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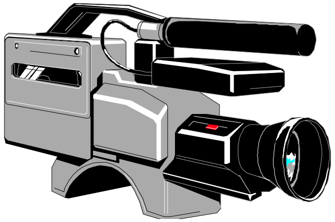

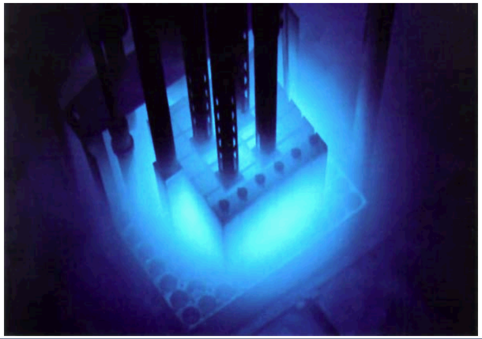

Standoff Video Surveillance for High Radiation Applications

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U.S. DEPARTMENT OF ENERGY

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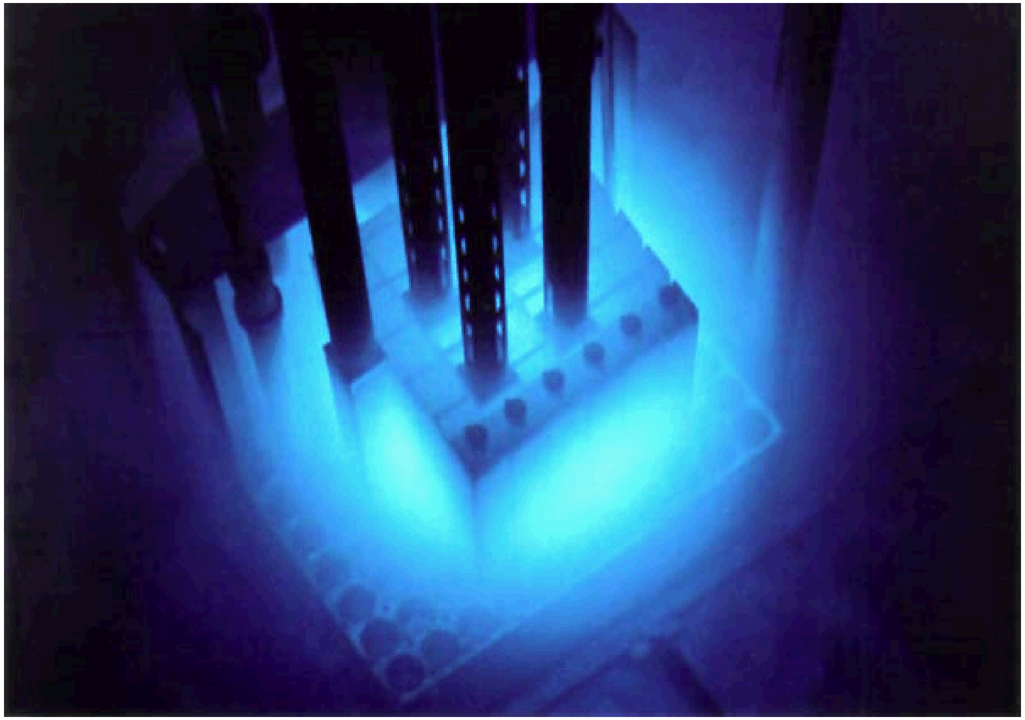
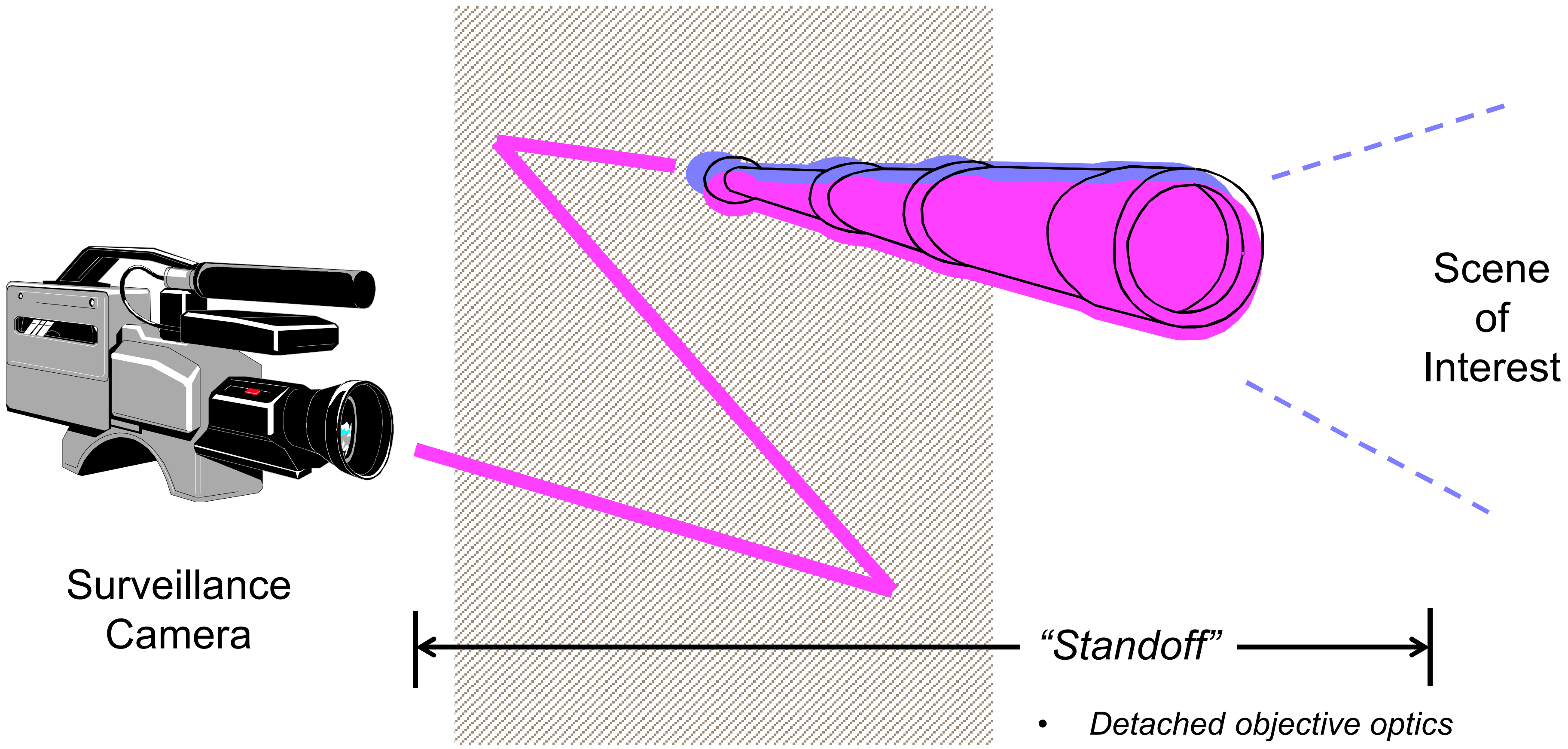
This is an example of a place where expensive surveillance cameras do NOT belong



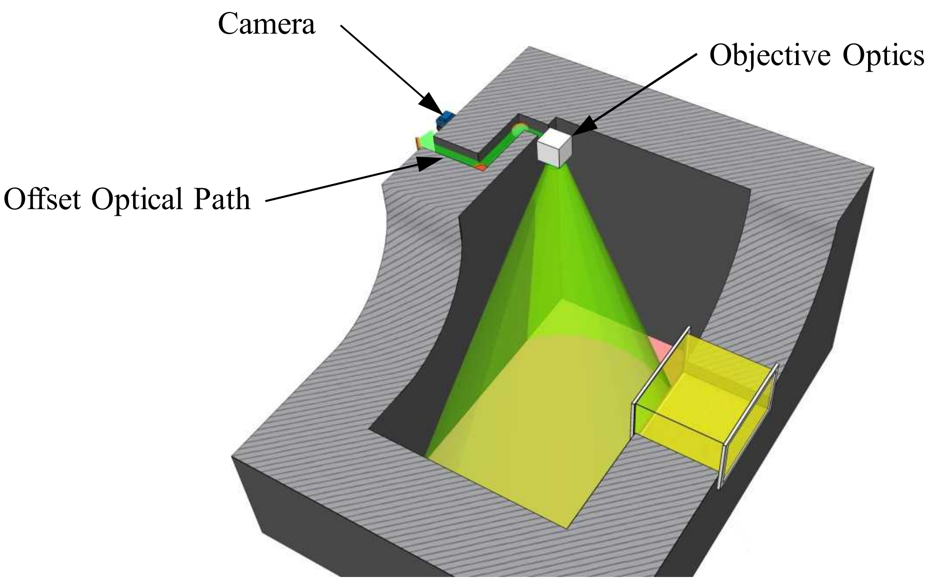
But if we do need surveillance in a high radiation area, how would we do it?

The Idea: put only a minimum part of the camera system in harm's way

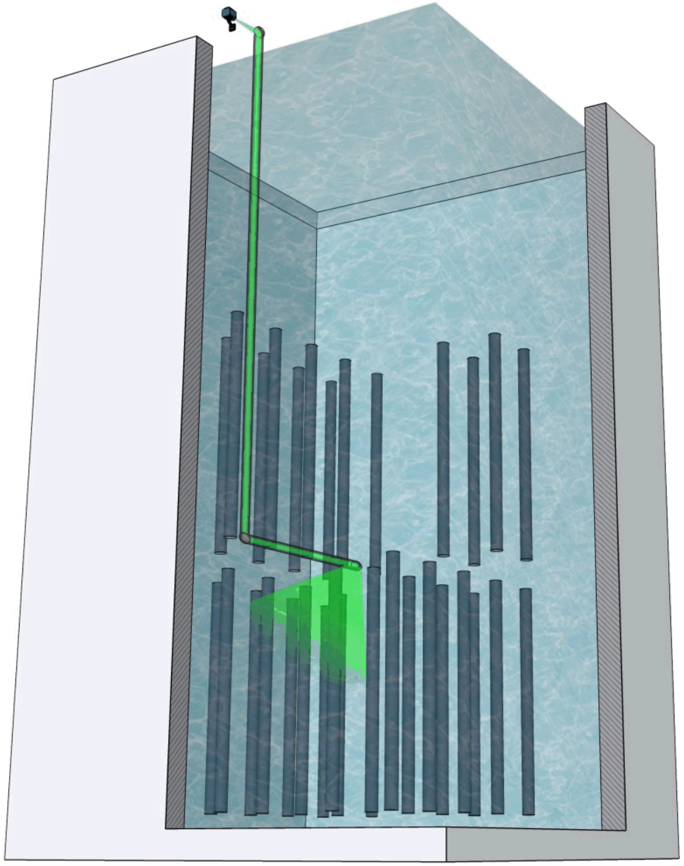


- *Detached objective optics*
- *Separation distance*
- *Offset path through shielding*

Practical example applications of the idea



Hot Cell

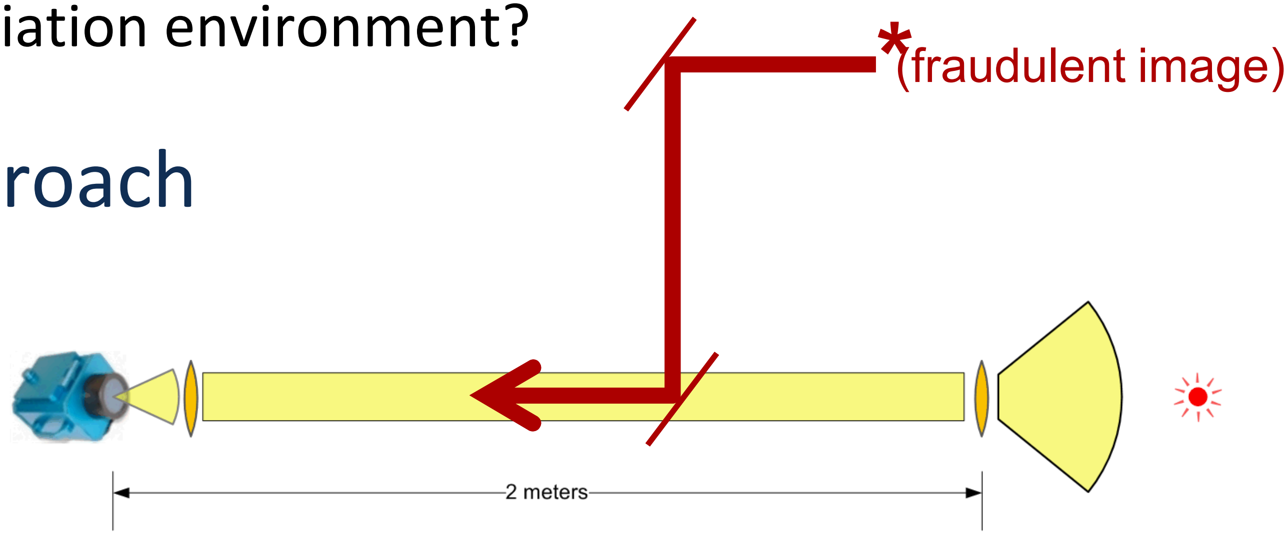


Stacked Fuel in
Cooling Pond

The Challenges

- **Standoff:** Technically, how does one separate the camera's objective lens and its image plane?
- **Image Authentication:** How can we be sure we're looking at what we think we are?*
- **Rad-Hardness:** Can the front end (objective optics) survive in a high radiation environment?

The Approach



"Baseline Scenario"

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

Front end reflective image collection

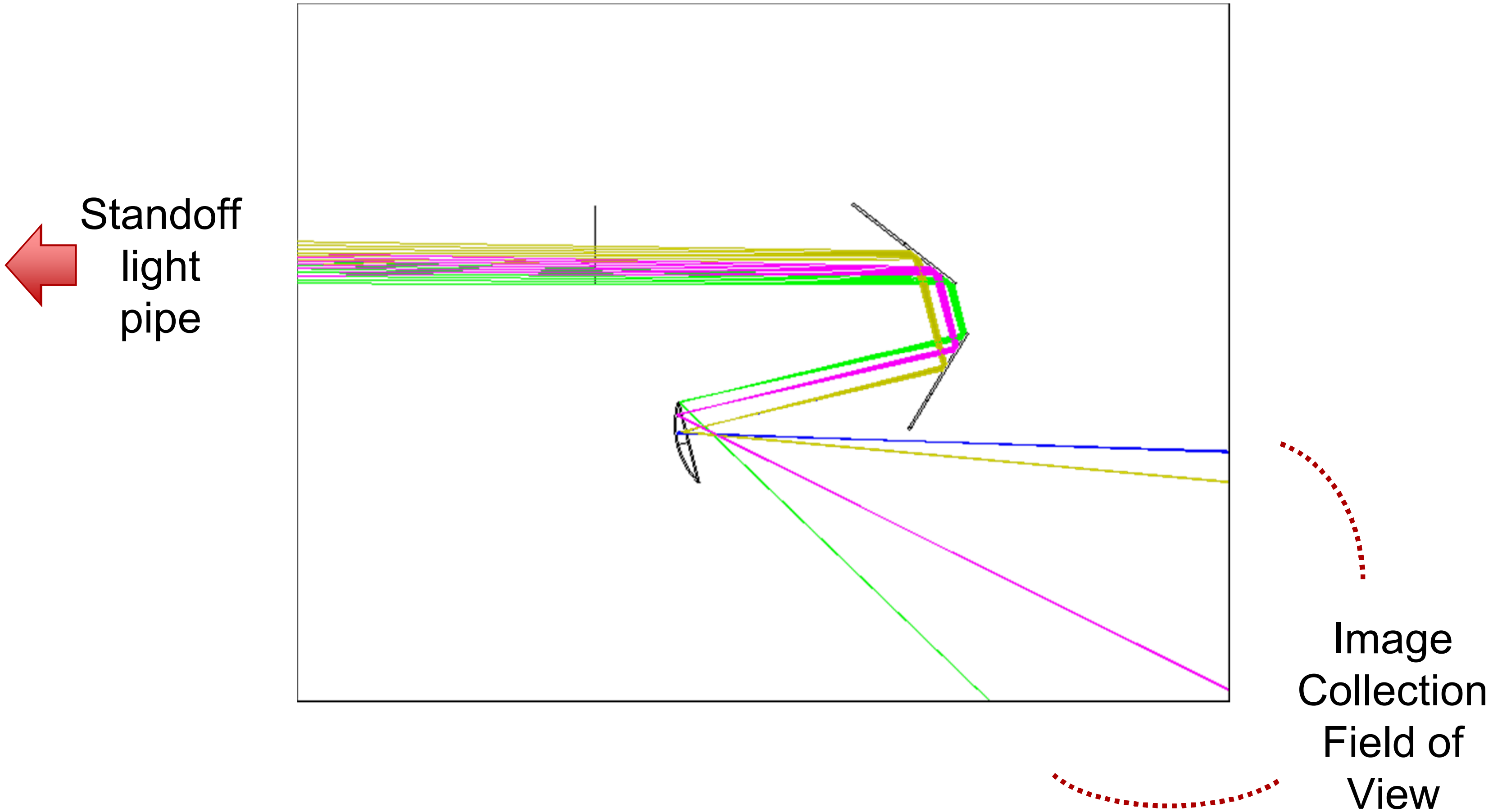


Image Authentication for Video Surveillance

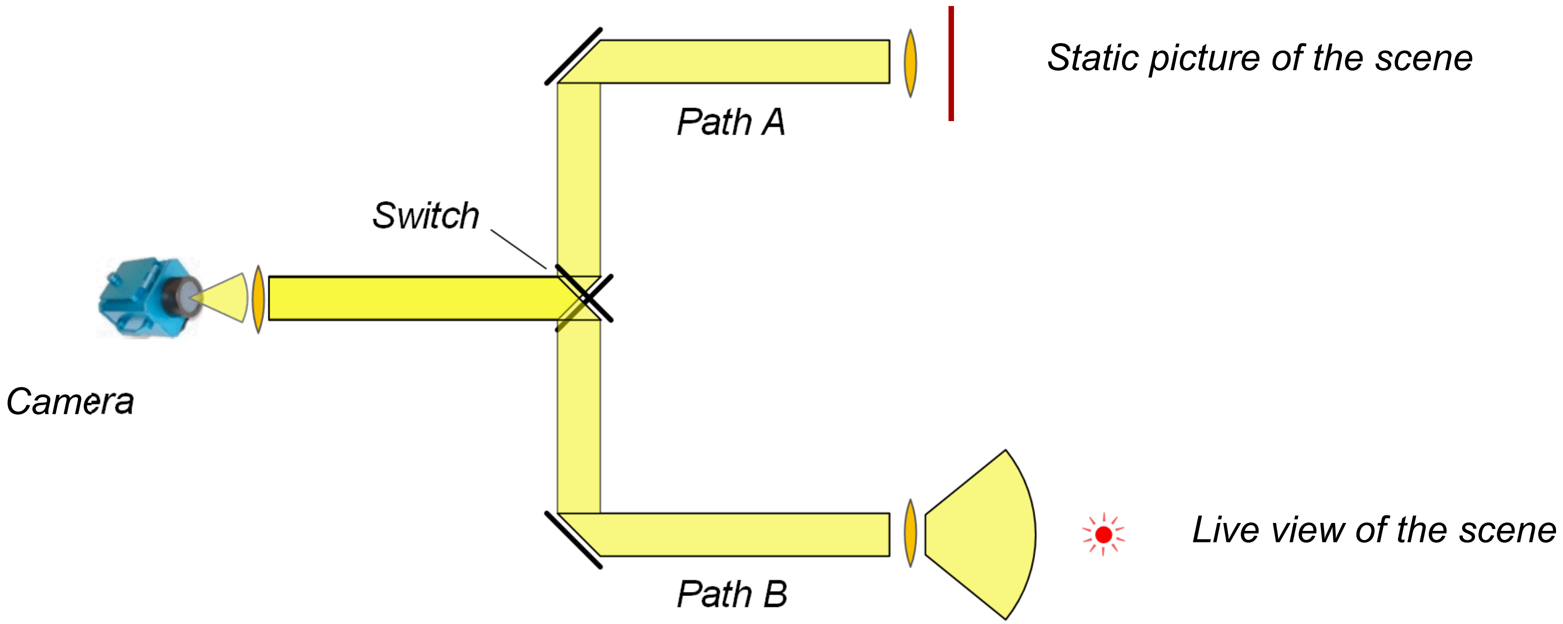
- Purpose: Ensure that acquired images are truly of the scene under surveillance
- Conventional Method:
  - Enclose the surveillance camera in a tamper-indicating housing
  - Cryptographically "sign" the digital image data close to the CMOS sensor, within the housing
- Does not address "before the lens" tampering

For standoff video

- There is greater opportunity for tamper (extended optical path)
- Mitigation approaches:
  - Secure just the standoff optical path
  - Incorporate "in-scene" authentication

Testing image authentication with multiplexed image sources

- Increase the complexity of the baseline scenario
  - Straight path now replaced with offset paths (periscopes)
  - Include a switch (mirror) to select the active path to the camera



Status and next steps

- Baseline scenario now being assembled on an optical bench
- Acquire image of arbitrary scene through the standoff optics
  - Need to shield the camera from extraneous light
  - Can we get sufficient brightness and resolution coupled through the optical path?
- Reassemble with two optical paths multiplexed to the camera
- Devise and test optical authentication of the standoff image
  - In-scene
  - Standoff only
- Engineering of a demonstration standoff system
  - Enclosed pipe to exclude ambient light
  - Adaptation to camera housing for the standoff pipe and relay lens
  - Enclosed housing and window for the objective optical components
- Radiation hardness qualification

Future: increasing application complexity

- Multiplexed optical paths
  - Multiple front end optical paths sharing a single camera
- Fixed surveillance location
  - Movable front end (pan/ tilt)
- Underwater application (e.g., spent fuel pools)
  - Air pipe: buoyancy compensation
- Movable surveillance location
  - Objective optics on the end of a movable boom
  - More image relay optics would be involved in designing a jointed surveillance “arm”

Conclusion

- A capability for authenticated standoff video surveillance would facilitate safeguards implementation in hostile environments, such as hot cells and spent fuel pools.
- We have developed a stepwise approach to investigating image authentication for standoff video surveillance, featuring a mirror-based image collection system coupled via air pipe to a remote camera.

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