (DeInterlaced)

Comparison of Current (0.5 m/sec.) and Planned (1.0 m/sec.)
Temporal Resolution at the 0.5 Meter from Dome “Sweet Spot”.

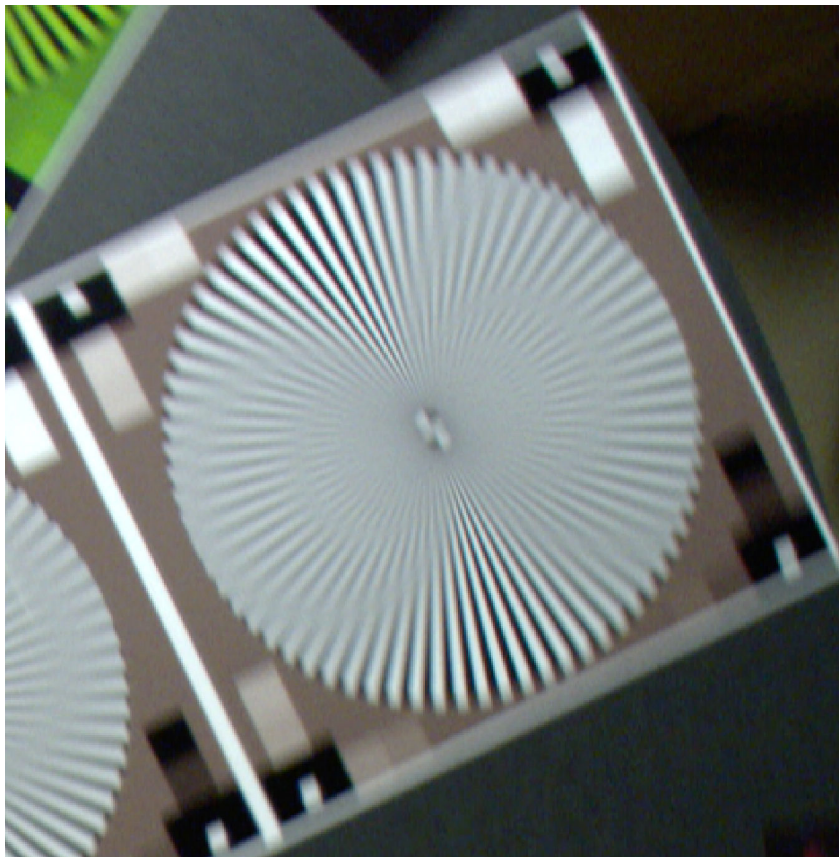


Ikegami HDL50/HS, Zeiss 5mm Lens,
110 lux, 1920x 1080i 30
Disk 6 RPM (~ 0.5 m/sec)
File: Test_73_White.tiff (DeInterlaced)

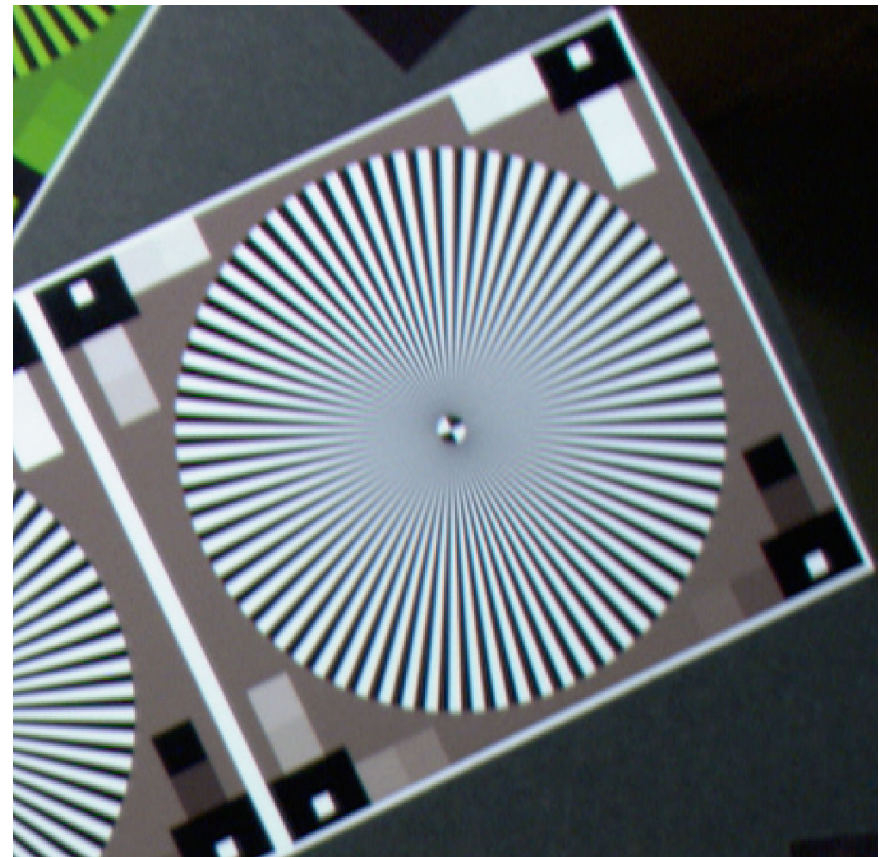


Ikegami HDL50/HS, Zeiss 5mm Lens,
170 lux, 1920x 1080 P60
Disk 11 RPM (~ 1 m/sec)
File: : Test_76_White.tiff

The Effect of Camera Shutter at The Planned (1.0 m/sec.) AUV Velocity tested at the 0.5 Meter from Dome “Sweet Spot”.

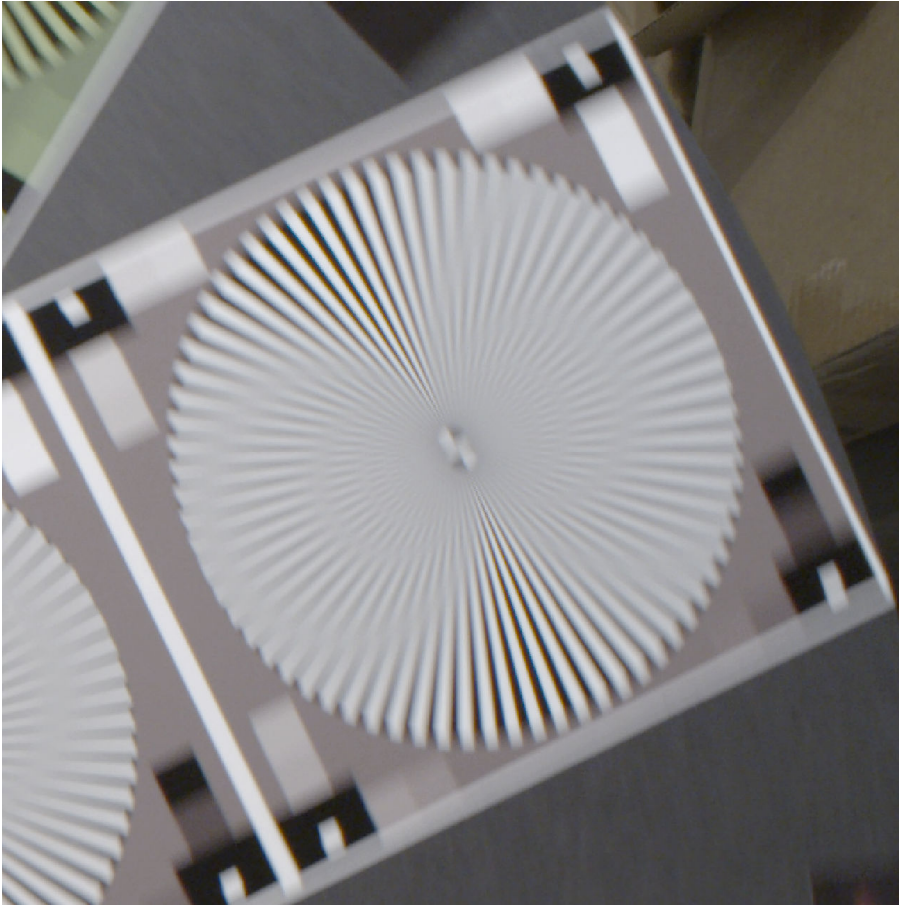


Sony HDCP1, Zeiss 5mm Lens,
120 lux, 1920x 1080 P60
Disk 11 RPM (~ 1 m/sec), No Shutter
File: Test_66_White.tiff



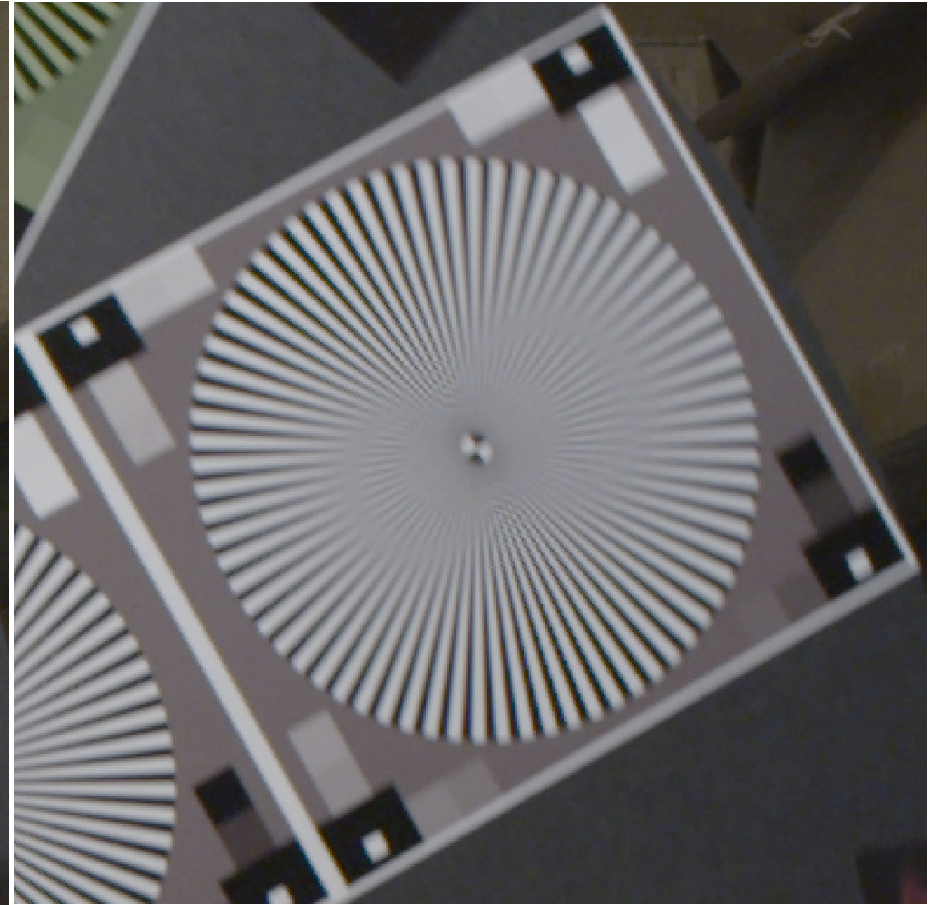
Sony HDCP1, Zeiss 5mm Lens,
800 lux, 1920x 1080 P60
Disk 11 RPM (~ 1 m/sec), Shutter 1/250
File: Test_68_White.tiff

What is the Advantage of Frame Rates Higher Than 60 FPS? – 120FPS



Sony F-5, Zeiss 12mm Lens, 2000 EI, 700 lux
4K 60 FPS

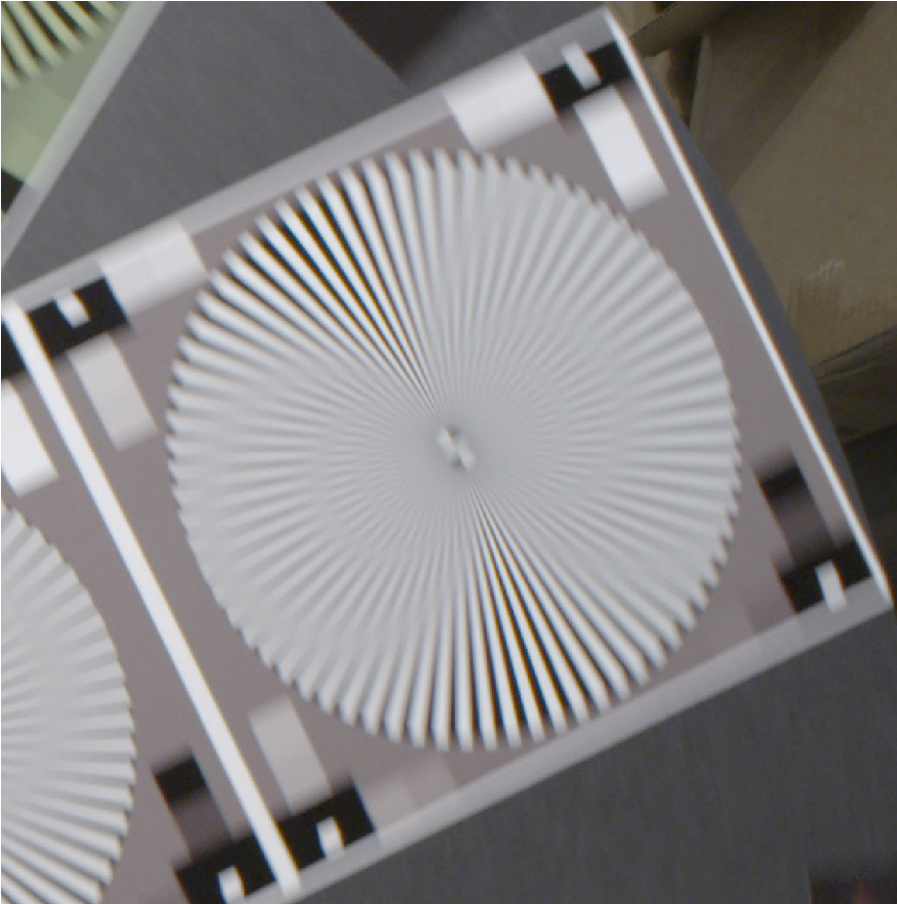
File: Test_57B_4k444_White.tiff



Sony F-5, Zeiss 12mm Lens, 2000 EI, 640 lux
2K 120 FPS

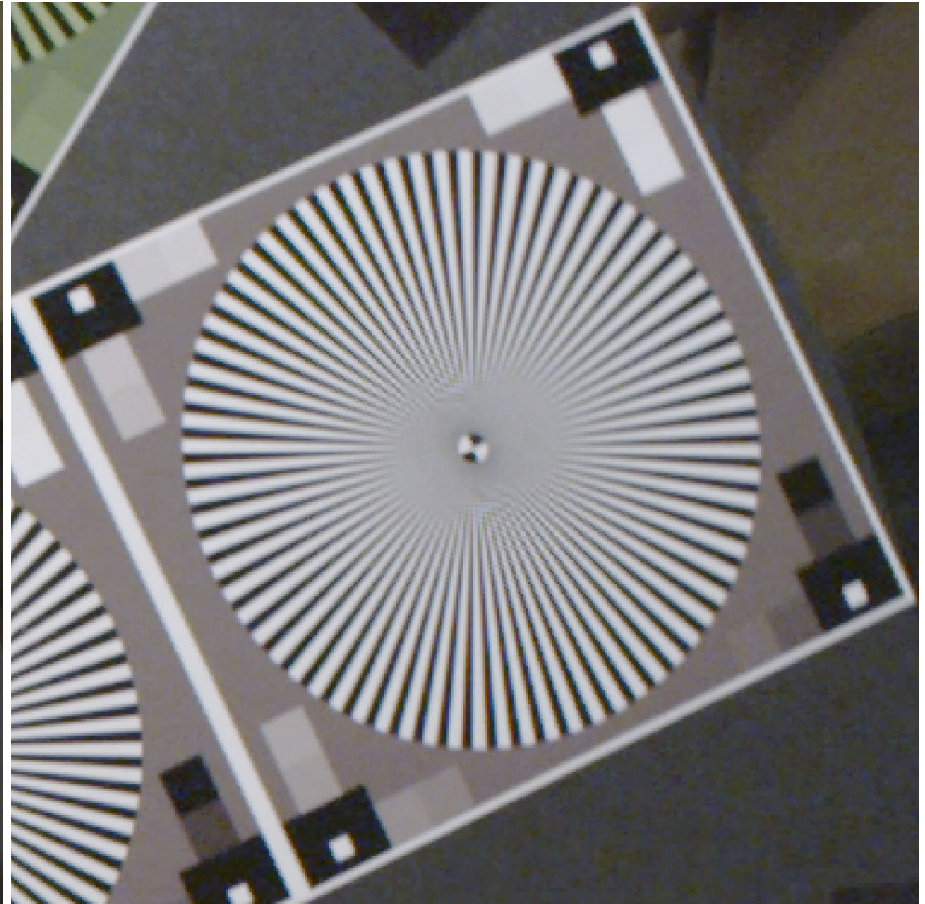
File: Test_59_2k444_White.tiff

What is the Advantage of Frame Rates Higher Than 60 FPS? – 240 FPS



Sony F-5, Zeiss 12mm Lens, 2000 EI, 700 lux
4K 60 FPS

File: Test_57B_4k444_White.tiff



Sony F-5, Zeiss 12mm Lens, 3200 EI, 640 lux
2K 240 FPS (adjusted brightness +20%)

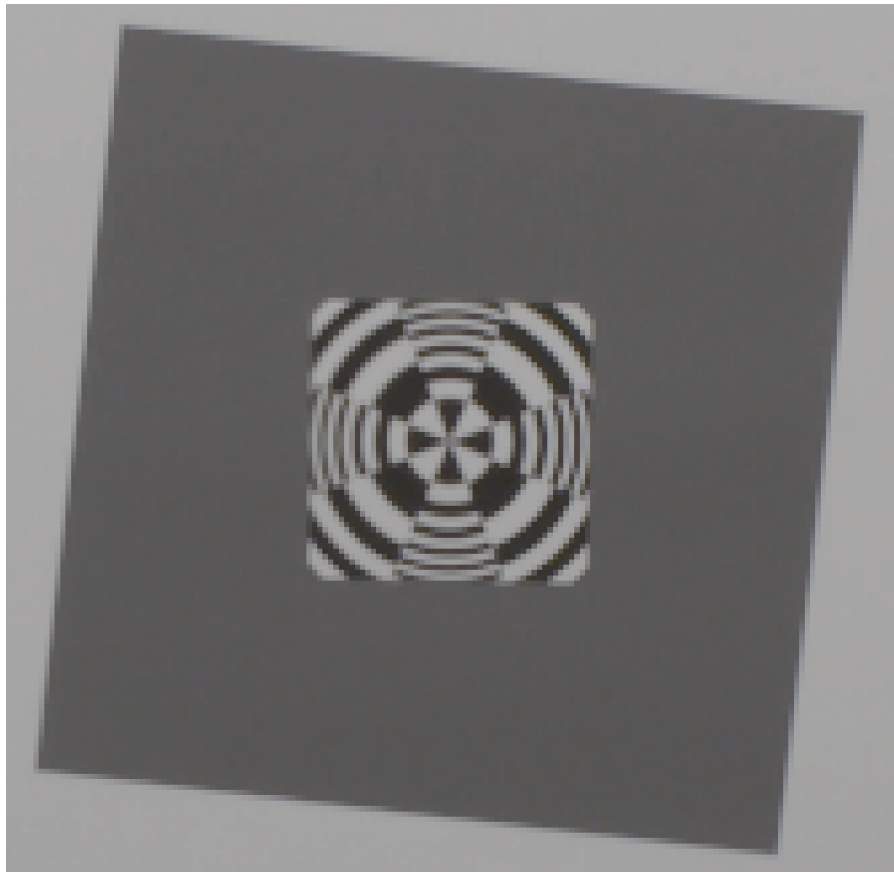
File: Test_61B_2k444_White.tiff

Additional Testing

- Comparison of increased camera resolutions:
 - 1920 X 1080 to 2048 X 1080 lines (2k) resolutions.
 - 1920 X 1080 to 4096 X 2160 lines (4k) resolutions.
- Color Space Comparison, 422 vs 444 encoding.
- Video Compression CODEC Testing
 - Can a difference be seen between uncompressed video and Apple ProRes 422(HQ) video?
 - Apple ProRes 422(HQ) vs Sony XACV

Sony F-5 1920 X 1080 vs. Sony F-5 2048 X 1080 (2K)

Center Resolution



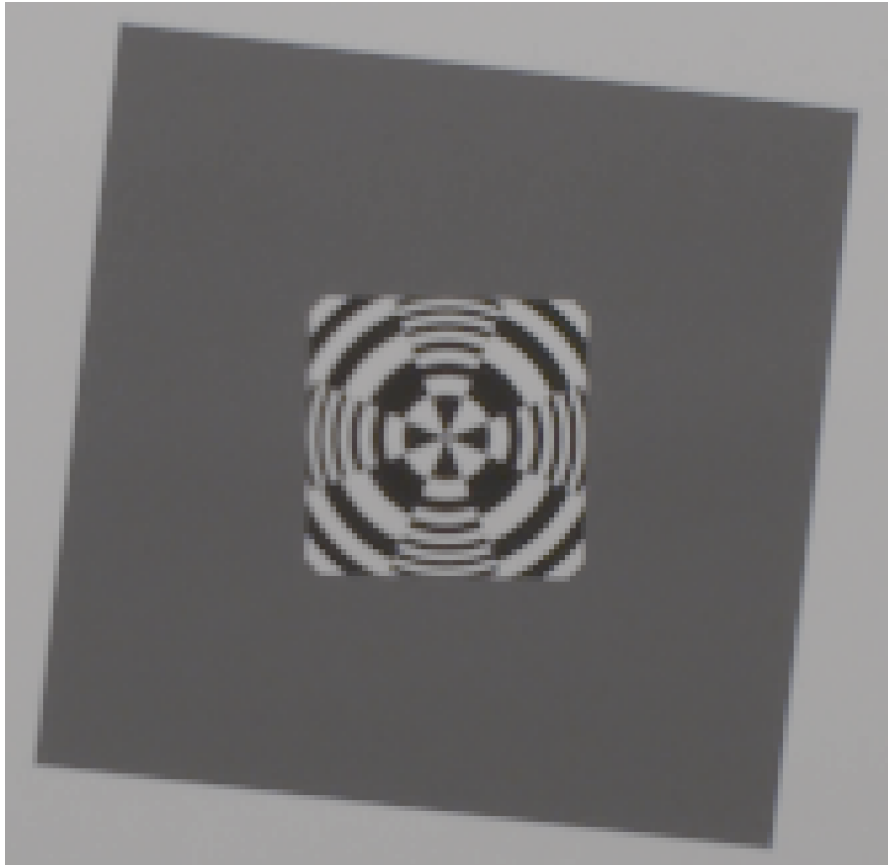
Sony F-5, Zeiss 12mm Lens, 400 lux,
IE 800, Target 36 inches, 1920x 1080 P60
(no color correction)
File: Test_54_1920_4444.tiff



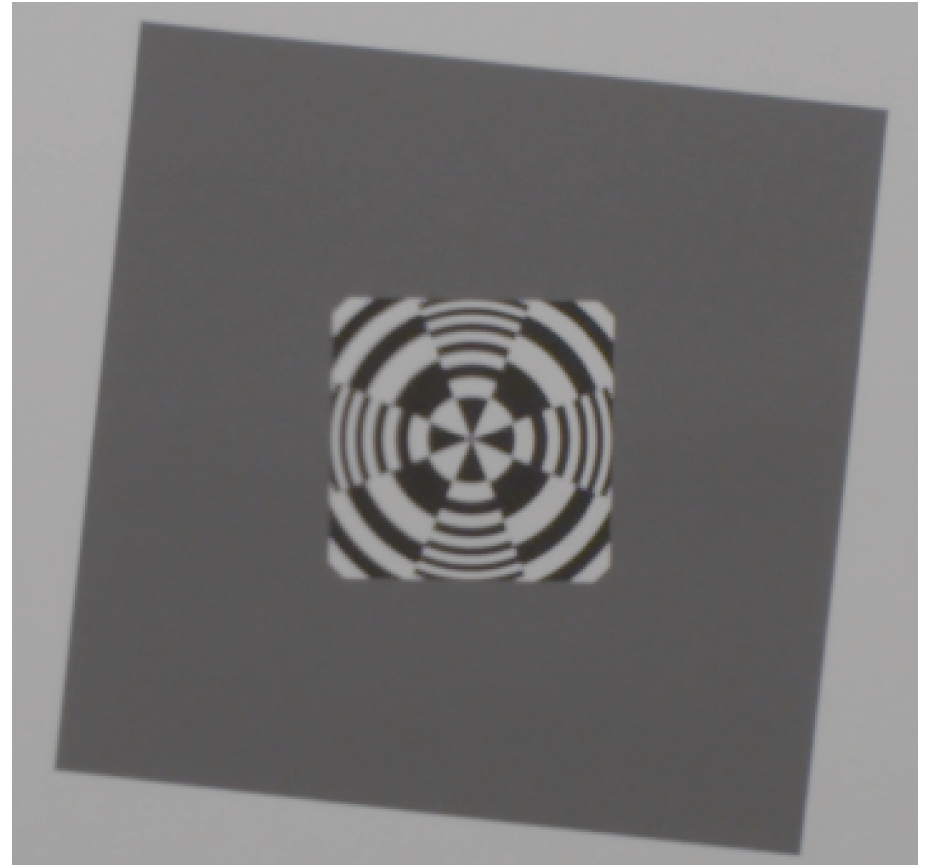
Sony F-5, Zeiss 12mm Lens, 800 lux,
IE 2000, Target 34 inches, 2K P60
(no color correction)
File: Test_54_2K.tiff

Sony F-5 1920 X 1080 vs. Sony F-5 4096 X 2160 (4K)

Center Resolution



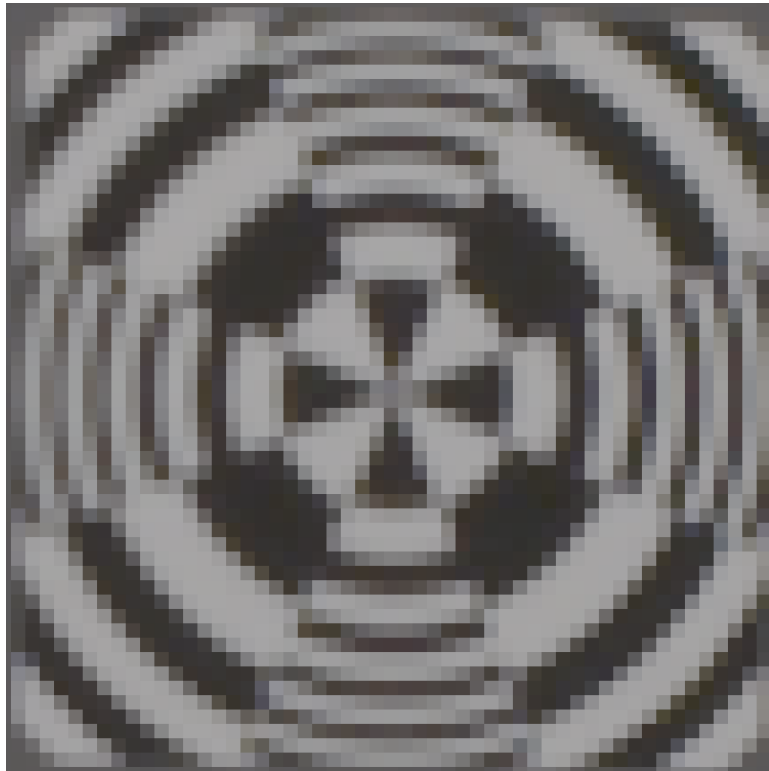
Sony F-5, Zeiss 12mm Lens, 400 lux,
IE 800, Target 36 inches, 1920x 1080 P60
(no color correction)
File: Test_54_1920_4444.tiff



Sony F-5, Zeiss 12mm Lens, 800 lux,
IE 2000, Target 34 inches, 4K P60
(no color correction)
File: Test_54_4K4444.tiff

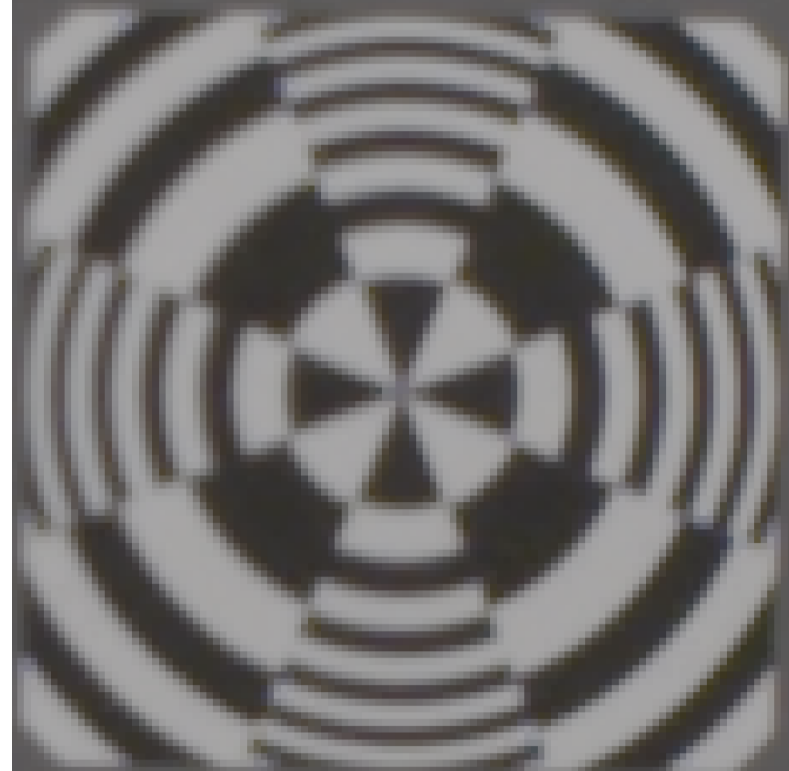
Sony F-5 1920 X 1080 vs. Sony F-5 4096 X 2160 (4K)

Center Resolution - Detail



Sony F-5, Zeiss 12mm Lens, 400 lux, ISO 800, Target 34 inches, 1920x 1080 P60
(no color correction)

File: Test_54_1920_4444.tiff



Sony F-5, Zeiss 12mm Lens, 800 lux, IE 2000, Target 34 inches, 4K P60
(no color correction)

File: Test_54_4K4444.tiff

Sony F-5 1920 X 1080 vs. Sony F-5 4096 X 2160 (4K)

Edge Resolution

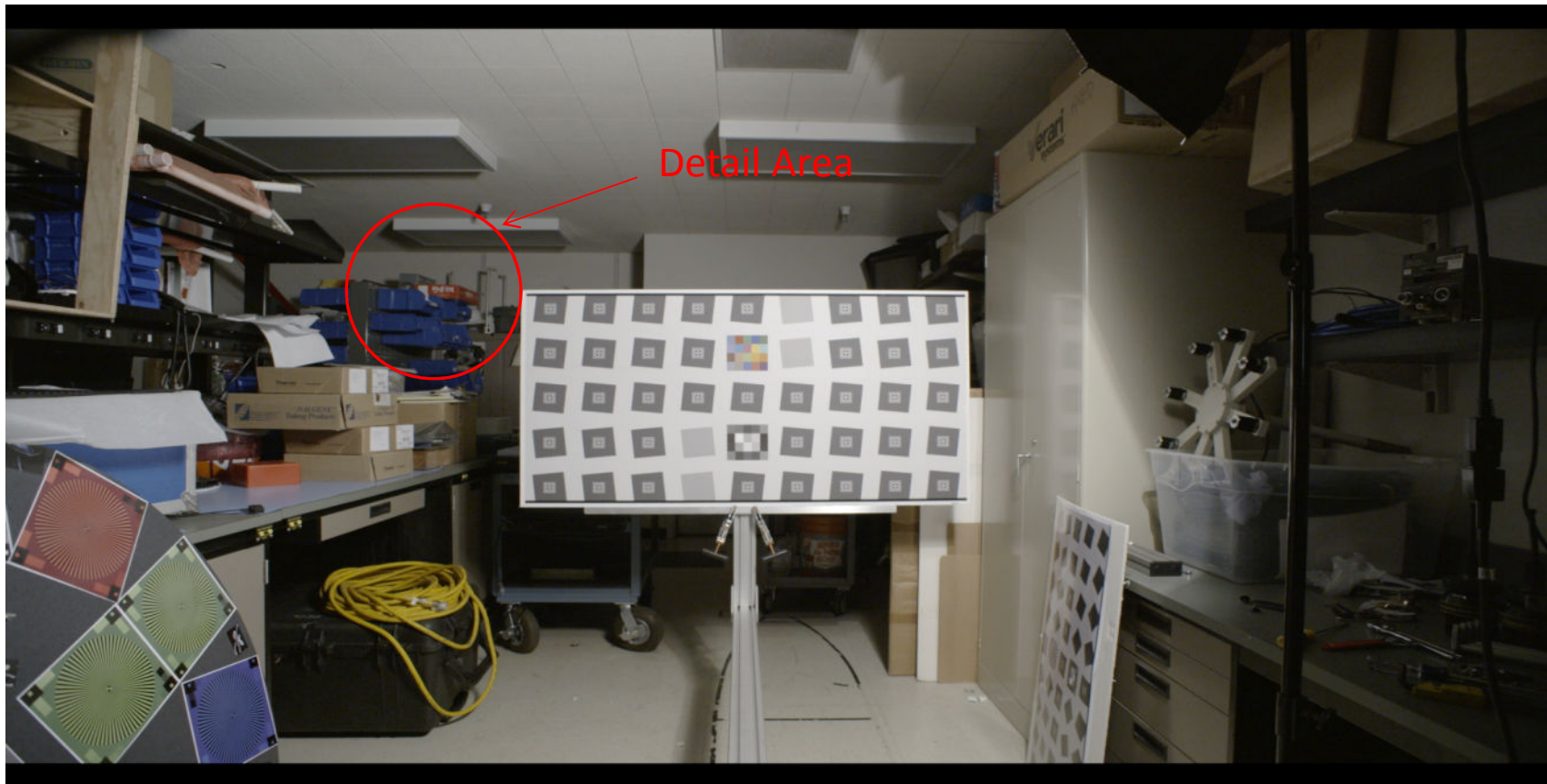


Sony F-5, Zeiss 12mm Lens, 400 lux, ISO 800, Target 34 inches, 1920x 1080 P60
(no color correction)
File: Test_54_1920_4444.tiff



Sony F-5, Zeiss 12mm Lens, 800 lux, IE 2000, Target 34 inches, 4K P60
(no color correction)
File: Test_54_4K4444.tiff

Sony F-5 1920 X 1080 vs. Sony F-5 4096 X 2160 (4K) Resolution Example



Sony F-5, Zeiss 12mm Lens, 500 lux, IE
2000, Target 113 inches, 2K P60
(no color correction)
File: Test_53_2K.tiff

Sony F-5 1920 X 1080 vs. Sony F-5 4096 X 2160 (4K) Resolution Example 1

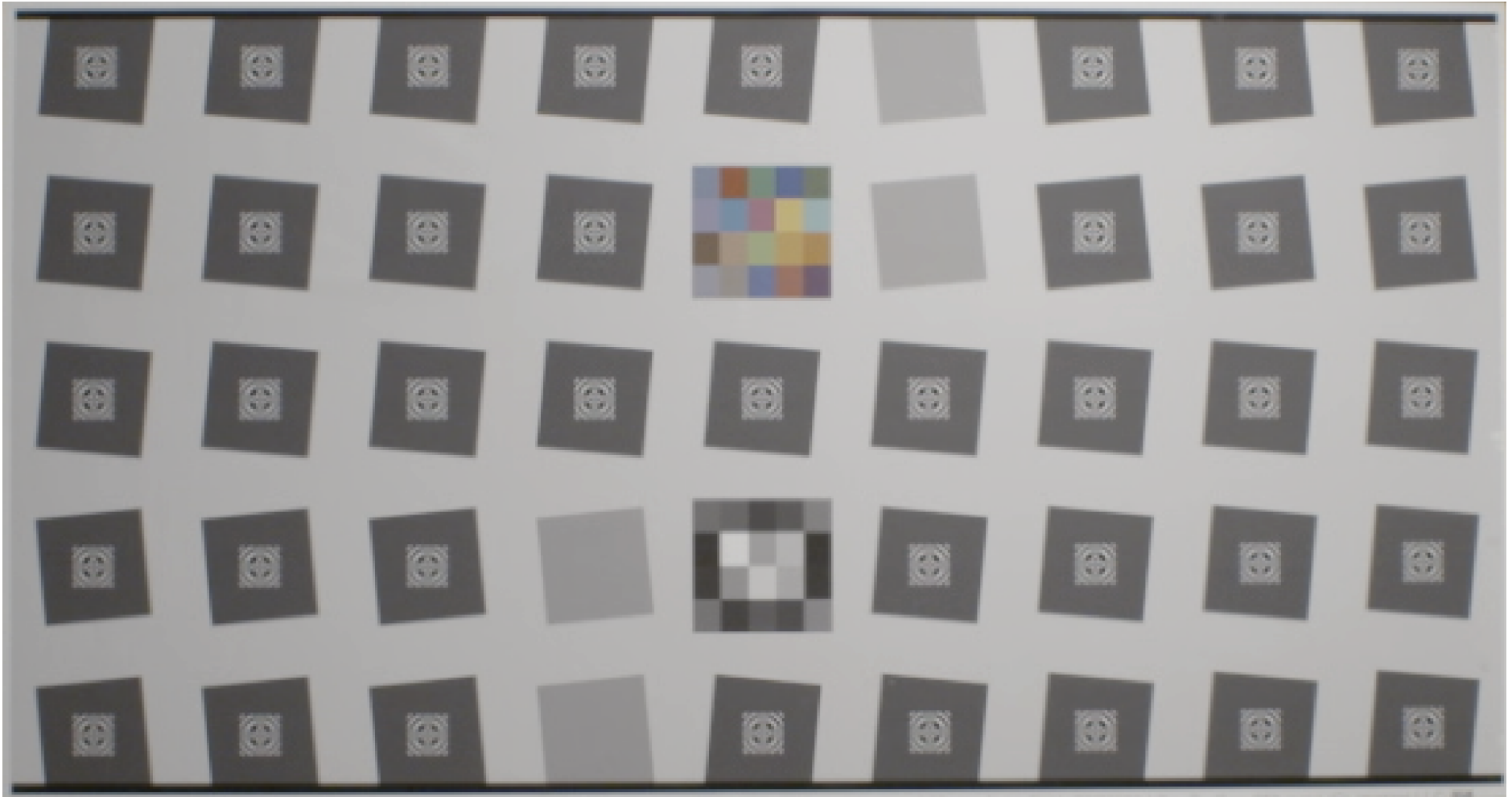


Sony F-5, Zeiss 12mm Lens, 400 lux,
IE 800, 1920x 1080 P60
(+20% brightness correction)
File: Test_53_2K4444.tiff



Sony F-5, Zeiss 12mm Lens, 800 lux,
IE 2000, 4K P60
(+20% brightness correction)
File: Test_53_4K4444.tiff

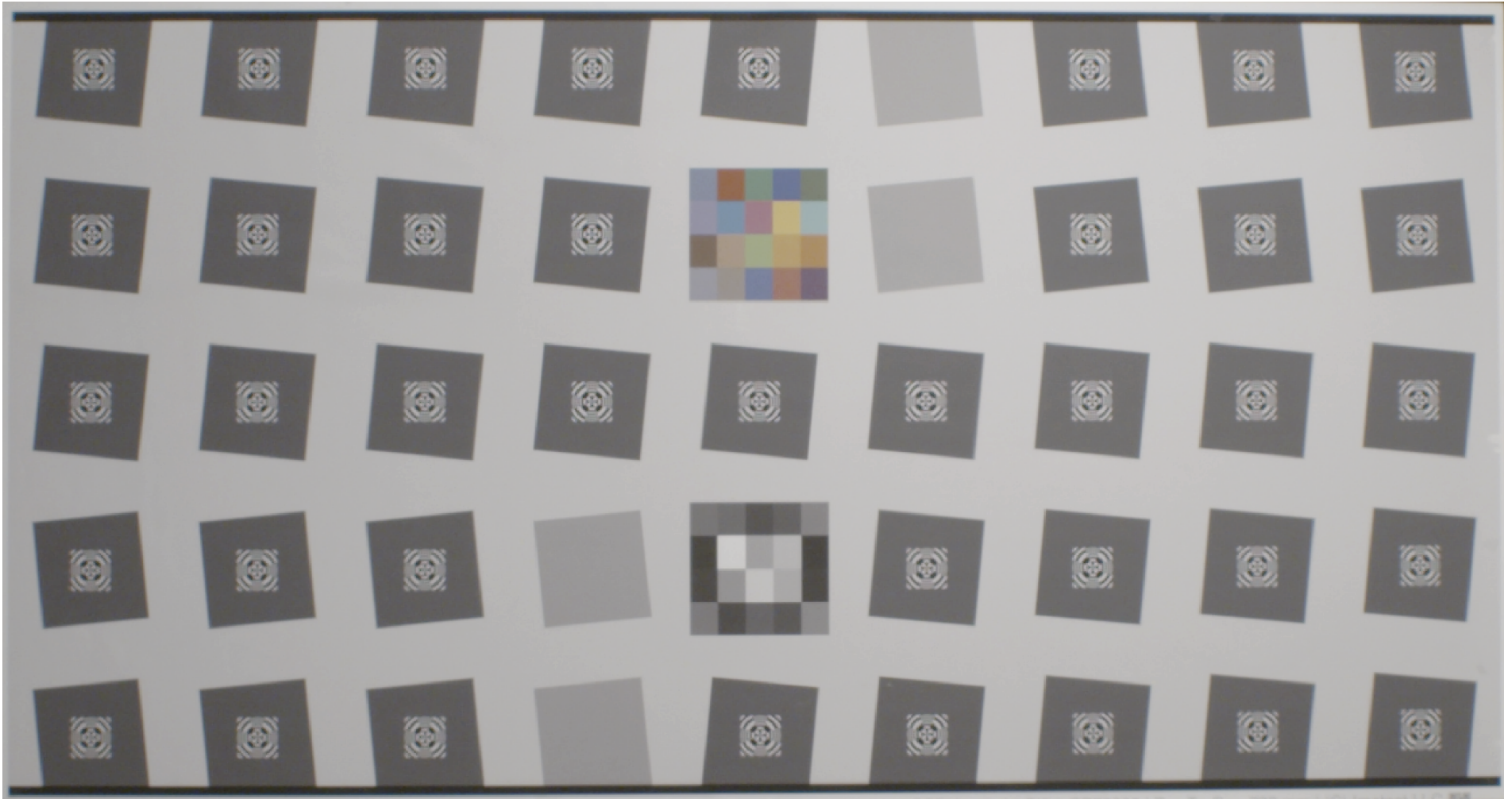
Sony F-5 1920 X 1080 vs. Sony F-5 4096 X 2160 (4K) Resolution Example 2A



Sony F-5, Zeiss 12mm Lens, 500 lux, IE 2000, Target 113 inches, 2K
P60 (Lightened 10%) File: Test_53_2K.tiff

Sony F-5 1920 X 1080 vs. Sony F-5 4096 X 2160 (4K)

Resolution Example 2B



Sony F-5, Zeiss 12mm Lens, 500 lux, IE 2000, Target 113 inches,
4K P60 (Lightened 20%) File: Test_53_4K444.tiff

Is There a Significant Dis-Advantage in 4:2:2 Color Space vs 4:4:4?



4:2:2 Color Space

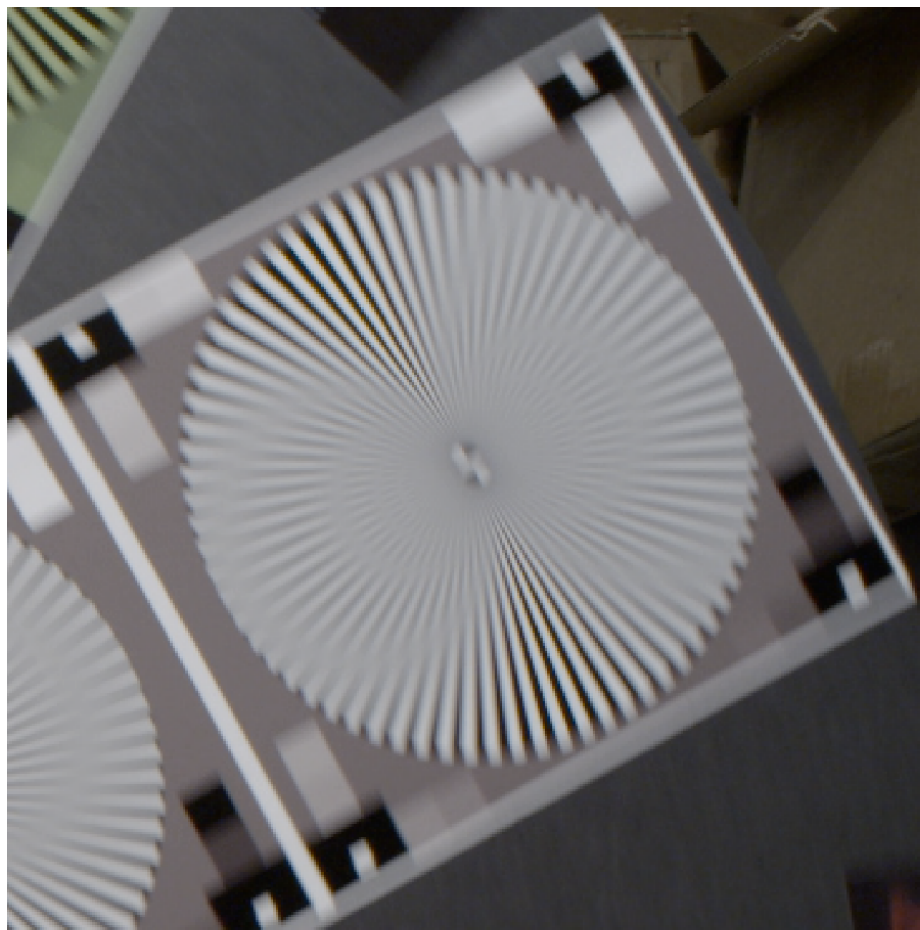
Sony F-5, Zeiss 12mm Lens, 800 lux,
IE 2000, Target 34 inches, 1920x 1080 P60
(color saturation 150%)
File: Test_54_1920_422(HQ).tiff



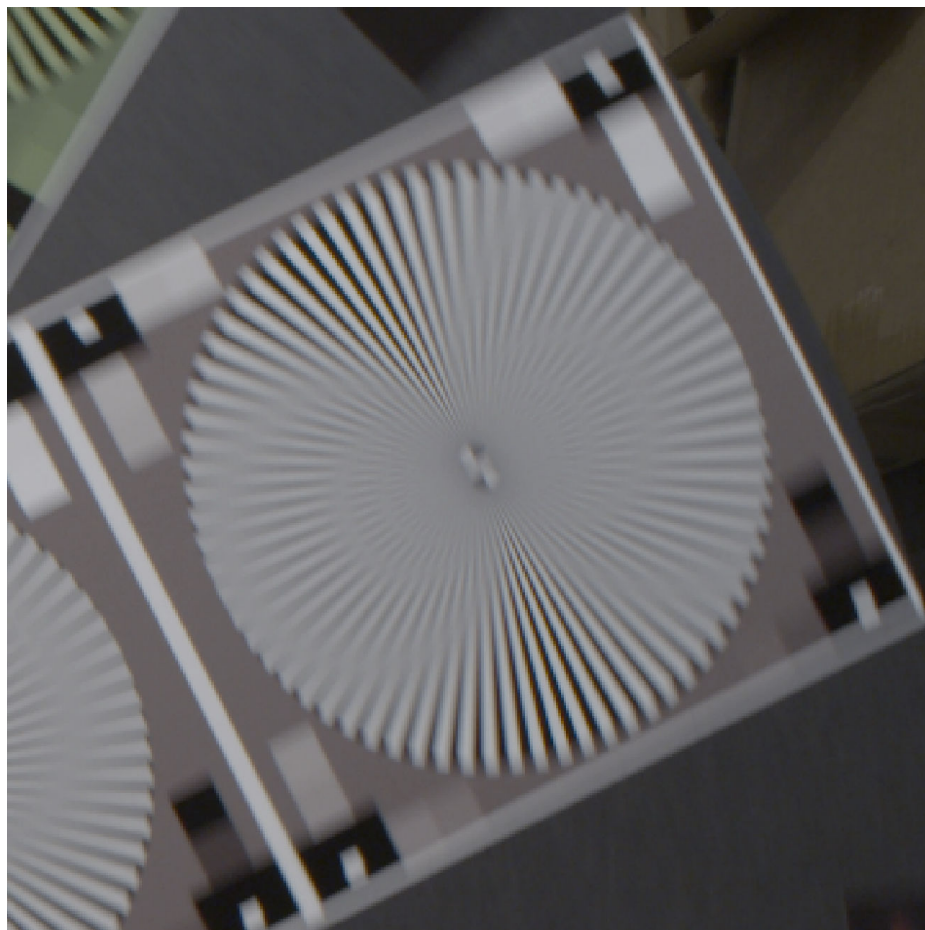
4:4:4 Color Space

Sony F-5, Zeiss 12mm Lens, 800 lux,
IE 2000, Target 34 inches, 1920x 1080 P60
(color saturation 150%)
File: Test_54_1920_444.tiff

CODEC TEST - How does ProRes 422(HQ) compare to Uncompressed Images?

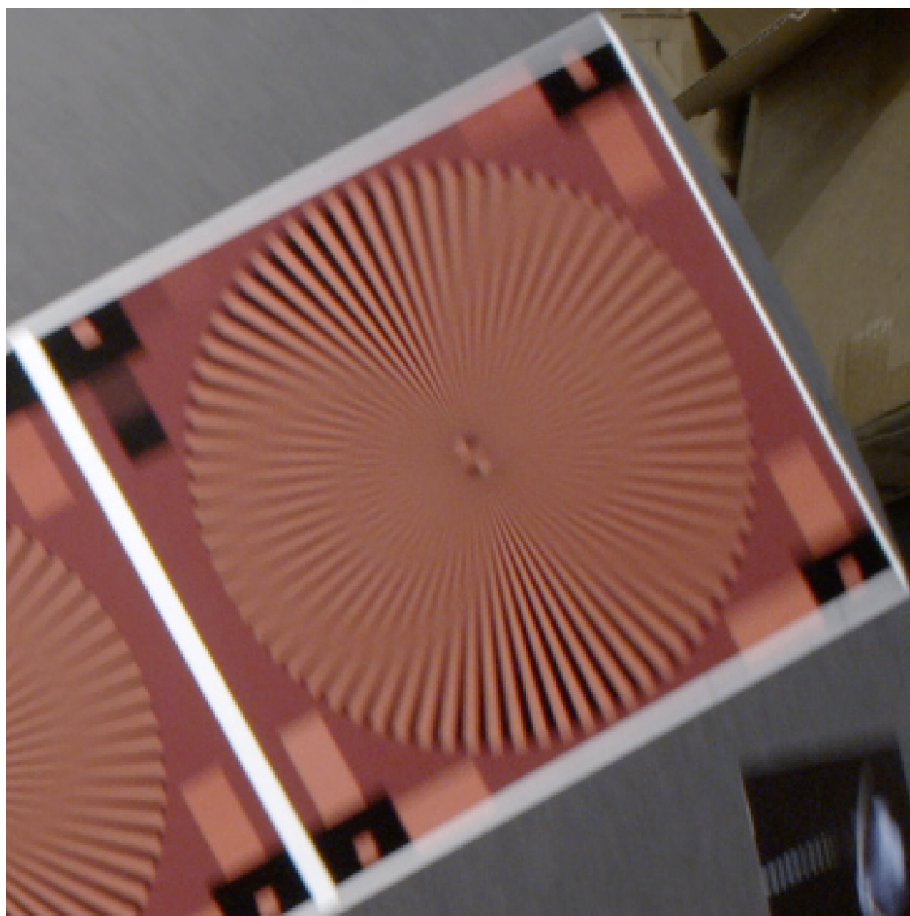


Sony F-5, Zeiss 12mm Lens, 700 lux,
IE 2000, Target 34 inches, 1920x 1080 P60
File: Test_57_1920_422(HQ)_White.tiff

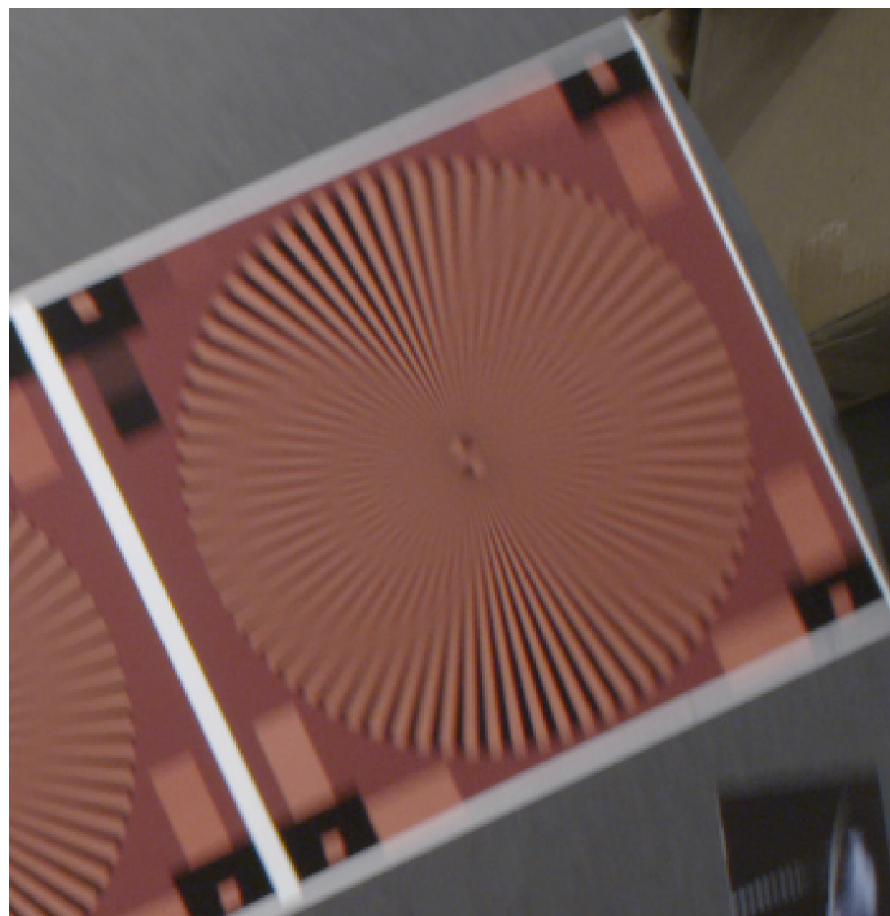


Sony F-5, Zeiss 12mm Lens, 700 lux,
IE 2000, Target 34 inches, 1920x 1080 P60
File: Test_57_1920_DPX444_White.tiff

CODEC TEST - How does ProRes 422(HQ) compare to Uncompressed Images?



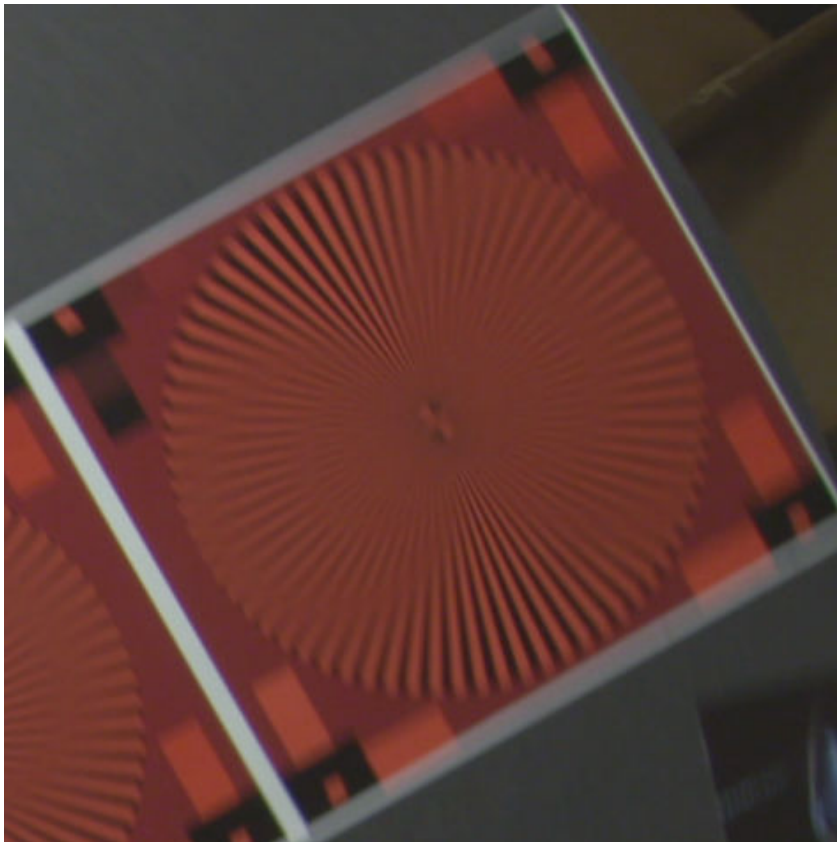
Sony F-5, Zeiss 12mm Lens, 700 lux,
IE 2000, Target 34 inches, 1920x 1080 P60
File: Test_57_1920_422(HQ)_Red.tiff



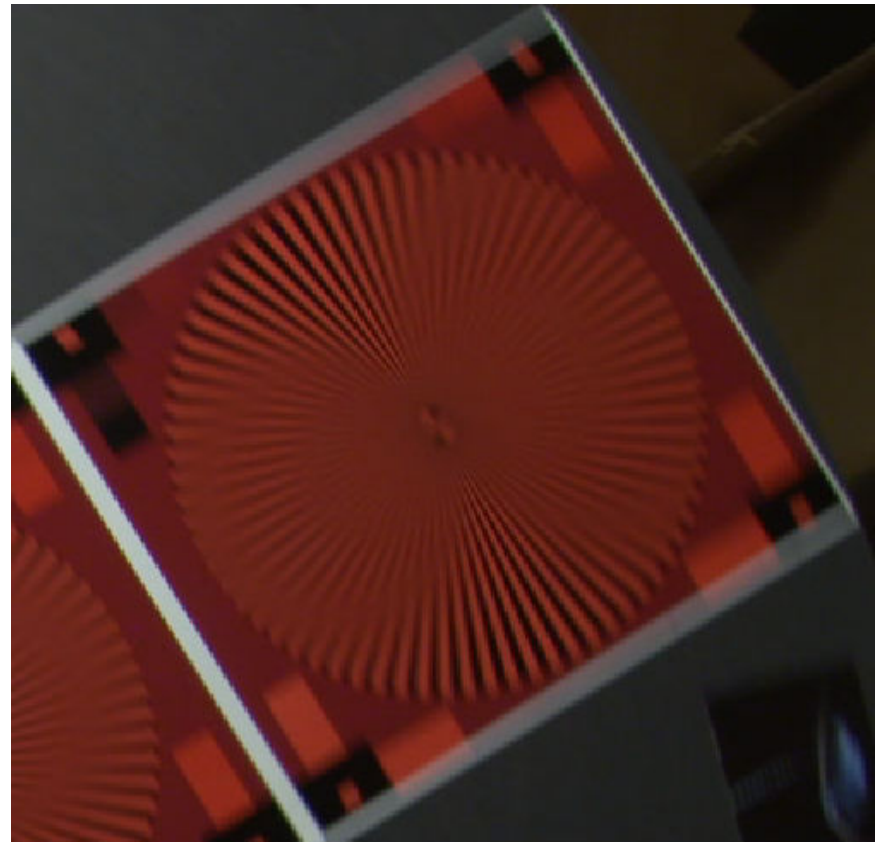
Sony F-5, Zeiss 12mm Lens, 700 lux,
IE 2000, Target 34 inches, 1920x 1080 P60
File: Test_57_1920_DPX444_Red.tiff

Sony F-5/SCL-P11X15 Lens: Test 6

Spinning Disk - 1920 x 1080 60P



Apple ProRes 422 10 bit HQ
(440 mbit/sec.)



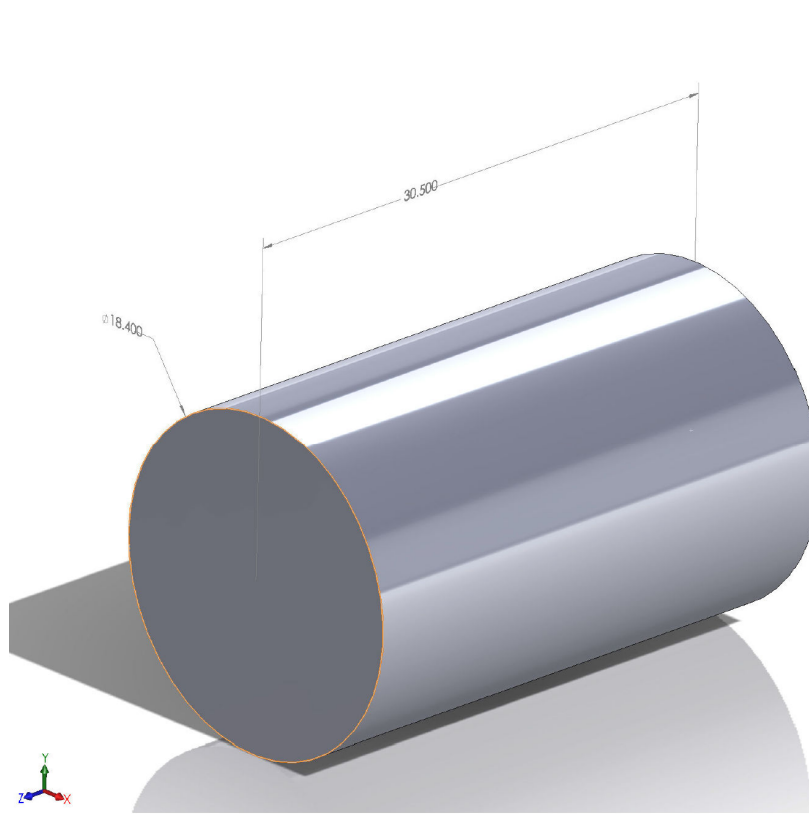
Sony XAVC
(223 mbit/sec.)

Issues and Observations

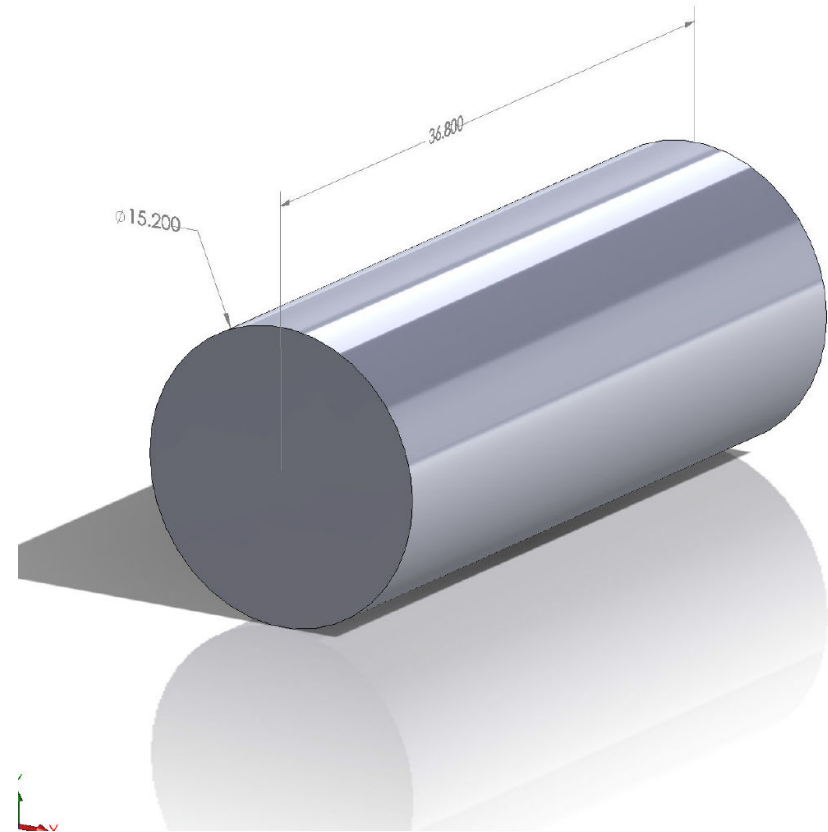
- ProRes de-interlaced the 1080i .tiff frame grabs.
- De-interlaced video looks surprisingly good compared to progressive scan.
 - Quick time playback does NOT de-interlace.
- Ikegami has black adjustment issues on power-up boot. Suggest putting 100% filter in one position in filter wheel
 - would require camera control.
- Still need to test the F-5 with the Sony lens at 4K to make sure it will hold up.
- Shutter of 1/250 is needed to freeze motion of transect.

Camera and Lens Size Comparison

(dimensions in centimeters)



Sony F-5, SCL-P11X15 Lens



Ikegami HDL-50/HS, Zeiss 5mm Lens

Estimated Cost Comparison

Cost Comparison	Sony F-5	Ikegami HDL50/HS
Camera	\$17,000	\$28,630
Lens	\$7,000	\$9,100
Recorder	\$3,995	\$3,995
Memory	\$2,590	\$2,590
Total	\$30,585	\$44,315

Budget is ~ \$57,592

Which is the best camera for us?

- Ikegami HDL-50/HS 2/3" box camera Vs the Sony F-5 super 35 format camera.
 - Box camera has a great picture but is limited to 1920 X 1080 60 frames per second.
 - Box camera is the smallest and likely the easiest to integrate.
 - F-5 Cine camera has 4K sensor and offers a migration path to higher resolution formats, 2K and 4K.
 - Current recording limitation is 2048 X 1080 60 frames per second.
 - AJA has recording hardware in development that supports 4K at 60 frames per second that may be available in the future.
 - Sony F-5 can be upgraded to F-55 with 4K output for \$12,000.

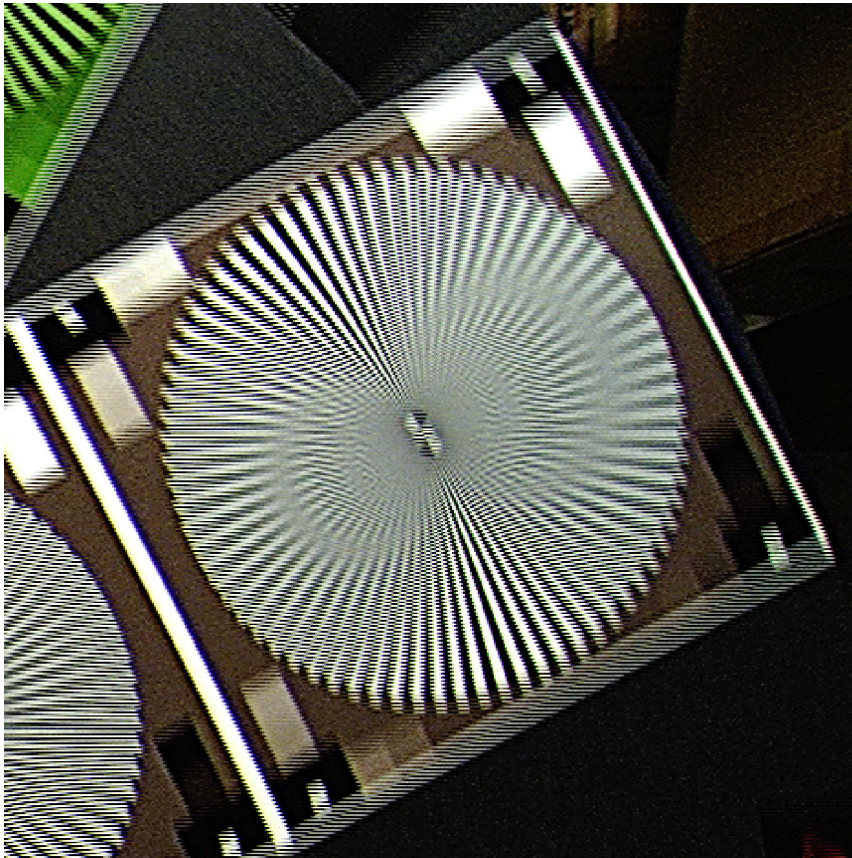
Preliminary Conclusions

- The Ikegami 2/3" HDL-50HS camera is significantly better in resolution than the Sony HDCP1.
- The F-5 camera is about 2 stops slower when depth of field control is taken into account.
- The NEX-FS700U is about as fast as the 2/3" cameras and has good resolution but the color reproduction is poor.
- The Apple ProRes 422(HQ) CODEC is visually lossless.
- The Ikegami HDL-50/HS would completely meet our present requirements.
- The Sony F-5 (or F-55) would allow possible future migration:
 - To 4K imaging + \$12k & new recorder.
 - To higher frame rates
- We have adequate illumination.
 - Need ~ 1000 lux maximum
 - 4 lights measure at ~ 3500 – 5000 lux at 0.5 meters from dome.
- With AUV at 1 m/sec. shuttering at 1/250th has about the spatial resolution of 240 FPS but not temporal resolution.
 - Unfortunately we cannot currently record faster than 60 FPS.
 - F5 can record internally at 180 FPS for 60 minutes using XAVC CODEC (our current requirement is 120 minutes).
- Surprisingly, de-interlaced 1080i 29.94 has similar temporal resolution to 1080P 60, although the spatial resolution is only half.

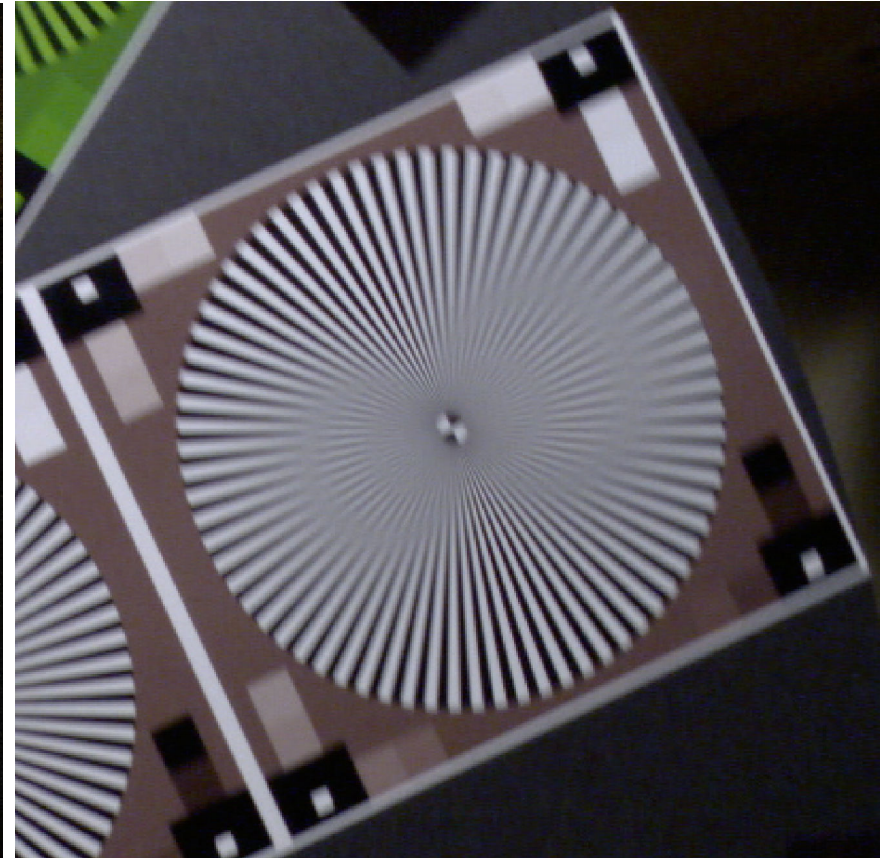
The Temporal Resolution of Progressive format Vs Interlaced format

- Example of 1920 x 1080i 29.97 frames per second
(the current ROV video format)
Vs
- 1920 x 1080 P60 progressively scanned 60 frames
per second as proposed for i2MAP
- Example of de-interlaced 1080i video showing
the results of dropping the odd lines and
interpolating.

Comparison of the current ROV standard of 1920x 1080i 29.97 at
simulated AUV Speed of 0.5 m/sec. and 1920x 1080 P59.4
(Progressively Scanned)

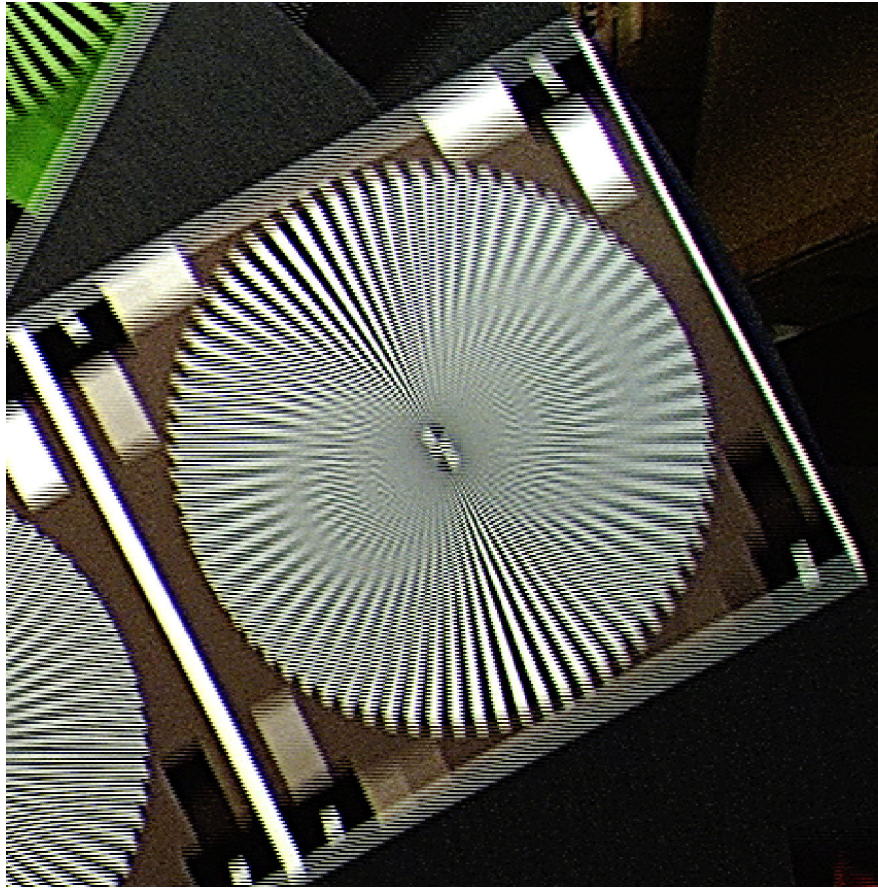


Ikegami HDL45, Fujinon 5.5x10 Lens,
110 lux, 1920x 1080i 29.97
Disk 6 RPM (~0.5 m/sec)
File: Test_103_White.tiff (not DeInterlaced)

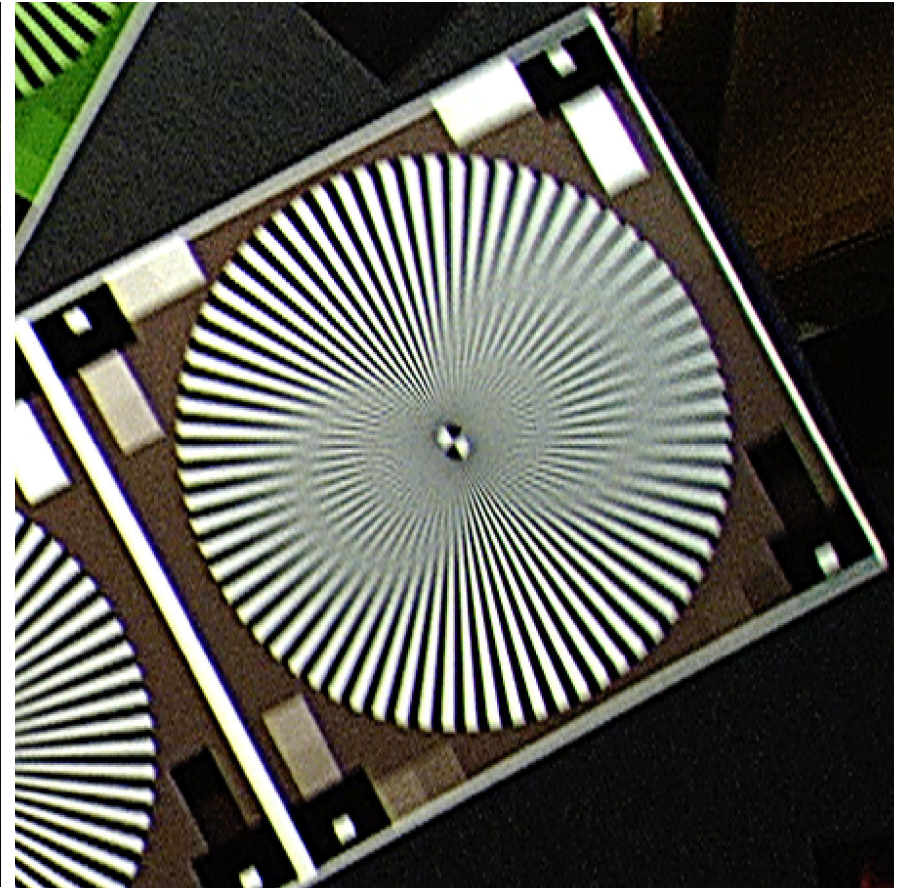


Ikegami HDL50/HS, Zeiss 5mm Lens,
170 lux, 1920x 1080 P60
Disk 6 RPM (~0.5 m/sec)
File: : Test_74_White.tiff

Comparison of the current ROV standard of 1920x 1080i 29.97 at simulated 0.5 m/sec. and the same image de-interlaced using Photoshop

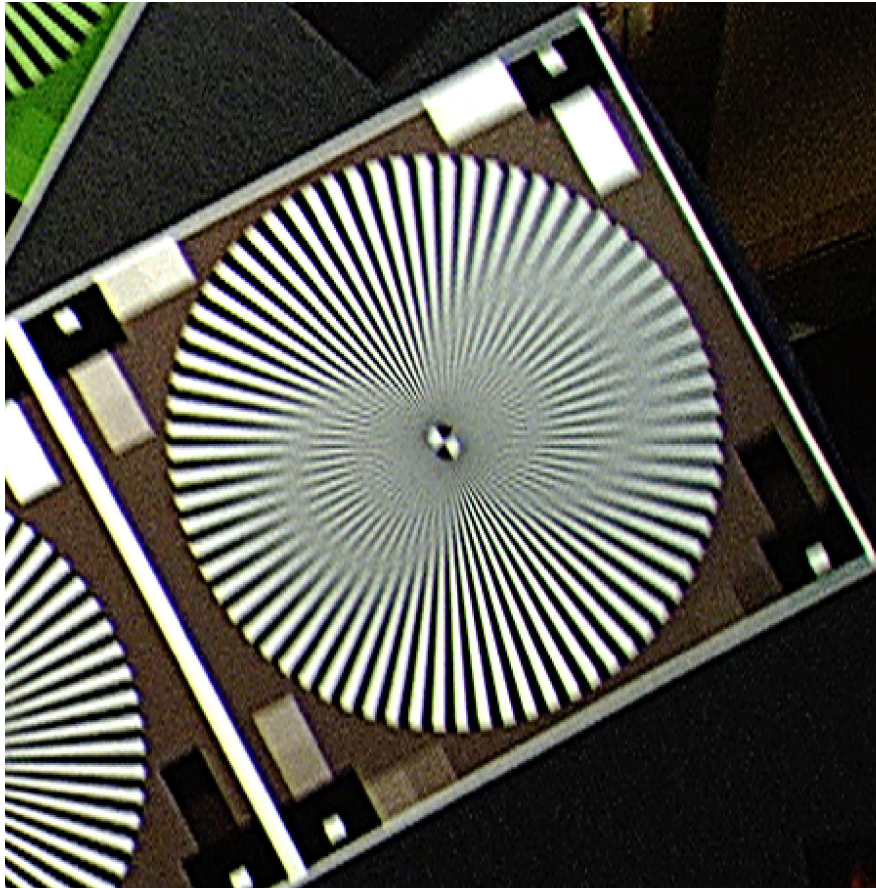


Ikegami HDL45, Fujinon 5.5x10 Lens,
110 lux, 1920x 1080i 29.97
Disk 6 RPM (~0.5 m/sec)
File: Test_103_White.tiff (not DeInterlaced)

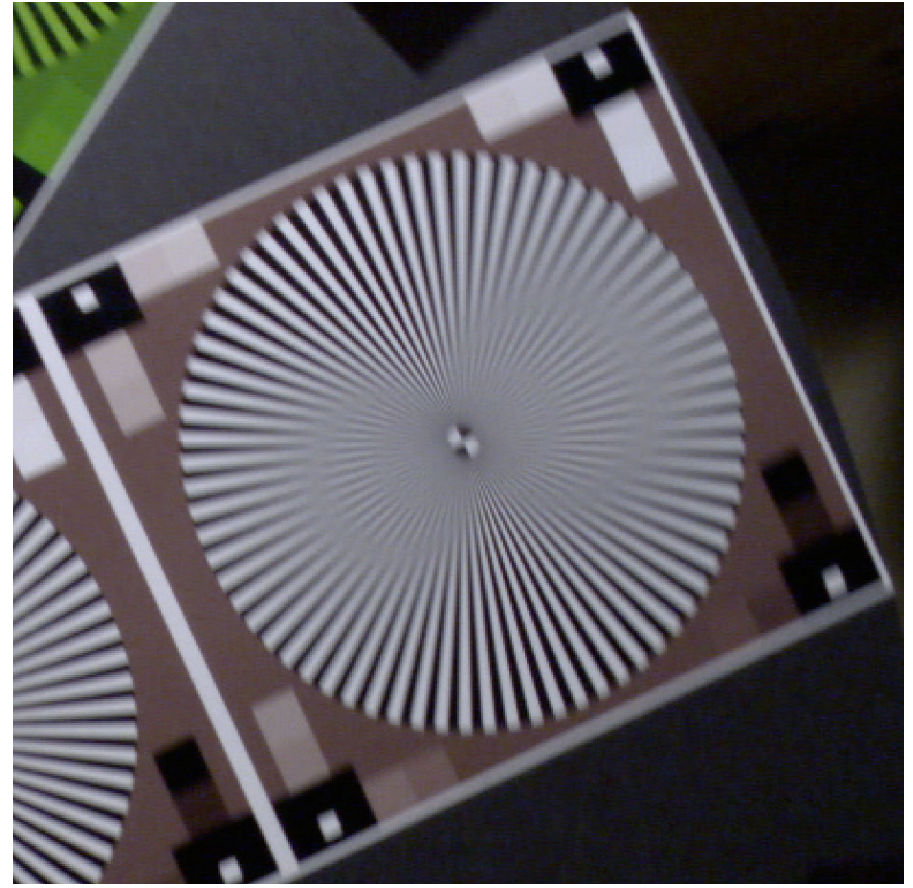


Ikegami HDL45, Fujinon 5.5x10 Lens,
110 lux, 1920x 1080i 29.97
Disk 6 RPM (~0.5 m/sec)
File: Test_103_White.tiff (DeInterlaced)

Comparison of the current ROV standard of 1920x 1080i 29.97 at simulated 0.5 m/sec. De-Interlaced and 1920x 1080 P59.4 (Progressively Scanned)



Ikegami HDL45, Fujinon 5.5x10 Lens,
110 lux, 1920x 1080i 29.97
Disk 6 RPM (~0.5 m/sec)
File: Test_103_White.tiff (DeInterlaced)



Ikegami HDL50/HS, Zeiss 5mm Lens,
170 lux, 1920x 1080 P60
Disk 6 RPM (~0.5 m/sec)
File: : Test_74_White.tiff

Lens Comparison at 4K Resolution

- Sony SCL-P11X15 Ultra wide Zoom (in 11mm position)

Vs

- Zeiss 12mm T2.1 Standard Prime

Vs

- Zeiss UP 12mm T2 Ultra Prime

Sony F-55 and Sony SCL-P11X15 Lens, 11mm focal length at 4096 X 2160 (4K),
target 34 inches, f 5.6, focus distance 31.5 inches (0.8m)



Sony F-55, SCL-P11X15 Lens, 900 lux, 75 IRE, Target 34 inches File: Test_110_4K.tiff
Note: the edge waviness is actual ripples in the target.

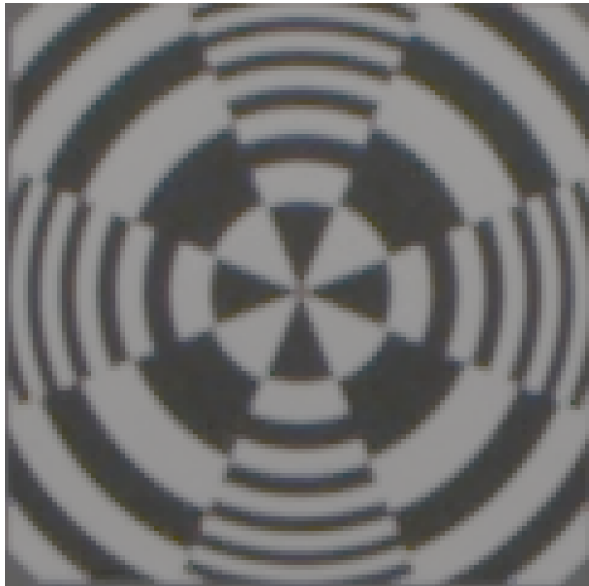
Sony F-55 and Zeiss 12mm T2 Ultra Prime Lens at 4096 X 2160 (4K), Target 38 inches, f 5.6, focus distance 31.5 inches (0.8m)



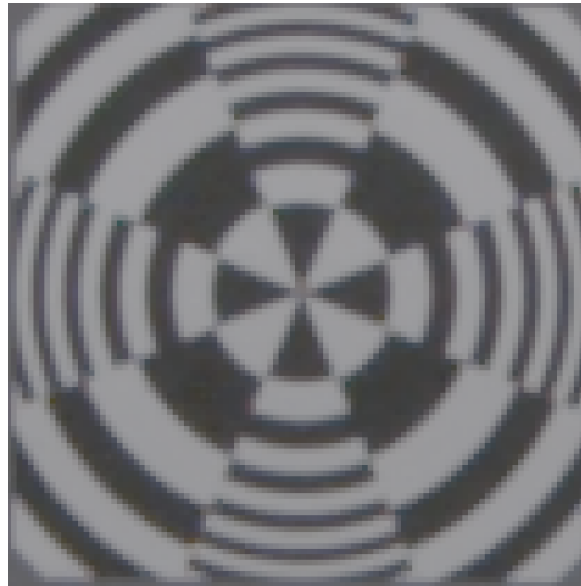
Sony F-55, Zeiss UP 12mmT2 Lens, 840 lux, 75 IRE, Target 38 inches File: Test_112_4K.tiff
Note: the edge waviness is caused by actual ripples in the target.

Lens Comparison at 4096 X 2160 (4K)

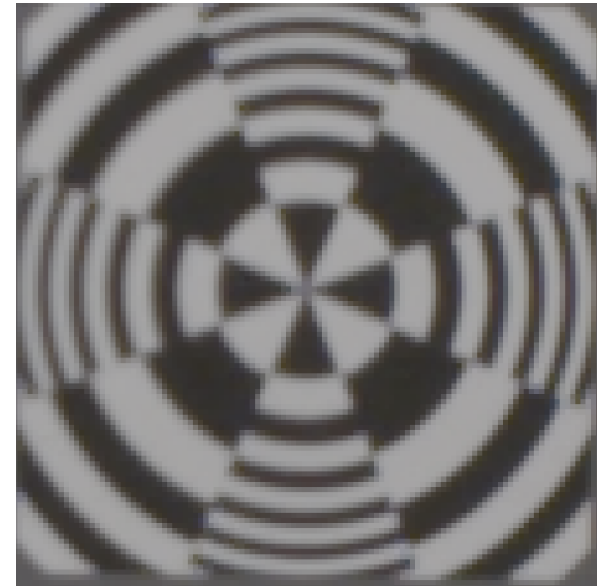
Center Resolution – Detail, target 34 inches, f 5.6, focus distance 31.5 inches (0.8m)



Sony F-55, Zeiss 12mm
T2 Ultra Prime Lens
Lens, 840 lux, EI 1250,
Target 34 inches, 4K P60
File: Test_111_4K.tiff



Sony F-55, Sony SCL-
P11X15 Lens, 900 lux,
EI 1250, Target 34
inches, 4K P60
File: Test_110_4K.tiff



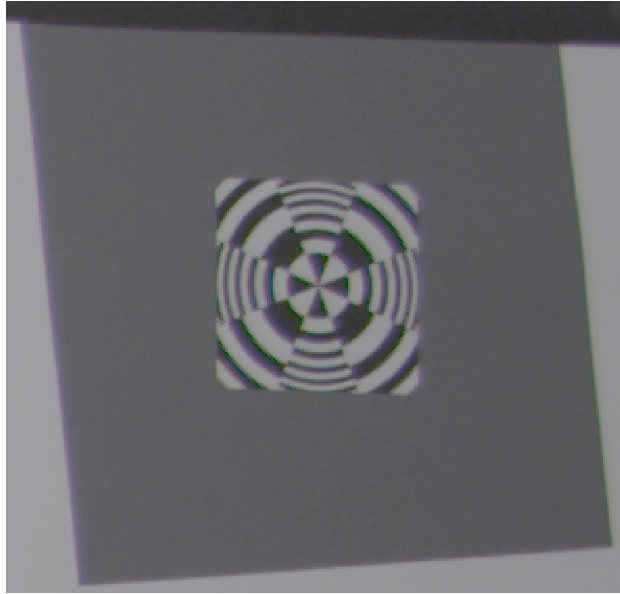
Sony F-5, Zeiss 12mm T2.1
Standard Prime Lens, 800 lux,
EI 2000, Target 34 inches, 4K
P60
File: Test_54B_4K_DPX.tiff

Lens Comparison at 4096 X 2160 (4K)

Edge Resolution, target 34 inches, f 5.6, focus distance 31.5 inches (0.8m)



Sony F-55, Zeiss 12mm
T2 Ultra Prime Lens,
840 lux, EI 1250, Target
34 inches, 4K P60
File: Test_111_4K.tiff



Sony F-55, Sony SCL-
P11X15 Lens, 900 lux,
EI 1250, Target 34
inches, 4K P60
File: Test_110_4K.tiff

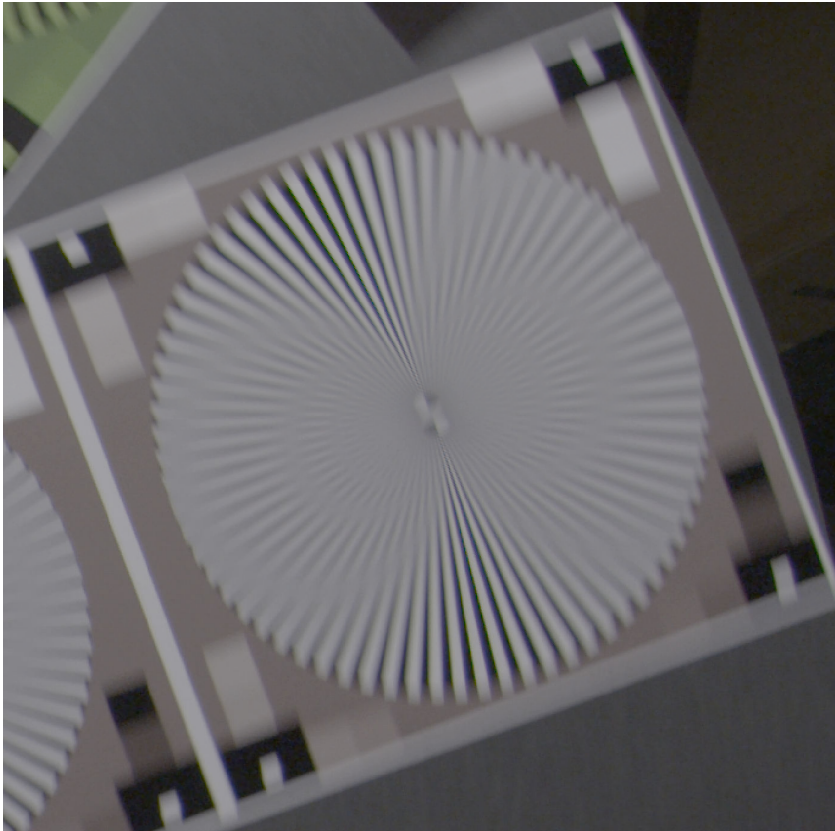


Sony F-5, Zeiss 12mm T2.1
Standard Prime Lens, 800 lux,
EI 2000, Target 34 inches, 4K
P60
File: Test_54B_4K_DPX.tiff

The Temporal Resolution of 4K and the Appropriate Shutter Speeds

- Example of 4096 X 2160 (4K) 60 P (frames per second) at:
 - No shutter (59.94 fps)
 - 1/125th second shutter
 - 1/250th second shutter
 - 1/500th second shutter
- Note that 4K requires a faster shutter to maintain full pixel resolution than 2K!
- Therefore needs more light, estimate 5000 lux on target.

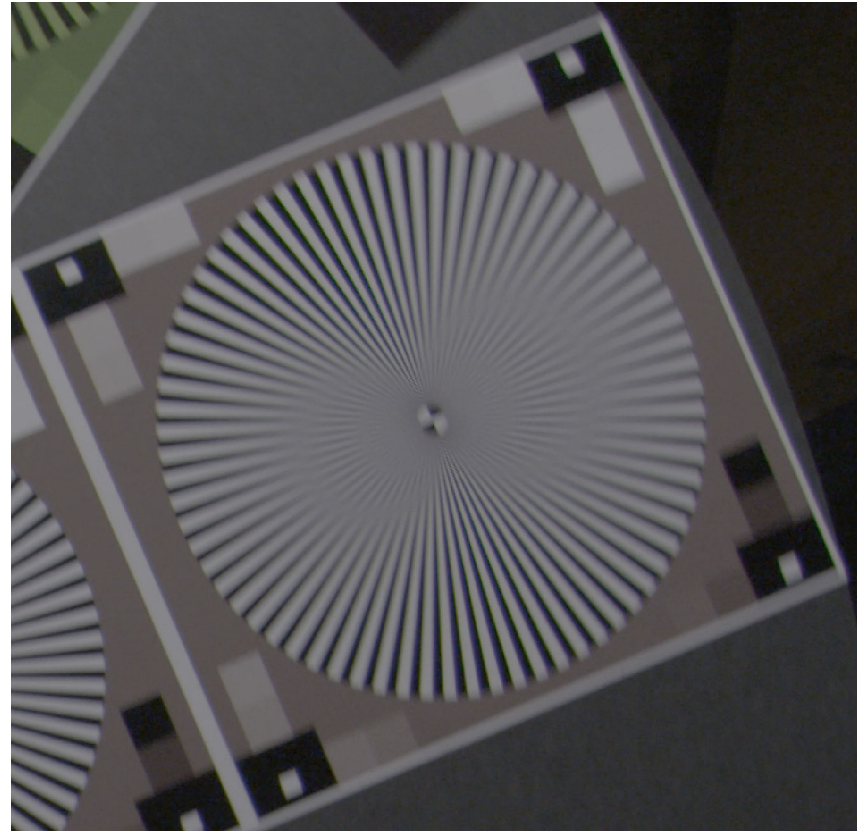
Comparison of Shutter Speeds at Planed 1.0 m/sec.
Velocity (11 R.P.M.) at the 0.5 Meter from Dome “Sweet Spot”.



No Shutter

Sony F-55, SCL-P11X15 lens, 640 lux,
ire 75, EI 1250

File: Test_116_4K.tif

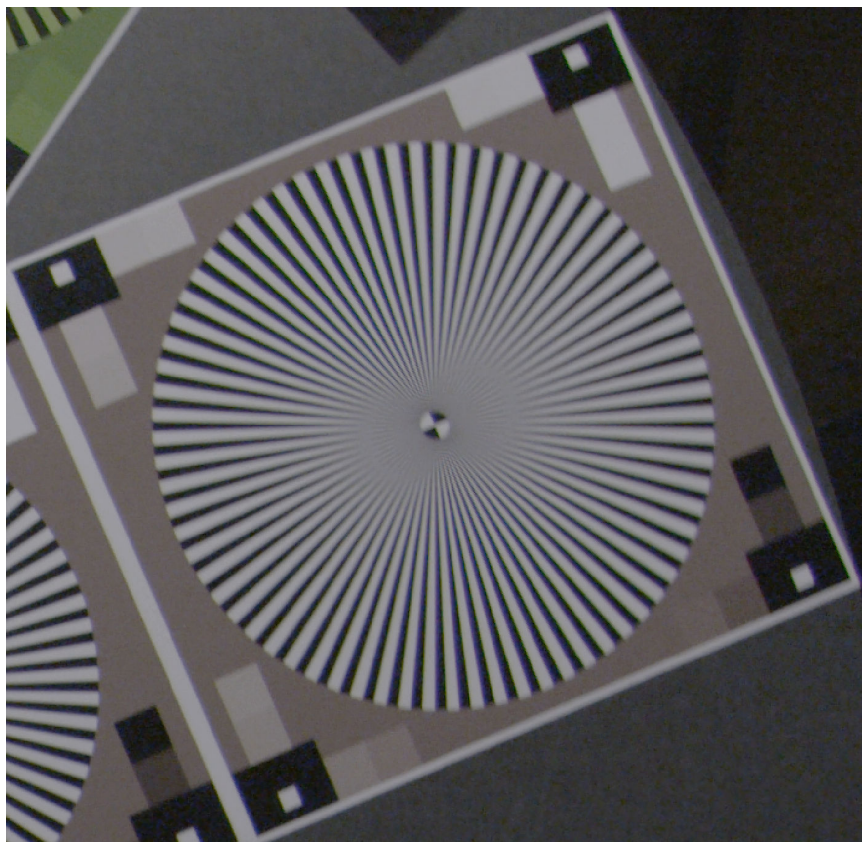


Shutter 1/125

Sony F-55, SCL-P11X15 lens, 640 lux,
ire 55 EI 1250 + 1 stop

File: Test_117_4K_+1Stop.tif

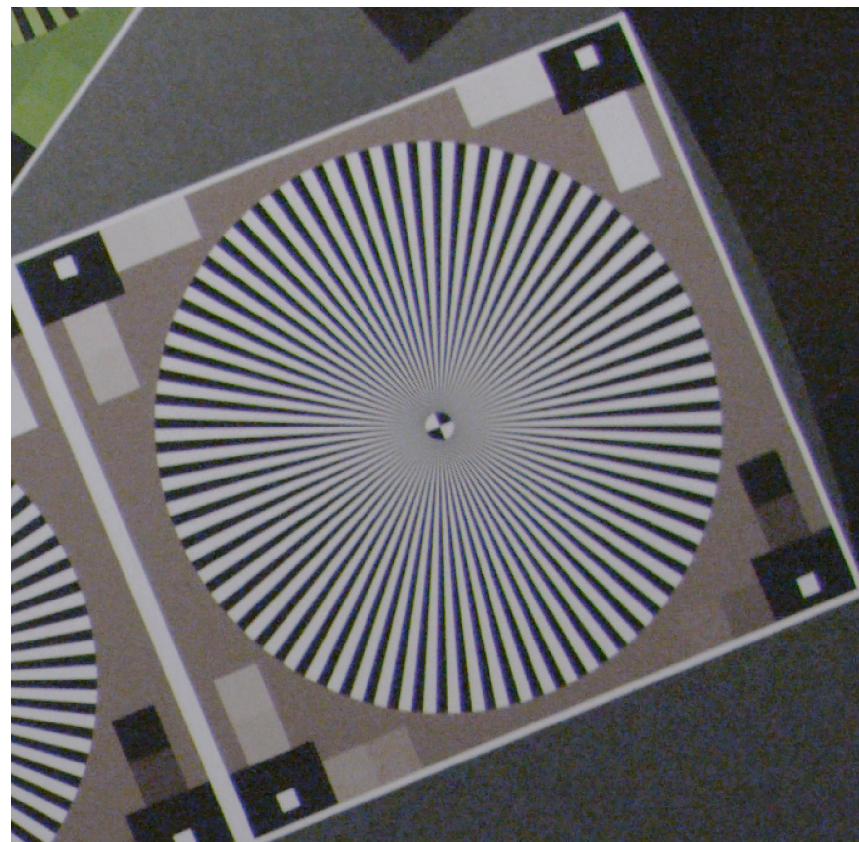
Comparison of Shutter Speeds at Planed 1.0 m/sec.
Velocity (11 R.P.M.) at the 0.5 Meter from Dome “Sweet Spot”.



Shutter 1/250

Sony F-55, SCL-P11X15 lens, 640 lux,
ire 50, EI 1250 + 2 stops +20% brightness

File: Test_118_4K_+2Stop.tif



Shutter 1/500

Sony F-55, SCL-P11X15 lens, 640 lux,
ire 45, EI 1250 + 3 stops +20% brightness

File: Test_119_4K_+3Stop.tif