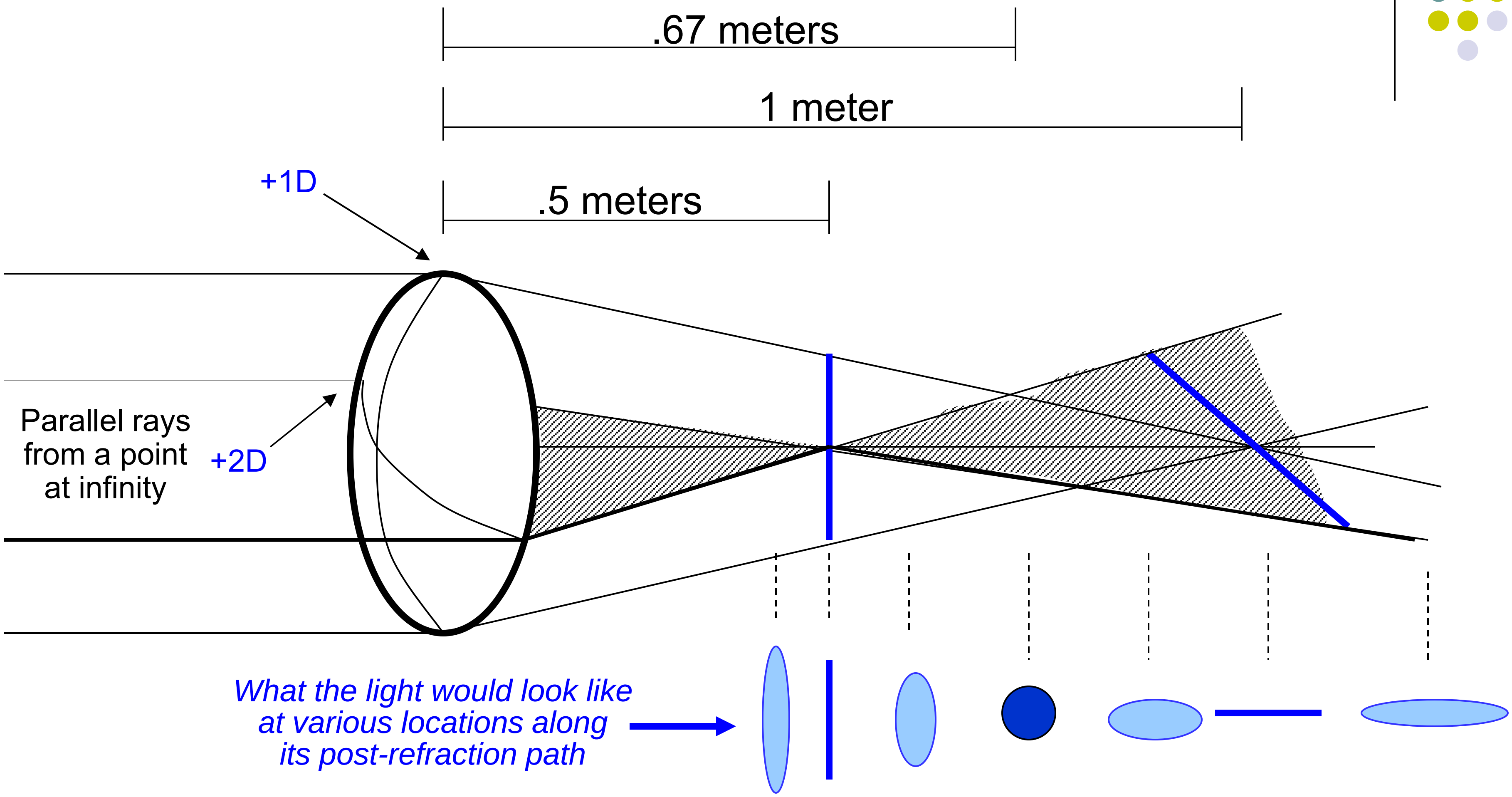
Astigmatic Refractive Error: The Conoid of Sturm

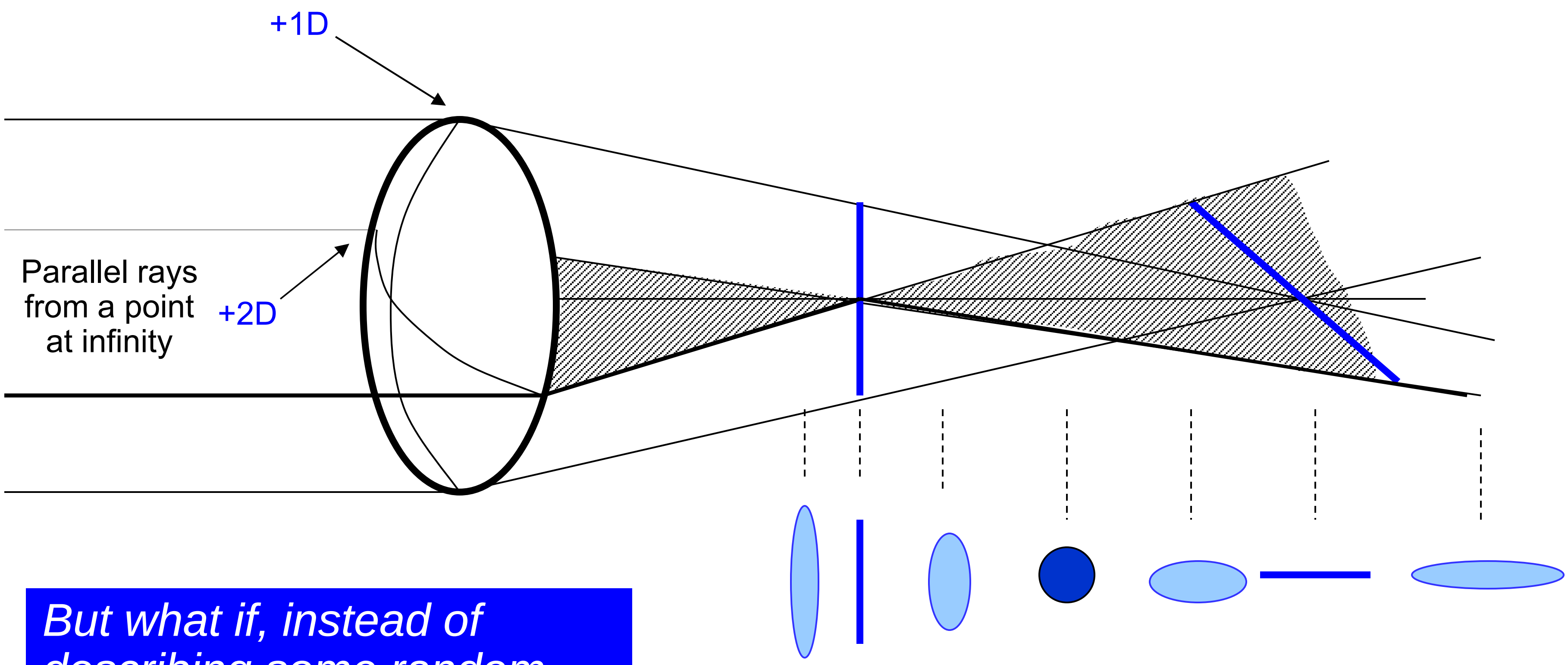
Basic Optics, Chapter 11

Spherocylindrical Lenses



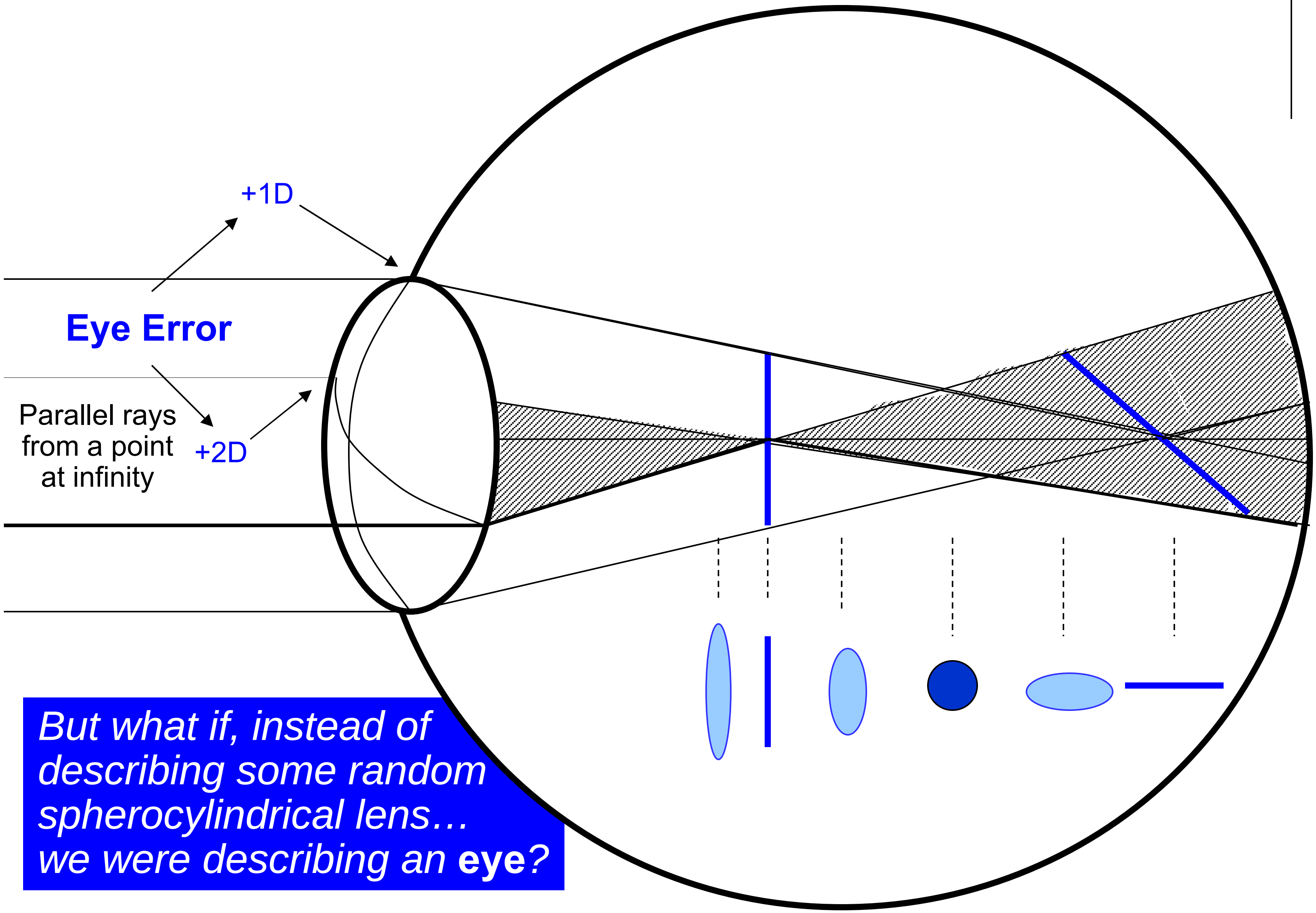
In Chapter 10, we saw that a spherocylindrical lens focuses parallel rays not to a single secondary focal point, but rather to a pair of secondary focal *lines* separated by a circle.

Spherocylindrical Lenses



But what if, instead of describing some random spherocylindrical lens…

Astigmatic Eye Error



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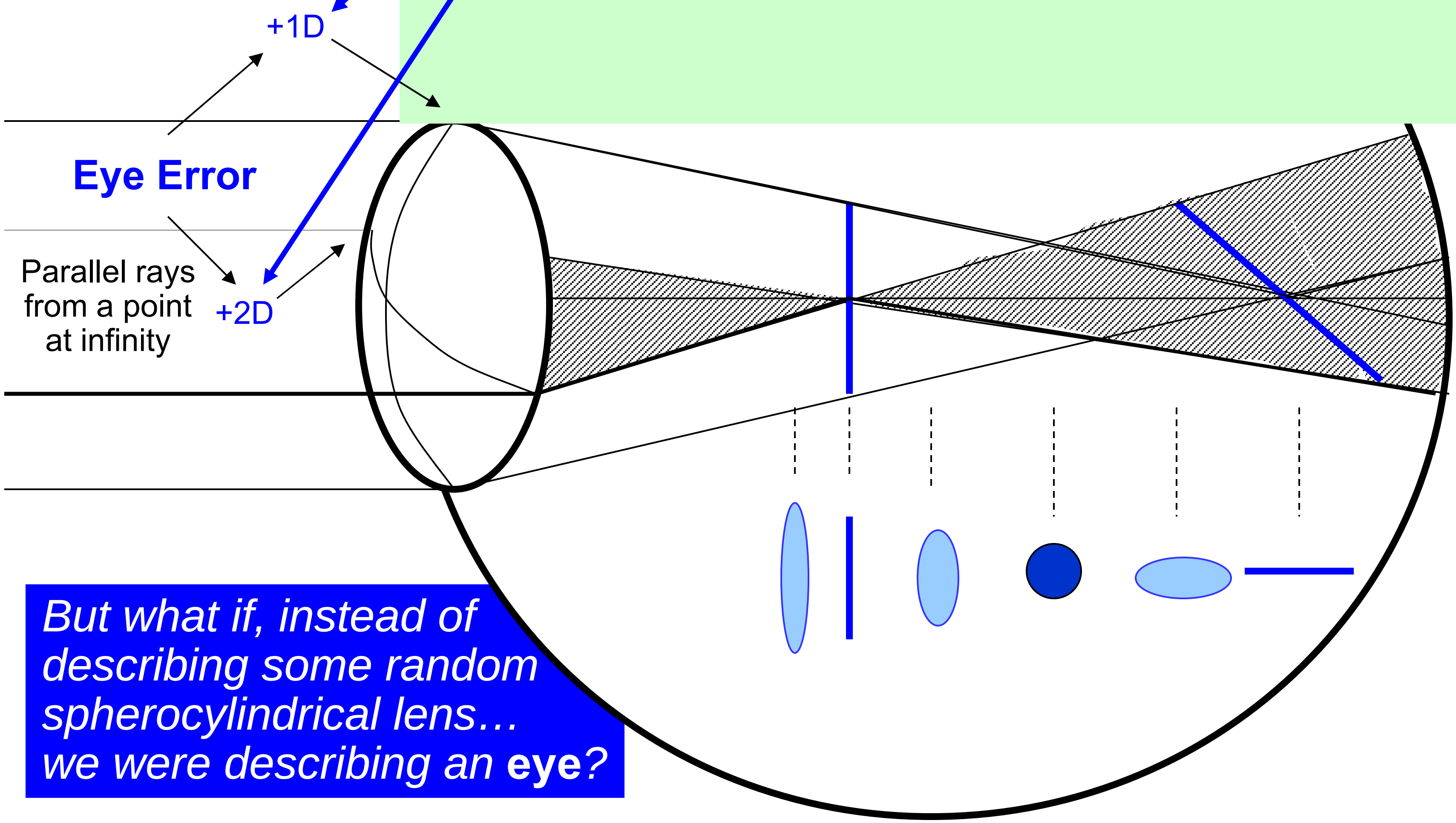

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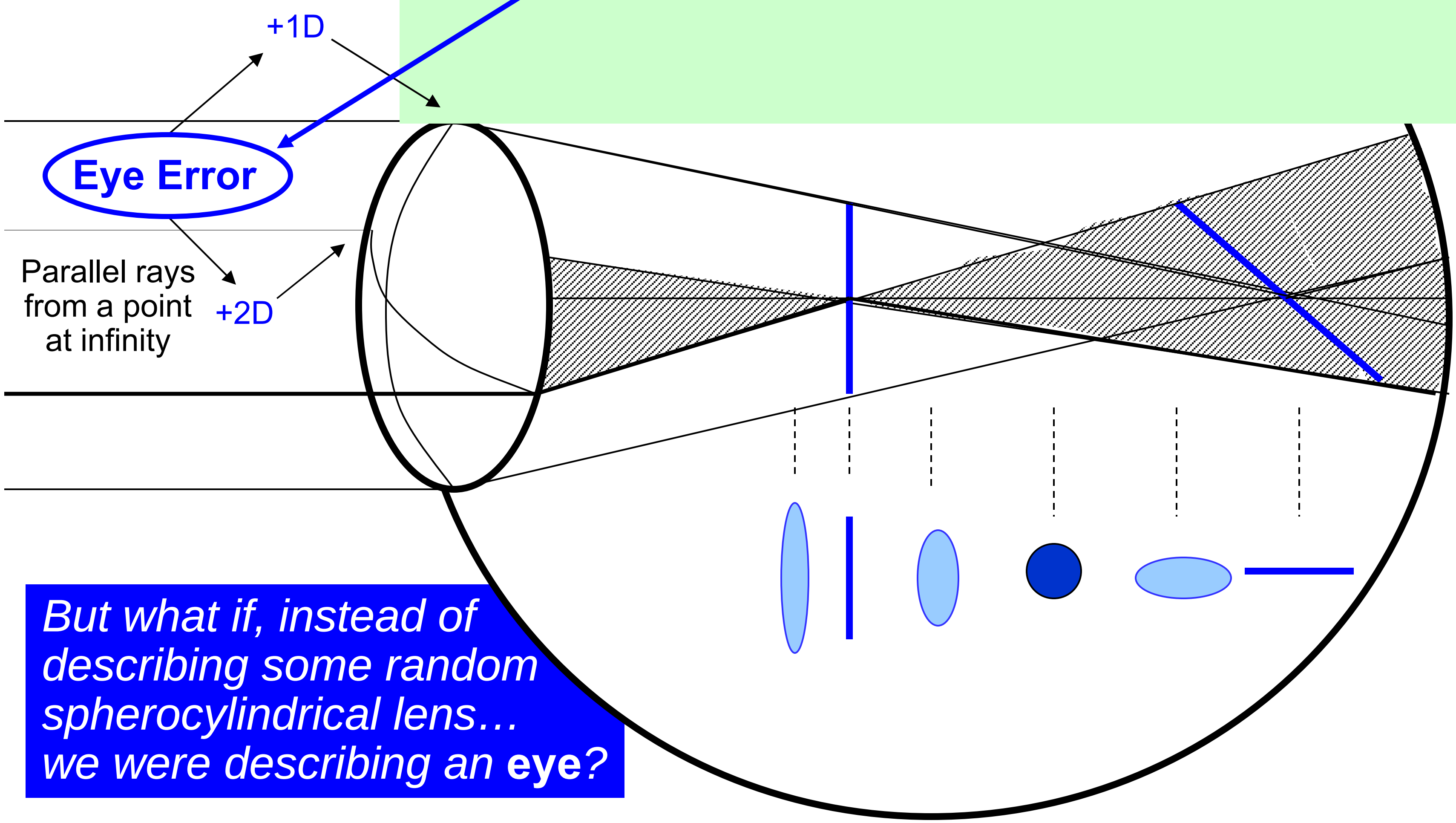

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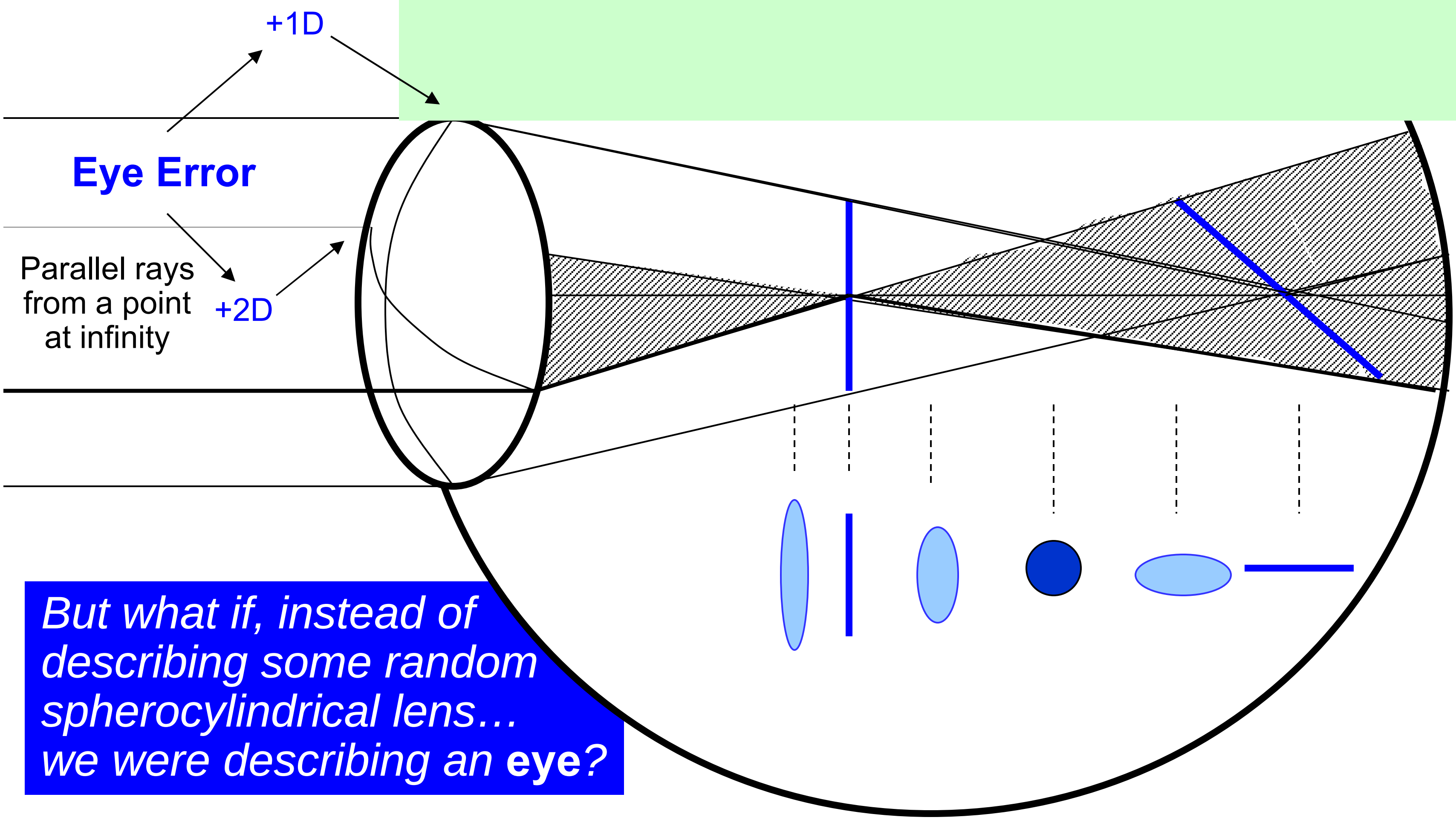

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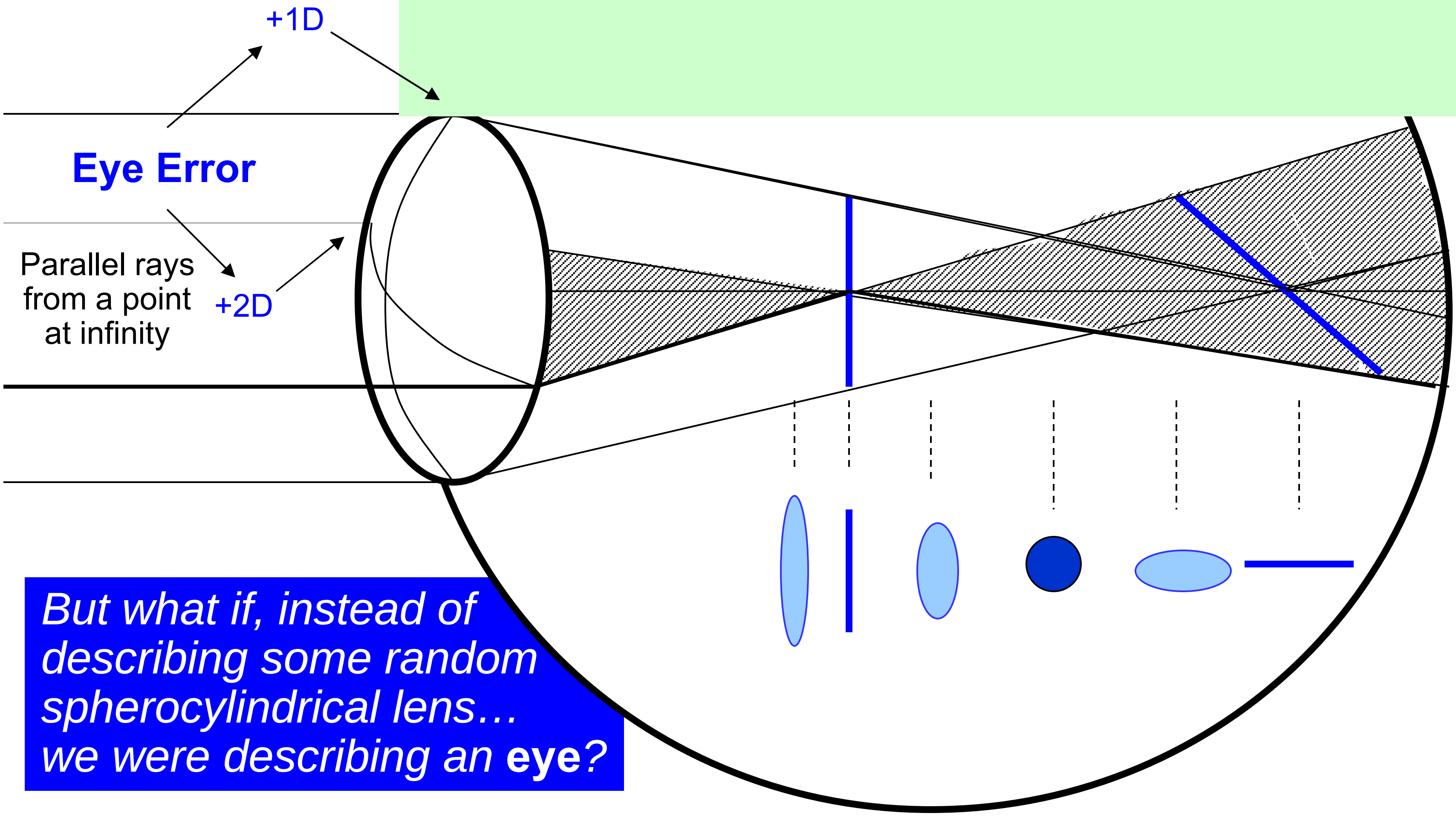

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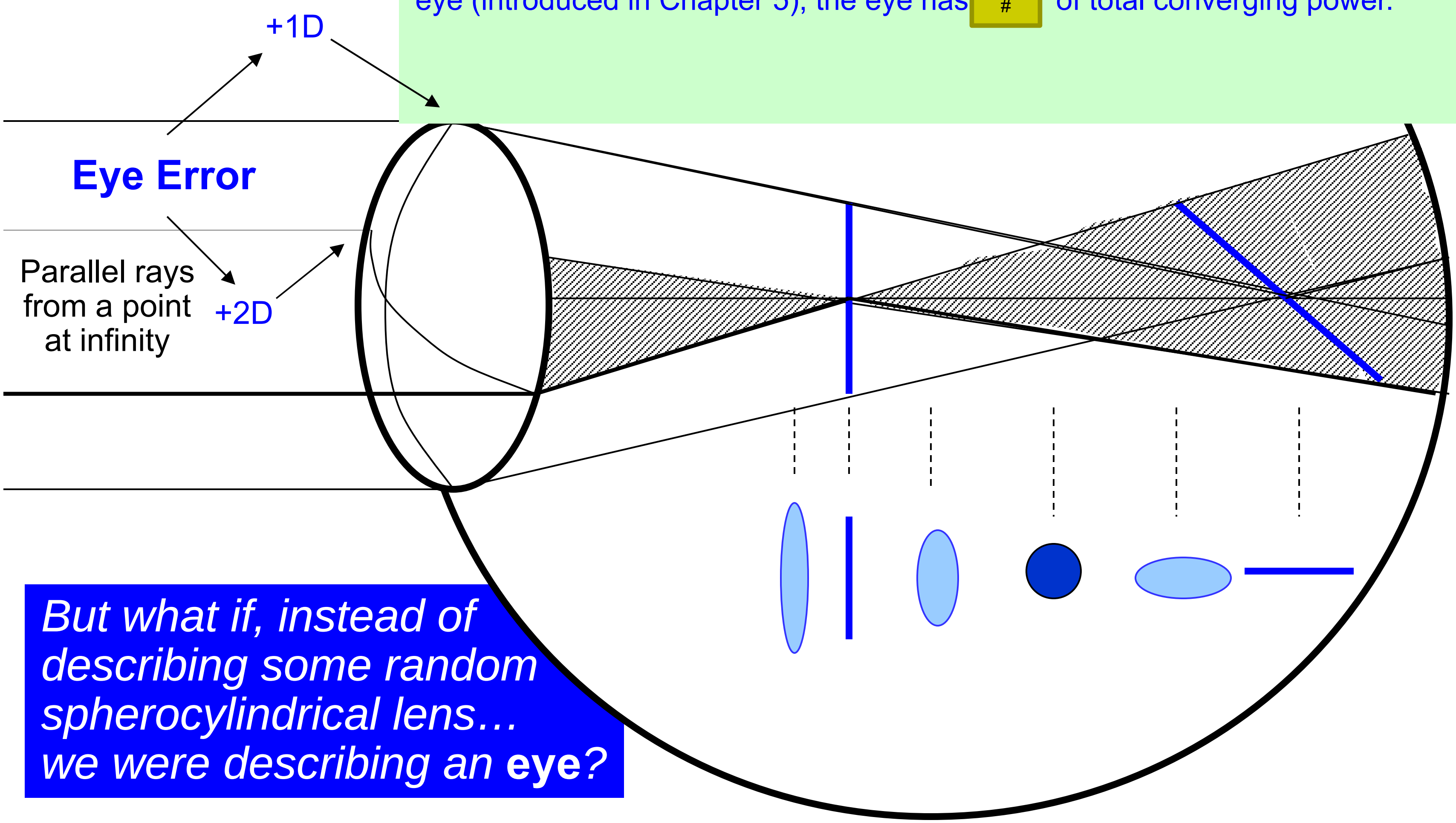
That depends on the total power of the eye in question. In Güllstrand's reduced schematic eye (introduced in Chapter 5), the eye has # of total converging power.



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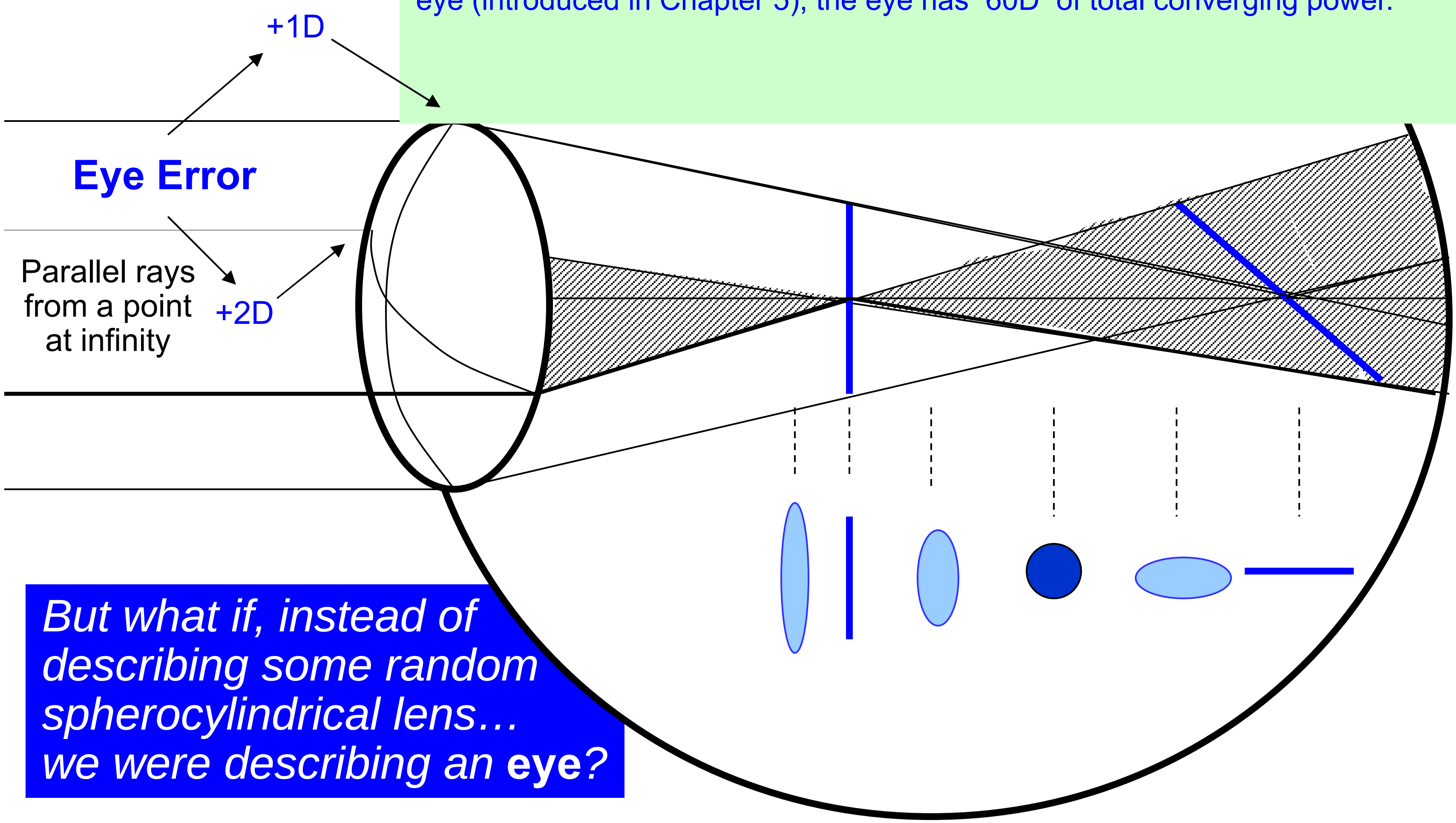

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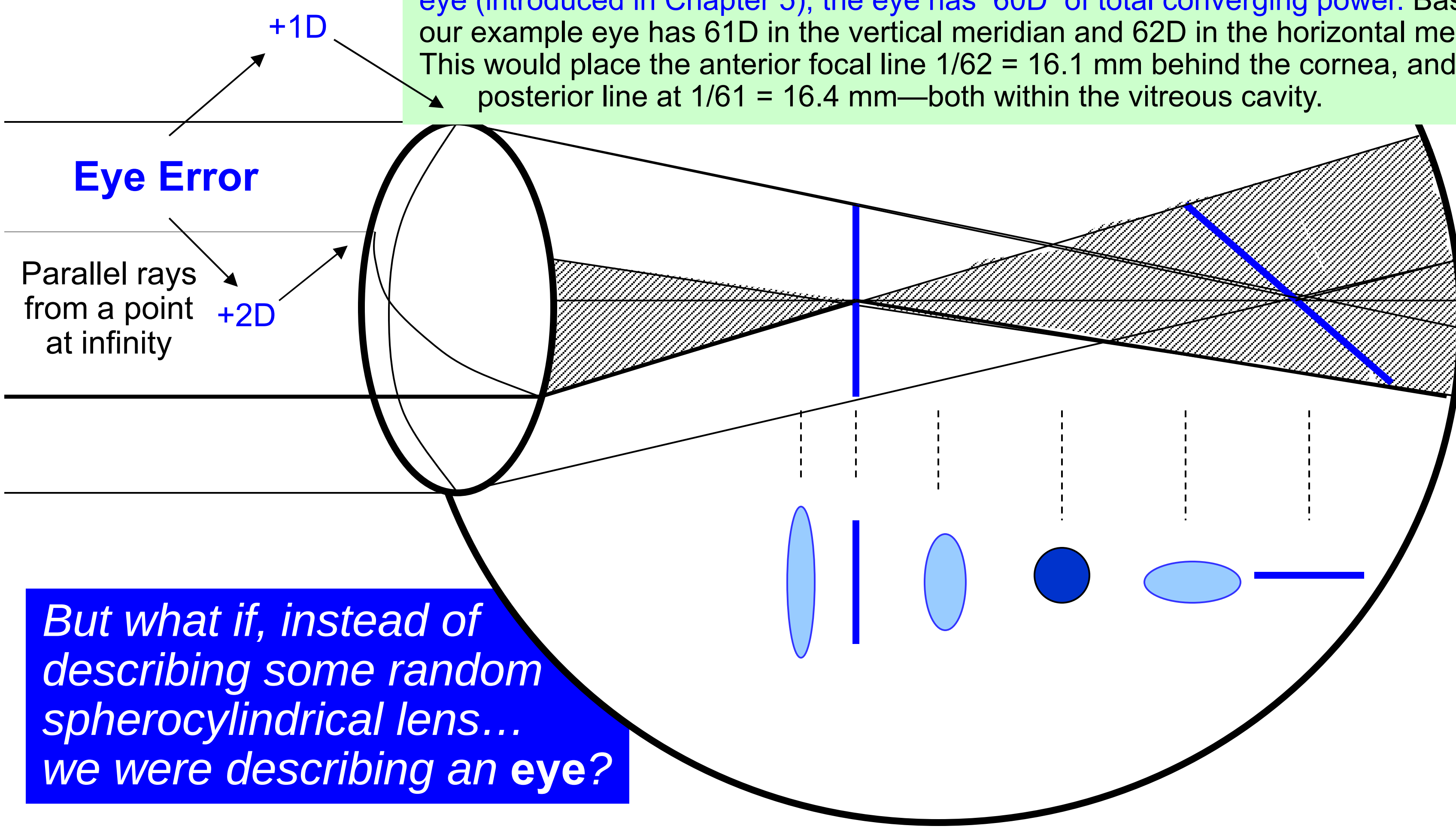
So where would the focal lines be, exactly?

That depends on the total power of the eye in question. In Güllstrand's reduced schematic eye (introduced in Chapter 5), the eye has 60D of total converging power. Based on that, our example eye has 61D in the vertical meridian and 62D in the horizontal meridian.

This would place the anterior focal line 1/62 = 16.1 mm behind the cornea, and the posterior line at 1/61 = 16.4 mm—both within the vitreous cavity.



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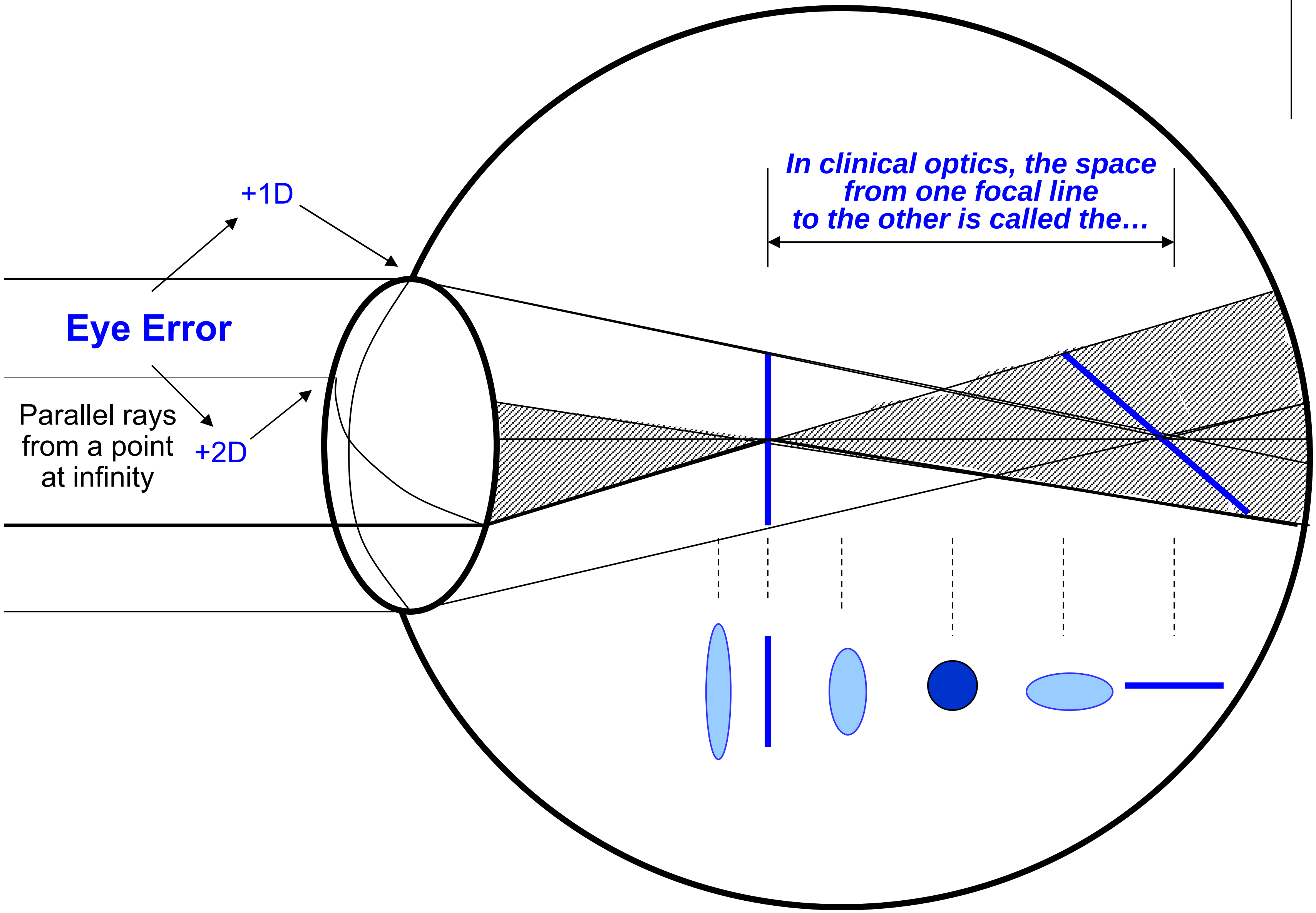
Astigmatic Eye Error



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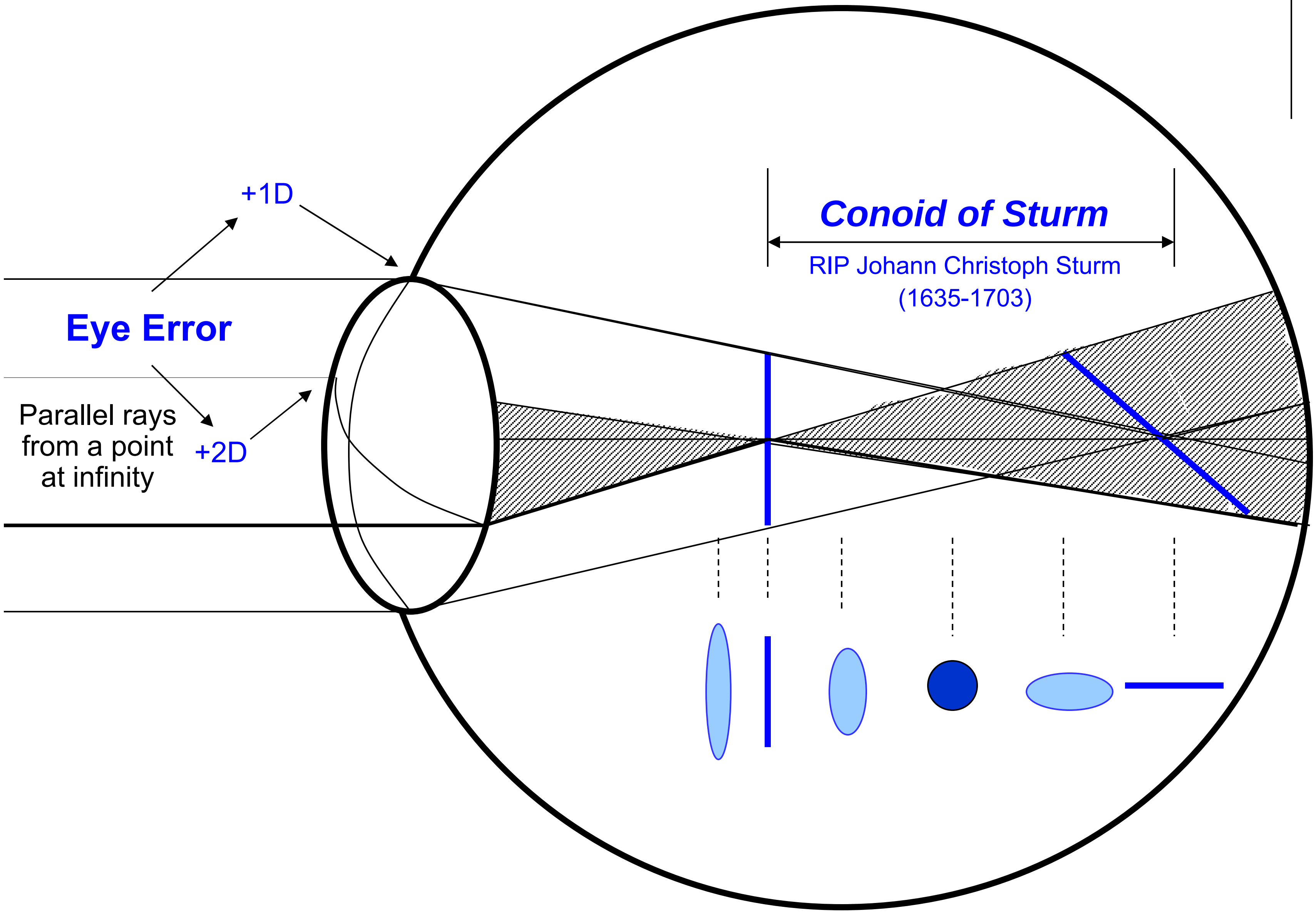

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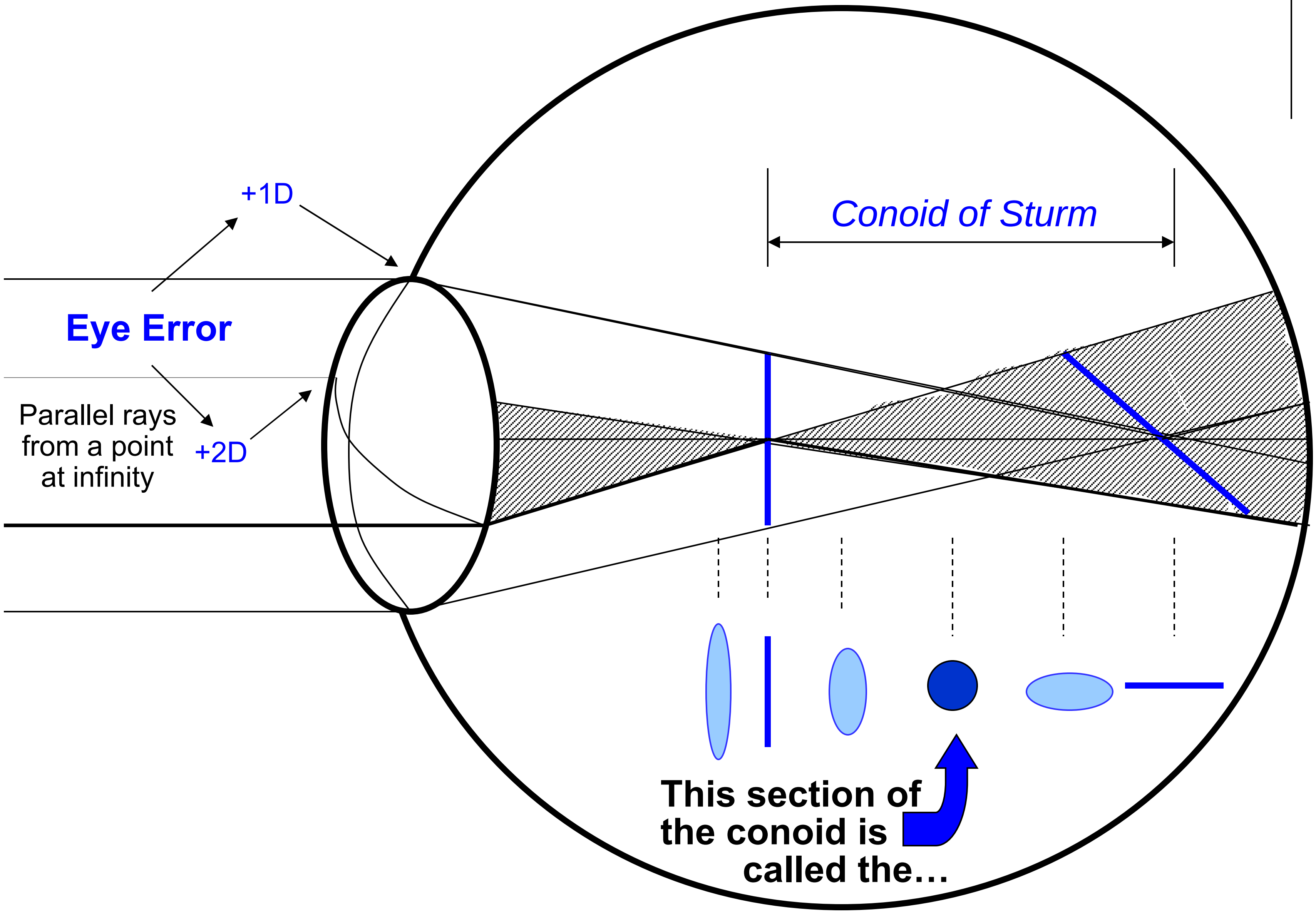

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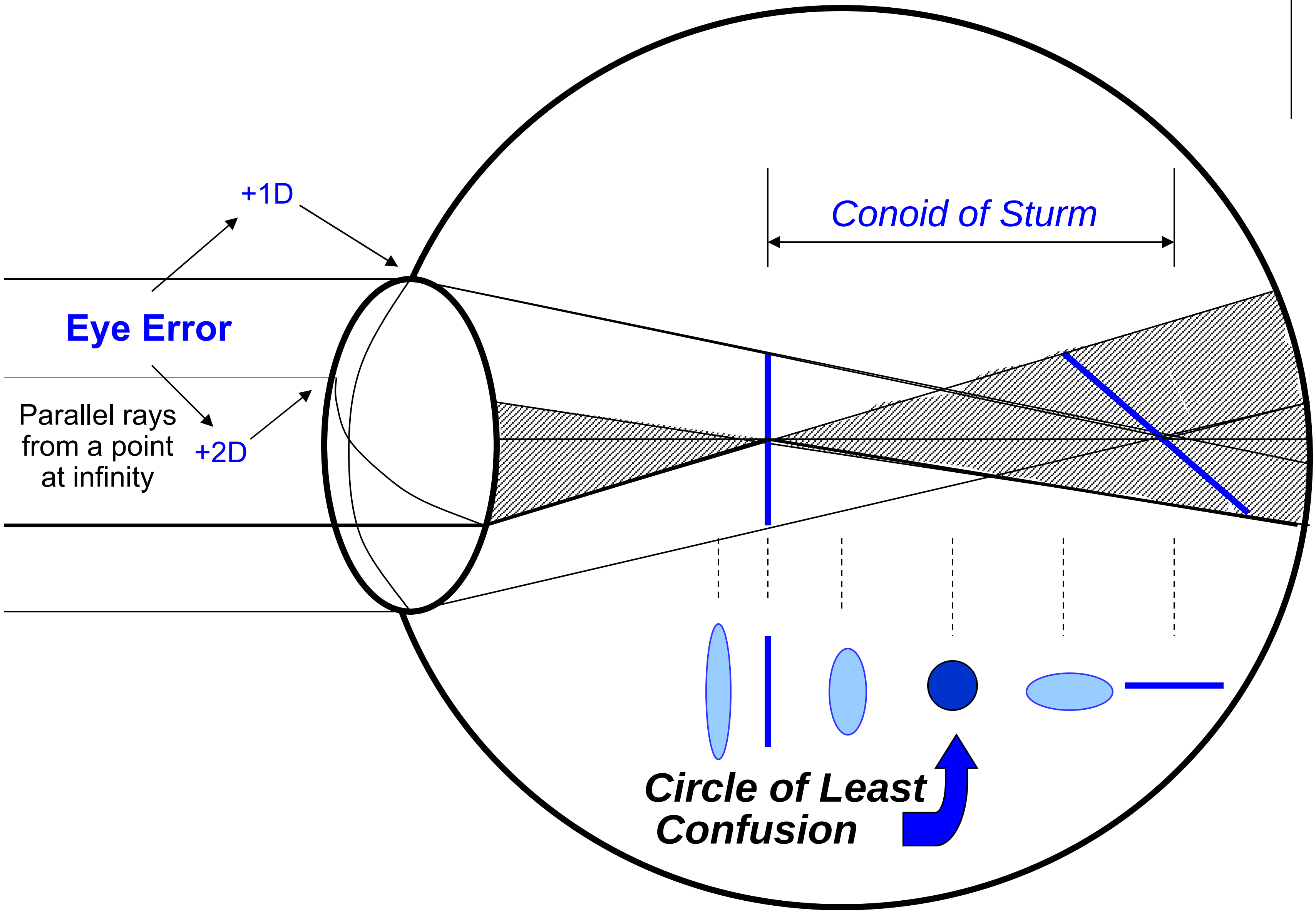

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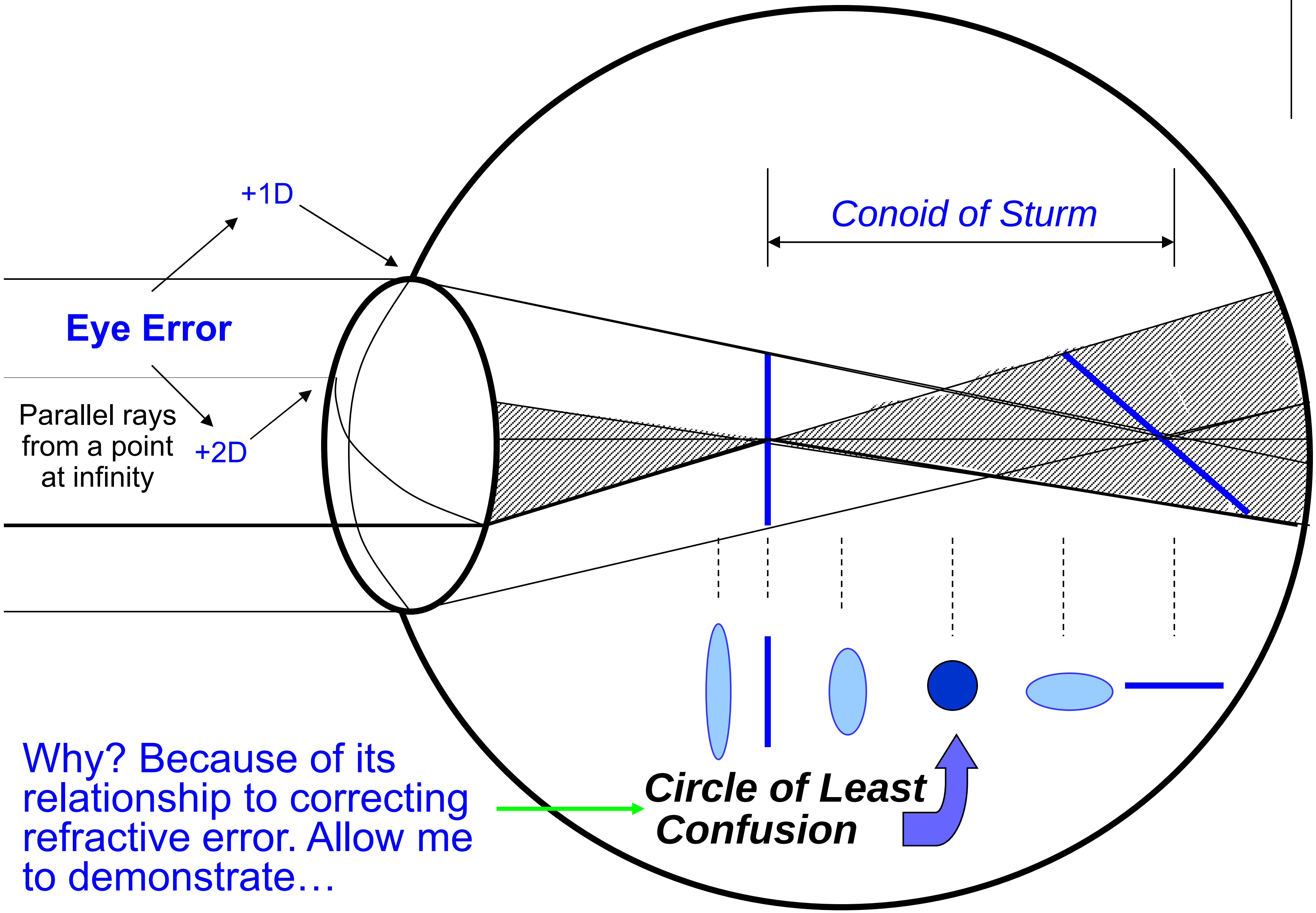
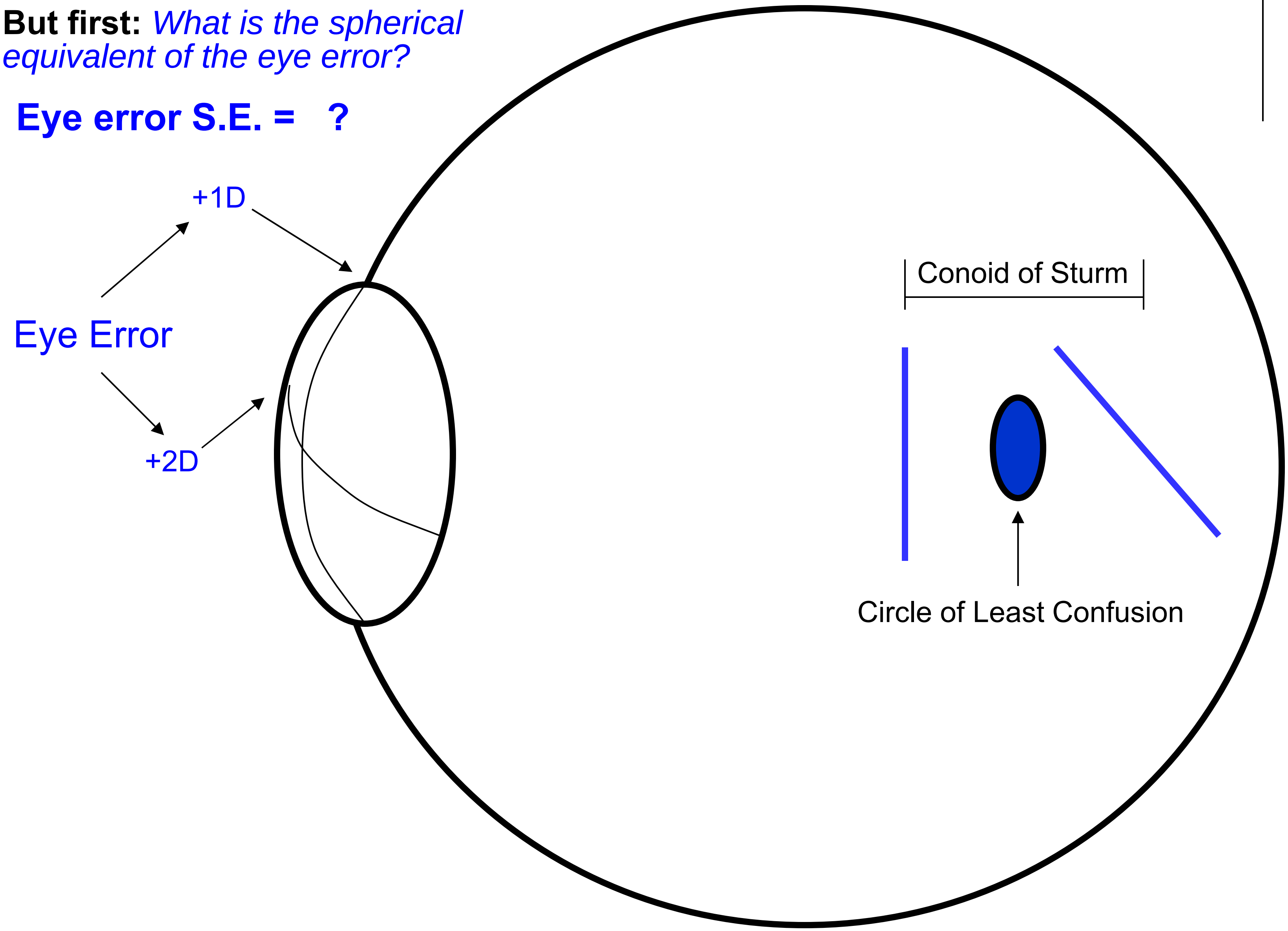


Why? Because of its relationship to correcting refractive error. Allow me to demonstrate…

Astigmatic Eye Error

But first: *What is the spherical equivalent of the eye error?*

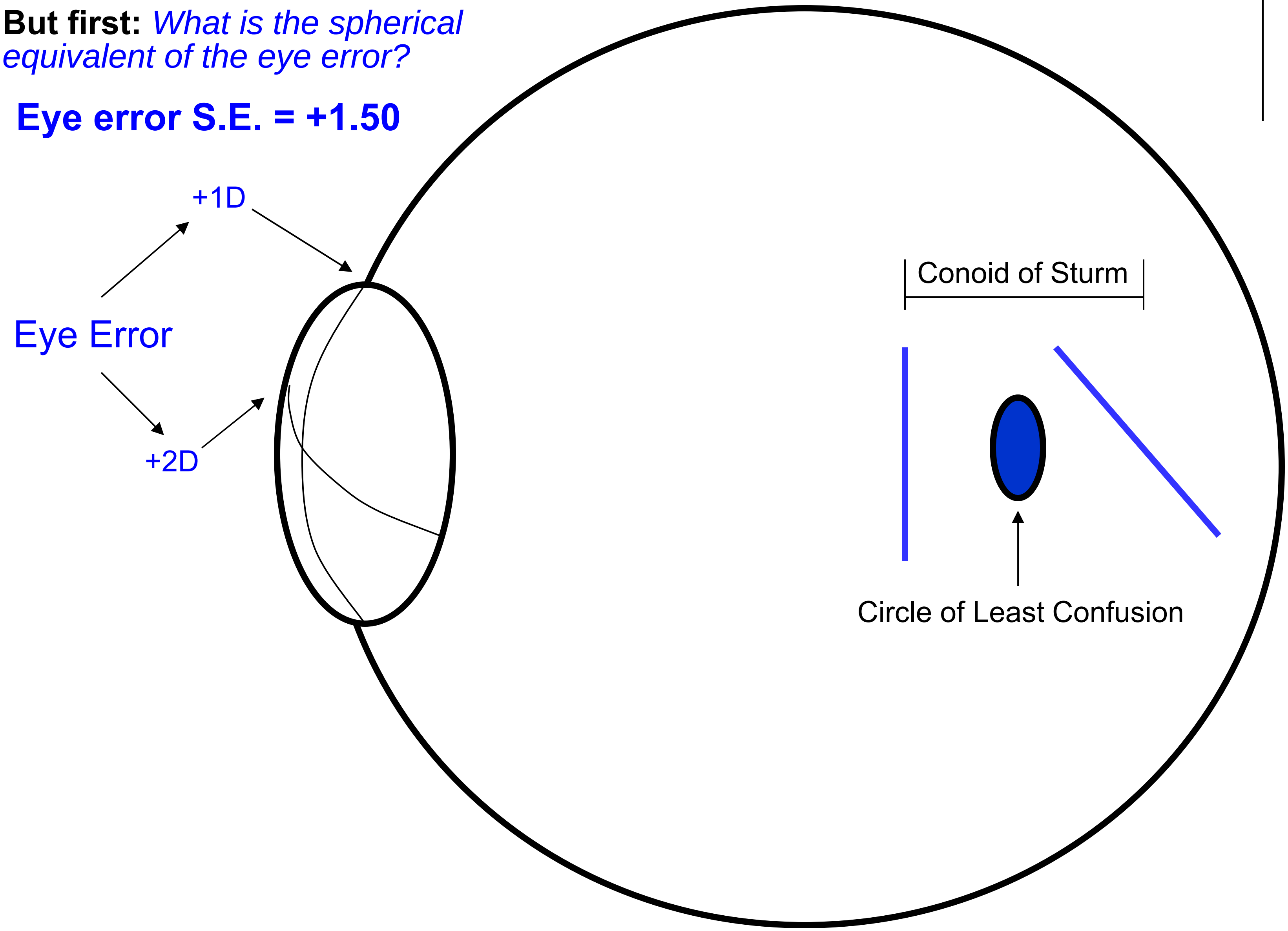
Eye error S.E. = ?



Astigmatic Eye Error

But first: *What is the spherical equivalent of the eye error?*

Eye error S.E. = +1.50



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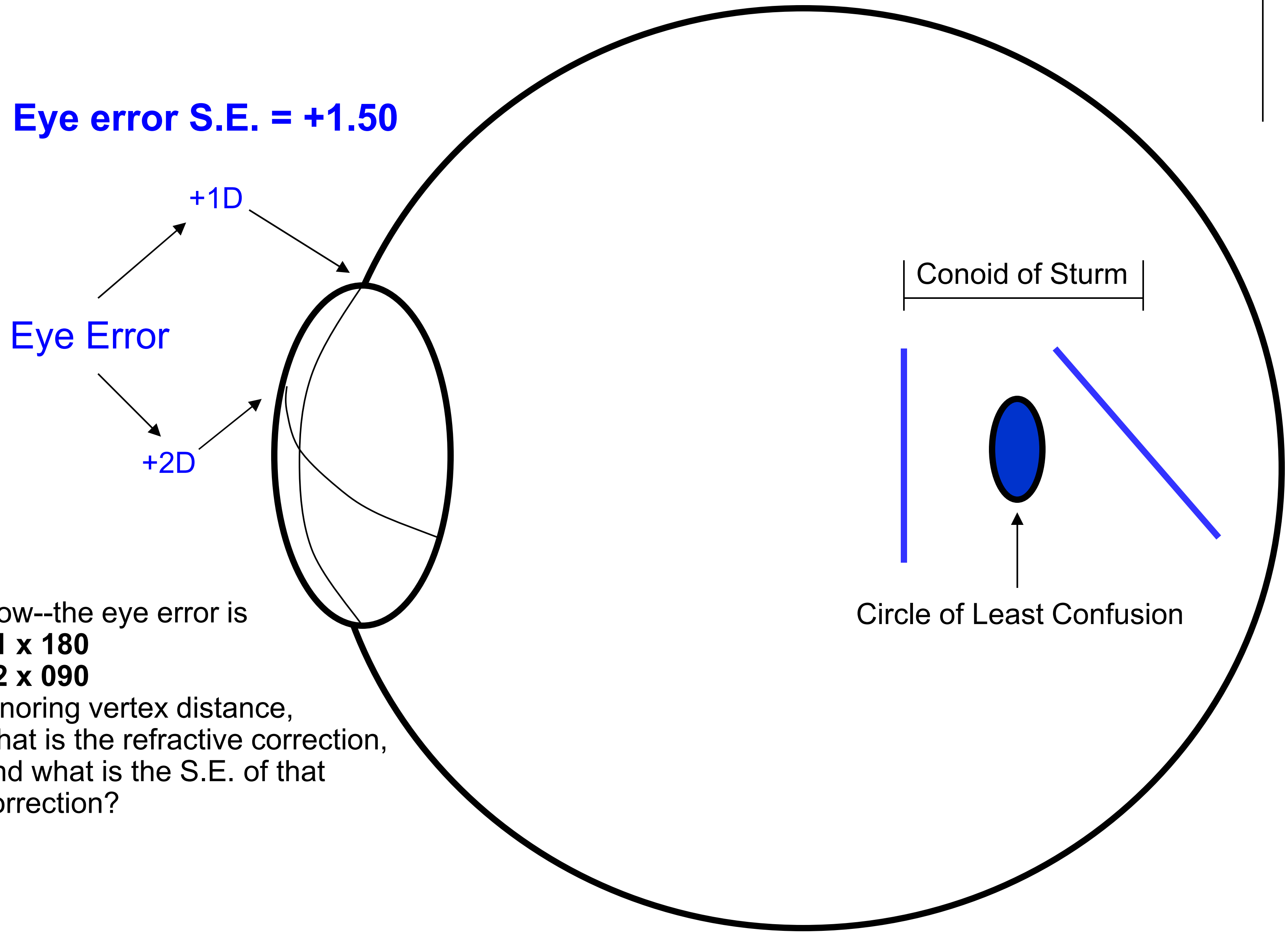
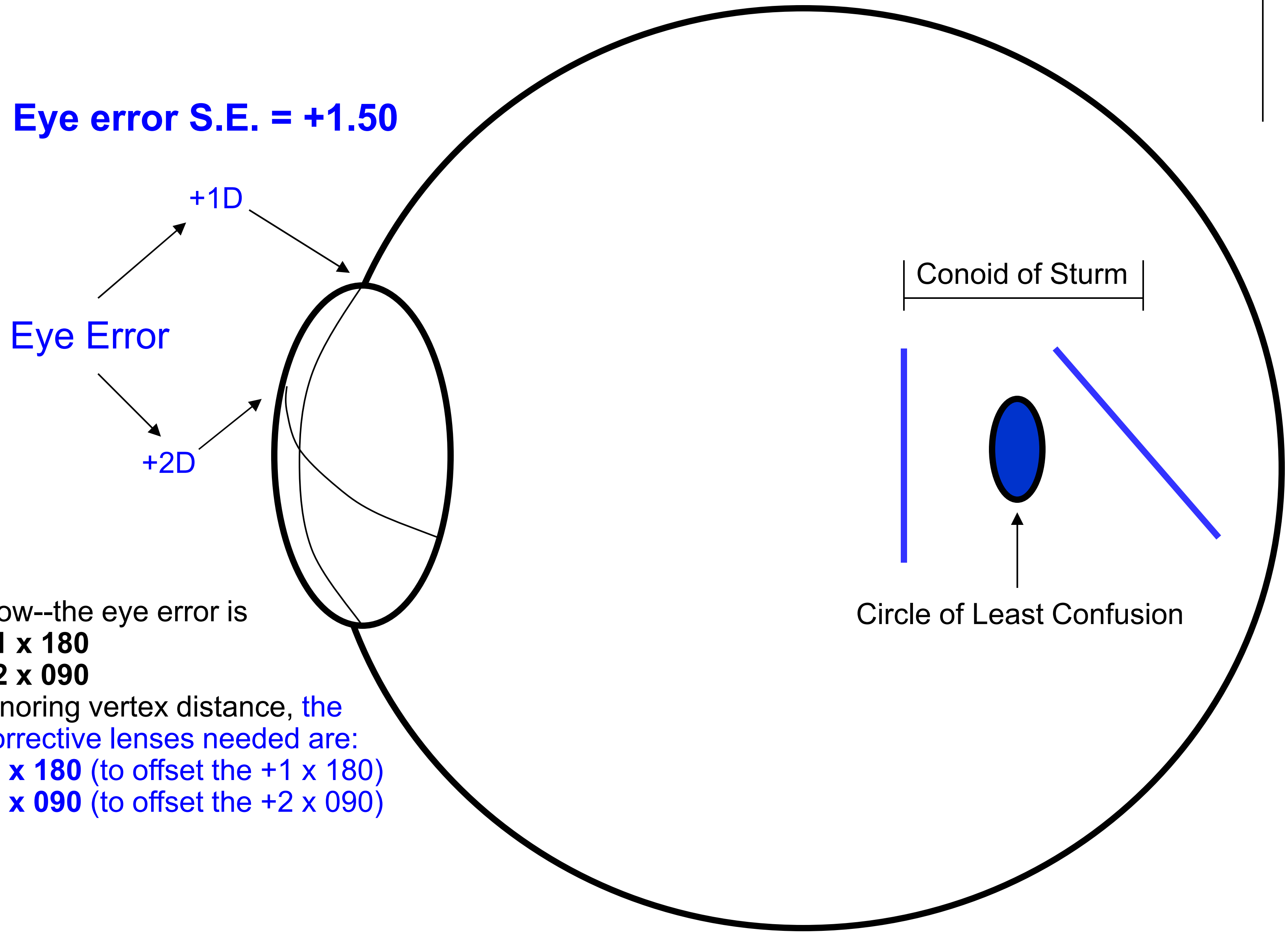


Now--the eye error is
+1 x 180
+2 x 090
Ignoring vertex distance, what is the refractive correction, and what is the S.E. of that correction?

Astigmatic Eye Error

Eye error S.E. = +1.50



Now--the eye error is
+1 x 180
+2 x 090
Ignoring vertex distance, the corrective lenses needed are:
-1 x 180 (to offset the +1 x 180)
-2 x 090 (to offset the +2 x 090)

Astigmatic Eye Error

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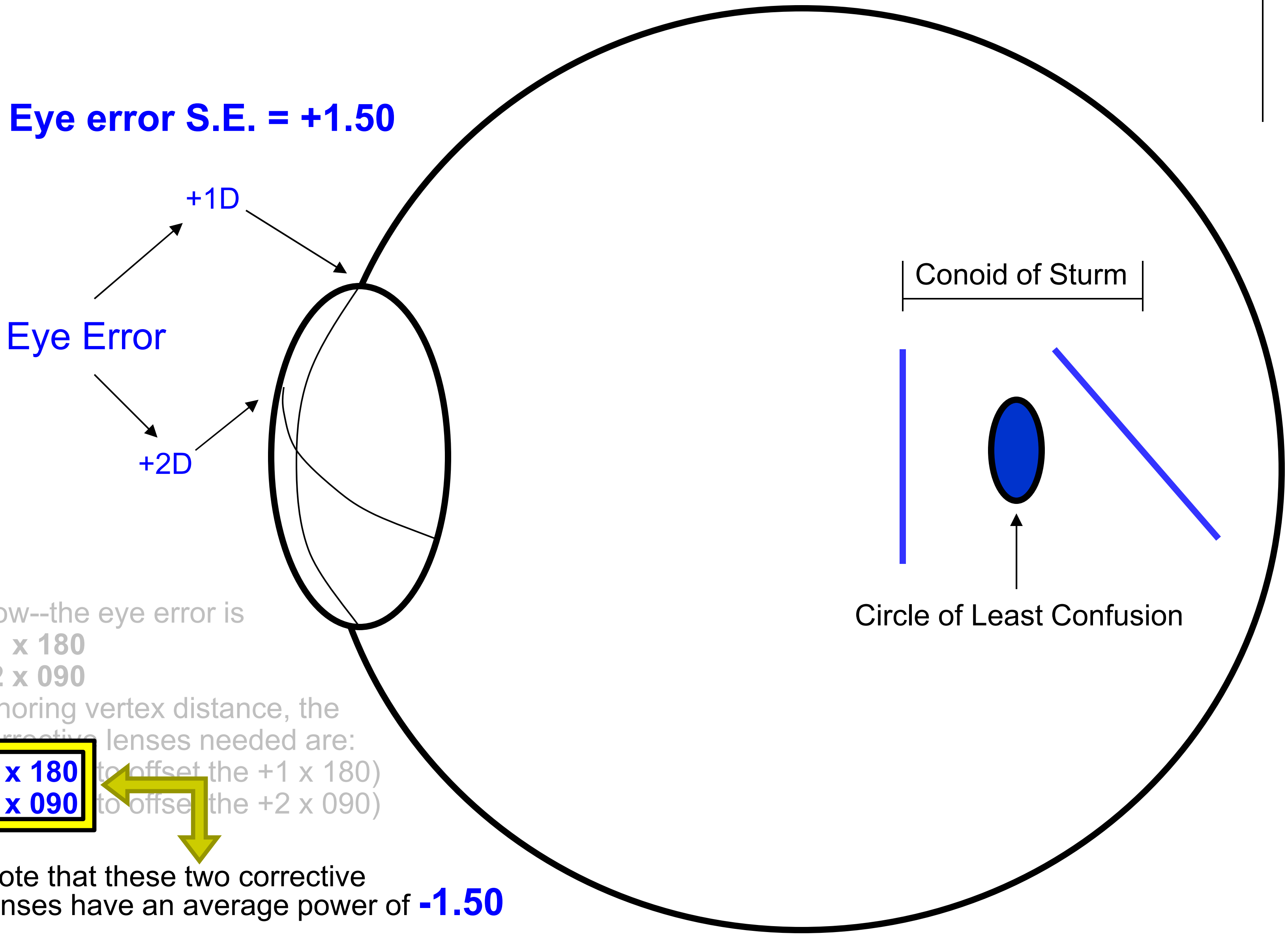

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Ignoring vertex distance, the corrective lenses needed are:
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Note that these two corrective lenses have an average power of **-1.50**

Astigmatic Eye Error

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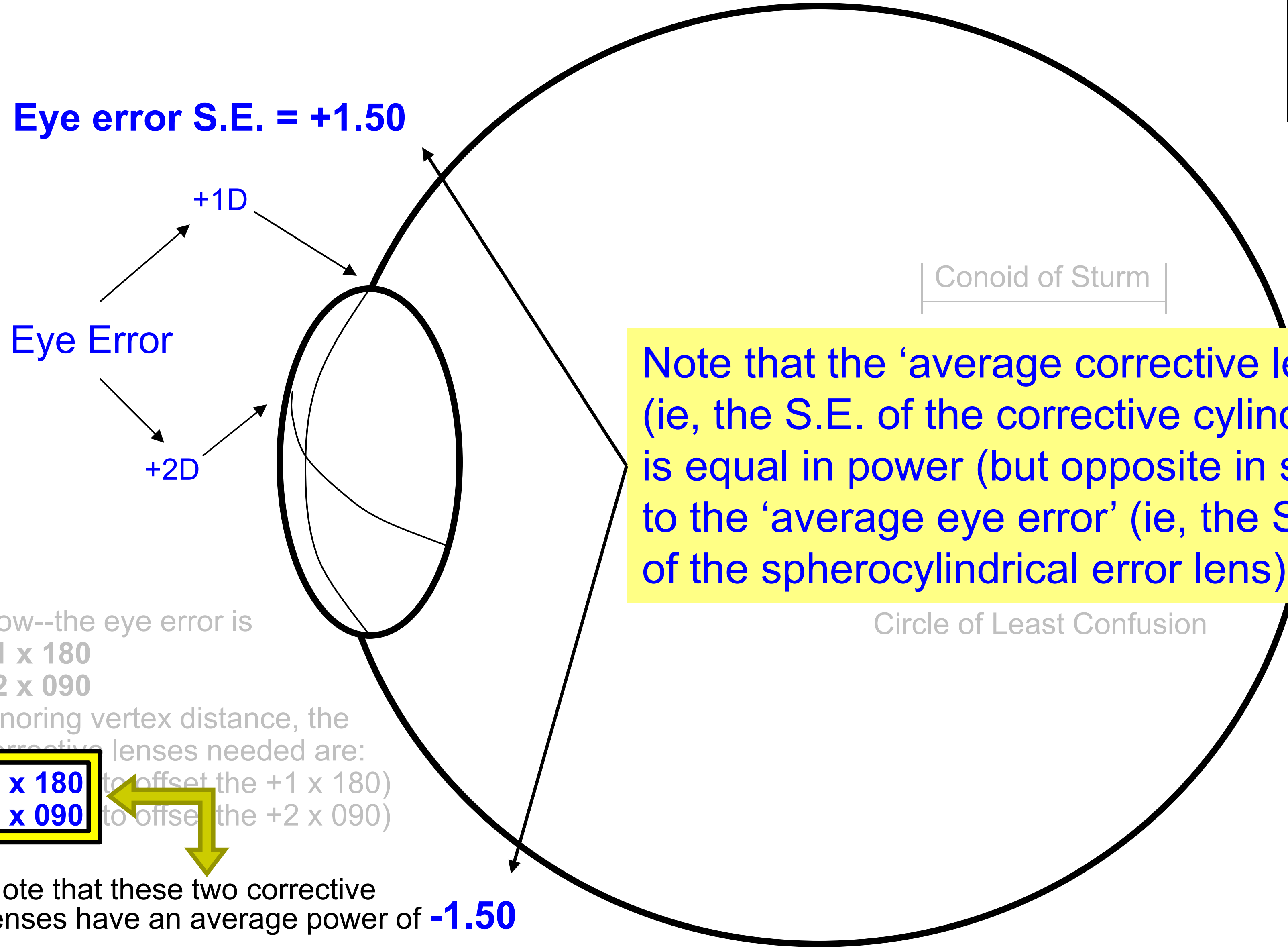

Note that the 'average corrective lens' (ie, the S.E. of the corrective cylinders) is equal in power (but opposite in sign) to the 'average eye error' (ie, the S.E. of the spherocylindrical error lens).

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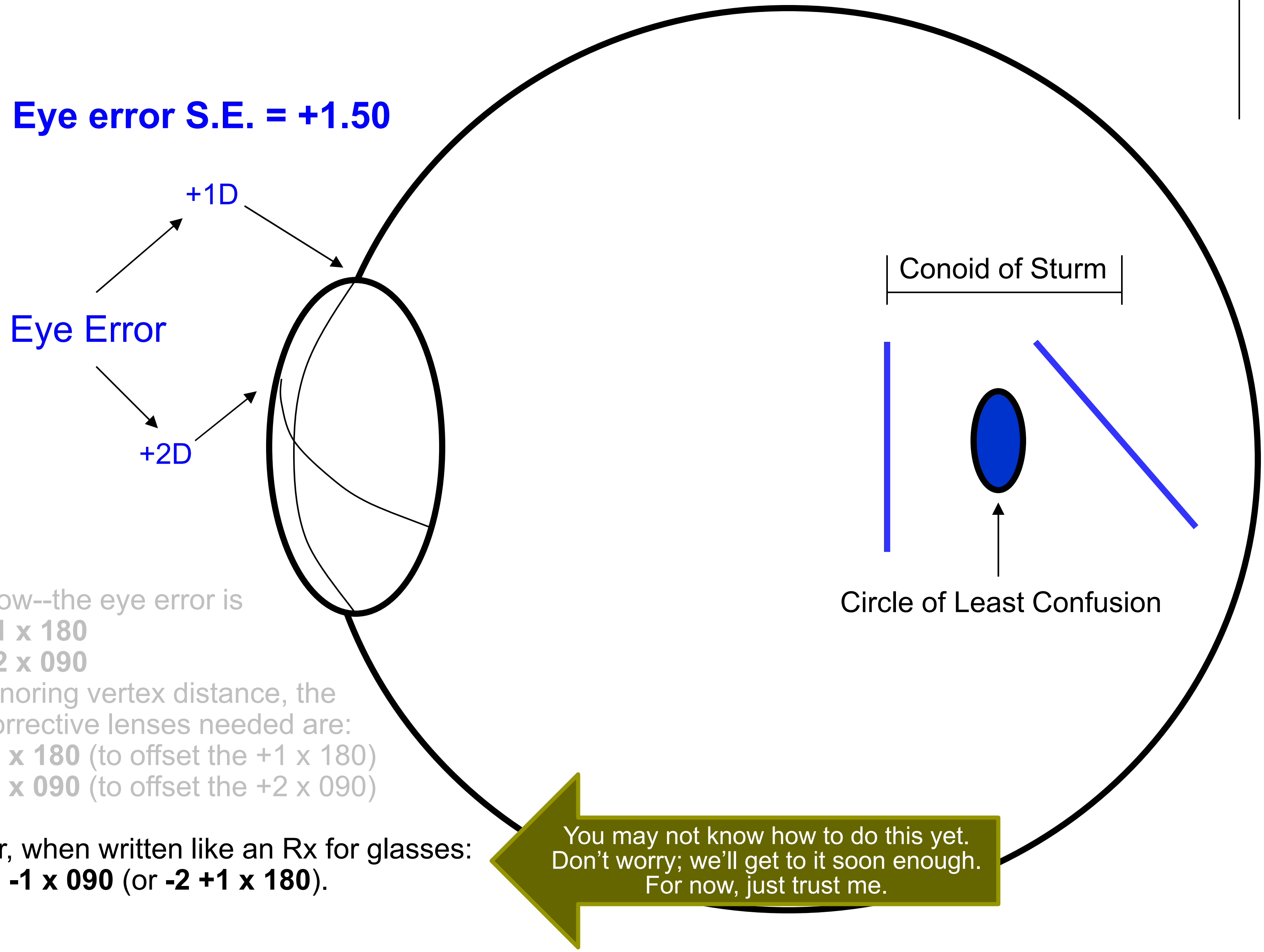

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Ignoring vertex distance, the corrective lenses needed are:
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Or, when written like an Rx for glasses:
-1 -1 x 090 (or **-2 +1 x 180**).

Astigmatic Eye Error

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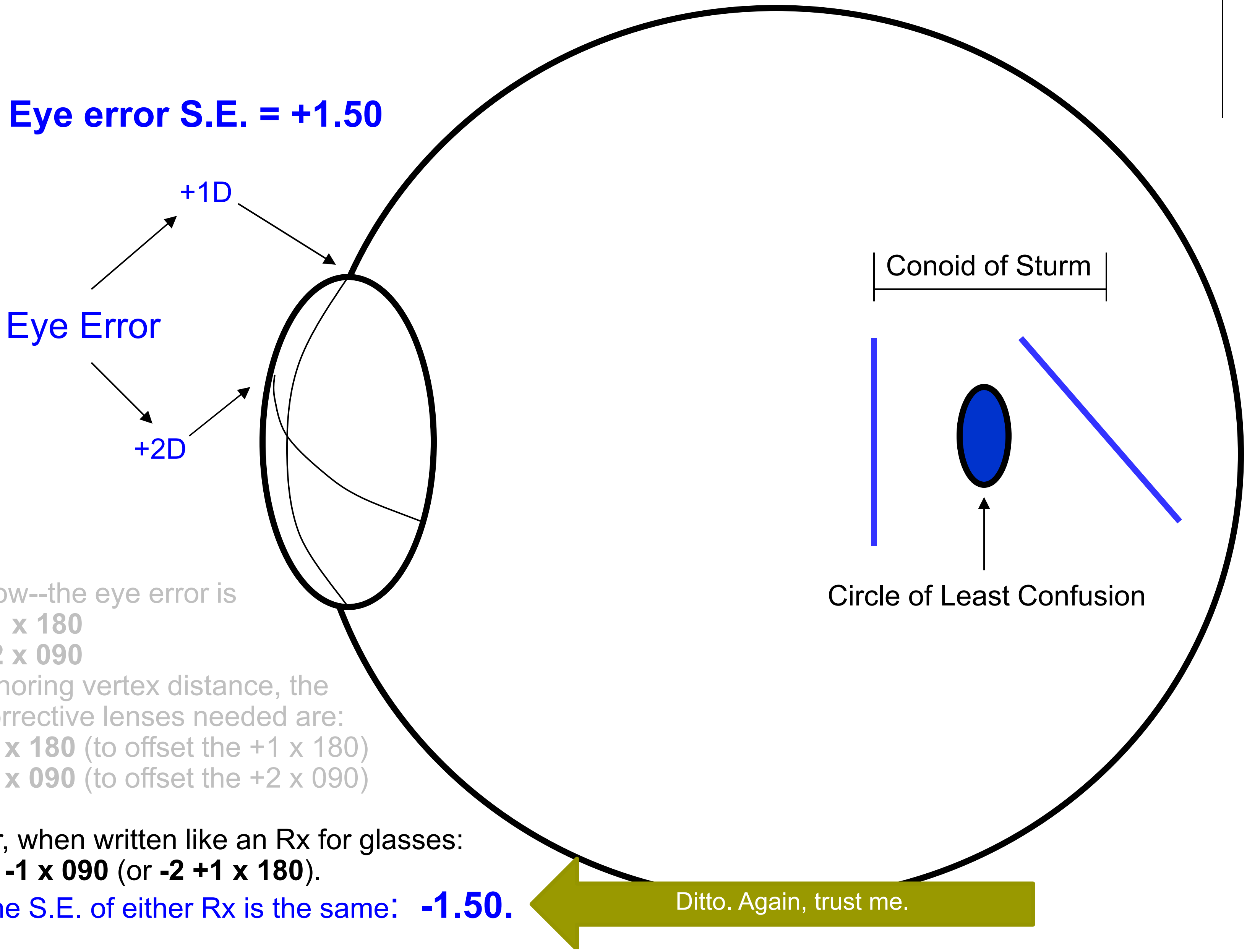

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Or, when written like an Rx for glasses:
-1 -1 x 090 (or **-2 +1 x 180**).
The S.E. of either Rx is the same: **-1.50.**

Ditto. Again, trust me.

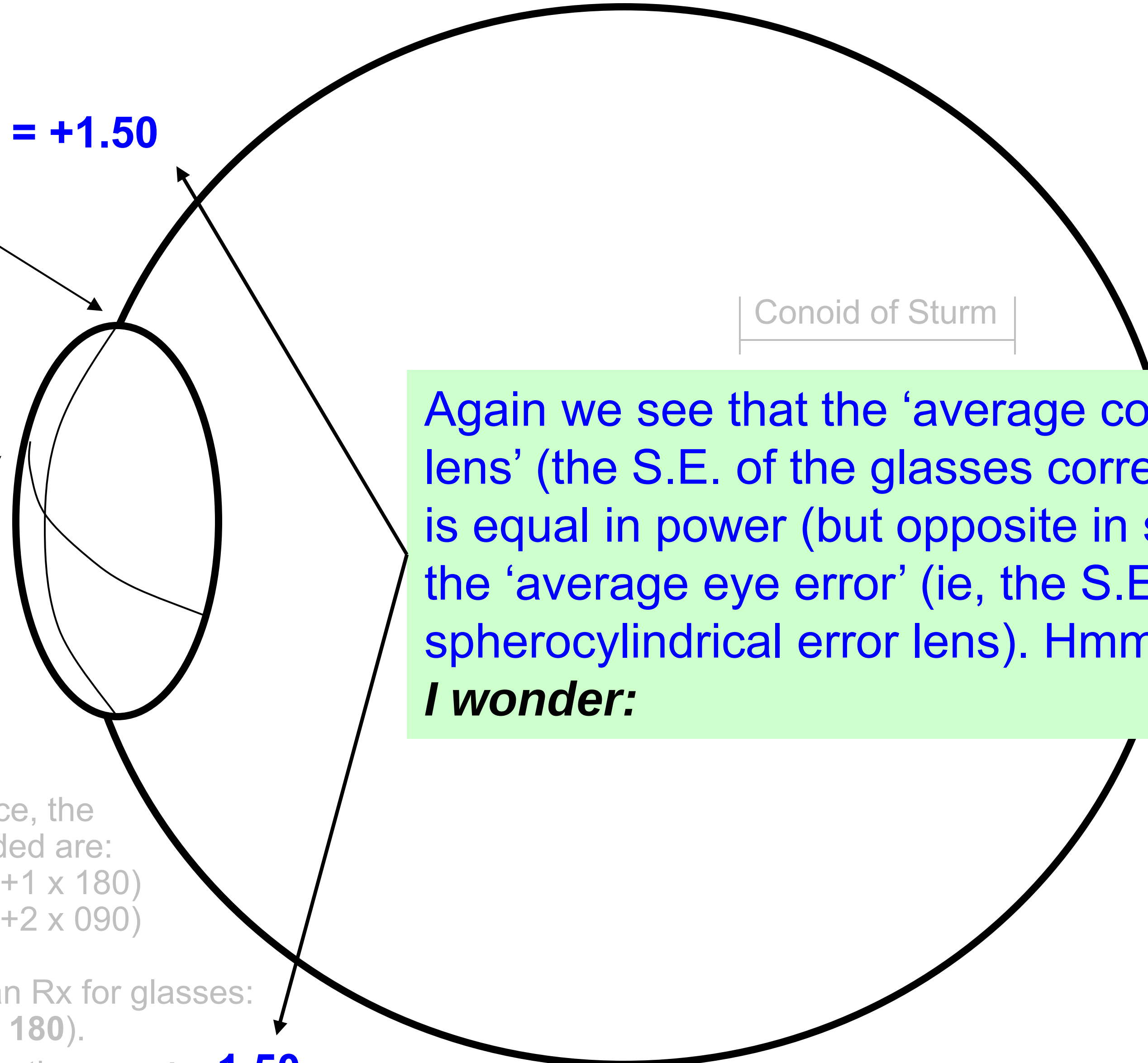
Astigmatic Eye Error

Eye error S.E. = +1.50

Eye Error

+1D

+2D



Again we see that the 'average corrective lens' (the S.E. of the glasses correction) is equal in power (but opposite in sign) to the 'average eye error' (ie, the S.E. of the spherocylindrical error lens). Hmm…
I wonder:

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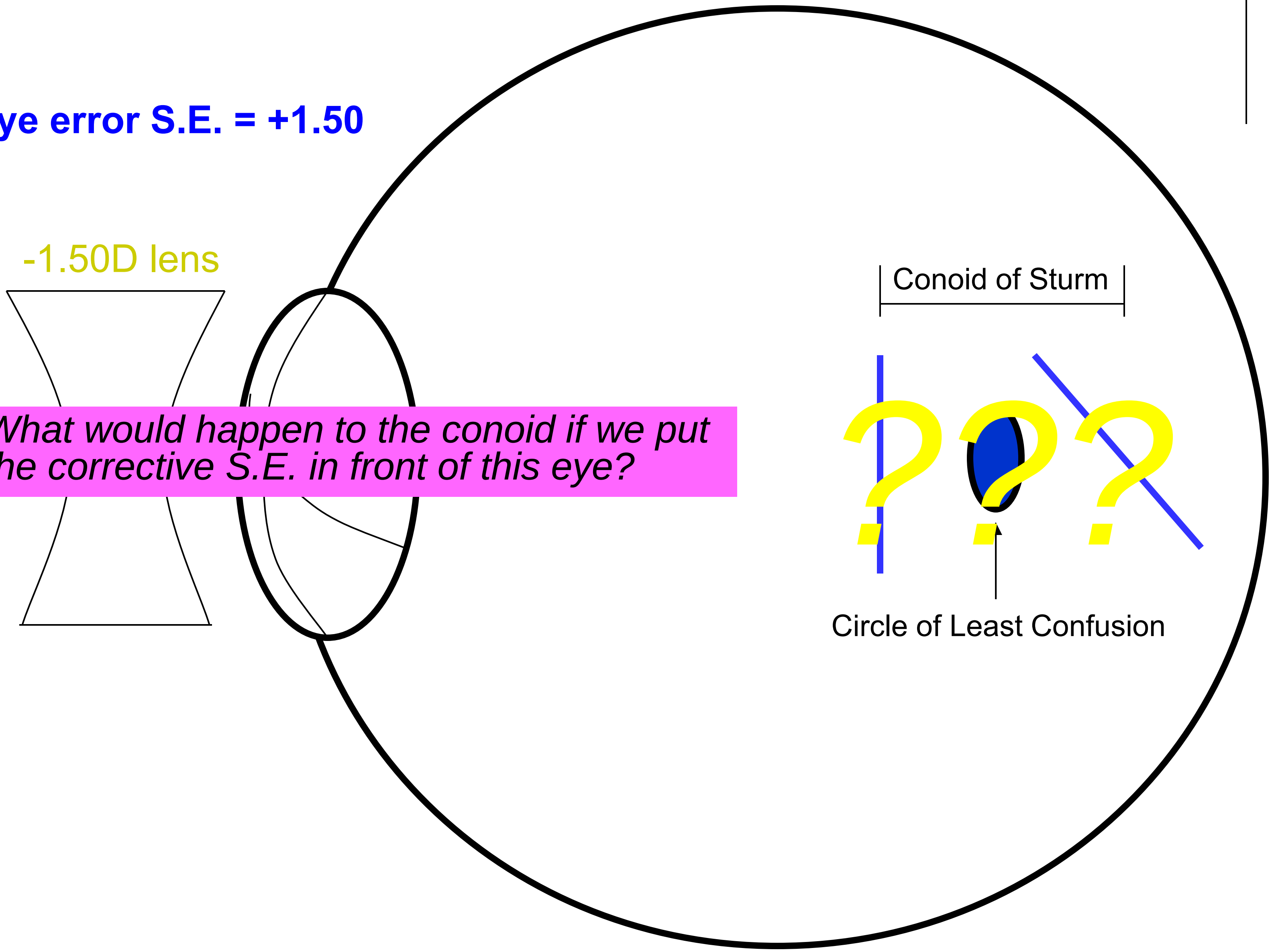

What would happen to the conoid if we put the corrective S.E. in front of this eye?

Astigmatic Eye Error

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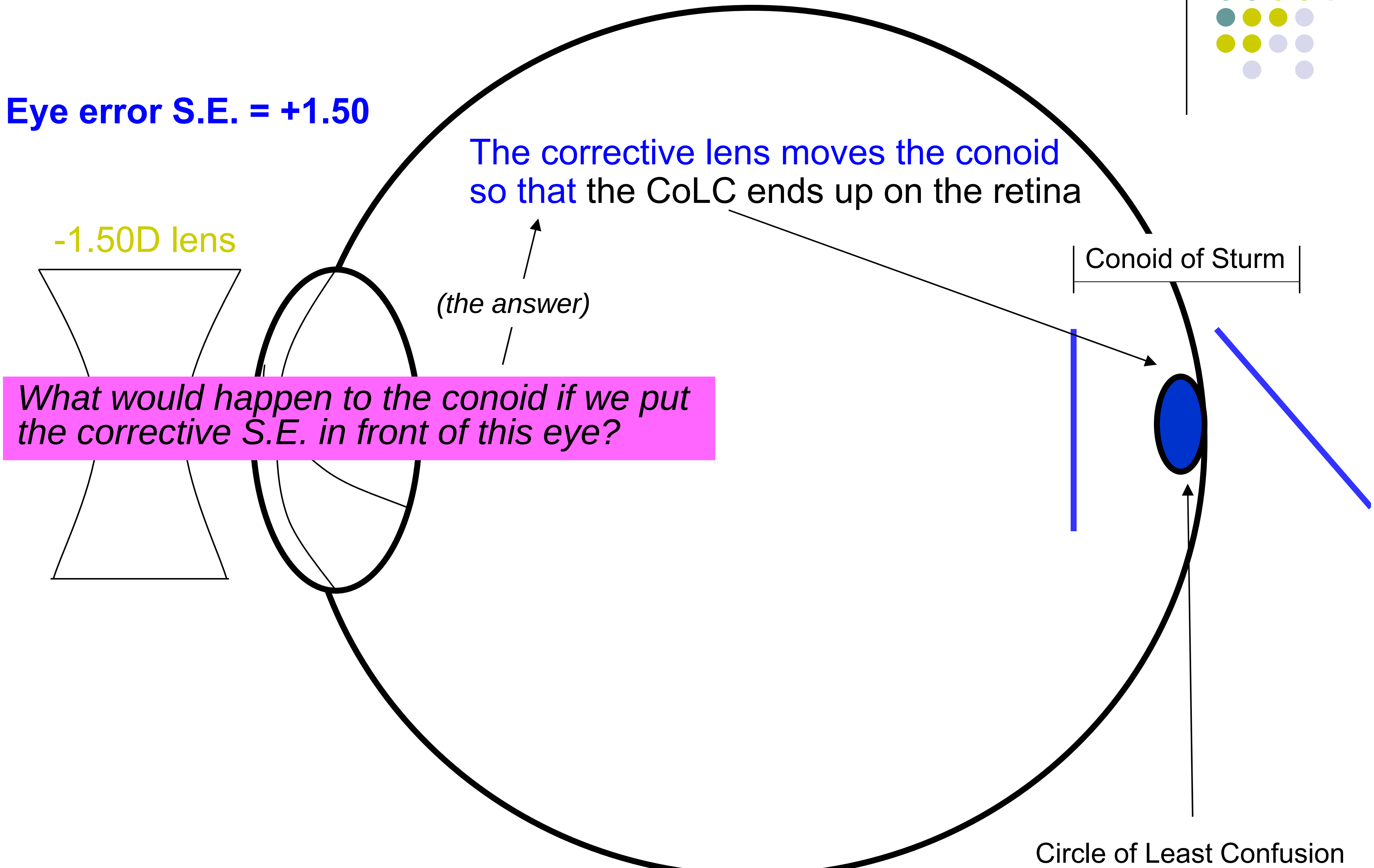

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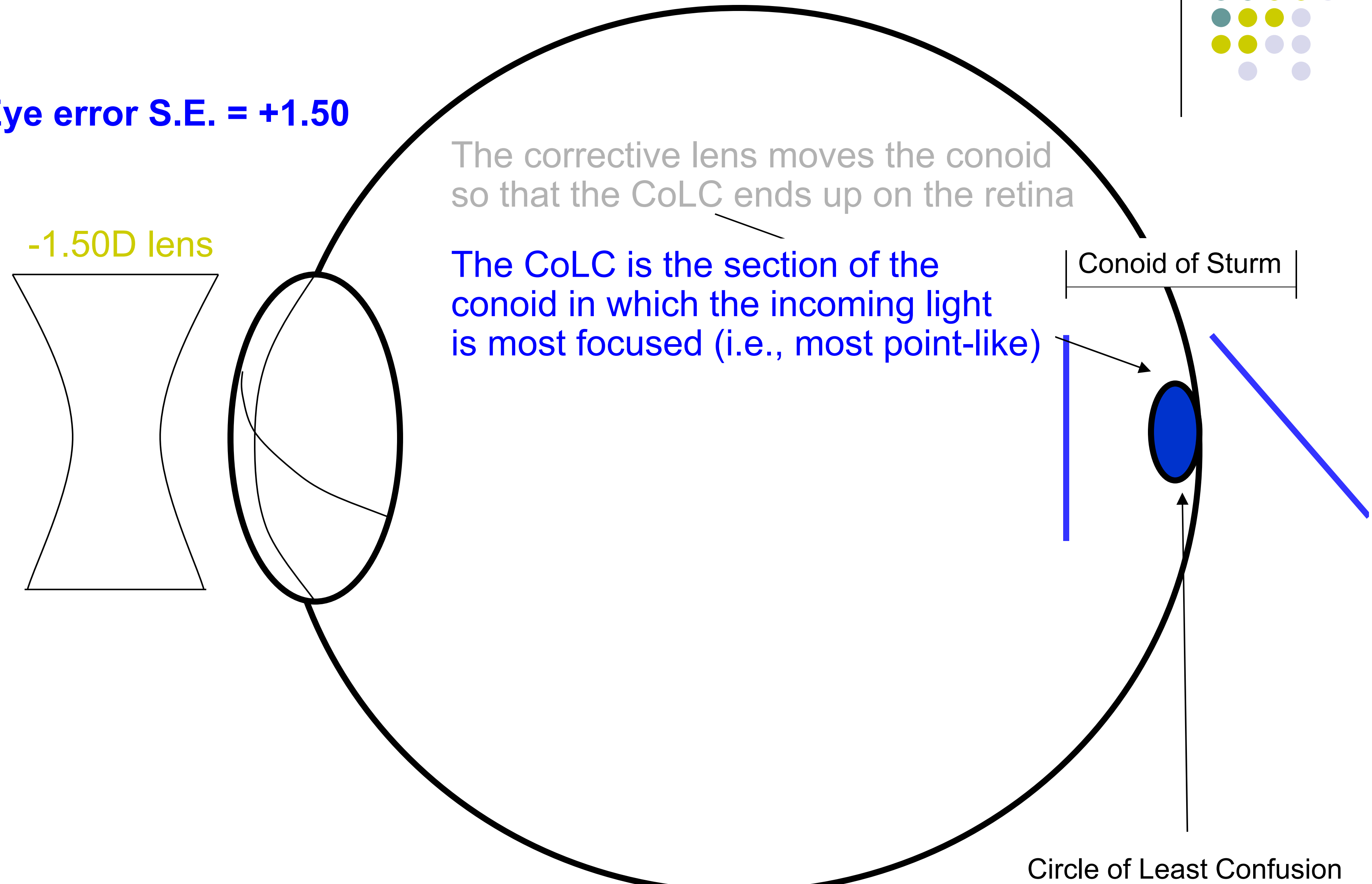

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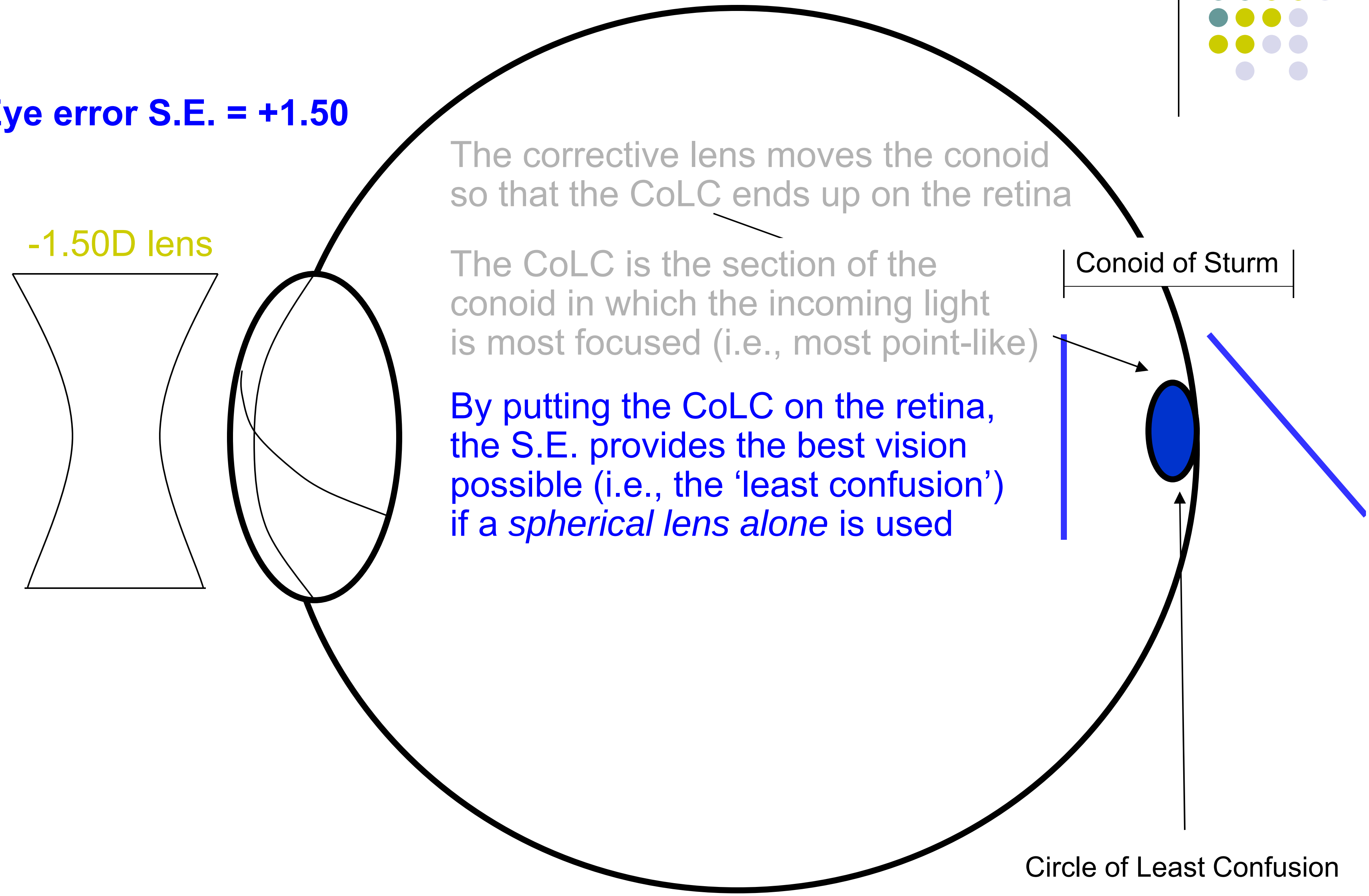

The corrective lens moves the conoid so that the CoLC ends up on the retina

The CoLC is the section of the conoid in which the incoming light is most focused (i.e., most point-like)

By putting the CoLC on the retina, the S.E. provides the best vision possible (i.e., the ‘least confusion’) if a *spherical lens alone* is used

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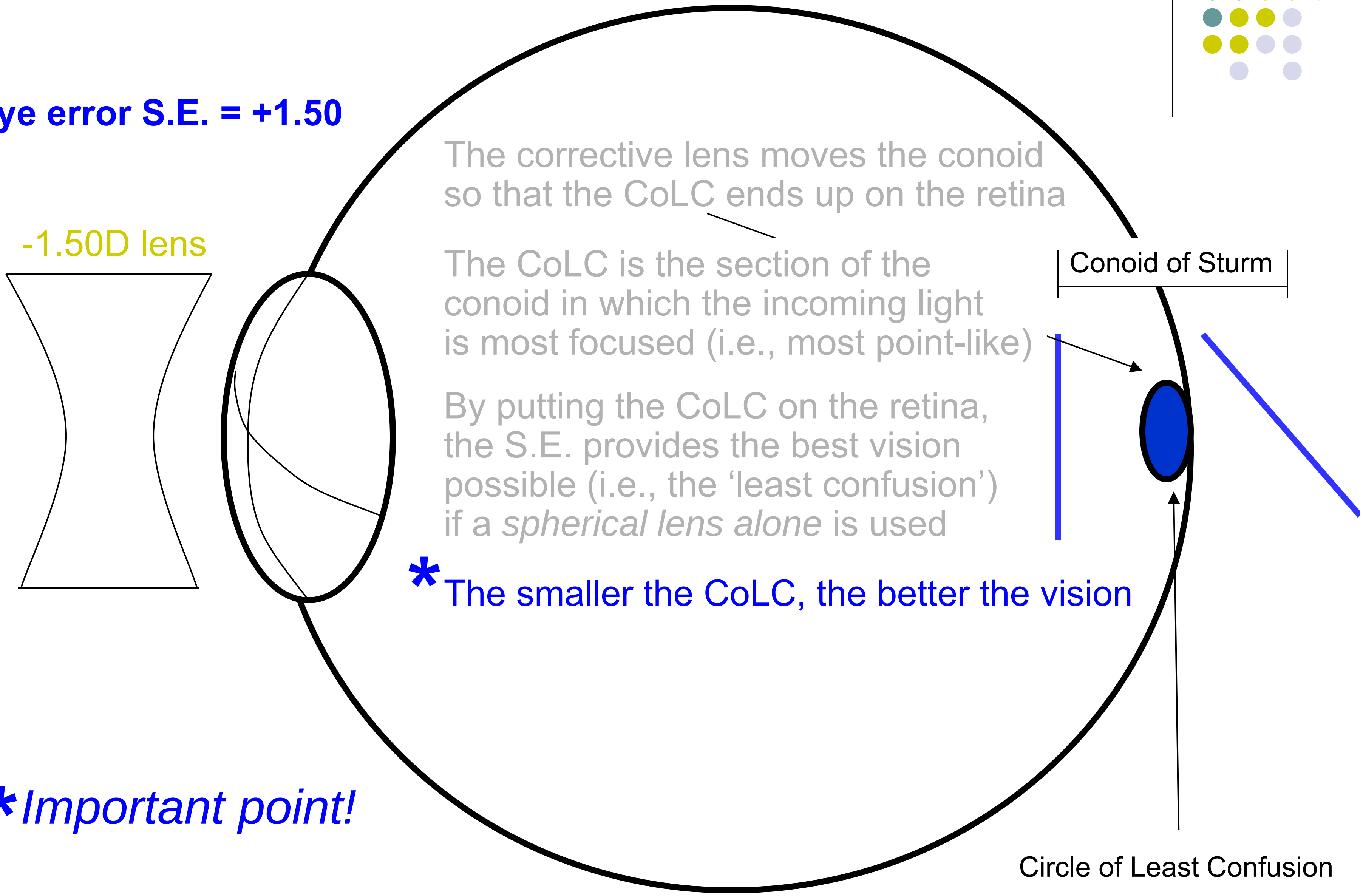

The corrective lens moves the conoid so that the CoLC ends up on the retina

The CoLC is the section of the conoid in which the incoming light is most focused (i.e., most point-like)

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*The smaller the CoLC, the better the vision

**Important point!*

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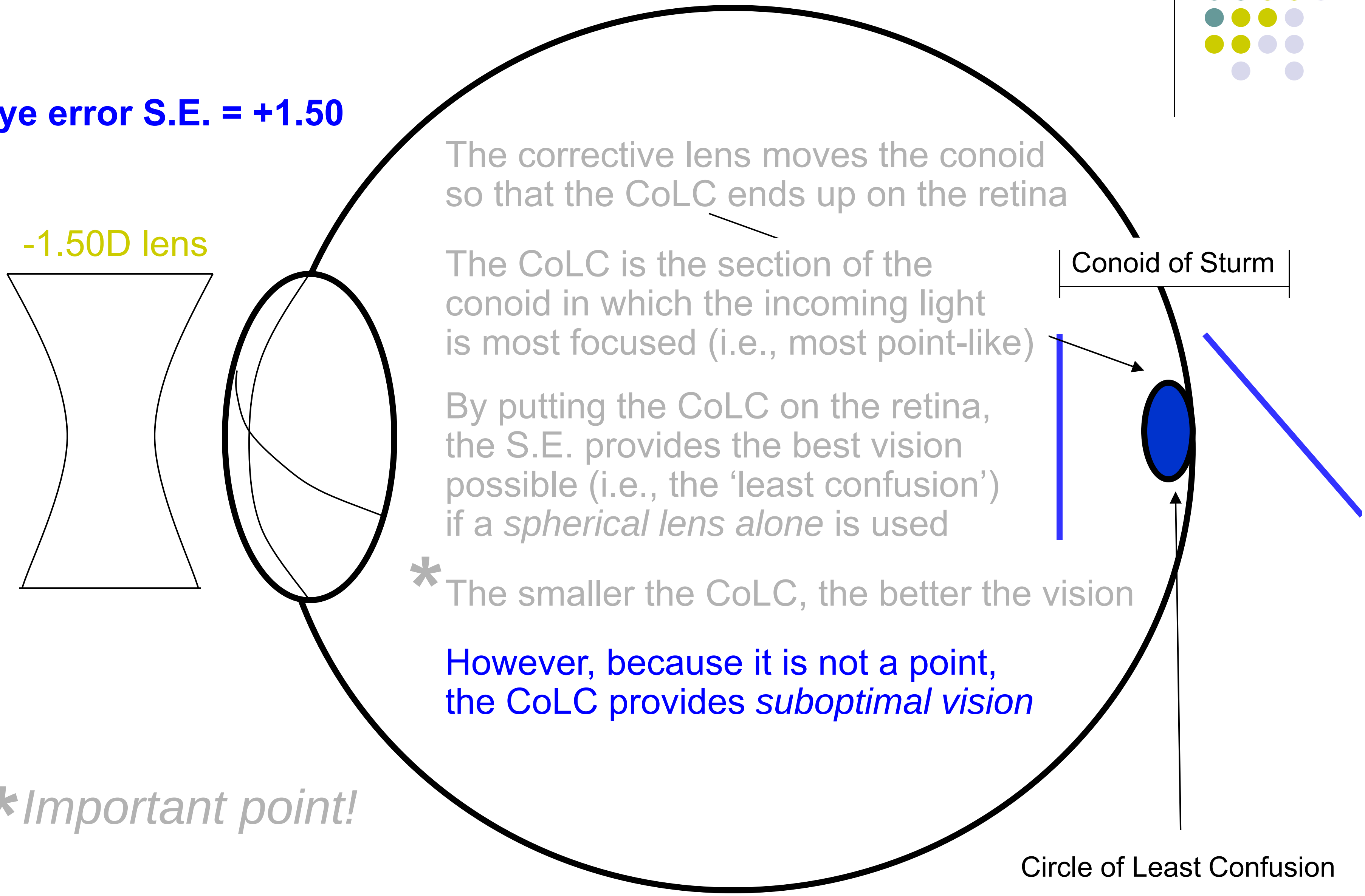

The corrective lens moves the conoid so that the CoLC ends up on the retina

The CoLC is the section of the conoid in which the incoming light is most focused (i.e., most point-like)

By putting the CoLC on the retina, the S.E. provides the best vision possible (i.e., the 'least confusion') if a *spherical lens alone* is used

* The smaller the CoLC, the better the vision

However, because it is not a point, the CoLC provides *suboptimal vision*

**Important point!*

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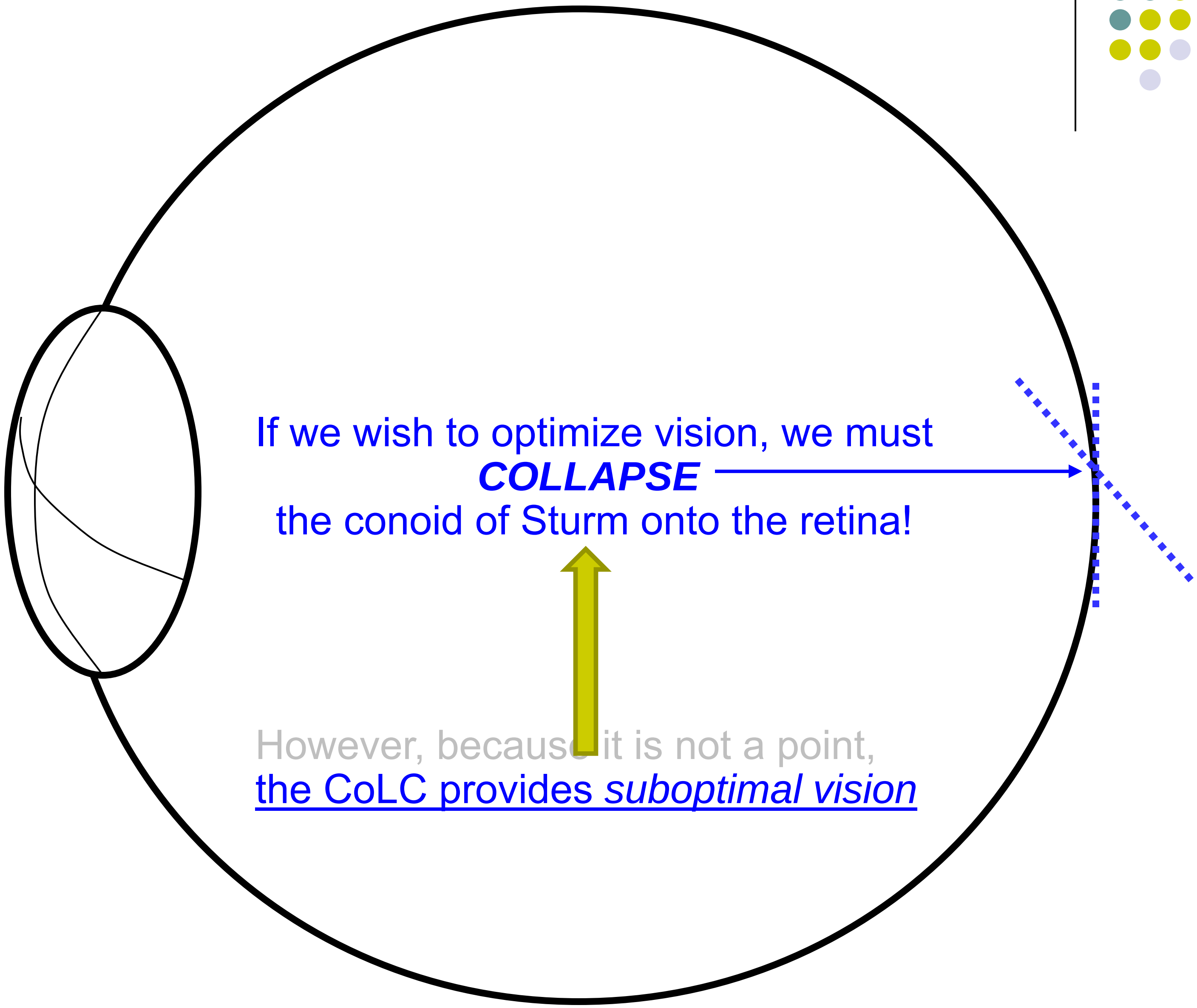

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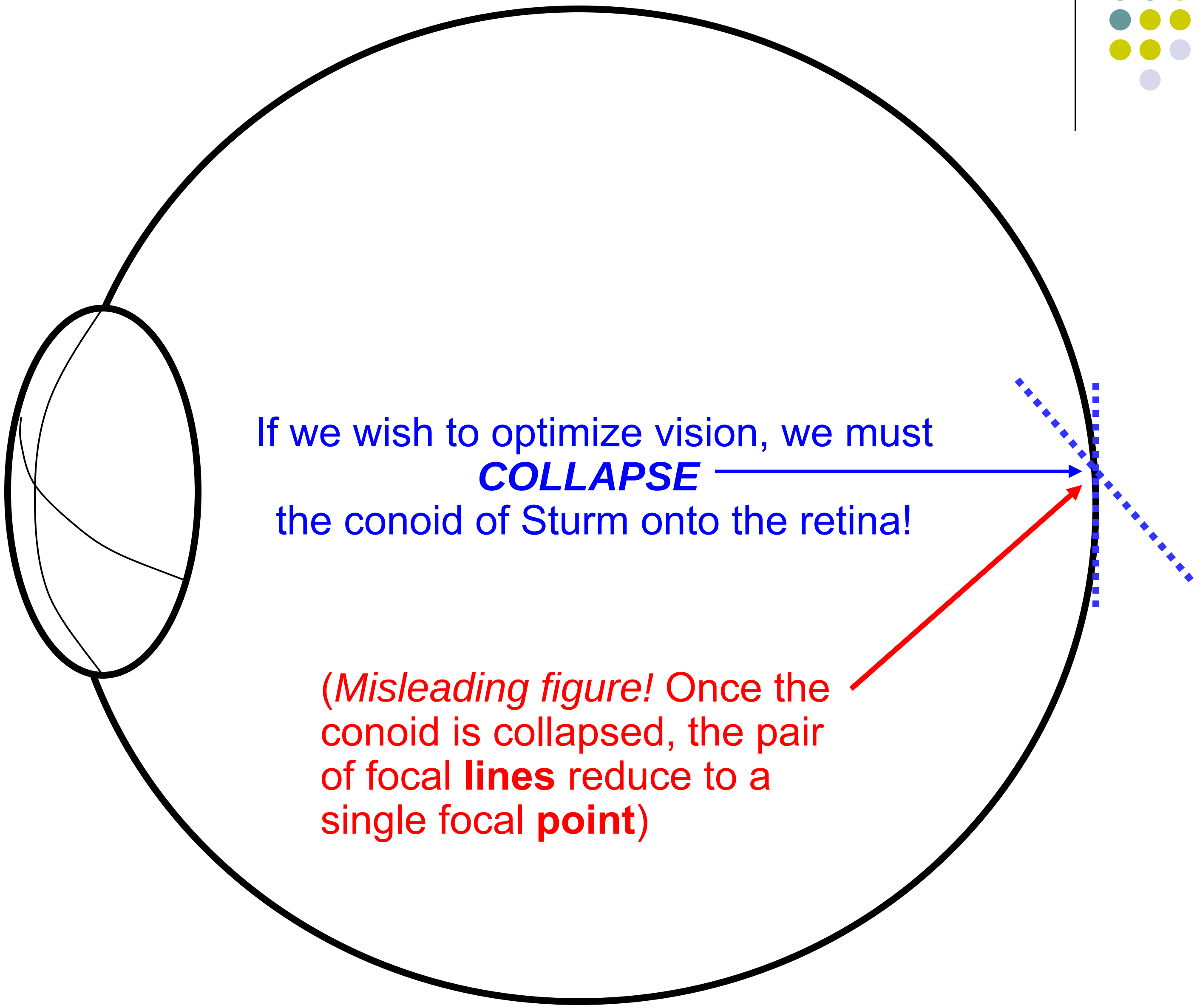

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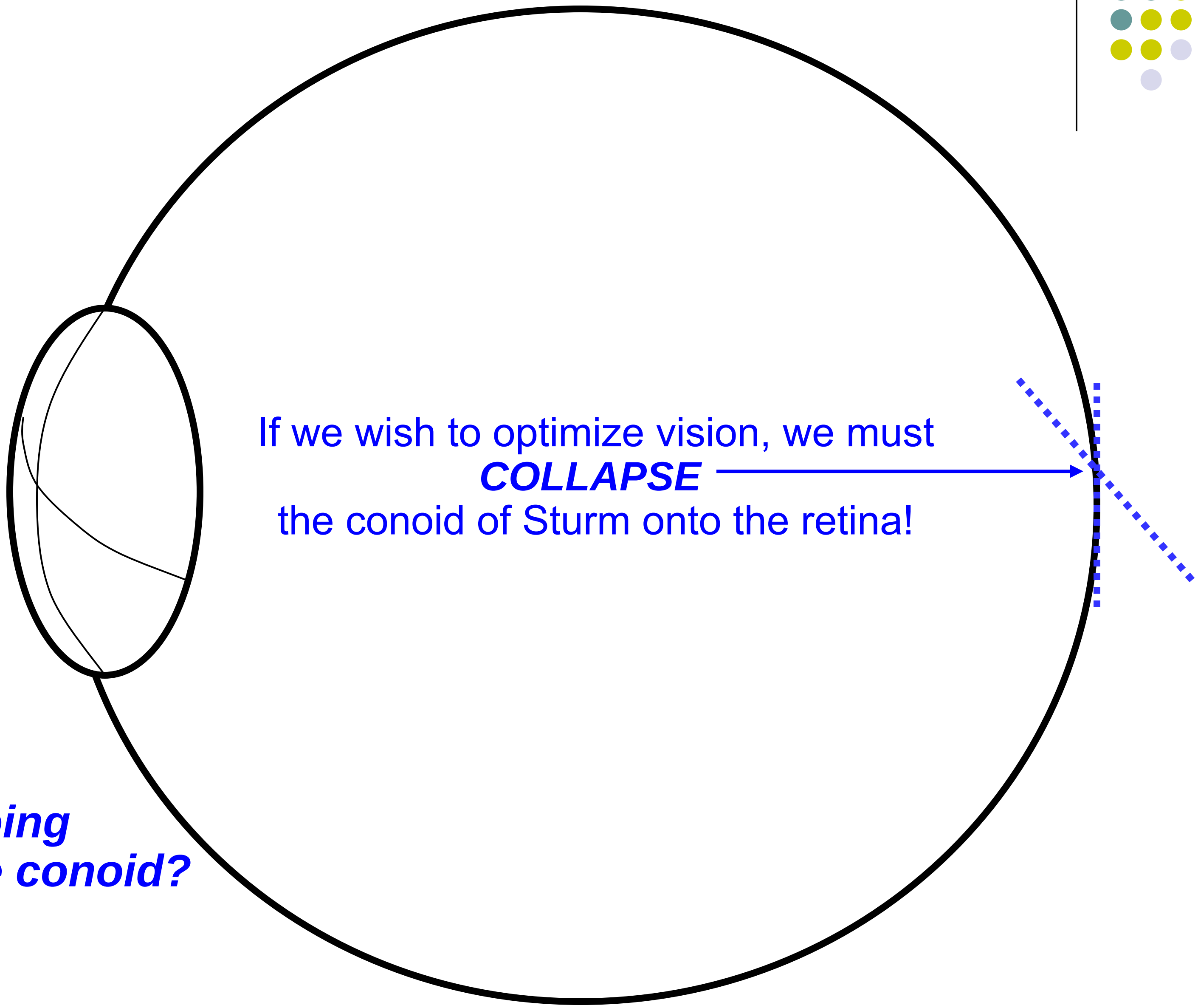

How are we going
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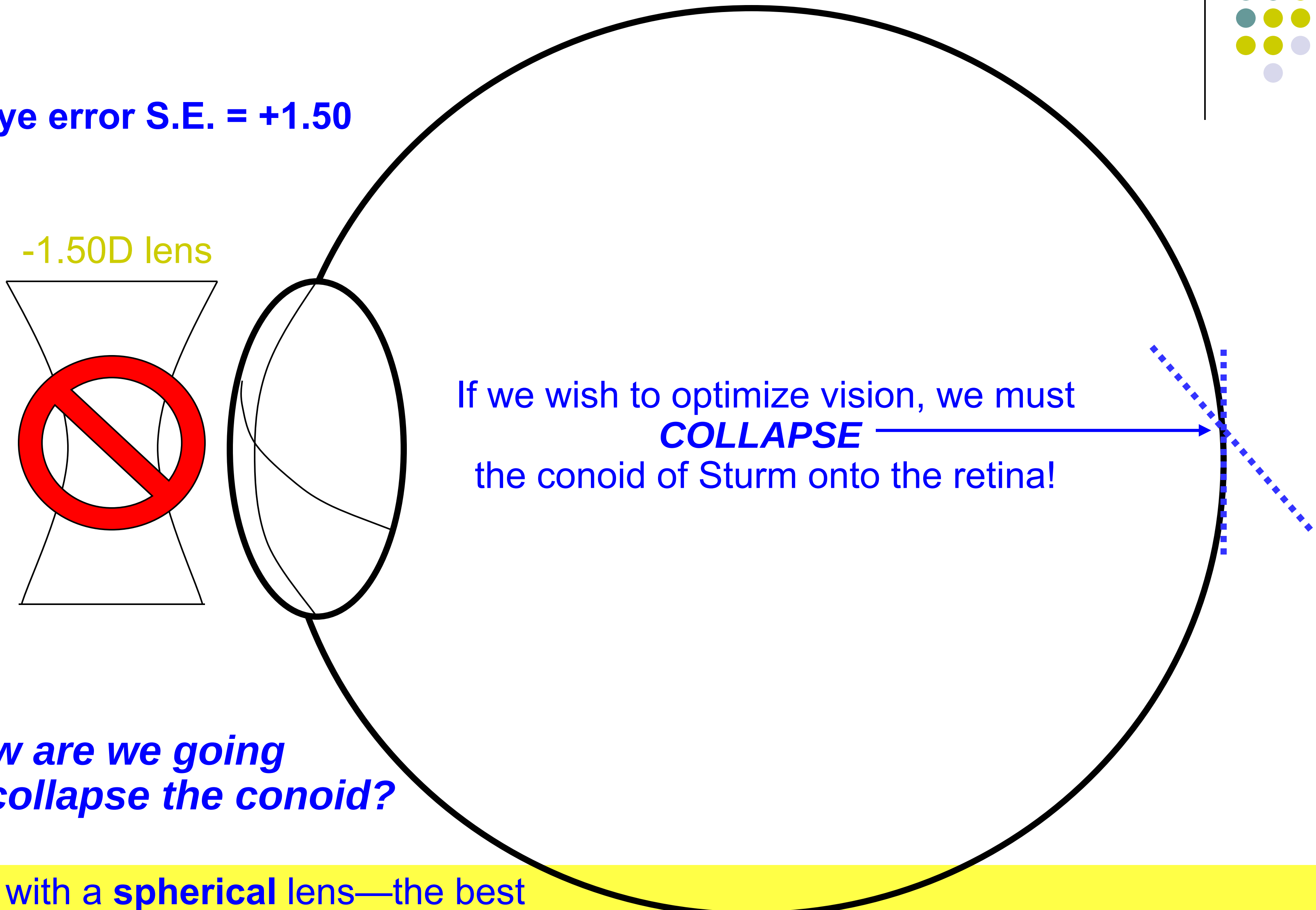
Astigmatic Eye Error

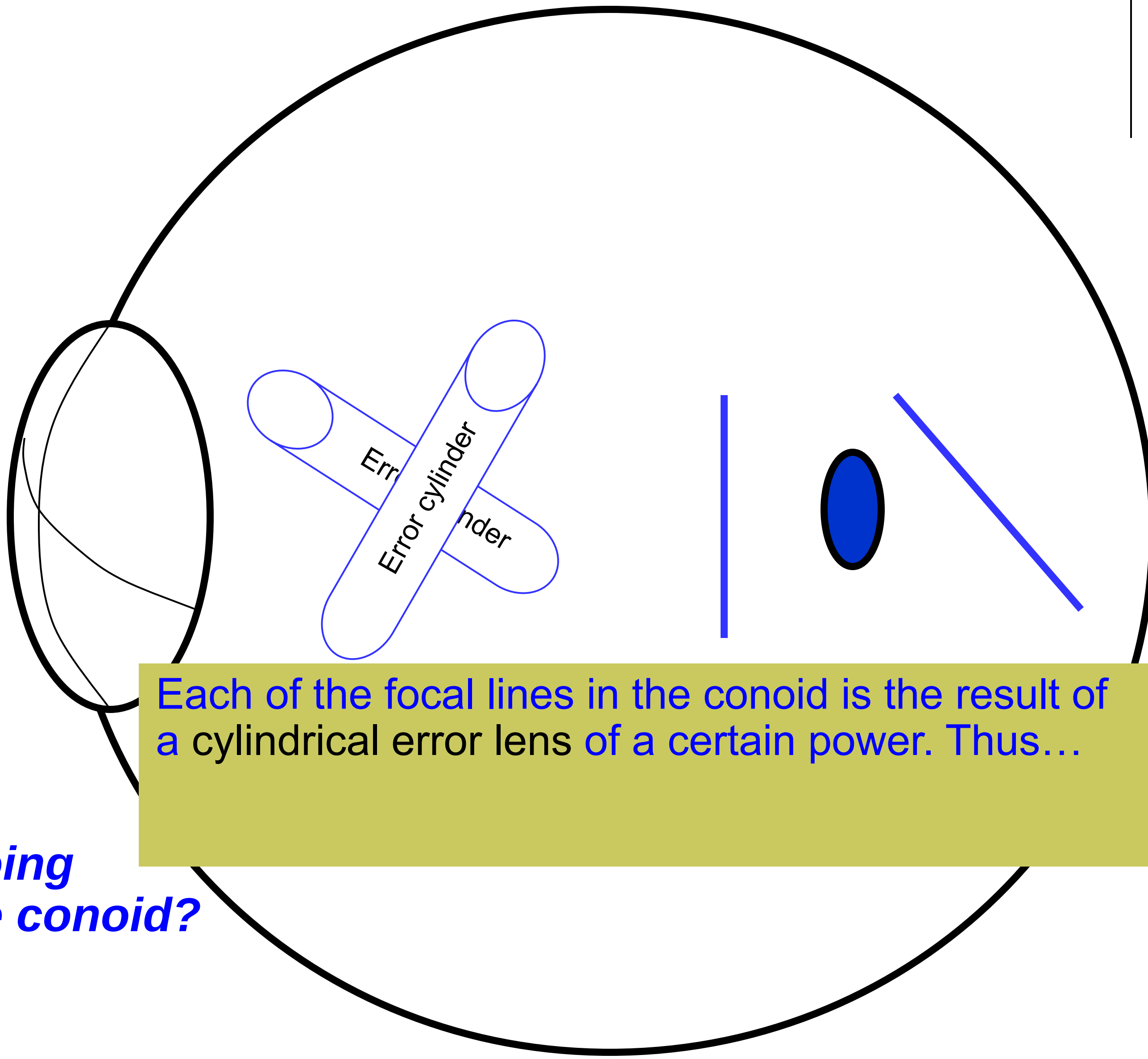
Eye error S.E. = +1.50



How are we going to collapse the conoid?

Not with a **spherical** lens—the best
it could do would be to put the CoLC on the retina, with suboptimal resulting vision

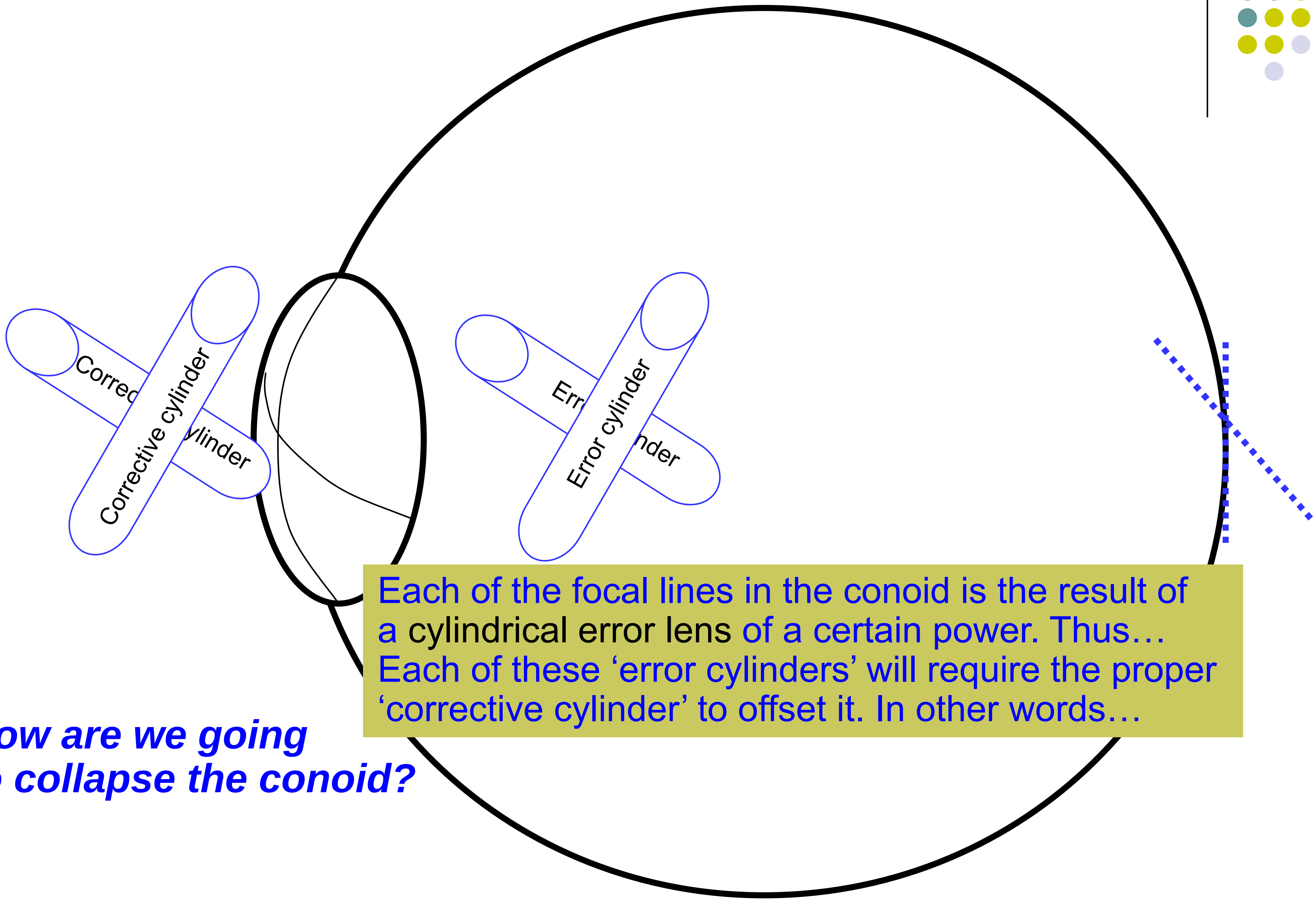
Astigmatic Eye Error



Each of the focal lines in the conoid is the result of a cylindrical error lens of a certain power. Thus…

How are we going to collapse the conoid?

Astigmatic Eye Error

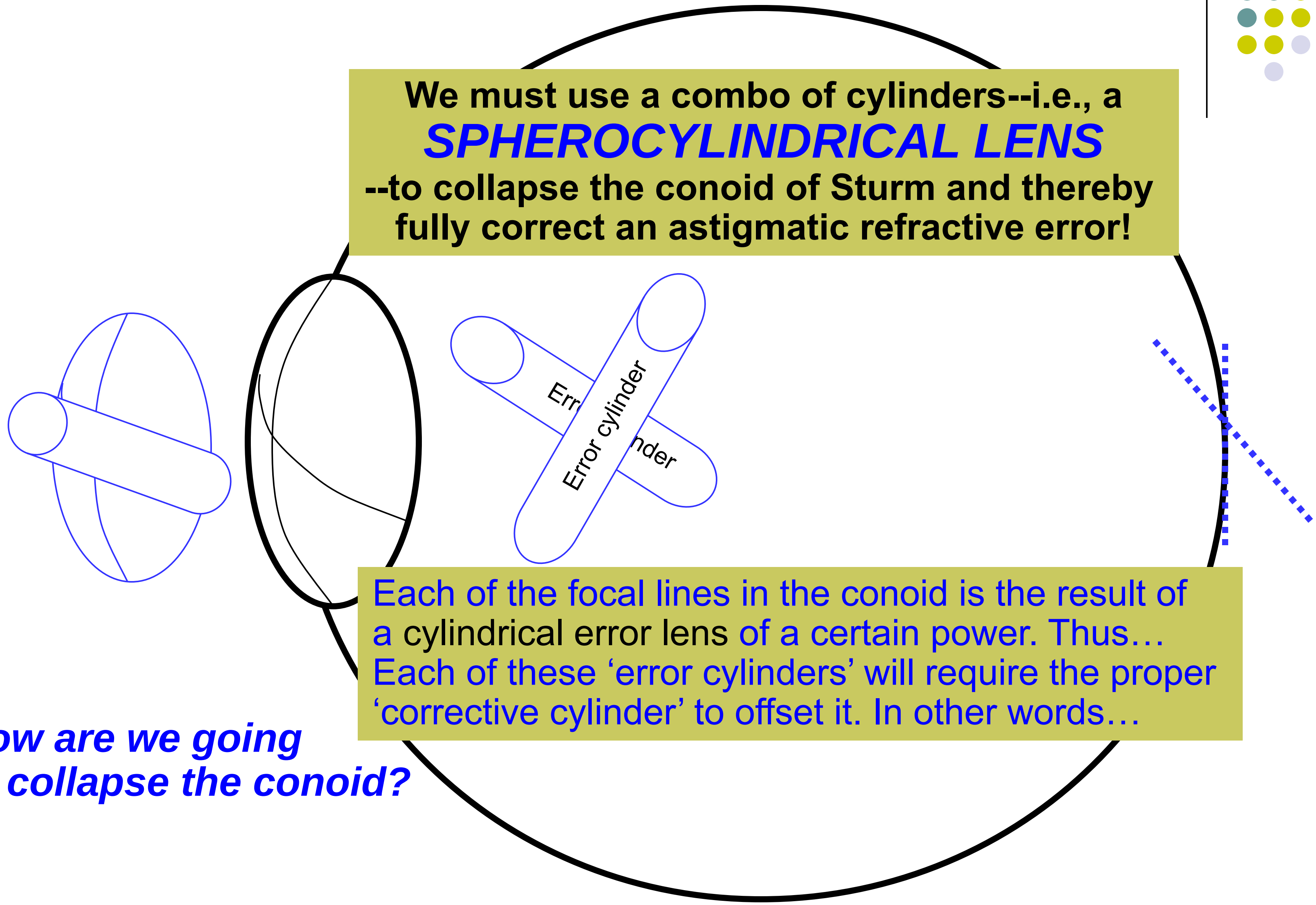


Each of the focal lines in the conoid is the result of a cylindrical error lens of a certain power. Thus… Each of these ‘error cylinders’ will require the proper ‘corrective cylinder’ to offset it. In other words…

How are we going to collapse the conoid?

Astigmatic Eye Error

We must use a combo of cylinders--i.e., a
SPHEROCYLINDRICAL LENS
--to collapse the conoid of Sturm and thereby fully correct an astigmatic refractive error!



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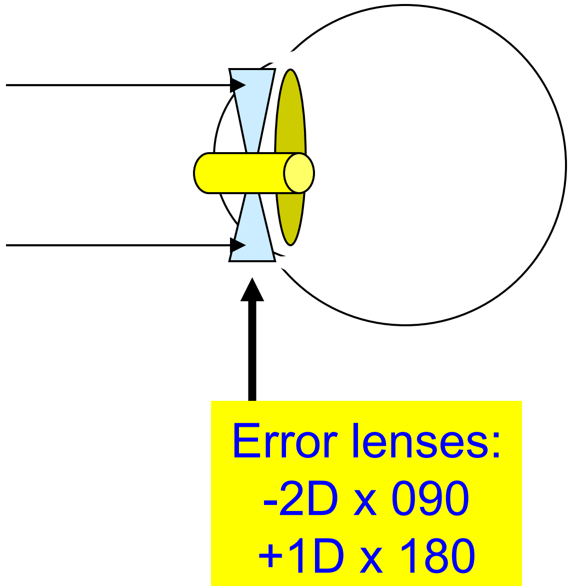
Astigmatic Eye Error

For example…



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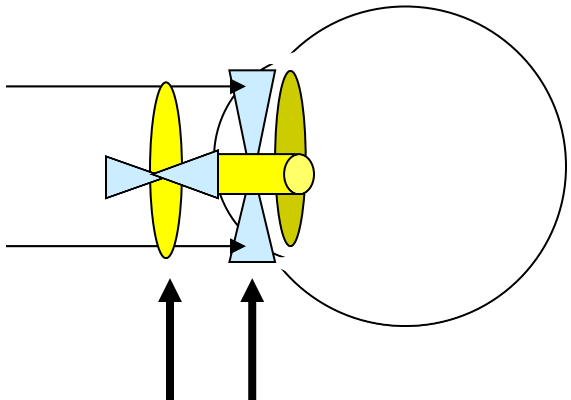


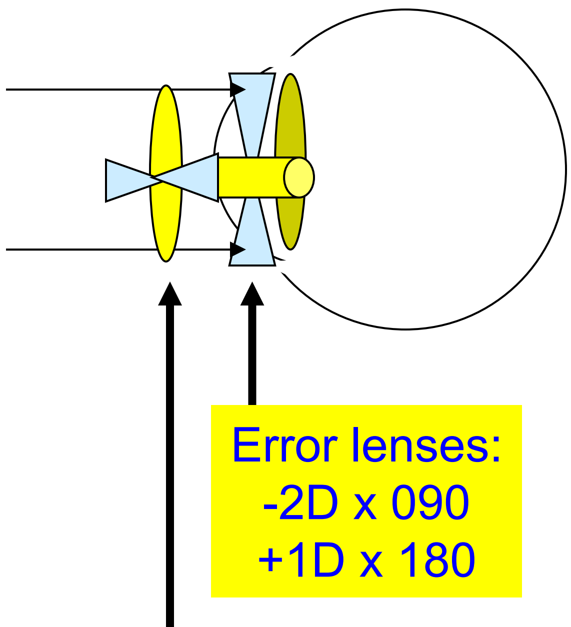
Error lenses:
-2D x 090
+1D x 180

Corrective Lenses:
+2D x 090
-1D x 180

(Note: These corrective lenses do not account for vertex distance)

Astigmatic Eye Error

For example…



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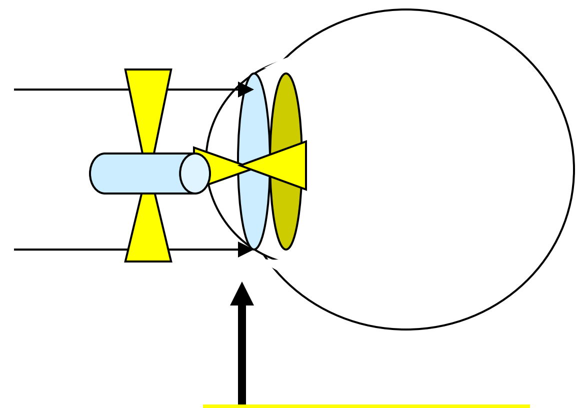
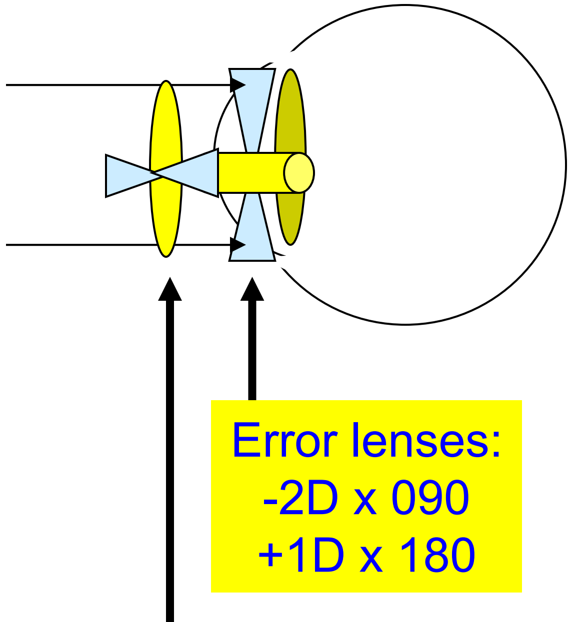


Error Lenses:
+4 x 090
-1.5 x 180

Astigmatic Eye Error

For example…



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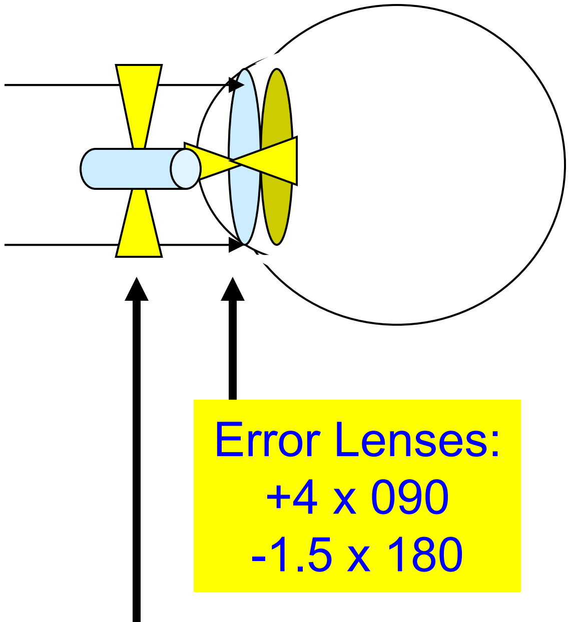

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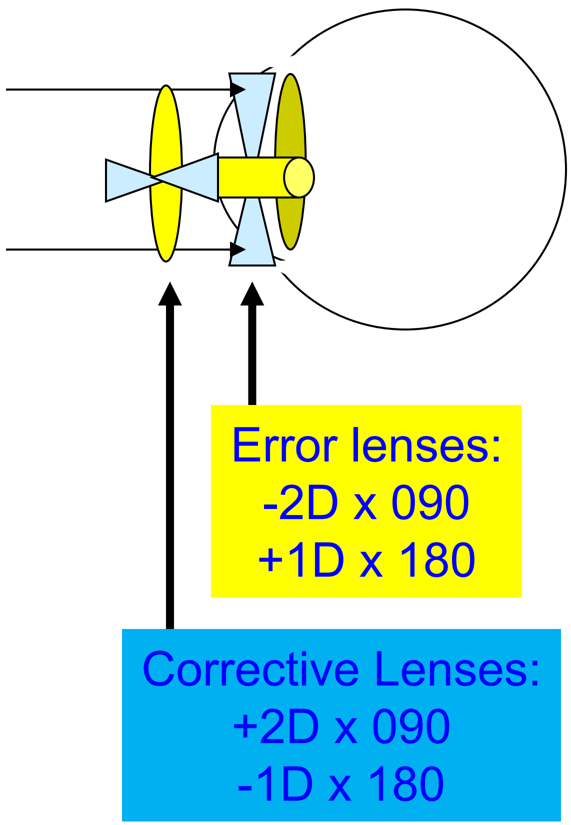
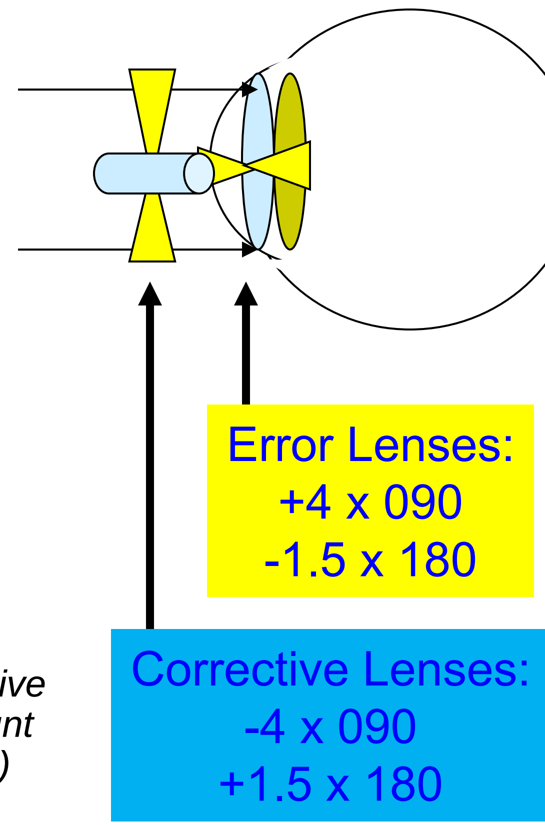
Astigmatic Eye Error

For example…



(Note: These corrective lenses do not account for vertex distance)



We will take up the topic of how one refracts an astigmatic eye in the next chapter