



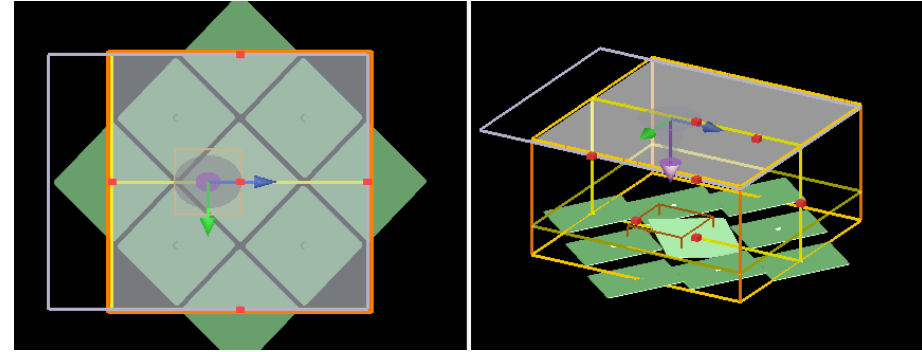
University
of Manitoba



Observatories



Digital micromirror device as a reconfigurable slit unit for UV multi-object spectroscopy



Charles Lee¹, John Piotrowski², Tyrone Woods¹, John Pazder³, Dmitry Vorobiev⁴,
Frédéric Zamkotsian⁵, Patrick Côté³

University of Manitoba¹, Carnegie Observatories², NRC Herzberg Astronomy & Astrophysics³, University of Colorado Boulder⁴, Laboratoire d'Astrophysique de Marseille⁵

NUVA e-Meeting 2026

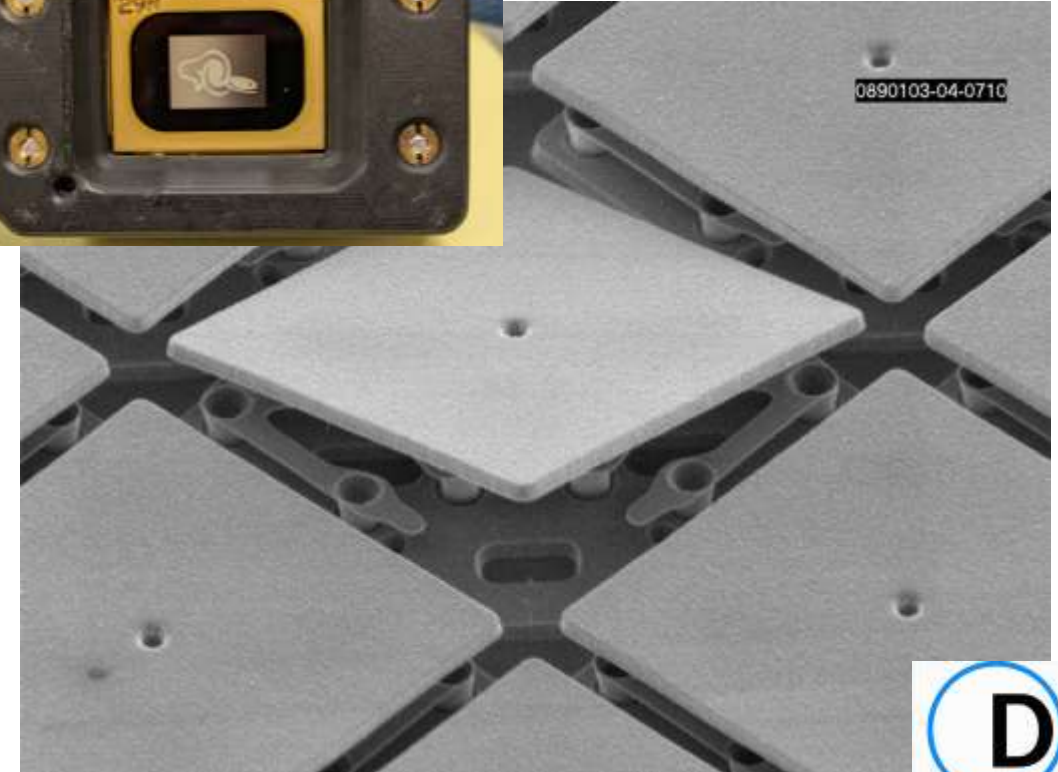
Oct 8th, 2026

Digital Micro-Mirror Devices (DMD)

- MOEMS device made by *Texas Instruments* consisting of tiny mirrors that tilt ± 12 deg
 - Can be used to digitally modulate light pixel-by-pixel
- Utilized in astronomy for *spatially resolved spectroscopy*
 - No flight heritage, but validated to NASA & ESA standards for space environments



DMD image credit: Heather Lenz



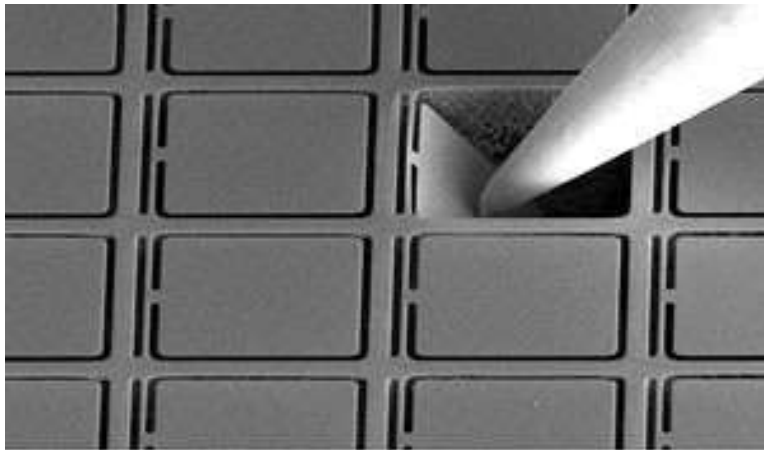
Credit: Larry Hornbeck



Spatial light modulators (SLM)

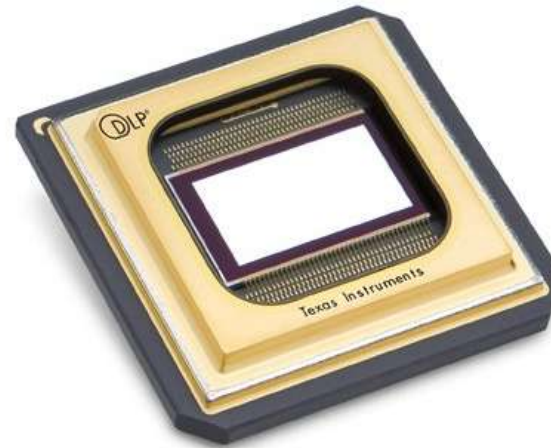
Optical devices that adjust the *intensity*, *phase*, and/or *polarization* across spatial dimensions

Micro-shutter arrays



Micro-shutter arrays (Credit: NASA)

Digital Micromirror Devices



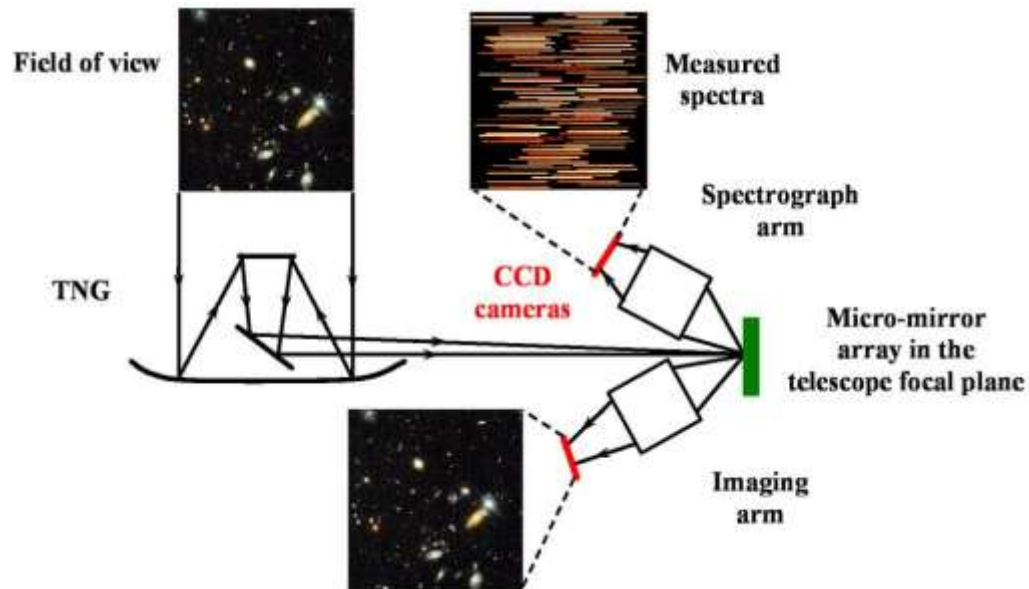
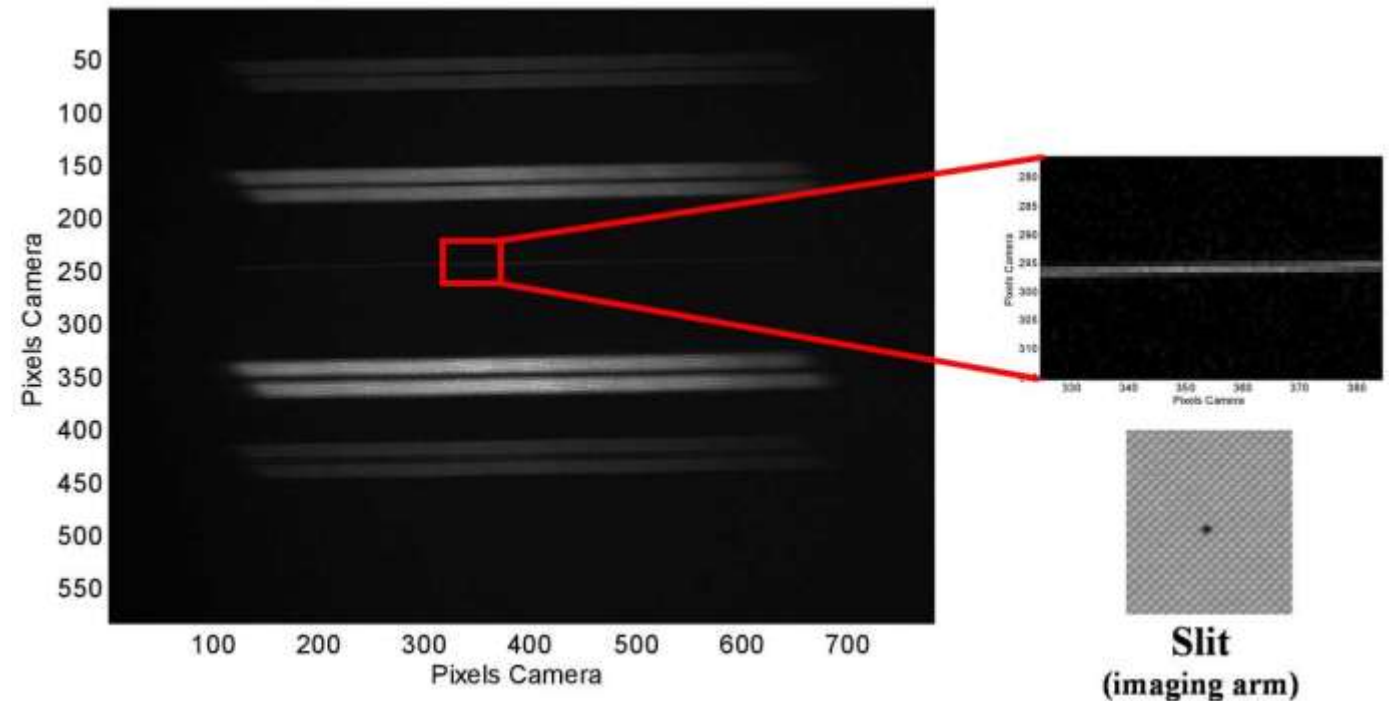
Credit: Texas Instruments

Liquid Crystal SLM



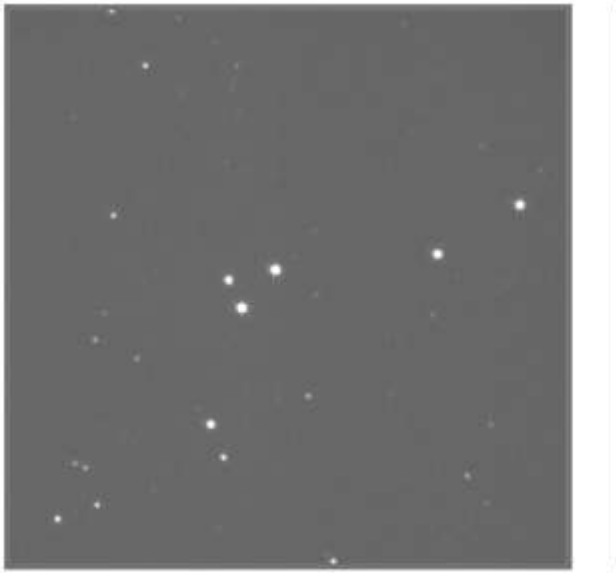
Credit: Holoeye

DMDs have been demonstrated for multi-object spectroscopy in astronomy



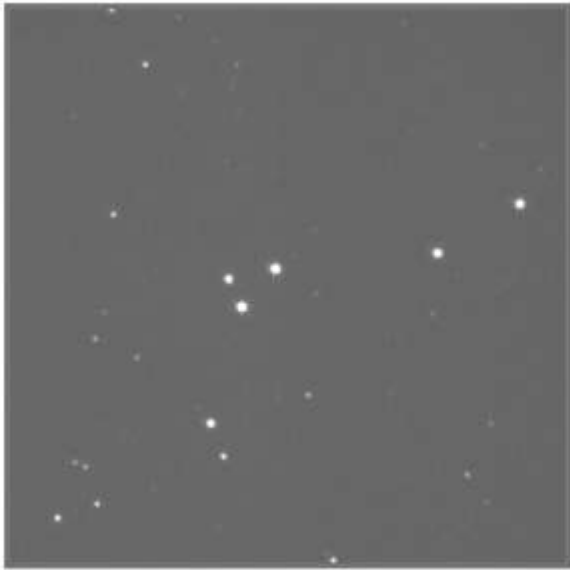
Zamkotsian, Frédéric. BATMAN: a DMD-based multi-object spectrograph on Galileo telescope (2014)

DMD Patterns as “Slits”

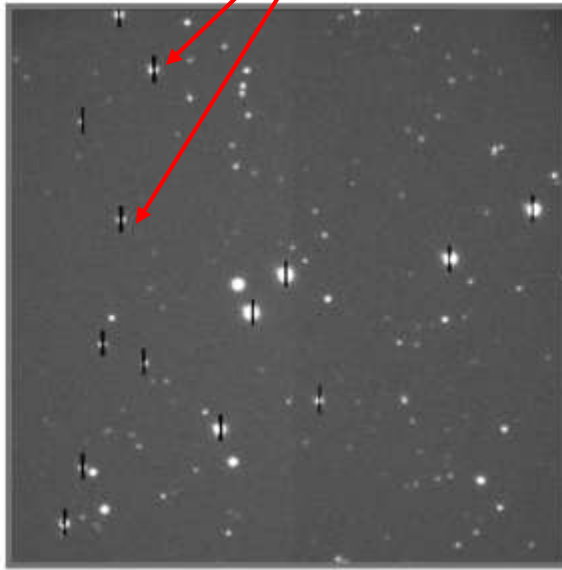


Target

DMD Patterns as “Slits”

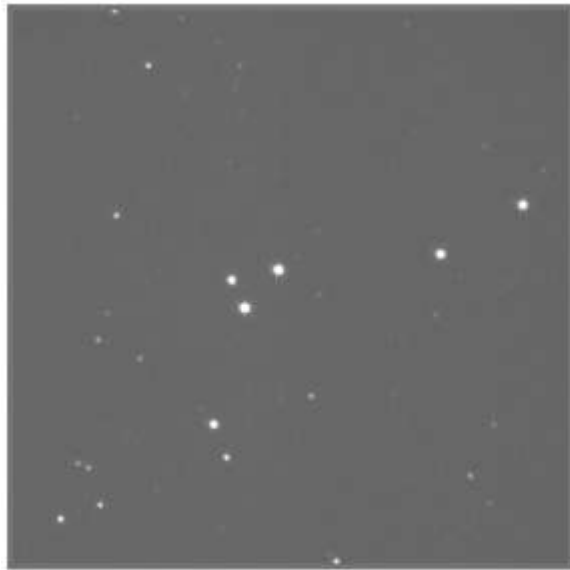


Target

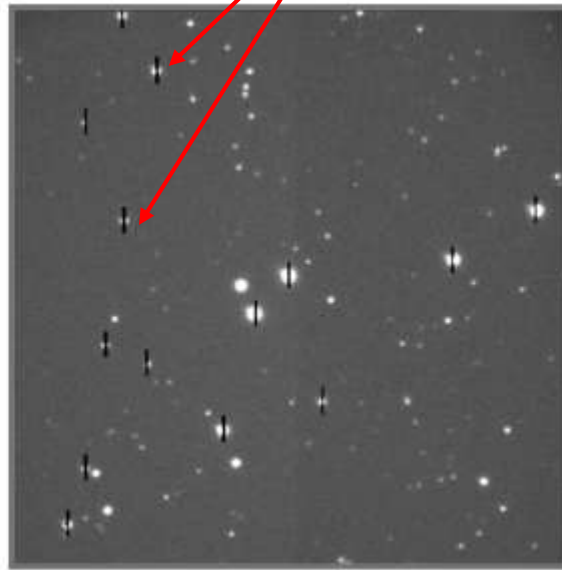


DMD “Slits”

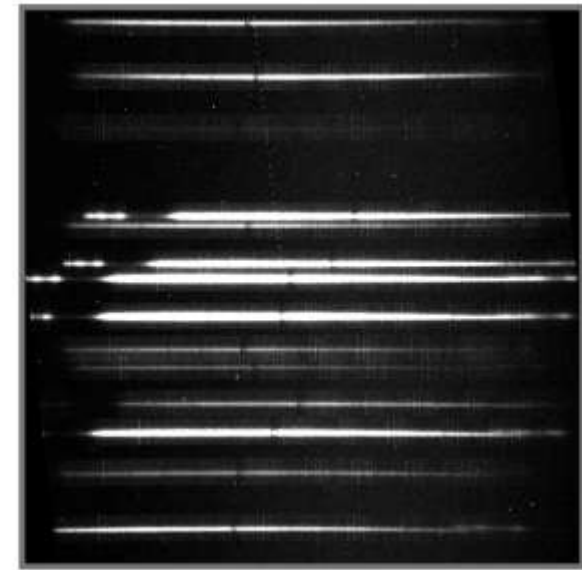
DMD Patterns as “Slits”



Target



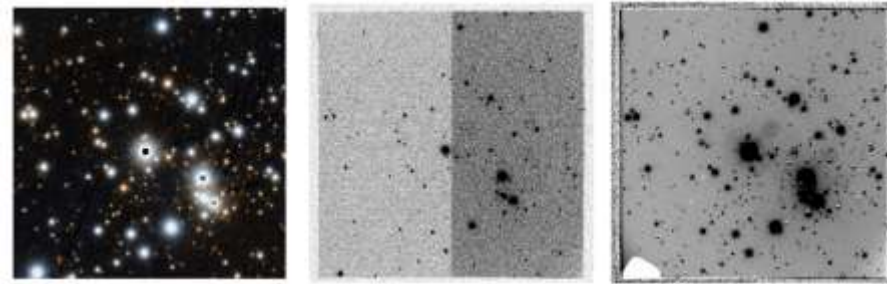
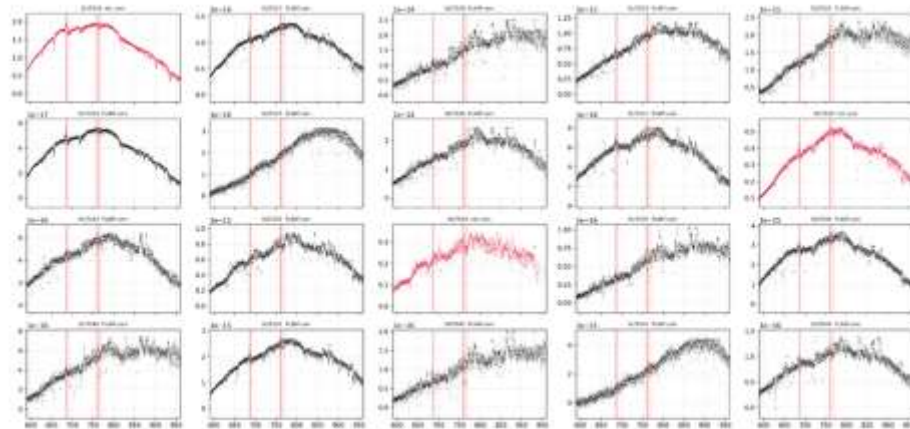
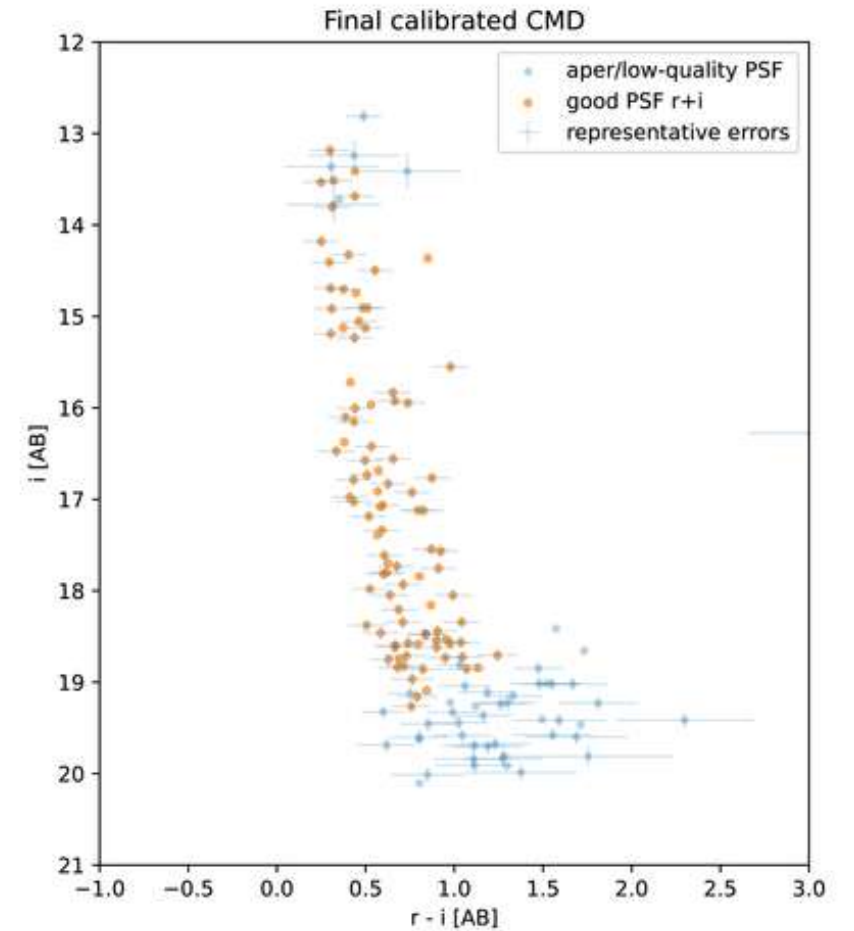
DMD “Slits”



**Resolved spectroscopic
output on sensor**



SAMOS on the 4.1m
SOAR telescope



Robberto M. et al. *Operational capabilities and on-sky performance of SAMOS at the completion of science commissioning*(2026)

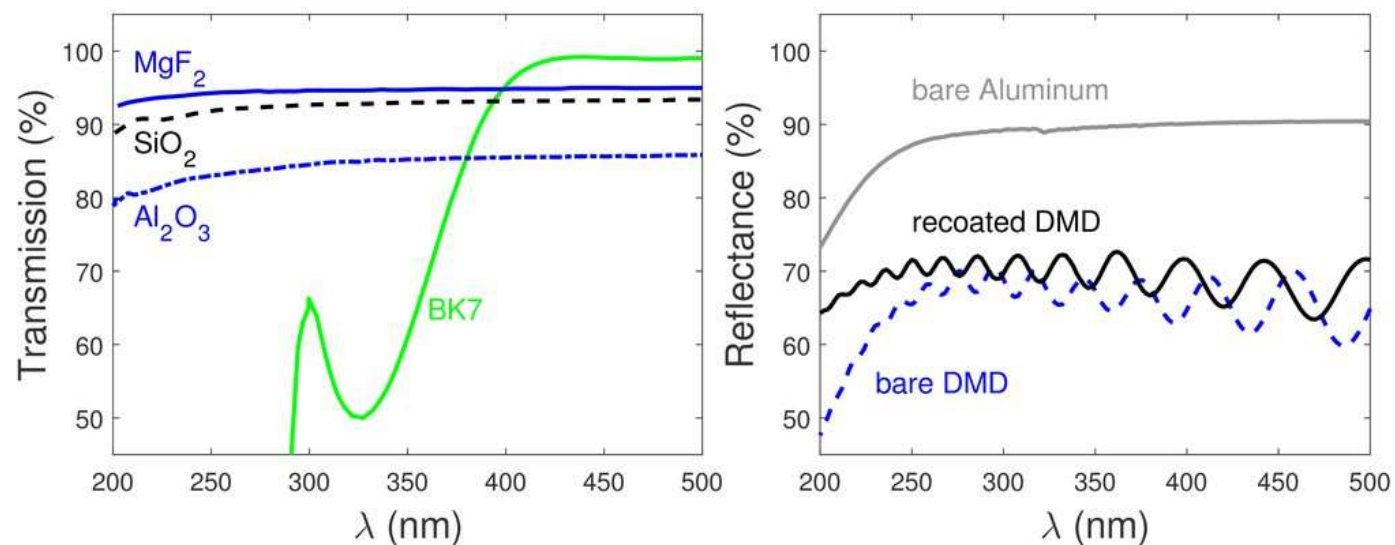
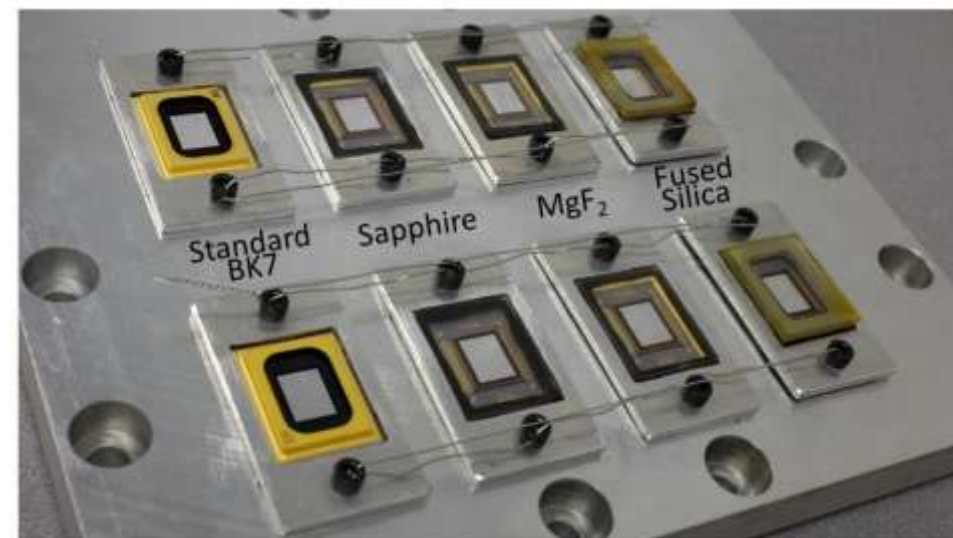
NRC Small Teams study

\$2M over 3 years develop the UVMOS concept to Technology Readiness Level 6 (TRL-6) with collaborators

- LASP (Colorado) – DMD re-window & coating
- LAM (France) – UV convex blazed grating
- VUVLab (Calgary) – component testing & vacuum UV facilities
- UofM (Manitoba) – software simulation for mission planning & design
- NRC (Victoria) – project management



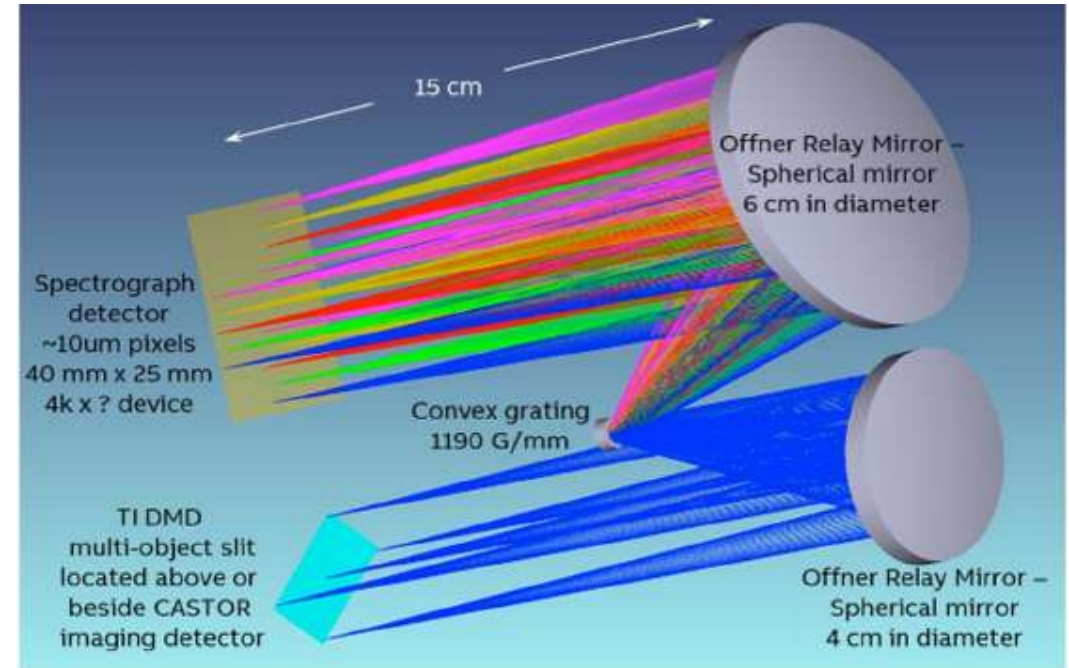
DMDs in ultraviolet?



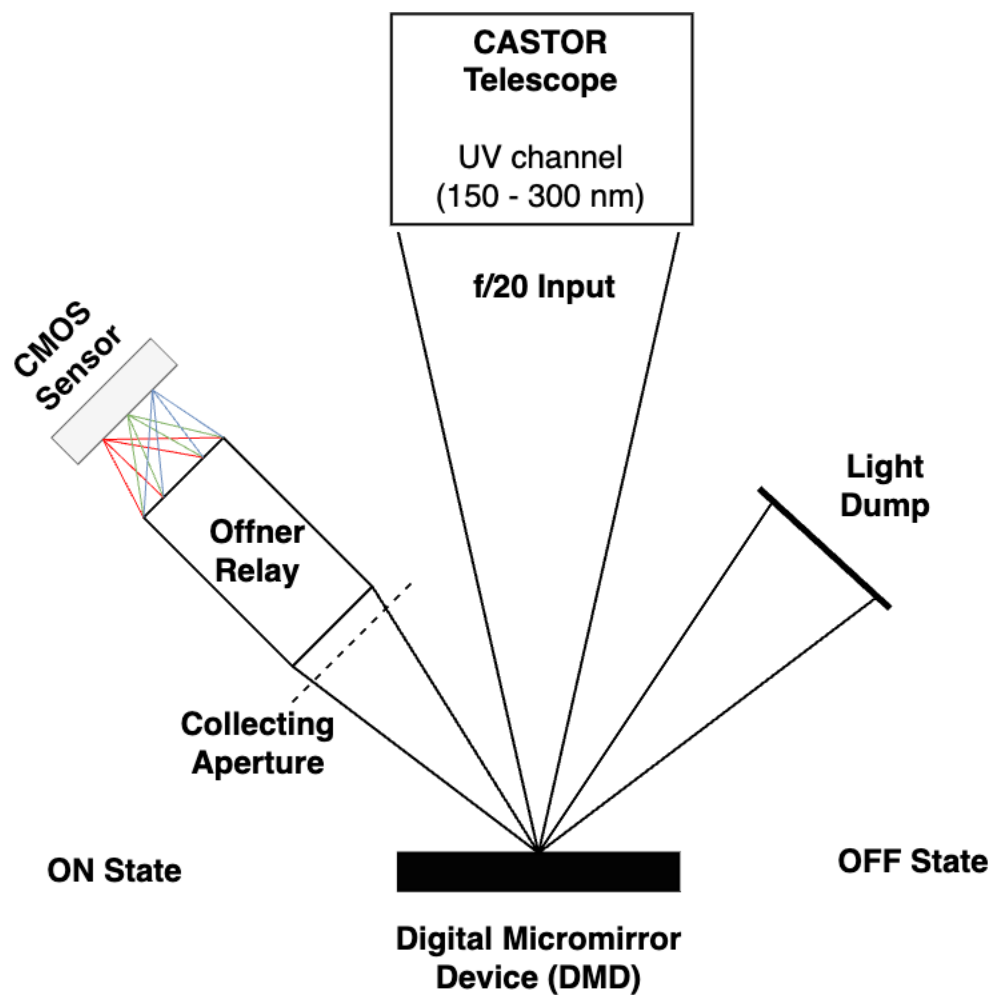
Vorobiev, D. *et al*/Far-UV multi-object spectroscopy with digital micromirror devices (DMDs) (2020)

UV Multi-Object Spectrograph (UVMOS)

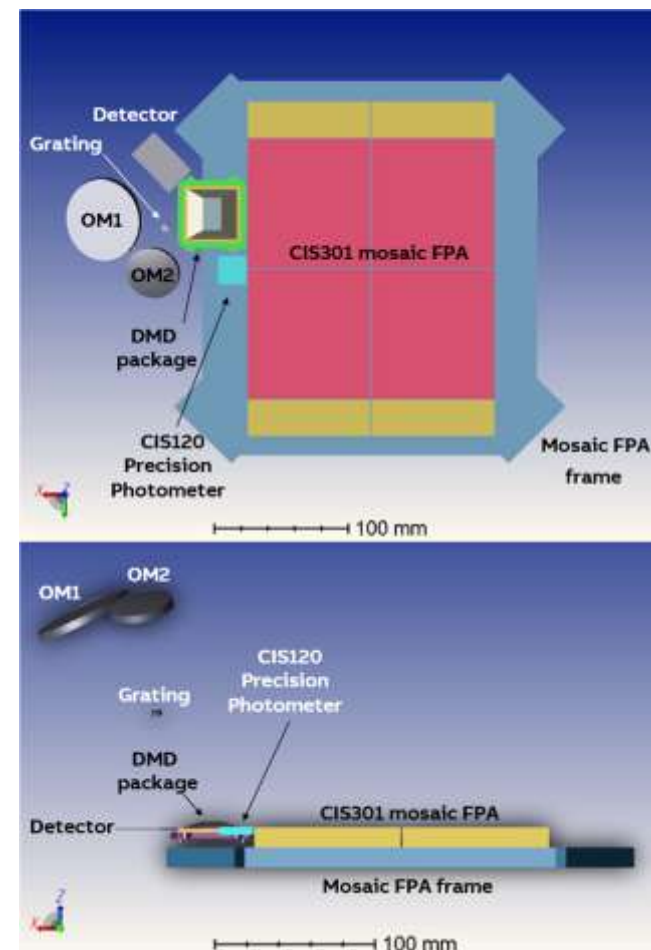
- **Low-medium resolution ($R \sim 2000$) multi-object spectrograph in the UV (150 to 300 nm)**
 - Modified Offner-relay design based on BATMAN
 - UV-optimized CMOS detector from Teledyne (CIS300 series)



UVMOS Operating Principle



Optomechanical Design



UManitoba research into DMDs

- Develop a simulation model for the DMD in the ultraviolet (150-300 nm)
 - Study diffractive & scatter mechanisms and their effects on instrument efficiency & stray light
 - Inform our design of the instrument demonstrator
 - Devise a model for our exposure time calculator

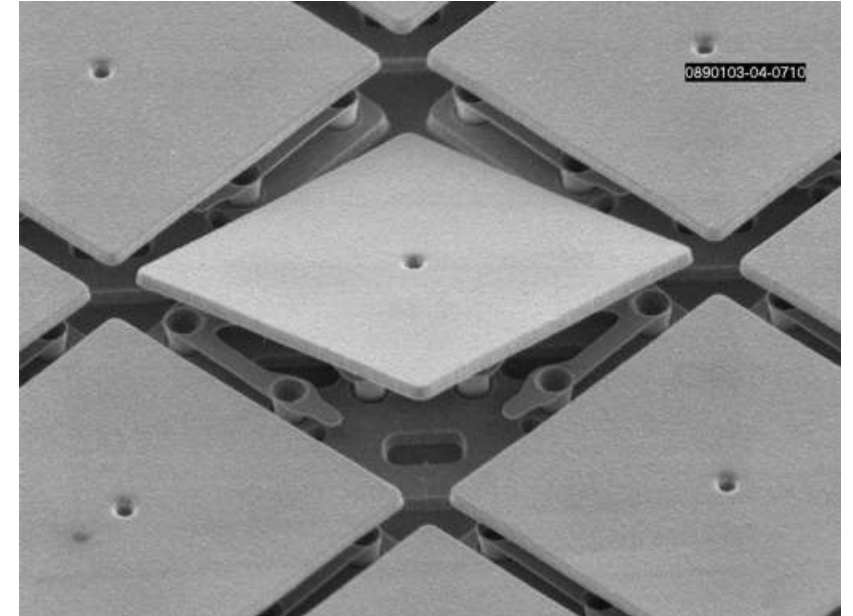
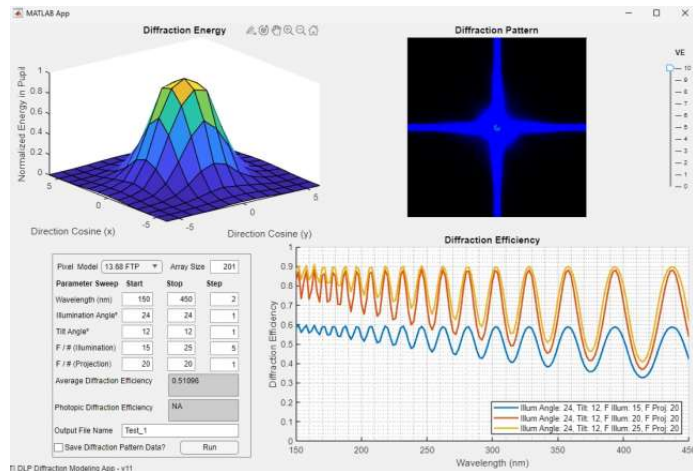


Image by Larry Hornbeck

DMD simulation methods

- Simplest method: estimate as 1D diffraction grating
- Numerical Methods:

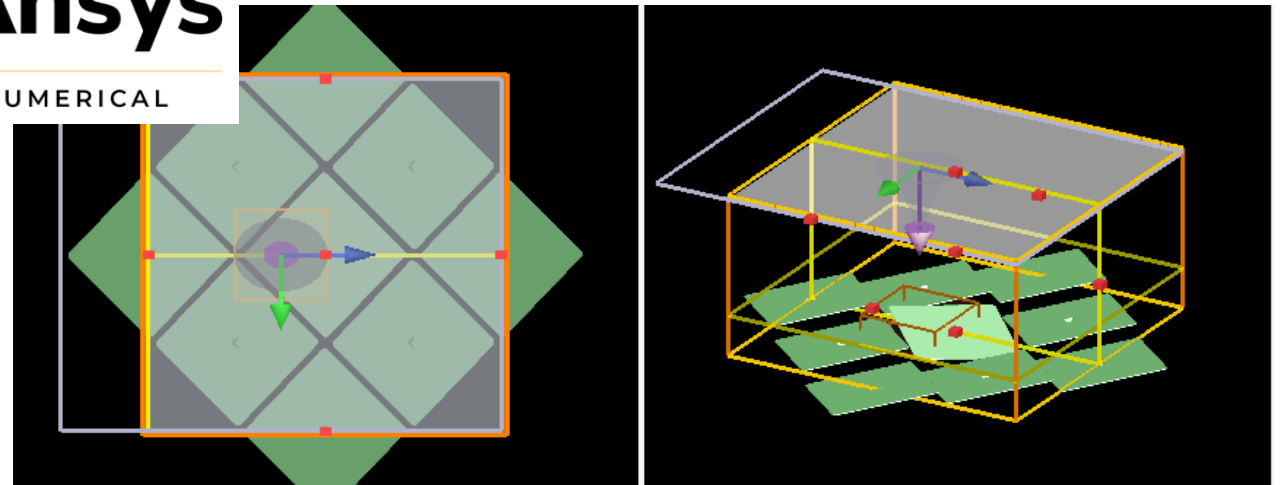
Texas Instruments Efficiency calculator uses a non-paraxial diffraction



Wave optics simulation using Finite Difference Time Domain (FDTD) methods

Ansys

LUMERICAL



DMD induces wavelength-dependent diffraction losses

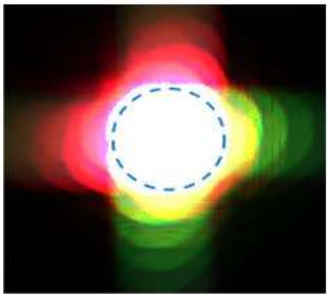


Figure 4-4. Mirror On State Diffraction Pattern Model with Mirror ($\theta = 12^\circ$, $\Phi = -45^\circ$), Illumination ($\theta = 24^\circ$, $\Phi = -45^\circ$)

Source: Texas Instruments

13.6 μm

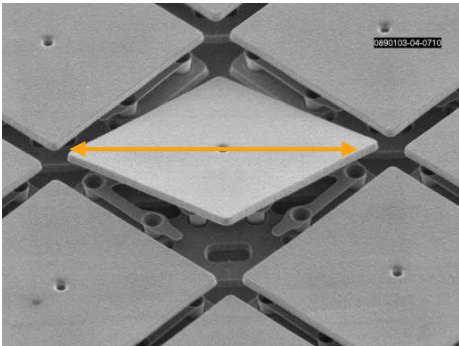
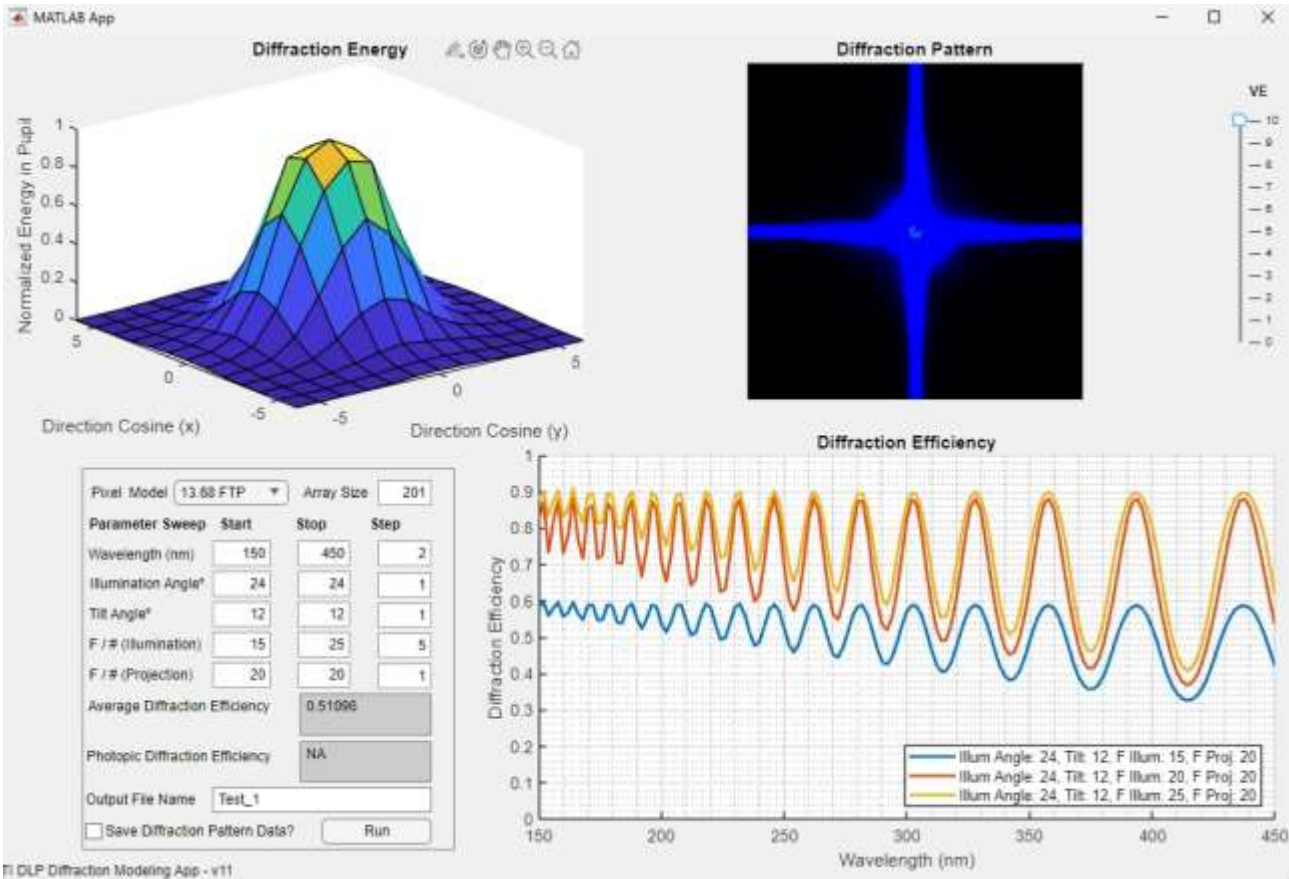
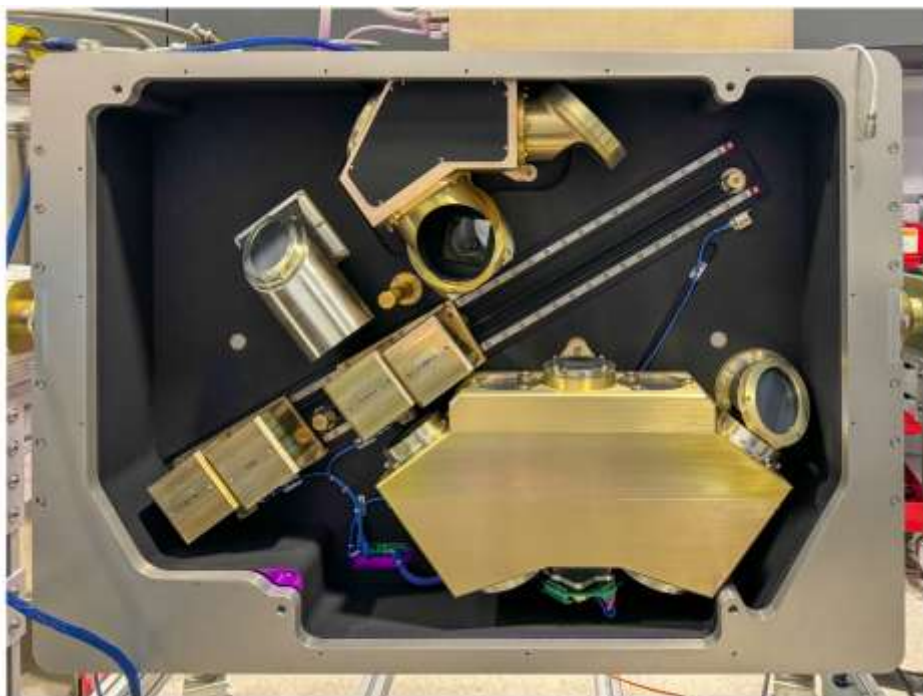


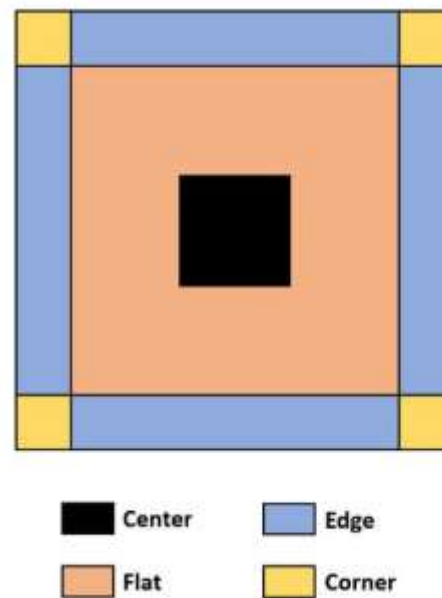
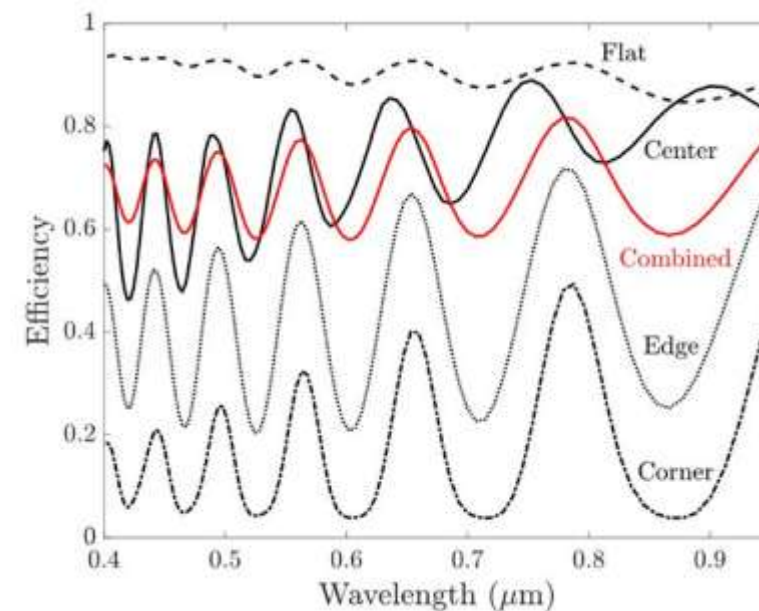
Image by Larry Hornbeck



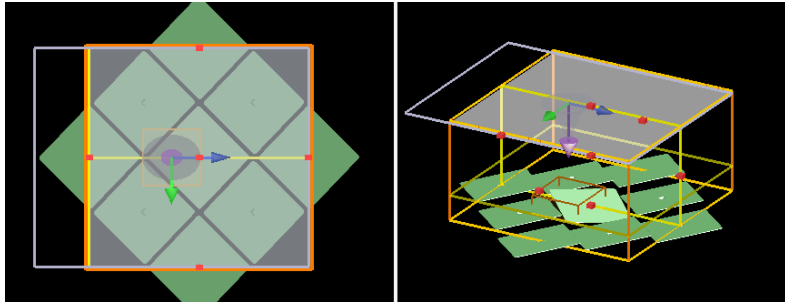
Simulation for SAMOS



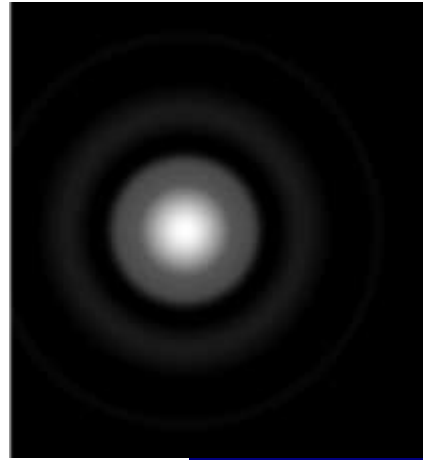
SAMOS, as built
Taken from Robberto, M. et al. SPIE 141490D (2026)



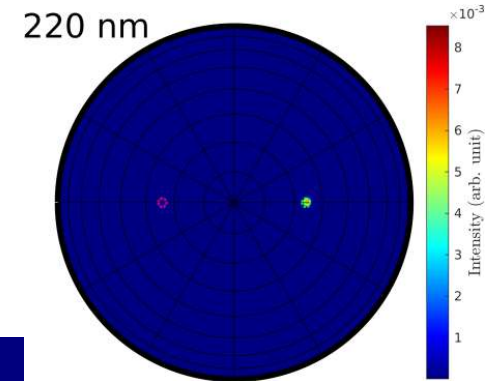
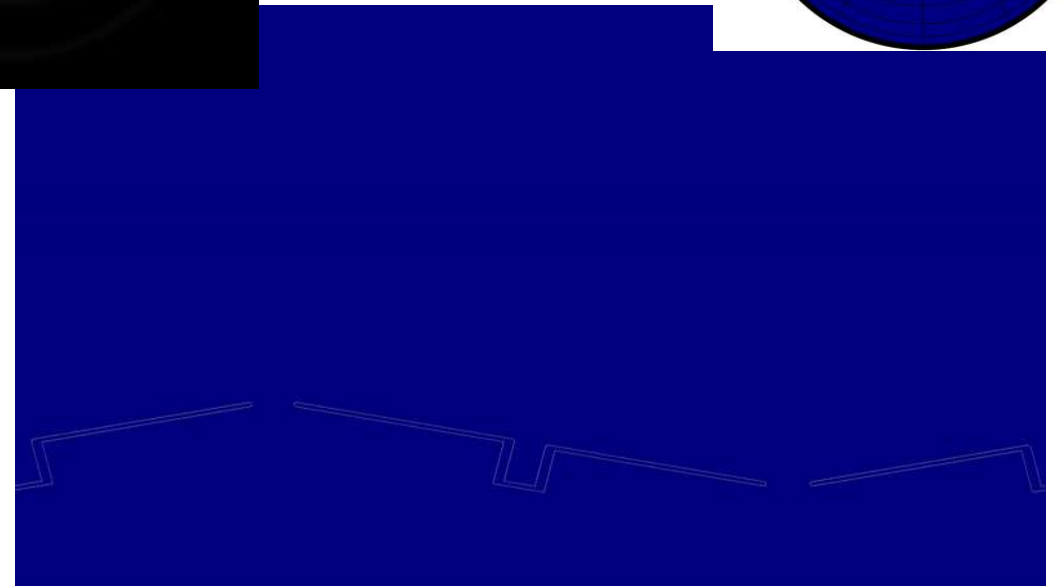
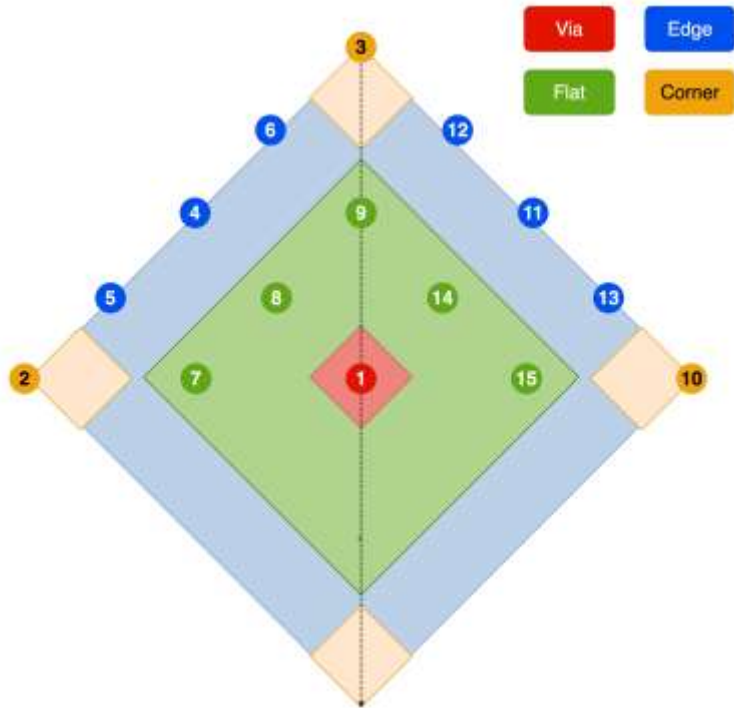
Piotrowski, J. *Optical simulation of device efficiency and contrast ratio for a digital micromirror device* (2023)



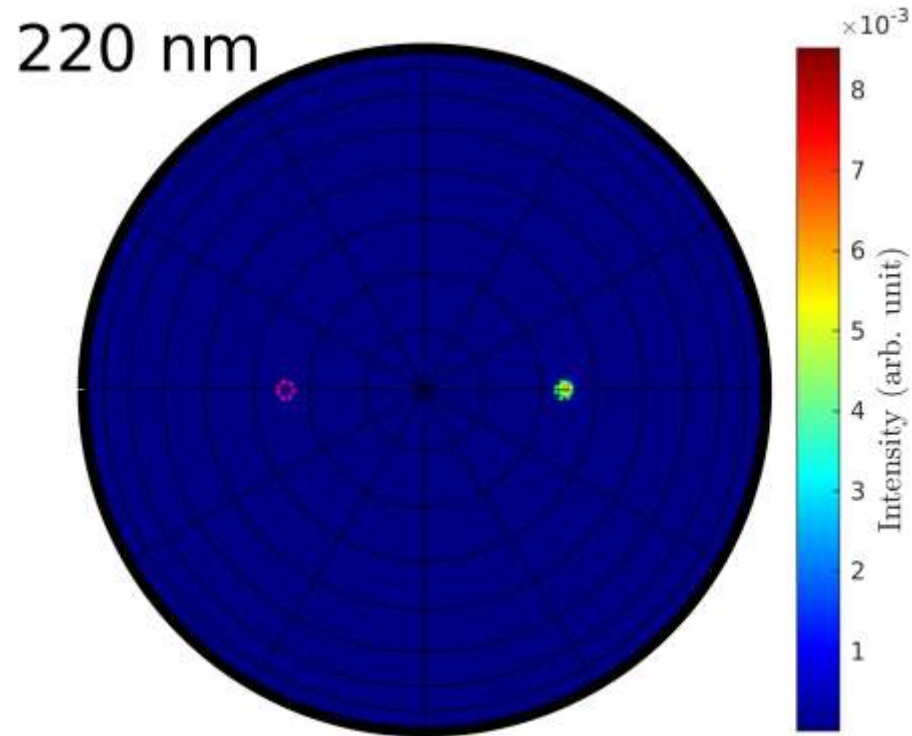
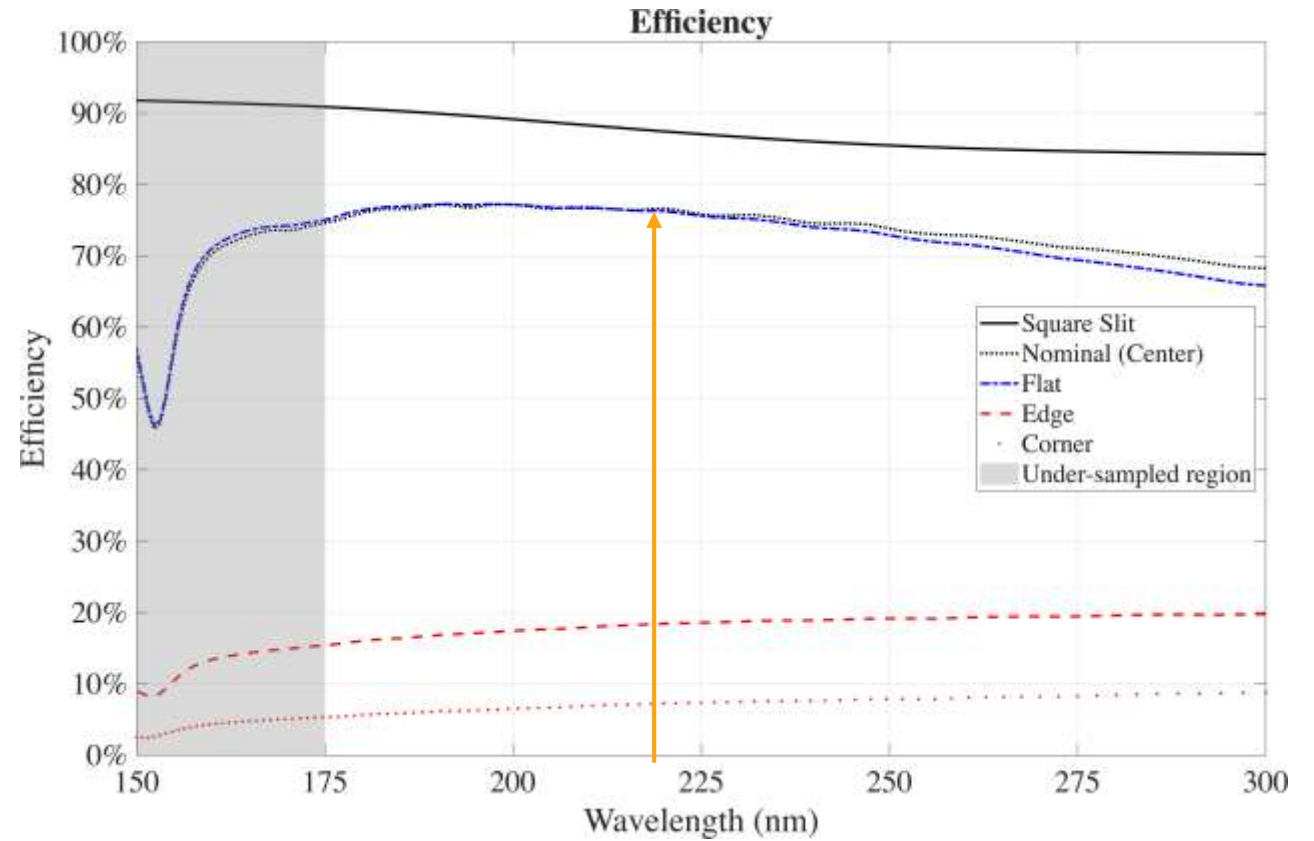
Diffraction-limited input beam

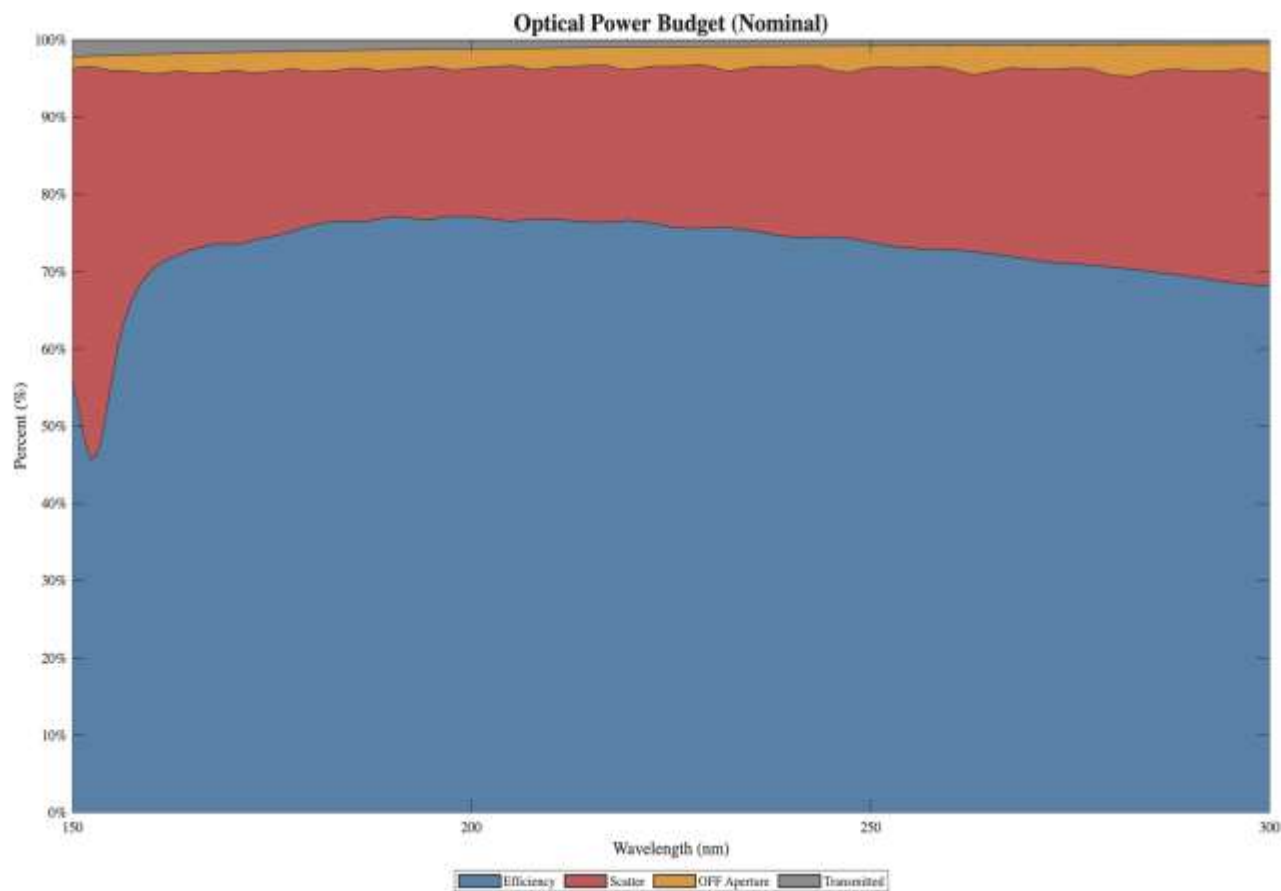


Far-field result

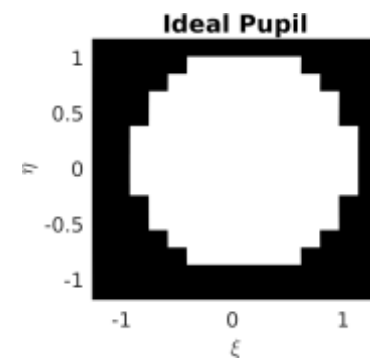
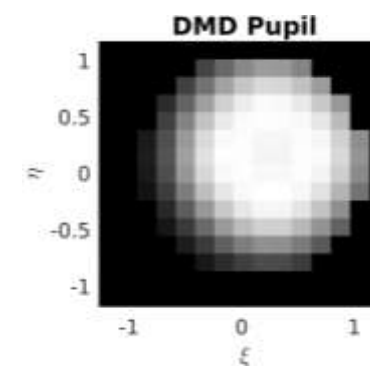


Simulation for UVMOS





Pupil transmission (@ 220 nm)

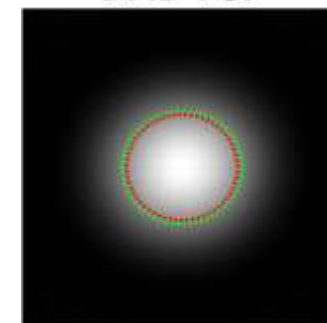
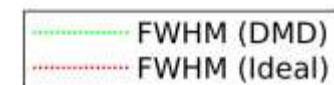


PSF (@ 220 nm)

Ideal PSF

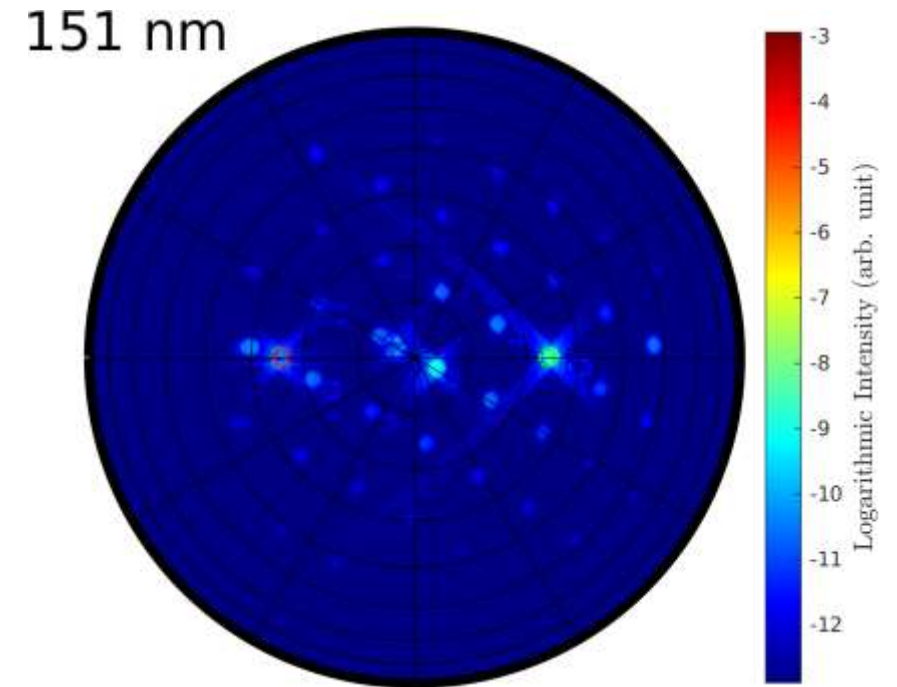


DMD PSF



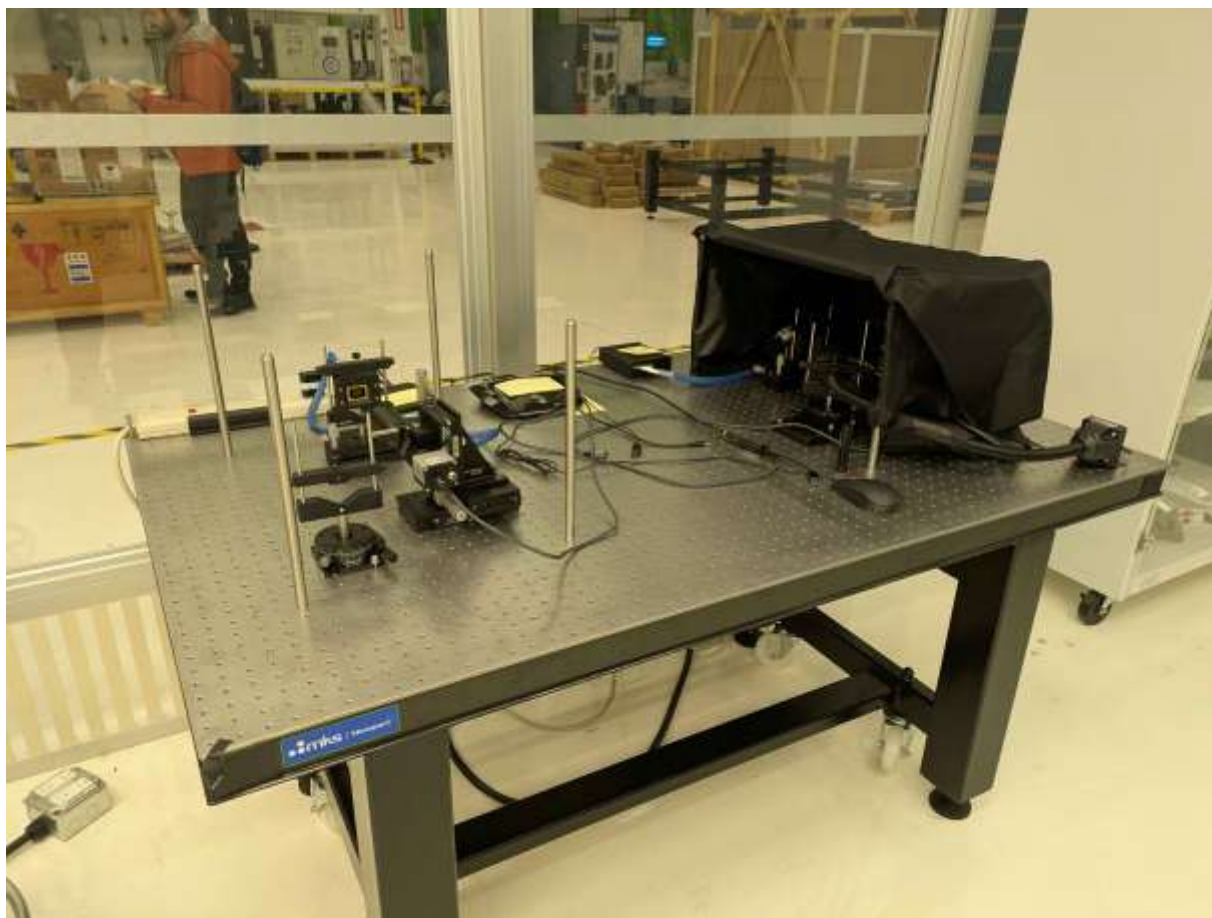
Future work

- Current simulations are not spatially sampled enough
- Analyze sensitivity of the model to variations in physical parameters
- Define impacts on optical design parameters for **UVMOS demonstrator (expected 2028)**

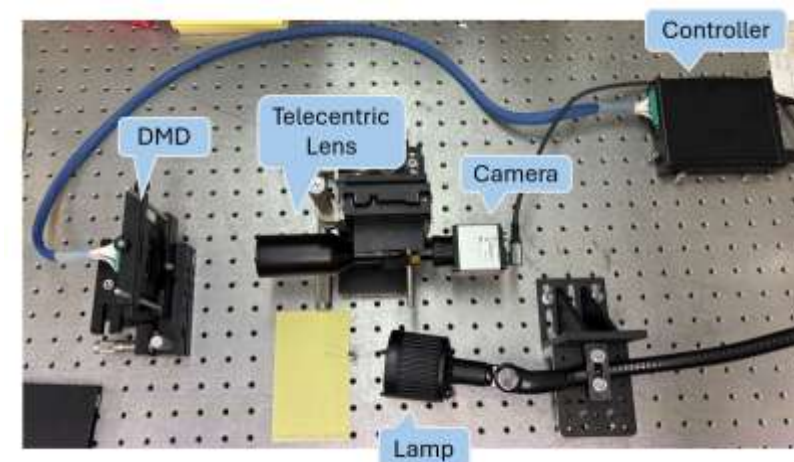
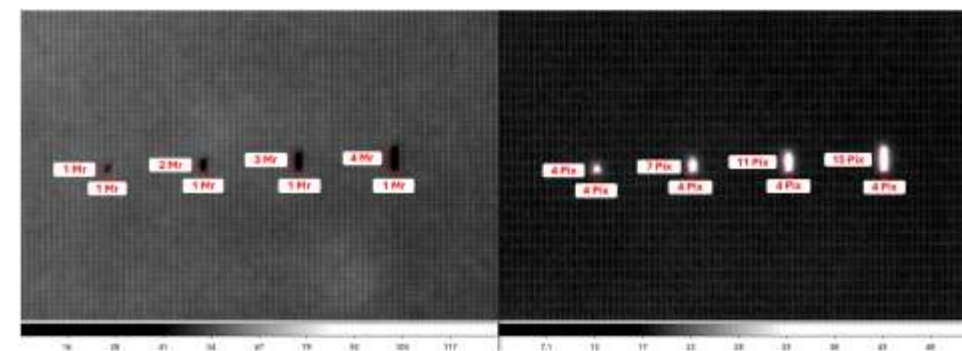


Staircasing at lower wavelengths

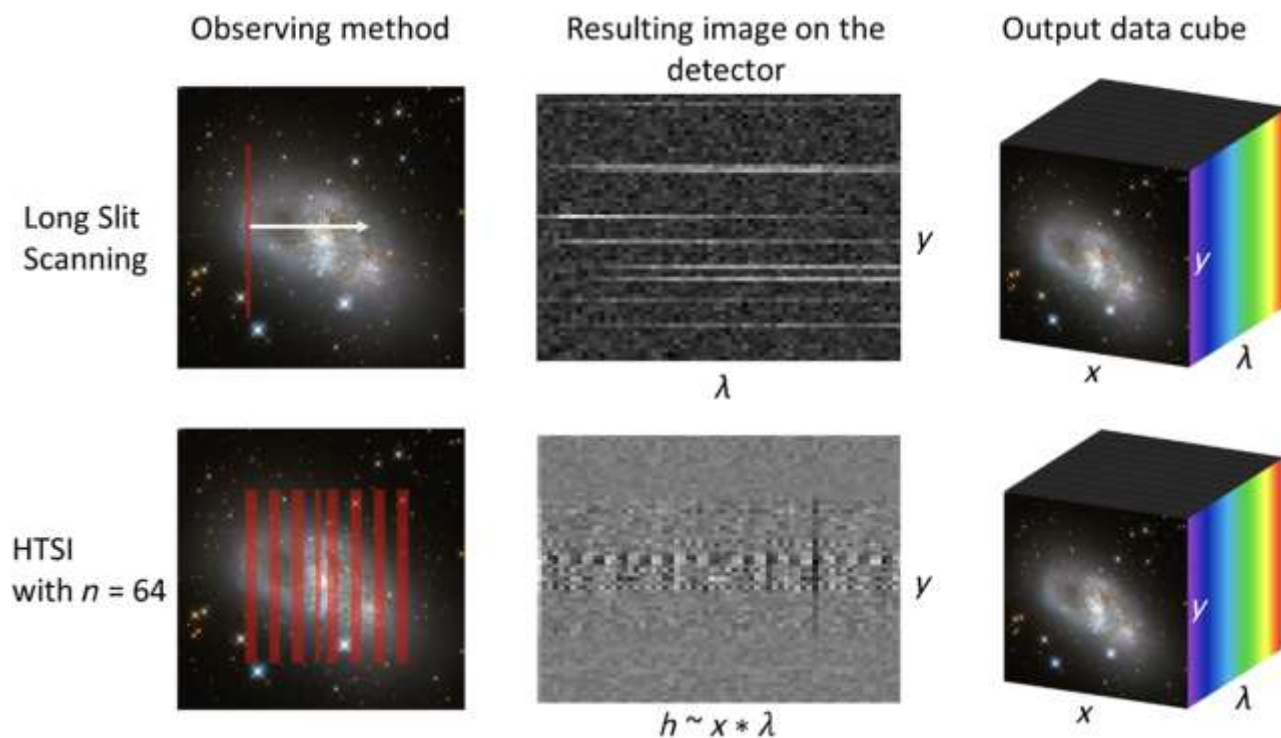
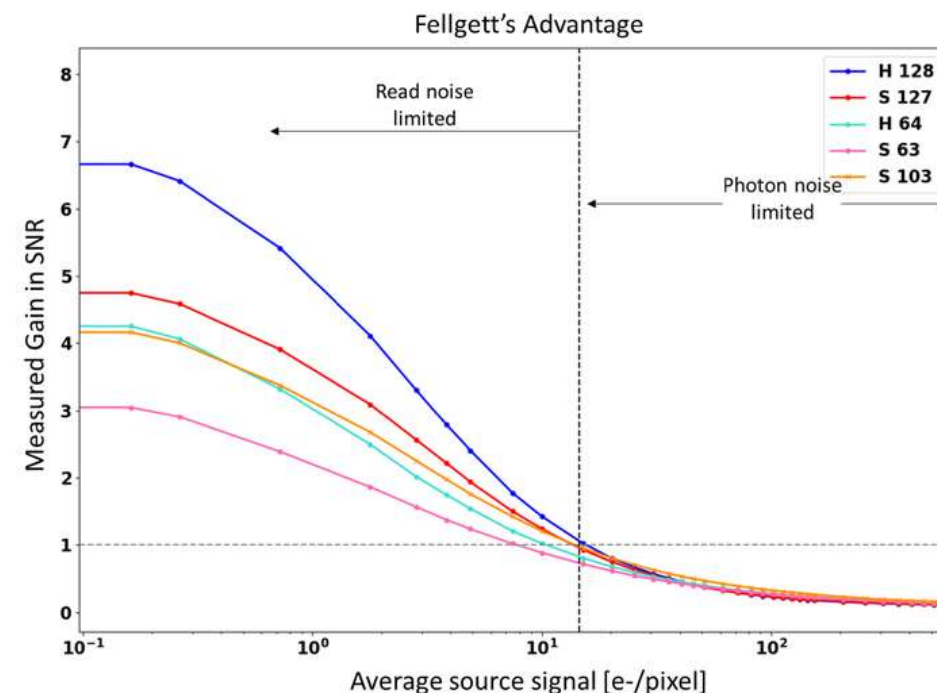
Lifetime testing



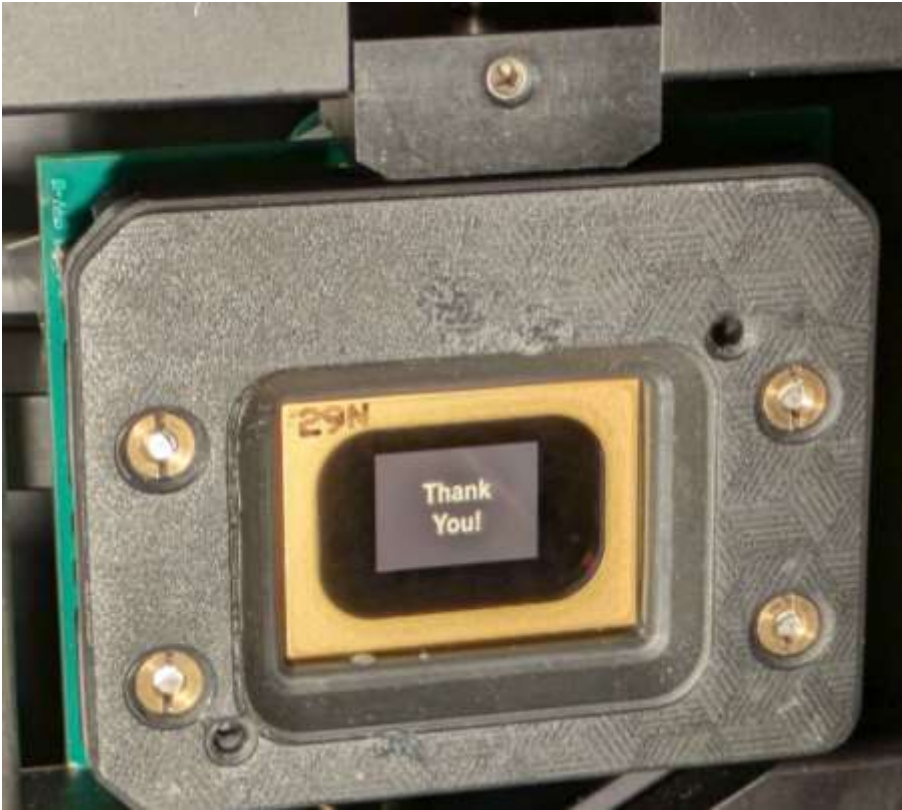
Credit: Heather Lenz & Trianna Cornejo Gonzalez



Potential IFU-like modes?



Oram, K. et al. *Modeling the performance of the Hadamard transform spectral imaging technique with SAMOS: a ground-based MEMS spectrograph* (2022)



This work is supported by the National Research Council of Canada's Small Teams Program



Credit: Heather Lenz & Trianna Cornejo Gonzalez