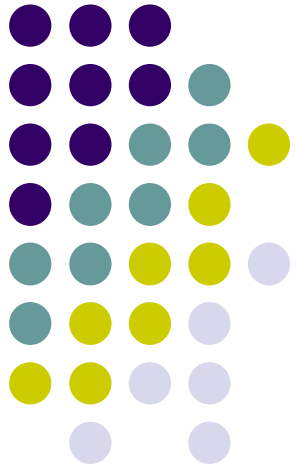
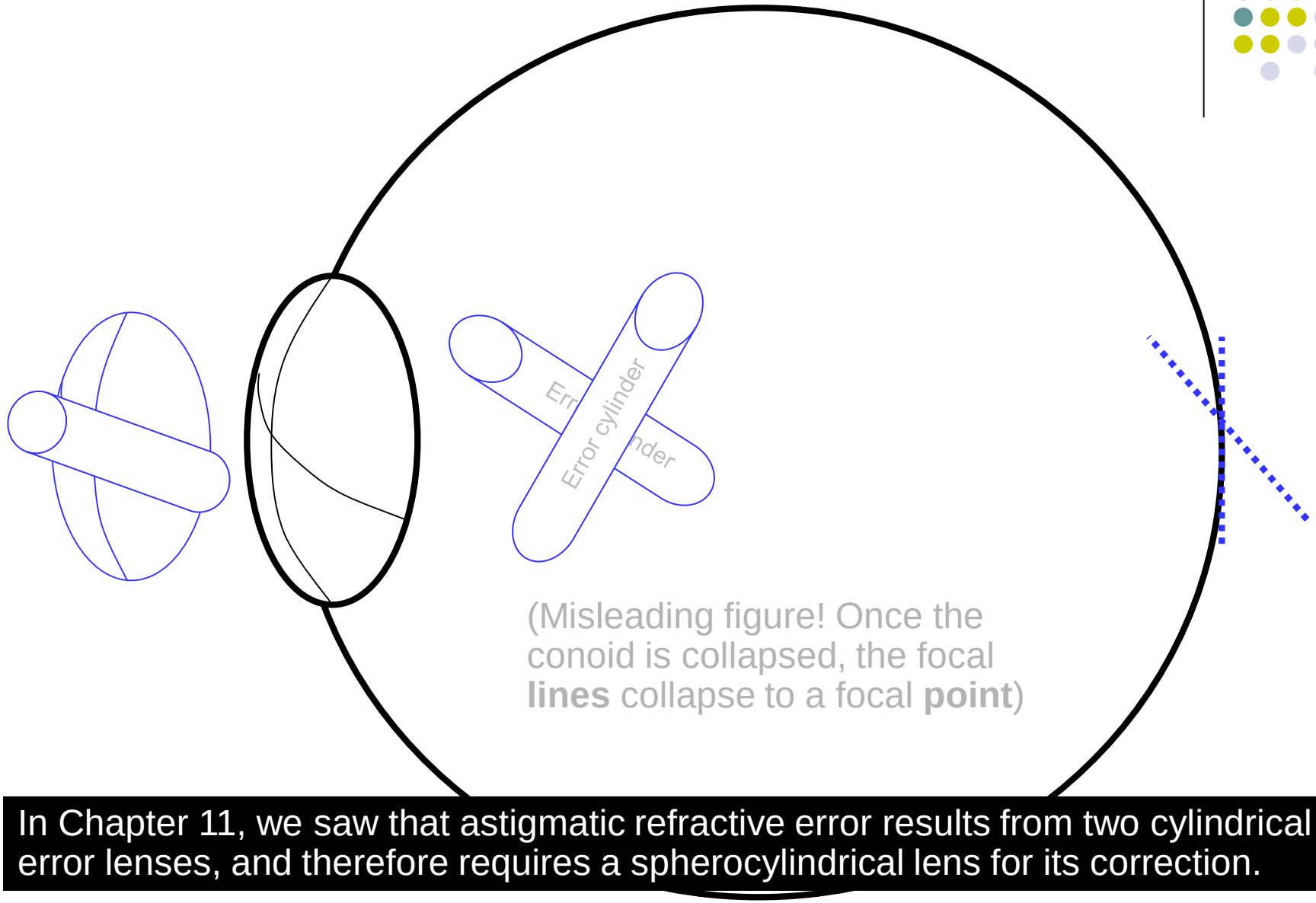
Astigmatic Refractive Correction: *Jackson Cross*

Basic Optics, Chapter 13



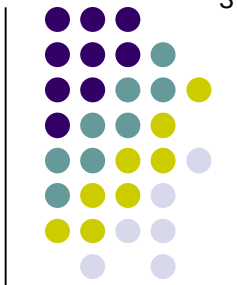
Astigmatic Eye Error



(Misleading figure! Once the conoid is collapsed, the focal **lines** collapse to a focal **point**)

In Chapter 11, we saw that astigmatic refractive error results from two cylindrical error lenses, and therefore requires a spherocylindrical lens for its correction.

Astigmatic Correction



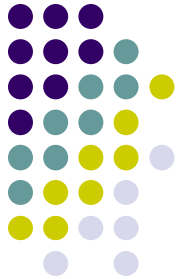
- There are two commonly-used clinical techniques for refracting the astigmatic patient:
  - *Retinoscopic*
  - *Jackson Cross*

Astigmatic Correction

- In Chapter 12 we saw how retinoscopic astigmatic refraction works. Now we will turn our attention to the Jackson Cross approach.

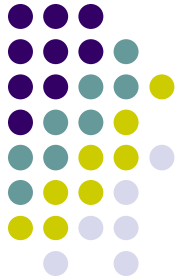
	Retinoscopic	***Jackson Cross***
Step 1	Use sphere to place **one focal line** on the retina	***?***
Step 2	Use cylinder to place the **other focal line** on the retina	***?***
Result	**Conoid collapsed to a point on the retina**	**Conoid collapsed to a point on the retina**

Astigmatic Correction: *Jackson Cross*



- In the *Jackson Cross* approach, the focal lines are attacked *simultaneously*
  - ***First***, sphere is used to place the Circle of Least Confusion on the retina

Astigmatic Correction: *Jackson Cross*

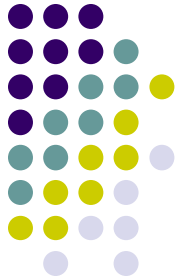


- In the *Jackson Cross* approach, the focal lines are attacked *simultaneously*
  - ***First***, sphere is used to place the Circle of Least Confusion on the retina
  - ***Then***, the Jackson cross cylinder is used to…

    1) identify the axis of astigmatism, and

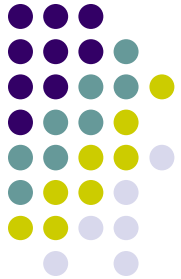
    2) determine the power of astigmatism
  - And this information is used to collapse the conoid onto the retina!

Astigmatic Correction: *Jackson Cross*



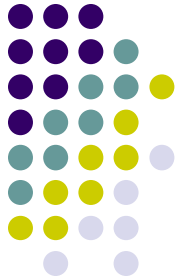
- But first: *What is a Jackson cross lens?*

Astigmatic Correction: *Jackson Cross*



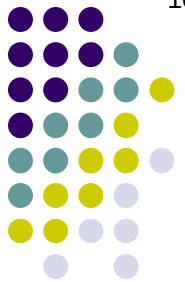
- But first: *What is a Jackson cross lens?*
  - It is a spherocylindrical lens containing plus ***and*** minus cylinders of equal-but-opposite powers oriented 90^{o} apart

Astigmatic Correction: *Jackson Cross*



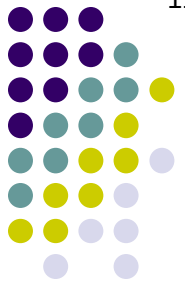
- But first: *What is a Jackson cross lens?*
  - It is a spherocylindrical lens containing plus ***and*** minus cylinders of equal-but-opposite powers oriented 90^{o} apart
    - Key property: A Jackson cross lens has no net spherical power (i.e., its spherical equivalent power is zero)

Astigmatic Correction: *Jackson Cross*



- But first: *What is a Jackson cross lens?*
  - It is a spherocylindrical lens containing plus ***and*** minus cylinders of equal-but-opposite powers oriented 90^{o} apart
    - Key property: A Jackson cross lens has no net spherical power (i.e., its spherical equivalent power is zero)
      - Because it has no sphere power, *a Jackson cross lens will not move the Circle of Least Confusion* when placed before an astigmatic eye

Astigmatic Correction: *Jackson Cross*



- Jackson cross lens: Spherocylindrical-notation examples
  - +1.0 -2.0 x 090
  - -2.0 +4.0 x 180
  - +0.25 – 0.50 x 135

Note that for each of these, S.E. = 0

Astigmatic Correction: *Jackson Cross*

- Jackson cross lens: Spherocylindrical-notation examples
  - +1.0 -2.0 x 090
  - -2.0 +4.0 x 180
  - +0.25 – 0.50 x 135

Note that for each of these, S.E. = 0

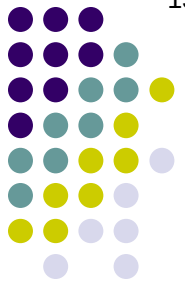
+1 x 180
-1 x 090

-2 x 090
+2 x 180

+.25 x 045
-.25 x 135

Here are the same Jackson cross lenses written in **power-cross notation**.

Astigmatic Correction: *Jackson Cross*



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+1 x 180
-1 x 090

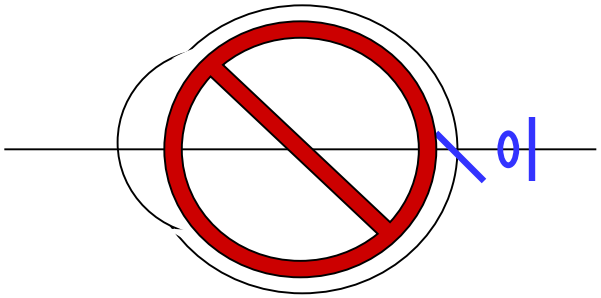
-2 x 090
+2 x 180

+.25 x 045
-.25 x 135

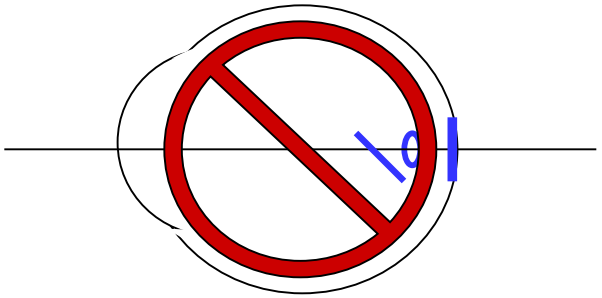
Here are the same Jackson cross lenses written in **power-cross notation**. In this format, it is easier to appreciate that each consists simply of plus and minus cylinders of identical but opposite powers, oriented 90^{o} apart. (We'll talk more about power crosses later in this chapter.)

OKAP pearl: You must be able to recognize/identify a Jackson cross!

Astigmatic Correction: *Jackson Cross*



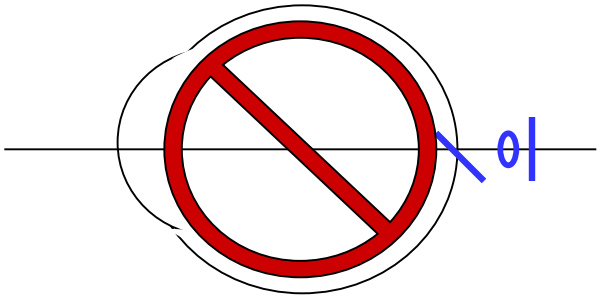
Simple Hyperopic
(if using a plus-cyl phoropter)



Simple Myopic
(if using a minus-cyl phoropter)

When using the Jackson cross, the starting point is **not** the same as it was for the retinoscopic approach

Astigmatic Correction: *Jackson Cross*



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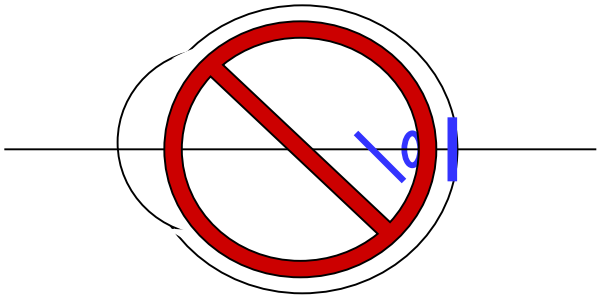

Simple Myopic
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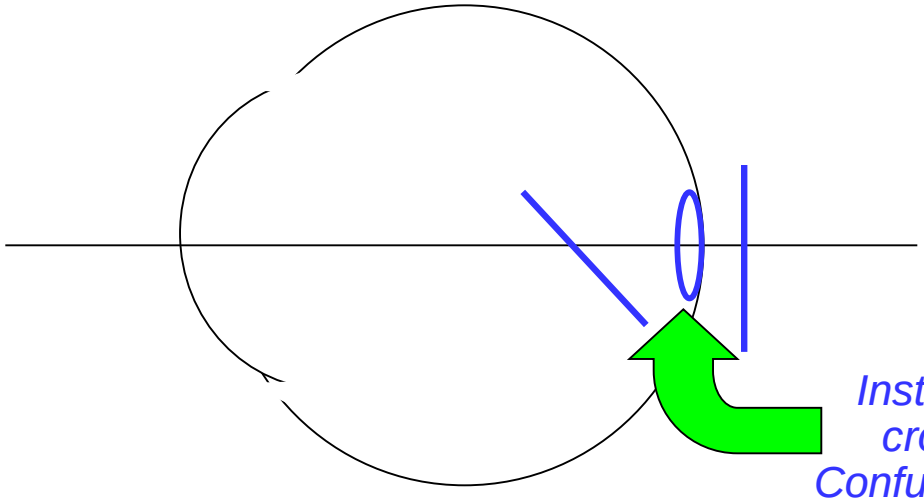
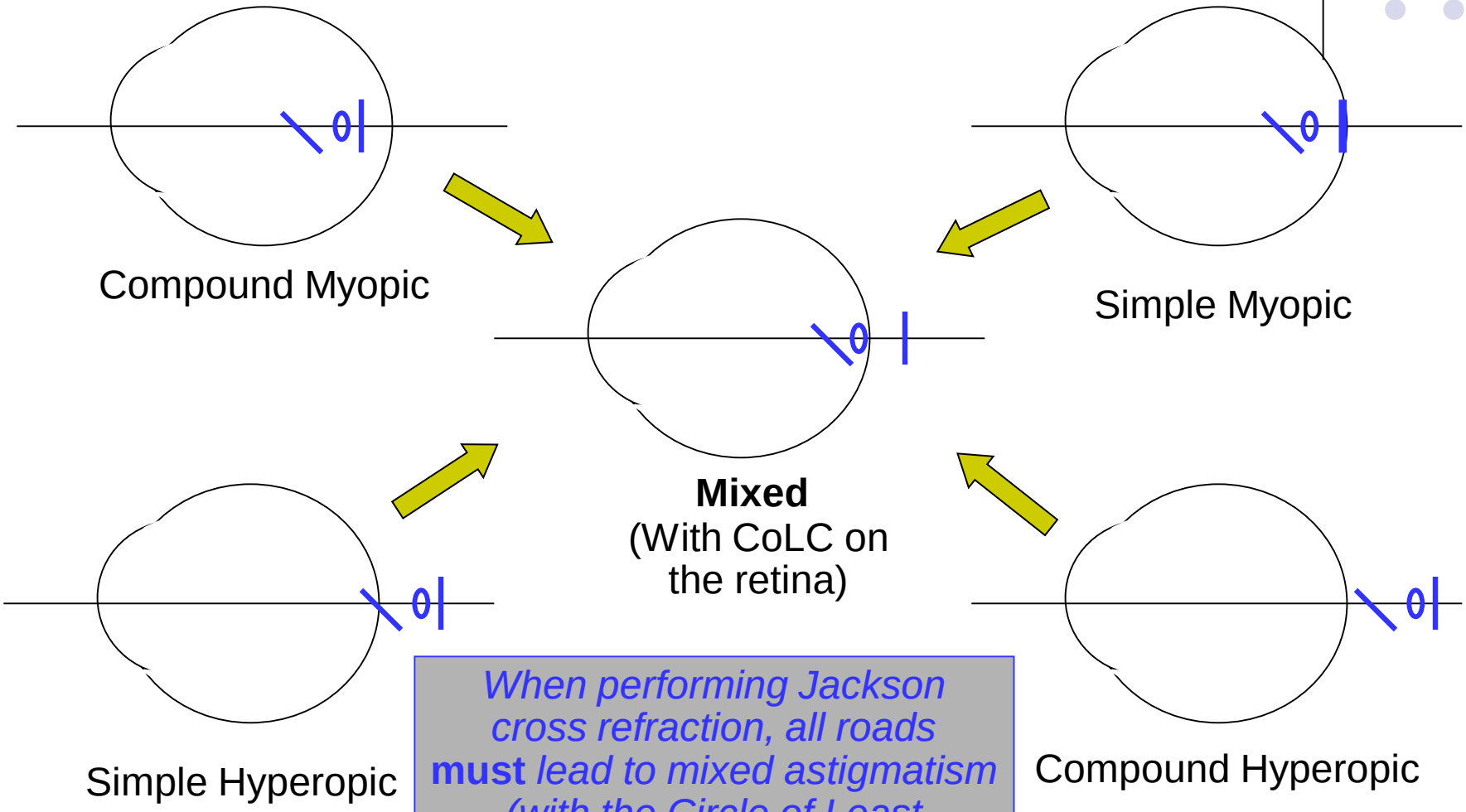


Mixed

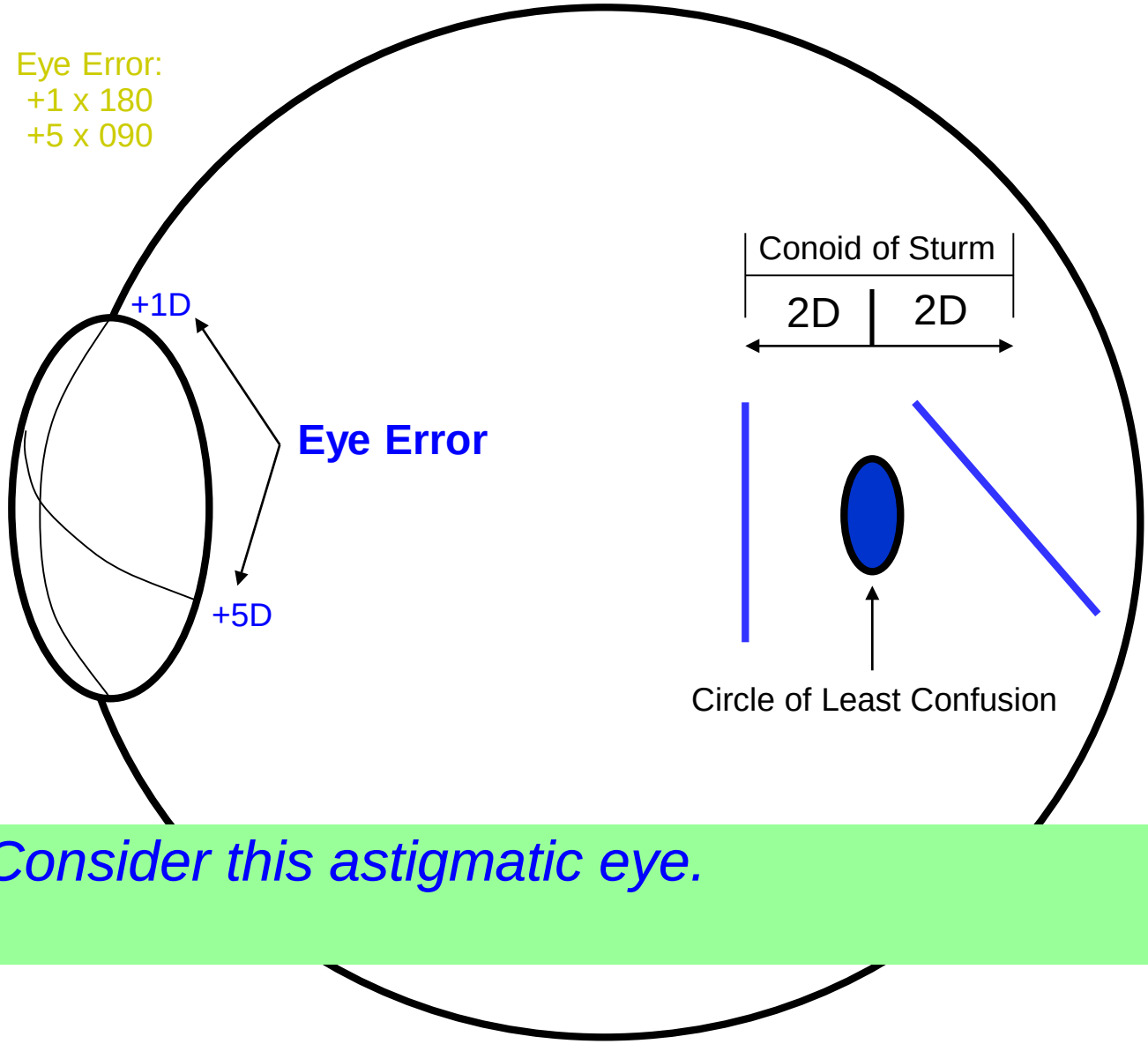
Instead, to use the Jackson cross, the Circle of Least Confusion must be on the retina

Astigmatic Correction: *Jackson Cross*



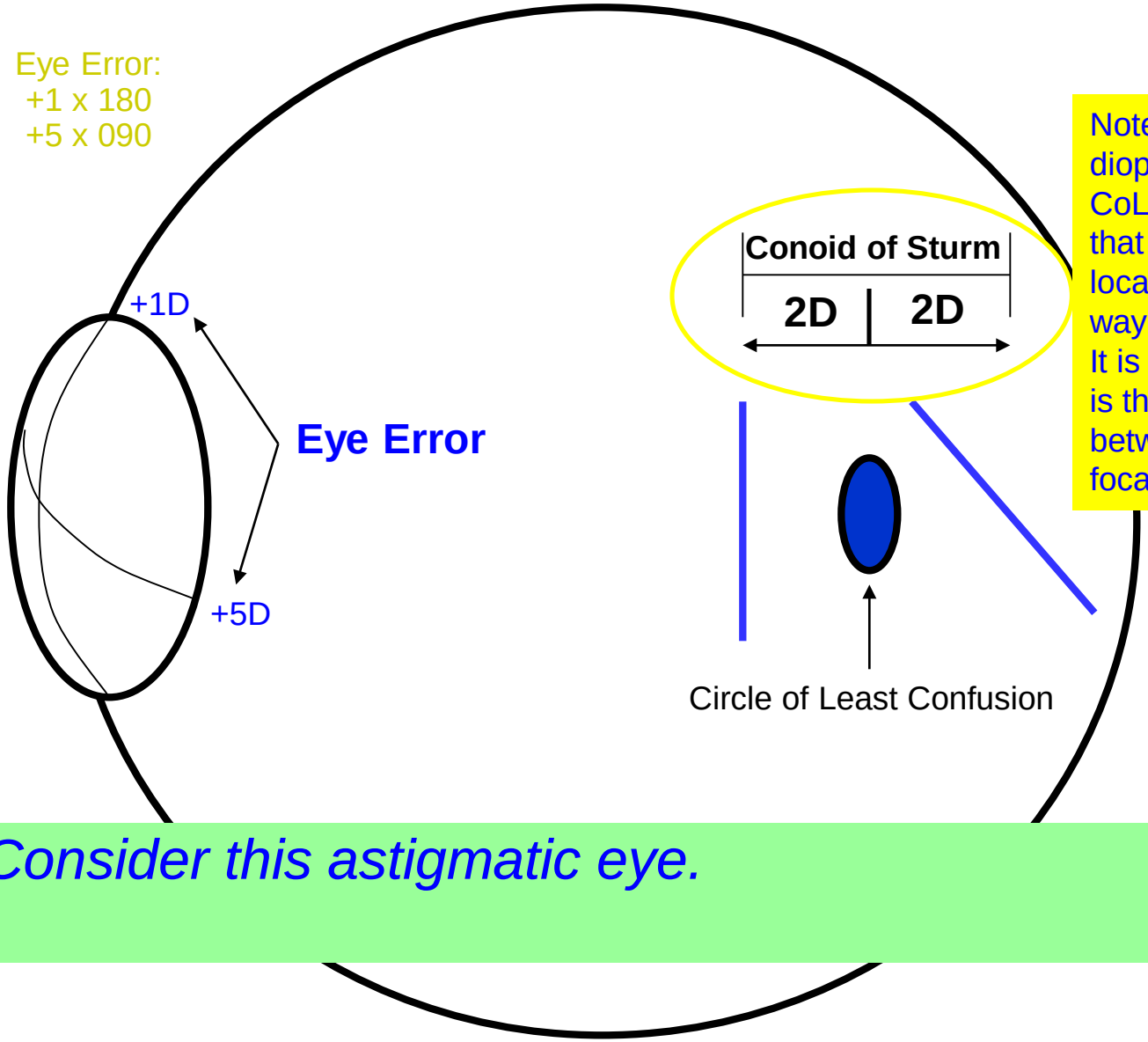
When performing Jackson cross refraction, all roads **must** *lead to mixed astigmatism (with the Circle of Least Confusion on the retina) before cylinder is introduced*

Astigmatic Correction: *Jackson Cross*



Consider this astigmatic eye.

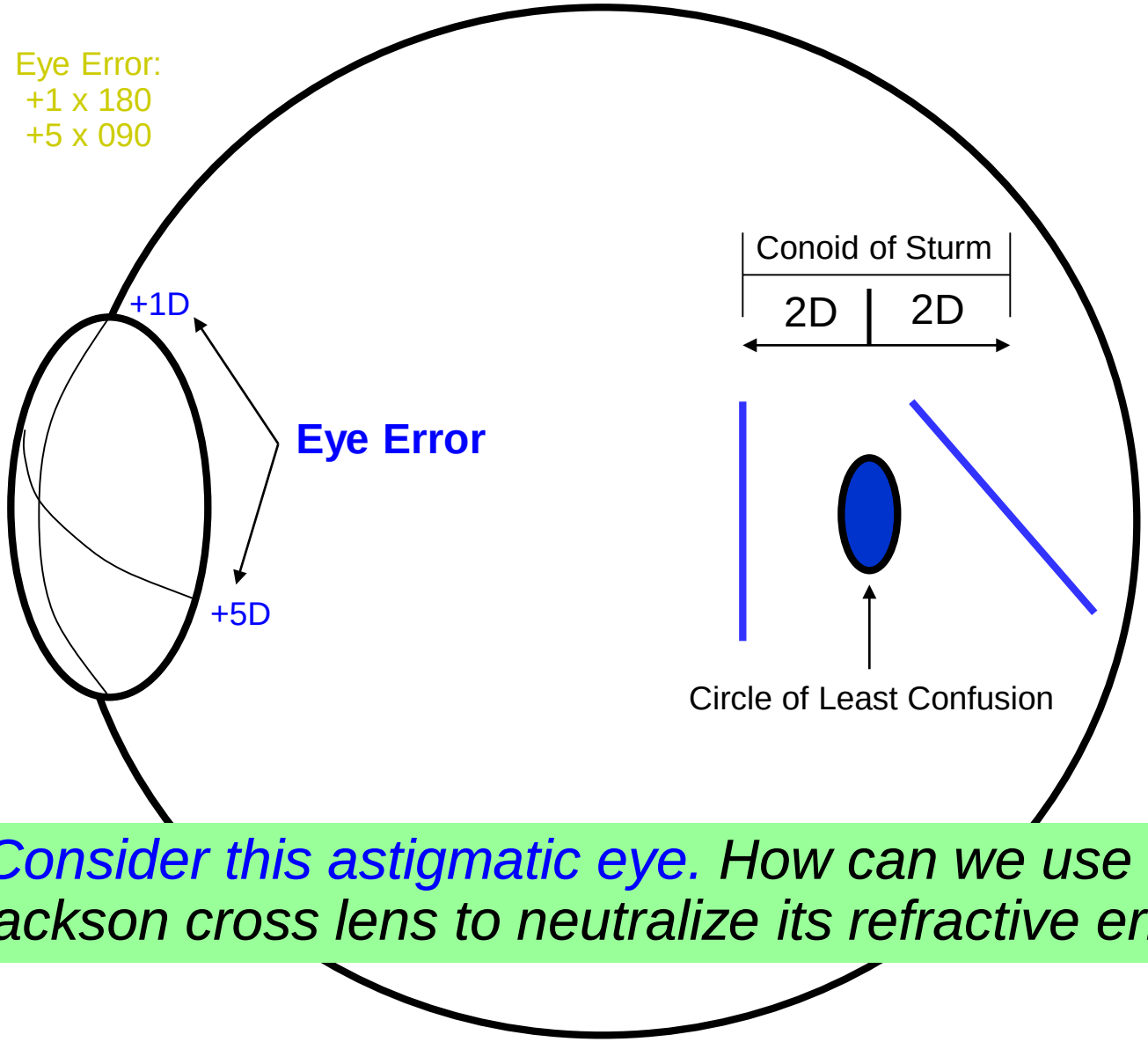
Astigmatic Correction: *Jackson Cross*



Note the conoid is four diopters wide, with the CoLC in the middle (recall that the CoLC is always located at the dioptric half-way point of its conoid). It is 4D wide because that is the difference in power between the two eye-error focal lines [(+5)-(+1)=4].

Consider this astigmatic eye.

Astigmatic Correction: *Jackson Cross*



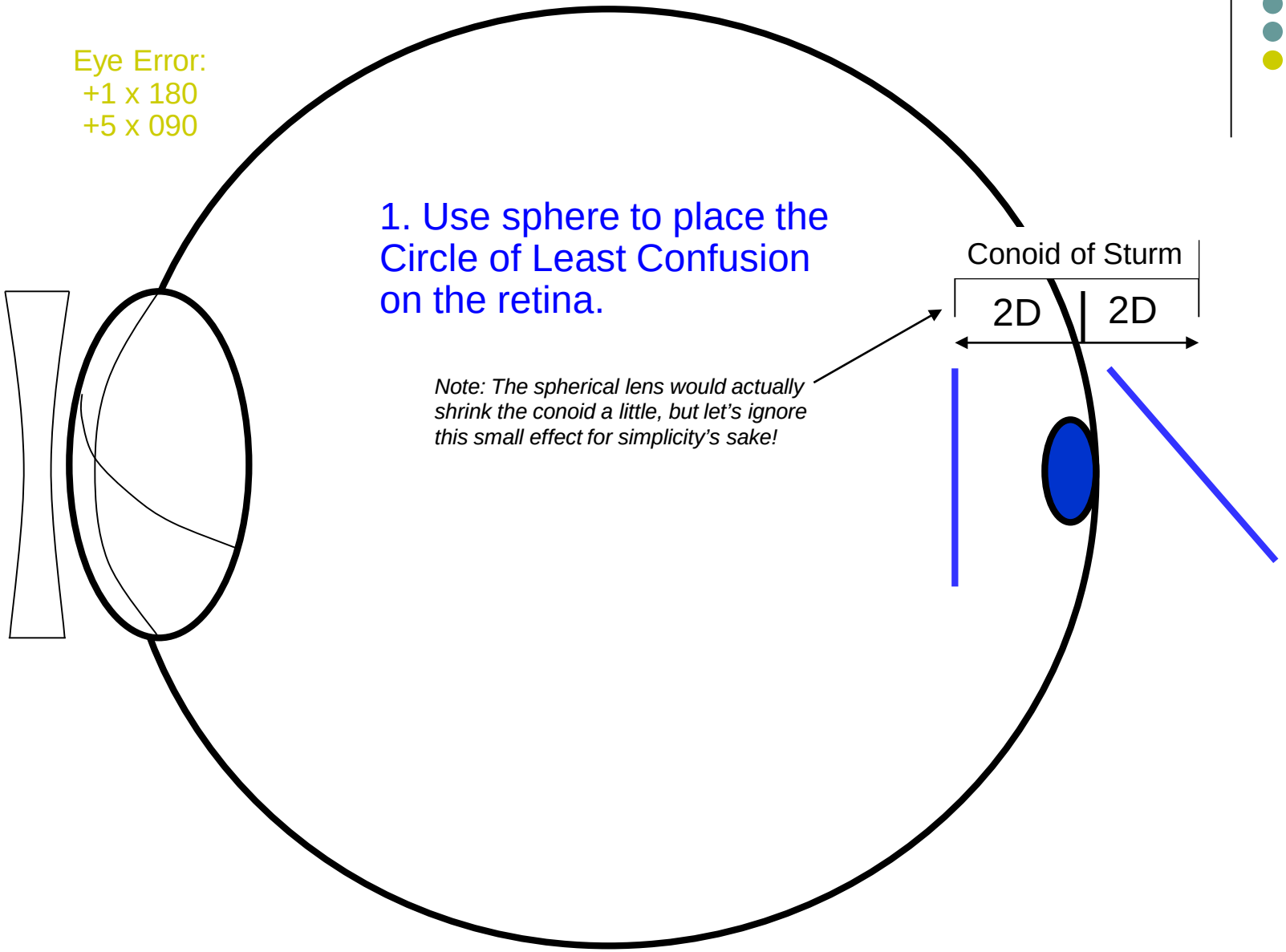
Consider this astigmatic eye. How can we use the Jackson cross lens to neutralize its refractive error?

Astigmatic Correction: *Jackson Cross*

Eye Error:
+1 x 180
+5 x 090

1. Use sphere to place the Circle of Least Confusion on the retina.

Note: The spherical lens would actually shrink the conoid a little, but let's ignore this small effect for simplicity's sake!



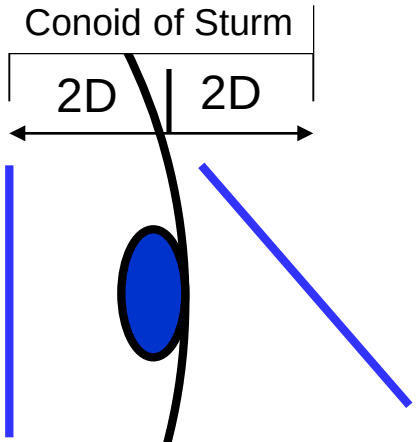
Astigmatic Correction: *Jackson Cross*

How much sphere?

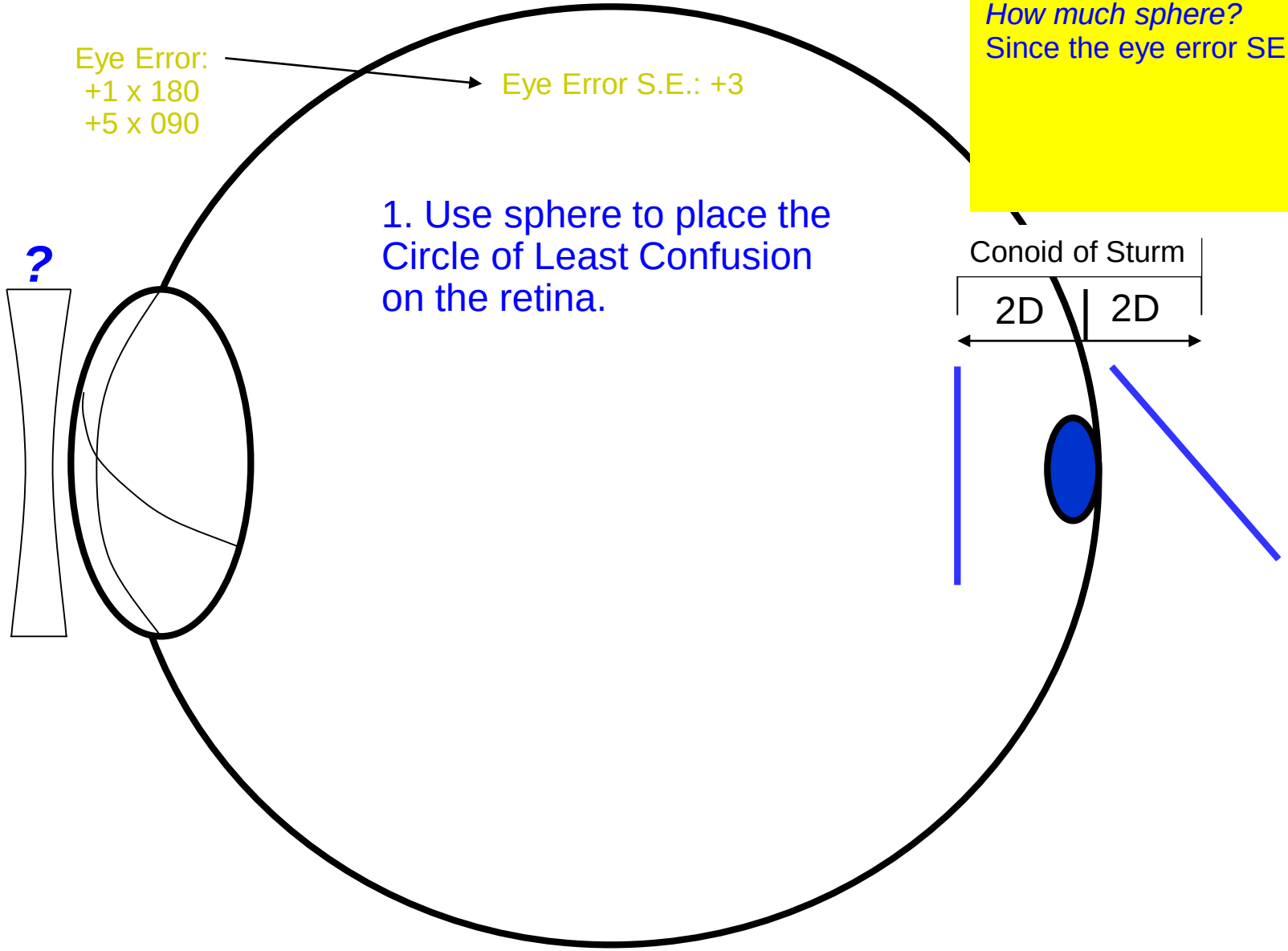
Eye Error:
+1 x 180
+5 x 090

?

1. Use sphere to place the Circle of Least Confusion on the retina.



Astigmatic Correction: *Jackson Cross*



How much sphere?
Since the eye error SE = +3…

Astigmatic Correction: *Jackson Cross*

How much sphere?
Since the eye error SE = +3… a spherical -3D lens will place the CoLC on the retina (if we set aside the vertex distance issue).

Eye Error:
+1 x 180
+5 x 090

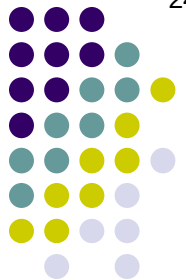
Eye Error S.E.: +3
Corrective S.E.: -3
(Ignoring vertex distance)

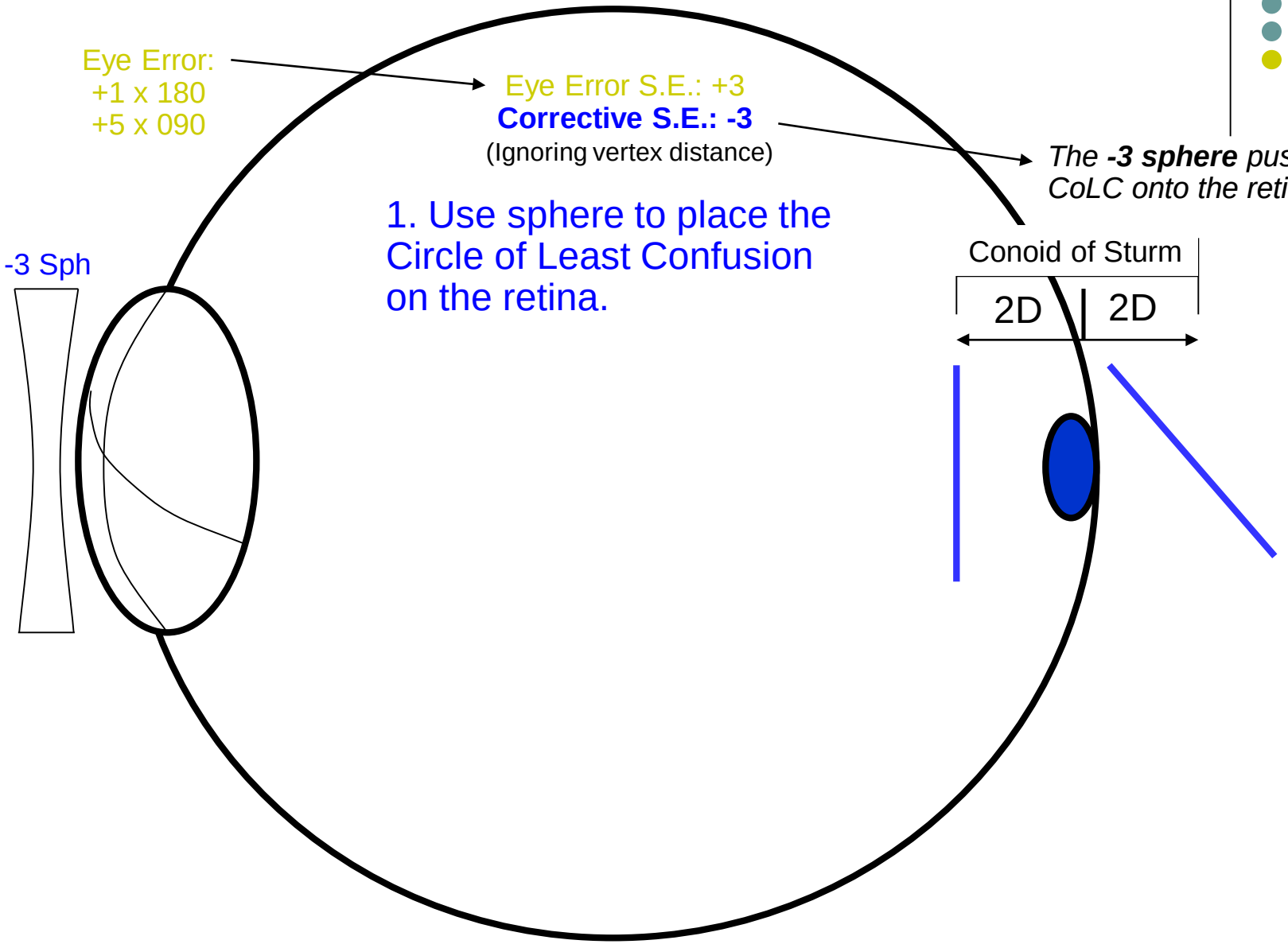
1. Use sphere to place the Circle of Least Confusion on the retina.

-3 Sph

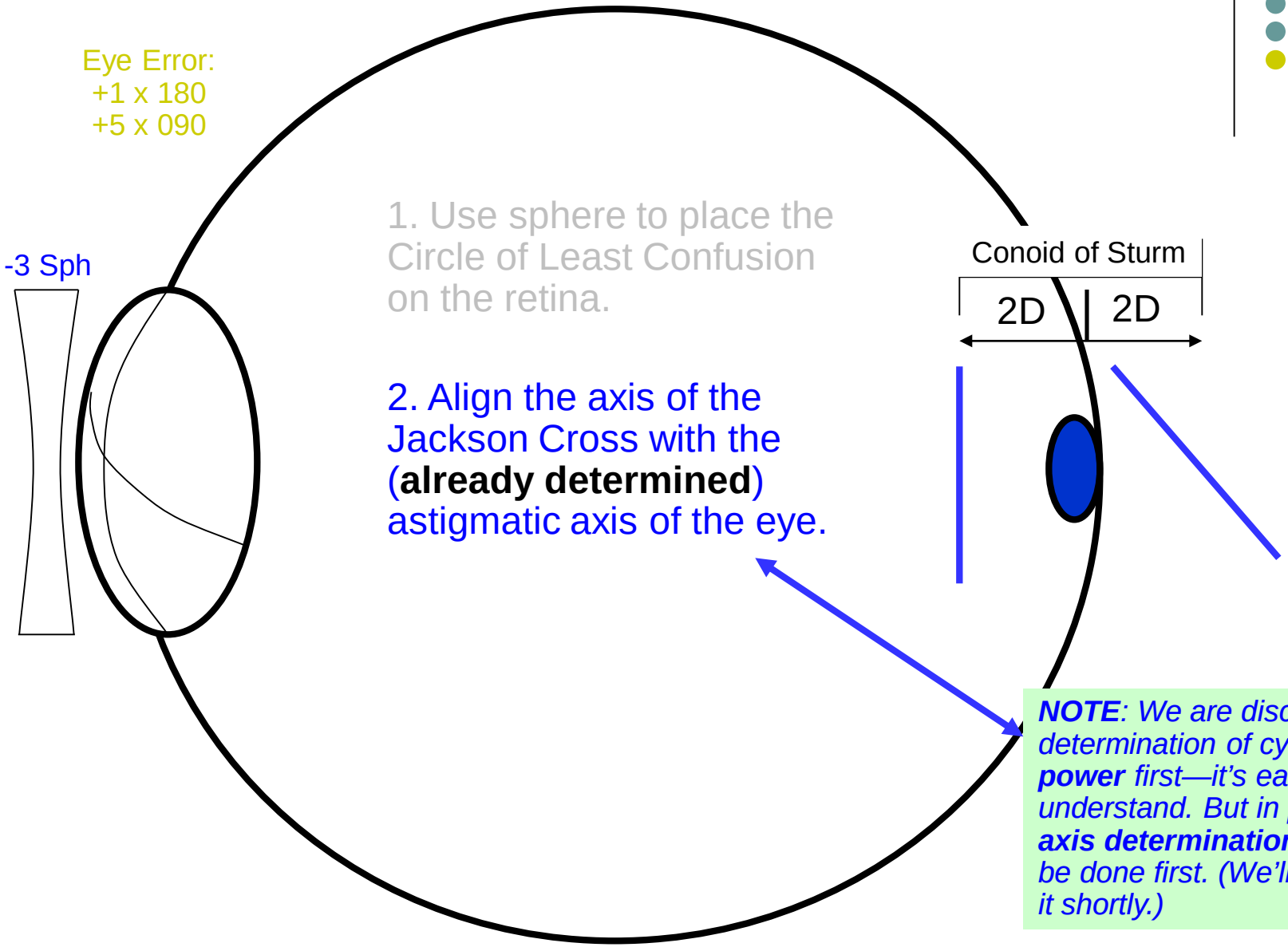
Conoid of Sturm
2D 2D

Astigmatic Correction: *Jackson Cross*



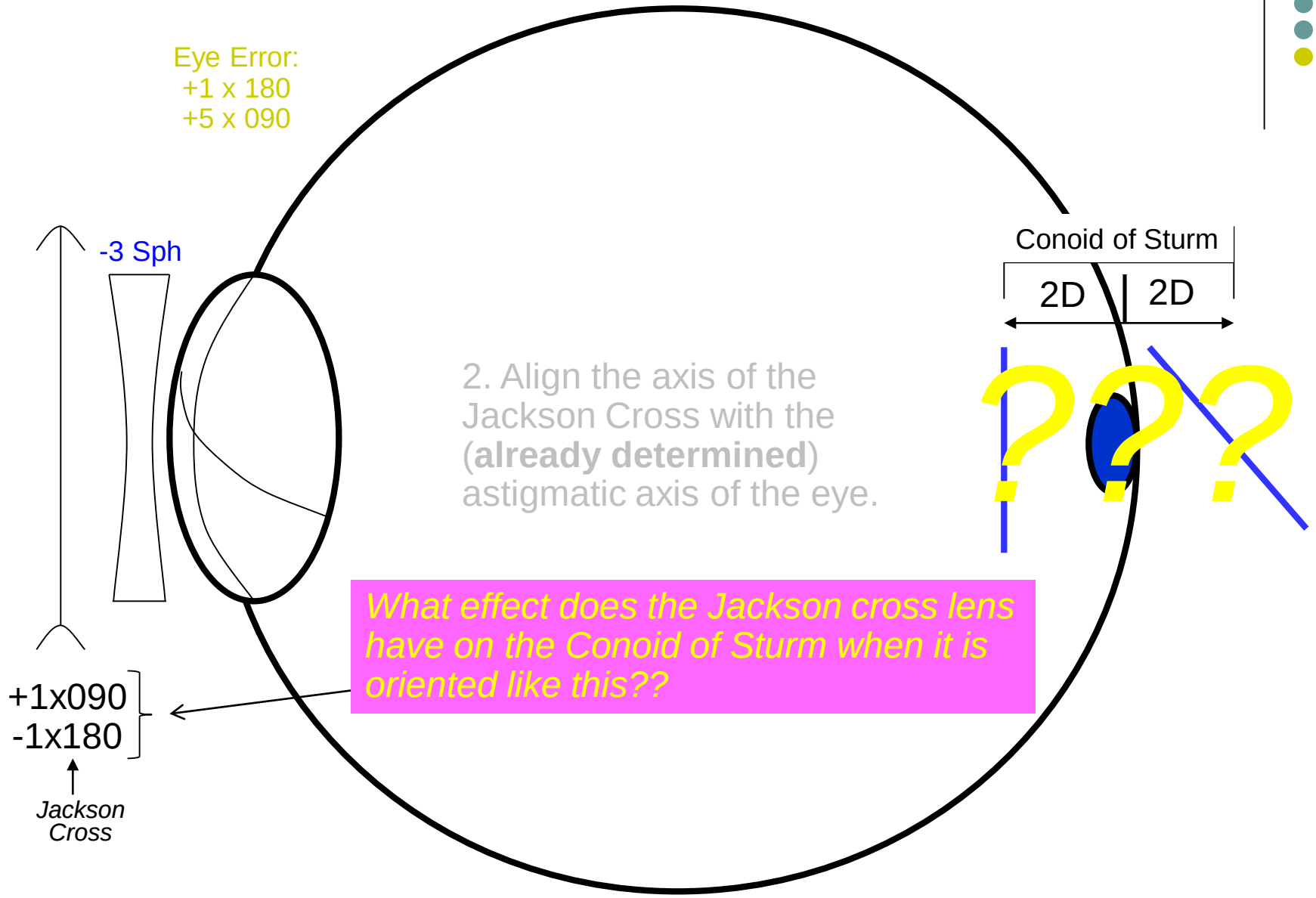


Astigmatic Correction: *Jackson Cross*



***NOTE**: We are discussing determination of cylinder **power** first—it's easier to understand. But in practice, **axis determination** must be done first. (We'll get to it shortly.)*

Astigmatic Correction: *Jackson Cross*



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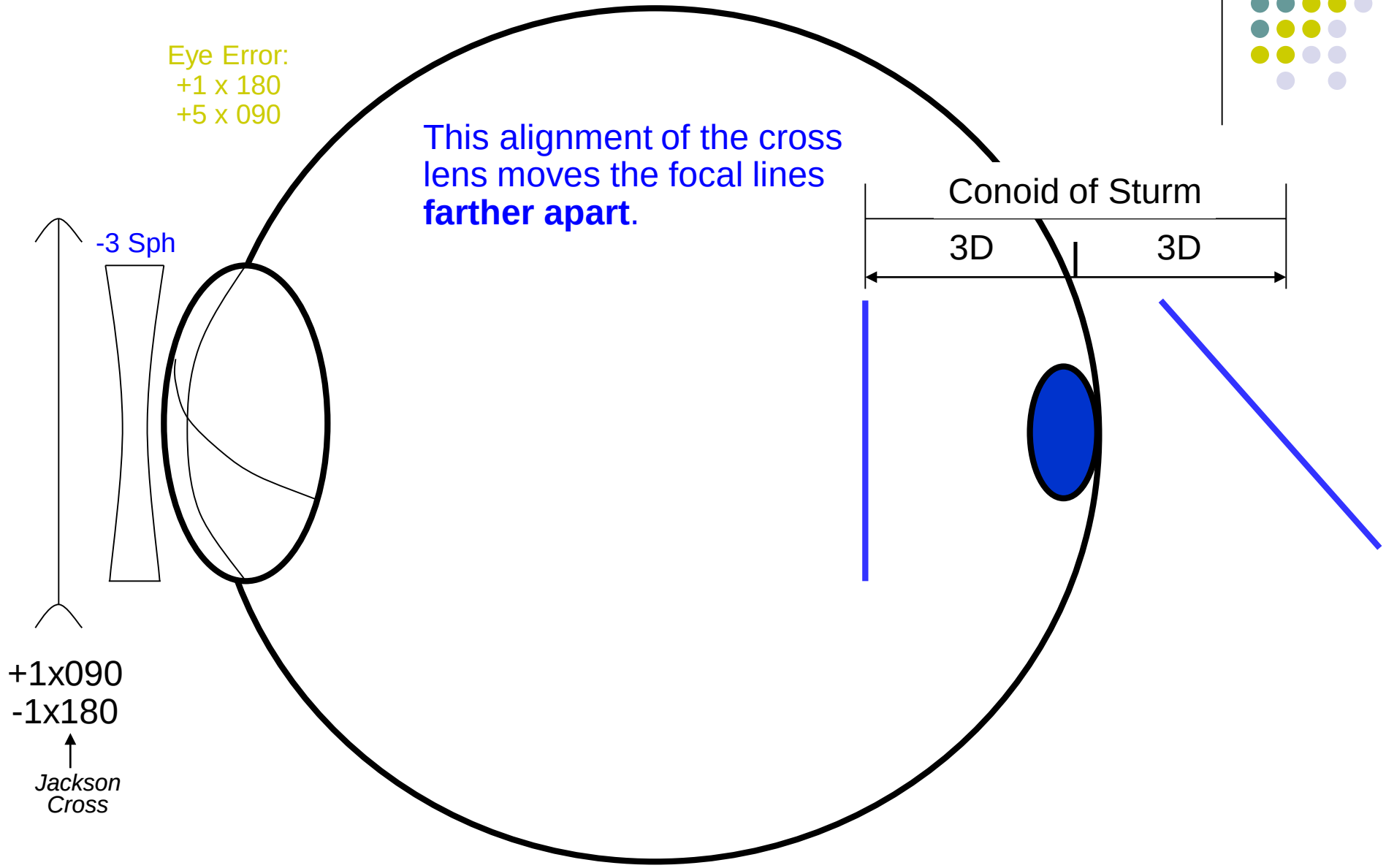

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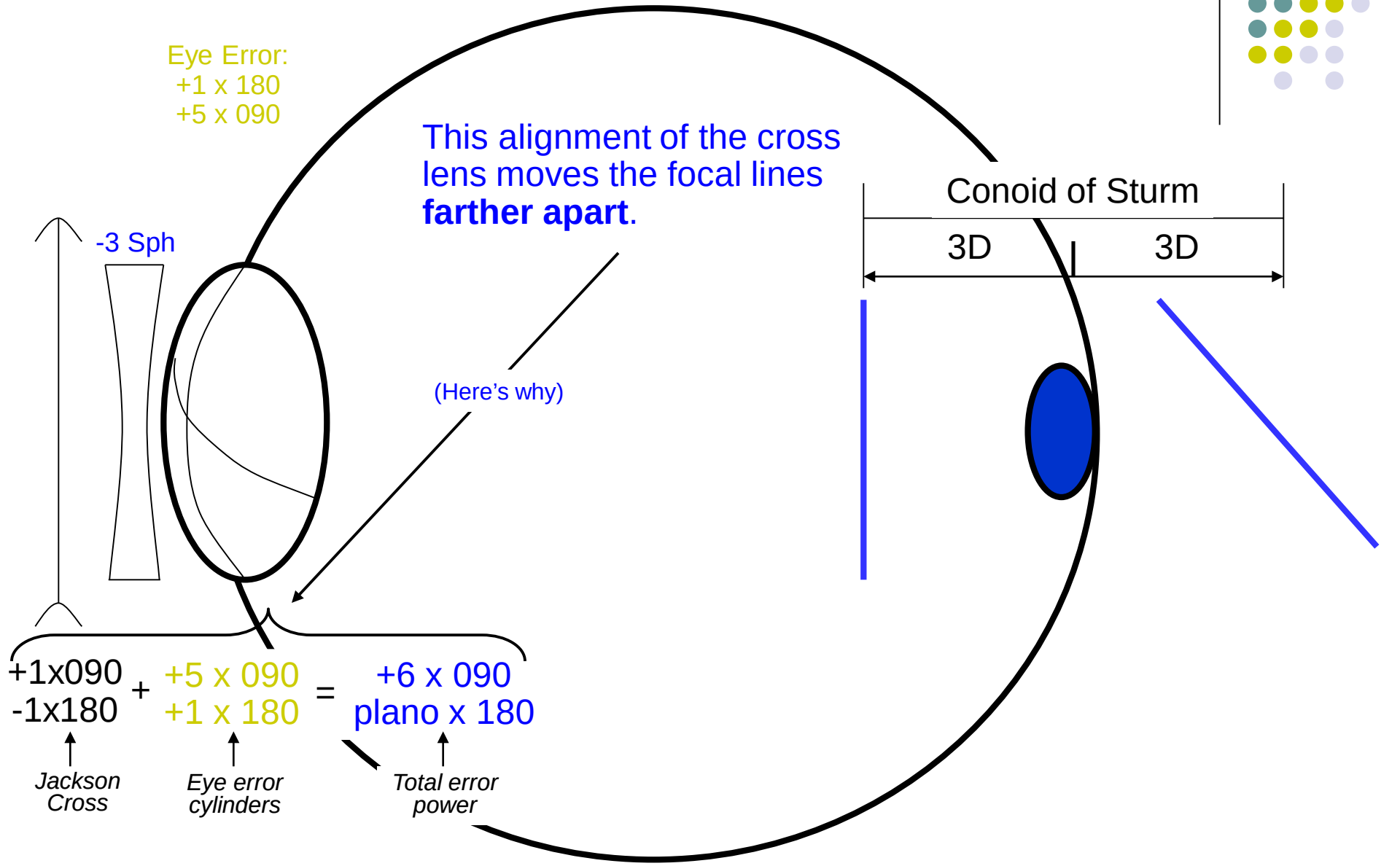

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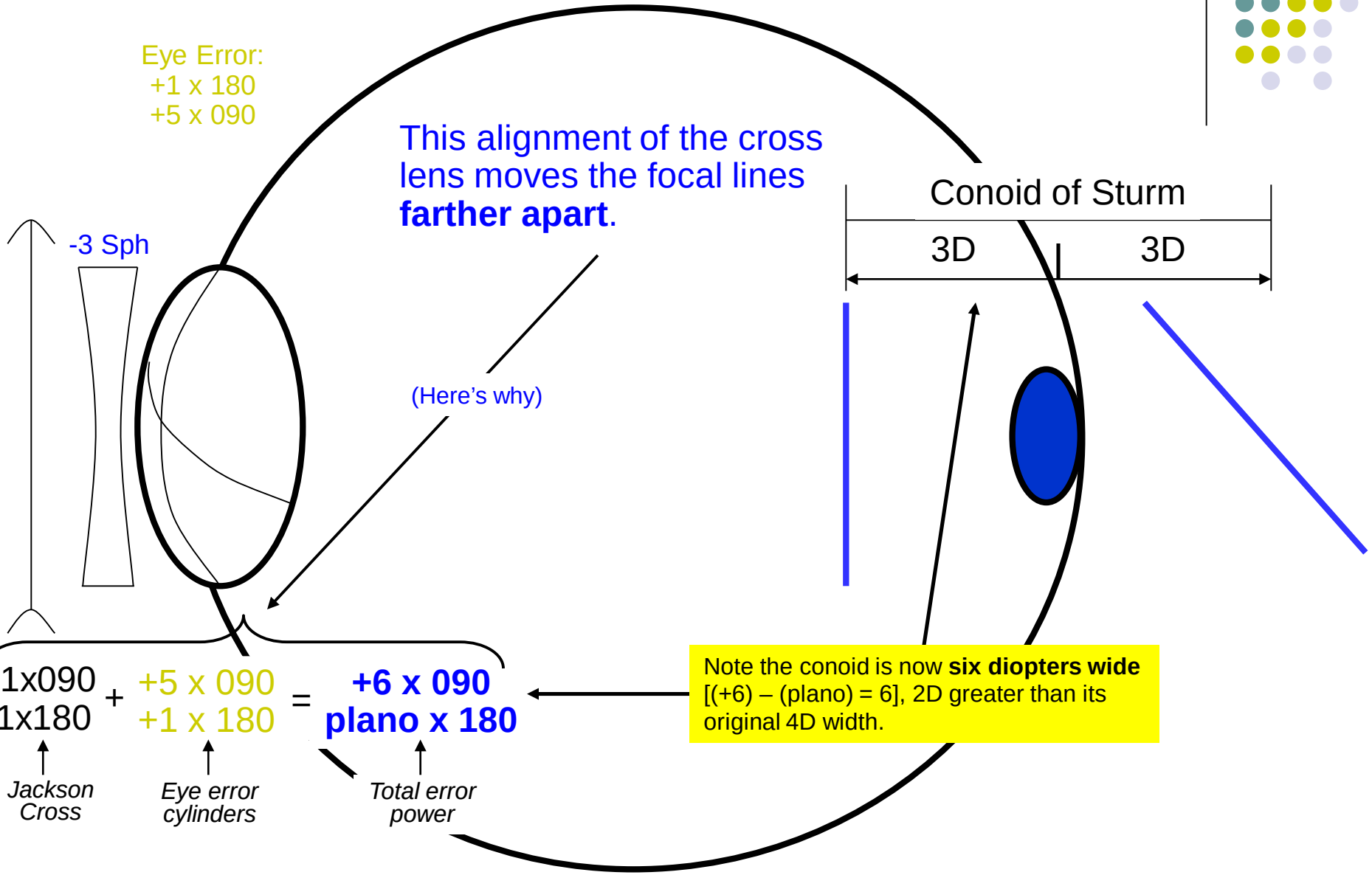

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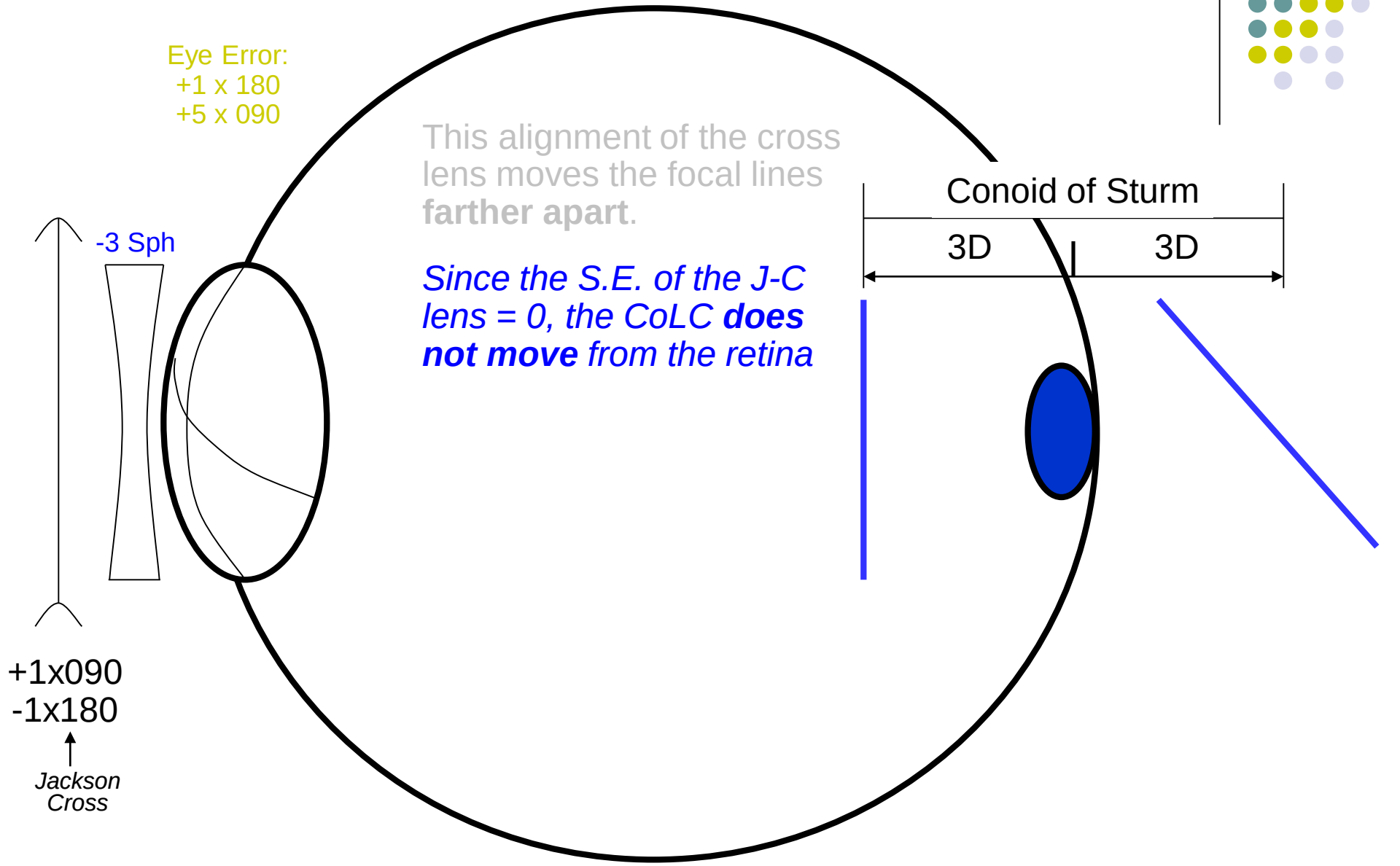

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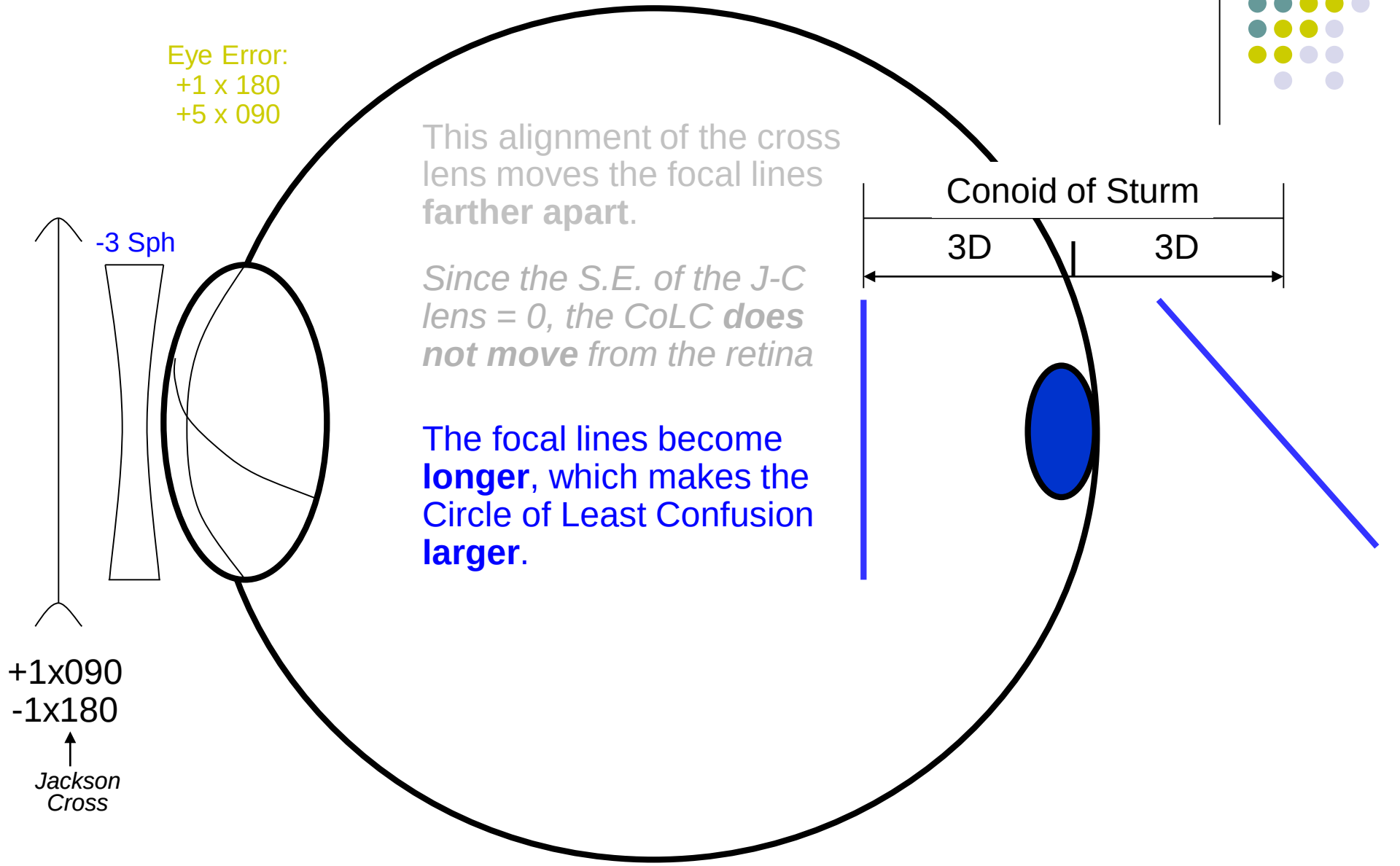

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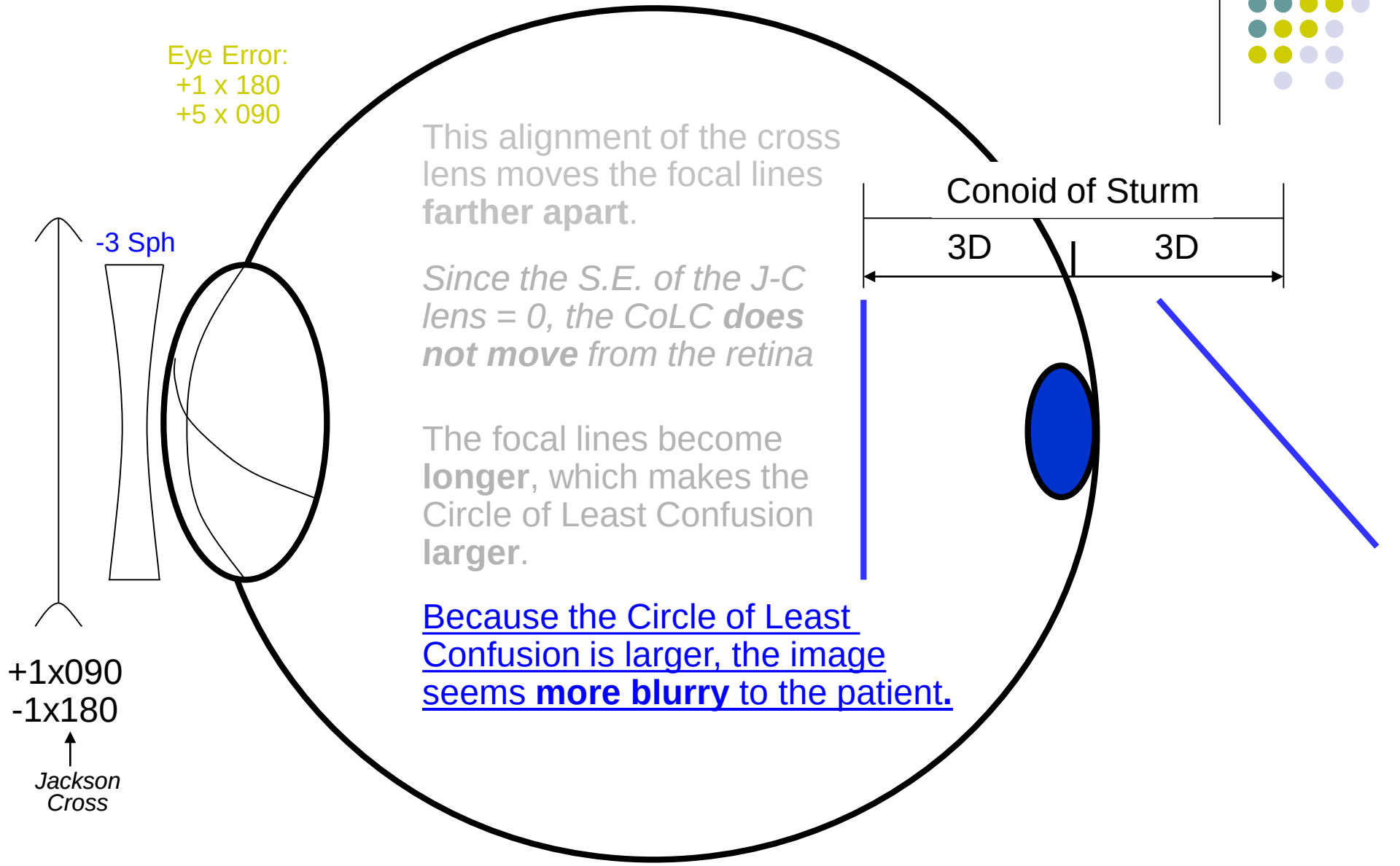

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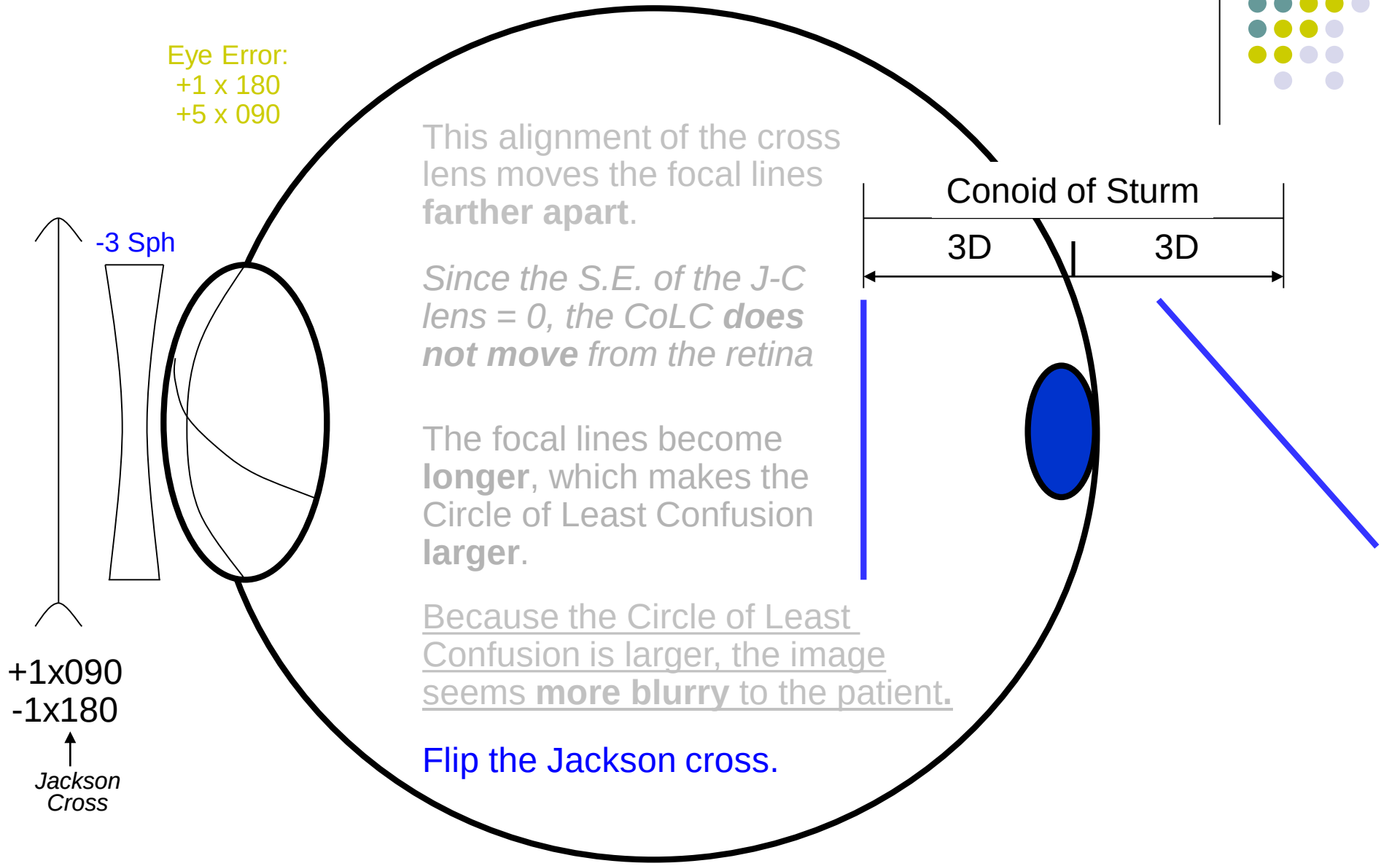
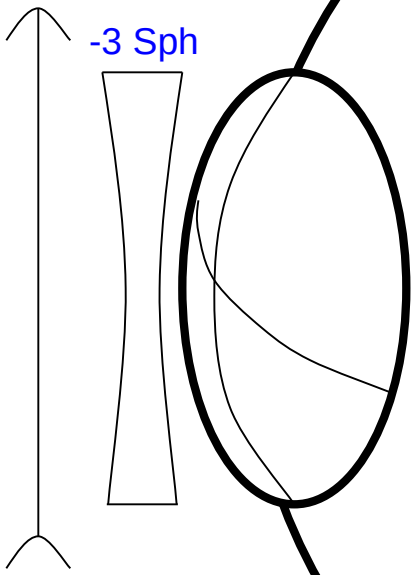


Astigmatic Correction: *Jackson Cross*

Eye Error:
+1 x 180
+5 x 090



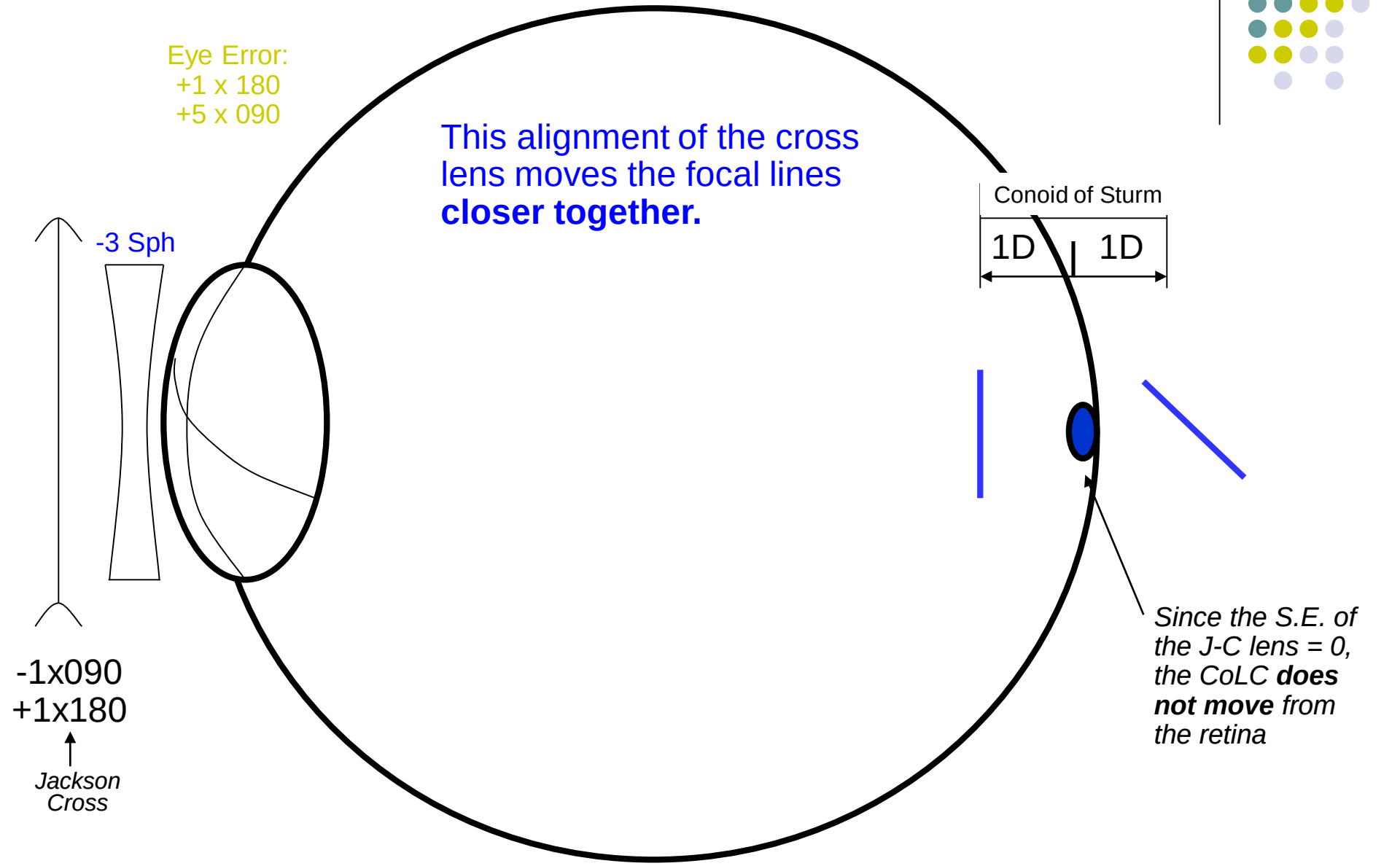
???

What happens to the Conoid when the Jackson cross is flipped?

-1x090
+1x180

Note the change!

Astigmatic Correction: *Jackson Cross*



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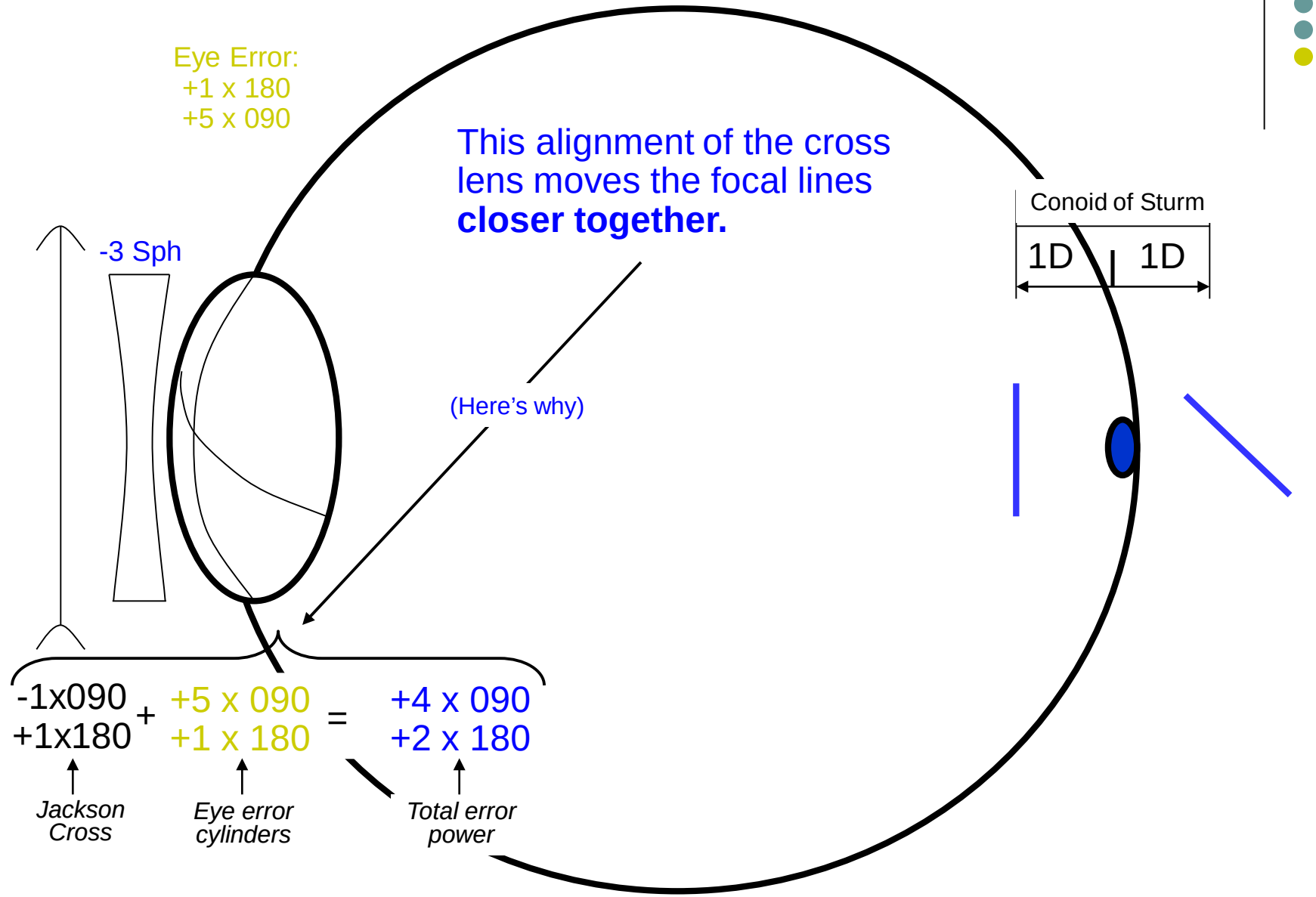

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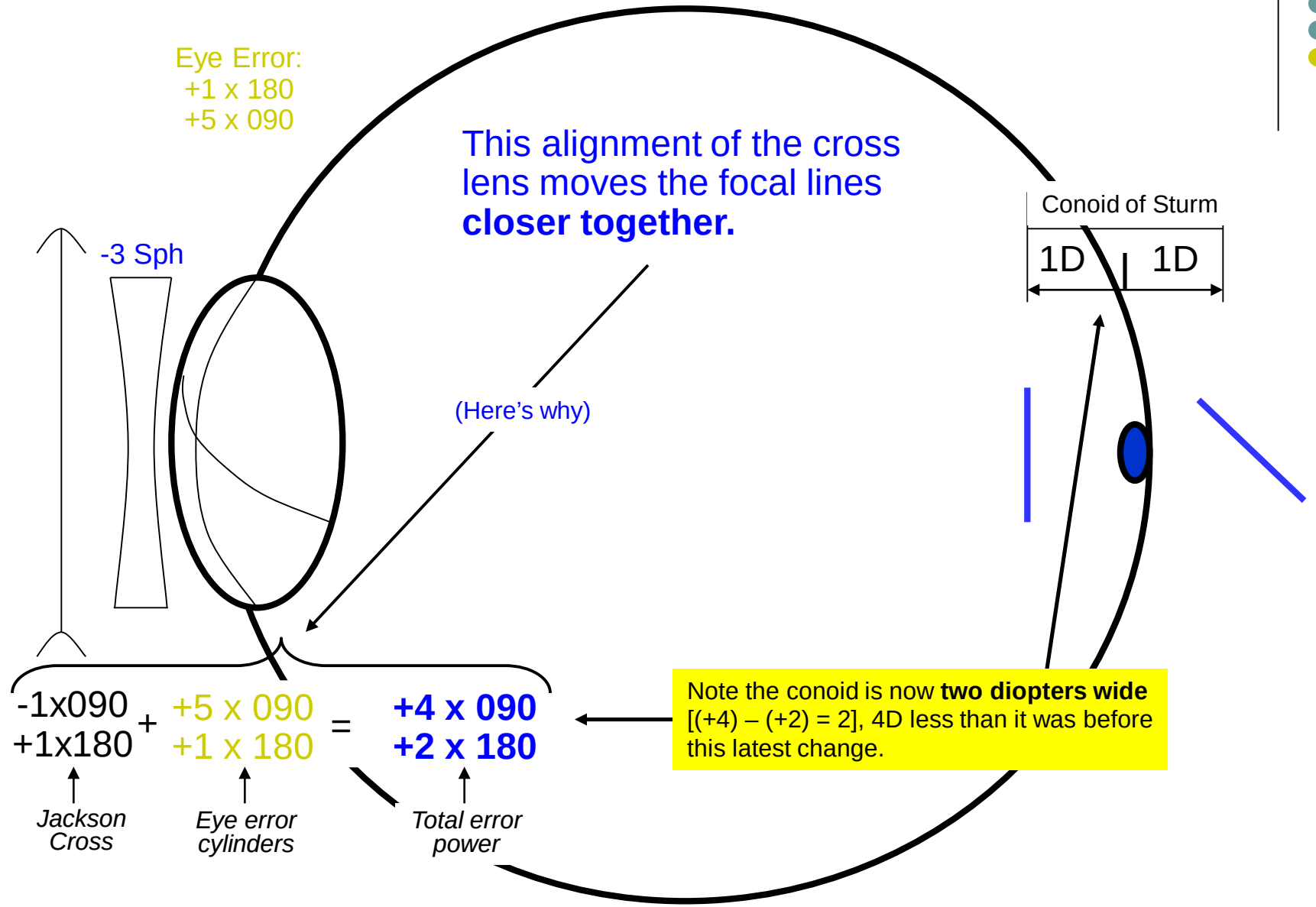

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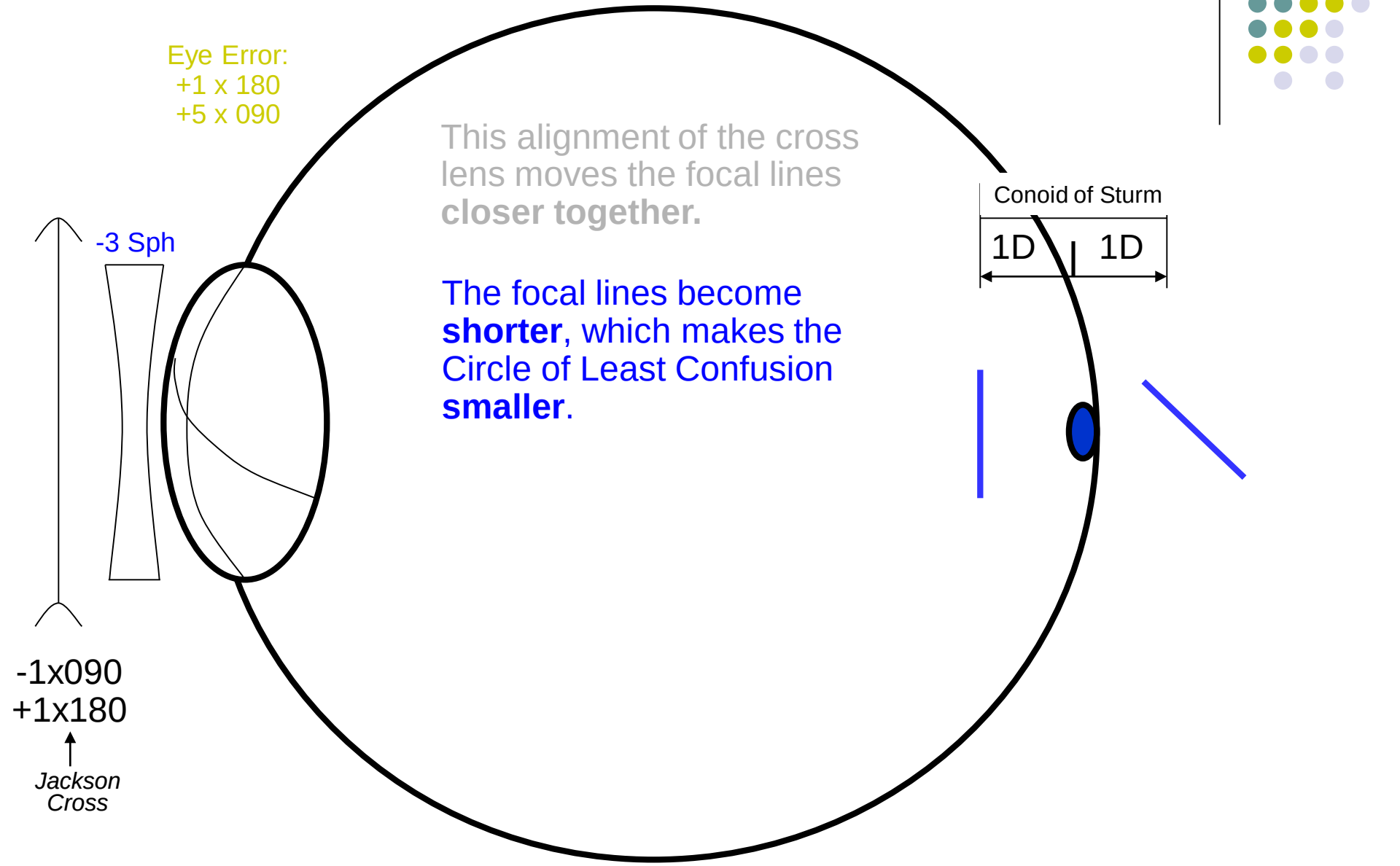

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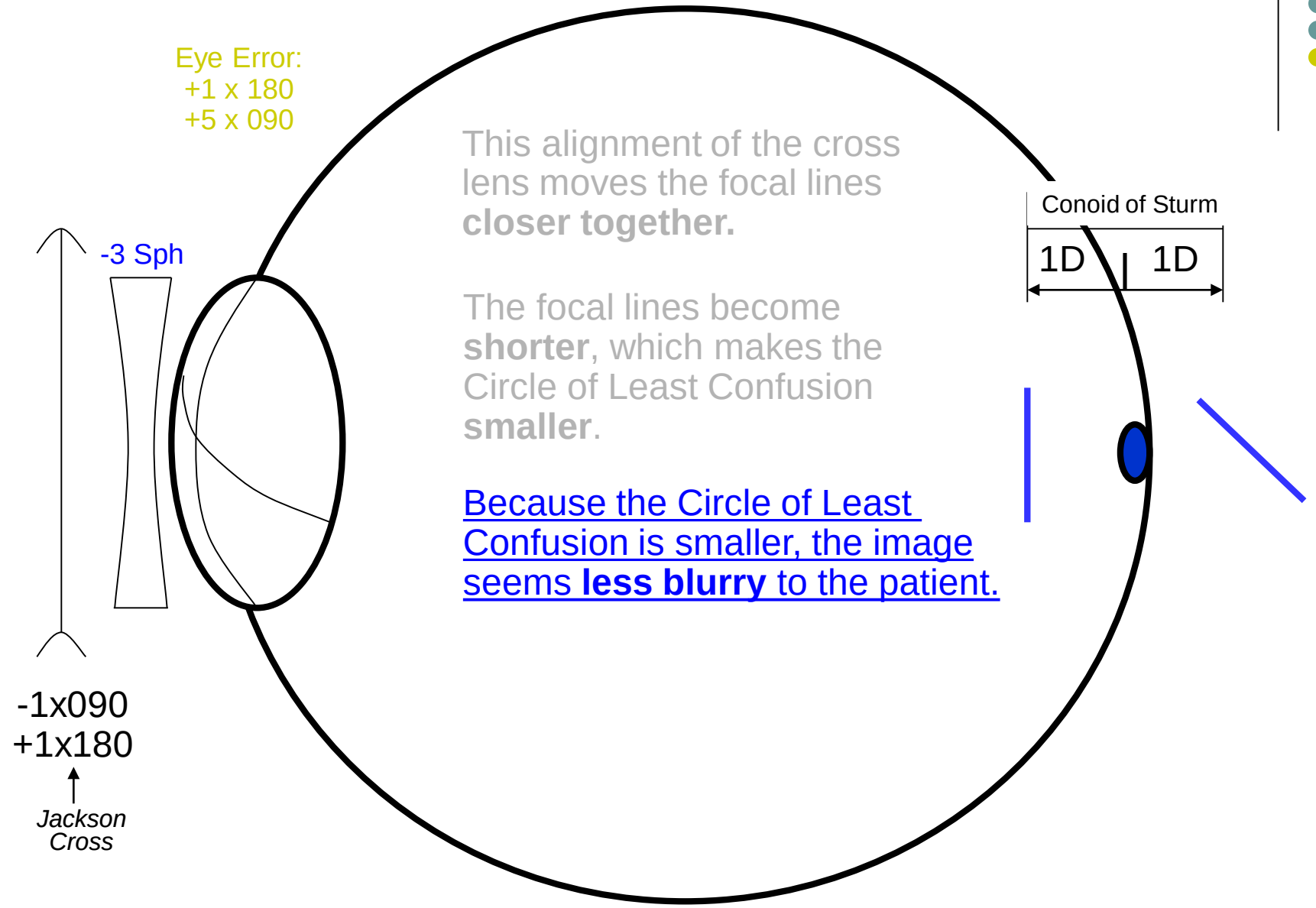

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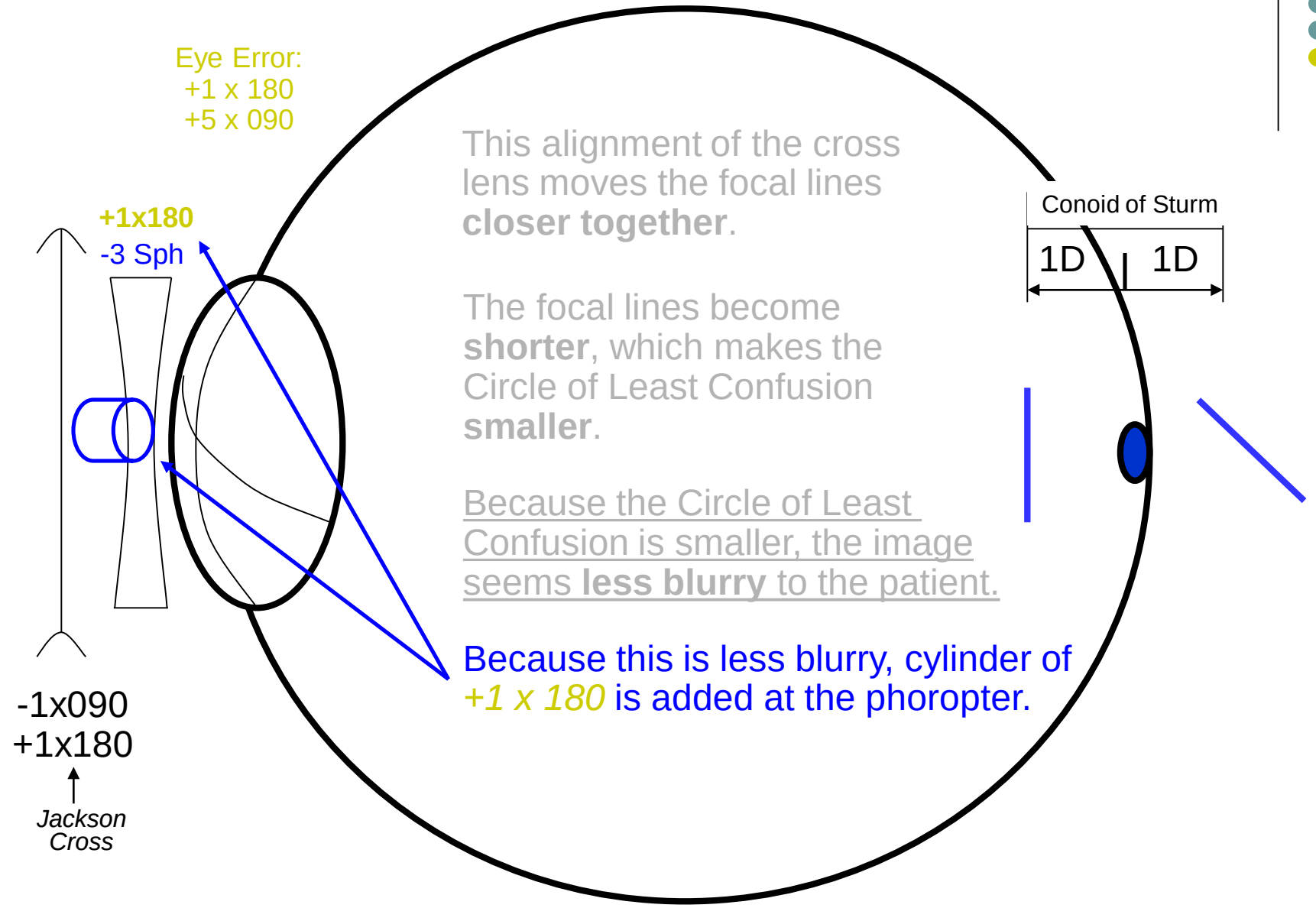

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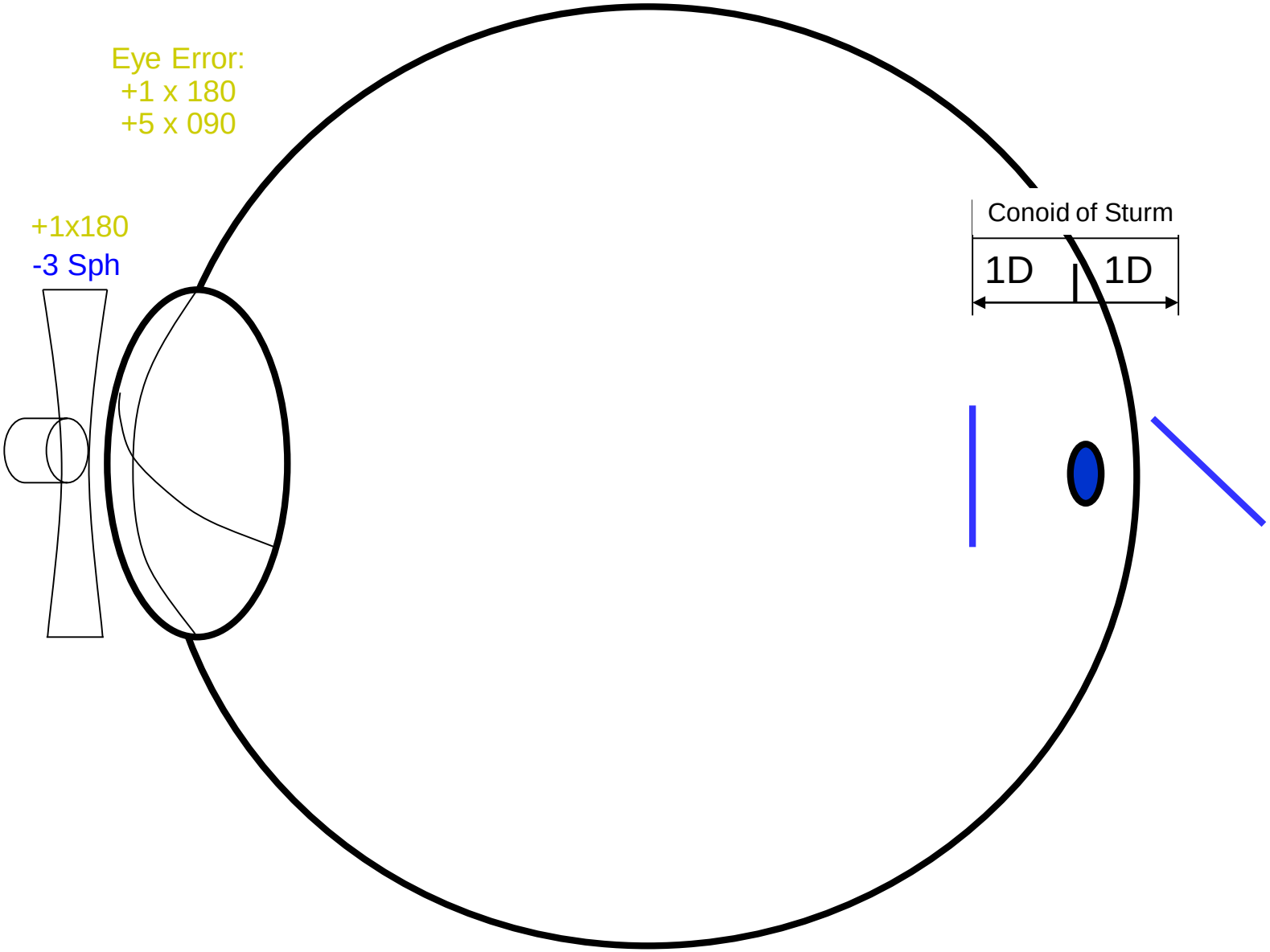

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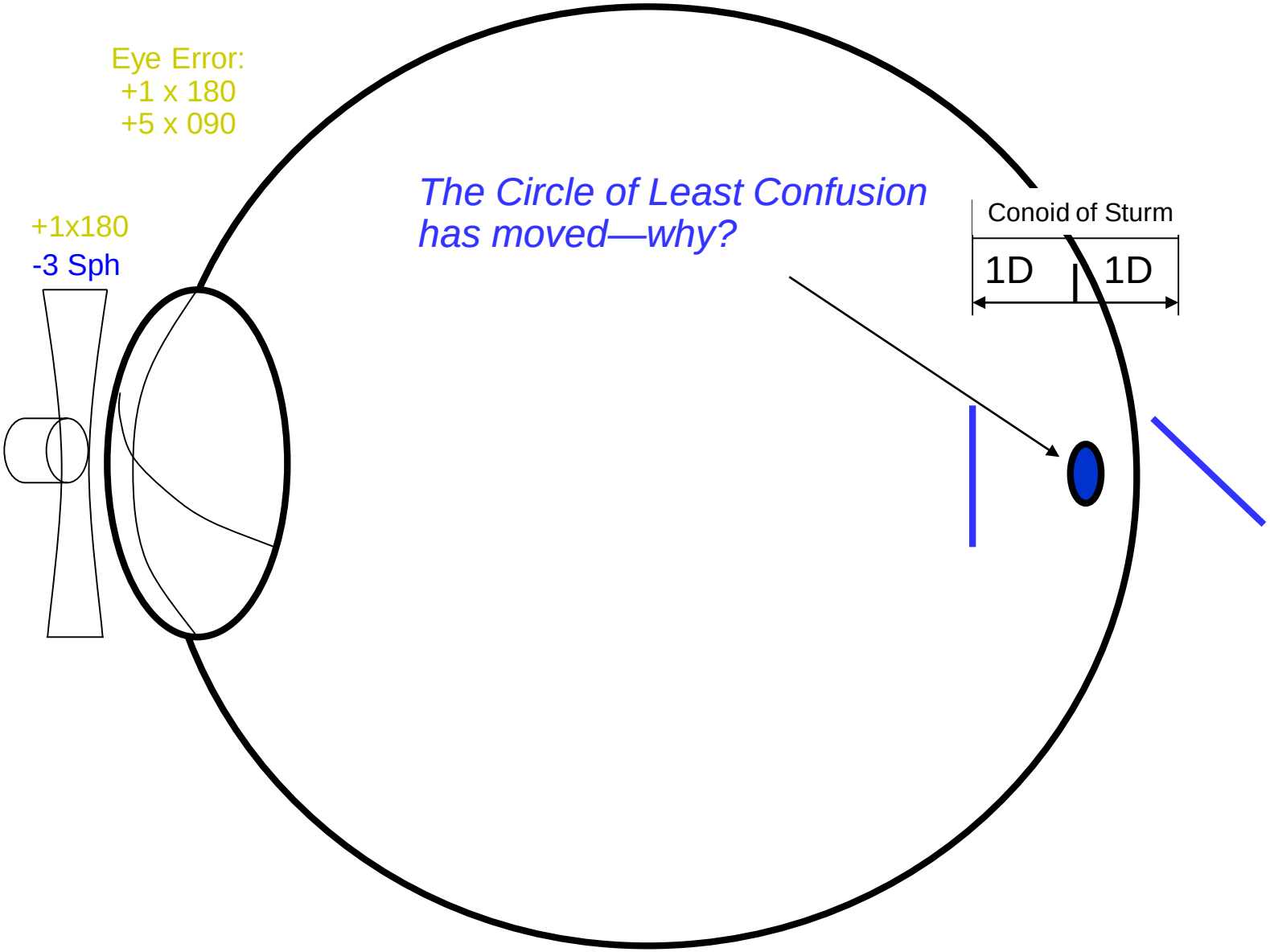

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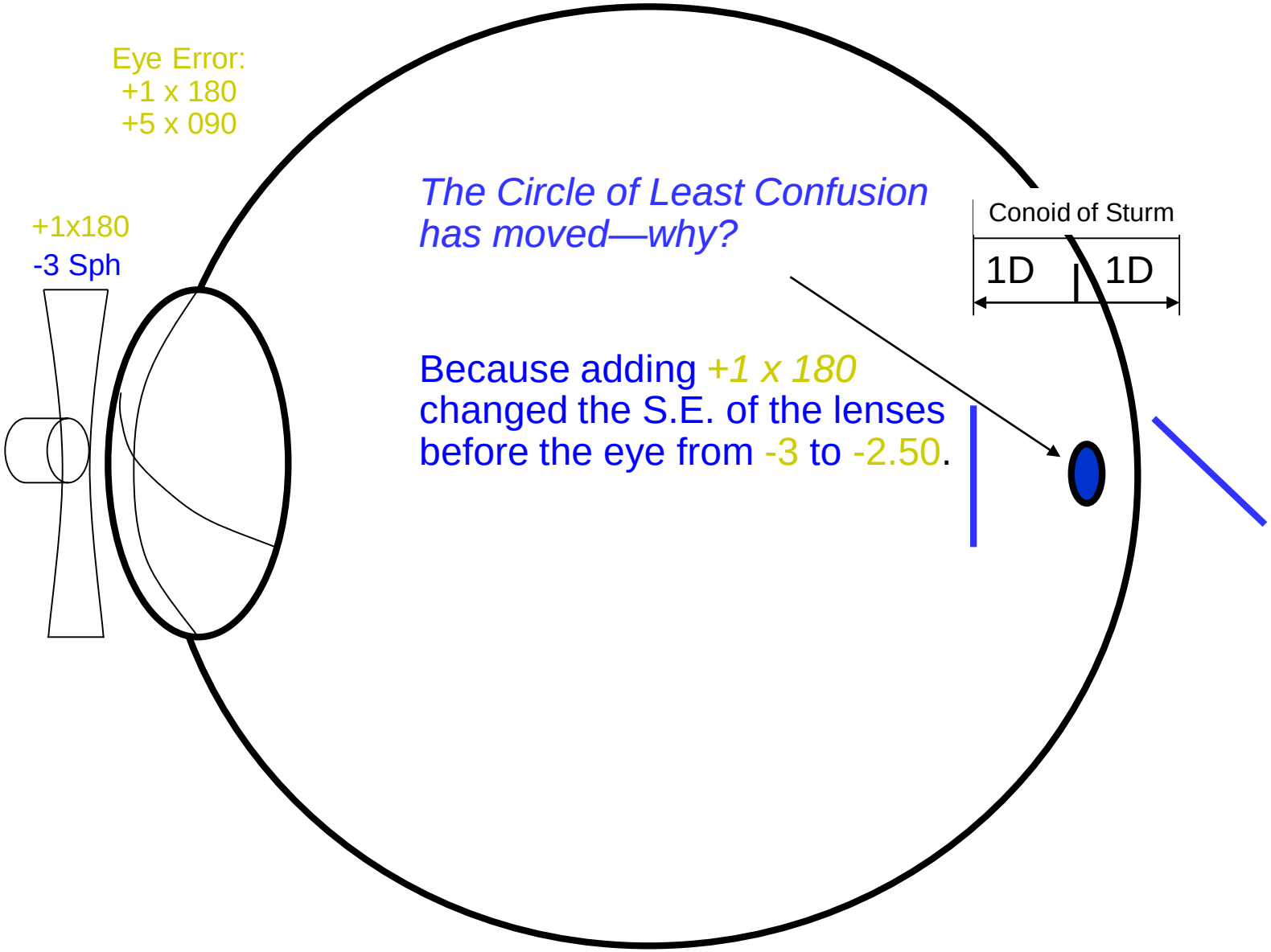

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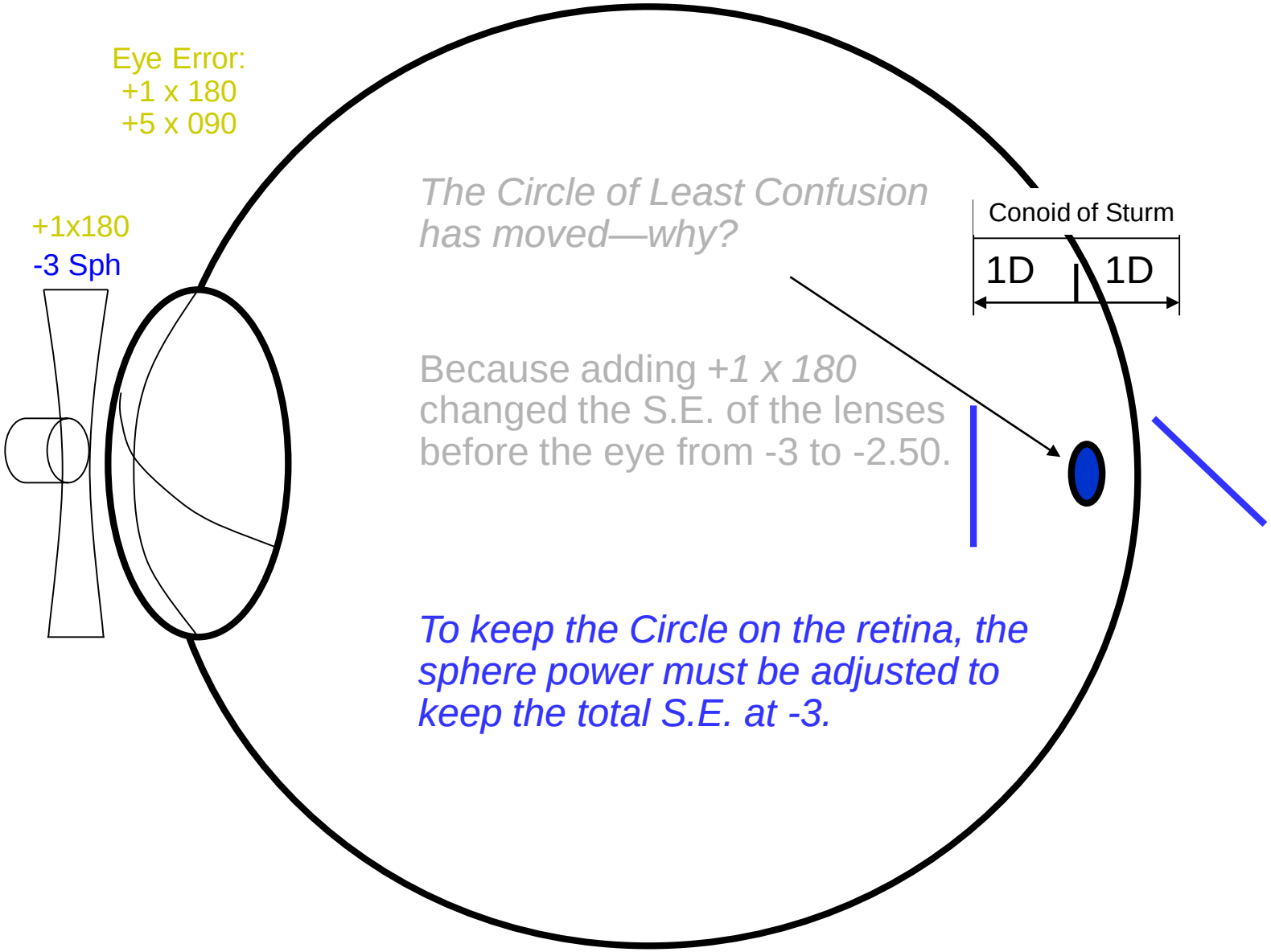

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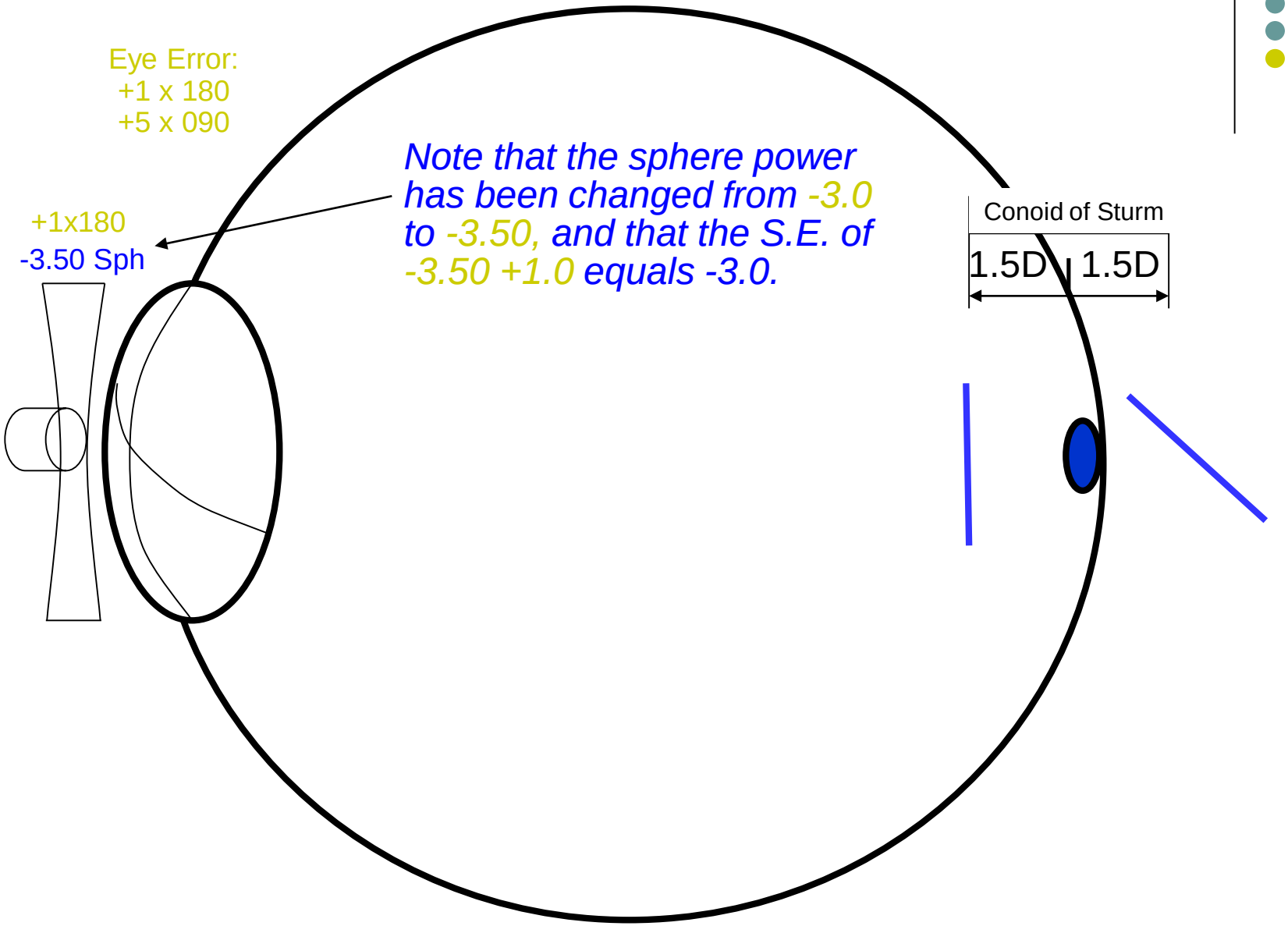
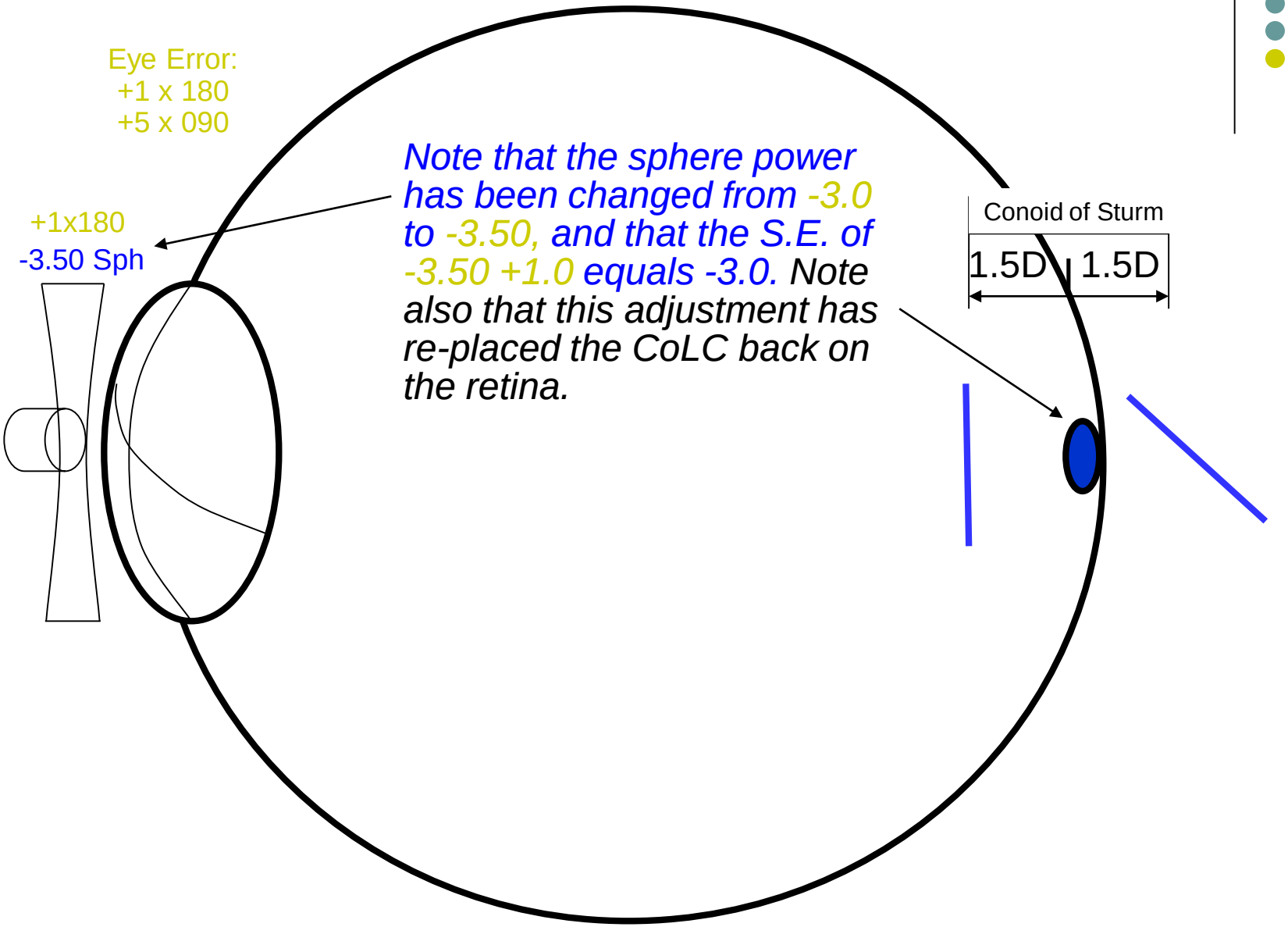
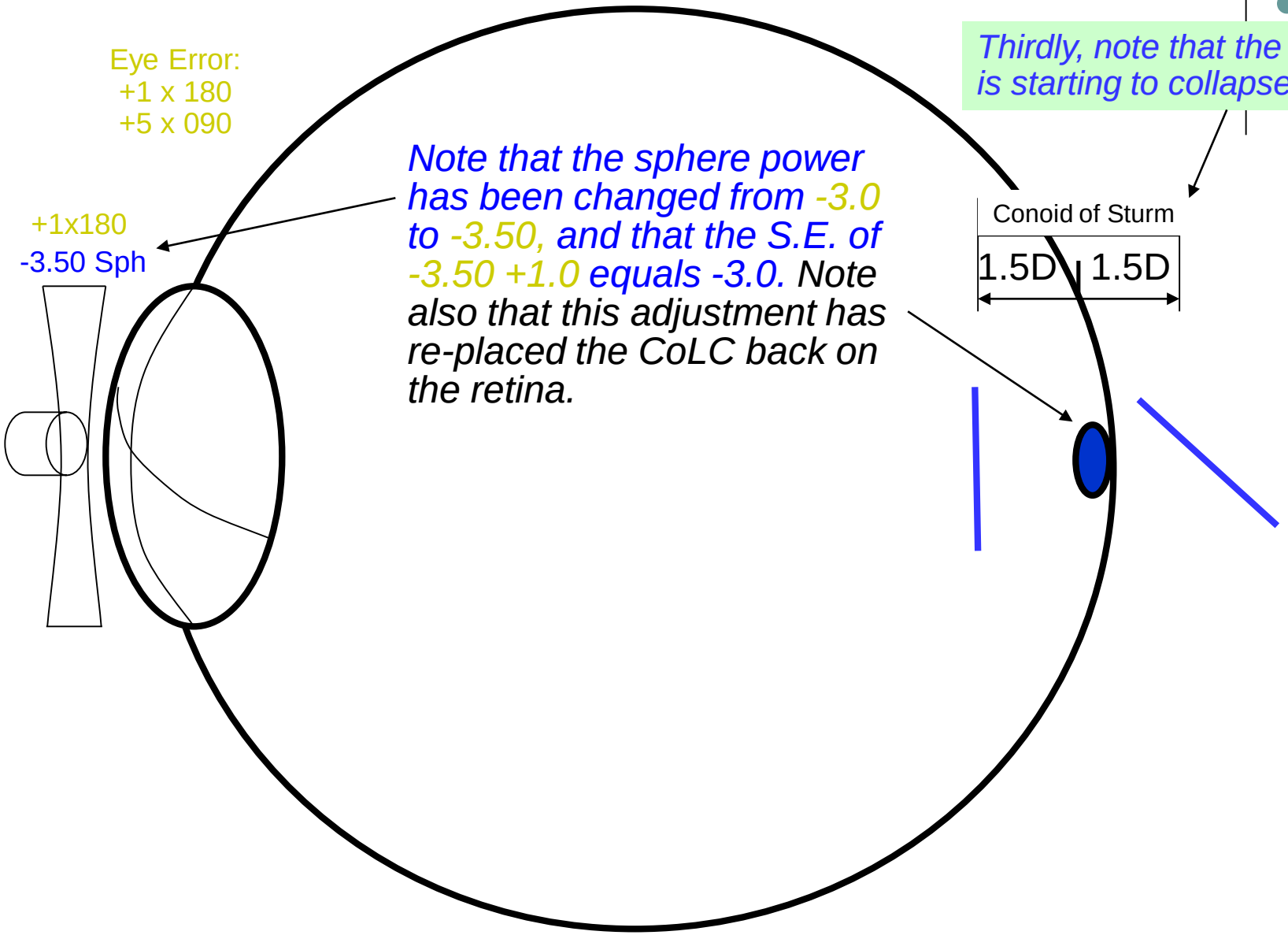


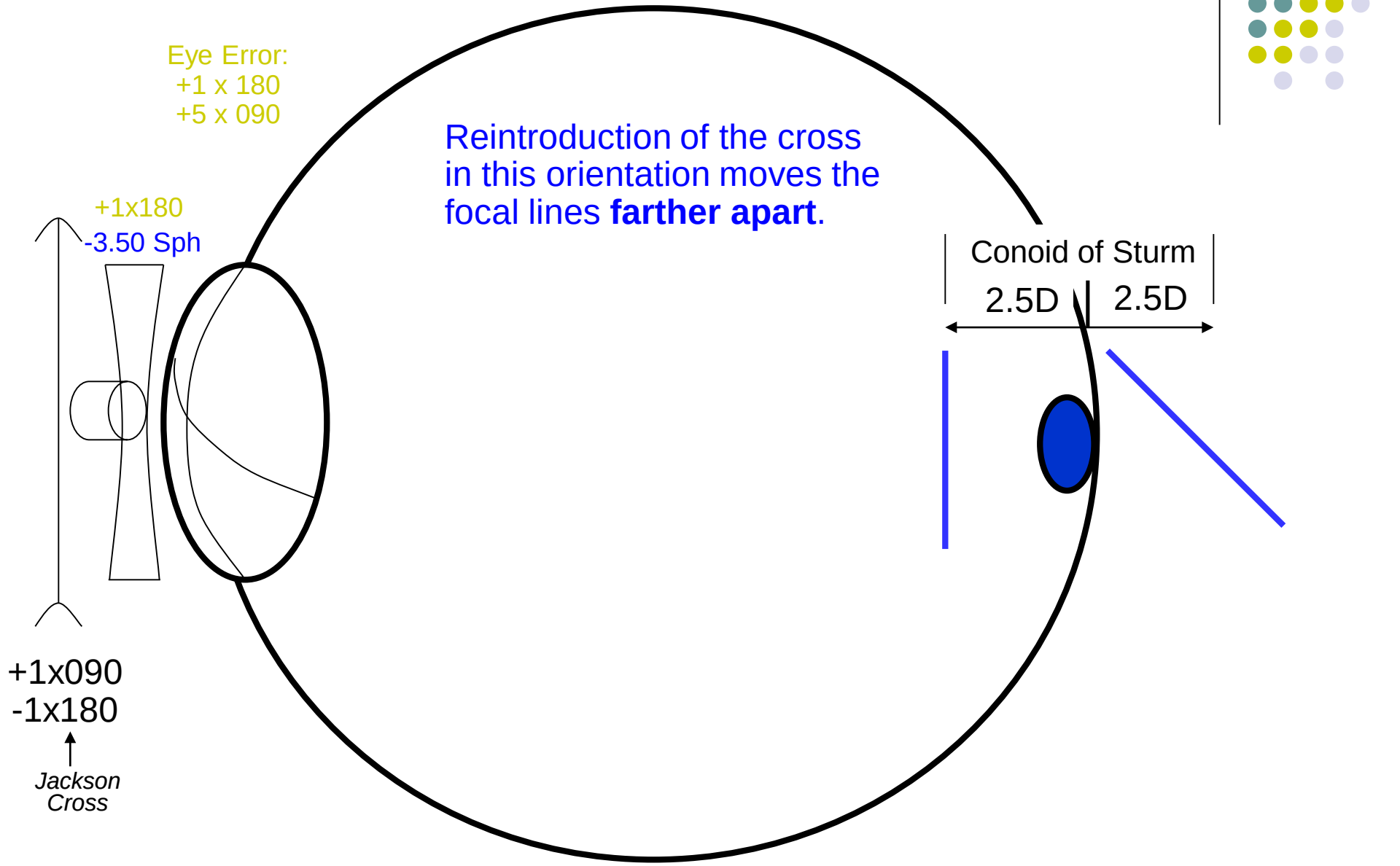
Astigmatic Correction: *Jackson Cross*



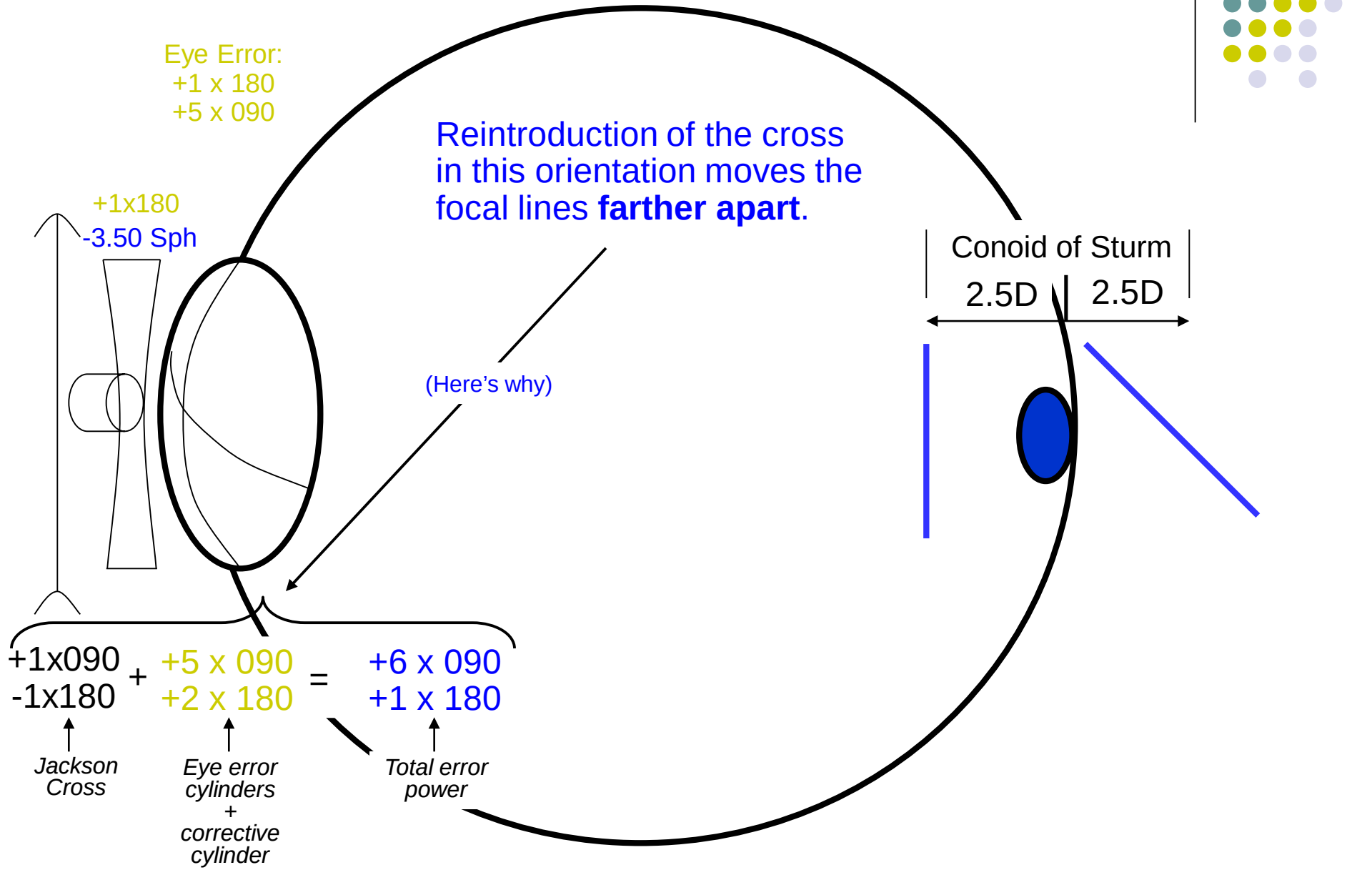
Astigmatic Correction: *Jackson Cross*



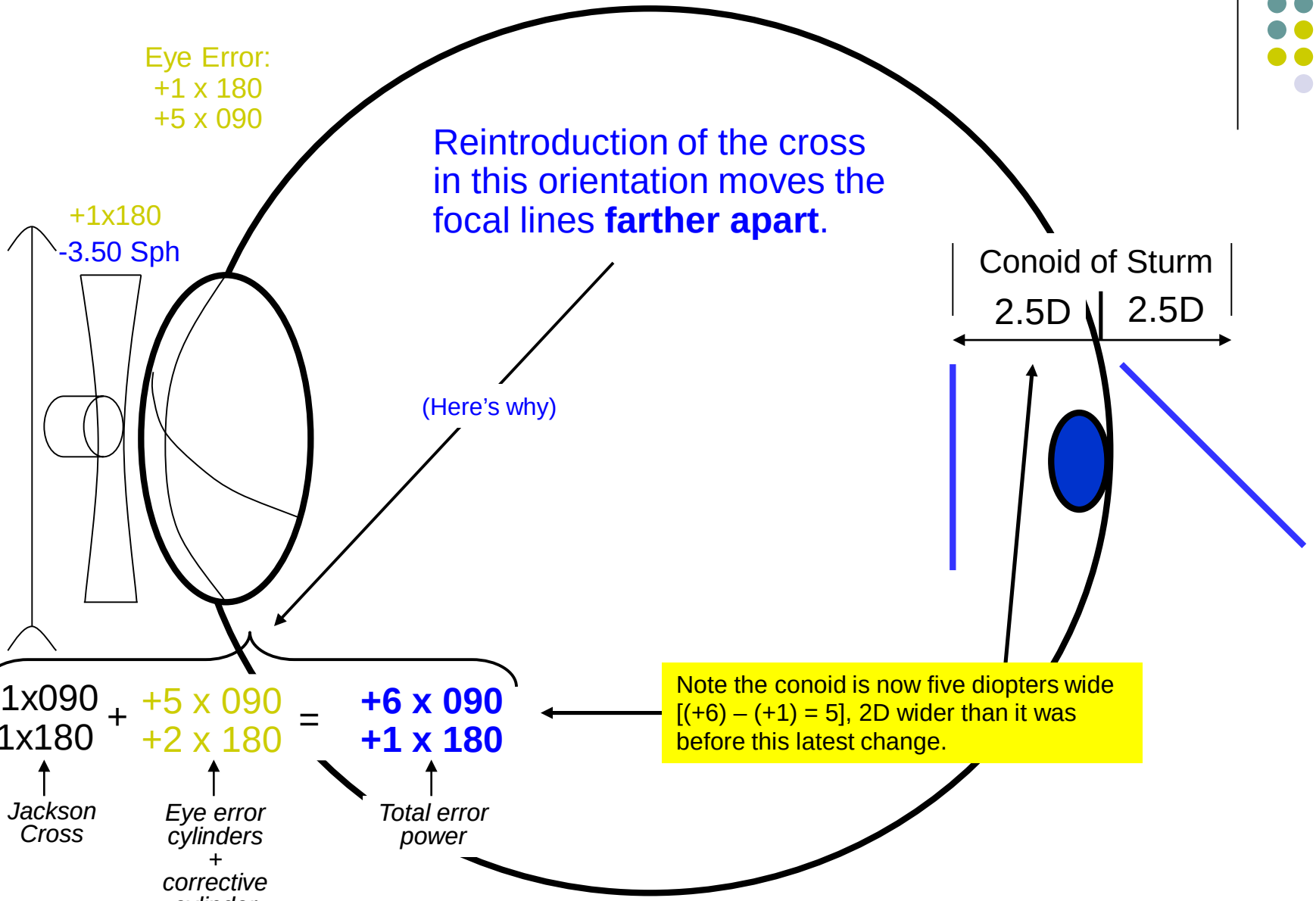
Astigmatic Correction: *Jackson Cross*



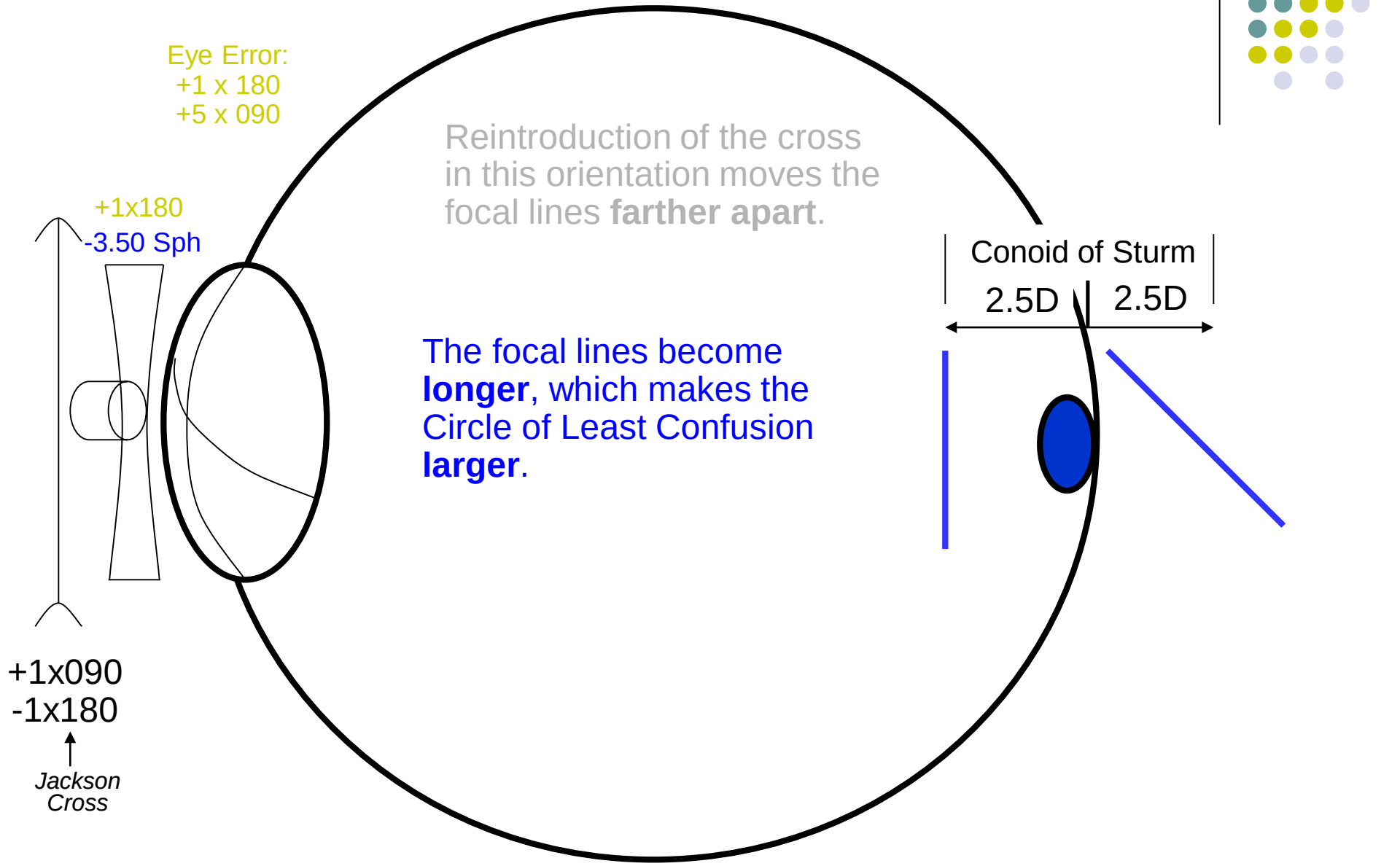
Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*

Eye Error:
+1 x 180
+5 x 090

Reintroduction of the cross in this orientation moves the focal lines **farther apart**.

+1x180
-3.50 Sph

Conoid of Sturm
2.5D 2.5D

The focal lines become **longer**, which makes the Circle of Least Confusion **larger**.

Because the Circle of Least Confusion is larger, the image seems **more blurry** to the patient.

+1x090
-1x180

Jackson Cross

Astigmatic Correction: *Jackson Cross*

Eye Error:
+1 x 180
+5 x 090

+1x180
-3.50 Sph

+1x090
-1x180

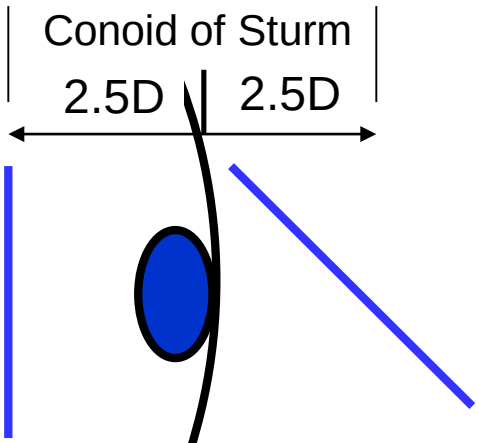
Jackson Cross

Reintroduction of the cross in this orientation moves the focal lines **farther apart**.

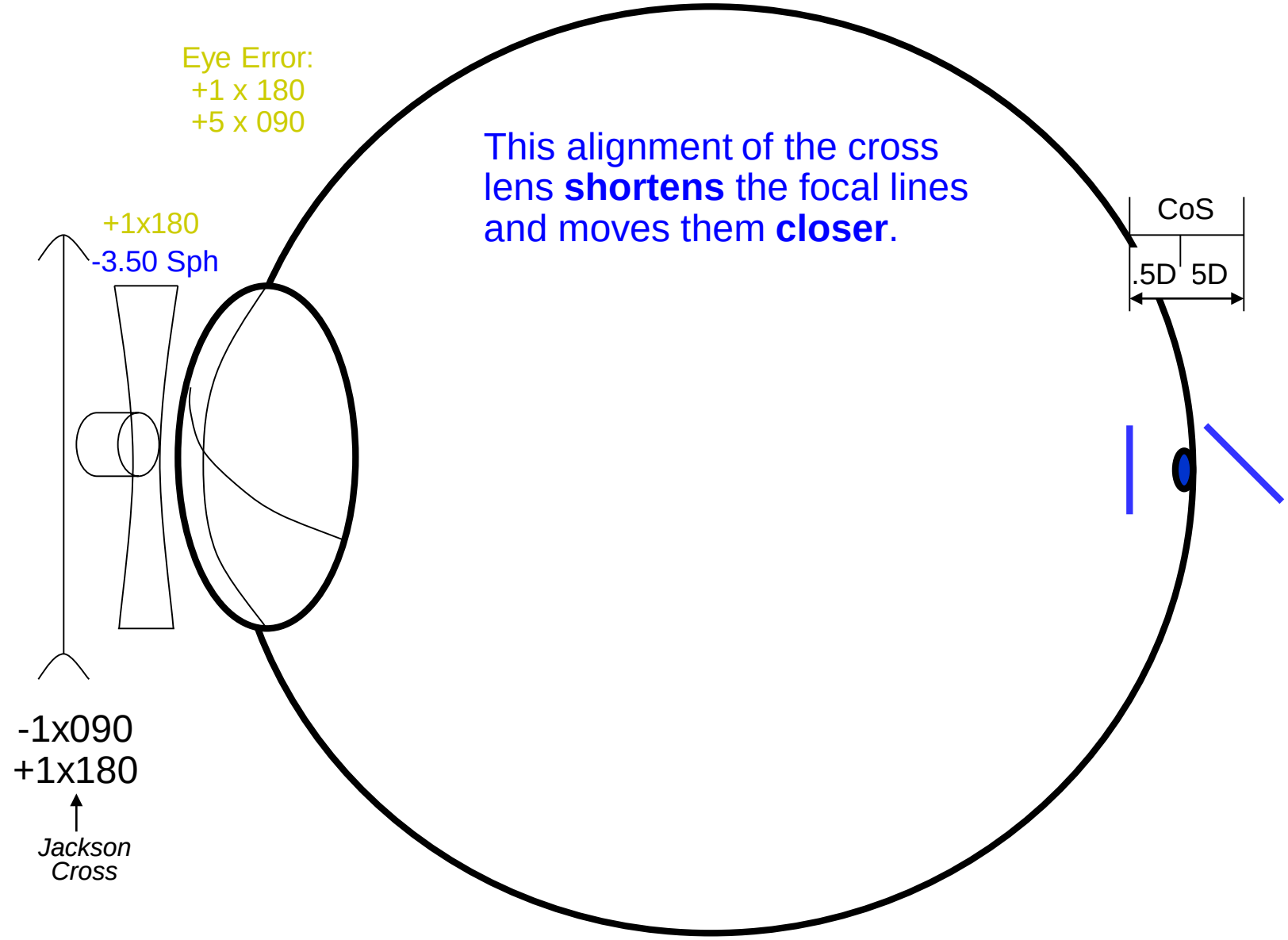
The focal lines become **longer**, which makes the Circle of Least Confusion **larger**.

Because the Circle of Least Confusion is larger, the image seems **more blurry** to the patient.

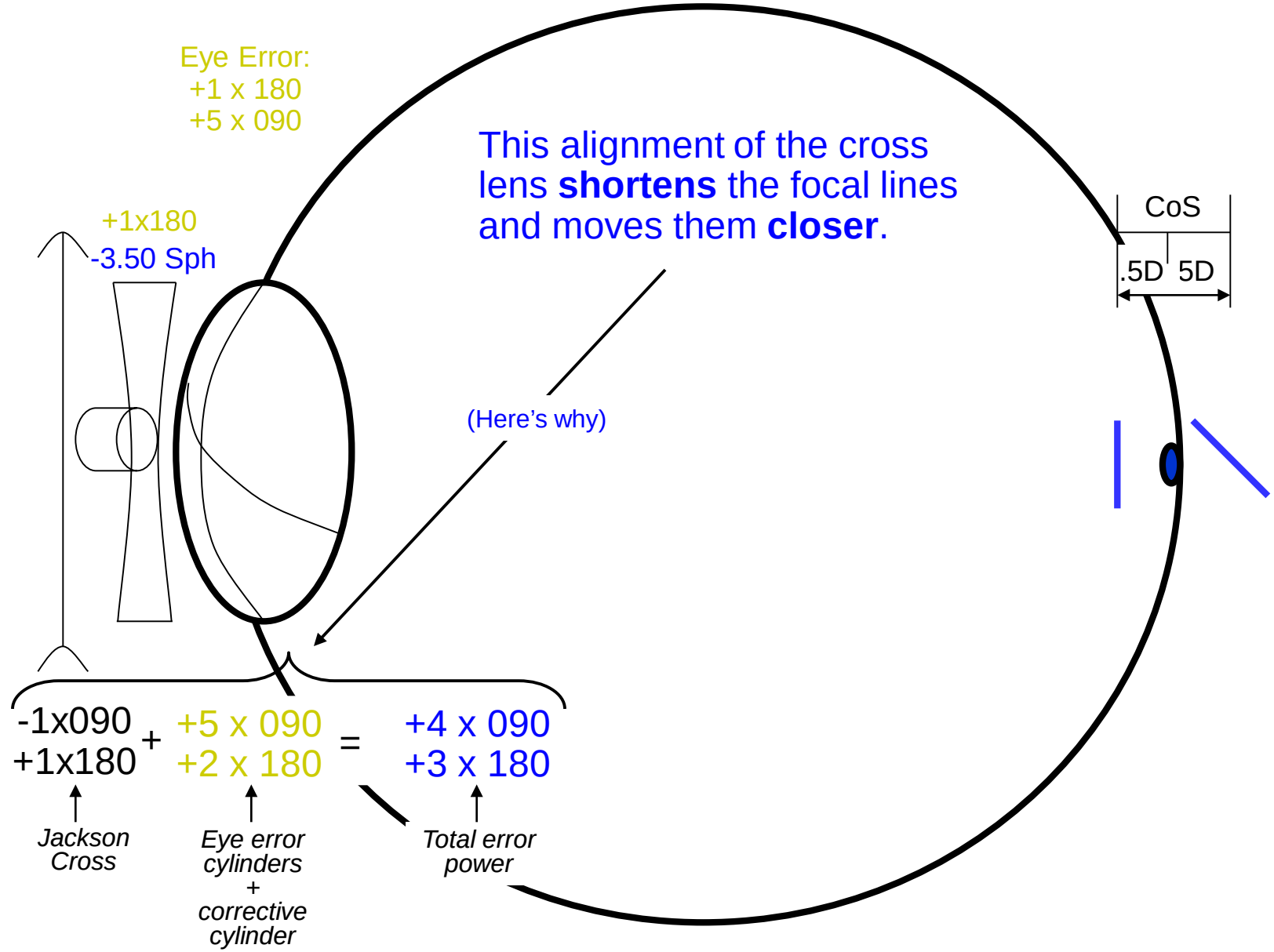
Flip the Jackson cross.



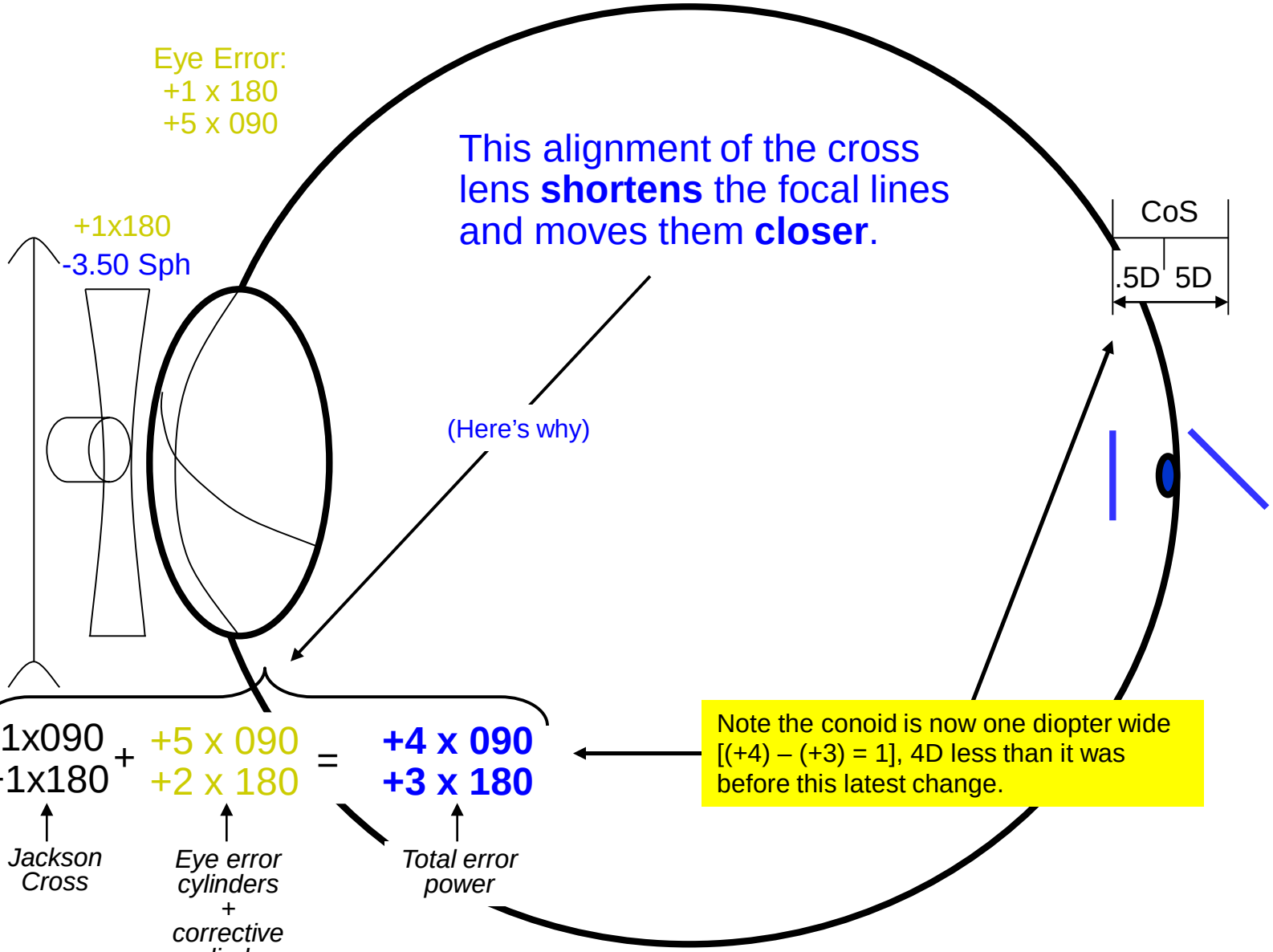
Astigmatic Correction: *Jackson Cross*



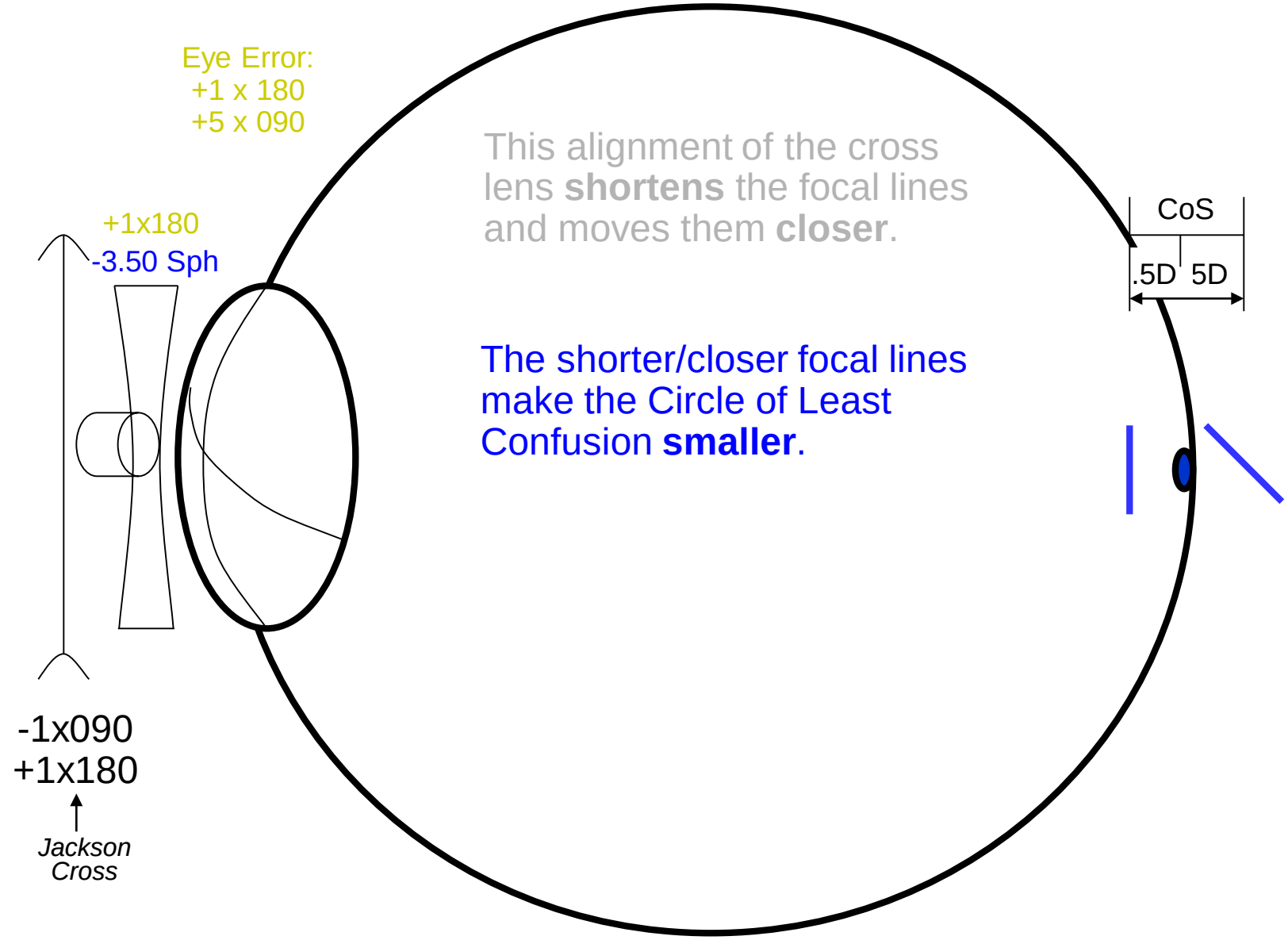
Astigmatic Correction: *Jackson Cross*



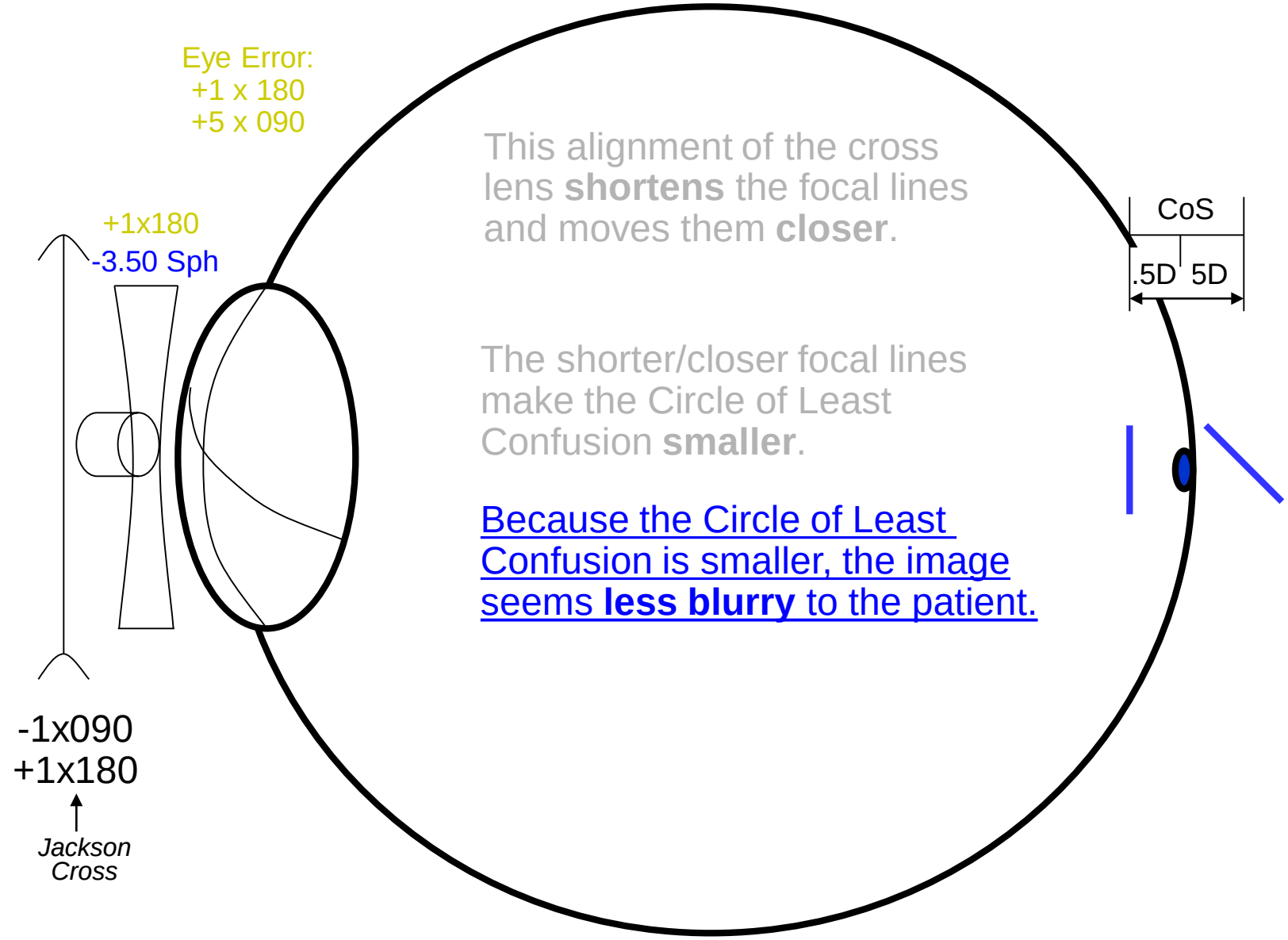
Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



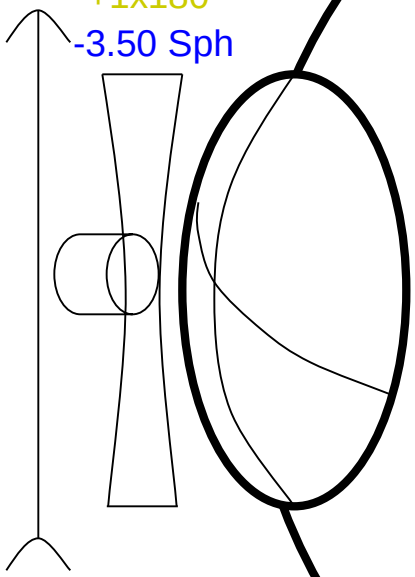
This alignment of the cross lens **shortens** the focal lines and moves them **closer**.

The shorter/closer focal lines make the Circle of Least Confusion **smaller**.

Because the Circle of Least Confusion is smaller, the image seems **less blurry** to the patient.

Astigmatic Correction: *Jackson Cross*

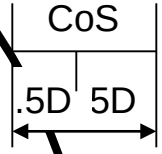
Eye Error:
+1 x 180
+5 x 090



-1x090
+1x180

Jackson Cross

This alignment of the cross lens **shortens** the focal lines and moves them **closer**.

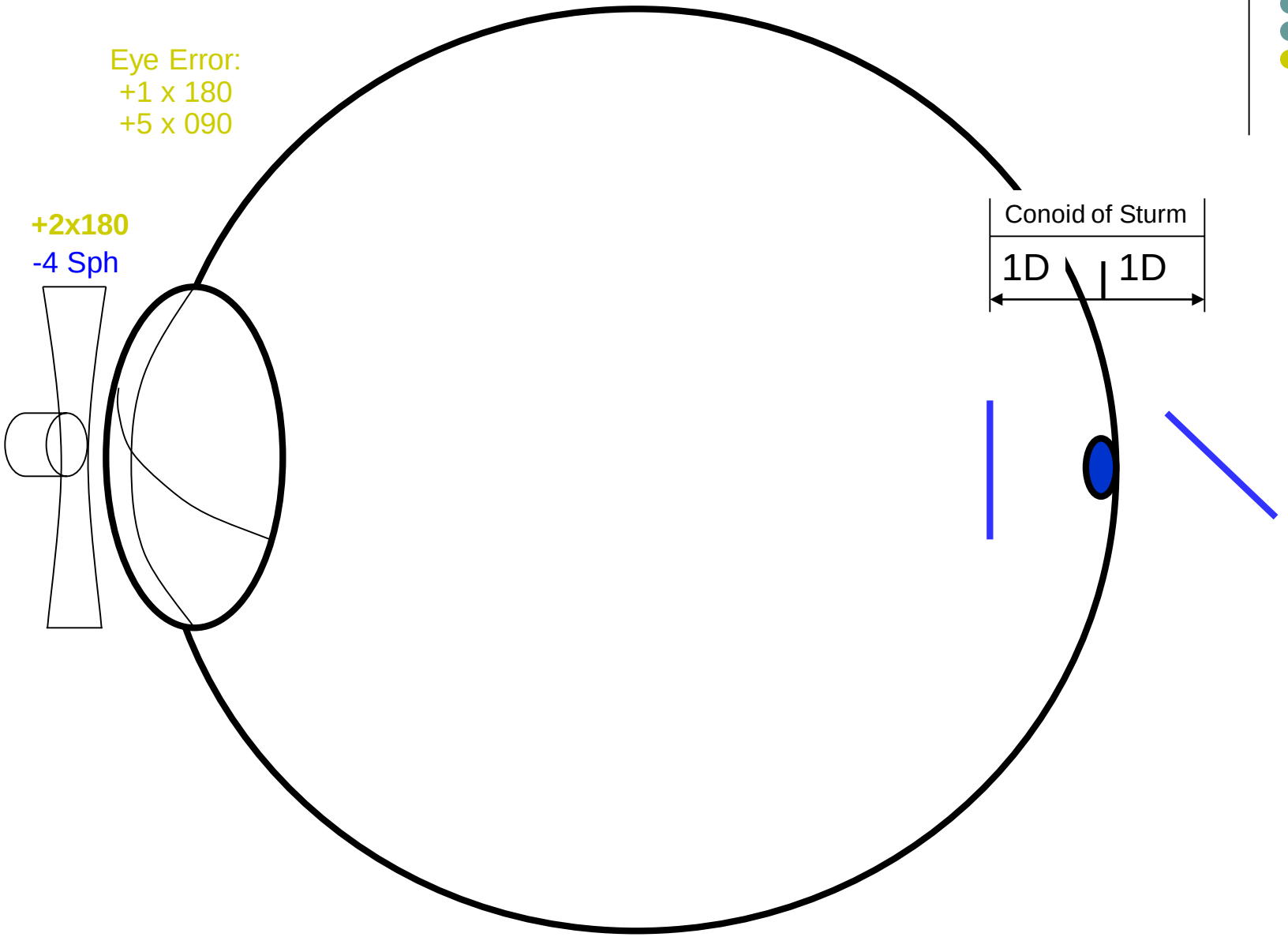


The shorter/closer focal lines make the Circle of Least Confusion **smaller**.

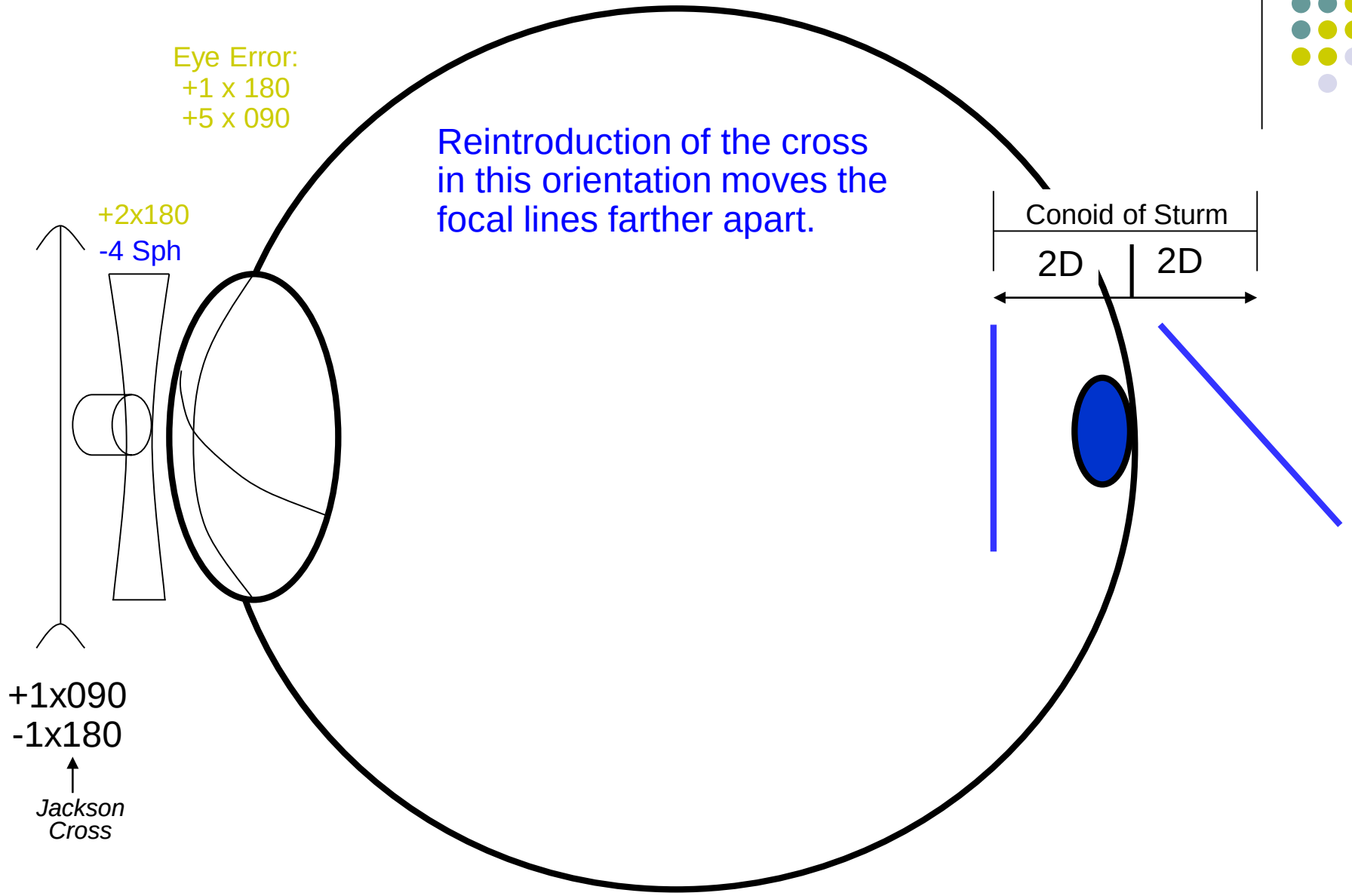
Because the Circle of Least Confusion is smaller, the image seems **less blurry** to the patient.

Because this is less blurry, +1 x 180 is added at the phoropter. (You remember to adjust the sphere.)

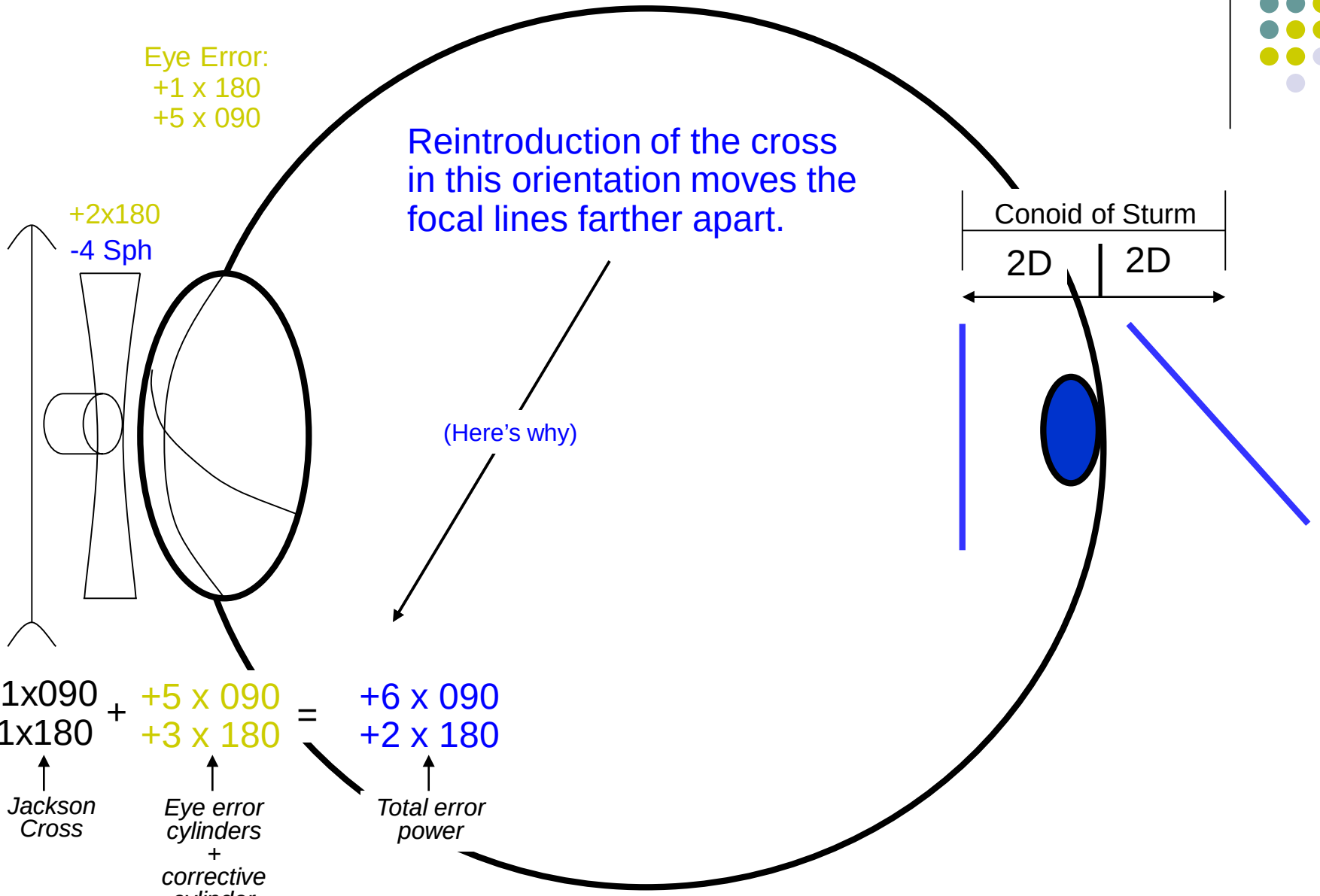
Astigmatic Correction: *Jackson Cross*



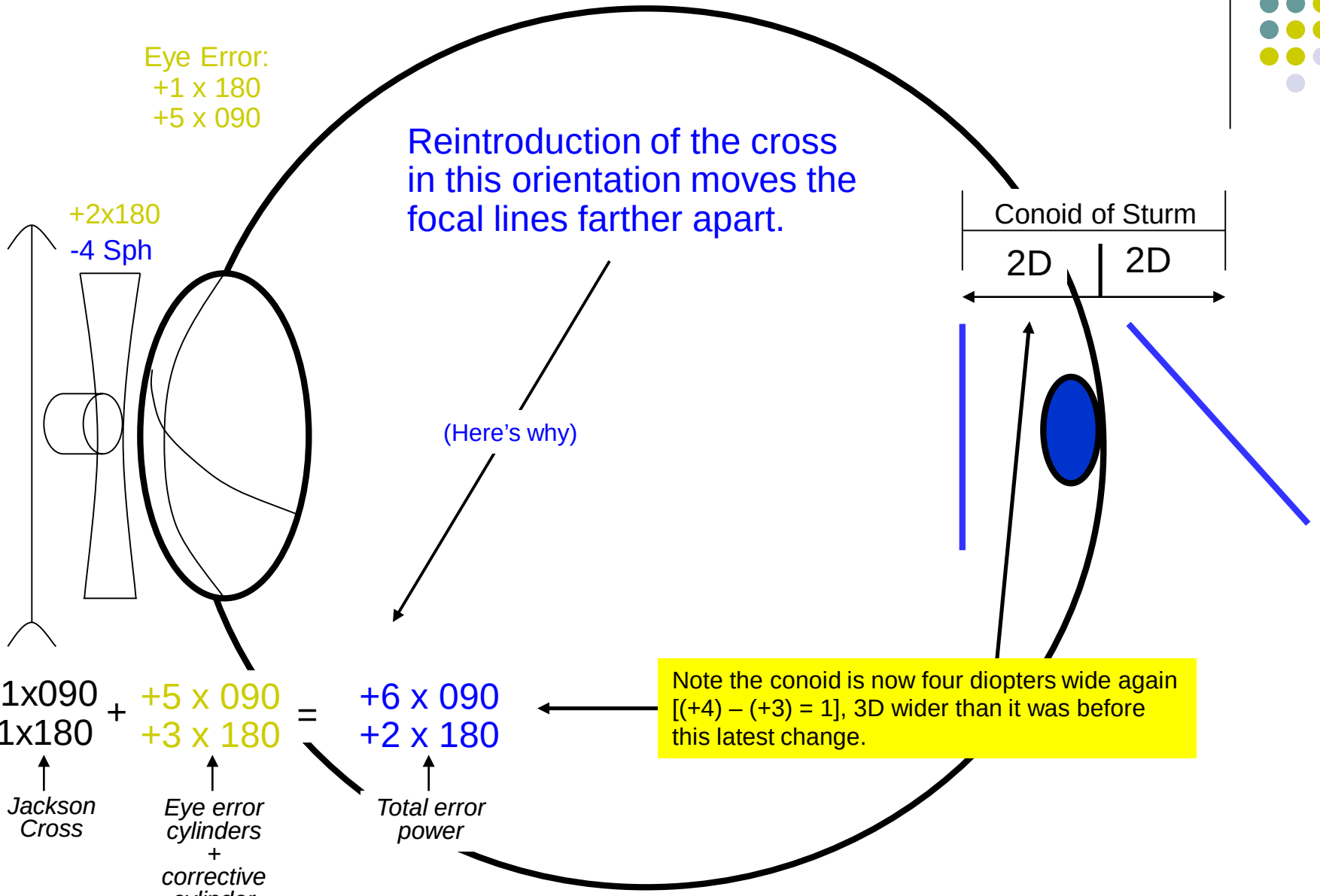
Astigmatic Correction: *Jackson Cross*



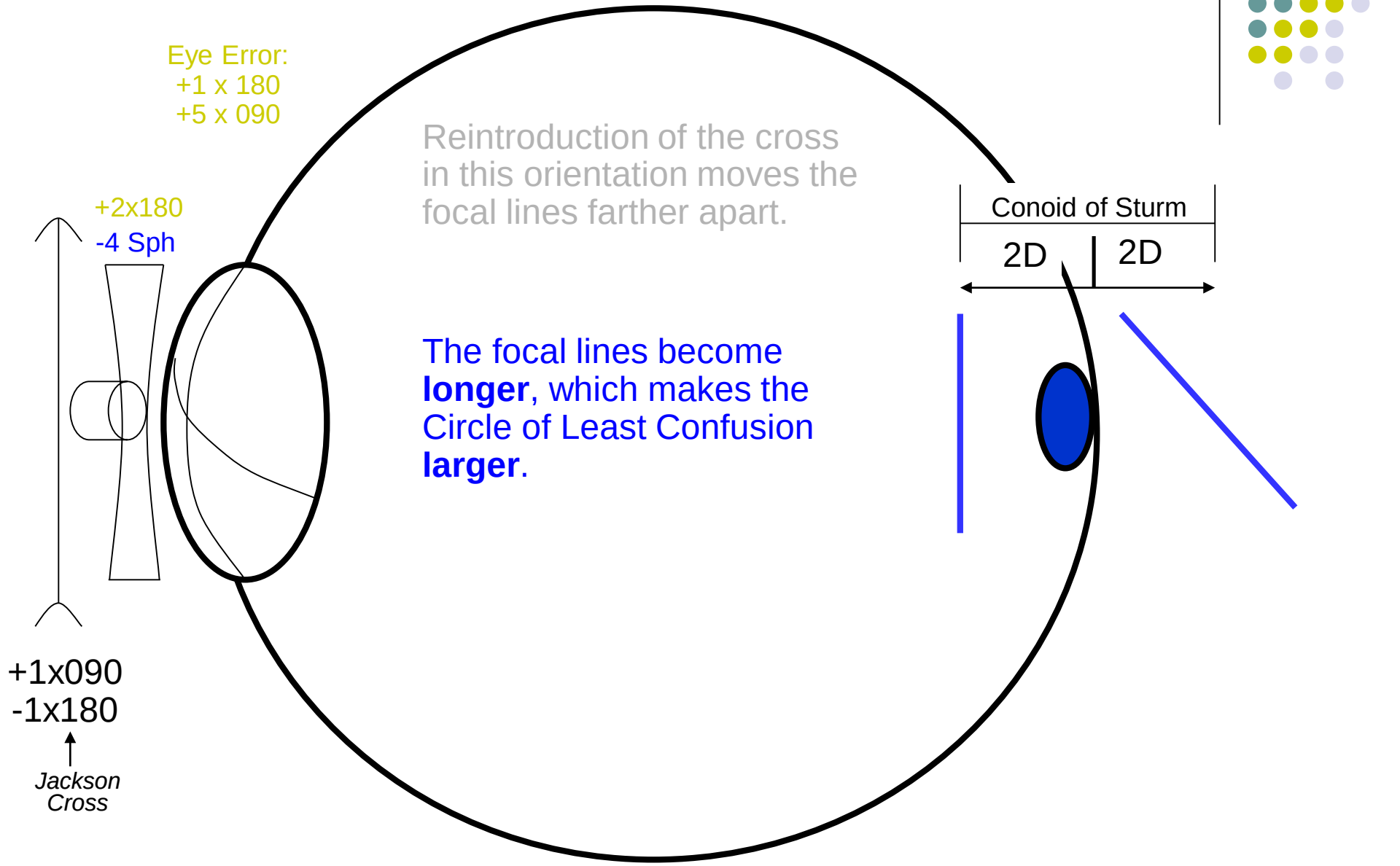
Astigmatic Correction: *Jackson Cross*



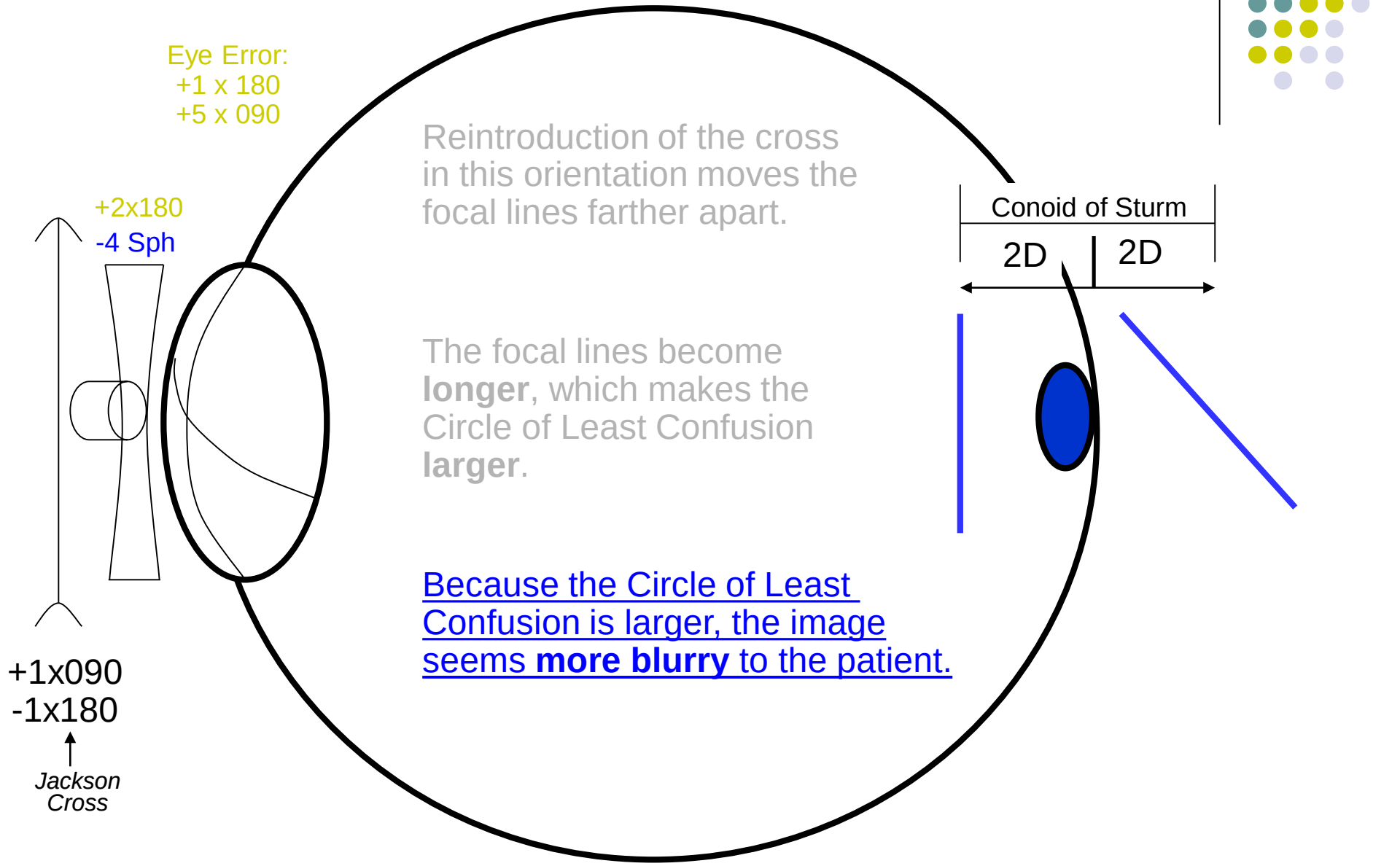
Astigmatic Correction: *Jackson Cross*



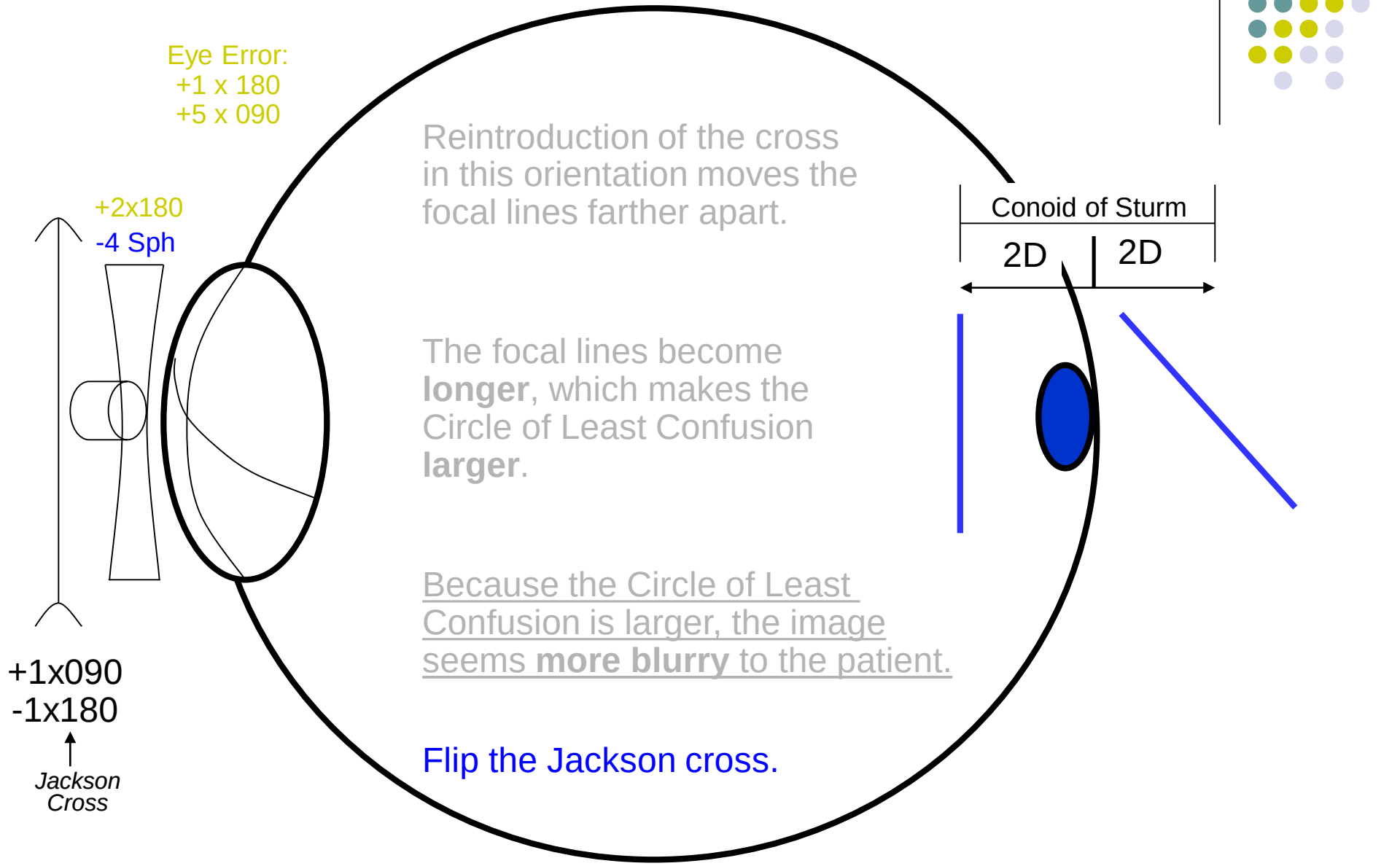
Astigmatic Correction: *Jackson Cross*



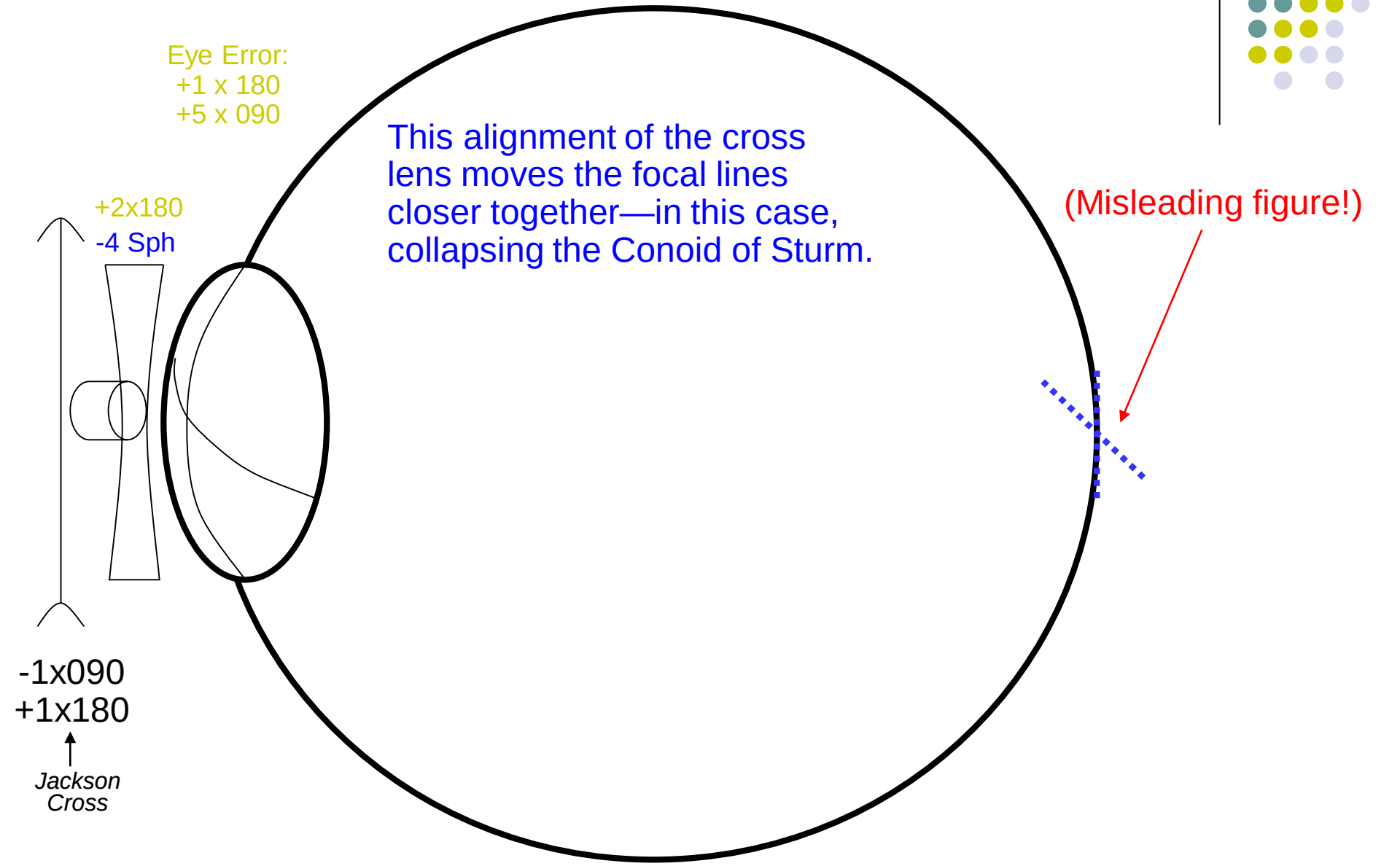
Astigmatic Correction: *Jackson Cross*



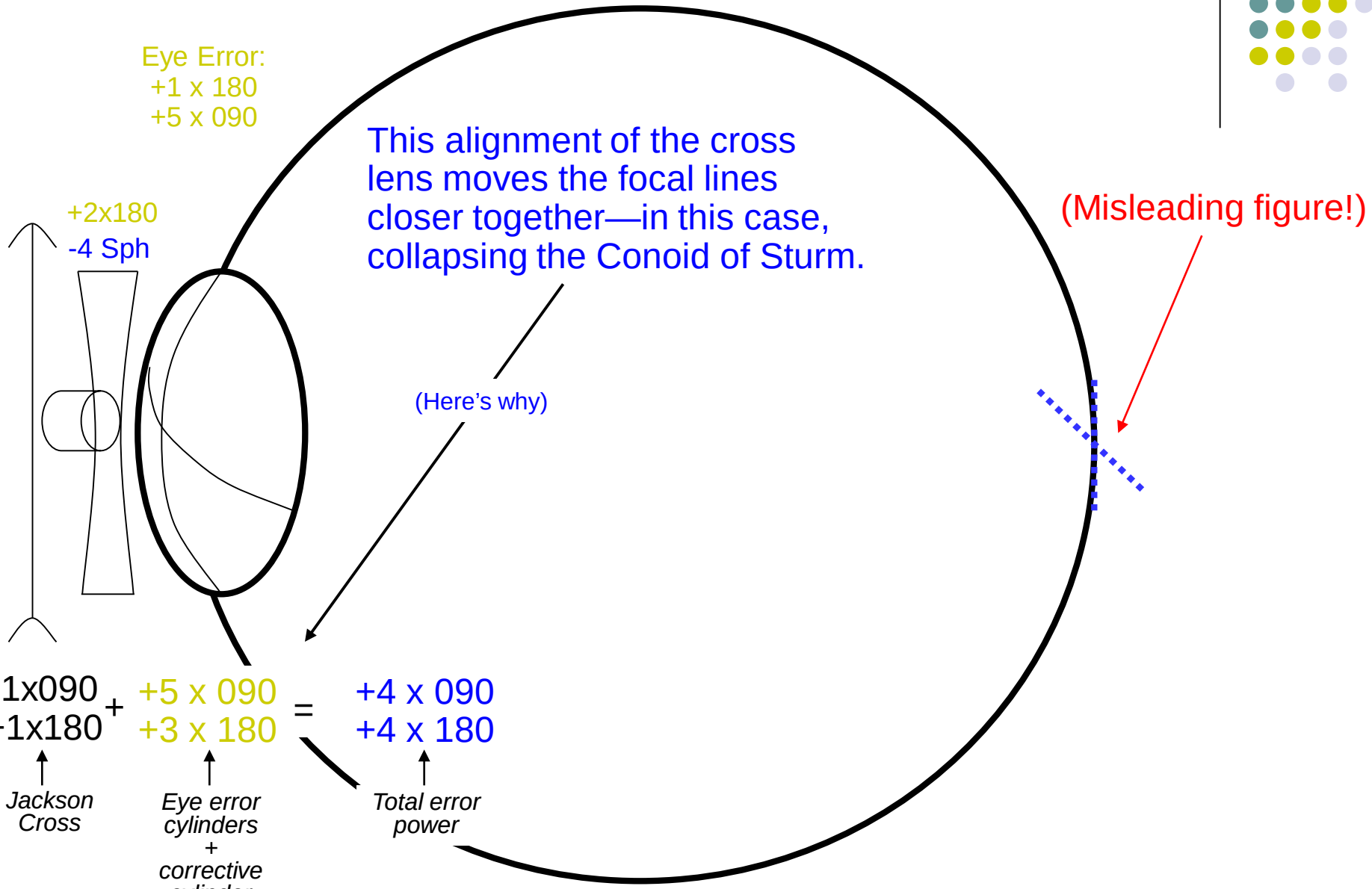
Astigmatic Correction: *Jackson Cross*



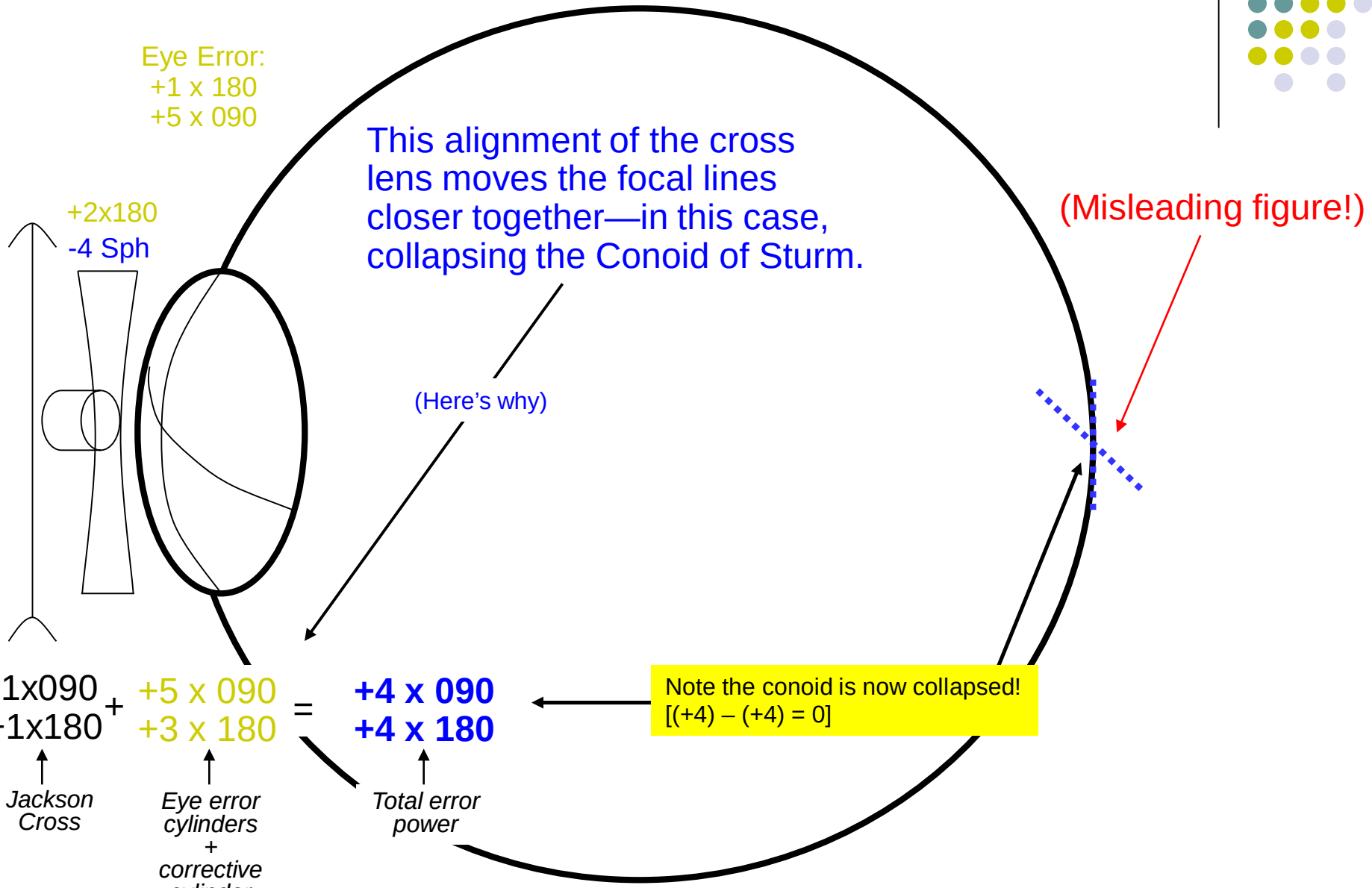
Astigmatic Correction: *Jackson Cross*



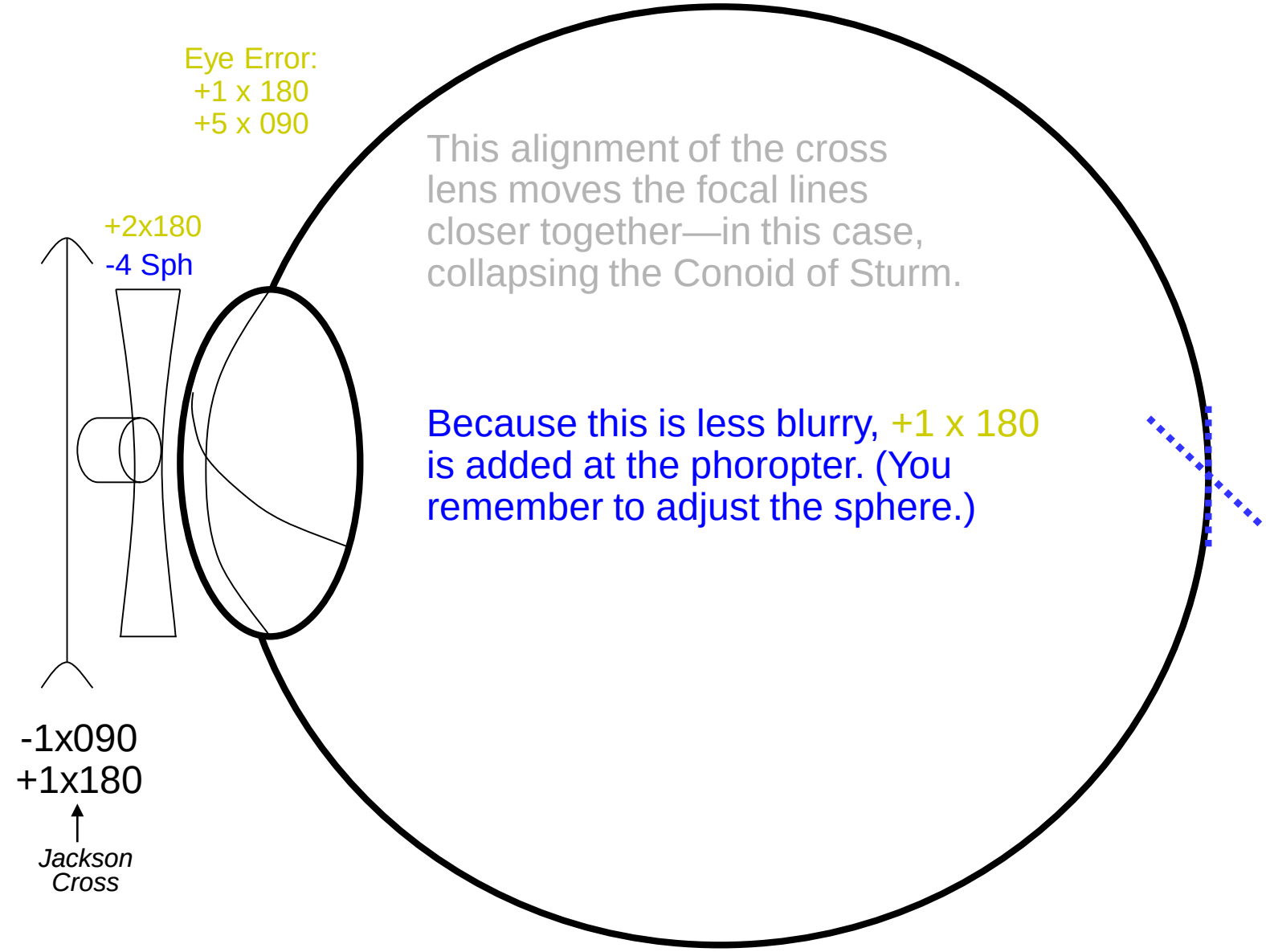
Astigmatic Correction: *Jackson Cross*



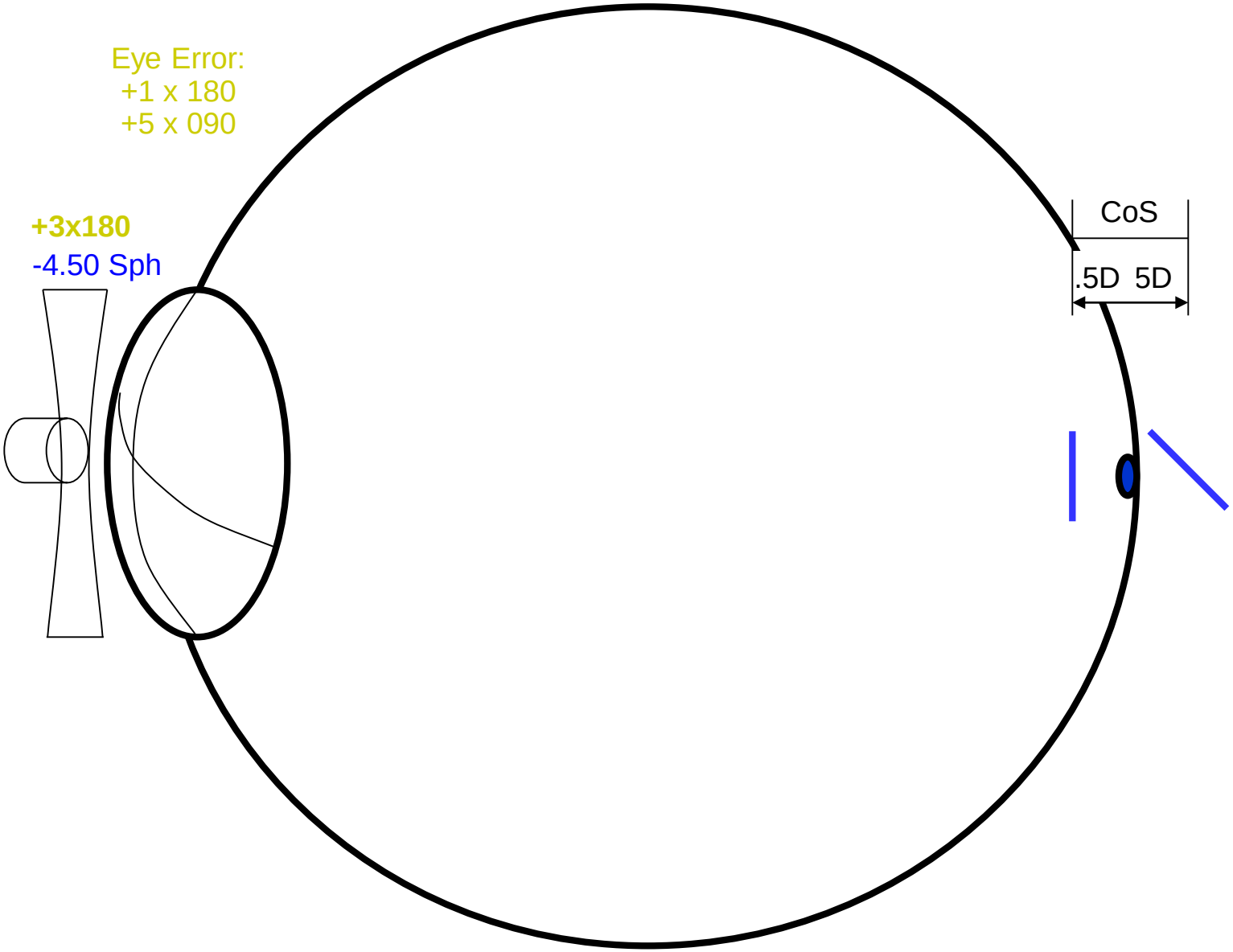
Astigmatic Correction: *Jackson Cross*



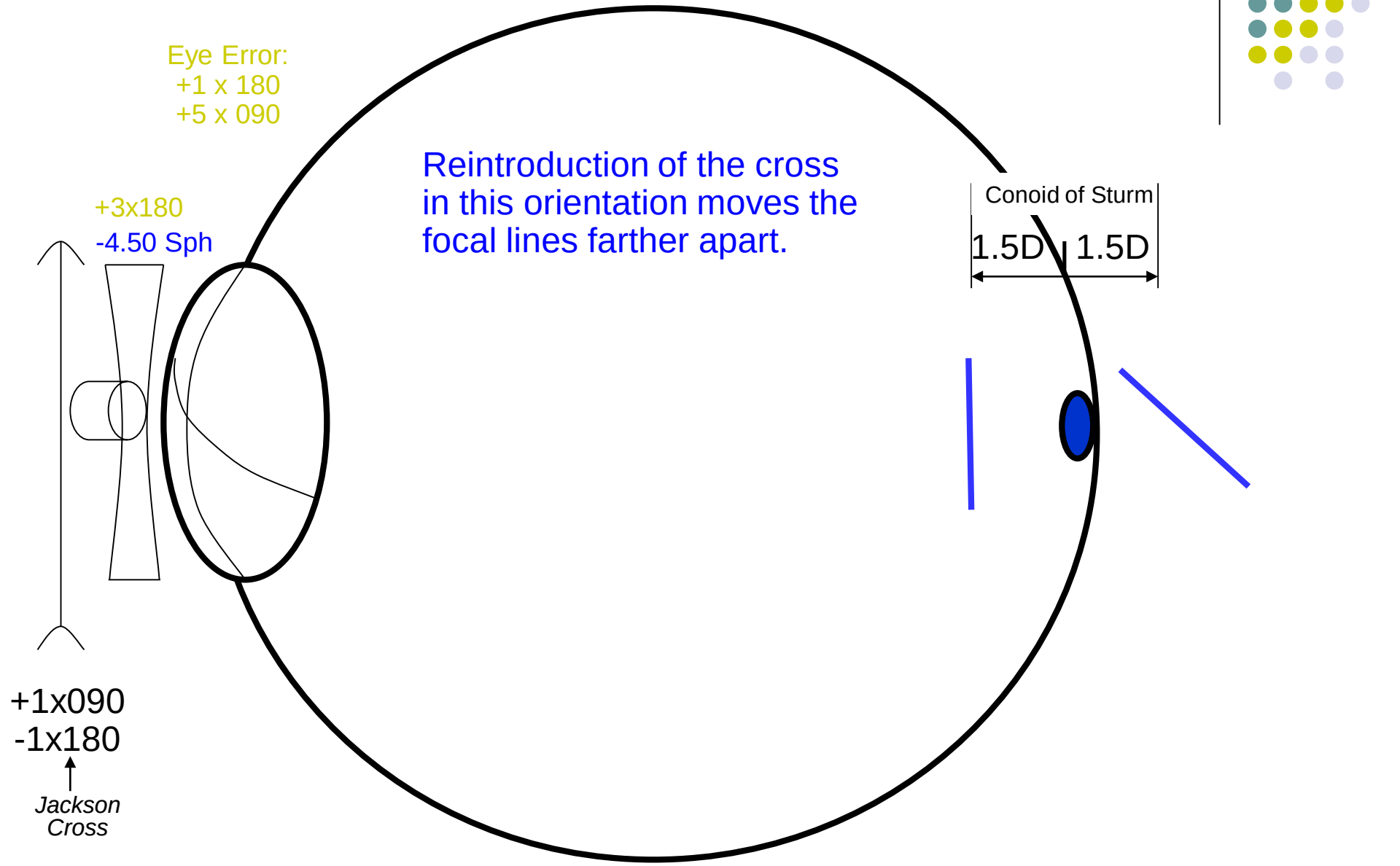
Astigmatic Correction: *Jackson Cross*



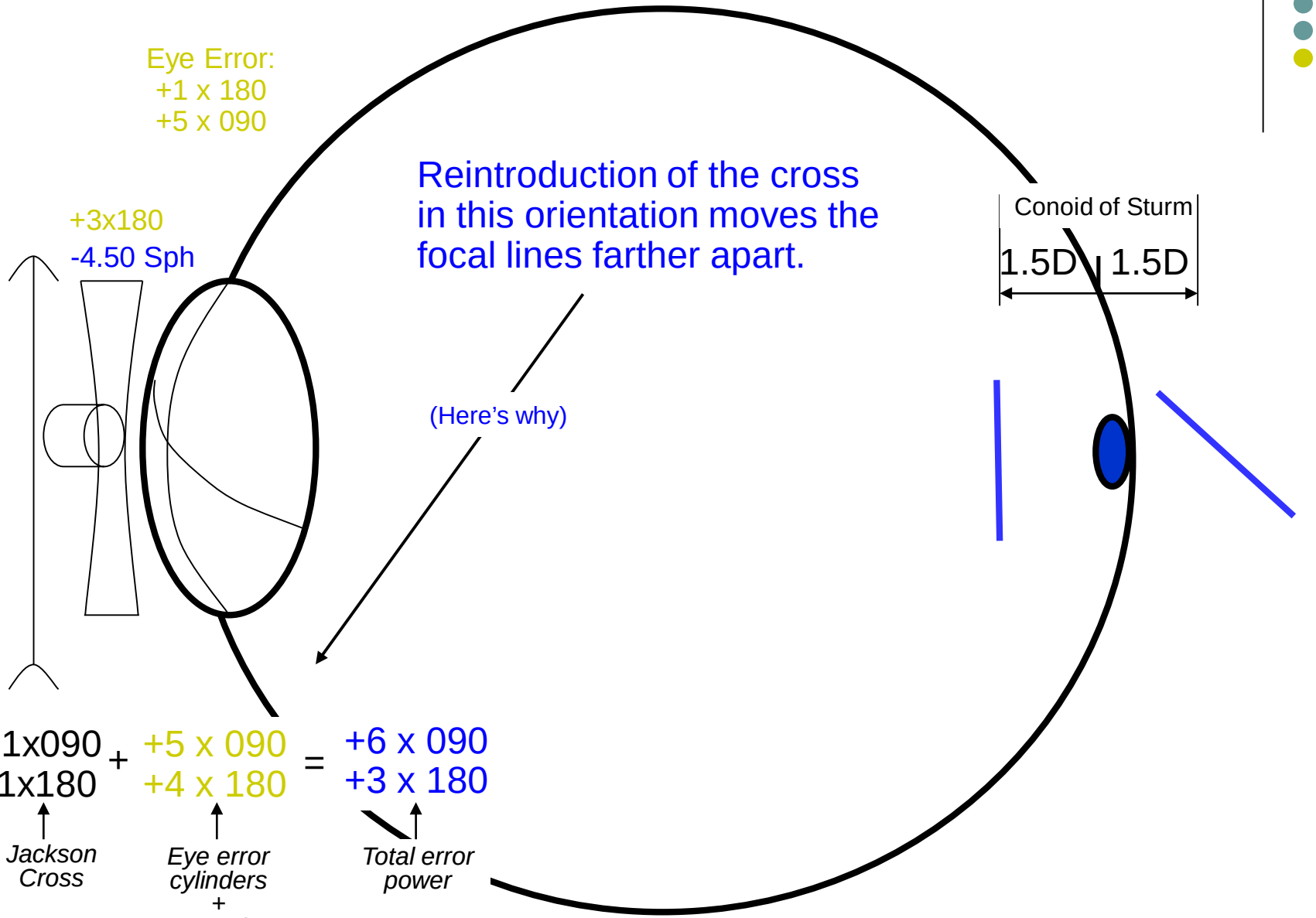
Astigmatic Correction: *Jackson Cross*



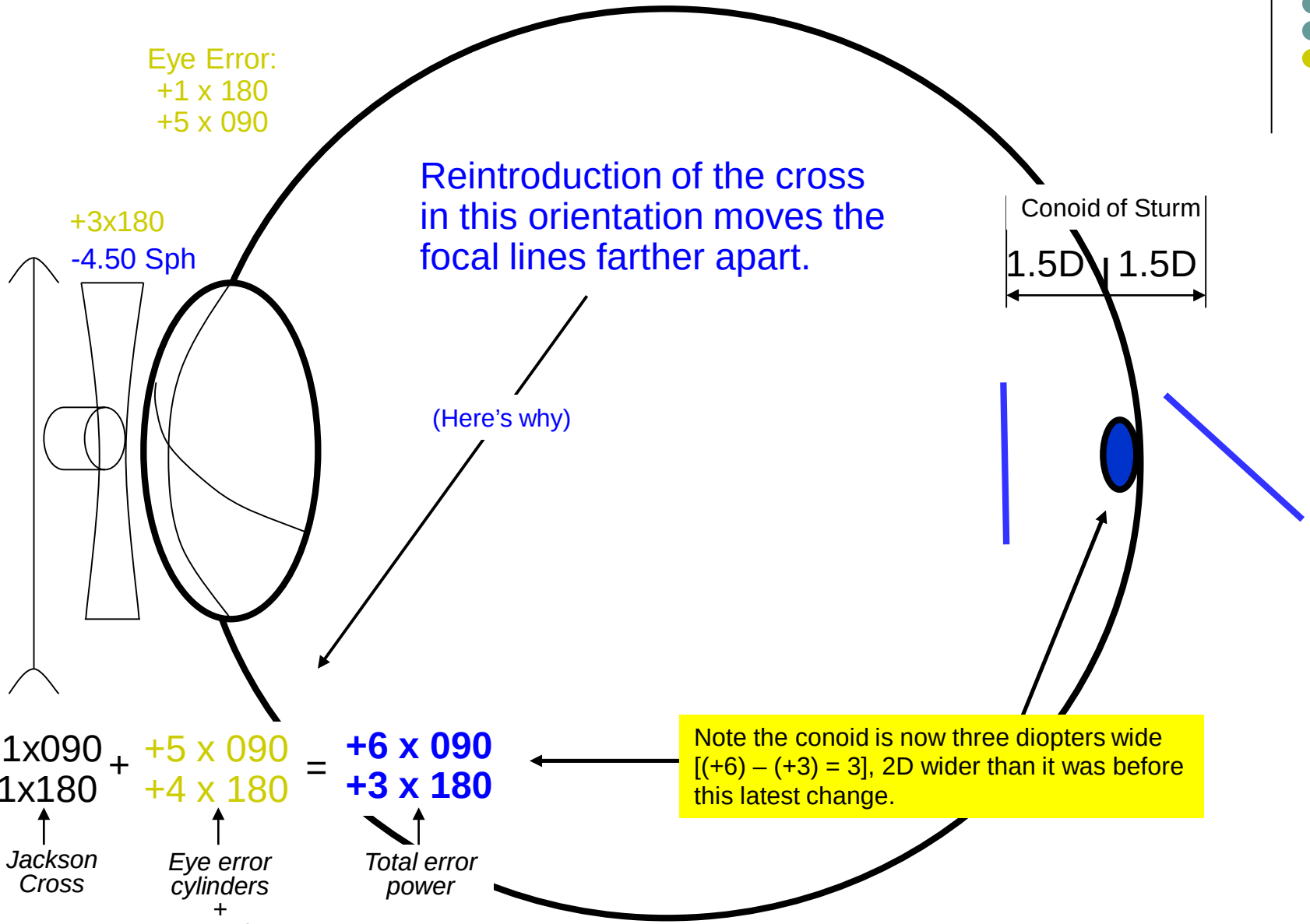
Astigmatic Correction: *Jackson Cross*



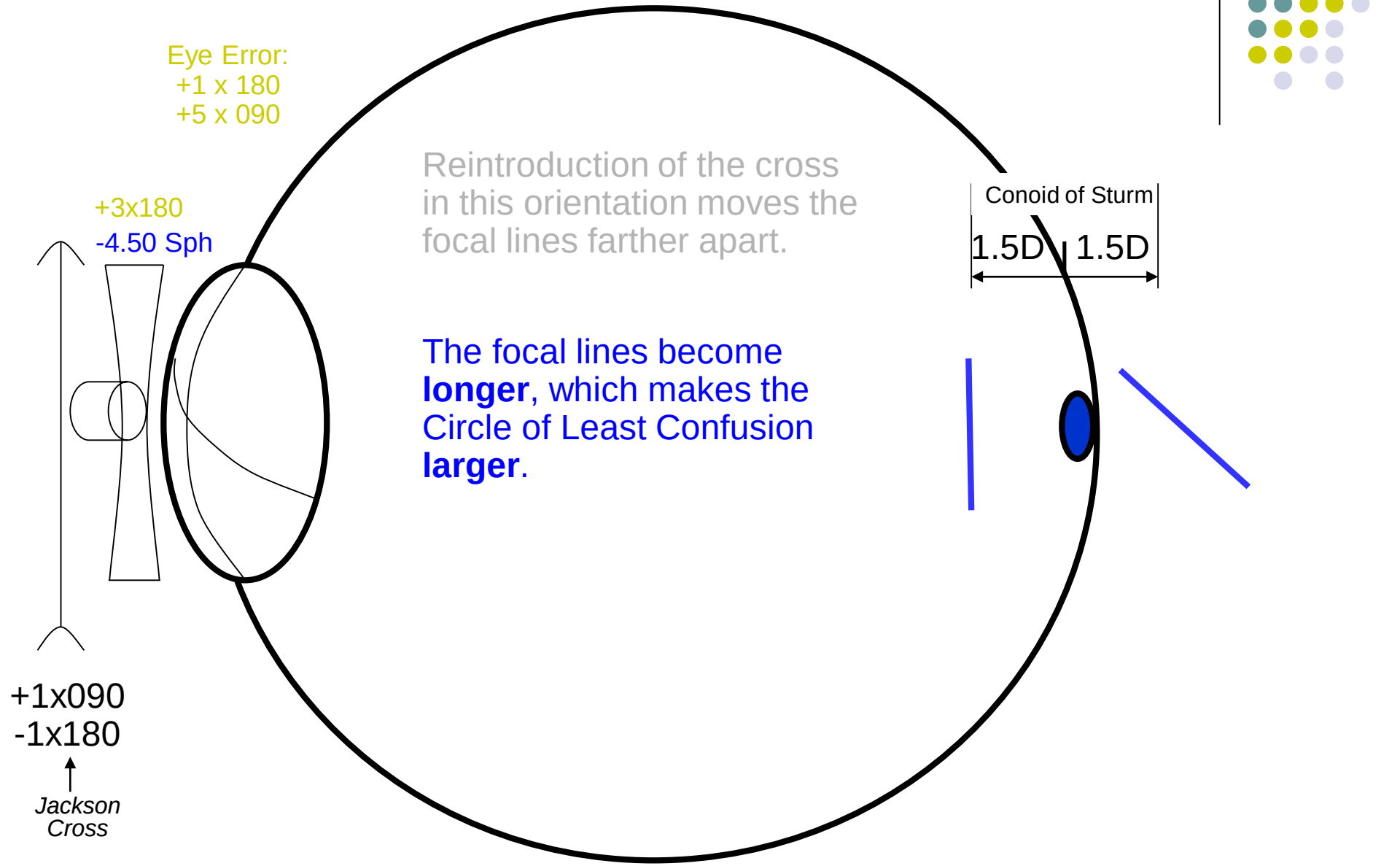
Astigmatic Correction: *Jackson Cross*



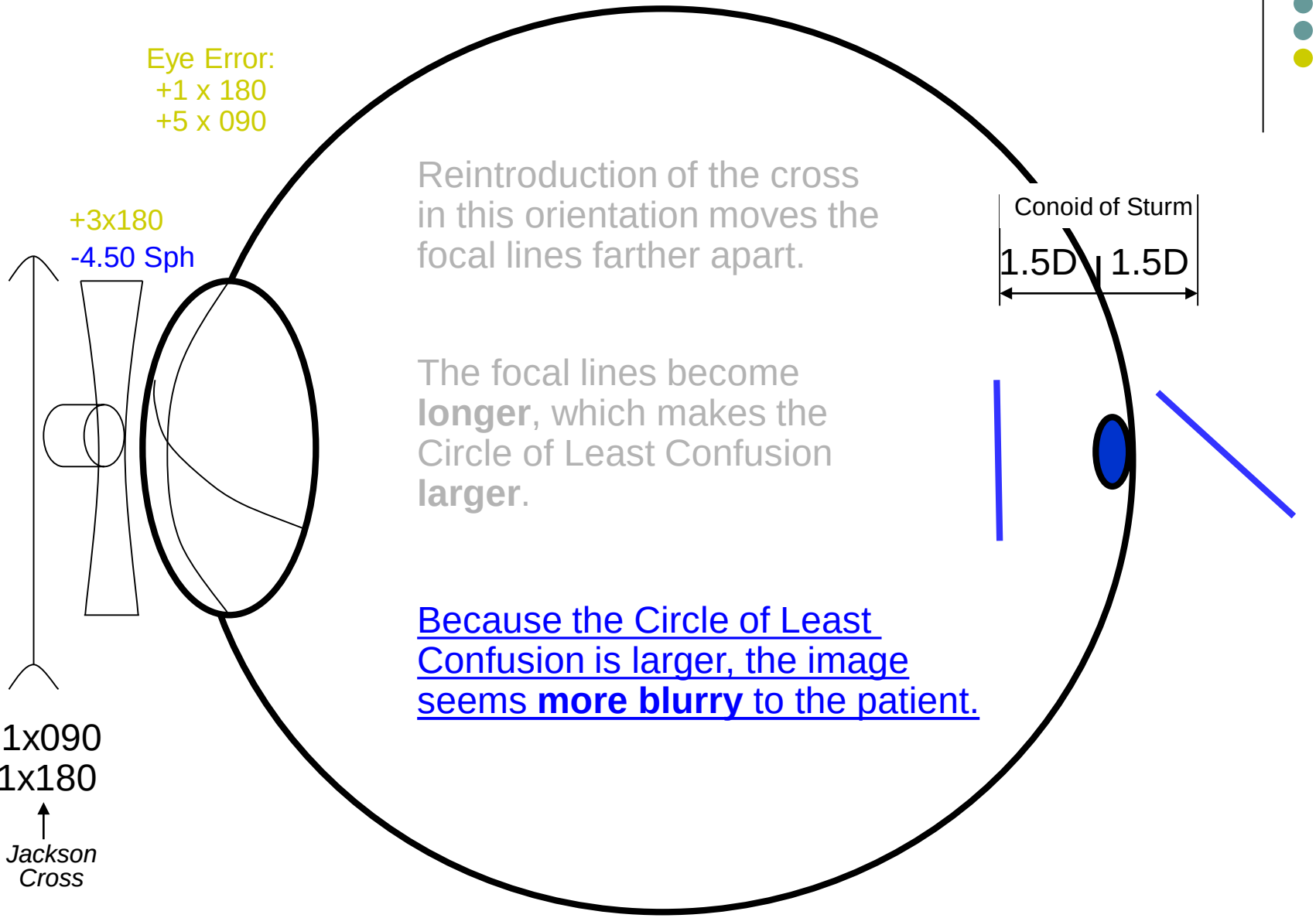
Astigmatic Correction: *Jackson Cross*



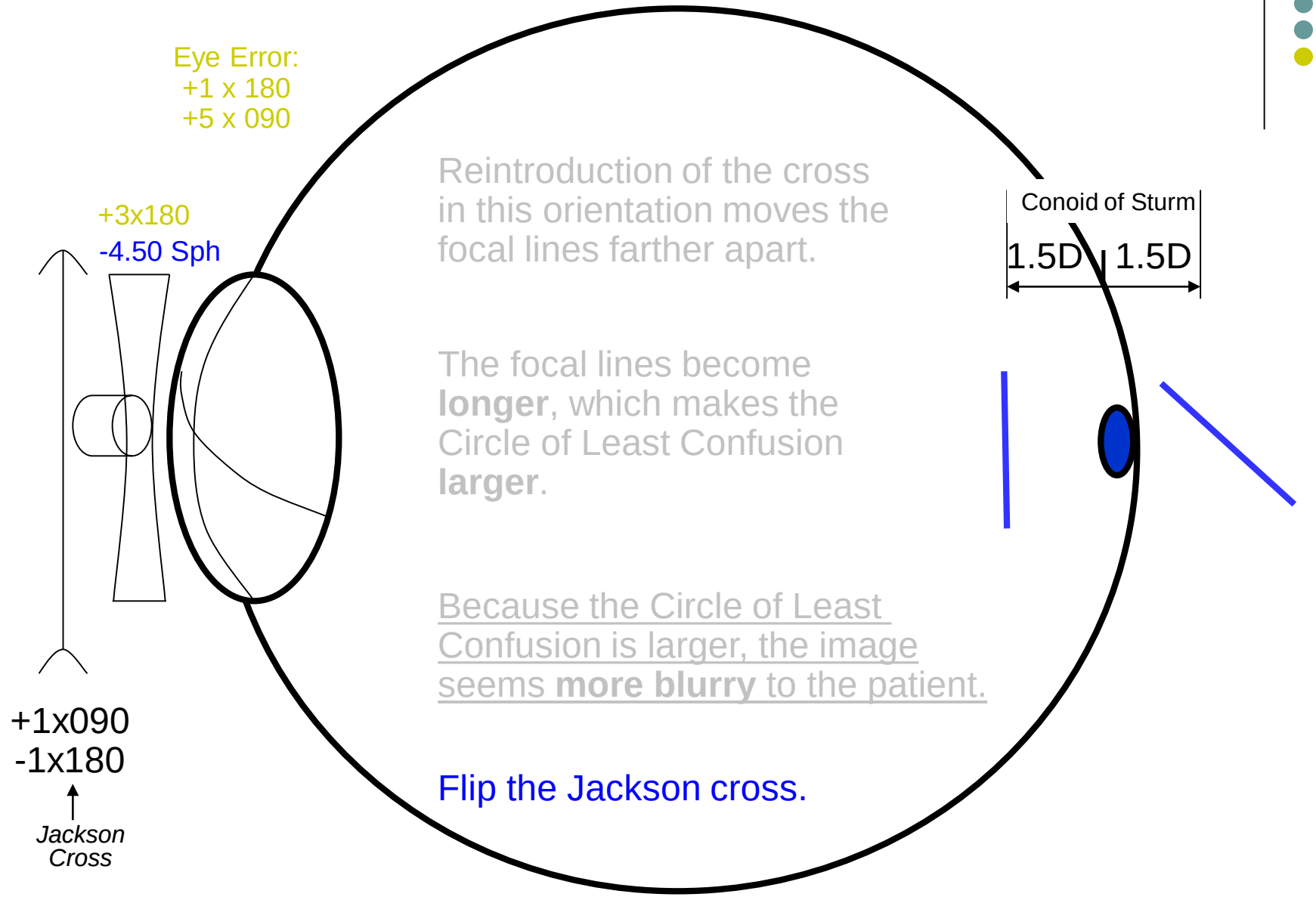
Astigmatic Correction: *Jackson Cross*



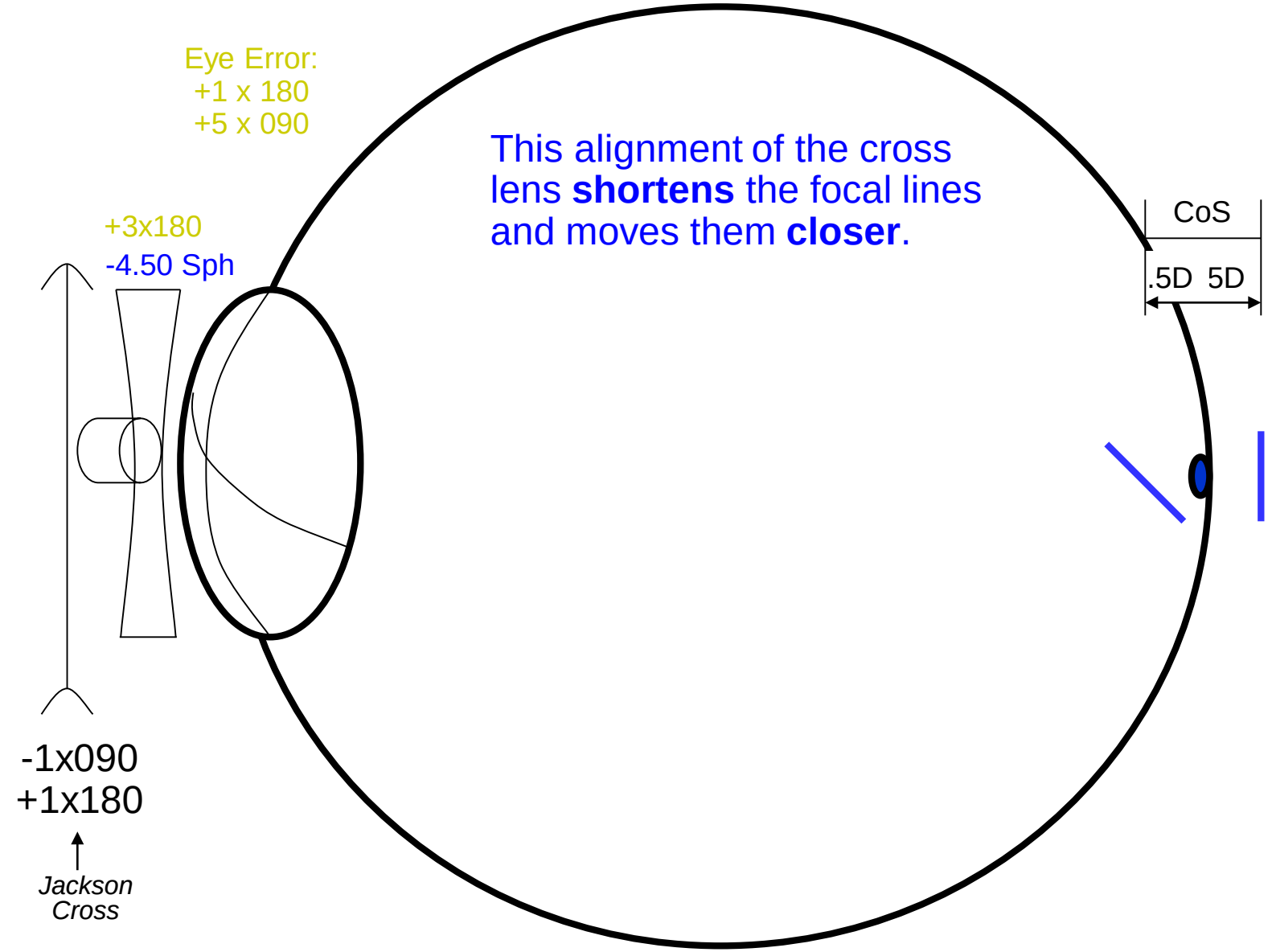
Astigmatic Correction: *Jackson Cross*



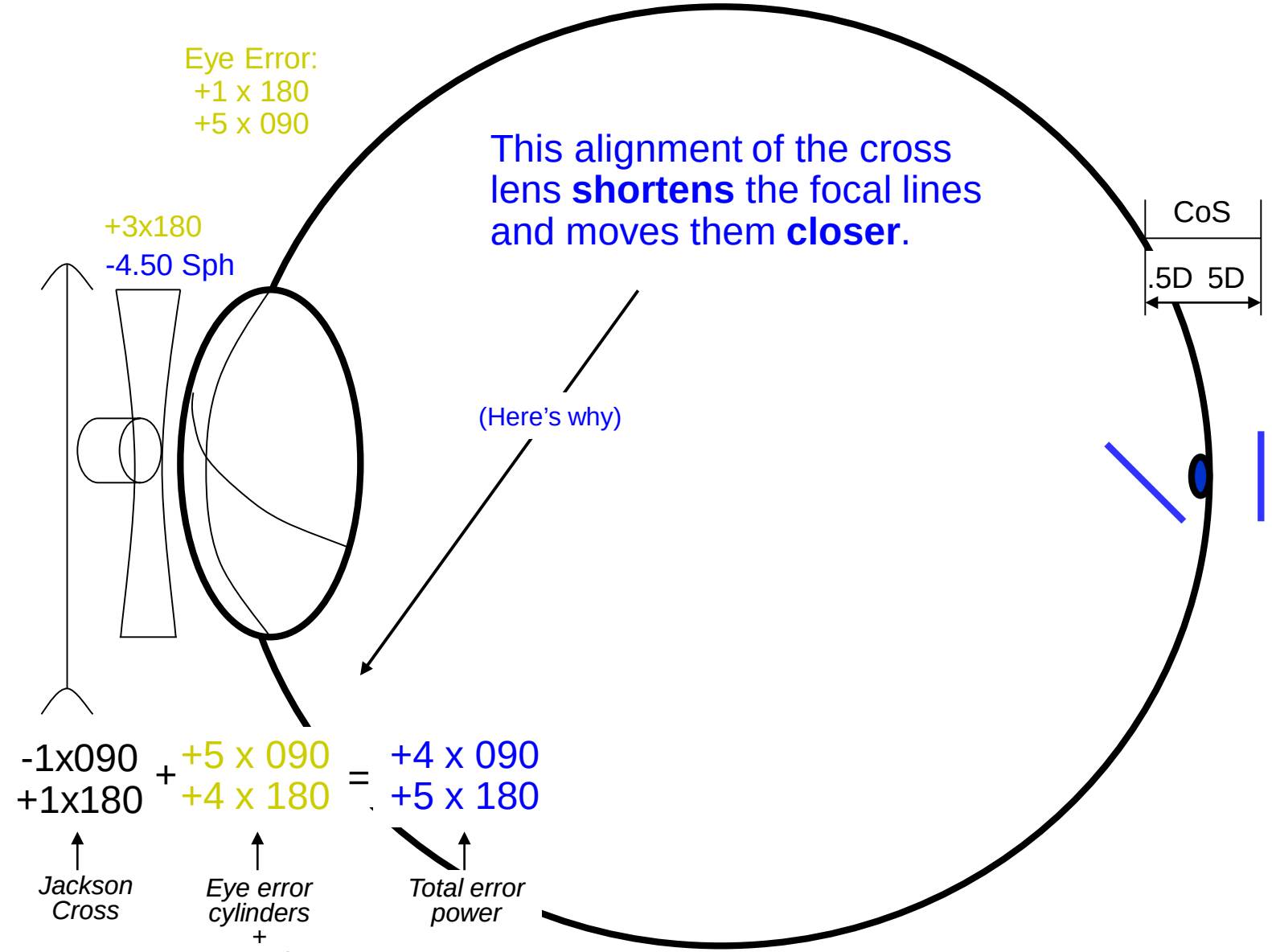
Astigmatic Correction: *Jackson Cross*



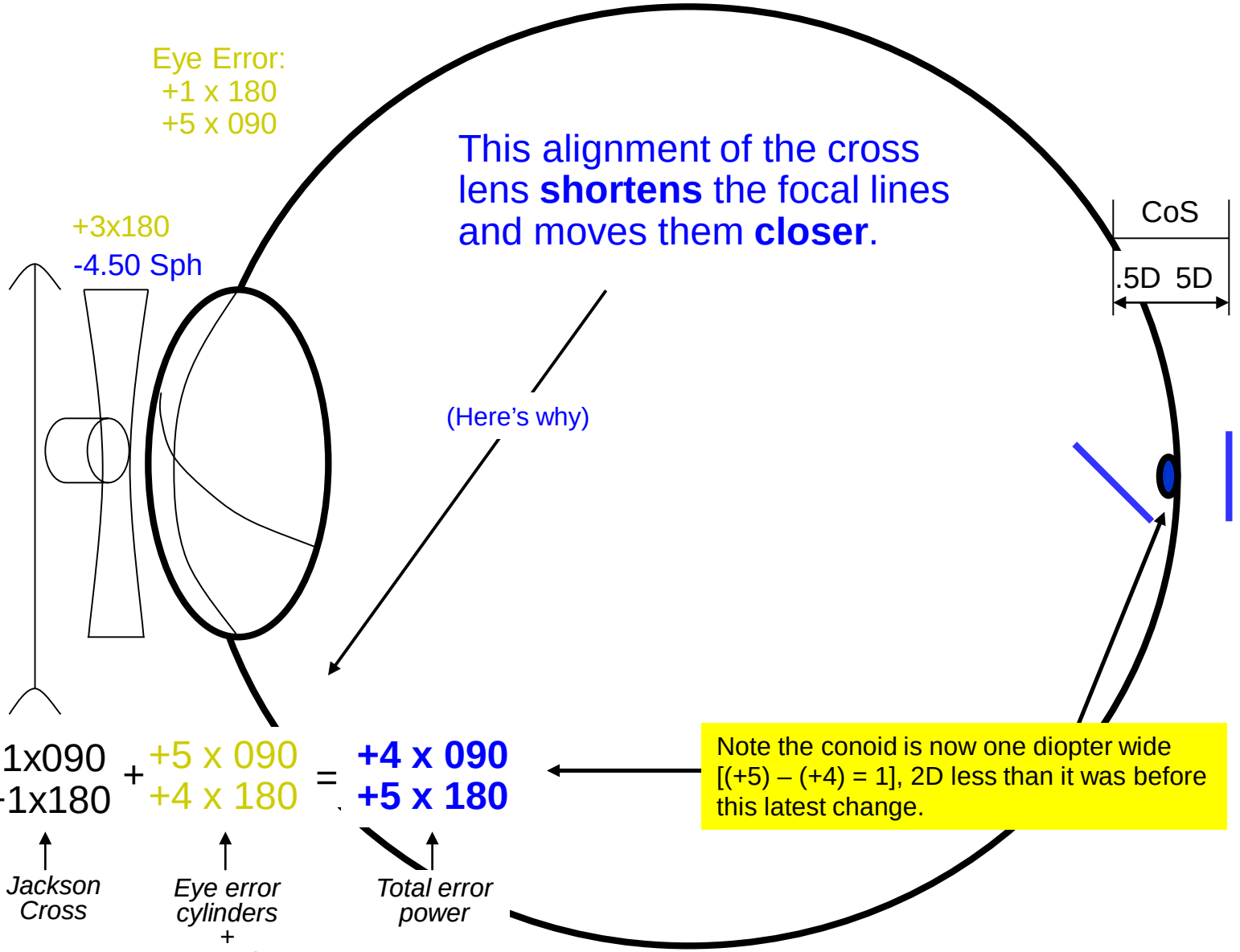
Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*

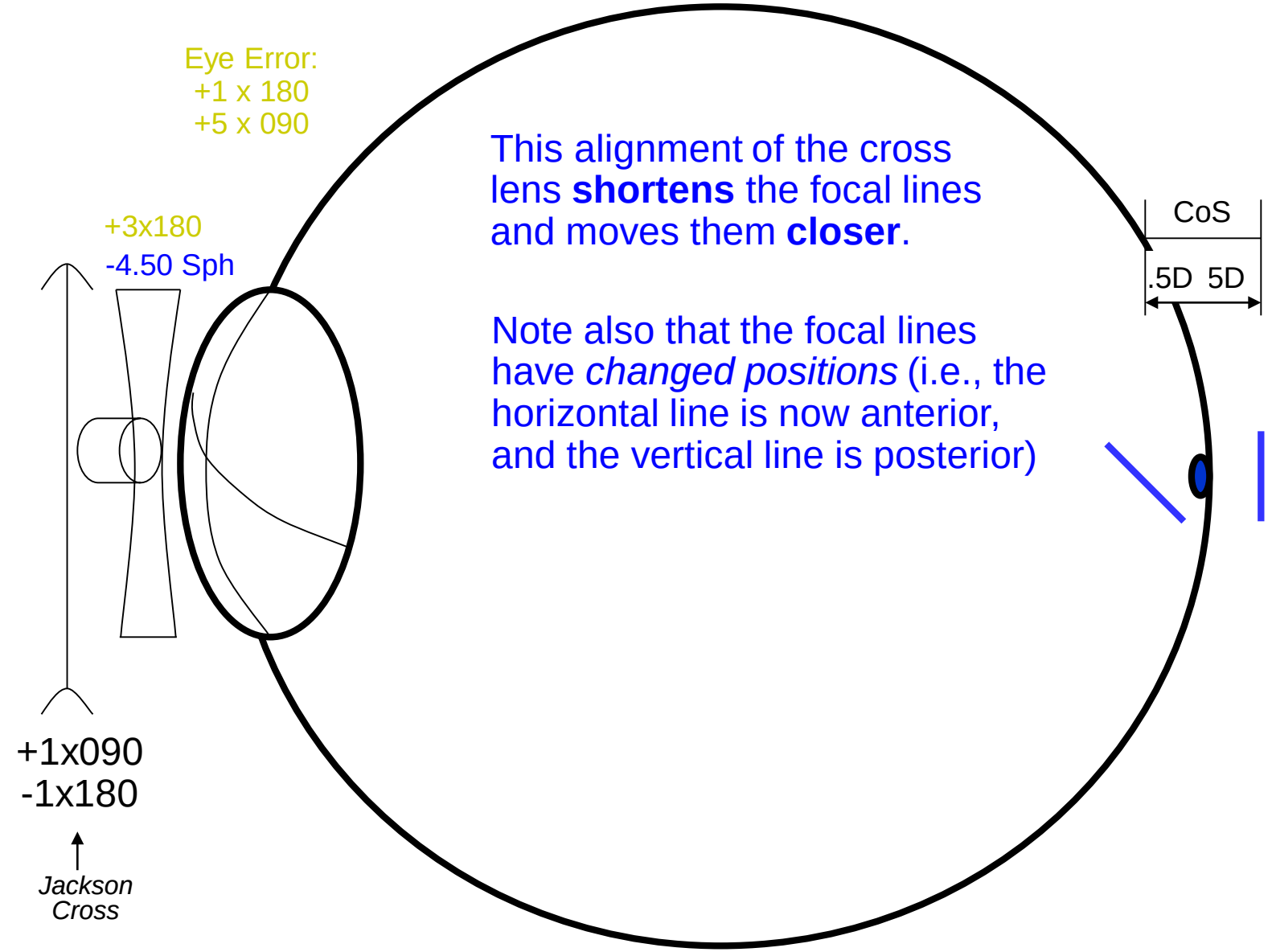


Astigmatic Correction: *Jackson Cross*



Note the conoid is now one diopter wide [(+5) – (+4) = 1], 2D less than it was before this latest change.

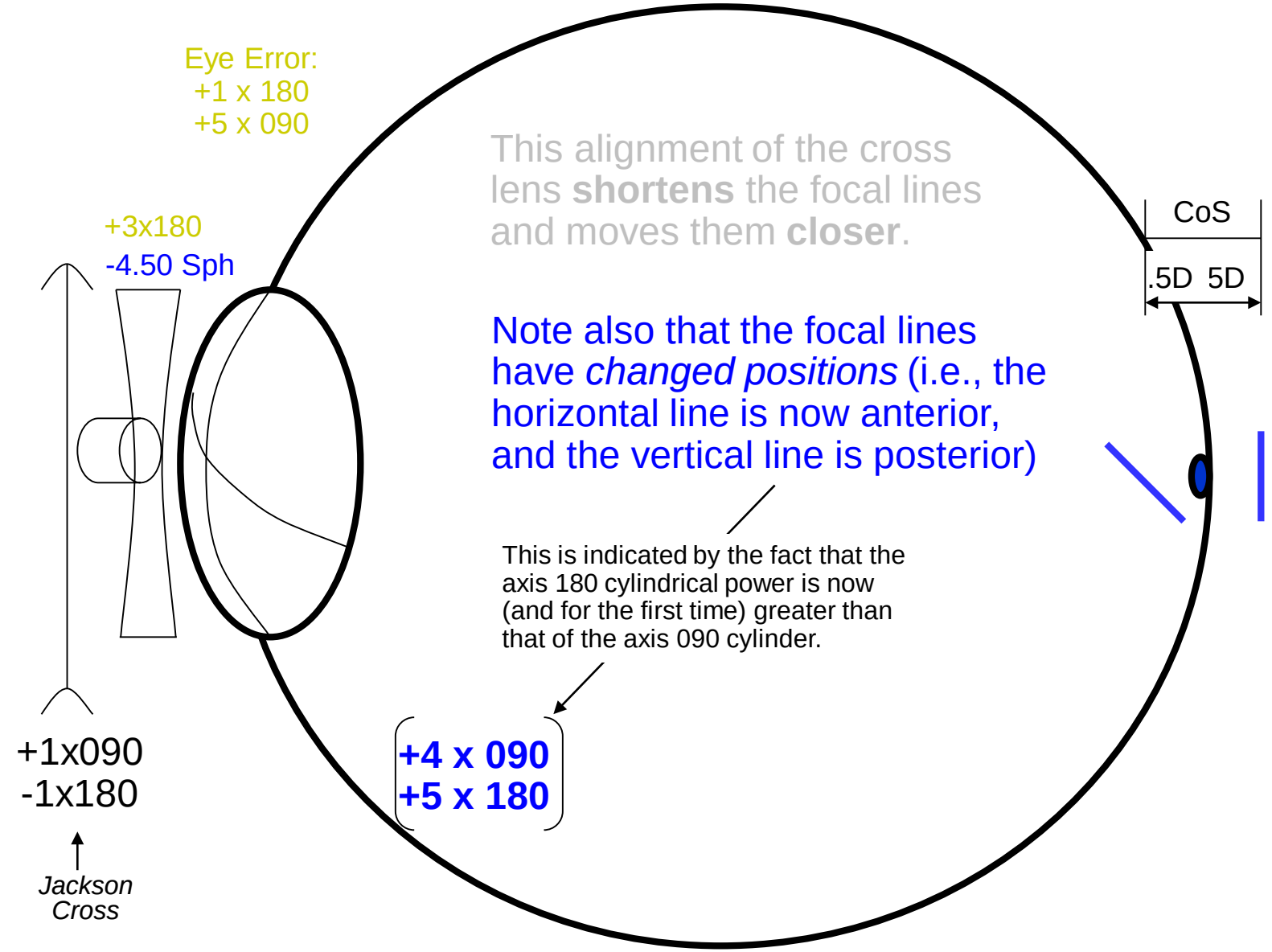
Astigmatic Correction: *Jackson Cross*



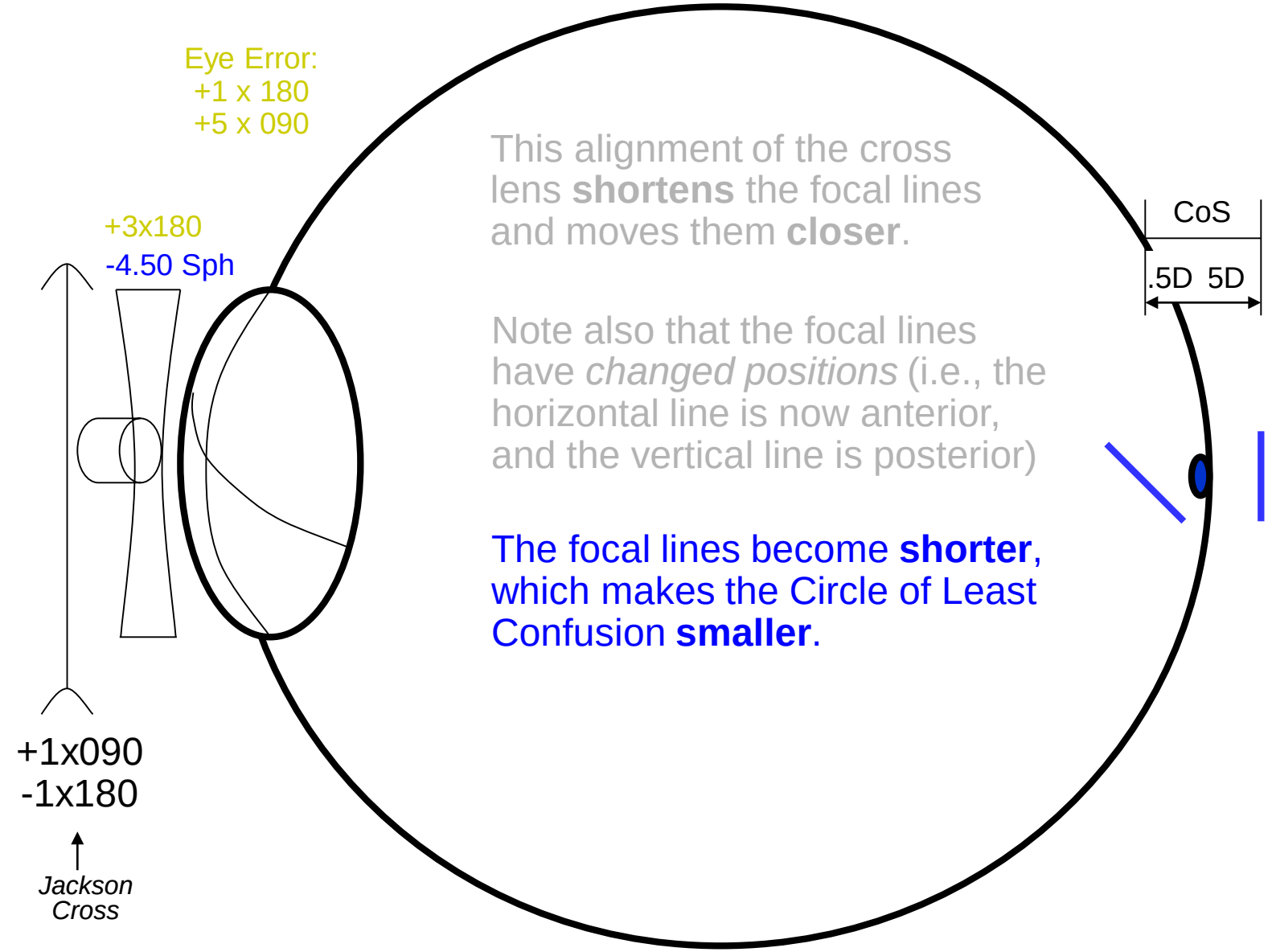
This alignment of the cross lens **shortens** the focal lines and moves them **closer**.

Note also that the focal lines have *changed positions* (i.e., the horizontal line is now anterior, and the vertical line is posterior)

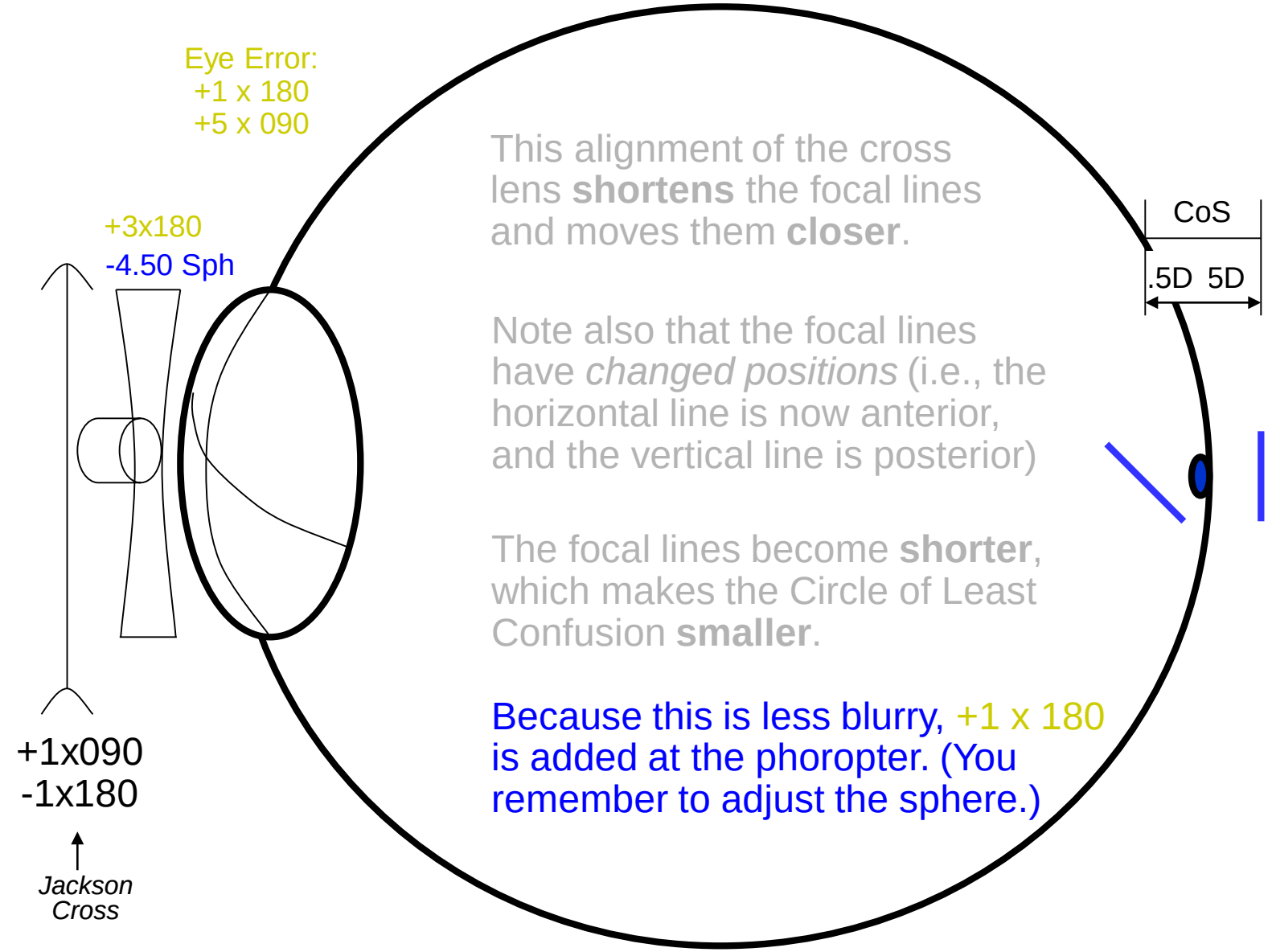
Astigmatic Correction: *Jackson Cross*



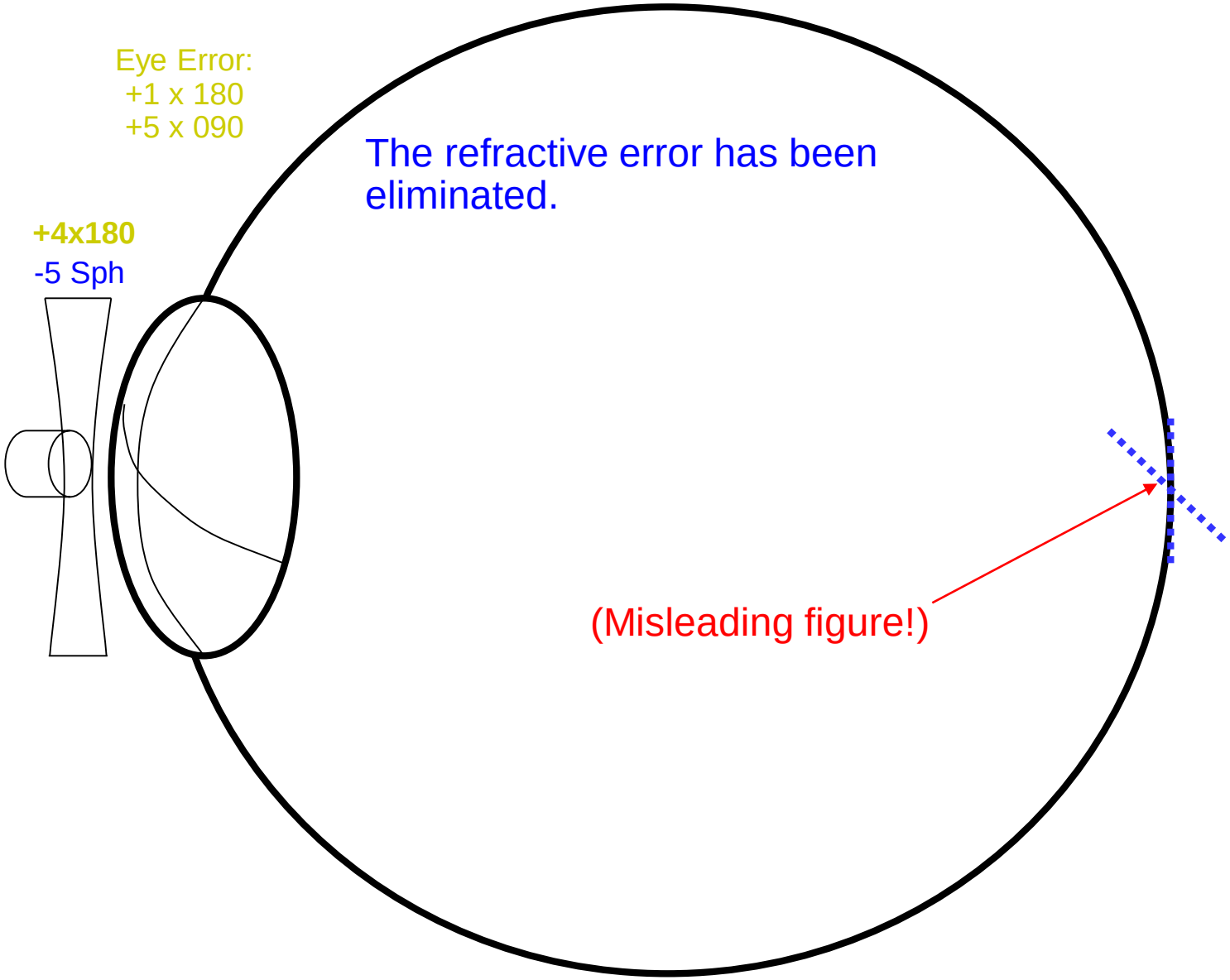
Astigmatic Correction: *Jackson Cross*



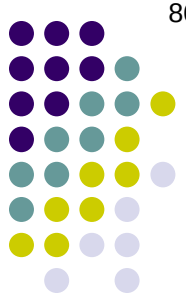
Astigmatic Correction: *Jackson Cross*

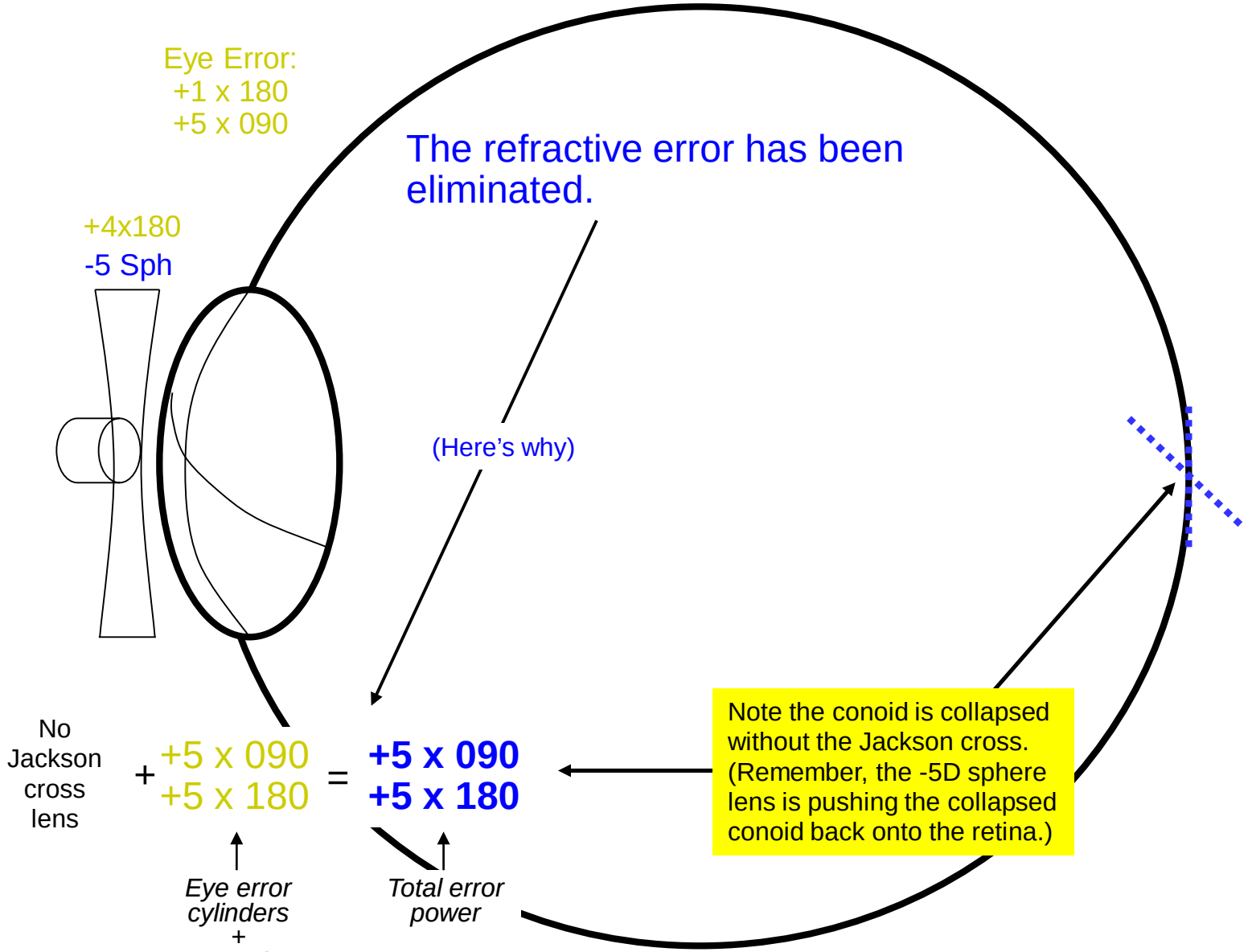


Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



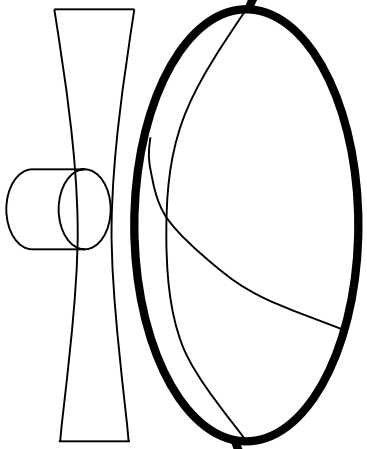


Astigmatic Correction: *Jackson Cross*

Eye Error:
+1 x 180
+5 x 090

The refractive error has been eliminated.

+4x180
-5 Sph



(Here's why)

No Jackson cross lens

\+ +5 x 090 +5 x 180 = **+5 x 090 +5 x 180**

Eye error cylinders + corrective cylinder

Total error power

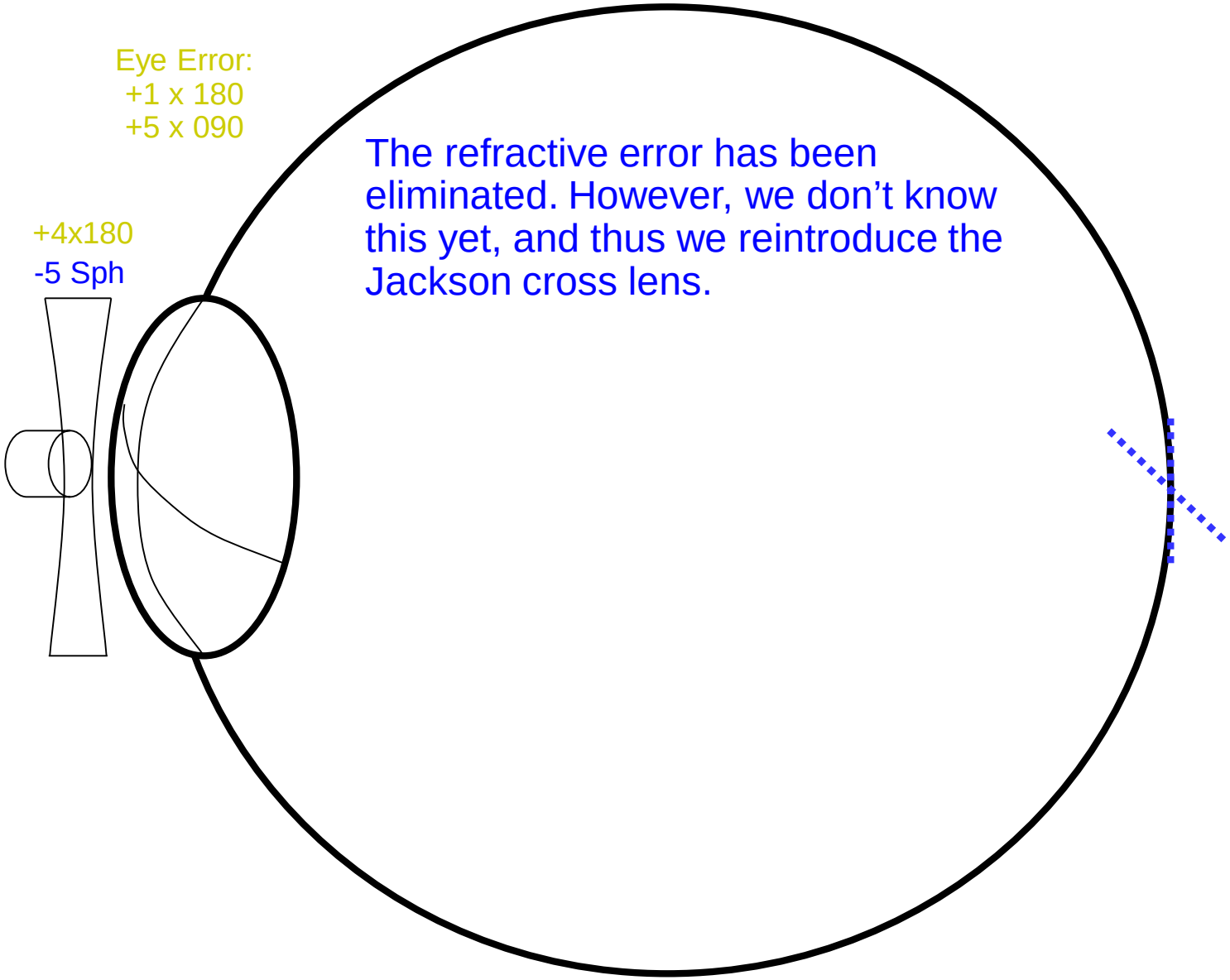
Note the conoid is collapsed without the Jackson cross. (Remember, **the -5D sphere lens is pushing the collapsed conoid back onto the retina.)**

To understand why, recall that we can think of any spherical lens as being composed of two cylindrical lenses oriented 90° apart. So, in this case, think of the -5D sphere lens as being composed of two -5D cylinders, one of which is at axis 090 and the other at axis 180.

Astigmatic Correction: *Jackson Cross*

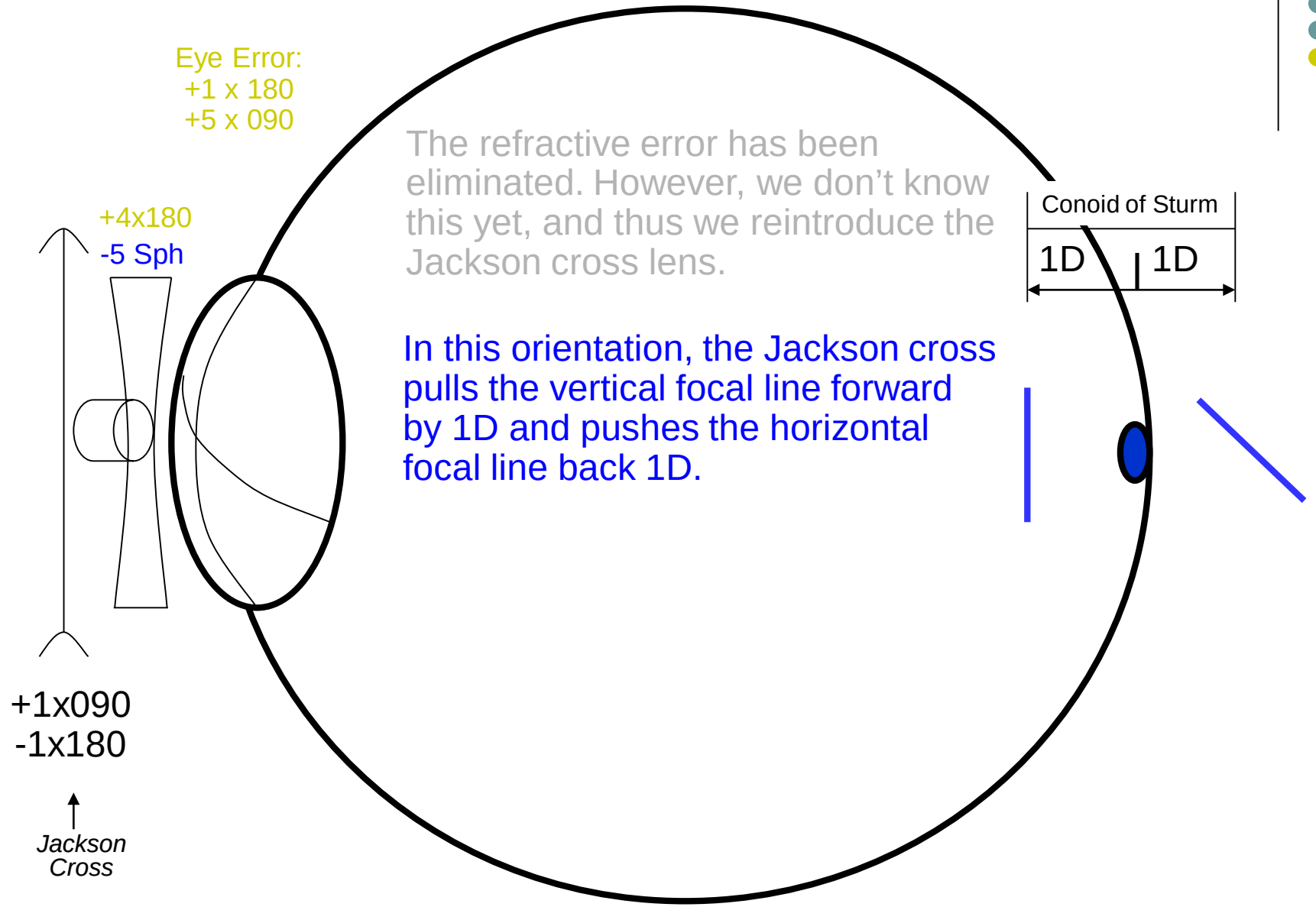
Eye Error:
+1 x 180
+5 x 090

+4x180
-5 Sph

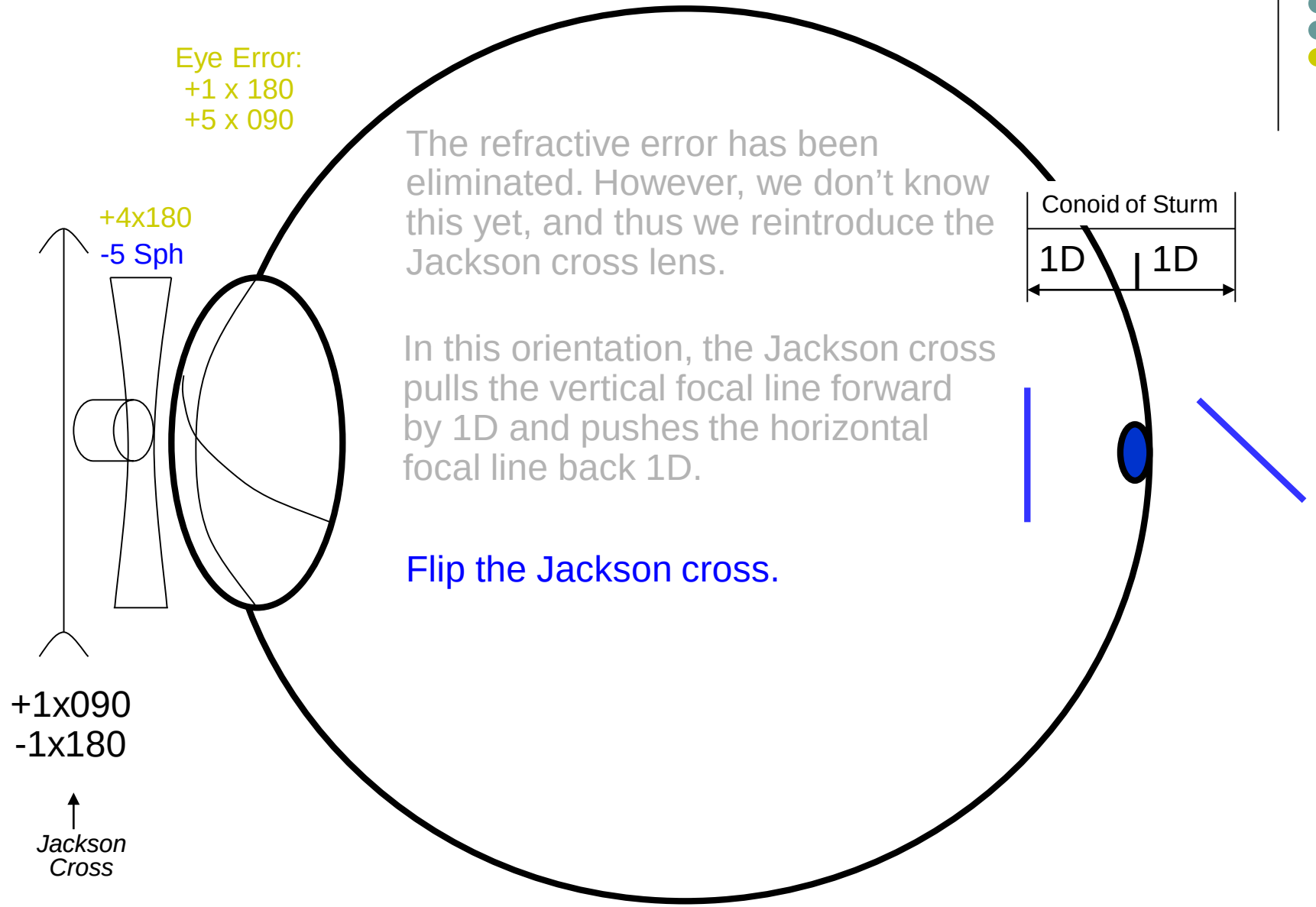


The refractive error has been eliminated. However, we don't know this yet, and thus we reintroduce the Jackson cross lens.

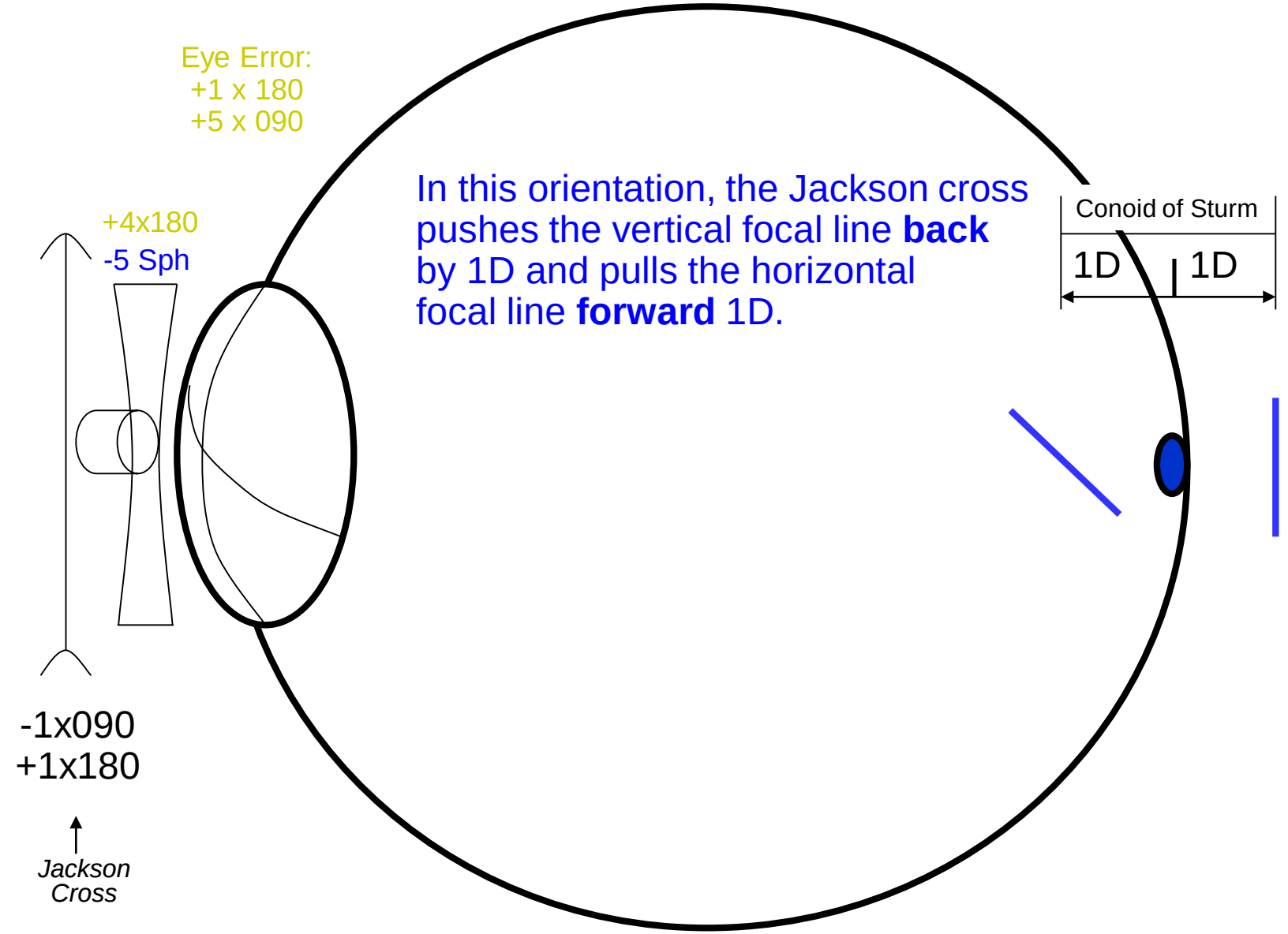
Astigmatic Correction: *Jackson Cross*



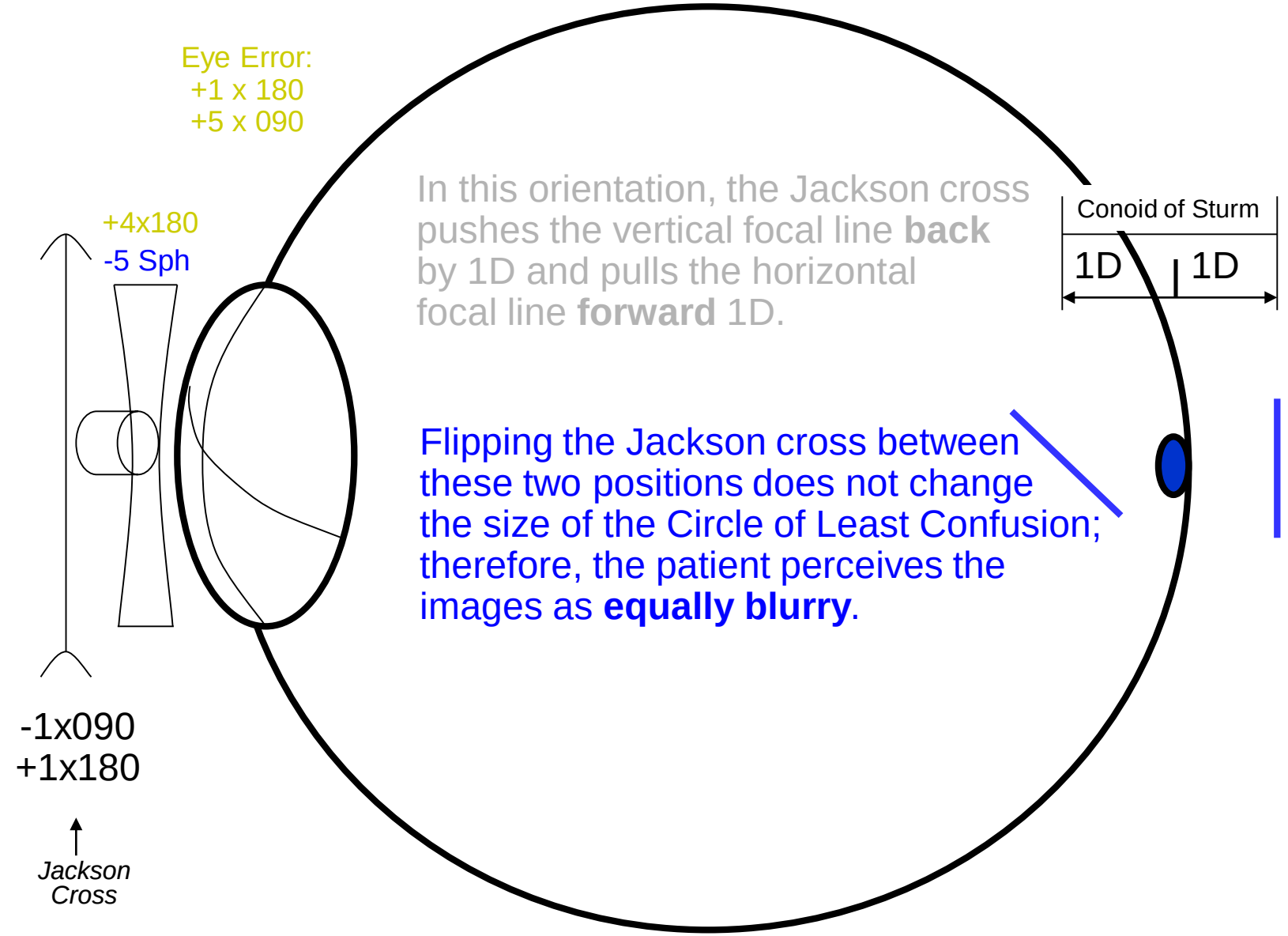
Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*

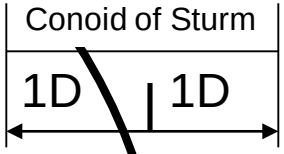
Eye Error:
+1 x 180
+5 x 090

+4x180
-5 Sph

-1x090
+1x180

Jackson Cross

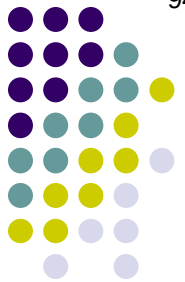
In this orientation, the Jackson cross pushes the vertical focal line **back** by 1D and pulls the horizontal focal line **forward** 1D.



Flipping the Jackson cross between these two positions does not change the size of the Circle of Least Confusion; therefore, the patient perceives the images as **equally blurry**.

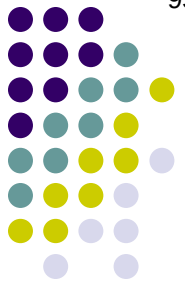
Because the images are **equally blurry**, we know the refractive error has been eliminated!

Astigmatic Correction: *Jackson Cross*



Take a deep breath…

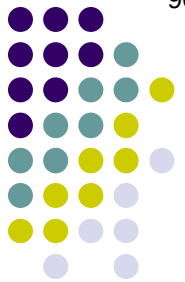
Astigmatic Correction: *Jackson Cross*



Take a deep breath…

Now we're ready to discuss the more difficult concepts involved in using the Jackson cross to determine cylinder ***axis.***

Astigmatic Correction: *Jackson Cross*



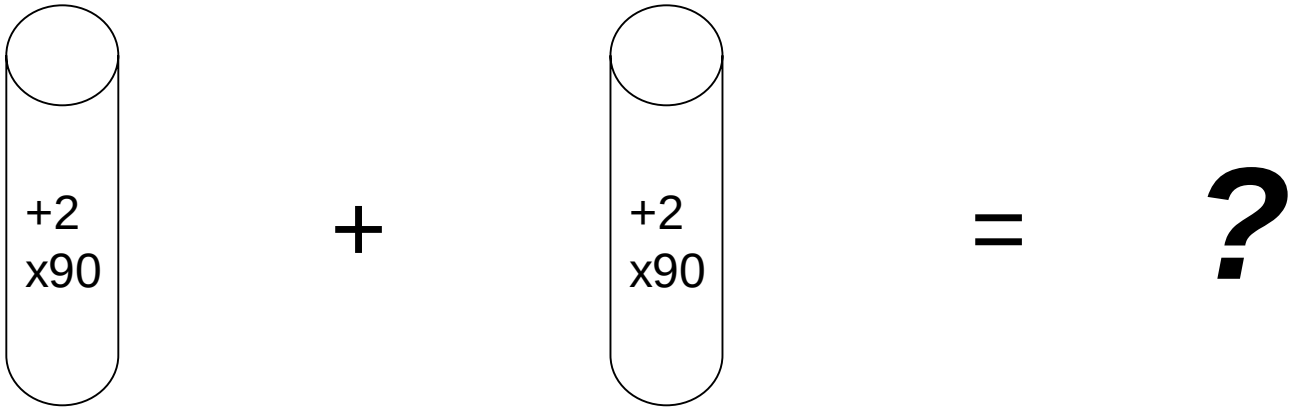
Take a deep breath…

Now we're ready to discuss the more difficult concepts involved in using the Jackson cross to determine cylinder ***axis.***

But first, let's talk more about combining cylinders…

Astigmatic Correction: *Jackson Cross*

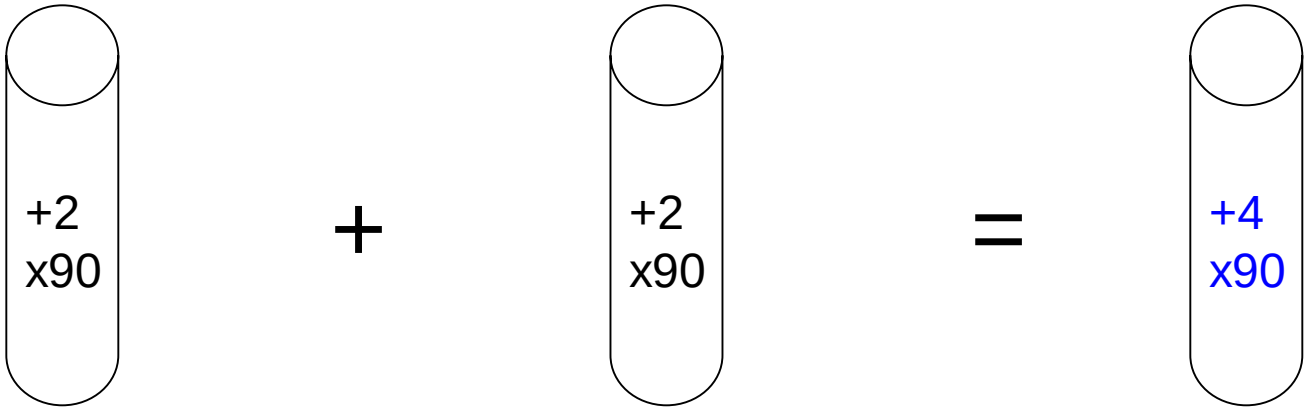
Combining PLUS Cylinders



What will be the resulting lens when two identical plus cylinders of identical orientation are combined?

Astigmatic Correction: *Jackson Cross*

Combining PLUS Cylinders

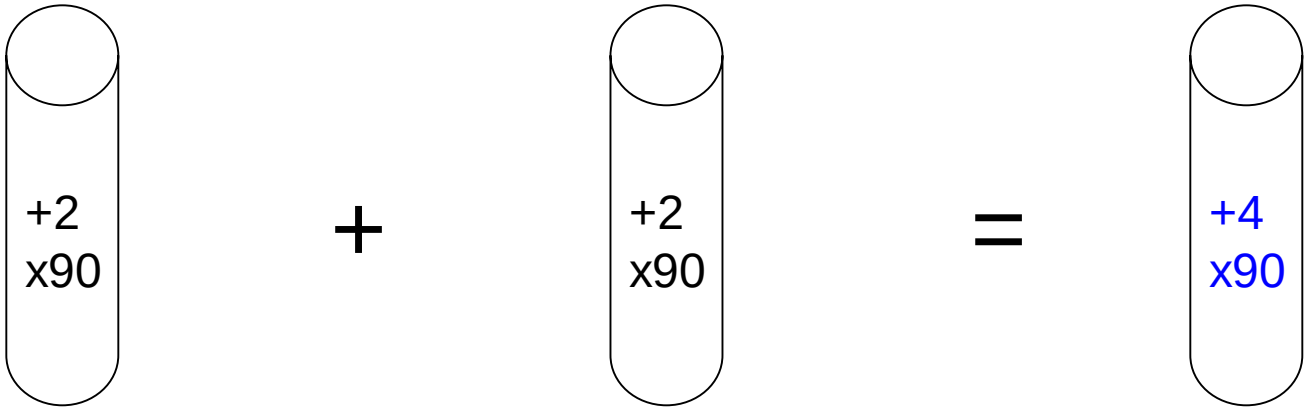


No sphere
All cylinder

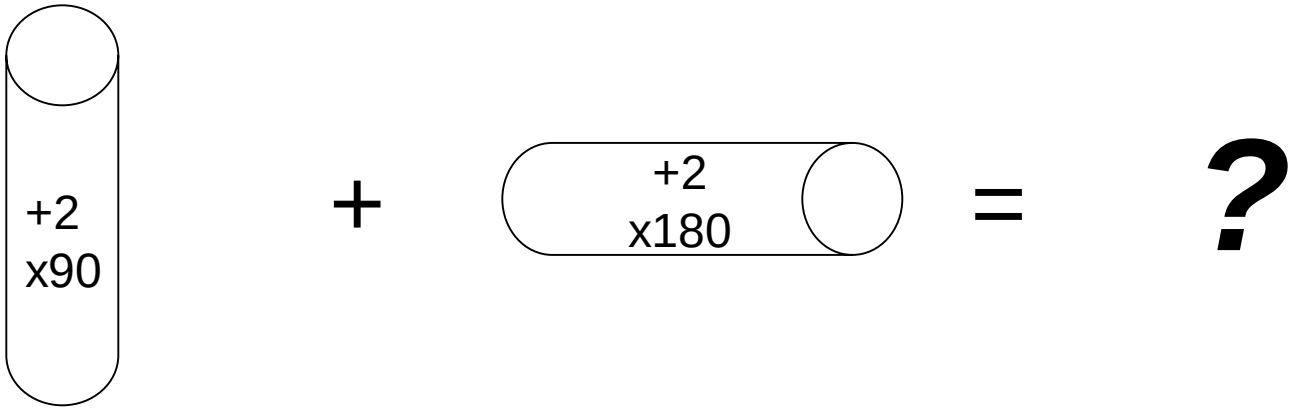
What will be the resulting lens when two identical plus cylinders of identical orientation are combined?
A cylindrical lens with axis identical to that of the parent cylinders and power equal to the **sum** of their powers. Note that the resultant lens has ***no*** spherical power.

Astigmatic Correction: *Jackson Cross*

Combining PLUS Cylinders



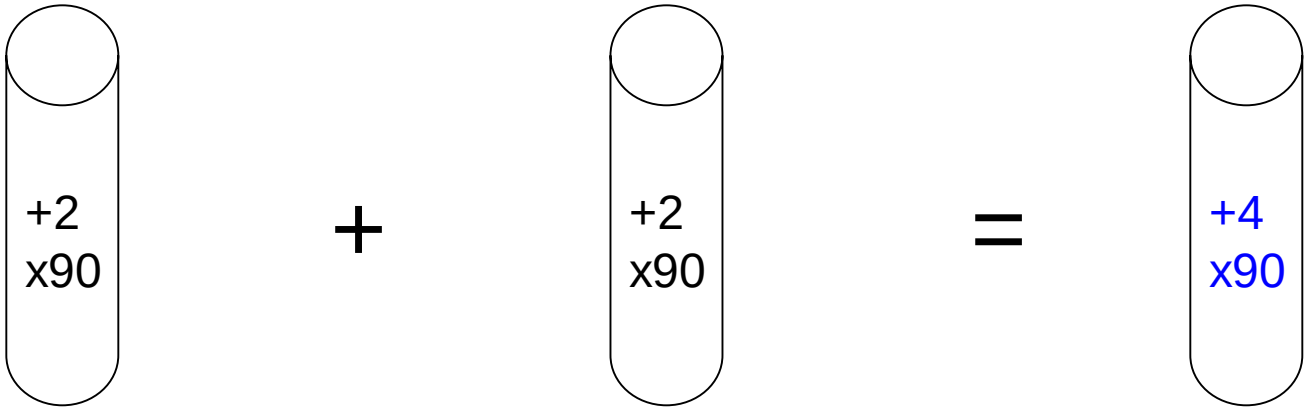
No sphere
All cylinder



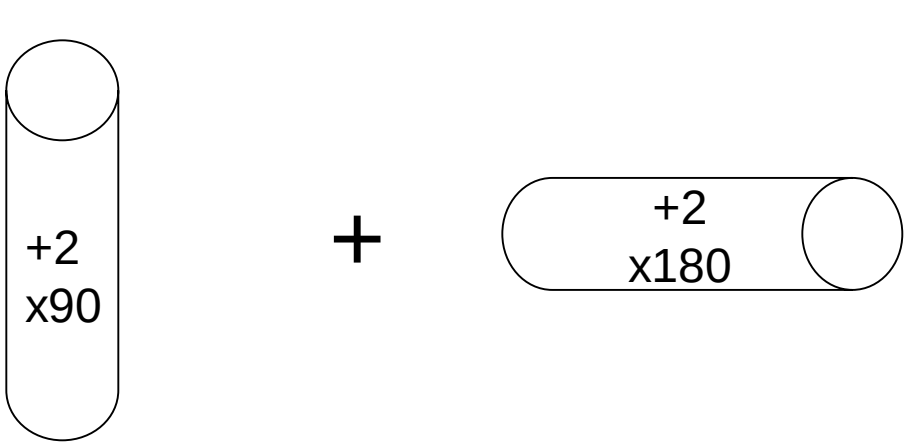
What will be the resulting lens when two identical plus cylinders oriented **90º apart** *are combined?*

Astigmatic Correction: *Jackson Cross*

Combining PLUS Cylinders



No sphere
All cylinder



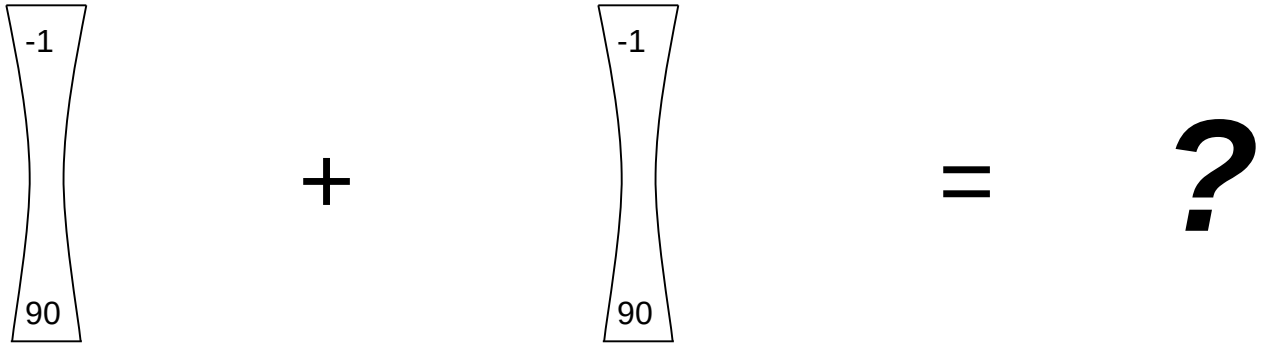
All sphere
No cylinder

+2 sphere

What will be the resulting lens when two identical plus cylinders oriented **90º apart** *are combined?*
A spherical lens with **no** cylinder; its power is the same as (***not*** the sum of) that of the parent lenses.

Astigmatic Correction: *Jackson Cross*

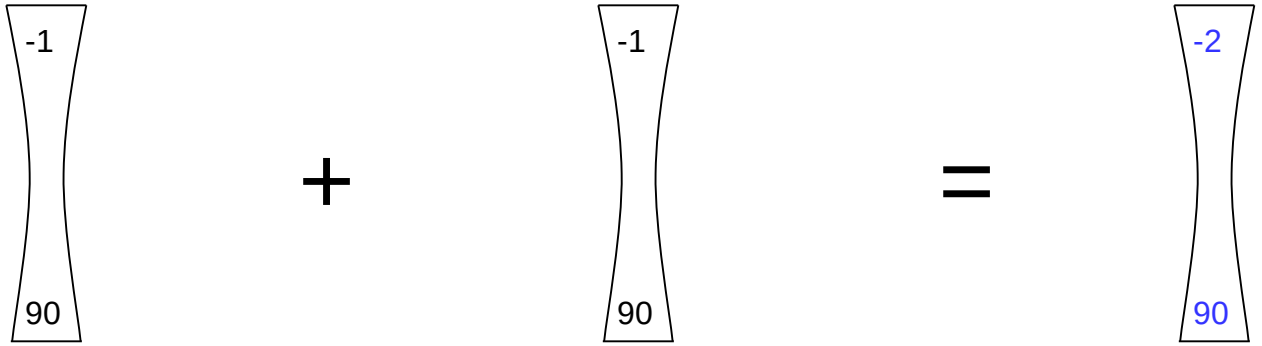
Combining MINUS Cylinders



What will be the resulting lens when two identical **minus** *cylinders of identical orientation are combined?*

Astigmatic Correction: *Jackson Cross*

Combining MINUS Cylinders

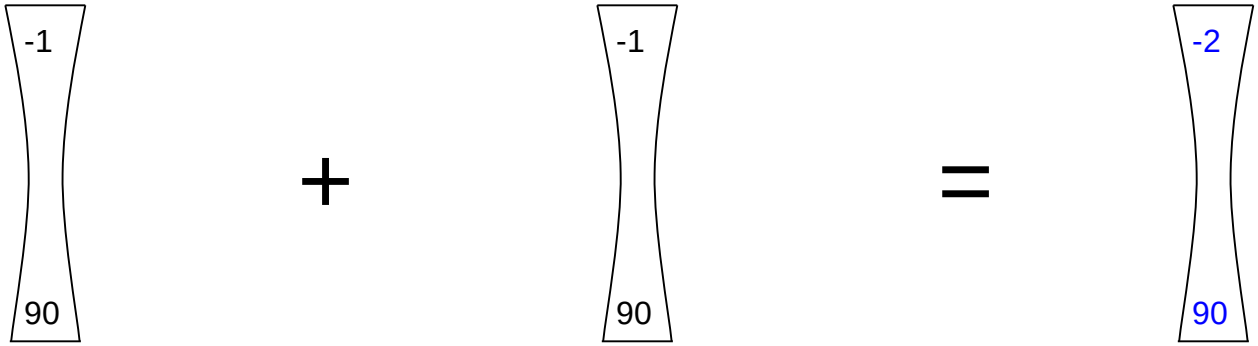


No sphere
All cylinder

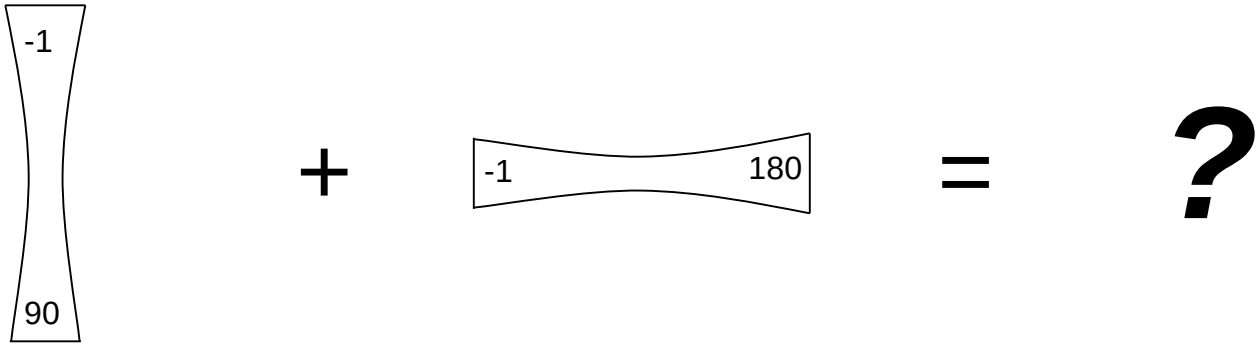
What will be the resulting lens when two identical **minus** *cylinders of identical orientation are combined?*
The same as in the plus-cylinder situation: A cylindrical lens with axis identical to that of the parent cylinders, power equal to the sum of their powers, and no spherical power.

Astigmatic Correction: *Jackson Cross*

Combining MINUS Cylinders



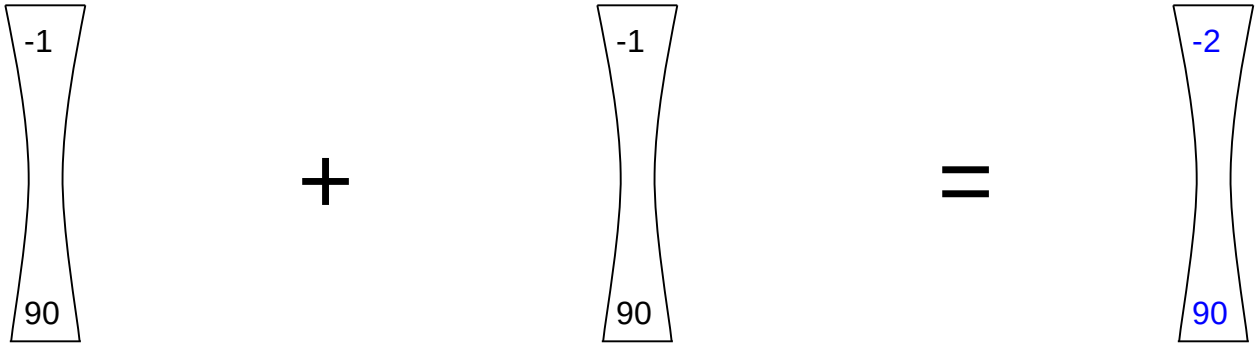
No sphere
All cylinder



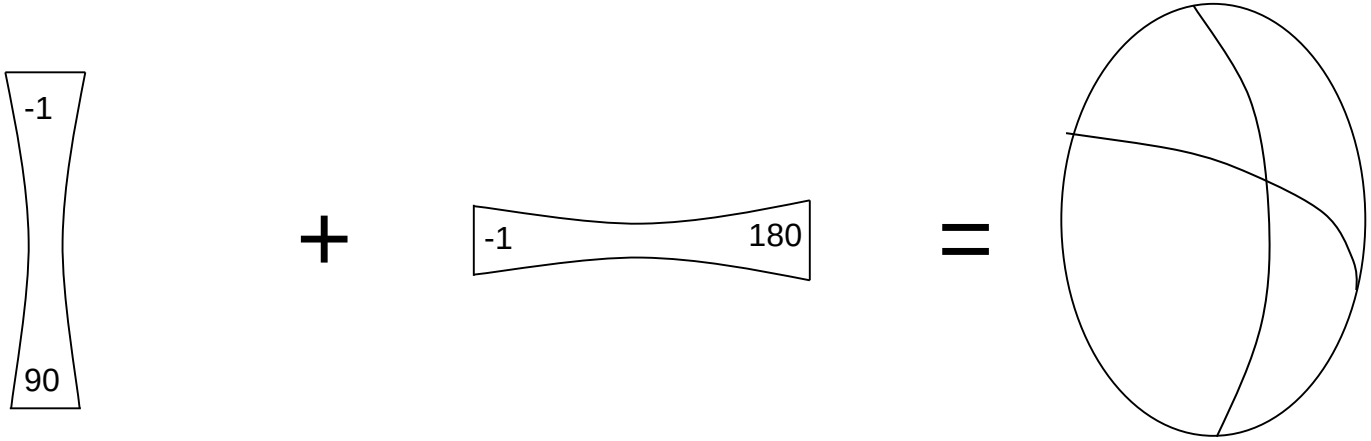
What will be the resulting lens when two identical minus cylinders oriented **90º apart** *are combined?*

Astigmatic Correction: *Jackson Cross*

Combining MINUS Cylinders



No sphere
All cylinder



All sphere
No cylinder

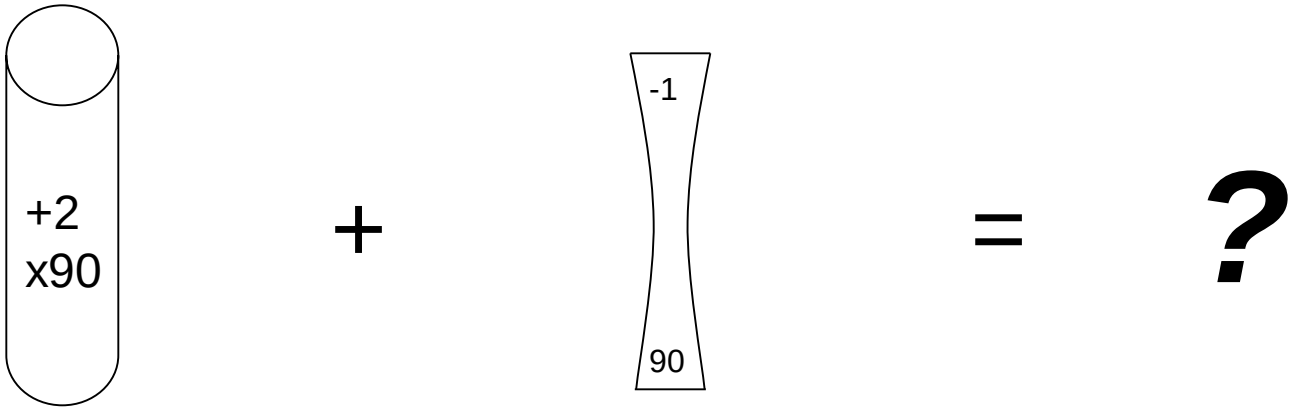
-1 sphere

What will be the resulting lens when two identical minus cylinders oriented **90º apart** *are combined?*

Same as with the plus: A spherical lens with no cylinder, and power the same as that of the parent lenses.

Astigmatic Correction: *Jackson Cross*

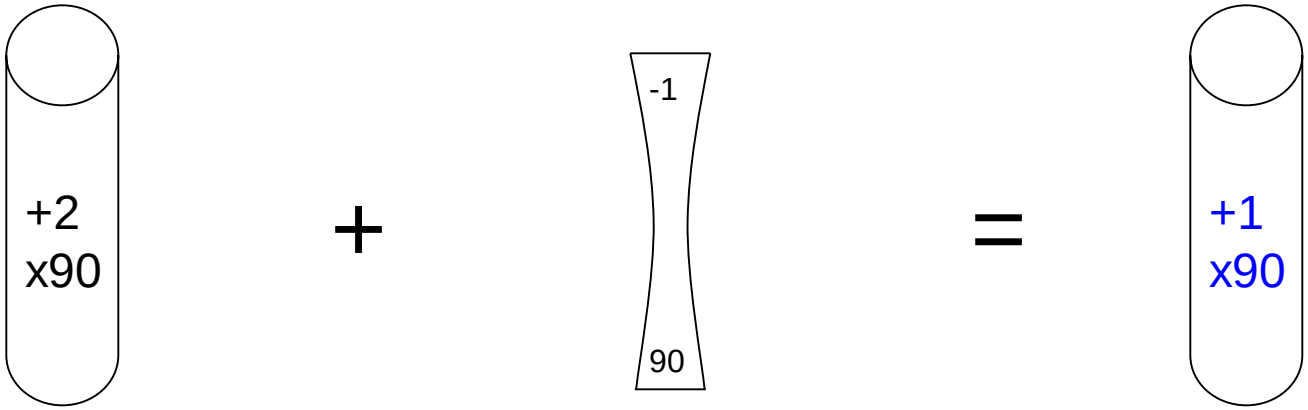
Combining **MIXED** Cylinders



But what if the lens is of mixed parentage, with a plus and a minus lens of identical axis but different powers?

Astigmatic Correction: *Jackson Cross*

Combining **MIXED** Cylinders

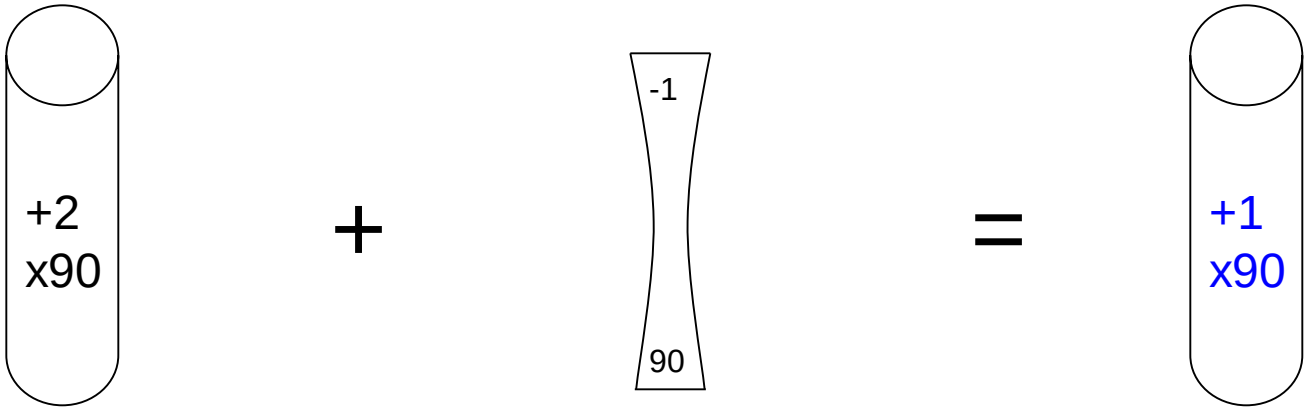


No sphere
All cylinder

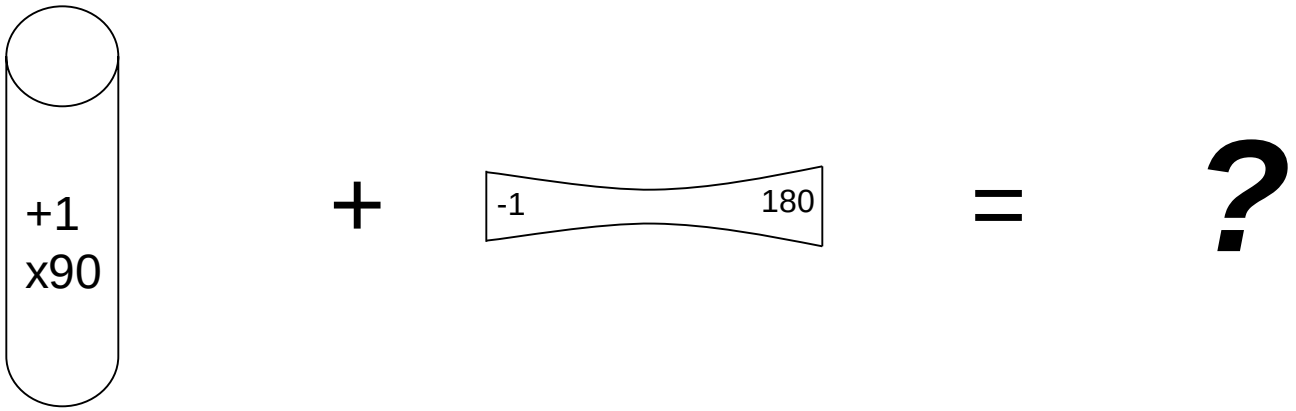
But what if the lens is of mixed parentage, with a plus and a minus lens of identical axis but different powers?
As with the 'purebred' cases, the resultant will be a cylindrical lens with axis identical to that of the parent cylinders and power equal to the sum of their powers, with no spherical power.

Astigmatic Correction: *Jackson Cross*

Combining **MIXED** Cylinders



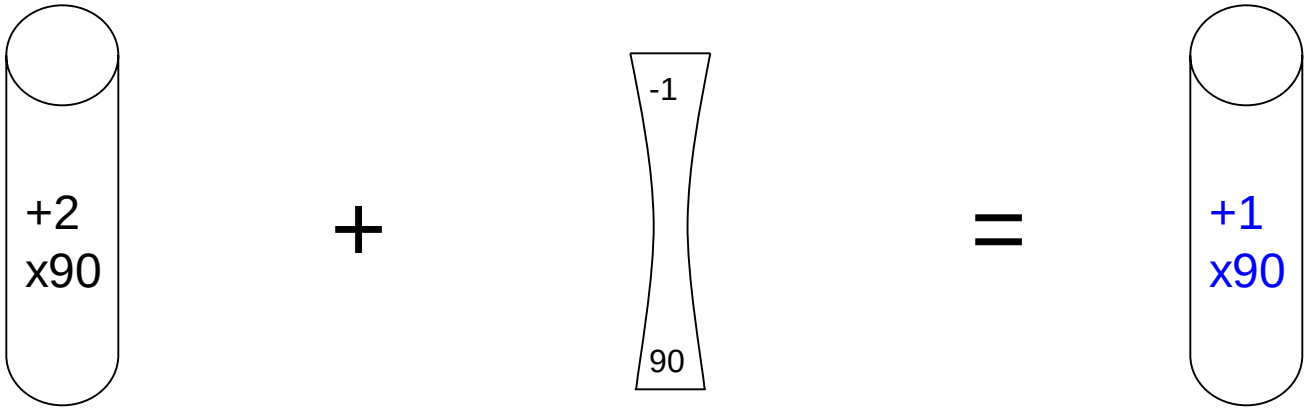
No sphere
All cylinder



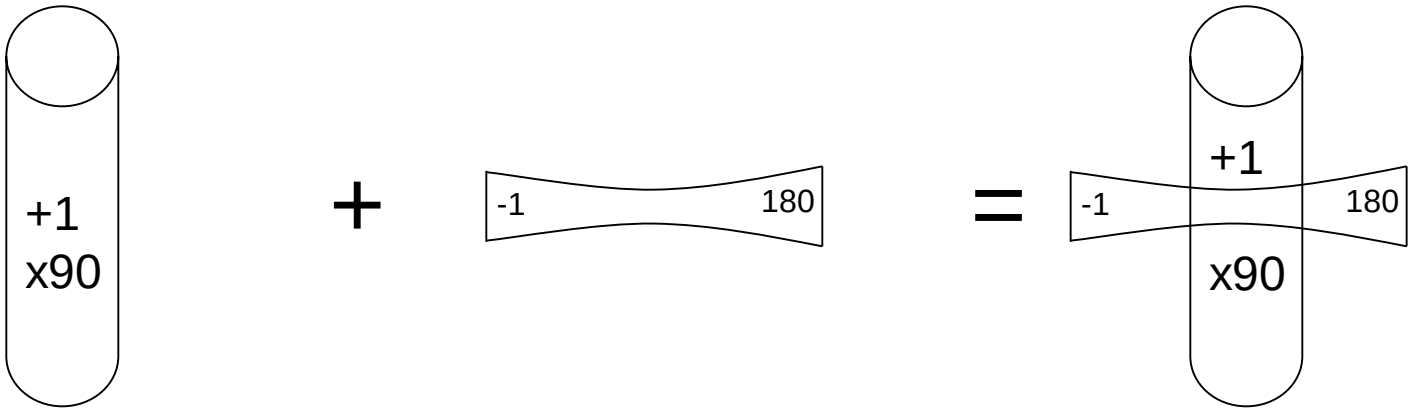
What if the plus and minus parents are of identical powers but oriented **90º apart***?*

Astigmatic Correction: *Jackson Cross*

Combining **MIXED** Cylinders



No sphere
All cylinder



Sphere=0
Plus **and**
minus cyl

Jackson Cross

What if the plus and minus parents are of identical powers but oriented **90º apart***?*
This is the definition of a ***Jackson cross*** lens. (You recognized that immediately, though.)

Astigmatic Correction: *Jackson Cross*

BUT, in each of these situations, the orientation of the cylinder combination has been *regular*: either **on-axis** or **90º apart**.

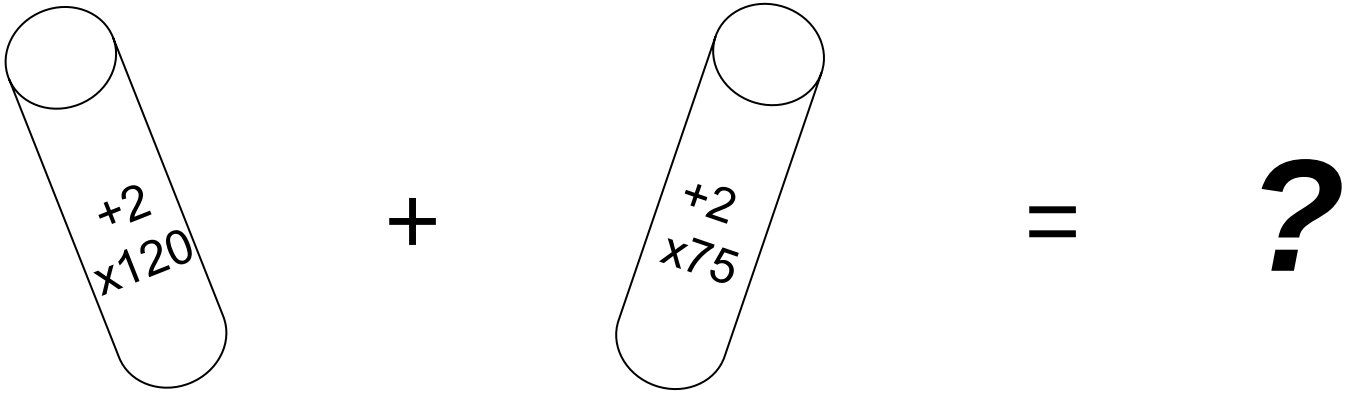
But what if the alignment is *oblique*, i.e., neither on-axis nor 90º apart?

Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders: SAME Sign

Astigmatic Correction: *Jackson Cross*

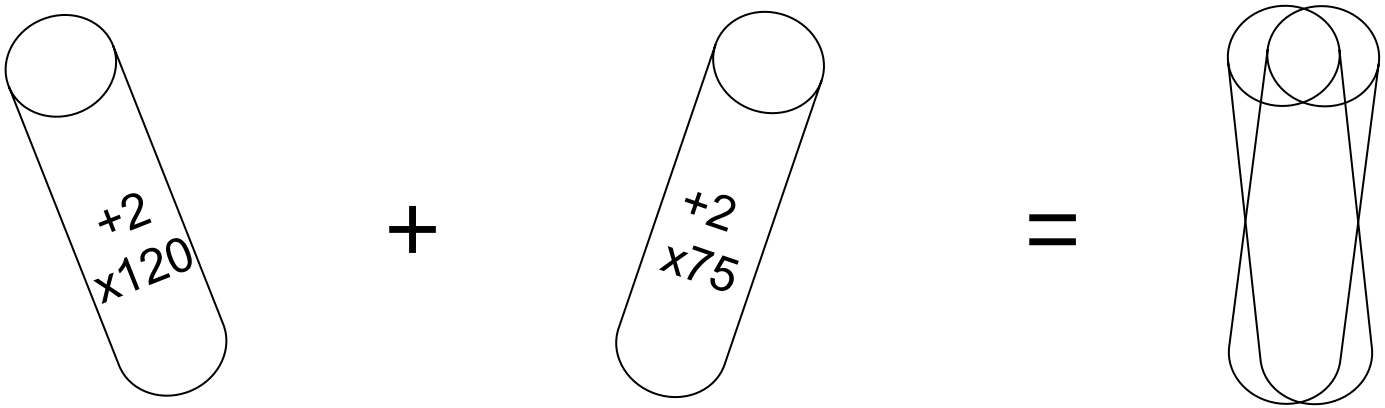
Combining Oblique Cylinders: SAME Sign



What will be the resulting lens when two identical plus cylinders with oblique orientation are combined?

Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders: SAME Sign

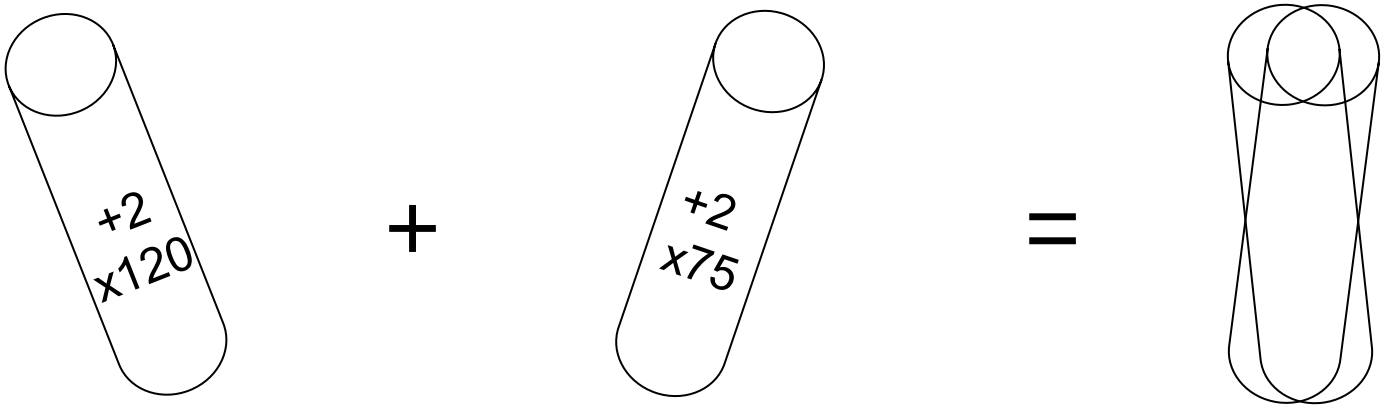


Some sphere
Some cylinder
Axis between

What will be the resulting lens when two identical plus cylinders with oblique orientation are combined?
A ***spherocylindrical*** lens with the axis of plus power oriented between the axes of the parent cylinders.
(An equivalent result would occur if two identical **minus** cylinders were similarly combined.)

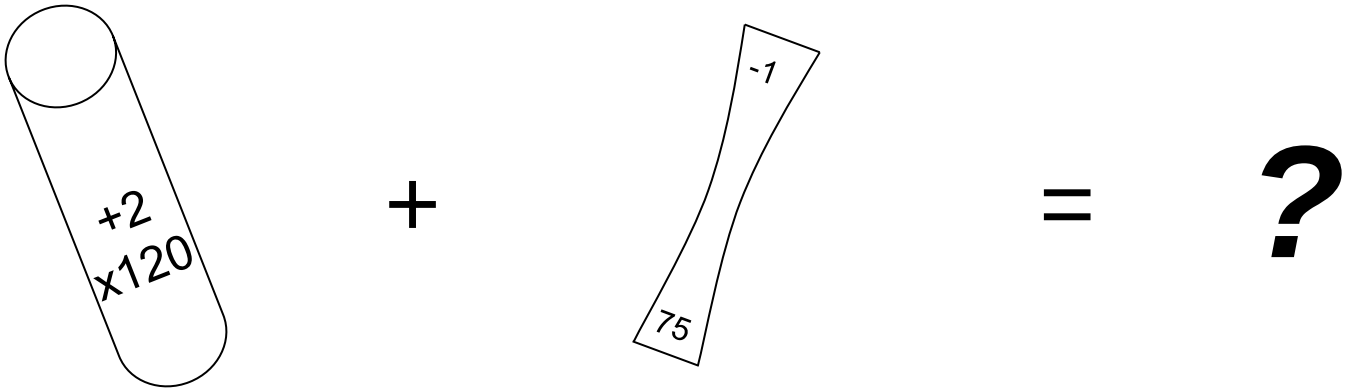
Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders: SAME Sign



Some sphere
Some cylinder
Axis between

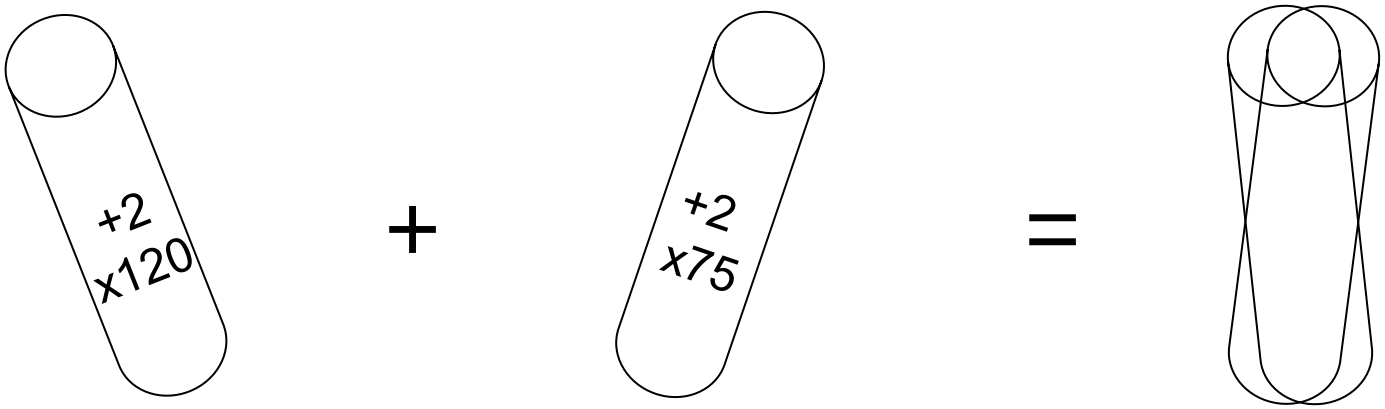
Combining Oblique Cylinders: DIFFERENT Sign



*What if the obliquely-oriented parent cylinders are of **different signs**?*

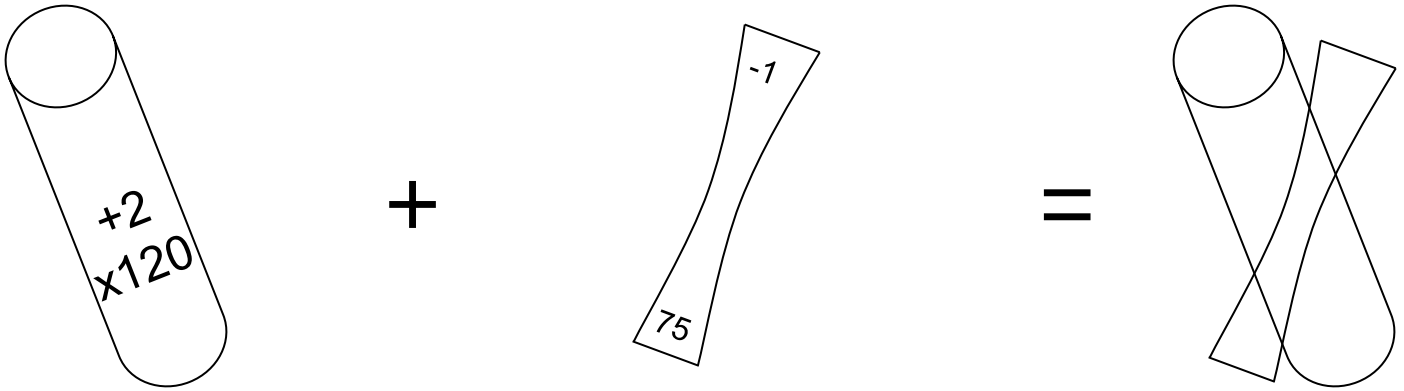
Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders: SAME Sign



Some sphere
Some cylinder
Axis between

Combining Oblique Cylinders: DIFFERENT Sign

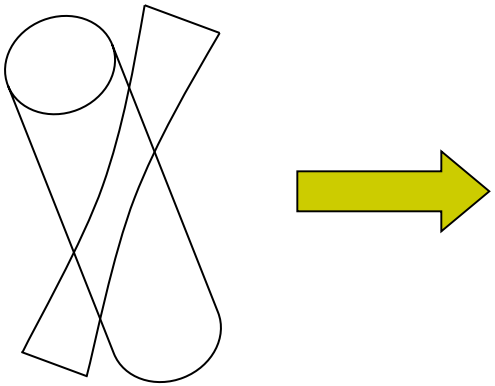


Some sphere
Some cylinder
~~**Axis between**~~

*What if the obliquely-oriented parent cylinders are of **different signs**?*
As in the same-sign situation, a spherocylindrical lens will result. However, the axis of cylinder power will ***not*** be oriented between the axes of the parent cylinders! Let's look at this in more detail…

Astigmatic Correction: *Jackson Cross*

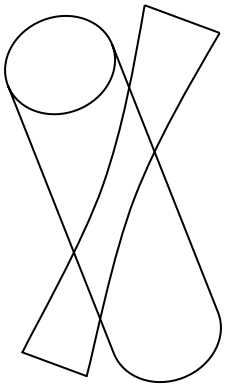
Combining Oblique Cylinders:
DIFFERENT Sign



When cylinders of opposite sign and oblique orientation are combined, the resultant lens is…

Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders:
DIFFERENT Sign

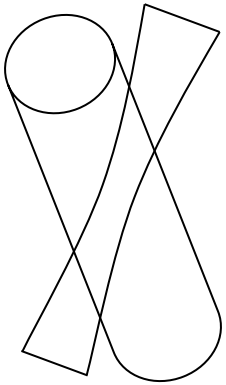


Jackson Cross !

When cylinders of opposite sign and oblique orientation are combined, the resultant lens is…a *Jackson cross*!

Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders:
DIFFERENT Sign



Jackson Cross !

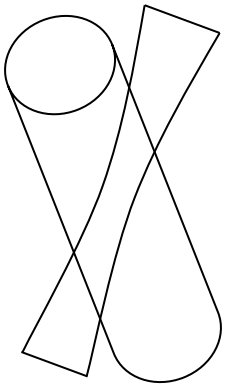
Power?
Axes?

When cylinders of opposite sign and oblique orientation are combined, the resultant lens is…a *Jackson cross*!
Understanding the specific orientation of the axes of the resultant Jackson cross requires a new concept…

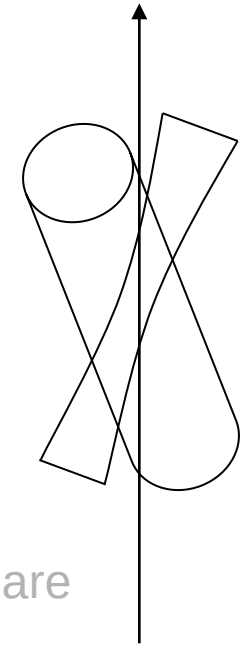
Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders:
DIFFERENT Sign

'**Bisector Angle**'
½ between cylinder axes
(if powers are equal)



Jackson
Cross



When cylinders of opposite sign and oblique orientation are combined, the resultant lens is…a *Jackson cross*!

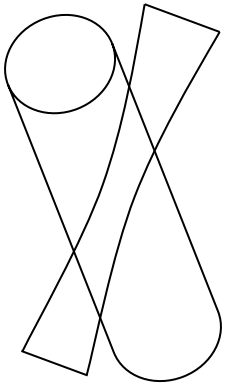
Understanding the specific orientation of the axes of the resultant Jackson cross requires a new concept…

The ***bisector angle***: The axis halfway between those of the parent cylinders (assuming they are of equal but opposite powers).

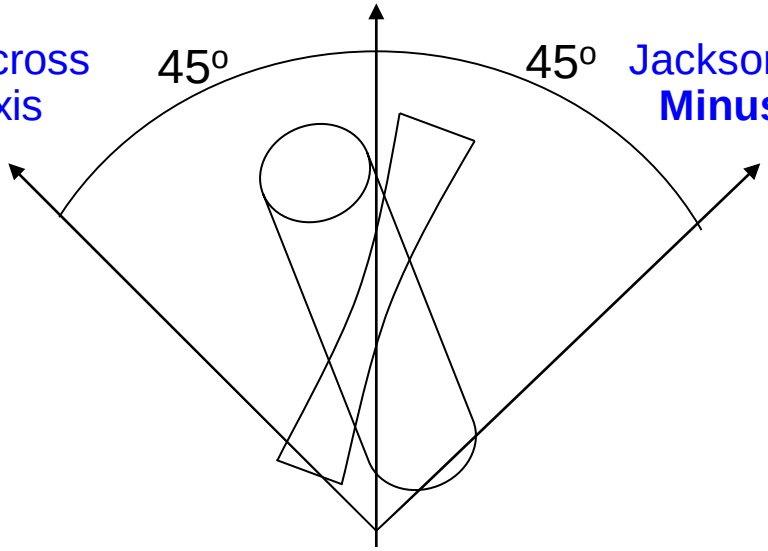
Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders:
DIFFERENT Sign

‘**Bisector Angle**’
½ between cylinder axes
(if powers are equal)



Jackson Cross

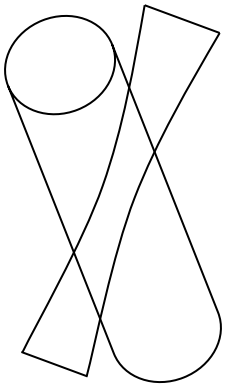


When cylinders of opposite sign and oblique orientation are combined, the resultant lens is…a *Jackson cross*!
Understanding the specific orientation of the axes of the resultant Jackson cross requires a new concept…
The ***bisector angle***: The axis halfway between those of the parent cylinders (assuming they are of equal but opposite powers). **The axes of the resultant Jackson cross are to be found 45º to each side of the bisector angle.**

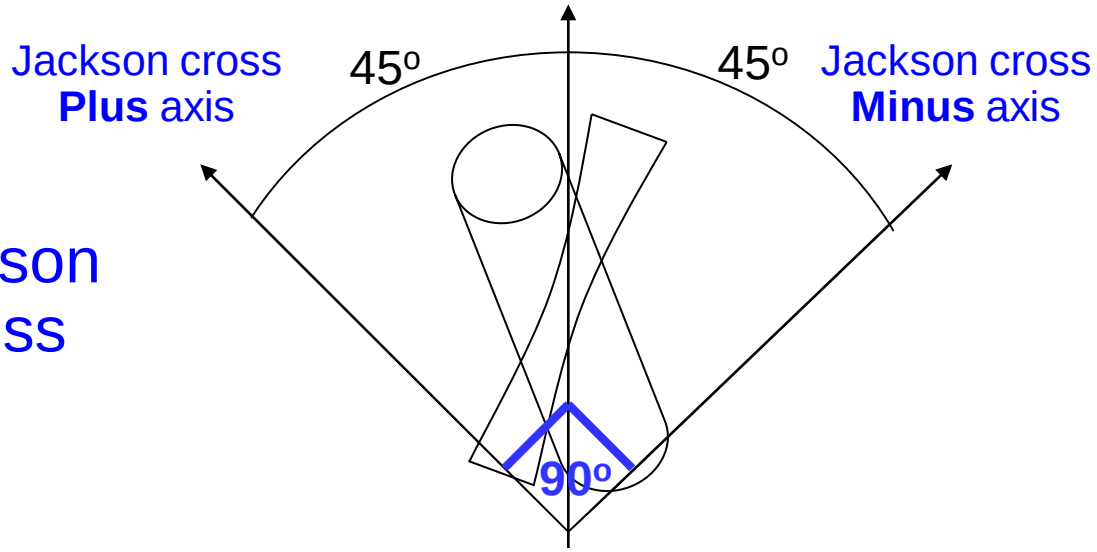
Astigmatic Correction: *Jackson Cross*

Combining Oblique Cylinders:
DIFFERENT Sign

‘**Bisector Angle**’
½ between cylinder axes
(if powers are equal)



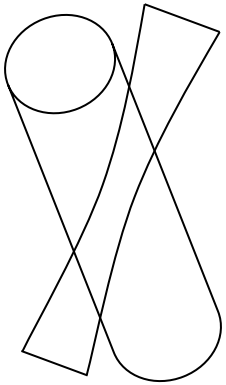
Jackson Cross



When cylinders of opposite sign and oblique orientation are combined, the resultant lens is…a *Jackson cross*!
Understanding the specific orientation of the axes of the resultant Jackson cross requires a new concept…
The ***bisector angle***: The axis halfway between those of the parent cylinders (assuming they are of equal but opposite powers). **The axes of the resultant Jackson cross are to be found 45º to each side of the bisector angle.**
(Note that this ‘double 45º requirement’ puts the axes 90º apart, as is required in a Jackson cross.)

Astigmatic Correction: *Jackson Cross*

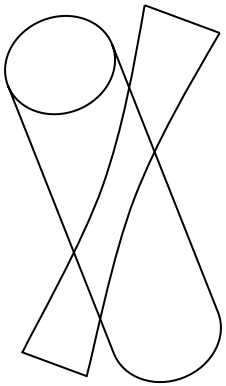
For Example…



-2 x 085 +2 x 095

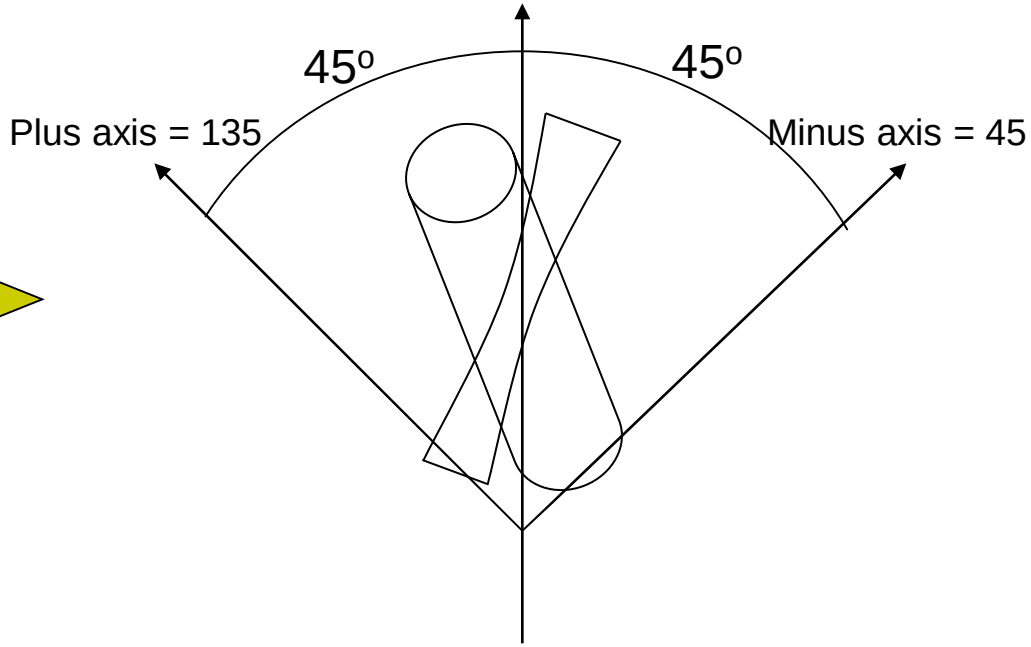
Astigmatic Correction: *Jackson Cross*

For Example…



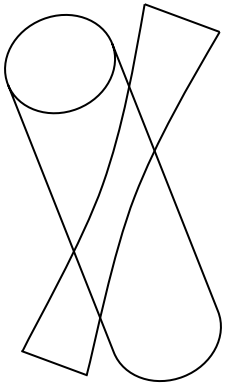
-2 x 085 +2 x 095

Bisector Angle = 090



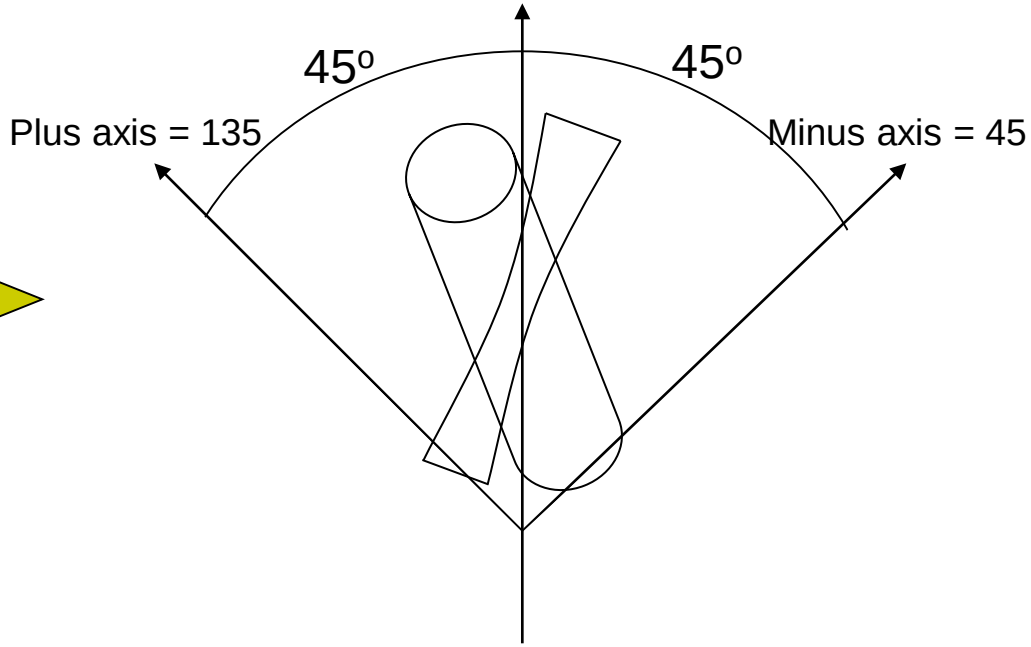
Astigmatic Correction: *Jackson Cross*

For Example…



-2 x 085 +2 x 095

Bisector Angle = 090



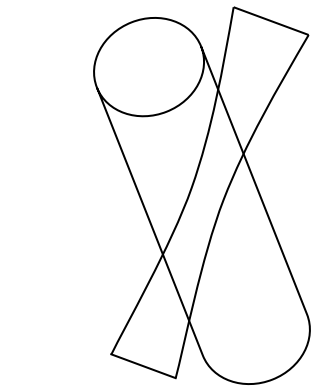
Resultant:
-.35 +.70 x 135

(Note that this is in fact a Jackson cross)

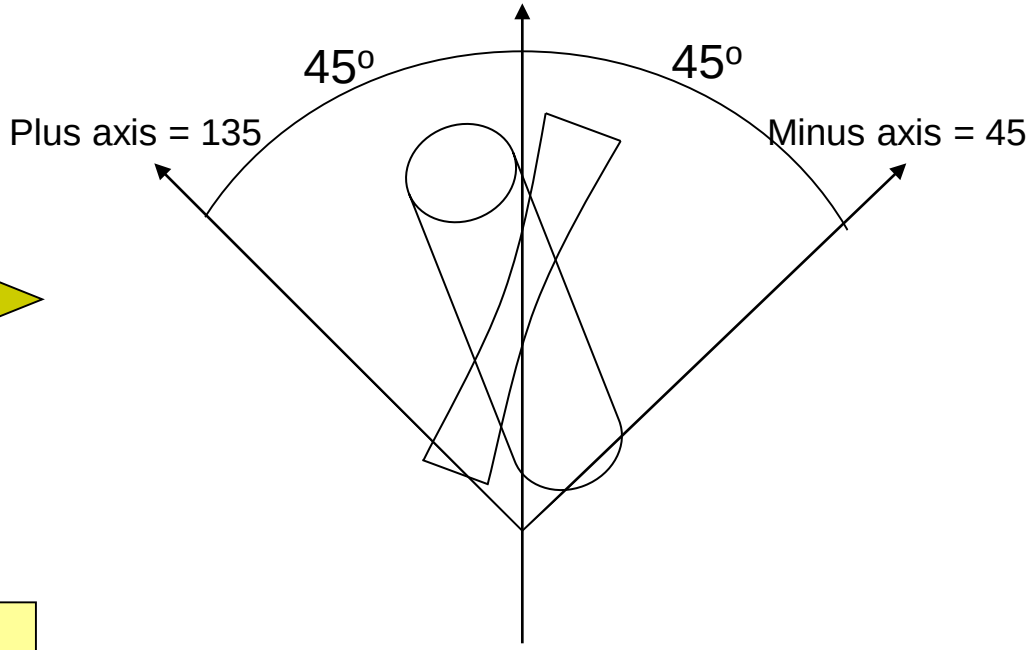
Astigmatic Correction: *Jackson Cross*

For Example…

Bisector Angle = 090



-2 x 085 +2 x 095

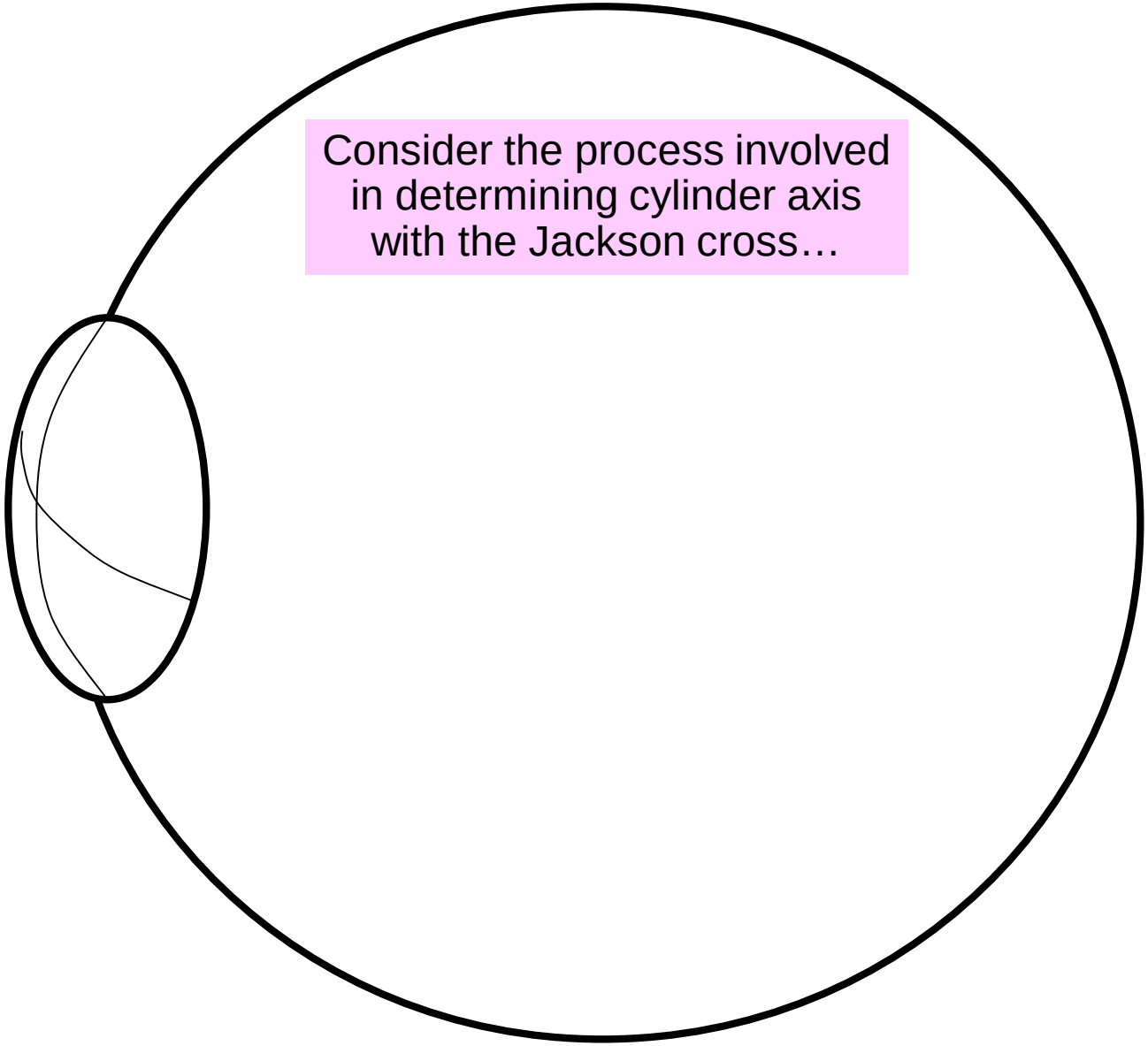


Resultant:
-.35 +.70 x 135

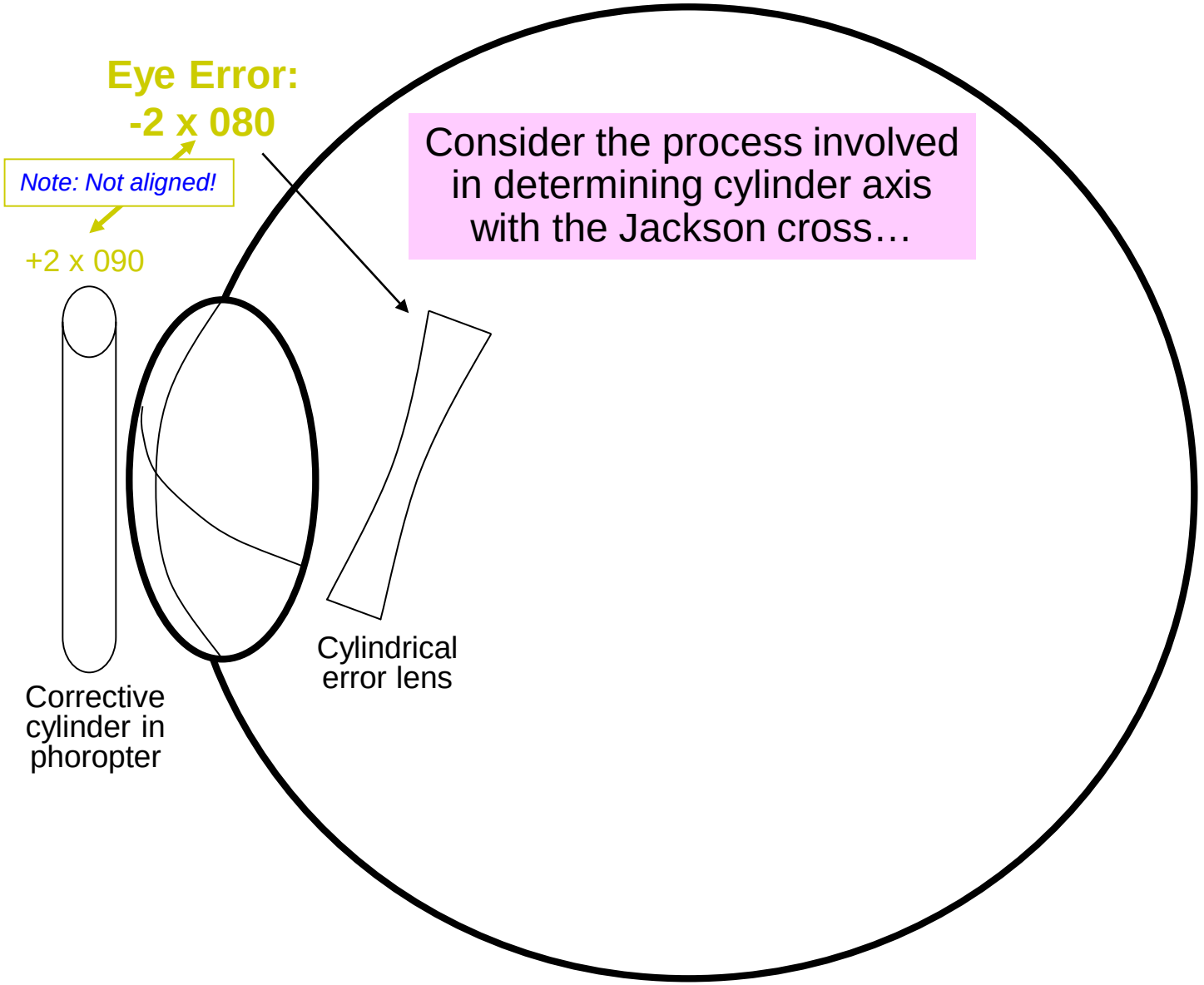
Why should we care about all of this cylinder mumbo-jumbo?

(Note that this is in fact a Jackson cross)

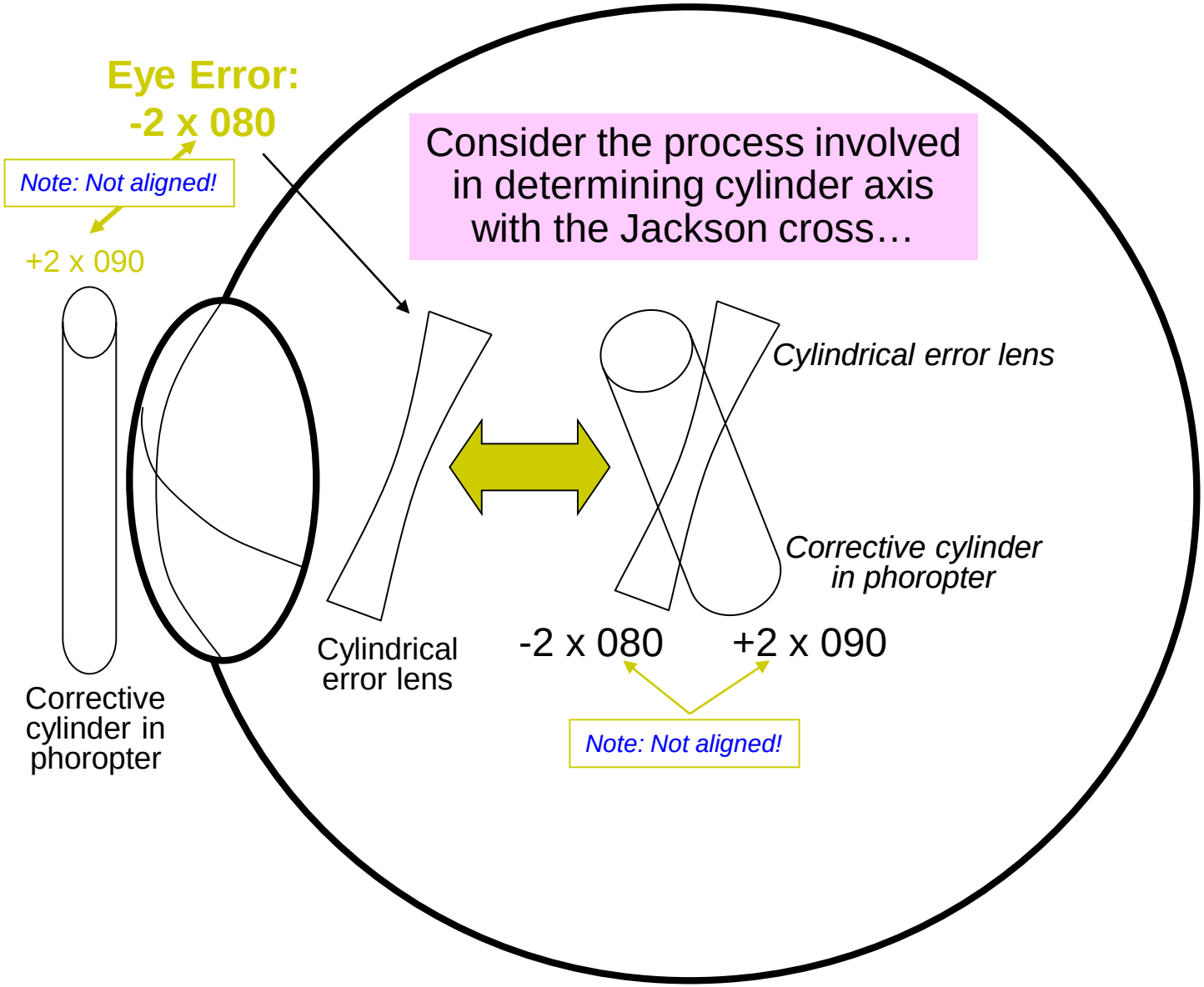
Astigmatic Correction: *Jackson Cross*



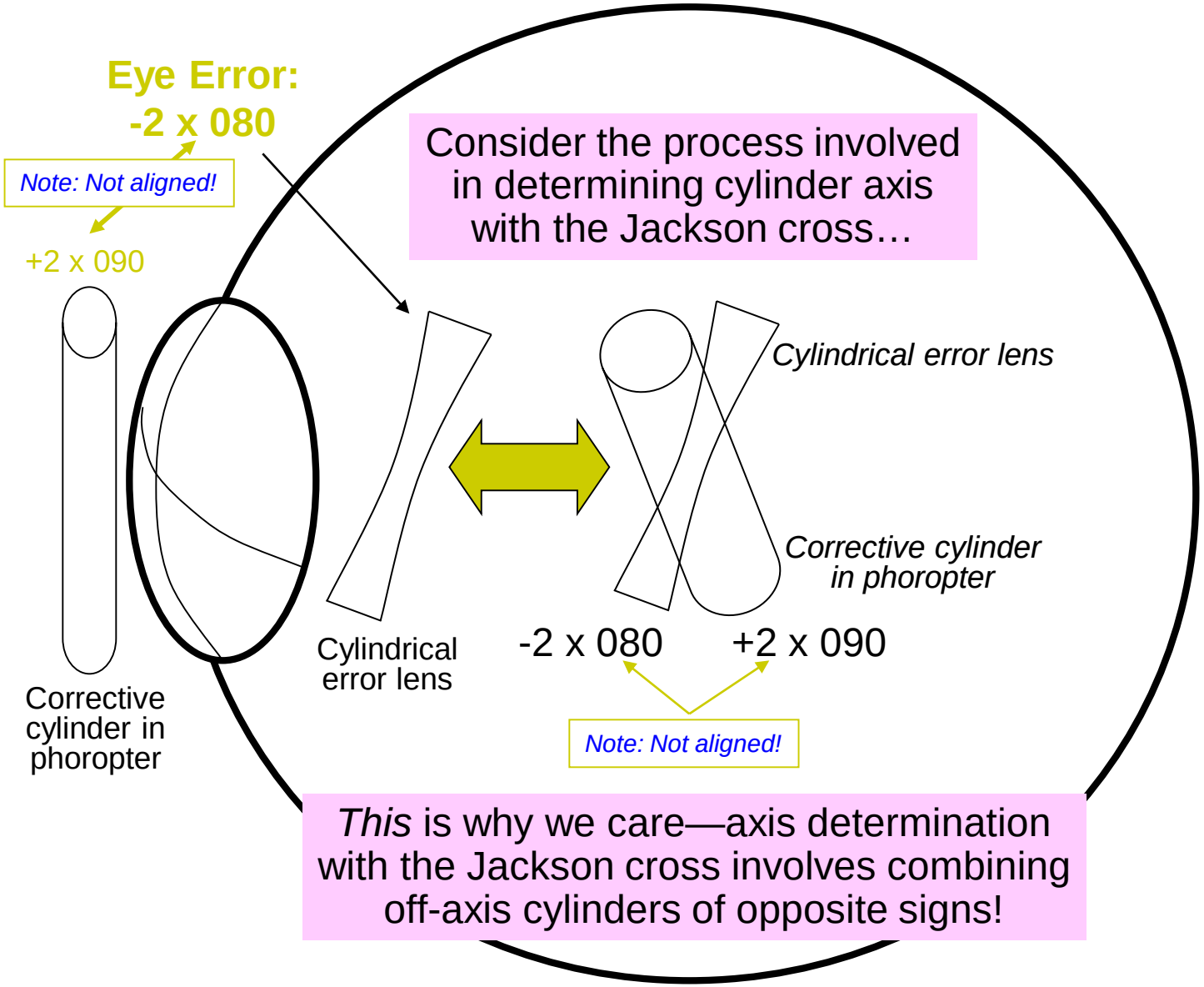
Astigmatic Correction: *Jackson Cross*



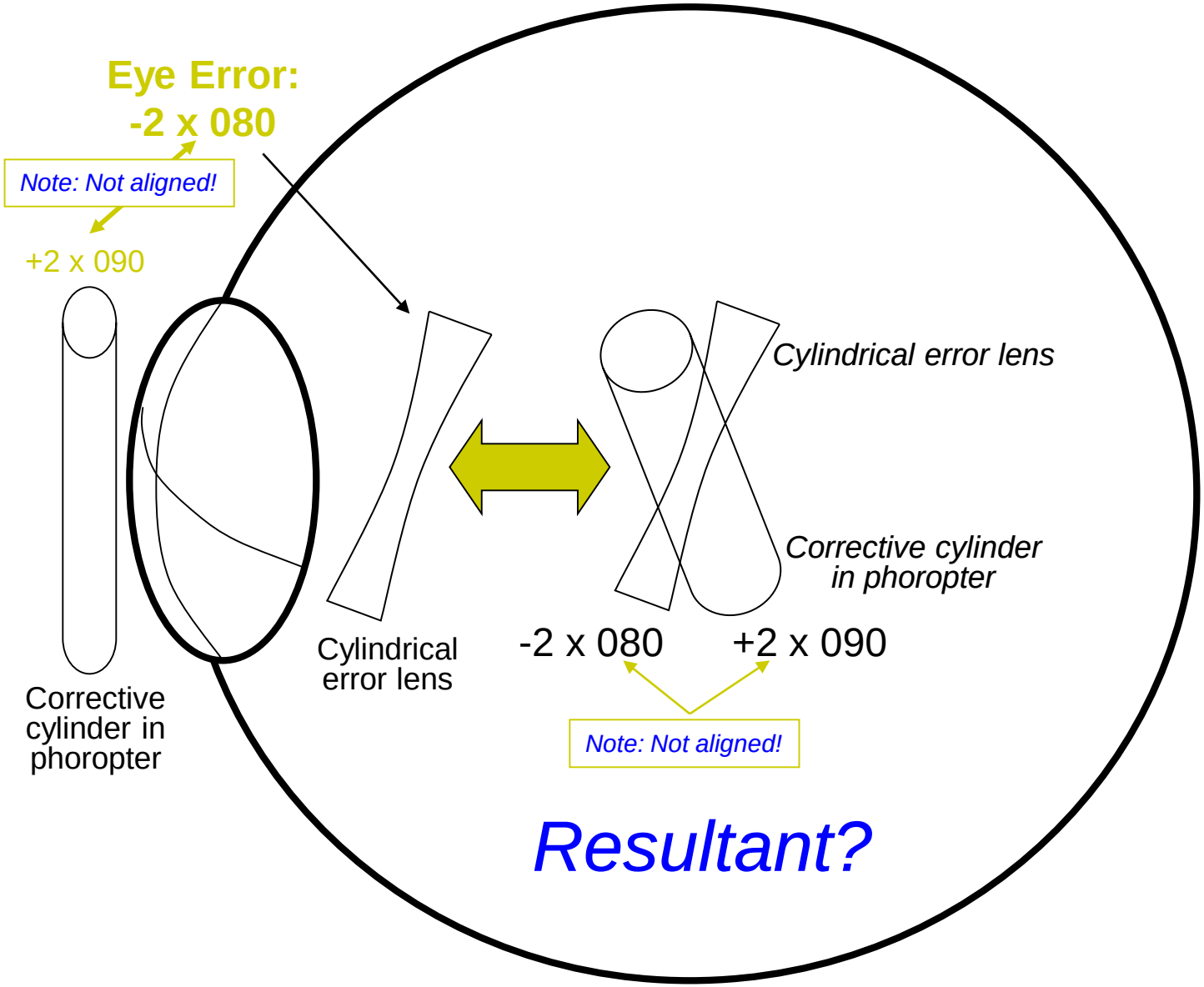
Astigmatic Correction: *Jackson Cross*



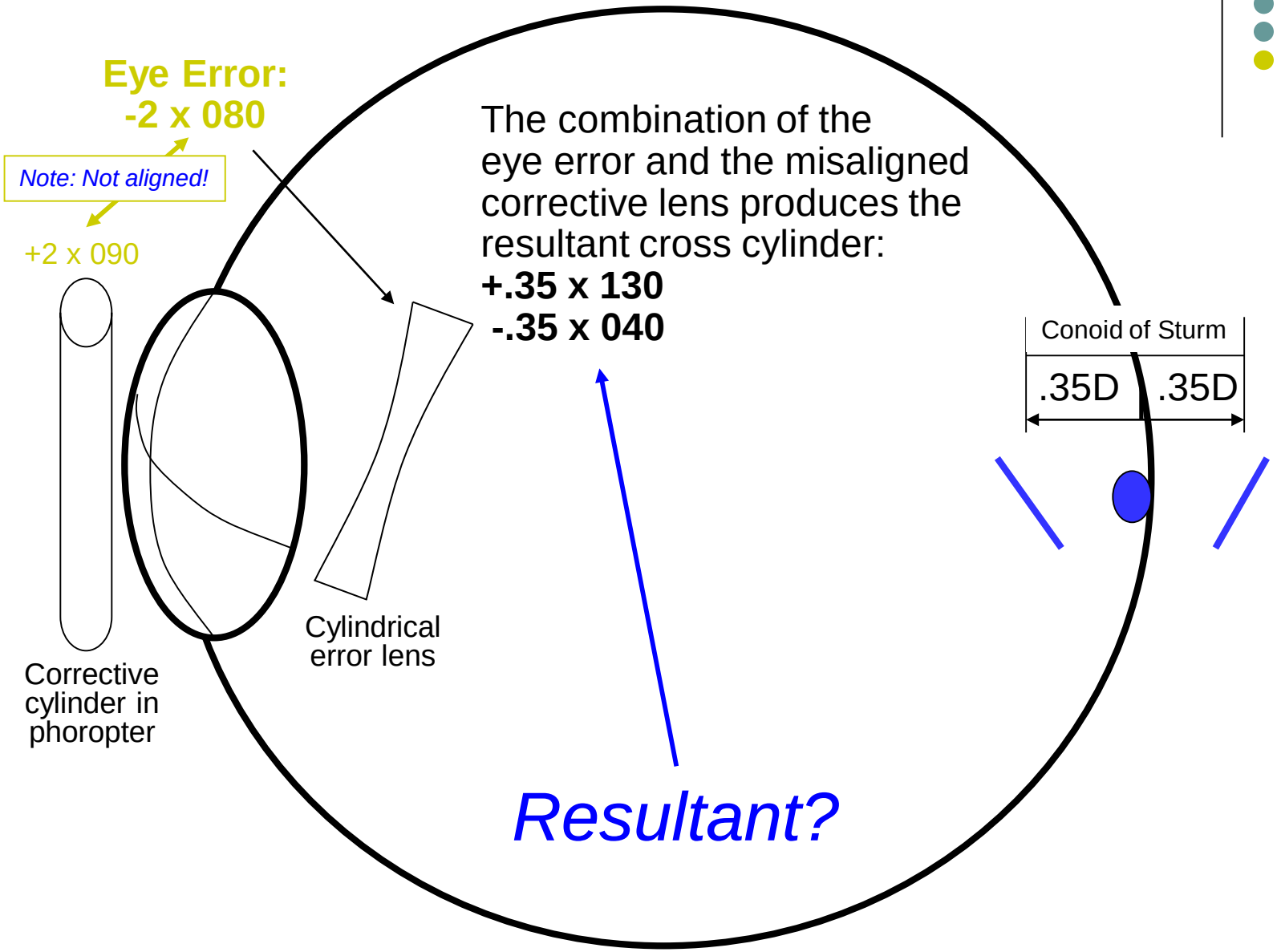
Astigmatic Correction: *Jackson Cross*



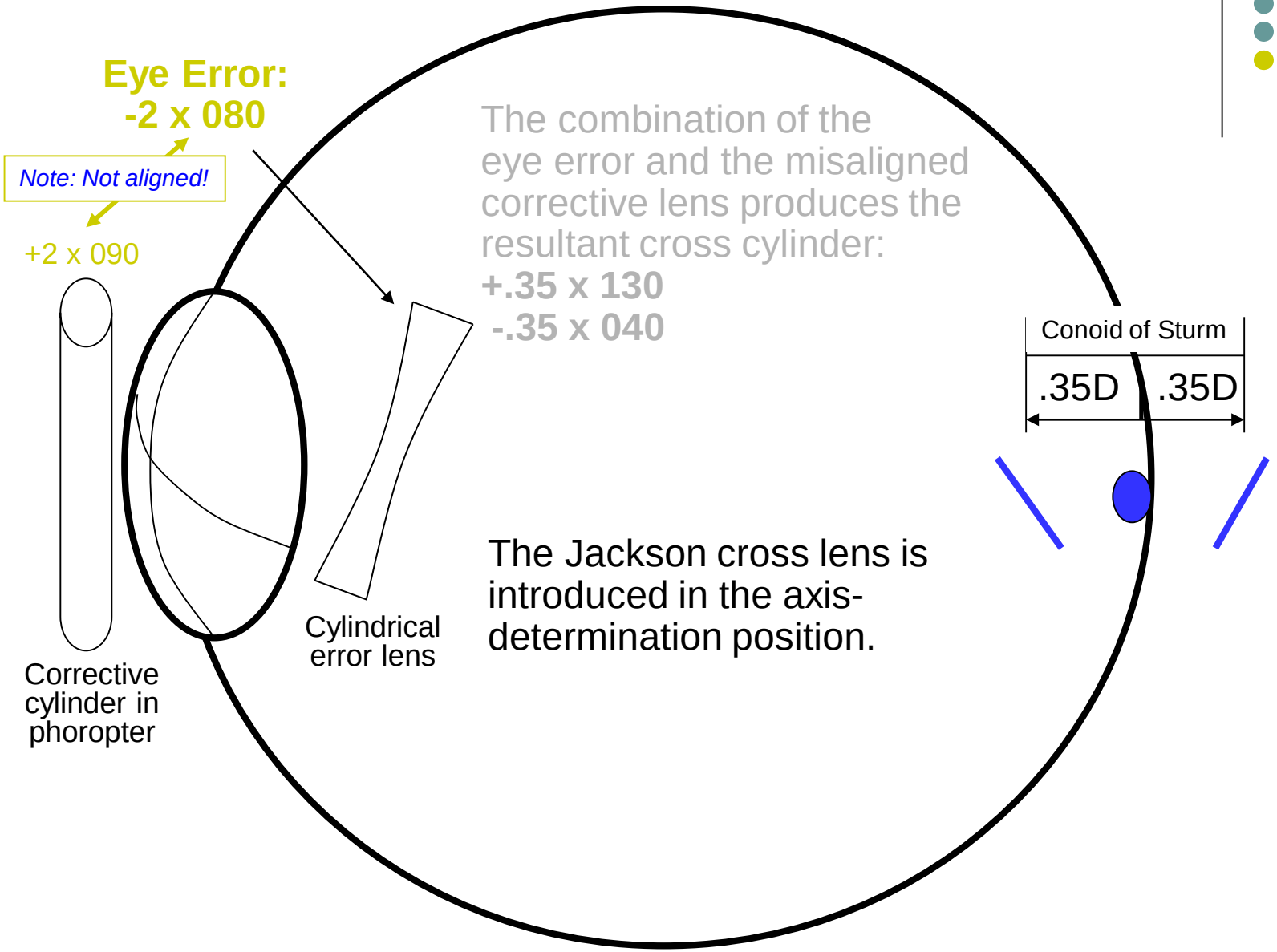
Astigmatic Correction: *Jackson Cross*



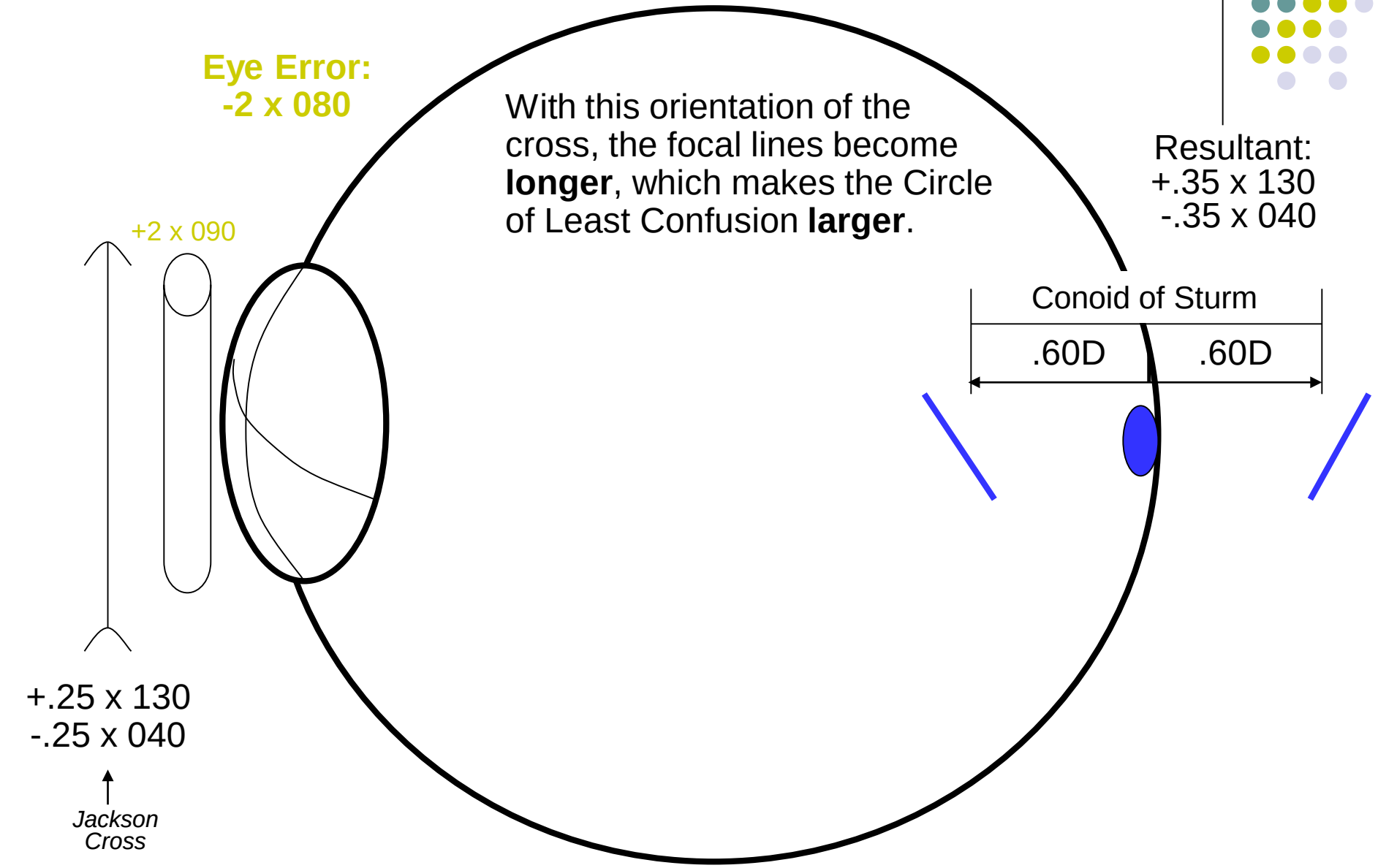
Astigmatic Correction: *Jackson Cross*



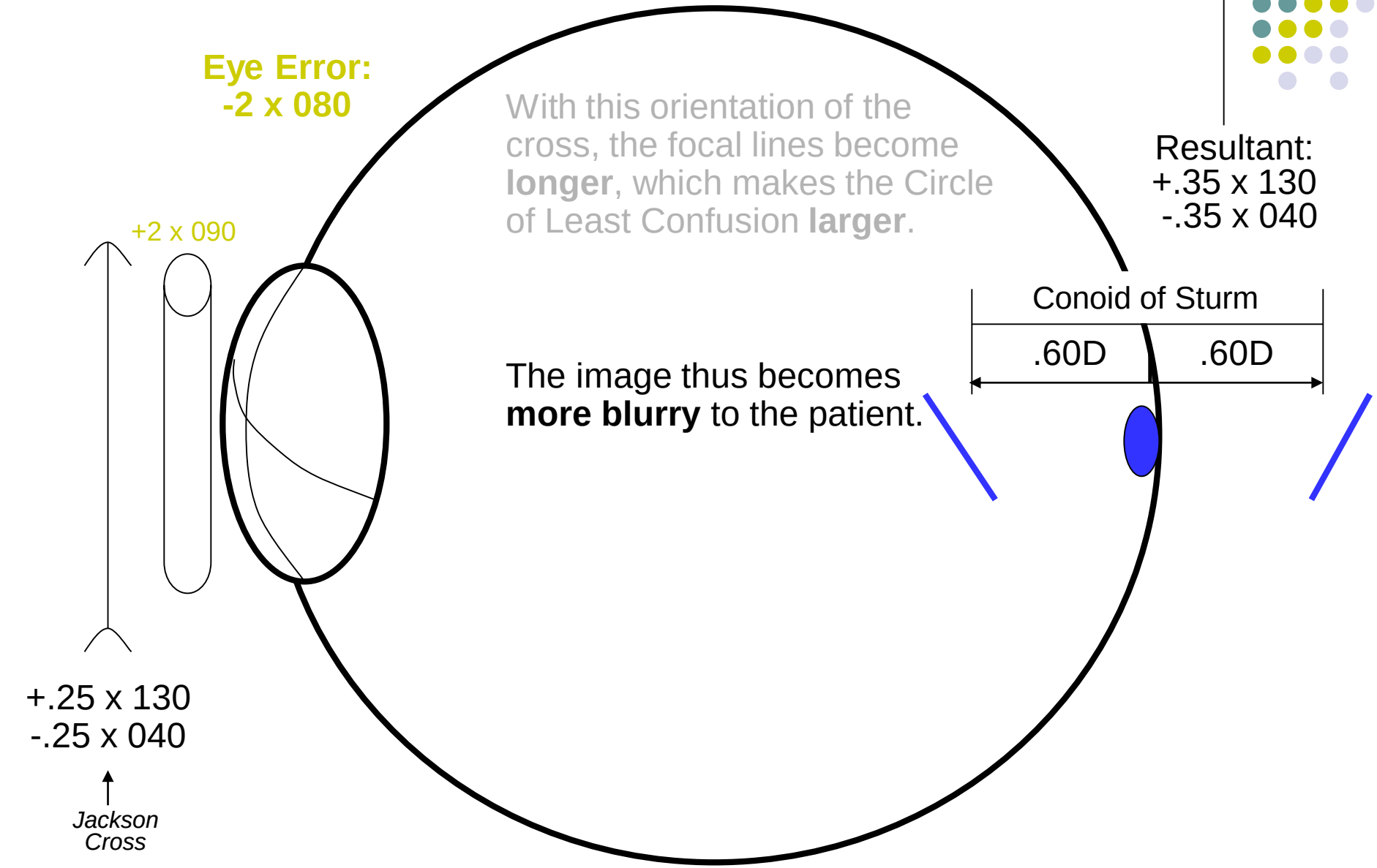
Astigmatic Correction: *Jackson Cross*



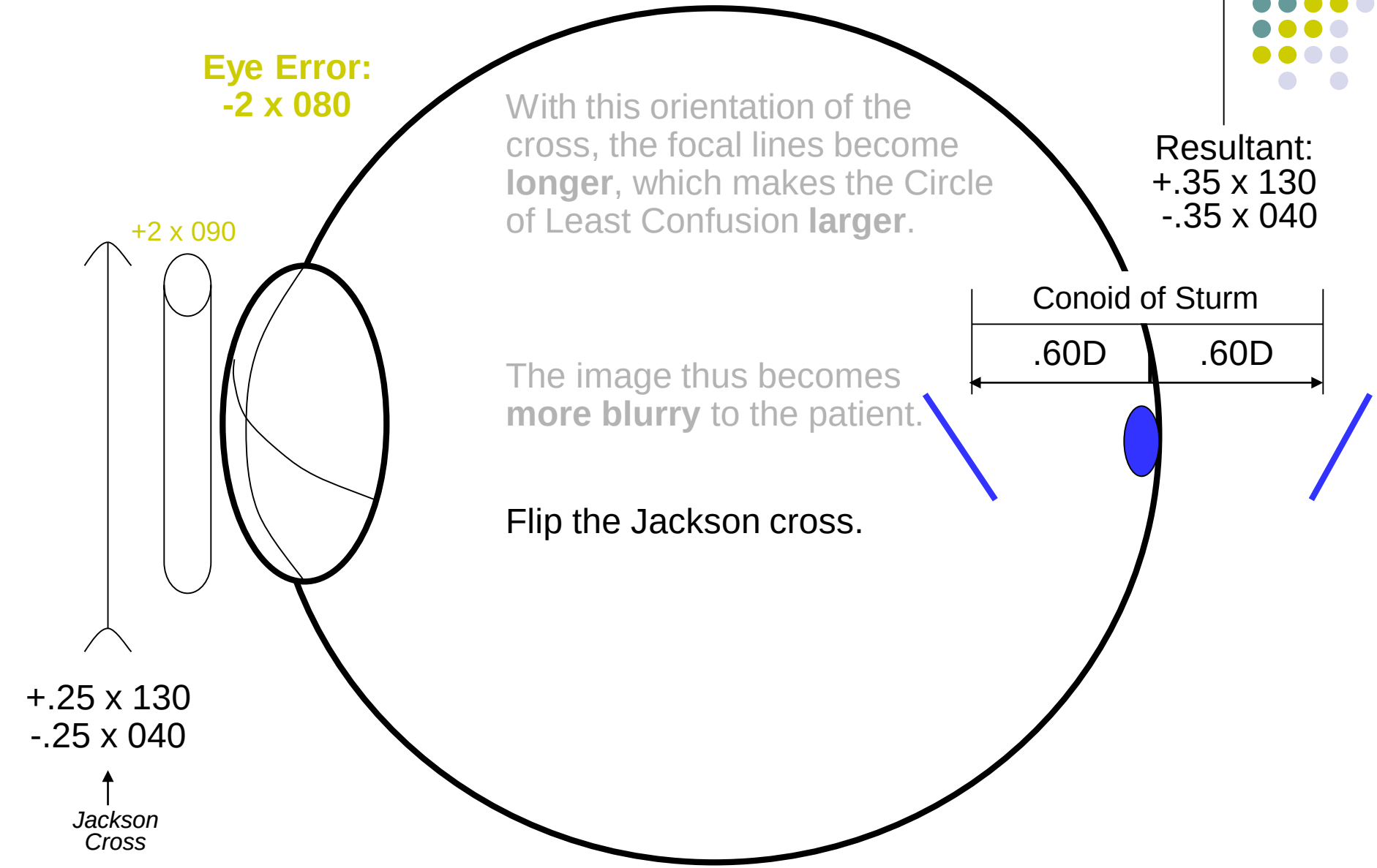
Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*



Astigmatic Correction: *Jackson Cross*

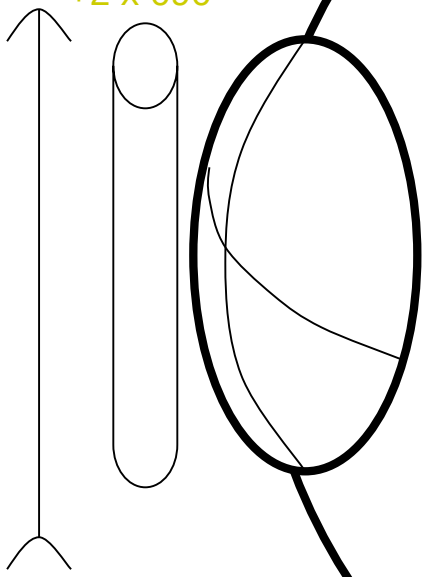


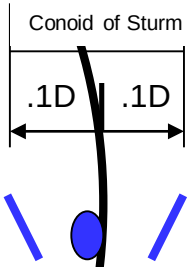
Astigmatic Correction: *Jackson Cross*

Eye Error:
-2 x 080

In this orientation, the focal lines become **shorter,** which makes the Circle of Least Confusion **smaller**.

Resultant:
+.35 x 130
-.35 x 040





-.25 x 130
+.25 x 040

Jackson Cross

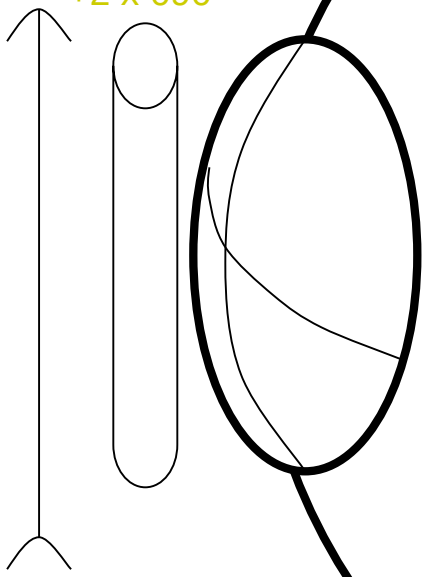
Astigmatic Correction: *Jackson Cross*

Eye Error:
-2 x 080

In this orientation, the focal lines become **shorter,** which makes the Circle of Least Confusion **smaller**.

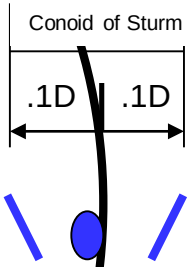
Because this is less blurry, the cylinder axis is rotated 10º toward the plus.

Resultant:
+.35 x 130
-.35 x 040



-.25 x 130
+.25 x 040

Jackson Cross



Astigmatic Correction: *Jackson Cross*

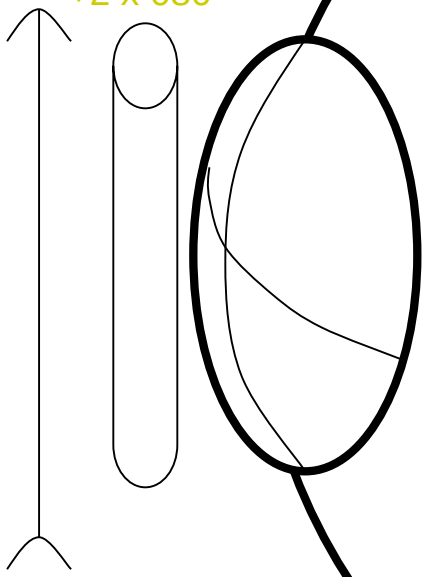
Eye Error:
-2 x 080

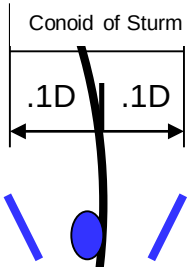
In this orientation, the focal lines become **shorter,** which makes the Circle of Least Confusion **smaller**.

Because this is less blurry, the cylinder axis is rotated 10° toward the plus.

The Jackson cross is reintroduced.

Resultant:
+.35 x 130
-.35 x 040





-.25 x 130
+.25 x 040

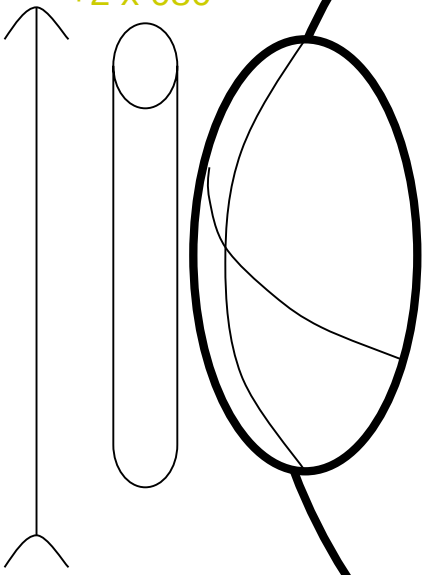
Jackson Cross

Astigmatic Correction: *Jackson Cross*

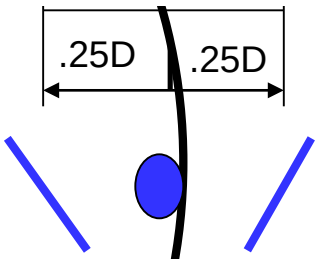
Eye Error:
-2 x 080

Now the only error present is due to the Jackson cross cylinder itself.

+2 x 080



Conoid of Sturm



+.25 x 130
-.25 x 040

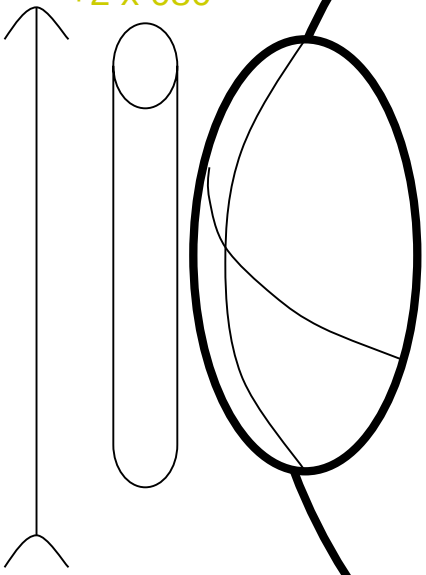
Jackson Cross

Astigmatic Correction: *Jackson Cross*

Eye Error:
-2 x 080

Now the only error present is due to the Jackson cross cylinder itself.

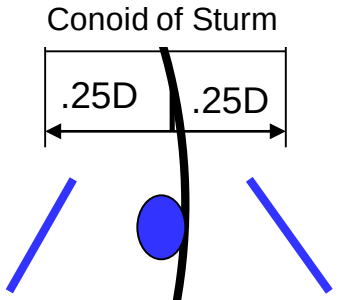
+2 x 080



-.25 x 130
+.25 x 040

Jackson Cross

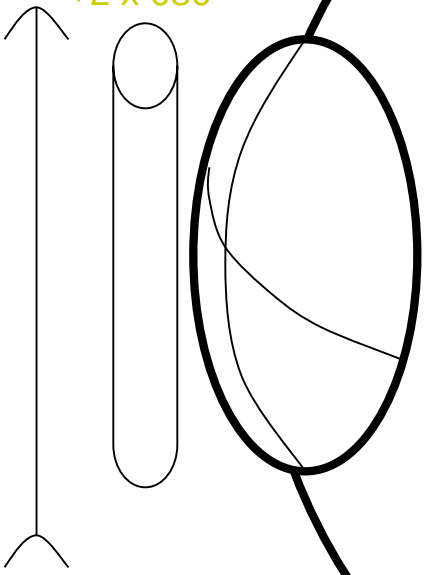
As the Jackson cross is flipped, the positions of the focal lines reverse, but the Circle of Least Confusion does not change in size.



Astigmatic Correction: *Jackson Cross*

Eye Error:
-2 x 080

+2 x 080



+.25 x 130
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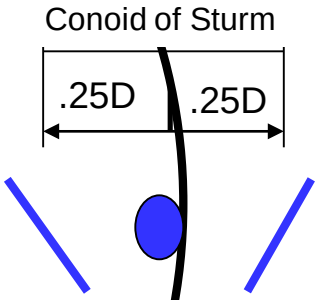
Jackson Cross

Now the only error present is due to the Jackson cross cylinder itself.

As the Jackson cross is flipped, the positions of the focal lines reverse, but the Circle of Least Confusion does not change in size.



Because the Circle does not change in size, the patient perceives the two positions as equally blurry, and we know the correct axis has been found.

Astigmatic Correction: *Jackson Cross*

- So that's how Jackson Cross refraction works!

	Retinoscopic	***Jackson Cross***
Step 1	Use sphere to place **one focal line** on the retina	Use sphere to place the **CoLC** on the retina
Step 2	Use cylinder to place the **other focal line** on the retina	Use cross to simultaneously **collapse both focal lines**
Result	**Conoid collapsed to a point on the retina**	**Conoid collapsed to a point on the retina**