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LIBS COLLECTION OPTICS: COMPARATIVE ANALYSIS OF DIFFERENT MIRROR-BASED CONFIGURATIONS

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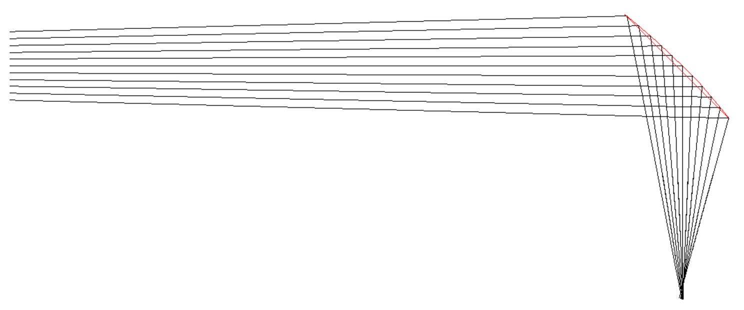
We have evaluated the efficiency of different reflection based optical systems using numerical simulation. We have realized and started testing the most promising one.

Introduction

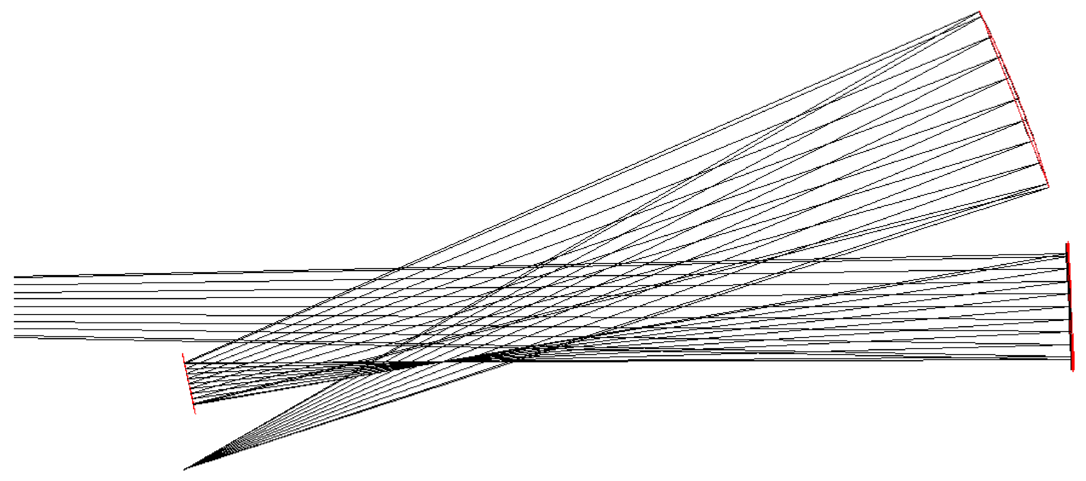
Analysis of organic compounds by means of **LIBS** (Laser Induced Breakdown Spectroscopy) usually requires to collect the plasma emitted light over a **broadband spectrum** (typically ranging from 200 nm to 900 nm). As known, when operating over such a wide spectrum, refraction based optical systems exhibit a **strong chromatic aberration**, due to high chromatic dispersion in the deep UV region. Since achromatic doublets and triplets are very expensive and the aperture is usually small, we have evaluated the possibility of utilizing **reflection based optical systems** (that do not suffer from chromatic aberrations) instead of lenses.

Set-up requirements

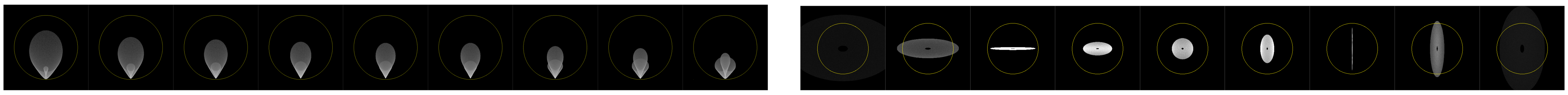
The object of our study is a LIBS system that has to operate in field with a **moving sample** (like e.g. a mineral ore transported over a conveyor belt). Since in this case the **object distance can vary from shot to shot**, the collecting optics should have a **depth of field** large enough to collect an almost constant signal over the explored region**.** To maximize the energy fed into the optical fiber utilized for bringing the signal into the spectrometer, the system should create an **image** of the emitting region **smaller then the fiber core** (namely 600 um) with a **NA** lower than the fiber one. As a further requirement, the apparatus should be as small as possible.



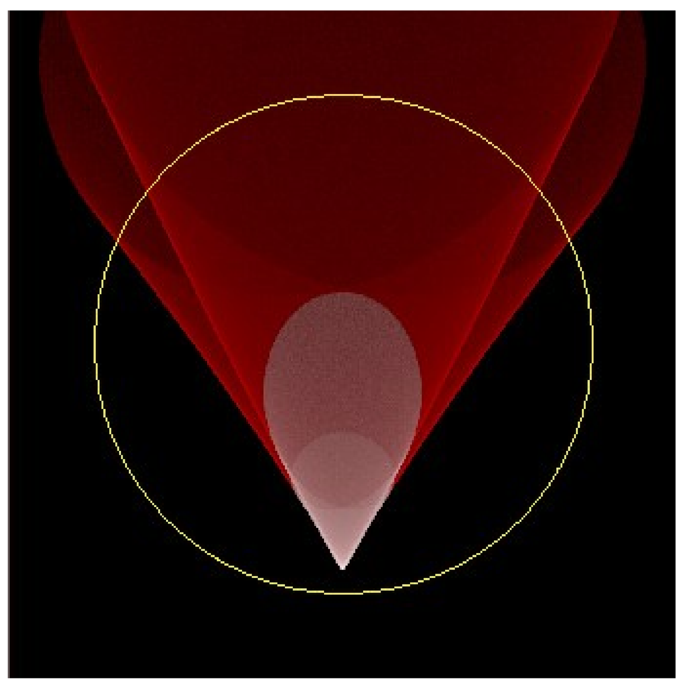
Schematic representation of the set-up using the parabolic mirror: we used a 2" holed parabolic mirror with a parental focal length of 4". The light source is far on the left



Ray tracing relevant to a setup based on the use of a holed 2" mirror and a 3" mirror, both with equivalent focal length of 8". A third 0.5" flat mirror is used in order to reduce the apparatus size. The light source is far on the left



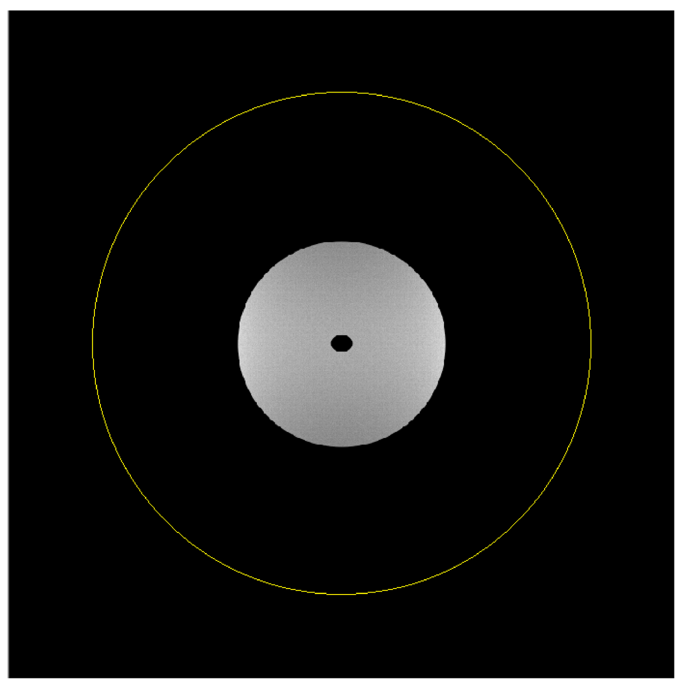
Simulation of the image produced by a point light source on the fiber's face, taken for different distance of the source from the mirror: only the collected light is represented. The yellow ring represent a 600um core fiber. On the left, the simulation for the parabolic mirror, on the right the simulation for the spherical mirrors set-up. The image are taken for the following distances, from left to right: 90cm, 95cm, 97cm, 99cm, 100cm, 101cm, 103cm, 105cm, 110cm.



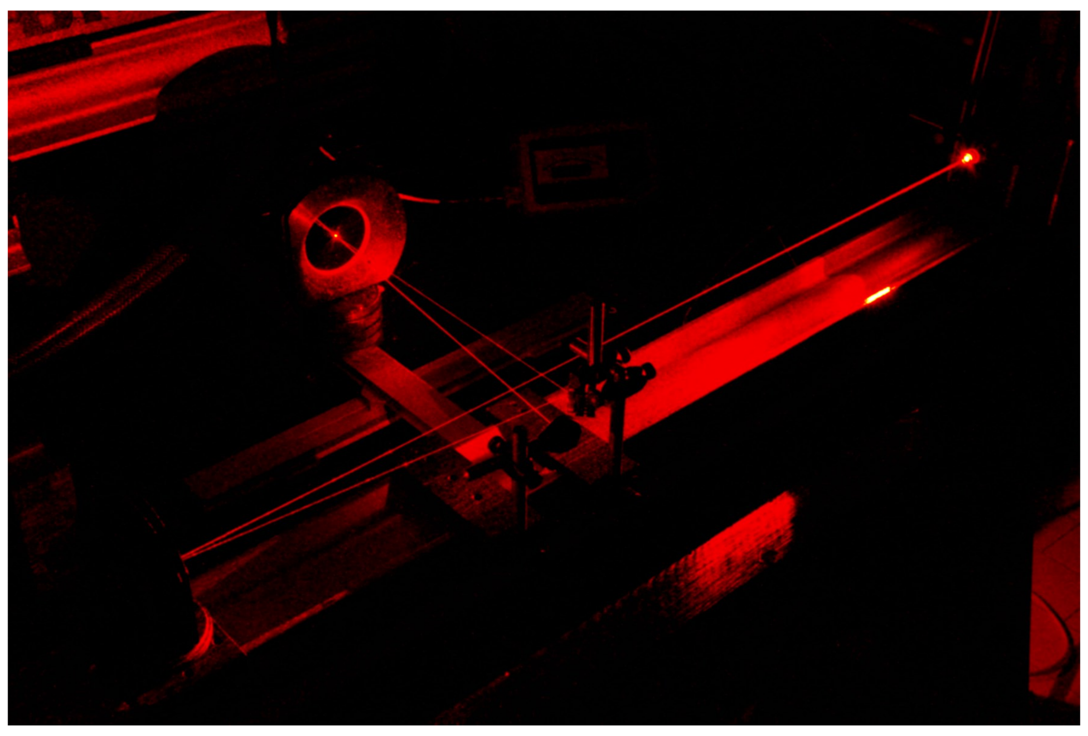
Simulation of the light spot on the fiber face generated by a point light source at 1m from the mirror: in white the collected light, in red the fraction discarded due to limited NA of the fiber

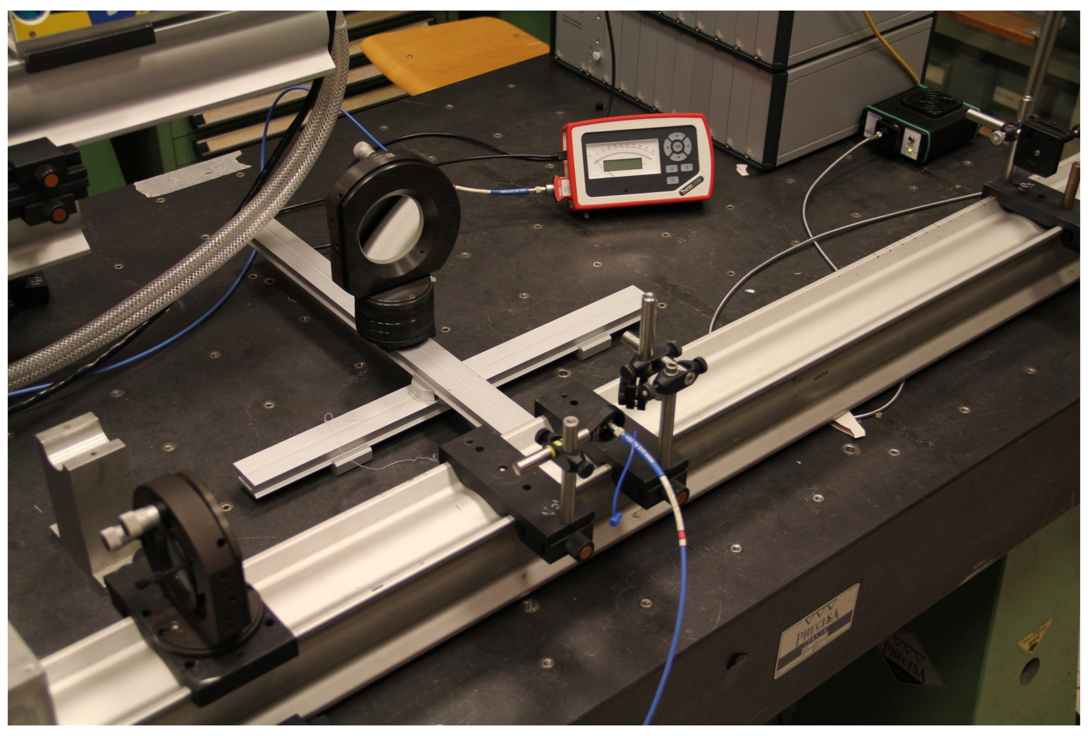
The simplest configuration is based on the use of a single holed off-axis parabola. Ray tracing shows a **good uniformity of the collected intensity** but a **low collection efficiency**. In fact, most of the light is lost because of the limited optical fiber NA. The collection volume (measured as the FWHM) is about 30 cm long and 3mm wide. The calculated maximum collection efficiency (given by the ratio between the power emitted by a point like source and the collected power) is about 3.7e-5.

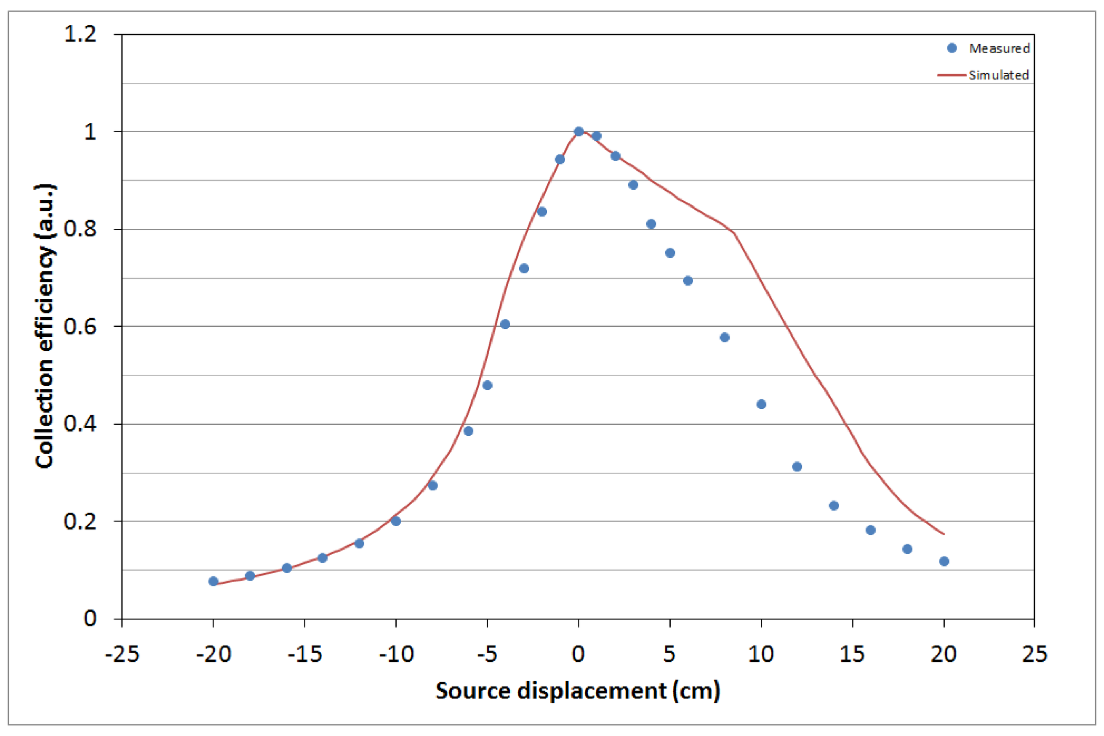
The second set-up we have considered is based on the use of two spherical mirrors with the same curvature radius. A third plane mirror is introduced in order to reduce the overall system length. This configuration avoid the coma aberrations (typical of parabolic mirrors) and correct the spherical aberrations, but is strongly astigmatic. The collection volume is about 17cm long and 2.5mm wide while the expected maximum collection efficiency is 1.1e-4



Calculated light spot on the fiber input face due to a point like source positioned at 1m from the first mirror. In this configuration no light is lost due to fiber's NA.







We tested experimentally the second set-up by means of a 200um core optical fiber, a spectroscopic lamp as light source and a power meter to measure the output signal. We found some differences between the measured data and the calculated ones. This is probably due to misalignments between the mirrors and the collection fiber. Further investigations are required.

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