Application of NDE Simulations to Estimate Probability of Detection

Joe Gray, Irving Gray
NDE Technologies, Inc.
Charlottesville, Virginia

Components of Probability of Detection

- ## Equipment variability

  inherent filtration of x-ray tube
  eddy current lift off and coil tilt
  broad band center frequency

- ## Setup variability

  placement of the central axis of the x-ray tube
  orientation of the UT probe
  scan variation in lift off and probe tilt

- ## Signal Noise

- **Flaw morphology effects**
    size
    shape
    position in the part
    orientation in the part

- **Visual acuity – human variability of the eye**
    cracks
    pores

    effects of complex images

- **Human factors**
    mood
    training
    environment

Need for 2D Detectability criteria

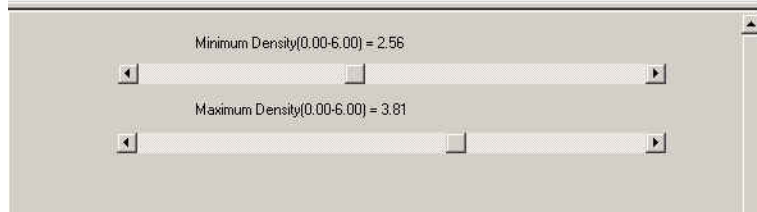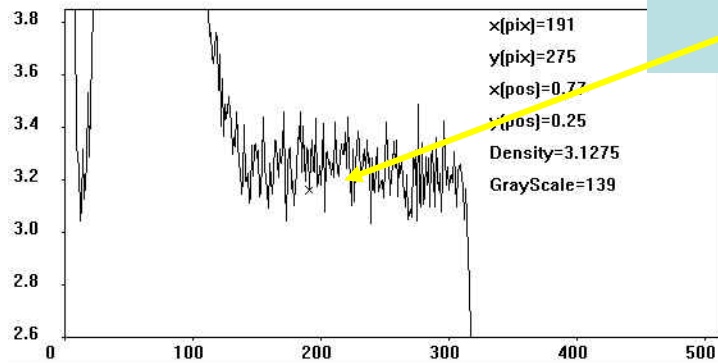Increased use of scanned data in inspections
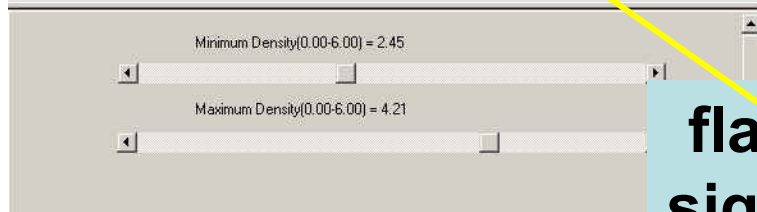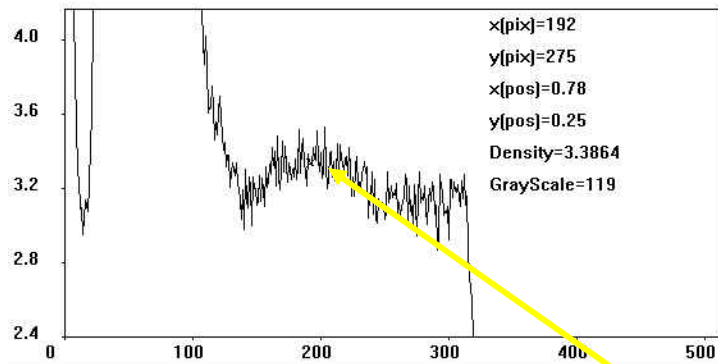
X-ray, ultrasonics, eddy currents
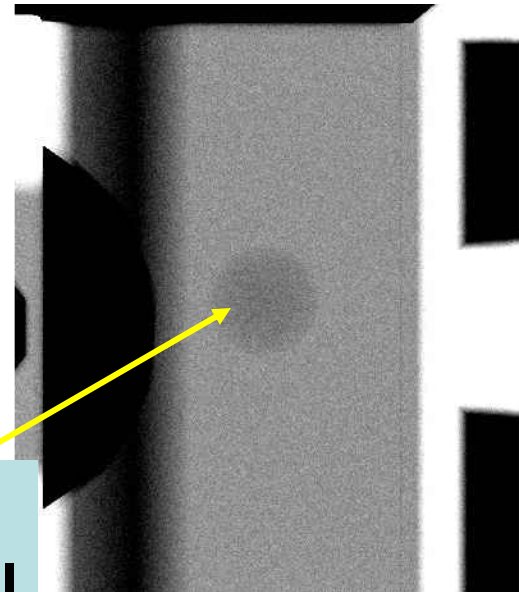
1D scans
2D raster scans
2D imaging arrays
3D computed tomography

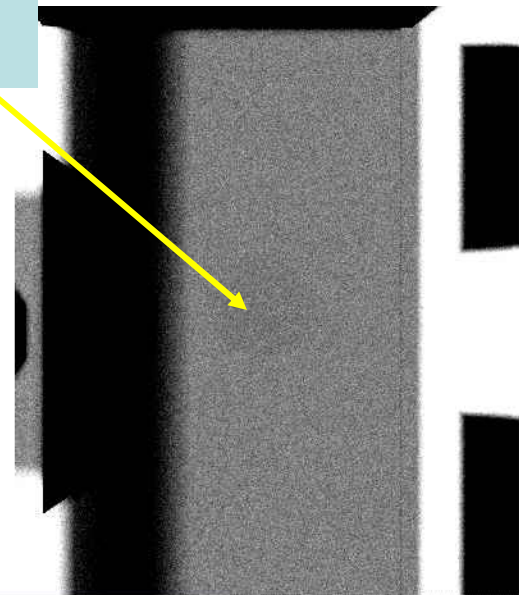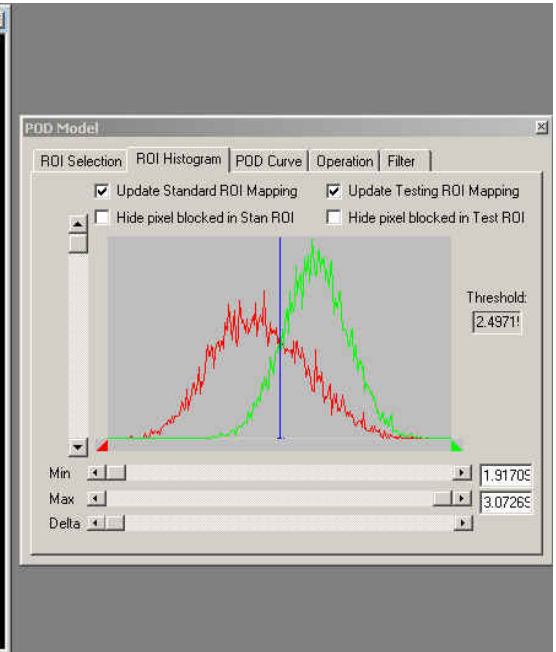scans offer multiple measurements of a flaw
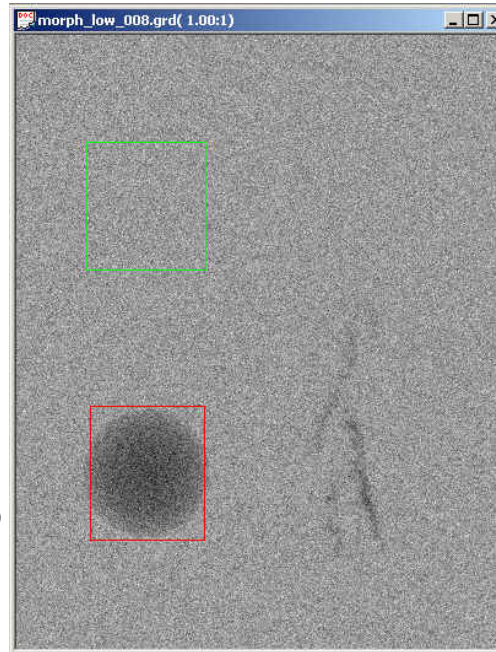
1D measurement

2D measurement

flaw
signal

2D Data Detectability

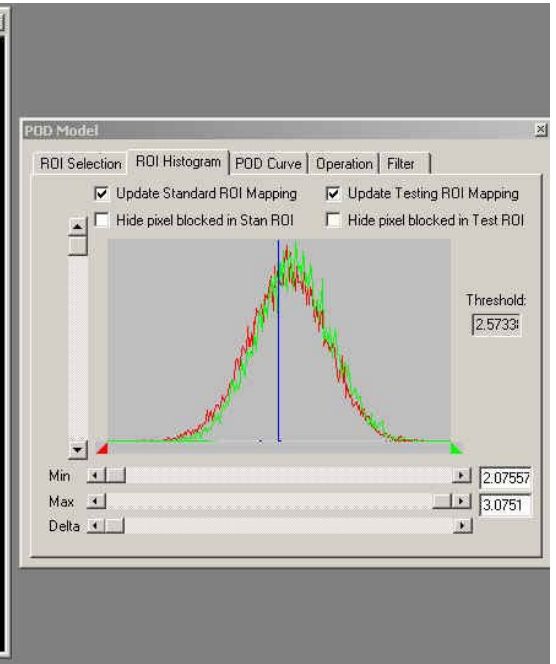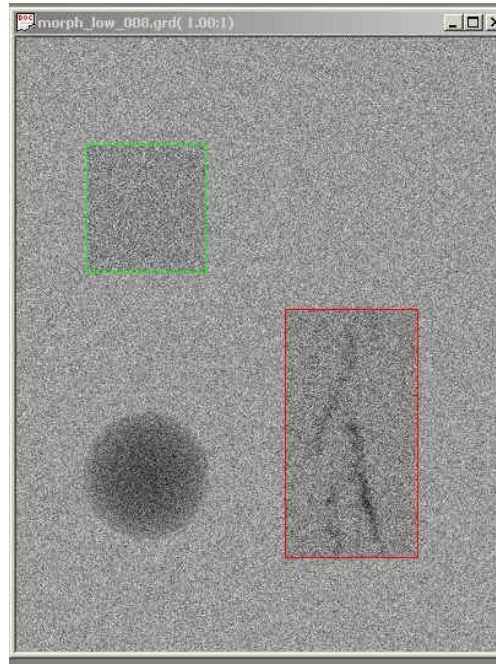**Both flaws are easily detected.**

SNR=0.675

Signal to Noise Ratio

$$SNR = \frac{\left| D_{background} - D_{flaw} \right|}{\sigma}$$
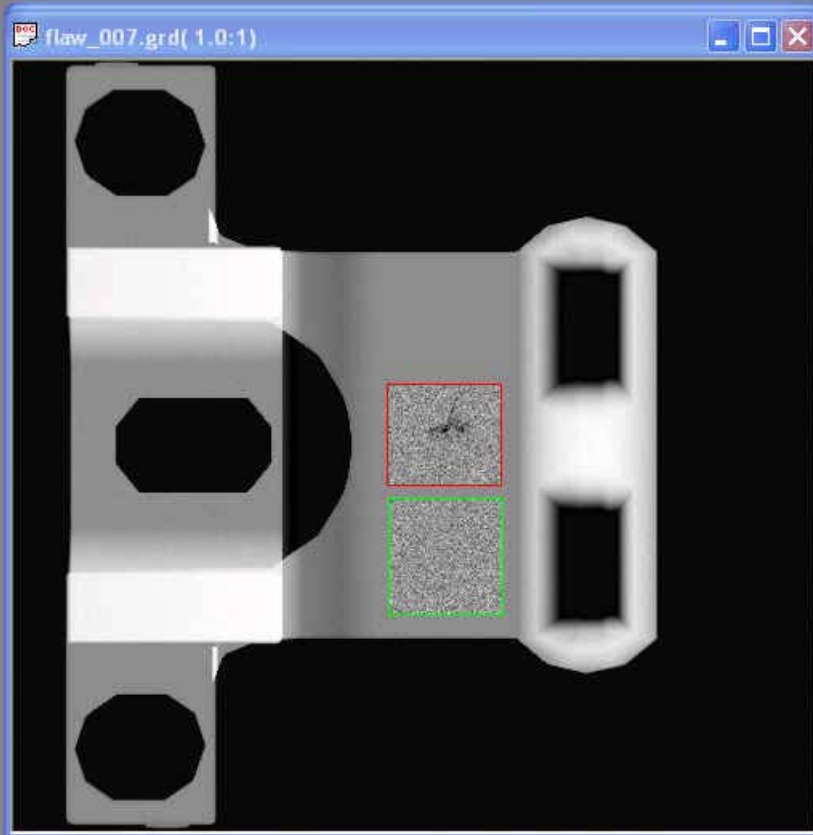

SNR=0.298

Automated Detectability Scans

binomial hypothesis test

- Given a signal mean and noise distribution

- What is the probability of a noise fluctuation producing the observed histogram of measured signals in the 2D area?

- Threshold for the test is a 5% false call

Large flaw
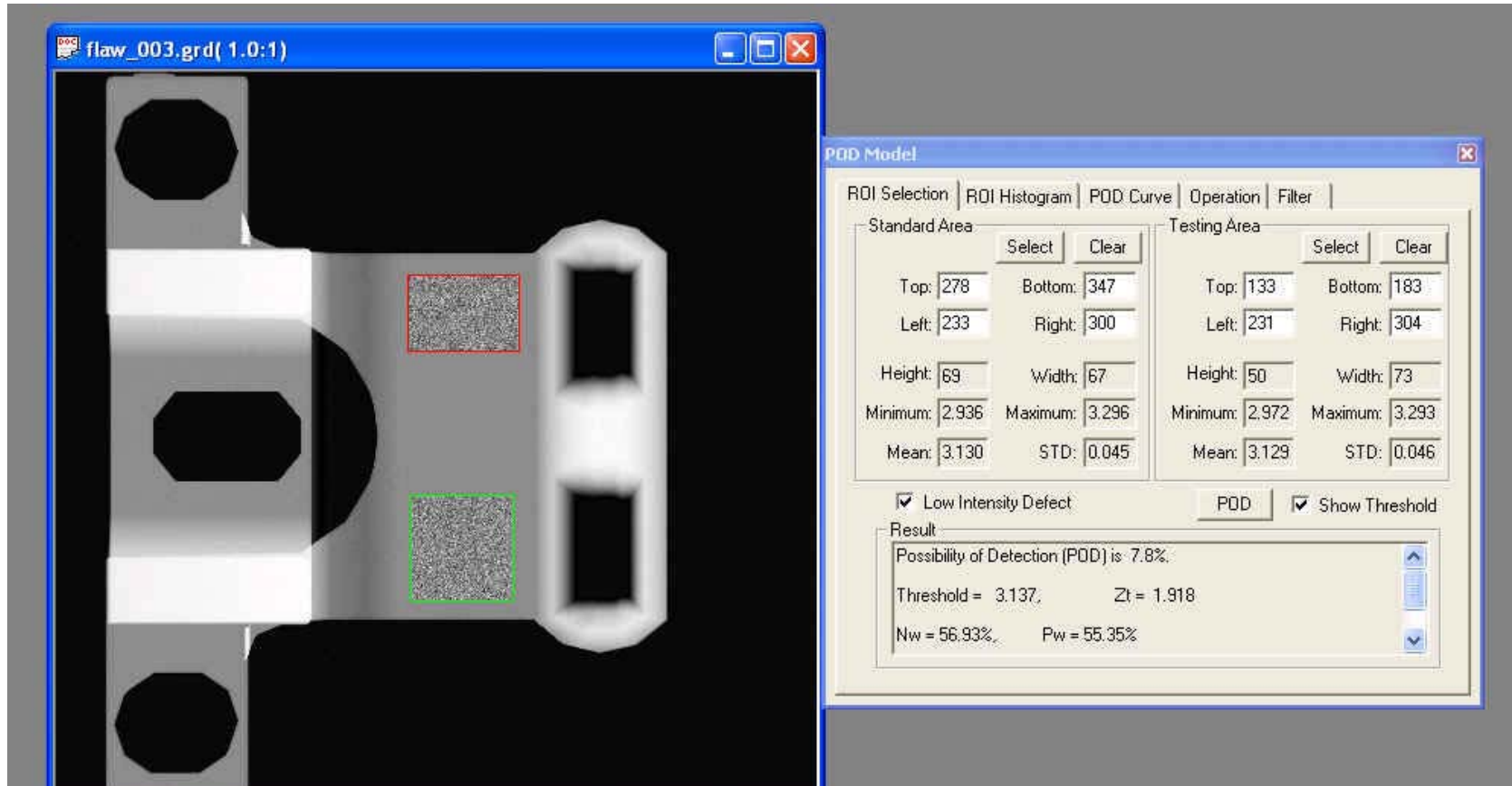

Green region standard

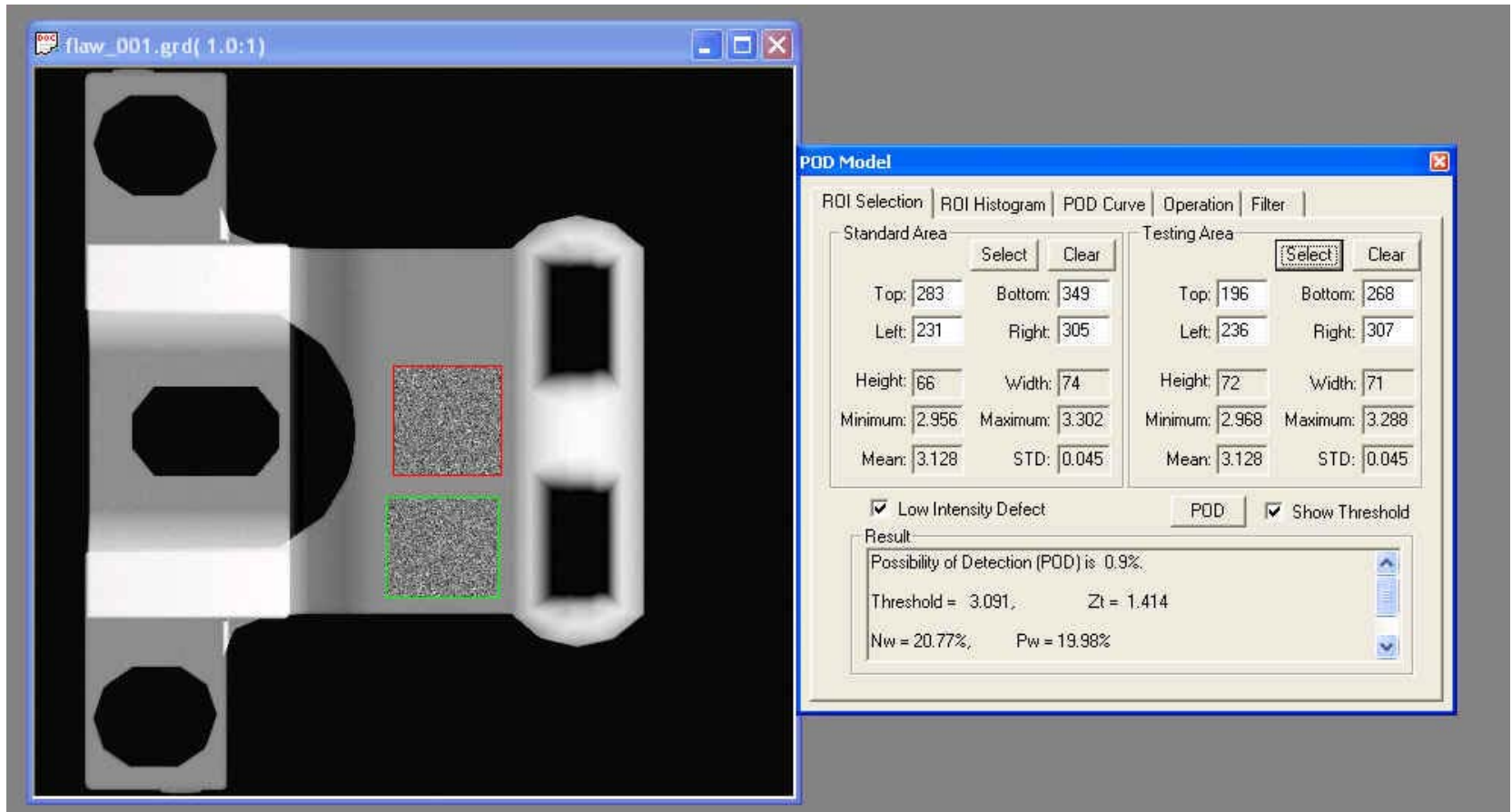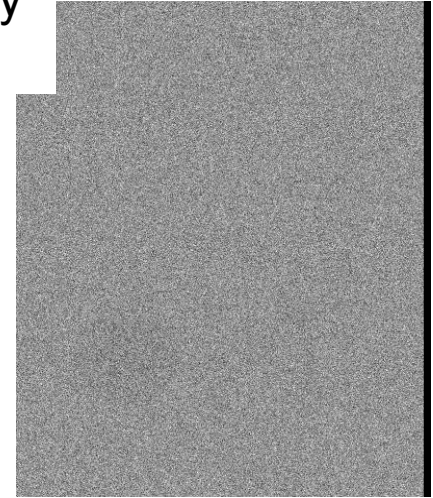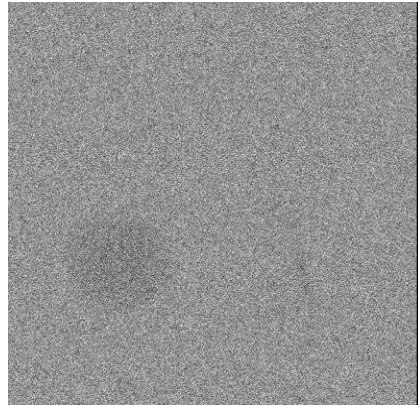Red region test area

Probability 99.7%

No flaw region

Green region standard

Red region test area

Probability 7.8%

Small flaw
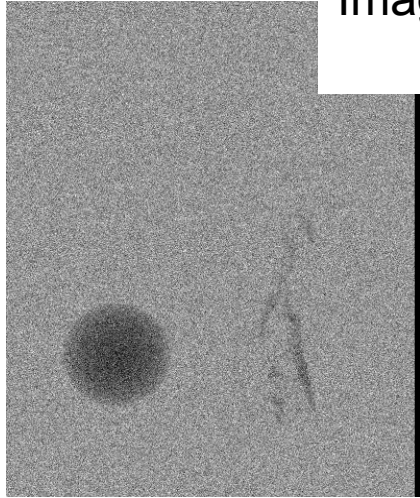

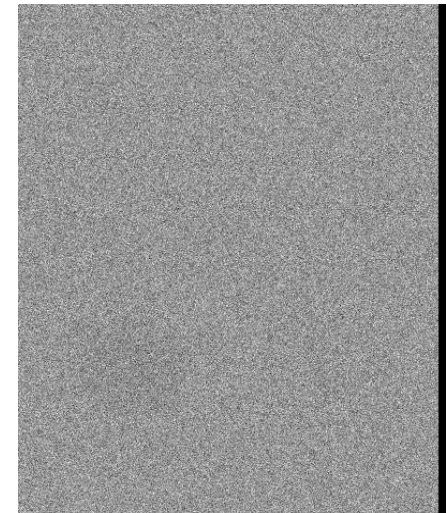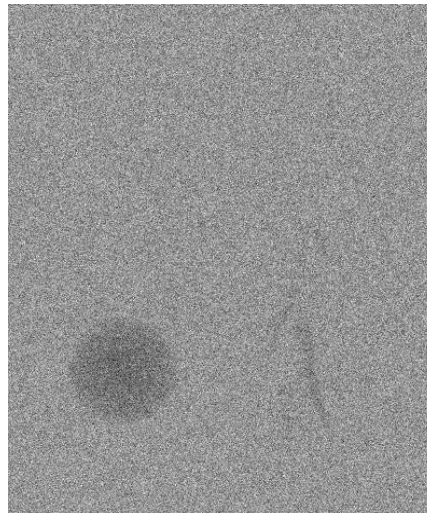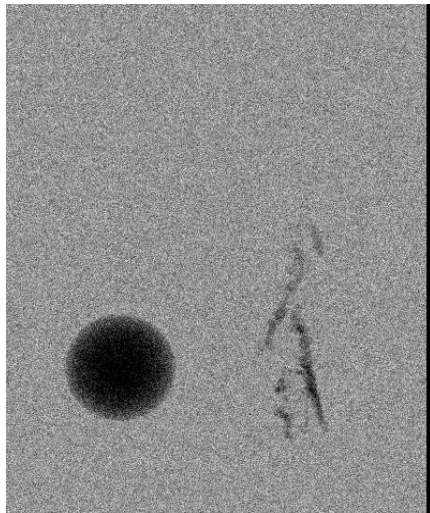| Green region standard | Red region test area | Probability 0.9% |

Simple shapes versus real flaws

Images with different flaw morphology
taken under with different kVP

High KVp

Large contrast
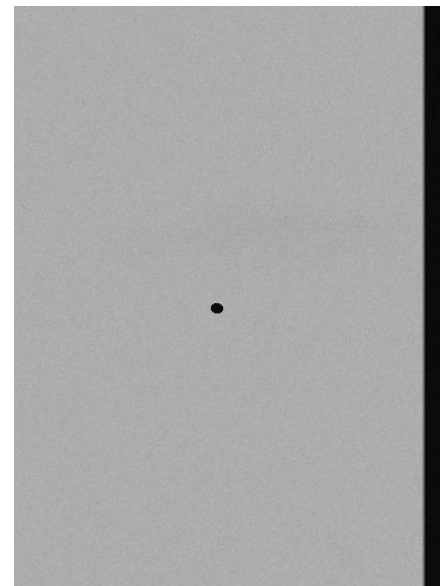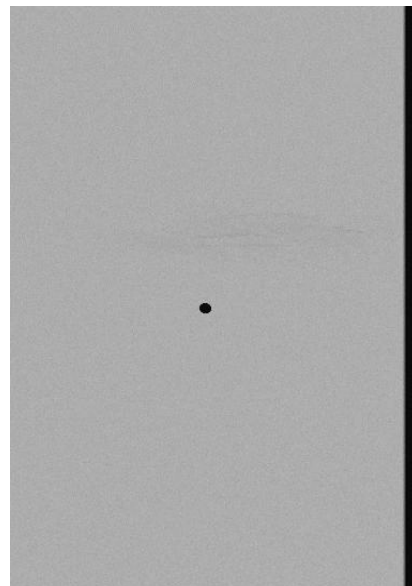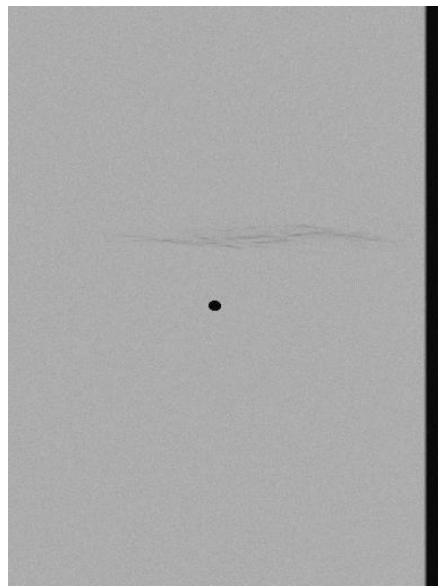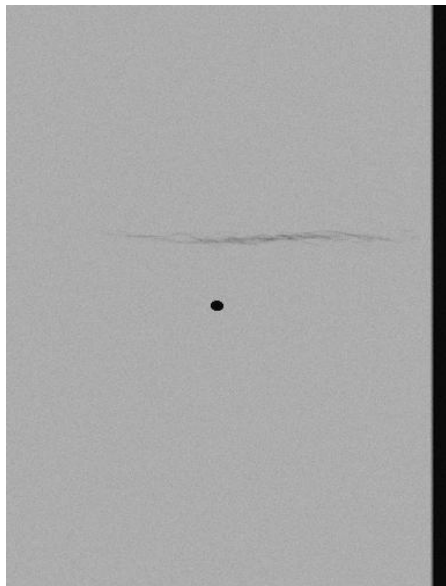
low KVp

Low contrast
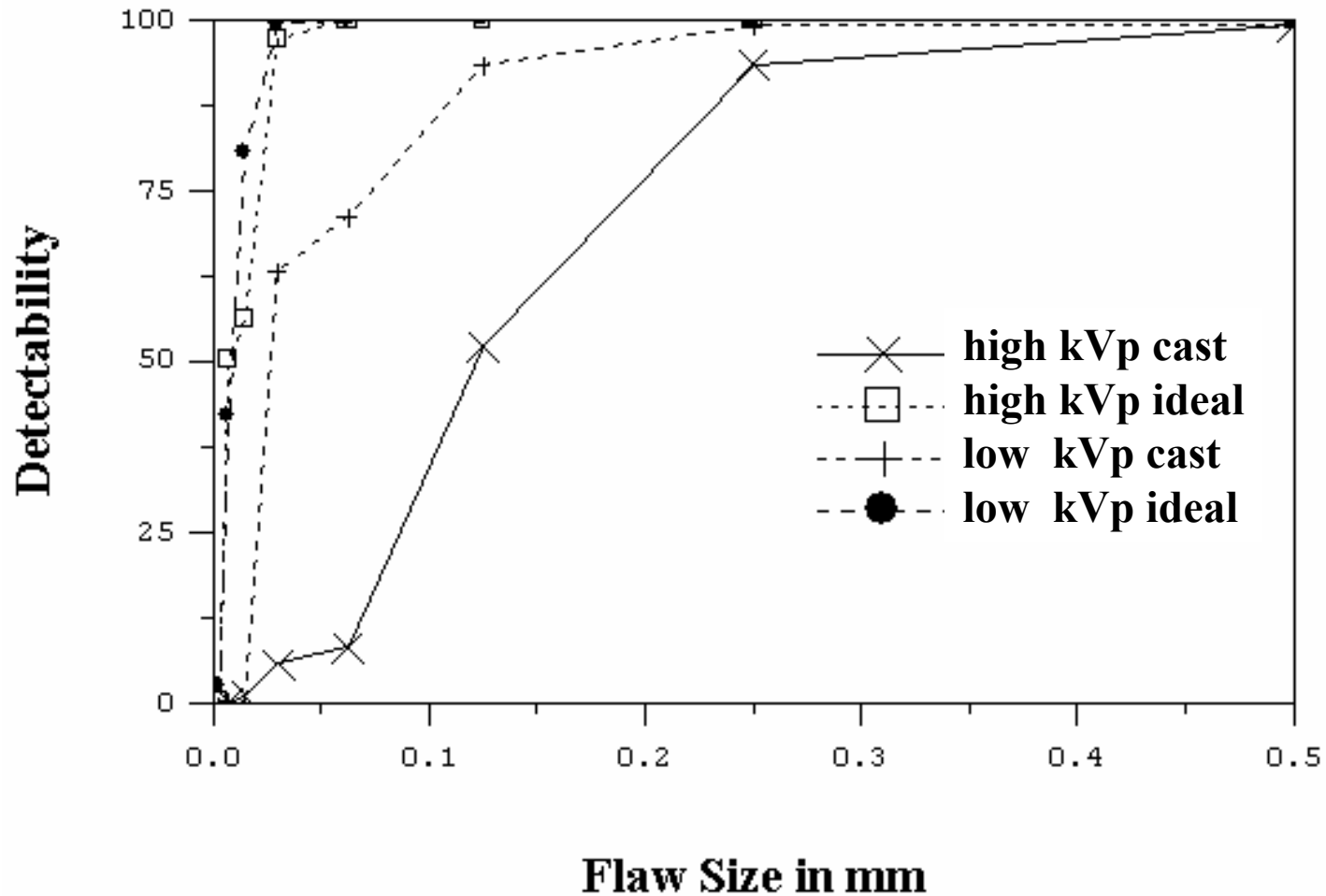
Simple shapes versus real flaws

Effect of Defect Morphology on Signal
same crack size, different signal

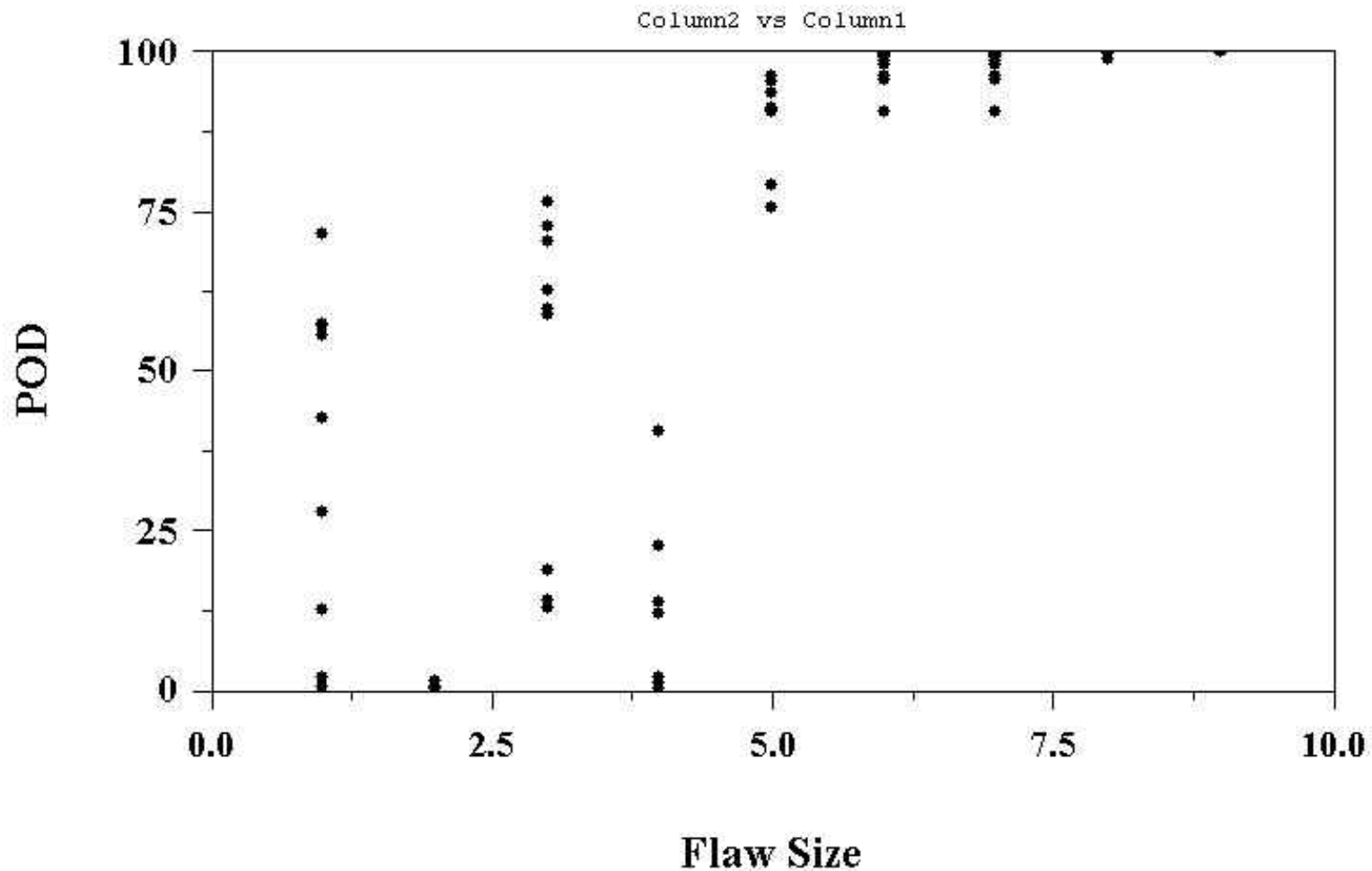optimal
orientation

poor
orientation

Effect of Flaw Morphology and Kilovoltage on Detectability

Detectability vs. Flaw Size in mm

Legend:
- high kVp cast
- high kVp ideal
- low kVp cast
- low kVp ideal

Note: inclusion is not detectable

Effect of Flaw Morphology, Composition and Orientation

Column2 vs Column1

Conclusions

- **Detectability criteria for scan data**

- **Application of NDE simulations**

  Simple shapes versus real flaws