

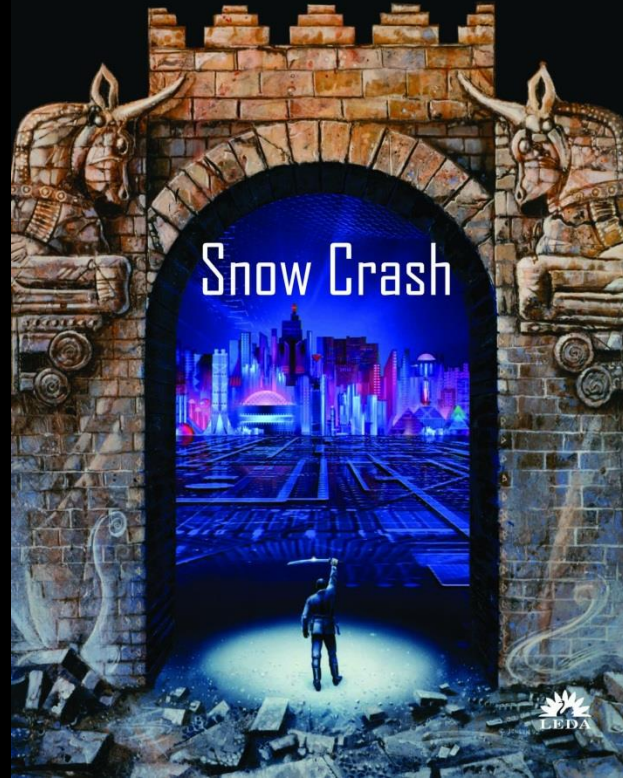


MICHAEL ABRASH

VALVE

**WHAT VR COULD, SHOULD, AND ALMOST
CERTAINLY WILL BE WITHIN TWO YEARS**

NEAL STEPHENSON



Q U A K E



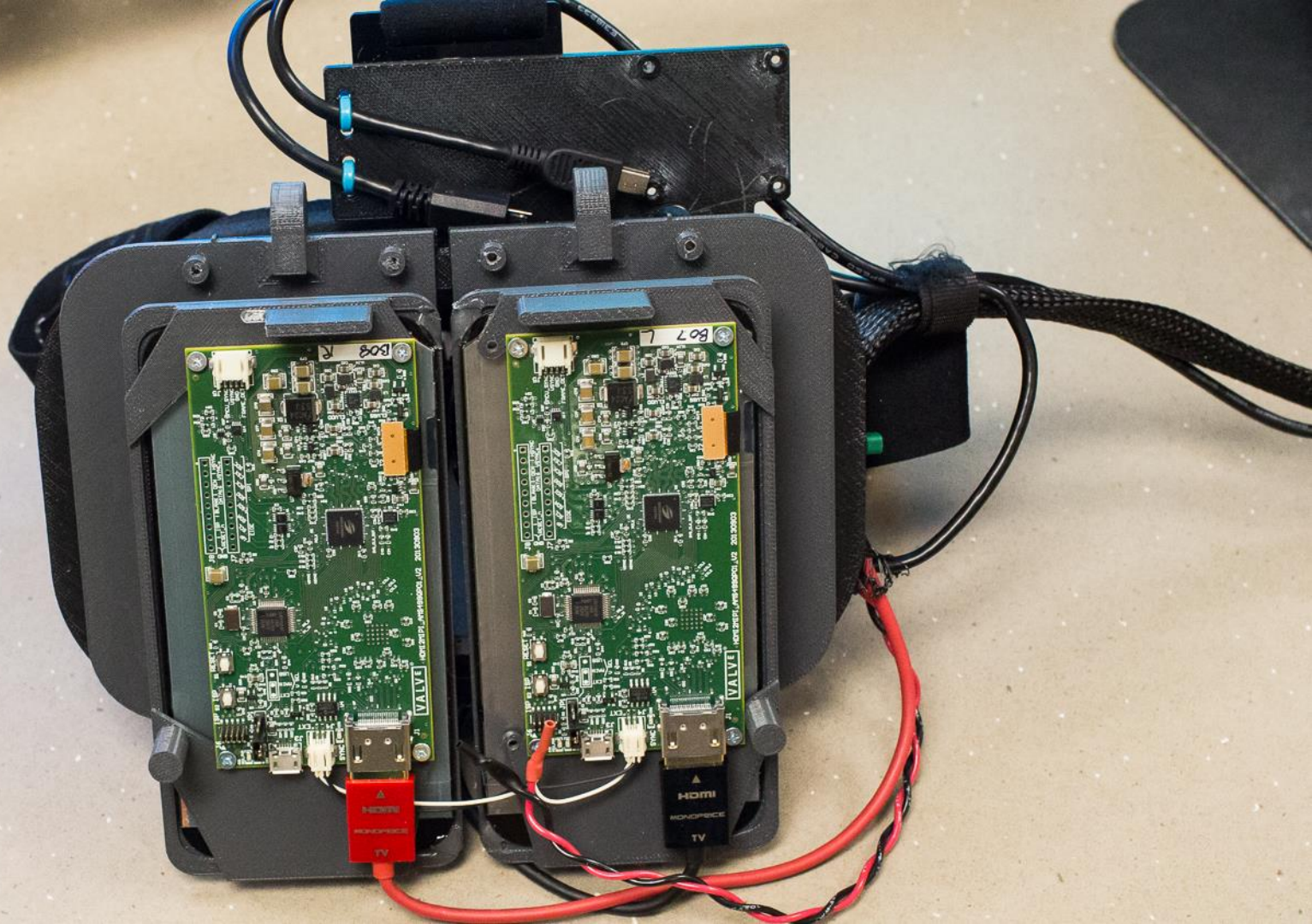
Full registered version.



The near future of virtual reality



- VR is likely to be here sooner than you think
- We've learned this from our R&D
- We've built a hardware prototype that creates presence



The near future of virtual reality



- Presence is VR magic
- We think people are going to want presence badly

The near future of virtual reality



- The same hardware reduces motion sickness
- This hardware makes it possible to create incredible VR experiences that won't make people sick
- We believe that a consumer version is feasible within two years

Who might ship this?

- Oculus is the obvious candidate
- The DK1 is a good first step, but not good enough
- Crystal Cove is a big step in the right direction
 - Resolution, latency, persistence, translation
 - Low persistence driven by Valve prototyping
 - Valve and Oculus collaborated on tracking
- We're continuing to work with Oculus to drive PC VR forward

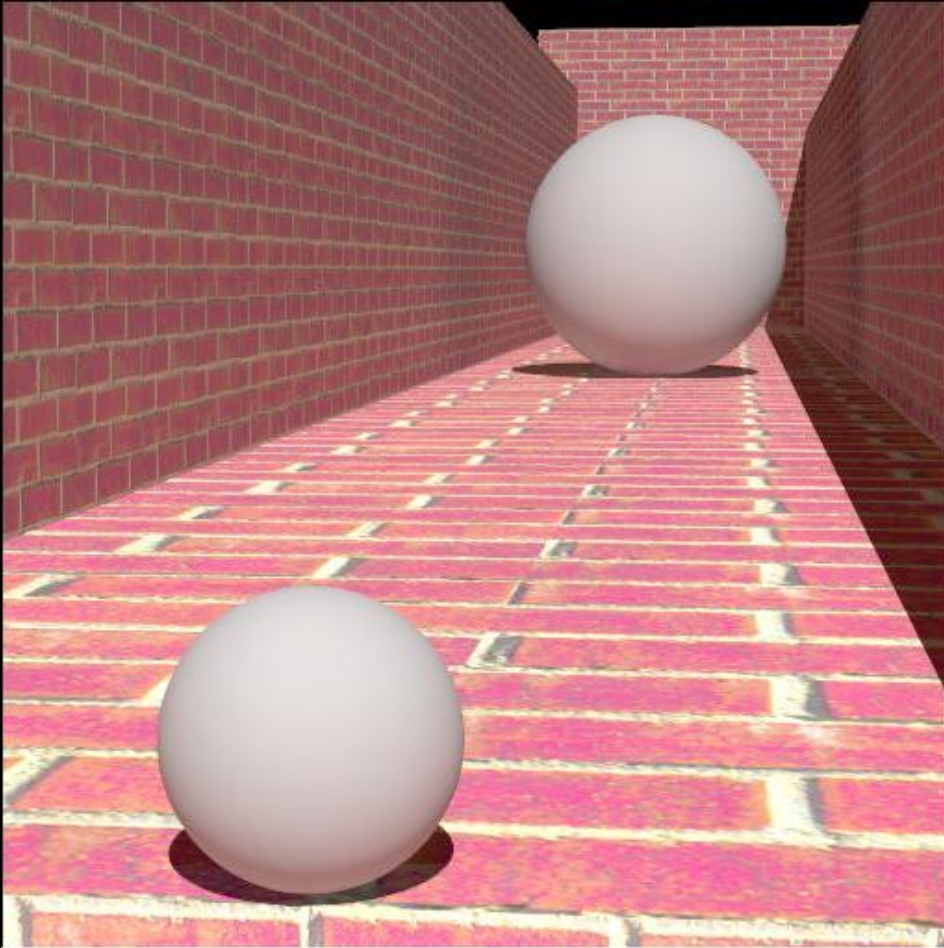
Implications of presence

- VR could evolve into a major platform
- Presence could tip the balance of the entire industry toward computer entertainment
- Presence requires a head-mounted display connected to lots of local compute power
- The PC is going to be the best place for VR

Decide for yourself

- Try it for yourself and decide what you think the future looks like
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WHAT DOES IT TAKE TO MAKE VR COMPELLING?



Murray, S.O., Boyaci, H., and Kersten, D. (2006). The representation of perceived angular size in human primary visual cortex. *Nature Neuroscience*. 9, 429-434. doi:10.1038/nn1641

Fang, F., Boyaci, H., Kersten, D., and Murray, S.O. (2008). Attention-dependent representation of a size illusion in human V1. *Current Biology*, 18 (21), 1707-1712. doi:10.1016/j.cub.2008.09.025

<http://www.bilkent.edu.tr/~hboyaci/Vision/SizeAppletLarge.html>

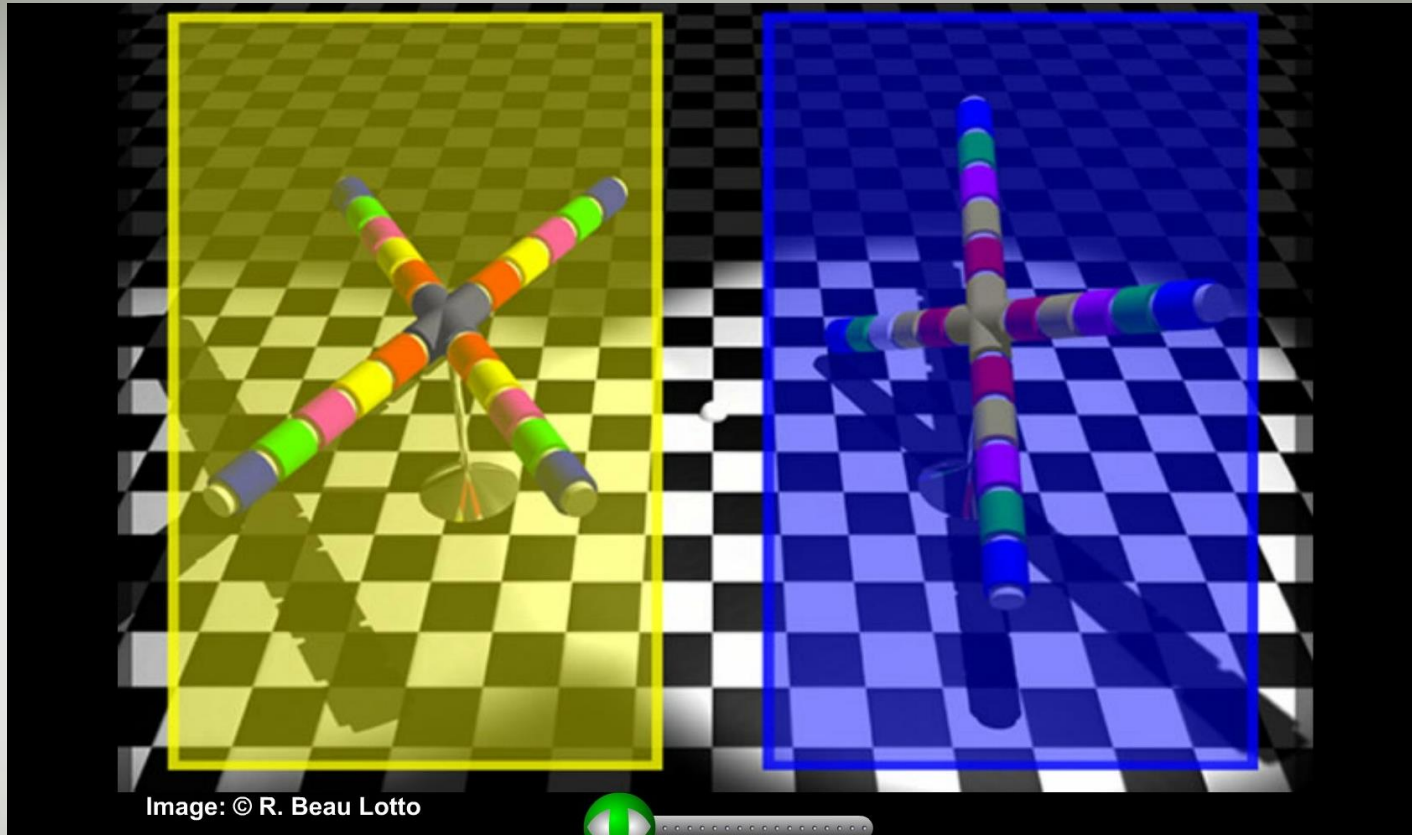


Image: © R. Beau Lotto

<http://www.echalk.co.uk>

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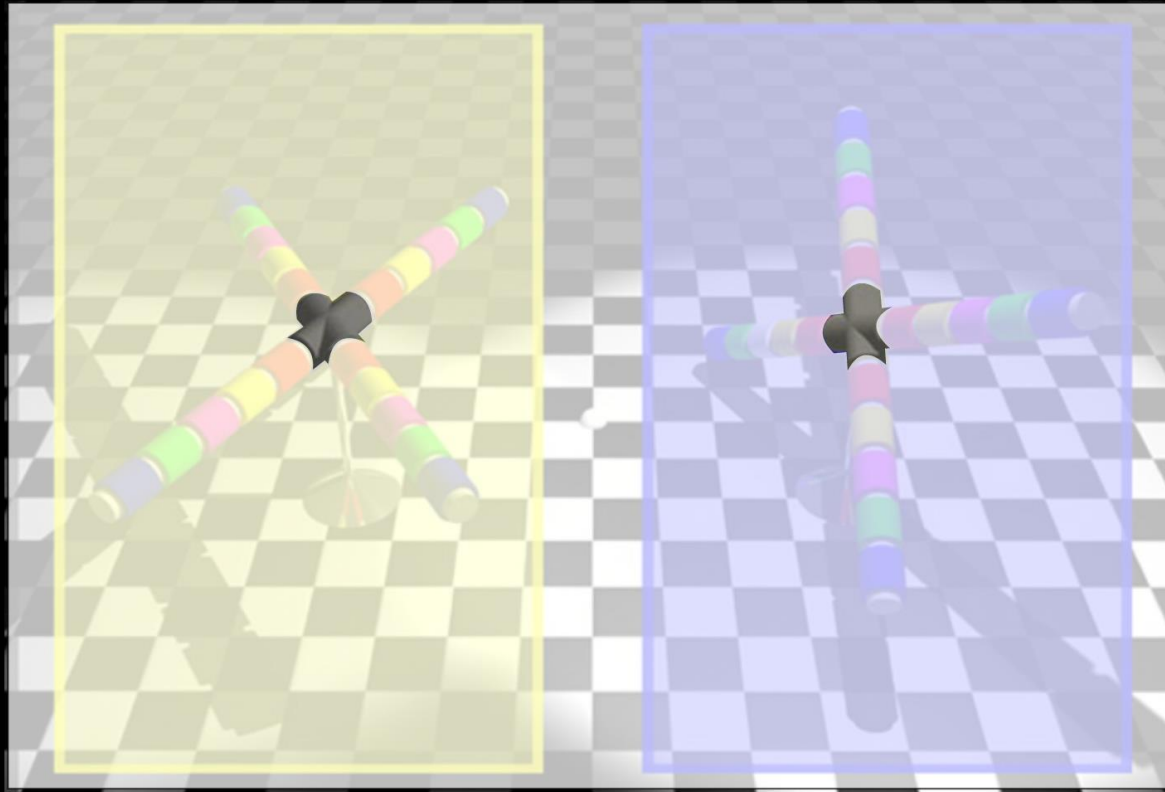
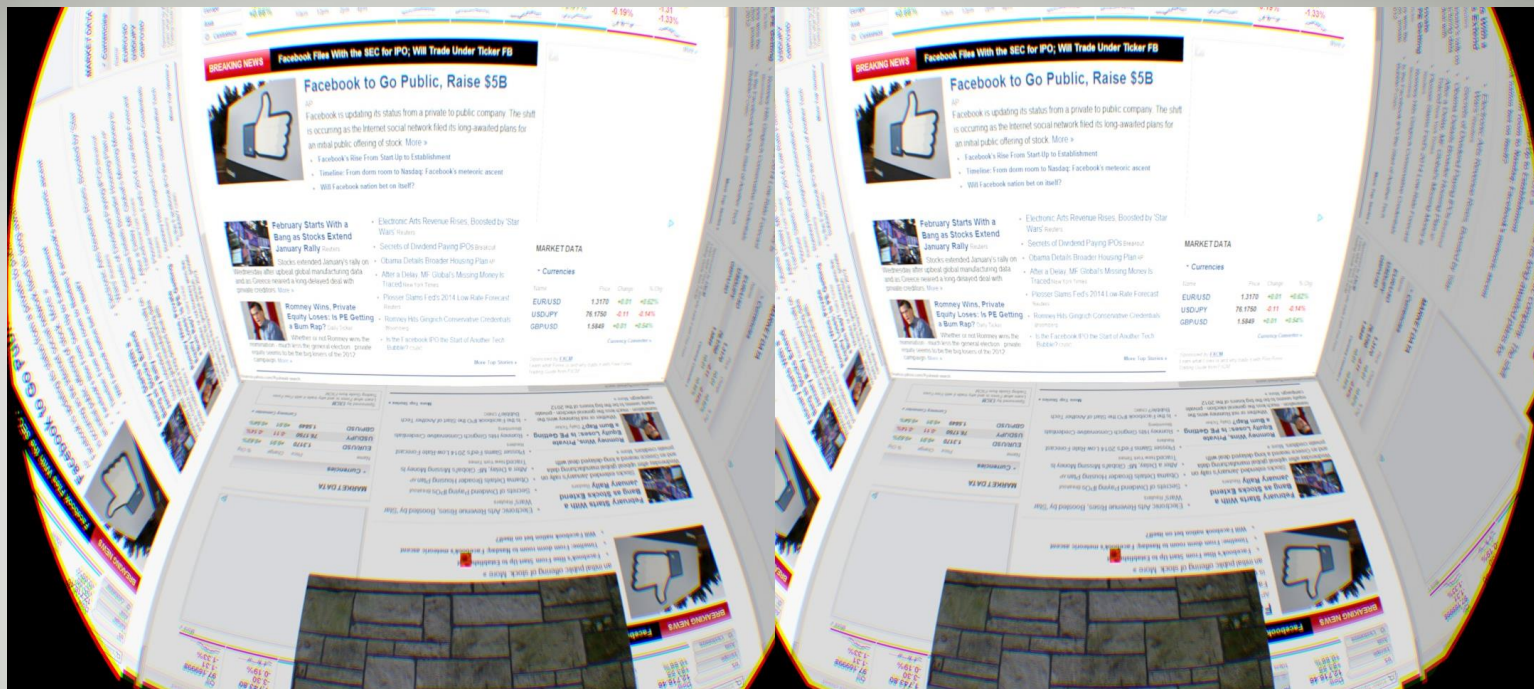


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Presence

- The sense that you are really someplace else
- More than just immersion
- Can only understand by experiencing it

Presence

- Varies from person to person
- Has gotten stronger as technology has improved

Presence

- It's why we're so excited about VR
- Powerful at a visceral level
- Unique to VR
- Likely to be the key to VR's success

All of the following are needed

- A wide field of view
- Adequate resolution
- Low pixel persistence
- A high enough refresh rate
- Global display
- Optics
- Optical calibration
- Rock-solid tracking
- Low latency

A wide field of view

- Immersion
- Peripheral cues
- At least 80 degrees
- More is better

Adequate resolution

- Problematic for VR due to wide field of view
- One-seventh the pixel density per degree of a wide-screen TV
- 1080p works
- More is better



Low pixel persistence

- Necessary to avoid blurring with eye motion
- No more than 3 ms

Smear from persistence



A high enough refresh rate

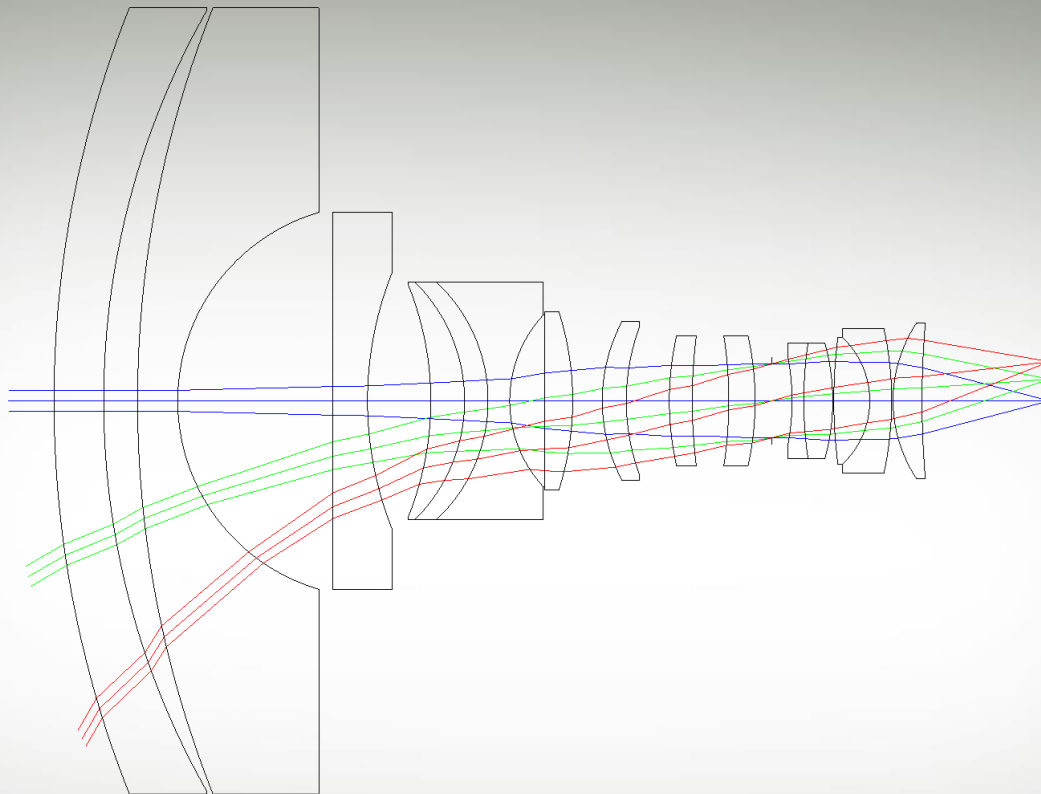
- Necessary to avoid flicker with low persistence
- 95 Hz seems to be sufficient
- Somewhat less than 95 Hz may be adequate

Global display

- Illuminates all pixels simultaneously
- Avoids motion-induced compression, stretching, and skewing
- Rolling display may work, but will have failure cases without low-latency eye tracking

Optics

- Only one or at most two lenses per eye
- Not enough to allow simultaneous control of
 - Focal length
 - Viewing distance
 - Size
 - Distortion
 - Various forms of aberration



Layout

Wide Angle Lens

1/10/2014

Total Axial Length: 460.68220 mm

Wide Angle Lens.ZMX

Optics

- Search for best tradeoffs in a huge space
- Evaluation has to be done by a human

Optical calibration

- The human visual system is amazingly sensitive to deviations
- Many problems are impossible to identify until calibration is nailed

Tracking

- Must support translation (position in x, y, and z) as well as orientation
- Position with at least millimeter accuracy
- Orientation with at least quarter-degree accuracy
- Volume at least 1.5 meters on a side



Low latency

- 20 ms motion-to-last-photon works
- 25 ms may be good enough

Presence is emergent

- *All* of these factors have to be good enough
- No one factor is enough by itself

SO WHEN IS PRESENCE COMING?

Feasible 2015 consumer HMD

- 20 ms motion-to-last-photon latency
- 3 ms pixel persistence
- 95 Hz refresh
- 110-degree FOV
- 1K x 1K resolution per eye
- High-quality, well-calibrated optics
- Tracking
 - millimeter-accurate resolution translation
 - quarter-degree-accurate rotation
 - volume of roughly 2 meters cubed

Presence in 2015

- We've built prototypes to this spec
- We believe the technology is transferable to consumer-priced head-mounted displays
- We'll share what we've found with PC companies that want to develop VR hardware

There's a lot left to be done

- Improve every key element
 - Up to 100X resolution would help
 - Optics are far from optimal
 - Head tracking isn't fully solved
 - Eye tracking is far from solved
- Solve per-user lens positioning (IPD, eye relief)
- Get rid of the tether
- Get a display manufacturer to make VR-optimized panels

There's a lot left to be done

- 3D audio
- Haptics
- Body tracking
- Input
 - Especially the interaction between input and game design in VR

VR software

- Movement
- Gameplay
- Multiplayer
 - Could be the best online social experience yet
- Content

This is where you come in

- Could be one of the biggest platform shifts ever
- Platform shifts create opportunities
- Great VR requires custom experiences
- Someone is going to write the *DOOM* of VR

The PC will be the hotbed for VR

- PC – Linux, Windows, OSX - will be the VR epicenter
 - Rapid evolution
 - Already happening with the Rift
 - Many developers and IHVs, with complete freedom to innovate
 - Most powerful platform, and getting more so
 - Valve will continue to help drive VR on the PC & Steam forward

Takeaway

- A great VR system at a consumer price in 2015 is primed to happen
- It will happen, in 2015 or soon after

Thank you

- Find more information and join the conversation at <http://blogs.valvesoftware.com/abrash/>