

10th Aegean
Summer School
in Visual Optics

Presbyopia: Origins, effects,
optical and surgical treatment
modalities

October 2-4 2011
Terra Maris Hotel
Hersonissos, Greece

Image Quality in Multifocal systems

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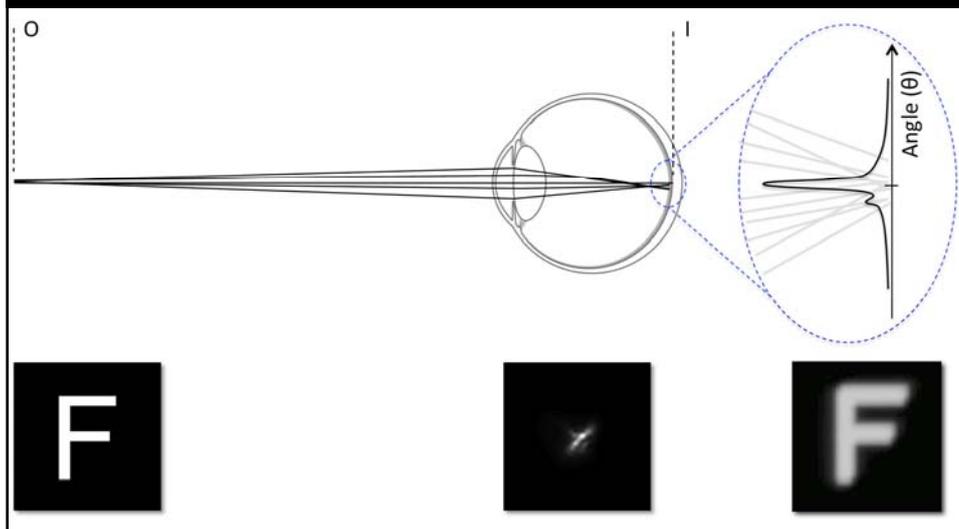
Institute of Vision and Optics (IVO)
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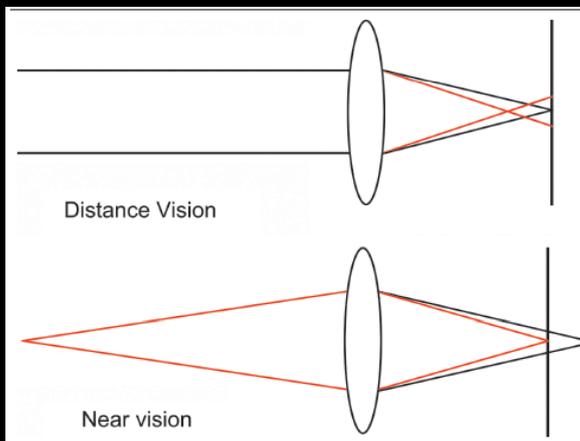


The PSF of the human eye



Multifocal IOLs

Every multifocal IOL provides at least two dioptric powers, with two images of the same object forming on the retina. The defocused image reduces contrast.

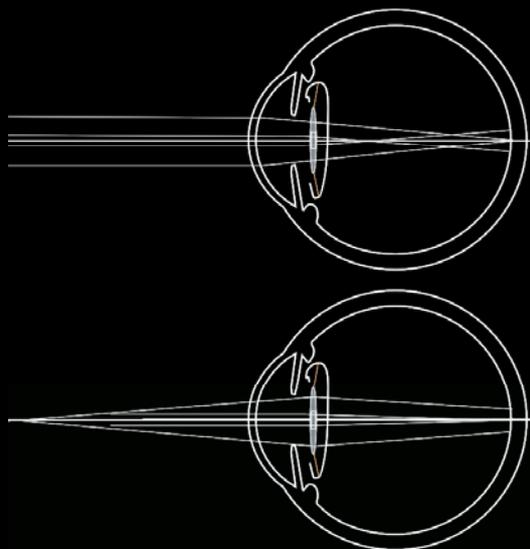


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Adding a multifocal element in the eye

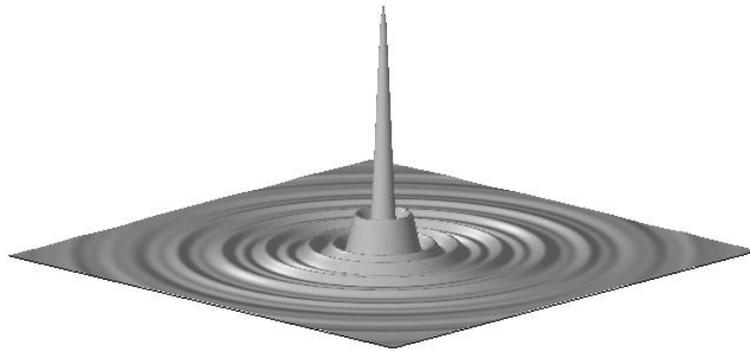
Angle k ,
pupil diameter,
alignment,
centration



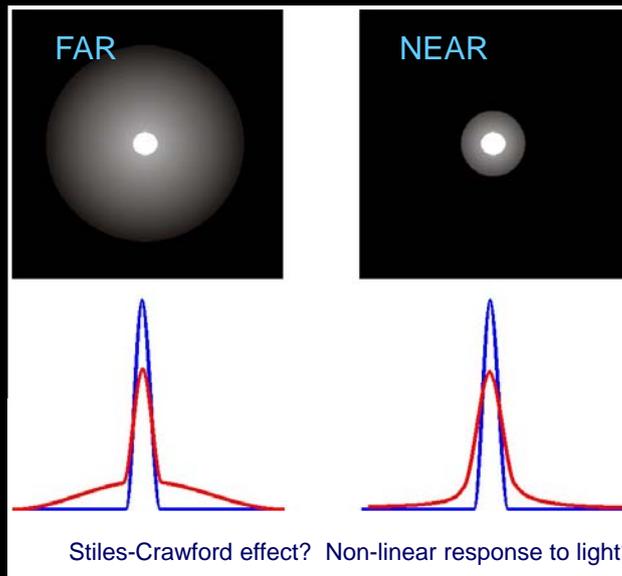
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PSF with a bifocal element



PSF with a bifocal element



Stiles-Crawford effect? Non-linear response to light?

Through focus image quality

(Aberration-free system)

(5/10 Snellen letter)

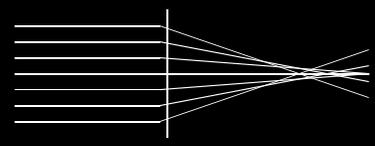


Small pupil diameters such as artificial diaphragms increase depth of focus - they reduce the impact of defocus by selecting paraxial rays only.



Through focus image quality

(System with Spherical aberration, 2microns@6mm pupil)

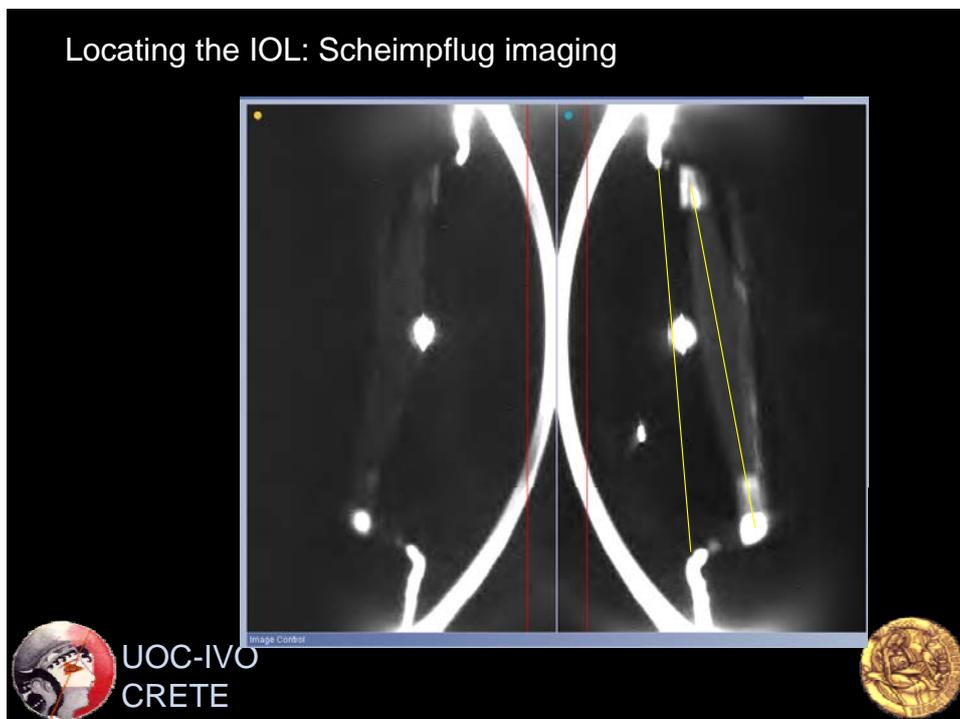
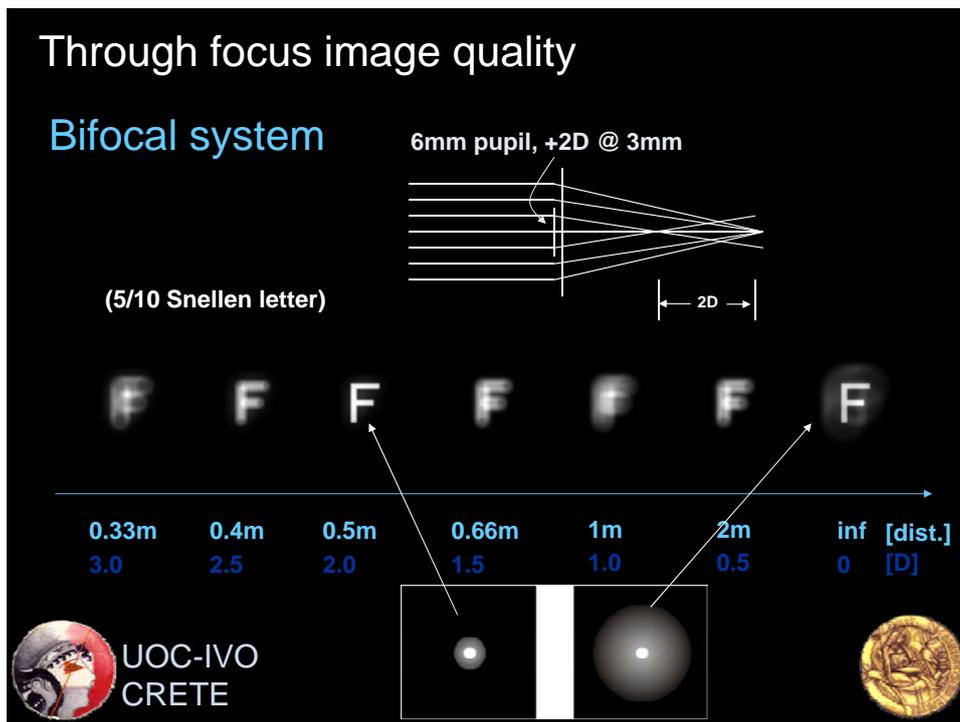


(5/10 Snellen letter)

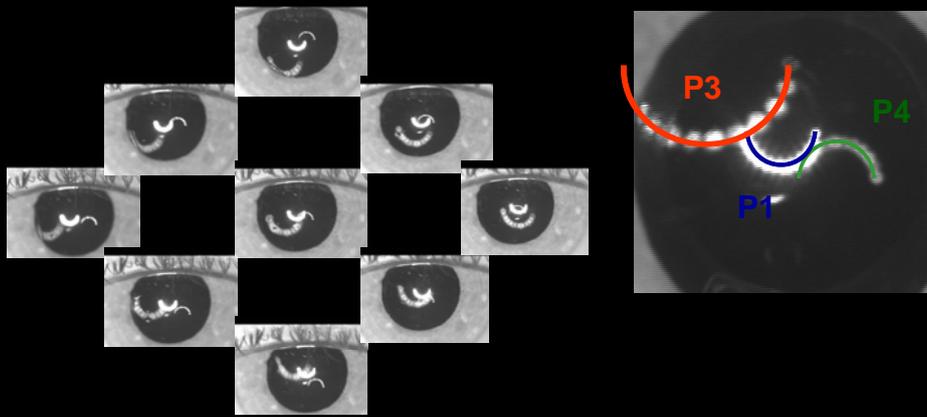


Aberrations (in particular spherical aberration) may contribute to increased depth of focus at the expense of image quality. Note that the 5/10 letter remains legible for a range of more than 4 D.





Locating the IOL: Purkinje imaging



After Tabernero et al, Optics Express 2006



Simulations

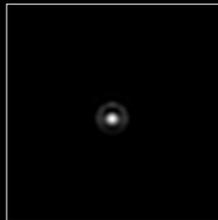


Far vision 5.5 mm pupil, normative aberrations, +1.5 D at the central 2 mm.

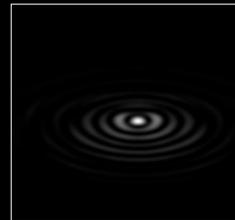
Far PSF



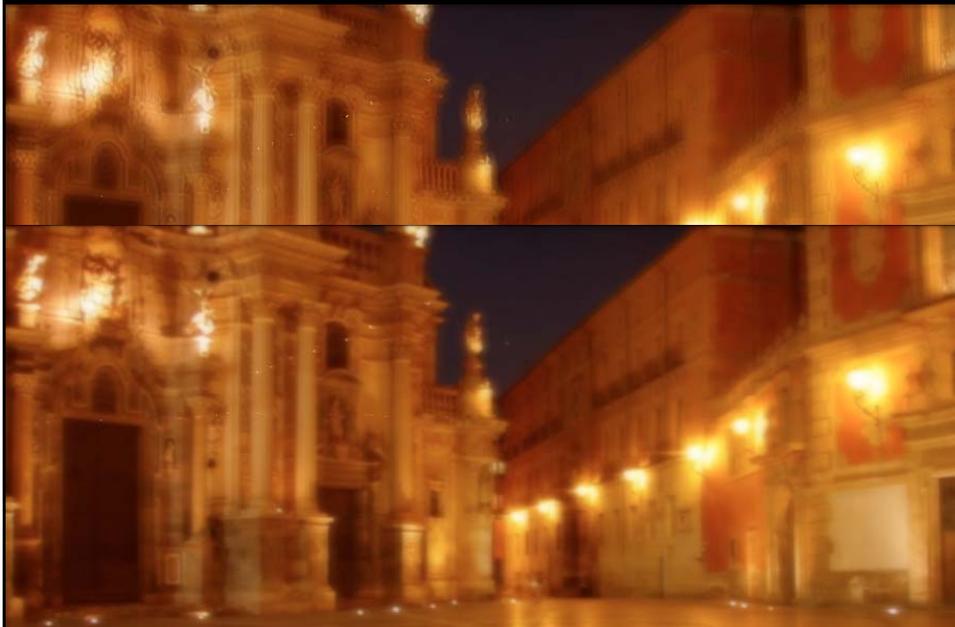
4 degrees tilt



0.5mm decentration



Far vision 5.5 mm pupil, normative aberrations, +1.5 D at the central 2 mm.



Functional Aspects



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Natural scene simulation



Natural scene simulation

with high dynamic range



Adaptation mechanisms



Observe the red dot for 20 sec



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After Webster et al Nature Neuroscience 2002



Adaptation mechanisms



After Webster et al Nature Neuroscience 2002



Discussion - conclusions

- IOL tilt and an misalignment cause aberrations that deteriorate image quality. More dramatic effect: Meniscus of “unfocused” part of the pupil.
- The visual system can adapt to aberrations improving the perceived image quality over time
- Multifocal elements should be centered in the center of the pupil in order to perform as designed. Decentration is more detrimental than tilt.



