FFX DENOISER REFLECTIONS

DOMINIK BAUMEISTER

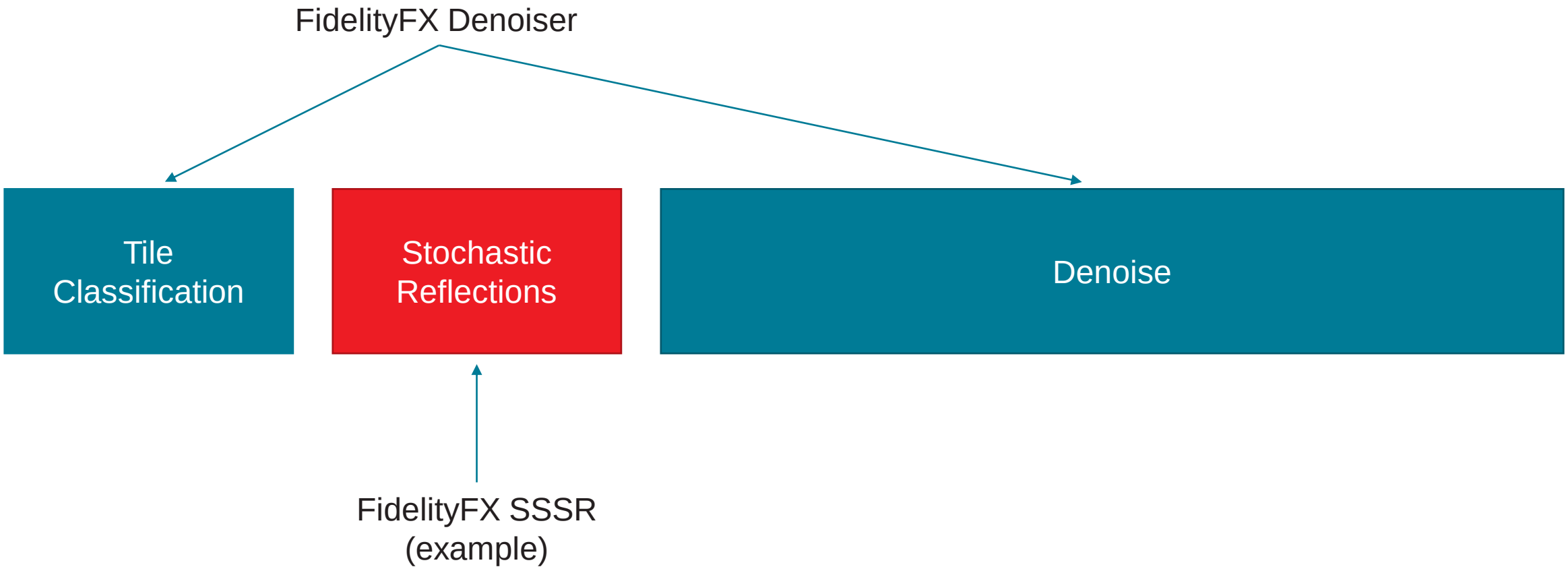
TOBIAS FAST

REFLECTION DENOISER

- Based on industry leading algorithm
- High performant spatiotemporal denoisers
- Tile Classifier to skip non reflective areas
- Temporal Variance Guided Tracing
- Support for D3D12 and Vulkan
- Shaders written in HLSL utilizing SM 6.0 wave-level operations

PIPELINE

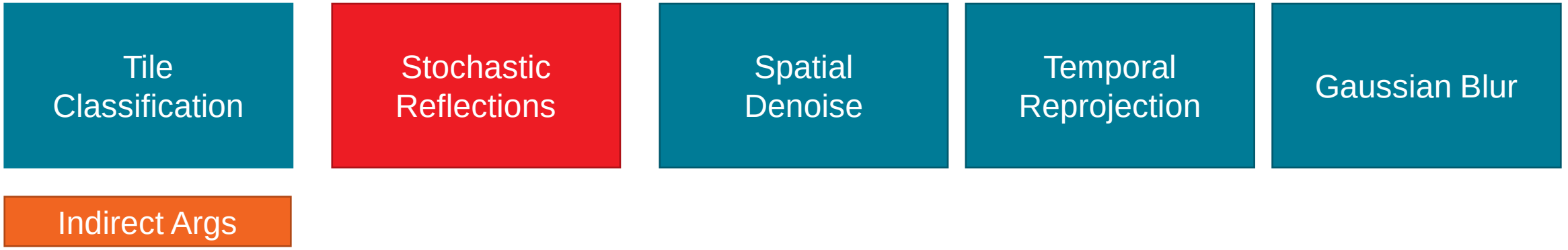
PIPELINE


FidelityFX Denoiser
Tile Classification
Stochastic Reflections
Denoise
FidelityFX SSSR (example)

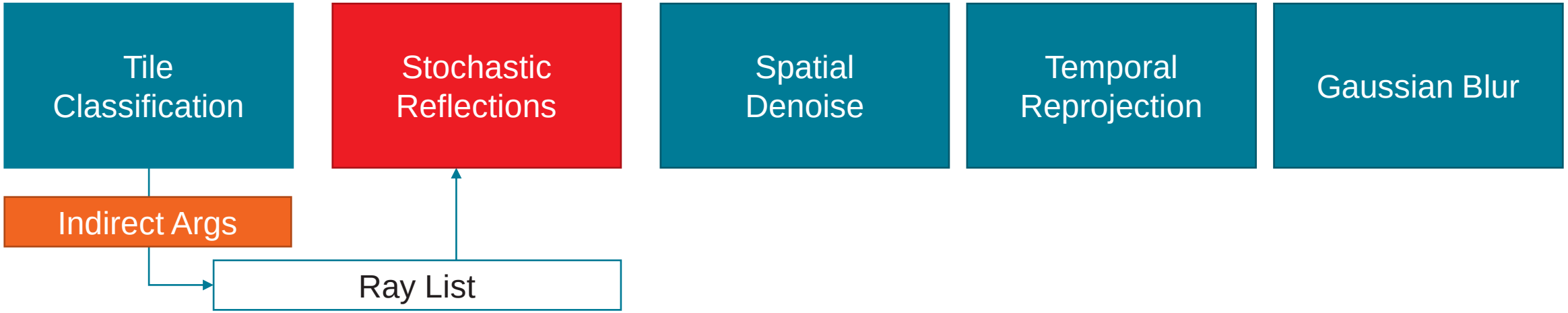
PIPELINE


Tile Classification
Stochastic Reflections
Spatial Denoise
Temporal Reprojection
Gaussian Blur

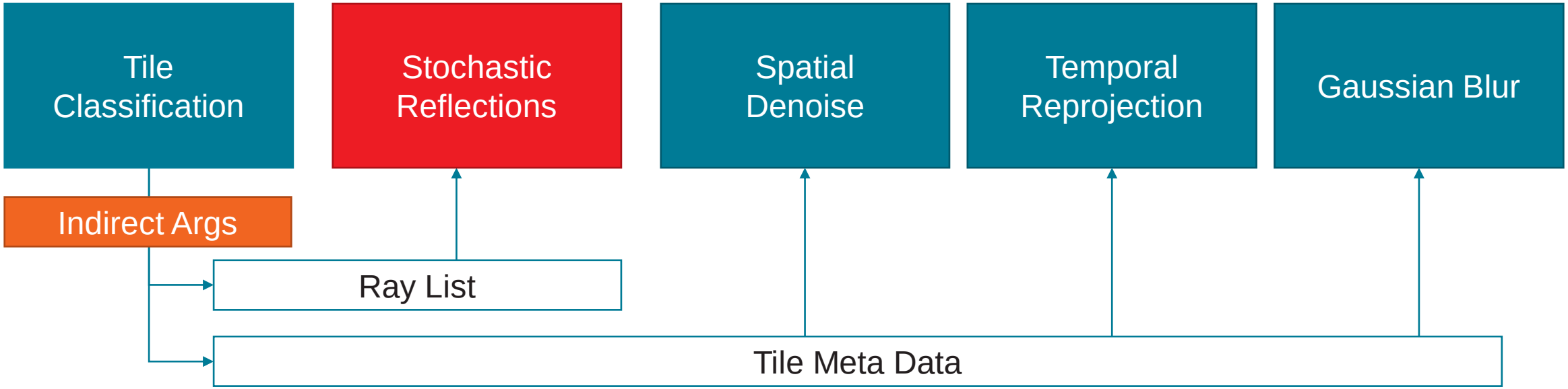
PIPELINE


Tile Classification
Stochastic Reflections
Spatial Denoise
Temporal Reprojection
Gaussian Blur
Indirect Args

PIPELINE


Tile Classification
Stochastic Reflections
Spatial Denoise
Temporal Reprojection
Gaussian Blur
Indirect Args
Ray List

PIPELINE


Tile Classification
Stochastic Reflections
Spatial Denoise
Temporal Reprojection
Gaussian Blur
Indirect Args
Ray List
Tile Meta Data

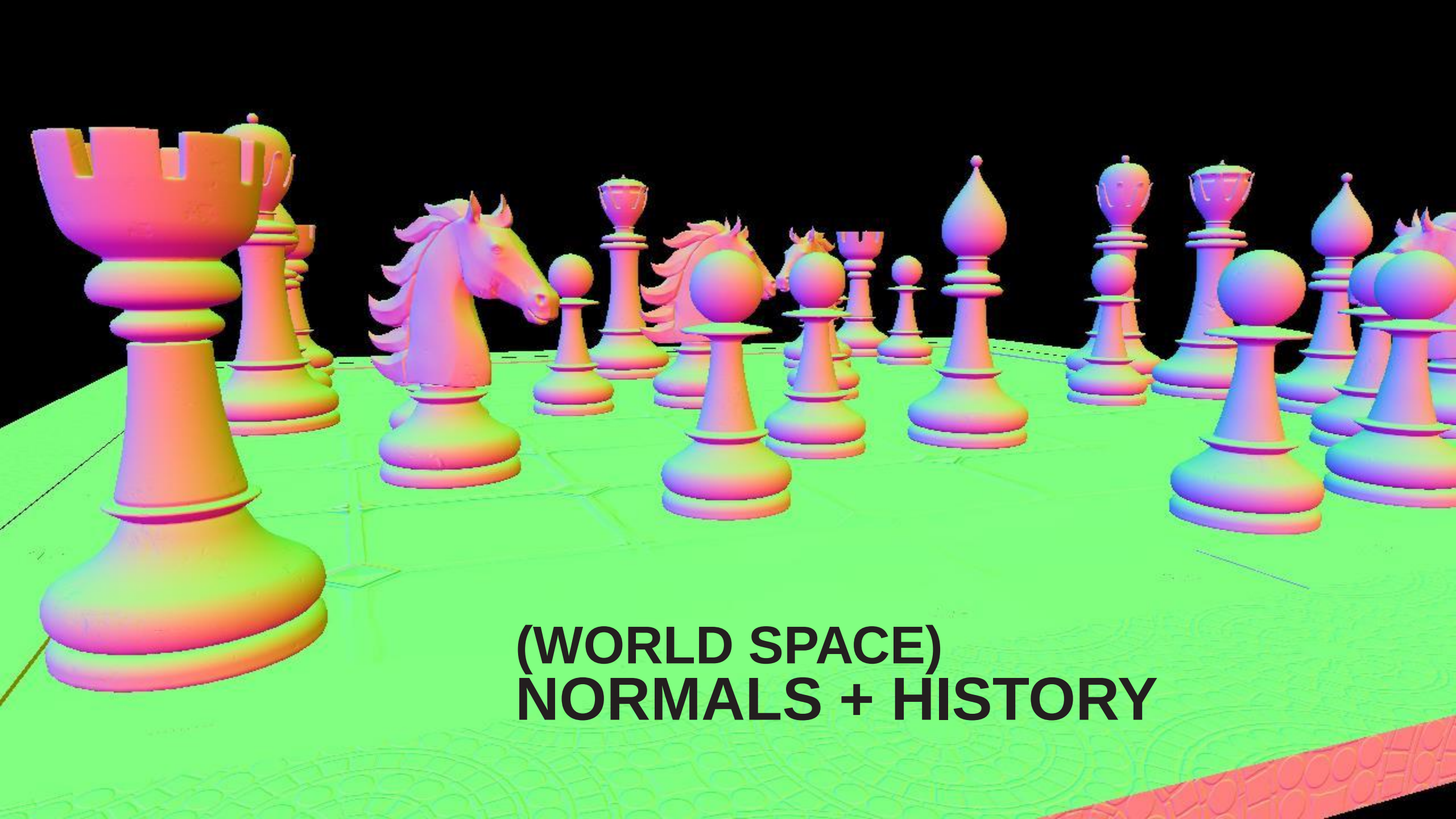
INPUTS

App side surfaces

- Depth
- Per pixel motion vectors
- Normals for current and last frame
- Roughness for current and last frame
- **Cleared** reflection target
- Noisy Reflections

ROUGHNESS + HISTORY

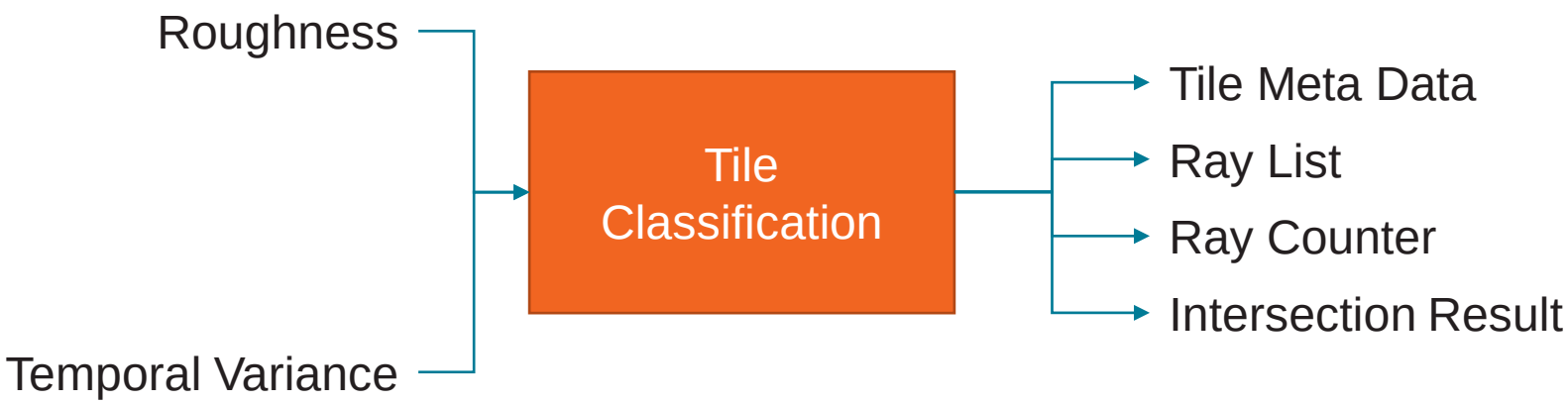

DEPTH


(WORLD SPACE)
NORMALS + HISTORY

MOTION VECTORS


LIT SCENE

TILE CLASSIFICATION

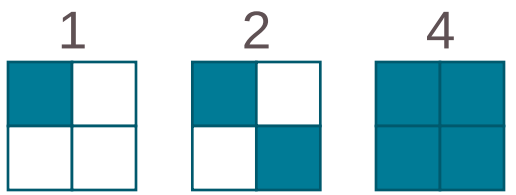


TILE CLASSIFICATION

Per Pixel Decision Pipe:

- Do we have to run a denoiser for this pixel?
  - Is non-mirror reflection
  - And is roughness within threshold
- Do we have to trace a ray for this pixel?
  - Is mirror reflection
  - Or has temporal variance
  - Or is roughness within threshold and survives variable rate decision
- Do we have to copy the result to neighbors?
  - Is base ray
  - And neighbor needs denoiser
  - And neighbor does not shoot a ray itself
- Local prefix sum to compact rays
- Increment **Ray Counter** and append pixel coordinates and copy information to **Ray List**

variable rate:
samples per quad



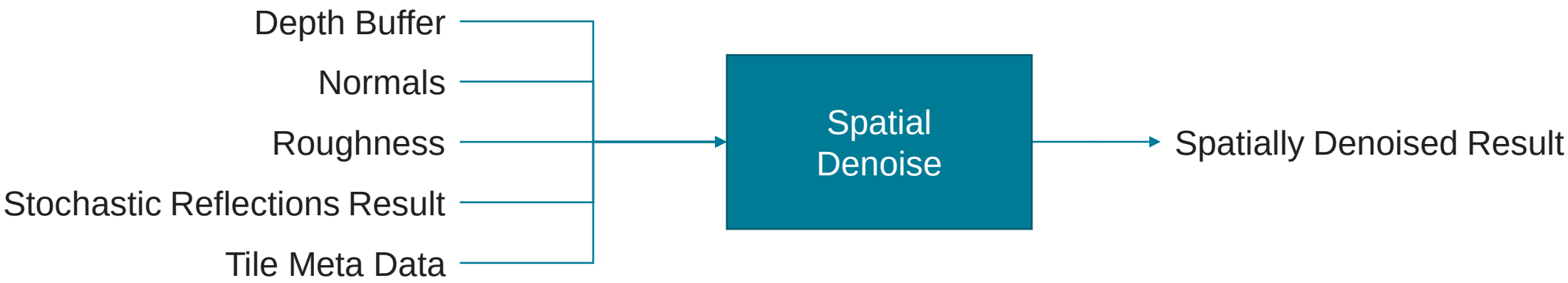
TILE CLASSIFICATION

Per Tile Decision Pipe:

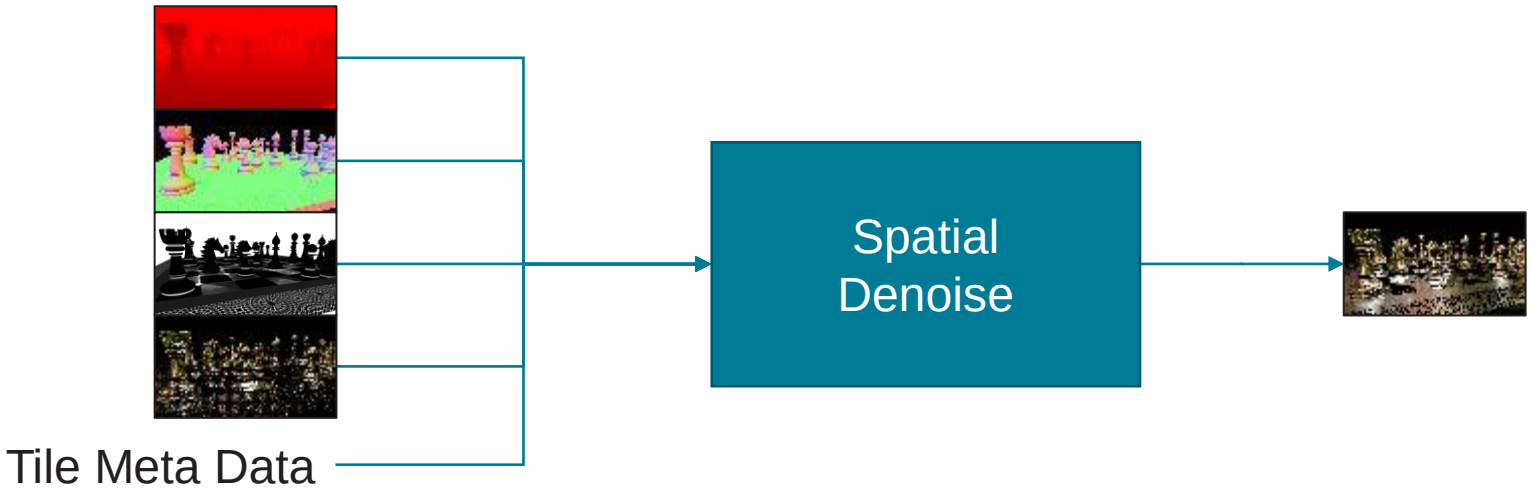
- 8x8 Tiles – matches denoiser granularity
- Do we have to run a denoiser on that tile?
  - Any pixel required a non-mirror ray?
- Set **Tile Meta Data** accordingly

STOCHASTIC REFLECTIONS

SPATIAL DENOISE



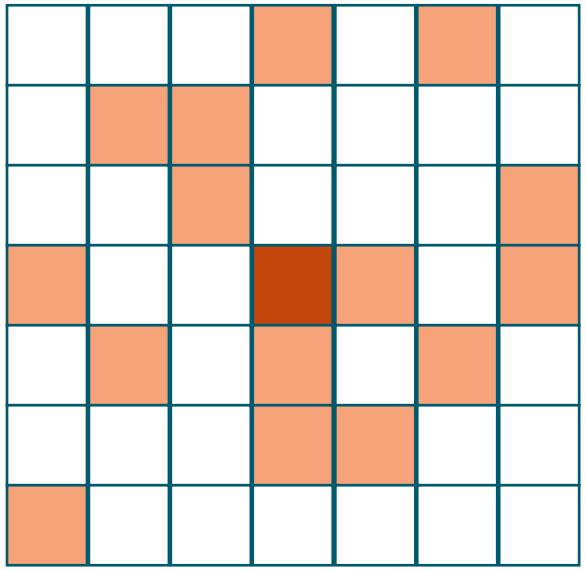
SPATIAL DENOISE



SPATIAL DENOISE - APPROACH

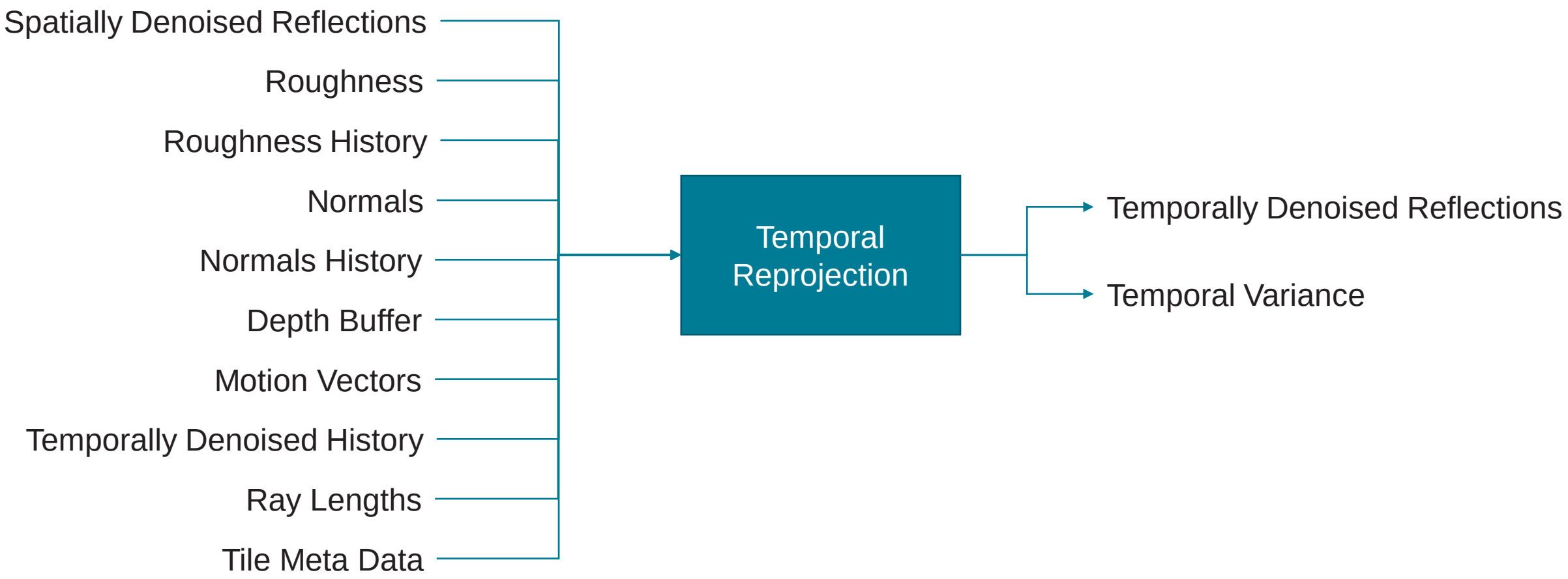
- 16 samples of Halton Sequence (2,3) discretized to 7x7 region
- Mirror sequence based on position within a quad
- Edge stopping weight based on normal
- Gaussian weight based on depth difference

- Accumulate all radiance values
- Normalize using accumulated weights

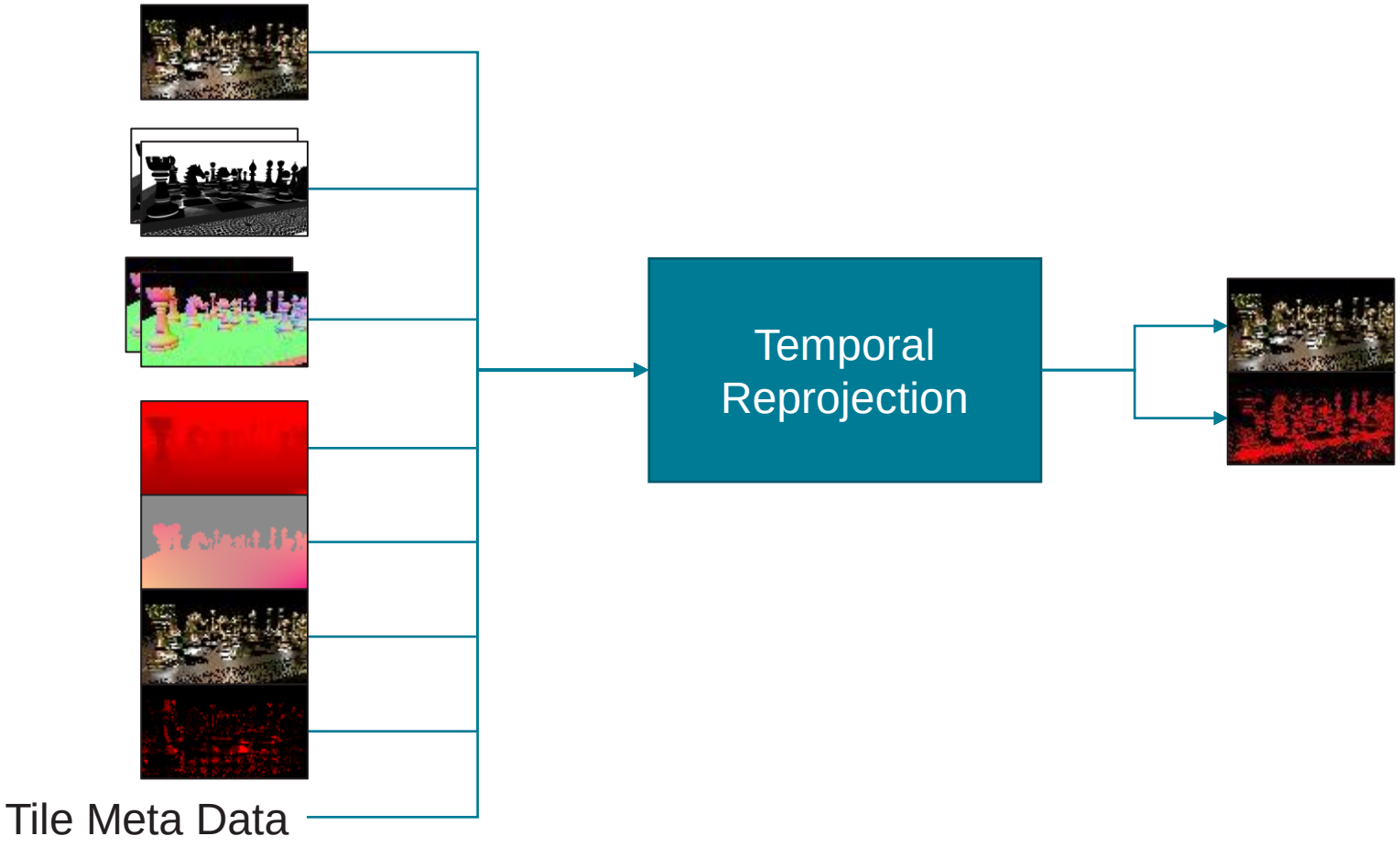


SPATIAL RESULT

TEMPORAL REPROJECTION



TEMPORAL REPROJECTION

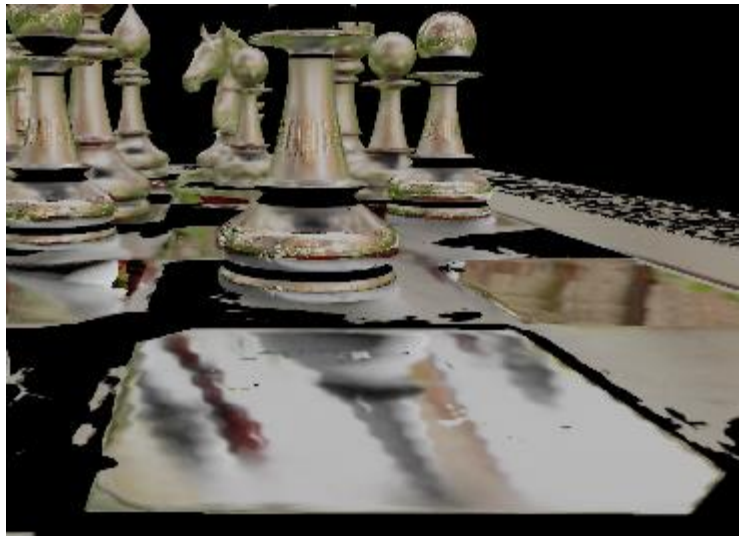


TEMPORAL REPROJECTION

- Accumulate history in ping pong buffer
- Use two different reprojection techniques to find history values:
  - **Surface reprojection** using motion vectors
  - **Hit reprojection** using ray lengths for parallax reprojection
- **Clip** history values to 3x3 neighborhood to fight ghosting
- **Blend** new values with history values based on confidence
  Edge stopping functions use history normal and history roughness
- Use difference of old ping pong buffer to new result to estimate **temporal variance**

TEMPORAL REPROJECTION

- Surface reprojection
  - Very rough surfaces
  - Use motion vectors to find history value



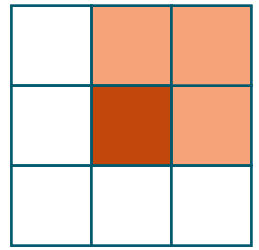
Surface reprojection breaks on very reflective surfaces

- Hit reprojection
  - Very shiny surfaces
  - Use parallax reprojection to find history value
  - Extend ray from camera to surface by the distance to the hit point
  - Reproject that world position back to the last frame
  - Project to screen space to see where it ended up last frame

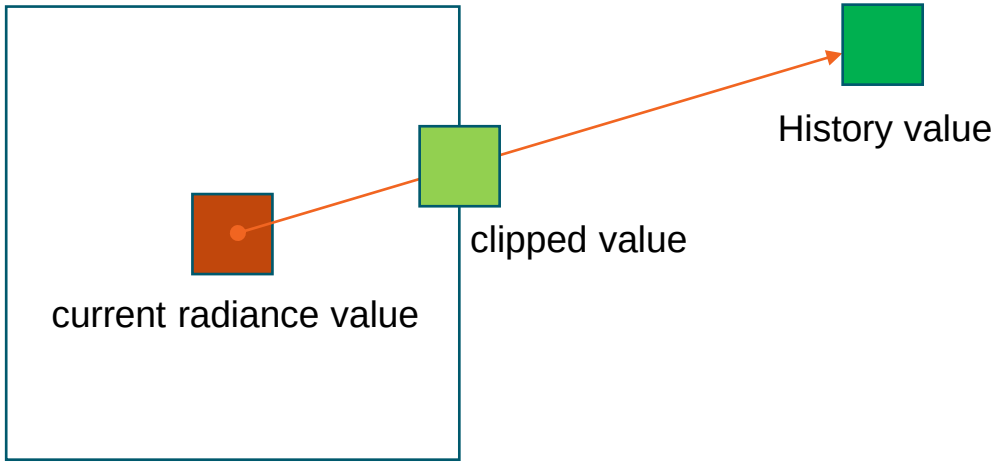
Hit reprojection breaks on very rough surfaces

TEMPORAL REPROJECTION

- Can still get ghosting artifacts
- Thus, clip history values to 3x3 region:
  - Calculate standard deviation
  - Create box around new radiance value using standard deviation
  - Extend box further to allow for some leeway



3x3 neighborhood

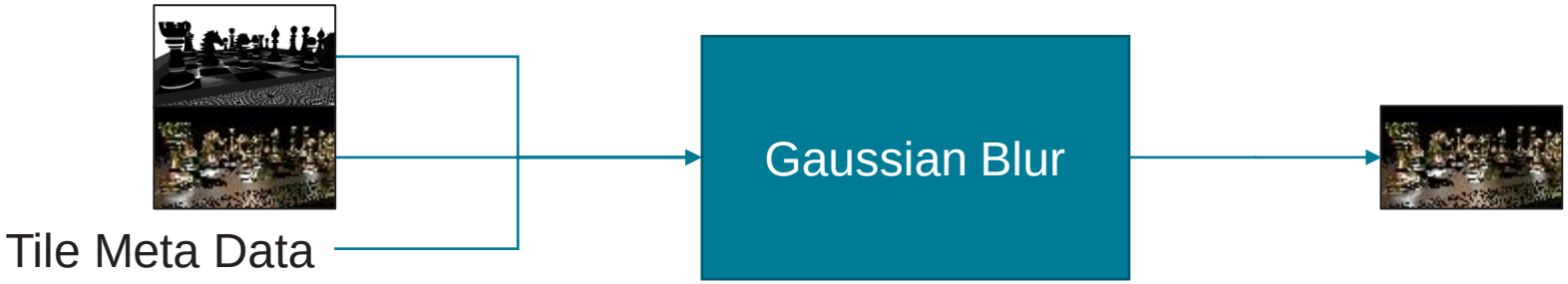


box in color space using scaled standard deviation

TEMPORAL RESULT

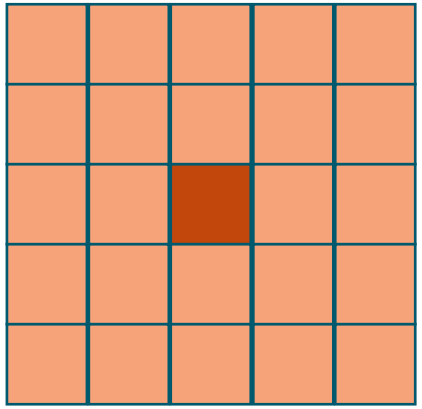
GAUSSIAN BLUR

GAUSSIAN BLUR



GAUSSIAN

- Goal is to get rid of remaining spatial noise
- Edge aware Gaussian blur in 5x5 region
- For performance reasons the edge stopping function is only done on roughness values



FINAL RESULT


APPLIED

SOURCE

- GPUOpen FFX Denoiser Product Page
  https://gpuopen.com/FidelityFX-Denoiser
- GitHub
  https://github.com/GPUOpen-Effects/FidelityFX-Denoiser
- GPUOpen FFX SSSR Product Page – Sample Application
  https://gpuopen.com/FidelityFX-SSSR

REFERENCES

- Frostbite presentations on Stochastic Screen Space Reflections
  https://www.ea.com/frostbite/news/stochastic-screen-space-reflections
- EA Seed presentation on Hybrid Real-Time Rendering
  https://www.ea.com/seed/news/seed-dd18-presentation-slides-raytracing
- SVGF
  https://cg.ivd.kit.edu/publications/2017/svgf/svgf_preprint.pdf
- Playdead Games - Temporal Reprojection Clipping
  https://github.com/playdeadgames/temporal