# Understanding Problems with Presbyopic IOLs: Look to the Cornea

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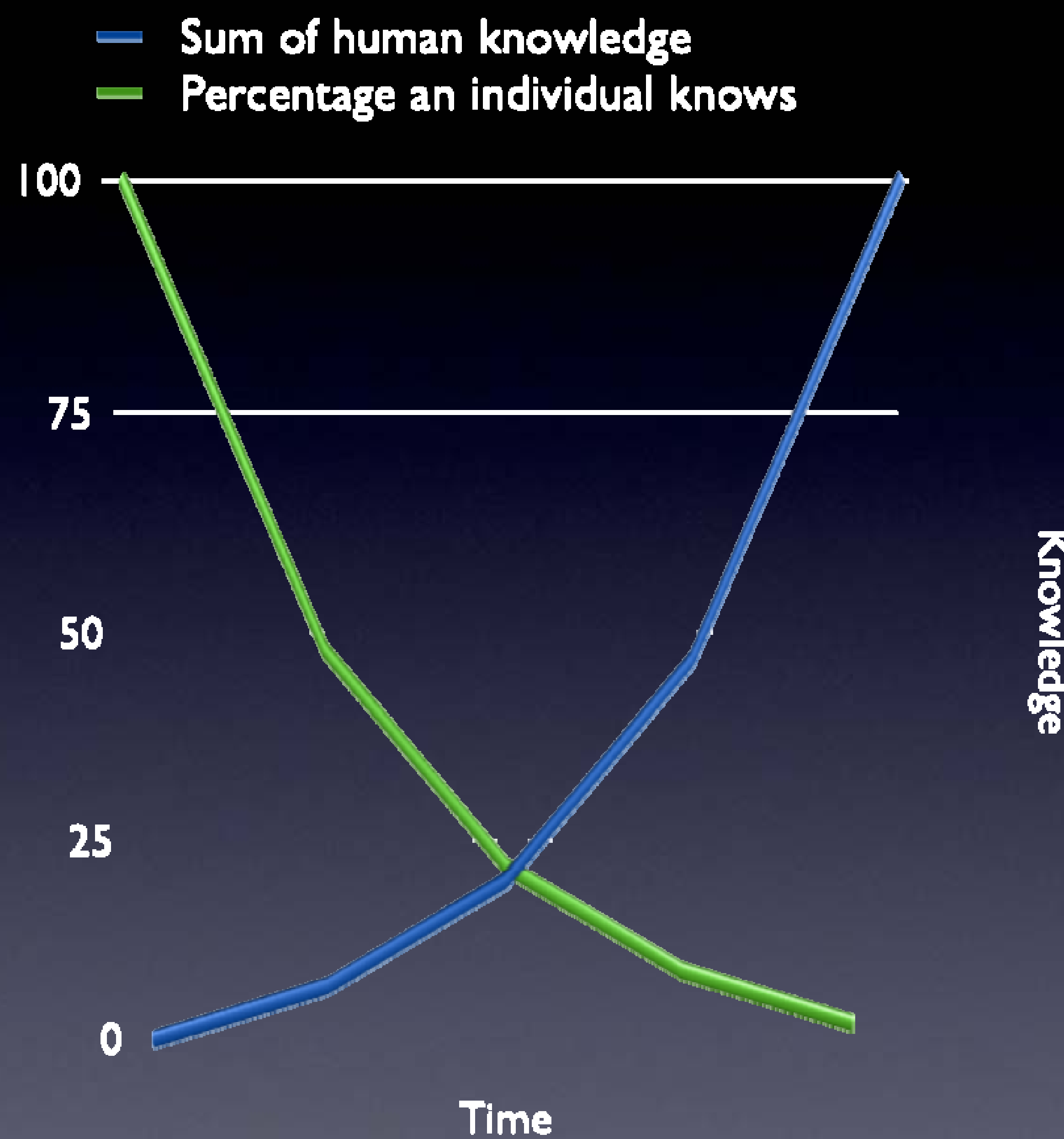
- As physicians we focus on ever smaller parts of the human body



To properly care for our patients, we must view our tiny piece in part of a larger context

# Post-Presby IOL problems

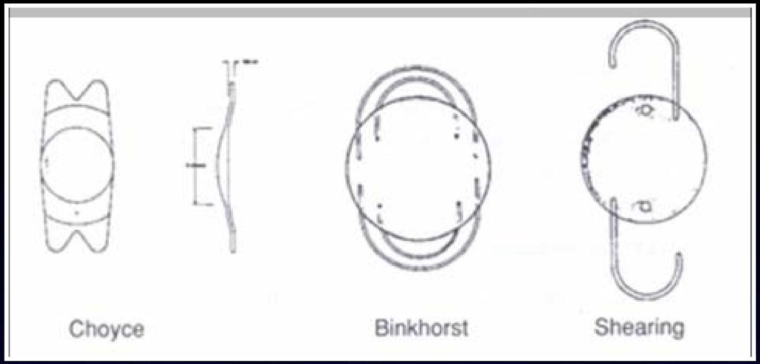
- Difficult to predict which patients will be unhappy
- No obvious explanation for problems in many unhappy patients
- Main selection strategy has therefore become to operate on less demanding patients

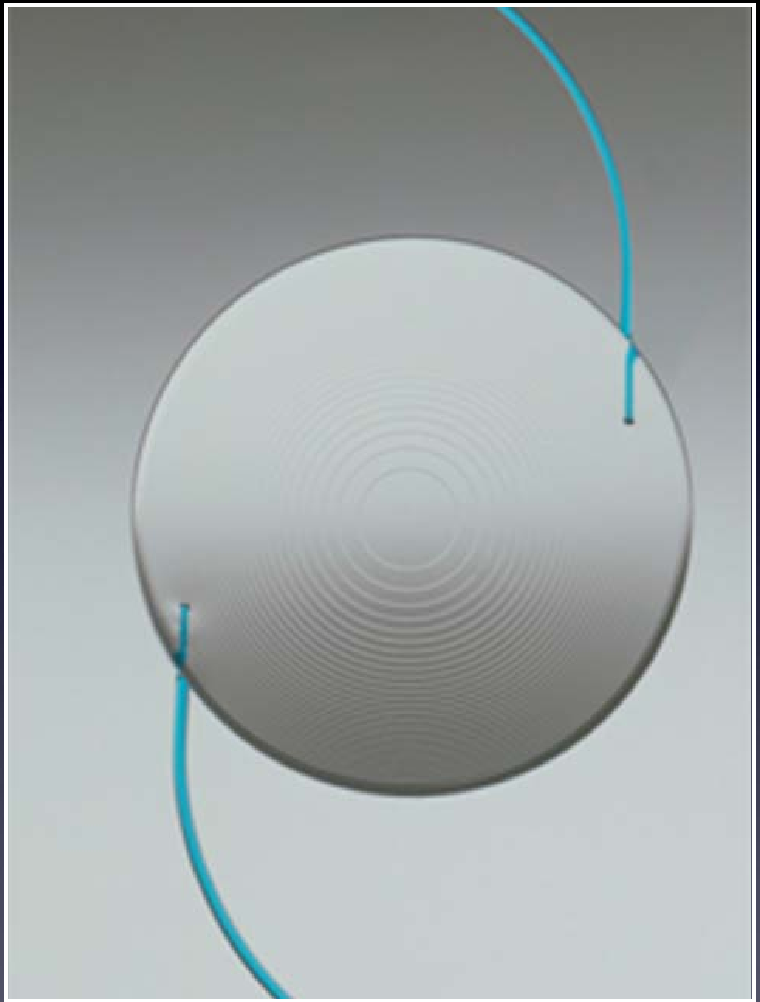
# Post-Presby IOL problem

- First impluse:
  - What is wrong with IOL?
- Second impulse:
  - What is wrong with the patient?
- Rarely do we consider other non-lens parts of the eye
  - Cornea  (anterior and posterior surface)
  - AC depth
  - Pupil size and dynamic range

- Why do we have to worry about non-lens structures *NOW*?
  - *I never cared about the cornea when I was using monofocal lenses…*
  - *What has changed now?*

# Evolution of IOL technology and precision



- New presbyopic IOLs have achieved unprecedented spacial resolution and precision

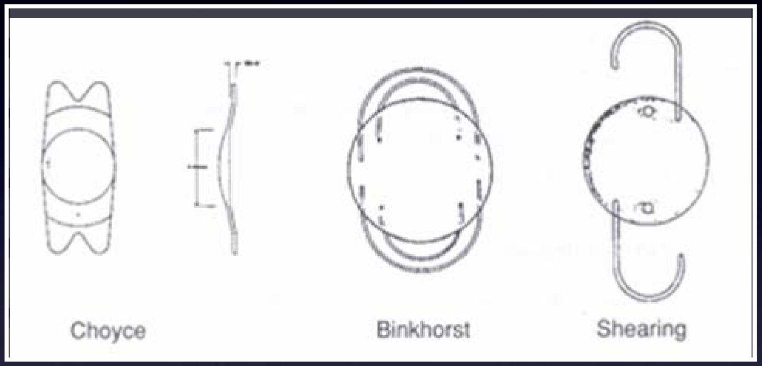
# Traditional Monofocal IOLs were cruder therefore demanded less precision from other structures

Monofocal lenses are uniform in structure

Relatively crude optics

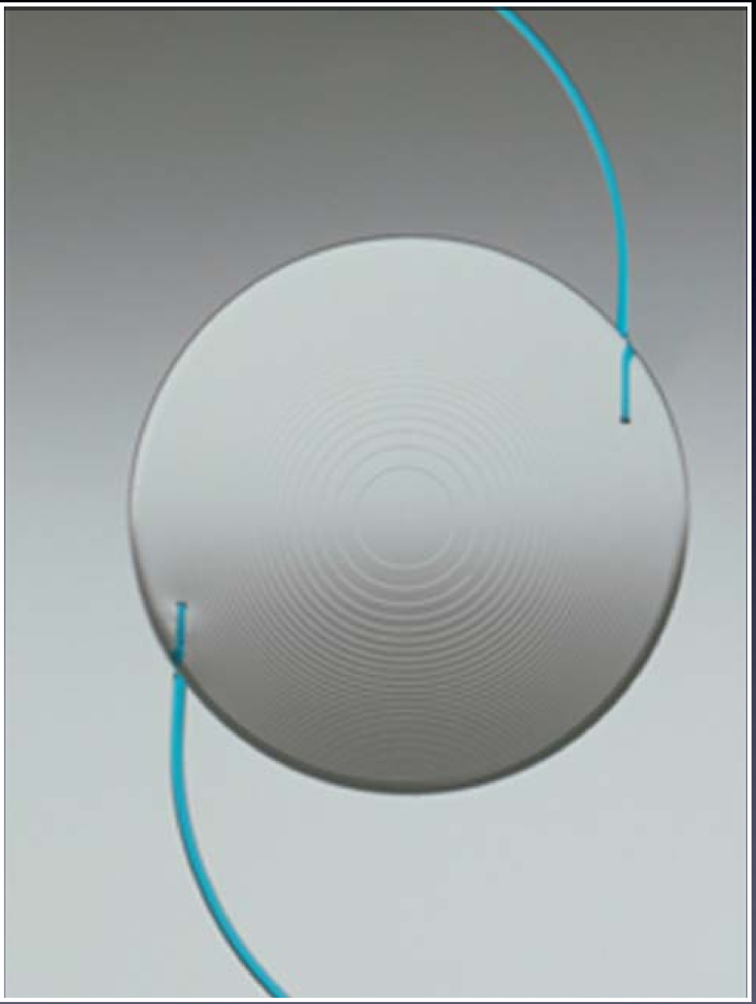
Spacial variation occurs on large scale (mm)

More tolerant of optical imprecision of other (non-lens) ocular structures (when such structures' irregularities misdirect light rays)



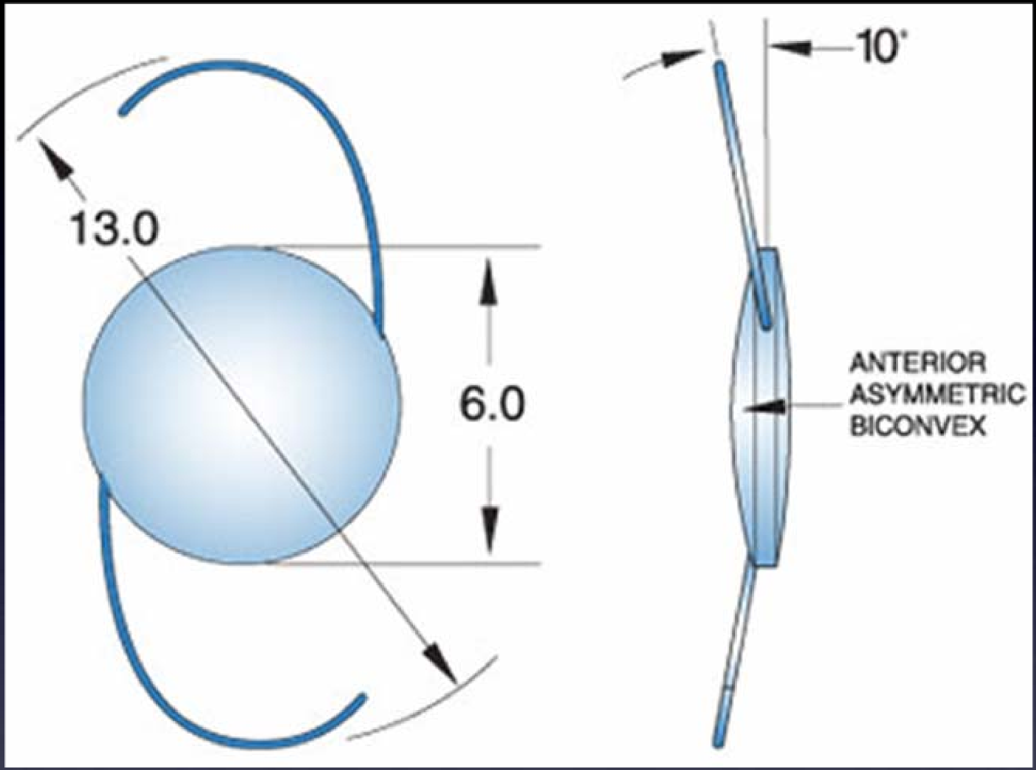

# New Presbyopic IOLs are much more precise and therefore demand more precision from other structures

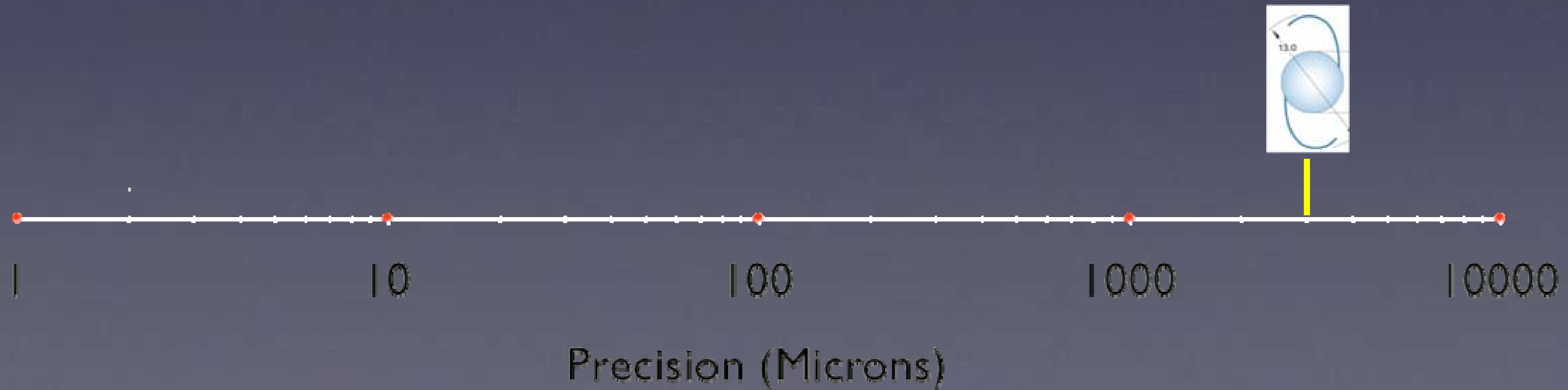
- Spatially finer features
- Minute displacement of light by a few microns caused by other non-lens ocular structures can be significant
- Therefore, greater demand on precision and regularity of non-lens ocular structures (such as cornea)



# Spacial precision of a monofocal IOL

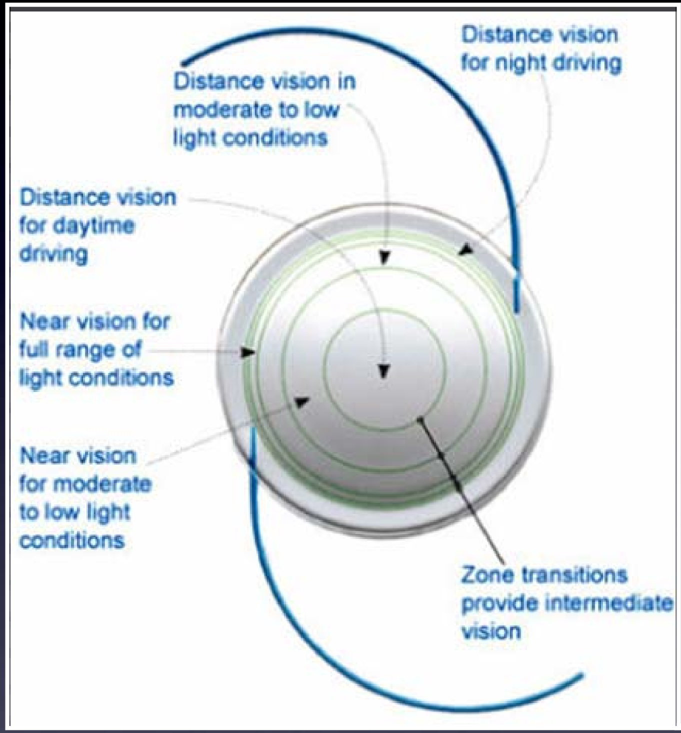
- 6mm optic (3mm radius)
- Uniform optics throughout
- Therefore, spacial precision is 3mm, or 3000 microns

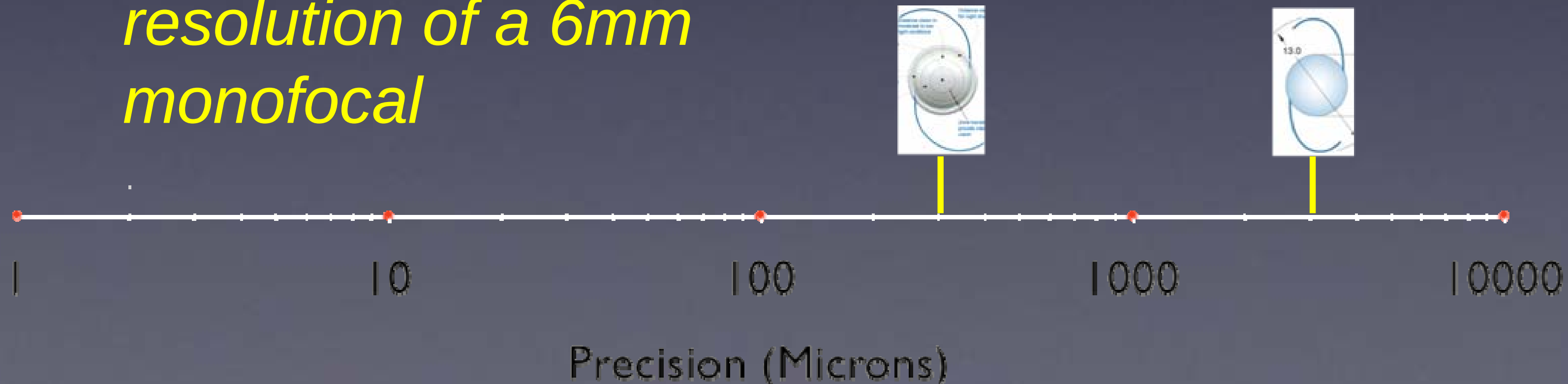


# Spacial precision of presbyopic-IOL: ReZoom

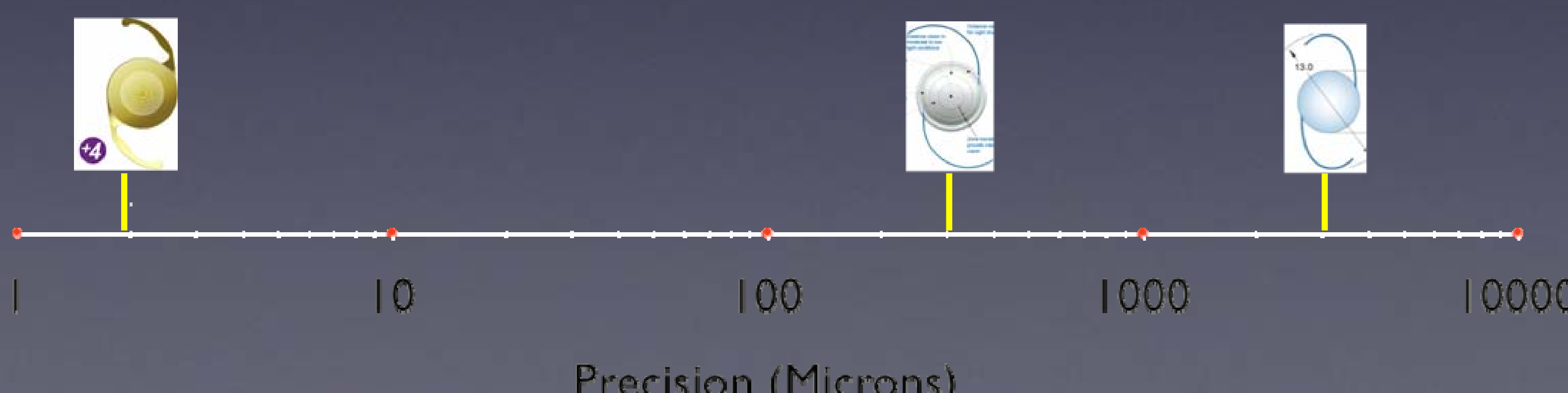
- 6mm optic (3mm radius)
  - 5 concentric rings
  - 5 transition zones
- 3mm / (5+5) = average zone size of 300 microns
  - *10x spacial resolution of a 6mm monofocal*



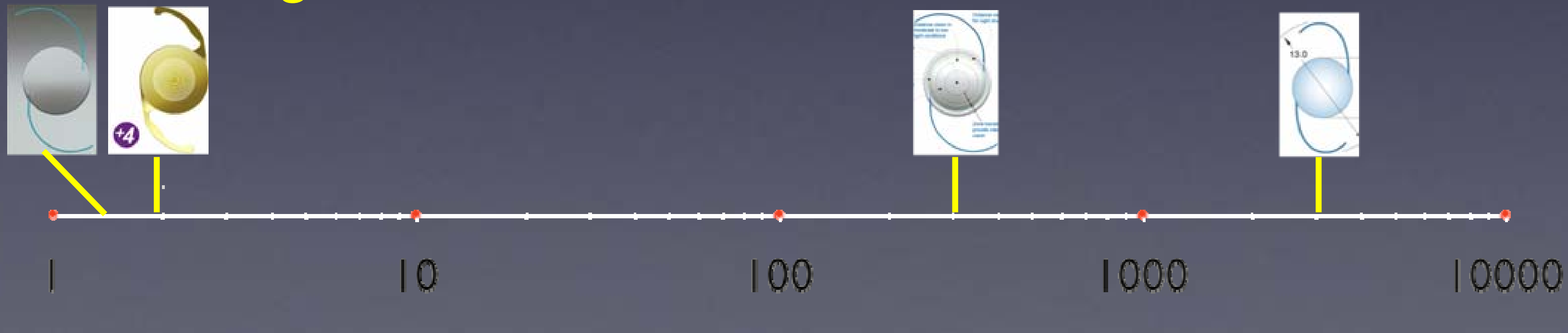
# Spacial precision of presbyopic-IOL: ReSTOR

- 6mm optic
  - refractive zone
  - diffractive zone (central 3.6mm)
    - 5 micron steps
  - *Almost 100x more demanding!*



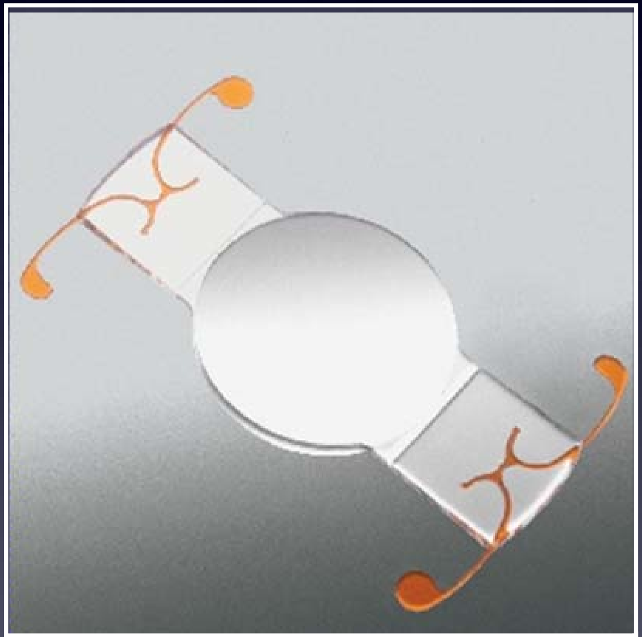
# Spacial precision of presbyopic-IOL: Tecnis Multifocal

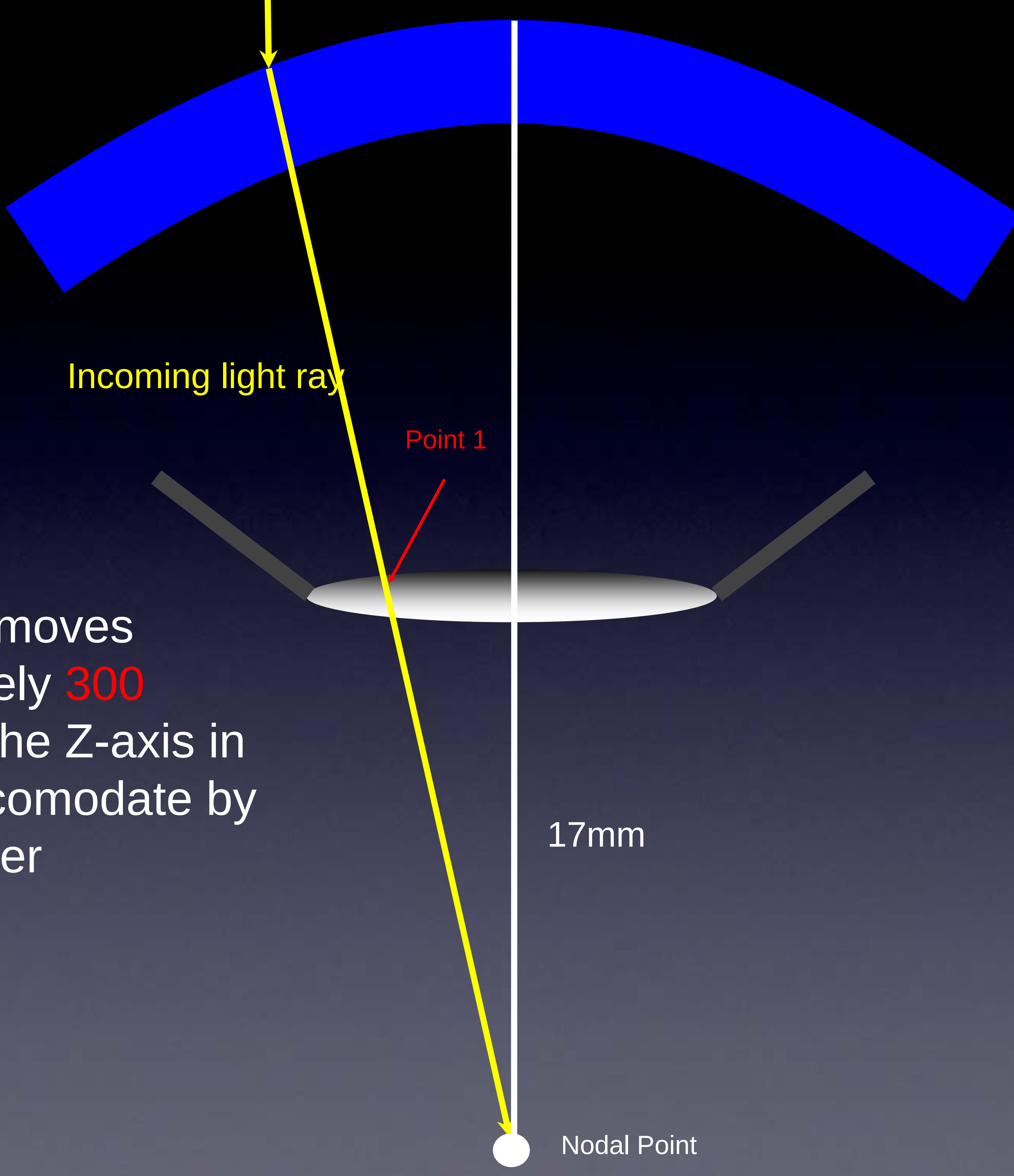
- 6mm optic
  - diffractive zone
    - entire 6mm optic
    - < 5 micron steps
  - *More than 100x more demanding!*



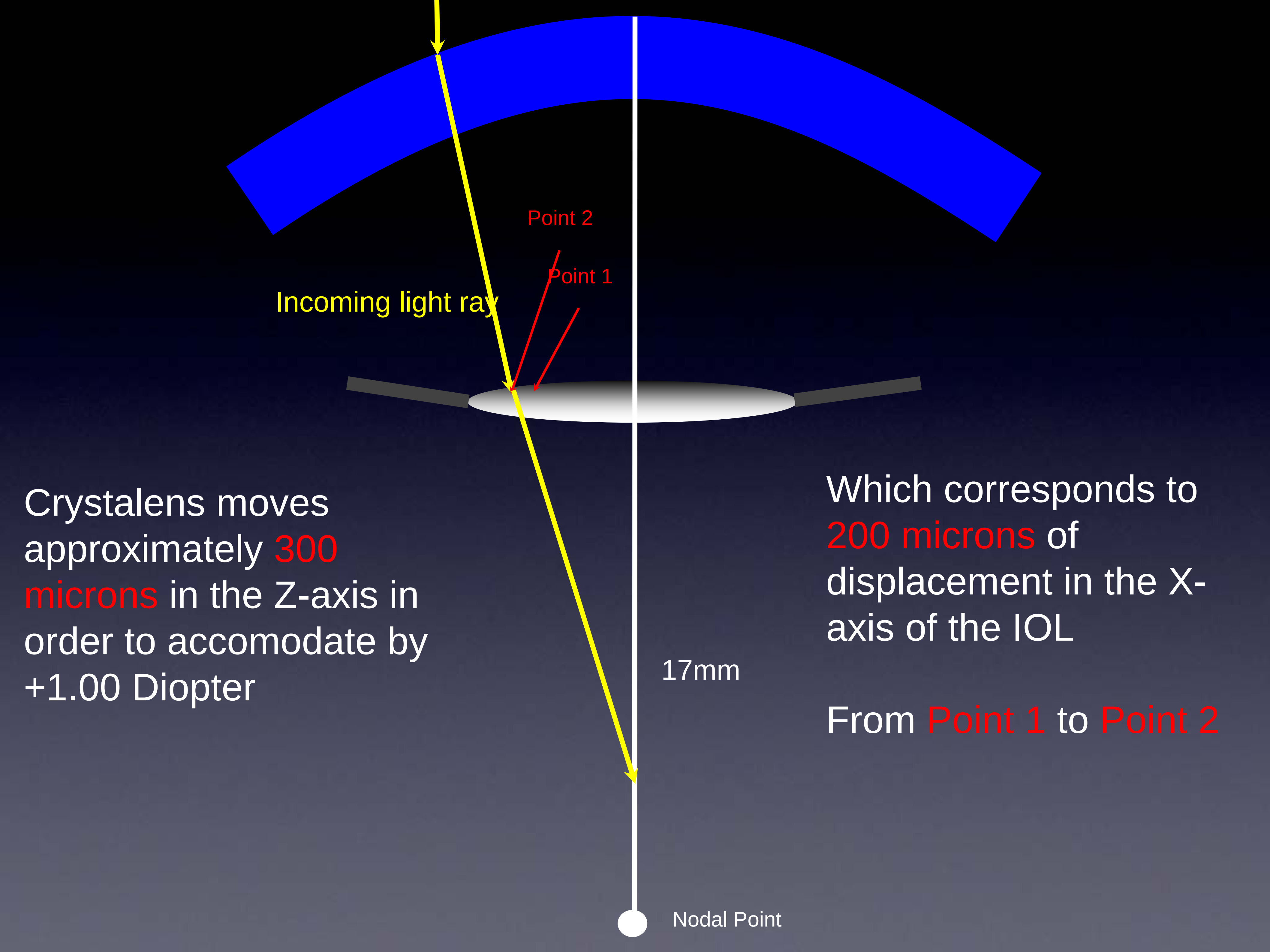
# Spacial precision of presbyopic-IOL: Crystalens

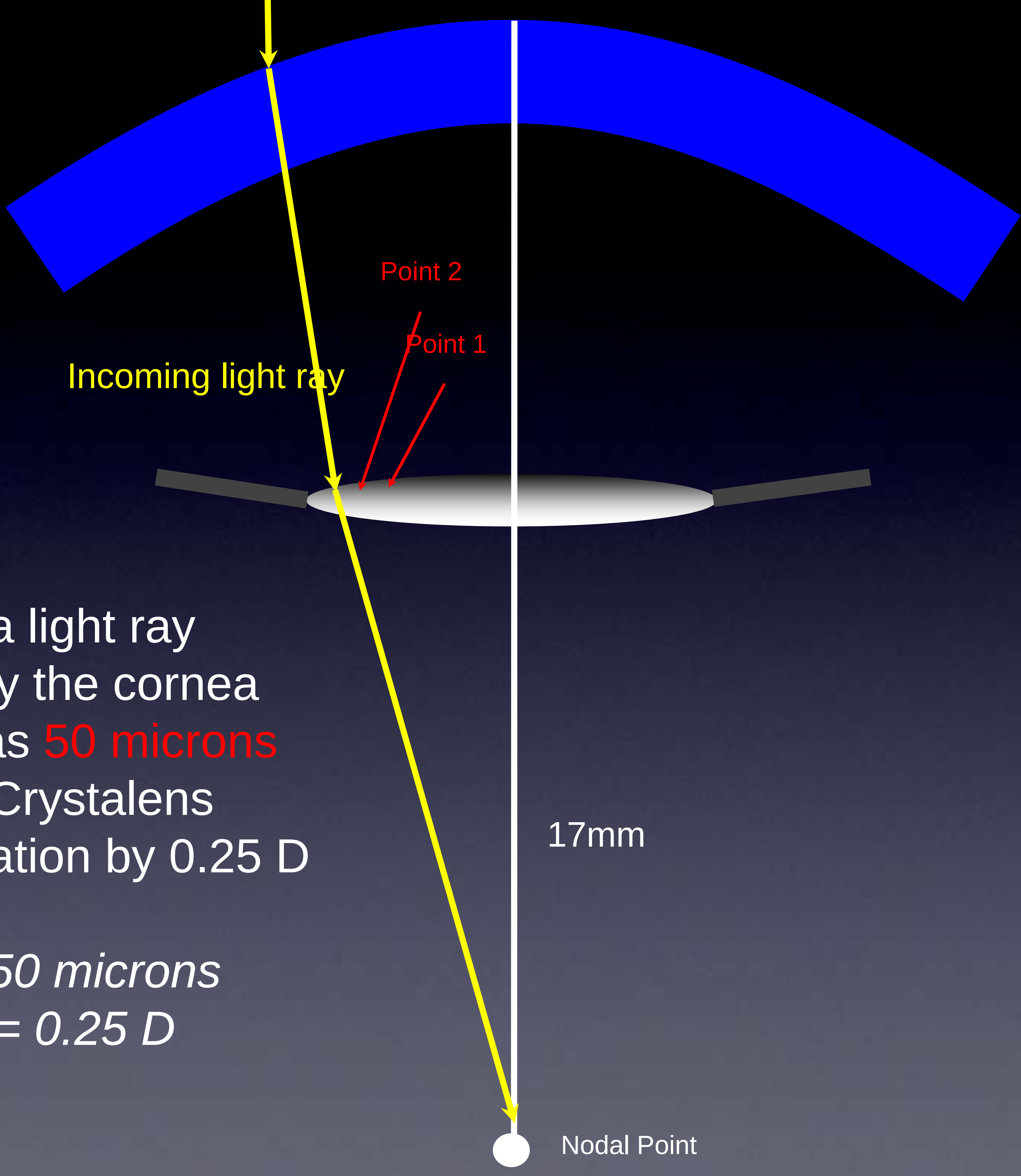
- Only 5mm optic
- Z-Axis movement
  - Alters point at which light strikes
  - Enhances demand for accurate positioning






Crystalens moves approximately 300 microns in the Z-axis in order to accomodate by +1.00 Diopter


Point 2
Point 1
Incoming light ray
Crystalens moves approximately 300 microns in the Z-axis in order to accomodate by +1.00 Diopter
Which corresponds to 200 microns of displacement in the X-axis of the IOL
From Point 1 to Point 2
17mm
Nodal Point

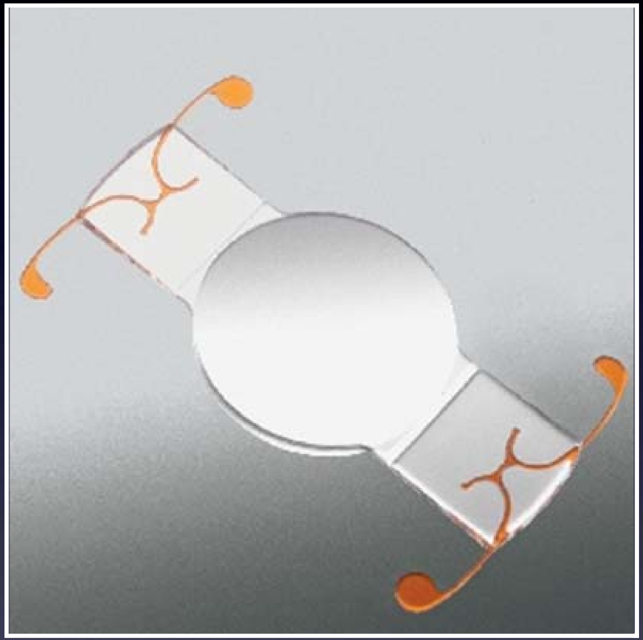


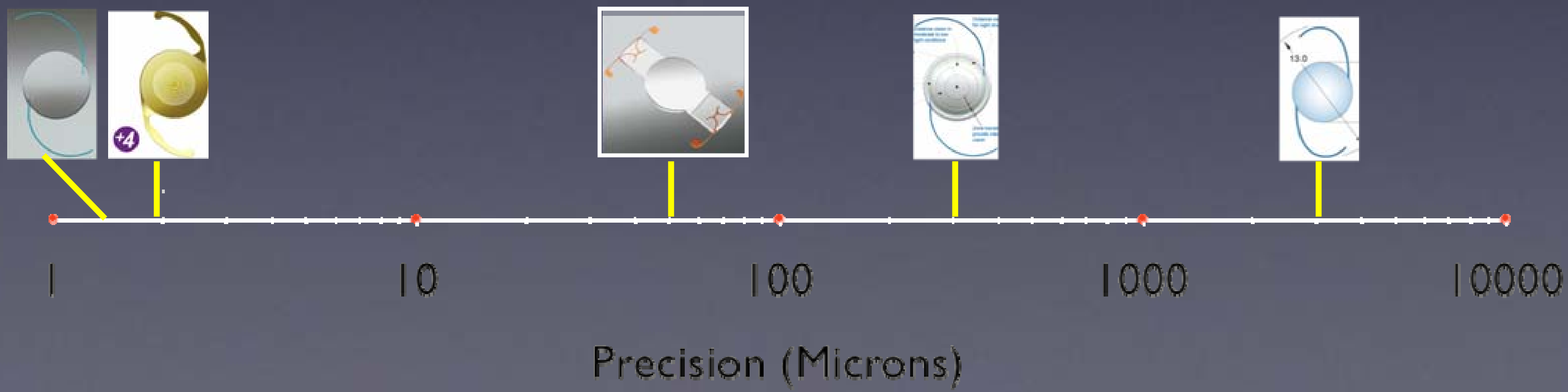

Therefore, a light ray displaced by the cornea by as little as 50 microns may affect Crystalens accommodation by 0.25 D

*(200 / 4) = 50 microns*
*(1.00D / 4) = 0.25 D*

# Spacial precision of presbyopic-IOL:
# Crystalens

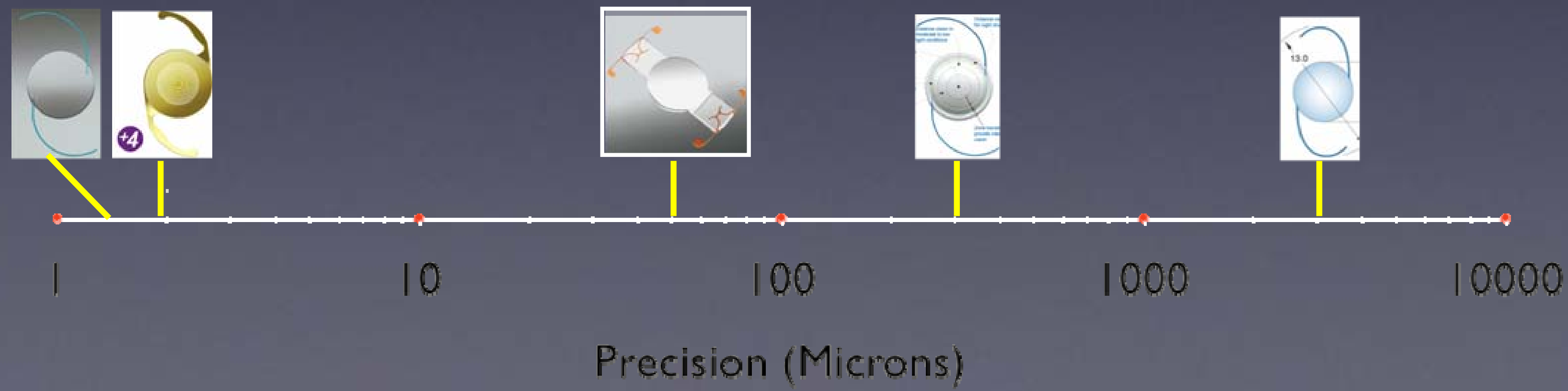
- So we know that because of it's Z-Axis movement, the spacial precision of the Crystalens is on the order of 50 microns





# All Presbyopia Correcting IOLs share one feature:

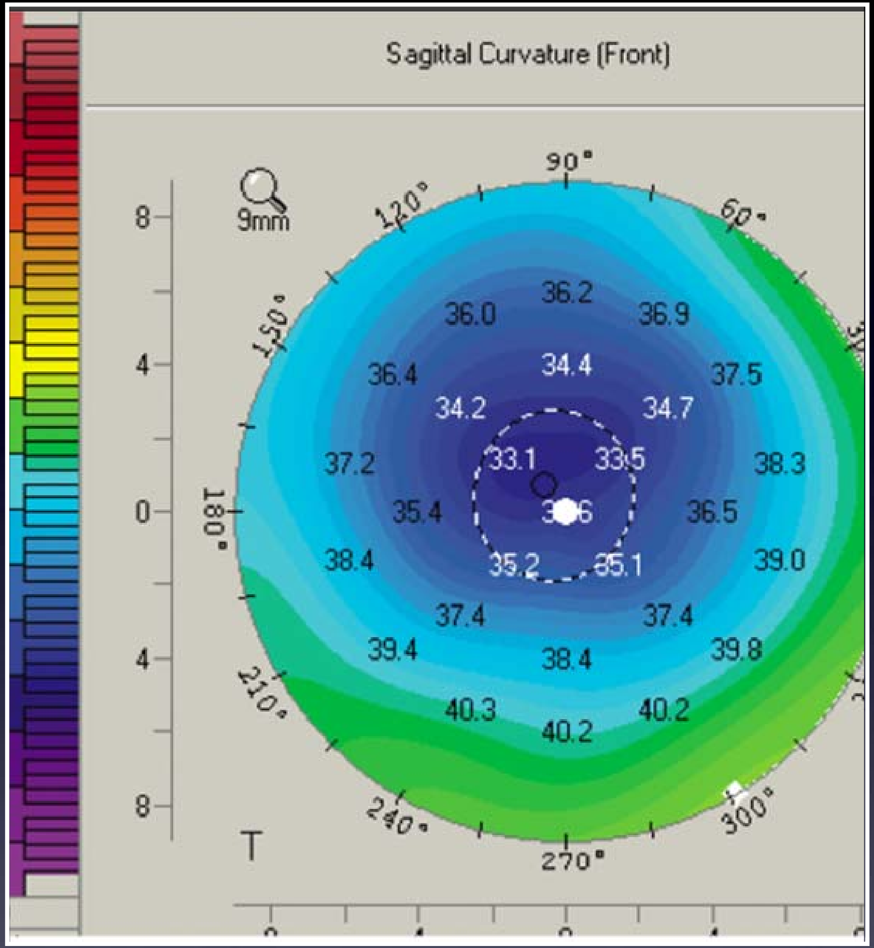
- Require a higher degree of corneal regularity than monofocal IOLs

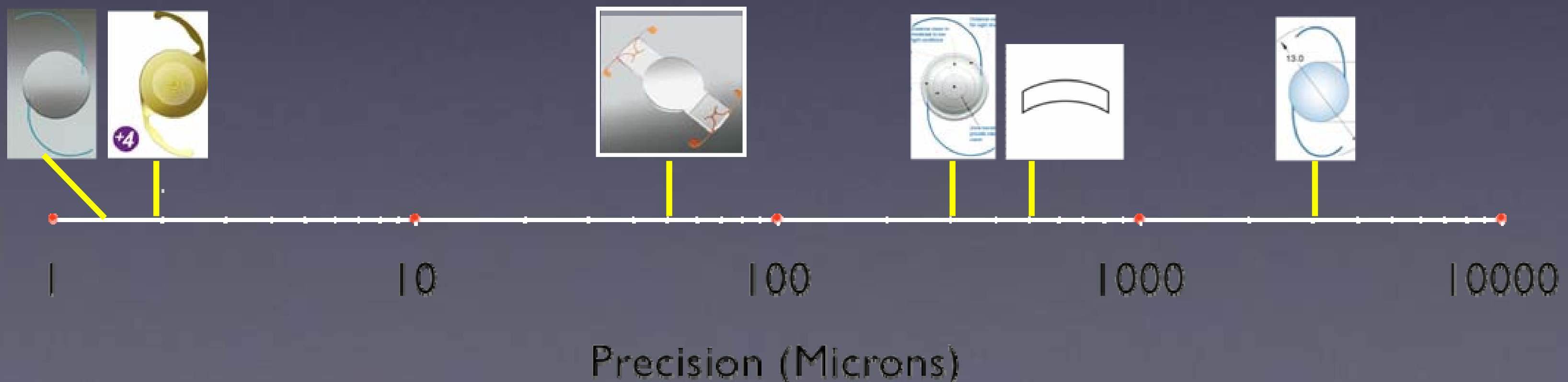


# precision

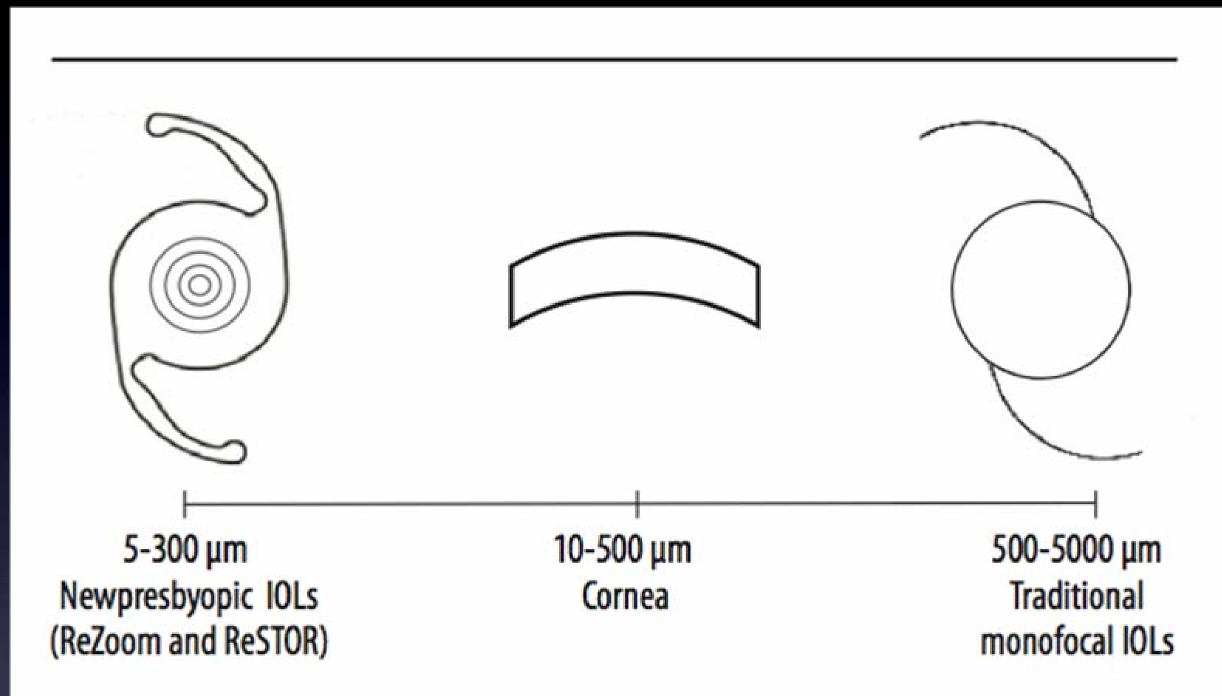
From our refractive surgery knowledge base we know:

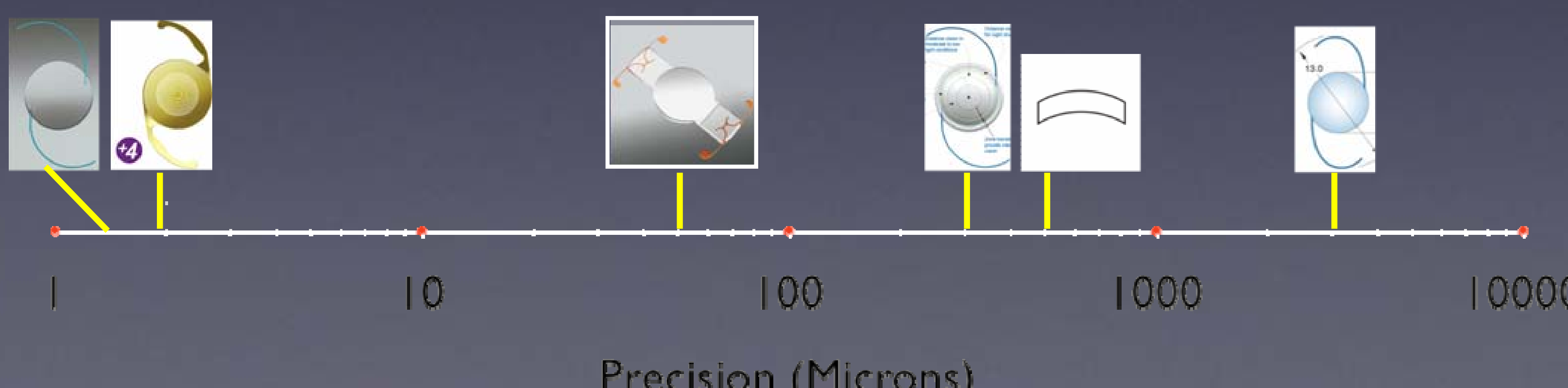
- 10microns in Z-axis = 1 diopter
- 500microns in X-Y = significant vision symptoms
- Thus, corneal scale of clinical relevance:
- 10 - 500 microns



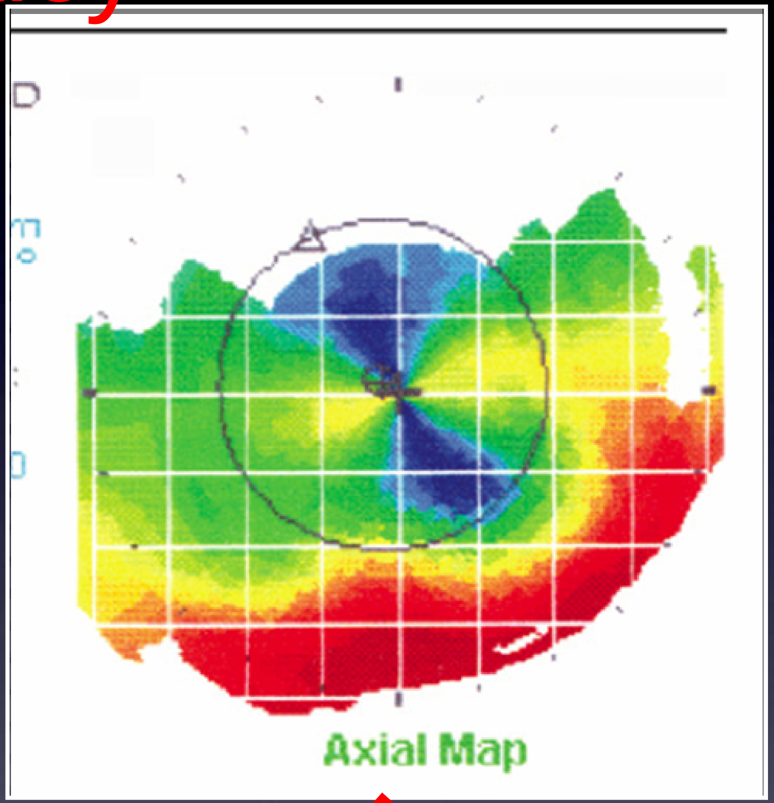
# Scale

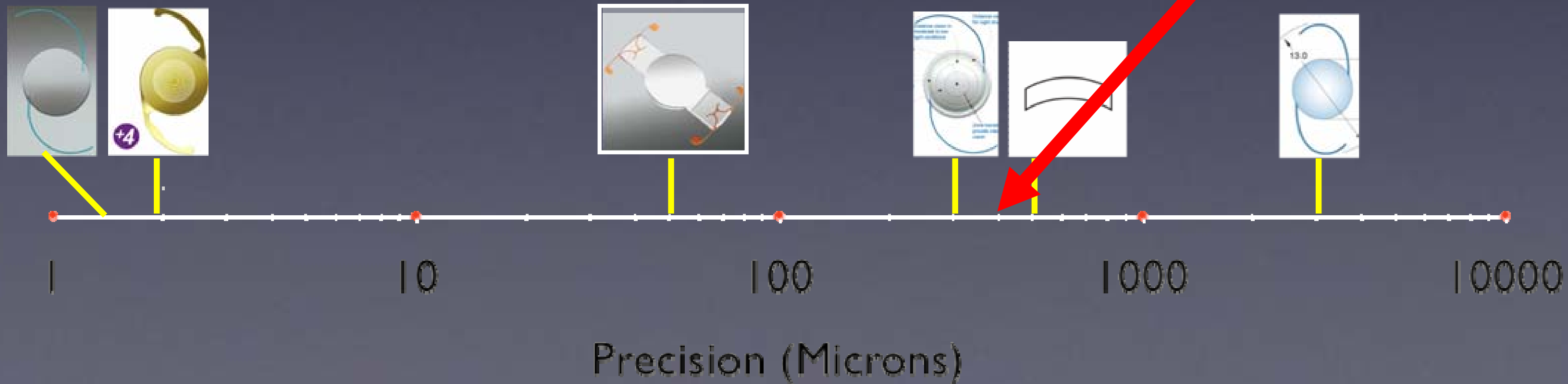

5-300 µm
Newpresbyopic IOLs
(ReZoom and ReSTOR)
10-500 µm
Cornea
500-5000 µm
Traditional
monofocal IOLs


1
10
100
1000
10000
Precision (Microns)

# This scale is important because it *redefines* the definition of normalcy

- Example:
  - Definition of bent Bowtie
    - OLD (monofocal) criteria: > 10 degrees
      - ~300 micron change
      - Therefore 99% considered normal
    - NEW (presby-IOL) criteria: > 1 degree (?)
      - Therefore only 90% considered normal



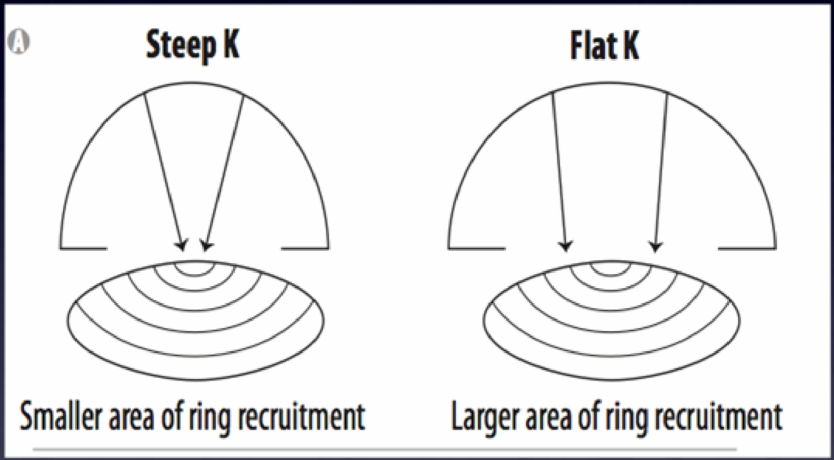



# Would implanting presbyopic IOLs only in patients with normal Wavefront eliminate the problems?

- Measures entire optical system, but cannot distinguish corneal abberations from lenticular abberations
- There is a natural compensation between cornea and crystaline lens which can *mask* corneal aberrations thus they are not detected by Wavefront
  - Thus, strategy of using presbyopic IOLs only in patients with normal wavefront is *flawed!*

# Corneal Steepness also affects presbyopic IOL performance

- Steeper cornea
  - Bends light more
  - Light strikes a *smaller* area
  - Preferential use of center of lens

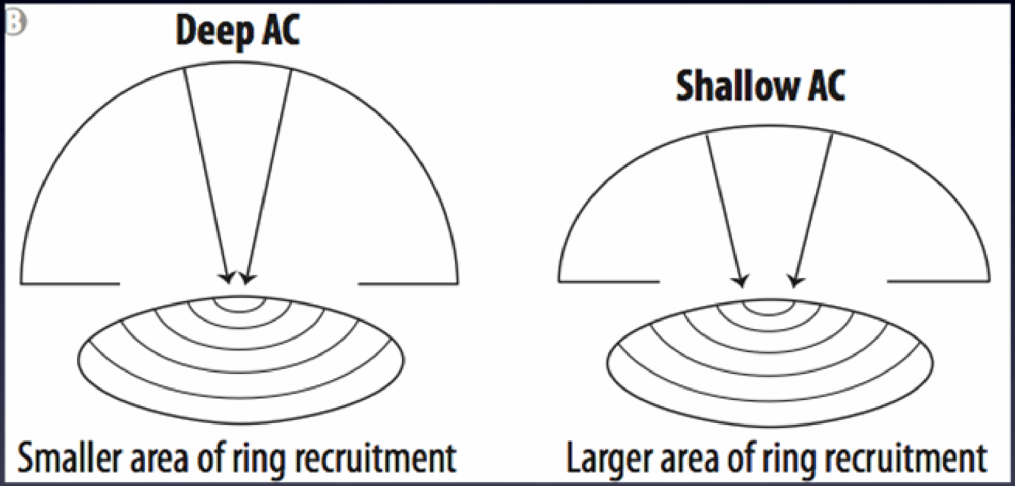


# Steep cornea results in preferential use of IOL Center

- Preferential use of center
  - Insignificant for Monofocal
  - Significant for Multifocal
    - ReZoom:  distance > near
    - ReSTOR and Tecnis MF:  near > distance

# AC Depth also affects presbyopic IOL performance

- Shallow AC
  - Light strikes larger area of IOL
- Deeper AC
  - Light strikes smaller area of IOL



# Deep AC results in preferential use of IOL Center

- Preferential use of center
  - Insignificant for Monofocal
  - Significant for Multifocal
    - ReZoom:  distance > near
    - ReSTOR and Tecnis:  near > distance

# Pupil size and dynamic range also affects presbyopic-IOL performance

- Size
- Dynamic range
- Speed of Change

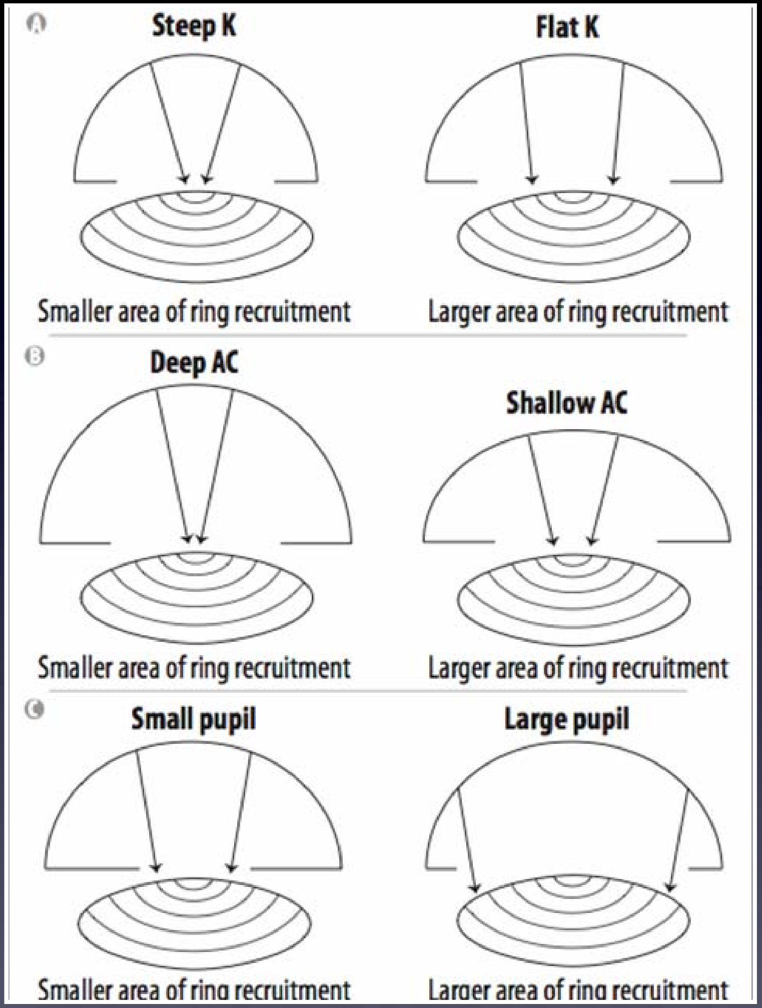
- Irrelevant for Monofocal IOL
- *Significant* for presbyopic IOL

# Pupil Effect

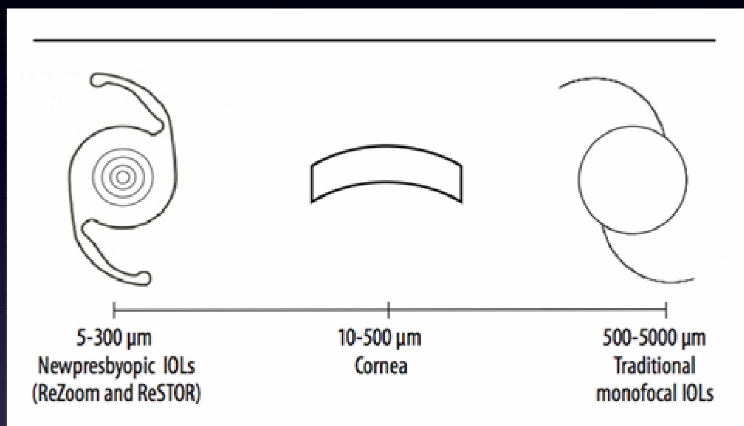
- Small pupil
  - ReSTOR / Tecnis:  Near > Distance
  - ReZoom:  Distance > Near
  - Crystalens:  Enhanced depth of field
- Performance influenced by ambient light

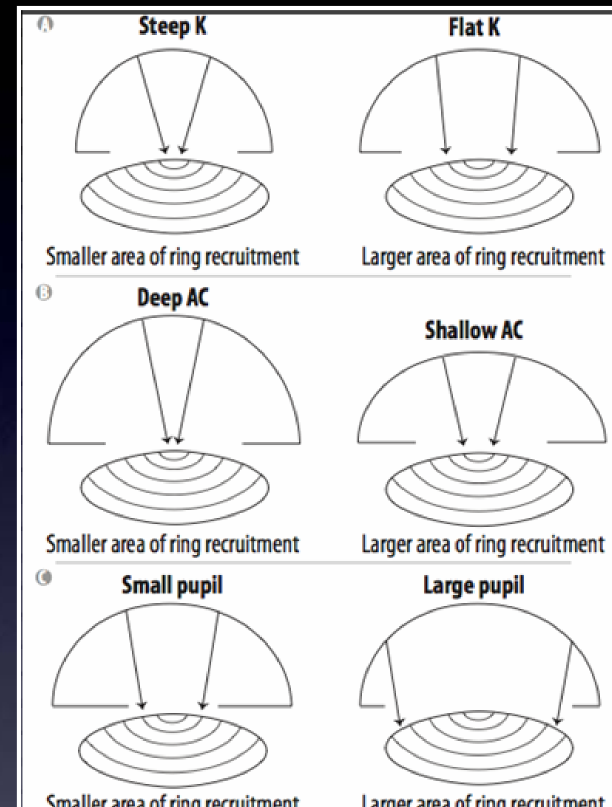
Steepness, ACD, Pupil

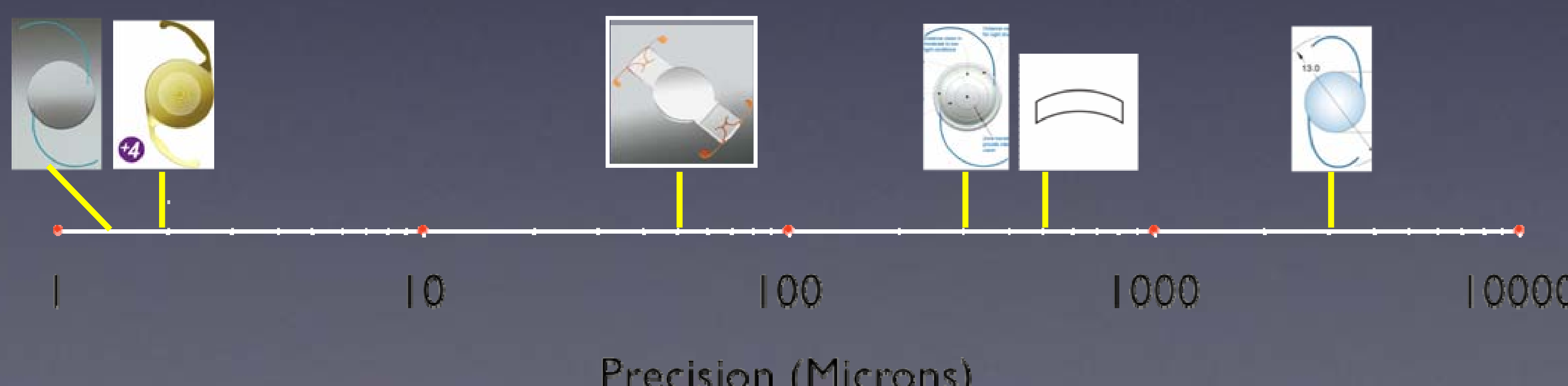
We can indeed go beyond psychology in patient selection!



# factors affecting presby-IOL performance

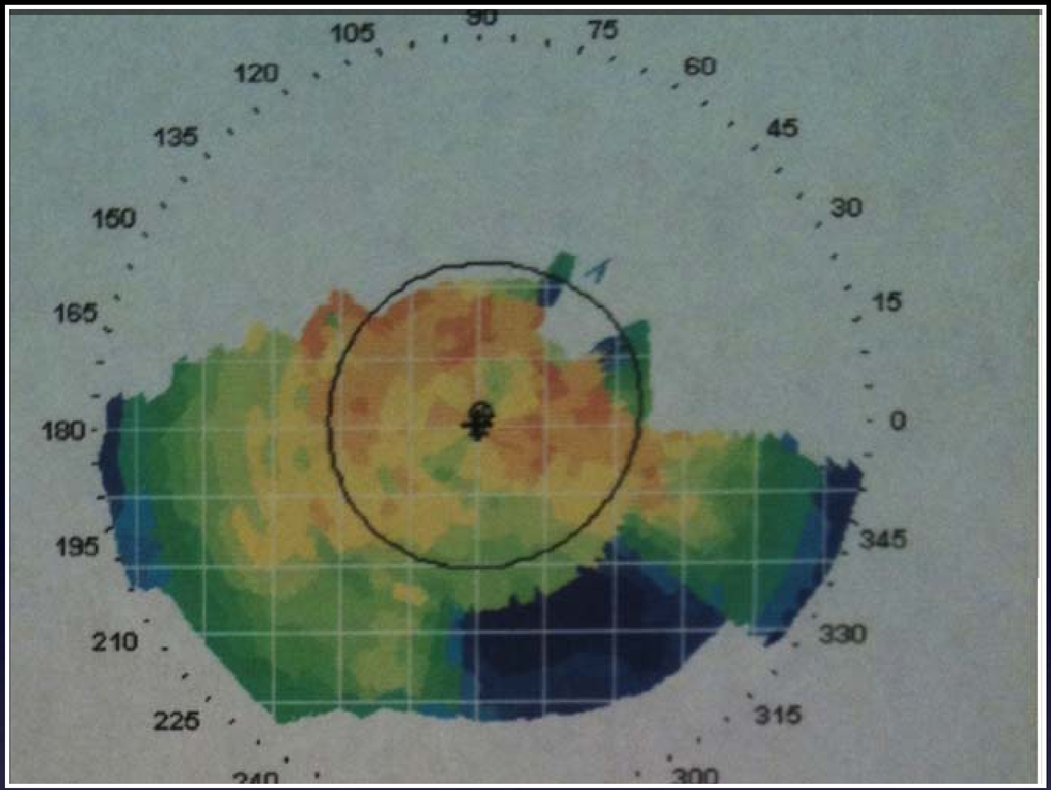


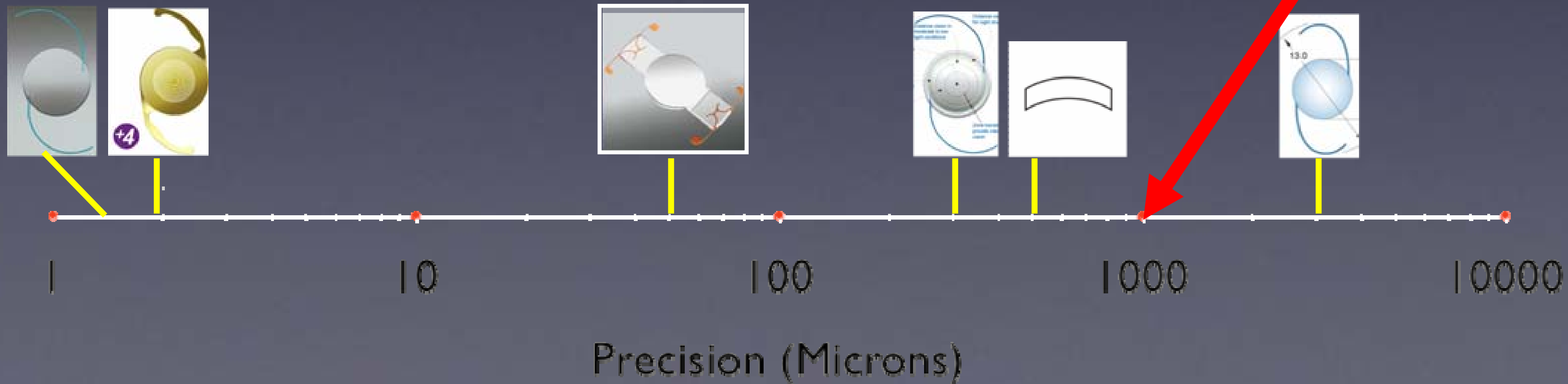



# Case 1

- 68 y/o woman, c/o Blurry Vision both eyes
- Exam:
  - Bilateral cataracts
  - BCVA 20/50 OU
  - Decreased tear film
  - Punctate epitheliopathy




- Dry Eye!
- Spacial precision on order of 1000 microns



# Case II

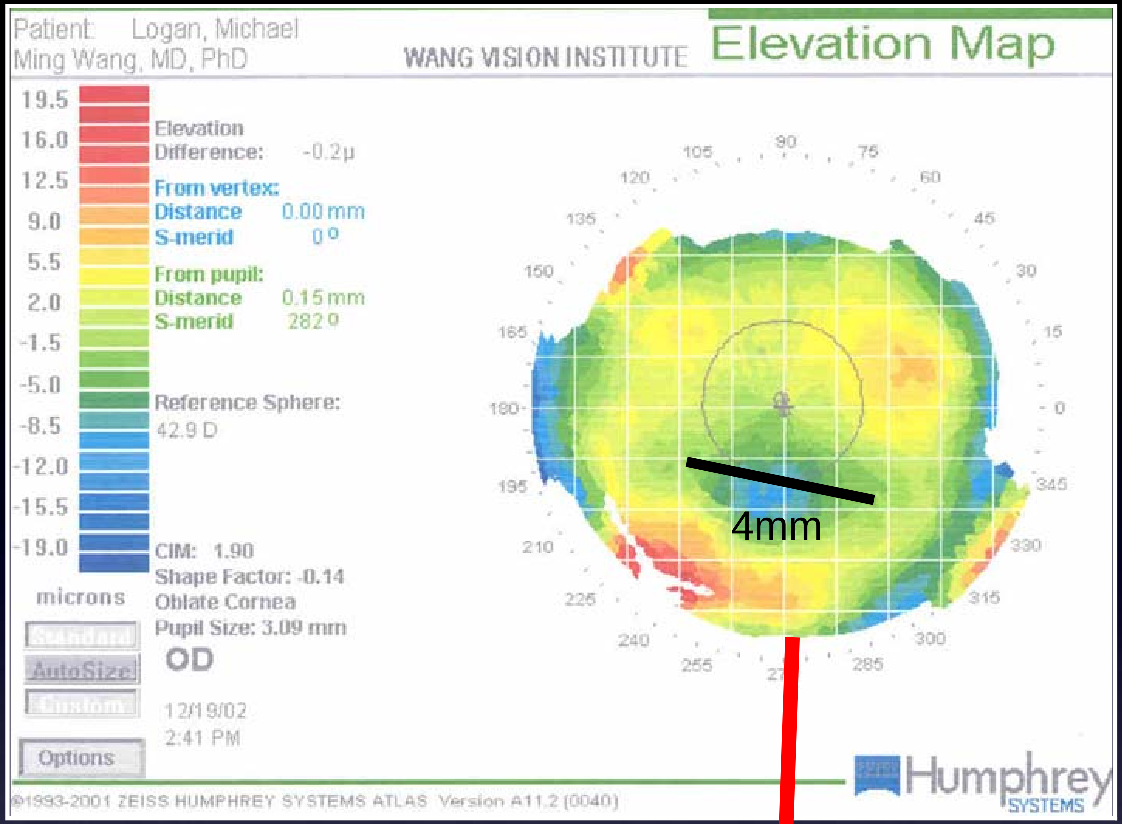
- 58 y/o male, c/o blurry vision both eyes, worsening over the past 5 years
- LASIK surgery 2003 OU, mechanical microkeratome
    - Never has been satisfied with visual quality

# Case II continued

- Pre-LASIK refraction:
  - OD -6.50 + 100 x 95  20/20
  - OS  -7.25 +0.75 x 80  20/20
- Post-LASIK refraction (2003):
  - OD:  -0.25 + 0.50 x 95 20/30
  - OS:  PL + 0.25 x 60 20/20
- Current refraction (2009):
  - OD: -100+0.50 x 090 20/100
  - OS:   -0.75 +0.25 x 060 20/25

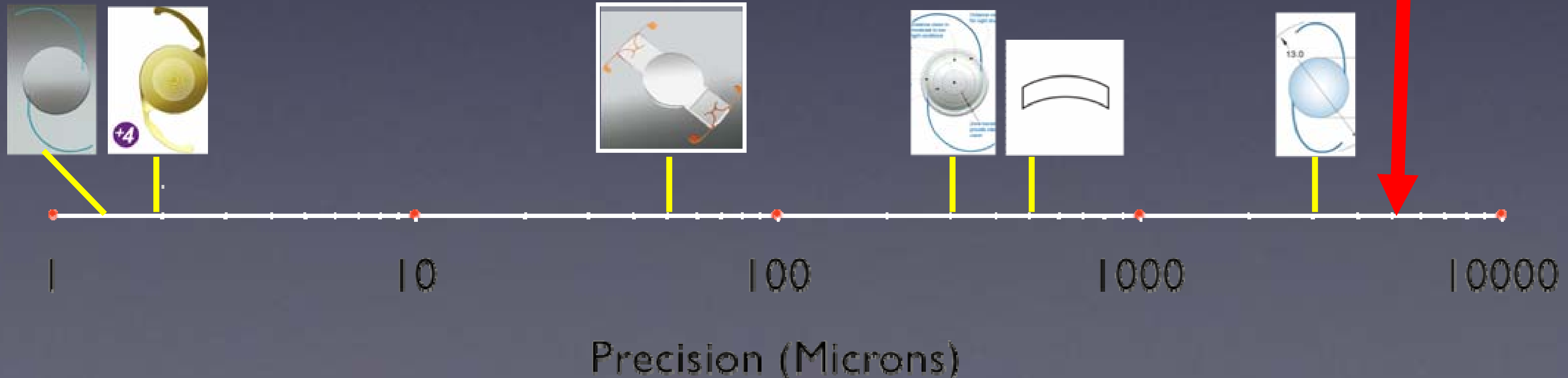
# Case II continued

- 2-3+ PSC cataract OD
- Otherwise normal eye exam



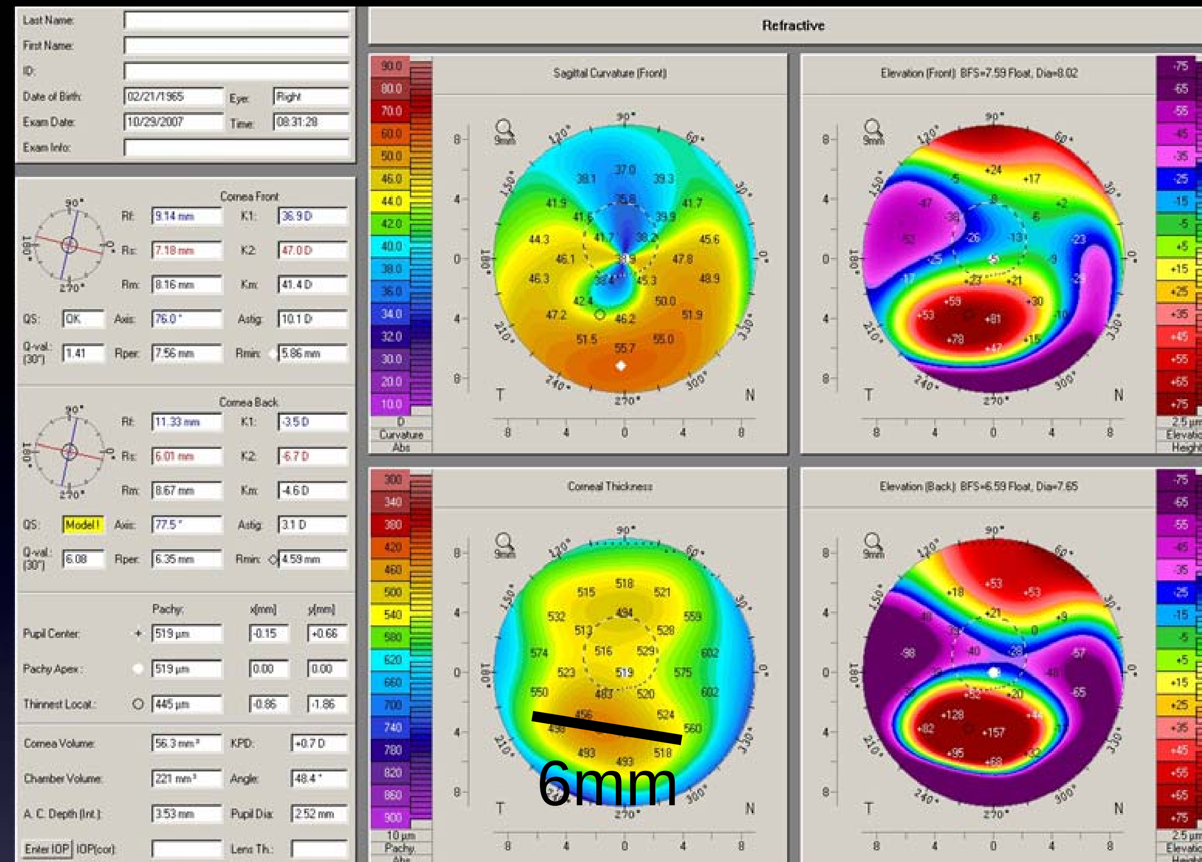

- Decentered LASIK!

Precision on order of 4000 microns



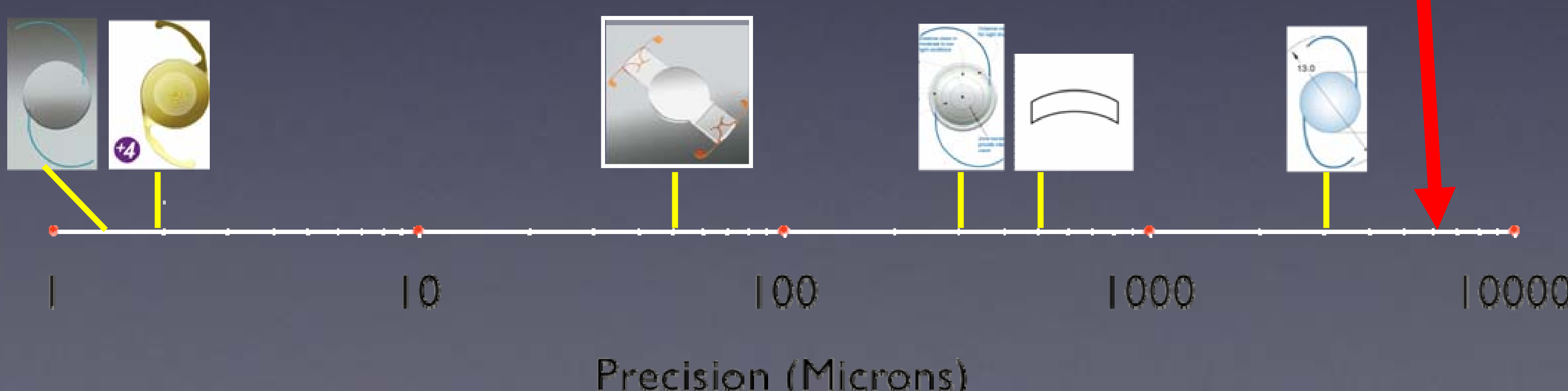
# Case III

- 65 y/o woman
- History of GPCL wear for 30 years becuase of “astigmatism”
- Referred for cataract sugery
- BCVA 20/80 OU
- 2+ NS with 1+PSC OU




Pellucid Marginal Degeneration (form of FFKC)

Precision on order of 6000 microns

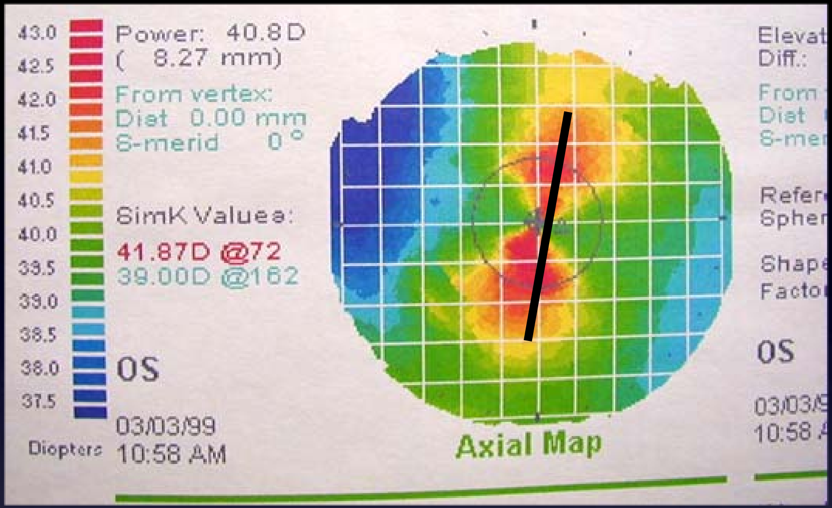


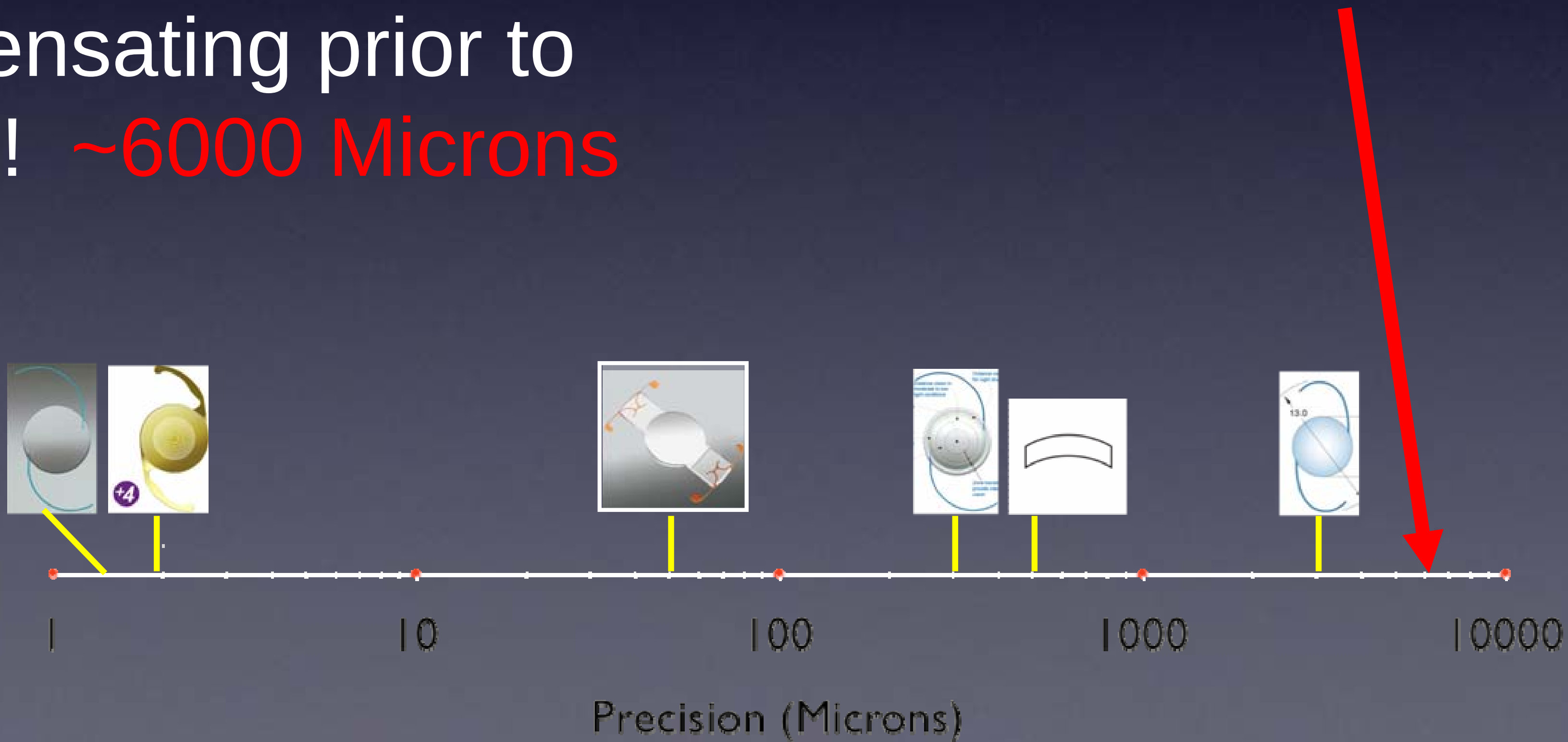
# Case IV

- 57 y/o female
- S/P phaco OD with ReSTOR IOL.
- UCVA: 20/30
- Before surgery: -2.00 sphere no cylinder
- After surgery: -.75 +1.75 x 090 20/20
    - *Where did the cyl come from?*

# Case IV

Anterior corneal astigmatism!
Thus the *lenticular* astigmatism was compensating prior to phaco! ~6000 Microns

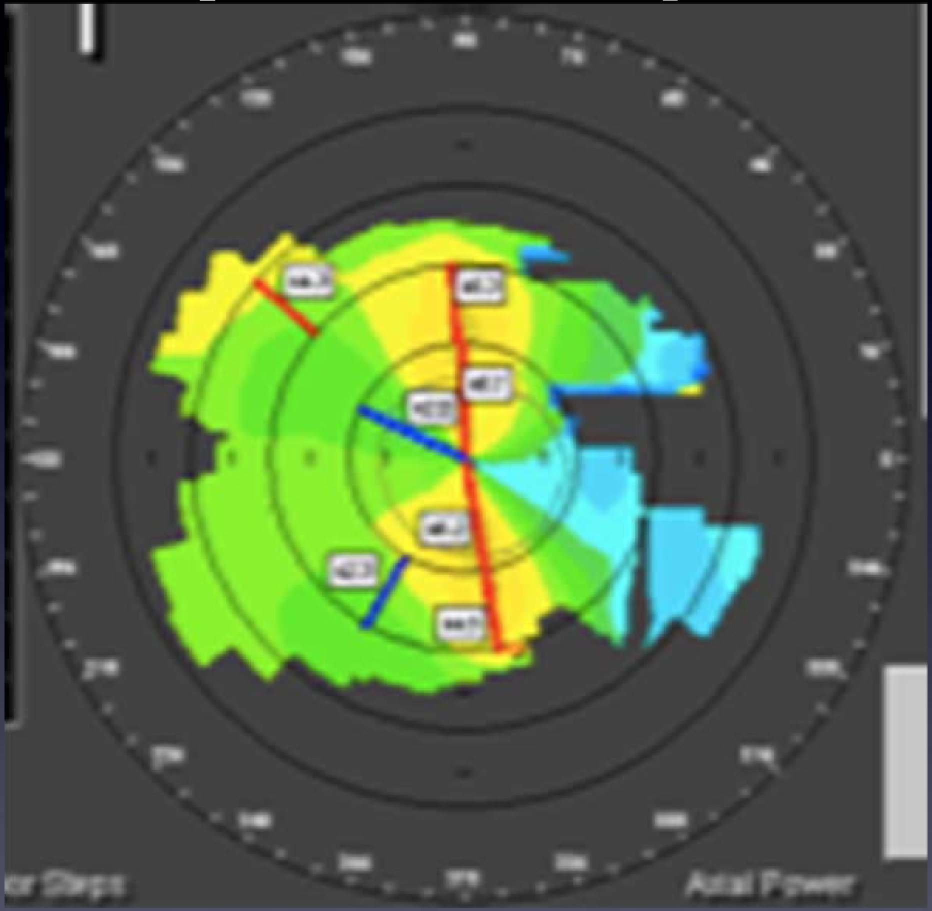


# Case V

- 67 y/o male s/p phaco with ReSTOR
- Unhappy with vision, still blurry at distance
- Refraction before phaco:
  - -3.00 + 0.75 x 135 20/40
- LRI performed during phaco
- Post op refraction: Plano sphere 20/30
- ? topo

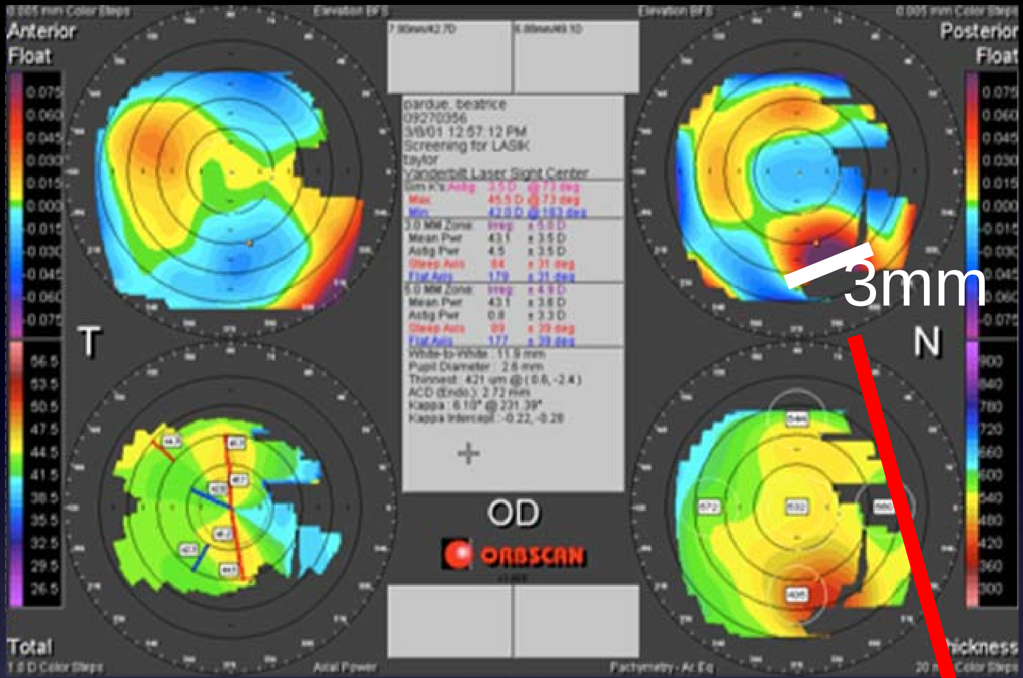
# Case V (before phaco)



# What else could be wrong?

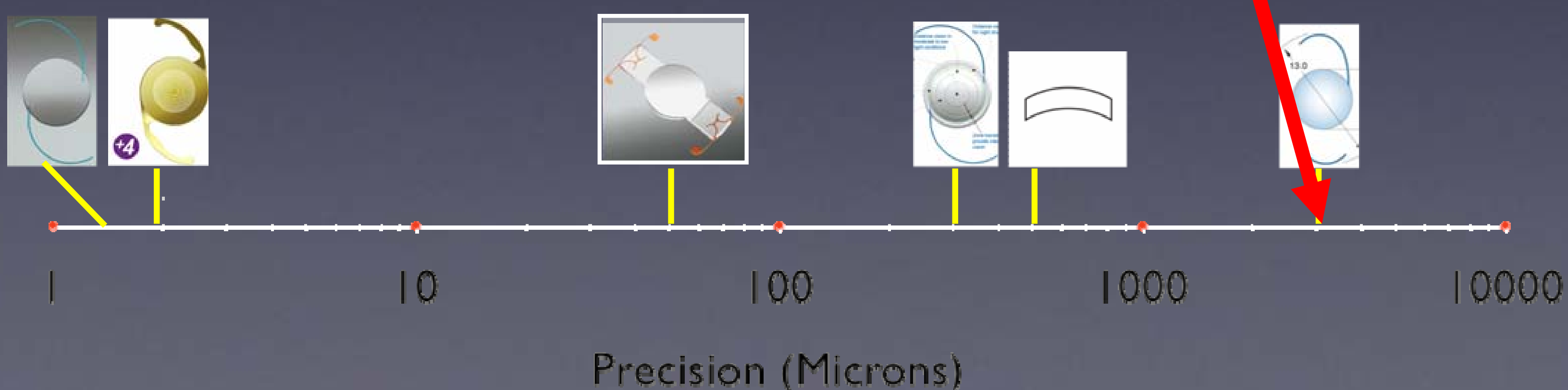
- Pre-op 0.75 cyl
- Normal pre-op topo
- Cyl corrected during sugery
- Plano post-op refraction, but BCVA only 20/30 and patient unhappy
- So what else could have been a warning sign *before* surgery?

# Case V



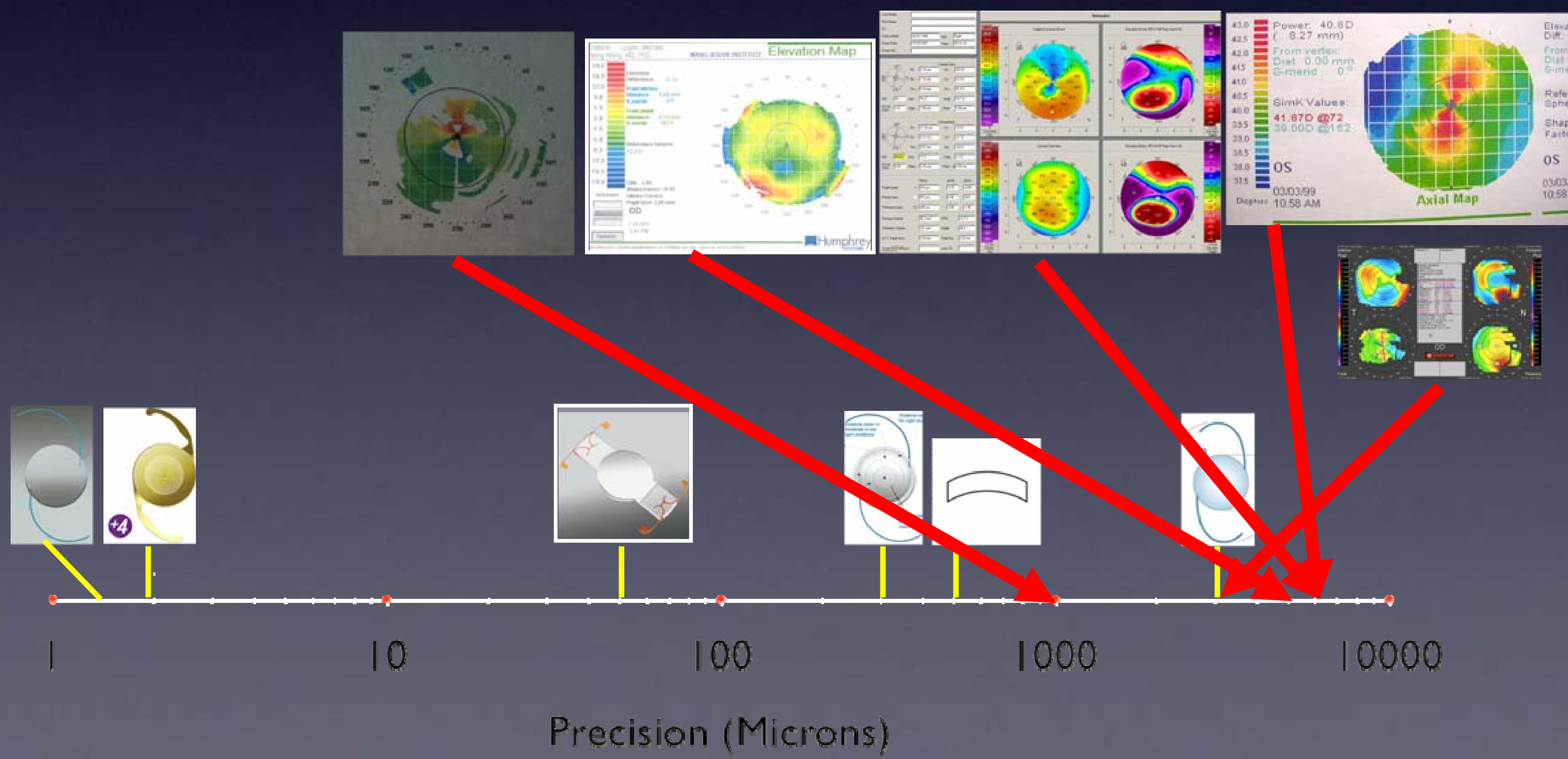

Irregular *posterior* surface!

Precision on the order of 3000 microns



# Take-home message of case presentations

- Irregular cornea can create more spacial imprecision than that of presbyopic IOLs



# “Big Picture”

- Improvement in one area of medicine (IOL) may reveal another area (cornea) as the new rate-limiting step

# Future Approach

- Careful attention to corneal regularity
  - If topography suspicious consider RGP over-refraction
- Careful attention to corneal steepness, ACD, and pupil size
- Consider Crystalens or Monofocal