# B87 The Roles of Projectile Energy and Apparel Fabric Damage in Assessing the Magnitude of Long-Range Shooter Distances

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**Learning Overview:** The goal of this presentation is to show how the relationship between projectile energy and fiber end morphology can be used to assess muzzle-to-target distances in long-range shooting incidents.

**Impact on the Forensic Science Community:** This presentation will impact the forensic science community by demonstrating a link between projectile energy and apparel fabric damage and by demonstrating the value in microscopic observation of fiber end morphology for forensic determination of long-range shooter distances.

In most short-range shootings, muzzle-to-target distance is determined via Gunshot Residue (GSR) using colorimetric assays such as the sodium rhodizonate or Modified Griess test or by scanning electron microscope to detect lead, barium, and antimony particles. However, at distances where little to no GSR is found on evidentiary items, these methods become unsuitable. In many such firearms-related homicides, the projectile perforates one or more articles of the victim's clothing. Through careful examinations of these bullet-perforated fabrics, critical information regarding the shooter's distance can be uncovered.

Observed morphologies of the fabric, yarns, and fibers of apparel textiles are commonly used to determine the type of weapon used in the commission of a crime. These include changes to yarn spacing at the fabric level, degree of fraying or melting of the yarn ends at the yarn level, and pushing, shearing, tearing, or cutting of individual fibers at the fiber level. When the damage has been found to be caused by a bullet, those same observations can be utilized to approximate the bullet's energy. Morphological factors at these three levels will vary distinctly with input energy. Bullet holes will show less uniformity, yarns will show an increased degree of fray, and individual fibers will show a smaller magnitude in shearing with increased tearing and pushing of fibers when projectile energy has been significantly decreased.

The longer a projectile travels through the air, the more it will be slowed by air drag. The kinetic energy of a projectile, proportional to its velocity squared, therefore continues to decrease the longer the projectile is in flight. Long-range projectiles thus will have lower energy levels at the target than their short-range counterparts. Furthermore, the terminal velocity, along with manufacturer data such as muzzle velocity, can mathematically determine an approximate muzzle-to-target distance.

The hypothesis of this research rests on these two axioms: (1) as input projectile energy decreases past a threshold energy level, the observed fabric and fiber damage will show distinct morphologies, and (2) projectile energy loss can approximate the long-range distance of the shooter. If both of these axioms hold true, then there must exist one or more threshold distances beyond which the observed morphologies of bullet holes in apparel fabrics are distinguishable from those within that distance. This will create an opportunity for approximated long-range shooting reconstruction to feature prominently in casework.

Various shooter distances were simulated at an indoor range. Shots were fired at swatches of seven different fabrics from distances of 1m, 3m, 5m, and 10m. A fraction of the gunpowder in the cartridges was removed at 5m and 10m in an attempt to decrease the muzzle velocity, which decreased the energy imparted to the fabrics. This decreased energy transfer simulates the projectile having traveled further than 10m and decelerating more due to air drag. Downloaded cartridges contained 90%, 75%, and 60% by mass of the manufactured gunpowder inside the cartridge. The seven fabrics consisted of a cotton t-shirt, cotton jeans, polyester blouse, polyester athletic shorts, cotton/polyester blended t-shirt, men's button-down shirt, and sweatshirt materials. Thickness and weave-pattern construction were varied among the sample population as well. Stereo microscopy was employed to study fabric and yarn level damage, and polarized light microscopy was employed to study fiber level damage.

By understanding the link between projectile energy at the time of fabric perforation and observed morphologies in apparel fabrics and fibers, the forensic scientist can determine for investigators whether the shooter was near or far from the victim when the shot was fired, which can aid in scene reconstruction as well as evaluation of conflicting accounts.

**Fibers, Fabric, Projectile Energy**