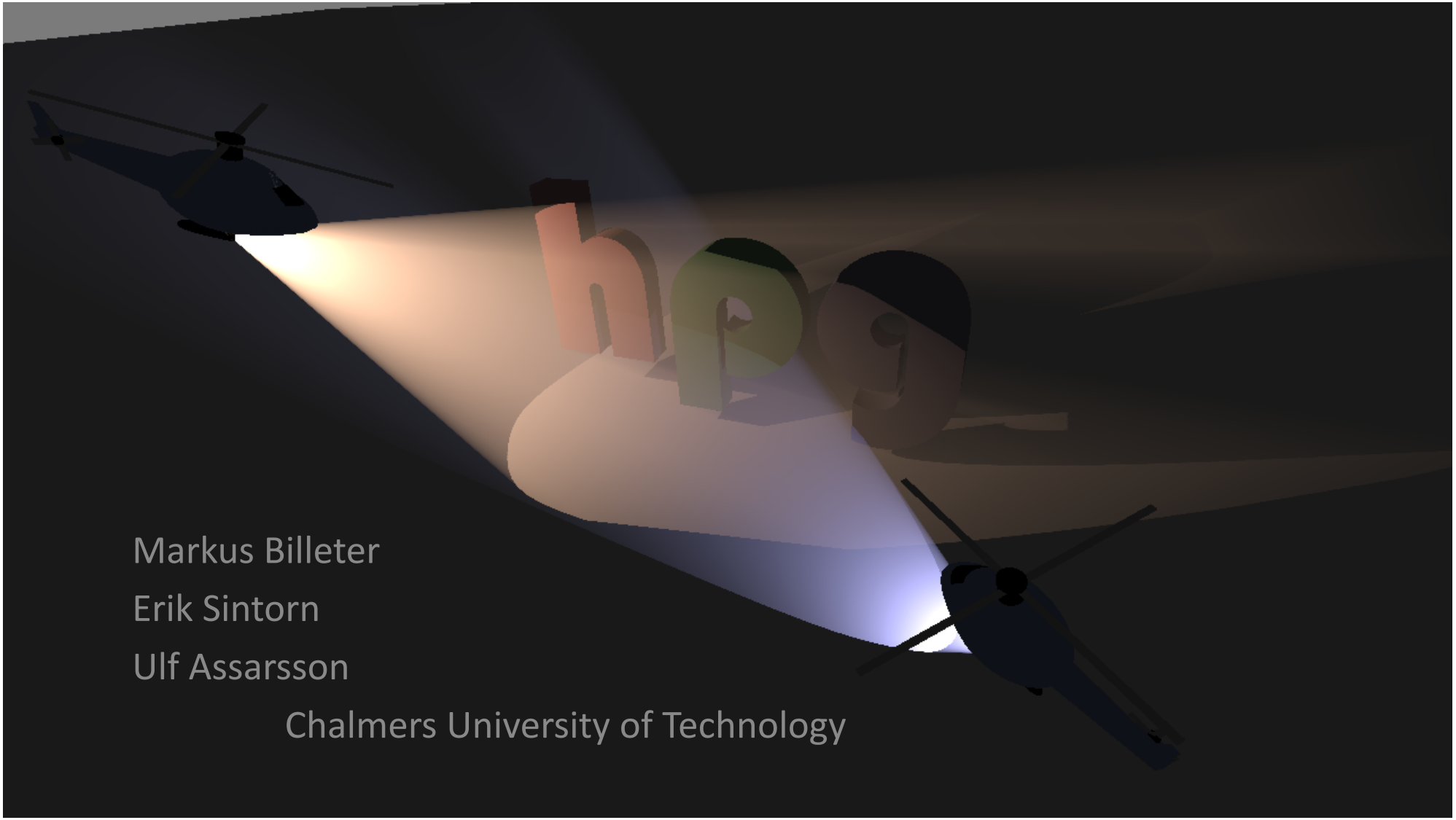
REAL TIME VOLUMETRIC SHADOWS USING POLYGONAL LIGHT VOLUMES



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Erik Sintorn
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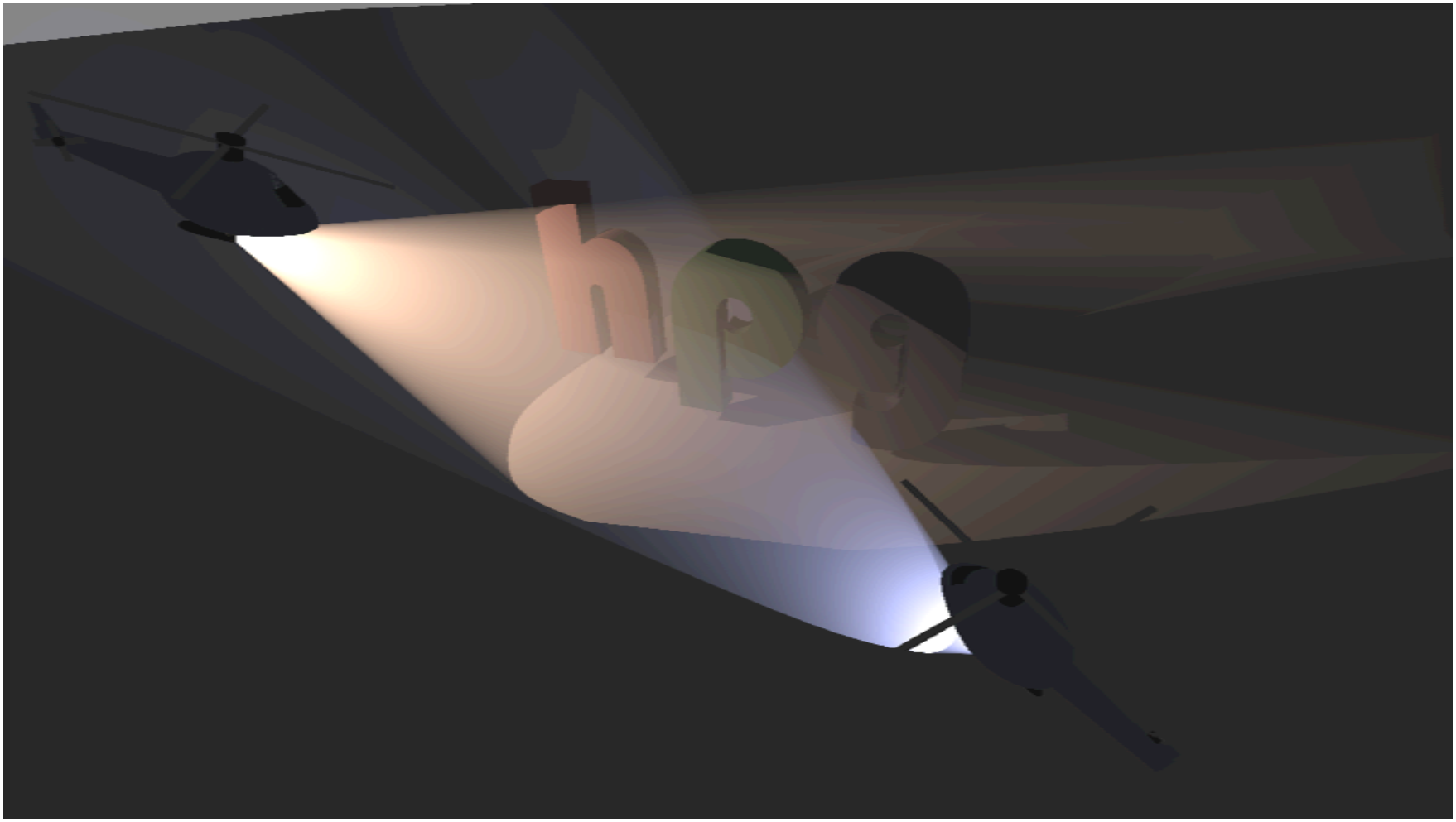
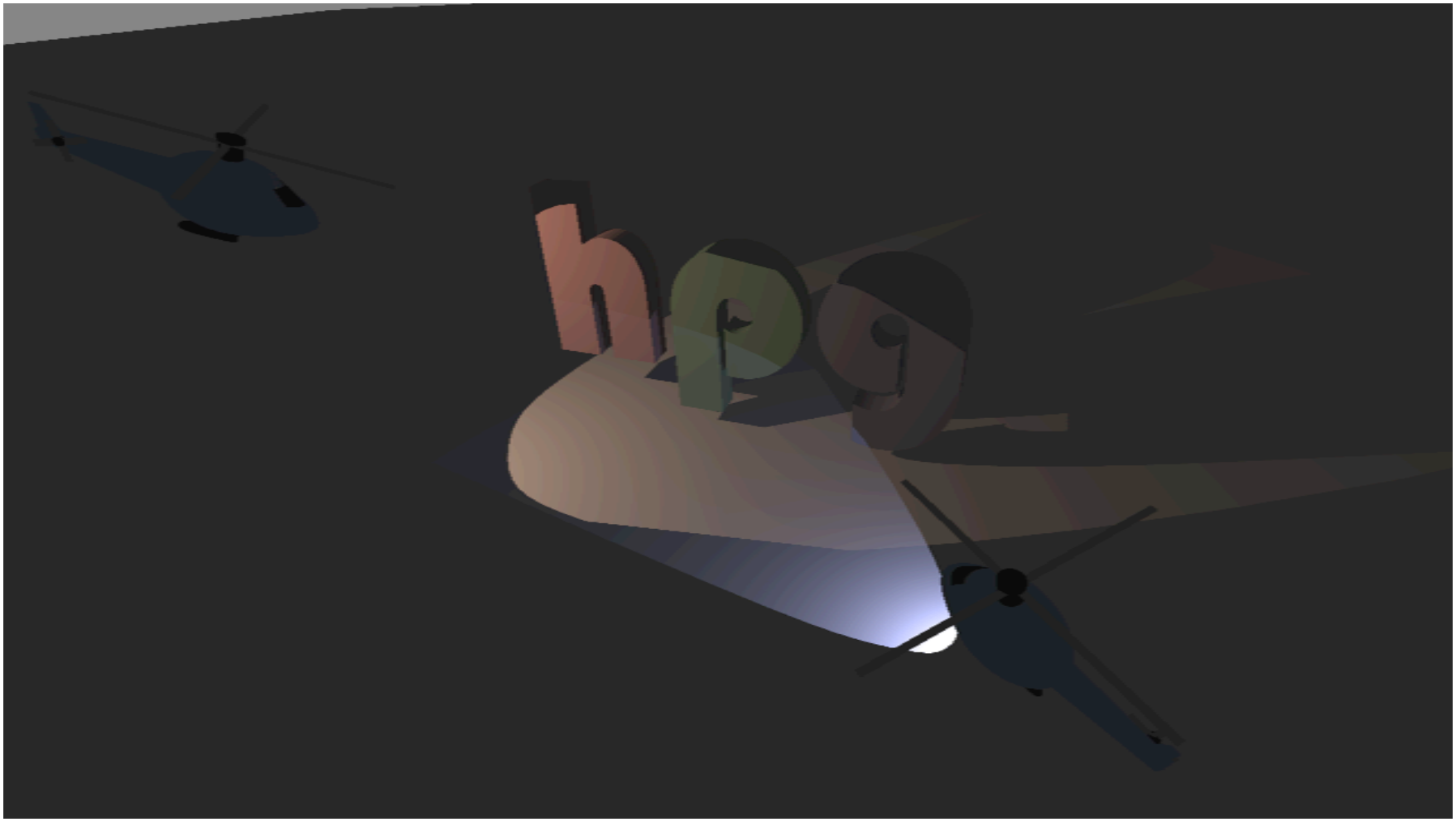
Overview

- Introduction: Airlight
- From Ray Marching to Light Volumes
- Light Volume Algorithm
- Adaptive Tessellation
- Demo / Movie
- Results
- Conclusion

Introduction:
Airlight / Participating Media



Direct Light and Hard Shadows Only



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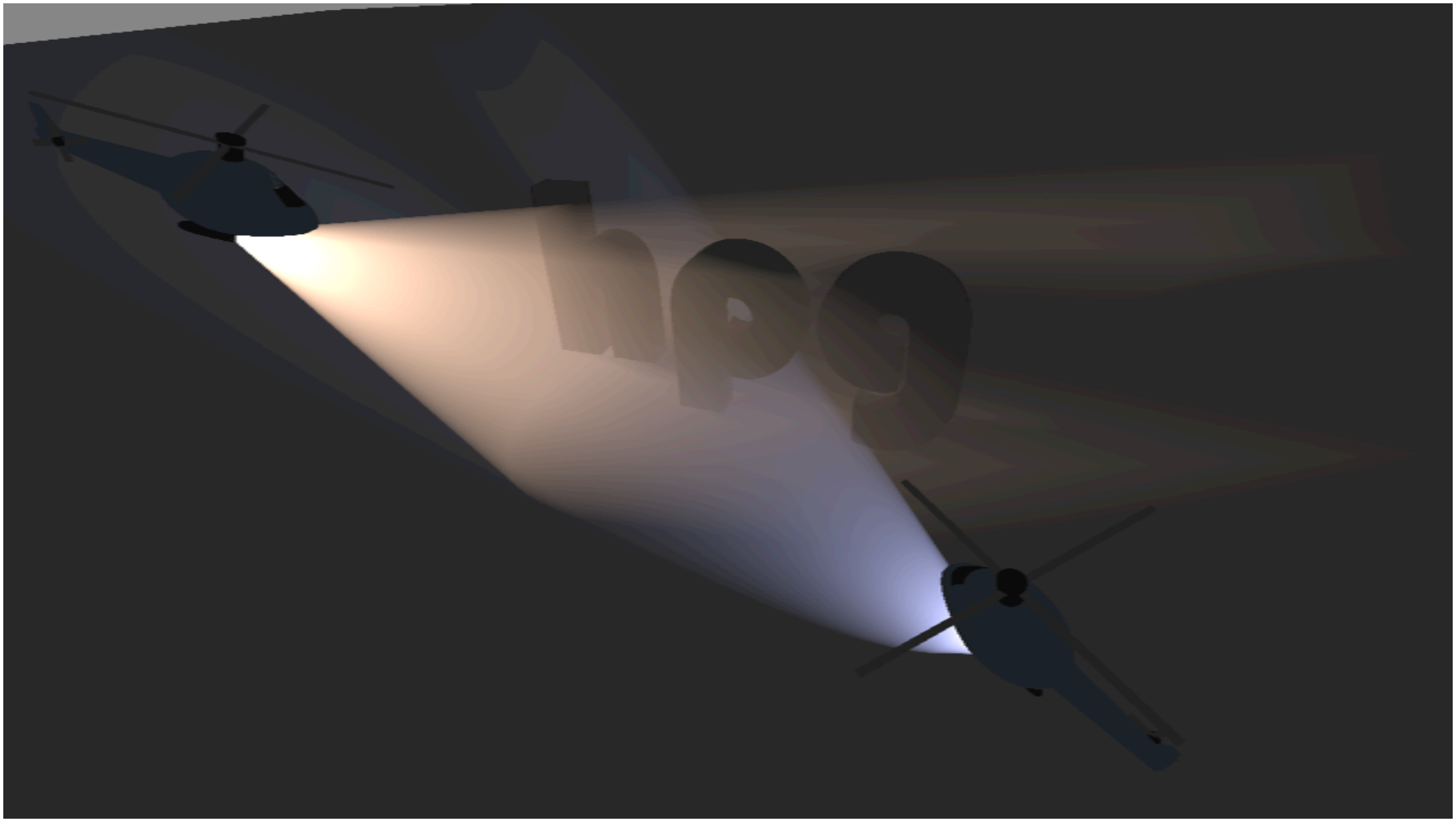
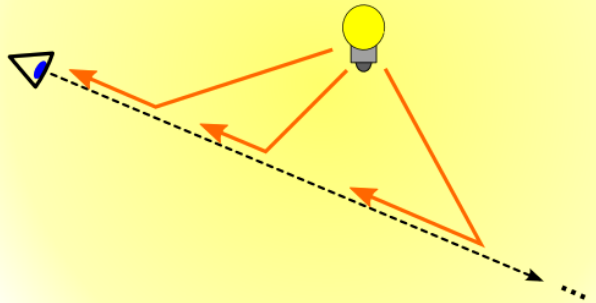
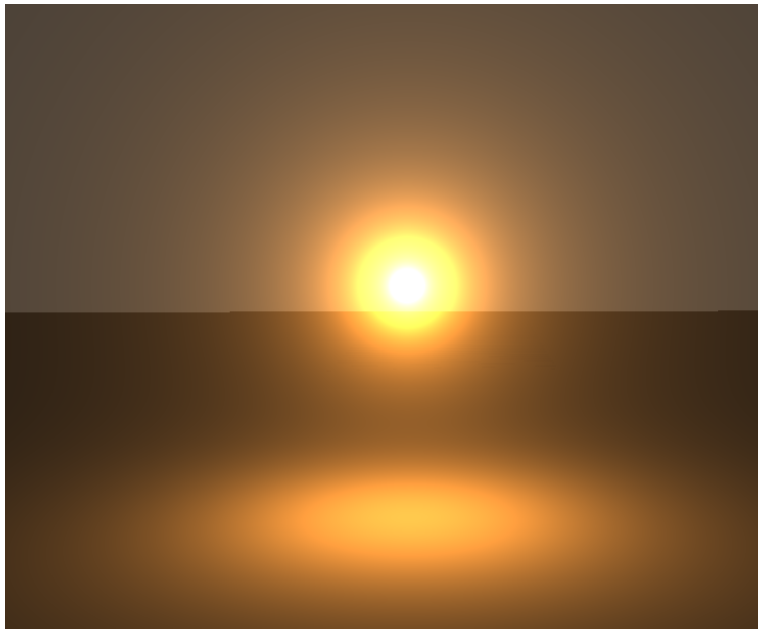


Airlight

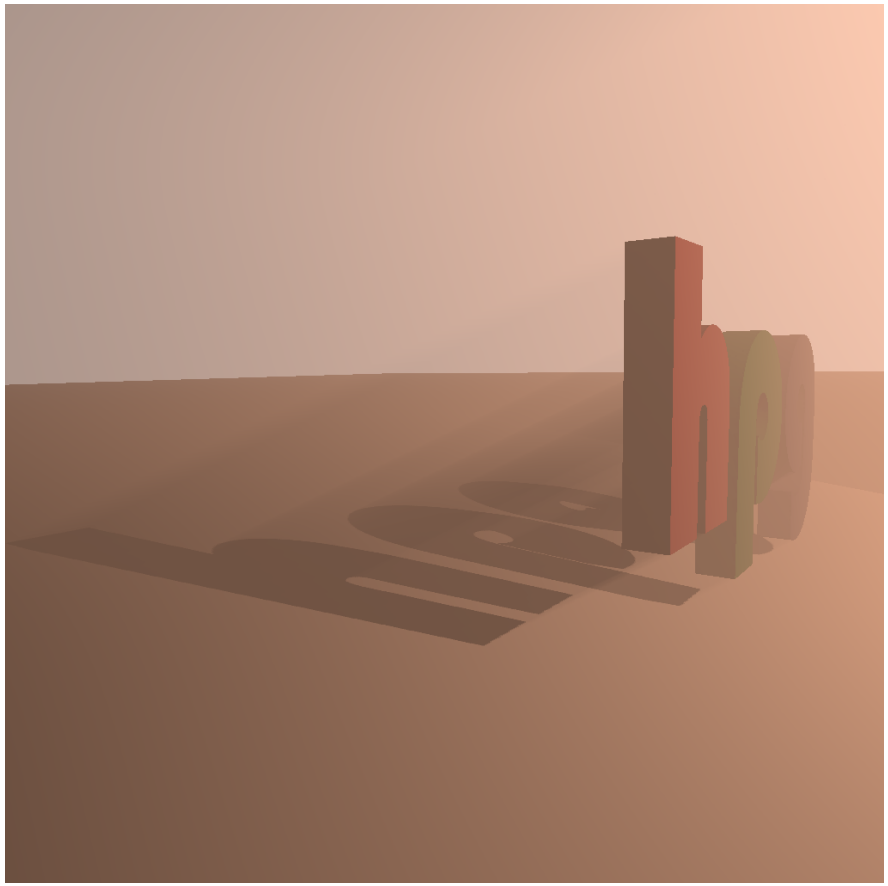
- Use single scattering model
  - Integral along ray
  - Nishita et al. in 1987
- Direct solution using texture lookups
  - Gives in-scattered light (Airlight) on line segment
  - E.g. Sun et al. in 2005
- Ignores occlusion





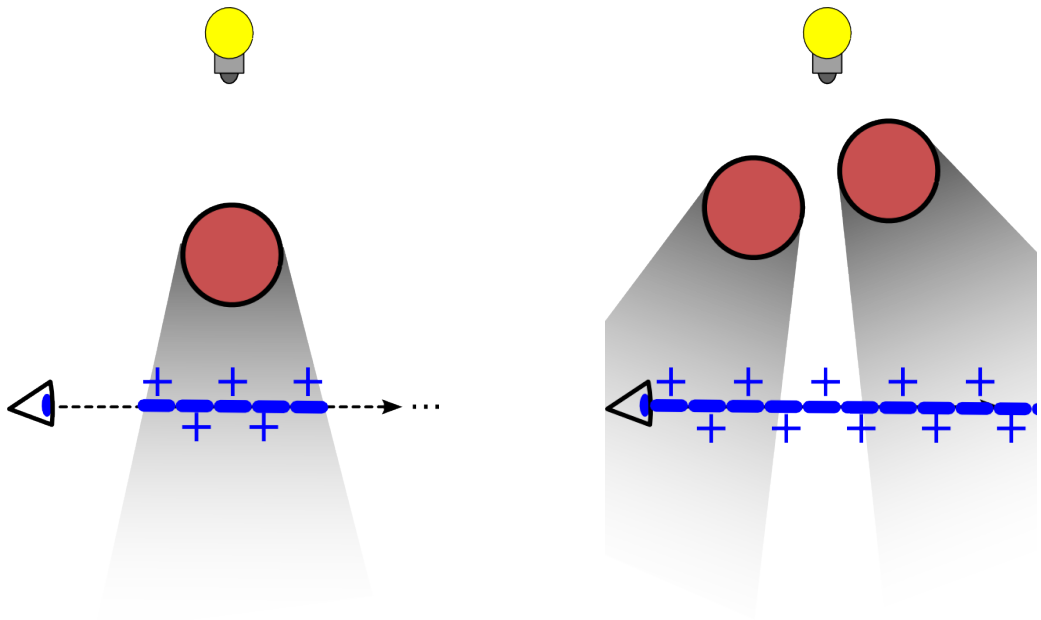
Ray-marching

- Ray march to find illuminated regions
  - At each point, determine if illuminated
- Done with
  - alpha blended planes
    - Dobashi et al. in 2002
    - Imagire et al. in 2007
  - Loop in fragment shader
    - E.g. Toth and Umenhoffer in 2009



Ray-marching, Improved

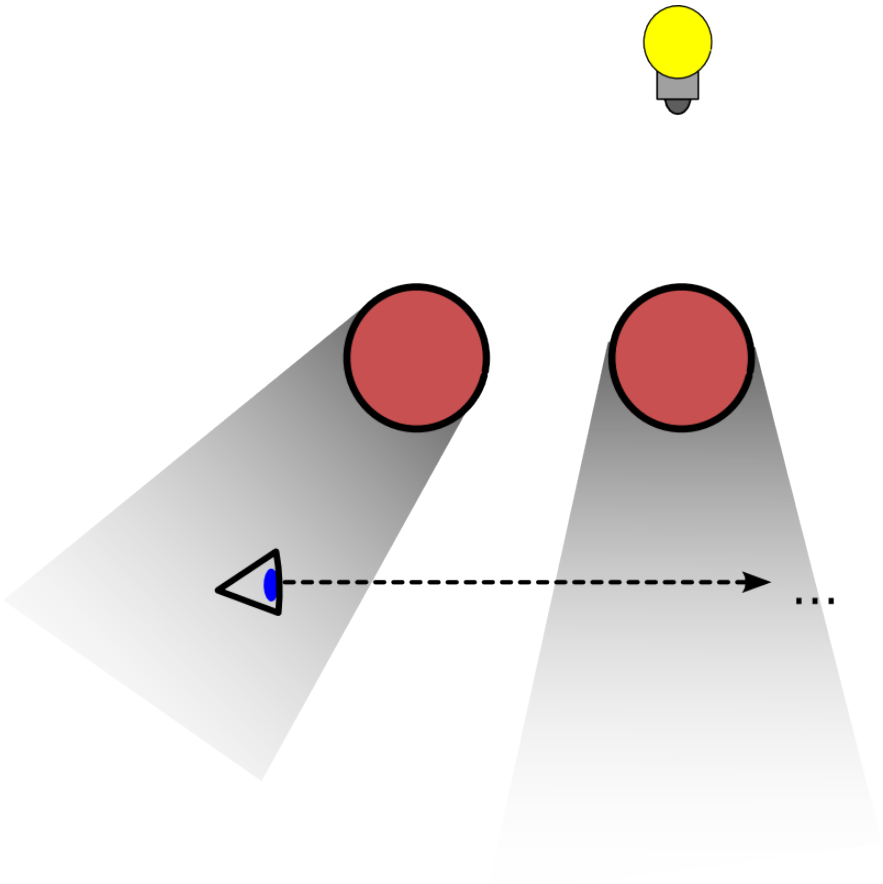
- Limit ray marched regions
  - Use shadow volumes to bound interesting region
  - Wyman et al. in 2008
- Cases where the bounds don't help…



Light Volumes, Introduction

- Avoid ray marching entirely
  - Lit range on ray can be evaluated directly
  - Need to find ranges/ boundaries

$\Rightarrow$ Shadow Volumes!



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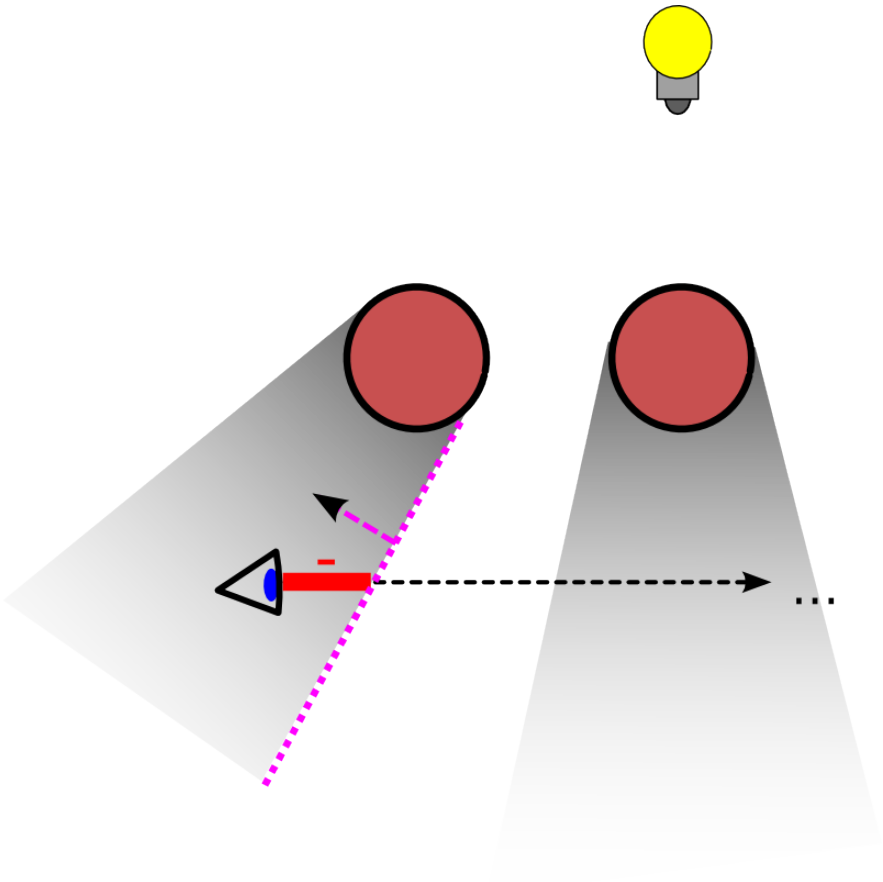

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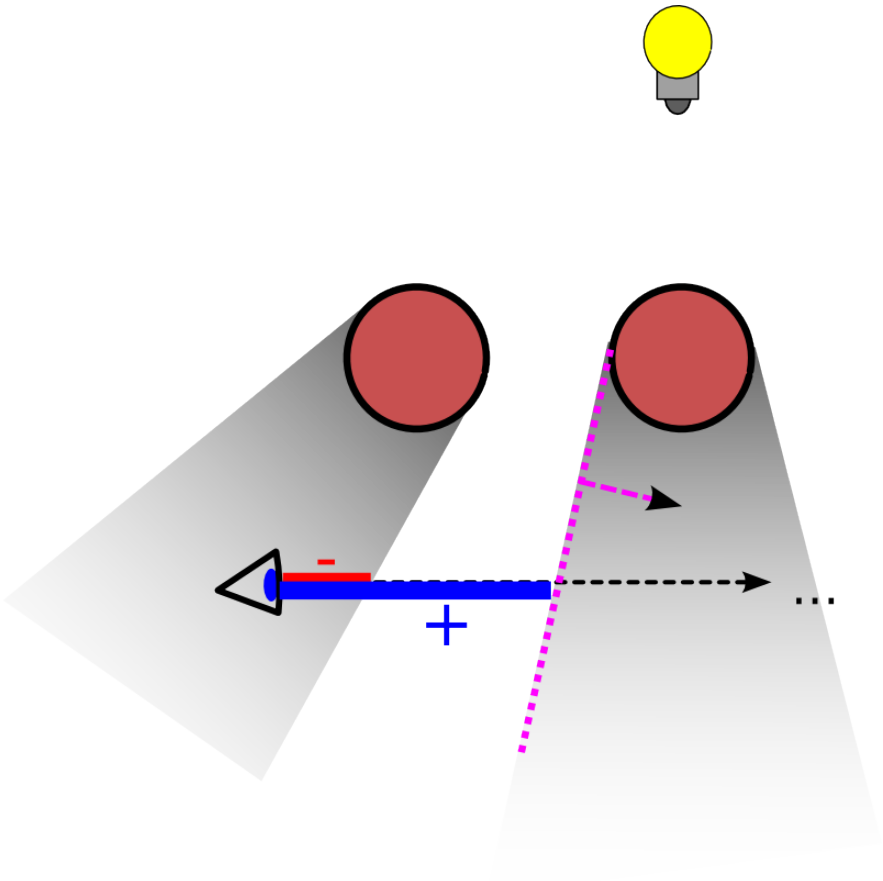

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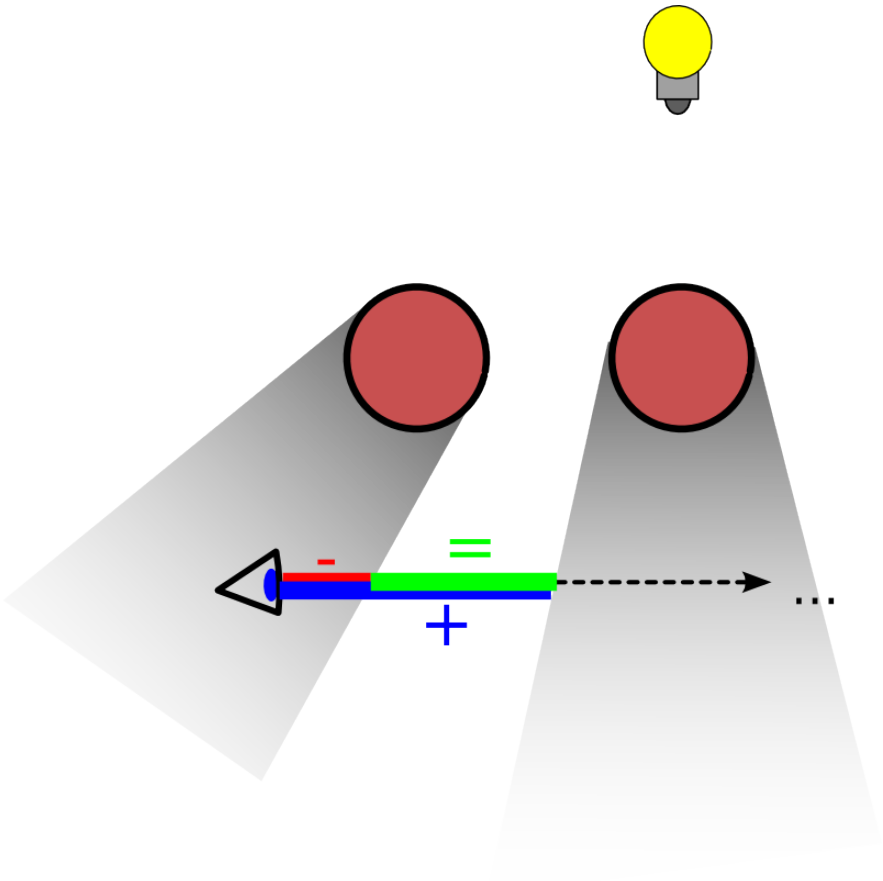

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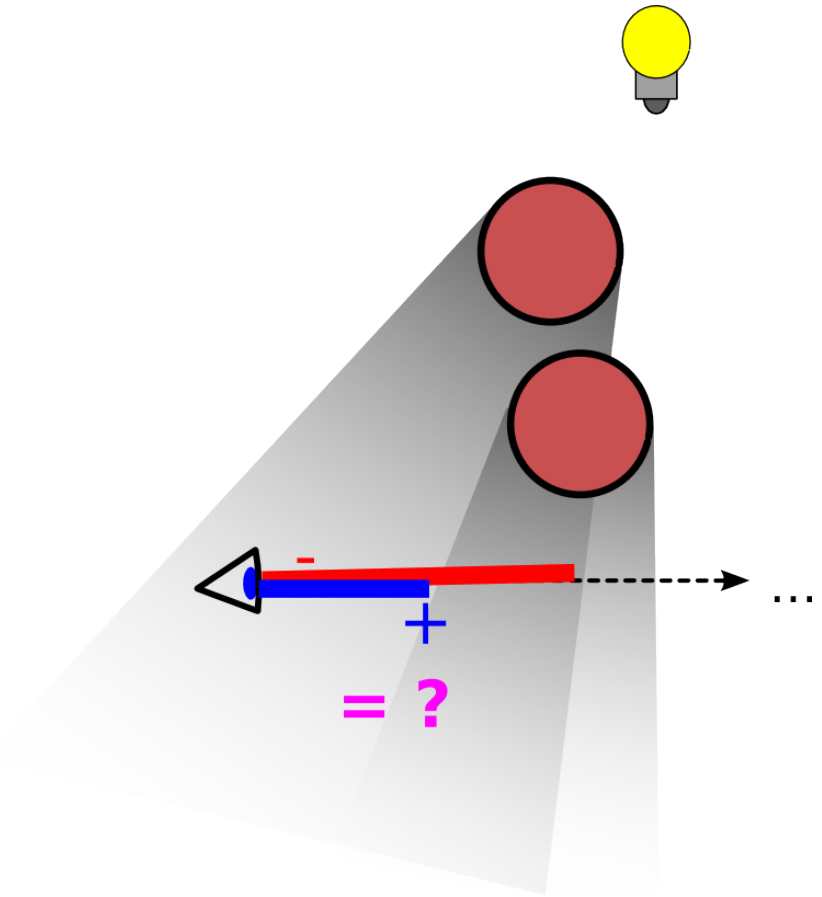
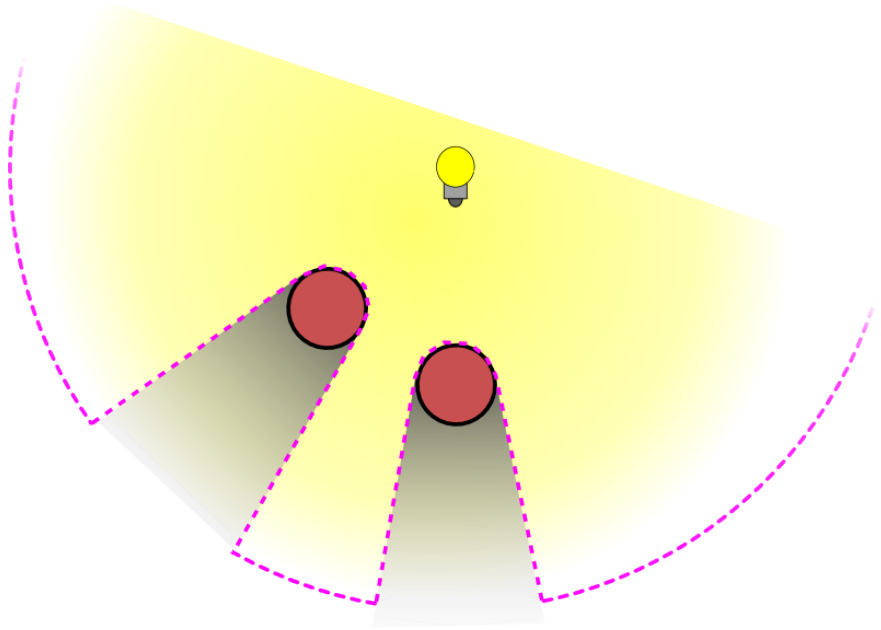
⇒ Shadow Volumes!

- Problems:
  - Overlapping Volumes



Light Volumes

- Fix problems by:
  - Sort/depth peel volumes
    - Venceslas et. al. in 2006
    - James in 2003
- Reconstruct volume from shadow map!
  - Reconstruction explored by McCool in 2000
  - Use bounded light volume



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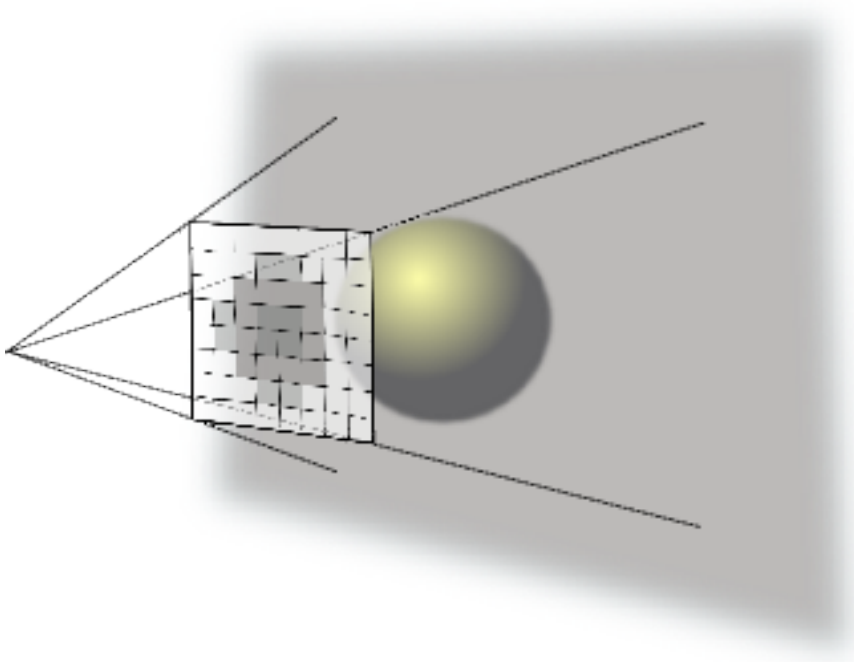

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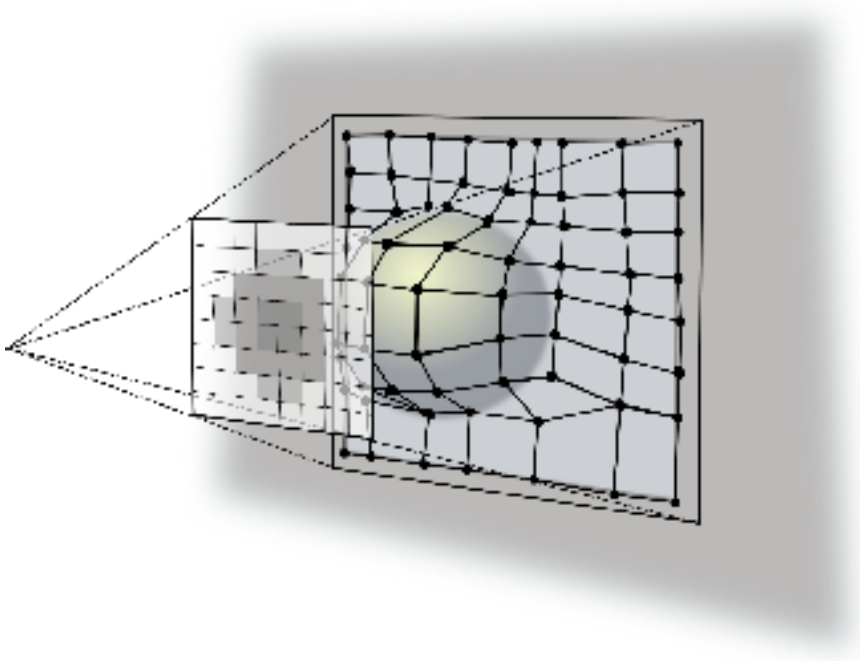

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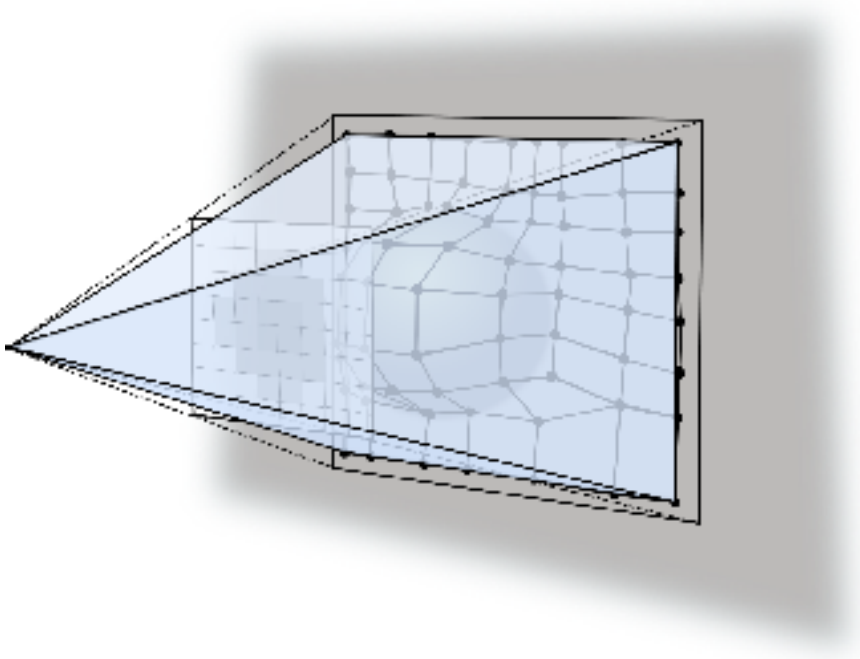
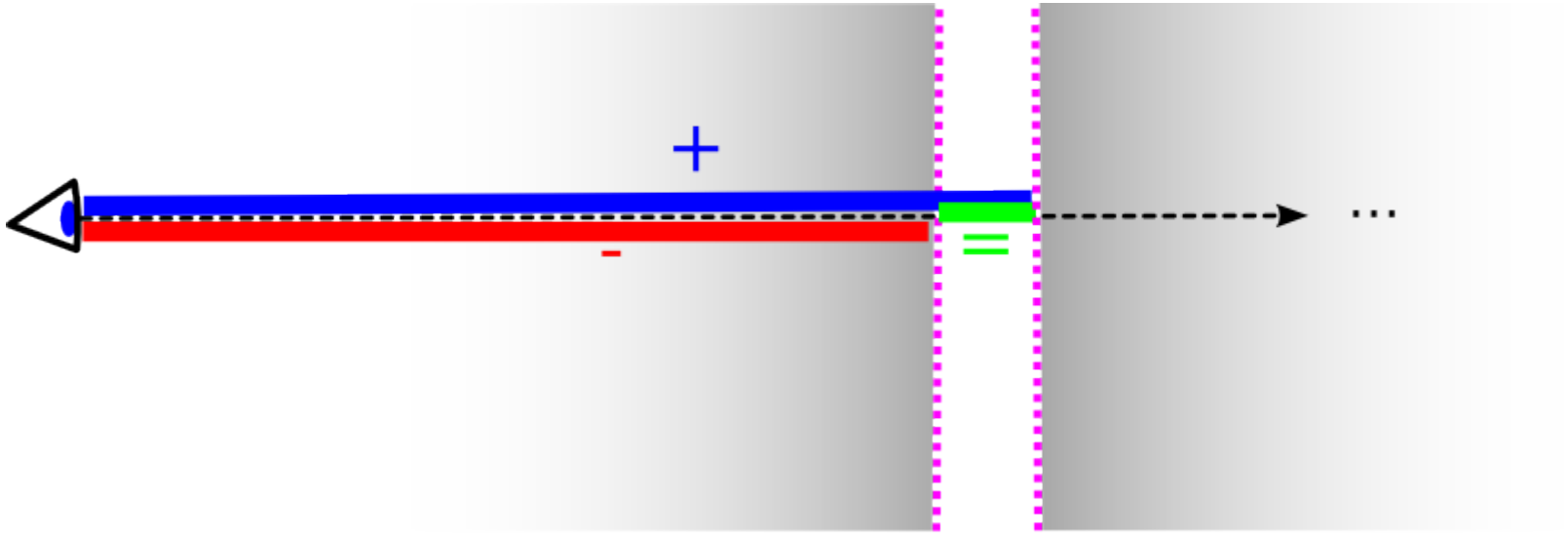


Problems

- Shadow maps are inherently inexact
  - Sampling errors, quantization errors
- Very important: must **not** miss transitions!
  - Add and subtract large values



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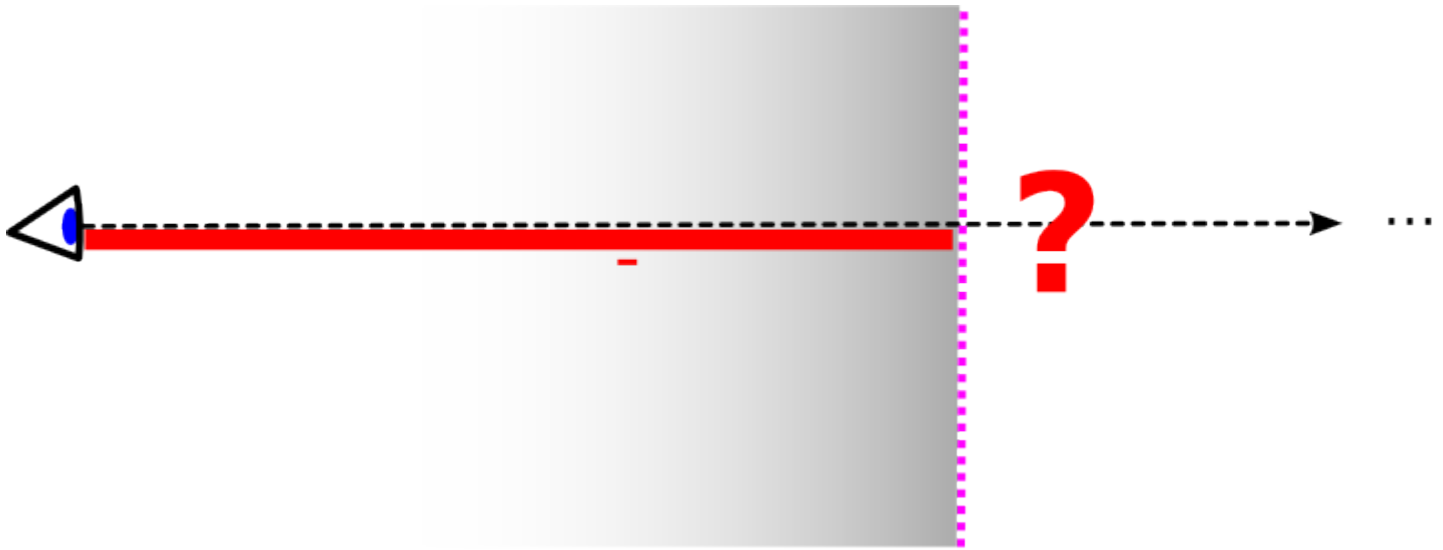
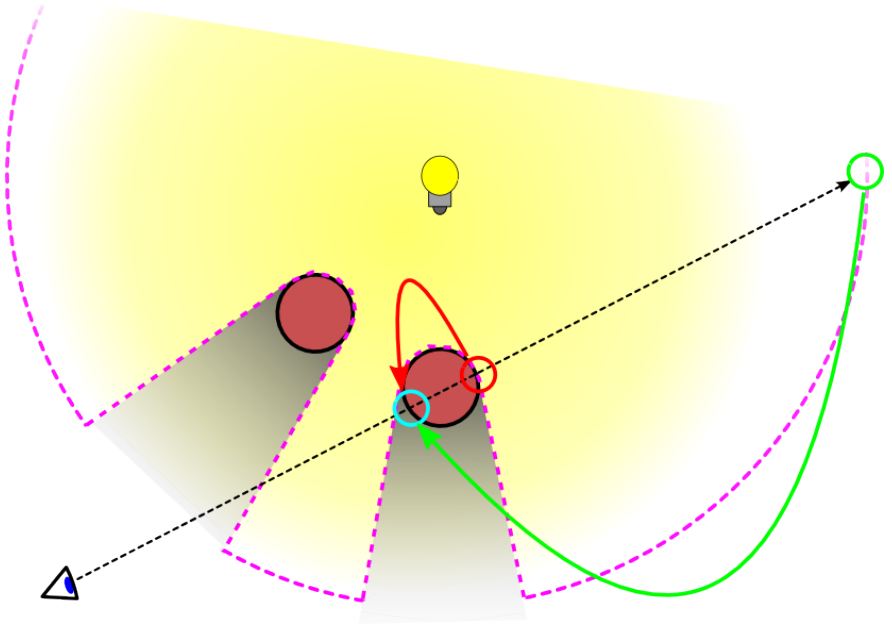


Solution: Clamp Transitions

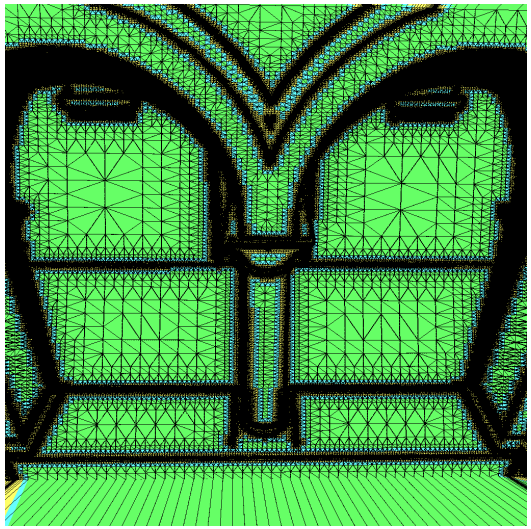
- Don't use Z-culling of volumes
  - clamp to screen-space Z
- Example Figure:
  - Two identical contributions after clamp…
  - ⇒ …will cancel

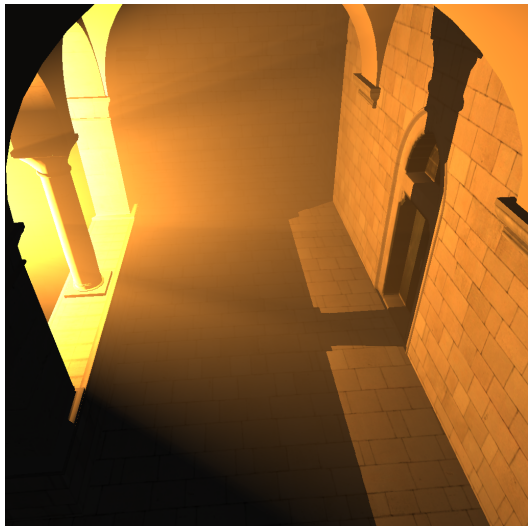
⇒ Airlight behind visible objects will never contribute to the final image.



Adaptive Tessellation

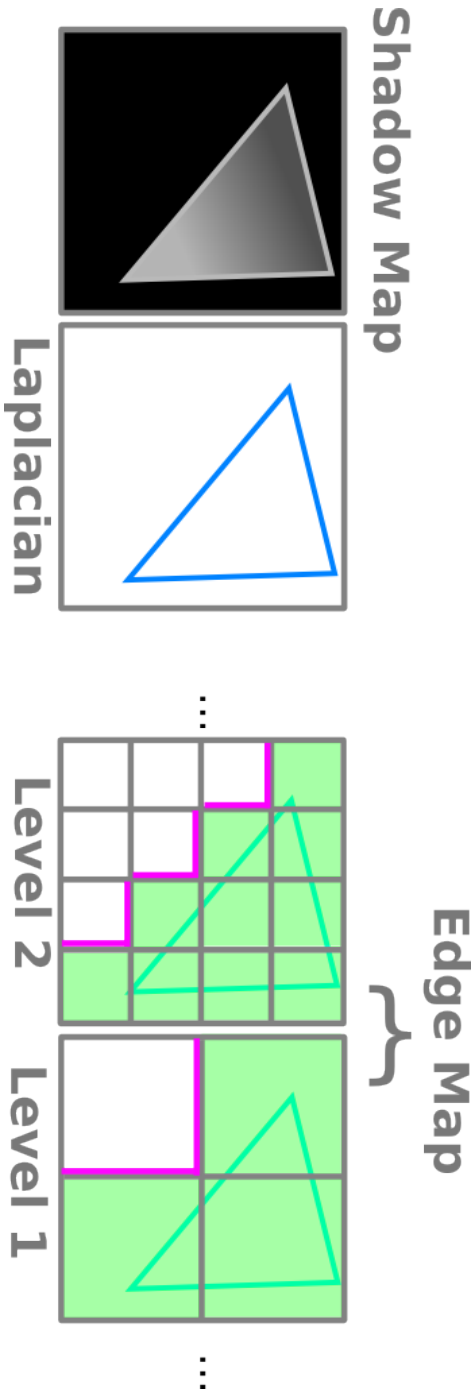
- Light volume: potentially lots of geometry
  - @ 1024^2 : ~2M triangles
  - Use adaptive tessellation to reduce this
- Tessellation performed with
  - Geometry shaders and transform feedback





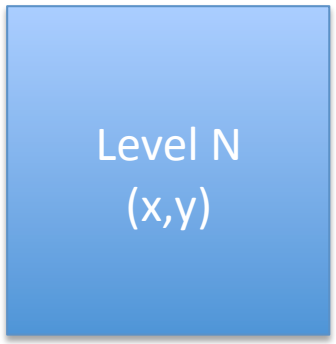
Adaptive Tessellation

- Find edges in shadow map (Laplacian)
- Build edge map
  - Mip-map hierarchy
- Each texel contains:
  - Subdivision required?
  - Stitching (neighborhood) information
- Ensure max 1-level of difference between neighbors



Adaptive Tessellation

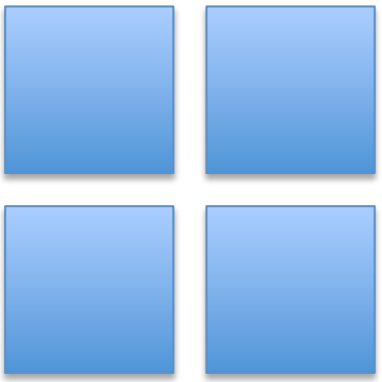
Input:



+ edge map at level N @ (x,y)

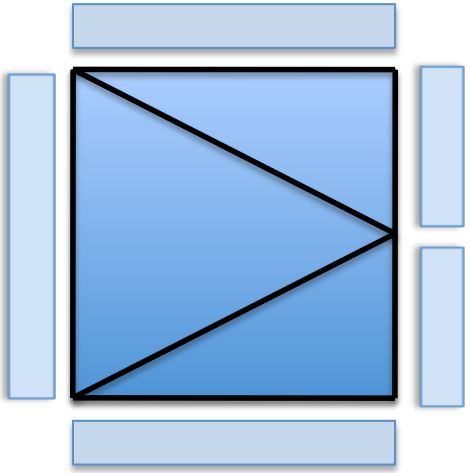
If(subdivide):

- Emit four smaller quads
- Repeat (Level N+1)



Else:

- Check neighbor-information
- Emit triangles



Adaptive Tessellation Performance

- Reduces triangles by
  - Sibenik: at least 50% for 1024^2 shadow maps
    - Average: 30% triangles compared to static tessellation
  - Sponza: at least 60% for 1024^2 shadow maps
    - Average: 30% triangles compared to static tessellation
- Not an exhaustive test

Sponza2 1024^2 SM	Laplacian	0.66ms
	Edge Map	0.68ms
	Tessellate	3.11ms
	Render	7.51ms
Static Tessellation:		*9.0ms*
Sponza2 4096^2 SM	Laplacian	10.11ms
	Edge Map	9.14ms
	Tessellate	4.13ms
	Render	17.75ms
Static Tessellation:		*93.9ms*

- NVIDIA GTX280
- Same as paper!

Demo / Movie

- Recorded on a NVIDIA GTX 480
  - Resolution is 1024x768 in all clips
  - Performance figures on next slide!

Scene: Sponza2

- 5 light sources
- 512^2 shadow map
- 100 FPS on average

Demo / Movie

- Recorded on a NVIDIA GTX 480
  - Resolution is 1024x768 in all clips
  - Performance figures on next slide!
- Live Demo session
  - On this notebook (9400M)

Results - Performance

	Shadow Maps	Adaptive Tessellation	Draw Volumes	Render Scene	TOTAL
Sponza2 5x 512^2	5.2ms	-	1.3ms	1.0ms	9.7ms
Sibenik 2x 1024^2	0.9ms	-	3.9ms	1.9ms	9.4ms
HPG 1x 1024^2	0.2ms	0.6ms	0.3ms	0.2ms	3.3ms

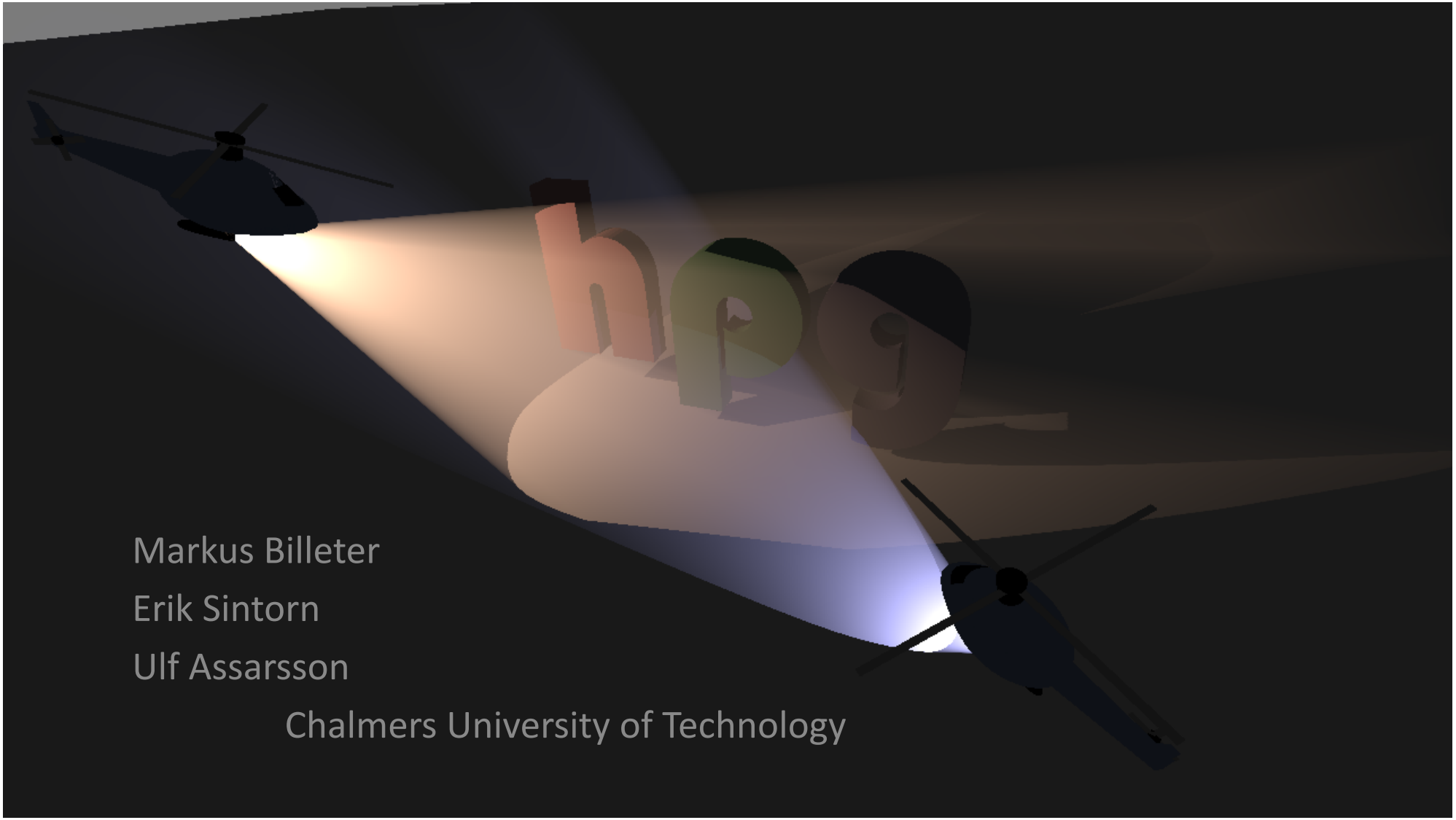
- NVIDIA GTX480
- View resolution: 1024x768
- Constant overhead: around 2ms
  - Information, post-processing, composition

Conclusions

- Only uses information from the shadow and depth map
  - Handles alpha masks, etc
  - Easy to add to existing programs (additional pass)
  - Shadow map size can be scaled
- However: does not handle textured lights
  - And only homogenous media

  ⇒Better solutions to the Single Scattering Integral?

Thank You for Your Attention!



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