Booth #801, West Hall

Nvidia.com/siggraph2018

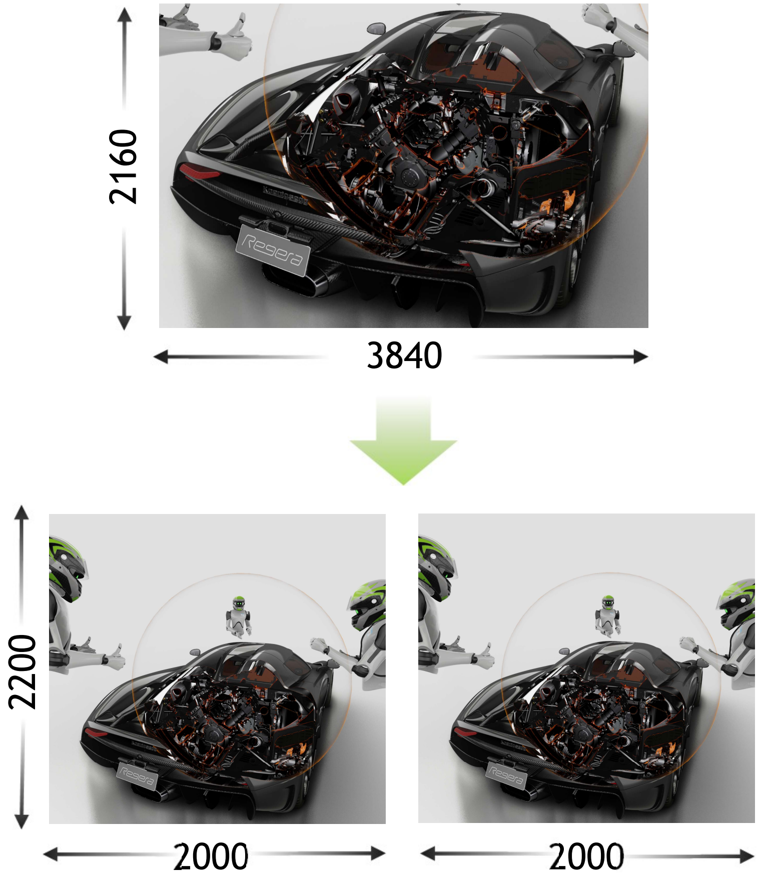
NVIDIA PROVIZ VR UPDATE

Robert Menzel, Ingo Esser

Siggraph 2018, August 14 2018

GRAPHICS PIPELINE

VR Workloads



GRAPHICS PIPELINE

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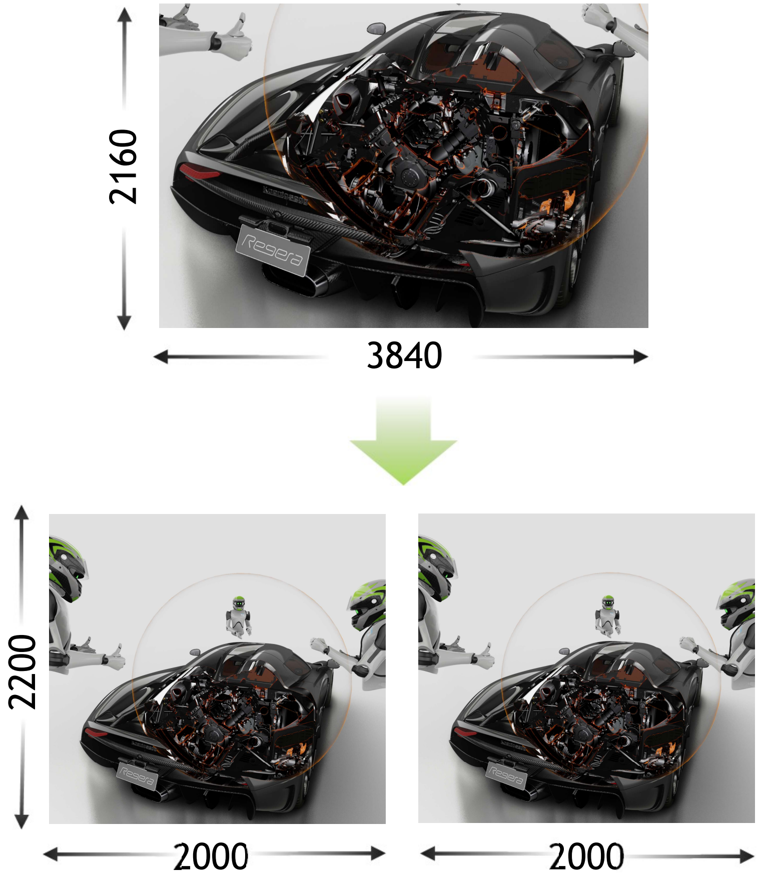
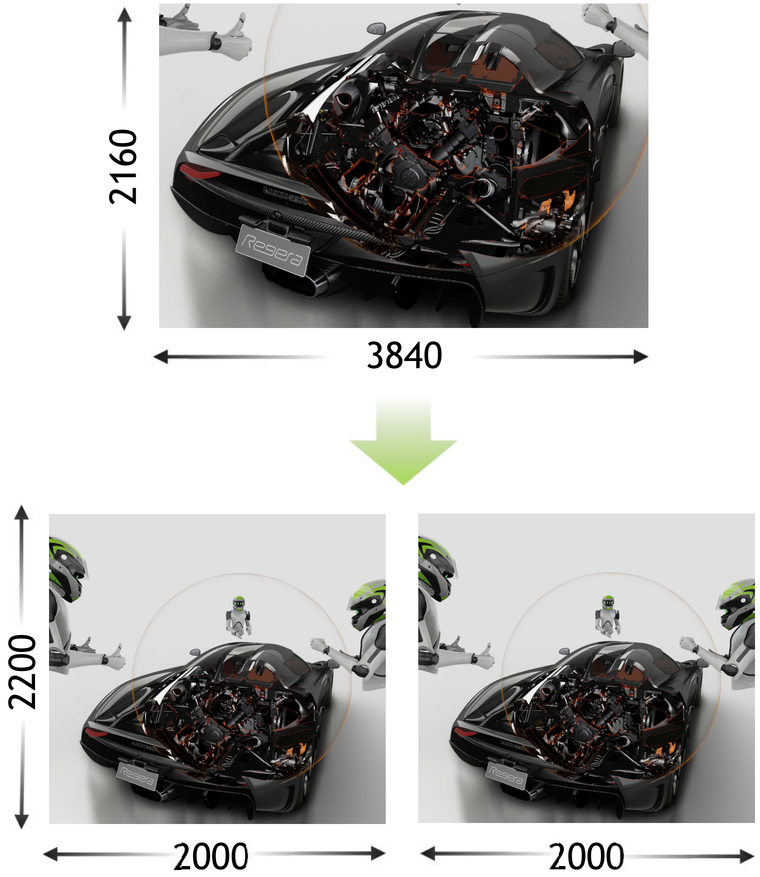


249M Pix/s
N vertices
30 Hz
(4K display)

792M Pix/s
2N vertices
90 Hz
(Vive Pro /w
oversampling)

GRAPHICS PIPELINE

VR Workloads



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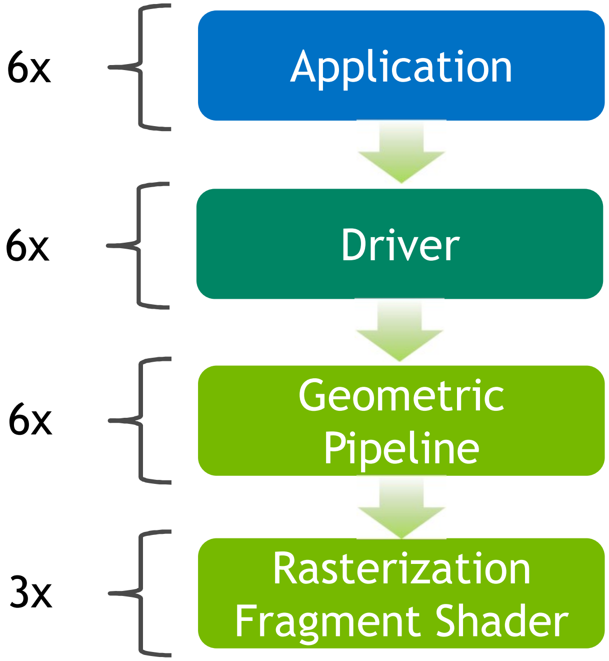
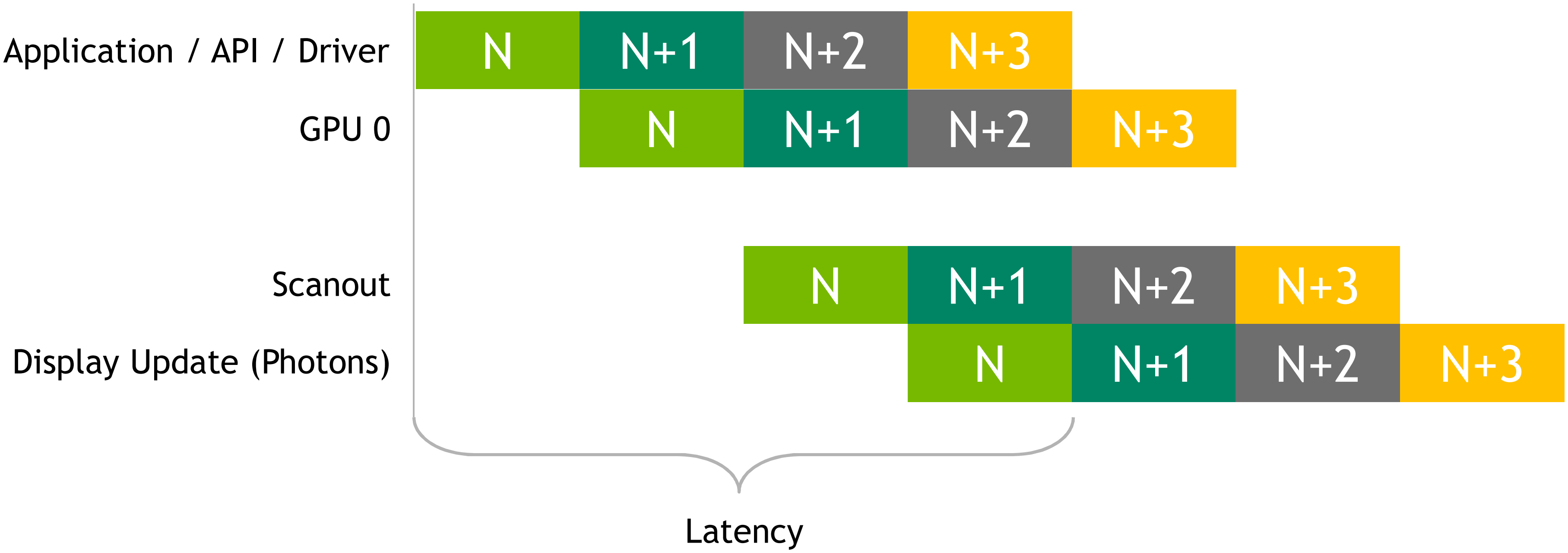


INCREASE FRAMERATE

Why can‘t we use SLI?



Application / API / Driver	N	N+1	N+2	N+3			
GPU 0		N	N+1	N+2	N+3		
Scanout			N	N+1	N+2	N+3	
Display Update (Photons)				N	N+1	N+2	N+3

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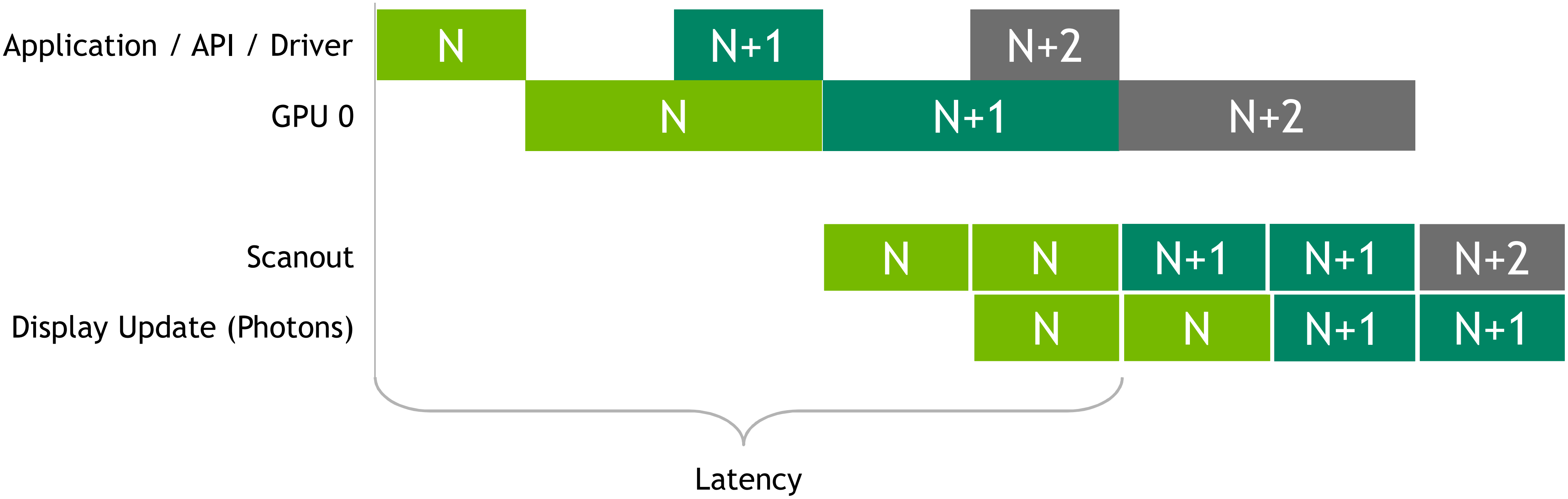

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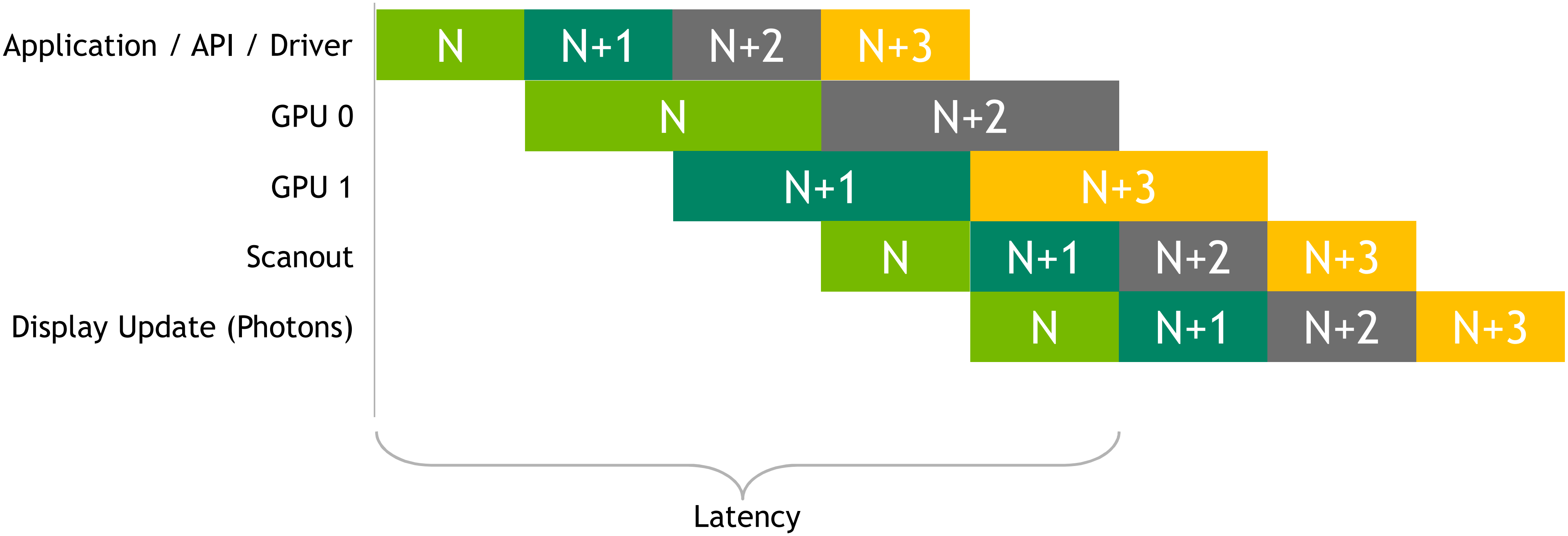


Application / API / Driver N N+1 N+2 N+3

GPU 0 N N+2

GPU 1 N+1 N+3

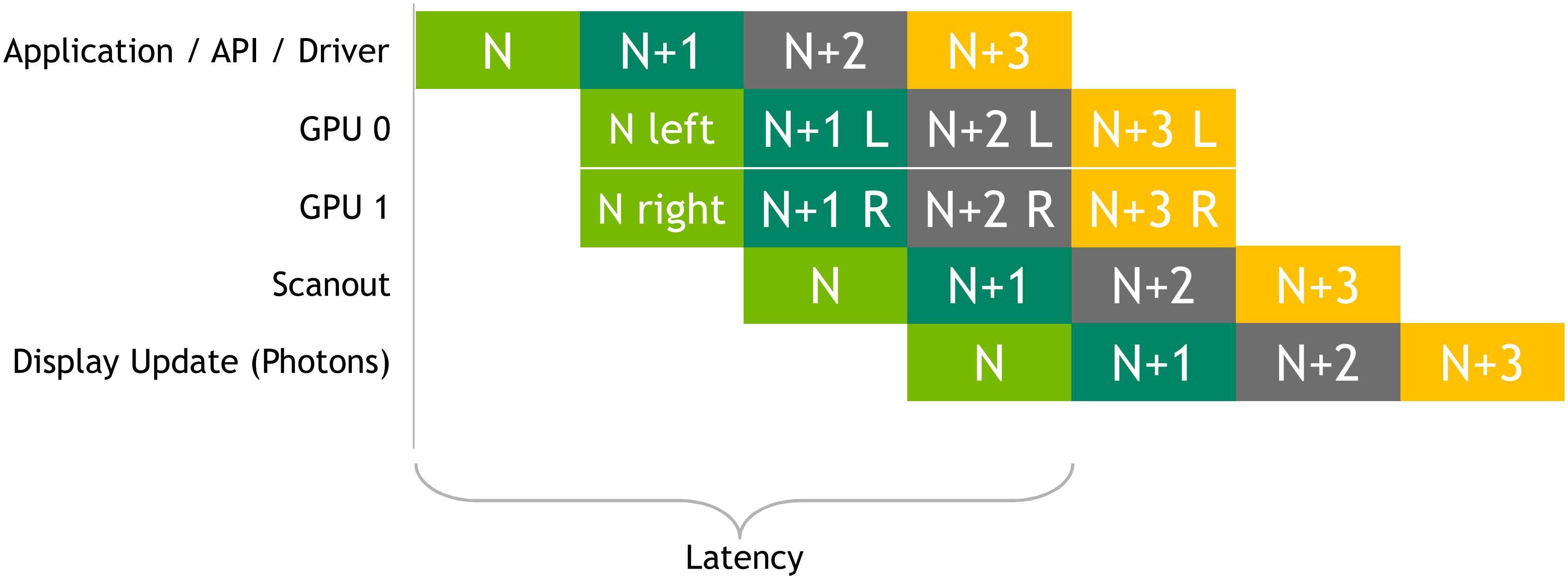
Scanout N N+1 N+2 N+3

Display Update (Photons) N N+1 N+2 N+3

Latency

INCREASE FRAMERATE

Dual GPU



Application / API / Driver	N	N+1	N+2	N+3			
GPU 0		N left	N+1 L	N+2 L	N+3 L		
GPU 1		N right	N+1 R	N+2 R	N+3 R		
Scanout			N	N+1	N+2	N+3	
Display Update (Photons)				N	N+1	N+2	N+3

INCREASE FRAMERATE

Dual GPU

- **One** Command Buffer, different viewmatrix
- Send this Command Buffer to each GPU
- Copy result from GPU 1 to GPU 0
- Present rendering on GPU 0 to VR run-time

GPU AFFINITY

VR SLI

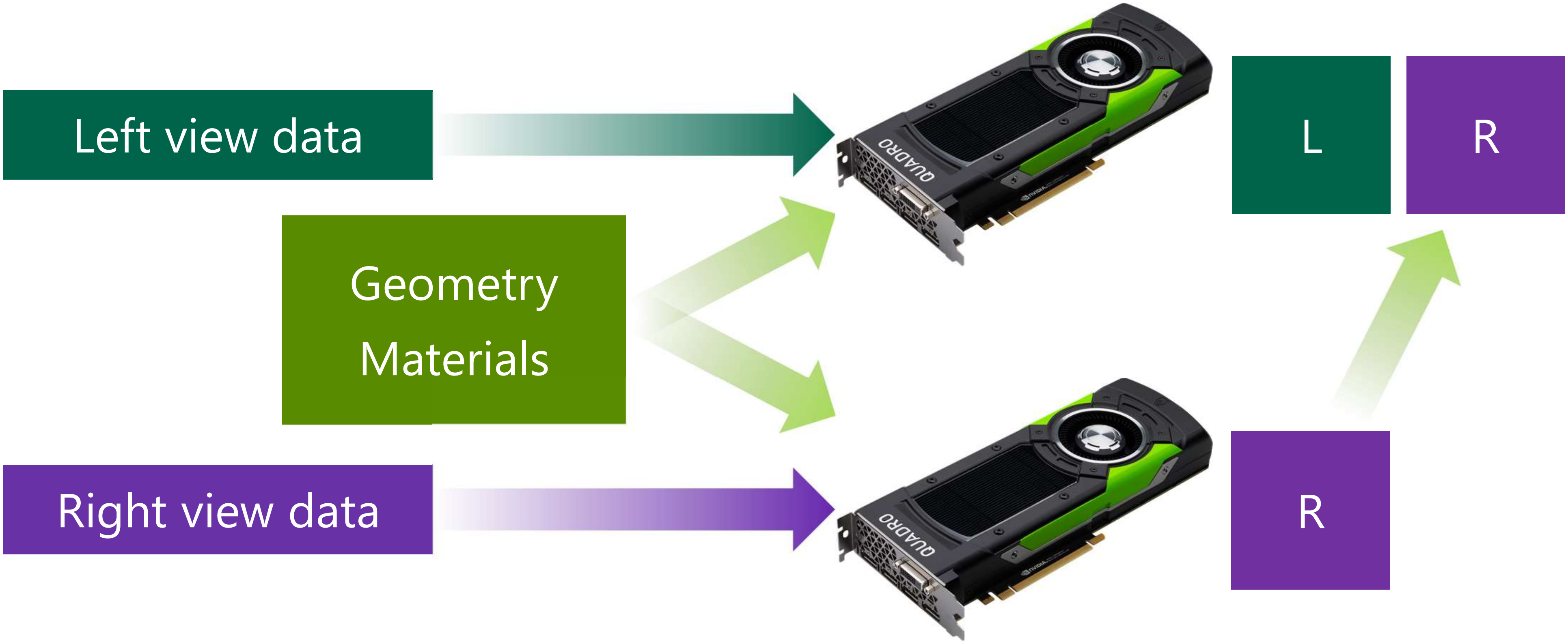
INCREASE FRAMERATE

GPU Affinity vs. VR SLI

GPU AFFINITY	VR SLI
OpenGL (NVIDIA Quadro)	All modern APIs
2 OpenGL contexts	1 context
Full CPU overhead of 2nd context	Low CPU overhead
Full flexibility	Only masking draw calls
Allowing different objects per GPU	Allowing different buffer / texture content per GPU

VR SLI

Crash course



Left view data

Geometry

Materials

Right view data

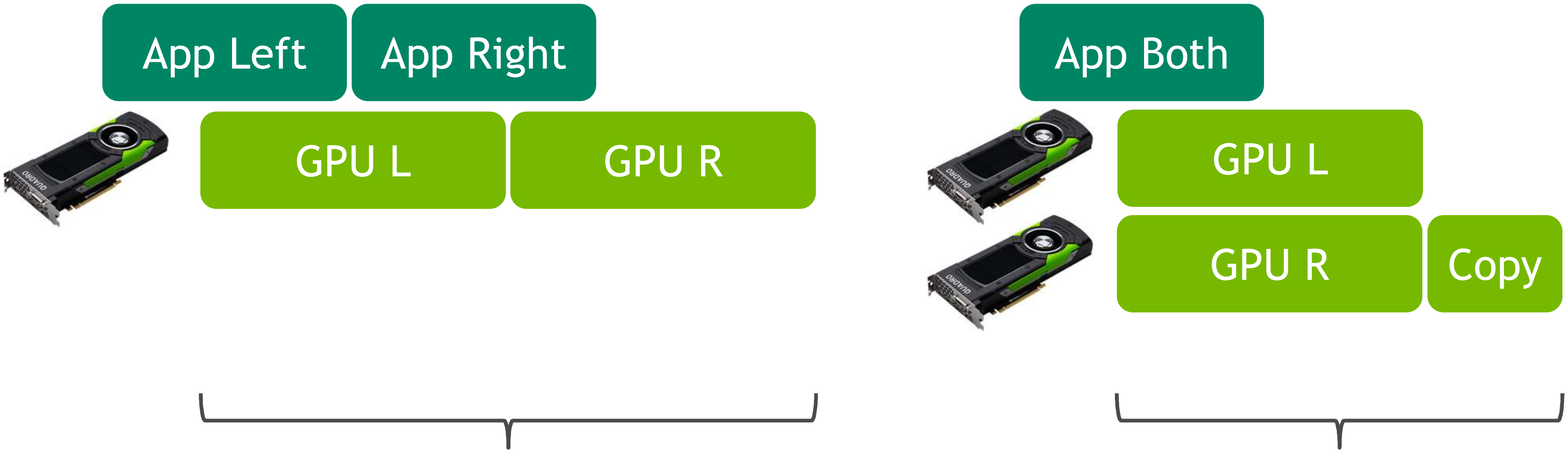
L

R

R

VR SLI

Scaling 1 vs 2 GPUs



App Left

App Right

GPU L

GPU R

App Both

GPU L

GPU R

Copy

Time: GPU L + GPU R

Time: GPU + Copy

$$Scaling = \frac{2 * GPU}{GPU + Copy}$$

VR SLI

Scaling determined by workload and copy time

$$Scaling = \frac{2 * GPU}{GPU + Copy}$$

Typical render resolution for Vive

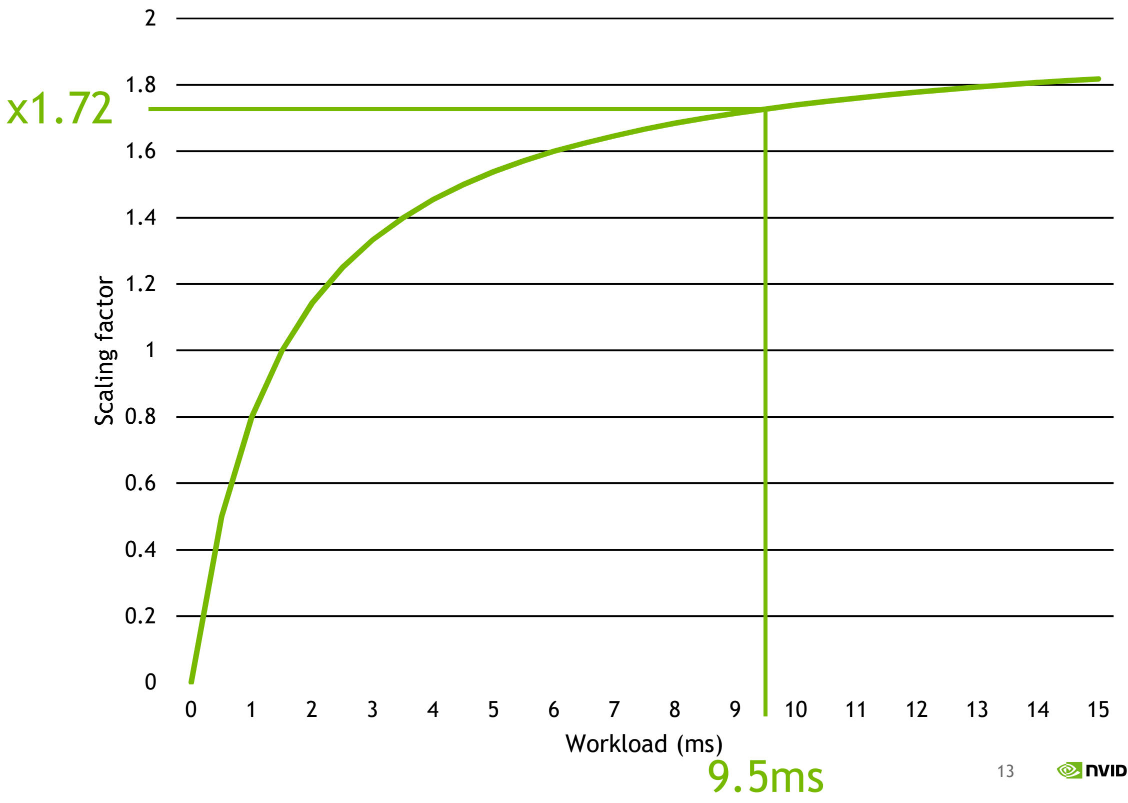
1512 x 1680 (per eye)

Copy time over PCIe (@6GB/s)

1.5ms

Max scaling with 11ms frame time

$$\frac{2*9.5ms}{9.5ms+1.5ms} = 1.72$$



VR SLI

Higher resolutions limit scalability

$$Scaling = \frac{2 * GPU}{GPU + Copy}$$

Vive Pro render resolution

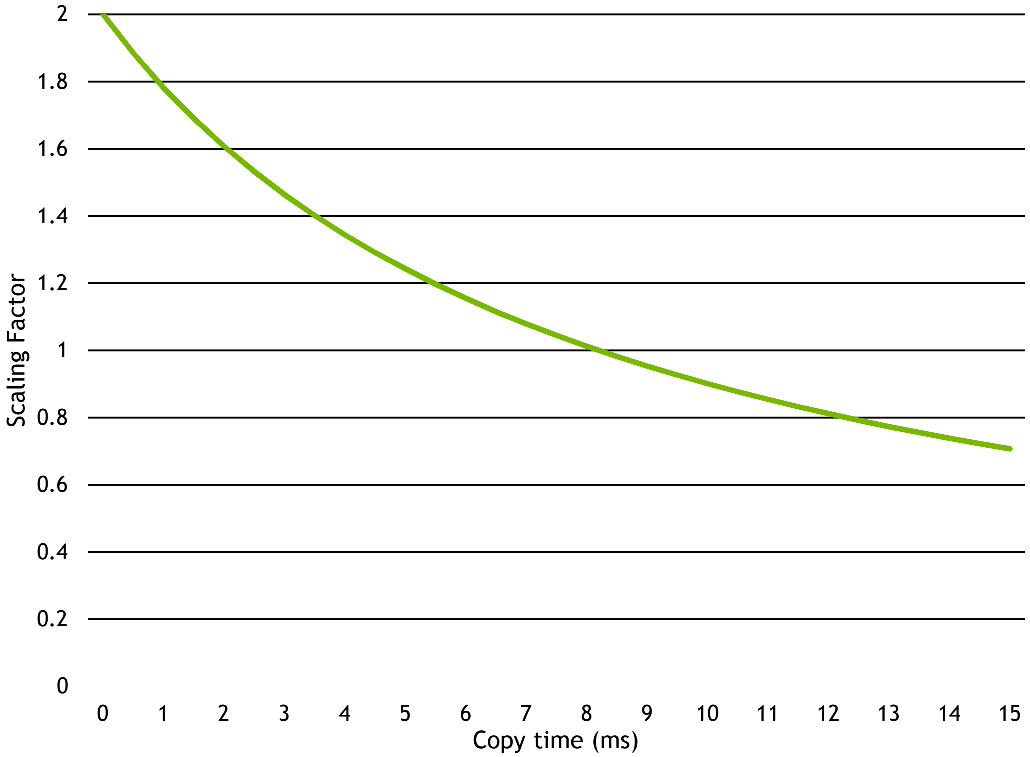
2016 x 2240

Copy time over PCIe (@6GB/s)

2.8ms

Max scaling with 11ms frame time

$$\frac{2*8.2ms}{8.2ms+2.8ms} = 1.49$$



VR SLI

Improve scaling using NVLink

Copy times can hurt scaling with higer resolutions

NVLink on dual Quadro GP100: 4x faster than PCIe 3.0

Copy time for Vive Pro (2016 x 2240): 0.7ms

Max scaling with 11ms frame time

$$\frac{2*10.3m}{10.3ms+0.7ms} = 1.87$$

NVLink is used automatically if present

NVLINK speed measured with 2 bridges, copy via OpenGL multicast, single frame of HTC Vive, on HP z840 workstation

OPENGL VR SLI: MULTICAST 2

Feedback on Multicast led to new functionality

Command & data broadcast

BufferSubData to specific GPU

CopyImageSubData & CopyBufferSubData

GPU-GPU Framebuffer Blit

Global barrier & directed sync functions

GPU Masks

Per-GPU sample locations

Per-GPU queries

Dynamic Multicast toggle (WGL_NV_multigpu_context)

GPU_ID built-in in GLSL shader

Per-GPU viewports & scissors

Texture & Buffer upload mask

Asynchronous copies

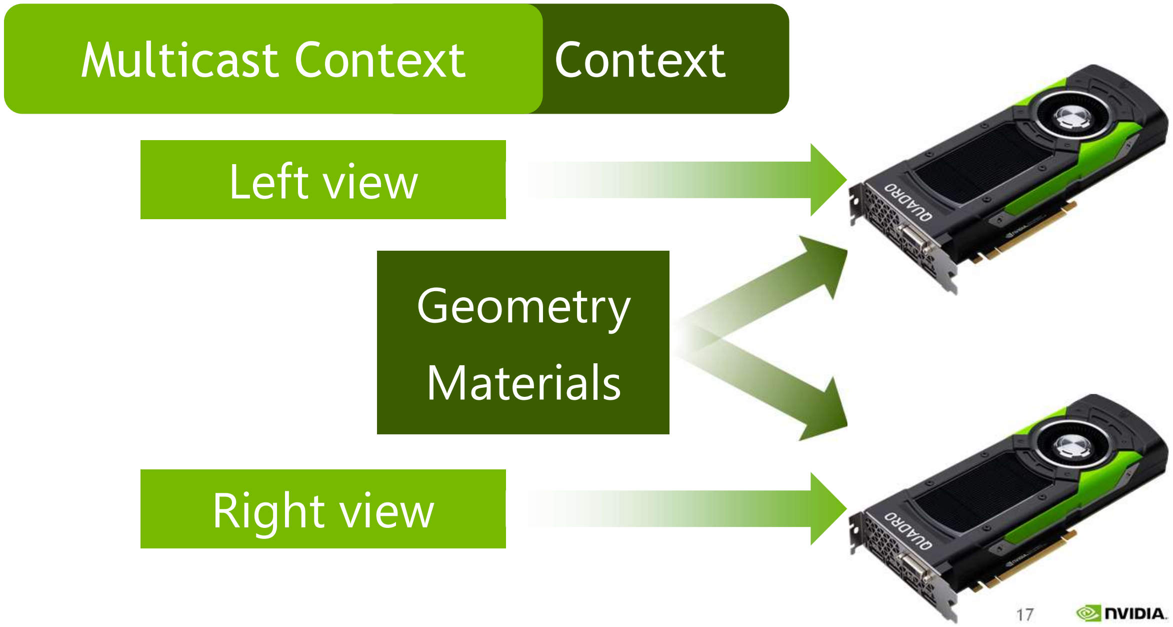
MULTICAST 2

Dynamic SLI mode

New extension WGL_NV_multigpu_context: Request SLI mode per context

No need to restart application

Possible to share resources between contexts



MULTICAST 2

Dynamic SLI mode

New extension WGL_NV_multigpu_context: Request SLI mode per context

No need to restart application

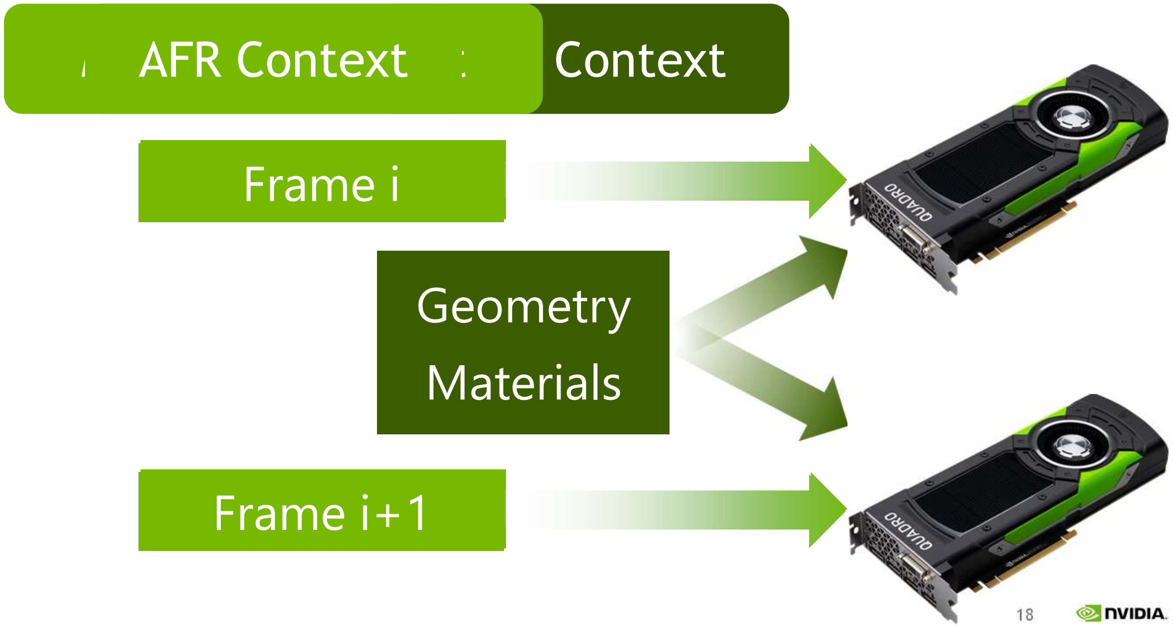
Possible to share resources between contexts

On toggle:

Clean up per-GPU resources

Keep scene data

Alternate Frame Rendering (AFR)



MULTICAST 2

GPU ID built-in: `gl_DeviceIndex`

Multicast v1 required per-GPU uploads

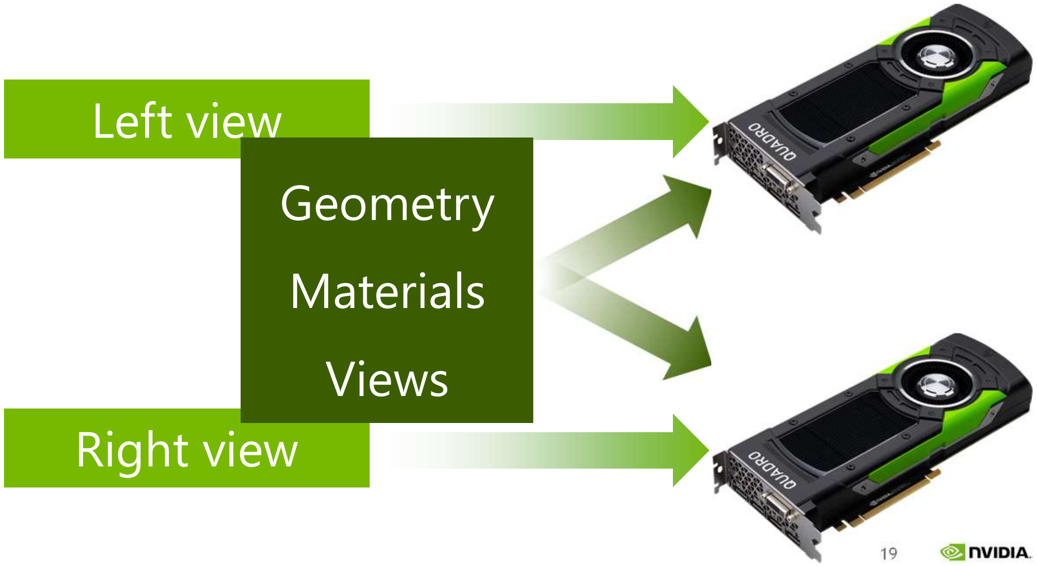
Larger code changes in some renderers

Add shader built-in: `gl_DeviceIndex`

- Upload all views to all GPUs
- Use per-GPU data in shaders

Renderer can remain unchanged

Just modify shaders instead



MULTICAST 2

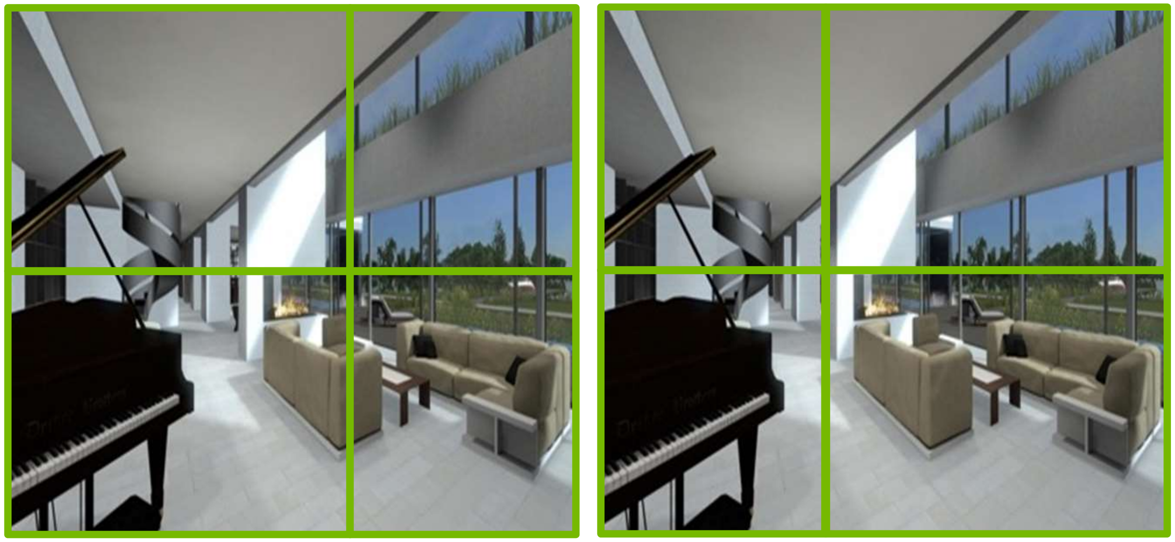
Per-GPU Viewports & Scissors

Add new function to set viewports and scissors per GPU

```
glMulticastViewportArrayvNVX( ... );

glMulticastScissorArrayvNVX( ... );
```

Per-GPU Lens Matched Shading



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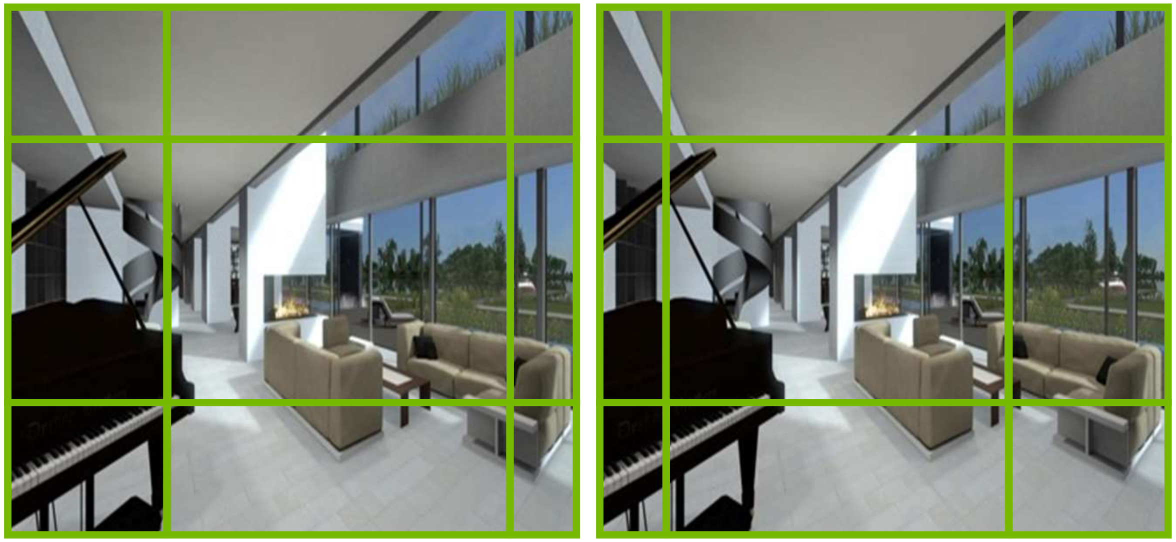
Per-GPU Lens Matched Shading

Per-GPU Multi Resolution Shading



MULTICAST 2

Per-GPU Viewports & Scissors

Add new function to set viewports and scissors per GPU

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glMulticastViewportArrayvNVX( ... );

glMulticastScissorArrayvNVX( ... );
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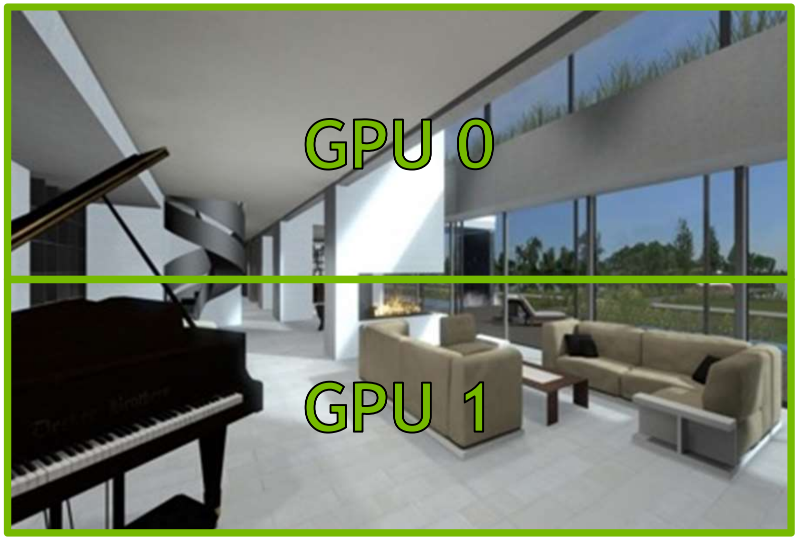


Per-GPU Lens Matched Shading

Per-GPU Multi Resolution Shading

Easily set up Split Frame Rendering (SFR)

MULTICAST 2

Texture & Buffer Upload Mask

Multicast provides per-GPU buffer uploads

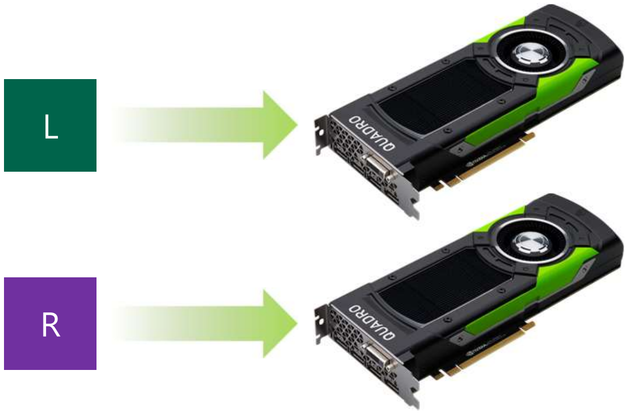
Asymmetrical functionality wrt texture upload functions

Add new mask function to modify texture & buffer uploads

```
        glUploadGpuMaskNVX( GLbitfield mask );
```

Useful for simpler per-GPU texture streaming

Conserve PCIe bandwidth



MULTICAST 2

Asynchronous Copies

Multicast copies stall source GPU while copy takes place

Easy to use because of implicit synchronization

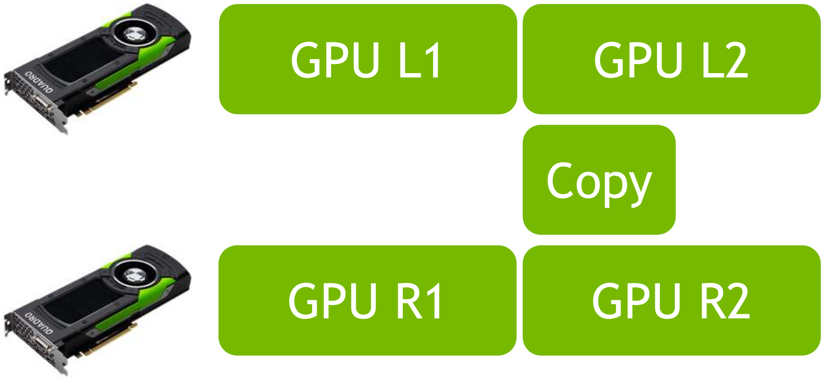
New copy functions do not stall, but also need more synchronization

```
glAsyncCopyBufferSubDataNVX( ... );

glAsyncCopyImageSubDataNVX( ... );
```

Copy while both GPUs can continue rendering

Allows for more complex rendering algorithms



GPU L1

GPU L2

Copy

GPU R1

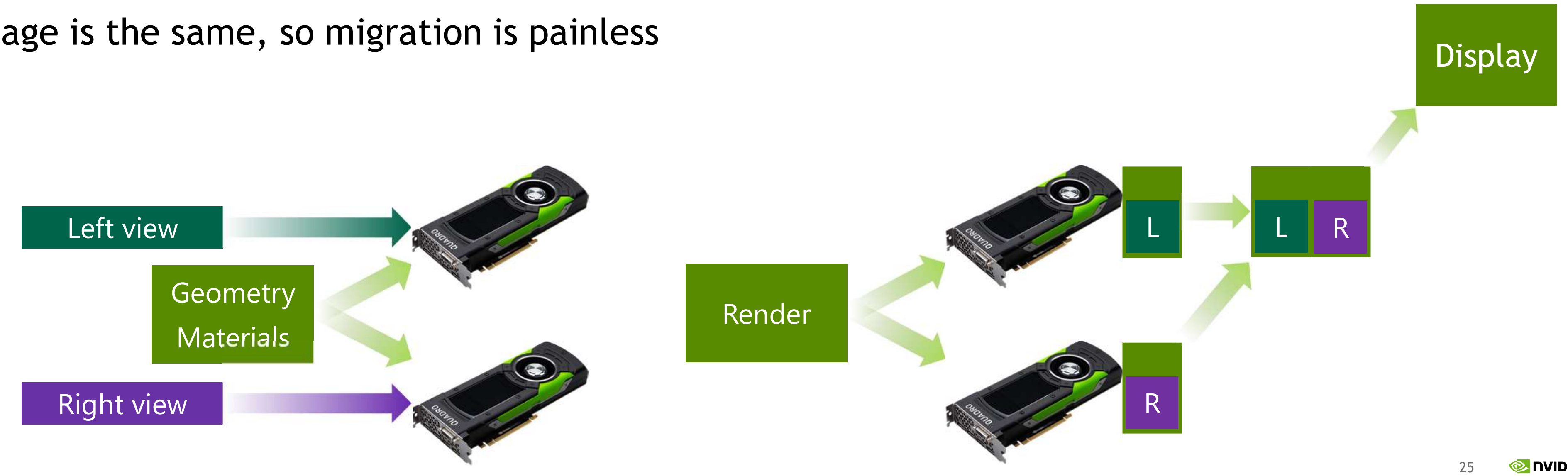
GPU R2

VULKAN VR SLI: DEVICE GROUPS

Update: VK_KHX_device_group ratified to VK_KHR_device_group with Vulkan 1.1

Make sure to use the right extension/Vulkan version combination!

Usage is the same, so migration is painless



VR SLI

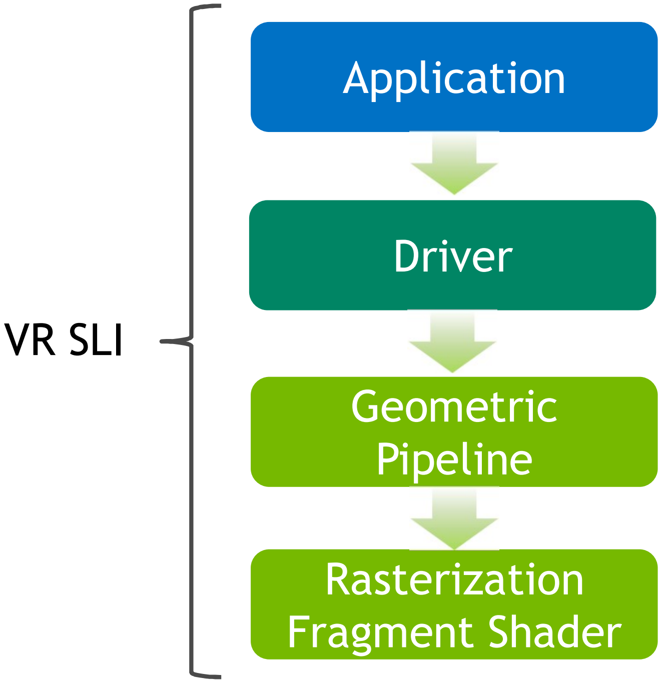
Recap

VR SLI covers a wide variety of workloads

Almost perfect load balancing between left/right eye and two GPUs

Copy overhead and view independent workloads limit scaling

NVLink can help improve scaling



OUTLOOK

Pushing the Limits

Professional users demand higher resolutions

Professional HMDs reach the limits of DP bandwidth

StarVR HMD image courtesy of Starbreeze

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Pushing the Limits

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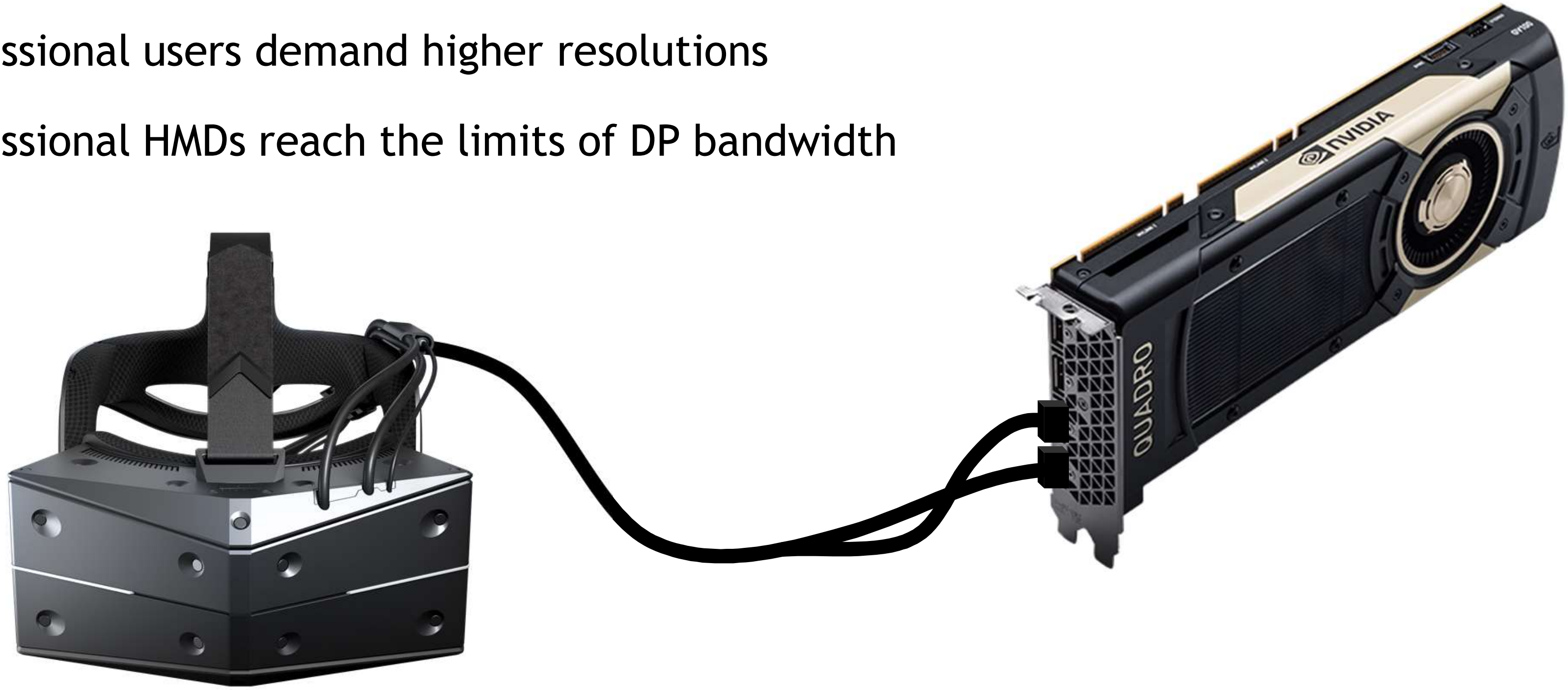
Professional HMDs reach the limits of DP bandwidth



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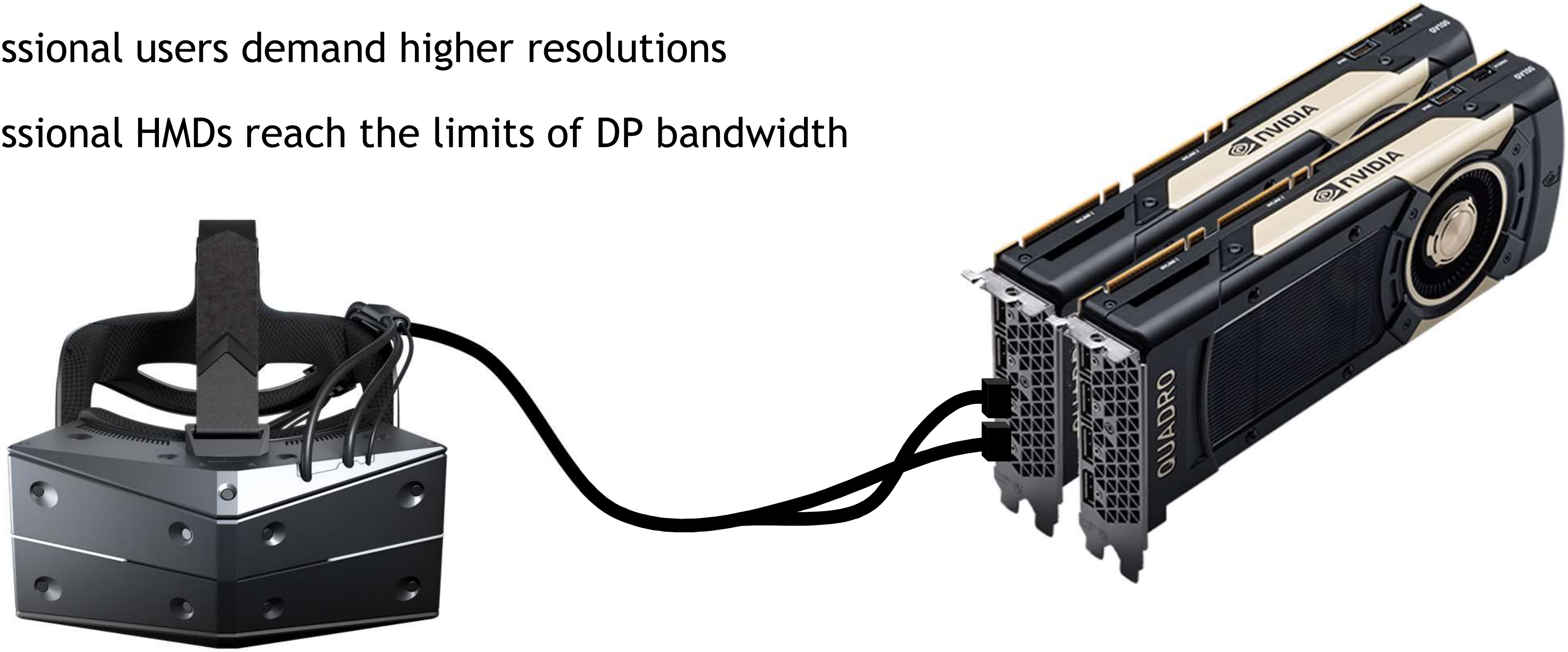

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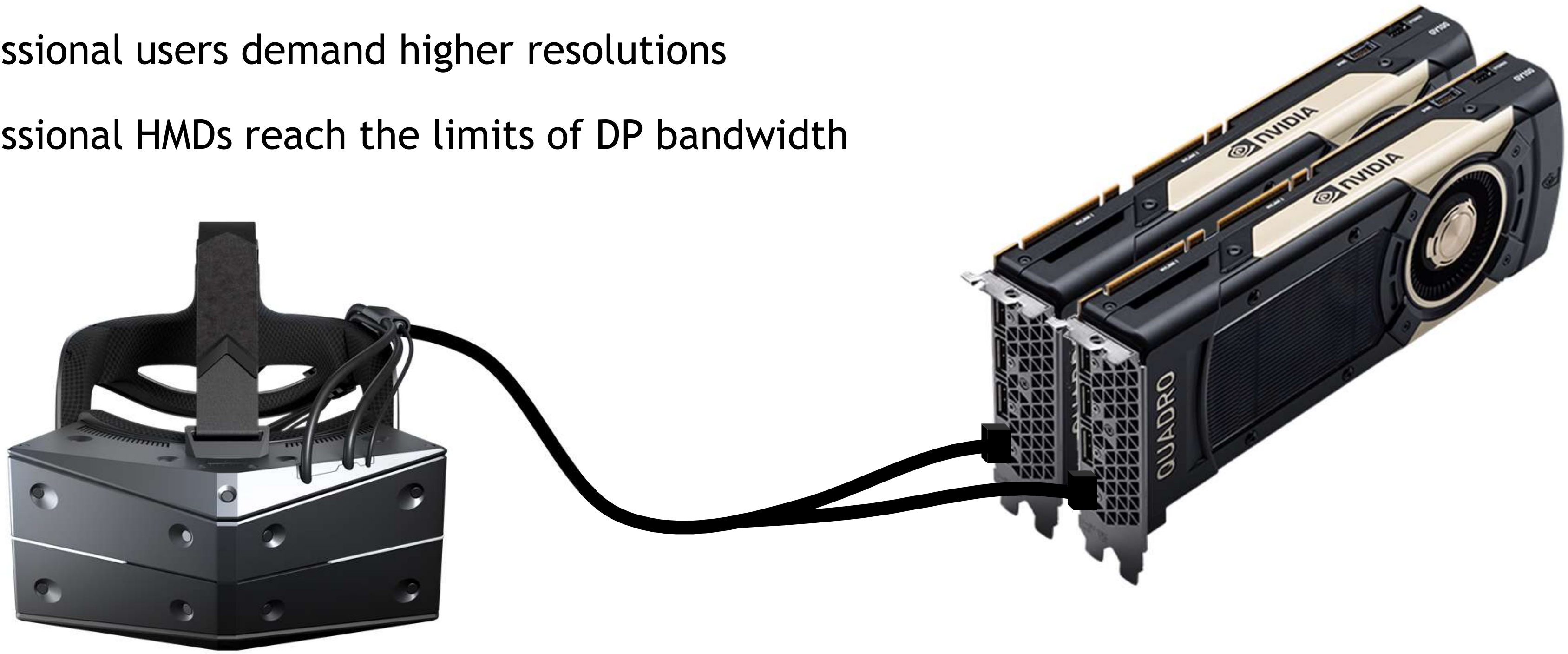


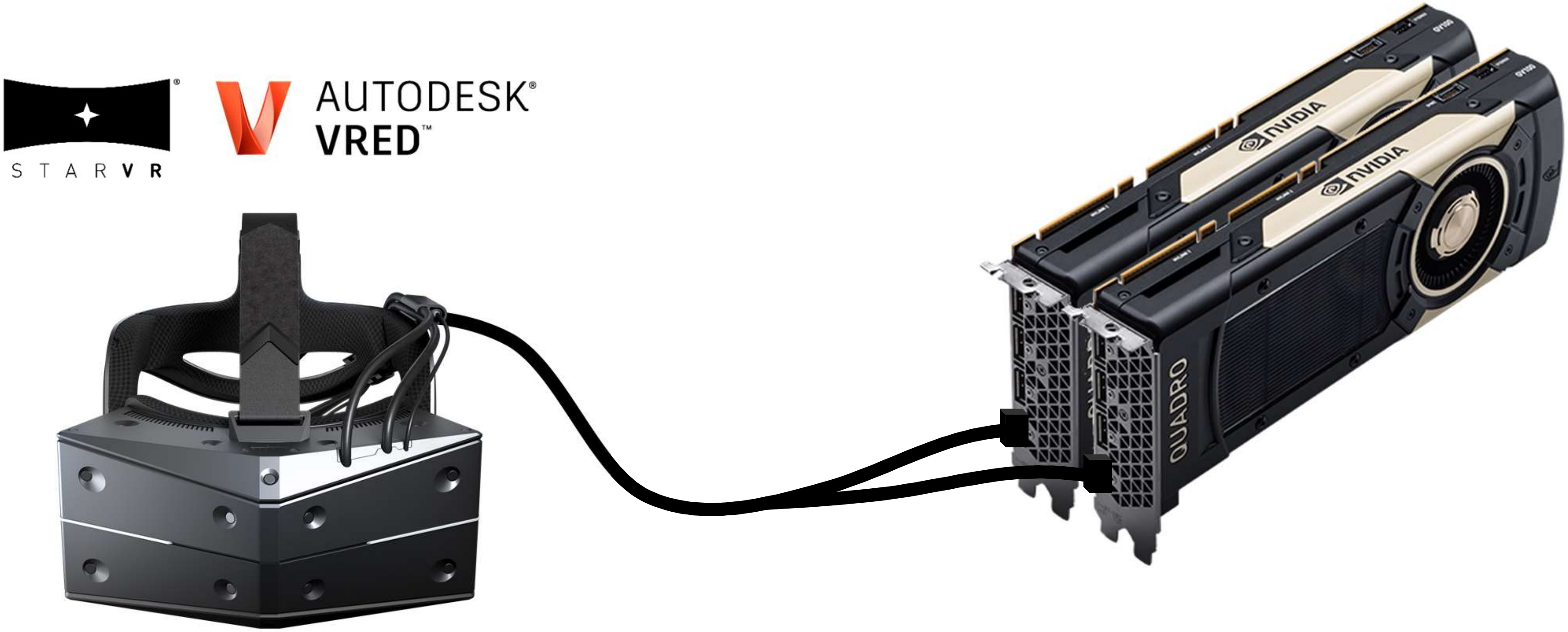
StarVR HMD image courtesy of Starbreeze

OUTLOOK

Pushing the Limits

STARVR

AUTODESK VRED

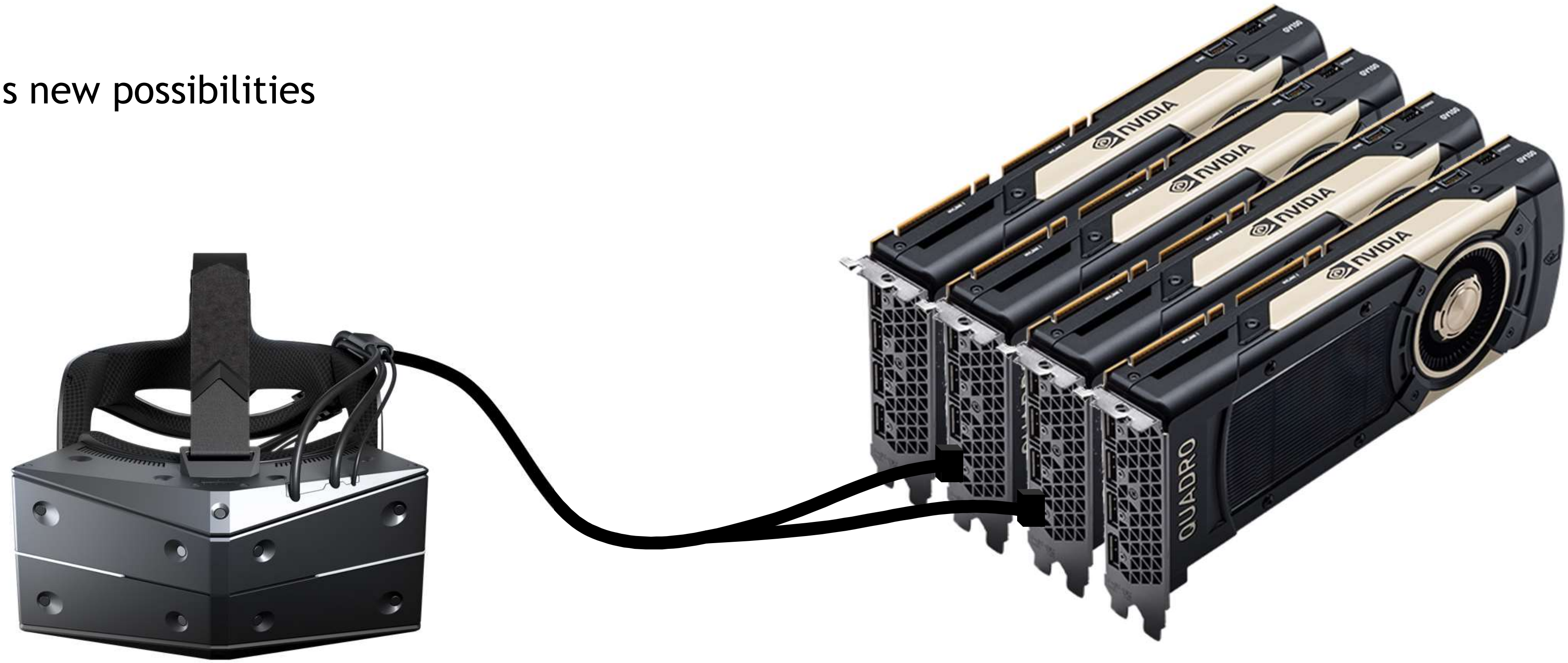


StarVR HMD image courtesy of Starbreeze

OUTLOOK

Pushing the Limits

Opens new possibilities



StarVR HMD image courtesy of Starbreeze

MORE BOOTH TALKS @ SIGGRAPH 2018

https://www.nvidia.com/en-us/events/siggraph/schedule/?session-type=talk

Tue, 4:00 PM	**Tackling the Realities of Virtual Reality**	(David Luebke)
Wed, 5:30 PM	**NVIDIA Holodeck Update**	(Dave Weinstein)
Thu, 2:00 PM	**How VirtualLink Drives a Revolution in VR Connectivity**	(Rambo Jacoby)

TRY IT OUT!

..and more information

NVIDIA VRWorks SDK provides OpenGL, Direct3D & Vulkan samples

developer.nvidia.com/vrworks

More detail in our previous GTC talks:

2018 – S8695 – NVIDIA VR Update

2017 - S7191 – Vulkan Technology Update

2016 - S6338 - VR Multi GPU Acceleration Featuring Autodesk VRED

2015 - S5668 - VR Direct: How NVIDIA Technology Is Improving The VR Experience

THANK YOU!

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