Validation of Cold Working Simulations with Contour Method and Digital Image Correlation Measurements

Scott Prost-Domasky • Kyle Honeycutt

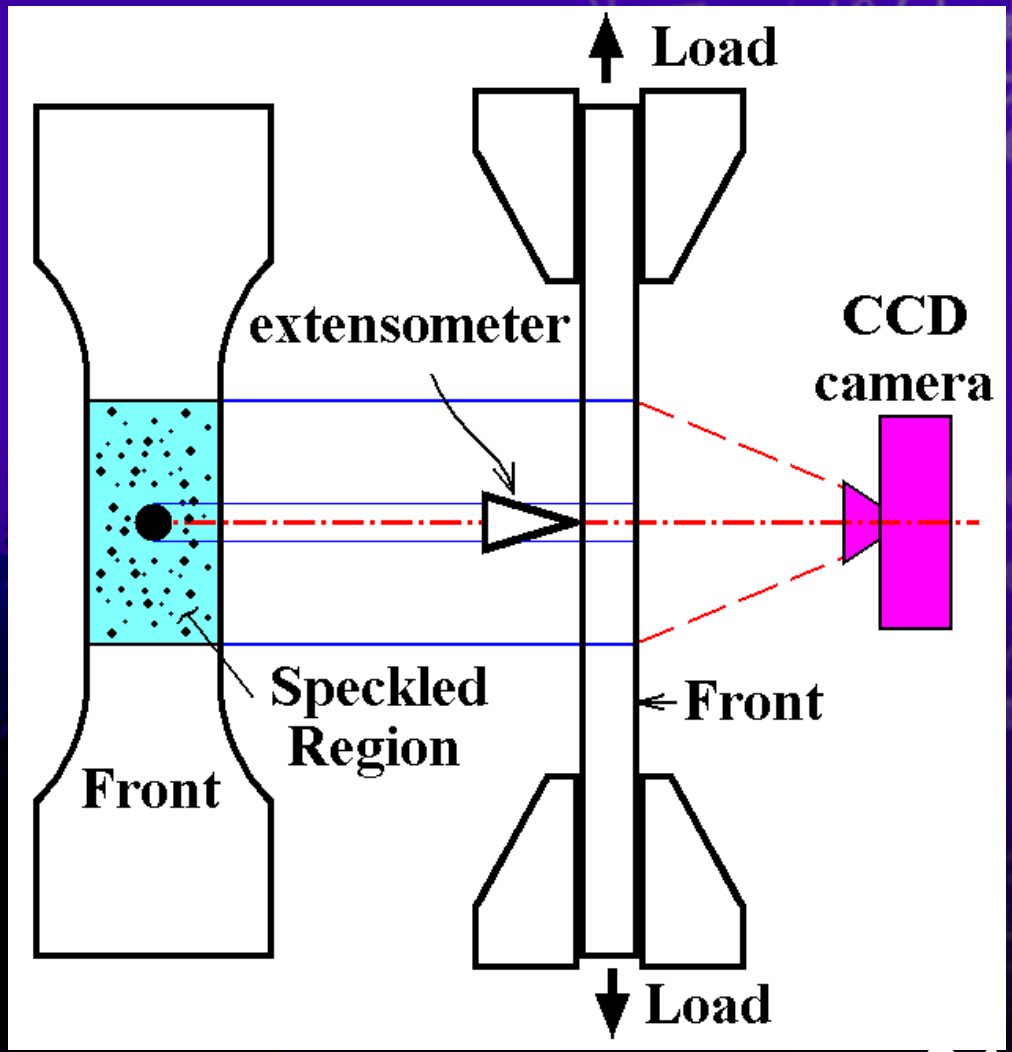
Analytical Processes/Engineered Solutions • 6669 Fyler Ave. St. Louis, MO 63139

Agenda

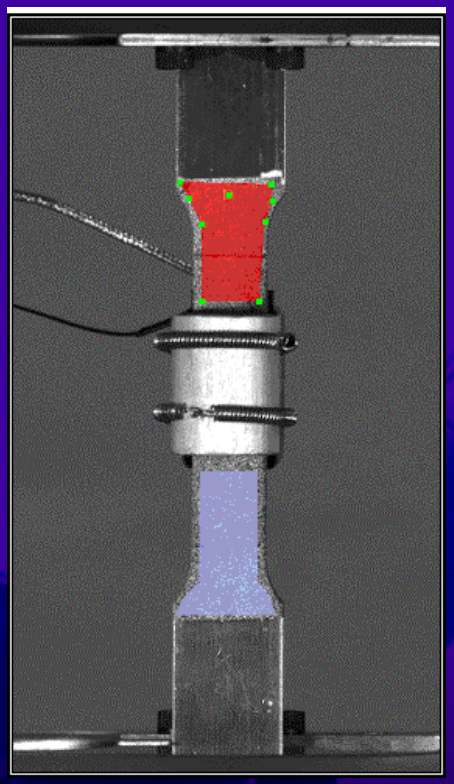
Digital Image Correlation (DIC) Basics
Validation of Uniaxial Stress Field
Validation of Notch (Hole) Stress Field
Error sources
Tips for Better Results
Conclusions

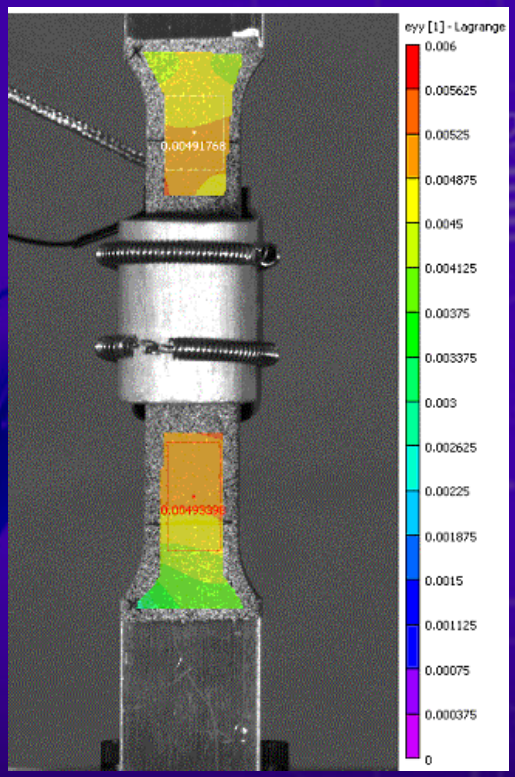
Digital Image Correlation (DIC) Conceptually Simple

- Hardware and software must be optimized together
- We use VIC-2D by Correlated Solutions



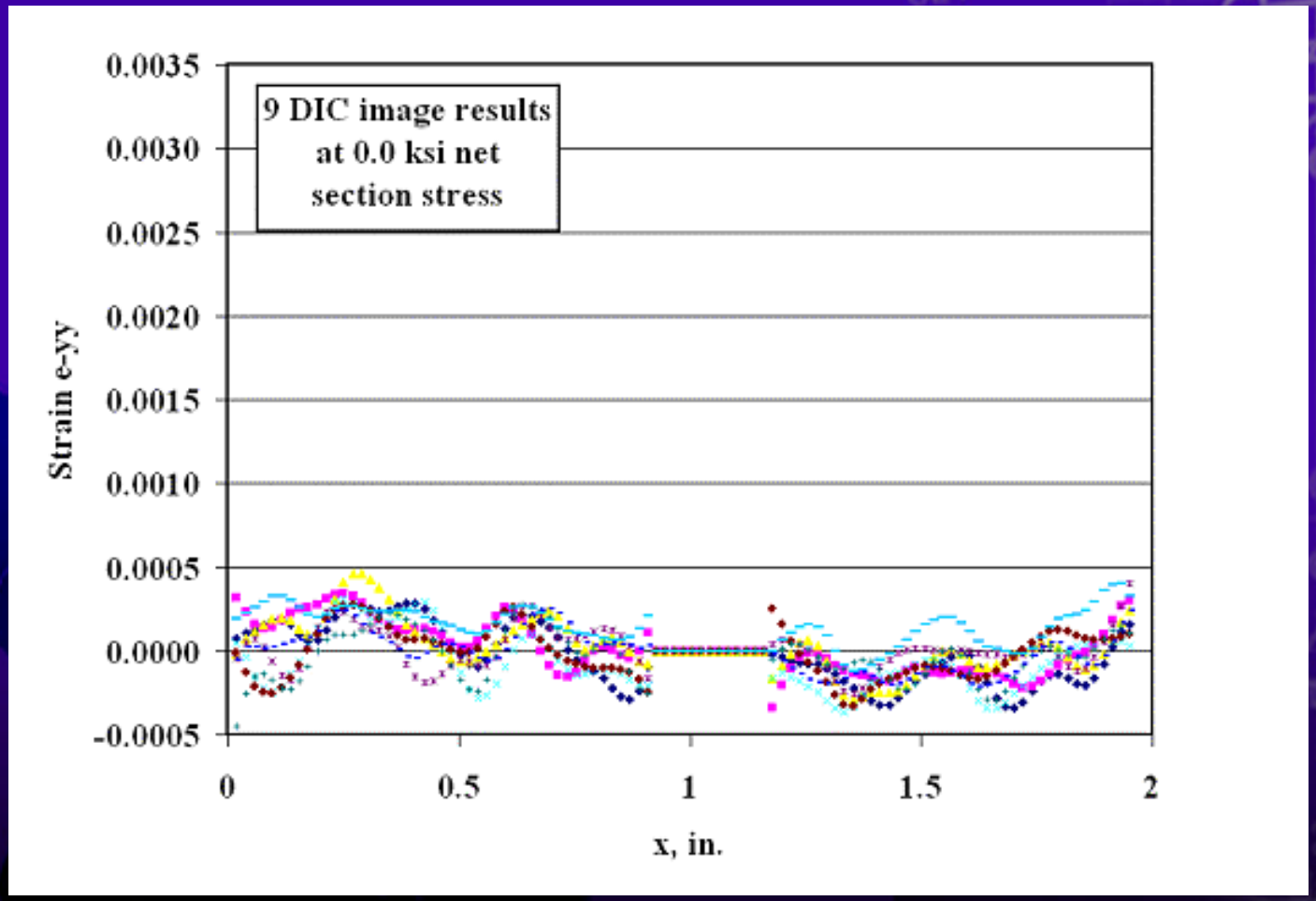
Validation in Uniaxial Stress Field





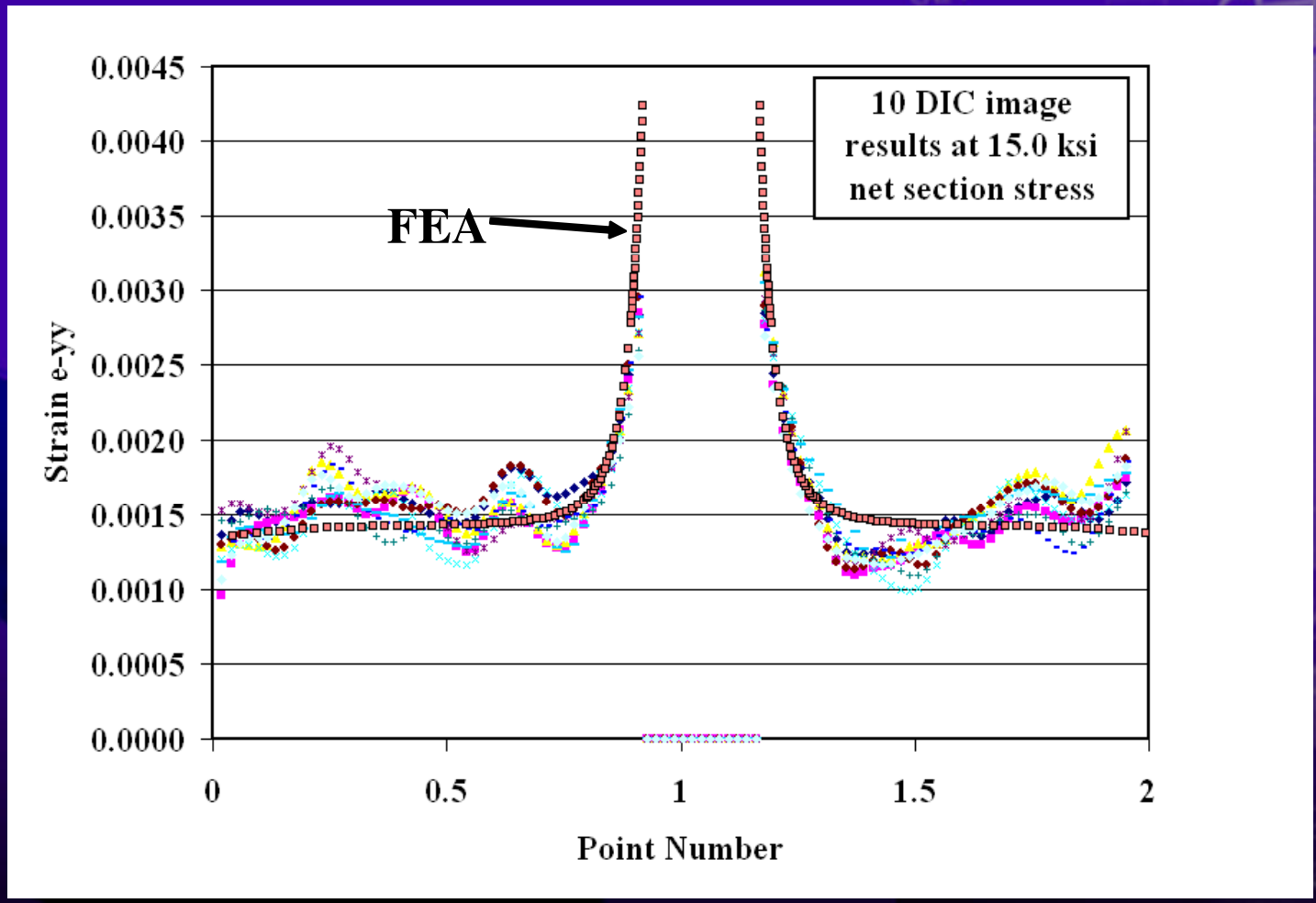
Location	Mean strain, μ_{strain} (inches/inch)	Standard Deviation, σ (inches/inch)	Theoretical difference
Upper rectangle	0.004894	0.0001135	+ 4.80%
Lower Rectangle	0.004874	0.0001808	+ 4.37%
Entire AOI	0.004652	0.0004191	- 0.385%

"Noise" Level about 0.05 % Strain-No Stress



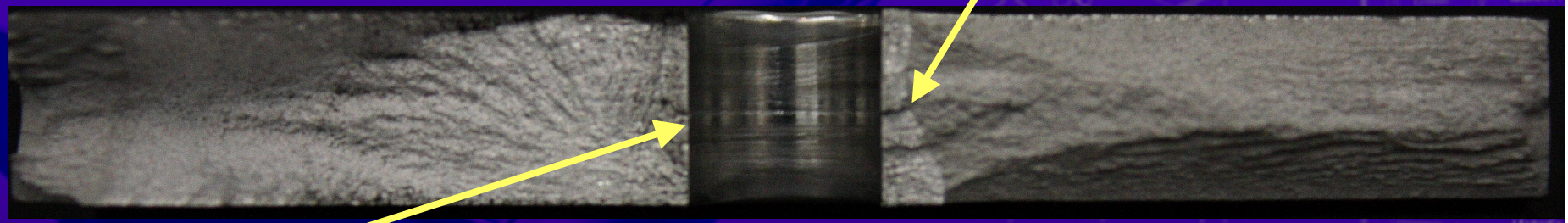
As-manufactured; no cold working

Validation with Open Hole, Non-cold Worked



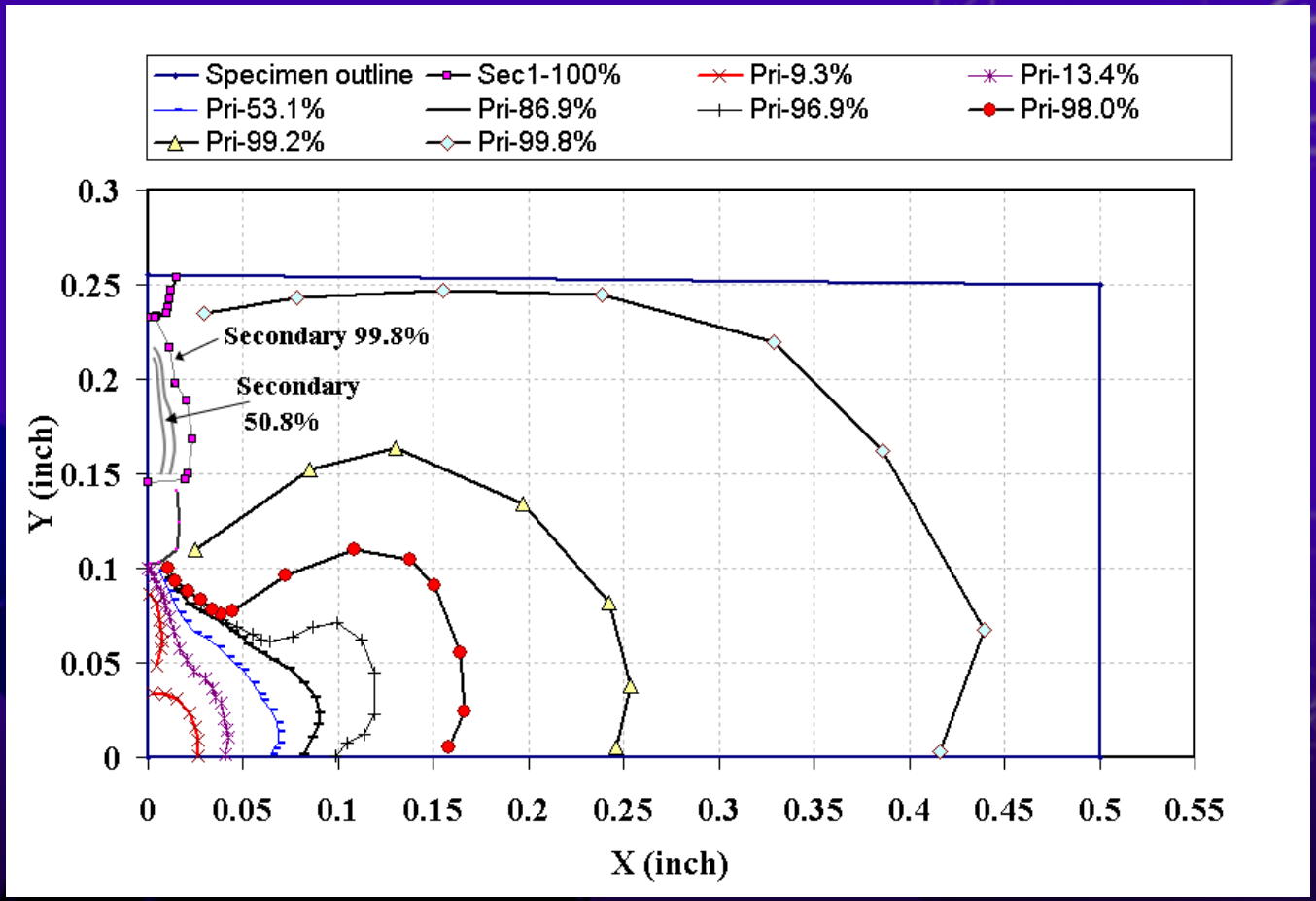
Fracture Features of CW Specimen

"Idaho" ??



At 25 ksi, cracks nucleate almost right away at corner and up and down bore

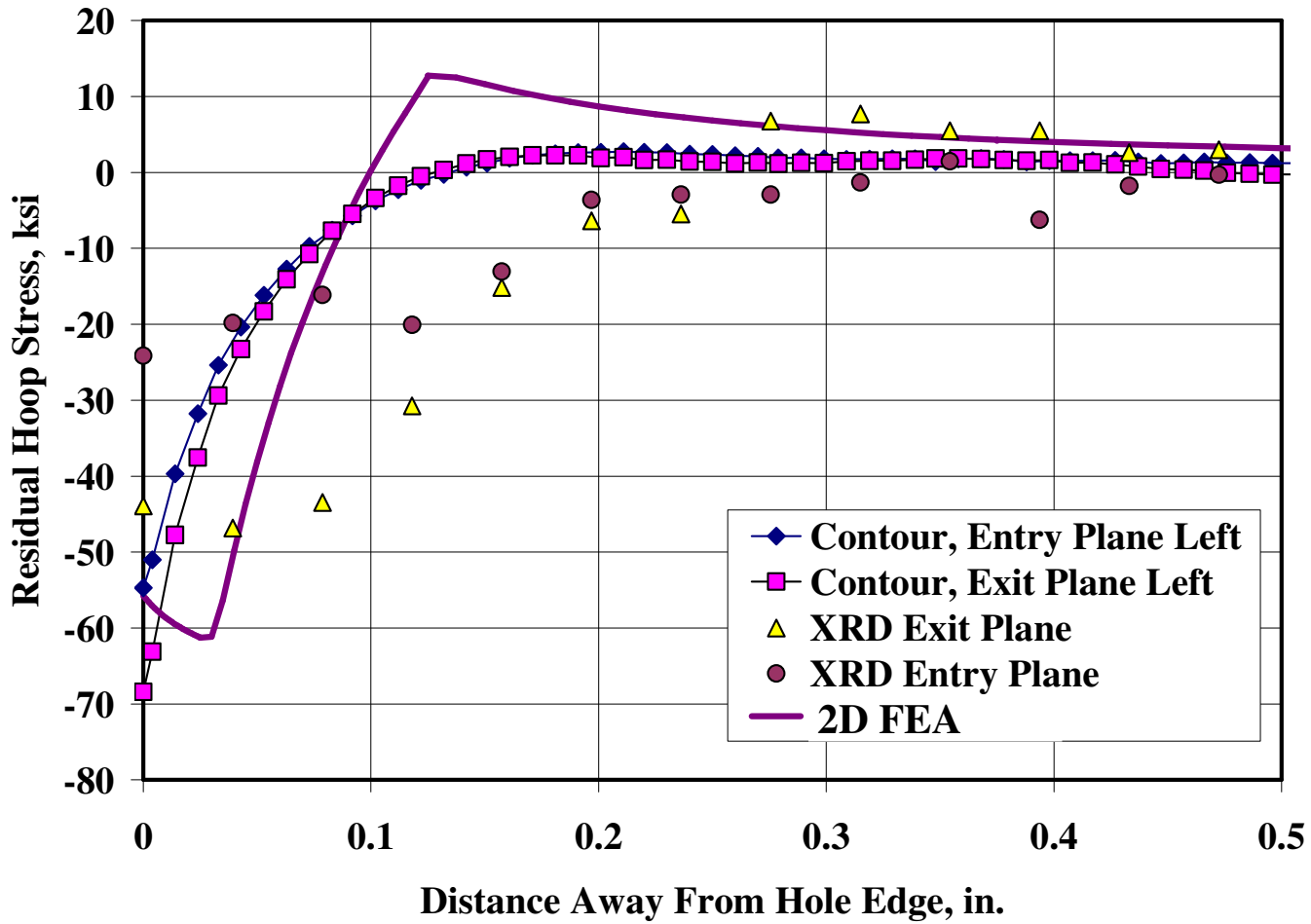
Crack Propagation through a Complex Cold Work R/S Field



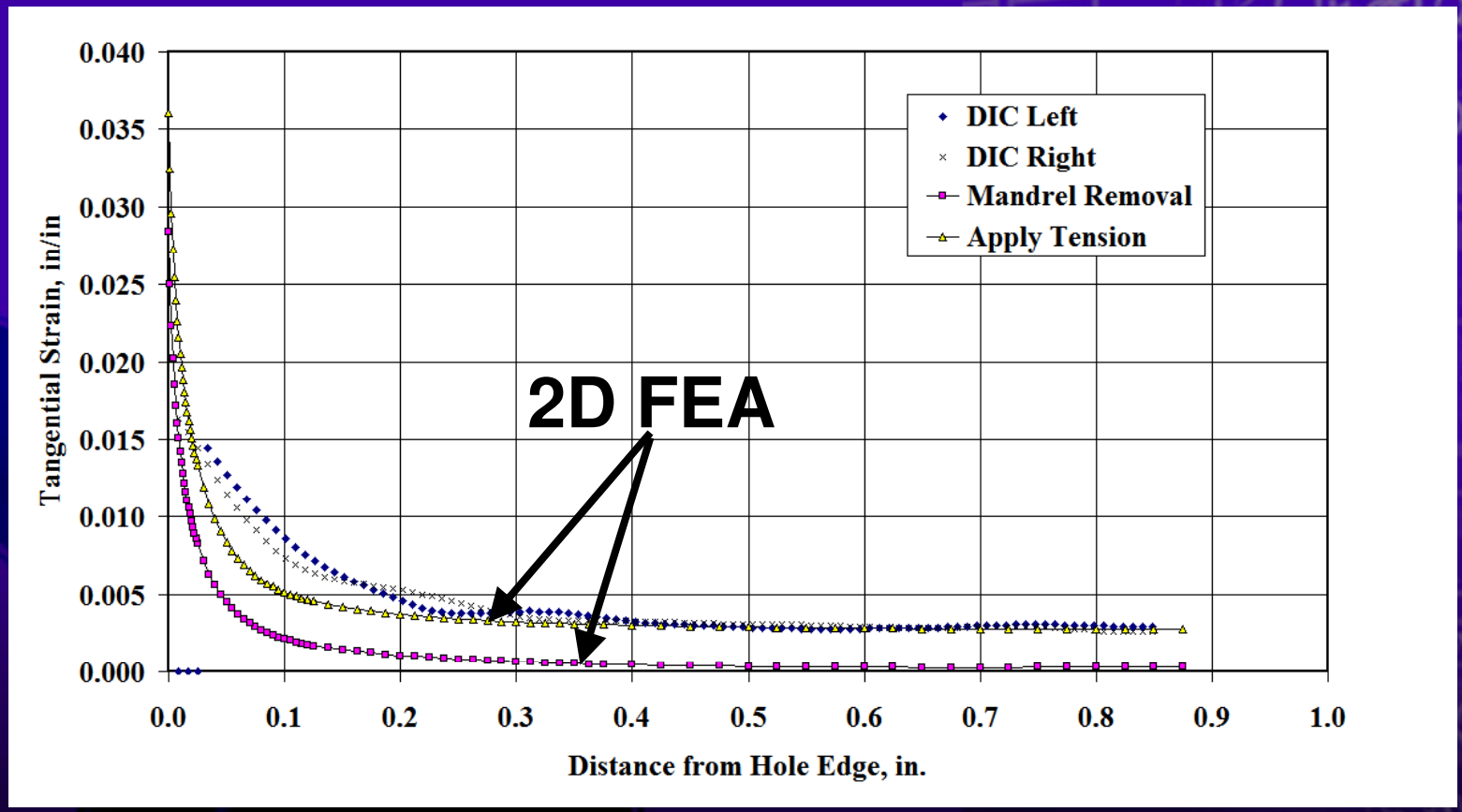
Crack Growth is predominantly below surface

Of course DIC can't see what's happening below surface

Residual Stress Measurements

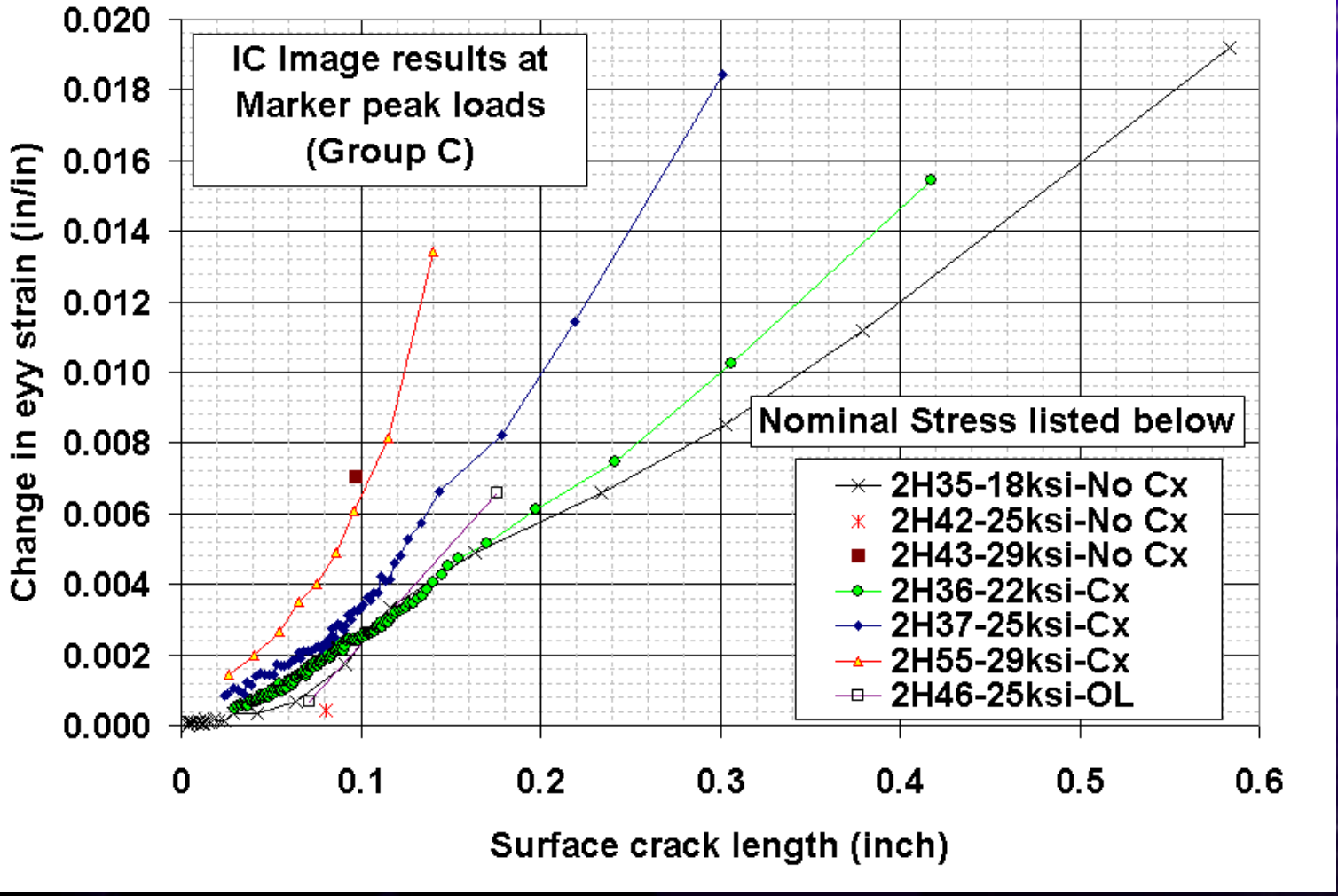


Validation with Open Hole, Cold Worked



Applied stress 27.5 ksi

Strain Changes Due to Crack Length

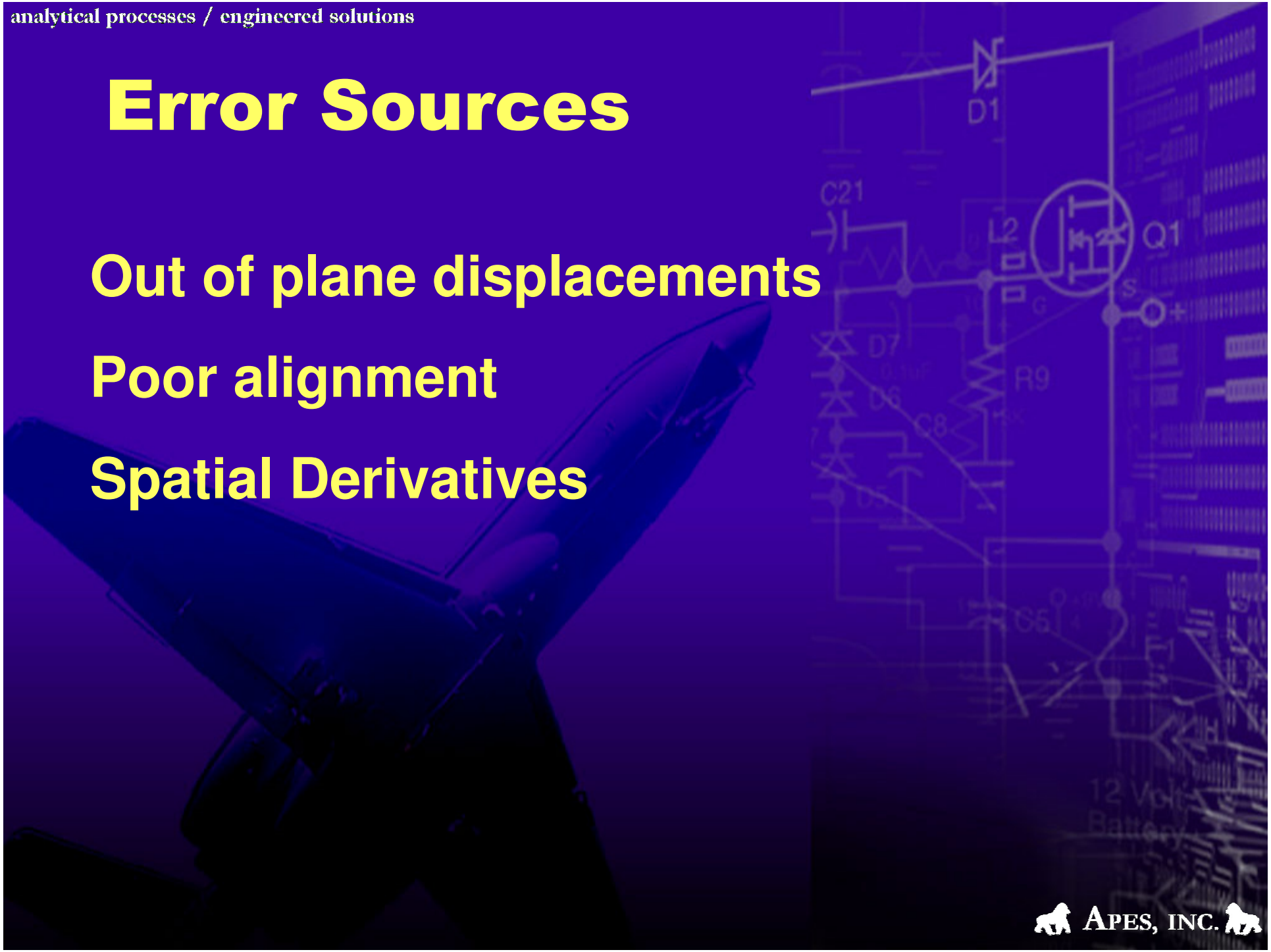


Error Sources

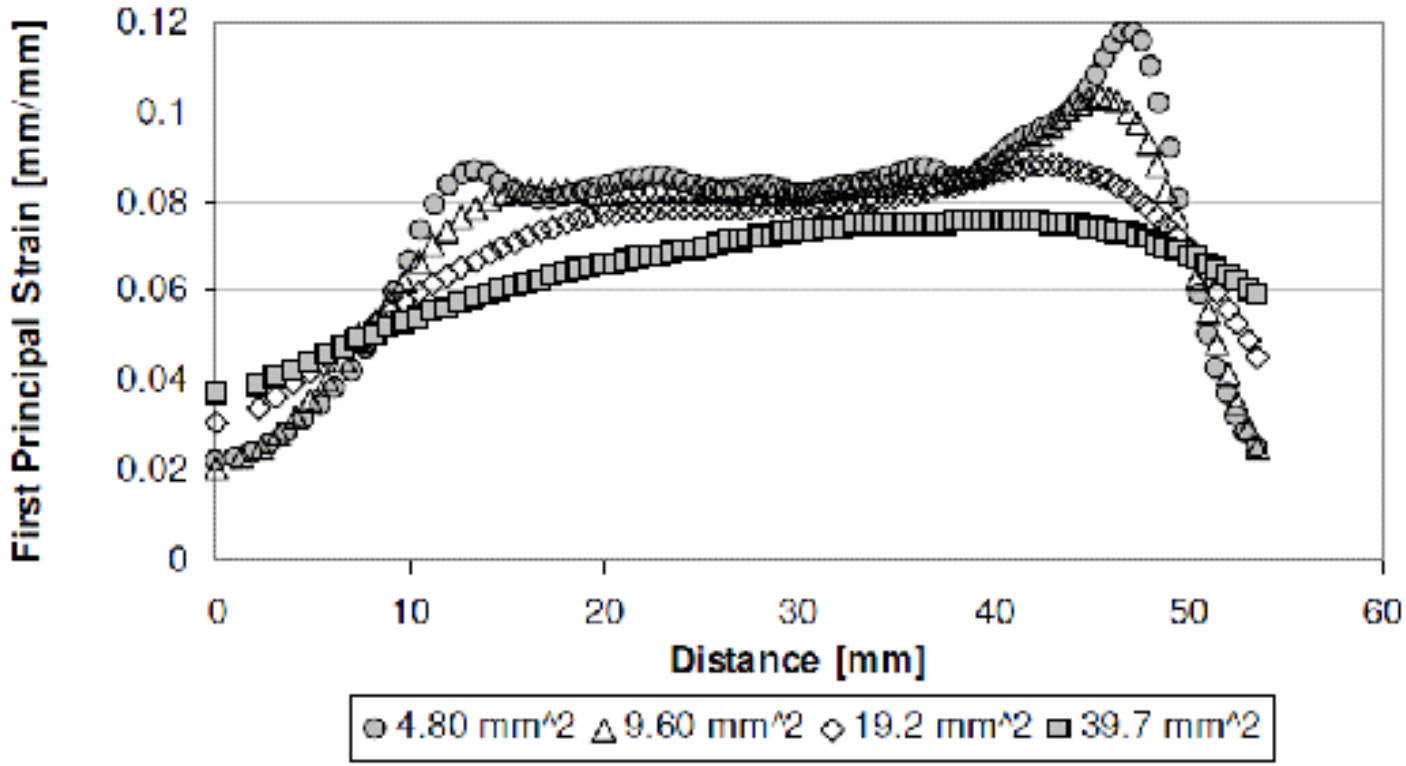
Out of plane displacements

Poor alignment

Spatial Derivatives



Smaller filter==more squiggles!!



Tips for Better Results

- Optimize distance from camera to speckled surface
- Fixed focal length lens
- Black paint on white or shiny surfaces (NRCC disagrees!)
- Maximize CCD field of view
- Wide variation in speckle size better than uniform distribution in space and size

Conclusions

- Digital image correlation (DIC) can be powerful tool for measuring surface strains
- Many potential error sources; worth the time to optimize for your lab