PreCam workshop

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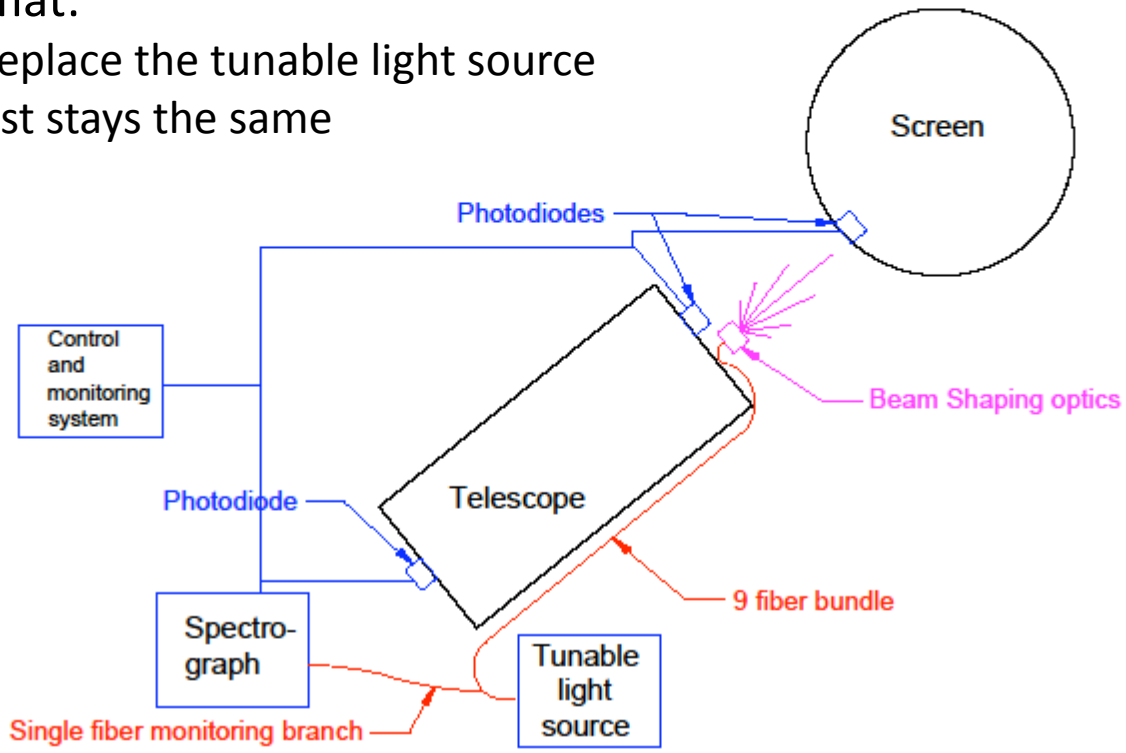
Update on the DECam Flatfield Calibration

Jean-Philippe Rheault, Texas A&M University

Schematic of the Calibration setup

- Spectrophotometric calibration:
  - Tunable light source provides narrow wavelength light
  - Fiber bundle delivers light to the top of the telescope
  - Beam shaping optics illuminate the screen uniformly
  - Screen reflects light back at telescope
  - Photodiodes and a spectrograph monitor the output power and wavelength
- For Daily flat:
  - LEDs replace the tunable light source
  - The rest stays the same

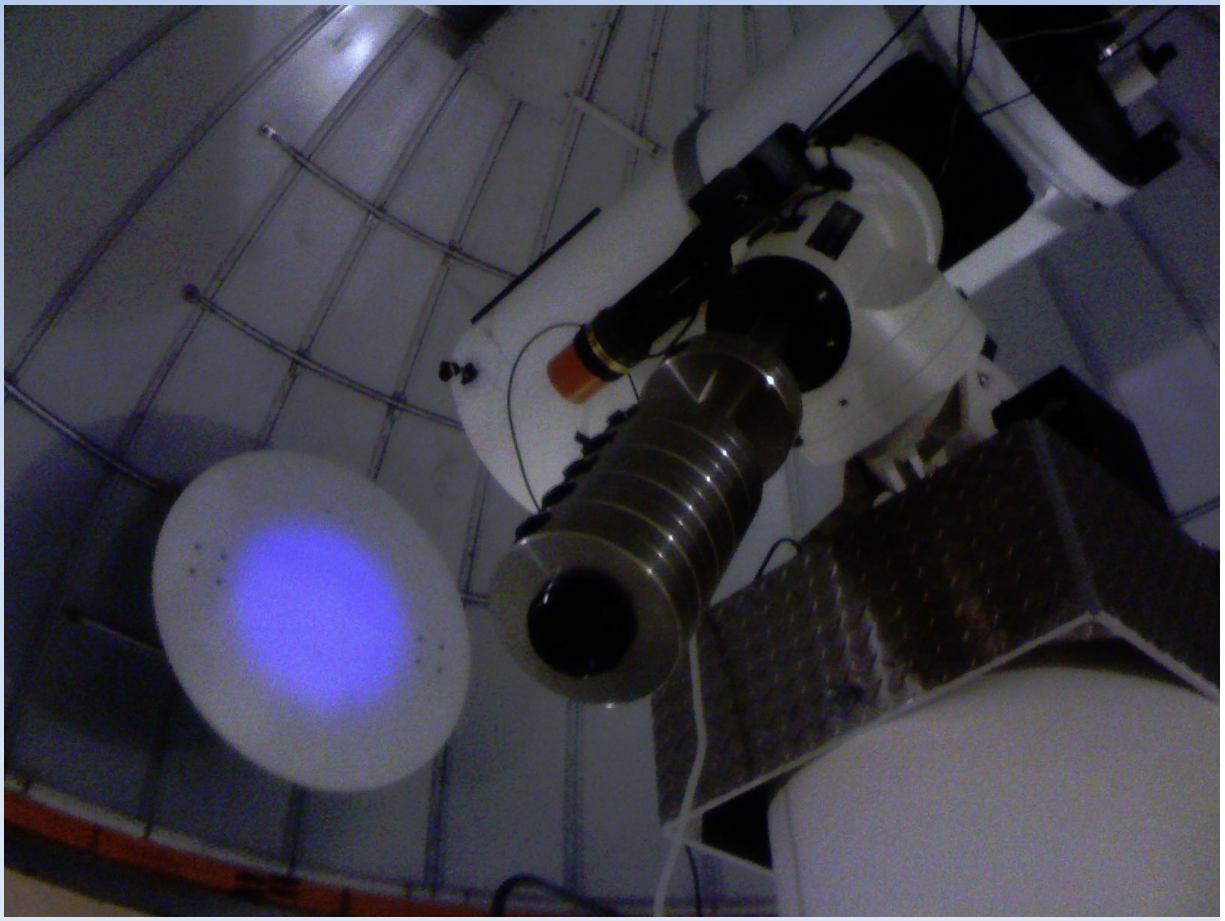


Requirements

- Dome flat
  - Calibration in u, g, r, i, z and Y (330-1100nm)
  - Homogeneous illumination of focal plane
    - Approx 1% uniform illumination
  - Sufficiently bright to keep integration time short and allow daytime flats
  - Stable light power output (minimal drift with time or from night to night)
- Spectrophotometric calibration
  - Tunable across g, r, i, z and Y (385-1100nm)
    - Goal 330 nm (u)
  - Stable and rugged, need to work reliably with limited maintenance
  - Narrow bandwidth (2-3 nm or less) to be able to probe filter edges.
  - Spectral Power greater than 1 mW/nm to keep integrating times reasonable (Scan all 5 DES filters in less than 4 hours)

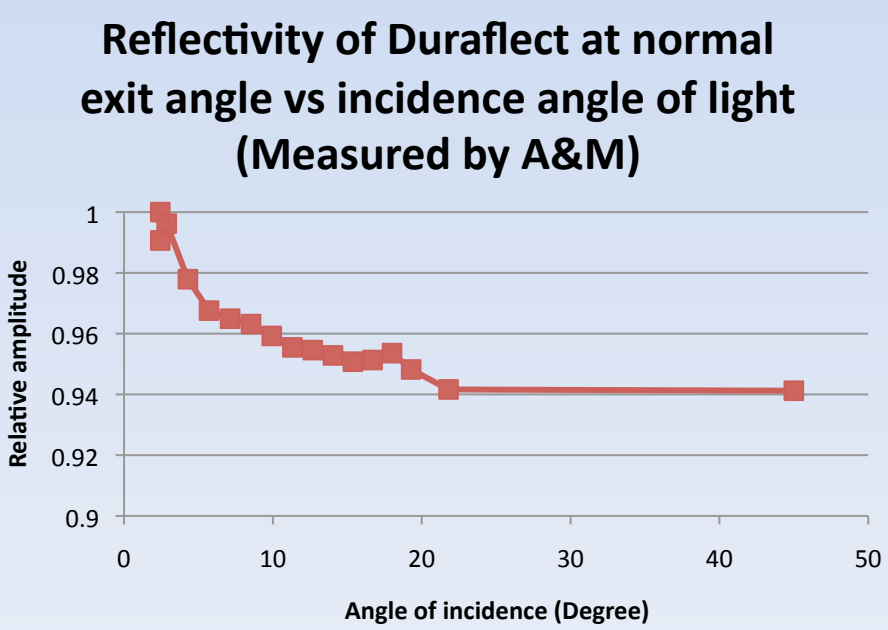
Prototype at TAMU 0.5 m Telescope

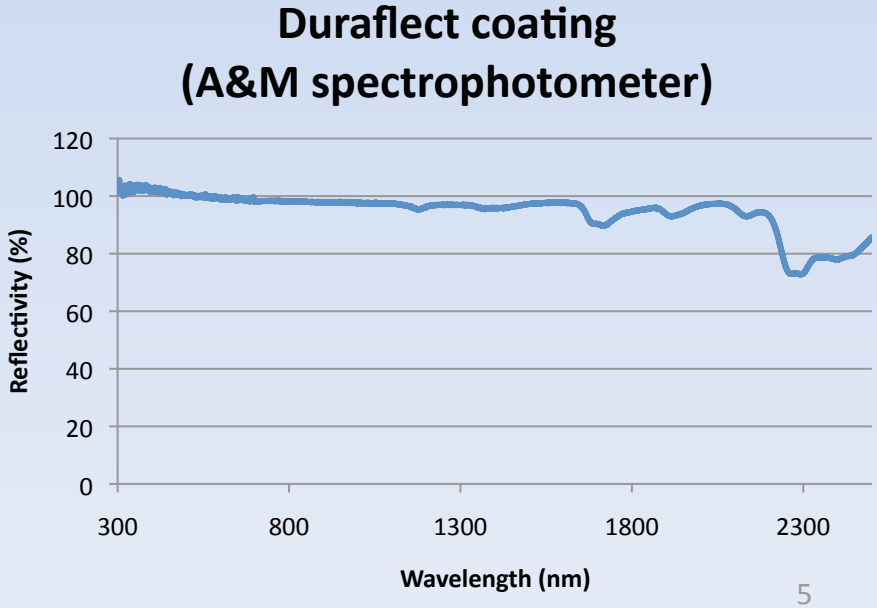
- We installed a prototype of the illumination system at the A&M 0.5m situated on campus.
- Prototype will be used frequently in the future for design verification



Screen

- The screen will be a lightweight honeycomb structure aluminum panel manufactured by Labsphere
- It will be coated with Labsphere's Duraflect coating.
  - It has excellent reflectivity over whole range
  - It is almost a perfect Lambertian diffuser. i.e. The angular dependence on the reflectivity is only ~ 5% for incidence angles up to 45 degrees
  - It is a very durable coating, designed to be used outdoors and even underwater
- We tested the impact of screw heads and seams using a segmented screen and found no measurable impact on the flatfield uniformity.
  - We plan to build the screen with 1-2 meters rectangular segments, coat the screw heads with the duraflect coating.

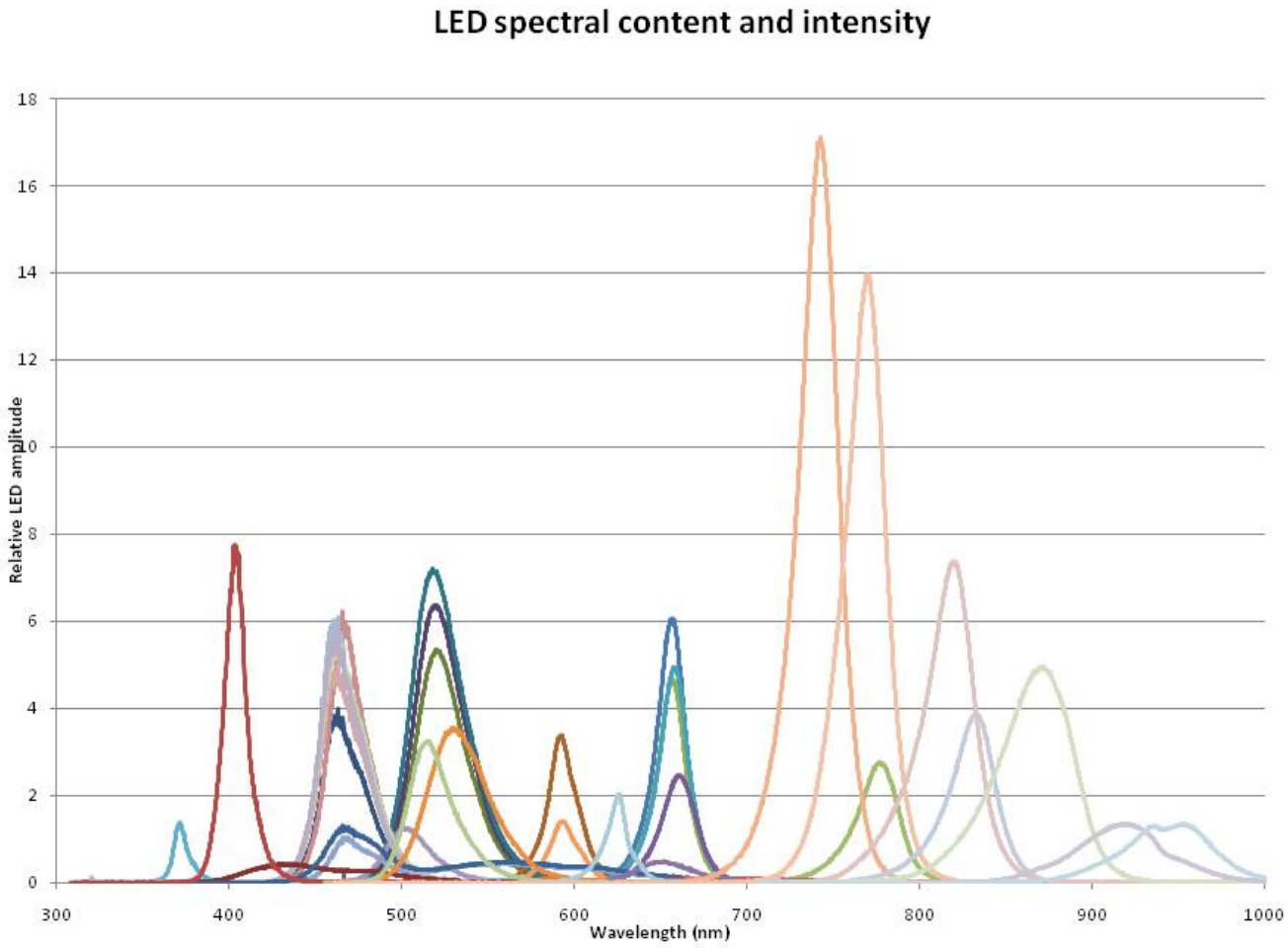




Light source for daily flats: LEDs

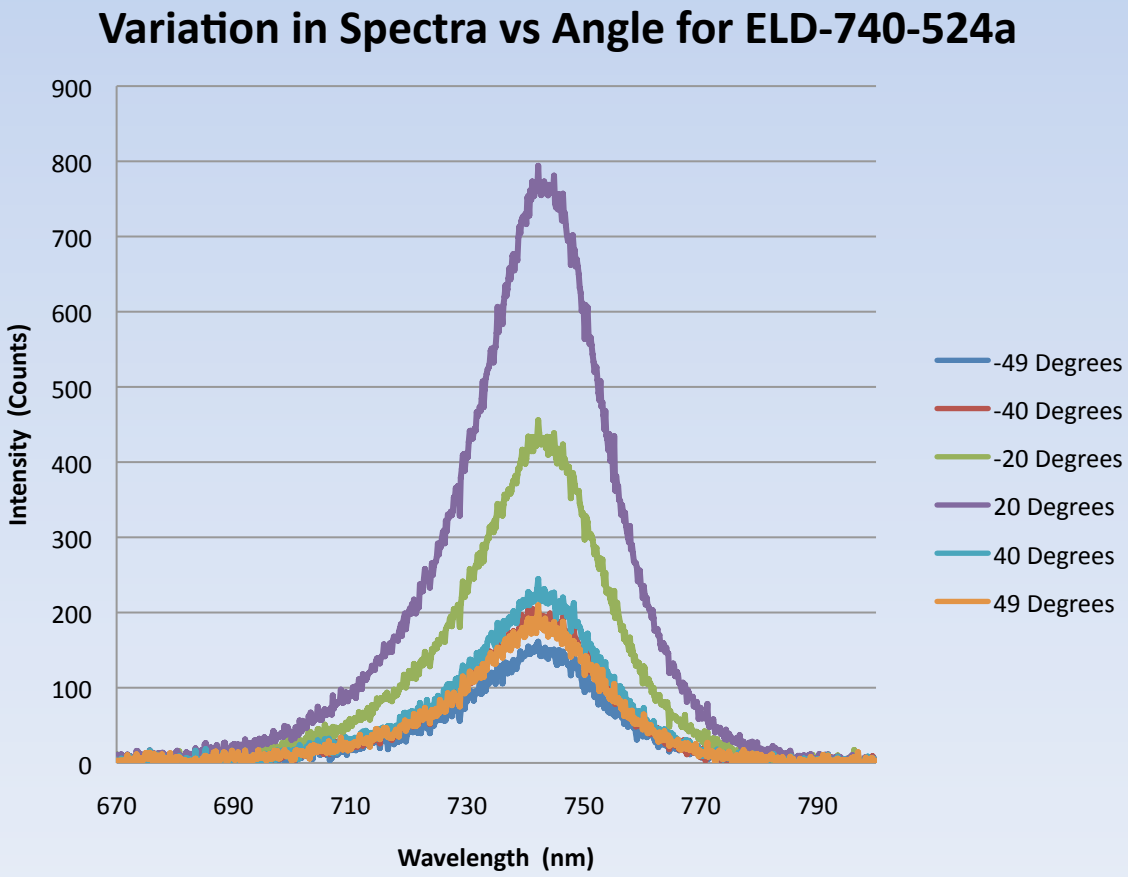
- LED characterization
  - No dependence on driving method (DC vs PWM)
    - We will use DC drivers for simplicity
  - There is up to a 10% variability in the power efficiency between identical LEDs.
  - Up to 4nm shift in central wavelength output between identical LEDs
  - Conclusion: We need to test batches of LEDs to match their output if we are going to use several at the same time.

LED wavelength output



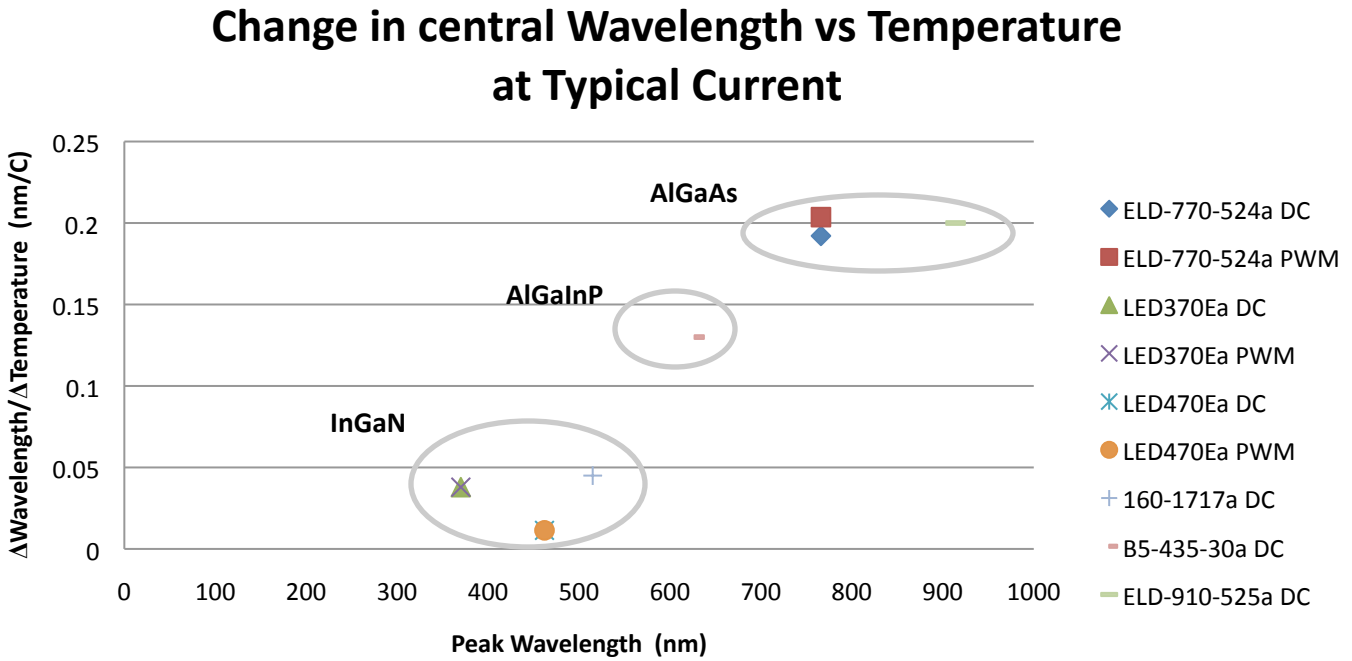
LED angular dependence

- No change in spectral output vs illumination angle



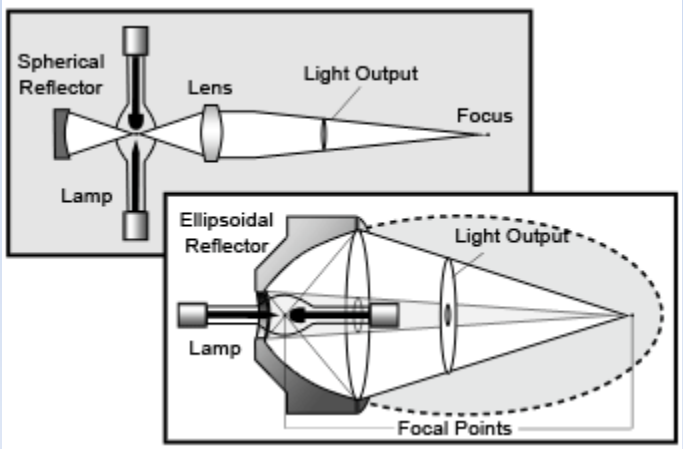
LEDs temperature dependence

- Temperature dependence of the output wavelength of up to 0.2 nm/°C
  - Depends on the LED material
  - Less than 10nm shift over expected temp range
    - We will do tests to assess impact on flatfield precision
  - If necessary, temperature control of the LEDs



Tunable light source: Monochromator

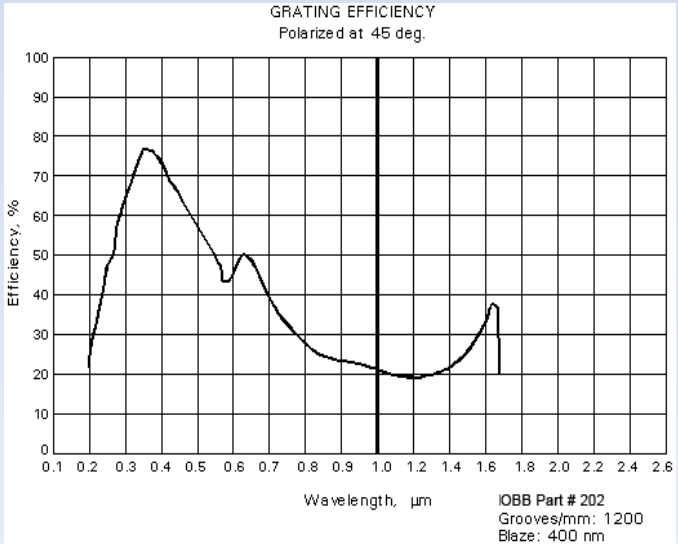
- Tunable high intensity light source manufactured by OBB
- Czerny-Turner monochromator, F/4.5, 50mm gratings
- Light source is 75W Xenon arc lamp with ellipsoidal reflector
  - collects 70% of the lamp output compared to 10-15% for typical condenser systems
  - All reflective = No aberrations
  - 500 hours lifetime for lamp,
    - easy to replace
- Adjustable slits
- 3 gratings
  - 300-600nm: 1200g/mm 400nm blaze.
  - 600-1000nm: 1200g/mm 750nm blaze.
  - 1000-2500nm: 600g/mm 1250nm blaze



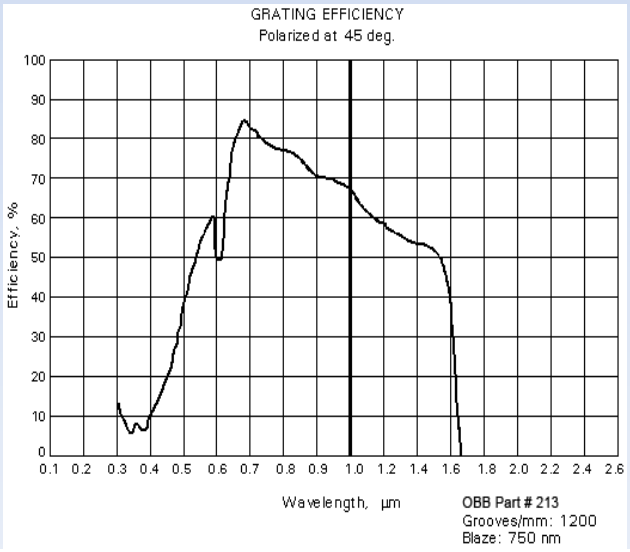
Monochromator

- Grating efficiency
  - The 2 gratings were chosen to provide good throughput over the whole range.
    - a third grating to cover the IR
  - The UV grating efficiency stays above 70% for the U band
    - Will help compensate for lower fiber throughput in that region

400nm Blaze

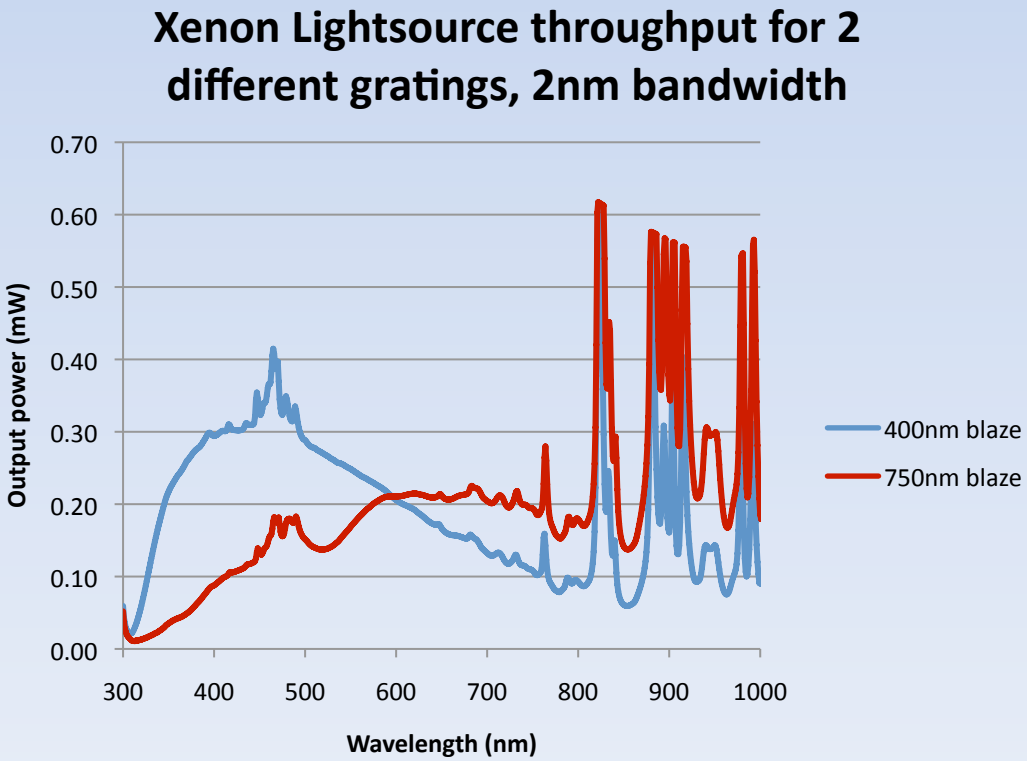


750 nm Blaze



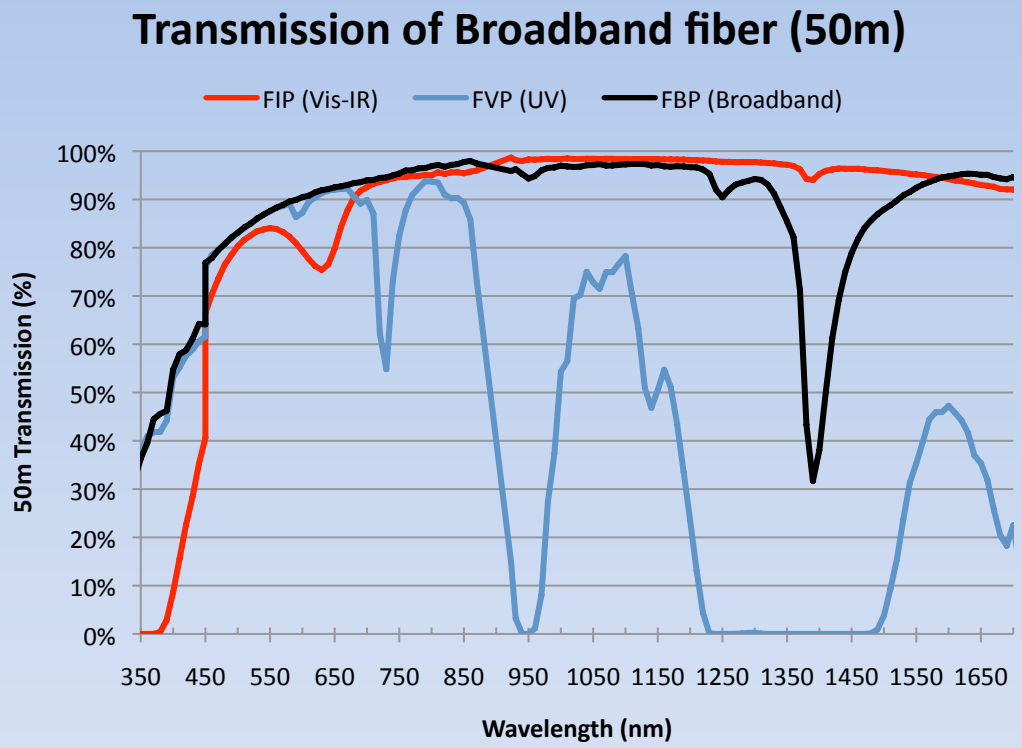
Monochromator

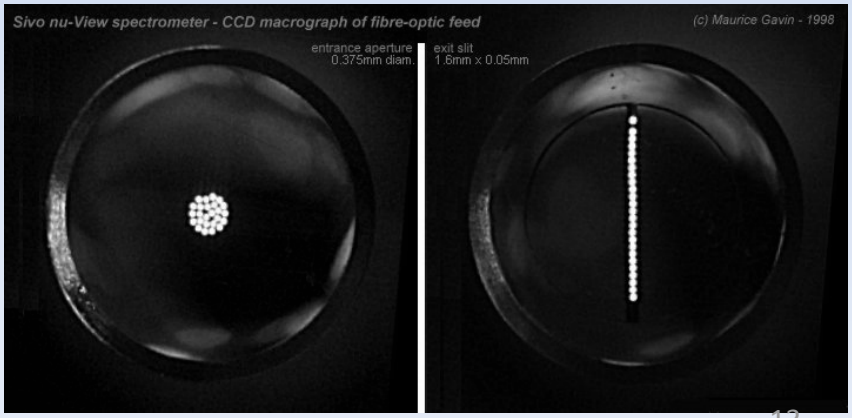
- Power output around 0.25 mW for 2nm Bandwidth
- Light throughput is good in the UV.
- Beyond 850nm, emission lines complicate the output: we will use an halogen lamp for that region.
- Assuming 50% coupling efficiency in the fiber bundle, this means around 180s exposure time to get 10000 electrons/pix.
- Binning might be required to speed things up.
  - 4x4 binning would bring exposure time down to 12s



Optical fiber

- Broadband fiber from Polymicro (FBP).
  - Good transmission from 350nm to 1700nm
  - Slit to spot 10 fiber bundle designed to match the slit output.
  - One of the fibers in the slit is bifurcated to monitor wavelength and power.
  - Tests on a 10m bundle to begin the next month

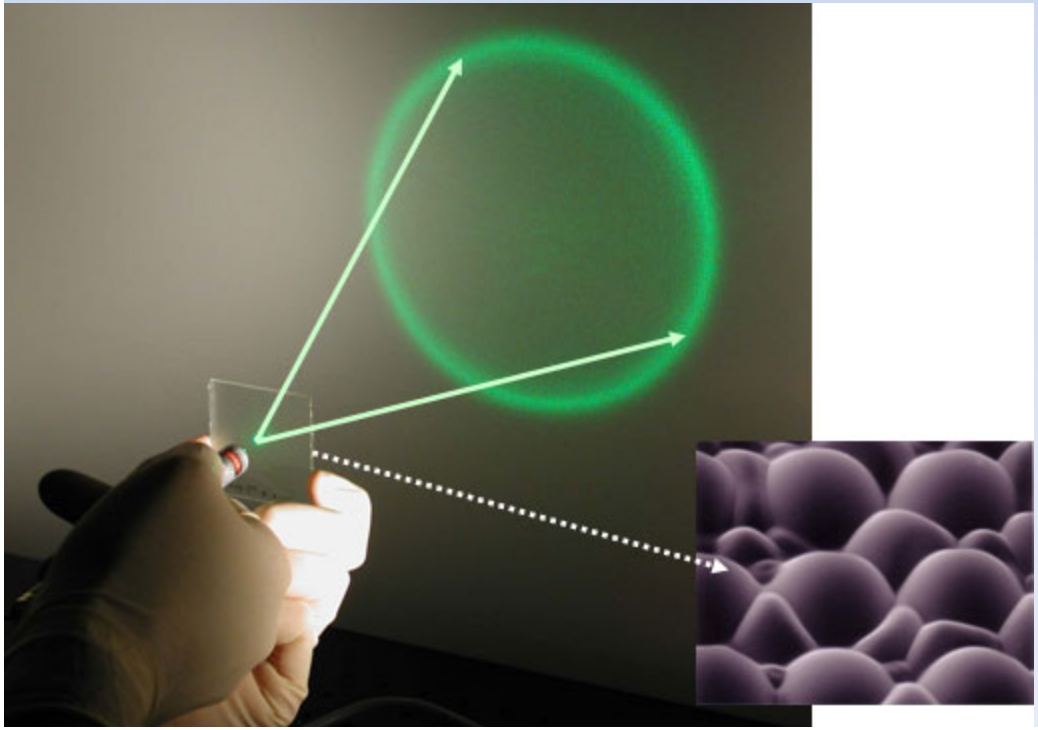


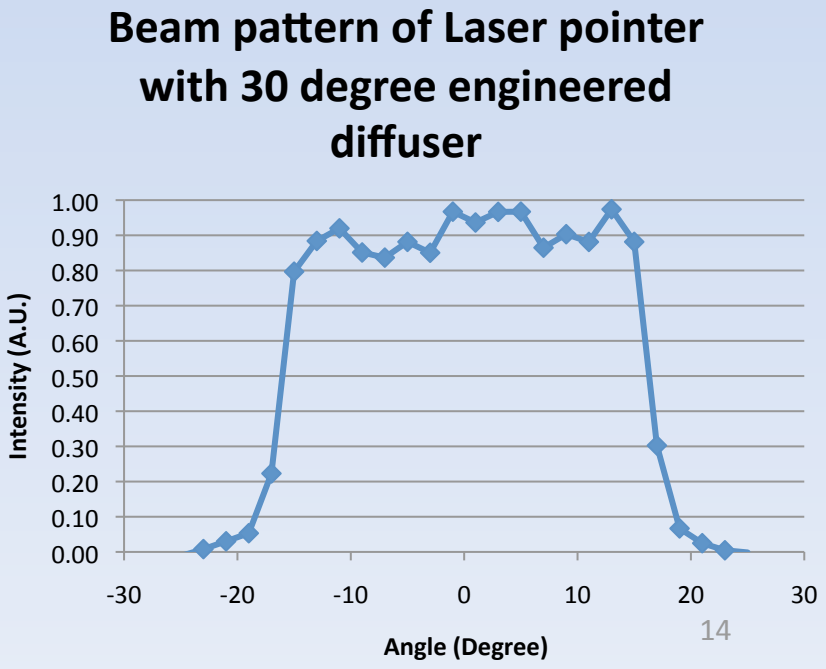


Example of a slit to spot bundle

Beam shaping optics

- Placed at fiber output on top of telescope to provide uniform illumination of the screen
- We will use an engineered diffuser etched by a holographic method to produce the desired beam pattern on the screen.
- We can select a specific diffraction angle diffuser to match the telescope-screen distance.





Photodiode monitoring

- Monitor output power and wavelength in real time
  - Monitoring points are:
    - Monochromator output (using bifurcating branch from bundle)
    - On the screen, facing the Light source
    - On top of telescope, facing the screen
    - In the focal plane ???
- Allows us to estimate the power incident on the CCD
- Based on NIST traceable calibrated photodiode from 300nm to 1800nm. (Si and Ge photodiodes)
- We are perfecting photodiode electronics to measure the 1nW-100 pW signal reflected from the screen accurately.

Conclusion

- Screen, fiber and beam shaping optics are good.
- Still working on improving tunable light source output and testing fiber coupling
- More work on monitoring photodiodes electronics and calibration
- Will use the Spectrophotometric calibration system on Swopes and Dupont in January