# Measuring the Properties of Optical Fibers: First Results from the AIP Fiber Testbench for Fiber Bundle IFUs

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## Abstract

We present a method that allows the repeatable determination of the focal ratio degradation properties of optical fibers. In order to allow testing of whole integral field units (IFUs) with up to several hundreds of single fibers the testbench is setup for automatic and semi automatic tests. Optical design, adjustment procedures and the software part of the *Potsdam Fiber Testbench* (PFTB) are introduced.

The testbench and measurement procedure is shown to produce highly repeatable results. First preliminary measurements of prototype IFUs for the VIRUS/HETDEX project (1) show the need of extensive tests for prototyping **and** quality control in such a large project, comprising of a total of more than 130 single IFU units.

*Key words:* Optical fibers, focal ratio degradation

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## 1 Introduction

Much effort has been made to measure the properties of optical fibers since they first were used in astronomy. Among others two main optical properties are of central interest for the design of optical systems containing fibers: **Transmission** and **focal ratio degradation** (FRD). This article will mainly deal with the second item and only marginally discuss transmission properties of the integrated light emerging the fiber exit of two prototype IFUs.

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[1] All measurements were carried out at the Astrophysikalische Institut Potsdam (AIP) with support from M.M.Roth, E.Popow, T. Fechner, A.Kelz and other AIP staff members.

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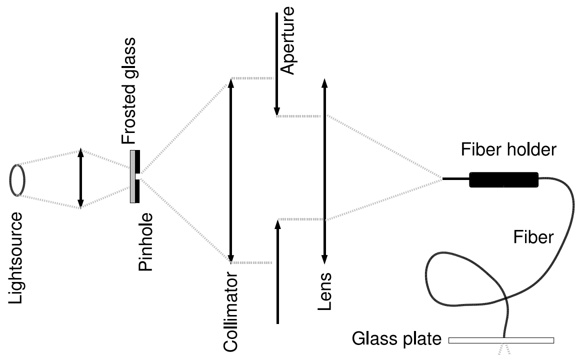

Fig. 1. Optical path of the Potsdam fiber testbench.

There are in general two approaches to measure the FRD of an optical fiber. The first one uses a collimated laser beam that is coupled into the fiber under a certain input angle $\theta_{in}$ and measures the position and shape of the ring shown at the fiber exit side. (See for example (2).)
The second way to measure FRD is to illuminate the fiber entrance with a light cone of given f-ratio (thus angle) and measure the f-ratio of the emergent beam at the fiber end. This method is closer to the practical astronomical use of the fiber where it is usually fed by the incoming beam of the telescope and can also be used to simulate central (or any) obscuration. This approach is used for example by (3) and (4)and will be followed in this analysis.

## 2 The Potsdam fiber testbench

The optical path of the testbench is shown in Fig. 1. The principal of the setup is close to the one of (3).

### *2.1 Hardware and fiber alignment system*

The experiment consists of 4 main parts: A continuum light source, the collimator – aperture – lens system, the fiber holder section, and the camera. A 12V bulb, driven by a stabilized laboratory power supply serves as light source. The central part, consisting of collimator, aperture wheel (containing 10 apertures reaching from $f = 2 \cdots 12$) was taken from the experiment described by (4). The fiber holder section consists of a three axis Newport linear drive system together with a manually adjusted tip-tilt plate holding the fiber end in a stress-free assembly. A $6.8\,\mu$ pixel size Kodak KAF-3200E chip, operated at room temperature and controlled by an AIP-built control electronics serves as camera system.

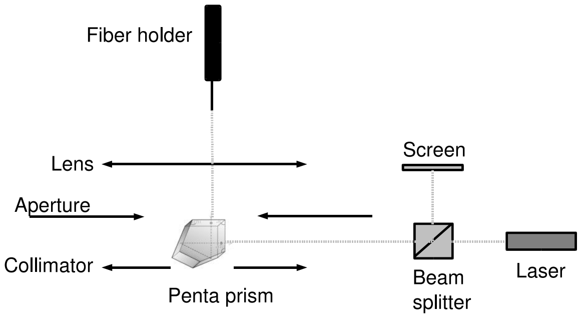

Fig. 2. Fiber entrance alignment system.

The fiber input is aligned using the laser system shown in Fig. 2. By ensuring that the reflected light from the fiber entrance takes the same path as the original beam we adjust the fiber parallel to the optical axes of the system.

### *2.2 Software*

Aperture wheel, camera controller and fiber input positioning system are controlled and operated from an IDL-programme making use of the `spawn` command to access shell commands and scripts.

There are three operational modes for the test: **Single fiber:** One fiber is manually adjusted and automatically exposed for all apertures. **IFU manual:** The fibers of an IFU are manually brought to the input beam and automatically exposed. **IFU automatic:** Only 2 (over edge) positions of a regular IFU are adjusted by hand. Knowing the system geometry the software calculates the exact position of every fiber and does the whole test fully automatically.

## 3 First results

First results without immersing the fiber to the camera entrance window – which seems to improve significantly on FRD – show the following:

### *3.1 Repeatability*

Figure 3 (left) shows three measurements of one fiber that was completely removed, turned around, reinserted, and readjusted after each exposure series. It shows that each exposure gives practically the same result.

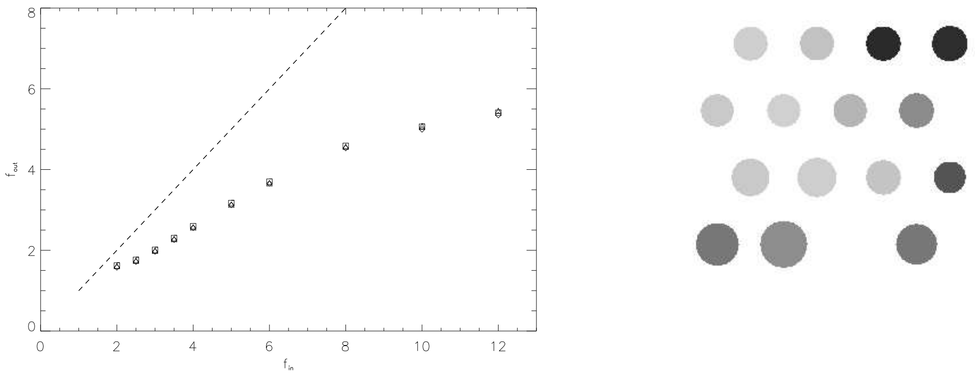

Fig. 3. Left: Same fiber adjusted and measured three times. Right: 4 × 4 test IFU. One fiber in the bottom row is broken.

### *3.2 FRD and throughput*

Figure 3 (right) indicates the absolute transmission and FRD properties of our first test IFUs. The size of the spots corresponds to the size of the outgoing light cone, the greyscale code of the spots indicates total transmission (white = high, black = low).

Two facts hit the eye when looking at Fig. 3 (right). First, the low throughput in the upper right corner of the $4 \times 4$ IFU prototype. This is due to remaining glue on the fiber input side. Second, the relatively low throughput and large degradation of the bottom line of fibers. This was the first row to be glued into the drilled IFU mask and obviously got stressed during the process of feeding the individual fibers through the mask and fixing them with glue. This confirms the idea of surrounding the fibers of an IFU with one or two layers of dummy fibers to protect the optically used fibers from stress at the border of the IFU or during the production process.

## References

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