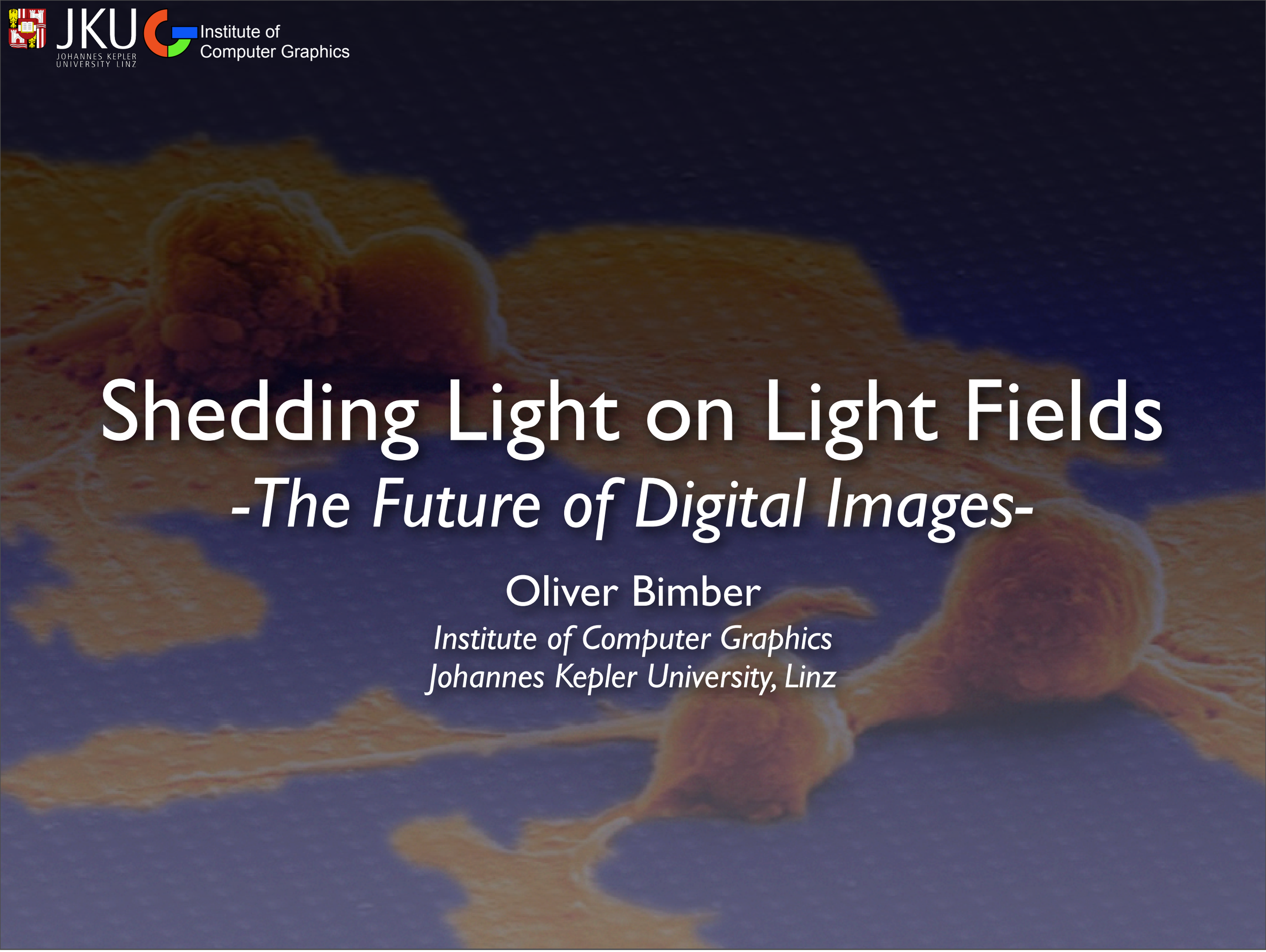

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Institute of Computer Graphics

Shedding Light on Light Fields

-The Future of Digital Images-

Oliver Bimber

Institute of Computer Graphics

Johannes Kepler University, Linz

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The Future of Digital Images

Visual Computing:
Computer Graphics, Computer Vision, Image Processing, Visualization

The Future of Digital Images

Imaging

Visual Computing:
Computer Graphics, Computer Vision, Image Processing, Visualization

Display

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The Future of Digital Images

Imaging

Analog
2D

Visual Computing:
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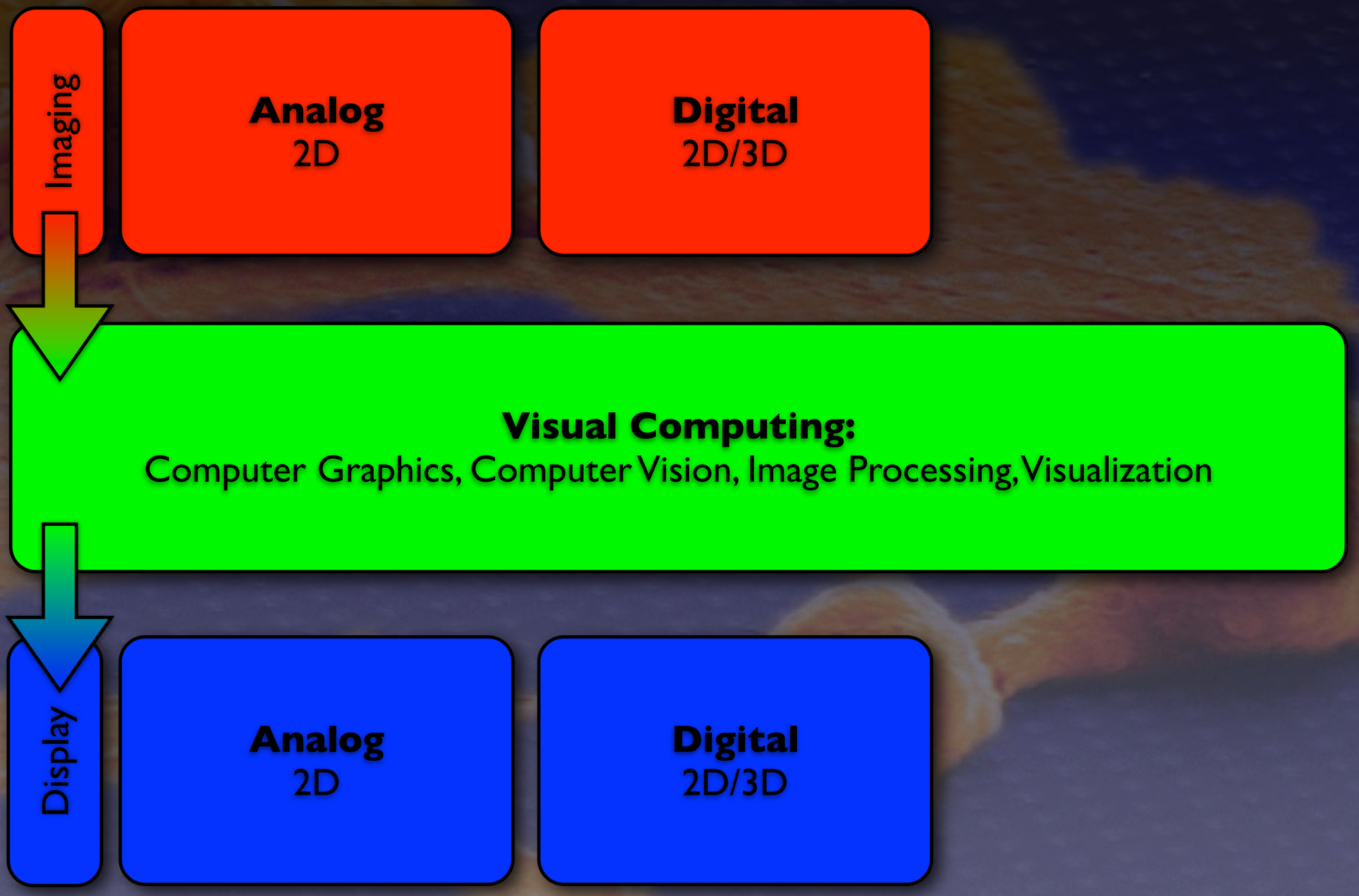
Display

Analog
2D

The Future of Digital Images



The Future of Digital Images

Imaging

Analog
2D

Digital
2D/3D

Computational
4D

Visual Computing:
Computer Graphics, Computer Vision, Image Processing, Visualization

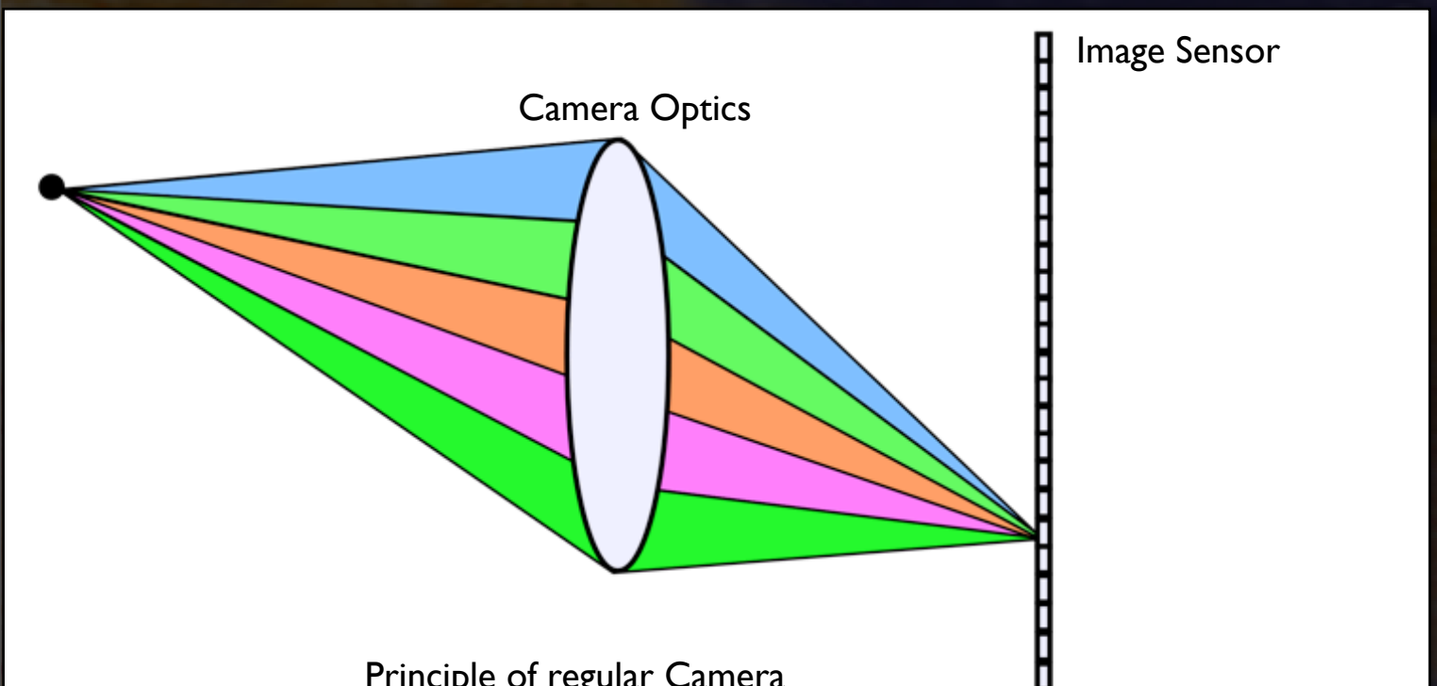
Display

Analog
2D

Digital
2D/3D

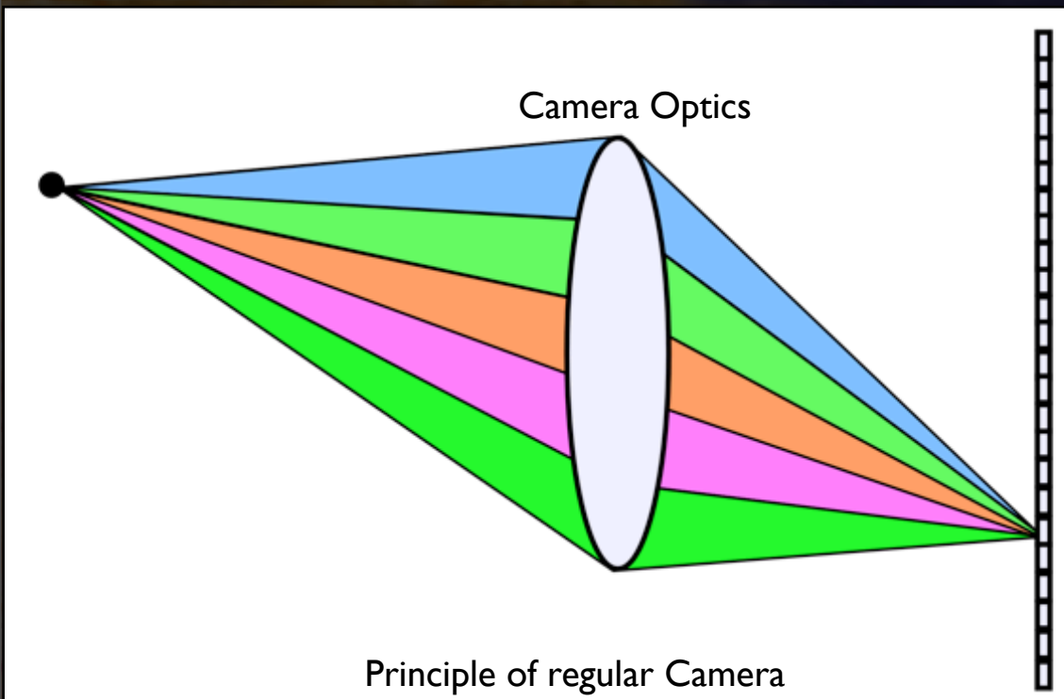
Computational
4D

What does a Camera capture?



Principle of regular Camera

What does a Camera capture?



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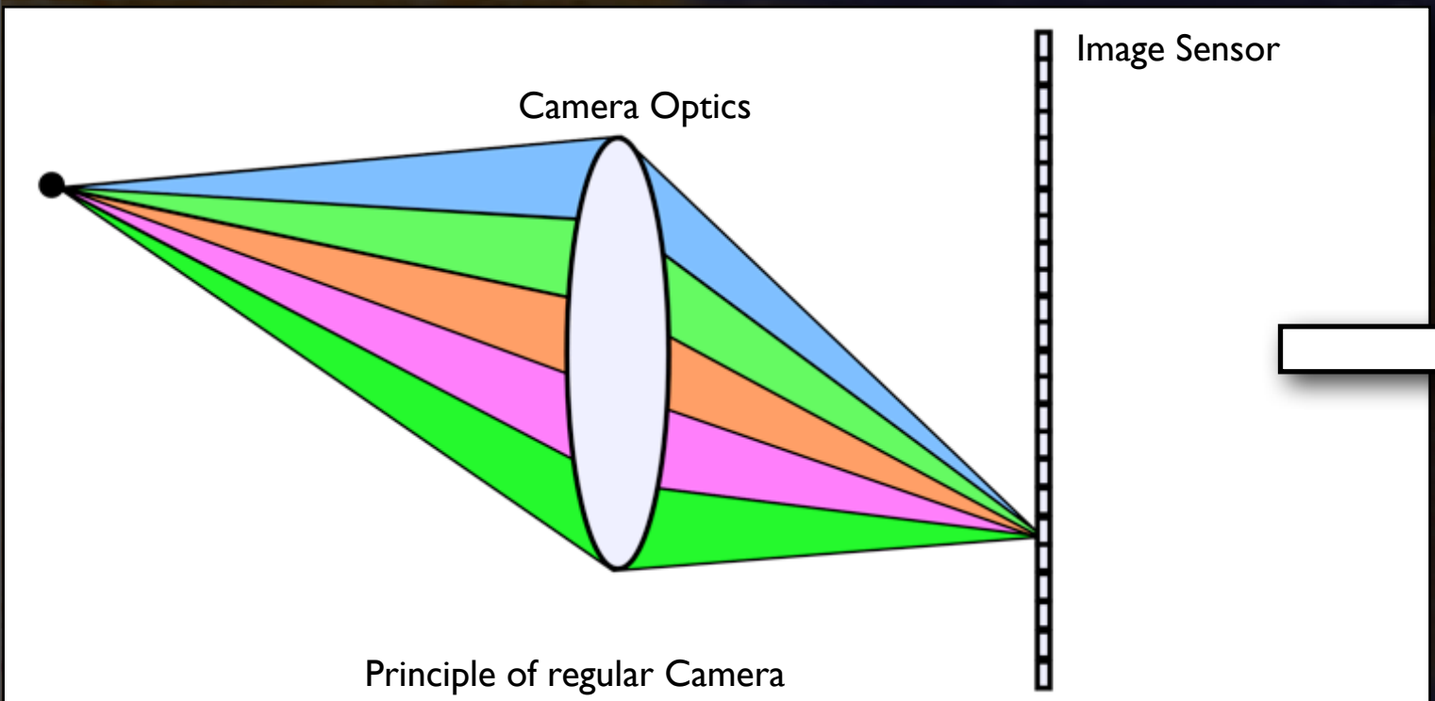
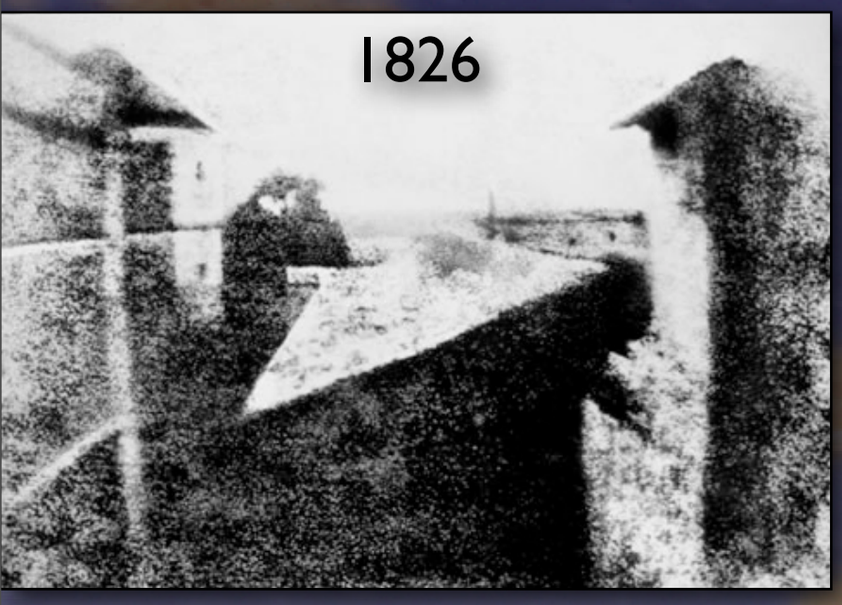


Principle of regular Camera



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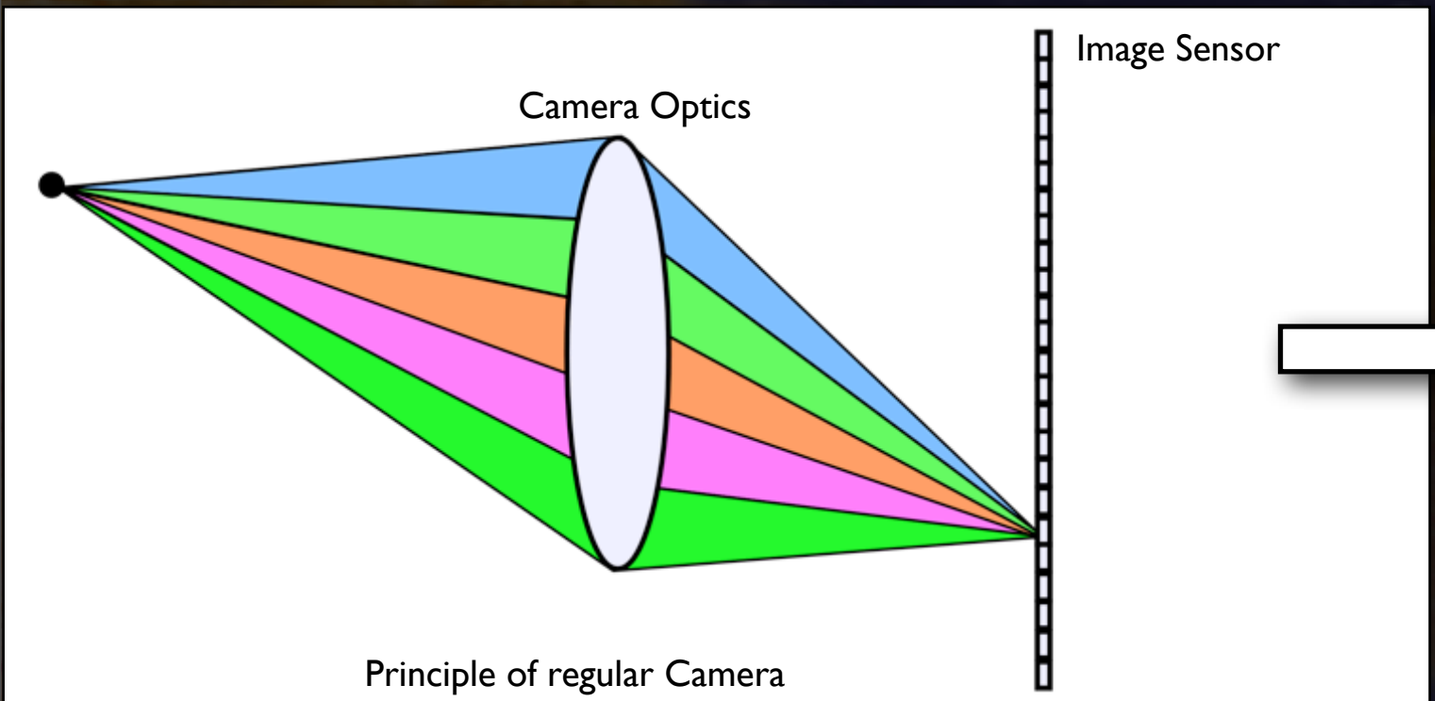

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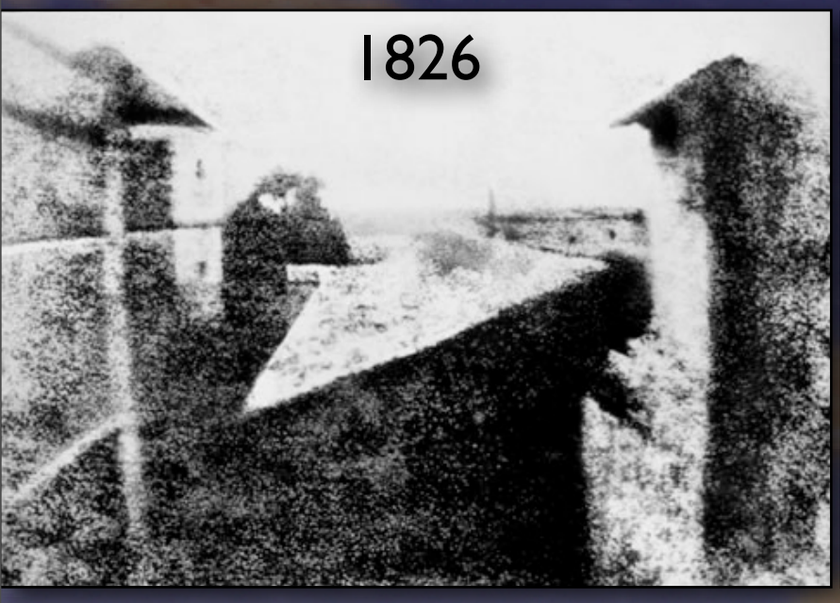

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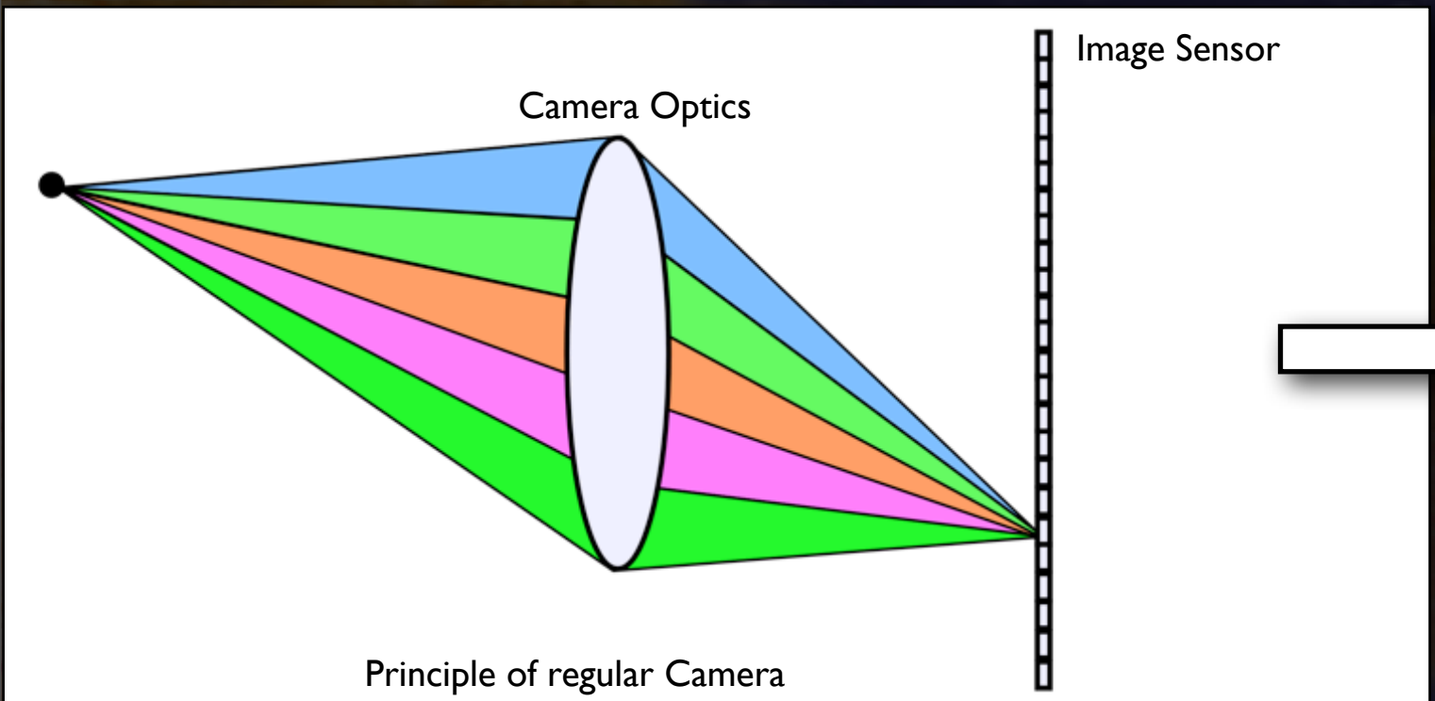

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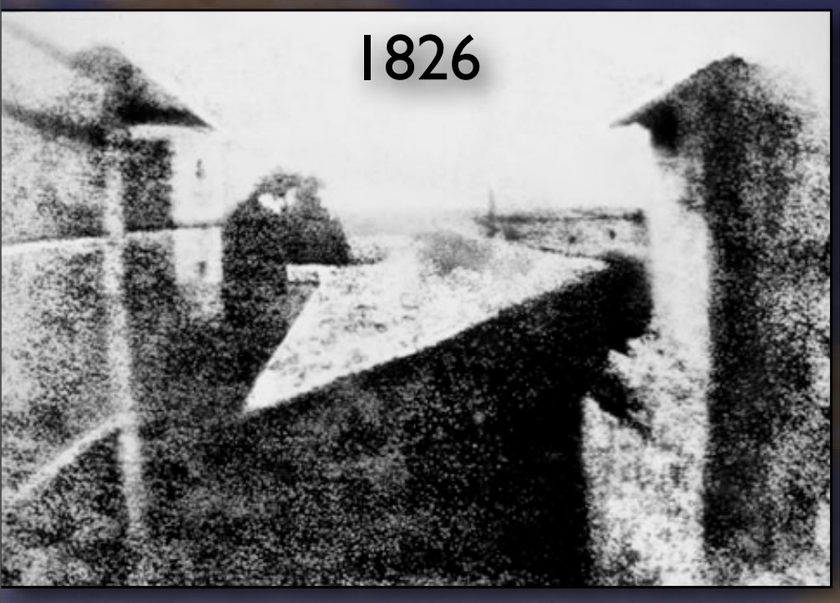

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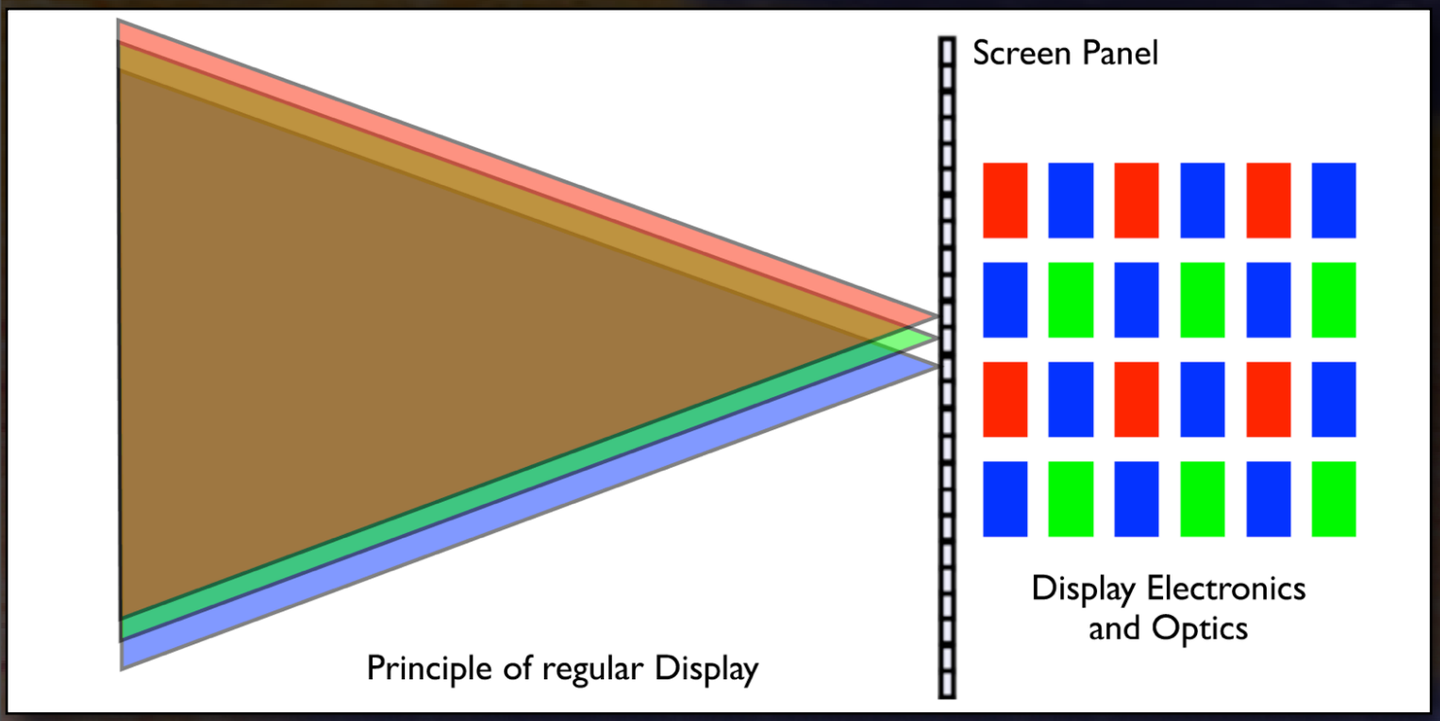

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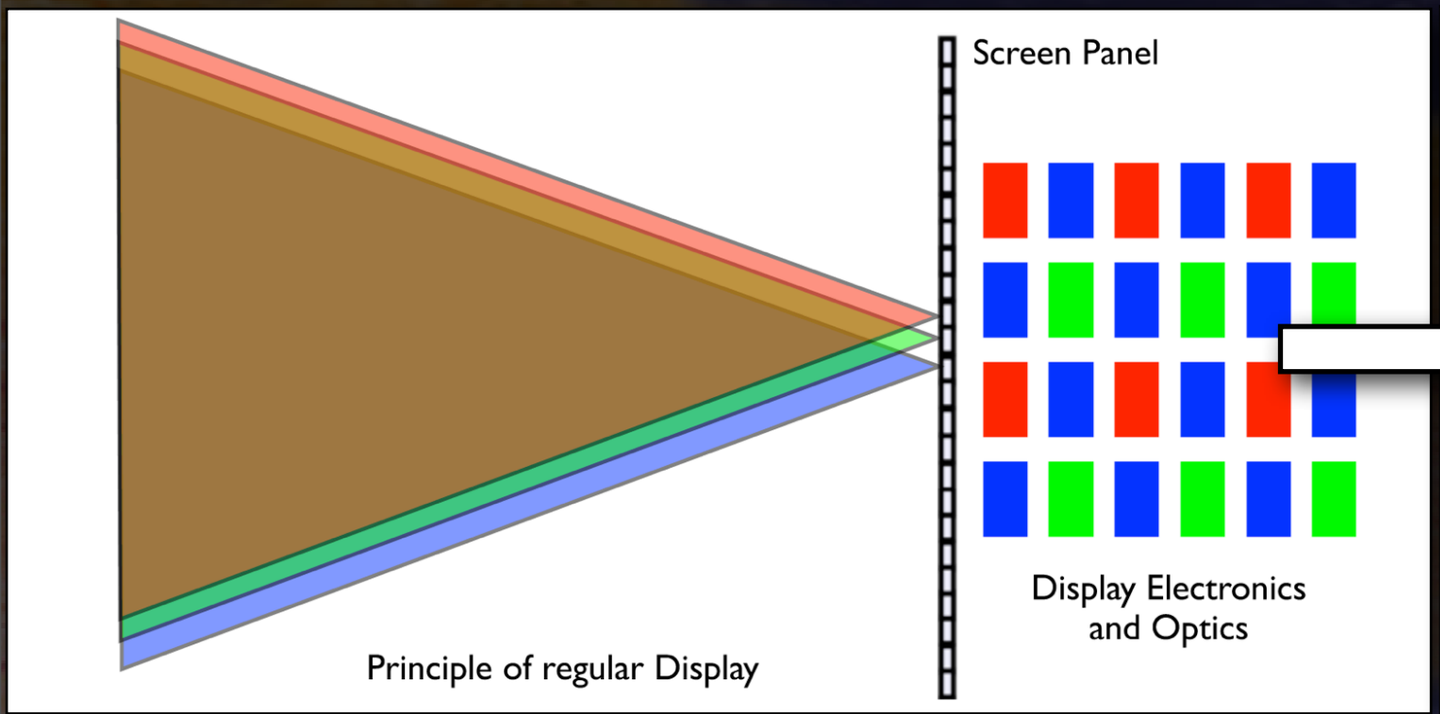

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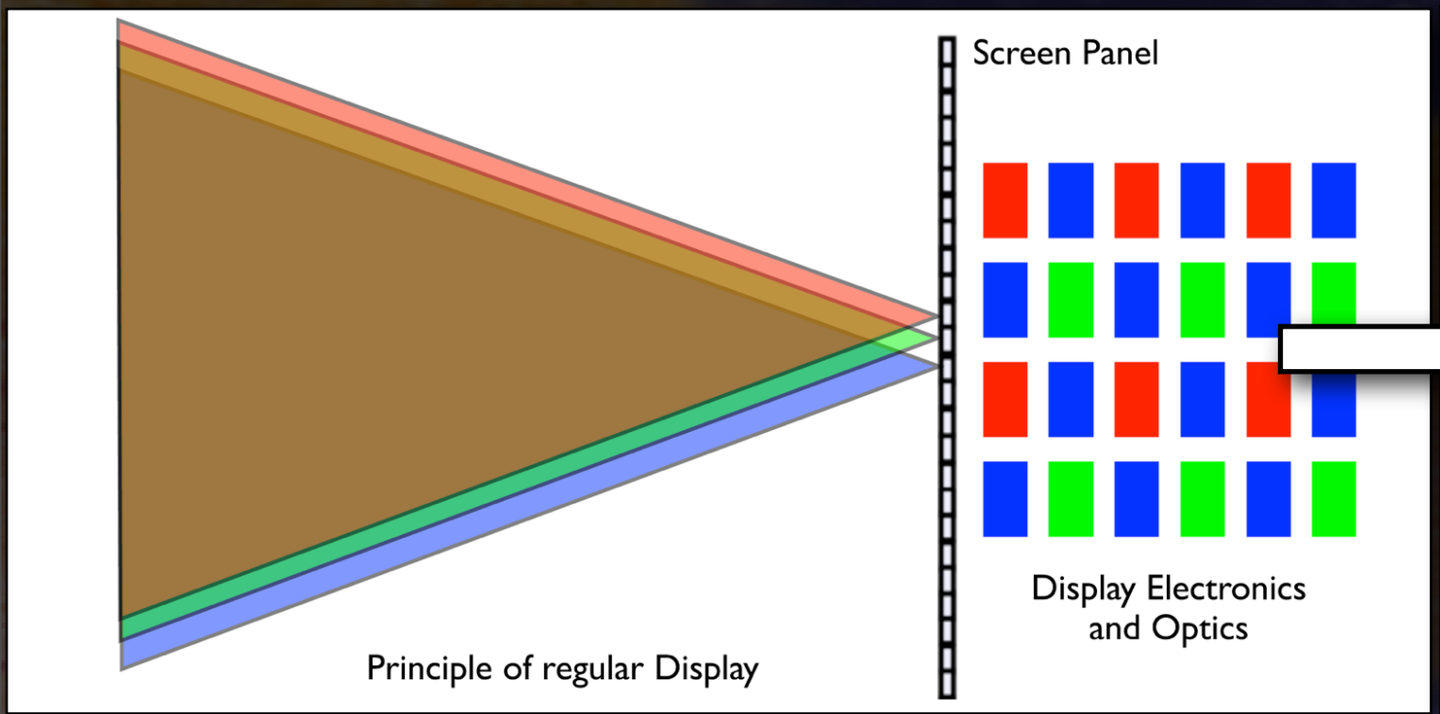

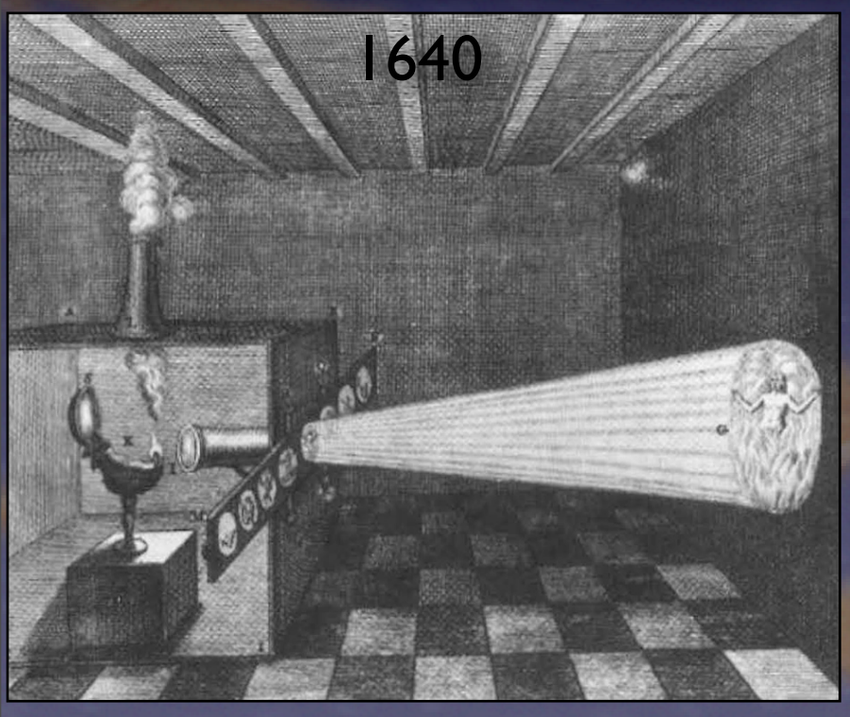

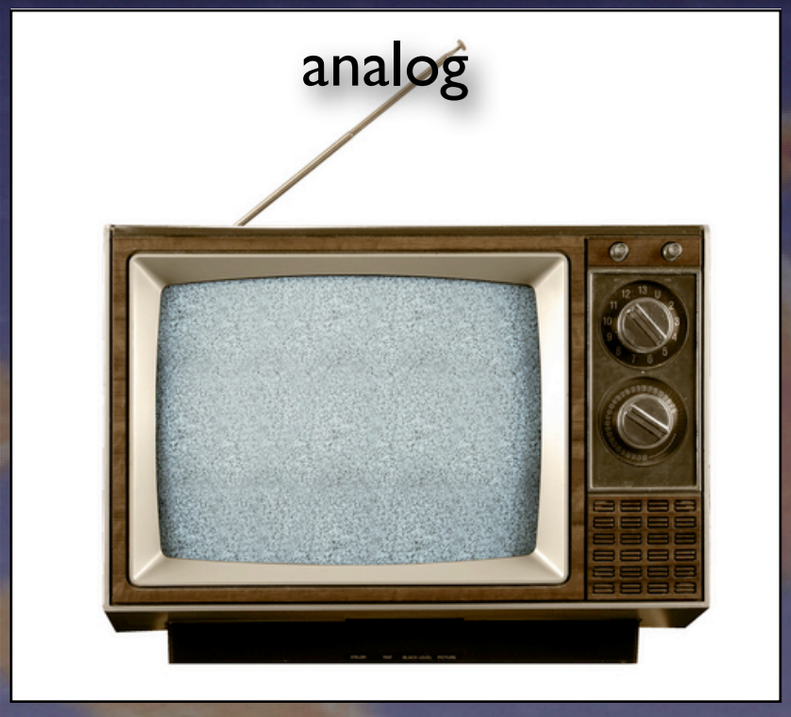

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What we want to capture and display!

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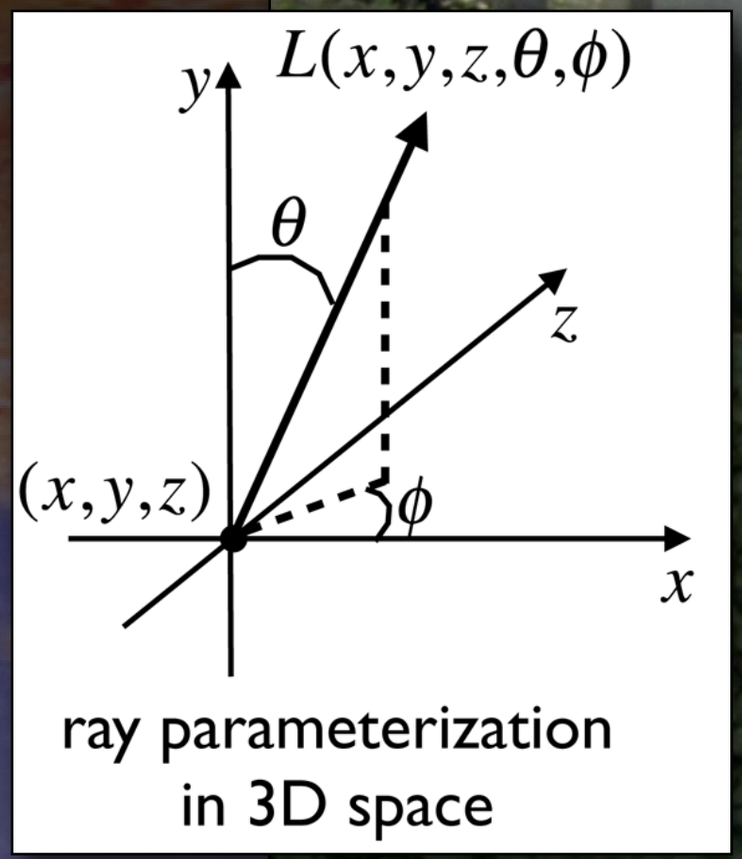

ray parameterization
in 3D space

What are Light Fields?

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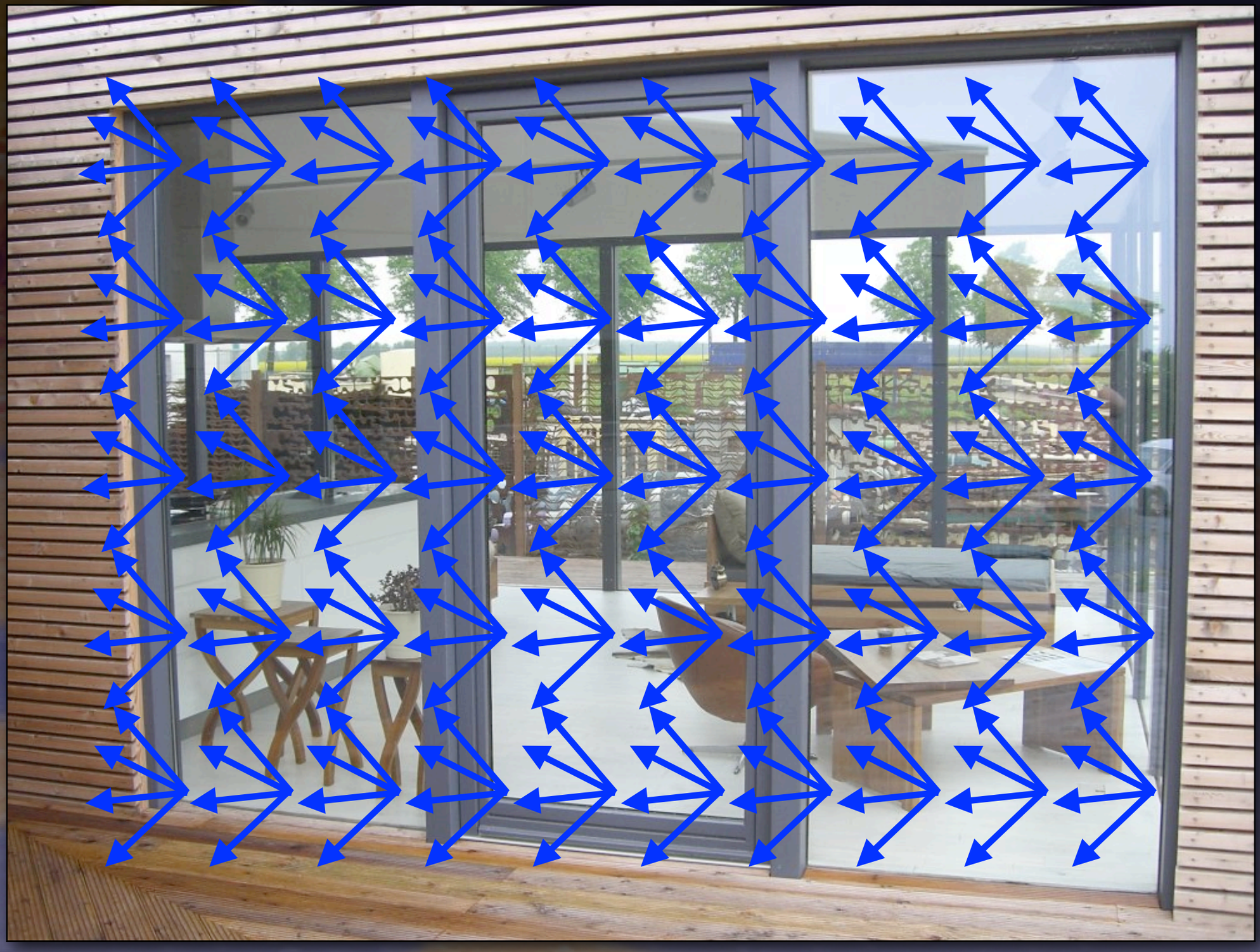
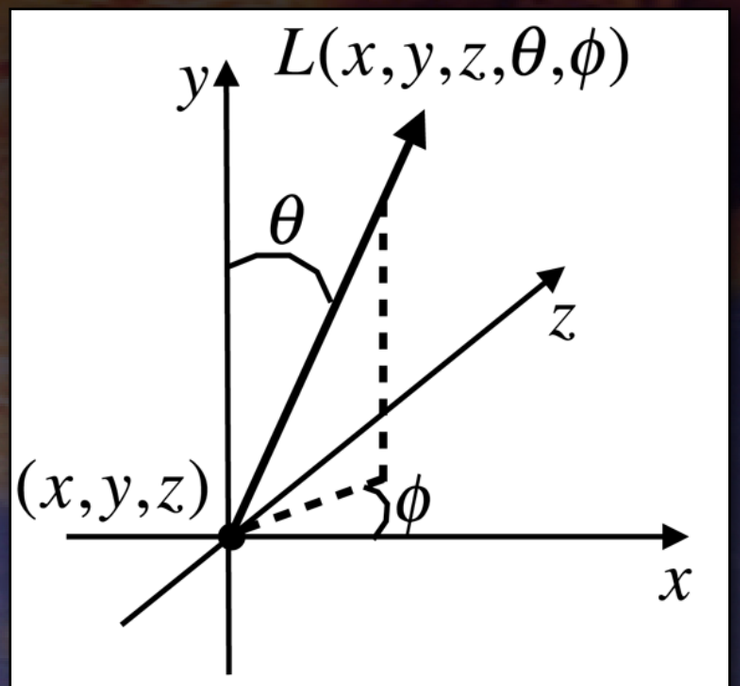
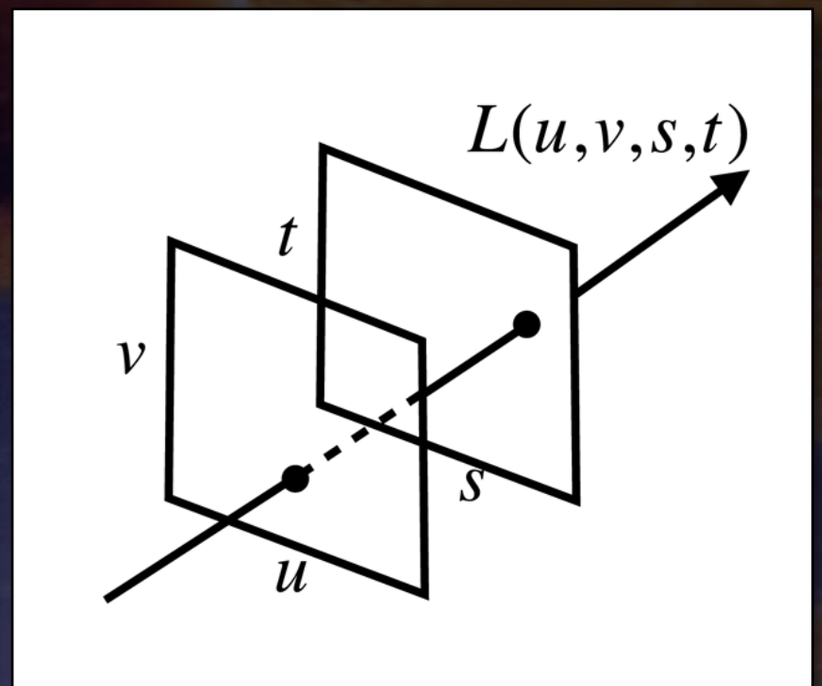


Ray Parameterization

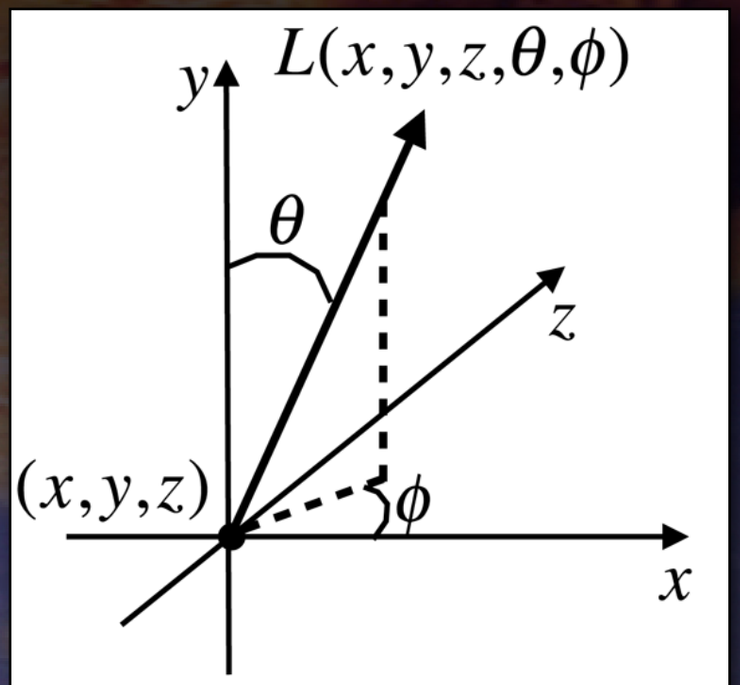


ray parameterization in 3D space

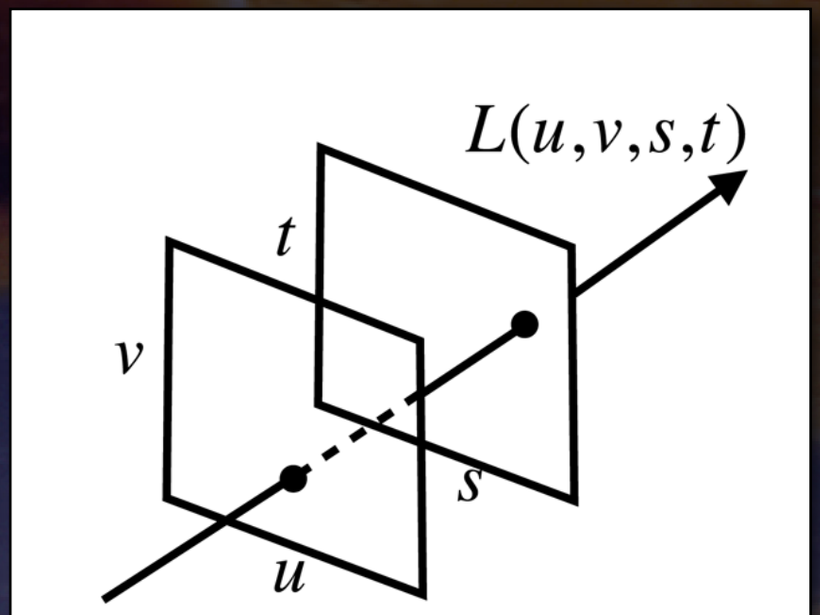


two-plane parameterization of light field

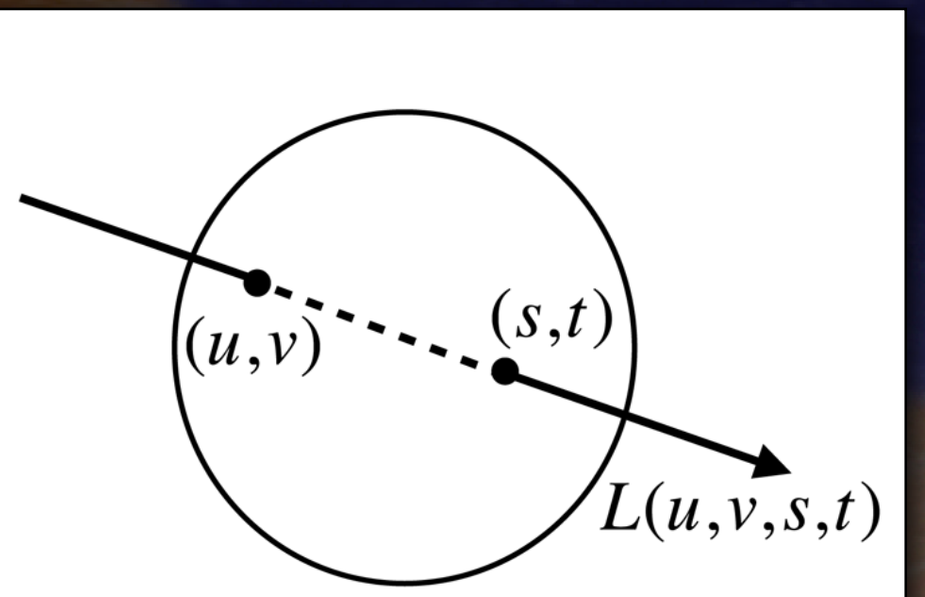
Ray Parameterization



ray parameterization in 3D space

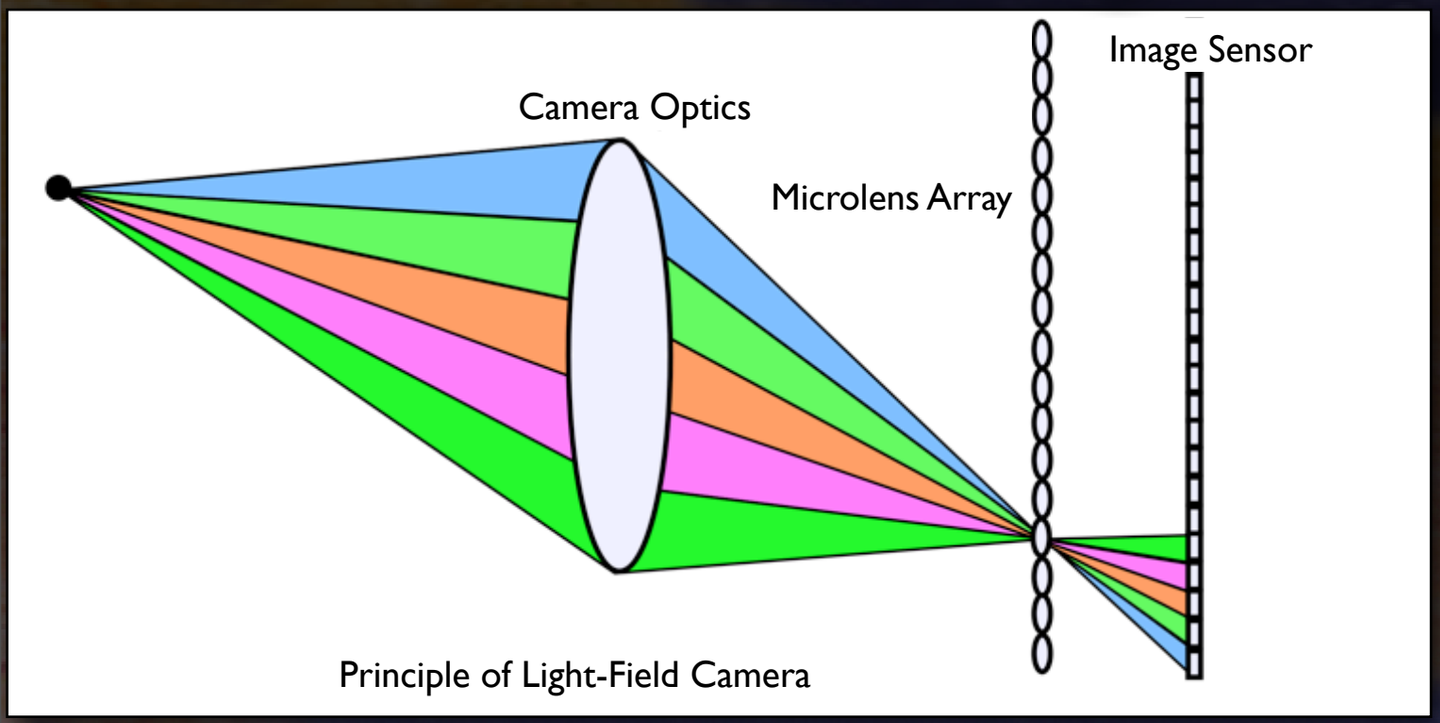


two-plane parameterization of light field



spherical light field parameterization

What are Light-Field Cameras?



Principle of Light-Field Camera

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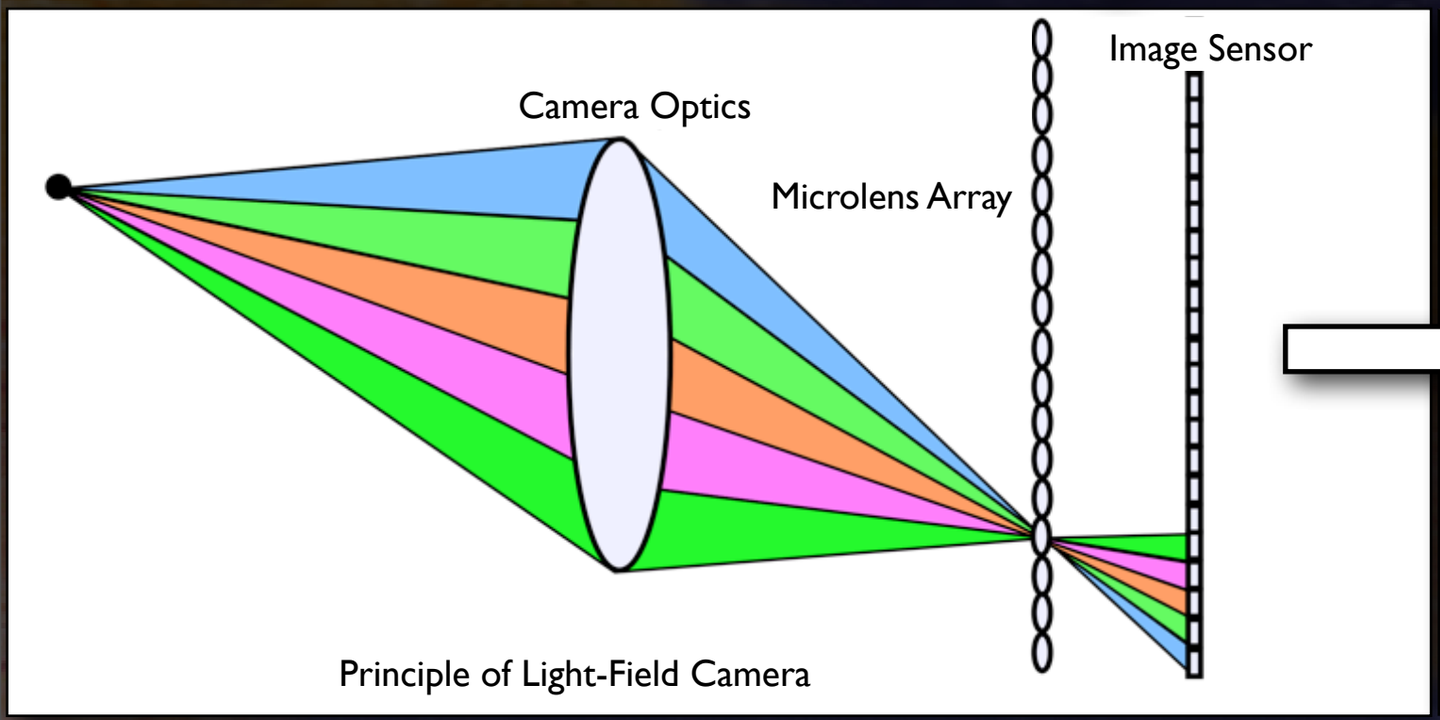

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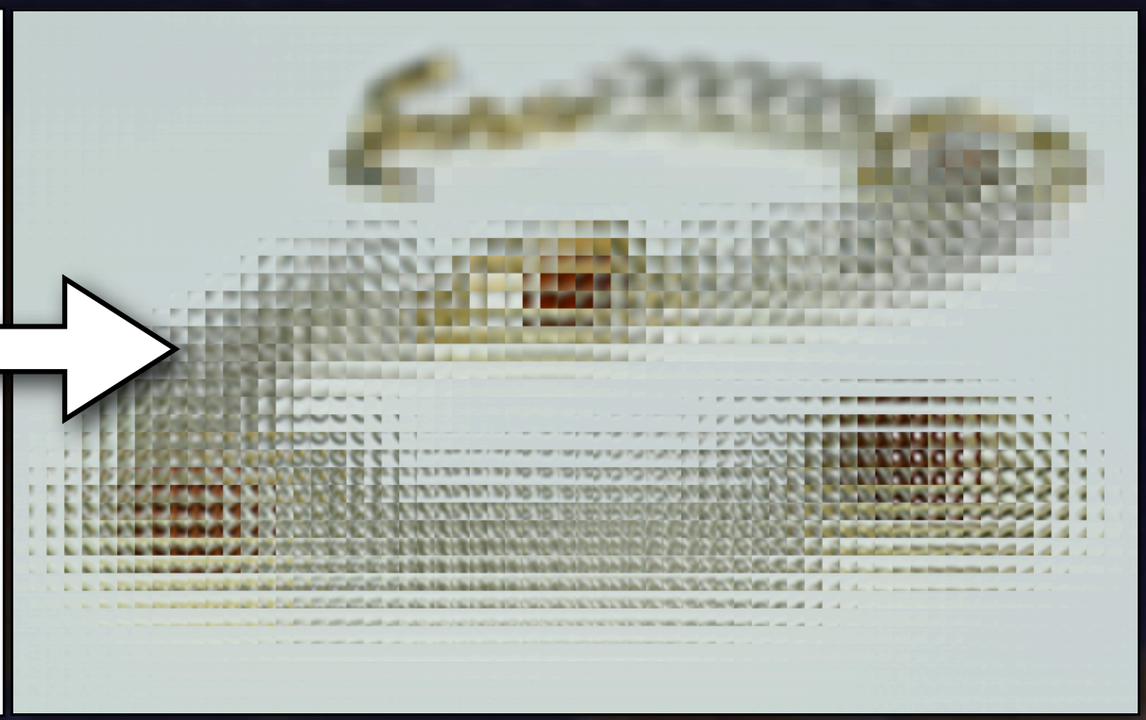

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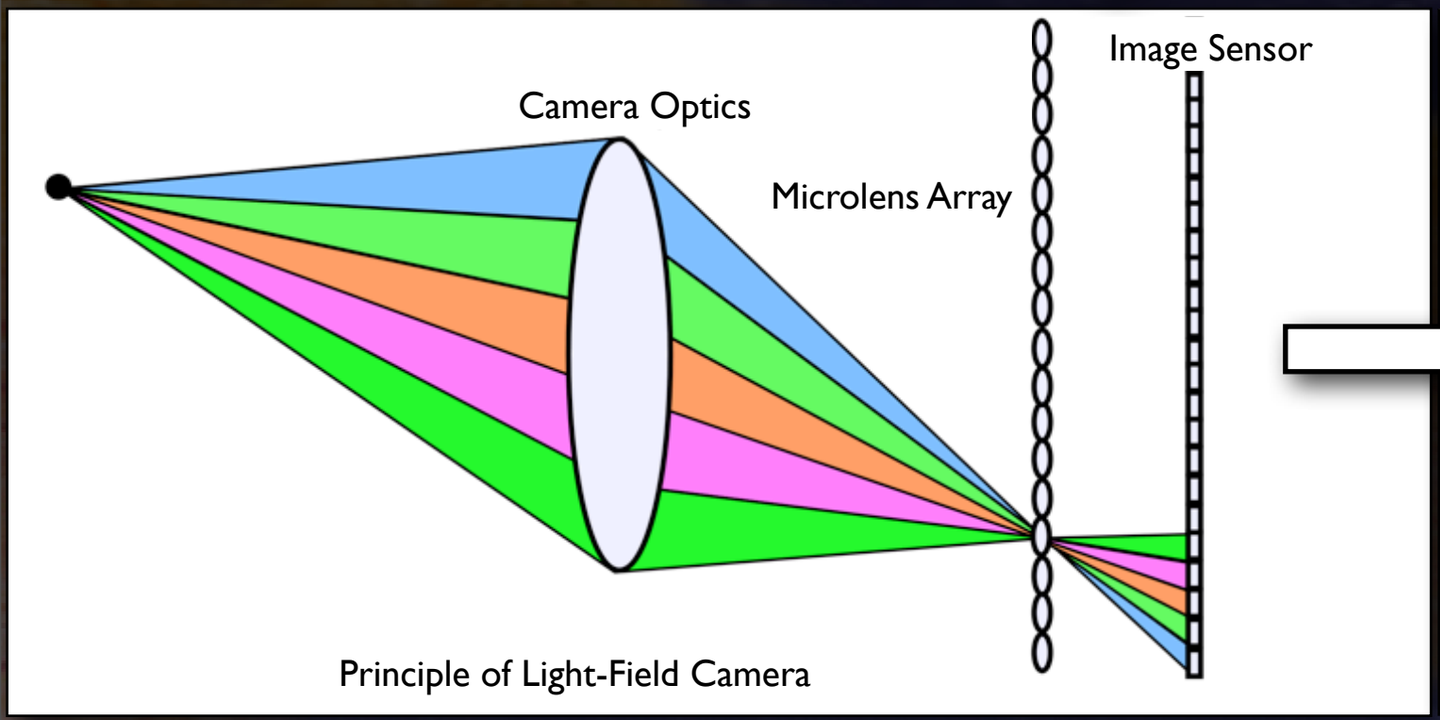

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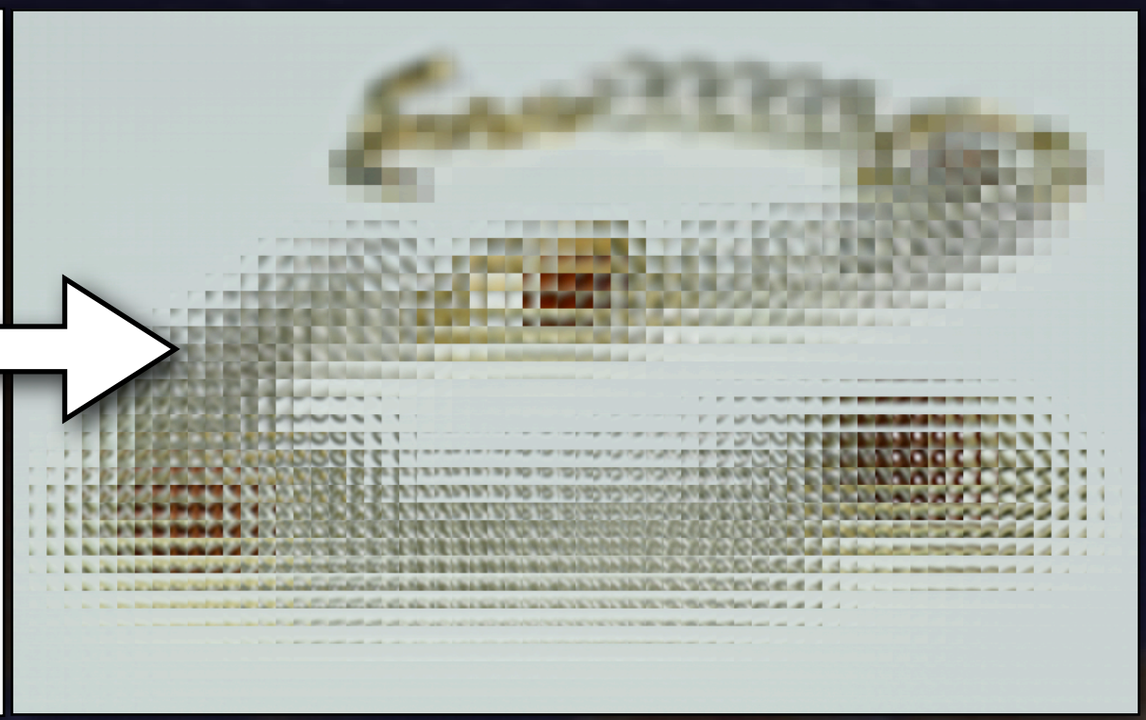

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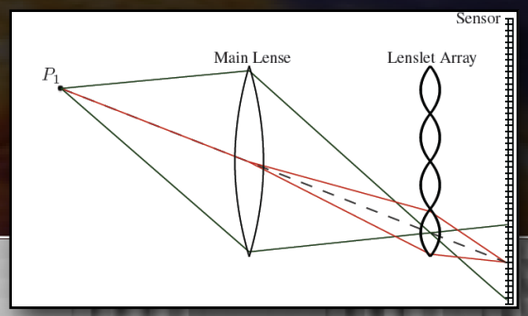

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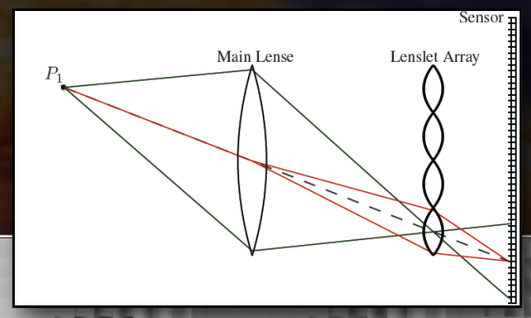

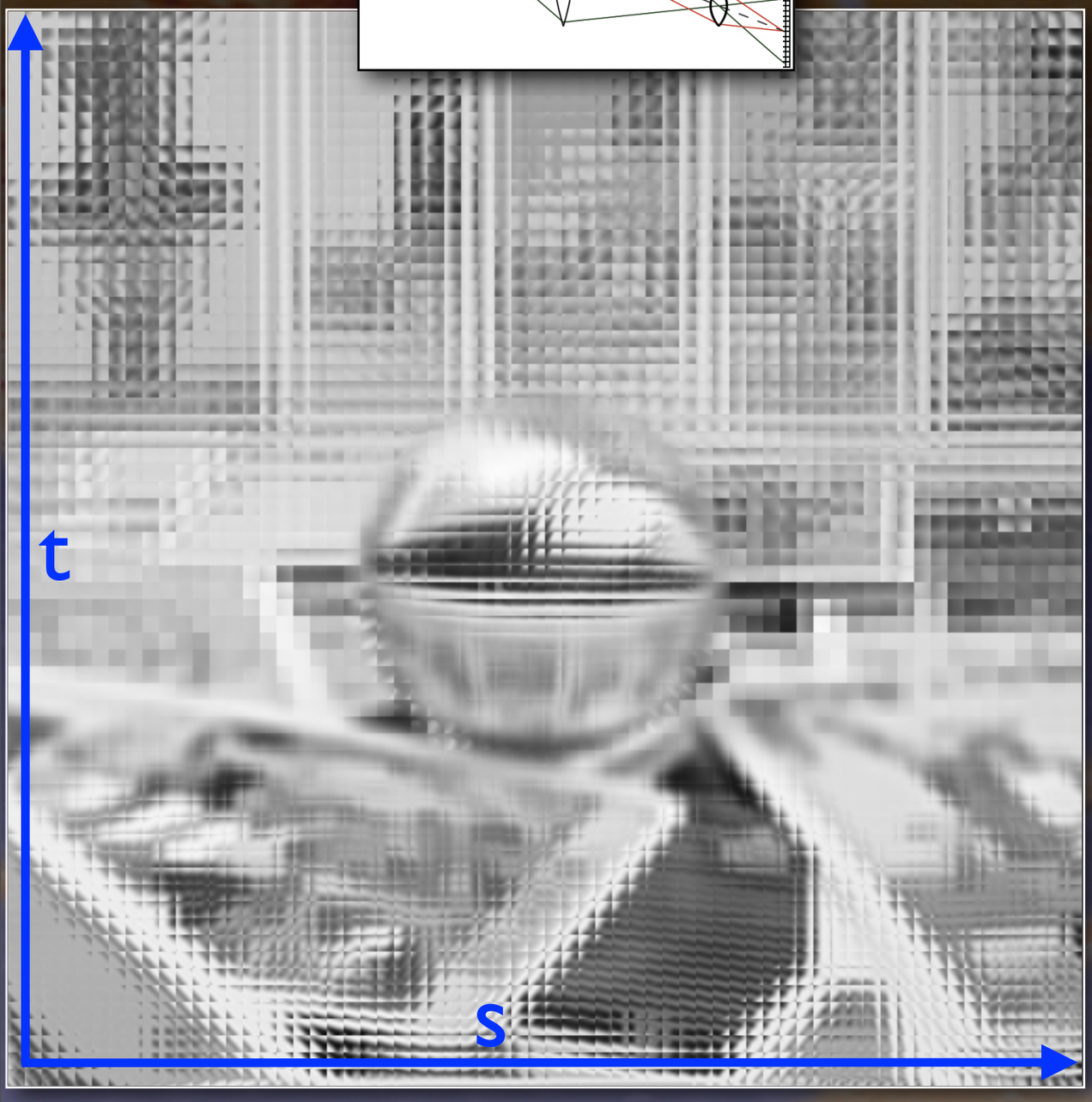

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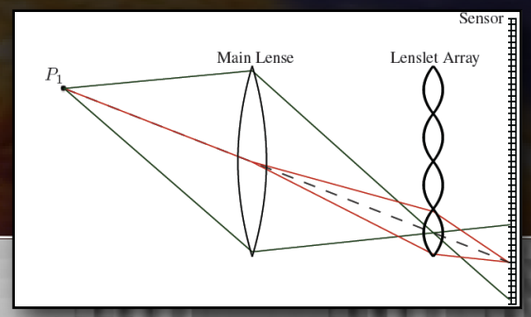

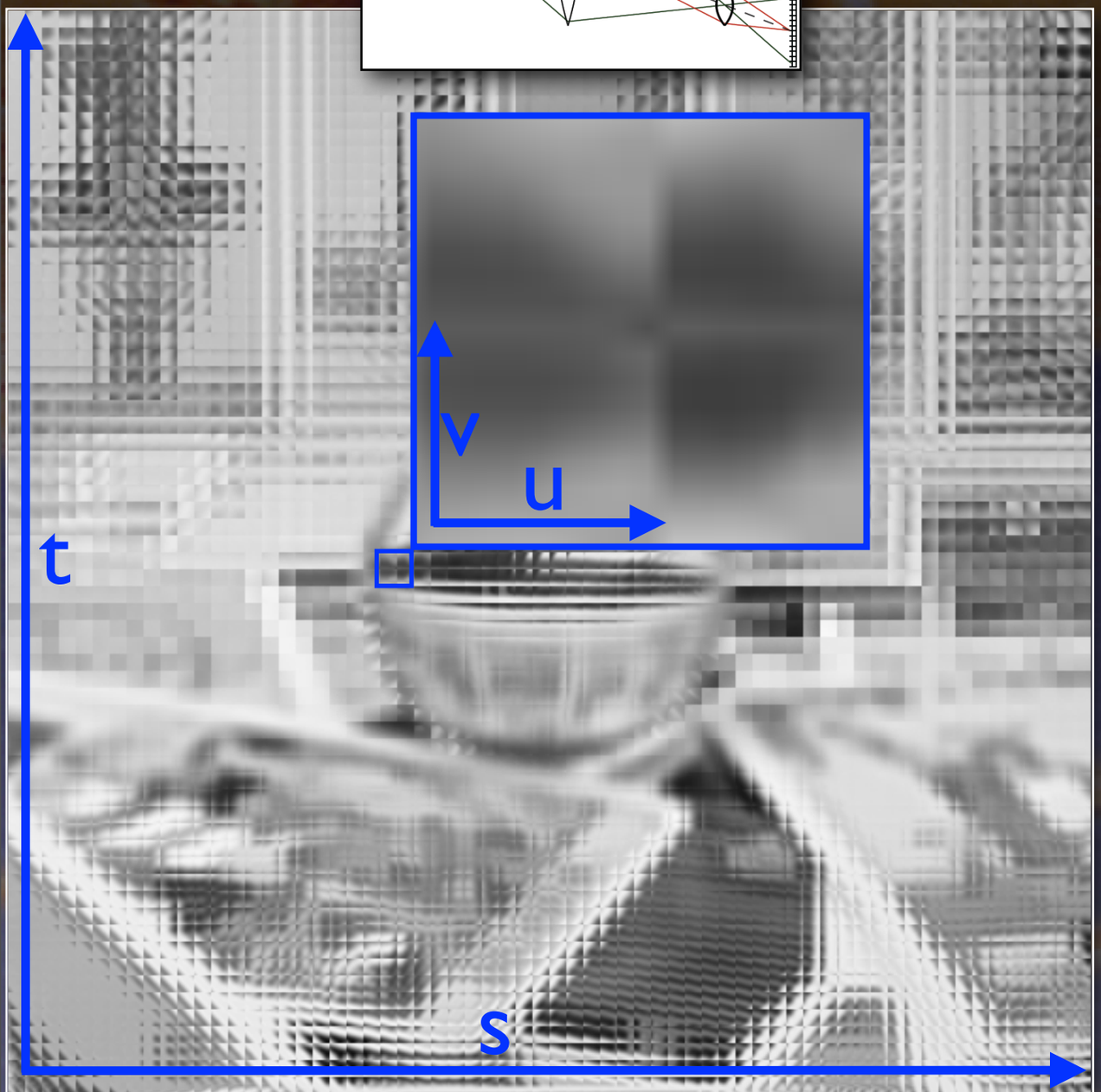

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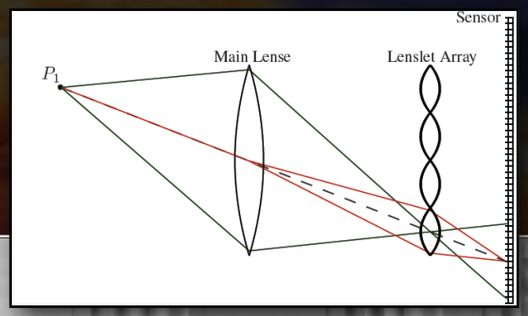

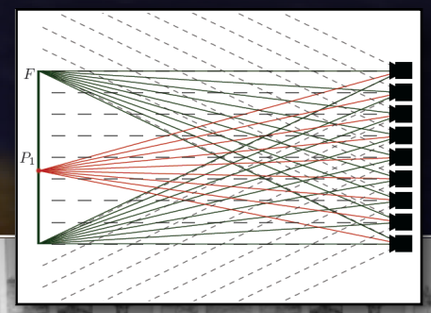

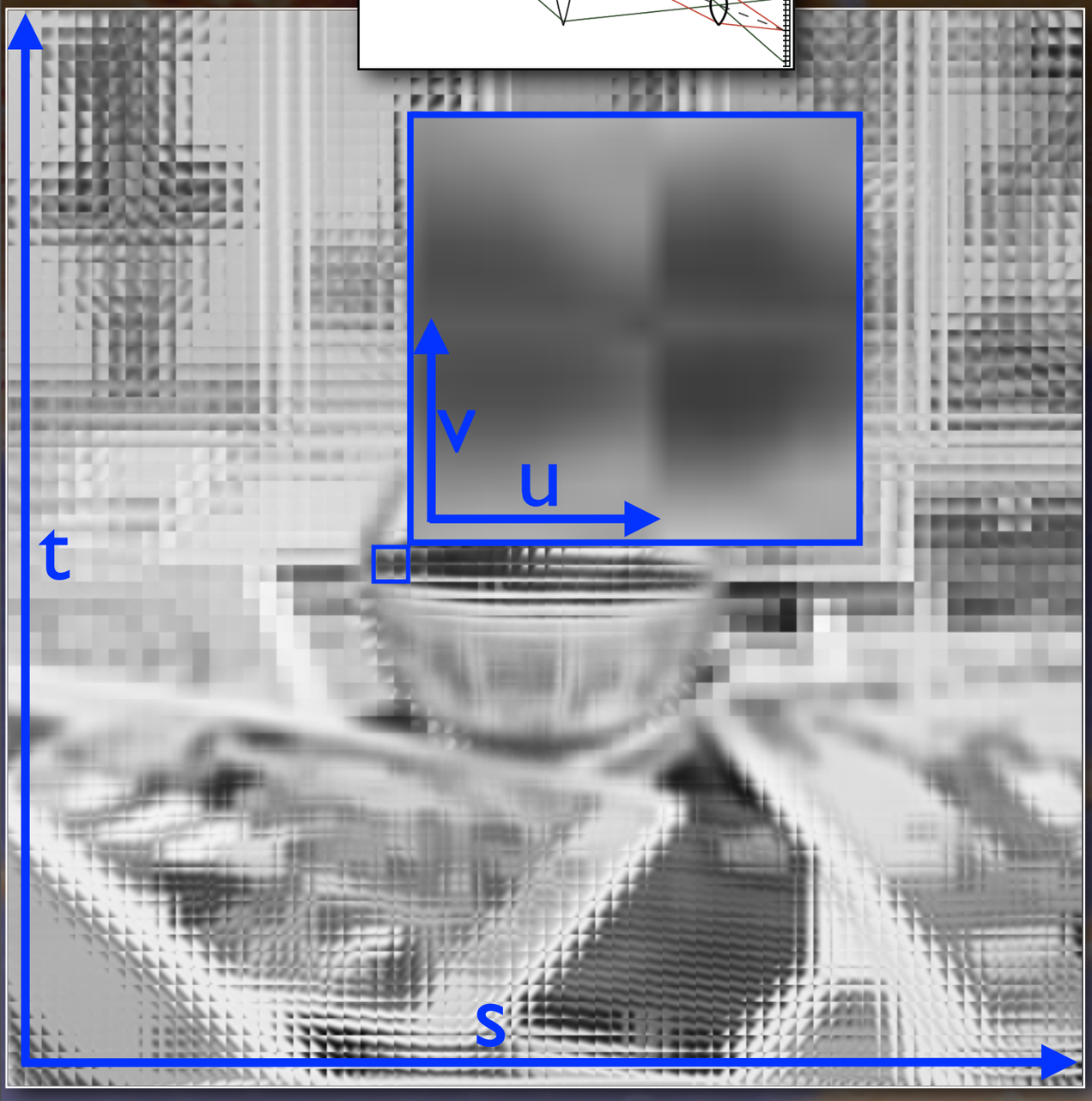

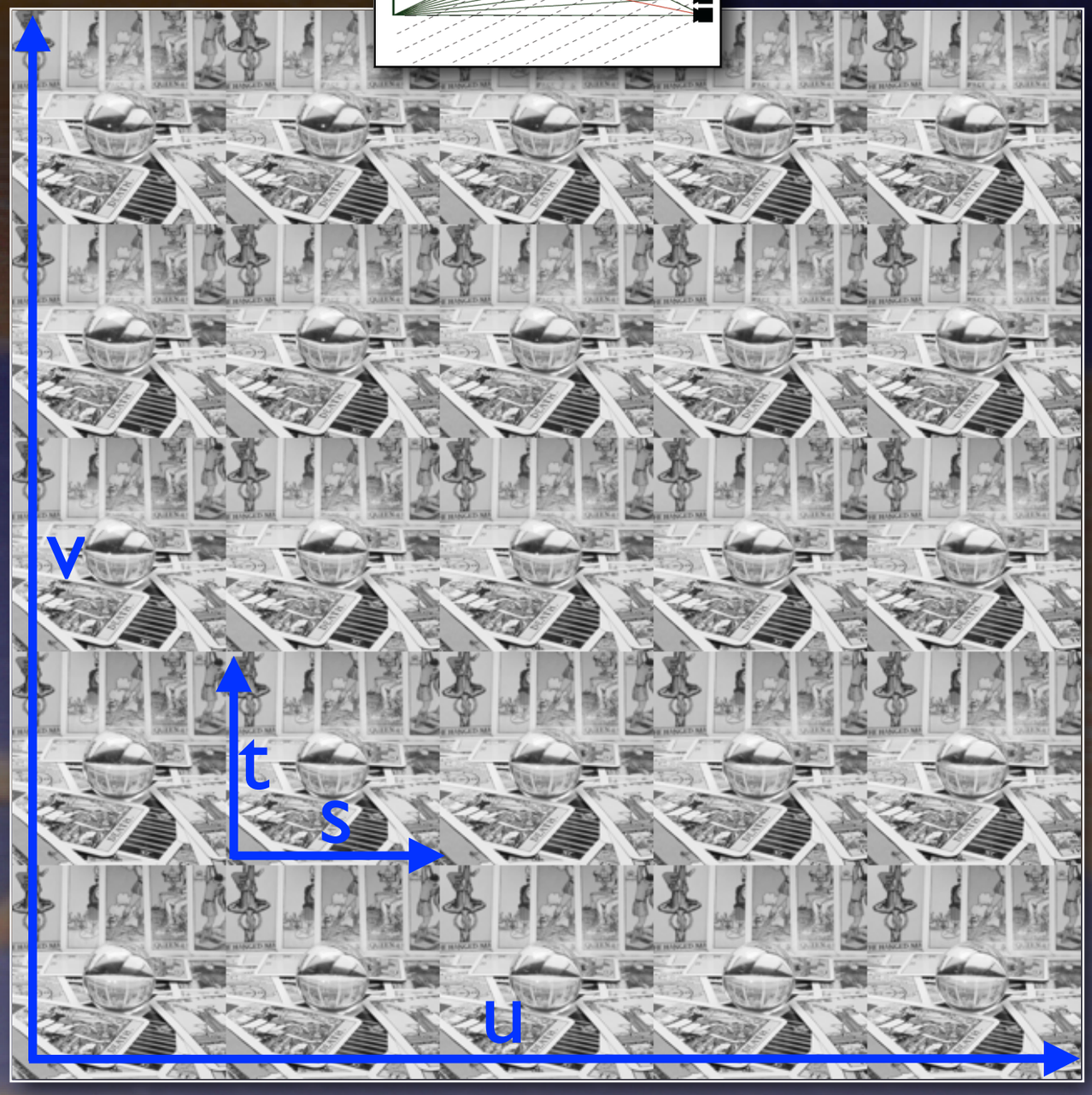

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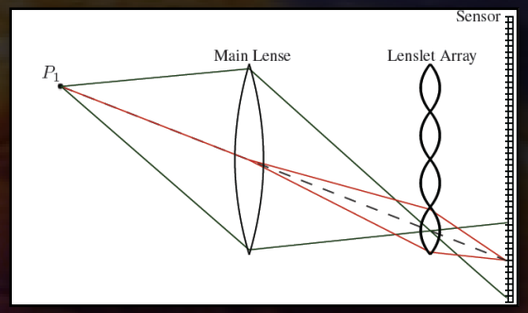
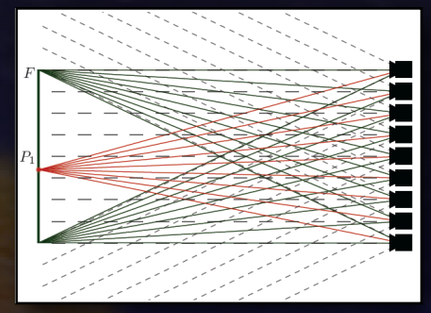
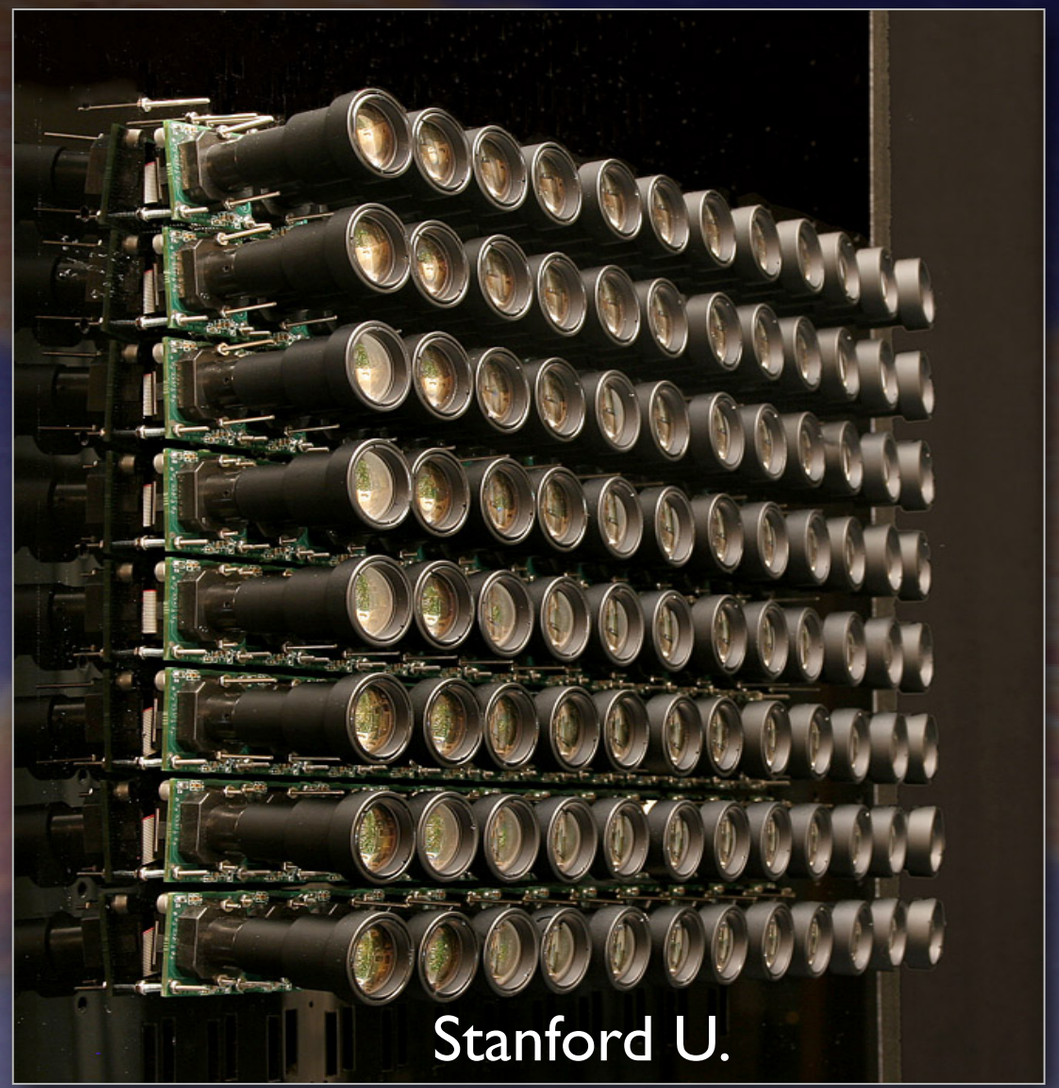




Lytro



Stanford U.

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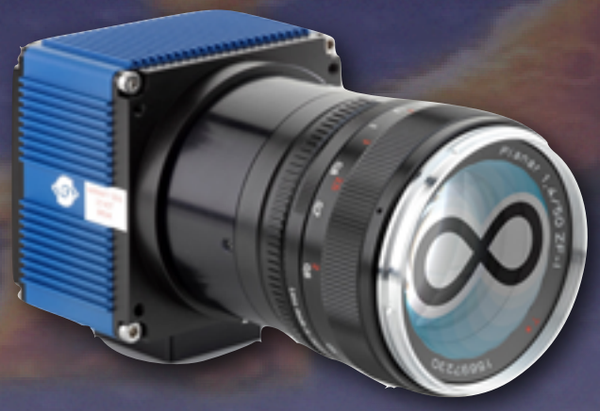
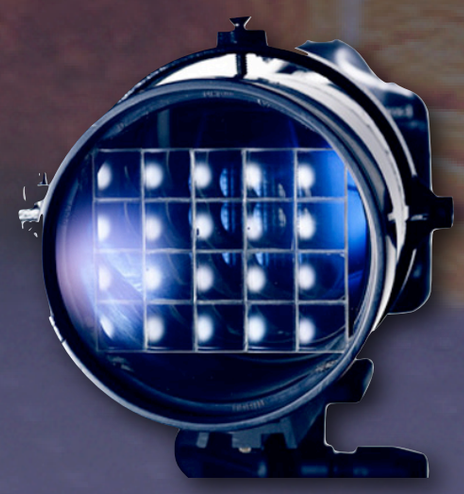
Lytro



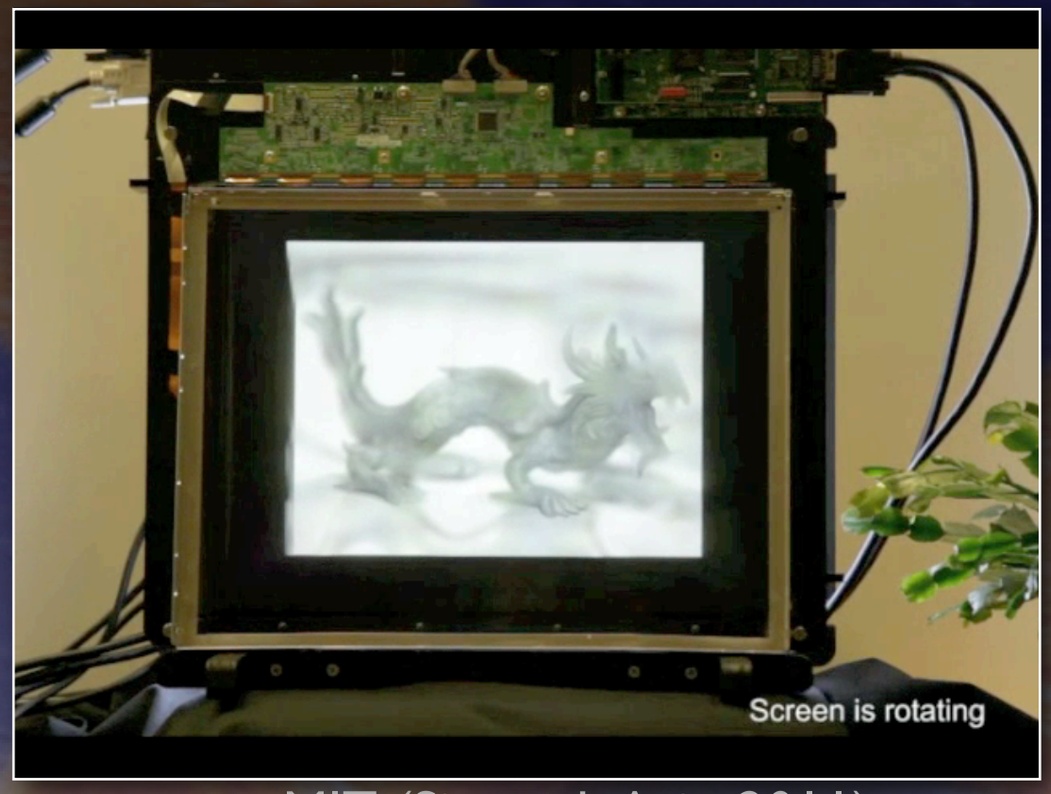
Raytrix



Adobe

From Light Fields to Images ...

Why?



MIT (Siggraph Asia, 2011)

Light-field displays are not yet beyond a basic research level!

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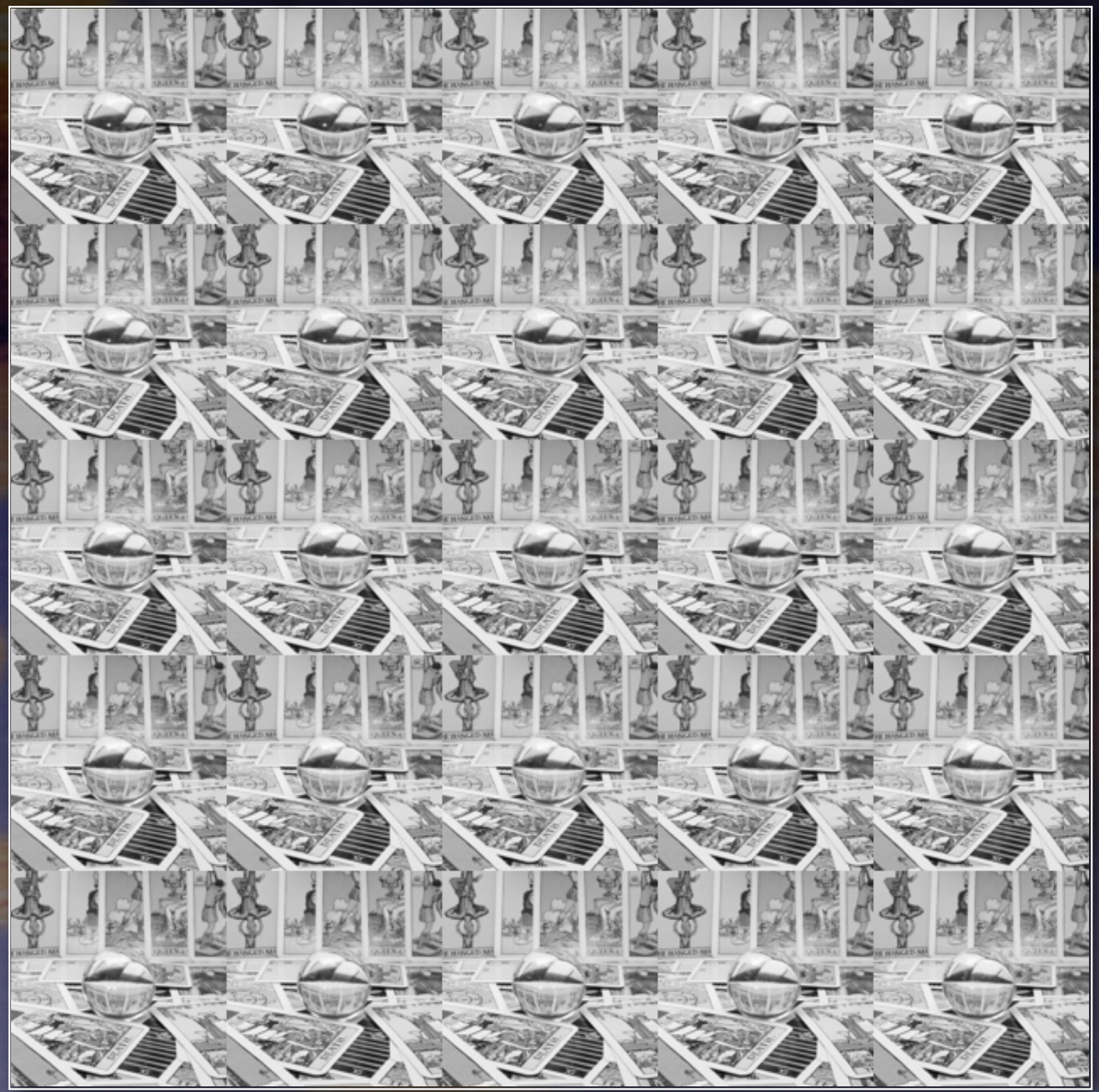
Synthetic Aperture Reconstruction



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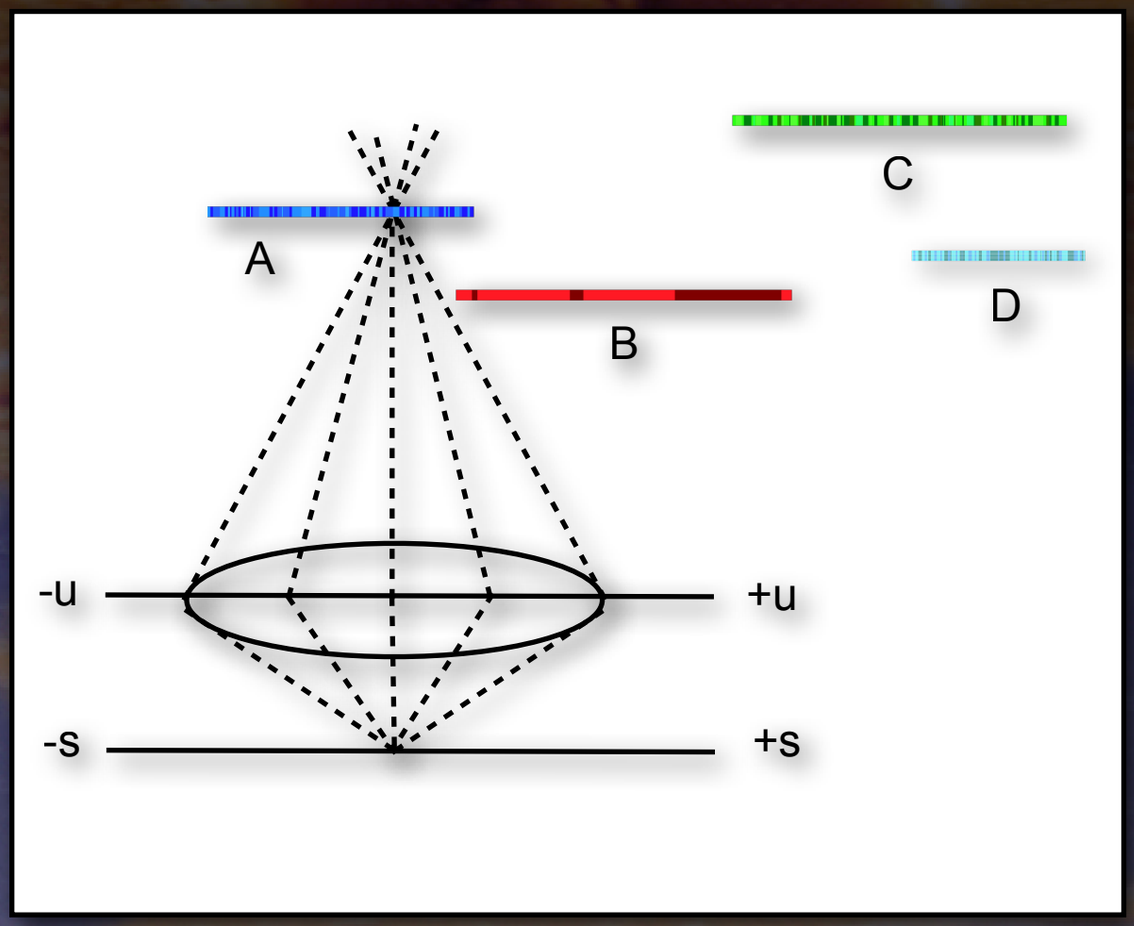

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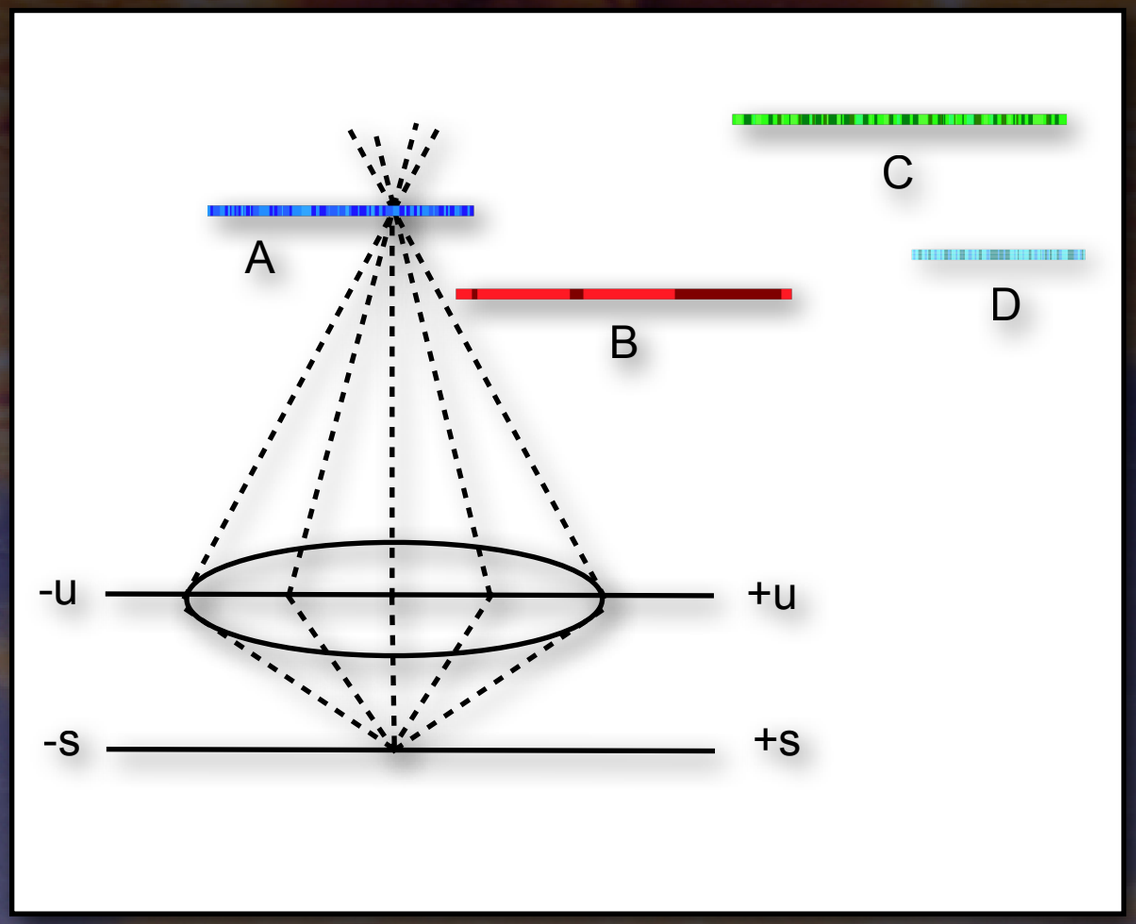

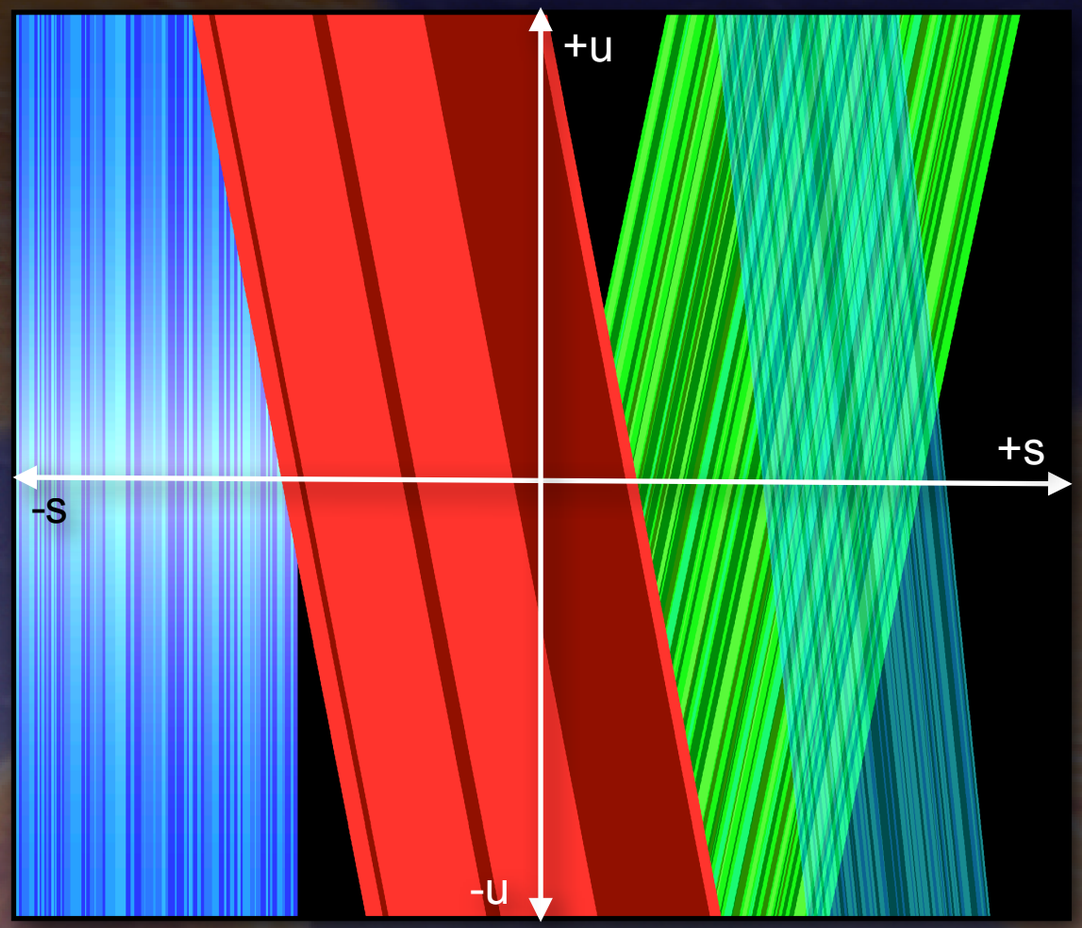

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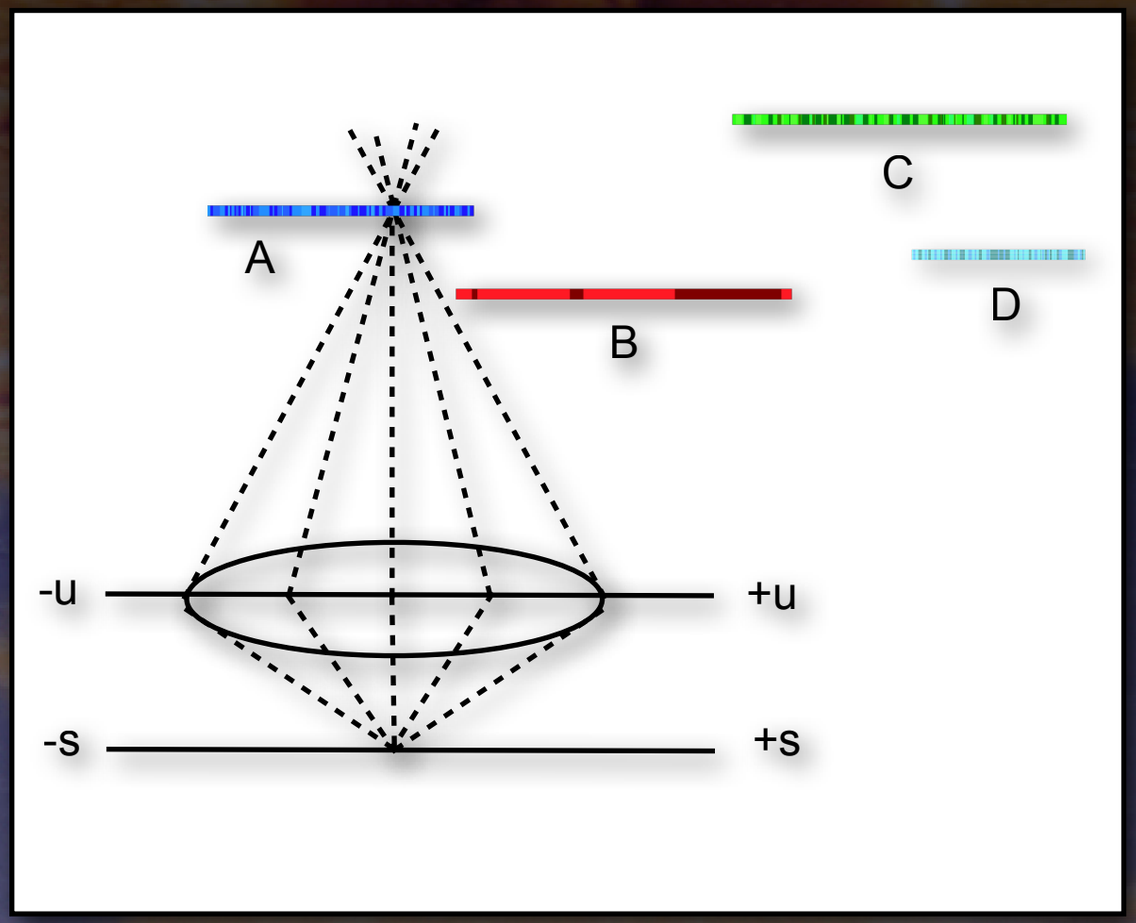

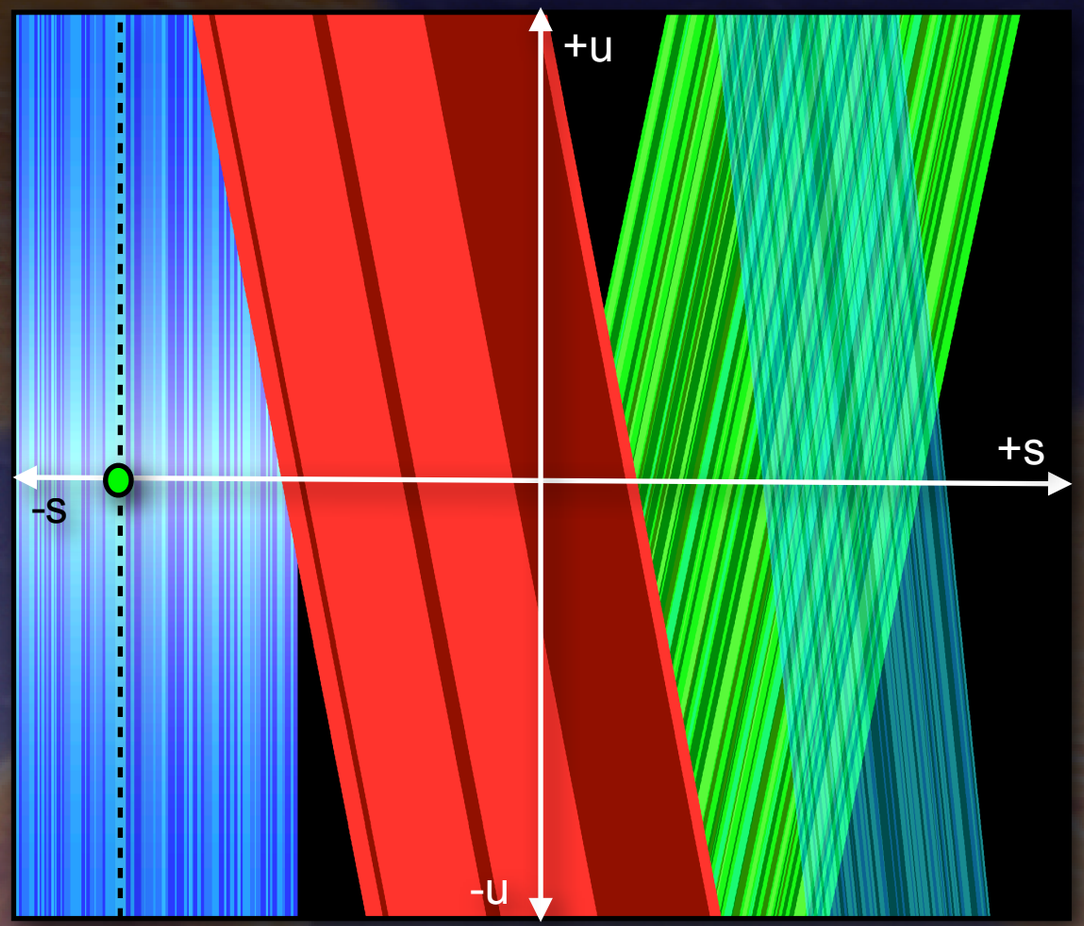

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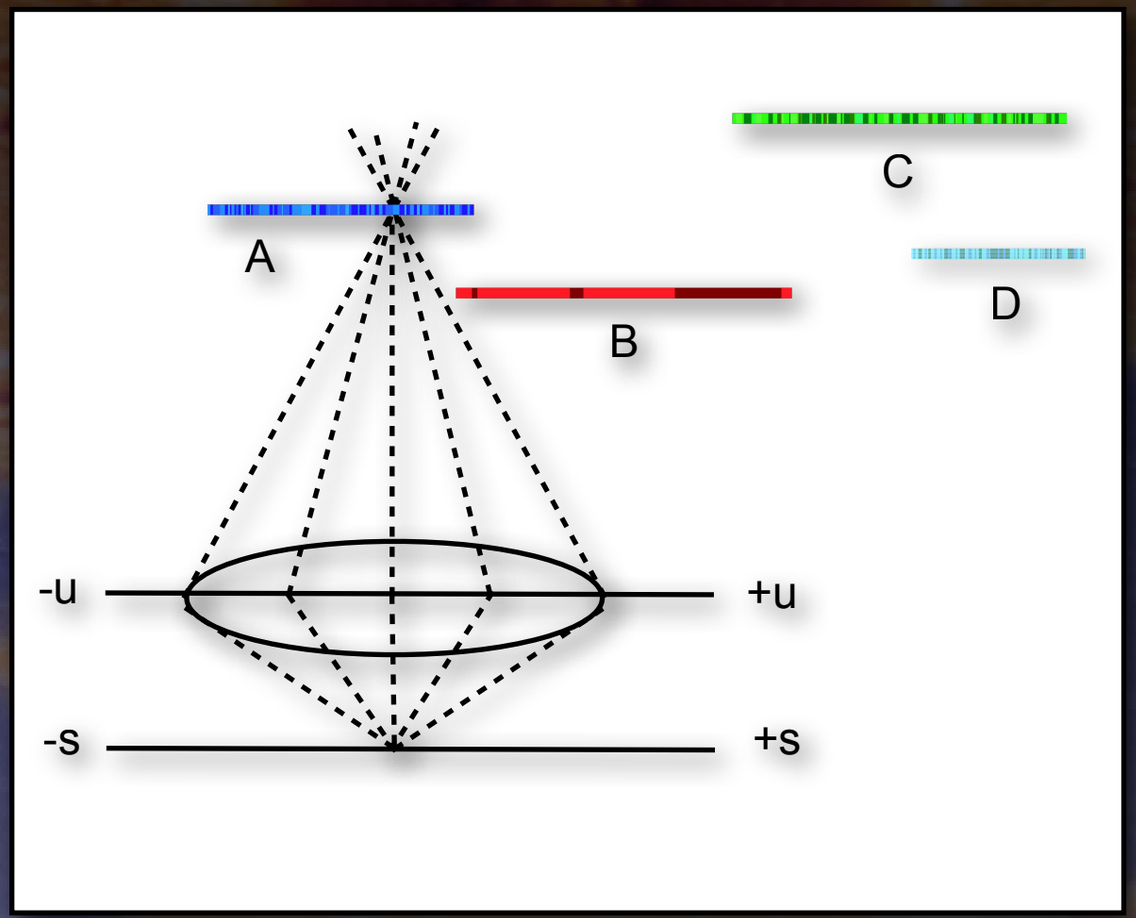

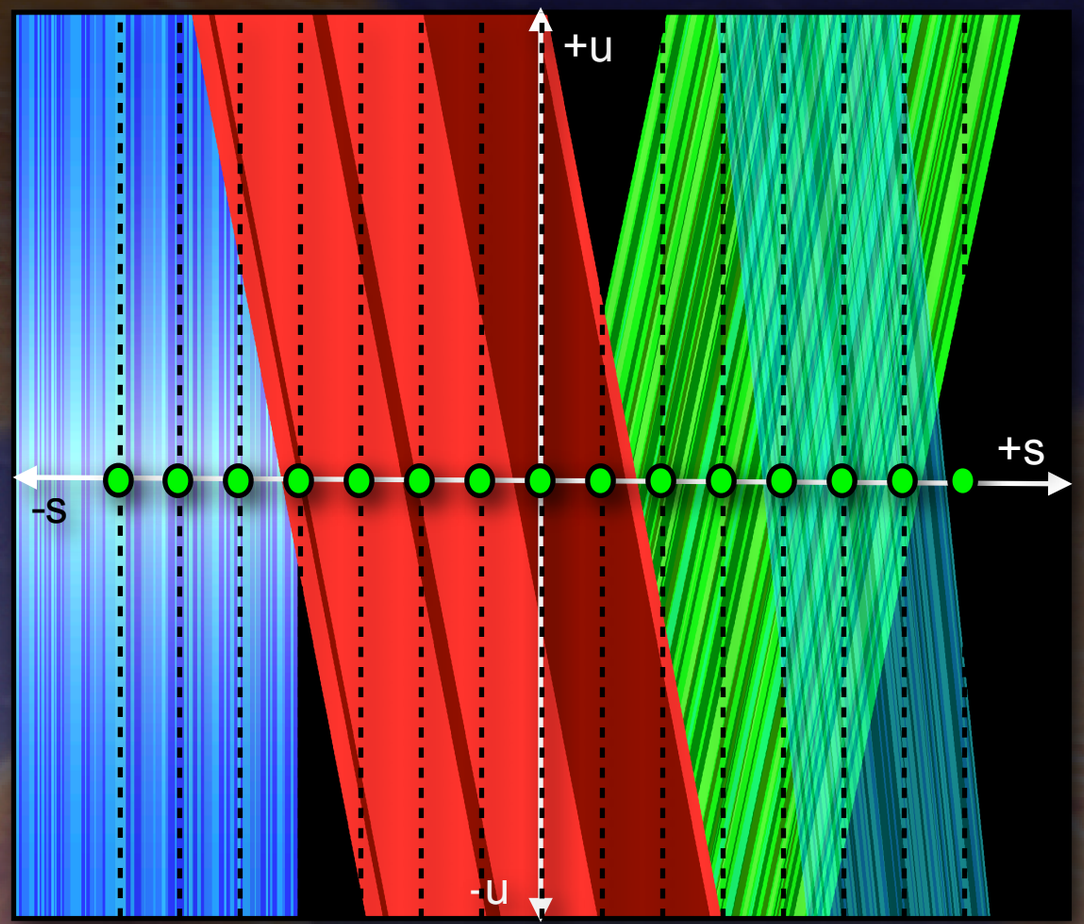

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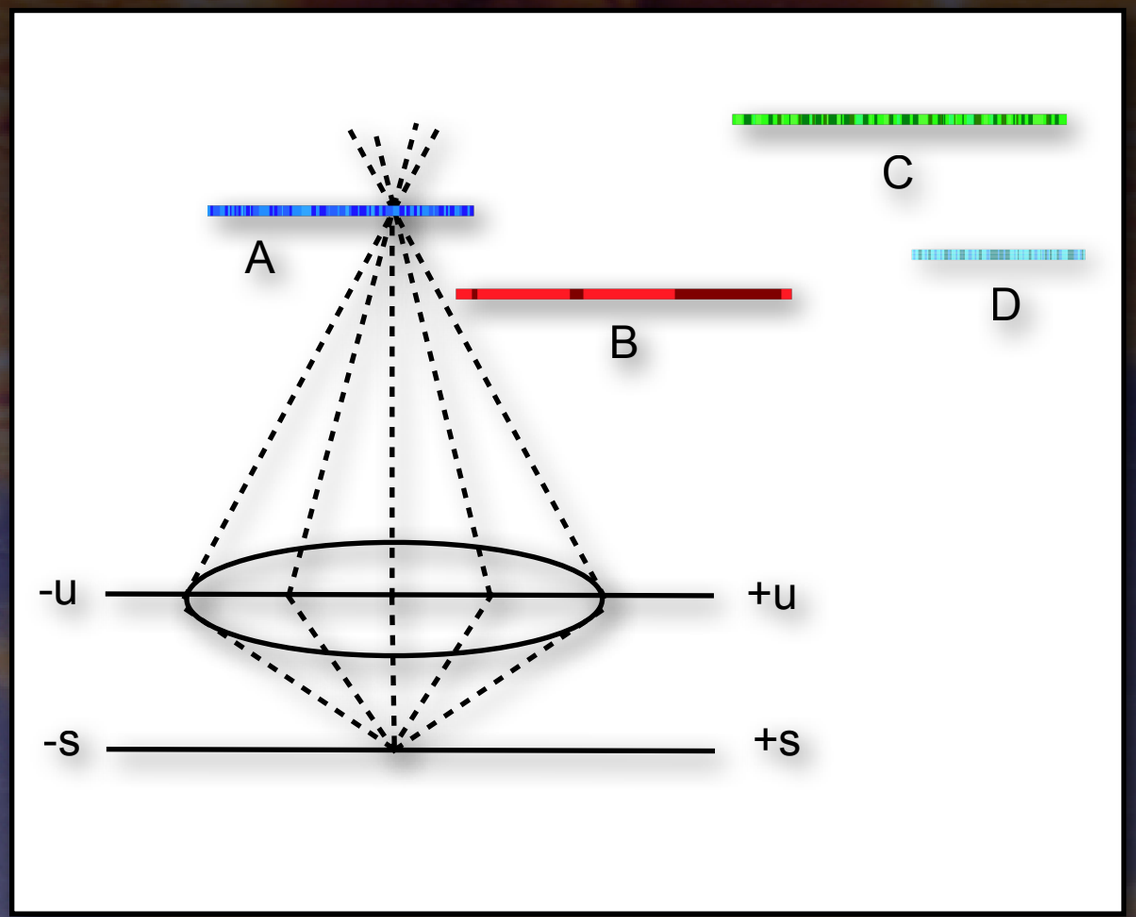

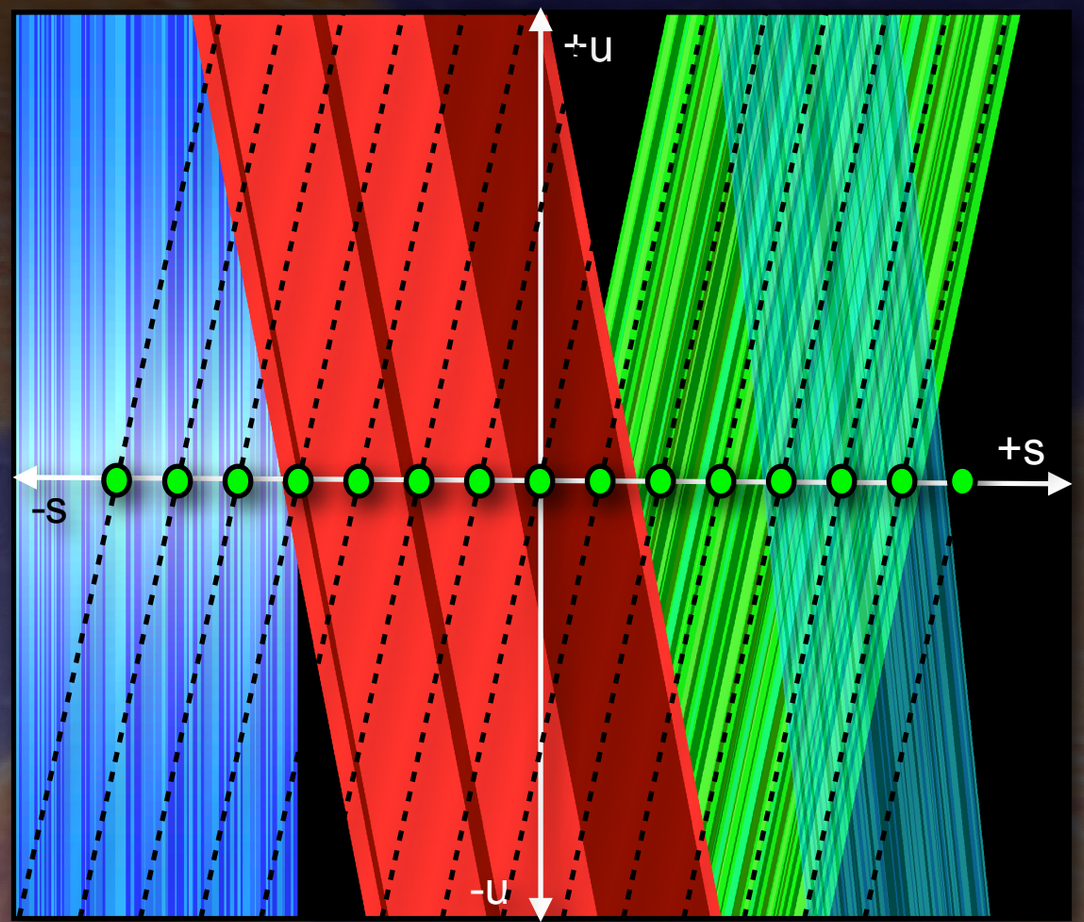

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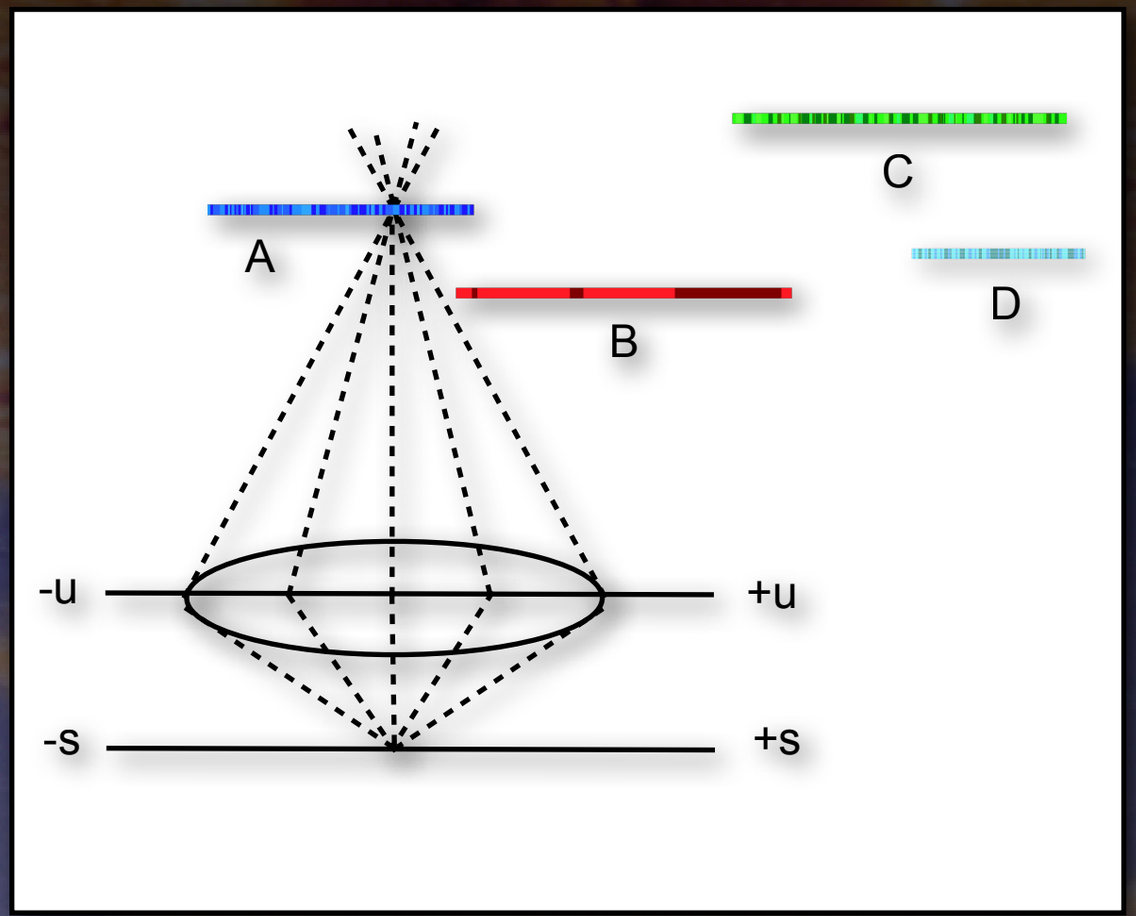

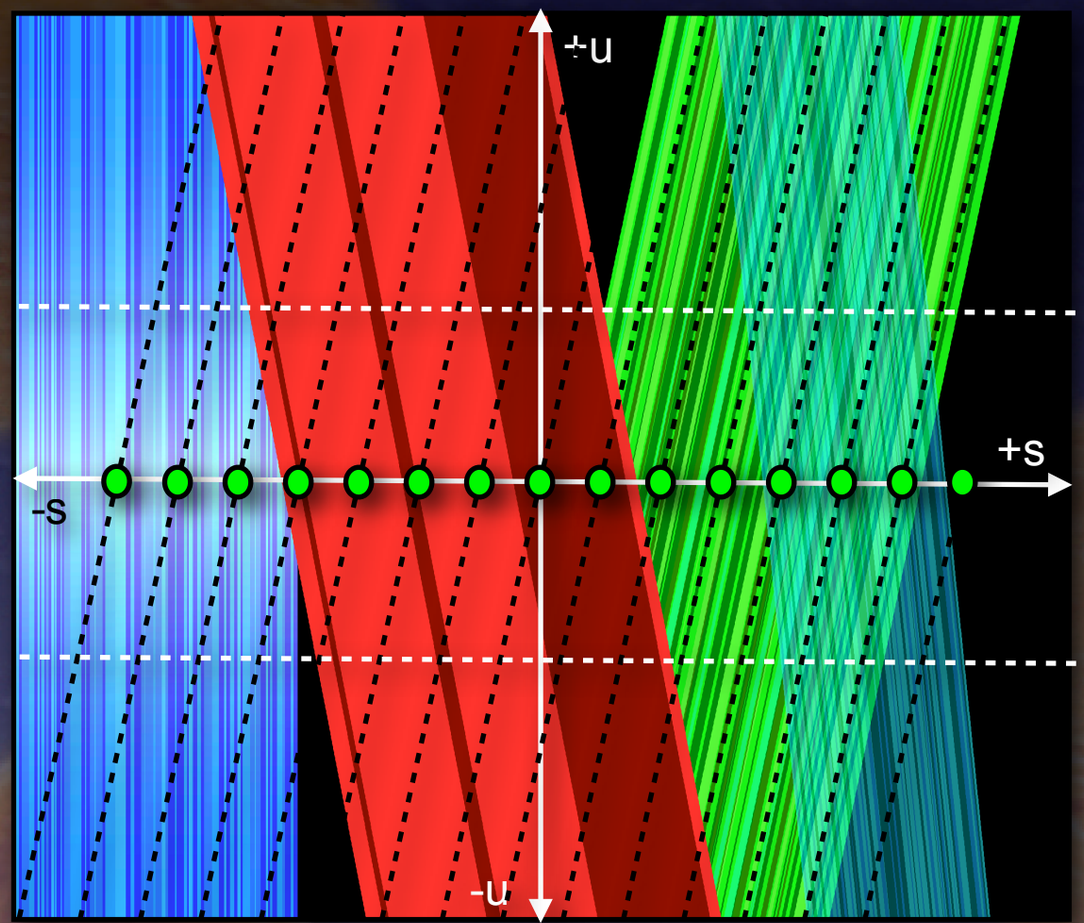

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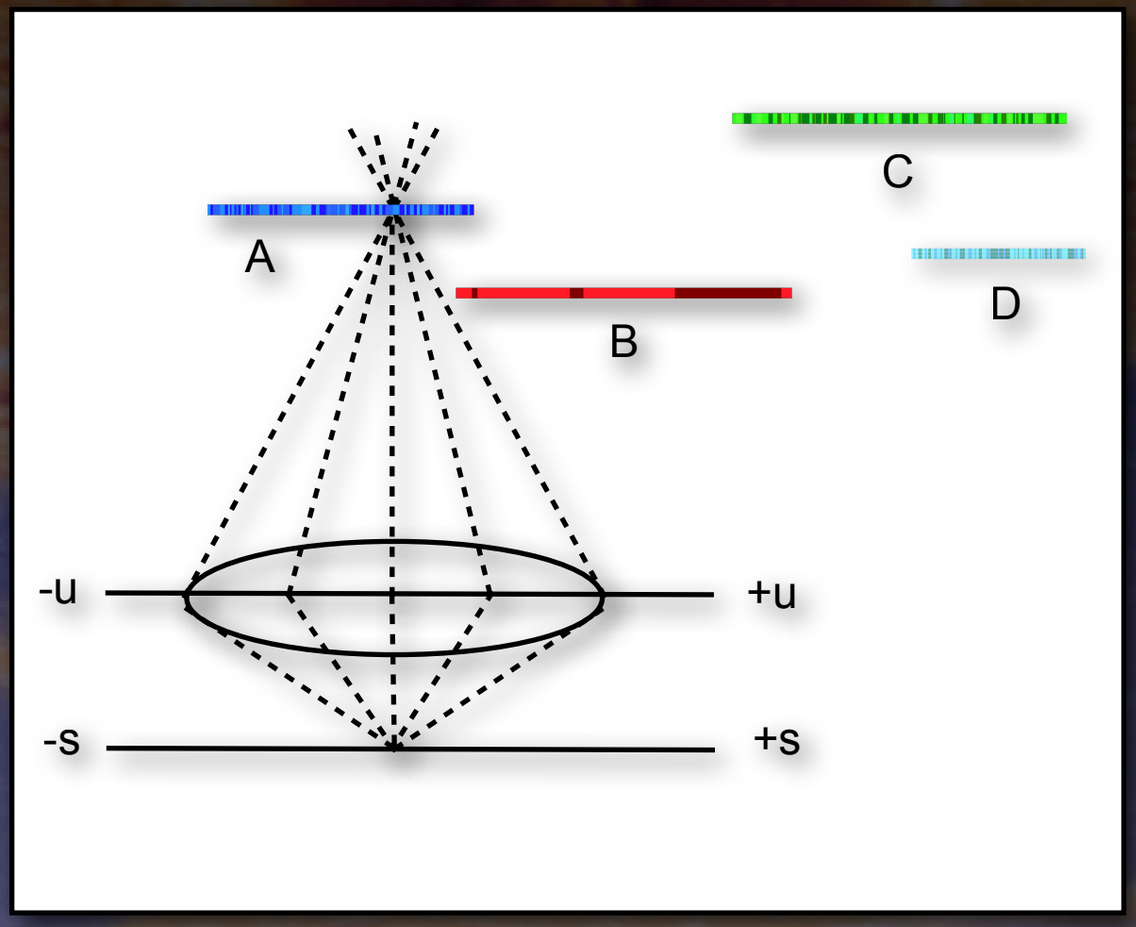
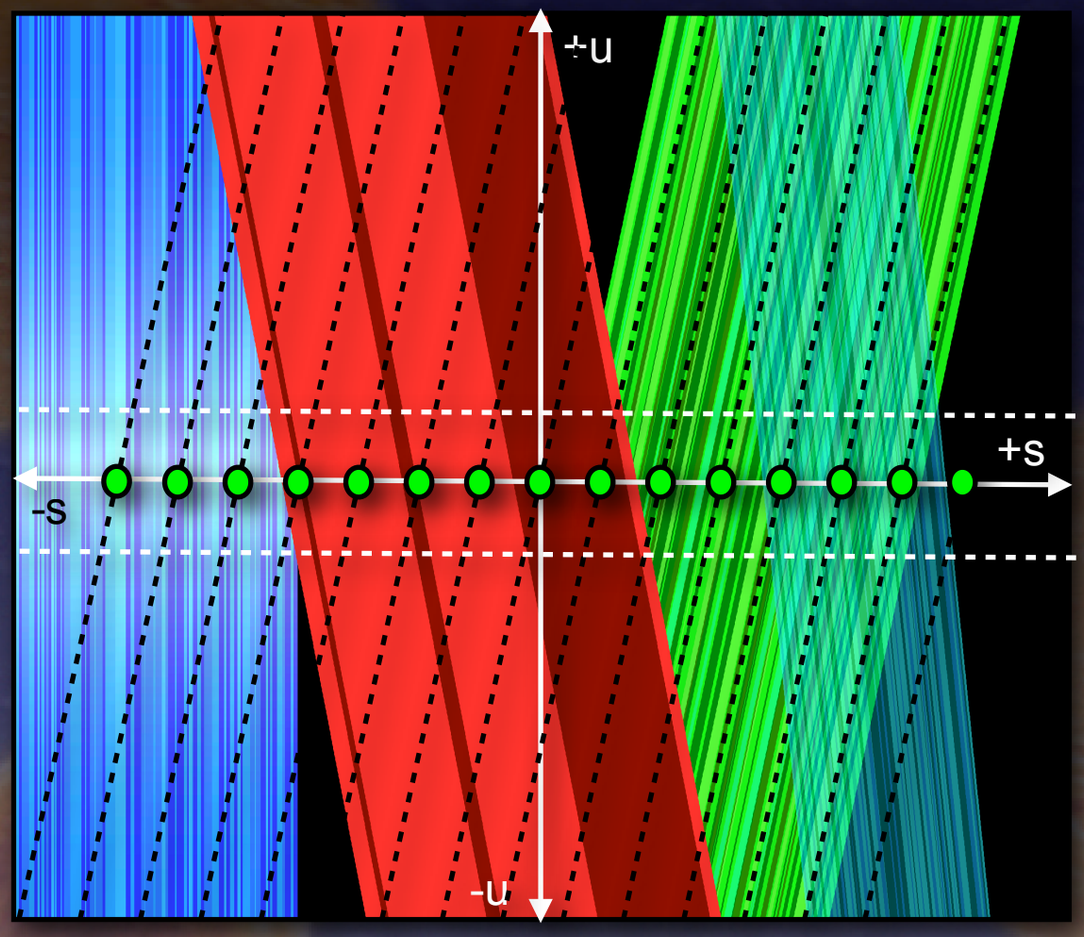
Synthetic Aperture Reconstruction





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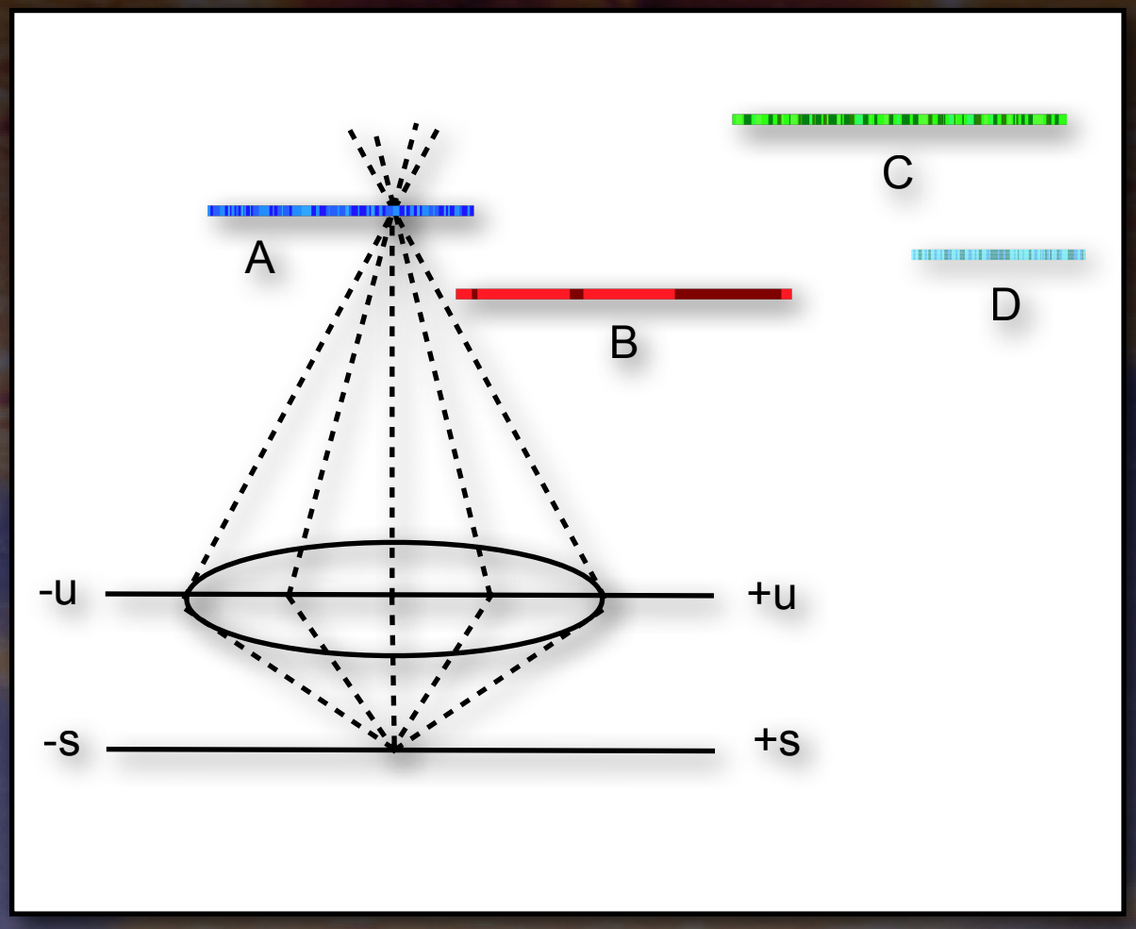
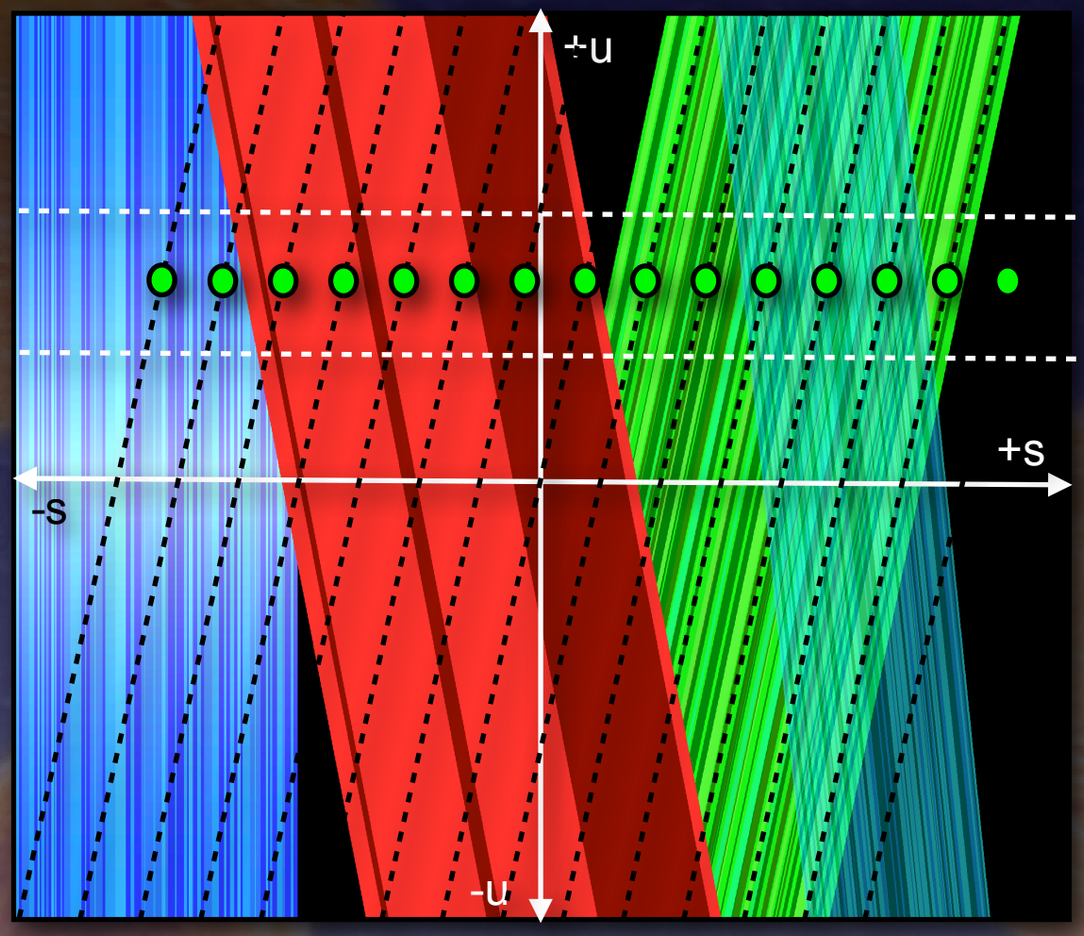
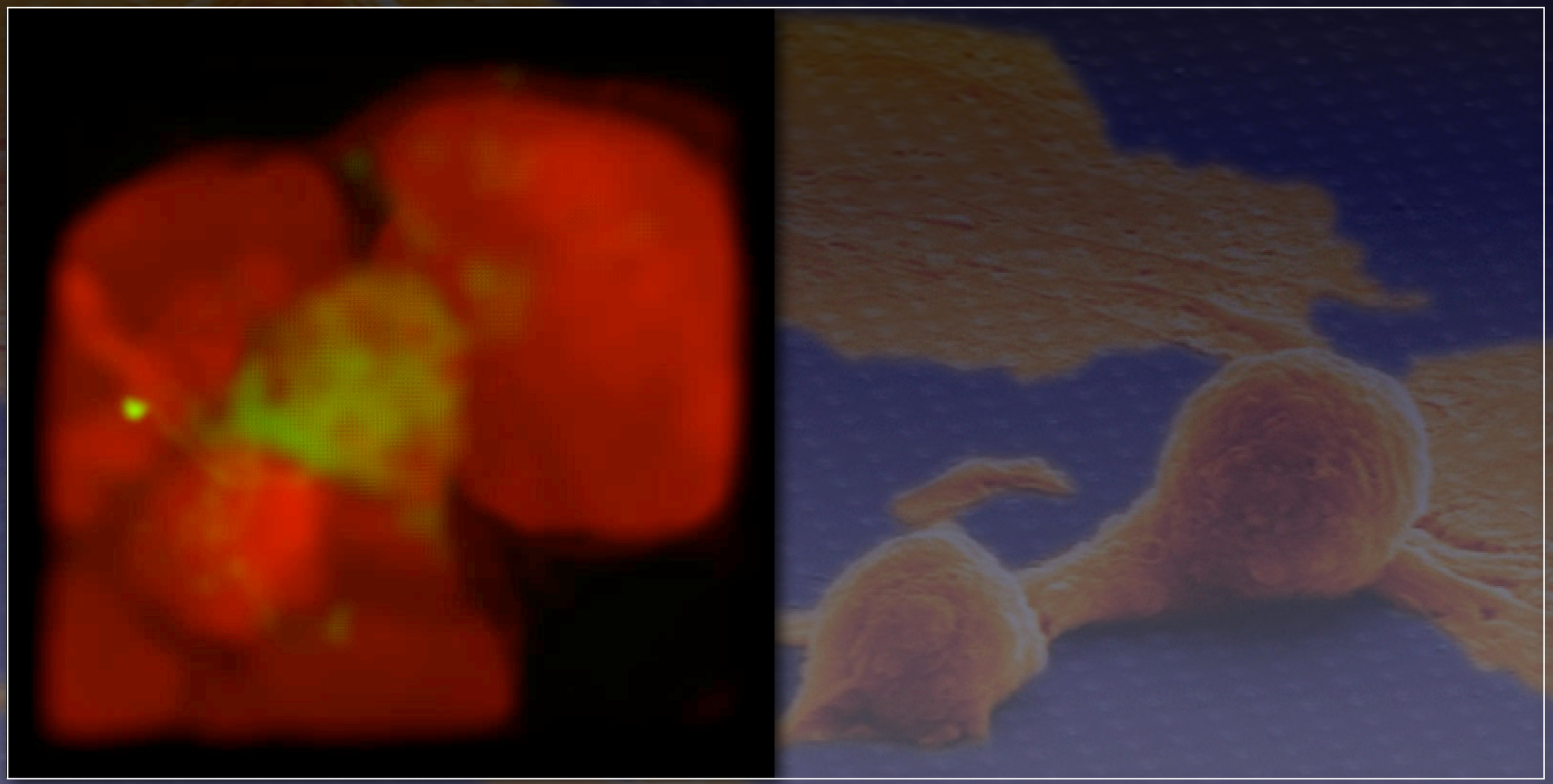
Synthetic Aperture Reconstruction

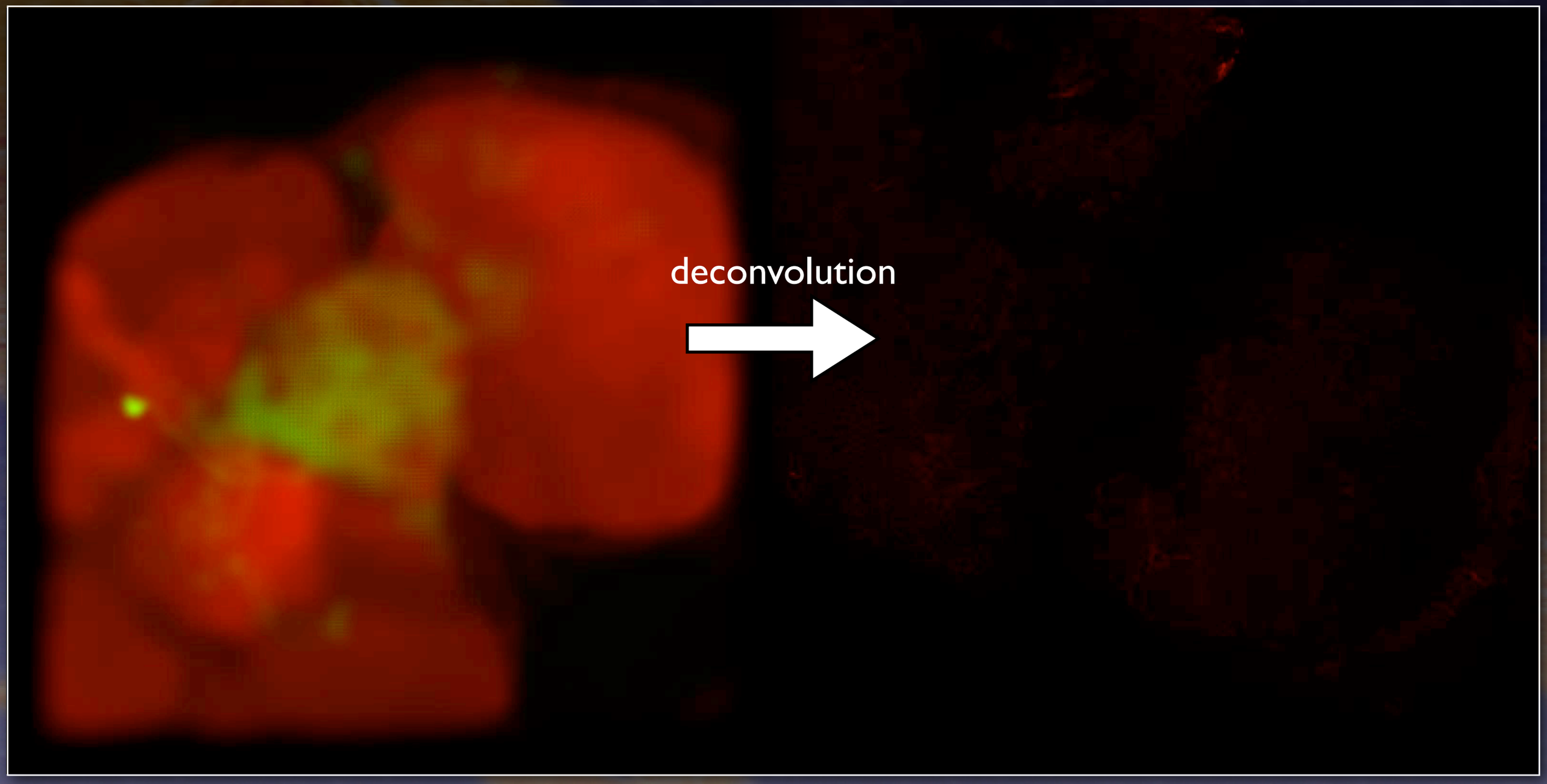




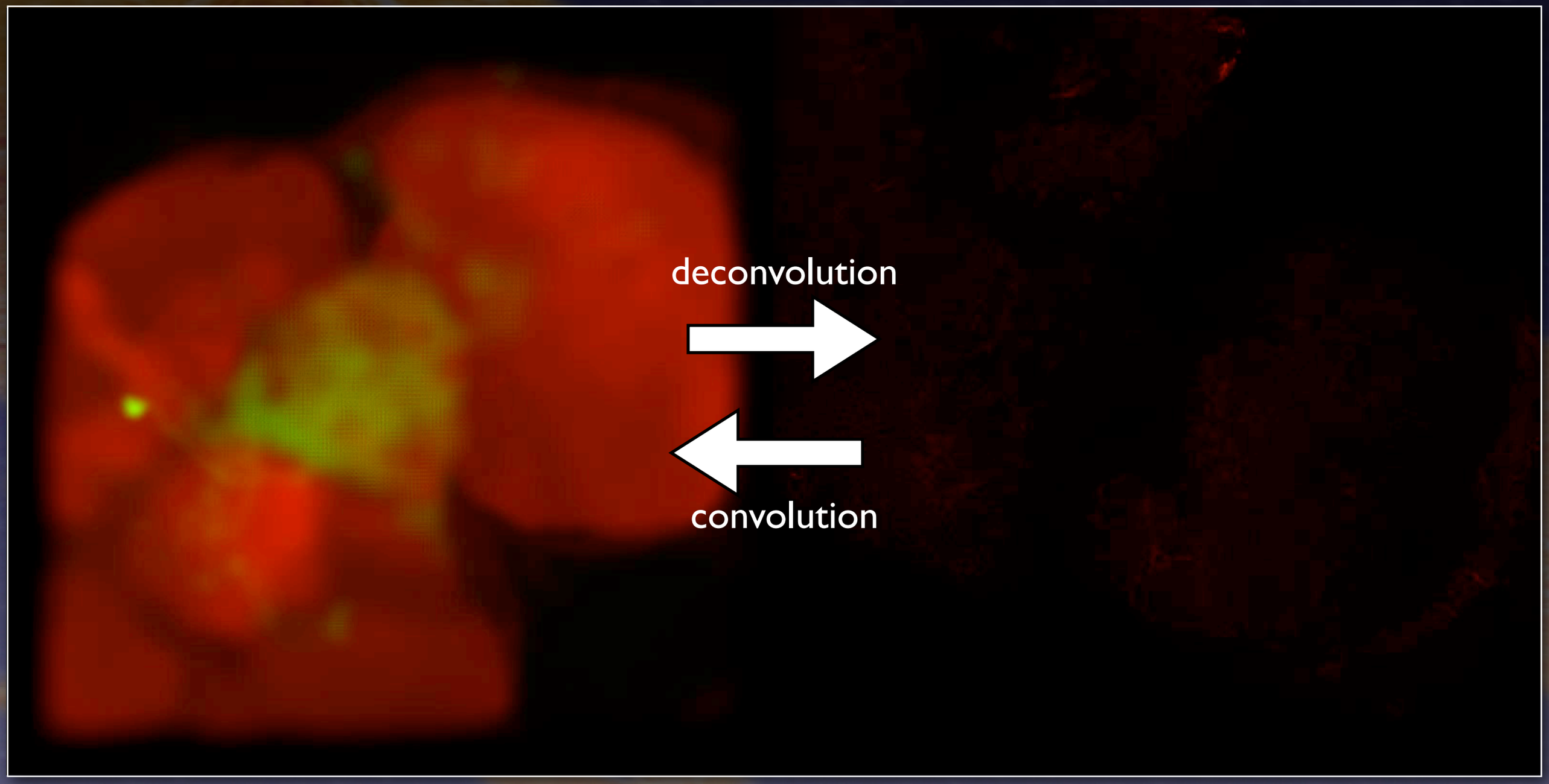
Focal Stacks and Z-Stacks



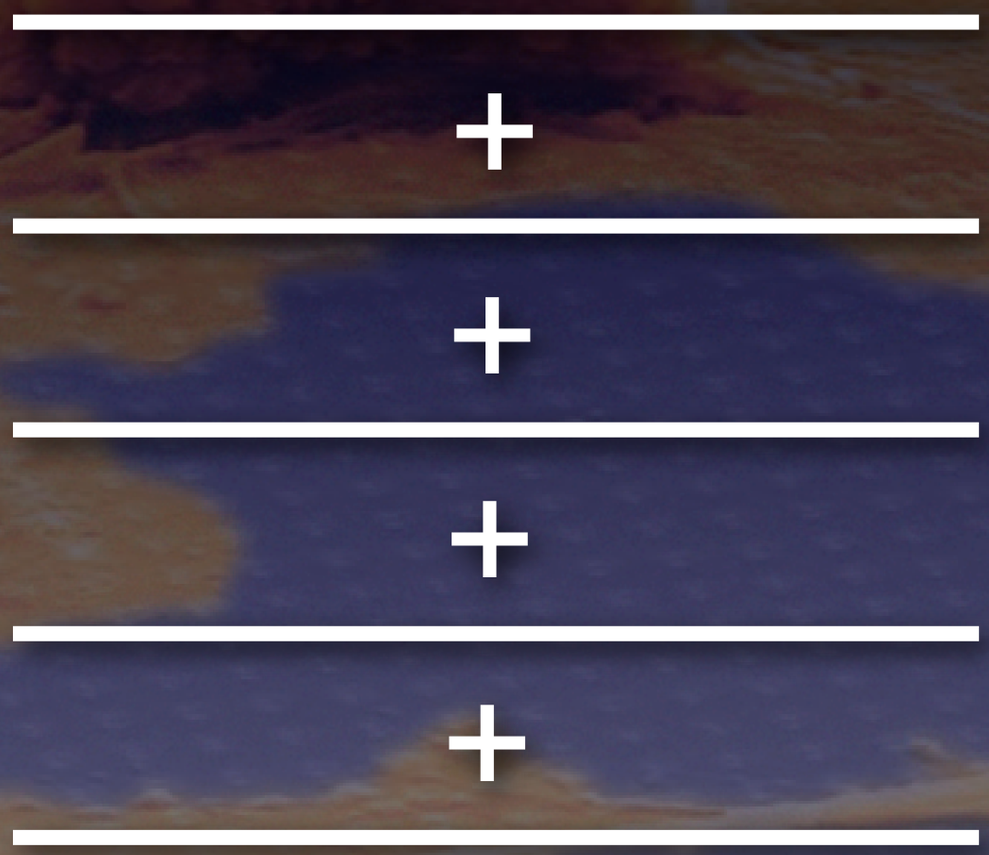
Focal Stacks and Z-Stacks

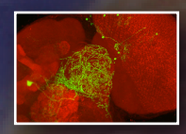


Focal Stacks and Z-Stacks



Z-Stacks to Light Fields





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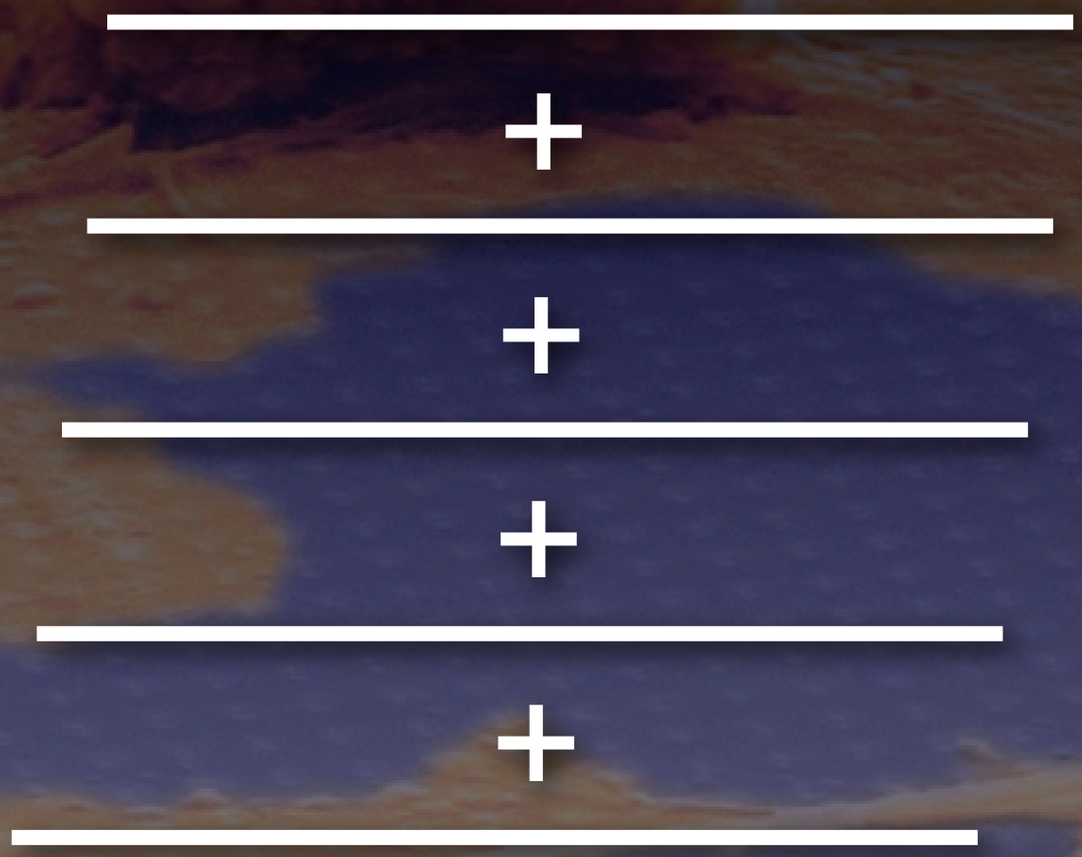
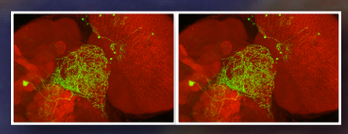
Z-Stacks to Light Fields





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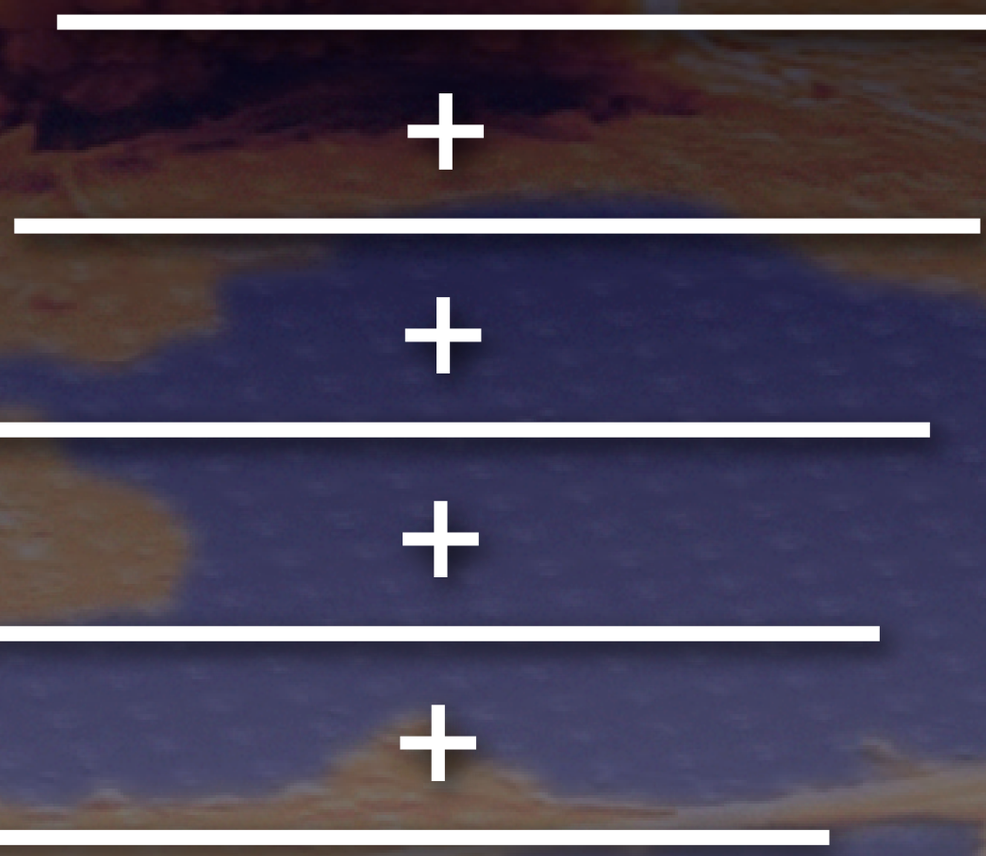
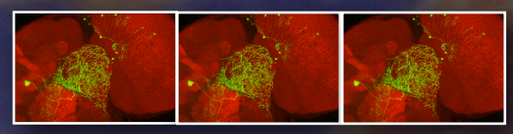
Z-Stacks to Light Fields





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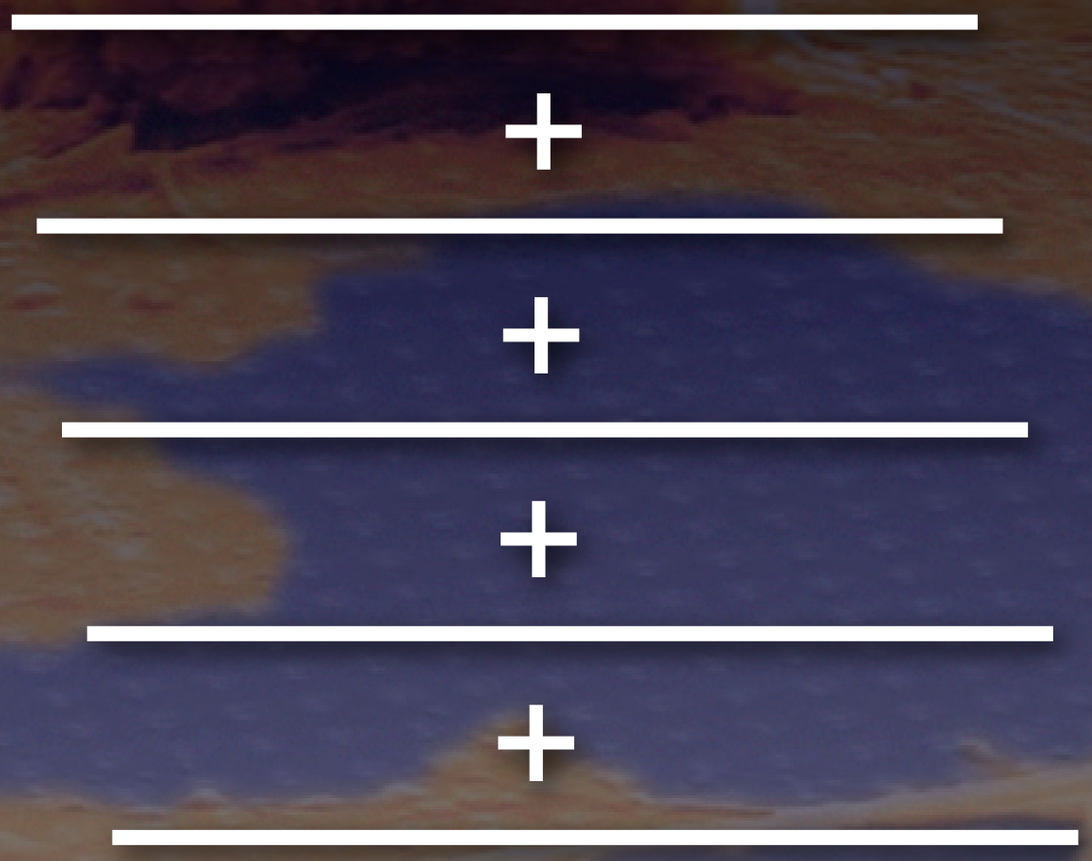
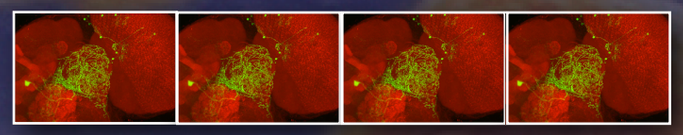
Z-Stacks to Light Fields





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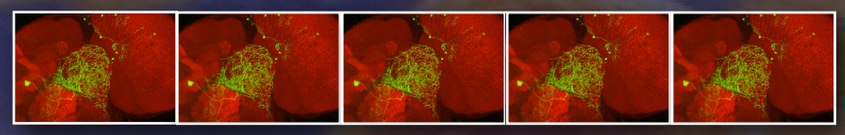
Z-Stacks to Light Fields



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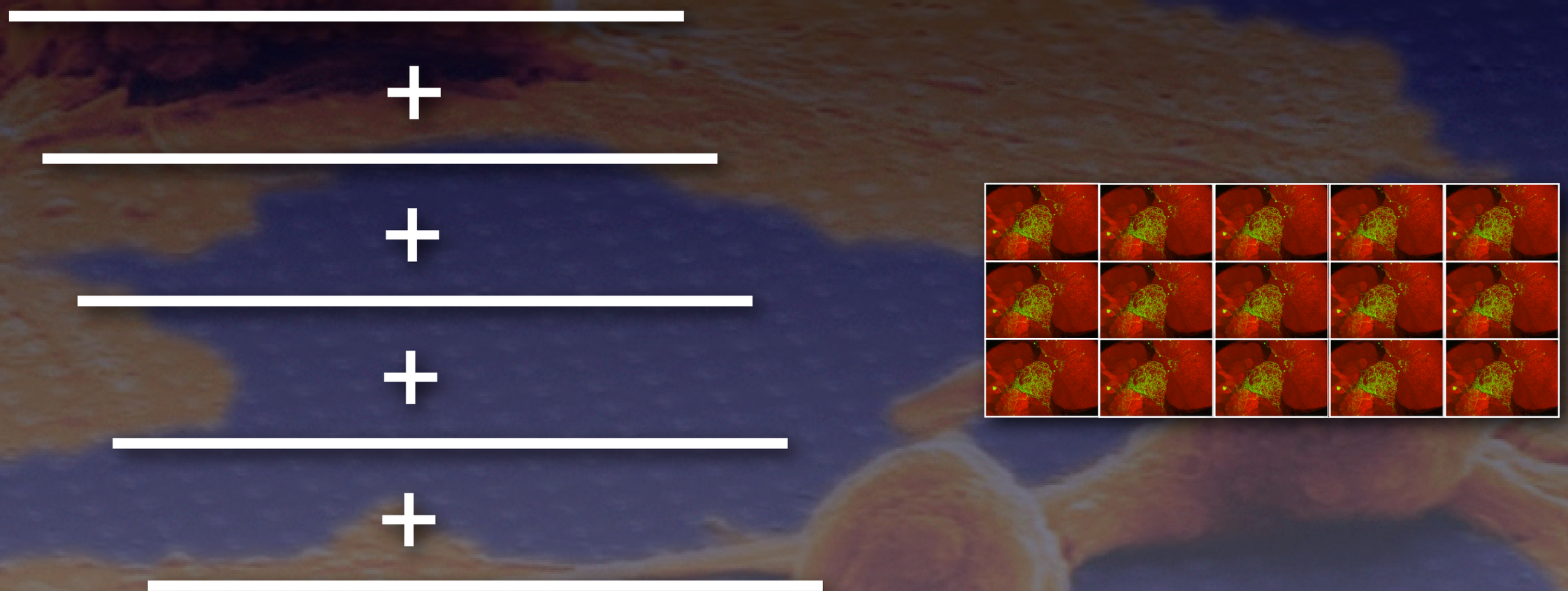
Z-Stacks to Light Fields



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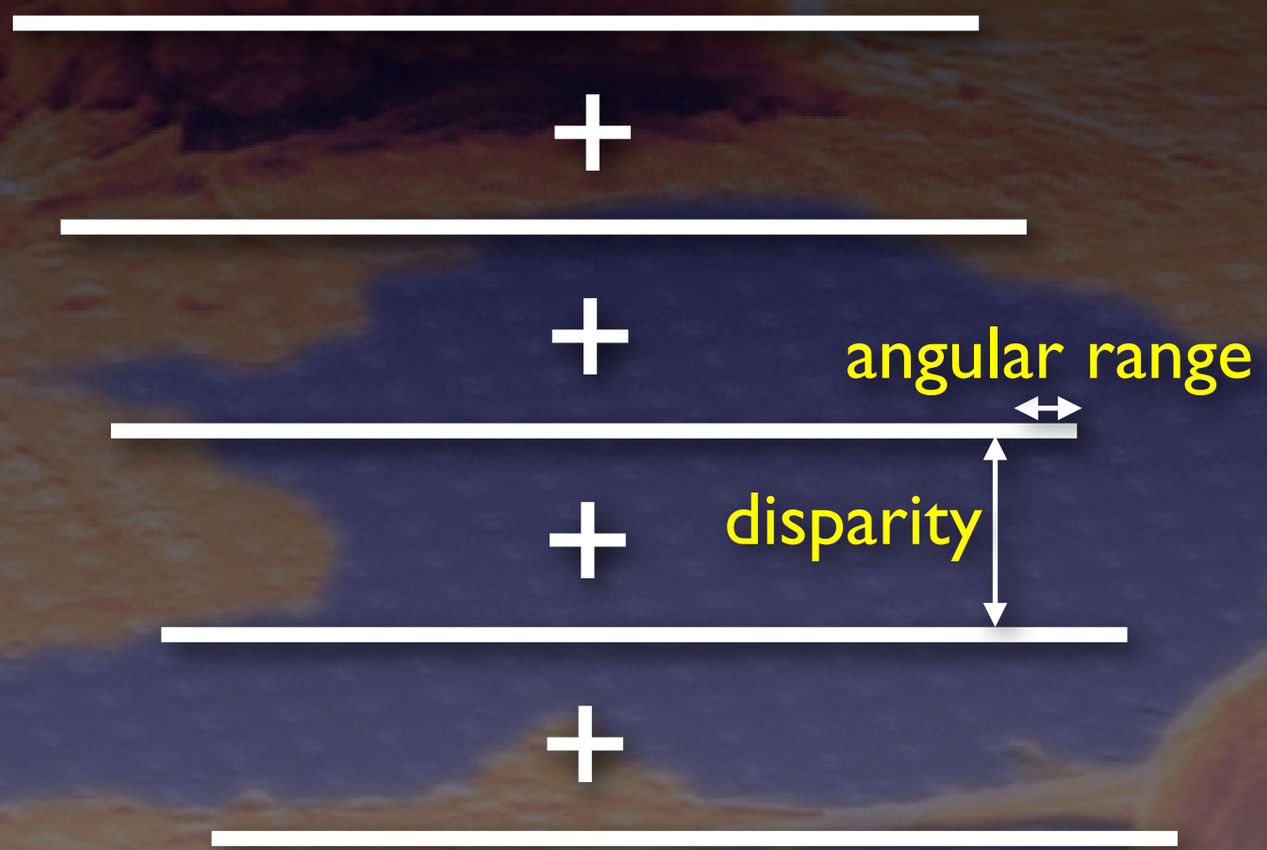
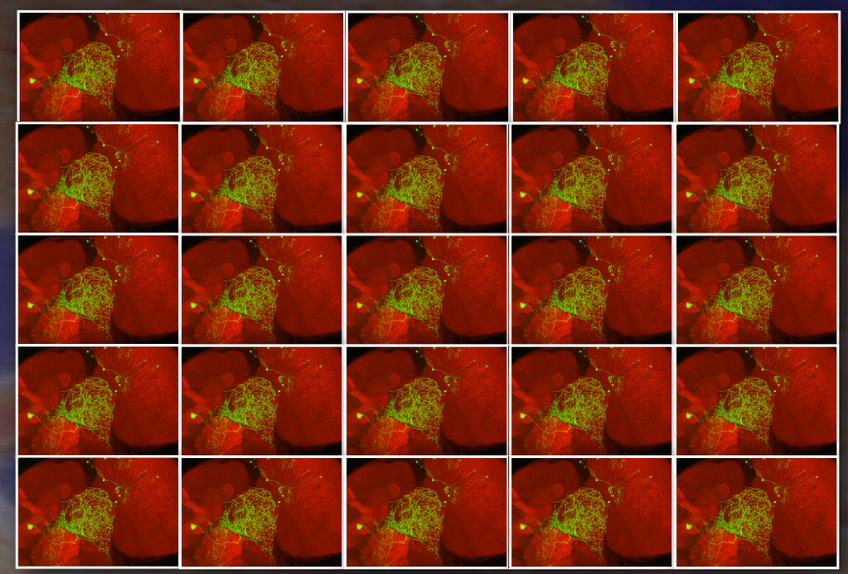
Z-Stacks to Light Fields





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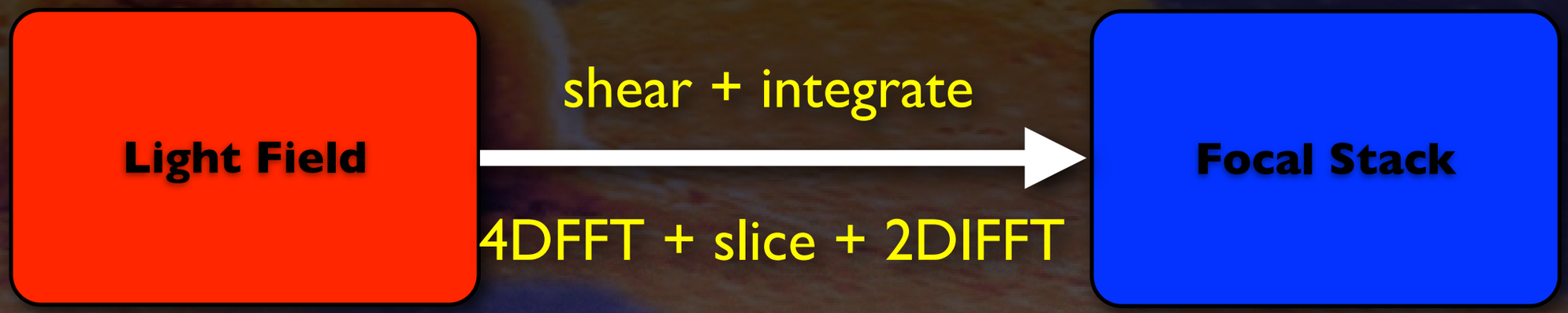
Transformations

Light Field

Focal Stack

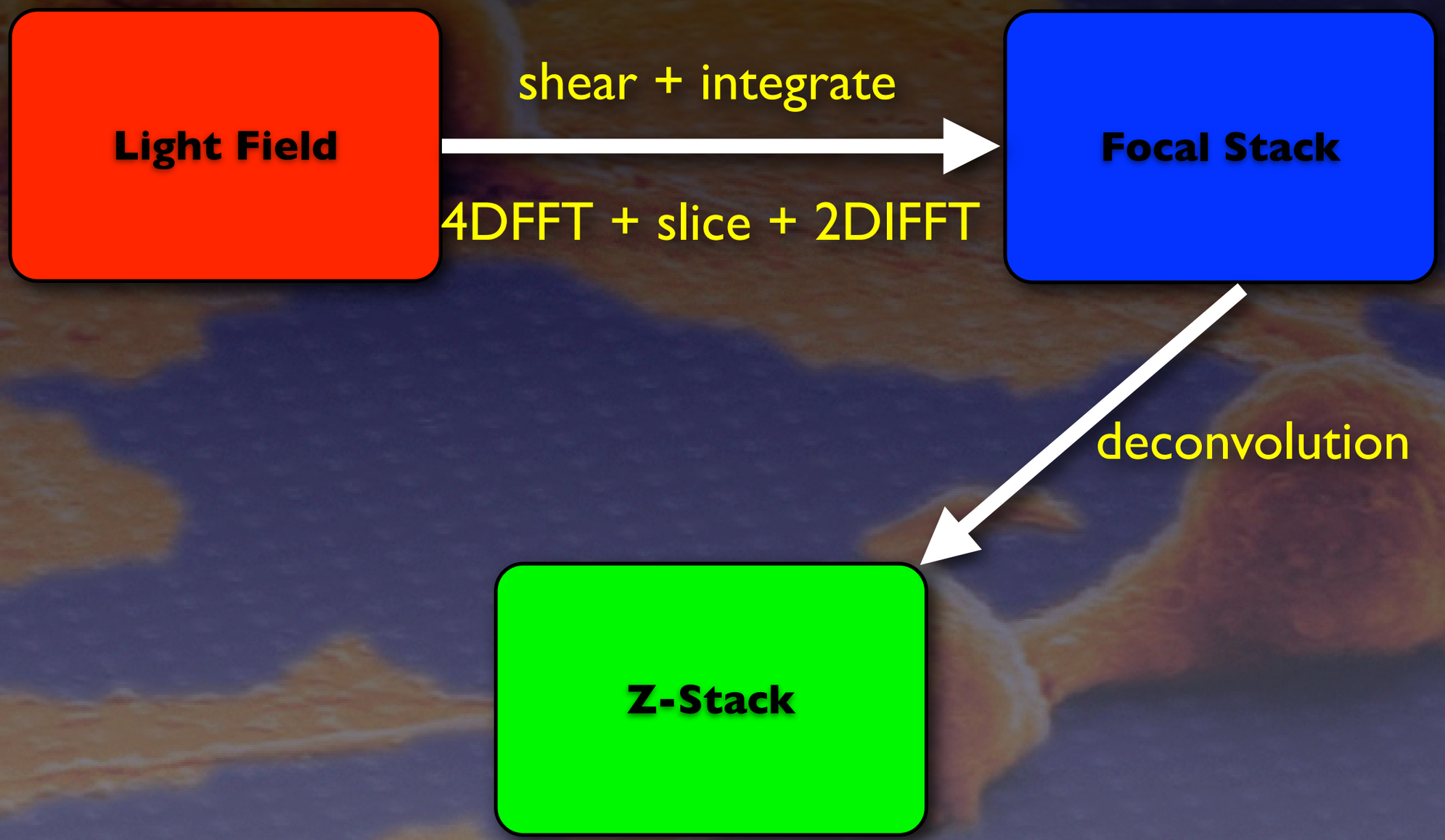
Z-Stack

Transformations



Z-Stack

Transformations



Transformations

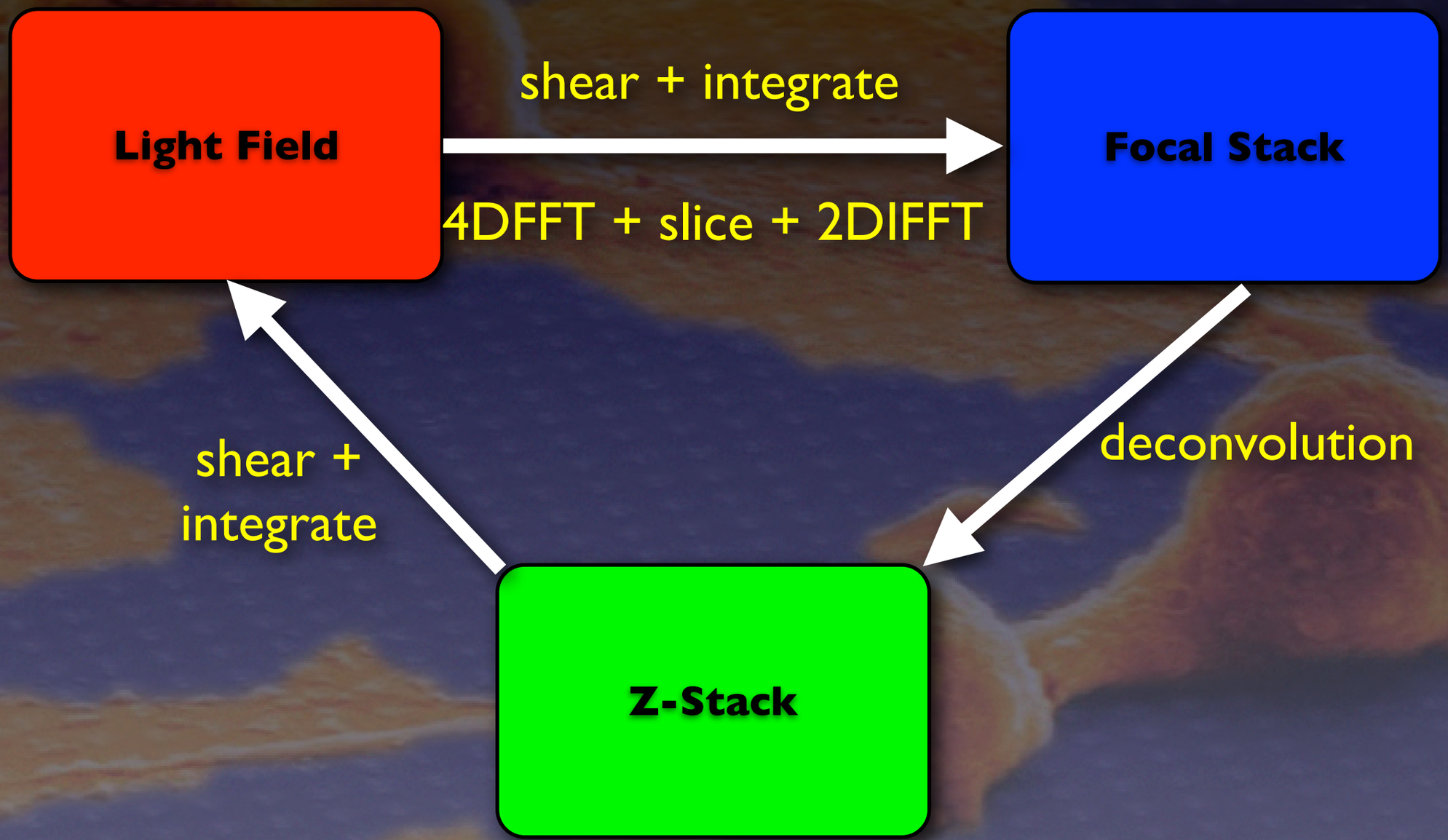


Image Processing Light Fields?

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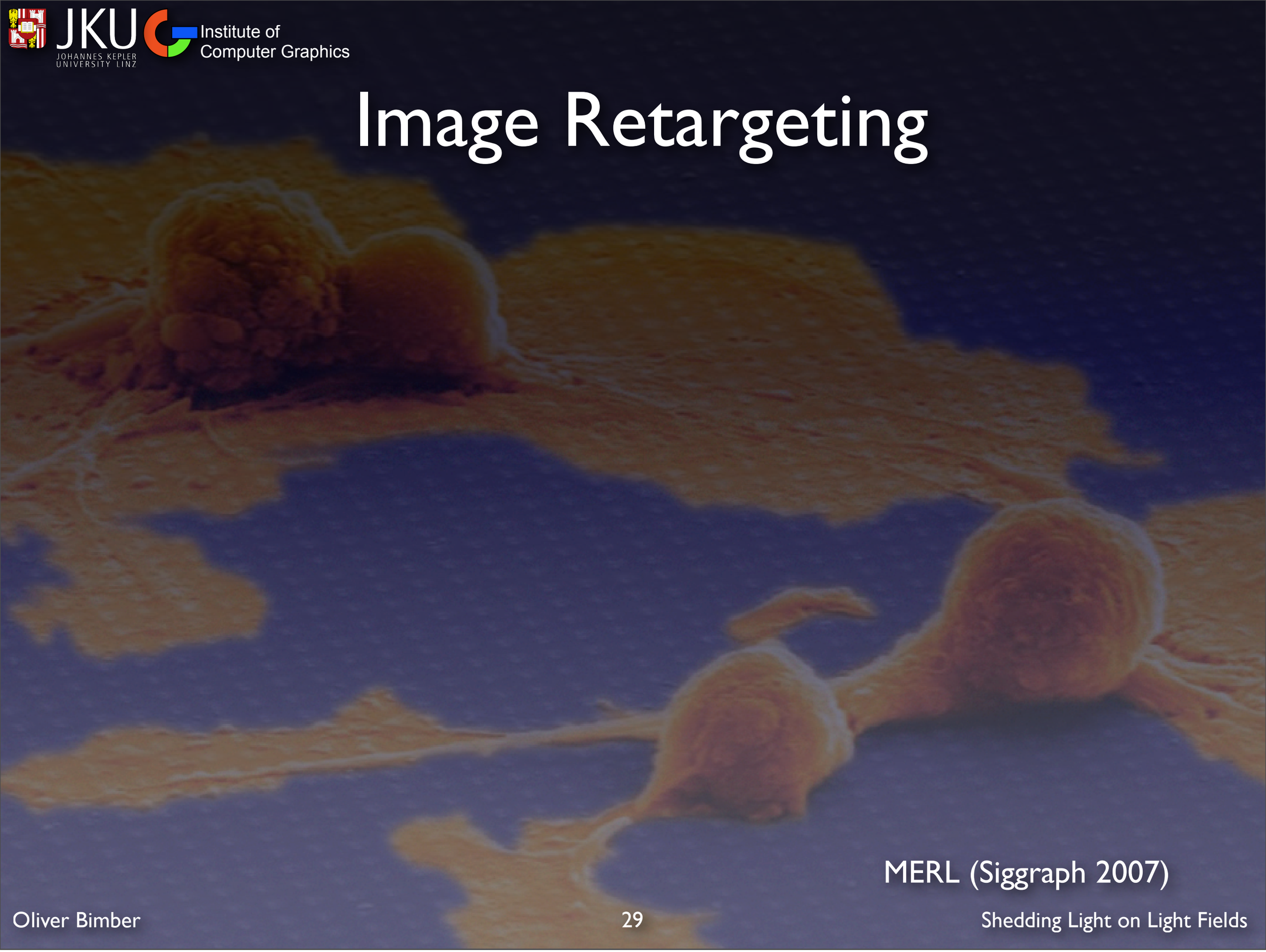
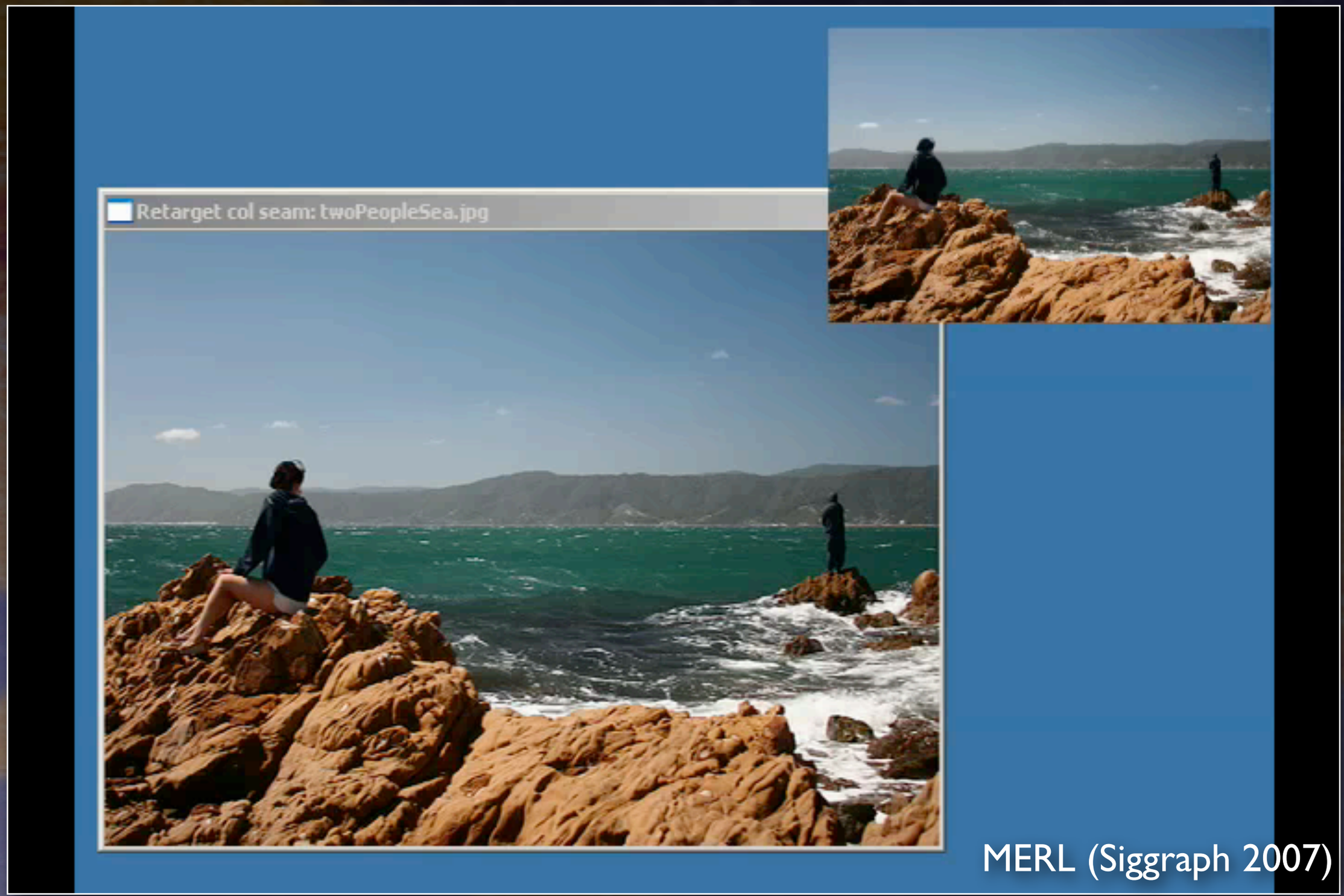
Image Retargeting



MERL (Siggraph 2007)

Image Retargeting



MERL (Siggraph 2007)

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Light-Field Retargeting

Eurographics 2012

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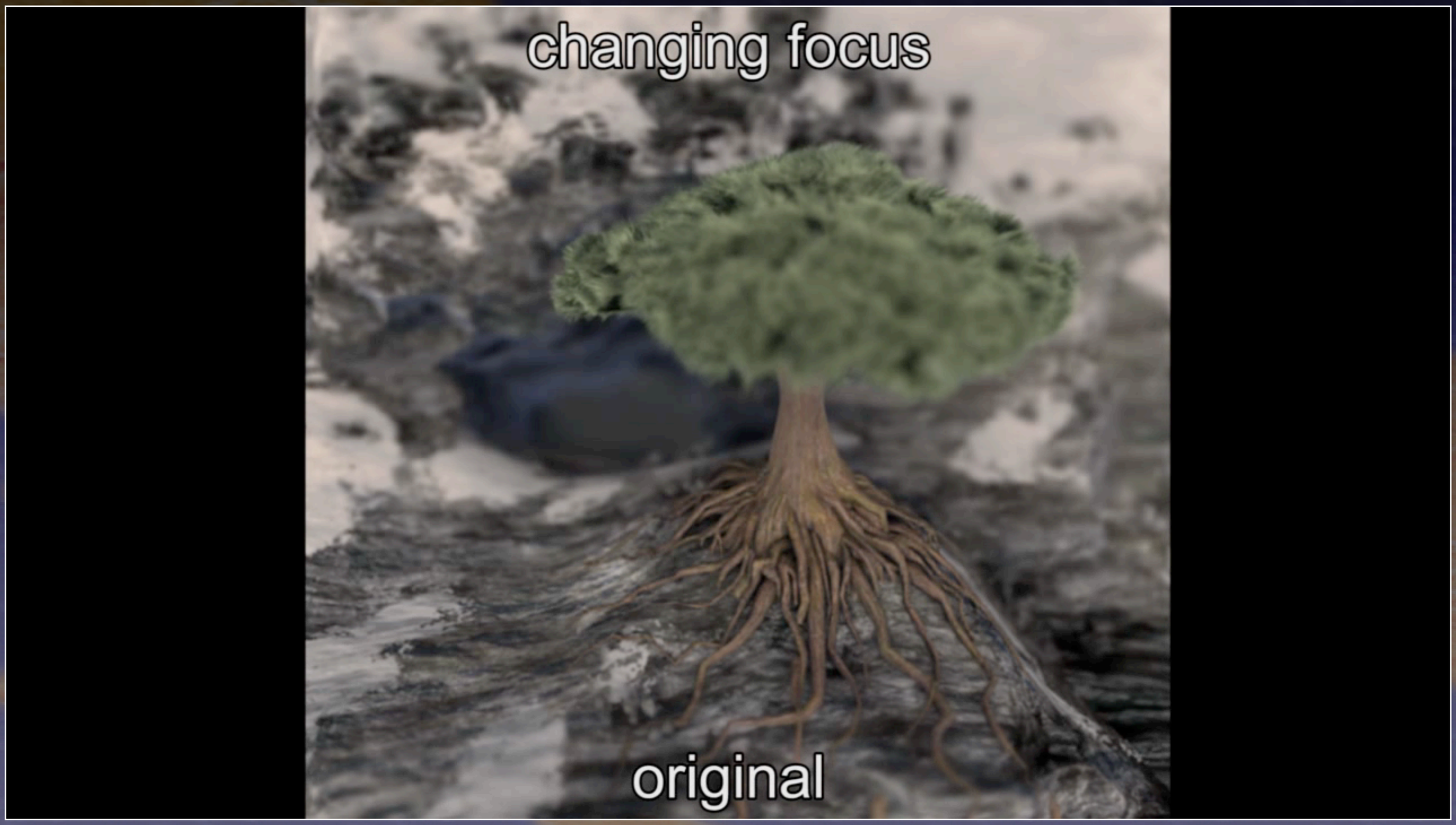

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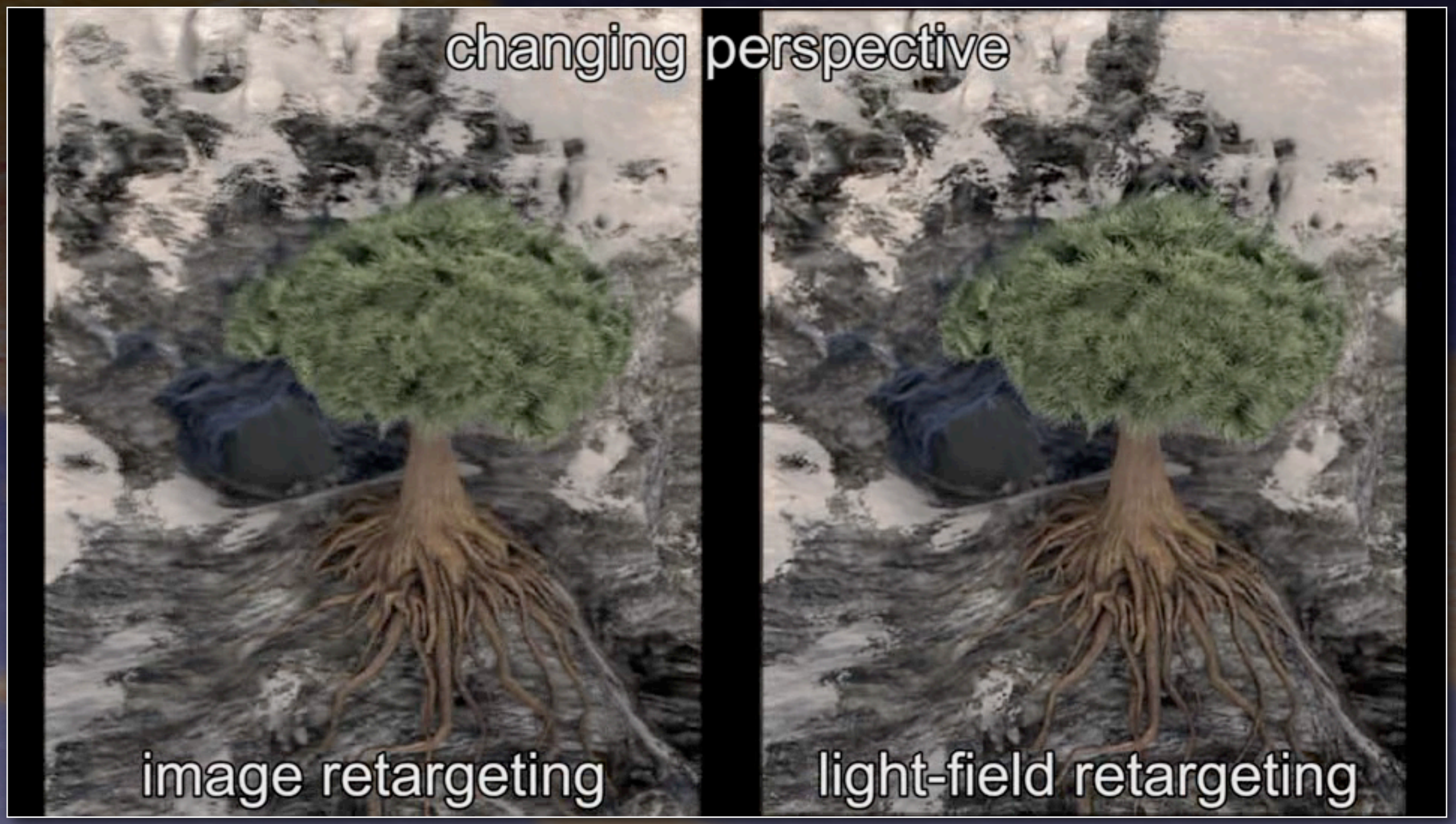
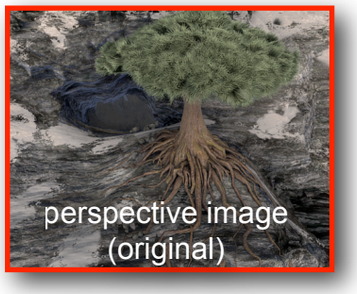
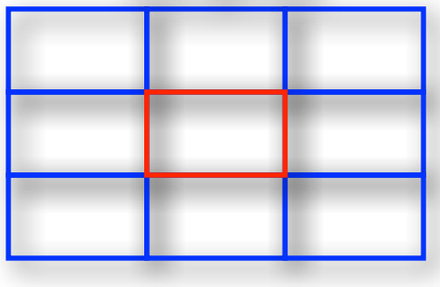


Light-Field Retargeting

Eurographics 2012

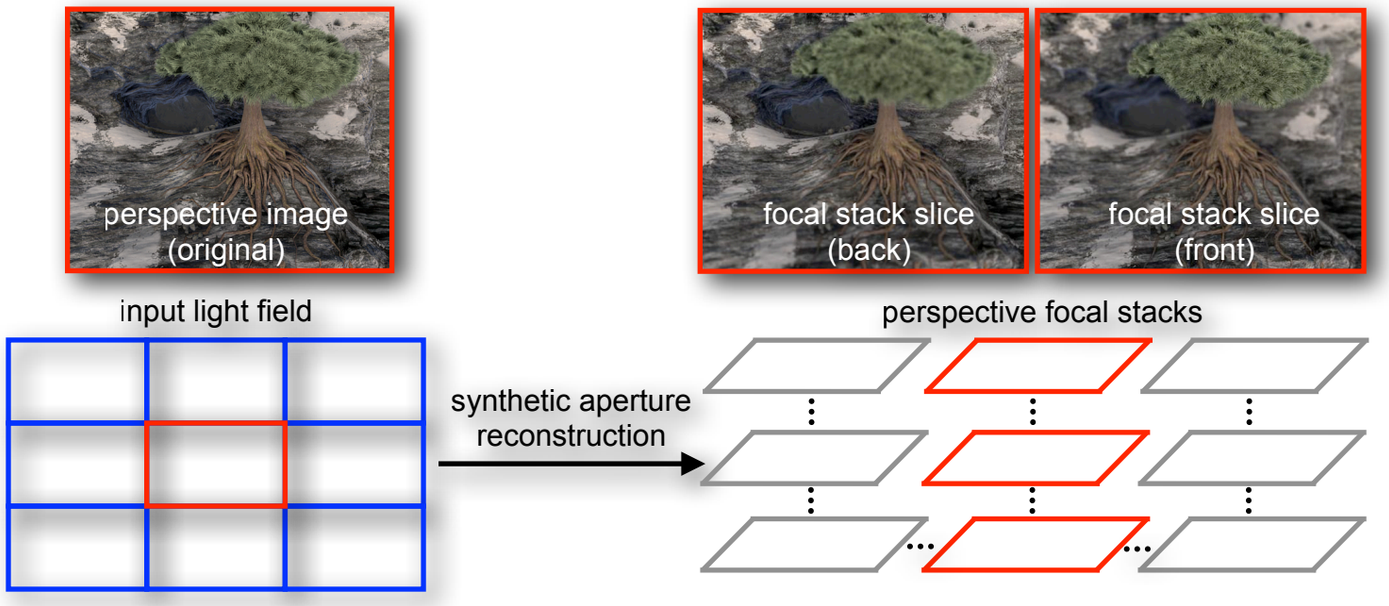


input light field



Light-Field Retargeting

Eurographics 2012



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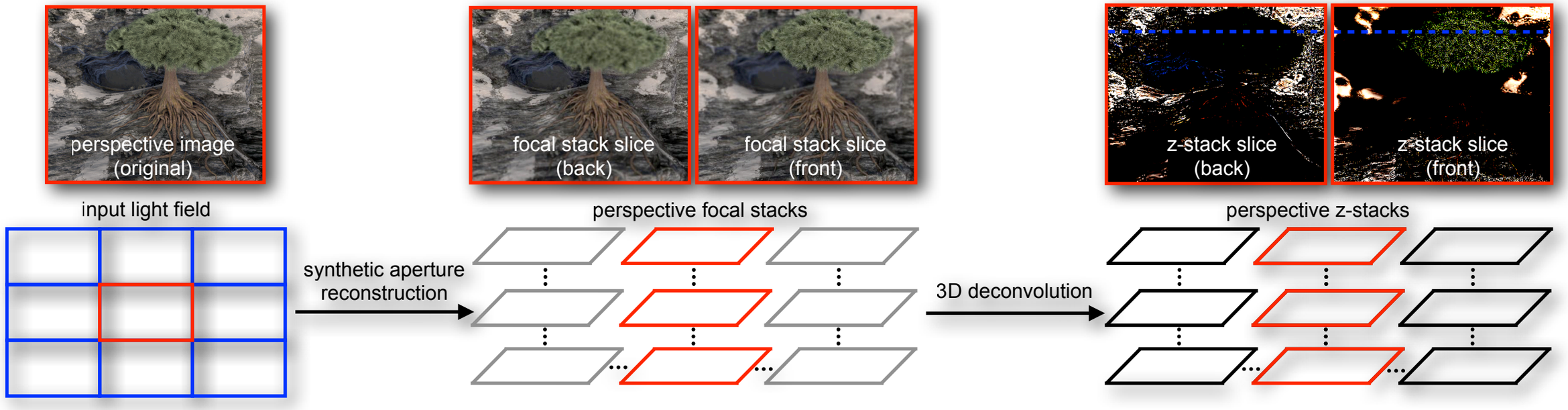

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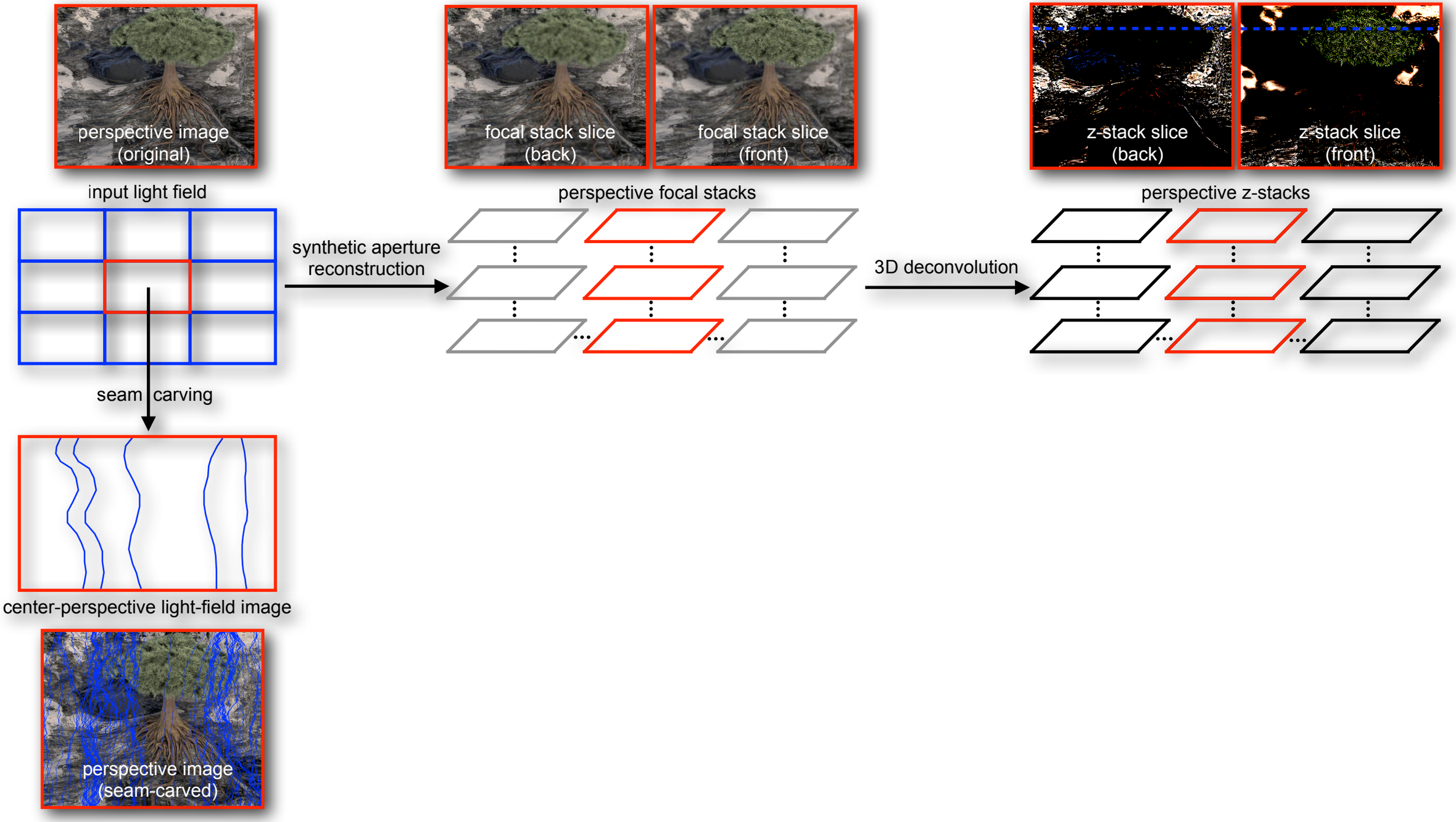
Eurographics 2012



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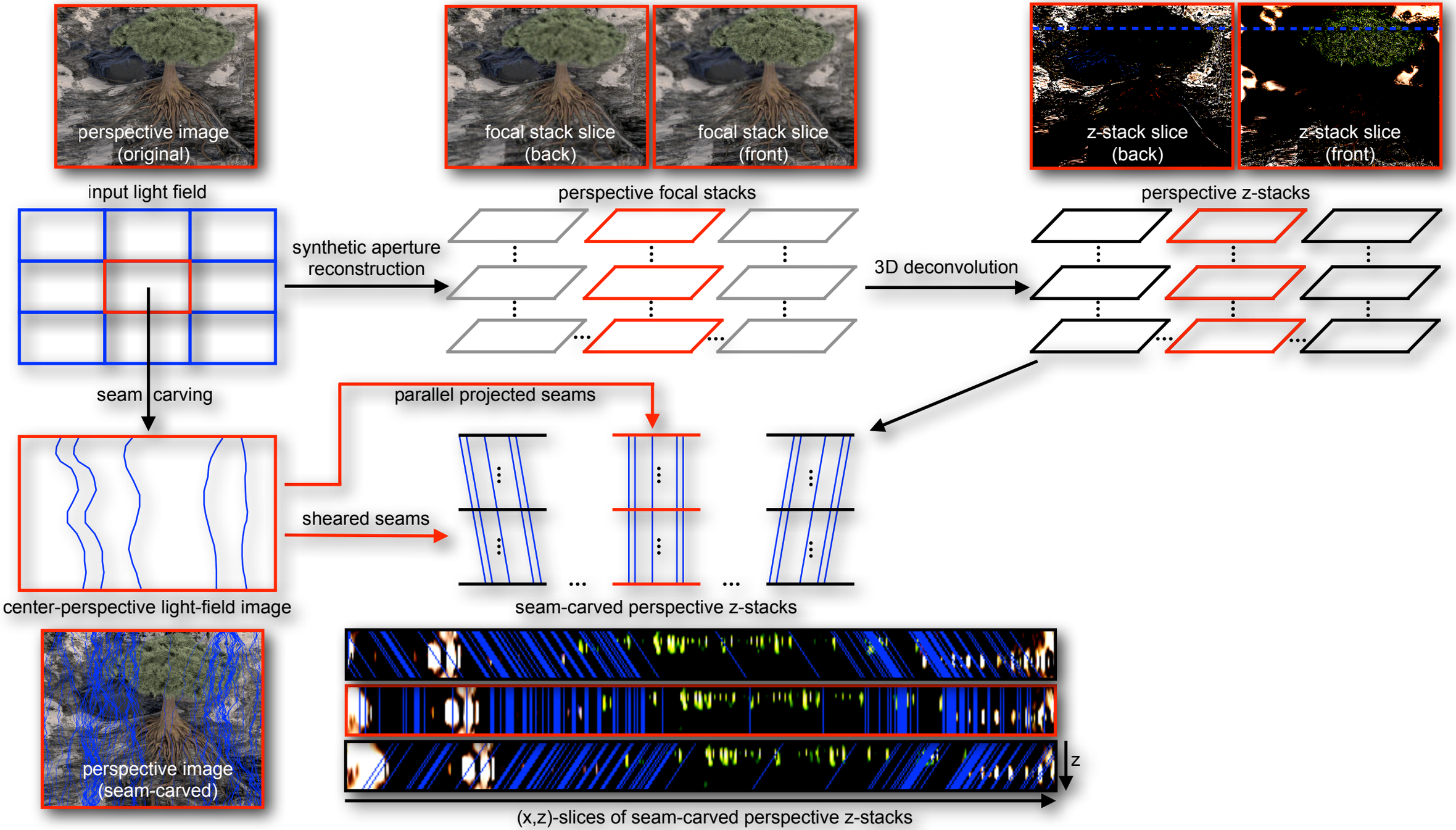
Eurographics 2012



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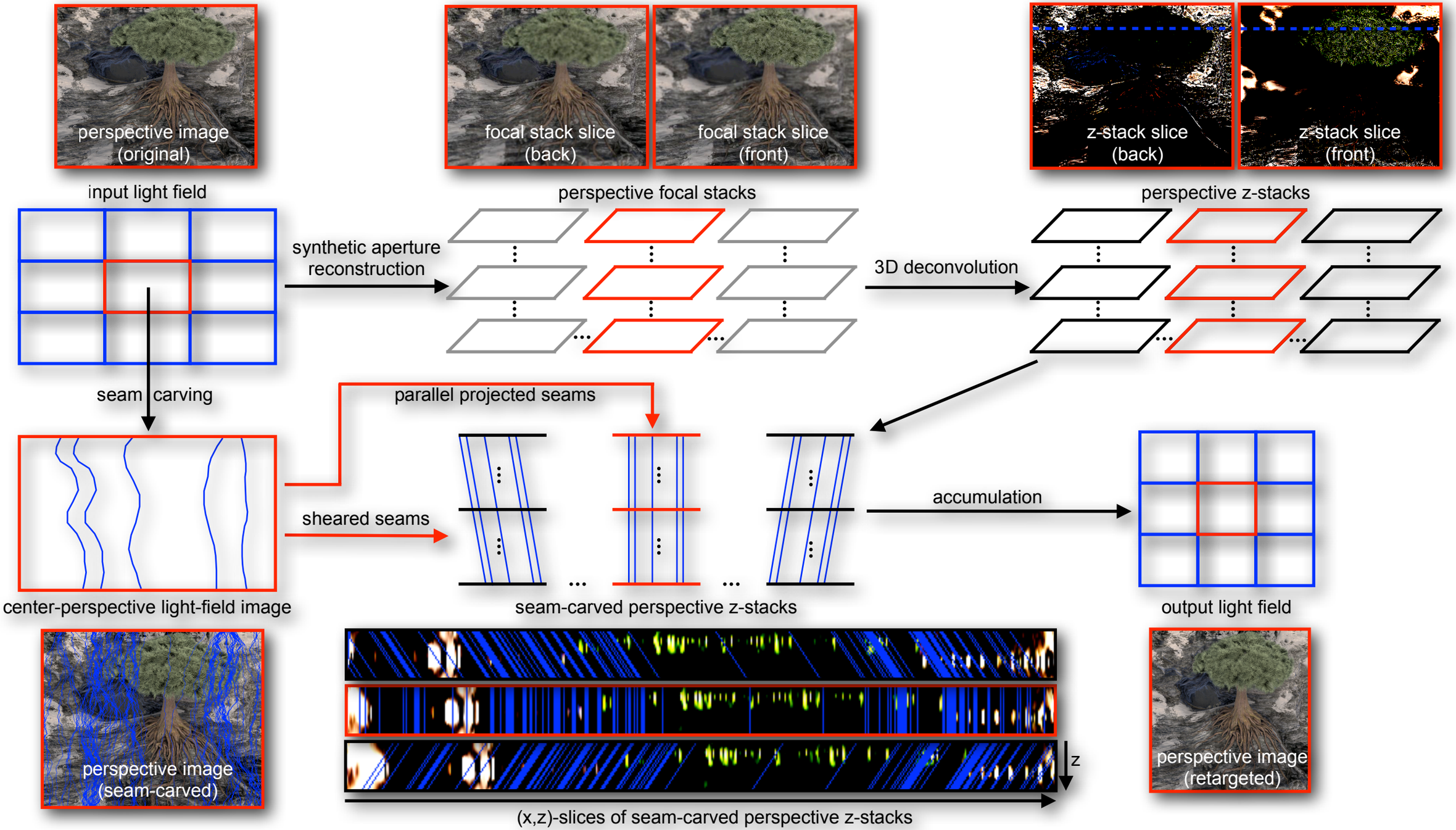
Light-Field Retargeting

Eurographics 2012



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Panorama Imaging

Panorama Imaging

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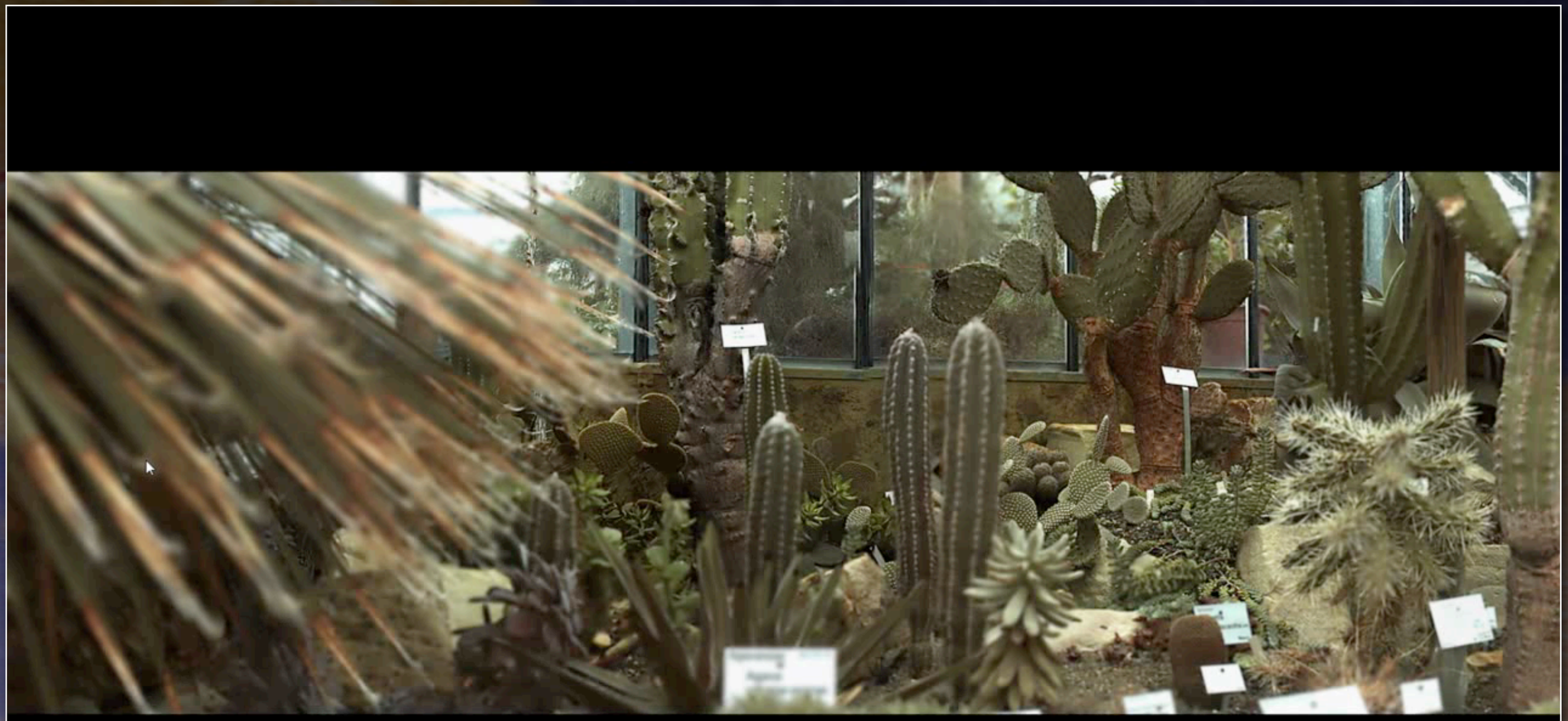
Panorama Light-Field Imaging

ACM Siggraph 2012



changing focus

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Panorama Light-Field Imaging

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input sub-light-fields

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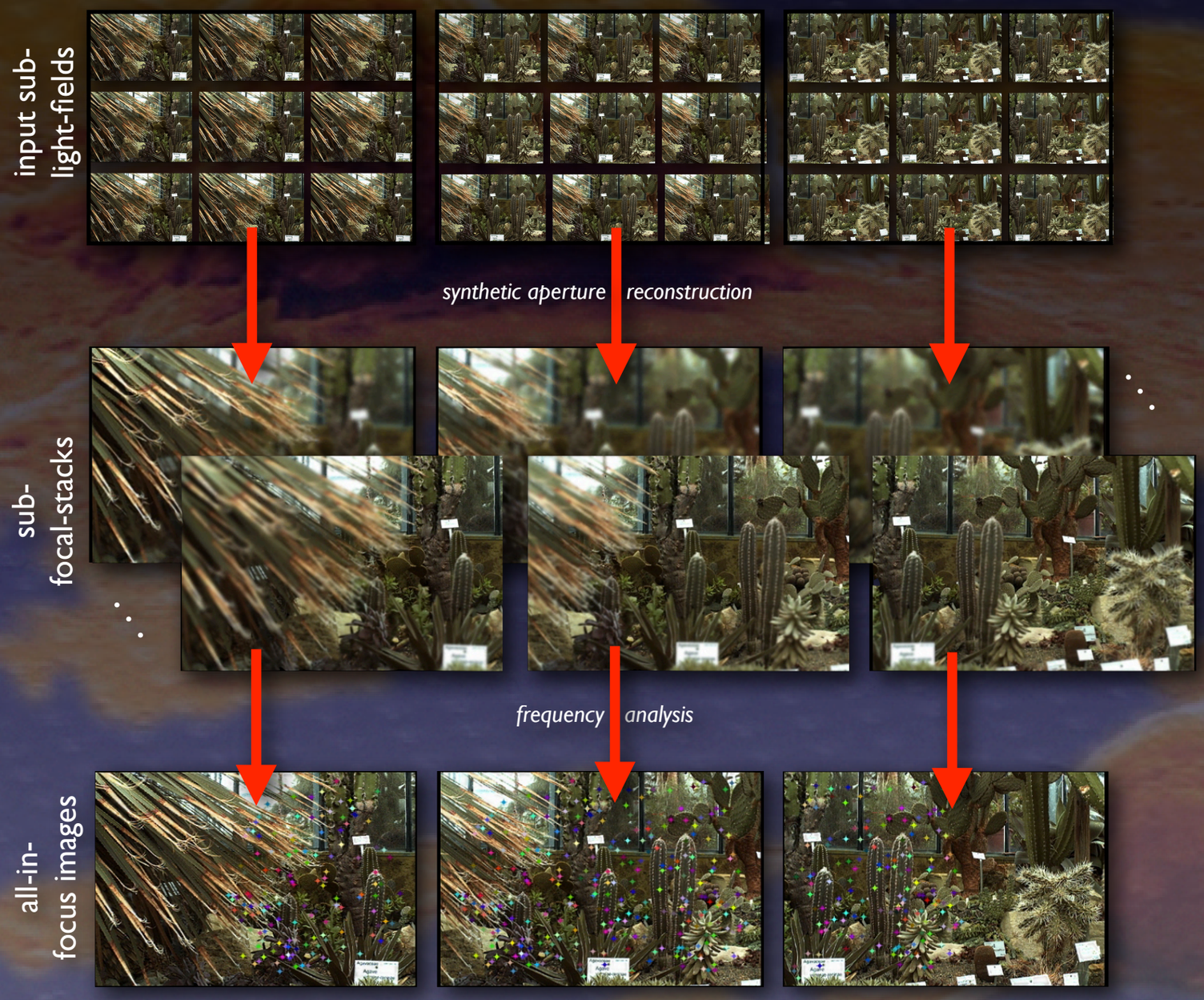
Panorama Light-Field Imaging

ACM Siggraph 2012



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Panorama Light-Field Imaging

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Panorama Light-Field Imaging

2.54 gigarays: 17,885×1,260x11x11 = 7.61 GB

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Panorama Light-Field Imaging

2.54 gigarays: 17,885×1,260x11x11 = 7.61 GB

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Rendering Gigaray Light Fields!

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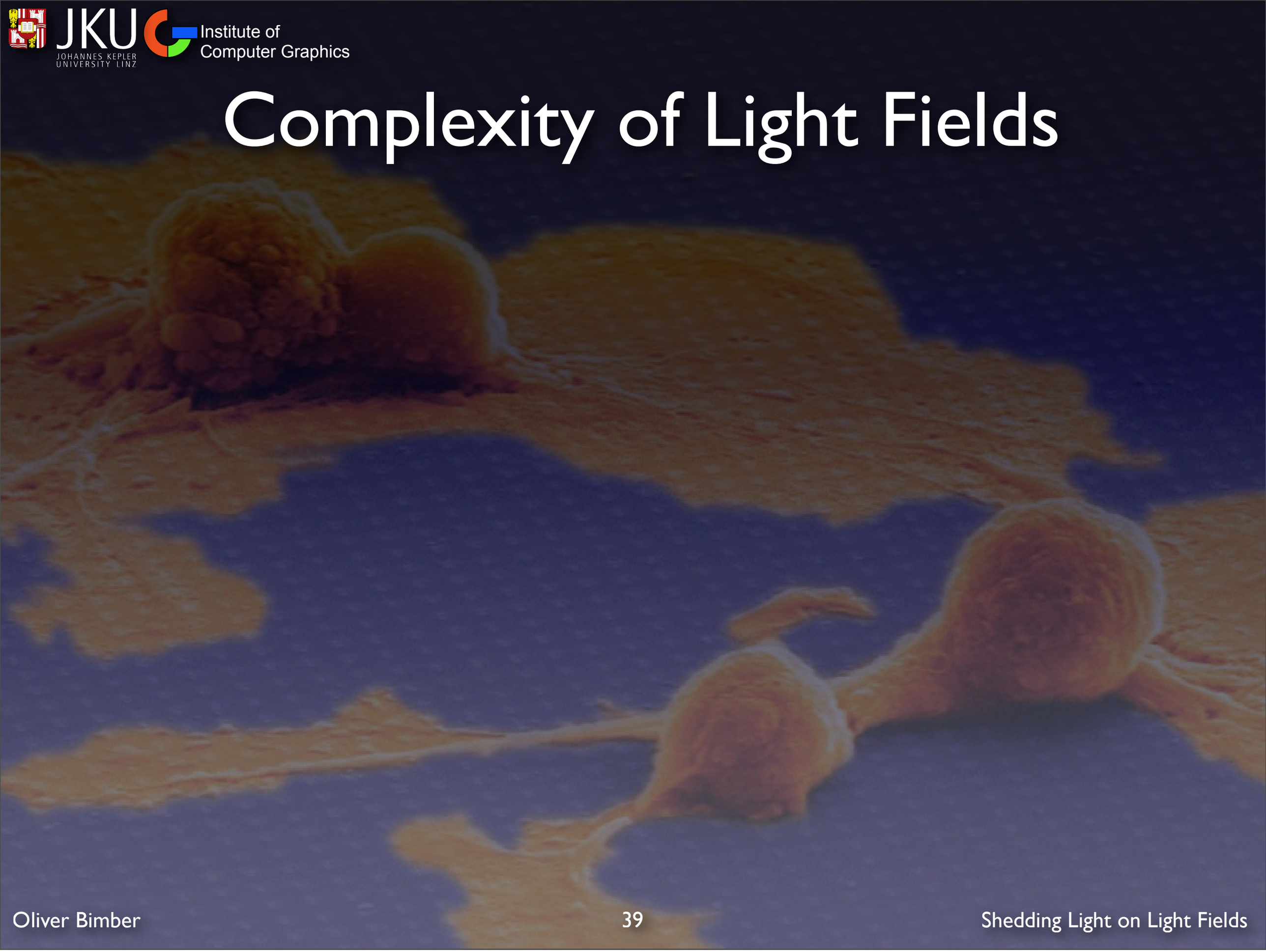
Complexity of Light Fields



Complexity of Light Fields

$2048^2 \times 19^2$

Complexity of Light Fields

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Complexity of Light Fields

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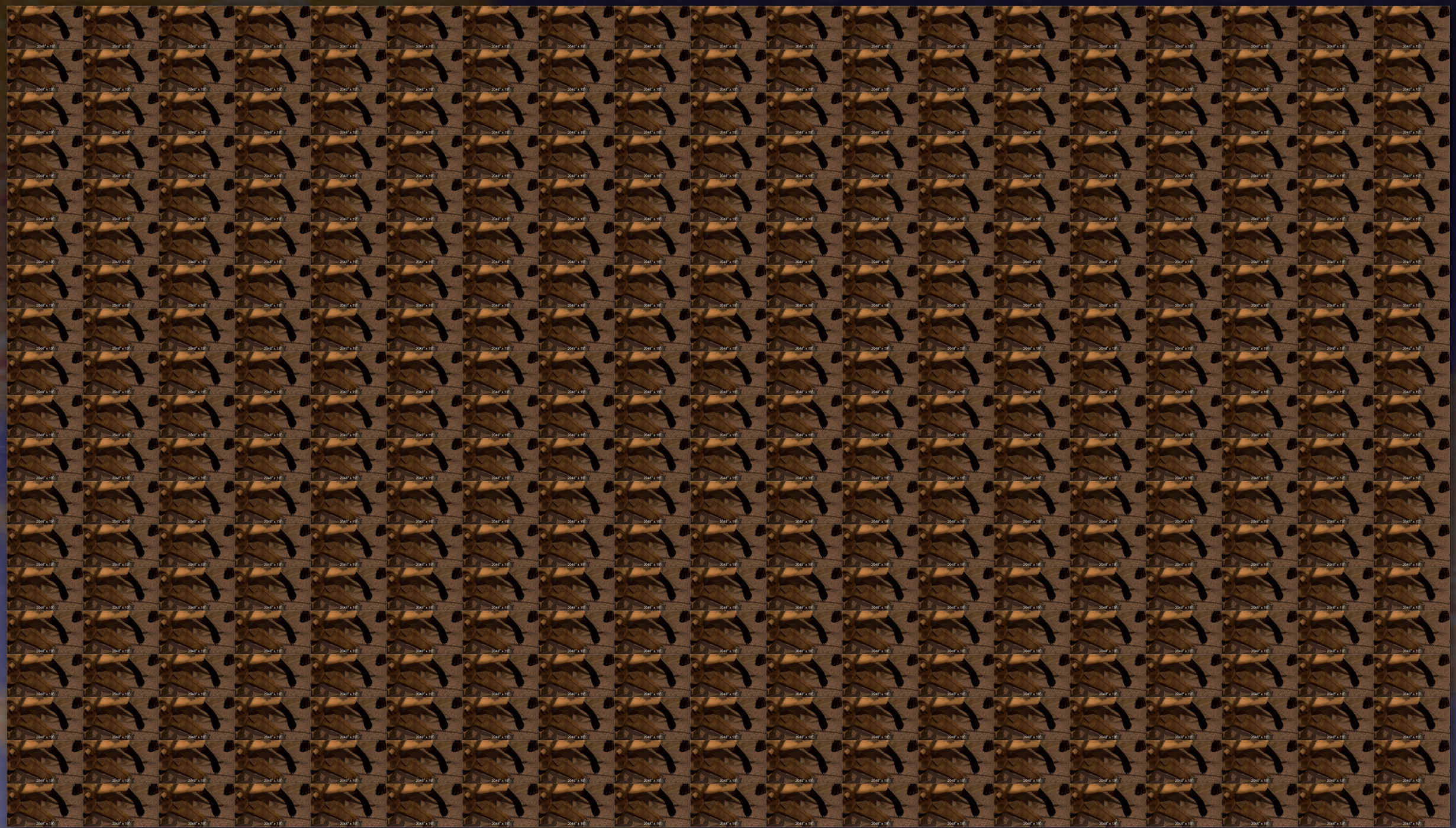
Complexity of Light Fields



Light-Field Caching

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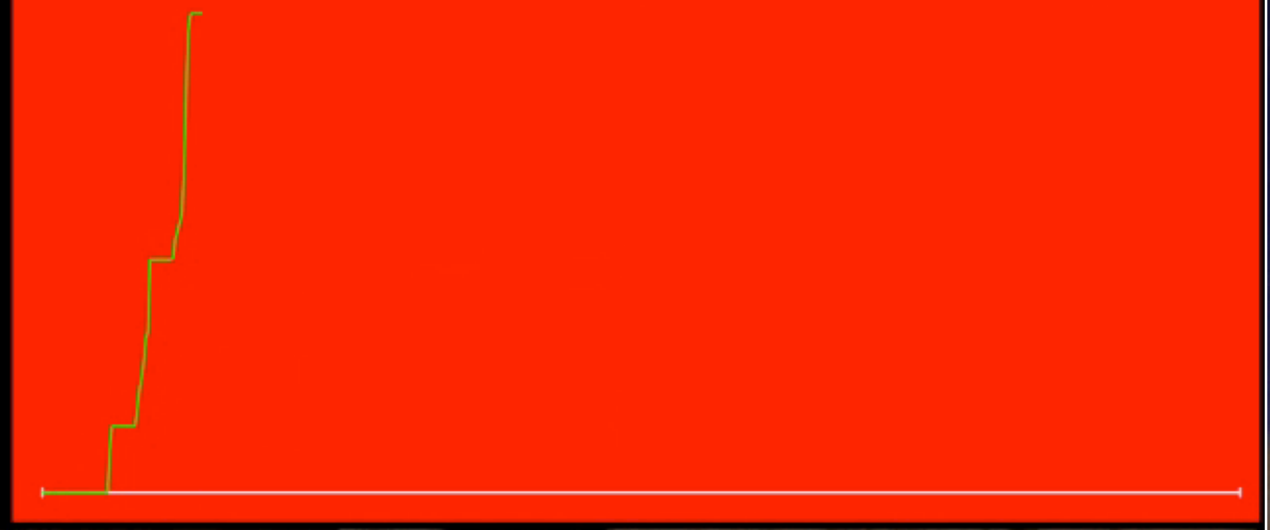
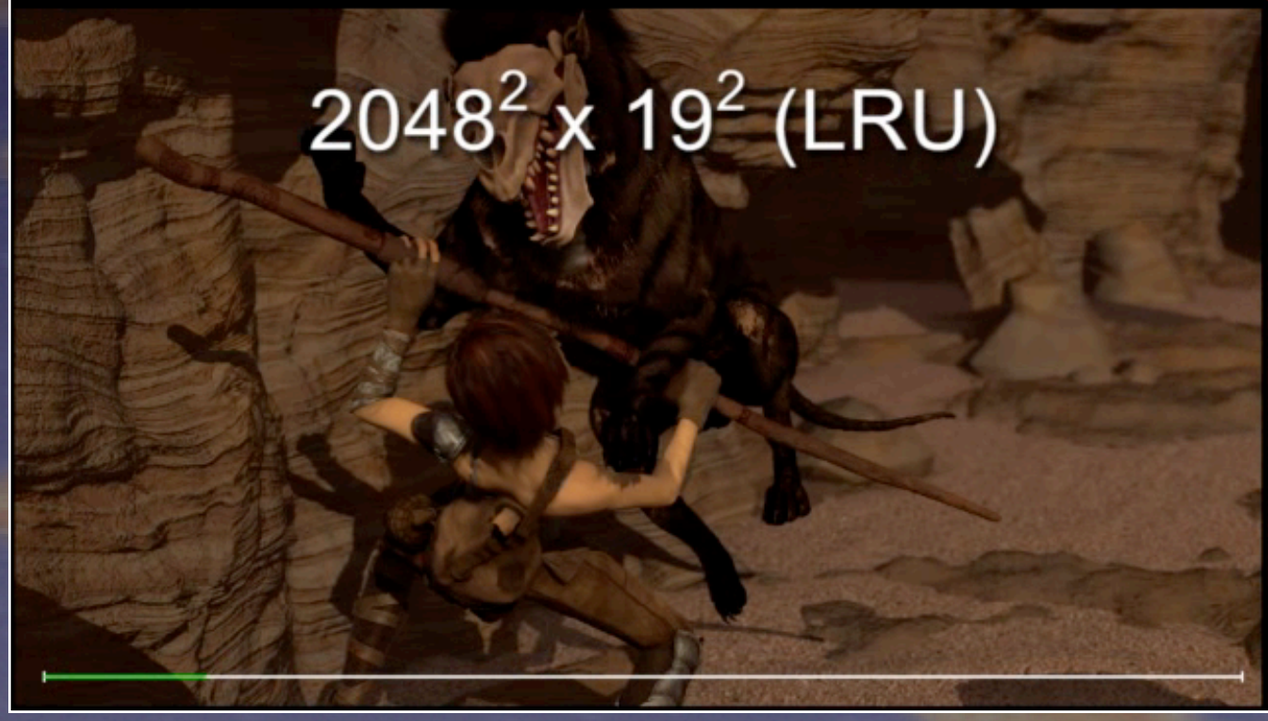
$512^2 \times 19^2$

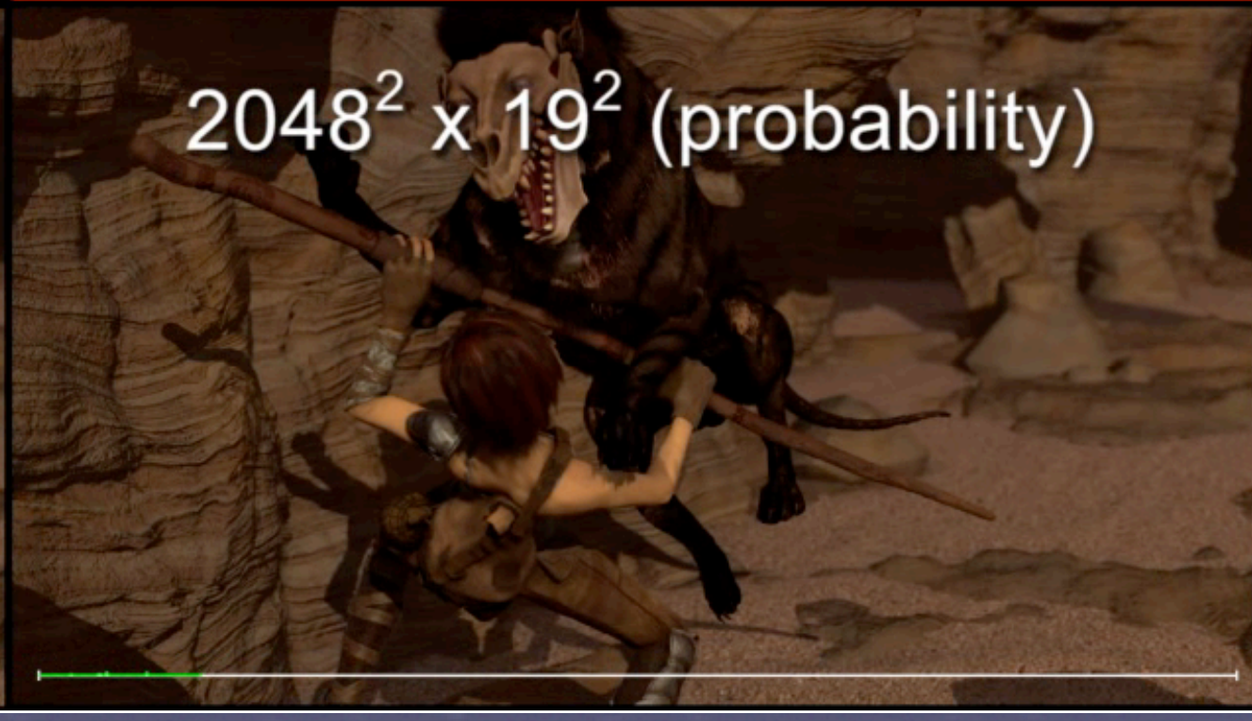
$2048^2 \times 19^2$ (on-demand)



$2048^2 \times 19^2$ (LRU)



$2048^2 \times 19^2$ (probability)

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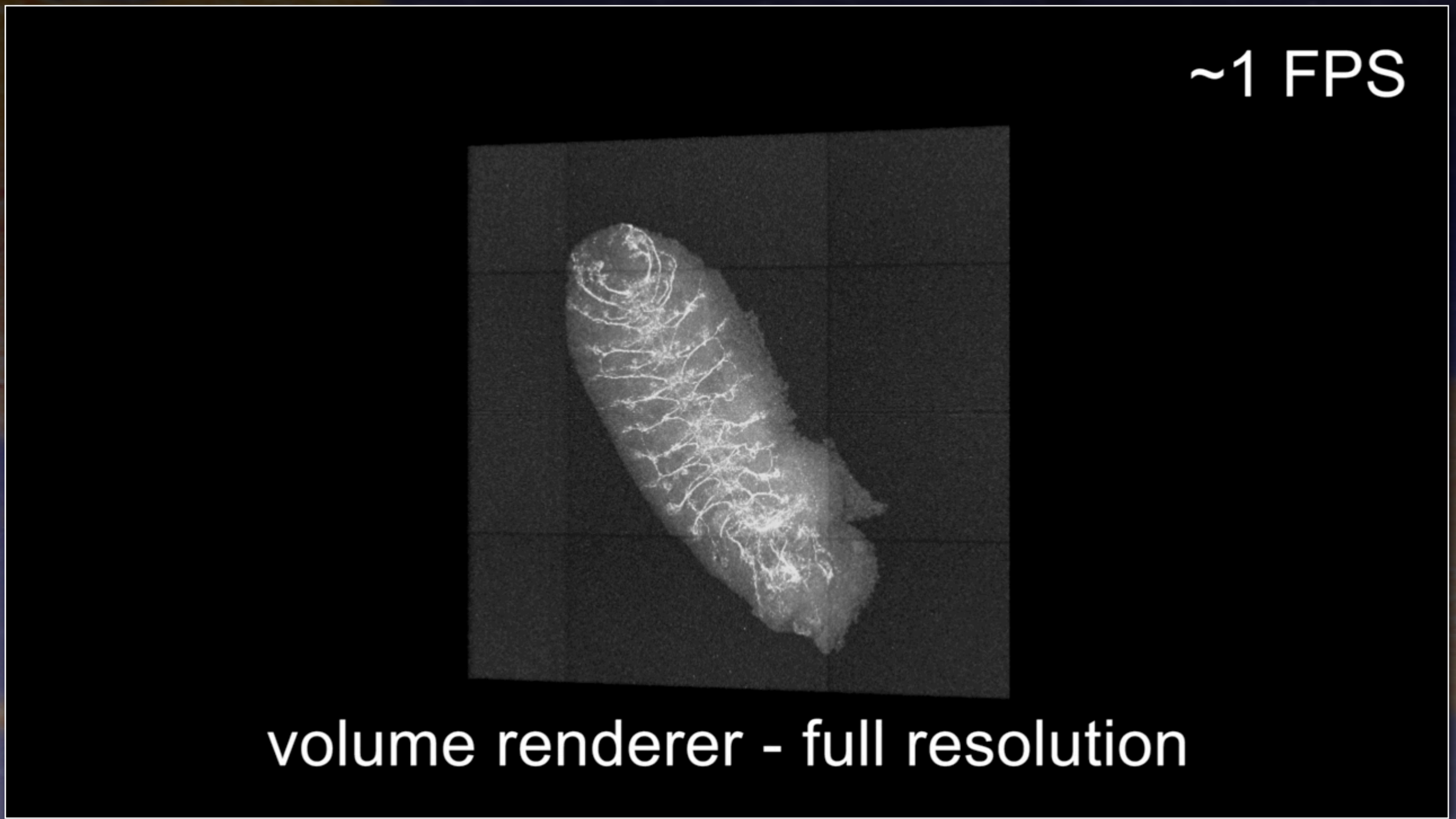
Light Fields meet Volumes

Volume Rendering



volume: 4,096×4,0960×61 (2.86 GB)

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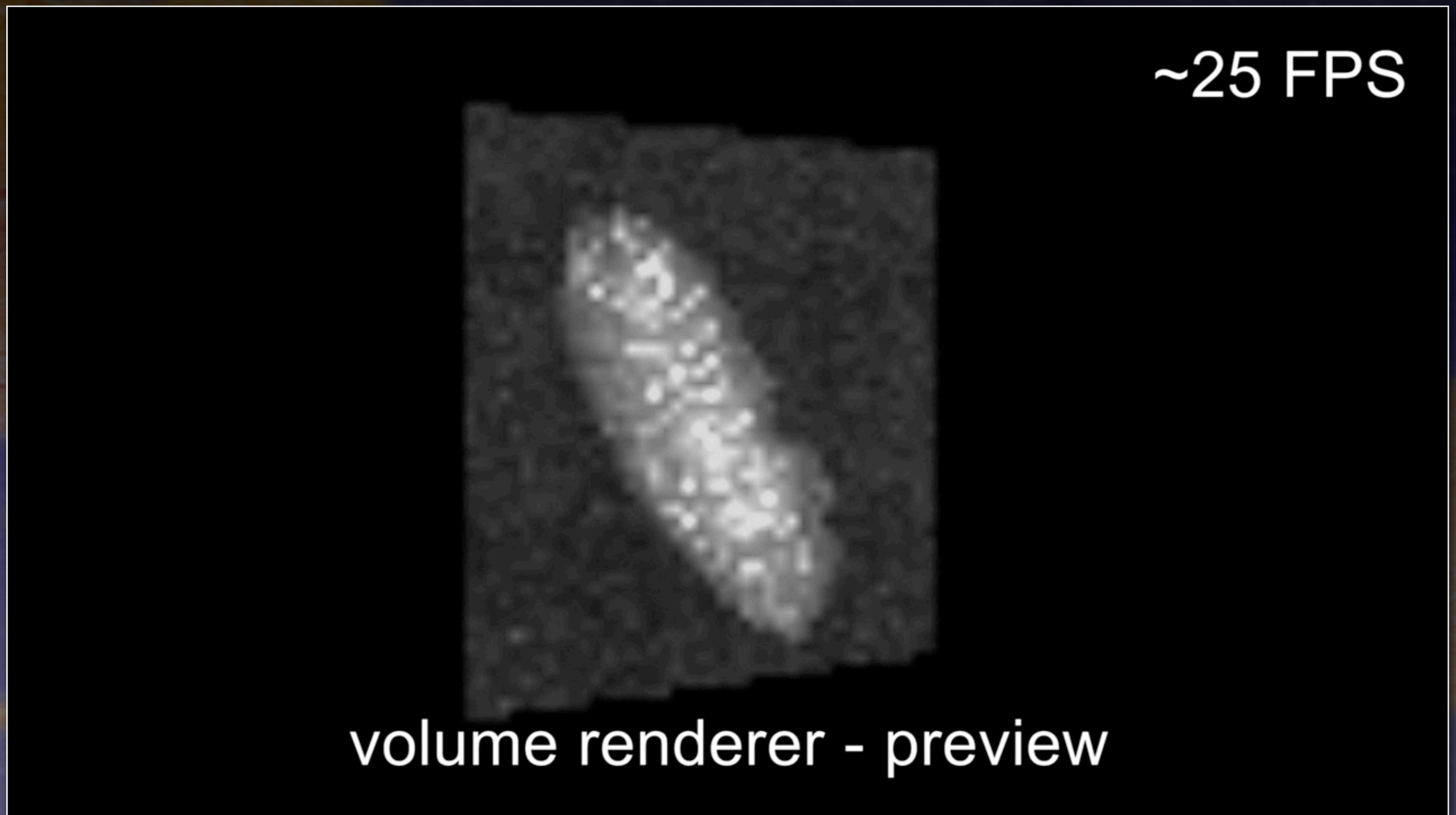
Volume Rendering



volume: 4,096×4,0960×61 (2.86 GB)

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Light-Field-Cached Volume Rendering

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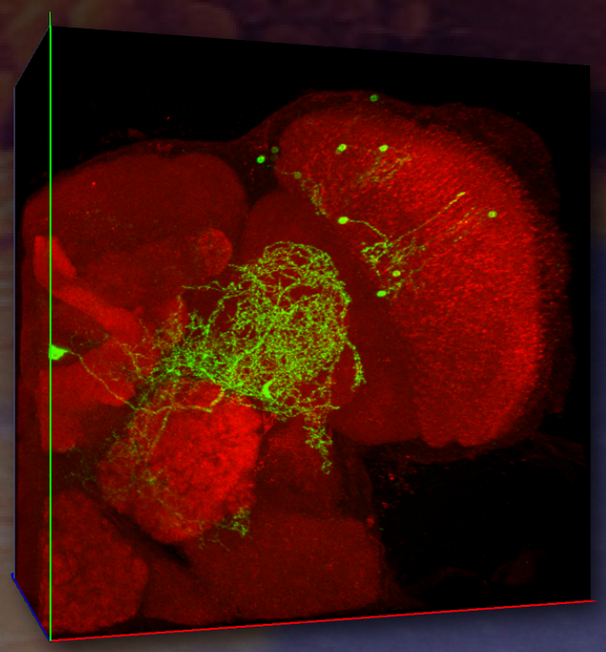

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Light-Field-Cached Volume Rendering

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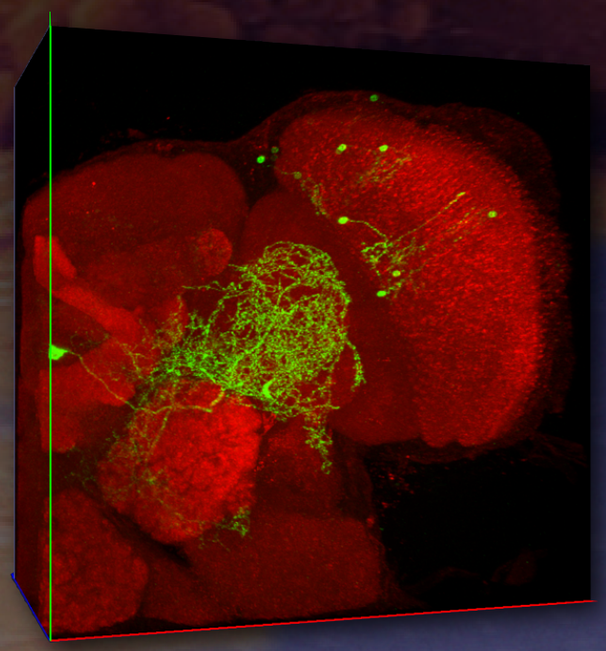
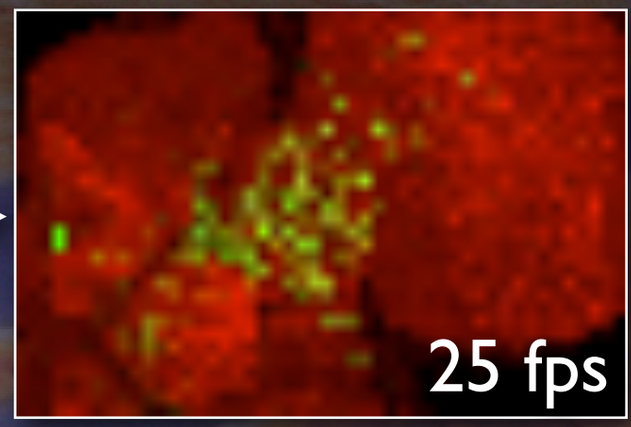


during navigation



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Light-Field-Cached Volume Rendering

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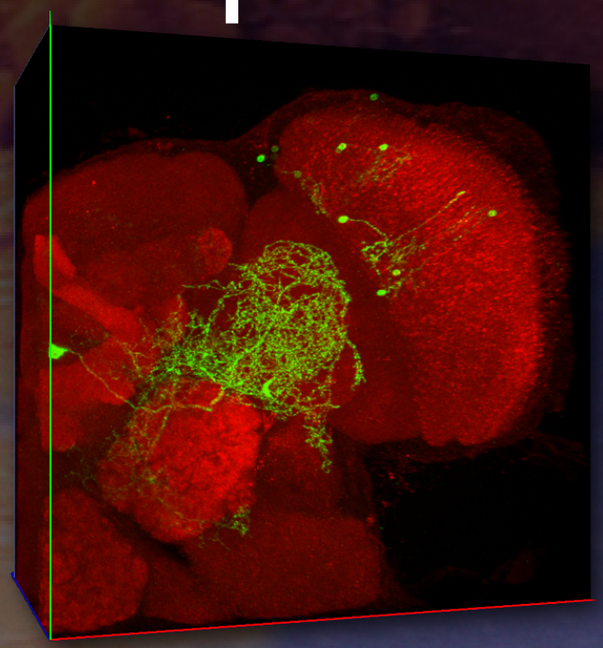
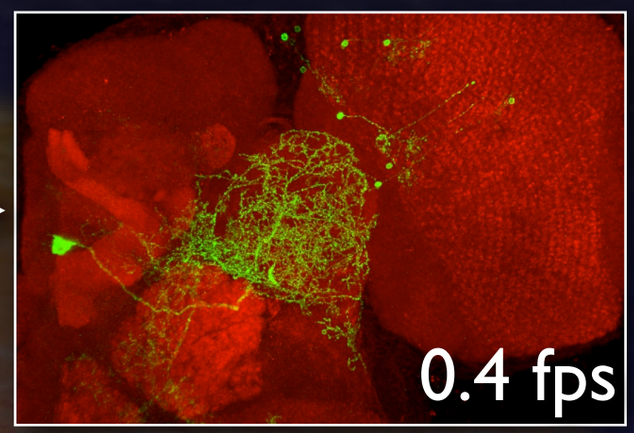
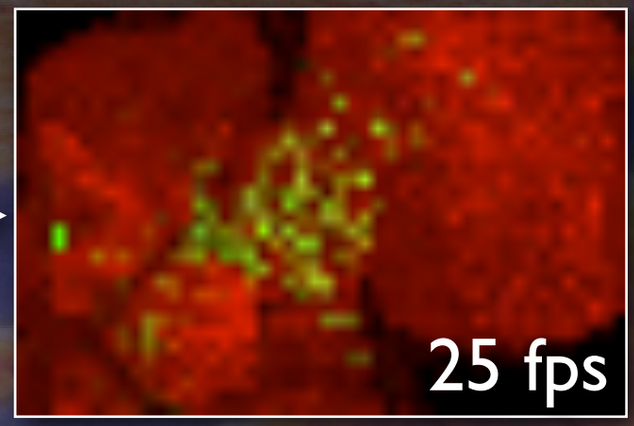
navigation stopped





during navigation



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Light-Field-Cached Volume Rendering

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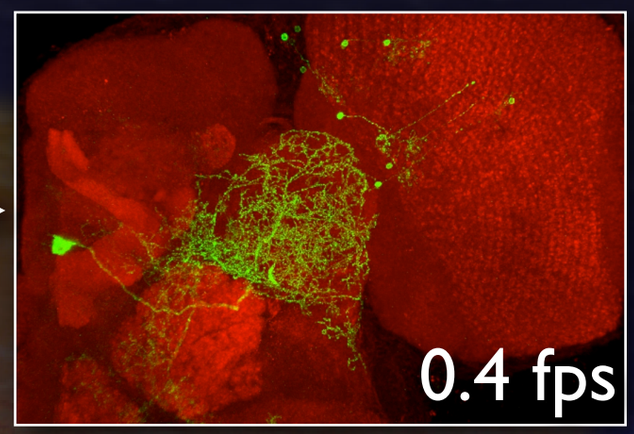
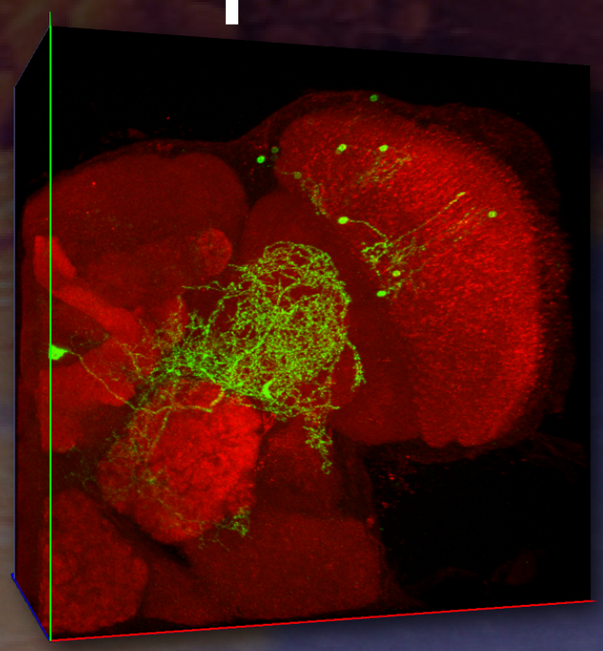
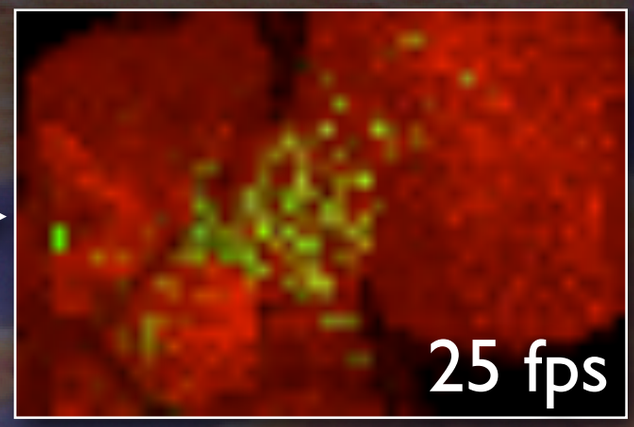
navigation stopped

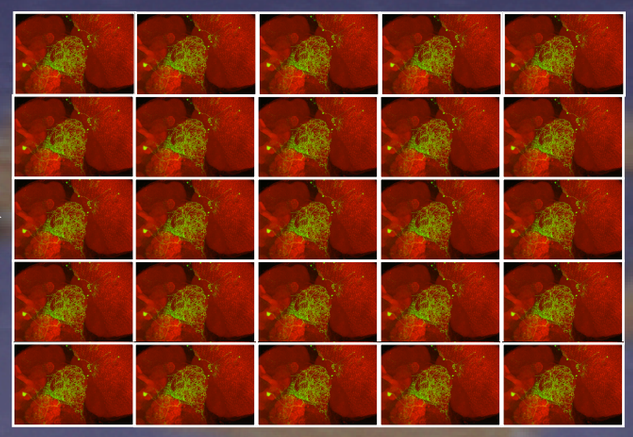




during navigation



during idle times



light-field cache

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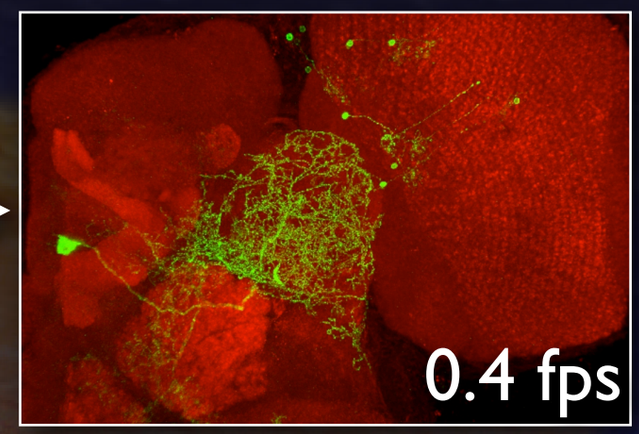
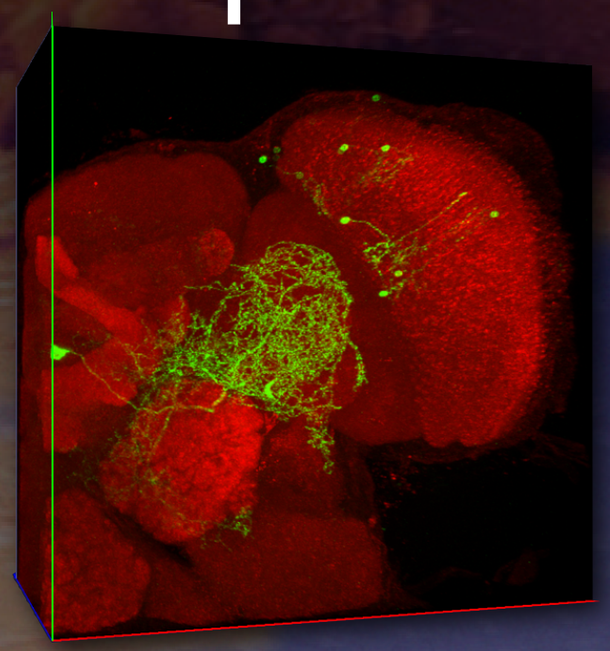
Light-Field-Cached Volume Rendering

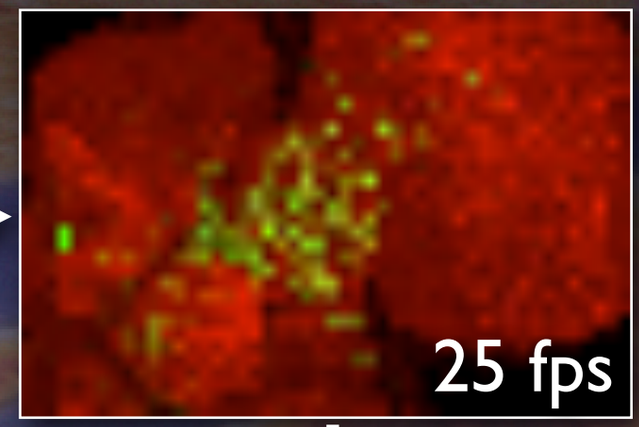
ACM Siggraph 2012

navigation stopped

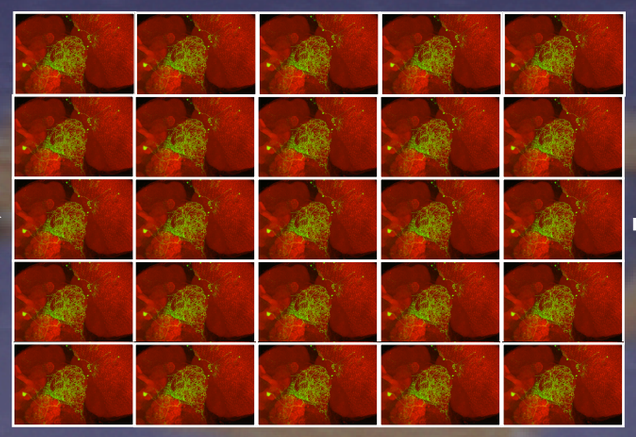




during navigation

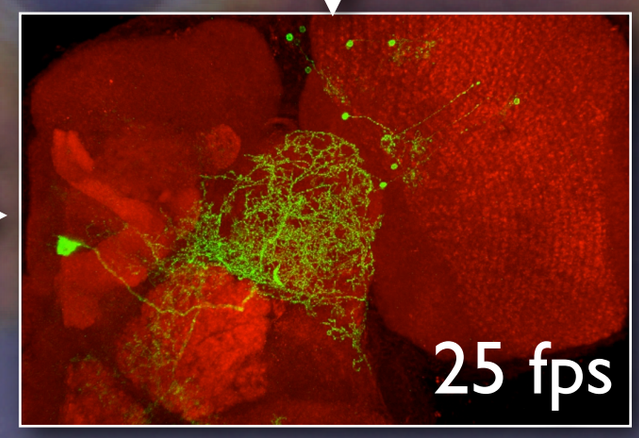


during idle times



light-field cache

during navigation



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Light-Field-Cached Volume Rendering

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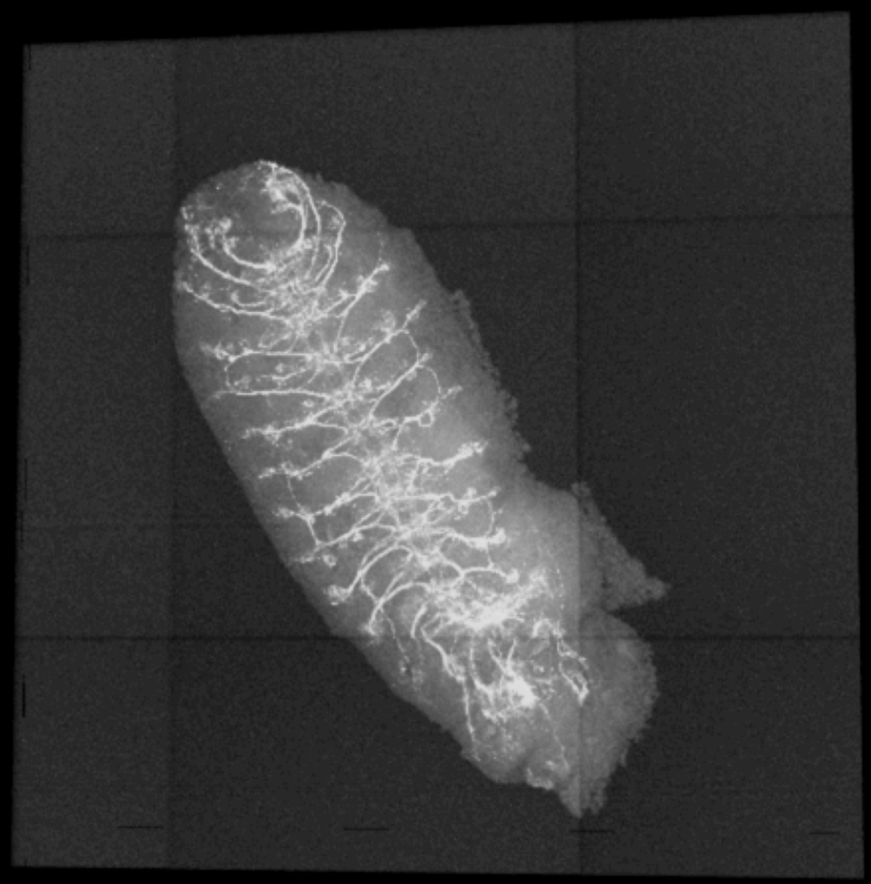
~25 FPS



light-field rendering + volume rendering

light field: 6,016×6,016×31×31 (34.8 gigarays)

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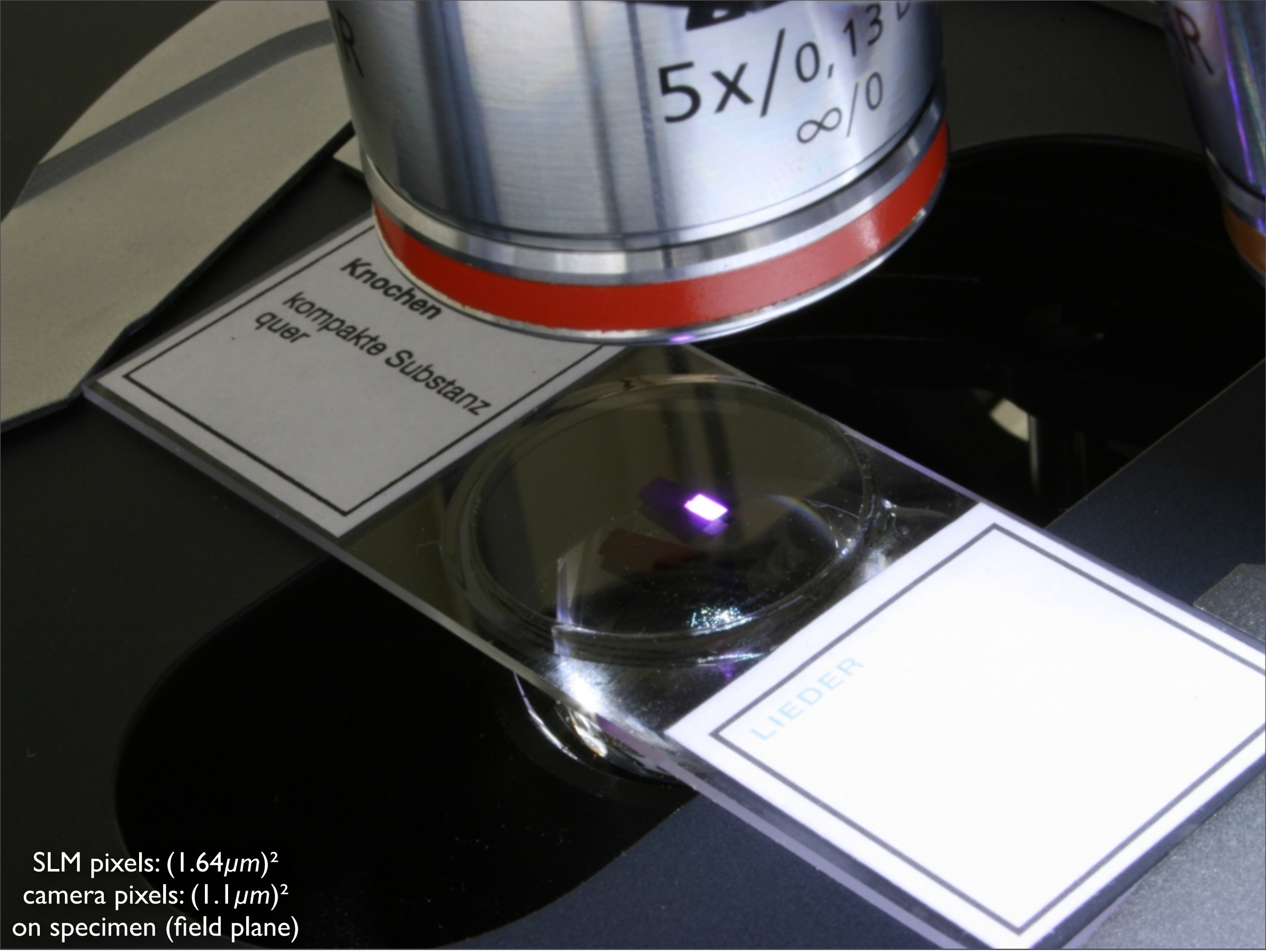
More Fun with Light Fields



SLM pixels: $(1.64\mu m)^2$
camera pixels: $(1.1\mu m)^2$
on specimen (field plane)

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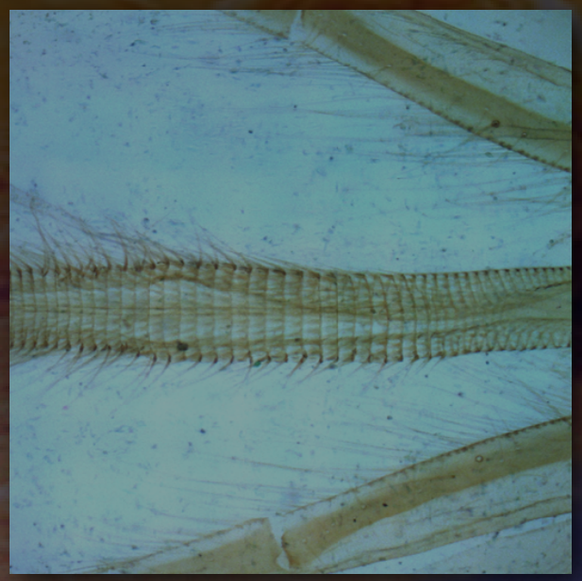
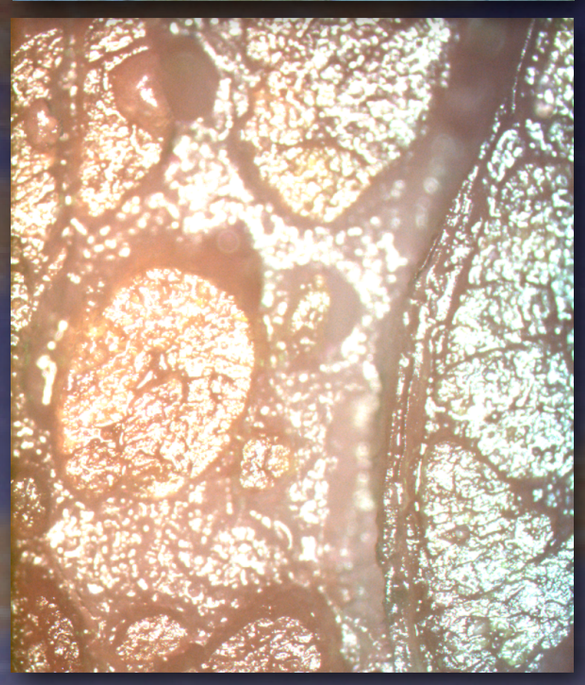
Closed-Loop Feedback Illumination

IEEE TVCG 2010



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Closed-Loop Feedback Illumination

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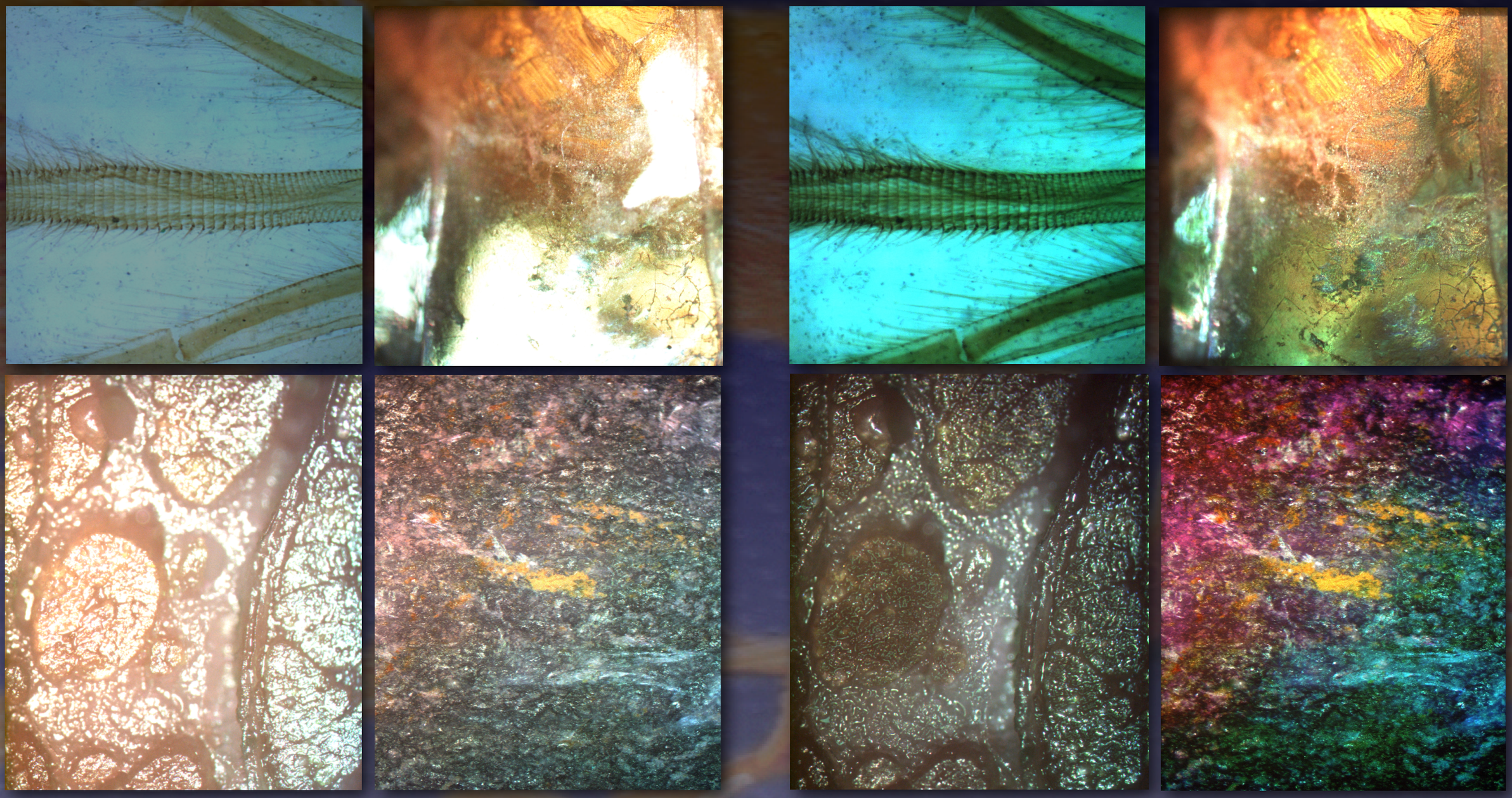

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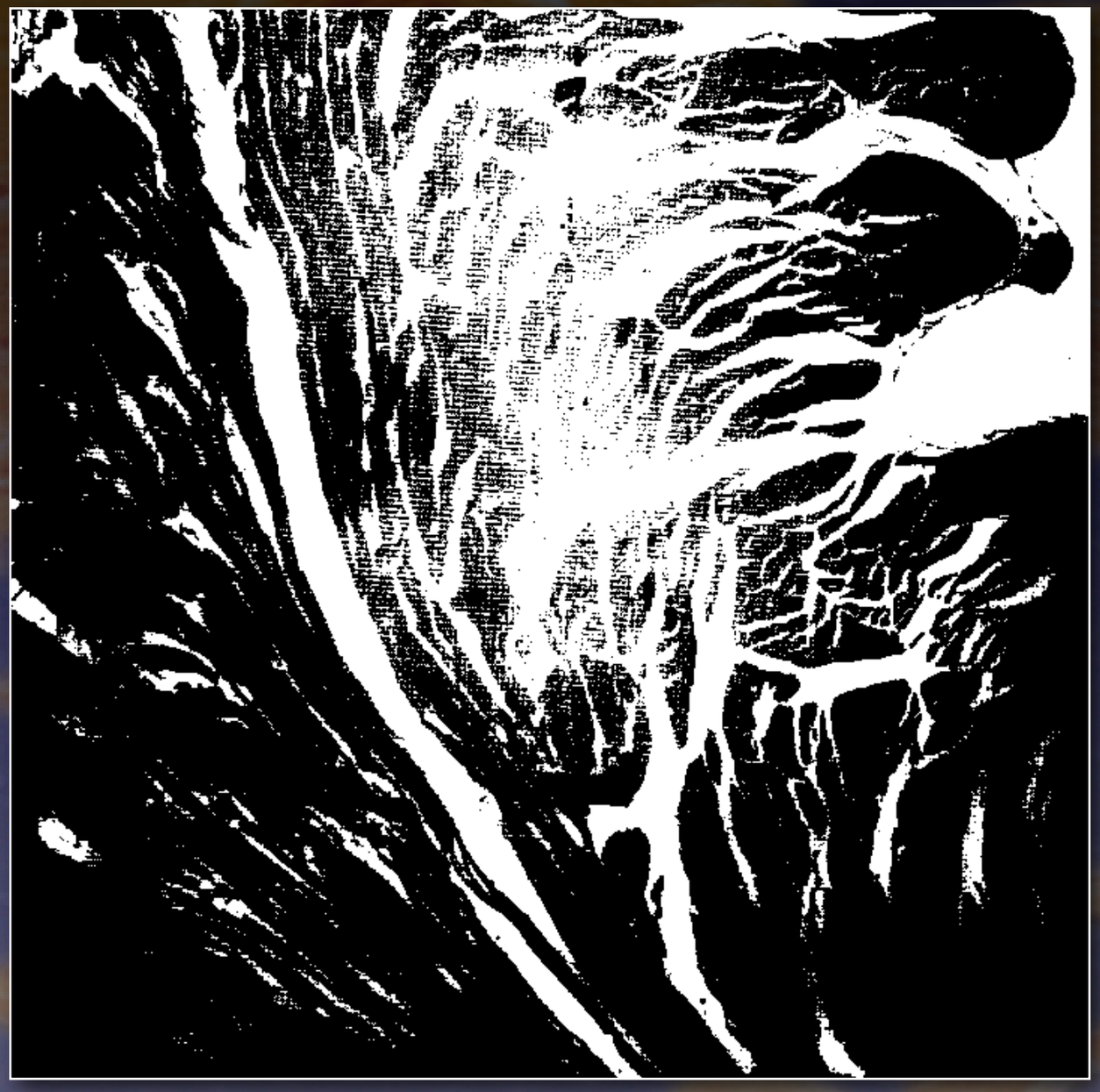

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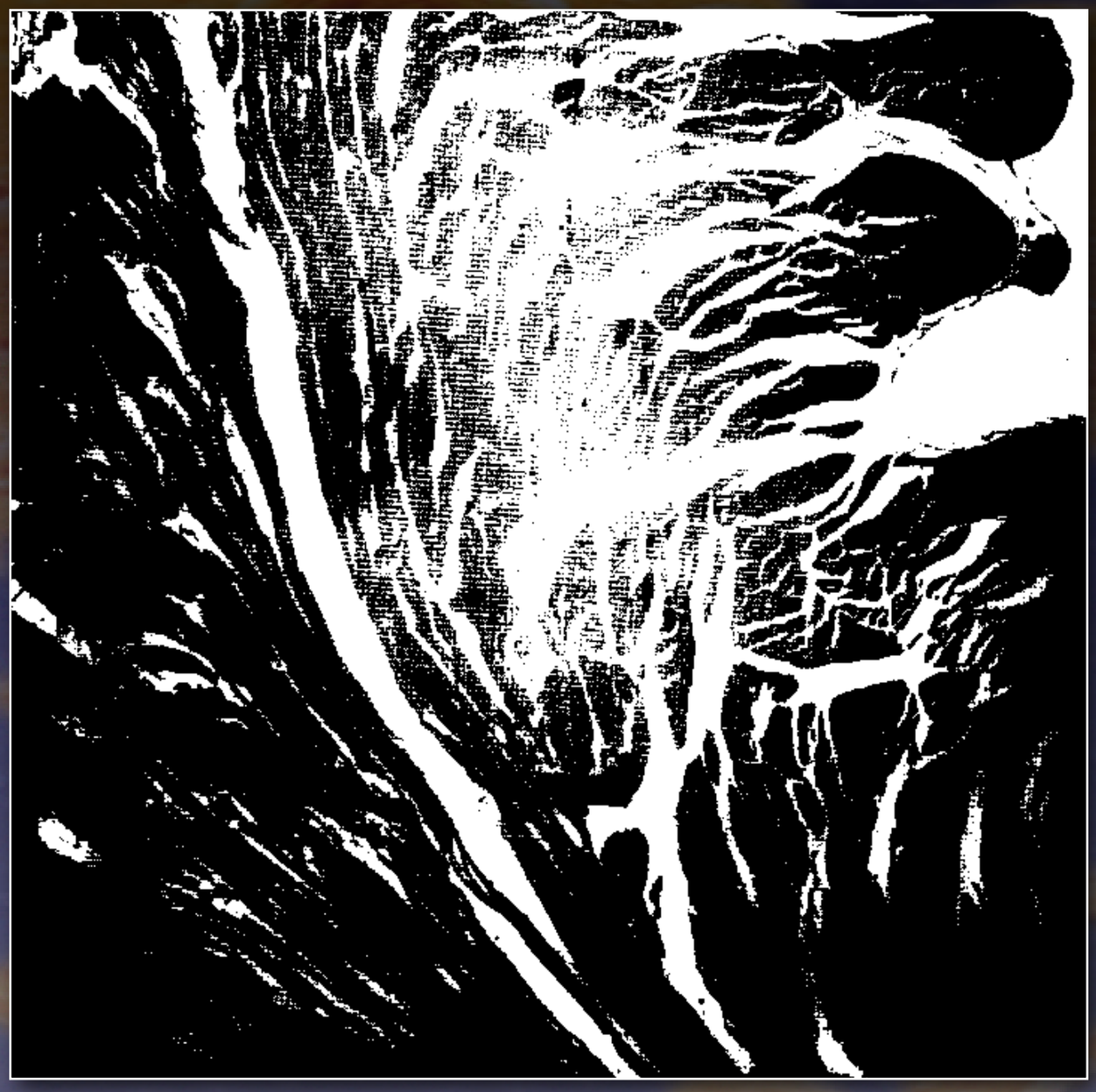
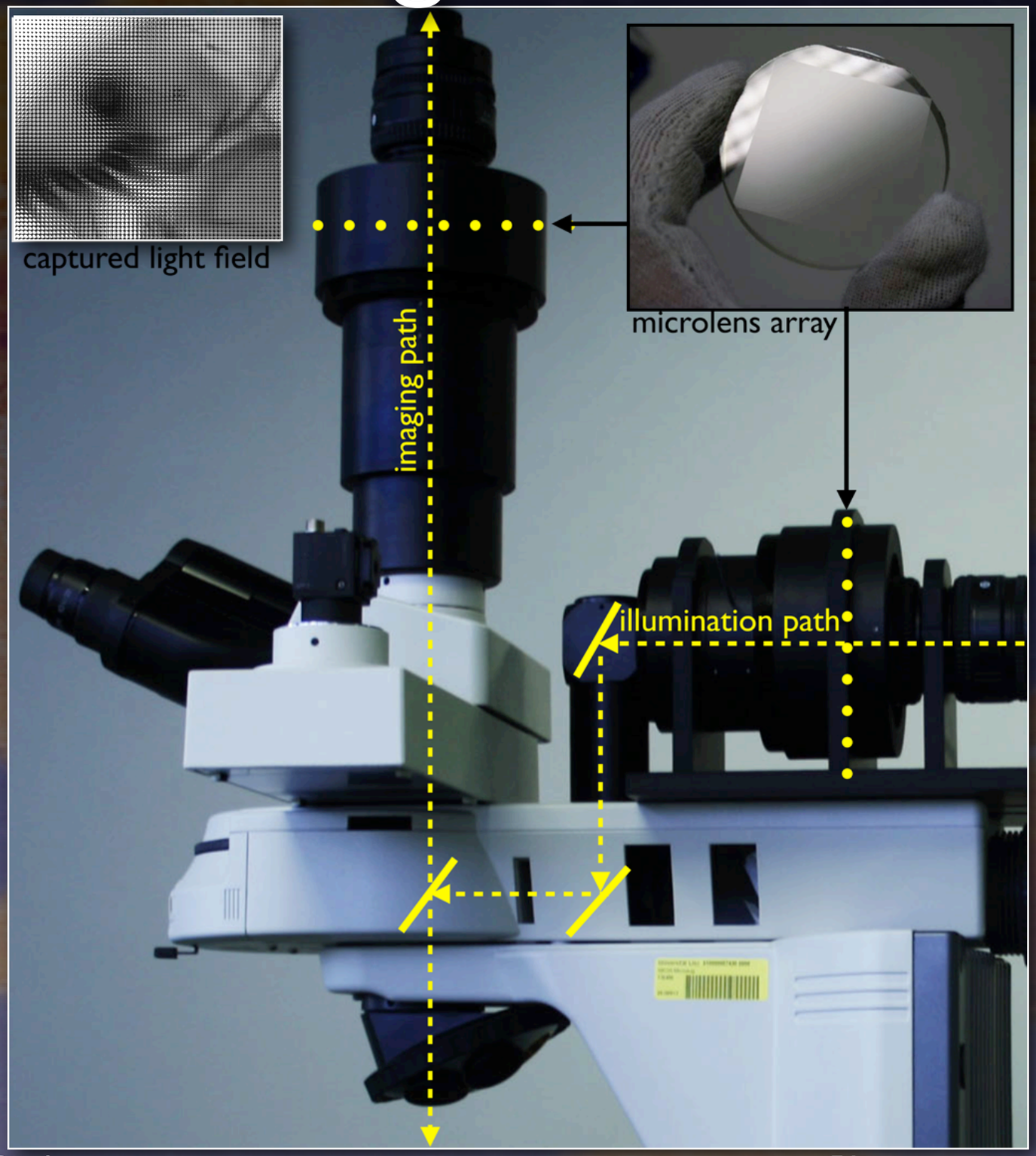
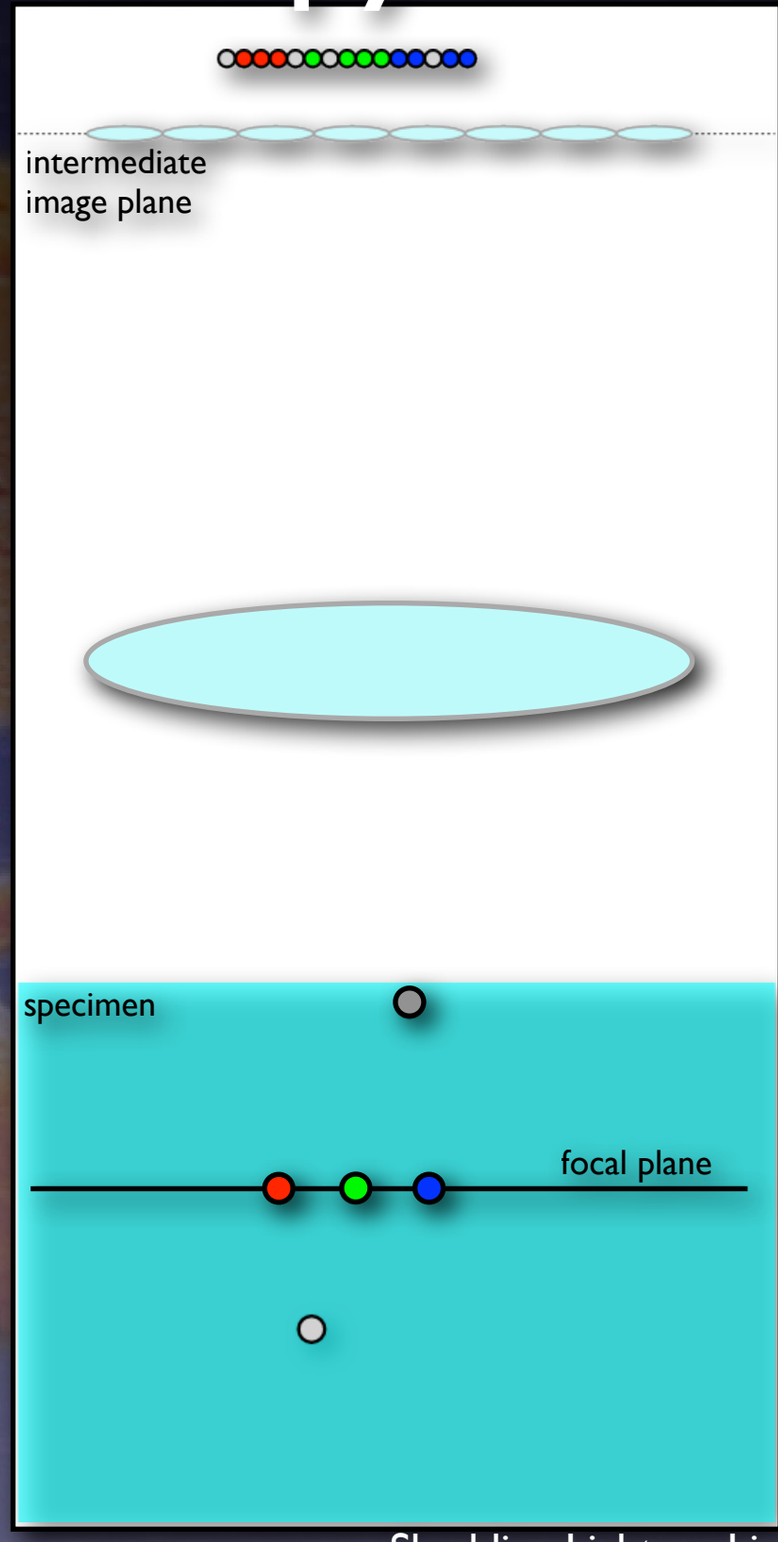


Light-Field Microscopy





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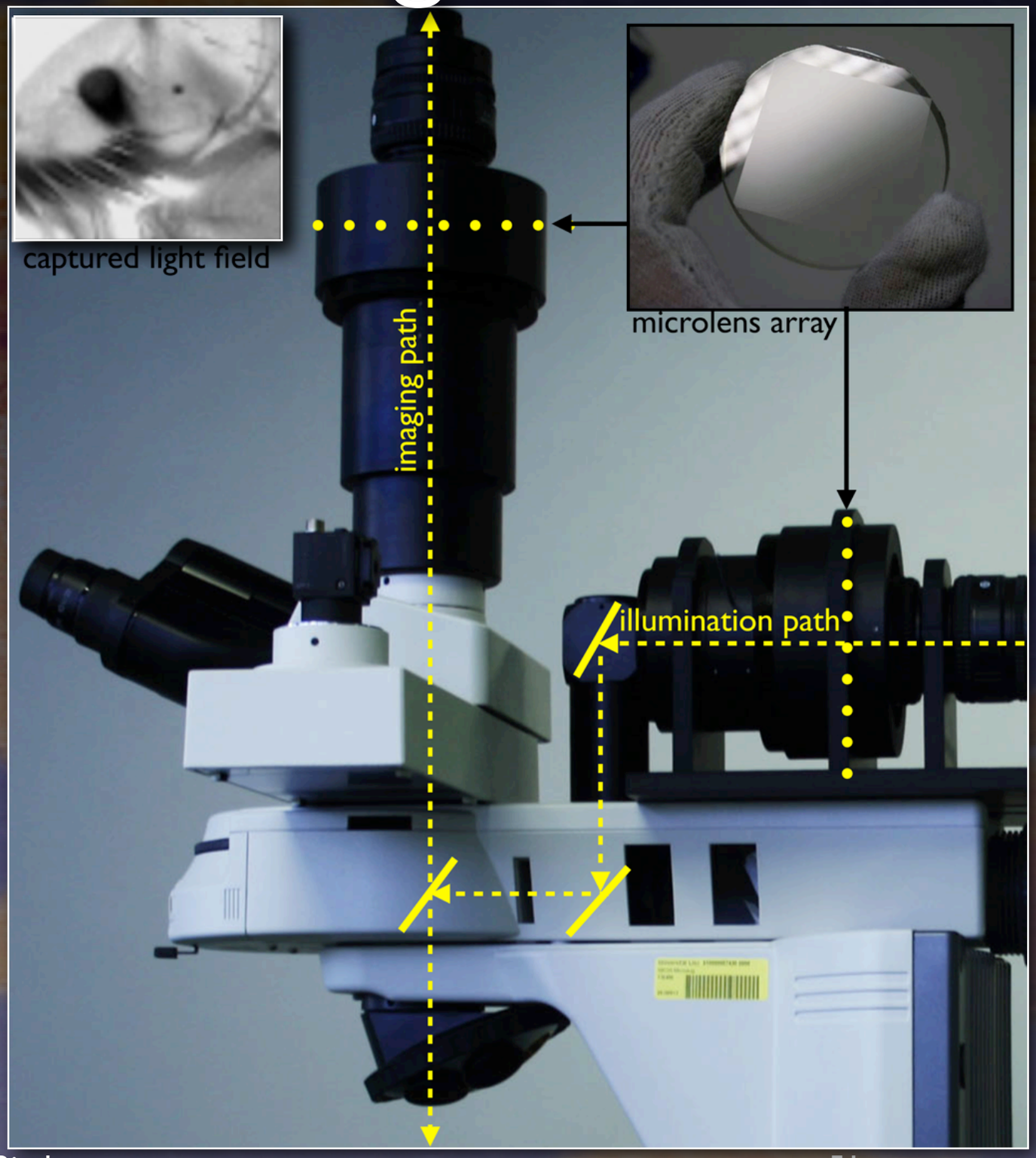

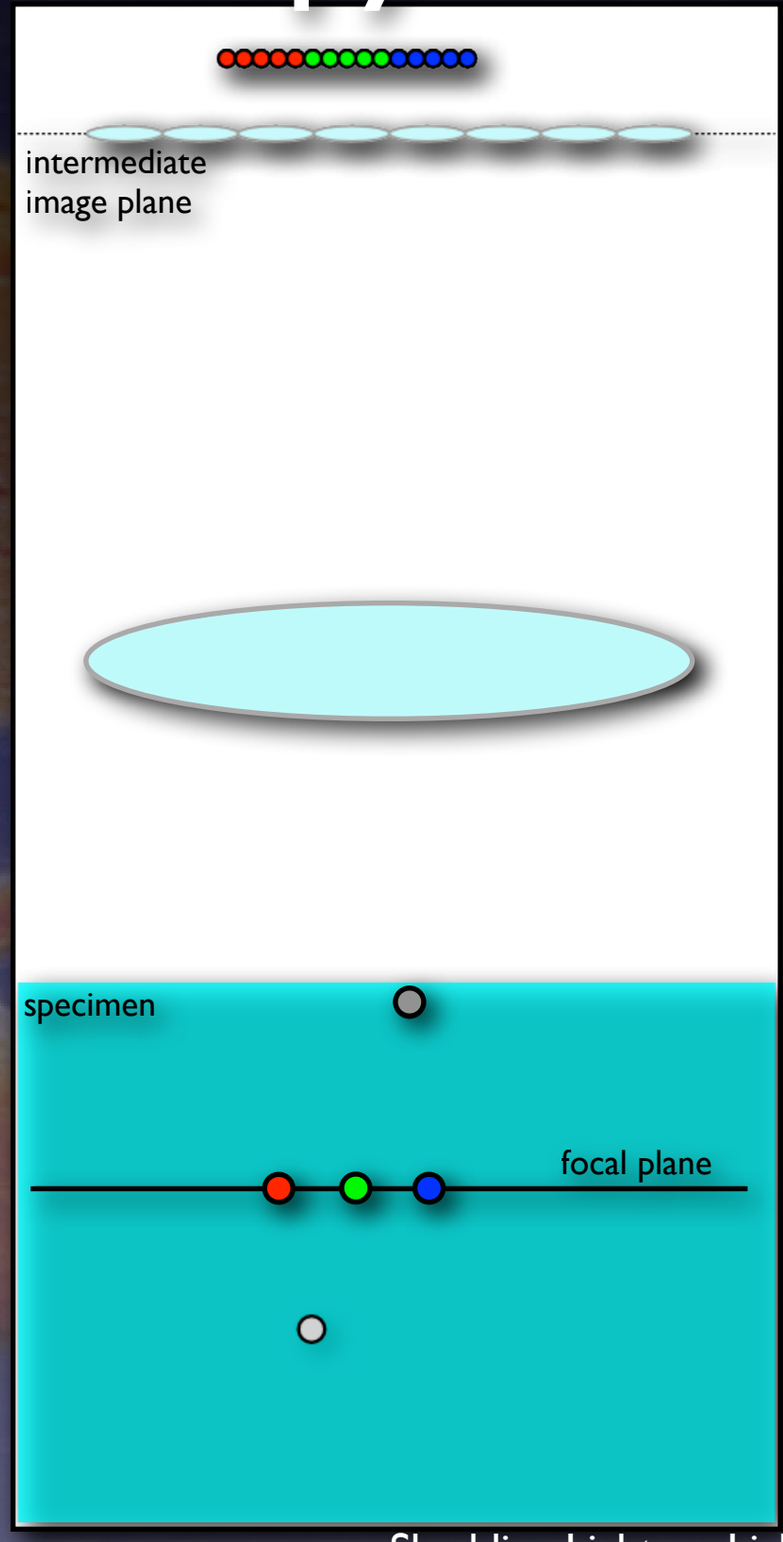

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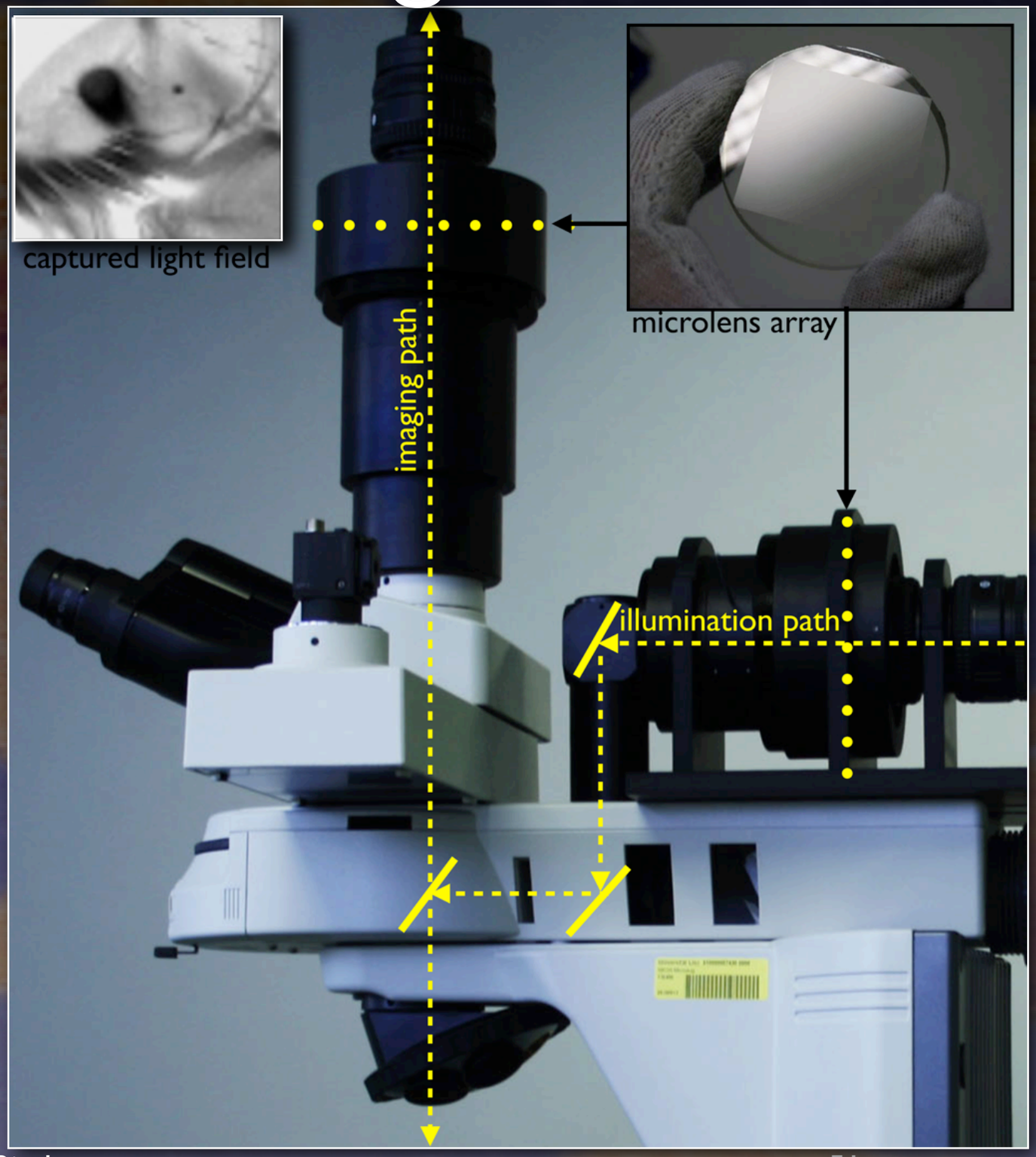

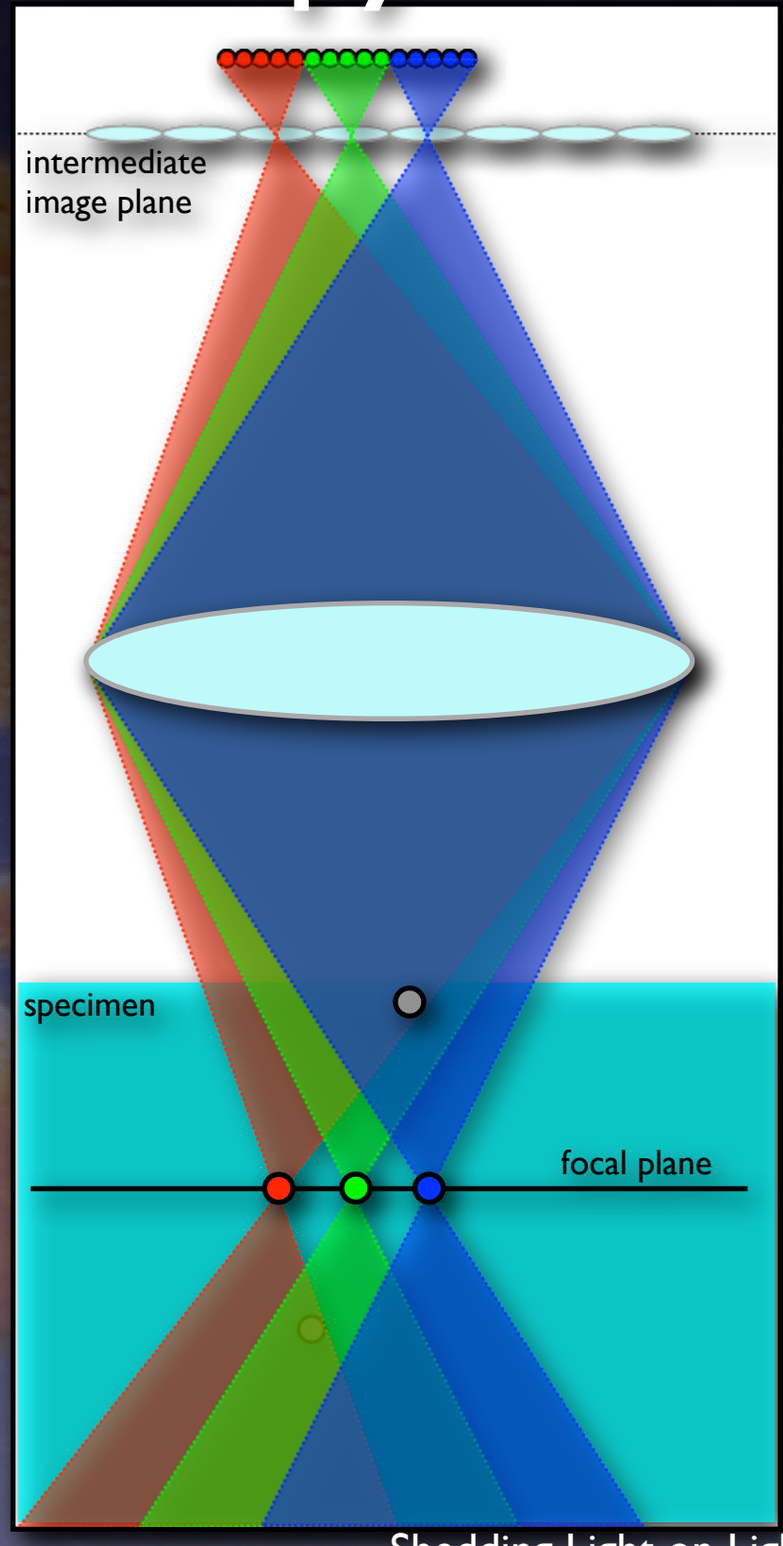

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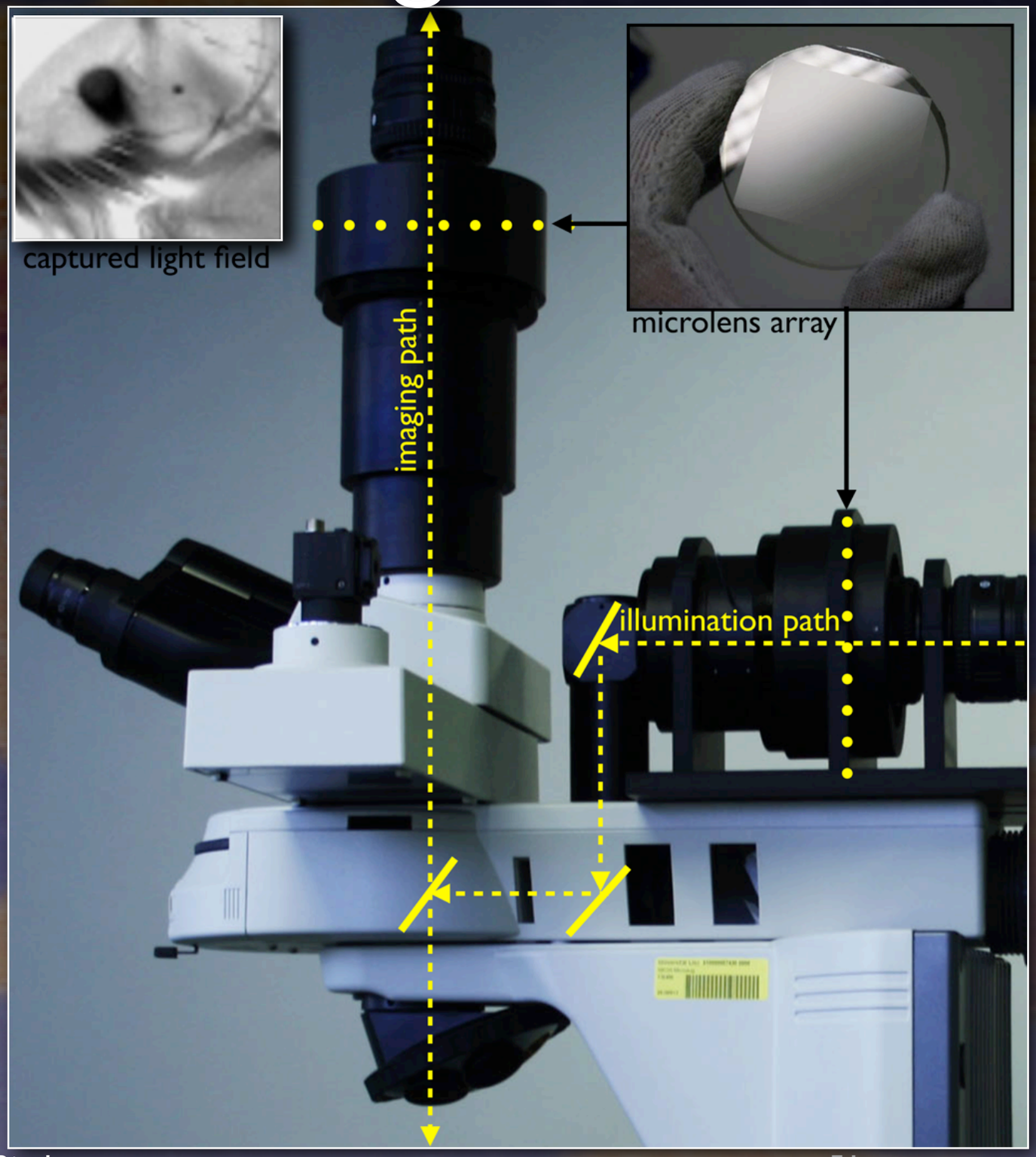

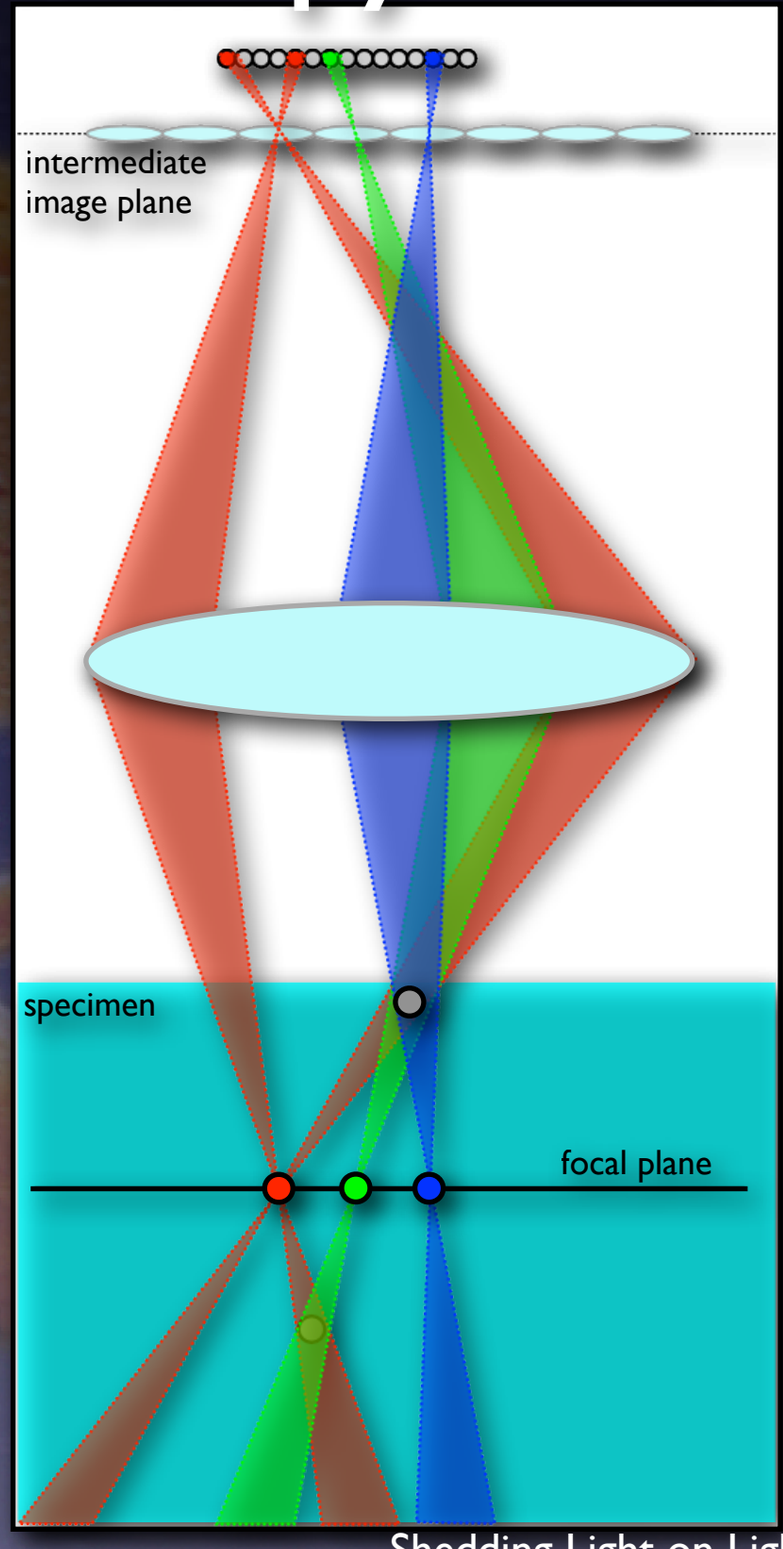

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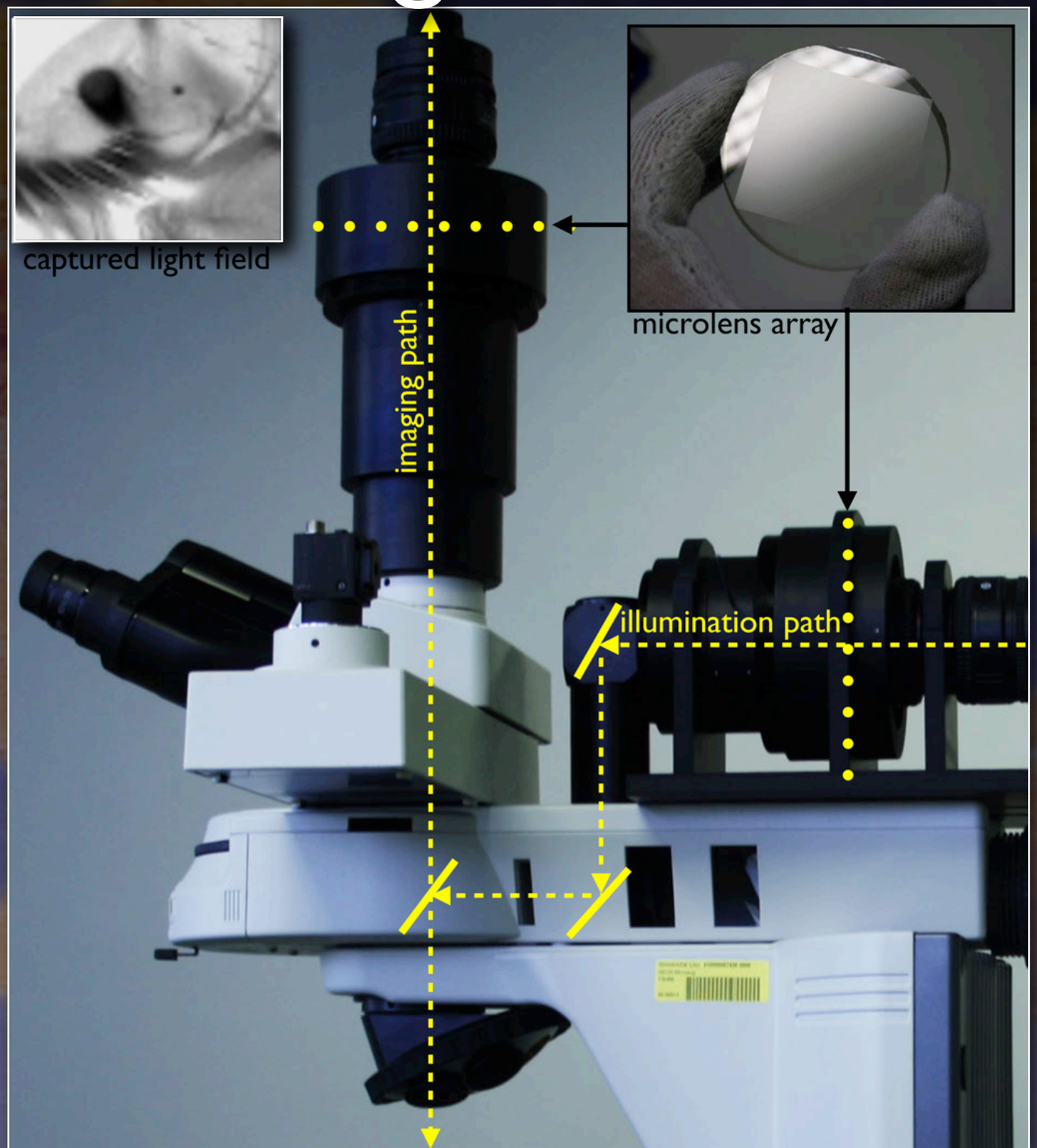
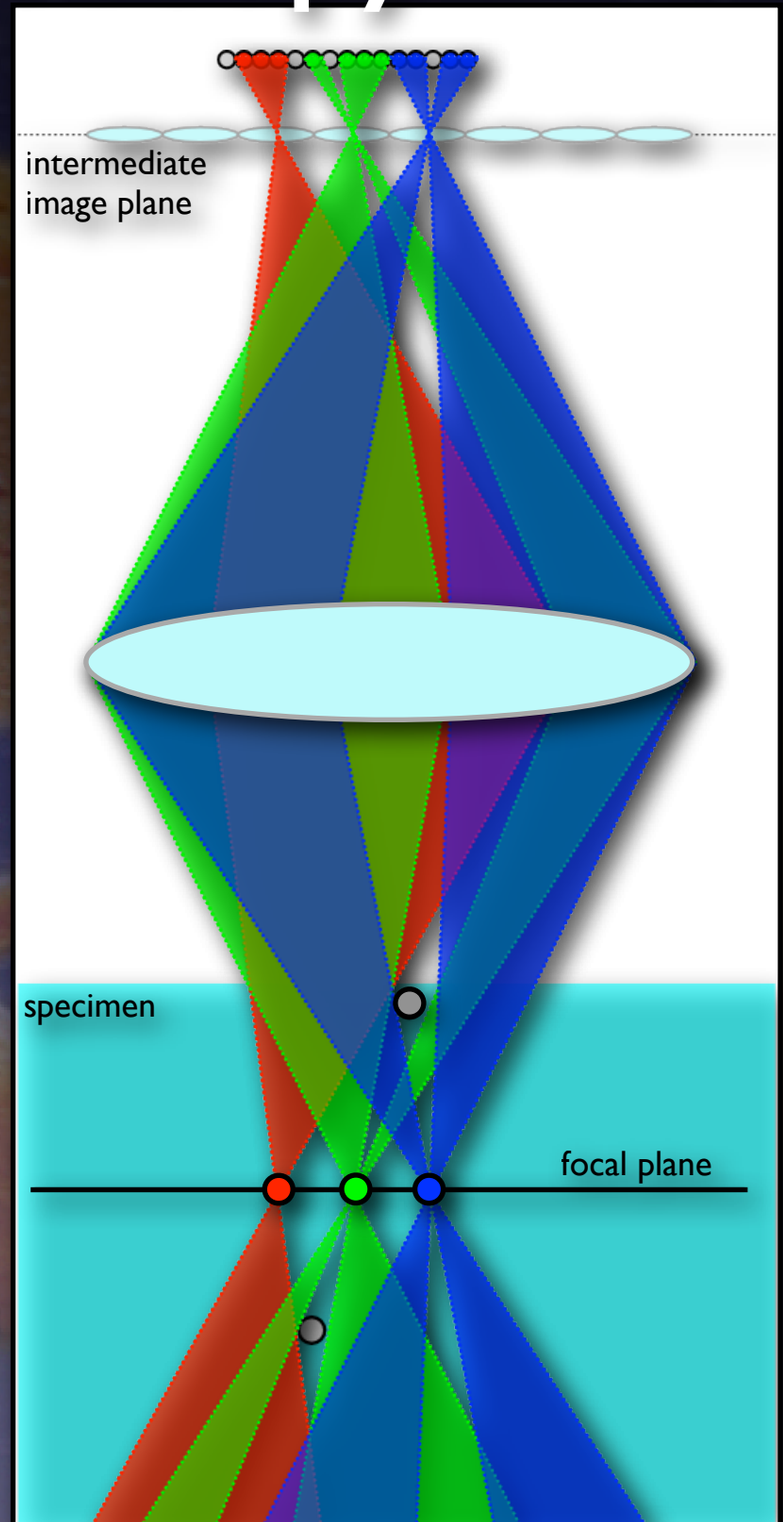
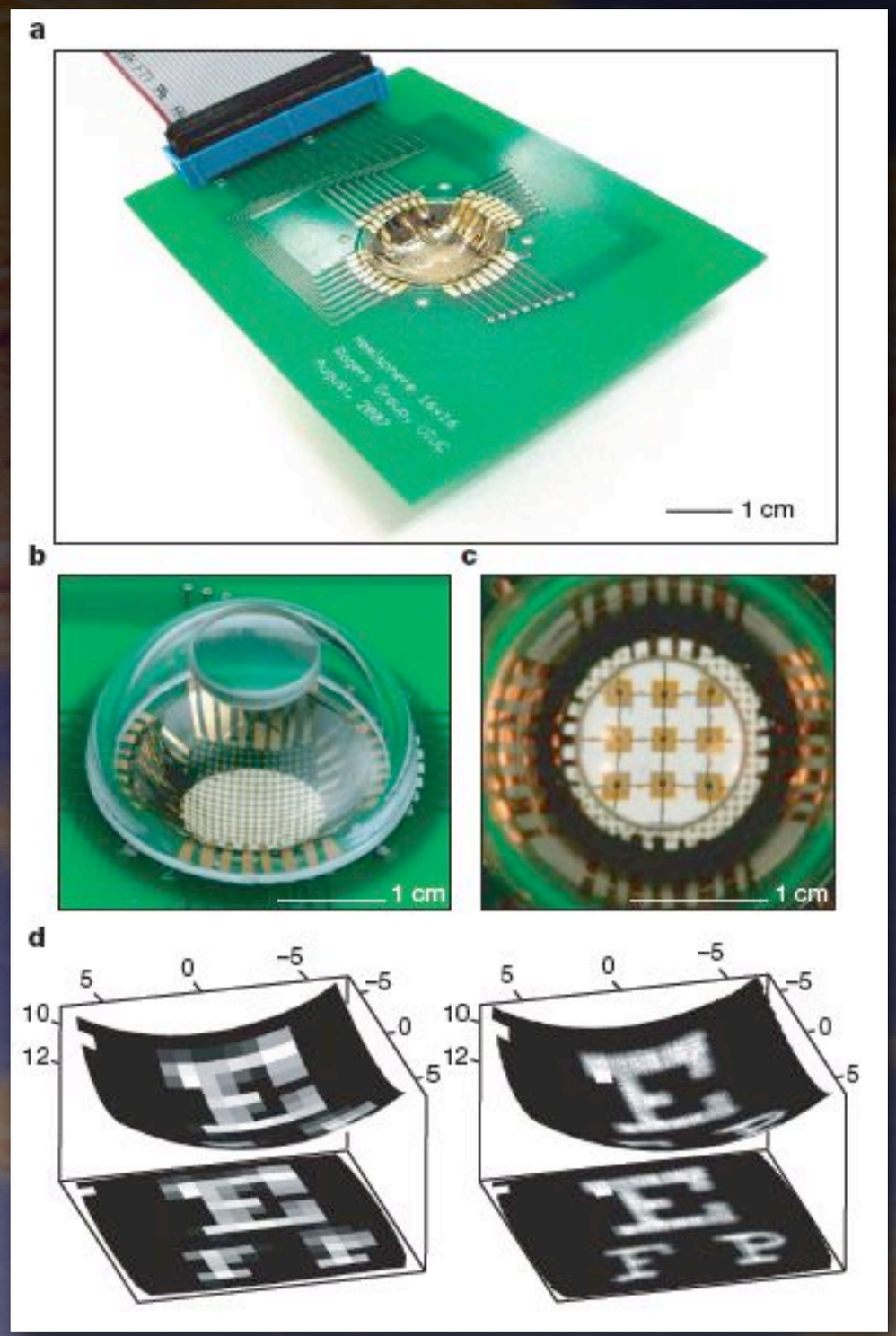
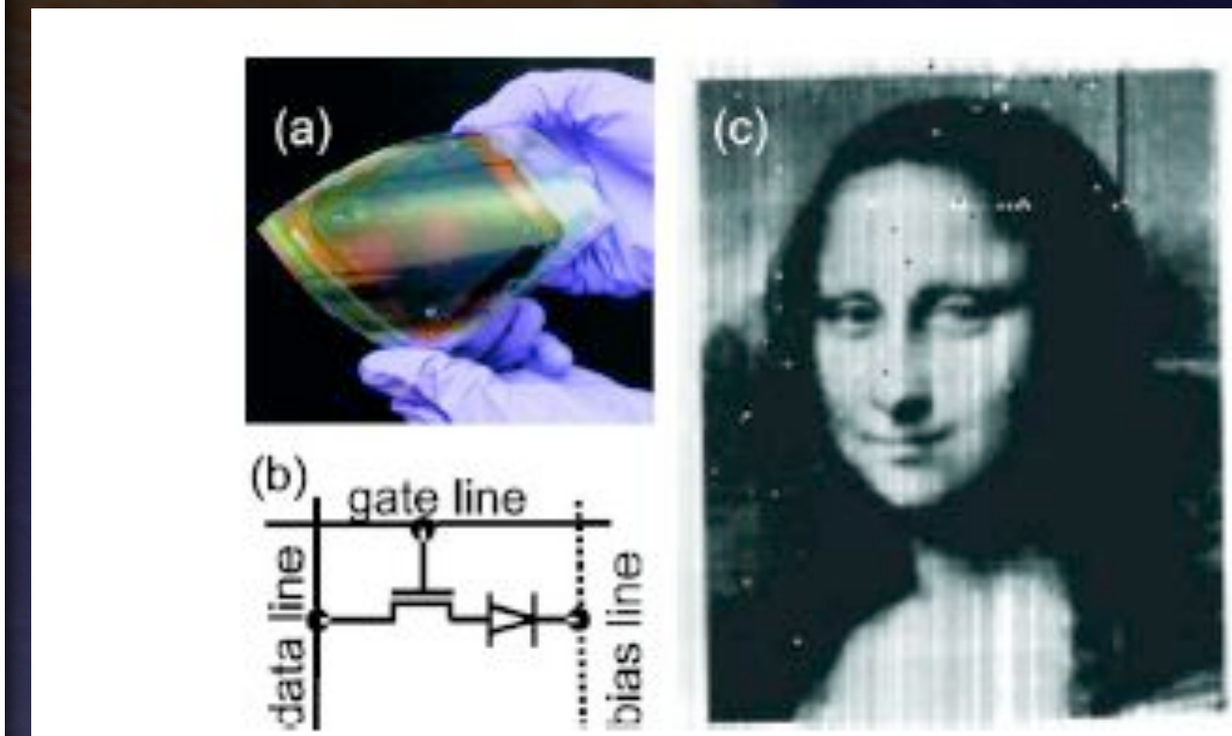




Flexible and Transparent Image Sensors



University of Illinois
(Nature 2008)



Palo Alto Research Center
(Applied Physics Letters 2008)

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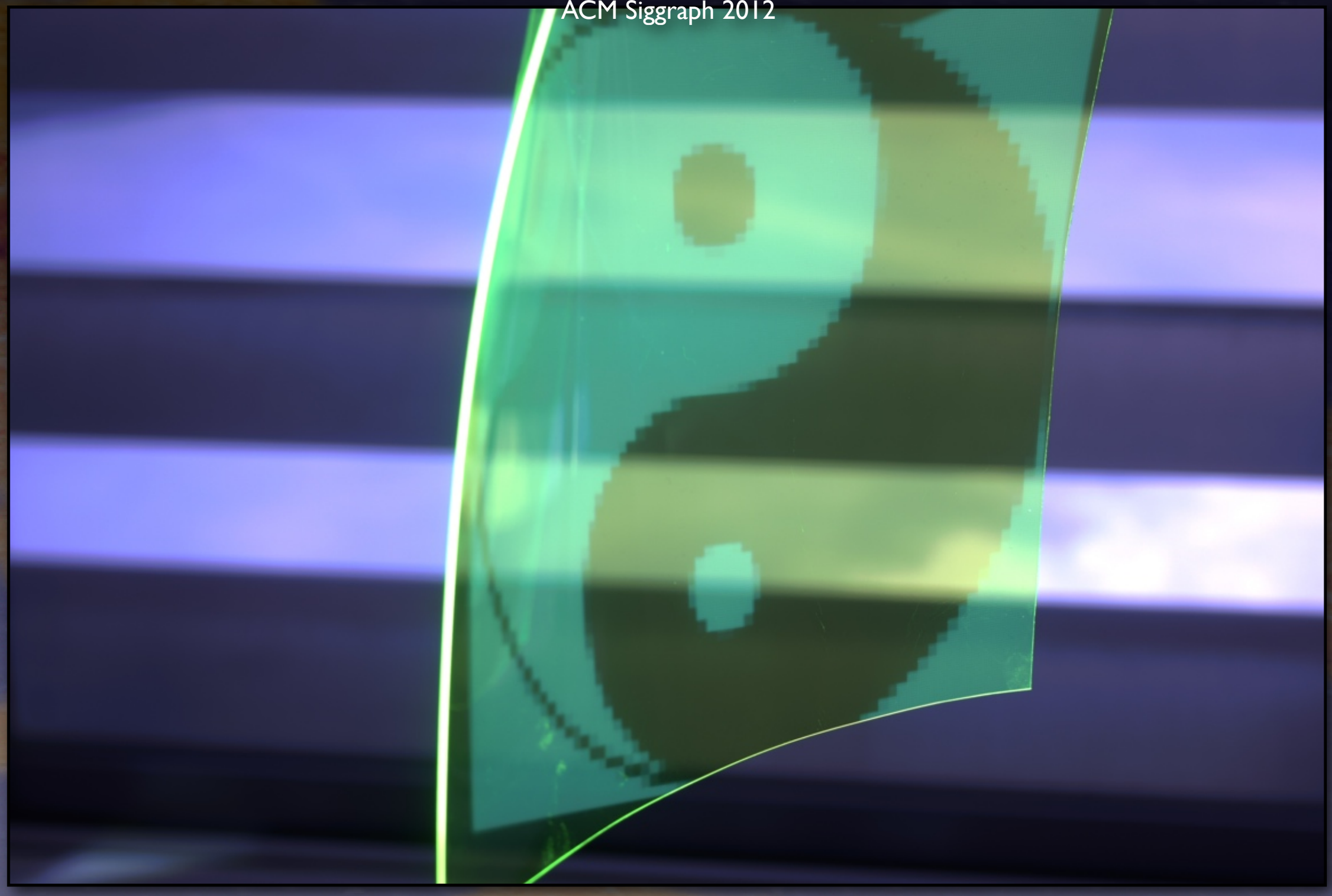
Thin-Film Luminous Concentrators

ACM Siggraph 2012



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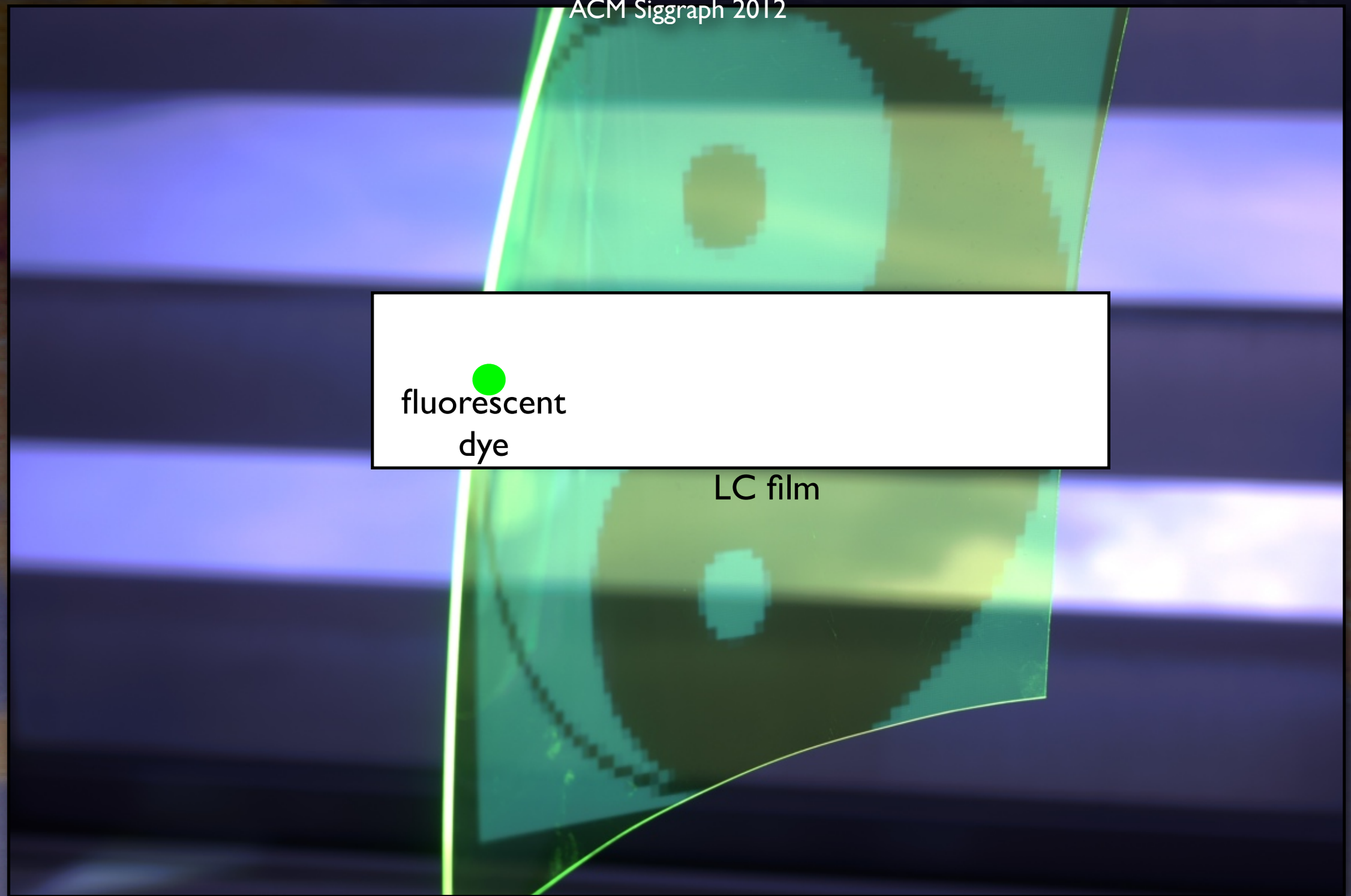

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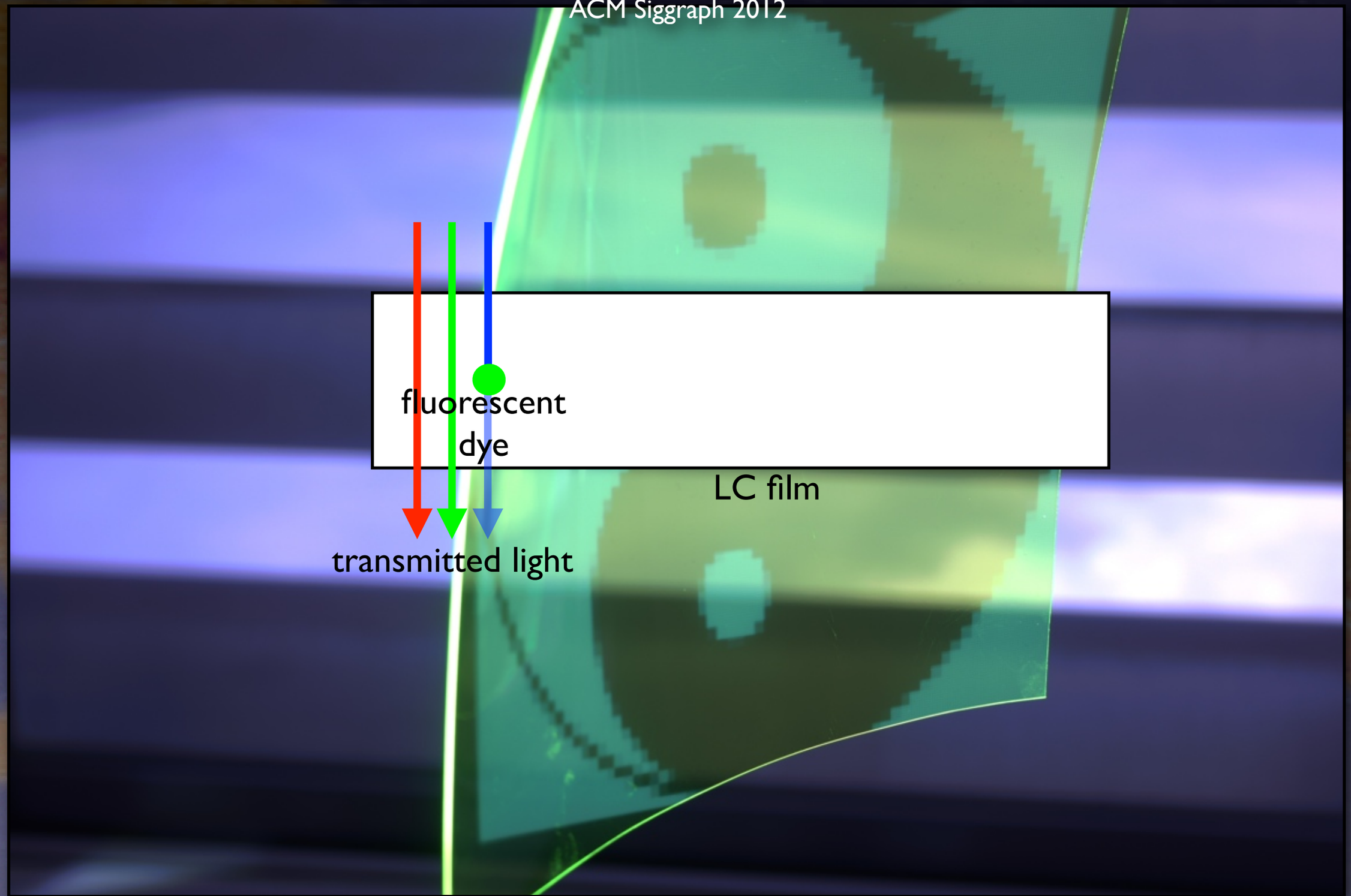

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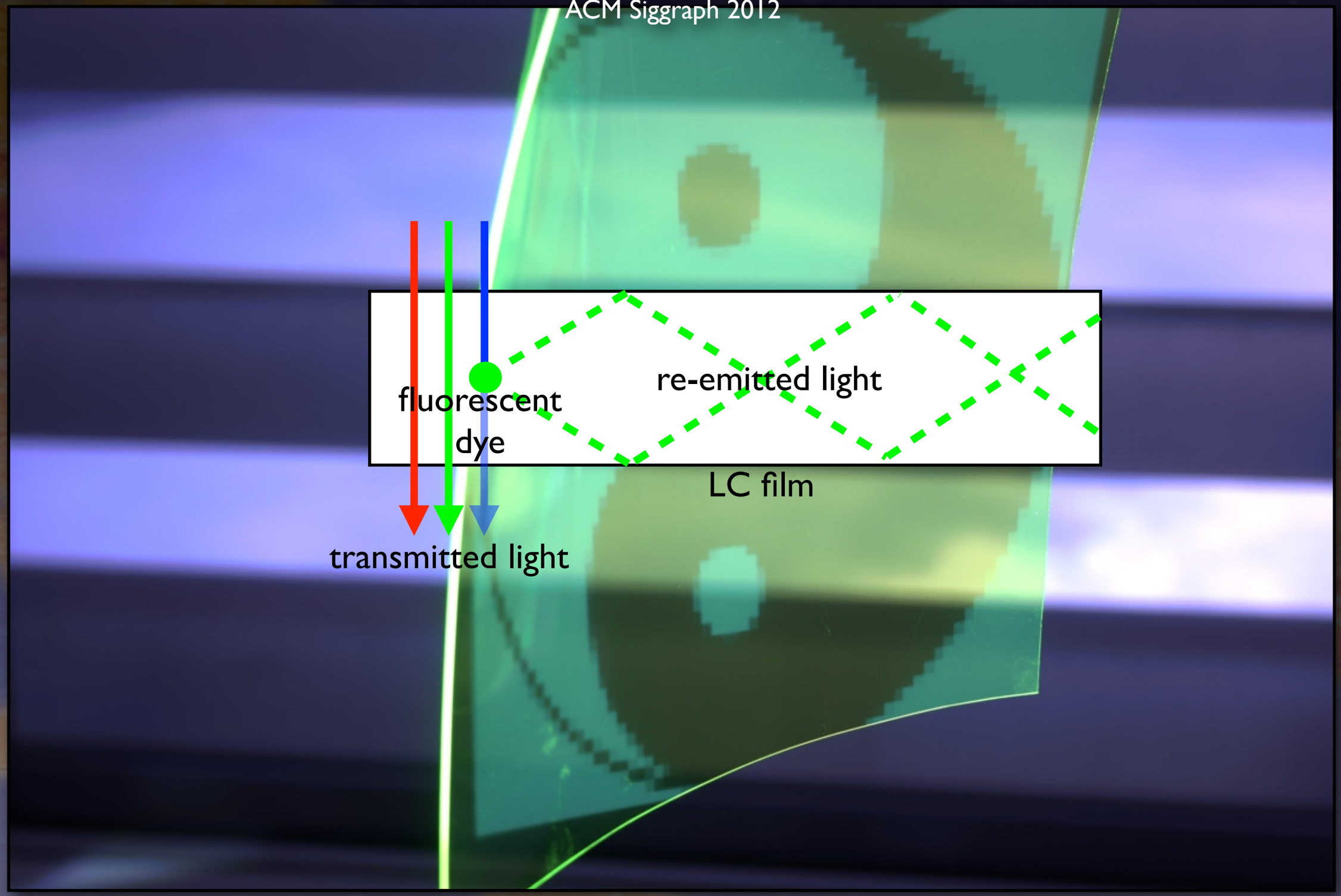

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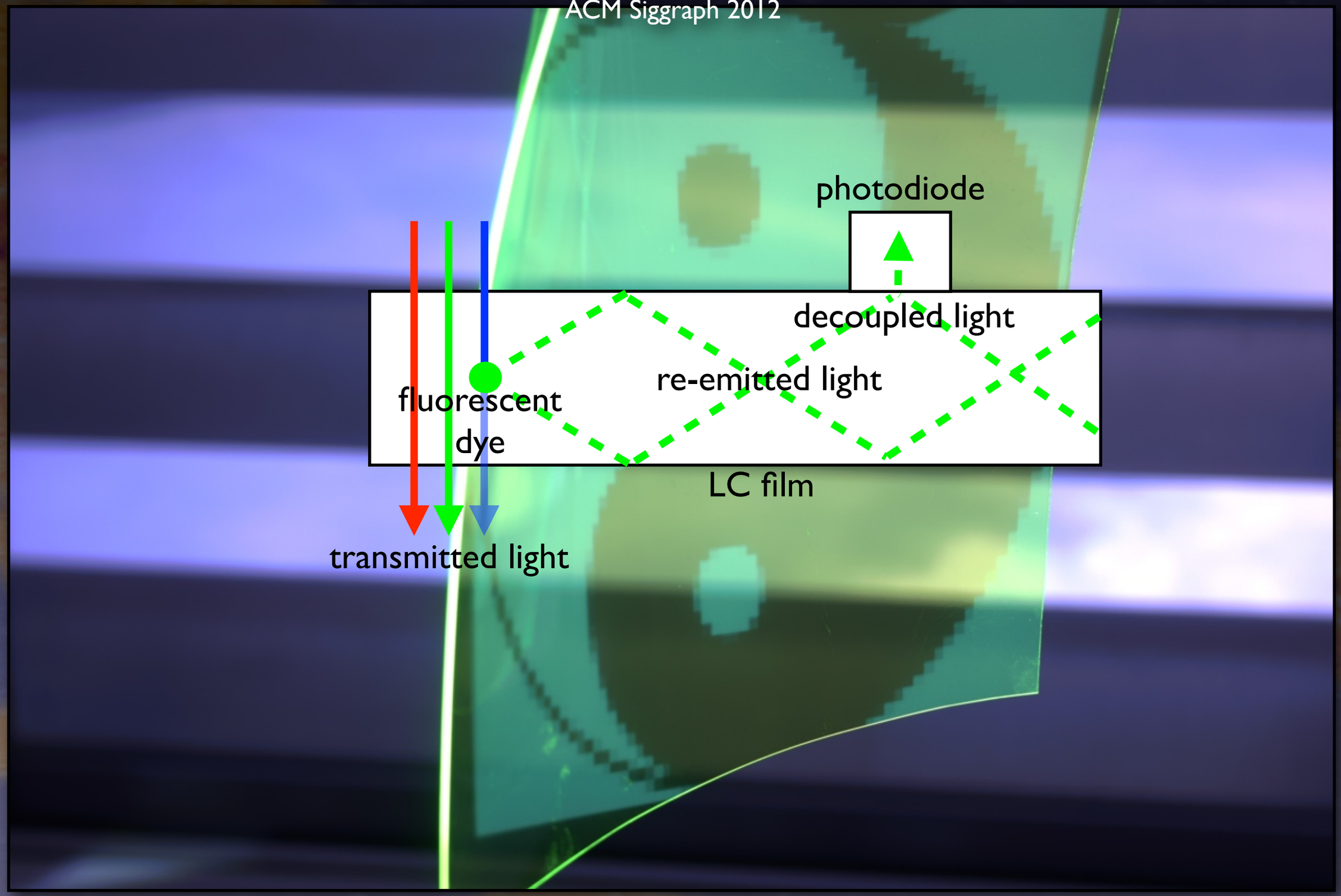

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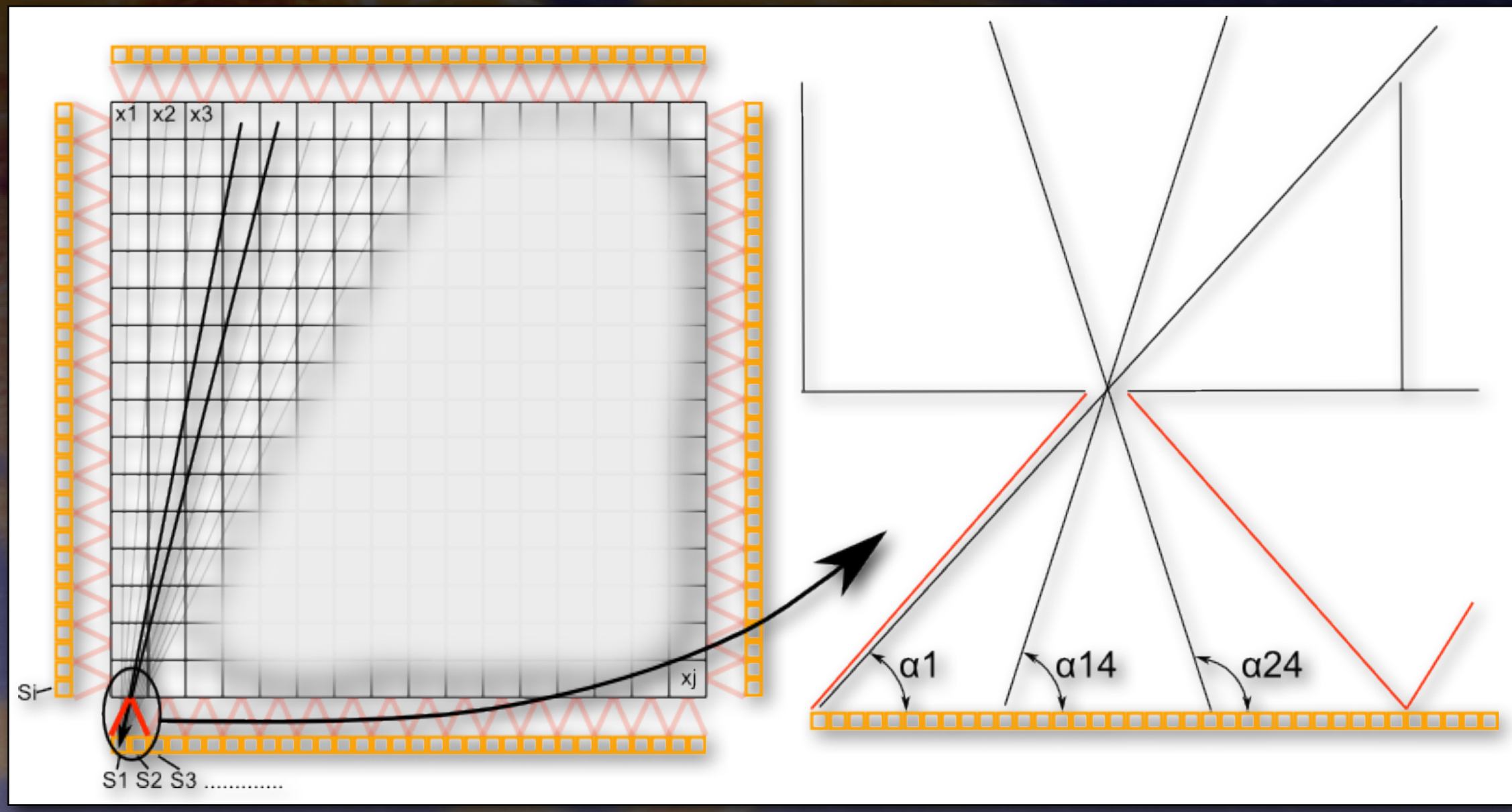
2D Light-Field Camera

ACM Siggraph 2012



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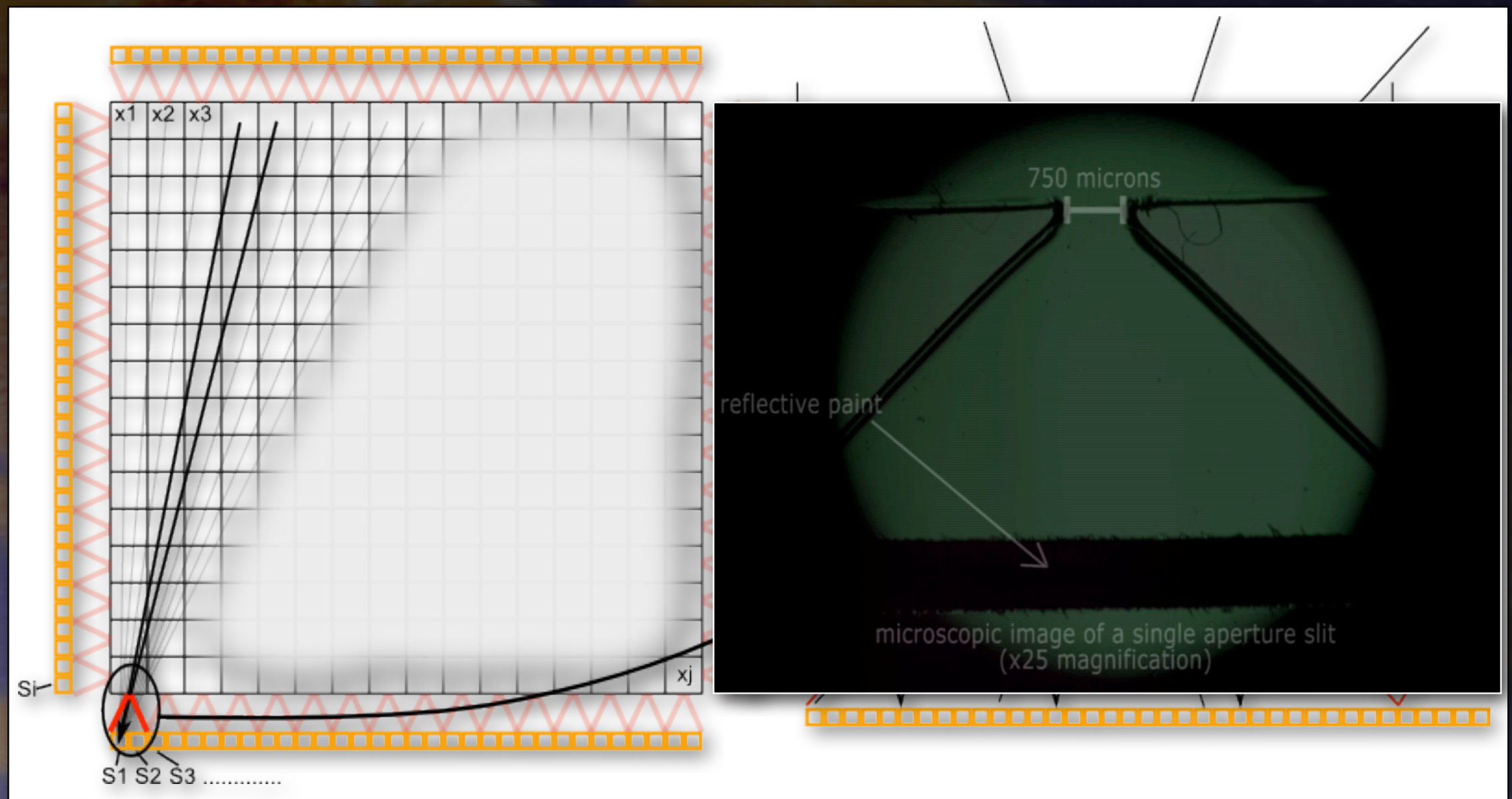
ACM Siggraph 2012



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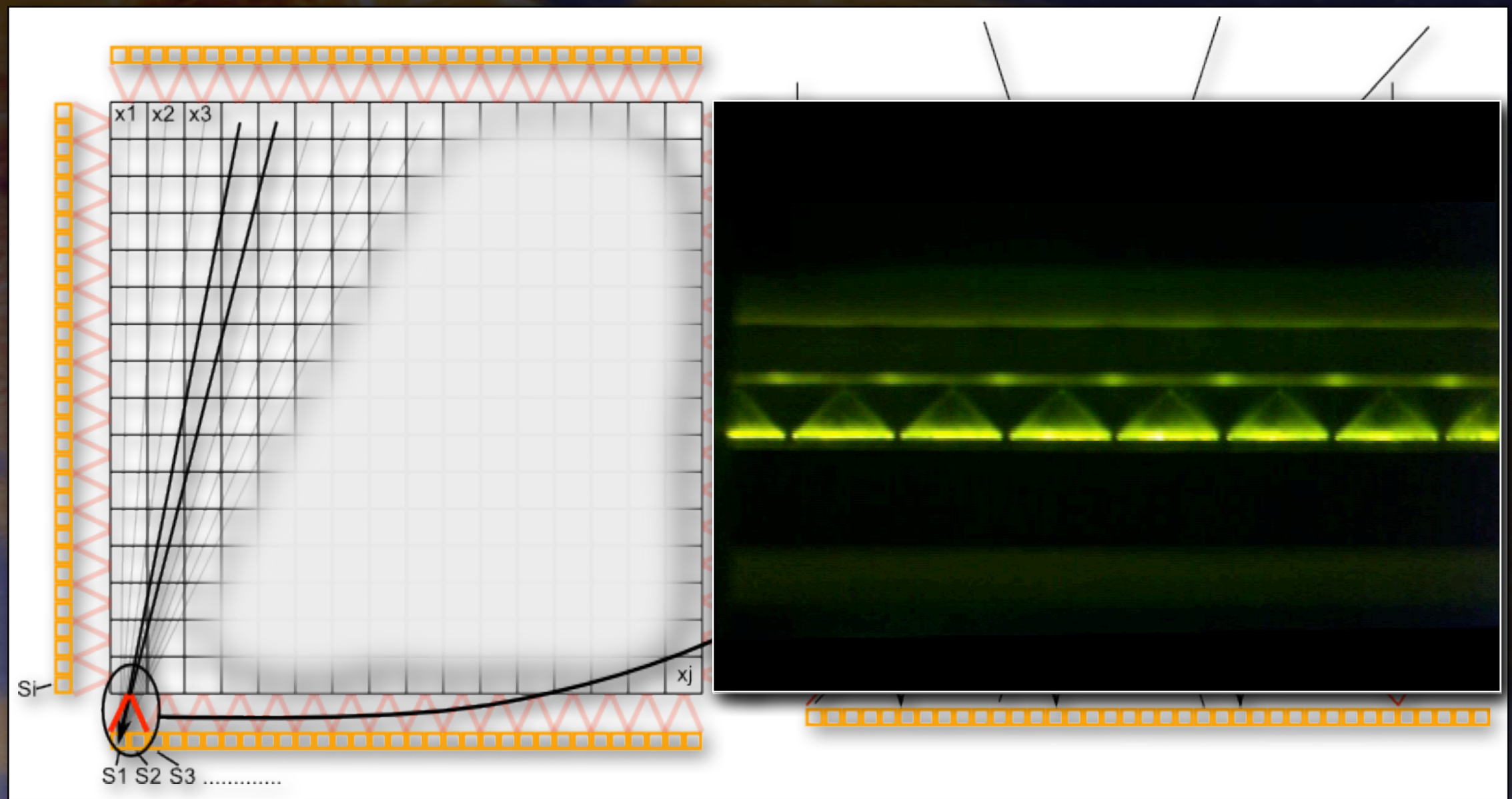
ACM Siggraph 2012



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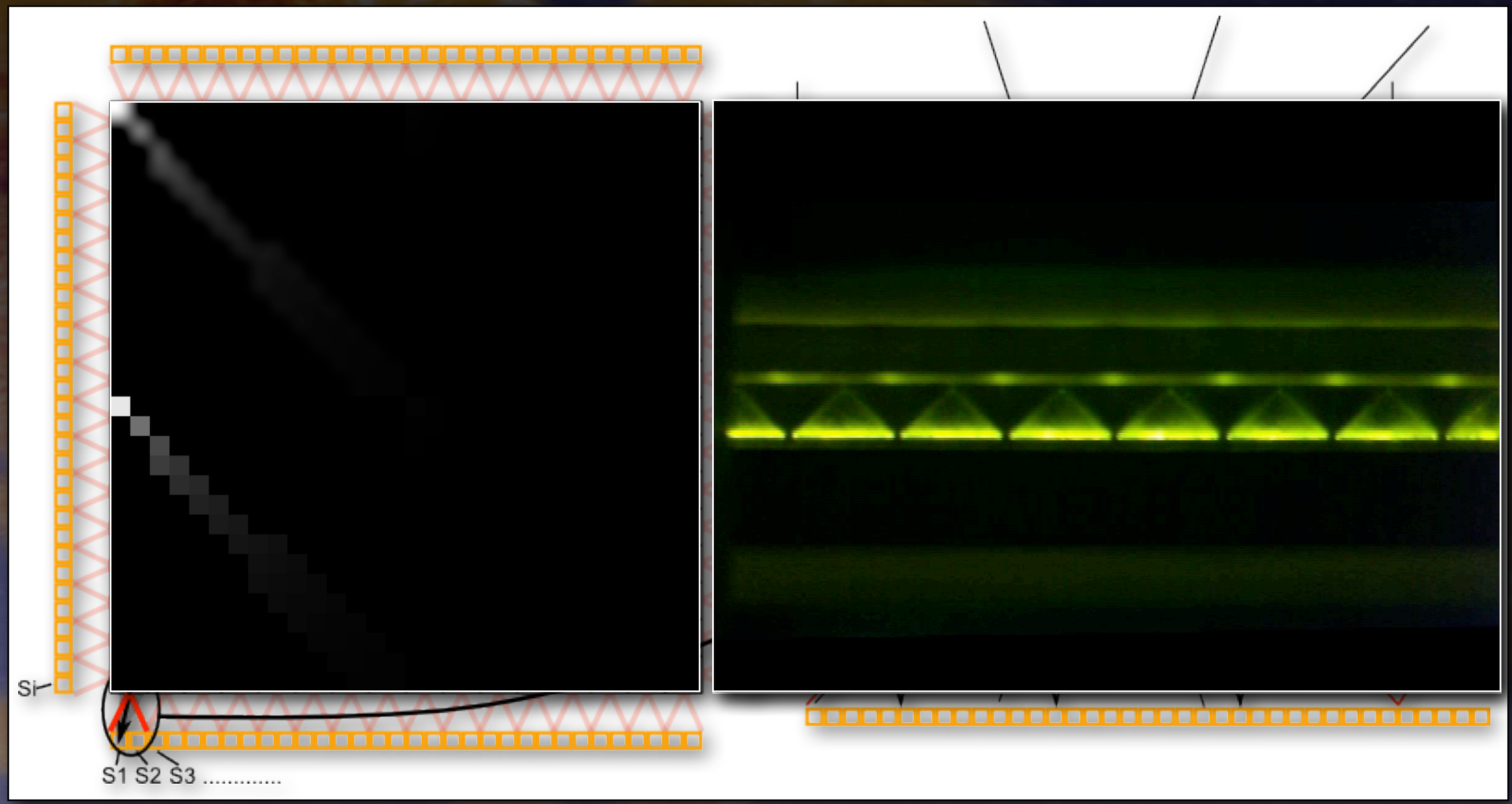
ACM Siggraph 2012



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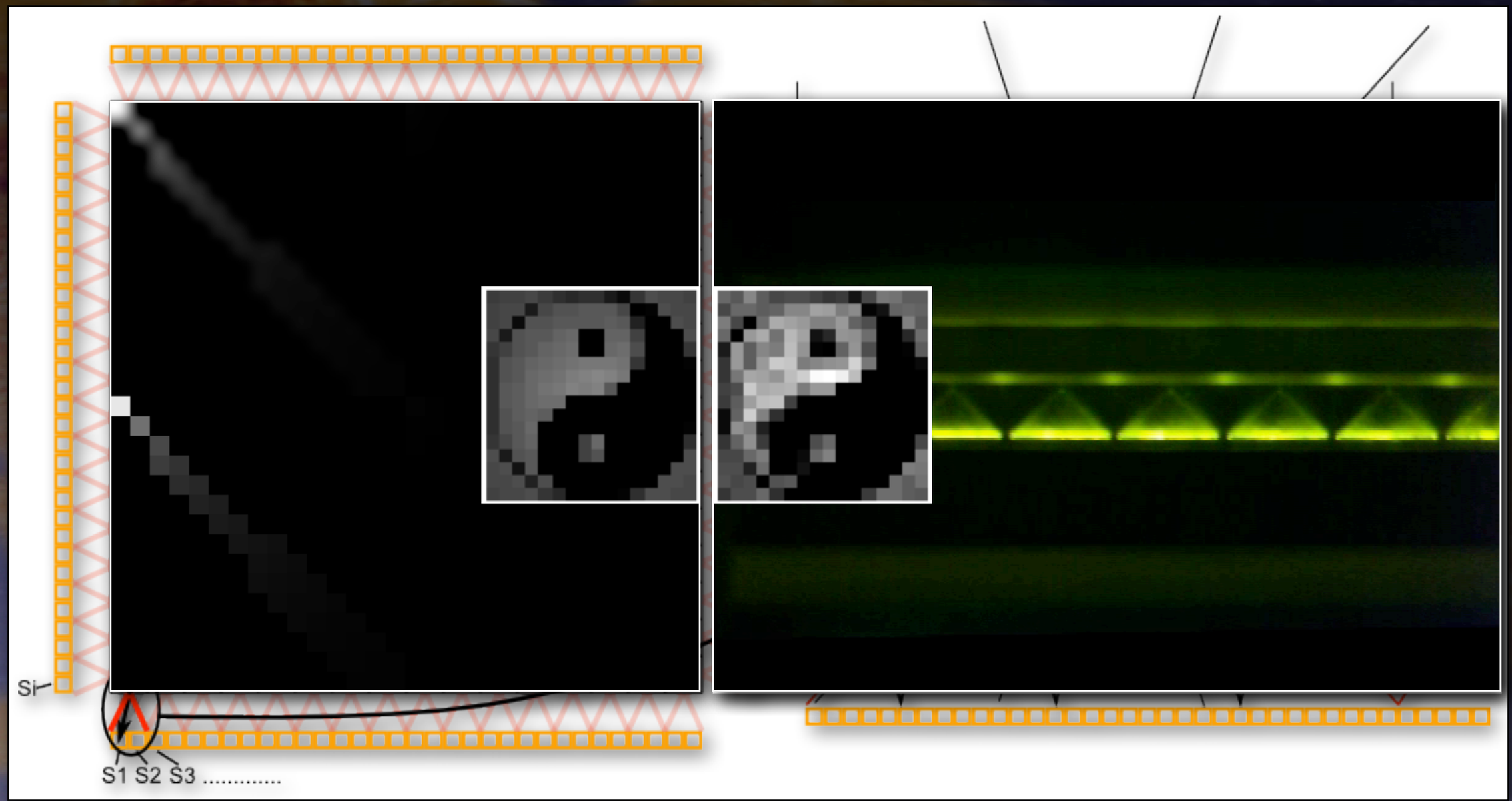
ACM Siggraph 2012



Potential and Challenges

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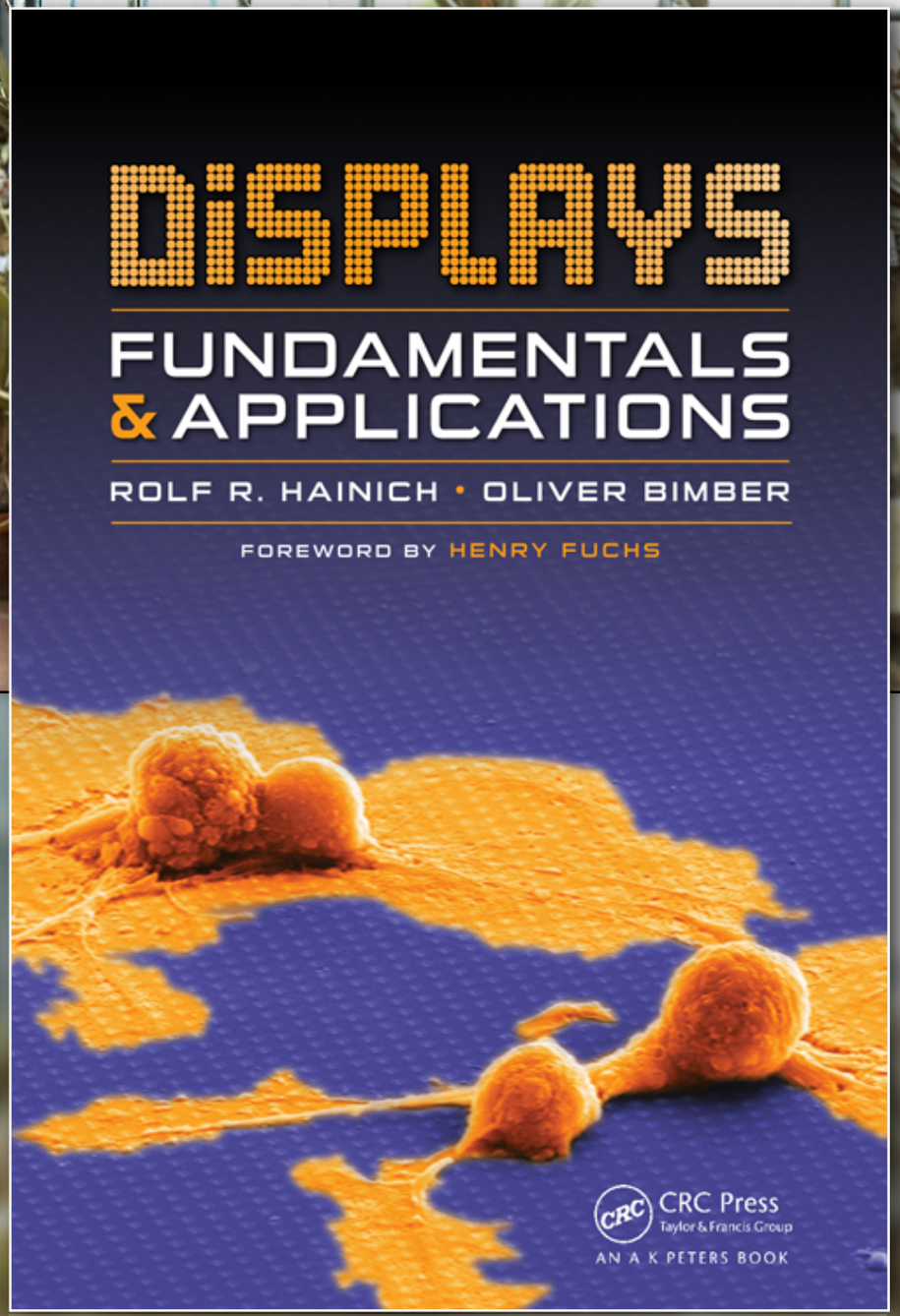
  - Huge amount of data (processing, storage, transmission)

Thank You!

Open PhD position in InfoVis:
marc.streit@jku.at
(deadline ends next week)



www.displaysbook.info

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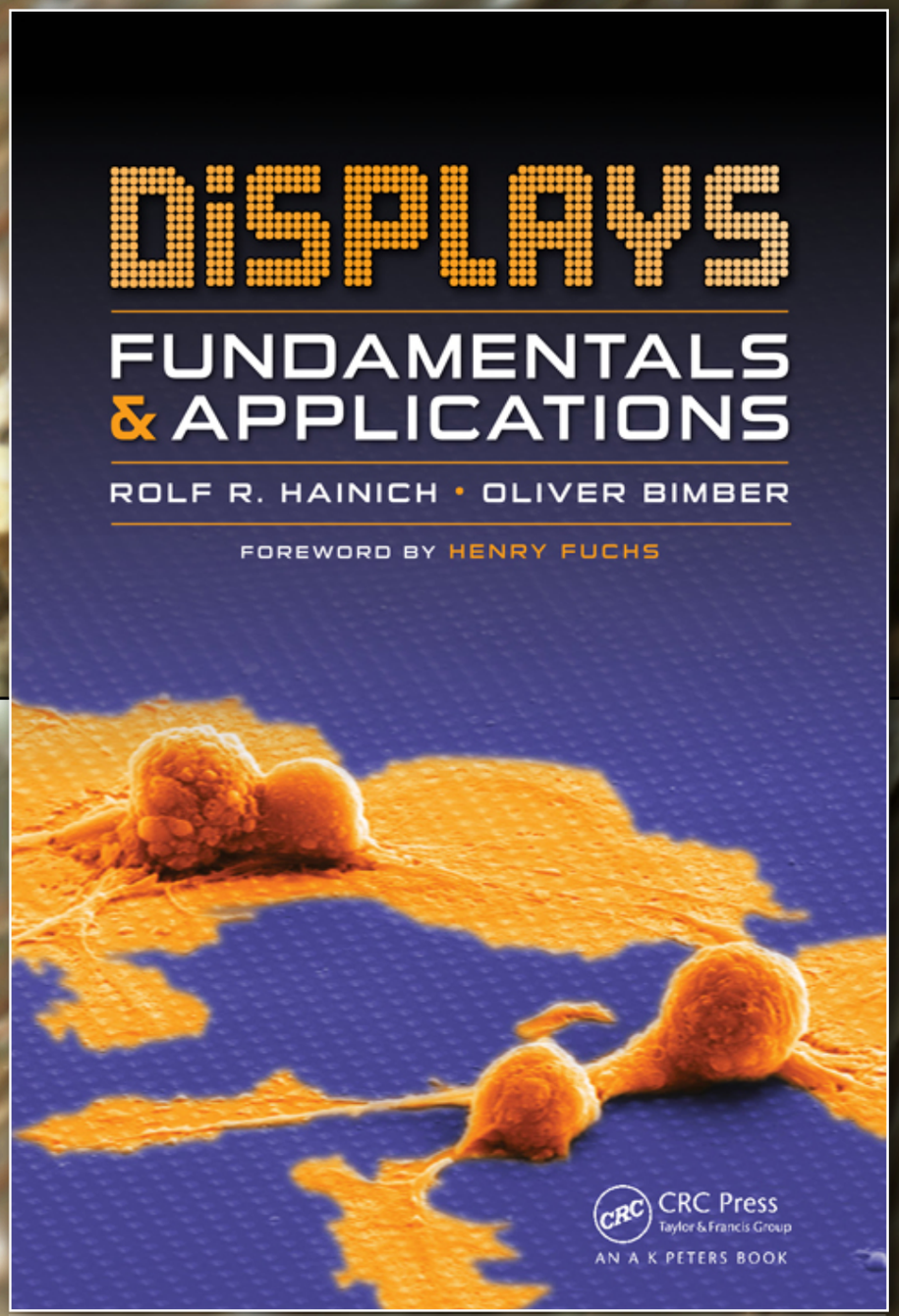

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