Calibration Screen Development

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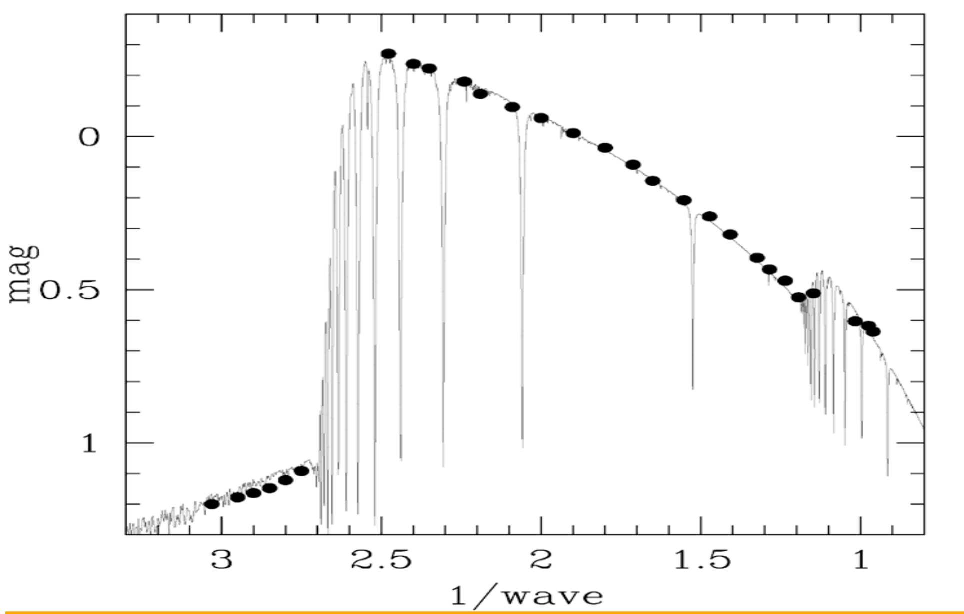
Overview

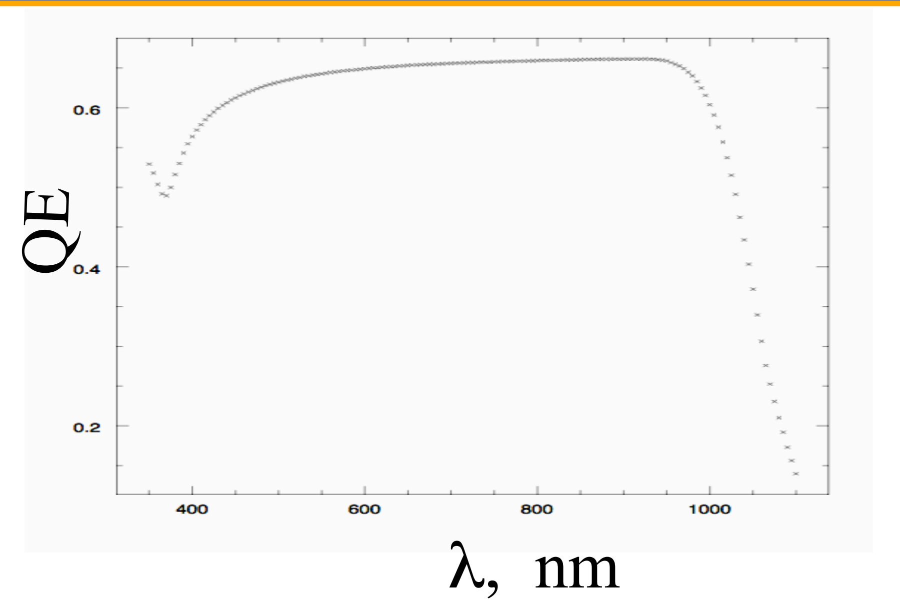
- Objectives
- Status
- Challenges
- Plans

Objectives

- We hope to achieve unprecedented *precision* in LSST photometry.
- This requires knowing
    - Relative sensitivity of apparatus vs. wavelength
    - Transmission of atmosphere.
- Our plan is to use a NIST-calibrated photodiode as the primary flux sensitivity reference.
- We will use full-aperture illumination of the system to map out each pixel's response vs. wavelength, for each LSST filter.
- (Measurement of atmospheric transmission is a distinct issue, for a later conversation)

Detectors are better characterized than *any* celestial source!

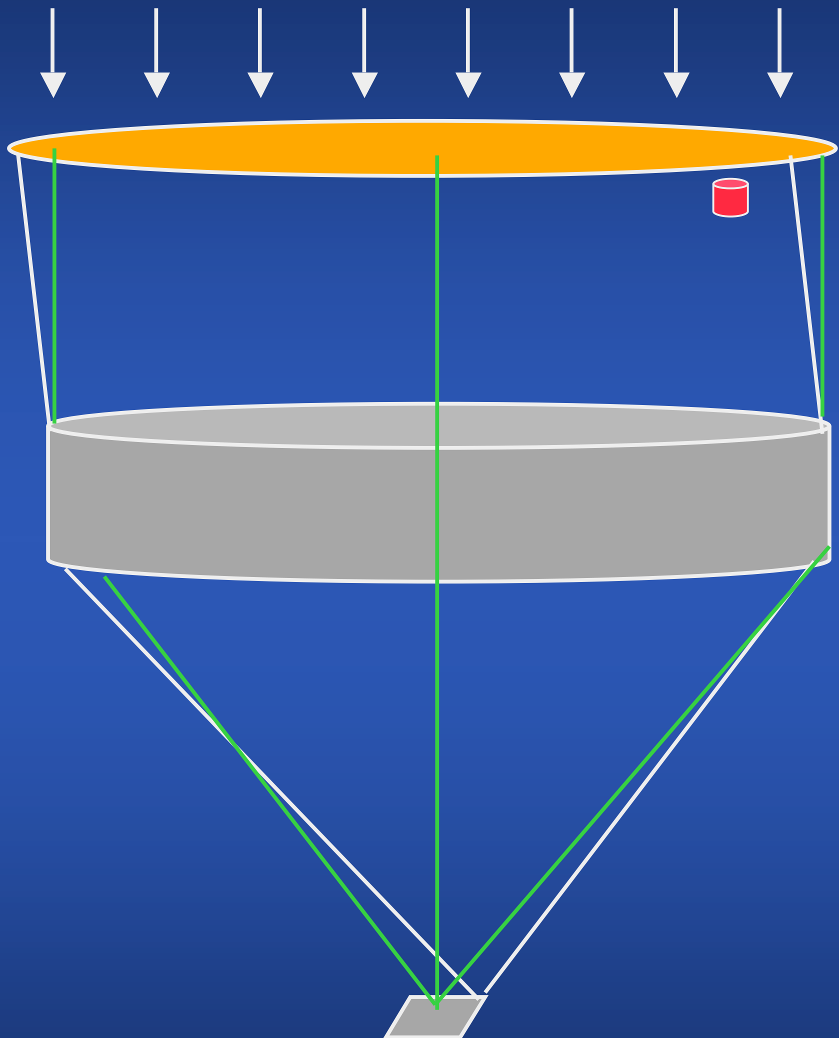




Spectrum of Vega

NIST photodiode QE

Basic Concept



Back-illuminated diffuser

Monitoring photodiode

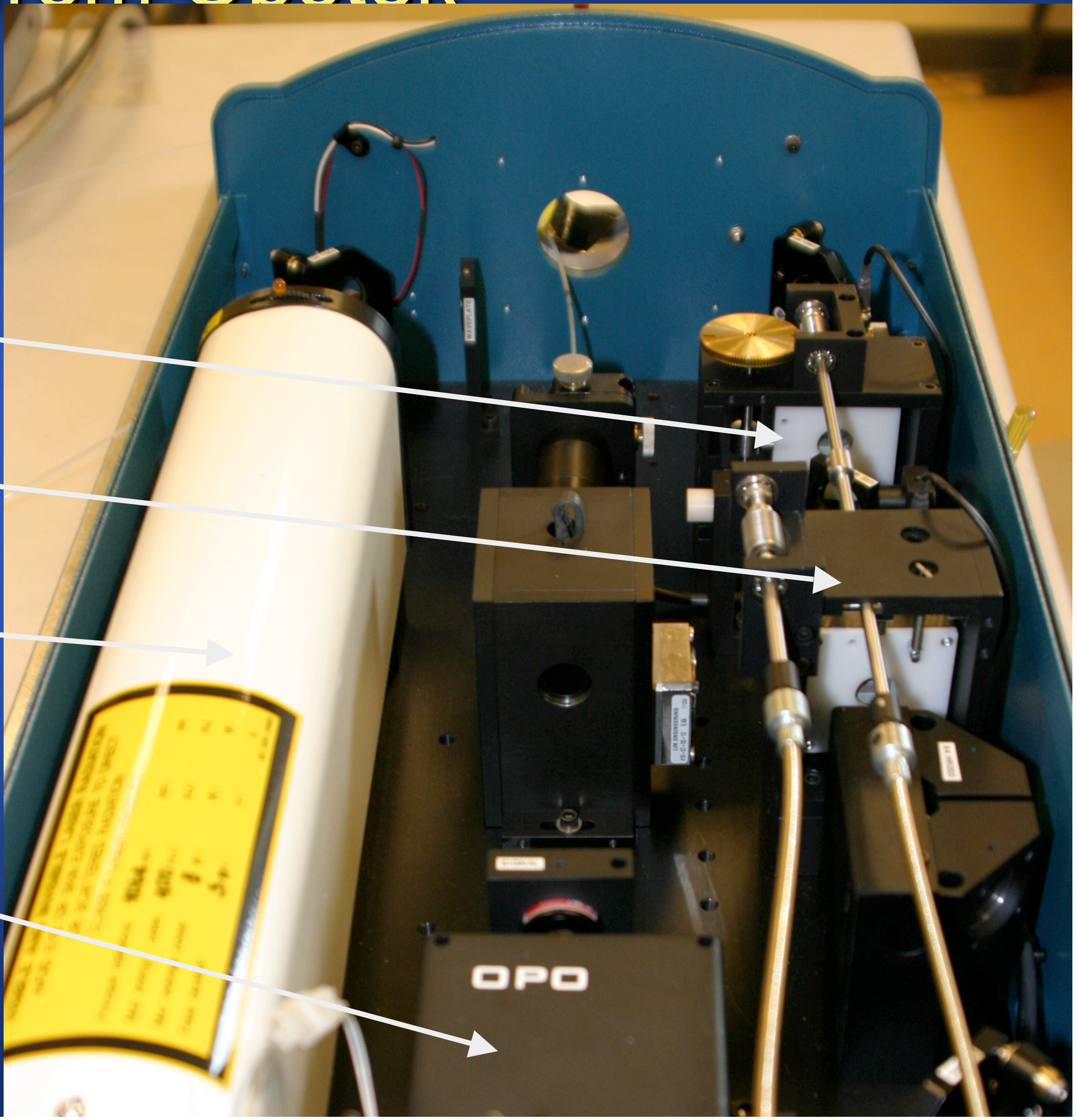
LSST aperture

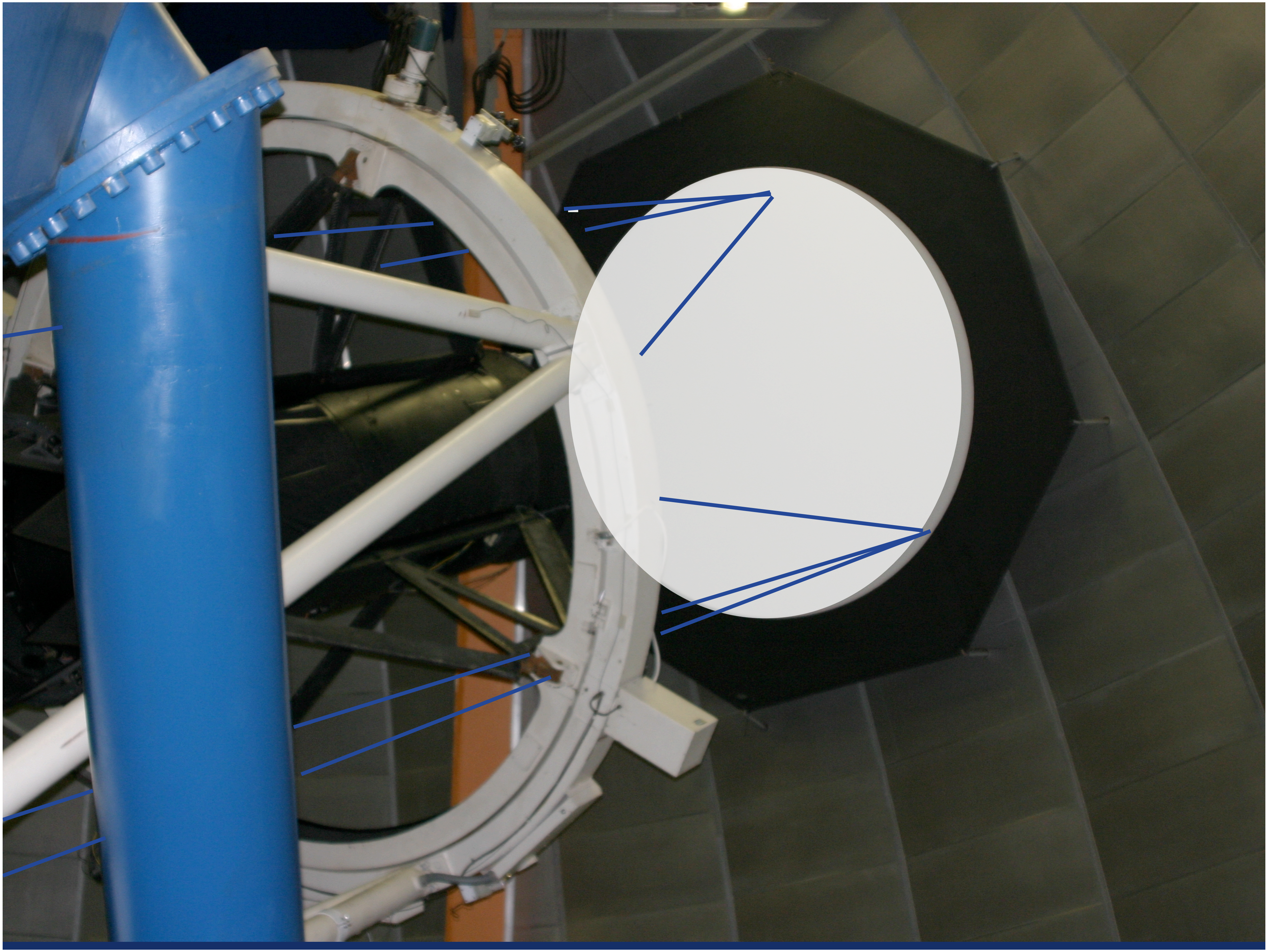
focal plane

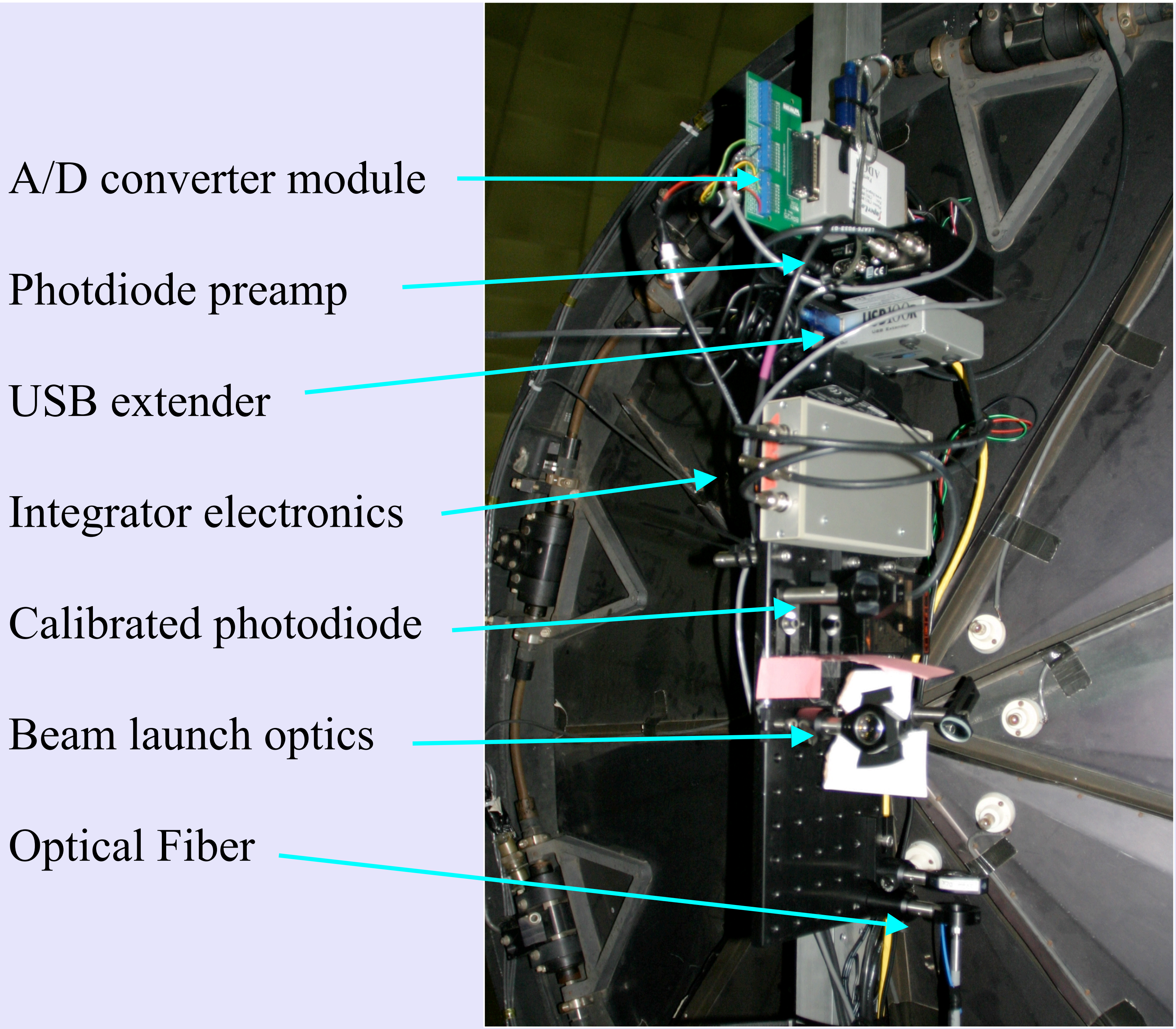
Demonstration of the concept at CTIO

- Measured full system transmission using a tunable laser and NIST diode.
- This was not a permanent installation.

Tunable laser (400 nm - 2 microns) from Opotek





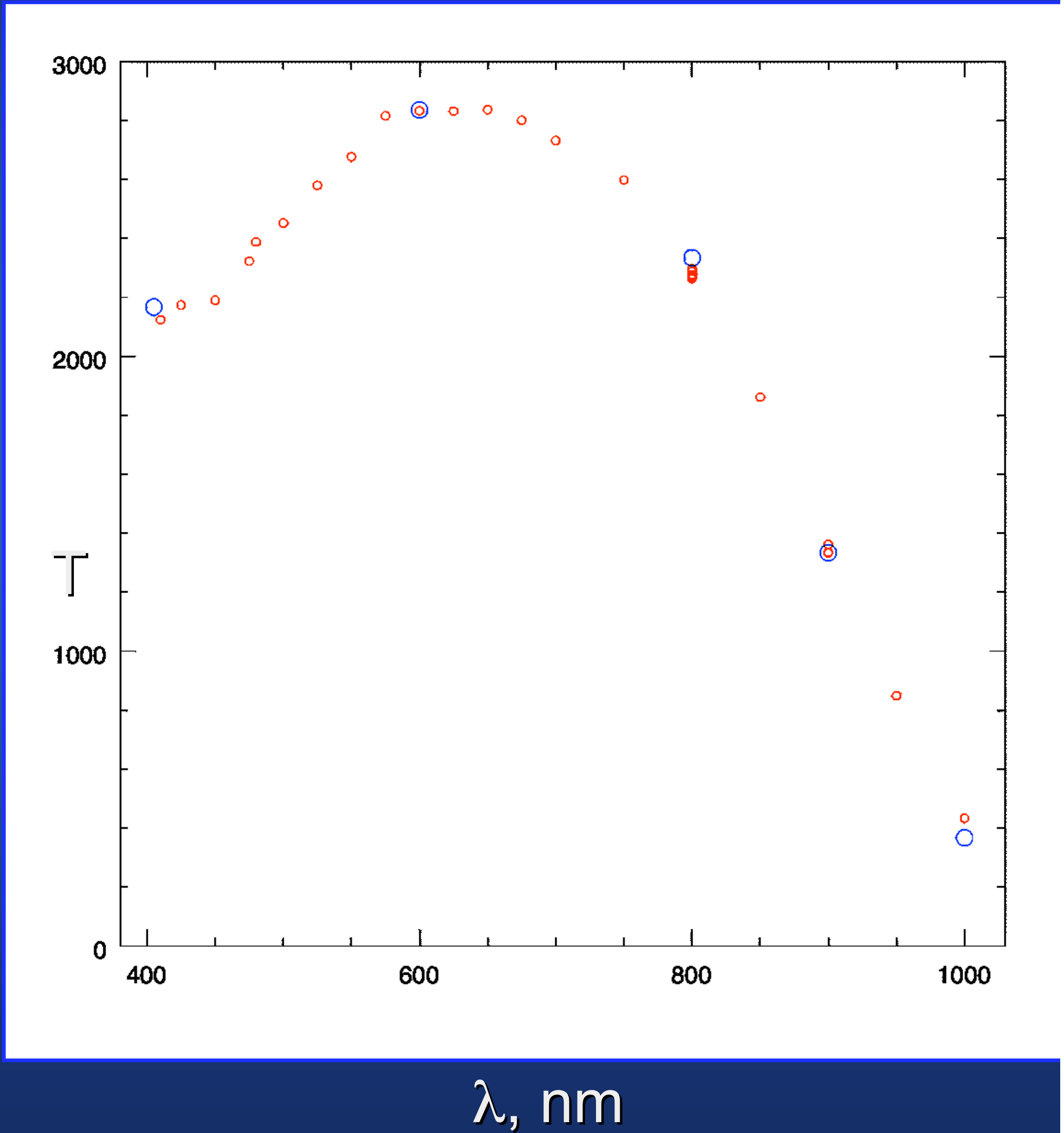

A/D converter module
Photdiode preamp
USB extender
Integrator electronics
Calibrated photodiode
Beam launch optics
Optical Fiber

Preliminary results from this approach

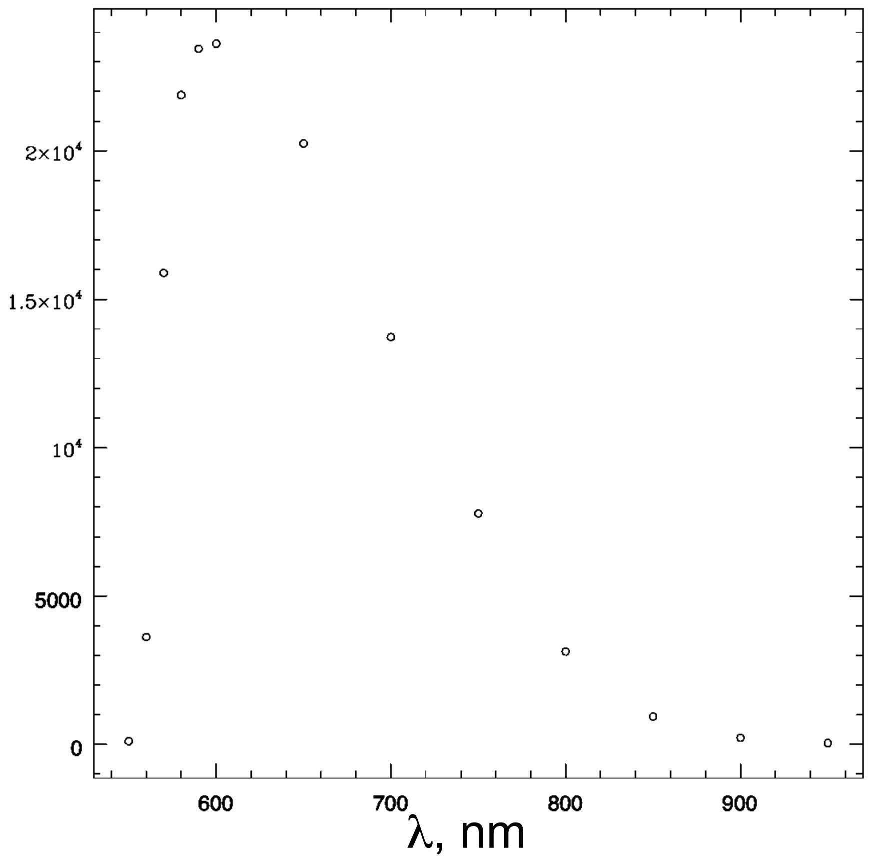
Relative system response vs. wavelength for CTIO Mosaic imager

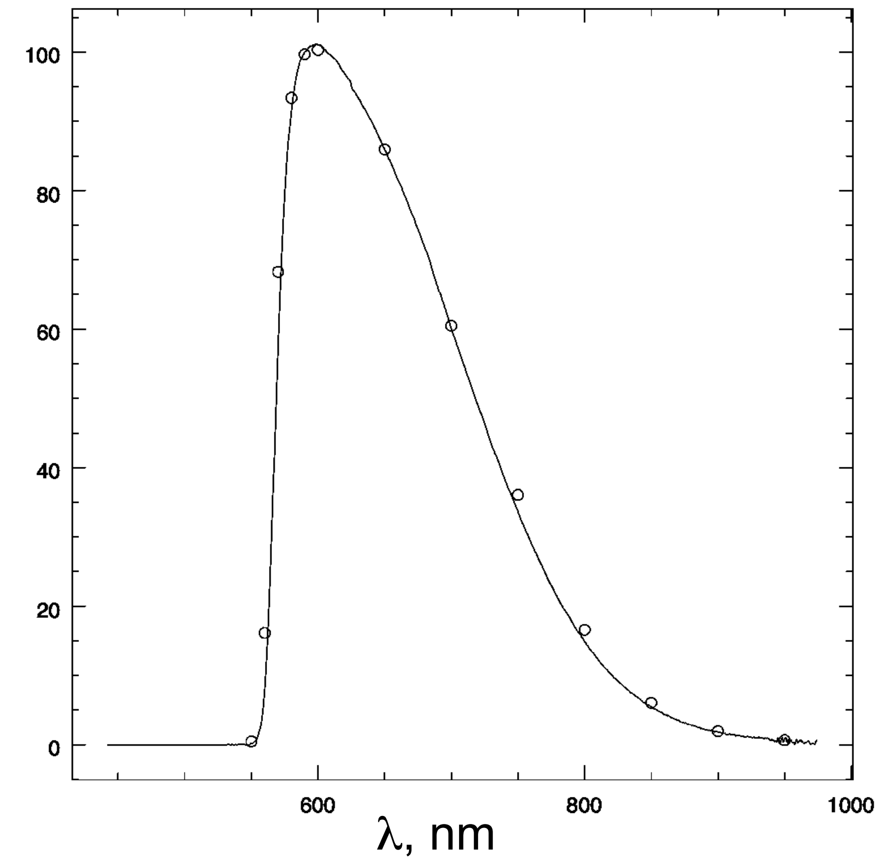
100 x 100 pixel block average

Multiple points at 800 nm show repeatability of 0.4%



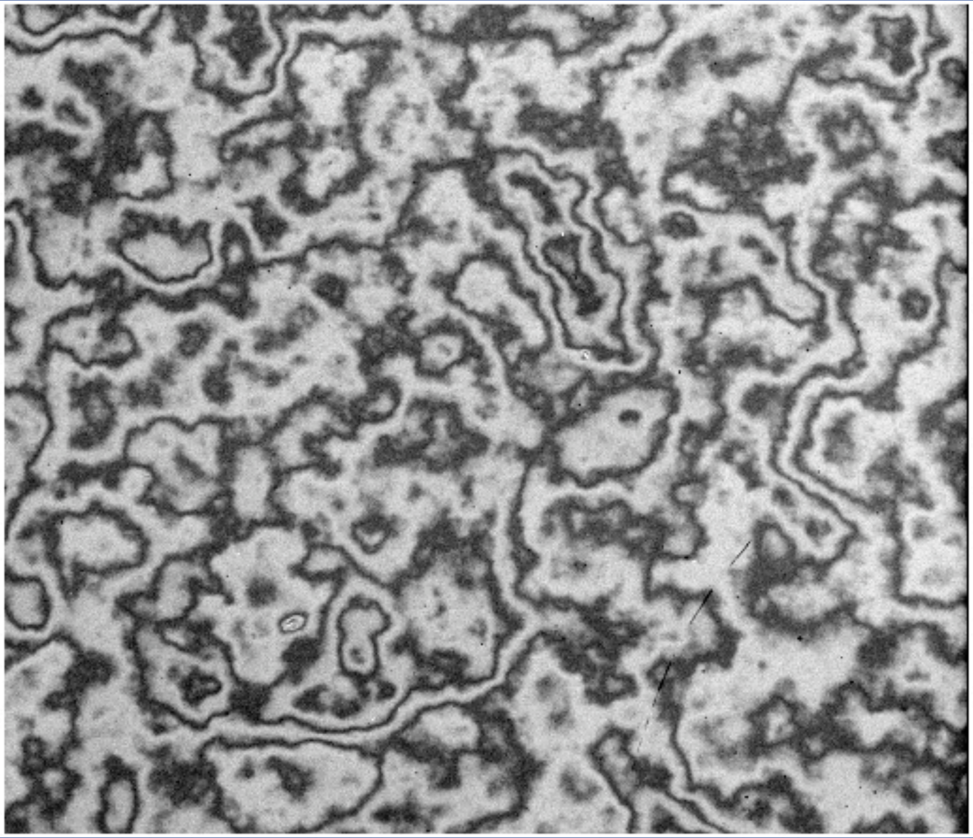
Actual data from CTIO R Band Colored Glass Filter



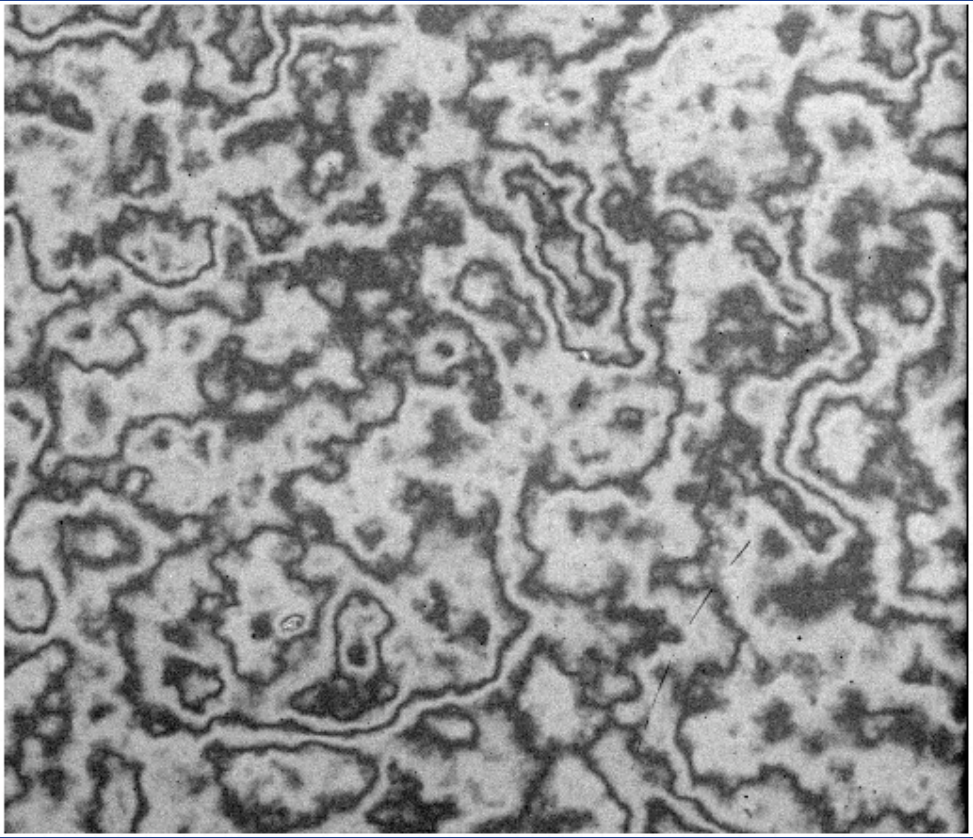


System throughput

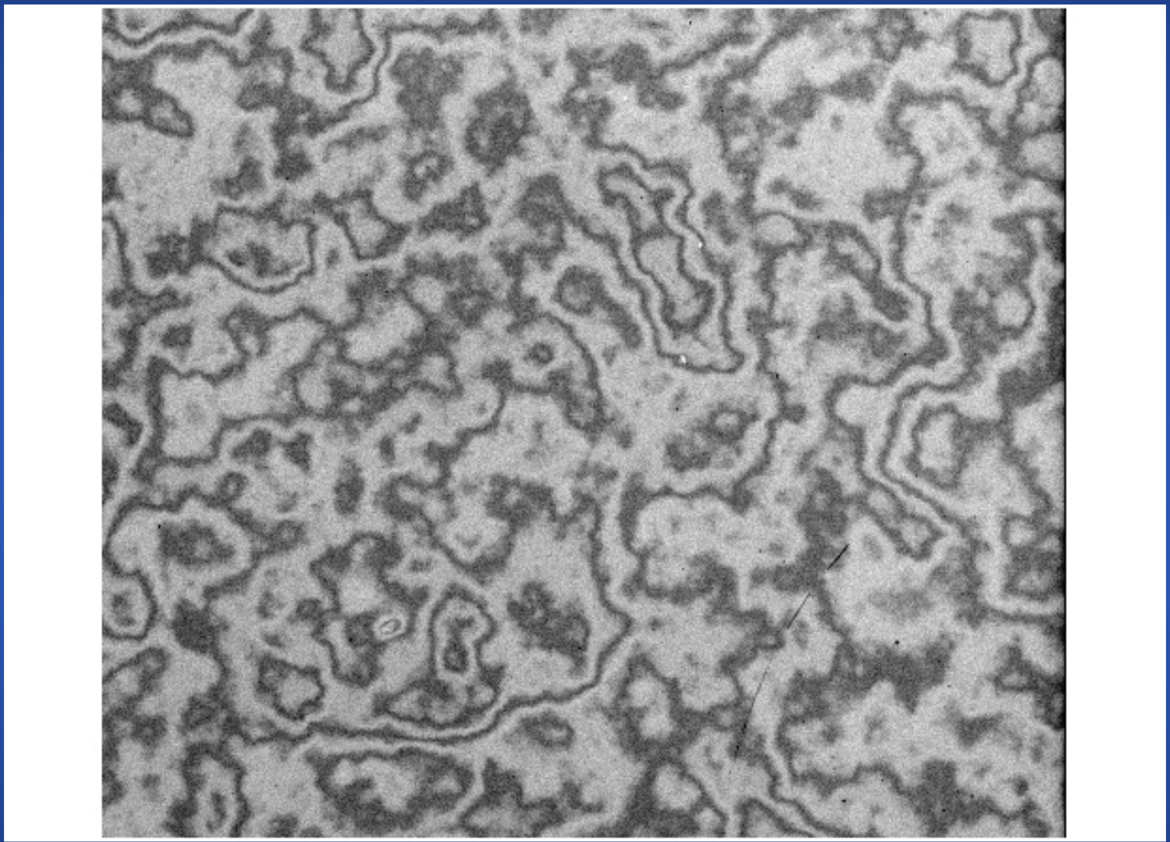
Filtered/blank=filter only



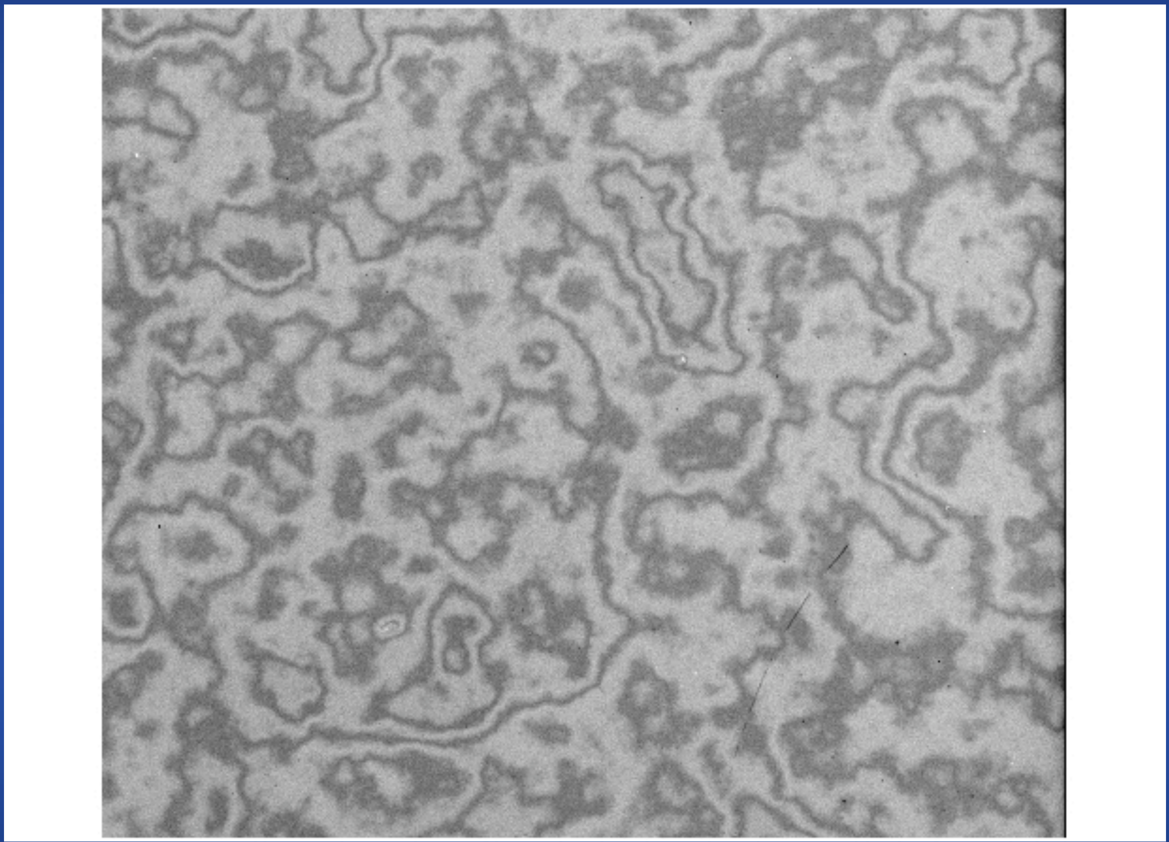
950 nm



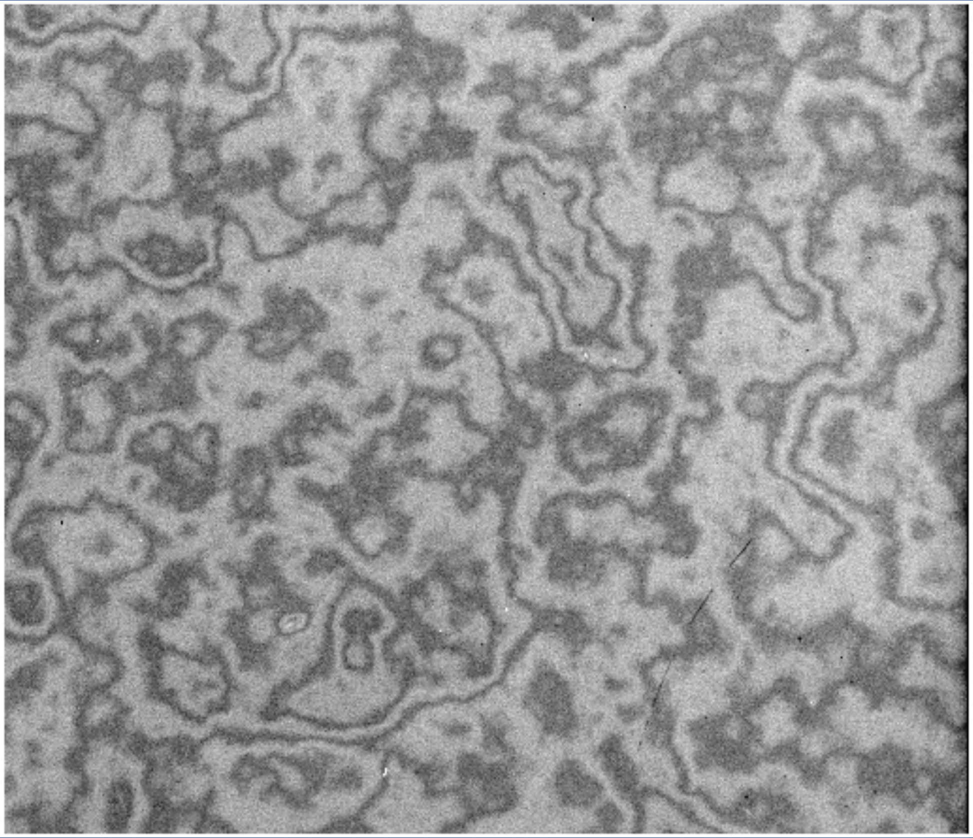
960 nm



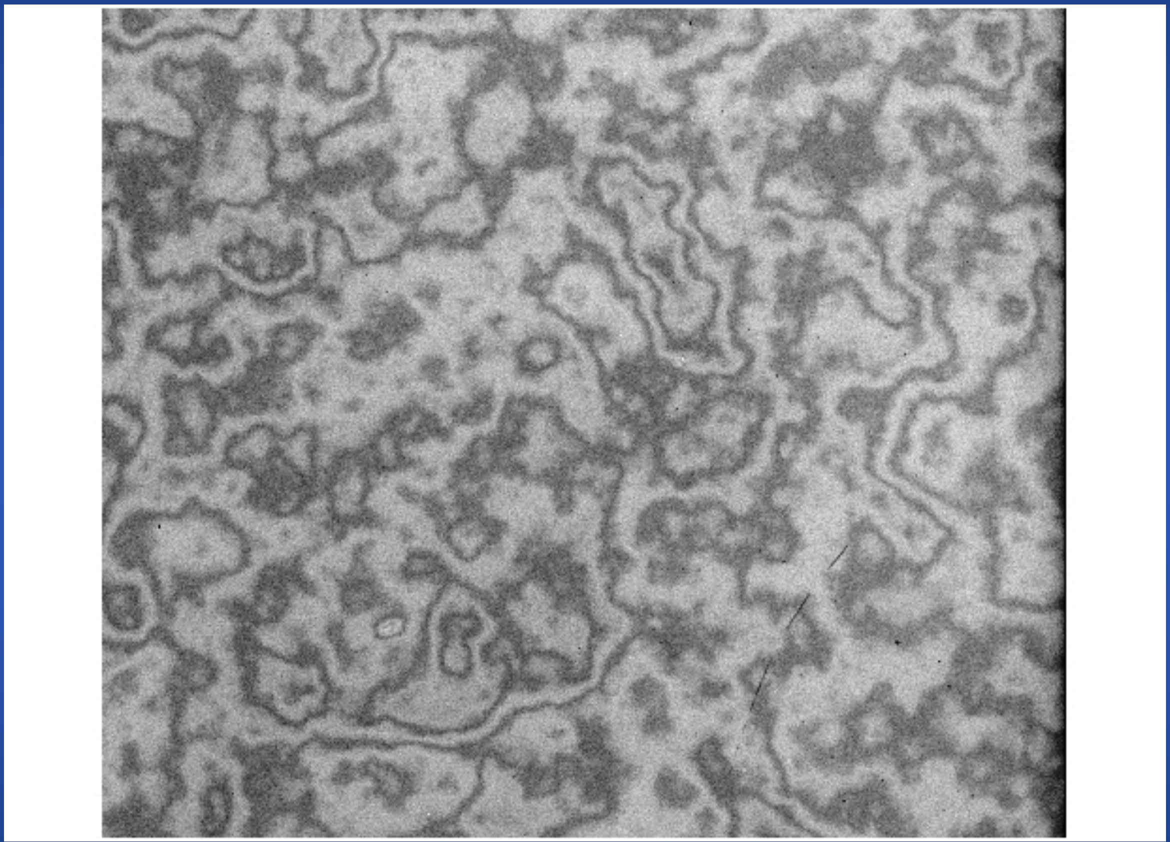
970 nm



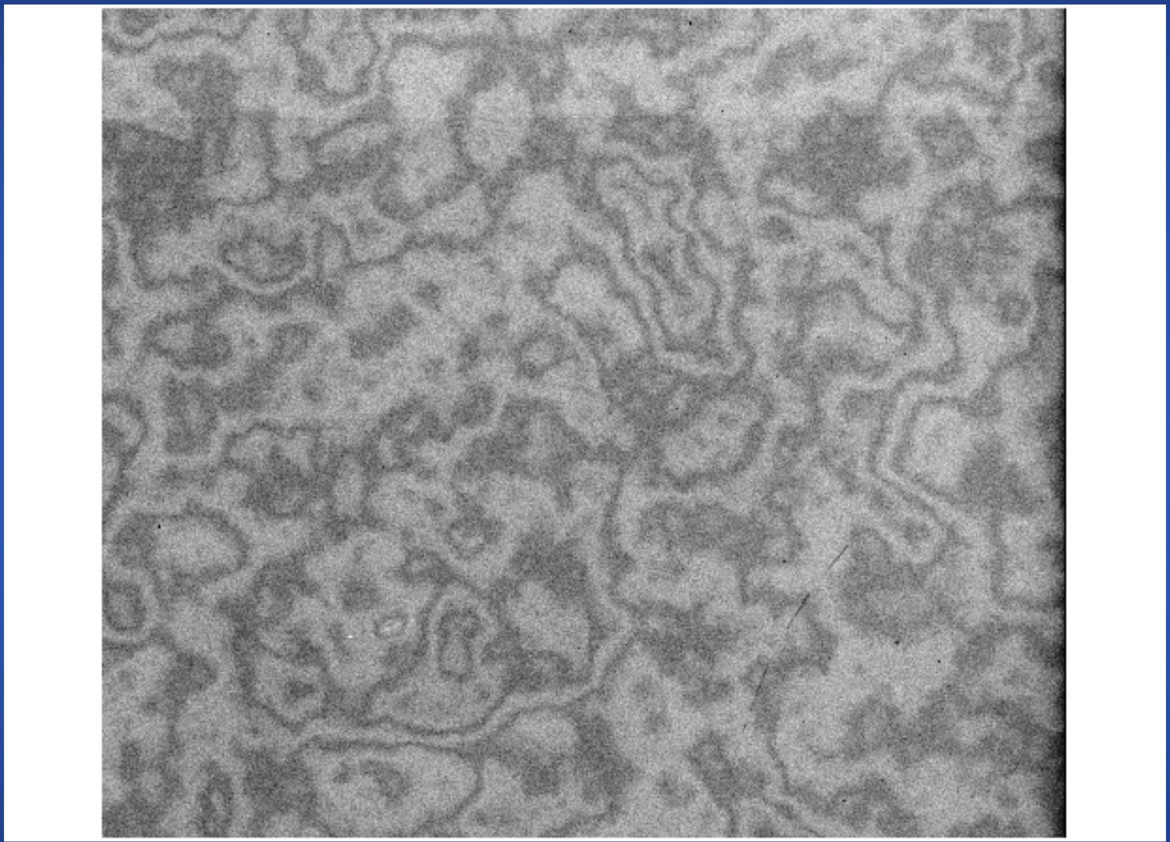
980 nm



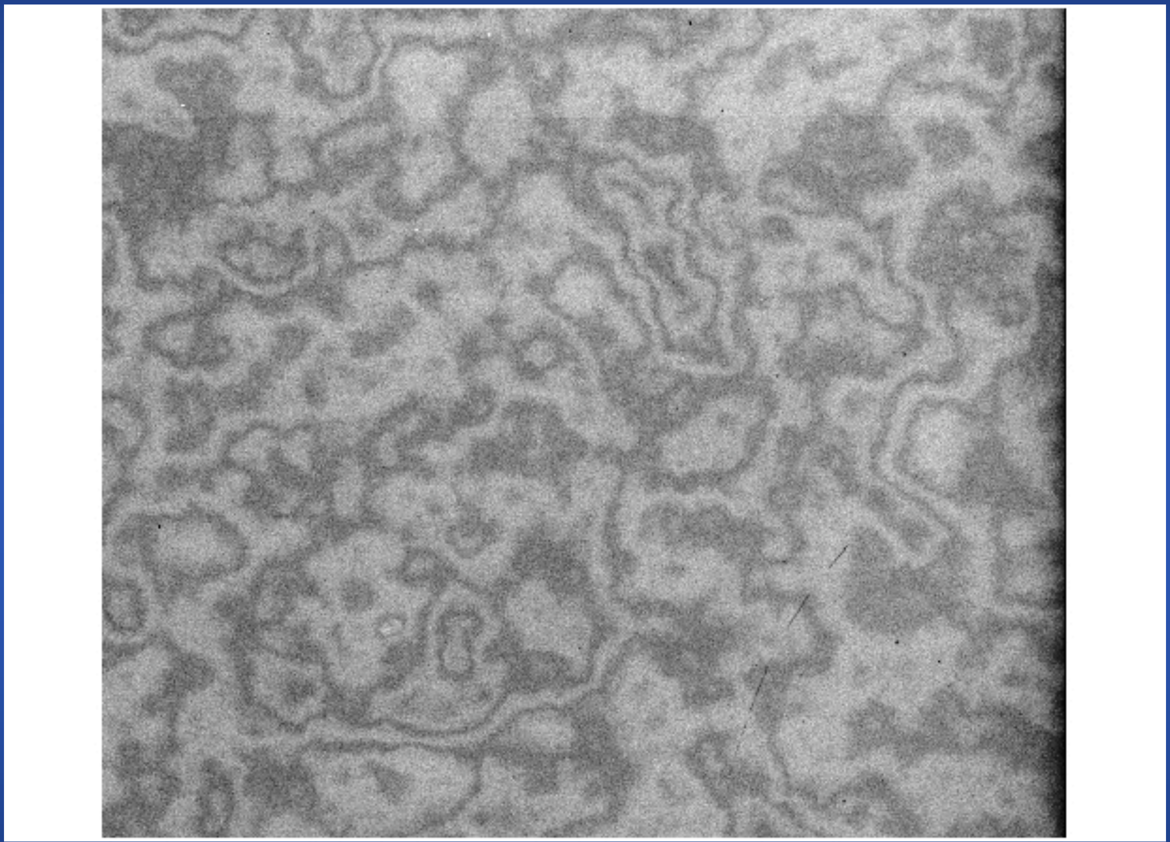
990 nm



1000 nm

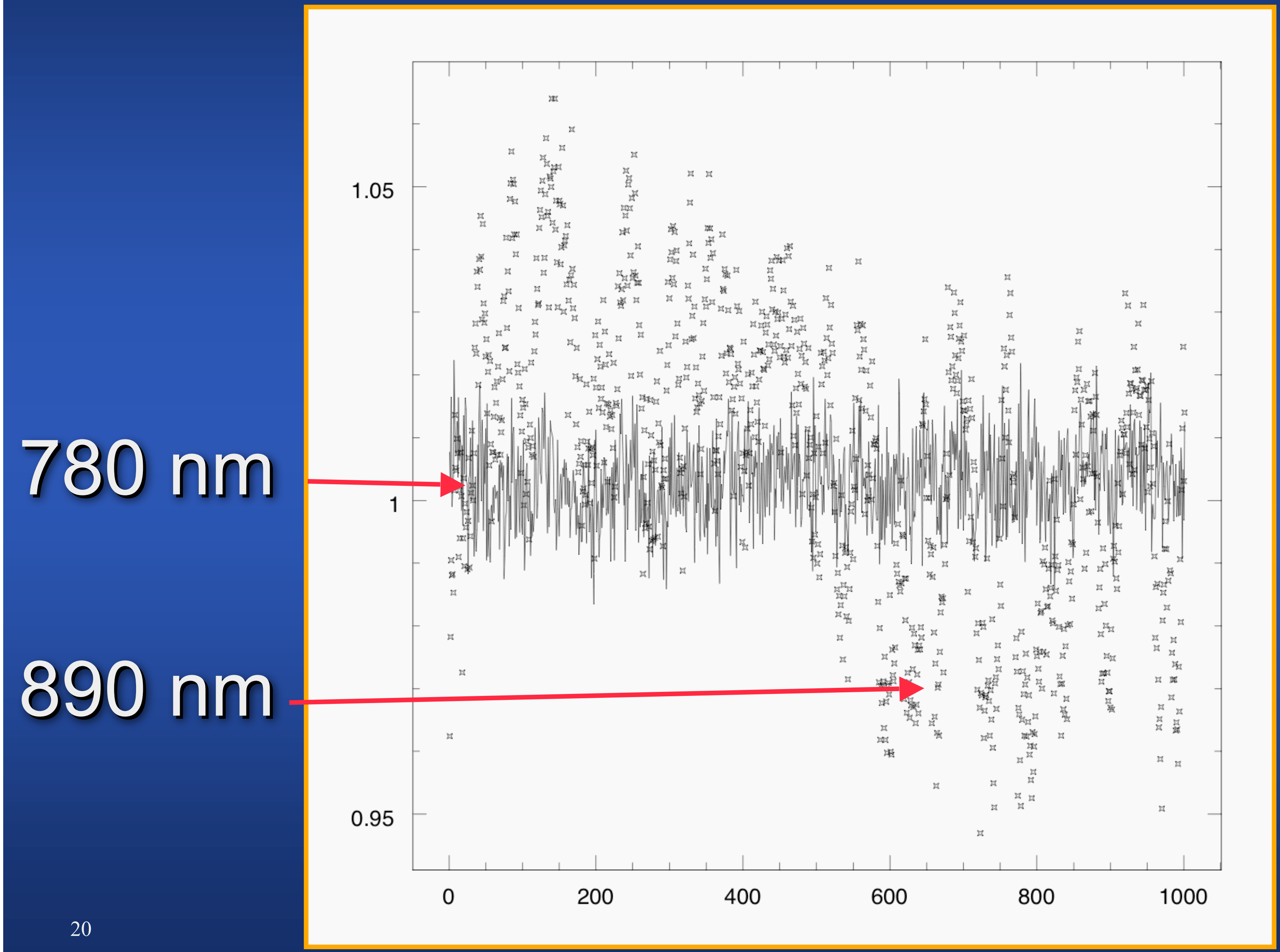


1010 nm



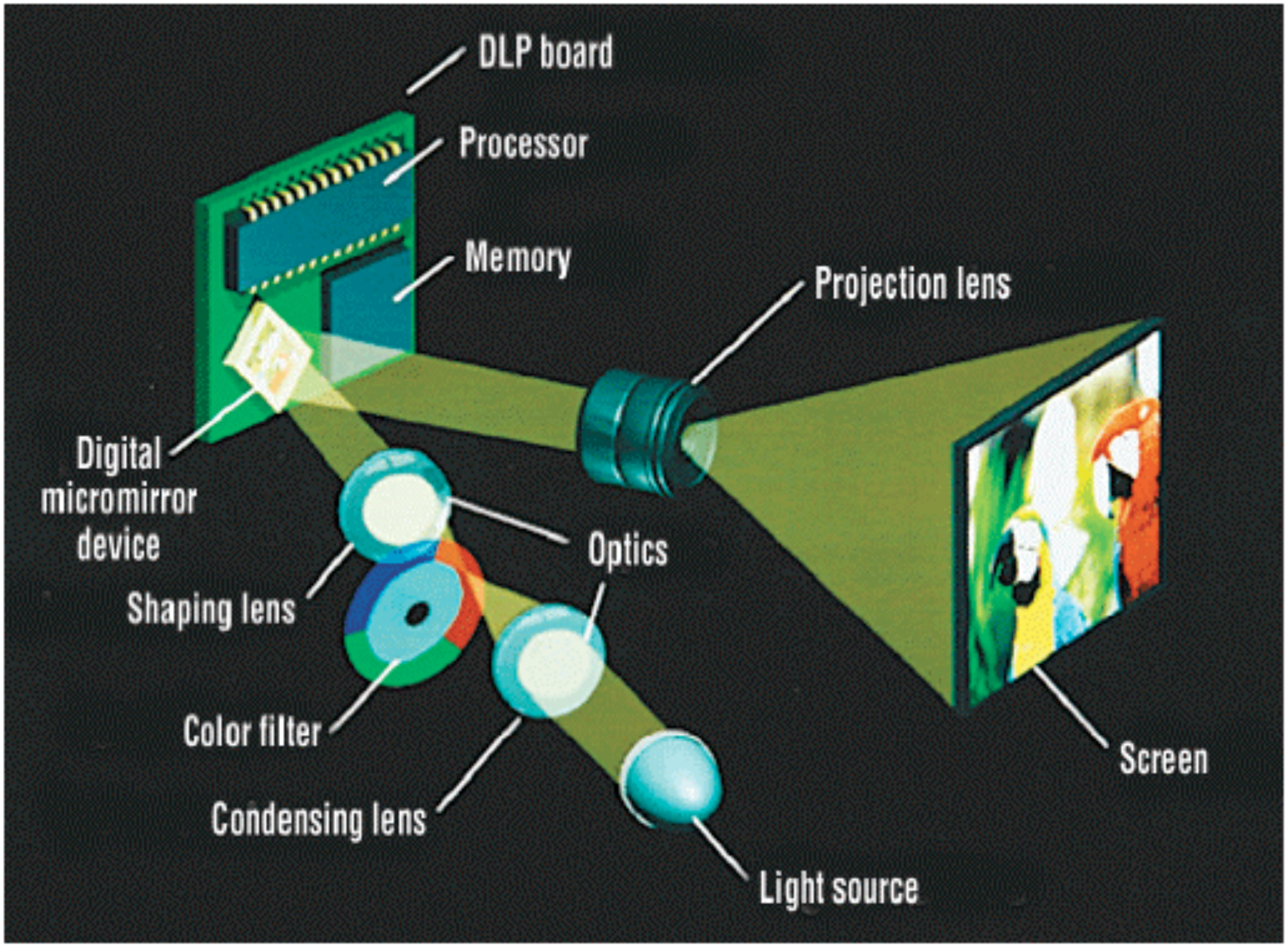
1020 nm

Position Dependence in Response



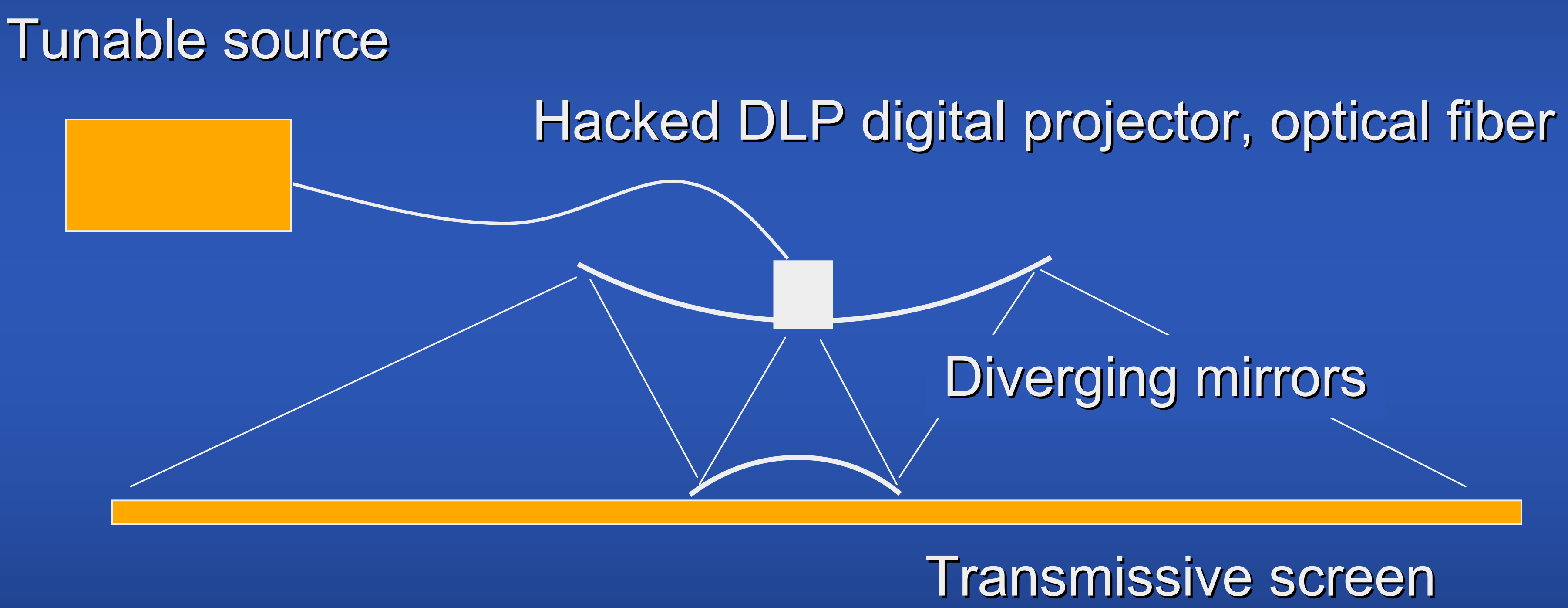
This approach requires

1. Photodiode monitor & circuit
2. Tunable light source with adequate intensity
3. Uniform radiance screen, to ~10%. An adjustable source of illumination across the screen would be nice!
4. Calibration pipeline that exploits these data.
5. Dark dome (or at least uniform illumination)



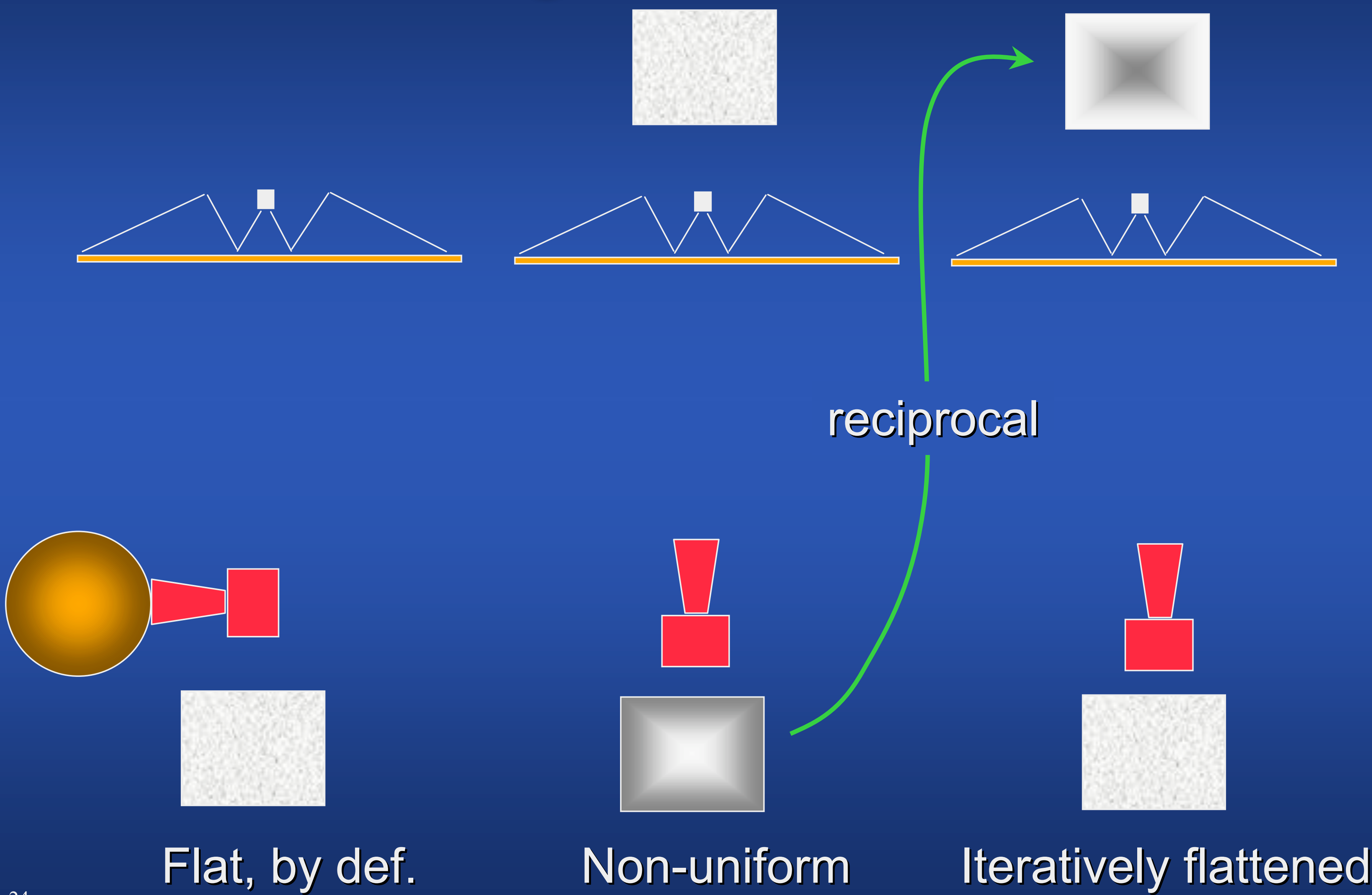
3. TI's digital light-processing engine is a reflective system comprising an array of tiny MEMS micromirrors. The mirrors allow light to be switched into or out of the optical path. A rotating color wheel, fed by a single- or three-chip light source, sequentially provides the red, green, and blue (and sometimes white) colors that are projected onto the screen. (Courtesy of Texas Instruments)

We are building a DLP-driven flatfield screen



We can currently generate a 2m dia spot in ~26 inches depth
I expect we can fill LSST screen uniformly with 2m depth

Transferring uniform radiance



Challenges

- We can add a collimator, to restrict angles of emission to the FOV of camera, but then uniformity measurement is difficult.
- Need optimized optical surfaces for reflectors to project decent spot in minimal standoff distance.
- Tunable light sources below 400nm are difficult.
- Don’t yet know requisite cadence of filter transmission measurements.
- Plan to ship v1.0 to PanSTARRS in May.

Selected References

- Stubbs & Tonry "*Toward 1% Photometry: End-to-End Calibration of Astronomical Telescopes and Detectors*" ApJ 646, 1436 (2006)
- Stubbs et al. "*Preliminary Results from Detector-Based Throughput Calibration of the CTIO Mosaic Imager and Blanco Telescope Using a Tunable Laser*" astro-ph/0609260 (2006)
- Stubbs et al, "*Toward More Precise Survey Photometry for PanSTARRS and LSST: Measuring Directly the Optical Transmission Spectrum of the Atmosphere*" PASP 119, 1163 (2007)
- Technical Memo on Screen Design Considerations. C. Stubbs Dev 2007.