5. Fundamentals of Measuring LAM Machines

INTRODUCTION

Recently, a new emerging technology of metal 3-D printing or LAM (Laser Additive Manufacturing) is recognized as the new advantageous process for metal parts manufacturing. For this application, lasers play a significant role since they can focus large amounts of energy on a wide range of material powders, fusing the particles into 3-D parts. Important laser and machine optical parameters need to be analyzed in order to insure repeatable and excellent results. The LAM process is based on a layer-by-layer construction, wherein each layer is selectively fused on top of each other until the part is a finished product. Although many technologies are involved in making an LAM machine, this tutorial will concentrate in laser critical parameters and their measurements for better performance. Today, most lasers for 3-D printing machines are based on fiber optics high power technologies in conjunction with an optical scanning head for effectively placing the laser beam at the necessary locations.

PARAMETERS TO BE MEASURED

The most important parameters affecting the machine performance will then be: focus spot width and location, focal shift, centroid location, absolute power and the real time measurement of laser dynamics. Duma offers a measurement instrument that will perform these measurements in real time using knife-edge or camera systems technologies. Moreover, for ensuring precise measurements, the instrument has a special optical beam path design which is calibrated to the beam location at its fusing surface. To allow fitting the system into tight spaces, the system dimensions are minimal and in such a way that it can be integration as a part of the LAM machine.

MEASUREMENTS MADE EASY

The LAM Beam Analyzer is designed to enable exact positioning over the point to be measured by providing a reference hole on its bottom. Beams striking the input aperture will focus exactly on the surface layout where the instrument is stationed on. Laser beam position in 3 axes – X, Y and Z, will be displayed in real time relative to the reference hole. To complete required measurement parameters, the beam profile will be measured at this exact same location to yield a real time full test

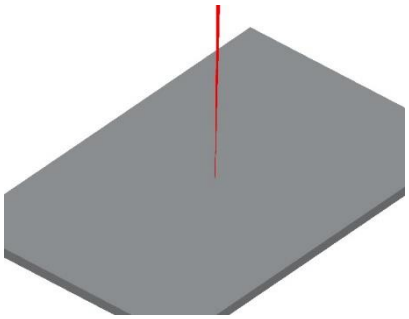

Figure 1

diagnostics.

Figure 1 shows in a schematic way a focused beam designed to focus on the top plane. For quality assurance of laser beam performance, we'd like to measure the laser beam characteristics as follows: power, position & profile. In order to do so, the instrument will be accurately positioned at the point of interest – this is facilitated by a reference hole on the instrument's bottom, which exactly represents the measuring point of the instrument.

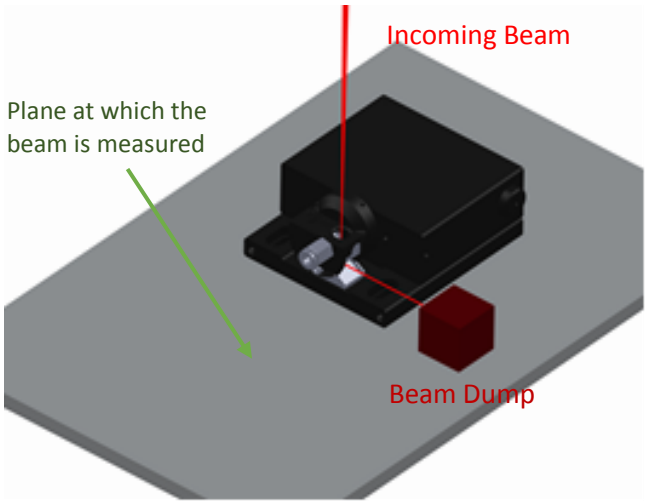

Figure 2

Figure 2 shows the instrument mounted on the point of interest on top of the plane, performing the necessary measurements. The ray trace design is such that the incident beam is sampled as if its position is exactly at the plane's incident point.

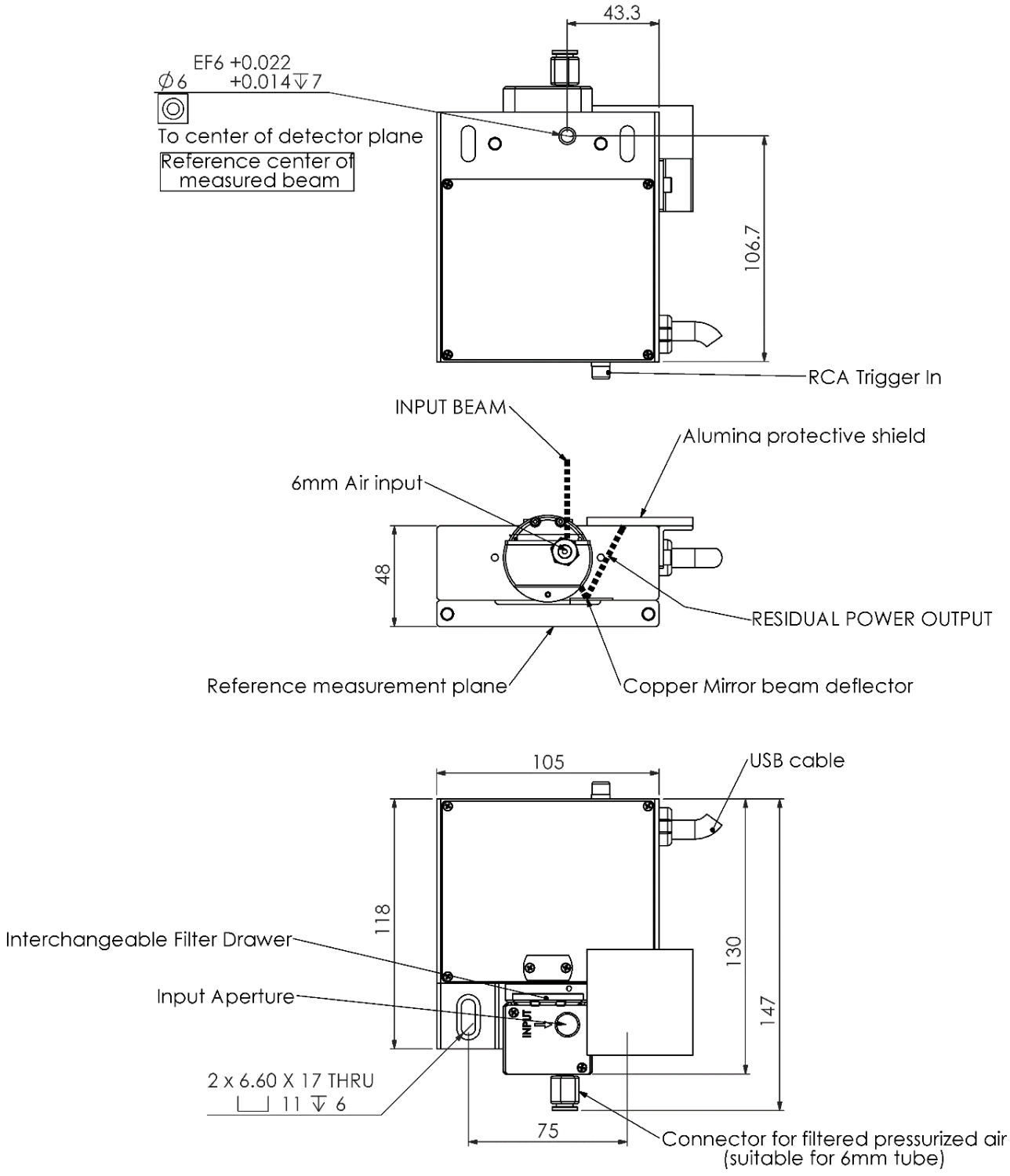

Figure 3

Figure 3 is a detailed drawing of LAM Beam Analyzer, featuring a built-in beam dump, where the residual power output is directed to a copper mirror beam deflector, which in turn deflects the beam to a specially designed alumina protective shield, which absorbs the power. This arrangement will allow momentary measurements of a few seconds of all relevant parameters. The input aperture will accept a beam of about 8 mm maximum. Care should be taken when applying high power to be within the accepting aperture, it will be a good practice to use the visible marker in order not to miss input aperture and not cause any damage. Built-in pressurized air cooling should be used with 5-8 atmospheres standard filtered air. This will actively

cool the input aperture while blowing away dust particles to prevent harmful build-up on optical elements. Please note that the reference center pin hole is provided in the bottom of the instrument and is perfectly concentric with the 0;0 position of the detector. Moreover, measuring plane of the detector coincides with the system bottom plane as per drawing. Besides the LAM Beam Analyzer, the company offers LAM U3 which performs similarly but has a camera detection system. With this system you can also align the center of the marking laser to be coincident with the high-power direction. This is achieved by a special dichroic filter which allows visible light to pass while attenuating the high-power IR radiation. This filter is provided with the system and is mounted or removed using the interchangeable filter drawer.