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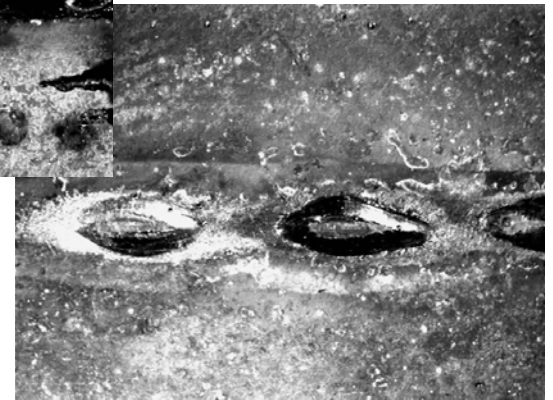
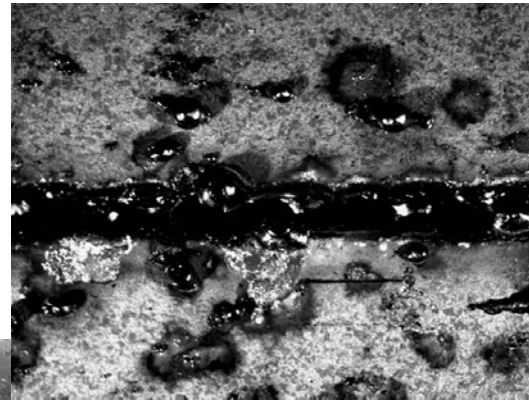
# Potentials of Image Processing for Quality Assurance in Laser Welding Processes

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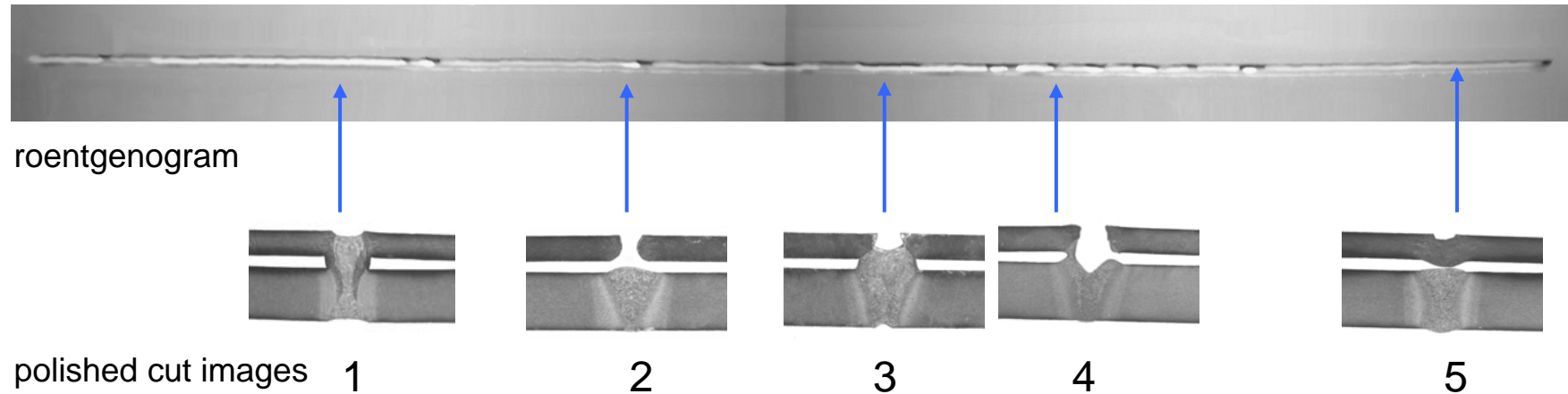
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# Goal

Detection of defects of laser weld seams for avoidance of rejects due to defects during production

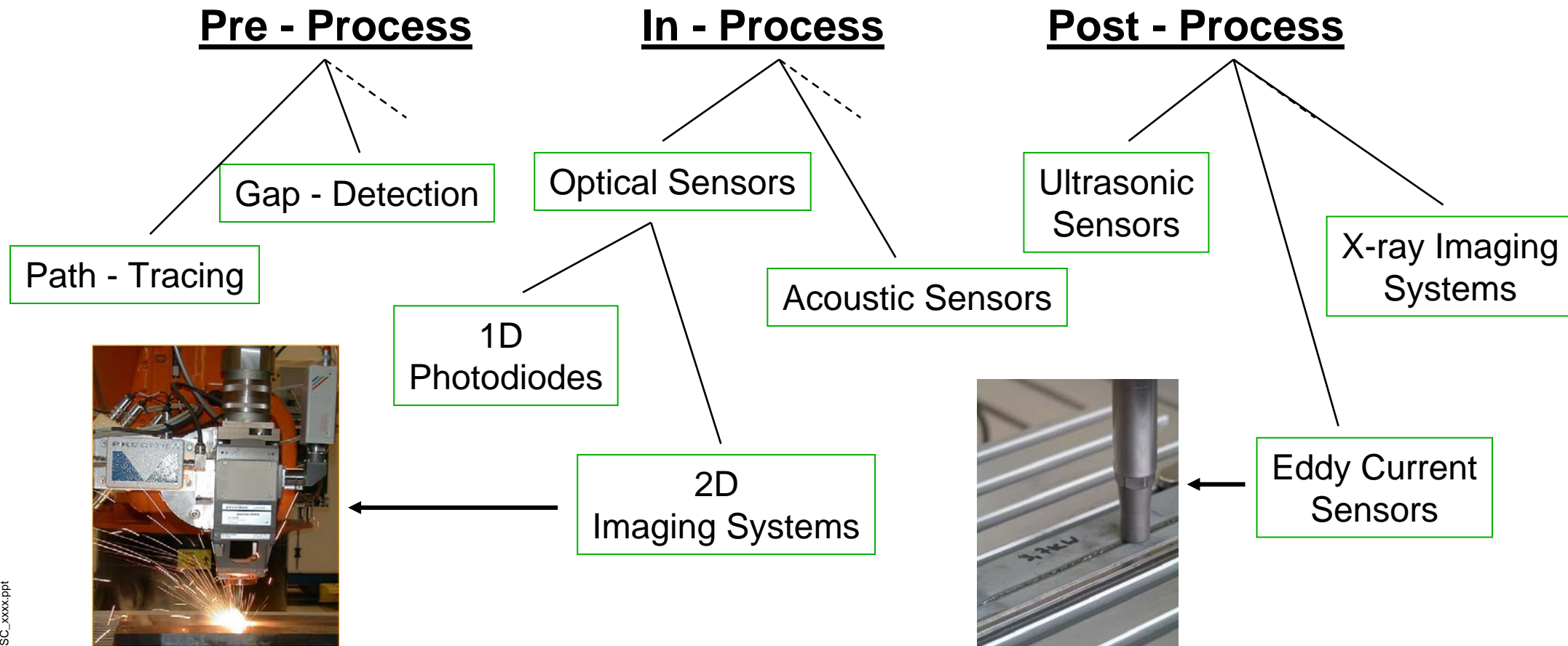


# Possible Defects (i.a.)

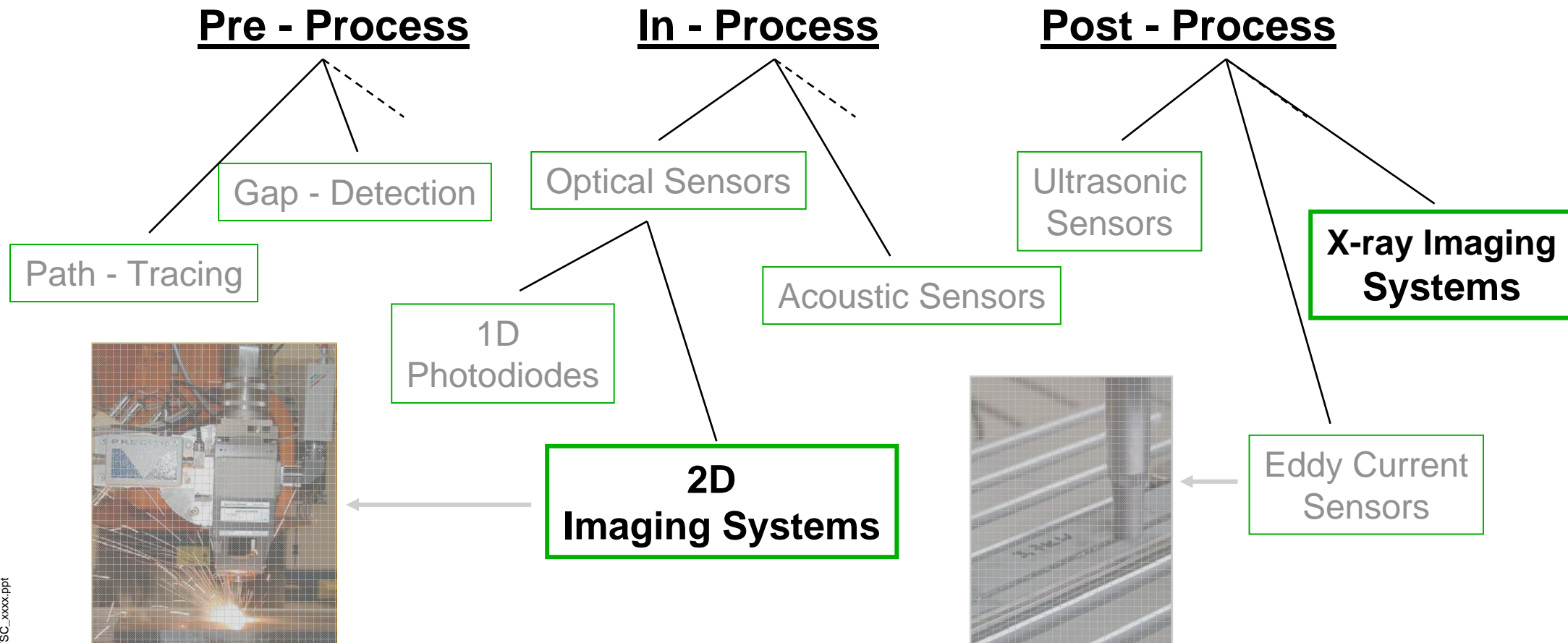


- 1 Weld Seam o.K.
- 2 Upper metal plate cut
- 3 Weld seam felled in
- 4 Partial connection
- 5 Missing connection

# Possible Sensor Systems

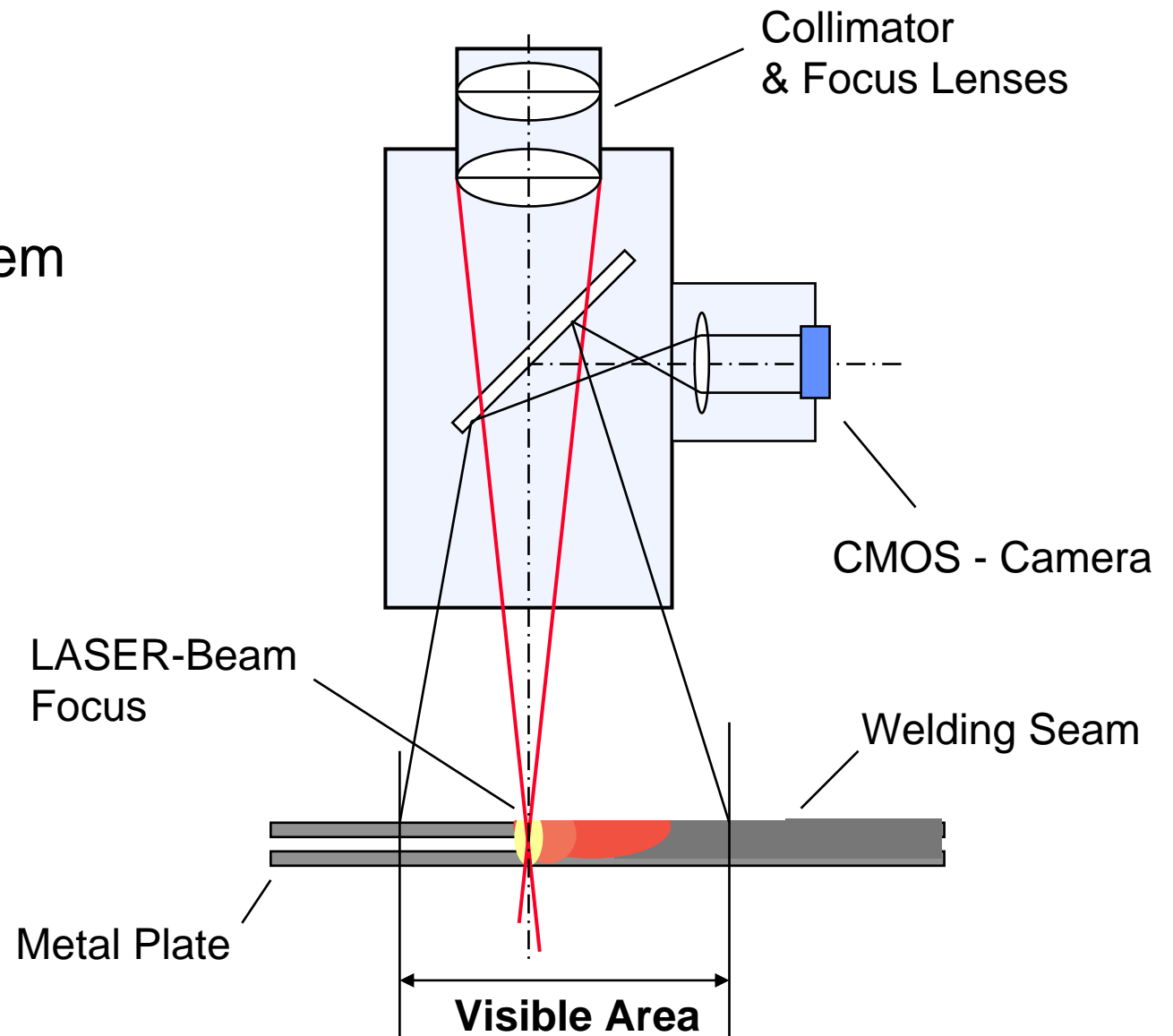


# Possible Sensor Systems



# 2D Imaging

## Co-axial Camera System



# 2D Imaging

Example:  
Start and end crater cavity



Start Crater Cavity



CMOS Image: Start  
without Root Fusion



CMOS Image: Root Fusion  
with Key Hole

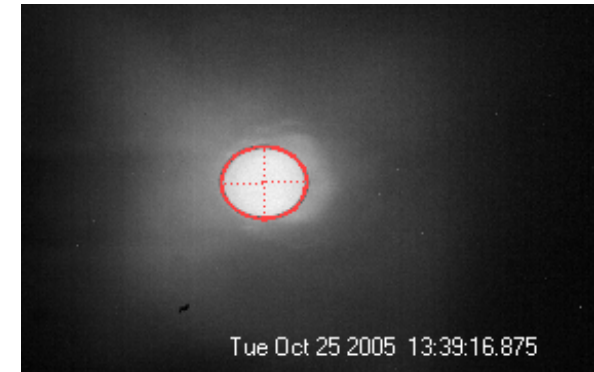


CMOS Image: Weld Spatter



# 2D Imaging

- **Geometry Monitoring**
- Key Hole Monitoring
- Watching of Spouting and Irregularities



CMOS Image: Start



CMOS Image: Root Fusion  
with Key Hole



CMOS Image: Weld Spatter



# 2D Imaging

- Geometry Monitoring
- **Key Hole Monitoring**
- Watching of Spouting and Irregularities



CMOS Image: Start



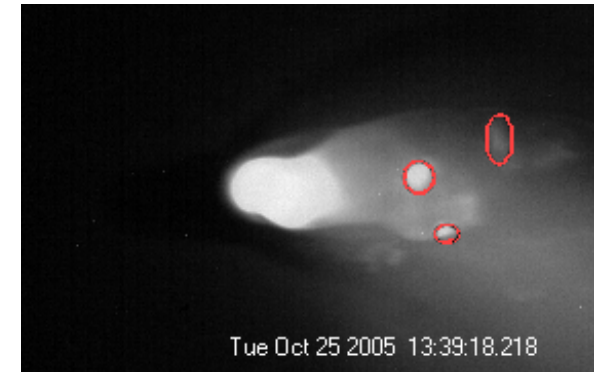
CMOS Image: Root Fusion  
with Key Hole



CMOS Image: Weld Spatter

# 2D Imaging

- Geometry Monitoring
- Key Hole Monitoring
- **Watching of Spouting and Irregularities**



CMOS Image: Start

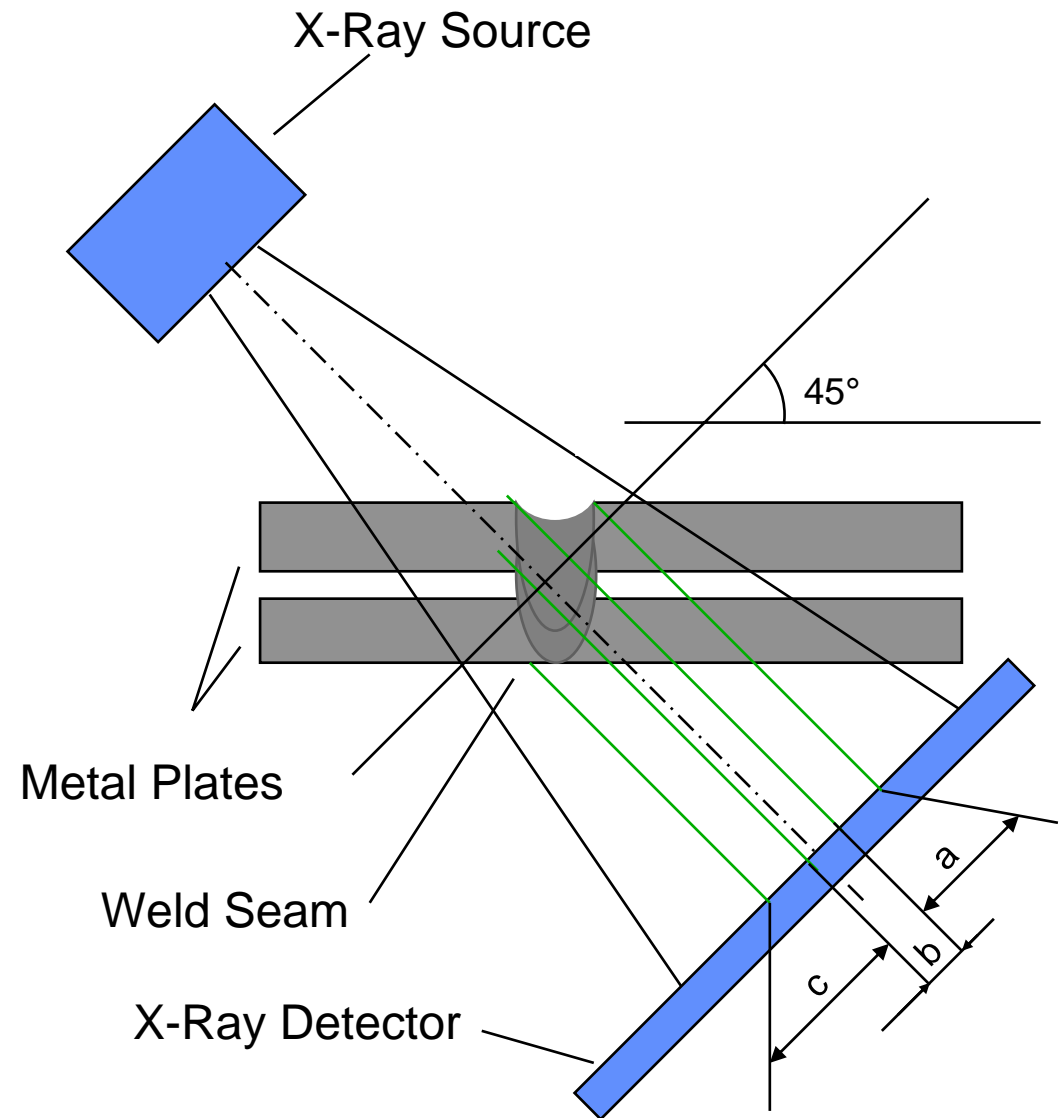
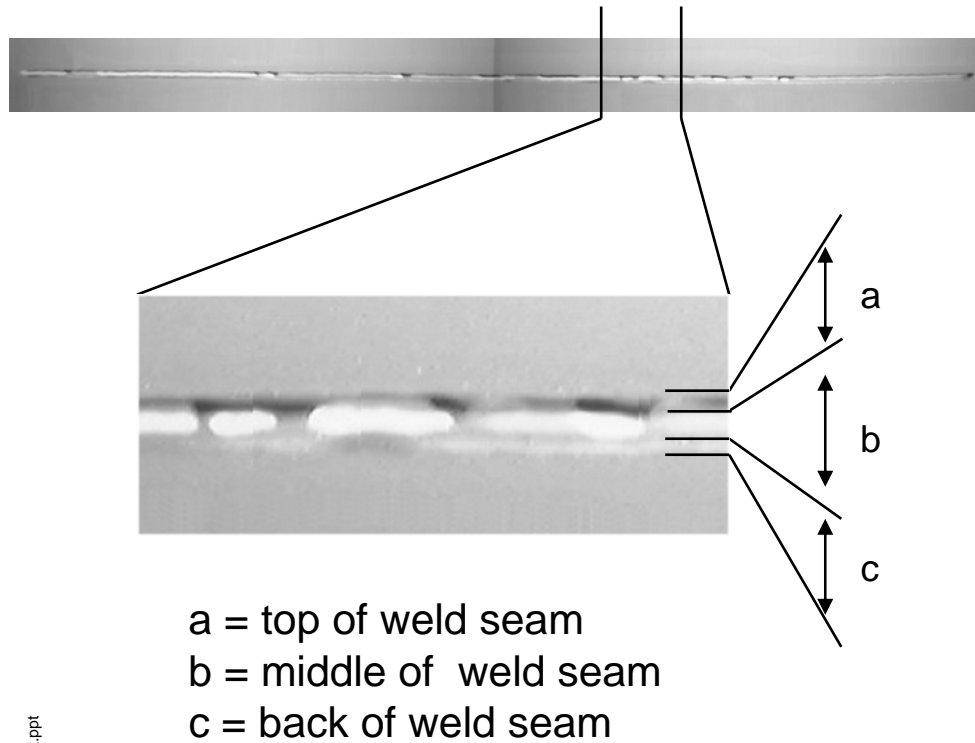


CMOS Image: Root Fusion  
with Key Hole

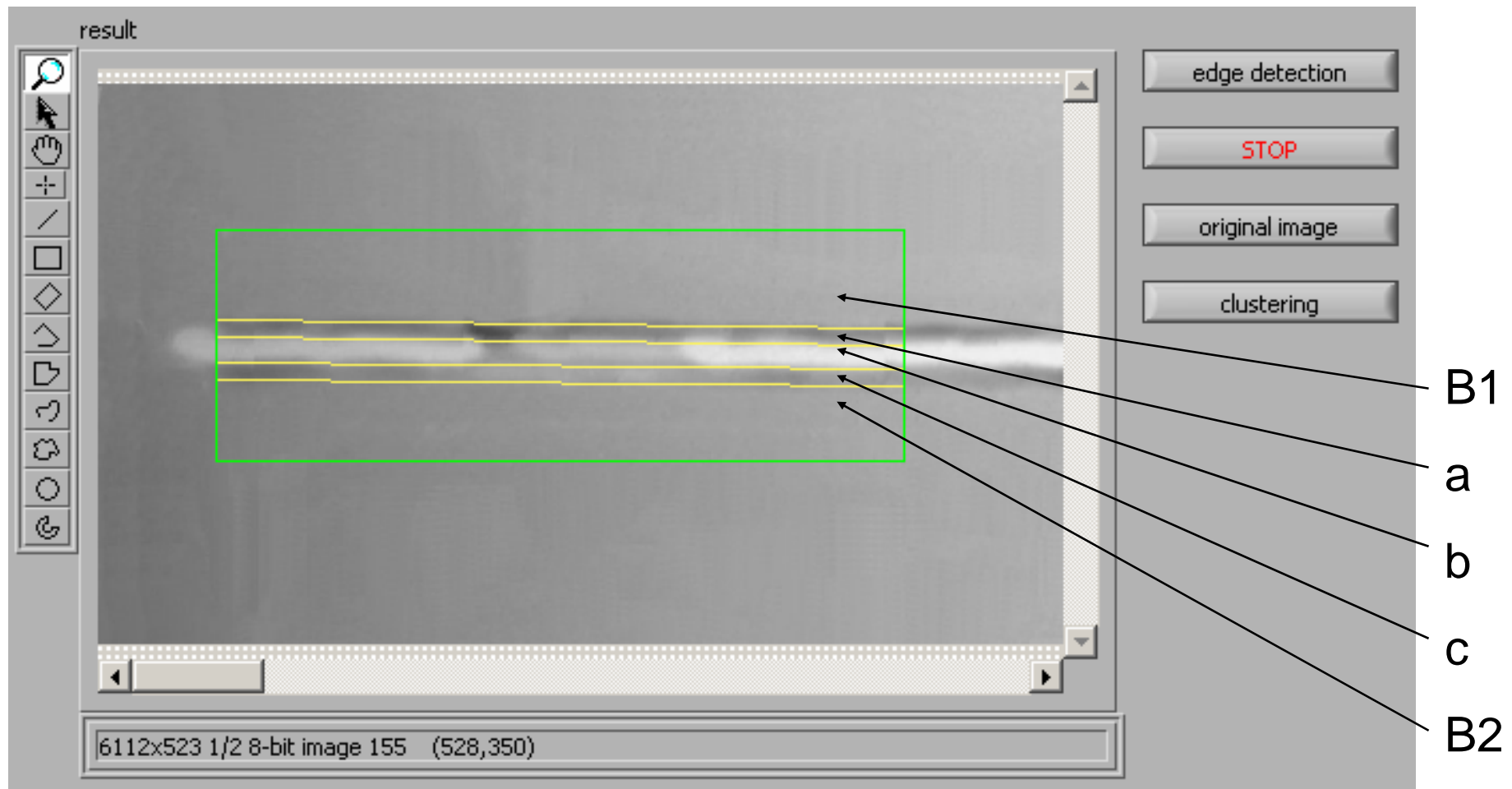


CMOS Image: Spouting

# X-Ray Imaging



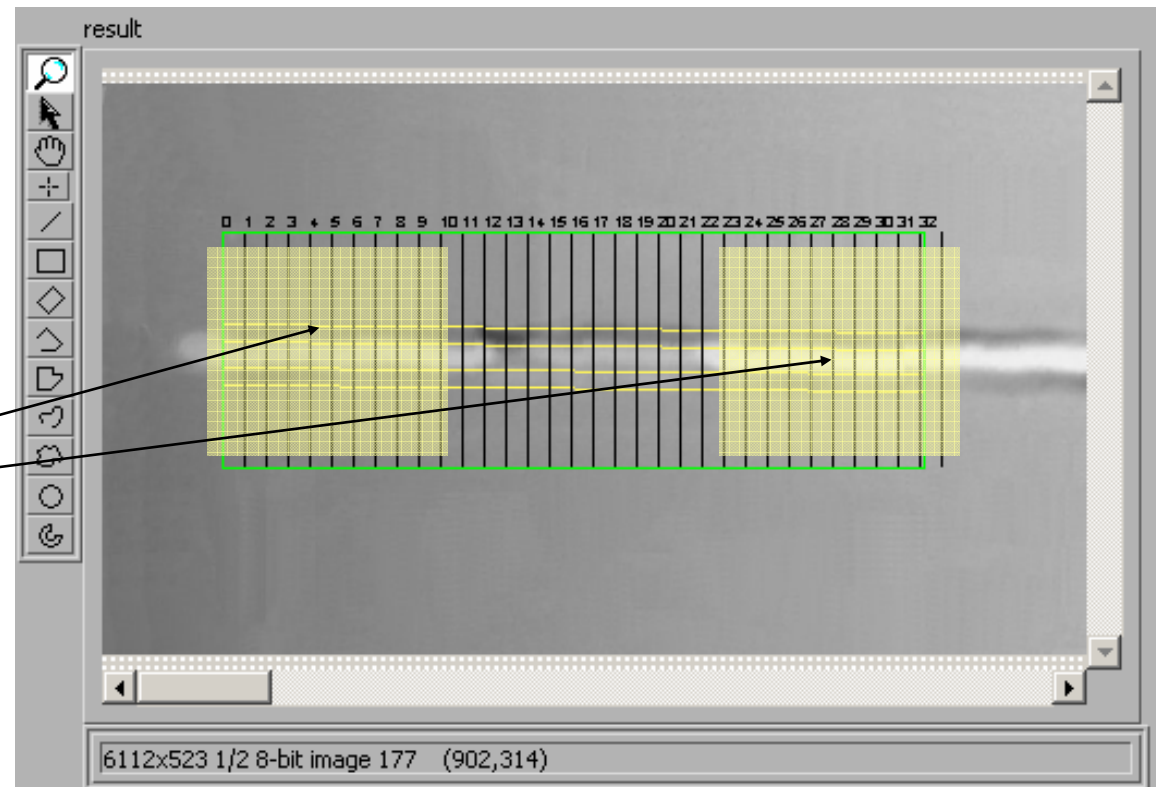
# Selection and separation of ROI



# Picture standardization

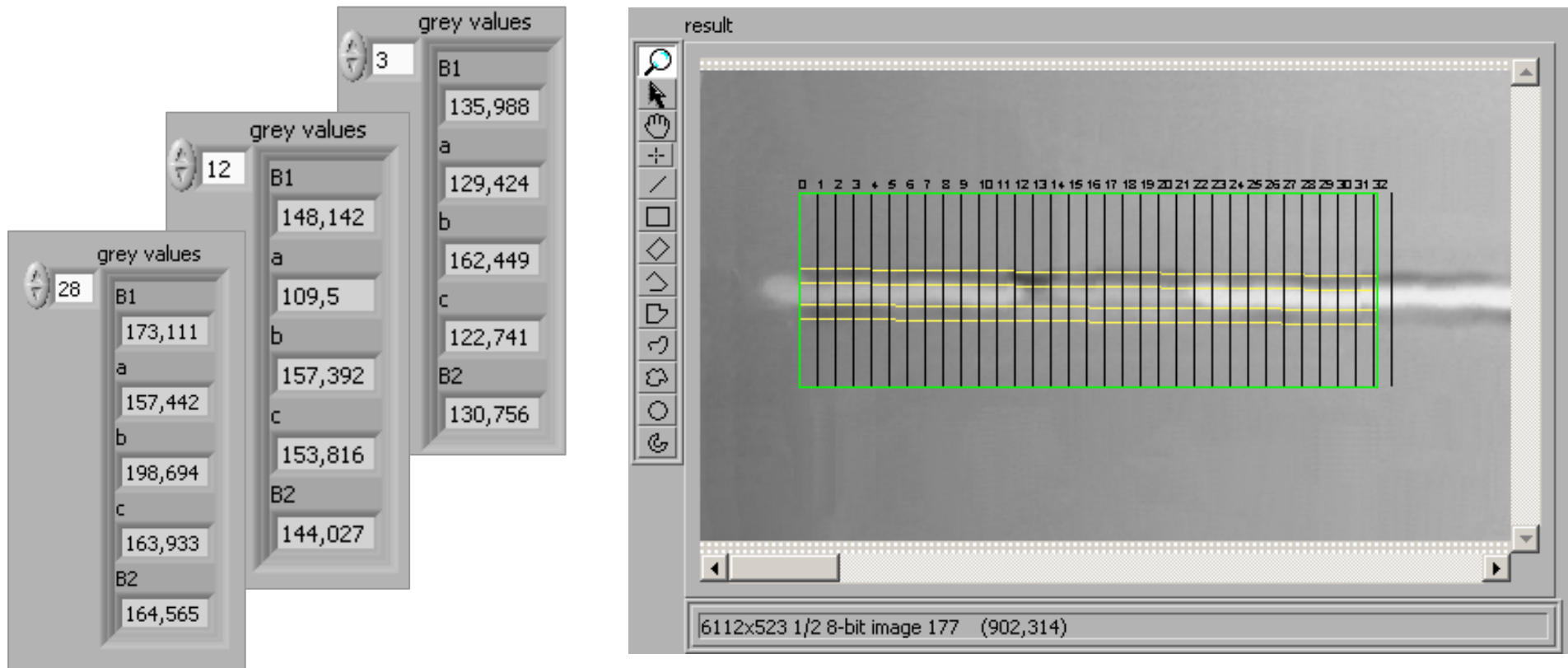
- Adaptive grey value adjustment

weld seam O.K.



# Defect detection and Classification

- Evaluation of grey values



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# Advantages / Disadvantages

## 2D Imaging

- Online monitoring
- Two-dimensional aggregation of information
- Different important parameter such as root fusion detectable
  - only surface effects visible

## X-Ray Imaging

- Two- or three-dimensional aggregation of information possible
- Aggregation of information from the inner weld seam
- Most of buried defects are detectable
  - In-line monitoring not possible at present
  - X-ray shield necessary



# Demands on In-line X-Ray Systems

- Small system contour
- No radiation exposure to outside the system
- High detection speed
- Process-stability in industrial environment  
→ temperature, dust, vibration

