# *Correlation-Aware Semi-Analytic Visibility for Antialiased Rendering*

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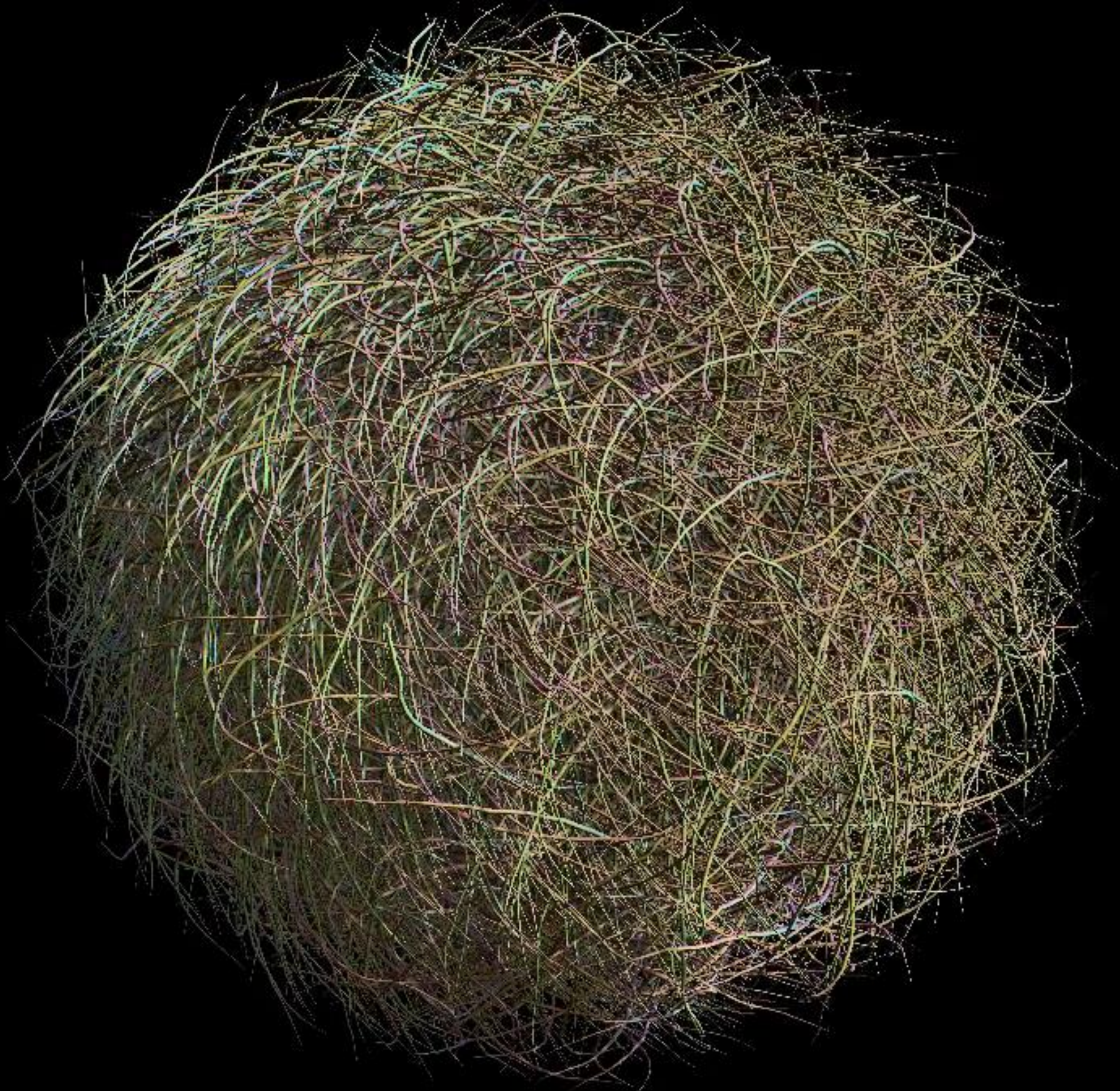
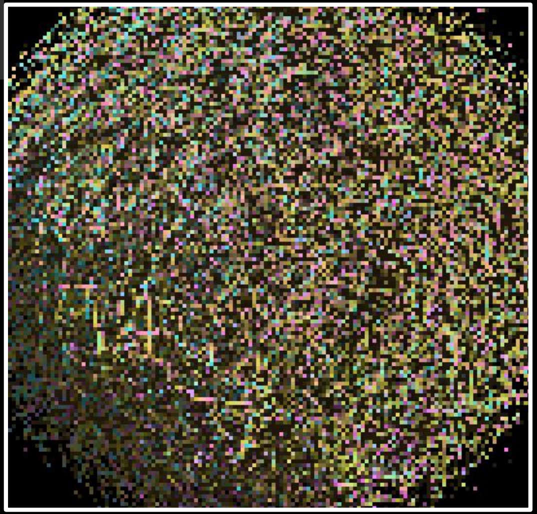
hpg 2018

NVIDIA

# 1 spp

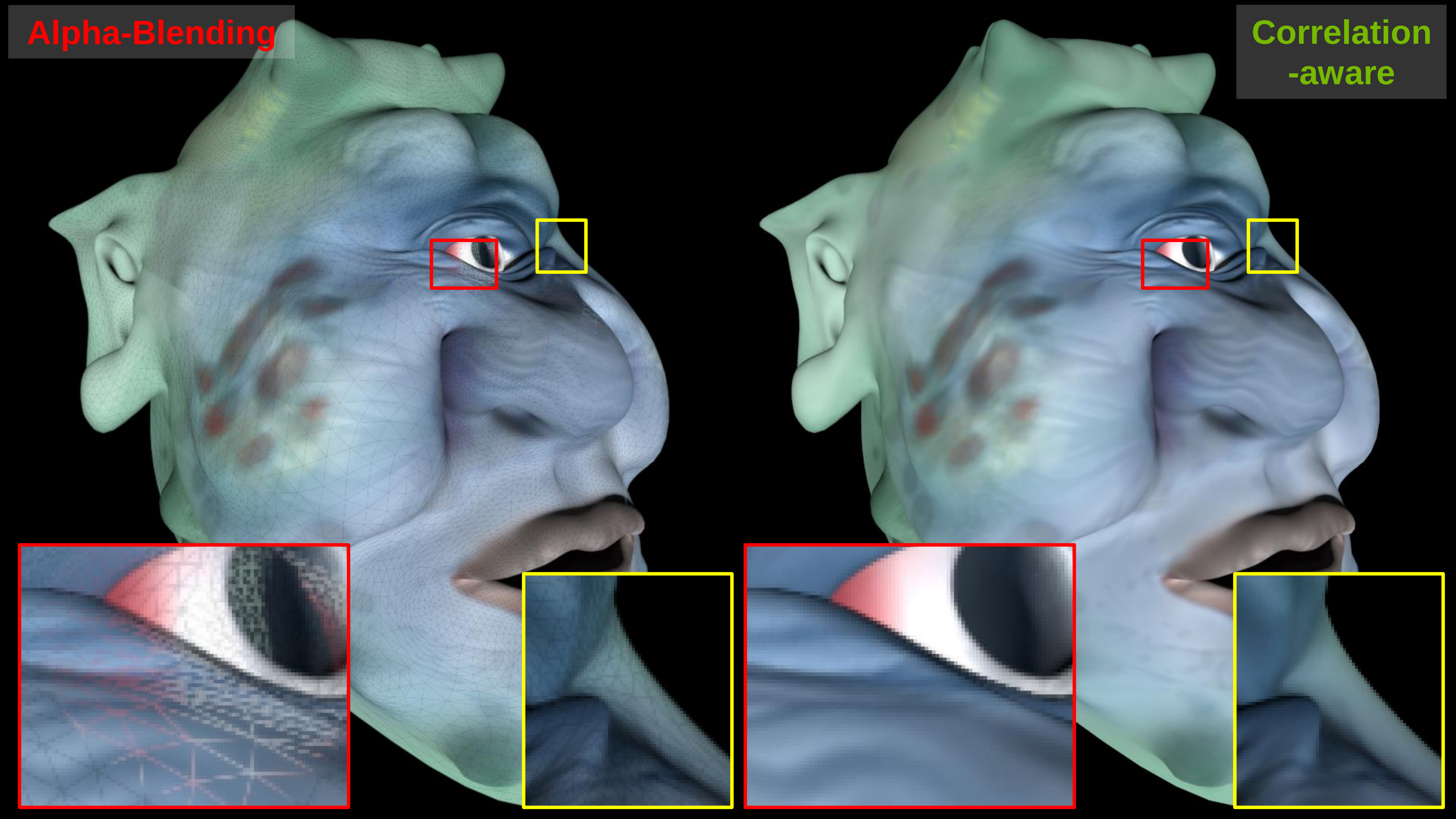




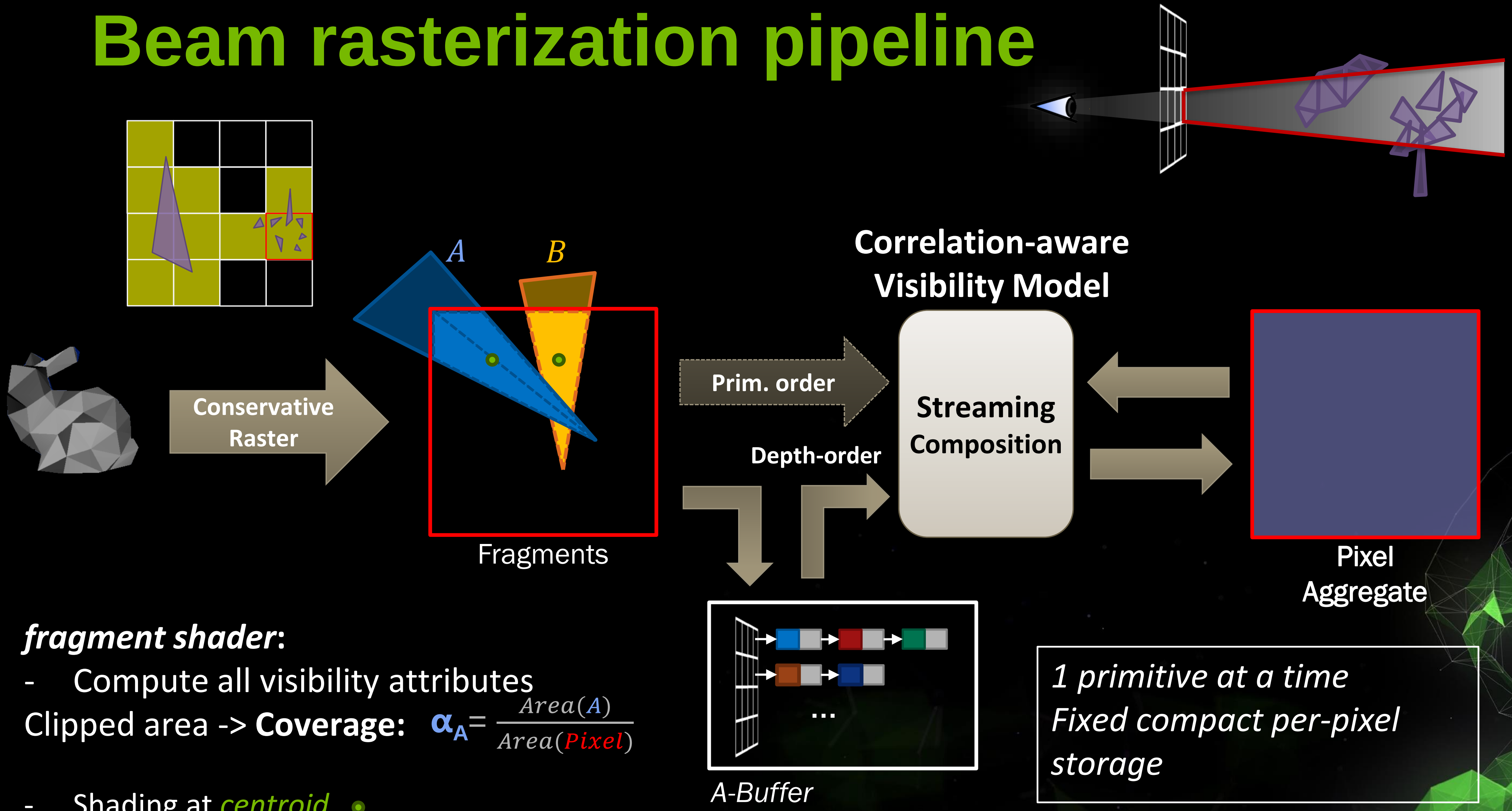
1/4 RESOLUTION

256x MSAA

Semi-Analytic


Alpha-Blending
Correlation
-aware

# Beam rasterization pipeline




***fragment shader***:

- Compute all visibility attributes

Clipped area -> **Coverage:** $\alpha_A = \frac{Area(A)}{Area(Pixel)}$

- Shading at *centroid*

*1 primitive at a time*
*Fixed compact per-pixel storage*

# Alpha-Composition

*Fractional coverage*

$$\alpha_A = \frac{Area(A)}{Area(Pixel)}$$

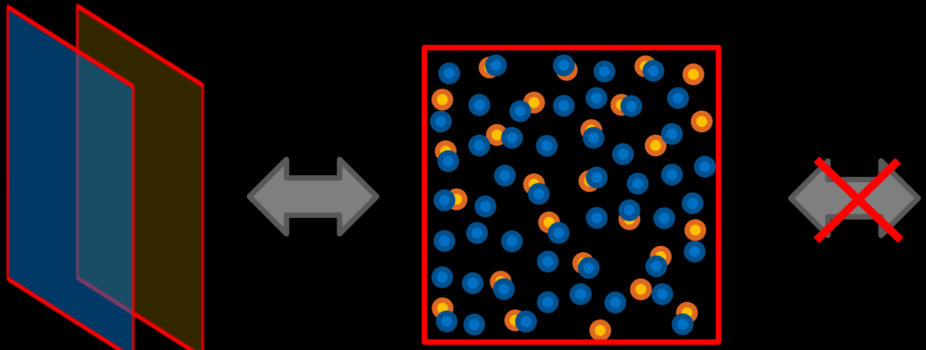
⬄

*Probability of coverage*

$\alpha_A = P(A)$ *in [0,1]*

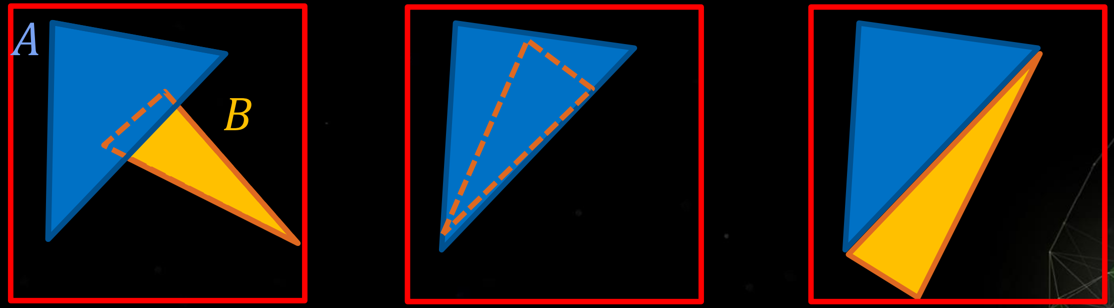
$$\begin{aligned}\alpha_A \text{ OVER } \alpha_B &= P(A \cup B) \\ &= P(A) + P(B) - P(A \cap B) \\ &= P(A) + P(B) - P(A) \times P(B) \quad = P(A) + P(B) \times (1-P(A)) \\ &= \alpha_A + \underbrace{\alpha_B \times (1-\alpha_A)}_{\textit{Visible contribution of B}}\end{aligned}$$

Assuming A, B statistically independent (<u>uncorrelated</u>):
$P(A \cap B) = P(A) \times P(B)$



A OVER B

Decorrelation




"Some"-correlation

**Full-correlation**:
$P(A \mid B) = 1$,
$P(A \cap B) = P(B)$ *
→ $P(A \cup B) = P(A)$

**Anti-correlation**:
$P(A \mid B) = 0$, $P(B \mid A) = 0$,
$P(A \cap B) = 0$
→ $P(A \cup B) = P(A) + P(B)$

**Aggregate geometry**
**Uncorrelated coverages**

**Structured geometry**
**Correlated coverages**

**[if P(A)>P(B)]*

# Correlation tracking

*Localization* bitmasks:

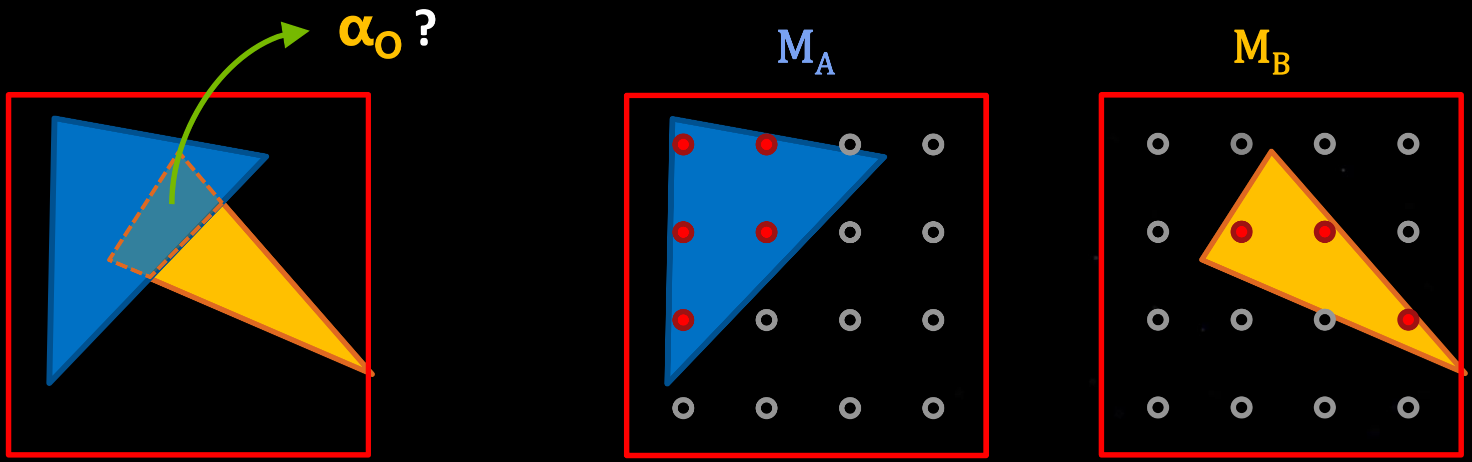
Track the spatial location of coverage

NOT *Coverage* masks !

**32-bit Mask**

**Jittered positions**

(Hammersley sequence)




$\alpha_A = 0.2$

$|M_A| = 5$

$\alpha_B = 0.13$

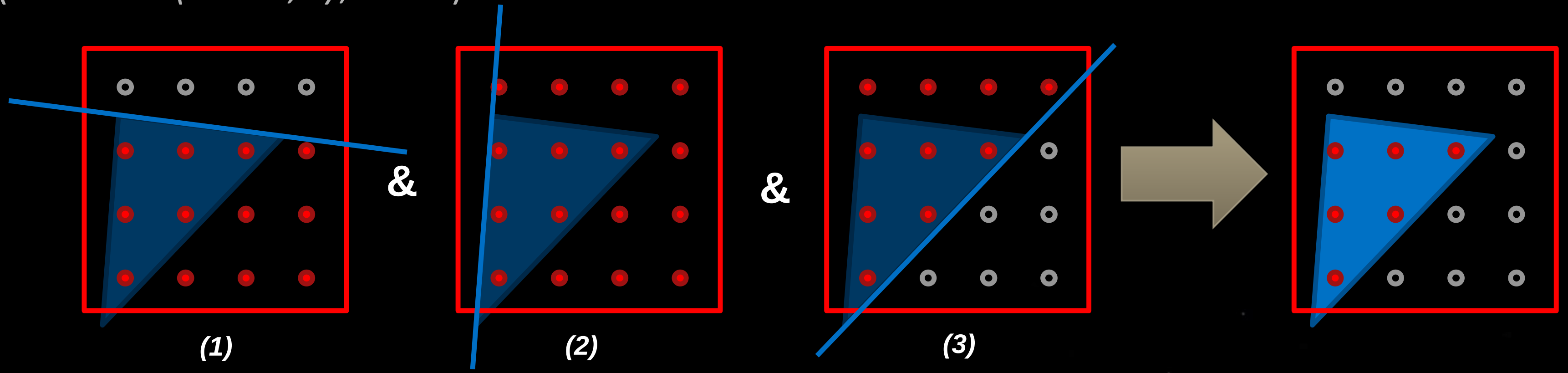
$|M_B| = 3$

# Generating *localization* masks

**Lookup table fetches:**

(2D Table *(Theta, r)*, 16KB)

[Waller et al. 2000, Sintorn et al. 2008…]

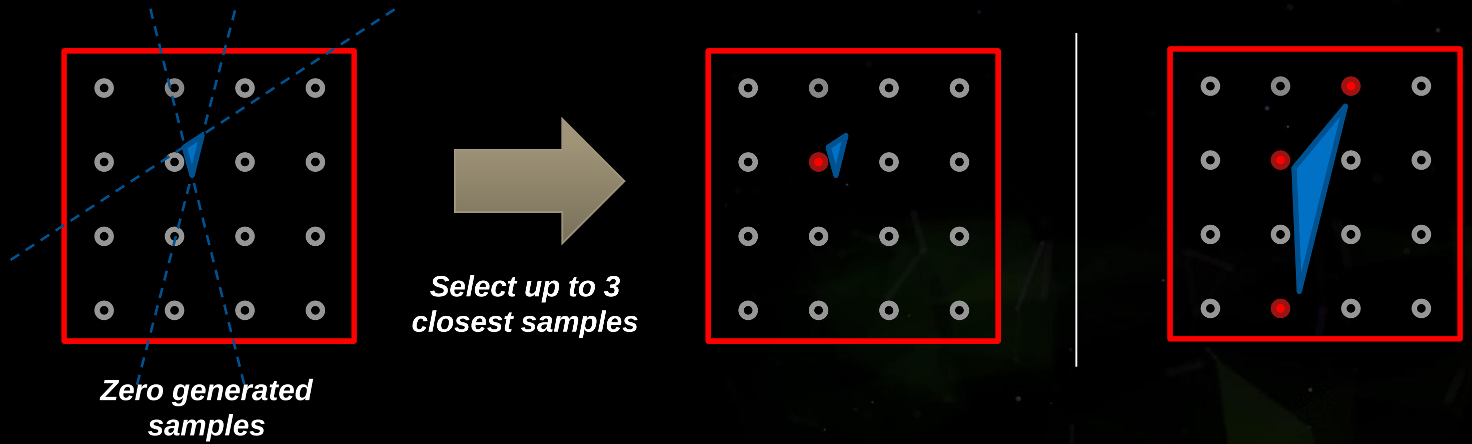


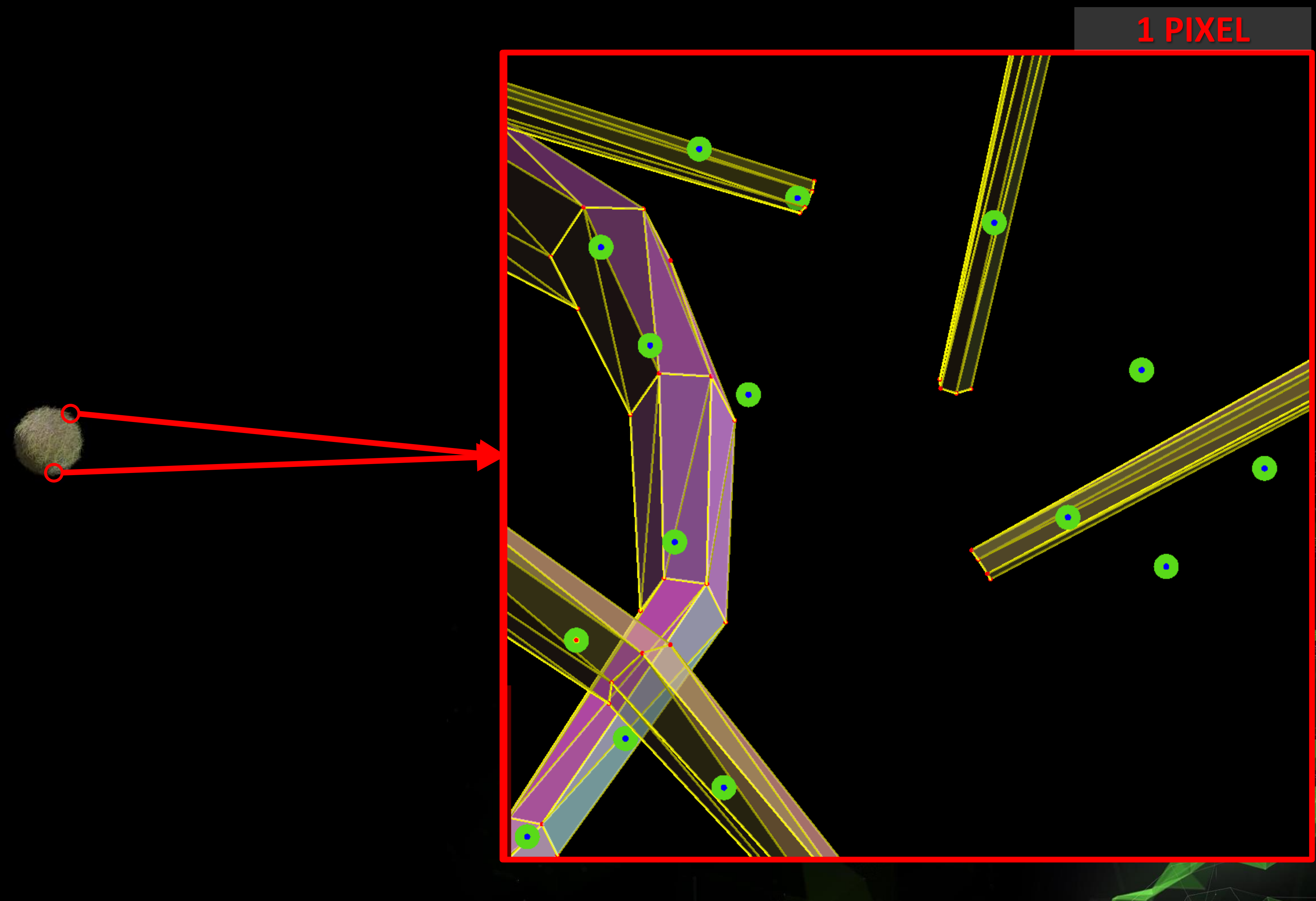

**32-bit Mask**

**Jittered positions**

(Hammersley sequence)

**Tiny, zero-coverage triangles:**

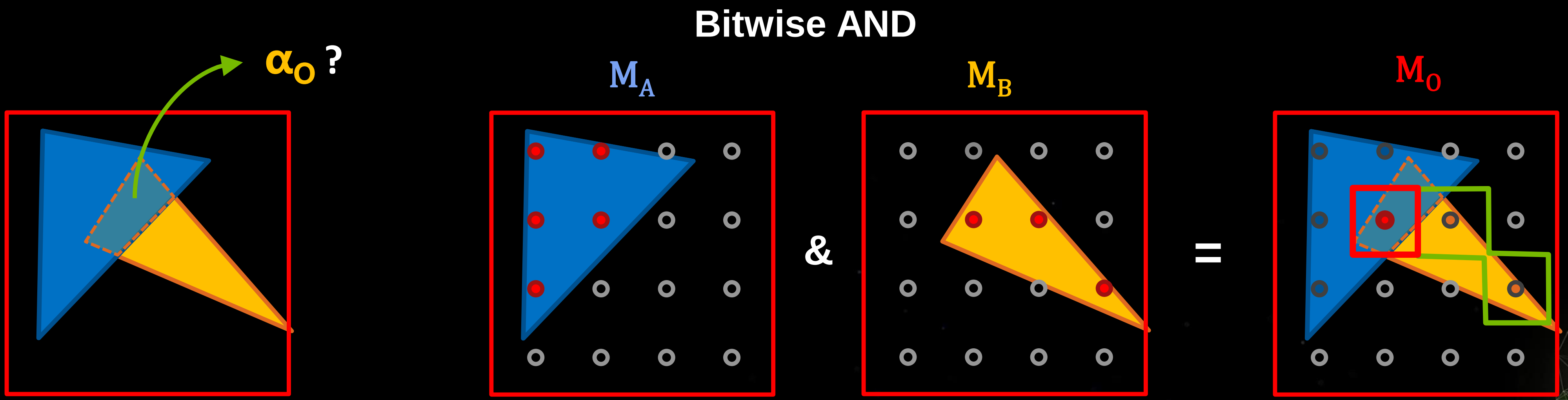



1 PIXEL

# Correlation tracking

*Localization* bitmasks:

Track the spatial location of coverage




$\alpha_A = 0.2$

$|M_A| = 5$

$\alpha_B = 0.13$

$|M_B| = 3$

$|M_O| = 1$

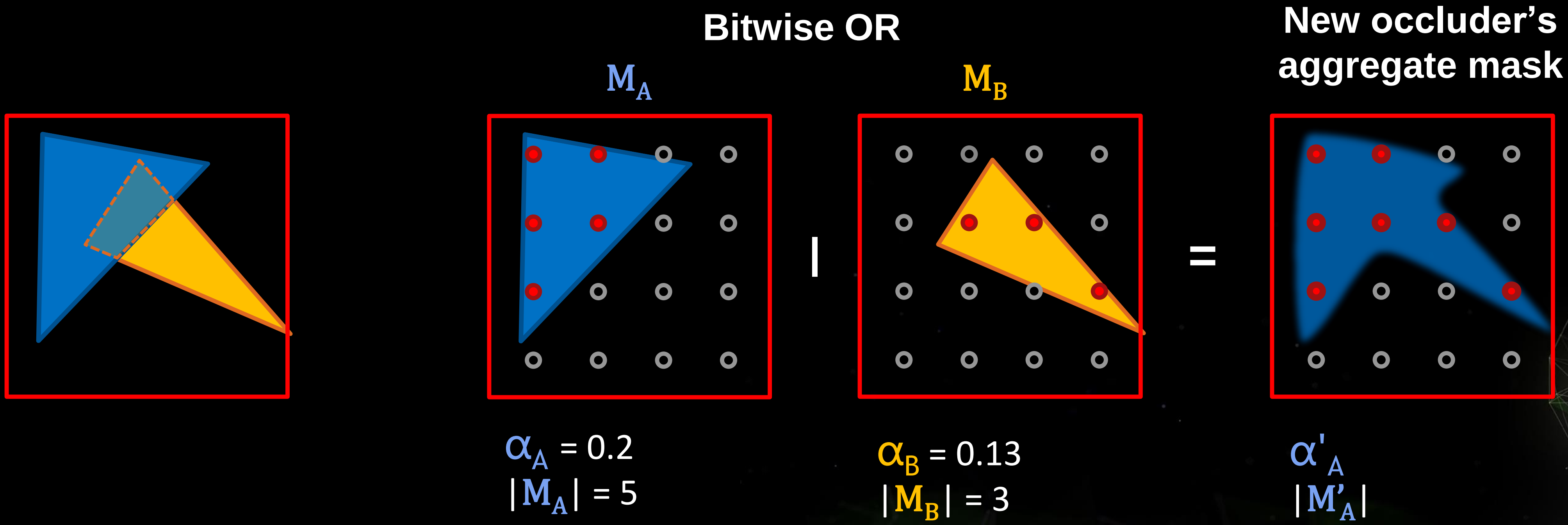
$$\alpha^O{}_A = \frac{|M_O|}{|M_A|}\alpha_A$$

$$\alpha^O{}_B = \frac{|M_O|}{|M_B|}\alpha_B$$

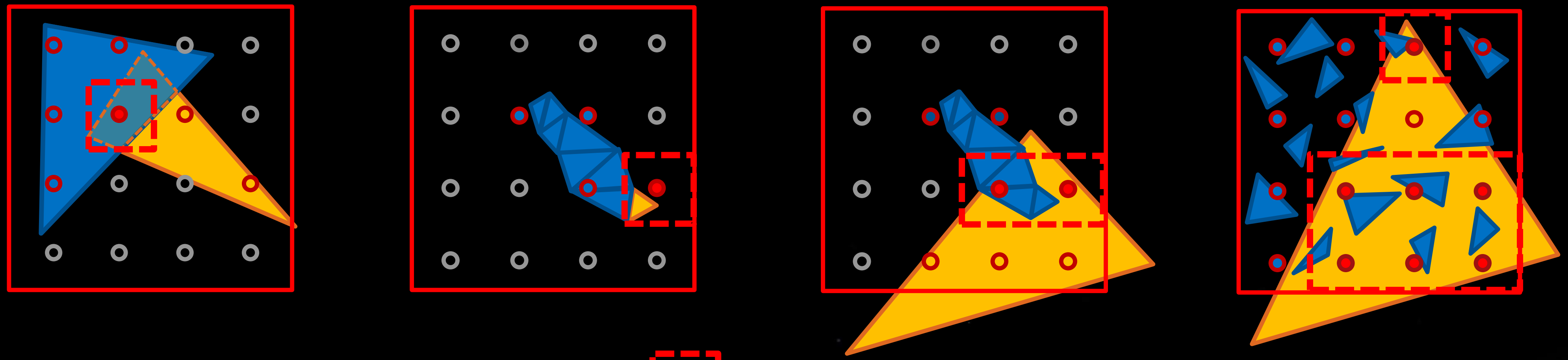
# Correlation tracking

*Localization* bitmasks:

Track the spatial location of coverage



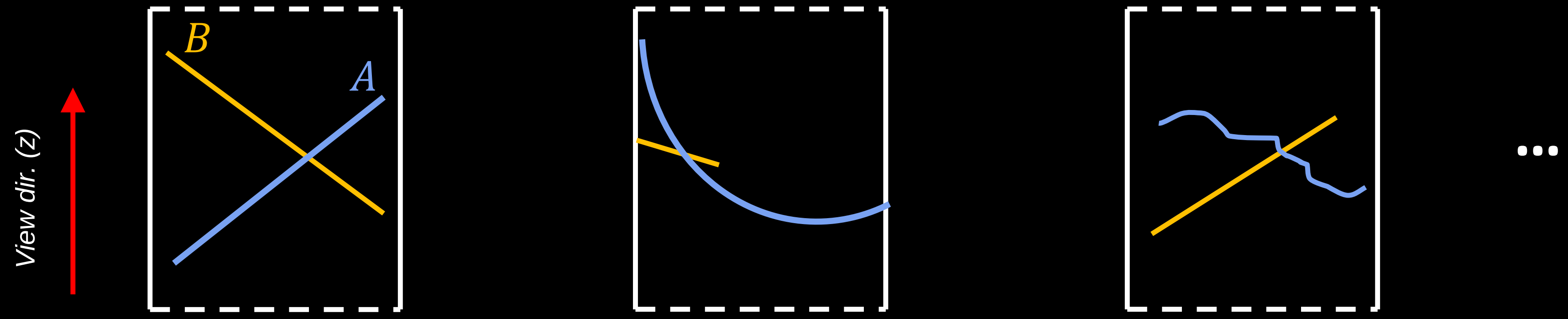
# *Potentially* overlapping regions

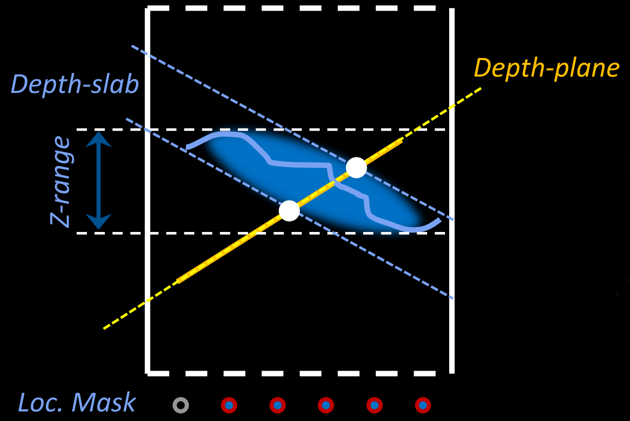


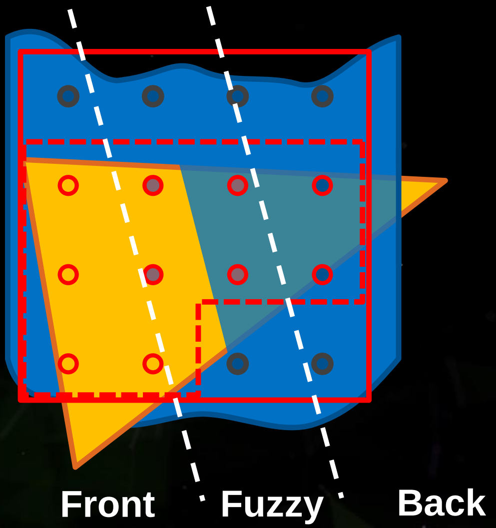
Inside the *potential* overlap region ***O***

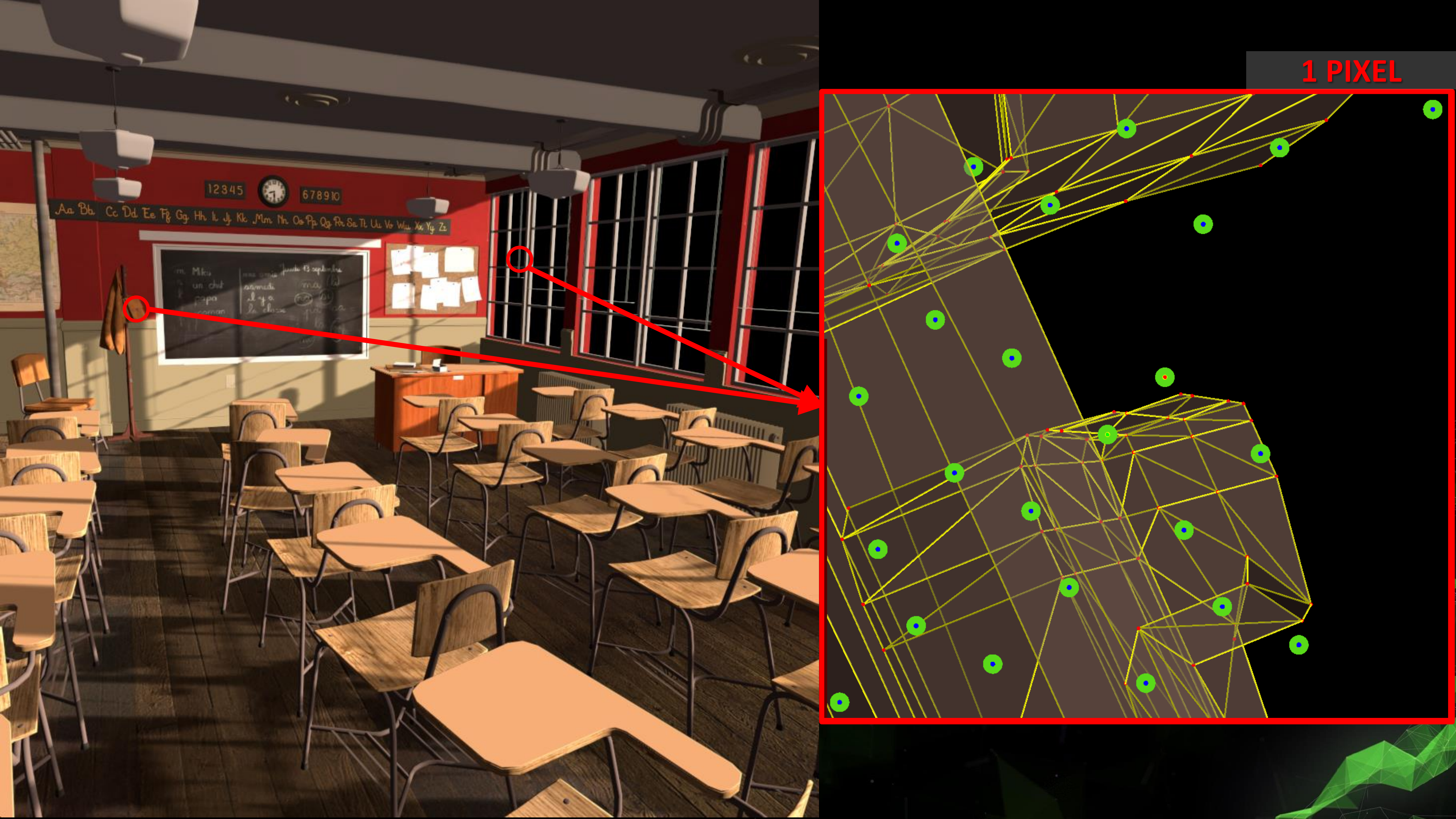
- **Assuming decorrelation** → **OVER** blending *(multiplicative composition)*
- **Use ad-hoc *fuzziness* heuristic → Transition ADD <-> OVER**
  - $\frac{|M_A|}{\alpha_A}$ x sadp(A, B)

# Surface Intersections

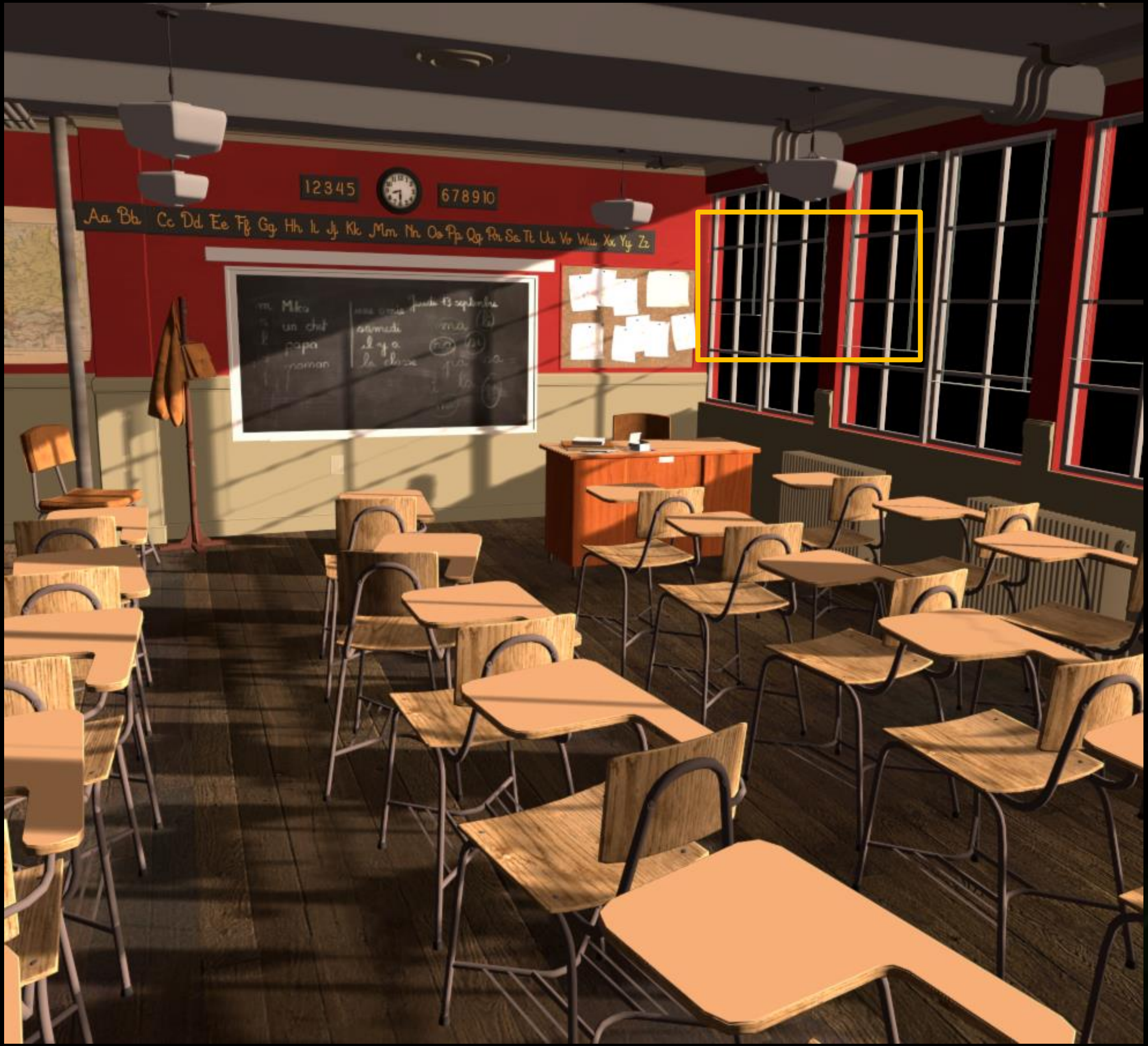


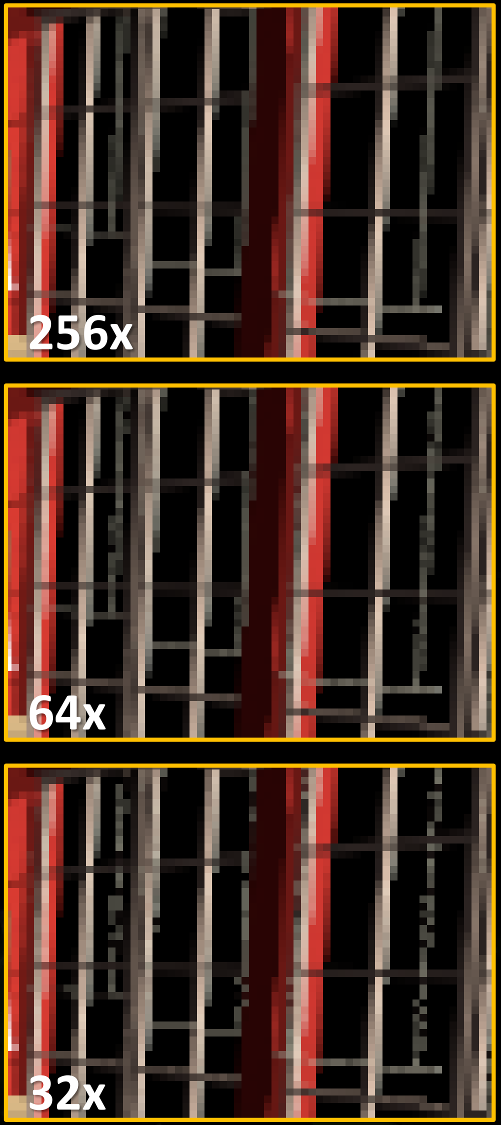




1 PIXEL
12345
678910

## 1/4 Resolution

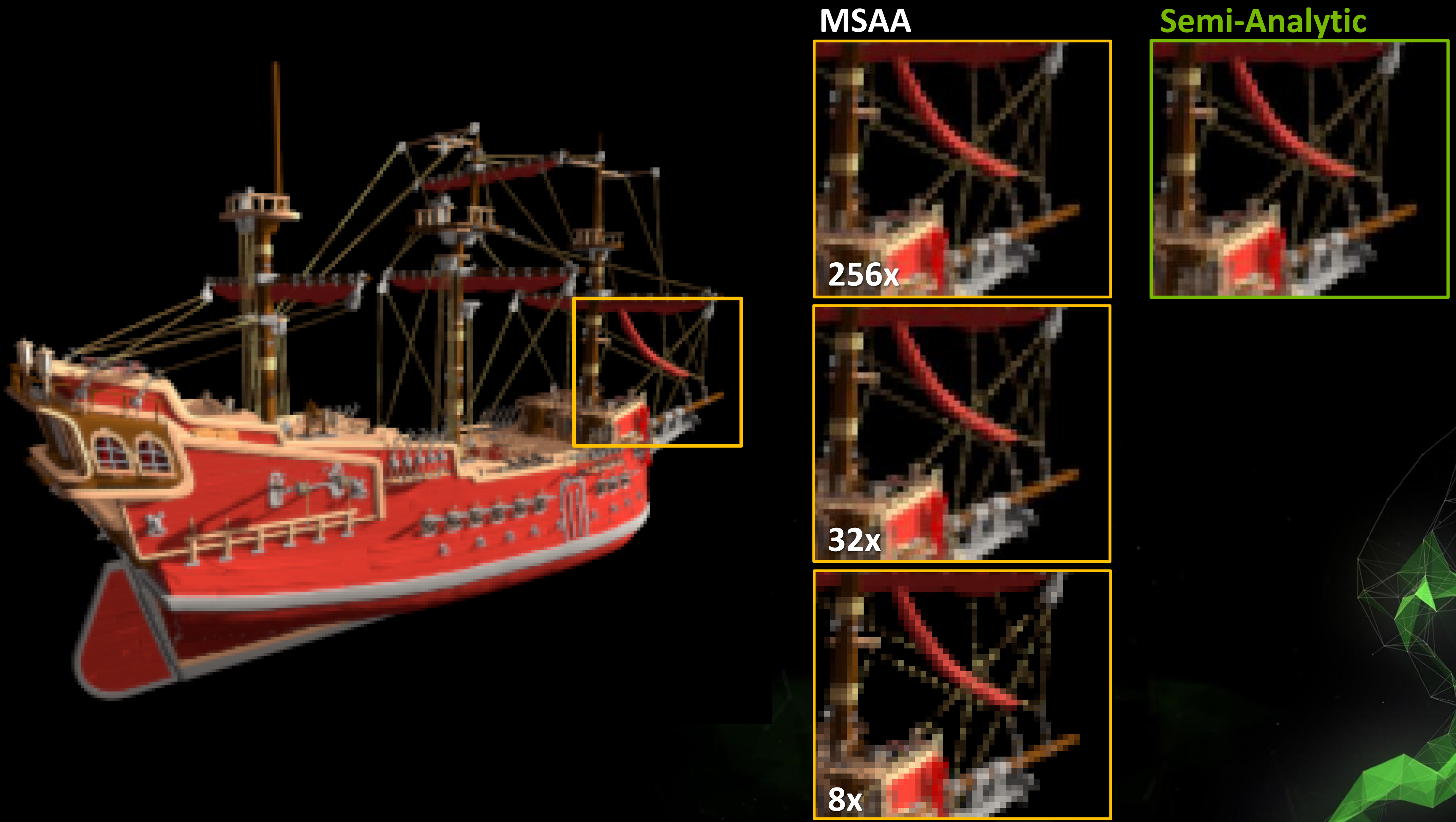



**MSAA**




**Semi-Analytic**

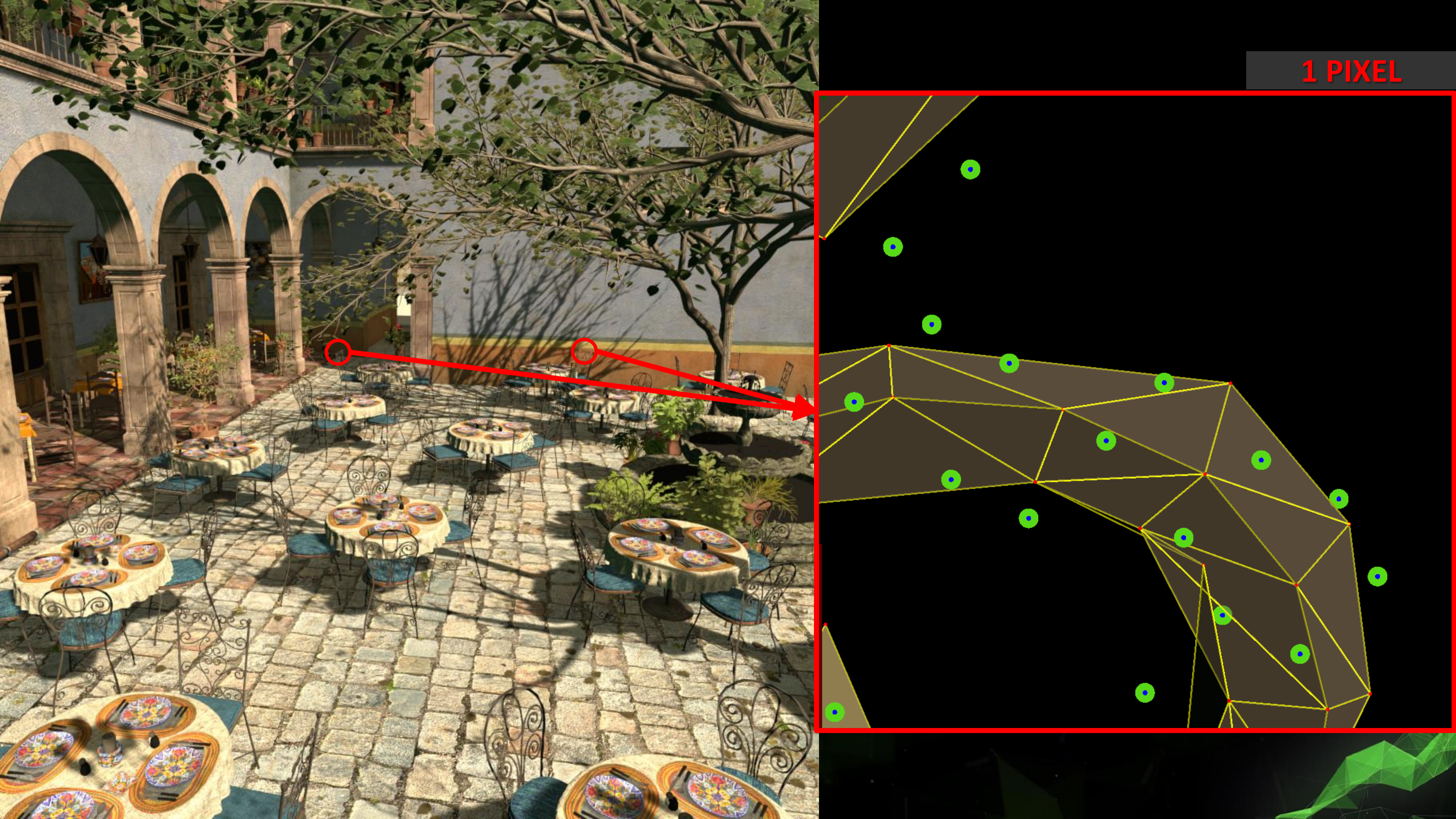
*~6x faster*



MSAA
Semi-Analytic
256x
32x
8x

MSAA

Semi-Analytic


1 PIXEL

[1/4 Resolution]

256x MSAA

Semi-Analytic


256x MSAA
8x MSAA
Semi-Analytic

# Thank You !

# Memory consumption

*Without compression*

- *Without color:*

Our approach: 36 Bytes/pixel

MSAA 8x: 24-32 Bytes/pixel

MSAA 32x: 96-128 Bytes/pixel

- *With fp16 color:*

Our approach: 42 Bytes/pixel

MSAA 8x: 72-80 Bytes/pixel

MSAA 32x: 288-320 Bytes/pixel

**Aggregate / Fragment Visibility rep.** *(42 Bytes)*

- **C** : Color (3x 2B)
- **α** : Coverage (4B)
- **M** : Localization Mask (4B)
- **S** : Depth Slab
  Plane equation (4x 4B) + thickness (4B)
- $Z_{min}$,$Z_{max}$: Depth range (2x 4B)