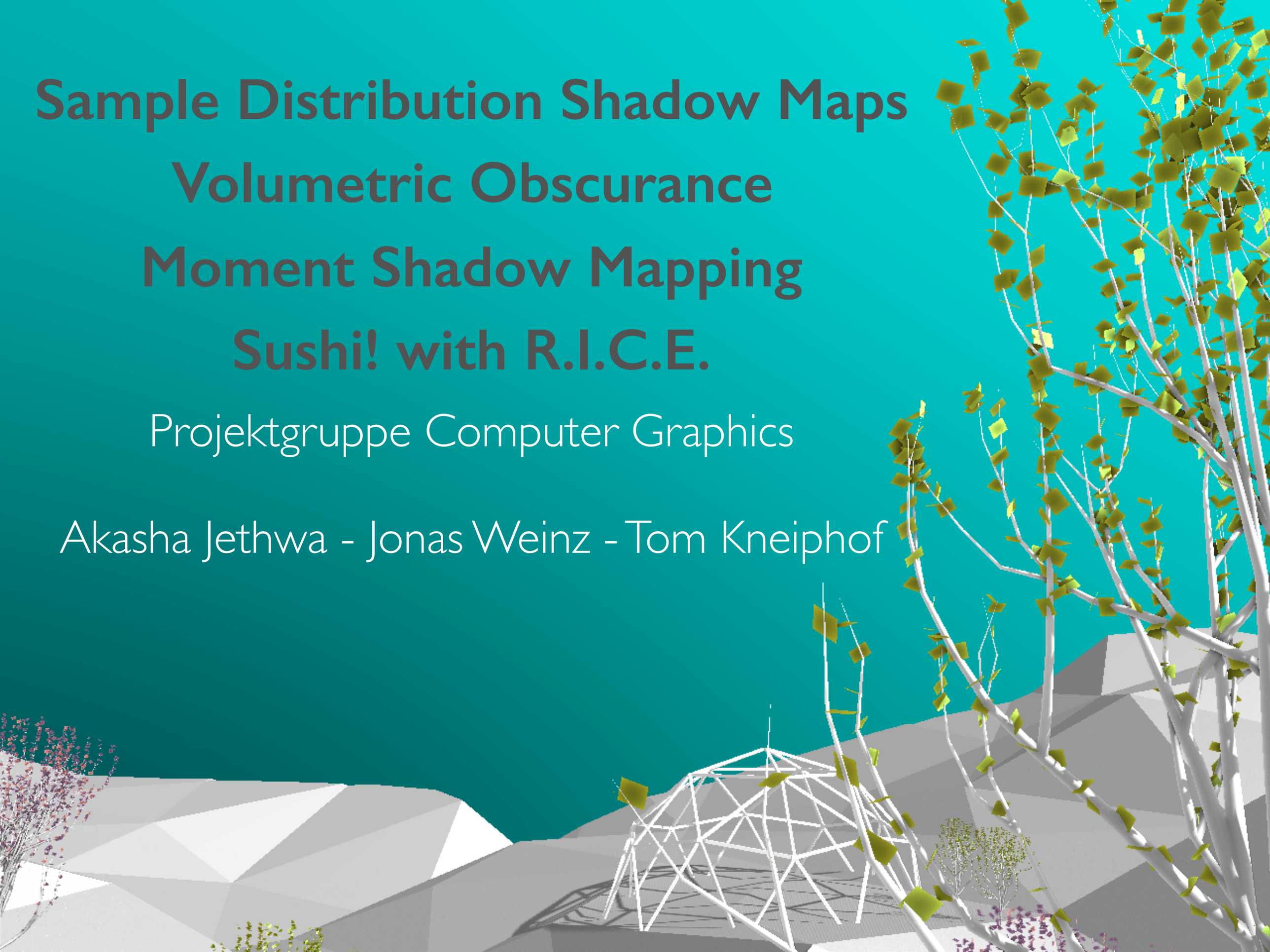
Sample Distribution Shadow Maps
Volumetric Obscurance
Moment Shadow Mapping
Sushi! with R.I.C.E.

Projektgruppe Computer Graphics

Akasha Jethwa - Jonas Weinz - Tom Kneiphof



I. INHALT

TECHNIKEN

2. Sample Distribution Shadow Maps

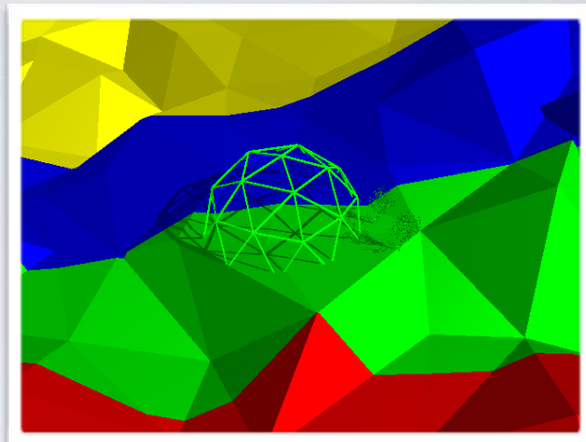
3. Volumetric Obscurance

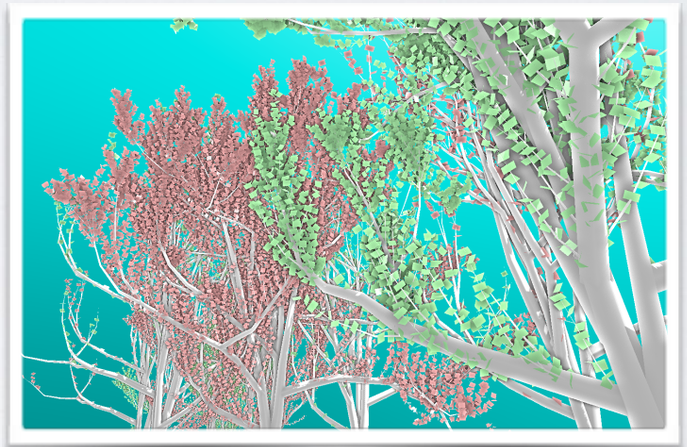
4. Moment Shadow Mapping

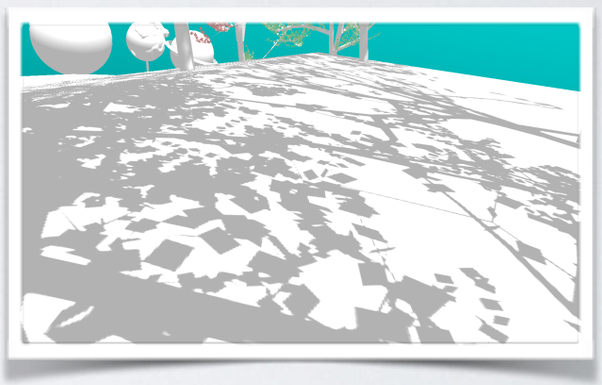
DEMO

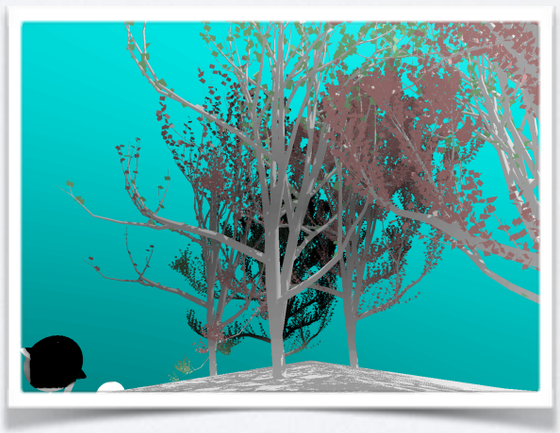
5. Sushi! with R.I.C.E.

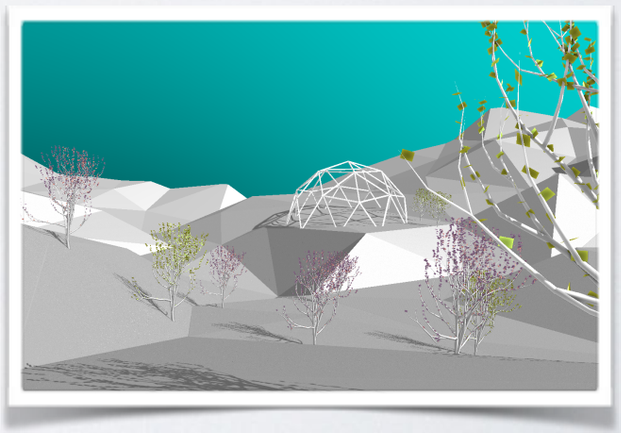
6. Fazit und Aussichten





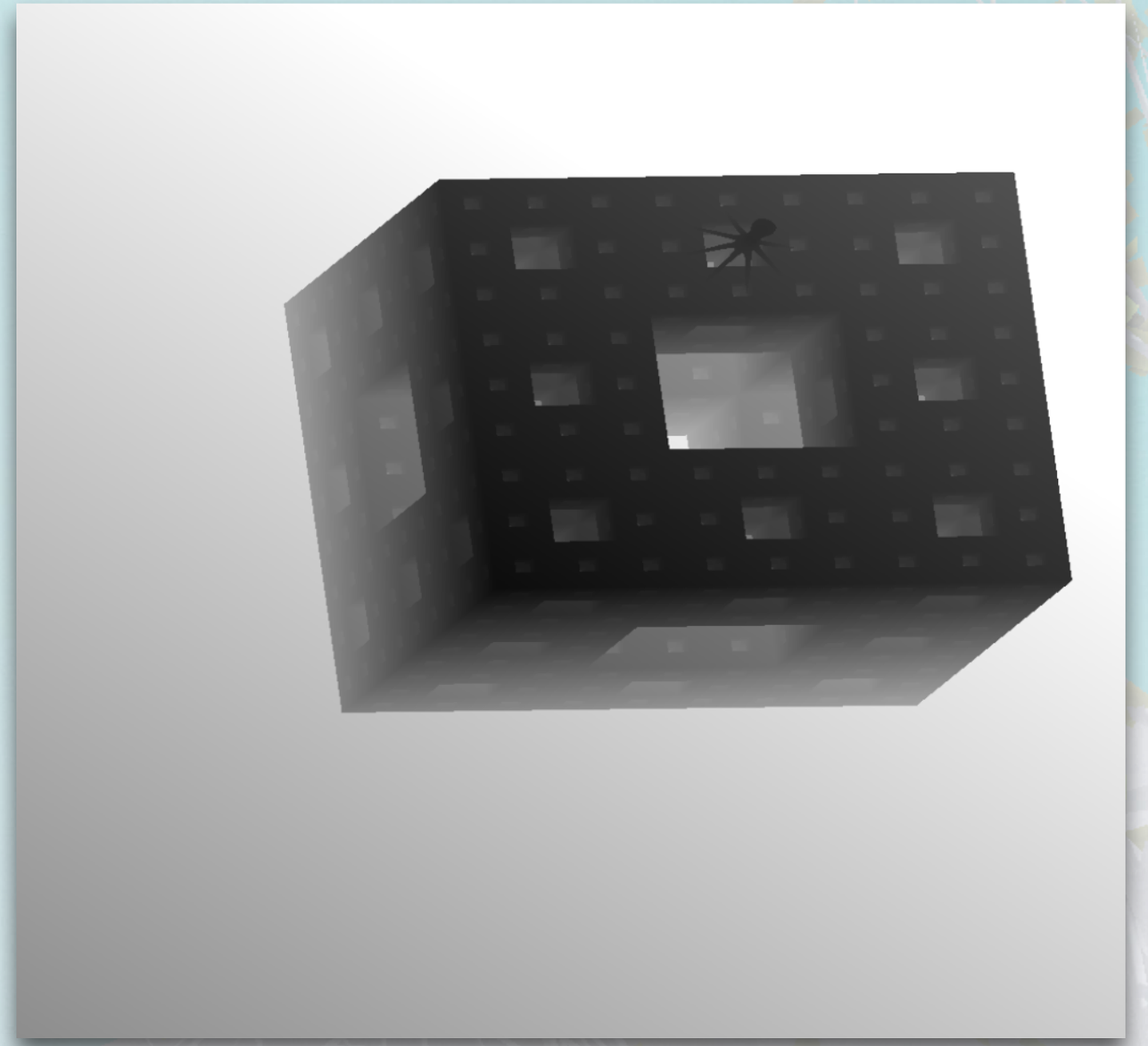






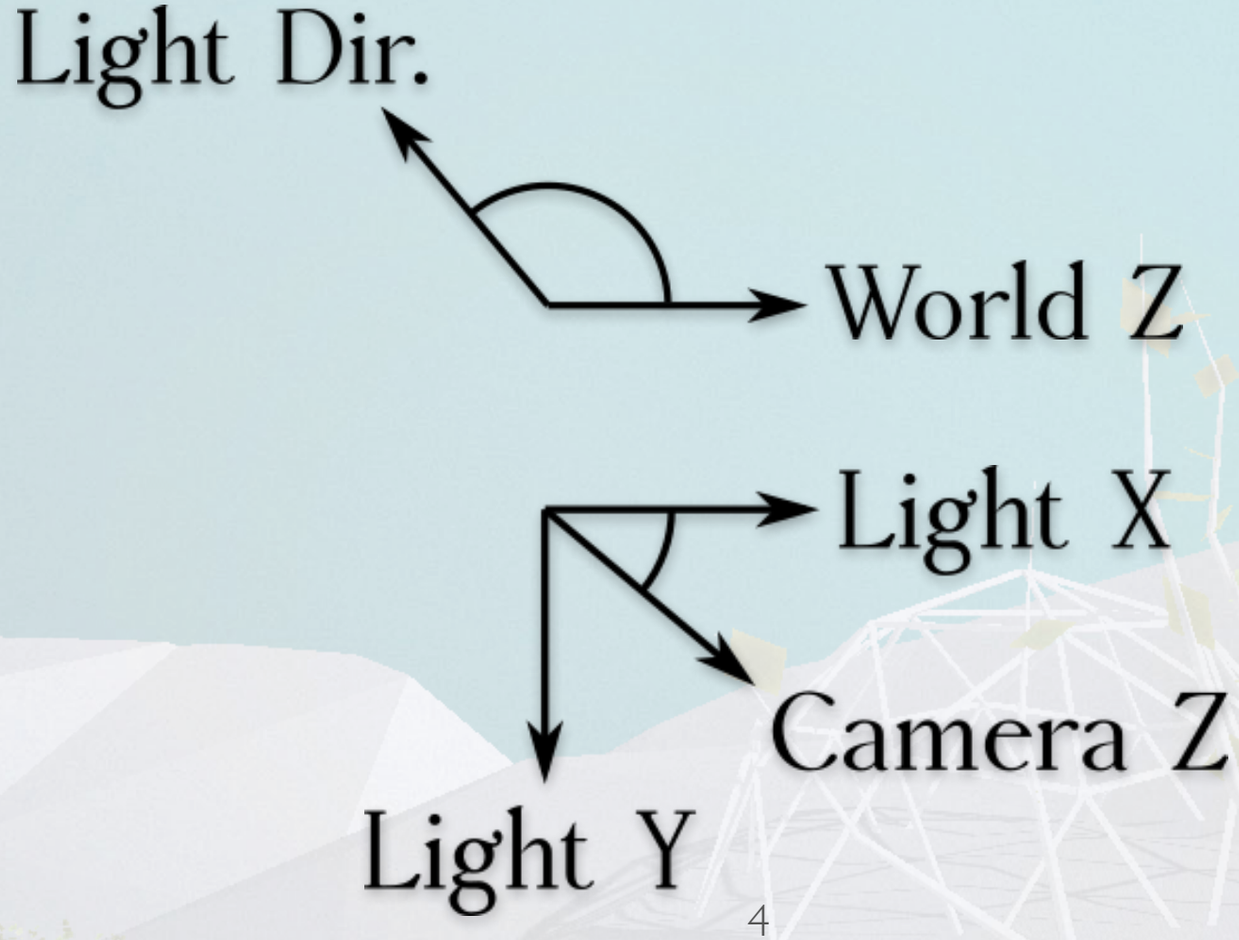
2.1 SDSM: MOTIVATION

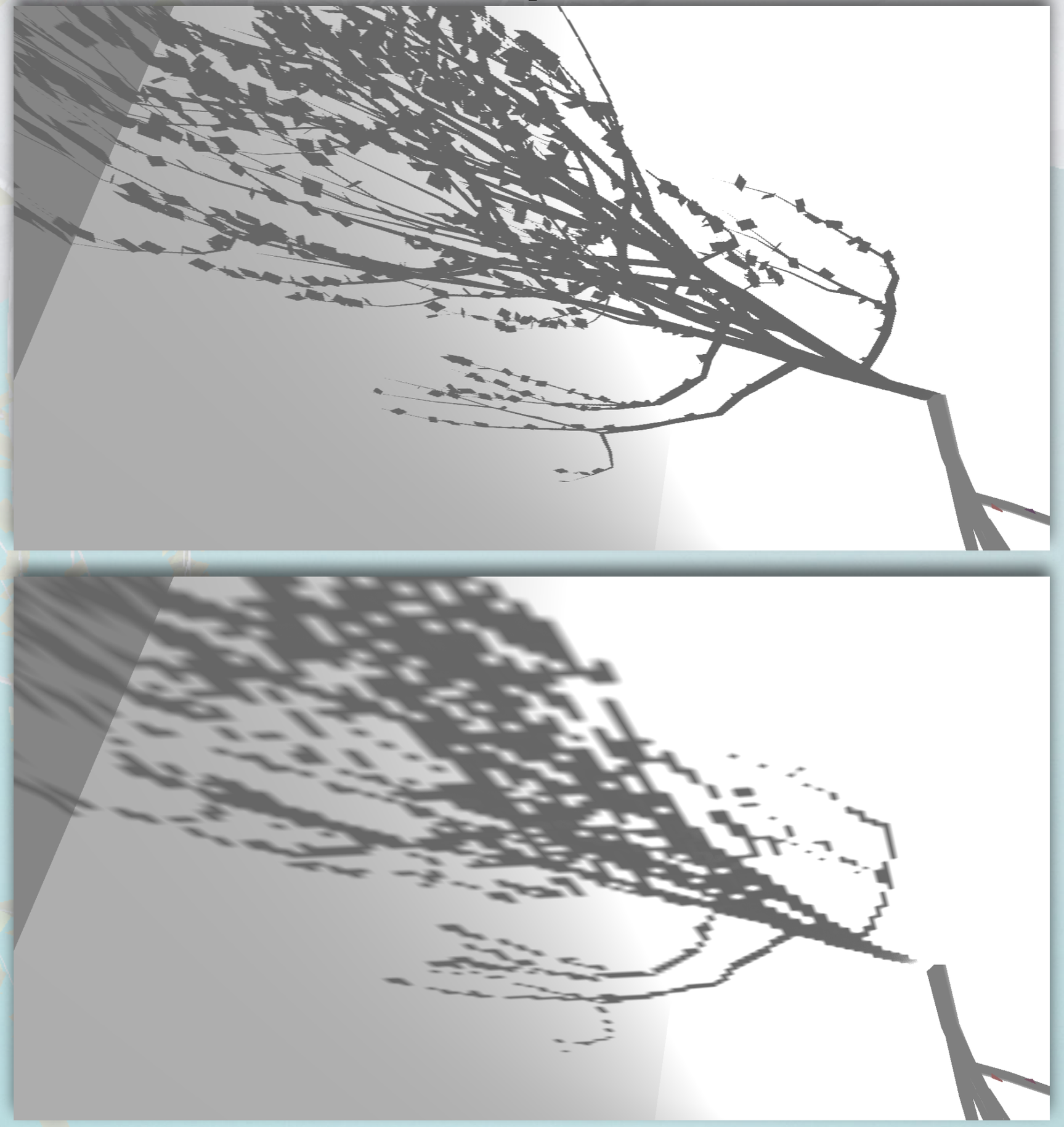
- Echtzeit Schatten
- Punktlichtquellen
- Render Tiefe aus Sicht des Lichtes



2.2 SDSM: LIGHT SPACE

- Rotiere Light Direction auf Z-Achse
- Rotiere Kamera Z-Achse um die resultierende Z-Achse auf X-Achse

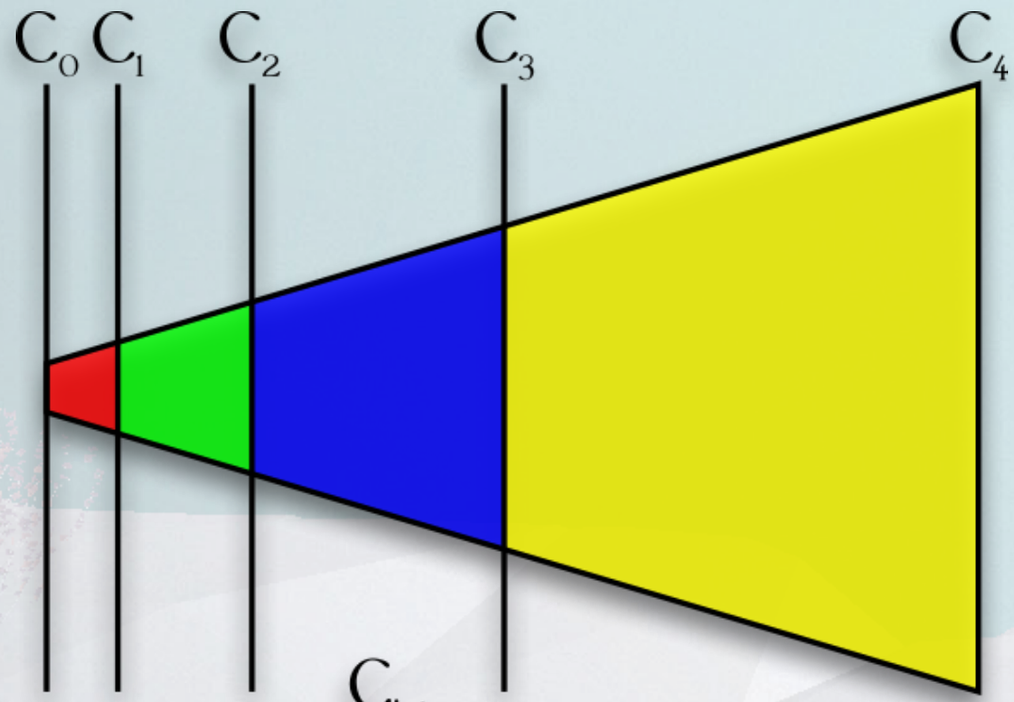




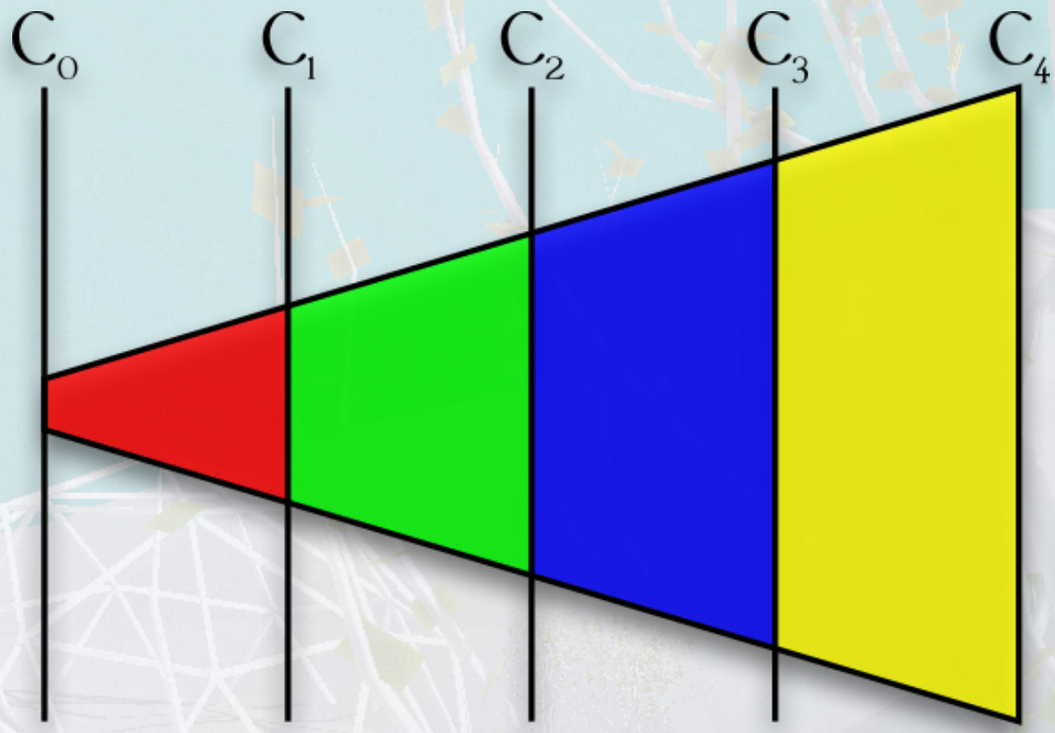
2.3 SDSM: PARALLEL SPLIT SHADOW MAPS

- Partiotionere Kamerafrustum entlang Z-Achse
- Eigene Shadowmap pro Kaskade
- Vermeide Oversampling, Undersampling, Geometrisches Aliasing

logarithmisch

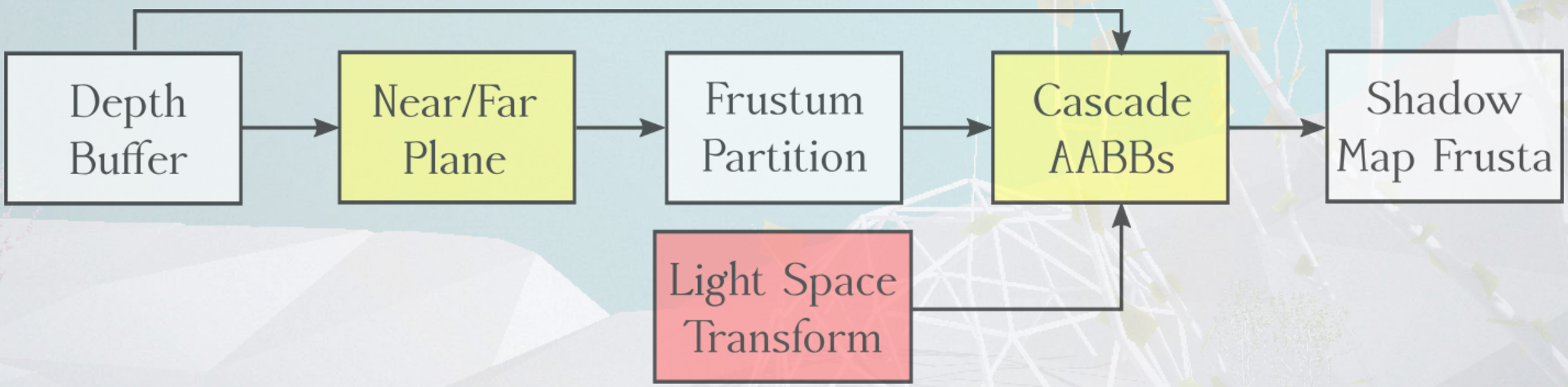


uniform



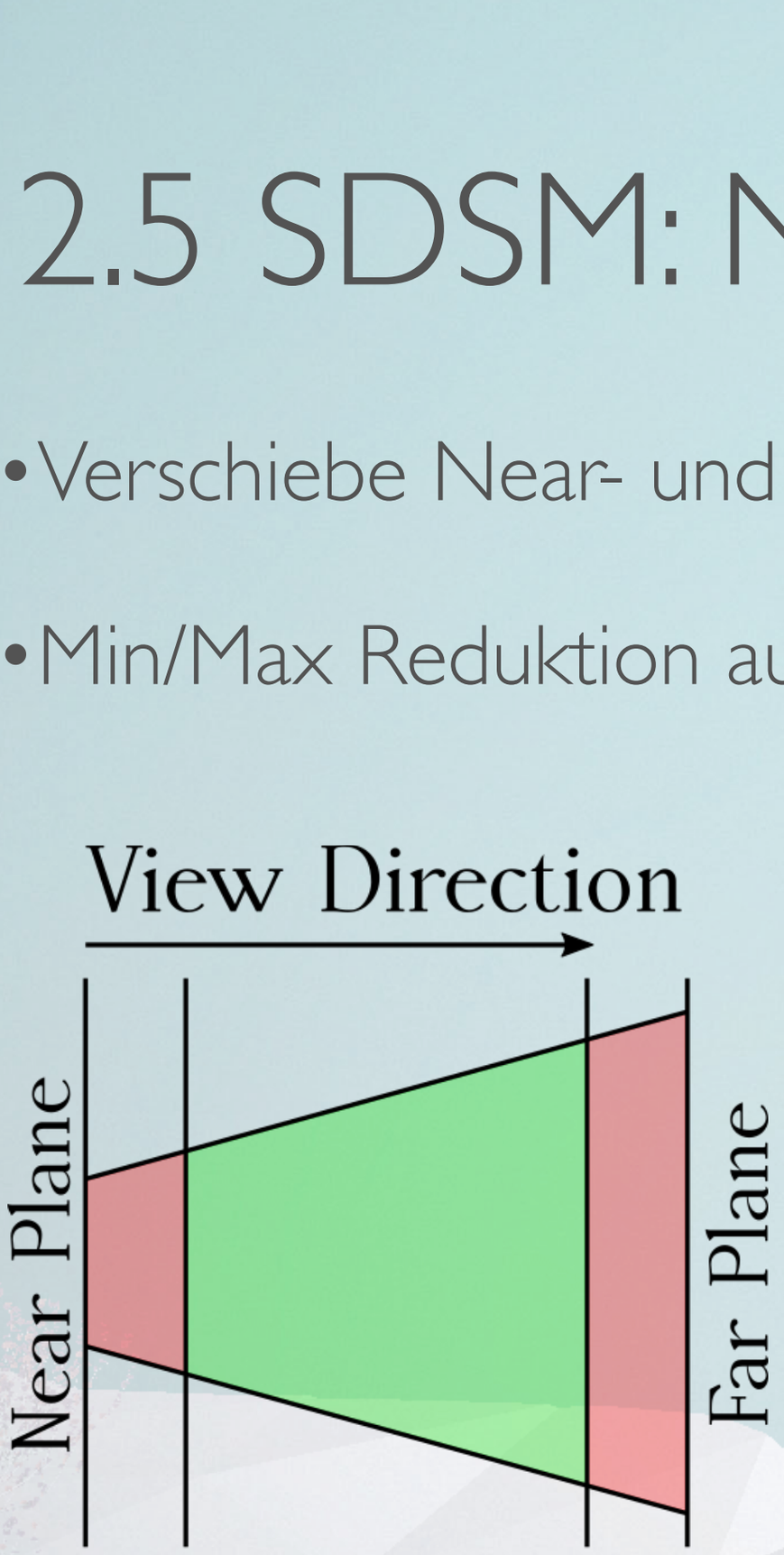
2.4 SAMPLE DISTRIBUTION SHADOW MAPS

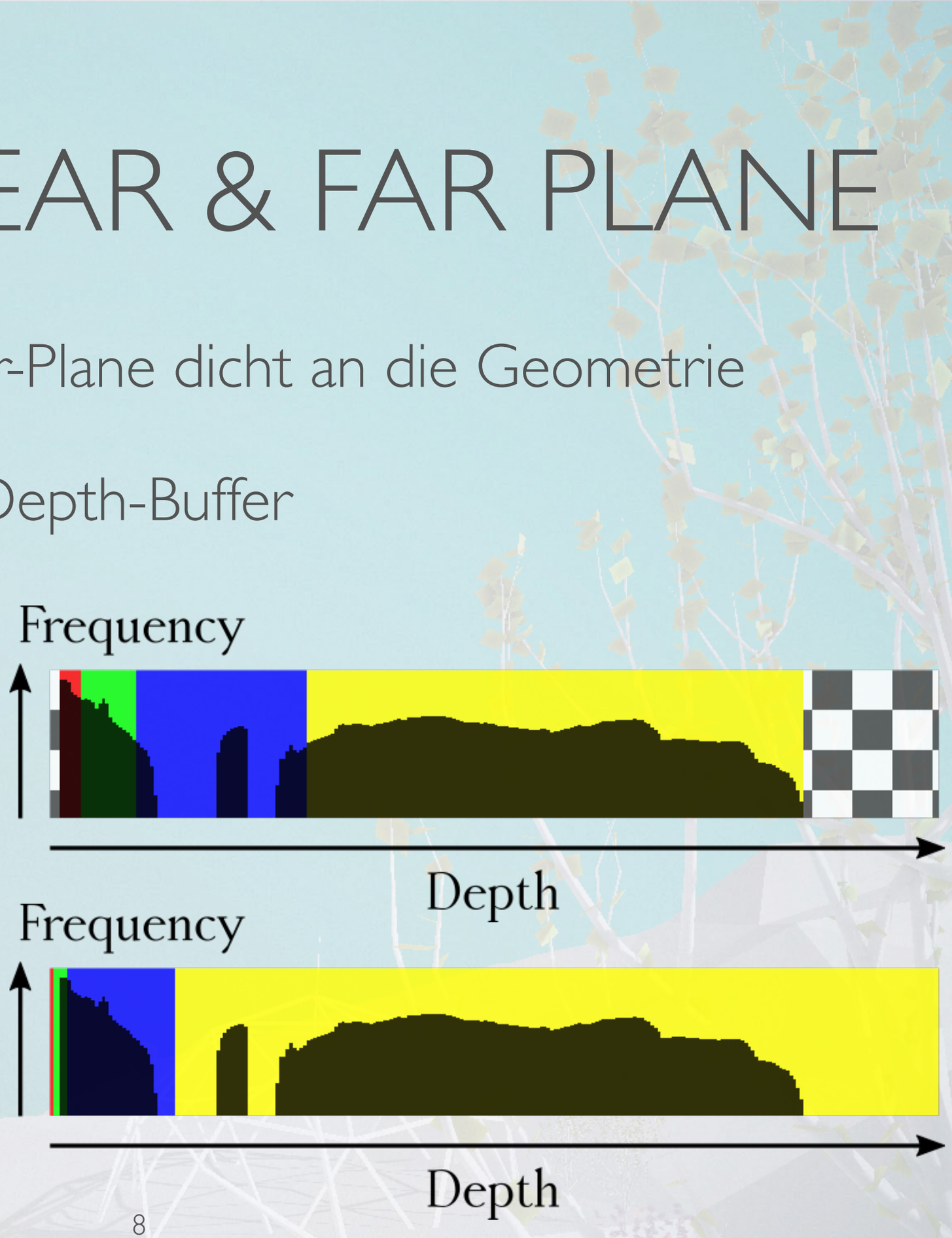
- Betrachtet Screen Space Samples im Light Space
- Adaptive Partitionierung
- Shadow Map Frustum eng um Geometrie



2.5 SDSM: NEAR & FAR PLANE

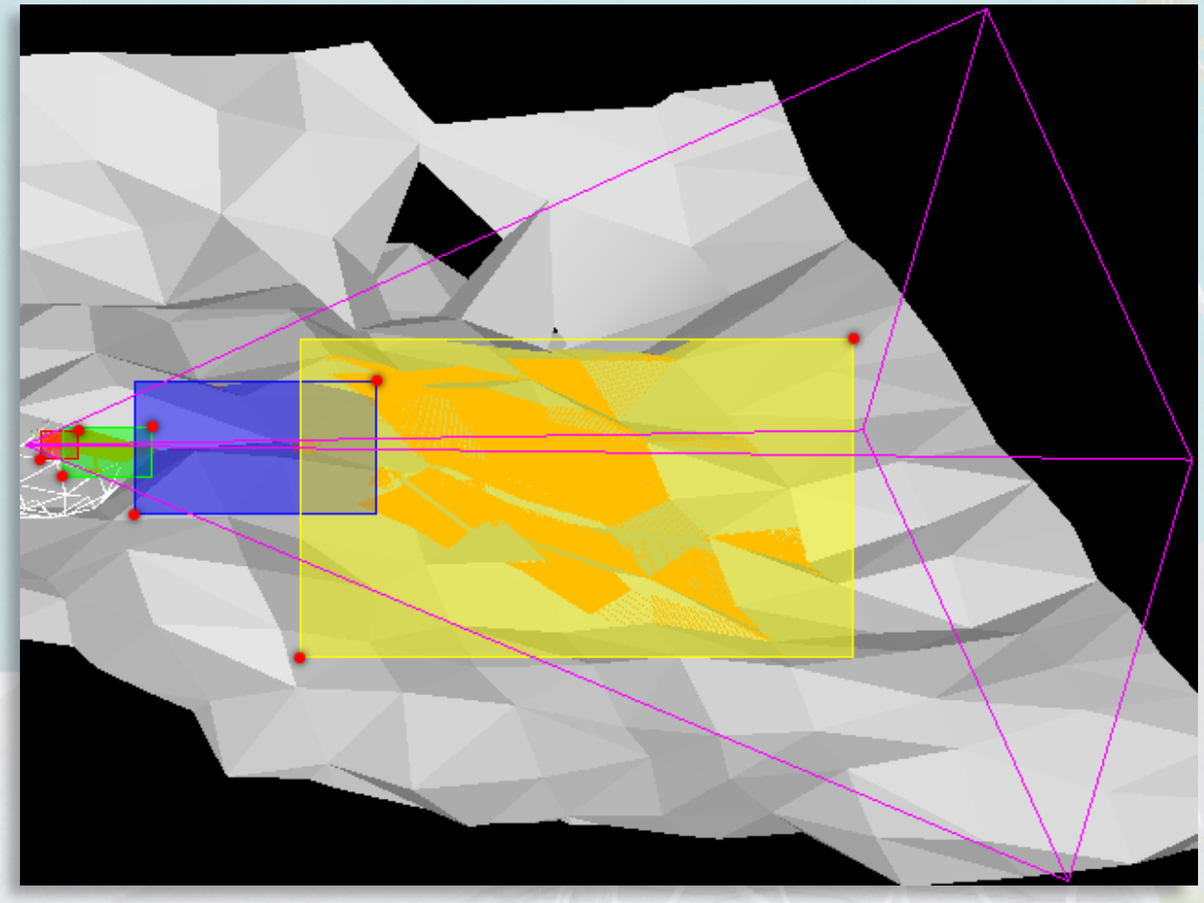
- Verschiebe Near- und Far-Plane dicht an die Geometrie
- Min/Max Reduktion auf Depth-Buffer



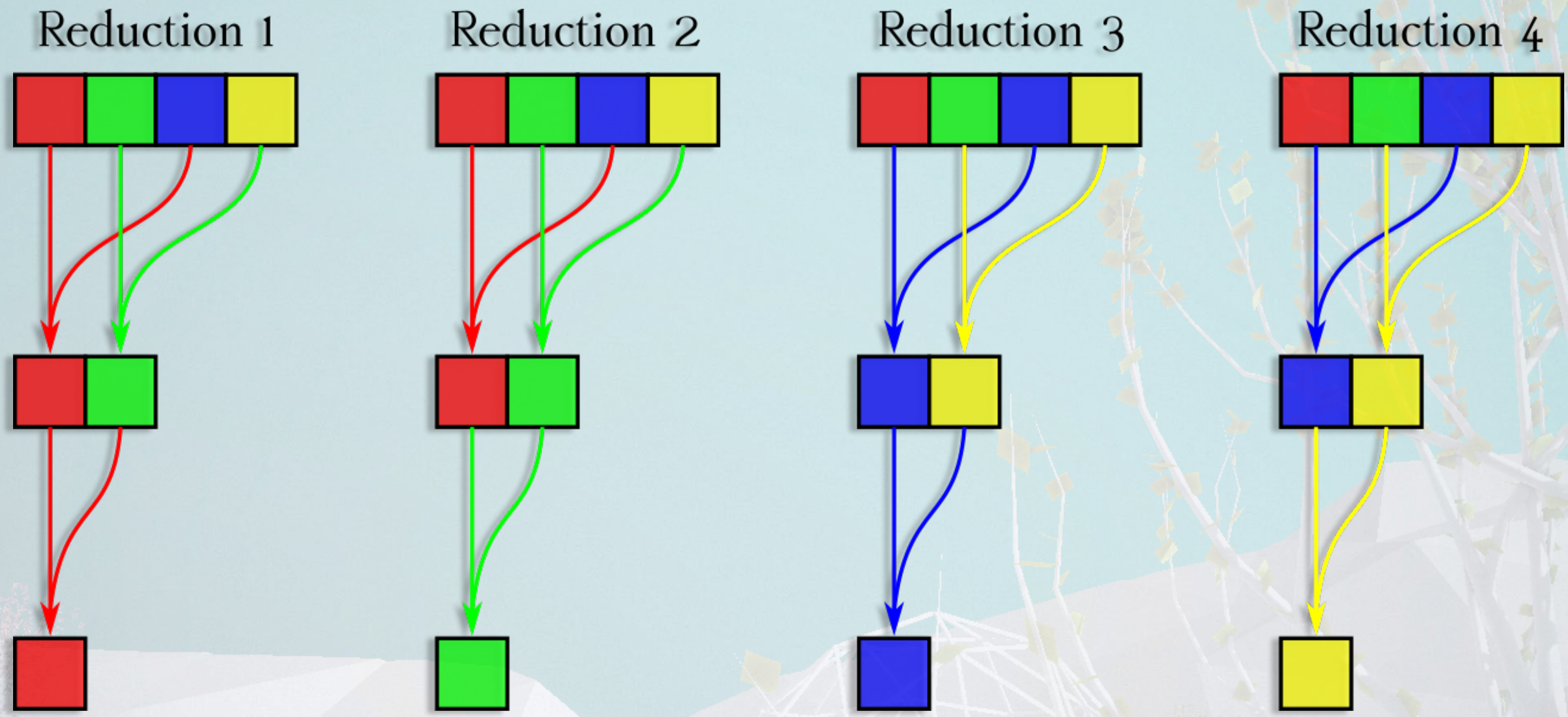


2.6 SDSM: TIGHT PARTITION FRUSTA

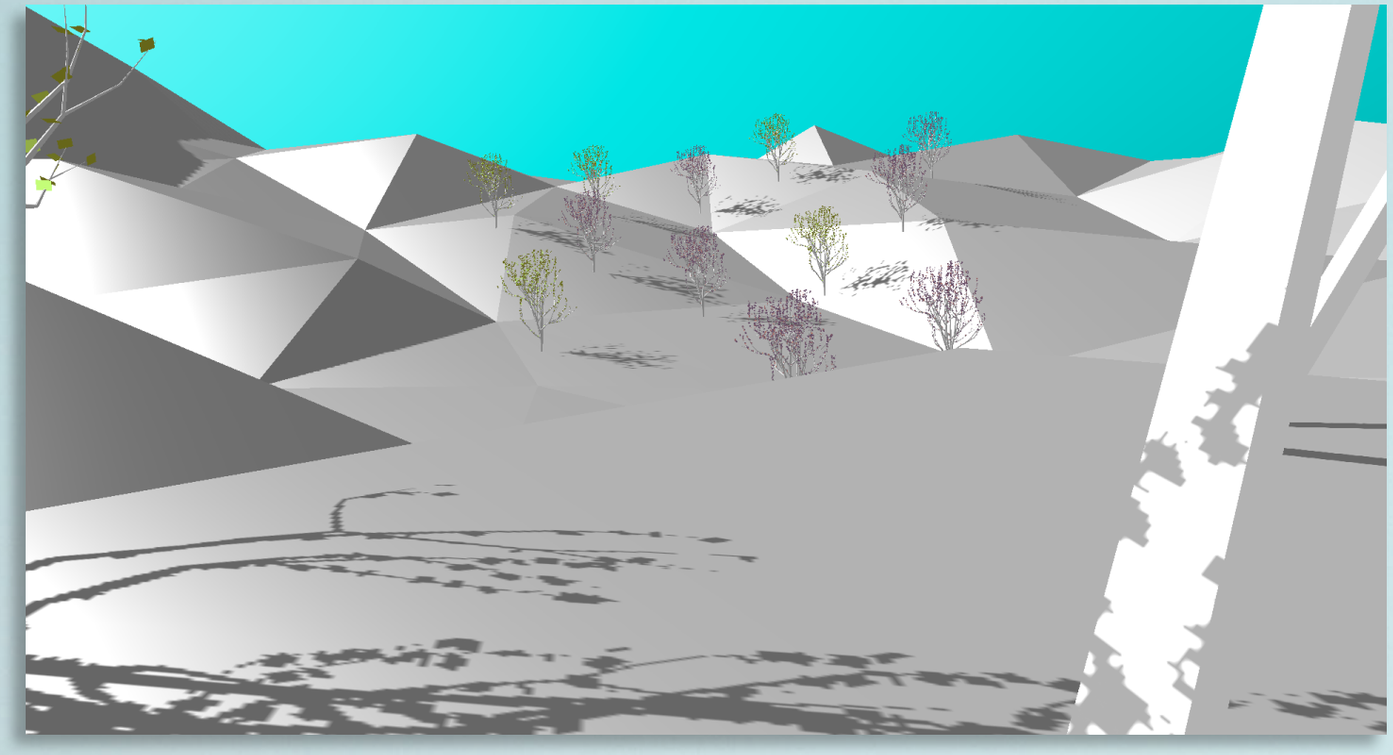
- Shadow Map Frusta eng um sichtbare Geometrie
- Berechne AABB der sichtbaren Geometrie per Reduktion

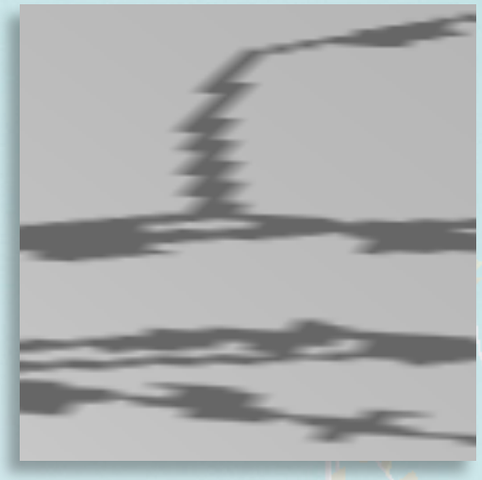


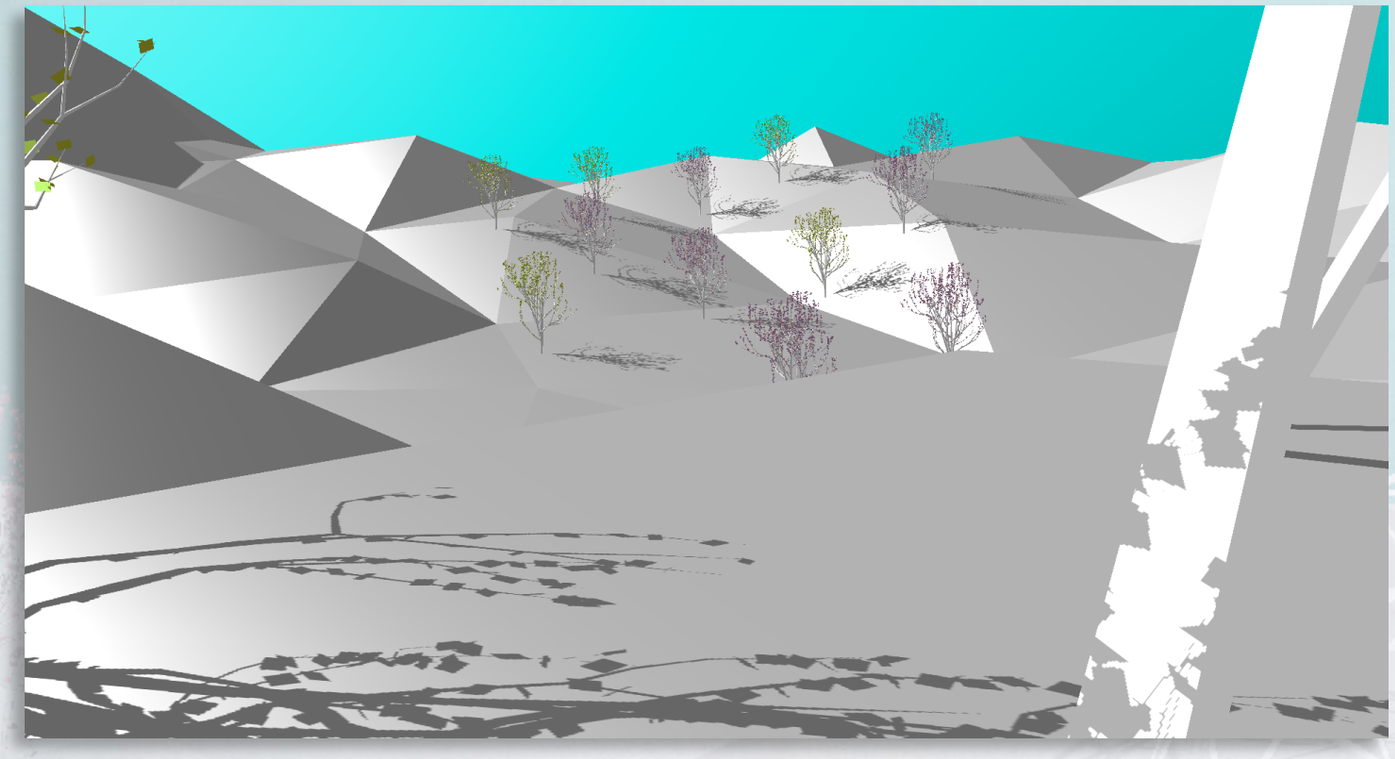
2.7 SDSM: REDUCTION

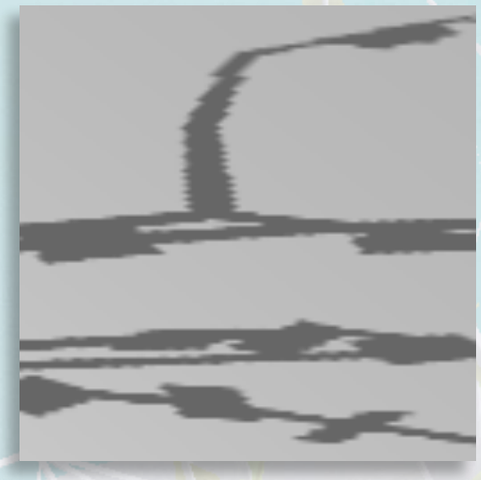


PSSM



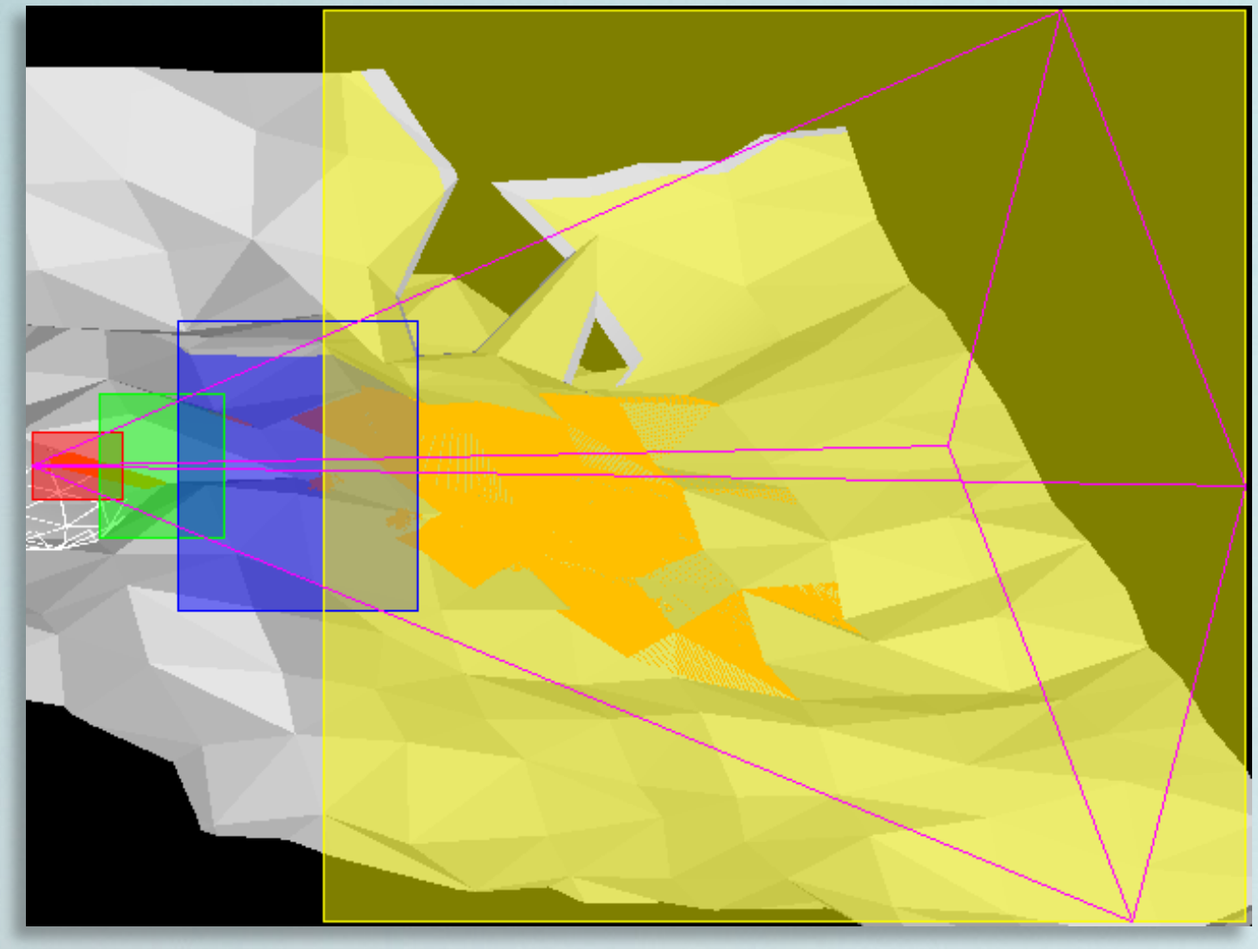




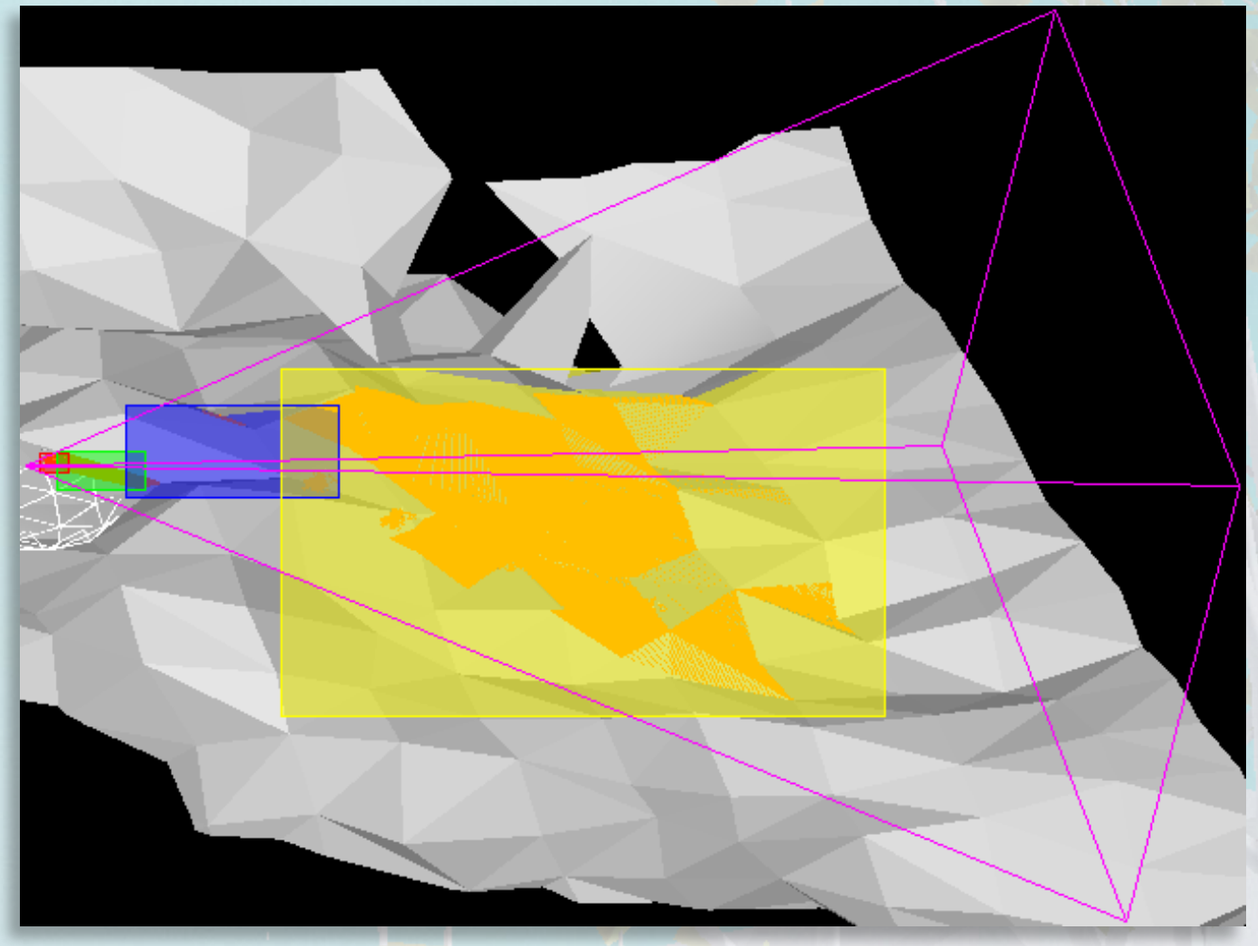


SDSM

2.8 SDSM: LIGHT SPACE FRUSTA



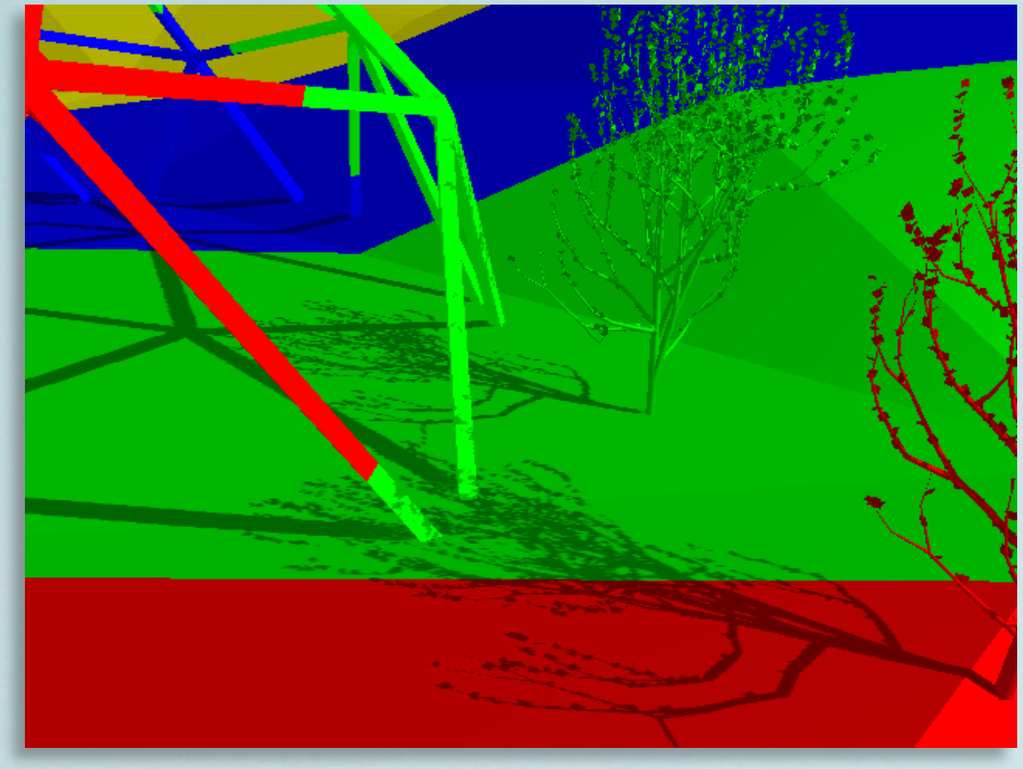
PSSM

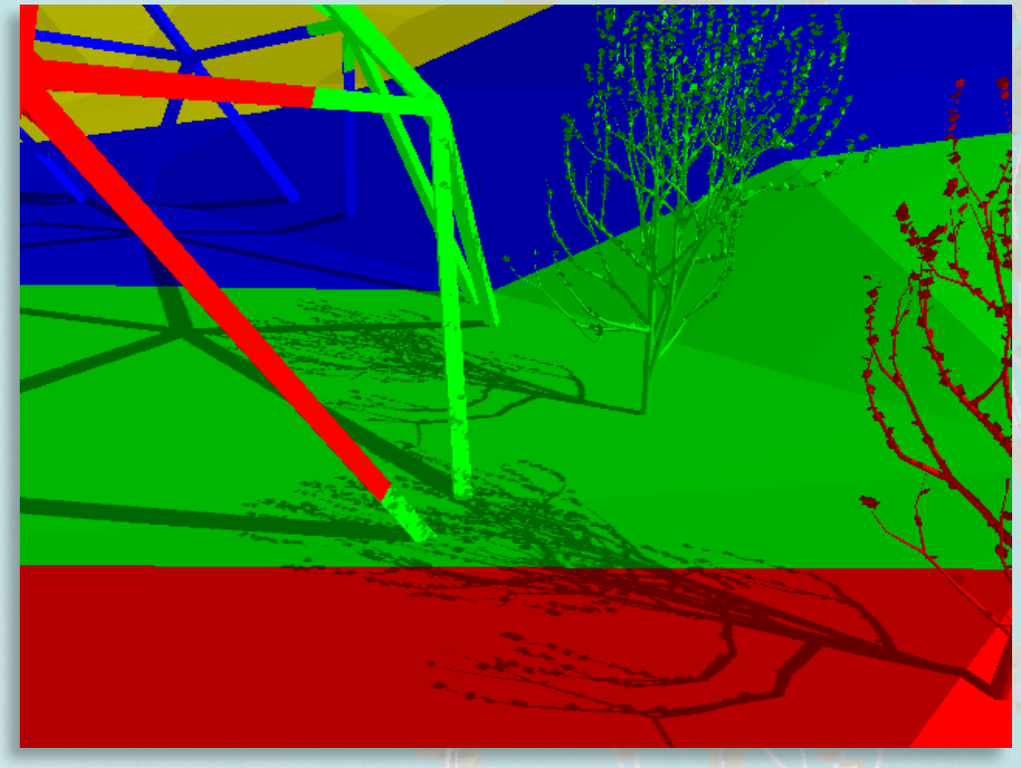


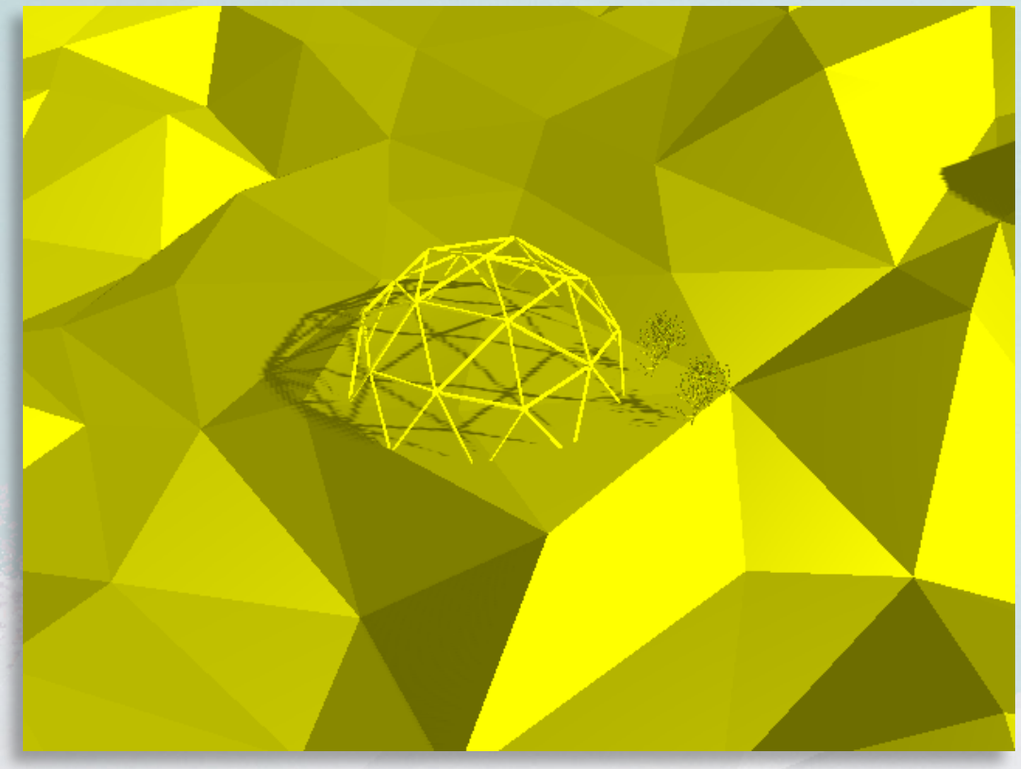
SDSM

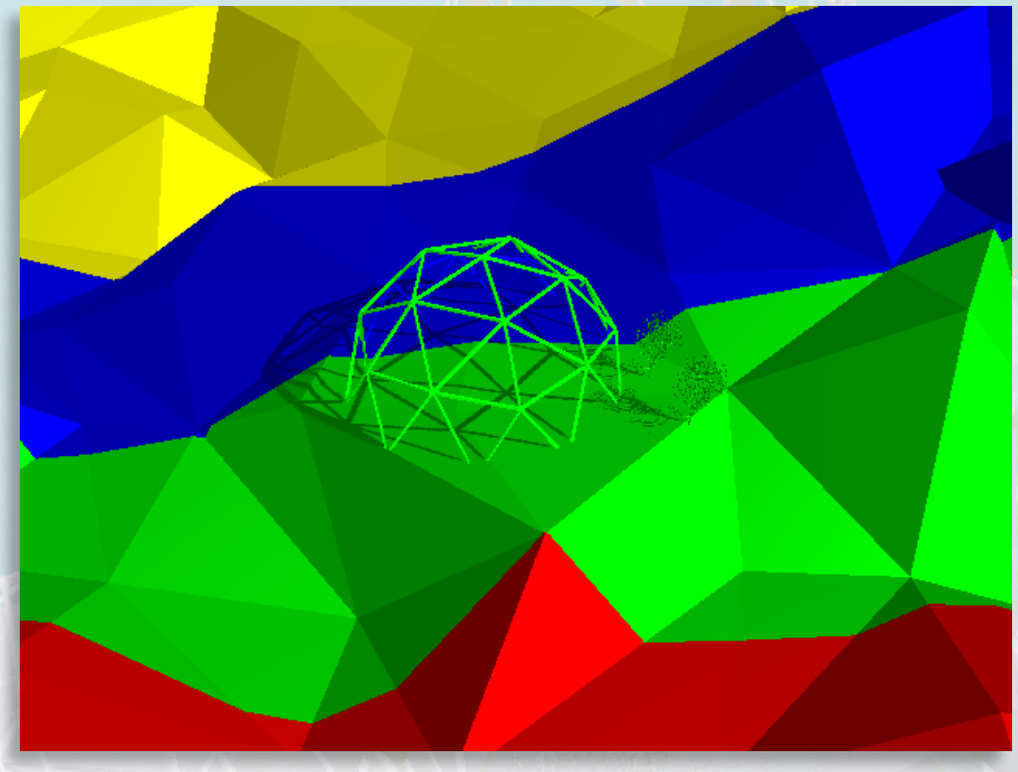
PSSM

SDSM



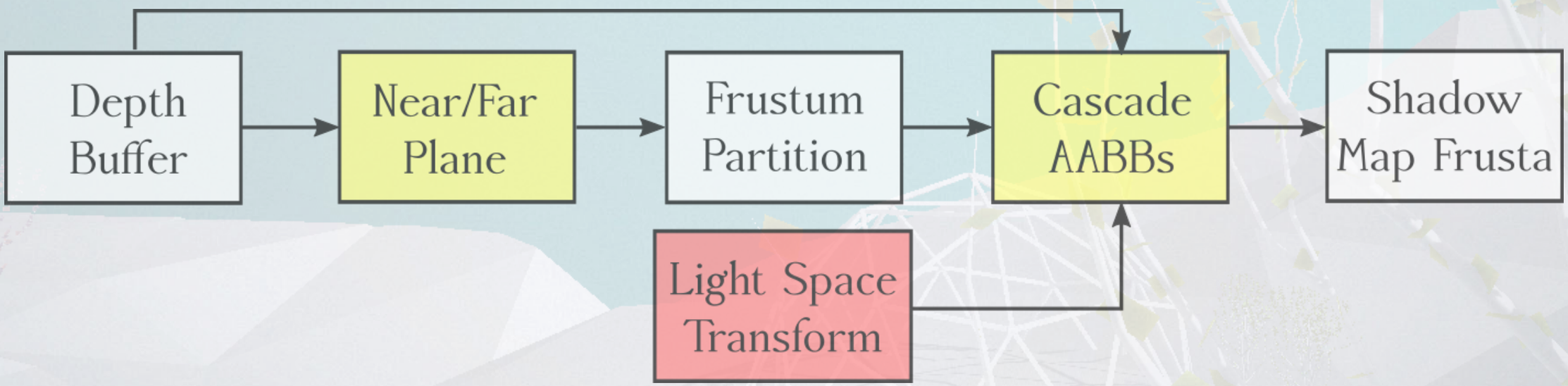




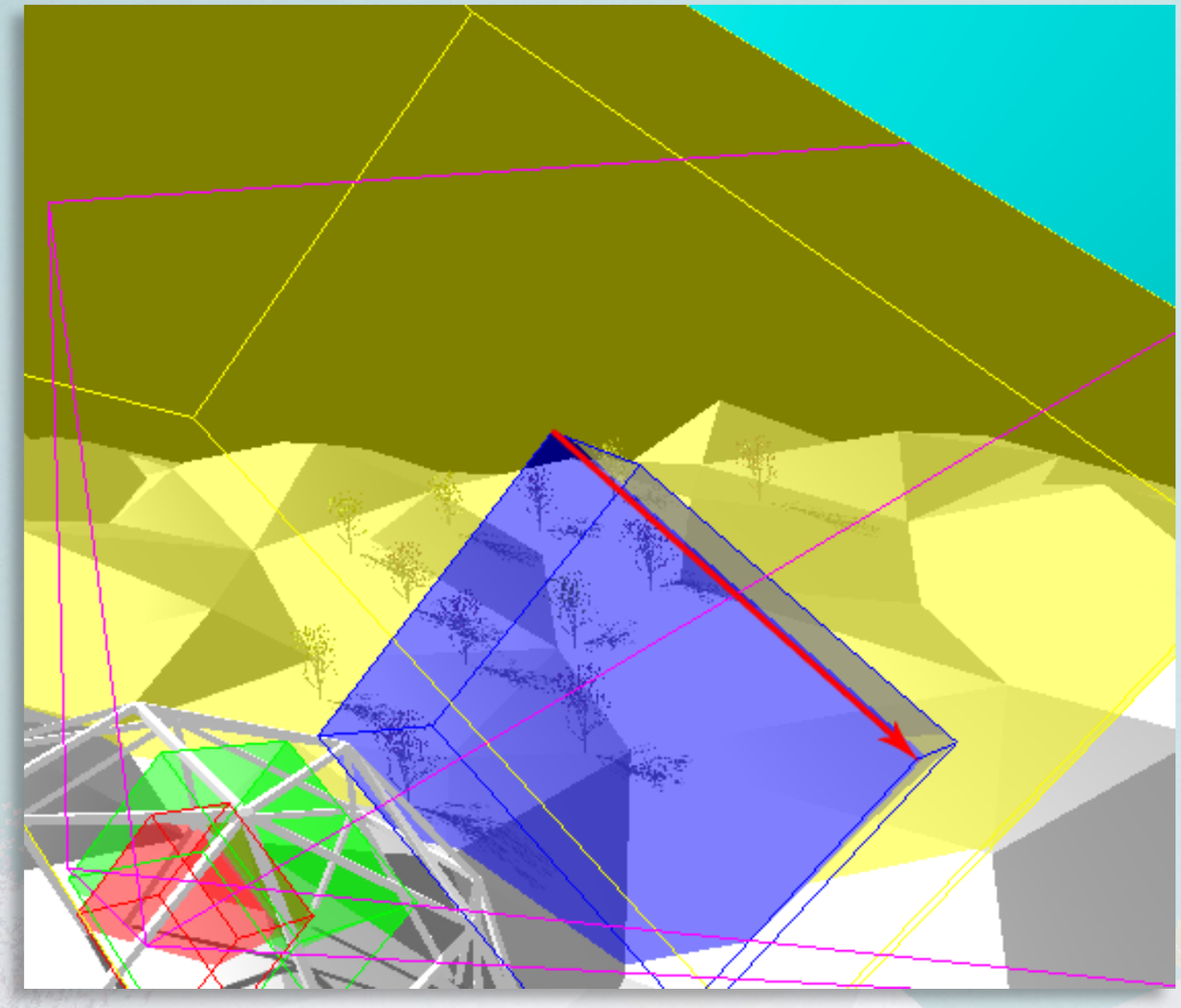


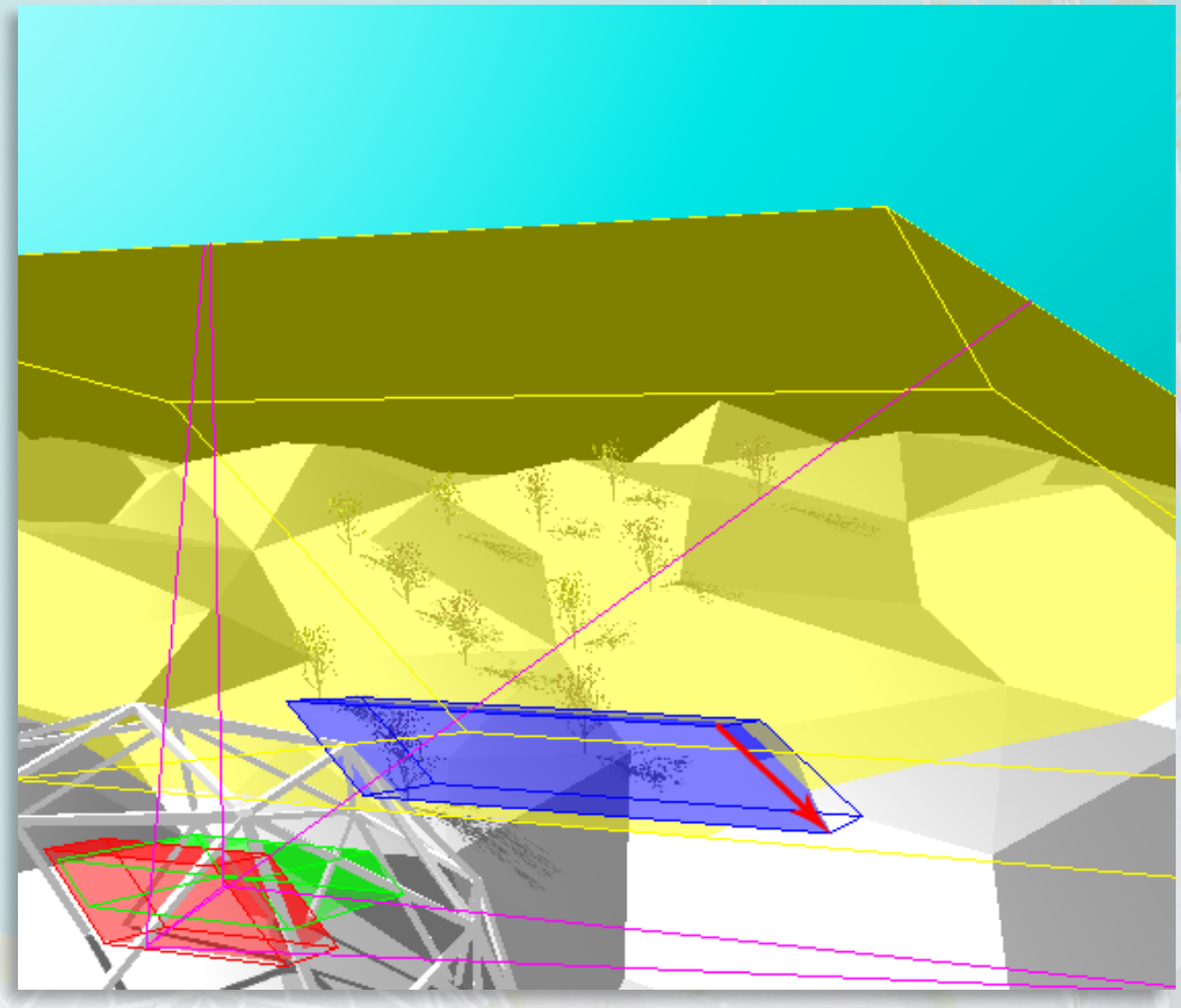
2.9 SDSM: ERGEBNISSE

- SDSM ist sehr robust
- Zuverlässige Ergebnisse
- Screenspace Algorithmus
- Vollständig auf GPU implementierbar



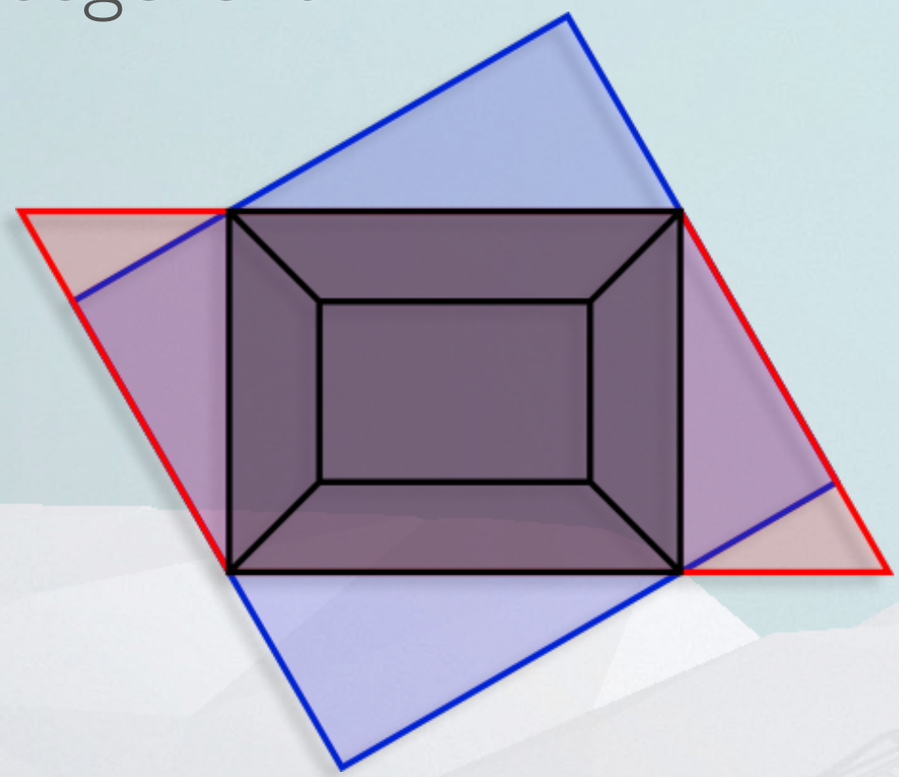
2.10 SDSM: SHEARED SAMPLE DISTRIBUTION SHADOW MAPS

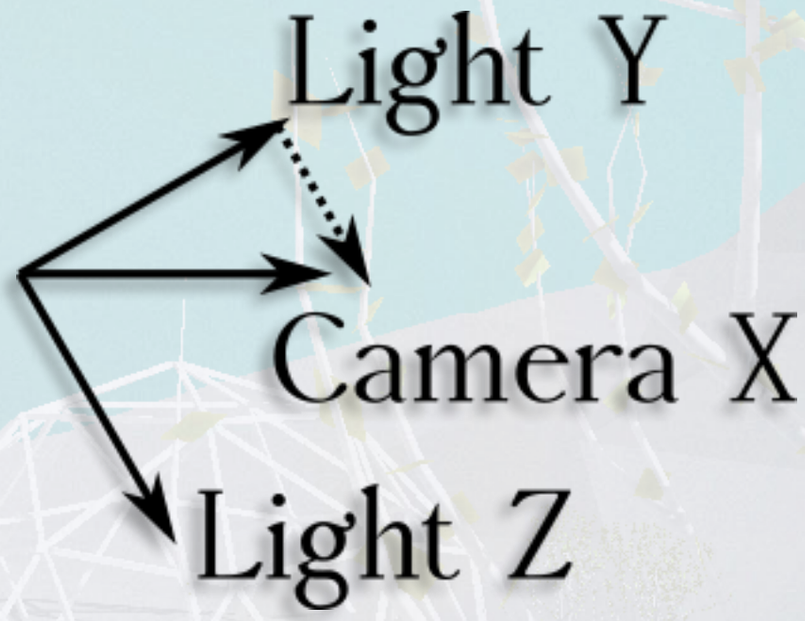




2.10 SDSM: SHEARED SAMPLE DISTRIBUTION SHADOW MAPS (2)

- Szene oft sehr flach, geneigtes Licht
- Horizontale Near- und Farplane der Shadow Map
- Unausgereift

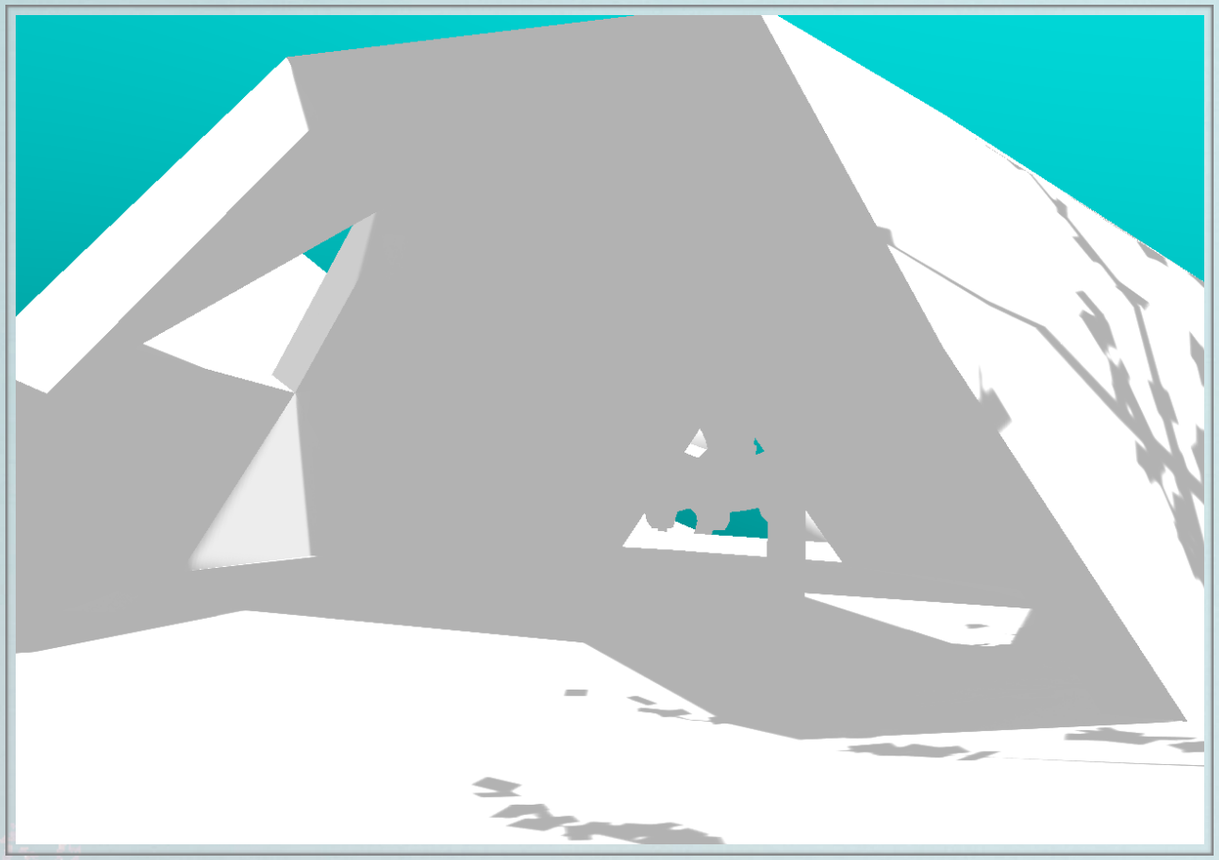


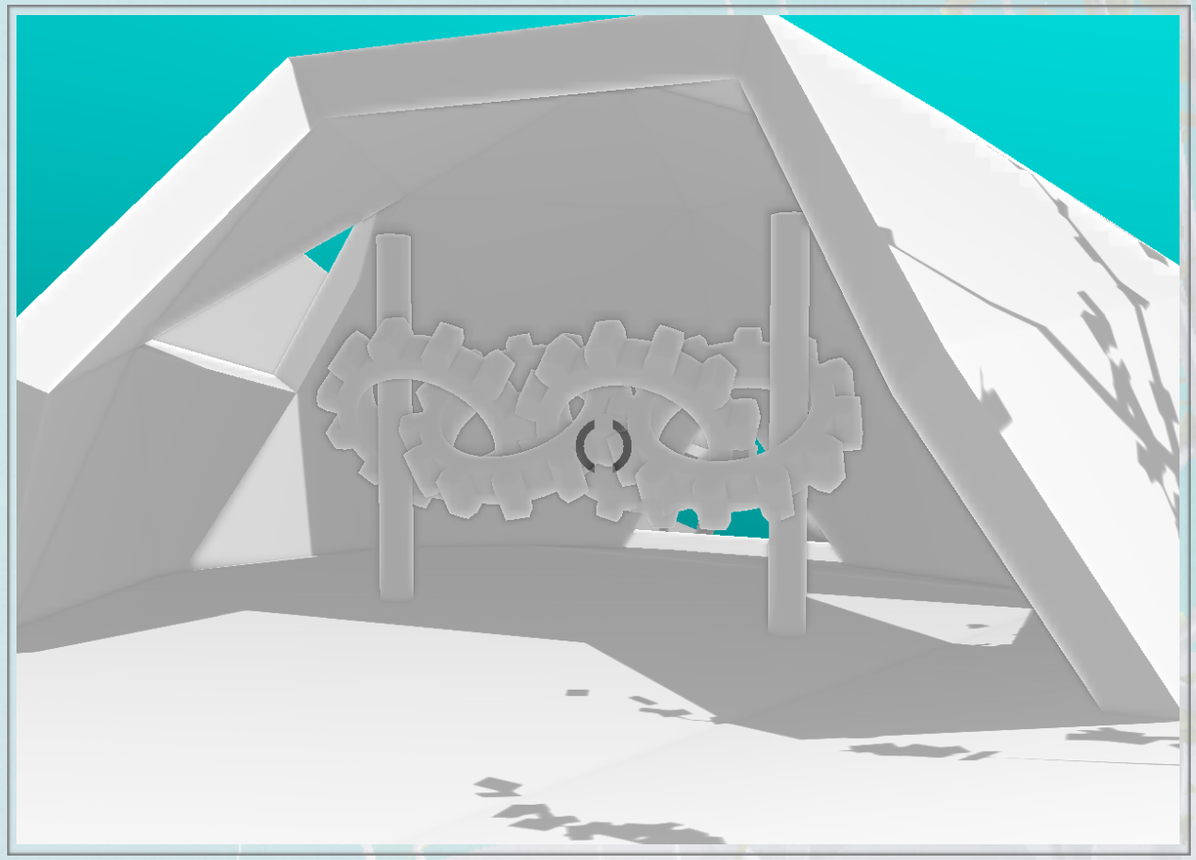


3. VOLUMETRIC OBSCURANCE

- Global Illumination Technik
- „Wo viel Geometrie ist, ist auch viel Schatten“
- Ambient Occlusion basiert auf diesem Prinzip
- Volumetric Obscurance bietet Alternative zu AO

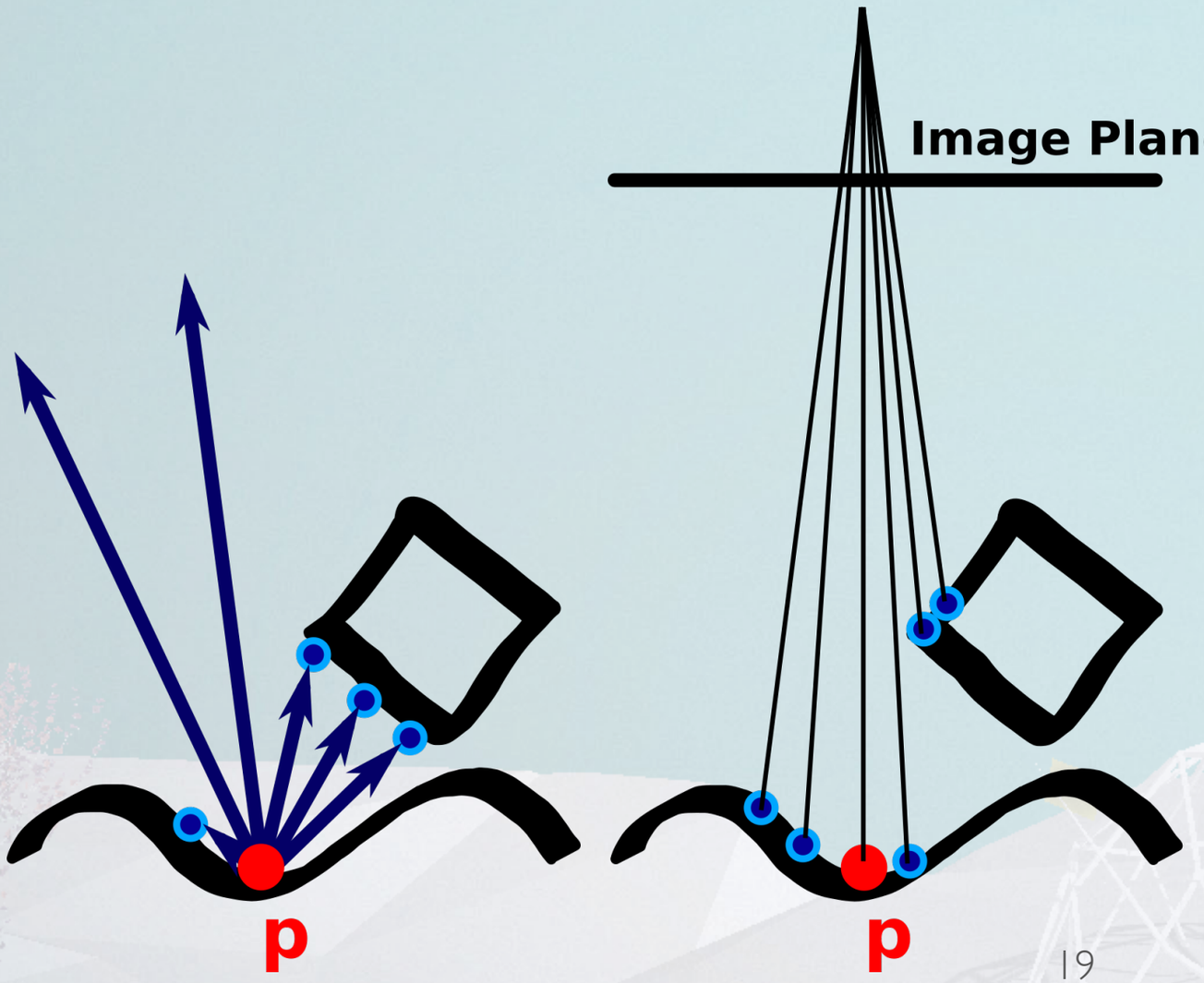
3.1 VO: MOTIVATION





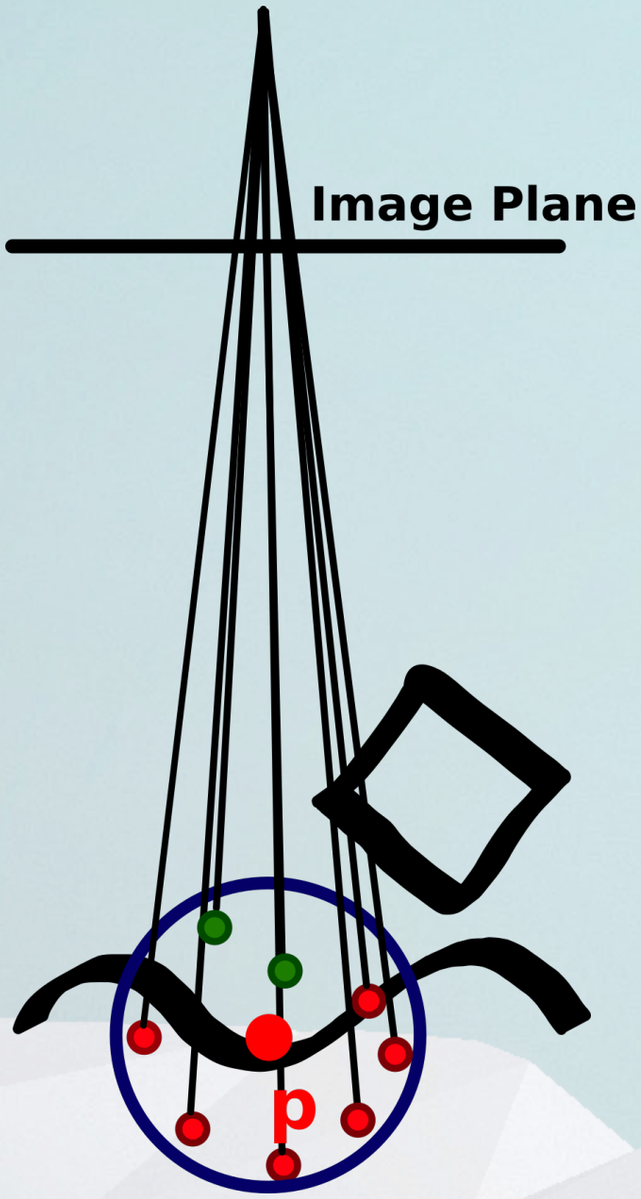
3.2 VO: AMBIENT OCCLUSION

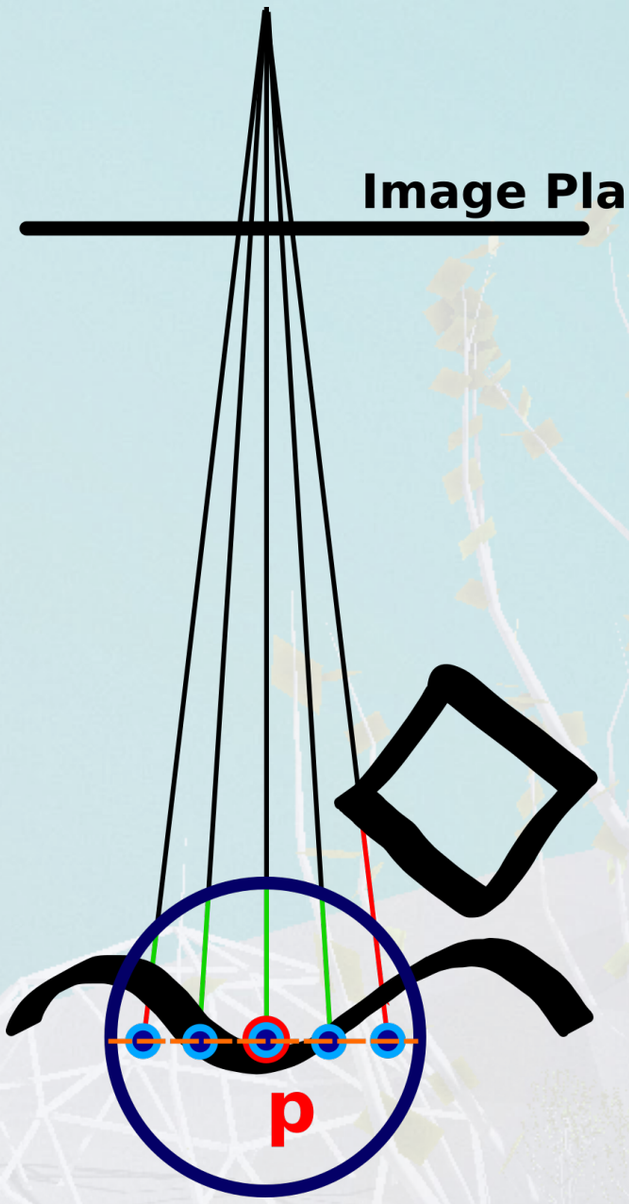
- Ambient Occlusion Ansätze:
  -(Global) Ambient Occlusion & Screenspace Ambient Occlusion



3. 3 VOLUMETRIC OBSCURANCE

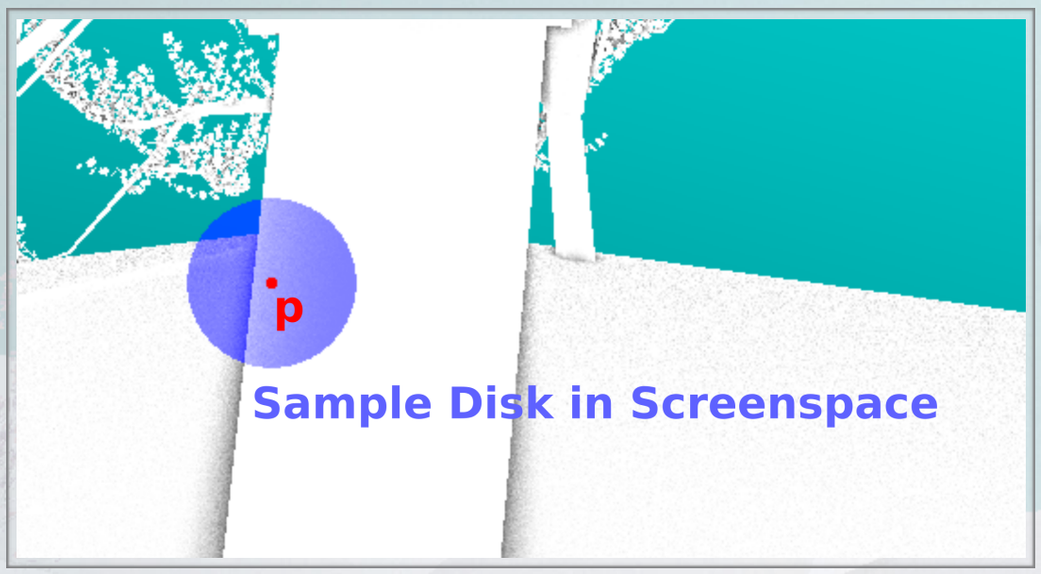
- Point Samples und Line Samples





3. 4 VO: LINE SAMPLING

- Betrachte für jeden Texel den korrespondierenden Punkt
- Sample Tiefenbuffer in Screenspace projizierter Umgebung
- Berechne verdecktes Volumen



3.5 VO: LINE SAMPLING ALGORITHMUS

Line Sampling Pseudo Code

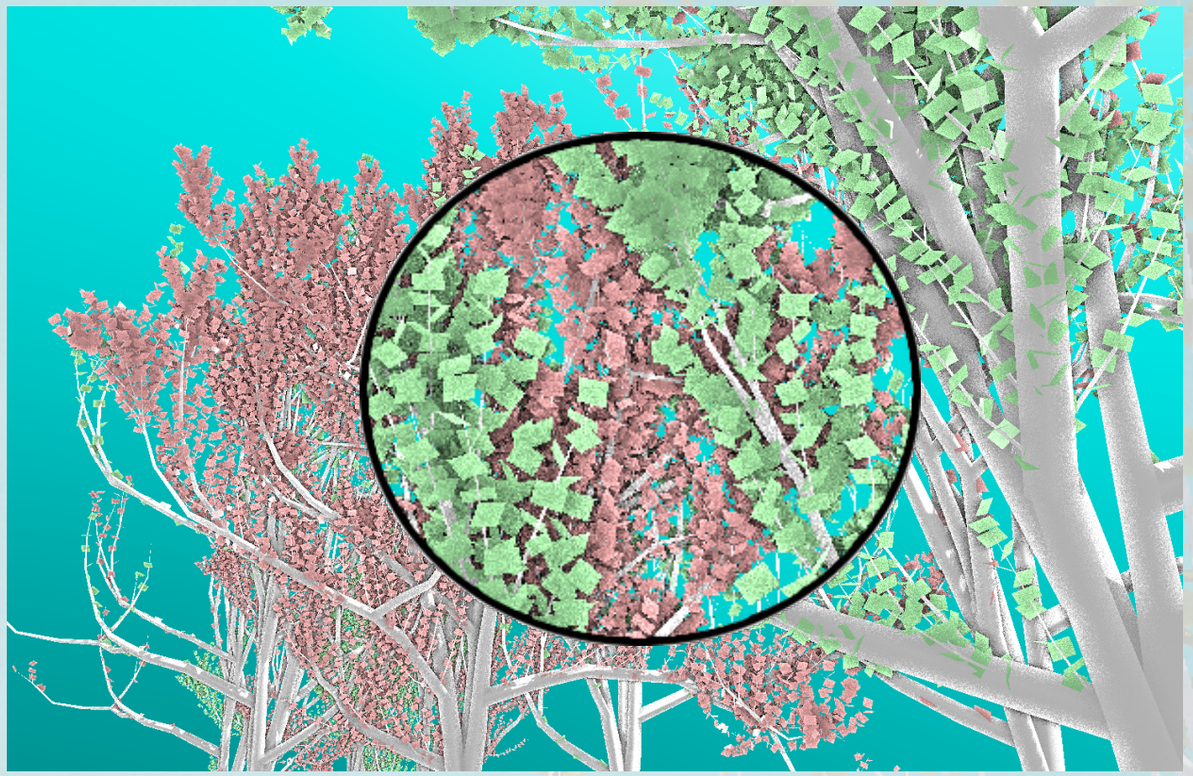
Function *LineSampling(nSamples, depth)*

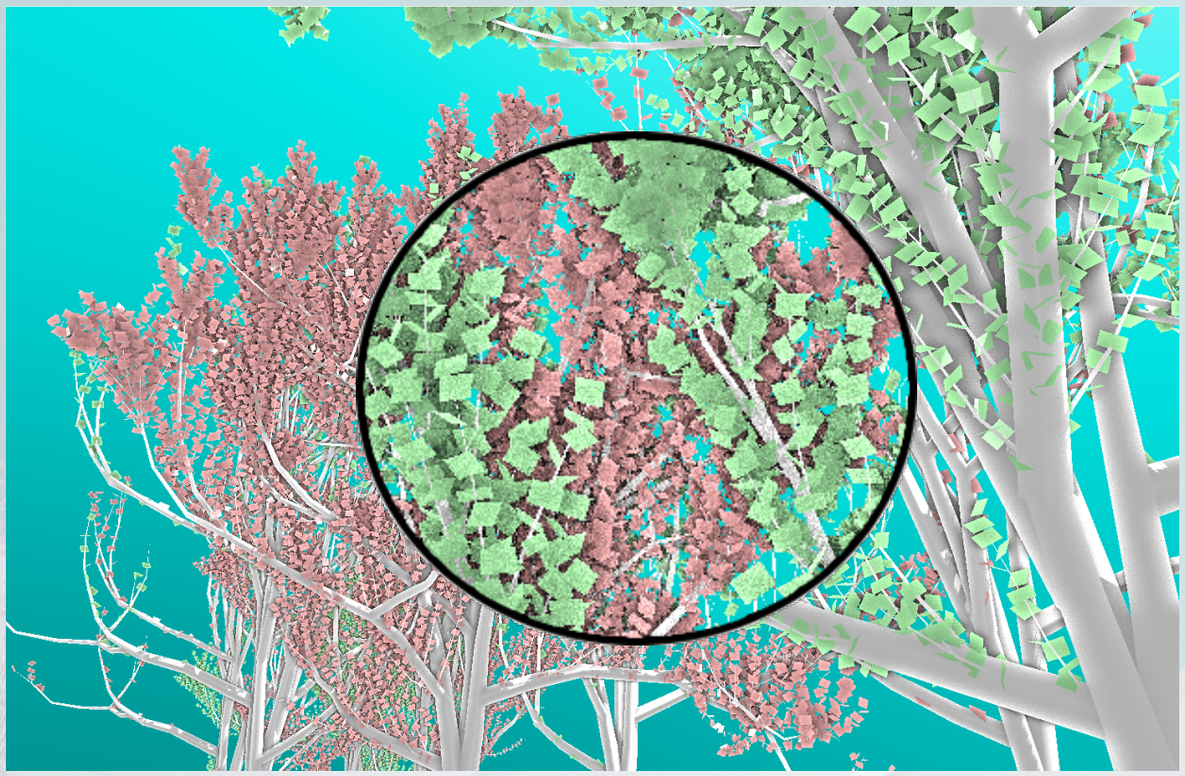
sumSamples $= 0$;
sumVolume $= 0$;
for $i = 0 \rightarrow nSamples$ - 1 **do**
radius $= \sqrt{\text{rand}()}$;
$\alpha = \text{rand}() \cdot 2\pi$;
$v_i = \sqrt{1 - radius^2}$;
$\text{p} = (\cos(\alpha) \cdot radius, \sin(\alpha) \cdot radius)^T$;
sumSamples $=$ sumSamples $+ v_i \cdot$ SamplePoint(p, depth);
sumVolume $=$ sumVolume $+ v_i$;
end
return $\frac{sumSamples}{sumVolume}$;

end

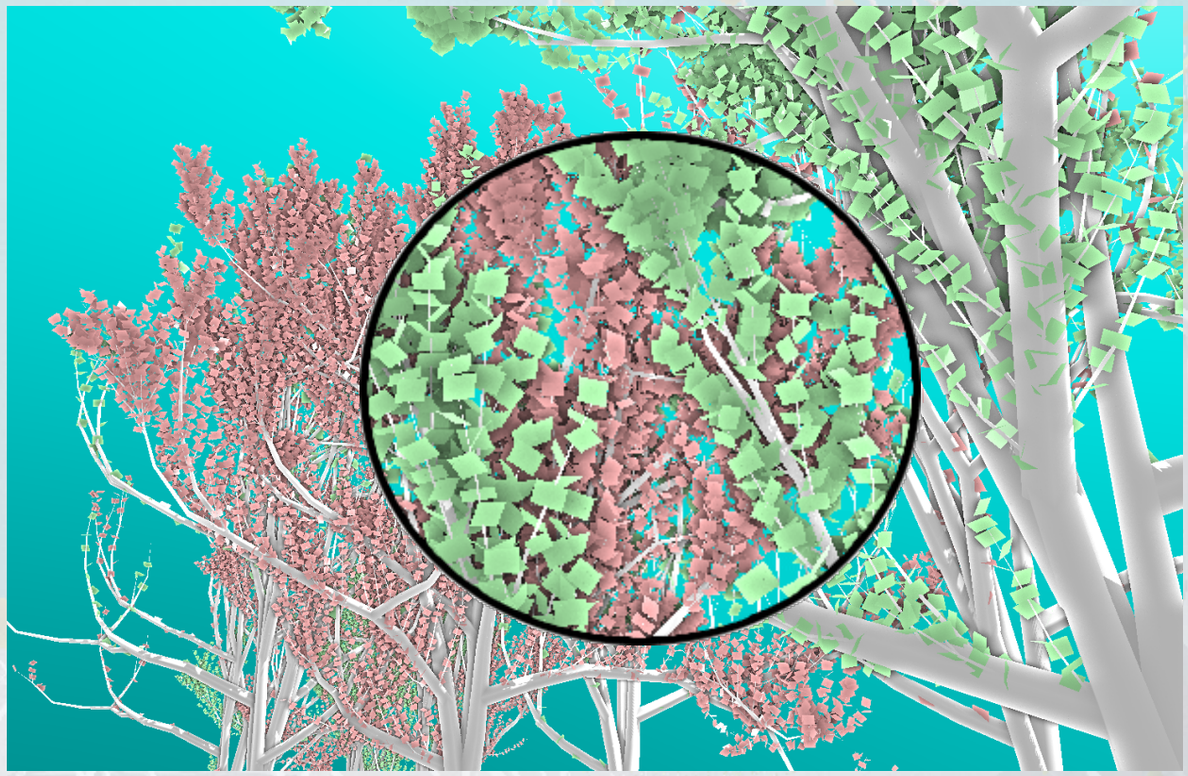
1 Samples

10 Samples





100 Samples

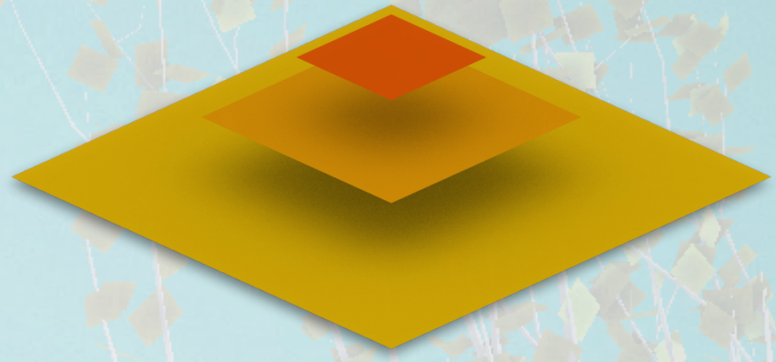


1000 Samples

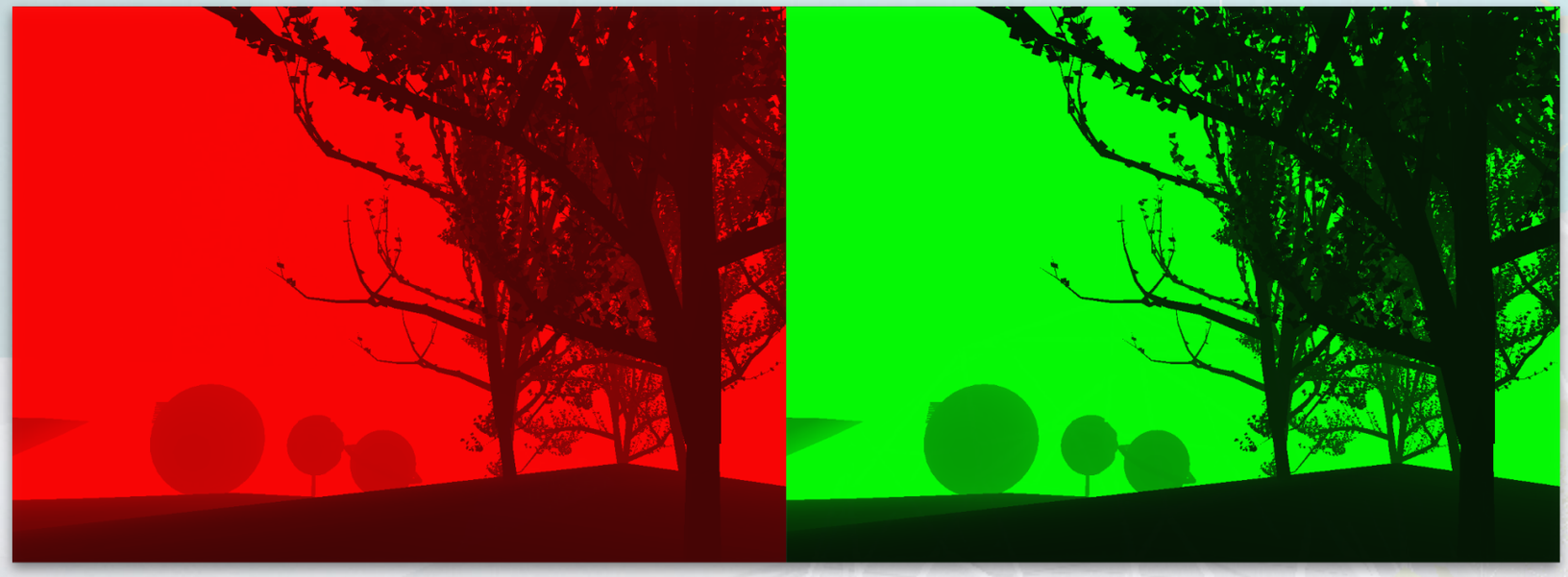
3.6 VO: AREA SAMPLING

- Line Sampling teuer, da viele Samples pro Pixel
- Statistische Beschreibung die eine Approximation der uniformen Tiefenverteilung ermöglicht
- VSM bietet gleiches Prinzip und kann auf VO angewendet werden

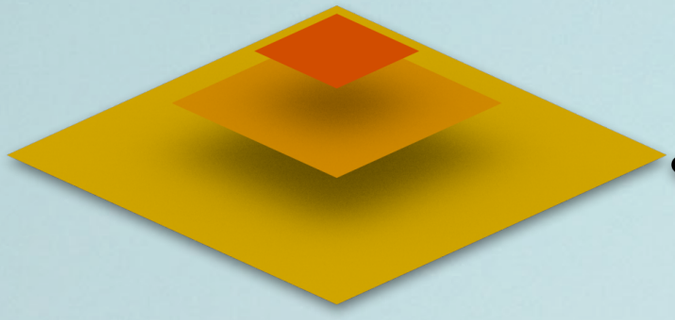
Depth (z)



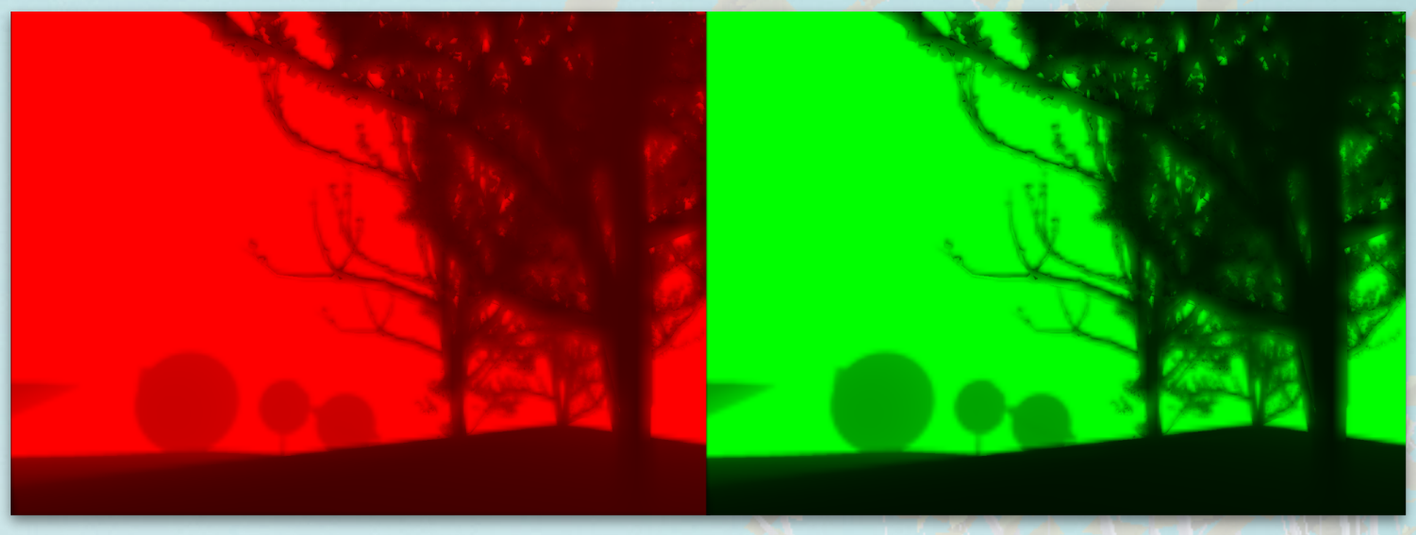
generate Mipmaps



z^1 z^2



Mipmaps

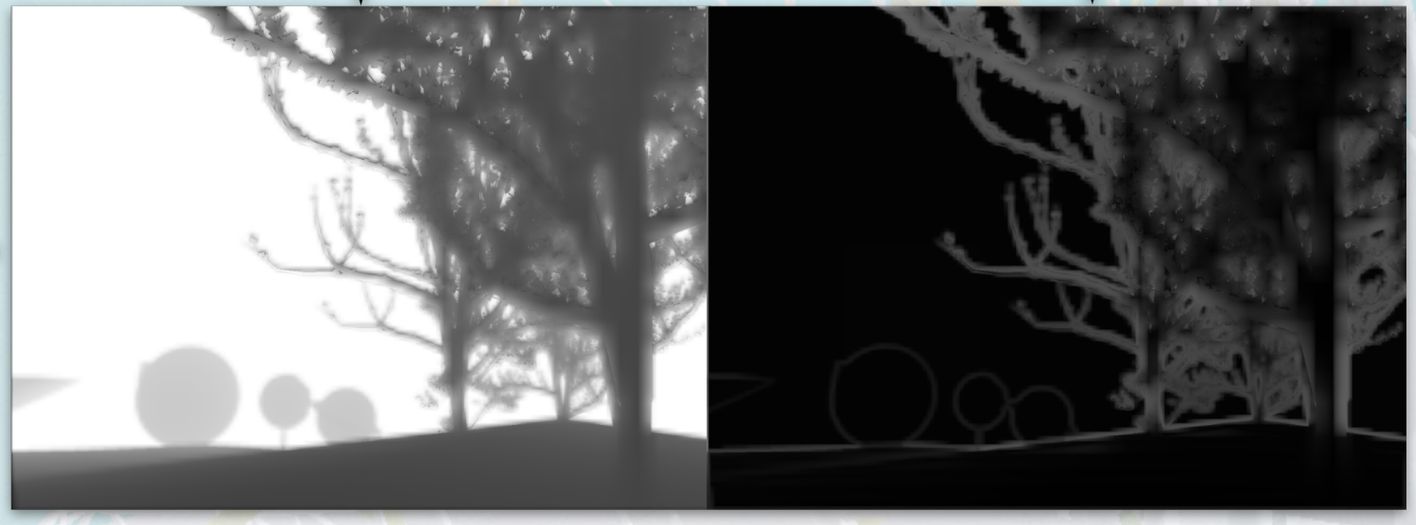


$\mu = R$ → $\sigma = \text{sqrt}(G - \mu^2)$

obscurance Term

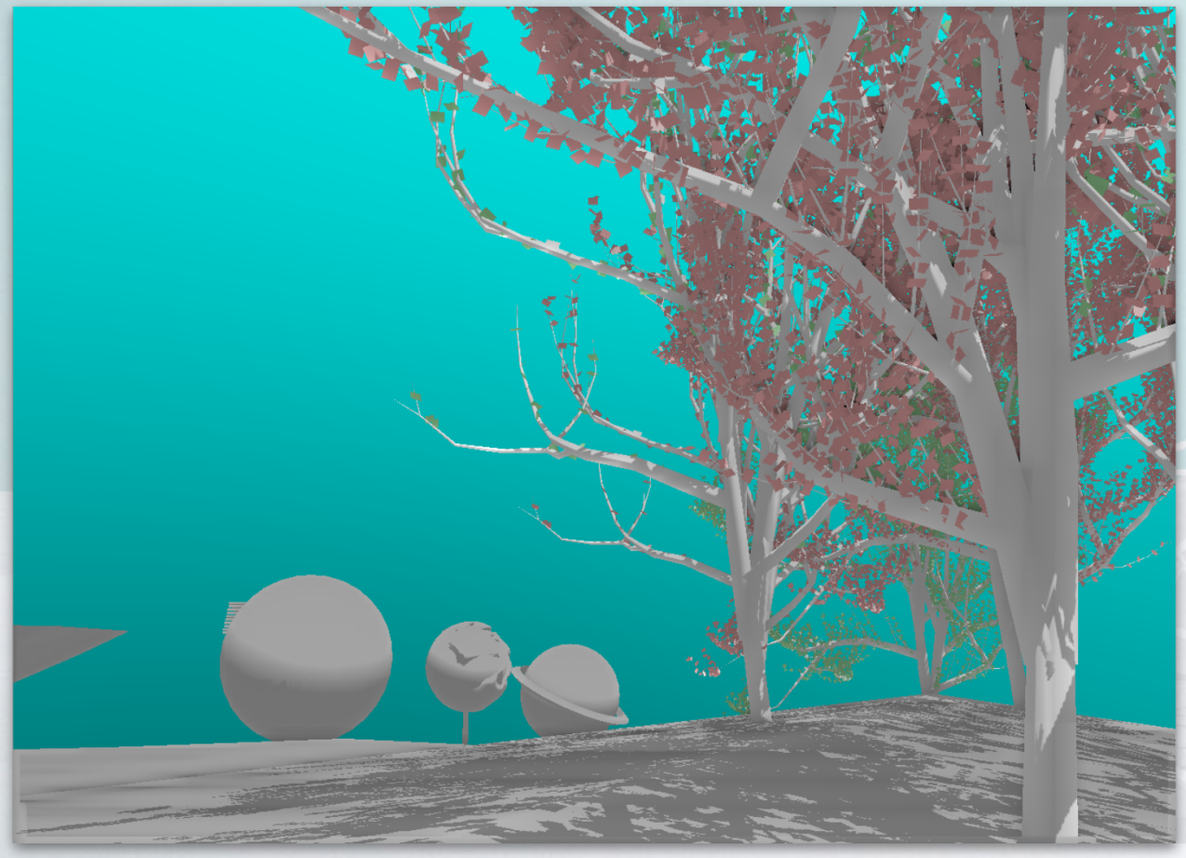
$$V_c(z_0, z_1, a, b) = a \cdot (z_1^2 - z_0^2)/2 + b \cdot (z_1 - z_0)$$

$$a = \frac{-1}{2 \cdot \sigma}; \quad b = -a \cdot (\mu + \sigma)$$



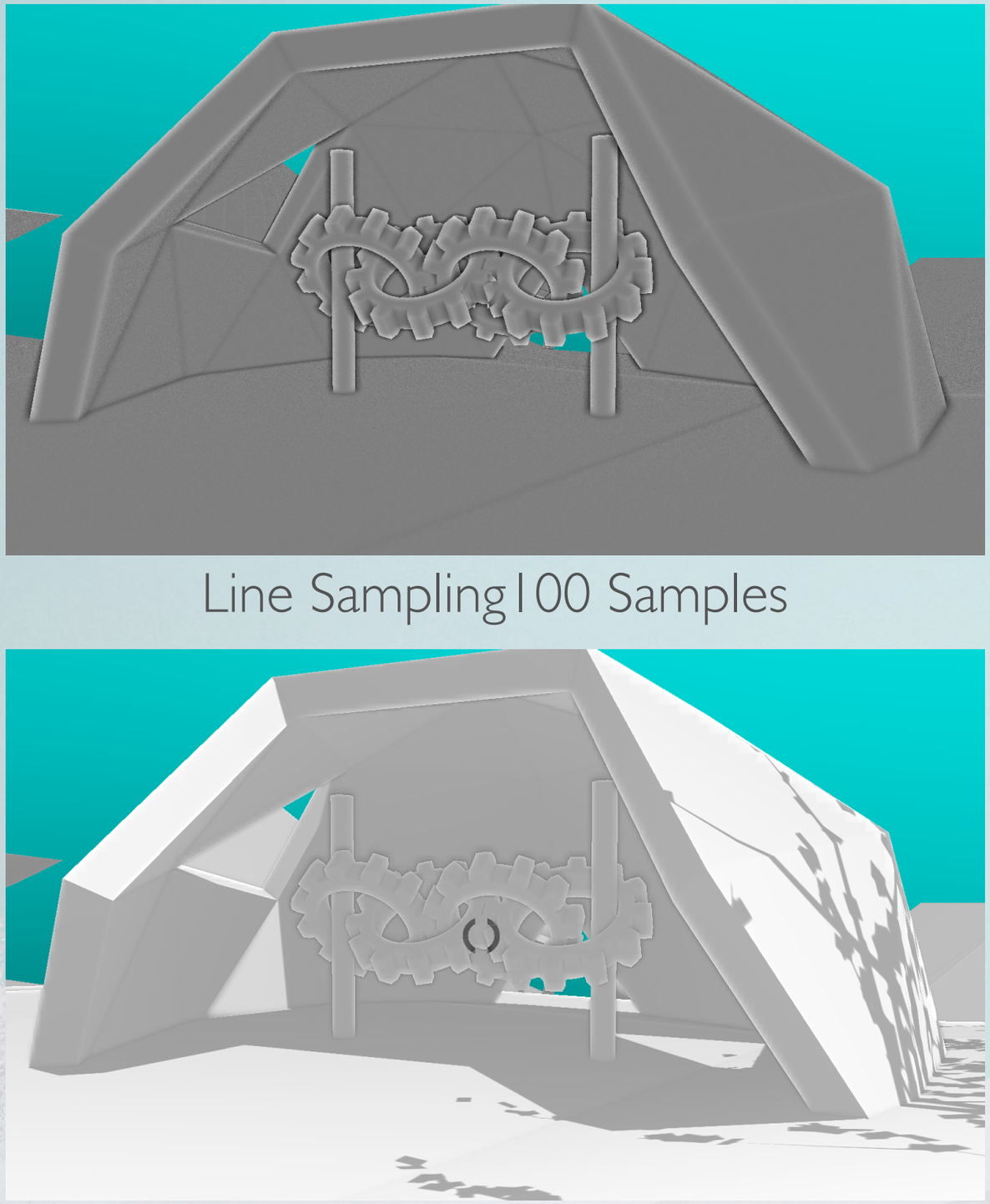
mean **standard deviation**

obscurance Term

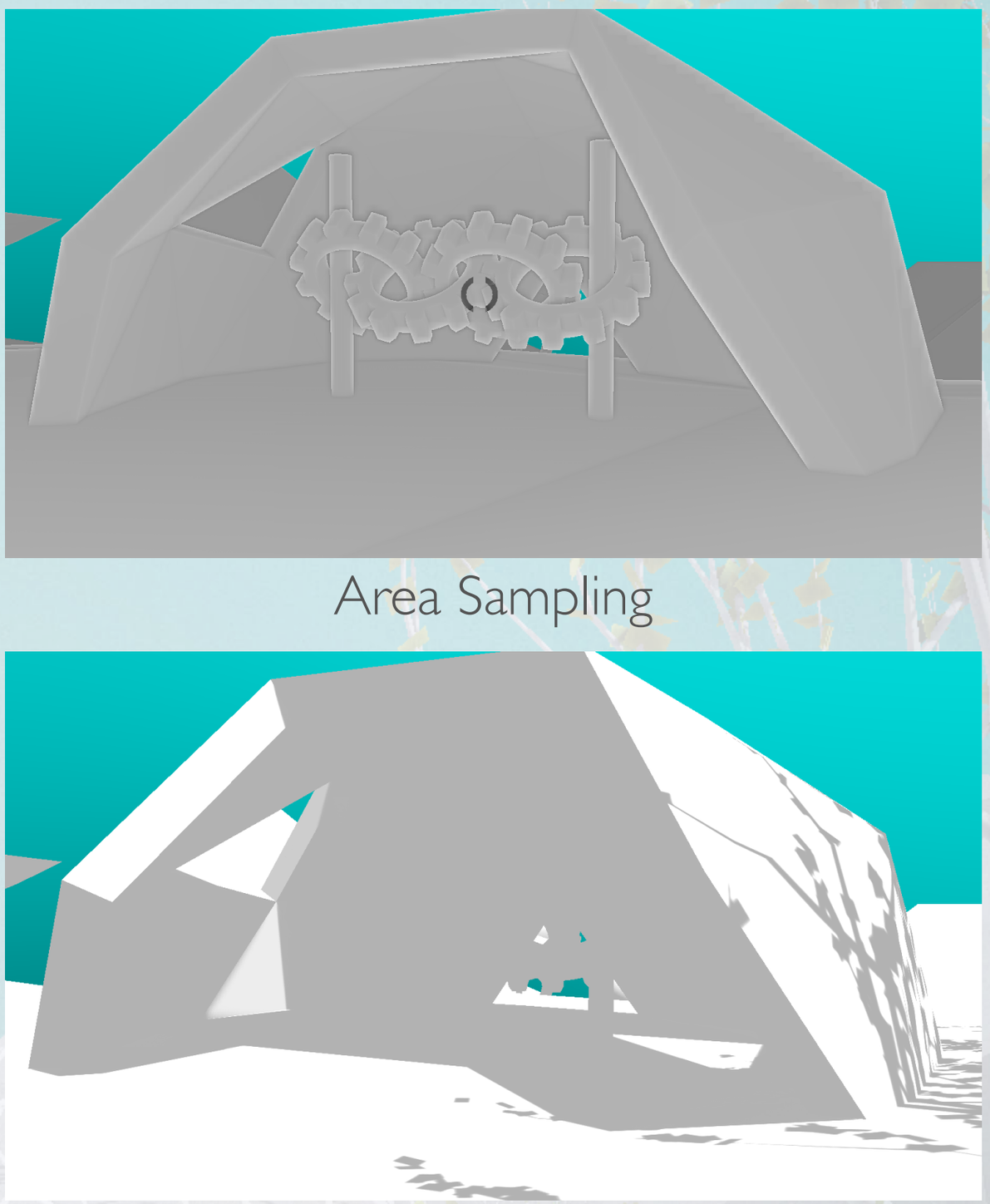


verrechnetes Bild

3.7 VO: ERGEBNISSE



Line Sampling 100 Samples



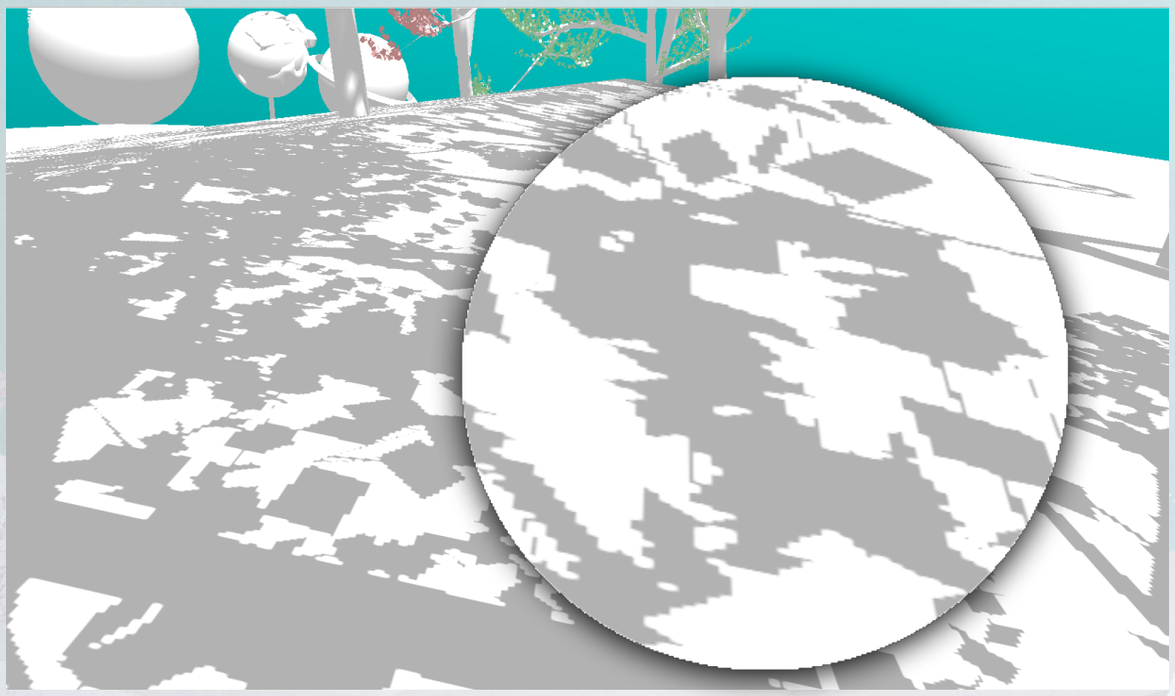
Area Sampling

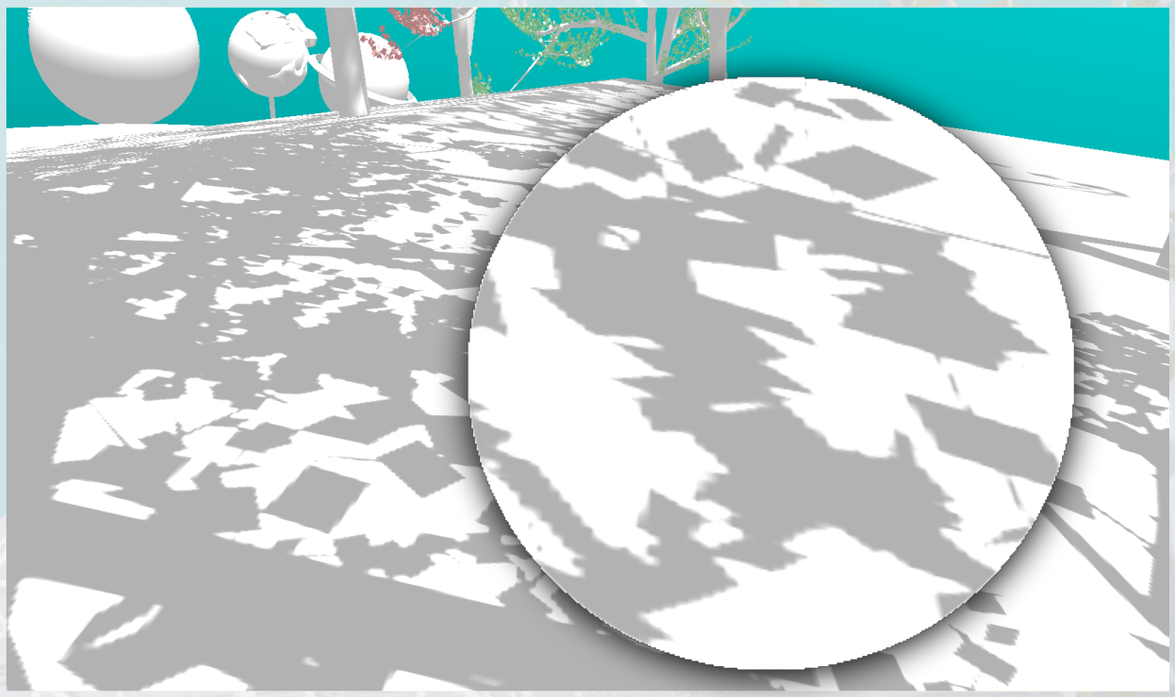
Szene mit Area Sampling

Szene ohne Area Sampling

4. MOMENT SHADOW MAPPING

- Echzeit Rendering & Hard Shadows mit hoher Qualität
- Anti-Aliasing(MSAA) auf Shadow Map
- nicht direkt filterbar, da sonst Geometrie verändert wird





4.1 MSM: ALGORITHMUS

- Hamburger Moment Shadow Mapping
- Tiefe und gefiltertes Sample der Moment Shadow Map
- Approximiert Schattenintensität

http://cg.cs.uni-bonn.de/aigaion2root/attachments/Talk.pptx

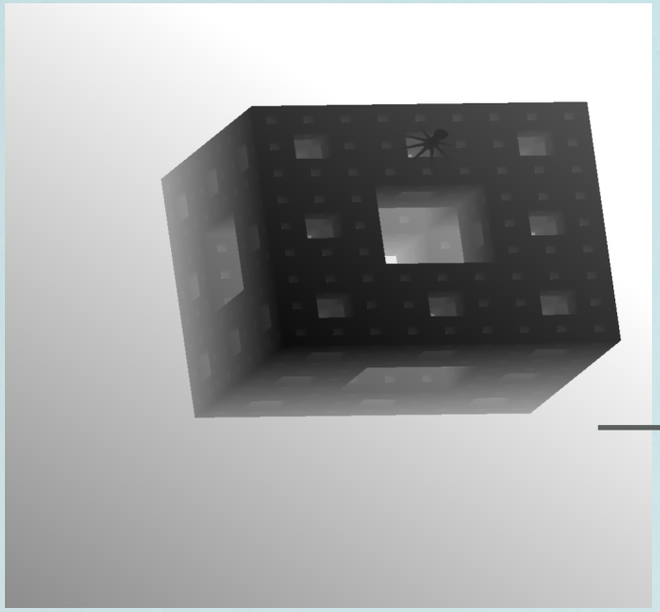
- Untere Schranke , Schattenintensität wird nicht überschätzt

- Input: Depth $z_f \in \mathbb{R}$, moments $b_j = \mathbb{E}_Z(\boldsymbol{z}^j)$ for $j \in \{1,2,3,4\}$
- Output: Approximate shadow intensity

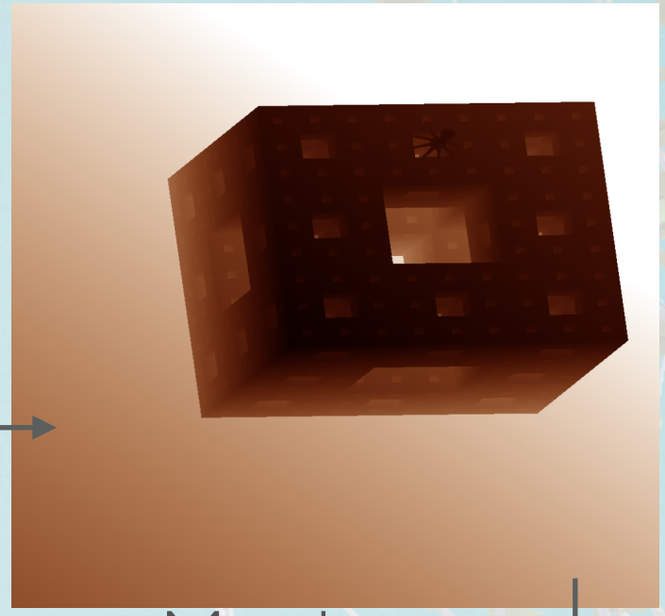
1. Solve $\begin{pmatrix} 1 & b_1 & b_2 \\ b_1 & b_2 & b_3 \\ b_2 & b_3 & b_4 \end{pmatrix} \cdot \begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} = \begin{pmatrix} 1 \\ z_f \\ z_f^2 \end{pmatrix}$
2. Solve $c_3 \cdot z^2 + c_2 \cdot z + c_1 = 0$ for $z_2, z_3 \in \mathbb{R}$
3. Solve $\begin{pmatrix} 1 & 1 & 1 \\ z_f & z_2 & z_3 \\ z_f^2 & z_2^2 & z_3^2 \end{pmatrix} \cdot \begin{pmatrix} w_1 \\ w_2 \\ w_3 \end{pmatrix} = \begin{pmatrix} 1 \\ b_1 \\ b_2 \end{pmatrix}$
4. Return $\sum_{i=2, z_i < z_f}^{3} w_i$

4.2 MSM: IMPLEMENTIERUNG

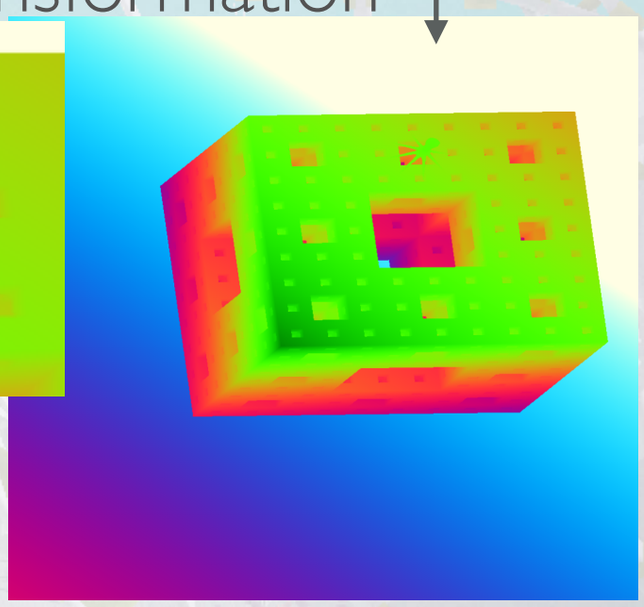
Tiefe z



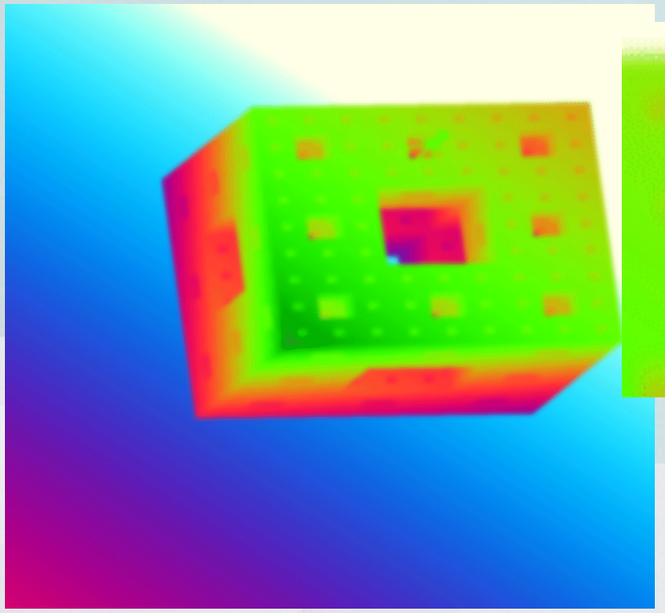
Speichern
$z,\ z^2, z^3, z^4$



Matrix-
transformation

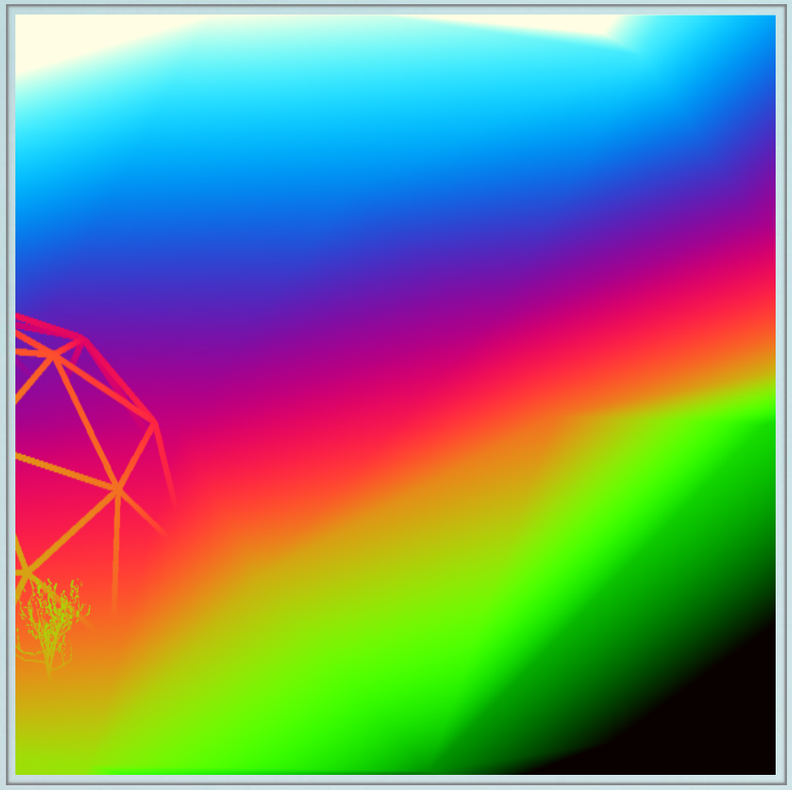


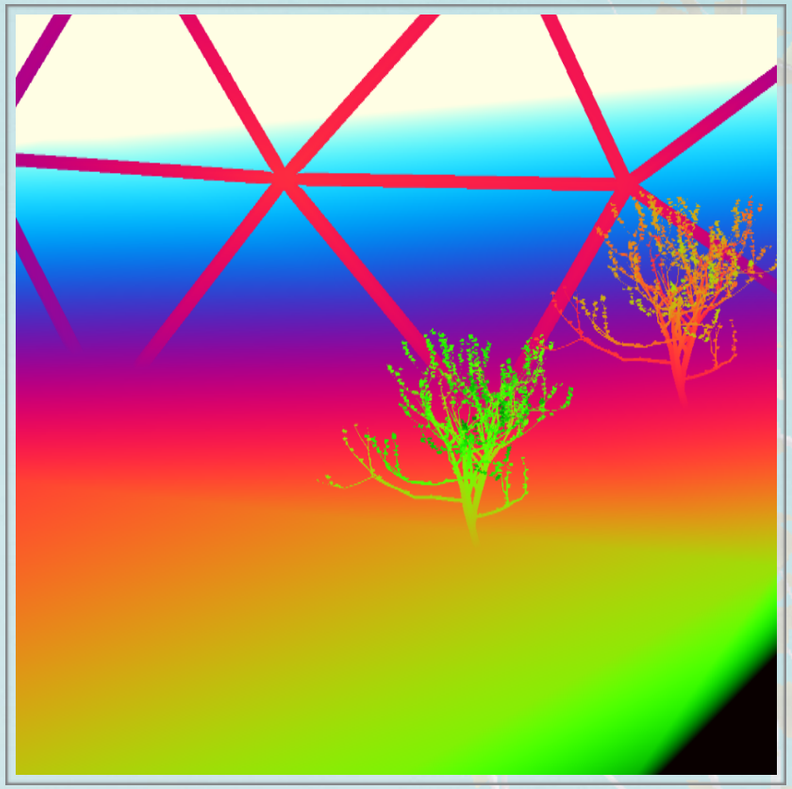
Rückrechnen
beim lesen

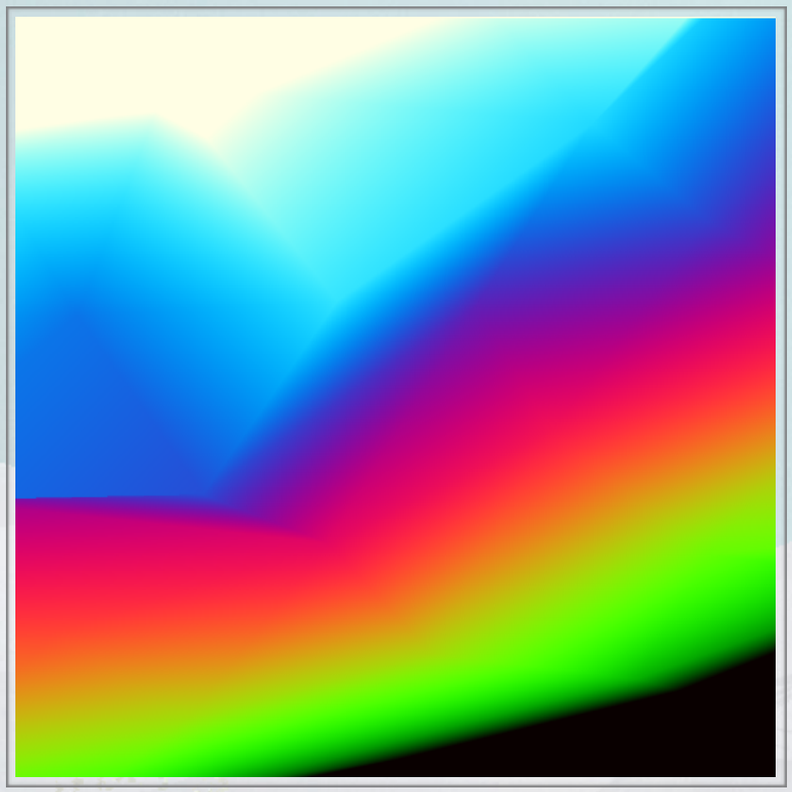


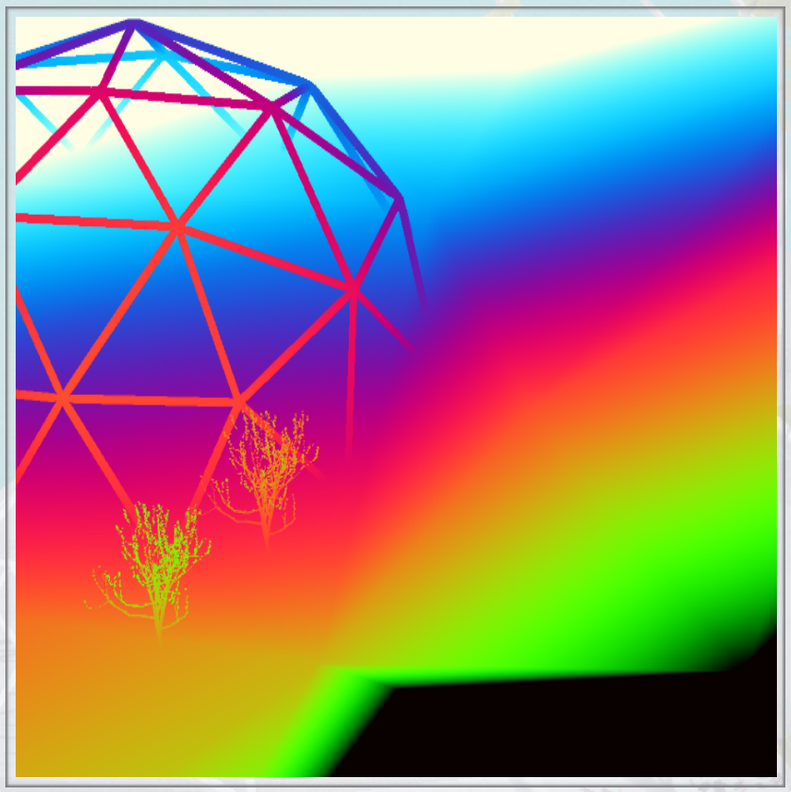
Schatten-
intensität

4.3 MSM: MOMENT TEXTUR









4.4 MSM: ERGEBNISSE

1xMSAA

2xMSAA

16xMSAA

GAUSS

4.4 MSM: ERGEBNISSE (2)

- Anti-Aliasing durch MSAA und Filtern durch Gauss
- Light Leaking wird besser verringert als bei VSM
- Kaum Auswirkungen auf Engine-Performance, das Filtern allerdings hohe Einbrüche

4.5 MSM: MBVO ALGORITHMUS

- Moment Based Volumetric Obscurance
- Area Sampling uniforme Verteilung
- Nutzbar durch MSM Technik, deshalb robuster und effizient
- 3 Tiefen werden gewichtet aufsummiert für VO Term

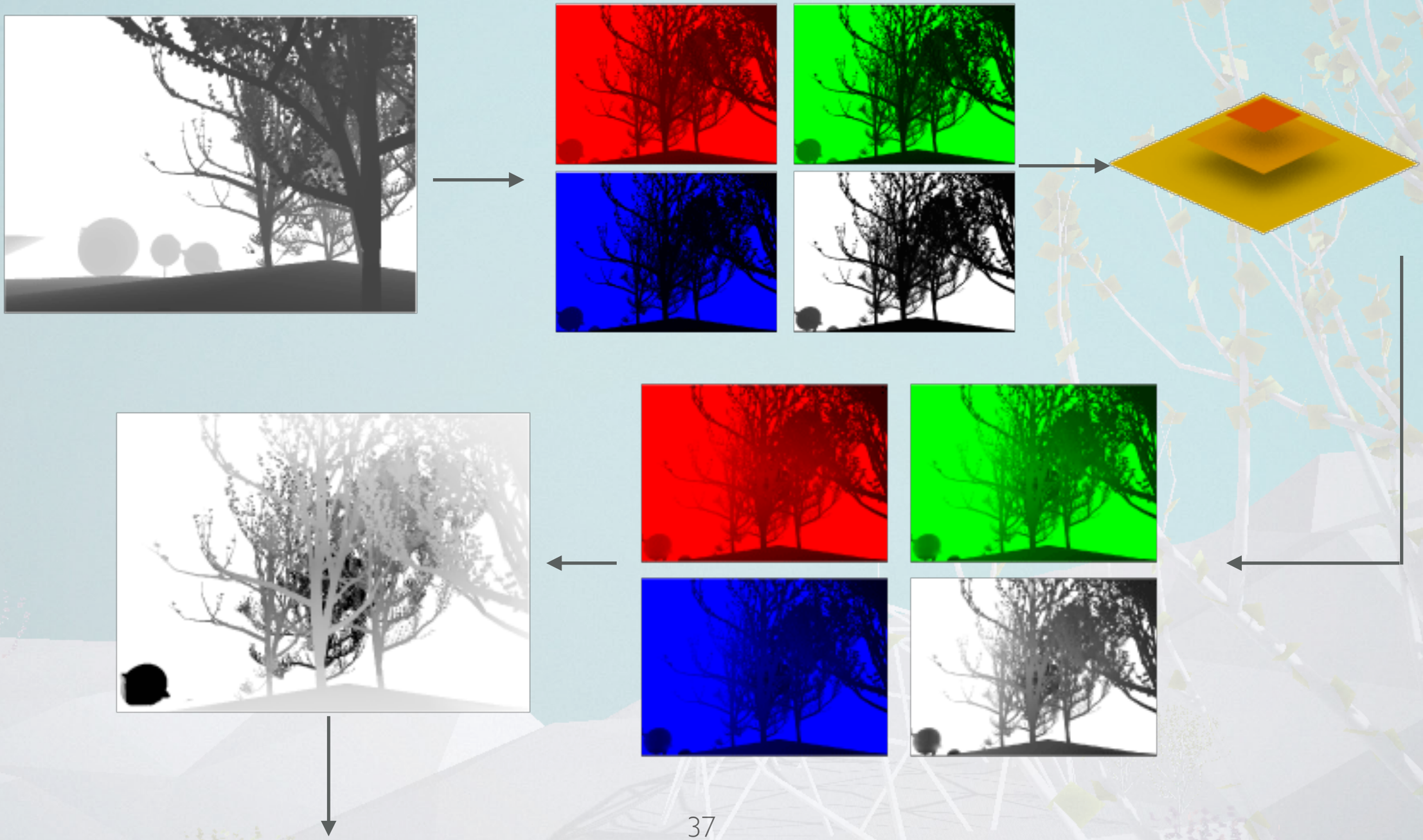
$$\mathbf{f}(z) := \begin{cases} 1 & \text{if } z < z_a, \\ \frac{z - z_a}{z_b - z_a} & \text{if } z_a \leq z \leq z_b, \\ 0 & \text{if } z_b < z. \end{cases}$$

$$\mathbb{E}_S(\mathbf{f}) = \sum_{i=1}^{n} w_i \cdot \mathbf{f}(z_i)$$

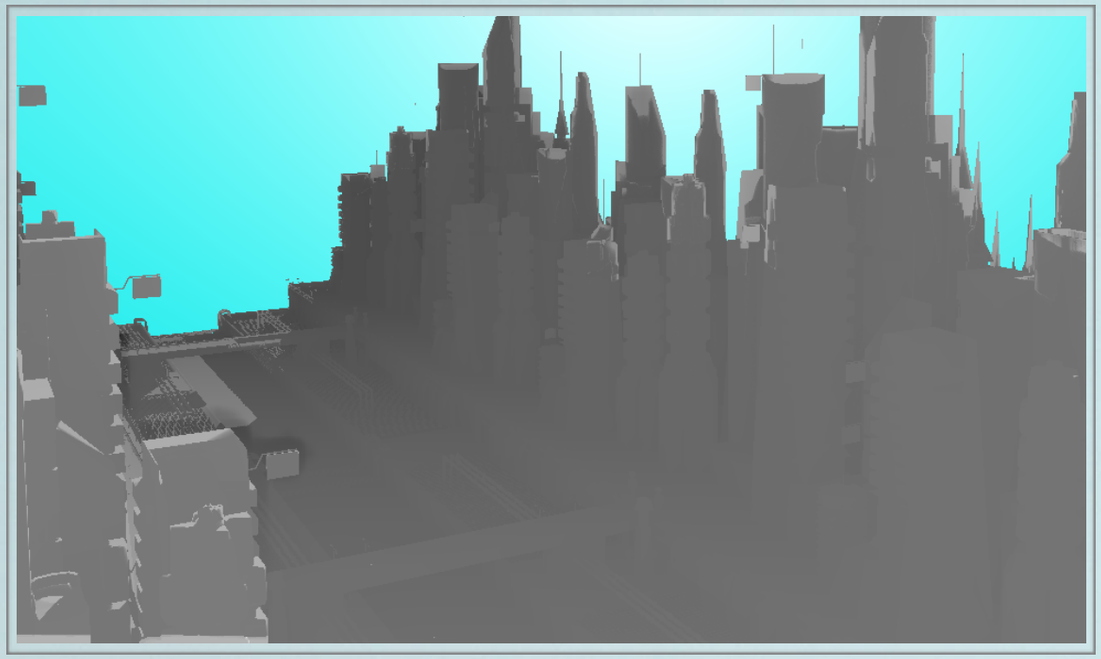
4.6 MBVO: IMPLEMENTIERUNG

- Moment Based Volumetric Obscurance Term berechnen
- Ähnlicher Aufbau wie für MSM
- Funktion der Intensität wird erweitert um Gewichte
- Summe aus Gewichten und F(z) Werten

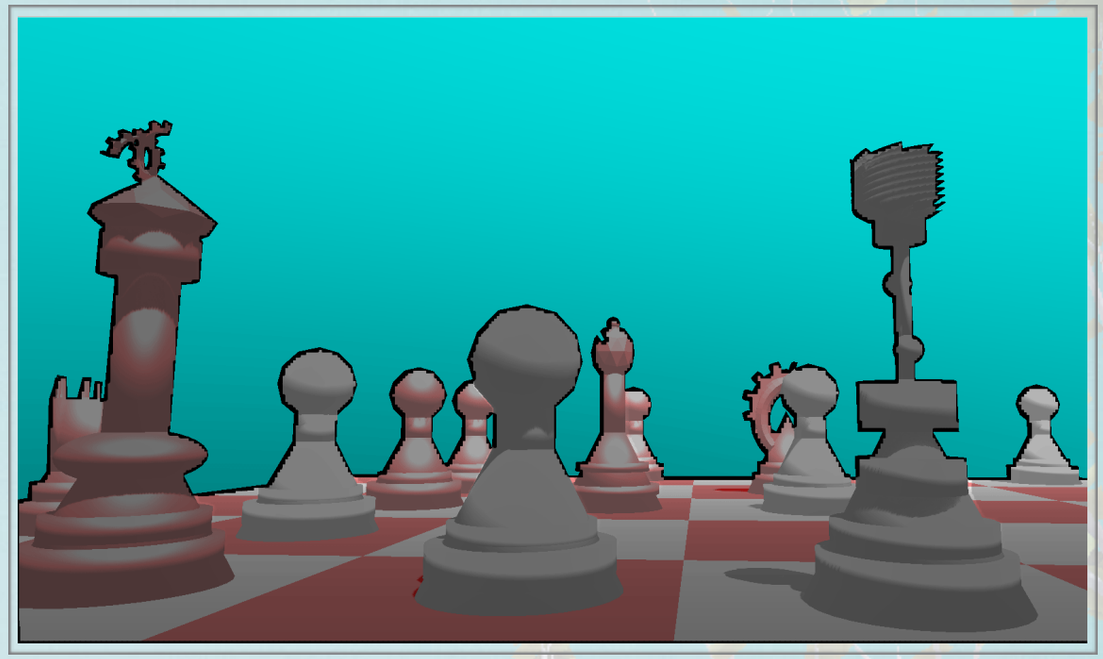
4.6 MBVO: IMPLEMENTIERUNG



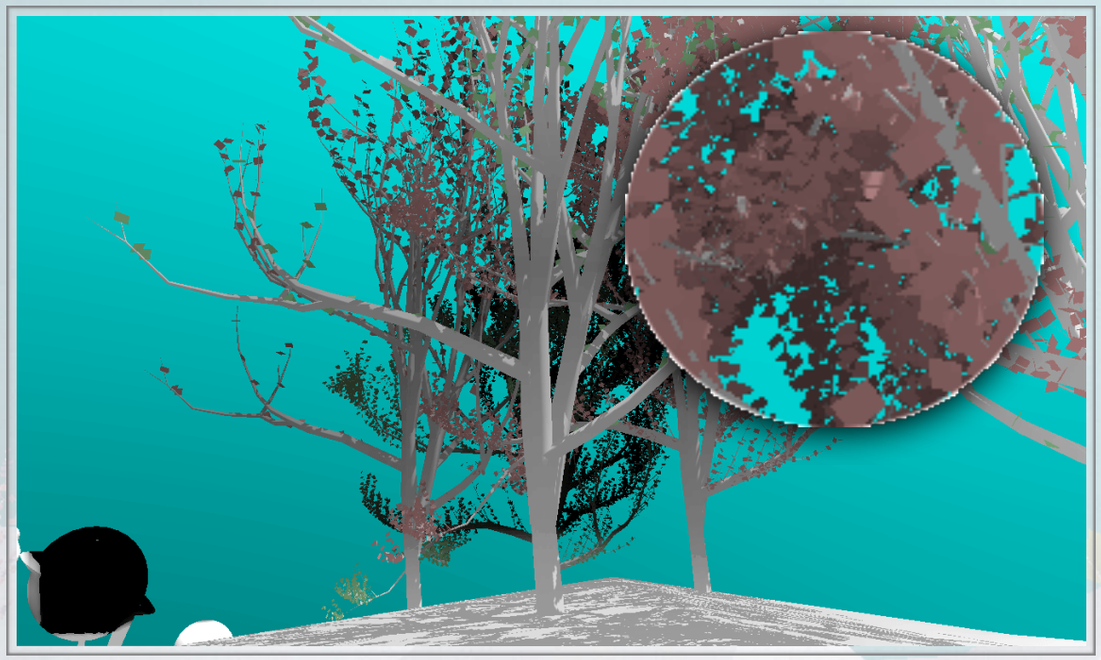
4.7 MBVO: ERGEBNISSE



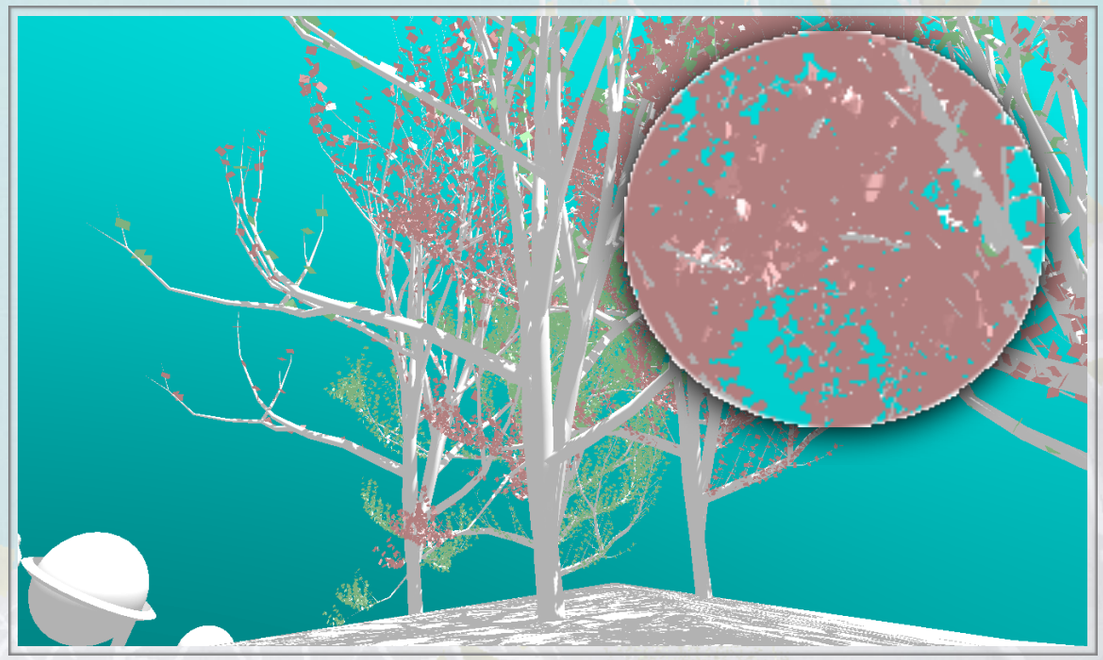
MBVO 1



MBVO 2



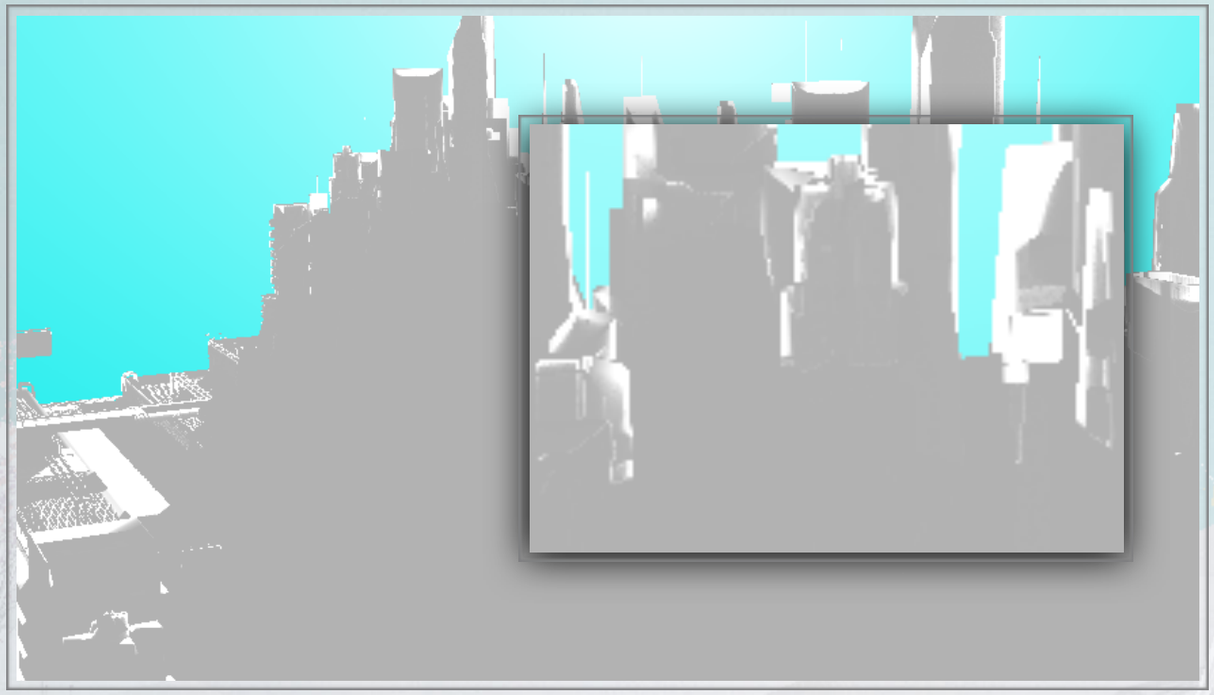
MBVO ON

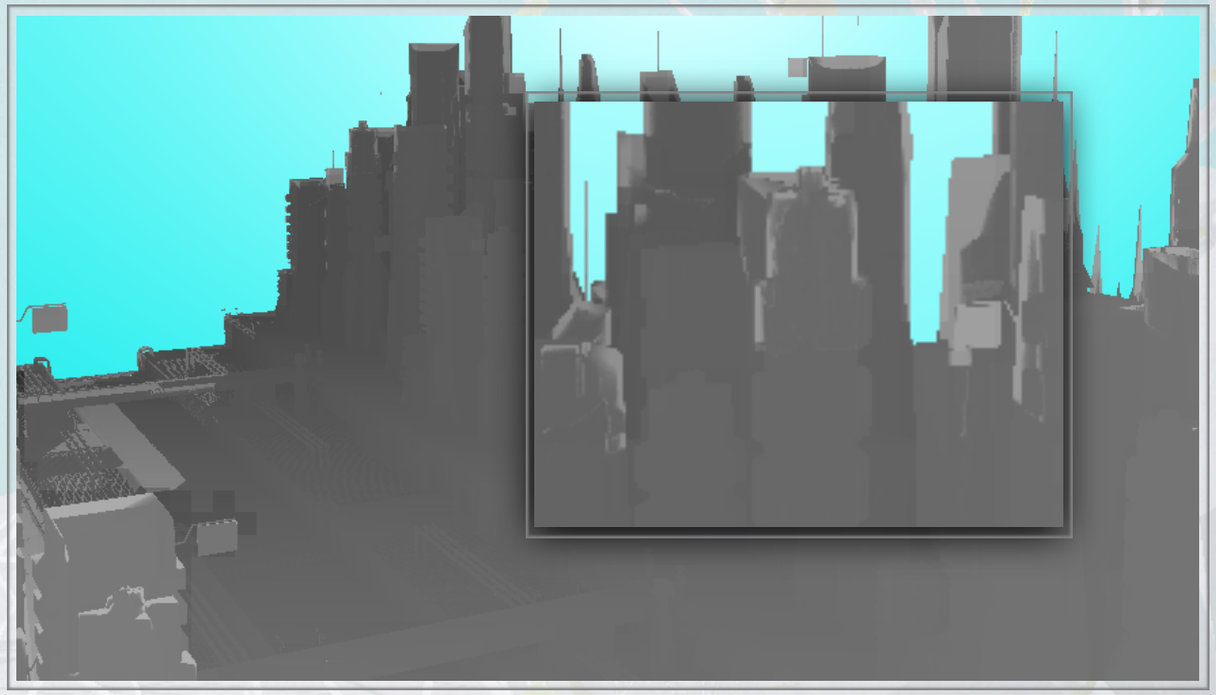


MBVO OFF

4.7 MBVO: ERGEBNISSE (2)

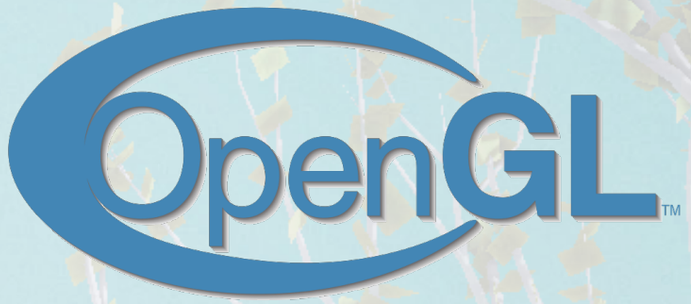
- Leicht umsetzbar durch Moment Technik
- Cell Shading ähnlicher Effekt mit falschen Werten
- Weiteres experimentieren nötig um ästhetisches Bild zu erhalten
  - glGenerateMipmaps

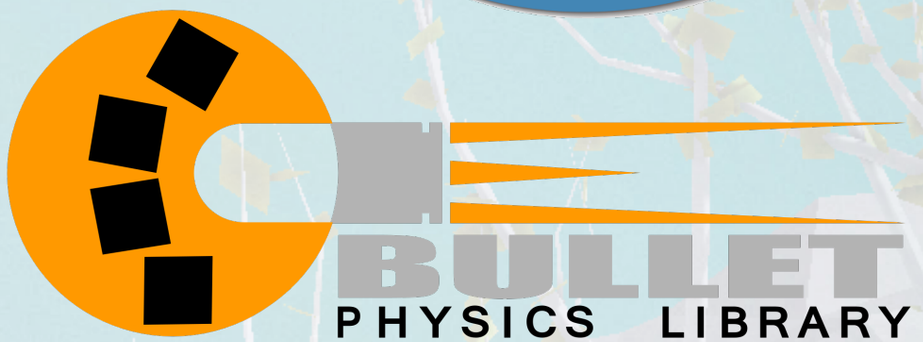


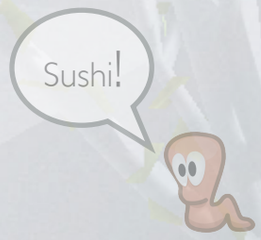


5. SUSHI! WITH R.I.C.E.

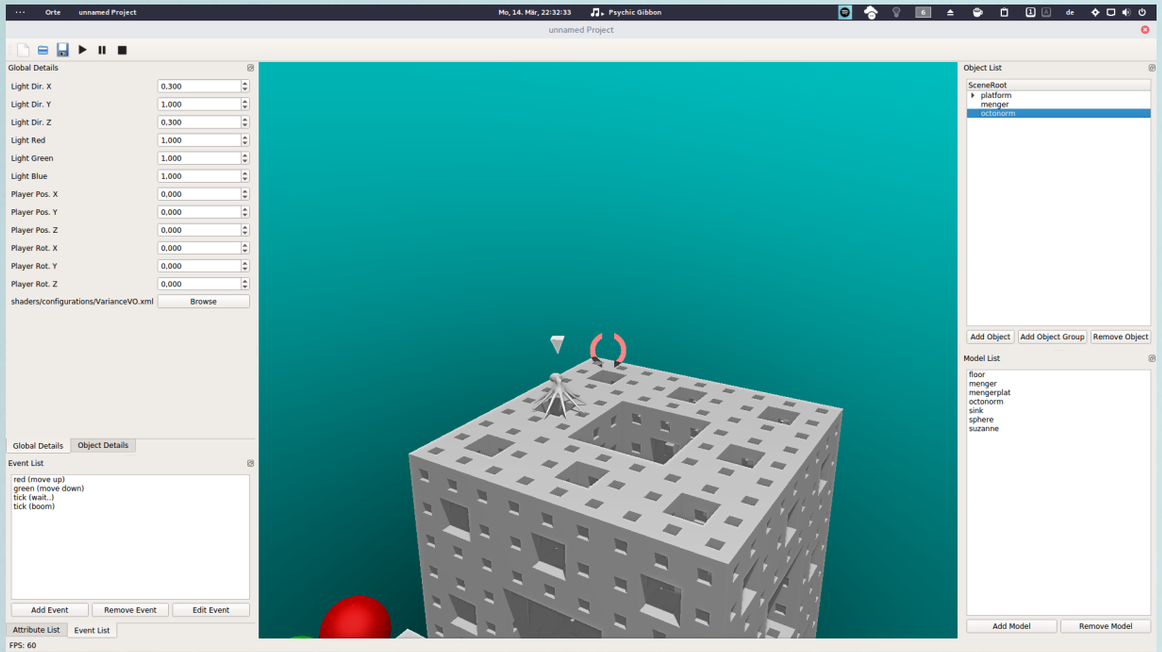
- **R**ealistic **I**nsane **C**omputer-Graphic **E**nvironment
- C++, Qt, OpenGL, Bullet Physics

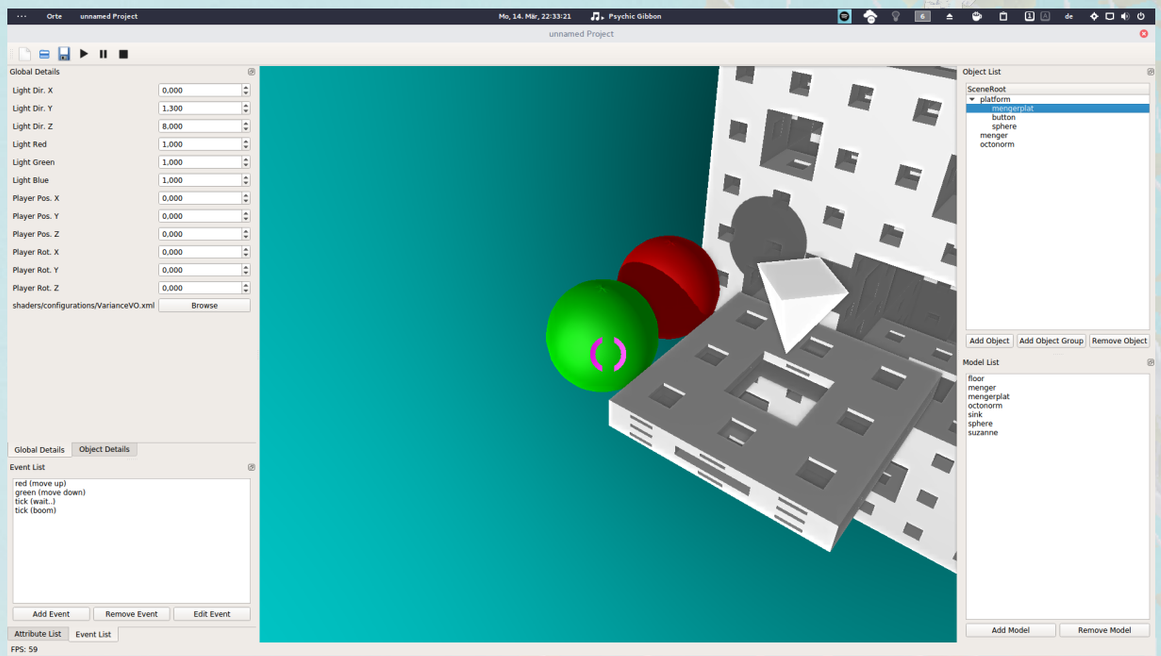


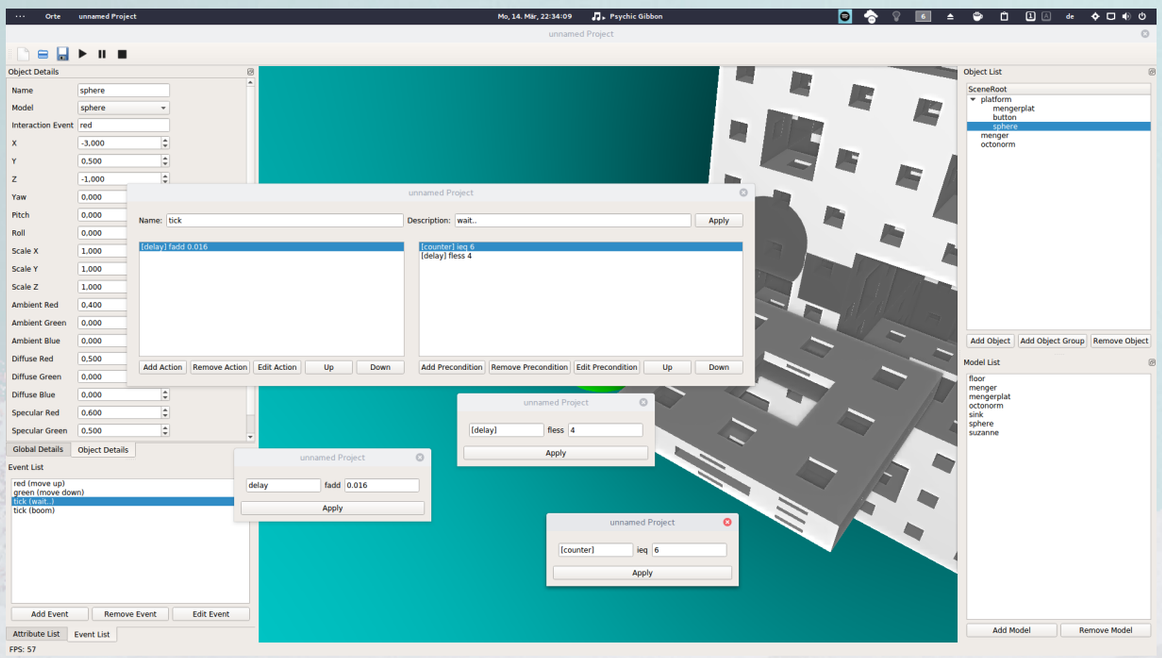


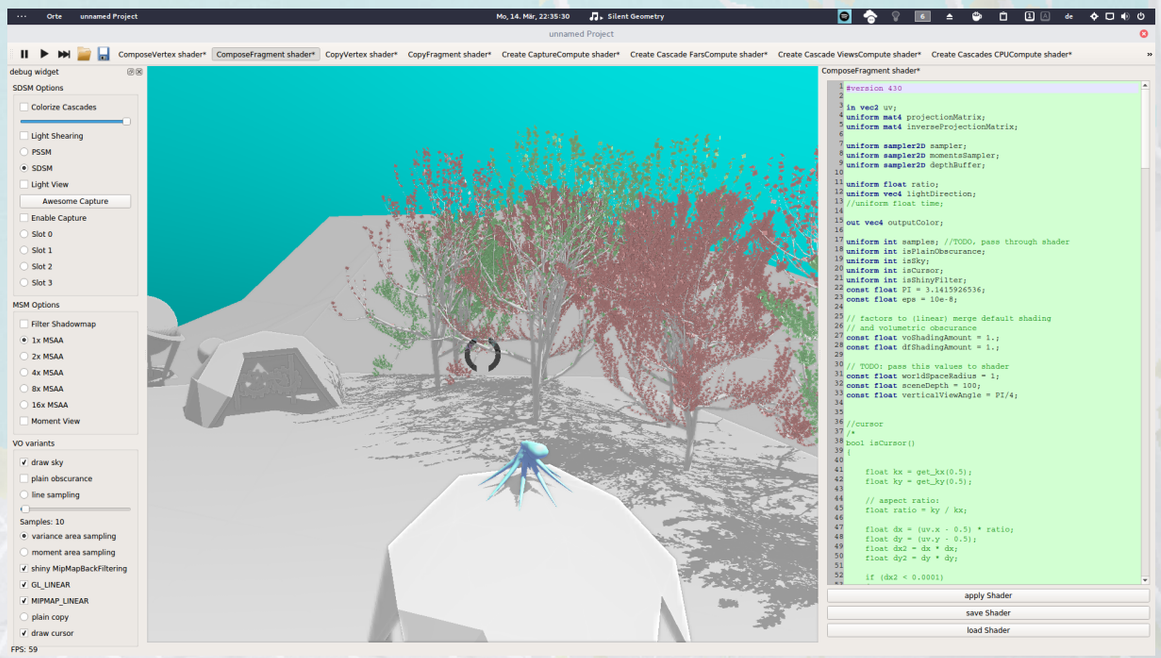


5. ENTWICKLERTOOLS



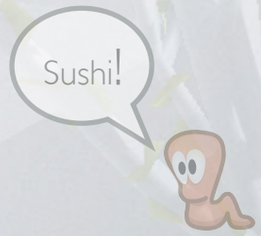






5.1 SUSHI!

PRESS START



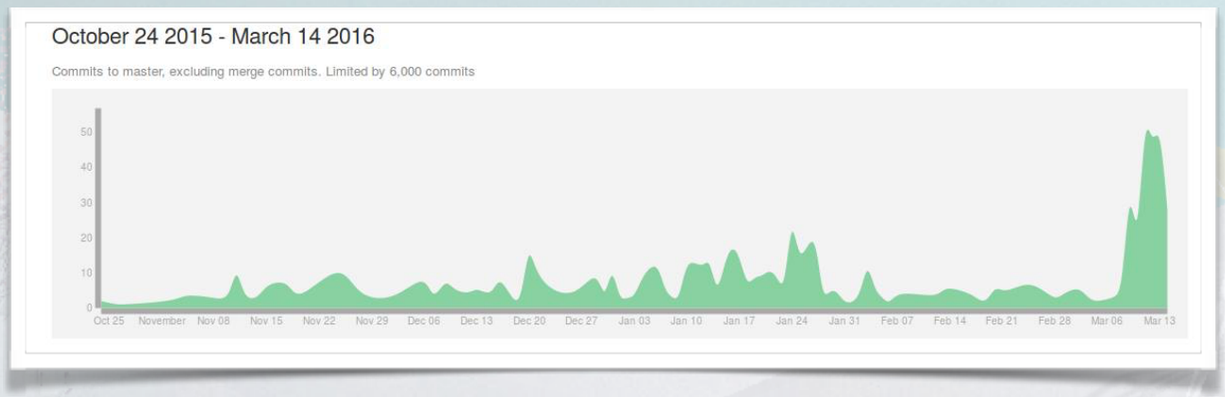
6. FAZIT UND AUSSICHTEN

- Spiel soll fertig entwickelt werden
  -weitere Techniken und Verbesserungen
  -weitere Levels, Rätsel, Menüs und Optionen

- Planung vs. Chaos

- Wir haben viel gelernt

- Wir hatten jede Menge Spaß



VIELEN DANK FÜR DIE AUFMERKSAMKEIT