Inside VR on Mobile

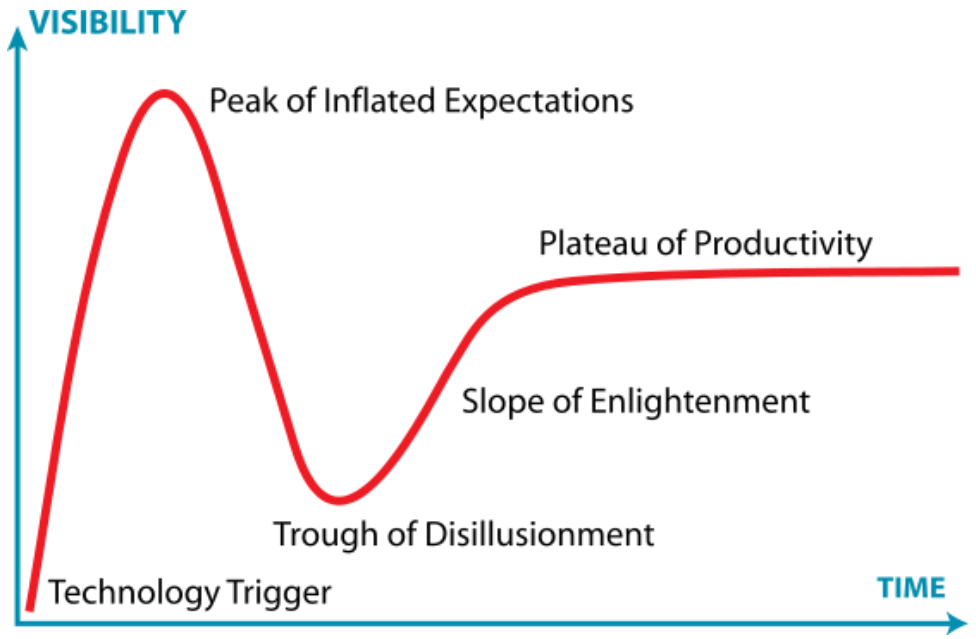
ARM

Sam Martin
Graphics Architect

GDC 2016

VR Today

- Emerging technology
- Main mobile VR ecosystems
  - Google Cardboard
  - Samsung GearVR
- In this talk:
- Latency
- Multiple views
- Performance tuning

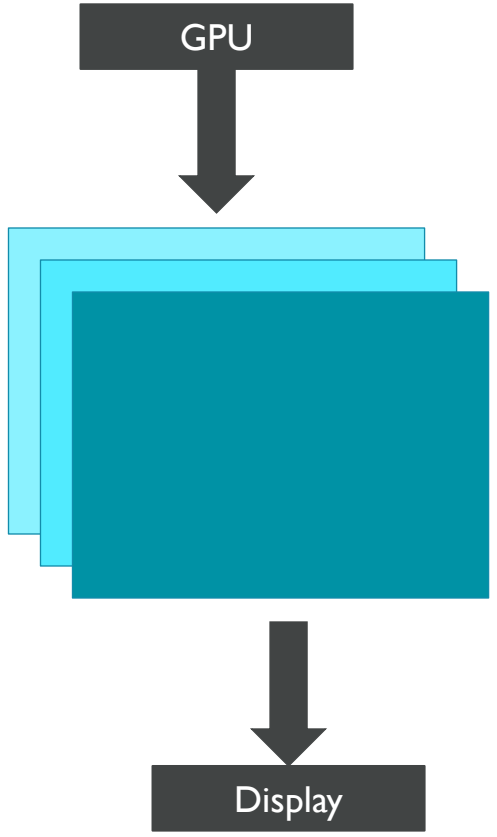


"Gartner Hype Cycle" by Jeremykemp at English Wikipedia. Licensed under CC BY-SA 3.0 via Commons

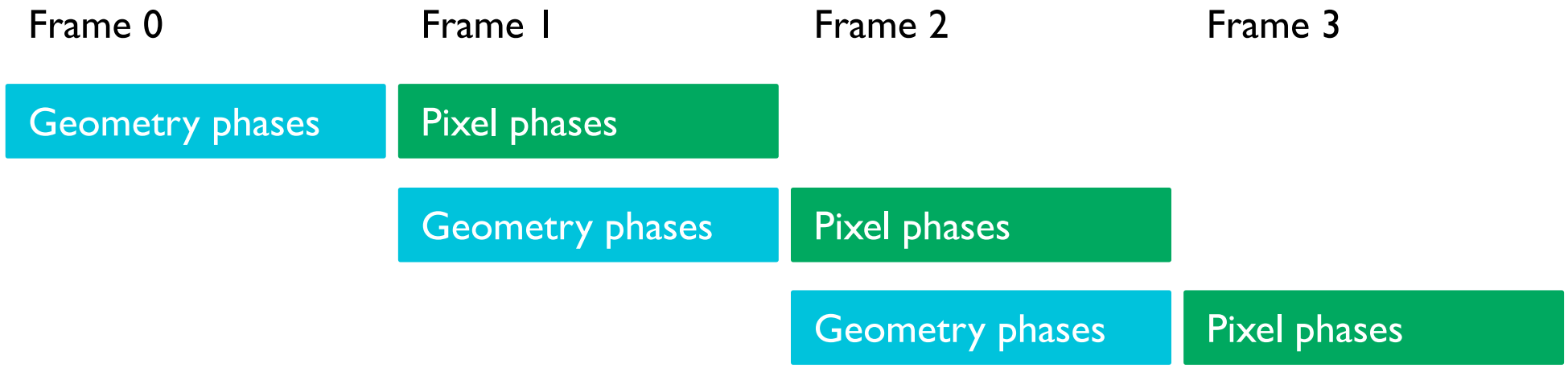
Latency

Latency

- "Motion to photons"
  - Target to be imperceptible: <20 ms
  - Achieved by GearVR and all tethered systems
- GPUs are throughput processors
- Usually ok to increase latency if it improves throughput…
- Android can/may triple buffer
- Graphics pipeline spread over multiple frames



Frame Pipelining



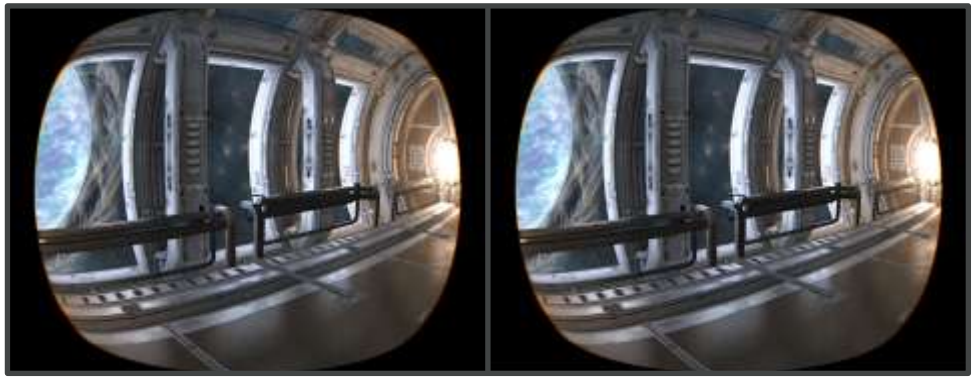
- Increases latency, but also increases throughput
- Vertex work typically bandwidth bound – low ALU / load-store ratio

- Overlapping with pixel work increases utilization

Recap of VR Pipeline

- Rendering to eye buffer
- Warped to display buffer
  - Lens magnification distortion
  - Chromatic aberration
  - Some redundant panel area
- Eye buffer one of several sources
  - UI
  - Video

Eye buffer – 2048x1024



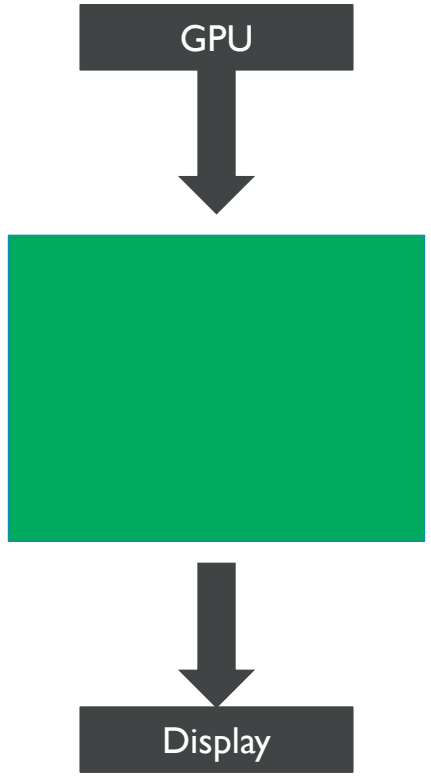
Display buffer – 2560x1440

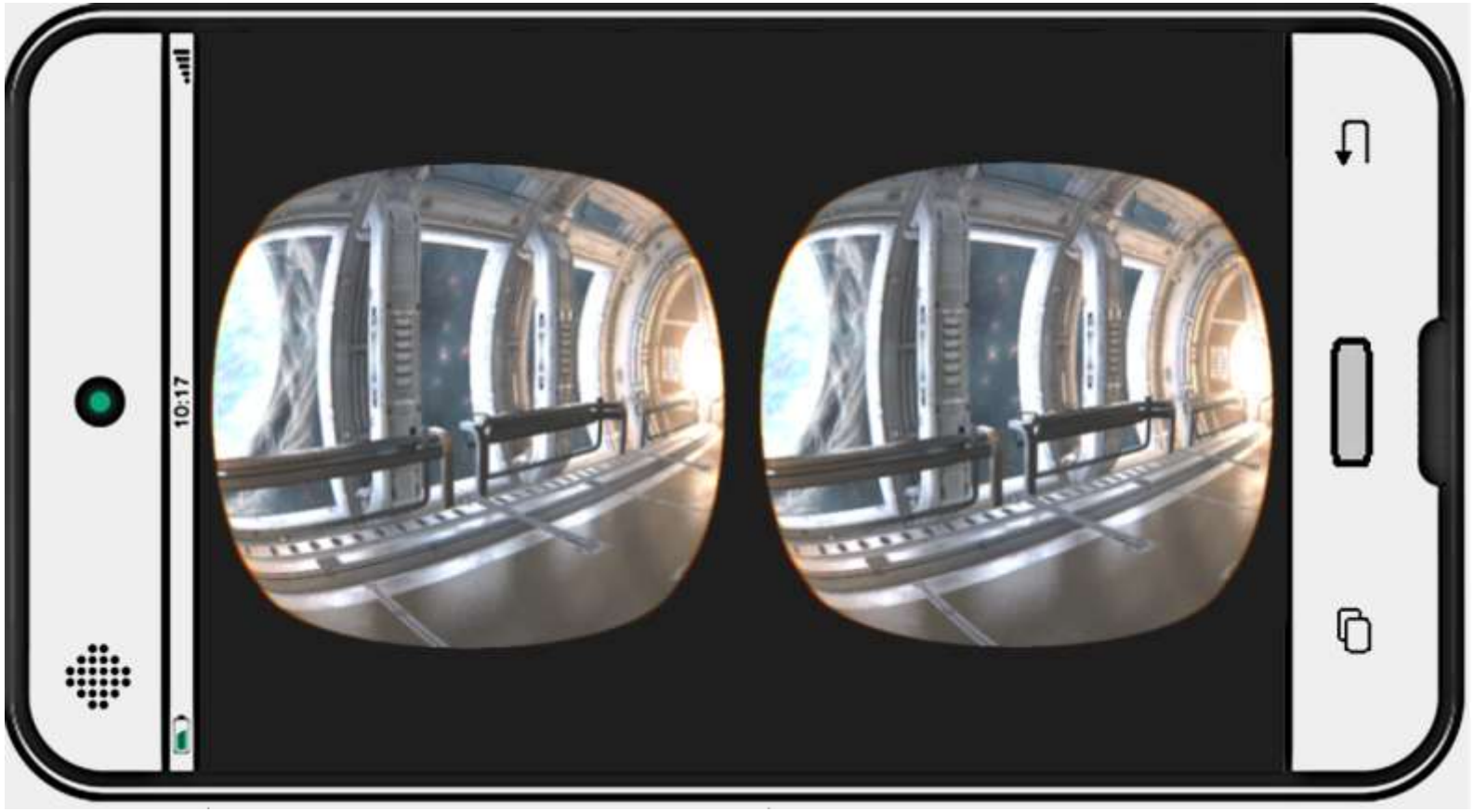
Front Buffer Rendering

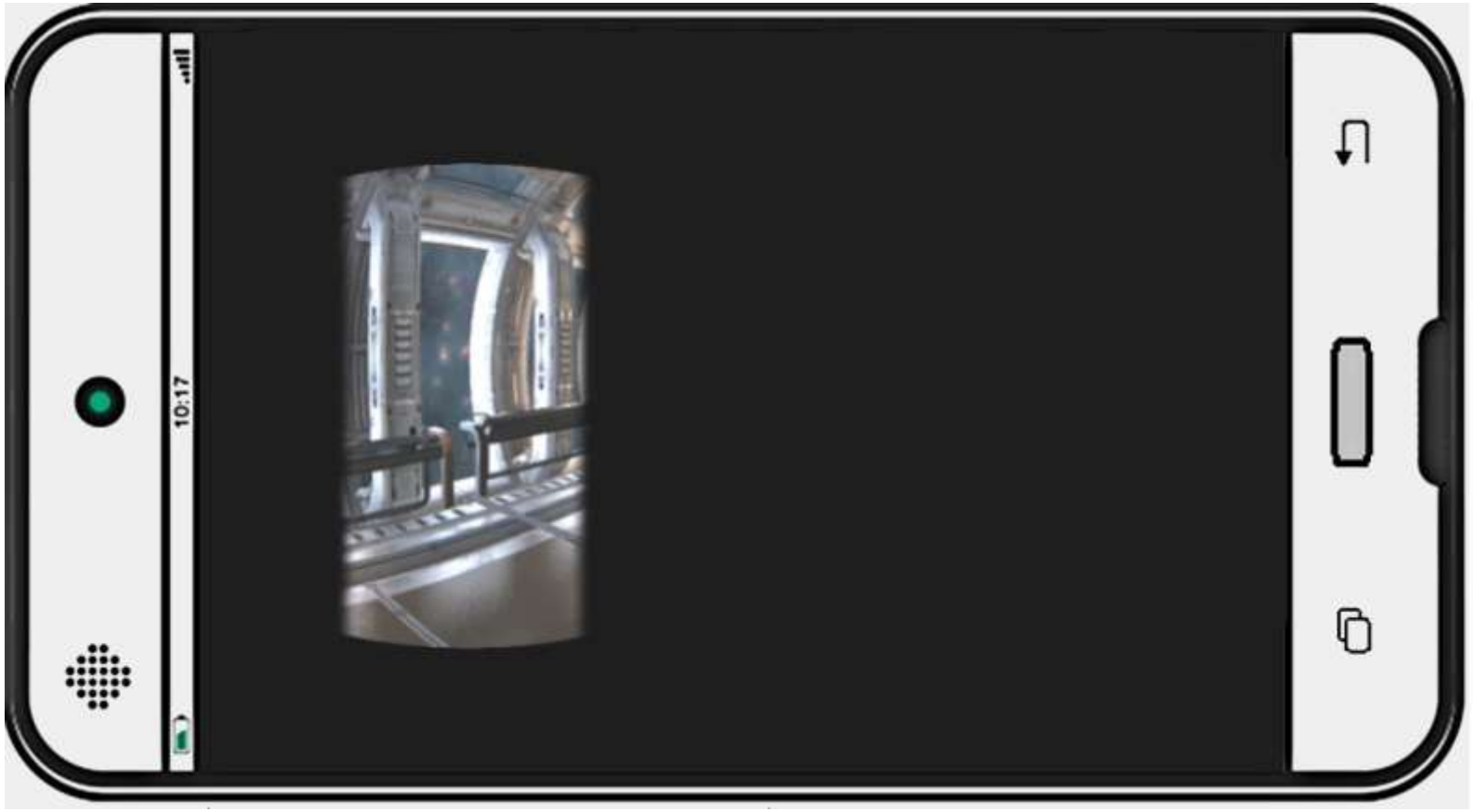
- GearVR-specific extension

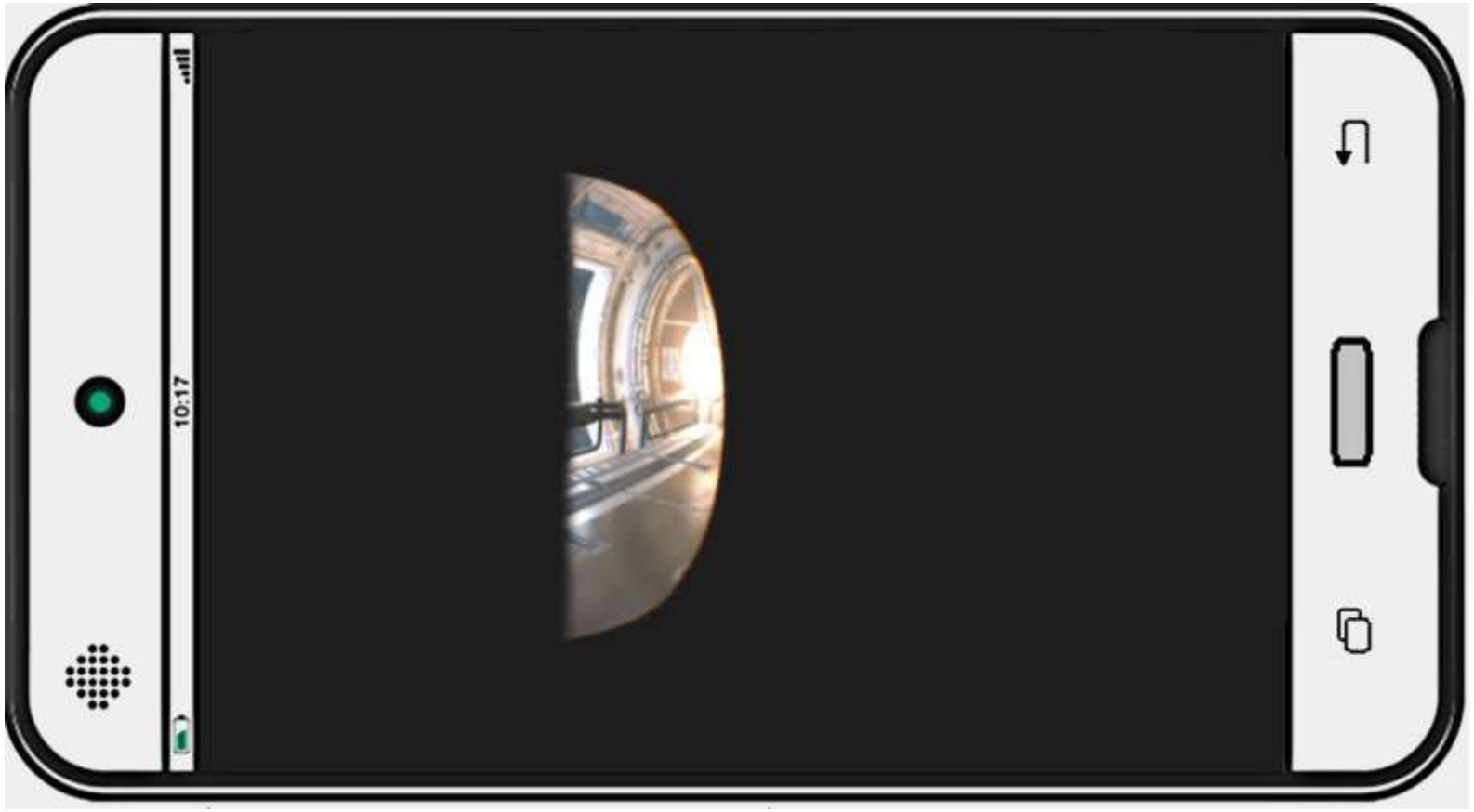
- Remove swap buffers, write to display frontbuffer
- Write to it "just in time"

- Low-persistence OLED display panels
  - Panel only partial illuminated as scanned out
  - Low persistence minimises blurring/smearing
  - 60Hz+ refresh rate

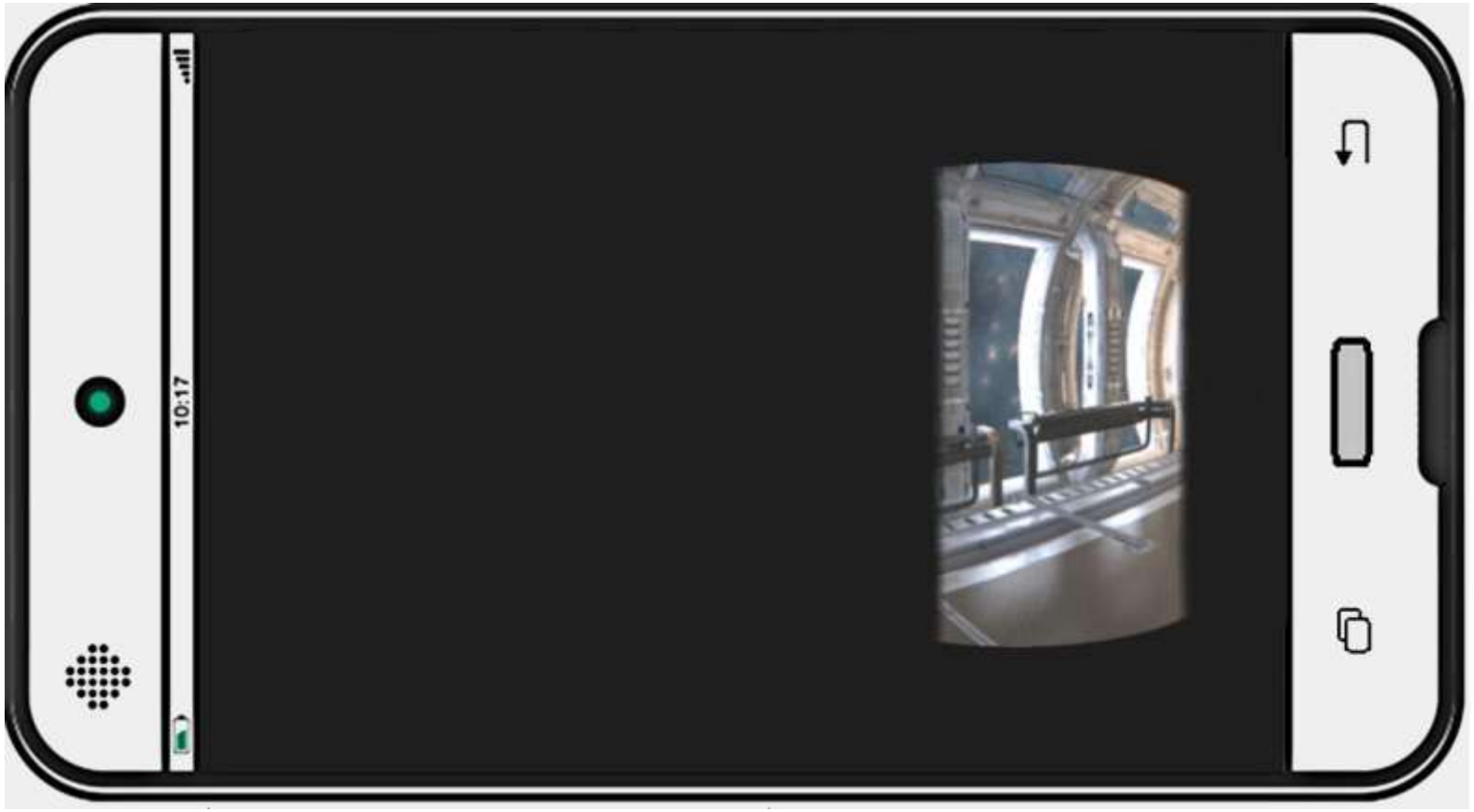


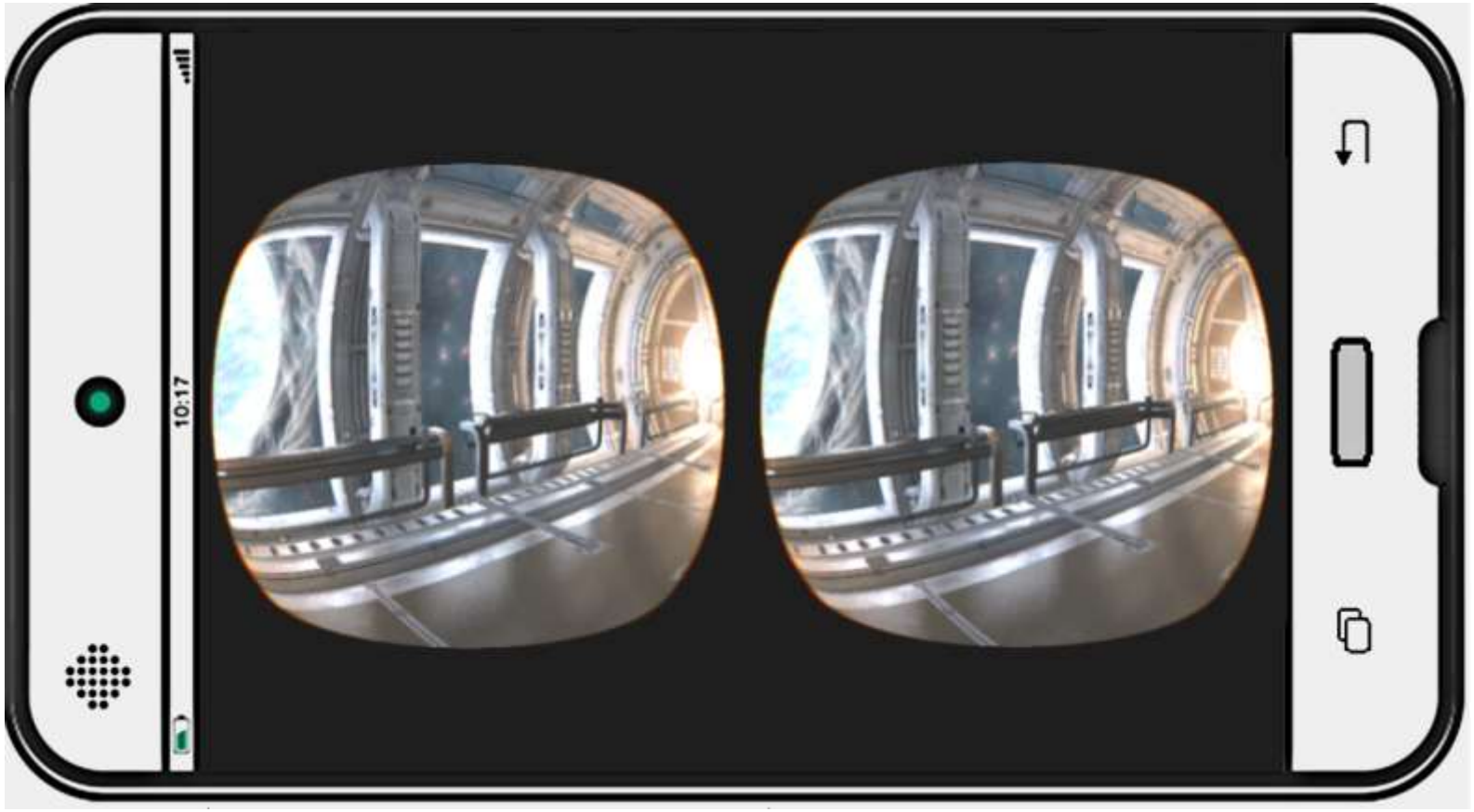




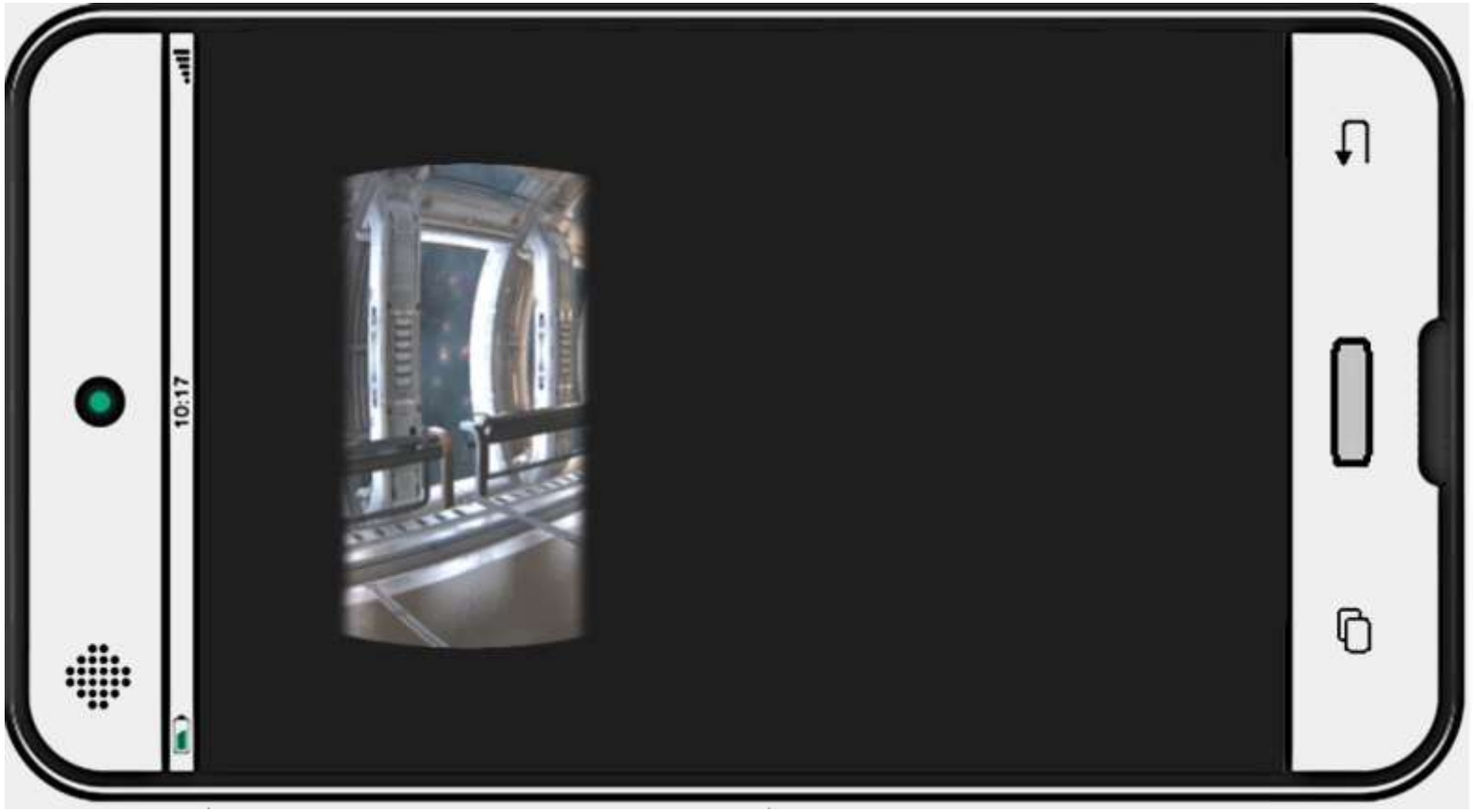


ARM



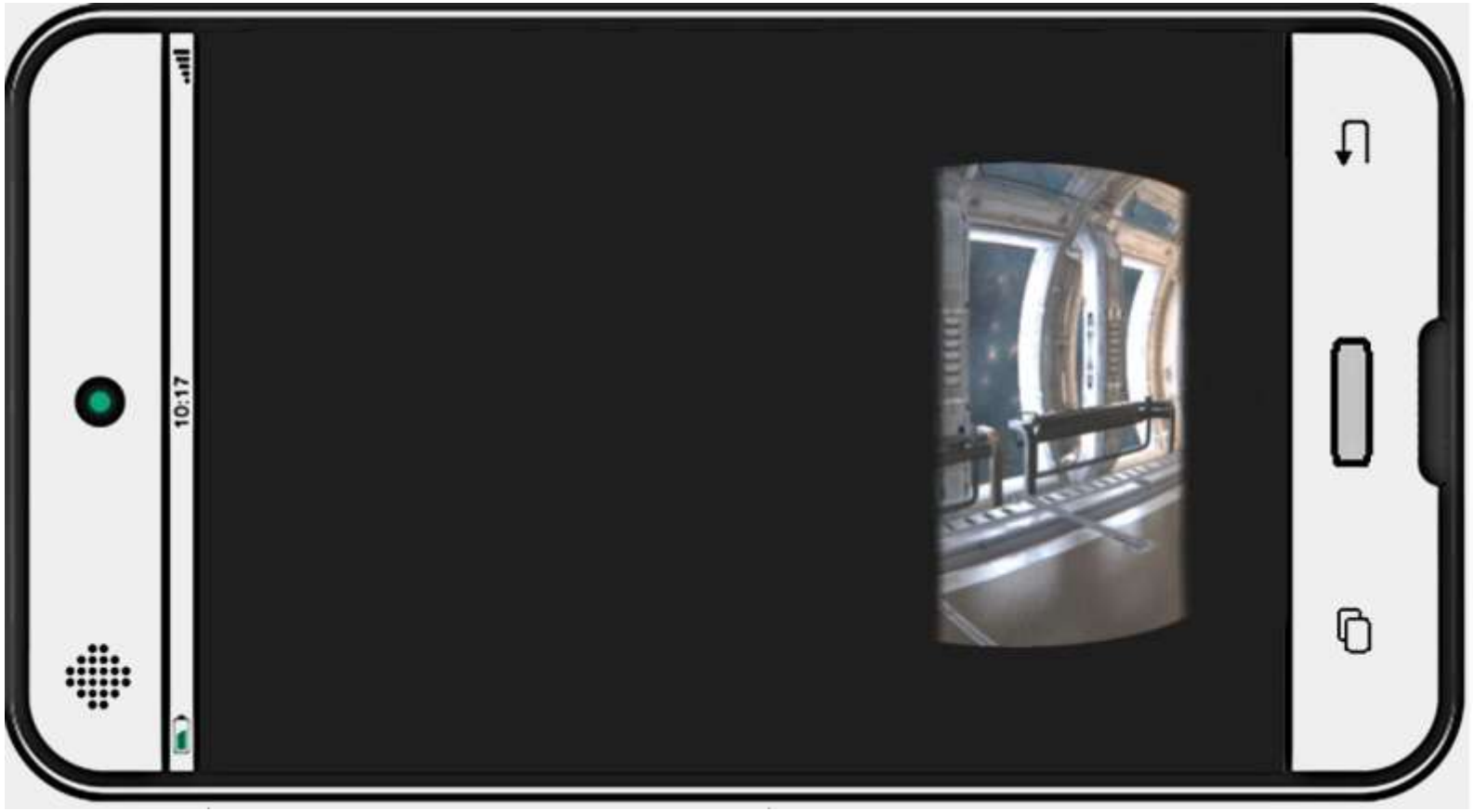


GPU write



Display read

GPU write



Display read

Asynchronous Time Warp

- High and regular priority contexts
  - Application - regular priority
  - Time warp - pre-emptive high priority
- Decouples application and time warp rendering
- Can't account for changes in occlusion
  - Animation
  - Camera motion
  - Near-eye objects

Multiple Views

Multiple Views

- Options
  - Submit everything twice
  - Geometry shaders
  - Multiview extensions: `OVR_multiview`, `OVR_multiview2`

- Multiview
  - Coming soon…
  - Vertex shader: `uint gl_ViewID_OVR`
  - `gl_Position`-only unless OVR_multiview2
  - Mali supports both
  - Inset rendering: num_views can be > 2!

- Disallows:
  - Transform feedback
  - Tessellation
  - Geometry shader
  - Timer queries

Mali Multiview Implementation

- Roughly
  - 1 x CPU submission cost
  - 1-1.5 x Vertex cost
  - 1 x Fragment cost

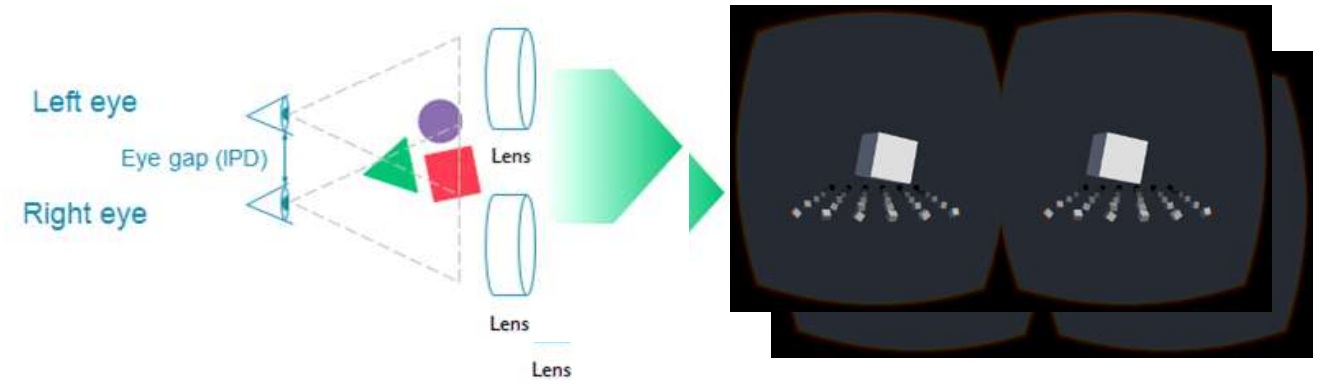
- Saves CPU time on all implementations
- Common vertex processing done once on Mali
  - Using view-dependent parameters will undo this

- Will reduce power / save energy
- May not affect performance unless vertex processing is a bottleneck

Mali VR SDK

- http://malideveloper.arm.com/resources/sdks/mali-vr-sdk/
- Sample code, documentation

- Introduces the concepts of stereoscopic vision
  - Fundamentals, calibration, correcting lens effects
- Multiview example
- 4x, 8x MSAA example



Performance Tuning

Clock Locking

- For stability
- Also saves power… but not as much as reducing work!

- Consider clocking as low as possible

- Beware of over-loading the CPUs
  - Use multiple threads

- Keep work off SCHED_FIFO if it's not critical path

Bandwidth / Quality

- Bandwidth is...
- …a consumer of power on high end systems
- …something an application can minimise

- Geometry
  - Usual advice - cull / reduce density where acceptable
  - Vertex data - compact layout, interleave elements except position
  - Varyings/interpolants - also cost bandwidth reducing precision can help

- Images
  - ASTC - available on all OpenGL ES 3.0 devices shipping in volume
  - AFBC - automatic

- 4x MSAA - close to “free” on Mali, use it!

Thank you!

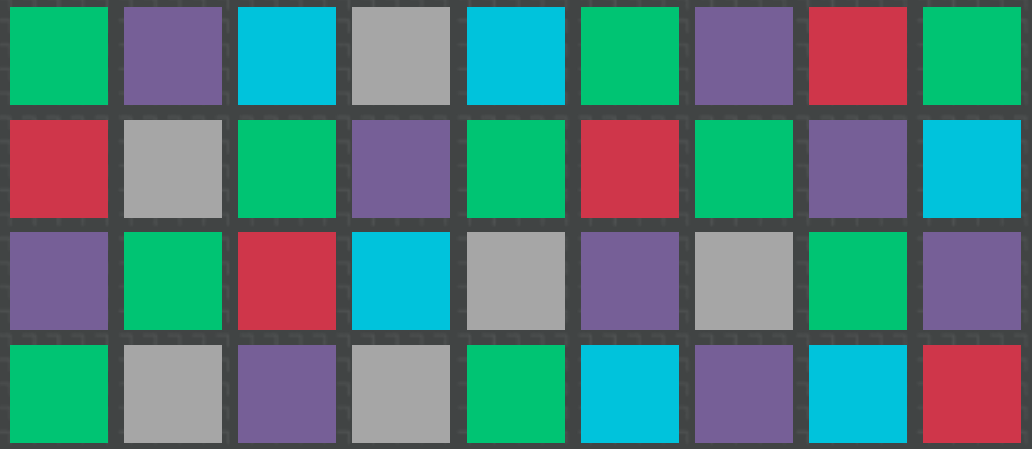
sam.martin@arm.com @palgorithm

ARM

Up next…

- Implementing Stereo Reflections in VR with Unity
- Roberto Lopez Mendez, ARM

To Find Out More….

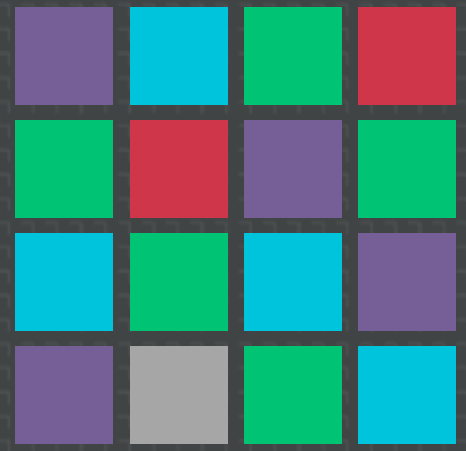


ARM Booth #1624 on Expo Floor:

- Live demos of the techniques shown in this session
- In-depth Q&A with ARM engineers
- More tech talks at the ARM Lecture Theatre

http://malideveloper.arm.com/gdc2016:

- Revisit this talk in PDF and video format post GDC
- Download the tools and resources



More Talks From ARM at GDC 2016

Available post-show at the Mali Developer Center: malideveloper.arm.com/

ARM EPIC GAMES SAMSUNG

Vulkan on Mobile with Unreal Engine 4 Case Study

Weds. 9:30am, West Hall 3022

ARM NINJA enlighten

Making Light Work of Dynamic Large Worlds

Weds. 2pm, West Hall 2000

ARM unity nDreams

Achieving High Quality Mobile VR Games

Thurs. 10am, West Hall 3022

ARM

Optimize Your Mobile Games With Practical Case Studies

Thurs. 11:30am, West Hall 2404

ARM enlighten allegorithmic

An End-to-End Approach to Physically Based Rendering

Fri. 10am, West Hall 2020