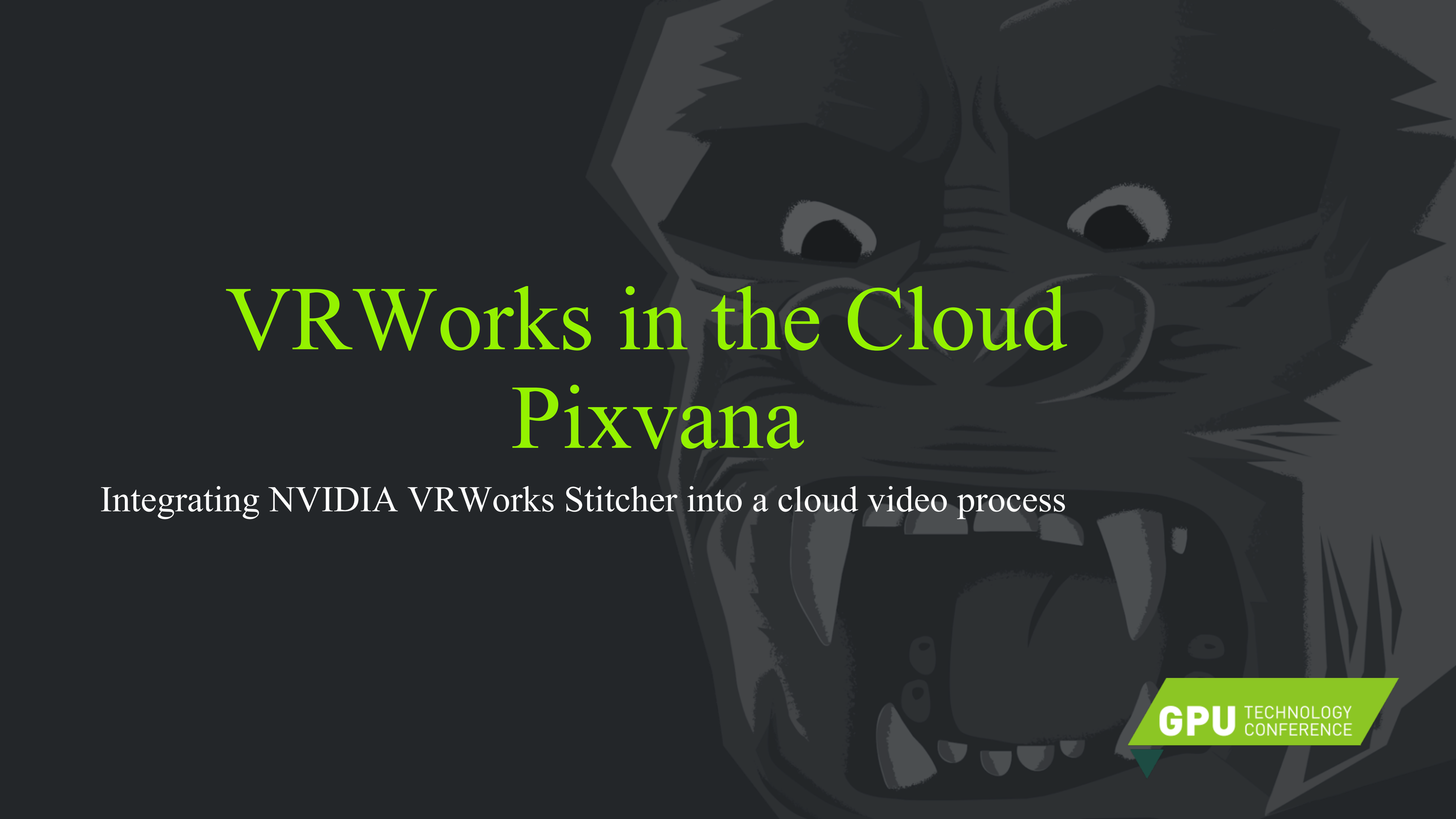
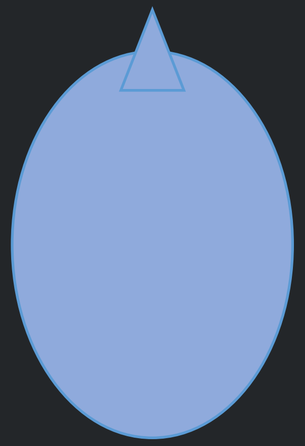


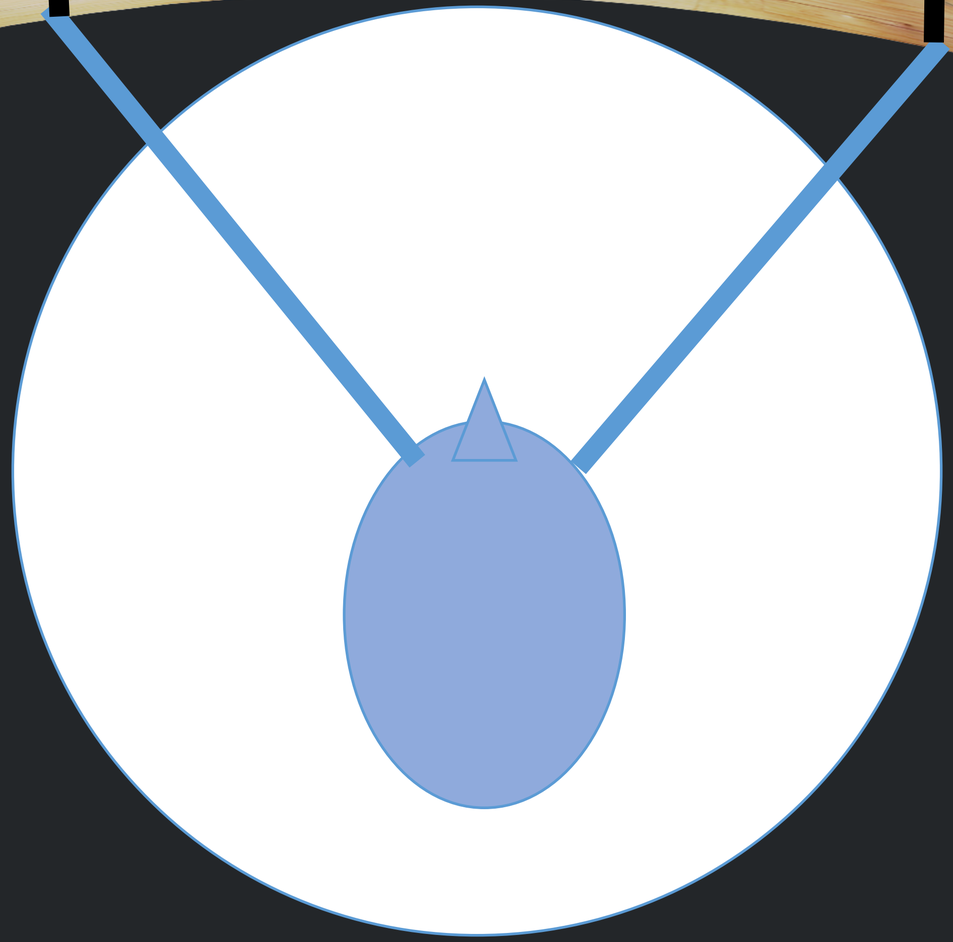
VRWorks in the Cloud
Pixvana

Integrating NVIDIA VRWorks Stitcher into a cloud video process

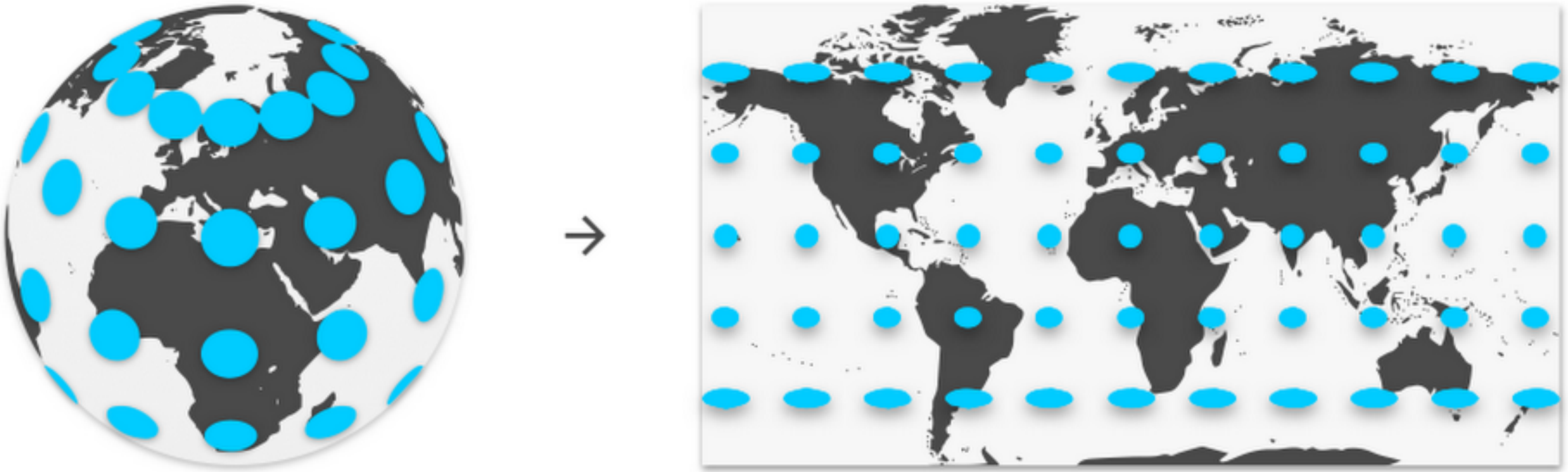
Scott Squires
Pixvana CTO/CD and Co-Founder



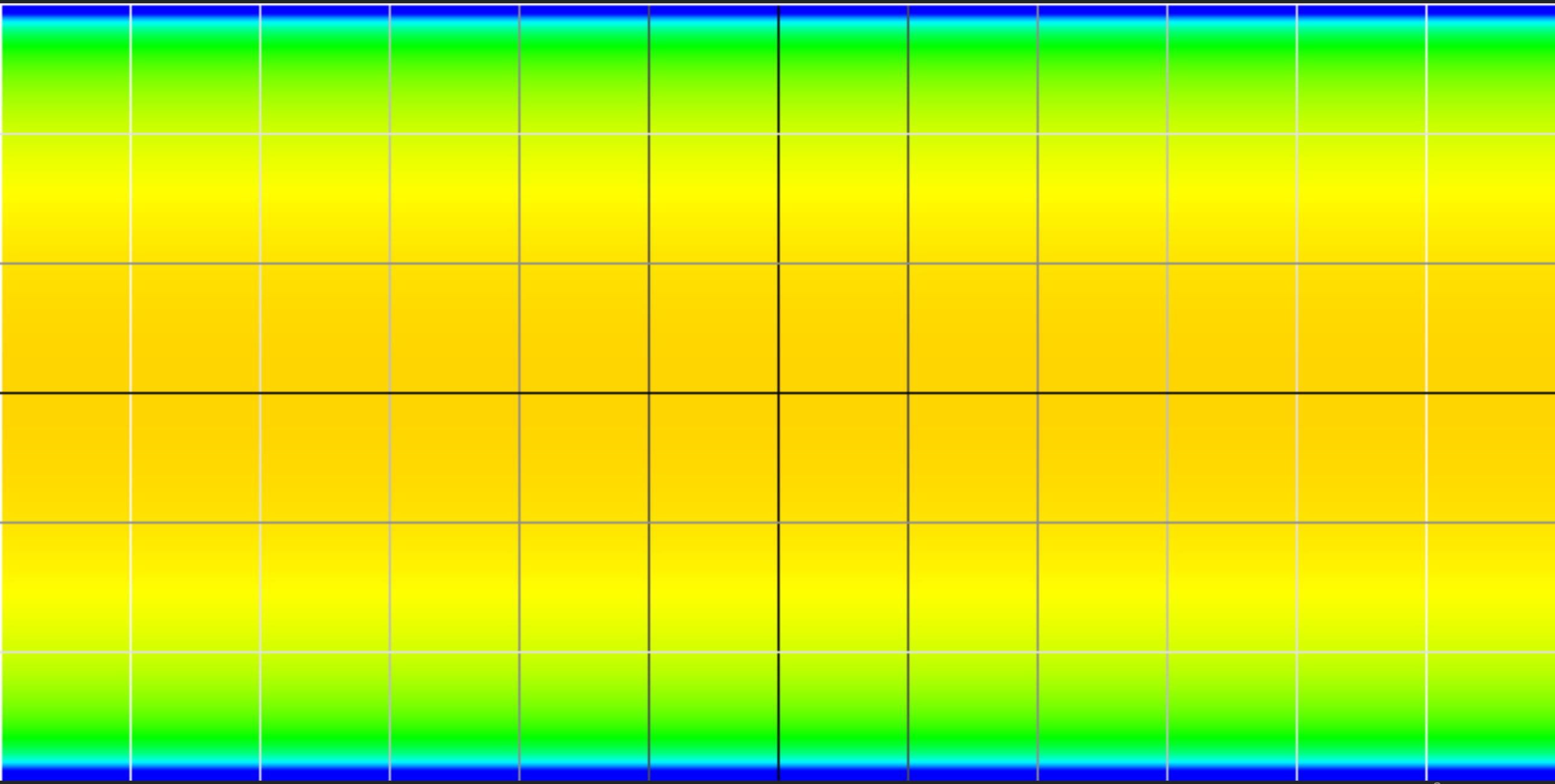
3840 x 1920



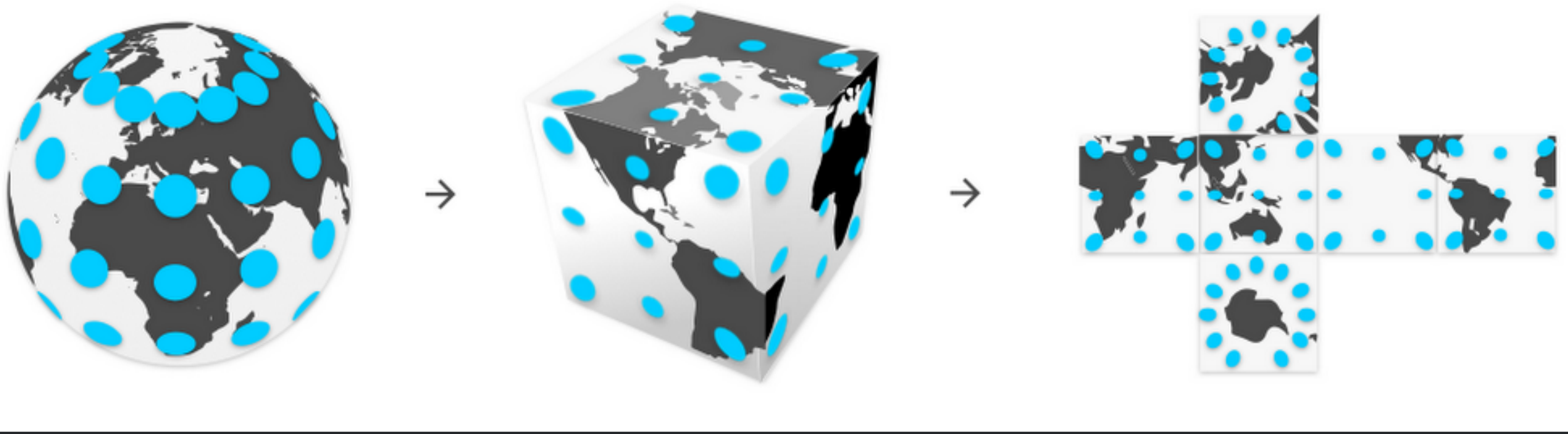
90 degrees FOV
= 960 pixels



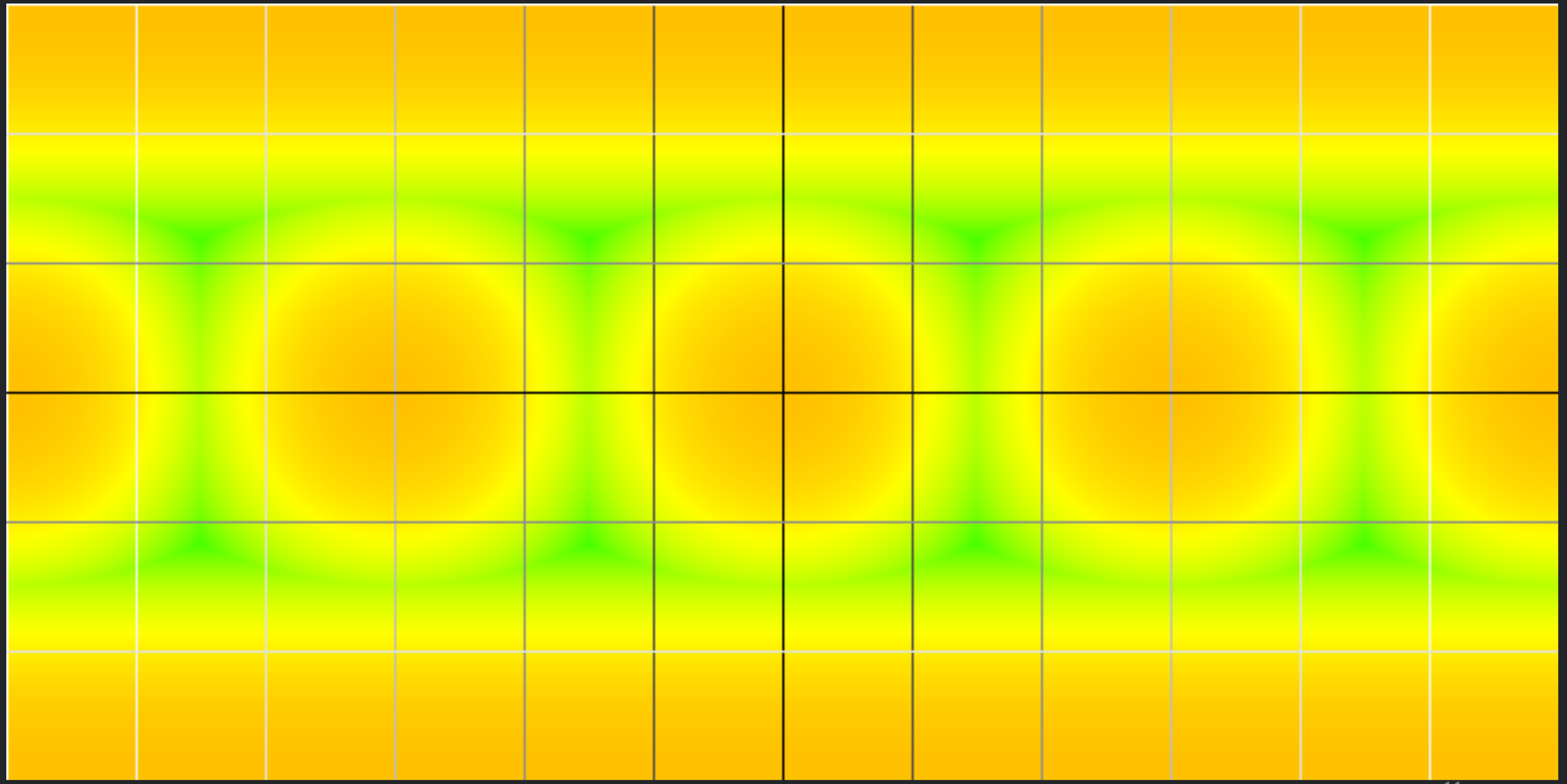
https://blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/



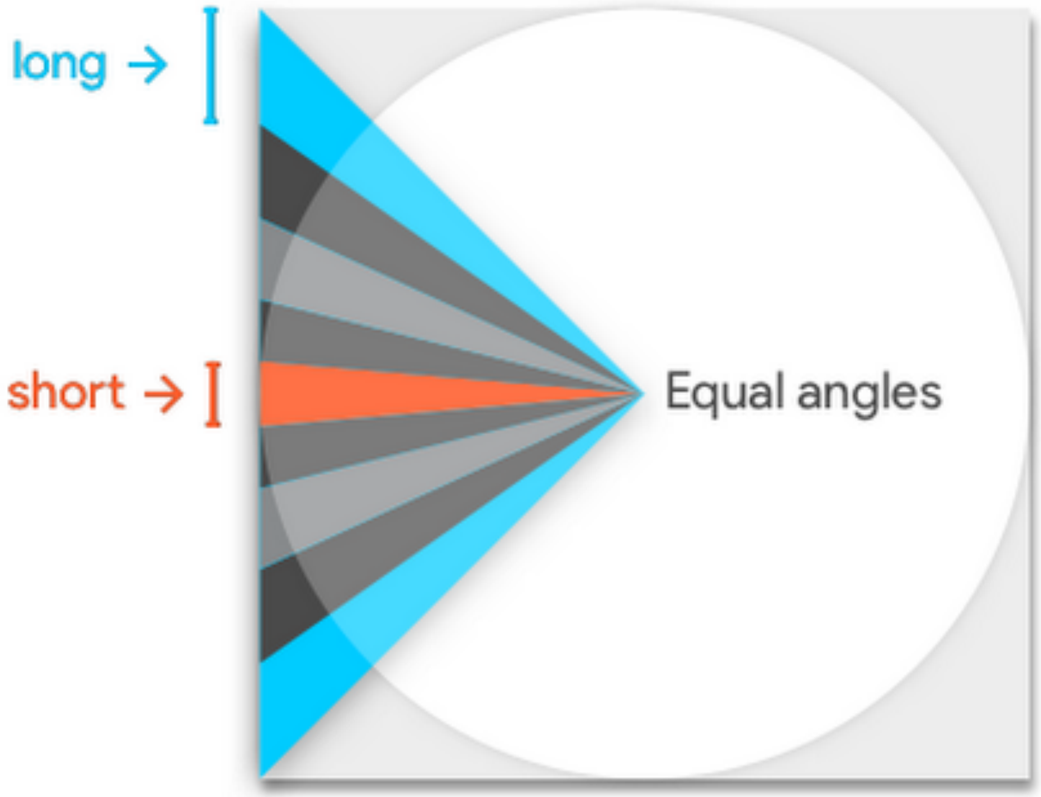
https://youtube-eng.googleblog.com/2017/03/improving-vr-videos.html



https://blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/



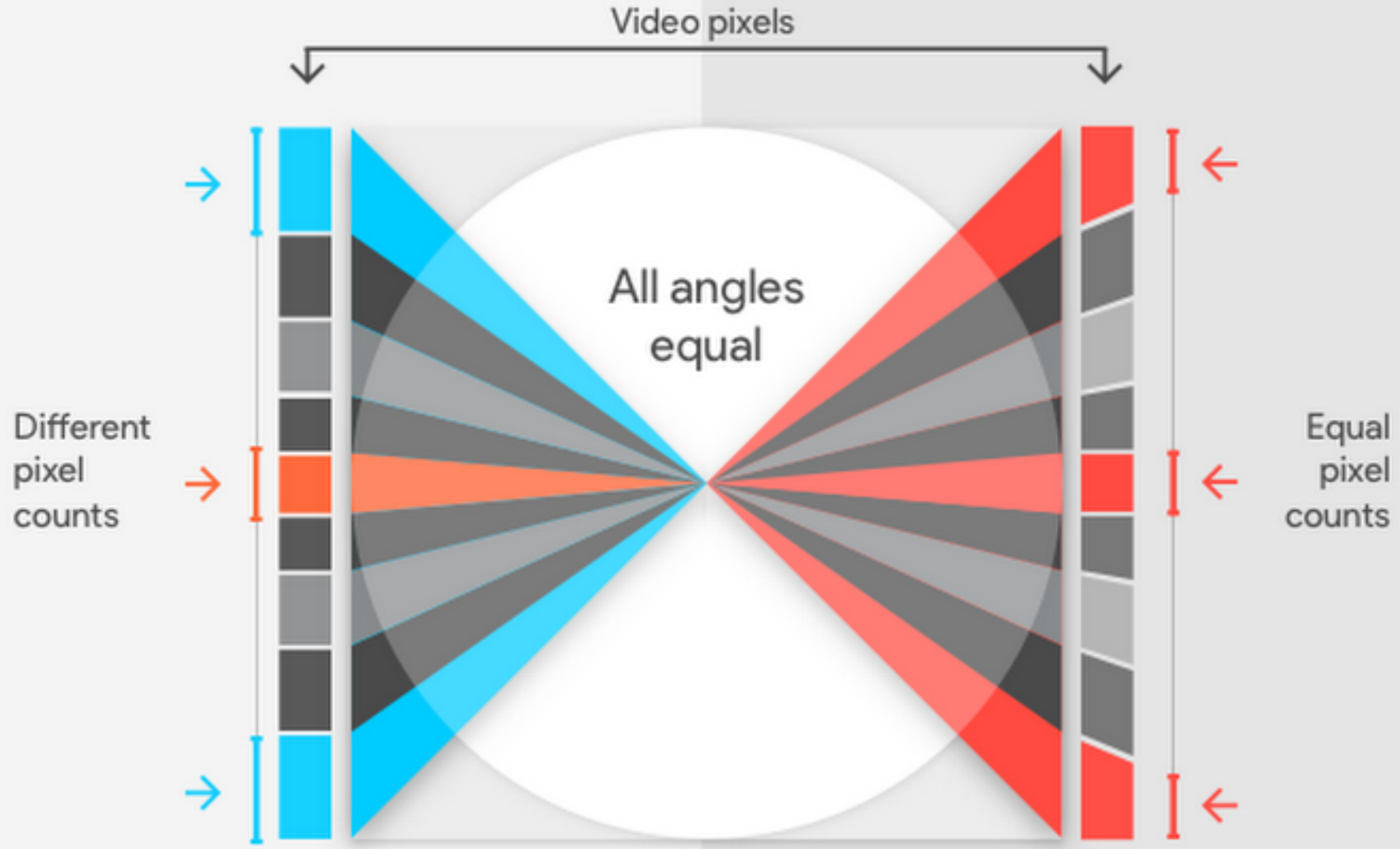
https://youtube-eng.googleblog.com/2017/03/improving-vr-videos.html



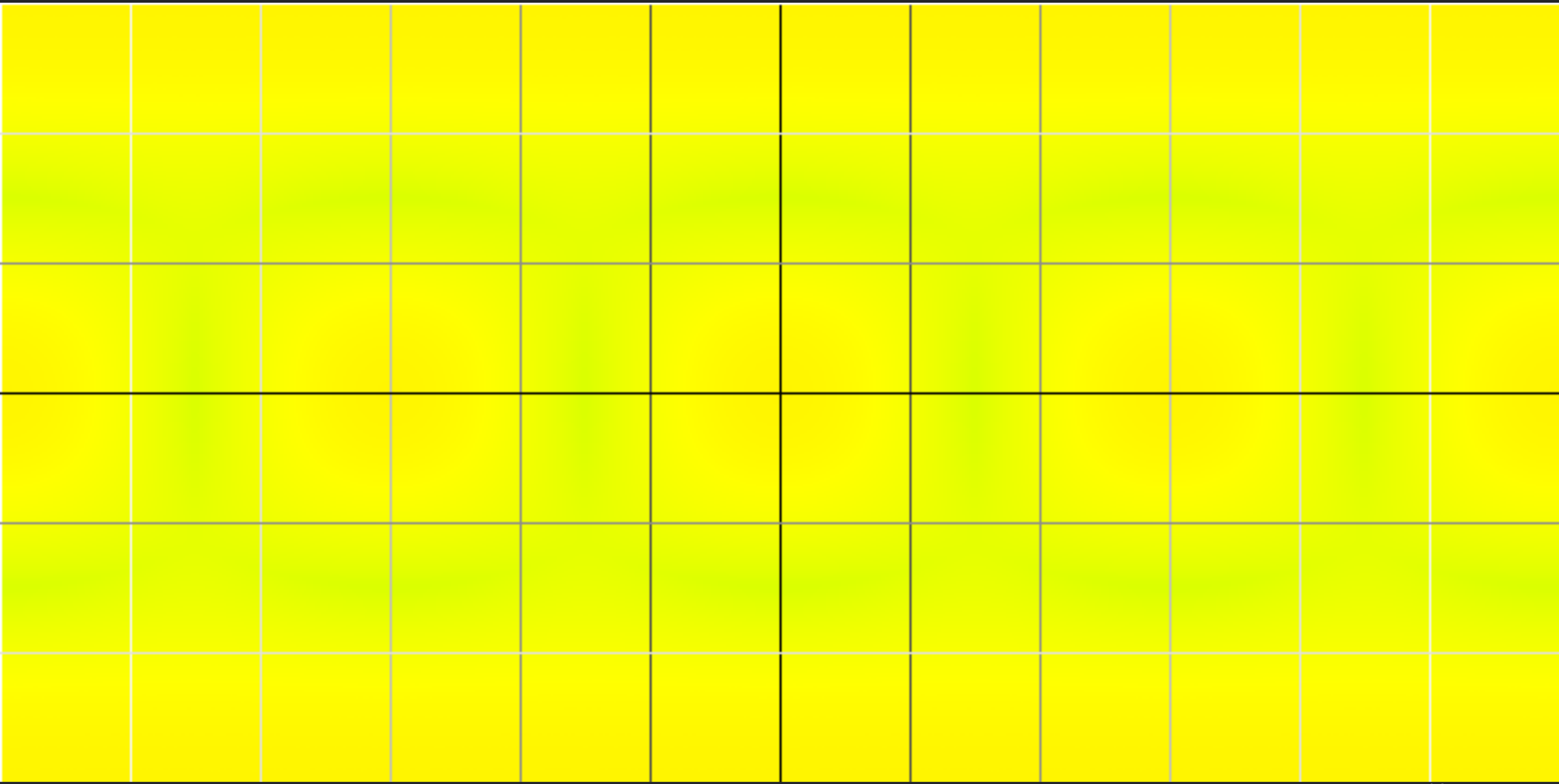
https://blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/

Standard Cubemap

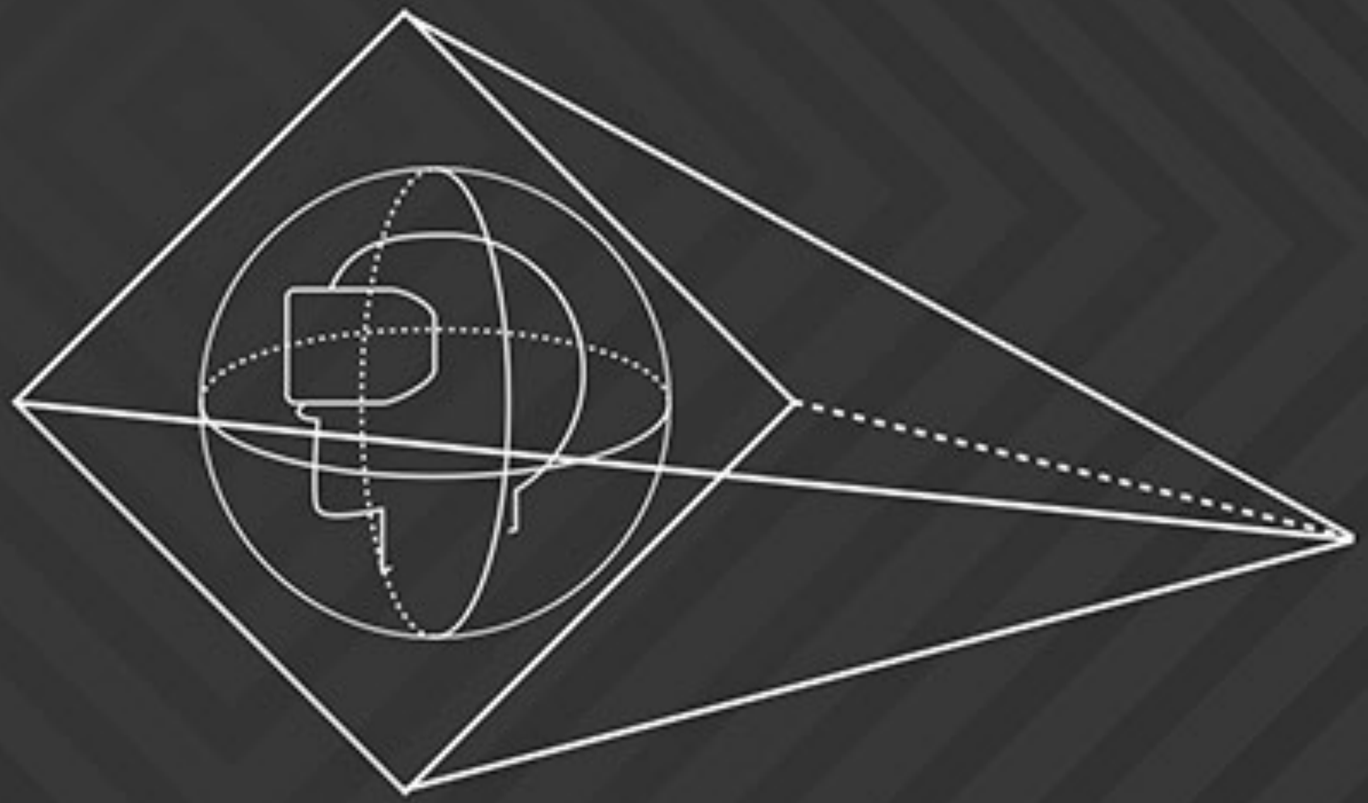
Equi-Angular Cubemap



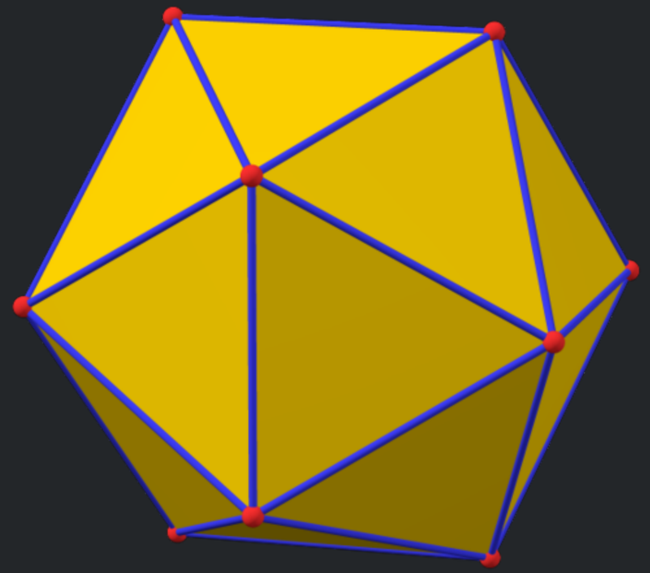
https://blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/



https://youtube-eng.googleblog.com/2017/03/improving-vr-videos.html



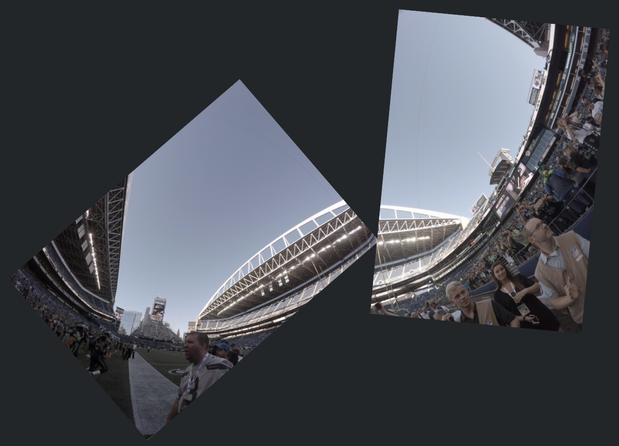
https://code.fb.com/virtual-reality/next-generation-video-encoding-techniques-for-360-video-and-vr/



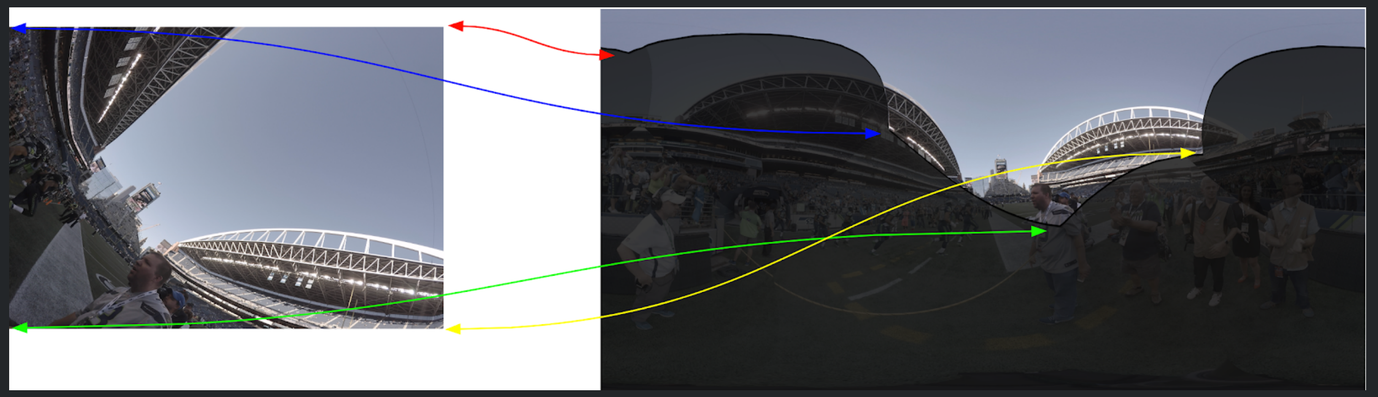
Icosahedron

Tiling

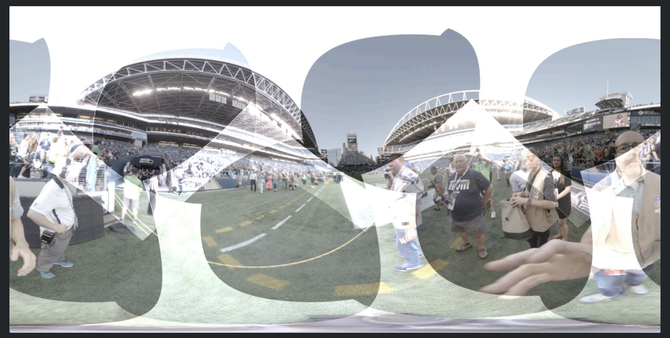
Step 1: Gather the videos (2+ sources)



Step 2: Camera Calibration and Warp



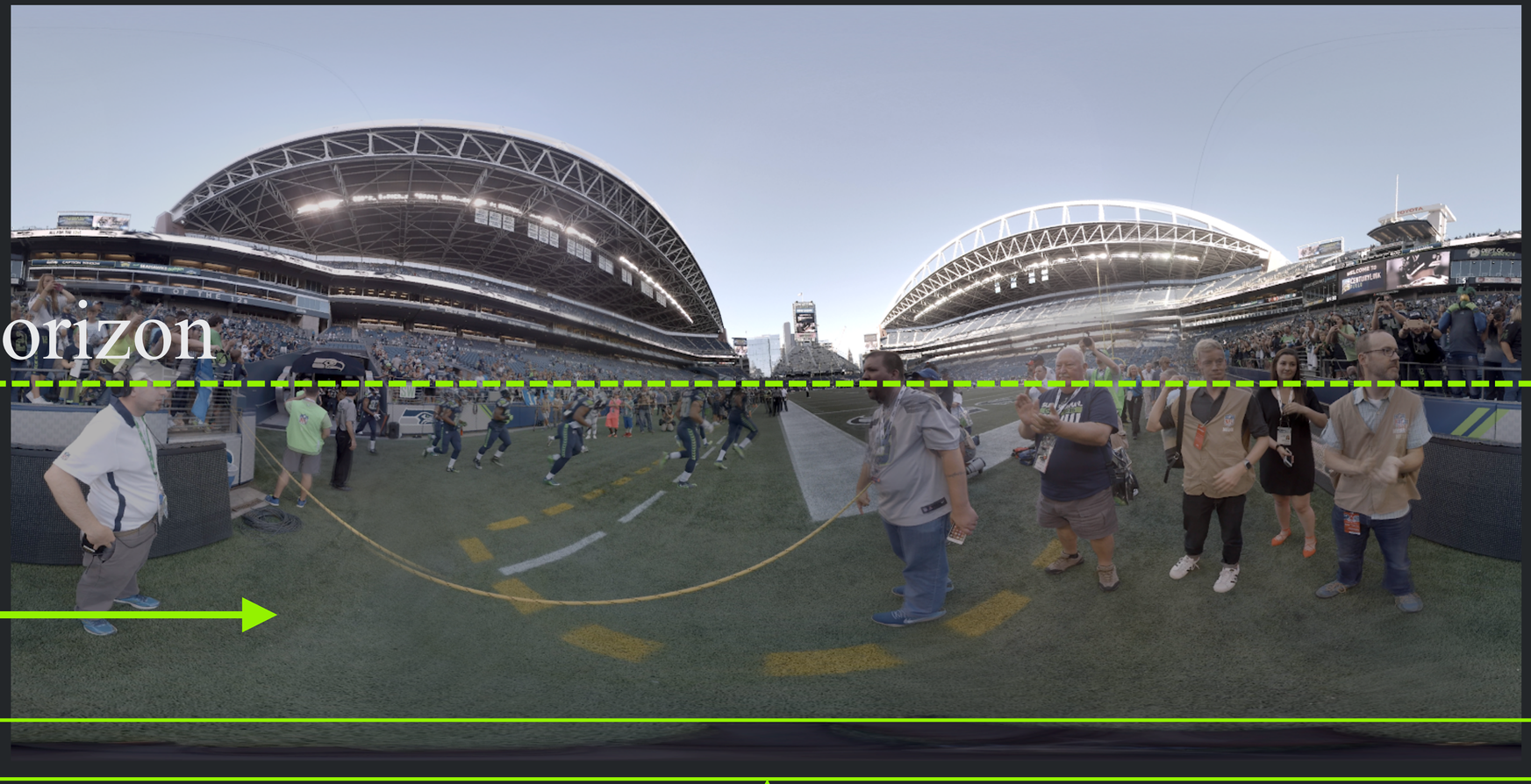
Step 3: Composite Graph and Exposure Balancing

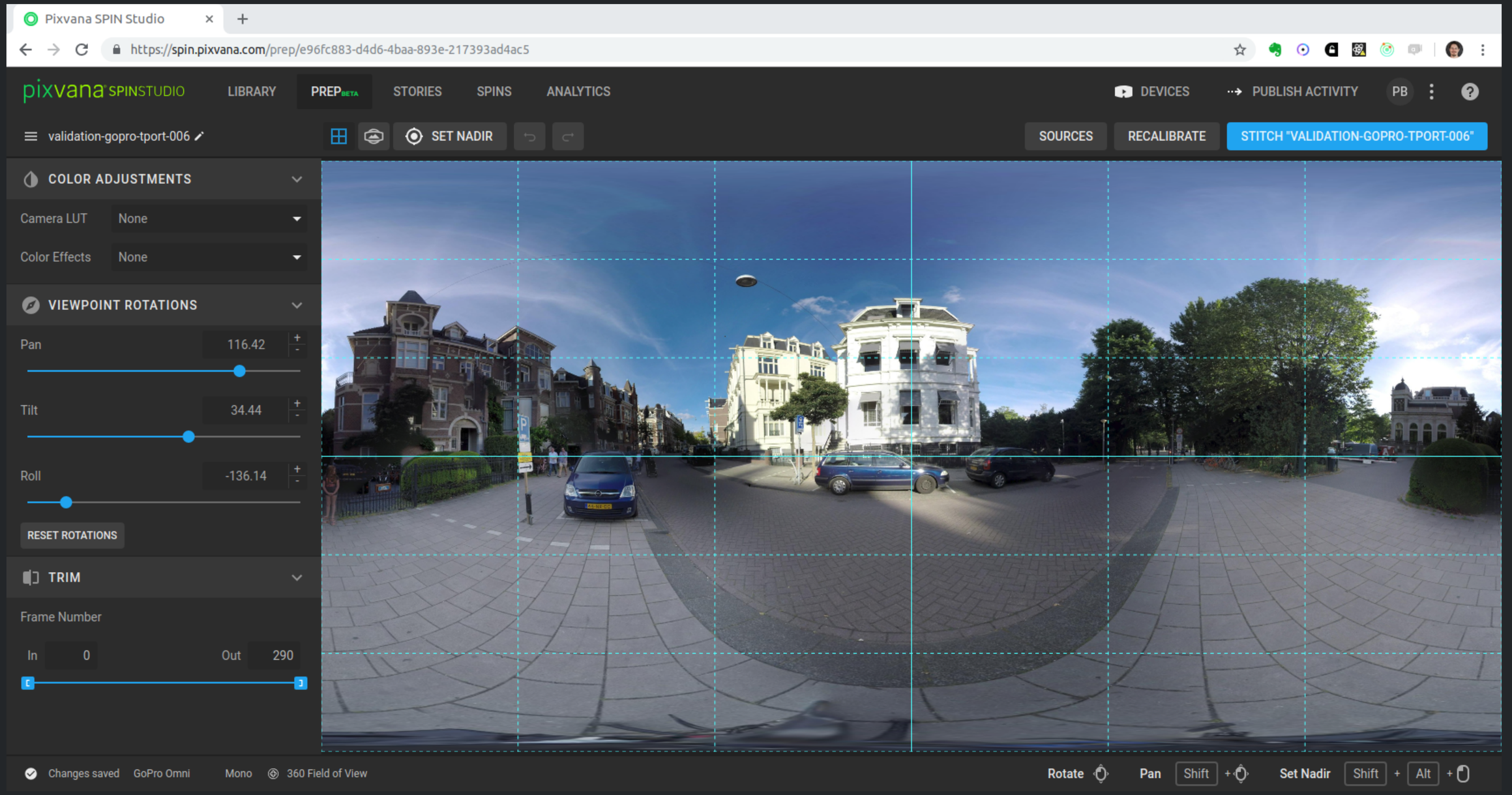


Step 4: Level Horizon

Step 5: Color Correction

Step 6: Patch Nadir



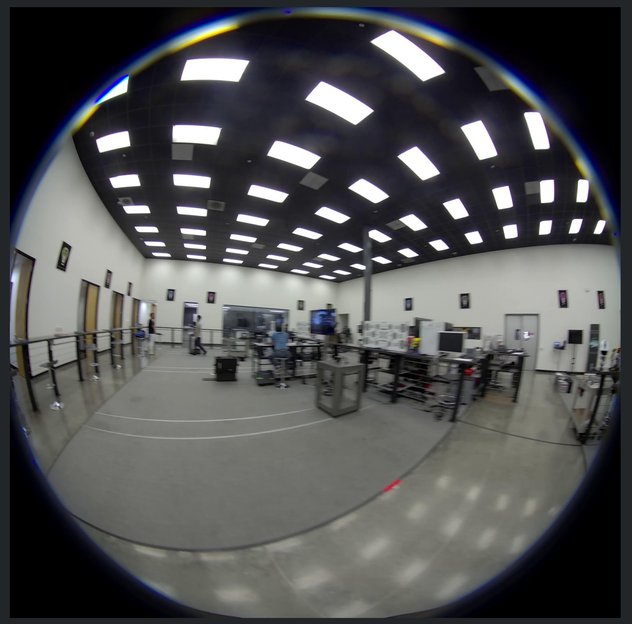

Pixvana SPIN Studio
https://spin.pixvana.com/prep/e96fc883-d4d6-4baa-893e-217393ad4ac5
pixvana SPINSTUDIO
LIBRARY
PREP BETA
STORIES
SPINS
ANALYTICS
DEVICES
PUBLISH ACTIVITY
PB
validation-gopro-tport-006
SET NADIR
SOURCES
RECALIBRATE
STITCH "VALIDATION-GOPRO-TPORT-006"
COLOR ADJUSTMENTS
Camera LUT
None
Color Effects
None
VIEWPOINT ROTATIONS
Pan
116.42
Tilt
34.44
Roll
-136.14
RESET ROTATIONS
TRIM
Frame Number
In
0
Out
290
Changes saved
GoPro Omni
Mono
360 Field of View
Rotate
Pan
Shift
Set Nadir
Shift
Alt

Factors that make for a challenging stitch

Too dark

Too bright

Motion blur



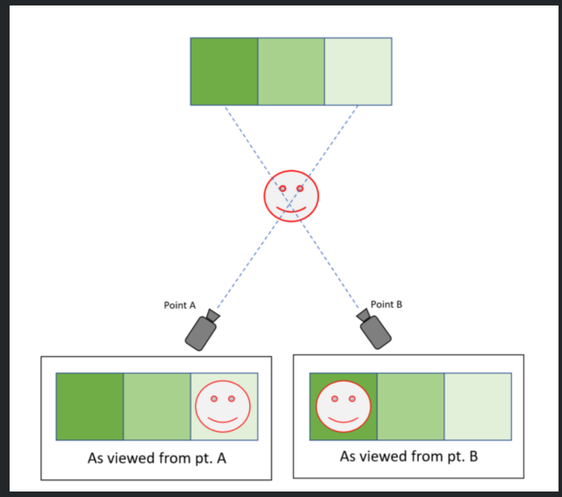
Subject too close to camera

Obscured or missing camera, or camera stops recording too early

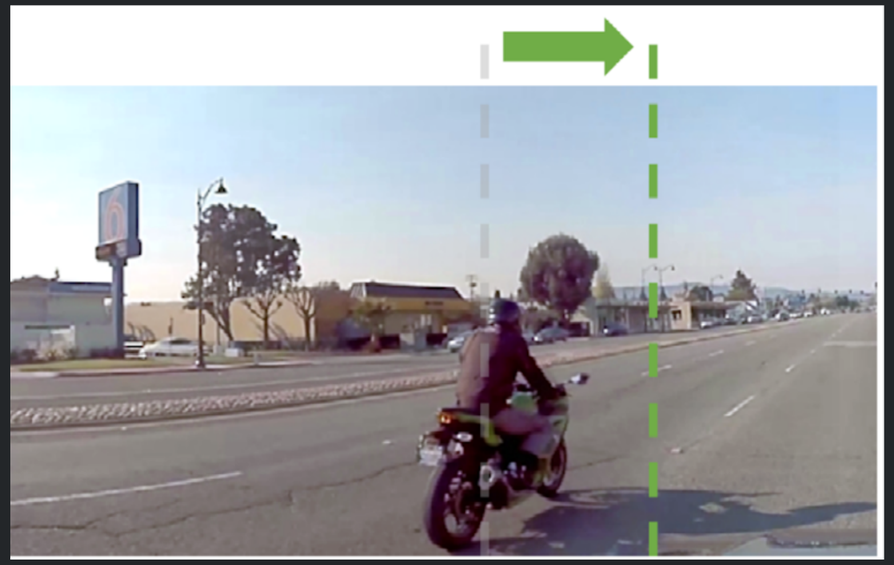
Providing incorrect source during stitching

What's new: NVIDIA VR Works SDK 2.0

Depth-based alignment



Manually adjustable stitch lines

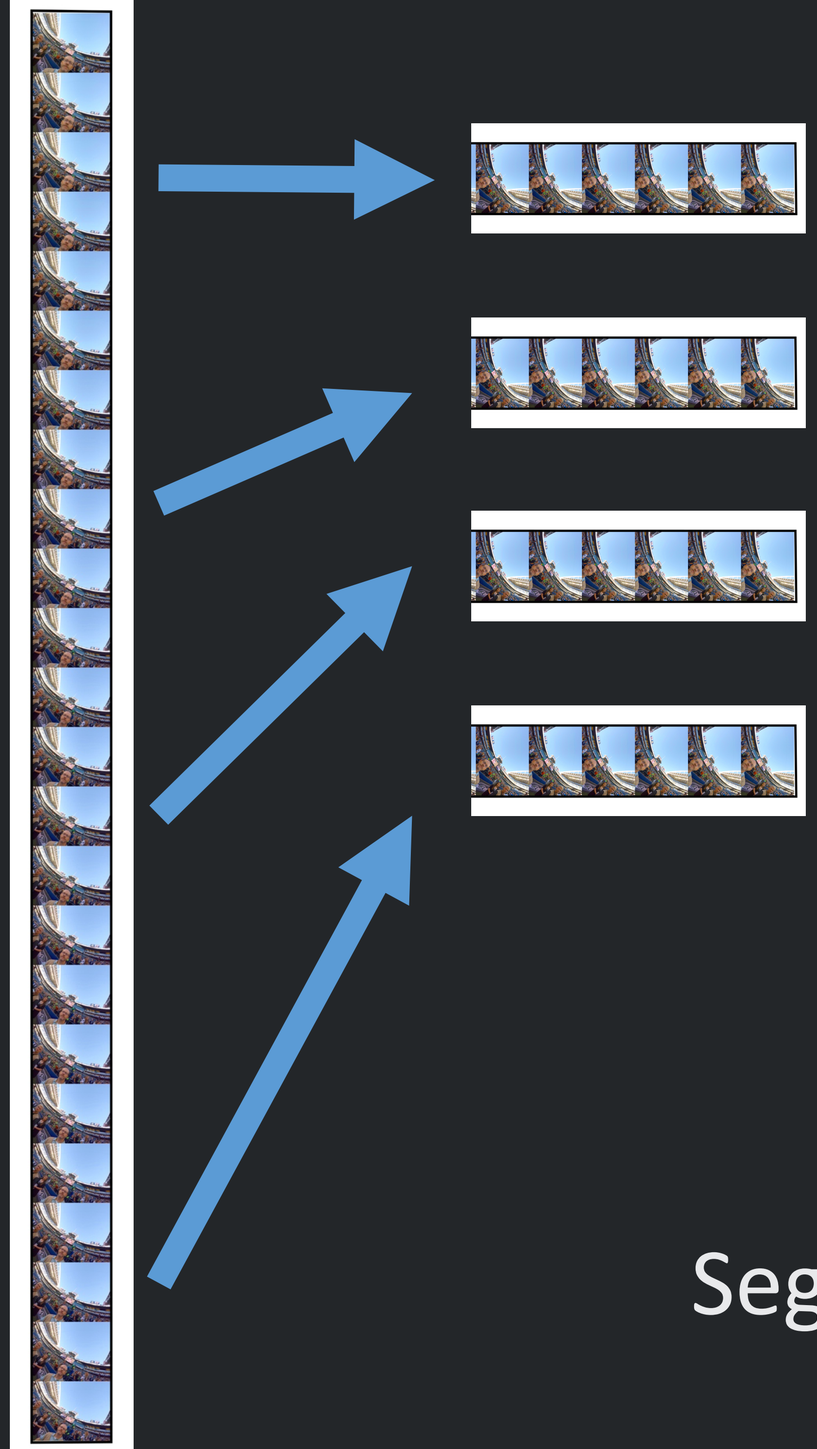


Pixvana SPIN Studio cloud processing

SPIN Studio stitches and encodes in parallel with up to 80 GPU-enabled machines running Linux on AWS/Azure.

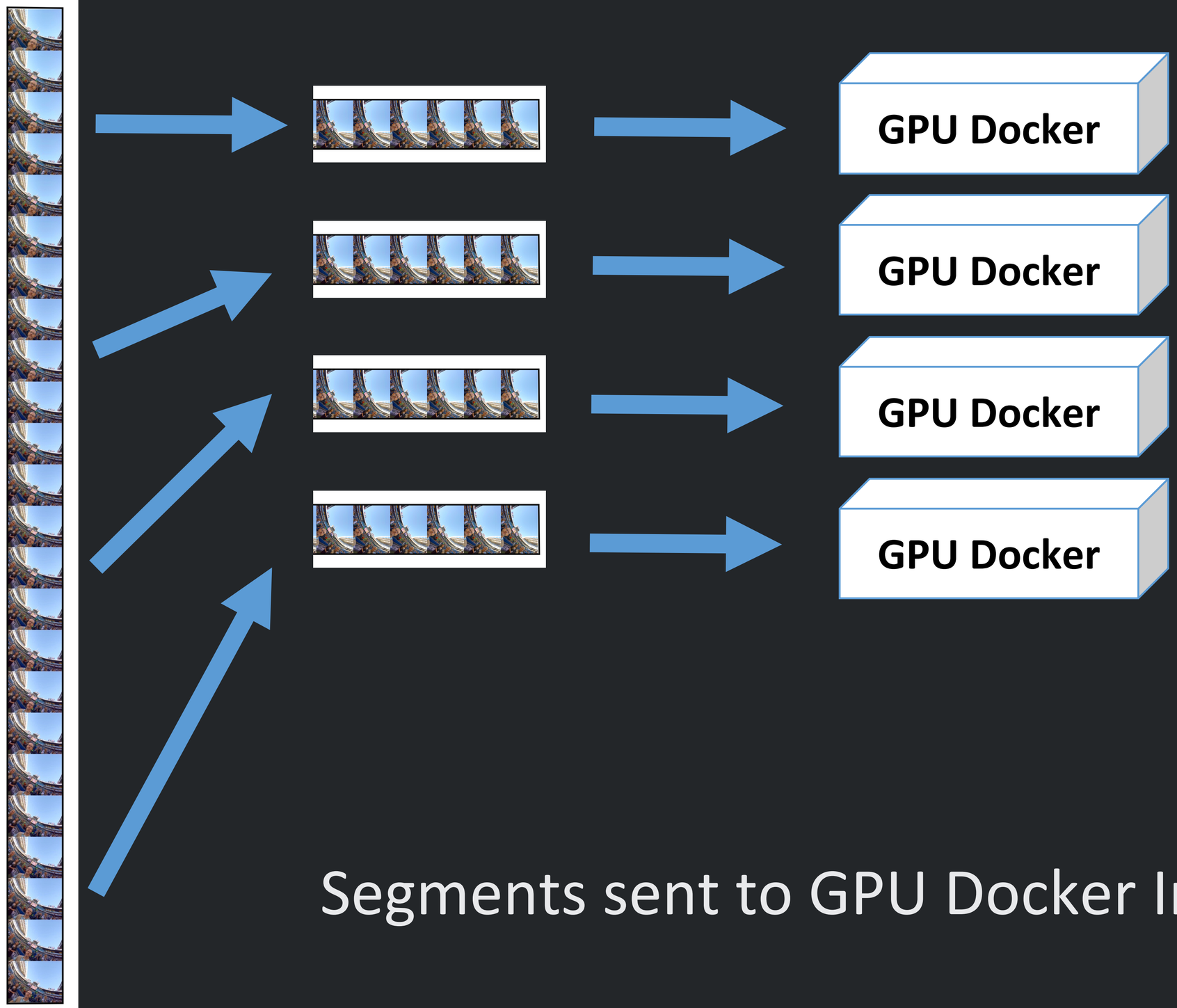
Full Video

Full Video

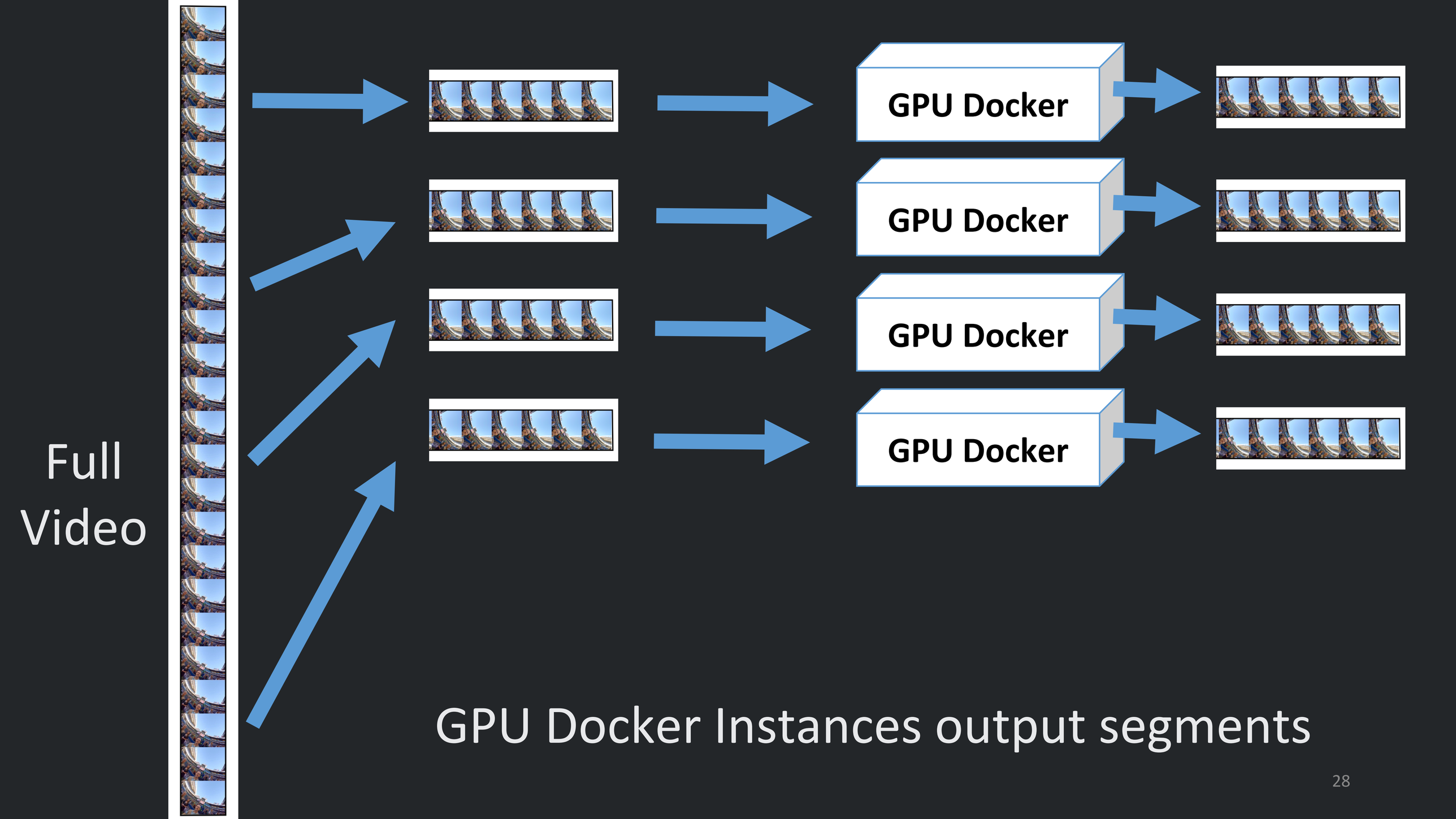


Segmented

Full Video

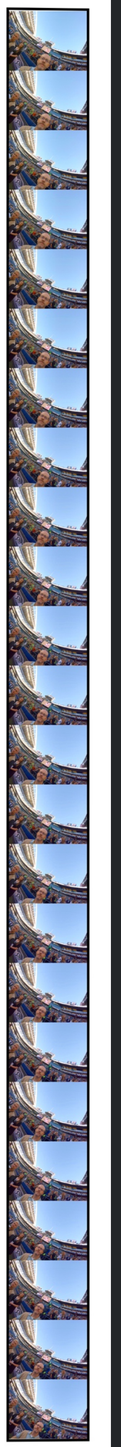


Segments sent to GPU Docker Instances



GPU Docker Instances output segments

Processed segments combined



Finished Full Video

Pixvana SPIN Studio cloud processing

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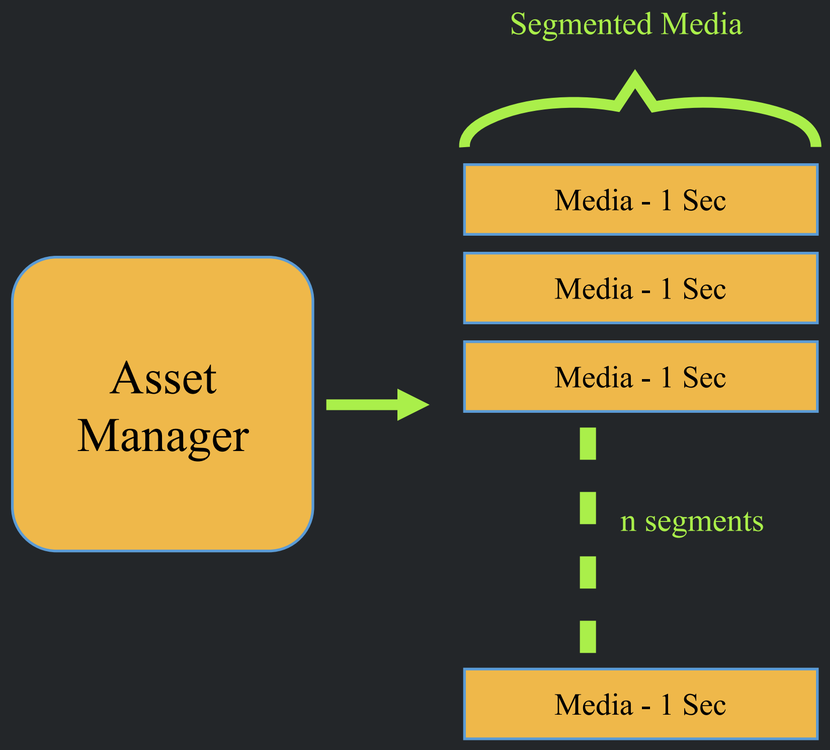

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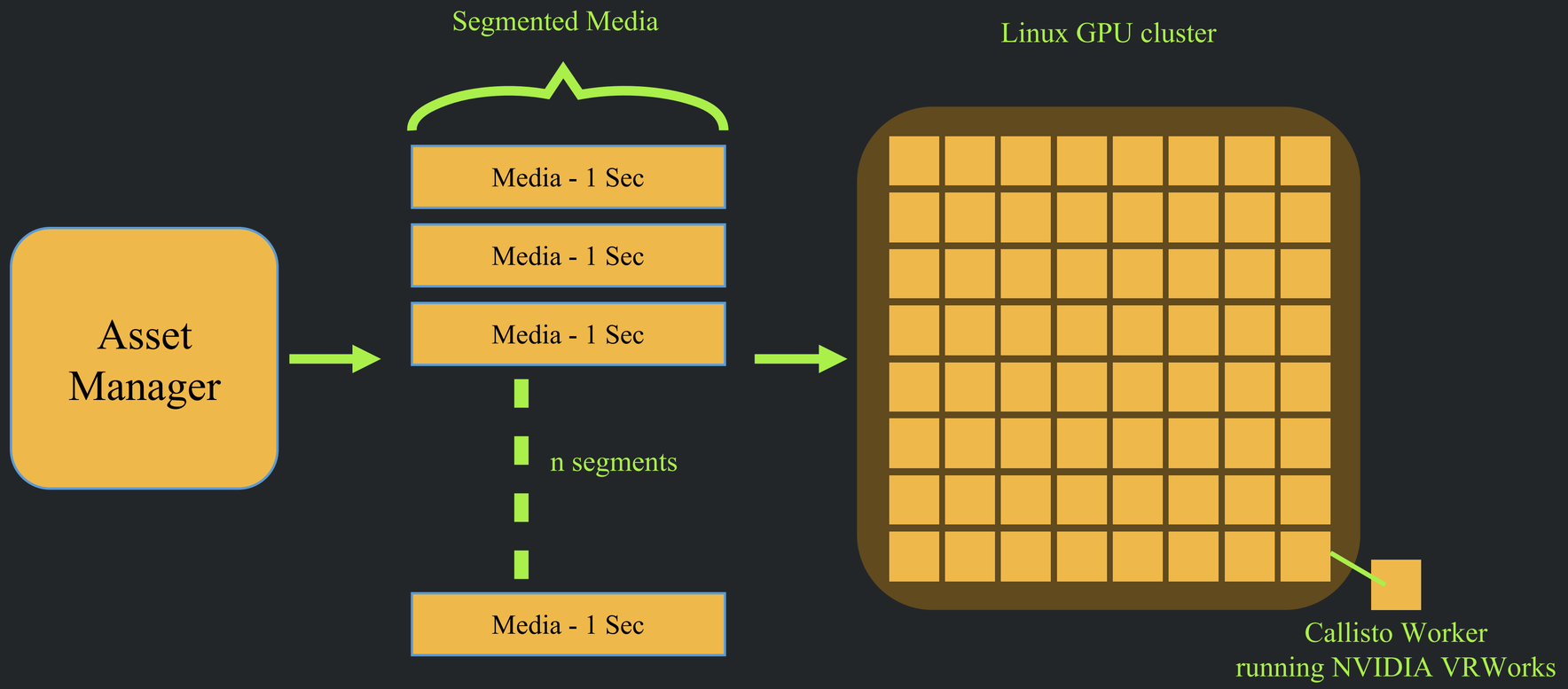

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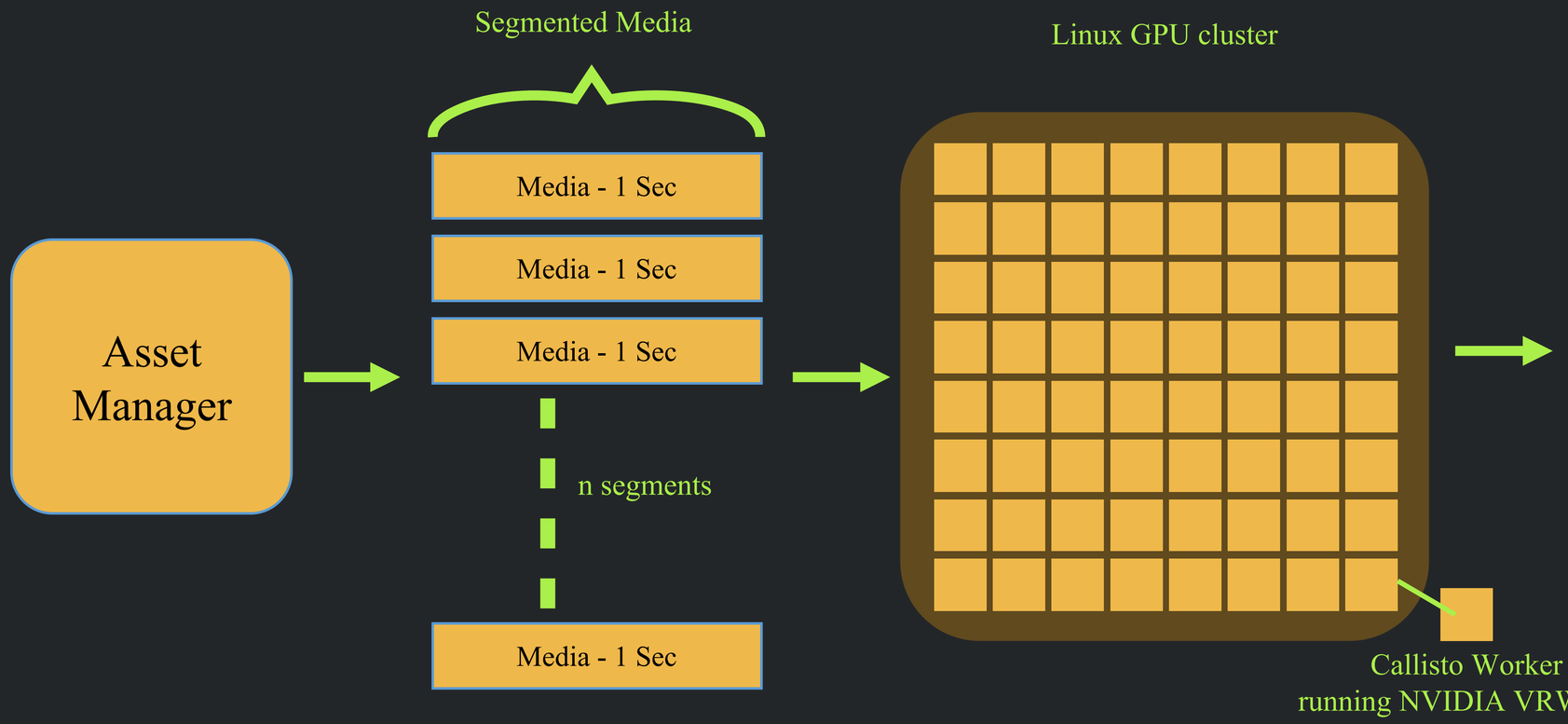

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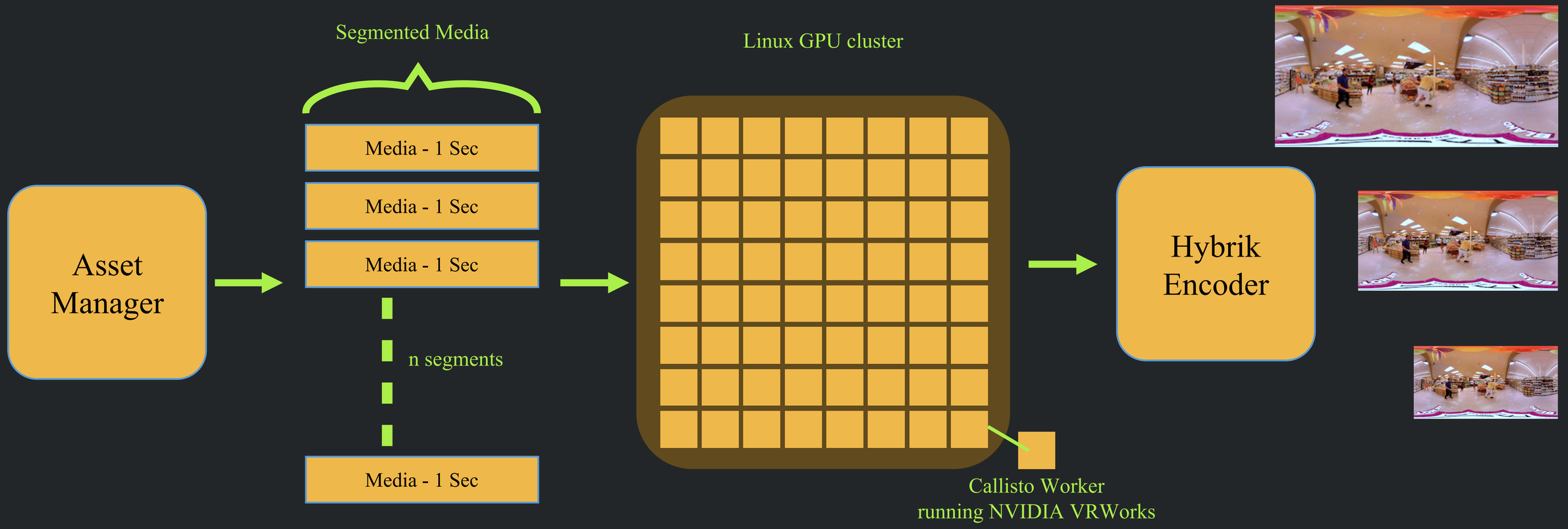

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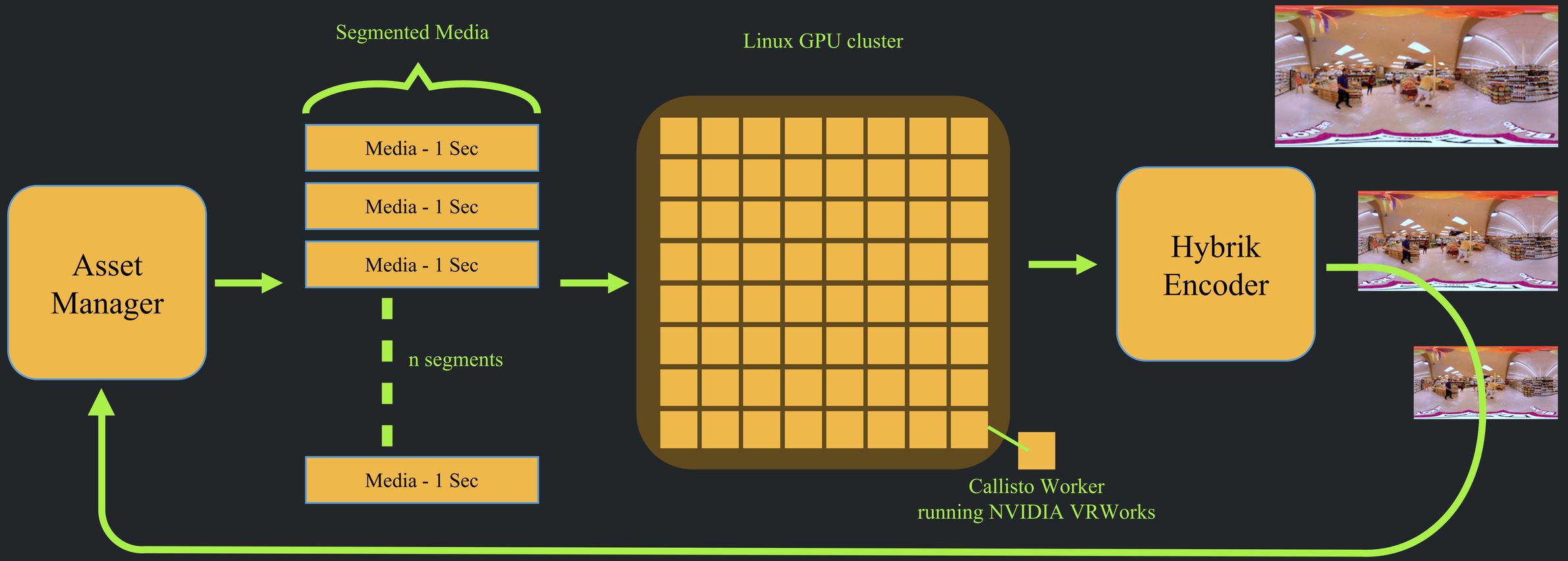
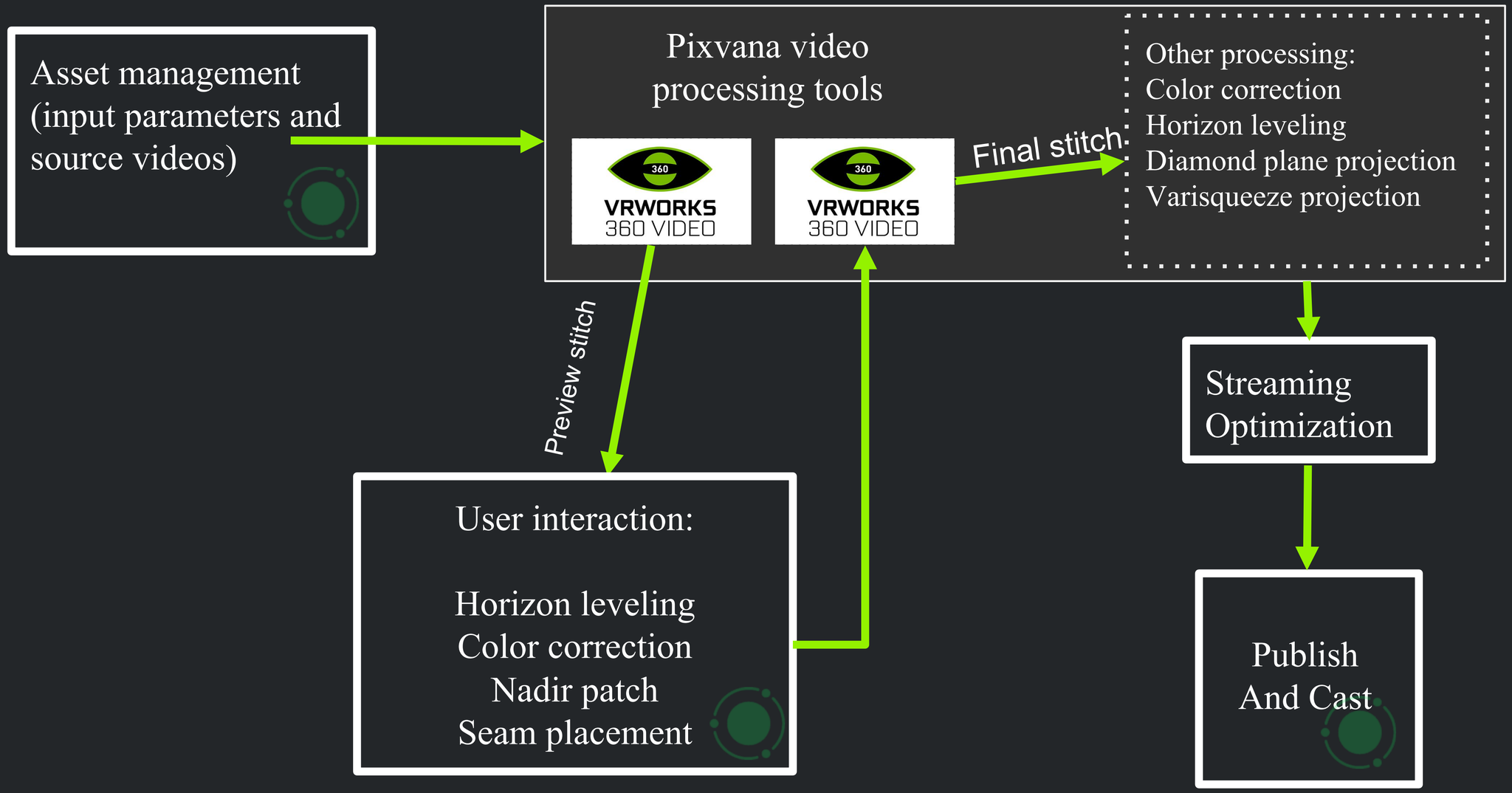



Callisto
(C++ CUDA)
VRWorks
360 Video
SDK
OpenCV
ffmpeg
Docker

Spin Studio stitching with VRWorks 360 Video



VRWorks

Set of APIS, libraries and engines specific to VR usages.
3 main categories are:

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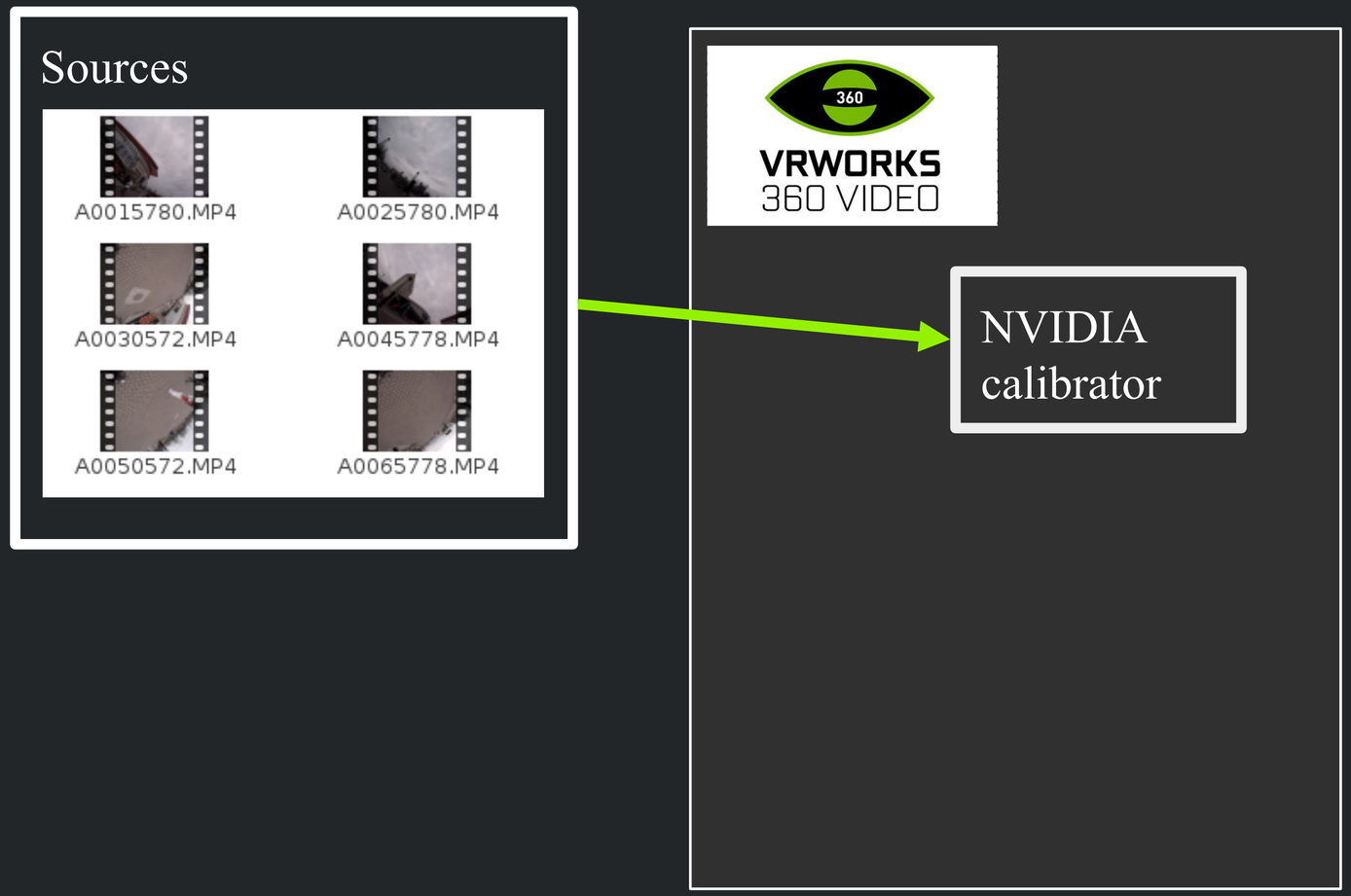
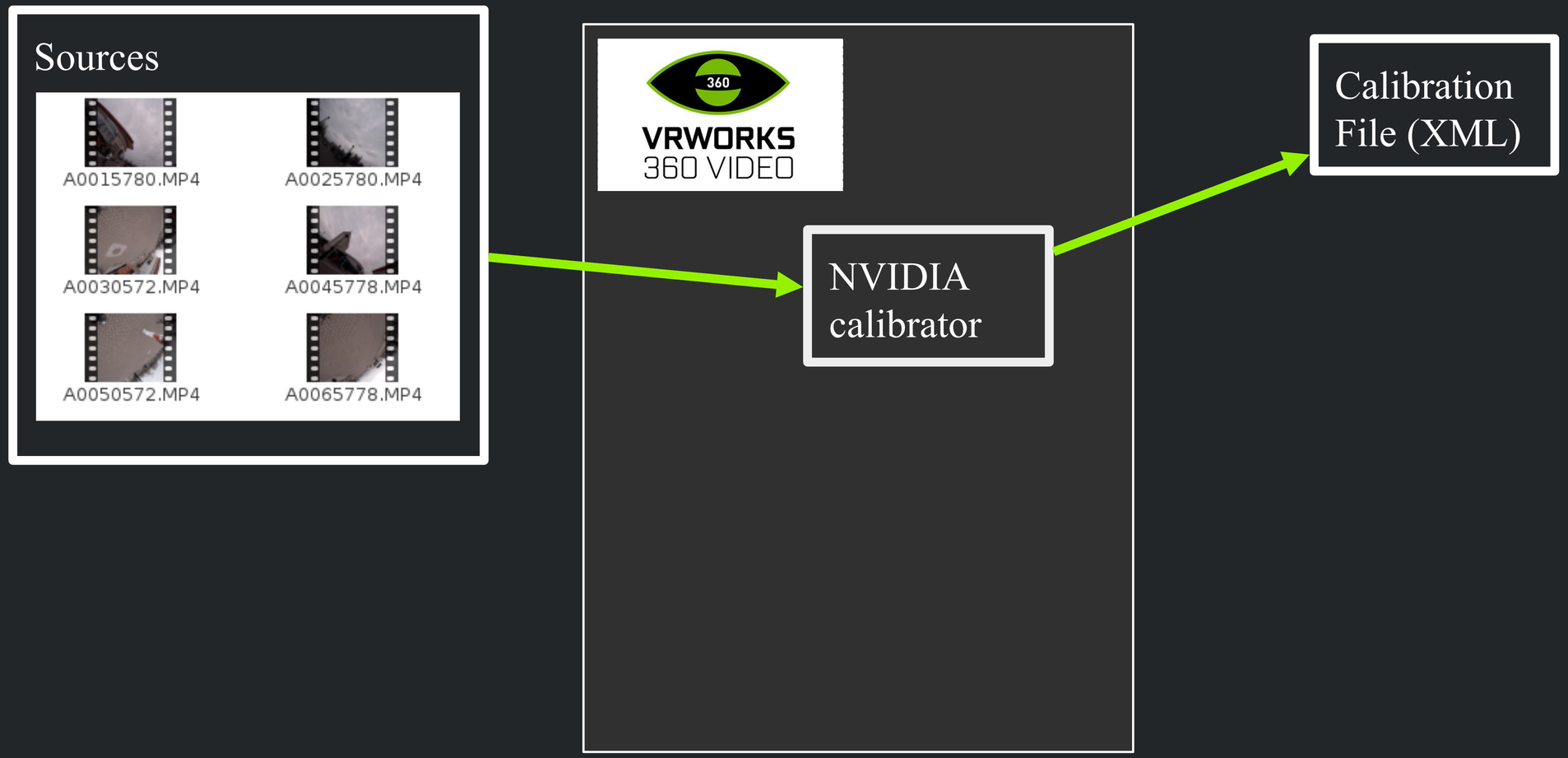
Set of APIS, libraries and engines specific to VR usages.
3 main categories are:

- Graphics SDK
- 360 Video SDK
- Spatialized Audio SDK

Pixvana Video Processing Tools

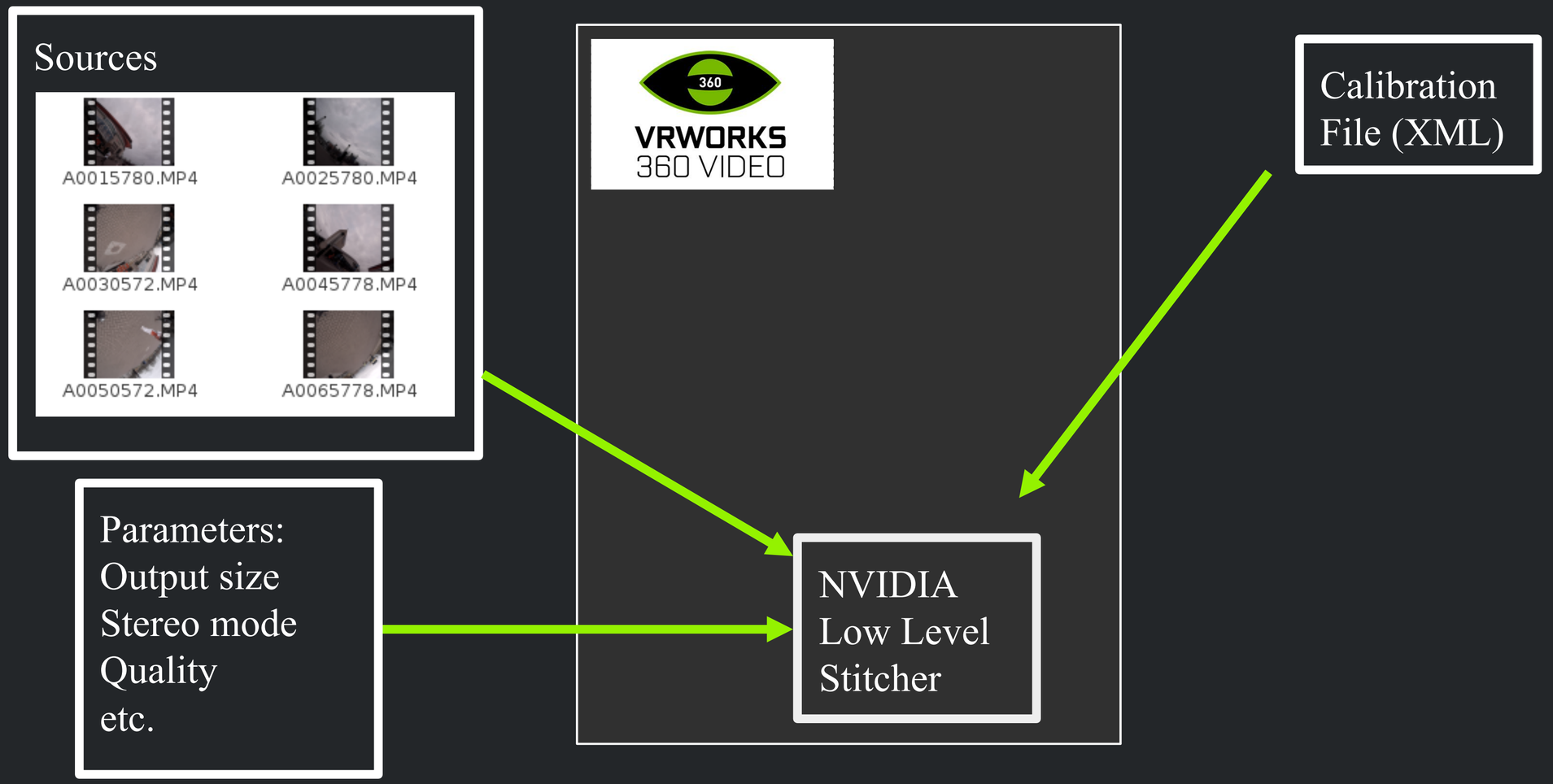


Pixvana Video Processing Tools



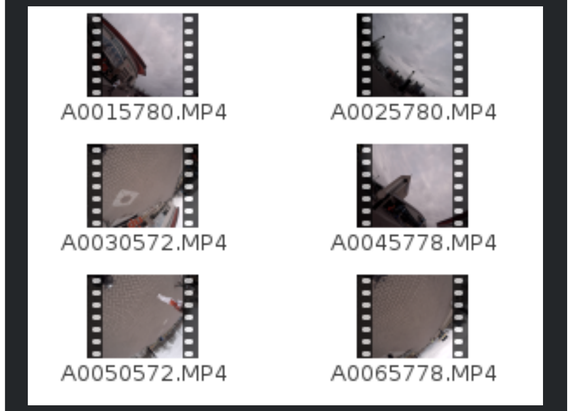
```
                    // for now, this is 1, but it is possible to increase it
DEV_LOG("Creating calibration instance.");
verifyResult(
    nvcalibCreateInstance(framesCount, camCount, &hInstance),
    hInstance,
    "create calibration instance");

DEV_LOG("Setting rig properties.");
verifyResult(
    nvcalibSetRigProperties(hInstance, &calResult.videoRig_), hInstance, "set rig properties");

DEV_LOG("Setting calibration options.");
setCalibrationOptions(hInstance, calOptions);

DEV_LOG("Setting images.");
setCalibrationImages(hInstance, calResult.videoRig_, calImages);

DEV_LOG("Starting VRWorks calibration.");
verifyResult(nvcalibCalibrate(hInstance), hInstance, "VRWorks calibration");

DEV_LOG("Retrieving rig properties.");
verifyResult(
    nvcalibGetRigProperties(hInstance, &calResult.videoRig_),
    hInstance,
    "retrieve rig calibration properties");

verifyResult(
    nvcalibDestroyInstance(hInstance), hInstance, "destroy VRWorks calibration instance");
```

Pixvana Video Processing Tools



Pixvana Video Processing Tools

Sources



VRWORKS 360 VIDEO

Calibration File (XML)

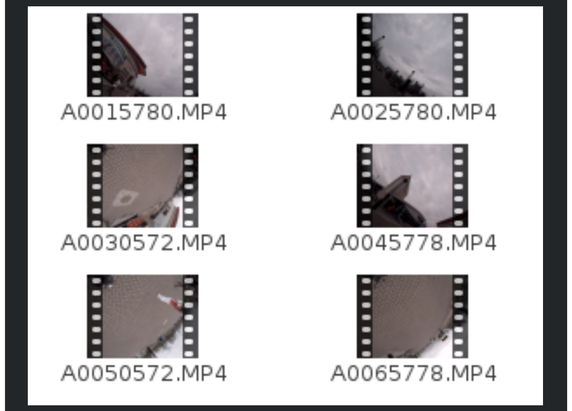
Parameters:
Output size
Stereo mode
Quality
etc.

NVIDIA Low Level Stitcher

Equirectangular stitch

Pixvana Video Processing Tools

Sources



VRWORKS 360 VIDEO

Calibration File (XML)

Parameters:
Output size
Stereo mode
Quality
etc.

NVIDIA Low Level Stitcher

Equirectangular stitch

Diamond plane & Varisqueeze projections

Bitrate ladder encoding

```
DEV_LOG("initialize stitcher instance.");
nvssVideoHandle stitcher;
nvssVideoCreateInstance(&stitcher_props, &calParams.videoRig_, &stitcher);

DEV_LOG("load the input data onto the GPU");
loadImages2GPU(stitcher, calParams.videoRig_, inputImages);

cudaStreamSynchronize(cudaStreamDefault);

DEV_LOG("Calling nvssVideoStitch");
nvssVideoStitch(stitcher);

cudaStreamSynchronize(cudaStreamDefault);

DEV_LOG("copying output panorama from CUDA buffer.");
if(cudaMemcpy2D( out_stacked , output_image.row_bytes, output_image.dev_ptr, output_image.pitch,
        output_image.row_bytes, output_image.height, cudaMemcpyDeviceToHost) != cudaSuccess)
{
    throwVRWorksError("Error copying output stacked panorama from CUDA buffer");
}

// Clean up
nvssVideoDestroyInstance(stitcher);
```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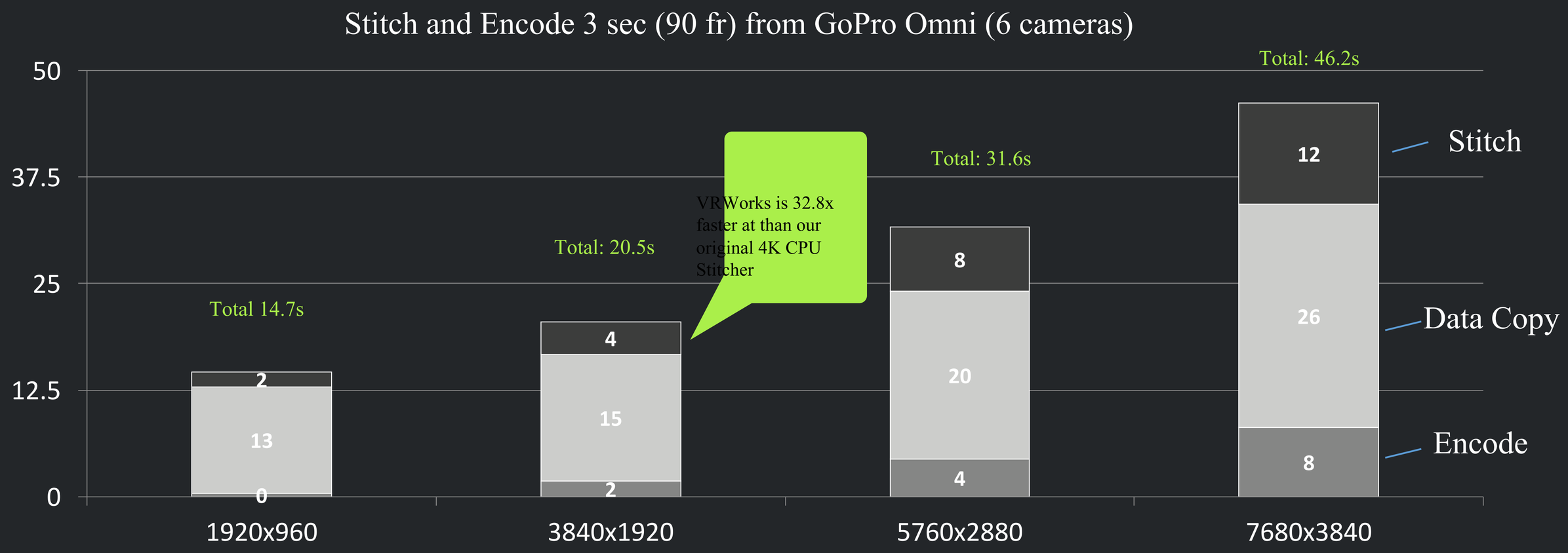
AND PROGRAMS
NOW ON VIEW

NVIDIA VRWorks Stitching in Callisto

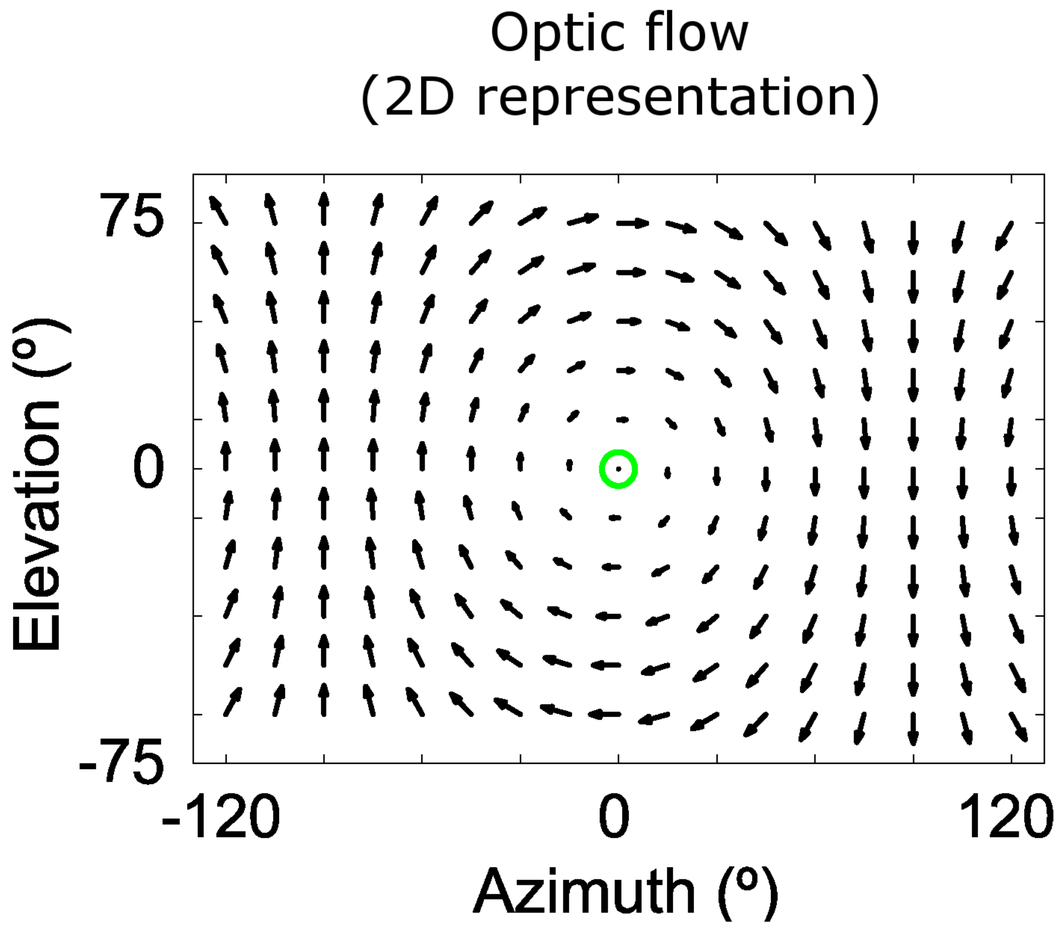


Frame Size	NVIDIA Stitcher (s)	Encode Frame(s)	Setup Time (s)	Total Time (s)	NVIDIA Stitch frame (ms)
2K	1.7	0.4	12.5	14.7	**19.3**
4K (UHD)	3.8	1.8	14.9	20.5	**42.7**
6K (5.7K)	7.5	4.4	19.7	31.6	**83.4**
8K (QUHD)	11.9	8.1	26.2	46.2	**132.0**

Current limits of VRWorks


mode
FUSION


Insta360 ONE X


Optic flow
(2D representation)
75
0
-75
Elevation (°)
-120
0
120
Azimuth (°)

https://digital-photography-school.com/making-best-use-hdr-landscape-photography/

8-bit per color limitation – No HDR support

Cloud Issues

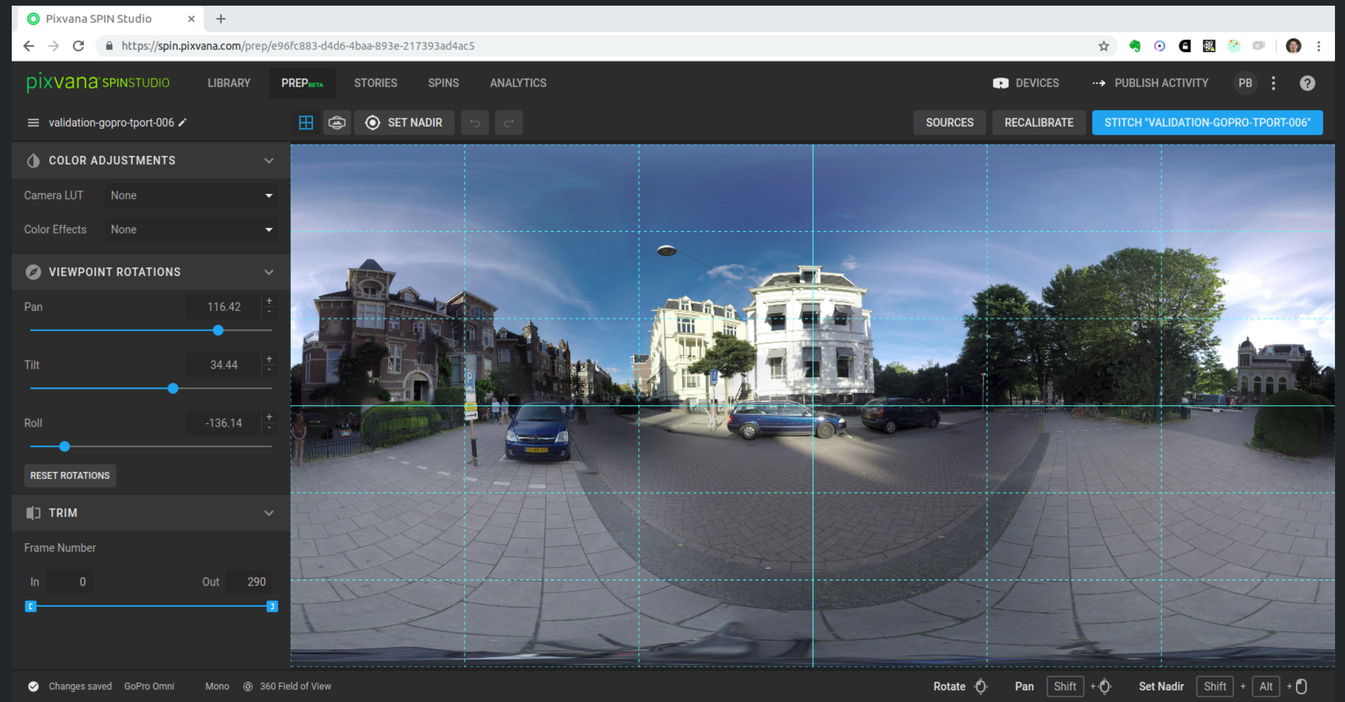
1. Limitations of GPUs on the cloud systems

Cloud Issues

1. Limitations of GPUs on the cloud systems
2. Cloud system requires several components compared to a desktop app.

Cloud Issues

1. Limitations of GPUs on the cloud systems
2. Cloud system requires several components compared to desktop apps.
3. Interaction of web front end and a cloud backend.



Cloud Issues

1. Limitations of GPUs on the cloud systems
2. Cloud system requires several components compared to desktop apps.
3. Interaction of web front end and a cloud backend.
4. Upload large volumes of data can be time consuming.

The Future

- Push boundaries of interactivity.

The Future

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- Push even more quality.

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    - Metadata of video content
    - Segment video and analyze to refine parallax stitch issues
    - Determine best compression and retain best quality
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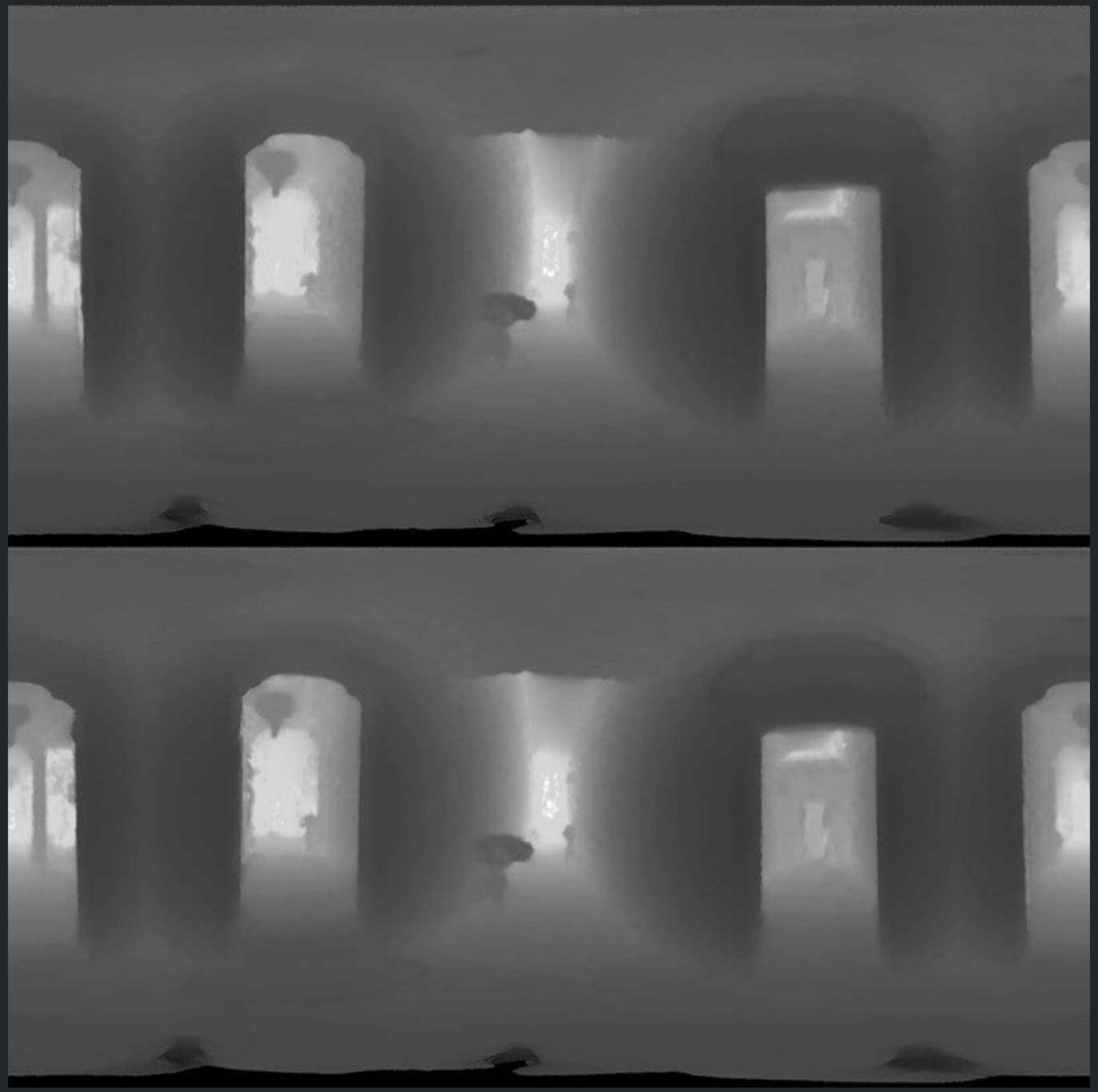
AR/MR and other immersive capture processes

https://shape.att.com/blog/shape-future-of-video

Depth Map

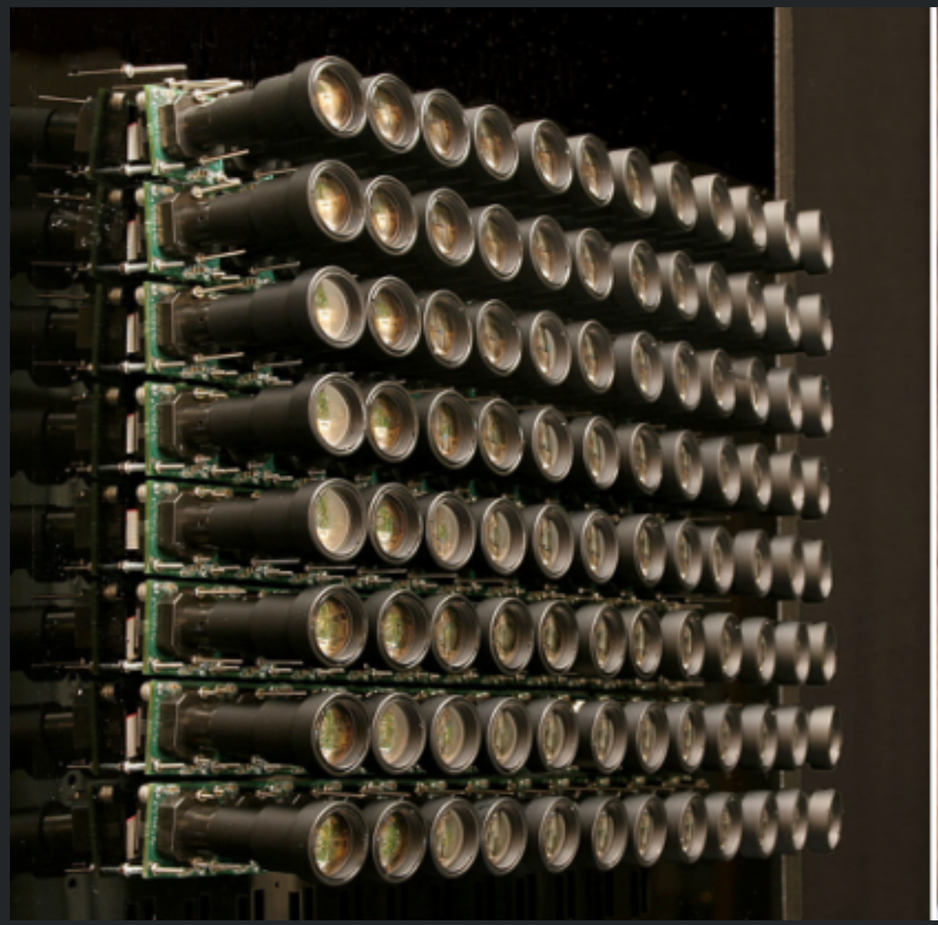


https://360videocamera.org/kandao-introduces-depth-mapping-to-360-degree-camera-software-vrfocus/

https://www.microsoft.com/en-us/mixed-reality/capture-studios

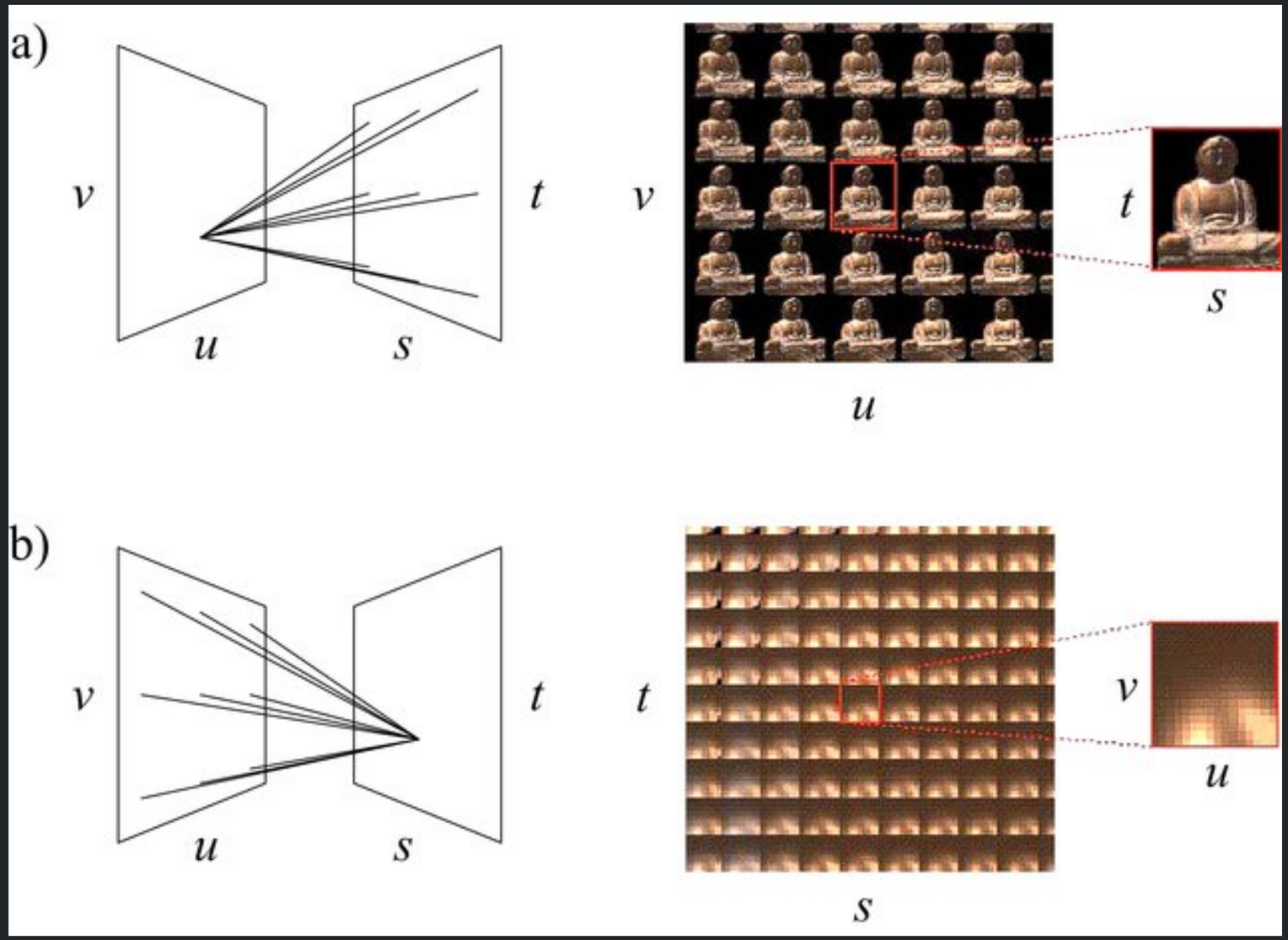
Volumetric

https://vrroom.buzz/vr-news/guide-vr/brief-history-volumetric-filmmaking

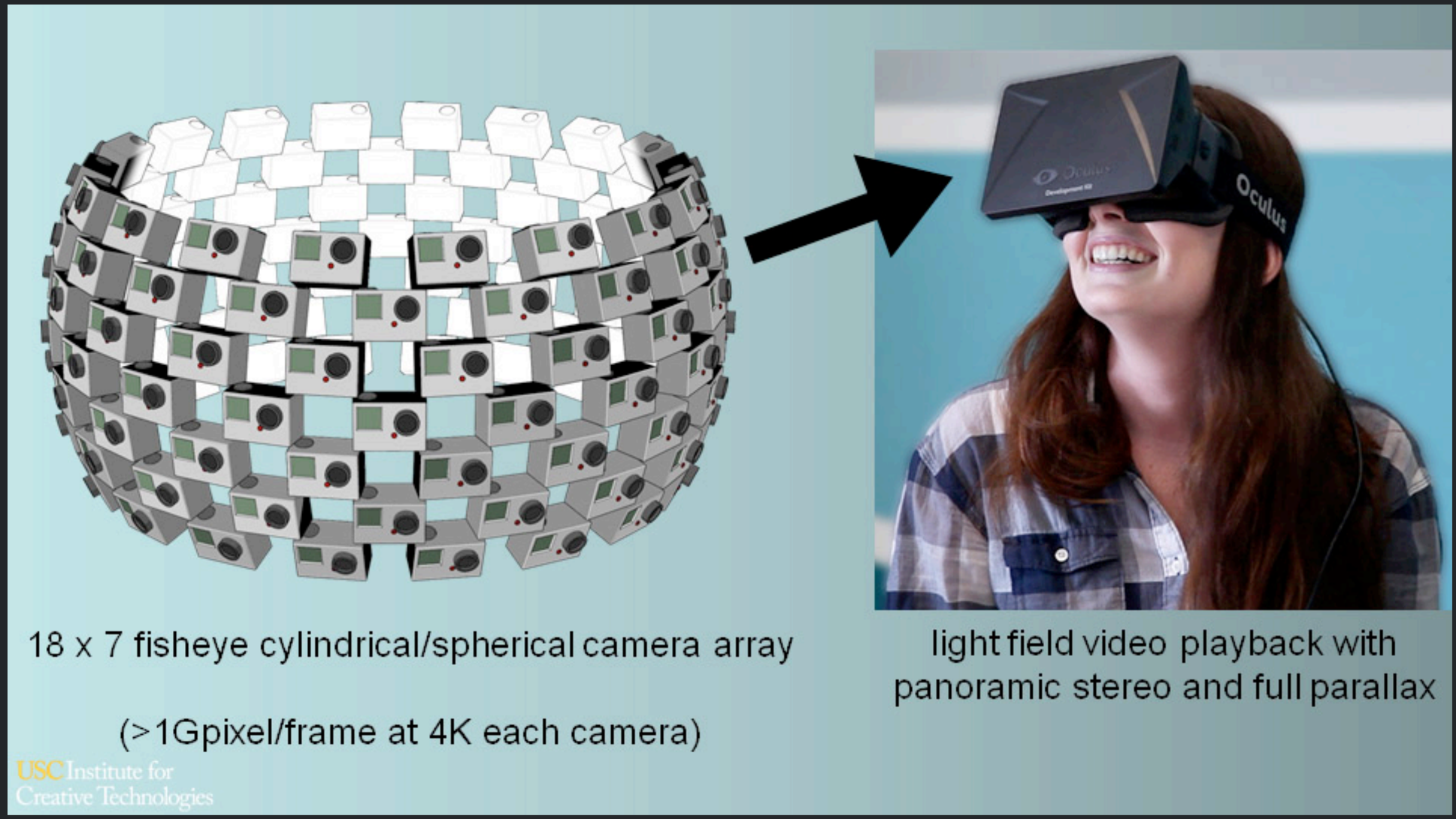


http://cs.brown.edu/courses/csci1290/labs/lab_lightfieldlab/

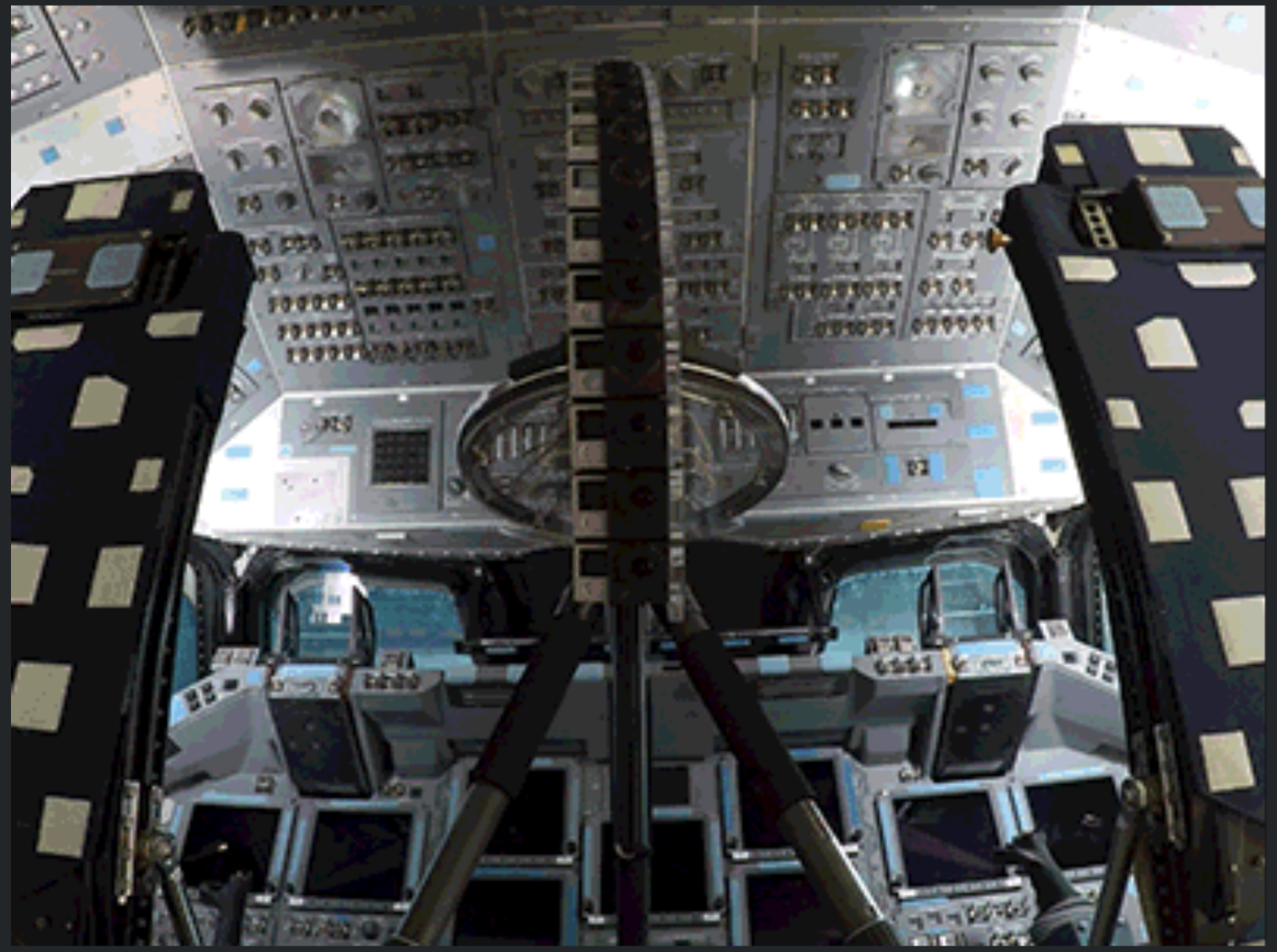
Light Fields

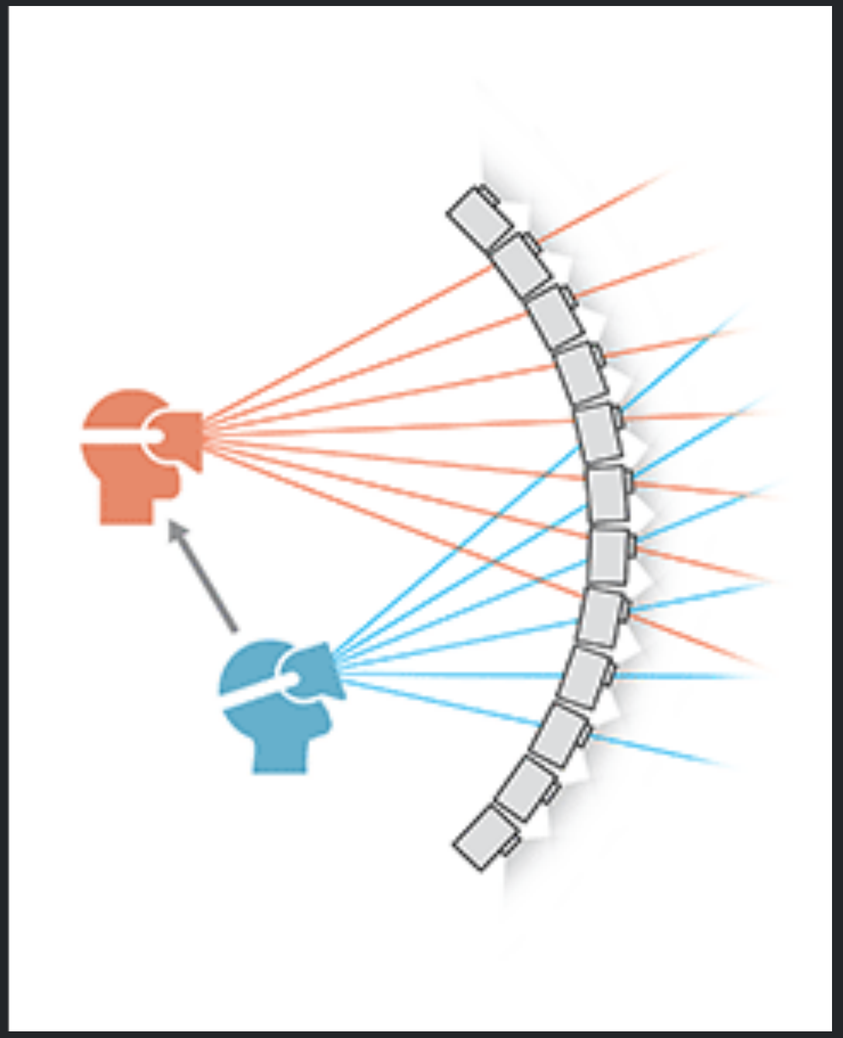


http://graphics.stanford.edu/papers/light/gamma-corrected/

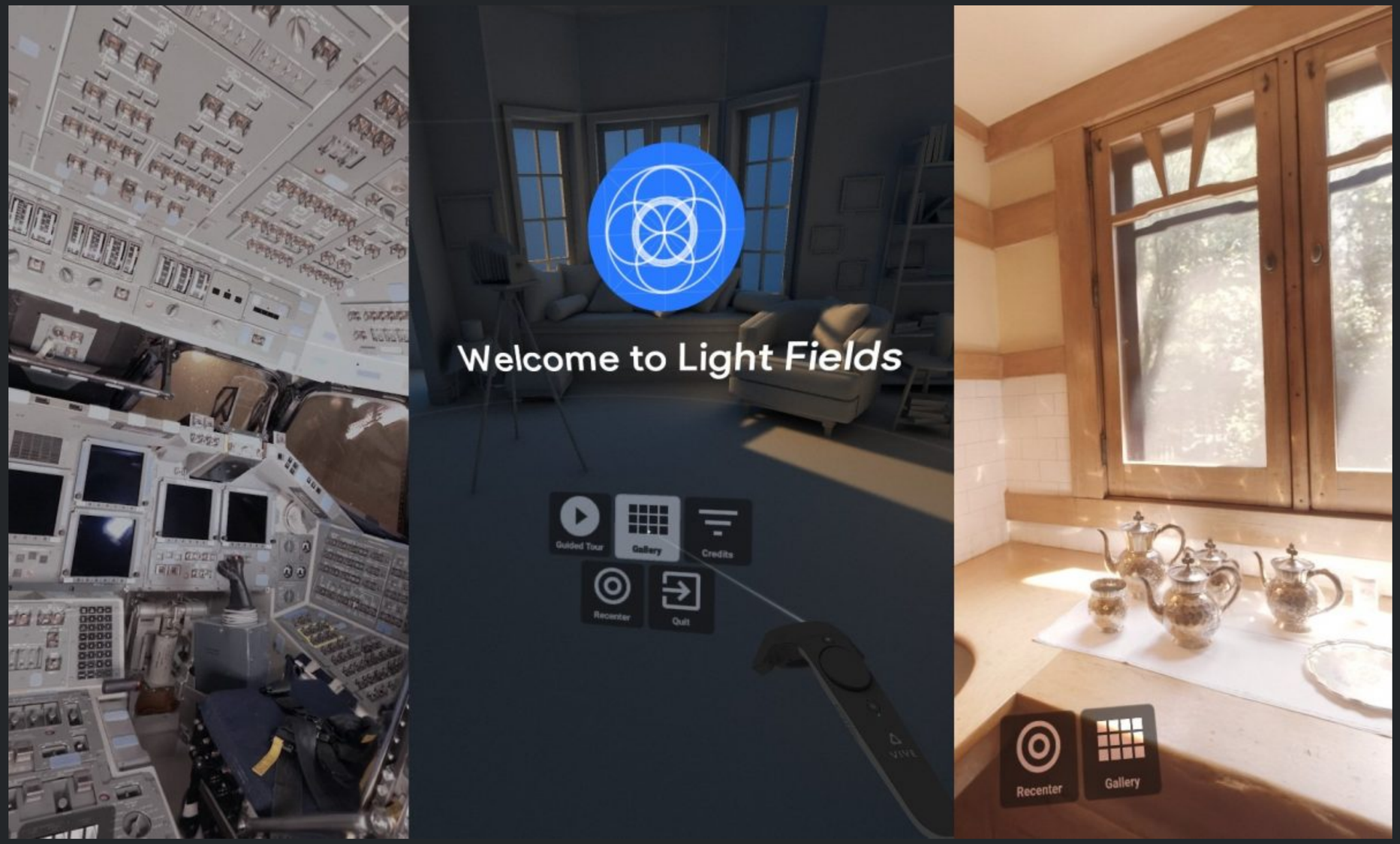


https://www.fxguide.com/featured/light-fields-the-future-of-vr-ar-mr/

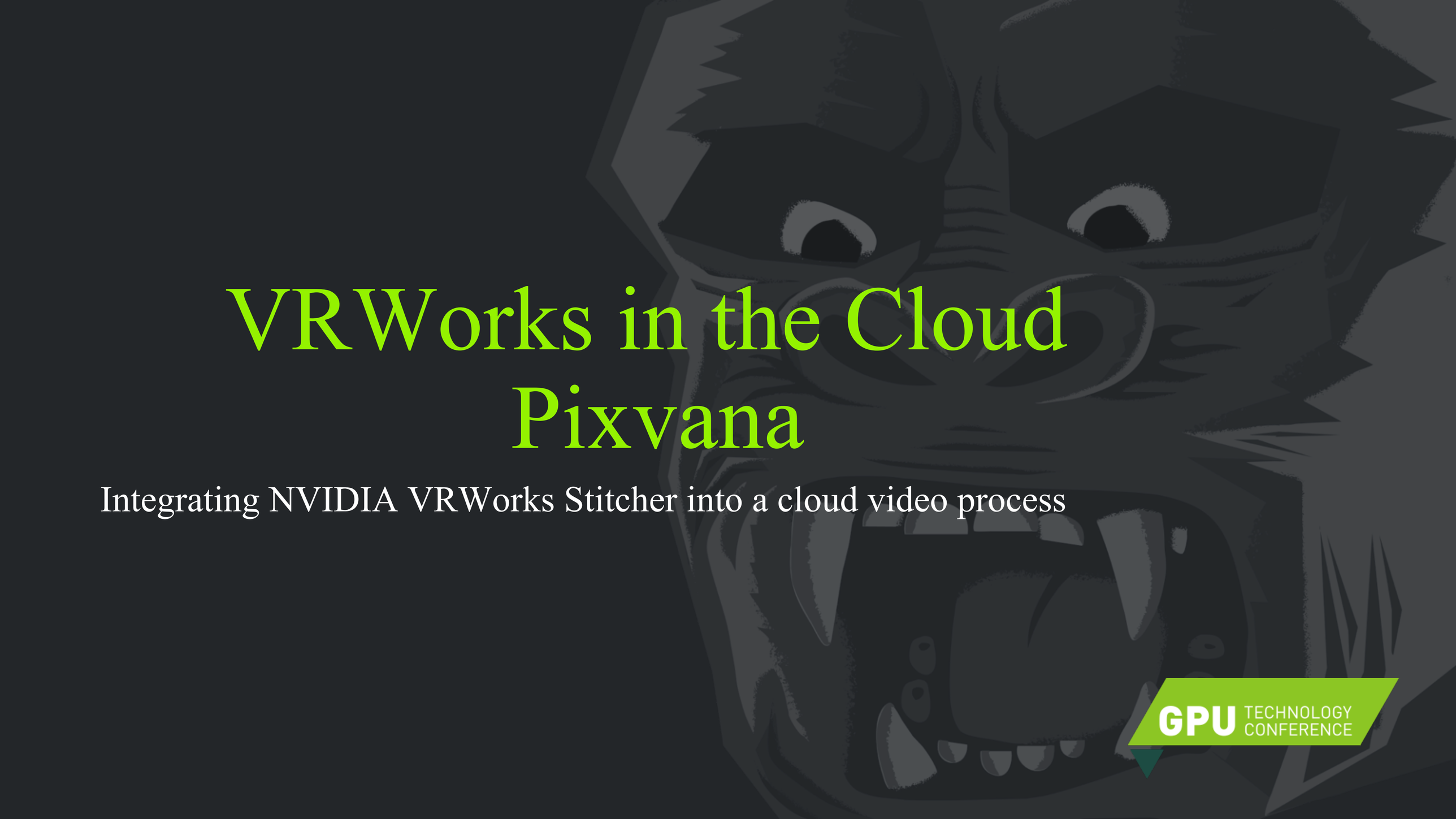




https://www.fxguide.com/featured/paul-debevecs-new-light-field-research/



https://uploadvr.com/siggraph-2018-learn-about-googles-efforts-to-capture-light-fields/



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