Research on Holographic Data Storage

at IBM

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- Introduction: the Dream
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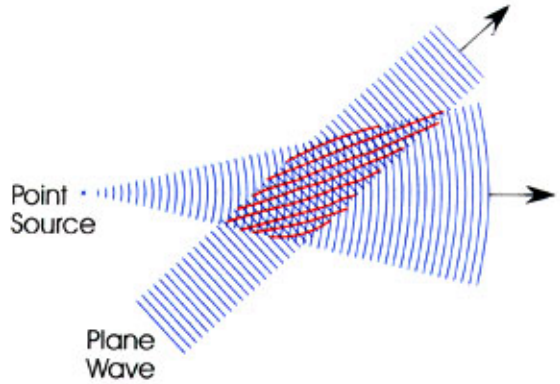
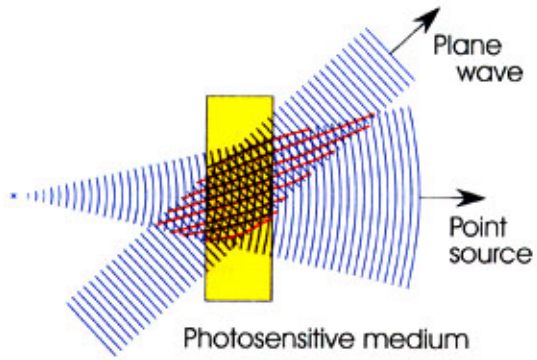


(a)

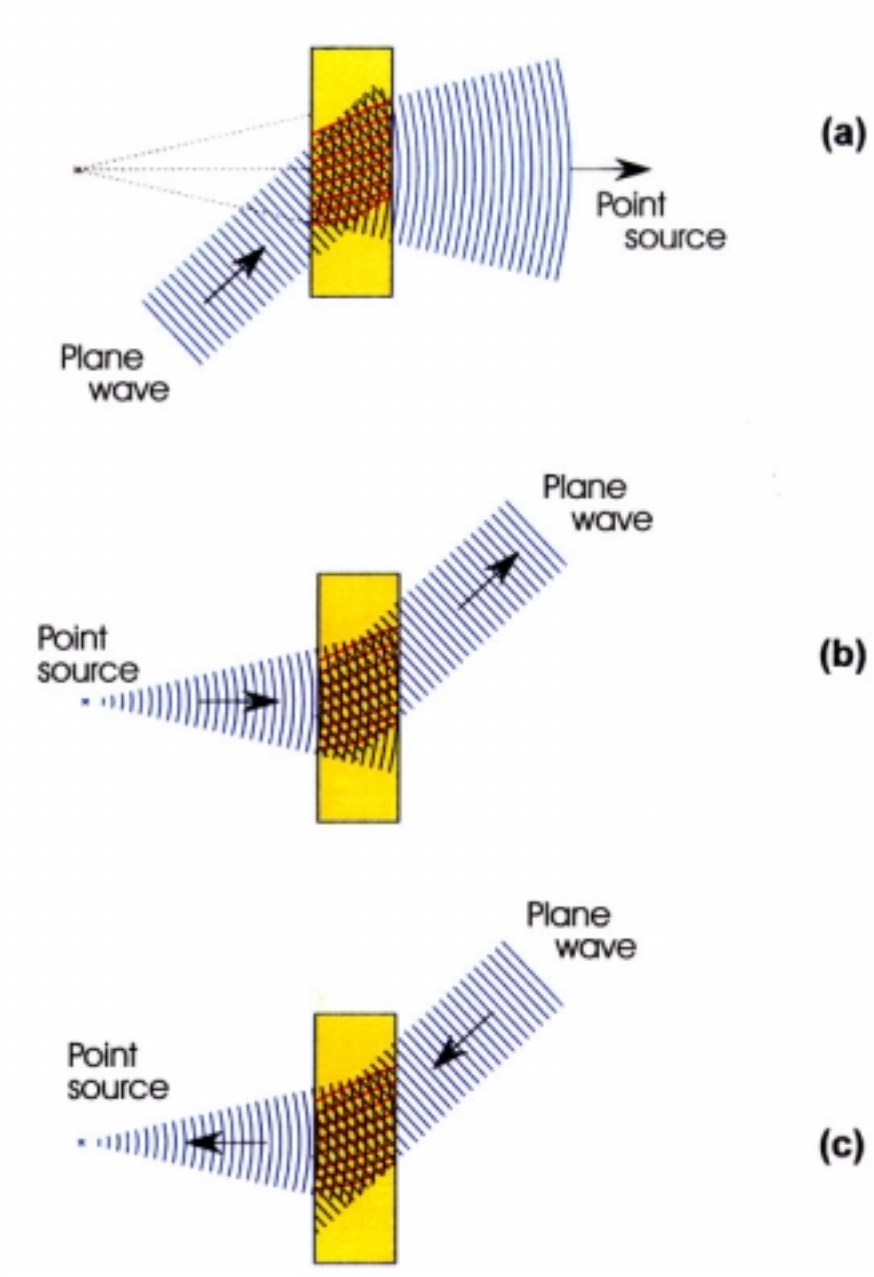


(b)

The photoresistive medium replicates the fringes as a change in:

- absorption
- refractive index
- thickness

(c)


(a)
Point source
Plane wave
Plane wave
Point source
(b)
Plane wave
Point source
(c)

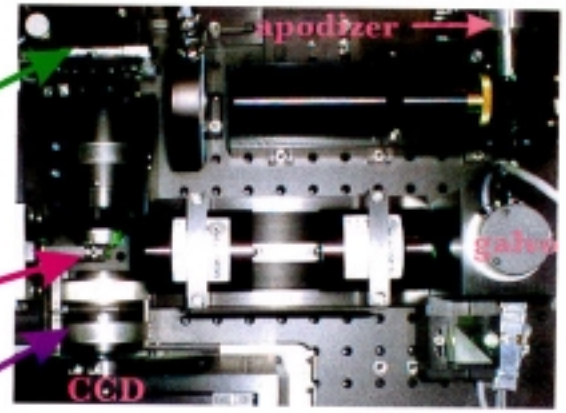
PRISM
Fixed SLM
1024 x 1024 pixels

DEMON
Dynamic SLM
320 x 240 pixels

DEMON 2

Dynamic SLM
1024 x 1024 pixels + short focal length optics

IBM Yorktown reflective SLM



$LiNbO_3$:Fe

custom optics
f=30mm
image distortion < 0.01%

Demon2 team

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H. Coufal	M. Jurich
C. Gollasch	R. Macfarlane
J. A. Hoffnagle	R. M. Shelby

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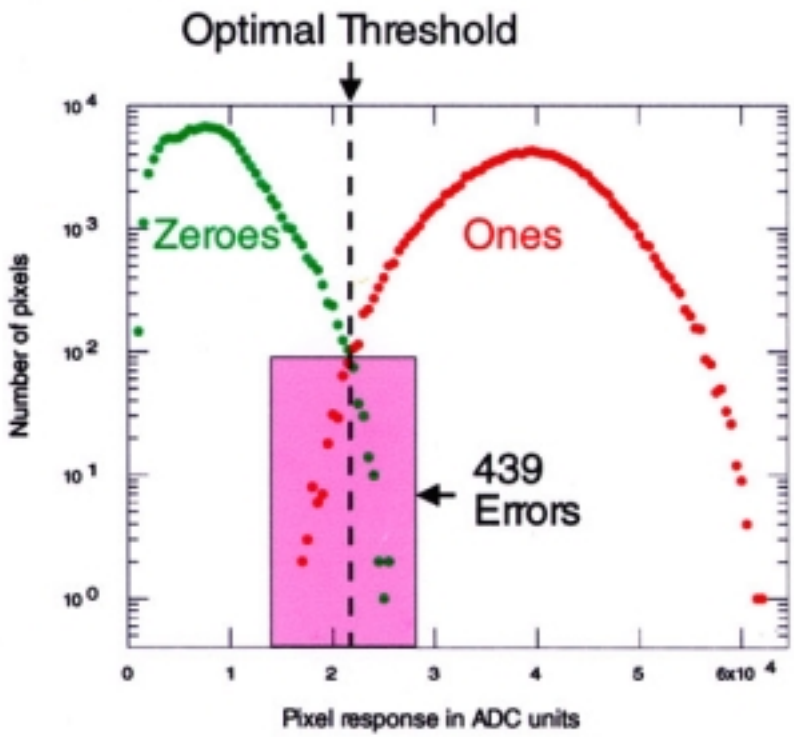
Bit Error Rate of a Poor Image

$\delta M = 8 \times 10^{-4}$



$$BER = \frac{\text{Errors}}{\text{Total Bits}} = \frac{439}{262{,}144} = 1.67 \times 10^{-3}$$

ARPA

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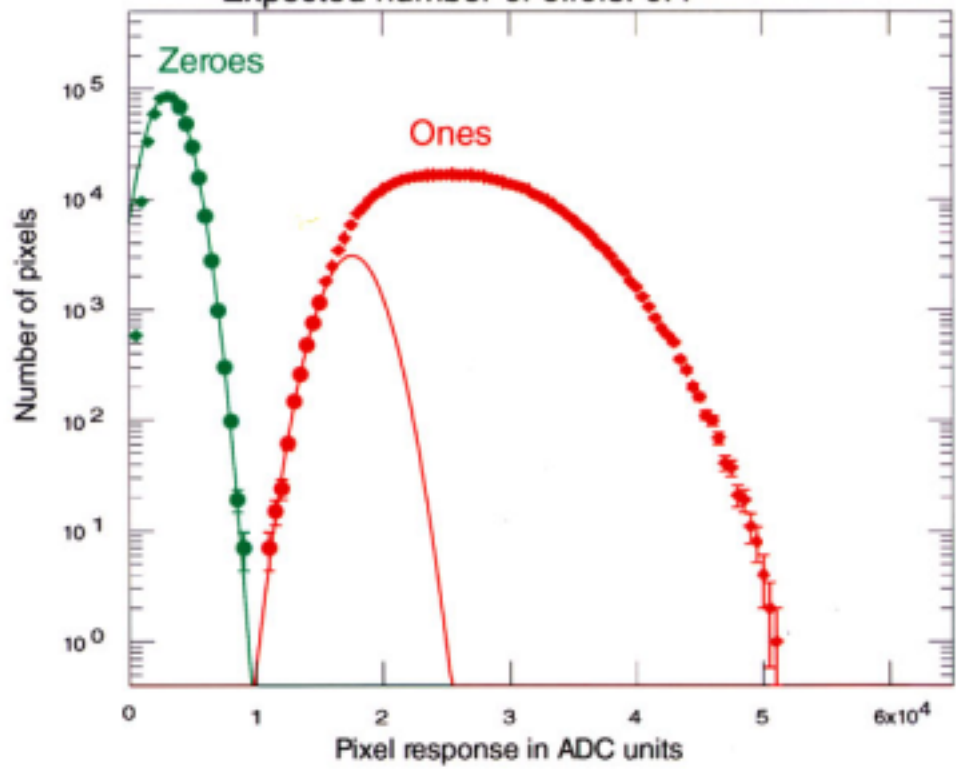
Bit Error Rate Calculation: Fitted histogram of 1 Mbit image

1024x1024 random bits on 9 µm centers
Computed BER = 3.6×10^{-7}
Expected number of errors: 0.4



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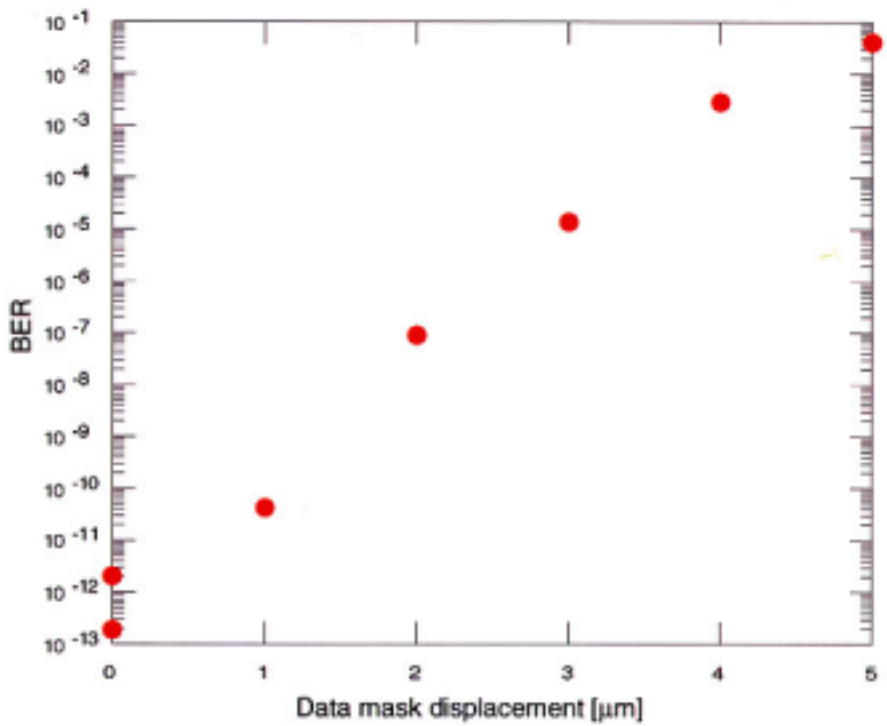
Dependence of the Bit Error Rate on alignment of the image to the CCD

512x512 random bits on 18 µm centers



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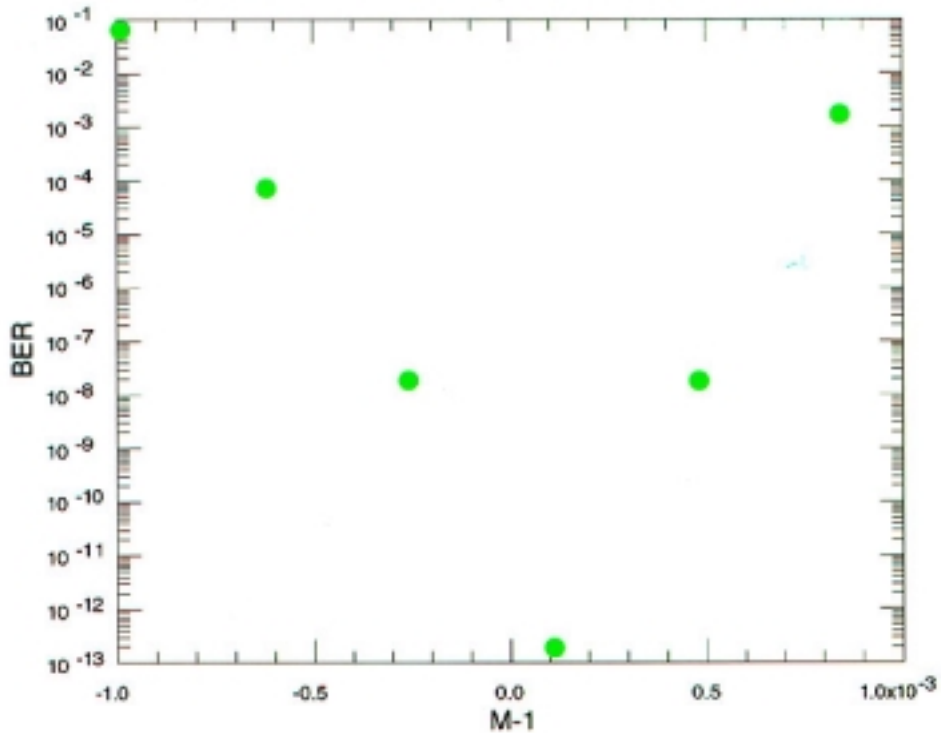
Dependence of the Bit Error Rate on magnification error in FT optics

512x512 random bits on 18 µm centers



DARPA

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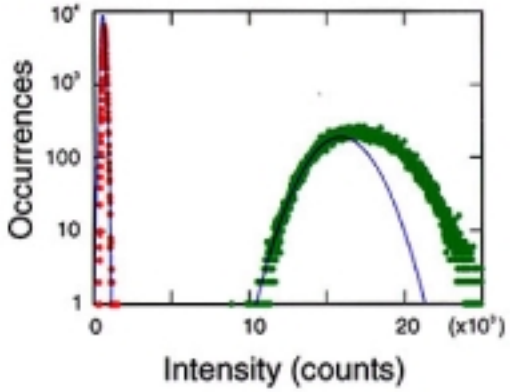
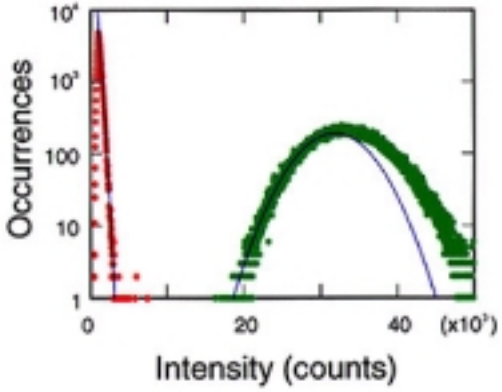
Lithium Niobate: Digital Holography
256 kilobit data page:

Error Rate: Image: 10^{-17} Hologram: 10^{-11}





DARPA

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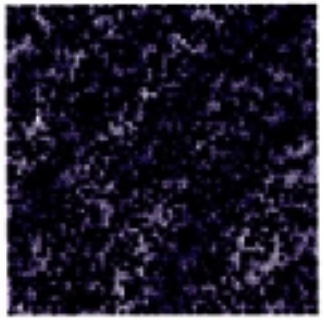
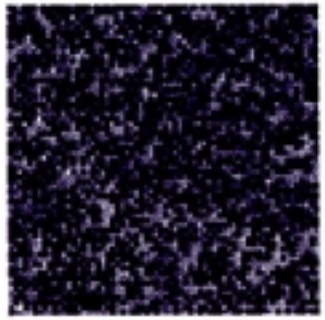
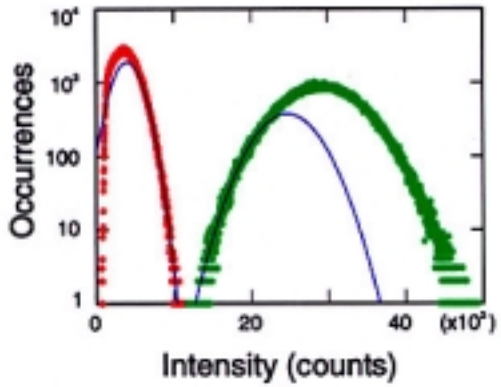
Lithium Niobate: Digital Holography
1 Megabit data page:

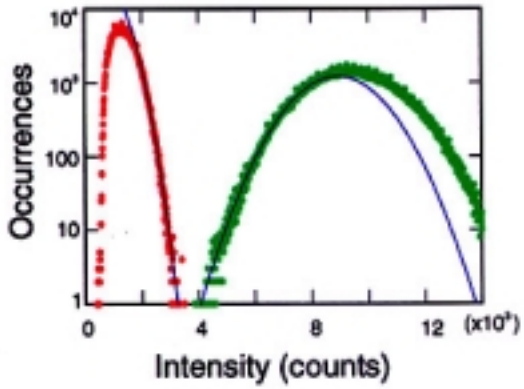




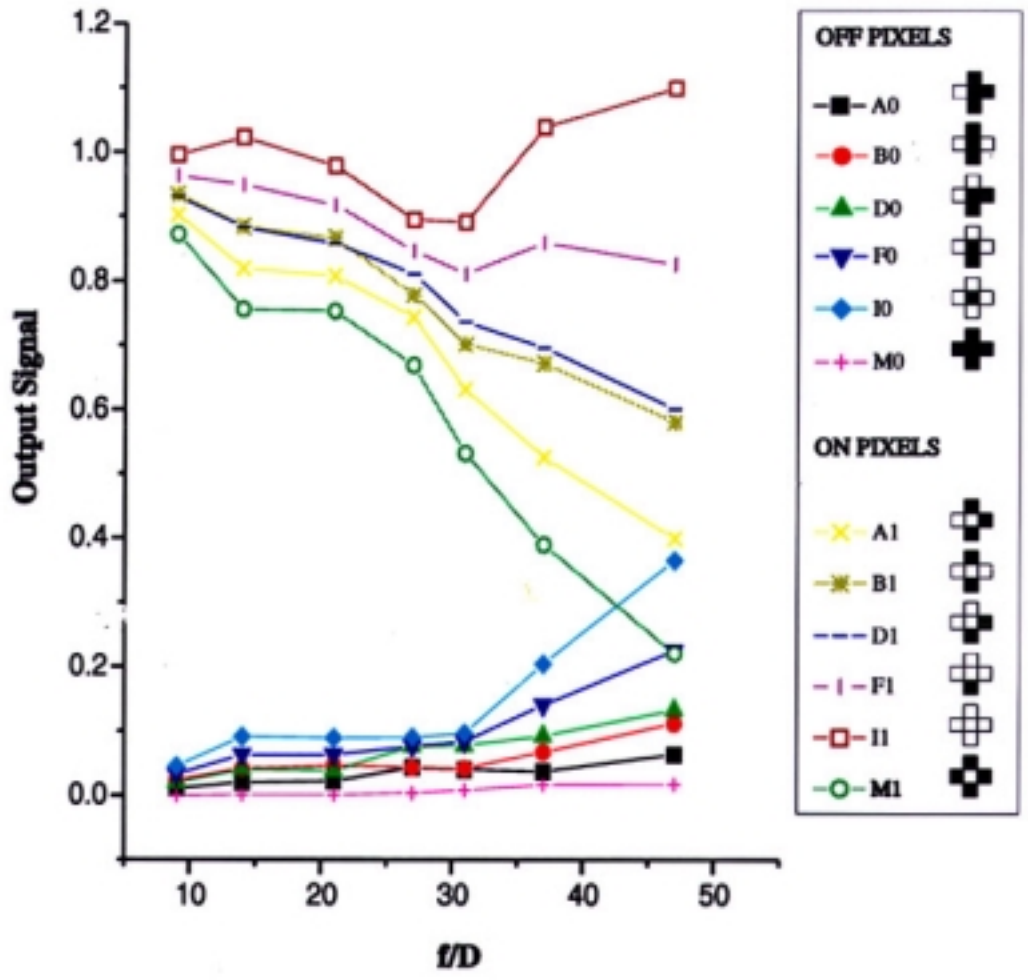
Error Rate: Image: 3.4×10^{-6}



Hologram: 2.4×10^{-6}



Inter-pixel crosstalk

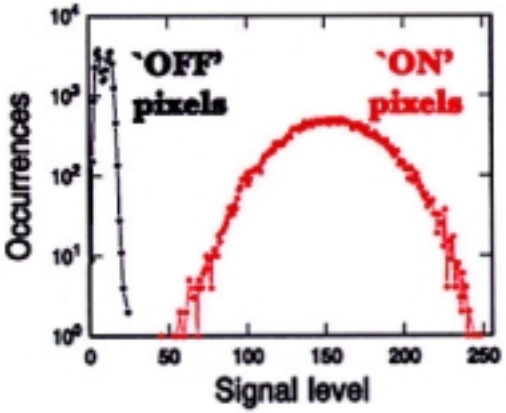


10/7/96

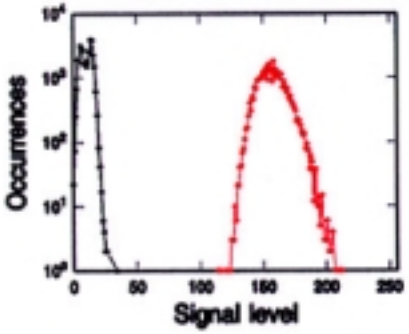
Predistortion

Removes repeatable variations among data pixels during recording

Histogram before

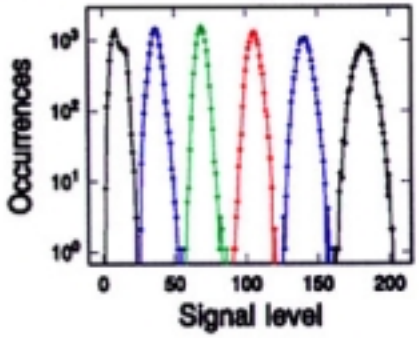


Histogram after



Burr et al, *Opt. Lett.* 23, 289 (1998).

Also allows `gray-scale'



Burr et al, *Opt. Lett.* 23, 1218 (1998).

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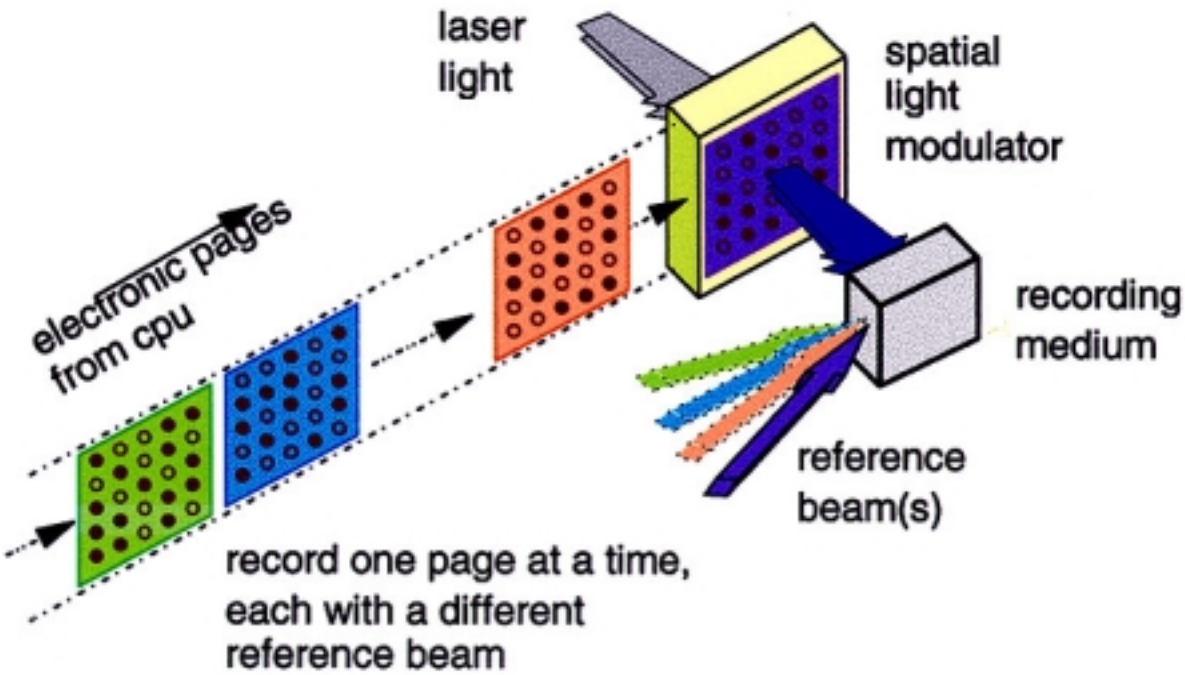
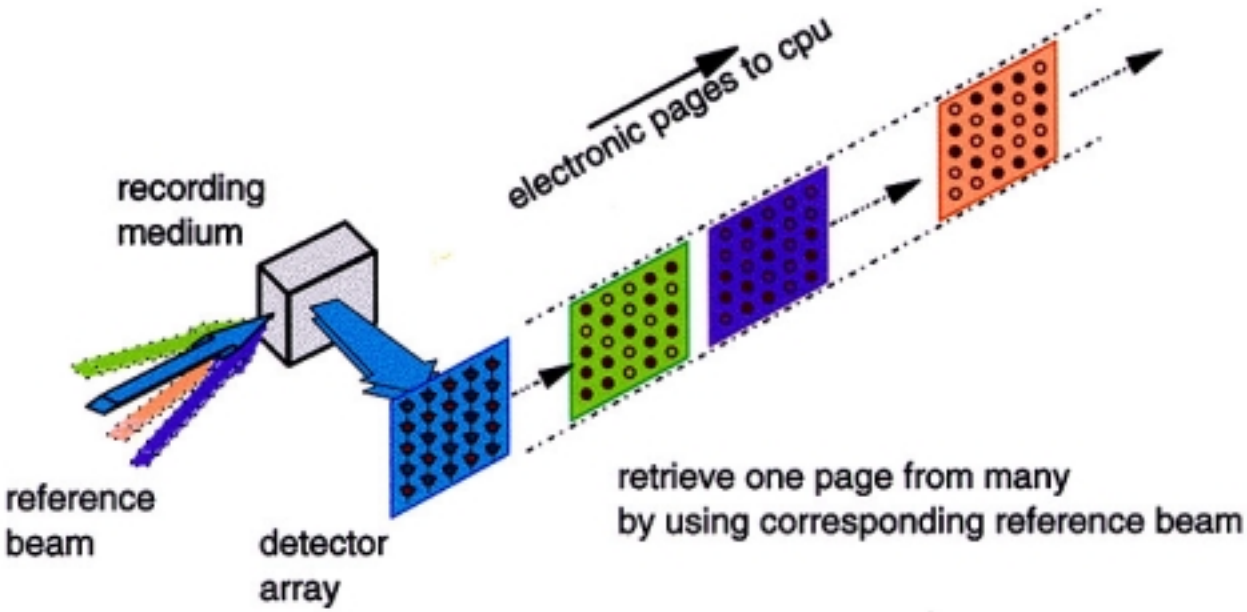
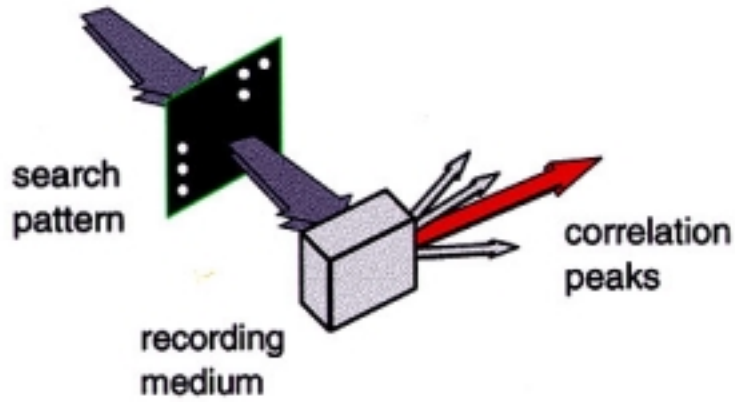
Holographic Storage - Recording Data

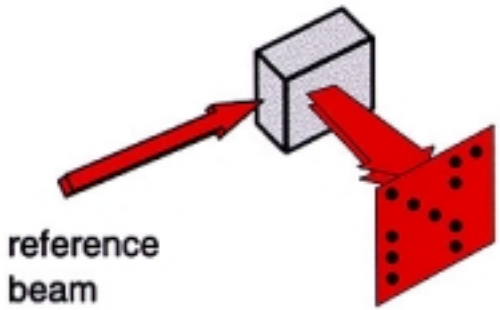


Holographic Storage - Retrieve by Address

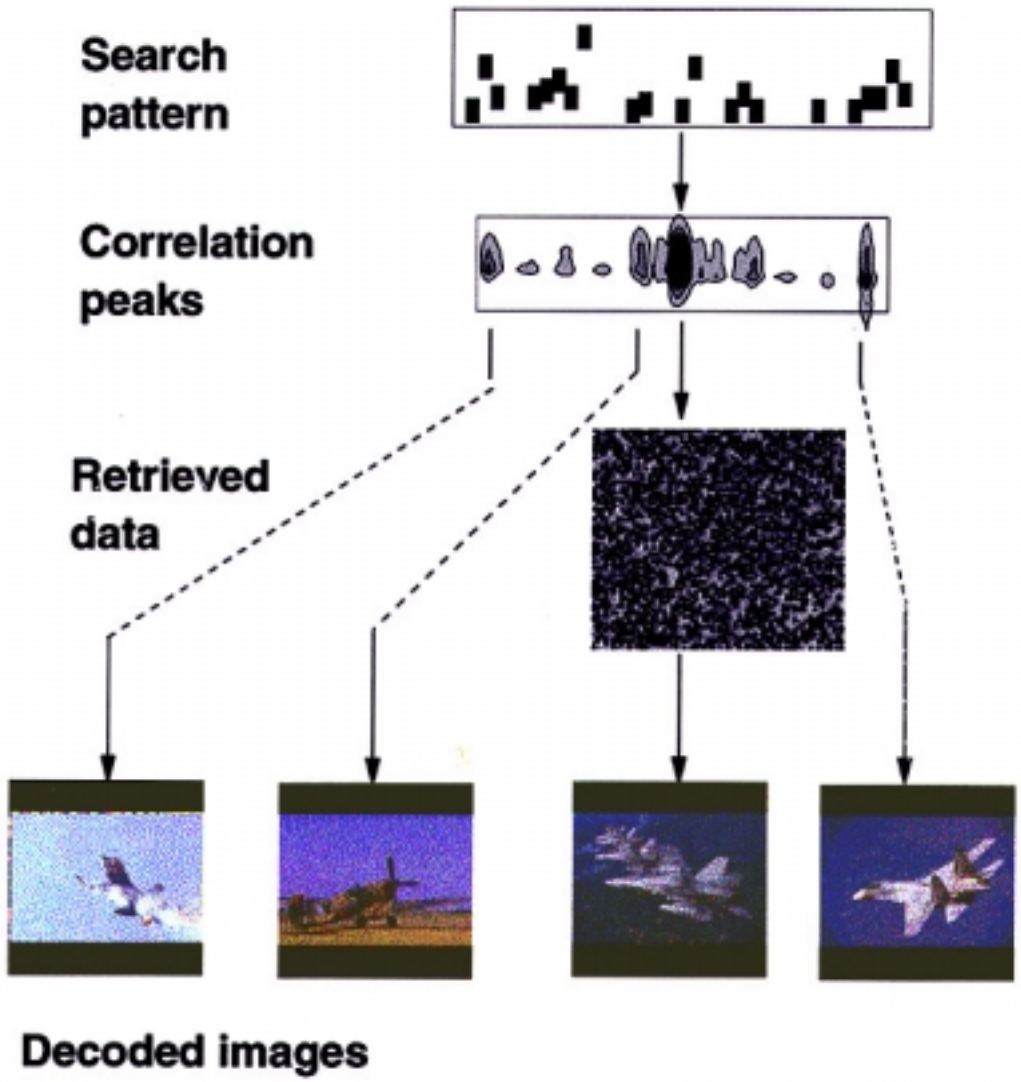


Retrieve by Content





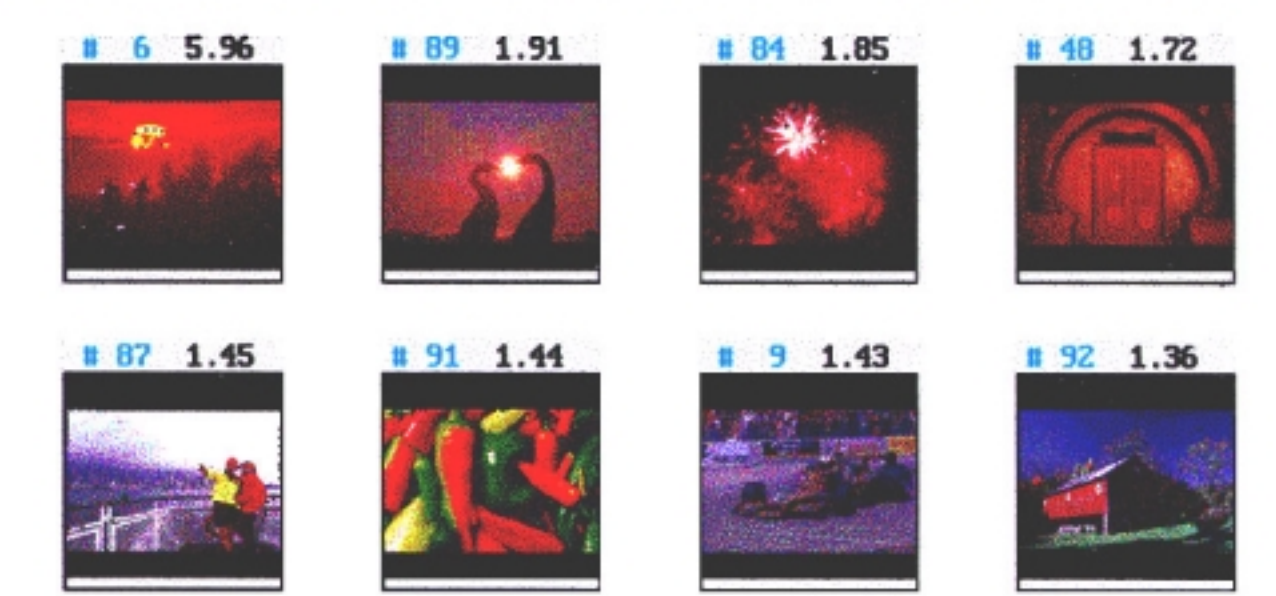
Associative Retrieval



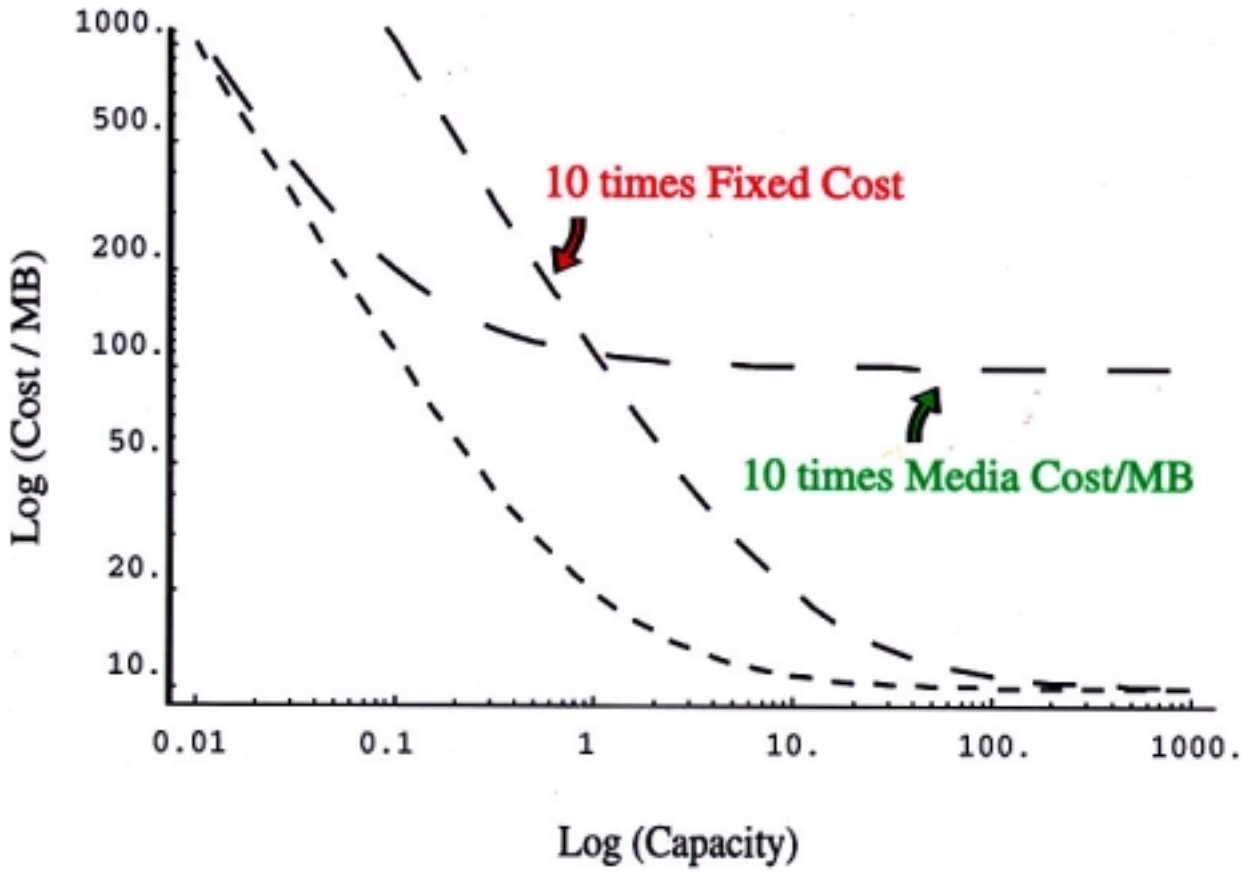
Holographic Associative Retrieval DEMO

F1 Configuration Menu/Change from Fast search
F2 to show random images
F3 to find matches to a displayed image
F4 for detailed search

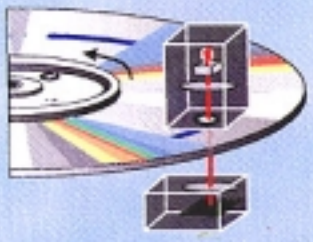
Search for matches to image # 6

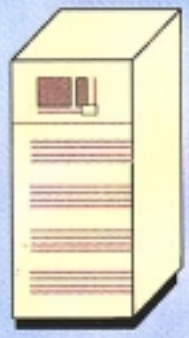


Cost Issues


1000.
500.
200.
100.
50.
20.
10.
Log (Cost / MB)
10 times Fixed Cost
10 times Media Cost/MB
0.01
0.1
1
10.
100.
1000.
Log (Capacity)

Holographic Storage
4 Product Scenarios





Extended DRAM Product	Hard Disk Drive (DASD) Product	Hard Disk Drive (CDROM-Type) Product	Rack Mounted Archive Product
• Total Capacity: 25 GB	• High Capacity: 1 TB	• High Capacity: 1 TB	• High Capacity: 1 PB
• Access Time: 10 µs	• Access Time: 10 ms	• Access Time: 10 ms	• Access Time: 10 s
• Non Volatile Cache	• High Reliability/Availability	• High Capacity/Low Cost	• High Volumetric Density

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