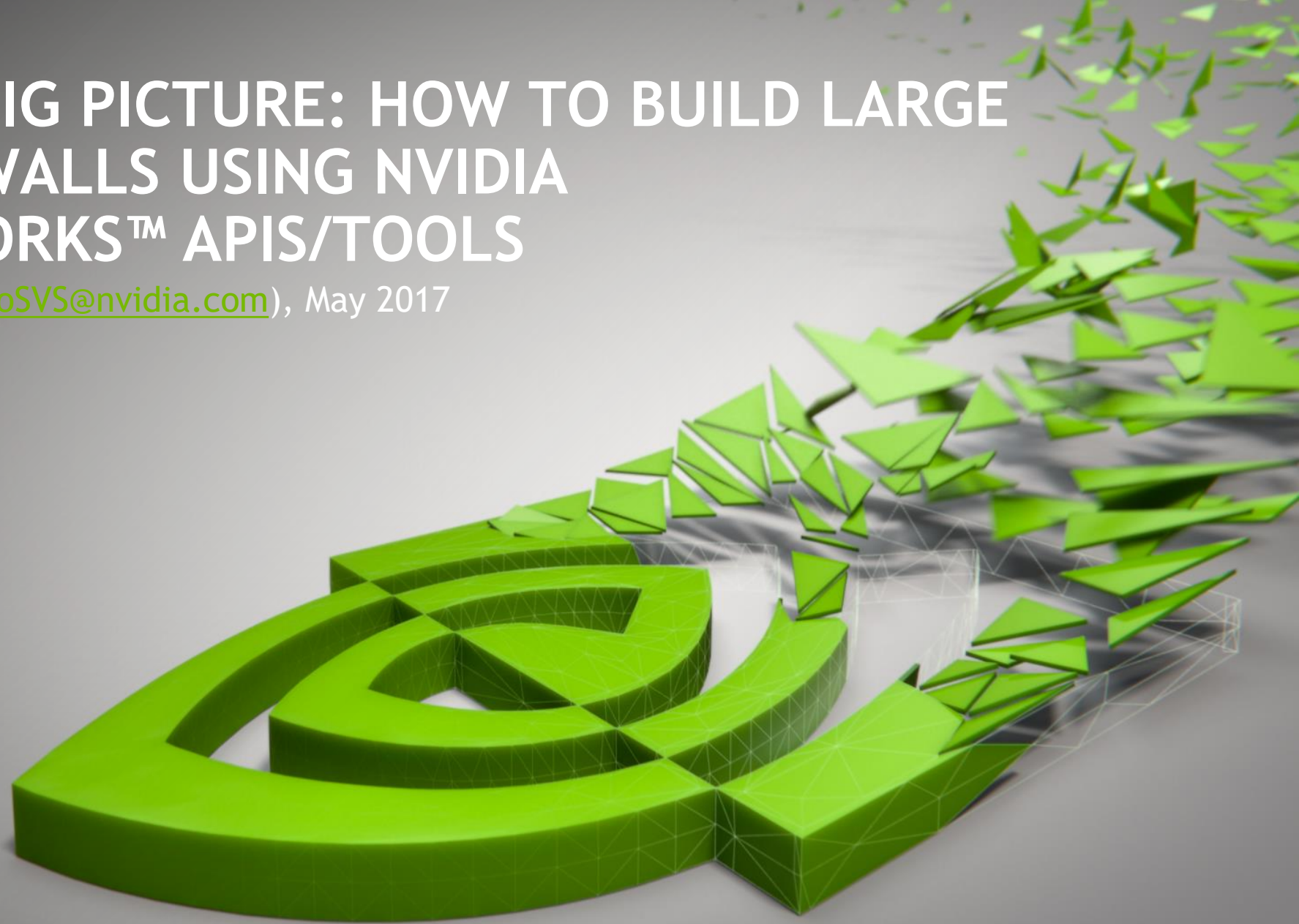


SEE THE BIG PICTURE: HOW TO BUILD LARGE DISPLAY WALLS USING NVIDIA DESIGNWORKS™ APIS/TOOLS

Doug Traill (QuadroSVS@nvidia.com), May 2017



COST PER PIXEL

Pixels are almost free



\$60k - 4096x2048@60Hz



0.9 cent per pixel

2009 - Sony 4K projector

QuadroPlex 7000 \$12k



\$5k - 7680x4320@60Hz



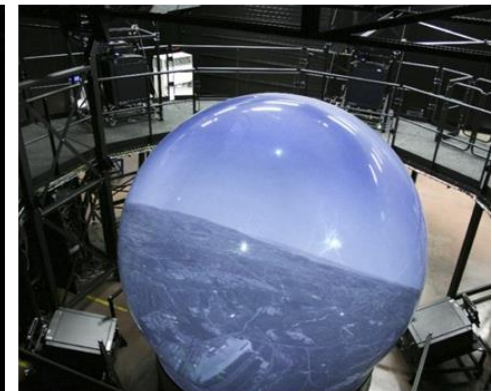
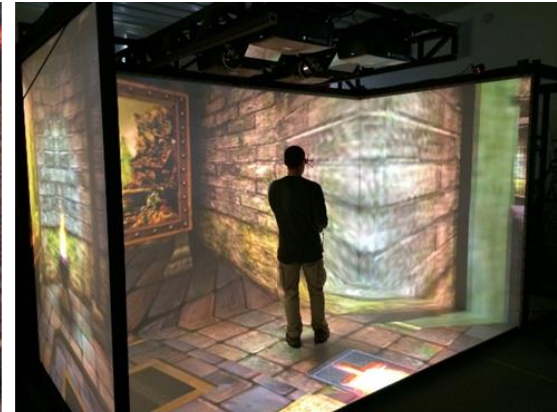
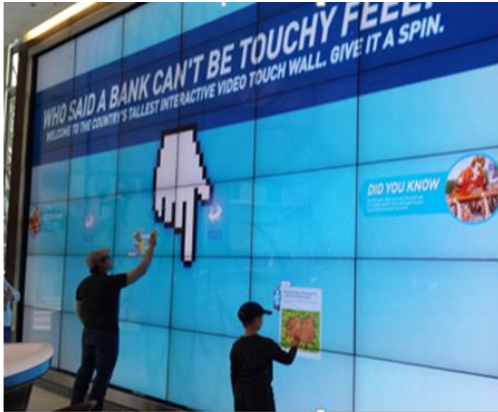
0.02 cent per pixel

2017 - Dell 8k monitor

Quadro P4000 - \$900

LARGE SCALE VISUALIZATION

See the big Picture



AGENDA

PASCAL HARDWARE

Quadro Pascal
SLI
NV-Link
DP1.4
Increased resolution

DISPLAY FEATURES

MOSAIC

QUADRO SYNC II

New Sync Card

DESIGNWORKS SDKS

NVAPI - Windows
NV-Control - Linux
Video SDK

Ultimate Double Precision performance
Dual slot FF with Sync support



Quadro GP100

Ultimate 3D performance & Interactivity
Dual slot FF with Sync support



Quadro P6000

Demanding 3D content & Interactivity
Dual slot FF with Sync support



Quadro P5000

Performance 3D content
Single slot FF with Sync support



Quadro P4000

Video and basic 3D content
Low profile for SFF systems



Quadro P1000

Video and basic 3D content
Single slot FF with 8 display outputs



NVS 810

2-way SLI support

2-way NV-Link

Quadro SyncII Support - 4 GPUs

Digital Signage

Interactive Displays, Conference Rooms

Scientific Visualization

Product Design Reviews

Specialty Applications



Digital Signage

- NVS810
- P1000



Product Design

- P5000
- P6000



Interactive Displays

- P1000
- P4000
- P5000



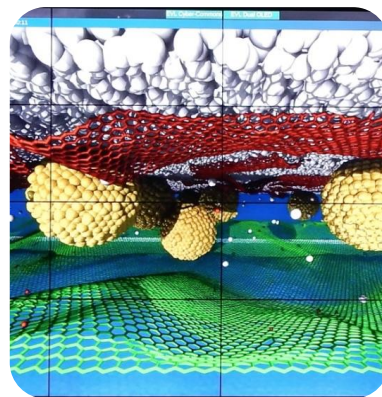
Events

- P5000 + SyncII
- P6000 + SyncII



Collaborative walls

- P1000
- P4000
- P5000



Scientific Viz

- P1000
- GP100

WHAT'S NEW

Display Features

MOSAIC



* Linux/ Win 7

DISPLAY PORT 1.4

HBR3 + HDR
Twice the Bandwidth
32.4 Gb/s (HBR3) - High Bit Rate
Support 5K - 5120x2880@60 Hz SST
7680x4320@60Hz (4:2:0) SST
No DSC (Display Stream Compression) Support
No Support 8K - 7680x4320@60Hz (RGB) SST



SLI BRIDGES

High bandwidth SLI bridge - SLI AFR



VIDEO

- Decode acceleration for MPEG-2, MPEG-4 Part 2 Advanced Simple Profile, H.264, HEVC, MVC, and VC1
- Dedicated H.264 and HEVC encoder
- HDR support over DisplayPort 1.4 (SMPTE 2084/2086, BT. 2020) (4K @ 60 Hz 10b/12b HEVC Decode, 4K @ 60 Hz 10b HEVC Encode)
- HDCP 2.2 support over DisplayPort, DVI, and HDMI connectors

MULTI-GPU MOSAIC

2-WAY SLI

Requires bridge
- either HBR or Single

2 Quadro cards
(P4000/P5000/P6000)
- 8 Displays

OEM Workstations
- Dell/HP/Lenovo

SLI Motherboards
- Certified list

NVLINK

Requires NVLINK
-either dual or single

2 Quadro cards (GP100)
- 8 Displays

Any motherboard with
correct spacing.

QUADRO SYNC II

2 to 4 Quadro Cards
(P4000/P5000/P6000/GP100)
-16 Displays

Any motherboard or
expansion chassis

Support for External Sync
- House Sync input/output
- Sync from a 2nd QSyncII*

*Dual Quadro Sync II support in the same chassis coming later this year

NVIDIA. DESIGNWORKS™

Display Management Technologies

MOSAIC



WARP + BLEND



DISPLAY MANAGEMENT APIS

Monitoring + Setup tools

- NVAPI
- NVWMI
- NV-CONTROL

SYNC



MOSAIC - SETUP & CONFIGURATION

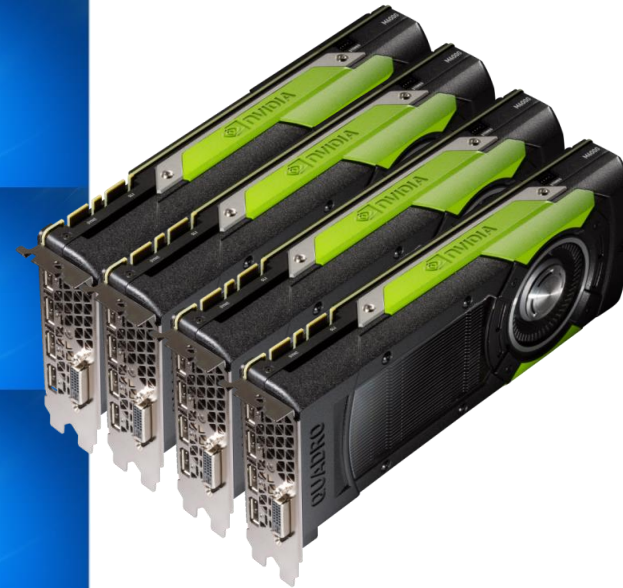
MOSAIC - WHY IS IT NEEDED?

- Windows on its own - Independent Desktops



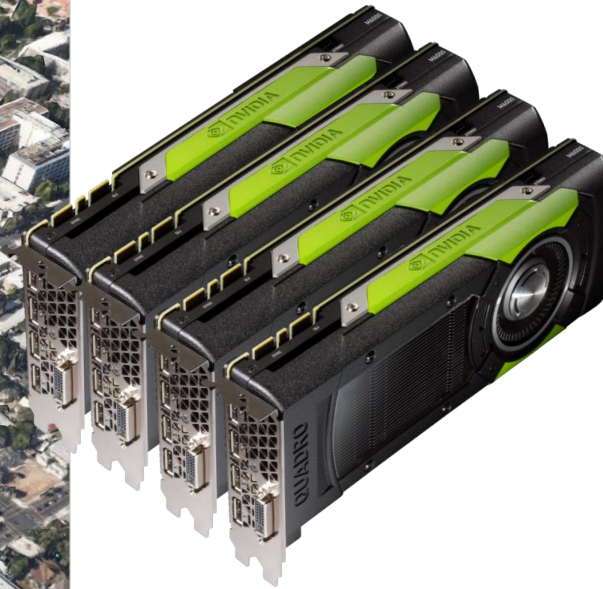
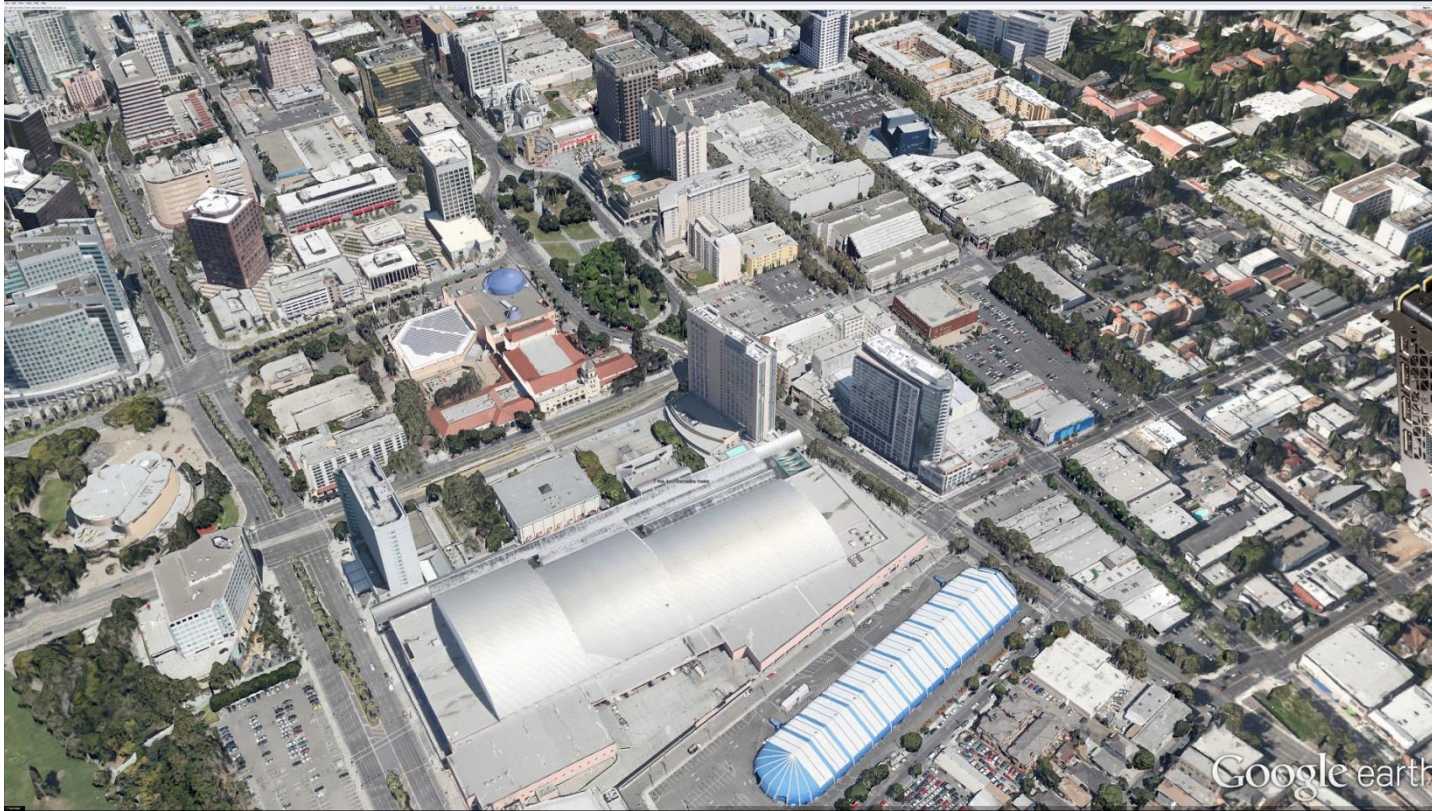
WINDOWS ON ITS OWN

- Independent Desktops

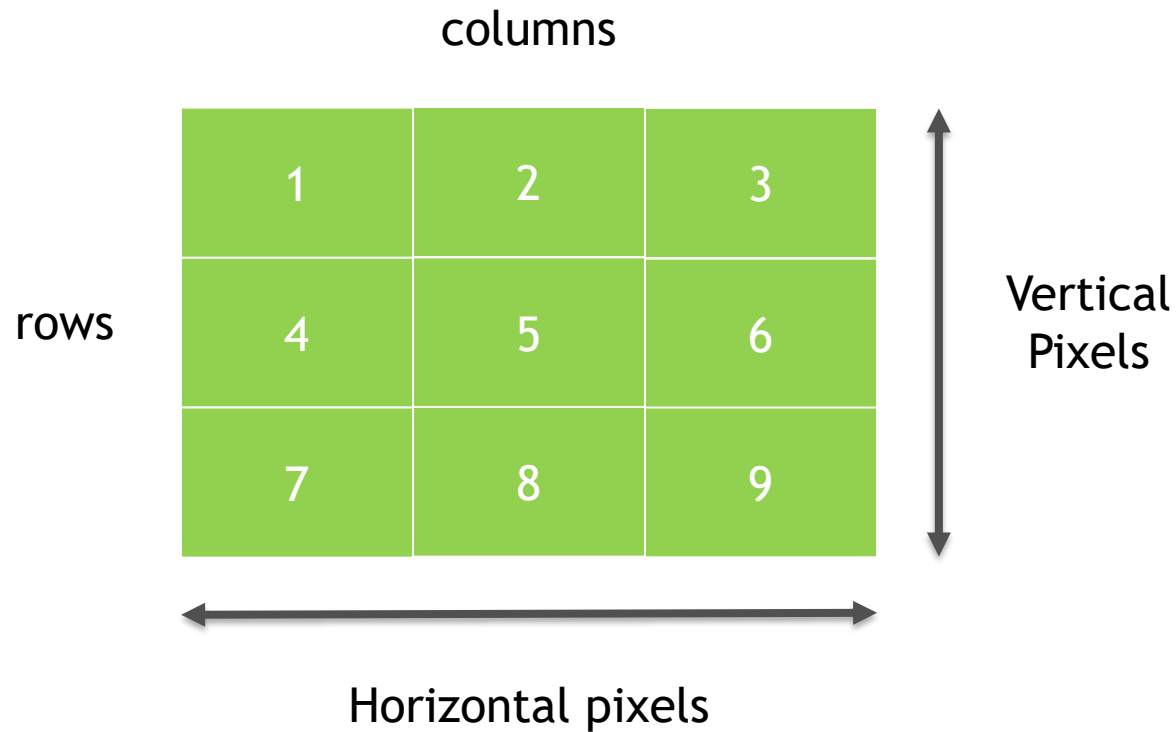


WITH MOSAIC

- One large Desktop



MOSAIC GRIDS



Rows x columns ≤ 16
Max Horizontal or vertical Pixels $\leq 32,768^*$
Enumeration of the Grid always starts top left and goes left to right

*32,768 on Linux & Win 7. 16,384 on Win 10

BEZEL AND OVERLAP CORRECTION

Bezel Correction

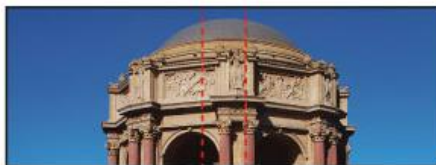
Will make the image look continuous as we render ur



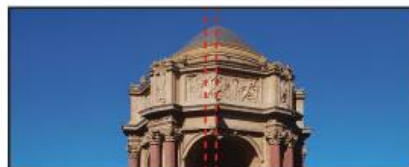
Bezel Correction



No Bezel Correction



Projector Overlap

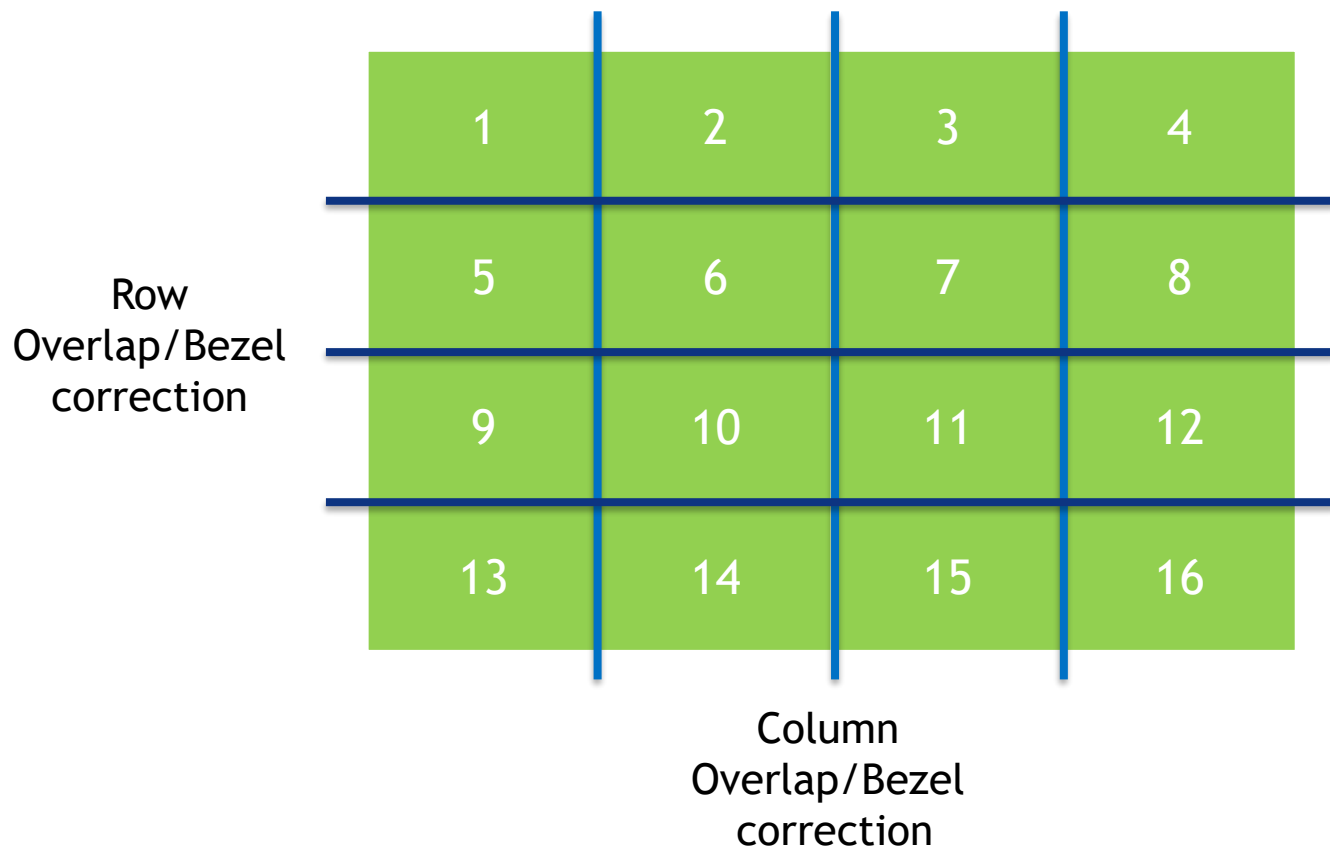


No Projector Overlap

Overlap Correction

For projectors it maintains the aspect ratio of the display.

UNDERSTANDING TOPOLOGIES



Bezel correction will increase overall pixel size

i.e. each display is 1920x1080
Bezel per column is 100

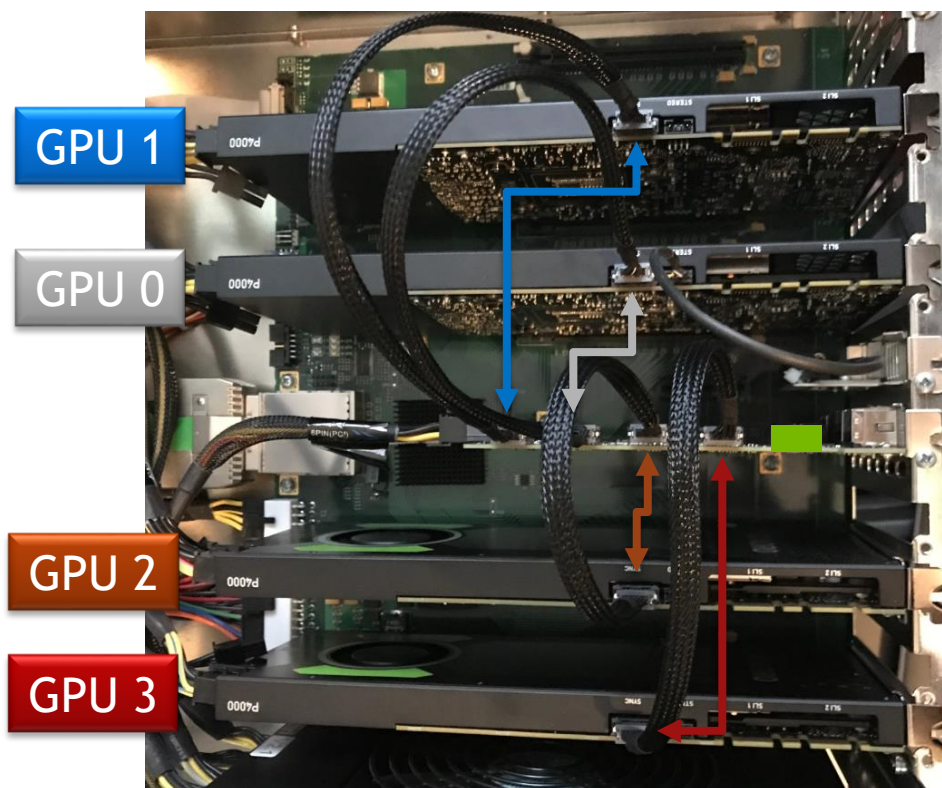
Total horizontal width
= $1920 * 4 + 100 * 3 = 7980$

Overlap correction will decrease overall pixel size

i.e. each display is 1920x1080
overlap per column is 100

Total horizontal width
= $1920 * 4 - 100 * 3 = 7380$

ANATOMY OF A SYSTEM



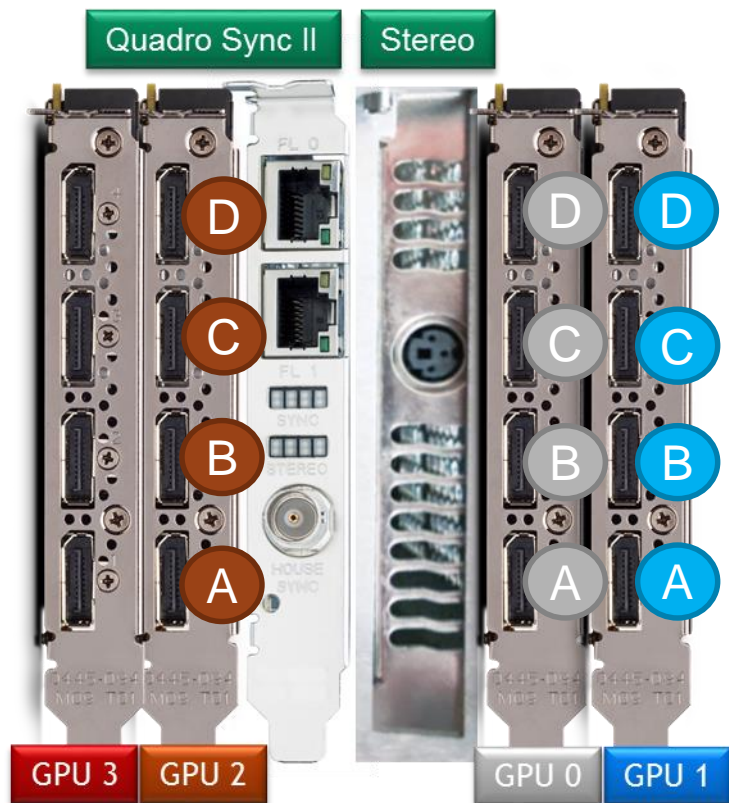
VESA STEREO

Quadro Sync II



PORT NUMBERING

Auto-enumeration

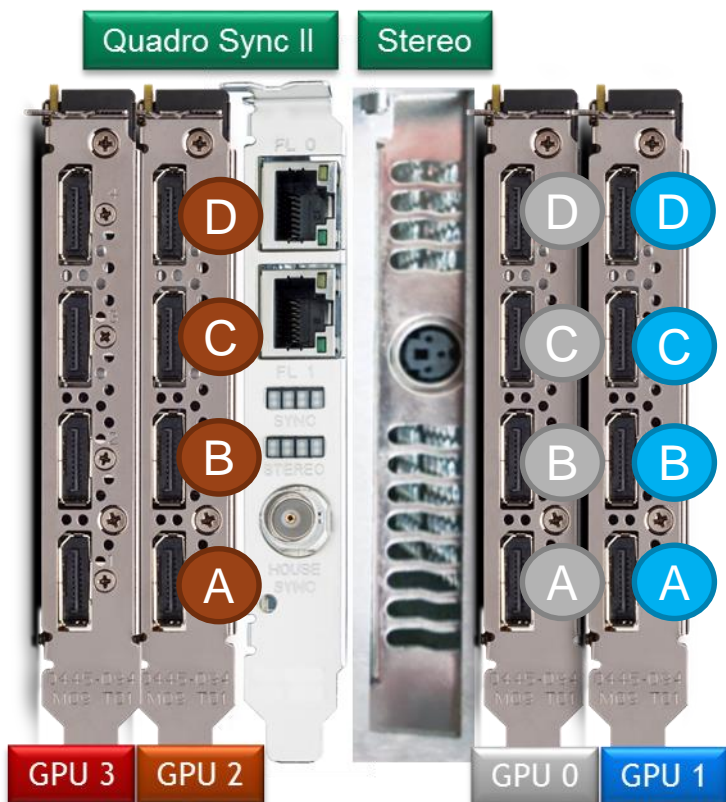


i.e. only B is attached
B = 0,0

A + E are attached
A = 1,0
E = 1,1

A + B + C + D are attached
A = 2,0
B = 2,1
C = 2,2
D = 2,3

UNDERSTANDING PORT NUMBERS



`configureMosaic-x64.exe set rows=3 cols=3`

`configureMosaic-x64.exe set rows=3 cols=3 out=0,0 out=0,1 out=0,2 out=1,0 out=1,1 out=1,2 out=2,0 out=2,1 out=2,2`

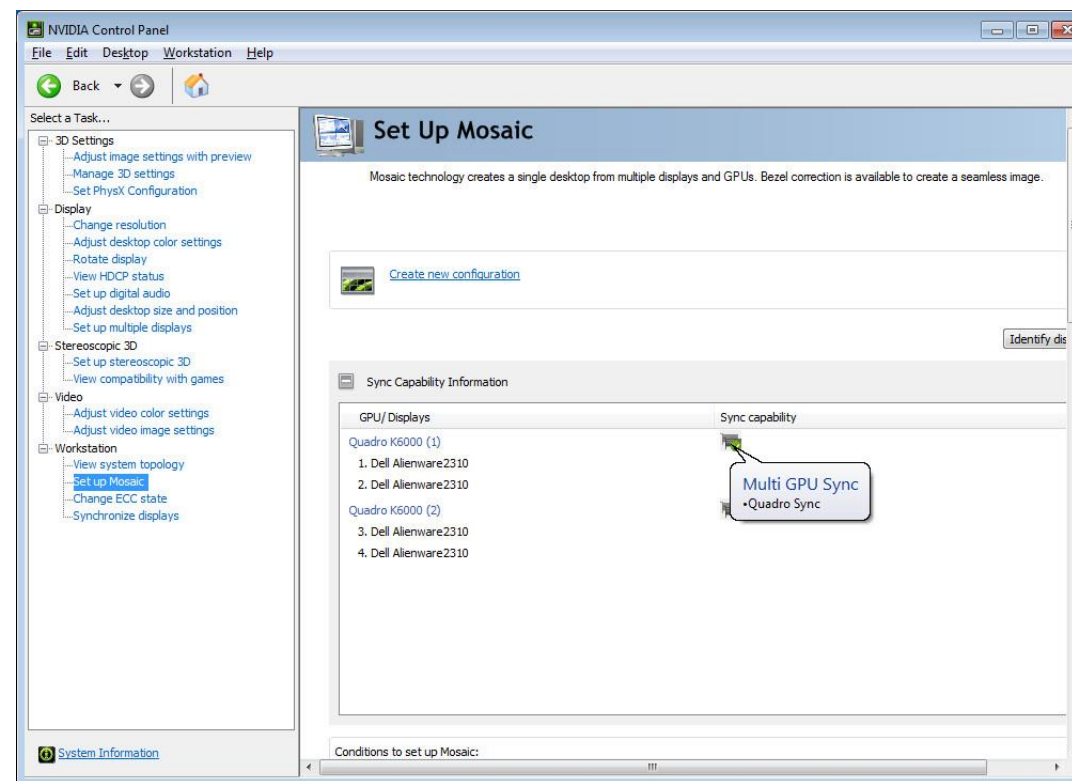


MOSAIC WITH SYNC

MOSAIC with Sync = Premium MOSAIC =
SLI MOSAIC

Setup MOSAIC Menu

- Roll over icon under “Sync capability”
- Indicates whether card can be sync'd
 - Multi-GPU Sync “Quadro Sync” - multi-GPU sync via Quadro Sync card
 - Mutli-GPU Sync “SLI Bridge” - 2-way GPU sync via SLI bridge
 - Single GPU Sync - outputs on single card can be framelocked.



CONFIGUREMOSAIC

<http://www.nvidia.com/object/quadro-advance-options.html>

▶ Basic Options

- ▶ set/test
- ▶ rows=2 cols=2
- ▶ res=1920,1080,60
- ▶ Listconfigcmd
- ▶ out

▶ Advanced (helpall)

- ▶ nextgrid
- ▶ rotate
- ▶ Passivestereo
- ▶ pixelshift

```
configureMosaic-x64.exe set rows=1 cols=1 out=0,0 nextgrid rows=2 cols=2 overlap=384,240 out=1,0 out=1,1 out=1,2  
out=1,3 nextgrid rows=2 cols=2 overlap=0,240 out=3,0 out=3,1 out=3,3 out=3,2 nextgrid rows=2 cols=2  
overlap=384,480 out=2,0 out=2,1 out=2,2 out=2,3
```

MOSAIC ON LINUX

xorg.conf

Single GPU



(bezel or overlap)

```
Option "MetaModes" "1920x1080 +0+0, 1920x1080 +1920+0,  
1920x1080 +0+1080, 1920x1080 +1920+1080"  
Option "nvidiaXineramaInfo" "FALSE"
```

Dual GPU
(no sync)



(bezel)

```
Option "BaseMosaic" "TRUE"  
Option "MetaModes" "GPU-0.DFP-0: 1920x1080 +0+0, GPU-0.DFP-1:  
1920x1080 +1950+0, GPU-1.DFP-0: 1920x1080 +0+1100, GPU-1.DFP-1:  
1920x1080 +1950+1100"  
Option "nvidiaXineramaInfo" "FALSE"
```

SLI, NVLINK
or Quadro Sync II



(bezel or overlap)

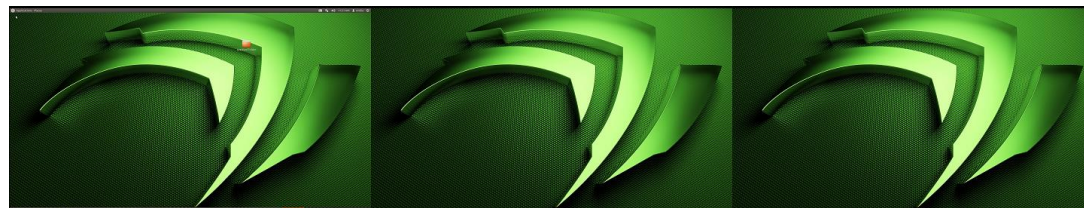
```
Option "SLI" "MOSAIC"  
Option "MetaModes" "GPU-0.DFP-0: 1920x1080 +0+0, GPU-0.DFP-1:  
1920x1080 +1820+0, GPU-1.DFP-0: 1920x1080 +0+1000, GPU-1.DFP-1:  
1920x1080 +1820+1000"  
Option "nvidiaXineramaInfo"
```

LINUX TIPS

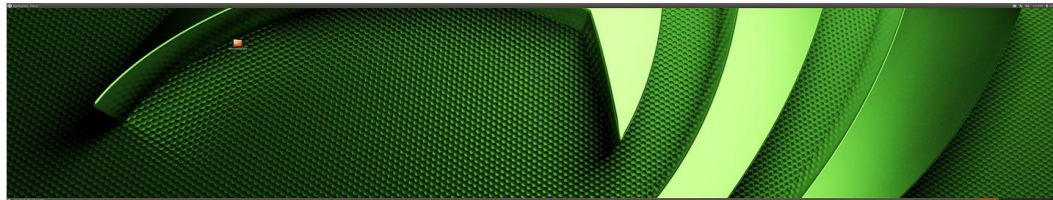
Window Manager (GNOME, Unity, KDE etc) may over-ride MOSAIC settings.

Option `"nvidiaXineramaInfo" "False"`

Option `"RANDR" "Disable"`



1x3 MOSAIC - but three separate Desktops
MOSAIC is running - i.e. Windows should open full screen



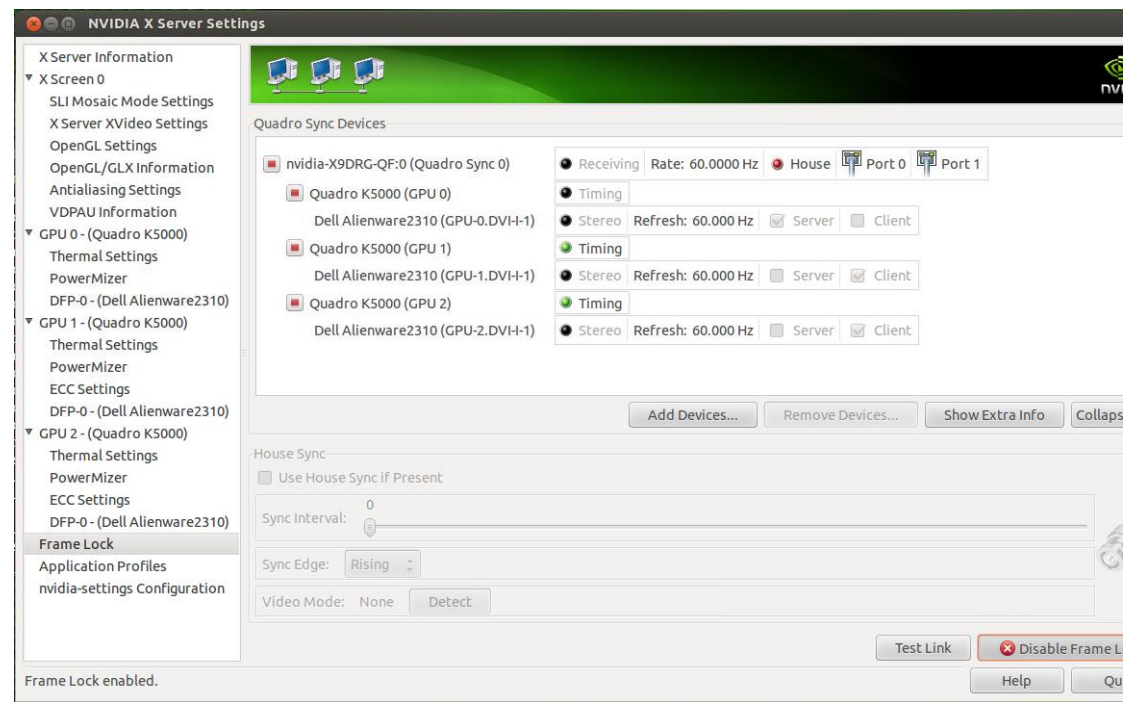
1x3 MOSAIC - Single Desktop

LINUX TIPS

MOSAIC with Quadro Sync

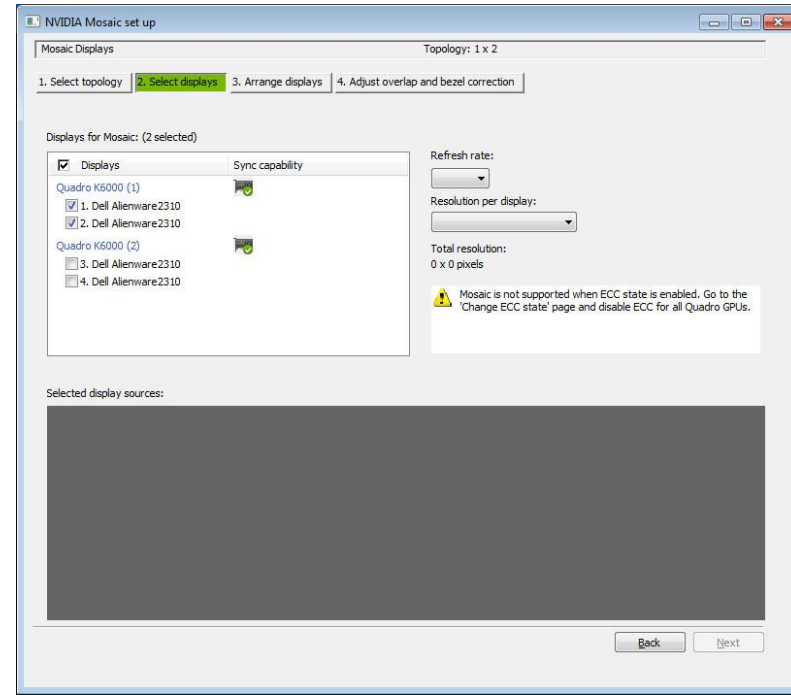
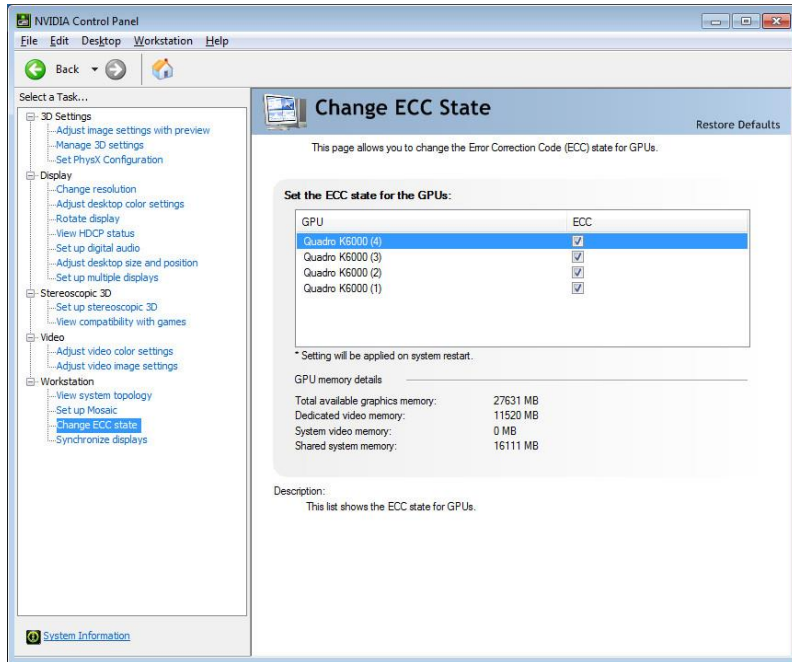
Set SLI MOSAIC in xorg.conf

After restarting X - Enable Framelock
(Not automatic)



COMMON MOSAIC SETUP ISSUES

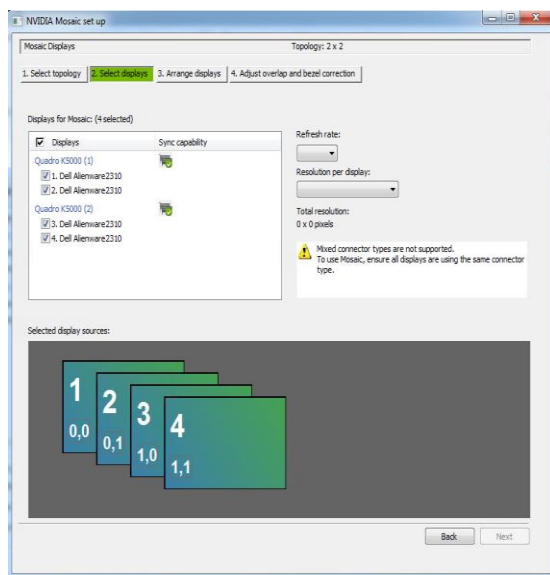
MOSAIC DOESN'T ENABLE ON MULTI-GPUS



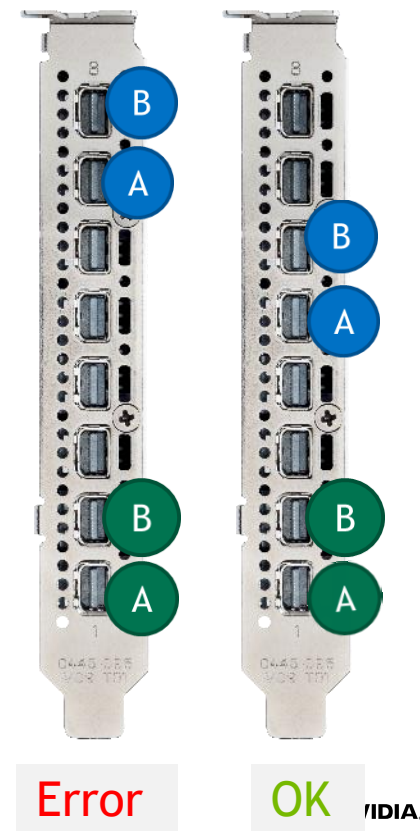
MOSAIC does not work with ECC ON - Make sure it is disabled

MOSAIC ERROR - MIXED CONNECTORS

Error - “Mixed Connectors are not Supported”



- ▶ Affects Multi-GPU MOSAIC
 - Match connector position on each GPU
 - For “odd” number setups make sure primary GPU has all connectors used
 - i.e 7 displays - use 4 connectors on GPU0 and 3 connectors on GPU1.
 - Make sure you are using dongles of all of one type - i.e. passive dongles.



MOSAIC TIPS

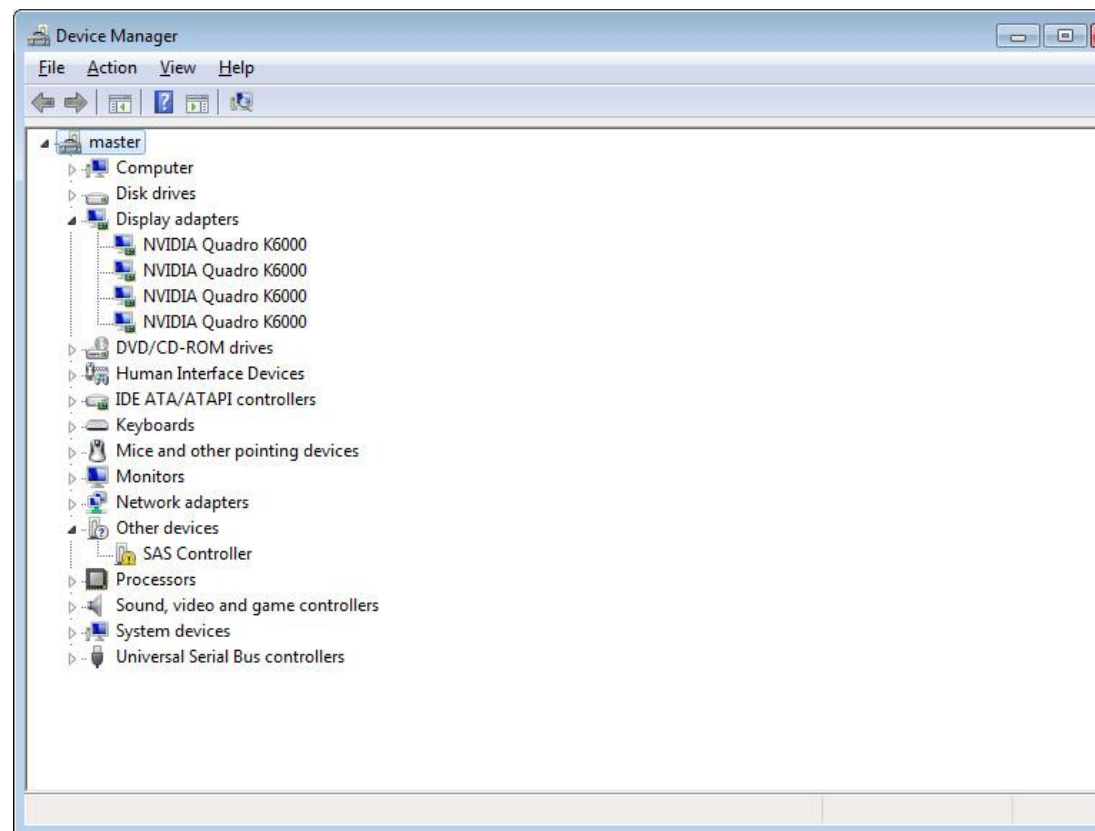
Check for mirror display drivers

Make sure there is no Mirror Driver installed

Mirror Driver is installed by remote admin software. It will sit between the OS and graphics driver.

Will often break

- 3D stereo
- accelerated video playback
- MOSAIC + Sync
- Cause DWM to crash



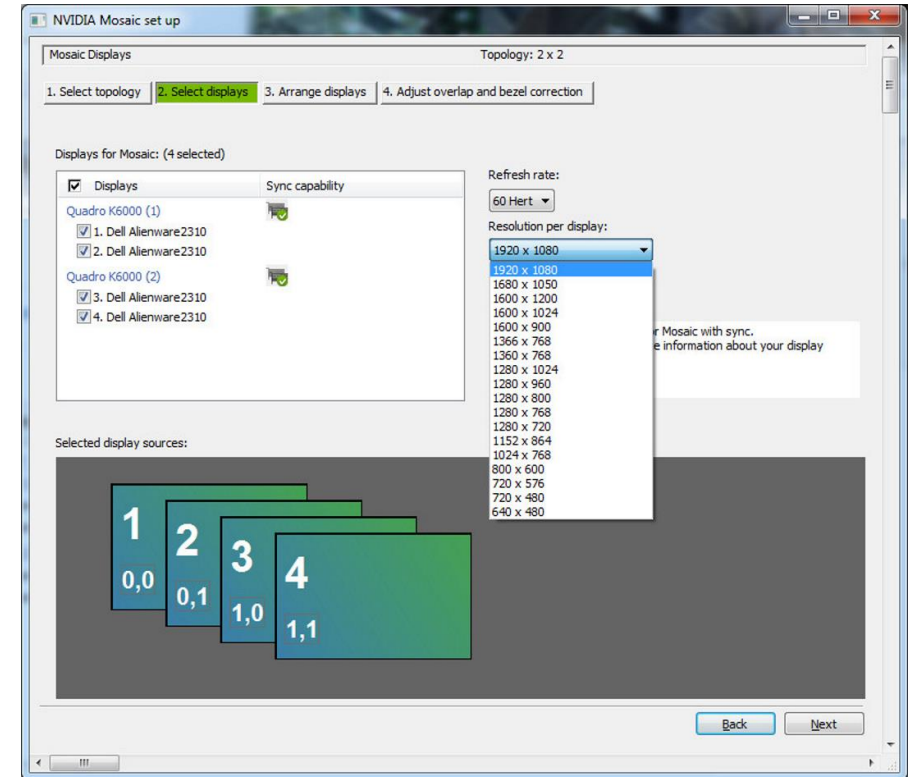
MOSAIC DISPLAY RESOLUTION NOT LISTED

Resolution missing from MOSAIC setup
menu

Display Resolution is missing in drop down

Three probably causes:

1. Expected Resolution is not **common** across all displays
2. The requested topology **exceeds** the **16K (Win10)** max width or height in pixels.
3. For displays with large number of display modes in EDID, **NVIDIA driver** will limit the number of modes exposed. (Use ManageEDID tool with a fake EDID with just the required display timing).



MOSAIC RESOLUTION NOT LISTED

No Common timings

- ▶ 1920x1080 @60 - just an identifier

Resolution, refresh rate	3840 × 2160 pixels, 60.000 Hz	
	Horizontal (2200)	Vertical (1125)
Active	1920	1080
Border	0	0
Front porch	88	4
Sync width	44	5
Back porch	148	36
Polarity	Positive (+)	Positive (+)

1. Displays have different EDIDs
2. Mixing EDID and Custom resolutions - custom resolution may not match EDID.
3. Wrong cabling
 - DP to HDMI dongle blocks resolutions
 - Single link DVI cables versus dual link

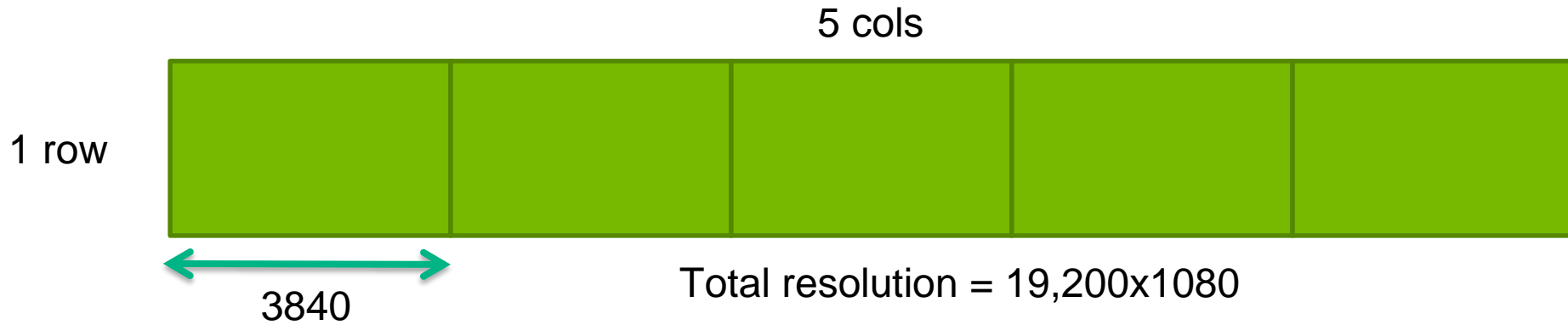
MOSAIC RESOLUTION NOT LISTED

No Common timings - Solutions

- ▶ Use **System Topology**
 - ▶ To check timing - will catch most differences
- ▶ Use **nvtimingdiag.exe**
 - ▶ Prints detailed timing to help identify miss-matched displays
 - ▶ Contact - QuadroSVS@nvidia.com for a copy.
- ▶ Use **ManageEDID**
 - ▶ Apply one good EDID to all sources
- ▶ **Avoid** mixing Custom Resolutions and EDIDs
 - ▶ Apply custom resolution to all displays.

MOSAIC RESOLUTION NOT LISTED

Max resolution cannot exceed 32,768 (Linux) or 16,384 (Win10)



Linux/ Win 7 - OK
Win 10 - Exceeds max resolution

Note Bezel Correction will add to the total resolution.

WARP + INTENSITY ADJUSTMENTS

PROJECTION BLENDING

Warp + Blend SDK

3rd party software available from



Image courtesy of Joachim Tesch
- Max Planck Institute for Biological Cybernetics



WARP AND BLEND

Session S7357 Wed 4.00pm - Room 230C

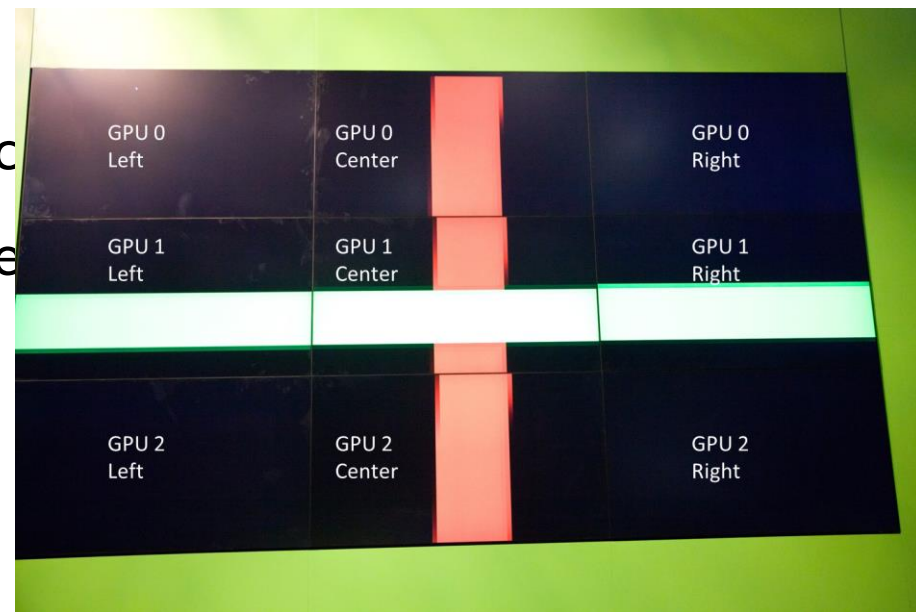
LCD TILE WALLS

MOSAIC + WARP

Solves issues with sync on LCD panels

Tearing between each row

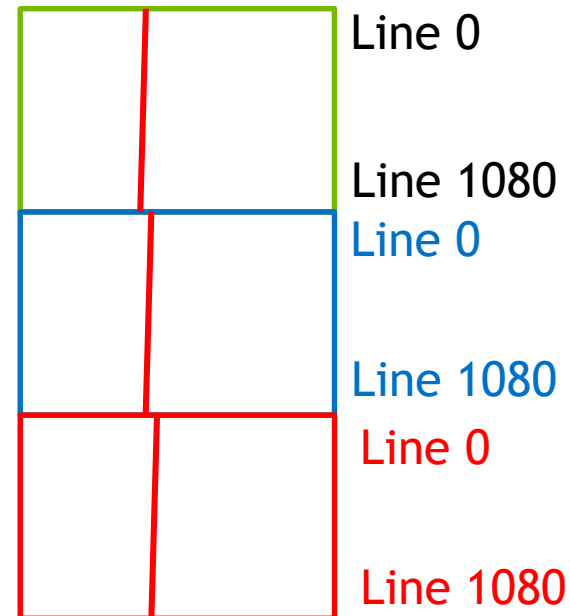
- Appears with fast moving video or interactive content
- Display wall is framelocked - but response time causes optical effect



LET'S TAKE A CLOSER LOOK

What's happening

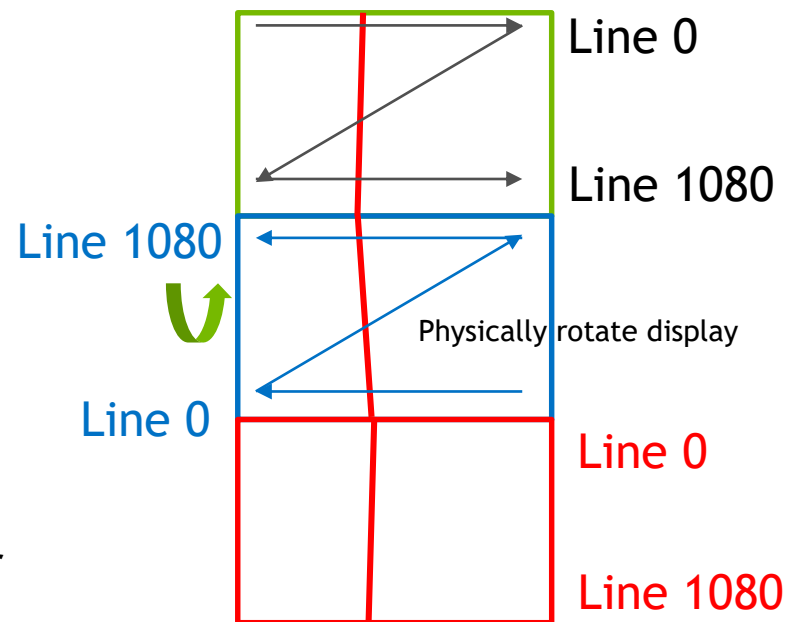
- Progressive scan-out from line 0 to line 1080
- Each lower row appears to be rendering ahead
- Columns within a row appear to be sync'd



SOLVING THIS PROBLEM

Use WARP API + rotated row

- Progressive scan-out from line 0 to line 1080
- Rotate every other row
 - Line 1080 -> Line 1080
 - Line 0 -> Line 0
- WARP API
 - Rotate Desktop image so looks correct to the viewer



DISPLAY MANAGEMENT APIS

NVWMI/NVAPI & NV-CONTROL

Remote management and NVIDIA control panel APIs manage complexity

NVWMI remote management API

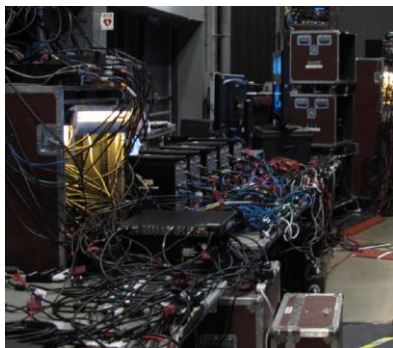
- Monitor and manage NVIDIA graphics from anywhere
- Do everything the control panel can do and more
- Plugs into Microsoft's WMI
- Perfmon support
- Scriptable | wmic | powershell | C# support

NVAPI for the NVIDIA control panel

- Custom resolutions
- EDID management
- Warp + Blend API (Quadro only)
- MOSAIC API

NV-CONTROL

- Custom resolutions
- Warp + Blend API (Quadro only)
- Quadro Sync II – setup and monitoring
- Event monitoring



Without NVIDIA Technology



With NVIDIA Technology



CES2017 – Presentation Display

NVAPI FUNCTIONS

Selection of different features

Custom Resolutions	MOSAIC	Sync Management	EDID Management
GFT, DMT, CVT, CVT-RB, Manual timing	Seamless desktop across multiple GPUs	Genlock/TTL sync, framelock (internal sync)	Capture and read EDID from file
EDID Management	WARP + Intensity API	Driver Profiles	Driver Settings
Capture and read EDID from file	Edge-blending, projection mapping on Windows or Linux	Global and nView profile management	Manage 3D settings selection
Display Setup	GPU Direct for Video	Color Management	GPU Utilization
Clone mode, display position	Picture-in-picture support	Color space conversion via NVAPI SDK	GPU utilization, memory etc.

NVAPI BASICS

Public & NDA Version

Public - developer.nvidia.com

Most functions available - MOSAIC, WARP etc **NO Custom Resolution.**

NDA - registered developer with NDA. NVIDIA provides access to partner network for download

All functions available - including custom resolution

More SDK examples

Structure versions

Each structure in NVAPI contains a version field that must be set.

```
NV_XXX.version = NV_XXX_VER;
```

displayIds - unique identifier for each display attached. Includes GPU info.

NVWMI

Plug into Windows Management Infrastructure

Accessible using:

- WMIC - command line
- Powershell
- C#

developer.nvidia.com/nvwmi

- SDK samples
- White paper



- [Main Page](#)
- [Related Pages](#)
- [Classes](#)

Programmer's Guide

2.25

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- [Introduction](#)
- [NVWMI compatibility](#)
- [Version-specific Implementation Details](#)
- [Cooler and Thermal Events](#)
- [NVIDIA Performance Counters](#)
- [Using NVWMI](#)
 - [Using NVWMI with the PowerShell](#)
 - [Using NVWMI with the WMIC tool](#)
 - [Logging and tracing NVWMI activity](#)

Introduction

1. General Purpose

NVWMI provider allows WMI clients to query and to monitor parameters of NVIDIA hardware. It is implemented as a decoupled WMI provider in a system service (nvwmi.exe in 32-bit or nvwmi64.exe in 64-bit flavors of Windows).

2. General Requirements

- NVIDIA hardware
- operational NVIDIA display driver
- installed NVWMI provider

3. Version-specific

For detailed information about version-specific changes, please refer to the implementation [Version-specific Implementation Details](#).

Installed with the driver - C:\Program Files\NVIDIA Corporation\NVIDIA WMI Provider

MOSAIC SETUP

NVWMI - adds remote setup support

- Class - DisplayManager
- Function - createDisplayGrids
- Input parameters - string containing grid information i.e.
 “rows=2;cols=2;stereo=0;layout=1.1 1.2 1.3
 1.4;mode=1920 1200 32 60”
- Layout - numbering starts at “1”.
 Different than control panel

```
ObjectGetOptions Options = new ObjectGetOptions();
ManagementPath Path = new ManagementPath("DisplayManager");
ManagementClass ClassInstance = new ManagementClass(Scope,
Path, Options);
ManagementBaseObject inParams =
ClassInstance.GetMethodParameters("createDisplayGrids");

string[] grid_input_params = { "rows=1;cols=2" };
inParams["grids"] = grid_input_params;

ManagementBaseObject outParams =
ClassInstance.InvokeMethod("createDisplayGrids", inParams,
null);
```

C# code snippet

NV-CONTROL

Linux display functions SDK

Source code/samples: <ftp://download.nvidia.com/XFree86/nvidia-settings/>

Samples include:

- nv-control-targets.c - print out system info - including connected displays
- nv-control-dpy.c - different options including generating custom modelines and printing out current modeline in use
- nv-control-framelock.c - Quadro Sync II card setup and control
- nv-control-events.c - Events - including sync events
- nv-control-warpblend.c - Warp and blend sample

QUADRO SYNC

KEY NEW FEATURES

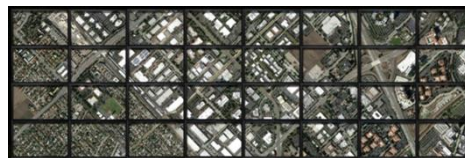
Quadro Sync II

QUADRO PASCAL SUPPORT



Quadro GP100
Quadro P6000
Quadro P5000
Quadro P4000

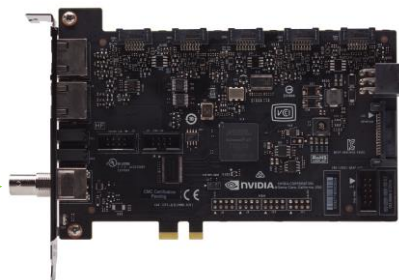
DUAL QUADRO SYNC II SUPPORT



Dual Quadro Sync II
8 GPU Support
(coming later this year)

TTL SYNC OUTPUT

Sync Generator

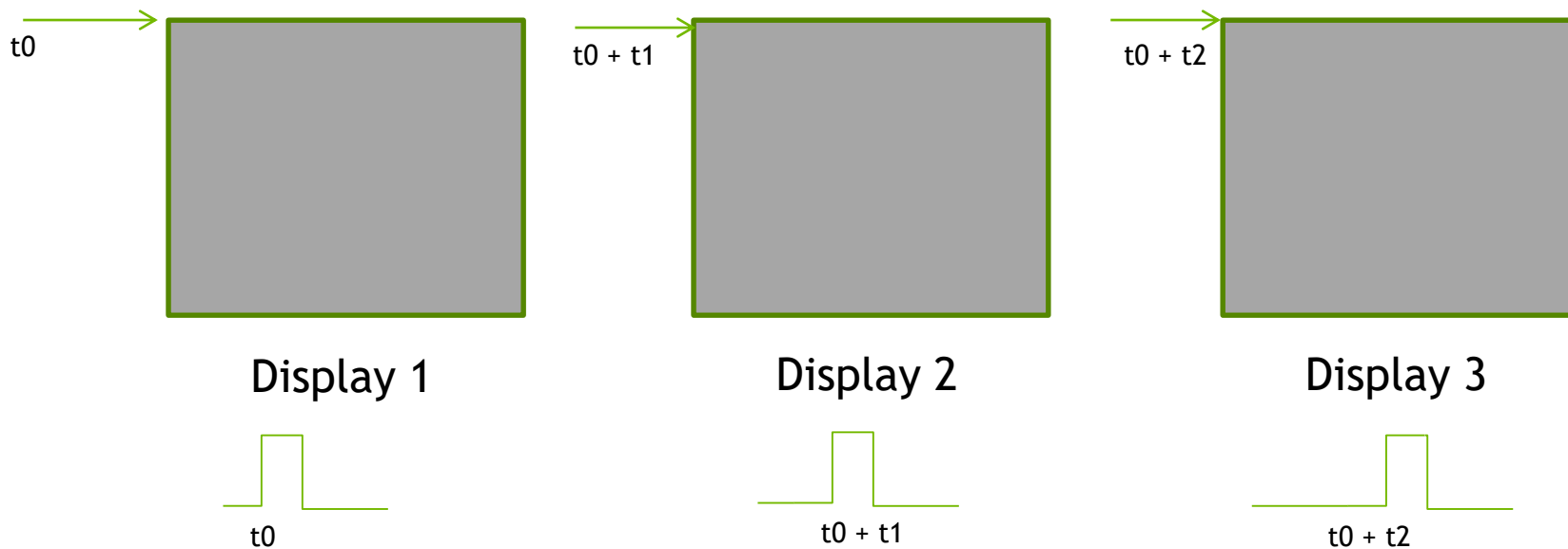


SELF LOCKING CONNECTORS

Sync Cable/Connector

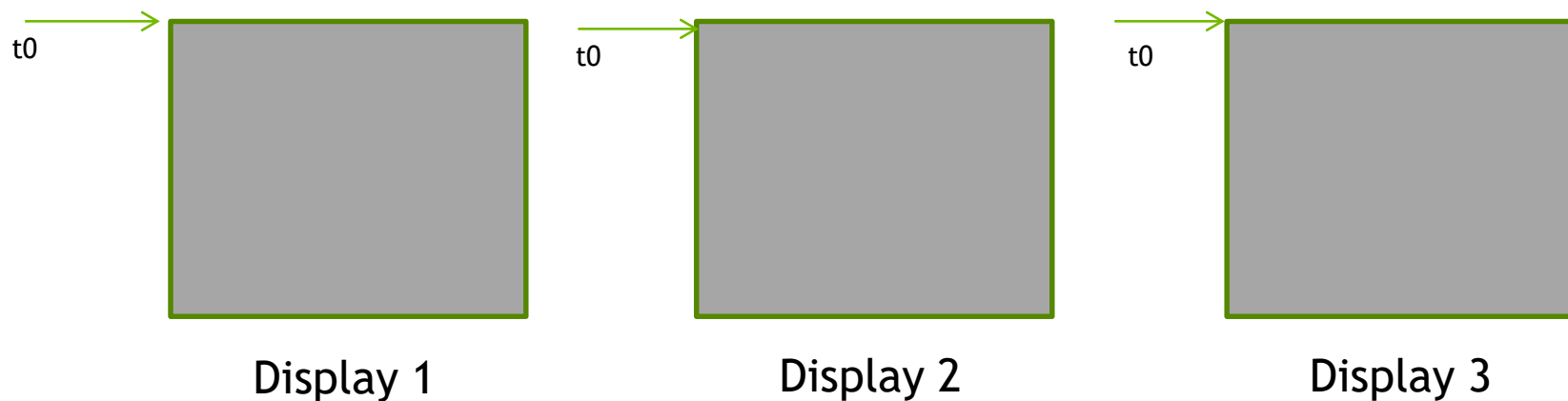


VERTICAL SYNC



- *Vertical Sync* is the pulse that indicates the start of the display refresh.
- To avoid *tearing* on a single screen the application swap buffers are synced to *vertical sync*.
- Although all three displays may have the same refresh rate - *vertical sync* start may be different.
- This can result in *tearing* between displays.

FRAMELOCK/GENLOCK

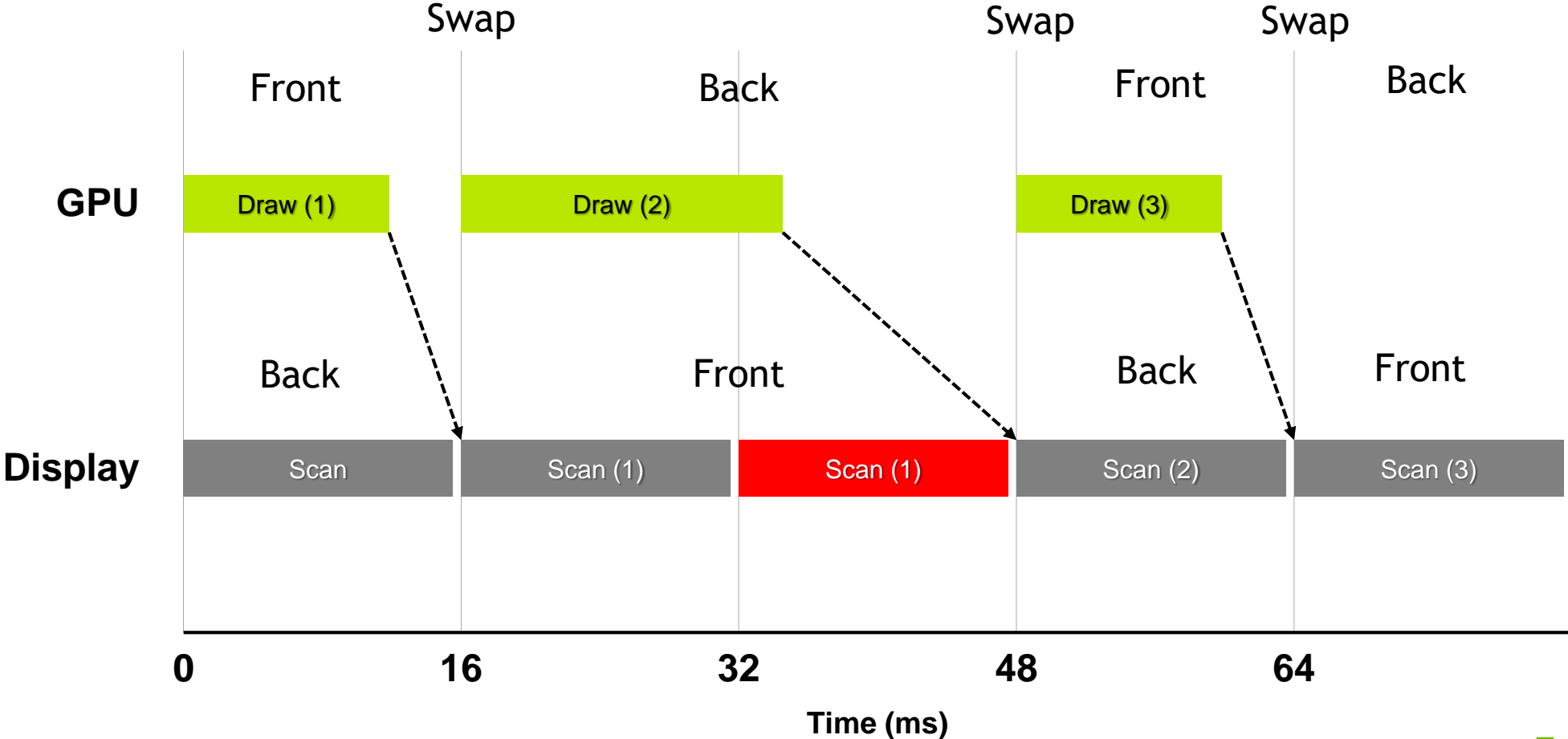


- *Frame Lock/Genlock* provides a common sync signal between graphics cards to insure the vertical sync pulse starts at a common start.
- This is commonly referred to as *Frame Synchronization*
- *Frame Lock* - Synchronization is generated from a master node. All other nodes would be sync to this.
- *Genlock* - synchronization is from an external sync generator (house sync). Each node attached to the genlock signal is synced from that signal.
- *Frame Lock & Genlock* can be mixed in the cluster. With the master node being synchronized from the genlock pulse.

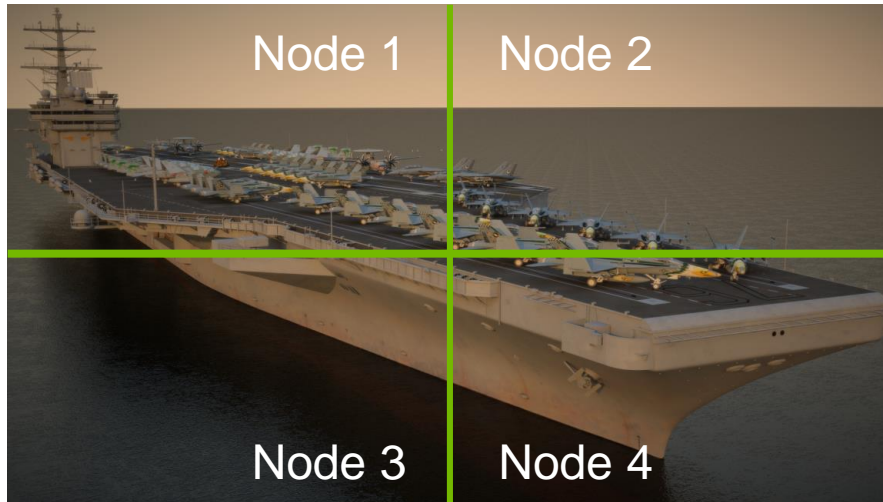
SWAPBUFFERS



SWAPBUFFERS



SWAPBUFFERS IN A CLUSTER



Each node is now rendering a scene with different complexity i.e from least to highest we get:

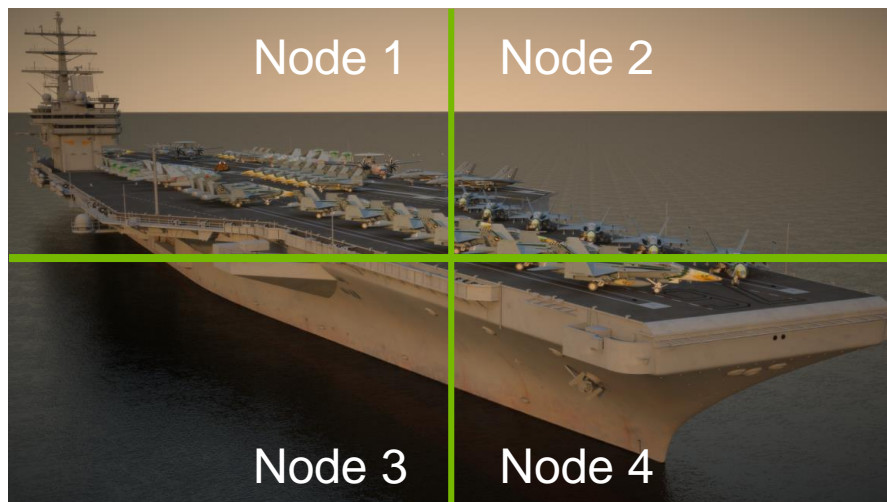
1. node 3 ~ 16ms = 60fps
2. node 4 ~ 36ms = 30fps
3. node 2 ~ 53ms = 15fps
4. node 1 ~ 99ms = 10fps

- With each node running at a different rate the user would perceive tearing on the screen.
- We need a mechanism to ensure that each node will *swap* at the same time.

SWAP GROUP AND SWAP BARRIER

NVIDIA Extensions to OpenGL /DirectX (via NVAPI)

- Swap Group - provides synchronization multiple GPUs in a single host
- Swap Barrier - provides synchronization of GPUs across multiple nodes.
- Use RJ45 (framelock) connection on Quadro Sync - so faster than sync over a network



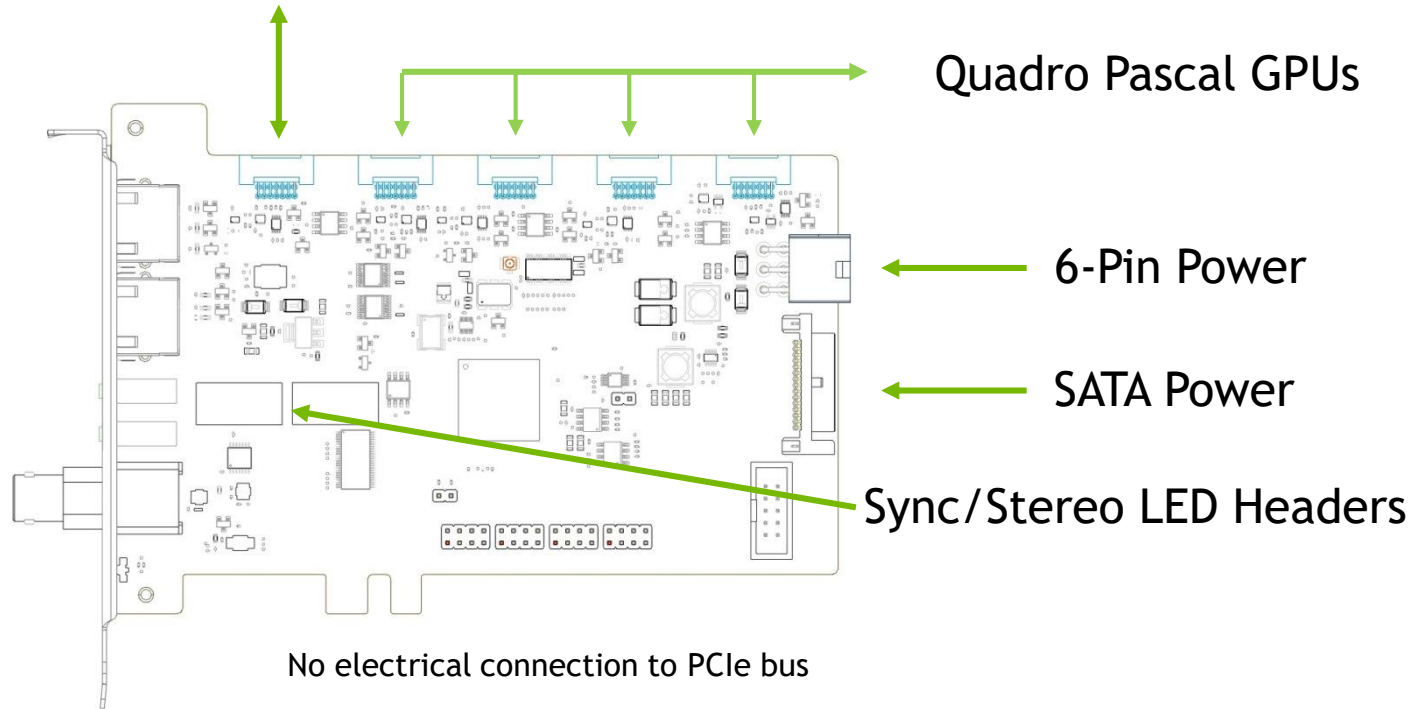
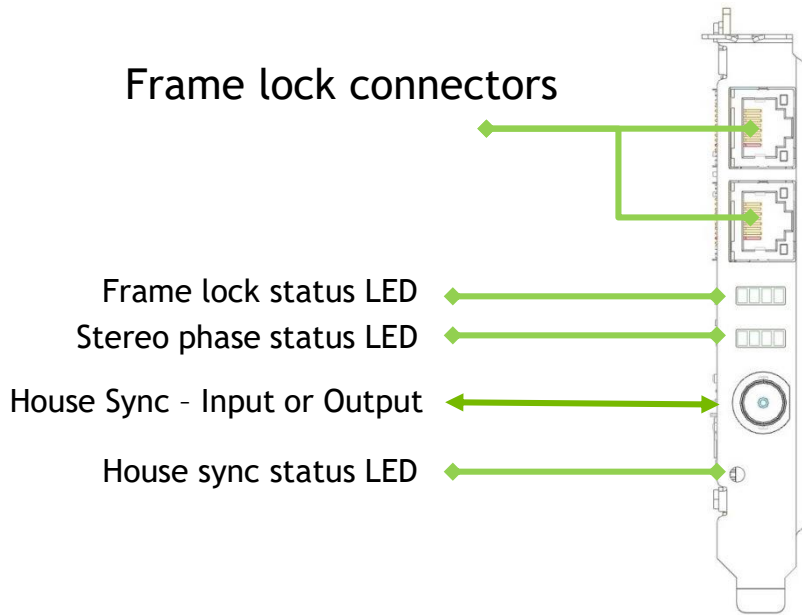
With *Swap Barrier* each node will wait until all nodes have completed their render

1. node 3 ~ 16ms = 10fps
2. node 4 ~ 36ms = 10fps
3. node 2 ~ 53ms = 10fps
4. node 1 ~ 99ms = 10fps

CONNECTIONS

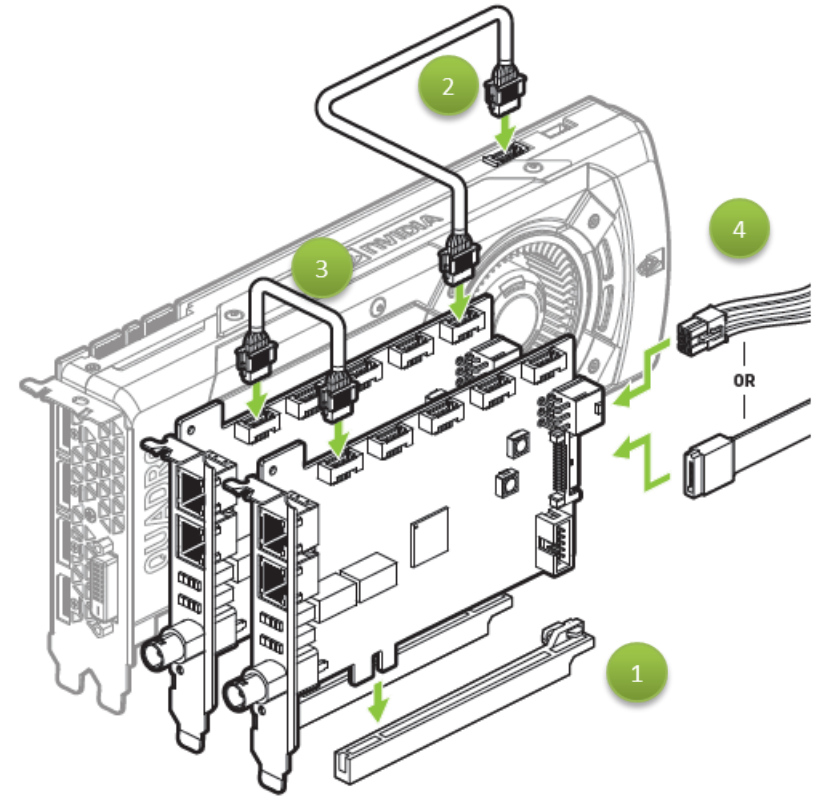
Quadro Sync II

2nd Quadro Sync II board



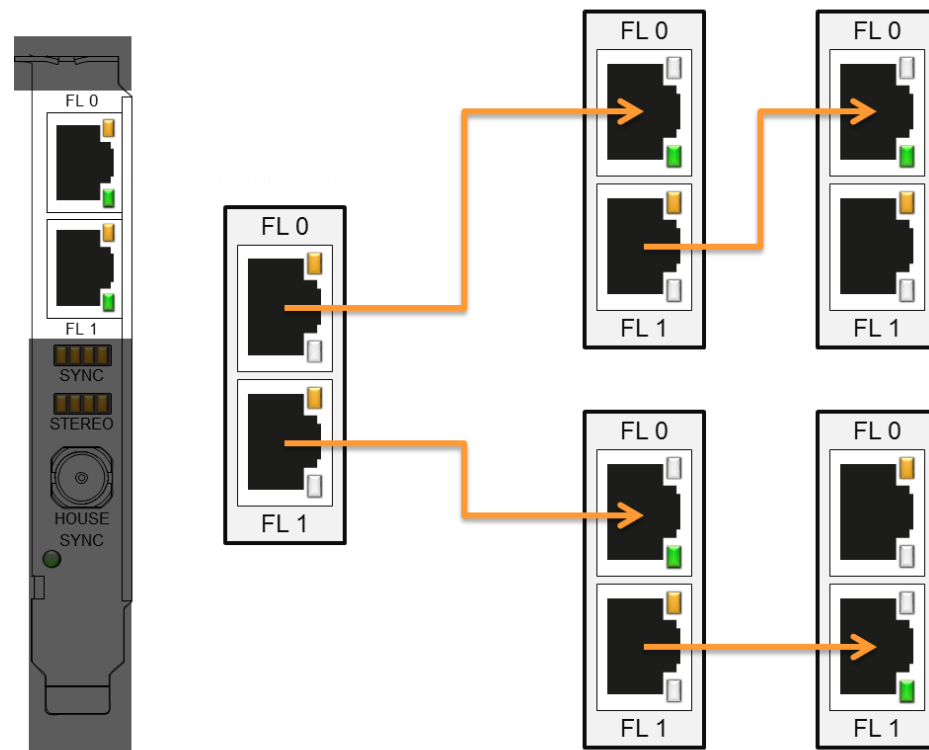
INSTALLATION

- 1) Place in free slot - PCIe may not bottom out in slot
- 2) Connect the board up to 4 Quadro cards using the included sync cables.
- 3) If Sync'ing more than 4 GPUs in a system connect to 2nd Quadro Sync card. We recommend the connector closest to the bracket
- 4) Connect power.



WIRING A CLUSTER

- Connect the nodes with quality CAT5 cables
 - We recommend cables to be as short as possible
- Put the “timing server” in the middle of the cluster
 - This create two sync chains

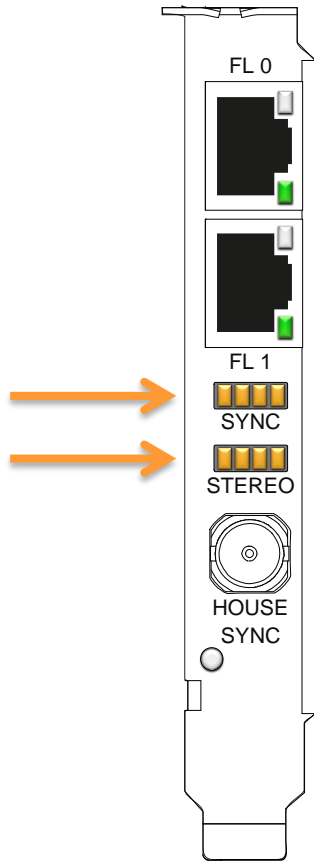


HOW BIG A CLUSTER DO WE SUPPORT?

Its complicated

- Contact QuadroSVS@nvidia.com since there is no easy answer
- For guidance the limiting factor with Sync is the number of sync boards not GPUs
 - We have tested 25 nodes on one chain and had margin to grow bigger. *We stopped because we ran out of systems not signal quality*
 - That's 200GPUs with 4 displays per card - 800 displays total.
 - The sync board re-drives all the signals on the CAT 5 cable.

BOOTING

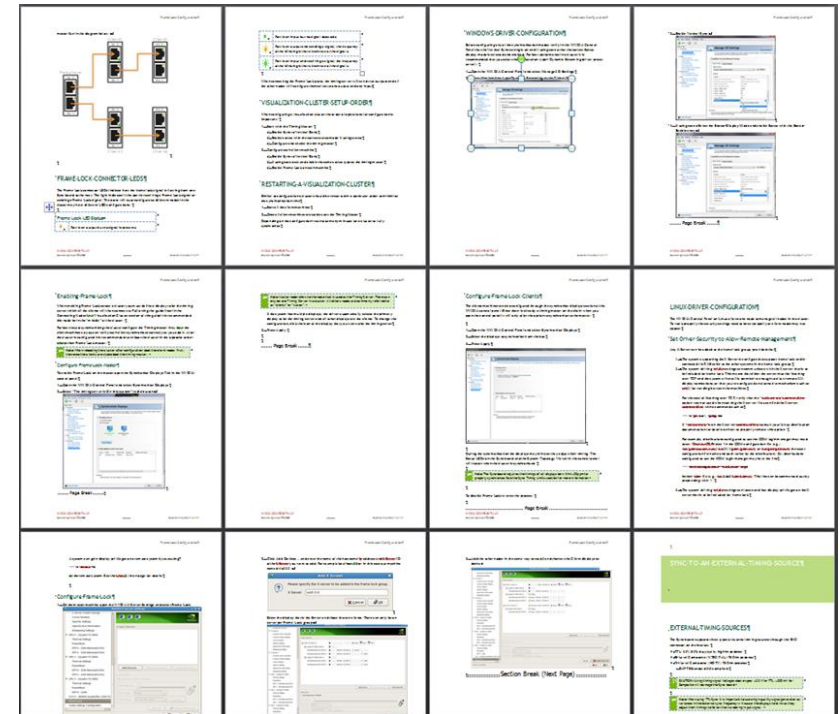


- When the board boots after shutdown ALL the Sync and Stereo lights turn **Solid Amber**, like at the left
 - A reboot will not change the LEDs from the previous state, only a power cycle does
 - The LEDs change to the correct status after the driver loads
- If there are no LEDs illuminated on system boot, check the power cable

DRIVER CONFIGURATION

Quadro Sync II User Guide

Read the User Guide.

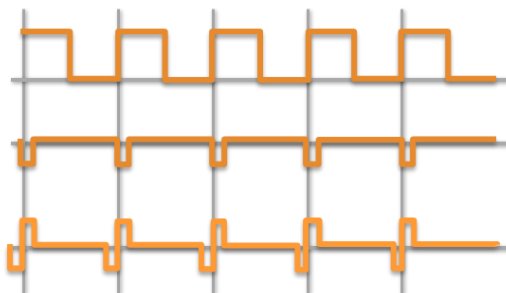


EXTERNAL SYNC

Input formats

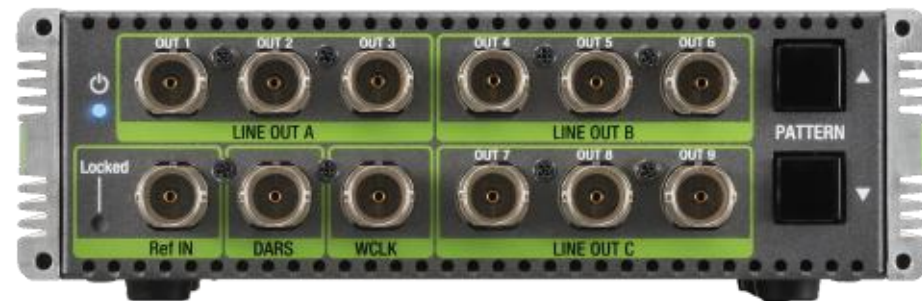
- 3 Formats of Sync Sources
 - TTL: 3.3V, 50% duty cycle, high impedance
 - Bi-Level Composite (NTSC/PAL): 75Ω, ±300mV
 - Tri-Level Composite (HDTV): 75Ω, ±300mV

TTL

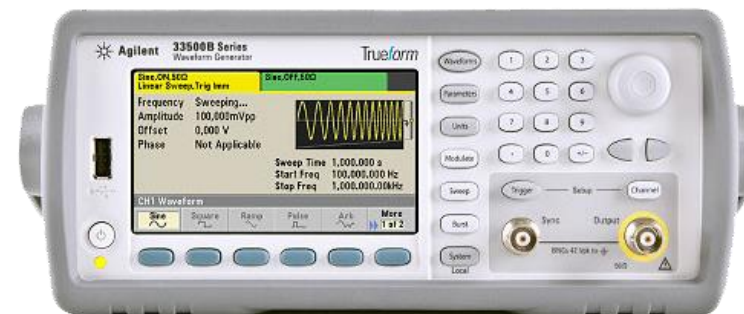


Bi-level

Tri-level



Grass Valley ADVC G4 (bi/tri level) $\leq 60\text{Hz}$



Agilent 33500B (TTL, bi/tri level) variable

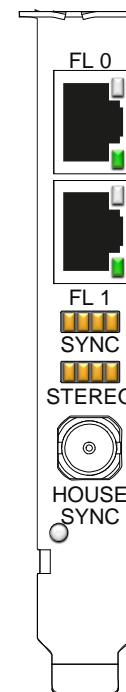
EXTERNAL SYNC

BNC Output

- TTL: 3.3V, 50% duty cycle, high impedance
- Removes the need to have external sync generator
- Sync output will match the display refresh rate.
- **Do not** attach to a sync generator if used in output mode. We may damage the generator.



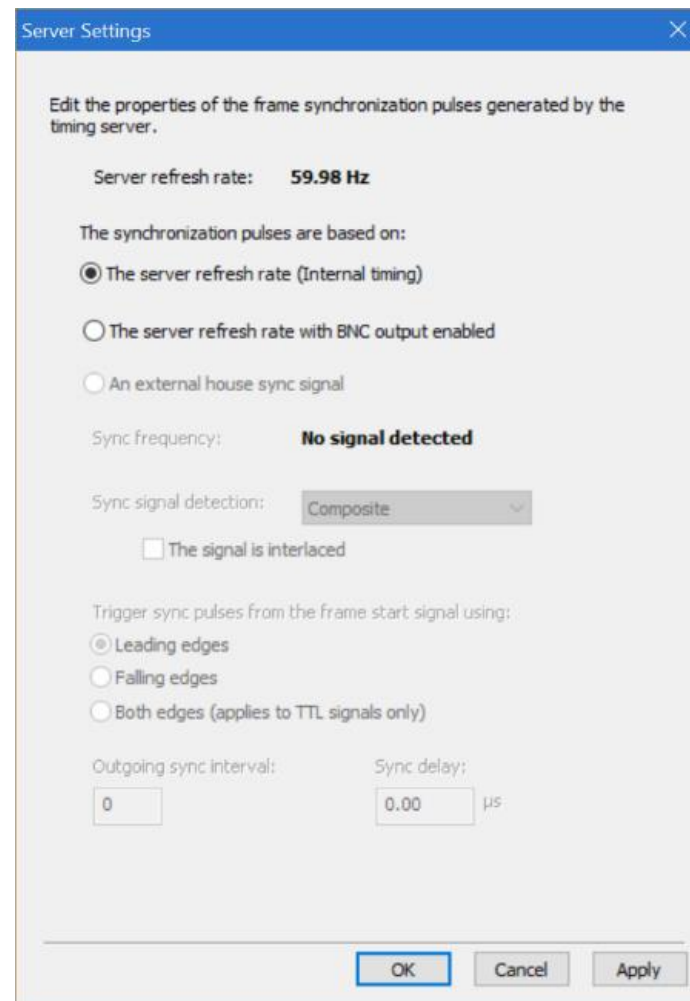
SYNC Output



EXTERNAL SYNC

BNC Output

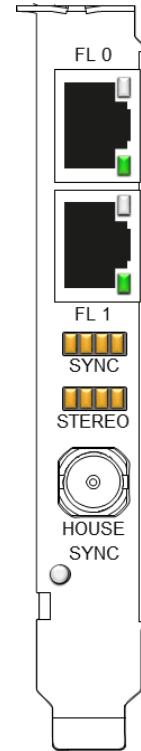
1. Open the NVIDIA Control Panel.
2. Select Synchronize Displays.
3. Click The timing server is “On this system” radio button.
4. Click the **Server Settings** button.
5. Select **The server refresh rate with BNC output enabled**.
6. Adjust the other options as needed.
7. Select OK.



CHECKING SYNC STATUS

LEDs on Board

- Frame Lock Sync & Stereo Phase per GPU
- House/External Sync
 - Solid **Green** - Present
 - Flashing **Green** - Active
- Frame Lock connectors (CAT5)
 - Amber **Output**
 - Green **Input**



Control Panel

System Topology Viewer provides per display sync information

automated computer con... (1 of 2)		
Display state	Server	
Resolution, refresh rate	1920 x 2160 pixels, 49.996 Hz	
	Horizontal (2200)	Vertical (2300)
Active	1920	2160
Border	0	0
Front porch	13	8
Sync width	140	10
Back porch	127	122
Polarity	Negative (-)	Negative (-)
Timing	The display is locked to an internal timing signal ←	
EDID source	Monitor...	
OS Screen Identifier	1	

HELP & RESOURCES

User Manual: <http://www.nvidia.com/object/quadro-sync.html>

Email: QuadroSVS@nvidia.com

