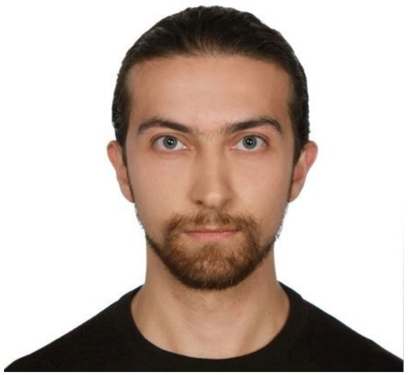
The OSA Display Technology Technical Group Welcomes You!

Technical Group Leadership 2019



Ozgur Yontem
Chair
Cambridge University

Edward Buckley
Vice Chair
Facebook Reality Labs

Golshan Coleiny
Webinar and Events Officer
Ledvance LLC

Alexandra Bremers
Social Media Officer
Jaguar Land Rover

Technical Group at a Glance

- Focus
  - Various aspects of display technologies
  - New device technologies used for displays: OLED, MEMS, etc.
  - The evolving field of 3-D displays: 3D holography, 3D light-field, 3DTV, etc.
  - Display holography
  - Investigating display and sensor technologies used for creating augmented reality and interactive environments
- Mission
  - To benefit *YOU* and to strengthen *OUR* community
  - Webinars, podcasts, publications, technical events, business events, outreach
  - Interested in presenting your research? Have ideas for TG events? Contact us at TGactivities@osa.org.
- Find us here
  - Website: https://www.osa.org/en-us/get_involved/technical_groups/iapd/display_technology_(it)/
  - Facebook: https://www.facebook.com/groups/OSADisplayTechnology/
  - LinkedIn: https://www.linkedin.com/groups/12205201/

Today's Webinar

OSA Display Technology Technical Group

Free-space volumetric displays

Dr. Daniel Smalley

Brigham Young University, USA

smalley@byu.edu

Speaker's Short Bio:

He experimented a great deal with holography, and for this reason was led to attend MIT where he earned a B.S., M.Eng, M.S., and Ph.D. degrees while working to create the world's first low-cost holographic video monitor. Now as a newly minted BYU professor, he is continuing his work in electroholography by fabricating new waveguide-based modulators. Professor Smalley aspires to create large, high resolution, interactive holographic and volumetric displays. He is also part of collaborations pursuing novel brain probes and tractor beam technologies.

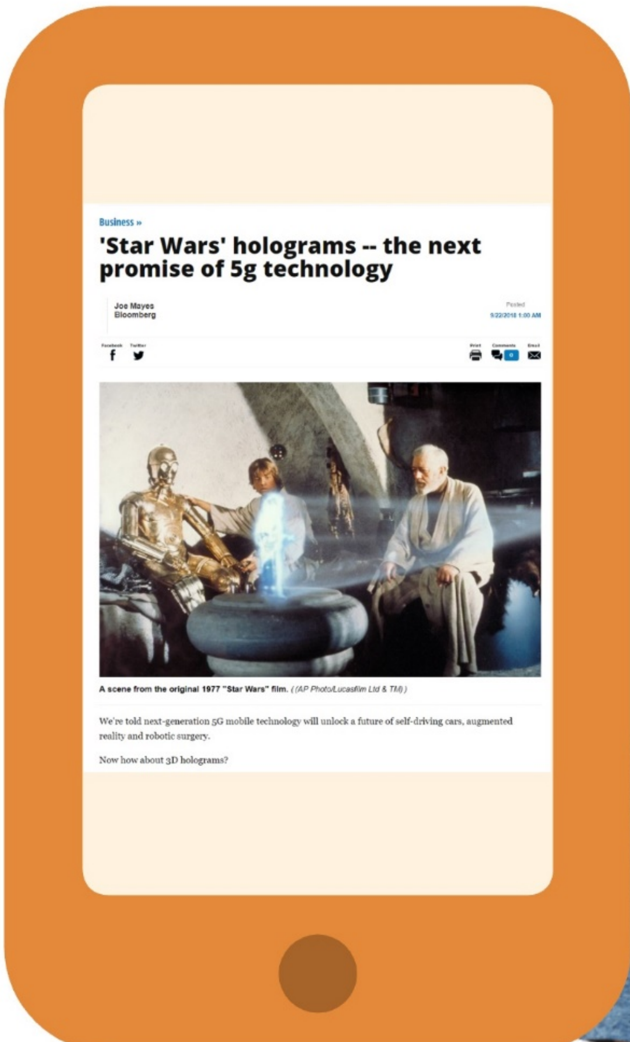
Freespace Volumetric Displays

Dr. Daniel Smalley

Brigham Young University

OSA Display Technology Technical Group, June, 4th 2019

Brokenhearted



Business »

'Star Wars' holograms -- the next promise of 5g technology

Joe Mayes
Bloomberg

Posted
9/22/2018 1:00 AM

Facebook Twitter Print Comments 0 Email

A scene from the original 1977 "Star Wars" film. ((AP Photo/Lucasfilm Ltd & TM))

We're told next-generation 5G mobile technology will unlock a future of self-driving cars, augmented reality and robotic surgery.

Now how about 3D holograms?

Brokenhearted

We want displays like this:

Possible?

Quora Home 1 Answer Spaces Notifications Search Quora

Holograms Holographic Principle Optics Physics

Are holograms physically impossible?

This question previously had details. They are now in a comment.

AMERICAN Scientist

refined and extended: The unsettling lifelikeness of
became even more eerily uncanny in such projected
improvements were accompanied by popular antici
extrapolated into the certainly impossible *Star Wars*
the holodecks in *Star Trek: The Next Generation* of 1
projected a holographic image away from the viewe

Despite these unrealistic expectations, new discover
important new variant was developed by Stephen B
later the Massachusetts Institute of Technology) in 1
1970s. Popularly called the rainbow hologram, it wa
optical component: a horizontal slit that limited *vert*
foreground objects to see behind them. When the h

reddit r/NoStupidQuestions Search r/NoStupidQuestions

r/NoStupidQuestions

Posts

3

Posted by 1 year ago

Are holograms scientifically impossible?

Answered

3D Holograms like you see in the movies (Back to the Future, Star Wars, Iron Man 2, etc).

Humans can't see a photon unless it enters your eyes, either directly or reflected off something?

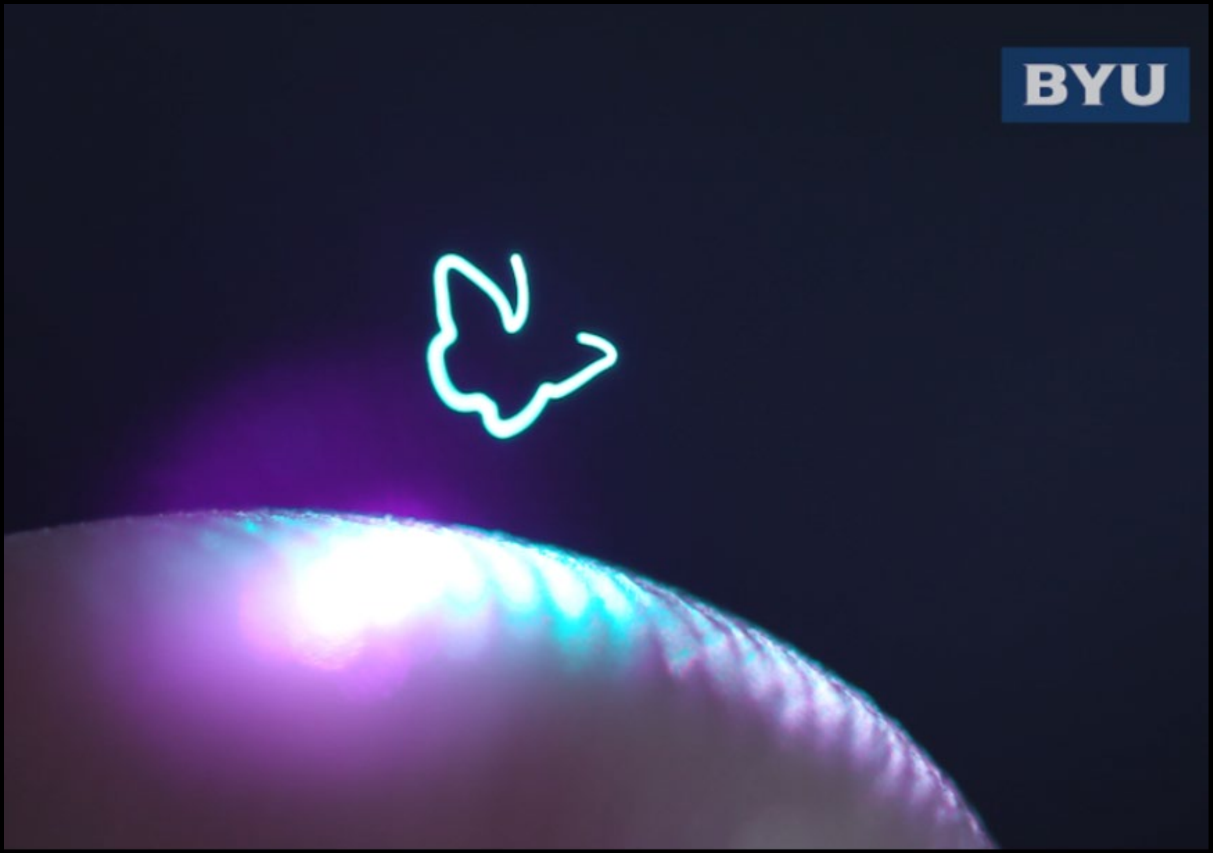
A 3D hologram can't do either since it's supposed to be just suspended in air and we can't see air?

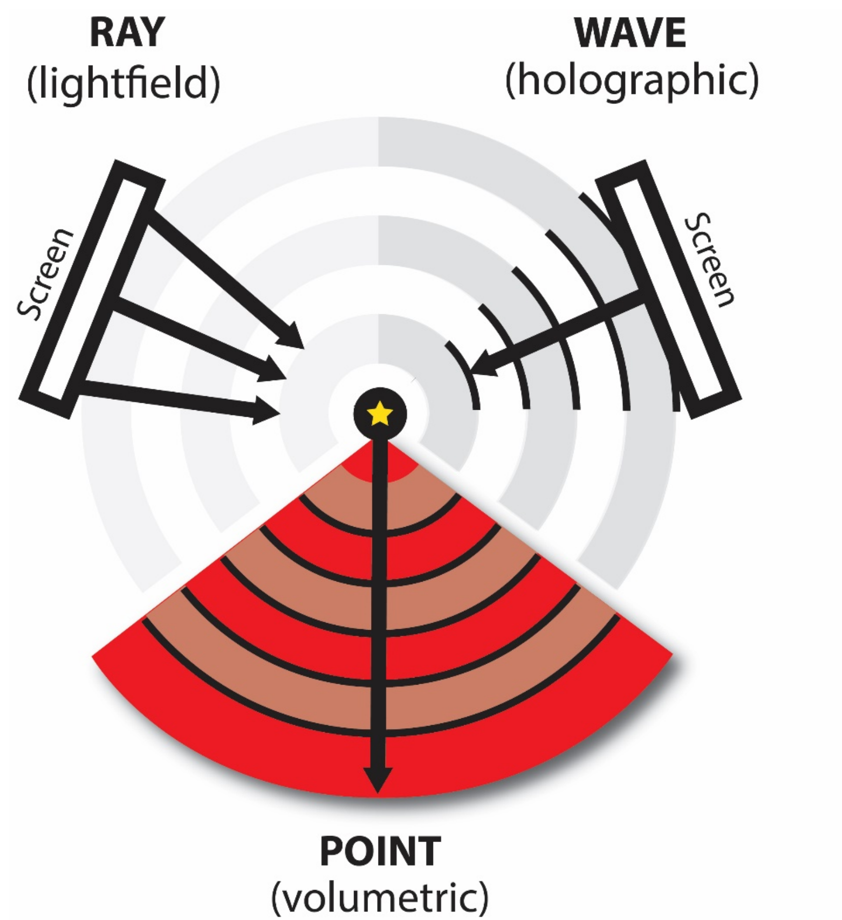
Examples:

- Iron Man II
- Ghost in the Shell

There is hope!

Thanks to *Freespace Volumetric Displays*!





Optics and Photonics News, ‘Volumetric Displays: Turning 3D Inside Out,’ 2018
(Ratified Illumiconclave II, 2018)

ILLUMICONCLAVE I

Description:
Meeting of experts convened to rule on topics related to advanced display.

Location:
Heidelberg, Germany 2016

Article I

DEFINITIONS

Ambiguous terms in display technology were given the following definitions:

1.1. ***Volumetric Display***—a volumetric display is defined as a display in which <u>all image points are collocated with physical scattering surfaces</u>. Consistent with this definition, volumetric displays have perfect accommodative cues as the viewer is able to focus on a material object in space. Also consistent with this definition and contrary to long-held popular opinion, it is *not* necessarily true that a volumetric display be incapable of self-occlusion as this may be possible by employing anisotropic scattering surfaces. However, at the time of this writing no volumetric display of which we are aware, meeting the above definition, has demonstrated self-occlusion.

1.1.1. *Examples* of volumetric displays include: helical and paddle swept volume displays,
particle displays, plasma ball displays, active and passive grids, mul

1.1.2. Examples of displays which are *not volumetric* by this definition in
configuration: Leia display Systems, iO2 technology (these would b
bundles intersect in regions space not collocated with the modulat
display hardware may be used to create images which are not volu
image point colocation with physical scatters) and lose the affordar
displays such as perfect accommodation (and, in so doing, may gair
instead—such as greater control over view-angle content).

1.1.3. *Display advantages* include perfect accommodation and very low b
requirements for sparse scenes.

1.1.4. *Display limitations* include the fundamental inability to display virt
dependent bandwidth as well as challenging scanning requirement

1.2. ***Holographic Display***—a holographic display is defined as a display for w
draw a straight line which intersects their eye, and image point and a re
information encoded in spatial frequency such as in a Raman-Nath or vo
grating. In volume holograms, including Denisyuk reflection holograms
volume reflection may also augment diffraction by providing color sensi
sensitivity (Bragg) or diffraction efficiency (edge-lit). In order for a holo
considered 'holographic video' or 'holovideo' it should be able to updat
quickly enough to make possible persistence of vision (e.g. greater than

1.2.1. Examples include displays based on diffraction from pixelated spati
(Qinetiq, SeeReal) and scanned aperture acousto-optic displays (M
as well as waveguide based diffractive displays.

Definition:

Lightfield: display that… modulates the position and direction of light rays (x,y, theta and phi)

Illumiconclave I: Article I Section 1.3

Definition:

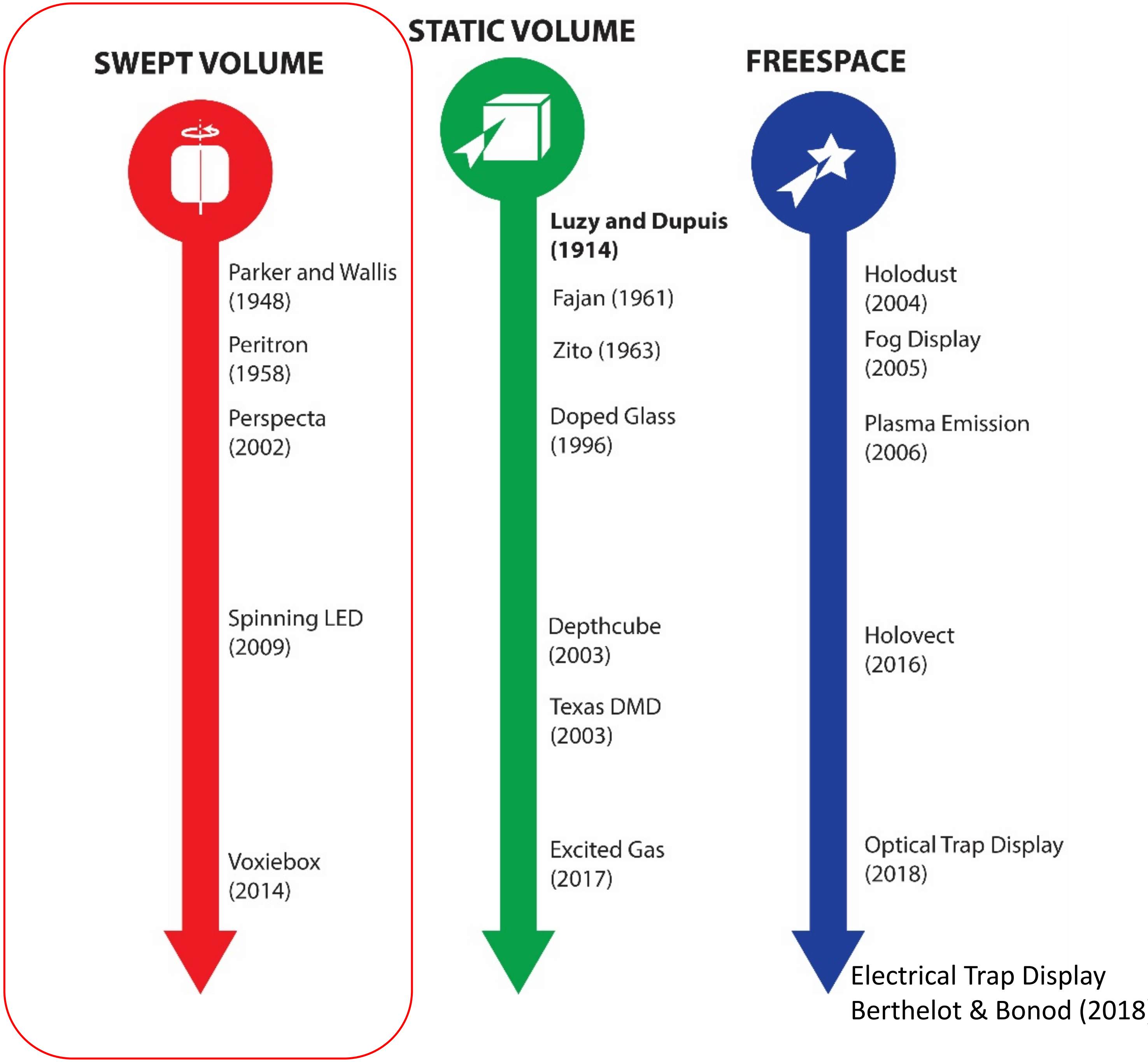
Holographic– 3D info in spatial frequency

Illumiconclave I: Article I Section 1.2

Definition:

Volumetric--colocation of image points and scatterers

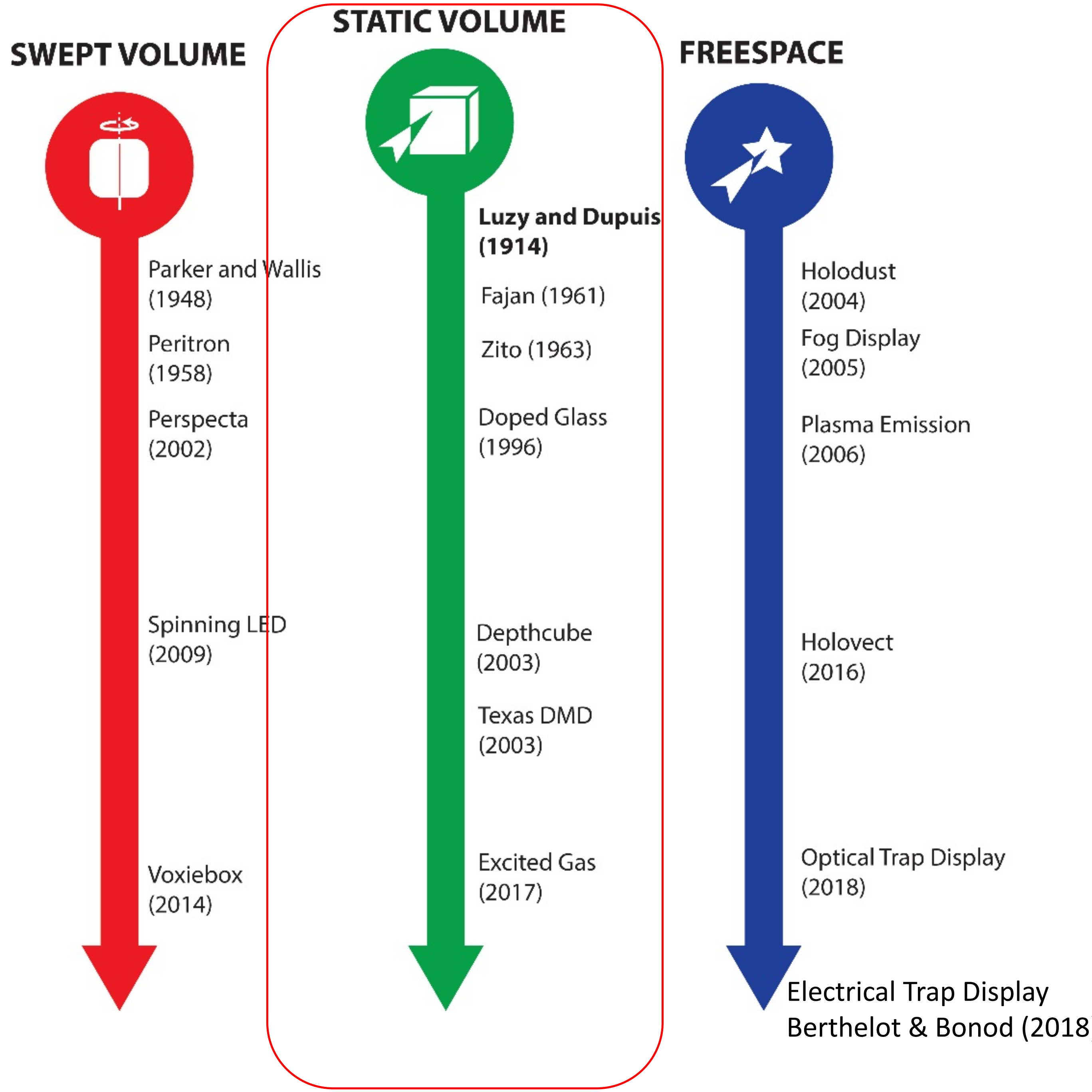
Illumiconclave I: Article I Section 1.1



SWEPT VOLUME
Parker and Wallis (1948)
Peritron (1958)
Perspecta (2002)
Spinning LED (2009)
Voxiebox (2014)
STATIC VOLUME
Luzy and Dupuis (1914)
Fajan (1961)
Zito (1963)
Doped Glass (1996)
Depthcube (2003)
Texas DMD (2003)
Excited Gas (2017)
FREESPACE
Holodust (2004)
Fog Display (2005)
Plasma Emission (2006)
Holovect (2016)
Optical Trap Display (2018)
Electrical Trap Display
Berthelot & Bonod (2018)

Swept-Volume

VX1, Courtesy of Voxon Photonics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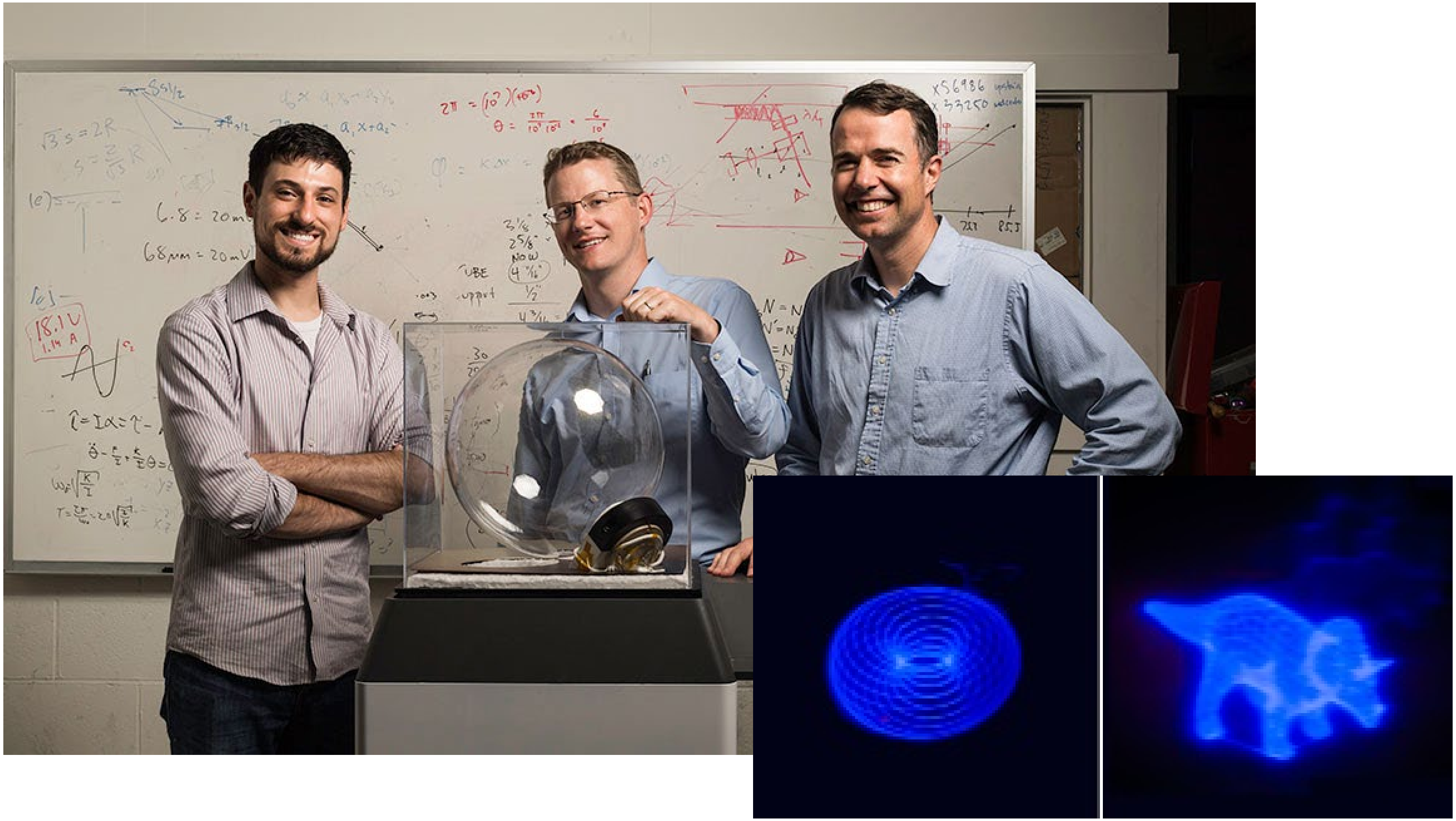
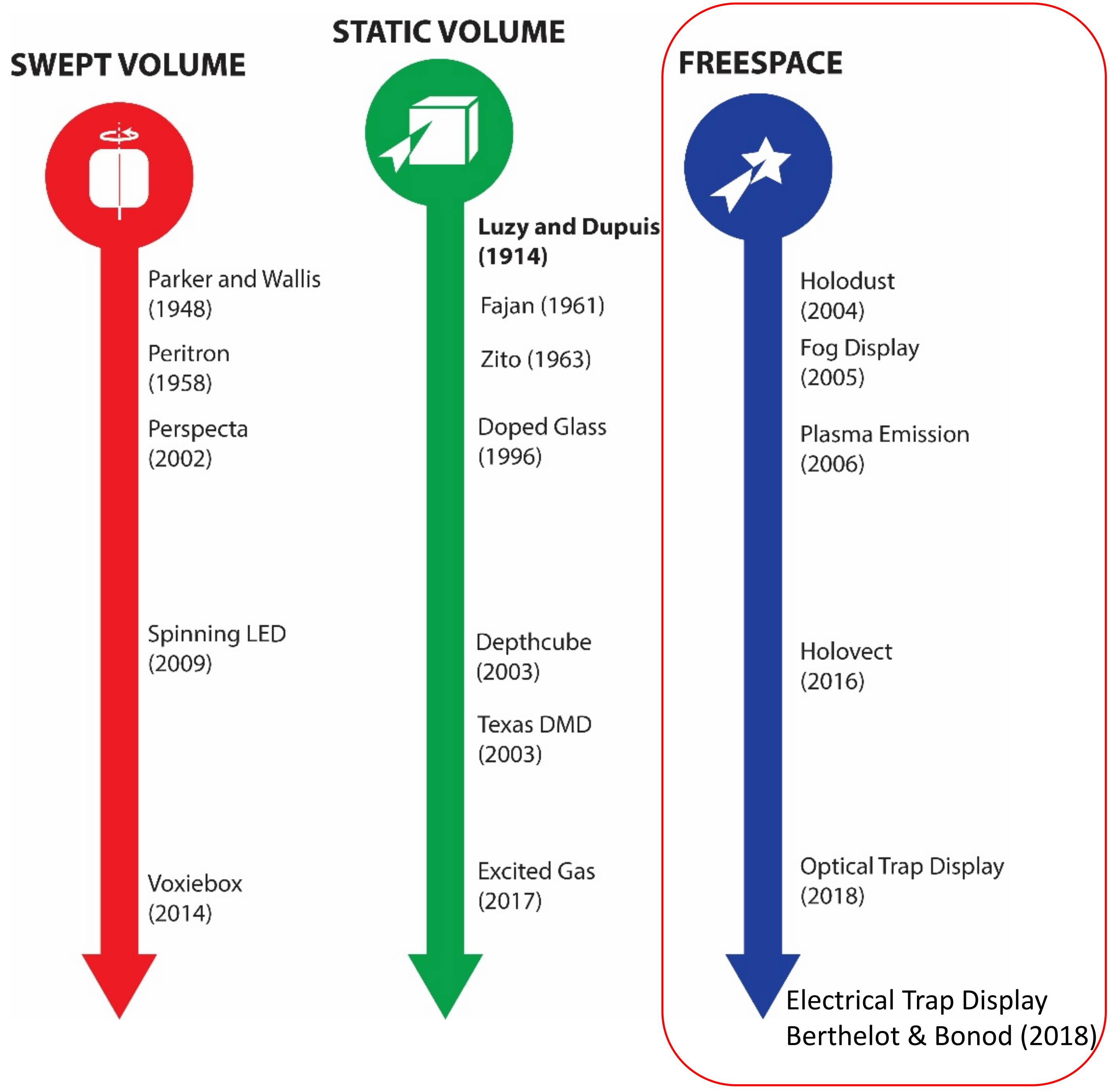
Static-Volume



Courtesy of Dr. Curtis Broadbent, University of Rochester



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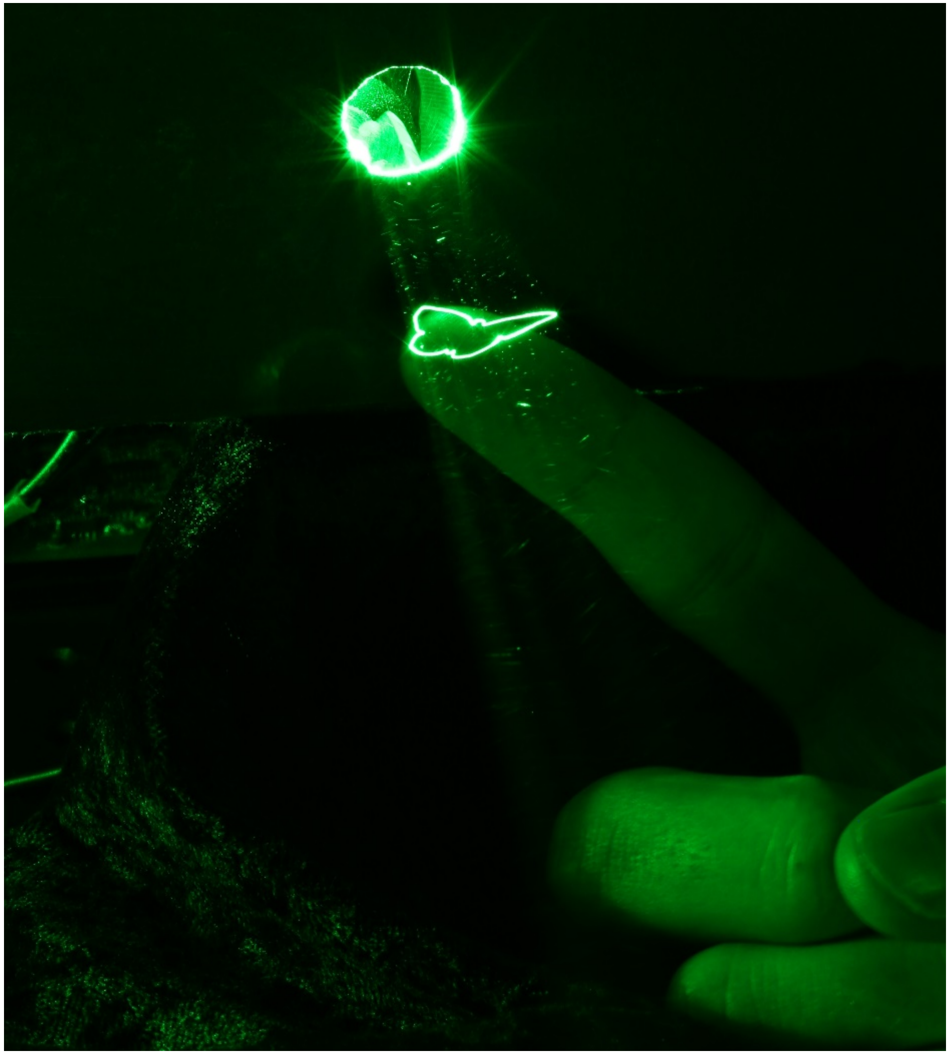
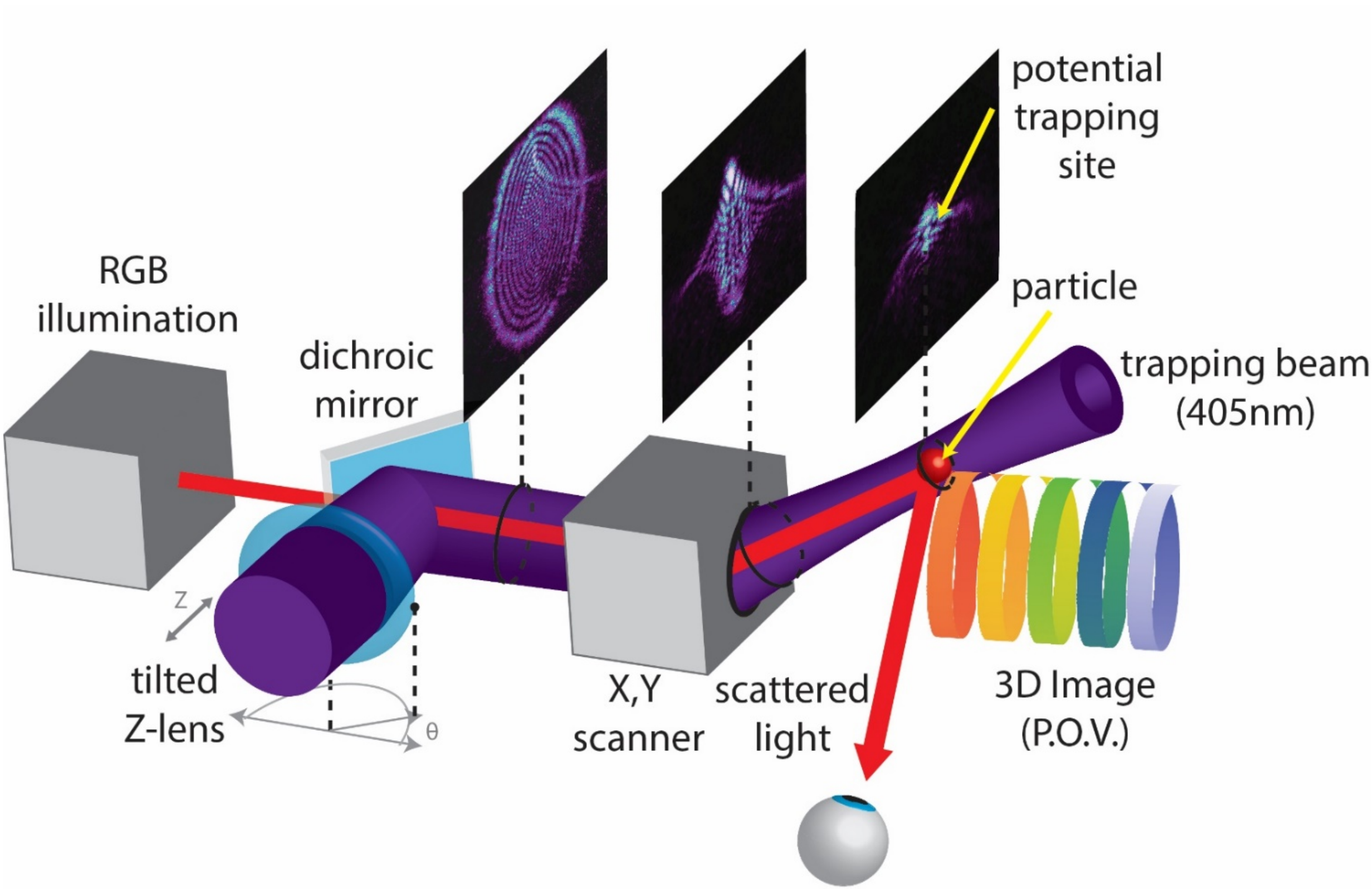
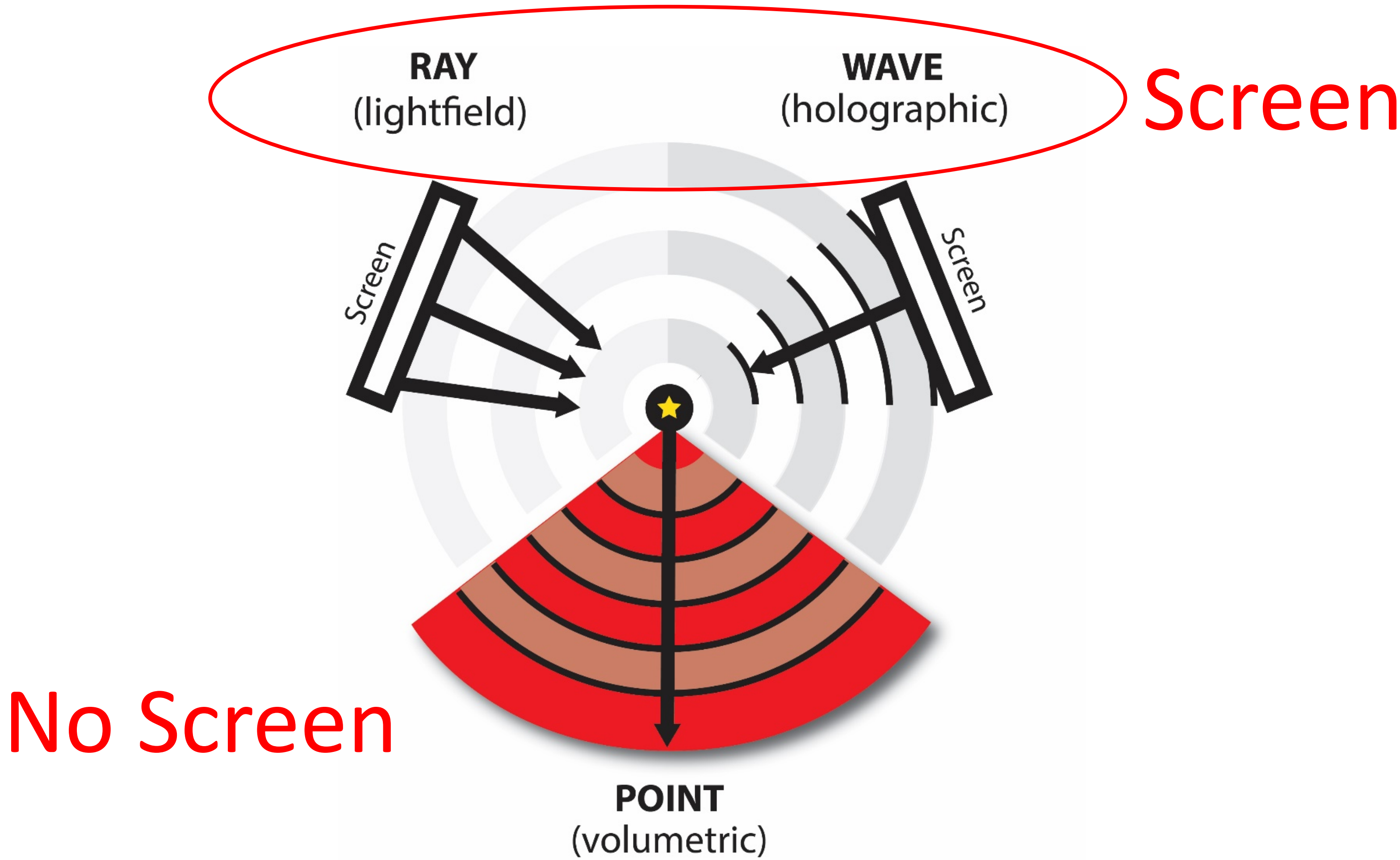
Freespace



Freespace: Optical Trap (OTD) Display



Freespace Advantages



Optics and Photonics News, 'Volumetric Displays: Turning 3D Inside Out,' 2018
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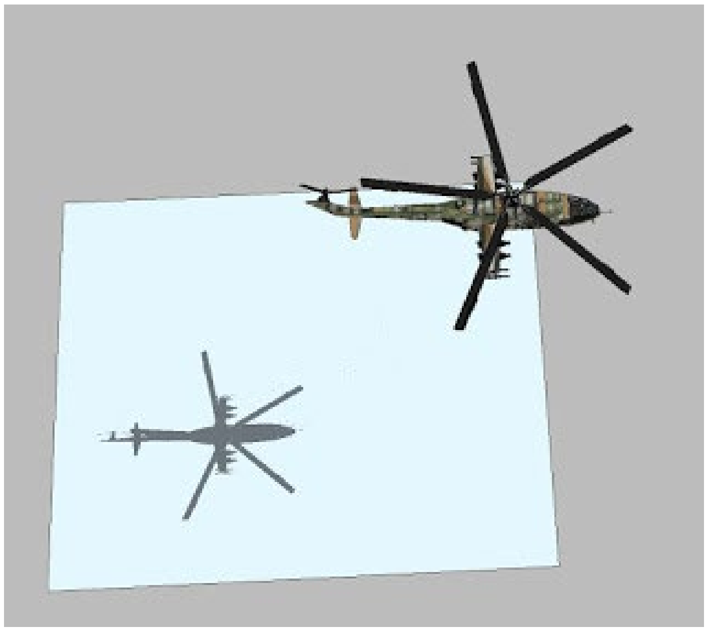
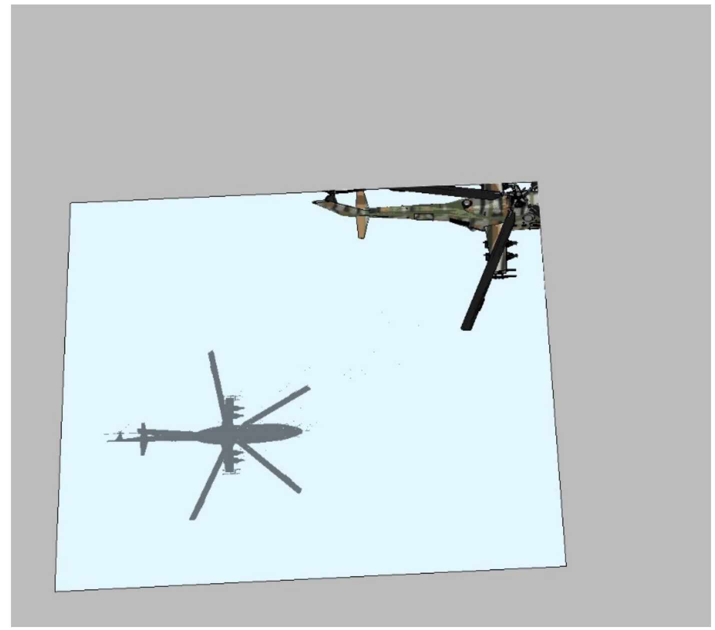
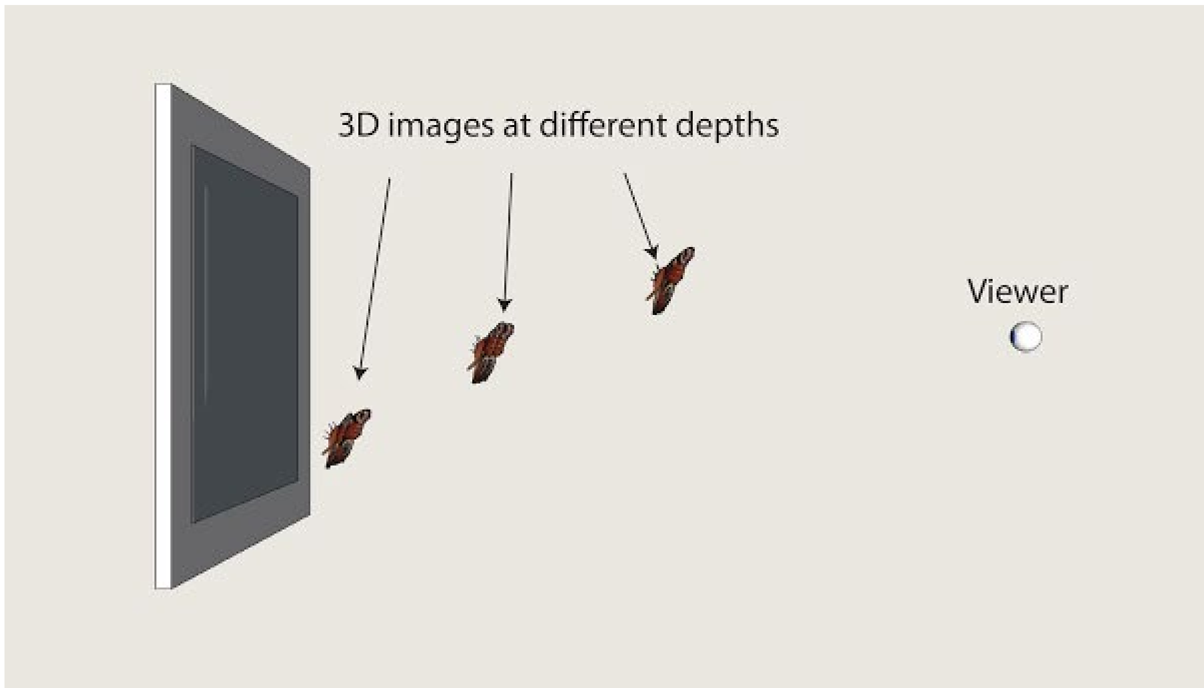
Screen→Clipping

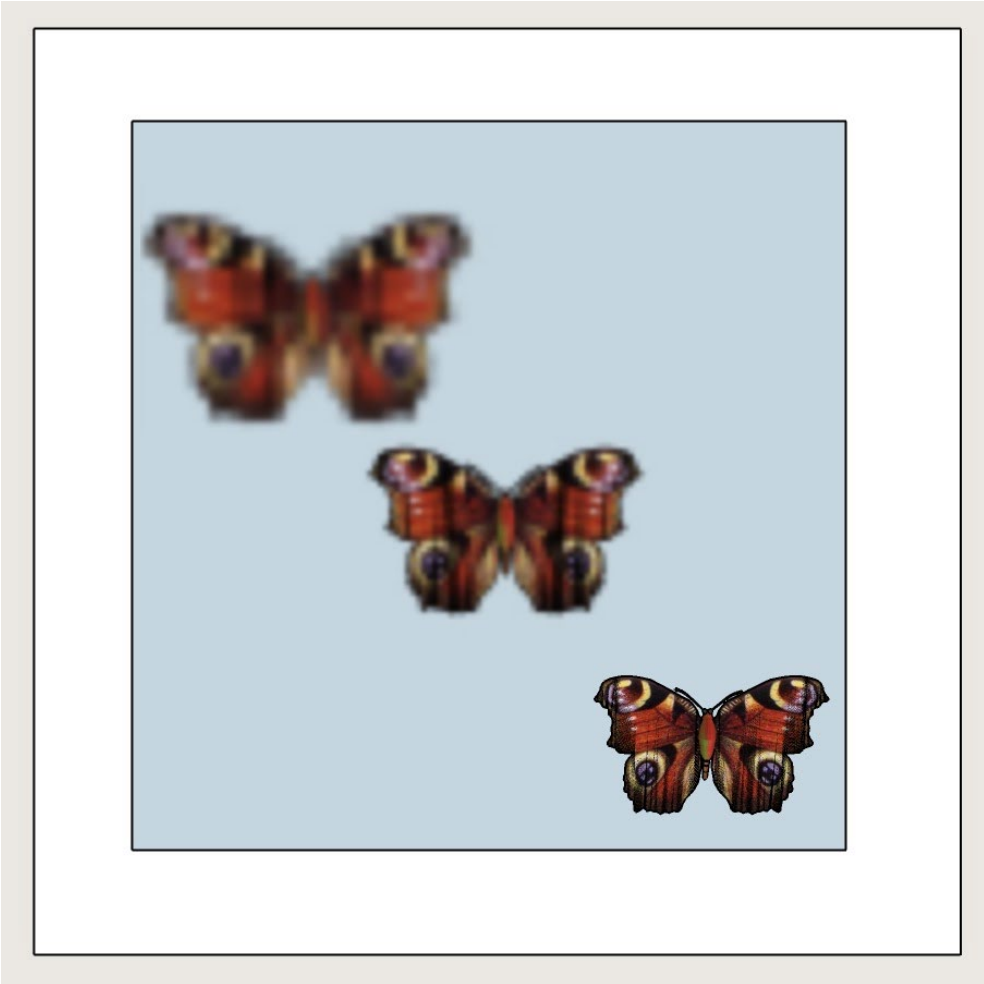




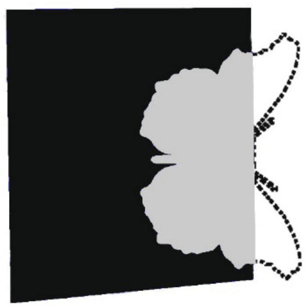
Screen→Fuzzing

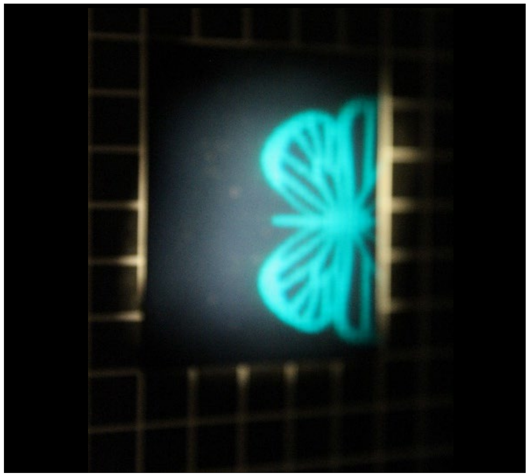


Screen→Fuzzing



No Clipping, No Fuzzing





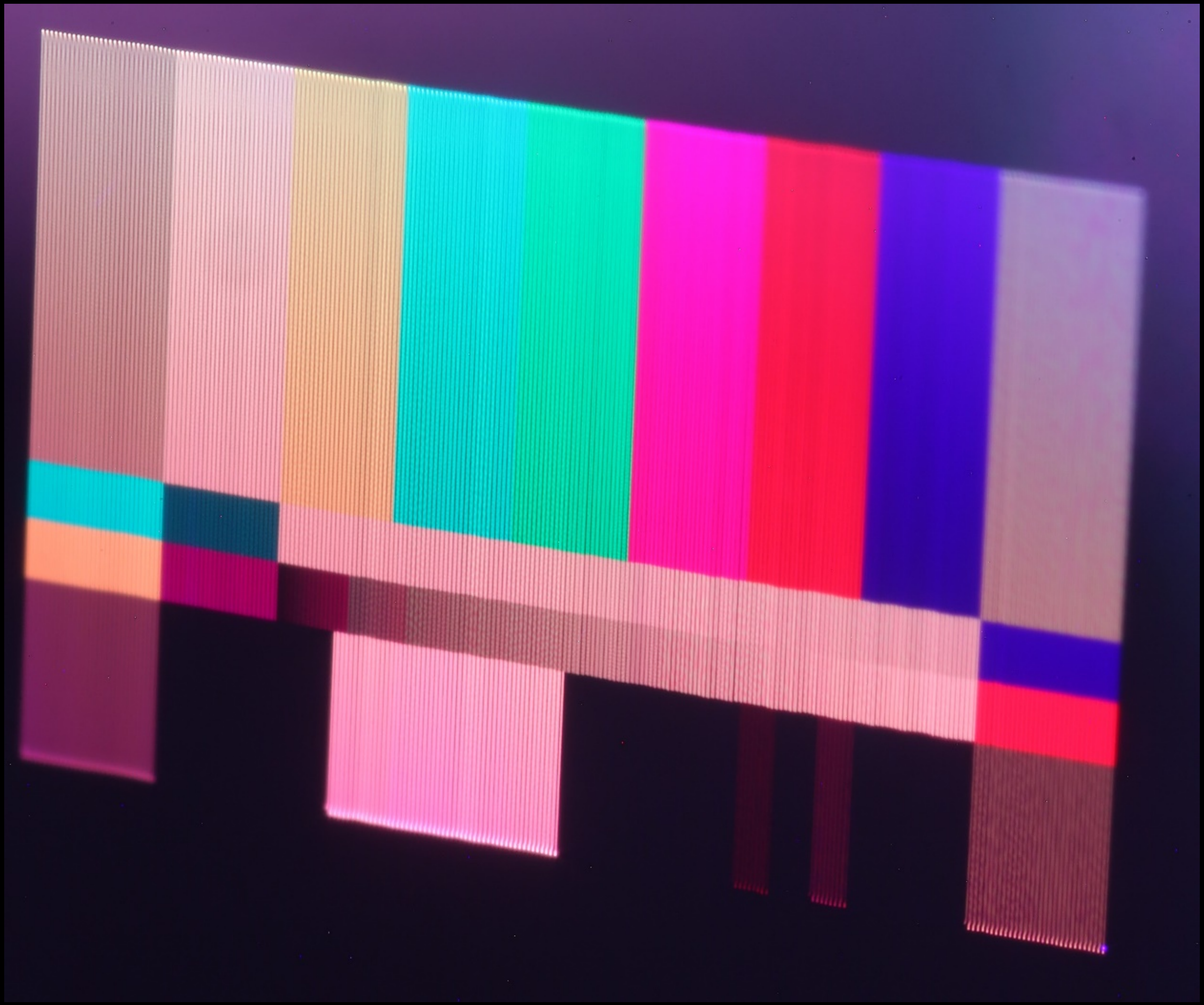
HOLOGRAPHIC

VOLUMETRIC

Additional Advantages

Specific to the OTD display

Color: high saturation



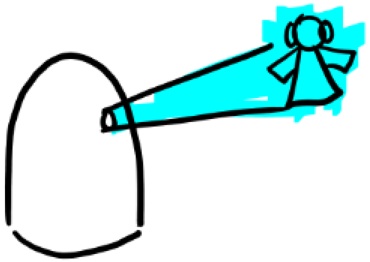
Color: low apparent speckle

Voxel definition 1600dpi

Sci-Fi Displays

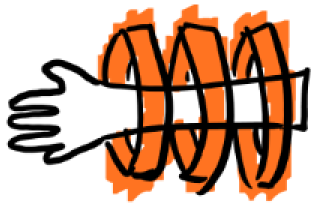
(Formerly) Forbidden Images

'Leia'
(long-throw Projection)

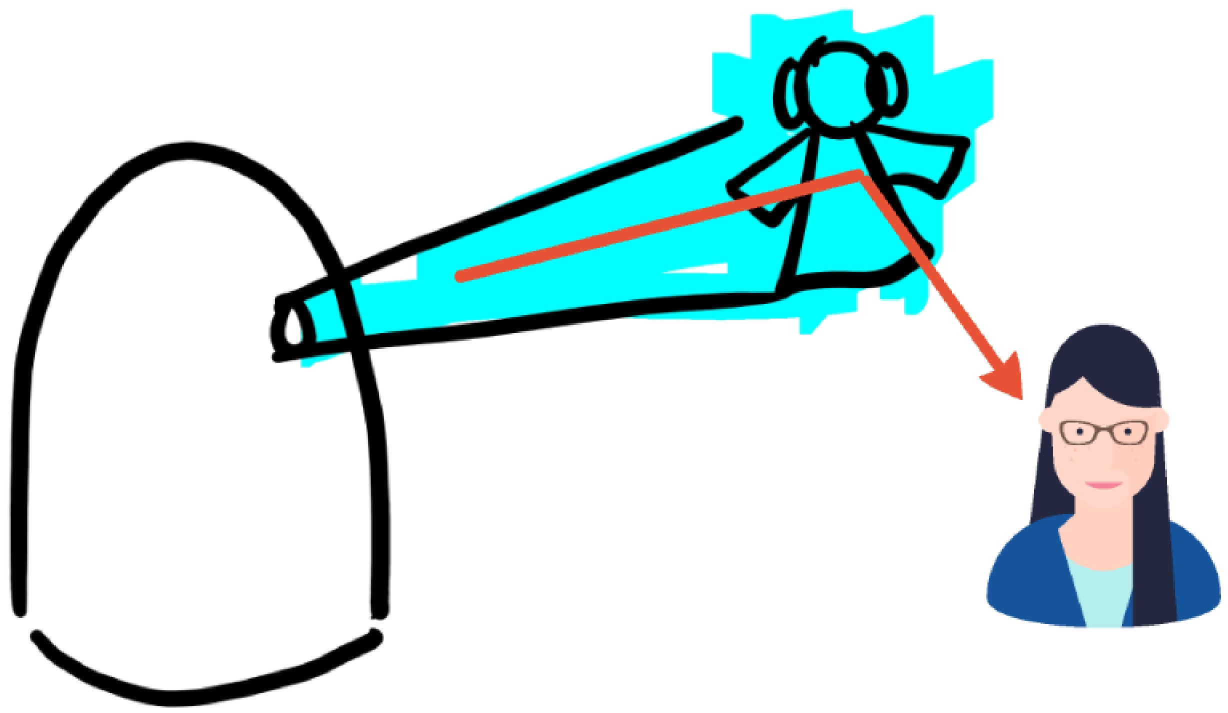


'Avatar'
(Tall Sandtable)

'Iron Man'
(Wrap-Around)

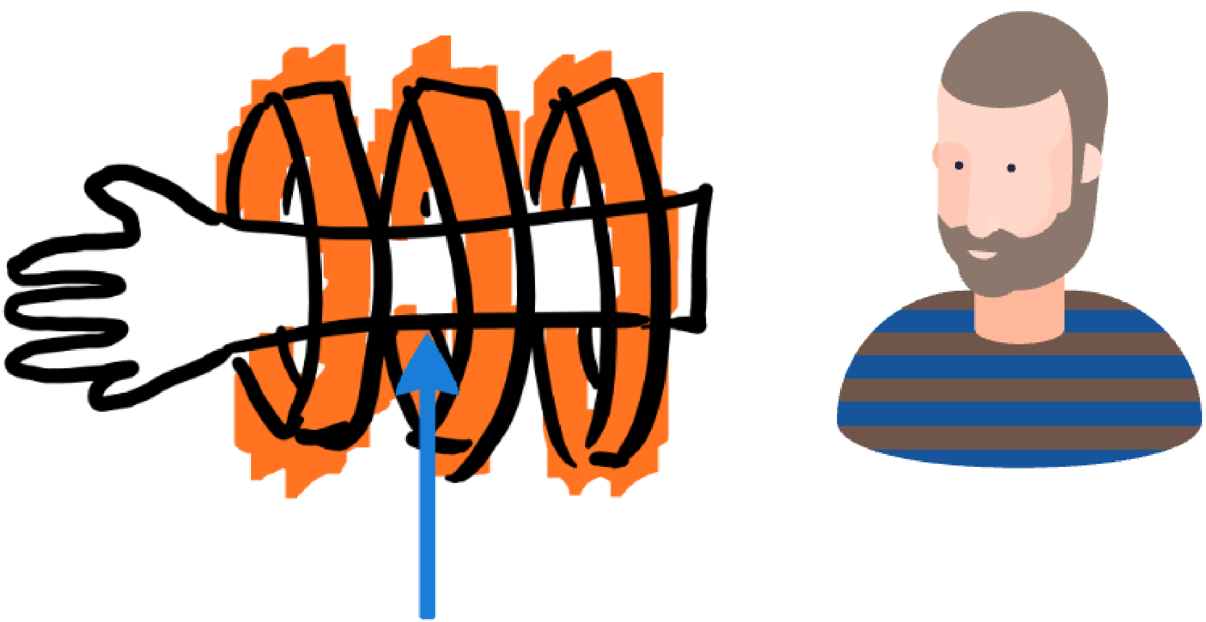


Leia (Long-Throw Projection)



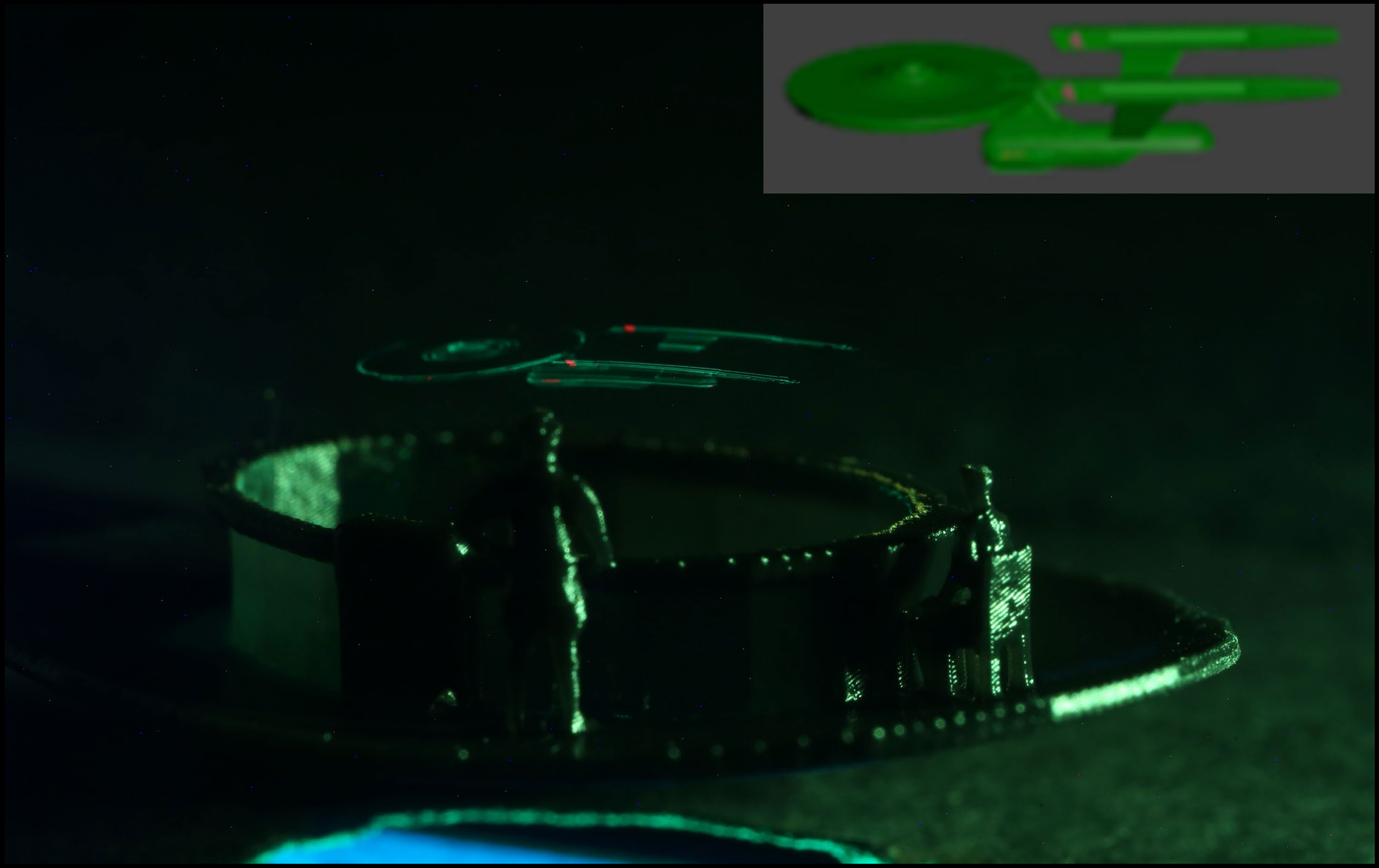
Avatar (Tall Sandtables)

Iron Man (Wrap-Around Display)

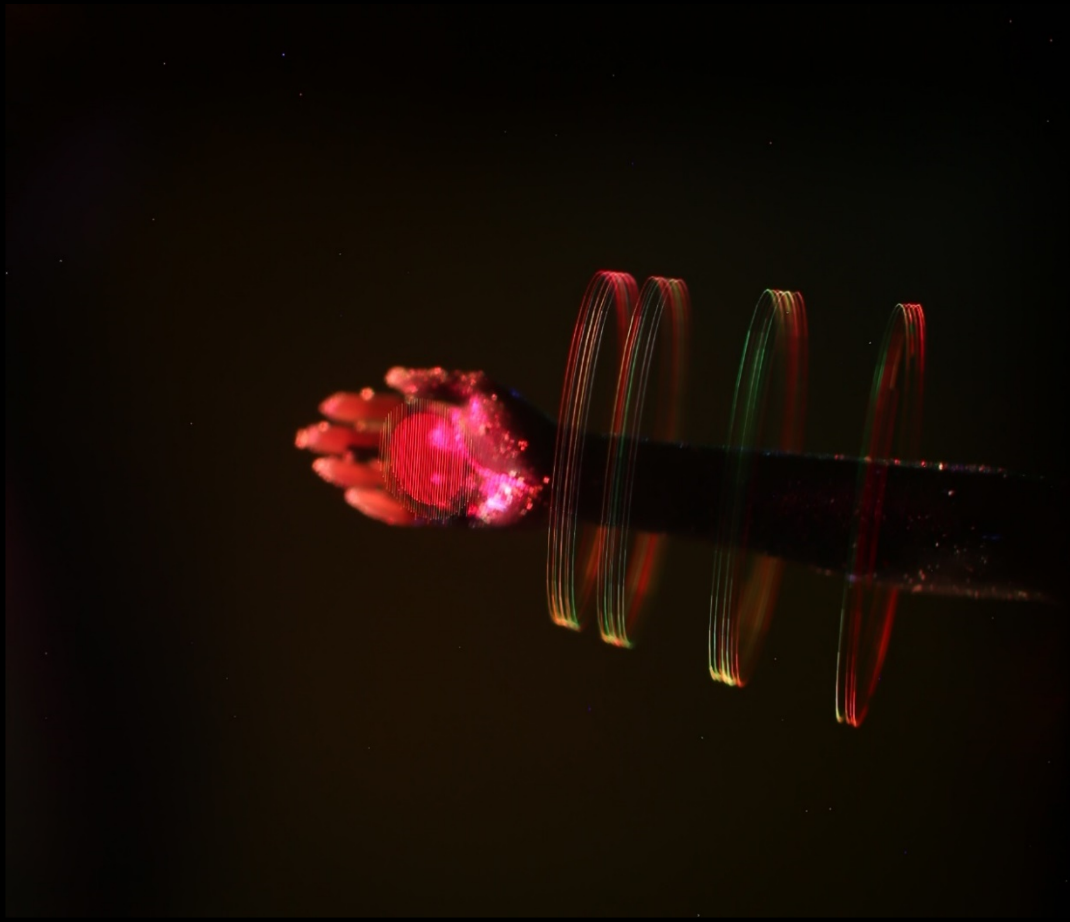


Forbidden Geometries: Long-Throw Projections

Forbidden Geometries:
Tall Sandtables

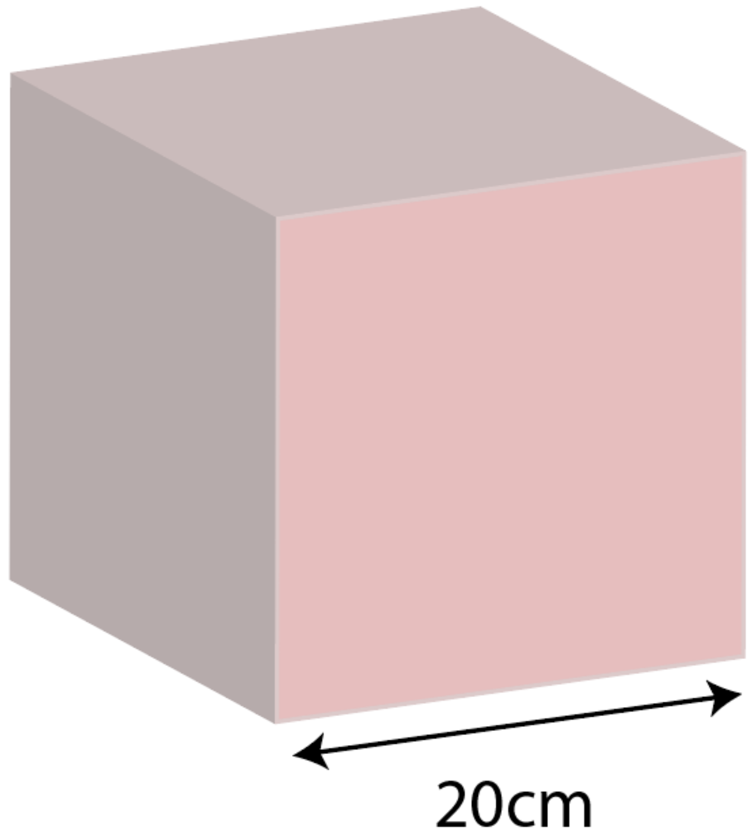


Forbidden Geometries: Wrap-Around Images

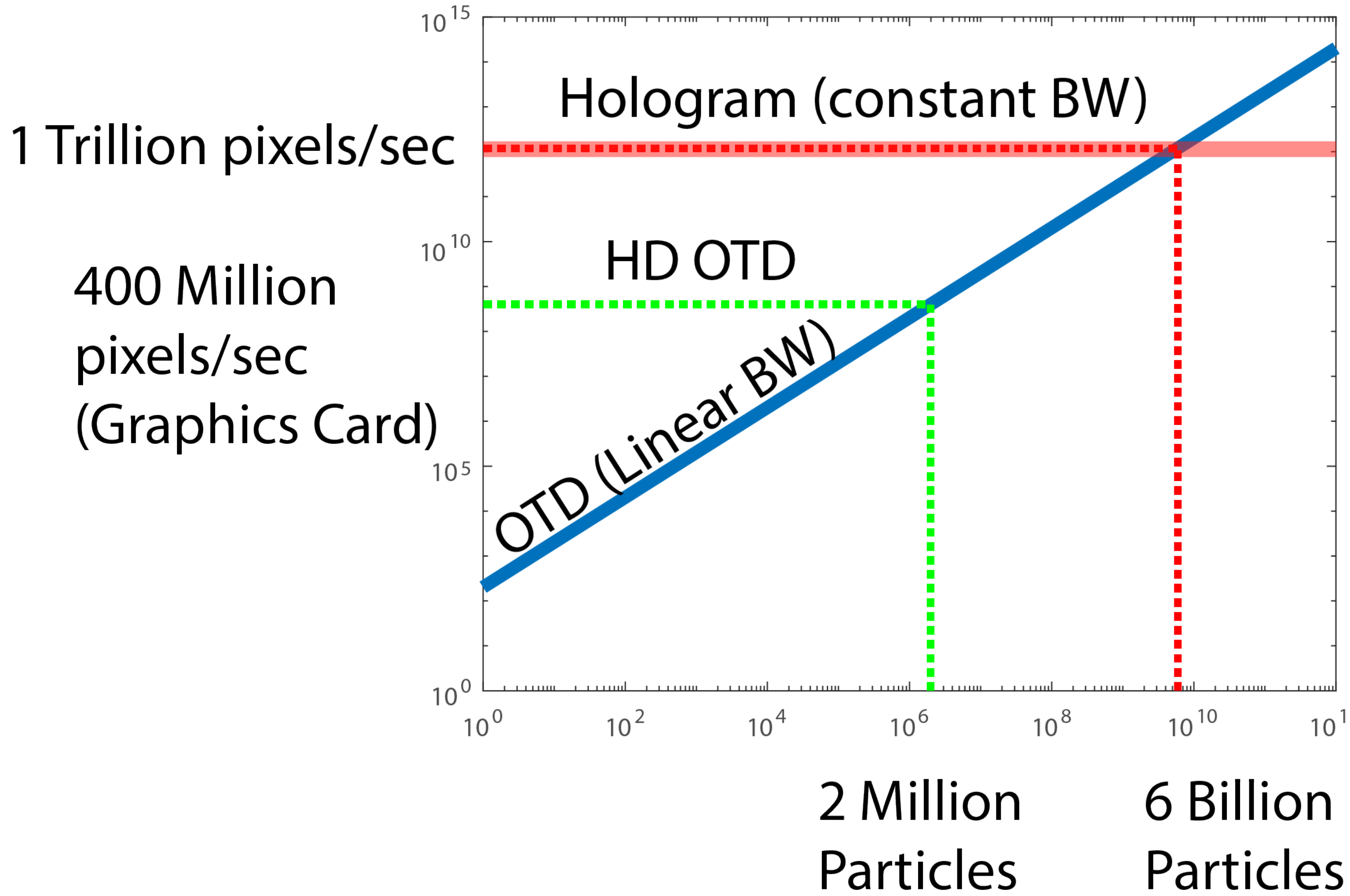


Hybrid Systems Possible

Low-Computational Complexity For Sparse Scenes



Pixel Bandwidth vs. Particle Bandwidth
(hologram vs. OTD in 20x20x20x cm Volume)



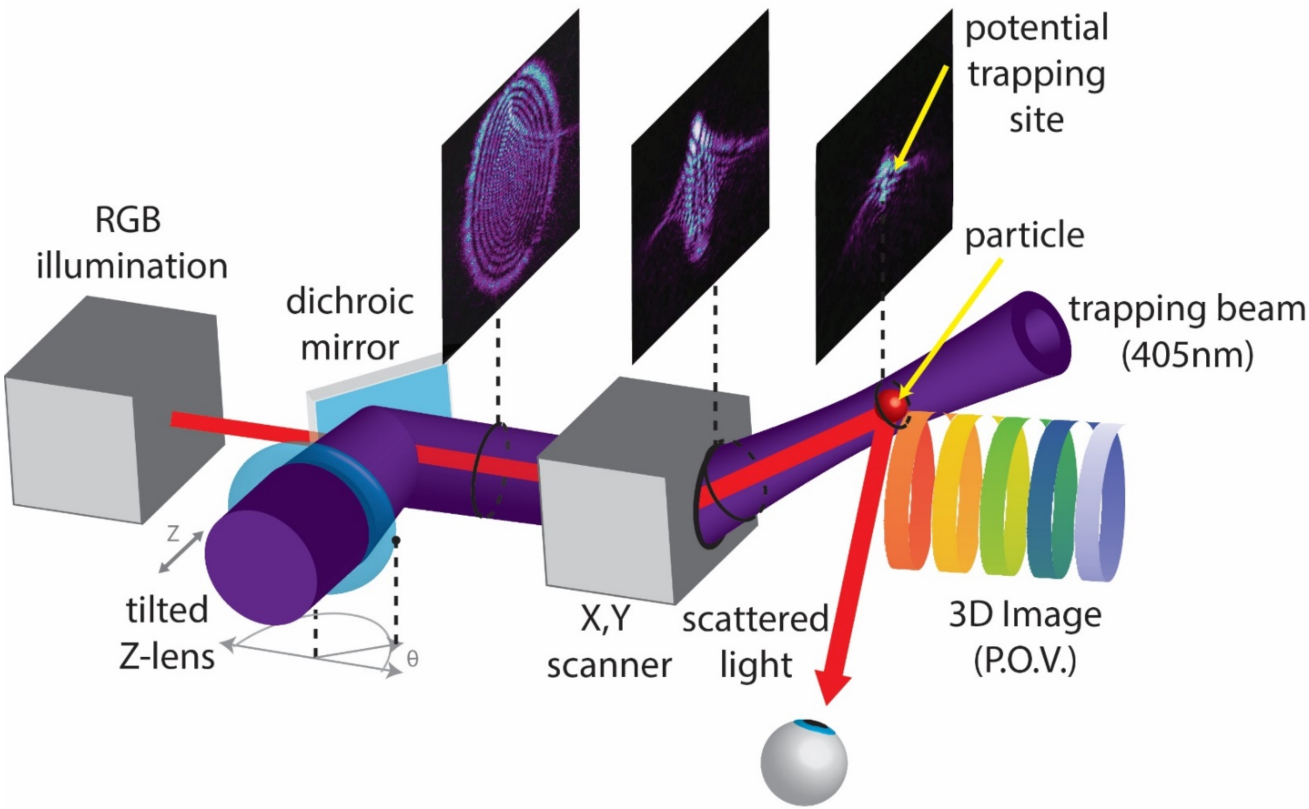
<400 MPixels/sec (commodity Graphics card)

OTD Improvements

Improvements:

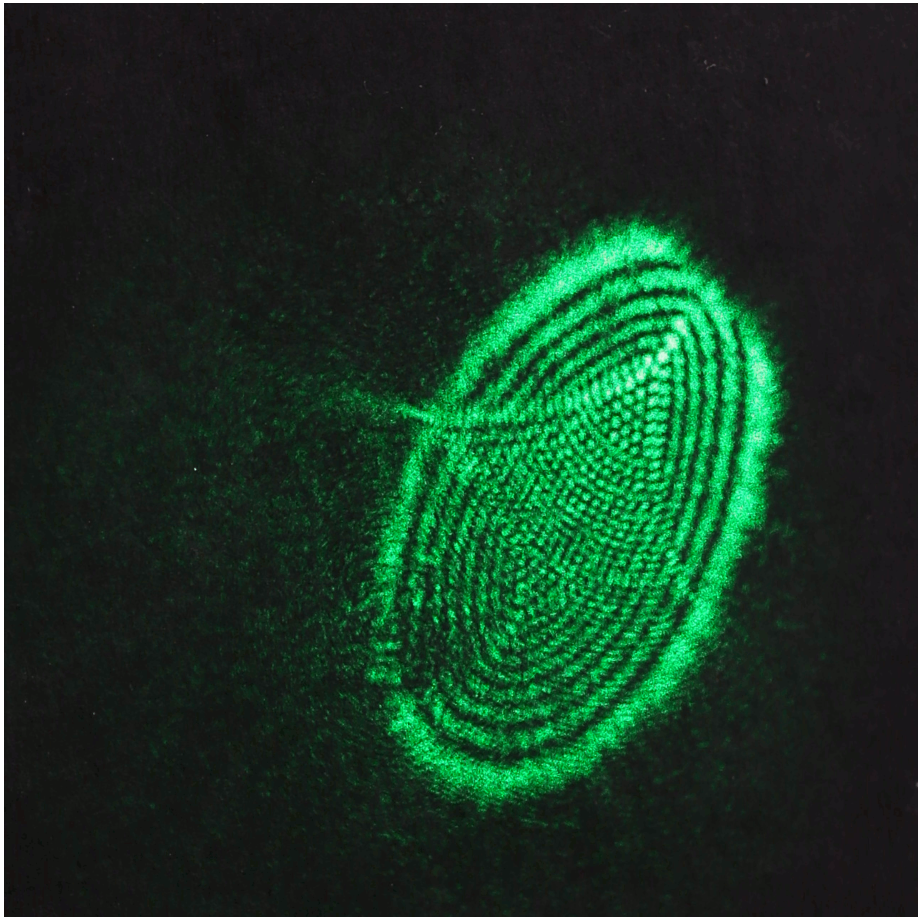
- Trap
- Particle
- Scanning
- Scaling
- Occlusion
- Robustness
- Safety

Challenge: Trapping

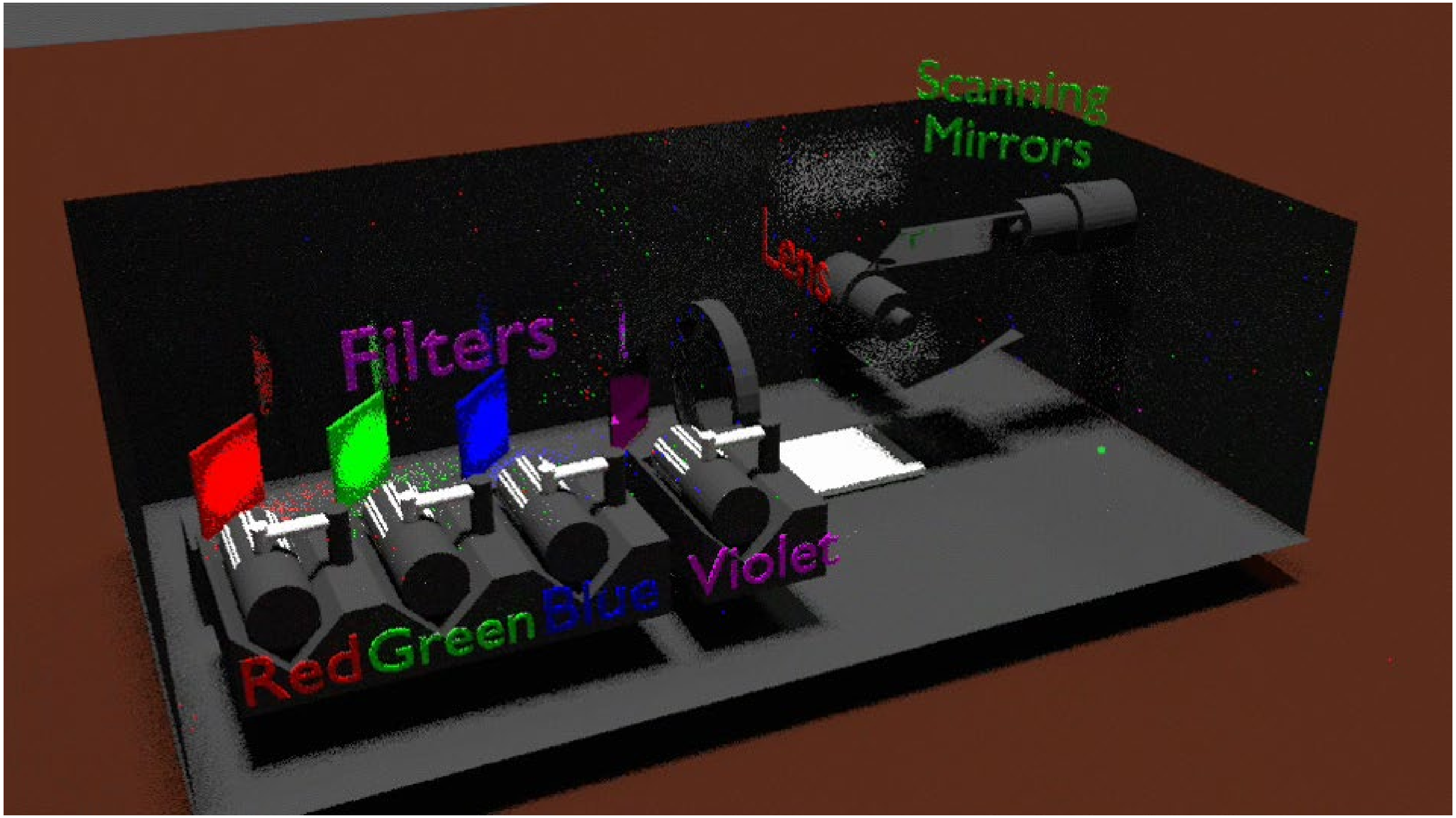


D. Smalley[*1] et al., "A photophoretic-trap volumetric display," *Nature,* vol. 553, p. 486, 01/24/online (2018).

Challenge: Trapping



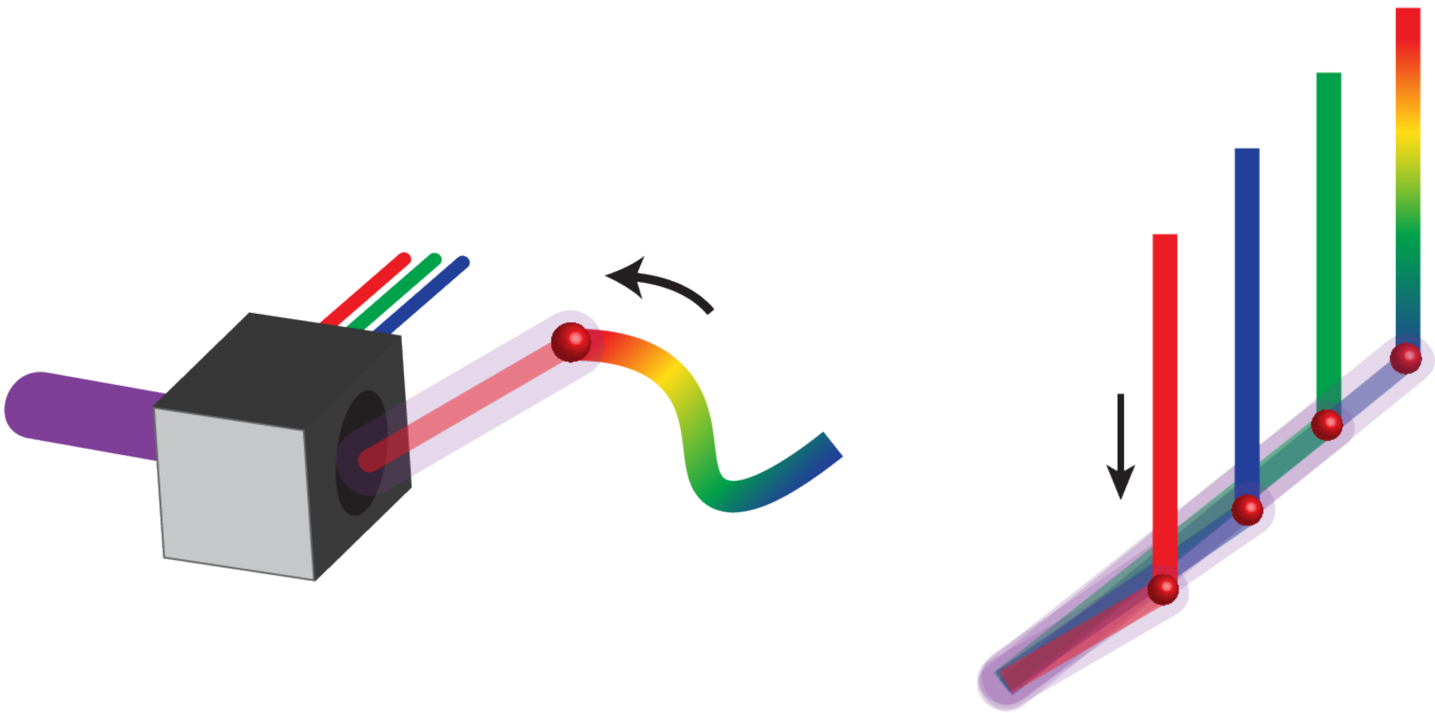
Challenge: Scanning



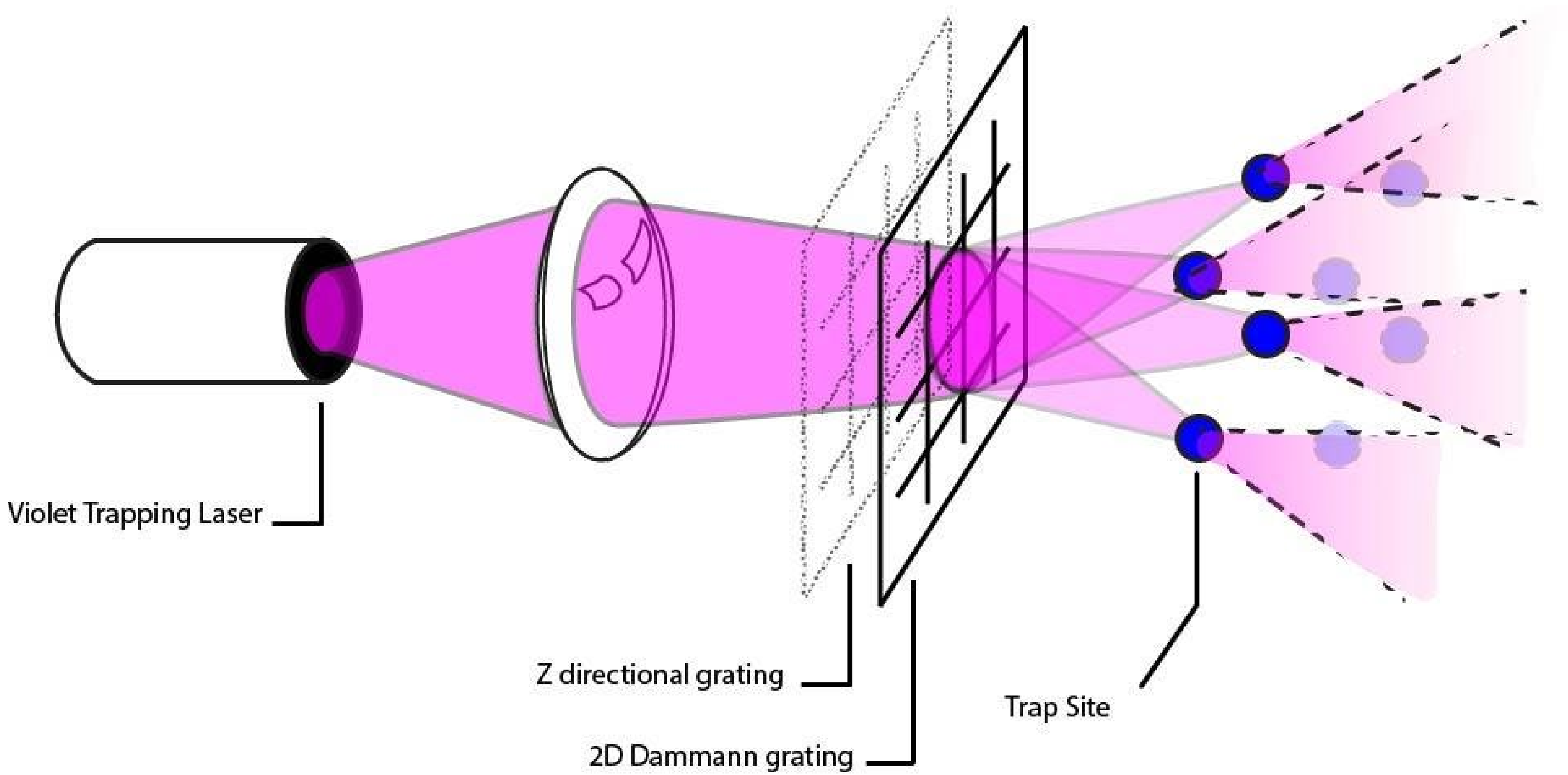
Challenge: Scanning

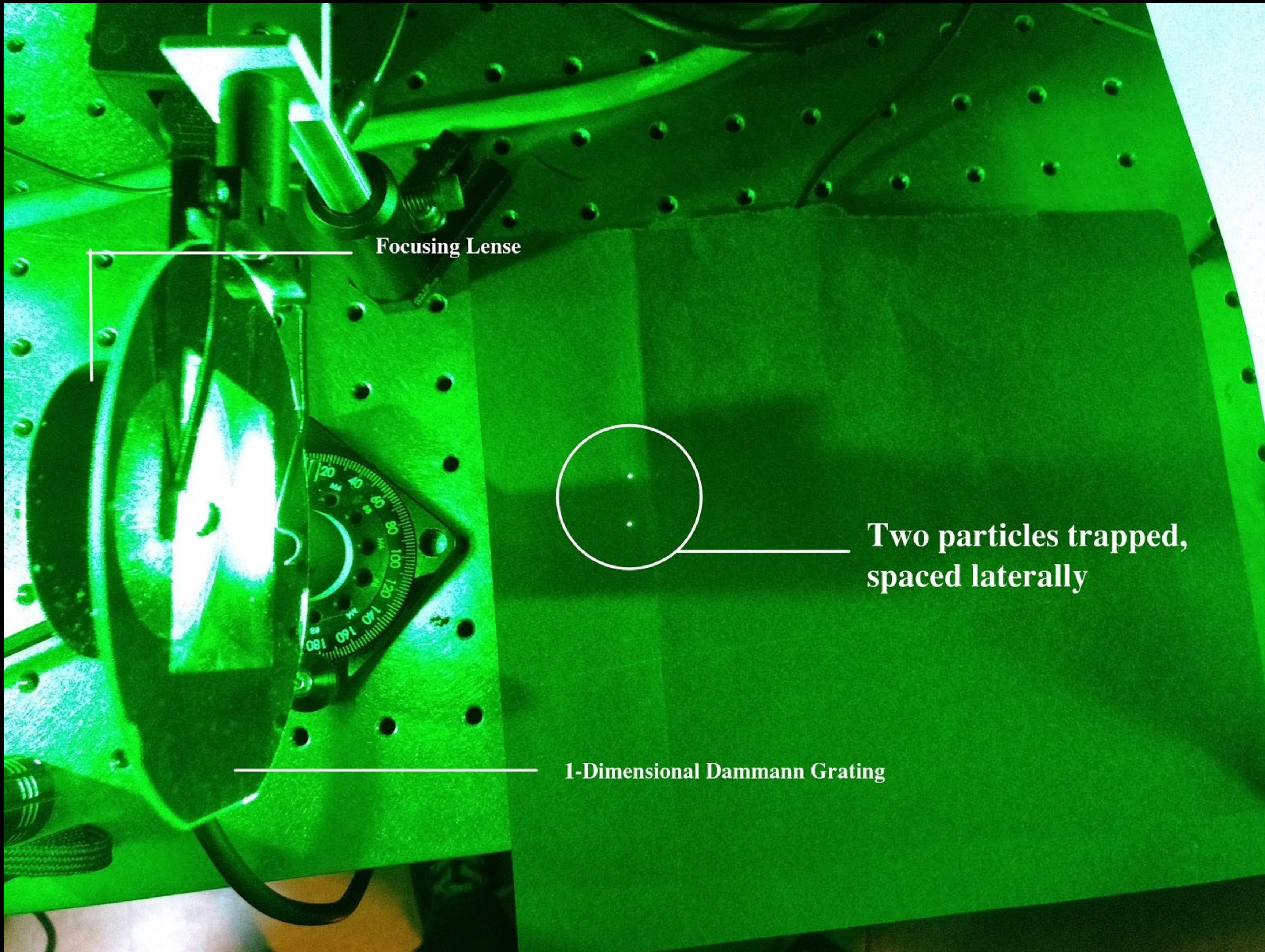
OTD parameters	
Max Particle Velocity	1,827mm s^{-1}
Max Frame Rate	12.8 fps
Max Acceleration	5.67g
Max Hold Time	17.2h (term. by researcher)
Max Pickup Rate	87% (N=67)
Computational Complexity	9bytes/point/frame
Voxel Dimension	10um
Linear Resolution	1600dpi
Addressable Volume	$100cm^3$
Color	24bit

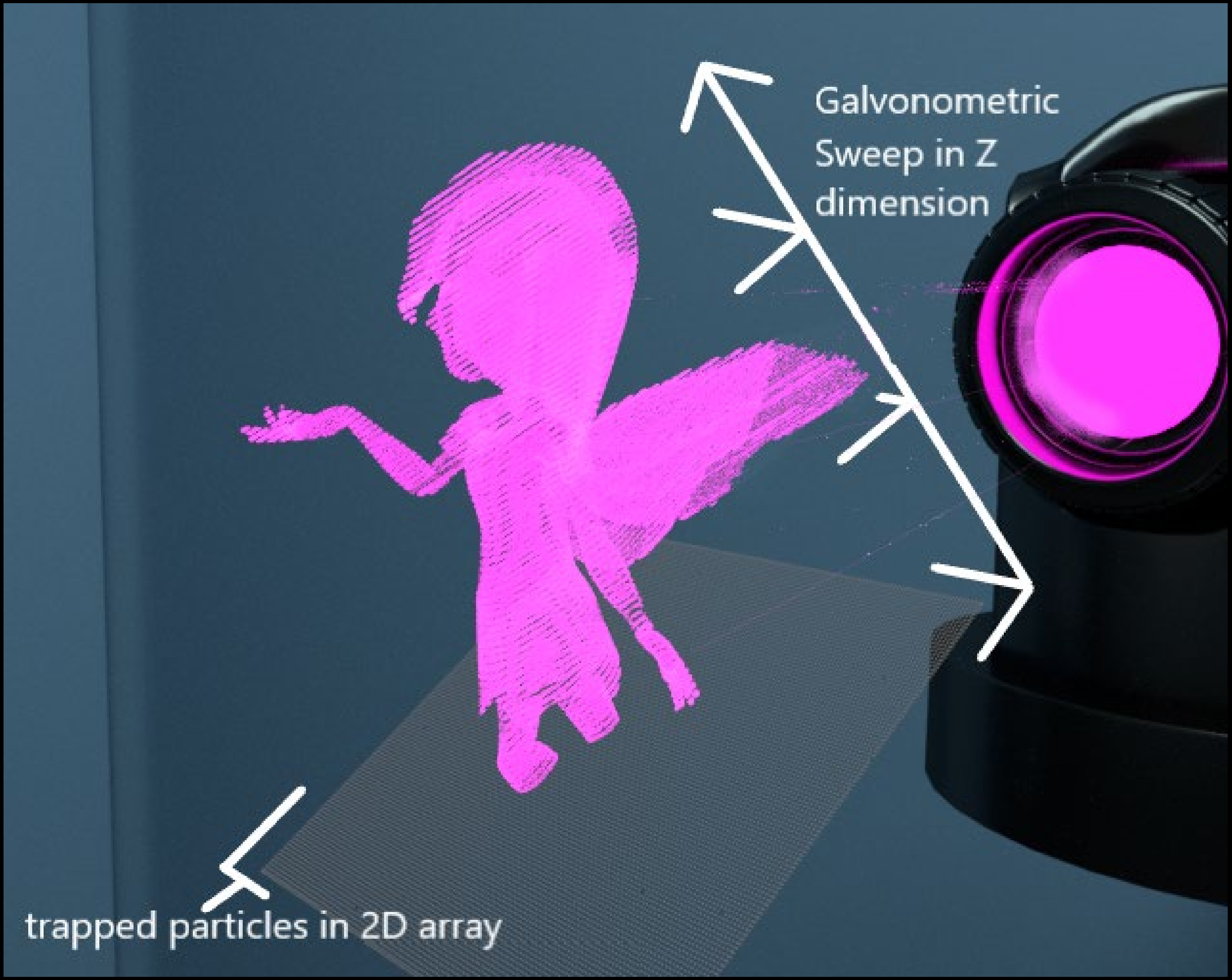
Challenge: Scaling



Challenge: Scaling



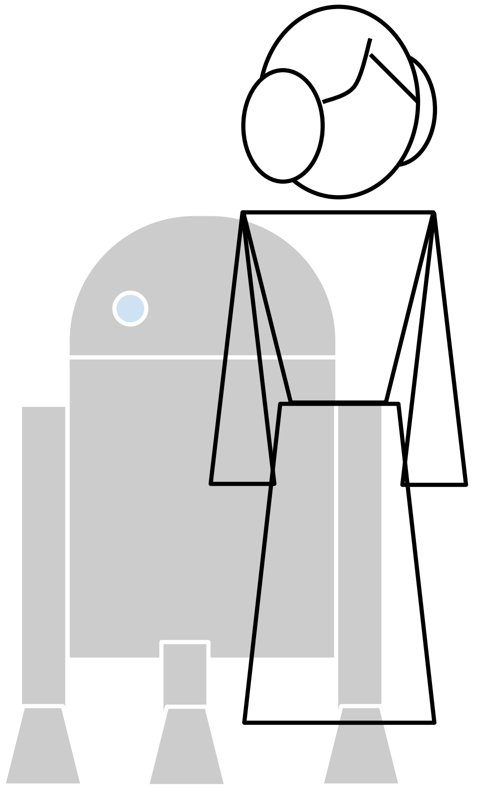

Focusing Lense
Two particles trapped,
spaced laterally
1-Dimensional Dammann Grating

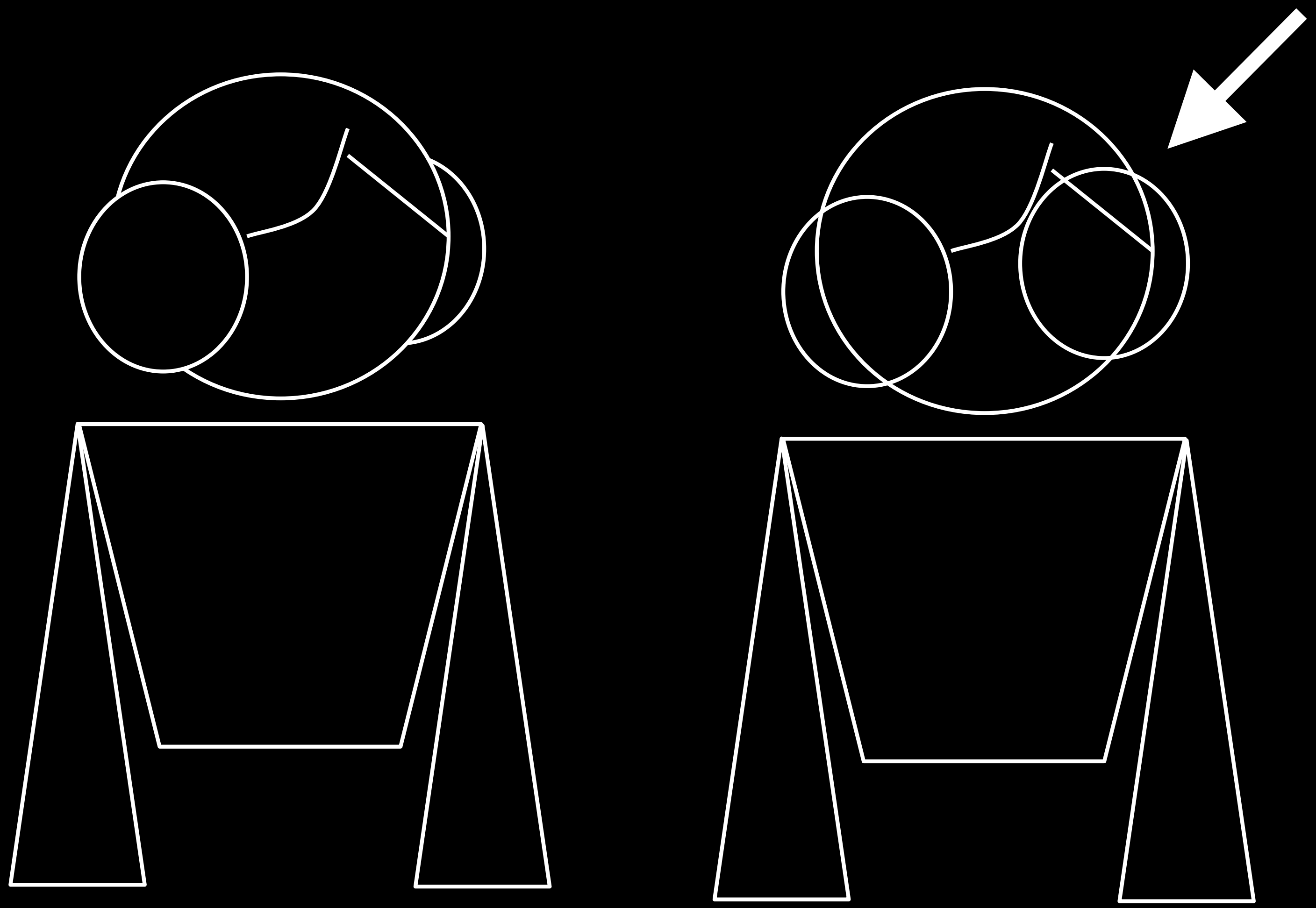

Galvonometric
Sweep in Z
dimension
trapped particles in 2D array

Most Volumetric Displays Limited to Ghosts and Hulls

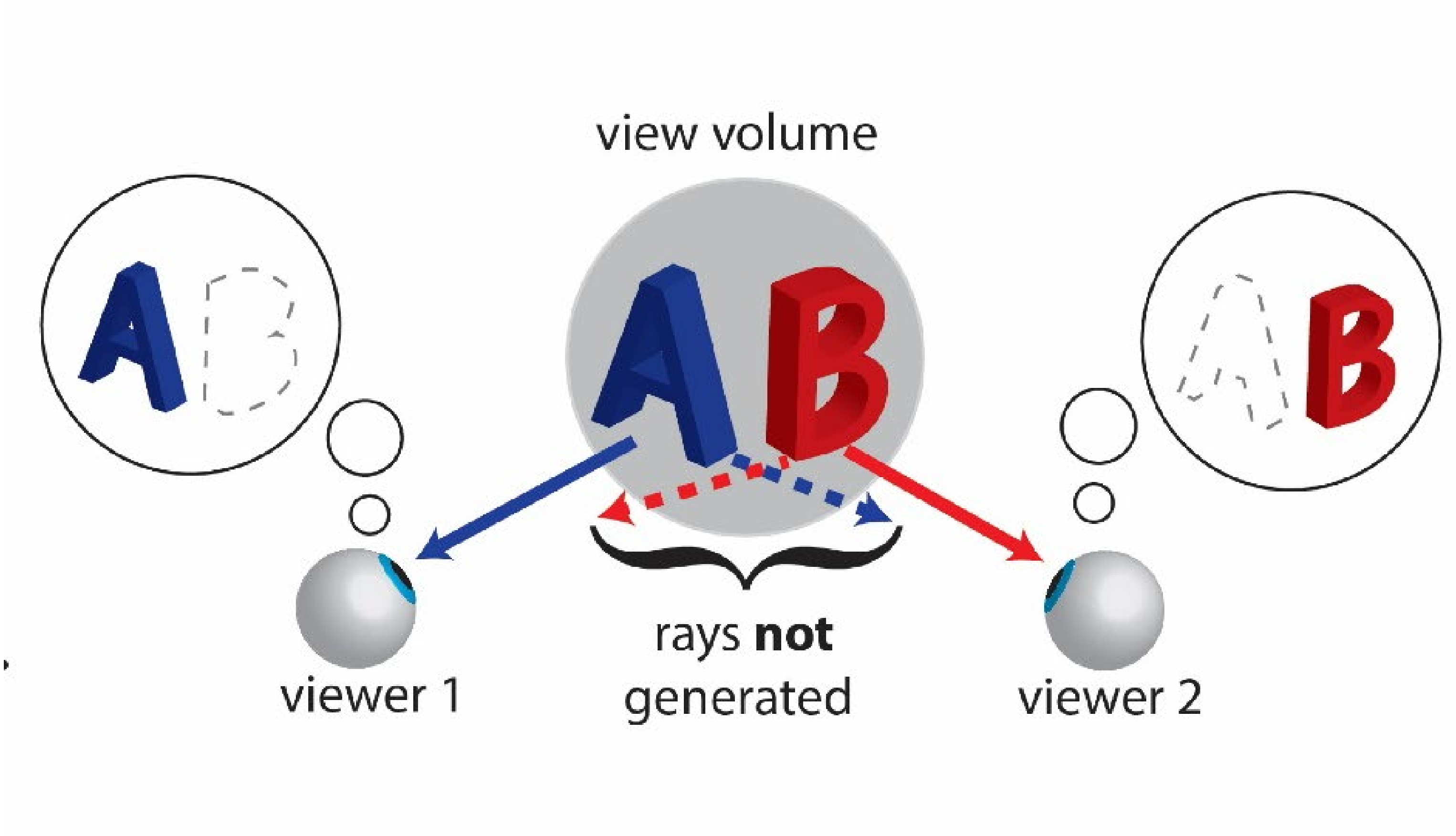
Challenge: Occlusion

Occlusion



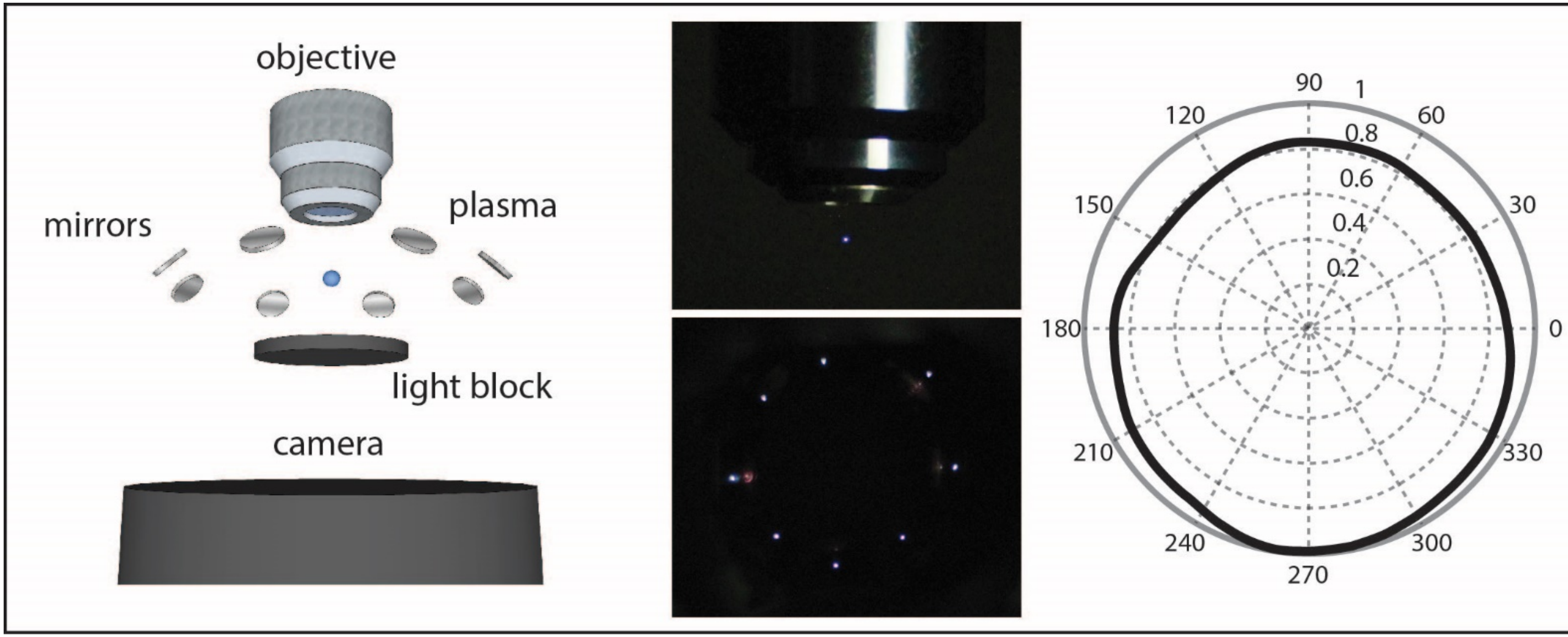


Occlusion impossible?

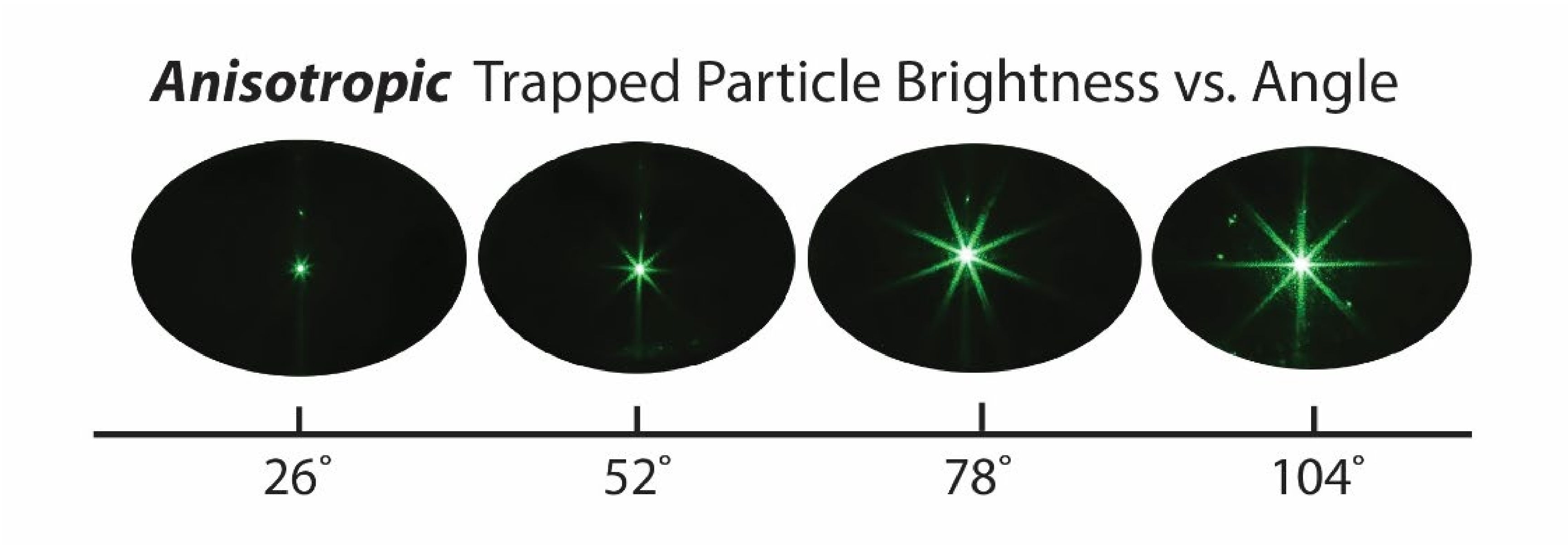


See also: Cossairt, Oliver S., et al. "Occlusion-capable multiview volumetric three-dimensional display." *Applied optics* 46.8 (2007): 1244-1250.

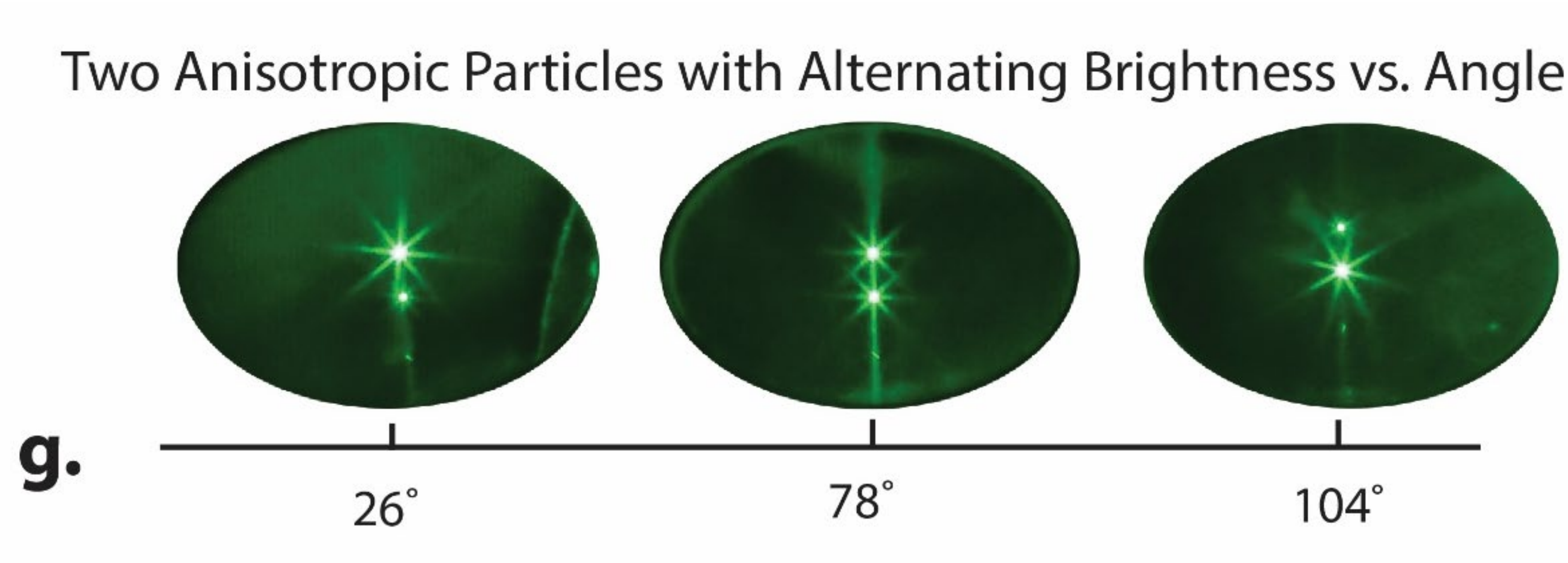
Isotropic Scatterers



Anisotropic Scatterers



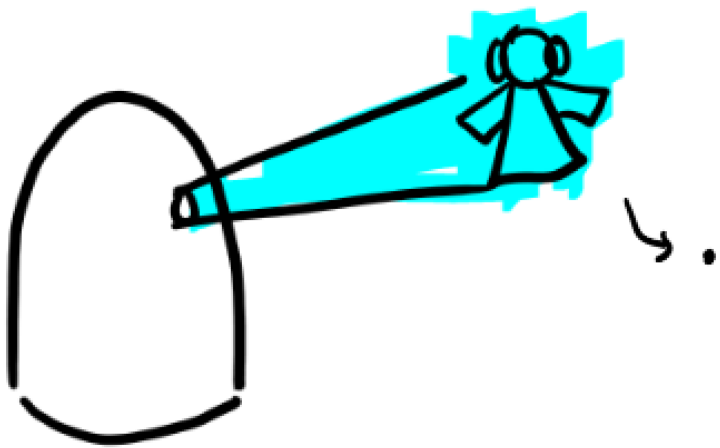
Alternating Particles




Math 101
for kids
– Mobius Strip –

Challenge: Robustness

What if the particle falls out?



80%

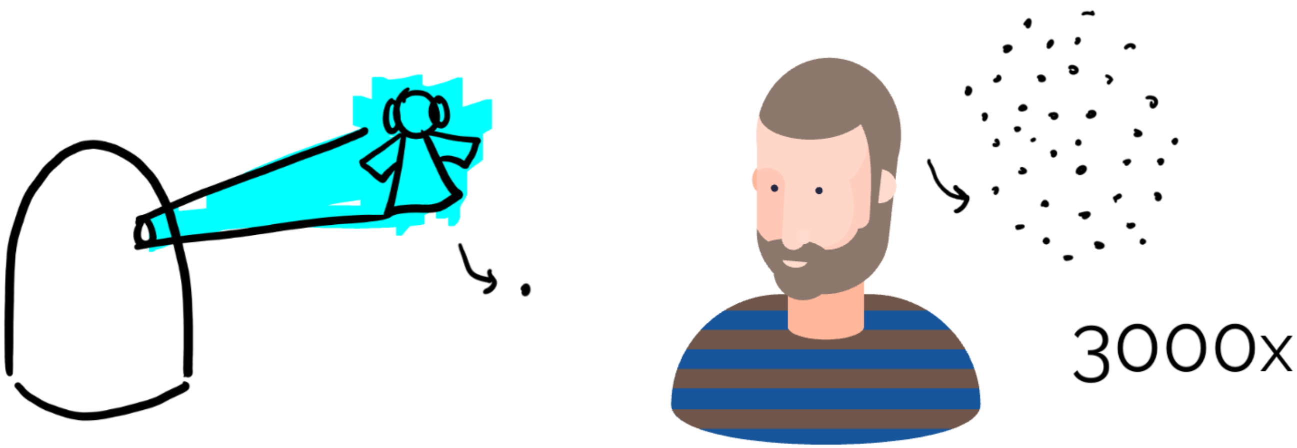
Challenge: Safety

Safety: Particles

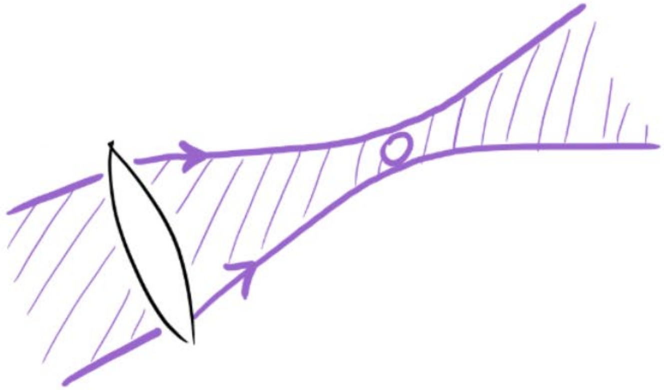
Particles:

Safety: Particles

Particles:

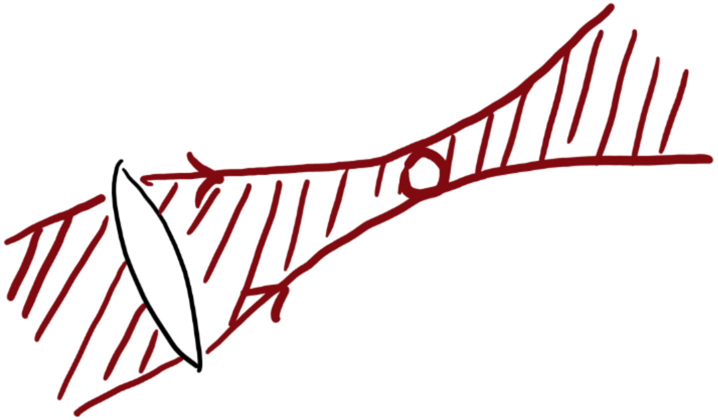


Safety: Lasers



Violet

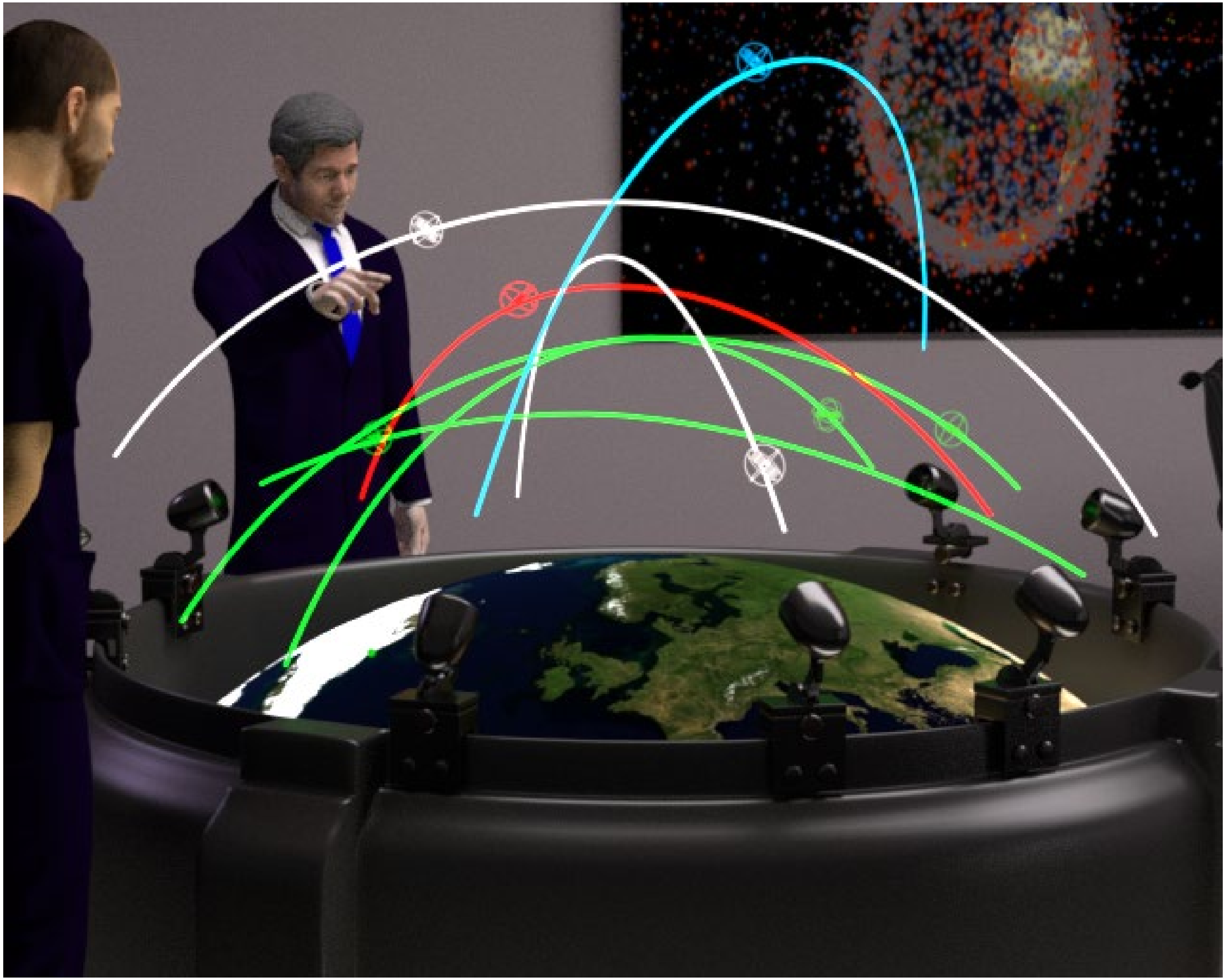
Safety: Lasers



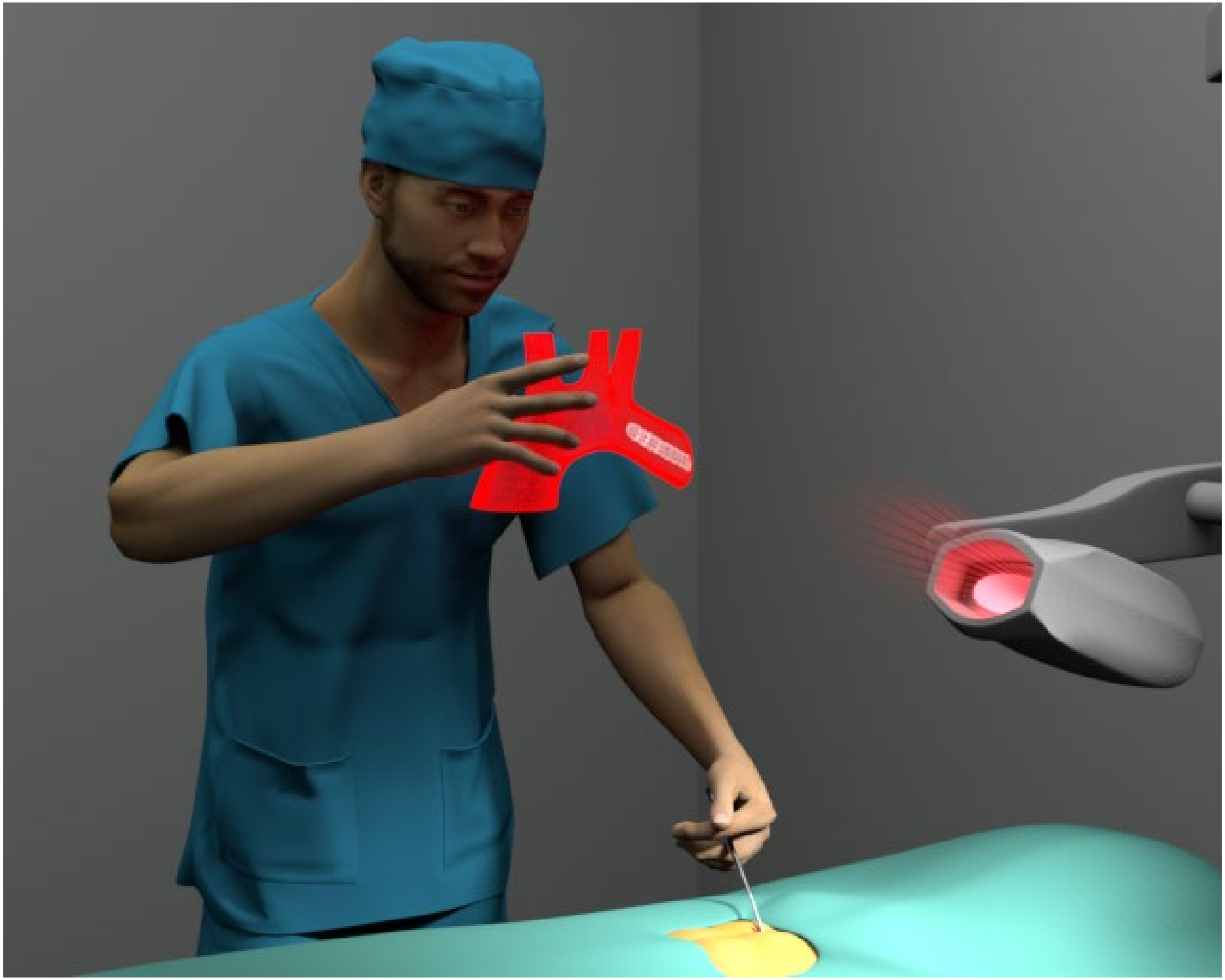
IR

Improved 8in display→6000hrs

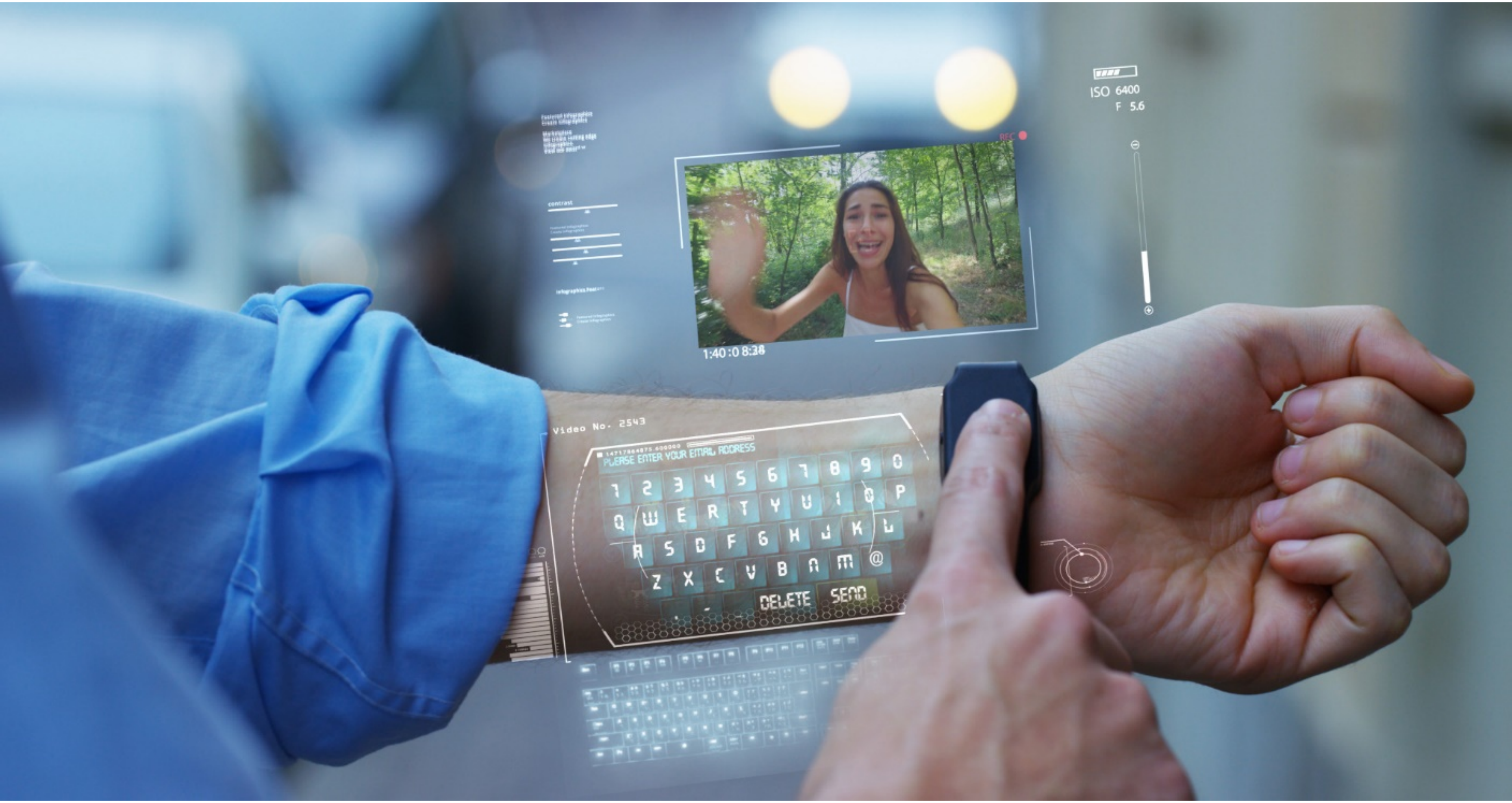
Freespace Volumetric Display Applications



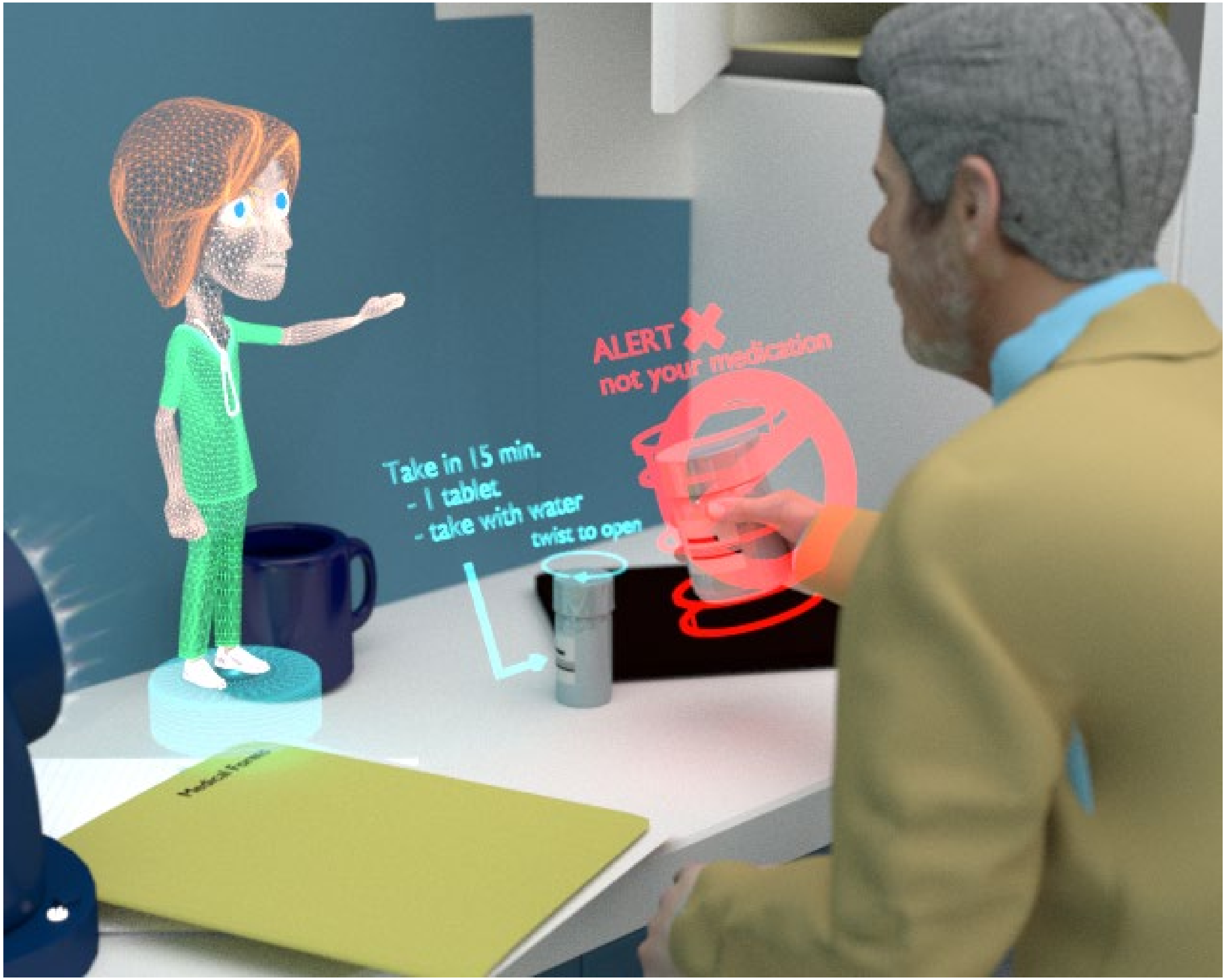
Early Application



Intermediate Application



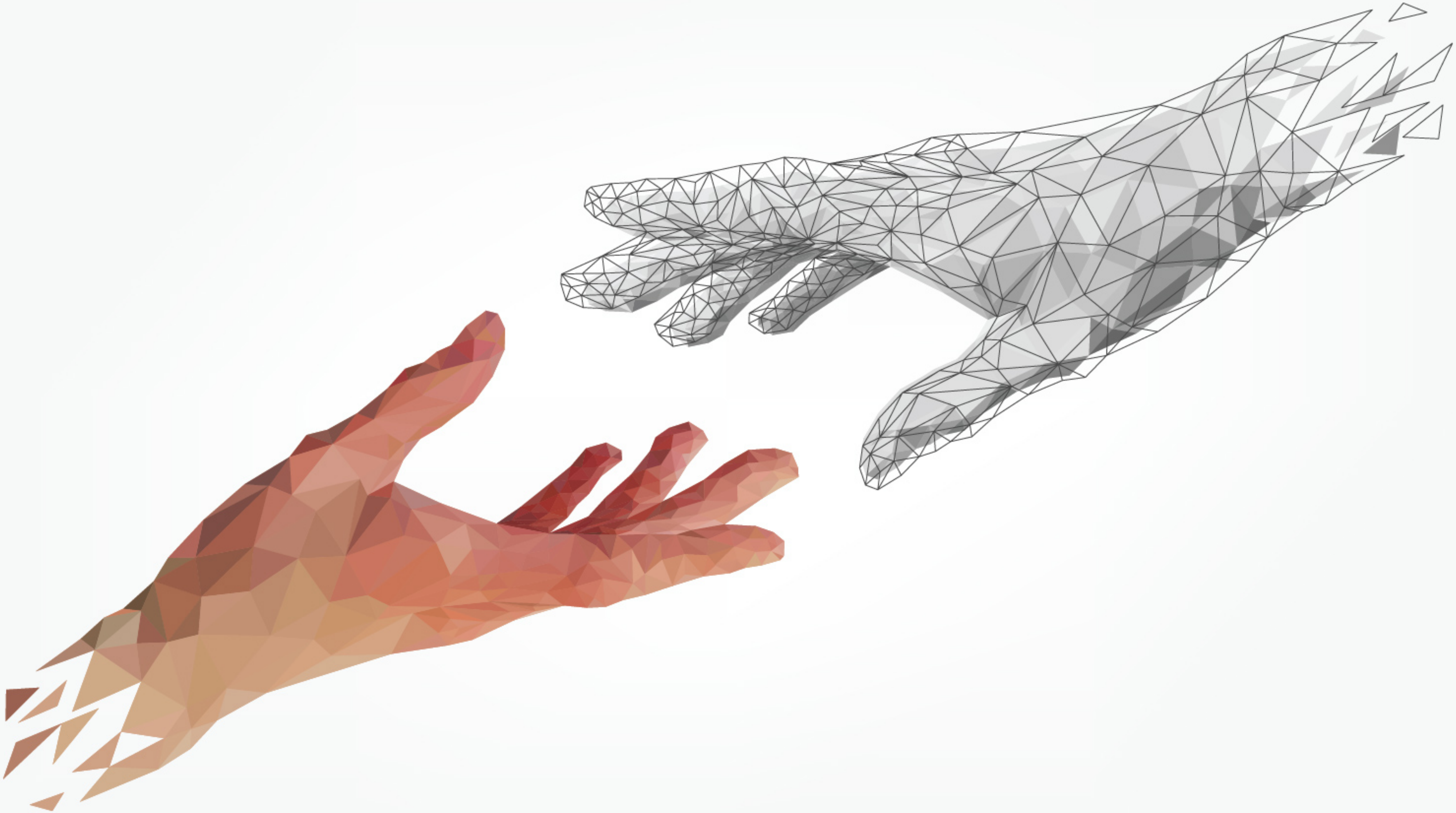
ISO 6400
F 5.6
REC
contrast
1:40 :0 8:38
Video No. 2543
PLEASE ENTER YOUR EMAIL ADDRESS
DELETE
SEND

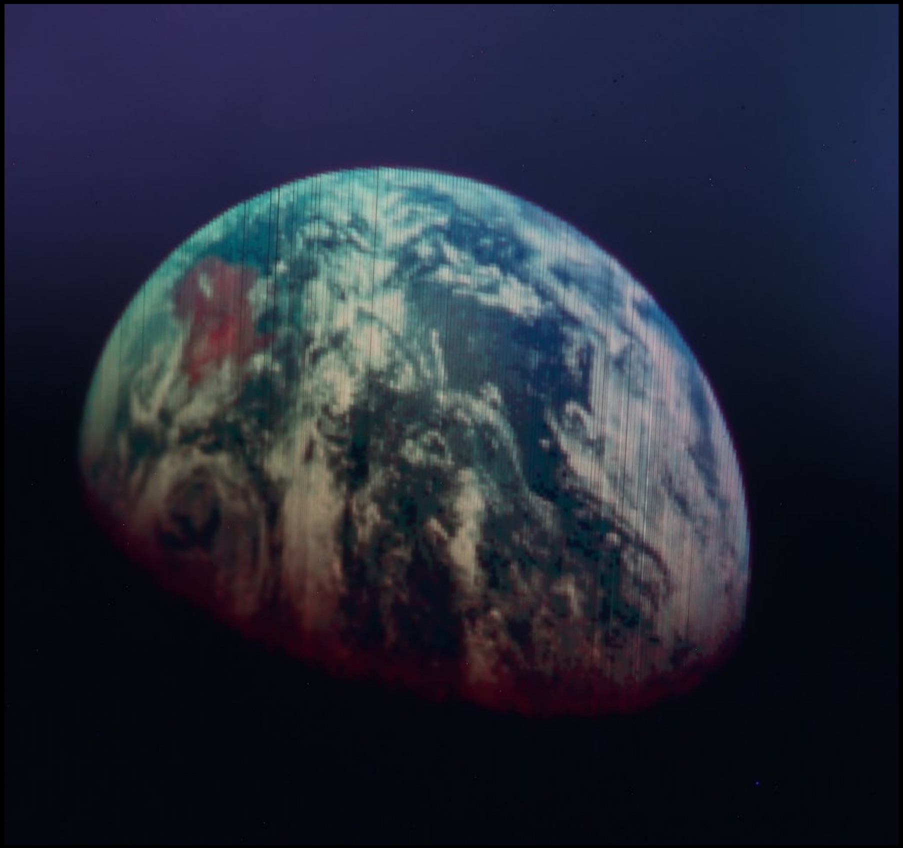


Long-term Application

Before: Photons

Now: Photons + Atoms





Thank You