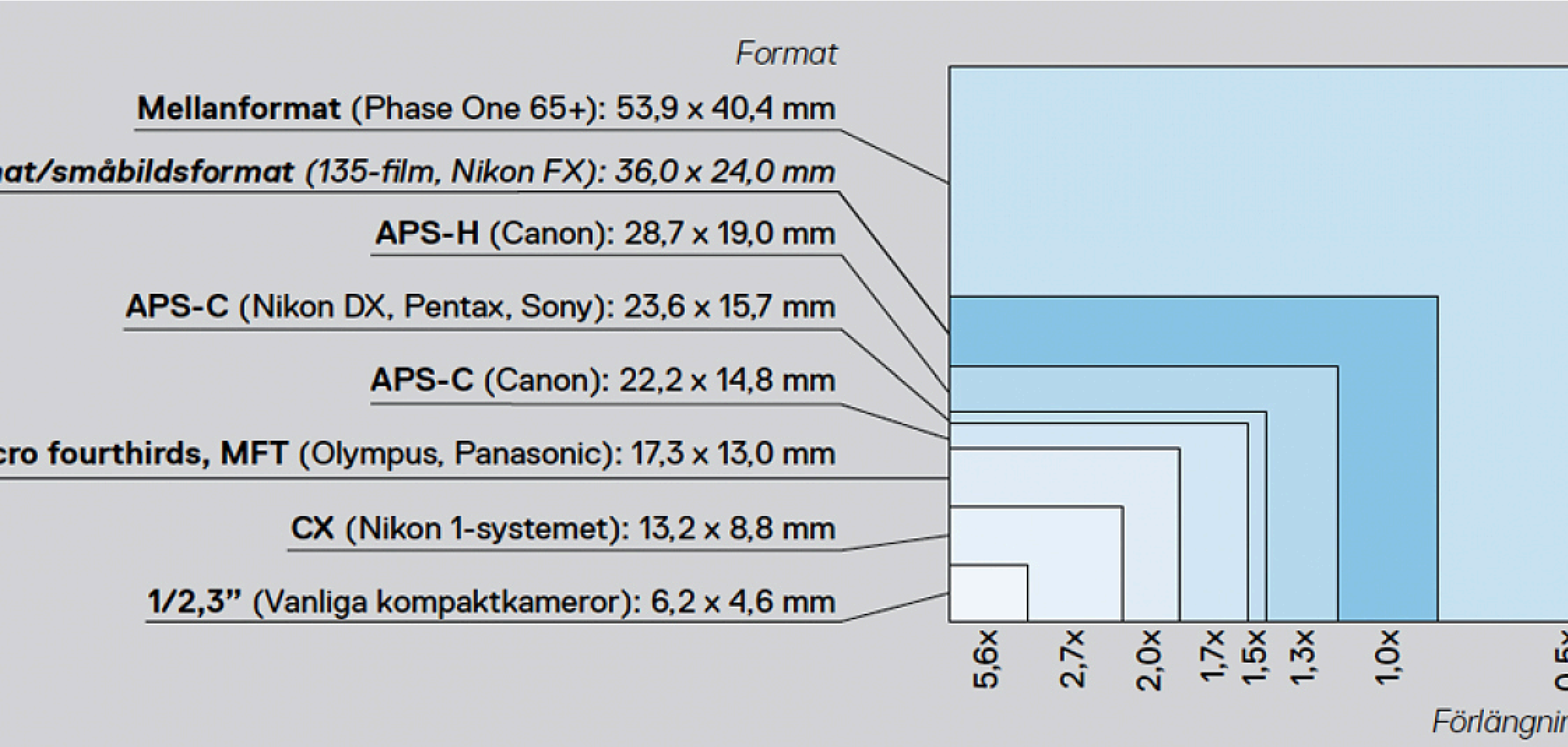
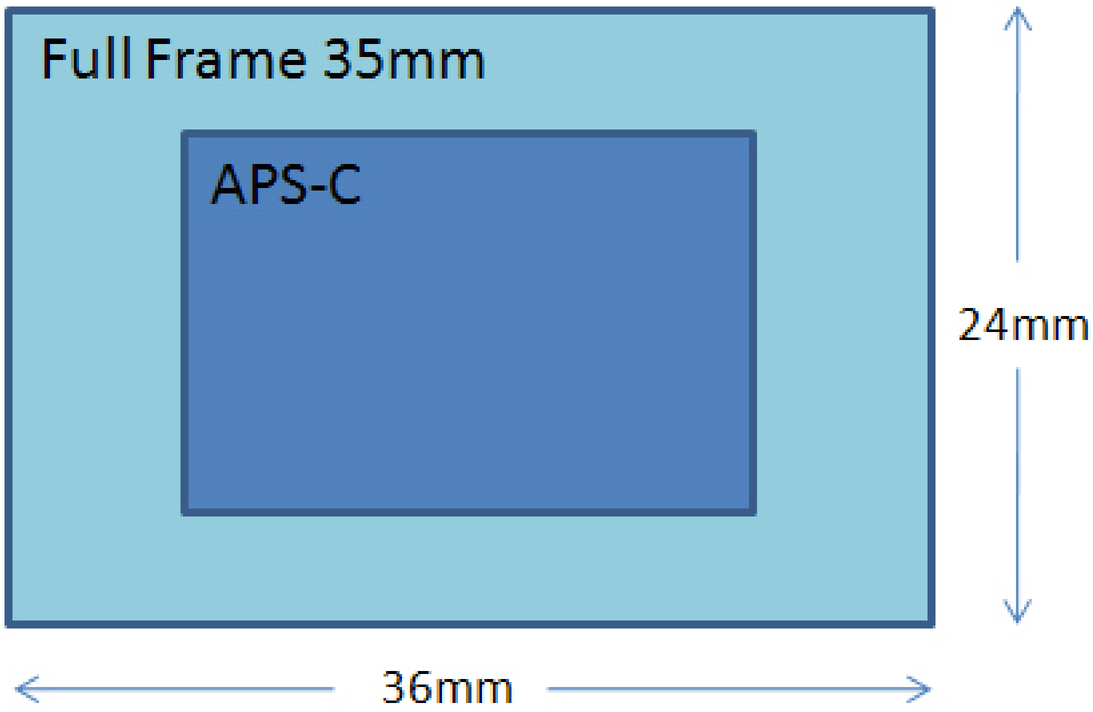
Skärpedjup

Vid allt annat lika gäller:

Bländare	Stor bländare (litet tal)	Litet skärpedjup
	Liten bländare (stort tal)	Stort skärpedjup
Avstånd	Kort avstånd	Litet skärpedjup
	Stort avstånd	Stort skärpedjup
Brännvidd	Kort brännvidd	Stort skärpedjup
	Lång brännvidd	Litet skärpedjup
Sensor	Liten sensor	Stort skärpedjup
	Stor sensor	Litet skärpedjup


Format
Mellanformat (Phase One 65+): 53,9 x 40,4 mm
…at/småbildsformat (135-film, Nikon FX): 36,0 x 24,0 mm
APS-H (Canon): 28,7 x 19,0 mm
APS-C (Nikon DX, Pentax, Sony): 23,6 x 15,7 mm
APS-C (Canon): 22,2 x 14,8 mm
…cro fourthirds, MFT (Olympus, Panasonic): 17,3 x 13,0 mm
CX (Nikon 1-systemet): 13,2 x 8,8 mm
1/2,3" (Vanliga kompaktkameror): 6,2 x 4,6 mm
5,6x
2,7x
2,0x
1,7x
1,5x
1,3x
1,0x
Förlängni…

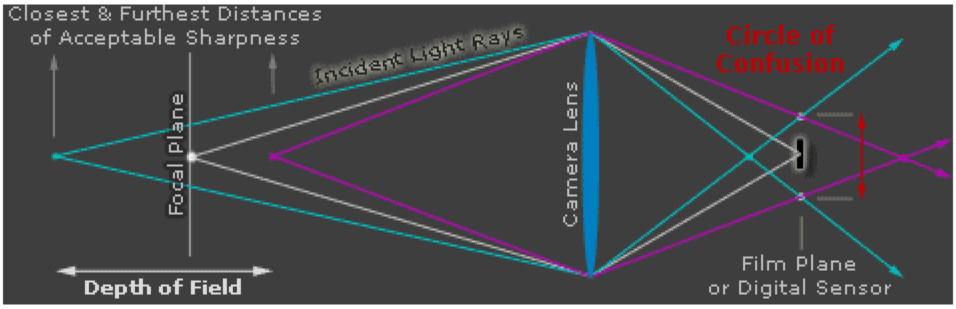

Full Frame 35mm
APS-C
24mm
36mm

Jämförelse av skärpedjup för olika sensorstorlekar

Sensor 1	*Bländare*	*Brännvidd*		*Sensor 2*	*Bländare*	*Brännvidd*
APS-C (1,5)	5,6	75 mm	*motsvarar*	Fullformat	8,5	114 mm
1/2,3"	4	20 mm	*motsvarar*	Fullformat	22,6	113 mm
				APS-C (1,5)	18	90 mm
1/2,3"	2,8	15 mm	*motsvarar*	APS-C (1,5)	12,6	67 mm
				Fullformat	15,8	85 mm
1/1,8"	2,8	75 mm	*motsvarar*	Fullformat	13,5	362 mm
				APS-C (1,5)	8,9	238 mm
Fullformat	2,8	200 mm	*motsvarar*	1/1,8"	0,5	35 mm
				APS-C (1,5)	1,8	132 mm
Fullformat	1,4	50 mm	*motsvarar*	APS-C (1,5)	0,9	33 mm
		85 mm		APS-C (1,5)	0,9	56 mm

Skärpedjupet avgörs av
#förstoringsgrad (som beror av brännvidd, avstånd och sensorstorlek)
samt
#vald bländare.

CIRCLE OF CONFUSION



Since there is no critical point of transition, a more rigorous term called the "**circle of confusion**" is used to define how much a point needs to be blurred in order to be perceived as unsharp. When the circle of confusion becomes perceptible to our eyes, this region is said to be outside the depth of field and thus no longer "acceptably sharp." The circle of confusion above has been exaggerated for clarity; in reality this would be only a tiny fraction of the camera sensor's area.

When does the circle of confusion become perceptible to our eyes? An acceptably sharp circle of confusion is loosely defined as one which would go unnoticed when enlarged to a standard 8x10 inch print, and observed from a standard viewing distance of about 1 foot.

Jämförelse: lika utsnitt (=samma förstoringsgrad = olika fotoavstånd)

Focal Length (mm)	Focus Distance (m)	Depth of Field (m)
10	0.5	0.482
20	1.0	0.421
50	2.5	0.406
100	5.0	0.404
200	10	0.404
400	20	0.404

Note: Depth of field calculations are at **f/4.0 on a camera with a 1.6X crop factor**, using a circle of confusion of 0.0206 mm.

Note how there is indeed a subtle change for the smallest focal lengths. This is a real effect, but is negligible compared to both aperture and focusing distance. Even though the total depth of field is virtually constant, the fraction of the depth of field which is in front of and behind the focus distance does change with focal length, as demonstrated below:

Distribution of the Depth of Field

Focal Length (mm)	**Rear**	**Front**
10	70.2 %	29.8 %
20	60.1 %	39.9 %
50	54.0 %	46.0 %
100	52.0 %	48.0 %
200	51.0 %	49.0 %
400	50.5 %	49.5 %

DEPTH OF FOCUS & APERTURE VISUALIZATION

Another implication of the circle of confusion is the concept of depth of focus (also called the "focus spread"). It differs from depth of field because it describes the distance over which light is focused at the *camera's sensor*, as opposed to the subject:

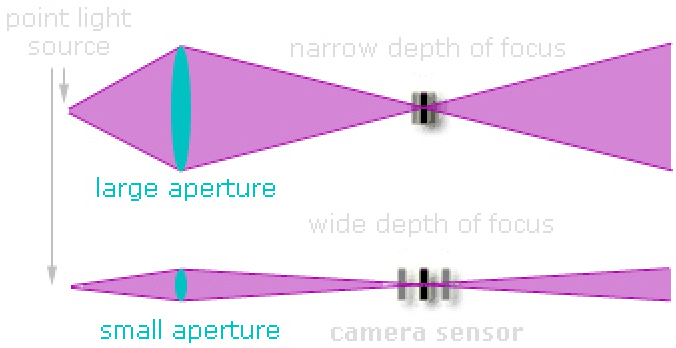
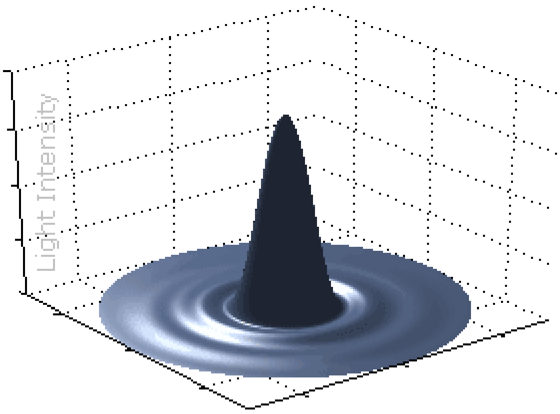


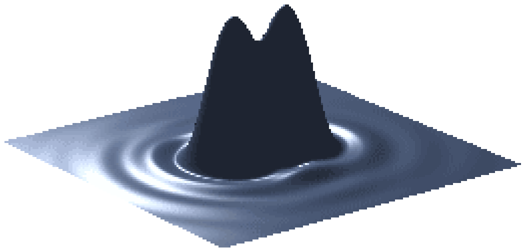
Diagram depicting depth of focus versus camera aperture. The purple lines comprising the edge of each shaded region represent the extreme angles at which light could potentially enter the aperture. The interior of the purple shaded regions represents all other possible angles.

The key concept is this: when an object is in focus, light rays originating from that point converge at a point on the camera's sensor. If the light rays hit the sensor at slightly different locations (arriving at a disc instead of a point), then this object will be rendered as out of focus — and increasingly so depending on how far apart the light rays are.

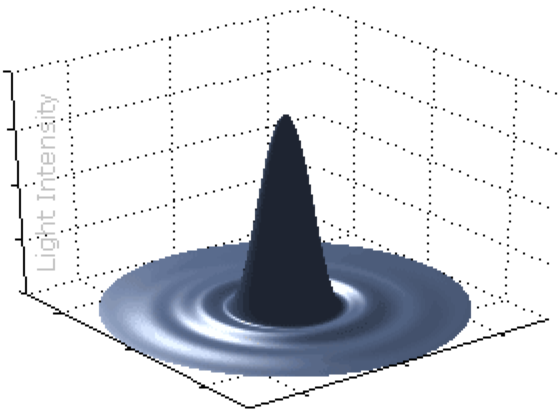
AIRY DISK OVERLAP & MICRO-CONTRAST



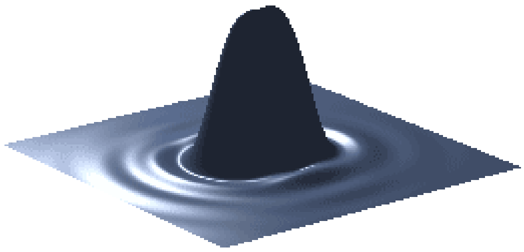
Airy Disk
(smallest point light source)



Closely Spaced Points
Barely Resolved

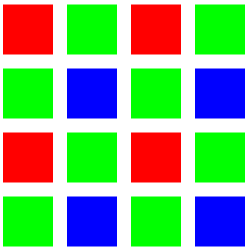


Airy Disk
(smallest point light source)

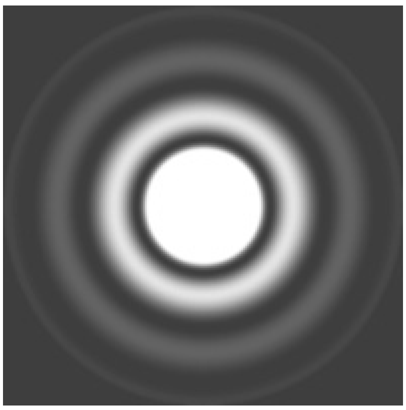


Closely Spaced Points

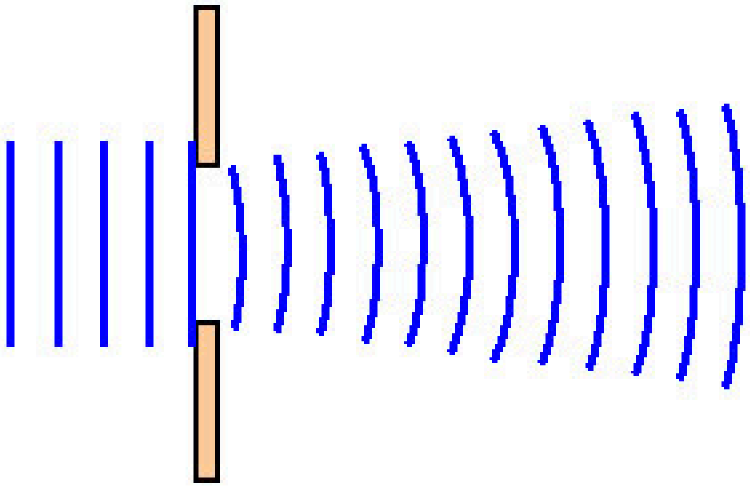
Unresolved



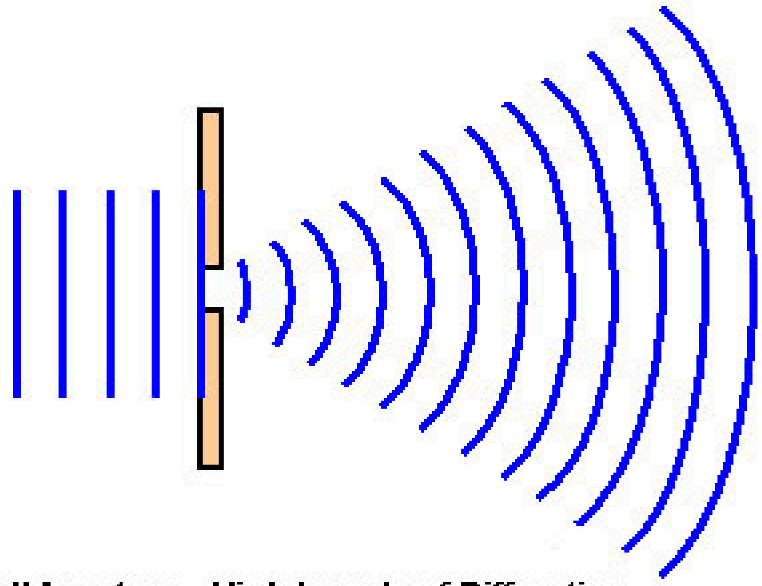
Bayer pattern



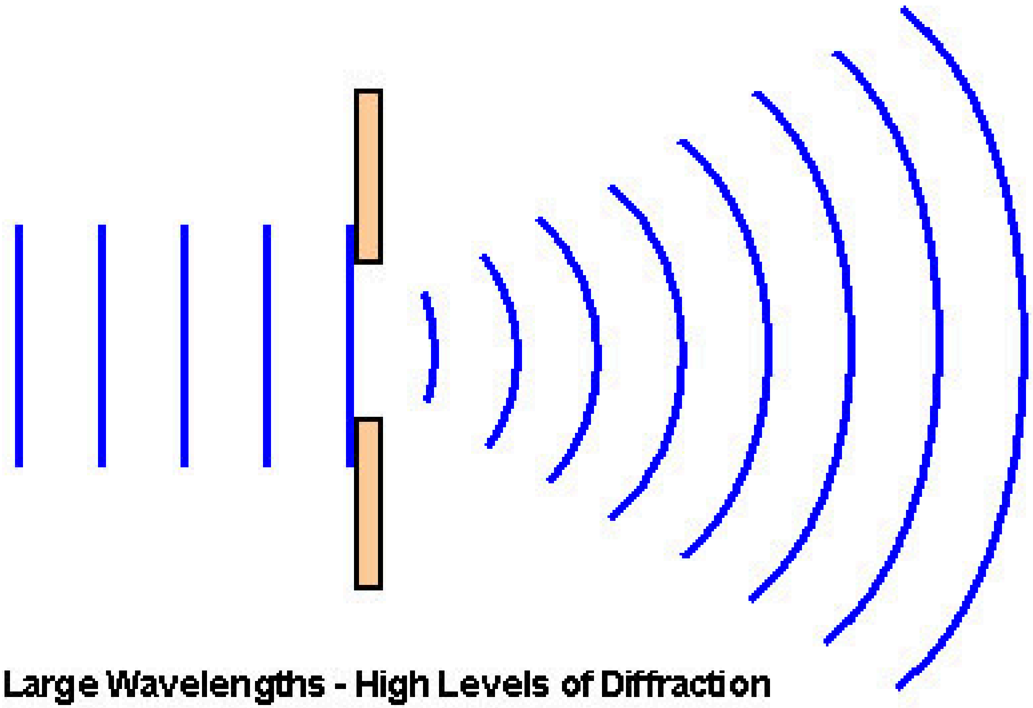
Airy disk



Large Aperture - Low Levels of Diffraction

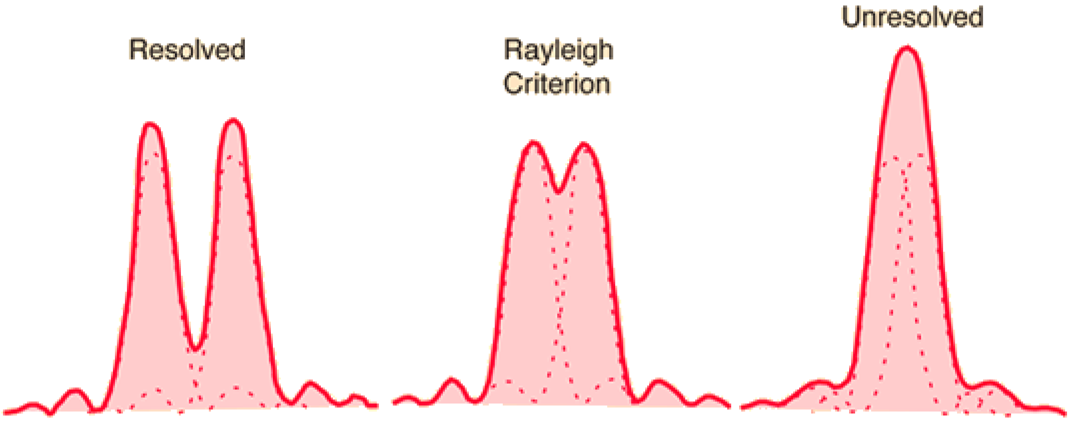


Small Aperture - High Levels of Diffraction

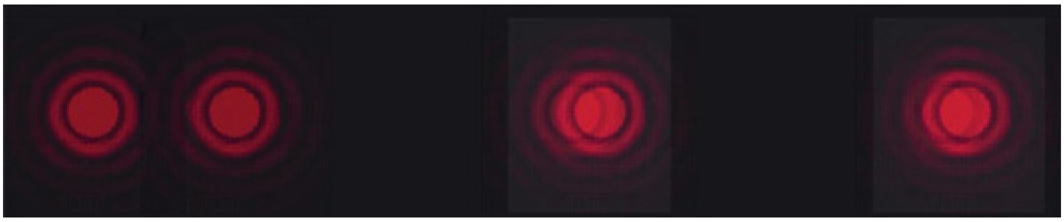


Large Wavelengths - High Levels of Diffraction

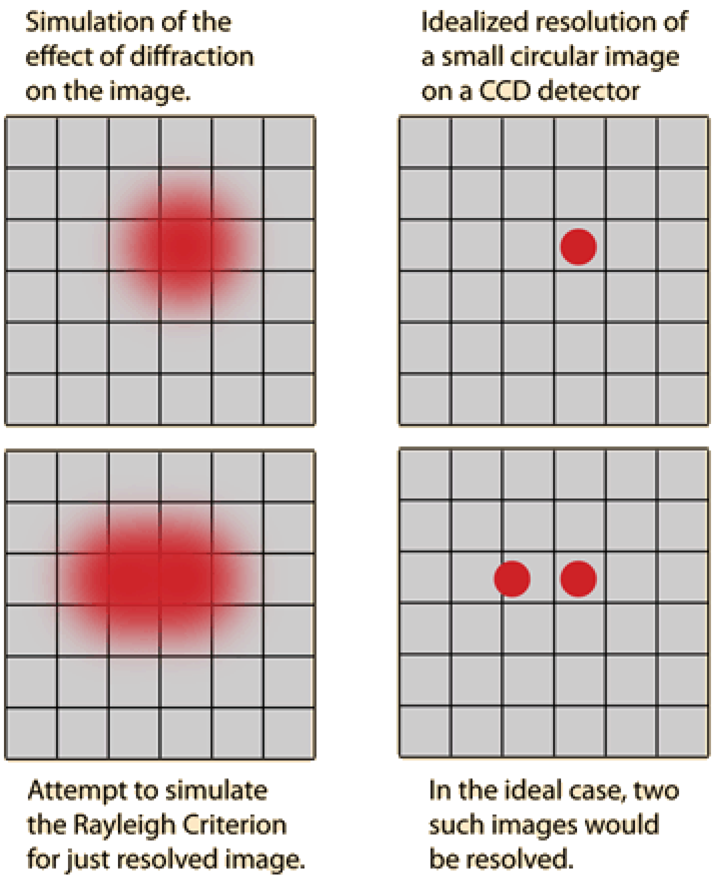
Presuming that diffraction is the determining factor, then the generally accepted criterion for the minimum resolvable detail is the Rayleigh criterion.



This shows the intensity curves for the radial distribution of the diffracted light for different separations. Your eye sees the characteristic bullseye distribution of light as illustrated below.



While perfect imaging of the source would be smaller perfect circles of light, this shows the smearing of the light by diffraction into the bullseye patterns.



For modern digital photography where the images are projected onto a CCD, the information is collected on pixels of the digital detector. At left is an attempt to show the effect of diffraction on such imaging in cases where the diffraction is the phenomenon that limits the resolution. If the image is in focus and free of visible affects of lens aberrations, then it may be that it will fit on one pixel. But if the aperture is small enough, then diffraction can spread the image onto neighboring pixels and constitute the limit on the resolution of the image.

Sensorformat och kritisk bländare (diffraktion)

Format	Sidförhållande	Mått (mm)	Yta	Faktor	Pixlar	Pixelstorlek (pitch)	Exempel	Kritisk bländare	Förderliche Blende
1/2.3"	4 : 3	6,2x4,7	29,1 mm2	5,6	16 Mp	1,4 µm	Nikon Coolpix P900 Olympus SH-2	2,6	2,1
1/2.3"	4 : 3	6,2x4,7	29,1 mm2	5,6	20 Mp	1,4 µm	Sony HX300 Nikon Coolpix A900	2,3	1,9
1/1.8"	4 : 3	7,2x5,3	38,16 mm2		16 Mp			3	2,4
1/1.8"	4 : 3	7,2x5,3	38,16 mm2		20 Mp			2,7	2,2
2/3"	4 : 3	8,8x6,6	58,1 mm2		12 Mp	2,1 µm	Fujifilm X10/X20	4,3	3,4
1"	4 : 3	13,2x8,8	116,2 mm2	2,7	20 Mp	2,4 µm	Nikon1 J5 Canon Powershot G9X	4,8	3,8
Four-thirds	4 : 3	17,3x13	224,9 mm2	2	16 Mp	3,8 µm	Olympus, Panasonic	7,3	6,2
Four-thirds	4 : 3	17,3x13	224,9 mm2	2	20 Mp	3,3 µm	Olympus, Panasonic	6,5	5,4
APS-C	3 : 2	23,7x15,6	370 mm2	1,5	16 Mp	4,8 µm	Nikon D7000	9,1	7,3
APS-C	3 : 2	23,7x15,6	370 mm2	1,5	24 Mp	3,9 µm	Nikon D7200	7,4	6,4
Fullformat	3 : 2	36x24	864 mm2	1	16 Mp	7,3 µm	Nikon D4s, Nikon Df	13,8	12
Fullformat	3 : 2	36x24	864 mm2	1	24 Mp	6,0 µm	Nikon D750	11,3	9,8
Fullformat	3 : 2	36x24	864 mm2	1	36 Mp	4,9 µm	Nikon D810	9,2	8

Diffraktionen (ljusspridningen) har störst påverkan vid *liten faktisk bländaröppning (i mm) och/eller liten pixelstorlek.*
Exemplet Nikon Coolpix P900 (faktisk brännvidd 4,3- 357 mm = fullformatekvivalent 24- 2000 mm) med 1/2.3"-sensor har en bländardiameter på *0,77 mm* för bländare f 5,6 vid brännvidden 4,3 mm (=ekv. 24 mm). Bländaromfånget hos kameran är också begränsat till 2,8 - 6,3.
En fullformats-Nikon har vid brännvidden 24 mm en bländaröppning på *4,3 mm* vid bländare f 5,6.

Bländardiametern 0,77 mm (som hos P900) skulle på fullformataren ge bländare f 32.