ANSI/NIST-ITL Standard Workshop 2013

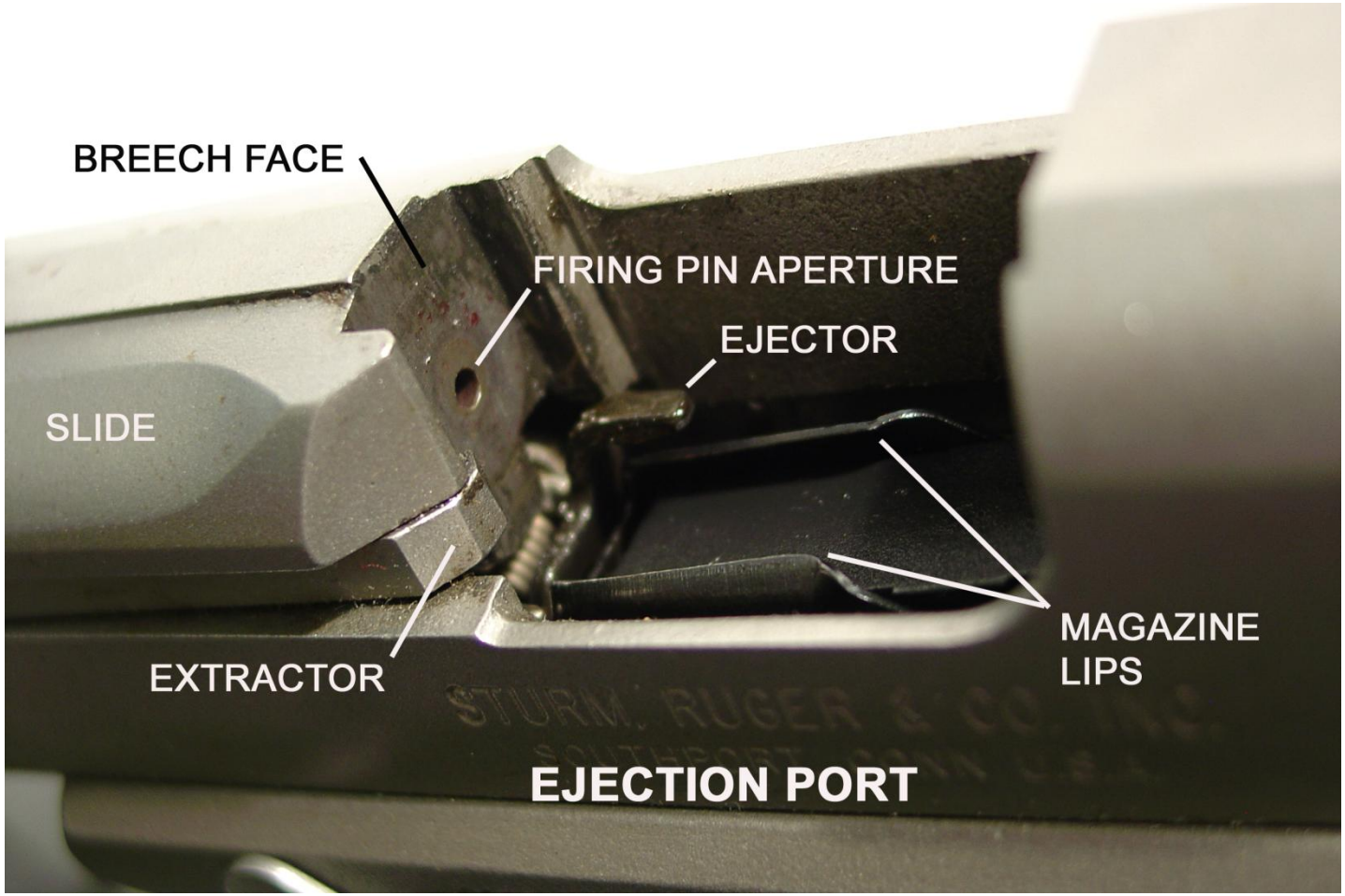
Firearm Evidence Surface Database; an Initiative Proposal

Robert M. Thompson
Program Manager – Forensic Data Systems

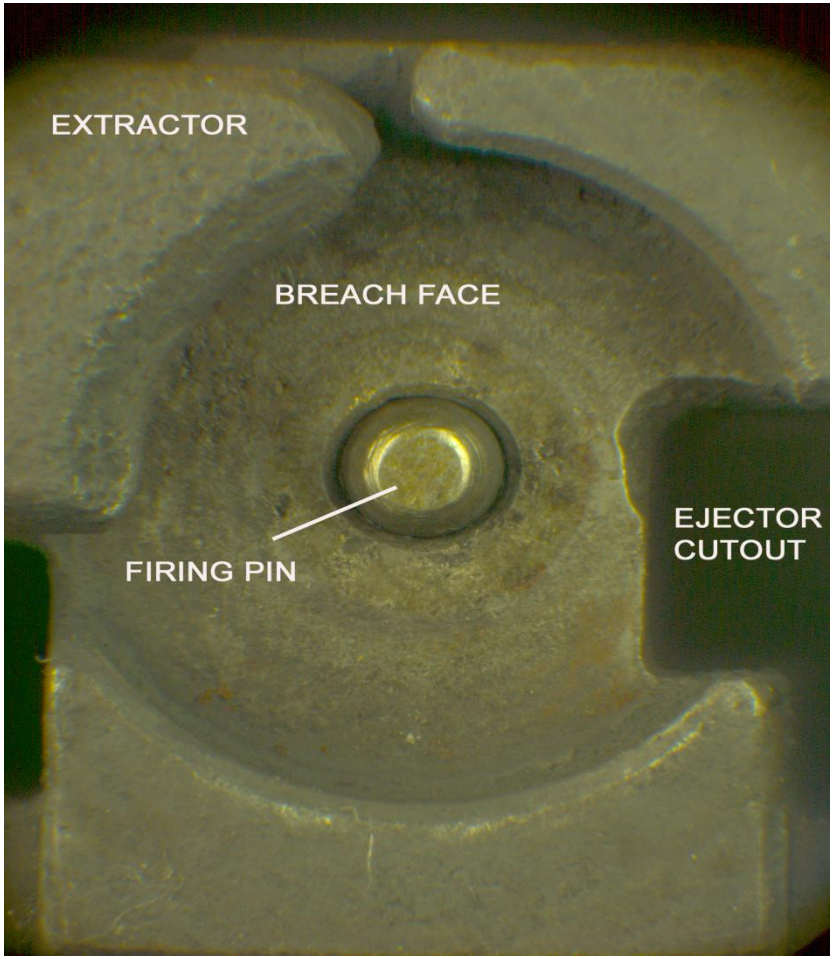
LAW ENFORCEMENT STANDARDS OFFICE

Firearm Evidence

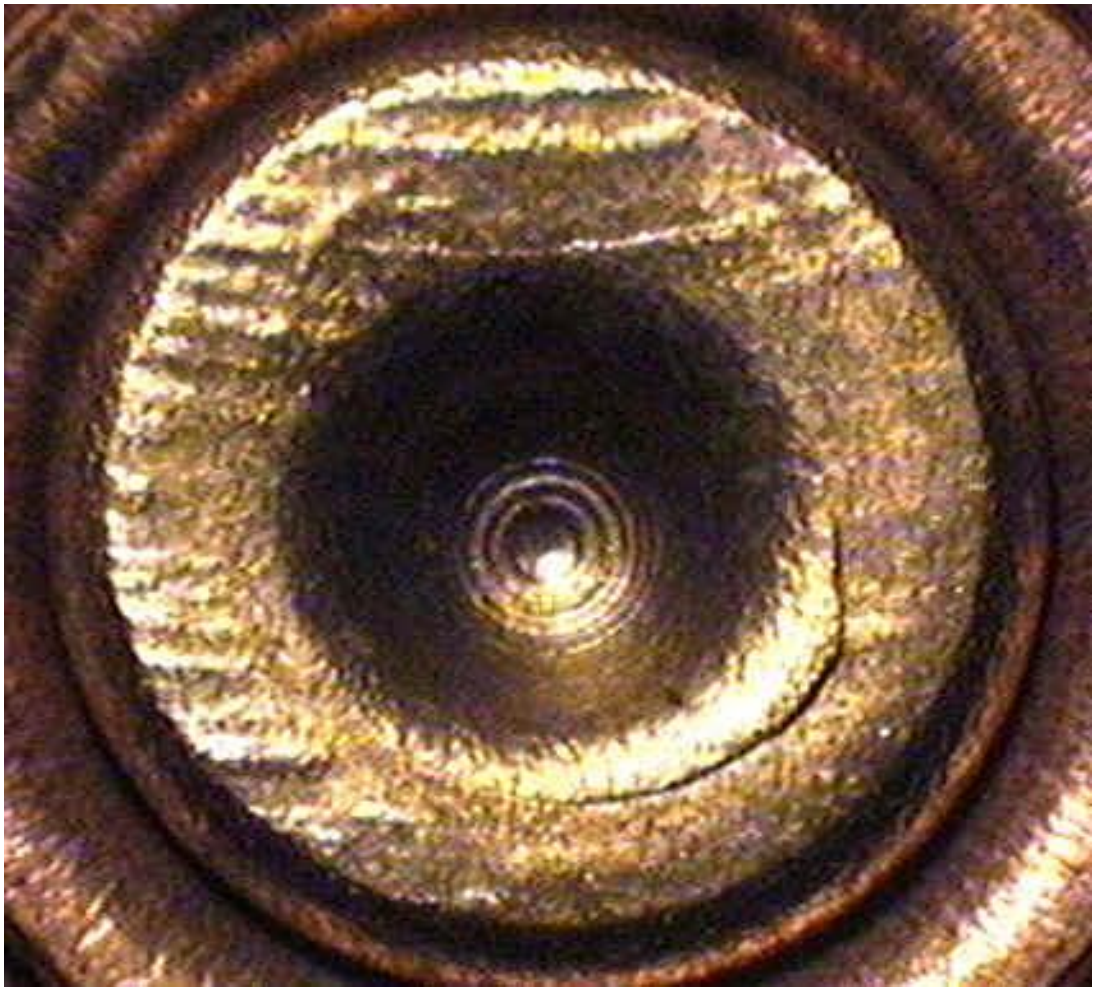
Source of Tool Marks



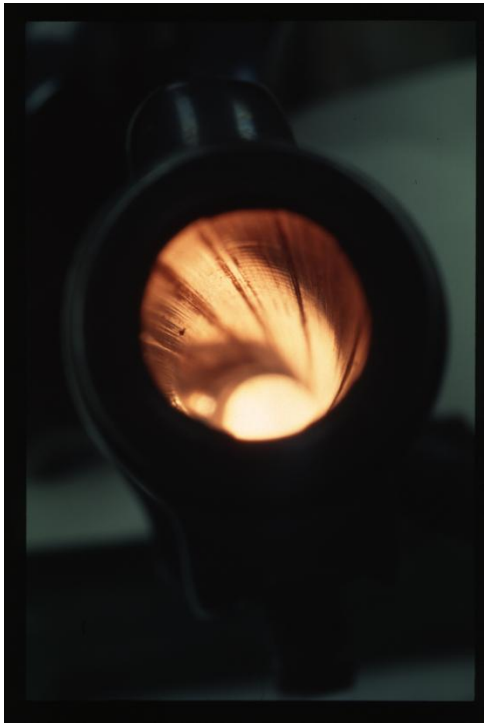
Source of Tool Marks

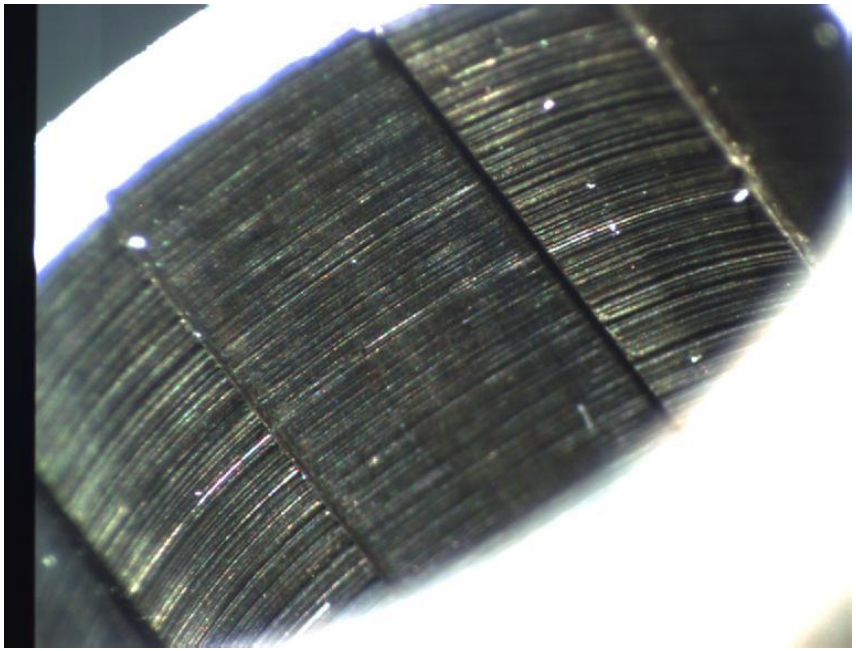


Breechface & Firing Pin Impressions



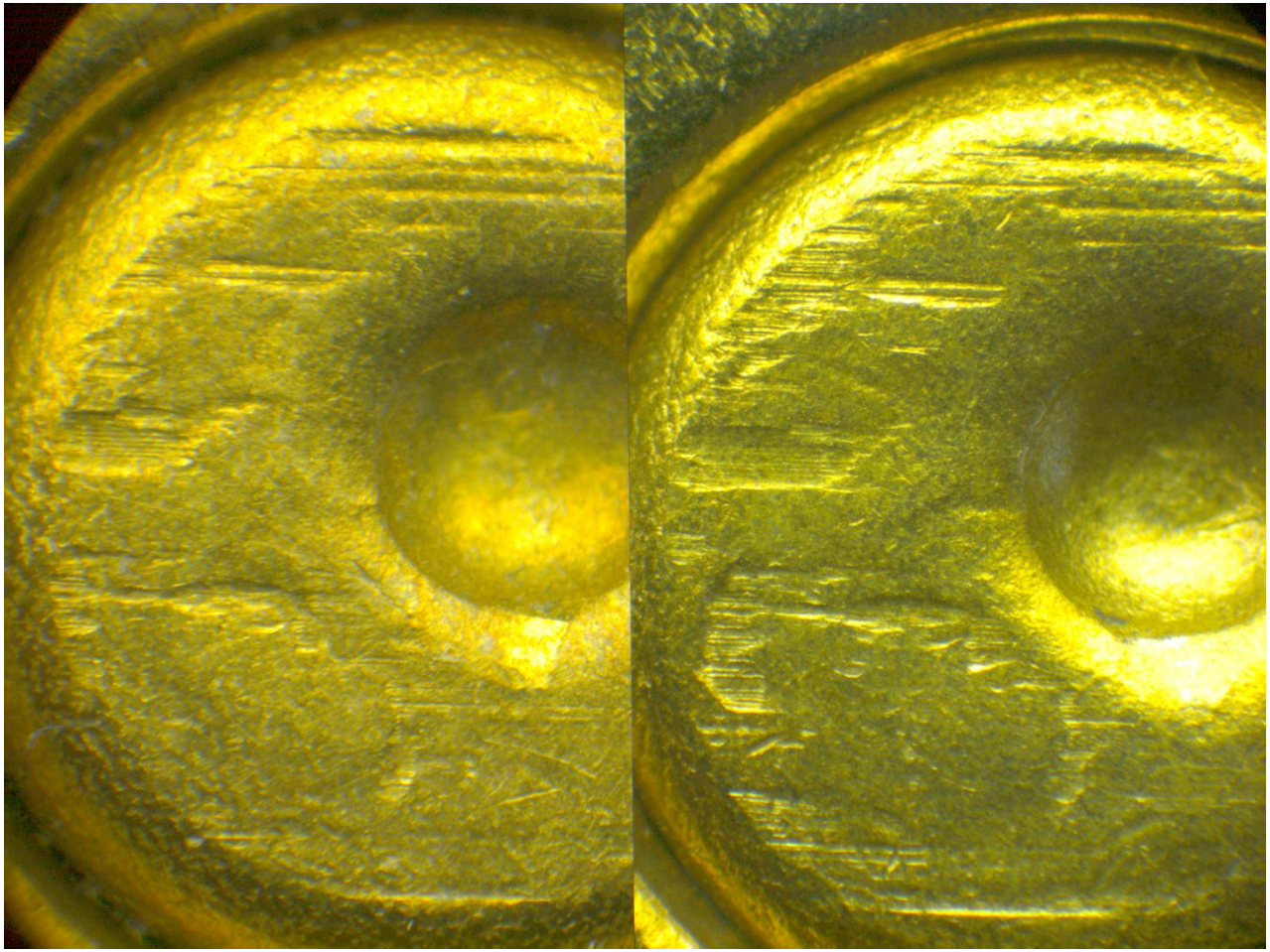
Rifling in Barrel



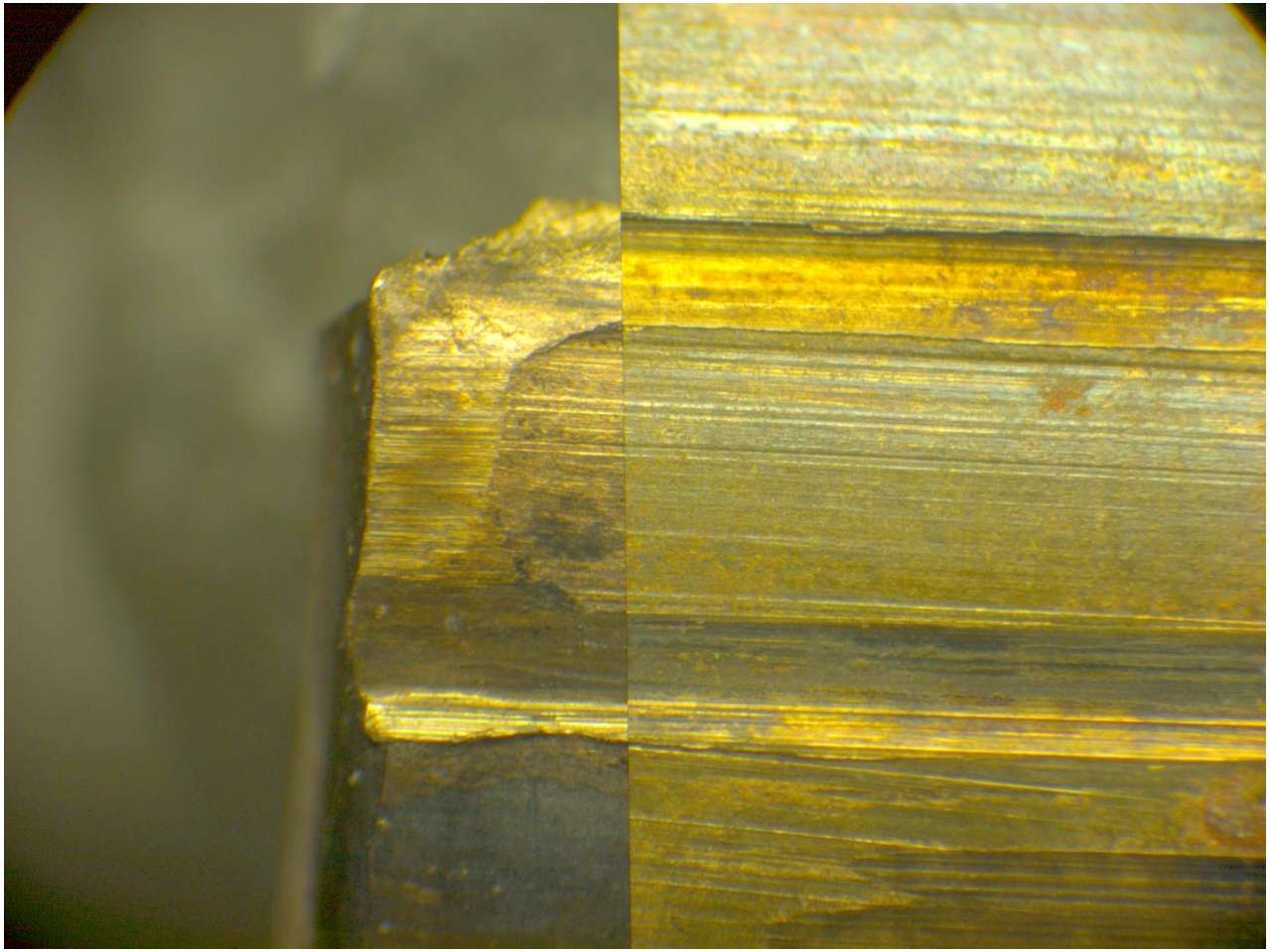


Barrel Rifling Engraving on Bullet

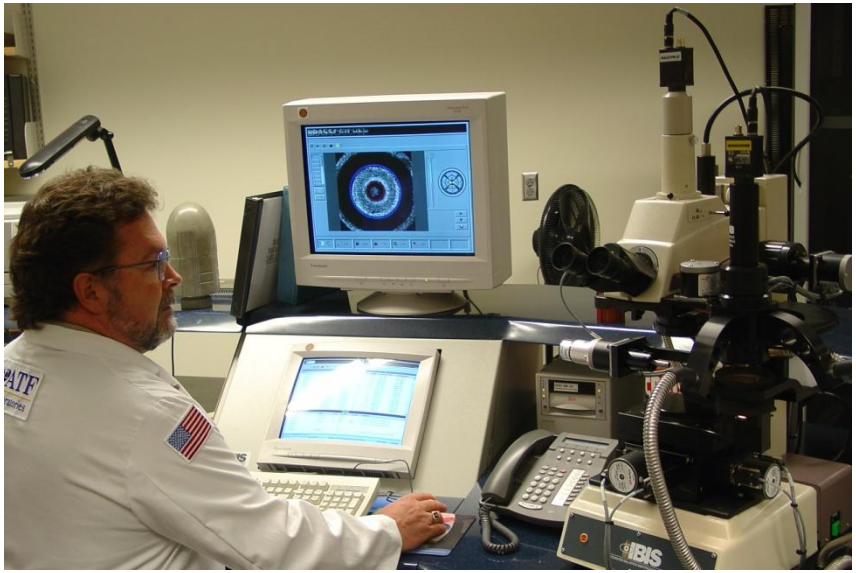
Cartridge Case Comparison



Bullet Comparison, One “Land” Engraved Area



Laboratory Examination & Ballistic Search Systems



Objective Criteria for Identification

NIST 3D Measurement System

Nanofocus Nipkow disk confocal microscope

Specifications:

- Measurement field: 800/320 µm
- for 20x and 50x lens.
- X/Y-Resolution: 1.5/0.6 µm.
- Z-Resolution: 20/10 nm.

Example of High Reproducibility of Topography Measurements

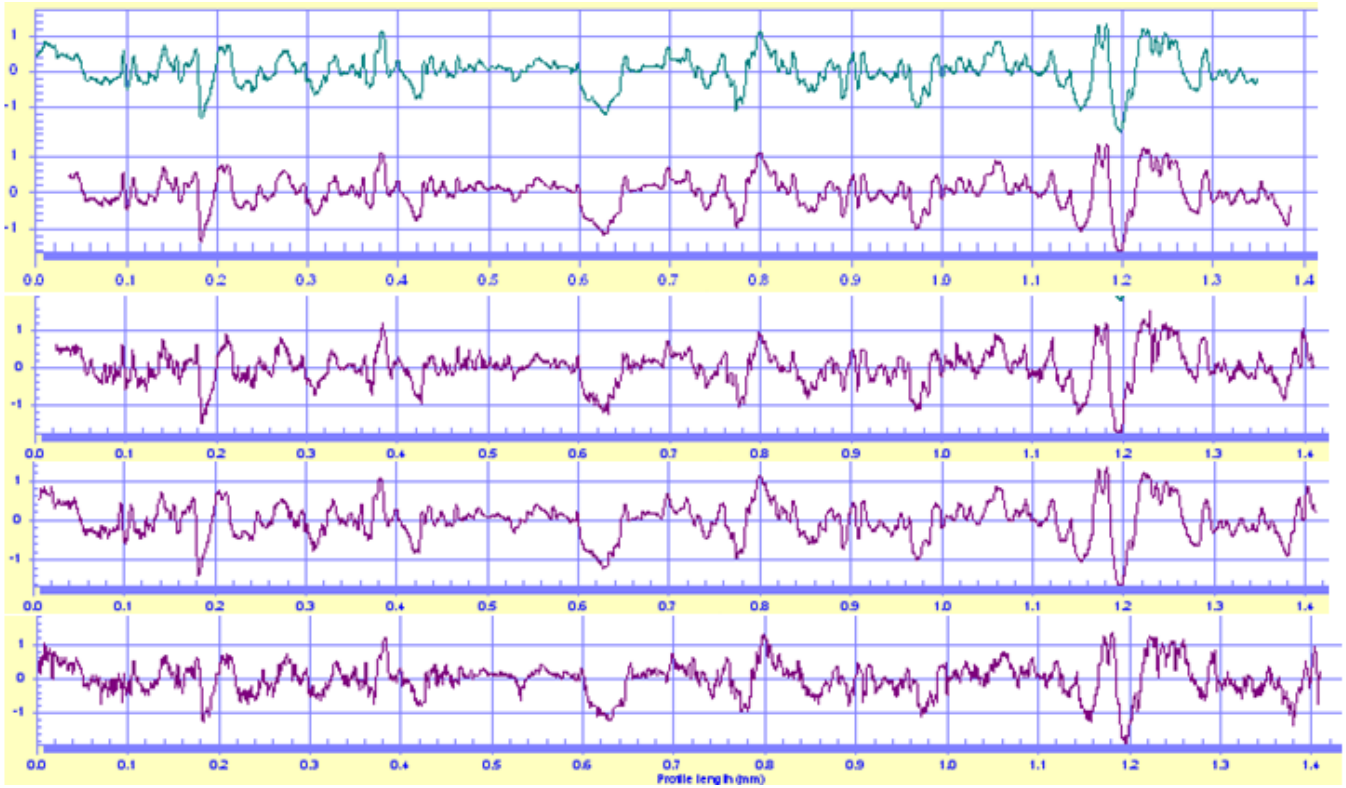
(1)

(2)

(3)

(4)

(5)



Measurement comparison of four techniques tracing the same SRM bullet:

(1) Virtual standard traced on a ATF master bullet used as a reference;

(2) Stylus instrument traces a SRM bullet: CCF_{max} = 99.6%;

(3) Interferometric microscope: CCF_{max} = 92.1%;

(4) Nipkow disk confocal microscope: CCF_{max} = 99.0%;

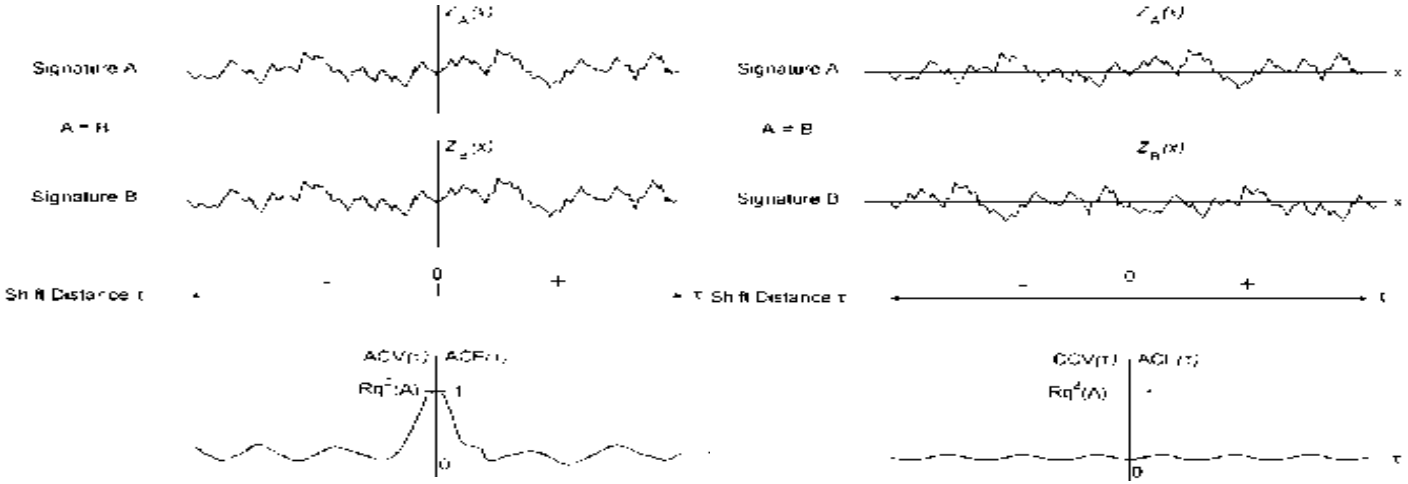
(5) Laser scanning confocal microscope: CCF_{max} = 95.3%.

Evaluation of the Similarity

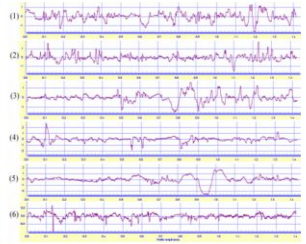
$$Rq = \left[\frac{1}{L}\int_0^L Z^2(x)dx\right]^{\frac{1}{2}} \approx \left[\frac{1}{N}\sum_{i=1}^{N} {Z_i}^2\right]^{\frac{1}{2}}$$

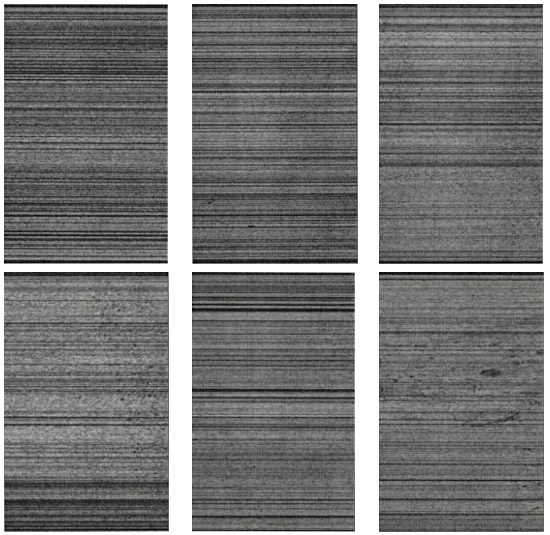
$$CCV(A,B,\tau) = \lim_{L\to\infty}\left(\frac{1}{L}\int_{-L/2}^{L/2} Z_A(x)Z_B(x+\tau)dx\right)$$

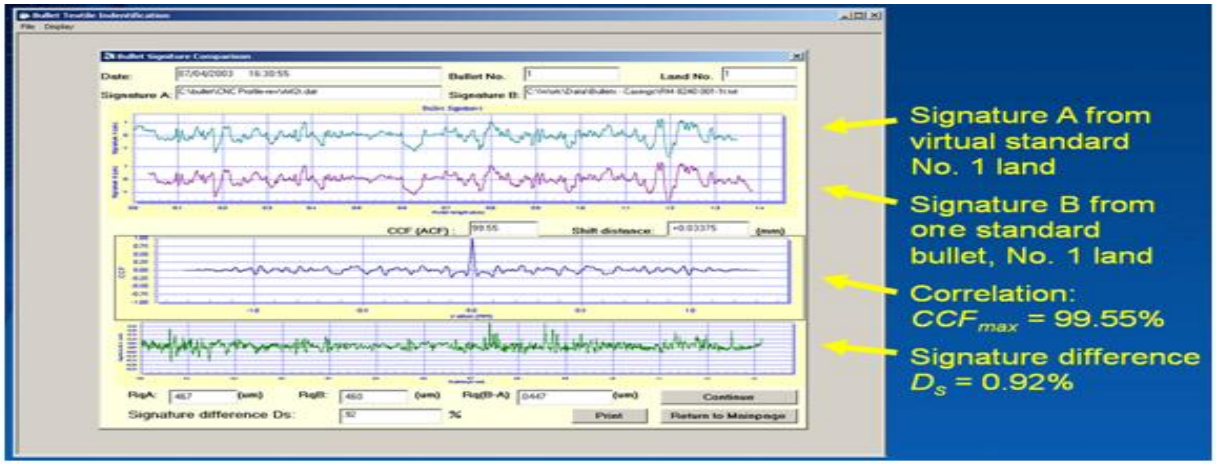
$$CCF(A,B,\tau) = \frac{CCV(A,B,\tau)}{Rq(A)Rq(B)}$$



Application of CCF in NIST Standard Bullet Comparisons





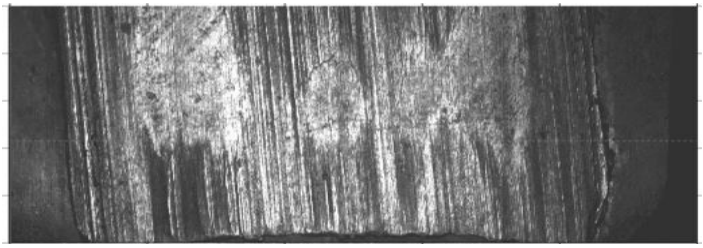


An example of CCF calculation result

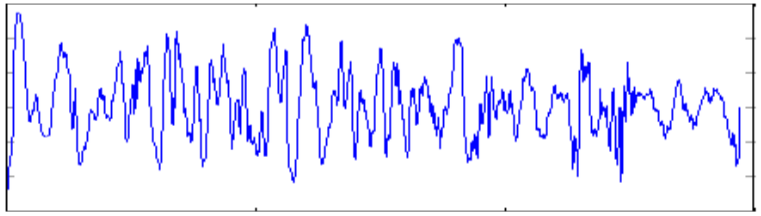
For Actual Bullets

Bullet signature

Data acquisition

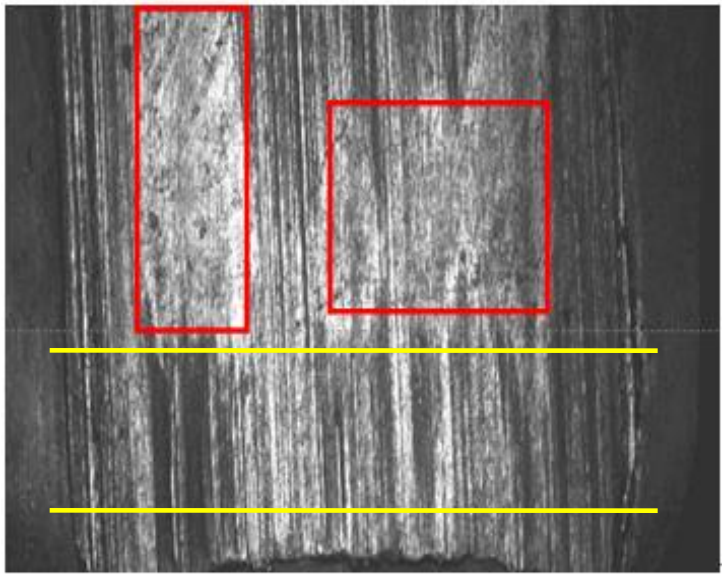


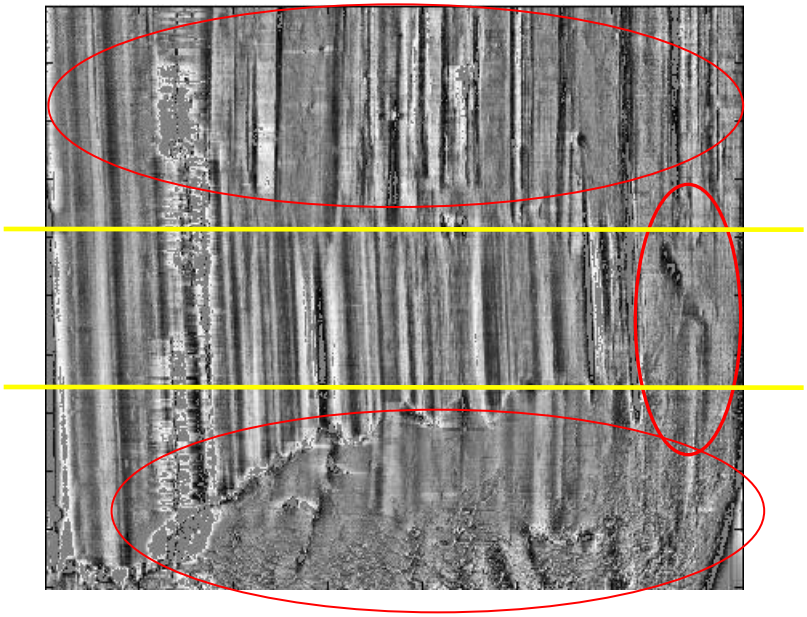
Processing



correlation

Selection of Valid Correlation Areas



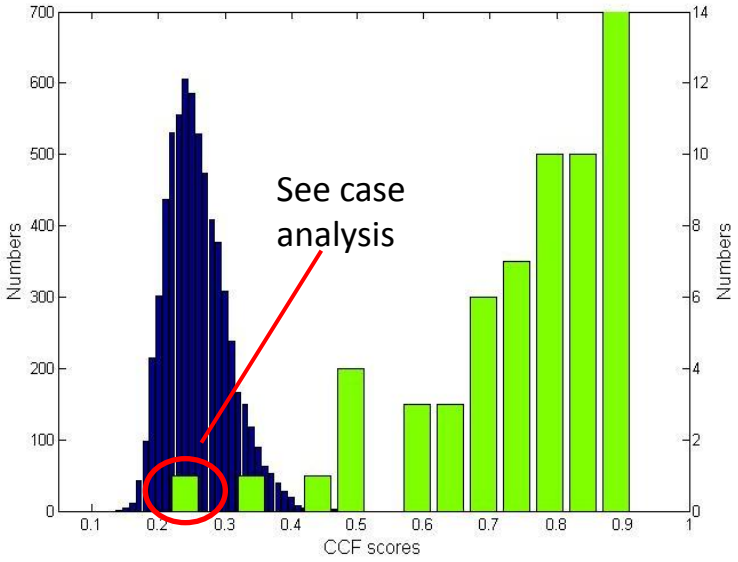


Land impression images may include areas that contain useless or wrong striation information (in red).

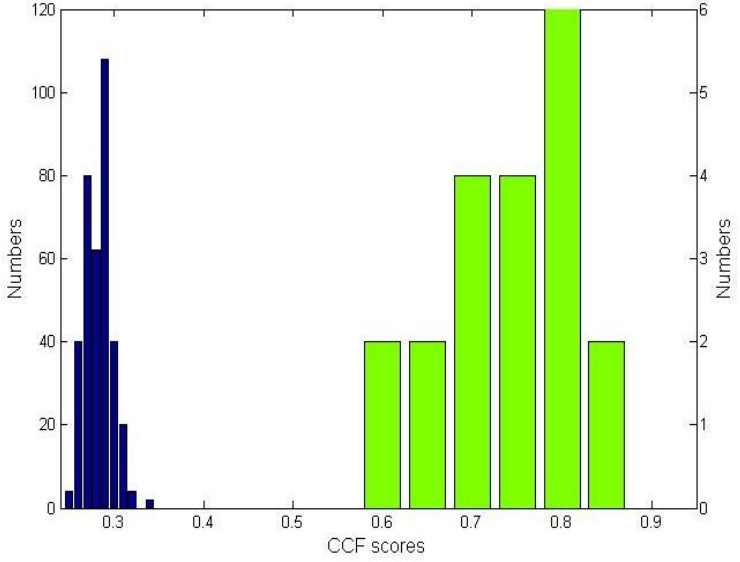
Question:

Can valid striated areas be intelligently distinguished from other invalid areas?

CCF Results



LEA comparison



Bullet comparison

Correlation values of all ten pairs of known-matching bullets scored highest on their correlation lists, yielding a correct identification rate 100 %.

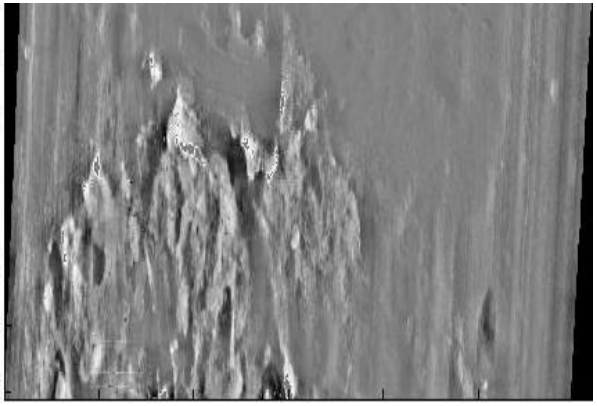
For 15 unknown bullets, all 30 pairs of matching bullets scored at the topmost position on their respective correlation lists. (Blind Test)

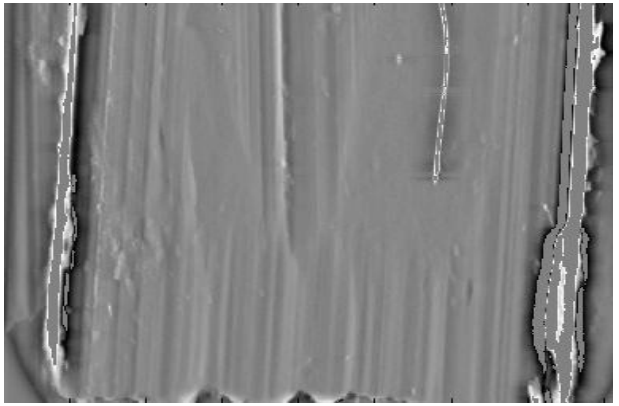
Case Analysis

There is only one comparison of matching LEA that did not have highest correlation score (22.85 %)

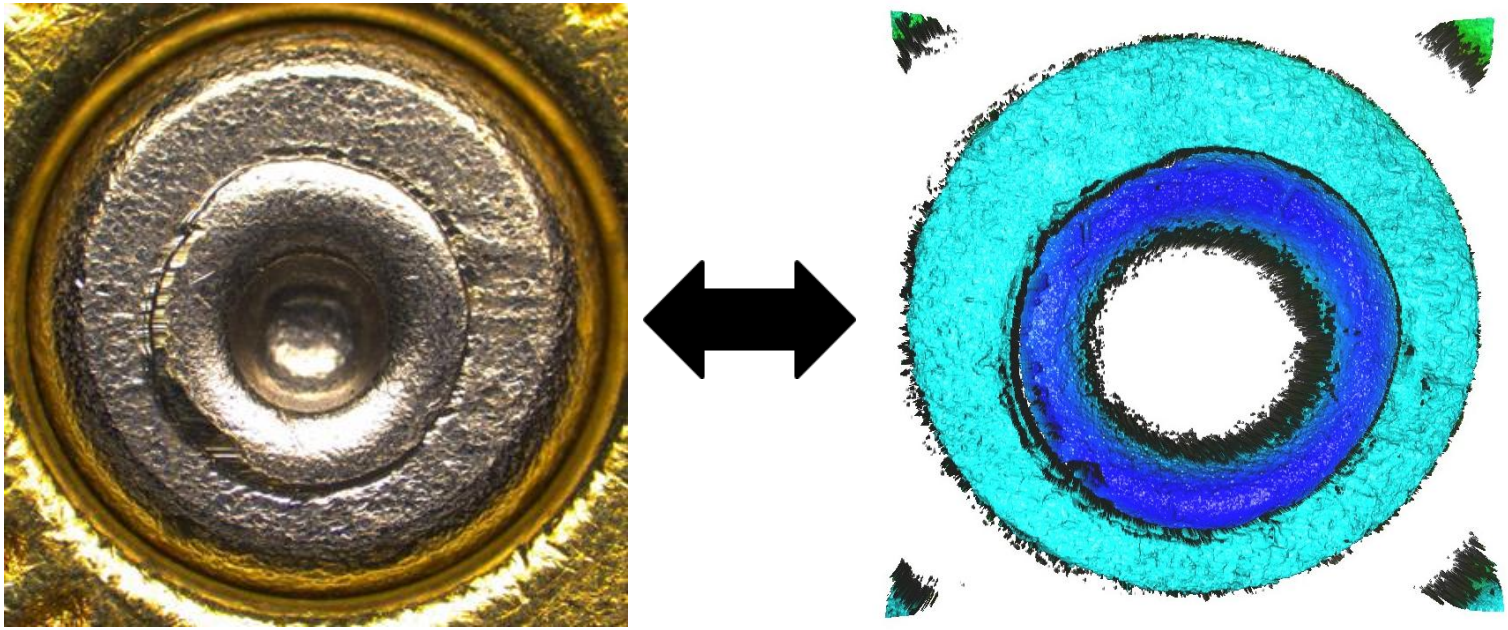
Confocal raw images; LEA to LEA comparison

Processing





Optical and Topography Data Files



Early Attempt for Standard Interchange

1996

The National Institute of Standards (NIST) in Gaithersburg, Maryland, was directed to provide technical assistance to assist with "ballistic imaging interoperability" between the DRUGFIRE and IBIS technologies.

1997

The ATF and the FBI agreed to make DRUGFIRE and IBIS® systems compatible. As a result, the National Integrated Ballistic Information Network Program (NIBIN) was established.

(NIJ/AFTE Training Module 2)

No Interoperability? FAIL!

- **As bullets fly, info doesn't**

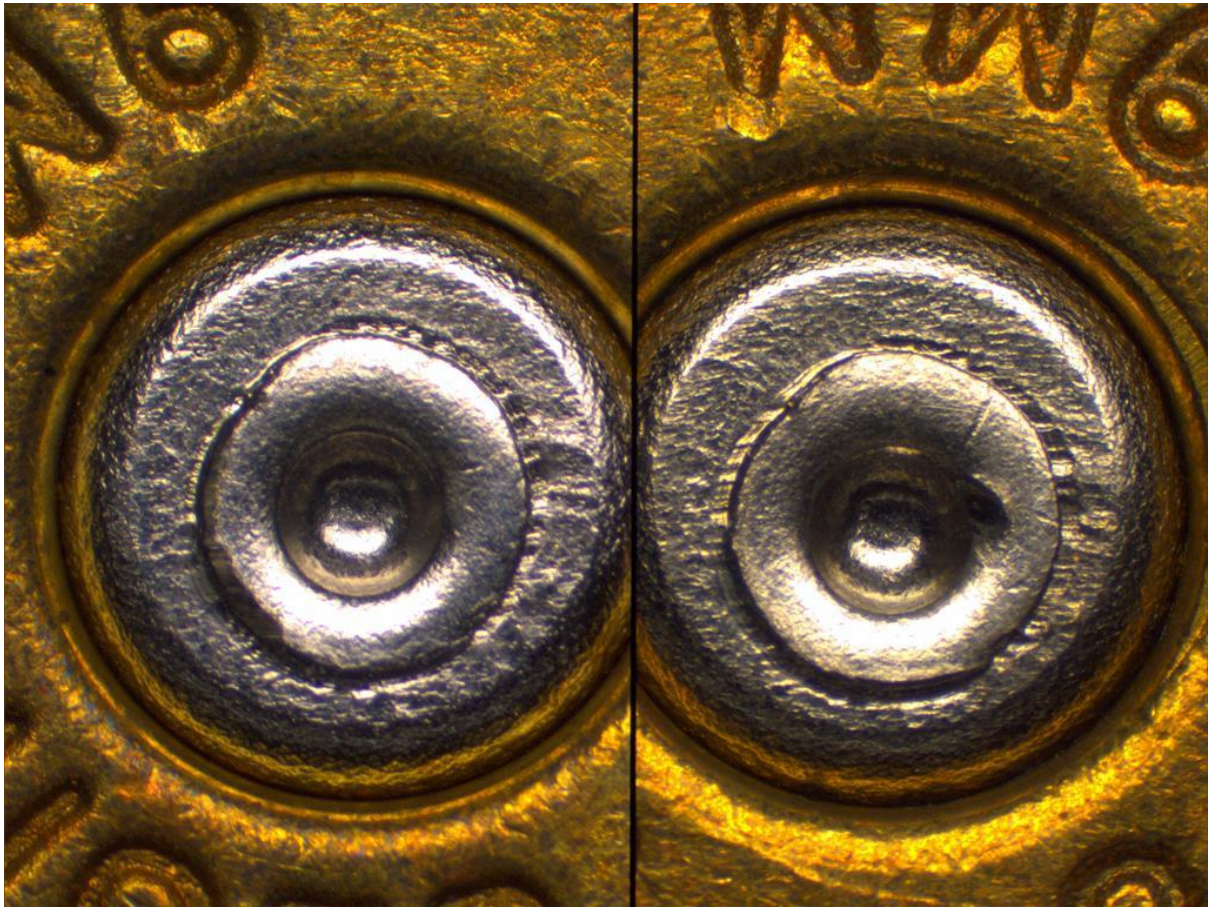
  FBI, ATF ammo-tracing systems can't interact After three years of research, officials from the National Institute of Standards and Technology (NIST) believe that by the end of the year they will have nailed the problem of reconciling two competing and incompatible bullet-tracing systems, one developed by the FBI and the other by the Bureau of Alcohol, Tobacco and Firearms. Still, no one is making any promises.

  NIST was brought in as a neutral third party in 1996 by lawmakers and others who realized that millions of dollars were being spent on two programs that worked along parallel lines — the FBI's Drugfire system, and ATF's Integrated Ballistics Identification System (IBIS). The NIST was asked to develop a standard for interoperability so that they could share information. *What was quickly determined was that there was no way to write such a standard...* Law Enforcement News, October 15, 1999

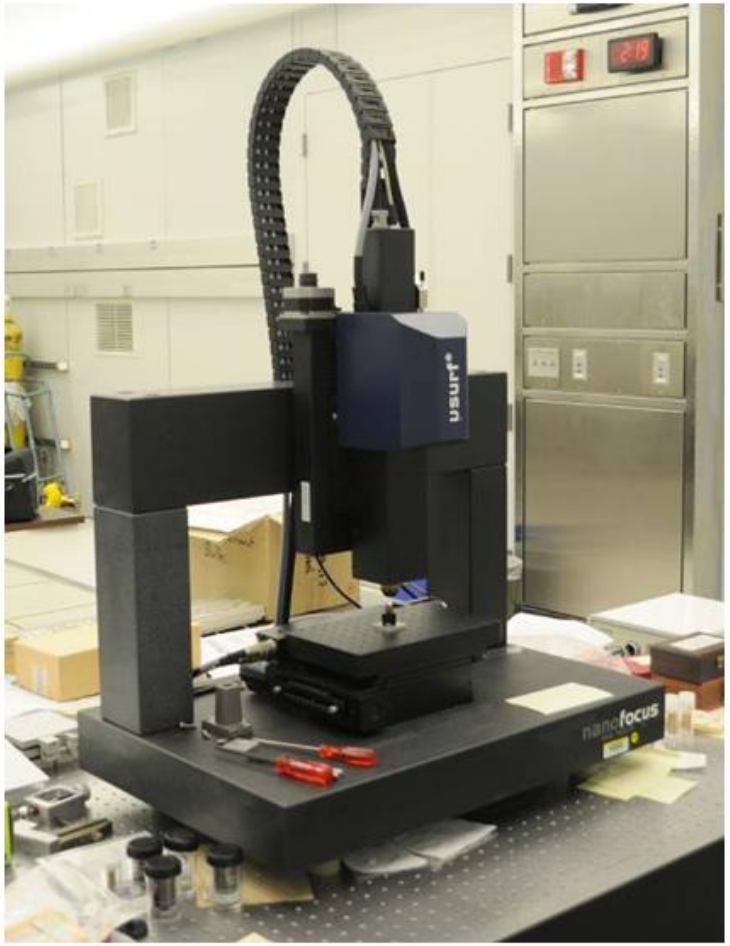
Comparison Microscope

Pictures Courtesy of Leica Microsystems

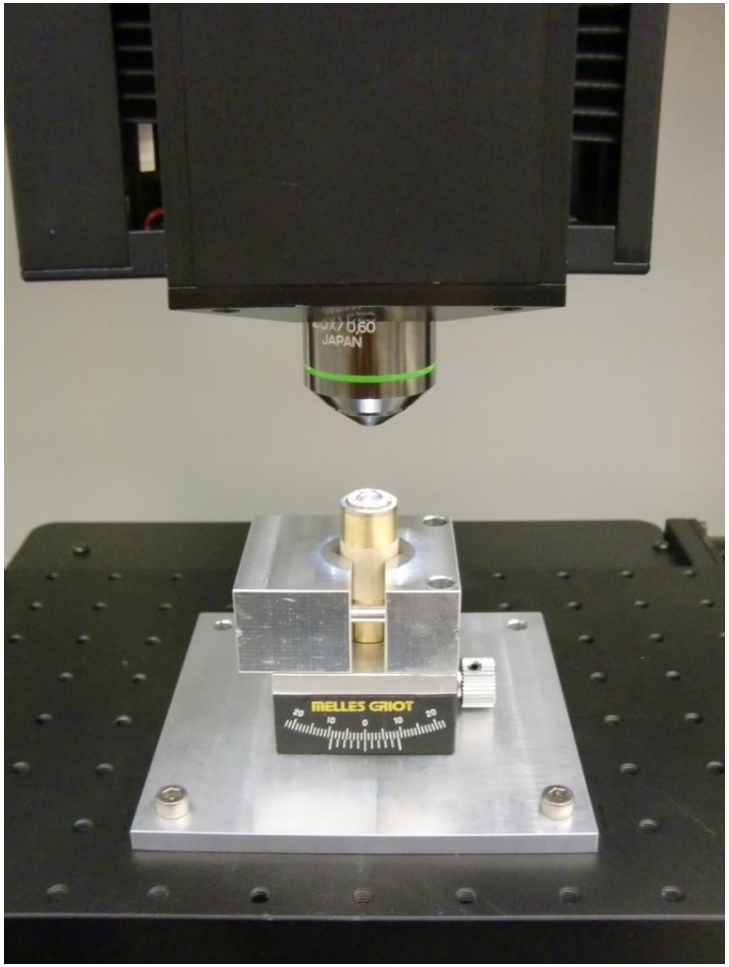
Comparison Microscope Images



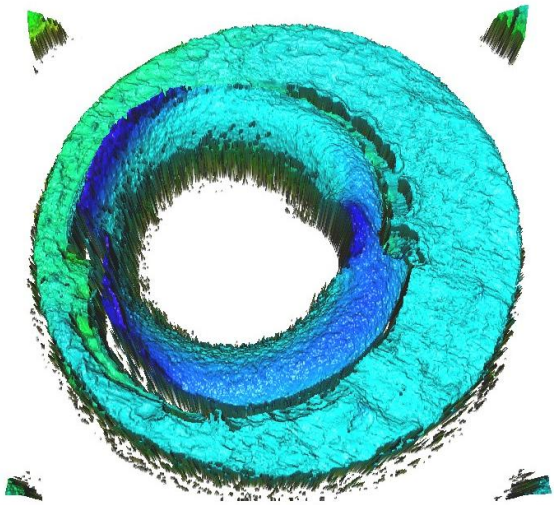
Nipkow Disk Confocal Microscope



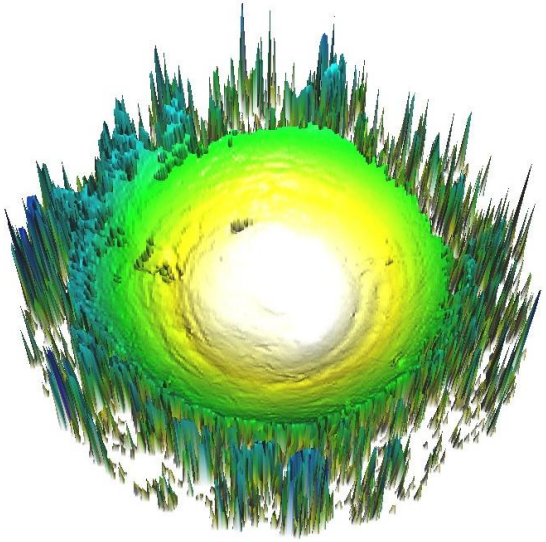
Measurement Setup



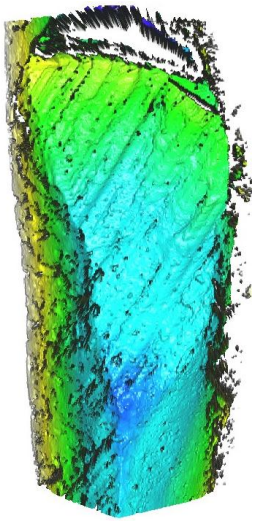
Confocal Microscope Data



Breech Face

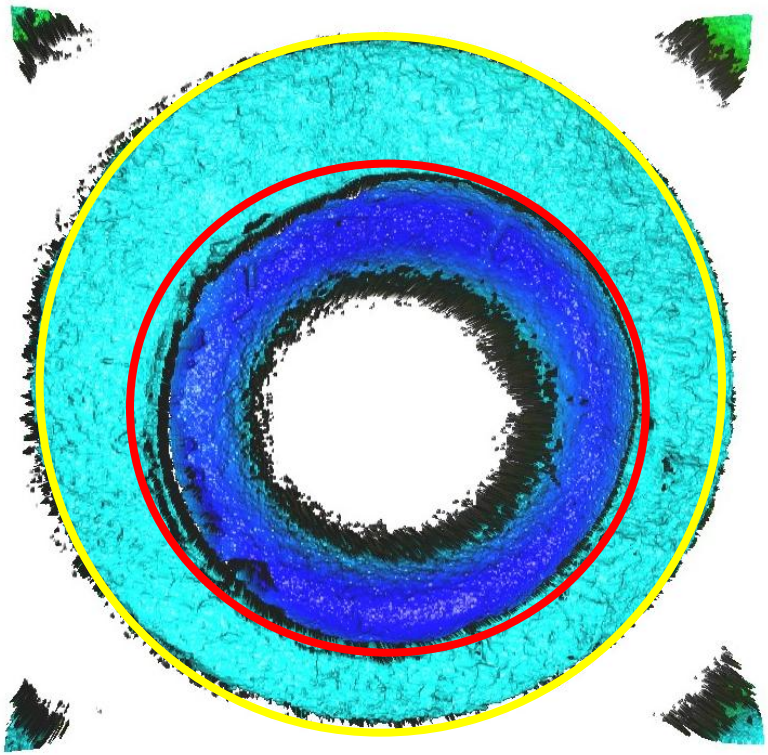


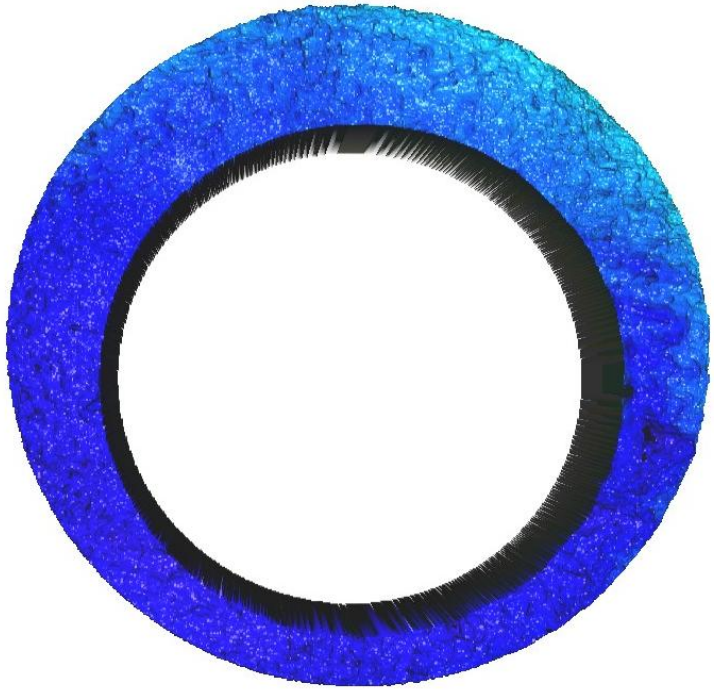
Firing Pin



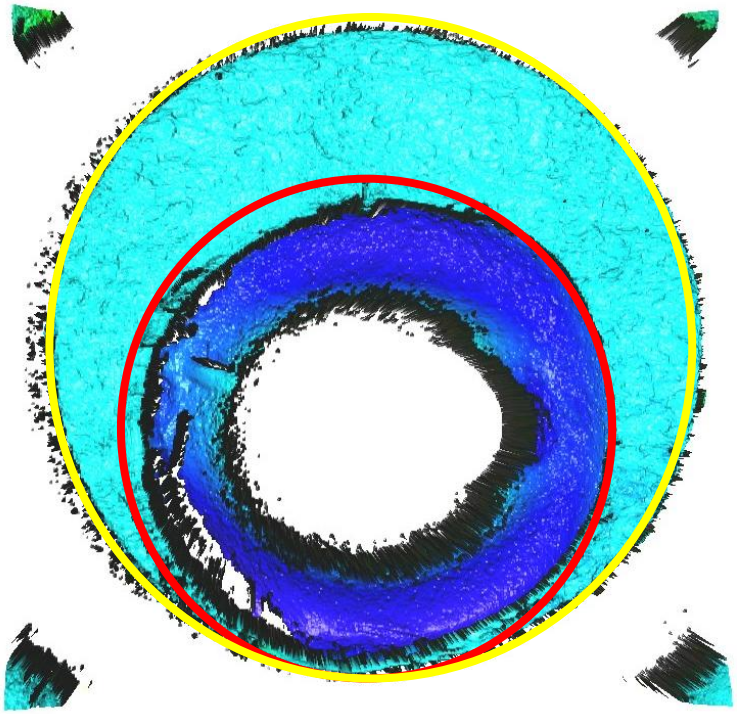
Ejector Mark

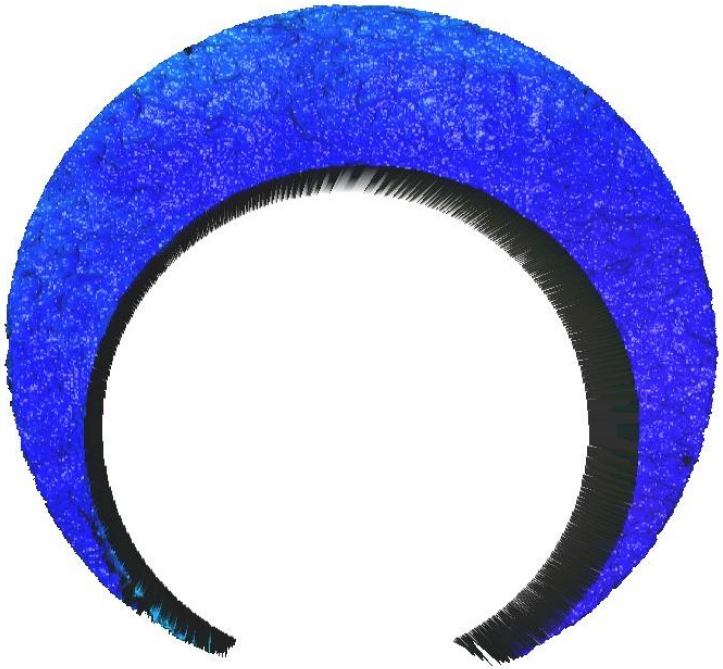
Data Trimming



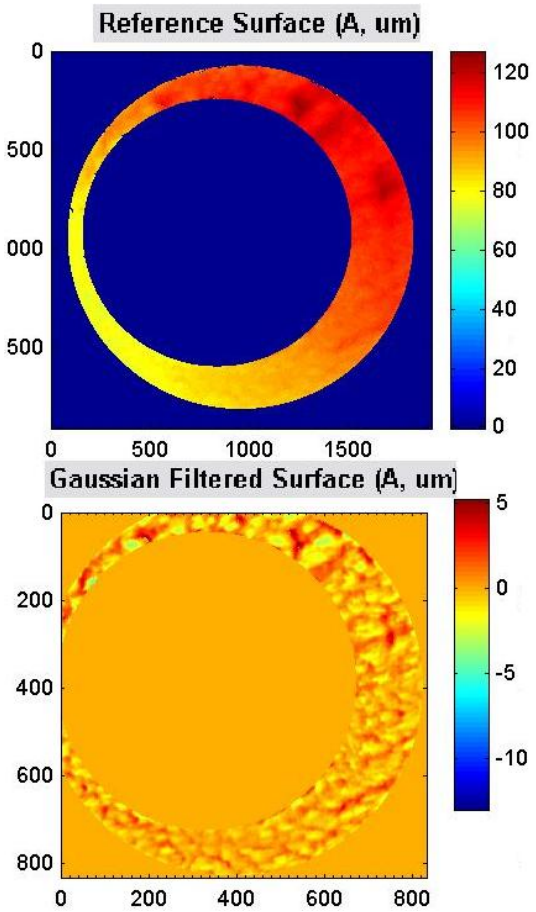


Data Trimming





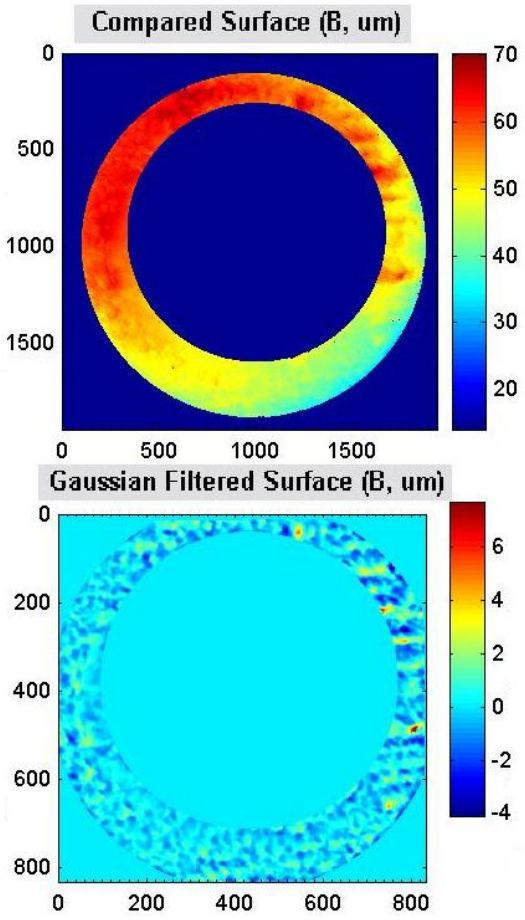
Data Filtering



Gaussian Filter

Removes Form and Waviness

Long Wavelength Cutoff
$\lambda c = 0.3$ mm



Areal Cross Correlation Equations

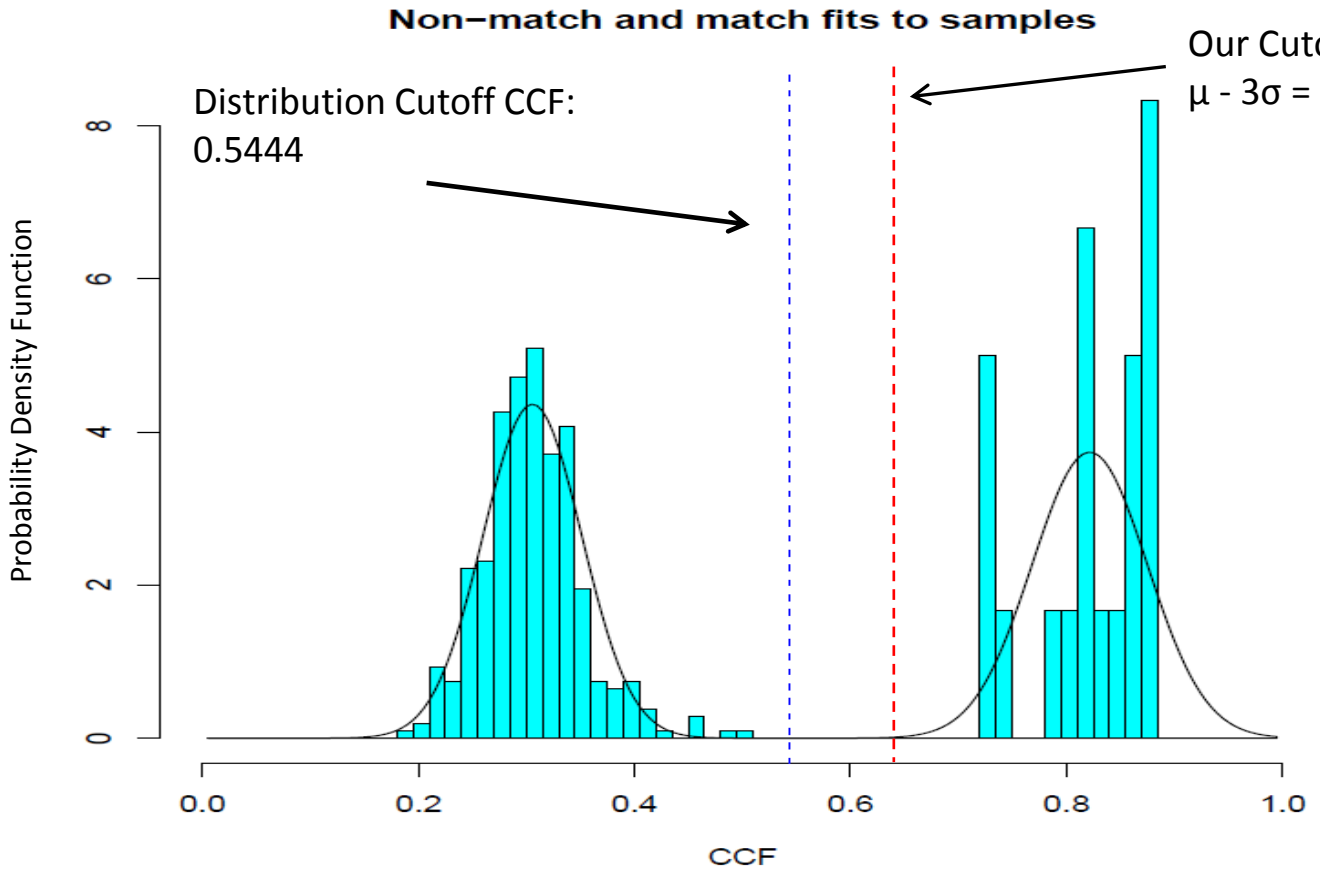
$$\mathrm{ACCV}(\mathrm{A},\mathrm{B},\tau_x,\tau_y)=\lim_{L_xL_y\to\infty}\left(\frac{1}{L_xL_y}\int_{-L_y/2}^{L_y/2}\int_{-L_x/2}^{L_x/2}Z_{\mathrm{A}}(x,y)Z_{\mathrm{B}}(x+\tau_x,y+\tau_y)dxdy\right)$$

ACCV is a Standard Statistical Function

$$\mathrm{ACCF}(\mathrm{A},\mathrm{B},\tau_x,\tau_y)=\frac{\mathrm{ACCV}(\mathrm{A},\mathrm{B},\tau_x,\tau_y)}{\mathrm{Sq}(\mathrm{A})\mathrm{Sq}(\mathrm{B})}$$

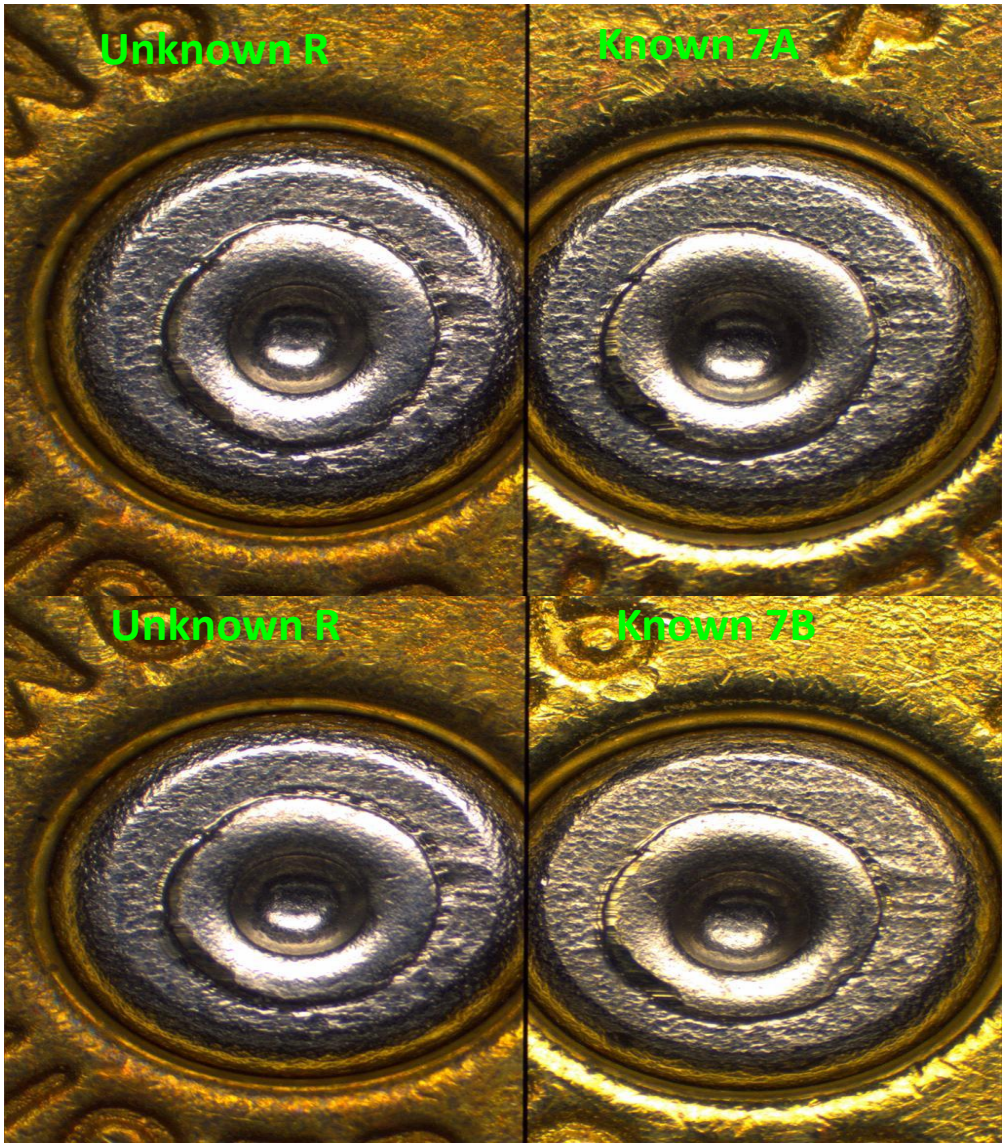
$$Sq=\left[\frac{1}{L_xL_y}\int_{-L_x/2}^{L_x/2}\int_{-L_y/2}^{L_y/2}Z^2(x,y)dxdy\right]^{\frac{1}{2}}\approx\left[\frac{1}{MN}\sum_{k=1}^{M}\sum_{j=1}^{N}Z^2(j,k)\right]^{\frac{1}{2}}$$

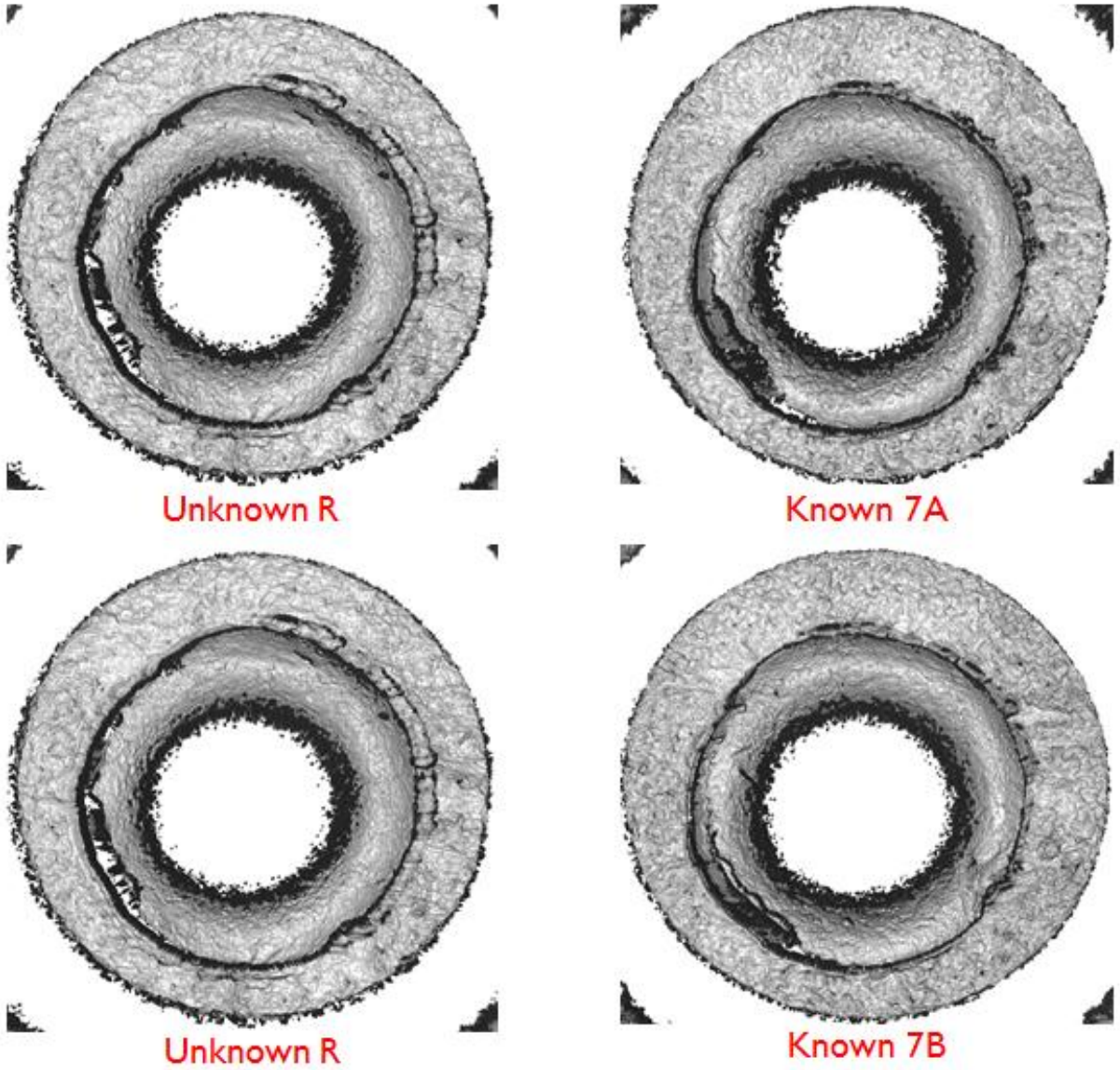
Statistical Analysis

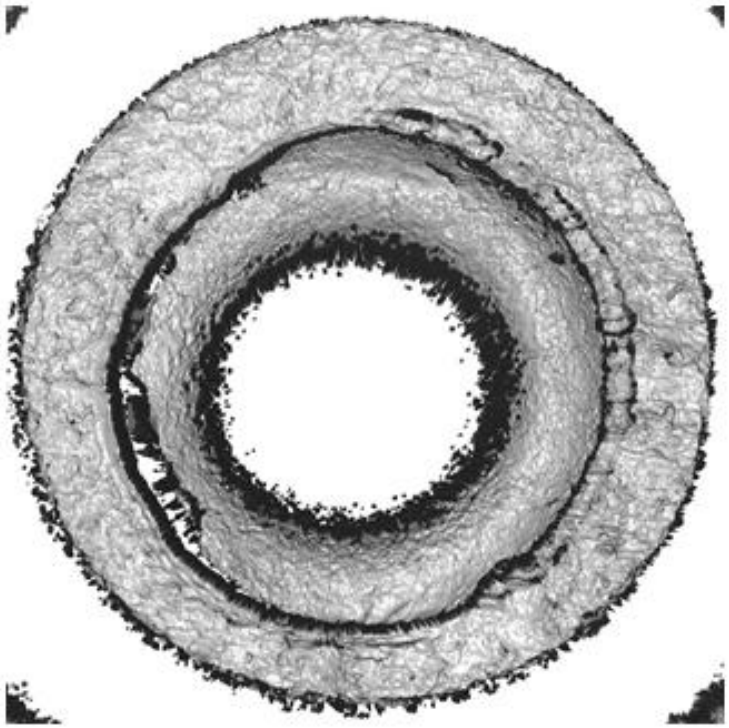


Non-matches:
Mean= 0.3056
Standard Deviation= 0.0457

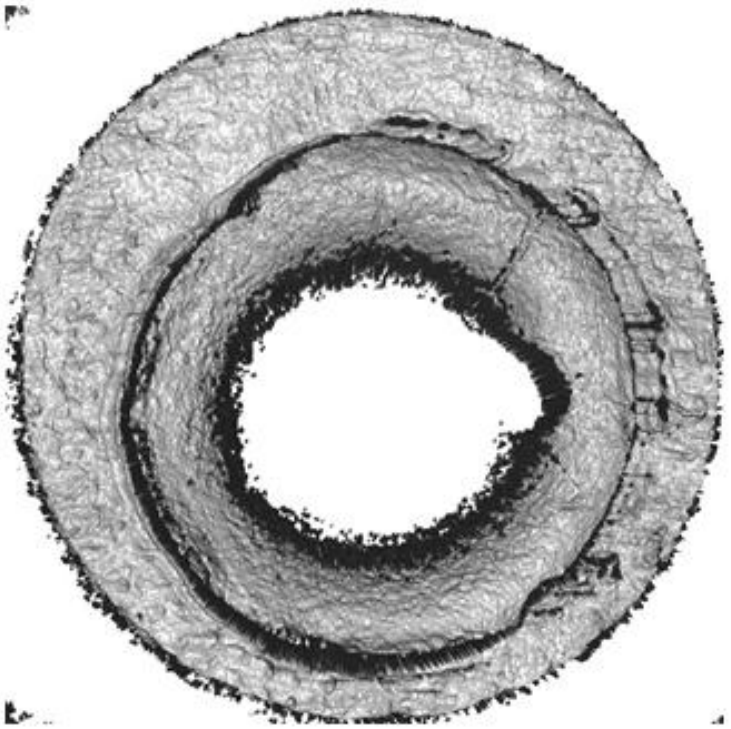
Matches:
Mean = 0.8216
Standard Deviation = 0.0534


Unknown R
Known 7A
Unknown R
Known 7B


Unknown R
Known 7A
Unknown R
Known 7B



Unknown R



Persistence S

Measurement Science and Standards in Forensic Firearms Analysis 2012

- The National Institute of Standards and Technology (NIST) in collaboration with The Association of Firearm and Tool Mark Examiners (AFTE) and the Scientific Working Group for Firearms and Toolmarks (SWGGUN) hosted a two-day conference exploring measurement science and standards in the forensic discipline of firearms analysis.
- http://www.nist.gov/oles/forensics_firearms_2012.cfm

Measurement Science and Standards in Forensic Firearms Analysis 2012

In the final discussions concerning the "road forward" for the advancement of firearm evidence comparisons using objective, scientific methods based on 3D topography; the development of a usable, validated, standardized research database where government, academic, and commercial researchers could leverage was considered a major priority.

Firearm Evidence Surface Database; A High-Level Vision of Standard File Transfer and Operability

Open “Sandbox” where there is a somewhat open exchange and deposition of database items from academic and commercial researchers. Most “rules” determined by the players with little outside monitoring.

(Photo: Teachlesslearnmore.com)

Research Database

- Research Database where a carefully constructed “read only” database of optical and topographic files are housed. Data entries are qualified as to source, minimum quality, and usability. The data would be qualified using peer determined factors, and standard file formats and transfer methods determined. Registered/qualified users would have moderated access.

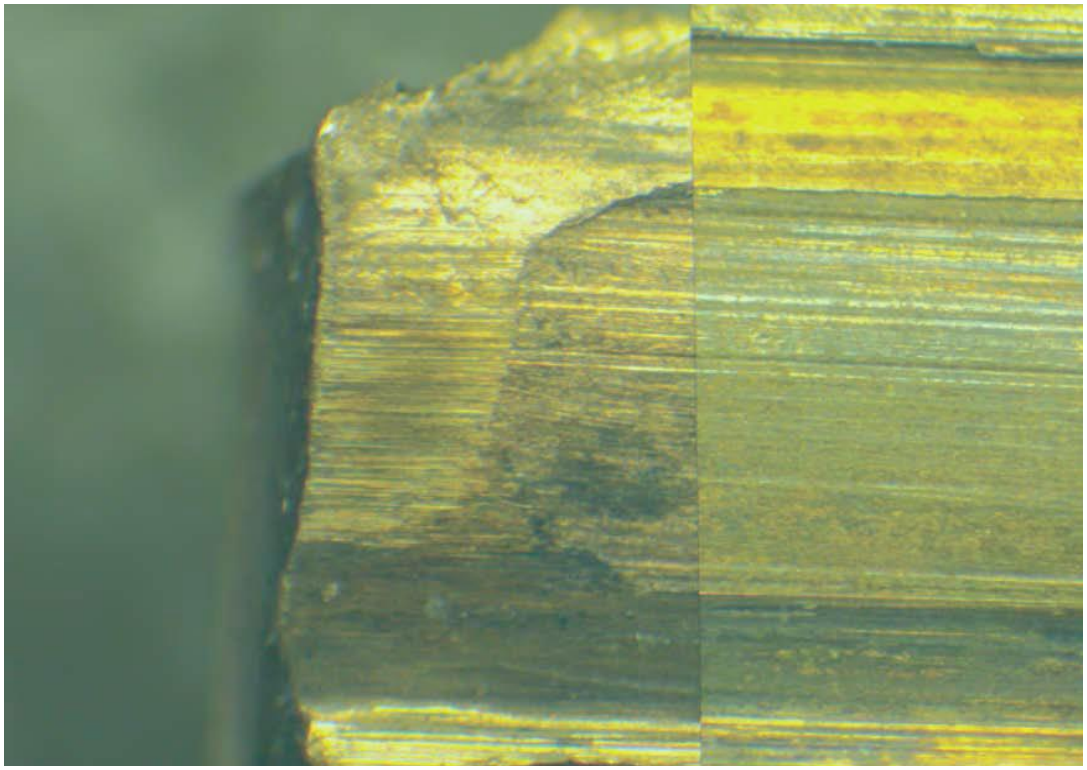
Sequestered Database

Sequestered database for performance testing. Similar to the research database in regards to controls and standards, but not available for the users. The database would be used for independent performance tests where reports are provided after testing.

Photo: motifake.com

Firearm Evidence Surface Database Challenges

- Image size(s)
- x, y, and z resolution in SI units?
- Format(s) for data, images, file types?
- Other compatible image and metadata formats?
- Hardware and software space, where installed?
- Size of statistically valid databases for research and performance testing?
- Costs for the construction, maintenance, and management of the initiative?
- Peer input in the development, database use, and quality management?
- Expansion to other forensic databases; footwear, tires tracks, etc.



***Firearm Identification in the Forensic Science Laboratory* by**
Robert M. Thompson

http://ndaa.org/pdf/Firearms_identity_NDAAsm.pdf

QUESTIONS?

Robert M. Thompson
Email: robert.m.thompson@nist.gov
Telephone: 703-924-0821