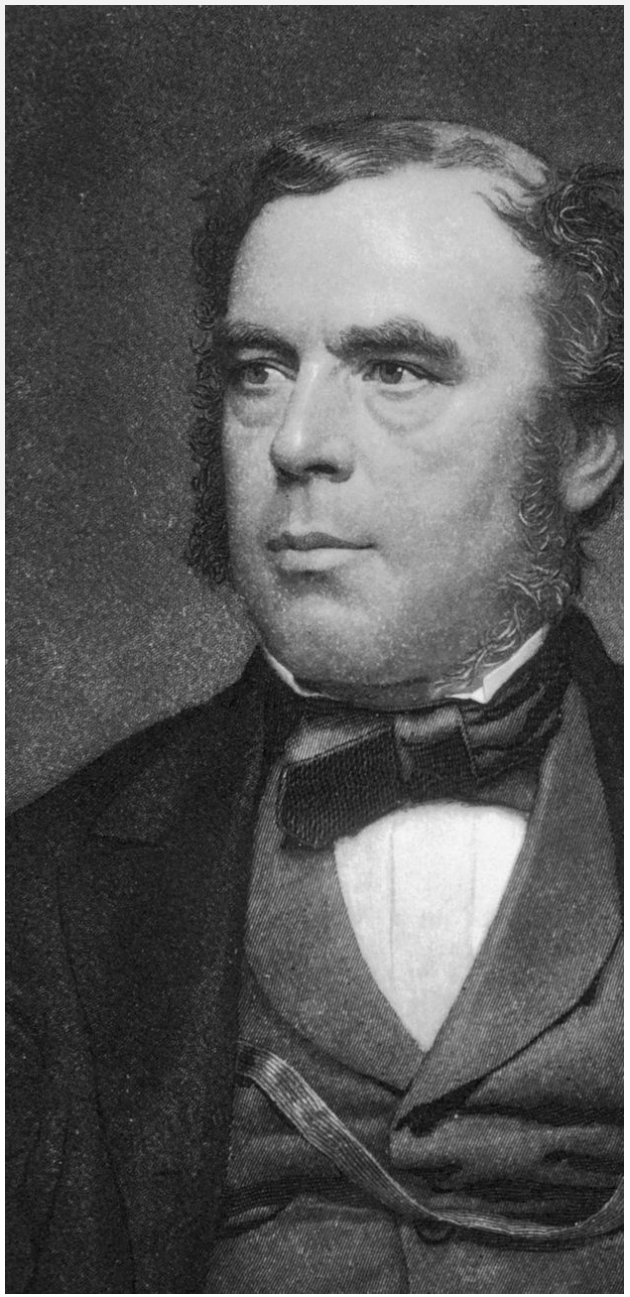
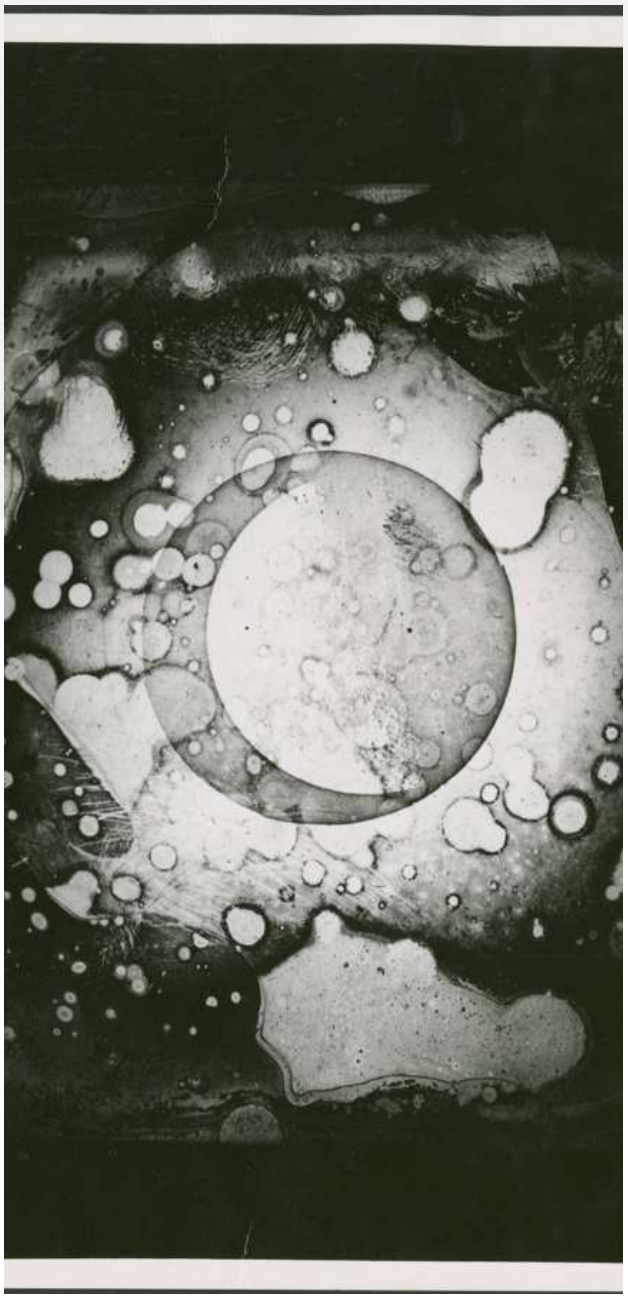
Τεχνολογίες CCD / CMOS

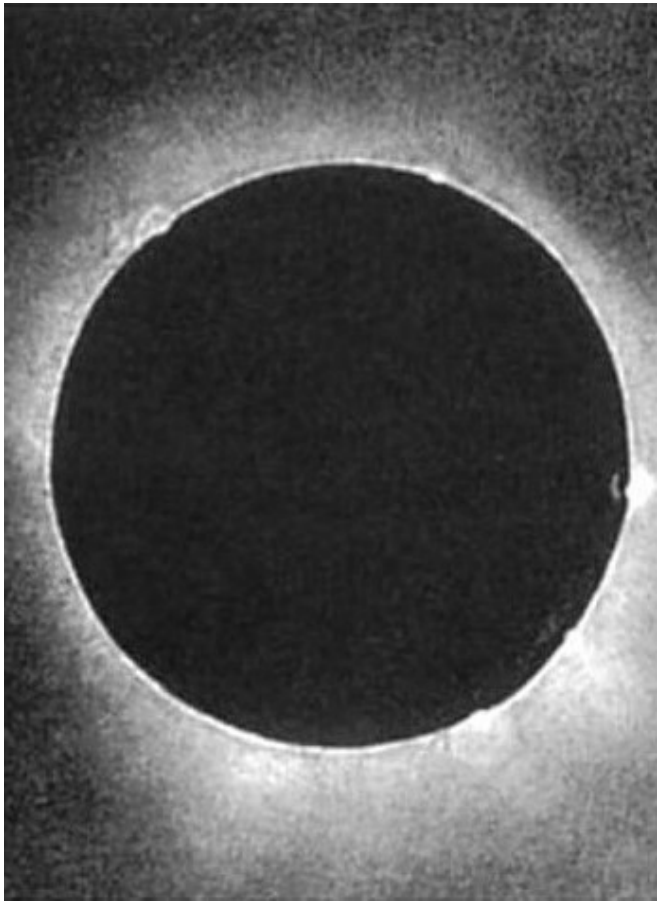
Χάρης Καμπάνης





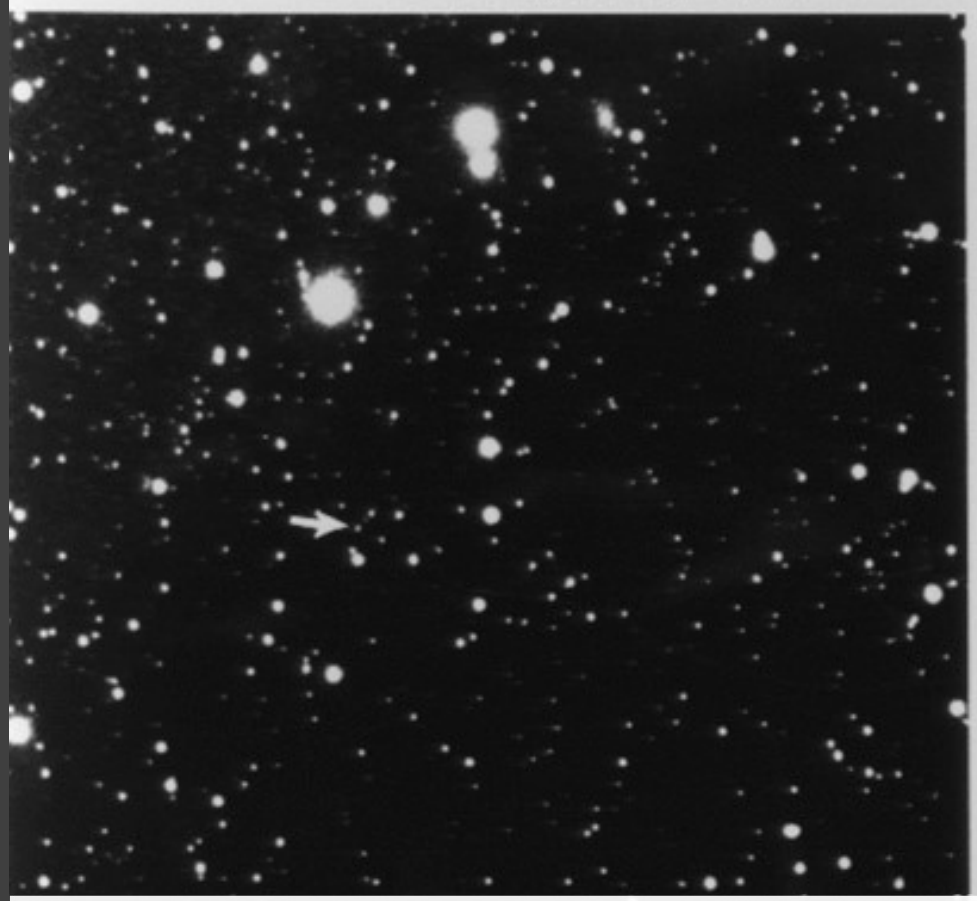
John Draper

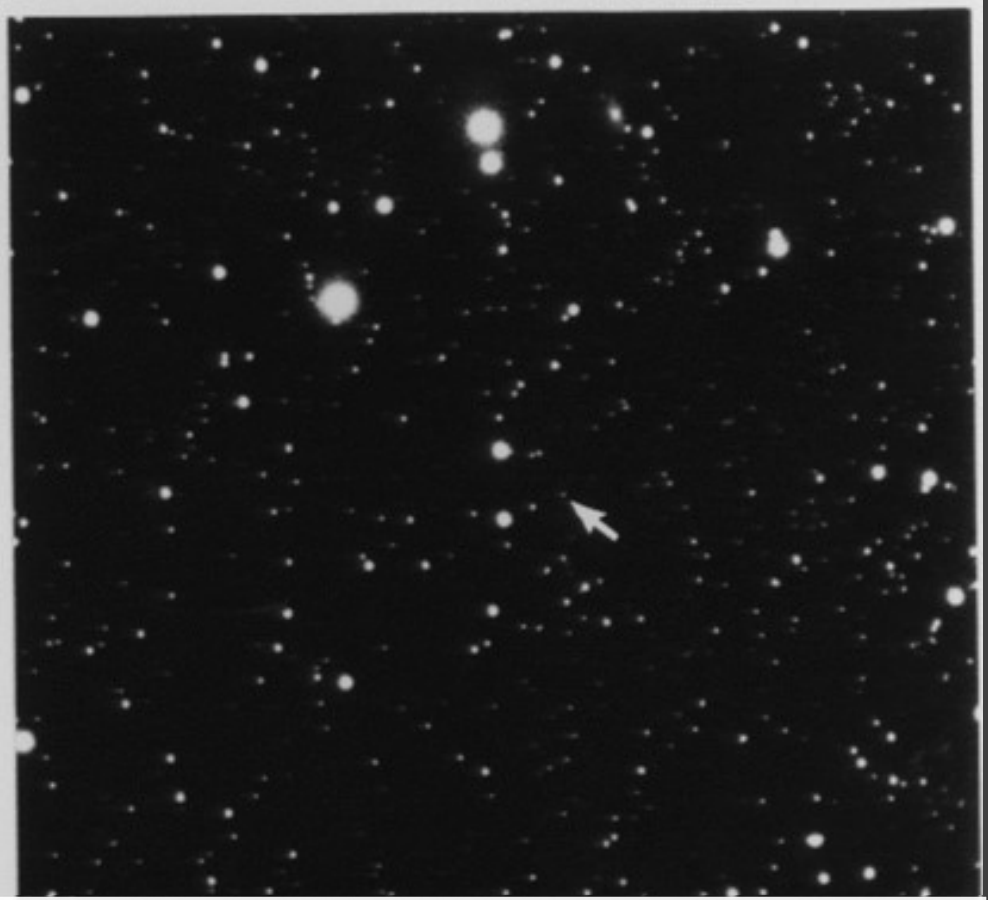
- Daguerreotype 1840



- Solar Eclipse Berkowski 1851
- Orion Nebula Andrew Ainslie 1883

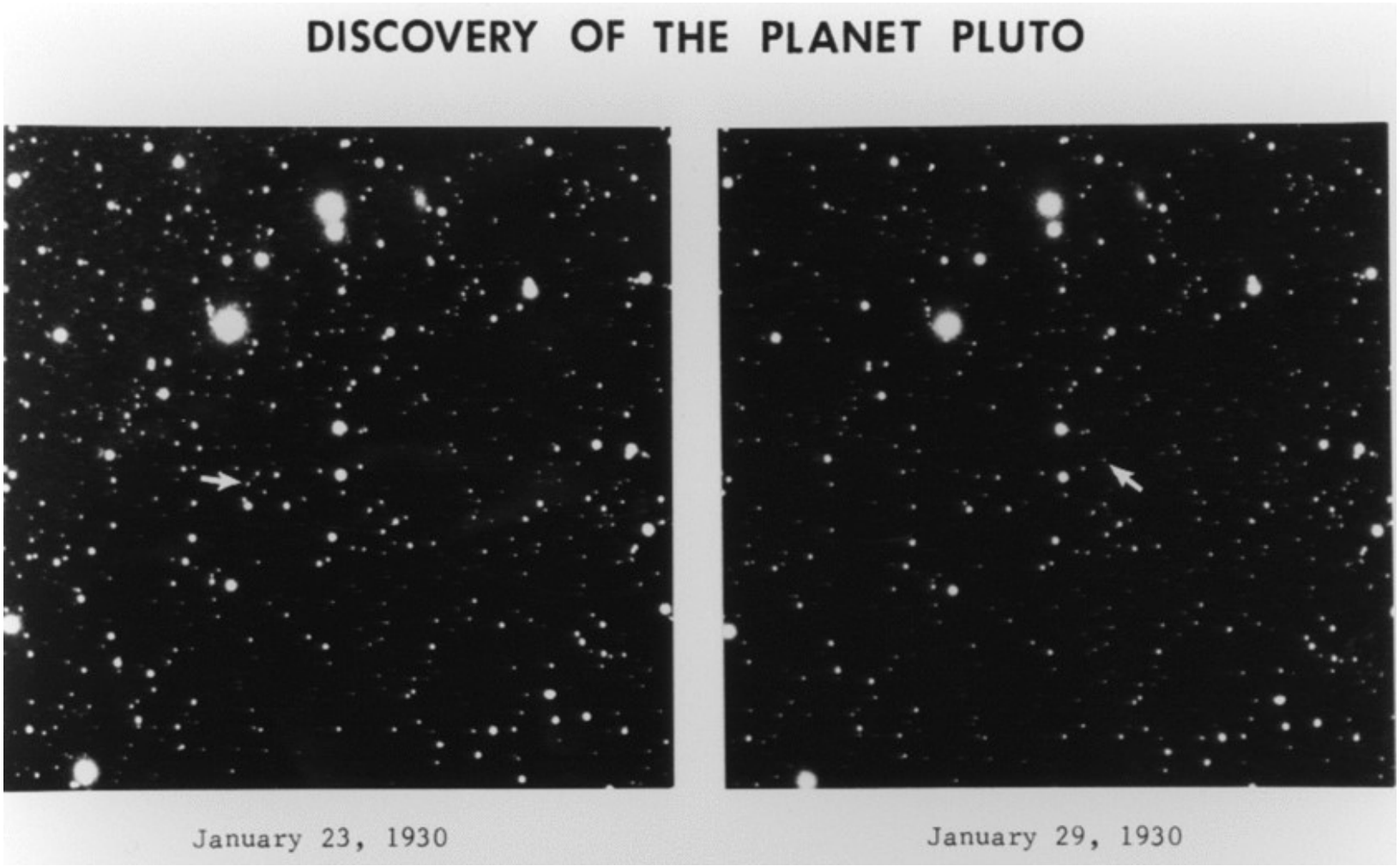
DISCOVERY OF THE PLANET PLUTO



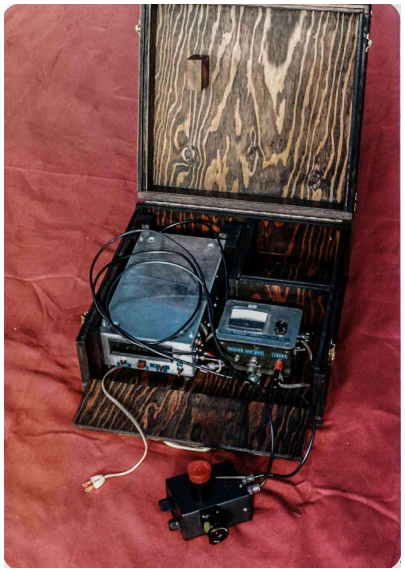


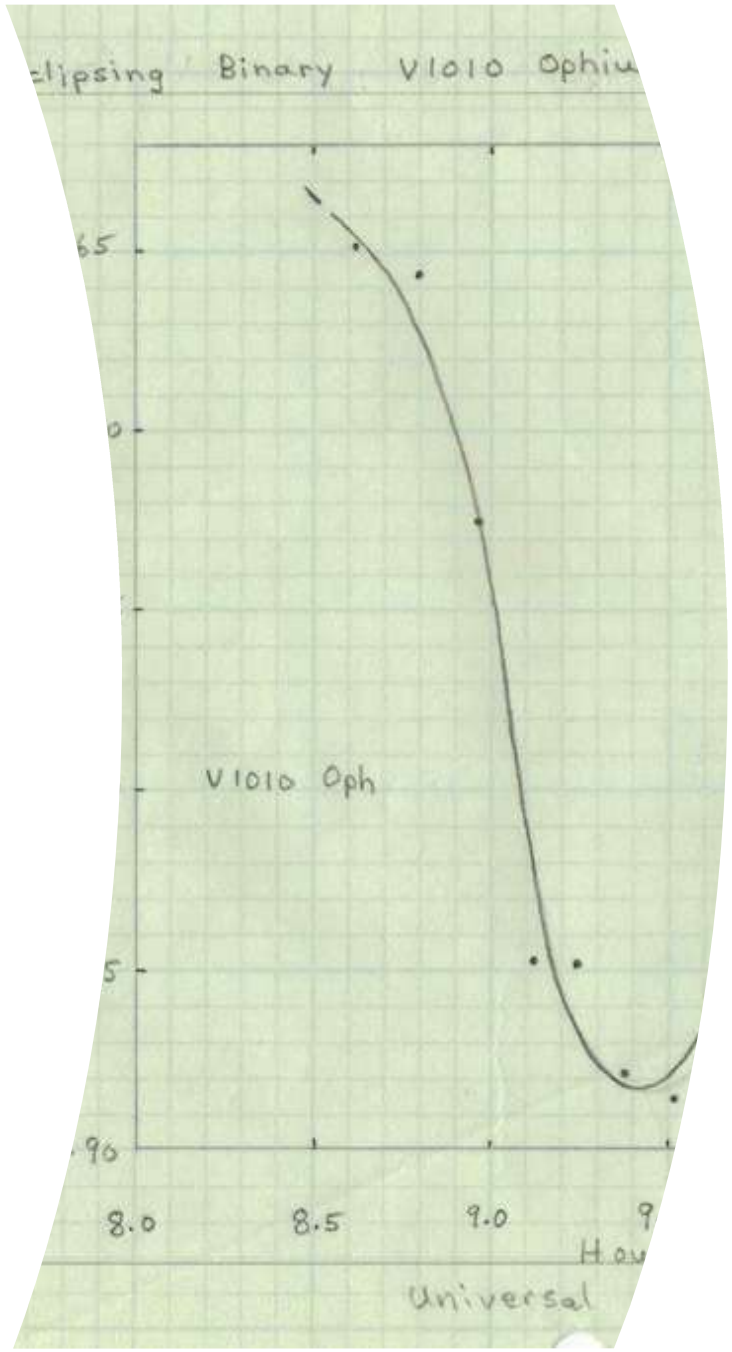
Φωτογραφικές Πλάκες

Φωτογραφικές Πλάκες



Φωτομετρία



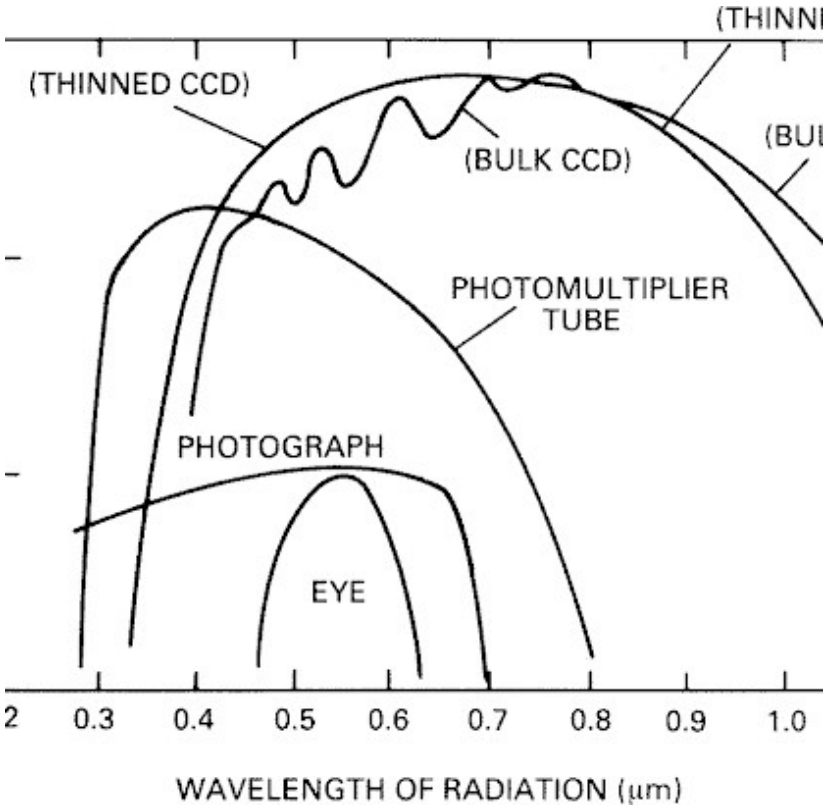


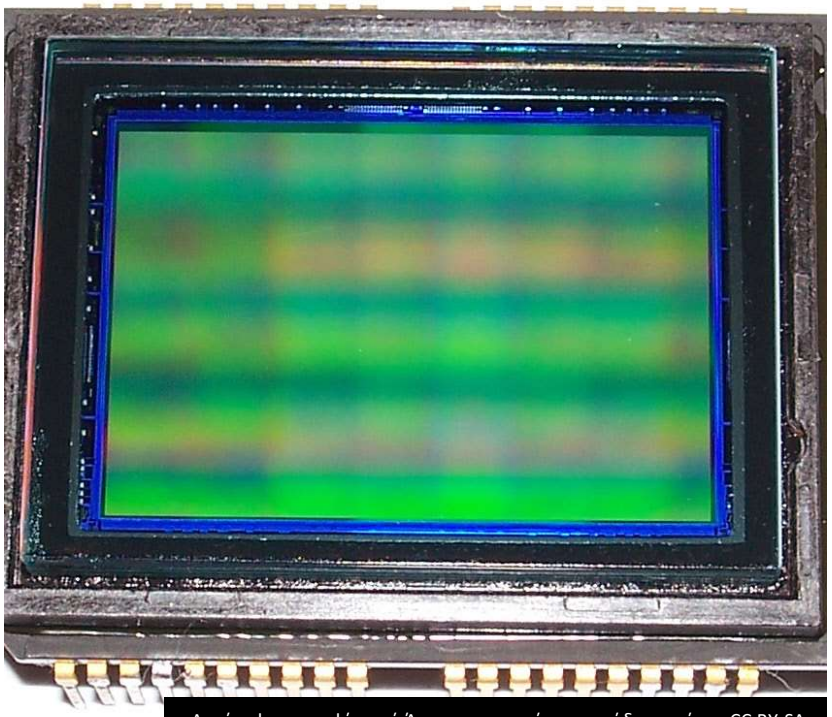


Φίλμ 1980-2000

CCD

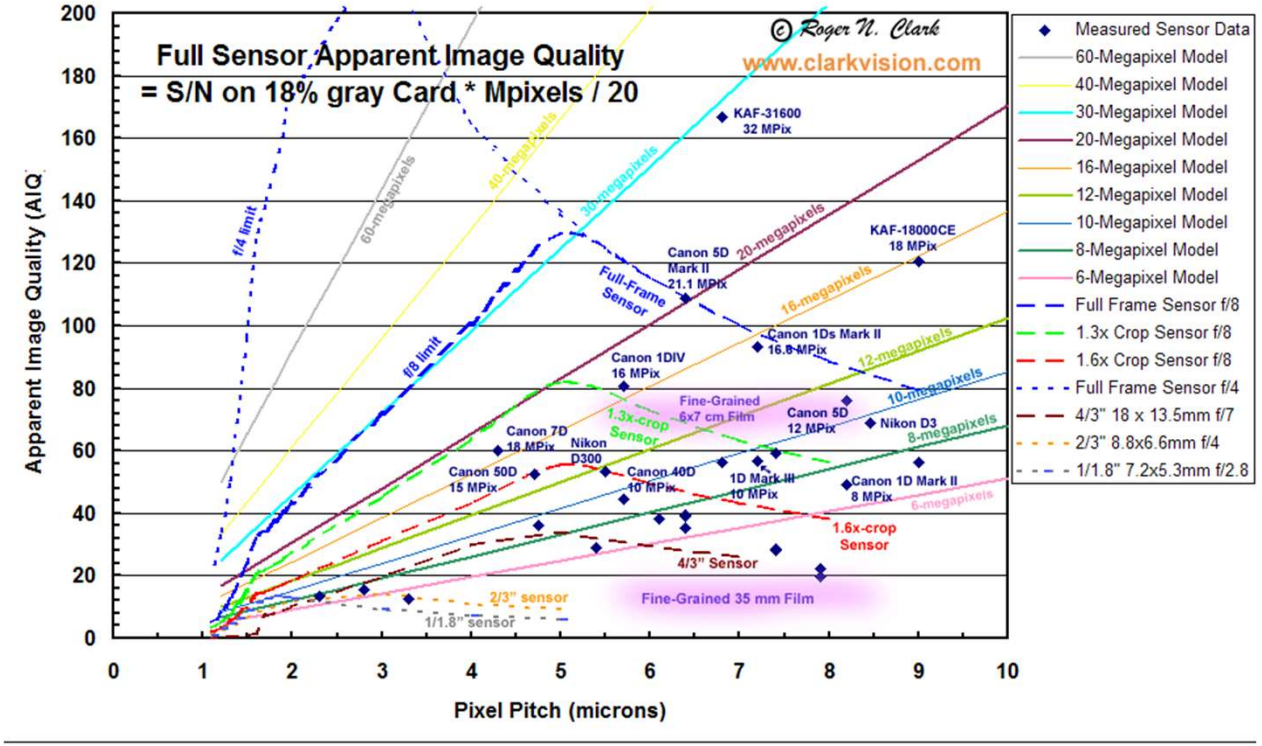
Υψηλή Κβαντική Απόδοση



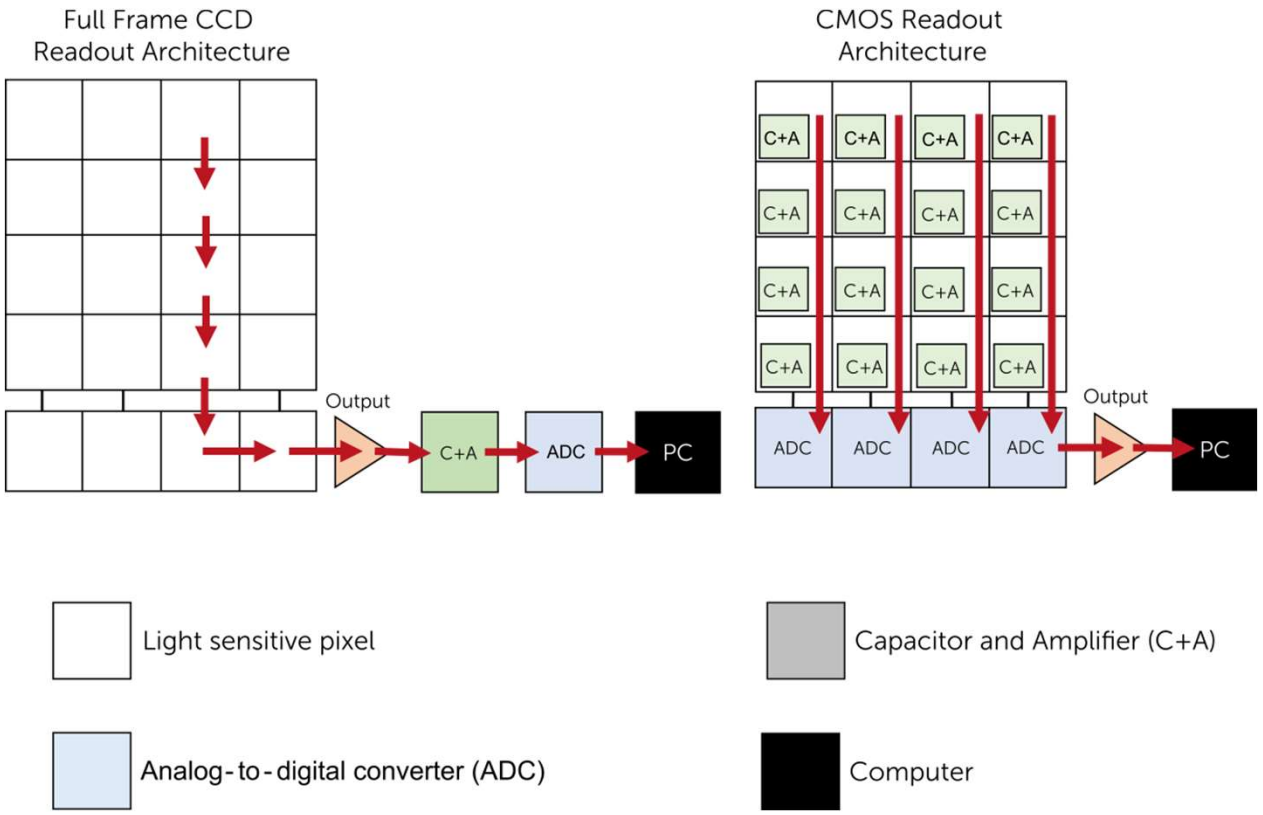


Ανάλυση έναντι Φίλμ

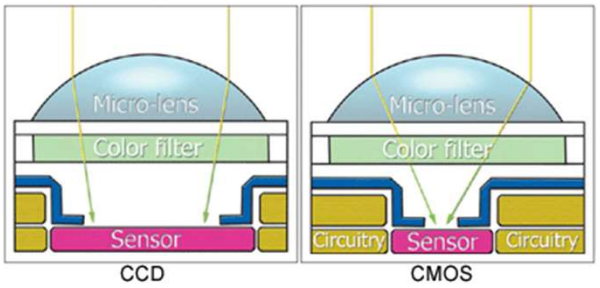
CCD/CMOS



CCD και CMOS ανάκτηση δεδομένων



Pixel Size	4.25µm	6.5µm	11µm
Full-Well Capacity	12,000e⁻	45,000e⁻ (~3.8X more e⁻)	80,000e⁻ (~6.3X more e⁻)



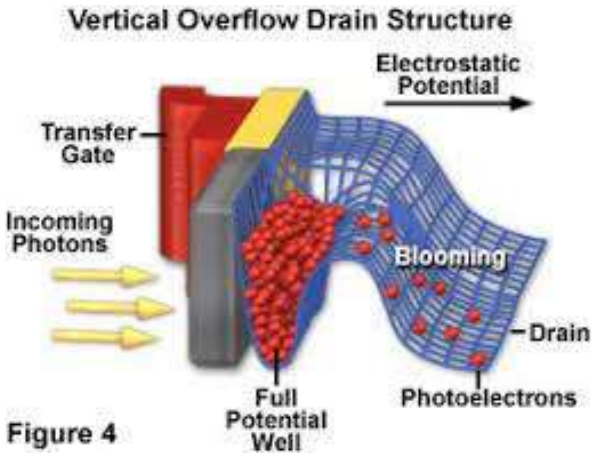
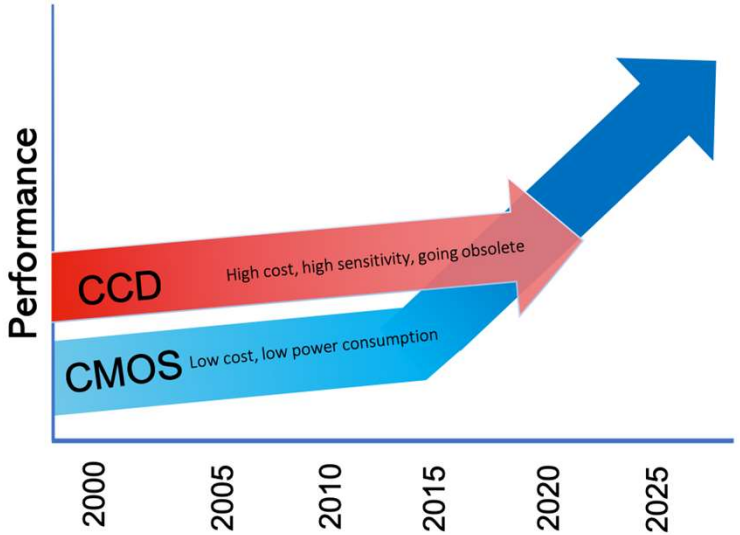
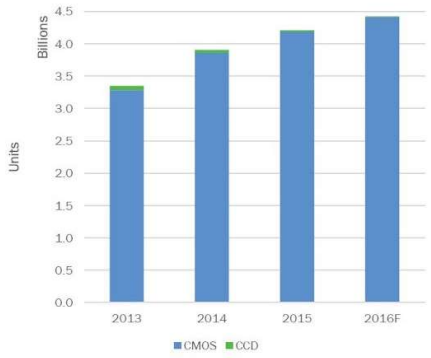
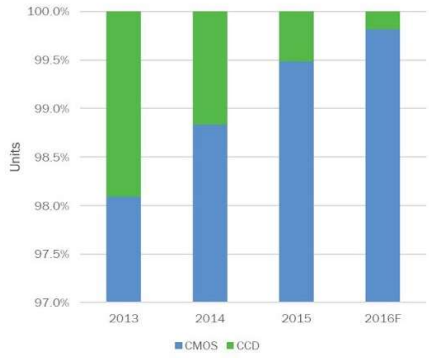


Figure 4

Τάσεις Αγοράς







Camera	Detector type	Size	Bits	Gain (e-/ADU)	RON (e-)	Dark signal (e-/s)	QE @ 400 nm	QE @ 486 nm	QE @589 nm	QE @ 656 nm	QE @ 800 nm
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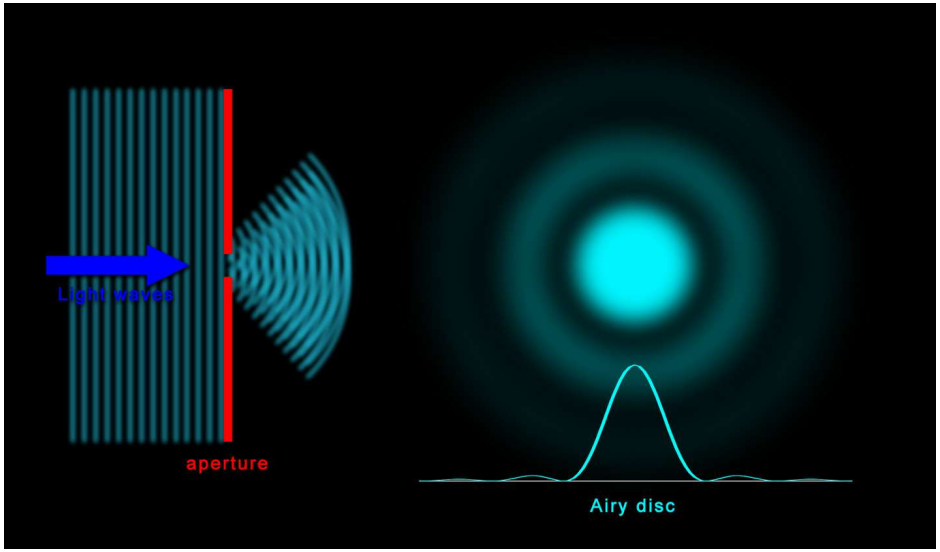
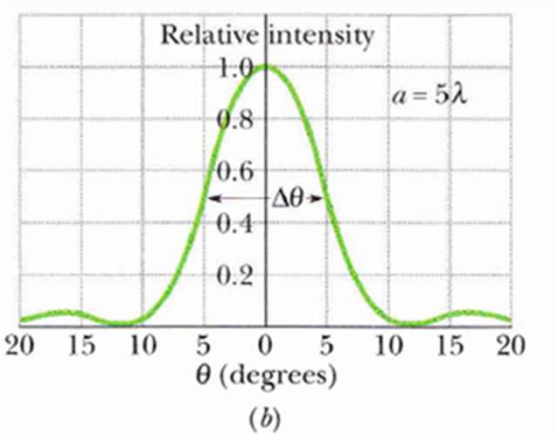
ASI1600MM	Panasonic MN34230PL CMOS	4656 x 3520 3.80 microns 17.7 mm x 13.4 mm	12	0,483 (20 dB)	1,4	0.0037 @ -20°C	49 %	57 %	50 %	40 %	16 %
ASI290MM	Sony IMX290 CMOS	1936 x 1096 2.90 microns 5.6 mm x 3.2 mm	12	0.362 (20 dB)	1.1	0.0500 @ - 20°C	67 %	75 %	71 %	61 %	24 %

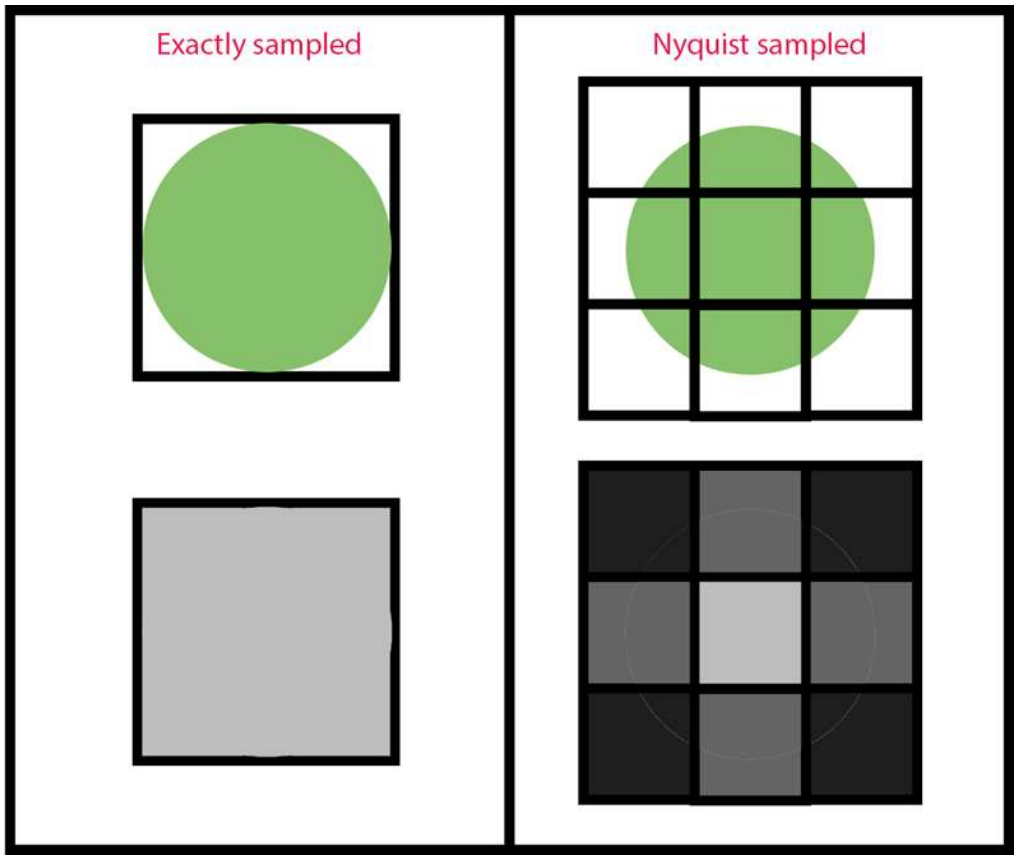
Χαρακτηριστικά CCD/CMOS

Star image


Light waves
aperture
Airy disc


Relative intensity
1.0
0.8
0.6
0.4
0.2
$a = 5\lambda$
$\Delta\theta$
20 15 10 5 0 5 10 15 20
θ (degrees)
(b)

Nyquist theorem data samplink

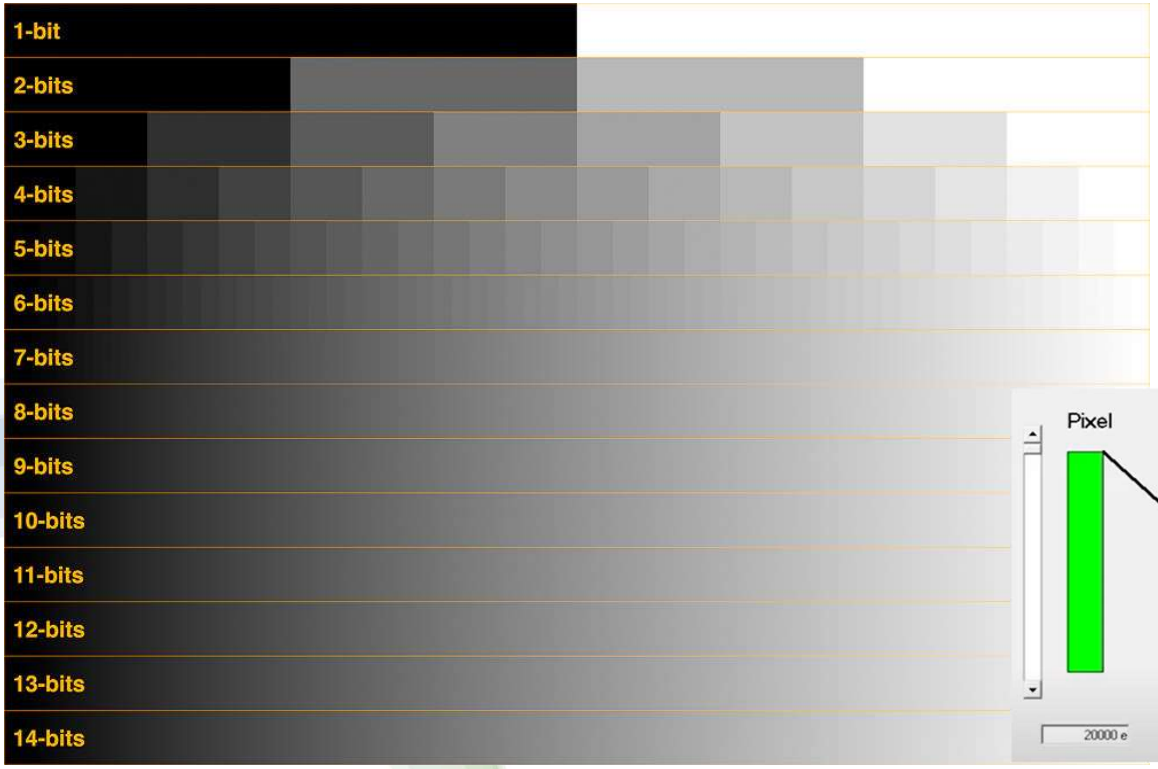


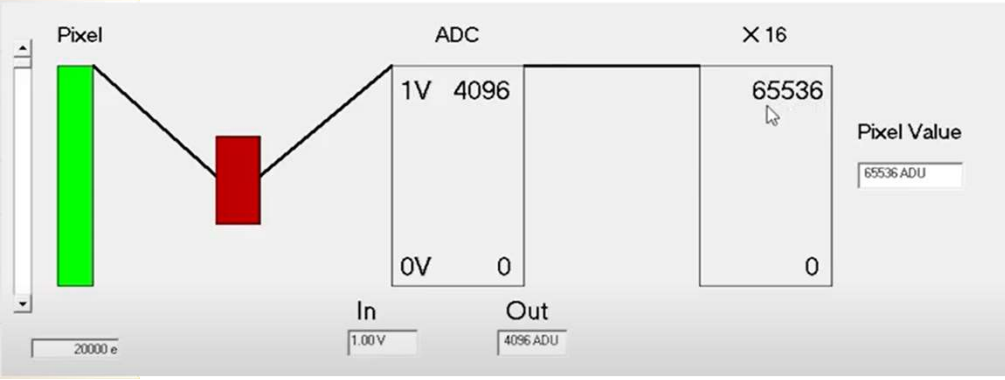
Nyquist theorem data samplink

Optimal CCD Camera size Calculation	*C9,25/Hyperstar*	*C9,25+ FR*	*C9,25*	*C9,25 + Barlow*
Telescope Diameter (mm)	235mm	235mm	235mm	235mm
Focal Ratio	F2.3	F7.0	F10.0	F25.0
Focal Length	541mm	1645mm	2350mm	5875mm
Telescope Limiting Angular Resolution	2.9ArcS	2.9ArcS	2.9ArcS	2.9ArcS
Camera Cell Size in Microns	4.5micr	4.5micr	4.5micr	4.5micr
CCD Vertical Resolution	2,200	2,200	2,200	2,200
CCD Horizontal Resolution	2,750	2,750	2,750	2,750
Camera CCD Size Vertical	9.99mm	9.99mm	9.99mm	9.99mm
Camera CCD Size Horizontal	12.49mm	12.49mm	12.49mm	12.49mm
Camera CCD Diagonal	15.99mm	15.99mm	15.99mm	15.99mm
Mpixels	6.1mpx	6.1mpx	6.1mpx	6.1mpx
Arc Seconds Per cell size	1.733ArcS	.569ArcS	.398ArcS	.159ArcS
Target Light Frequency in nano meters	550nm	550nm	550nm	550nm
Full Width Half Maximum (FWHM) Linear size in Microns	1.3micr	3.9micr	5.6micr	14.0micr
Full Width Half Maximum (FWHM) Angular Size in Arc Seconds	.5ArcS	.5ArcS	.5ArcS	.5ArcS
Sampling Level (1,2 or 3 Nyquist criterion for optimal sampling = 3.3)	3.3x	3.3x	3.3x	3.3x
Camera Pixel Size under Optimal Seeing	0.4micr	1.2micr	1.7micr	4.3micr
Optimal Telescope Focal Ratio with ideal seeing	F27	F27	F27	F27
Optimal Telescope Focal Length for Specific Camera with ideal seeing	6,276mm	6,276mm	6,276mm	6,276mm
Seeing in Arc Seconds	2.5ArcS	2.5ArcS	2.5ArcS	2.5ArcS
FWHM under Specific seeing Linear Size in Microns	6.5micr	19.9micr	28.5micr	71.2micr
Ideal CCD Pixel size for focal length and seeing conditions	2.0micr	6.0micr	8.6micr	21.6micr

Camera	Detector type	Size	Bits	Gain (e-/ADU)	RON (e-)	Dark signal (e-/s)	QE @ 400 nm	QE @ 486 nm	QE @589 nm	QE @ 656 nm	QE @ 800 nm
ATIK460EX	Sony ICX694 CCD	2749 x 2199 4.54 microns 12.5 mm x 10 mm	16	0,274	5.5	0.0028 @ -10°C	52 %	62 %	61 %	54 %	24 %
ATIK414EX	Sony ICX674 CCD	1391 x 1039 6.45 microns 9.0 mm x 6.7 mm	16	0,265	4.1	0.0010 @ -15°C	50 %	62 %	61 %	55 %	27 %
ASI1600MM	Panasonic MN34230PL CMOS	4656 x 3520 3.80 microns 17.7 mm x 13.4 mm	12	0,483 (20 dB)	1,4	0.0037 @ -20°C	49 %	57 %	50 %	40 %	16 %
ASI290MM	Sony IMX290 CMOS	1936 x 1096 2.90 microns 5.6 mm x 3.2 mm	12	0.362 (20 dB)	1.1	0.0500 @ - 20°C	67 %	75 %	71 %	61 %	24 %

Χαρακτηριστικά CCD/CMOS





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ATIK414EX	Sony ICX674 CCD	1391 x 1039 6.45 microns 9.0 mm x 6.7 mm	16	0,265	4.1	0.0010 @ -15°C	50 %	62 %	61 %	55 %	27 %
ASI1600MM	Panasonic MN34230PL CMOS	4656 x 3520 3.80 microns 17.7 mm x 13.4 mm	12	0,483 (20 dB)	1,4	0.0037 @ -20°C	49 %	57 %	50 %	40 %	16 %
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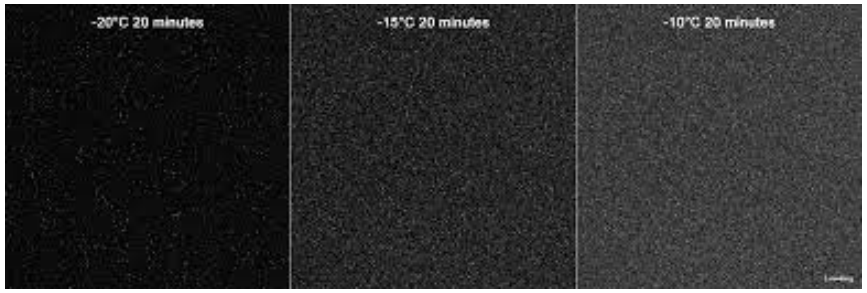
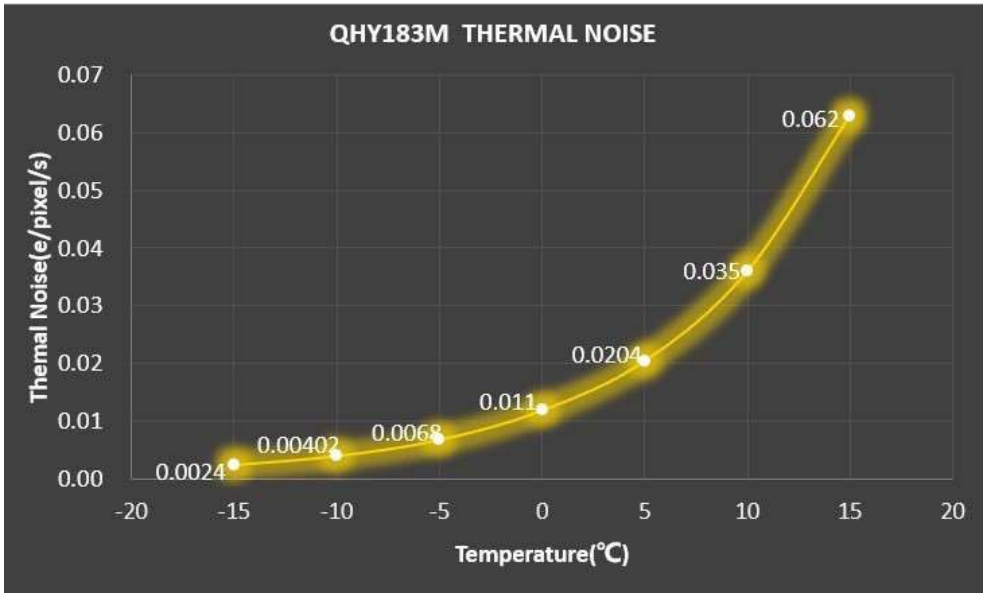
Χαρακτηριστικά CCD/CMOS





Χαρακτηριστικά CCD/CMOS

Camera	Detector type	Size	Bits	Gain (e-/ADU)	RON (e-)	Dark signal (e-/s)	QE @ 400 nm	QE @ 486 nm	QE @589 nm	QE @ 656 nm	QE @ 800 nm
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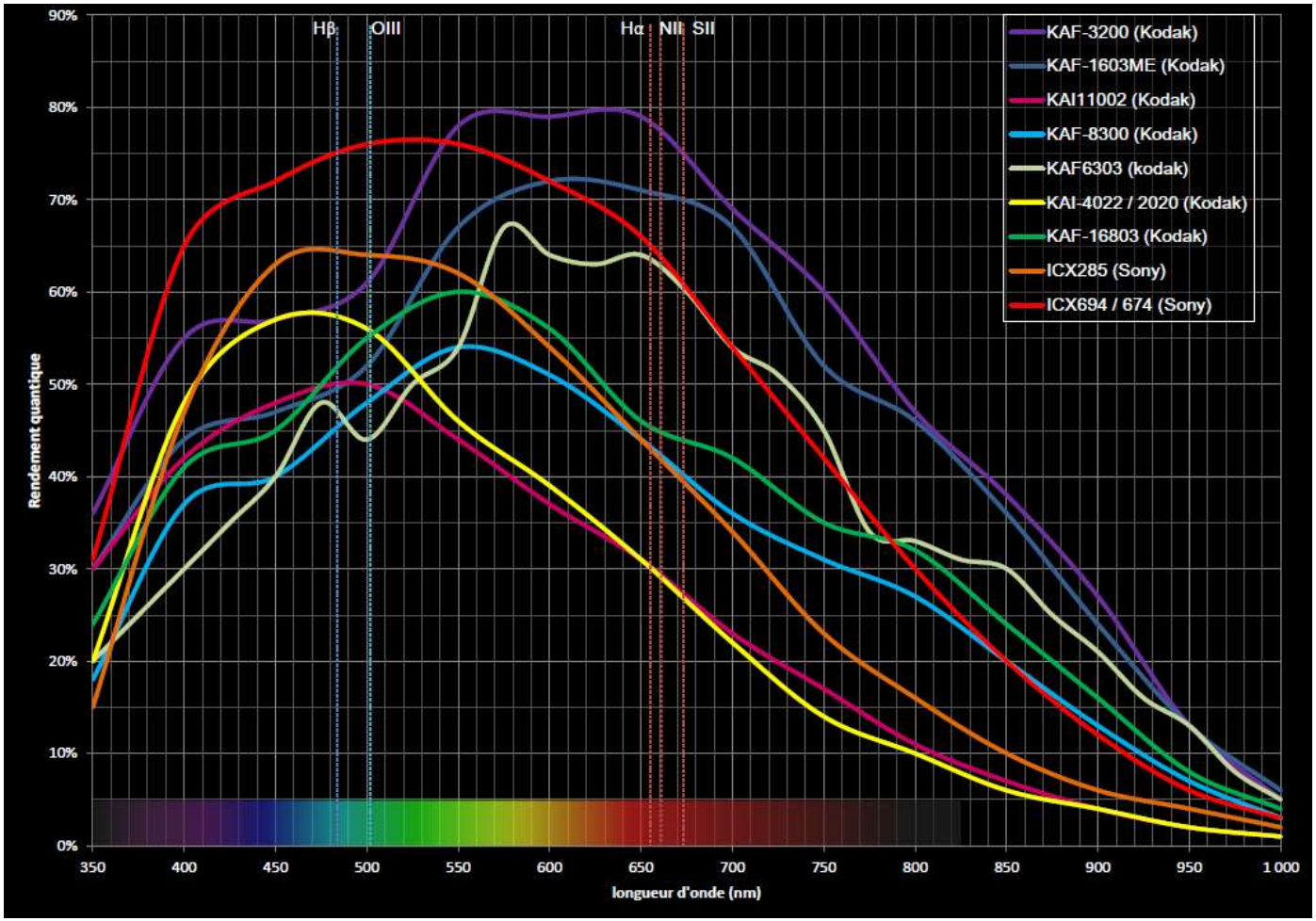
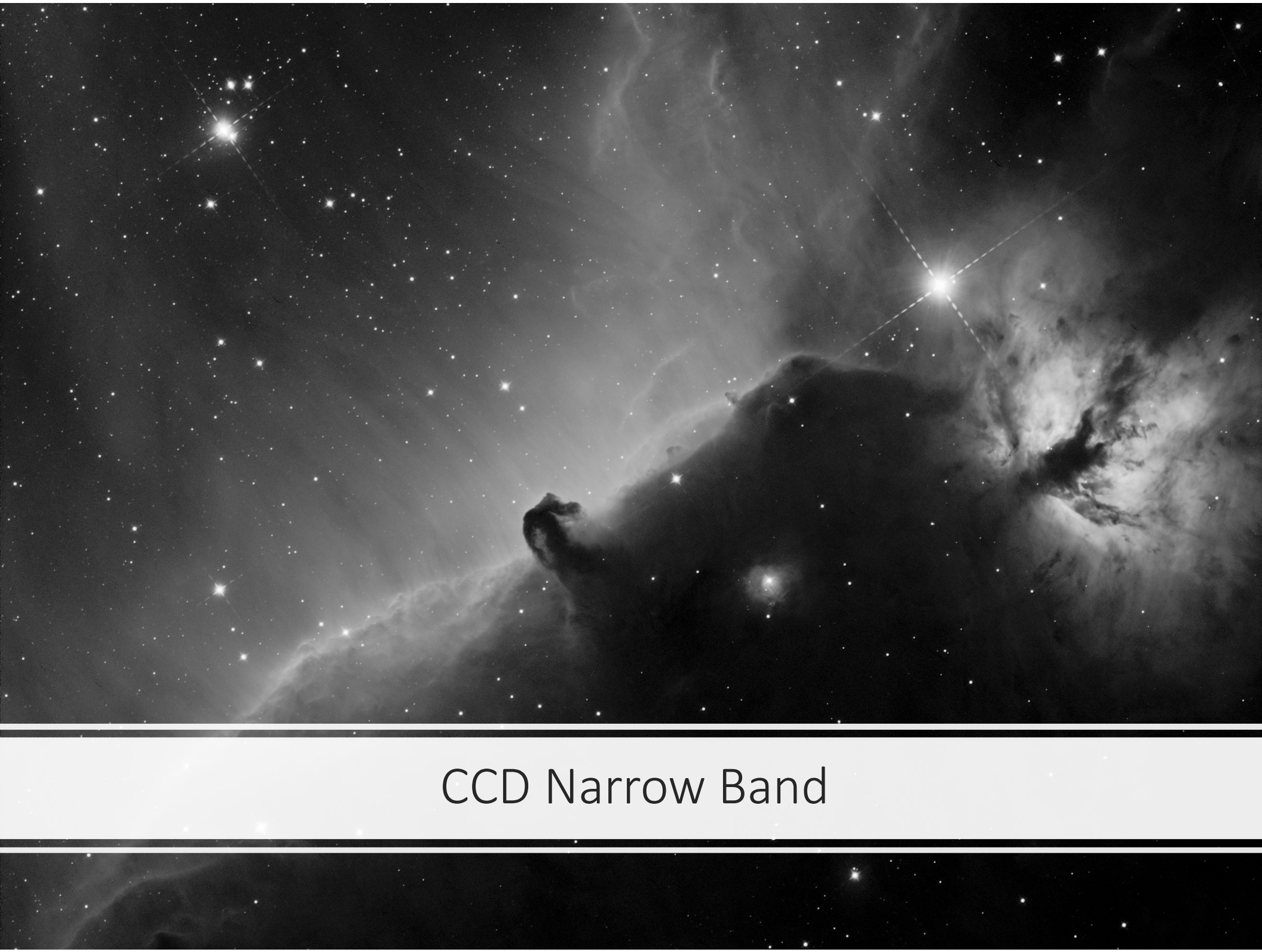
ATIK414EX	Sony ICX674 CCD	1391 x 1039 6.45 microns 9.0 mm x 6.7 mm	16	0,265	4.1	0.0010 @ -15°C	50 %	62 %	61 %	55 %	27 %
ASI1600MM	Panasonic MN34230PL CMOS	4656 x 3520 3.80 microns 17.7 mm x 13.4 mm	12	0,483 (20 dB)	1,4	0.0037 @ -20°C	49 %	57 %	50 %	40 %	16 %
ASI290MM	Sony IMX290 CMOS	1936 x 1096 2.90 microns 5.6 mm x 3.2 mm	12	0.362 (20 dB)	1.1	0.0500 @ - 20°C	67 %	75 %	71 %	61 %	24 %





CCD Narrow Band

Camera	Detector type	Size	Bits	Gain (e-/ADU	RON (e-)	ark signal (e-/s)	QE @ 400 nm	QE @ 486 nm	QE @589 nm	QE @ 656 nm	QE @ 800 nm
ATIK460EX	Sony ICX694 CCD	2749 x 2199 4.54 microns 12.5 mm x 10 mm	16	0,274	5.5	0.0028 @ -10°C	52 %	62 %	61 %	54 %	24 %
ATIK414EX	Sony ICX674 CCD	1391 x 1039 6.45 microns 9.0 mm x 6.7 mm	16	0,265	4.1	0.0010 @ -15°C	50 %	62 %	61 %	55 %	27 %
ASI1600MM	Panasonic MN34230PL CMOS	4656 x 3520 3.80 microns 17.7 mm x 13.4 mm	12	0,483 (20 dB)	1,4	0.0037 @ -20°C	49 %	57 %	50 %	40 %	16 %
ASI290MM	Sony IMX290 CMOS	1936 x 1096 2.90 microns 5.6 mm x 3.2 mm	12	0.362 (20 dB)	1.1	0.0500 @ - 20°C	67 %	75 %	71 %	61 %	24 %

Χαρακτηριστικά CCD/CMOS

[Signal to Noise and Subexposure Calculations (starrywonders.com)]

StarryWonders Astrophotography

Steve Cannistra's SubExposure Calculator (http://www.starrywonders.com/snr.html)

Enter Information Here

Camera Used: ATIK 460 EX
Software Used: Other
Enter 'F' in % (the desired fraction of maximum SNR): 95% (values between 9

Baseline Camera Data

Camera Gain (e/ADU): 0.27 e/ADU
Camera read out noise: 5.0 e RMS

Enter Test Image Statistics

Sky ADU (measure after calibration): 3,500 ADU
Exposure time in minutes (of test image used to obtain the Sky ADU above): 3 Minutes

Calculated Results:

Sky Flux (e/min): 306 e/min
Subexposure duration in minutes to achieve desired F value: **0.76 Minutes**

Notes:
1. This method determines the optimal subexposure time needed to achieve a certain fraction (F) of the maximum possible SNR at a given sky flux.
2. Sky ADU is measured from a test image, after calibration.
3. Sky flux is assumed to overwhelm object flux for this analysis (which is the case for very faint deep sky objects).
4. I provide this spreadsheet free to astrophotographers without guarantees. Please use at your own risk.
5. Please reference this spreadsheet if you find it useful: http://www.starrywonders.com/snr.html.
6. Please see John Smith's analysis for a different perspective on how to calculate subexposure time (http://www.hiddenloft.com/notes/acq.htm).

StarryWonders Astrophotography

Steve Cannistra's SubExposure Calculator (http://www.starrywonders.com/snr.html)

Enter Information Here

Camera Used: ATIK 460 EX
Software Used: Other
Enter 'F' in % (the desired fraction of maximum SNR): 95% (values between 9

Baseline Camera Data

Camera Gain (e/ADU): 0.27 e/ADU
Camera read out noise: 1.1 e RMS

Enter Test Image Statistics

Sky ADU (measure after calibration): 3,500 ADU
Exposure time in minutes (of test image used to obtain the Sky ADU above): 3 Minutes

Calculated Results:

Sky Flux (e/min): 306 e/min
Subexposure duration in minutes to achieve desired F value: **0.04 Minutes**

Notes:
1. This method determines the optimal subexposure time needed to achieve a certain fraction (F) of the maximum possible SNR at a given sky flux.
2. Sky ADU is measured from a test image, after calibration.
3. Sky flux is assumed to overwhelm object flux for this analysis (which is the case for very faint deep sky objects).
4. I provide this spreadsheet free to astrophotographers without guarantees. Please use at your own risk.
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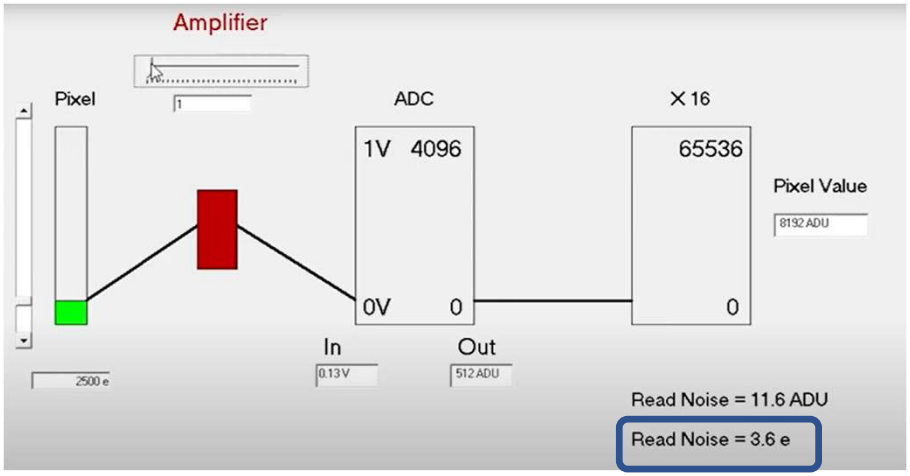
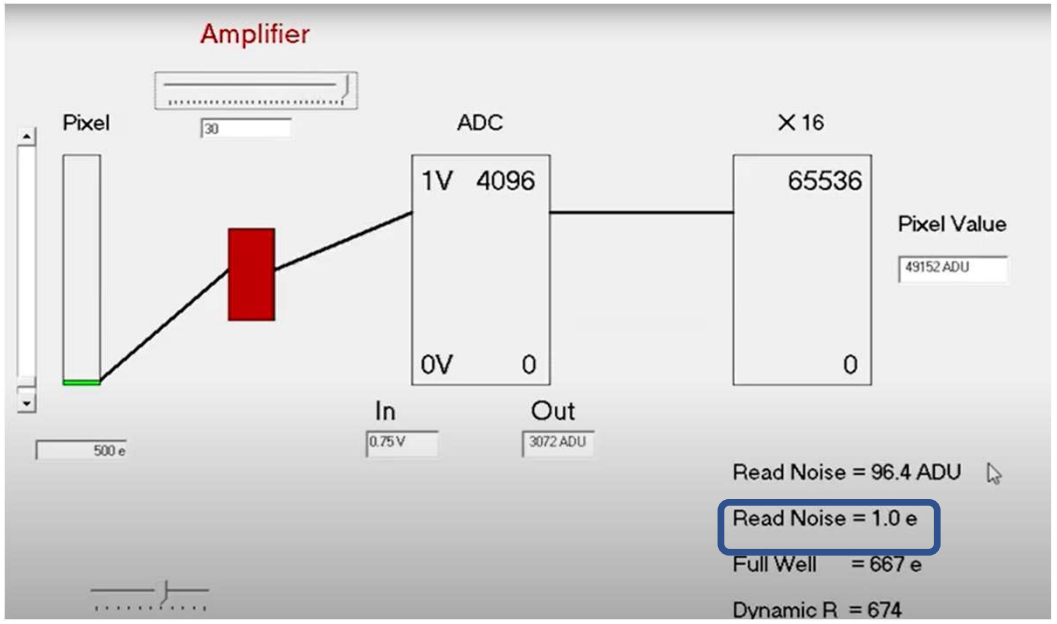
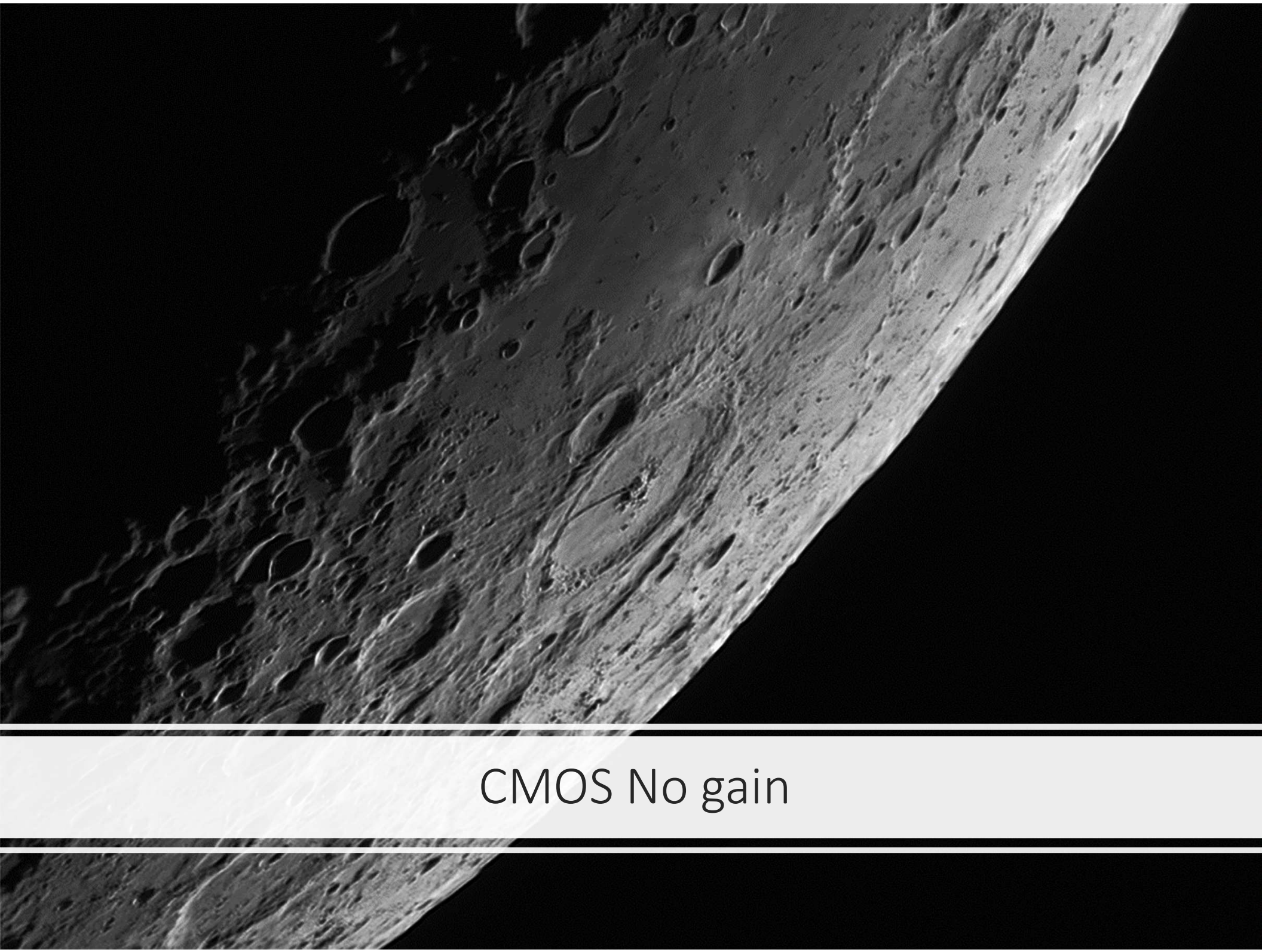
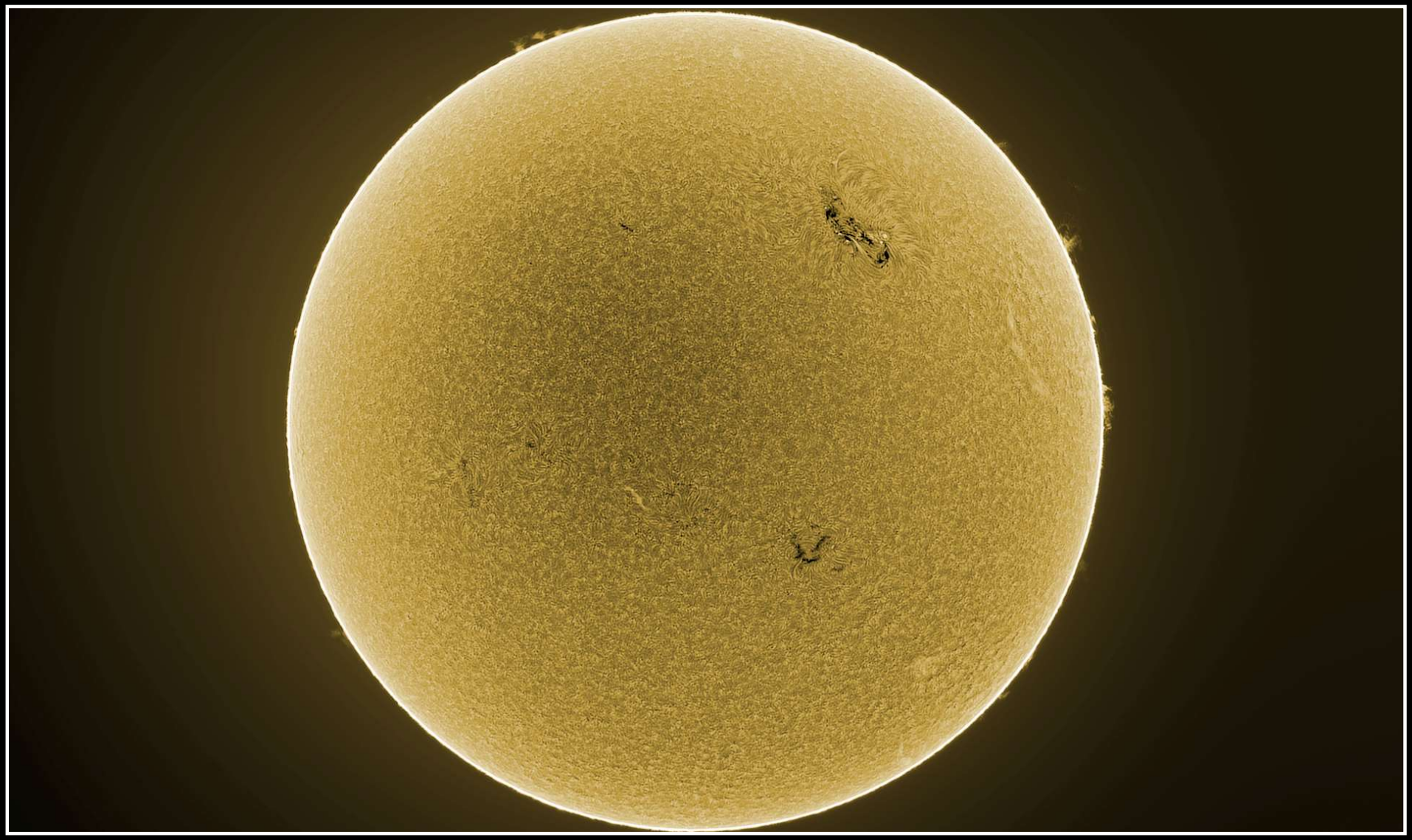
Χαρακτηριστικά CCD/CMOS



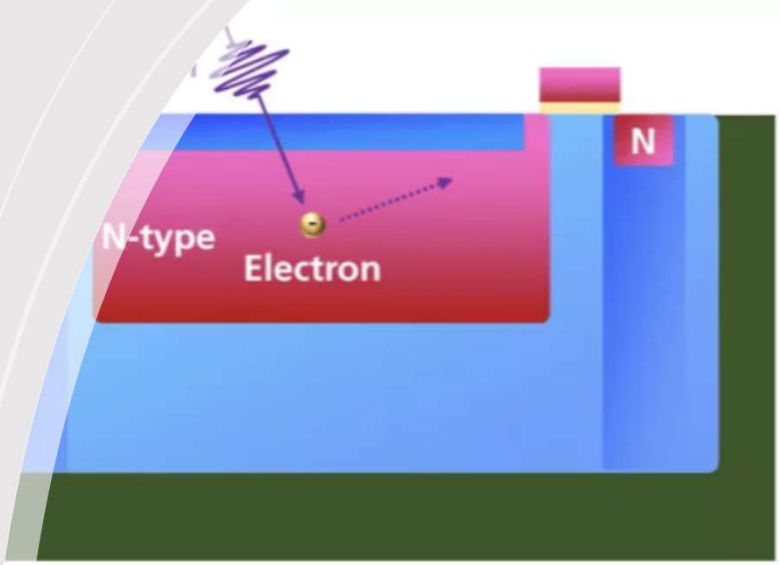




CMOS No gain



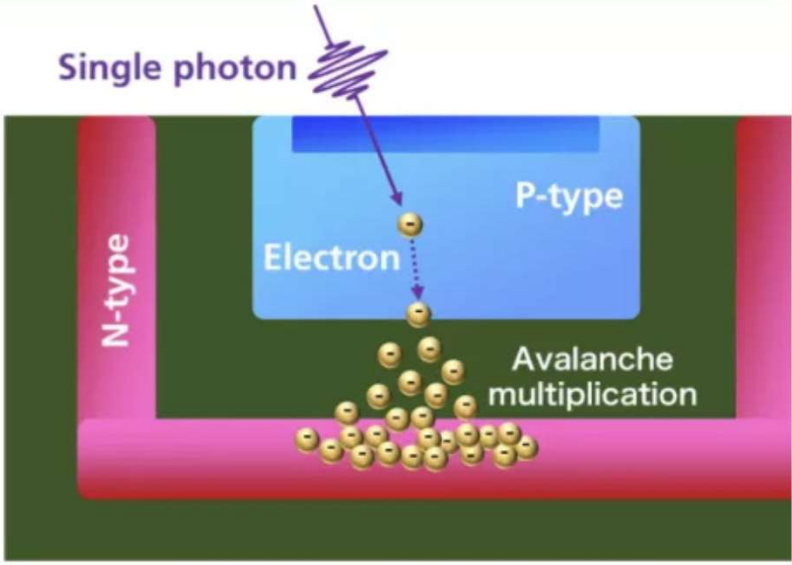
CMOS + Gain



approx. 1x multiplication

Possibility of noise causing inability to correctly detect photon entry, resulting in reduced accuracy.

CMOS sensor



approx. 1,000,000x multiplication

Correctly detects photon entry. More accurate information received per photon due to multiplicat

SPAD sensor

Ευχαριστώ