Victor Aviation™

Presented to: September 2014

Airlines for America™
We Connect the World

Victor Aviation™

Victor Sloan

FAA Approved Repair Station #BJ39399L

FAA - NDT RATINGS:

MP-Magnetic Particle ET-Eddy-Current UT-Ultrasonic RT-Radiographic

Affiliate Research Companies

Cryogenic NDT Phase Transformation Testing

Portable X-ray Diffraction Systems

Victor Aviation™

PULSTEC

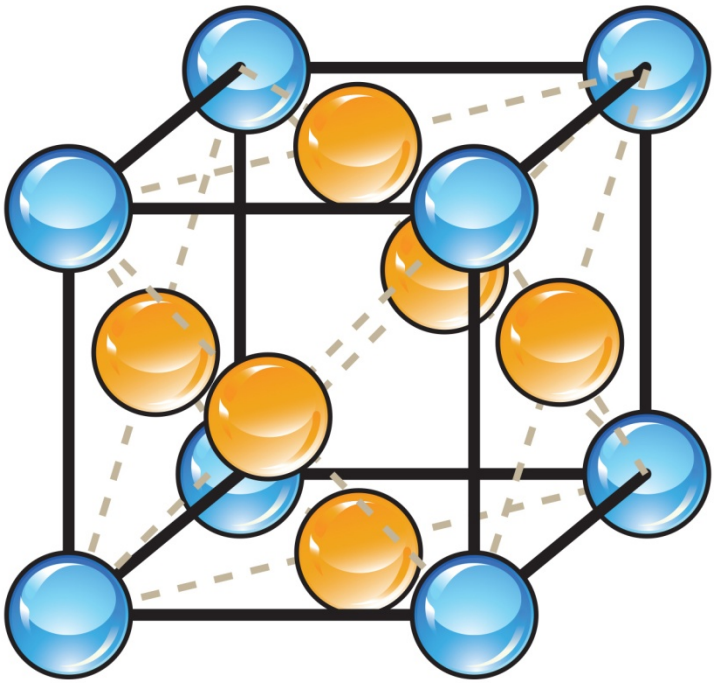
Cryogenic Liquid Nitrogen NDT Phase Transition Detection

ASM INTERNATIONAL® Heat Treating Society™
An Affiliate Society of ASM International®

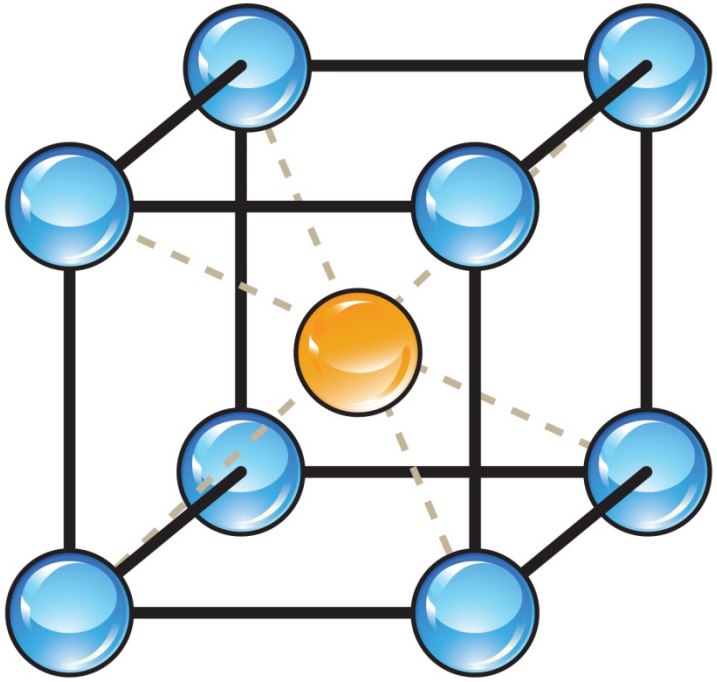
USA Patent Approved

Crystal Lattice Structure

FCC Face Centered Cubic



BCC Body Centered Cubic

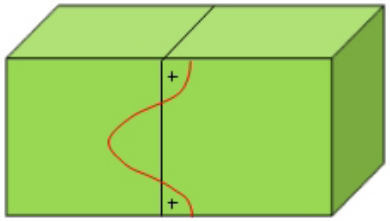


EXAMPLE: Destructive Residual Stress Measurement

CONTOUR METHOD Los Alamos National Laboratory

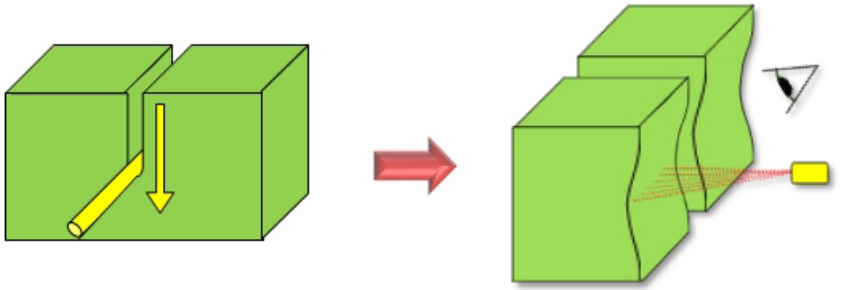
Cross-Sectional Mapping of Residual Stresses by Measuring the Surface after a Cut

Undisturbed body which contains residual stresses



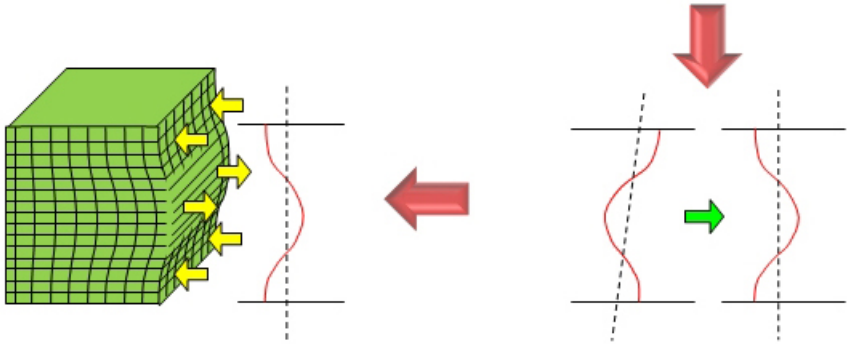
According to the **Theory of Elasticity**, a body containing residual stress will deform as a result of sectioning, and the tractions required to restore the deformed part to its original shape are equivalent to the residual stress released by sectioning.

Step 1 - Section the part using electric discharge machine (EDM)



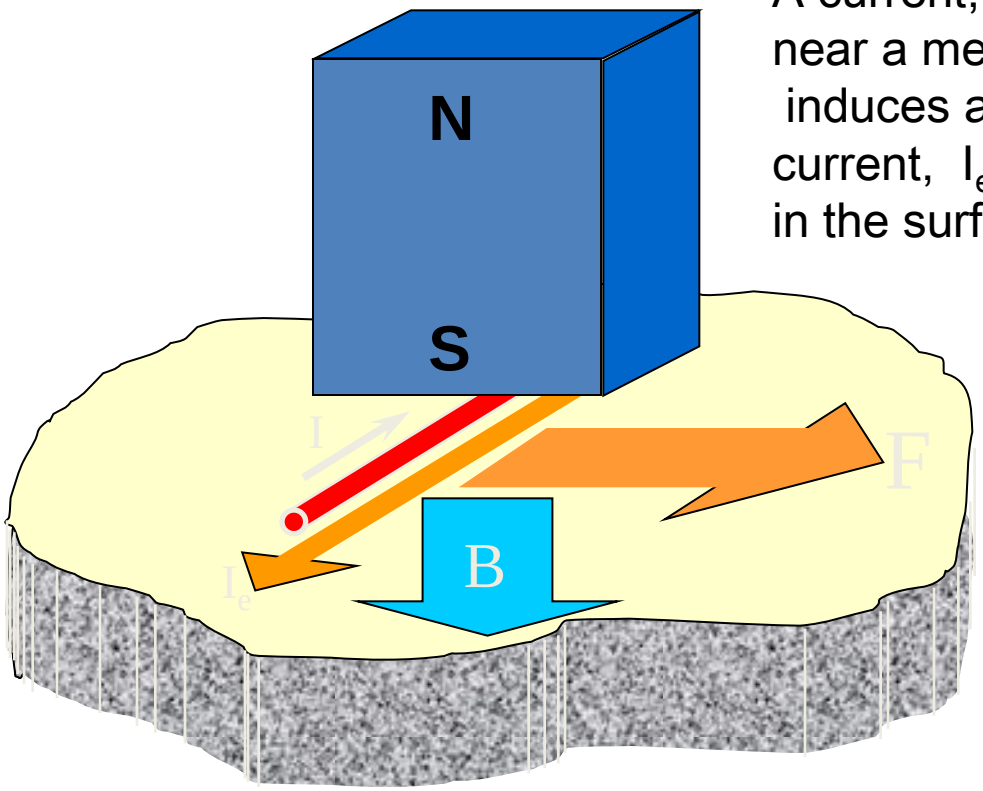
Step 2 - Measure the distortion using computer measuring machine (CMM) or Laser Optics.

Step 3 – Data analysis



EMAT Transduction

EMAT only needs electrical conductivity in the sample to function.



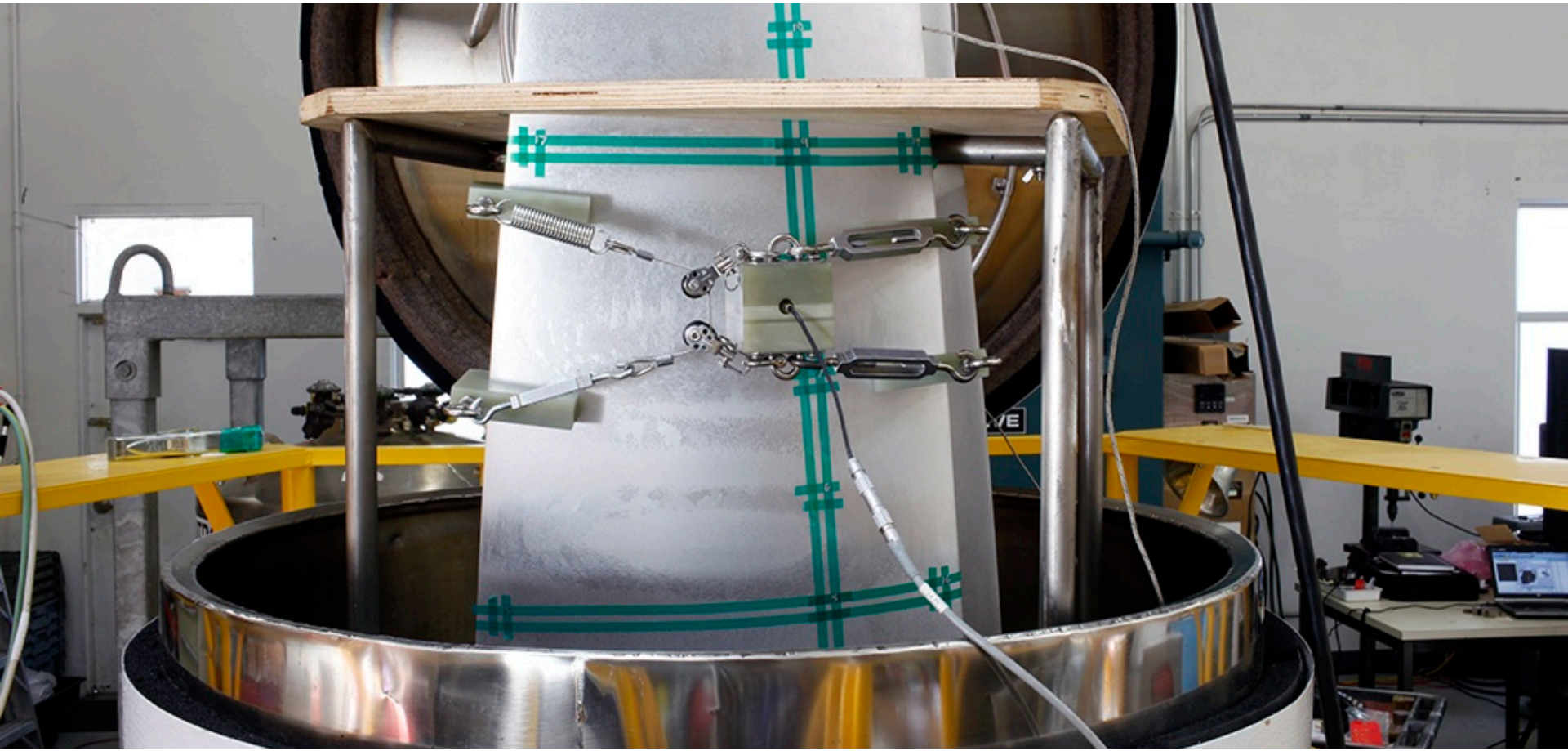
A current, I, in a wire
near a metal surface
induces an equal and opposite eddy current, I_e
in the surface of the metal.

When the eddy current occurs in a magnetic field a force is created in the metallic surface.

$$F = I \times B$$

This force can generate elastic waves, ie. ultrasonic Guided Waves

Real-Time EMAT Analysis



ASM INTERNATIONAL® Heat Treating Society™
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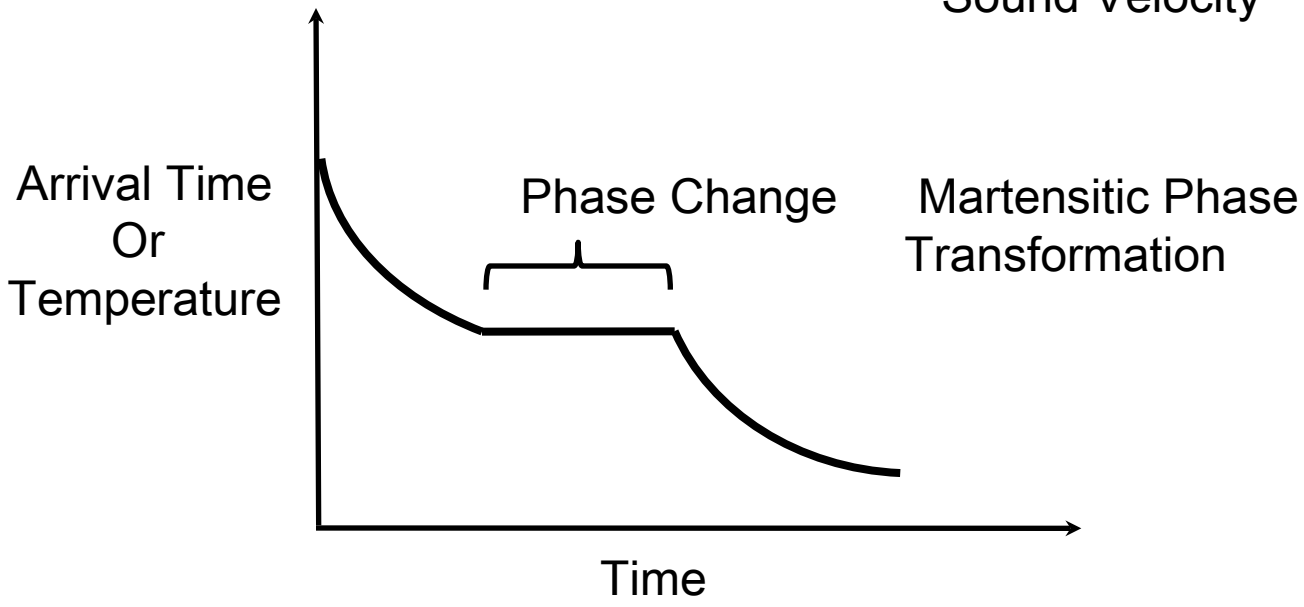
NASA Turbine Blade

Phase Transition Change During Thermal Processing

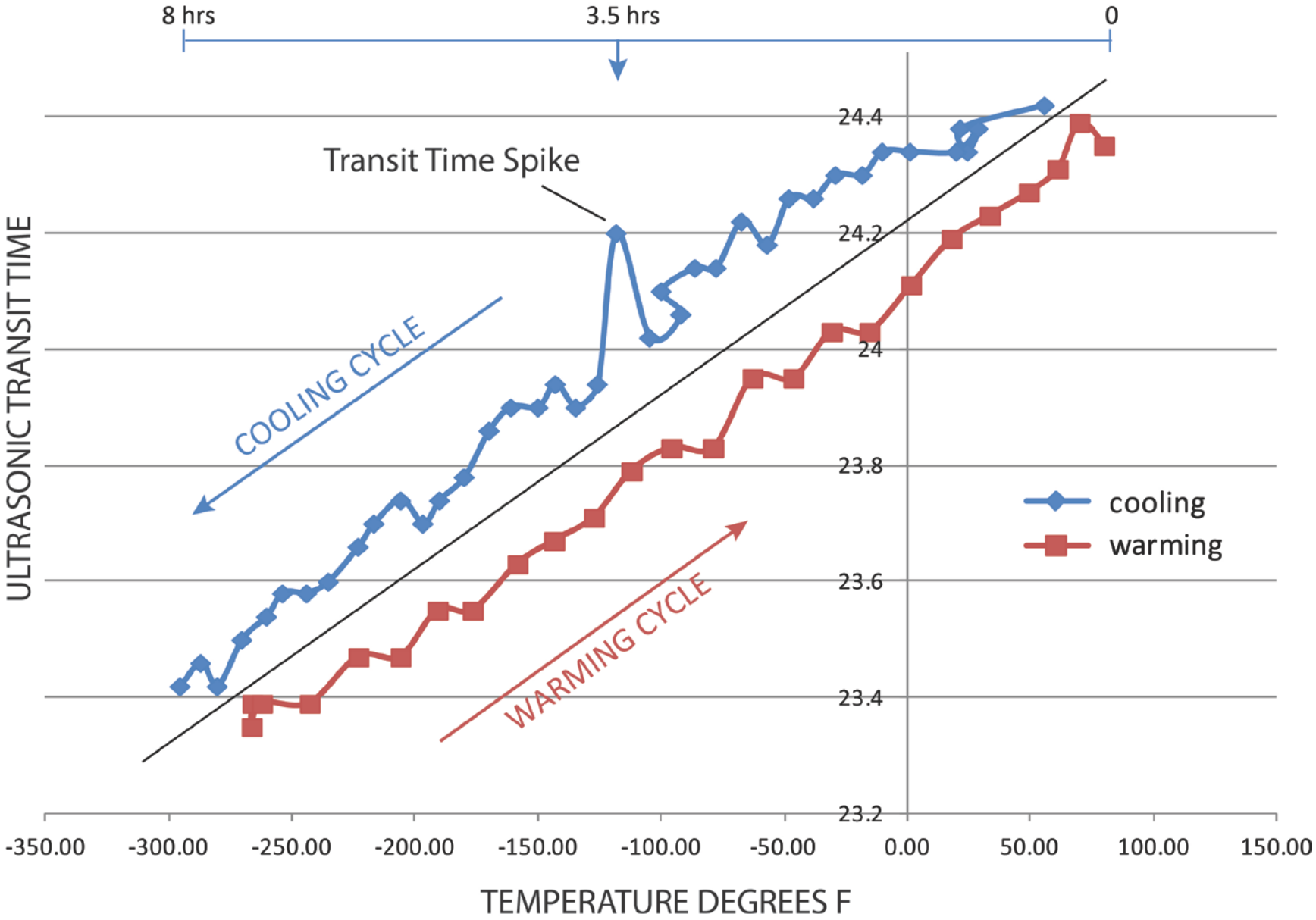
$$\text{Acoustic Arrival Time} = \frac{1}{\text{Sound Velocity}}$$



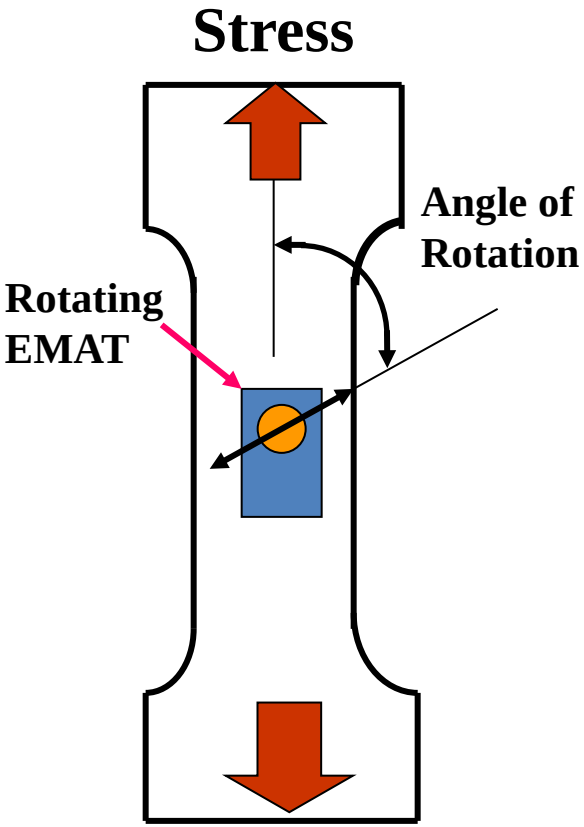
Metal

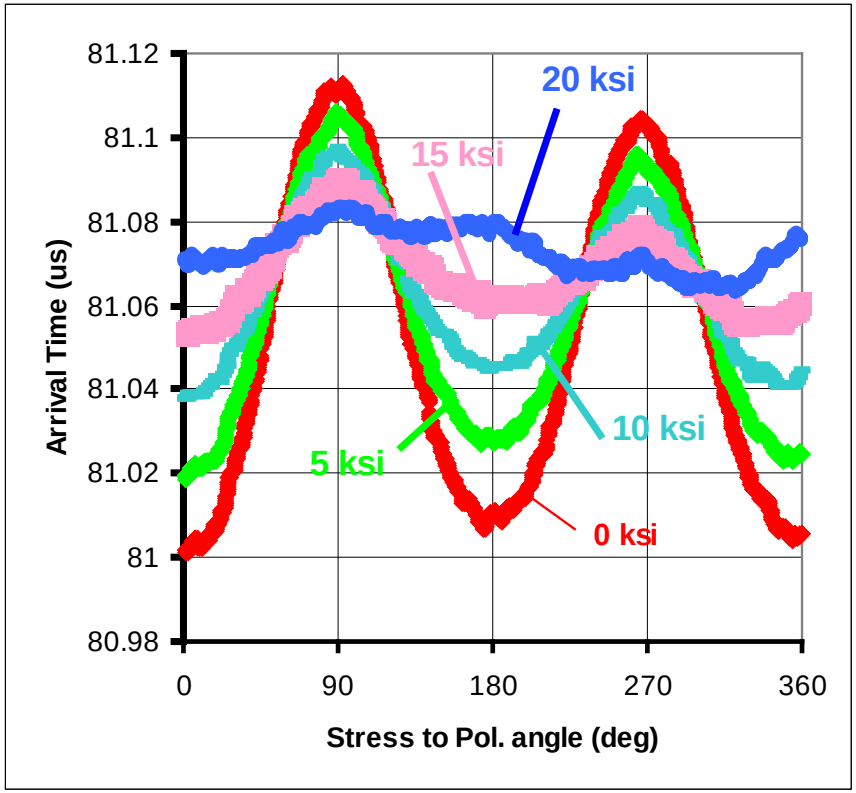
Metal submerged in LN2 during EMAT Velocity Monitoring

Hysteresis Graph - EMAT Ultrasonic */ NASA Turbine Blade*



Stress Measurement with EMAT

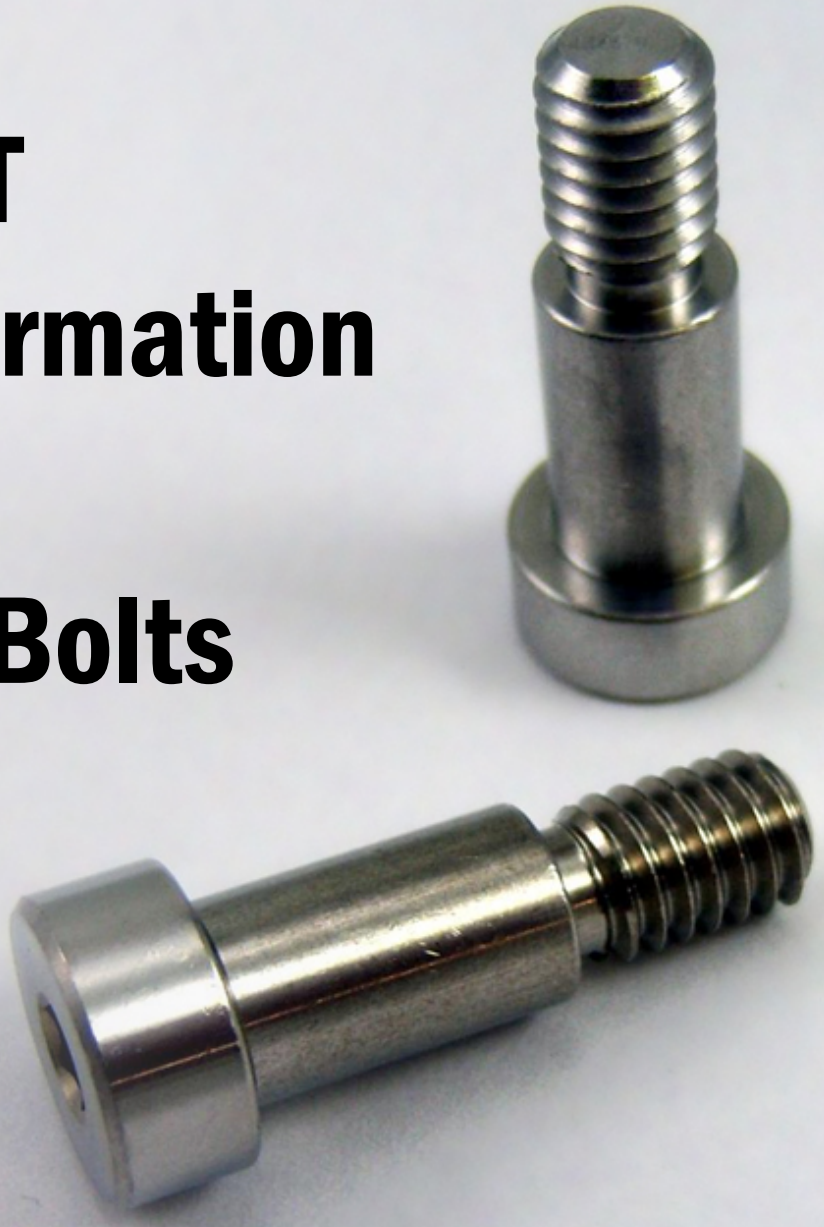




Shear Waves are polarized perpendicular to their propagation direction.
Rotating the polarization relative to stress can find and measure the principal stress in a part.

Cryogenic NDT Phase Transformation CASE STUDY Aircraft Wing Bolts

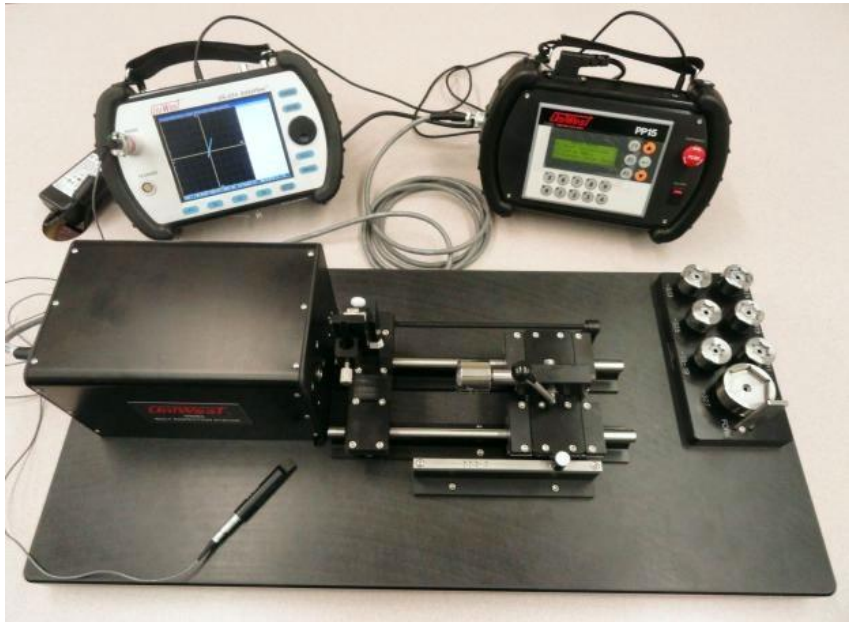
Tom Guettinger
Manager of Complex Systems
UniWest Pasco, WA



EDDY CURRENT SETUP for Cryogenic NDT Phase Transition

ETC-2000 Setup

Specialty Probe



Bolt-Inspection System

BEFORE

Cryogenic NDT Phase Transition

AFTER

Cryogenic NDT Phase Transition

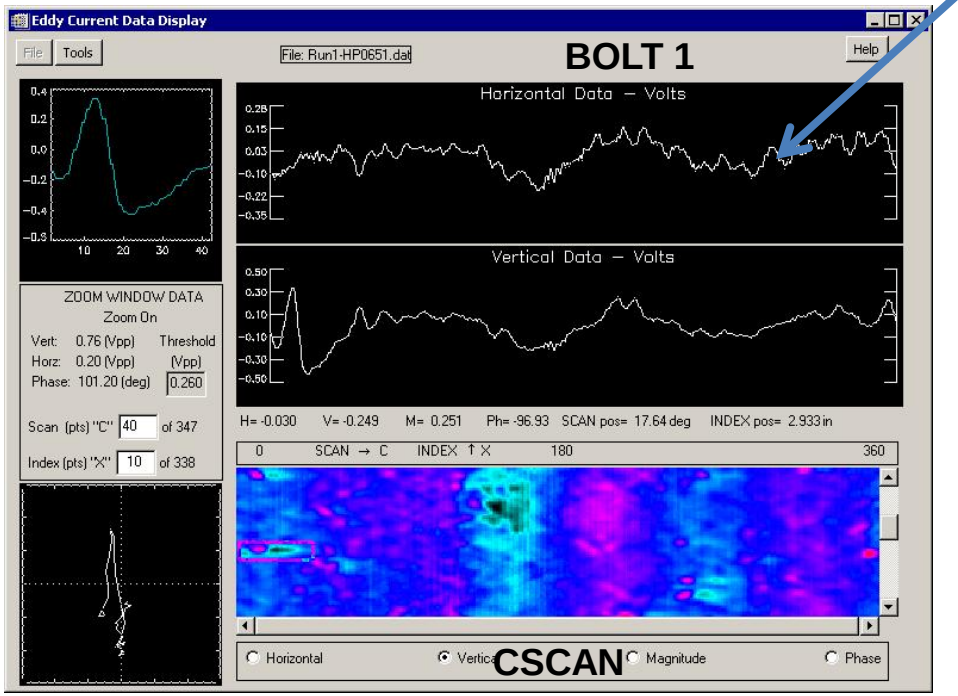
Bolt was classified as

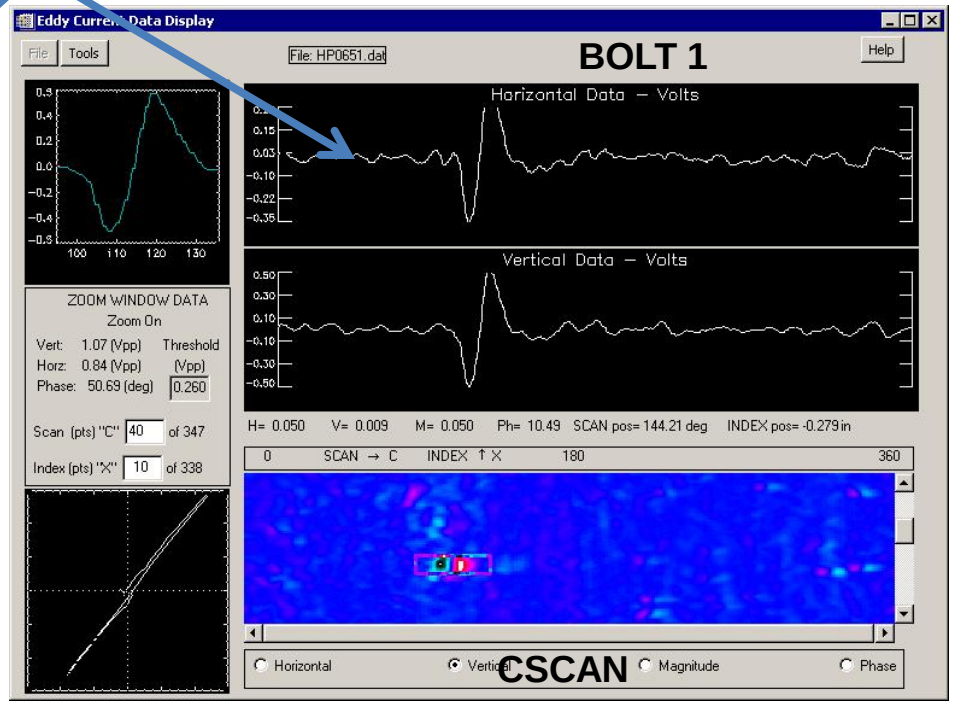
"UNINSPECTABLE"

SIGNAL NOISE

Bolt was classified as

"INSPECTABLE"





Flaws NOT Detectable

High Signal Noise

Flaws Detected

Significant Reduction of Signal Noise

BEFORE

Cryogenic NDT Phase Transition

AFTER

Cryogenic NDT Phase Transition

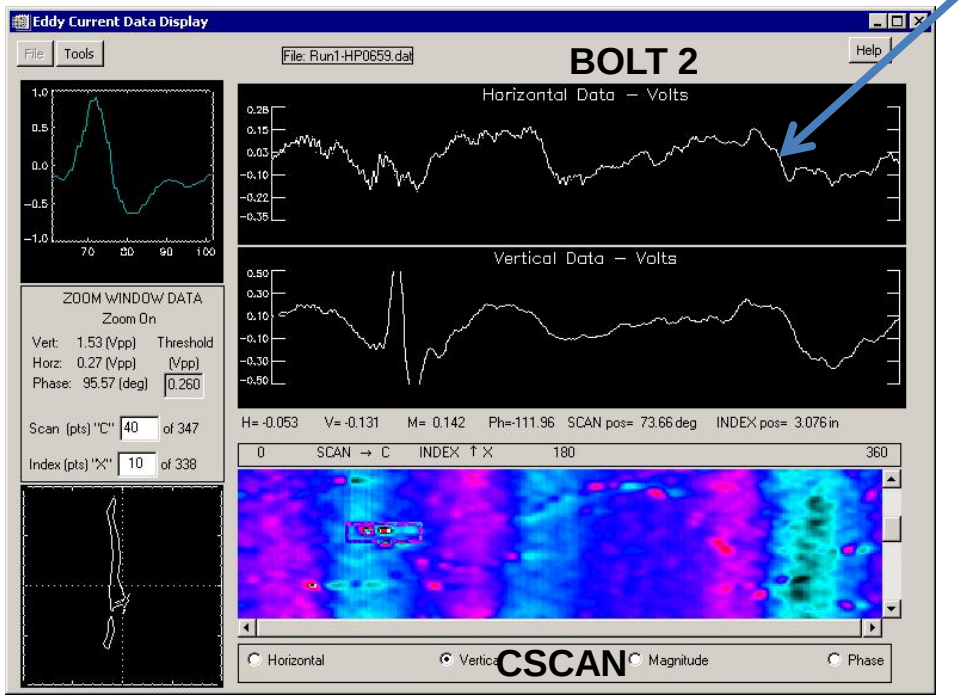
Bolt was classified as

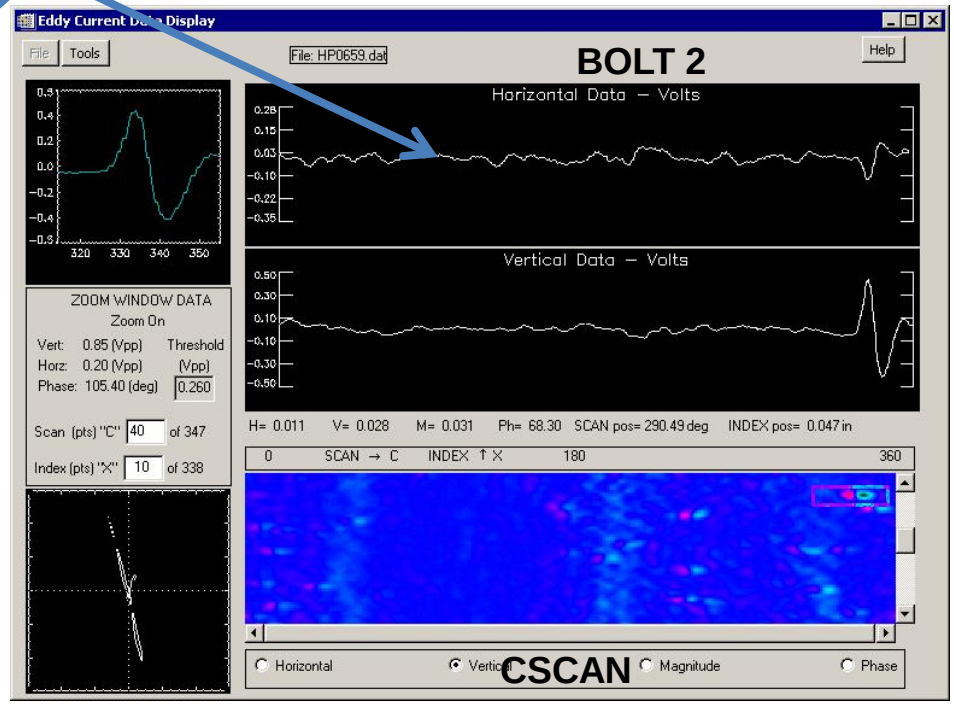
"UNINSPECTABLE"

SIGNAL NOISE

Bolt was classified as

"INSPECTABLE"





Flaws NOT Detectable

No Flaws Detected

High Signal Noise

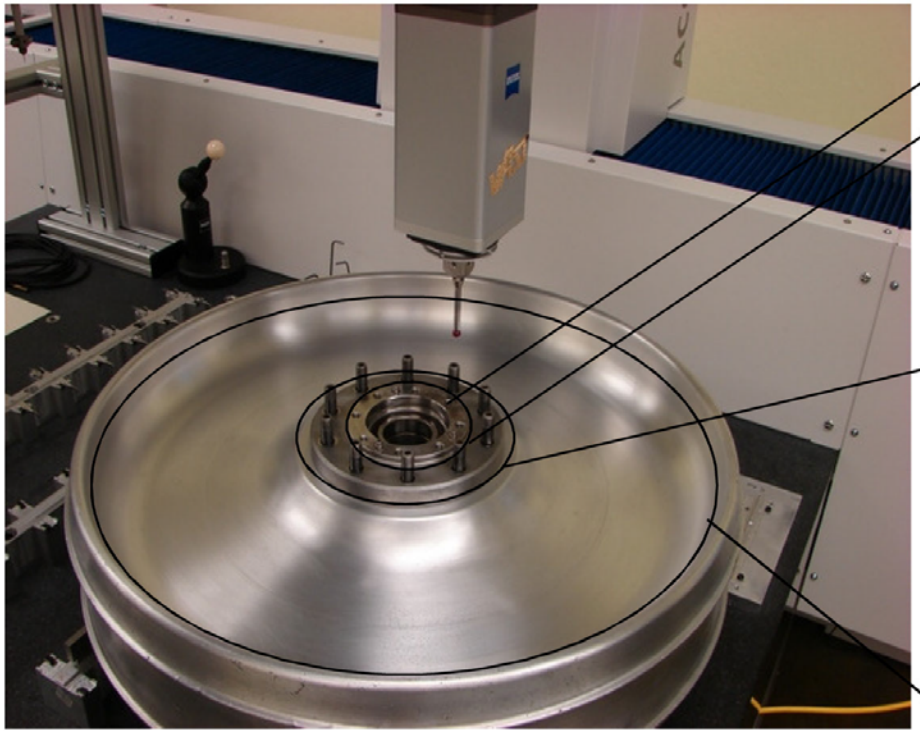
Significant Reduction of Signal Noise

Aluminum 7075 Steering Wheel CASE STUDY

F-104
North American Eagle

Zeiss CMM Computer Measuring Machine
Before and After Cryogenic NDT Shape Data

Eugen F 05.31.2011

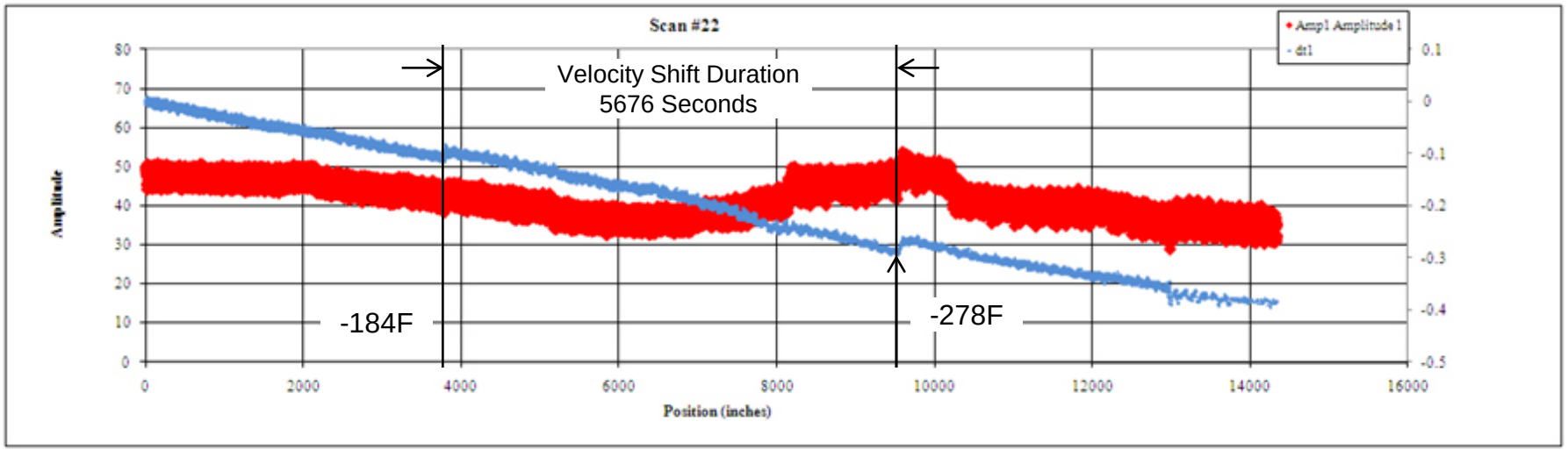


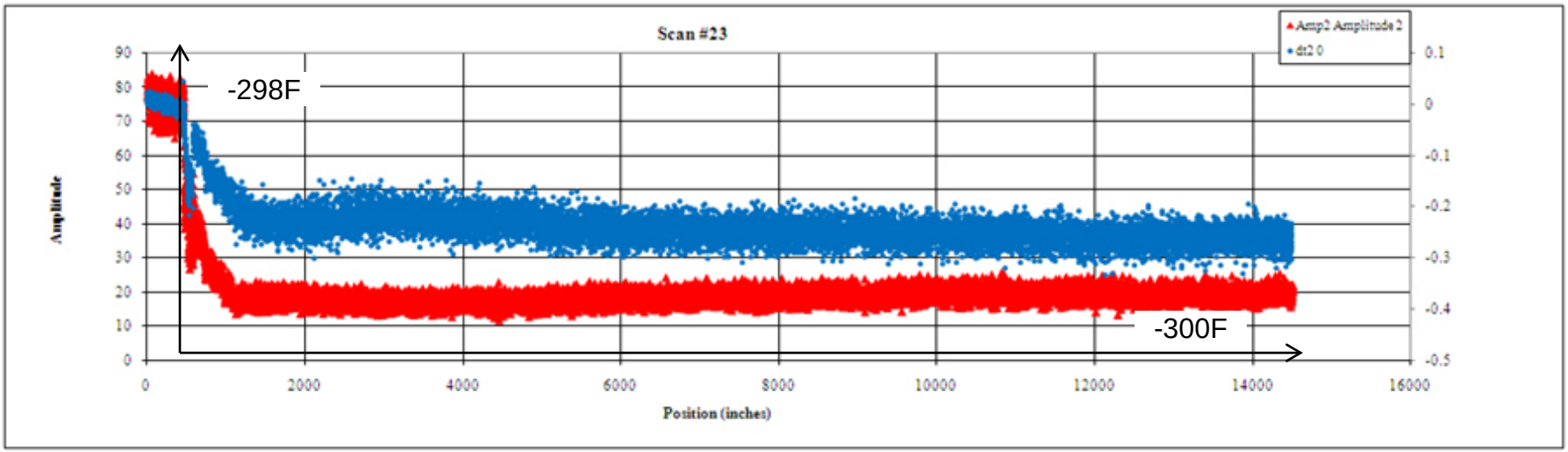
Aluminum 7075 Steering Wheel

24" Wheel

	Before	After	Difference
Flatness1	0.000572	0.000584	0.0000
Diameter_ID	3.000668	3.000748	-0.0001
Roundness1	0.000251	0.000245	0.0000
X Value_Pin	-1.87668	-1.87674	0.0001
Diameter_Pin	0.250095	0.250103	0.0000
Roundness2	0.000268	0.000277	0.0000
X Value_OD	6.94E-05	8.64E-05	0.0000
Y Value_OD	9.04E-05	9.61E-05	0.0000
Diameter_OD	6.998888	6.999025	-0.0001
Z Flange_Point1	-1.01239	-1.01251	0.0001
Z Flange_Point2	-1.01267	-1.01276	0.0001
Z Flange_Point3	-1.01132	-1.01141	0.0001
Z Flange_Point4	-1.01095	-1.01103	0.0001
Z Value_Point5	-2.48978	-2.48992	0.0001
Z Value_Point6	-2.48927	-2.48936	0.0001
Z Value_Point7	-2.49329	-2.49341	0.0001
Z Value_Point8	-2.49373	-2.49383	0.0001
RawDataCurve	0.009661	0.008896	0.0008
FilterDataCurve	0.002527	0.002602	-0.0001
Diameter_Circle4	22.52557	22.5261	-0.0005
Roundness3	0.00075	0.000346	0.0004
X Value_Circle4	-0.00079	-0.00076	0.0000
Y Value_Circle4	-0.00063	-0.00061	0.0000

EMAT Real Time Velocity & Conductivity Changes of Aluminum 7075 Wheel (-150F ramp down -300F)

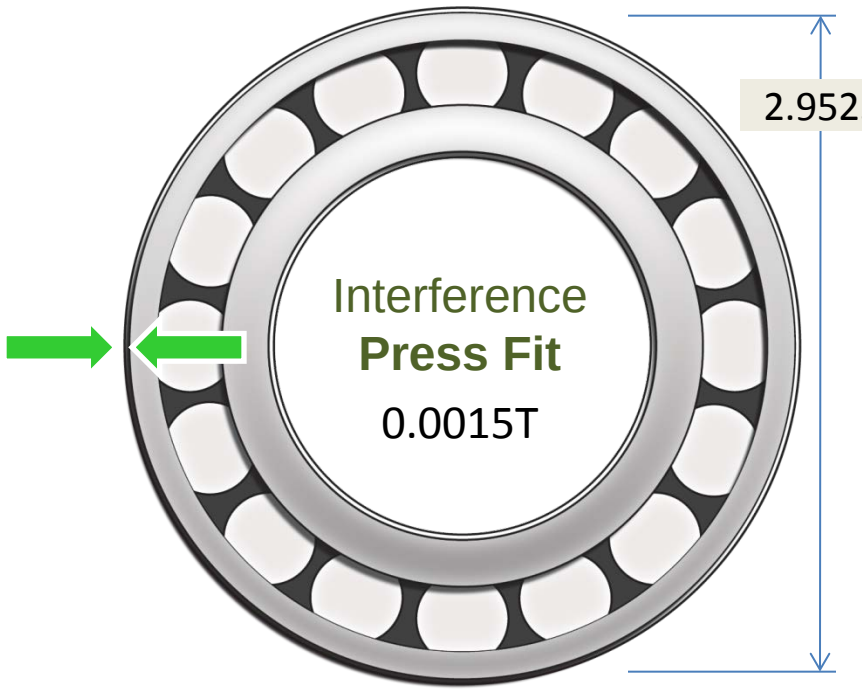




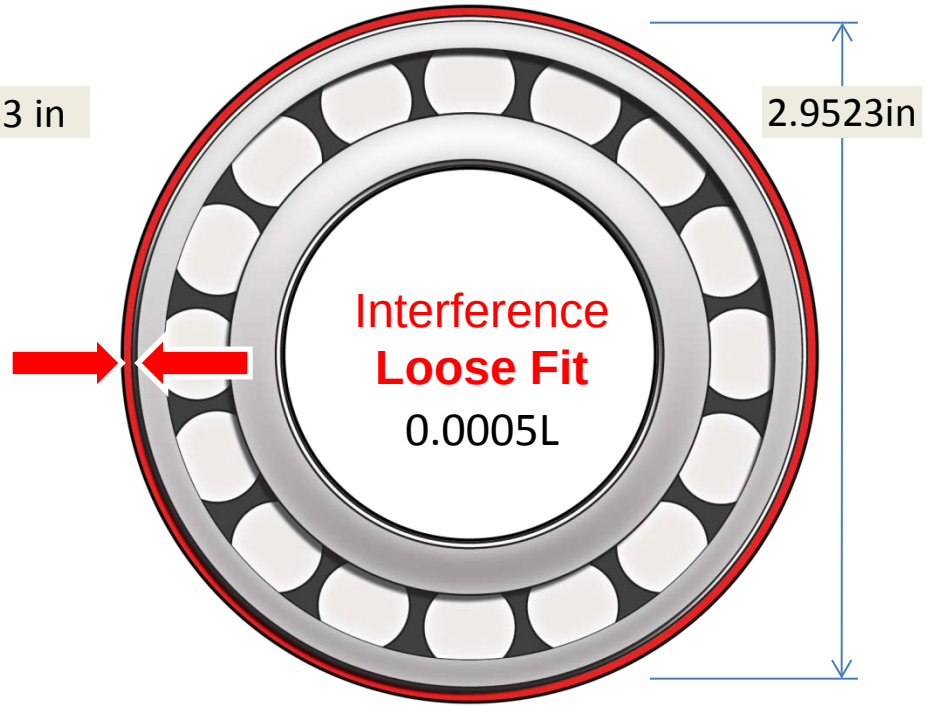
After Cryogenic NDT Testing
24” American Eagle 7075 Aluminum Wheel

Interference Fit of Wheel Bearing Outside Dimension
Vs. Wheel Bearing Bore Inside Dimensions Grew Larger

PRIOR TO Cryogenic NDT Testing



AFTER Cryogenic NDT Testing



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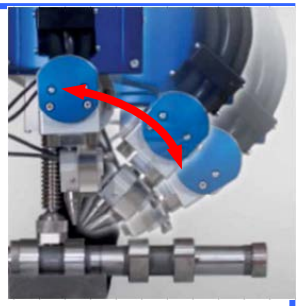
micro μ-X360 FULL 2D

Portable X-RAY Residual Stress Analyzer

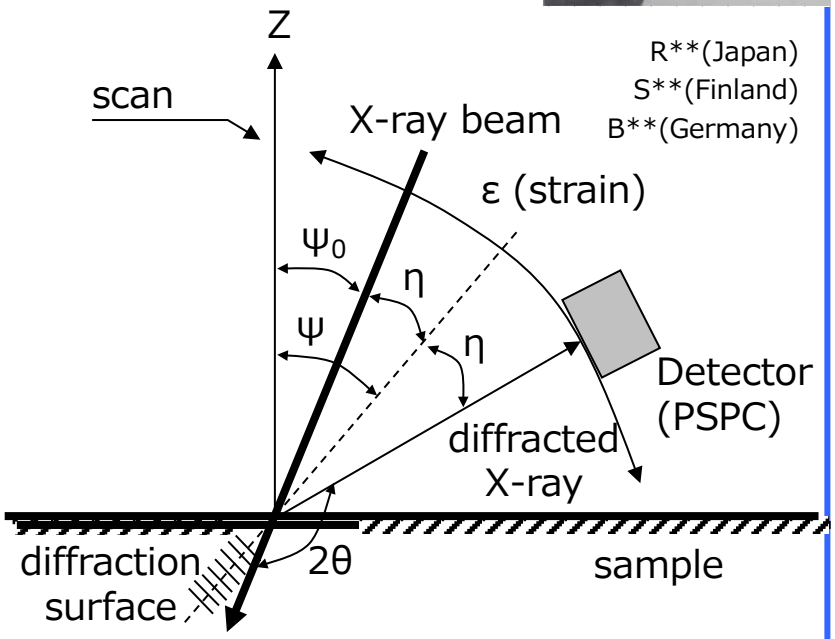
The Cos α & Sin²ψ Methods Compared

Comparison between the Sin²ψ and Cos α techniques – the Cos α requires only a single angular measurement for complete analysis .

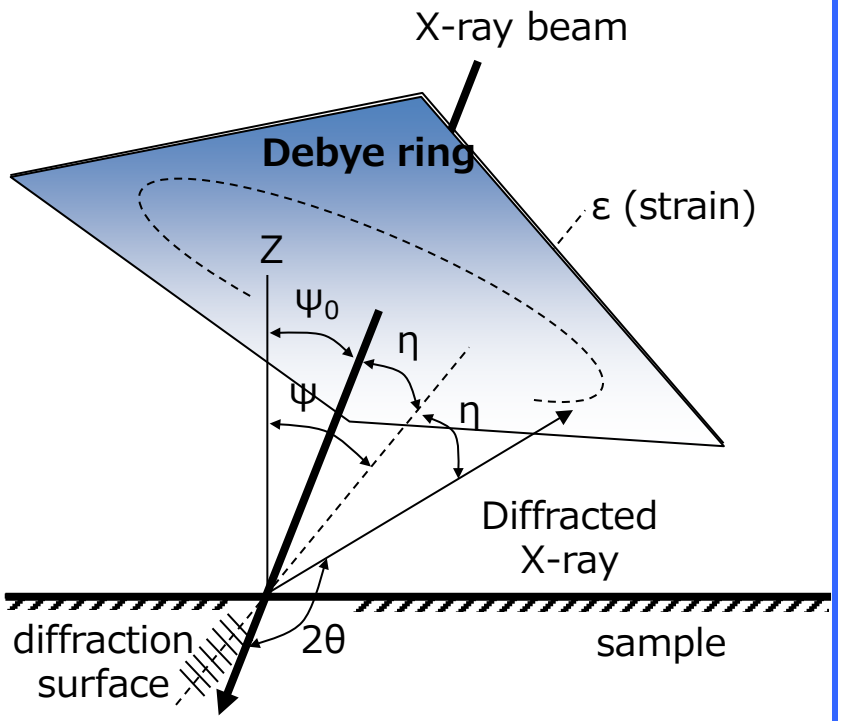
Sin²ψ technique (existing)
(Multi-positions of detector)



R**(Japan)
S**(Finland)
B**(Germany)



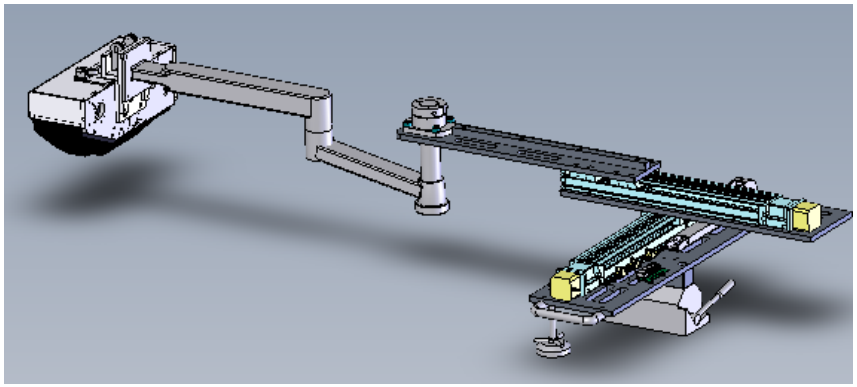
COS α technique (μ-X360)
(Single position of detector)

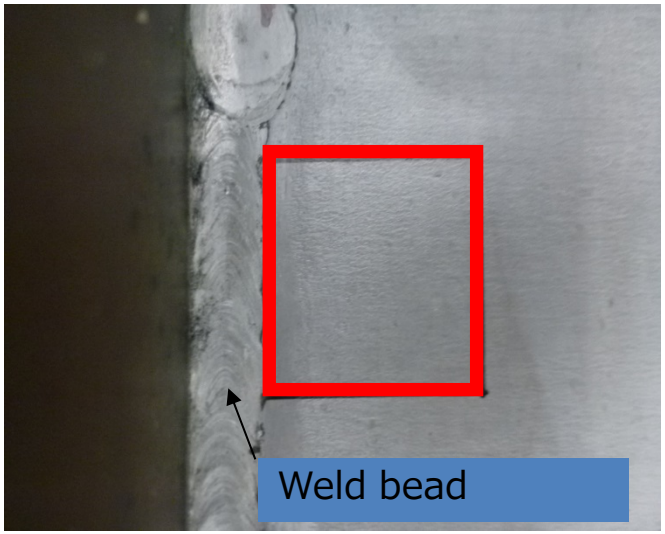


PULSTEC

X & Y Stage – Stress Mapping

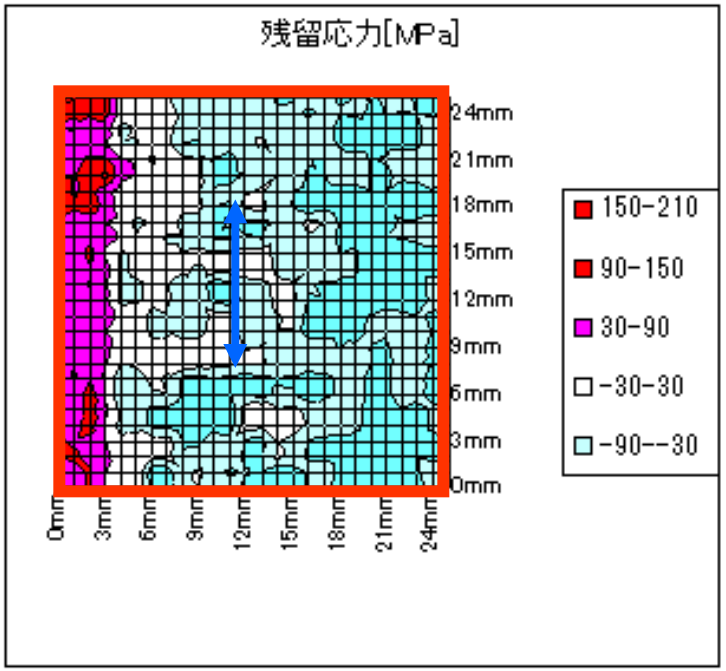
Stress mapping by controlling X & Y axis stage.





Measure 25mm (1inch)
by 1mm (0.04inch) Step.
26p×26p＝676point

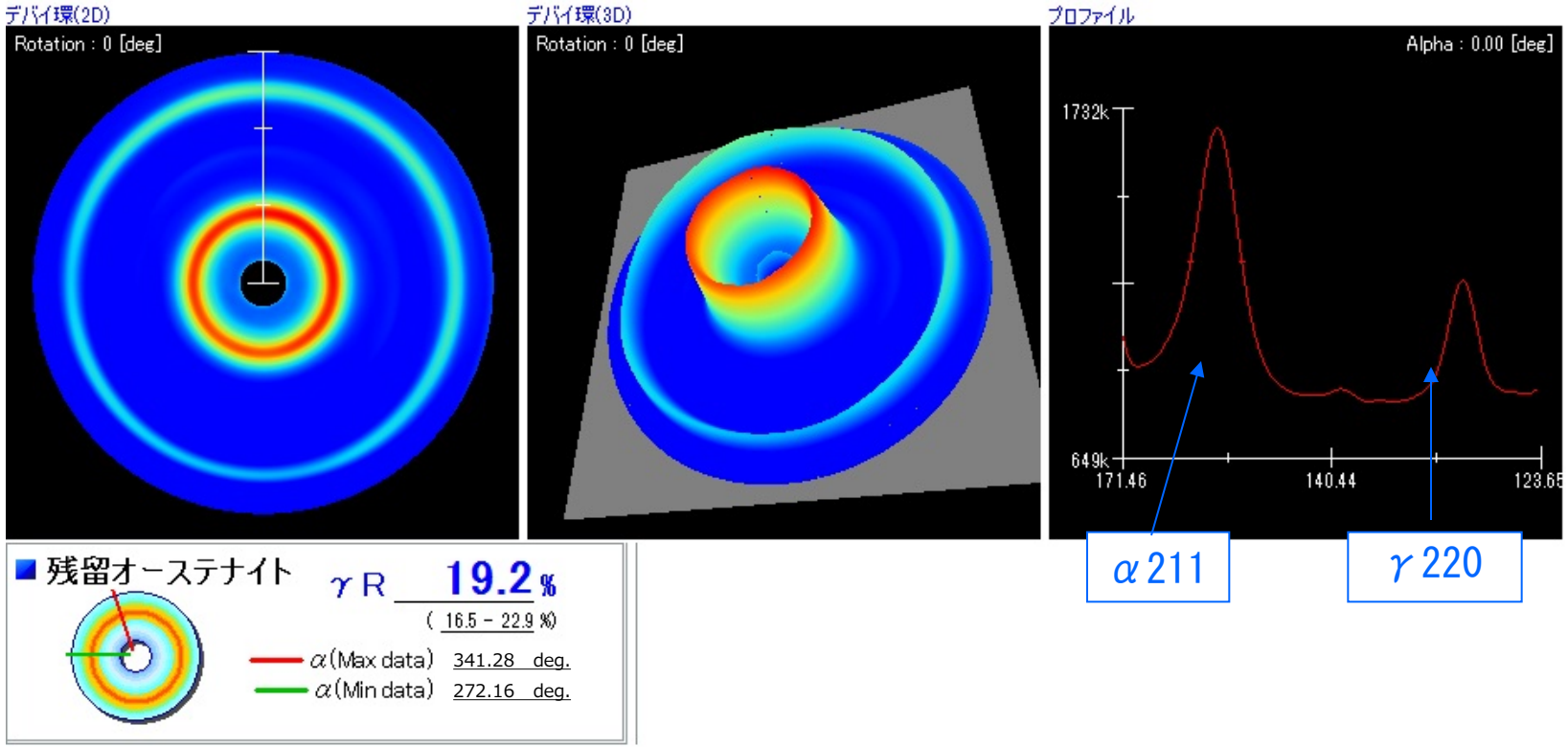
Mapping result



* 2 axis stage(X/Y) + Application software

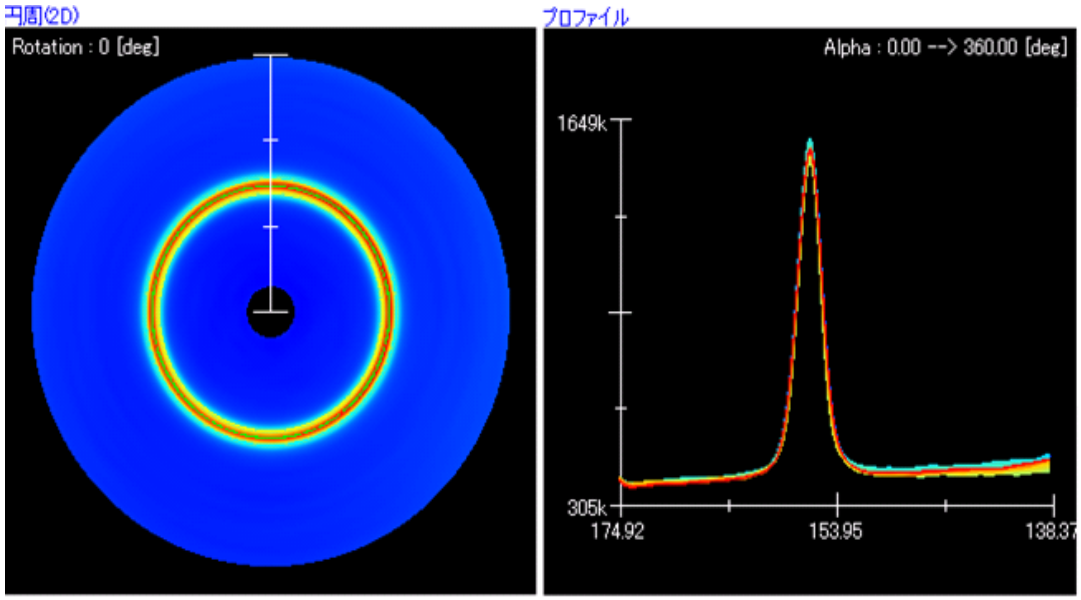
Retained Austenite Analysis

Displays the percentage of the retained austenite that has not transformed even at ambient temperature.

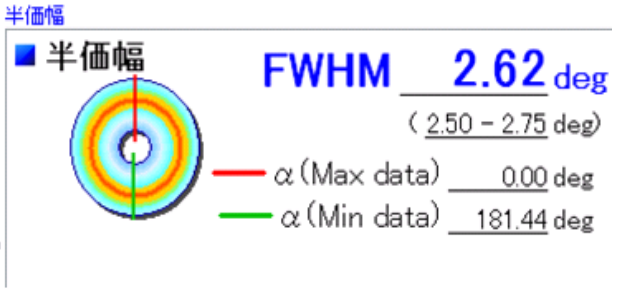


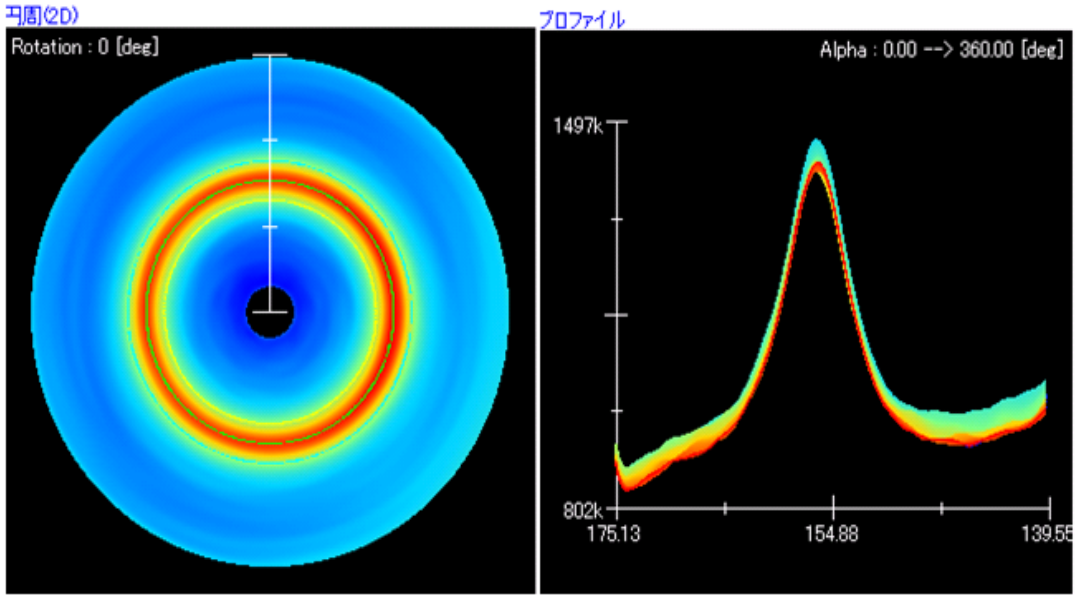
PULSTEC

Full Width Half Maximum / Grain Size

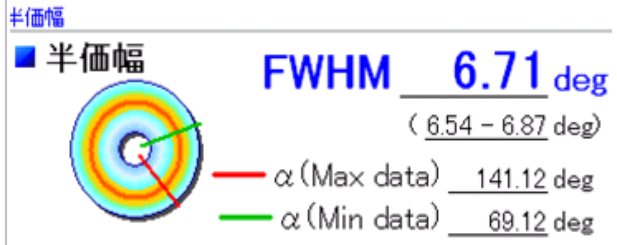


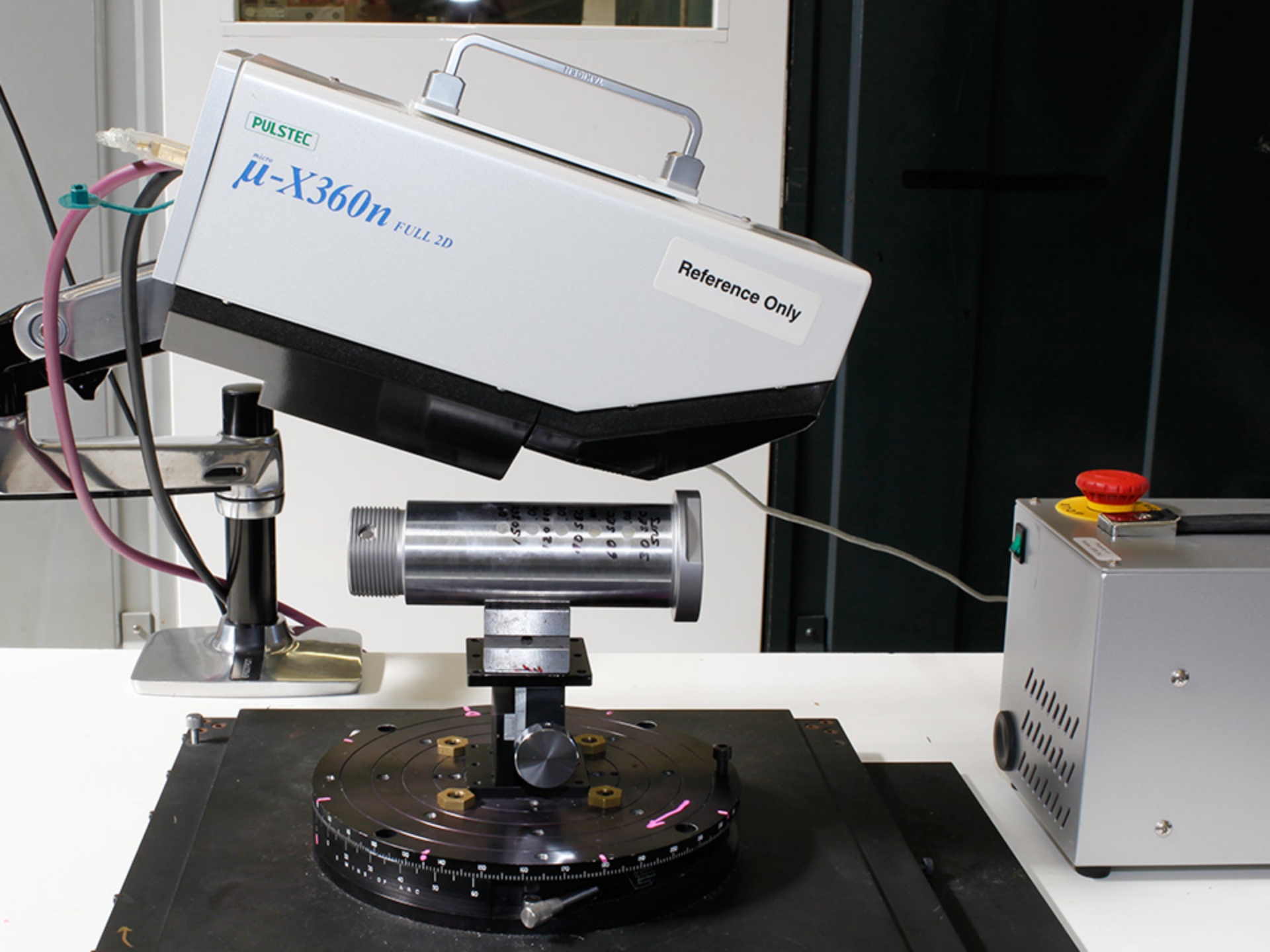
Grain size 5～10um



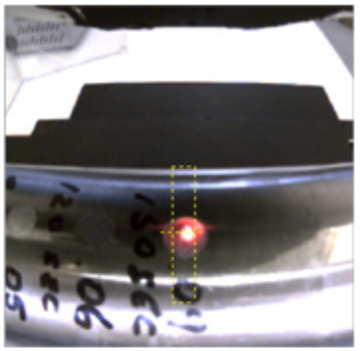


Grain size 3～5um

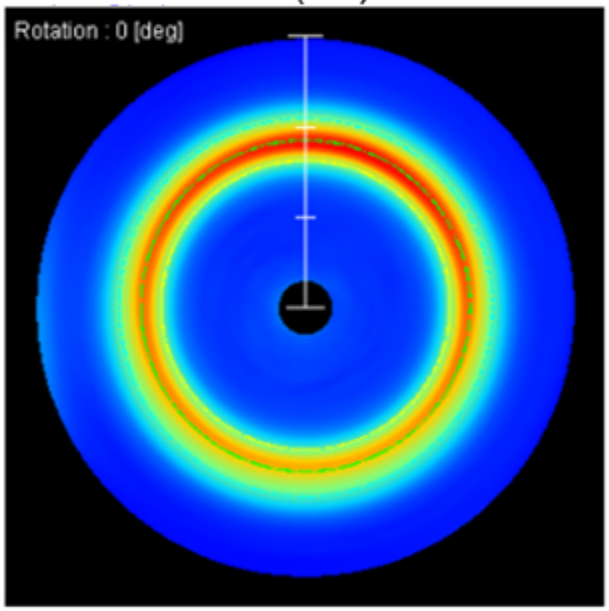



PULSTEC
μ-X360n FULL 2D
Reference Only

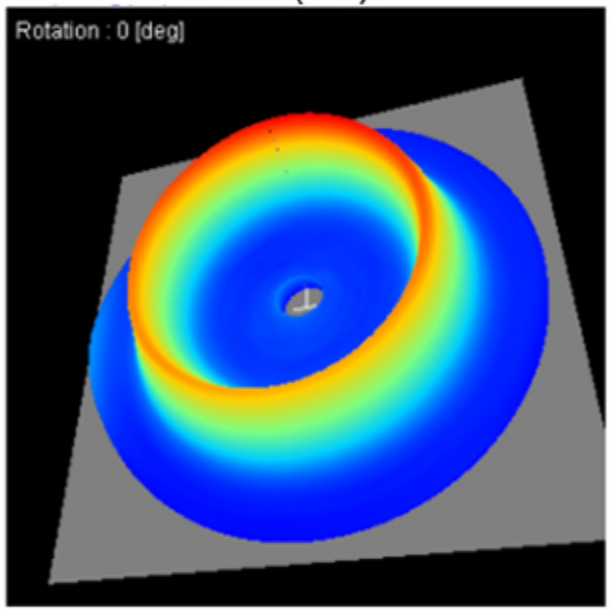
Measurement Information
Measurement time 2014/03/25 04:00 - 04:02
Comment 1 BOEING 757 PIN 161N4001-1
Comment 2 **90 Degree** .09mm Etched Axial



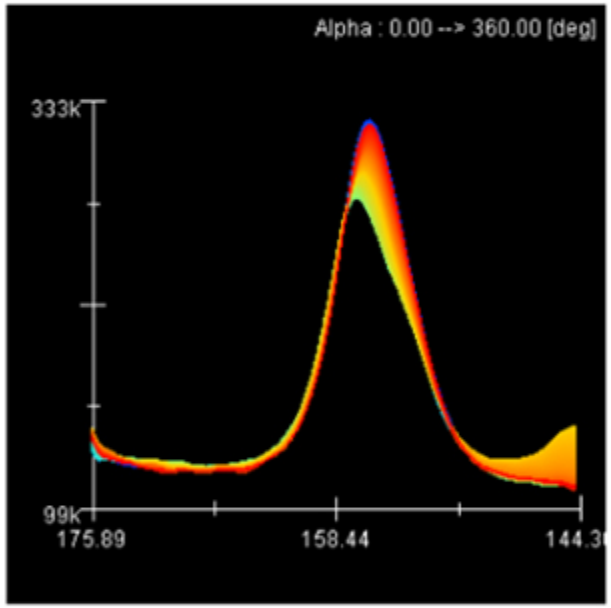
DEBYE RING (2D)



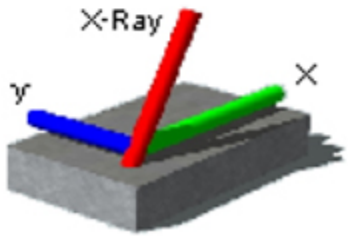
DEBYE RING (3D)



PROFILE

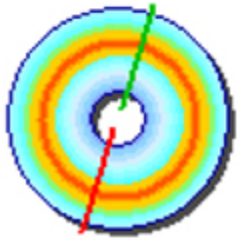


■ Residual stress



Sigma(x) -416 MPa
(Std. Dev. 8 MPa)
Tau(xy) 45 MPa
(Std. Dev. 5 MPa)

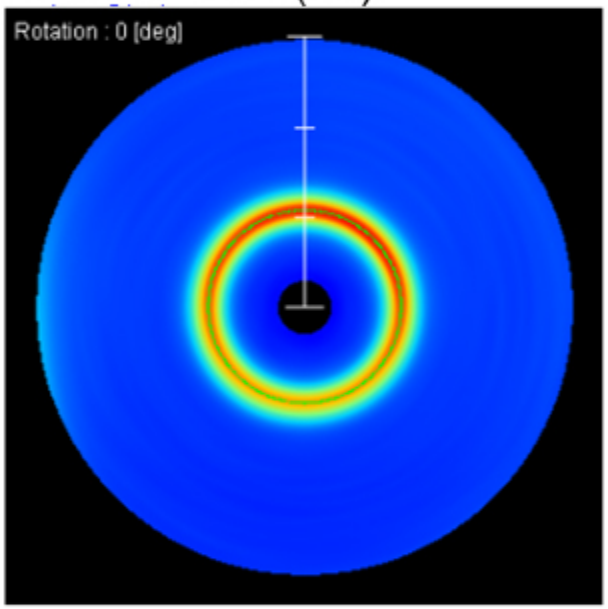
■ FWHM



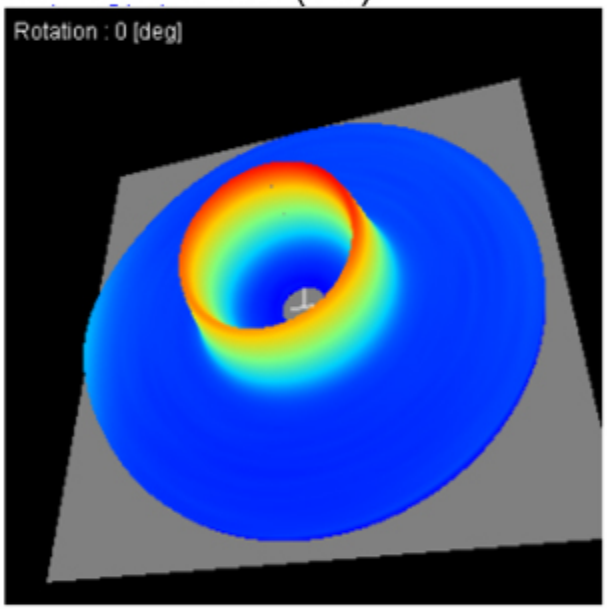
FWHM 5.94 deg
(5.67 - 6.38 deg)
Alpha(Max data) 198.00 deg
Alpha(Min data) 18.00 deg

Measurement Information
Measurement time 2014/03/23 06:26 - 06:28
Comment 1 BOEING 757 PIN 161N4001-1
Comment 2 **90 Degree** .09mm Etched Axial

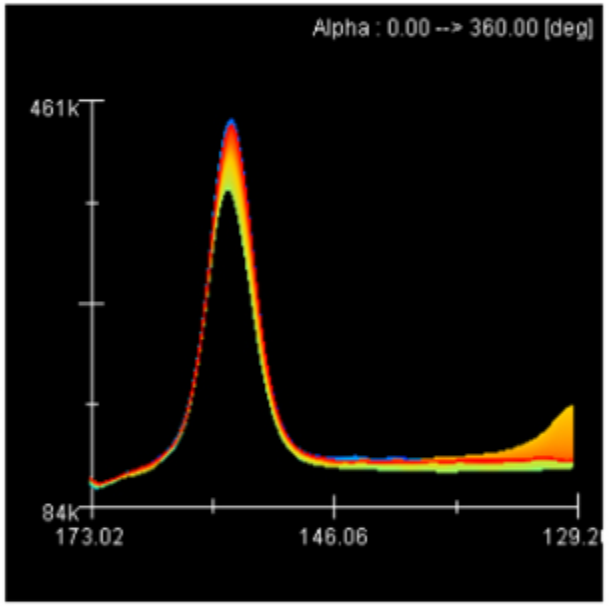
DEBYE RING (2D)



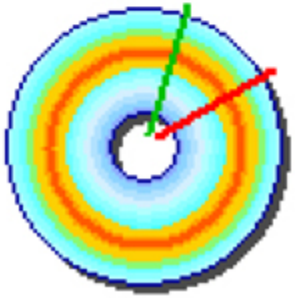
DEBYE RING (3D)



PROFILE

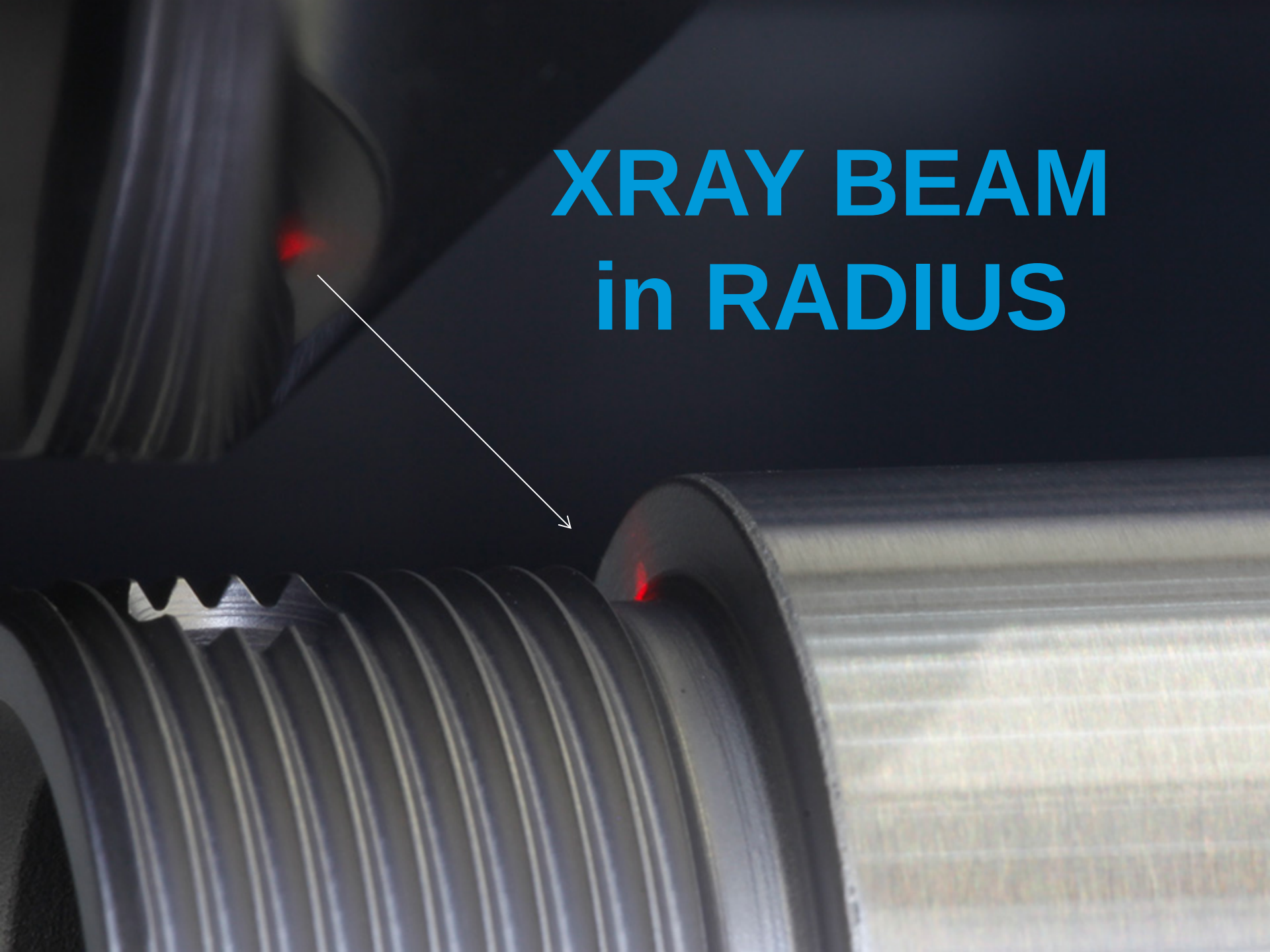


■ Retained austenite



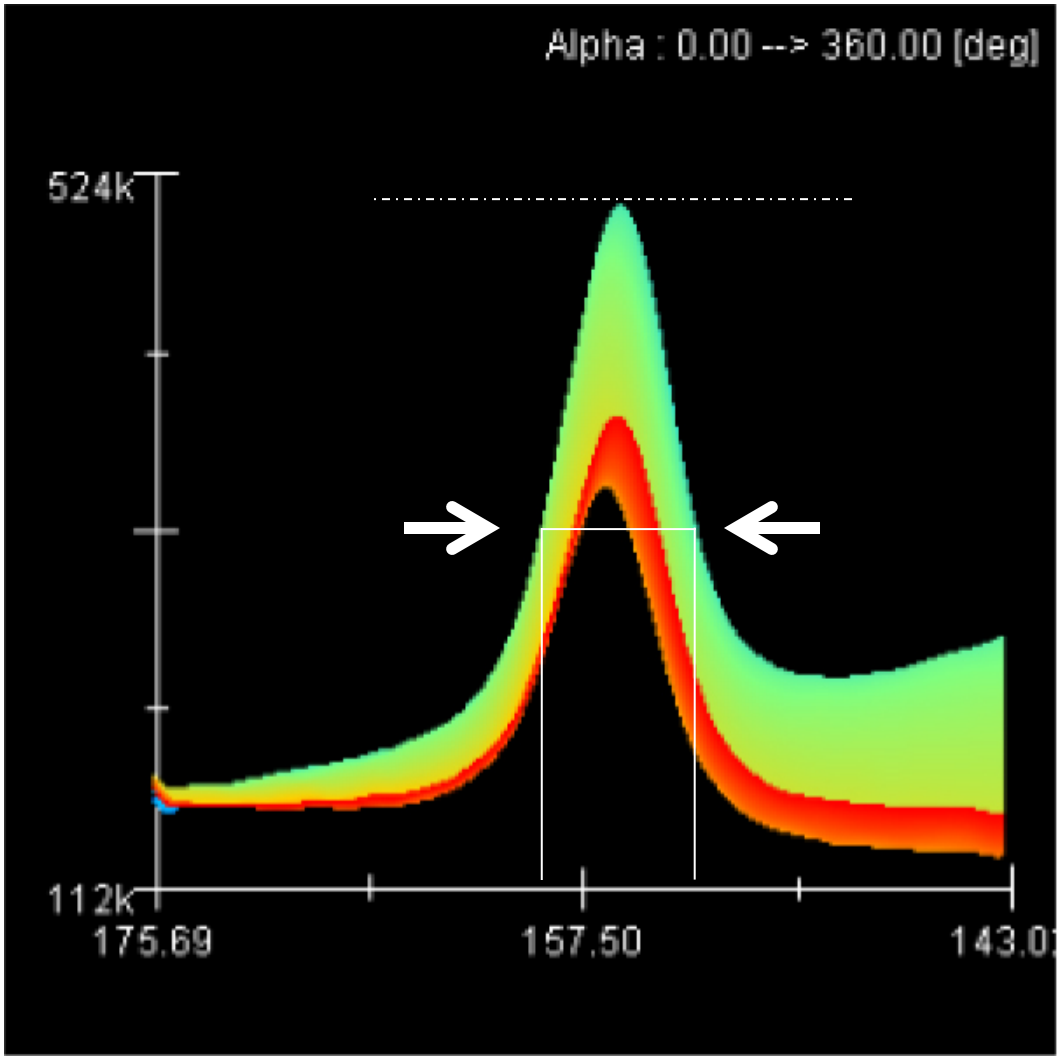
Gamma(R) 0.2 %
(0.0 - 1.5 %)
Alpha(Max data) 59.76 deg
Alpha(Min data) 18.00 deg

Retained Austenite


XRAY BEAM
in RADIUS

FWHM *(Full Width Half Maximum)*

½ max

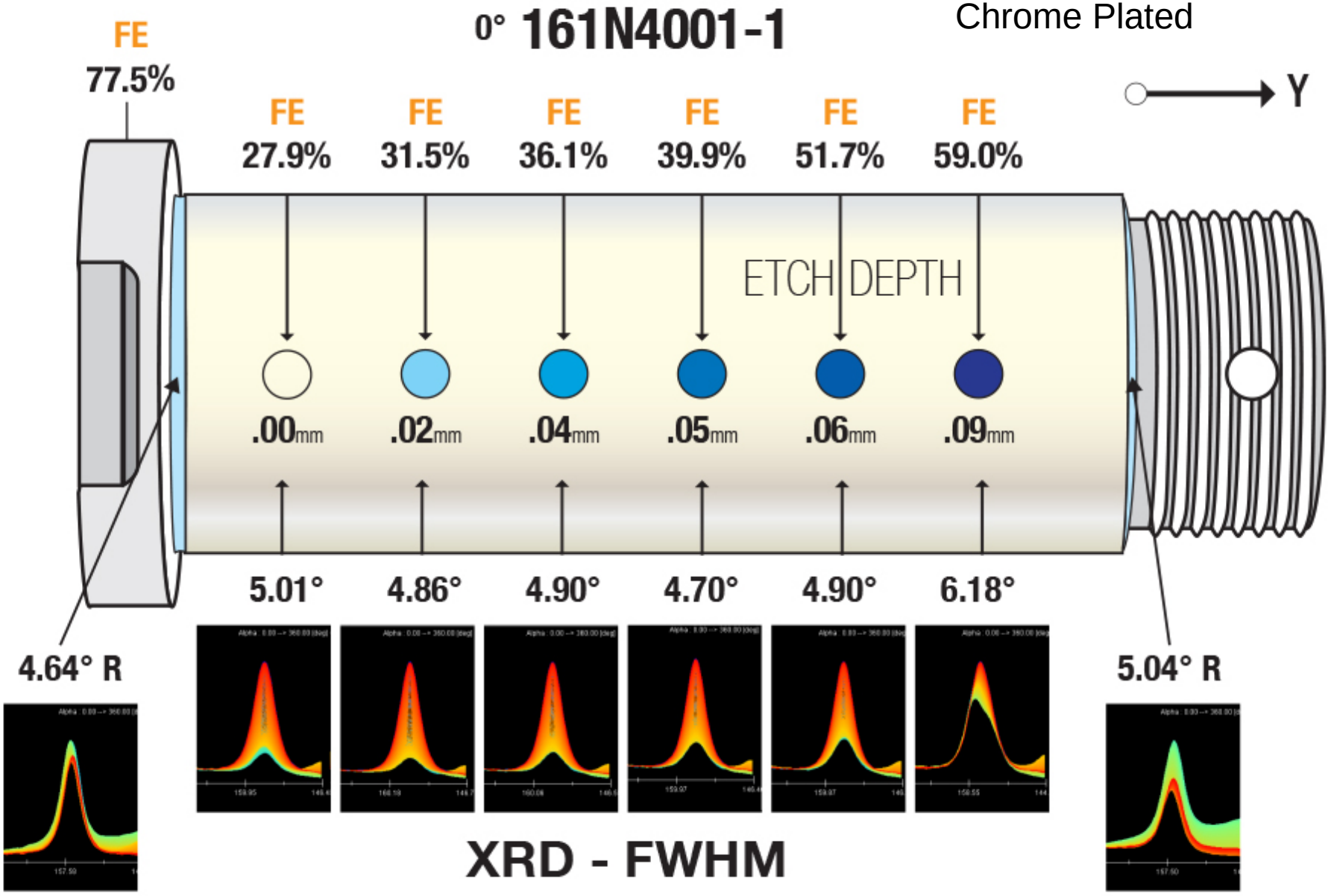


FE-Ferrite

757 LANDING GEAR PIN

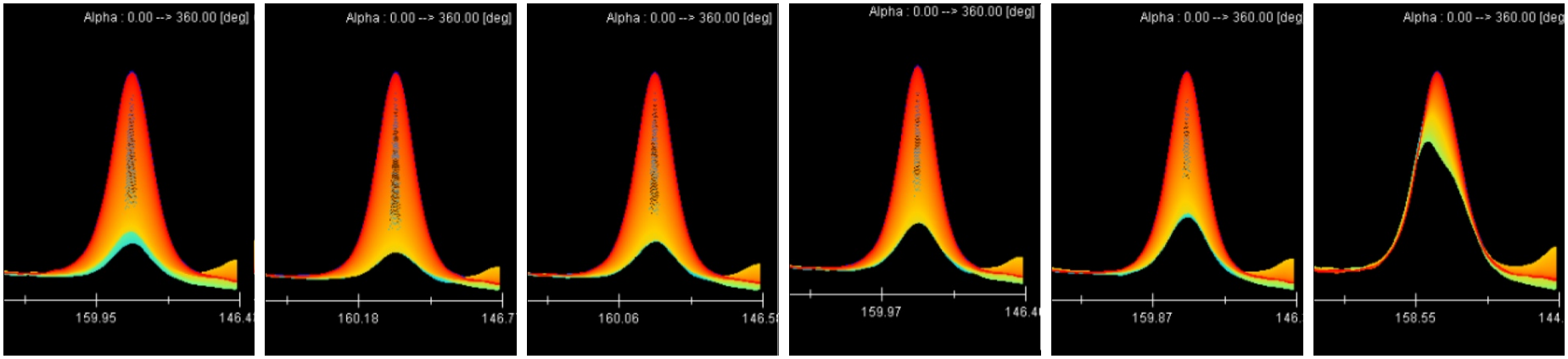
0° 161N4001-1

3.6 Thousandths
Chrome Plated

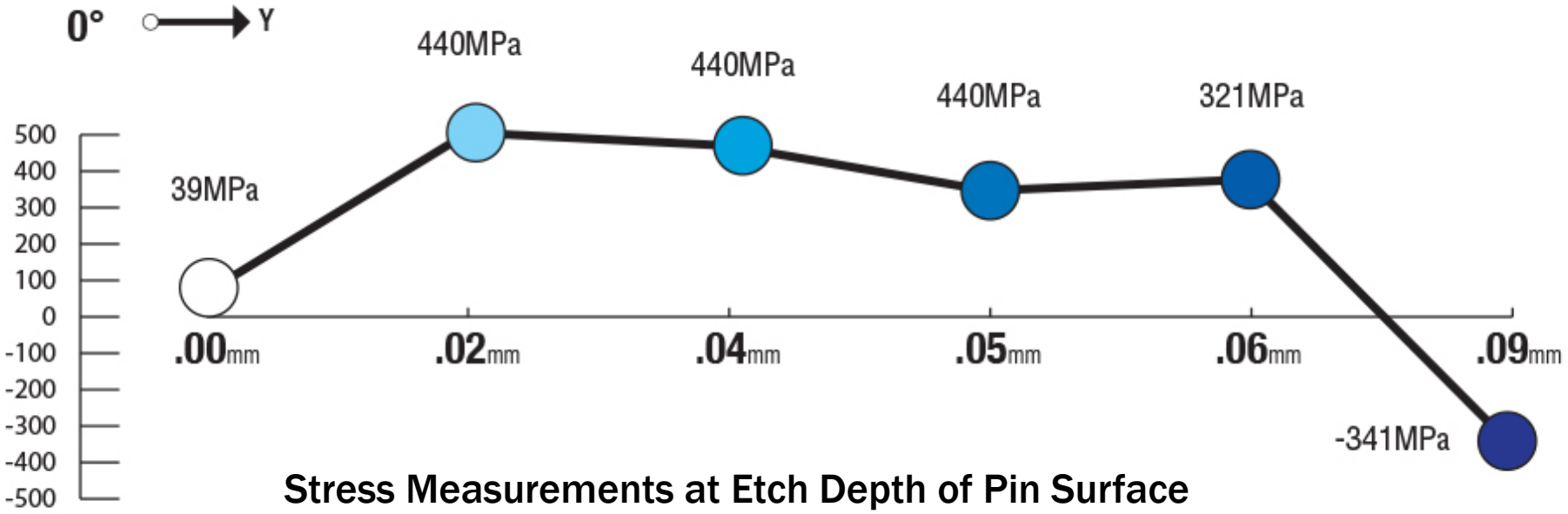


XRD - FWHM

X-ray Peak Profiles of 757 Gear Pin

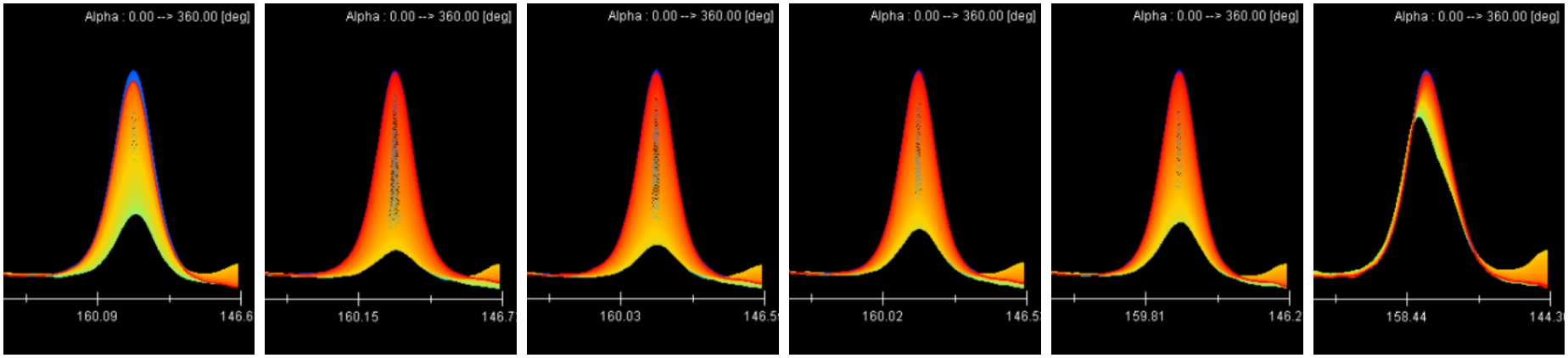


.00mm .02mm .04mm .05mm .06mm .09mm

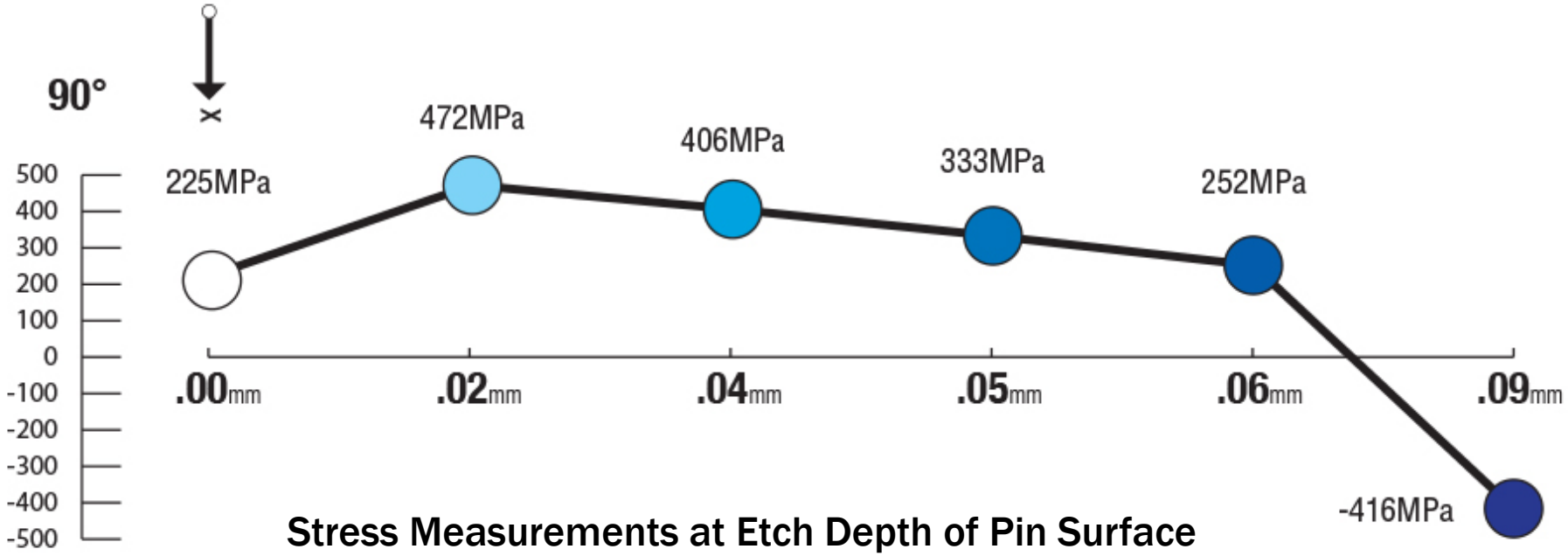


Stress Measurements at Etch Depth of Pin Surface

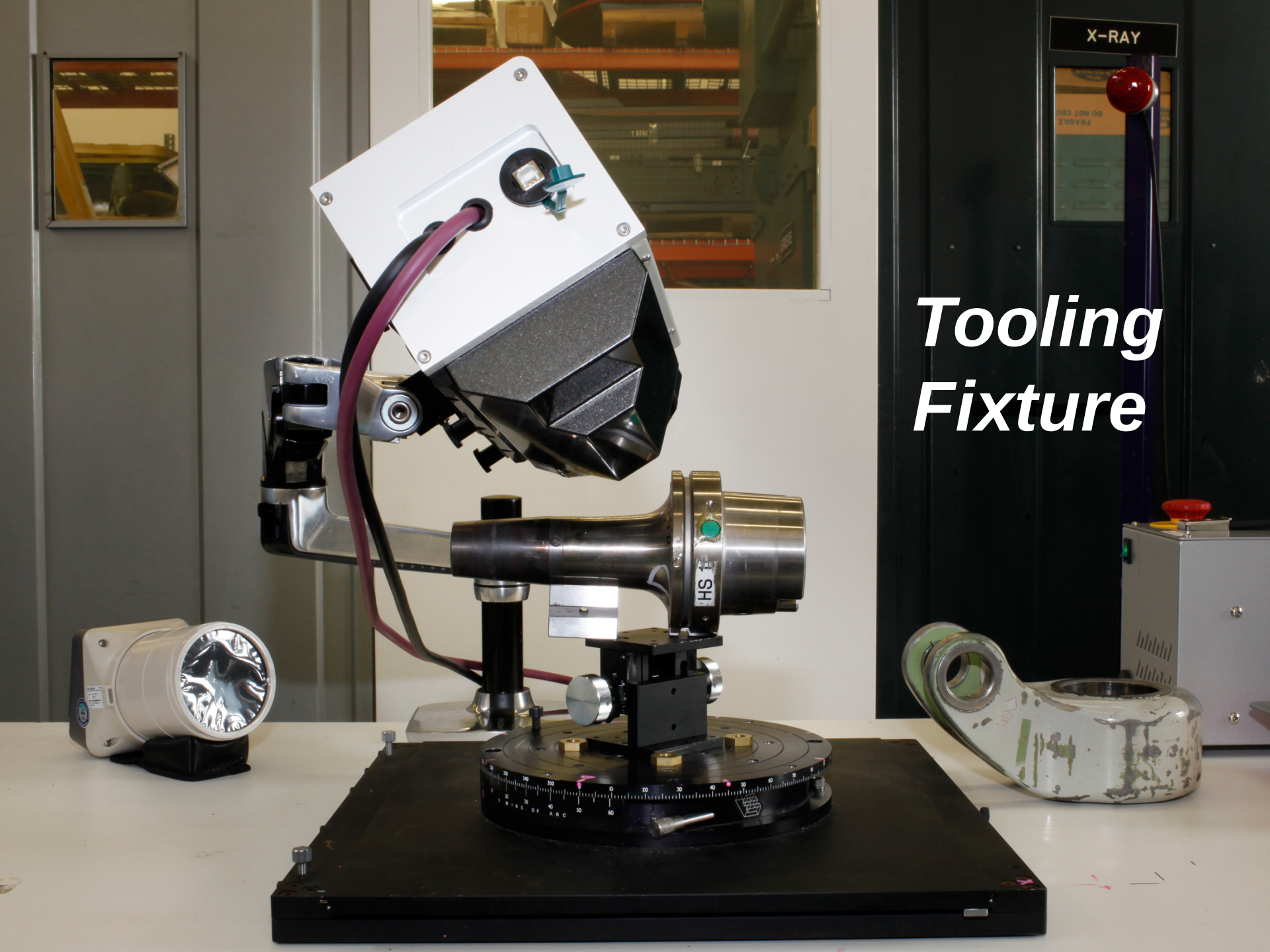
X-ray Peak Profiles of 757 Gear Pin

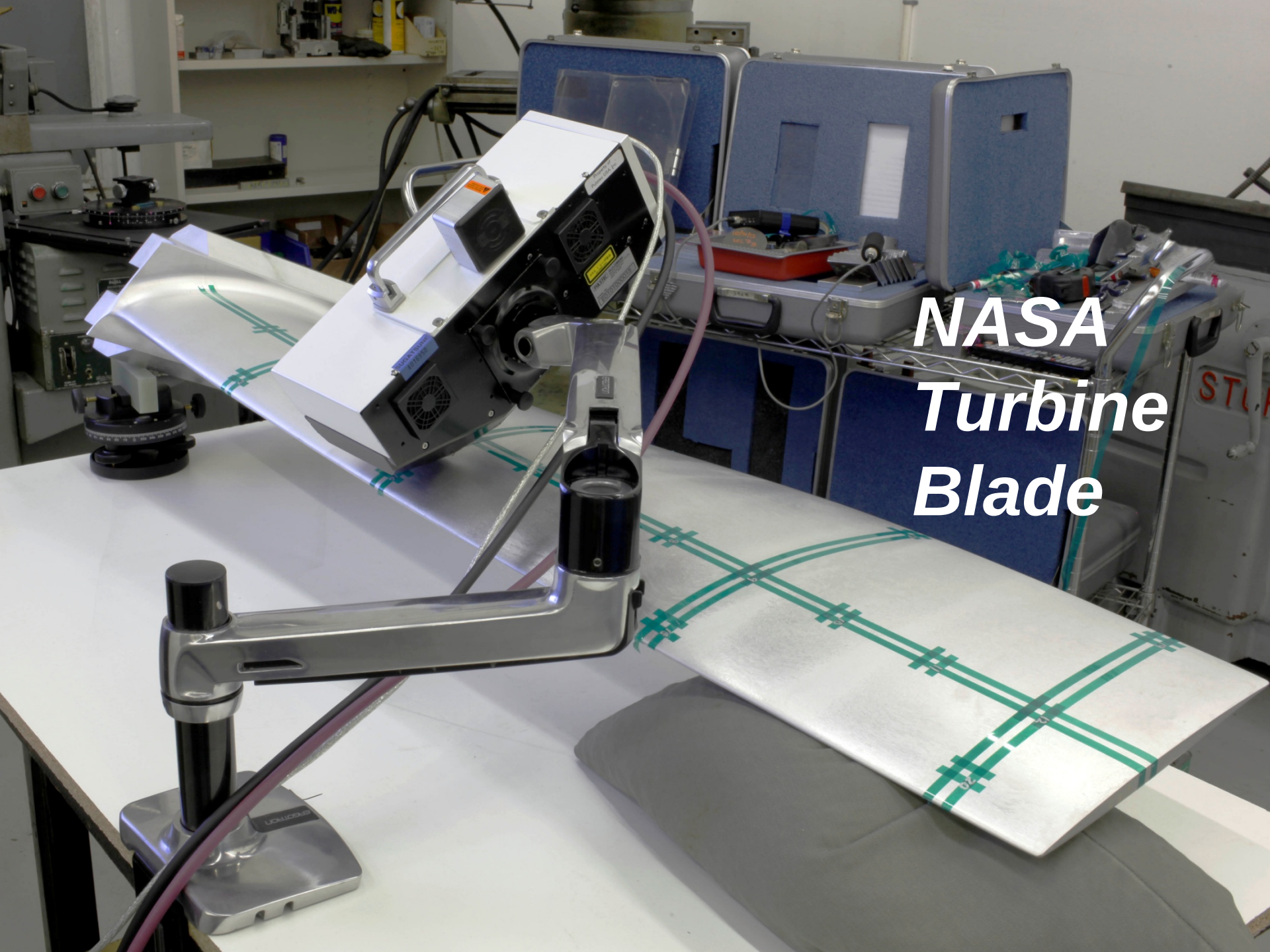


.00mm .02mm .04mm .05mm .06mm .09mm



Stress Measurements at Etch Depth of Pin Surface


X-RAY
Tooling
Fixture


NASA
Turbine
Blade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Aviation™