
# Accurate Light Source Acquisition and Rendering

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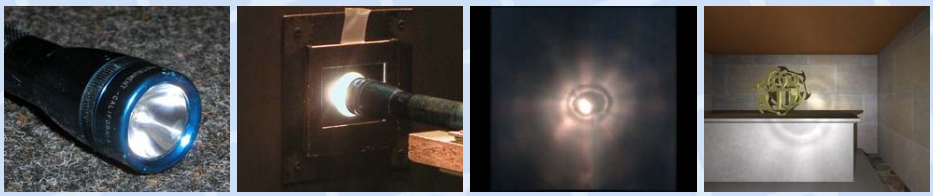
## Light Source Acquisition

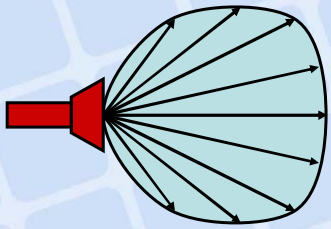



Goals:

- capture near field of a light source
- sampling with correct pre-filtering
- enable efficient rendering

## Near Field vs. Far Field

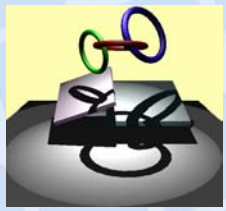

- far field assumption
  - only light direction
  - all light is emitted from a single point
  - intensity approximation valid for distances > 5x-20x emitting diameter

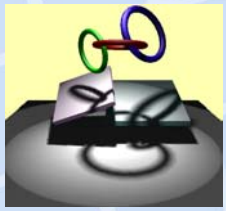


## Near Field vs. Far Field


near field data

- origin and direction of light (4D data)
- soft shadows
- distance effects
  - change of light pattern
  - slide projector in focus/out of focus





synthetic slide projector data set
focused at 3m, acquired at 90 cm

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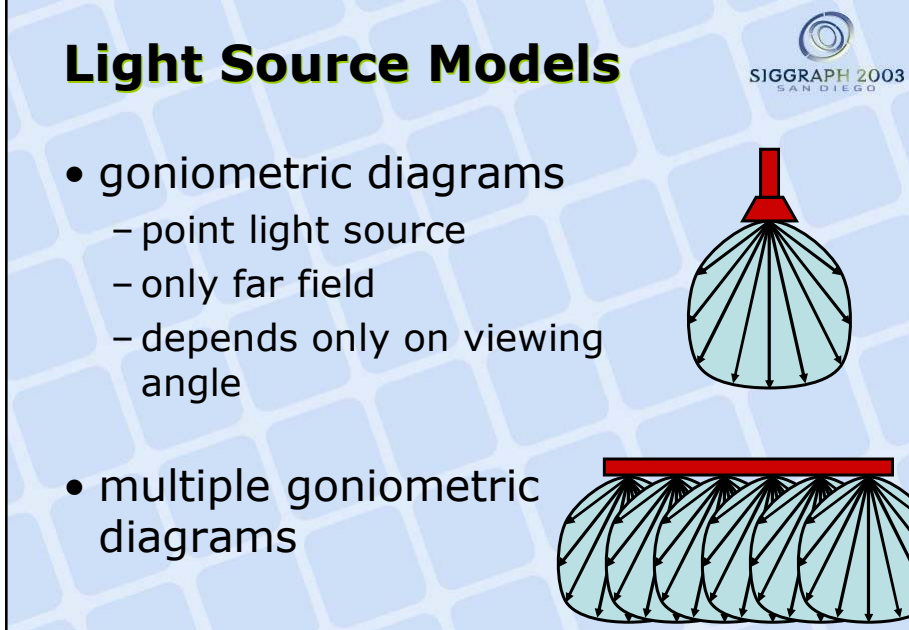
focused at 3m, acquired at 90 cm

## Light Source Models

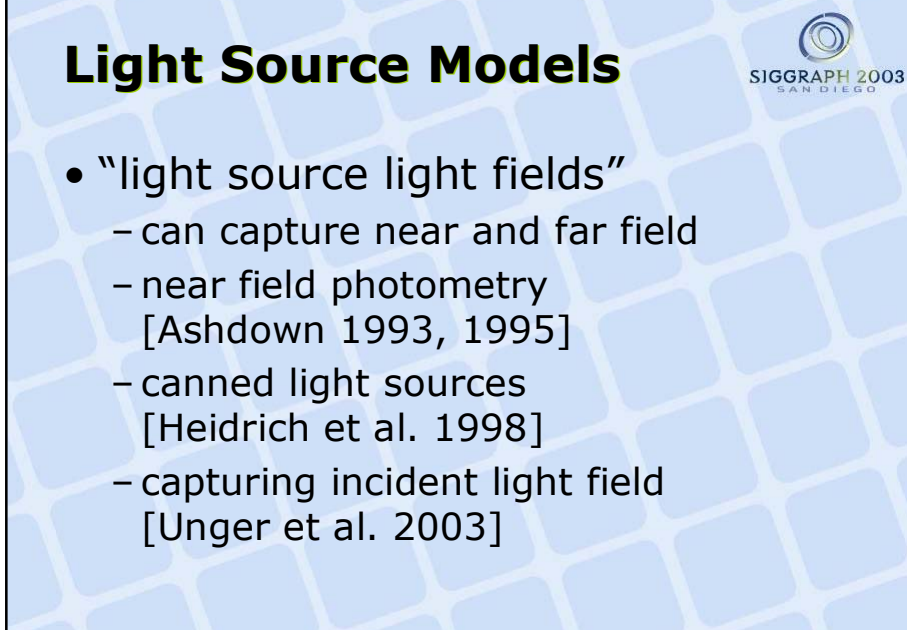



- goniometric diagrams
  - point light source
  - only far field
  - depends only on viewing angle
- multiple goniometric diagrams





## Light Source Models

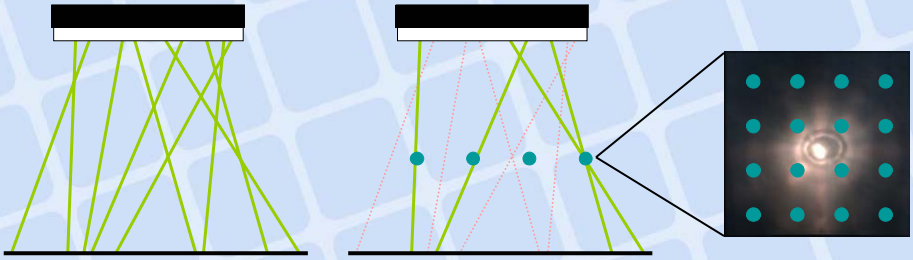



- "light source light fields"
  - can capture near and far field
  - near field photometry [Ashdown 1993, 1995]
  - canned light sources [Heidrich et al. 1998]
  - capturing incident light field [Unger et al. 2003]

## Sampling Issues

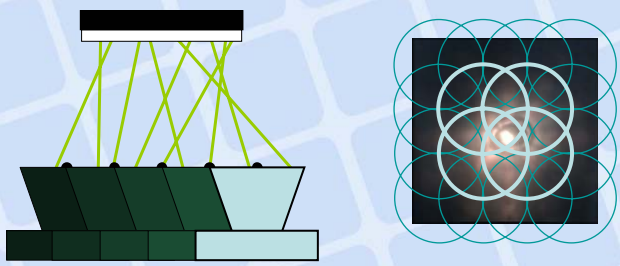

How to sample a light source?

- point sampling
  - miss a lot of rays
  - potential of aliasing
  - see also [Levoy and Hanrahan 1996]



## Sampling Issues


- camera and lens system
  - aperture 2 time sample spacing [Halle 1994]
  - get all rays multiple times
  - sampling behavior not well defined



## Our Contributions


Acquisition:

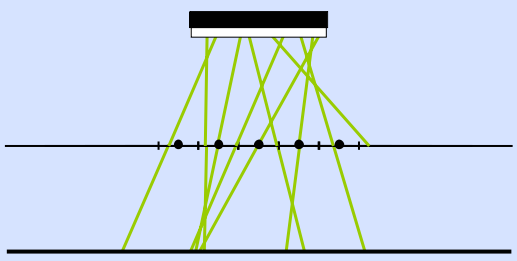
- optical filtering before sampling
  - projection of light field into 4D function basis
  - low pass filtering in spatial domain
  - avoids aliasing

Rendering:

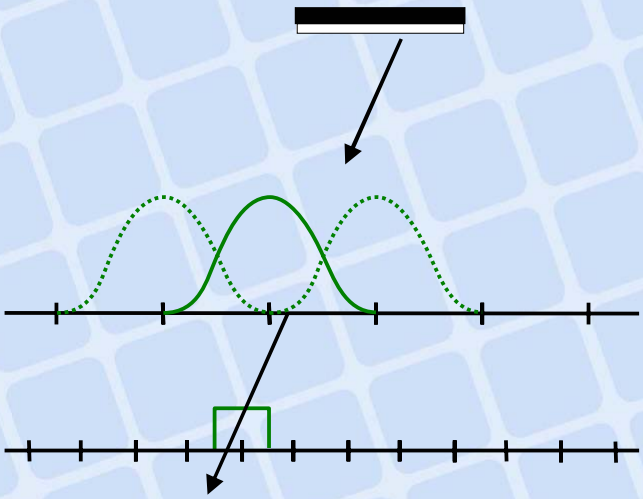
- importance sampling of light field
  - constant time particle emission

## Sampling Issues


- box filtering
  - everything exactly once
  - reduces aliasing
  - non-ideal basis (piecewise constant)



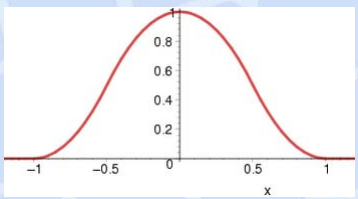
# Projection into 4D Function Space




# Projection into 4D Basis

- sampling plane S
  - coarse sampling
  - e.g. piecewise quadratic basis functions

$$\Phi_{i,bellq} = \begin{cases} 1-2x^2 & |x| \le 1/2 \\ 2(|x|-1)^2 & 1/2 < |x| \le 1 \\ 0 & else \end{cases}$$

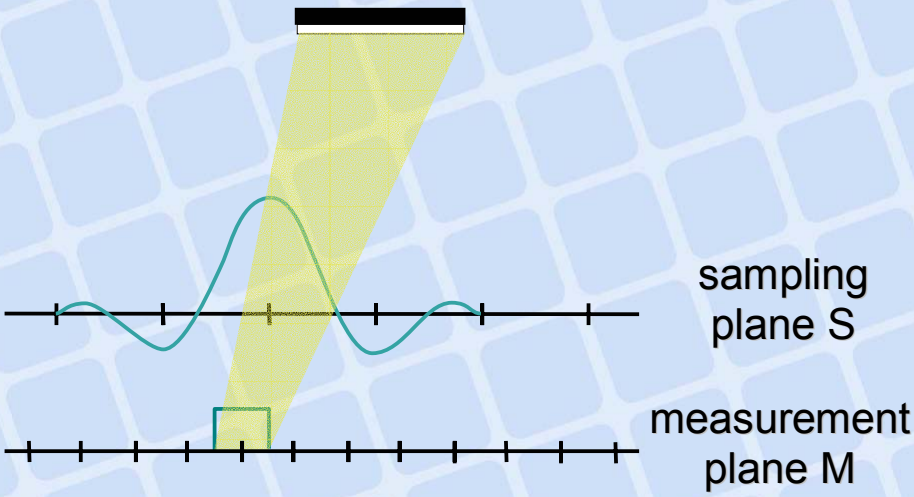


## Projection into 4D Basis

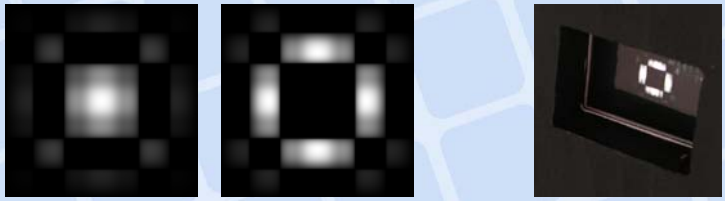

- measurement plane M
  - dense sampling
  - piecewise constant basis
- tensor product construction of 4D basis

$$\Phi_{ijkl}(u,v,s,t)$$
$$= \Phi_{ij}(u,v) \cdot \Phi_{kl}(s,t)$$
$$= \Phi_{i,bellq}(u) \cdot \Phi_{j,bellq}(v) \cdot \Phi_{k,linear}(s) \cdot \Phi_{l,linear}(t)$$

## Dual Basis as Filter

## Sampling Issues

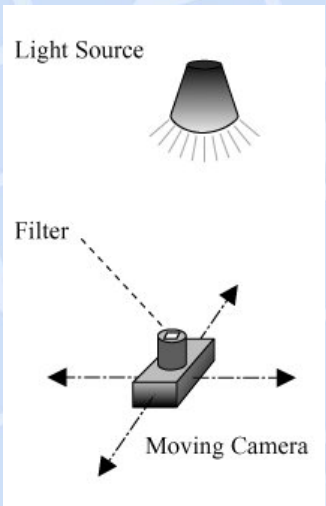


advanced filtering

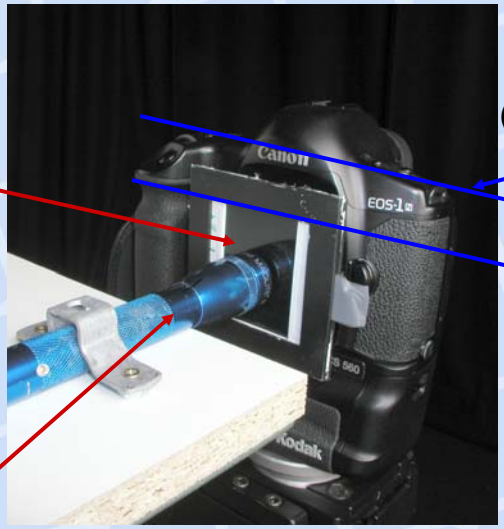
- use grayscale printed slide
- arbitrary filter kernel
- adapted to reconstruction algorithm
- negative coefficients possible

## Measurement Setup A

- replace camera lens system with filter
  - pinhole camera with filter as "pinhole"
- CCD chip as measurement plane
- move light source or camera

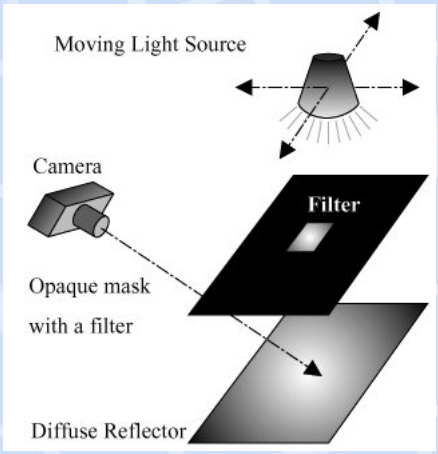


# Measurement Setup A

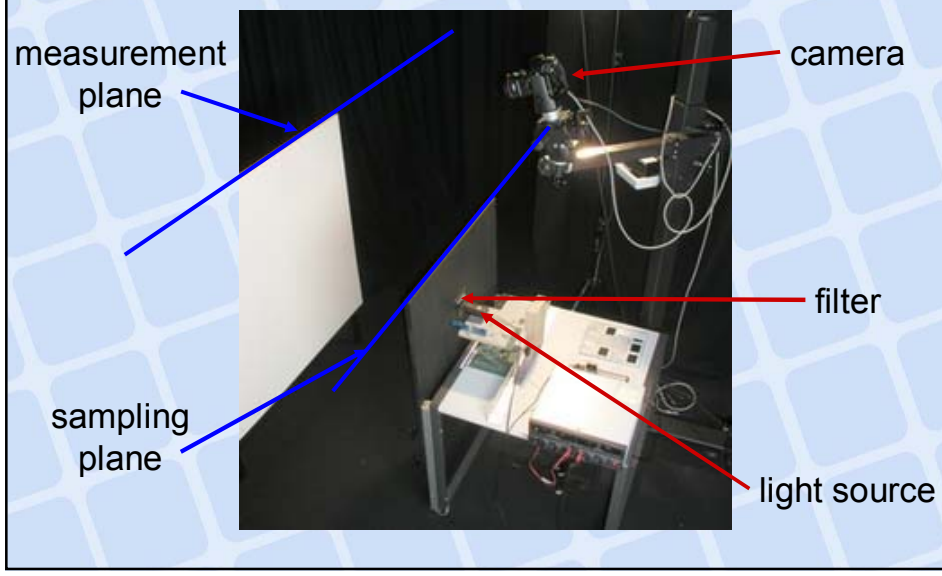



# Measurement Setup B

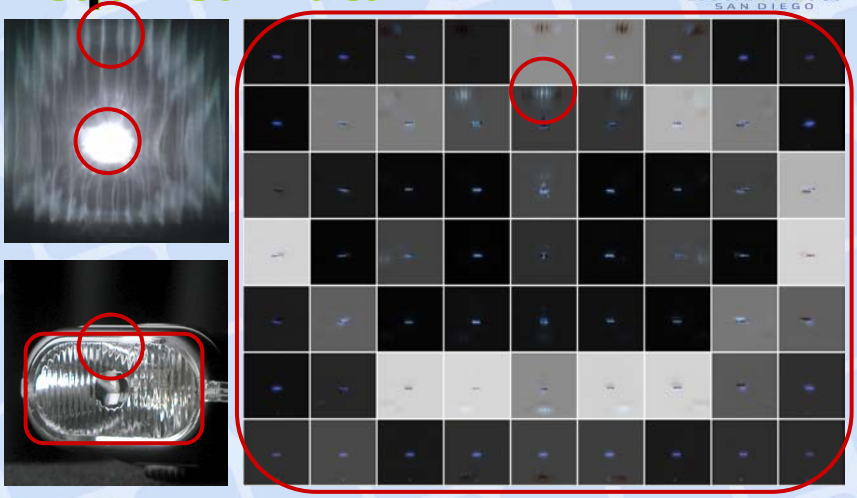
- filter projects light source on projection screen
- take pictures using standard photographic techniques



# Measurement Setup B




# Acquired Data



"directional information sorted by spatial origin"

## Rendering with Global Illumination

- particle emission (particle tracing, photon map)
- treat intensities in light field as importance function

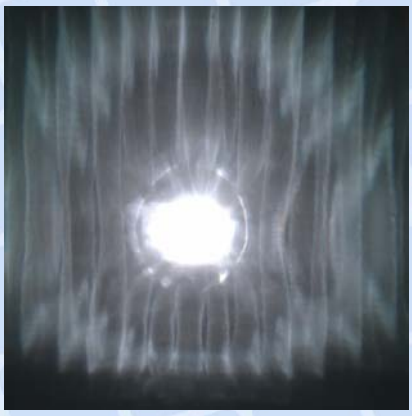
## Rendering with Global Illumination

- constant-time particle emission
  - independent of data set size (table lookup)
  - inverted cumulative density function
    - complex due to basis functions
    - 2 step approach
  - used for redistribution of random or quasi-random 4D samples (e.g. Halton sequence, jittered sampling)

# Hardware Accelerated Rendering

will be presented at Pacific Graphics 2003

# Results



measured bike light data set
(9x7 images)

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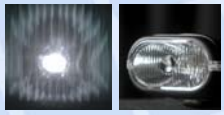

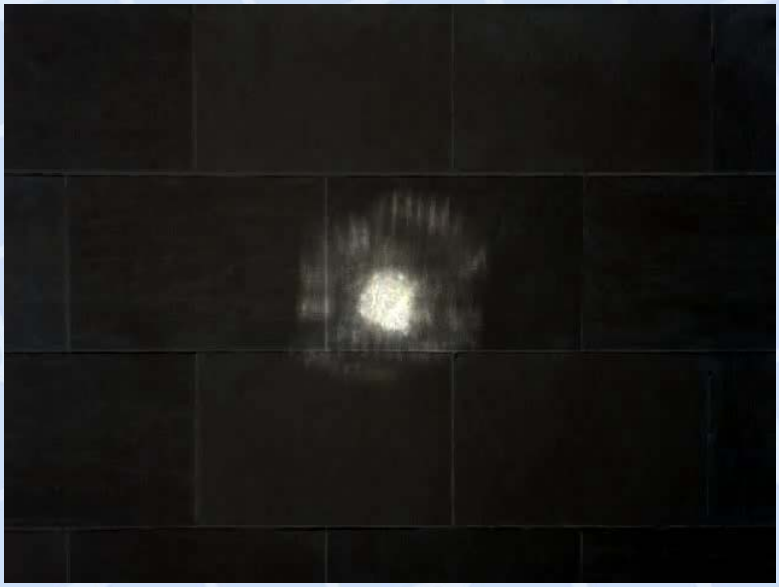

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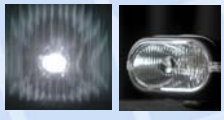


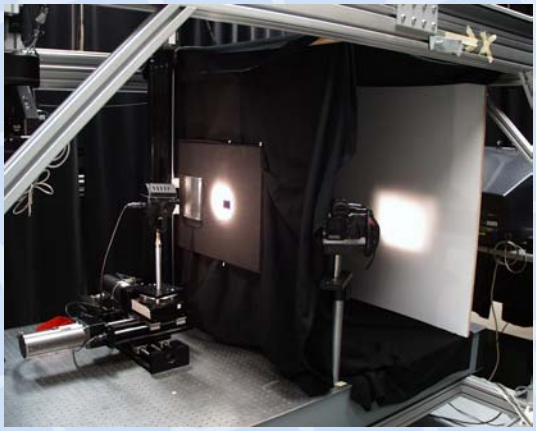
## Conclusion


- light source acquisition algorithm for near field and far field
- correct pre-filtering implemented
- efficient rendering

## Future Work


- sampling issues
  - choice of basis function
  - sampling density
  - replace printed filters with LCD panel
    - filters instantly exchangeable
    - hierarchical acquisition (wavelets)

## Future Work



- different sampling surfaces
  - automated setup
  - UBC Active Measurement facility (ACME) [Pai 2001]

## Thanks to …

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- Oliver Ashoff
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# Questions?

SIGGRAPH 2003
SAN DIEGO