



# The Challenge of Successfully Capturing and Comparing Bullet Topography

Presented by:

Alain Beauchamp, Ph.D.  
Manager, Research and Prototyping  
Forensic Technology

Contributors:  
Danny Roberge, Ph.D.

# Purpose

The purpose of this presentation is to give an overview of our R&D activities on BULLETRAX-3D since 2004

# Presentation Outline

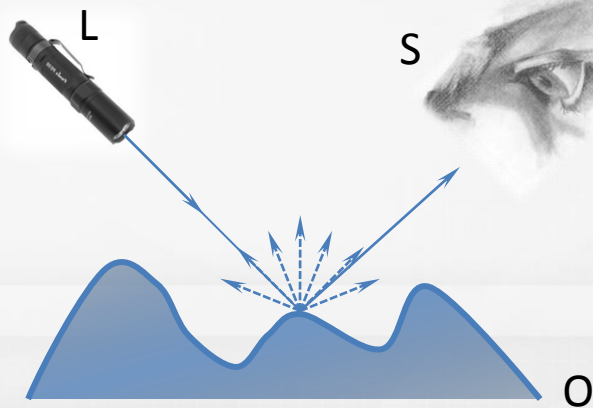
- 1- Captured data:
  - The importance of capturing the 3D topography for bullet analysis
- 2- Acquisition Sequence in BULLETRAX-3D
- 3- Splitting the Topography in Two Levels of Resolution improves visual analysis
- 4- Comparison Process (Correlation)
- 5- Achievement: Support to solving the Gurney Case
- 6- Conclusions



# Captured Data

# Captured Data

Firearm experts have been working with comparison microscope for years and never directly compared topography measurements.



L : Light source  
O : Object  
S : Signal

$$S = F(\text{Light}(\lambda, \Omega), \text{Object}(R, T))$$

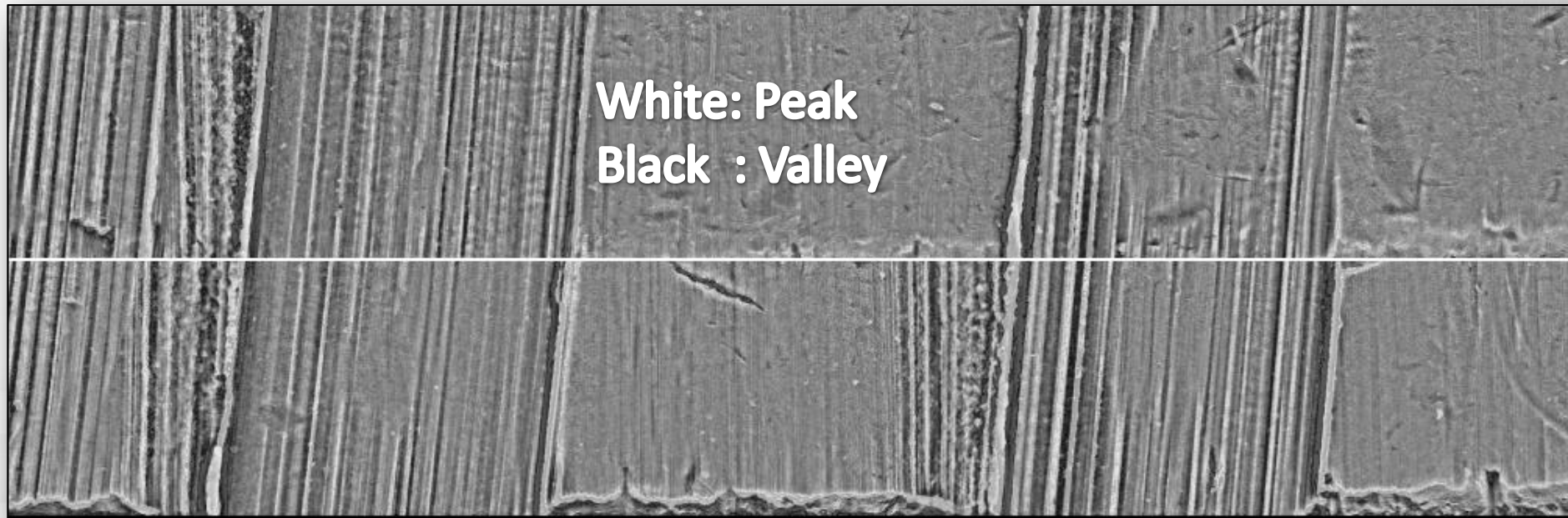
*S = interpretation of T*

3D reconstruction from 2D images  
→ Easy for Human brain: photo stereo reconstruction



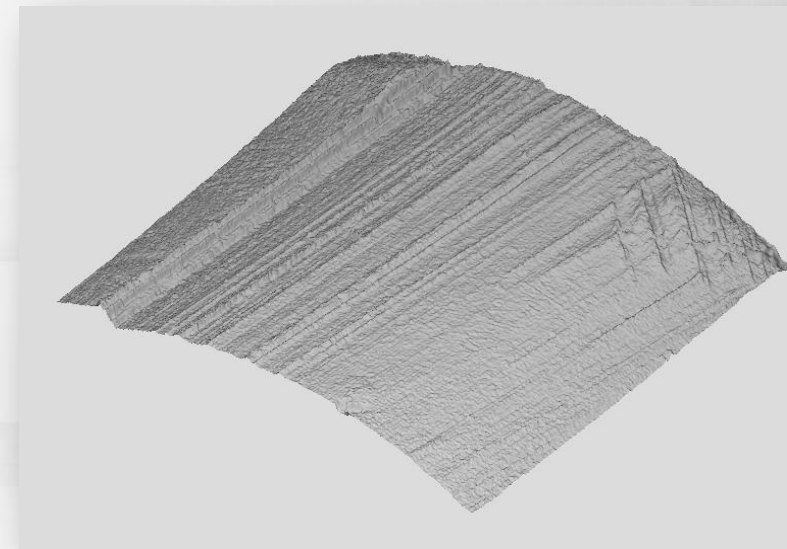
# Captured Data

2003: Select a confocal microscope for BULLETRAX-3D



# Automated Acquisition Sequence

- 3D resolution:
  - $\Delta X = 3 \text{ } \mu\text{m}$ ,  $\Delta Z = 0.2 \text{ } \mu\text{m}$
  - NIST bullet, digital profiles
- Many sensors with such resolutions on the market



The real challenge: **3D Automated Acquisition of the Bullet's Surface**

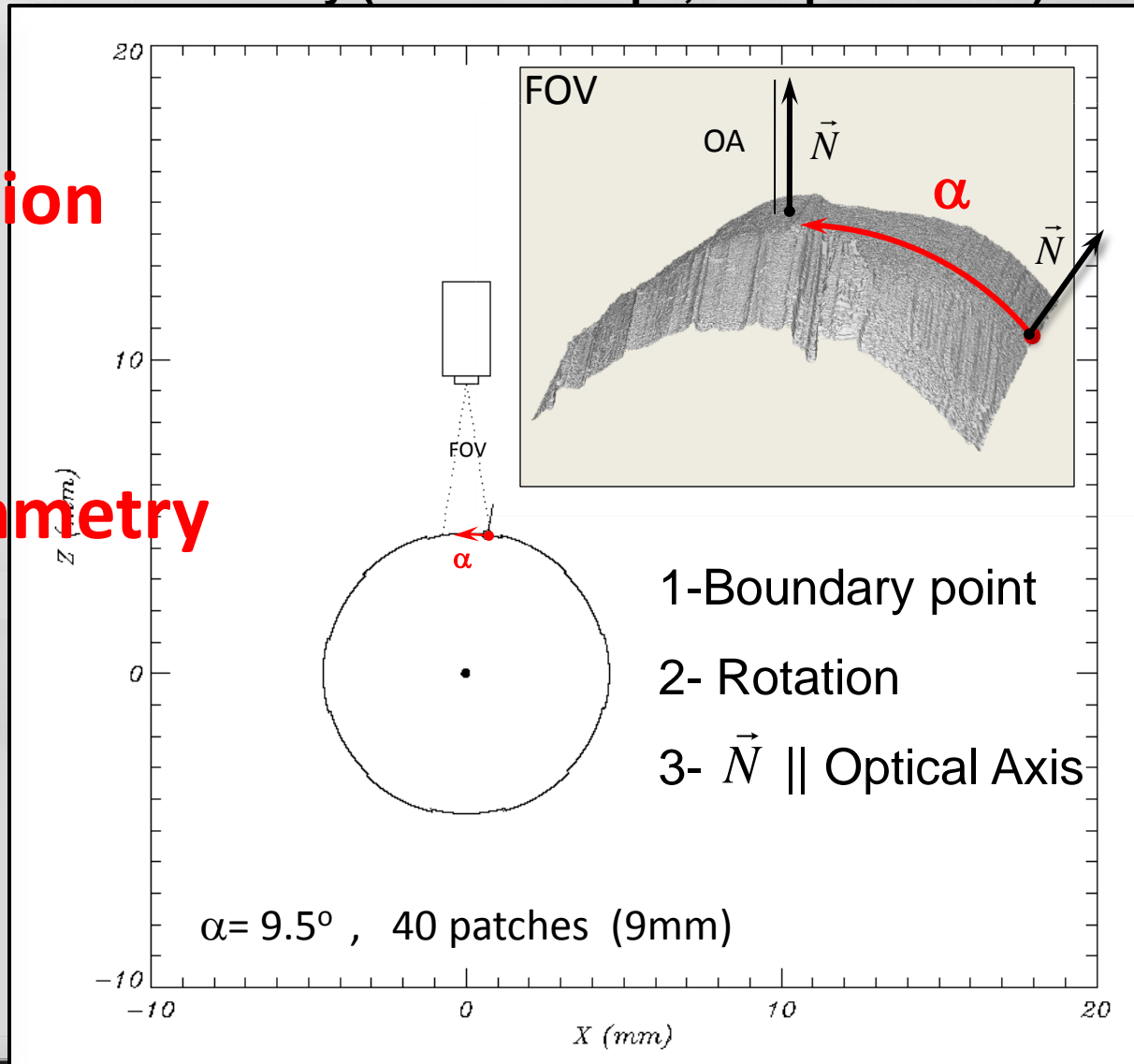
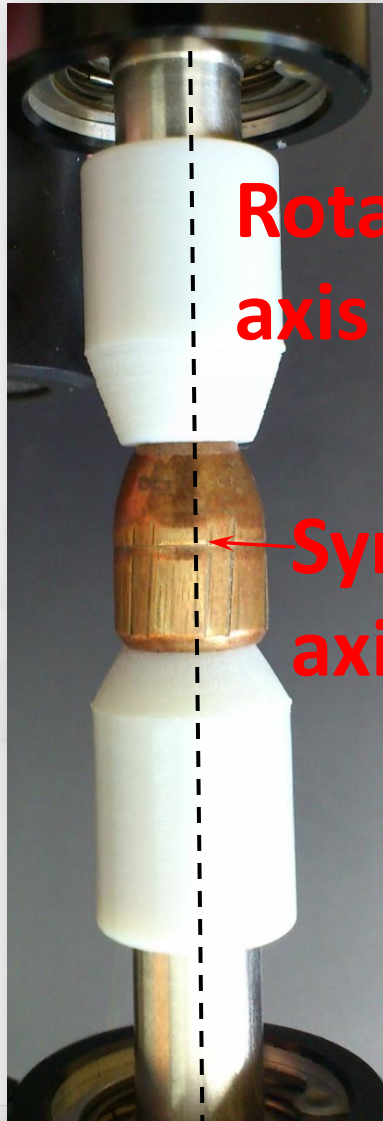


# Automated Acquisition Sequence



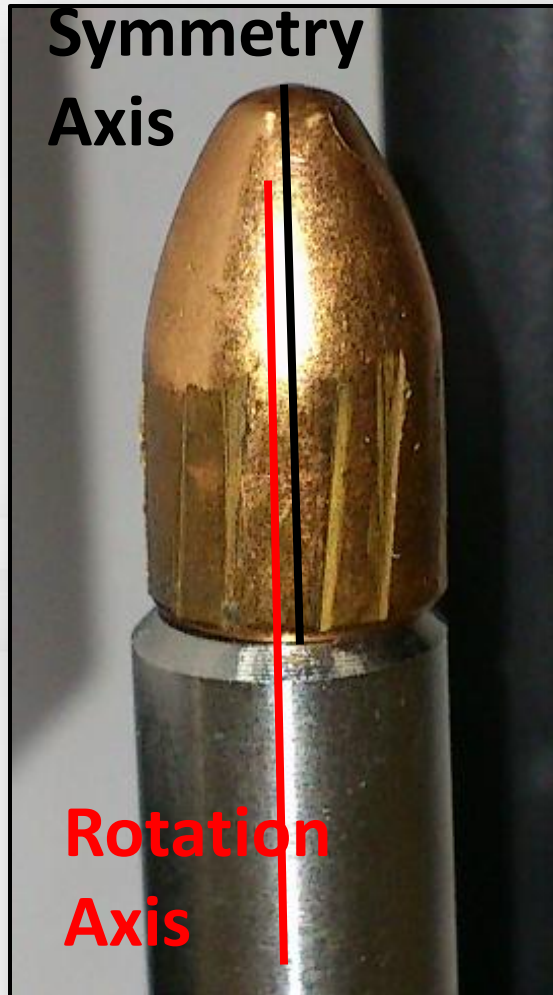
# Automated Acquisition Sequence

Rotation Mode Only (Pristine shape, well positioned)



# Bullet Acquisition Sequence

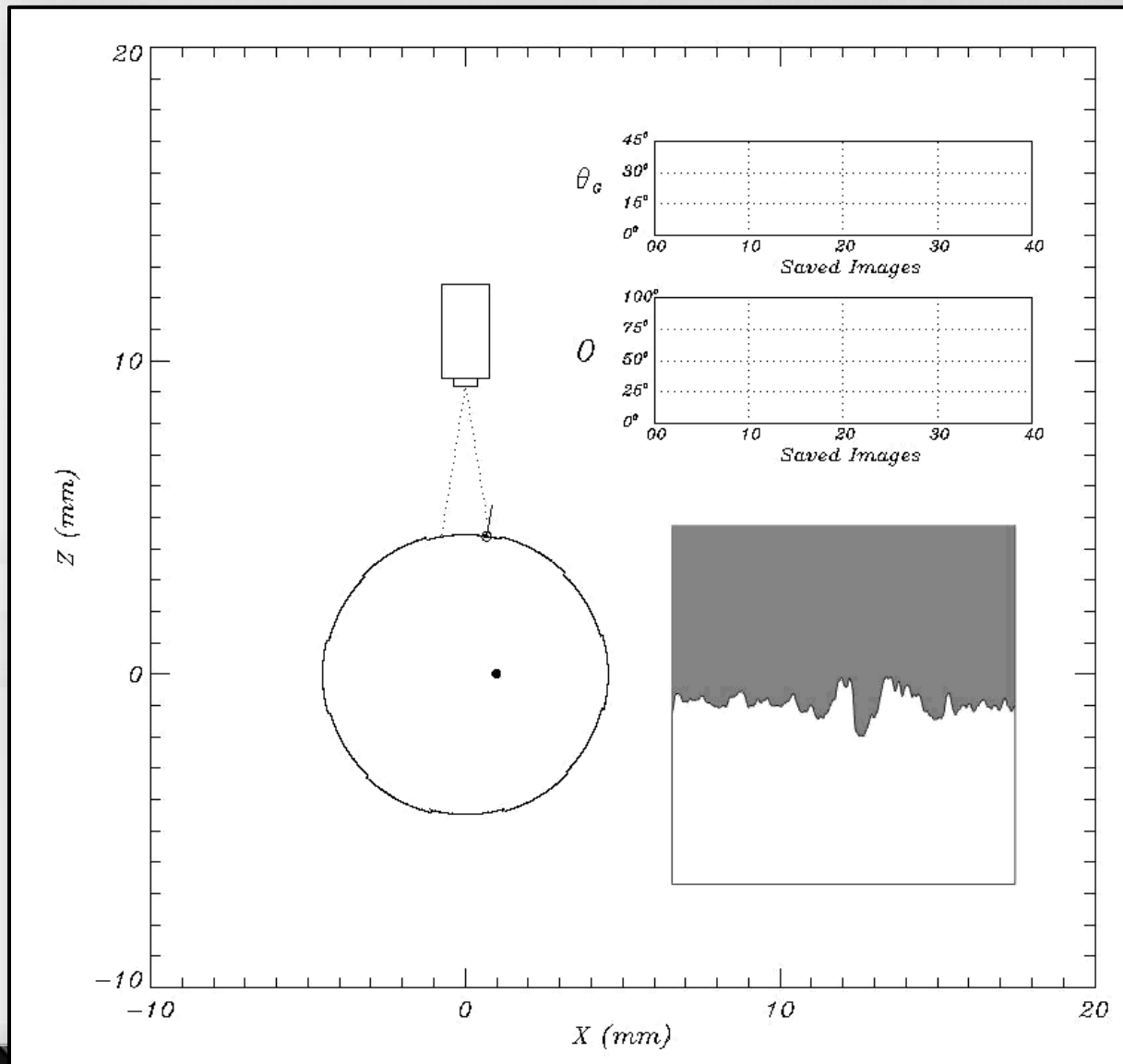
- User positioning variation (Pristine bullet)



What is the  
consequence of being  
off-axis when using  
Rotation mode only?

# Automated Acquisition Sequence

Rotation Mode Only (pristine shape, off-axis  $|\delta|=1\text{mm}$ )



# Automated Acquisition Sequence

1- Rotation mode only:

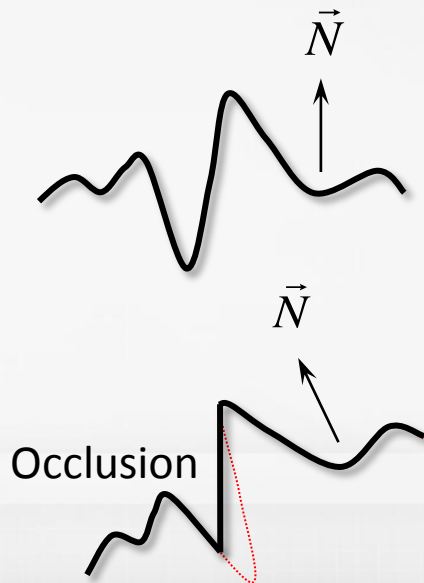
→ *Not sufficient for acquiring all pristine bullets*

2- Must Minimize occlusion

*Topography must be perpendicular to the optical axis*

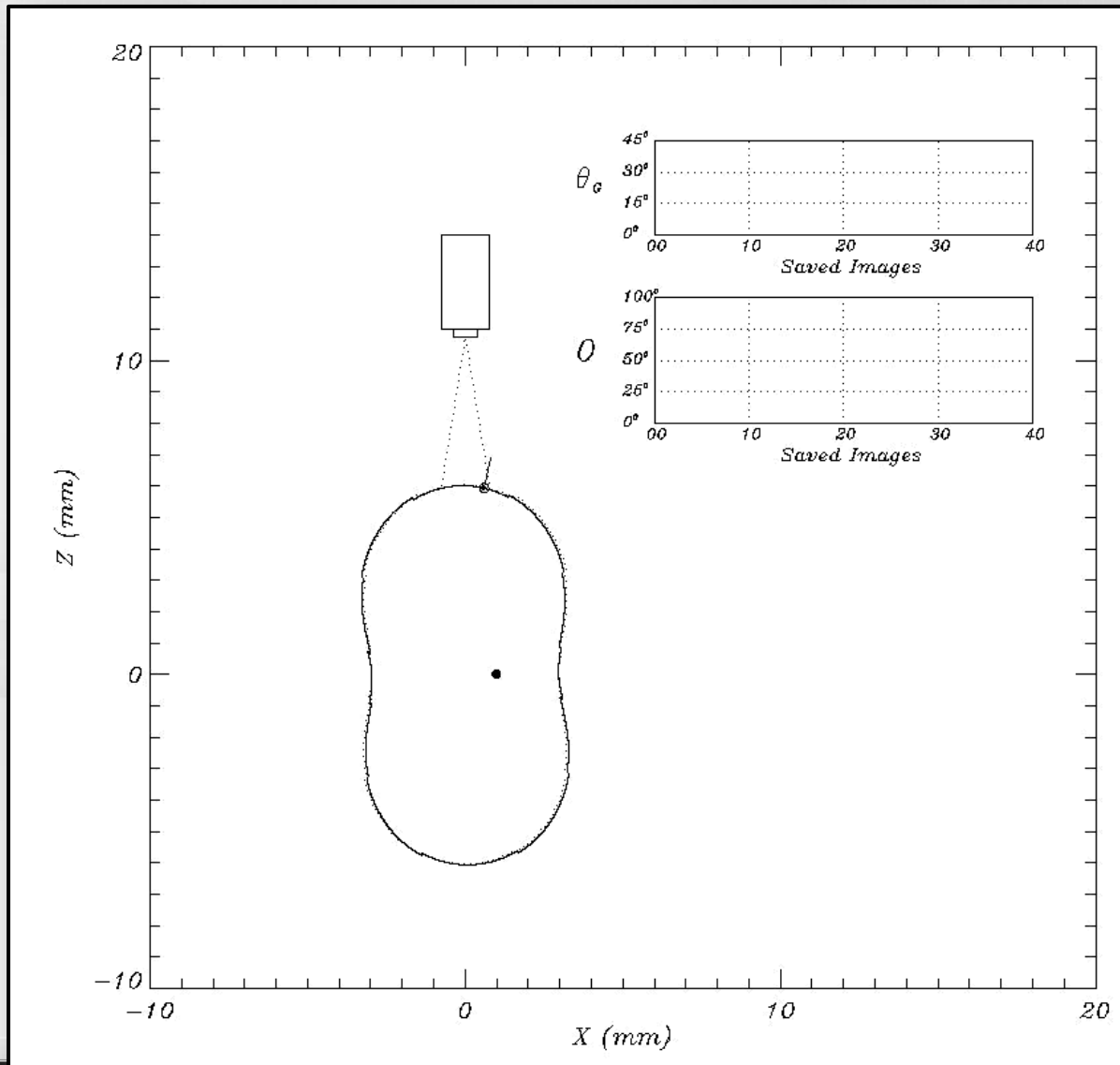
3- Solution: Combination of Rotation and Translation:

*Motorized Repositioning*



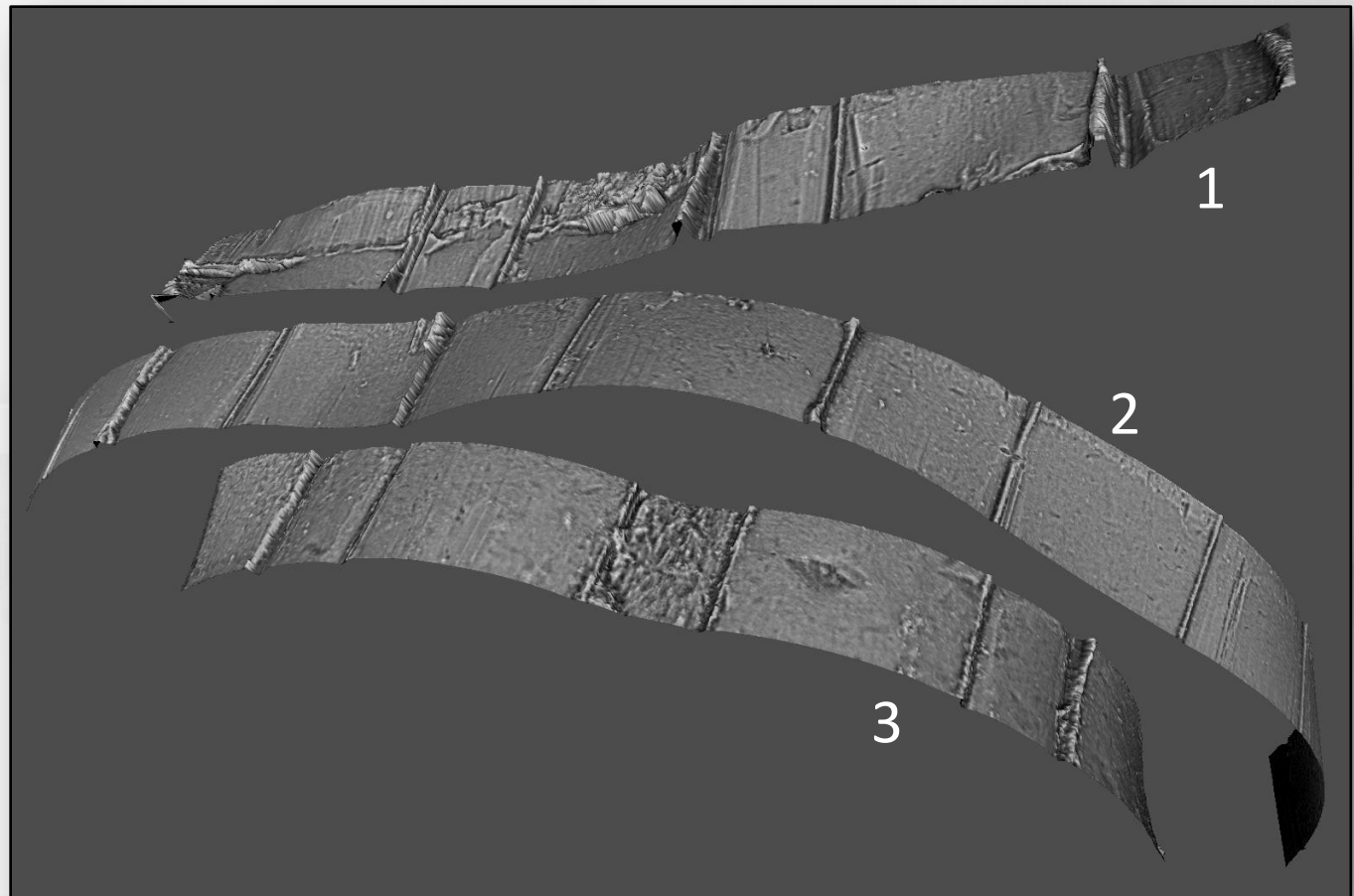
# Automated Acquisition Sequence

## Repositioning (Deformed shape, Off-axis $|\delta|=1\text{mm}$ )



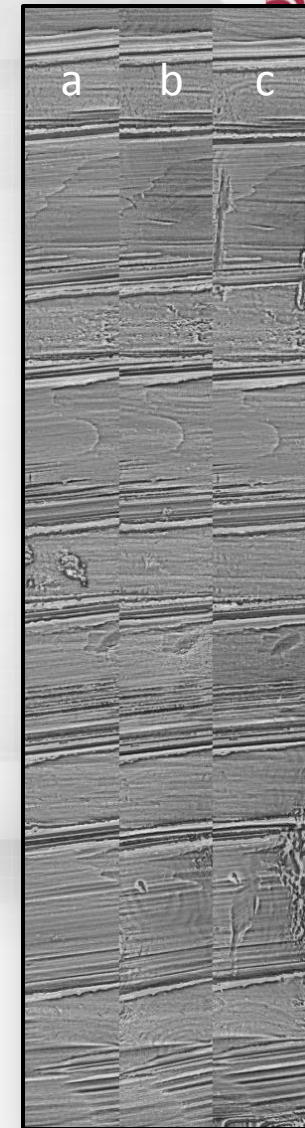
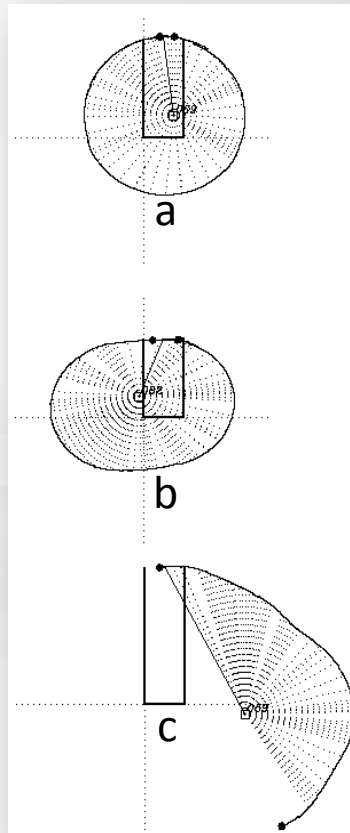
# Automated Acquisition Sequence

- This algorithm has been implemented in BULLETRAX-3D for deformed bullet acquisition.
  - 3 years of R&D



# Automated Acquisition Sequence

- Test: 3 levels of deformation of the same bullet

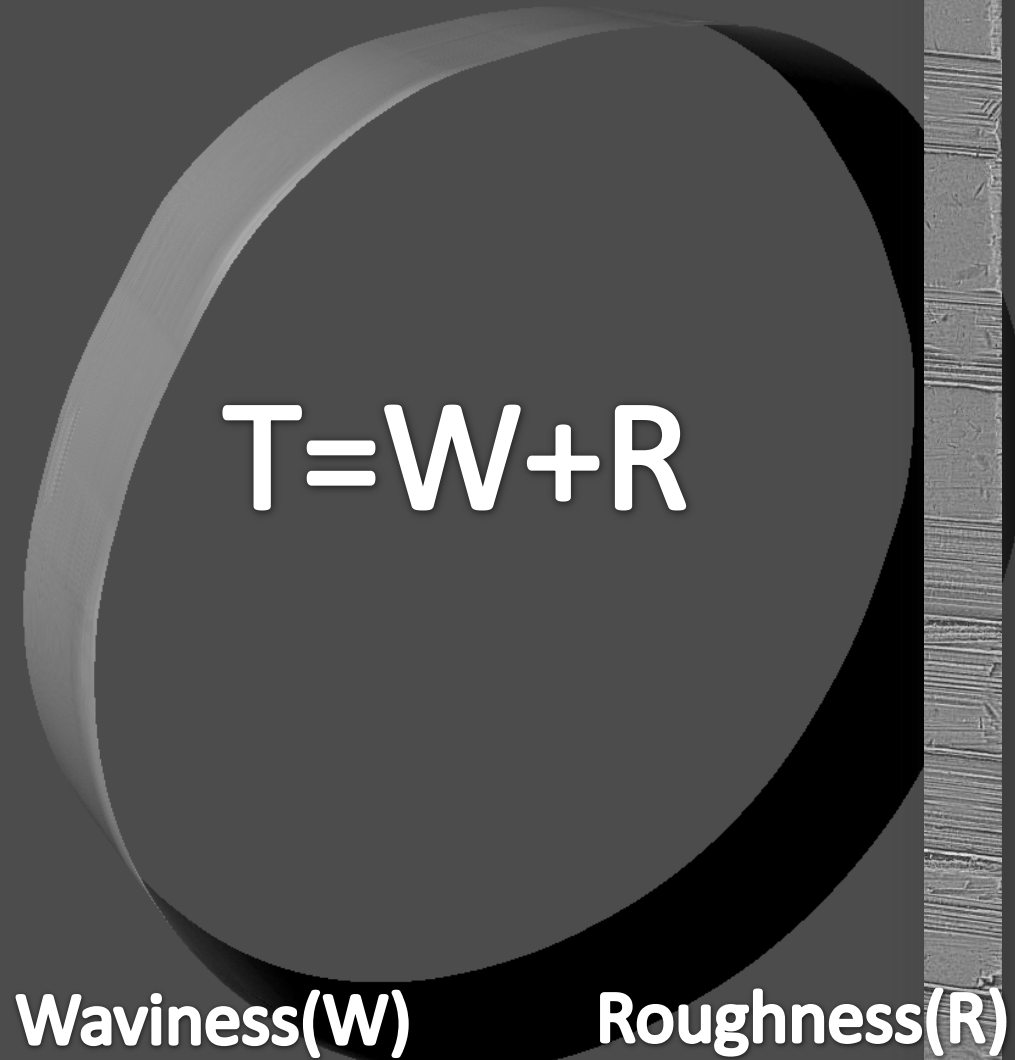
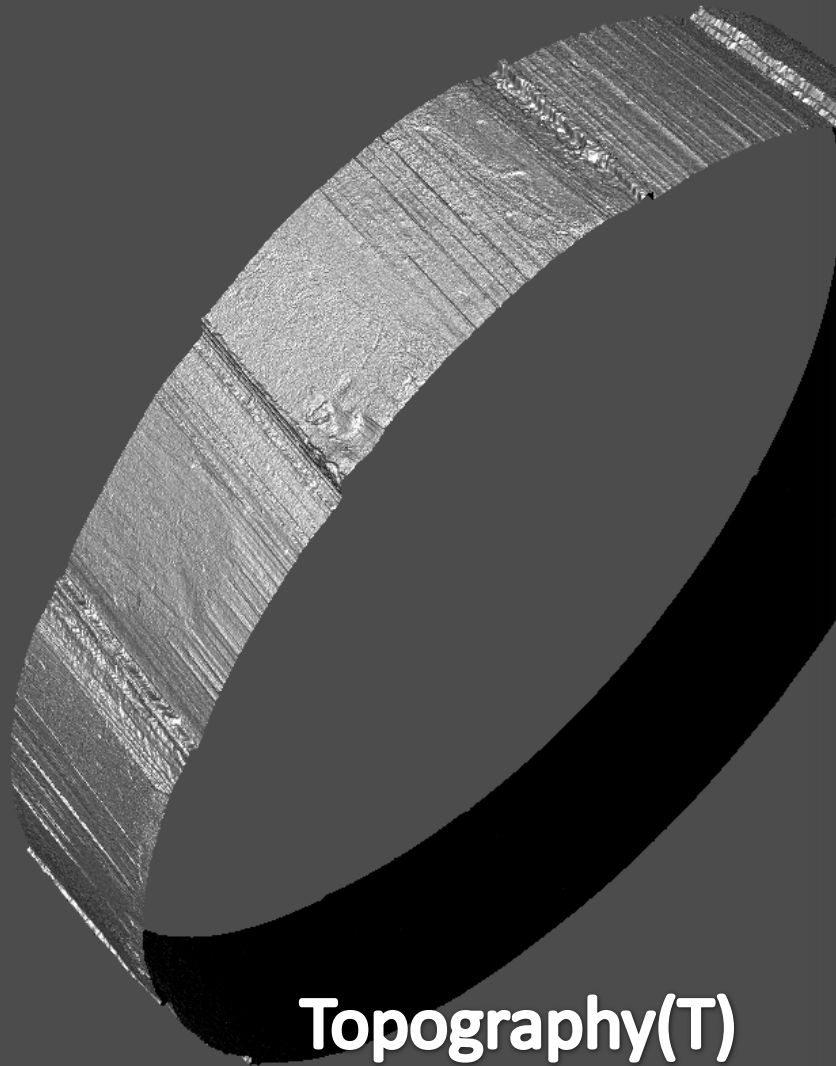




# Splitting the Topography Resolution



# Splitting the Topography Resolution

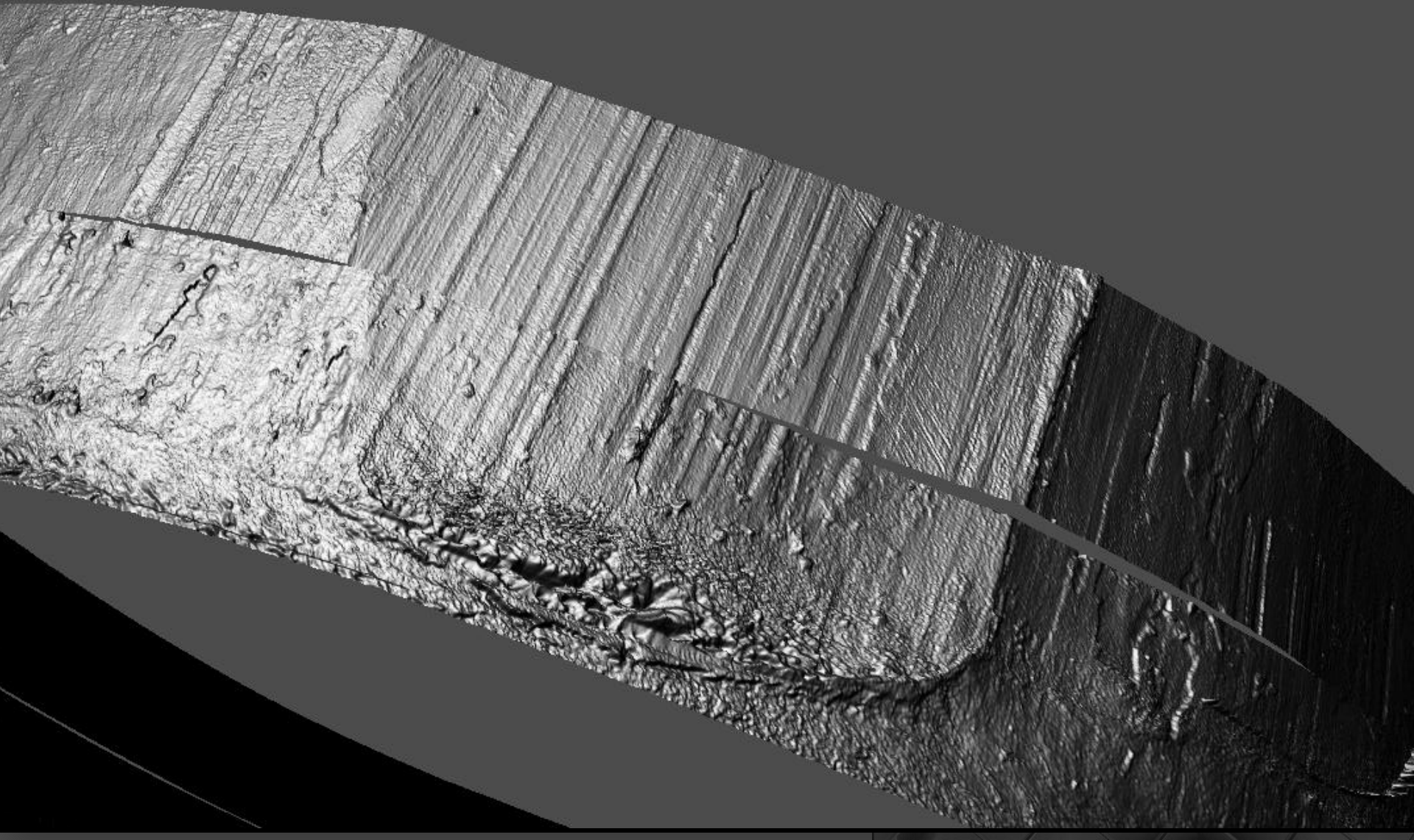


## Splitting Topography resolution

- Waviness cloning

- Roughness enhancement

} Visualization





# Comparison Process

# The Comparison Process (correlation)

- Trade-off scenario
  - Natural variation between known matches
  - Variation between known non matches
  - Compromise: Minimize false positive and false negative
- 3 correlation algorithms
  - Cut/Button, 4 calibers (2005)
    - 80% in Top 10, Copper jacketed
    - 60% in Top 10, Lead
  - Regular Polygonal, 3 calibers (2010)
    - 25% in Top 10
  - EBIS polygonal (2011)
    - 100% in Top 3
- Training set :
  - >1500 KM pairs
  - > 100 KM pairs per caliber



# **Achievement: Solving a Difficult Case**

# Achievement

- Rocky Edwards, from Santa Anna, came at the office 2 years ago
  - Gurney Case: the most difficult case he had to work on in 25 yrs.
- The murderer scratched the barrel of his gun, thinking that the test fire bullets would be in poor conditions ... and he was right!
- Rocky made a barrel cast and brought it to FT with 8 test fires and 3 pieces of evidences.
- We acquired them all on BULLETRAX-3D and put them on the IBIS Comparison Microscope-3D.

# Achievement

SANTA ANA – An Anaheim gang member was convicted Thursday of gunning down a rival in 2003 after testimony from a ballistics expert linked the defendant's handgun to the bullets fired.

Jaime Guadalupe Gonzalez, 23, now faces a potential life term in prison without parole for the first-degree murder with special circumstances of Juan Carlos Cena, 19, on Dec. 8, 2003.



Jaime Guadalupe Gonzalez

COURTESY OF THE ORANGE COUNTY DISTRICT ATTORNEY'S OFFICE.

Jurors in Superior Court Judge James Stotler's courtroom deliberated more than a day before finding the defendant guilty.

Deputy District Attorney Colleen Crommett said Gonzalez targeted Cena because the victim showed disrespect by trying to sell stolen bottles of shampoo in Gonzalez's gang's territory.

Gonzalez was "all pumped up" when he saw Cena because he knew that Cena was a rival gang member because of several personal altercations in the past, Crommett said.

So Gonzalez "hit up" Cena on an Anaheim street and then shot him several times, Crommett said.

The shooting went unsolved for nine years, Crommett said, until a Santa Ana police forensic ballistics expert using modern 3-D technology matched one the bullets taken from Cena's body to a mostly destroyed .38-caliber hand gun which had been confiscated from Gonzalez a month after the shooting.

**Guilty, 1st Degree Murder**

Guilty Bullet

on

Cu TF



# Conclusions



# Conclusions

- Captured raw data: **Topography**
- Capturing a single 3D patch is not a challenge anymore  
**Automated system**
- Rotation Mode is not sufficient even for pristine bullets  
**Motorized repositioning**
- Splitting topography resolution improve visual analysis  
**Waviness reshaping and Roughness enhancement**
- Achievement:  
**The system can help solving difficult cold cases**



**Thank you**