

Blade-Motion Comparisons

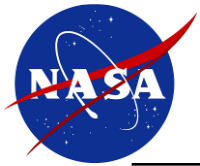
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UH-60A Airloads Workshop, University of Maryland

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Outline

- Motivation / Methodology
- Standard data comparisons - integrated rotor loads, sectional loads, pressures
- Deflections
- Concluding remarks



Motivation

- Increase confidence in both simulation and measurement via detailed comparisons of a hierarchy of data
 - Rotor loads/moments
 - Sectional loads/moments
 - Blade pressures and displacements
- Integrated loads can mask errors/differences
- Have previously looked at pressure distributions:
ALW Aug 2011 (flight test), ALW Feb 2012 (NFAC)
- Now look at blade displacement data from NFAC - unique information from NFAC, not available from flight test

Increasing detail
↓



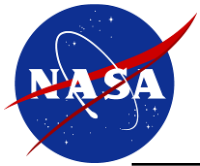
Blade Displacement Data

- Blade displacement data obtained from multi-camera photogrammetry
 - 48 targets distributed on blade lower surface, $r/R = 0.2$ to $r/R = 0.97$ at ~ 0.05 r/R increments
 - Complex processing of photo data results in pitch, flap, lead-lag and elastic deformations
 - Thanks to Al Burner for providing latest blade displacement data
 - Data processing is preliminary; subject to refinement
- At blade root, two alternate systems provide displacements: crab-arm system and laser system



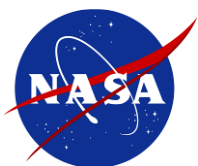
Results

- Run 42, Points 60-63
 - CFD/CSD simulations used average of conditions of nearly identical Points 60-63
 - $C_T/\sigma = 0.1$, $M_T = 0.649$, Adv. Ratio = 0.3
- Results obtained with FUN3D/CAMRAD for isolated rotor, 15M node mesh, 1° per time step, standard SA turb. model
- Comparisons with data
 - Integrated rotor loads
 - Sectional forces/moment
 - Pressure distributions
 - **Blade displacements**



Integrated Rotor Loads

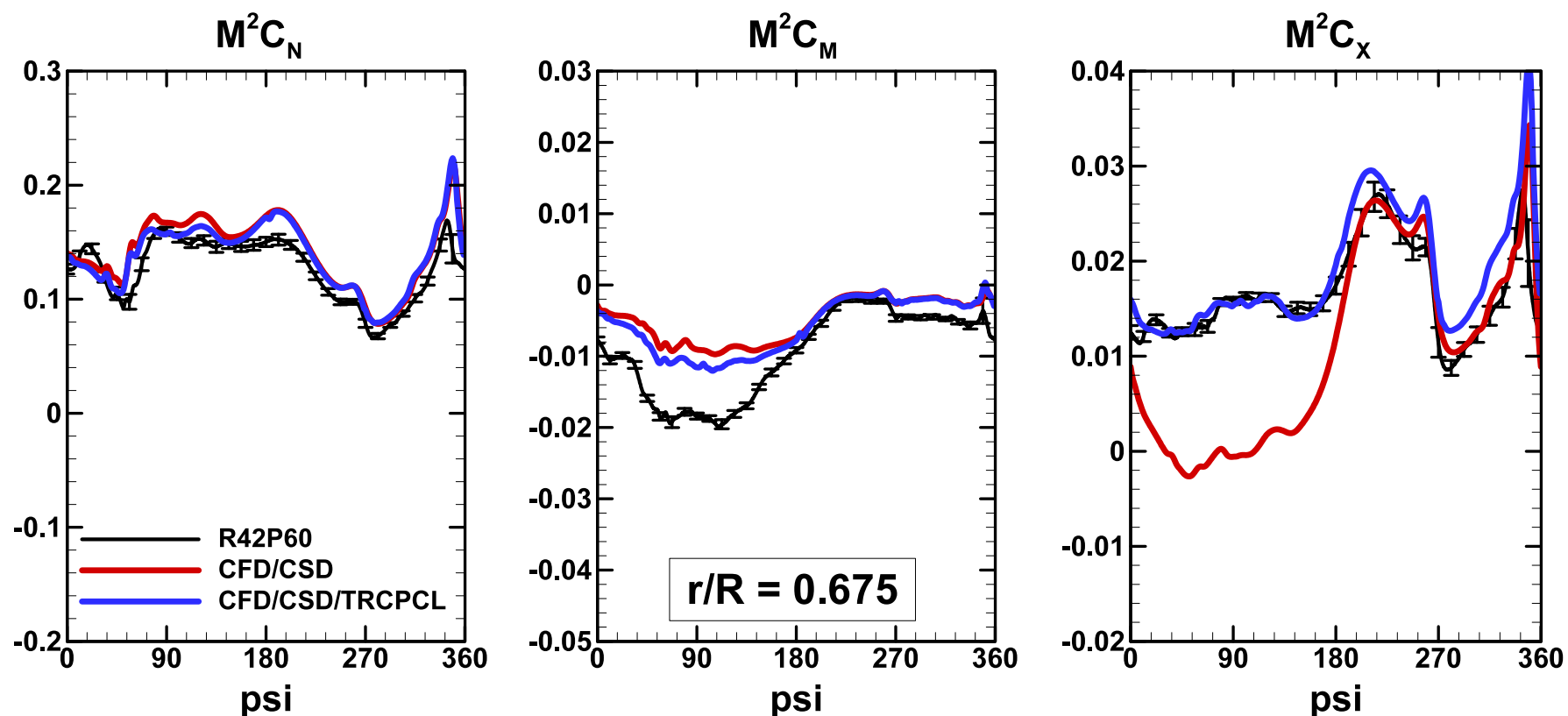
Quantity	NFAC	CFD/CSD	% Error
C_T / Sigma	0.10014	0.10048	0.3
C_Q / Sigma	0.00384	0.00376	2.1
C_x / Sigma	- 0.00222	- 0.00217	2.3

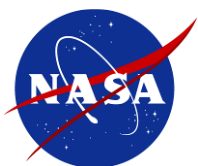


Sectional Airloads - $r/R = 0.675$

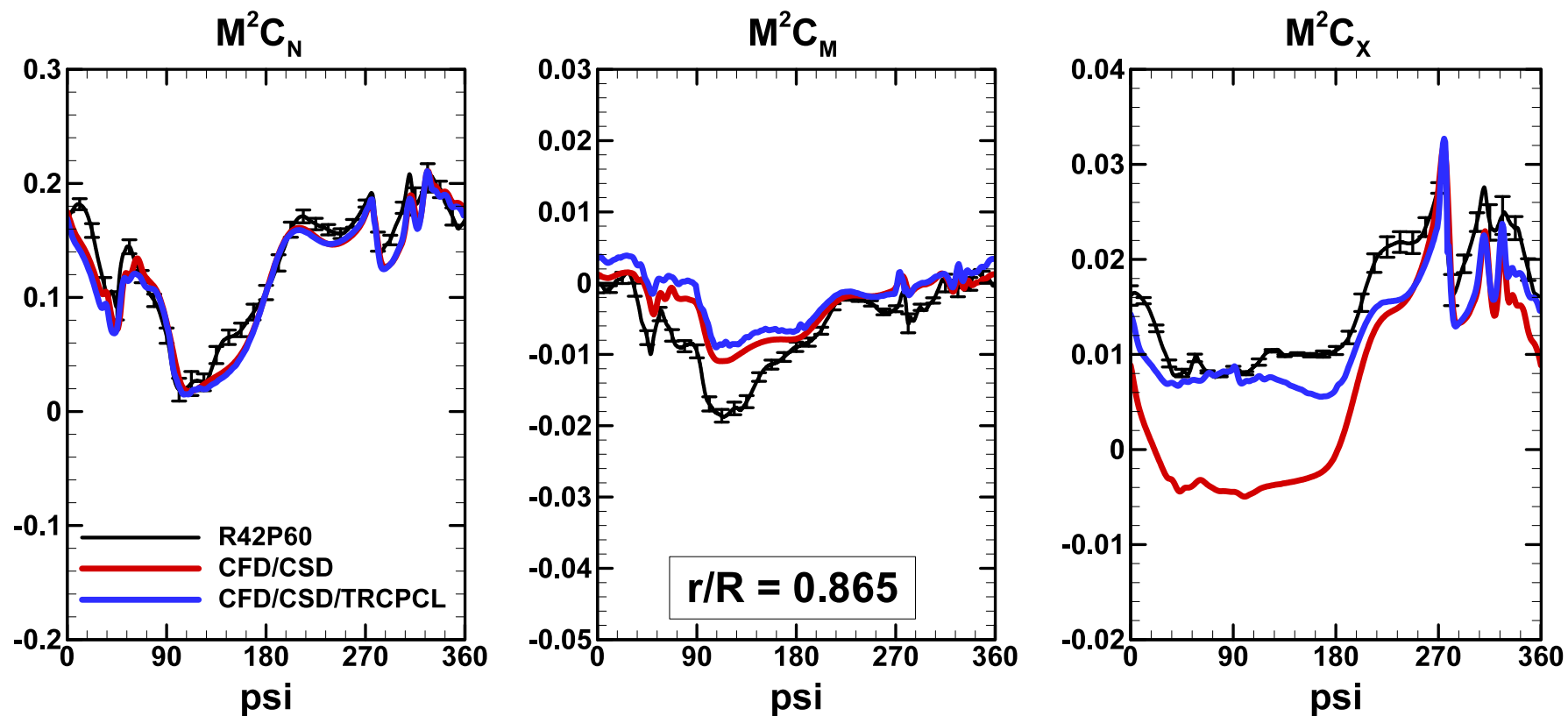
“CFD/CSD” - Standard CFD process using all grid points as appropriate;
includes skin friction

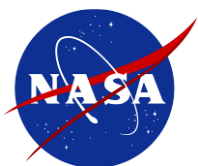
“CFD/CSD/TRCPCL” - Integration using only press. at exp. port locations;
processed using same procedure as exp. data



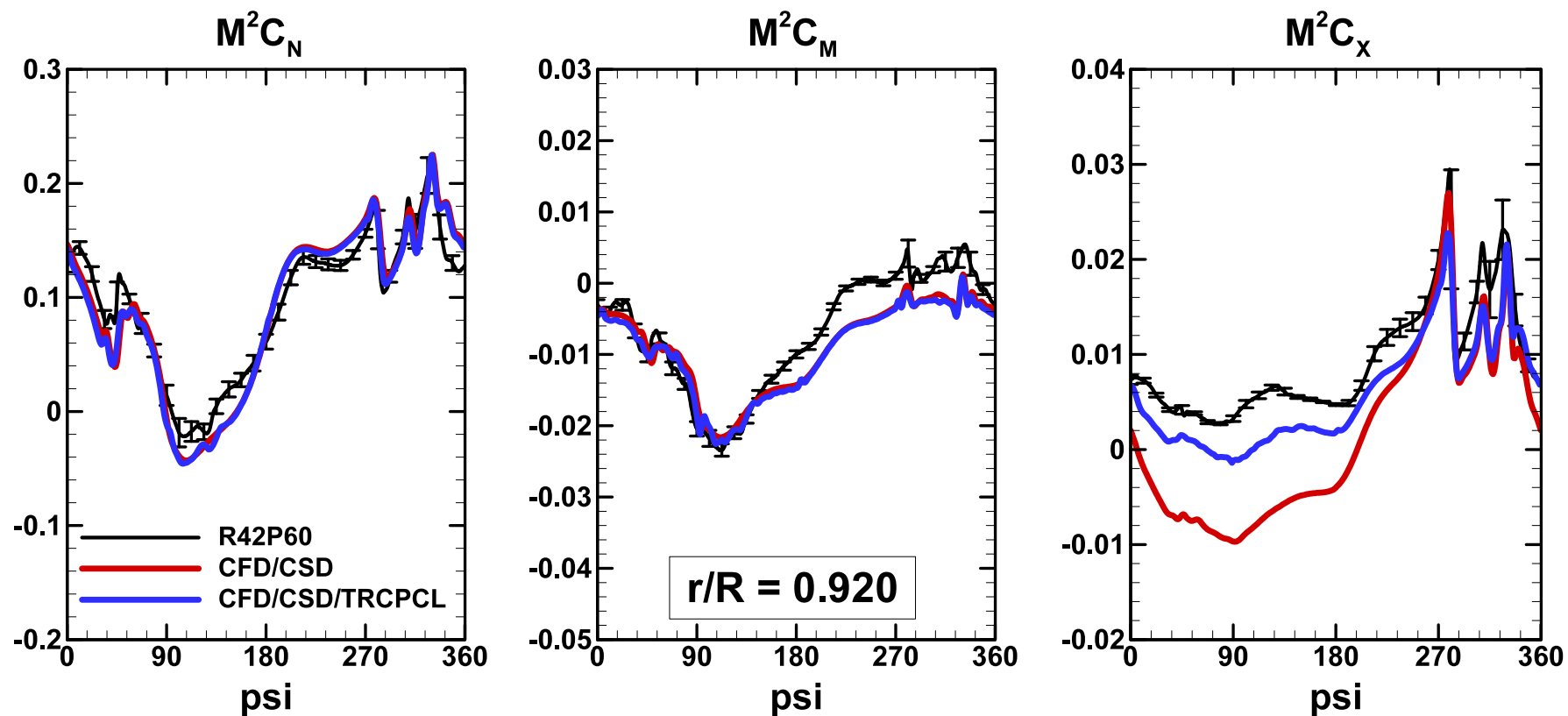


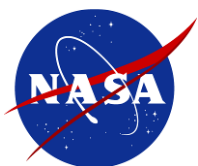
Sectional Airloads - $r/R = 0.865$



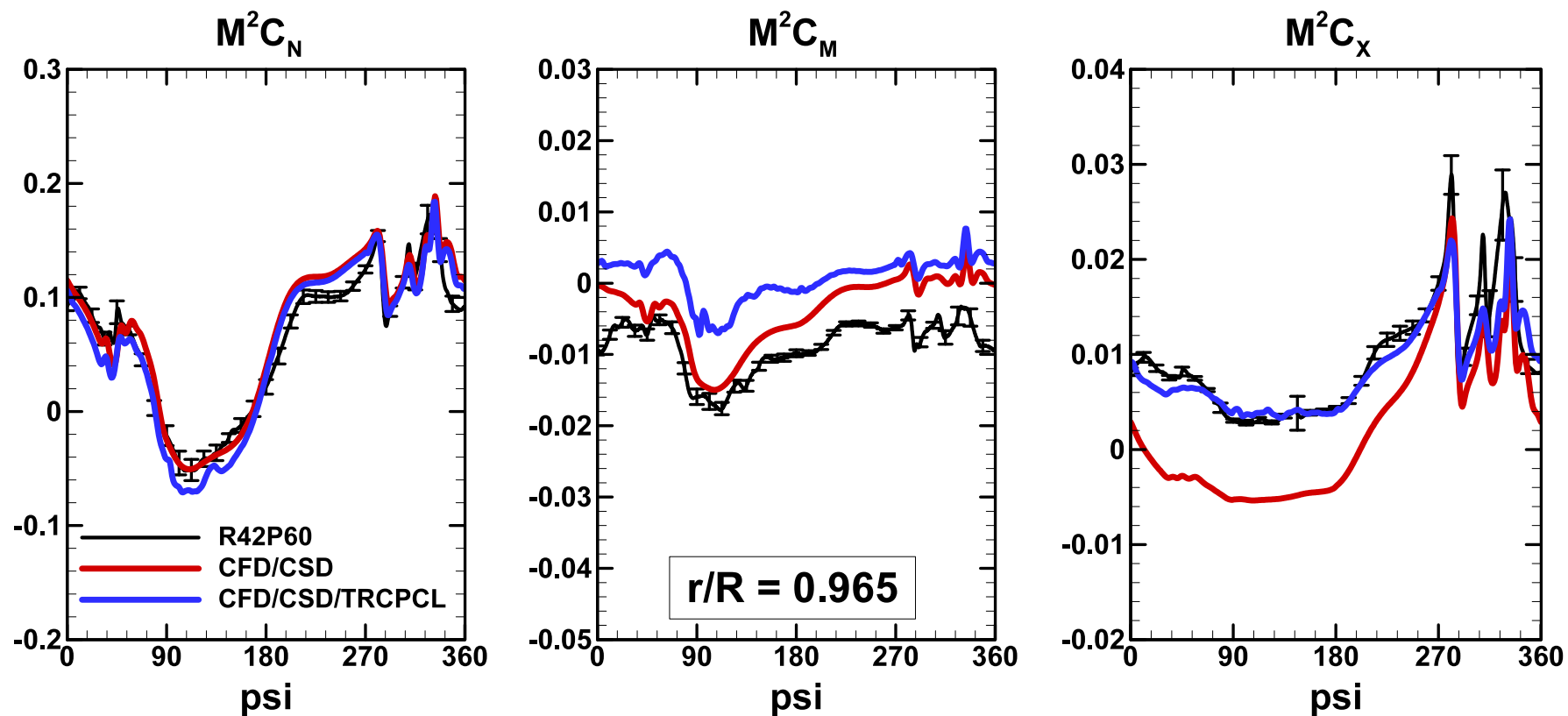


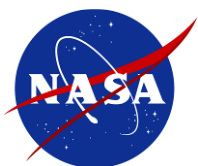
Sectional Airloads - $r/R = 0.920$



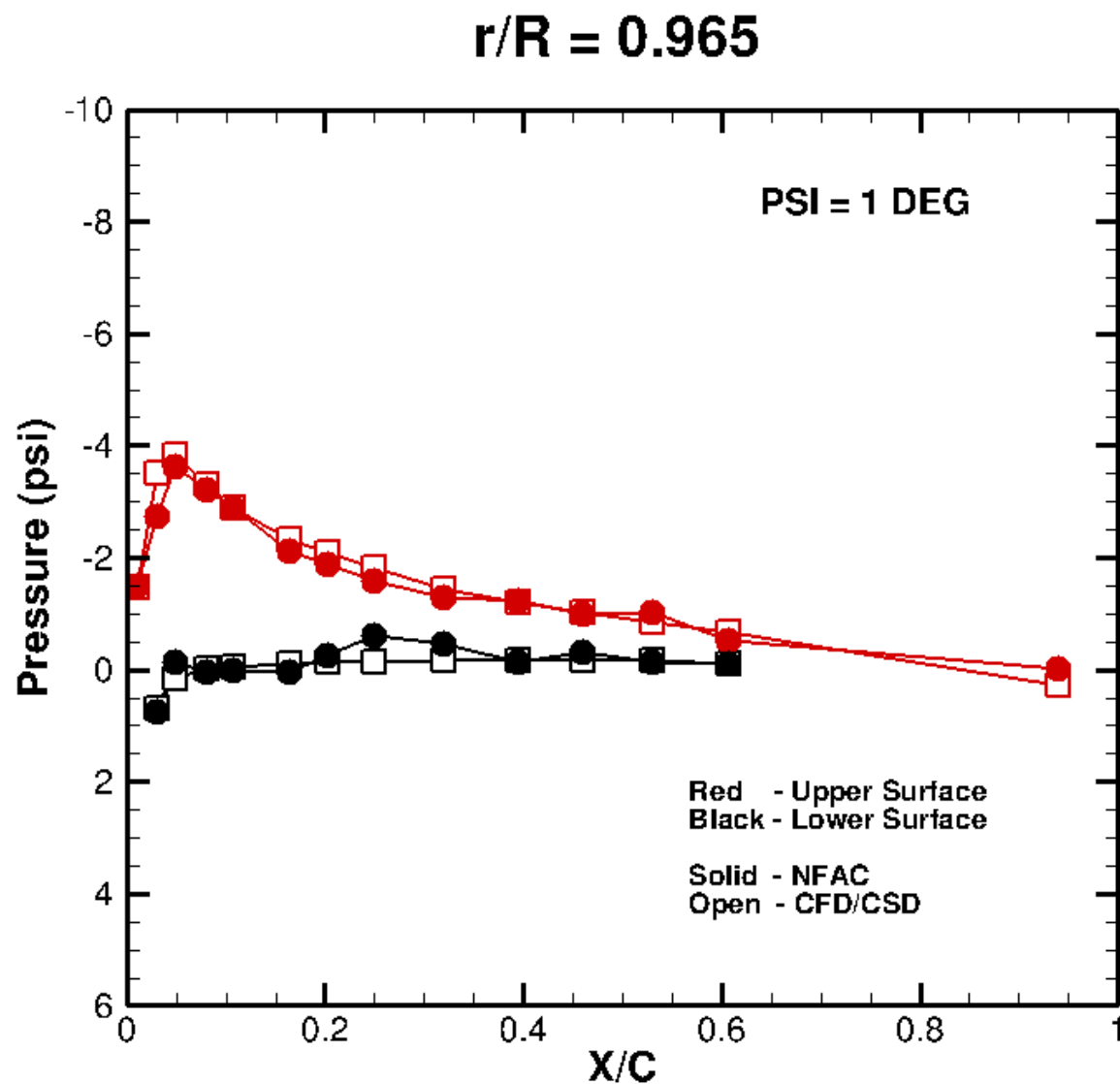


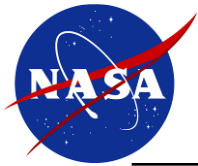
Sectional Airloads - $r/R = 0.965$





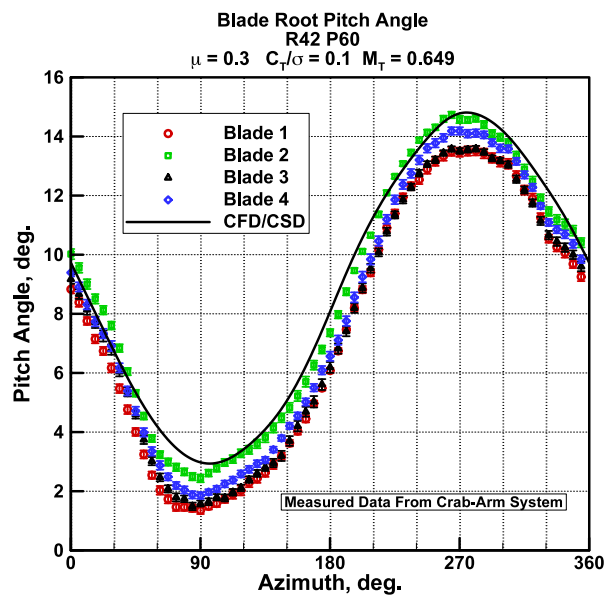
Pressure Distributions - $r/R = 0.965$



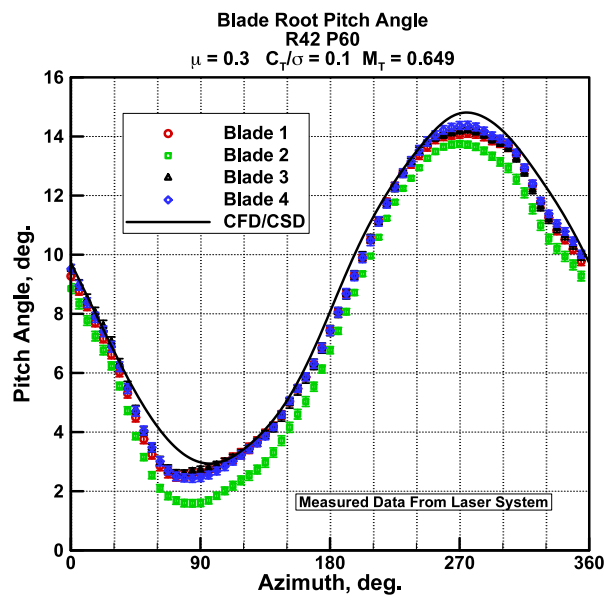


Root Pitch Angle

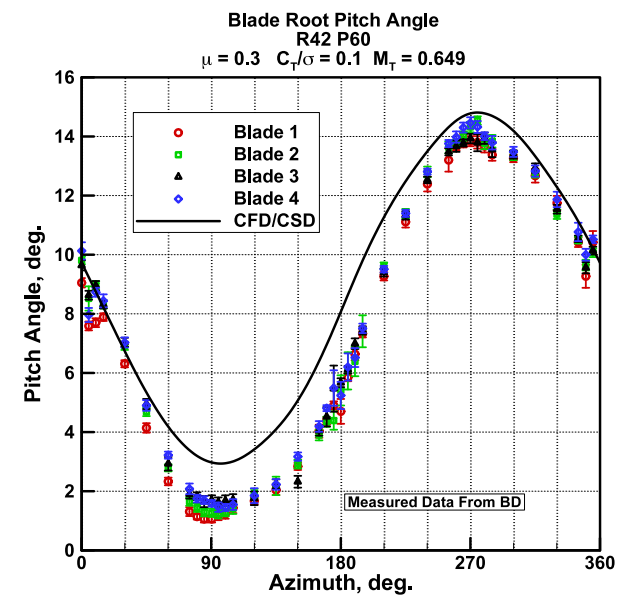
Crab-Arm System



Laser System



Blade-Displacement System



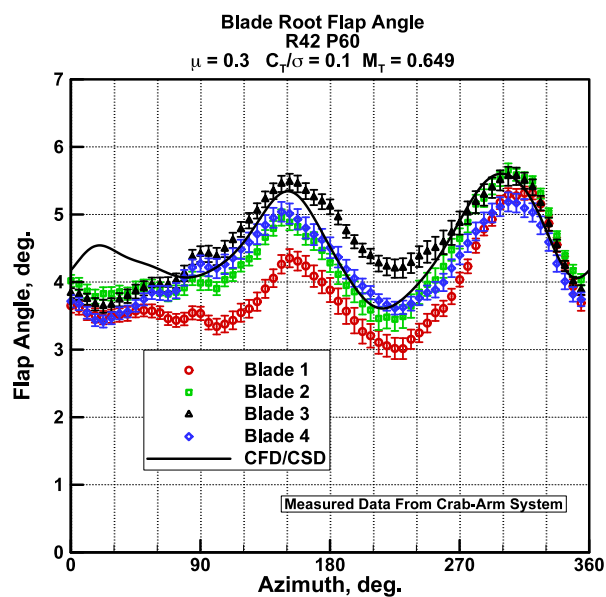
Data: every 5th point shown

Data: all points shown

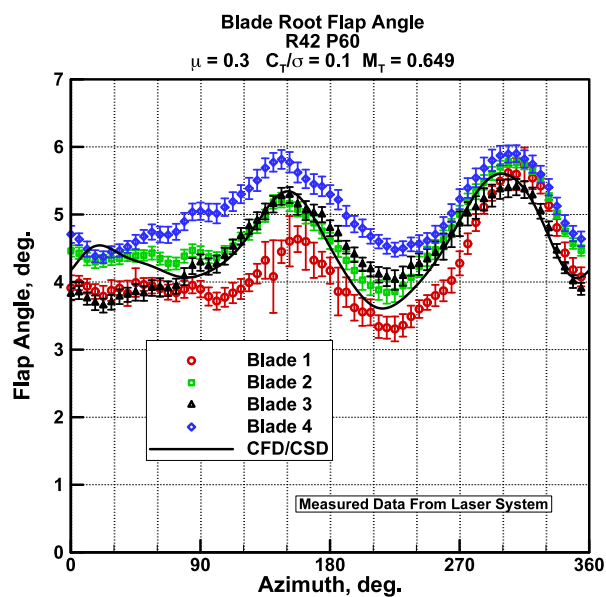


Root Flap Angle

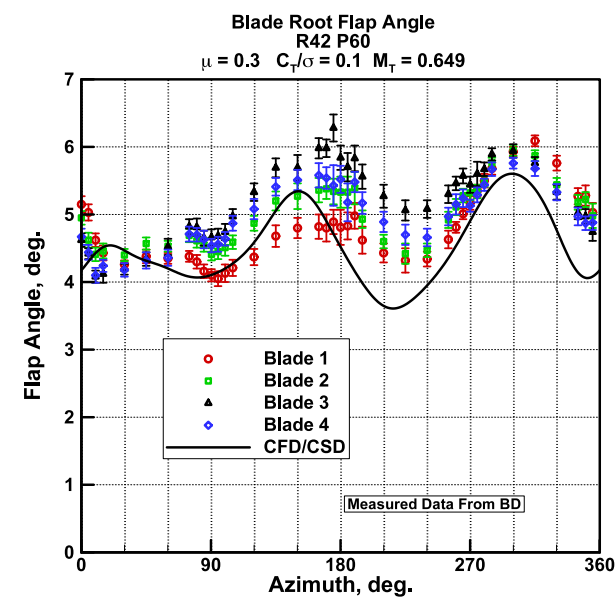
Crab-Arm System



Laser System

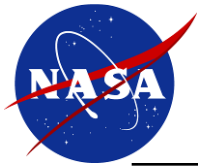


Blade-Displacement System



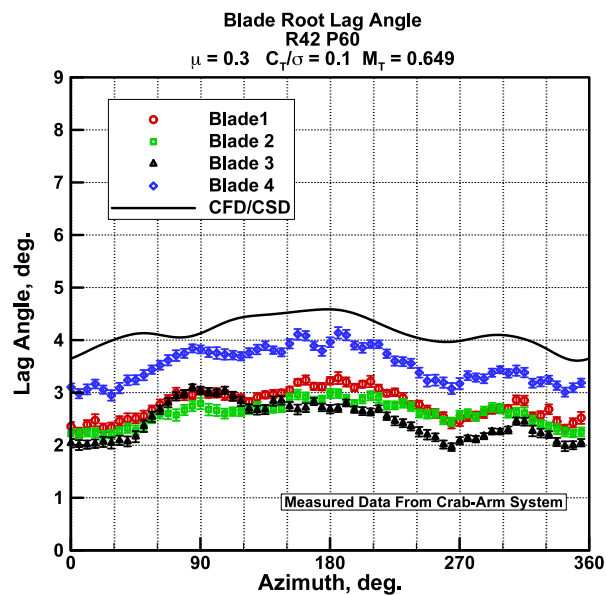
Data: every 5th point shown

Data: all points shown



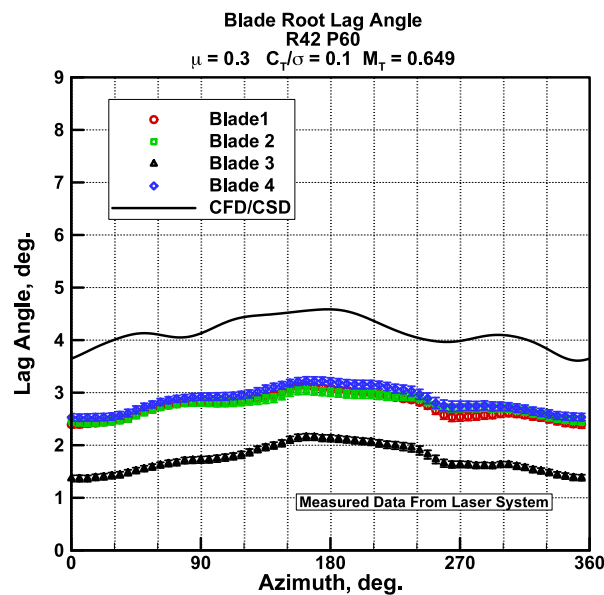
Root Lag Angle

Crab-Arm System

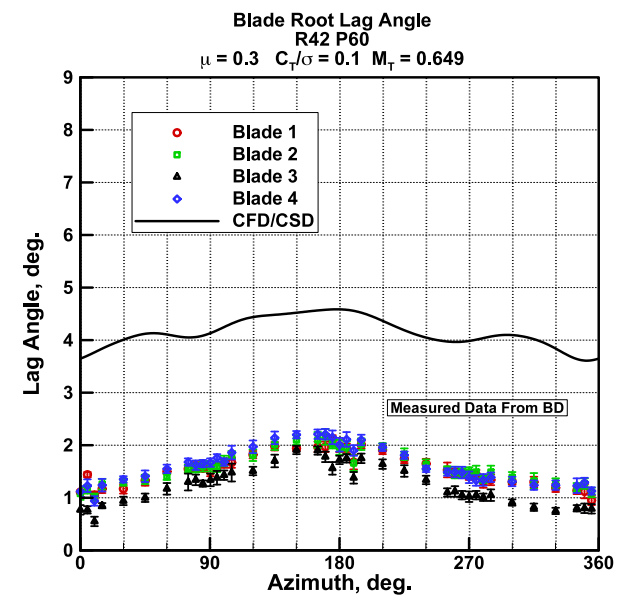


Data: every 5th point shown

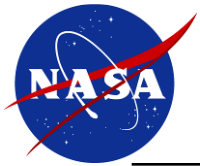
Laser System



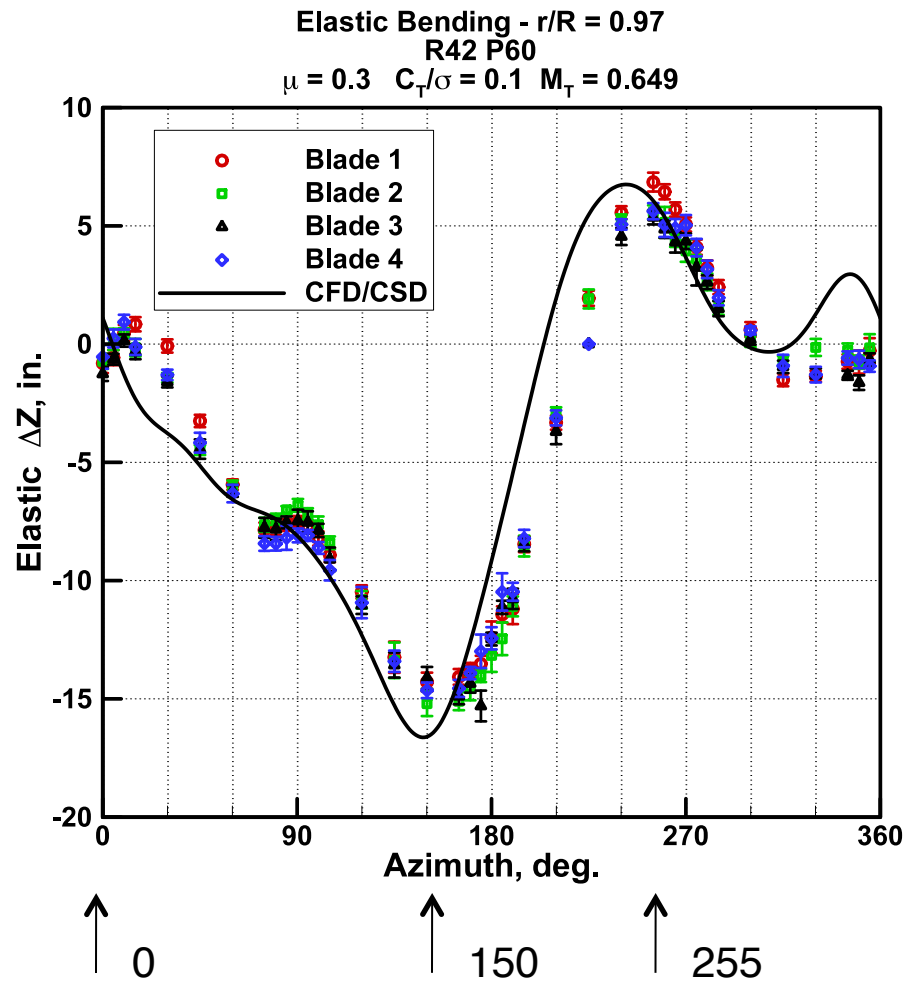
Blade-Displacement System



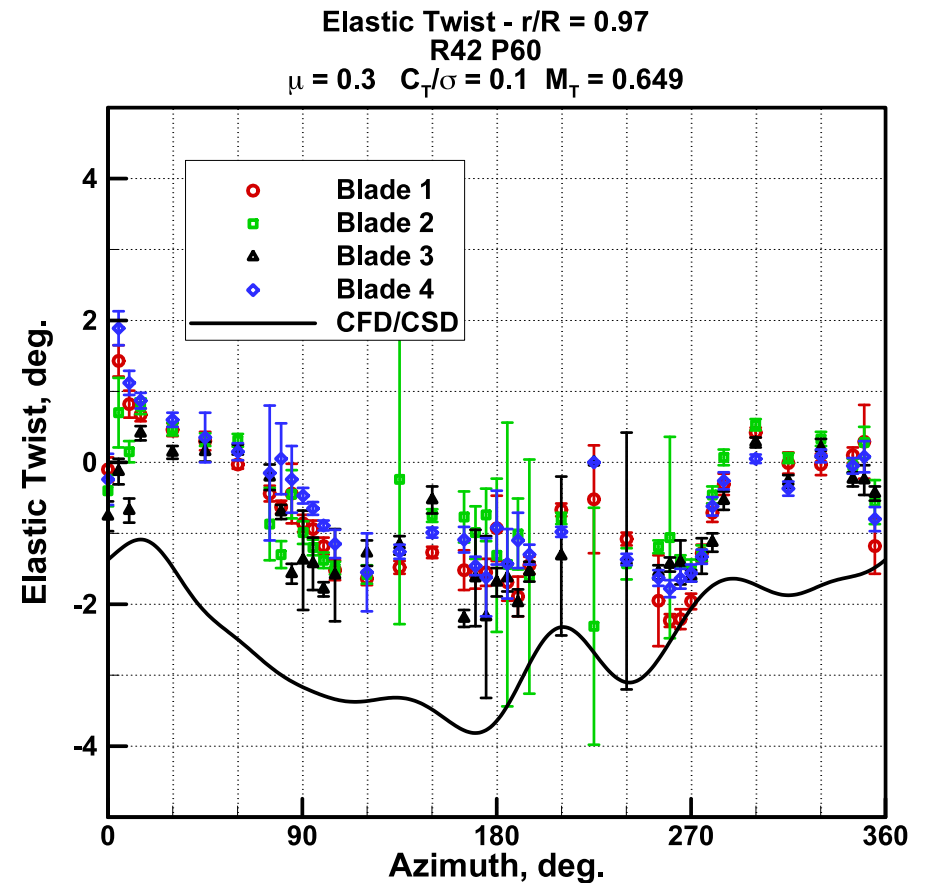
Data: all points shown

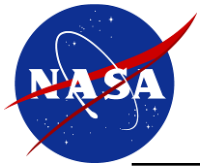


Tip ($r/R = 0.97$) Elastic Deflections



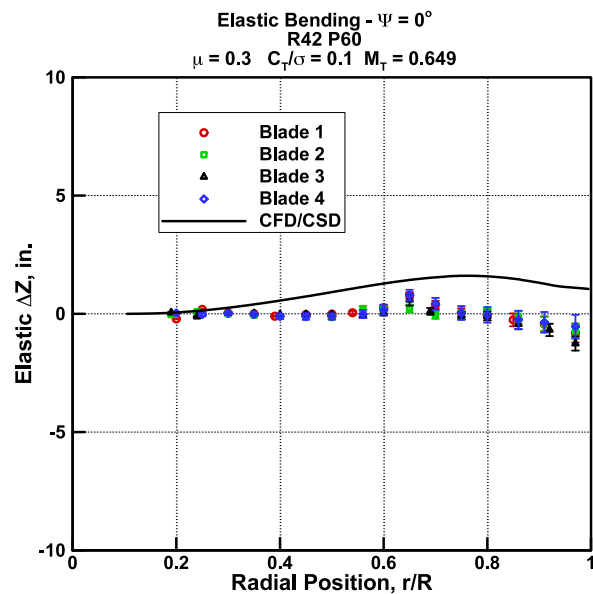
examine radial distributions at these azimuths



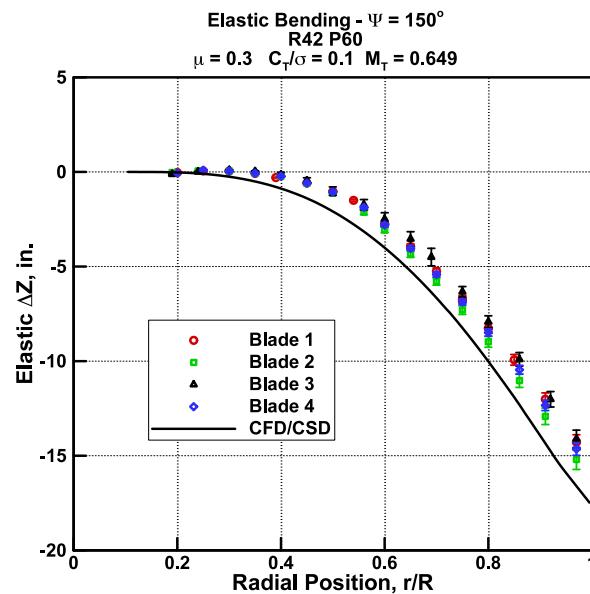


Radial Variation of Elastic Bending

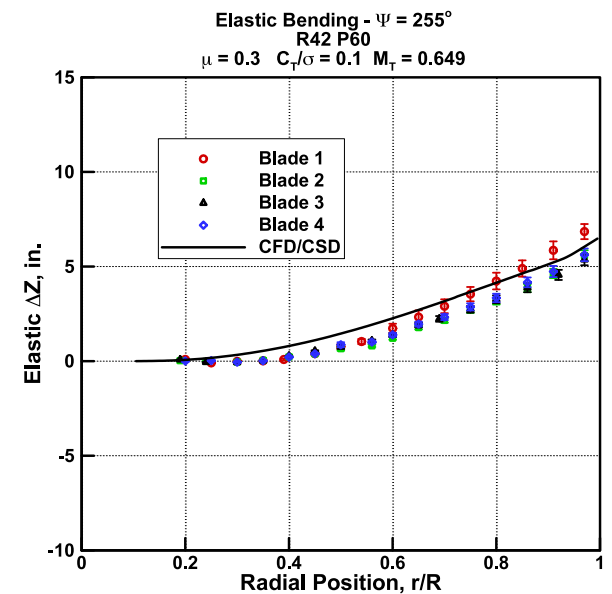
Psi = 0 deg.

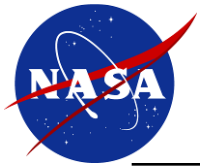


Psi = 150 deg.



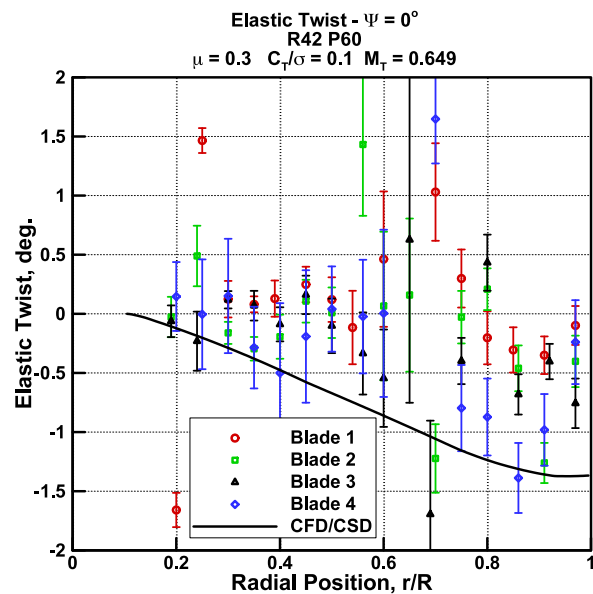
Psi = 255 deg.



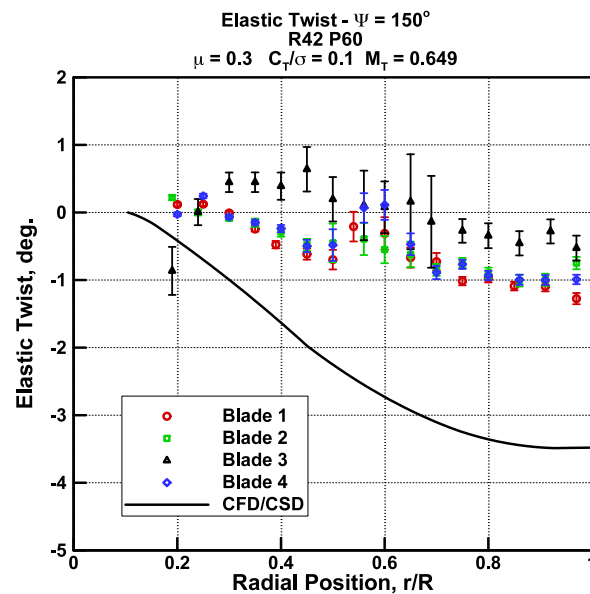


Radial Variation of Elastic Twist

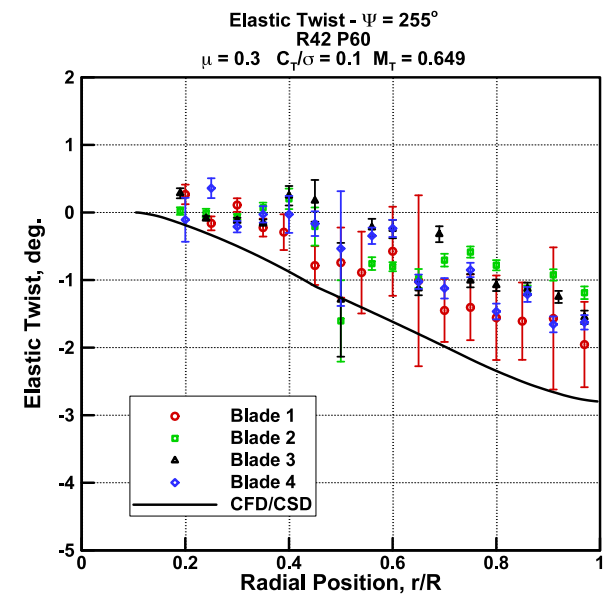
Psi = 0 deg.



Psi = 150 deg.

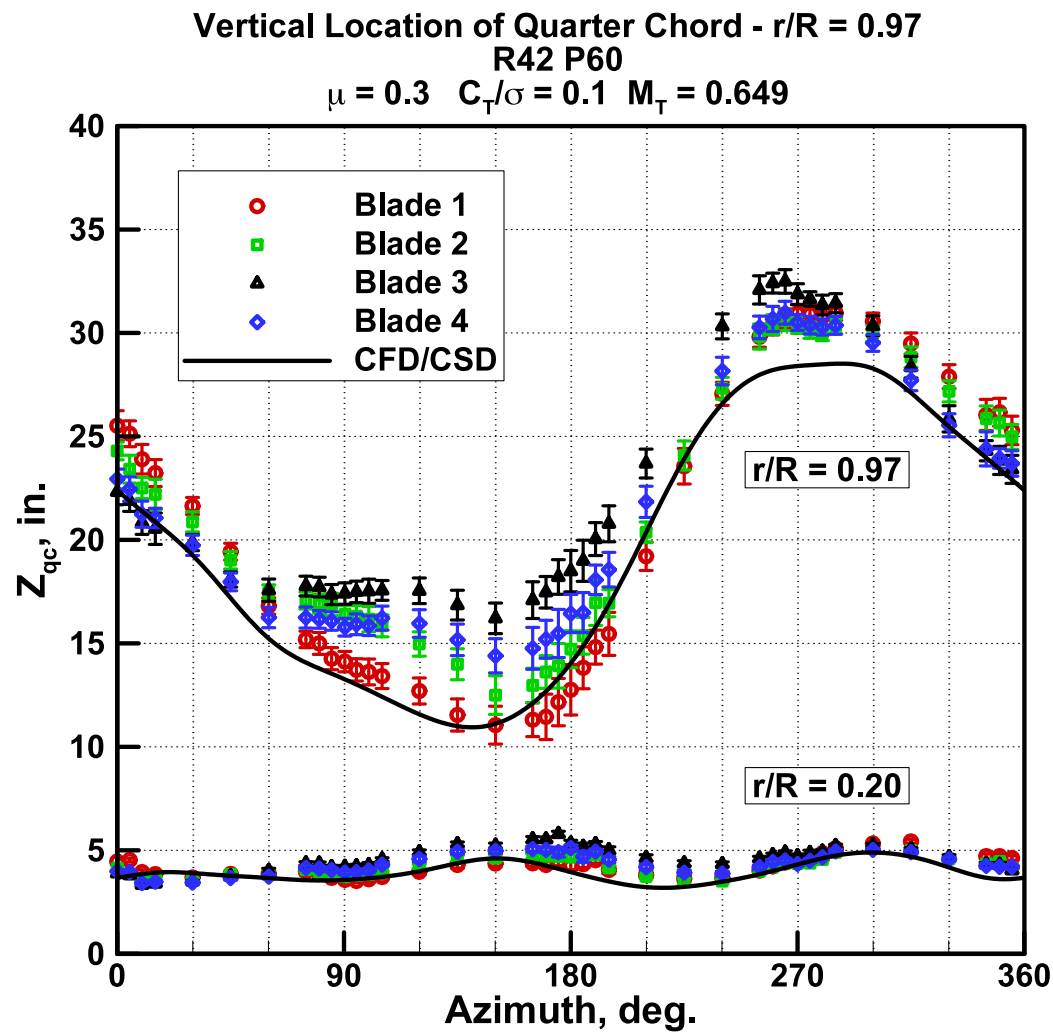


Psi = 255 deg.





Vertical Location of Quarter Chord





Concluding Remarks

- Performed initial examination of blade deflections computed using coupled FUN3D/CAMRAD
- Computed and measured performance data, sectional airloads, and pressure distributions show similar level of agreement as other NFAC and flight conditions
- Displacements
 - Root motions: crab and laser are closer together than BD, *trends* between all three systems agree with each other, and reasonably well with computation
 - Typically elastic bending shows better agreement between comp. and exp. than elastic twist
 - Large amount of scatter in current rendering of elastic twist measured with the BD system



Concluding Remarks (cont.)

- Lag shows 1-2 degree offset between computation and measurement
- BD data sensitive to root treatment
- Computed displacements very similar to those reported by Ethan Romander using OVERFLOW/CAMRAD (comparisons with earlier processing of measured data)