High-density Holographic Data Storage with Random Encoded Reference Beam

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Outline

- Motivation
- Outline of Theory
- System Design
- Results from a Shift Selectivity
- Conclusions

Motivation

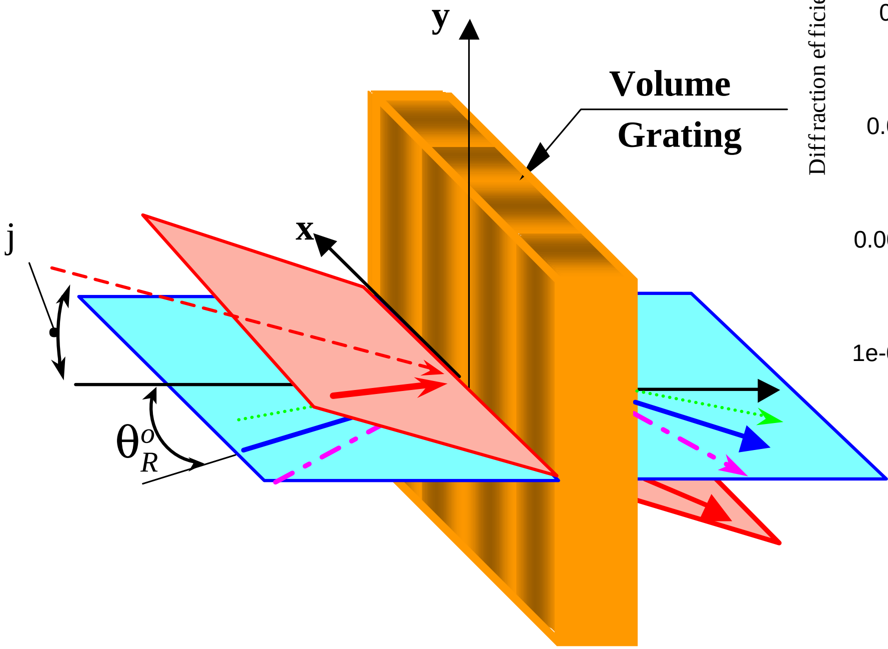
Holographic memory offers:

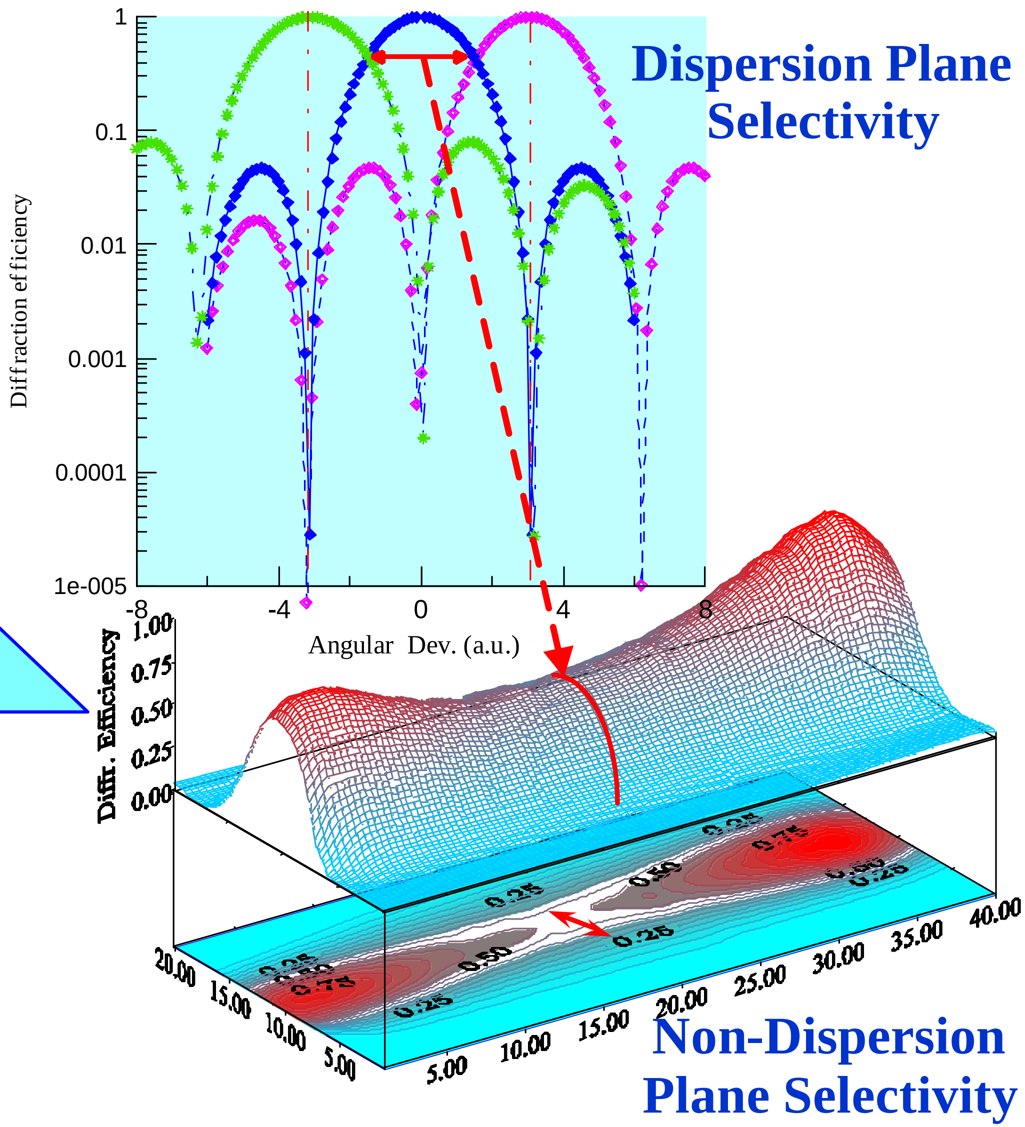
- bit storage density of the order of 10^{12}/cm^{3}
- parallel access and parallel data processing
- high retrieval rate
- solid-state configuration

Principles

- ***Selective properties of volume hologram***
- ***Volume holograms with amplitude-phase modulated reference beam and their selective properties***
- ***Solid-state configuration with random reference beam***

Angular Bragg Selectivity





Angular-spectral selectivity of volume hologram and random encoding of reference beam are used as basic mechanisms for data multiplexing

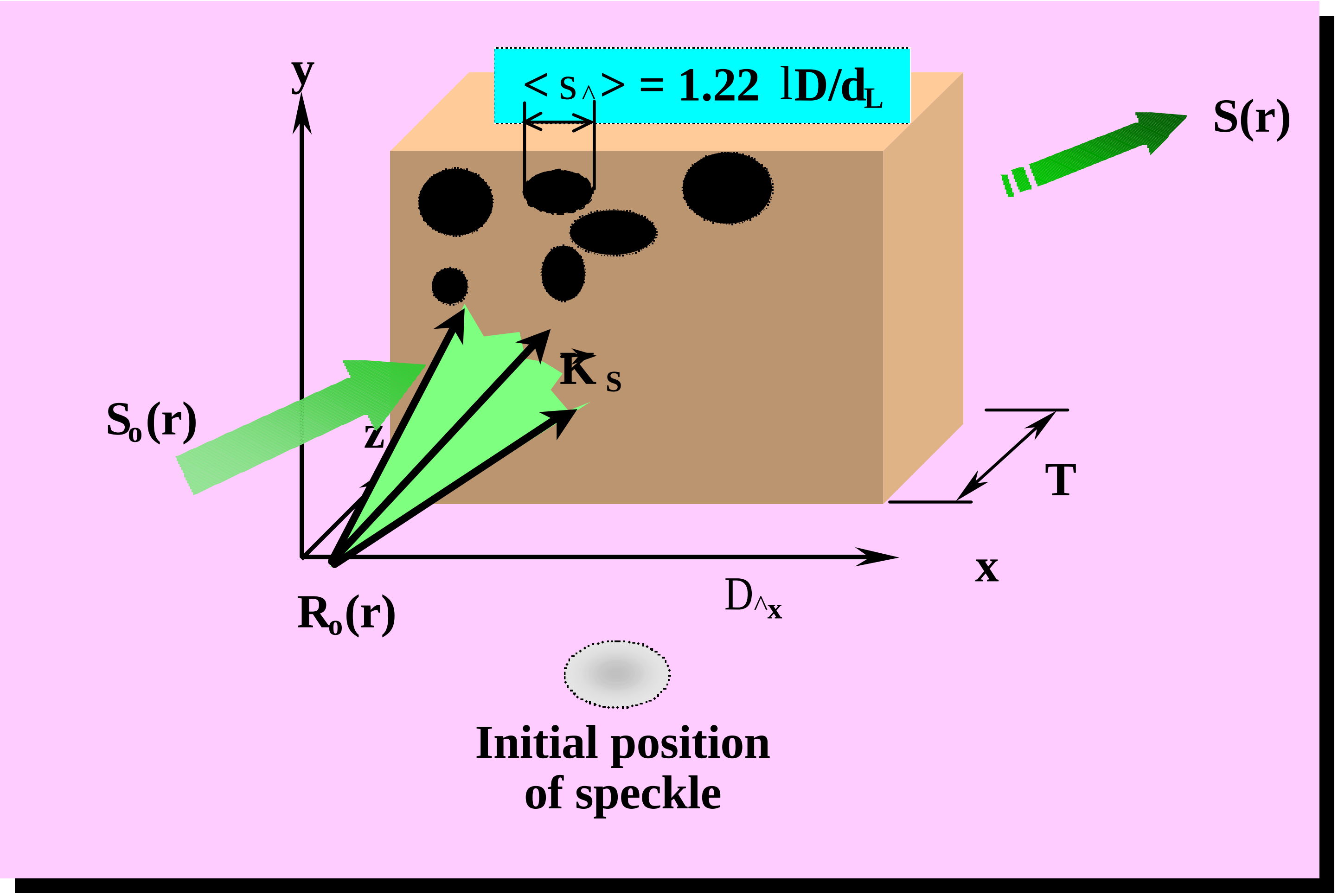
➢ ***Angular and Spectral Bragg selectivity results in:***

✓**non-isotropic diffraction at off-Bragg tuning**
✓**incremental noise**
✓**insecure data access**
✓**require moving parts.**

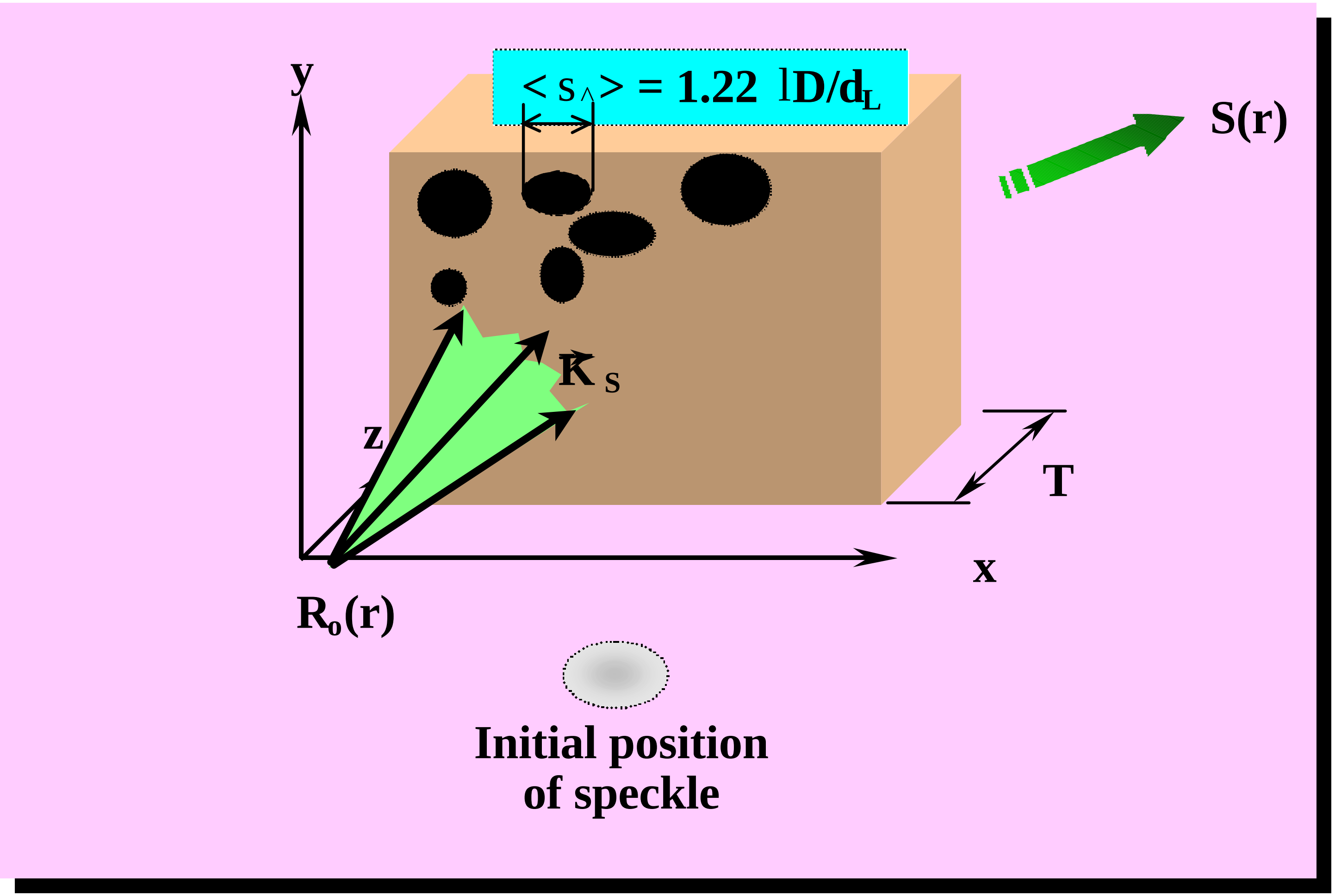
➢ ***Reference Beam Random Amplitude-Phase Encoding:***

✓**new type of *Spatial & Angular* (isotropic) selectivity;**
✓**solid-state architecture - no moving parts**
✓ **secure data access**

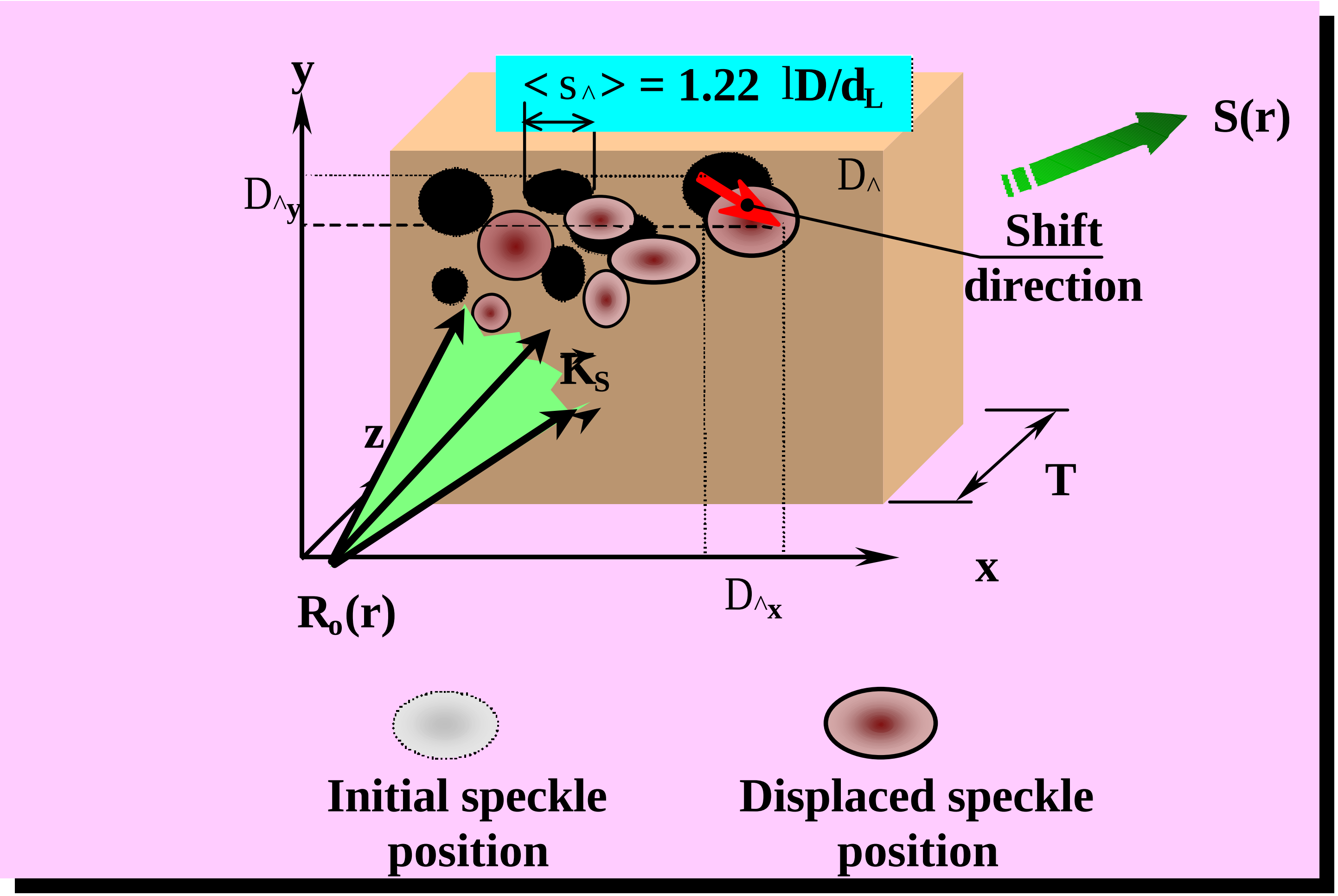
Random APM volume hologram - Recording



Random APM volume hologram - Reconstruction



Random APM volume hologram - Reconstruction



Basic results of the analysis

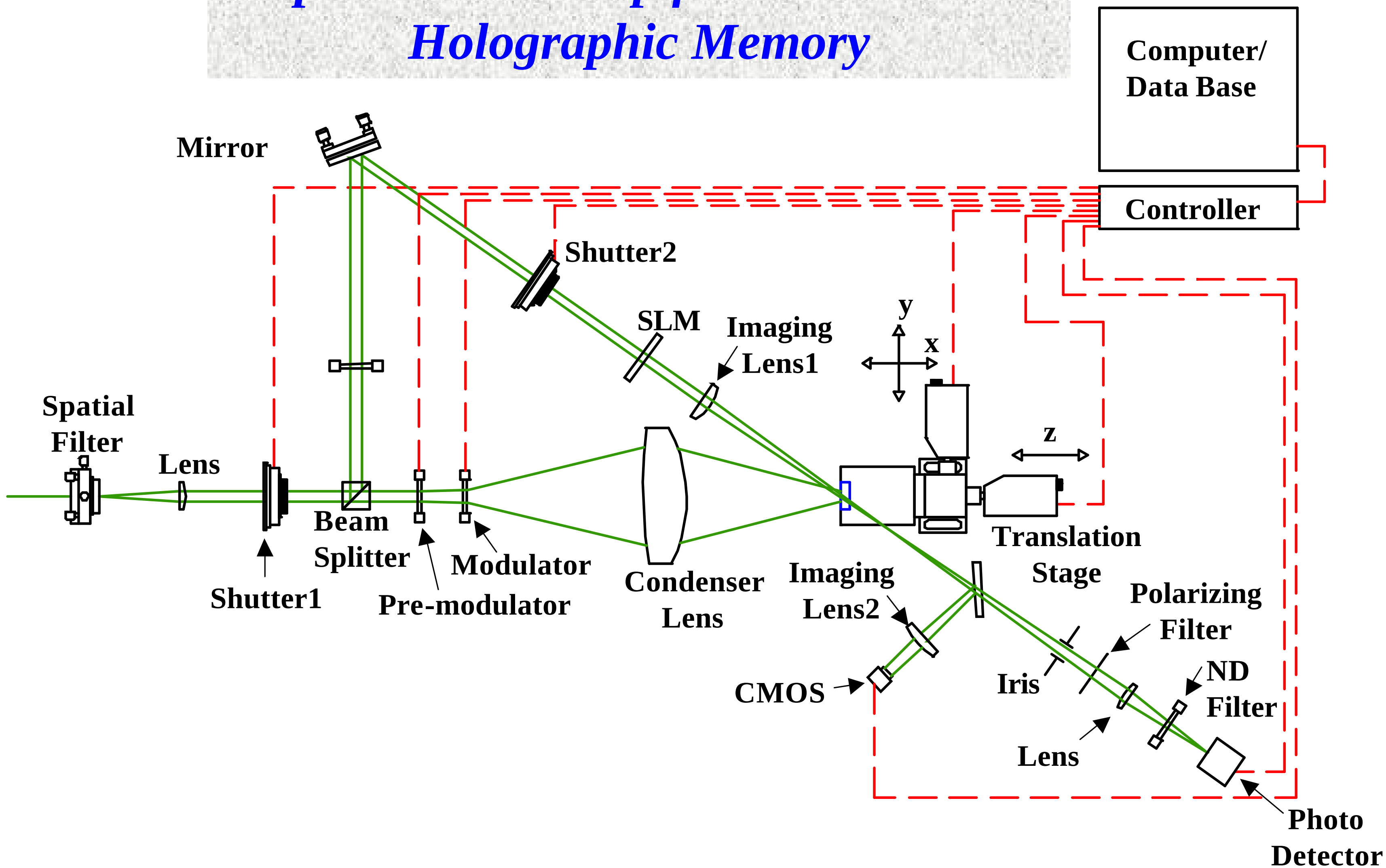
The diffracted field amplitude:

$$S(\vec{q},z') = exp[\,ik_o\, sin\,\theta_s\,] \iint_S \int_0^T R_o^*(\vec{q},z')R(\vec{q},z')dz'\,dq$$

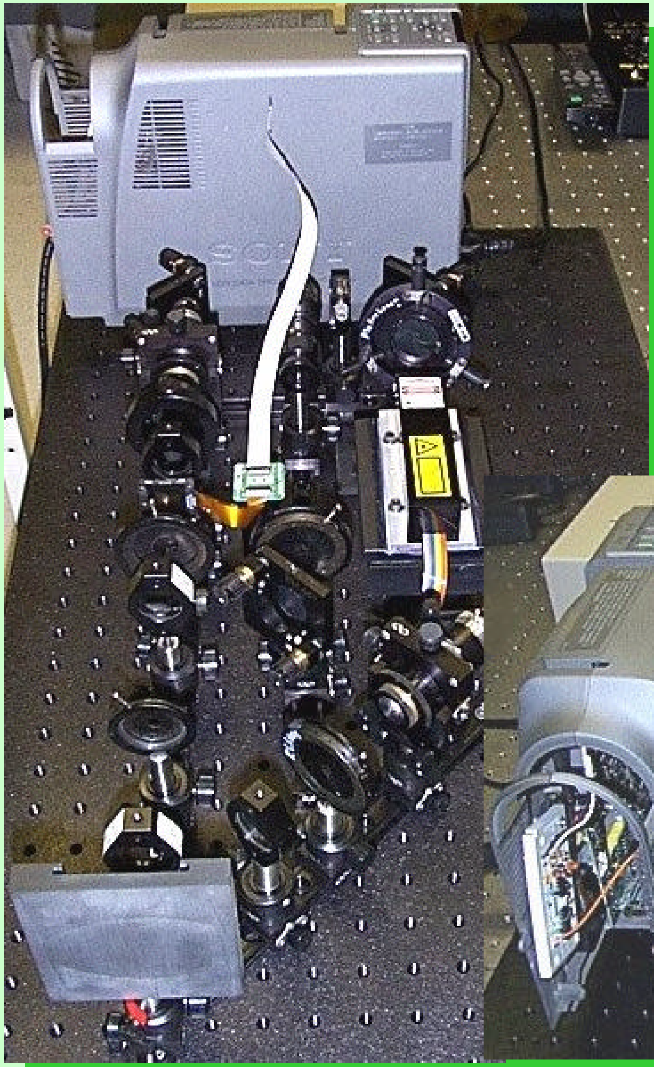
Where $R_o(q,z)R^{*(q,z)}$ is spatial correlation function of a random amplitude-phase modulated (speckle) field:

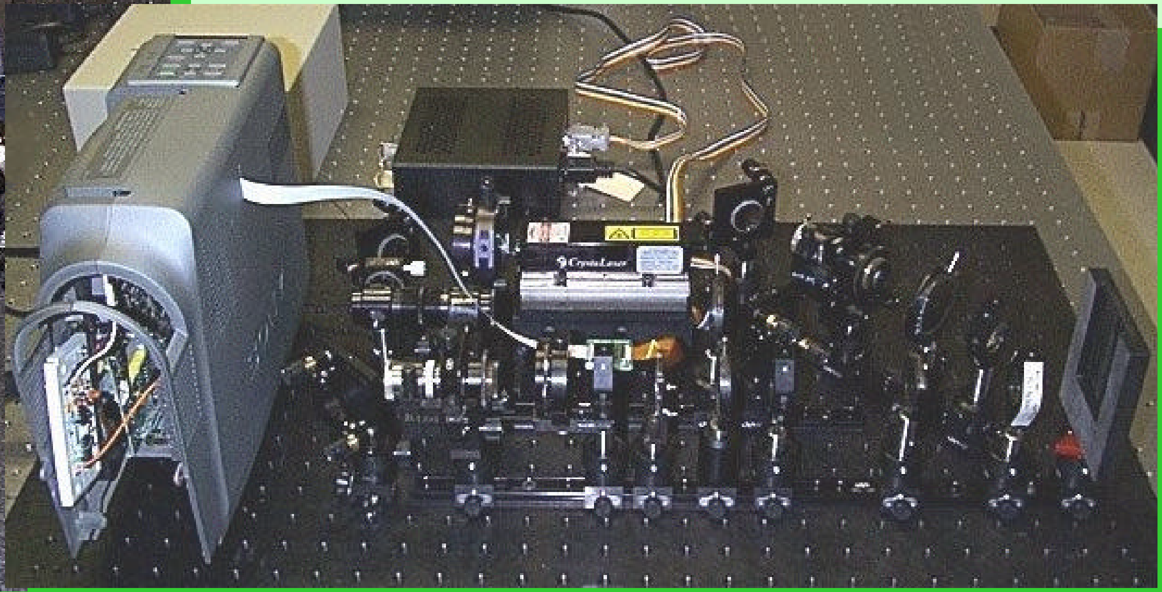
$$C_\perp(\vec{\Delta}_\perp, z') = \exp\left[\frac{ik_o n\vec{\Delta}_\perp^2}{2z_{eff}}\right]\int_{-\infty}^{+\infty}\int |P_L(\vec{q})|^2 \times \exp\left[-\frac{ik_o n}{z_{eff}}\vec{q}\vec{\Delta}_\perp\right]d^2q,$$

Experimental Setup for Random APE Holographic Memory



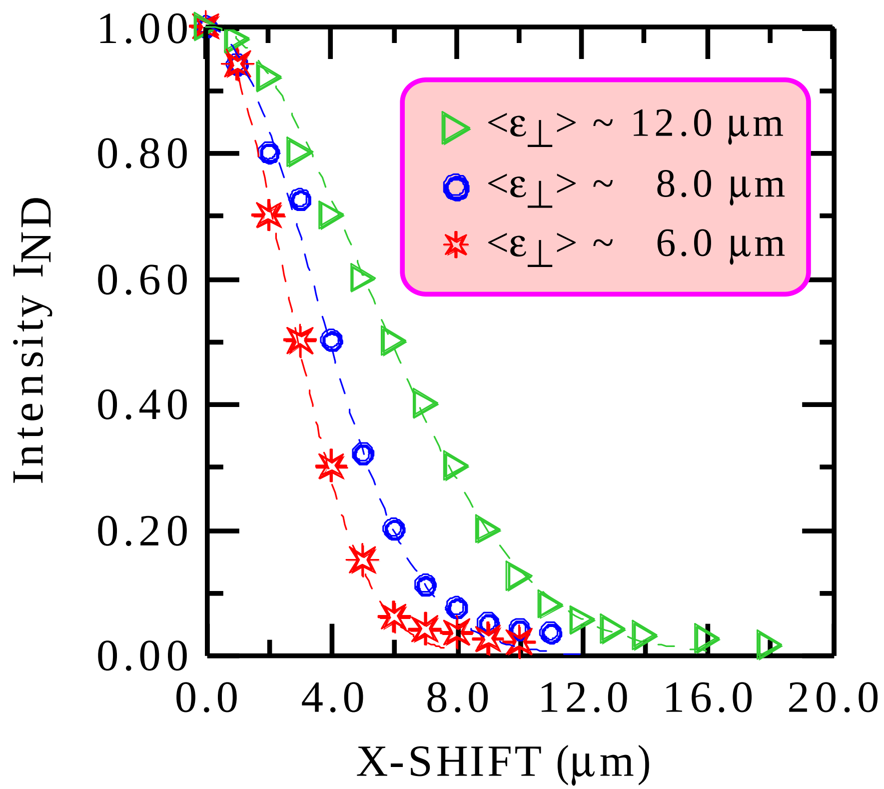
Laboratory setup for APM hologram





SPECKLE SHIFT SELECTIVITY

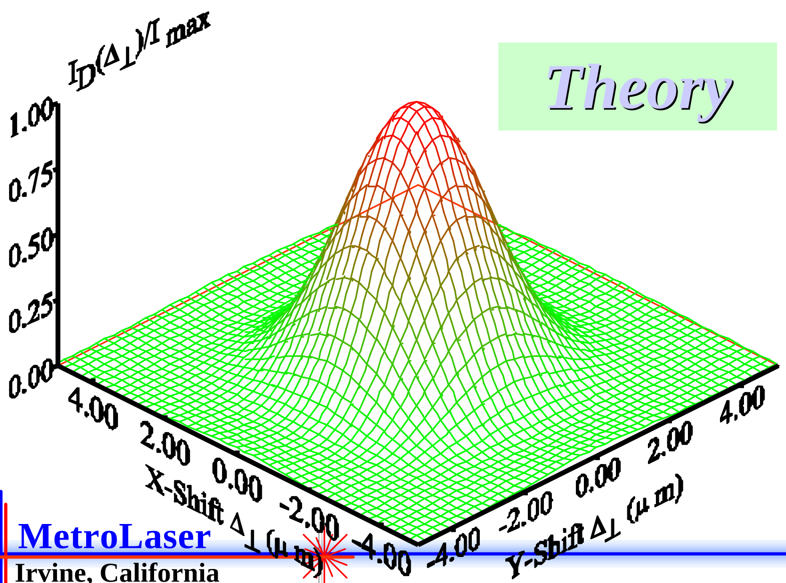
X-SHIFT SELECTIVITY (experiment)



$\langle \varepsilon_\perp \rangle$ - average speckle size

X-Y Speckle-Shift Selectivity

Speckle-Shift Selectivity is perfectly symmetric in both X and Y directions and the retrieved signal intensity decreases with $\Delta_\perp$ in almost 3 orders of the magnitude with no side-lobes. This promises low cross-talk and a high level of security.



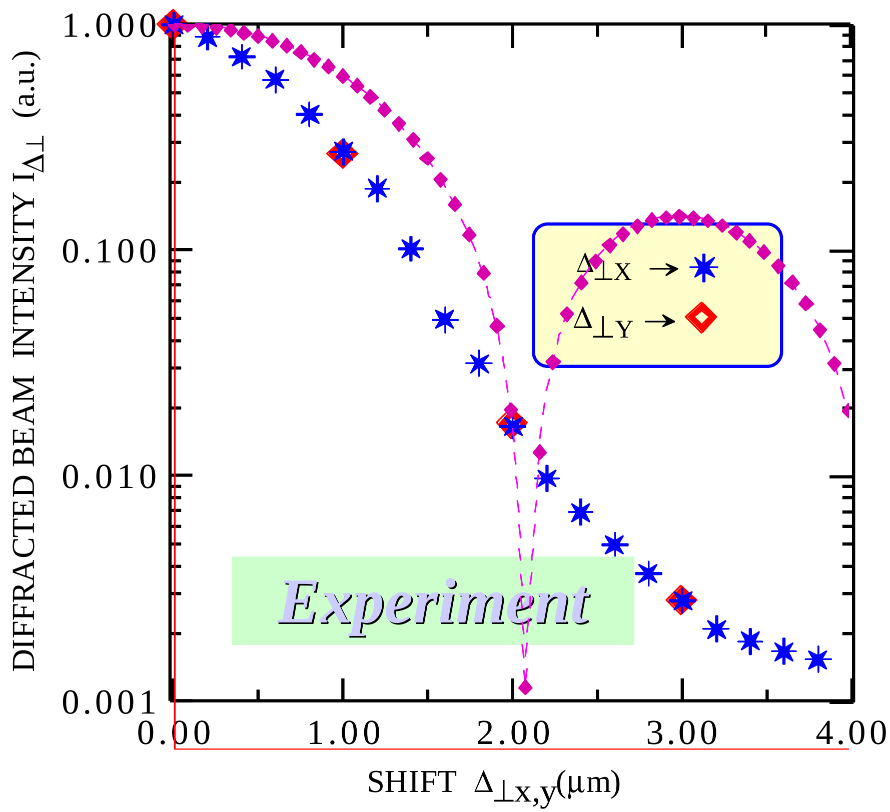
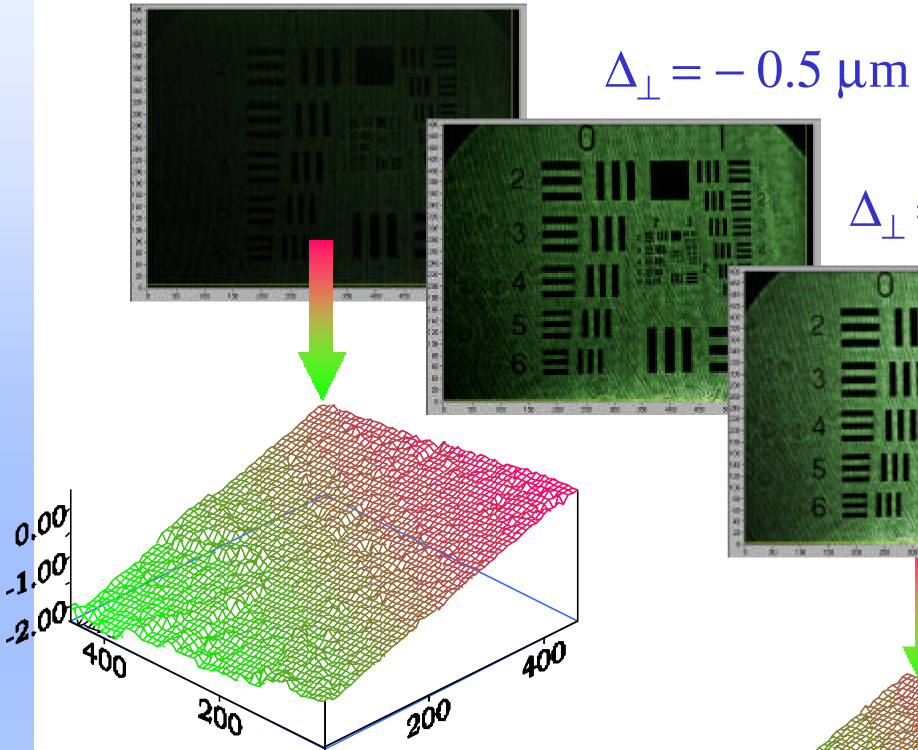
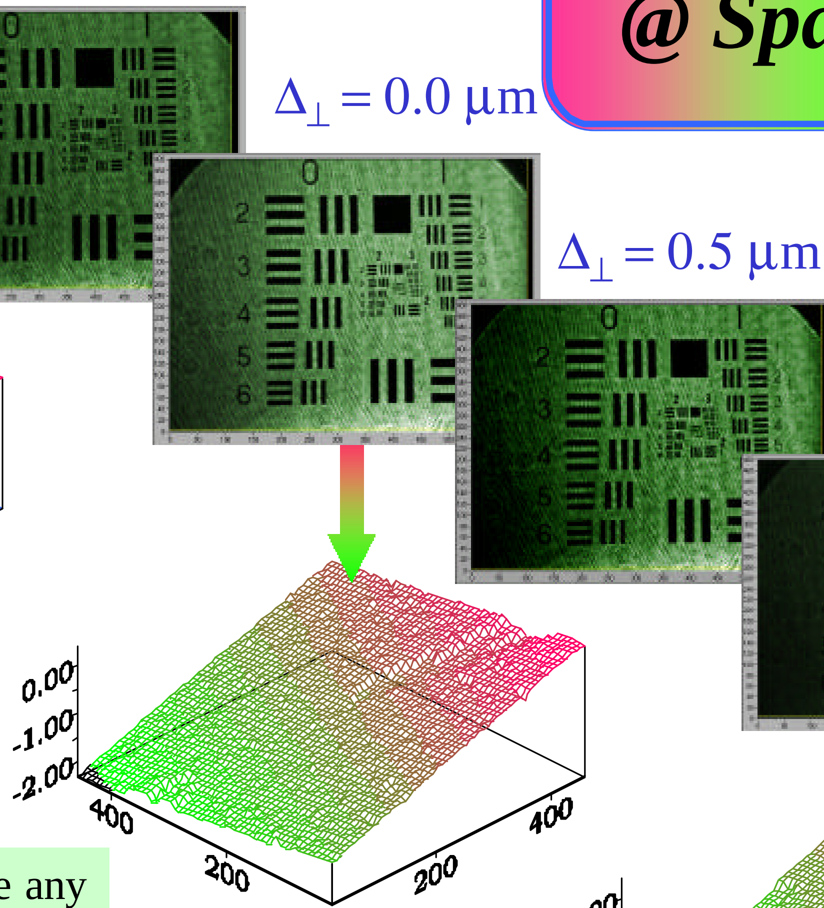
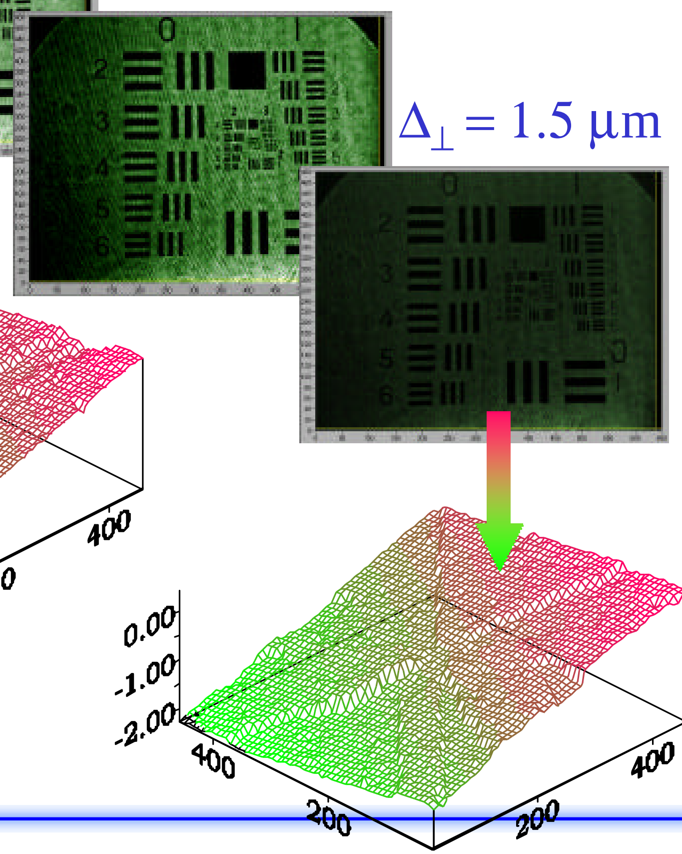


Image Characteristics @ Spatial Shift

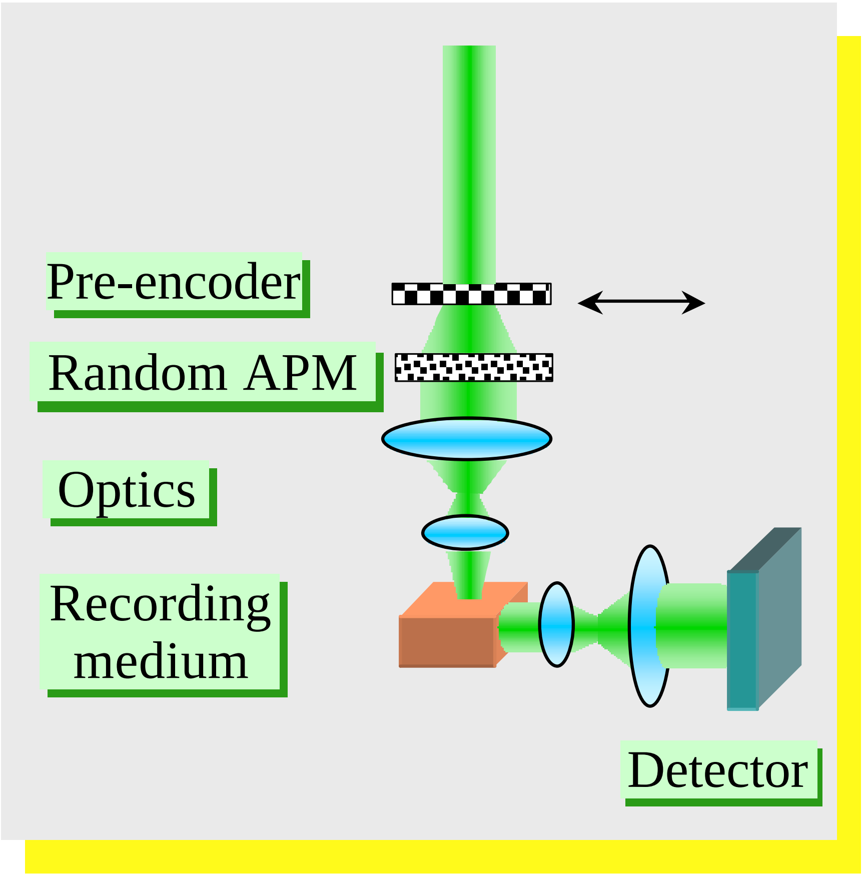




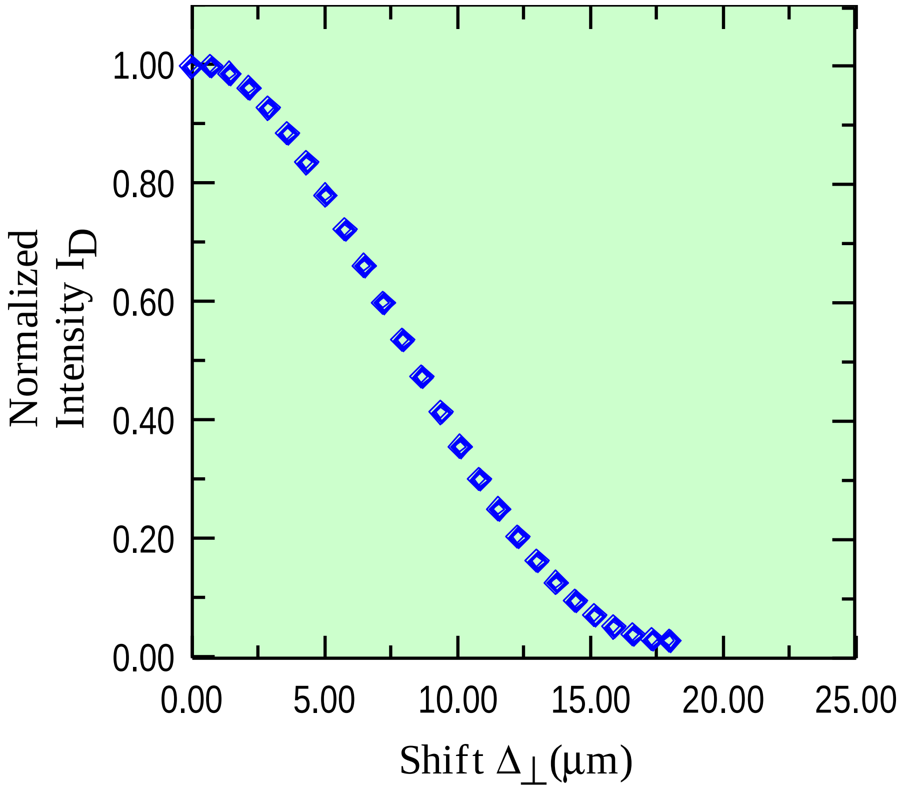


Spatial Shift doesn't introduce any side effects on the reconstructed image quality beside the intensity decrease. The phase distribution remains invariable with $\Delta_{\perp}$

Realization of Solid-State Data Storage Configuration



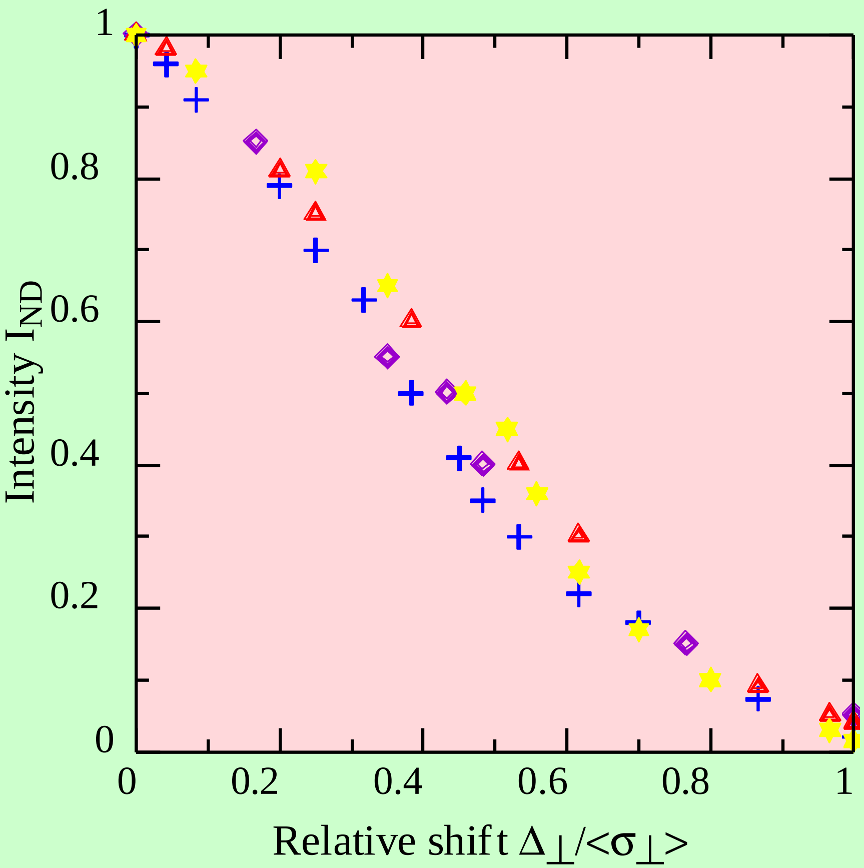
Principal setup



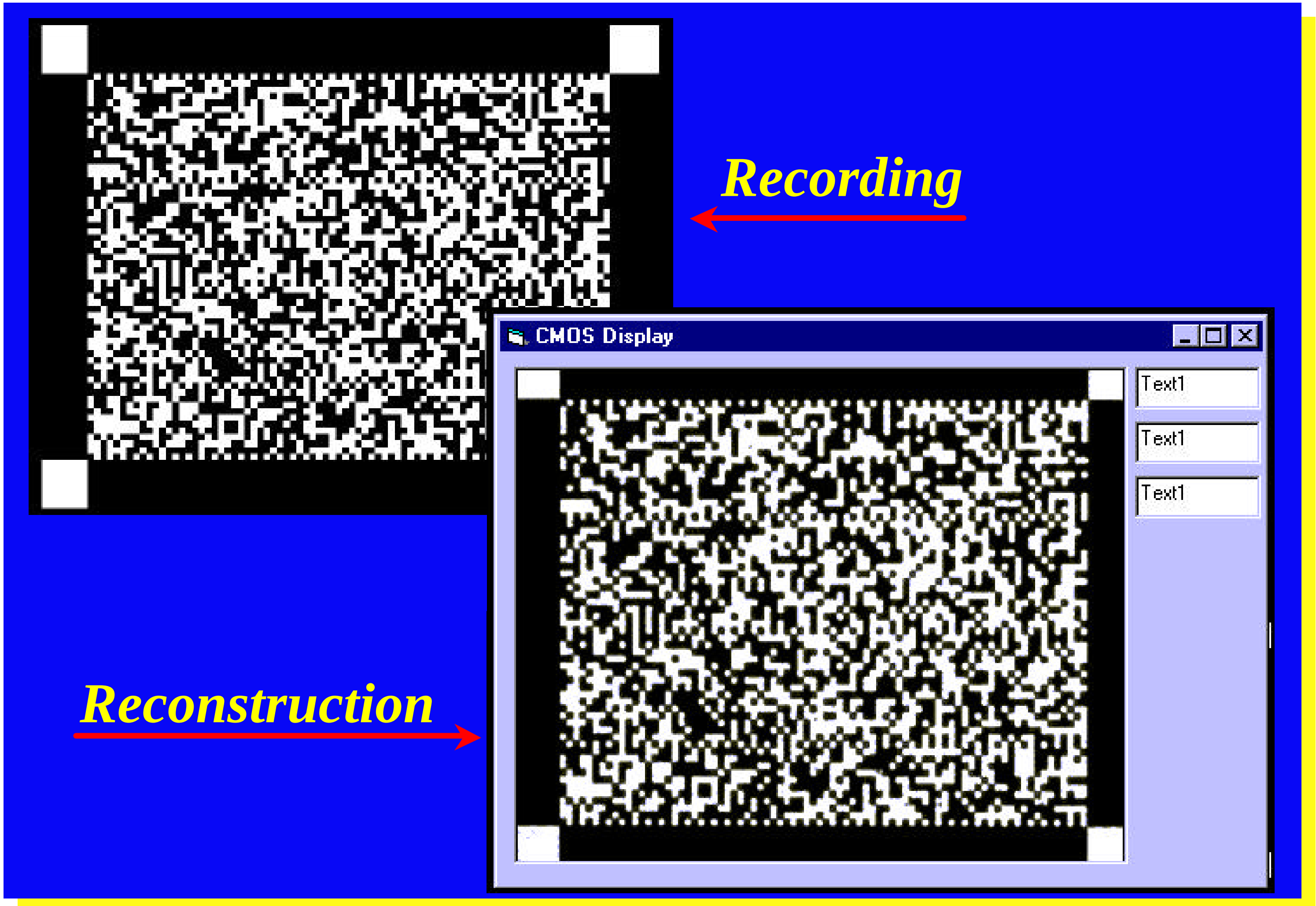
Solid-State technique validation

Decorrelation with:

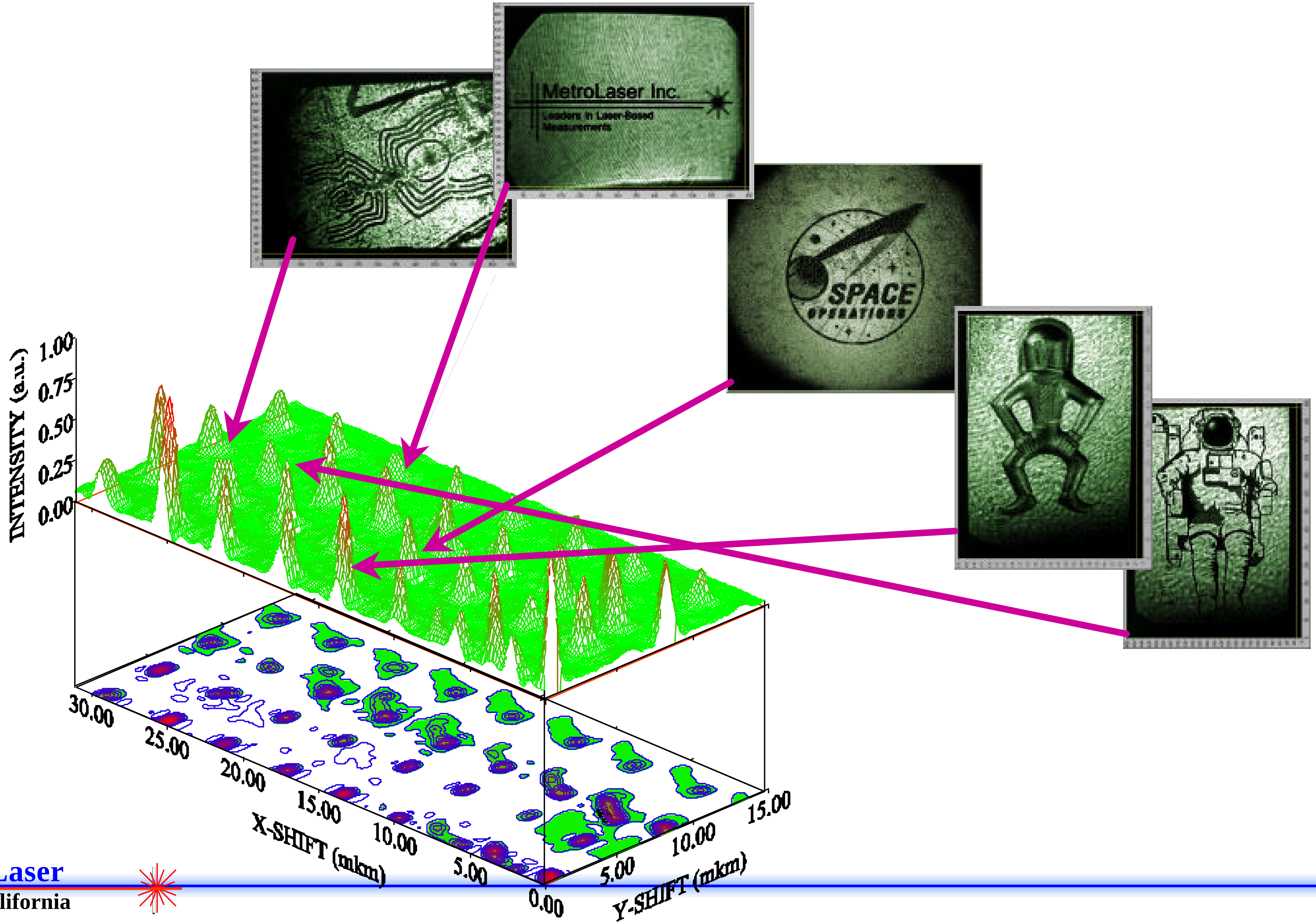
- Pre-encoder spatial variation (shift or rotation)
- Reference beam spatial steering
- Beam angular steering with deflector
- Encoder (or pre-encoder) rotation



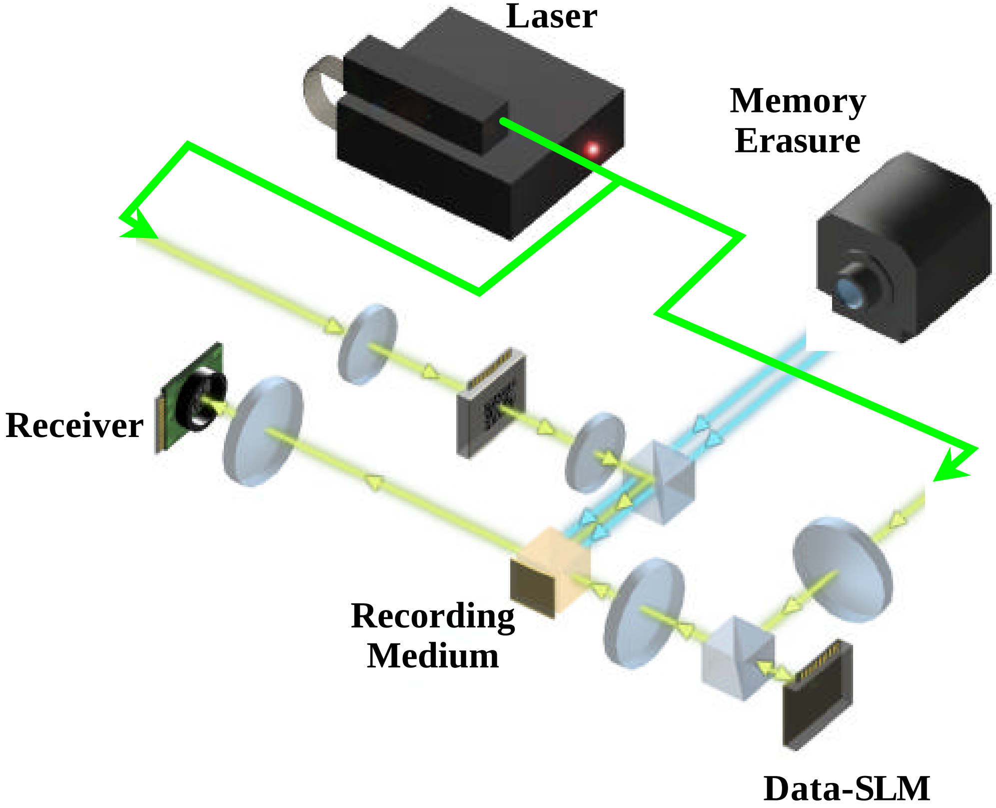
Page encoding and data recall



Data Recall Sequence



Holographic Memory Module architecture with solid-state configuration



Anticipated HMM parameters:

- *Capacity - 10^{11} b*
- *Trans. rate - 1 Gb/sec*
- *Size - < 0.4 ft^3*
- *Weight - <1.5 kg*
- *Power cons. - < 50 W*

Conclusion

- High- density holographic data storage is demonstrated with random encoded reference beam
- Parallel recording and retrieval
- Optical memory in solid-state configuring

Acknowledgment

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