

Ultrathin Fiberscope Utilizing a Single Channel for Both Illumination and Imaging

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- **Part I: Numerical Aperture Sharing to Achieve Single Channel Fiberscope**
- **Part II: Challenges in Constructing a Fiberscope**

Part I Content

- **Motivation and Challenges**
- **NA Sharing Principle**
- **System Hardware**
- **Results**
- **Expected and Actual Performance**
- **Future Directions**

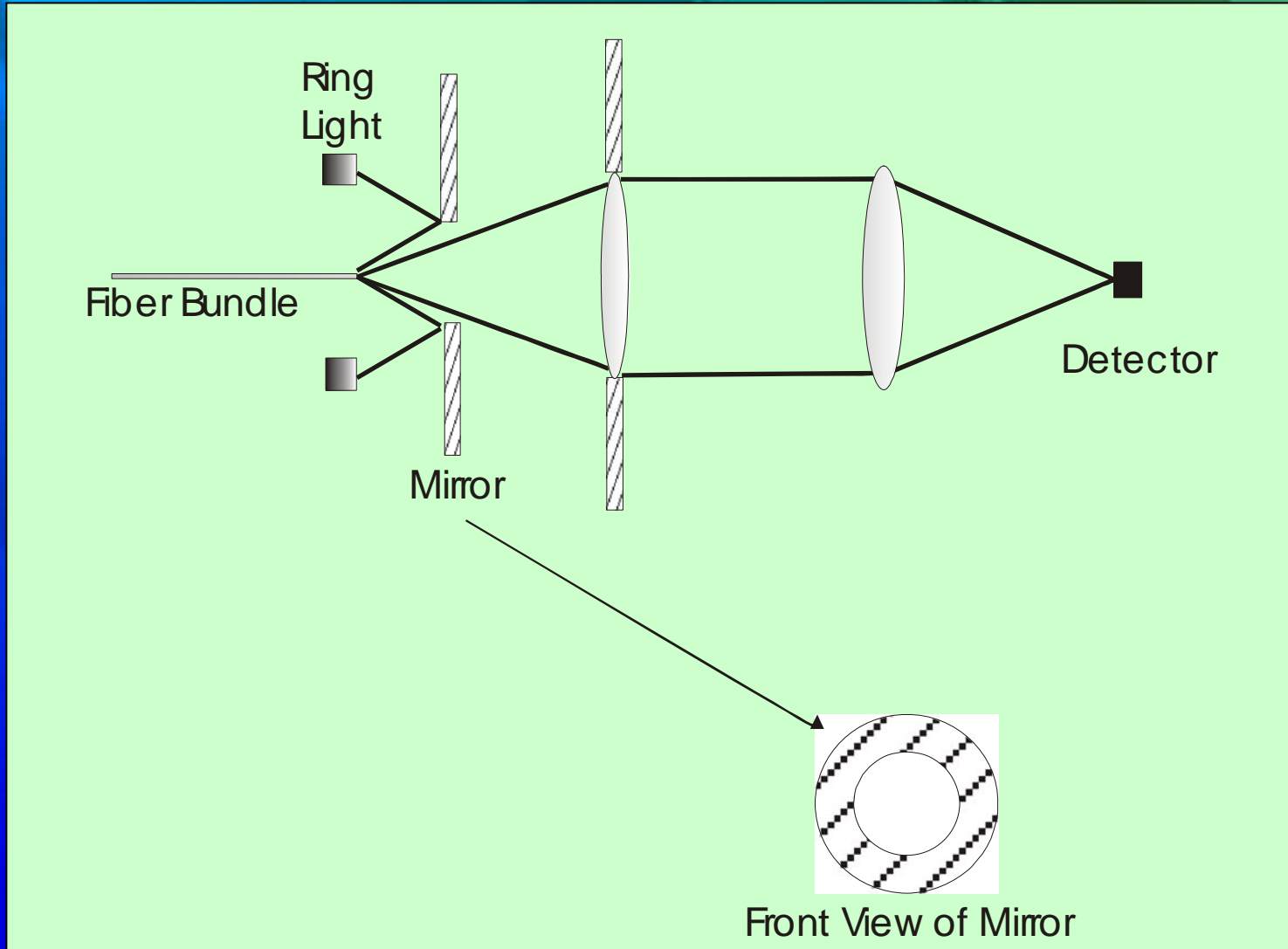
Ultrathin Fiberscopes

- **Ultrathin \Rightarrow < 2 mm diameter**
- **Applications:**
 - Imaging peripheral vasculature
 - Bronchial Imaging
 - Small Animal Imaging
- **Limitations:**
 - Diffuse white reflectance imaging is standard
 - Separate illumination and imaging channels
 - Limited space for imaging pixels

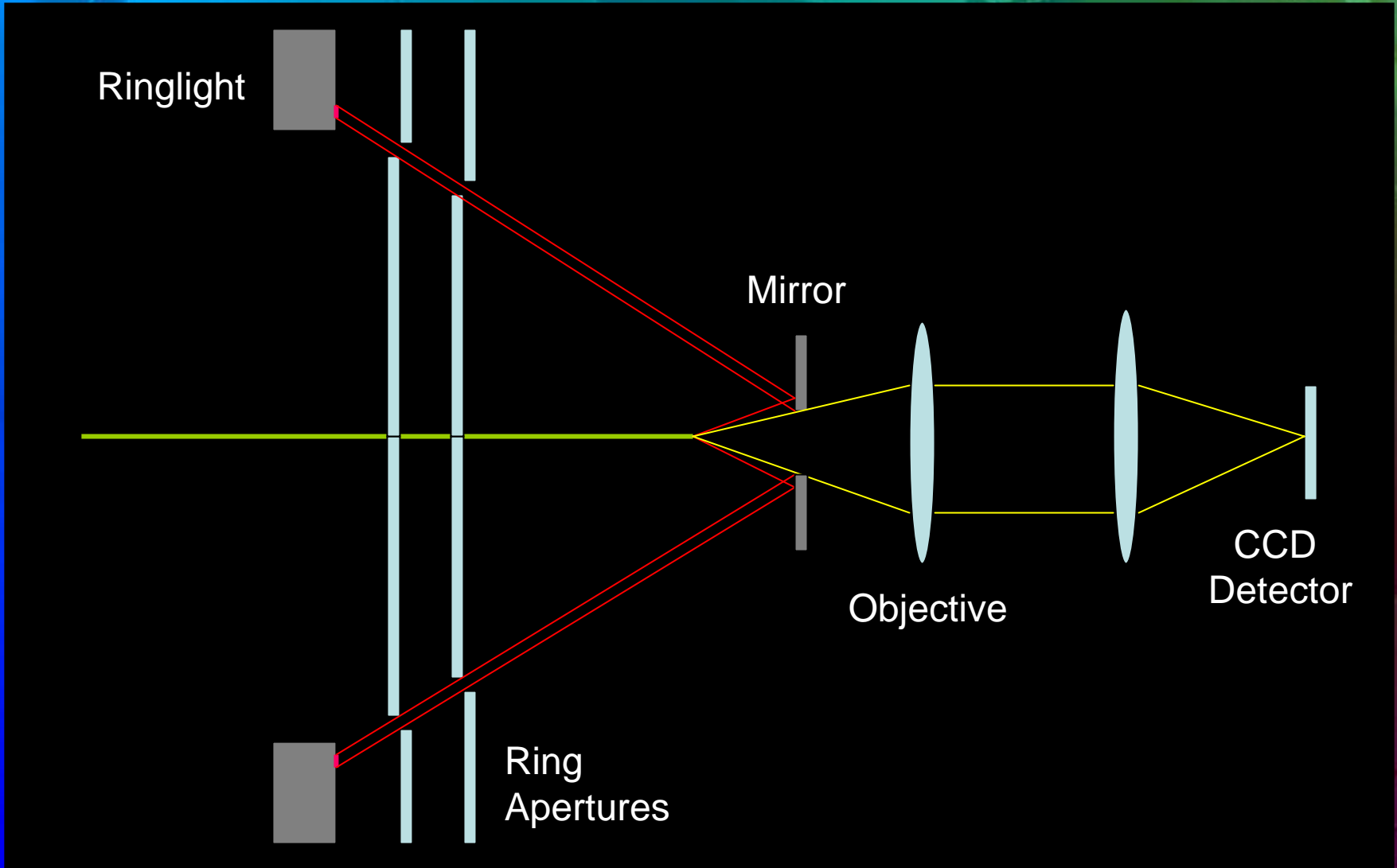
White Diffuse Reflection Imaging Through A Single Channel

- Illuminating and imaging through a single fiberoptic channel is routinely done in fields such as fluorescence
 - Filters can be used to remove reflections from the detection path
- Challenge:
 - Reduction reflections off of surfaces in the common illumination and detection paths.
 - Cross Polarizers
 - AR Coatings

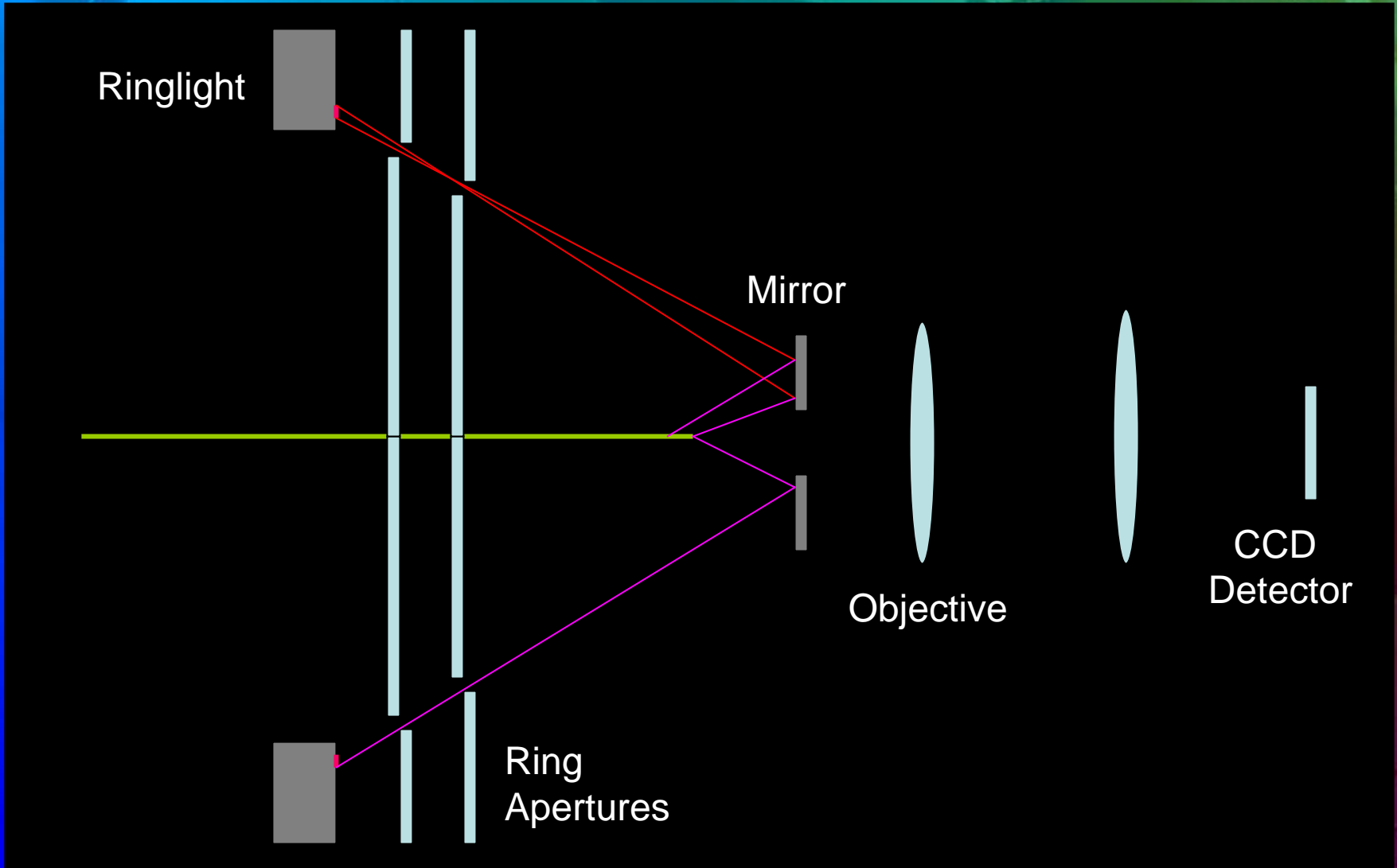
Principle of NA Sharing



NA Sharing Principle



NA Sharing Principle



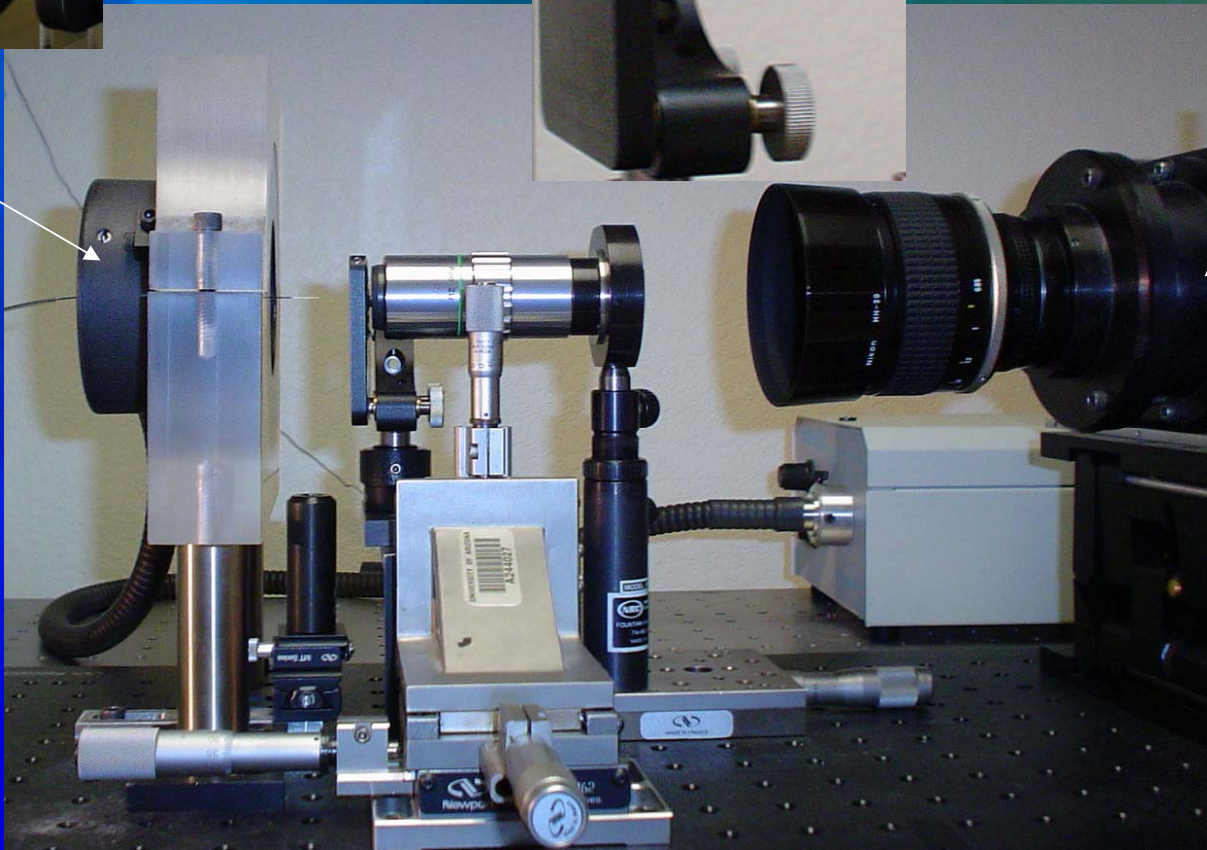
System Hardware



Baffles



Mirror

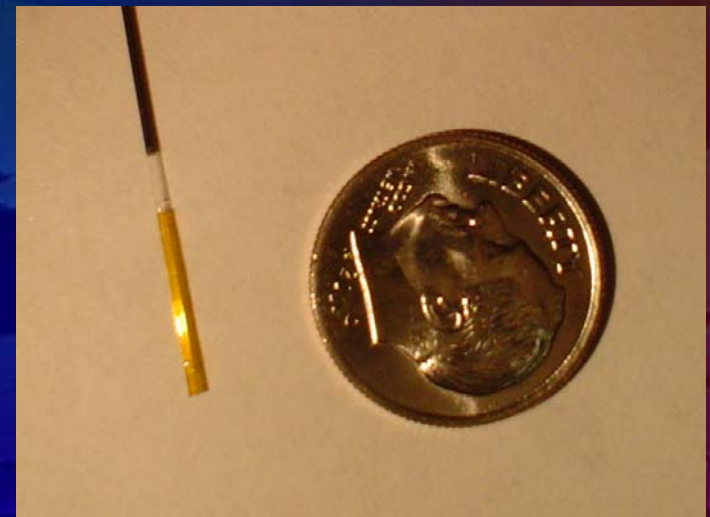


Ringlight

CCD Camera

Catheter Construction

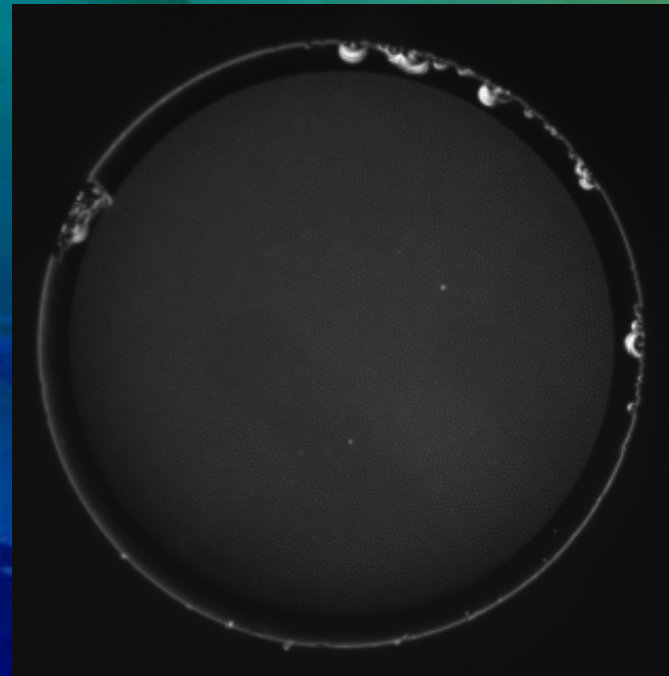
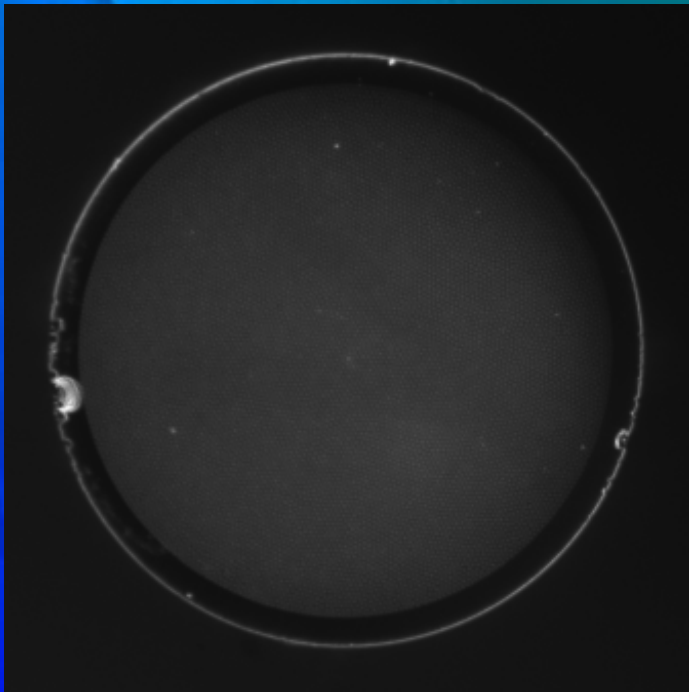
- **Coherent Fiber Bundle**
 - Sumitomo Electric
 - 0.59 mm diameter
 - 10,000 elements
 - 3.99 micron center-center spacing
 - core diameters of 2.39 microns
 - NA=0.35
- **GRIN Lens**
 - GRINTech GmbH
 - 0.5 mm diameter
 - NA=0.5
 - 1.5 mm working distance
 - Chiolite AR coating



Part I Content

- **Motivation and Challenges**
- **NA Sharing Principle**
- **System Hardware**
- **Results**

Results



Paper Object Imaged at WD of 1.5 mm

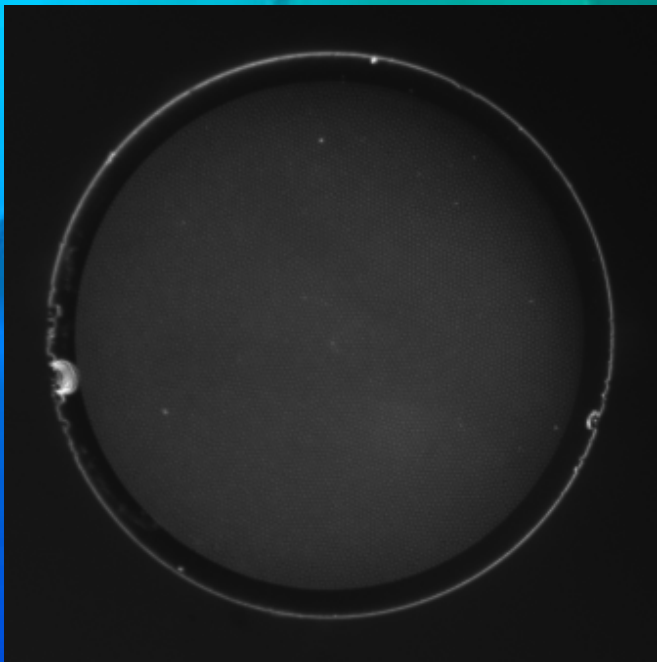
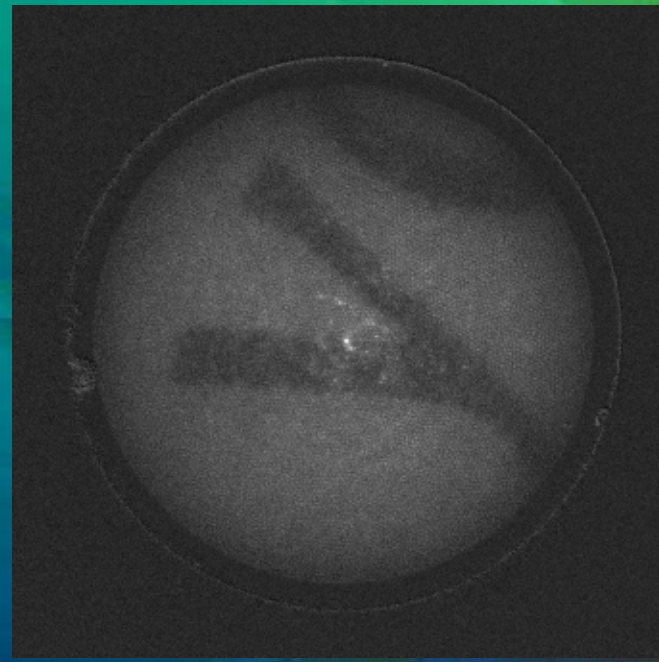
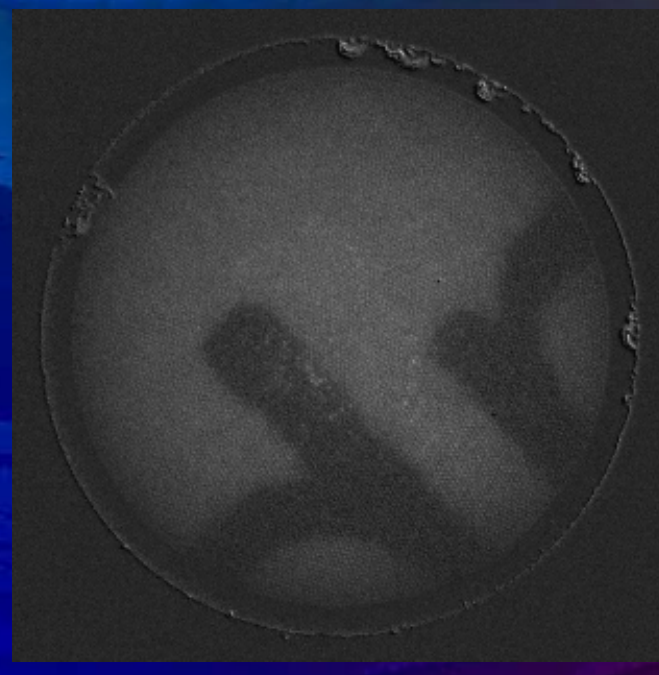
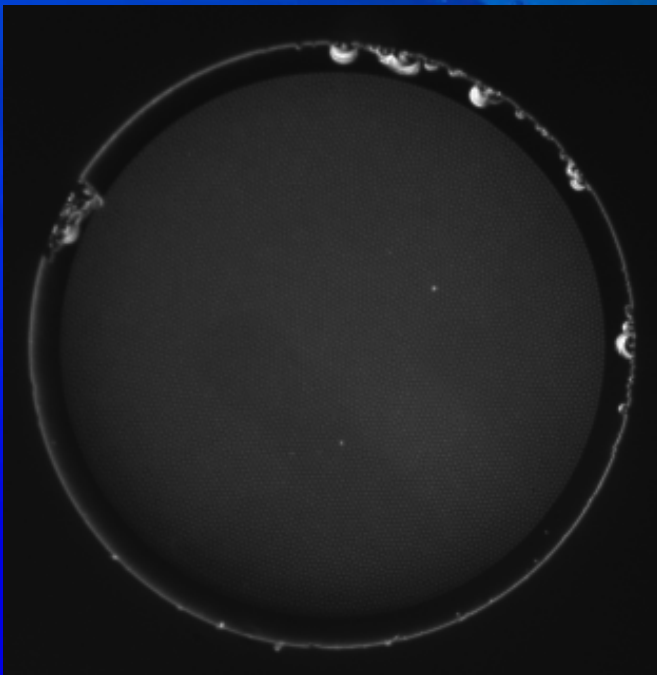


Image of Paper Object

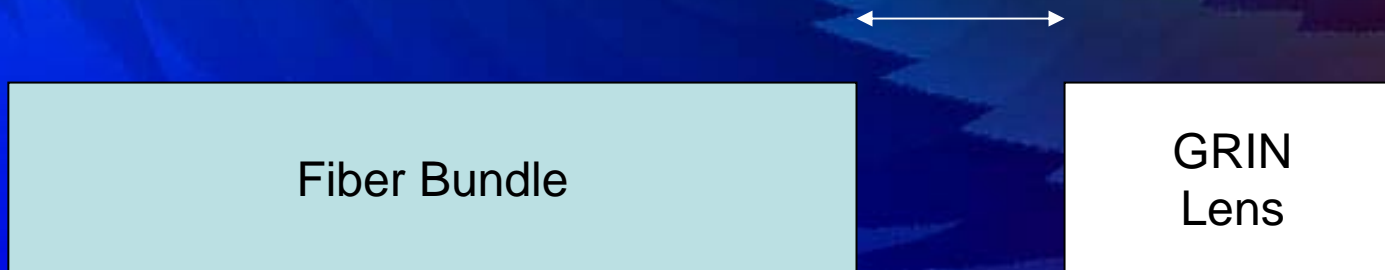


After Background Subtraction



Characterization Experiments

- Varying distances between GRIN lens and fiber bundle
- With and without index-matching adhesive
- No Object



Possible Sources of Reflections

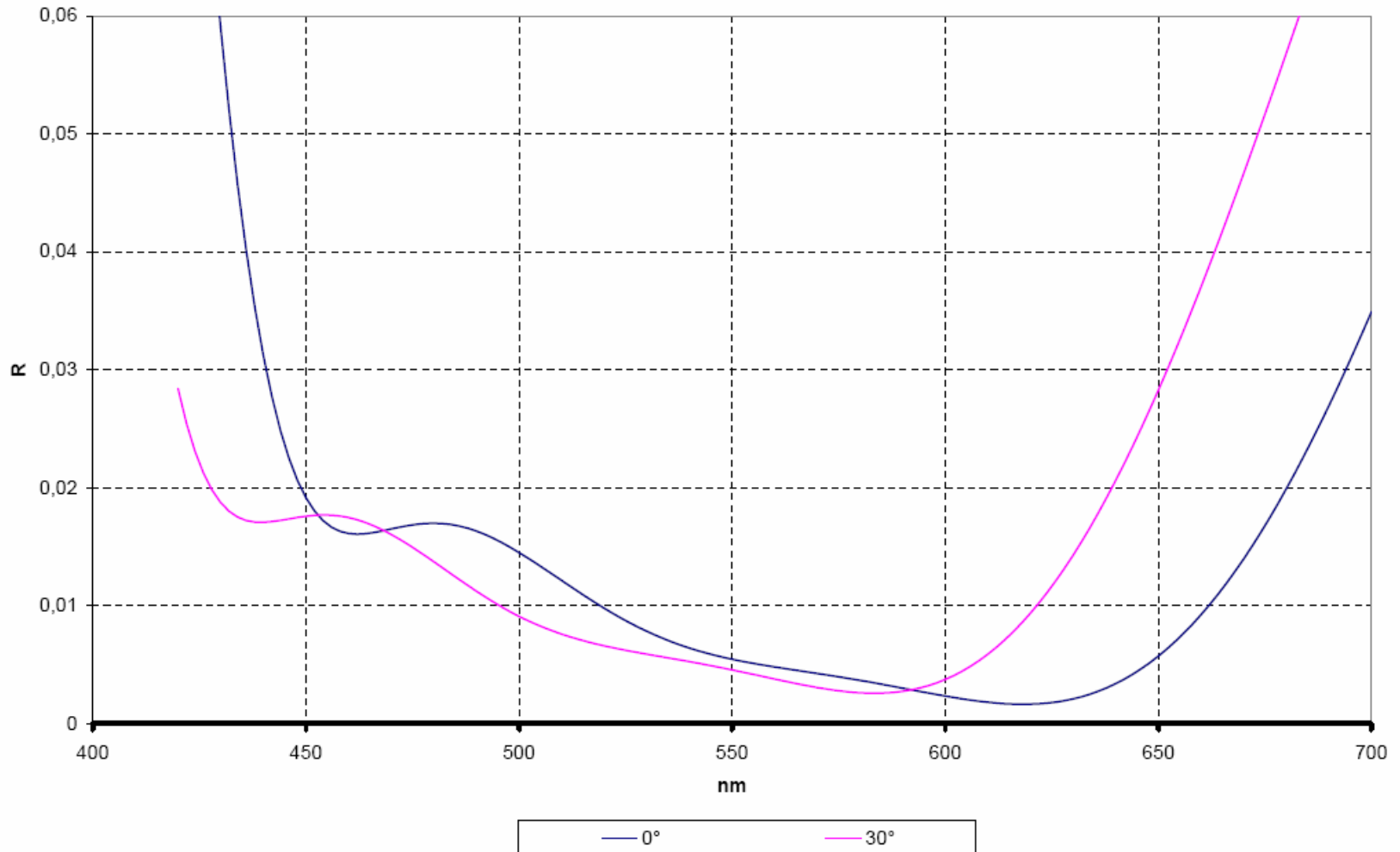
- **Back reflections from housing and fiber mount**
 - Blocked by fiber bundle
- **Proximal Face of Fiber Bundle**
 - NA Sharing
- **Fiber Bundle/GRIN Lens Interface**
 - Index match
- **Distal Face of GRIN Lens**
 - AR coating (~1%)

Sources of Reflections

- All values a percentage of illumination incident on the fiber bundle

	Expected Reflections	Actual Reflections
Proximal Fiber Face	4% w/o NA Share	0.34%
Distal Catheter Tip		
AR Coated	0.7%	2.4%
No Coating	3.2%	2.9%

Reflectance Curve for Chiolite AR Coating



Future Direction

- **Spectral filtering**
 - Optimal wavelength range for AR coating performance
 - GRIN lenses fluoresce with blue excitation
- **Incorporate ability to perform simultaneous white diffuse reflectance and fluorescence studies**

Part I Summary

- **Broadband single channel fiberscope**
- **NA Sharing**
- **Images**
- **Background Characterization**
- **Future Directions**



**Part II: Challenges in
Assembling a 0.5 mm
Fiberscope**

- **Assembly of the Catheter**
 - **Polishing of the Fiber Bundle**
 - **Mounting of the GRIN lens**
 - AR coating
 - Transporting
 - Mount
 - **Alignment of GRIN lens and fiber bundle**
 - Magnifying Scope
 - Tilt in xy
 - Need 2 views 90 degrees apart

- **Assembly of the Catheter**
 - **Cementing**
 - 24-36 hours
 - F-65
 - VTC-2 (UV cure)
 - **Gentle removal from mount**
 - **Protective covering of joint**
 - 24 hours
 - F-65