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2004

A B E R R O M E T R Y

Bernard Mathys, MD

BSCRS Meeting

Liège

January 31, 2004

Our goals :

- We want to improve our results
- Not only in terms of VA, but also in terms of quality of vision
- How can we do this?
- Better microkeratomes, new lasers, well-trained surgeons, improvement of post-op treatments,… and new algorithms ?

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Algorithm factor

- Improve the treatment itself: -3 of X is not necessarily -3 of Y
- Personalize treatment
- Improve VA without inducing new higher order aberrations over all physiologic pupil sizes
- Improve quality of vision
- Possibility to help people with thin corneas, large pupils, high ametropia
- Redo on previous unhappy patients

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Pitfalls of Aberrometry

- Understanding aberrometry
- New terminology
- Getting used to the new devices
- Have someone dedicated to the exams
- Perfect position of the patient
- Tracker + iris recognition

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Understanding & Terminology

- Topography measures the cornea (surface of the eye)
- Aberrometry measures surface of the eye + « inside the eye »
- HOW ?

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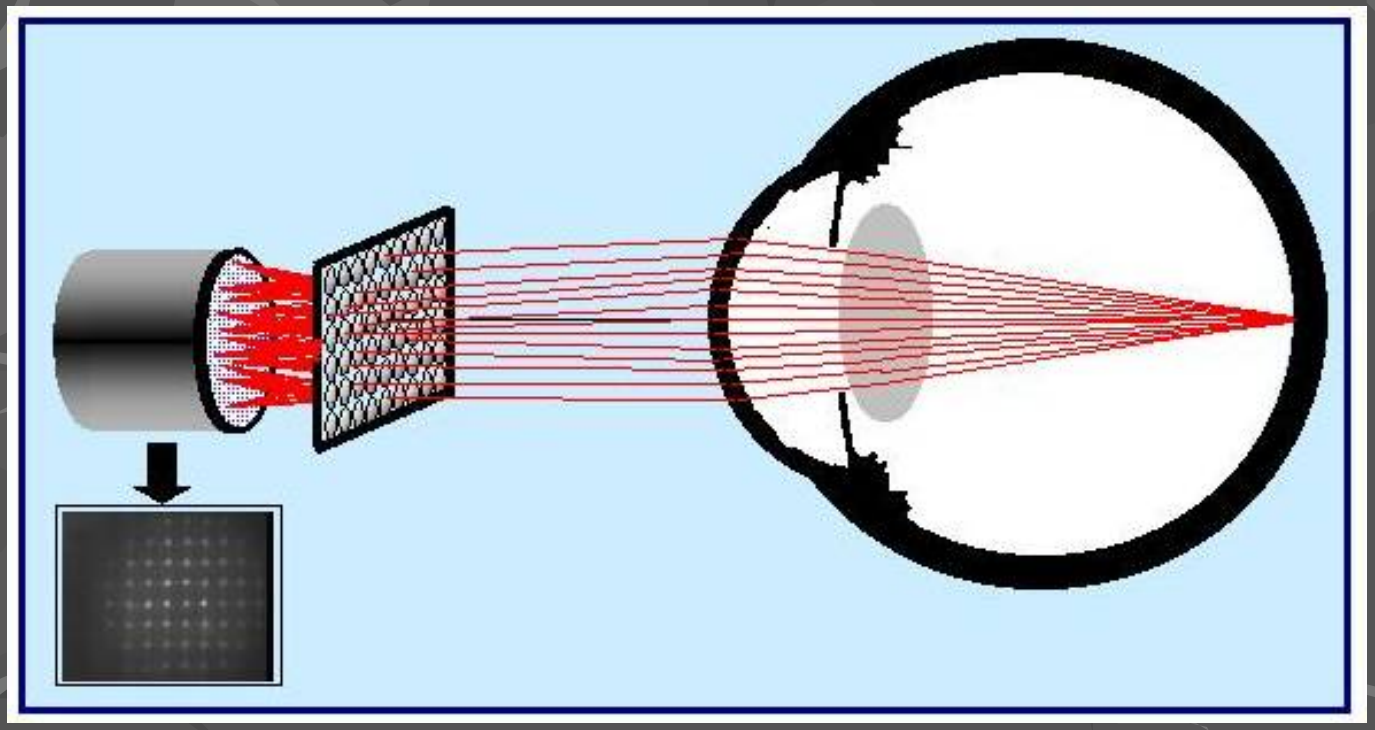

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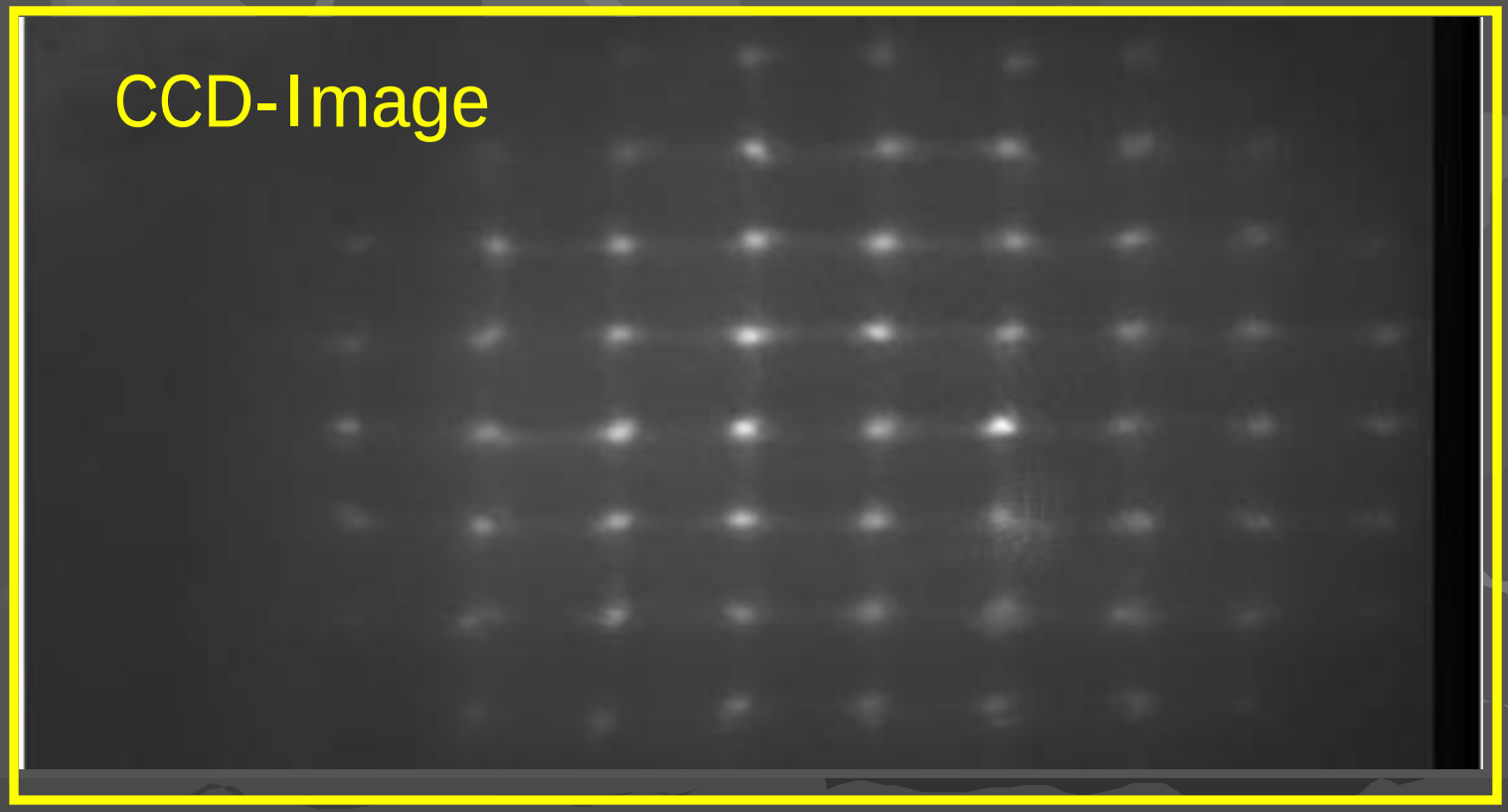
Wavefront analyse

Reconstruction of wavefront by CCD-image → Zernike coefficient



Hartmann-Shack Wavefront Measurement

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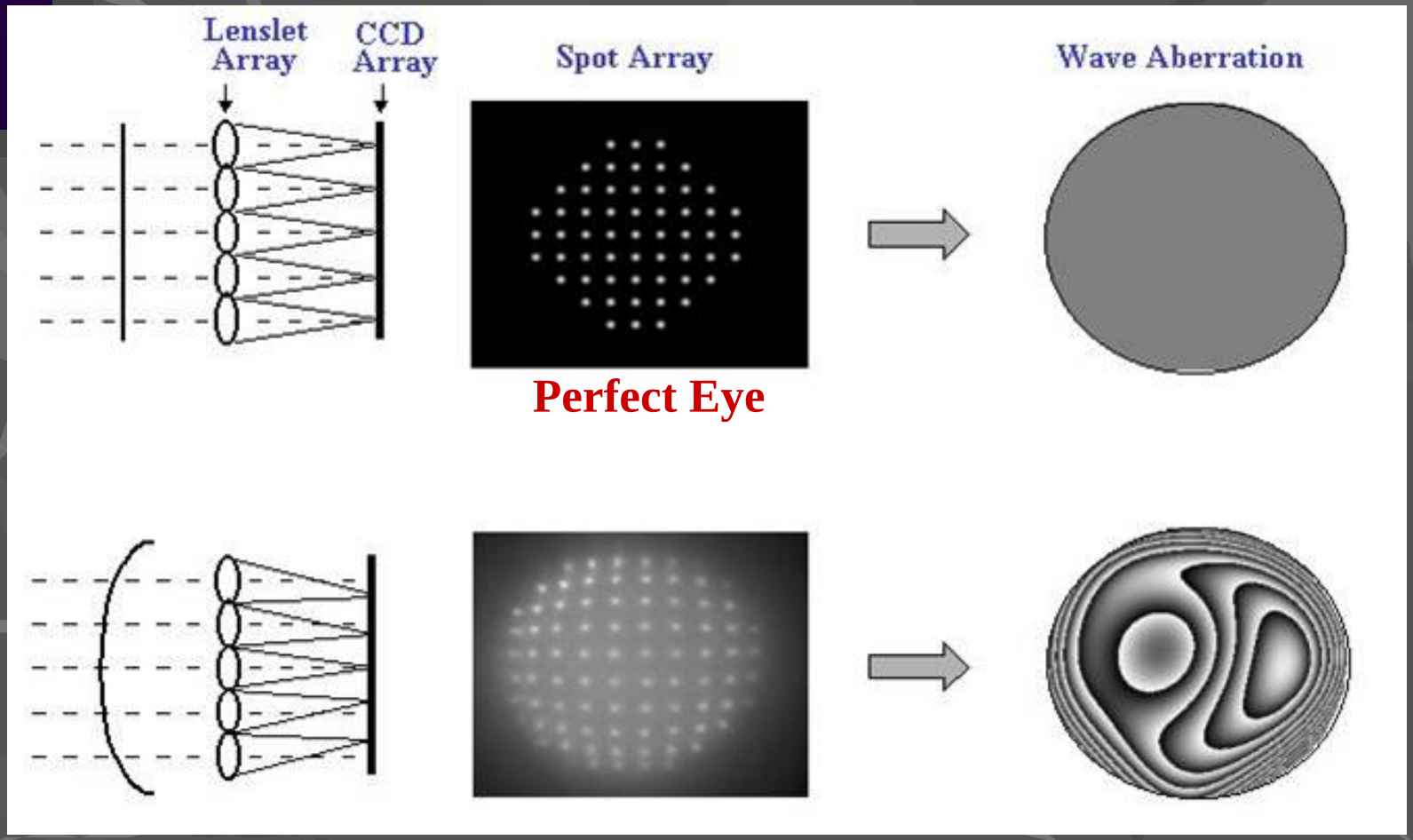

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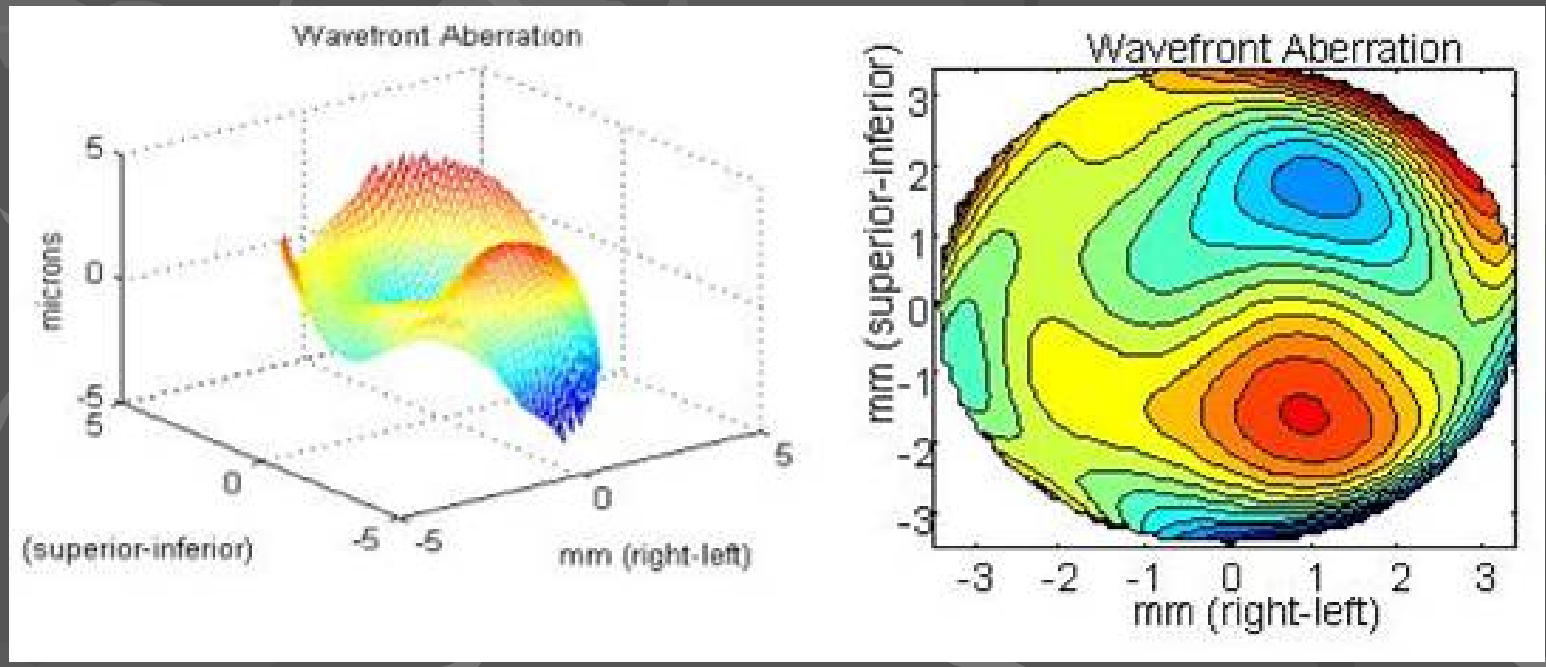
Wave Aberration of a Surface



3 D **2 D**

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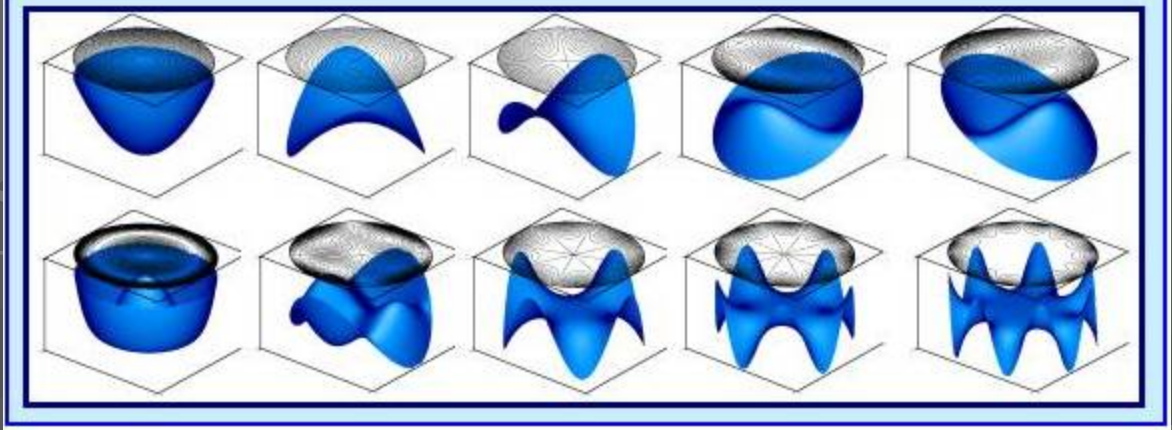
The shape of the wavefront is depicted in Zernike coefficient, each shape describes a deformation

$$W(x,y) = \sum_{n,m,\pi} A^{\pi}_{n,m} \times Z^{\pi}_{n,m}(x,y)$$



Zernike Modes

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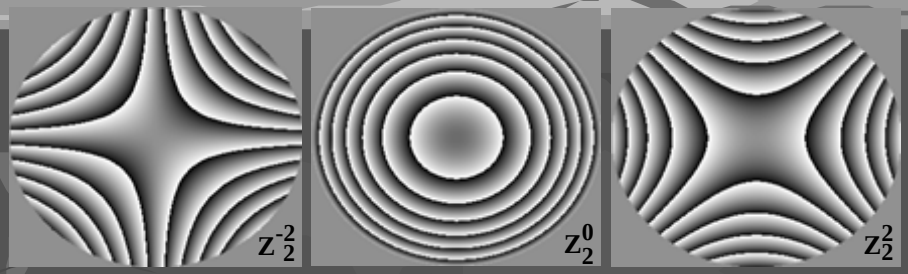
radial order

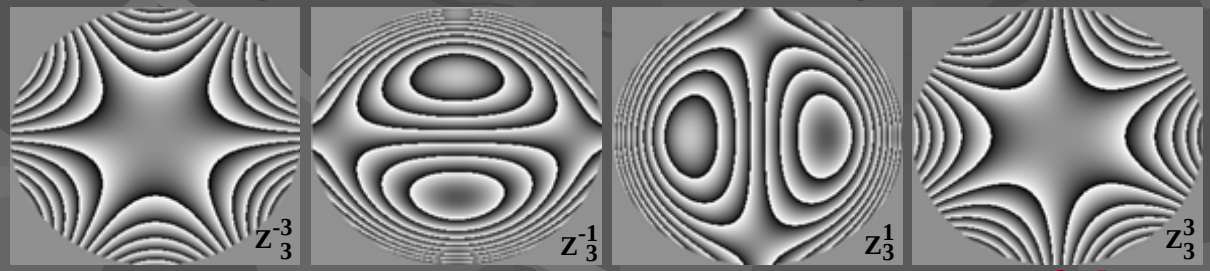
~ Conventional Refraction



astigmatism — defocus — astigmatism

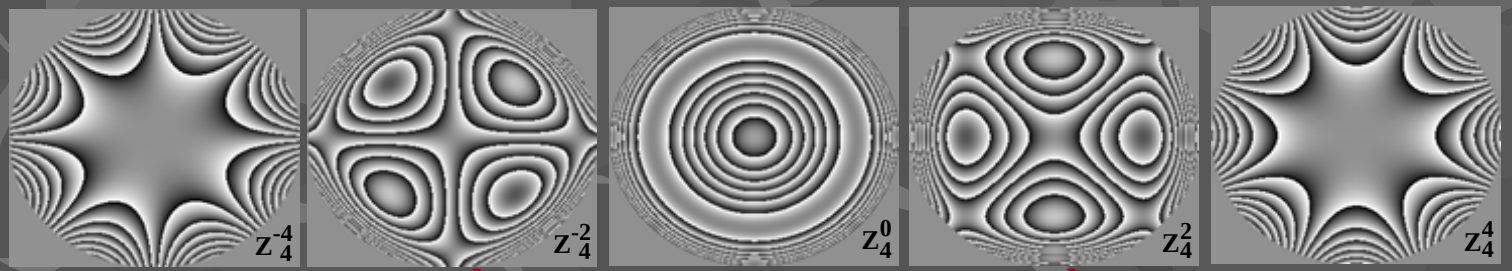
Higher Order Aberrations

3rd



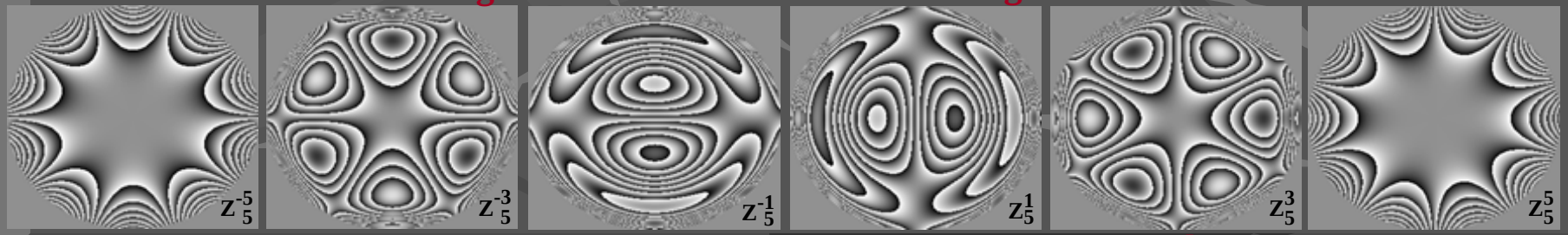
trefoil — coma — coma — trefoil

4th



quadrafoil — secondary astigmatism — spherical — secondary astigmatism — quadrafoil

5th



pentafoil — secondary trefoil — secondary coma — secondary coma — secondary trefoil — pentafoil

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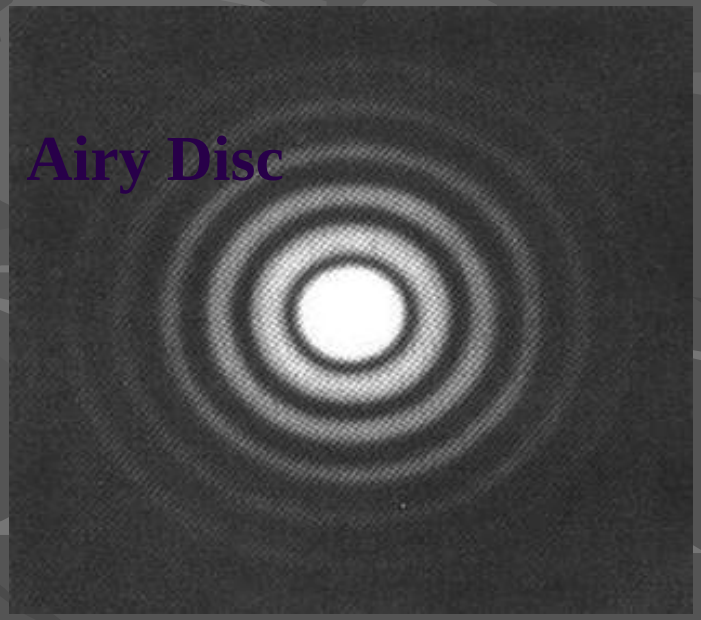
Point Spread Function (PSF)

- Point Spread Function: is the representation of an optical system of a punctual and distant light source (star in the sky)



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Point Spread Function vs. Pupil Size Perfect Eye

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Point Spread Function vs. Pupil Size Typical Eye

Each eye has different patterns of High Order Aberrations.

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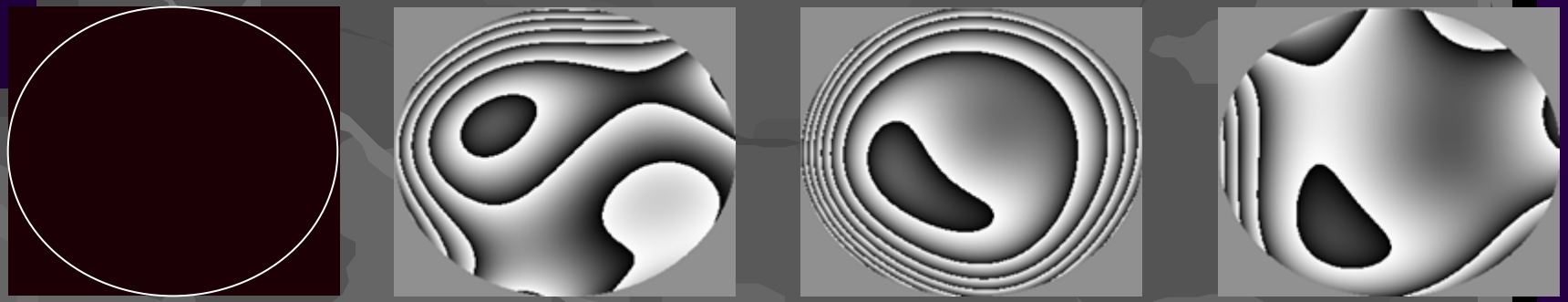
Perfect eye
(diffraction limited)

MRB

GYY

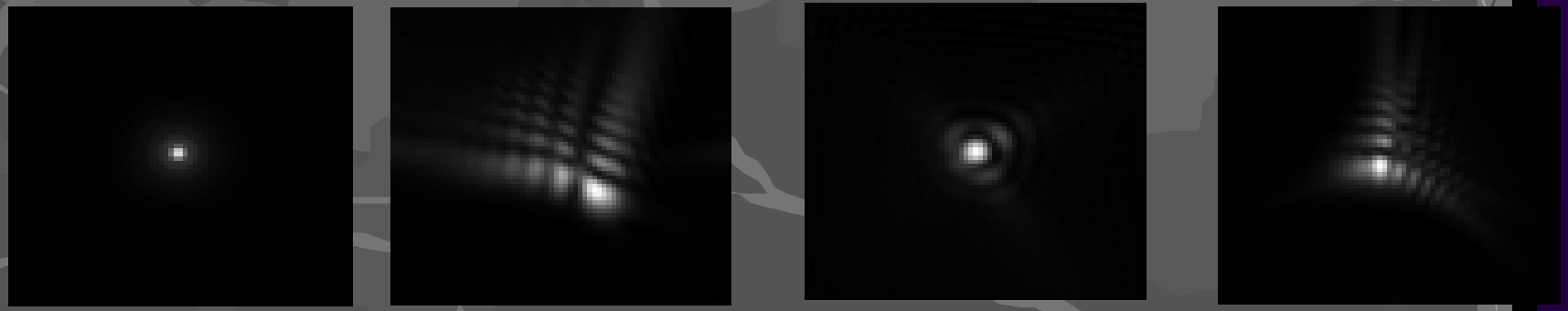
MAK

Wave Aberration



5.7 mm pupil

Pointspread Function



Retinal Image

← 0.5 deg →

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RMS

RMS (Root Mean Square)

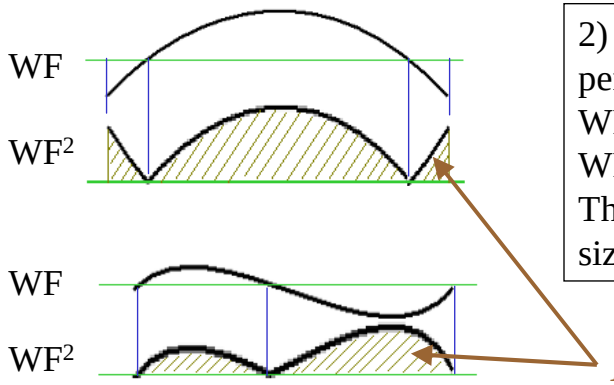
RMS is similar to a Standard Variation against ideal situation.

Ideally 1) all Zernikes are zero or 2) WF is zero / a plane.

RMS is used instead of an average value, because 1) Zernike coefficients and 2) WF both have positive and negative portions.

1) Zernike-RMS
2) WF-RMS

1) Zernike-RMS = $\sqrt{1/n * \sum(a_i)^2}$
where a_i = Zernike-coefficients



2) WF-RMS :
per definition the average height of WF over full size is zero.
WF-RMS: Square the WF-function.
The average height of WF ² over full size is the WF-RMS.

Area ∝ WF-RMS

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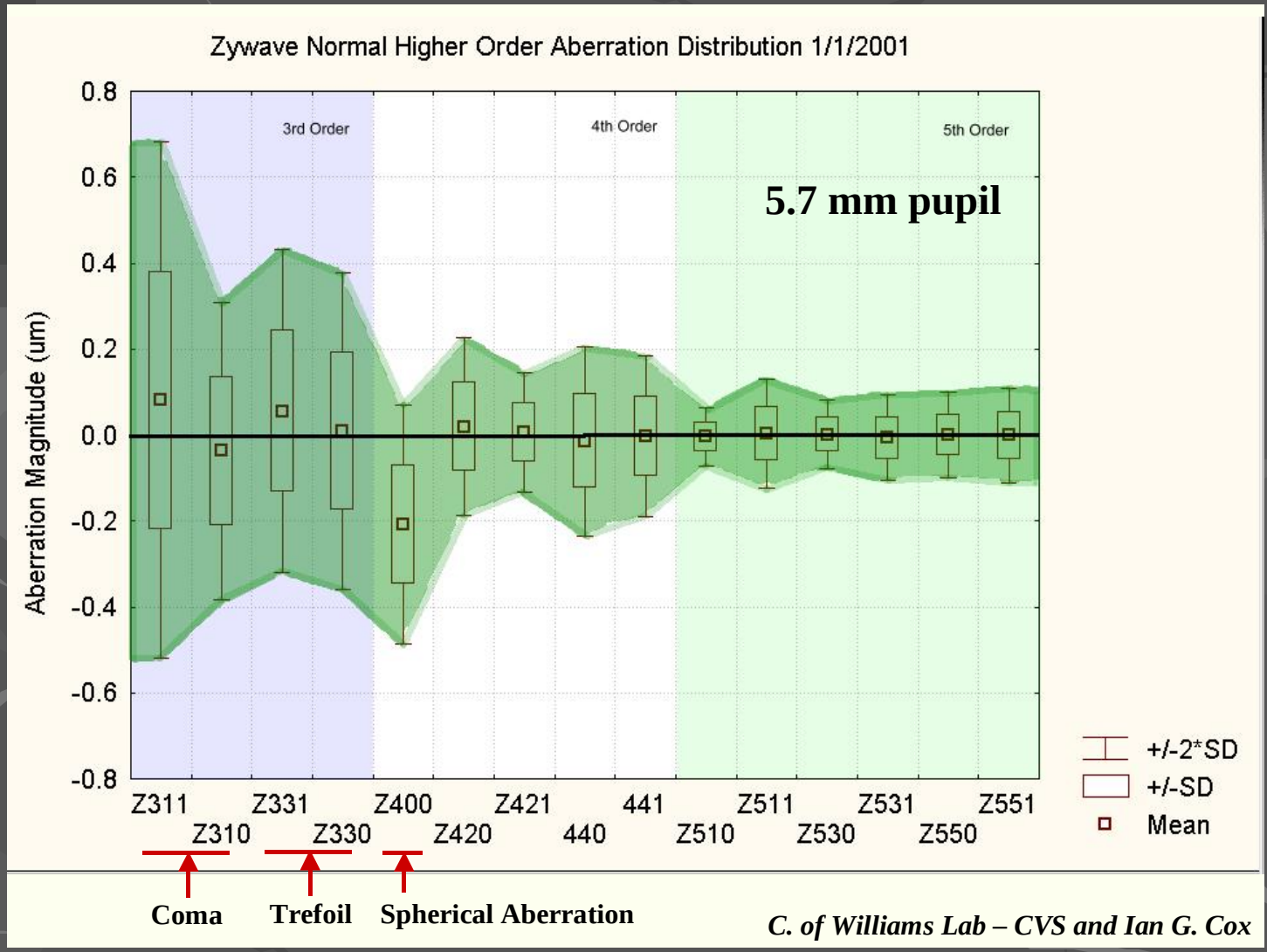

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Wavefront Analysis & Customized Ablations

- Ordinary refraction = correction over the entrance of the pupil
- Wavefront analysis = correction at each point measured over the pupil
- Tscherning aberrometer measures ingoing optics
- Hartmann-Shack measures outgoing optics

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Wavefront maps

- Interpreting is difficult
- Modified by lubrication, cataract, pupil dilation,…
- 2 important factors related to pupil size:
  - Size of the pupil: the more dilated, the more we analyze
  - Cycloplegia: the higher order aberrations may change the sphero-cylinder readings after pupillary dilation; eyes with higher values of higher-order aberrations would have lower values of sphere and cylinder readings