Improved Experimental Setup for the Read Out of Superheated Emulsion Bubble Detectors

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Abstract

An improved experimental setup for the counting and 3D localization of bubbles has been designed and constructed for the accurate read out of superheated emulsion bubble detectors. Since 1979, bubble detectors have found use in dosimetry, radiation alarms, and potentially nuclear warhead verification. Droplets suspended in a gel matrix undergo a phase transition when struck by high-energy neutrons in the detectors and are easily counted using optical methods. However, at high fluence the accuracy of counts is reduced due to occultation.

Motivation

Currently, our group uses images of a rotating detector to localize and count bubbles far past the occultation limit [1]. To improve the precision of localization and to reduce the time needed to read detector output, upgrades have been made to the control algorithm and setup of the bubble counter. Instead of capturing single-frame images, high-resolution videos of the rotating detectors are taken using a DSLR camera controlled by a Raspberry Pi. This new experimental setup allows for more precise placement of its components, lighting, and rotation, improving the reproducibility of experimental results. Additionally, the new setup provides a more user-friendly control interface and is contained in a compact enclosure.

Setup

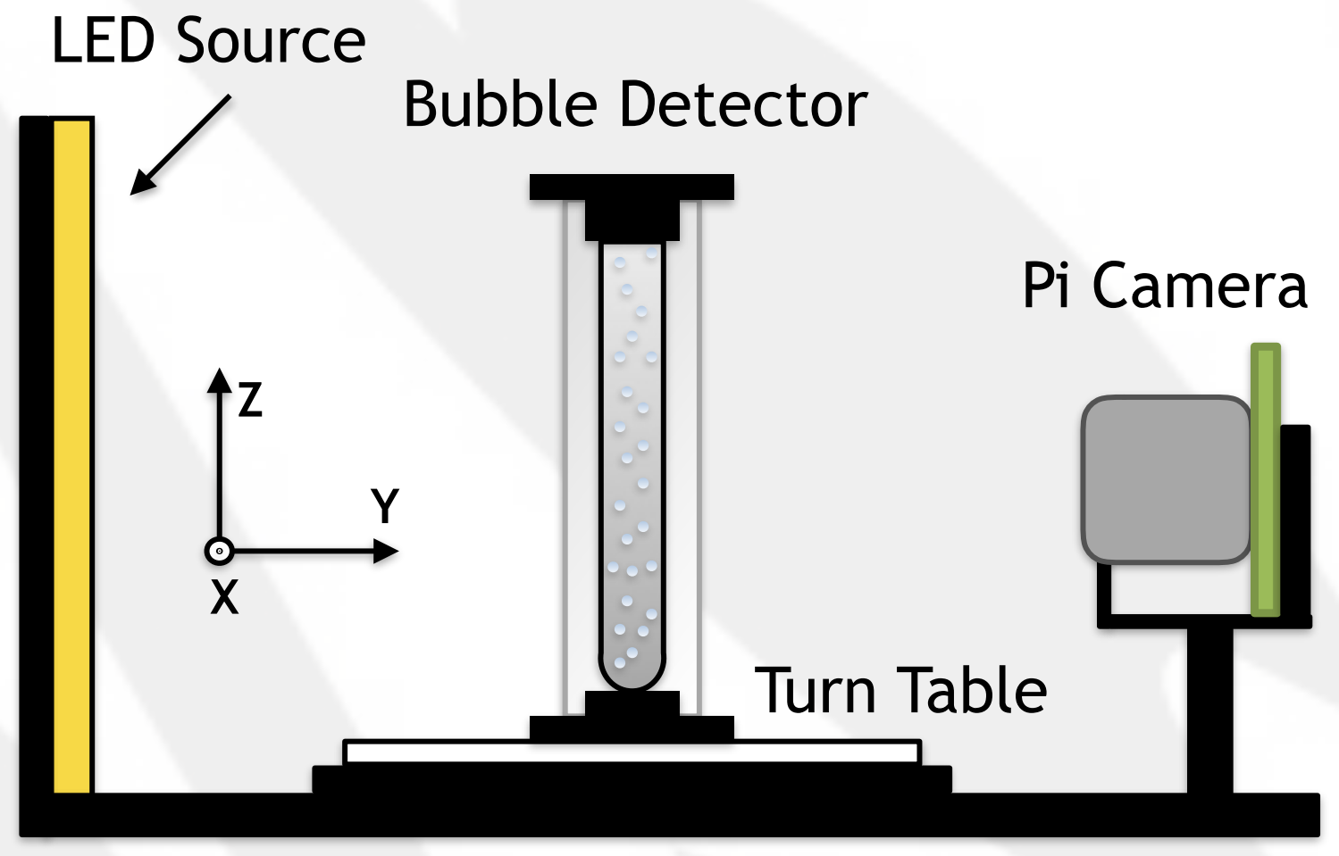

Figure 1: Side view diagram of original bubble detector setup shown in Fig. 2.

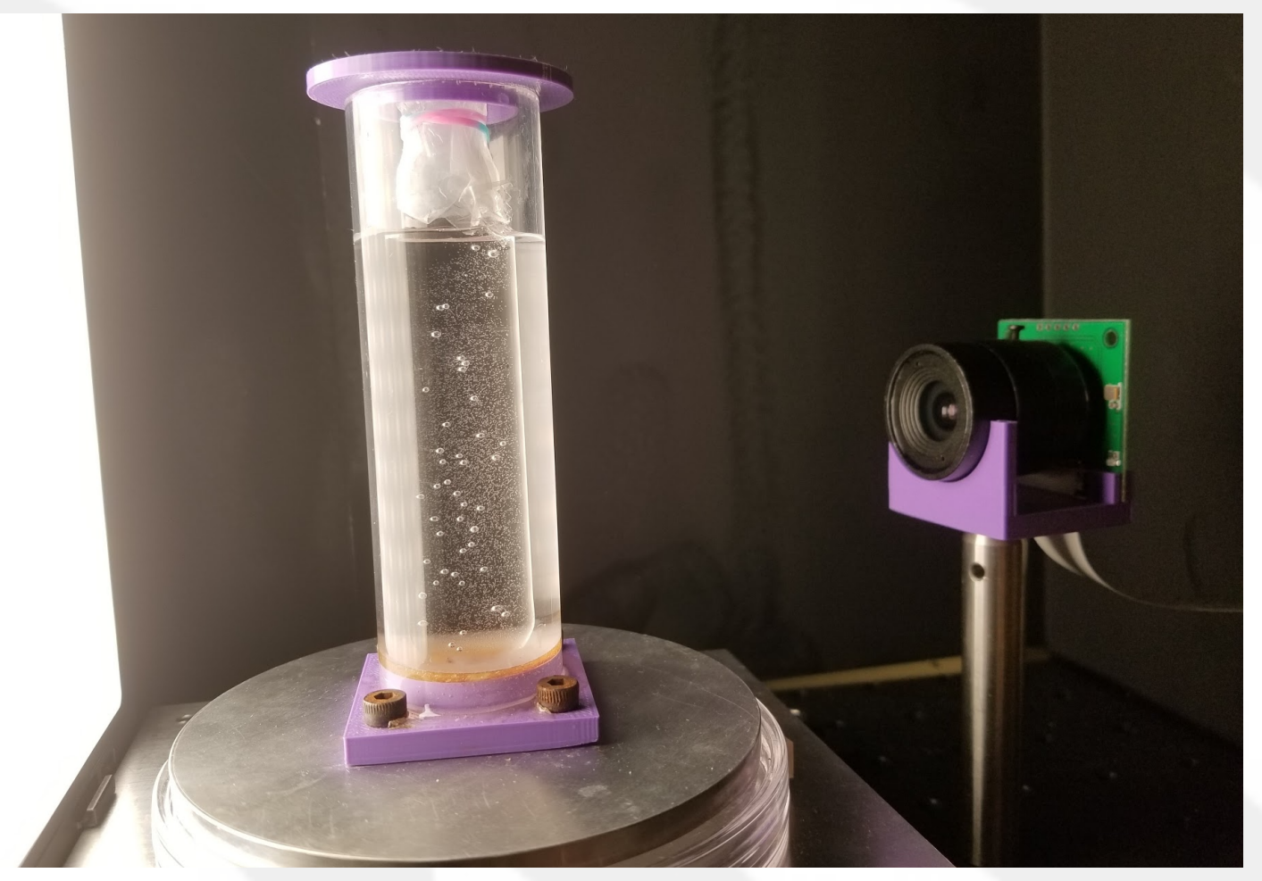

Figure 2: Image of the original bubble detector setup. Taken by M. Hepler.

Figs. 1-2 display both a picture and schematic of the original setup of the bubble detector which includes the following:

- LED Source
- Bubble Detector
- Turn Table
- Raspberry Pi Camera
- Stepper Motor

Figs. 3-4 show a schematic and picture of the newly designed version of the bubble detector. Placed inside an aluminum based enclosure, this improved setup includes the following new components:

- T-Rail System
- LED Indicator
- DSLR Camera
- Lab Jack
- Glass Tube
- Light Diffuser
- Framing
- Metal Base

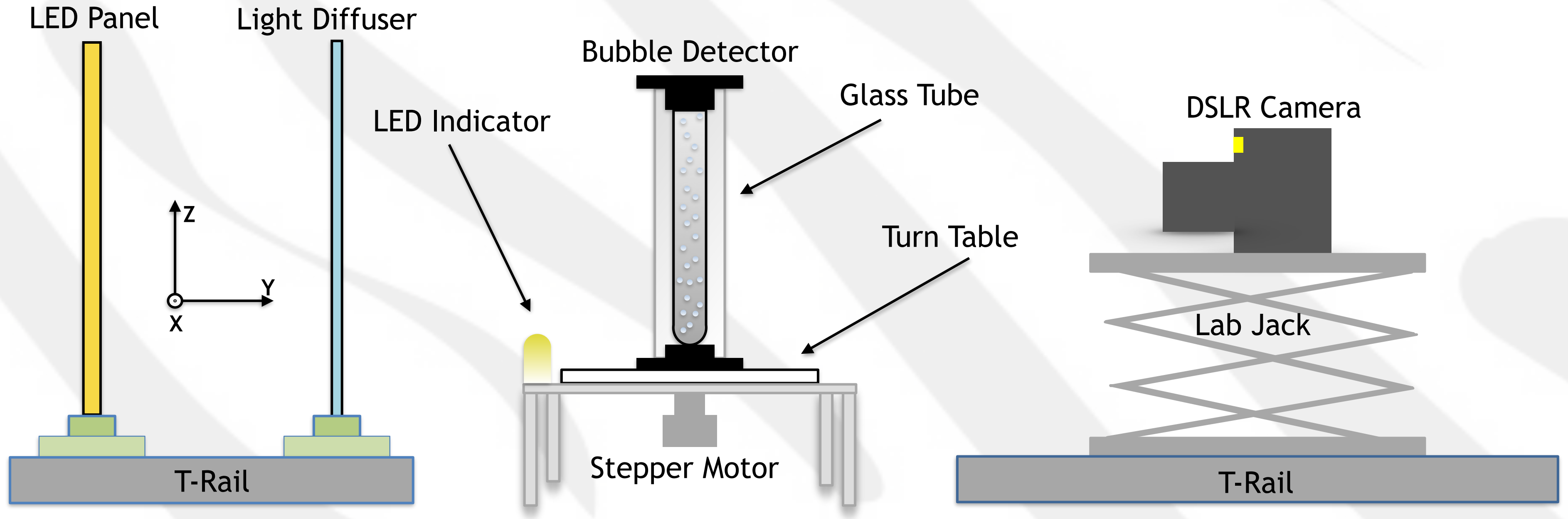

Figure 3: A side view diagram of the newly constructed bubble detector.

Upgrades

The new bubble detector design setup, shown in Fig. 3, which is being constructed improves upon the following:

- Reproducibility of results
- Maneuverability of parts
- Quality of videos and photos
- Precision of localization
- Time consumption of read out
- Accessibility of controls

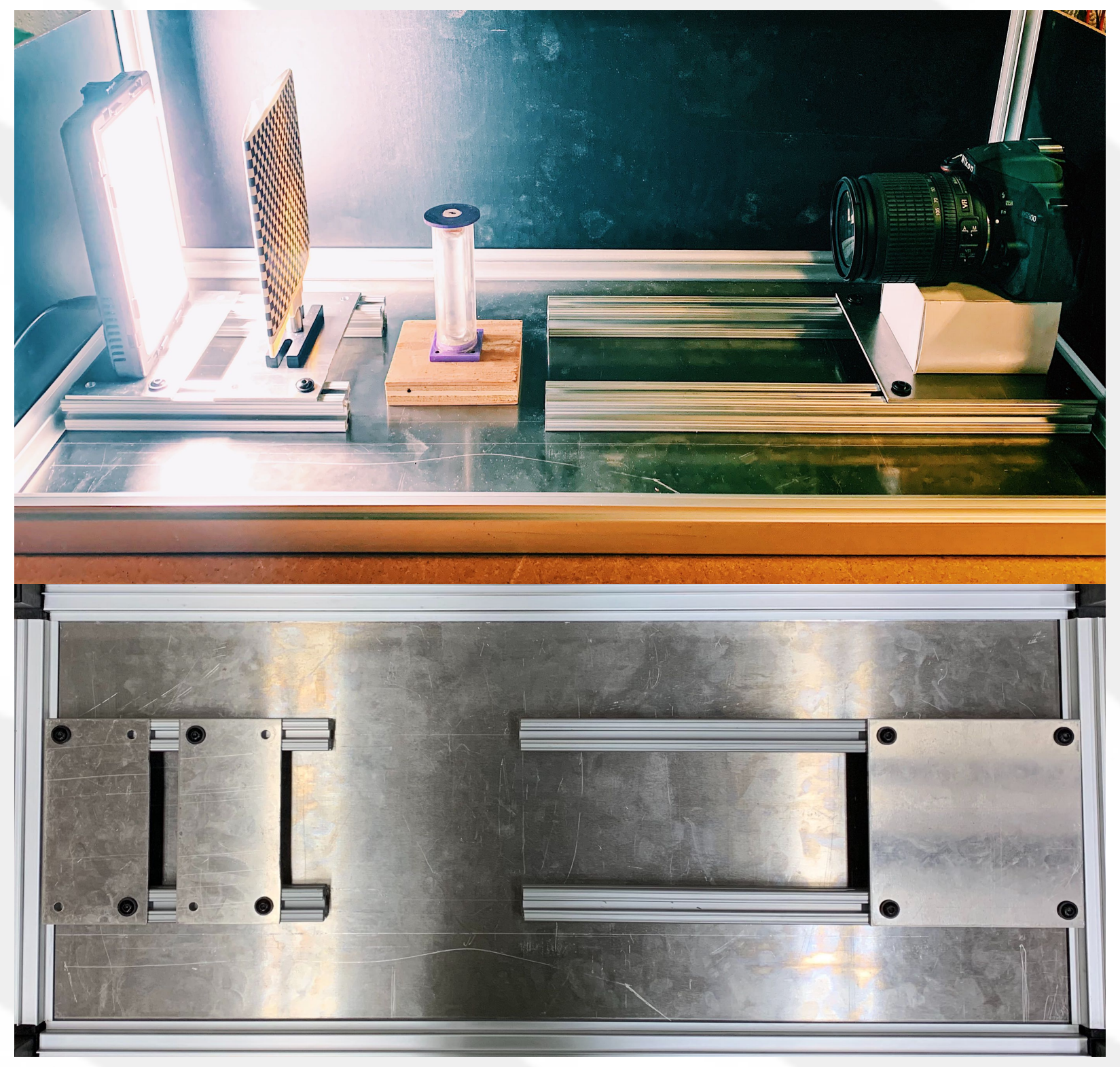

Figure 4: Top: Side view image of newly constructed design. Bottom: Aerial view of newly constructed base.

Applications

As previously stated, there are many uses for bubble detectors, including dosimetry and radiation alarms [2]. However, it has recently been applied in zero-knowledge nuclear warhead verification [3]. When verifying a highly-classified object, it is important to be able to verify the functioning of all components. Currently, electronic methods of recording neutron flux are prone to tampering and spoofing. Nobody trusts electronics because it's easy to build back doors and fake results. This is why bubble detectors, droplets in a gel matrix that interact with high-energy neutrons, are relevant. They are a completely analog method of measuring neutron flux, their physics is well-understood, and they can be compressed and examined without revealing secret information. Thus, they help to build trust during an inspection process.

Future Work

For the read out of superheated emulsion bubble detectors, an improved experimental setup has been designed and fabricated. All the parts of the improved design have been milled and machined. Each component is being put together, as shown in Fig. 4, based on previous schematics. Looking ahead, the code and camera that captures video to extract frames based on LED indication needs to be integrated into the enclosure. From there, a new user-friendly interface must be added into the setup as well. Once this has been complete, trials with the new design enclosure, interface and components can begin with the upgrades.

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