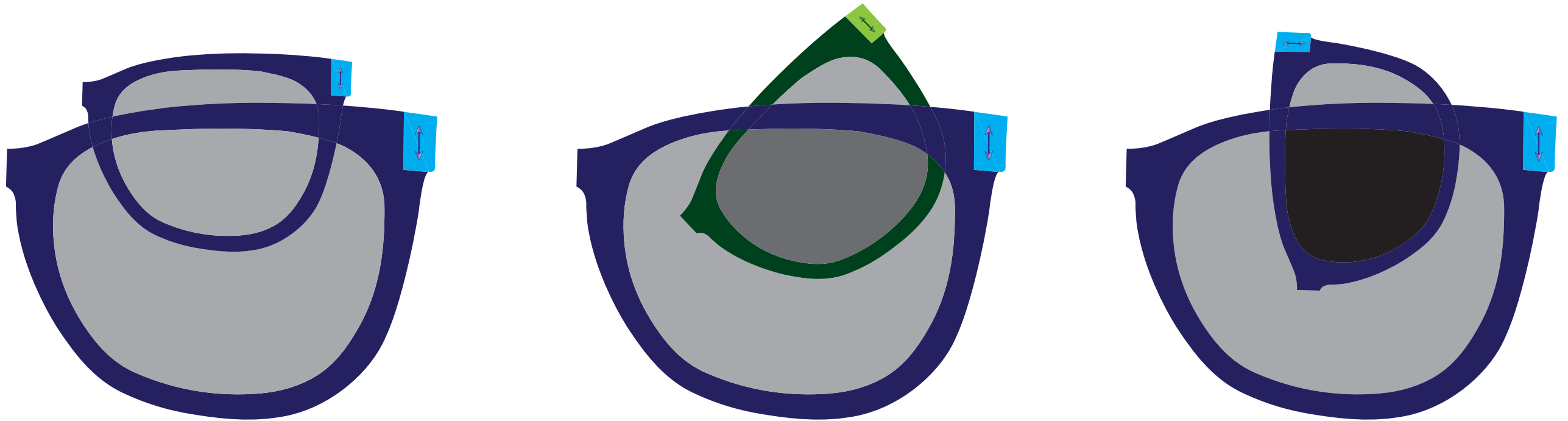


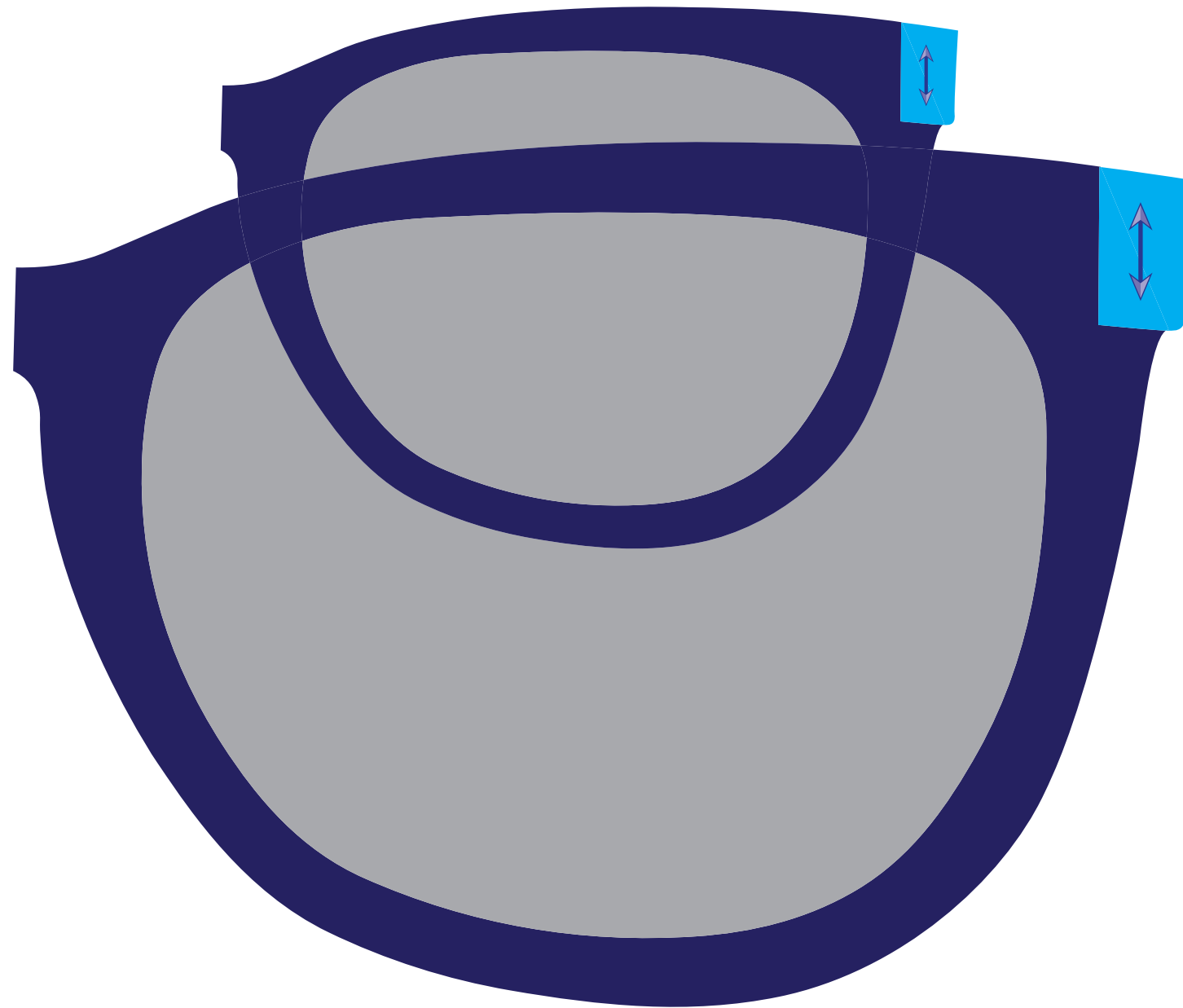
Quantum spooks

Sunglasses



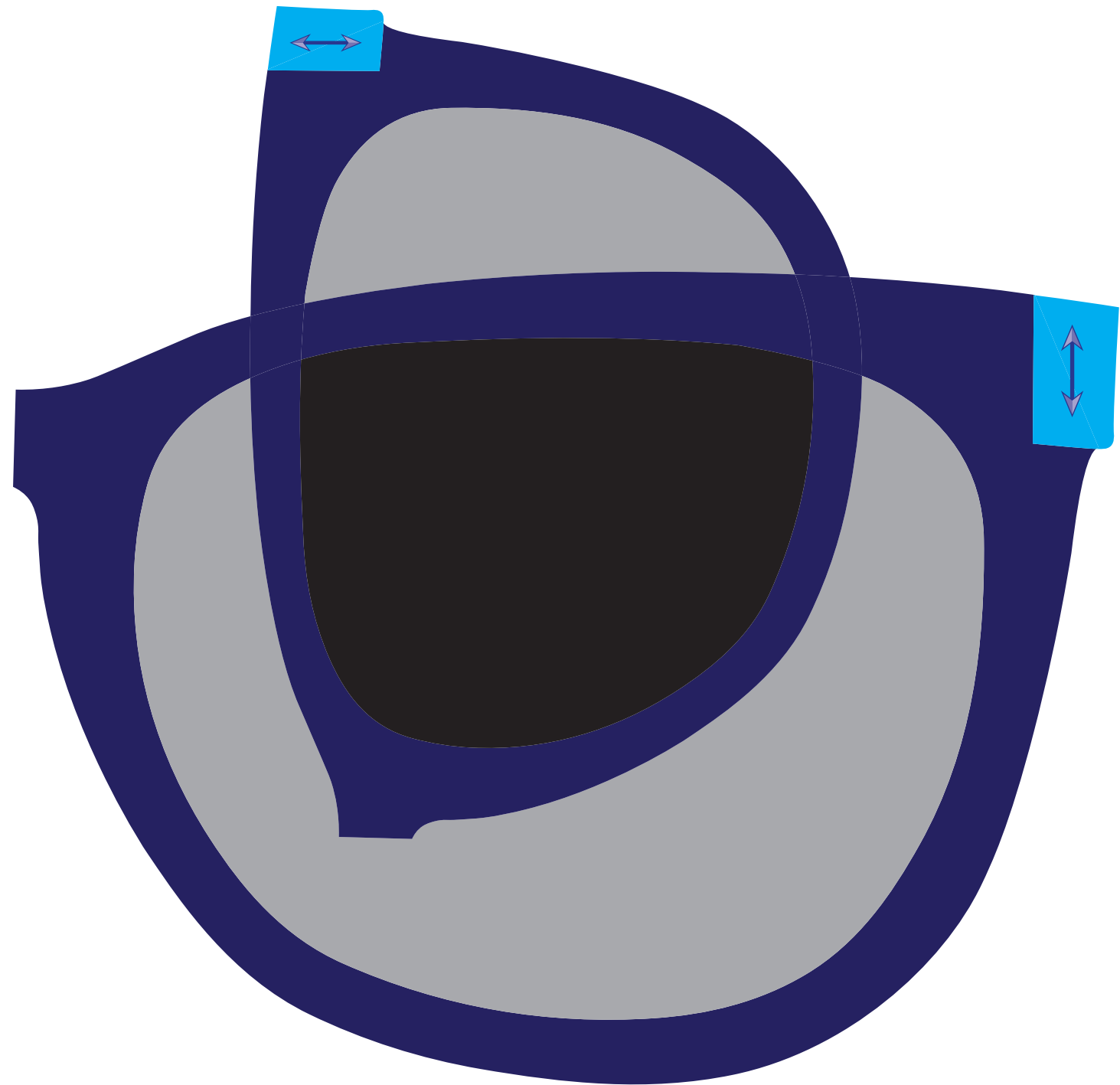
Two glasses

- Half of the unpolarized light (background) makes it through the rearmost glasses. Only vertically polarized light makes it through.
- Since forward glasses only let vertical polarization through, all the light that got through the first pair make it through the second.

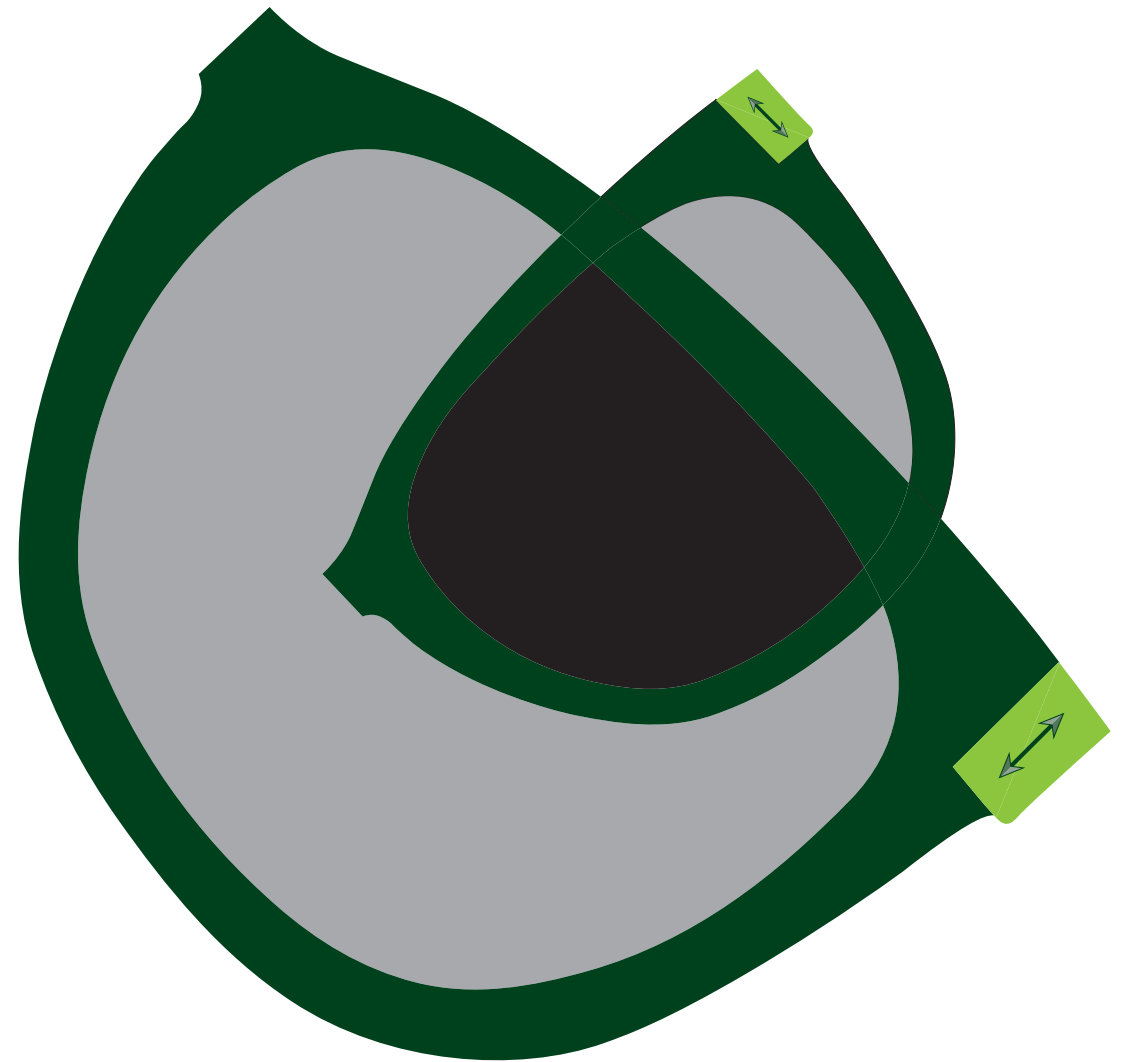
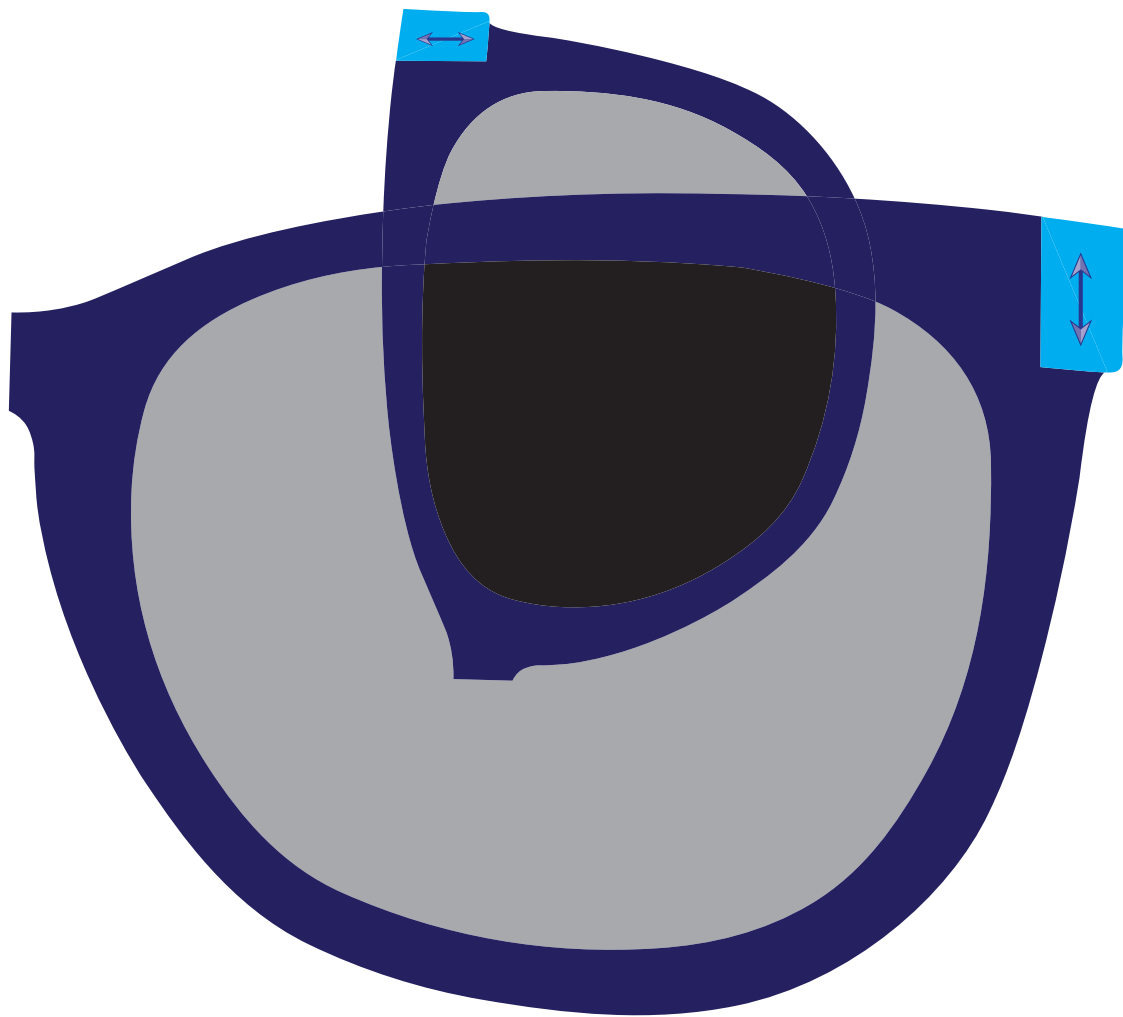


Two glasses

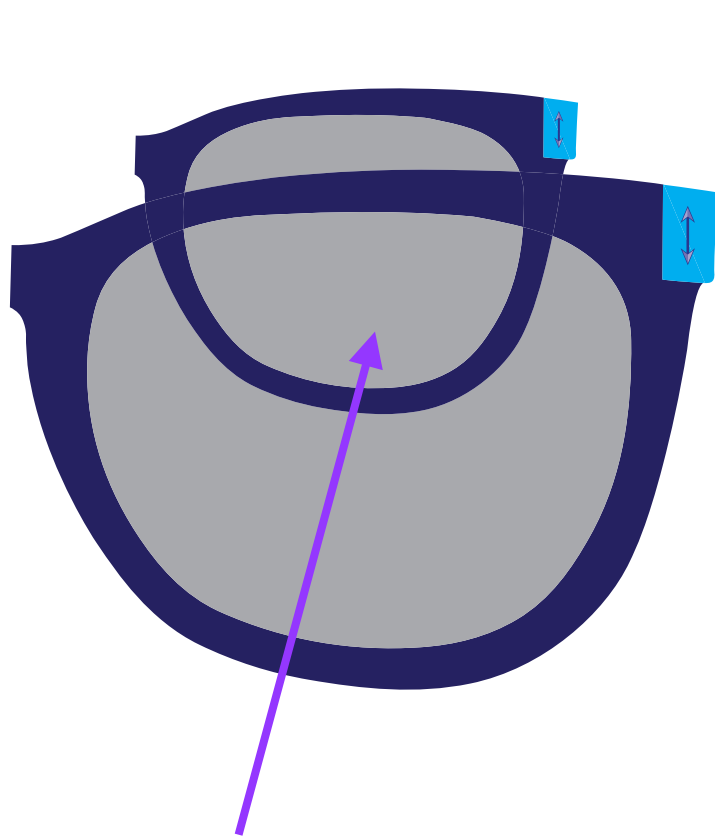
- Half of the unpolarized light (background) makes it through the rearmost glasses. Only horizontally polarized light makes it through.
- Since forward glasses only let vertical polarization through, all the light that got through the first pair is blocked by the second pair.



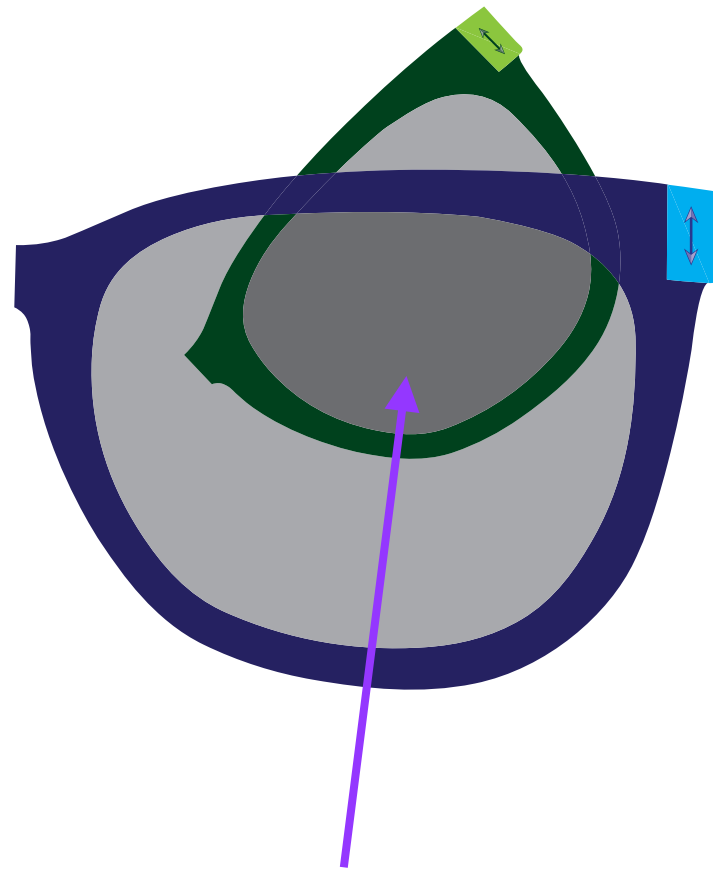
Only relative orientation matters



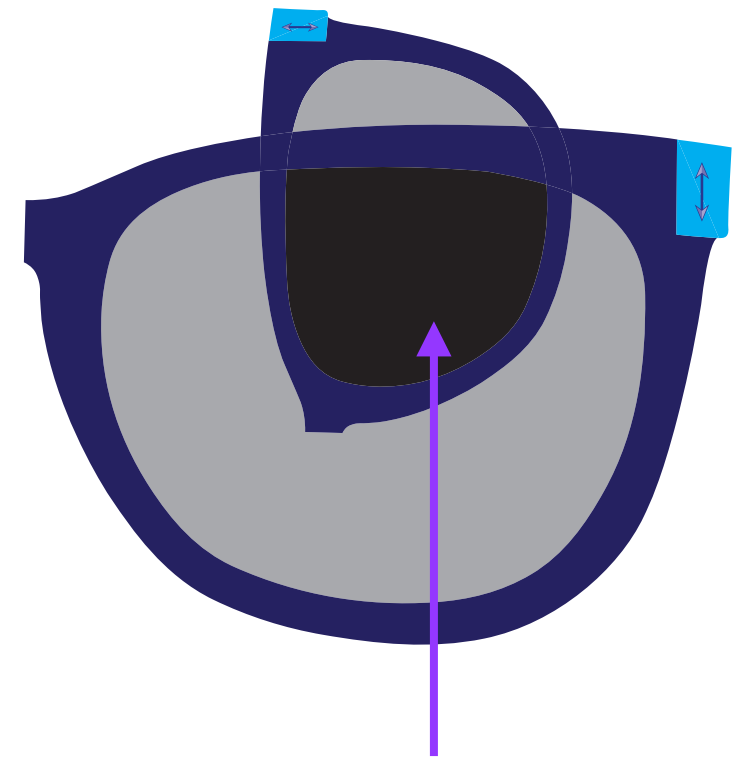
Mixing sets



$$1/2 * \text{all} = 1/2$$



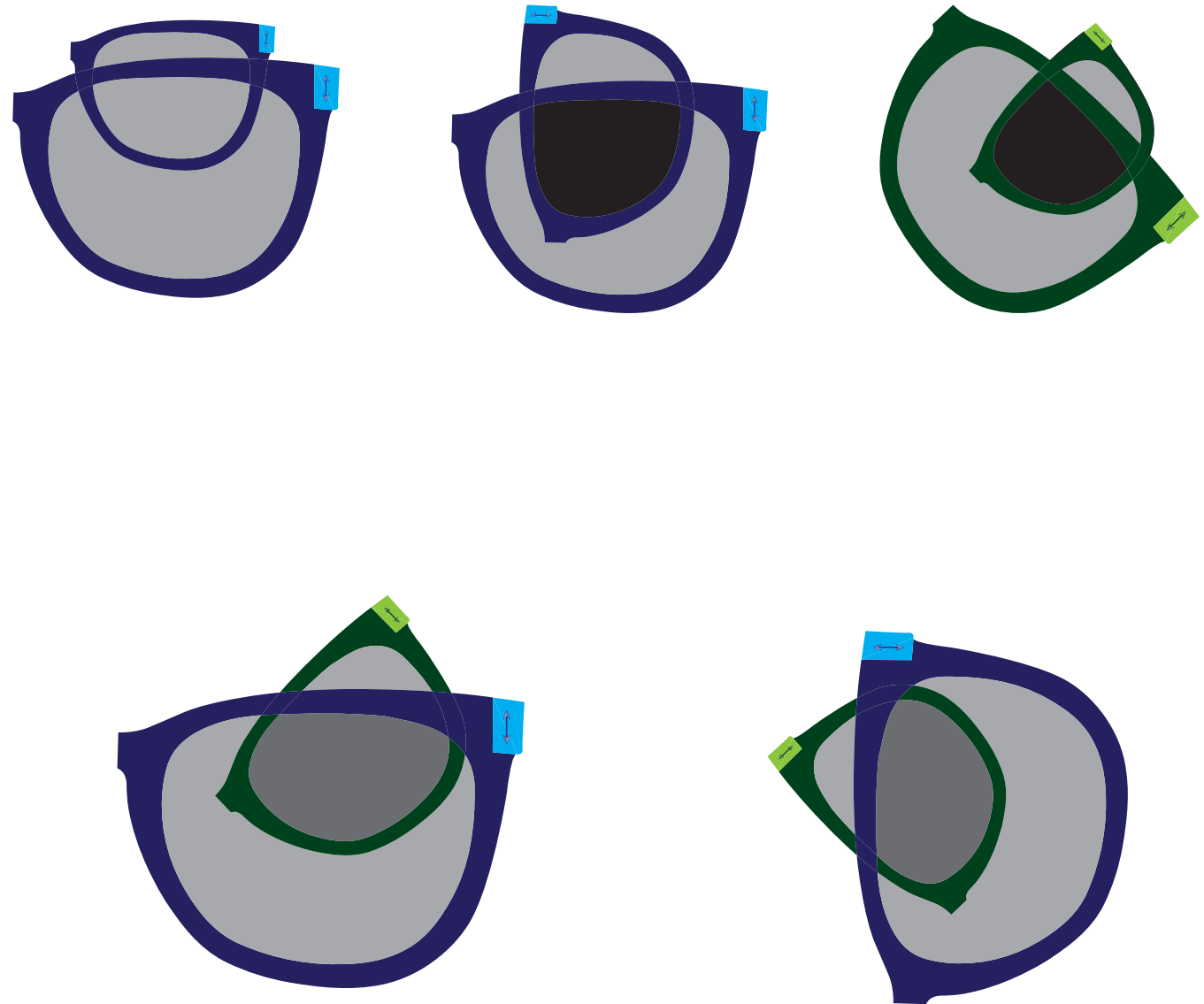
$$1/2 * 1/2 = 1/4$$



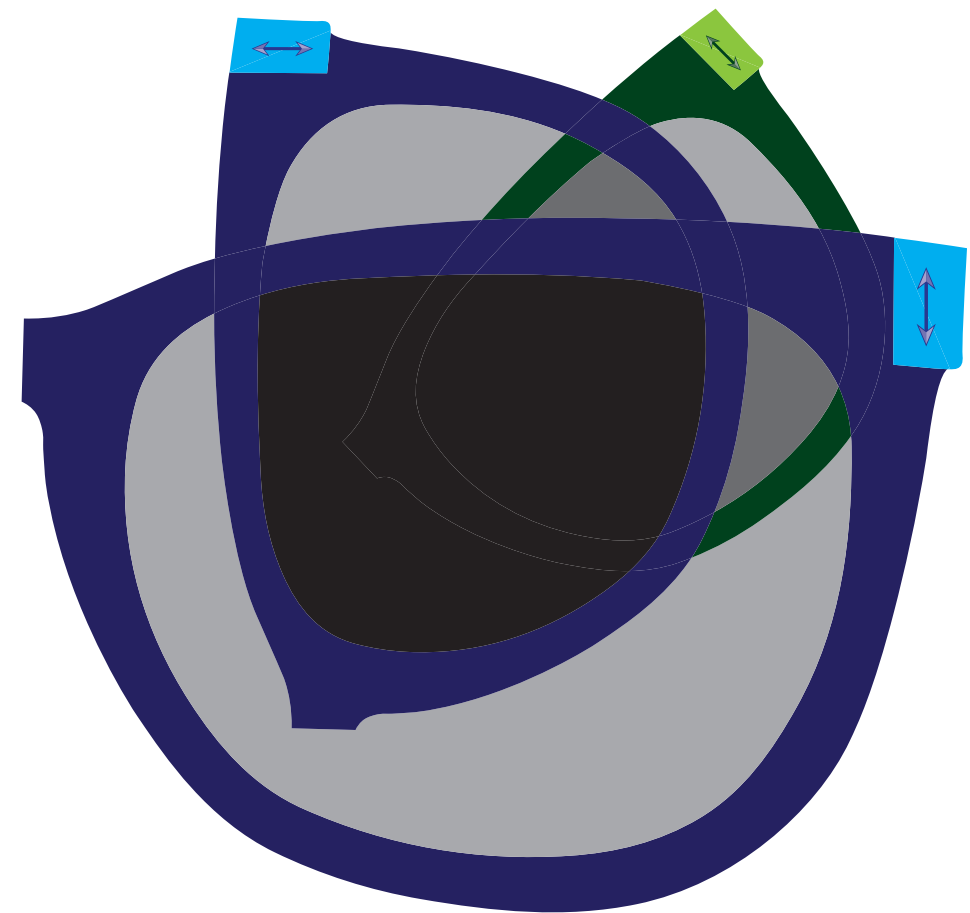
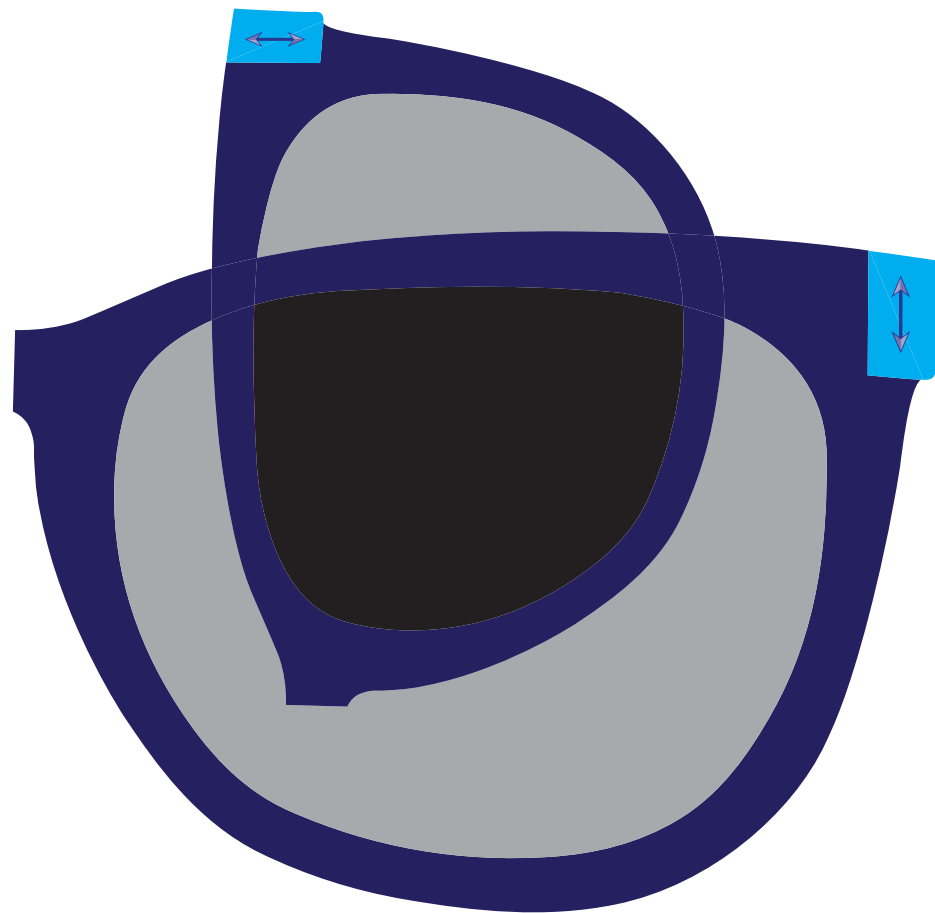
$$1/2 * \text{none} = 0$$

Mixing sets

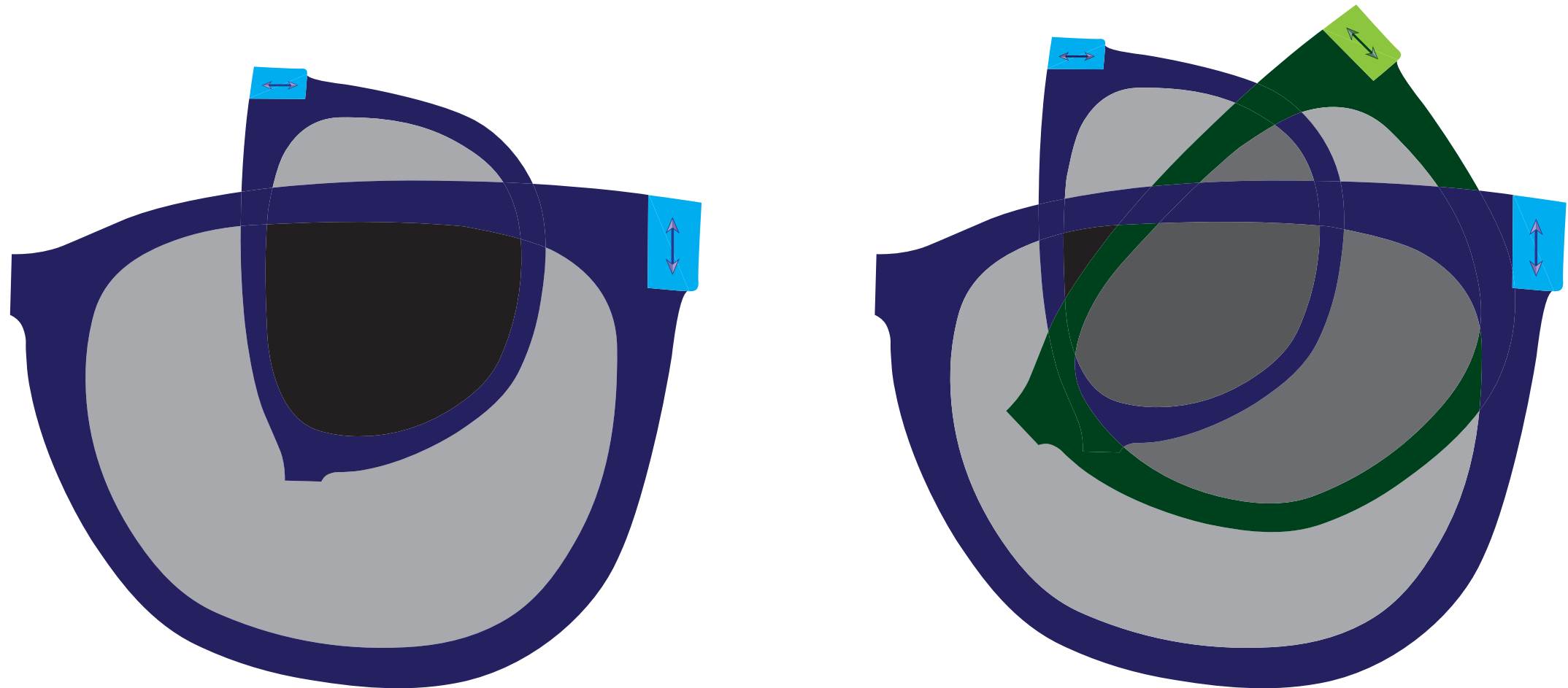
- Two glasses of the same 'set' (frame color) gives either all of light through the first or none.
- Two glasses from different sets always gives $1/2$ of light through the first pair.



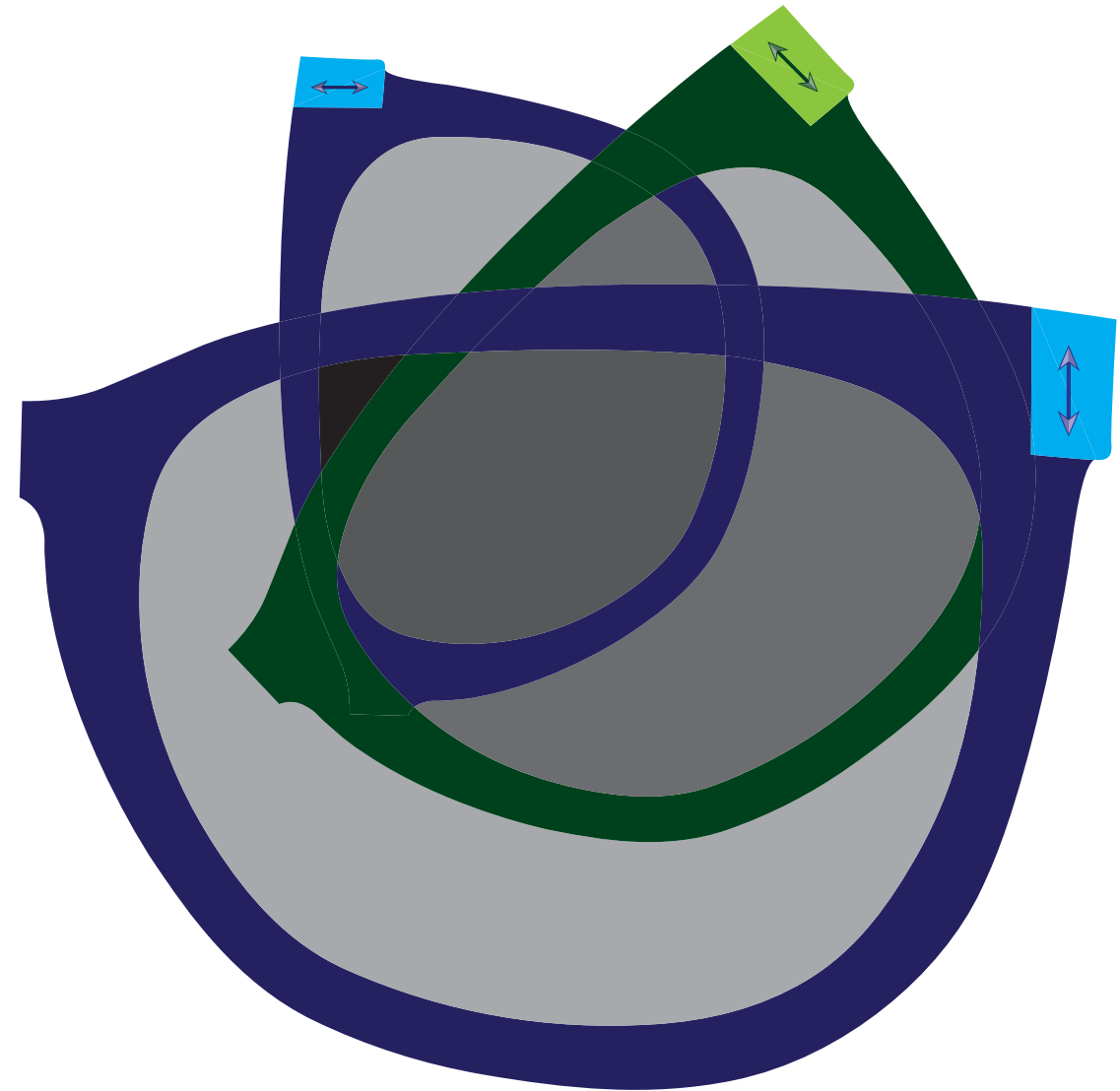
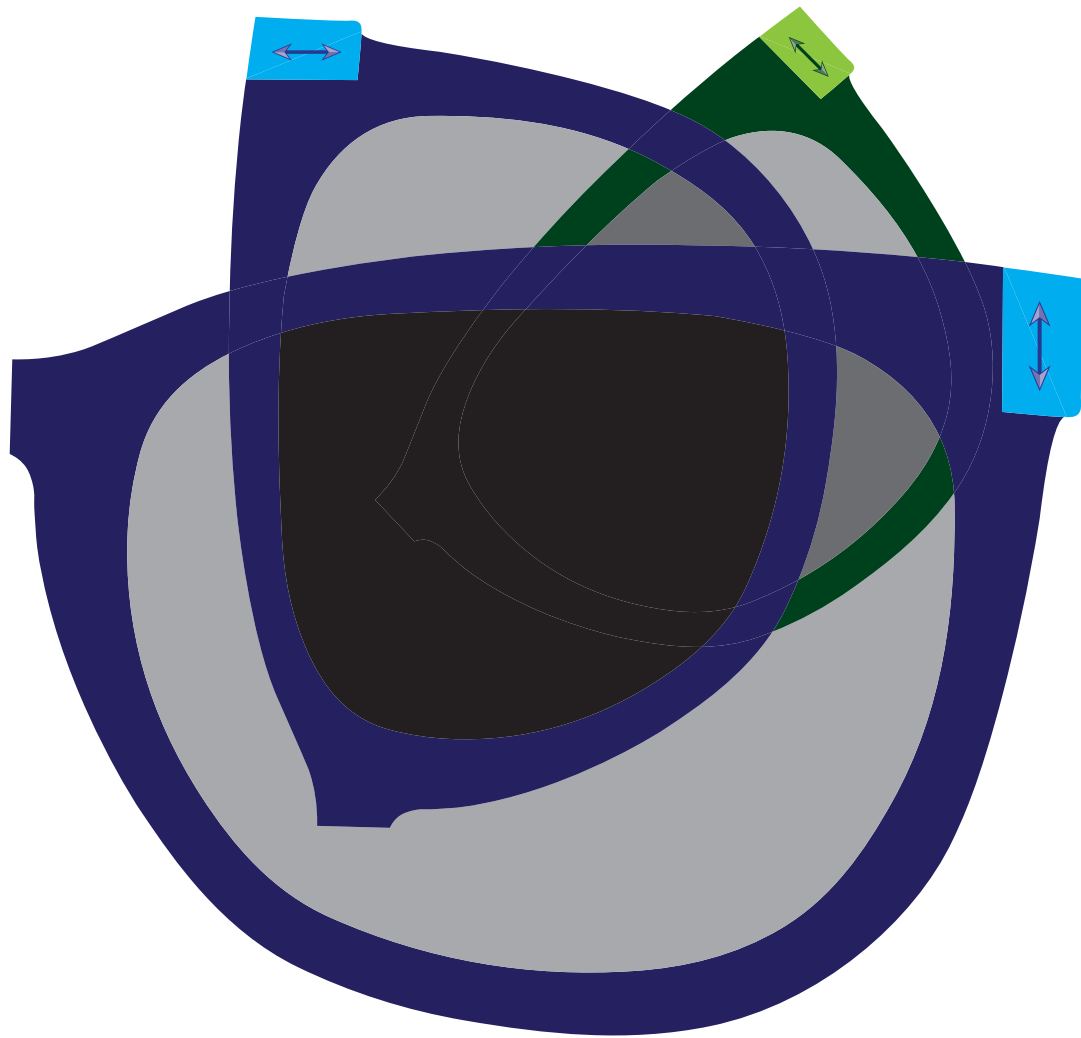
Adding a third pair of glasses



Adding a third pair of glasses



Order matters!

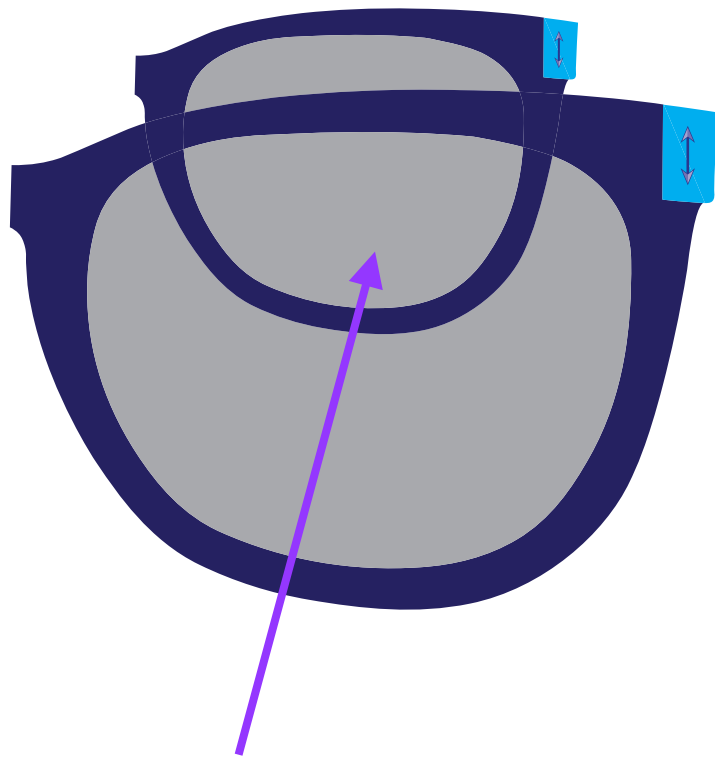


Wearing sunglasses at night

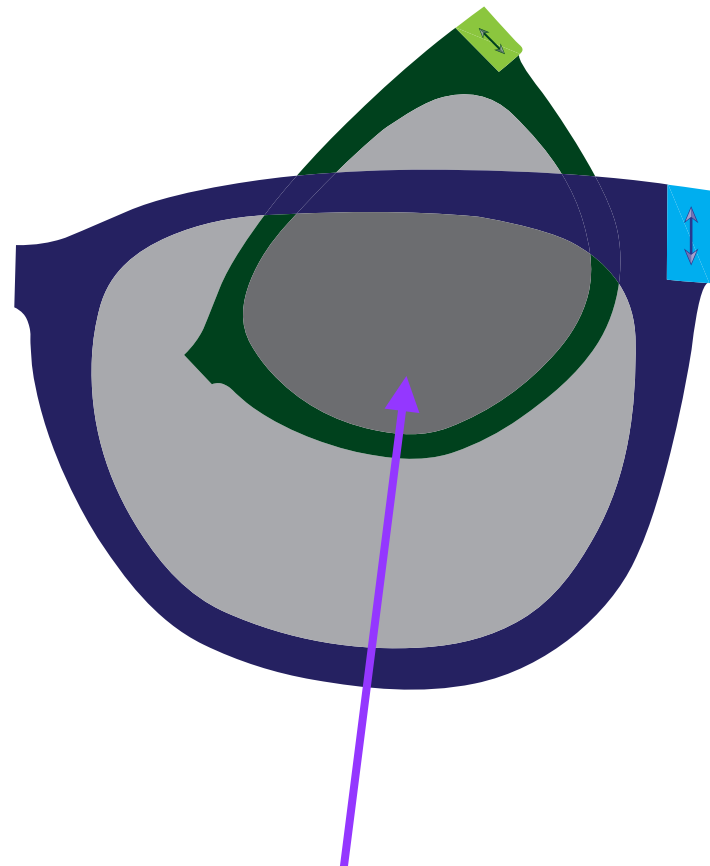


**Diane Knutson,
International Dark-Sky
Association**

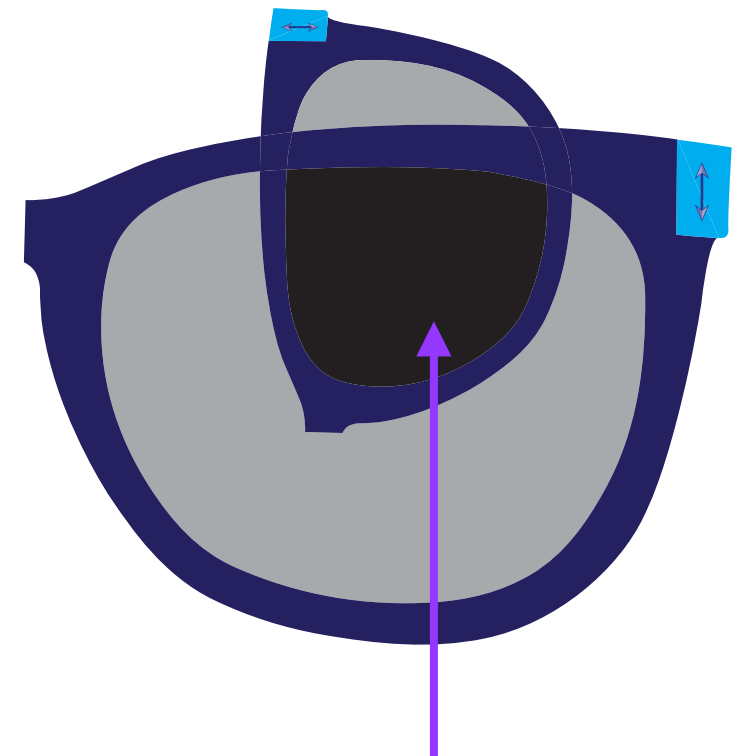
Fraction of photons making it through



$$1/2 * \text{all} = 1/2$$

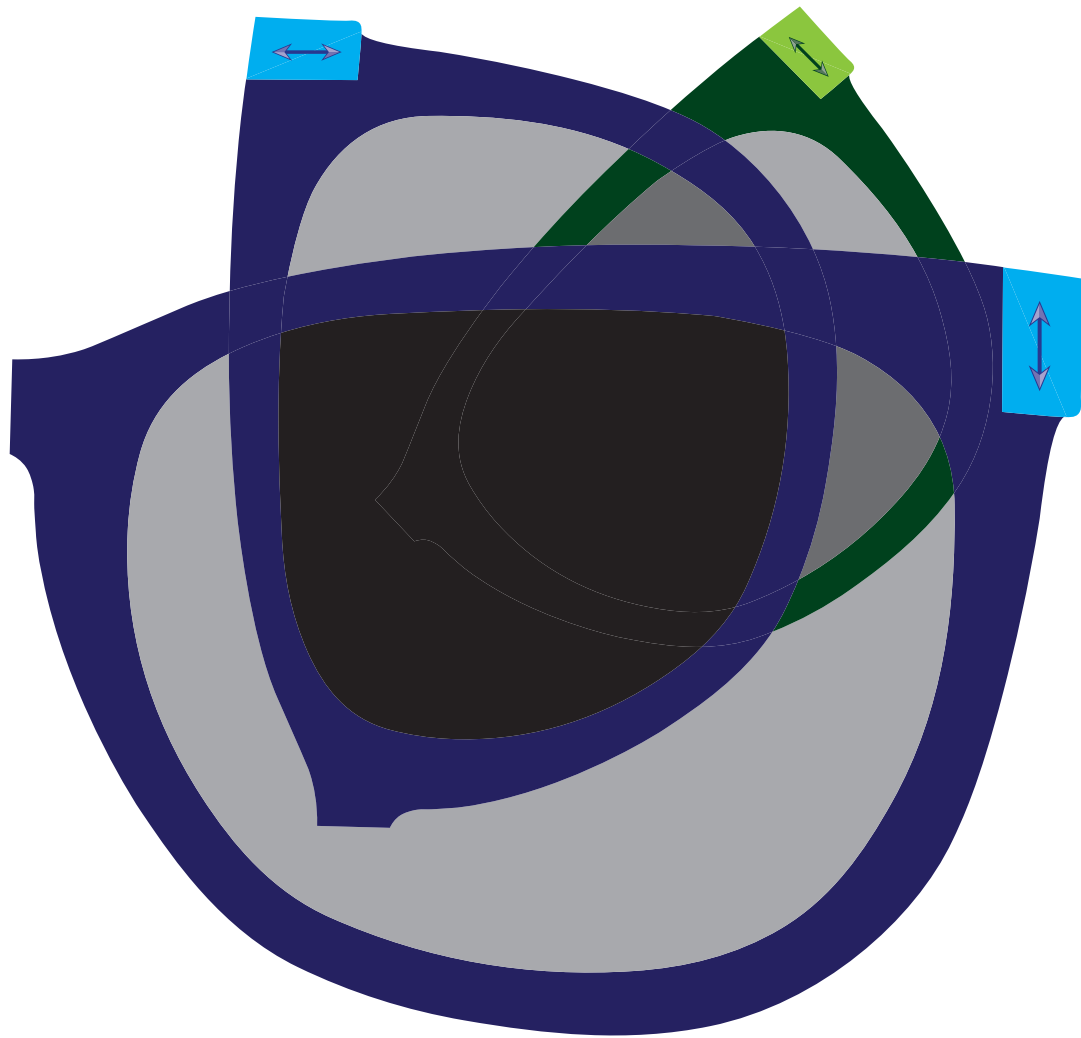


$$1/2 * 1/2 = 1/4$$

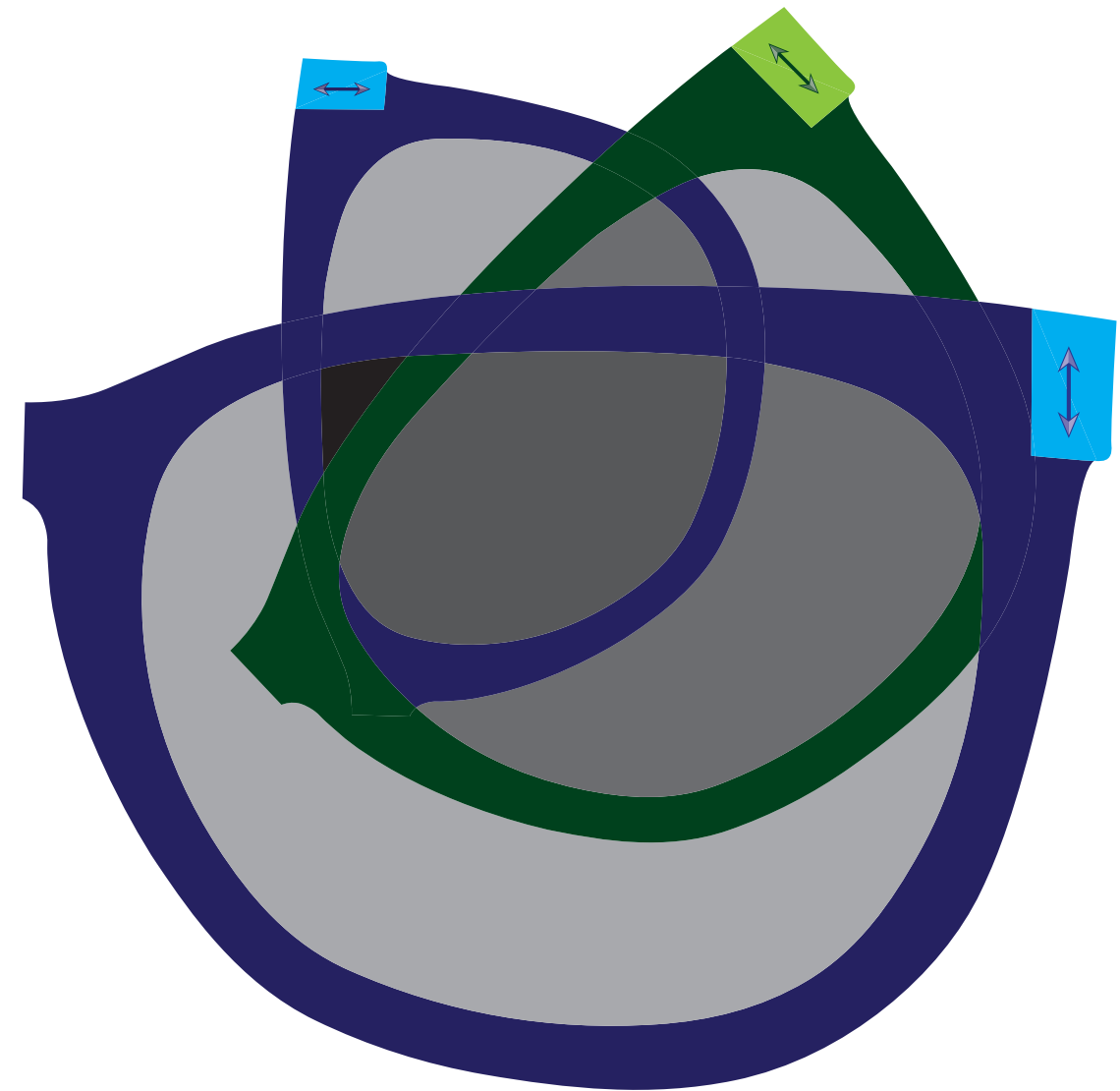


$$1/2 * \text{none} = 0$$

Fraction of photons making it through



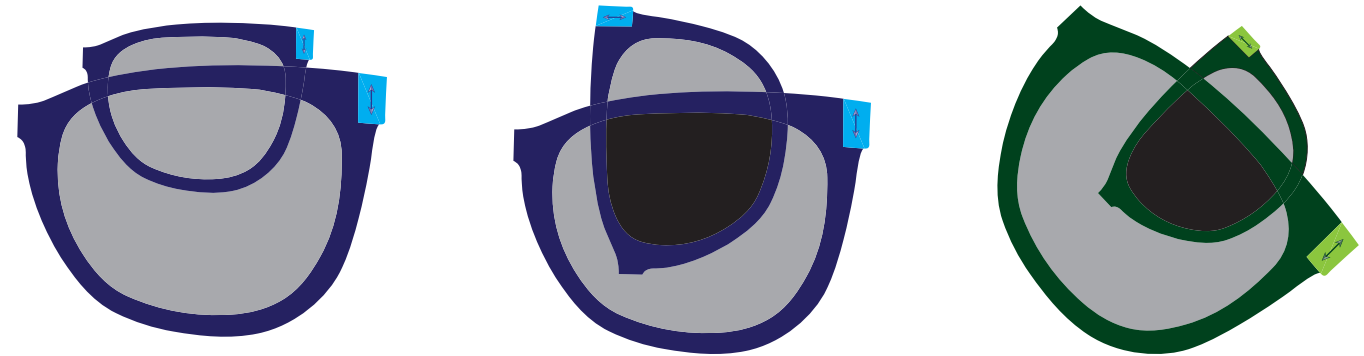
$$1/2 * 1/2 * \text{none} = 0$$



$$1/2 * 1/2 * 1/2 = 1/8$$

Deterministic or Random

- If two glasses from the same set (frame color), whether a photon makes it through the next pair is deterministic (all or none)



- If two glasses from different sets, probability of photon making it through the second pair is *random* (always 50-50)



Deterministic and random

- We've made two sets of glasses (green or blue frame color) that are internally deterministic but mutually random.
- A **deep** feature of quantum mechanics