INTRODUCING FIDELITYFX VARIABLE SHADING

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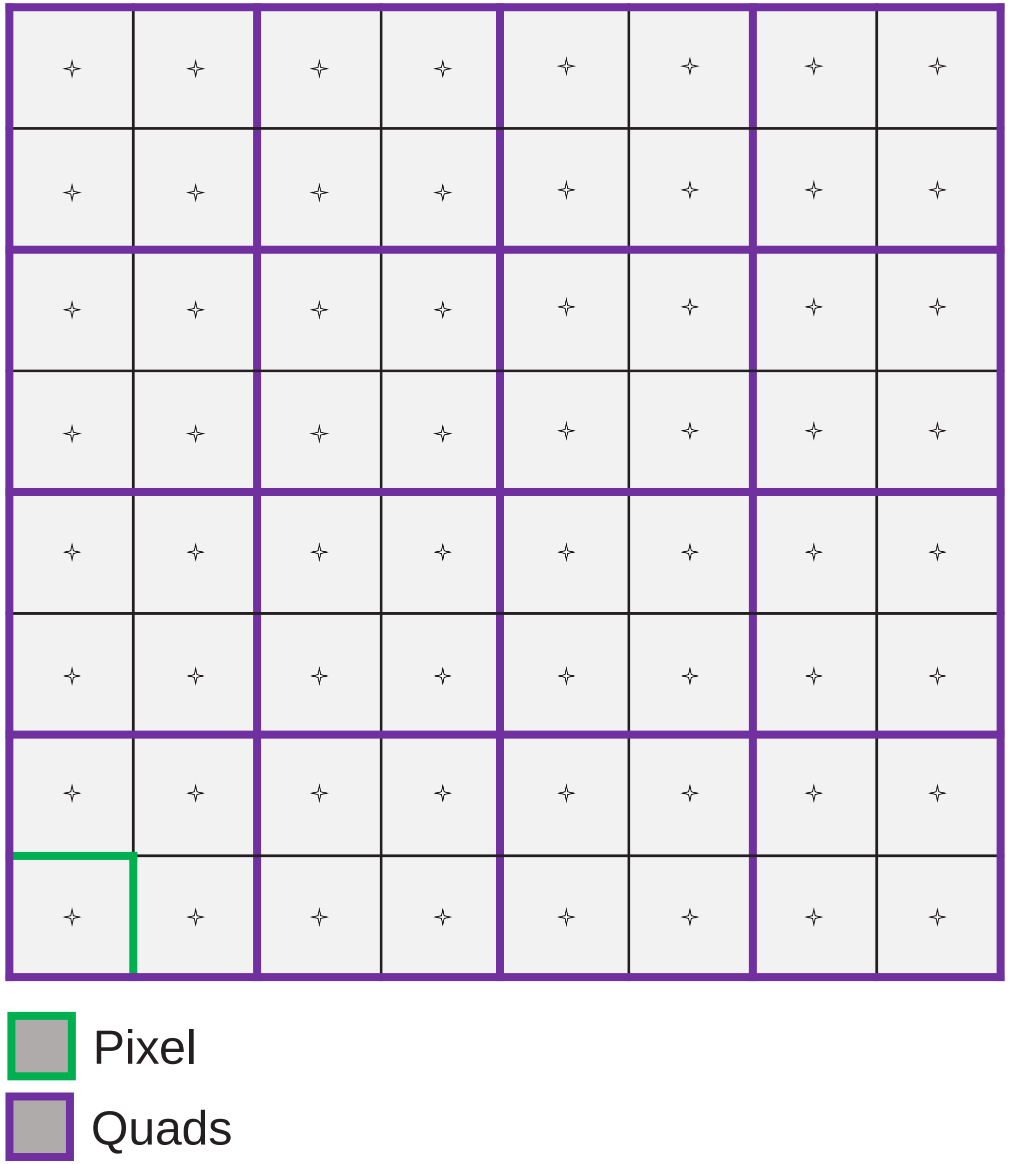
INTRODUCTION TO VARIABLE RATE SHADING

- Variable Rate Shading (VRS) is a feature of DirectX®12 Ultimate
- Goal of VRS is to save GPU work
  (where it does not significantly contribute to the final frame)
- Games today are usually played at very high resolution
  - Pixels are very small on screen
  - Adjacent pixels often have similar color
    (if they belong to the same primitive)
- Post-processing effects like Antialiasing, Depth of Field, or Motion Blur further reduce the difference between adjacent pixels

THE CONCEPT OF VRS



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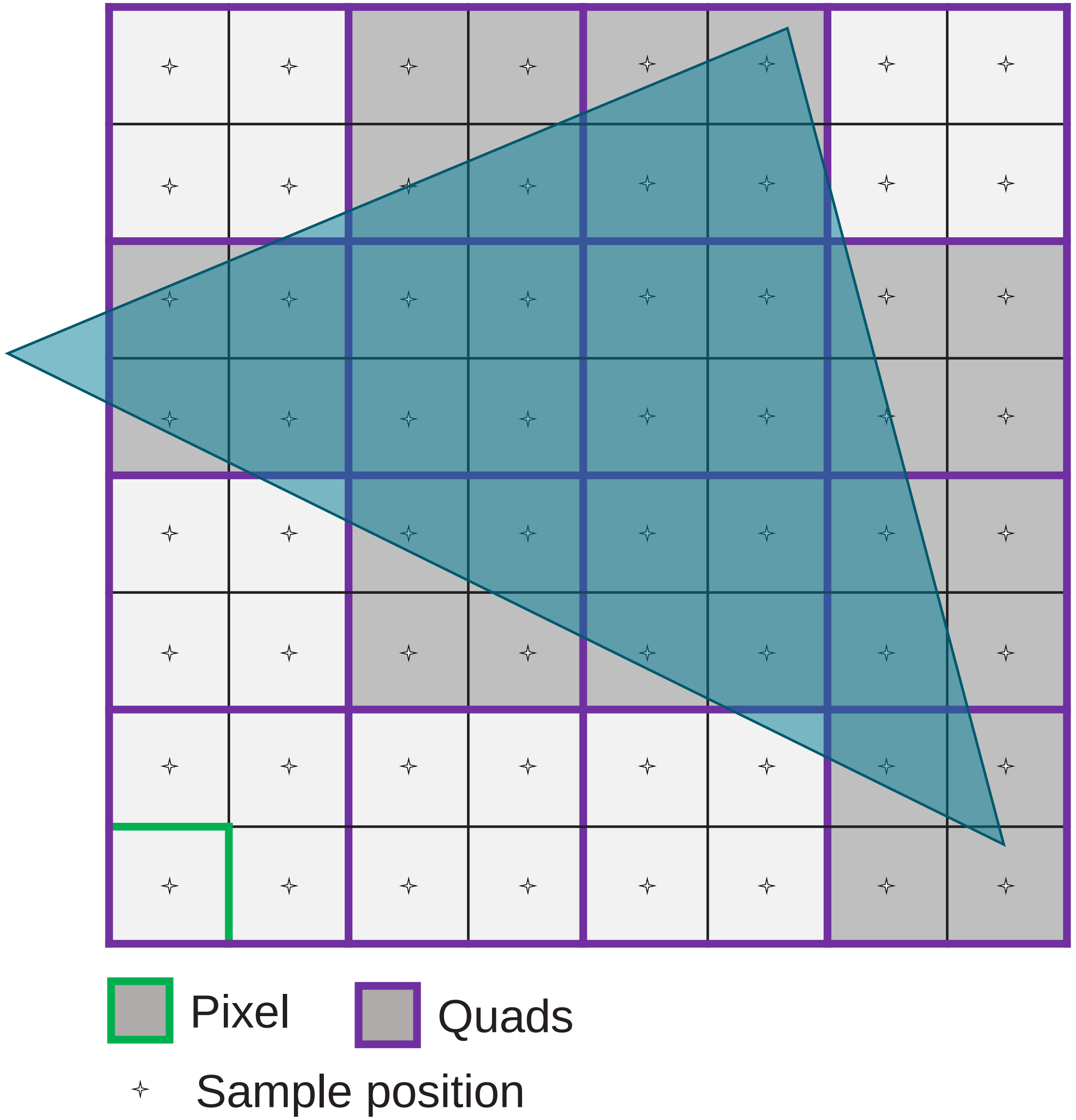
- **Without VRS**, 4 pixel shader (PS) threads are getting generated for every quad of which at least one pixel is covered by a primitive



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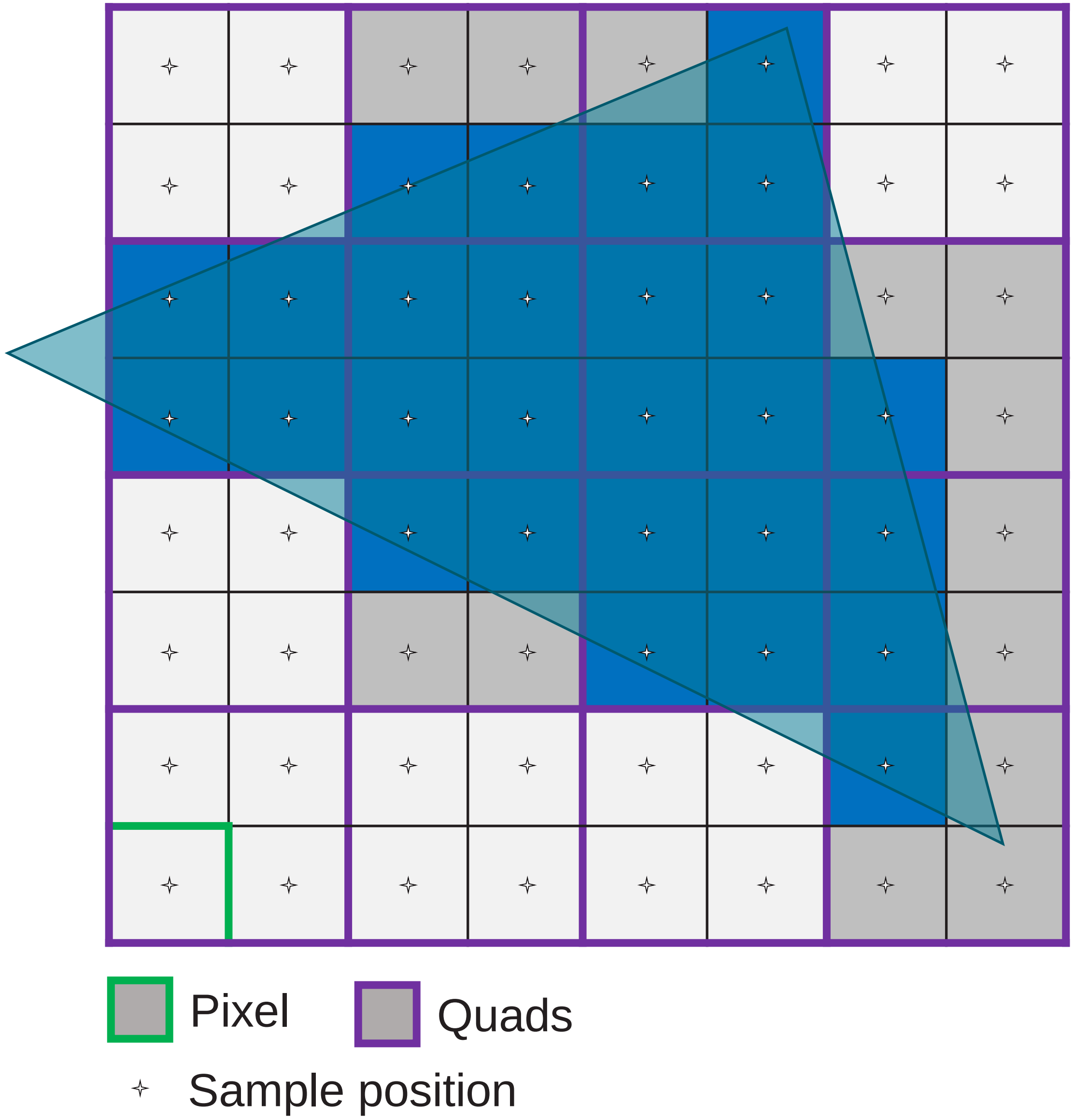
- **Without VRS**, 4 pixel shader (PS) threads are getting generated for every quad of which at least one pixel is covered by a primitive
  - For every pixel where the sample-position is covered by the primitive, the result of the PS gets written to the render target
  - Example:
    10 Quads/40 PS threads (27 active)



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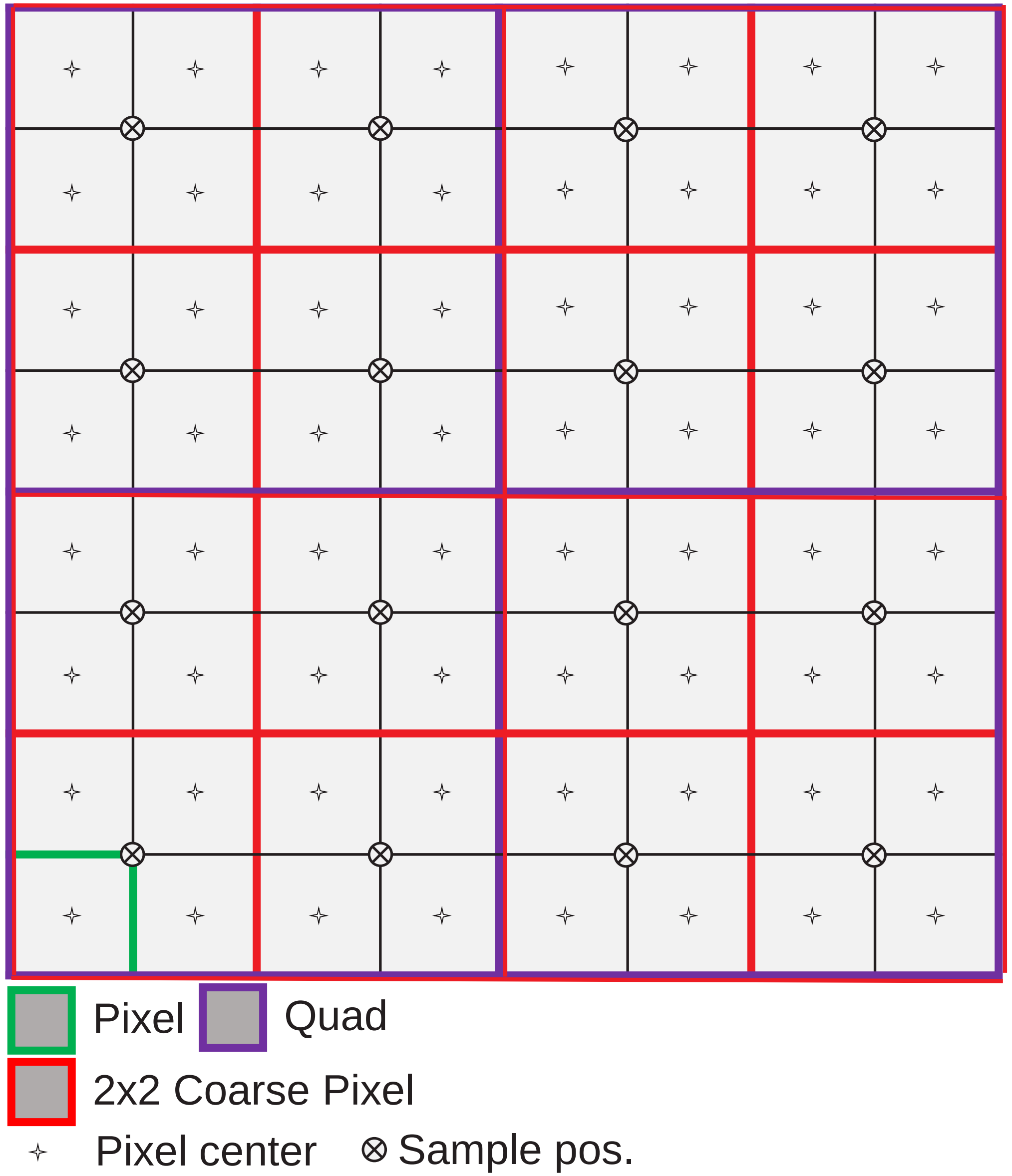

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    4 Quads/16 PS threads (10 active)
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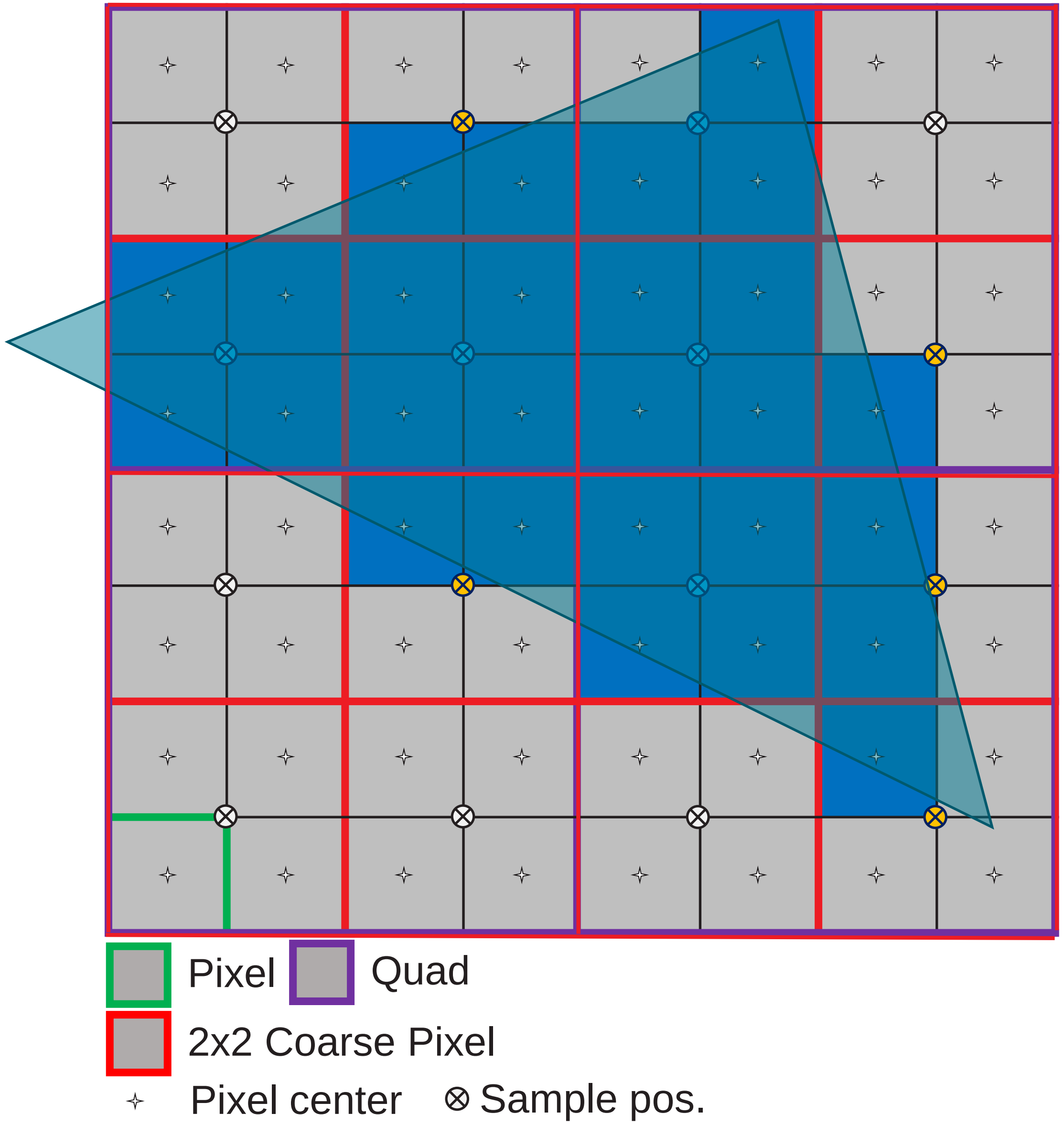

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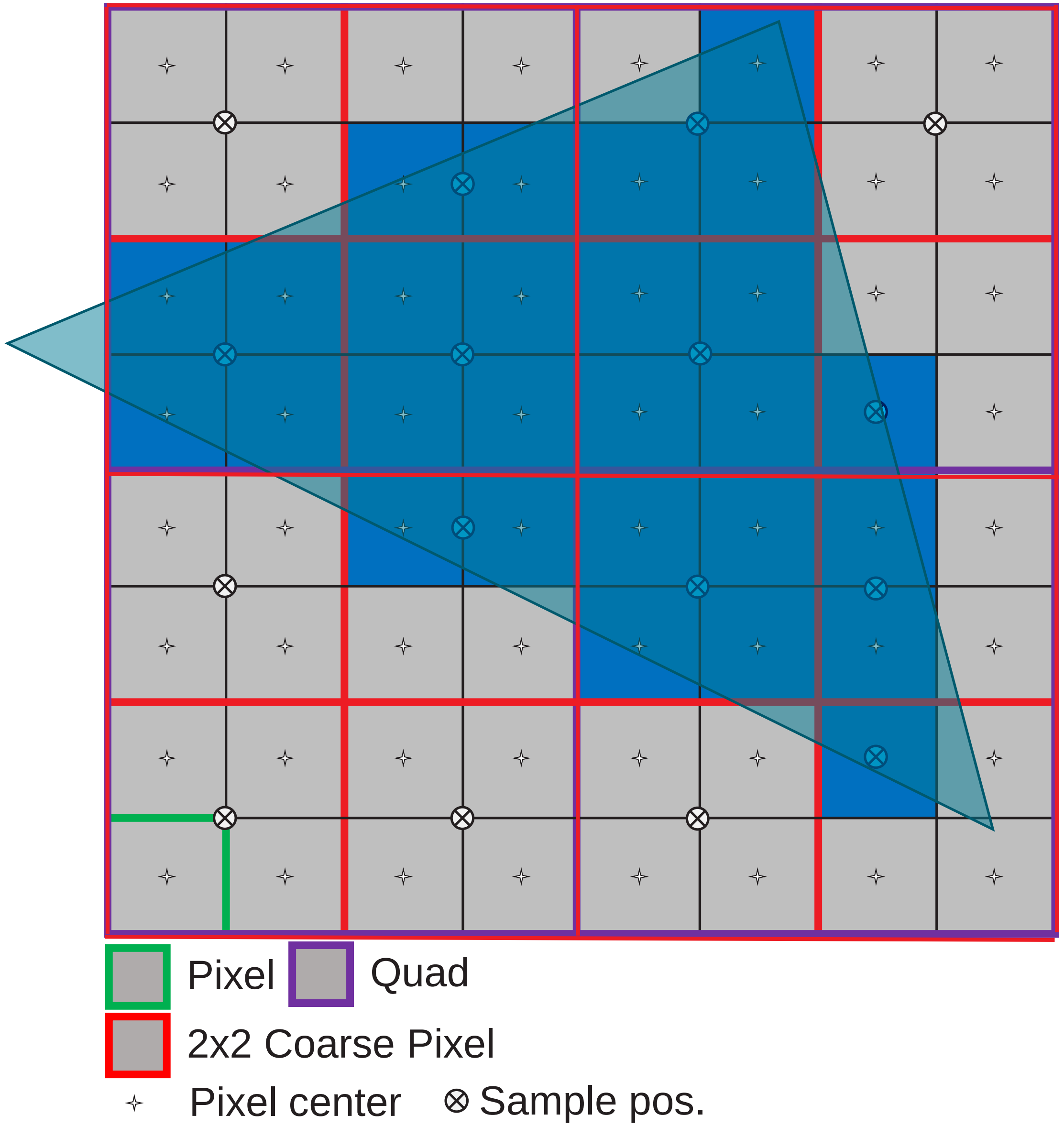
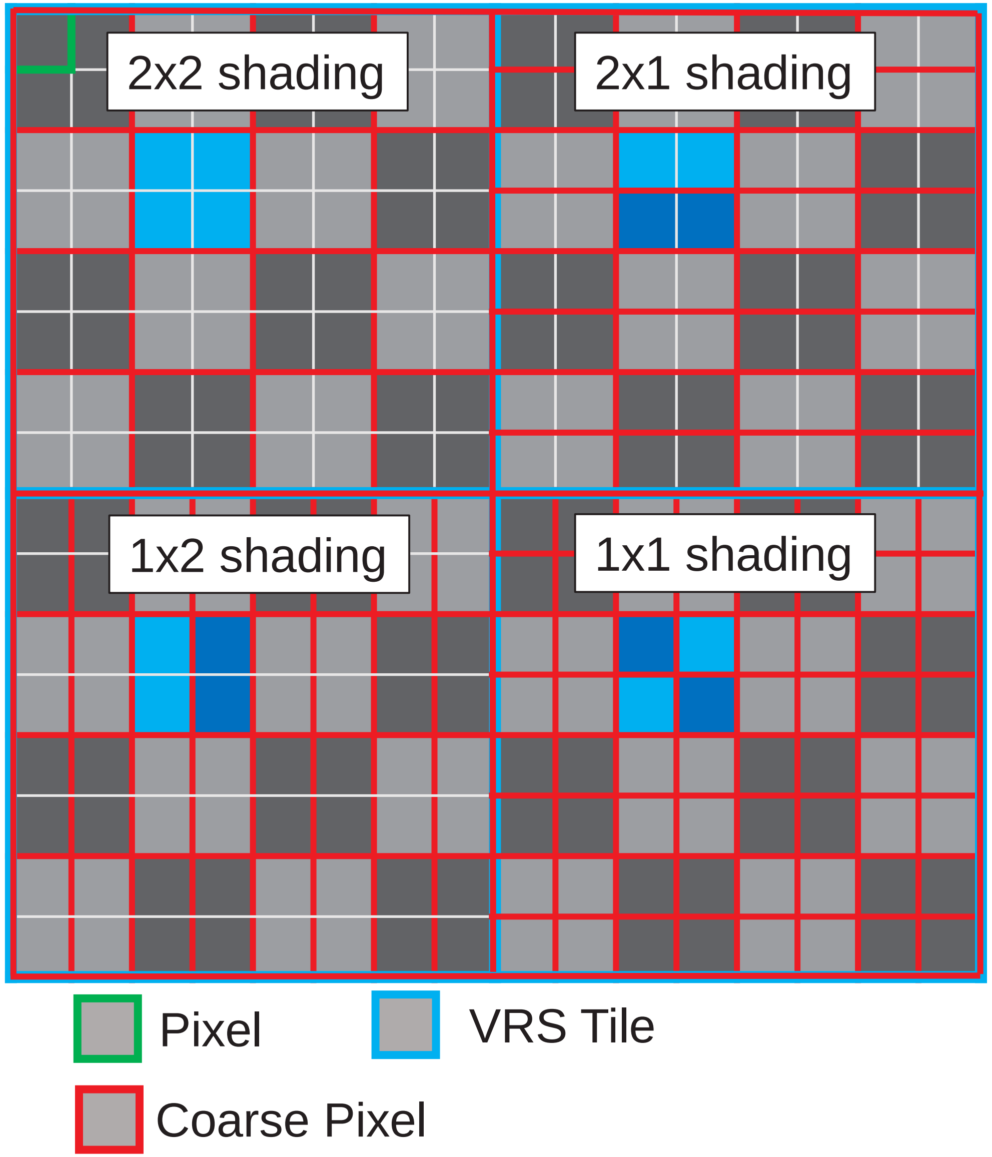
Make sure to use centroid interpolation!



VRS ON RDNA2

- VRS has multiple ways to control shading rate
  - Per drawcall (VRS tier 1)
  - Per primitive (VRS tier 2, VS/GS output)
  - Per screen tile (VRS tier 2, Image Based)
    - **8x8 pixel tile size**
    - Small tile size provides fine grained control
- **Additional shading rates not supported**
  - At common resolutions 4x can hardly be used without generating visual artifacts
  - Additional shading rates make image generation more complex
- VRS image gets copied into H-tile on bind
  - Small (but not negligible) overhead when binding the VRS image
  - No overhead during rendering!



IMPLEMENTING VRS (INITIALIZATION)

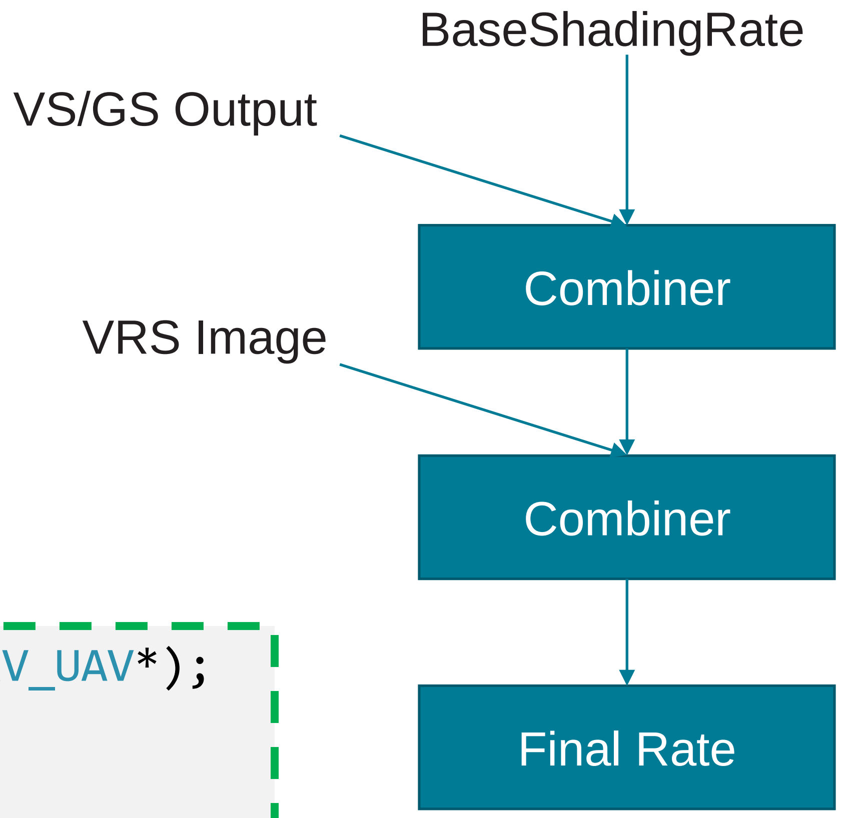
- Query Hardware details:
  - Is VRS supported / which shading rates?
    - Supporting 4x4 shading rate makes the image generation shader more complex
    - 4x4 is likely to cause visible quality degradation at common resolutions
  - Is tier 2 (Shader or Image Based VRS) supported?
    - For image based: What is the tile size?
- Create VRS Image & generation shader

```
void OnCreate(Device *pDevice,
       ResourceViewHeaps *pResourceViewHeaps,
       DynamicBufferRing *pConstantBufferRing,
       StaticBufferPool *pStaticBufferPool,
       DXGI_FORMAT overlayOutputFormat);
void OnDestroy();
void OnCreateWindowSizeDependentResources(uint32_t w, uint32_t h);
void OnDestroyWindowSizeDependentResources();
```

IMPLEMENTING VRS (RENDERING)

- Compute VRS image
- Bind VRS image
- Set base shading rate and combiners
- Unbind VRS image when done
- [Render VRS image as overlay for debugging]

```
void ComputeVrsMap(ID3D12GraphicsCommandList*, CBV_SRV_UAV*);
void SetShadingRate(D3D12_SHADING_RATE,
       const D3D12_SHADING_RATE_COMBINER*,
       ID3D12GraphicsCommandList*);
void StartVrsRendering(ID3D12GraphicsCommandList*);
void EndVrsRendering(ID3D12GraphicsCommandList*);
void DrawOverlay(ID3D12GraphicsCommandList*);
```



FIDELITYFX VARIABLE SHADING (CPP)

```cpp
struct FFX_VariableShading_CB
{
        uint32_t width, height;
        uint32_t tileSize;
        float varianceCutoff;
        float motionFactor;
};

static void FFX_VariableShading_GetVrsImageResourceDesc(
        const uint32_t rtWidth, const uint32_t rtHeight,
        const uint32_t tileSize,
        CD3DX12_RESOURCE_DESC& VRSImageDesc);
static void FFX_VariableShading_GetDispatchInfo(
        const FFX_Variable_Shading_CB* cb,
        const bool useAditionalShadingRates,
        uint32_t& numThreadGroupsX, uint32_t& numThreadGroupsY)
```

FIDELITYFX VARIABLE SHADING (HLSL)

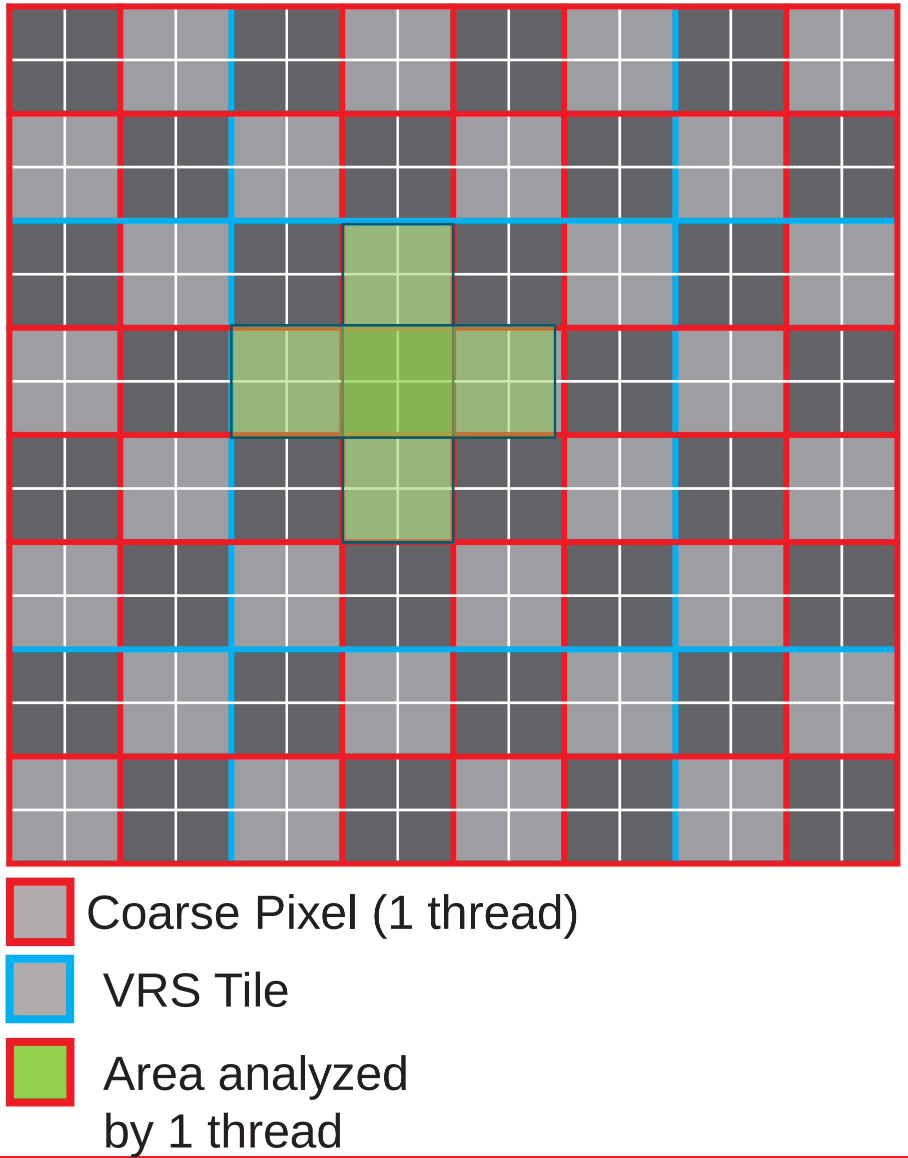
```
// Define: FFX_VARIABLESHADING_TILESIZE
// Optional: FFX_VARIABLESHADING_ADDITIONALSHADINGRATES

// Constant Buffer
cbuffer FFX_VariableShading_CB0 {
       int2    g_Resolution;
       uint    g_TileSize;
       float   g_VarianceCutoff;
       float   g_MotionFactor;
}

// Forward declaration of functions that need to be implemented
// by shader code using this technique
float  FFX_VariableShading_ReadLuminance(int2 pos);
float2 FFX_VariableShading_ReadMotionVec2D(int2 pos);
void   FFX_VariableShading_WriteVrsImage (int2 pos, uint value);
```

FIDELITYFX VARIABLE SHADING (HLSL USAGE)

```
// define FFX_VARIABLESHADING_TILESIZE on compile!
// may define FFX_VARIABLESHADING_ADDITIONALSHADINGRATES
RWTexture2D<uint>     imgDestination: register(u0);
Texture2D             texColor      : register(t0);
Texture2D             texVelocity   : register(t1);

#define FFX_HLSL 1
#include "ffx_variable_shading.h"

float FFX_VariableShading_ReadLuminance(int2 pos) {
       float3 color = texColor[pos].xyz;
       return dot(color, float3(0.30, 0.59, 0.11));
}

float2 FFX_VariableShading_ReadMotionVec2D(int2 pos) {
       return texVelocity[pos].xy * float2(0.5f, -0.5f) * g_Resolution;
}
```

HOW THE SHADER WORKS

1. One threadgroup computes between 1 and 4 tiles
   - Without additional shading rates, and 8x8 tile size, each group of 8x8 threads computes the shading rate for 4 tiles.
2. Analyze pairs of pixels within 2x2 region
   - Using LDS
   - Each thread also takes pixels outside the 2x2 box into account. This avoids burn-in (i.e. Low VRS rate because it was low in last frame)
   - Reduce luminance delta by motion influence
3. Compute largest luminance delta within tile
   1. Using wave intrinsics
4. Compare against threshold
5. Write out VRSImage

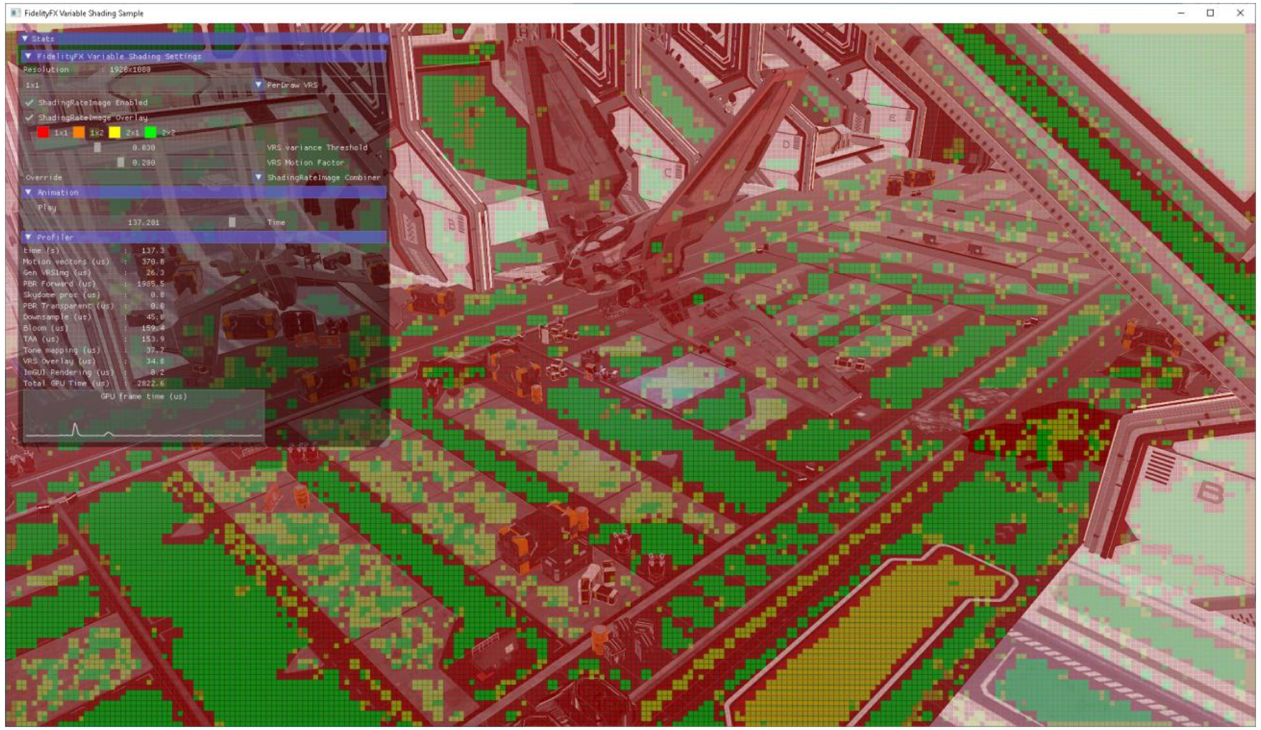


VRS OVERLAY

- Display VRS image as overlay for debugging tweaking
- Ready to use code in VrsOverlay.hlsl
- Easy to integrate:
  1. Build VS/PS pipeline and bind it
  2. Provide constant buffer containing resolution and tile size

     (same as for VRS image generation)
  3. Draw a single triangle

     (No vertex or index buffers required)


FidelityFX Variable Shading Sample
▼ Stats
▼ FidelityFX Variable Shading Settings
🟥 1x1 🟧 1x2 🟨 2x1 🟩 2x2
▼ Animation
▼ Profiler
GPU frame time (us)

```
Resolution          : 1920x1080
1x1                                  ▼ PerDraw VRS
✓ ShadingRateImage Enabled
✓ ShadingRateImage Overlay
                0.030                VRS variance Threshold
                0.200                VRS Motion Factor
Override                             ▼ ShadingRateImage Combiner
Play
              137.201                Time
```

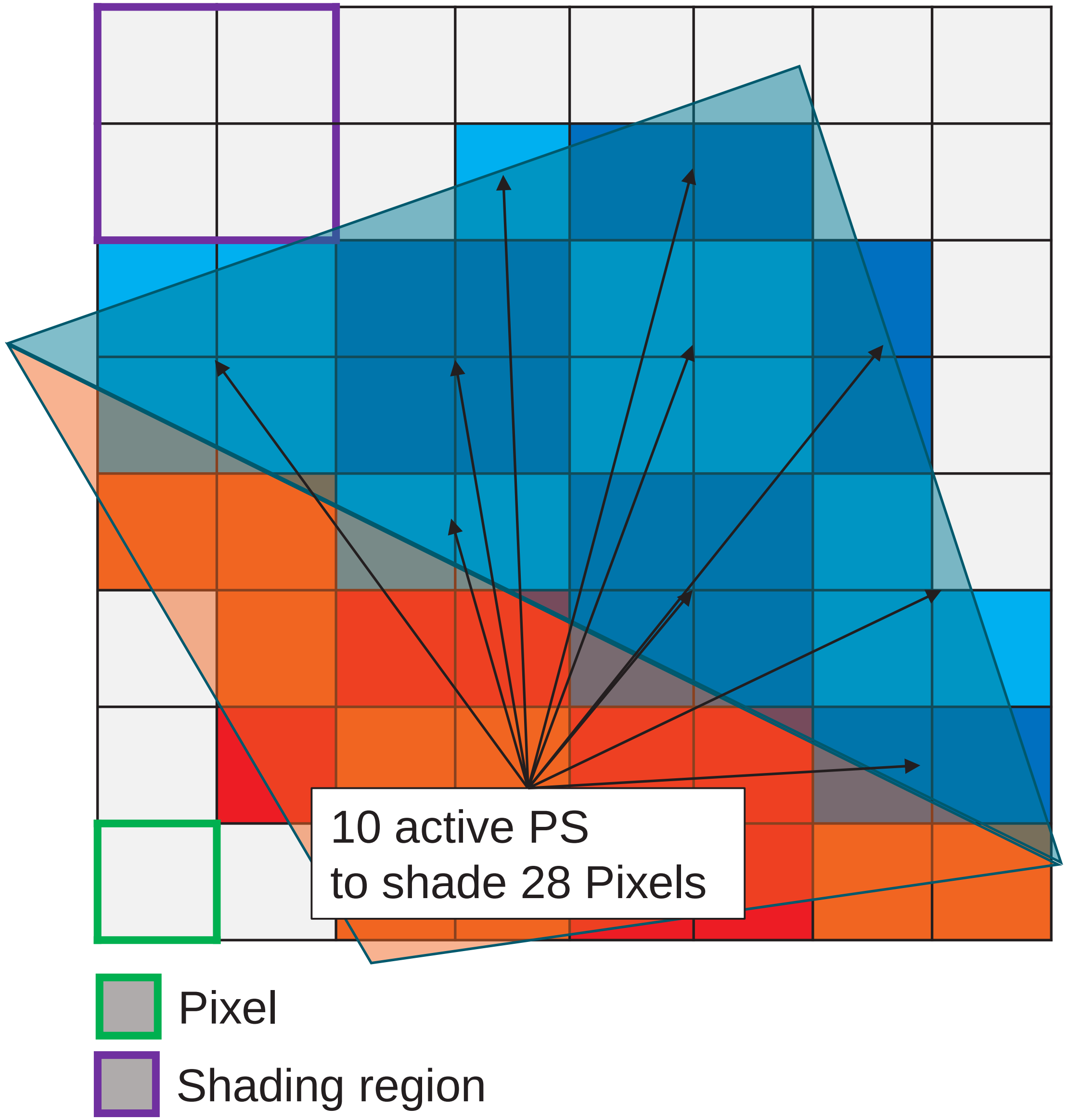
```
time (s)               :   137.3
Motion vectors (us)    :   370.8
Gen VRSImg (us)        :    26.3
PBR Forward (us)       :  1985.5
Skydome proc (us)      :     0.0
PBR Transparent (us)   :     0.0
Downsample (us)        :    45.6
Bloom (us)             :   159.4
TAA (us)               :   153.9
Tone mapping (us)      :    37.7
VRS Overlay (us)       :    34.0
ImGUI Rendering (us)   :     8.2
Total GPU Time (us)    :  2822.6
```

⚠ CAVEATS ⚠

Since VRS works by reducing number of PS executions:

- No benefit in depth/stencil only passes
- No benefit in fill rate bound scenarios
- No benefit in compute passes
- Very little benefit if average triangle size is very small (think of quad utilization)

Example: 2x2 shading rate



⚠ CAVEATS ⚠

Features that cause shading rate to drop to 1x1

- Depth export
- Post-depth coverage
- Raster Order Views
- 16xMSAA

Minimize the number of times per frame the VRS image gets bound or unbound!

  - If VRS needs to get disabled for a few draw calls while the same depth buffer is being used, (e.g. to render alpha-tested geometry) the best practice is to leave the VRS image bound and disable VRS by modifying the combiners.

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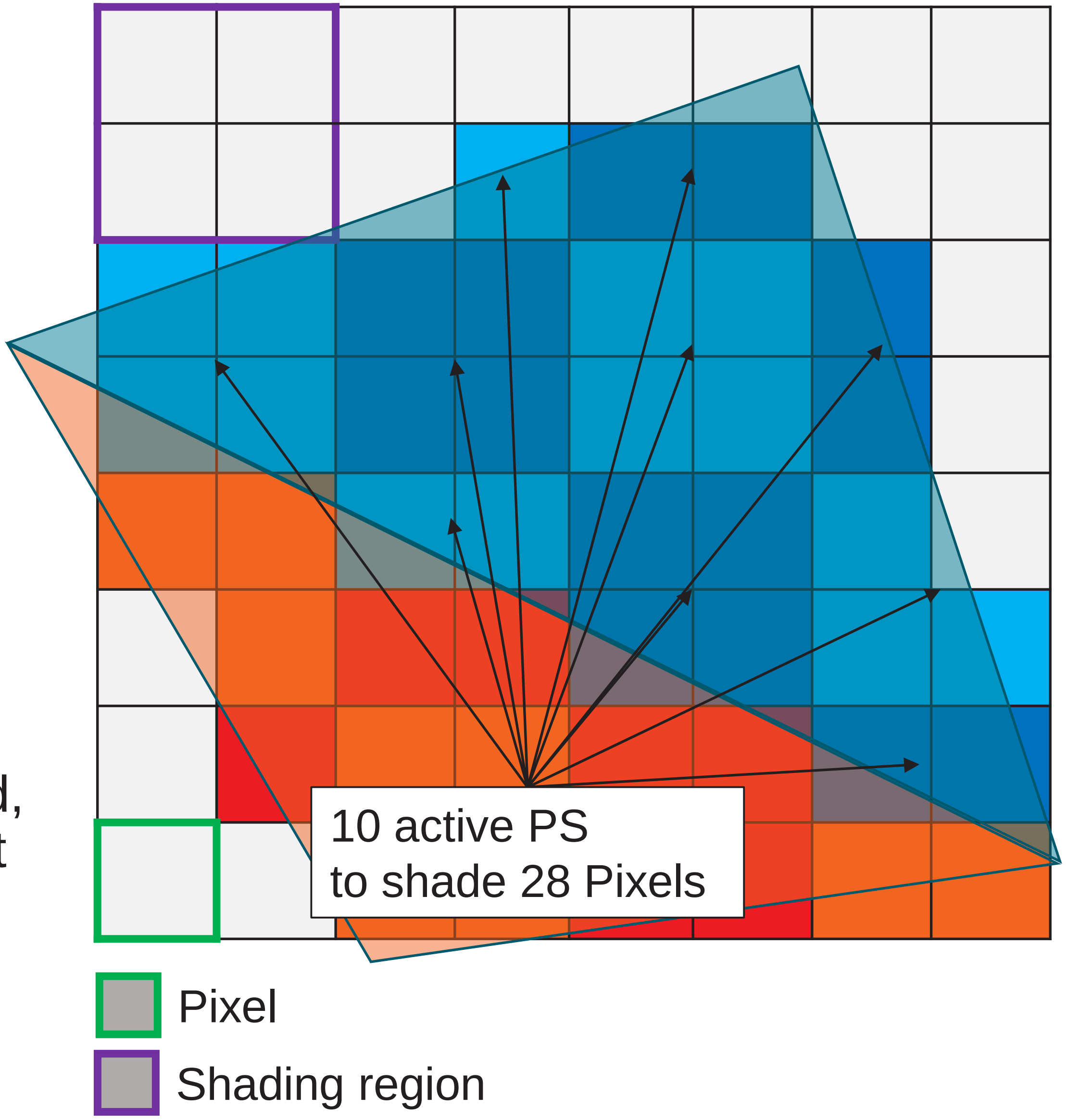
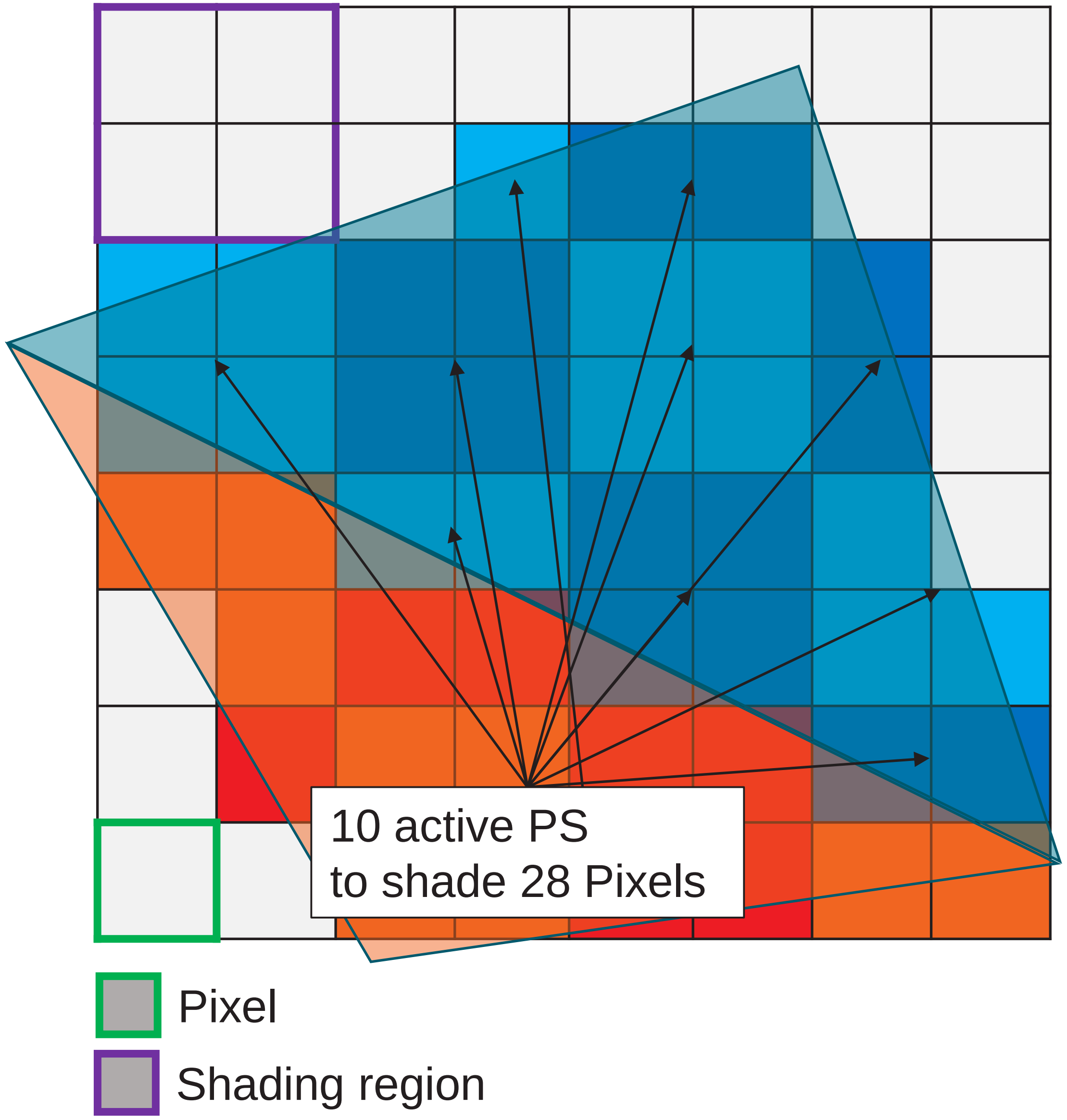


TAKEAWAY

- Easy to integrate
  - Free performance
- VRS preserves triangle edges
  - Also depth/stencil information
- Experiments show that 2x2 shading rate is ideal for commonly used resolutions

Example: 2x2 shading rate



10 active PS
to shade 28 Pixels

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