Schlegel/BigBOSS/HST

Just

Fibers

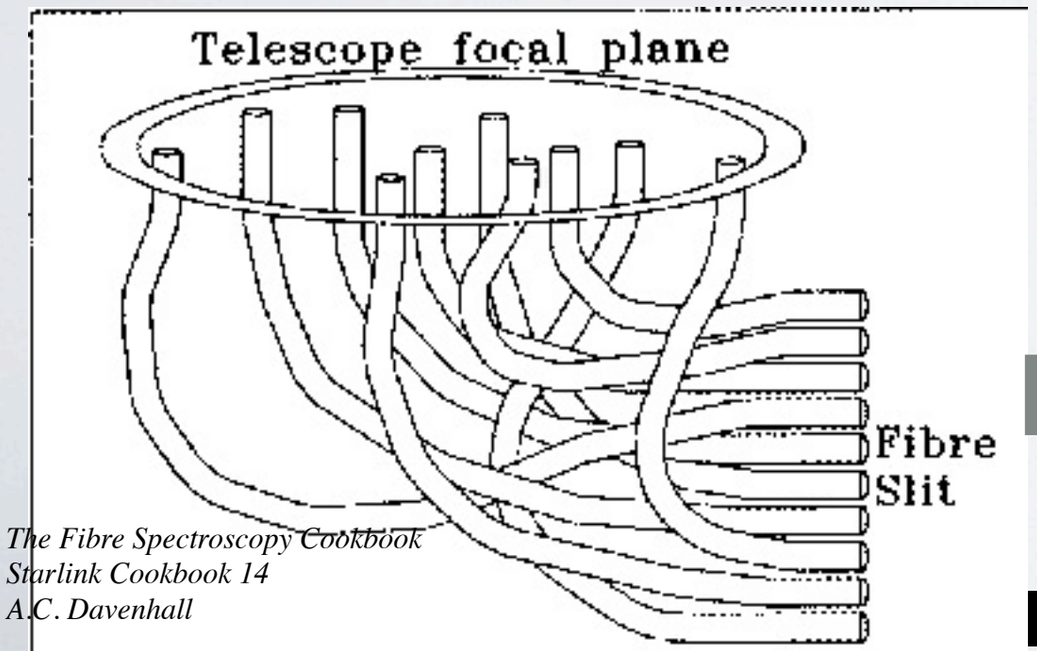
OPTICAL FIBER TESTING AT IEU

- This lecture is about my activities testing optical fibers for the BigBOSS (now known as MS-DESI) experiment, in the lab at the Institute for the Early Universe, Seoul.
- I hope you have an opportunity to visit a lab to see how optics measurements are performed.

FIBER SPECTROGRAPHS

- "Longslit" spectrographs are used to make one spectrum per pointing of telescope.
  - NO GOOD for large statistical studies or surveys with many objects

- Fiber-Feed spectrographs "multiplex" - you put a fiber at the position of each galaxy, fibers carry light to spectrograph

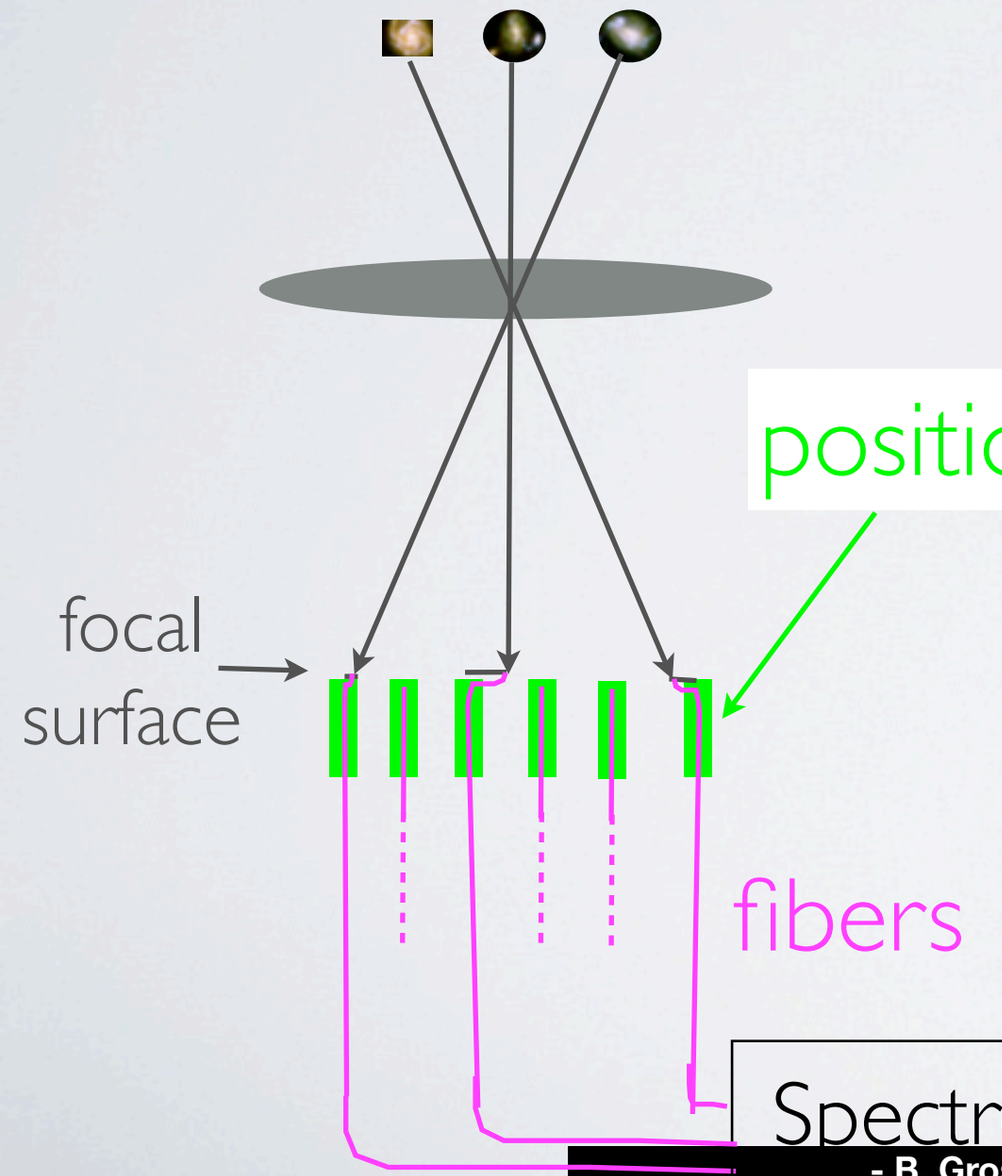


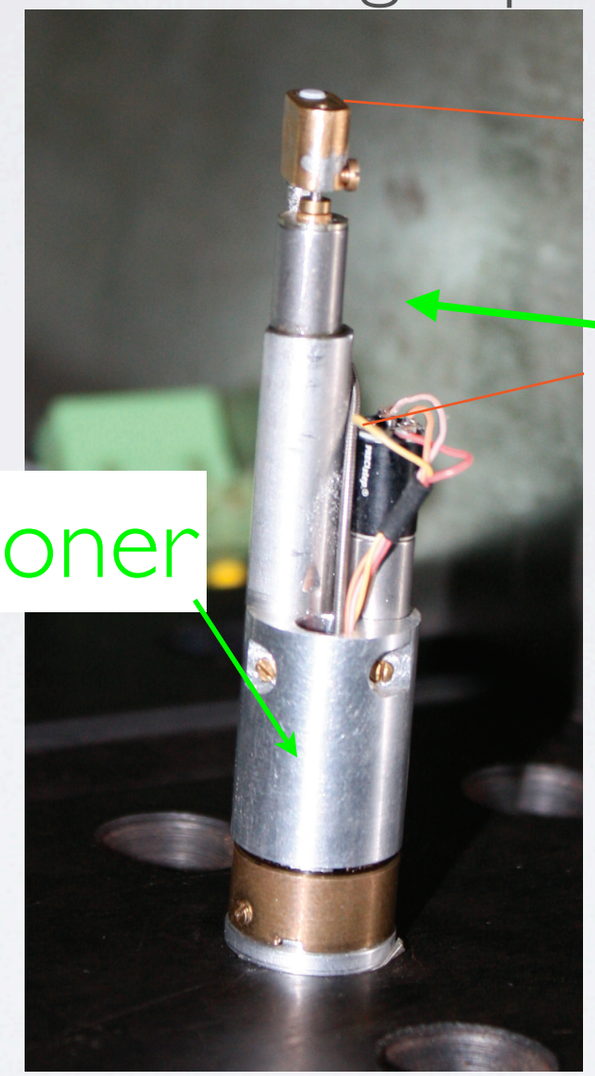
The Fibre Spectroscopy Cookbook
Starlink Cookbook 14
A.C. Davenhall

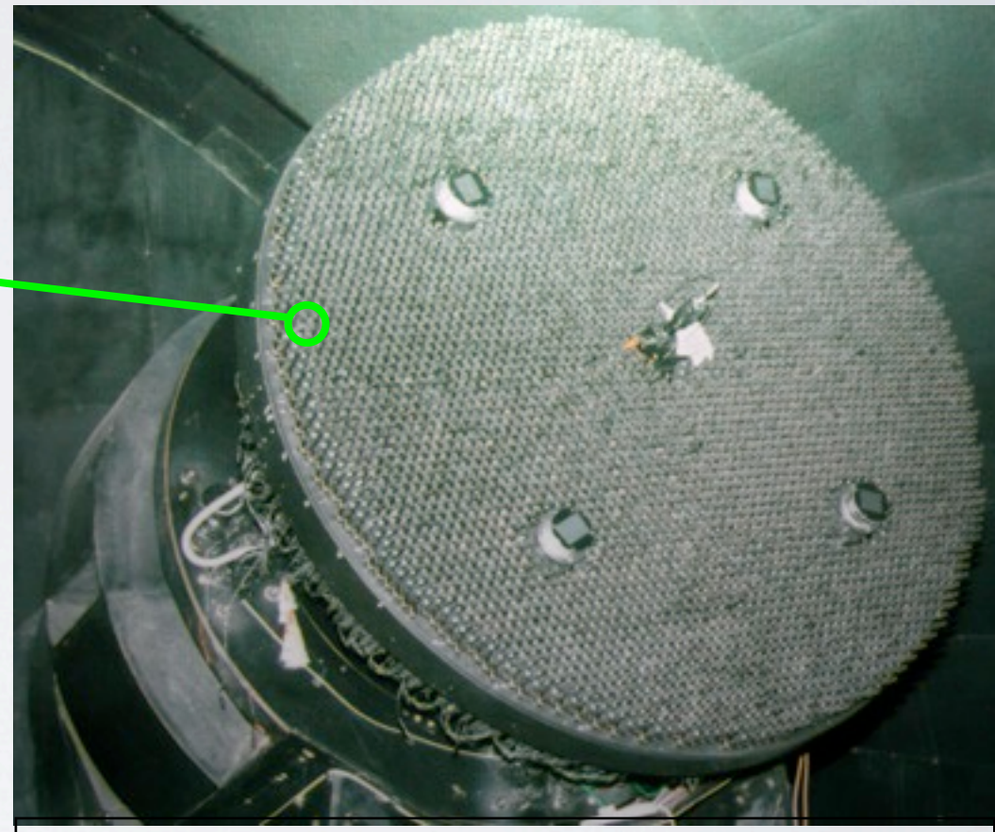
to spectrograph

KEY TO DESI INSTRUMENT: 5000 SPECTRA PER POINTING VIA ROBOT POSITIONERS

- 5000 positioners put fiber at target position



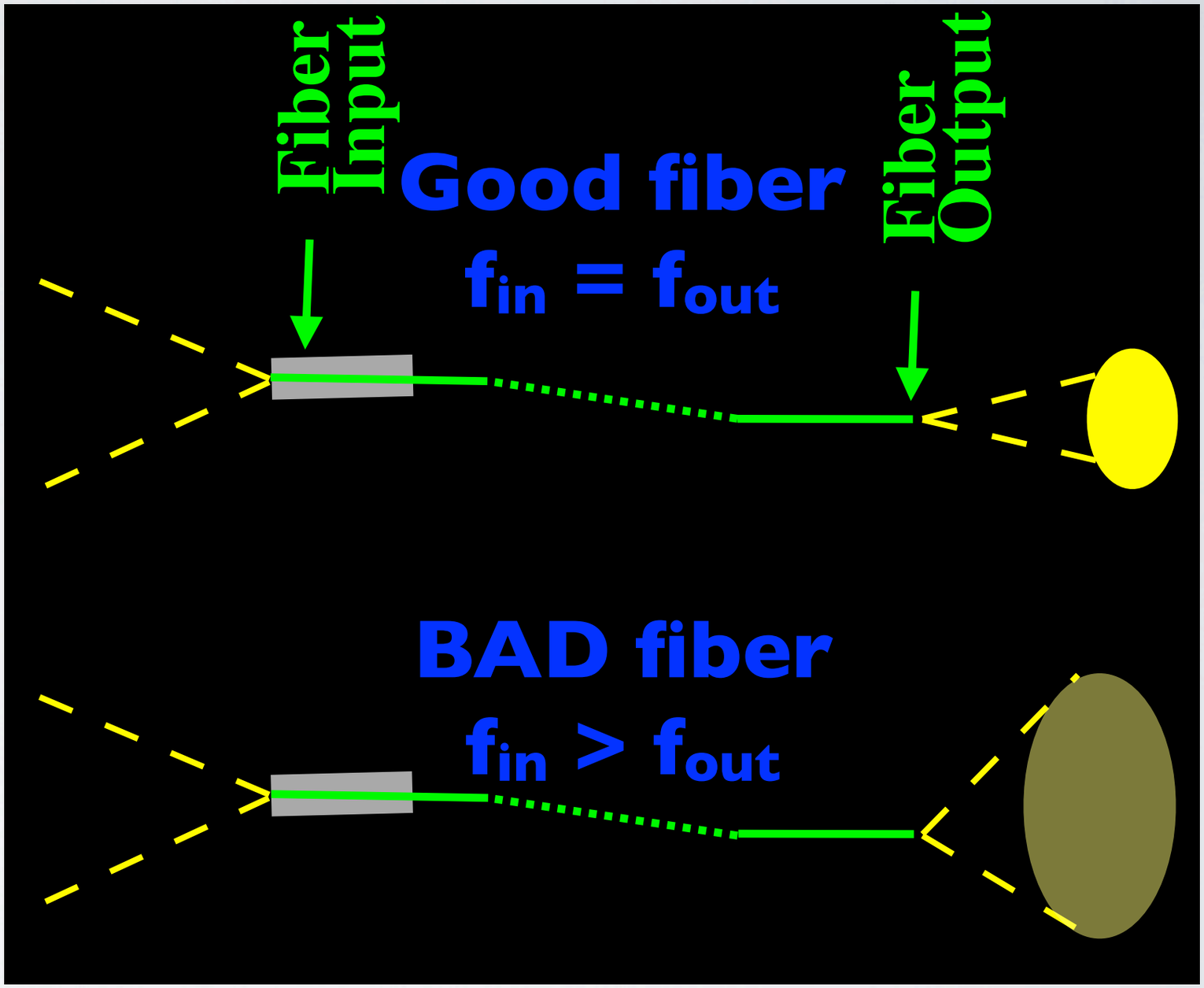




Focal Plane filled with positioners

WHY TEST OPTICAL FIBERS?

- **Focal Ratio Degradation** = when a fiber spreads out the incoming beam too much.
  - Beam spread is BAD in astronomy -multiplies read noise & background
  - BOSS experiment had many runs of fibers w/ bad FRD - must test.



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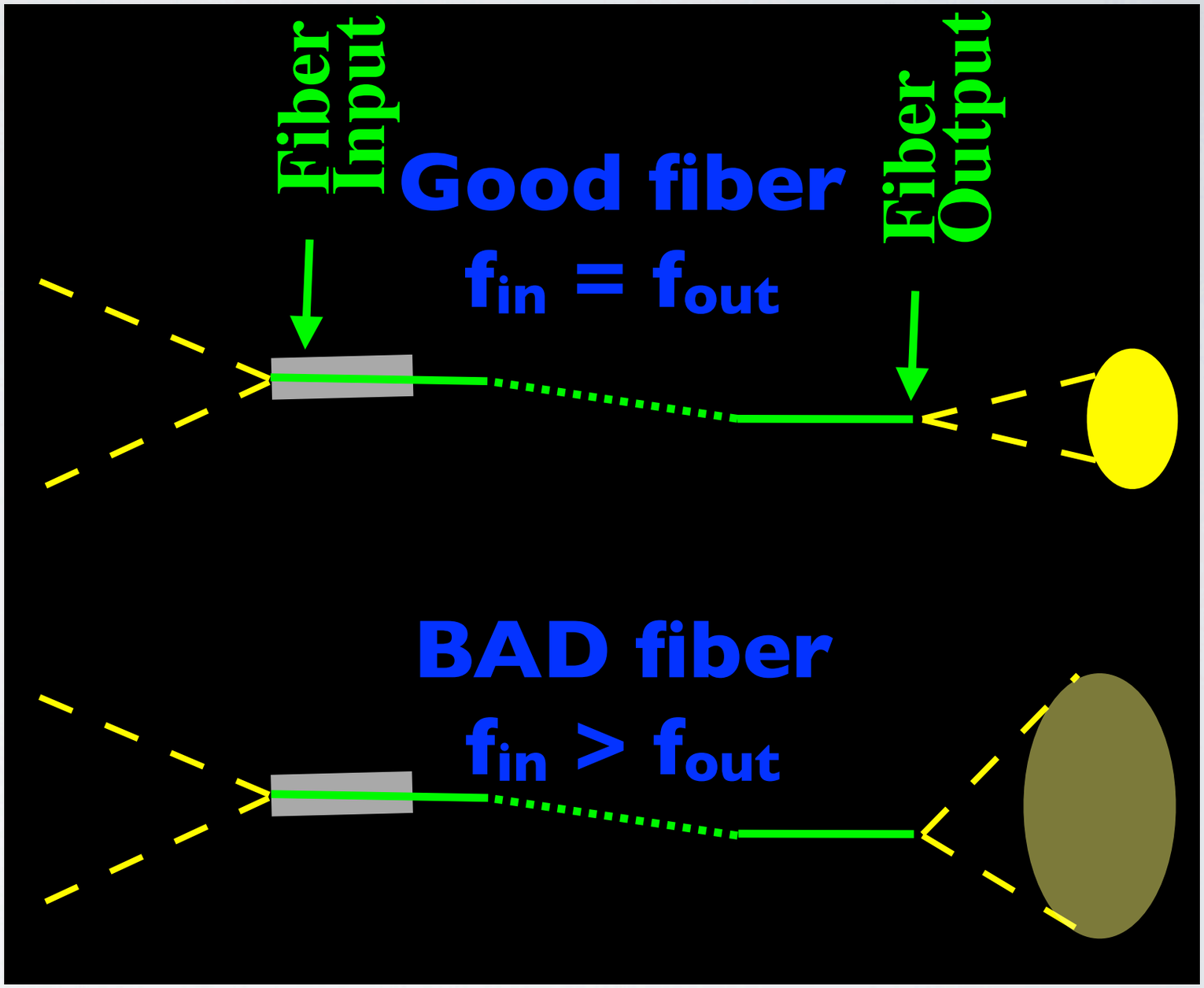
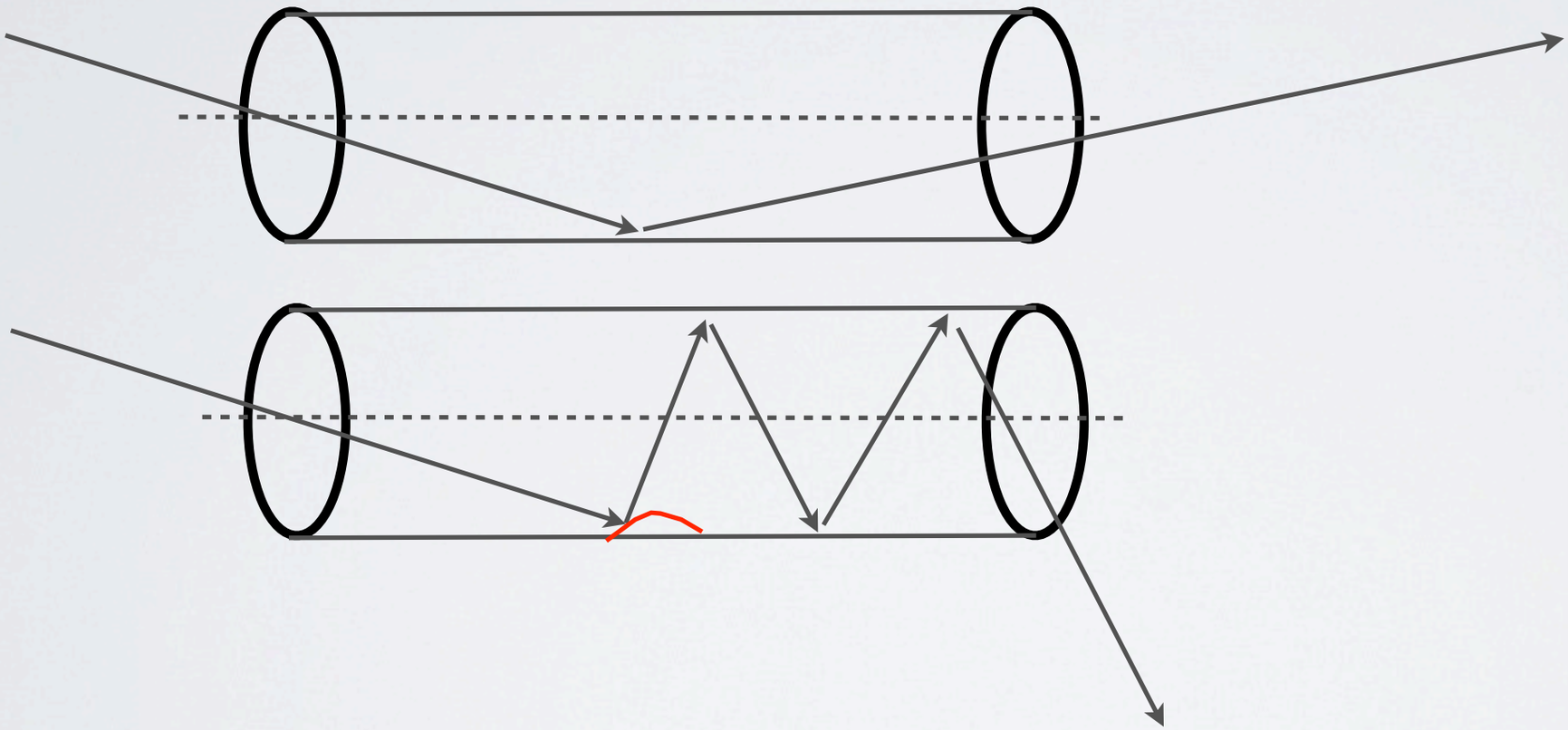


Critical- **all 5000** fibers must be tested for FRD!

WHAT CAUSES FRD?

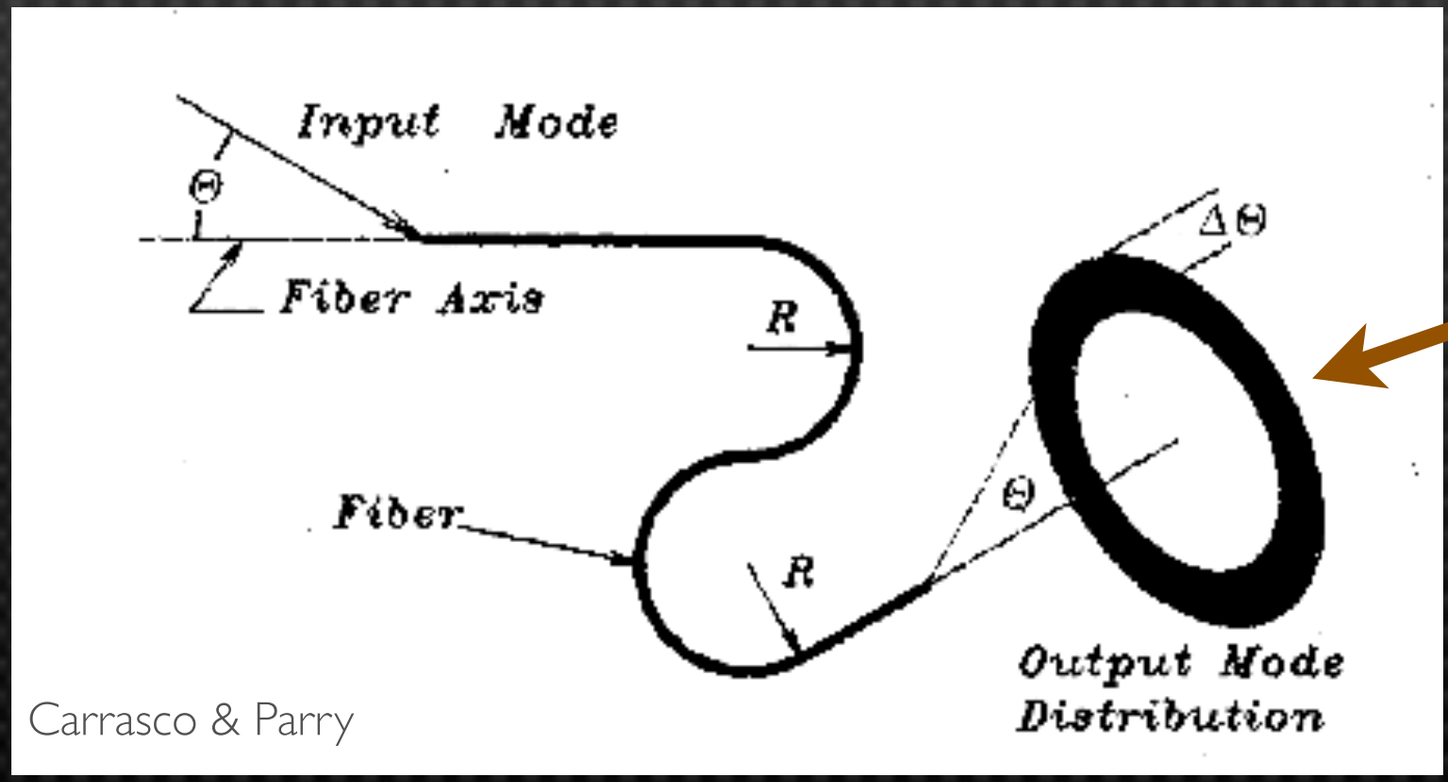
- Theory says microbends cause scattering of rays off of ideal path.



- the smaller the characteristic microbend radius, the worse the performance of the fiber. We measure this with the laser.

Measure-Collimated Light Test

- Shine LASER or other collimated source in fiber, look at ring pattern out
  - Width of ring must reflect variation of ray path through fiber
  - Can be translated into FRD measure



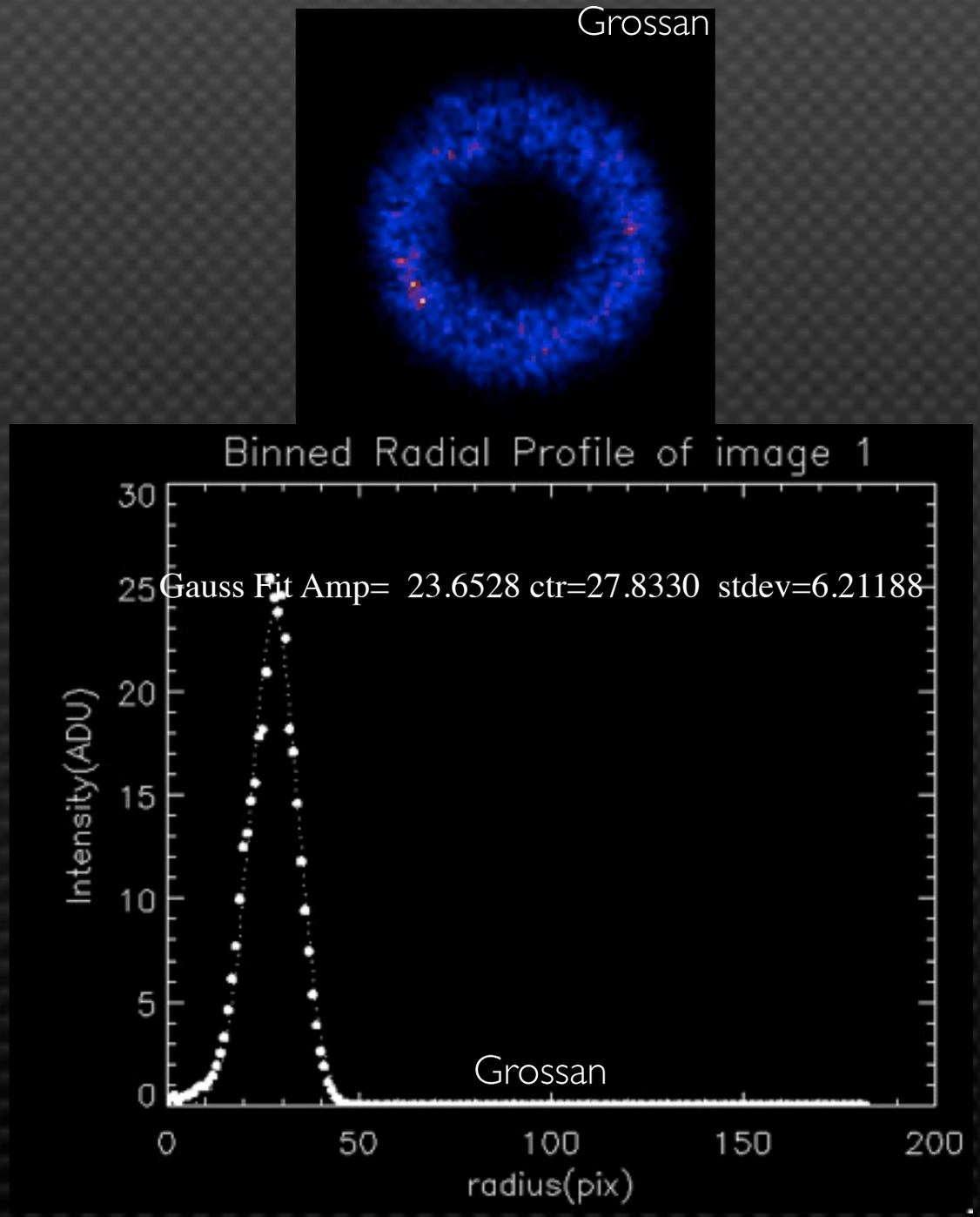
Carrasco & Parry

Narrow ring=good

Fat ring = bad

Measurements

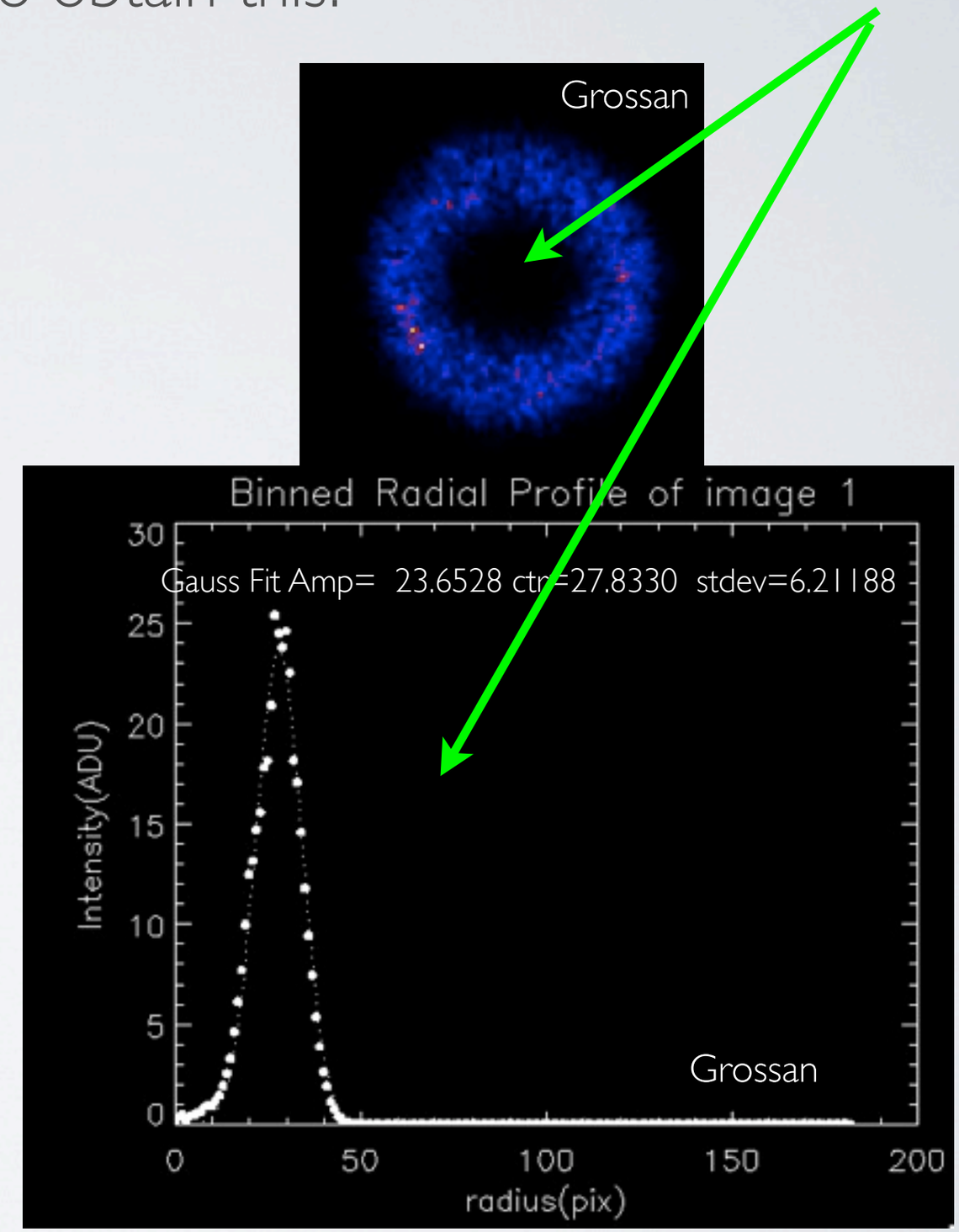
- Laser "Rings" AKA coherent Source Annulus

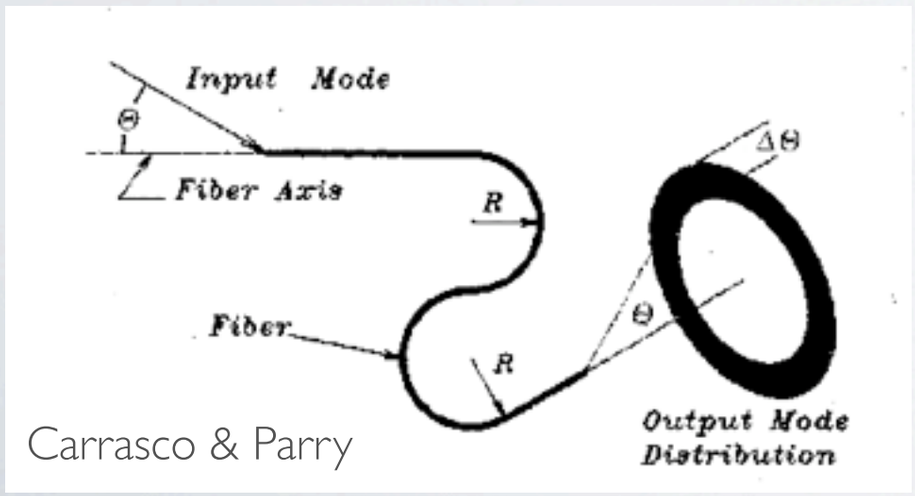


- B. Grossan. Use requires attribution of all sources -

EXERCISE

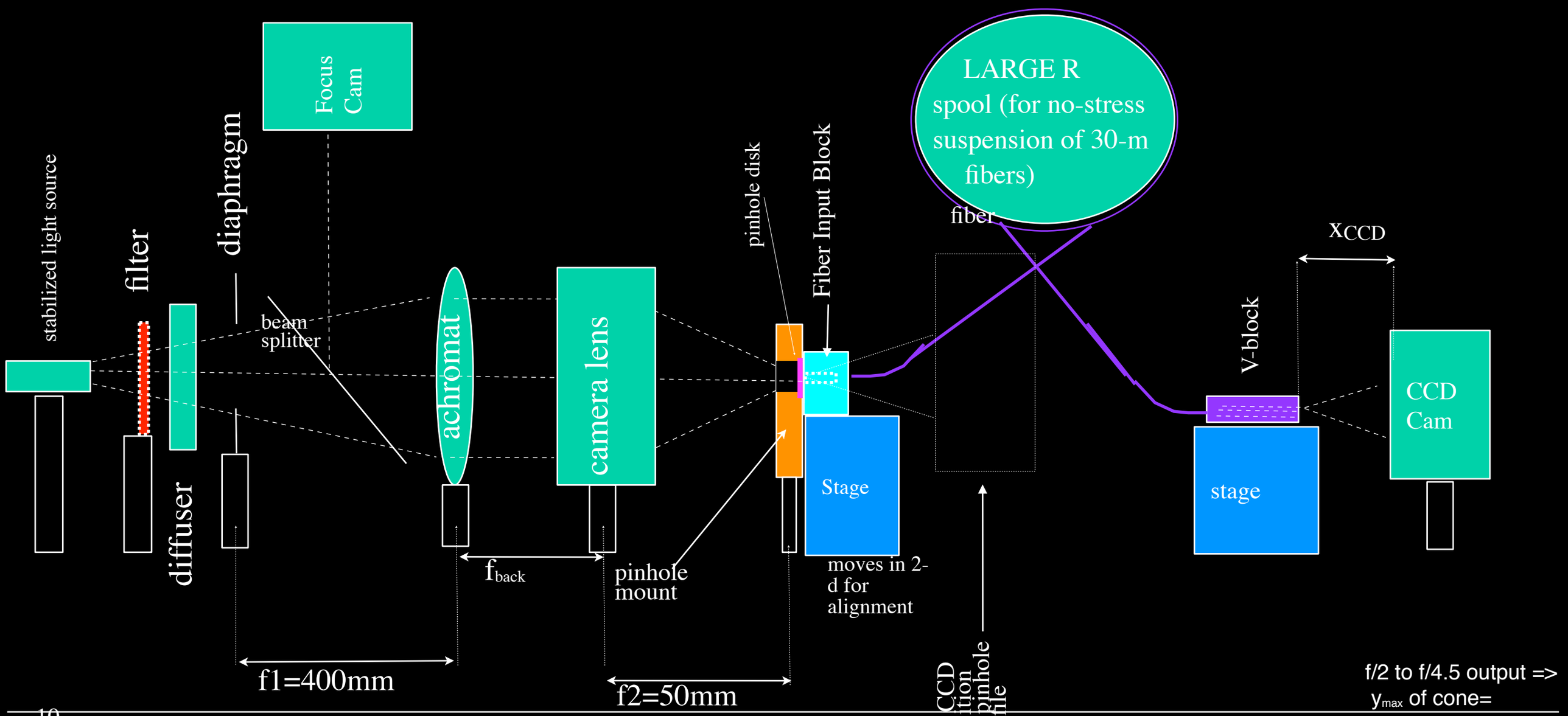
- How do you reduce these data to obtain this?
- How do you reduce these data to tell me the angular spread of the annulus (bagel)?
  - Hint: Draw the experiment, think about what you need to measure.
- Write the complete algorithm and program. Data are coming.





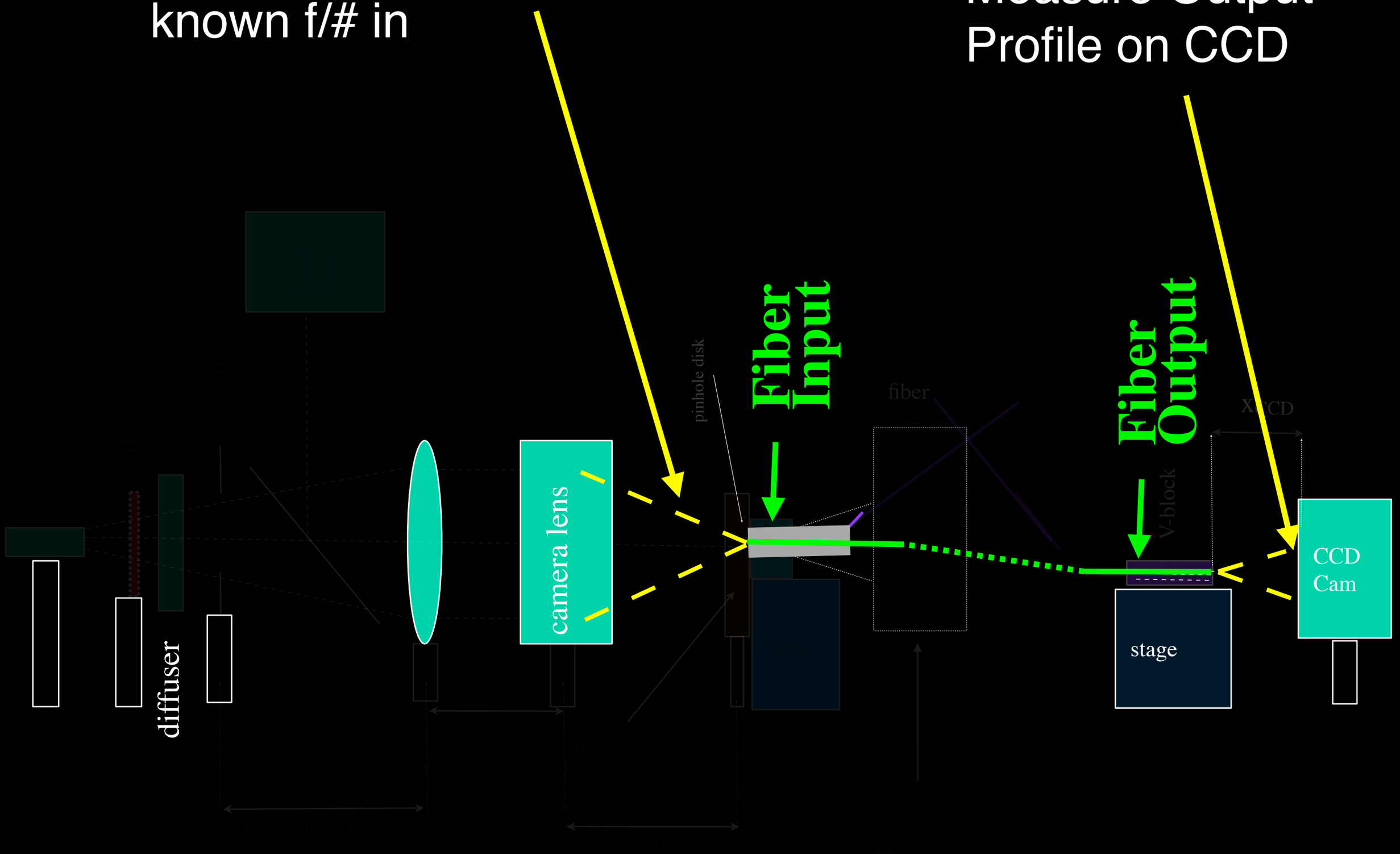
Carrasco & Parry

IBBOSS Lamp Setup (after Carrasco & Parry 94)



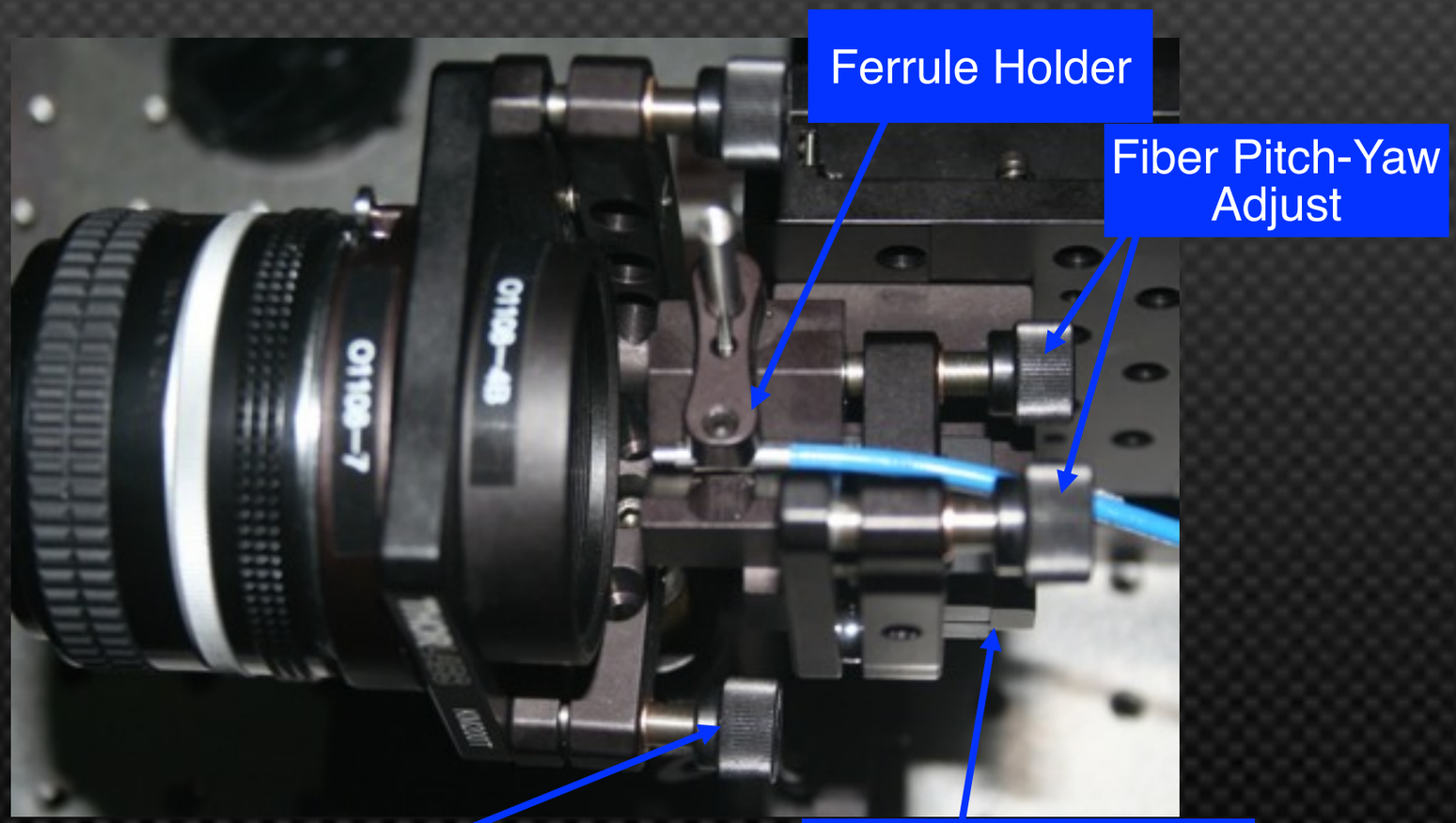
Simplified- Incoherent Beam Test

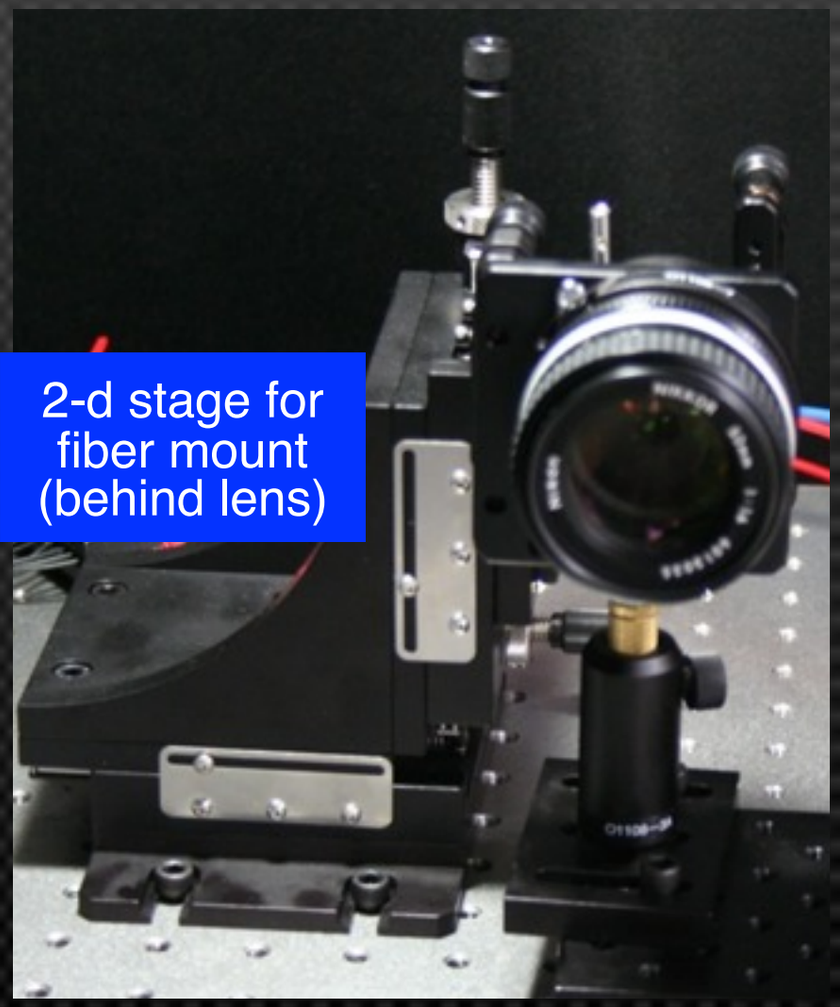
- Shine well-defined beam of known f/# in
- Measure Output Profile on CCD



2011-V3 Setup

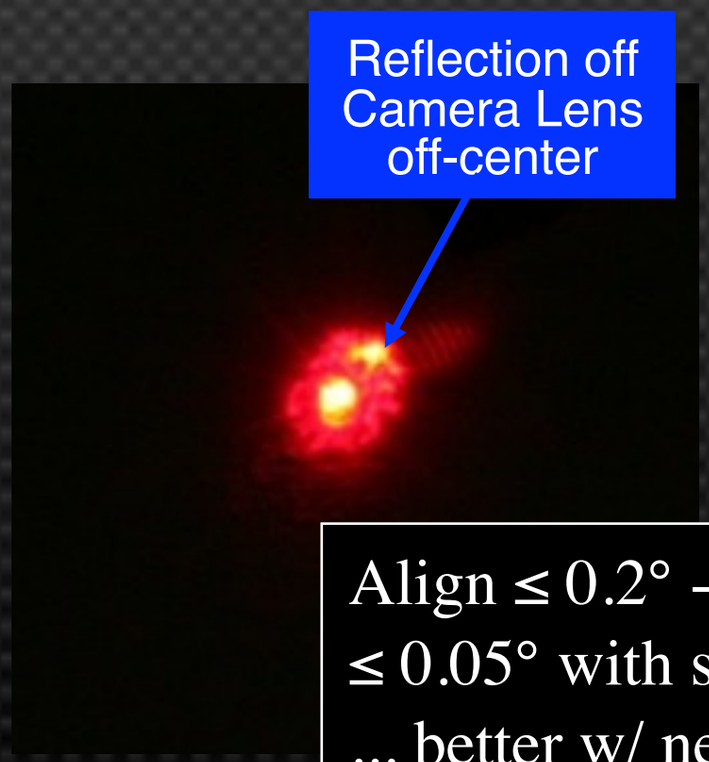
- 2011 Hardware
  - fibers are difficult to hold, need some special mounts
  - alignment of small fibers requires some special mounts and thinking about setup.

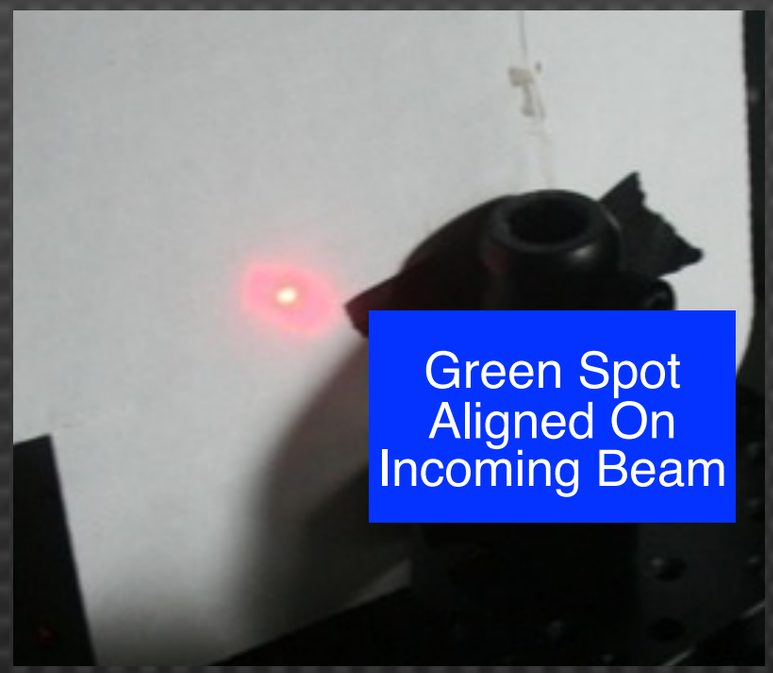


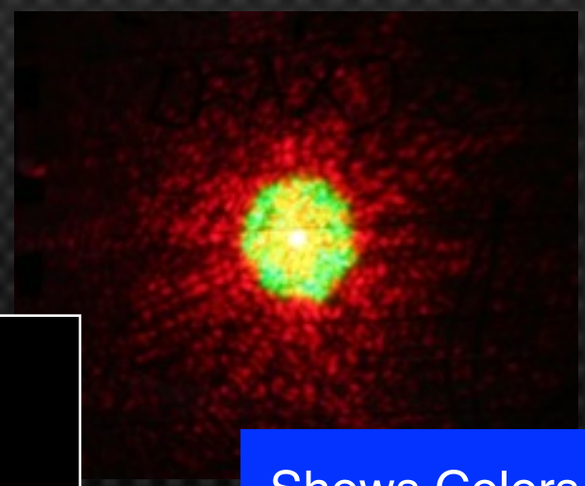


2011-V3 Setup

- Development of Align Techniques
  - Laser "cross-hairs" + Reflections for lenses
  - Different color laser back-illumination for fiber align





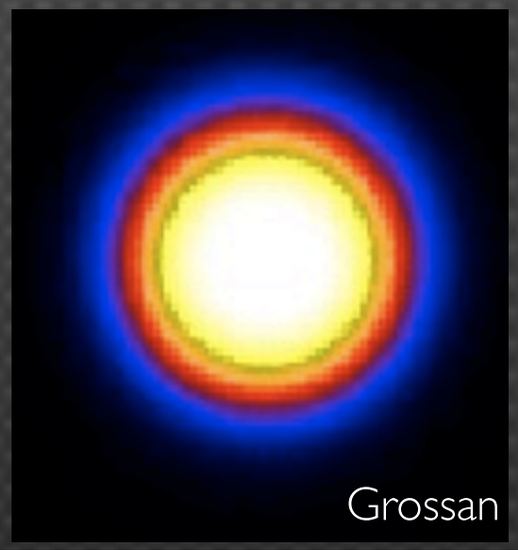


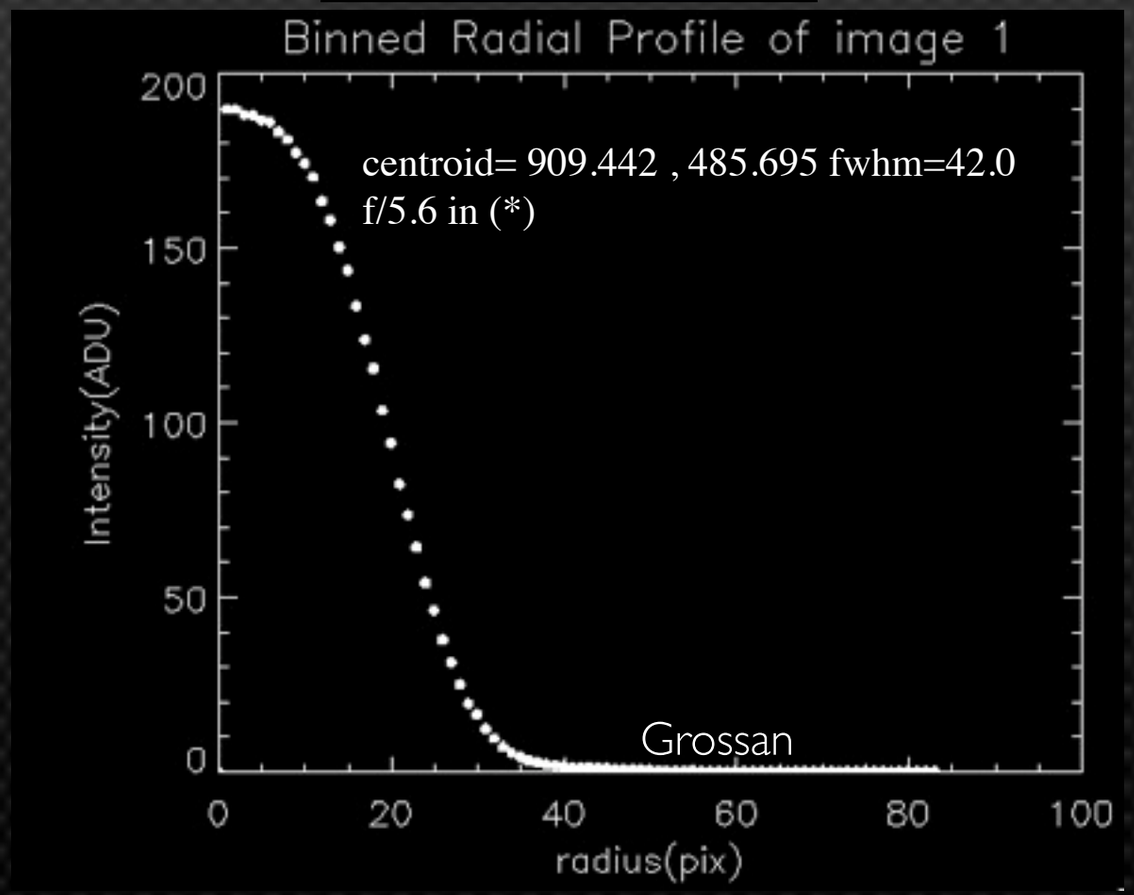
Align ≤ 0.2° - 0.3°/lens
≤ 0.05° with splitter cube
... better w/ new screen.

Thanks to M. Sholl for helpful suggestions.

Results....

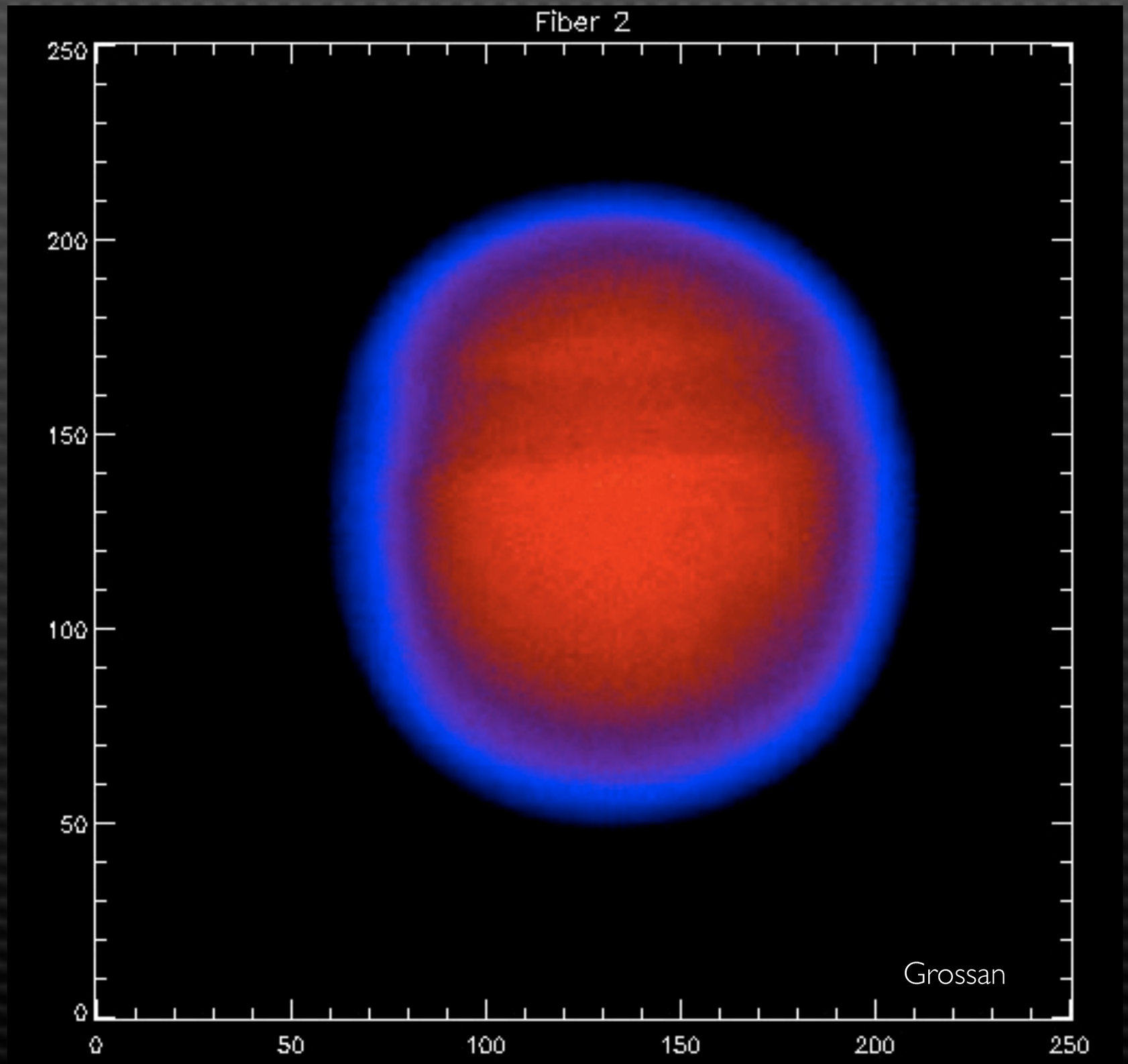
- Incoherent Source Profile





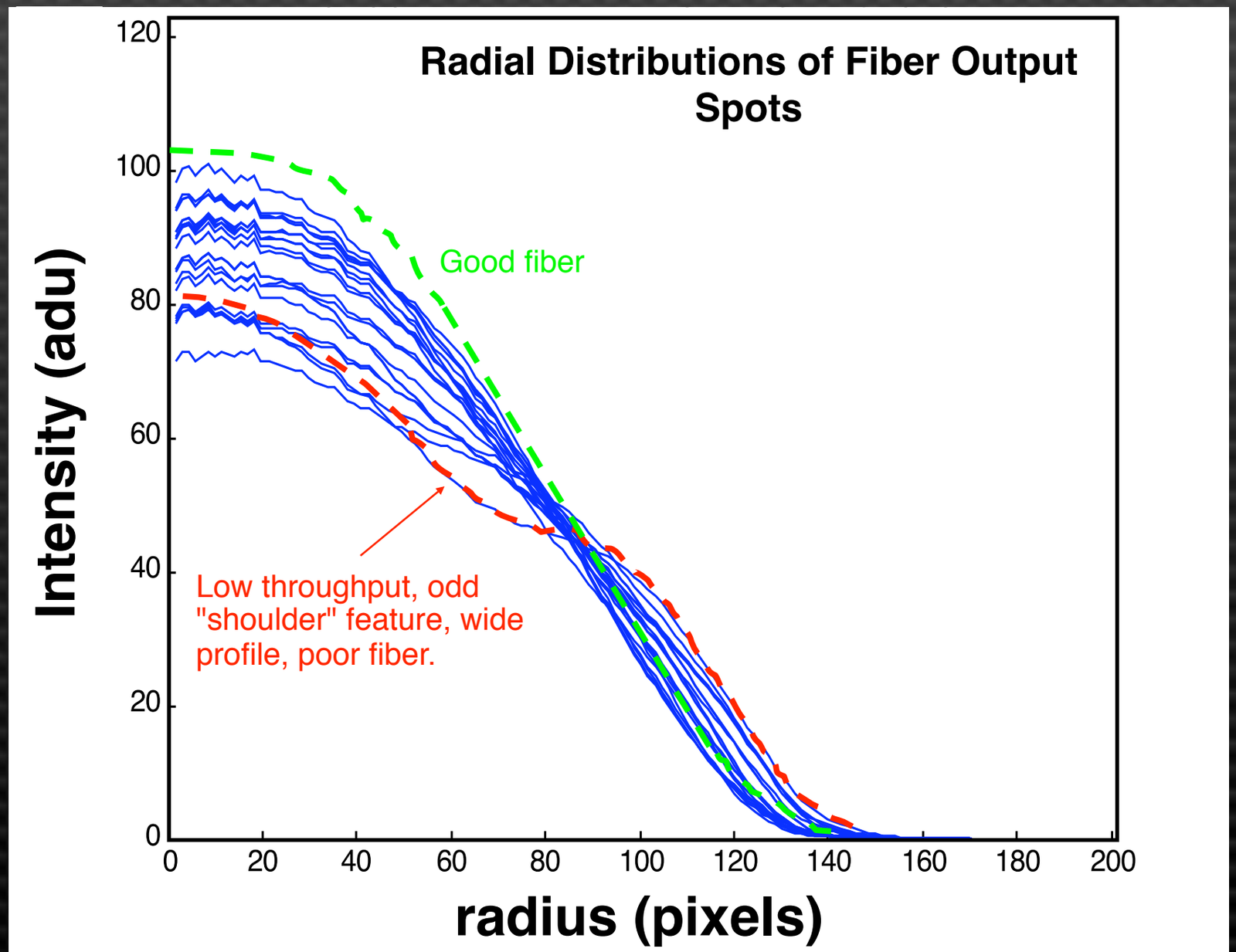
Bad Fibers

- "Oh no, the alignment must be screwd up?"
- NO! - Fiber 2 has an obviously non-round profile!



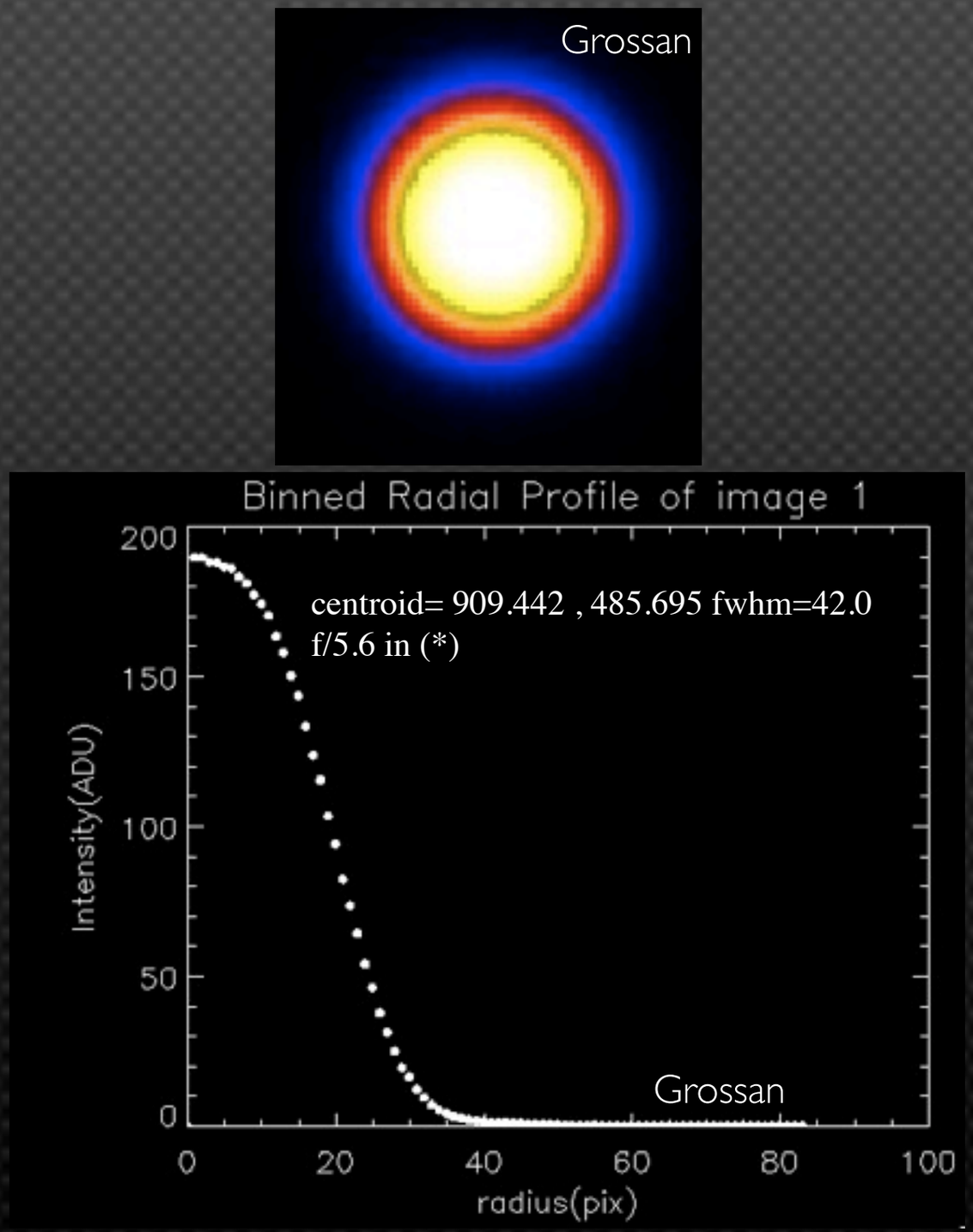
Comparison

- **Tests on BOSS 20-fiber bundle (rejected)**
  - Variety of output profiles observed
    - Note: one fiber had zero output



How do you measure?

- How do you turn this profile into an f/#?
- Please write the program

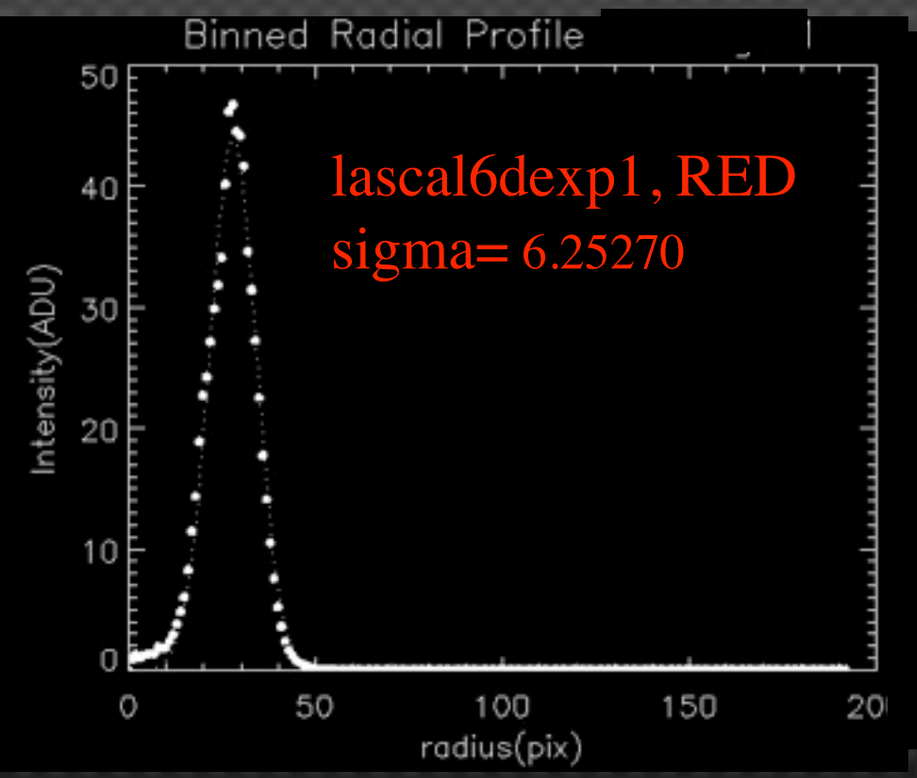


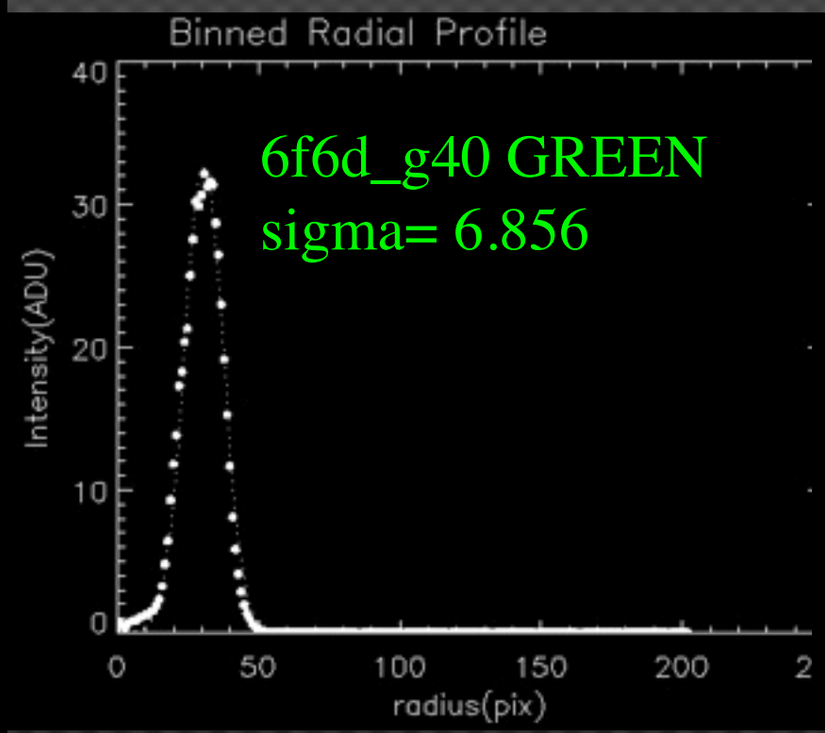
Color Effects

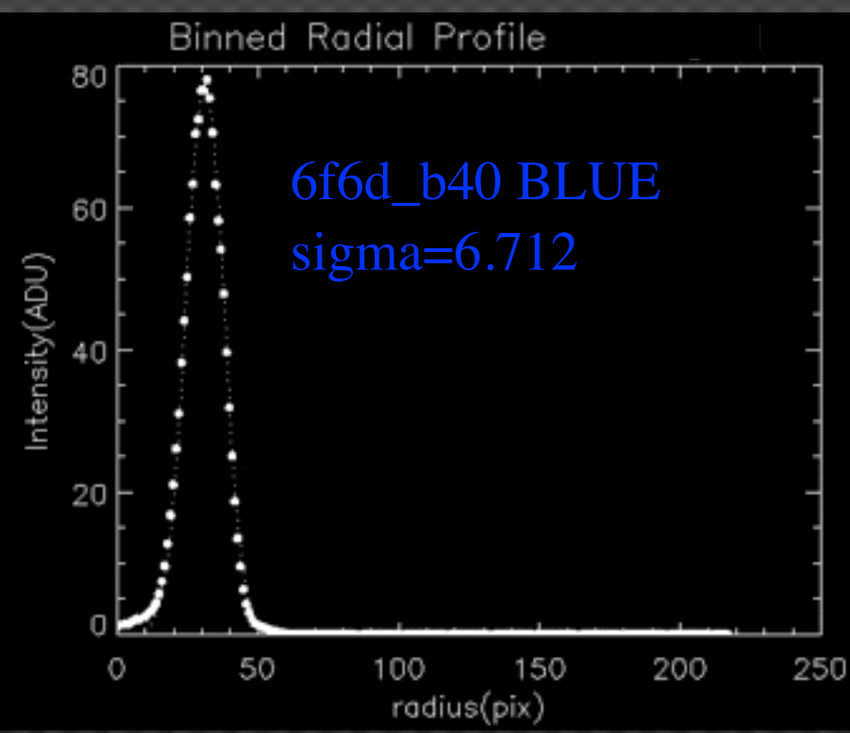
- Easy to do with diode lasers

Now Checking Color Effects

- Diode laser test FRD performance for 3 wavelengths.







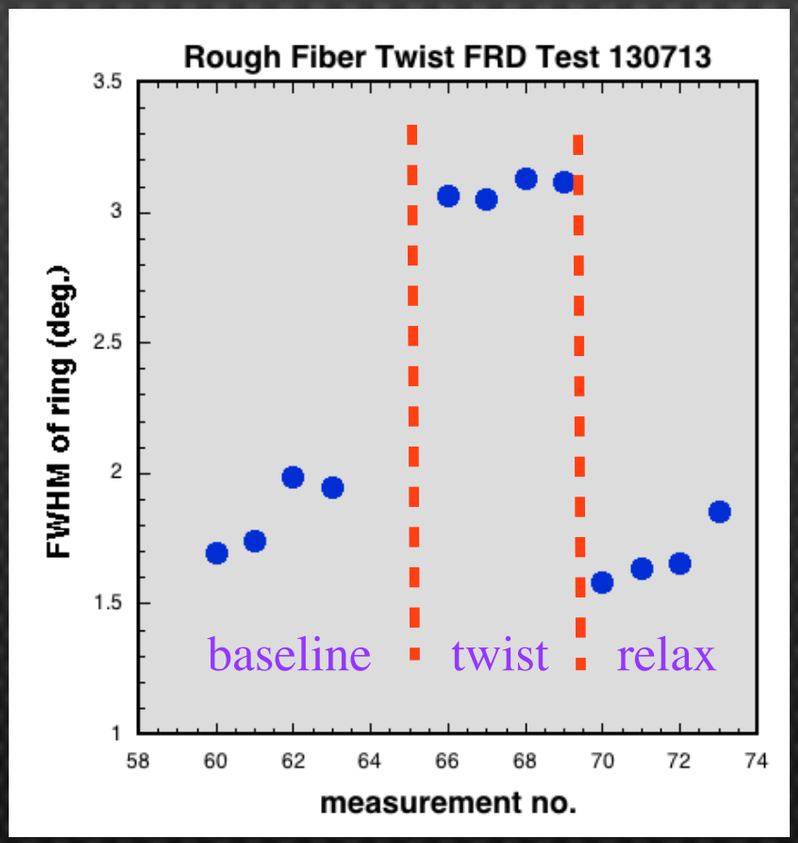
Fiber	Color/ incident angle	sigma fit width
Fib 6	Red/6 deg	6.25
Fib 6	Green/6 deg	6.85
Fib 6	Blue / 6 deg	6.71

Please note "6 deg" = label, only **rough** value of incident angle

preliminary -
Errors? Repeatability?
Varies with fiber?
λ dependence...?
...working on it now.

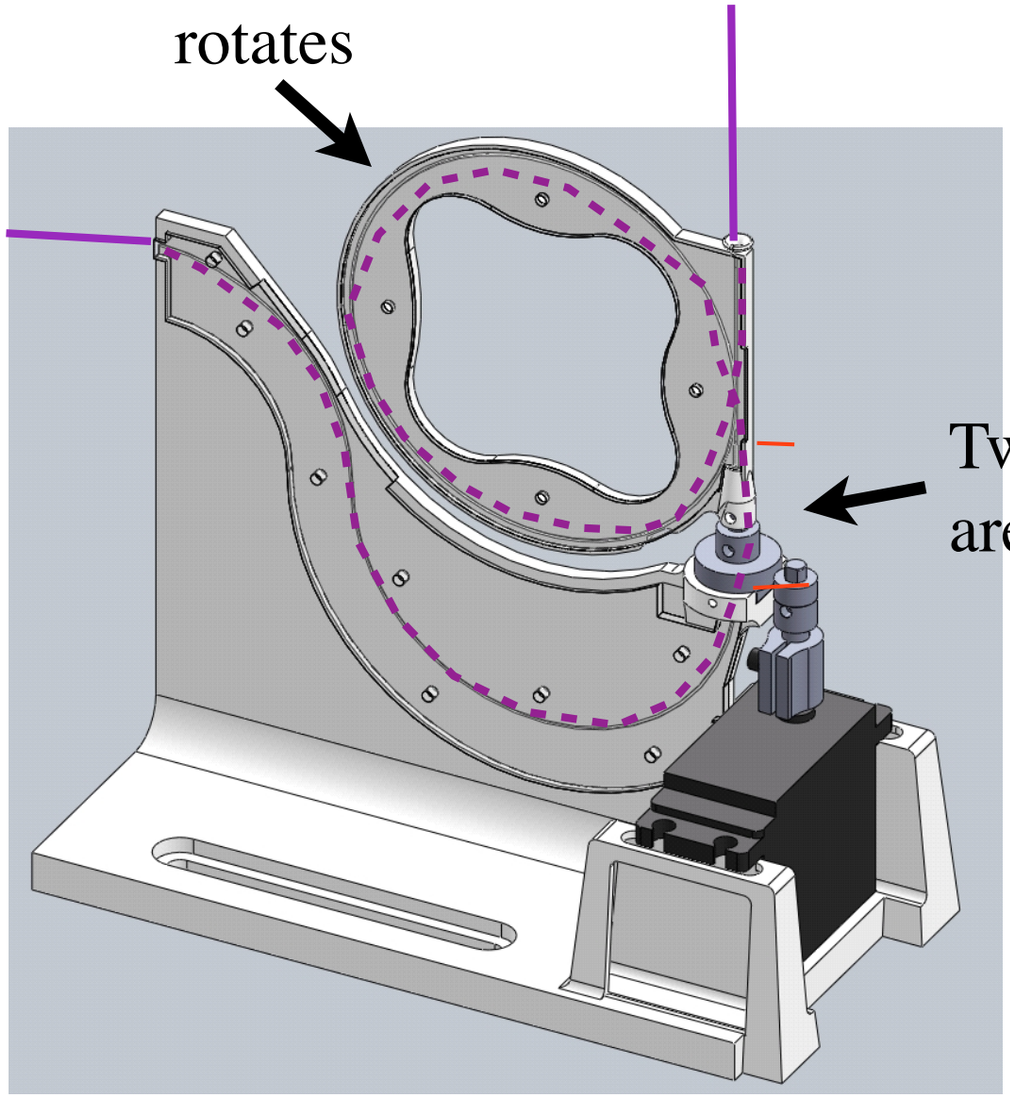
What about twisting?

- After crude test (pre-twister) of 360 deg. twist in 10 cm, severe FRD results.
- **But is this result of stress at holder, or twist?**



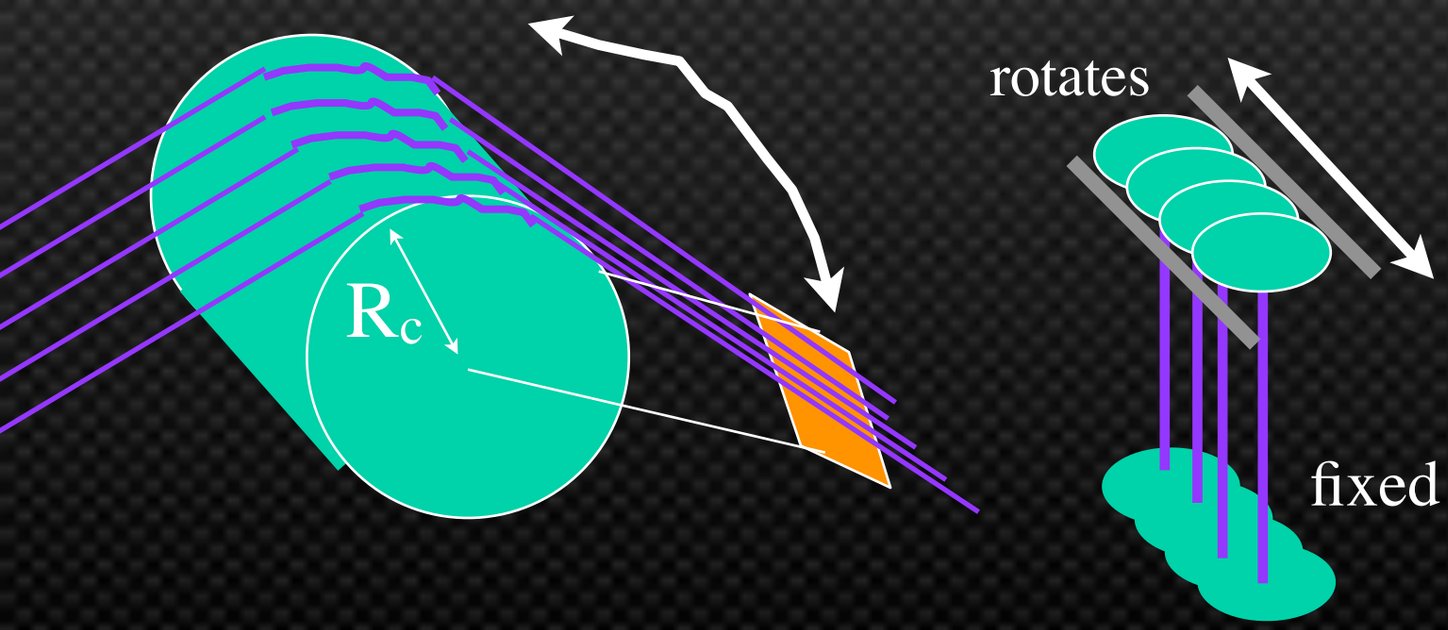
Twist Testing Device

- Meijer-Grossan twister design
  - Isolates twist so you can learn about it independently.



Fatigue Testing

- Sholl "Spindle-Board" tests "realistic" bend + twist
  - can mimic theta-theta or r-theta motions
  - easily reproduced in large numbers
  - (thus far guessing on curvature)
- Simple tests separate bend & twist
  - bend over fixed radius of curvature
  - mount fibers in disks, move disks synchronously

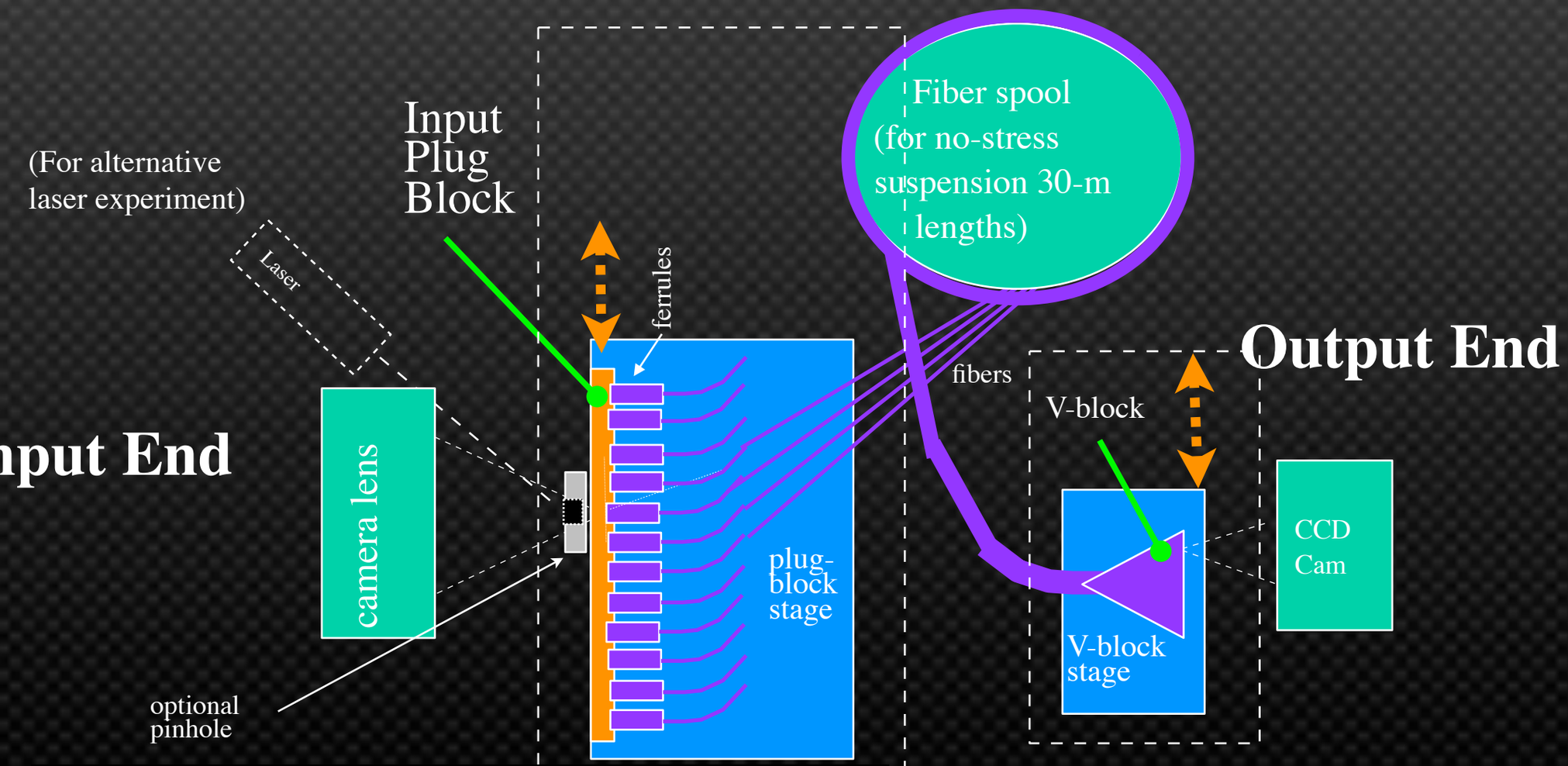


Cheap, scalable, programmable micromotors & controllers by Sholl.

- Test large samples using IEU people/facilities

Next Step:Automate for 5000 tests

- replace plug block(input end), V-block (output end)holder with 1-d computer-controlled stages
  - align first and last fiber on block
  - scan over each (some?) fiber(s) to find align point @ max intensity.
  - 2011: **Test Closed-Loop Feedback System**



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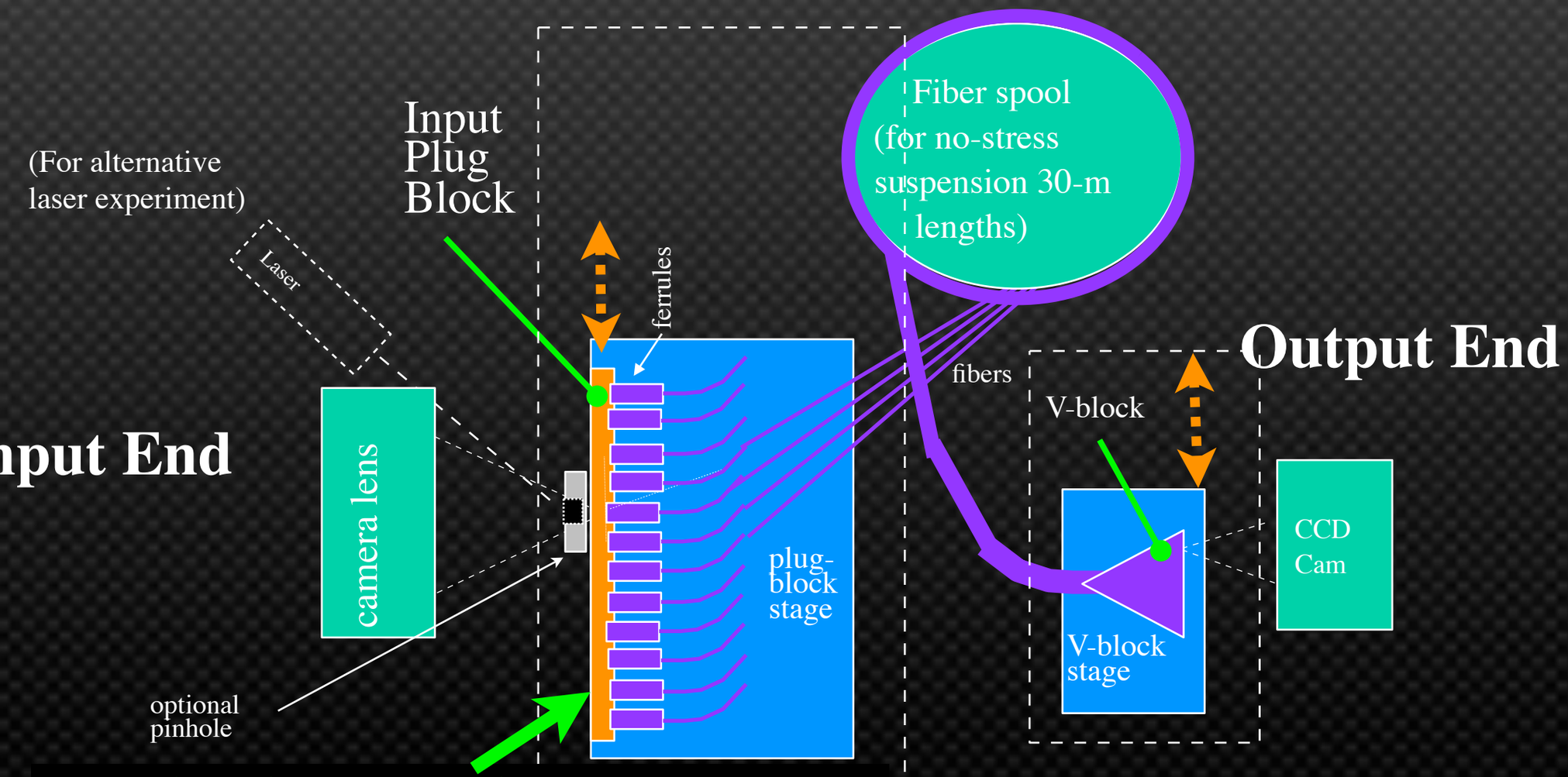
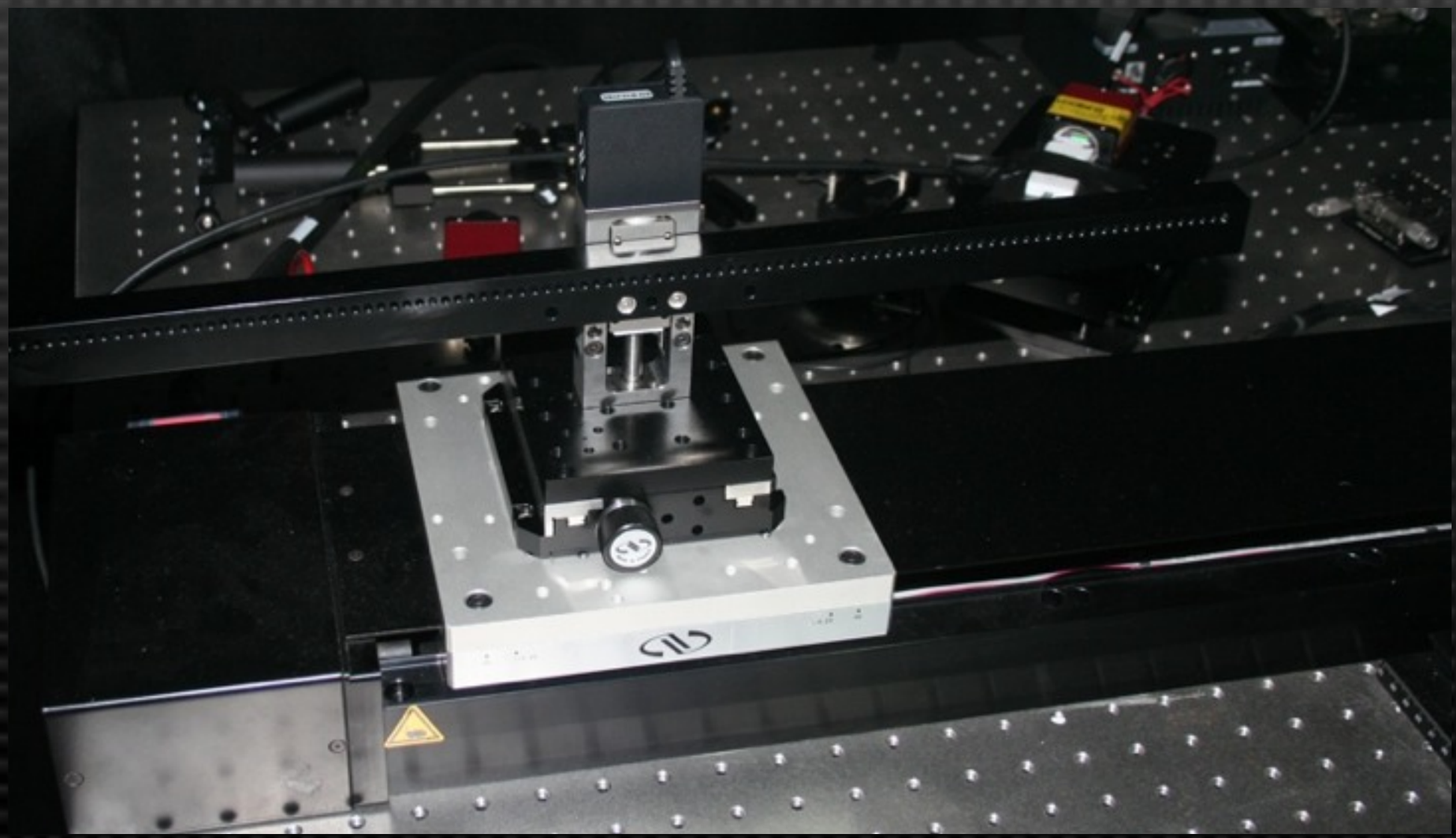


This plug block is very long (because many fibers). Need long-travel stage!

Computer Controlled Stages

- Challenge is alignment; cannot adjust thumbscrew for every fiber
- Currently Validating μm stage performance: how bad hysteresis during max. align scans? Accumulation of errors?



QUESTIONS

- Spectra are recorded as "strips" of light on CCD detectors.
  Let's say we measured FRD that made the width of a spot of a fiber 2X as wide as that for a perfect fiber.

- What would be the effect on signal-to-noise ratio of this FRD?

- Draw the spectrum of the [OII]3727Å, 3729Å infinitesimally narrow lines, for a spectrograph with 0.3Å FWHM resolution, 0.3 Å pixels, fed by a fiber with a FWHM spot size of 1 pixel (Draw reduced spectrum and draw "strip" on CCD).

- Again, this time with an optical fiber with 5 pixel spot size. Does this fiber affect the spectroscopy? If so, how?

SUMMARY

- You can use optical fibers, positioned in the places where light from galaxies falls on a telescope focal plane, to take multiple spectra in a single exposure. This allows you to do millions of objects spectroscopic surveys

- Fibers have FRD, a kind of imperfection which causes light coming through the fiber to spread out over a large area.

- Shining coherent light into a fiber makes a ring - the width of that ring tells you how much the fiber is spreading out the light.

- If you build a fiber spectrograph, make sure your fiber performance is good enough (FRD small enough) to get the answer you need!

END

- THANKS!