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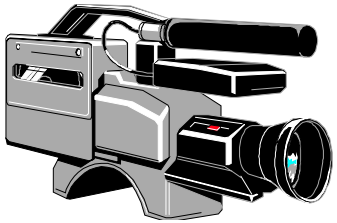

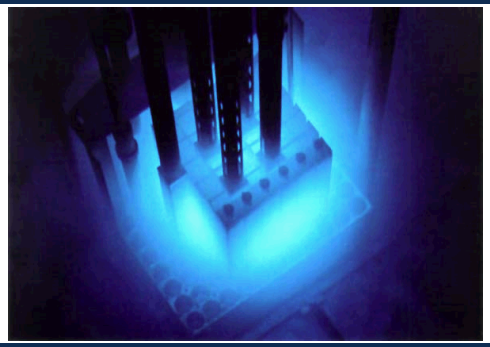

Authentication Approaches for Standoff Video Surveillance

George Baldwin, Shane Sickafoose, William Sweatt, and Maikael Thomas
Sandia National Laboratories

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NNSA National Nuclear Security Administration

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Outline

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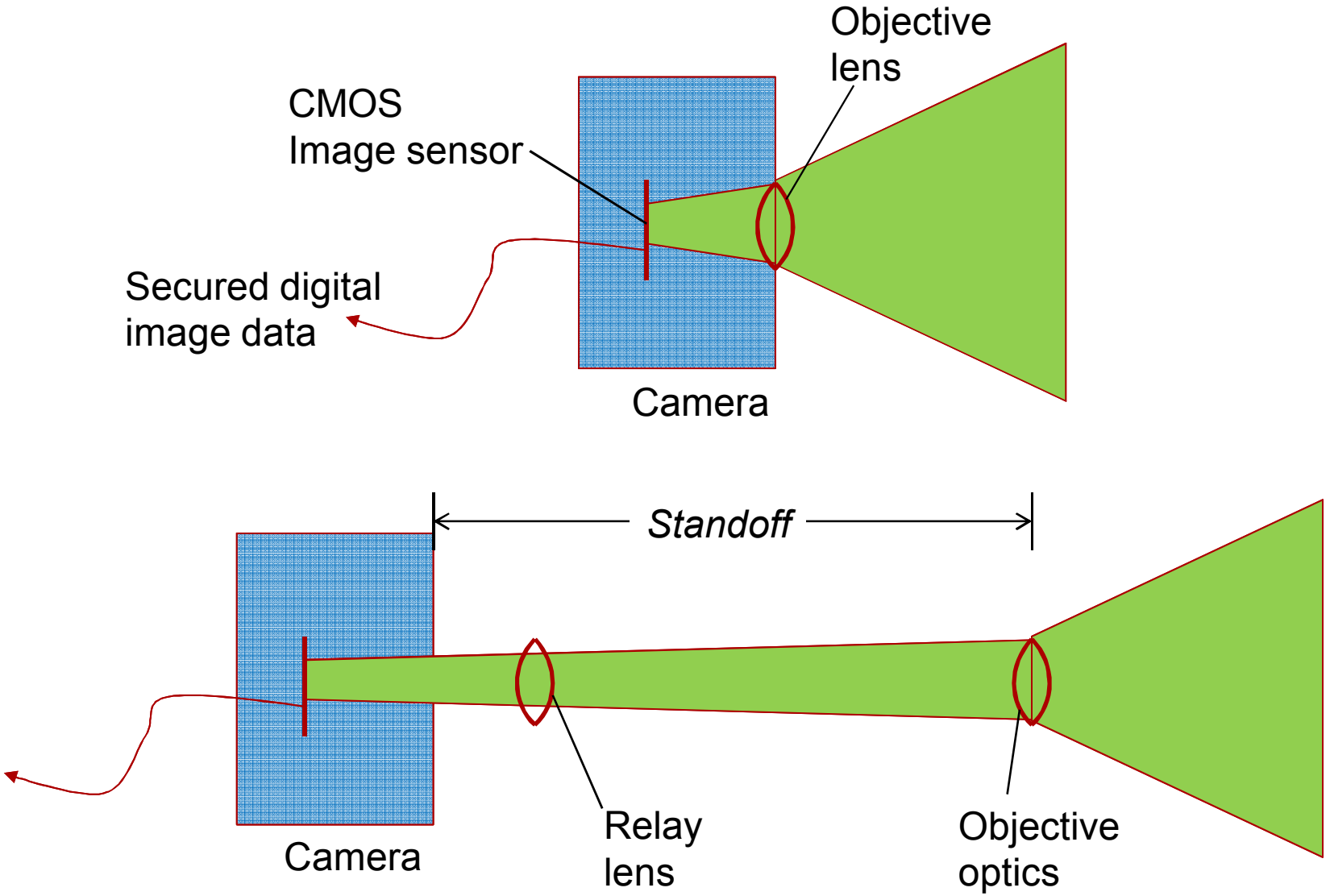
- Standoff video surveillance
  - What is it?
  - Where would it be useful for safeguards?
- Authentication of video images
  - The problem
  - Approaches
- Our work: scene interrogation
- Conclusions

What is standoff video?



Technical approach for incorporating standoff between the camera and objective optics

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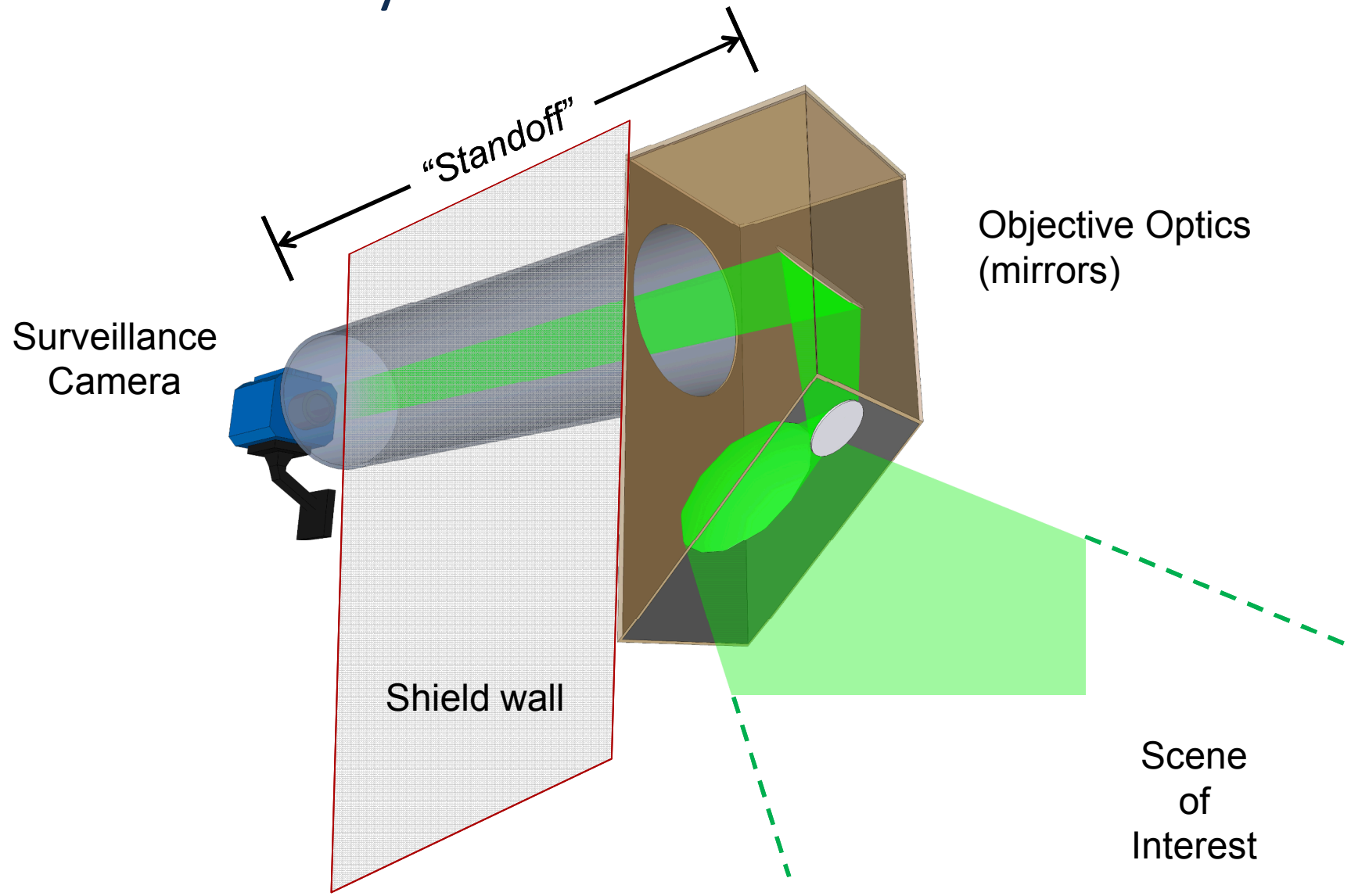
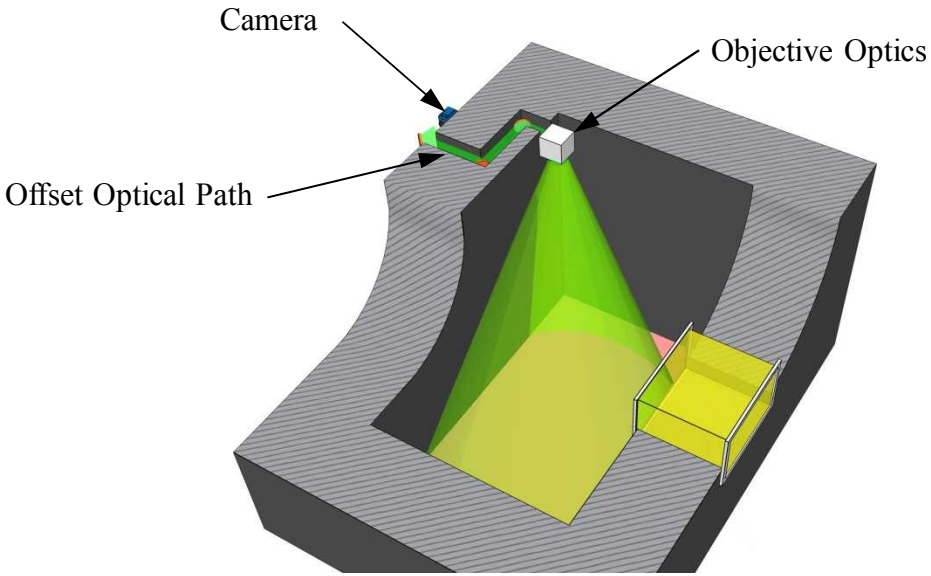
- Avoid the use of transparent, refractive media at the front end
  - Such as optical fibers, lenses
  - Instead use curved-surface mirror(s) and air pipes
- Acquire a wide field of view
  - Capture a wide field of view with a curved-surface mirror
  - Acquired image will be distorted: Remove distortion in software
- Transport the image over the standoff distance
  - Exclude ambient light by enclosing in an opaque-walled pipe
  - 2”-diameter optics give adequate resolution and light through-put
- Couple the image to the camera’s CMOS image plane
  - “relay” lens (telephoto)
  - Requires a redesigned housing, lens distance to the image plane

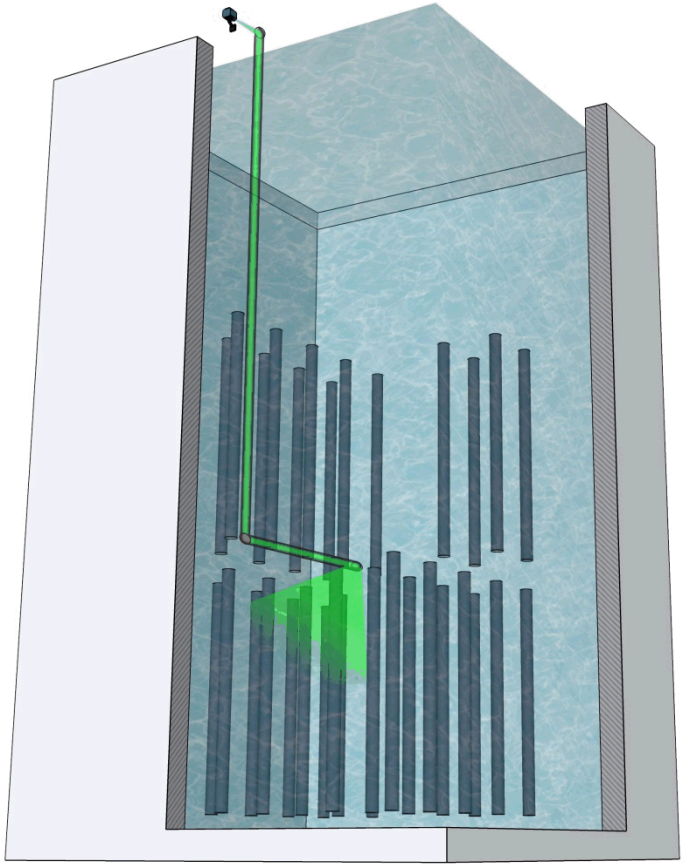
Standoff Video: put only a minimum part of the camera system close to the scene



Possible applications for standoff video



Hot Cell



Stacked Fuel in
Cooling Pond

Image Authentication for Video Surveillance

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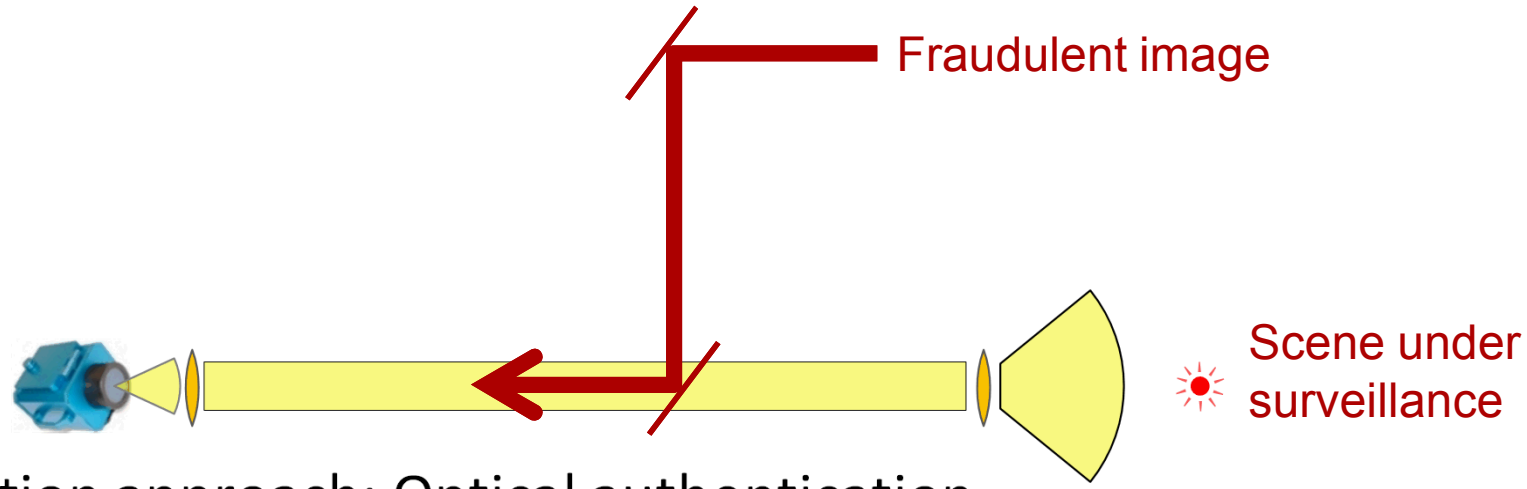
- The Surveillance Problem:
  How can we be sure we're looking at what we think we are?
- *Authentication* is what ensures that acquired surveillance data are truly valid images of the scene under surveillance
- Conventional Method:
  - Protect the security-critical components of the surveillance camera with a tamper-indicating enclosure (TIE)
  - Cryptographically sign the digital image data close to the CMOS sensor, within the TIE
- Does not address "before the lens" tampering
  - i.e., altering what the camera is able to see
  - For example, blocking the scene with a static photograph of the scene
  - To some extent, the risk can be mitigated with system approaches, e.g., use multiple cameras, each viewing another

Image Authentication for Standoff Video

- Standoff video exposes even more of the surveillance system to tamper, because of the extended optical path



- Mitigation approach: Optical authentication
- Alternatives
  - We could just secure the standoff optical path within the system
  - Or, better, extend the authentication into the scene itself

In-Scene Image Authentication

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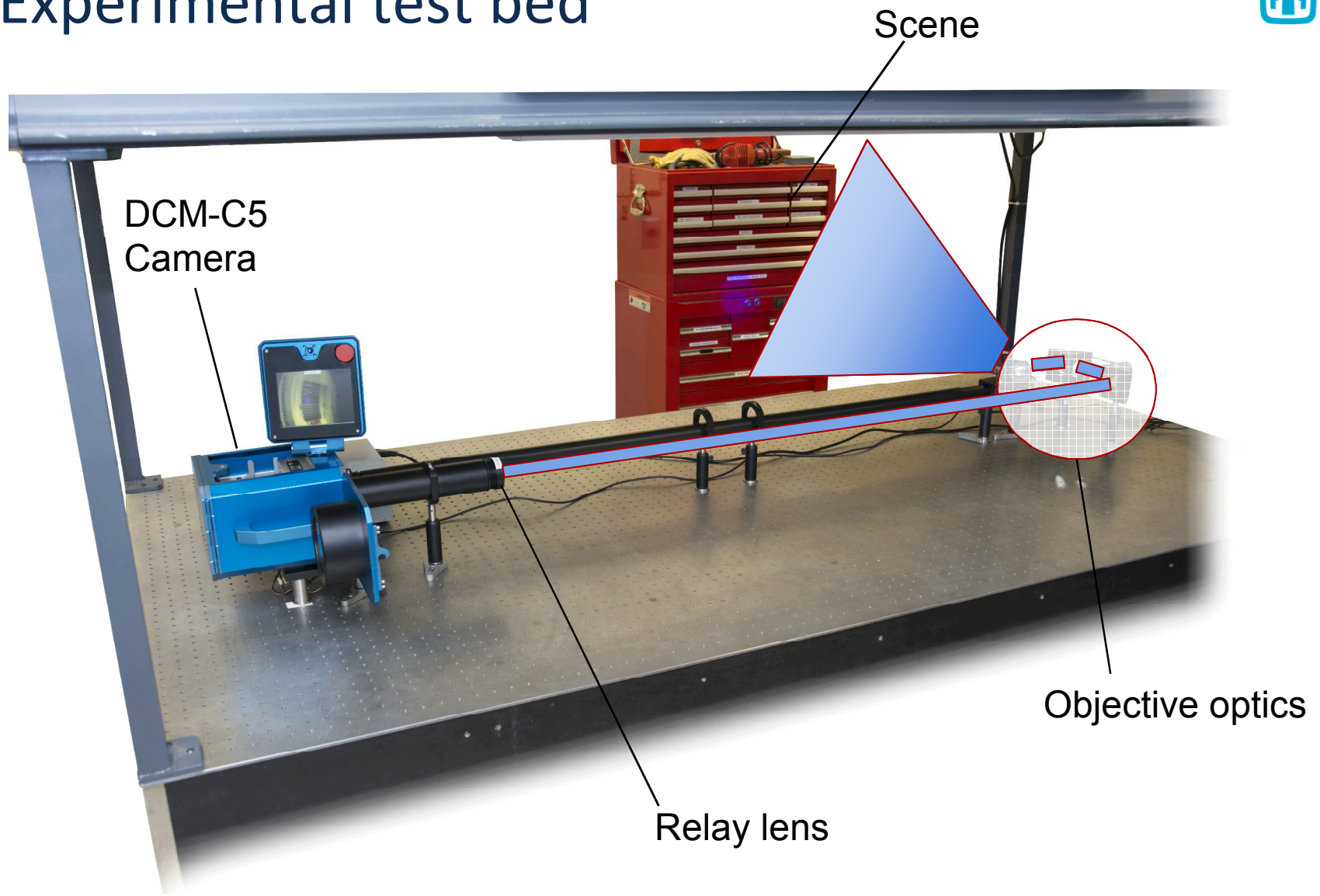
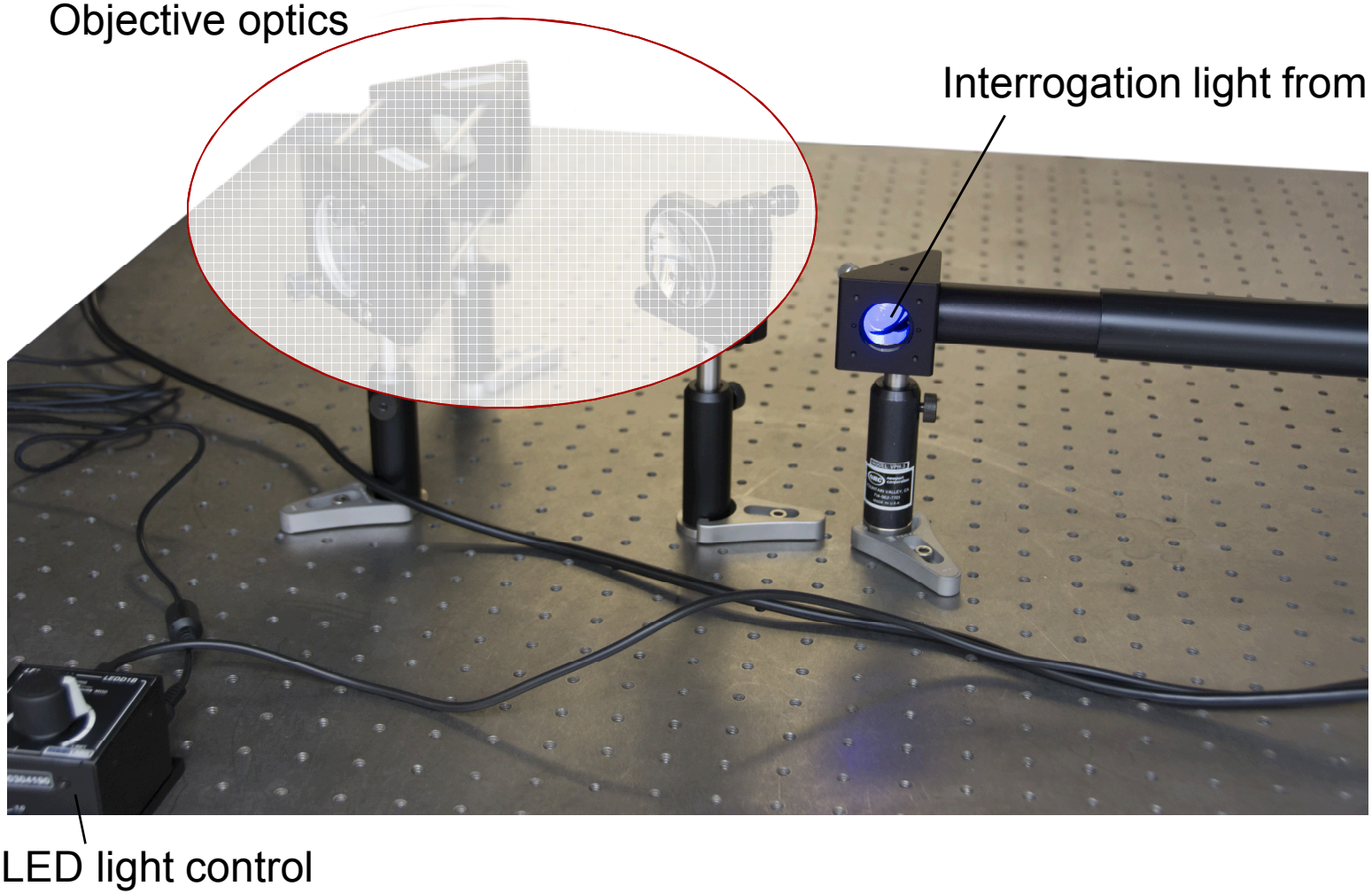
- Time varying information is already in the scene (e.g., a clock)
- Something controllable can be inserted in the scene
- Our approach: scene interrogation
  - Shine light into the scene in a known fashion
  - Validate by observing an expected resulting effect in the scene
  - Especially effective if the interrogation can make use of shadows, reflective surfaces, and other scene features to complicate the effect
- The interrogation can be enhanced by controlling multiple factors
  - Color of the light
  - Intensity
  - Timing when off/on
  - Number, location, and size of illuminating spots

Experimental test bed



Experimental test bed: front end optics



Interrogating illumination only needs to be detectable above ambient

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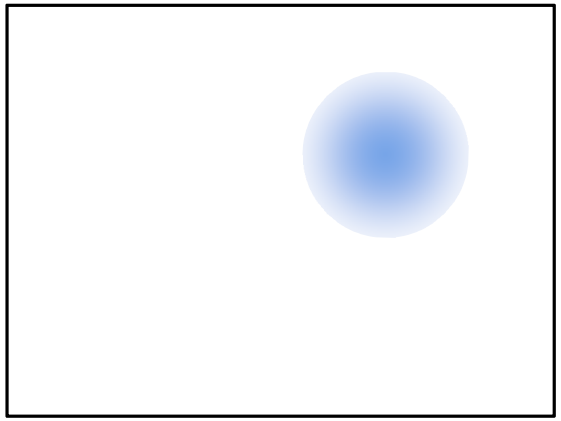
Scene without illumination

“Spot” illumination with LED



Computed Difference Image

Discussion

- LED vs laser illumination
  - LEDs do not introduce the eye hazards associated with lasers, but system implementation must deal with beam divergence (brightness issue)
- We are using nominally 1mW LEDs at 455nm, 565nm, and 625nm; could also investigate longer (IR) wavelength
- Various passive optical elements can be added to the interrogating light system to increase the complexity of the optical authentication

- It may be possible to do in-scene authentication by adding elements to the scene under surveillance (e.g. clock, “light bar”)
- Optical authentication has a significant advantage: *everything can be packaged with the surveillance camera system*

Where could we go from here?

- Further develop Standoff Video
  - Engineering: enclosed housing and window for the objective optical components
  - Underwater application (e.g., spent fuel pools): buoyancy issue
  - Fixed surveillance location, yet movable front end (pan/ tilt)
  - Movable surveillance location: objective optics on the end of a movable boom with a jointed surveillance “arm”
  - Multiplexed systems: multiple optical paths sharing a single camera
- Further develop Optical Scene Interrogation for authentication
  - Move to automated image processing to extract the image signature
  - Increase the sophistication of the projected spots in the scene, especially their temporal and spatial variation
  - Develop the capability for conventional video surveillance
- Future work needs to be application-driven

Conclusions

- Through this work we have explored new concepts for both
  - Video surveillance in hostile environments, using standoff
  - Optical authentication of video images

- Standoff video surveillance is a viable means to acquire images from hostile environments and protect camera electronics
- Scene interrogation is a promising approach for optical authentication of video surveillance images

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