Deep Shadows in a Shallow Box

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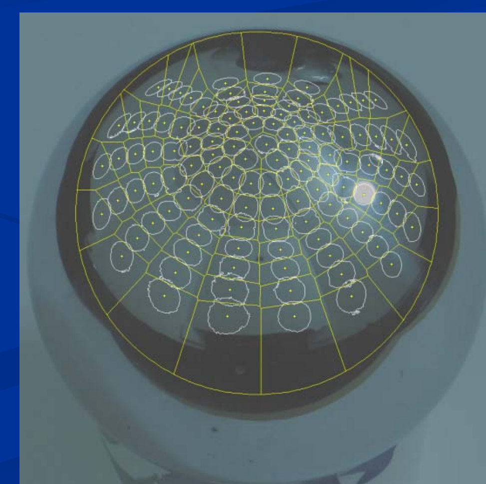
(a) Captured Image

(b) Computed Image

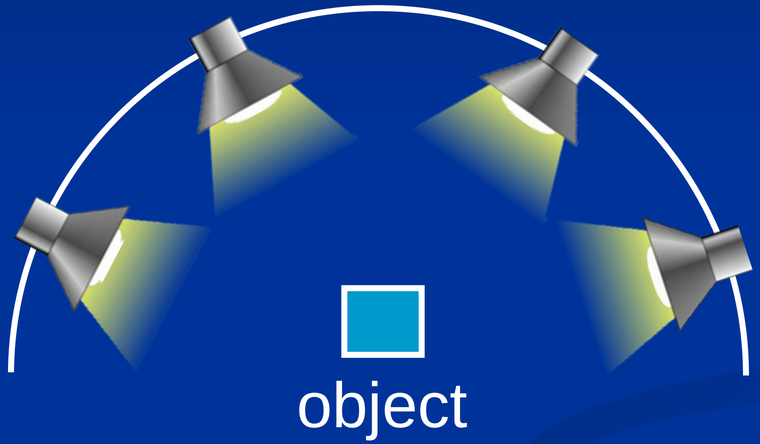


(c) Weighting Coefficients

Image Based Relighting (IBR) - Video

Courtesy Holger Winnemöller, et al. “Light Waving:
Estimating Light Positions From Photographs Alone” Comput. Graph. Forum 2005

Acquisition Basis Images for IBR



Courtesy Holger Winnemöller, et al. “Light Waving:
Estimating Light Positions From Photographs Alone” Comput. Graph. Forum 2005

Basis Images

Courtesy Holger Winnemöller, et al. “Light Waving:
Estimating Light Positions From Photographs Alone” Comput. Graph. Forum 2005

Capturing of Basis Images

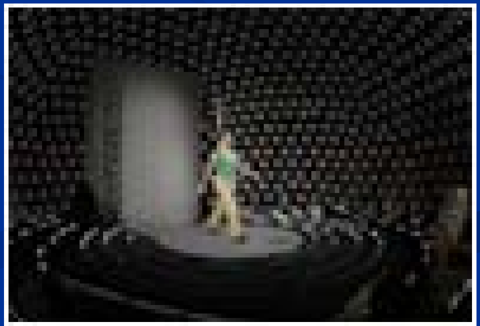
[Debevec et al. 2000]

[Debevec et al. 2002]

[Matusik et al. 2002]

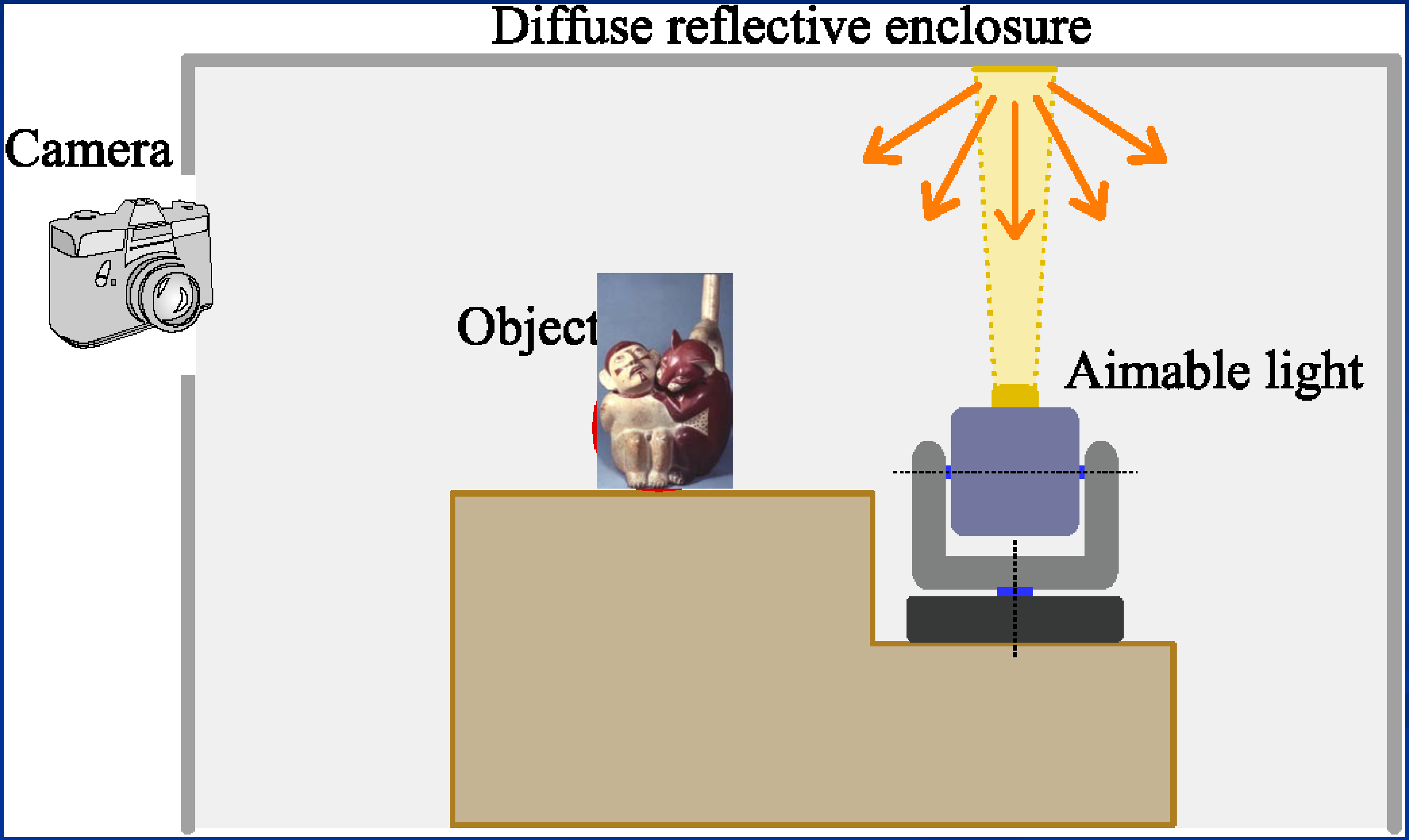
[Malzbender et al. 2002]

[Winnemöller et al. 2005]



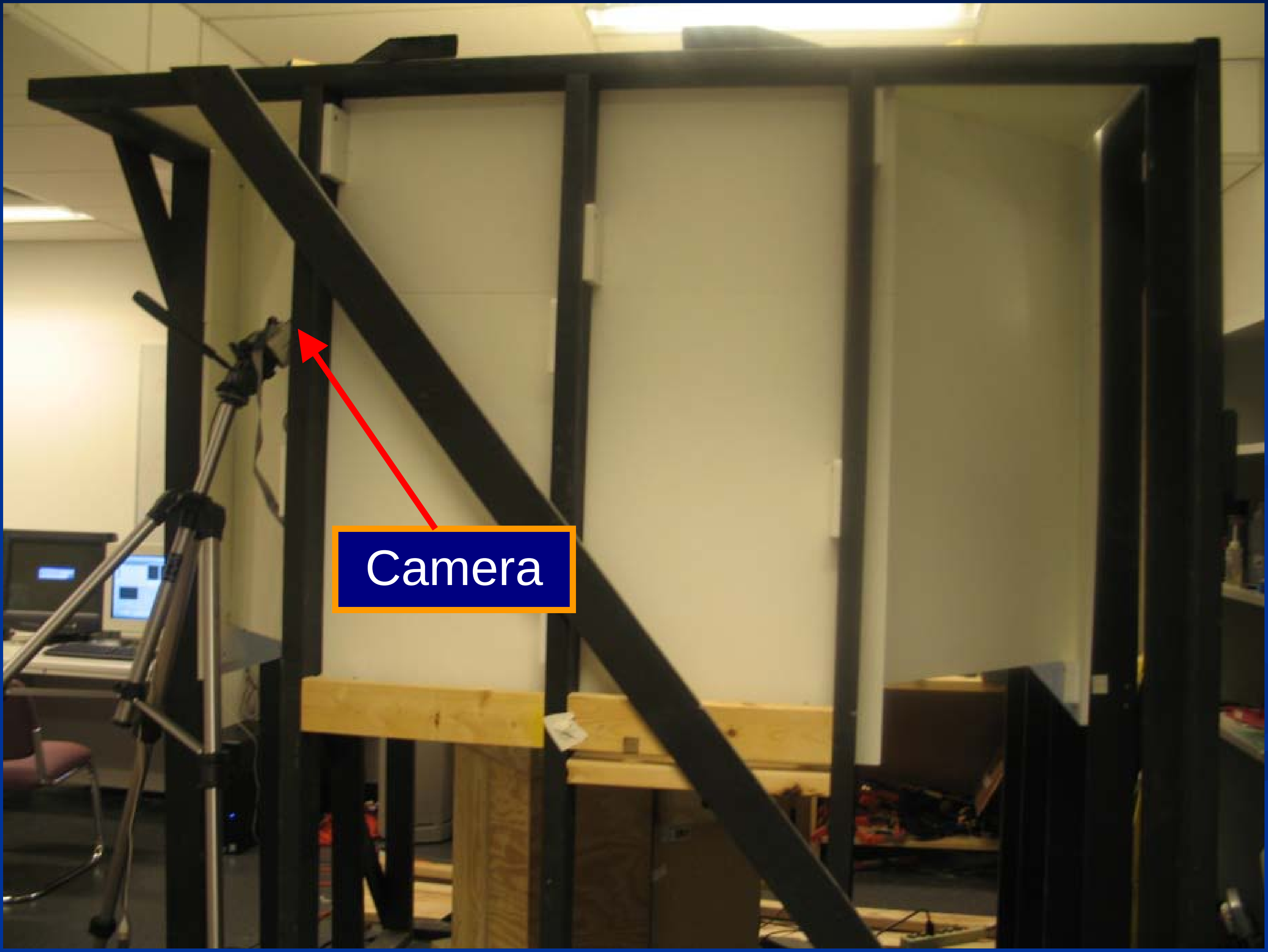
[Debevec et al. 2006]

Our Light Stage: Card-board



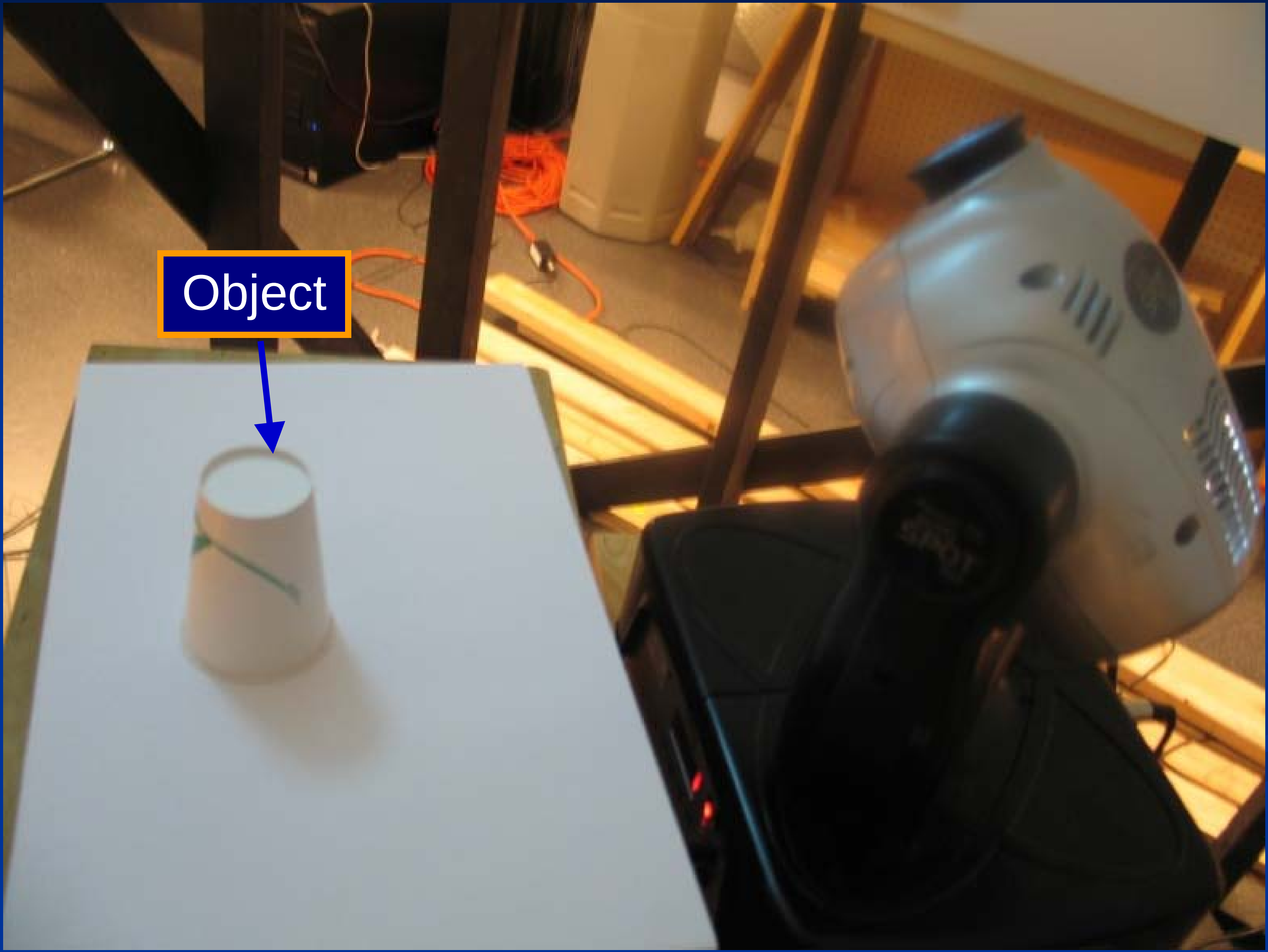
Our Light Rig: Outside

Our Light Rig: Outside

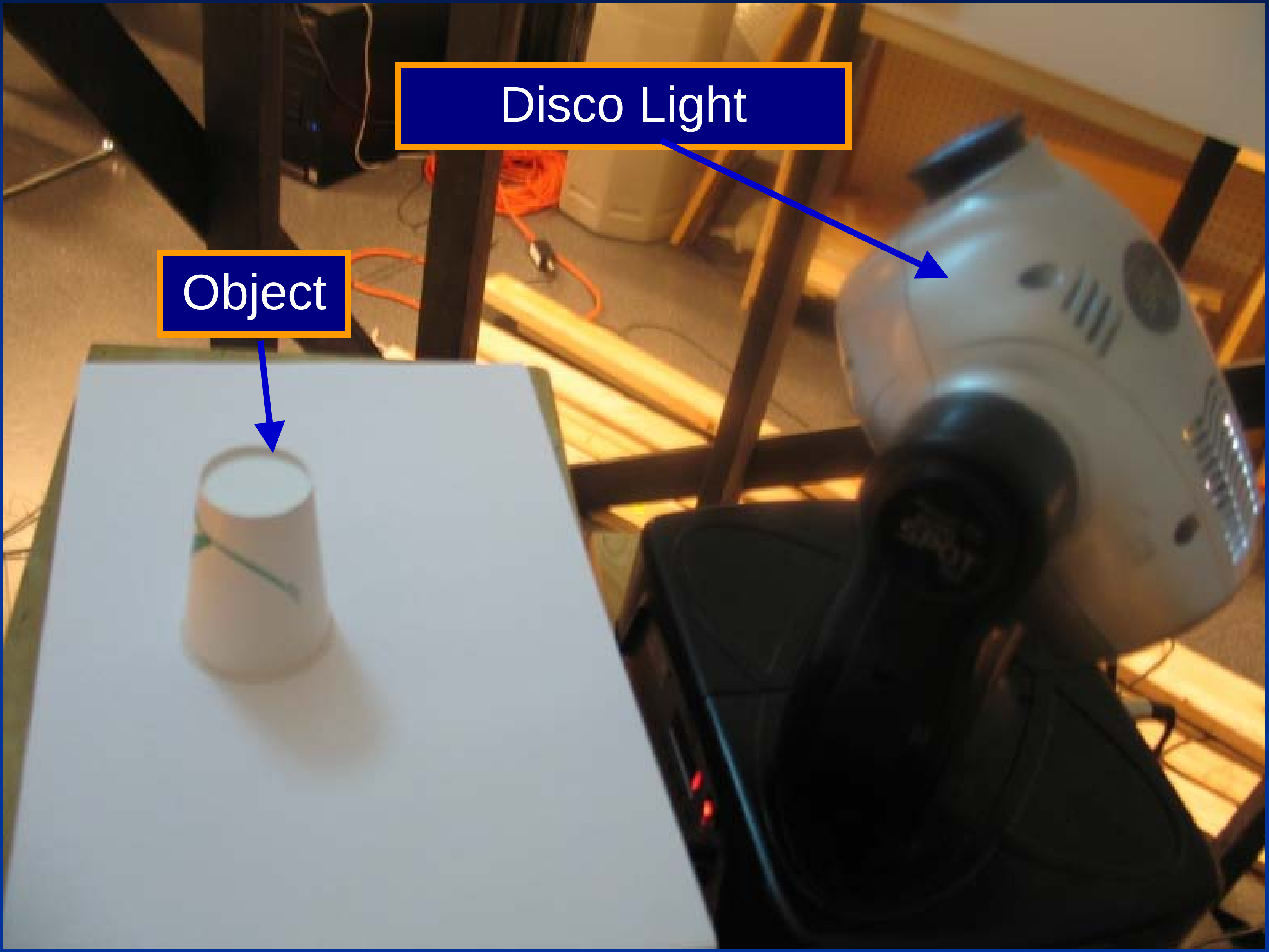


Our Light Rig: Inside

Our Light Rig: Inside



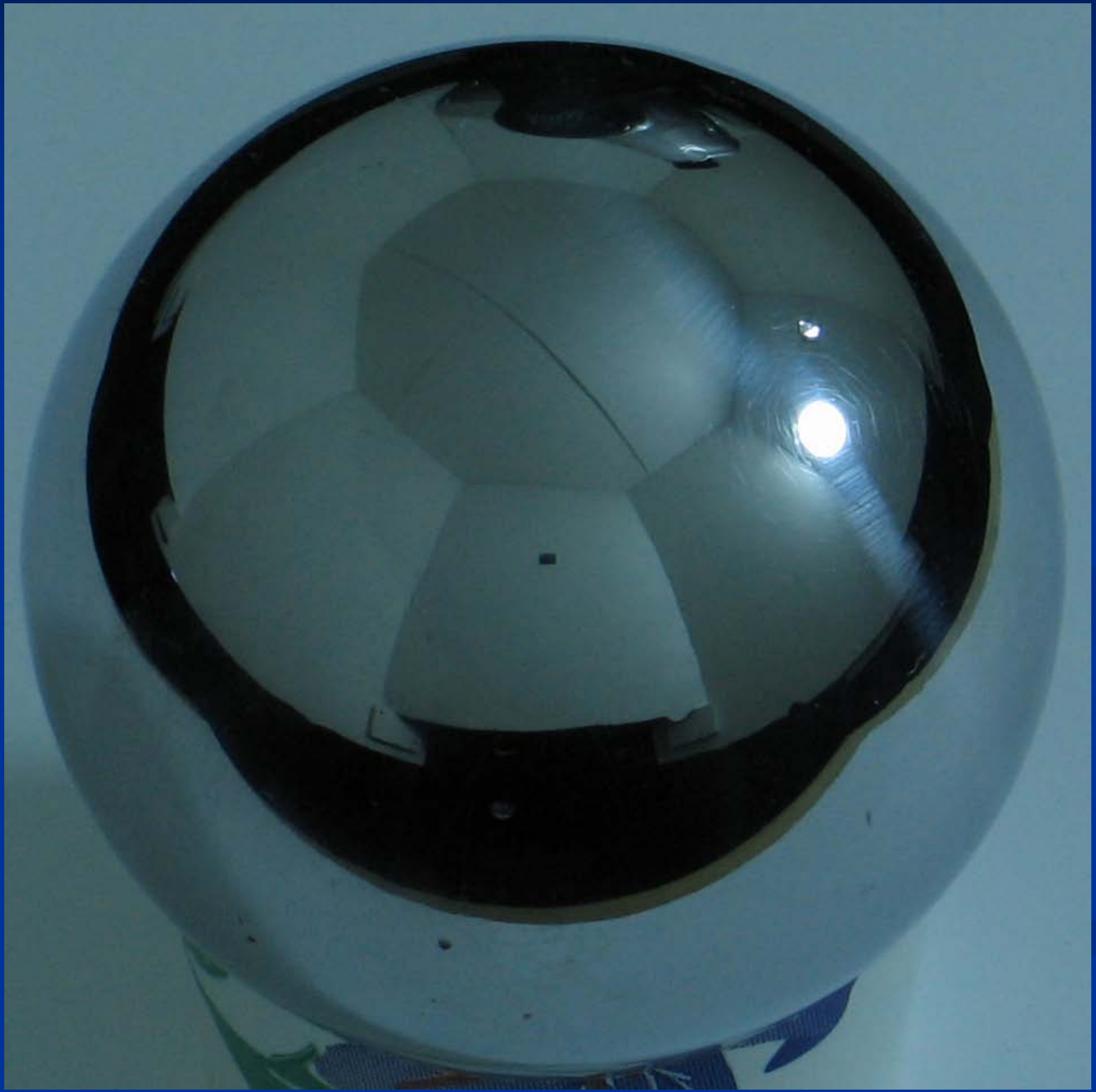
Our Light Rig: Inside



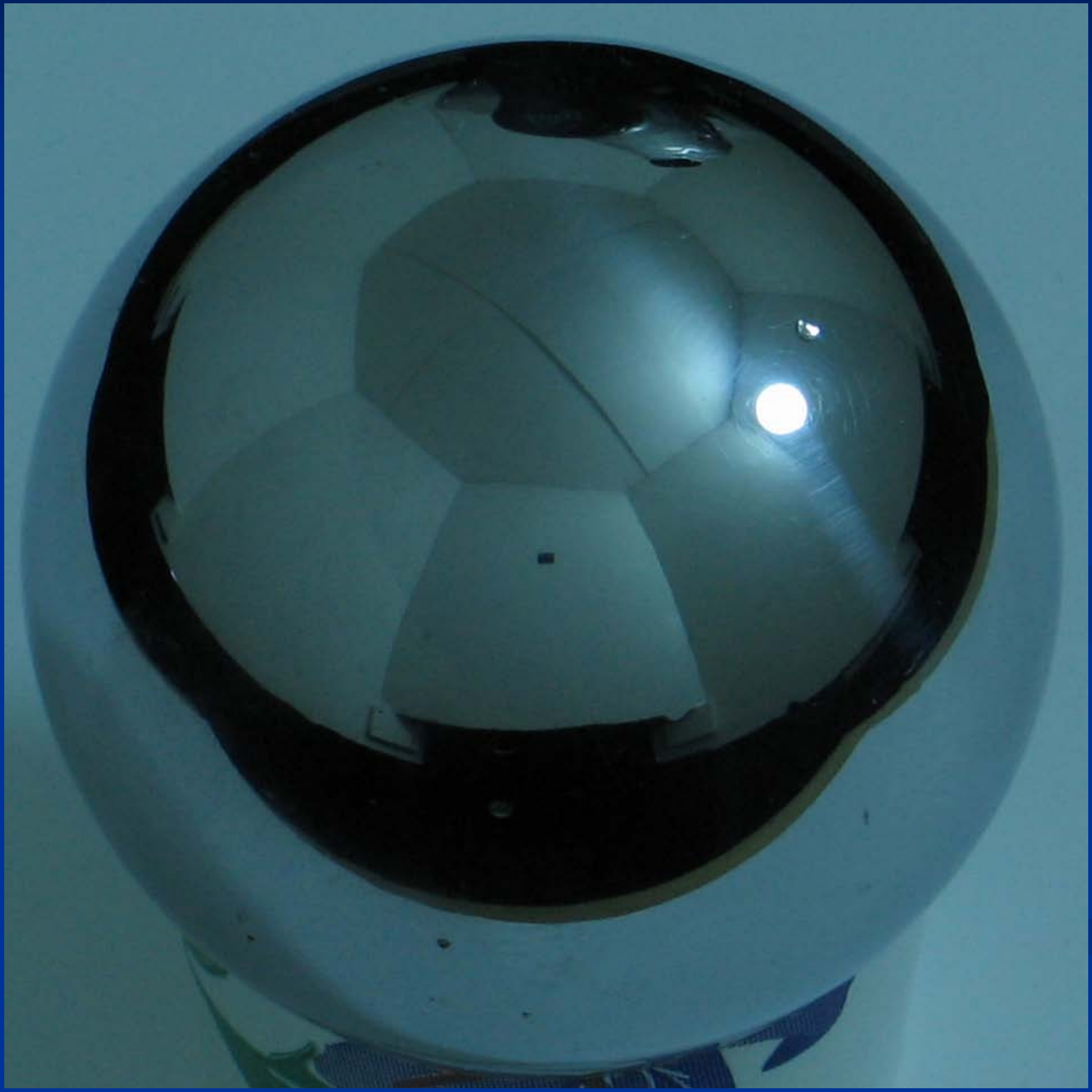
Our Light Rig: Inside

Replace Object with a Mirror Ball

Mirror Ball Image 1

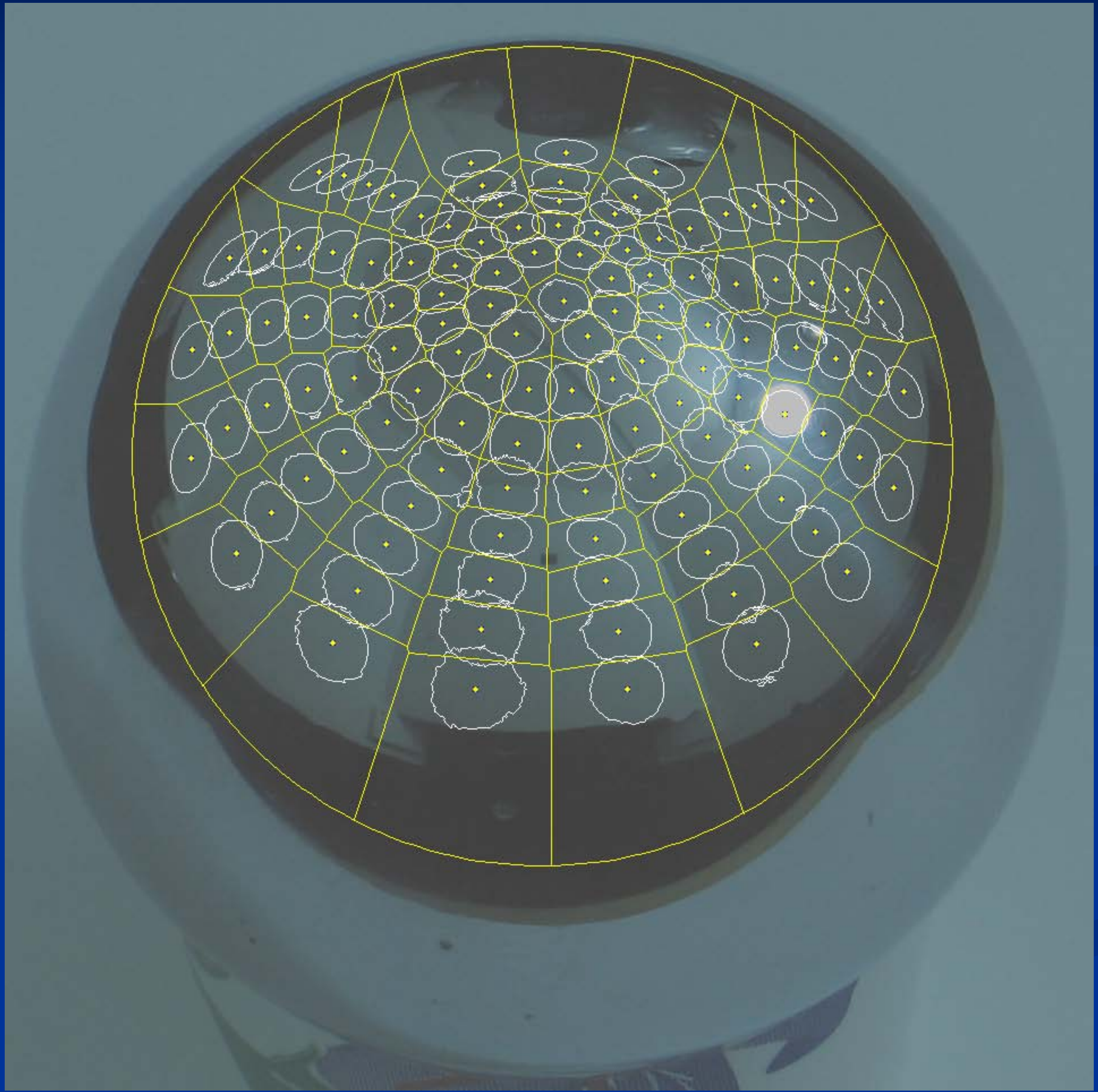


Mirror Ball Image 2

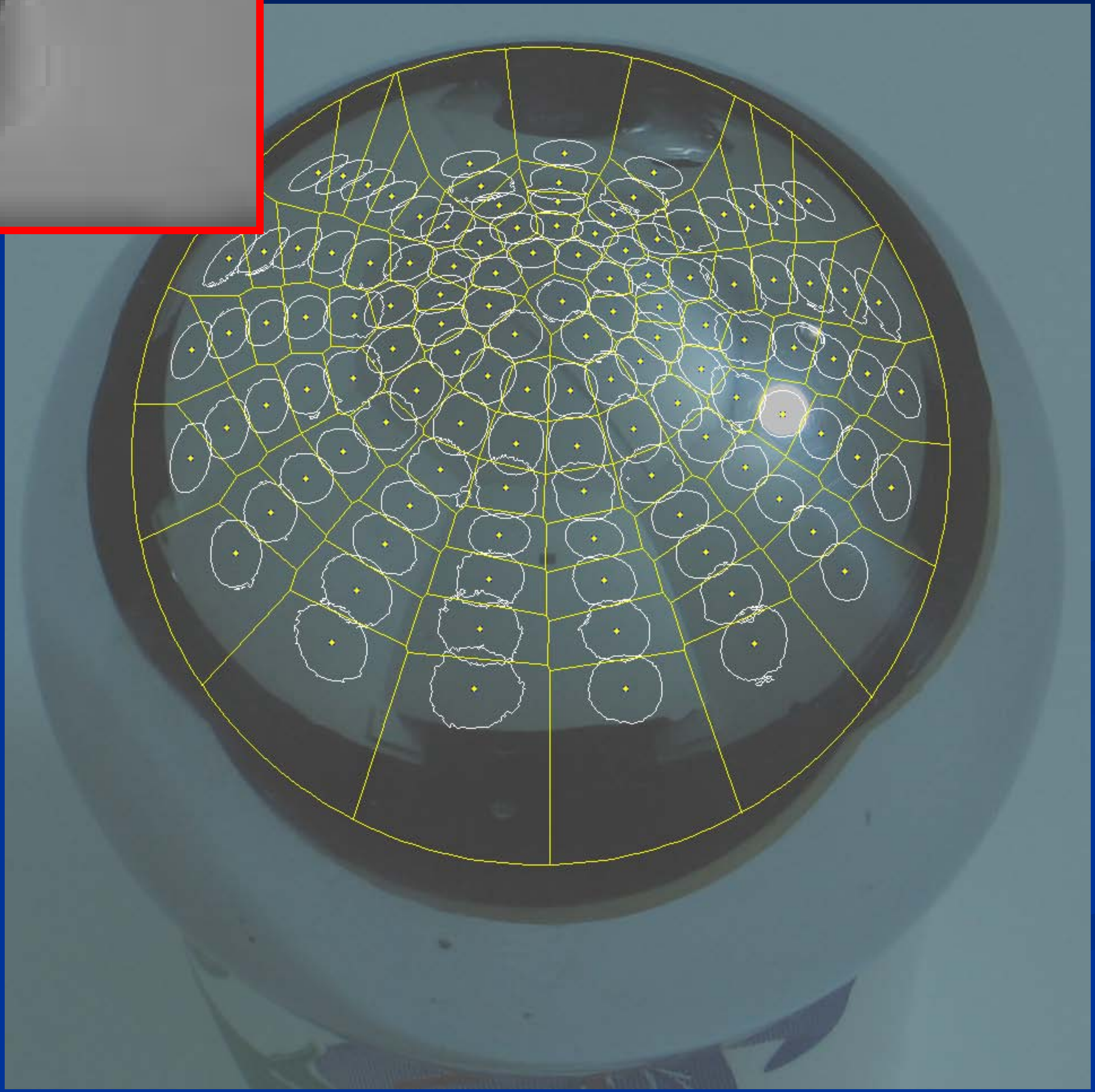


Mirror Ball Image 3

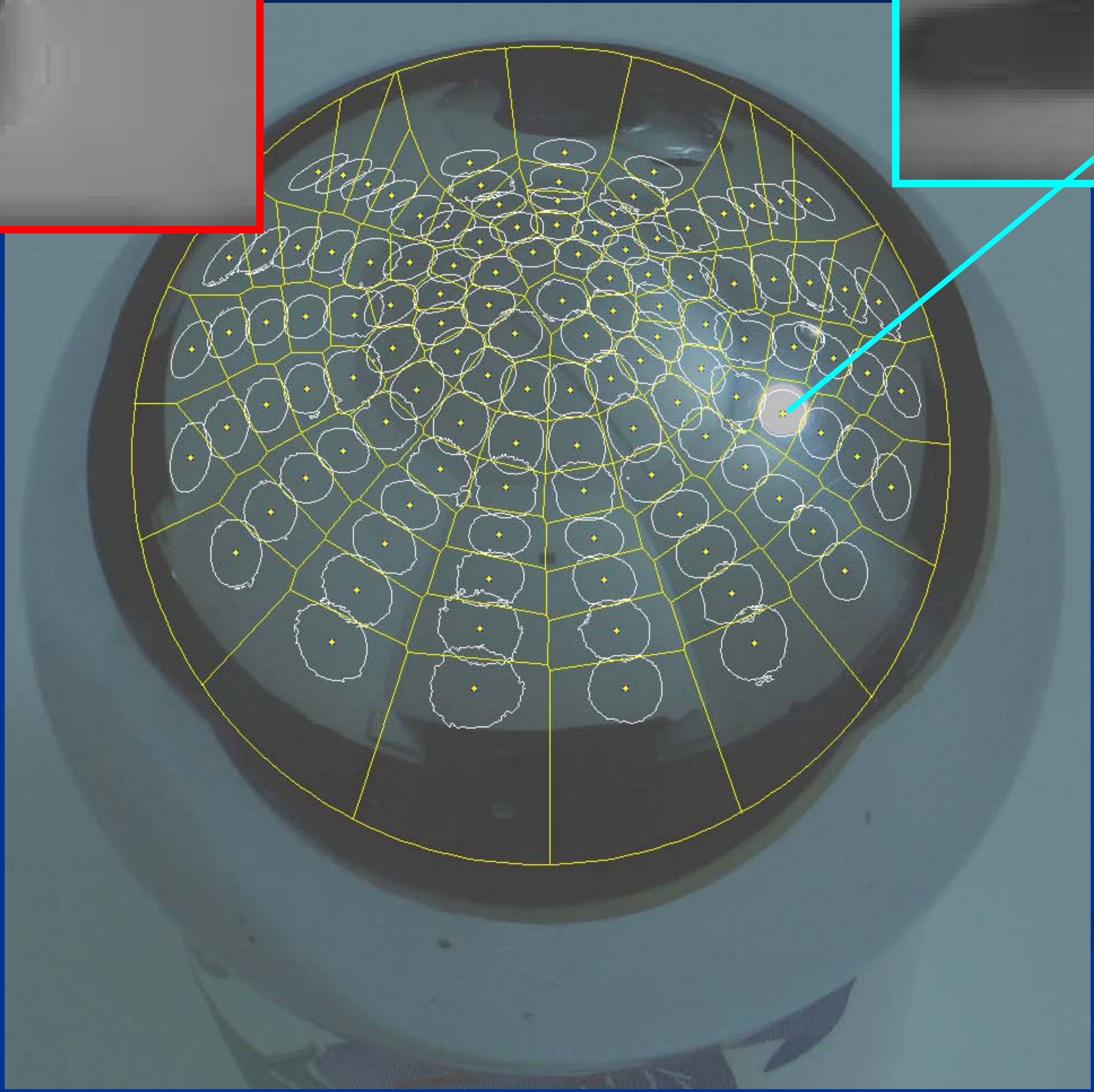
Voronoi Partition



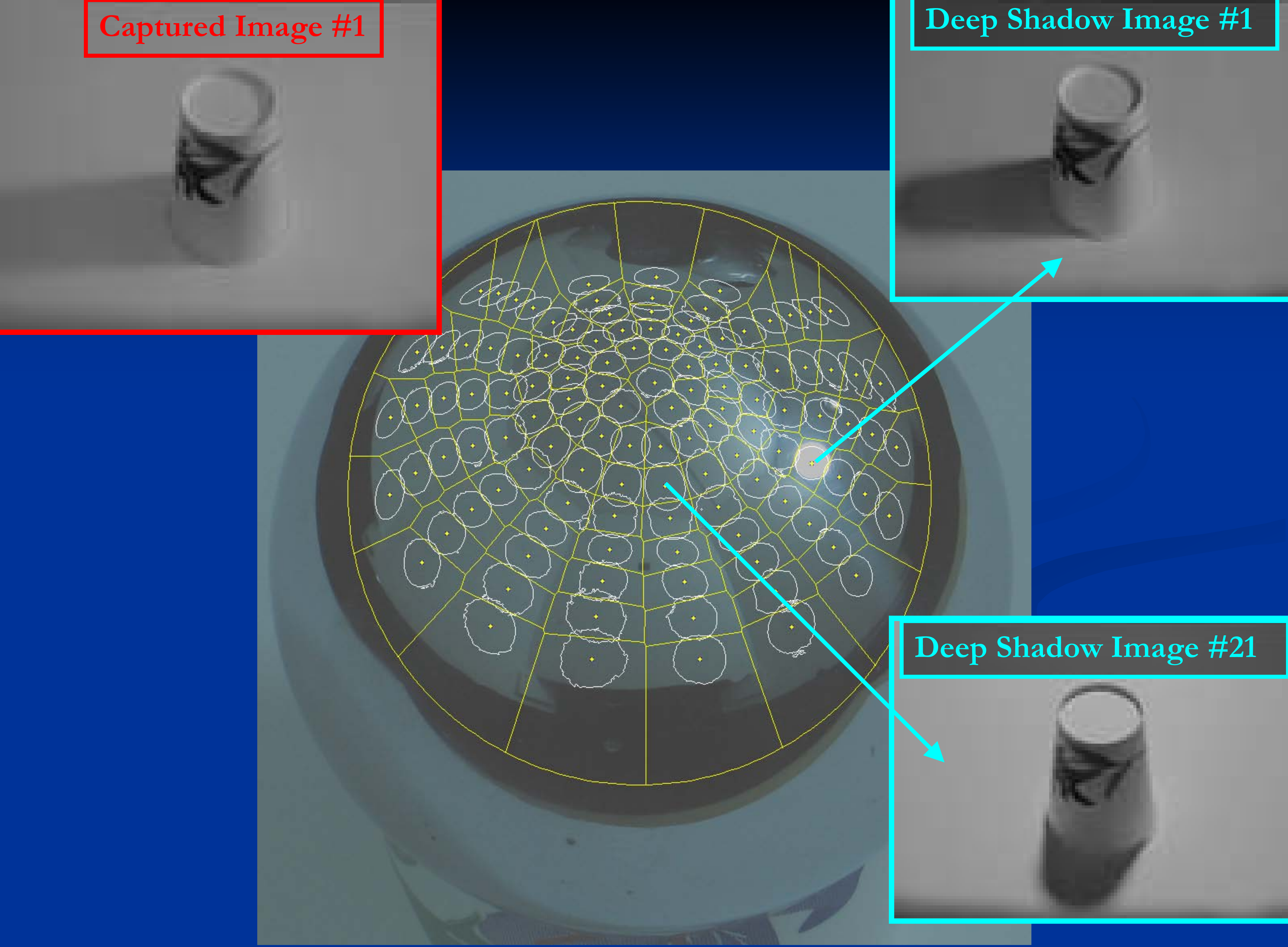

Captured Image #1



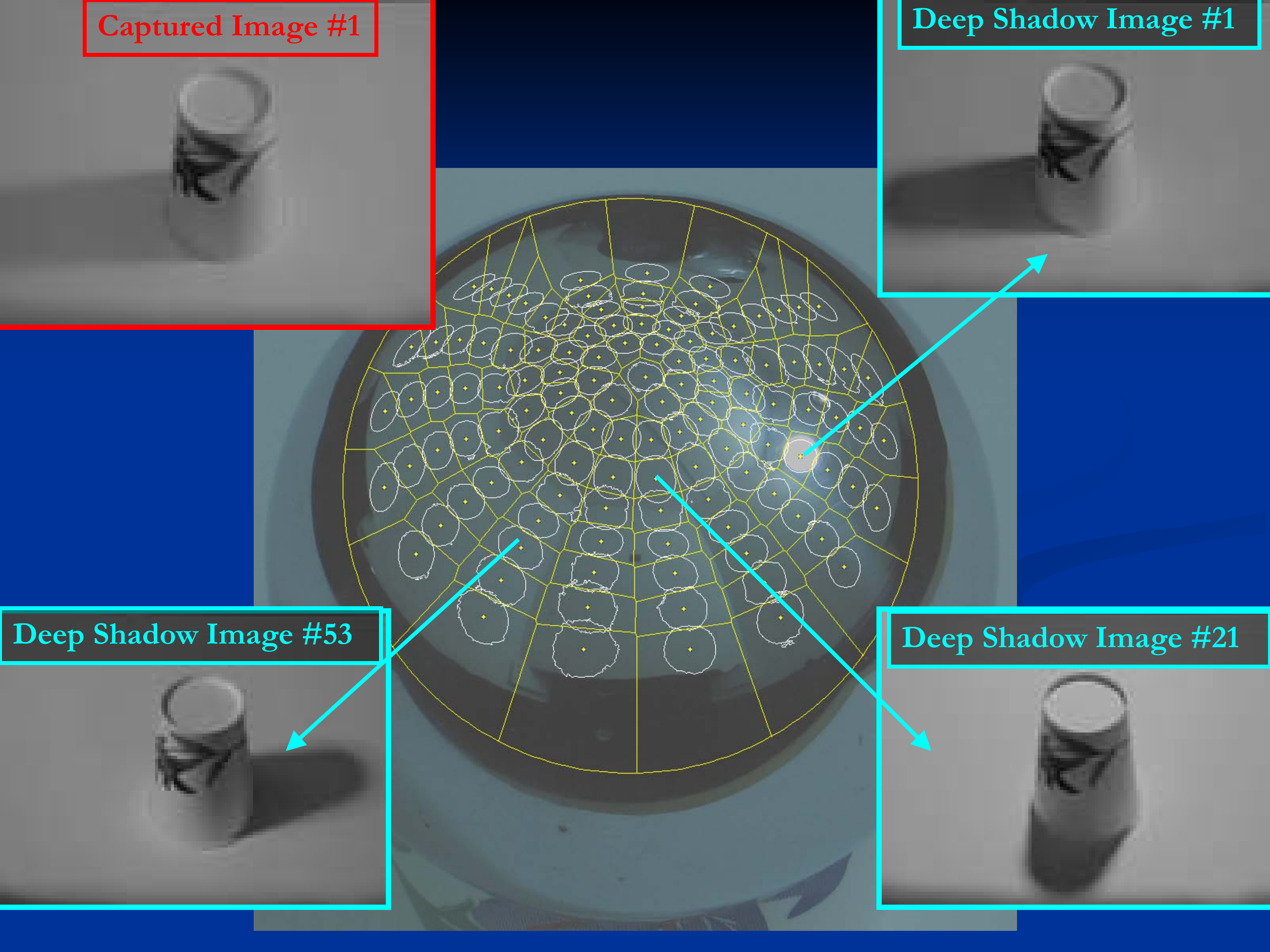

Captured Image #1

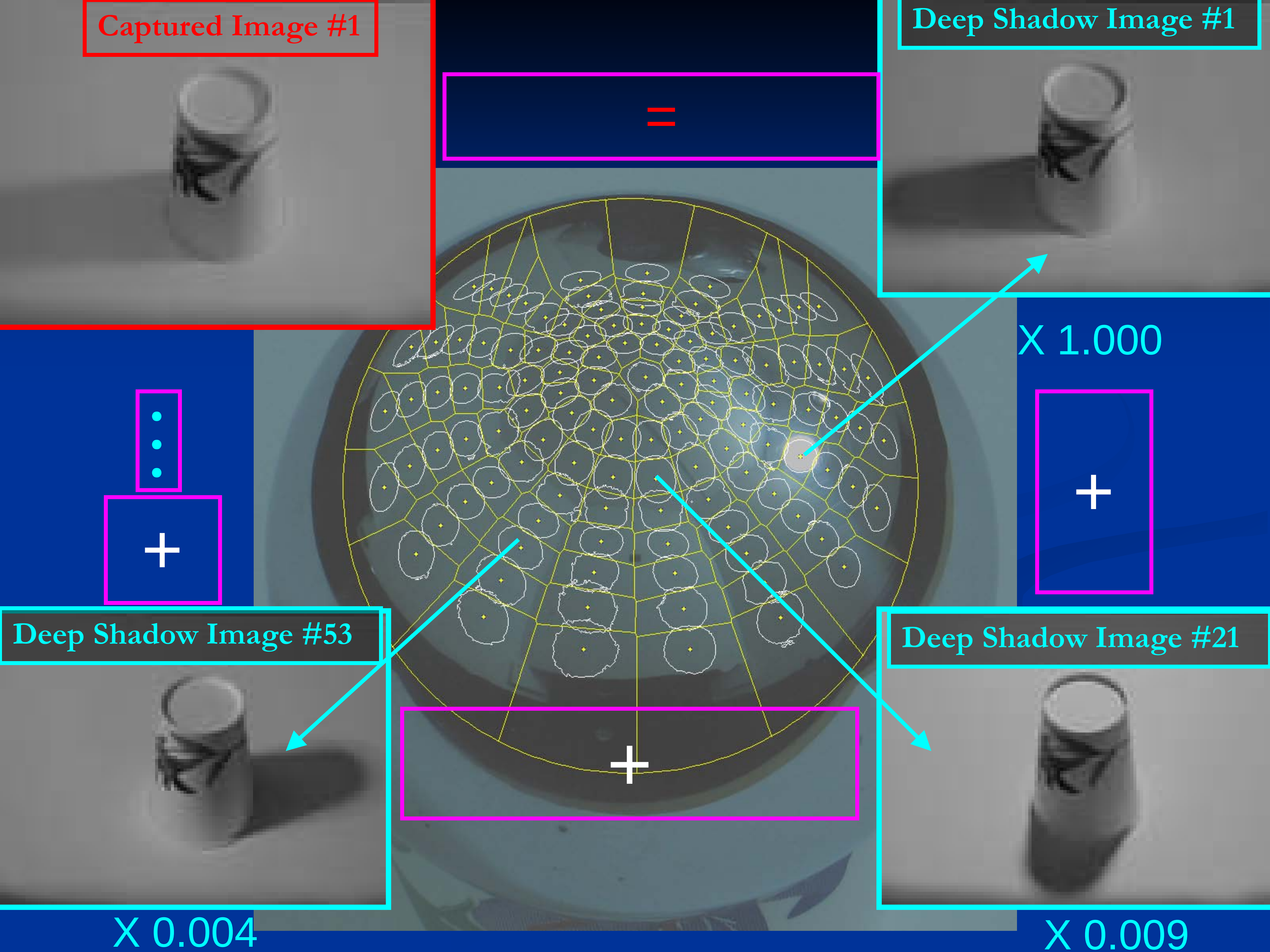



Deep Shadow Image #1



Captured Image #1
Deep Shadow Image #1
Deep Shadow Image #21


Captured Image #1
Deep Shadow Image #1
Deep Shadow Image #53
Deep Shadow Image #21



Captured Image #1
=
Deep Shadow Image #1
X 1.000
+
+
Deep Shadow Image #53
X 0.004
+
Deep Shadow Image #21
X 0.009

Captured Image is a Weighted Sums of Deep Shadow Images: Ax=b

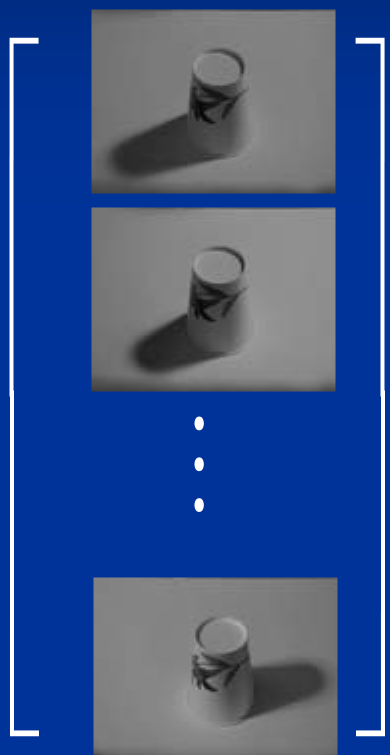
$$\begin{bmatrix} 1 & 0.009 & \cdots & 0.008 \\ 0.011 & 1 & \cdots & 0.010 \\ \vdots & \vdots & \ddots & \vdots \\ 0.012 & 0.011 & \cdots & 1 \end{bmatrix} \begin{bmatrix} ? \\ ? \\ \vdots \\ ? \end{bmatrix} =$$

Lighting Matrix

Deep Shadow Images

Captured Images

Remove Ambient Light: $x = A^{-1}b$



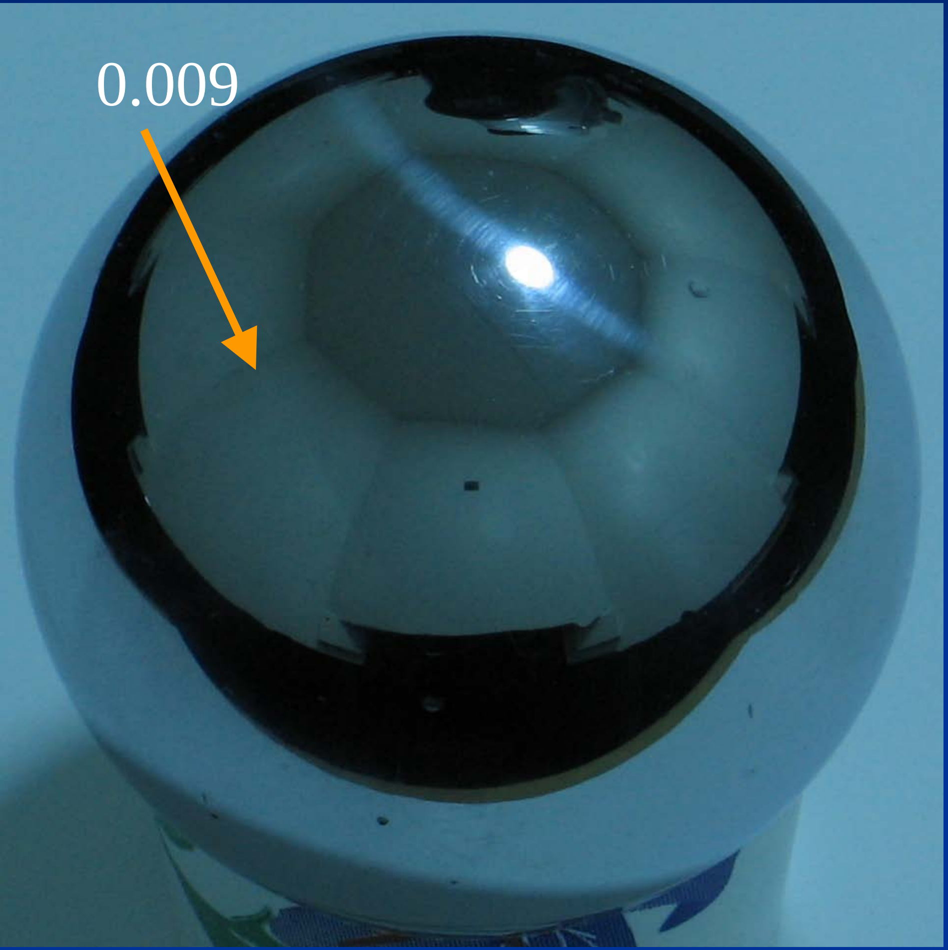
Deep Shadow

$$= \begin{bmatrix} 1 & 0.009 & \cdots & 0.008 \\ 0.011 & 1 & \cdots & 0.010 \\ \vdots & \vdots & \ddots & \vdots \\ 0.012 & 0.011 & \cdots & 1 \end{bmatrix}^{-1}$$

Lighting Matrix

Captured

HDR for High Contrasts



(a) Long exposure 1 second

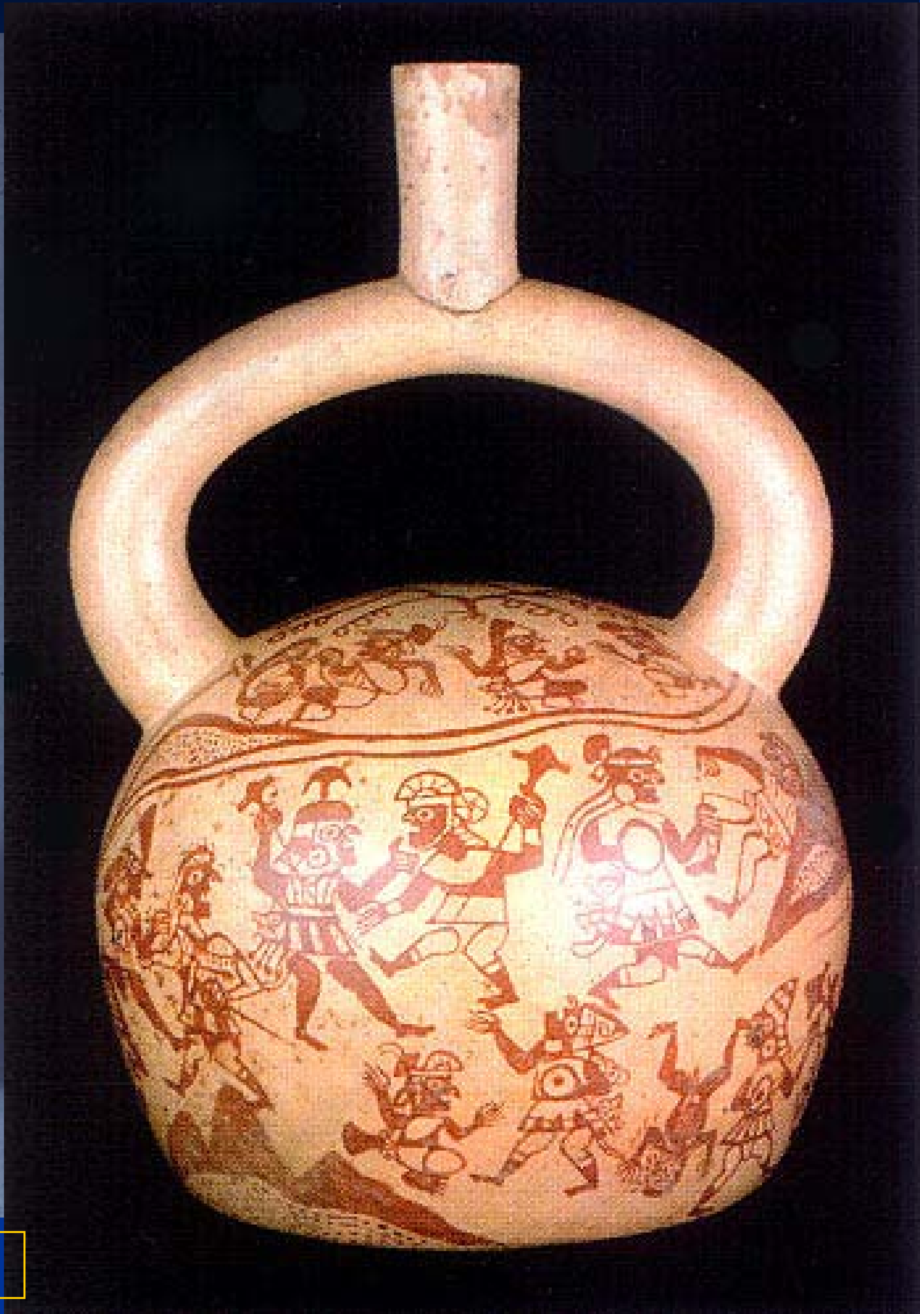
(b) Short exposure 0.05 second

Captured Image

Deep Shadow Image

Histogram Equalized Image

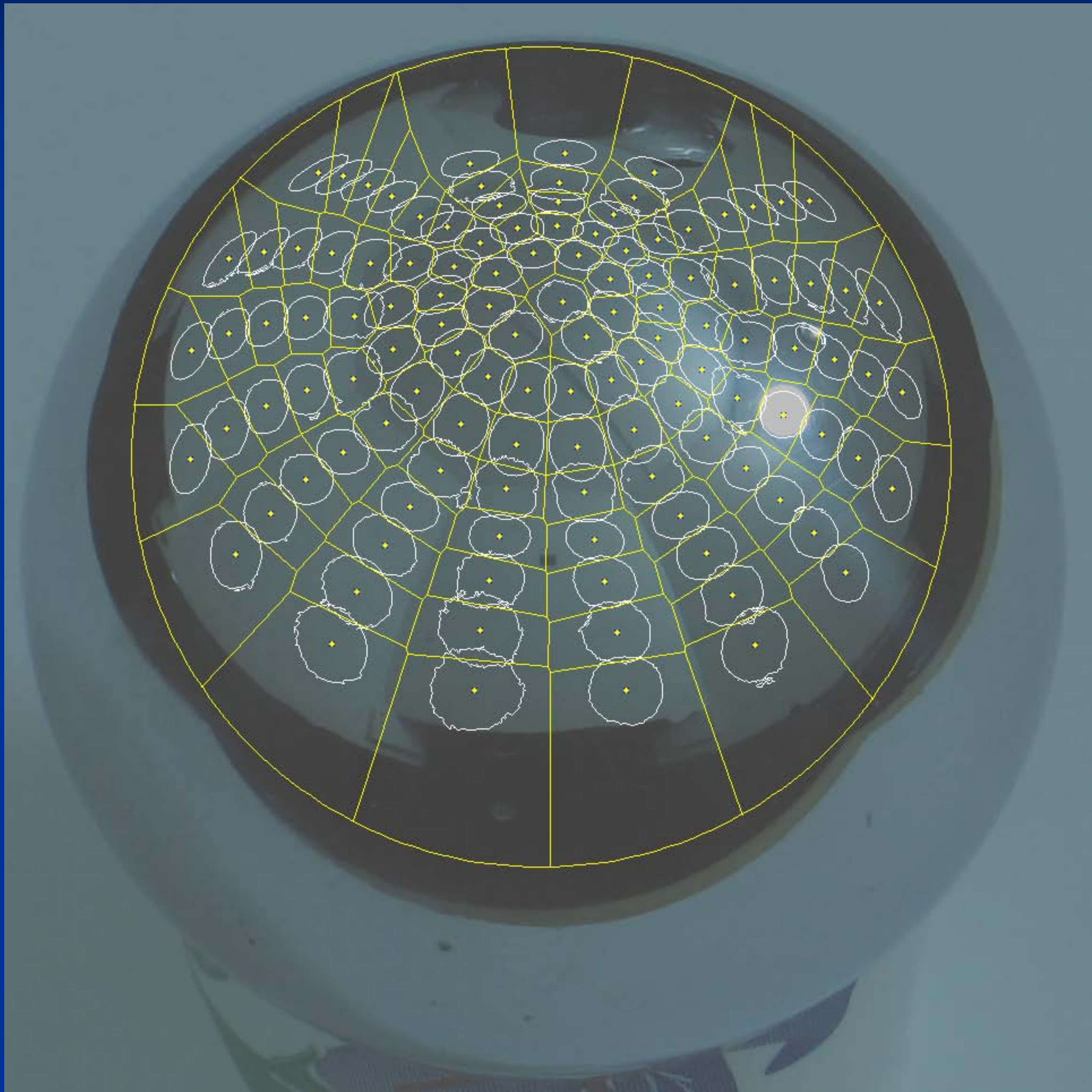
Field Museum Moche Pots (100-800AD, Peru…)



Courtesy Mary Weismantel, Northwestern University, Field Museum

Open Questions and Future Work

- Direct Physical Verification?
- Area *vs.* Point light?
- Light Shapes?



Thank you!

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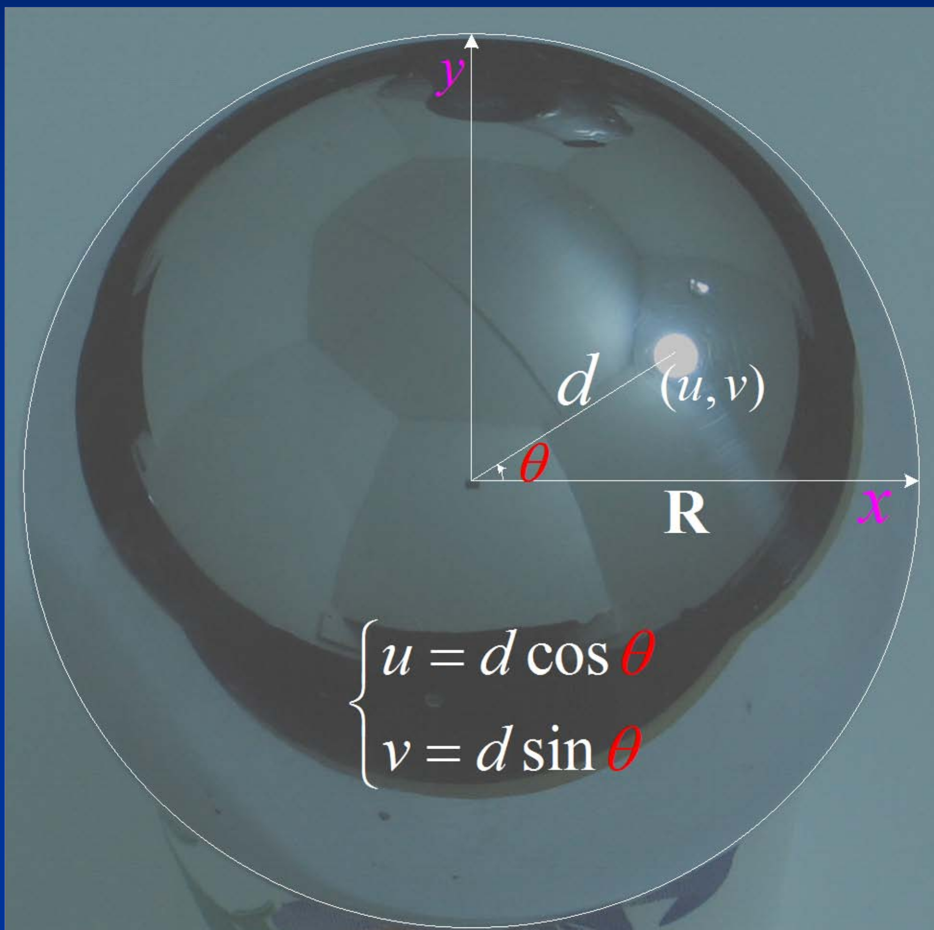
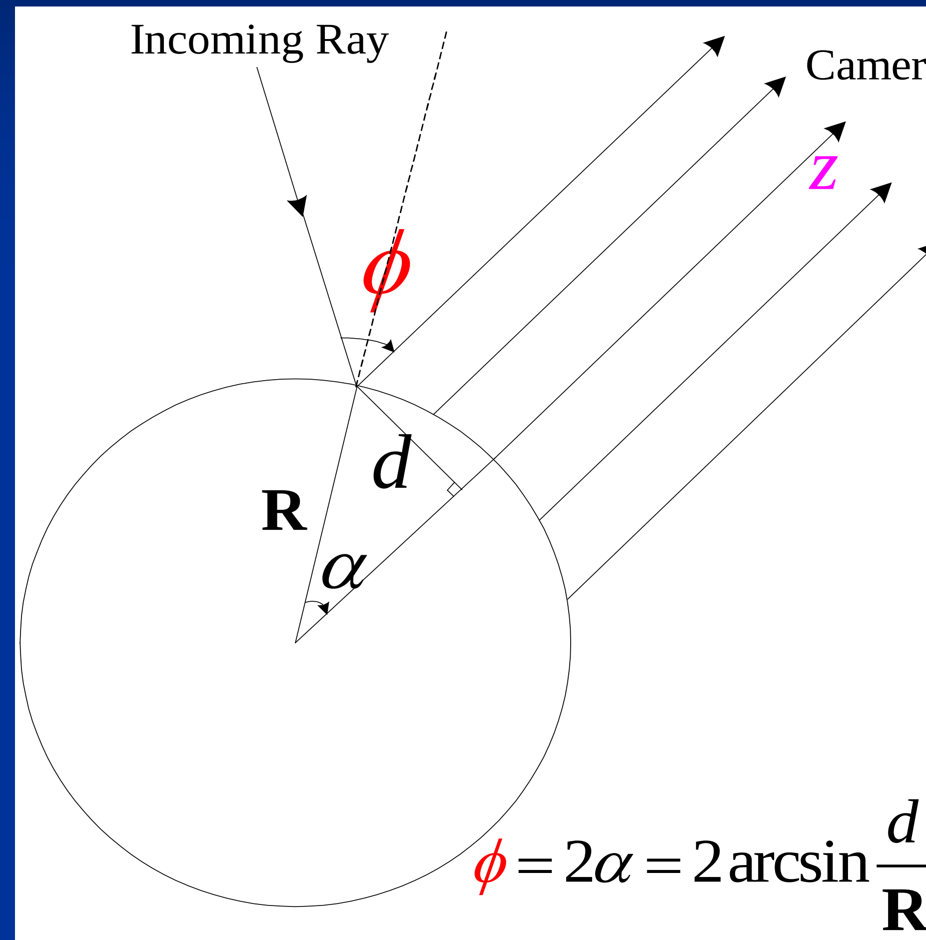
Compute Light Direction (θ, ϕ)



(a) Compute θ



(b) Compute Ø

Inverse L to Remove Ambient Light

- Linear Additive Principle

$$I = \sum_{i=1}^{N} R^{(i)} L^{(i)} \cdots\cdots (1)$$

Total energy received on a sensor pixel (I)

Light energy from direction i ($L^{(i)}$)

Reflectance field on direction i ($R^{(i)}$)

- $R^{(i)}$ the image lit ONLY from direction i

Our Solution

- Matrix Inverse to compute R

$$I = \sum_{i=1}^{N} R^{(i)} L^{(i)} \cdots\cdots (1)$$

$$\begin{bmatrix} L_1^{(1)} & L_1^{(2)} & \cdots & L_1^{(N)} \\ L_2^{(1)} & L_2^{(2)} & \cdots & L_2^{(N)} \\ \vdots & \vdots & \ddots & \vdots \\ L_N^{(1)} & L_N^{(2)} & \cdots & L_N^{(N)} \end{bmatrix} \begin{bmatrix} R^{(N)} \\ R^{(N)} \\ \vdots \\ R^{(N)} \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ \vdots \\ I_N \end{bmatrix}$$

$L_j^{(i)}$ light from direction i in image j

- Compute each pixel, each color channel seperately