



FIREARMS/TOOLMARKS UNIT

# AFTE 2018 – Sensofar Workshop

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## Disclaimer:

The Federal Bureau of Investigation does not support or endorse any of the products that will be discussed during the course of this presentation.



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# Presentation

- FBI, Firearms/Toolmarks Unit – ASSTR
- OSAC
- TWG3D2T
- Ruger Double Broach Barrels (Steve Norris)
  - Collection
  - Tests Production
  - Test delivery
    - LCM Results
  - Sensofar Test Evaluation
    - Results
- Sensofar – scan acquisitions and Virtual Comparisons



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ASSOCIATION OF  
FIREARM AND TOOL MARK EXAMINERS  
PROGRAM



NINETEENTH ANNUAL TRAINING SEMINAR  
JUNE 13-17, 1988



DuPage County, Illinois

"Computer Correlation of Cartridge Cases Using Breech Face Marks"

KEITH L. MONSON, Ph. D., Forensic Science Research Unit, FBI Academy, Quantico, Virginia 22135.

The goal of this research is to develop a computer-based system to objectively and quantitatively express the degree of similarity of breech face marks of any two fired cartridge cases. Conventional image cross-correlation algorithms have been extensively modified to allow comparison of two arbitrarily-shaped images. The operator can interactively select suitable subregions for comparison, specifically excluding the firing pin impression. This generality is important for eventual extension of the method to bullet comparisons. The computer overlaps the first image over the second in thousands of possible orientations, both rotational and translational, and evaluates the extent of similarity in each orientation. A numerical value can then be derived for the extent of similarity at the orientation which maximizes the cross-correlation function. Preliminary trials with a limited number of known matches and non-matches have given the expected results.

"The AKS and AKM Semiautomatic Rifles and Imported 7.62 X 39 Caliber Ammunition"

EDWARD L. ROBINSON, Los Angeles County Sheriff's Department, Los Angeles, California 90057.

Examination of the Chinese manufactured AKS/AKM semiautomatic rifles and the 7.62 x 39 caliber imported ammunition. A detailed slide presentation of test firing techniques, the breechface and firing pin impressions, disassembled ammunition, and primer compounds.

Examinations to this point reveal that the firearms from China are manufactured with similar general characteristics and with little individuality of breechface. The firing pin impression may isolate arsenal manufacture. The bullet jacket is a mild steel with a lead shield around a mild steel core. The primers are corrosive and rust barrel steel; corrosive compounds, mercury, and potassium chloride were identified with the Scanning Electron Microscope.

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# ASSTR:

## Supporting Documentation for FBI Approved Standards for Scientific Testimony and Report Language for the Firearms/Toolmarks Discipline – 2013

- “the likelihood”
- “practical impossibility”
- “to the exclusion of all others”

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# *FBI/FTU Research Group Instrumentation*

*Sensofar® – Confocal, Interferometry, and Focus Variation – 2013  
(Currently being validated for PI and PII)*

*Alicona® - Infinite Focus - Focus Variation – 2014 (validation completed  
1/2018 for General Rifling Characteristics)*

*Evofinder® - 2015 (VCM PI Validation completion date 5/18)*

*GIGAMacro® - 2016 (under assessment for PI)*

*Cadre Forensics, TopMatch GS 3D - 2012, Photometric Stereo  
(Validation PI completed 10/17 for casework)*



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RTI December 2016 publication “Forensic Optical Topography, Landscape Study”

*OSAC*

## Subcommittee Firearms and Toolmarks

Hardware – ensures instrument accuracy, calibration, and U of M.

Software – conditions for consistent and intretable comparisons

Implementation – reliable reproduction 3D data

Virtual Comparison Microscopy - The use of software to compare and evaluate the digital reproduction of microscopic features between two toolmarks.

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# Technical Working Group 3D2T

The purpose of the TWG3D2T is to provide guidance and recommendations to the Firearms/Toolmarks community in measurement assessment, virtual comparison microscopy, measuring practices, methodology, best practices, and quality assurance.



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# Technical Working Group 3D2T

## Goals:

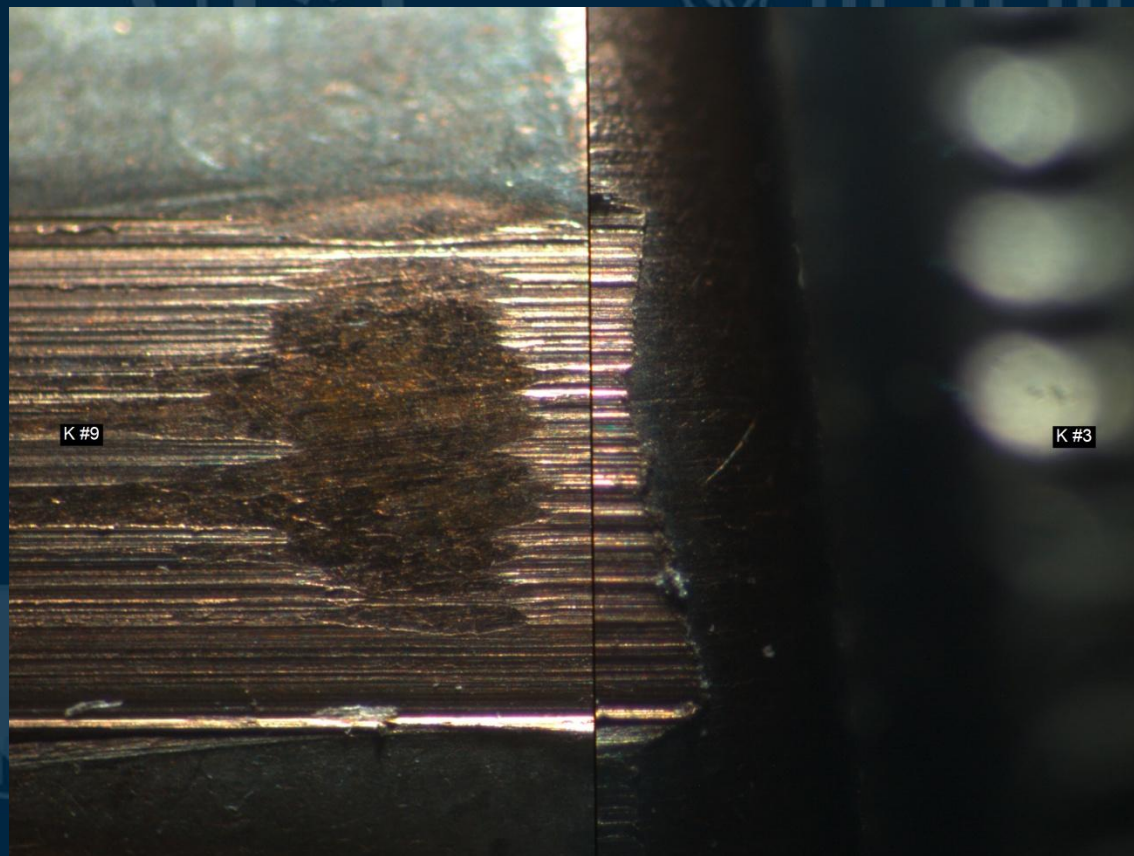
- Establish dialogue with stakeholders/users – critical needs
- Measuring standards
- Virtual Comparison Microscopy
- Best Practices
- Measuring Techniques
  - GR&R
  - Quality Assurance
  - Performance Checks
- 3D Technologies in casework flow
- Records – Chain of Custody
- Accreditation
- Algorithms

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# Identification of Bullets Fired from Consecutively Manufactured Double-Broached Ruger® SR9c Barrels Utilizing Comparison Microscopy and Confocal Microscopy



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# *FBI Laboratory Reference Collection of Consecutive Manufactured Slides and Barrels (RCCMSB) – Database Samples*

Twelve Double-Broached Ruger® barrels were collected, 10 consecutively manufactured (CM0-CM9) and two additional barrels selected down the production run (B22 and B33).



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# Ruger Double – Broached Barrels:

2<sup>nd</sup> Broach

1<sup>st</sup> Broach

Gun Drill

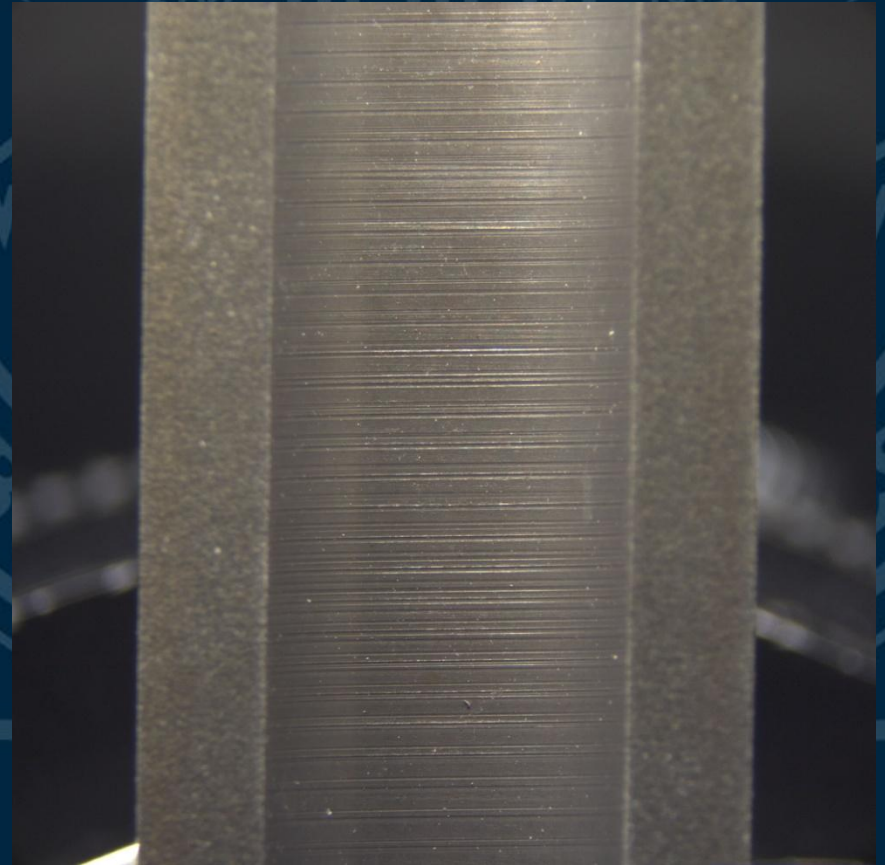


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- Barrel Blanks – from New Hampshire plant both steel and alloy, barrels are straighten in-house.
- Gun Drill station – bore dill tolerances =  $0.340'' \pm 0.003''$ , go/no go.
- Chamber station – chamber and exterior are finished, heat treated



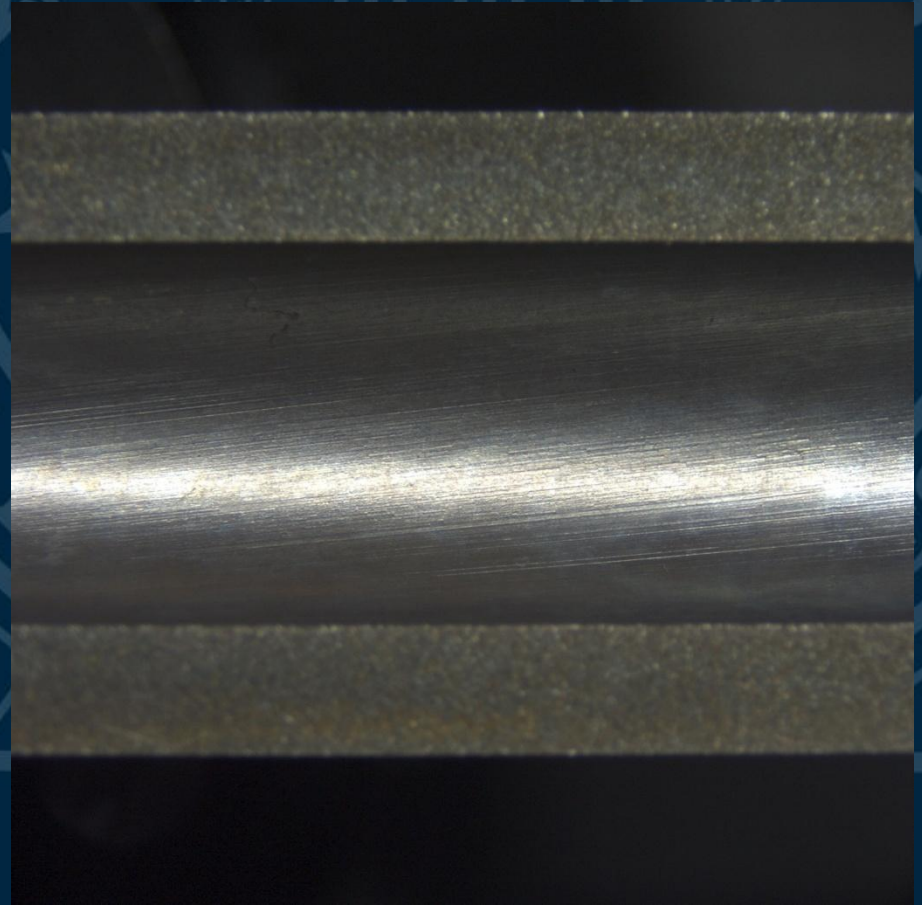
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# FBI/FTU – Research Group

- First broach is used to clean the bore and finish to bore diameter.
- As the broach is pulled through the barrel rotates.
- Bore diameter = 0.346” +/- 0.002”, go/no go gauge used to check depth of cut.

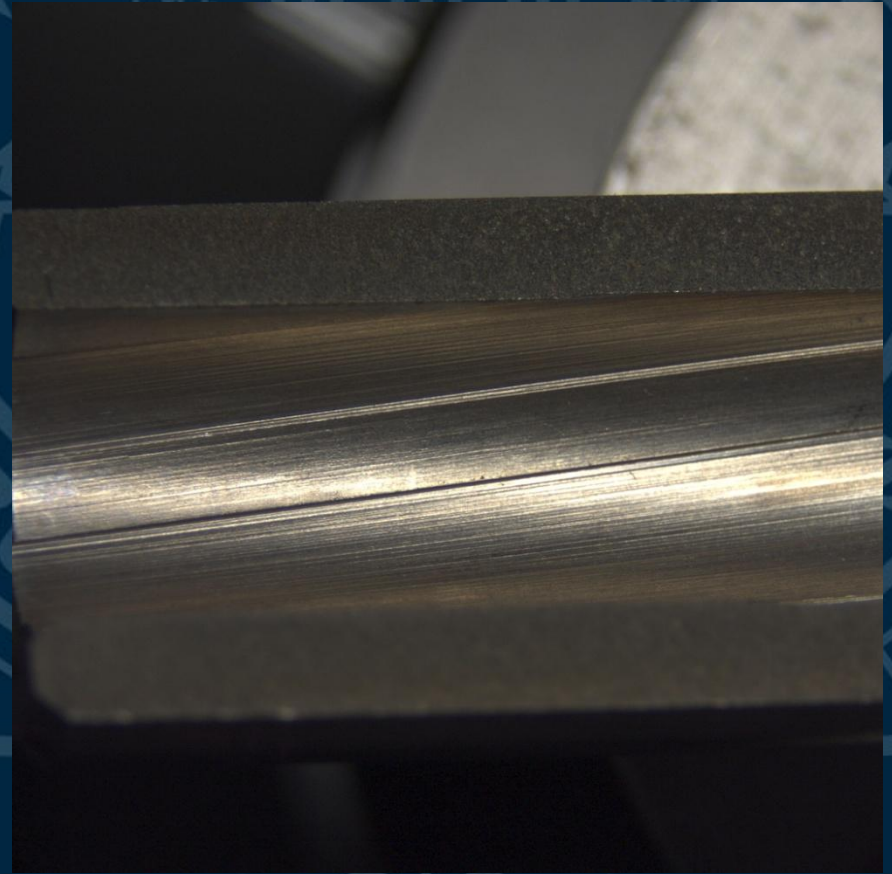


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- Second broach is pulled to cut the grooves while the barrel is rotated to create the desired twist.
- 1/20 barrels are physically inspected.
- Broaches last for approximately 1000 barrels before they are reconditioned.

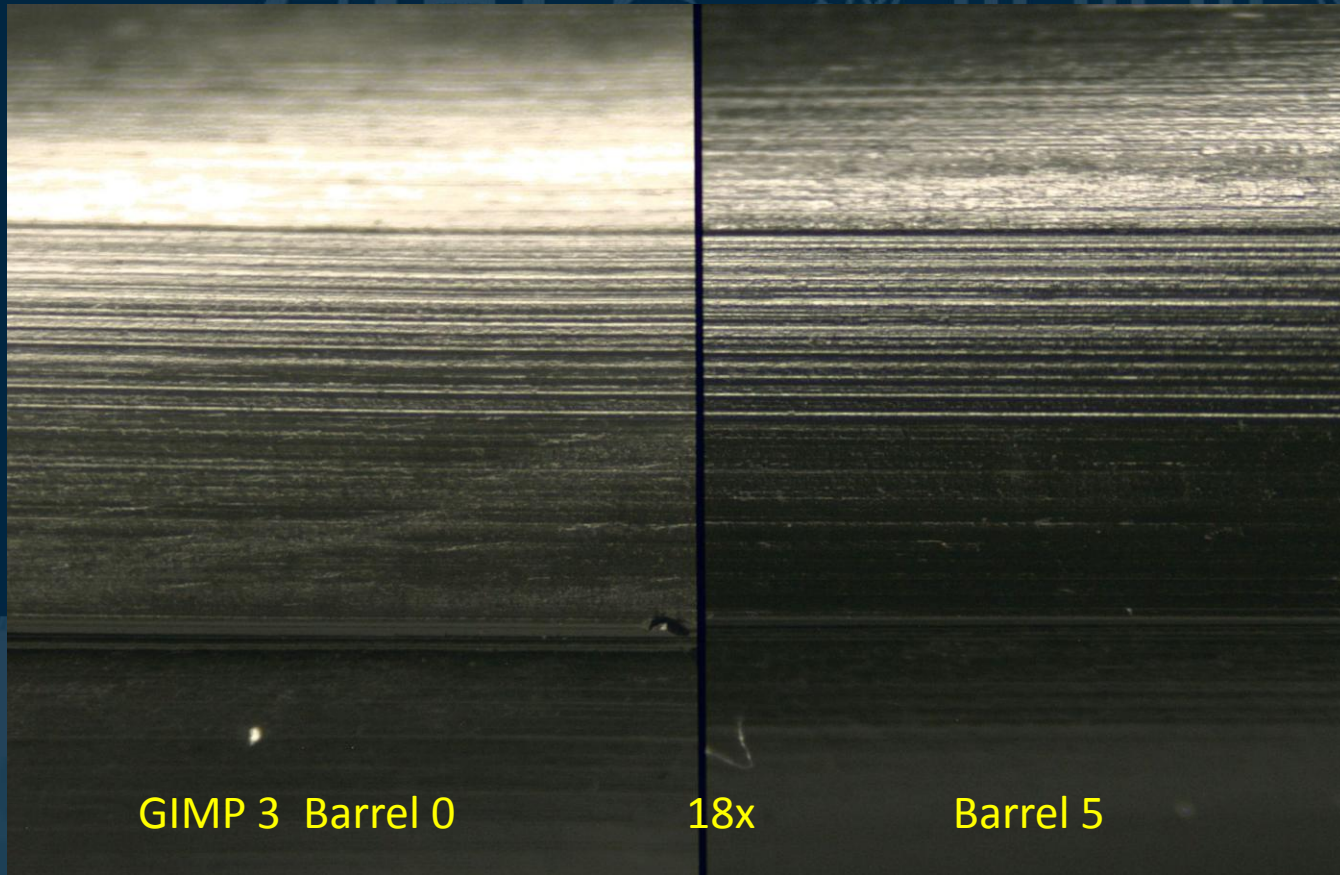


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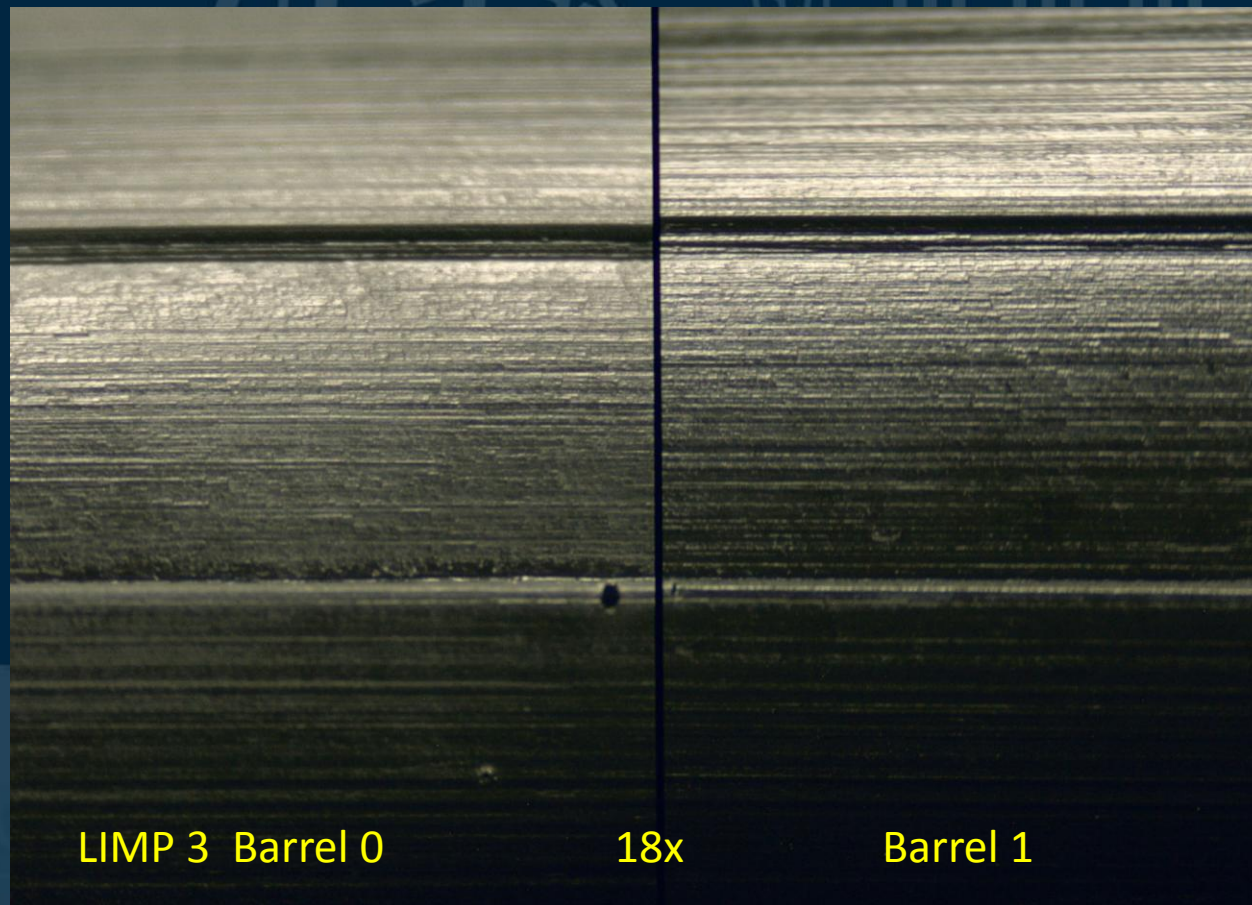
# Cast Evaluation – Subclass/Groove



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# Cast Evaluation – Land Impressions

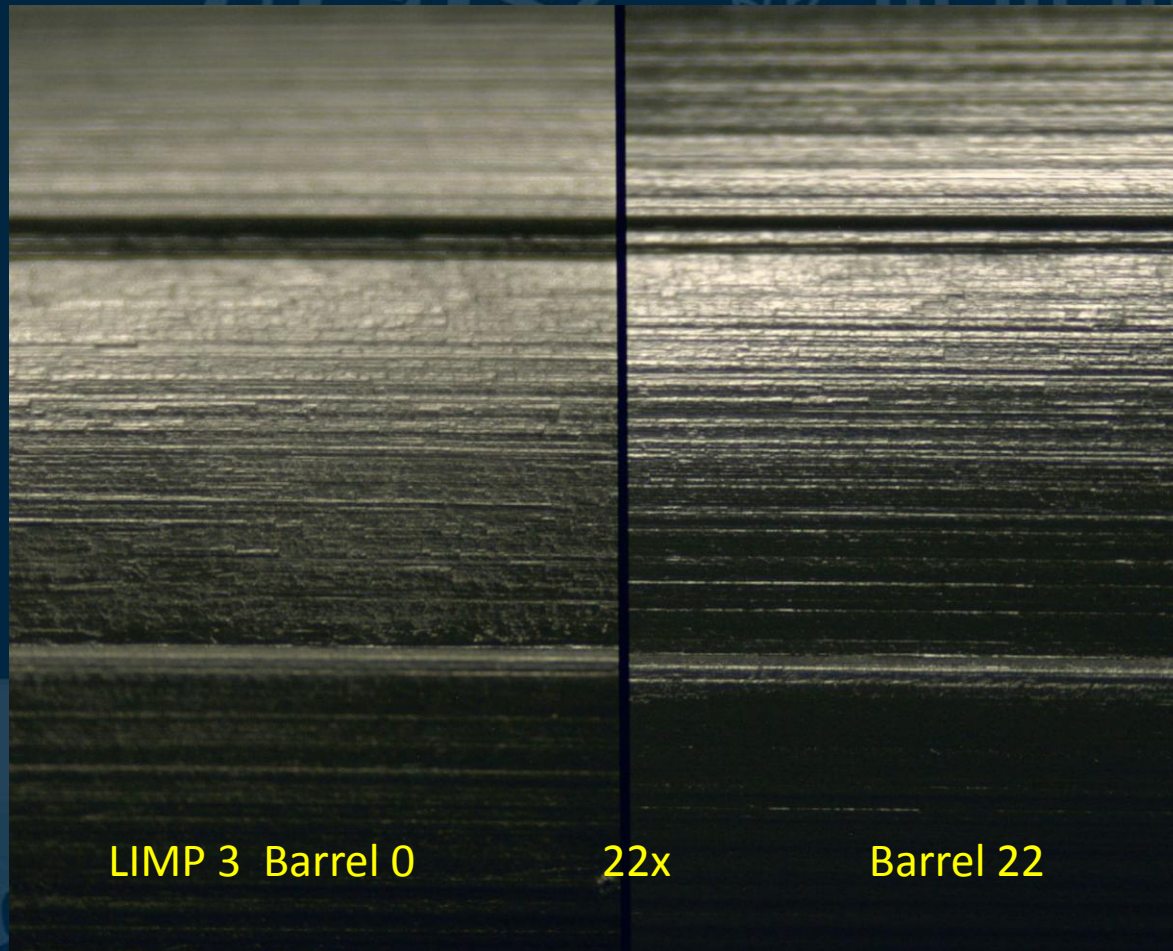


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# Cast Evaluation – Land Impressions



LIMP 3 Barrel 0

22x

Barrel 22

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# Test Sample Collection



Ammunition Remington® UMC® 9mm Luger, 115 grain, copper full metal jacket, each sample was laser engraved with a random identifier (100-500).

Ten cartridges were fired from each of the 14 barrels and 6 cartridges from FBI RFC-D1994 to provide a total of 146 cartridges.

The first six cartridges test fired collected (two from D1994) were not used for this study. The seventh through ten cartridges were used for test samples.



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# Test Packet

Five test sets each containing 12 bullets d.

Each packet had at least one matching pair from four or more production run double-broached barrels and at least one matching pair from the RFC pistols.

## Blind Test:

Tests packets were placed in an area for retrieval where test administrators could not determine the participant

No information regarding the origin of the samples was provided

No knowns for comparison

Answer worksheet was designed to ensure the anonymity of the participant.

TEST 0615-2											
	126	152	171	179	263	284	305	319	343	362	411
	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
115	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
126	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
152	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
171	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
179	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
263	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
284	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
305	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
319	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
343	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX
362	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX	EX



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# Results

From the five test packets there were a possible of 330 bullet comparisons with 28 “true” identifications

Participants recorded 27 correct identifications with 1 inconclusive were recorded for “true” identification results, with 303 inconclusive results.

Test Sensitivity<sup>1</sup>: the number of correct identifications divided by the number of exam results for “true” identifications.  $(27/(28 \times 6)) = 0.16$ ,  $(28/(28 \times 6)) = 0.166$ ,  $0.16/0.166 = 96\%$

Test Specificity<sup>1</sup>: the number of correct exclusions divided by the number of exam results for “true” exclusions (302 true exclusions), similar class characteristics – FTU SOP<sup>2</sup> “an elimination occurs when there is a discernible or measurable difference in class characteristics.”



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# Evaluation – Barrel 1 Test Fires

L1 v L1

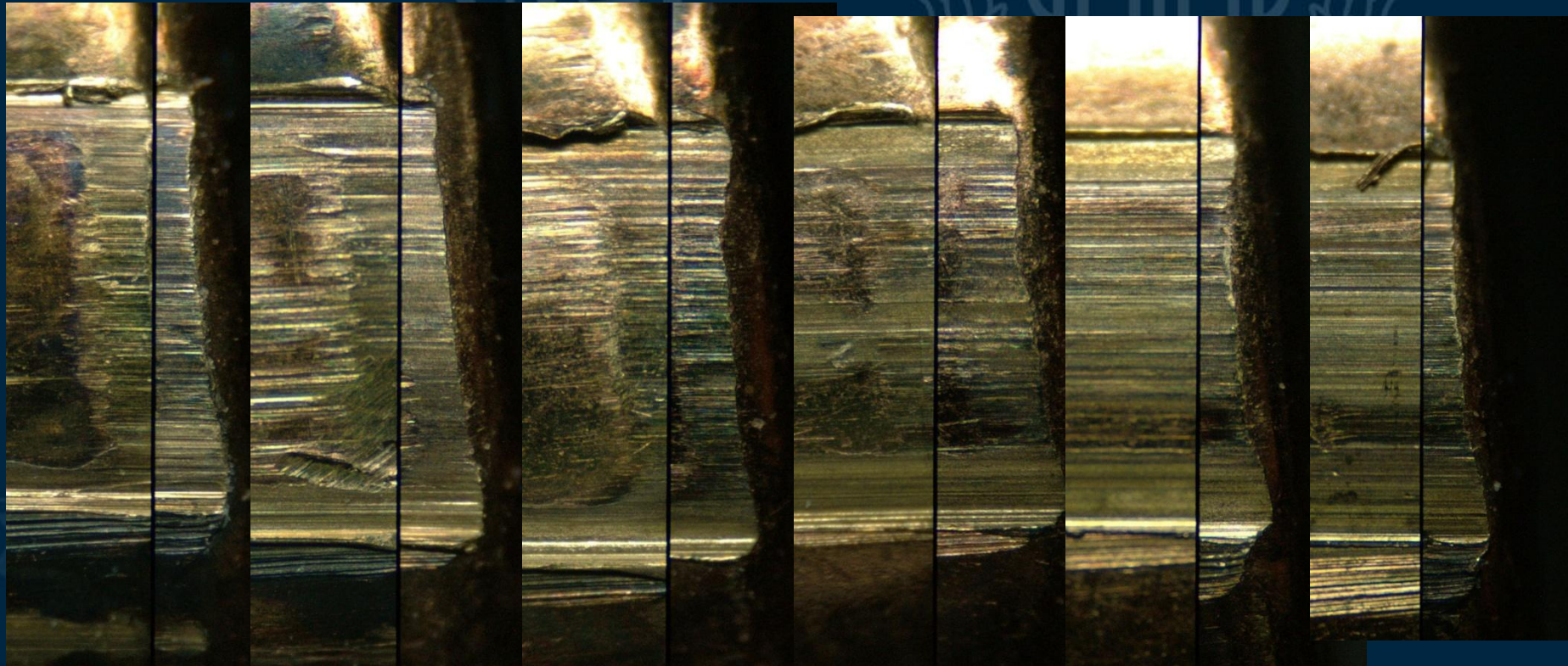
L2 v L2

L3 v L3

L4 v L4

L5 v L5

L6 v L6

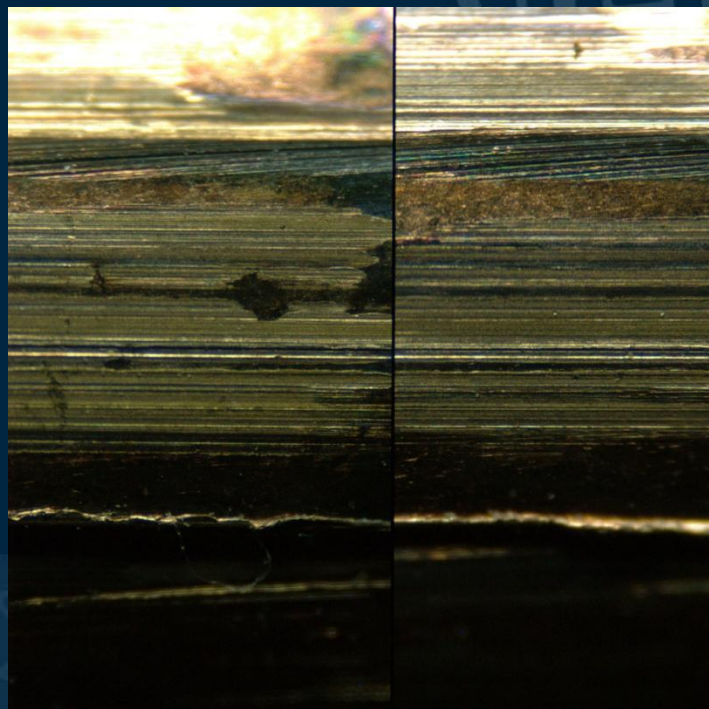


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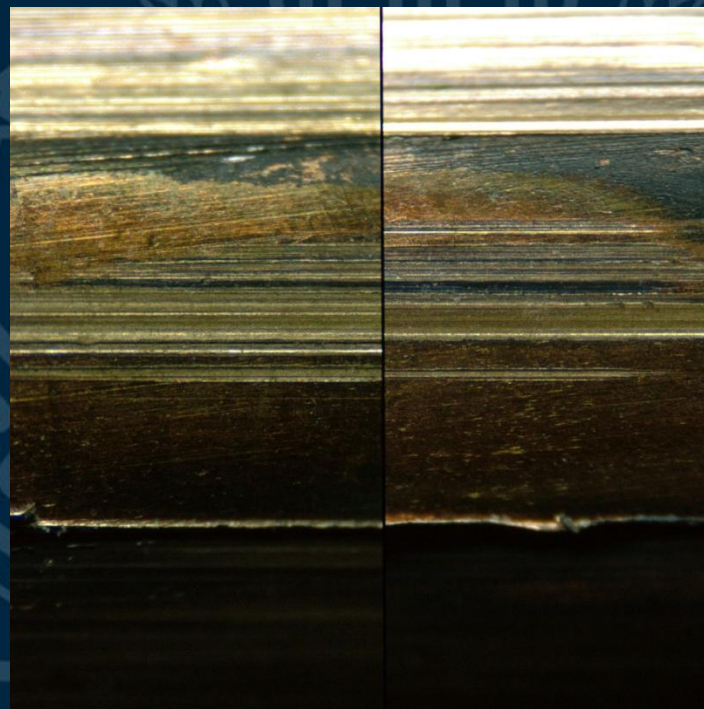




# Evaluation – Barrel 0 vs. 1 for Potential Subclass



GIMP 1 B1 v GIMP 1 B1



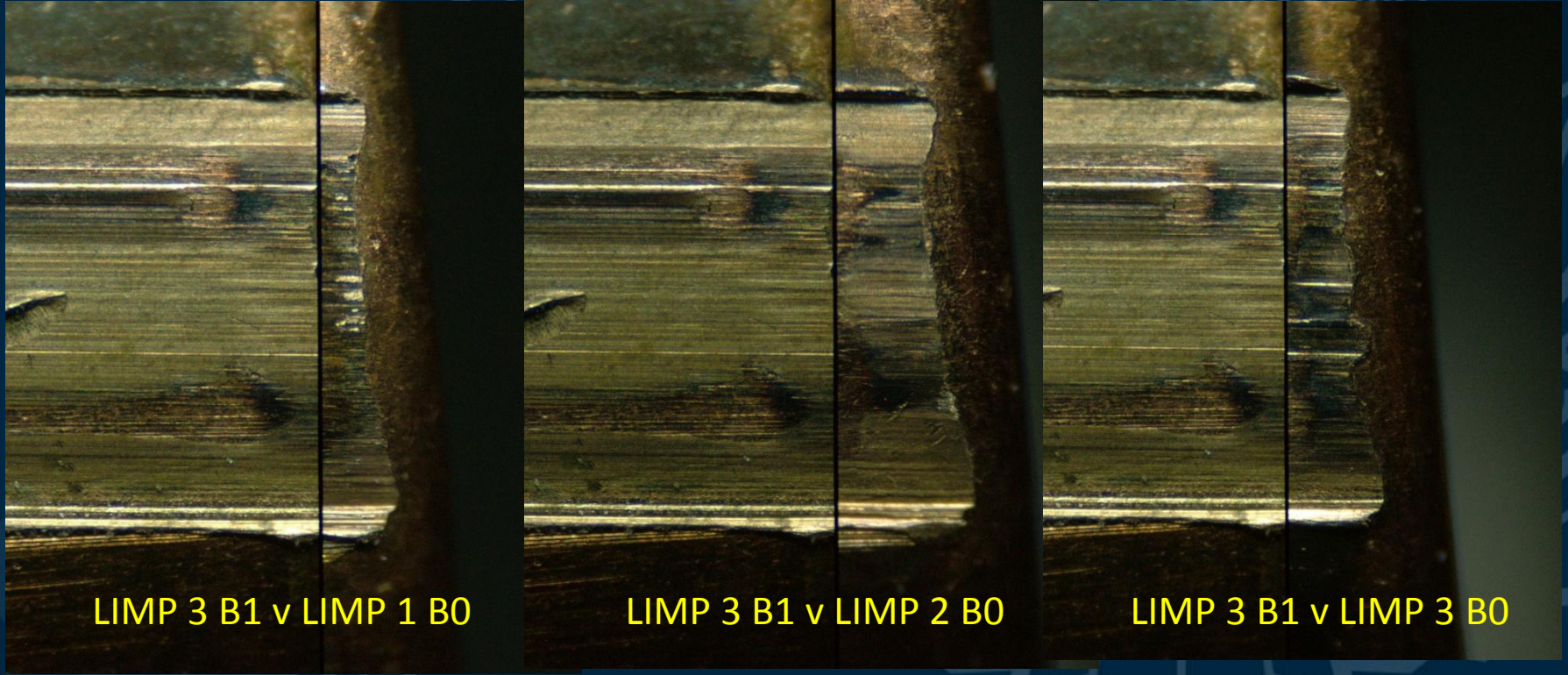
GIMP 1 B1 v GIMP 1 B0

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# Evaluation – Barrel 1 vs. 0 for Potential Subclass



LIMP 3 B1 v LIMP 1 B0

LIMP 3 B1 v LIMP 2 B0

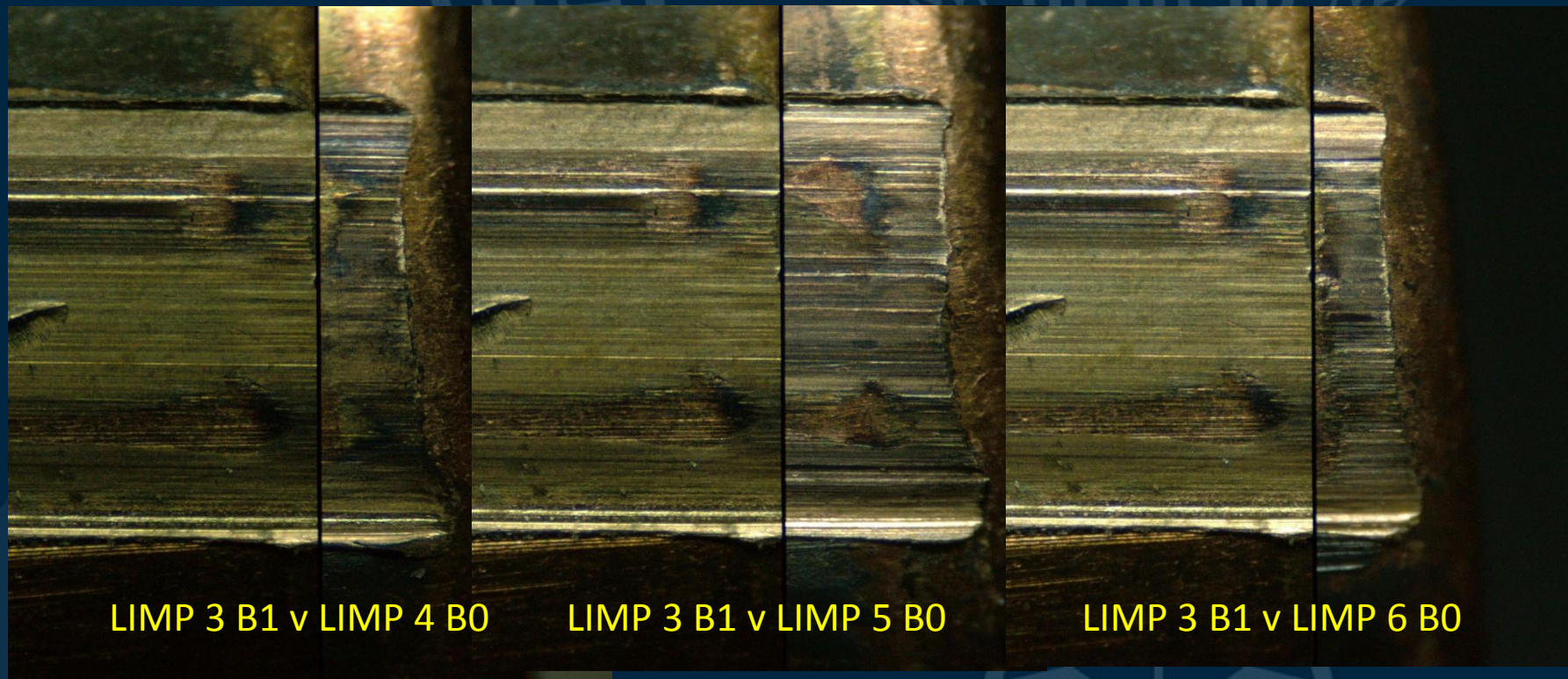
LIMP 3 B1 v LIMP 3 B0

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# Evaluation – Barrel 1 vs. 0 for Potential Subclass

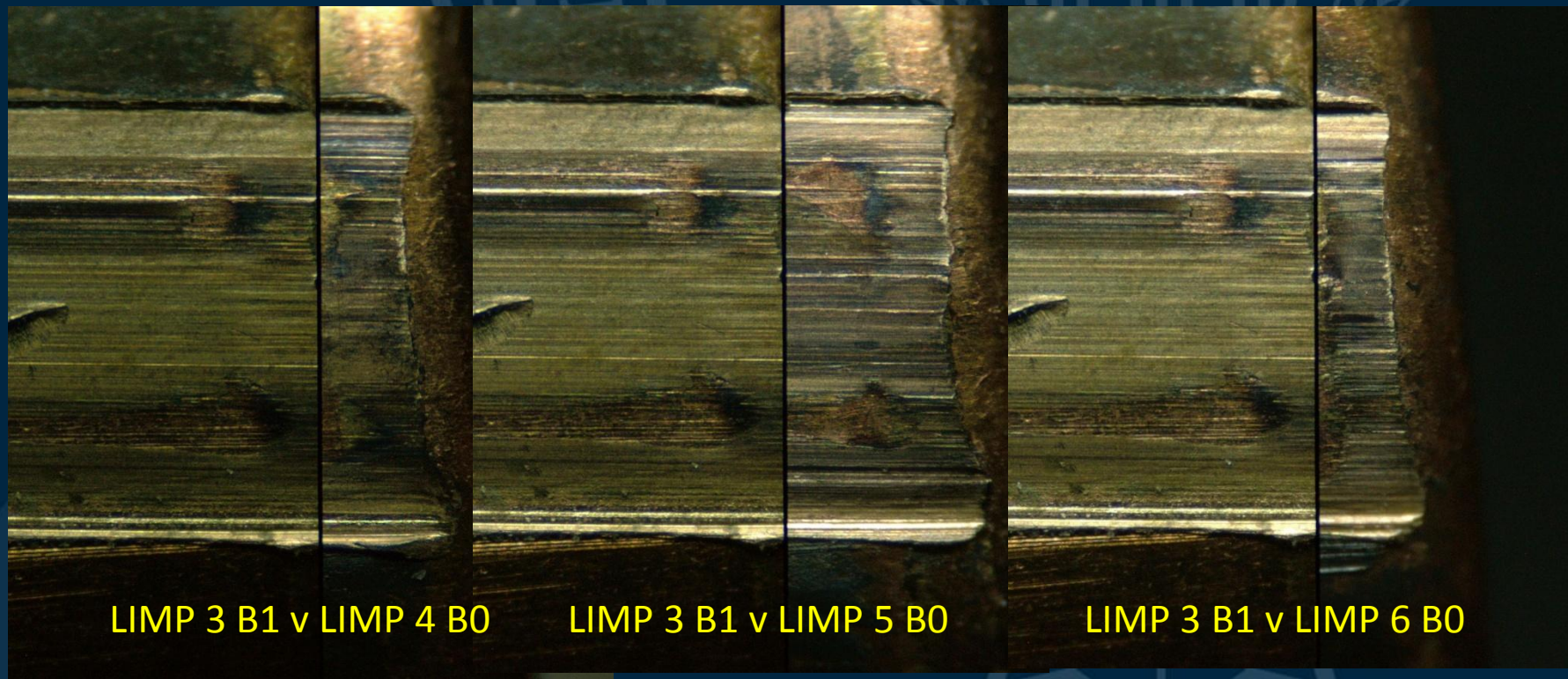


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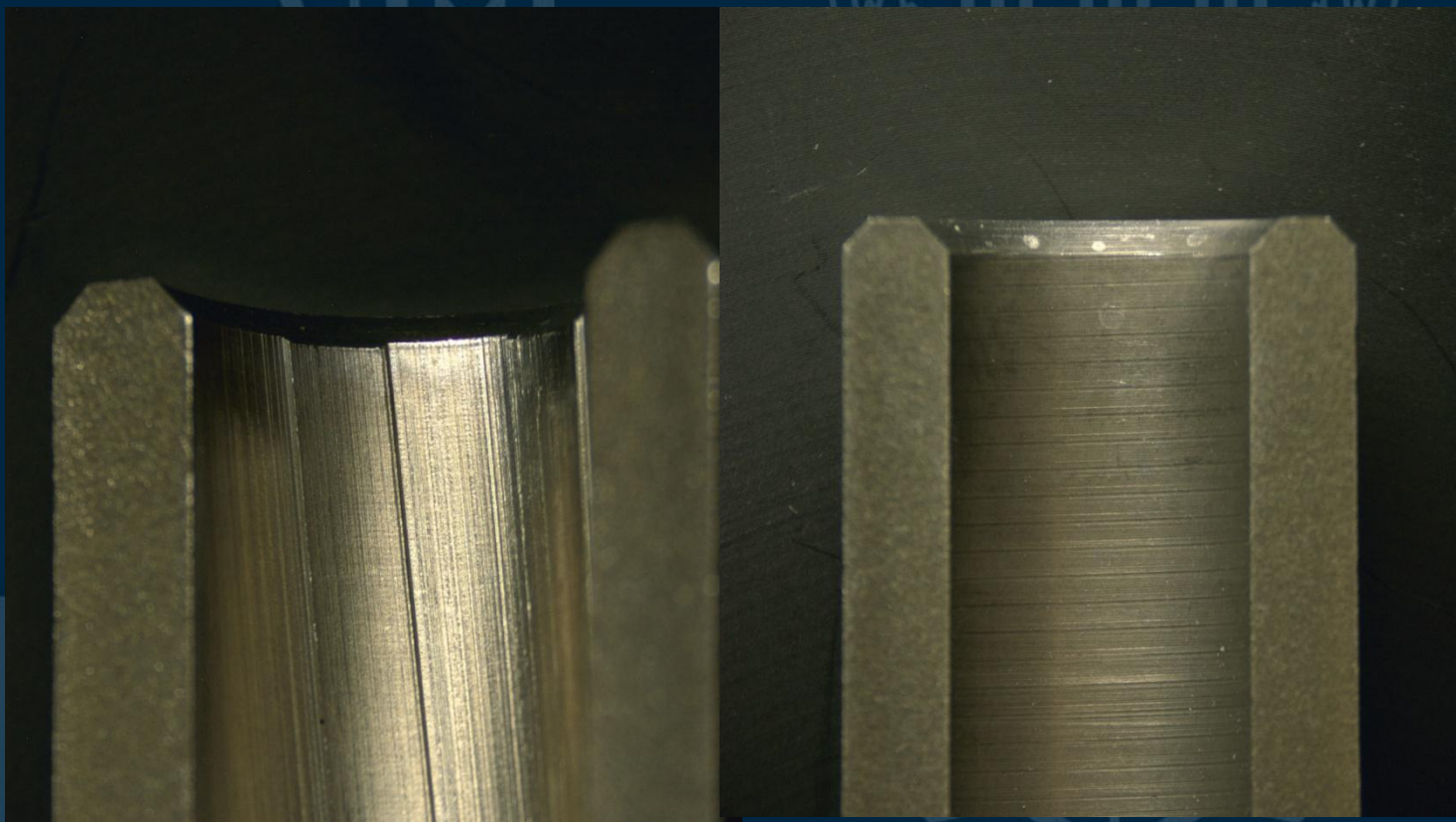
# Evaluation – Barrel 1 vs. 0 for Potential Subclass



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Sensofar ® Technologies S neox, micro-display scanning confocal microscope using 20X objective

Specifications<sup>3</sup> (20X):

- Vertical Resolution 8nm
- Maximum Slope 21° smooth, 86° rough

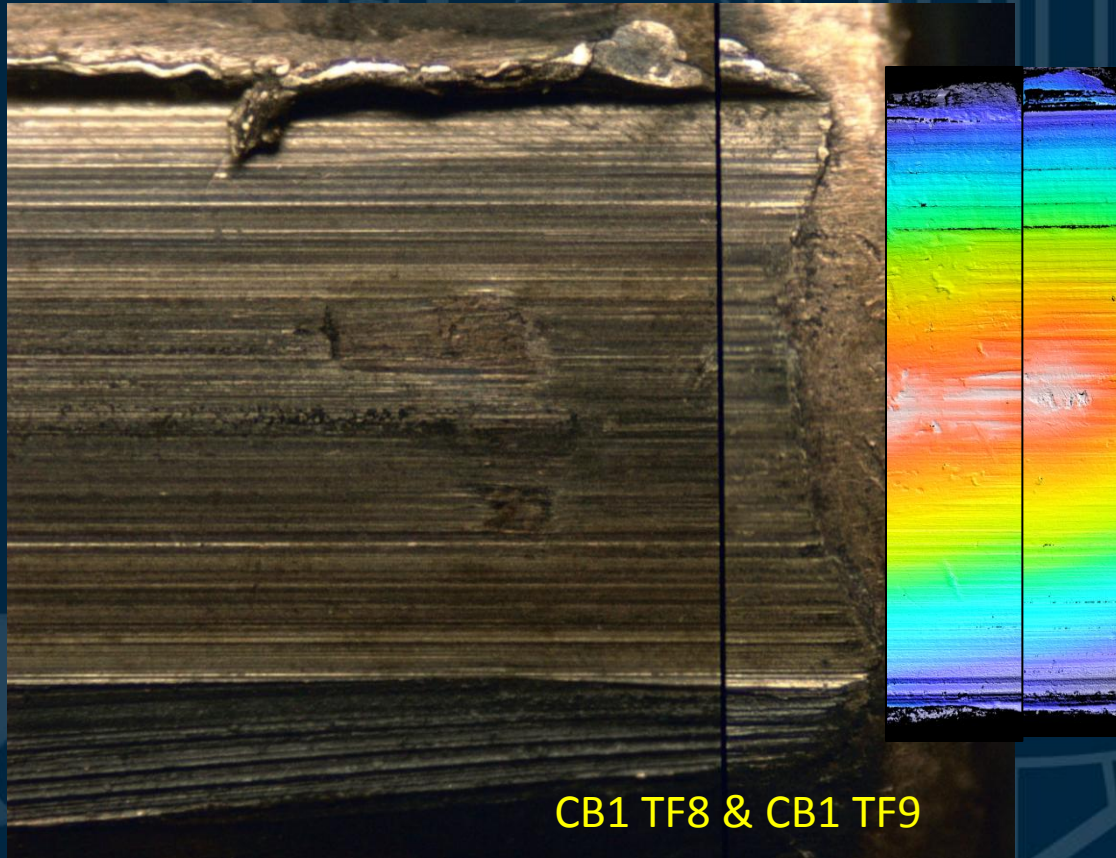
Quality Control:

- Calibration of objective
- Background noise check
- Roughness standard SRM2073a
- Step height standards (10 µm, 50 µm, 100 µm)
- Standard bullet SRM2460-003 LIMP 2



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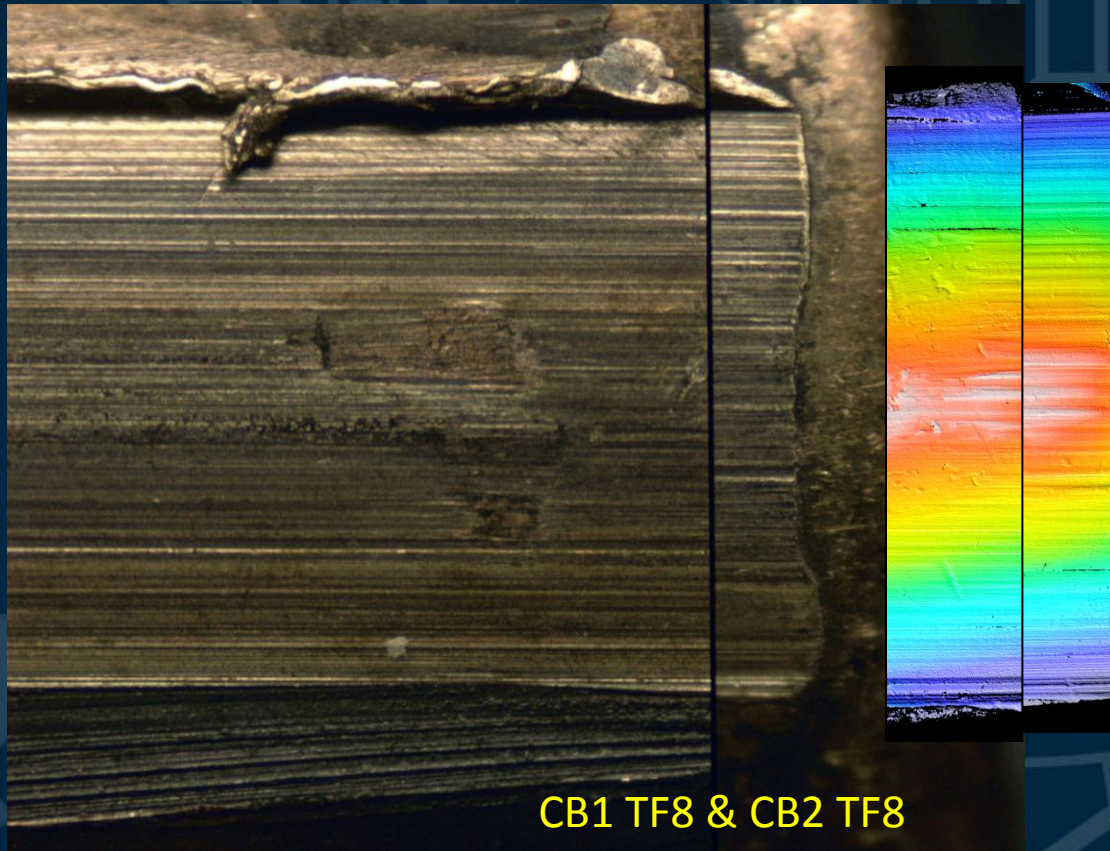
CB1 TF8 & CB1 TF9

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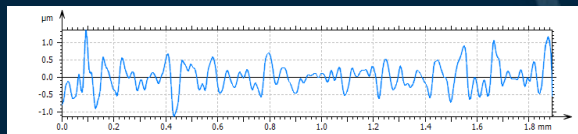


CB1 TF8 & CB2 TF8

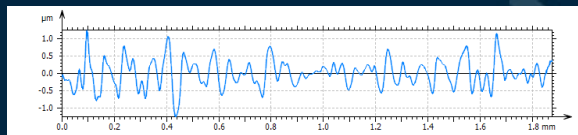
## FIREARMS/TOOLMARKS UNIT



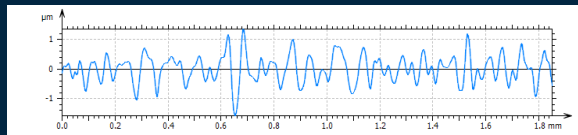
# FBI/FTU Research Group



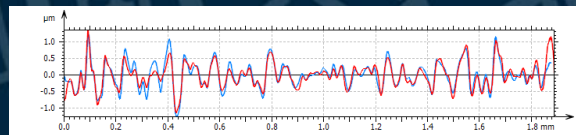
Average Profile CB1 TF9



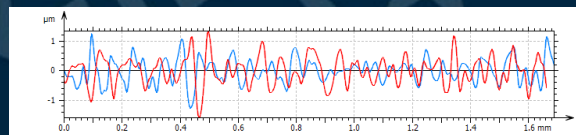
Average Profile CB1 TF8



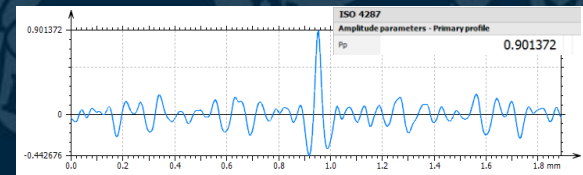
Average Profile CB2 TF8



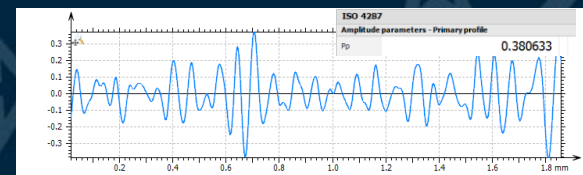
Best Fit CB1 TF8 & CB1 TF9



Best Fit CB1 TF8 & CB2 TF8



CCF Profile CB1 TF8 & CB1 TF9



CCF Profile CB1 TF8 & CB2 TF8



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# *Conclusions*

- Double Broaching Method did not exhibit significant subclass carry over causing an examiner to conclude that bullets from different barrel originated from the same barrel.
- Sensofar Confocal Microscope with matching software algorithm was successful in identifying matching pairs.



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1. AFTE.org (last viewed 5/21/2016), SWGGUN ARK, Error Rate Resources, 2010, Doug Murphy
2. FBI Laboratory, Firearms/Toolmarks Unit (FTU), Case Assignment, Records, Report Writing and Review, Revision 10, 07/24/10.
3. [www.sensofar.com](http://www.sensofar.com) (last viewed 5/21/16), Specifications
4. Jeff L. Lewin, The Genesis and Evolution of Legal Uncertainty About “Reasonable Medical Certainty”, 57 Md. L. Rev. 380 (1998).

The background of the slide features a large, faint, blue-toned seal of the Federal Bureau of Investigation (FBI). The seal is circular and contains the words "FEDERAL BUREAU OF INVESTIGATION" around the perimeter. In the center, there is a shield with a scale of justice and a banner that reads "FIDELITY BRAVERY INTEGRITY". Below the seal, there is a silhouette of a handgun pointing to the right.

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