Laser Ablation Technology

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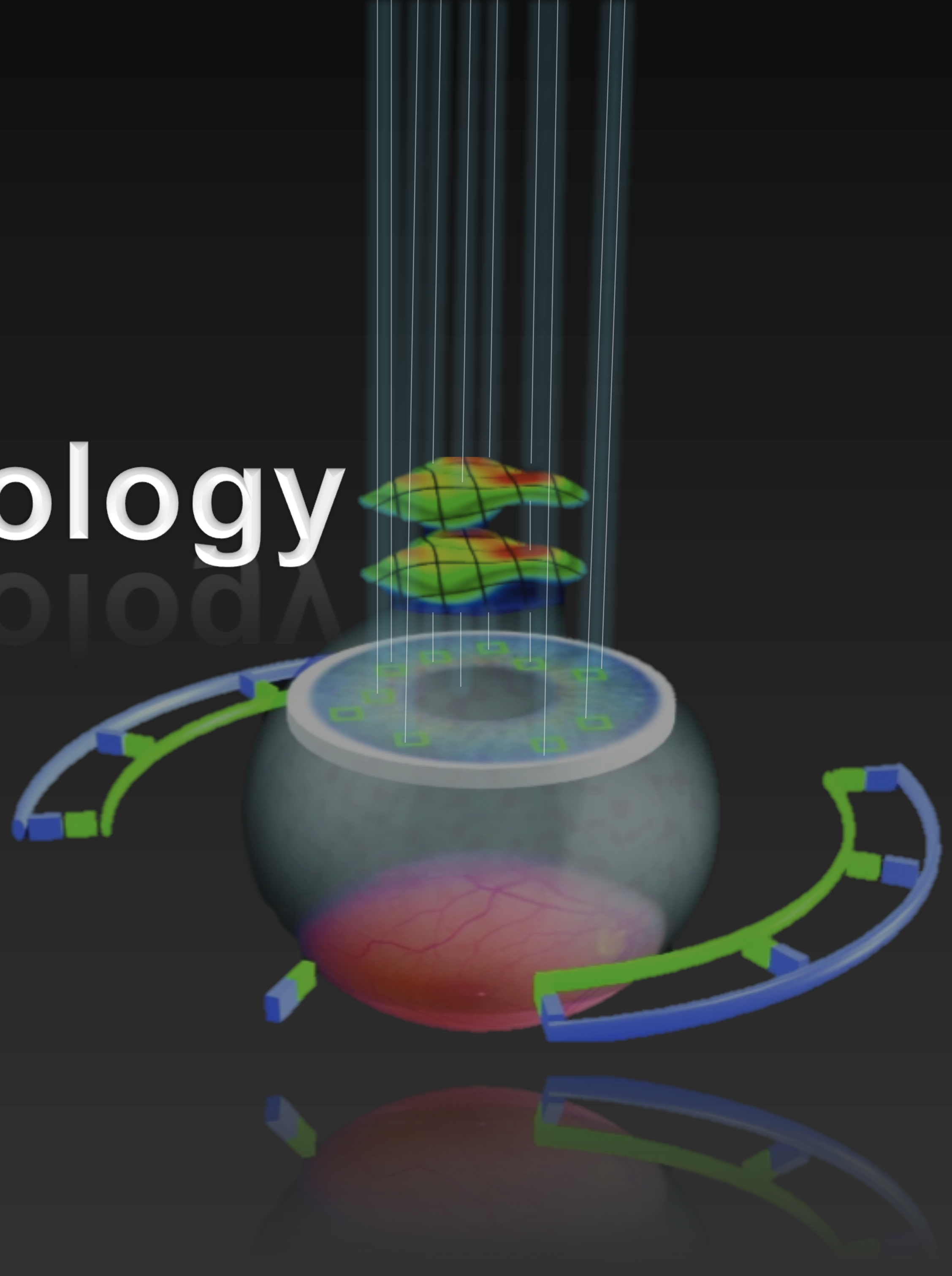
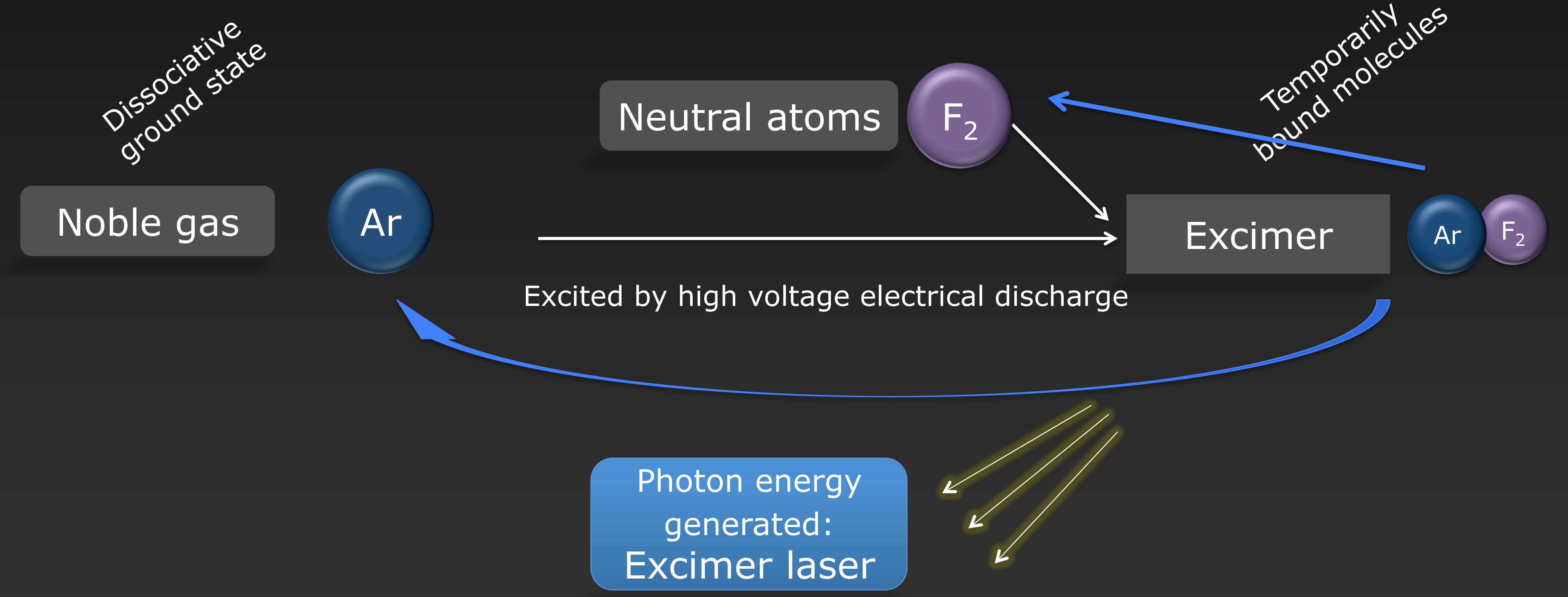


Financial Disclosure

- I have no financial interests or relationships to disclose.

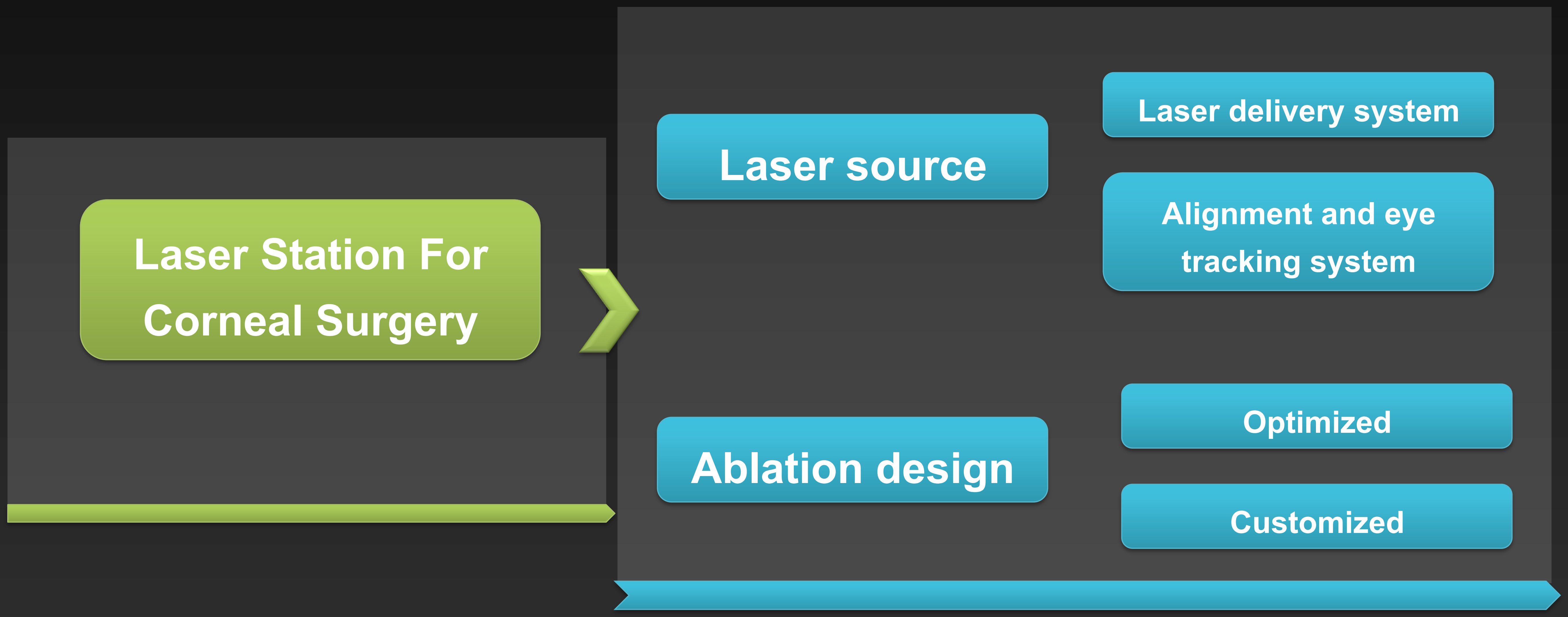
Principles of Excimer Laser

Excimer: "excited dimer"



“Laser cold ablating”

- Excimer laser photon energy high enough to break the chemical bonds of the corneal tissue (**laser ablation**)
- Generating very **little heat**
- The amount of photon energy is readily controlled --- Controlled amount of tissue ablated = **micron precision**


Laser Station For Corneal Surgery
Laser source
Laser delivery system
Alignment and eye tracking system
Ablation design
Optimized
Customized

Laser Delivery System

Beam size and shape

Beam profile

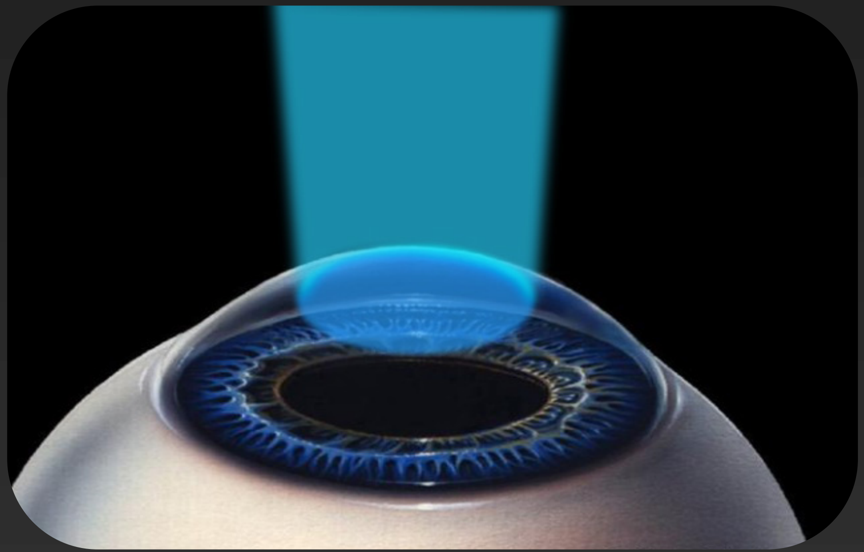
Ablation quality

Beam size and shape

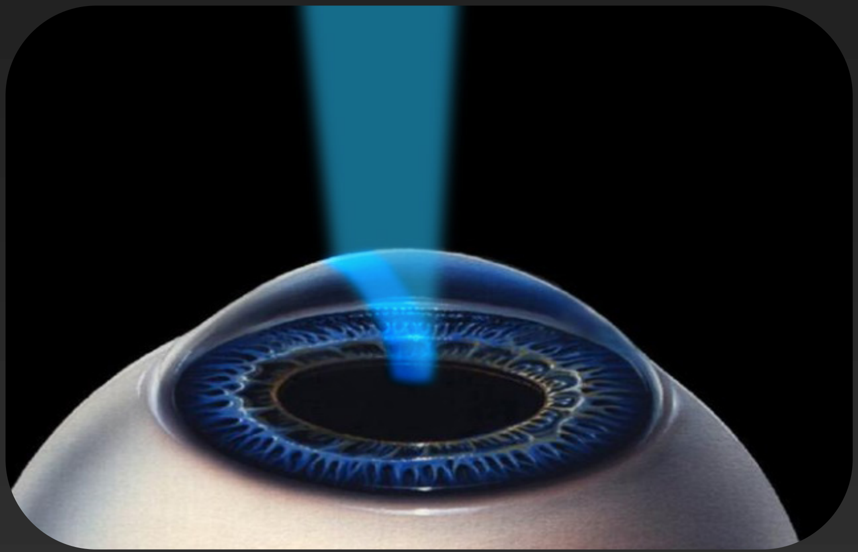
Opening or closing an iris diaphragm
Visx Star: 0.65-6.5mm, 10HZ

Swiping a slit Nidek EC-5000:
2x9mm, 60Hz

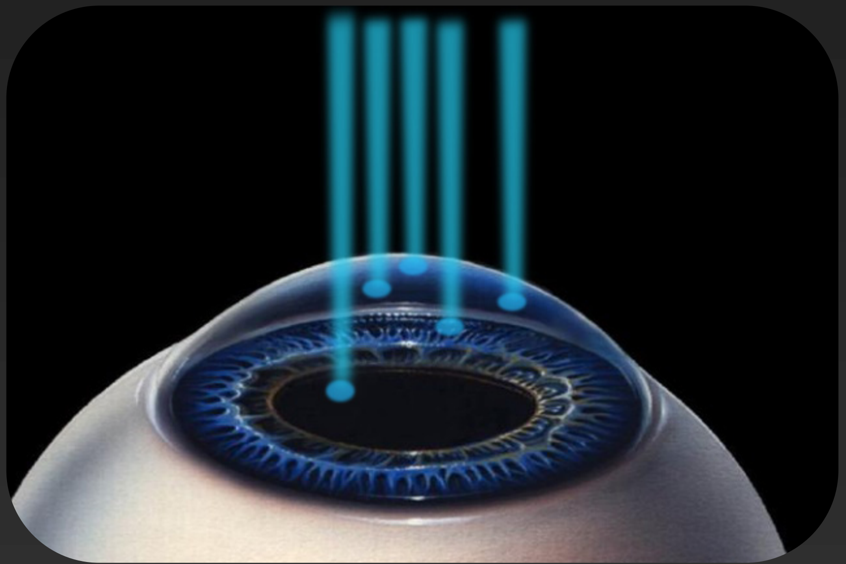
Galvanometric mirrors project a small spot LaserSight, Alcon, Bausch&Lomb, Wavelight, Zeiss, Schwind, iRES…
0.6mm~, ~1000Hz



Broad beam

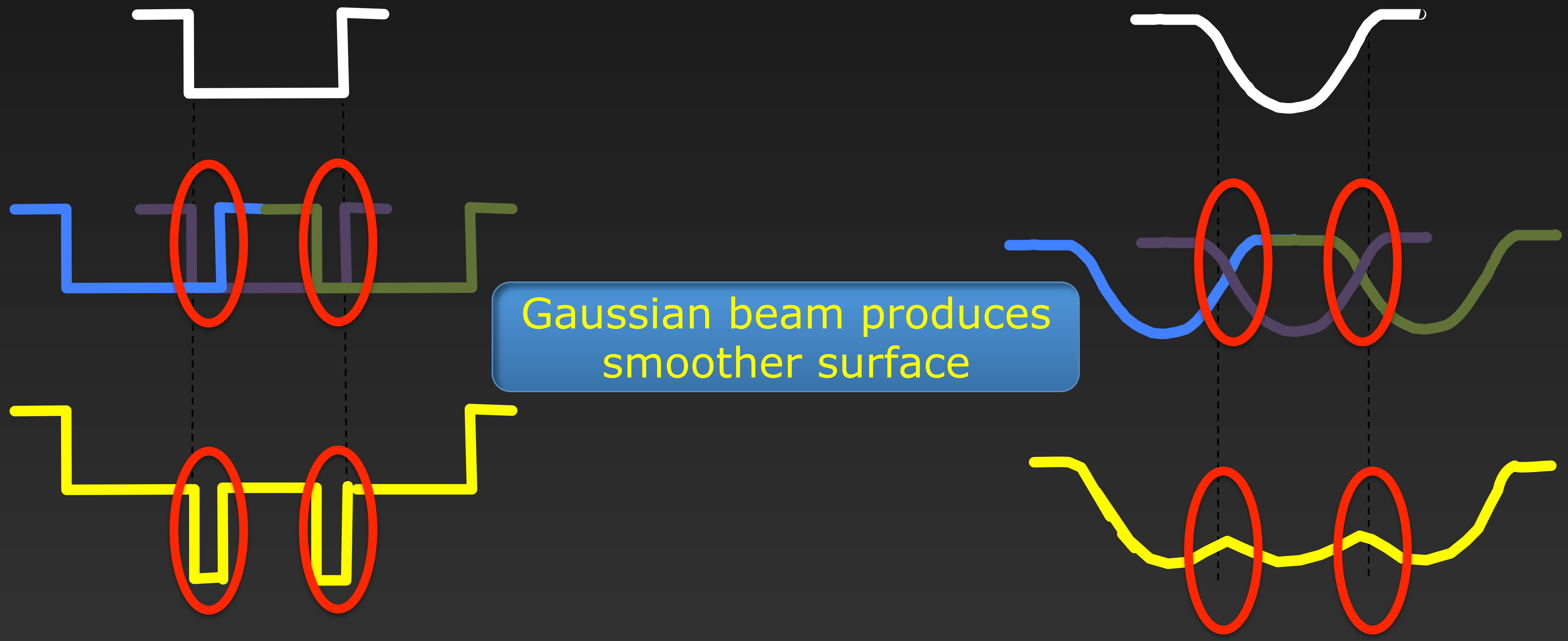


Scanning slit

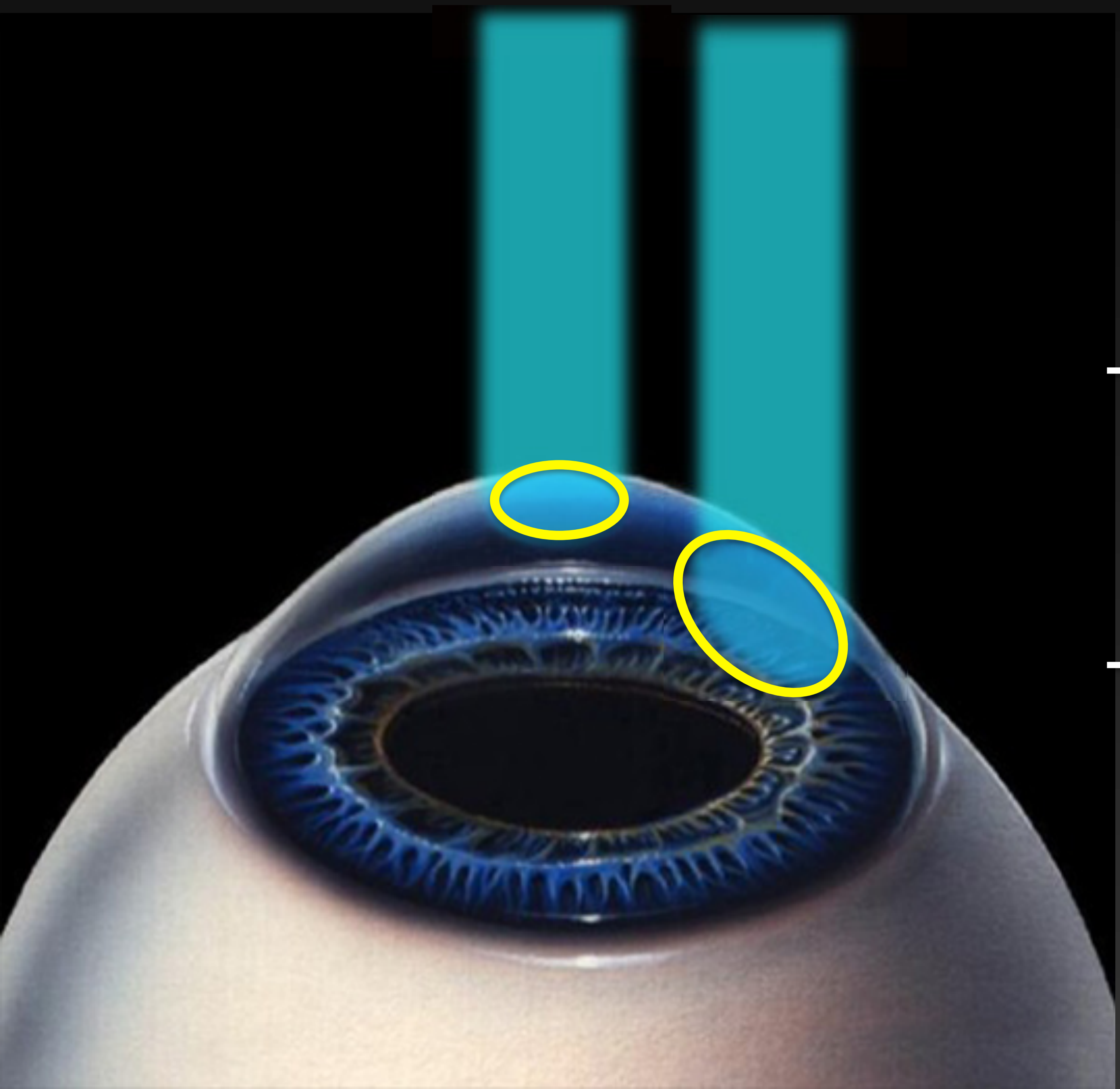


Flying spot

Beam Profile：Top-hat v.s. Gaussian



Laser Ablation Quality



Corneal curvature causes different conditions from center to **periphery**

- Oblique angle of incidence leads to…
- Larger beam projection area in the periphery

= Decrease of fluence (energy/area)

+ The optical reflection of the laser beam increases with obliqueness (cosine effect)

= Decrease of fluence (energy/area)

Photoablation effect reduced in the periphery

- Causes asphericity errors

- Needs compensation

Alignment and Eye Tracking

Alignment
=
Registration

Eye-
tracking

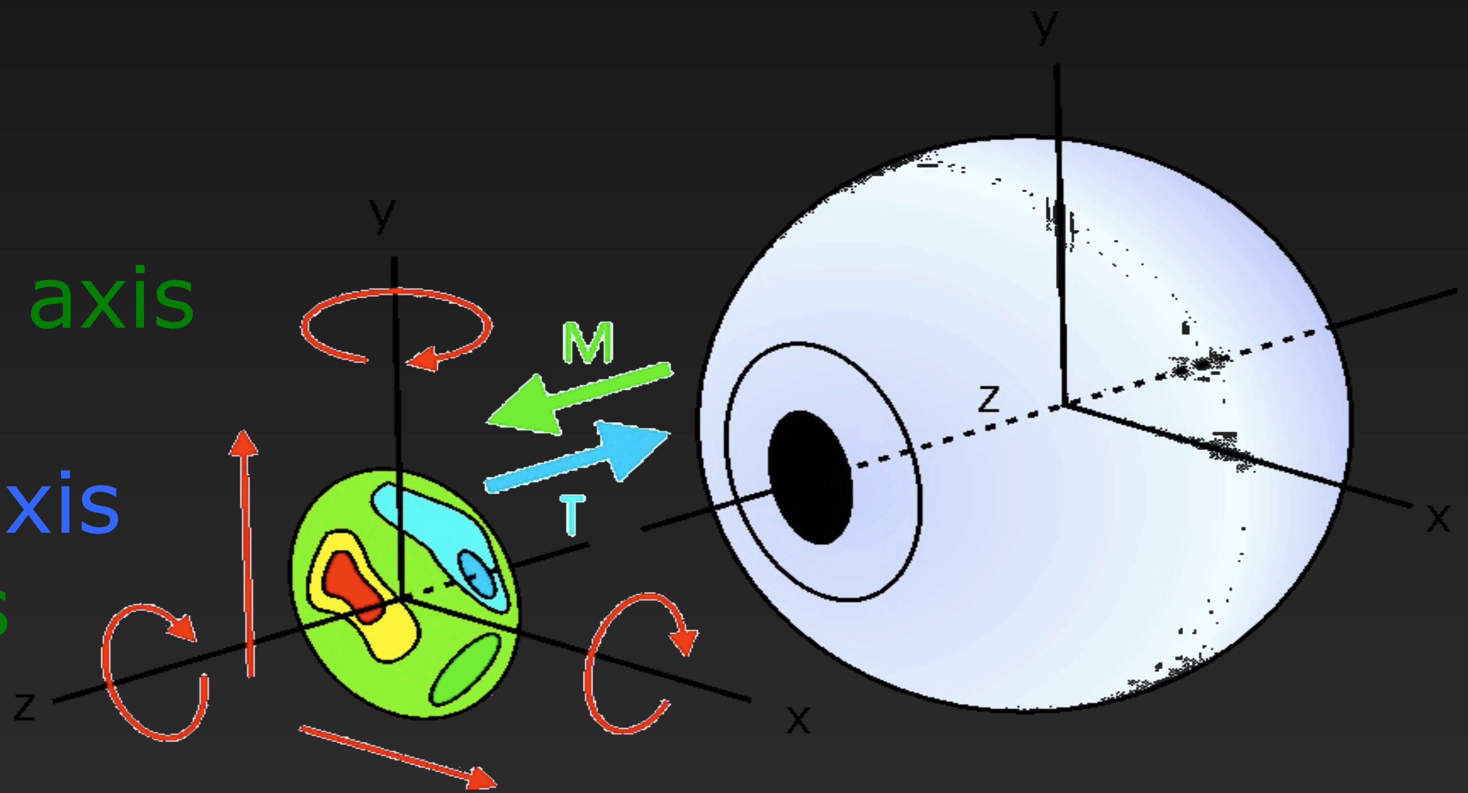
Registration(static) and Eye Tracking (dynamic)

- Various “manual” alignment systems (e.g., crossed pilot laser beams, projected slit images…), as well as computer controlled registration facilitate the appropriate alignment of the patient’s cornea in the x, y, and z axes and cyclotorsionally

- Eye tracker recognizes the eye movements and repositions the laser beam before the next laser pulse
  - Eye tracker is linked to the computer image of the entrance pupil for x,y tracking and to the …
  - Landmarks on the iris and limbus for cyclotorsional tracking

Max. Permissible Misalignment

- Horizontal shifts
- Vertical shifts
- Rotation around longitudinal axis (cyclotorsion)
- Rotation around horizontal axis
- Rotation around vertical axis
- z-Distance

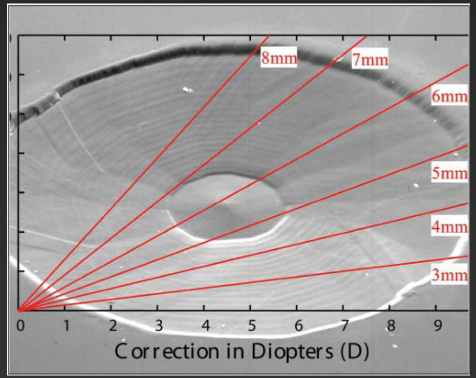


- *Bueeler & Mrochen - lateral: JCRS 2003; 29: 257-263 - torsion: JCRS 2004; 30: 17-25*

Laser Software

"Standard" ablation

- Munnerlyn formula



Customized ablation

- Low level = without importing external data
- High level = Import from the external diagnostic instruments

Customization

Pupil size And optical zone

- Ideally—o.z. should exceed mesopic pupil
- Influences ablation depth

Transition zone

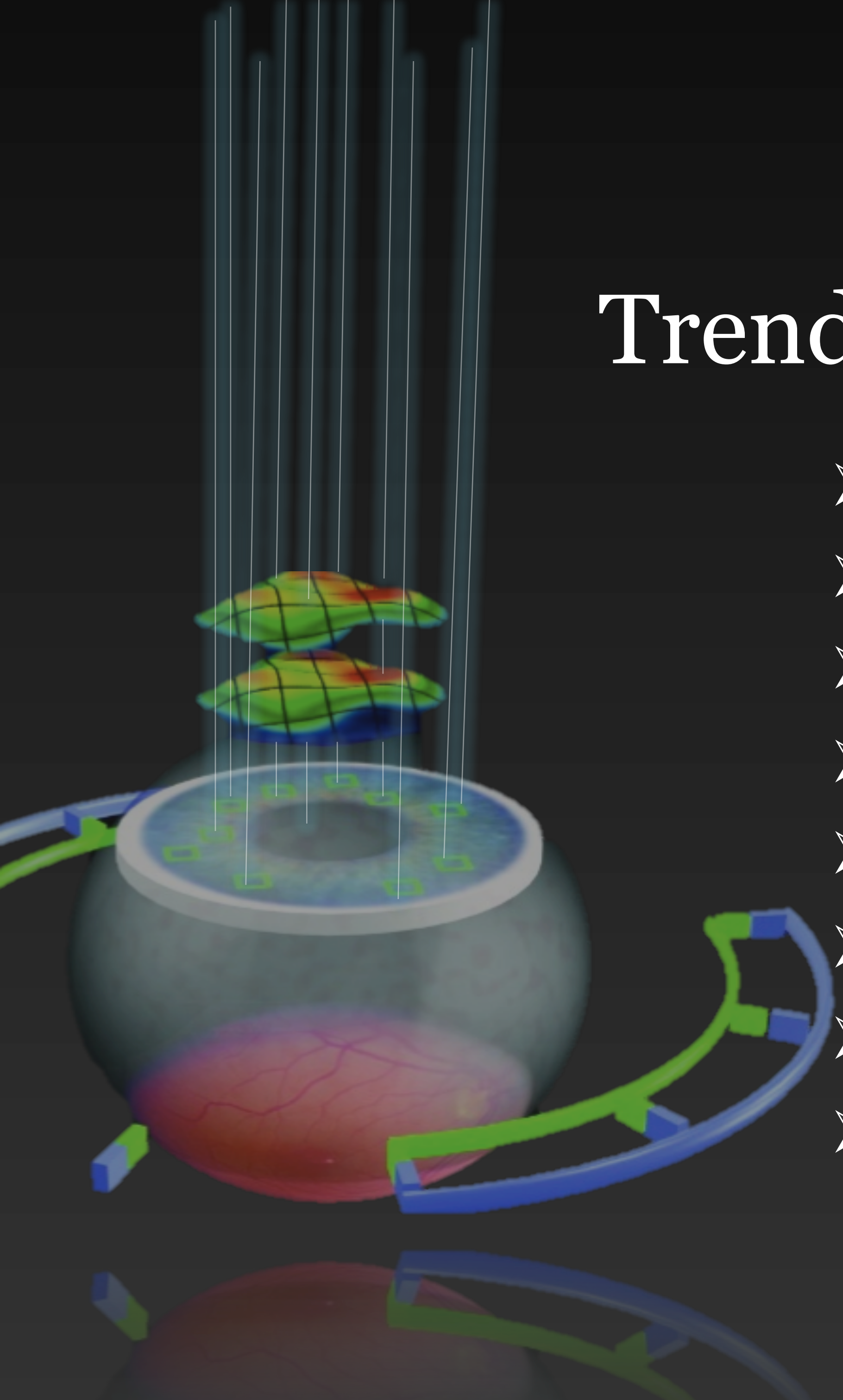
- Avoiding rapid curvature change
- Prevent regression
- Influences ablation depth

Higher order aberrations

- Wave-front guided — Ocular WF aberration
- Topography guided — Anterior corneal irregularities

Epithelium

- High frequency ultrasound biomicroscopy
- VHF digital ultrasound
- Optical coherence tomography (OCT)



Trend — Ideal laser

- Very stable energy output
- Ablation depth p.p ∼ 0.25μm
- Fast repetition rate >500Hz
- Gaussian beam with spot size < 1mm
- Delivery compensated for angle of incidence
- Compensated for thermal effect
- Reliable registration/tracking in measurements and treatments
- Customized ablation design

THANK YOU

For your attention!