SAND2022-15600C

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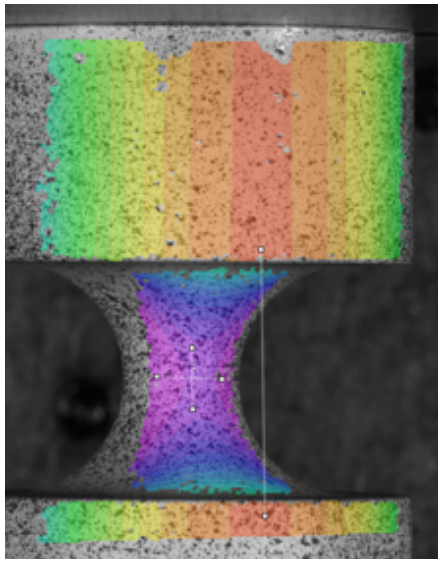
Challenges in Full-field Mechanical and Thermal Analysis for Extensive Mechanical Deformation of Complex Geometries



Kimberley A. Mac Donald*, Amanda Jones, & Bonnie R. Antoun

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Thermomechanics - November 9, 2022

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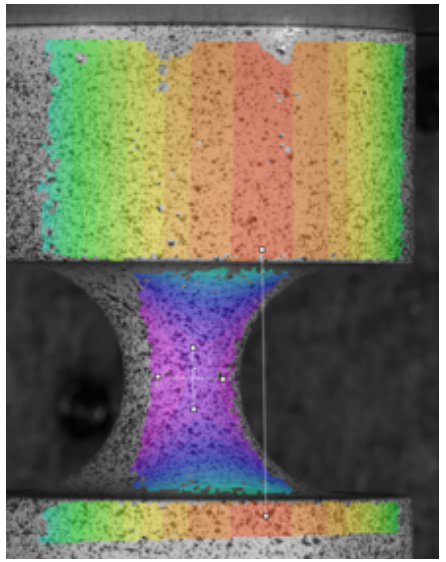

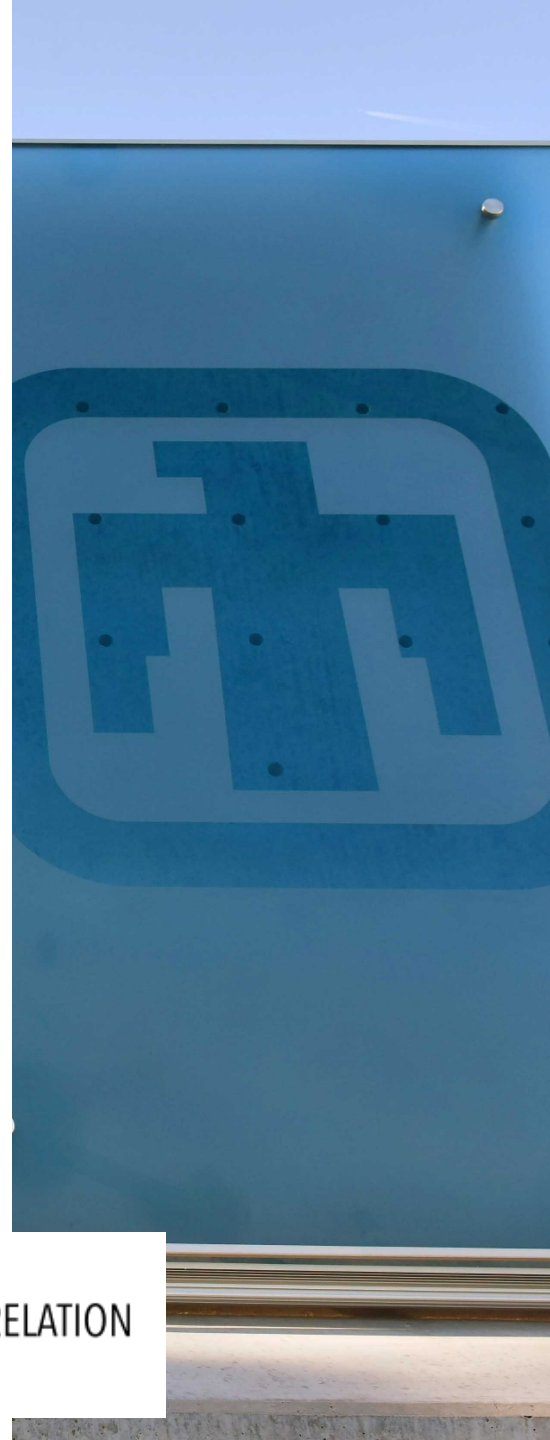

When taking (useful) pictures of stuff (aka: science) is really hard

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Benefits and challenges with imaging methods

Benefits and uses

- Don’t need *a priori* knowledge of where to put a strain gage/thermocouple
- Works where traditional methods fail – fast, non-contact, full-field
- Adjust ROI/virtual gage as much as you want
- Useful for adding complexity to models

  Thermal response/effects; Rate dependence/viscosity; Plasticity; Fracture/failure

Challenges and considerations

- Mechanical
- Optical
- Physical
- Software/hardware
- Cost ($ 🖫 ⌛)

2 Examples:

- Validation Problem: Can Crush

  Highly ductile 304L SS
- Notched Compression

  Moderately ductile Al 6061-T6

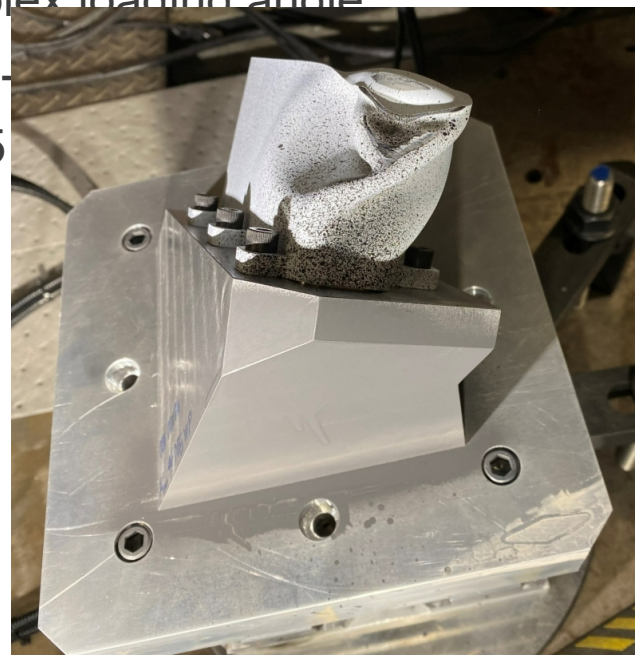
  Highly ductile 304L SS

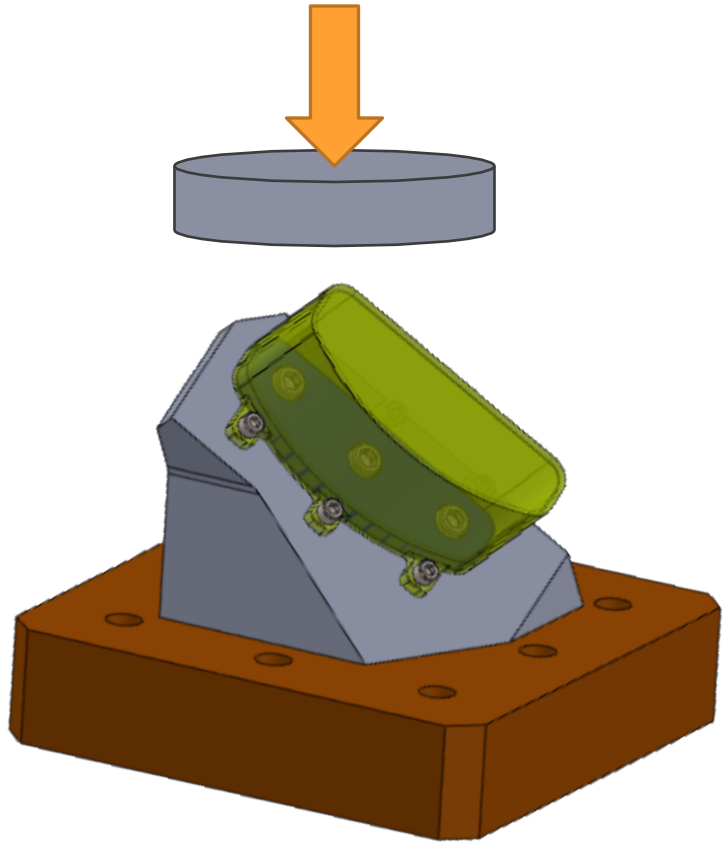
Example 1: Can crush validation experiment

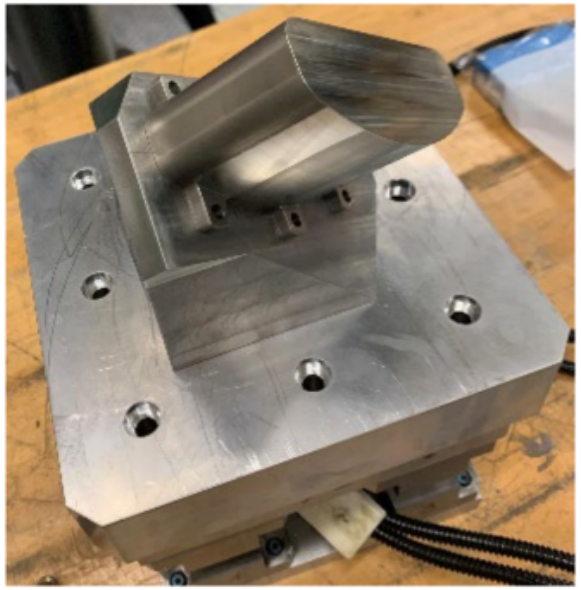
Goal: Validate elastic plastic material model for 304L-VAR material through ductile failure

Experiment:

- Thin walled, open, can-like geometry
- Directly machined (no welds or joints)
- Complex loading angle
- Quasi-
  (0.25



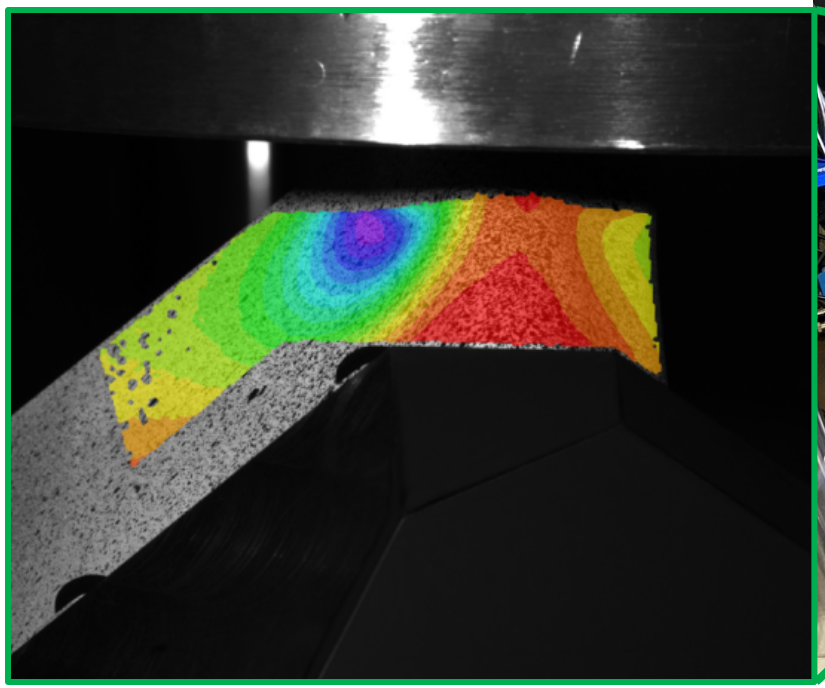


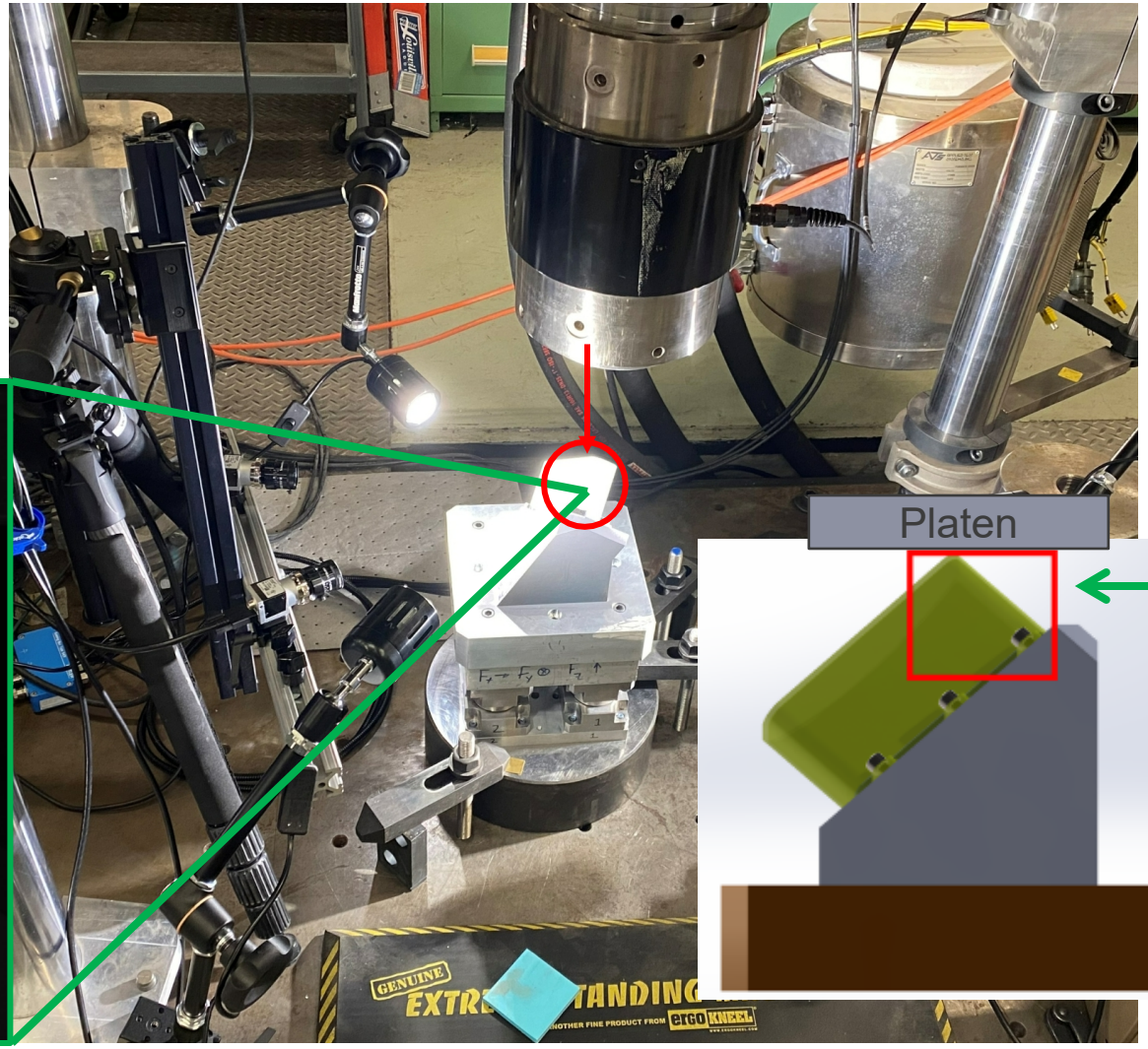


Antoun, BR, Mac Donald, KA, Talamini, B, Stershic, A, Lao, X, Jones, A, and Kramer, SL. *Validation Experiments for Extensive Mechanical Deformation of a 304L Stainless Steel Geometry.* Conference presentation at 2022 SEM Annual Conference on Experimental and Applied Mechanics, Pittsburgh, PA, USA, June 13-16, 2022.

3D-DIC (low-rate, 2 camera pairs)

Shadows, obstructed view

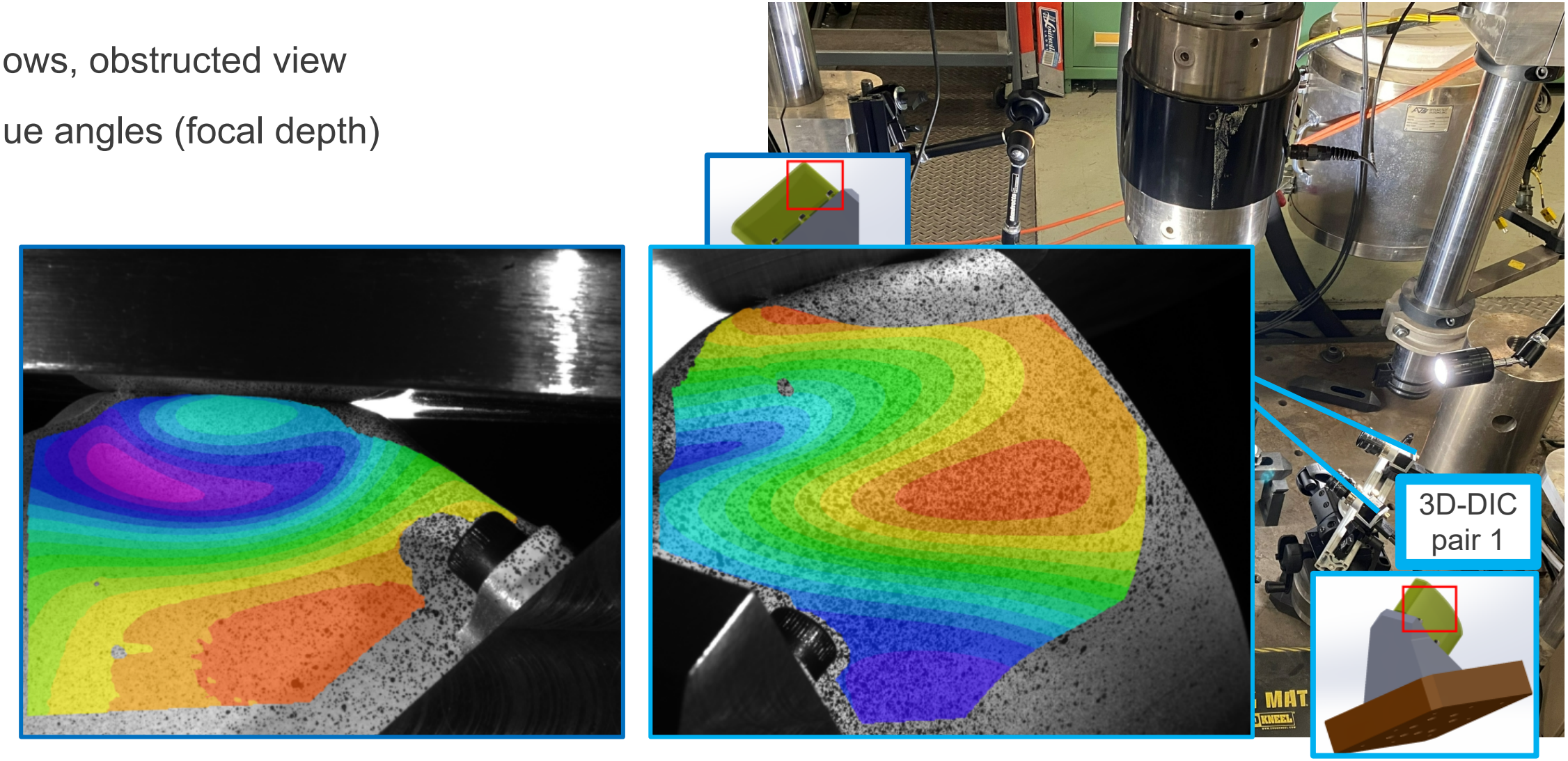




3D-DIC (low-rate, 2 camera pairs)

Shadows, obstructed view

Oblique angles (focal depth)

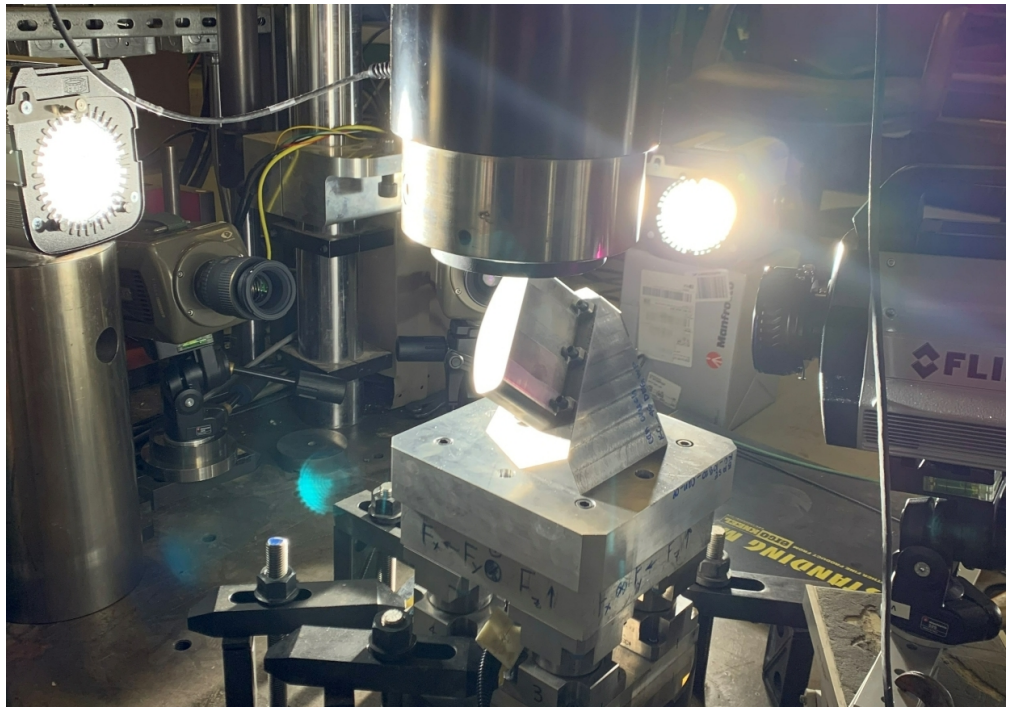


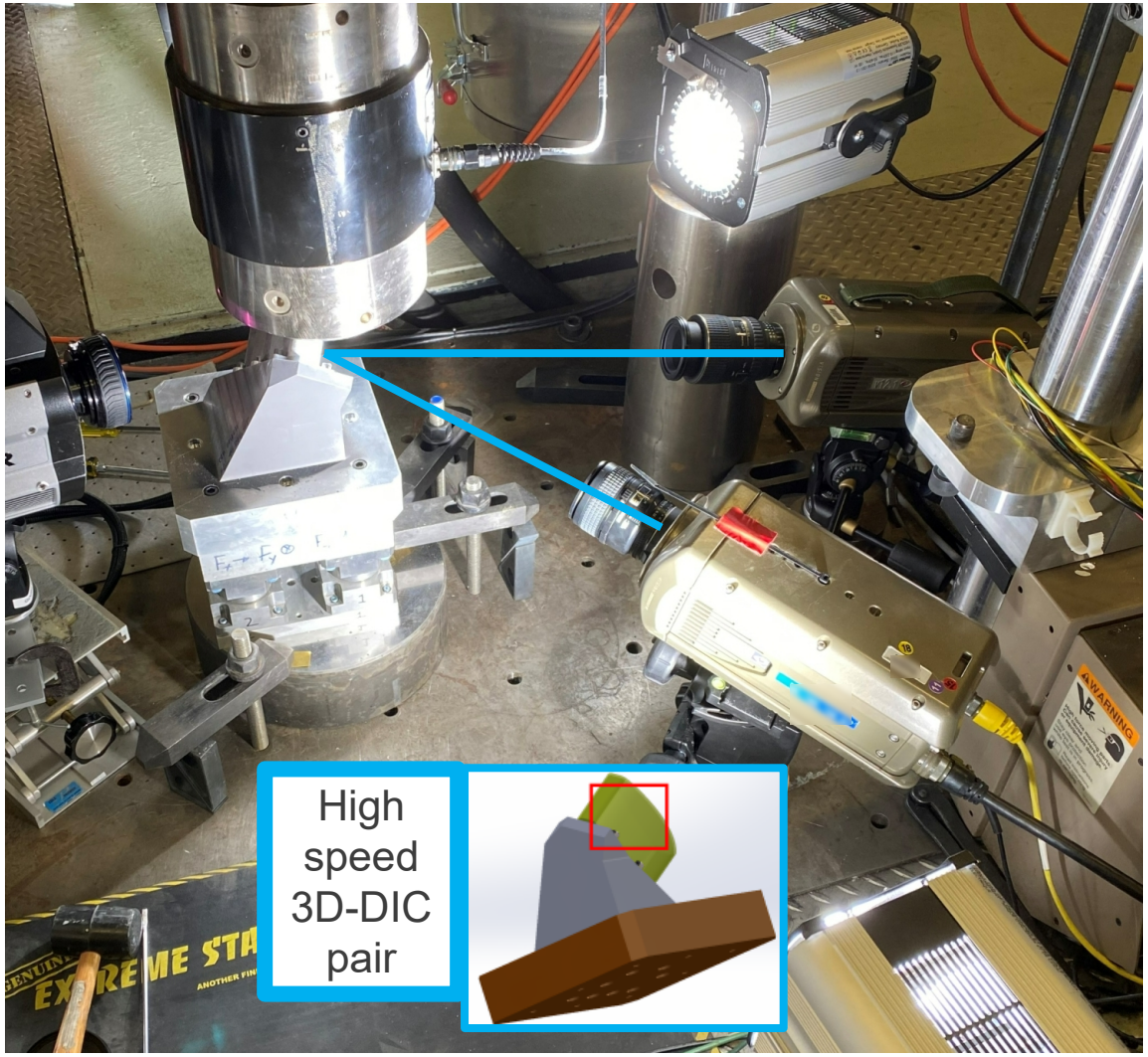
3D-DIC (high-rate)

Shadows, obstructed view, oblique angles

Physical size and space

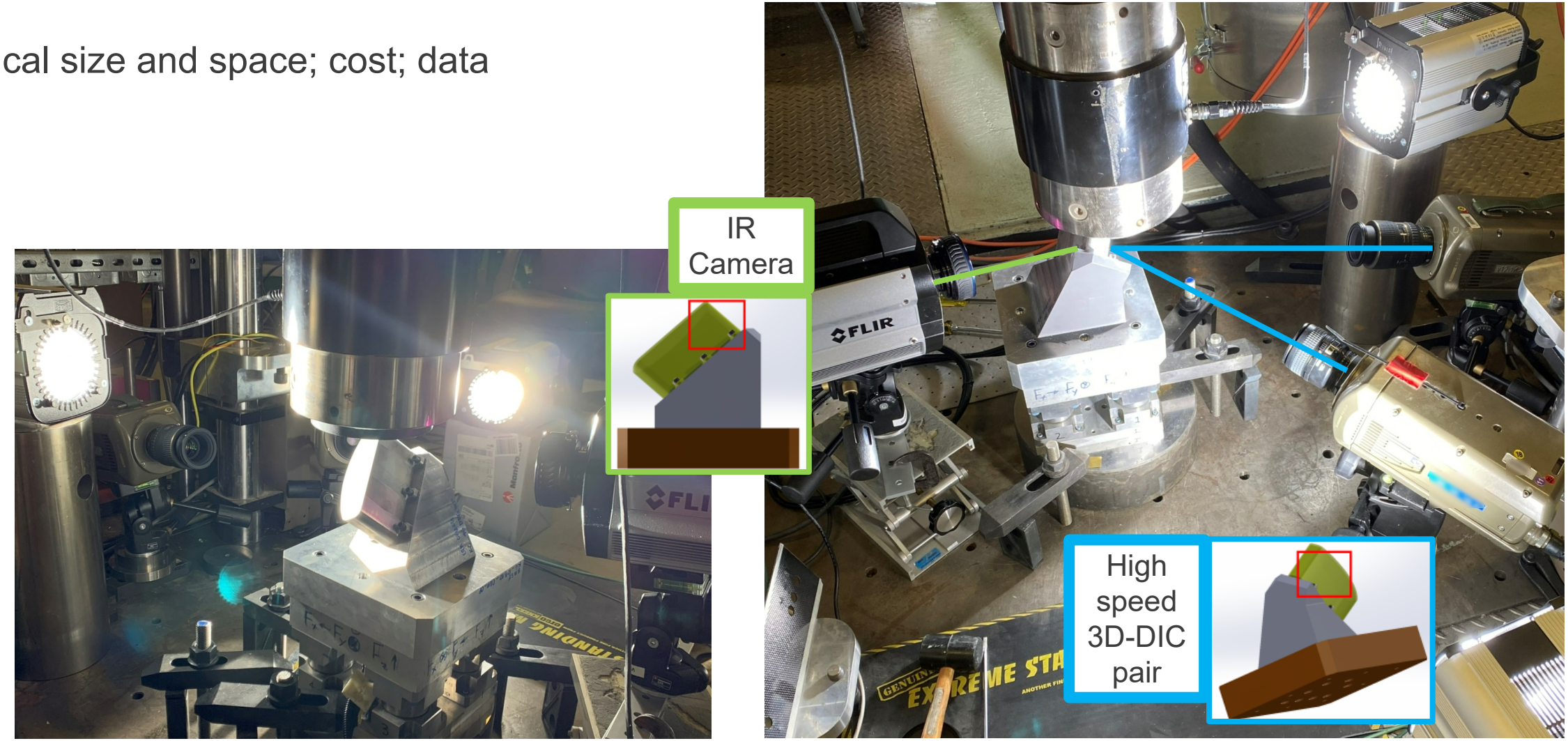
Cost, data transfer and storage





3D-DIC (high-rate) + IR imaging

Physical size and space; cost; data

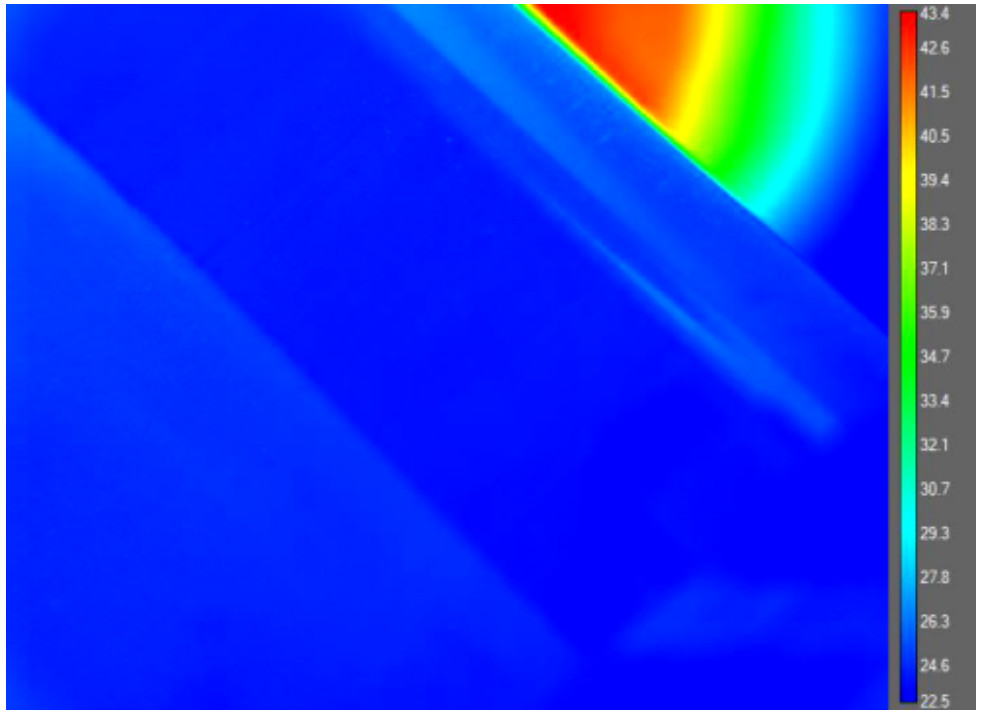


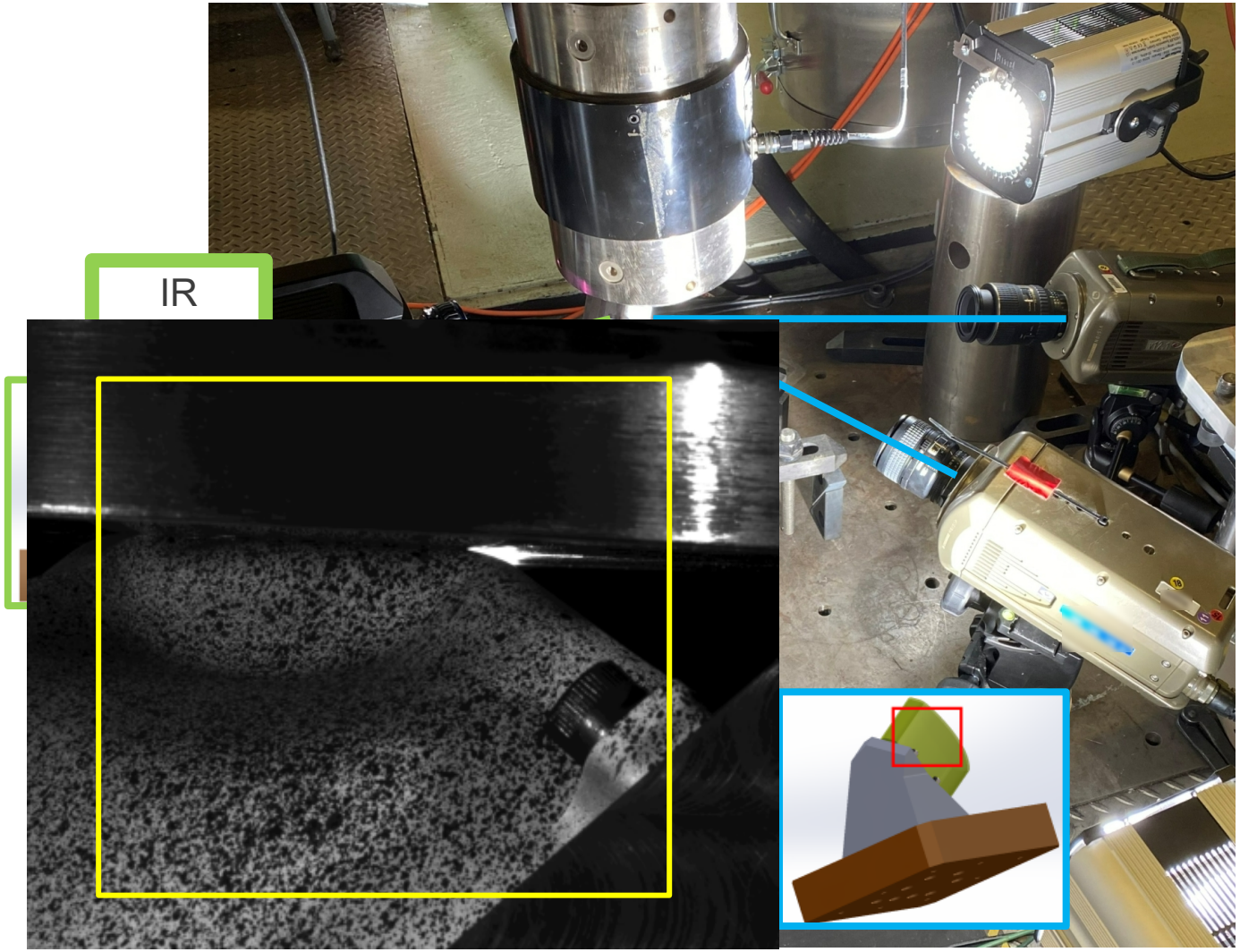
3D-DIC (high-rate) + IR imaging

Physical size and space; cost; data

Alignment; focal depth

Synchronization



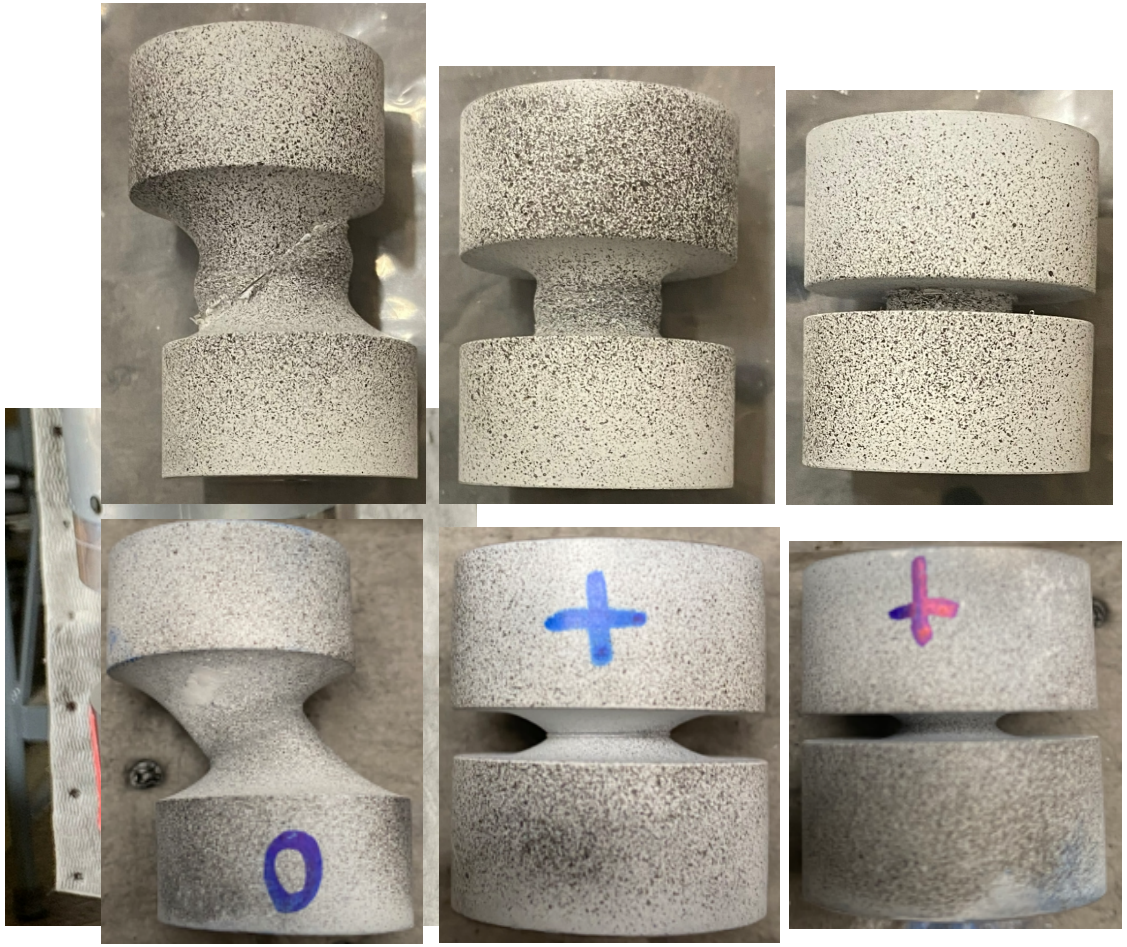


Example 2: Notched compression tests

Goal: Investigate range of low triaxiality (<0) load states in Al 6061-T6 and 304L SS materials

Experiment:

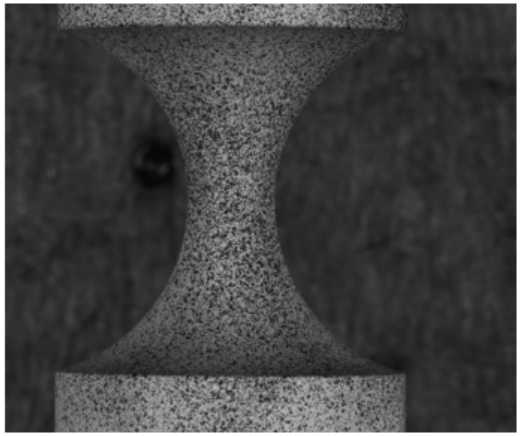
- Range of notch radii
- Compress to “failure”



3D DIC

Speckling/patterning

- Oblique angles
- Small space
- Even coating



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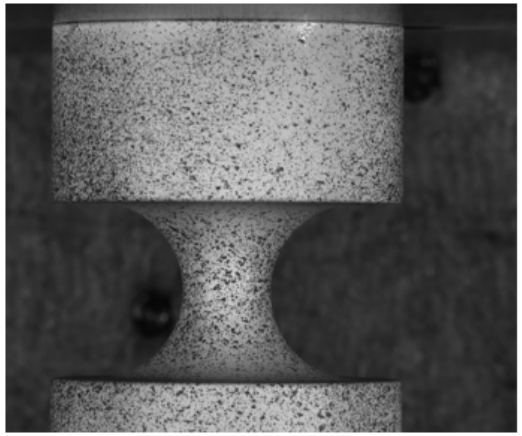

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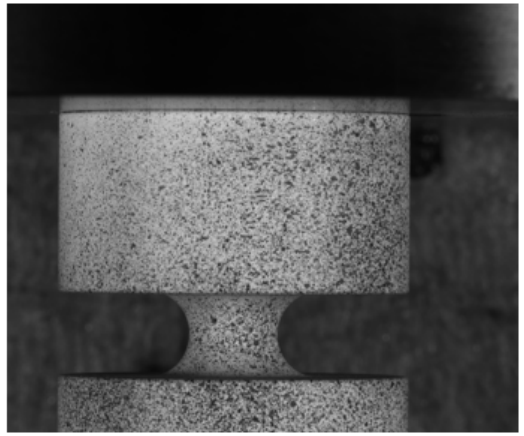

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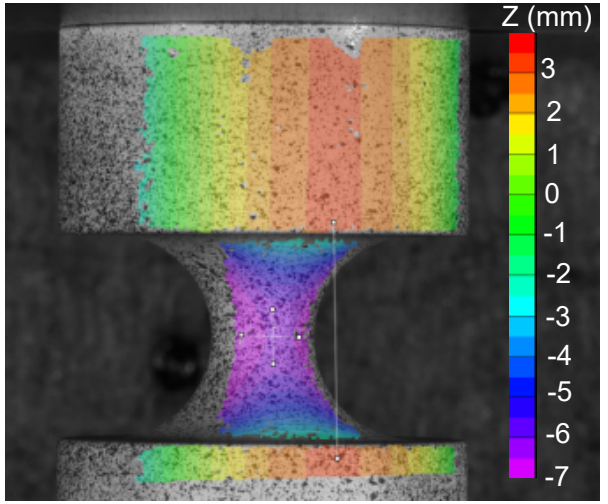


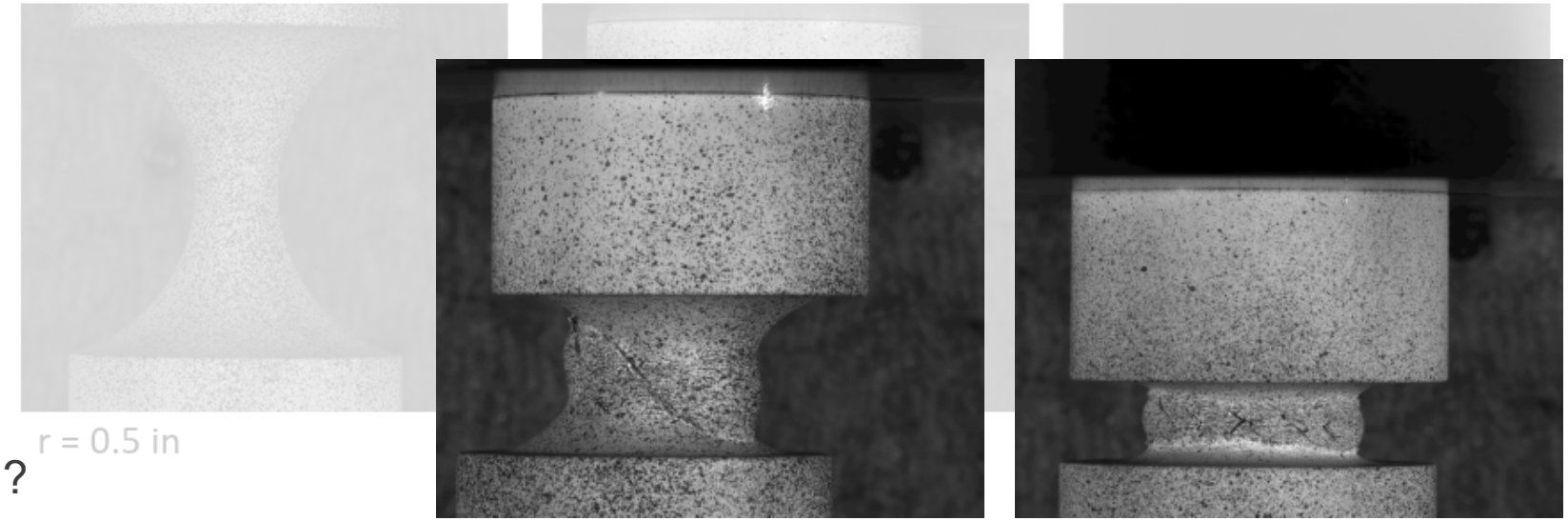
3D DIC

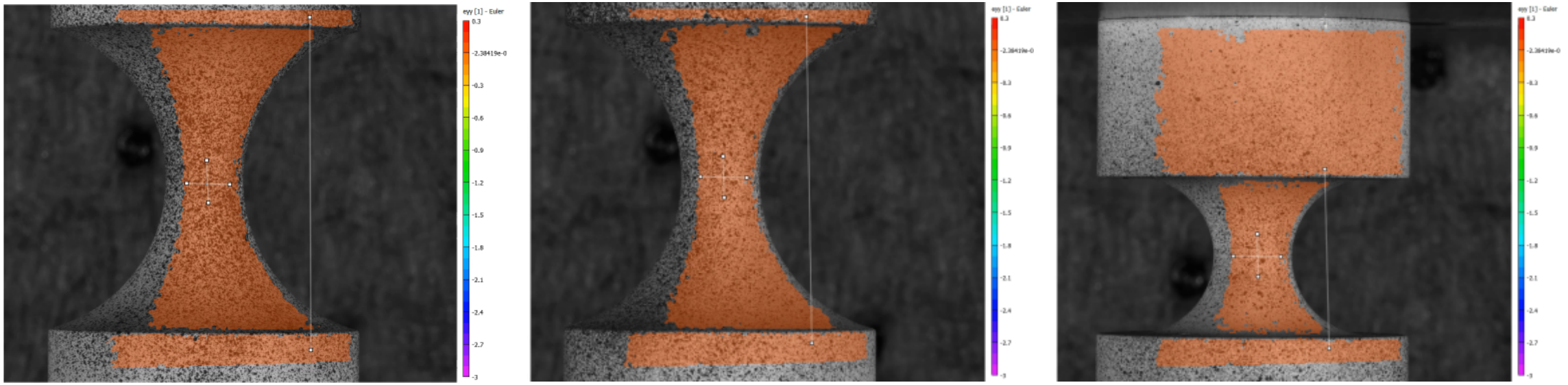
Speckling/patterning

- Oblique angles
- Small space
- Even coating
- Flexibility/deformability

Non-flat specimen

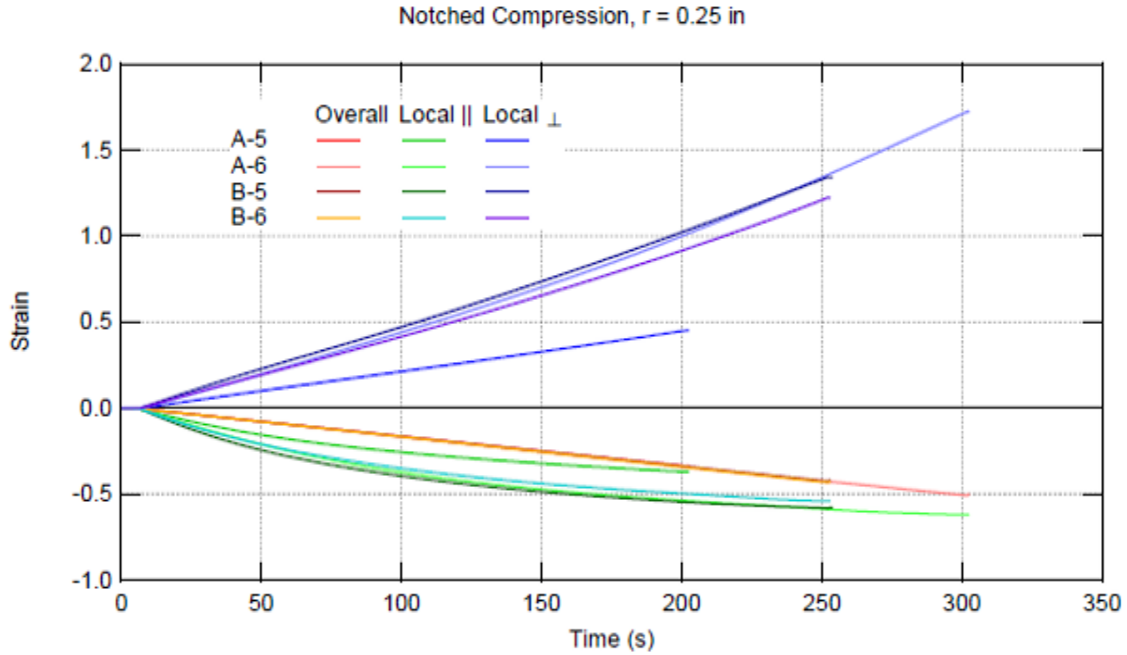
- Where does failure happen?

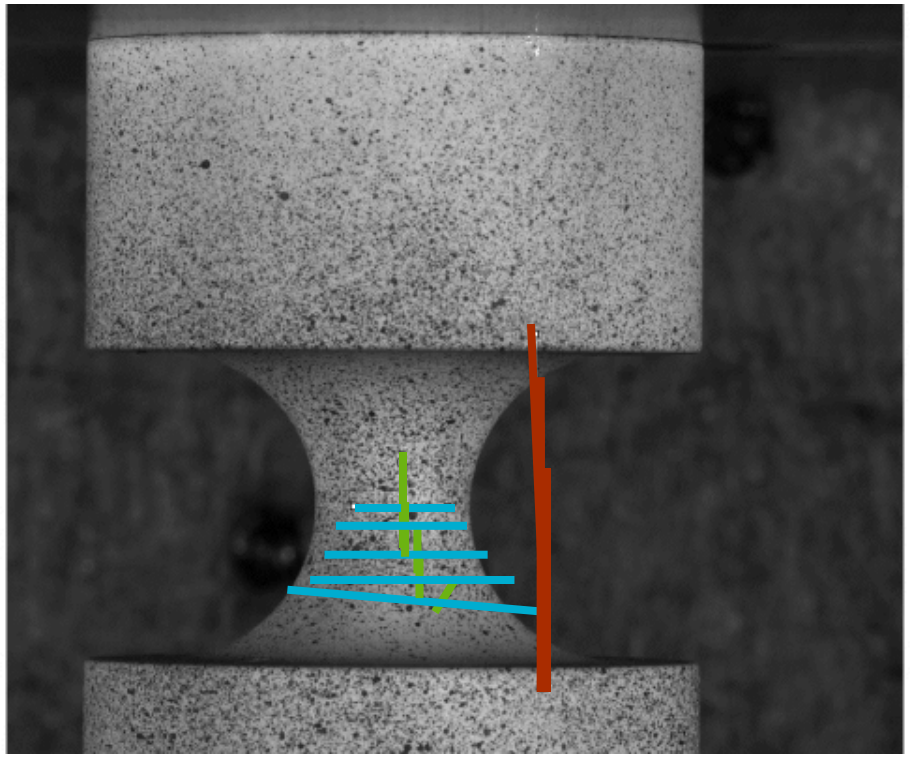




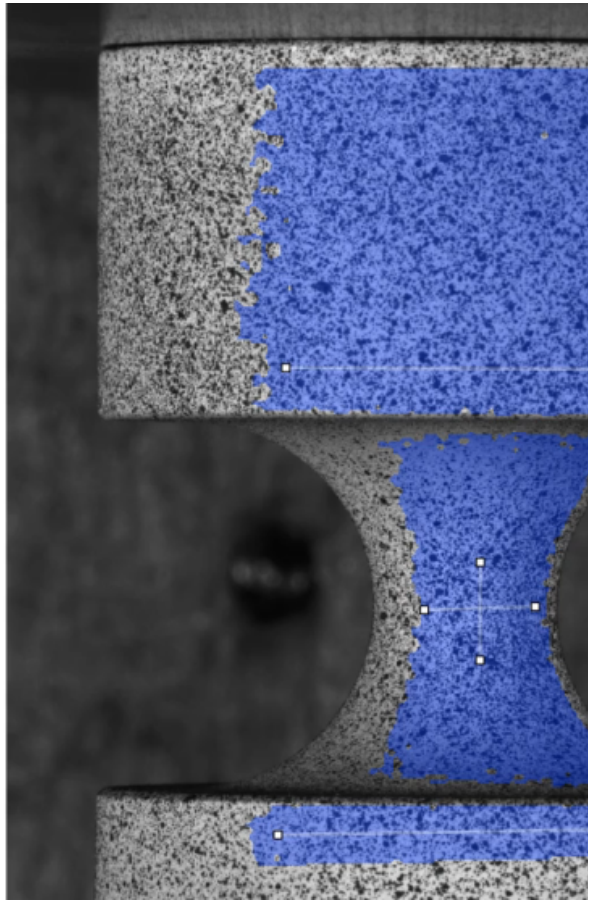
3D DIC – How to measure something useful

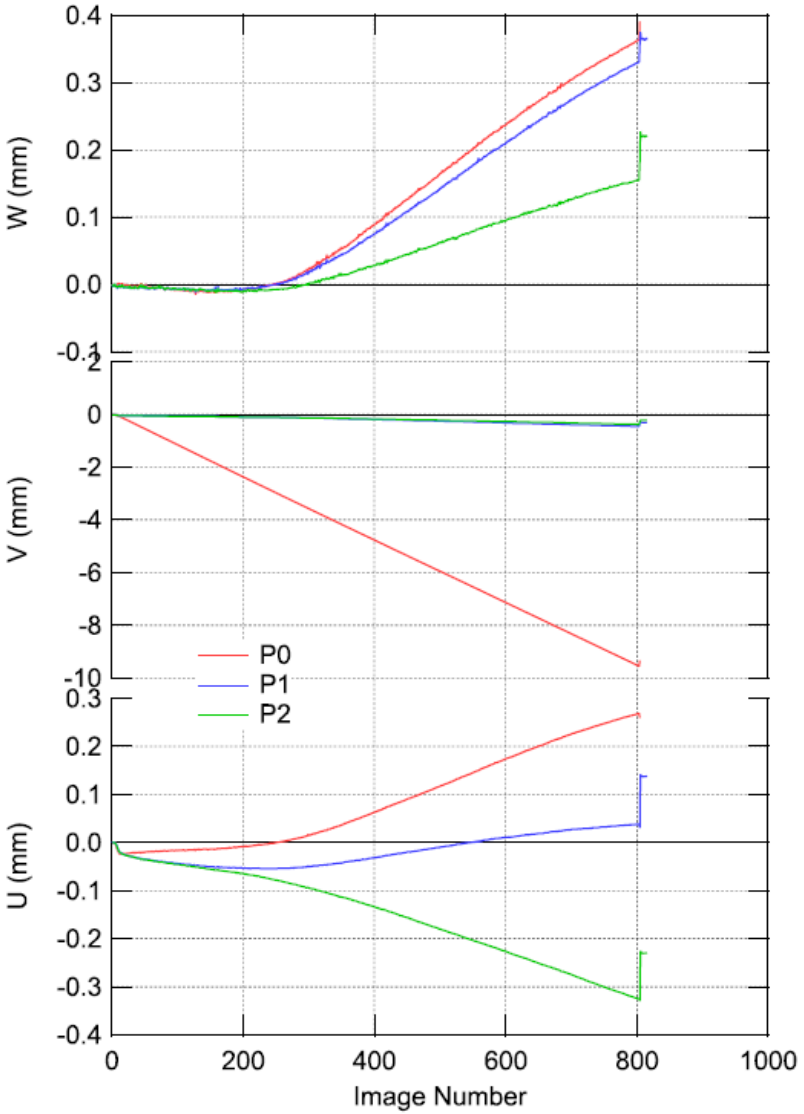
Virtual strain gages – global and local response

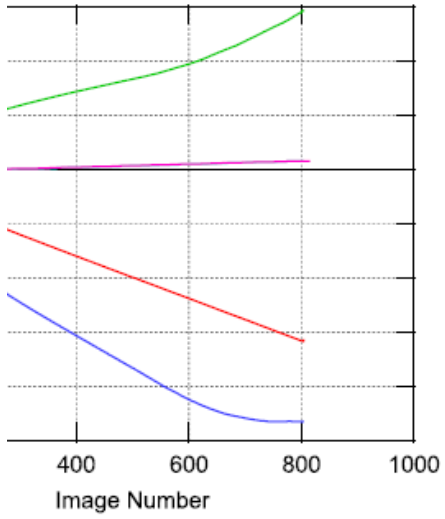




3D DIC – How to measure something useful







Lessons learned and recommendations

High complexity, thermomechanical testing

- Design experiments with imaging needs in mind
- Be clever with use of tripods and stands
- Make use of multi-purpose instruments/cameras
- Can you rotate the fixture/test article?
- If possible, always collect DAQ signals with images

Low complexity/”simple” mechanics

- Are there similar tests that are easier to speckle and image?
- Consider 360° systems (higher expense)
- Consider using mirrors (higher complexity – calibration, analysis)

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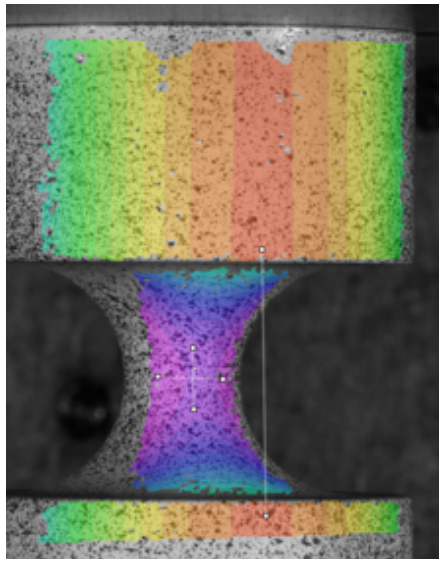

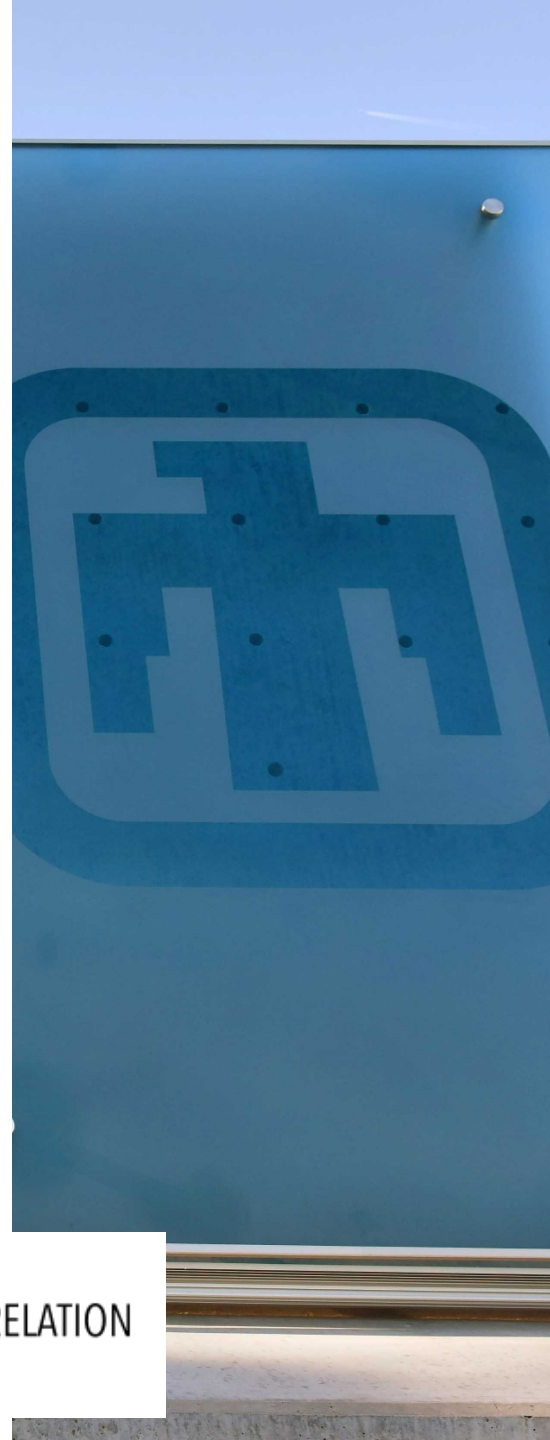

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