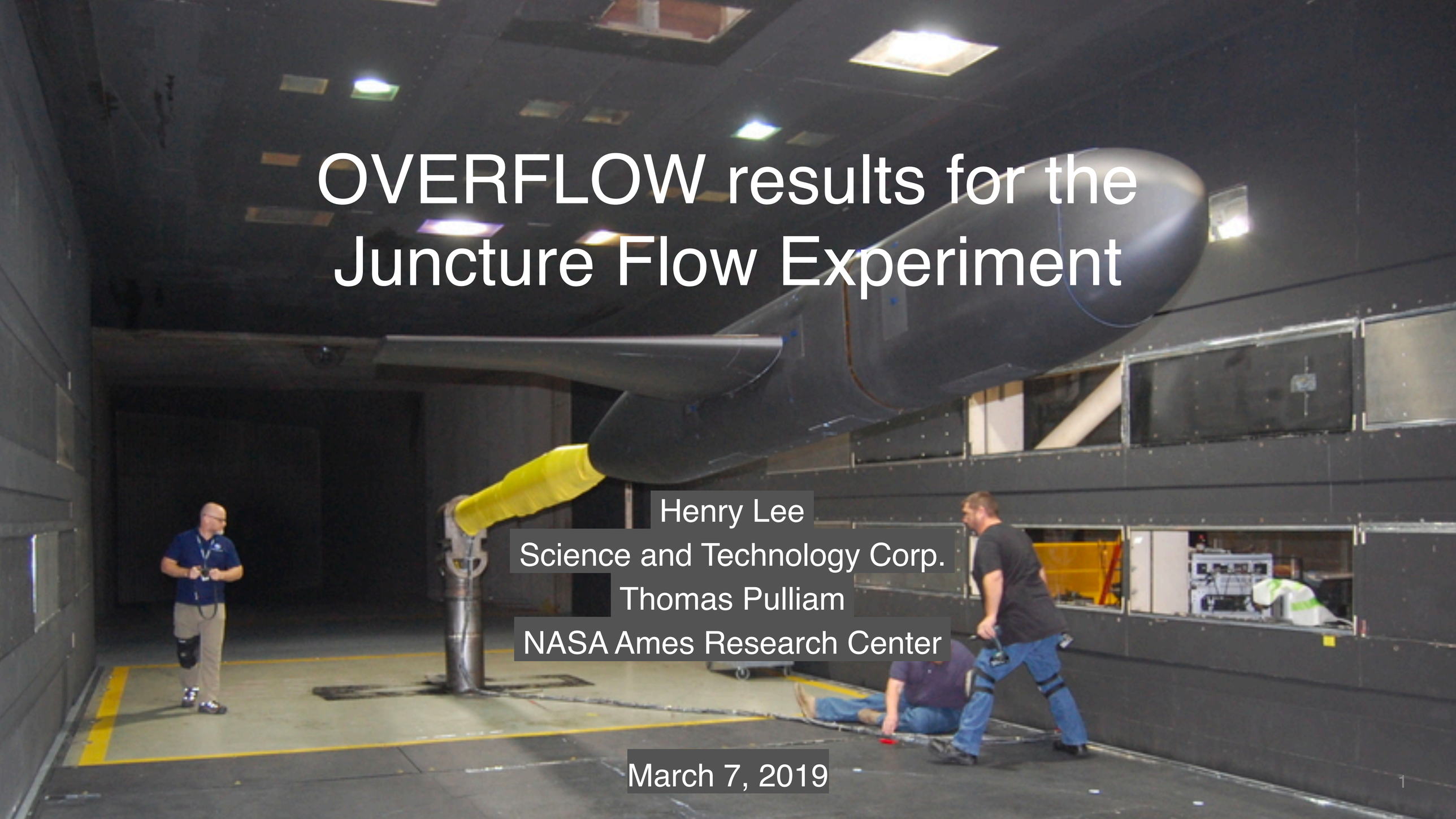


OVERFLOW results for the Juncture Flow Experiment

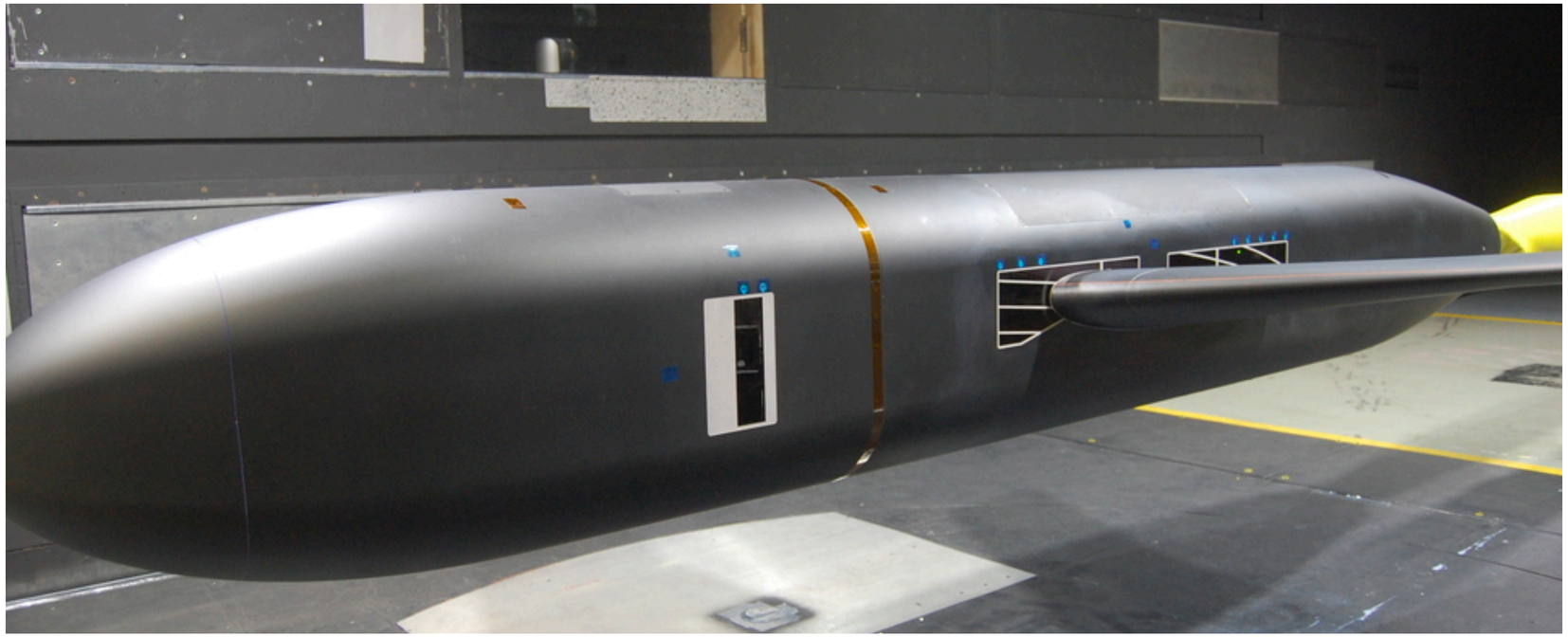
Henry Lee
Science and Technology Corp.
Thomas Pulliam
NASA Ames Research Center

March 7, 2019

Juncture Flow Experiment

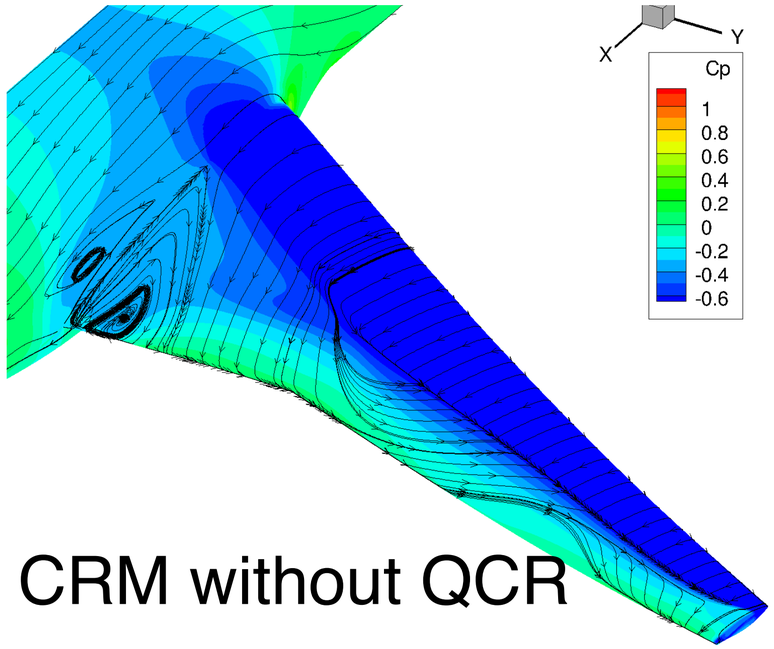
Sponsored by NASA's Transformative Aeronautics Concepts Program's Transformational Tools and Technologies (T^3) project

- Substantial effort to investigate the origin of separation bubbles found in wing-body juncture zones
- Primary goal is to gather validation level data, for future CFD code & turbulence model development
- Multi-year effort including several large-scale wind tunnel tests
  - First set of entries just finished: Nov 2017-April 2018
  - Planned Entries in the future

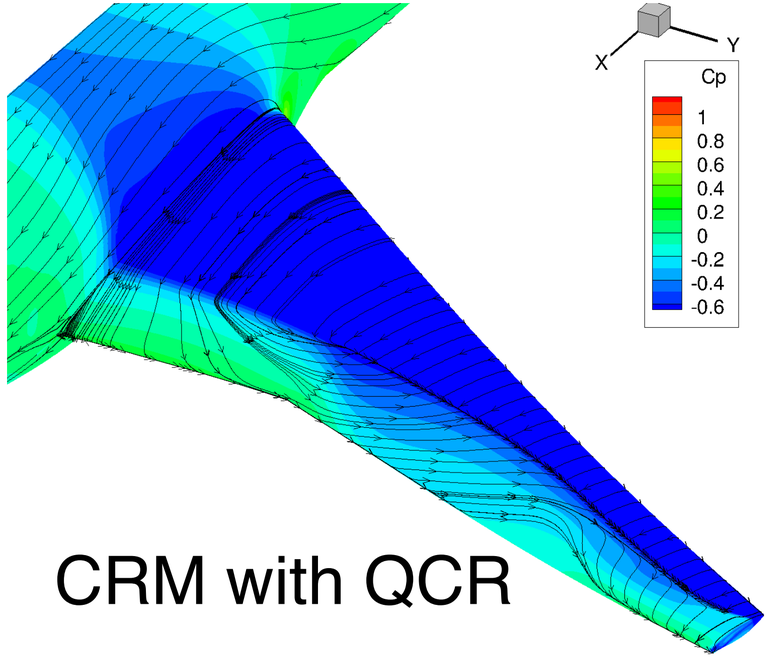


Juncture Flow Experiment Motivation

- Drag prediction workshops
  - Inconsistency between CFD codes
  - Sensitive to Grid Resolution (Air), solution methods, turbulence models
- Quadratic constitutive relation (QCR)
  - Reduced the inconsistency substantially



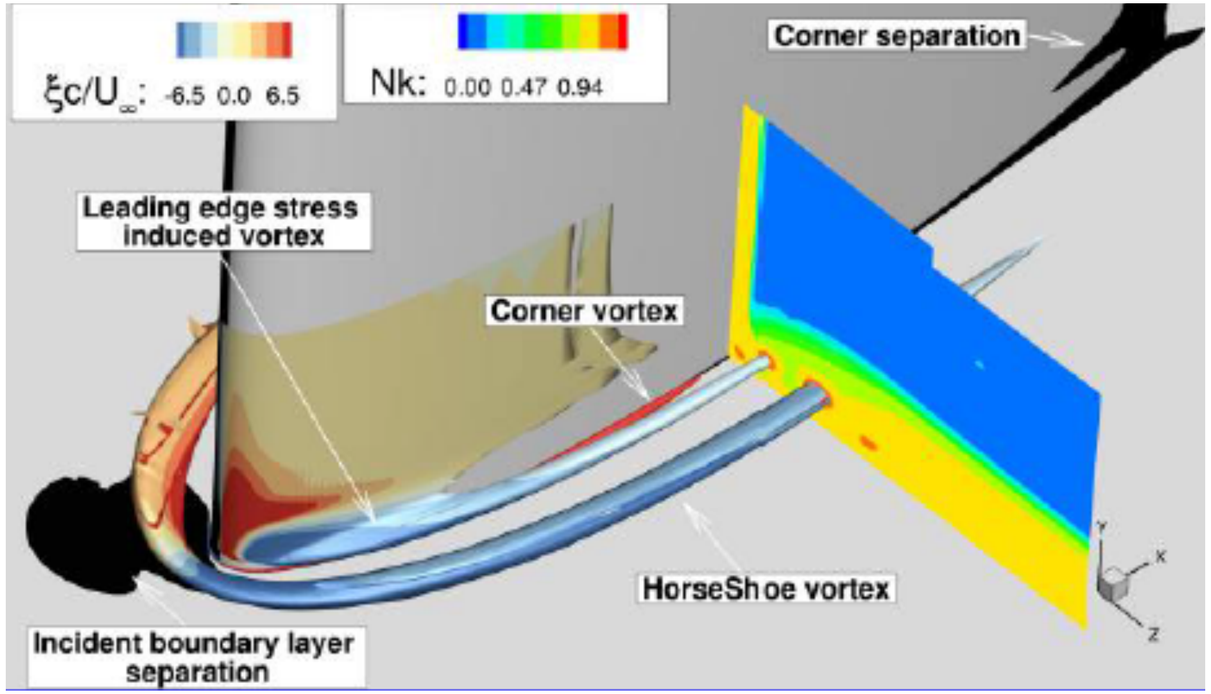
CRM without QCR



CRM with QCR

Juncture Flow Physics

- Flow physics of juncture flows are complex
  - Several vortical structures coexist: e.g., Horseshoe Vortex (HSV), corner vortex, stress-induced vortex
  - Many factors: incoming boundary layer momentum thickness, wing bluntness, and wing sweep, etc



From AIAA-2014-2690 (Bordji et al)

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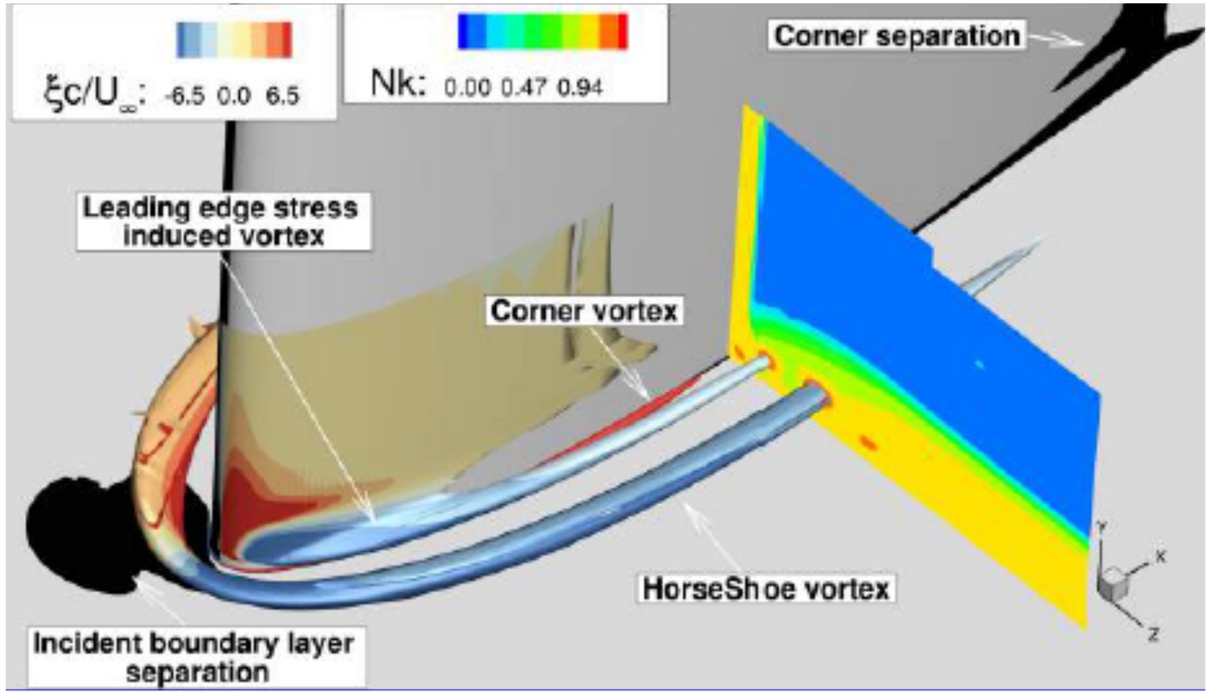
- JFM Experiment:
  - Swept wing / fuselage full-span configuration
  - Collect data for CFD validation
  - Obtain flow field details very near the corner



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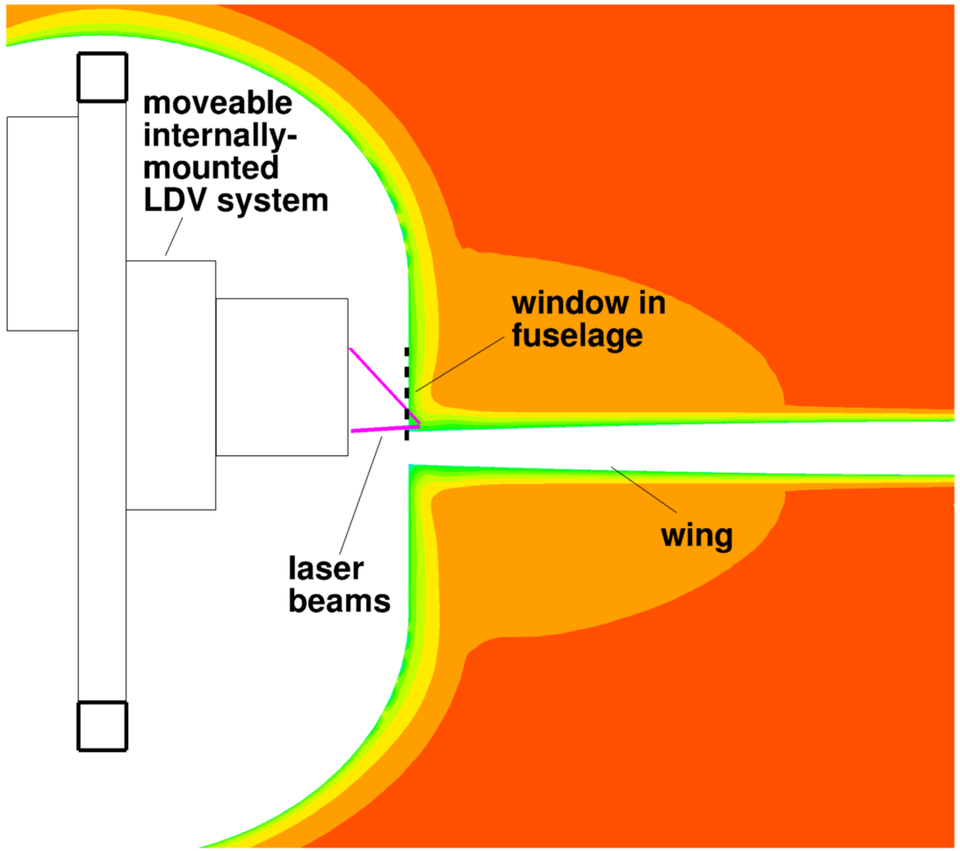
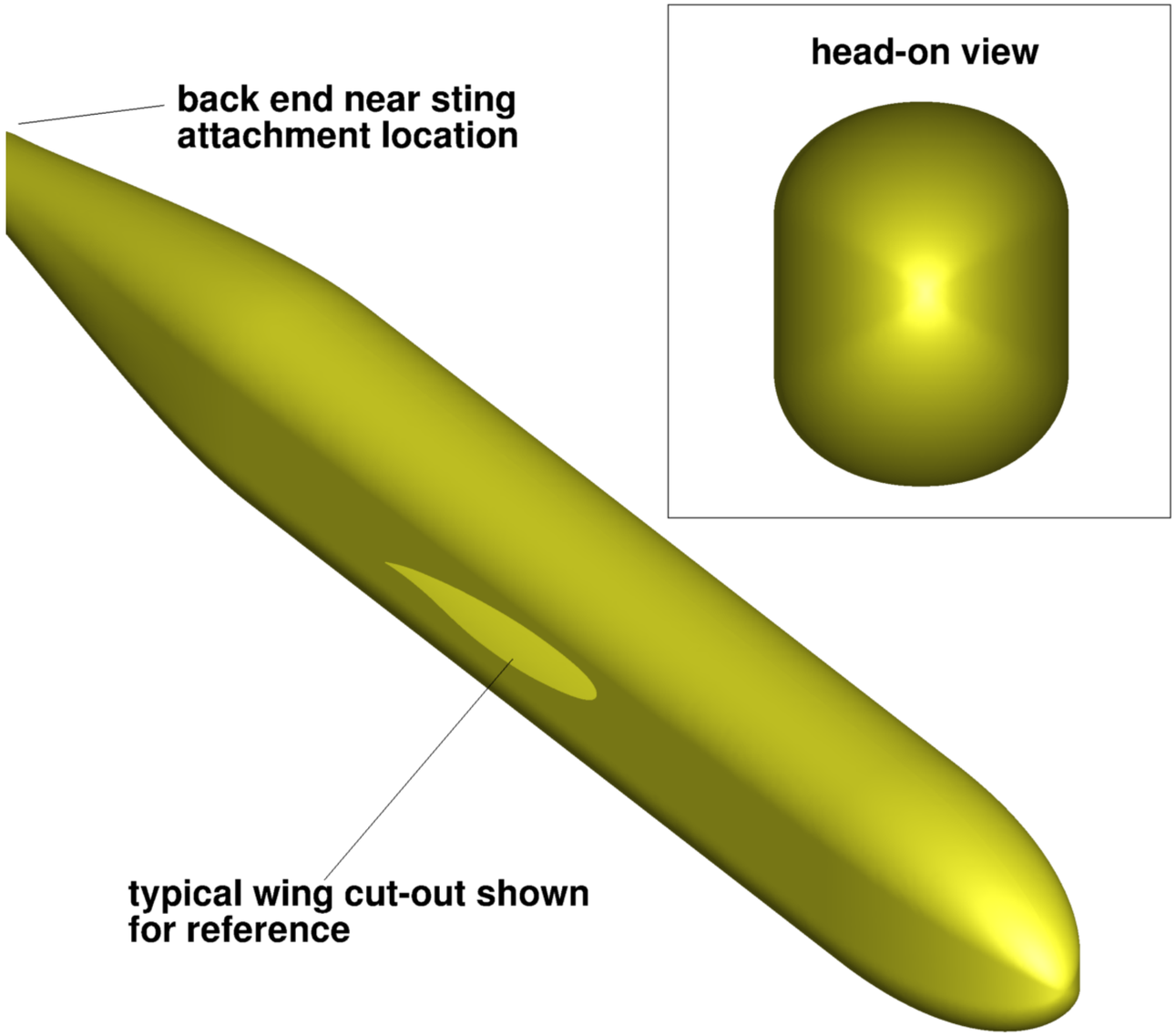
Juncture Flow Experiment Design

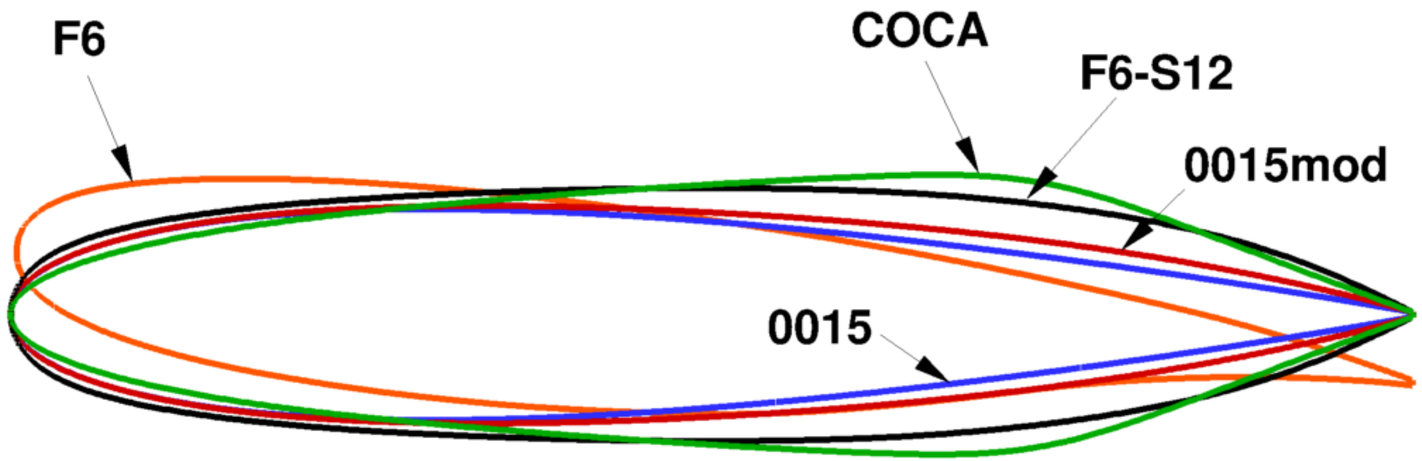
- Use internal Laser Doppler Velocimetry (LDV) system
  - Mounted inside of the fuselage
  - Movable three-axis traverse system
  - Measure the flow field through window on fuselage
  - Closest possible location to wing-body juncture



Fuselage Configuration

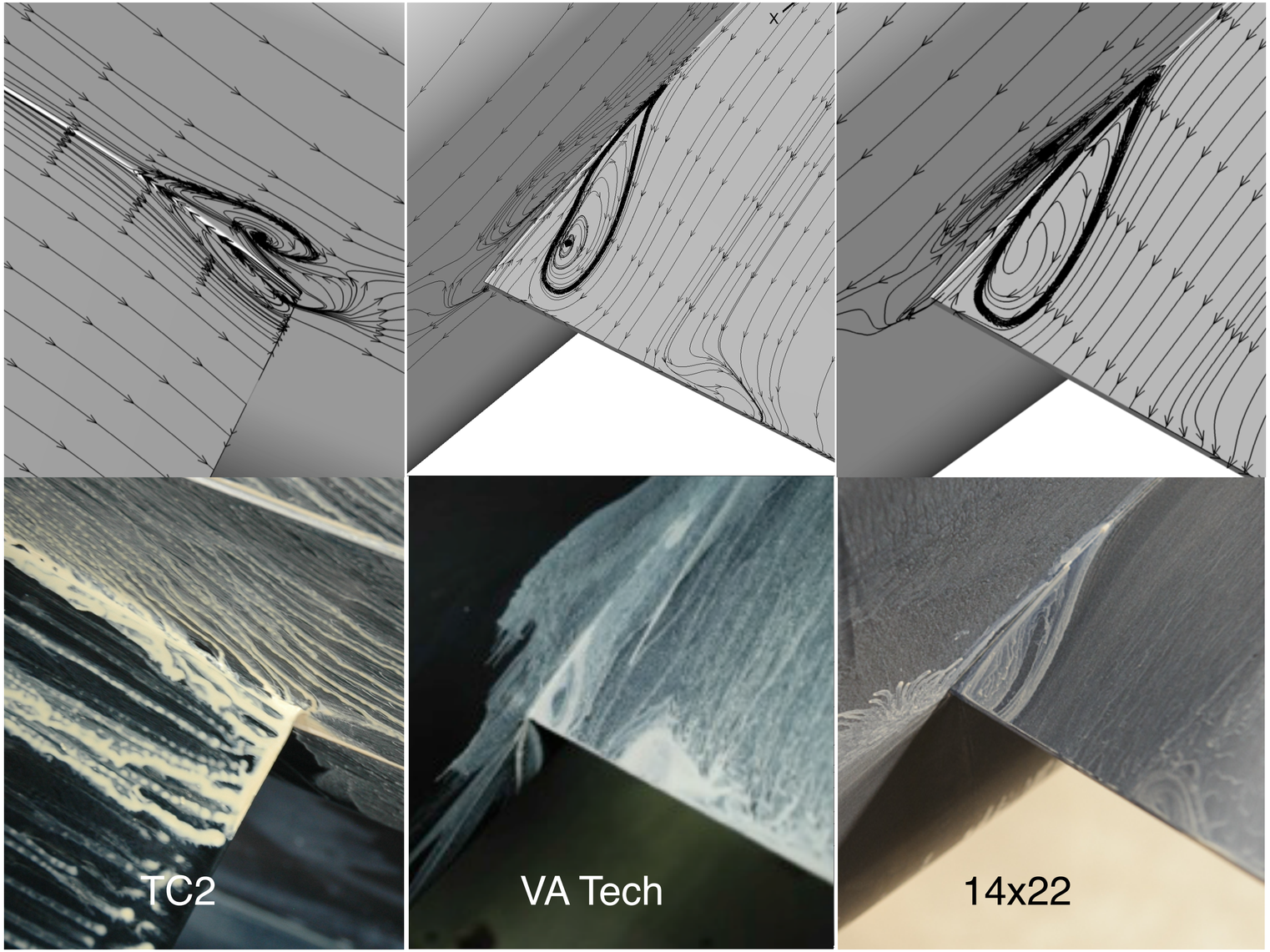


Wing Configuration Design



Evaluated Wing Candidates using CFD

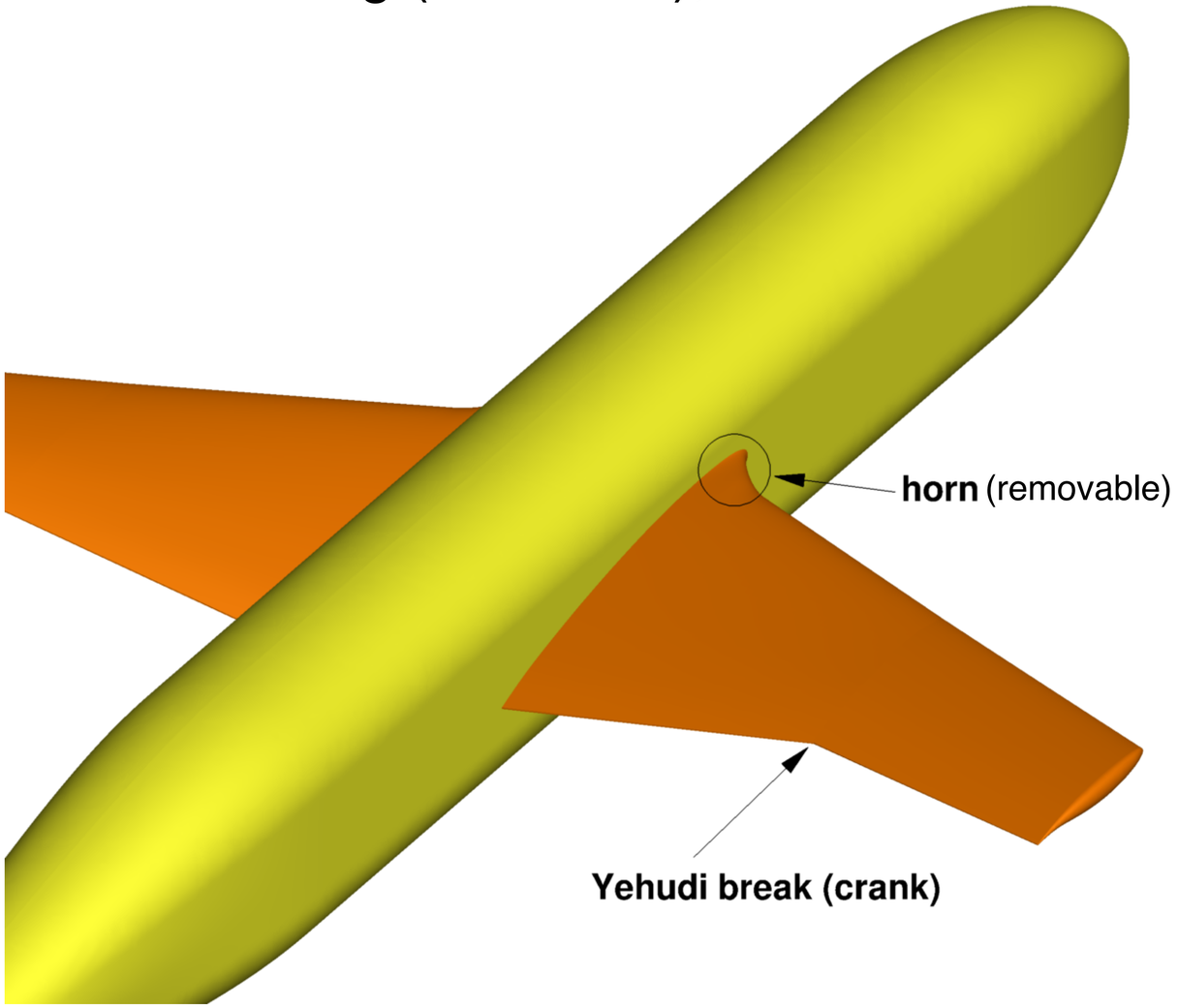
Wing Configuration Design

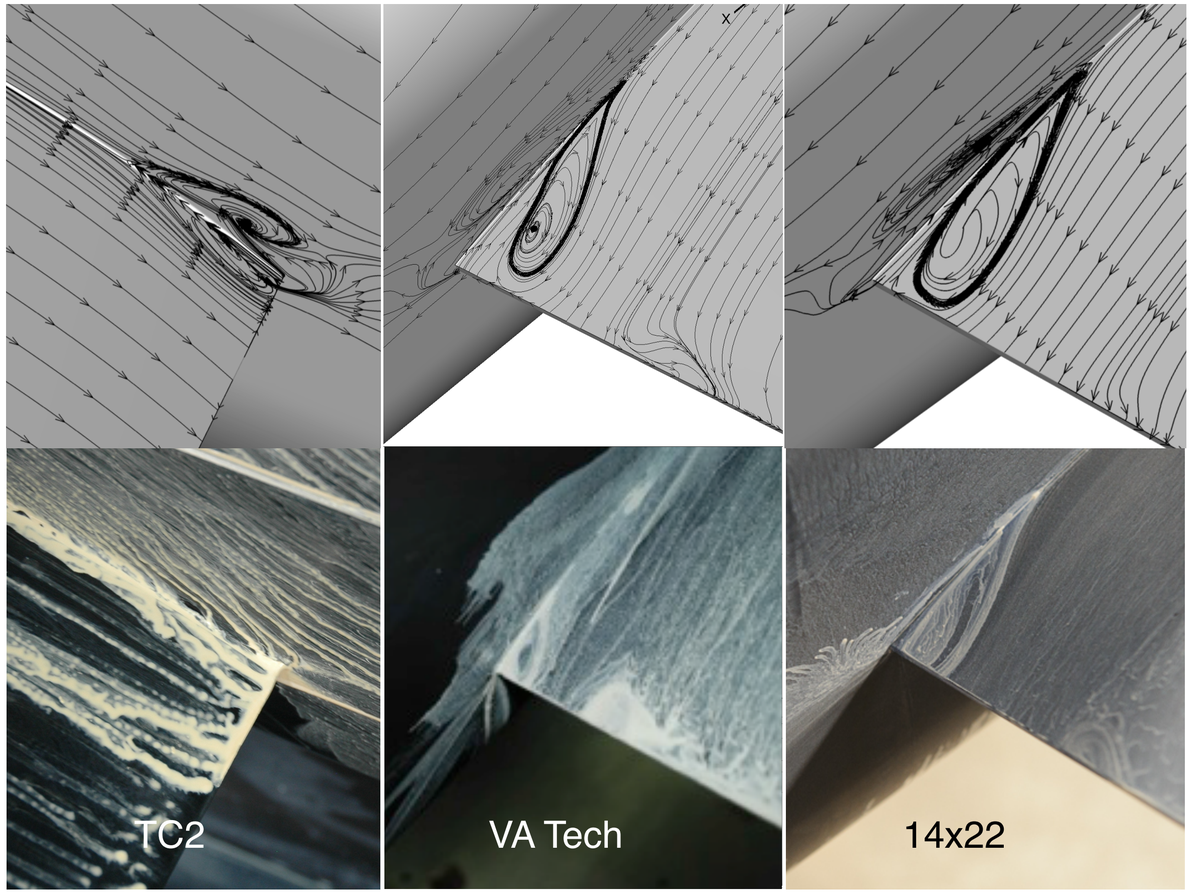


Risk Reduction Experiments & CFD —> Finalize Design

Wing Configuration Design

DLR-F6 Wing (truncated), removable horn





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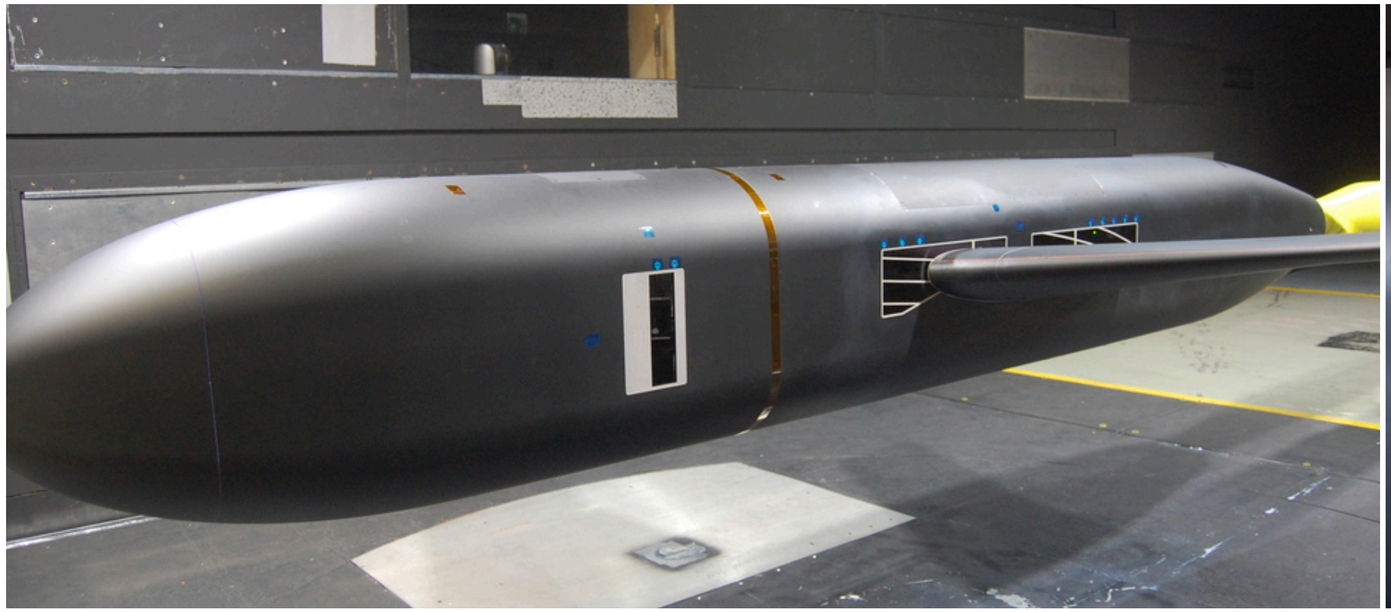
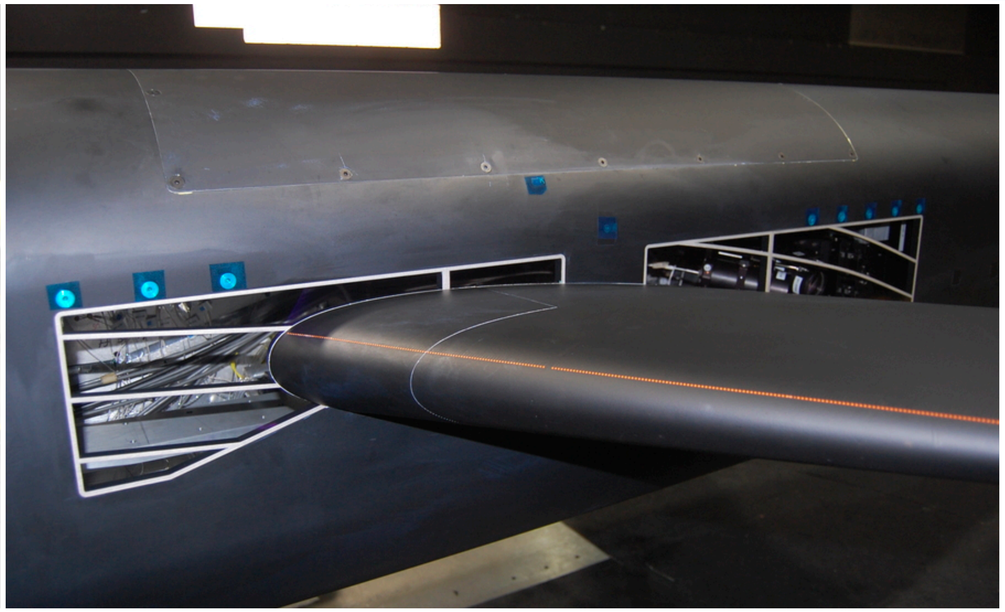
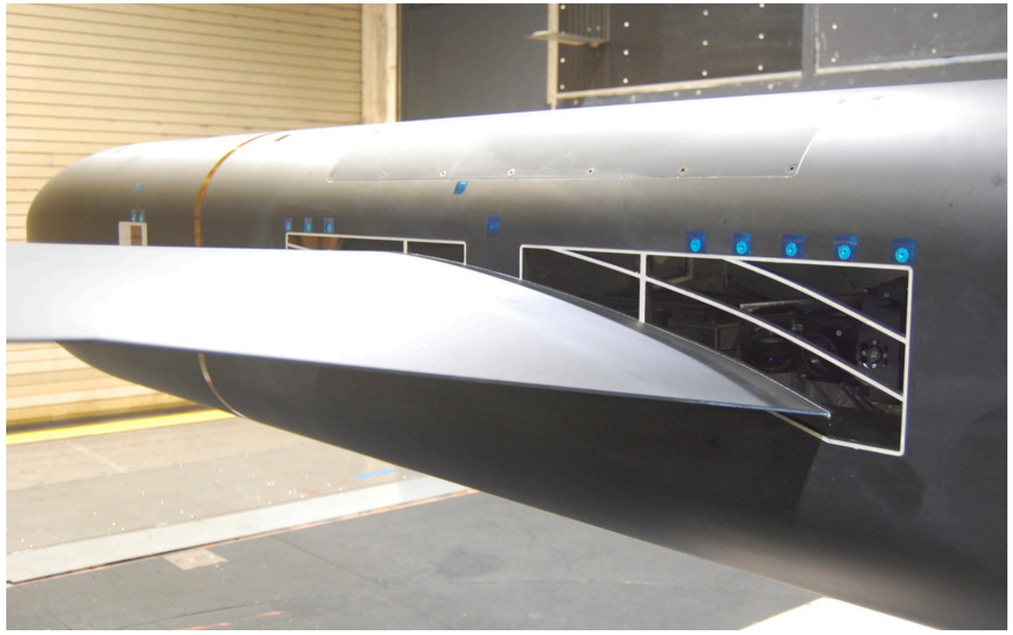
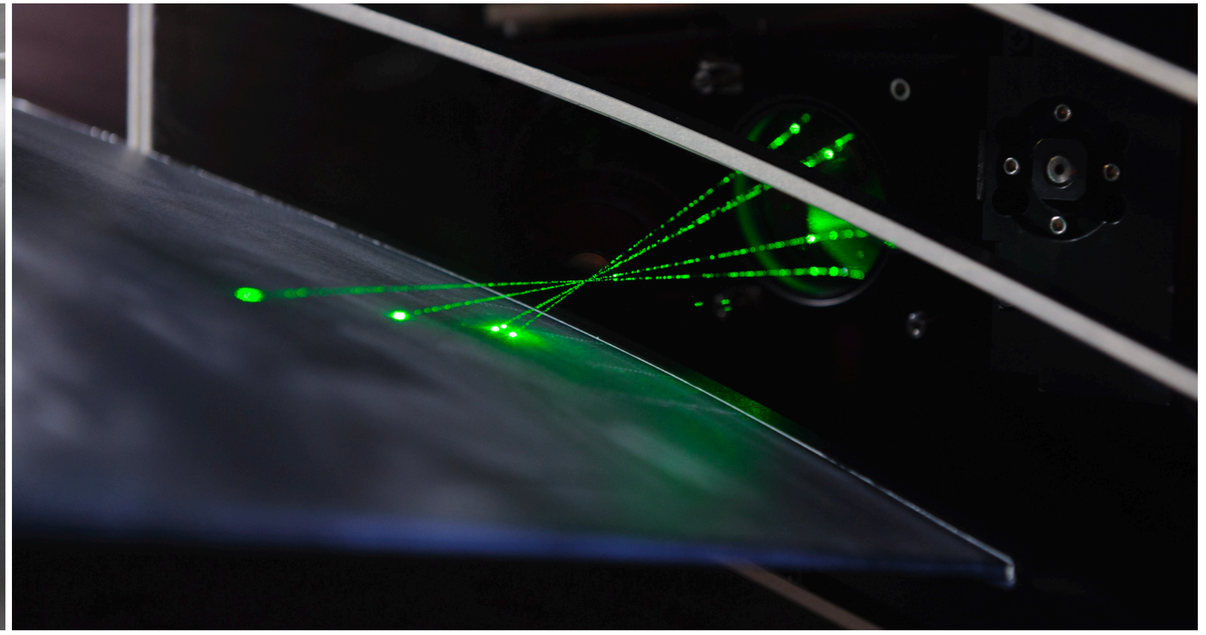
Experiment Pictures









Juncture Flow Experiment

- Heavy collaboration: CFD and WT design team
  - CFD used extensively in the experiment design
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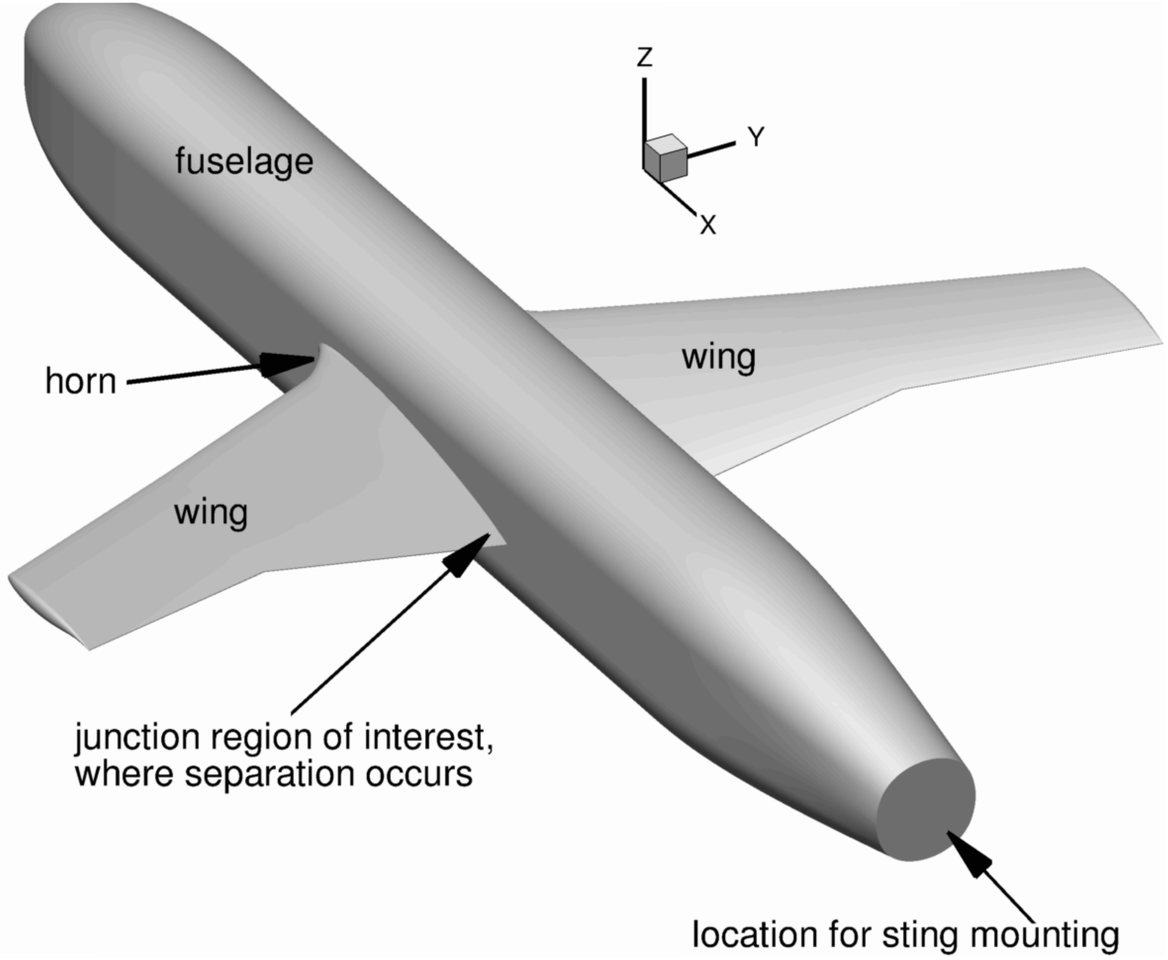
- Have experimental data now, how well does CFD RANS (OVERFLOW) do?

OVERFLOW Approach

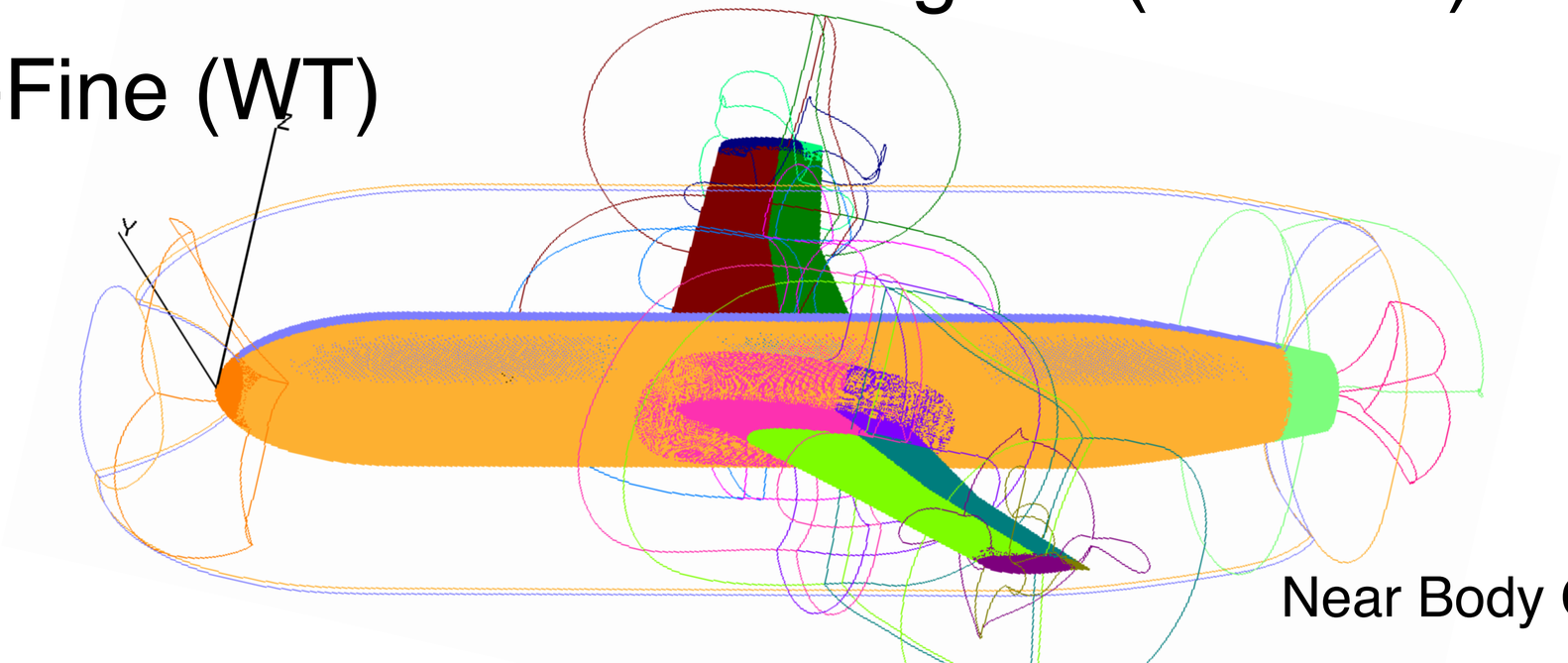
- OVERFLOW CFD RANS current “state of the art” evaluation
  - Grid Resolution (in Free Air)
  - Wall Effect, Free Air vs WT walls
  - Turbulence Model (in Free Air)

- Data Comparisons
  - Separation Size
  - Wing Pressure (cuts)
  - Surface Streamlines
  - Velocity Profiles
  - Reynolds Stress Profiles



OVERFLOW Grids

- Structured overset grid system
  - Free Air: Curvilinear near-body, Cartesian off-body
  - WT: Curvilinear near-body, Curvilinear wind tunnel wall grids
- Grid family created using guidelines from DPW series
  - Coarse-Medium-Fine-Extra Fine grids (Free Air)
  - Medium-Fine (WT)



Near Body Grids

OVERFLOW Grid Parameters

Configuration	Stretching Ratio	Near Body Grid Points	Total Grid Points
Free Air Coarse	1.20	19.4M	21.4M
Free Air Medium	1.15	47.6M	48.7M
Free Air Fine	1.10	163.6M	165.7M
Free Air Extra-Fine	1.08	382.1M	398.4M
Wind Tunnel Medium	1.15	47.6M	92.6M
Wind Tunnel Fine	1.10	163.6M	325.5M

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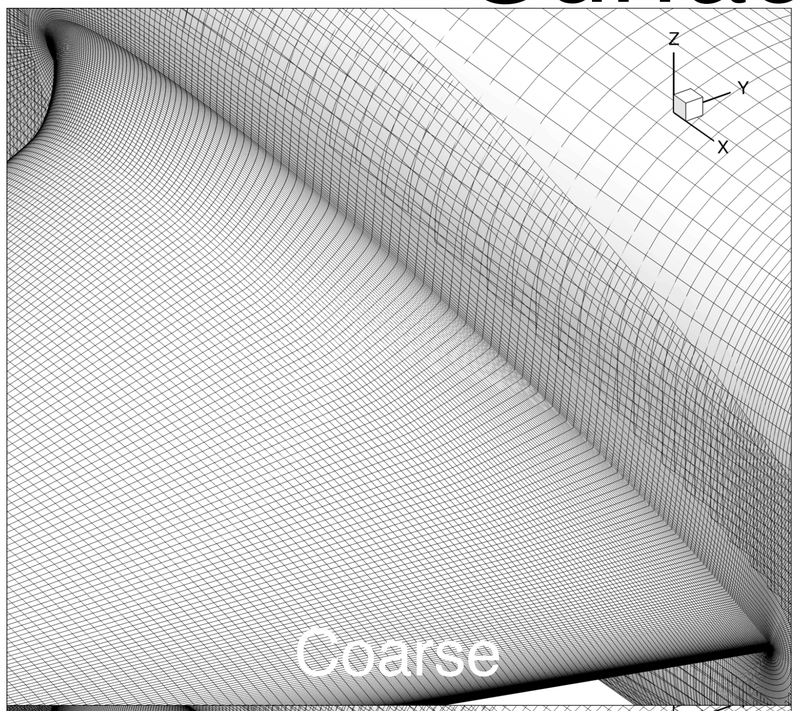
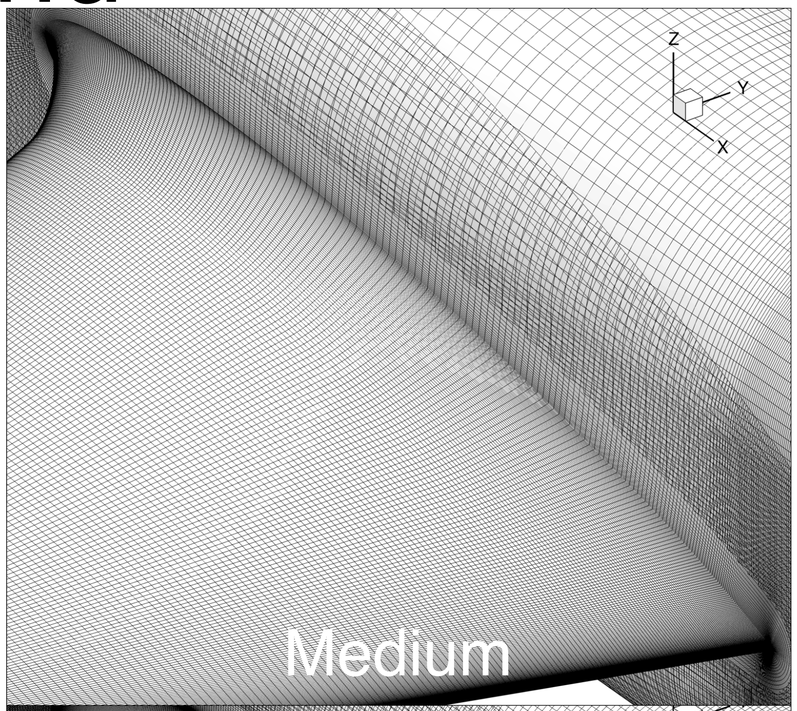
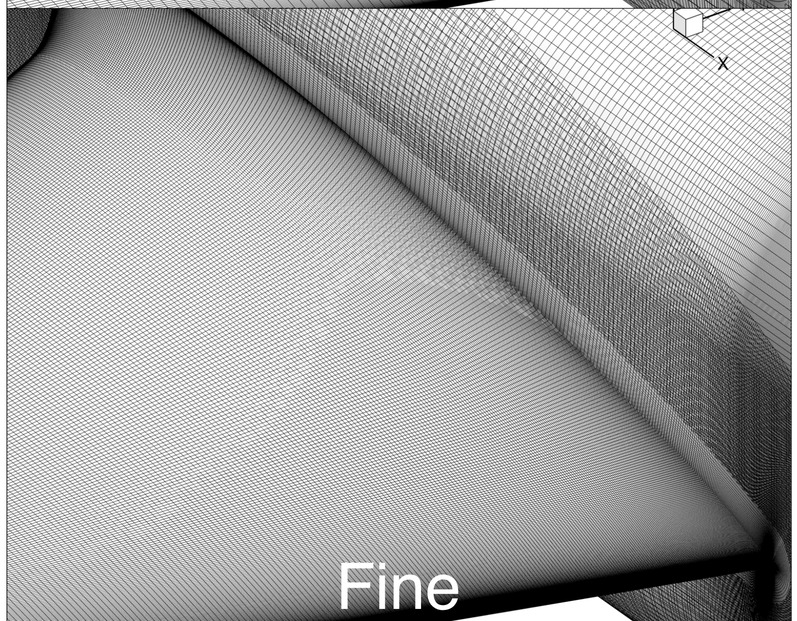
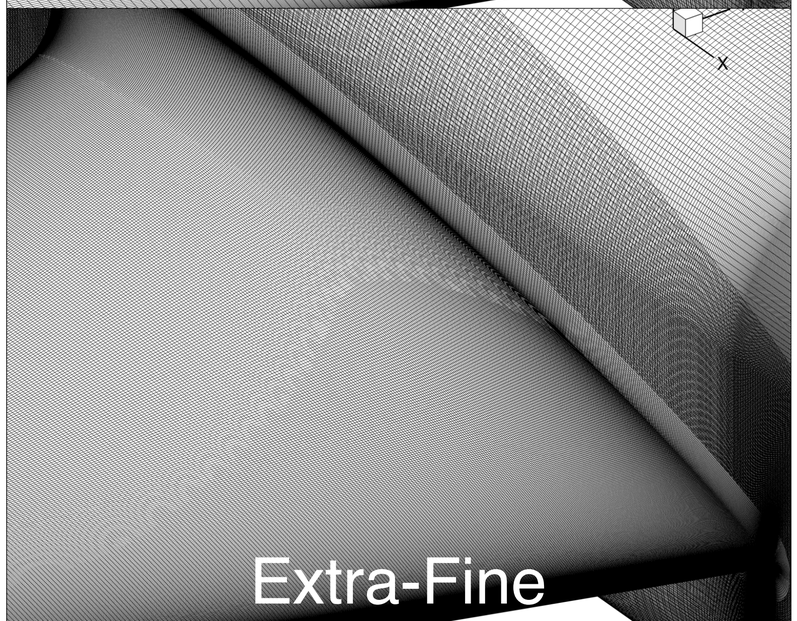
Same Near Body Grids

Surface Grid

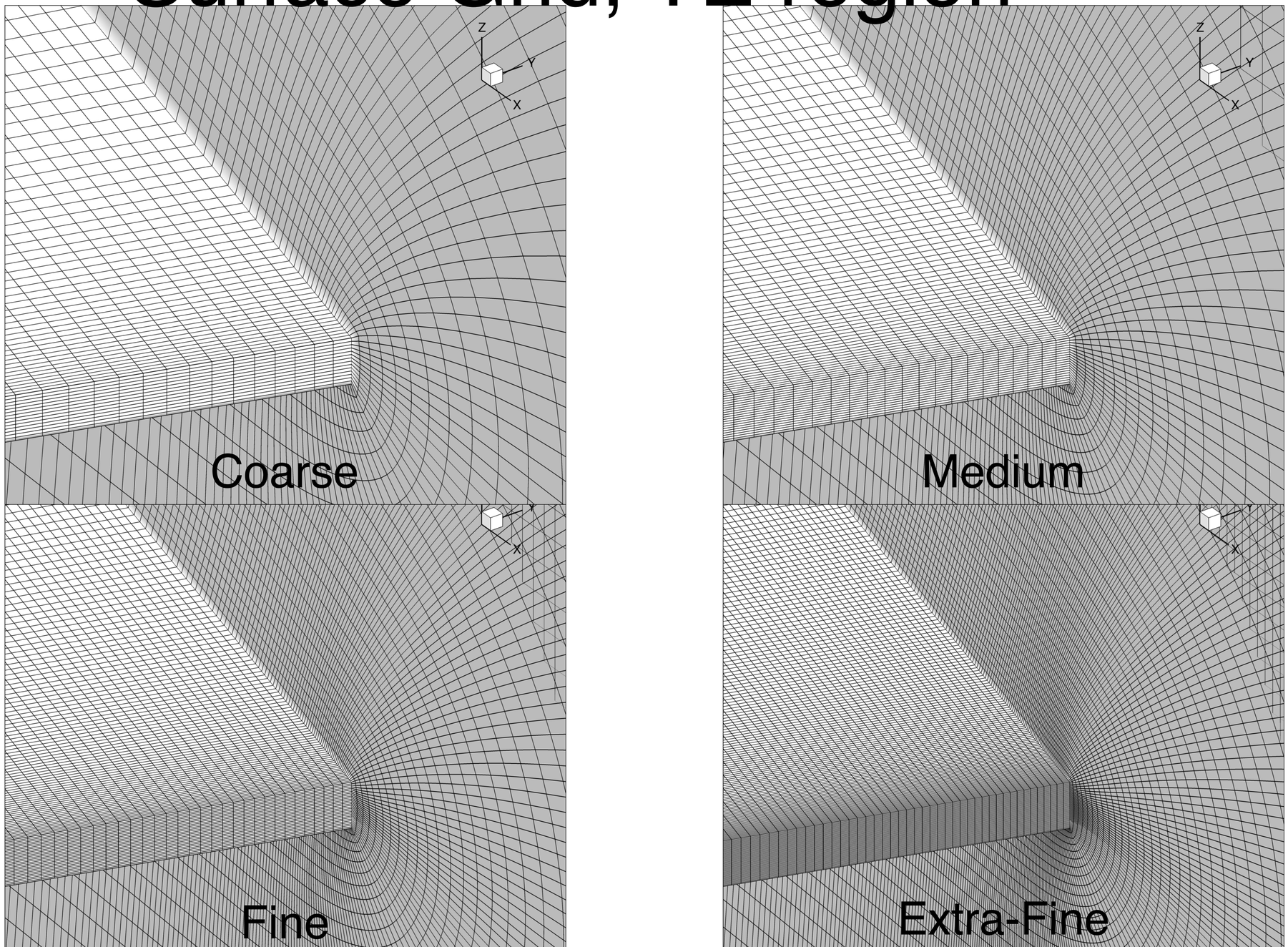




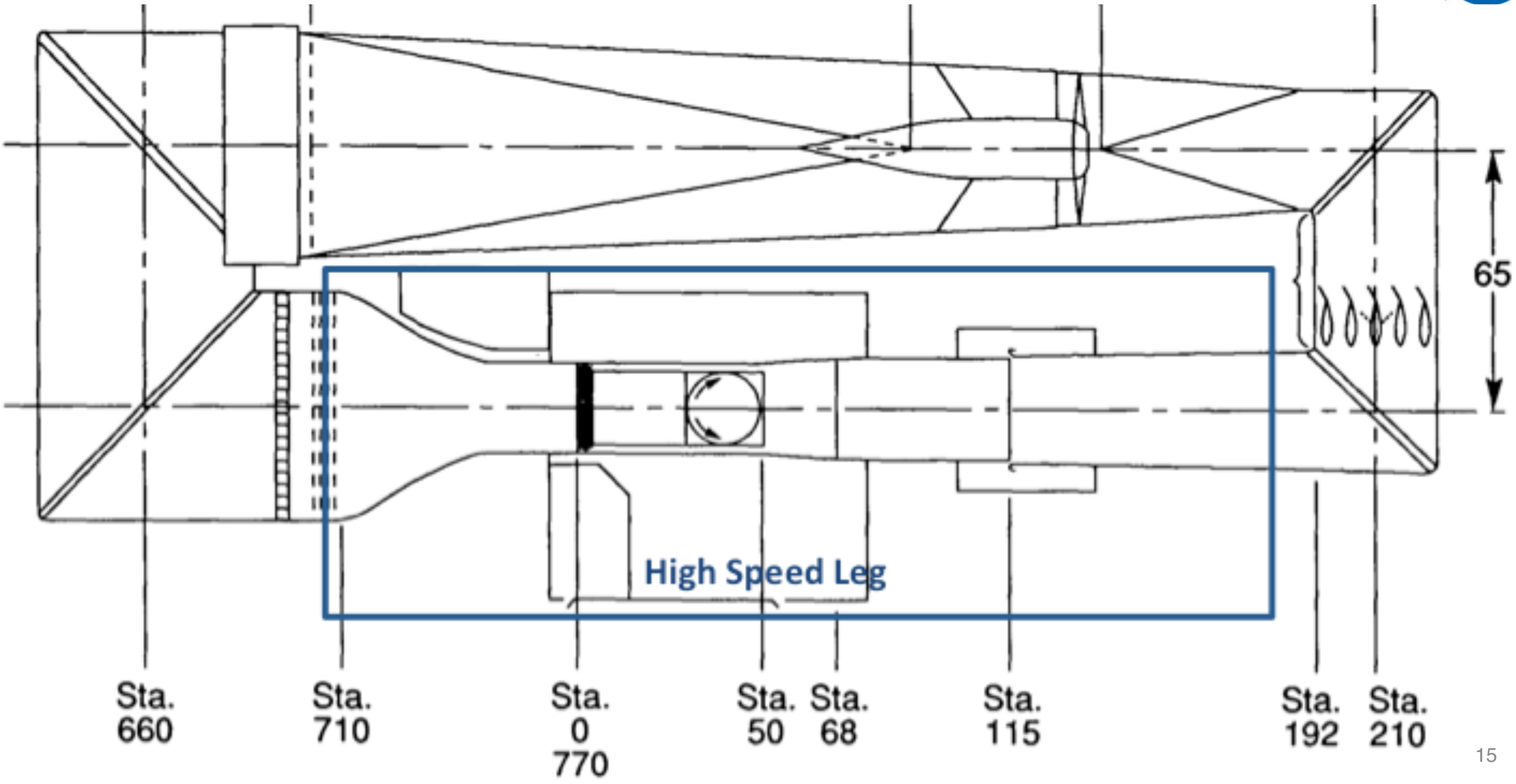




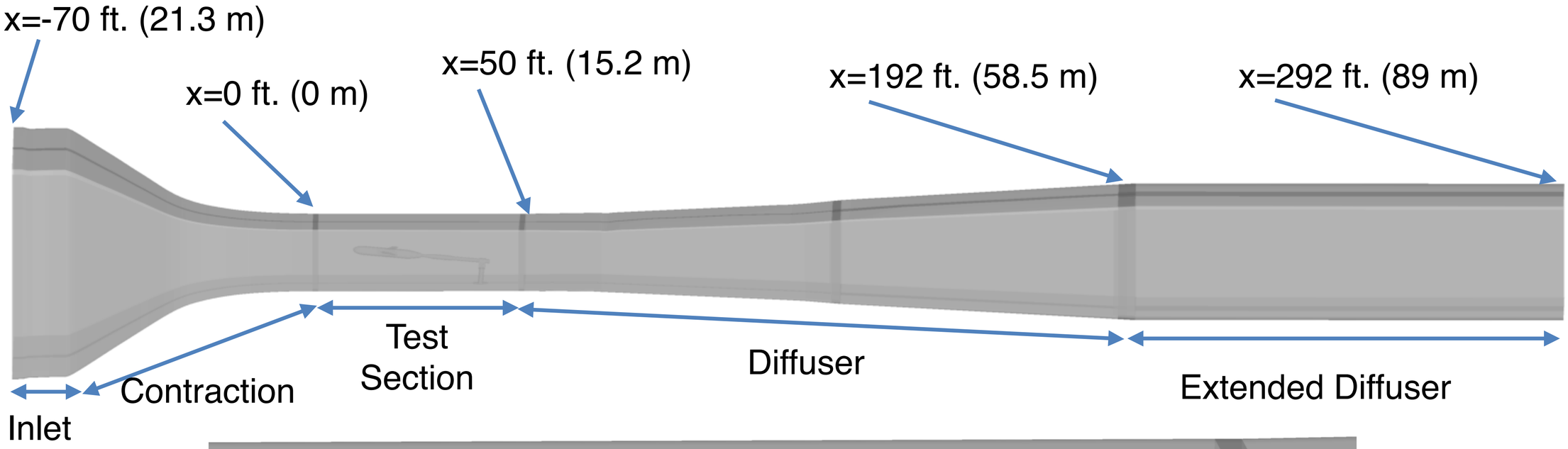
Surface Grid, TE region

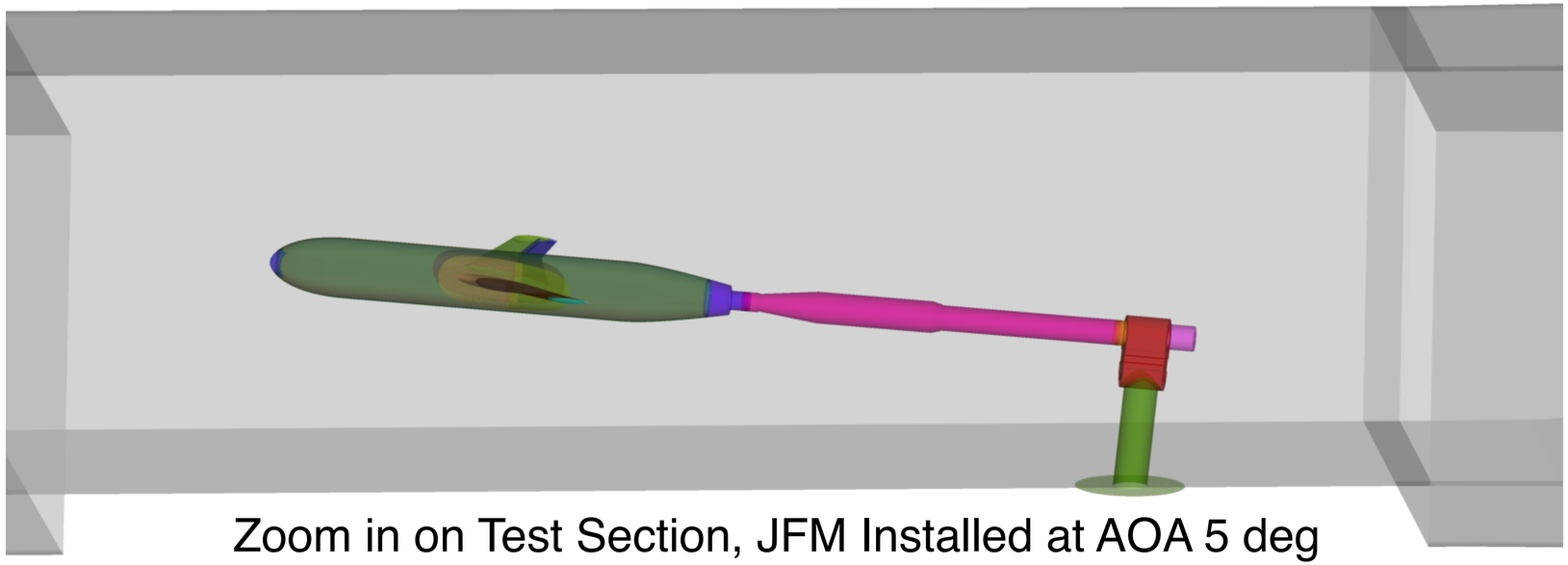


Langley 14- by 22-Ft. Subsonic Tunnel (14x22)



CFD 14x22 Wind Tunnel





Zoom in on Test Section, JFM Installed at AOA 5 deg

CFD 14x22 Wind Tunnel Setup

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Impose Stagnation conditions
Pressure & Temperature

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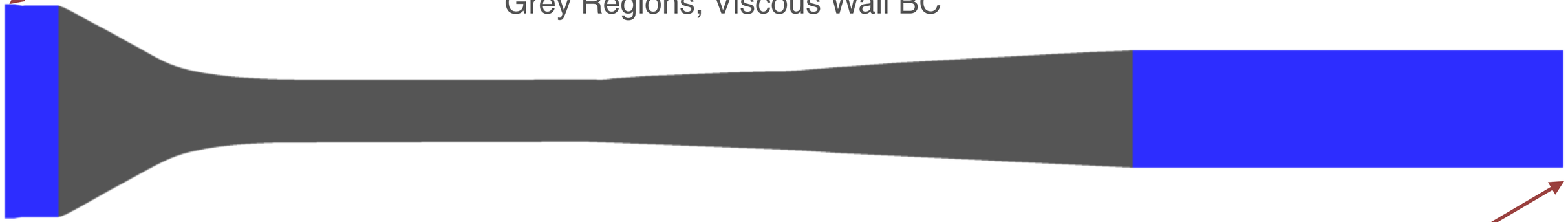
Iterate Back Pressure
ratio to match tunnel speed

CFD 14x22 Wind Tunnel Setup

Impose Stagnation conditions
Pressure & Temperature

Blue Regions, Inviscid Wall BC
Grey Regions, Viscous Wall BC



Iterate Back Pressure
ratio to match tunnel speed

Walls Treatment:

- Inviscid Inlet + Inviscid Diffuser Extension
- Viscous everywhere else

CFD 14x22 Wind Tunnel Setup

Walls Treatment:

- Inviscid Inlet + Inviscid Diffuser Extension
- Viscous everywhere else

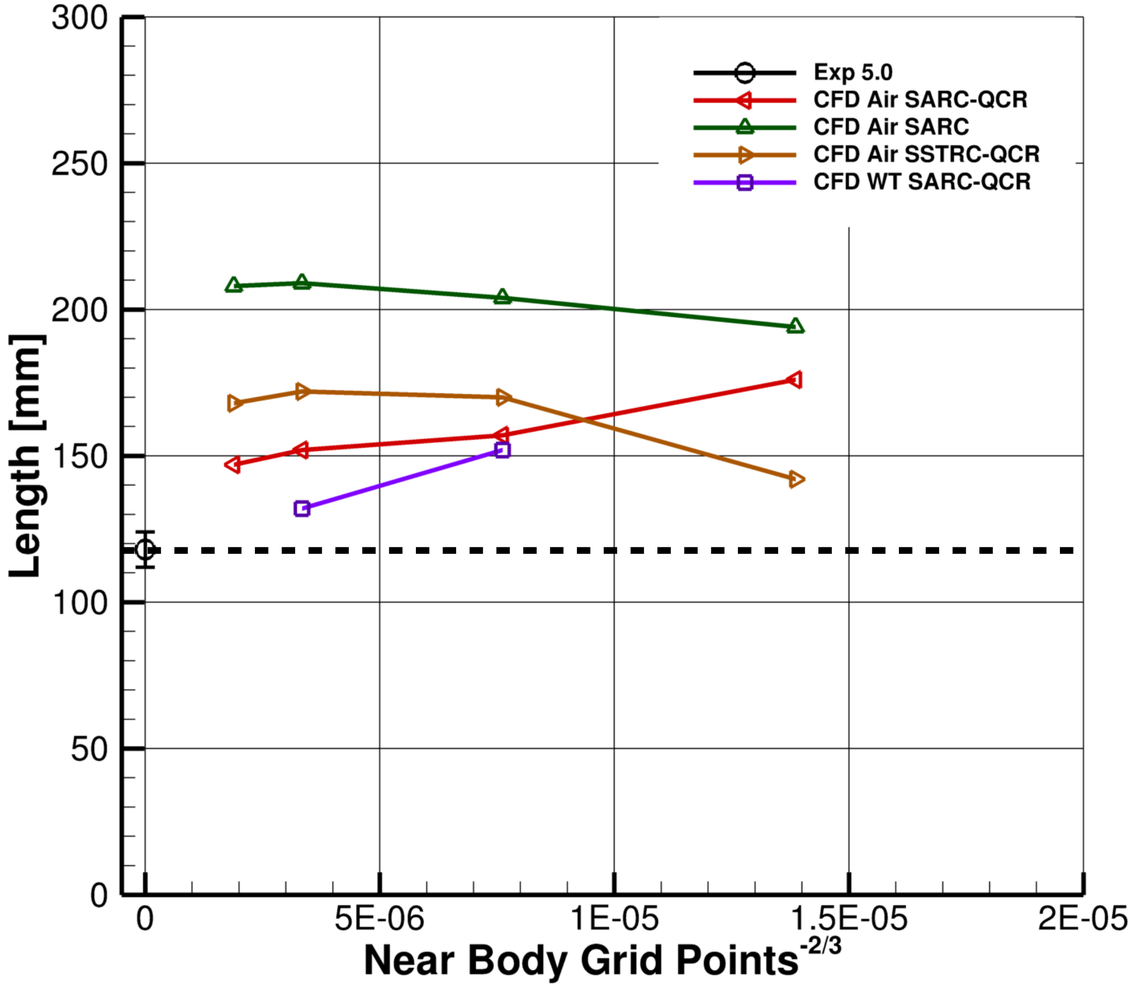
Tunnel speed:

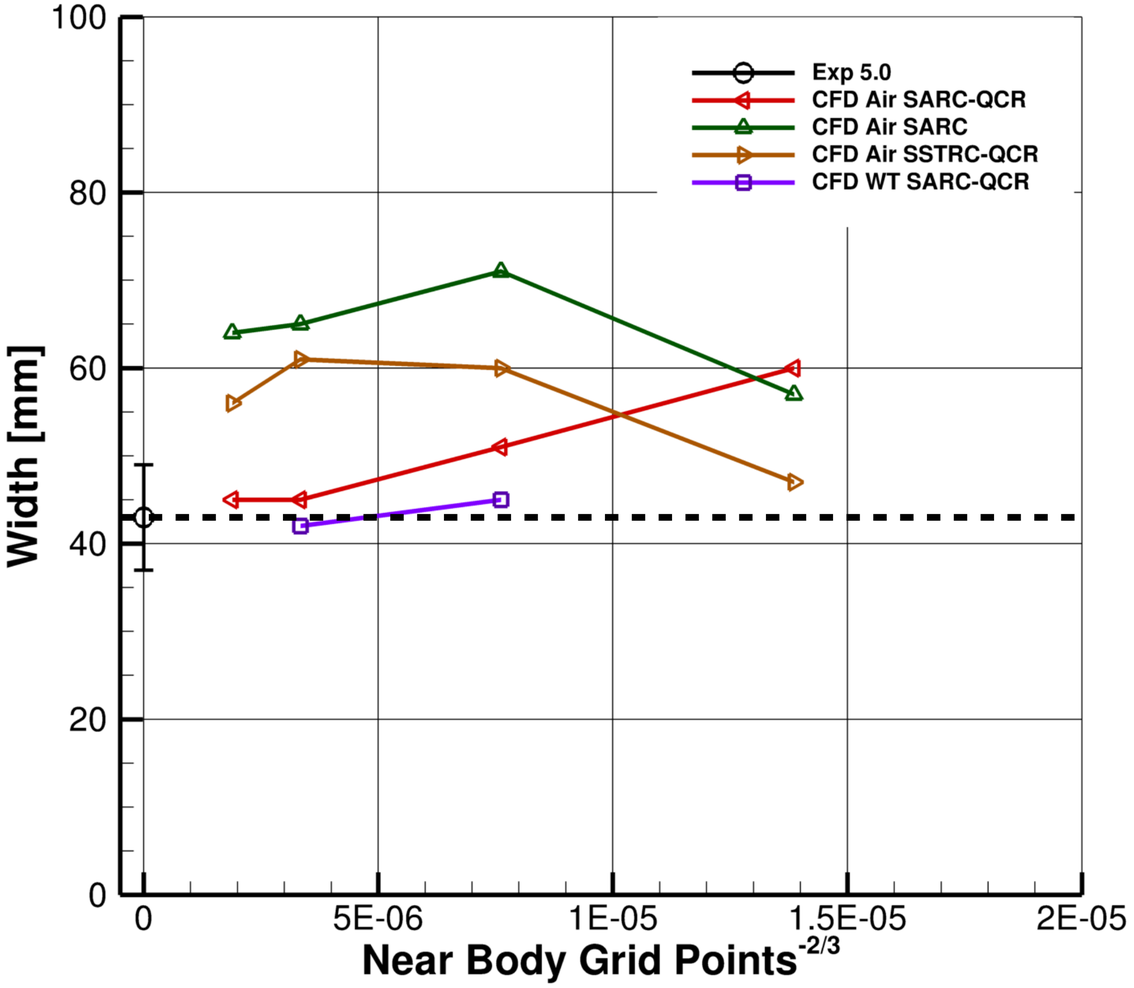
- Uses total pressure & static pressure “probe” values from their locations
- Calibrated equations -> tunnel speed
- Ref: Lee, et.al. STO-MP-AVT-284-02

Overflow Run Parameters

- OVERFLOW 2.2N
- 3rd-Order Roe upwind RHS
- ARC3D scalar pentadiagonal LHS
- Low-Mach preconditioning (in CFD WT)
- Fully Turbulent, Steady State
- RE = 2.4 Million based on crank chord
- Mach= 0.189, T= 519 Rankine (288.8 Kelvin) (median of run conditions)
- Turbulence Models:
  - SA-Noft2-RC-QCR2013 (SARC-QCR)
  - SA-Noft2-RC (SARC)
  - SST-RC-QCR2013 (SSTRC-QCR)

Side of Body Separation AOA = 5.0 deg





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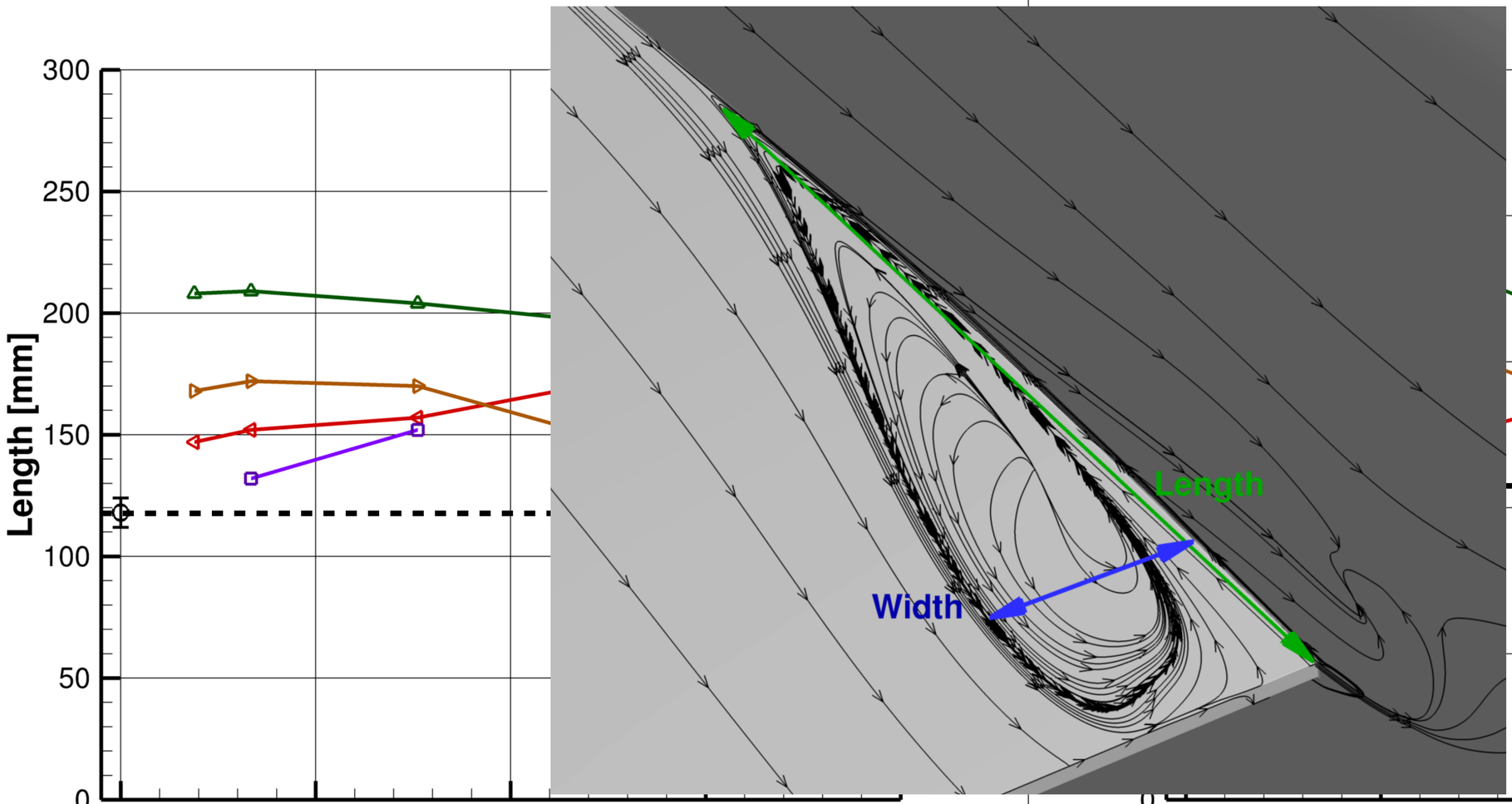

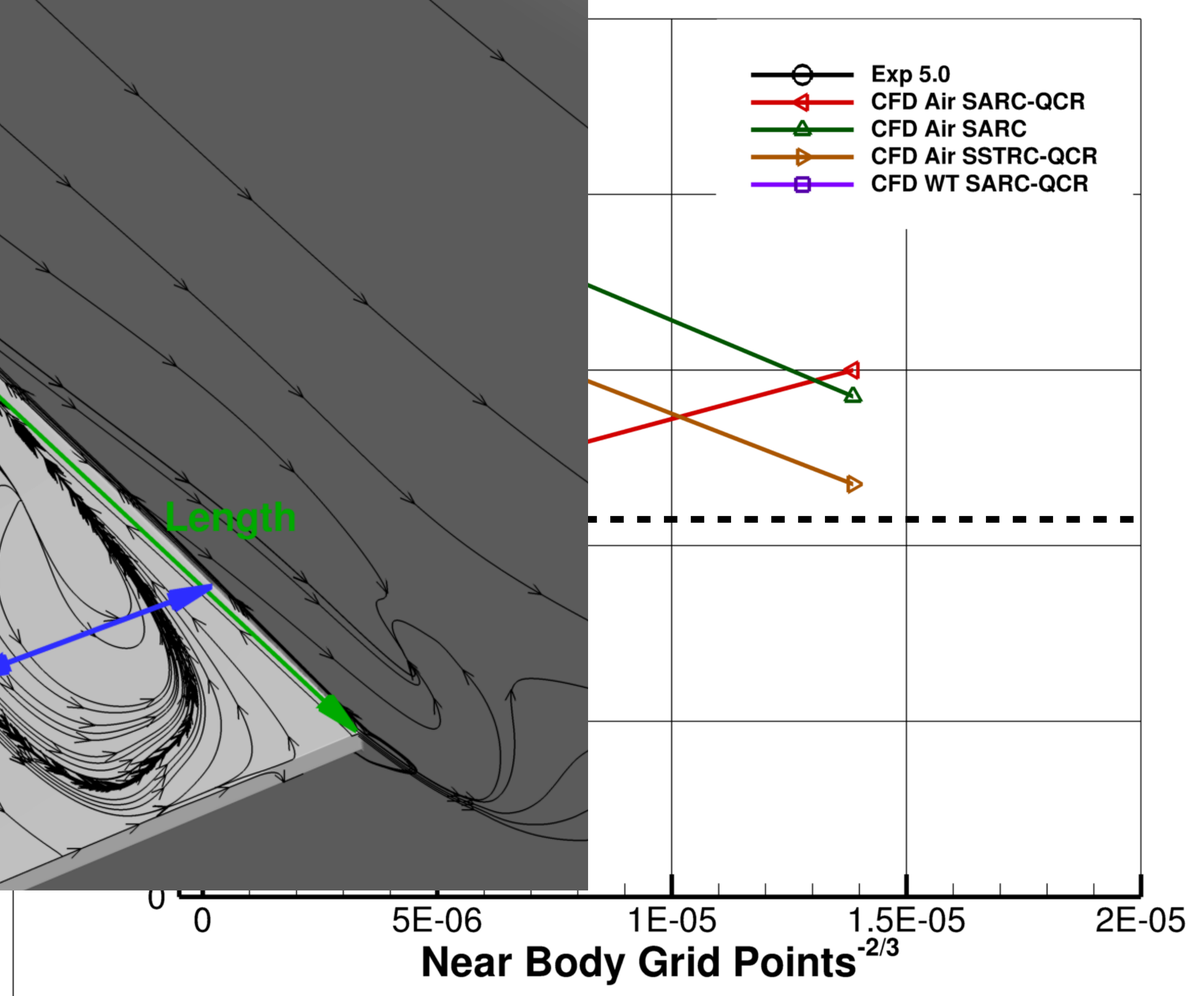

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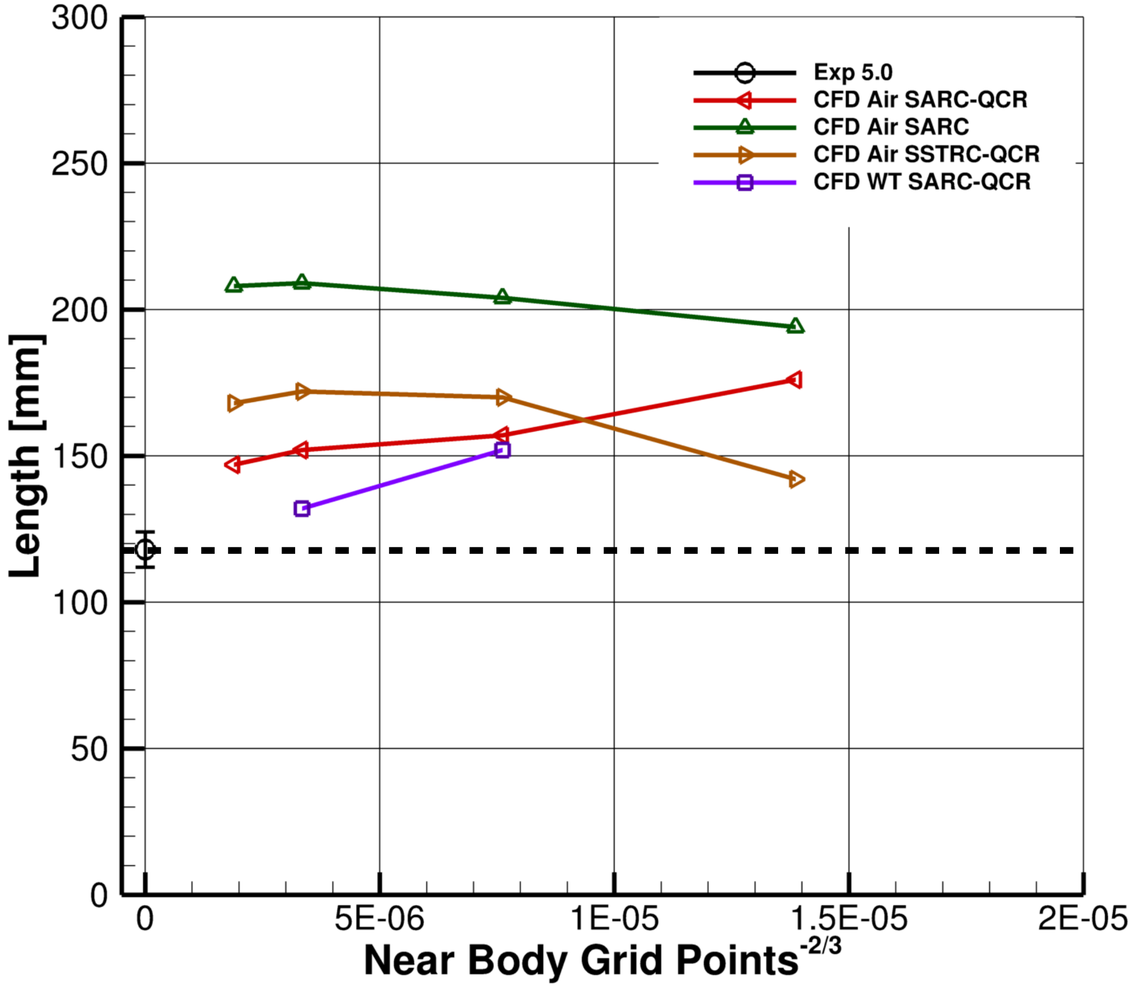

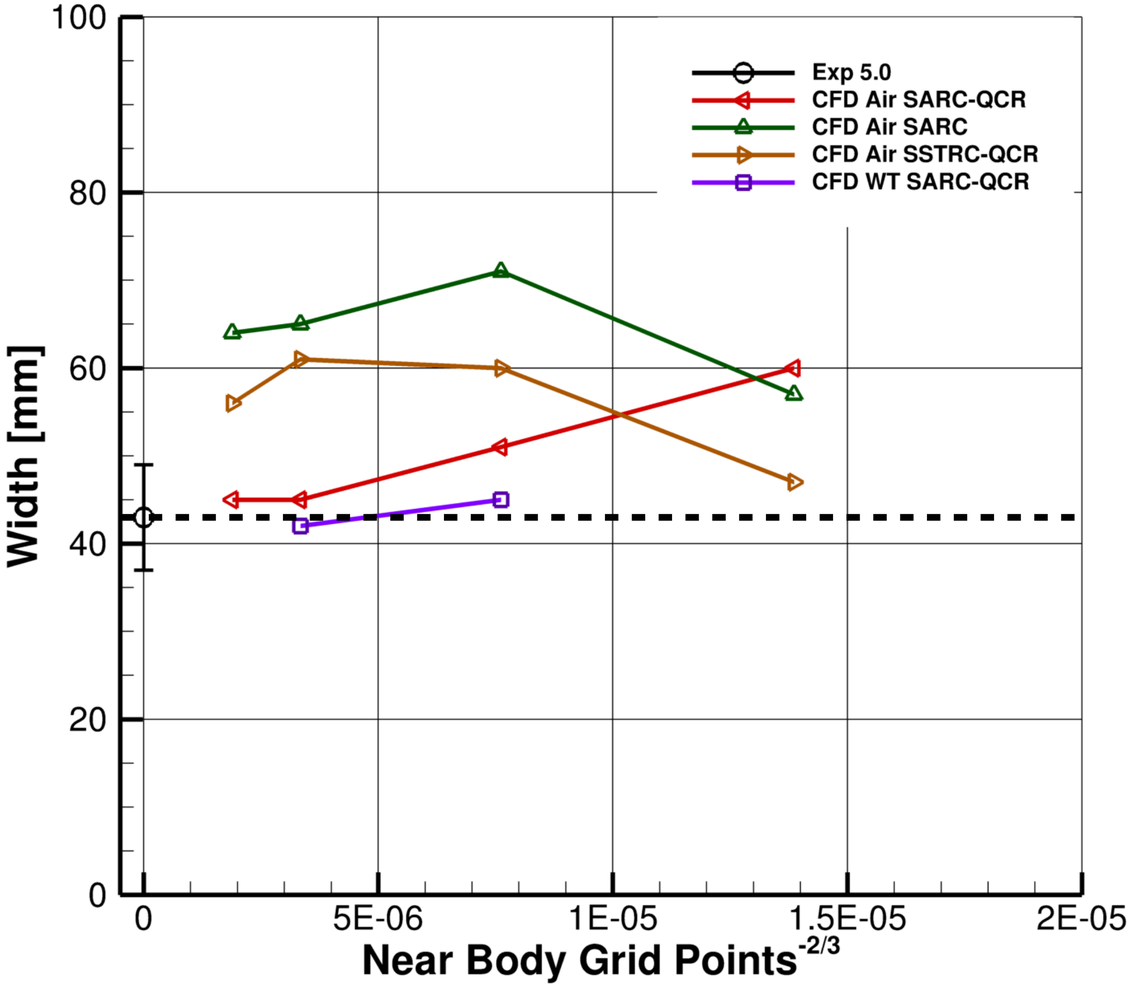

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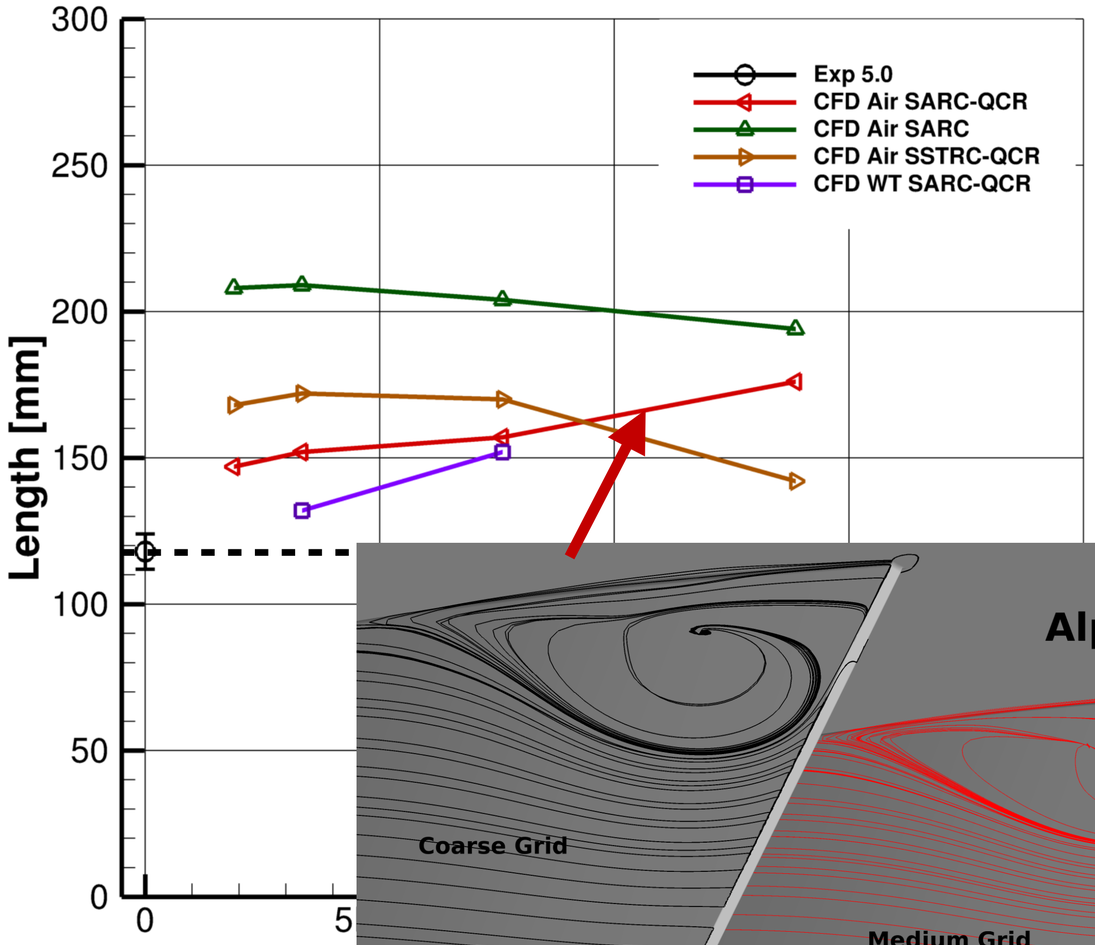

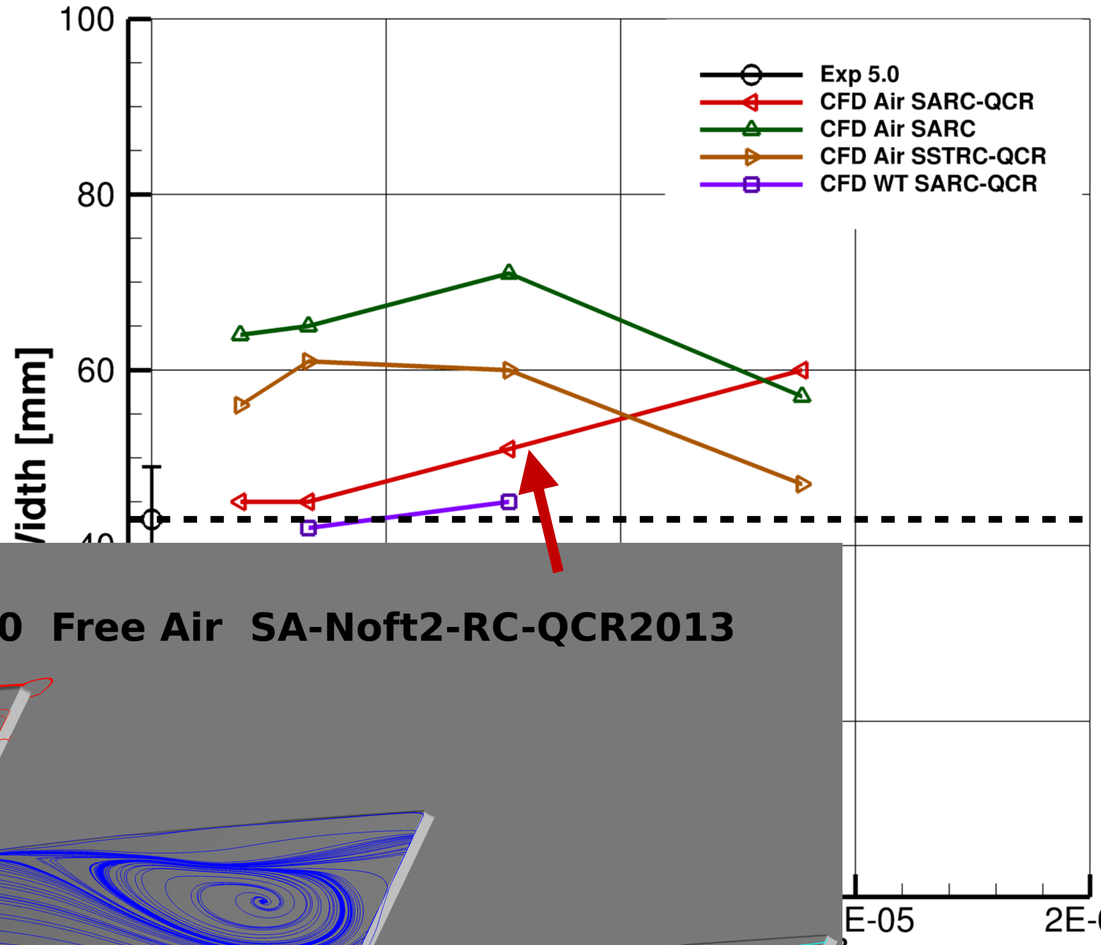

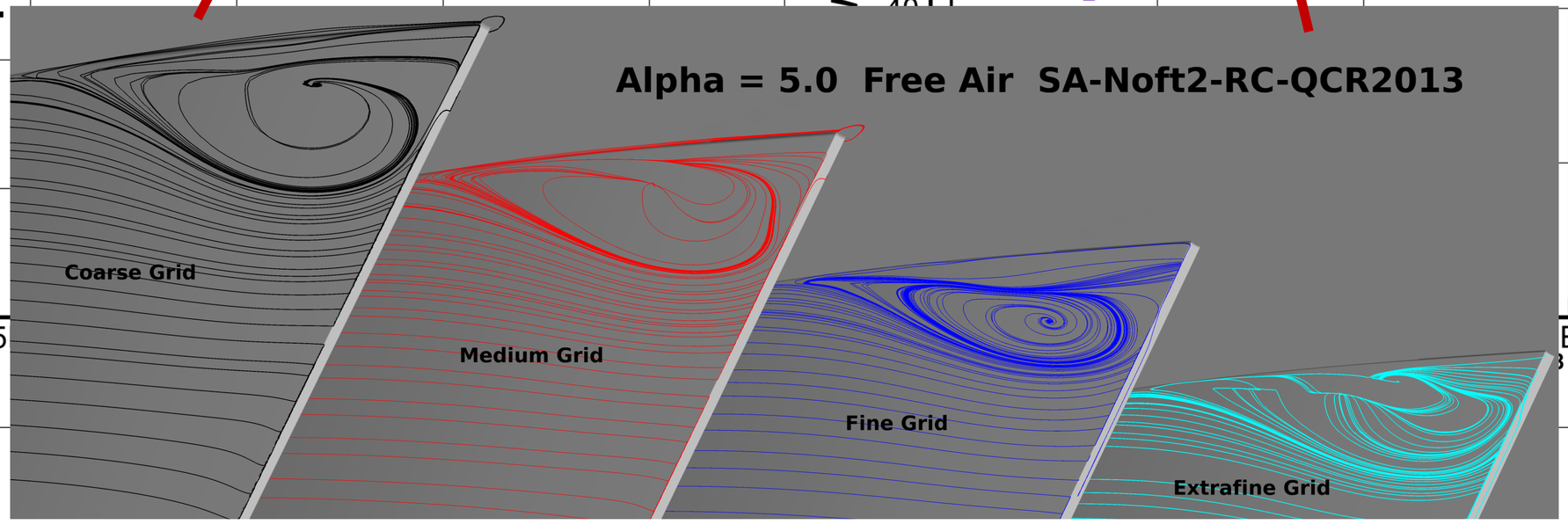

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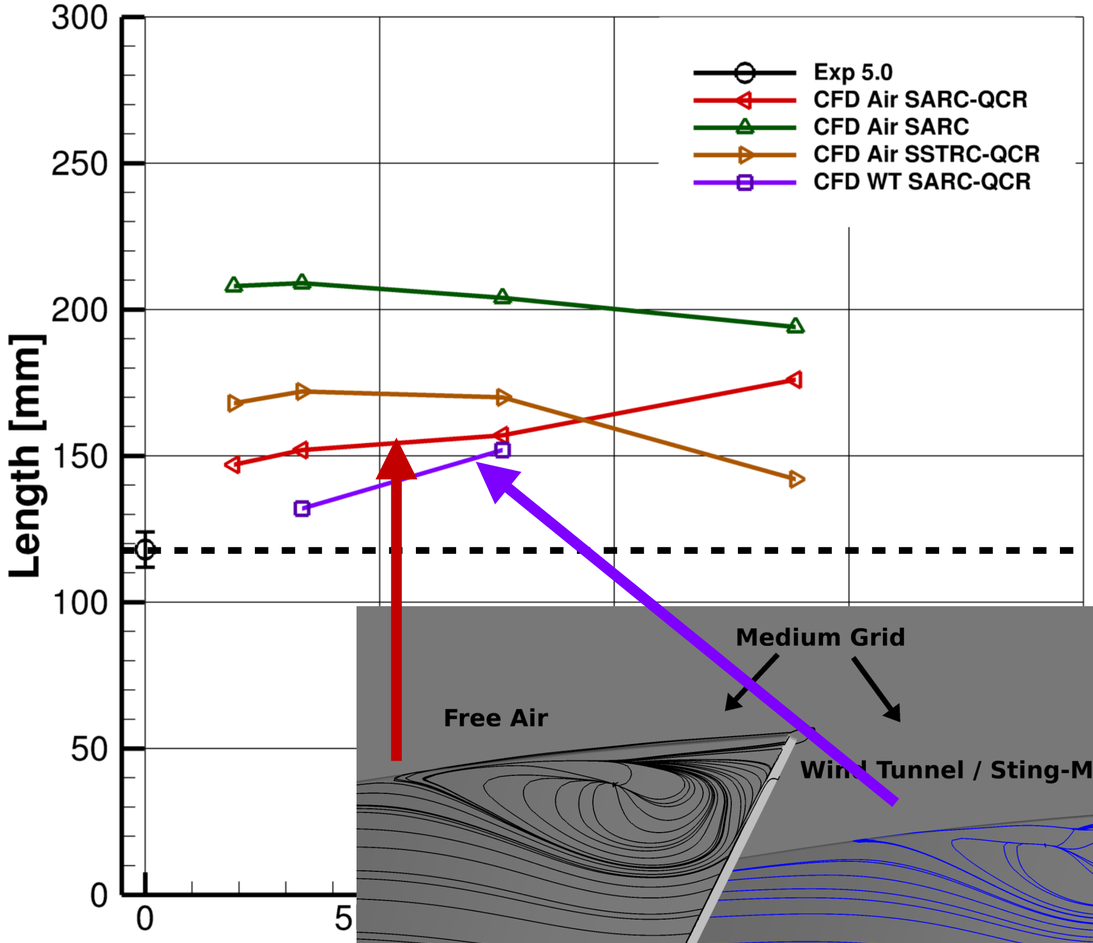

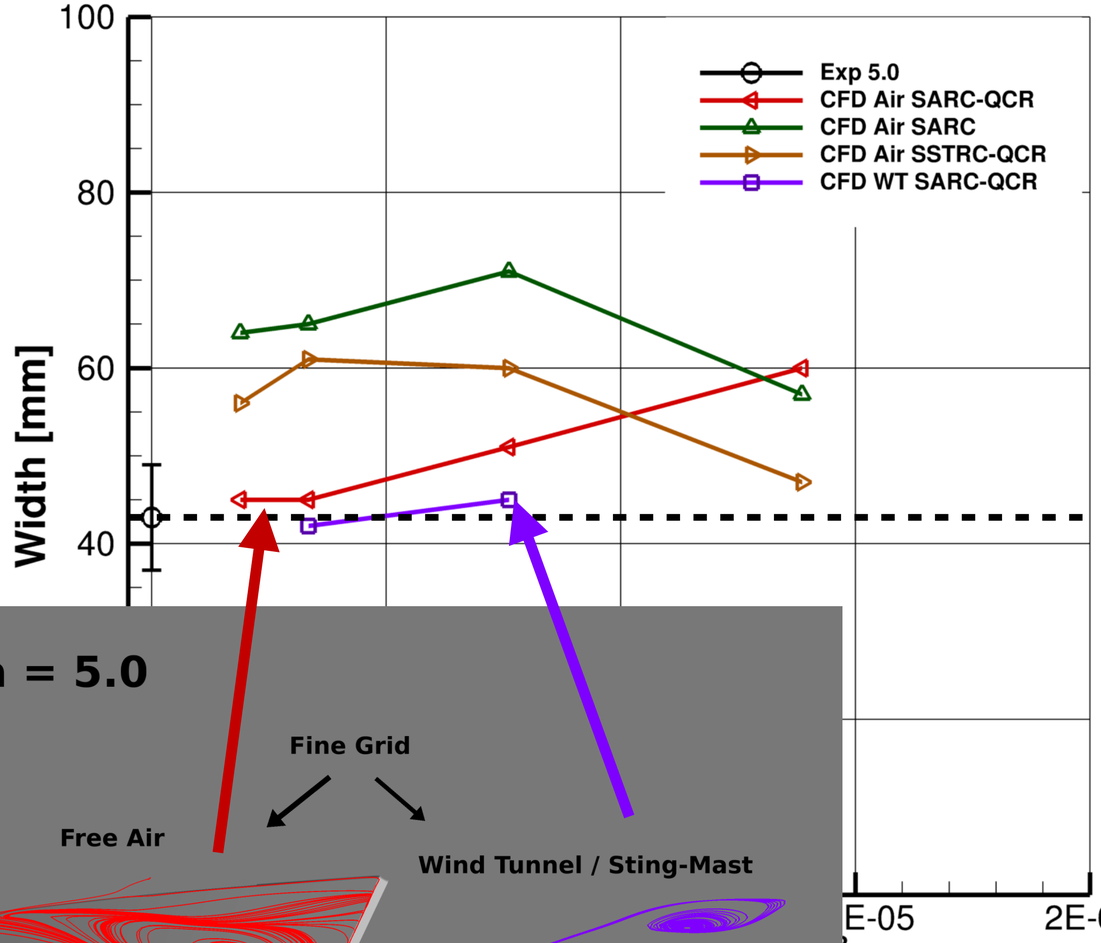

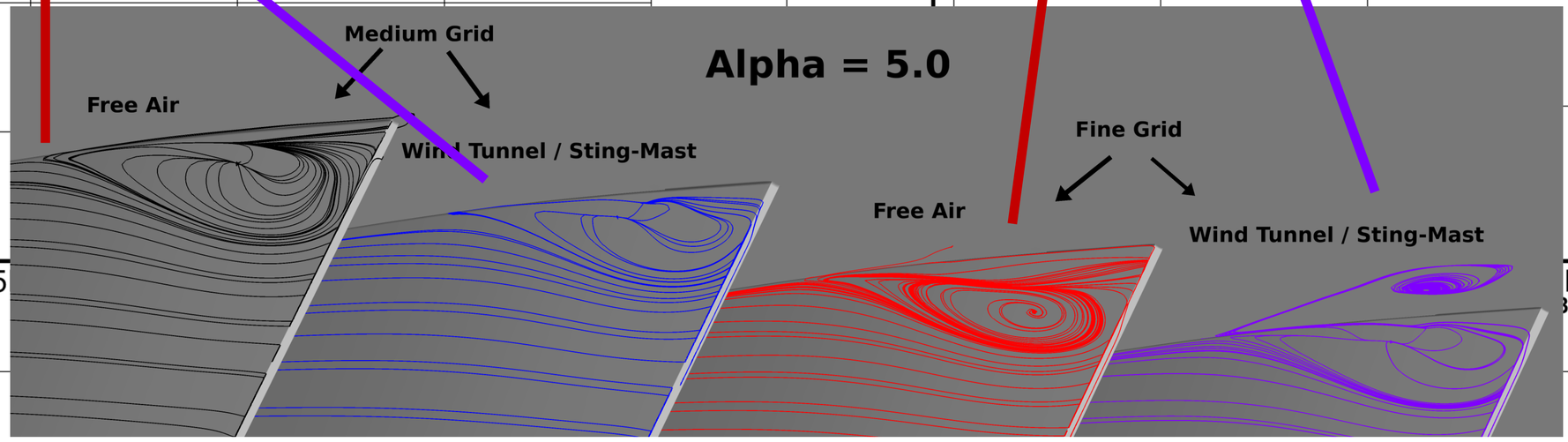

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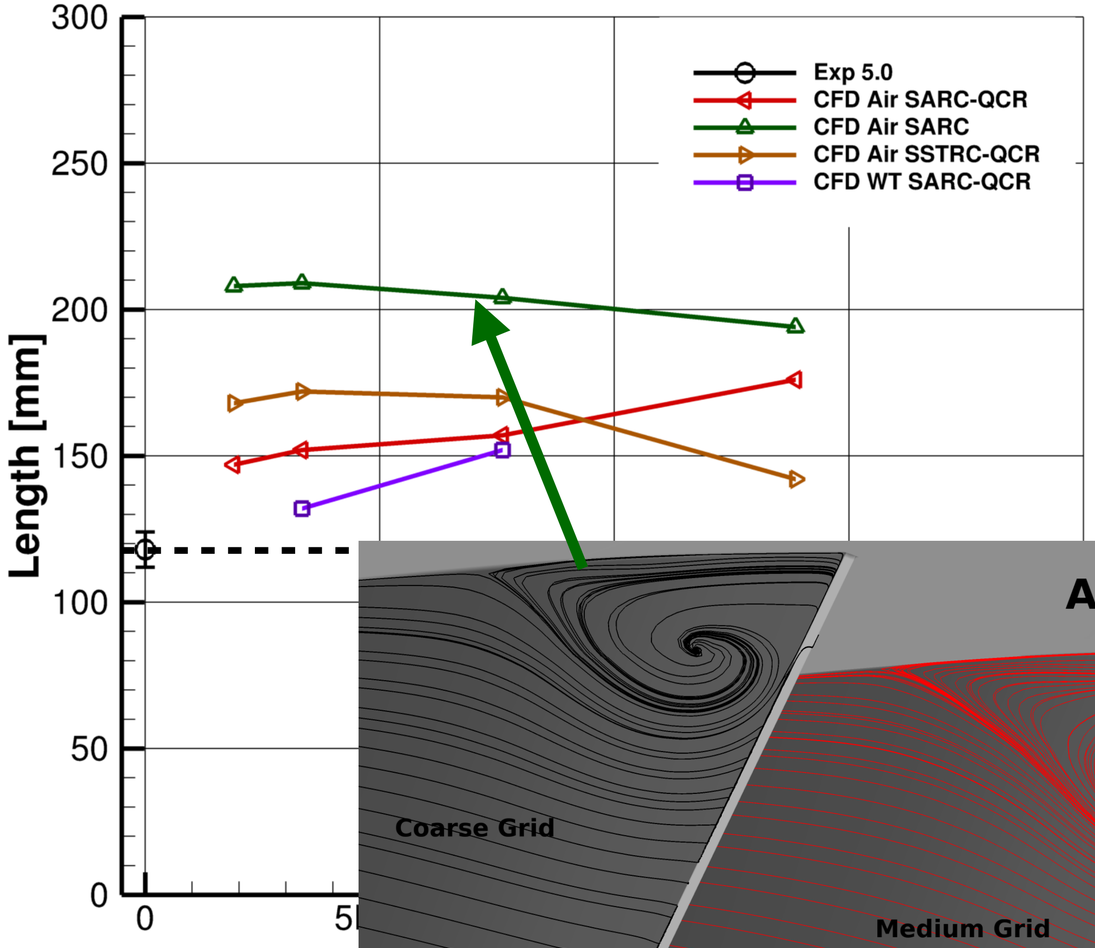

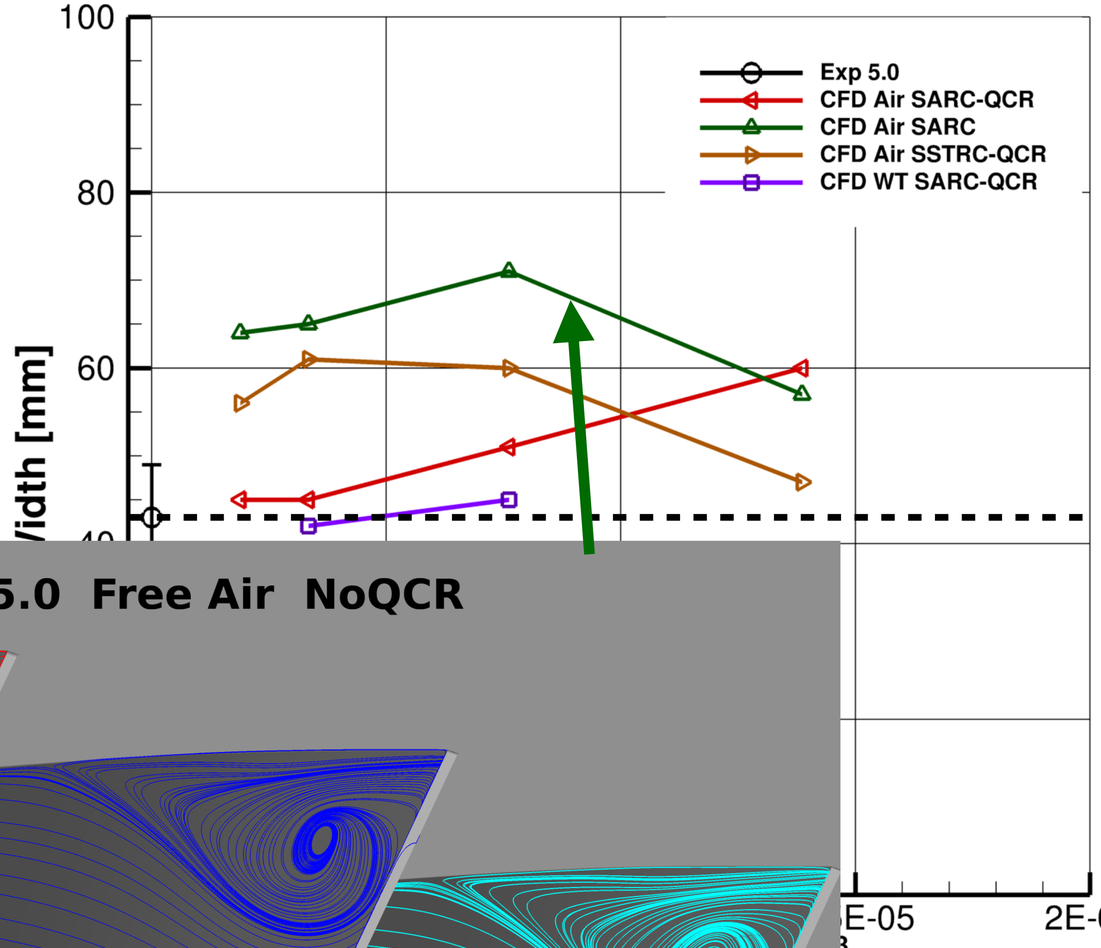

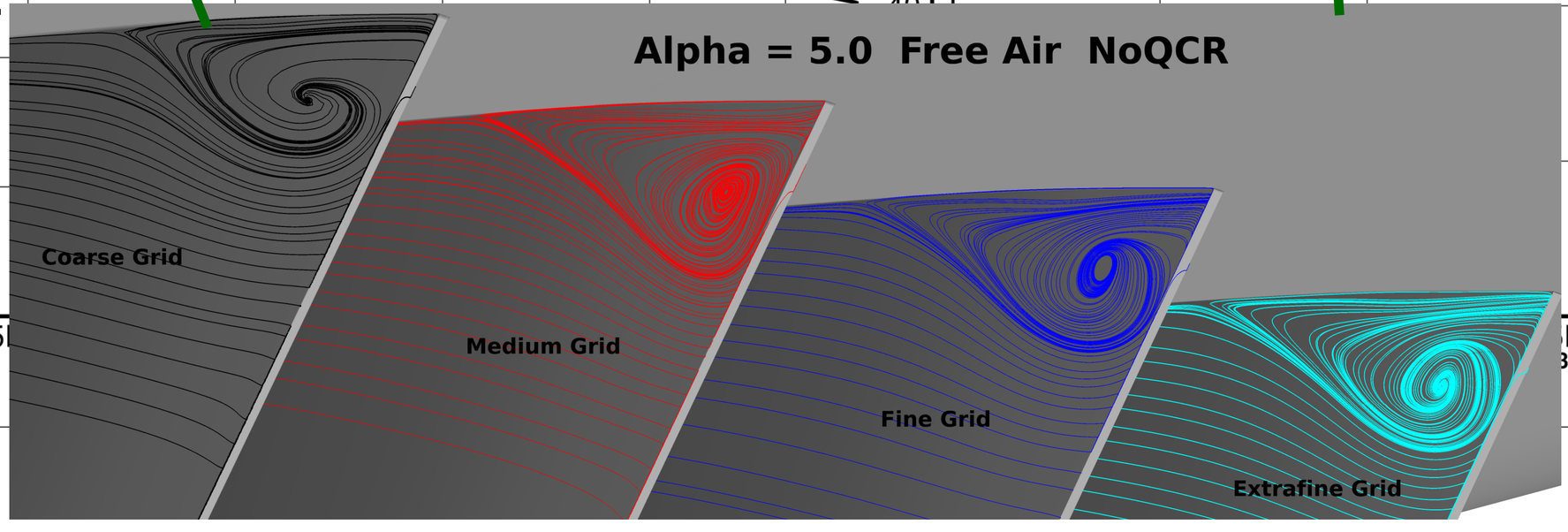

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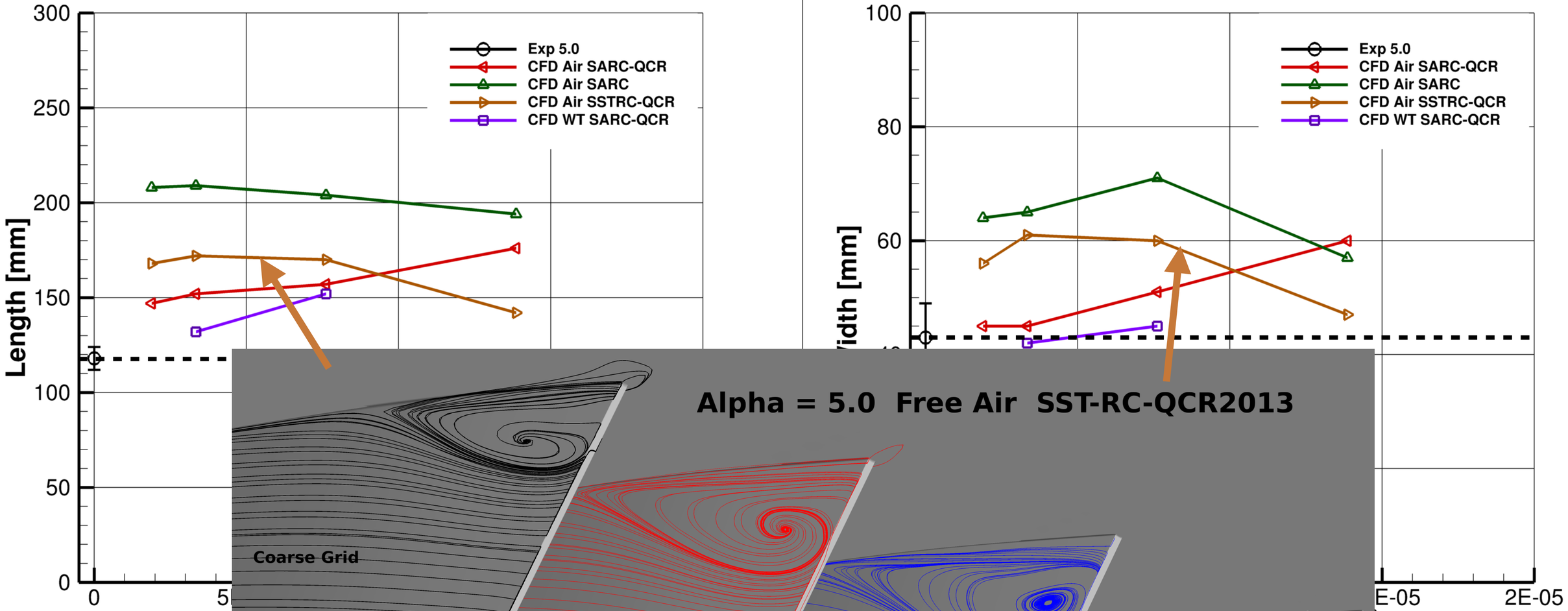

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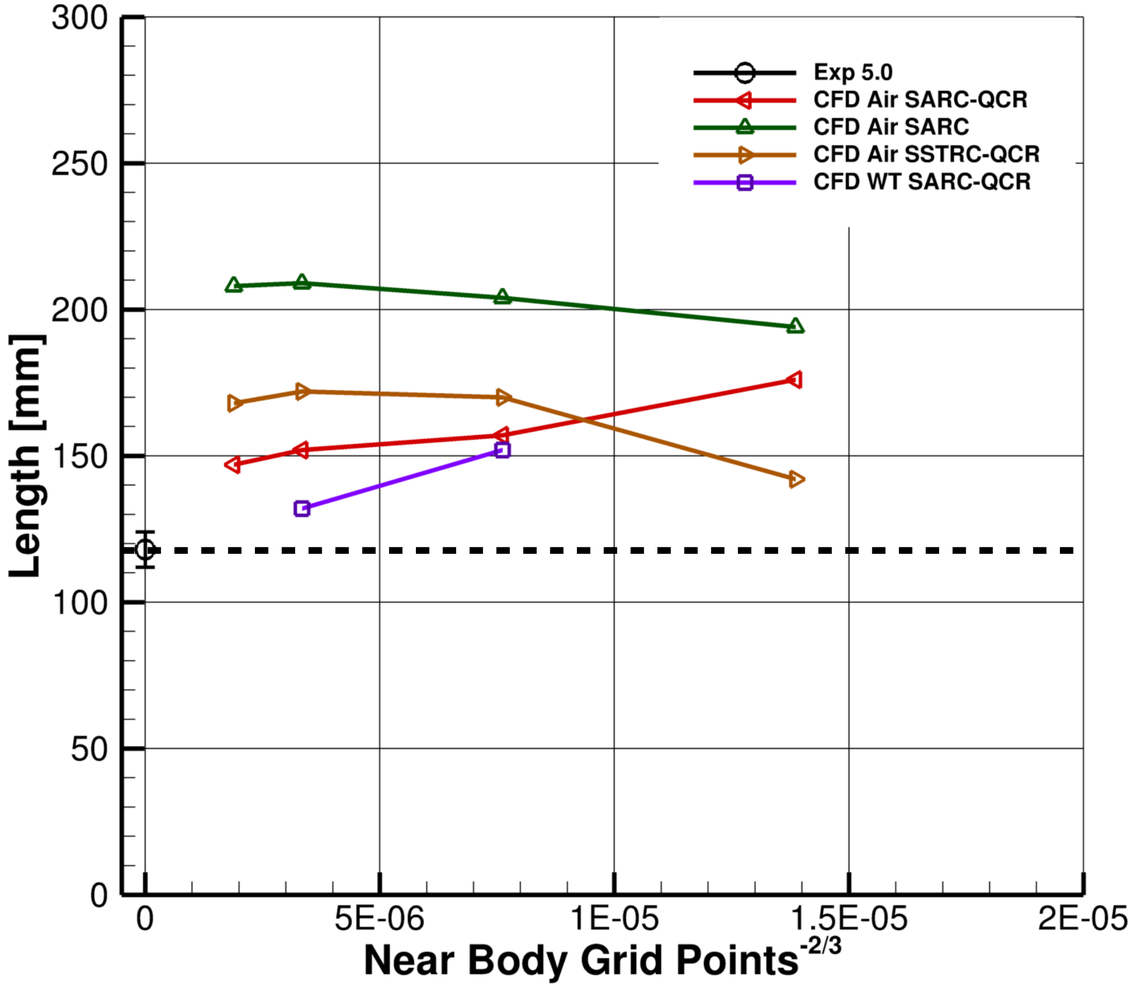
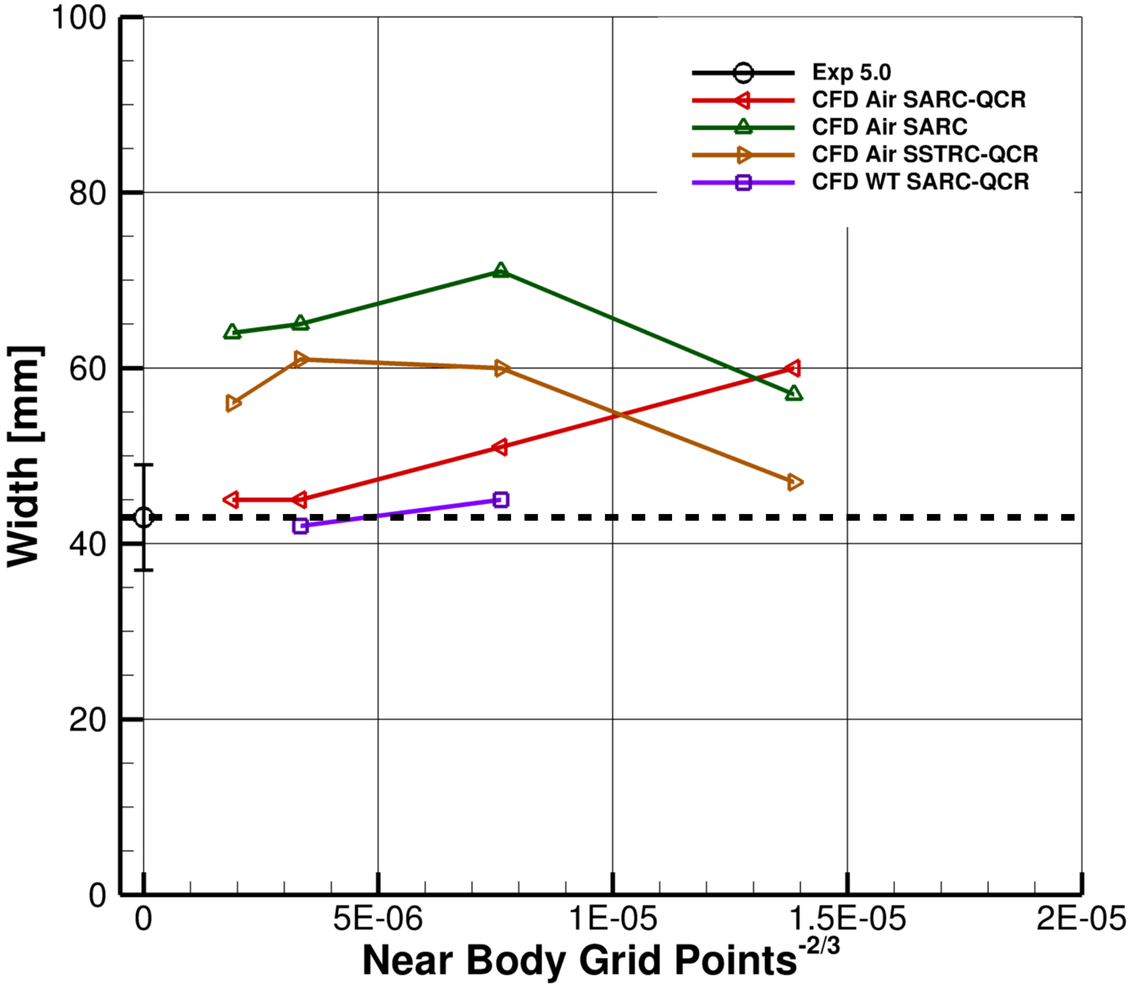
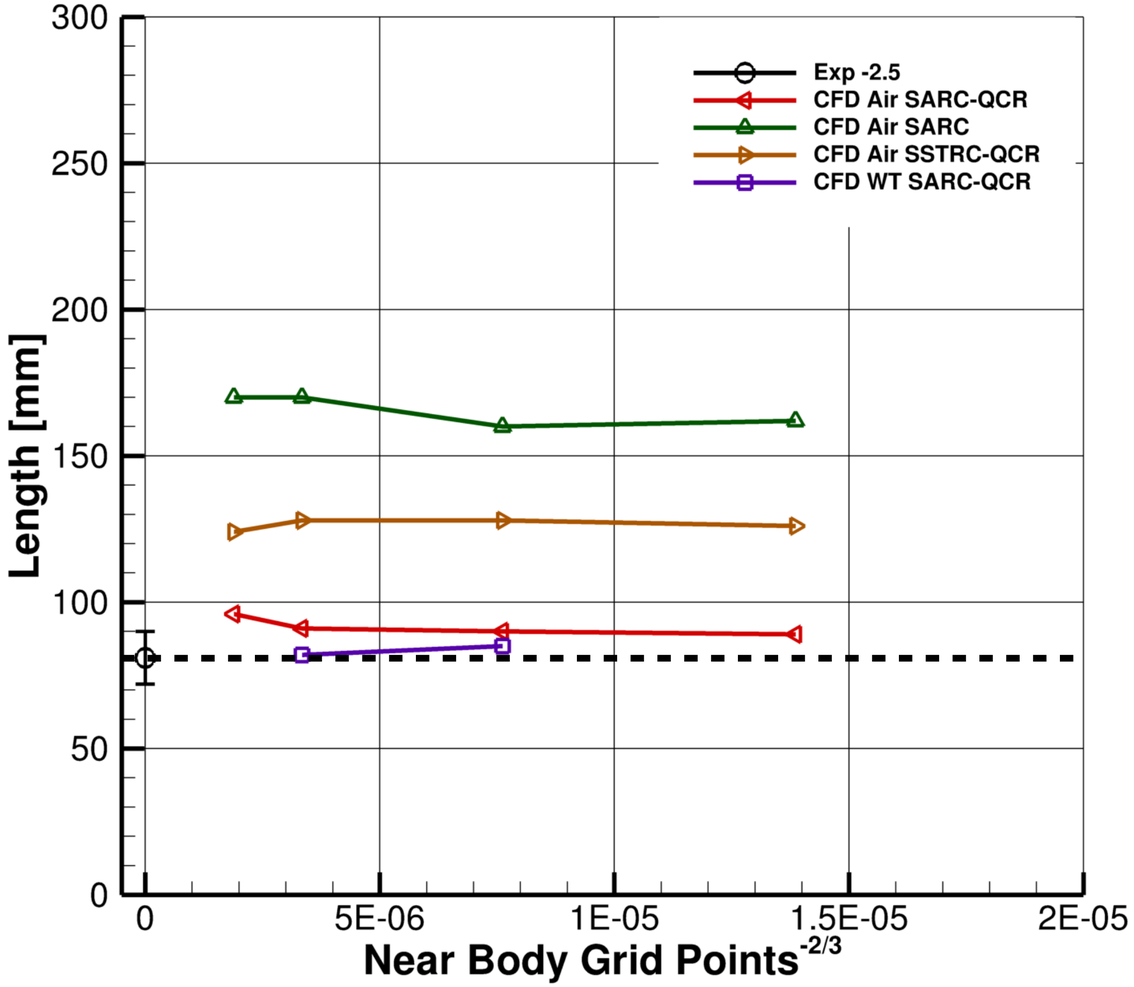
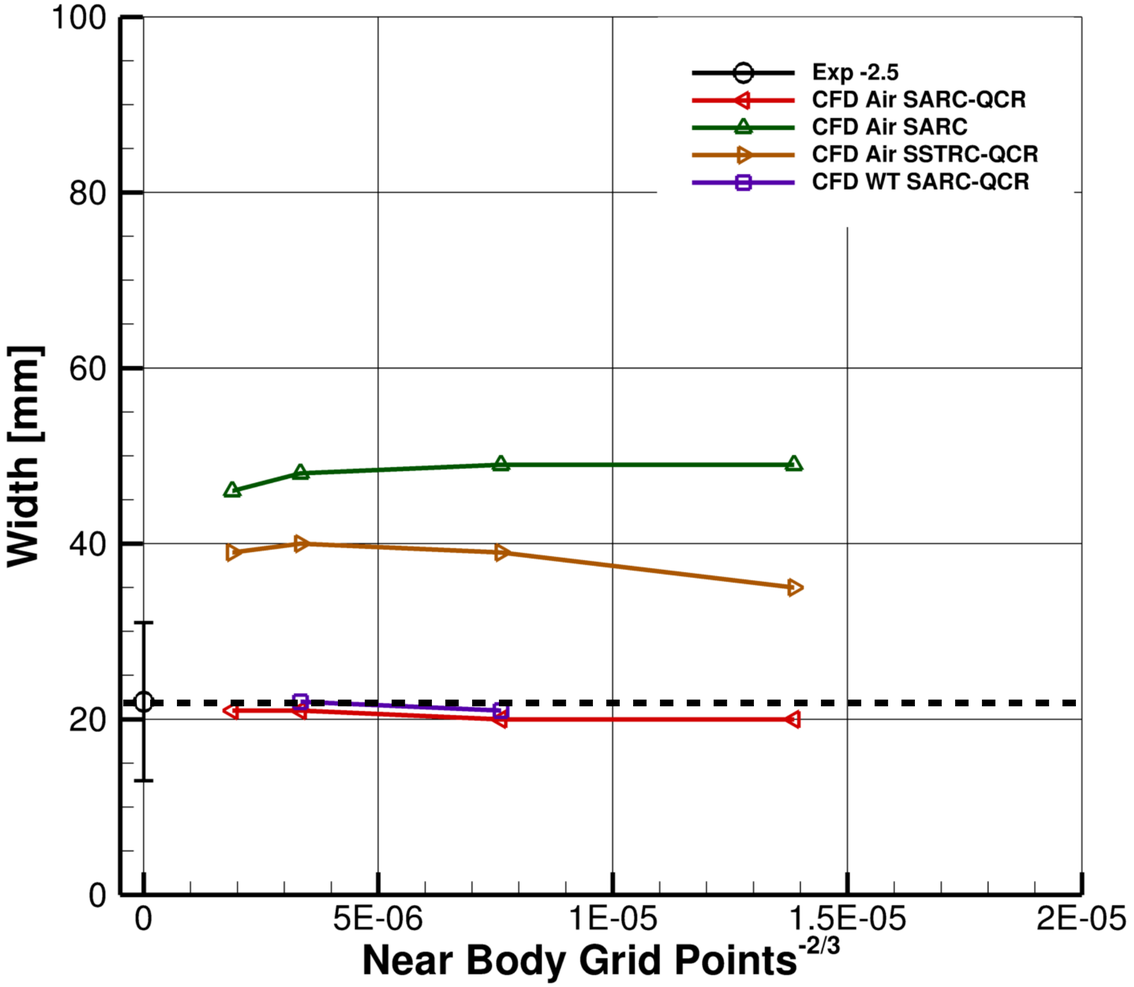


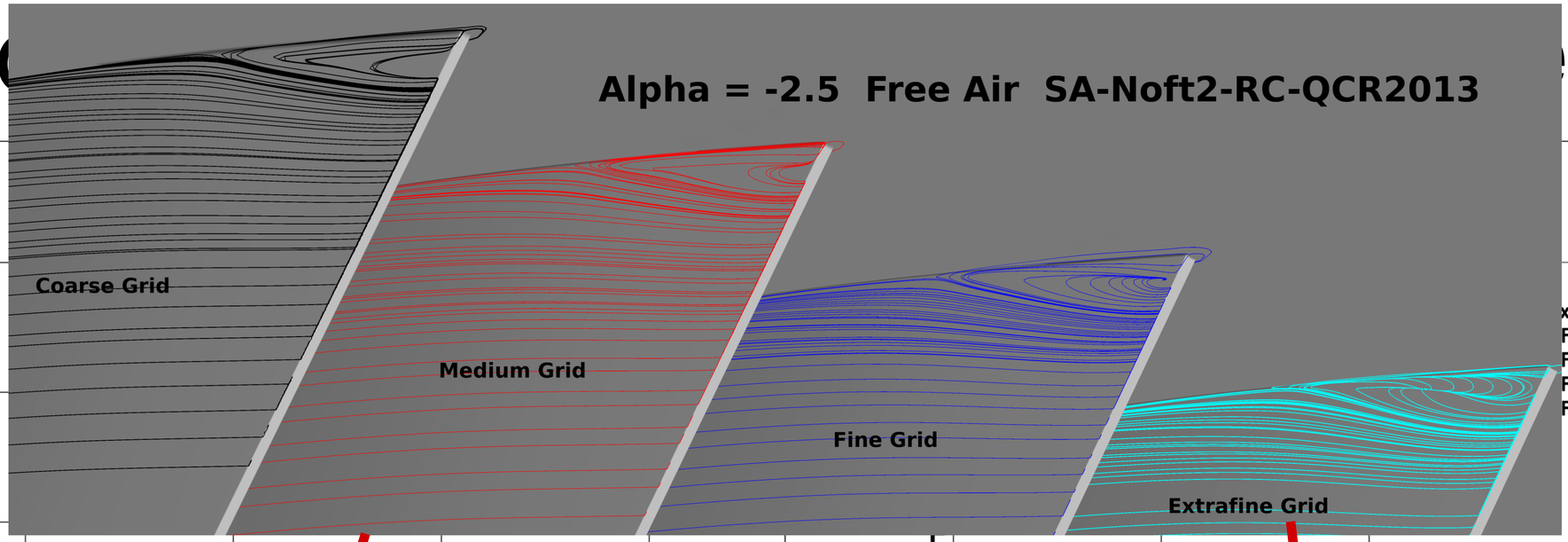


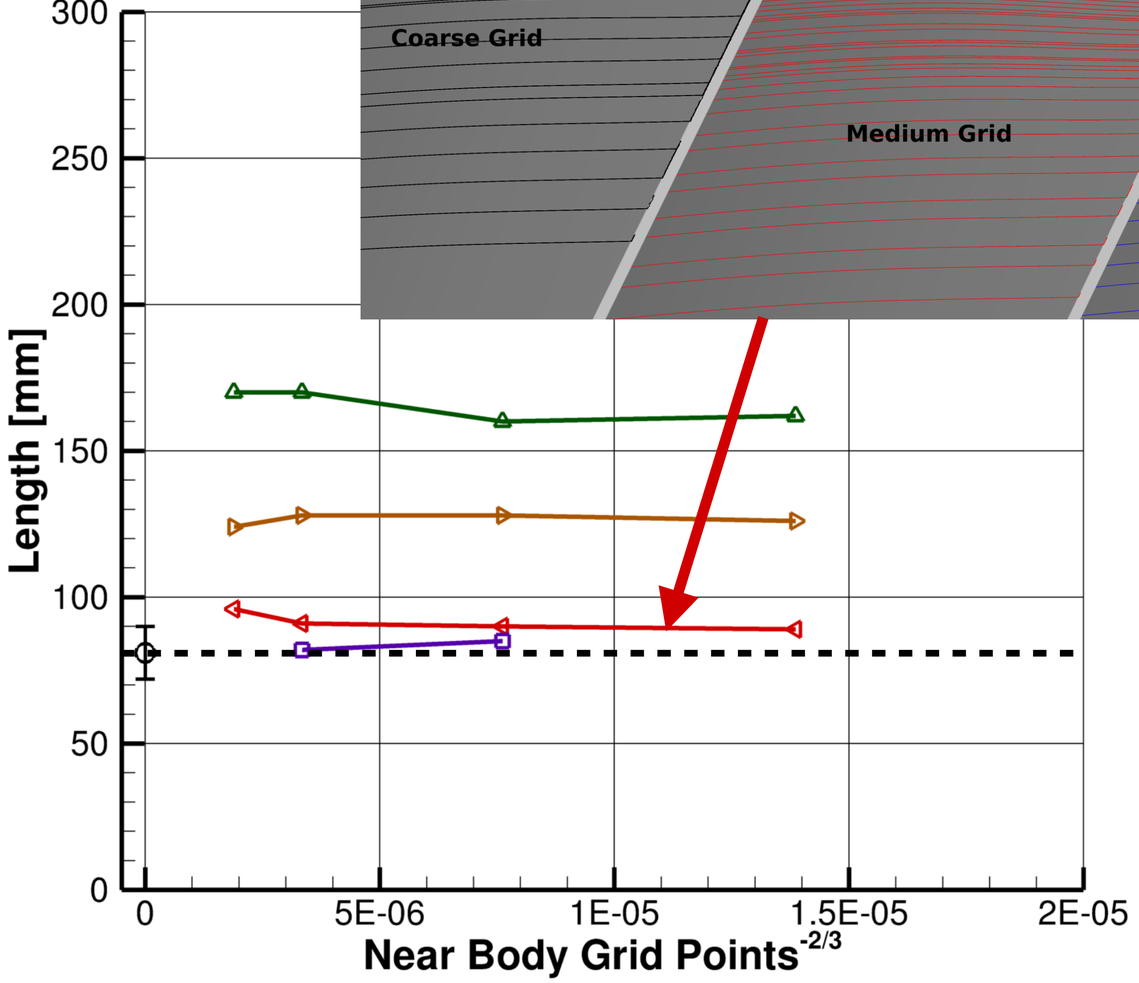
Side of Body Separation AOA = -2.5 deg

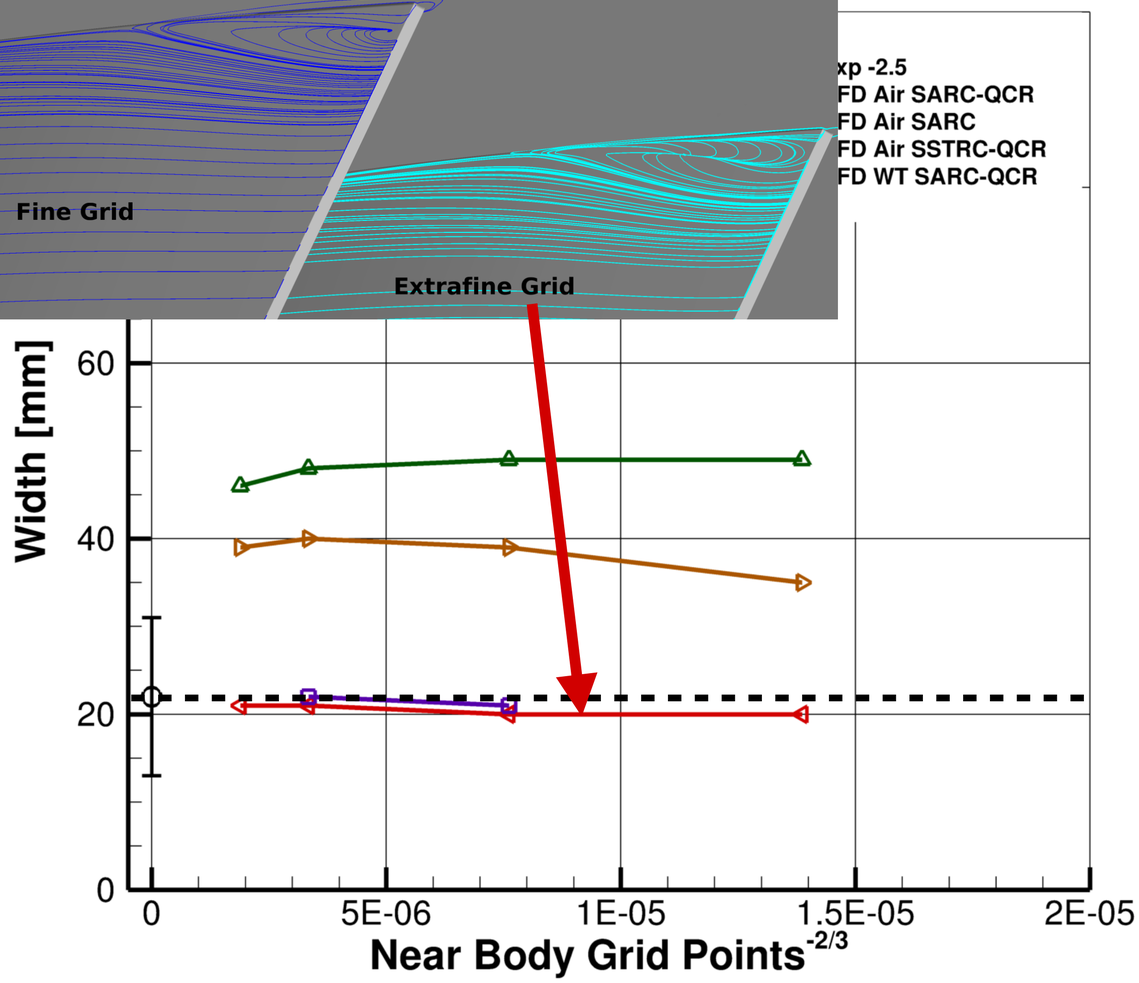




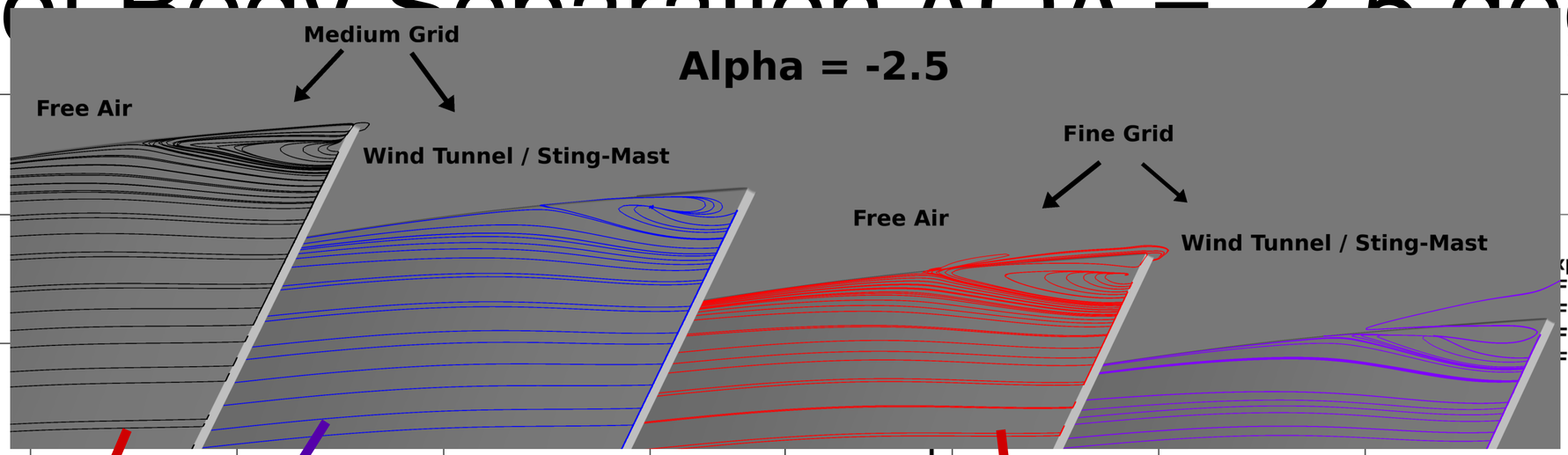
Side

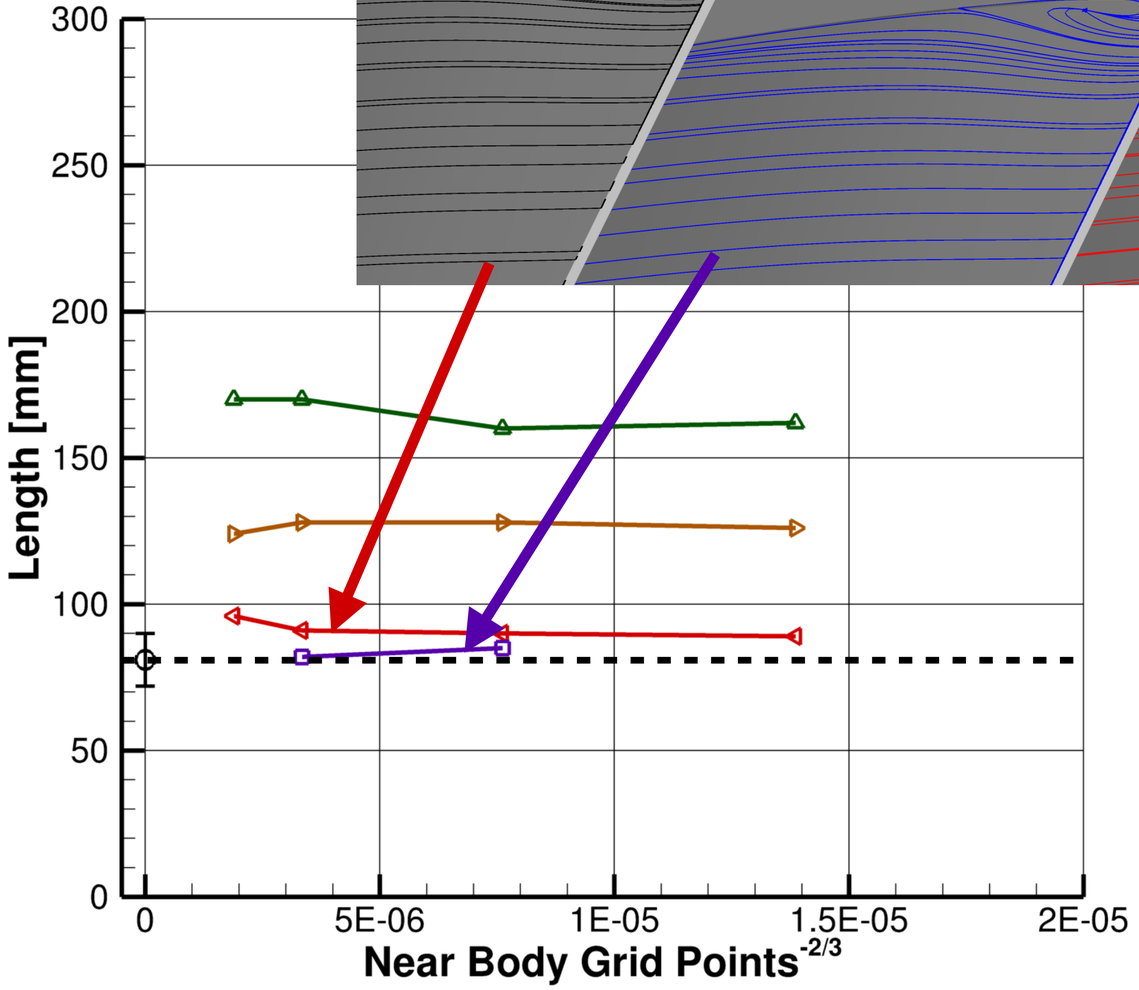

Alpha = -2.5 Free Air SA-Noft2-RC-QCR2013
Coarse Grid
Medium Grid
Fine Grid
Extrafine Grid

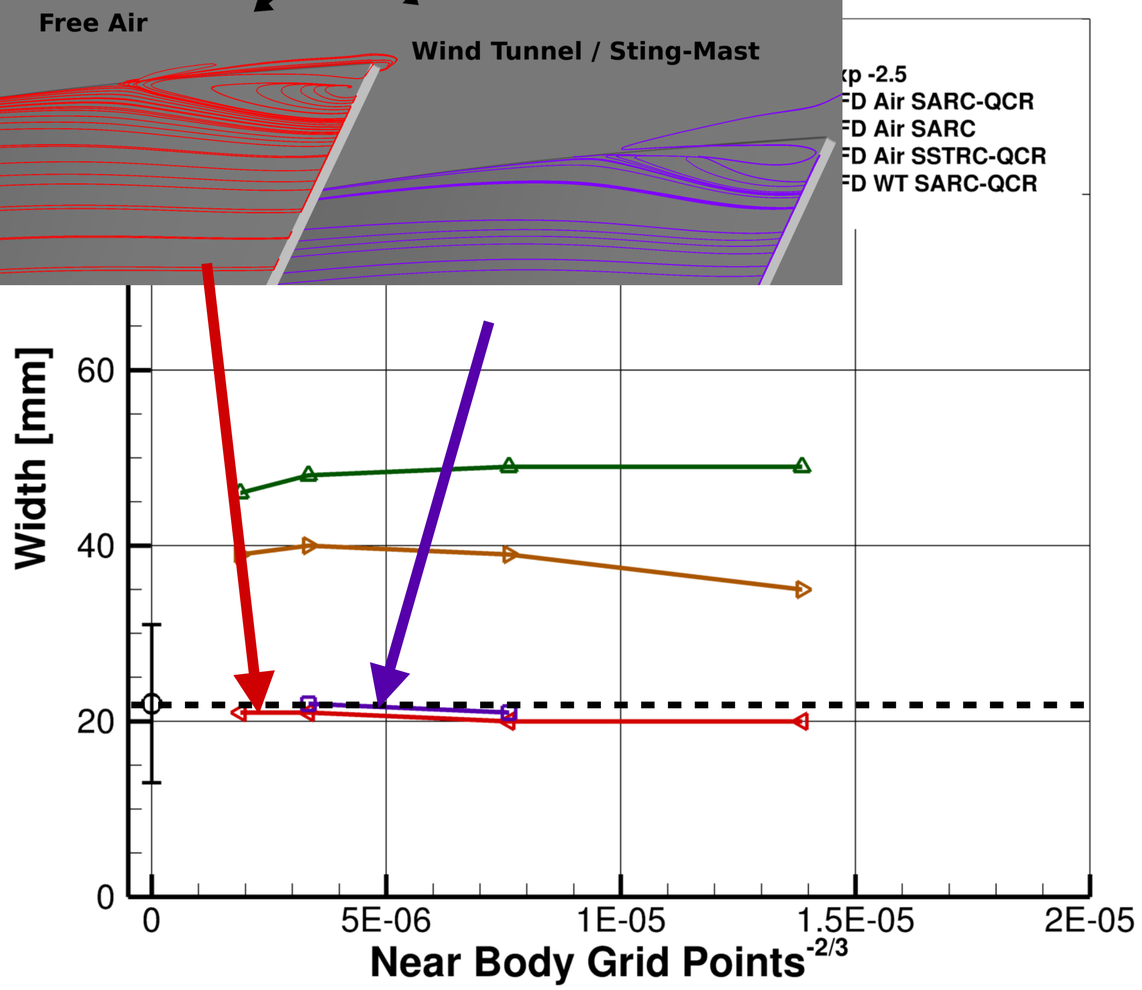

Length [mm]
300
250
200
150
100
50
0
0
5E-06
1E-05
1.5E-05
2E-05
Near Body Grid Points-2/3


xp -2.5
FD Air SARC-QCR
FD Air SARC
FD Air SSTRC-QCR
FD WT SARC-QCR
Width [mm]
60
40
20
0
0
5E-06
1E-05
1.5E-05
2E-05
Near Body Grid Points-2/3

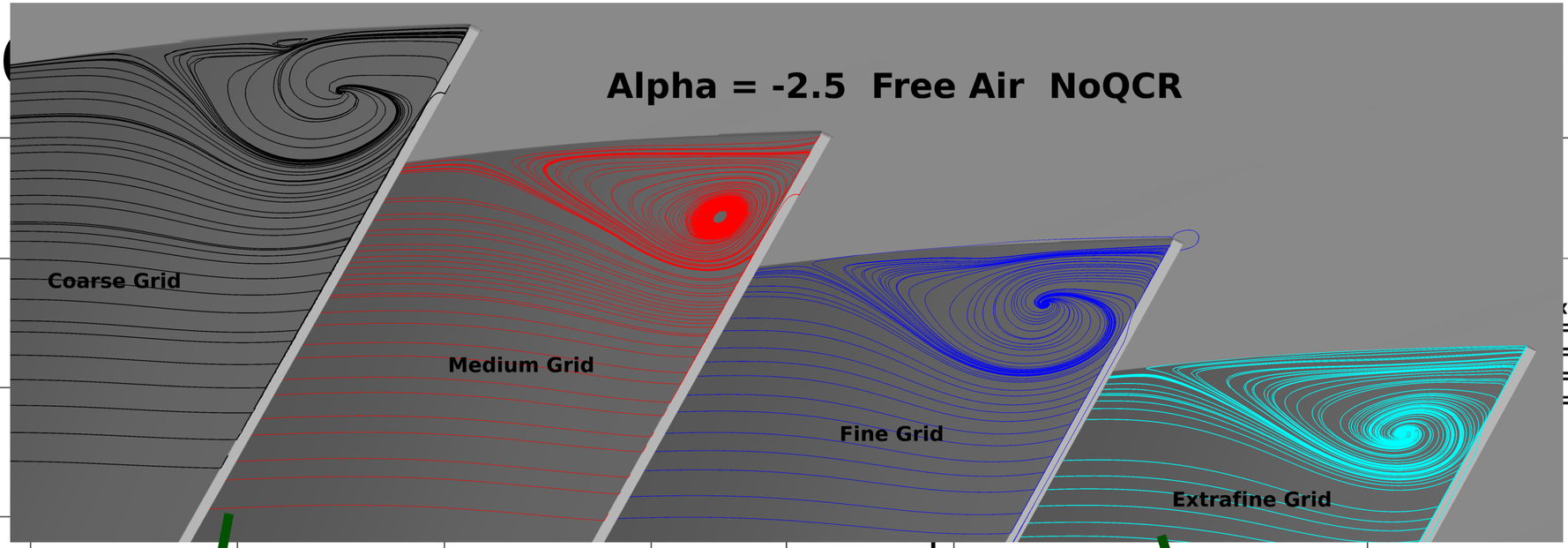
Side of Body Separation AOA = -2.5 deg

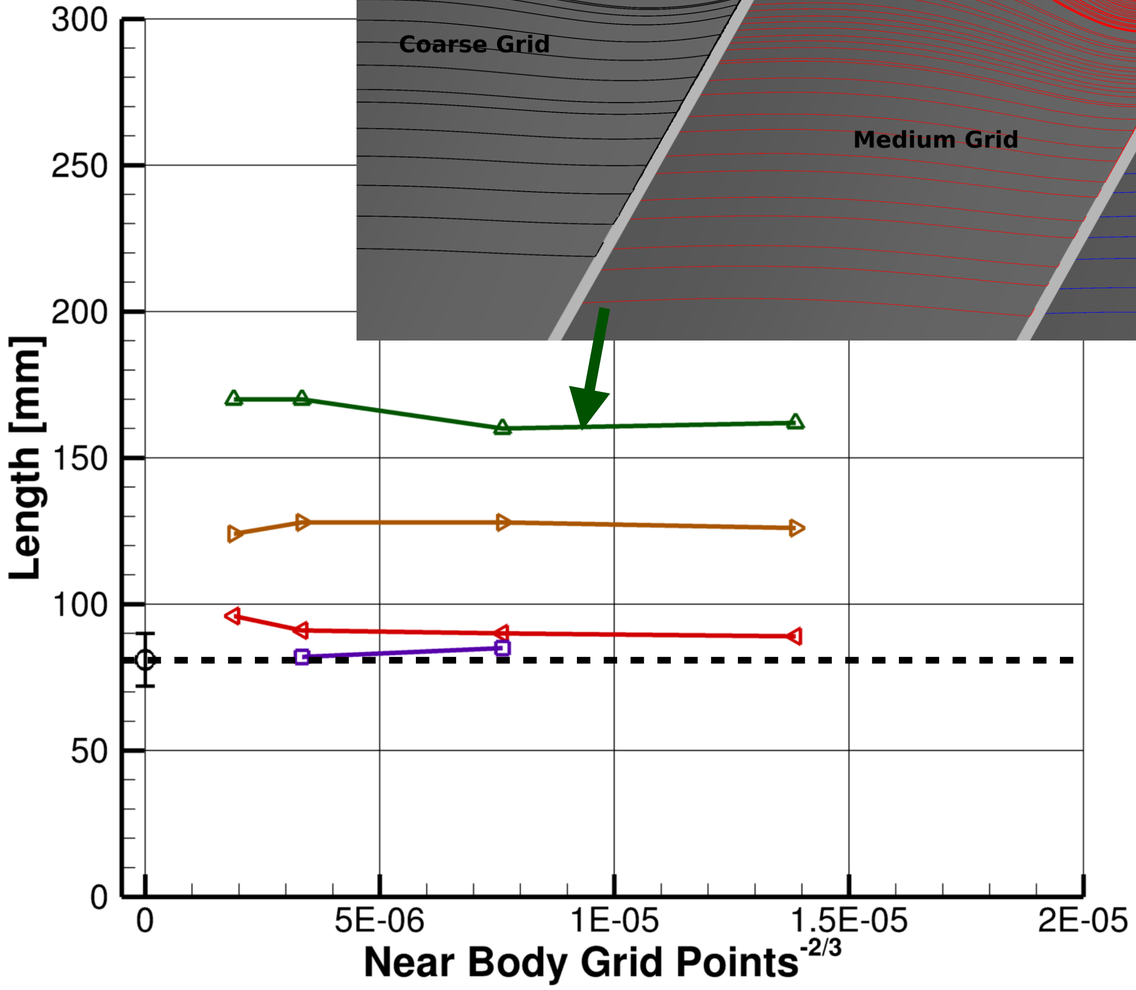


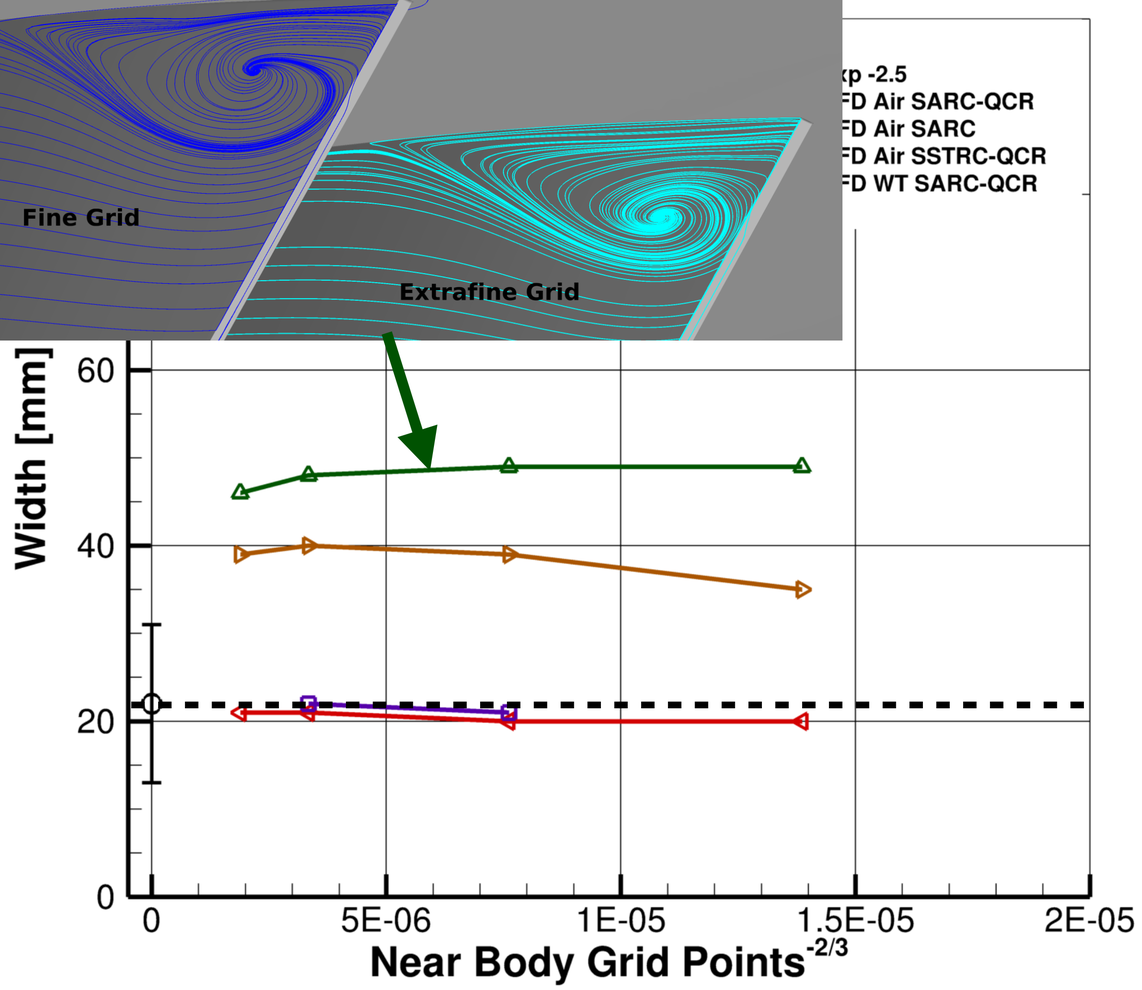




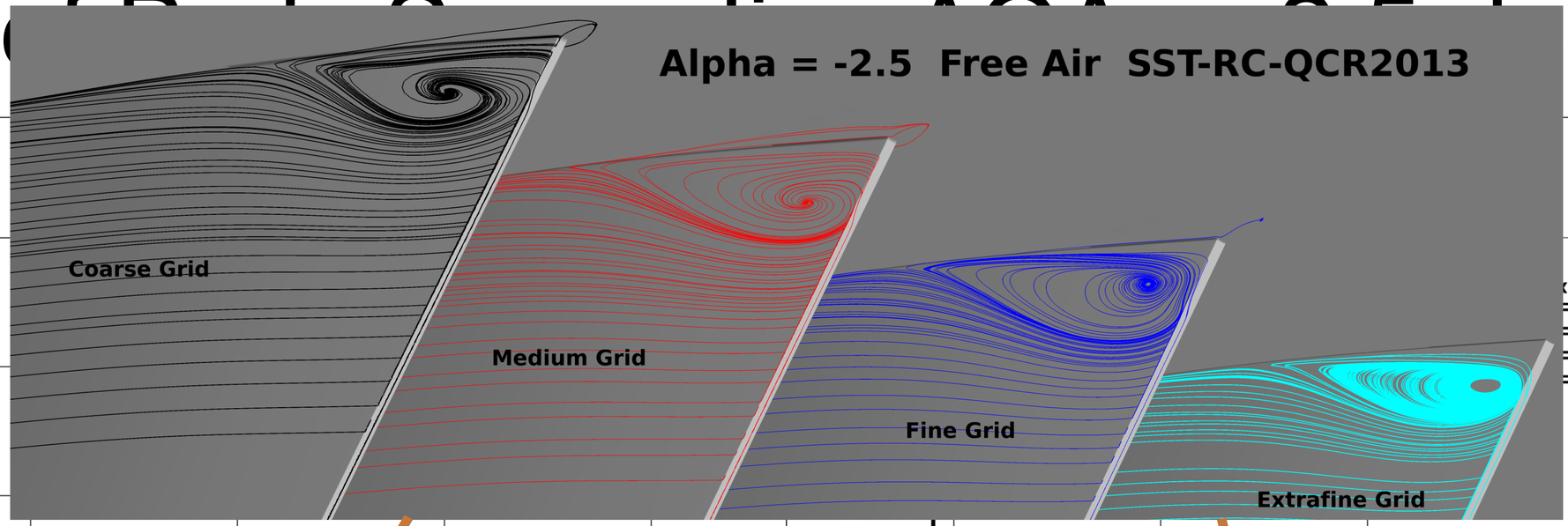
Side g

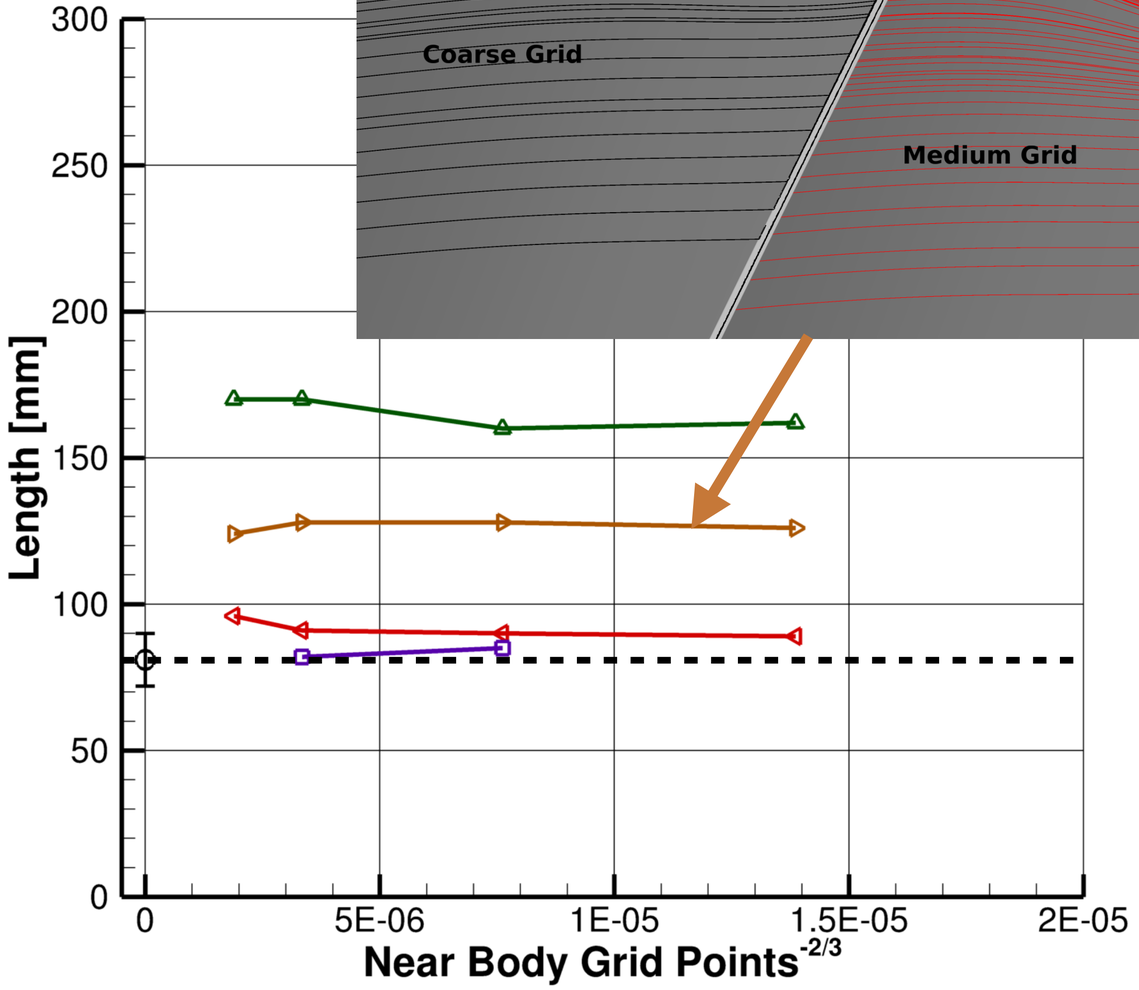

Alpha = -2.5 Free Air NoQCR
Coarse Grid
Medium Grid
Fine Grid
Extrafine Grid

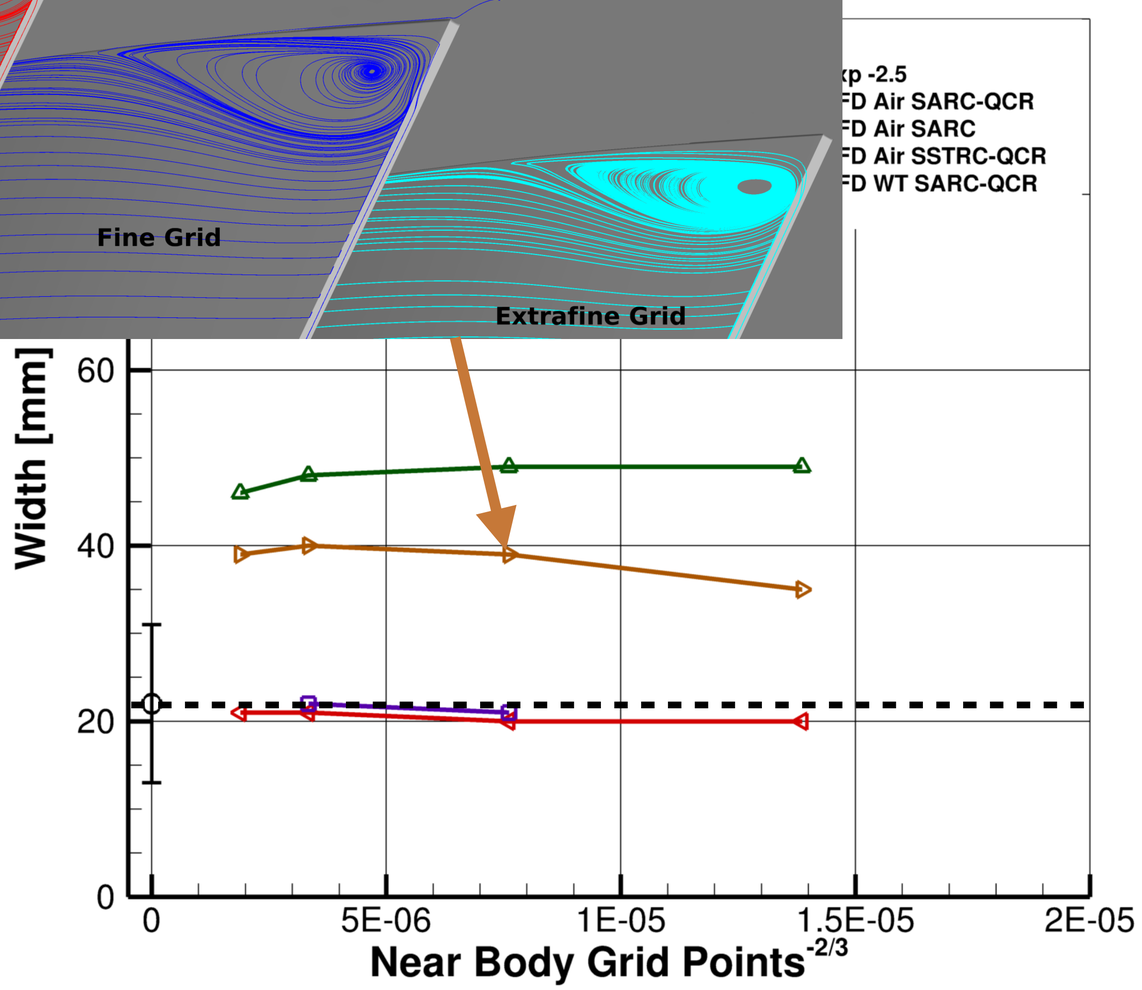

Length [mm]
300
250
200
150
100
50
0
0
5E-06
1E-05
1.5E-05
2E-05
Near Body Grid Points-2/3


xp -2.5
FD Air SARC-QCR
FD Air SARC
FD Air SSTRC-QCR
FD WT SARC-QCR
Width [mm]
60
40
20
0
0
5E-06
1E-05
1.5E-05
2E-05
Near Body Grid Points-2/3

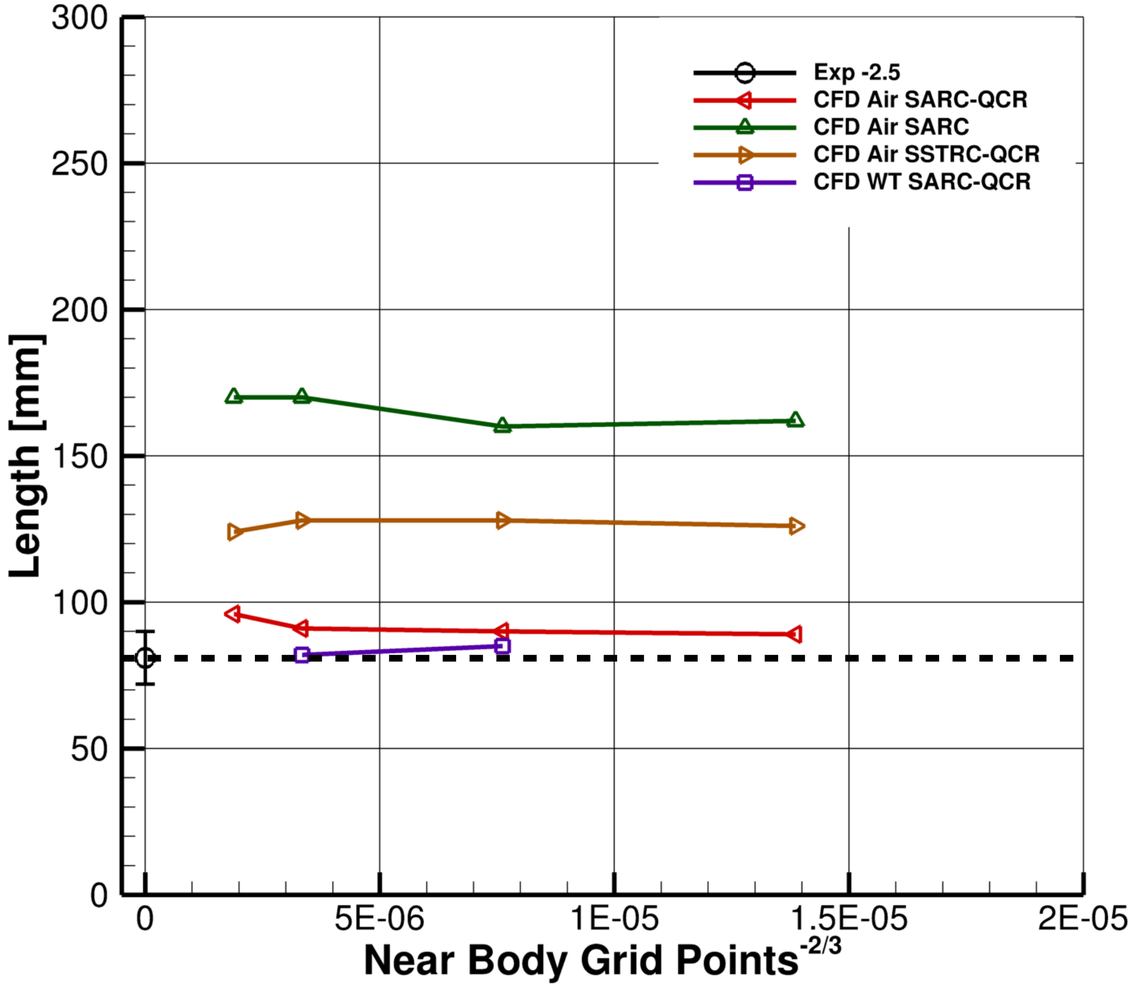
Side of Body Separation AOA = -2.5 deg

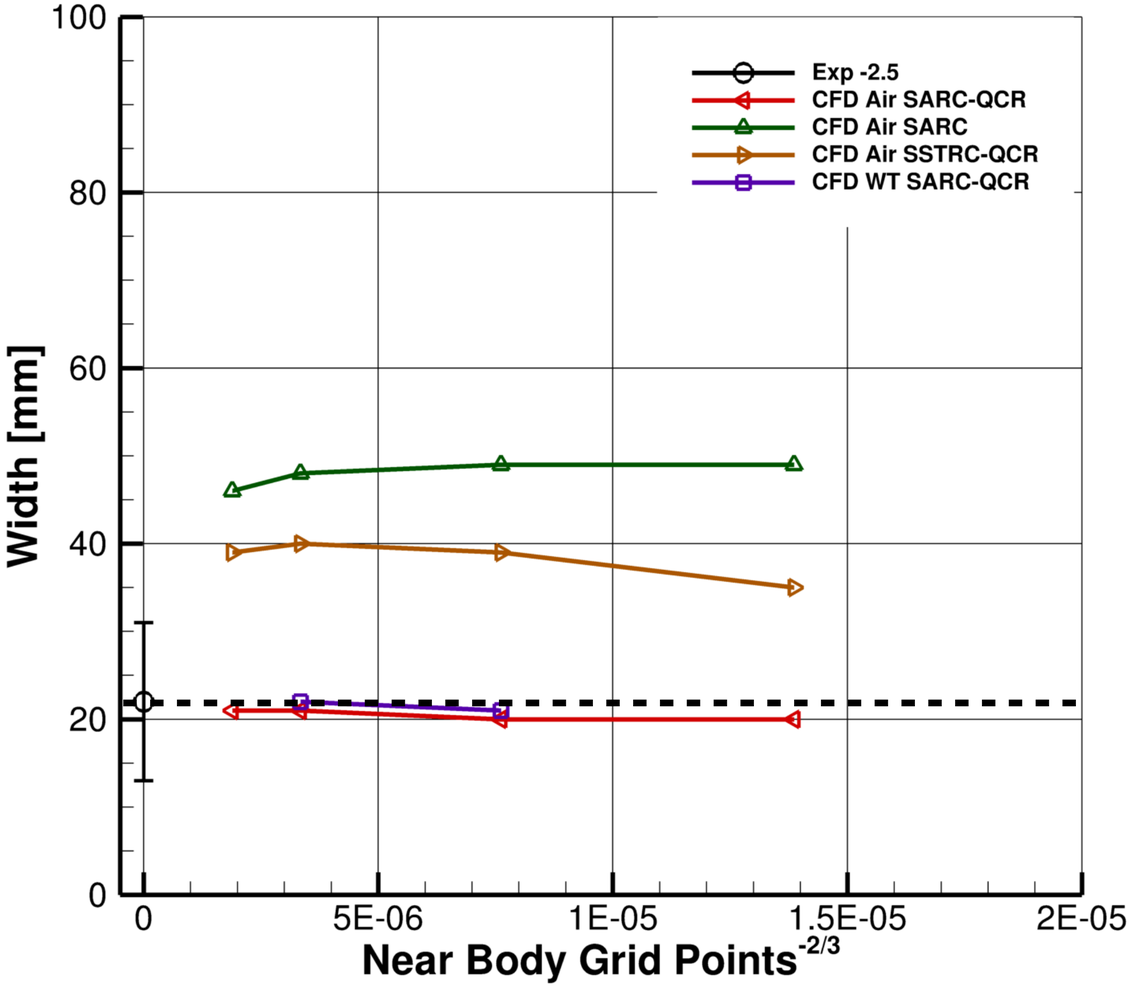




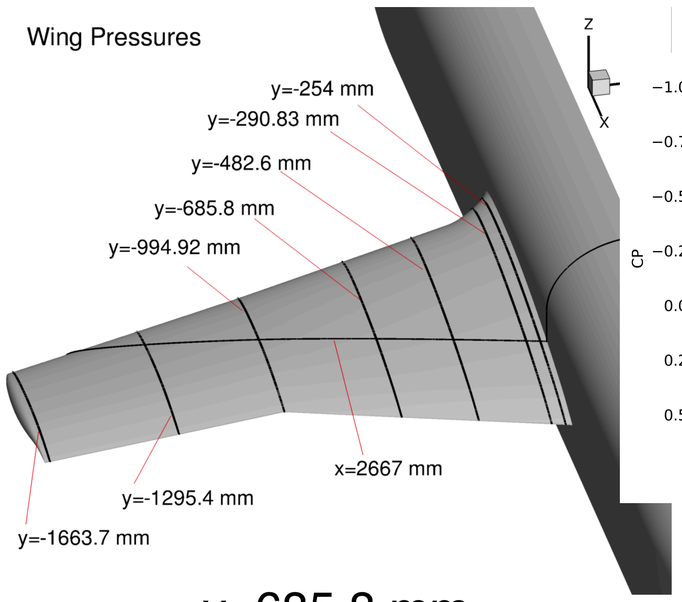


Side of Body Separation AOA = -2.5 deg

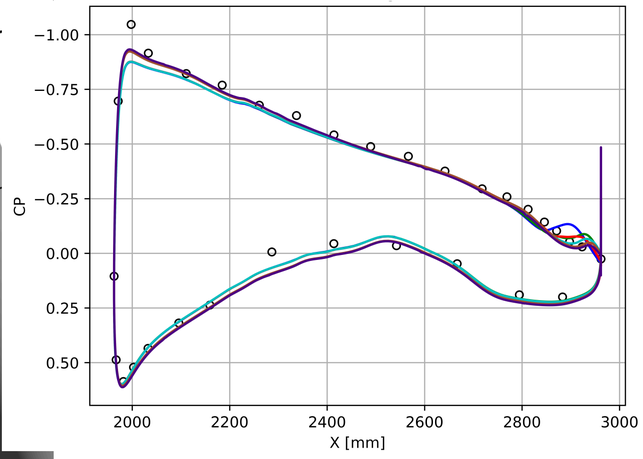




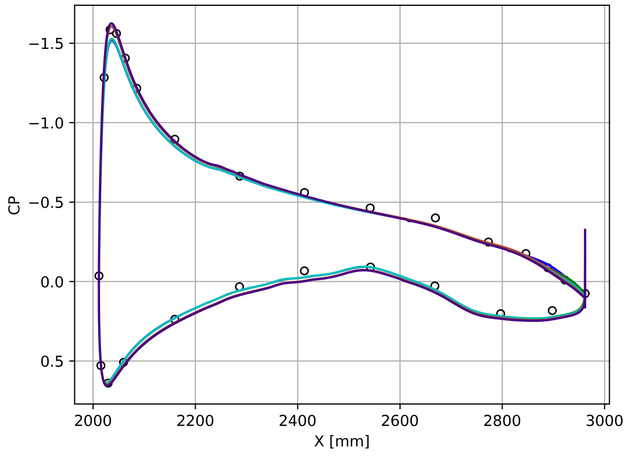
Wing Pressures, AOA = 5.0 deg



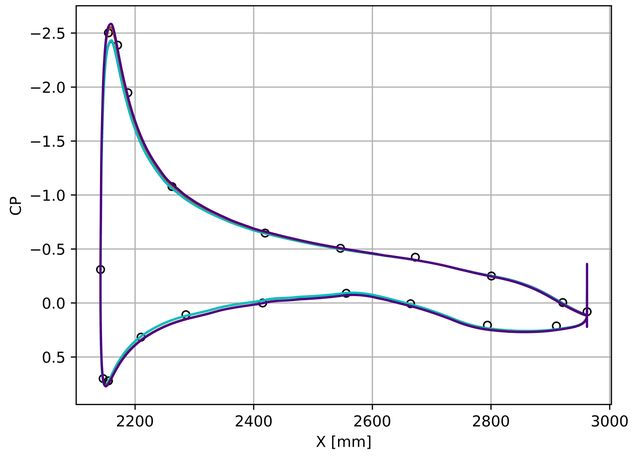
y=254.0 mm



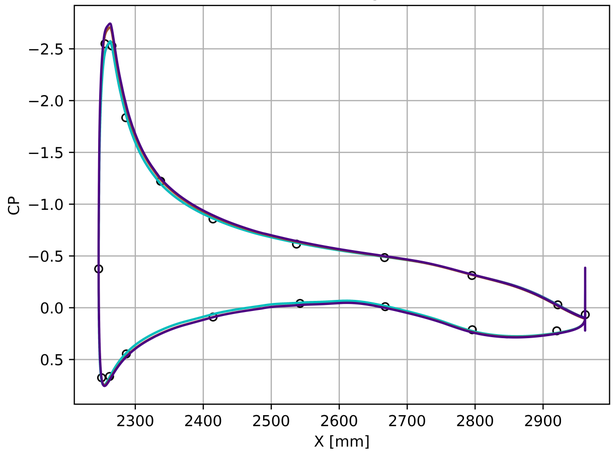
y=290.83 mm



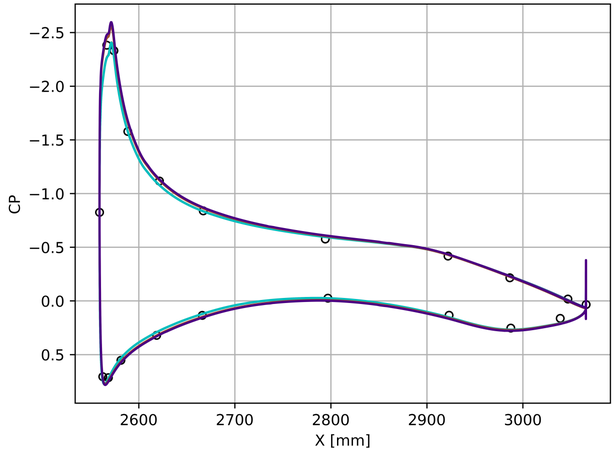
y=482.6 mm



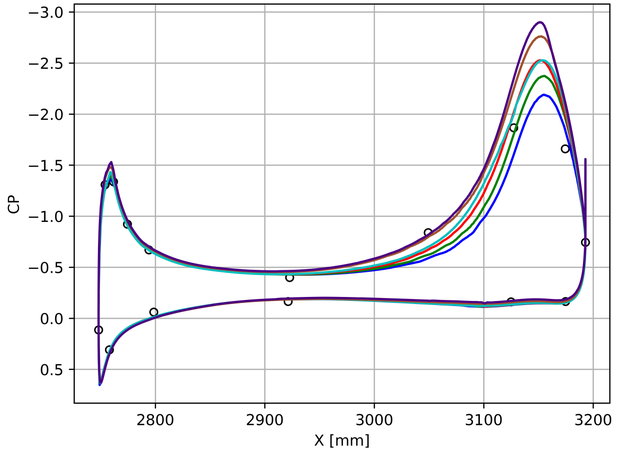
y=685.8 mm



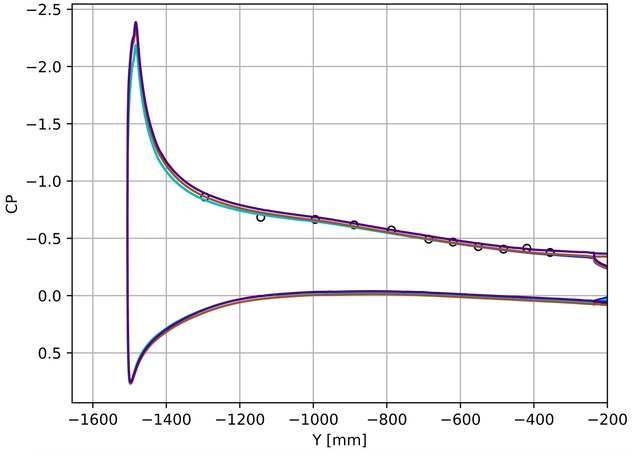
y=1295.4 mm



y=1663.7 mm

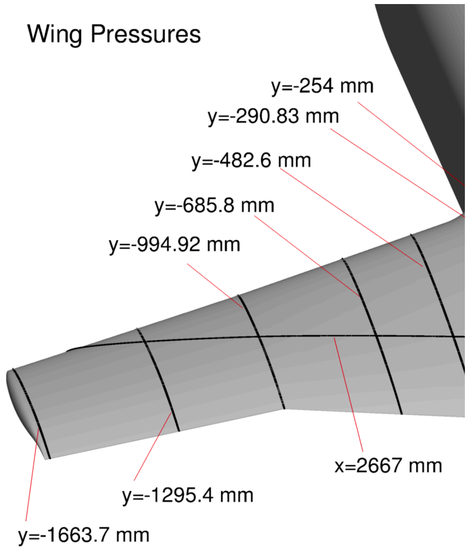


x=2667 mm

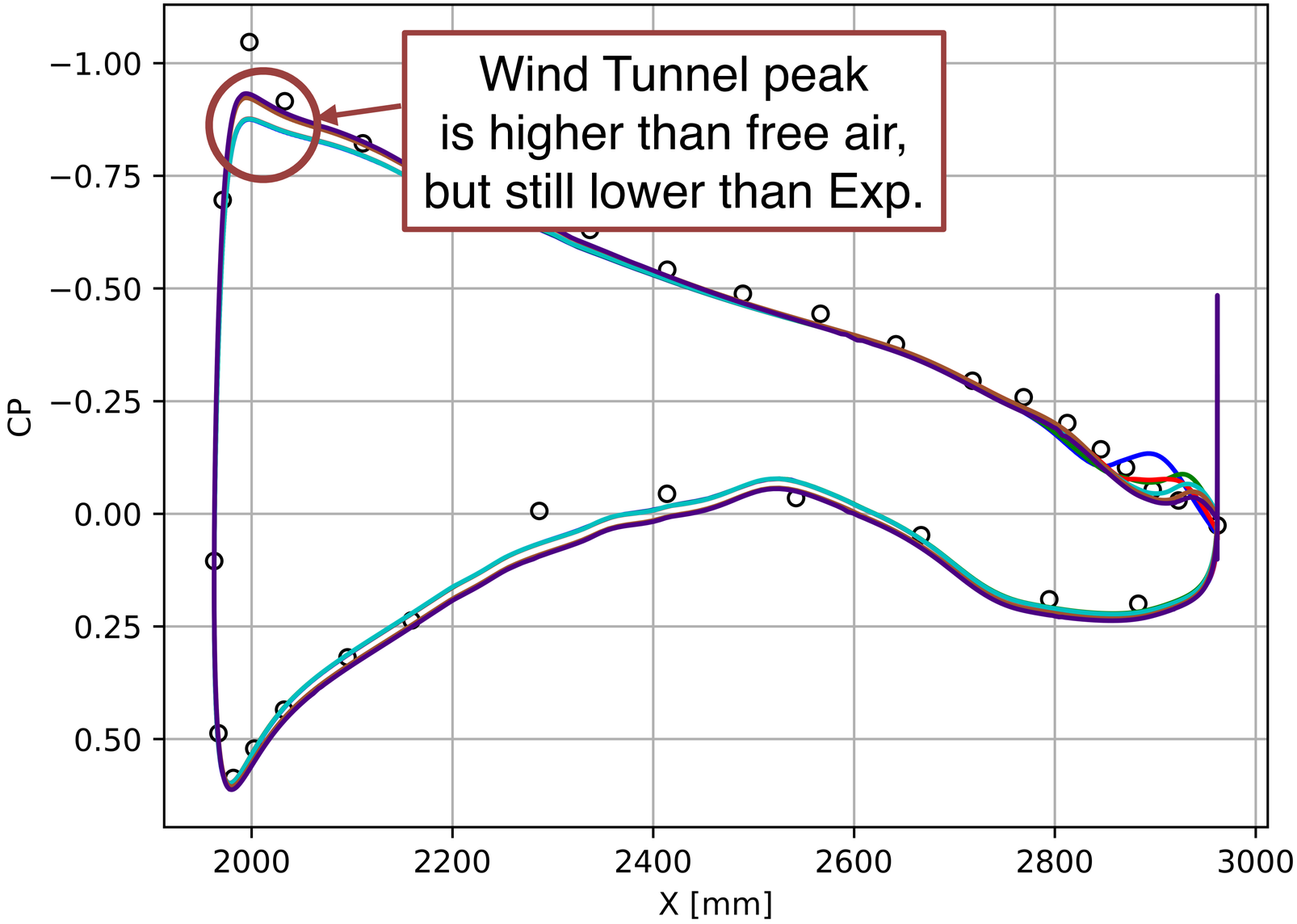


Experiment
CFD Coarse
CFD Medium
CFD Fine
CFD ExtraFine
CFD-WT+SM Medium
CFD-WT+SM Fine

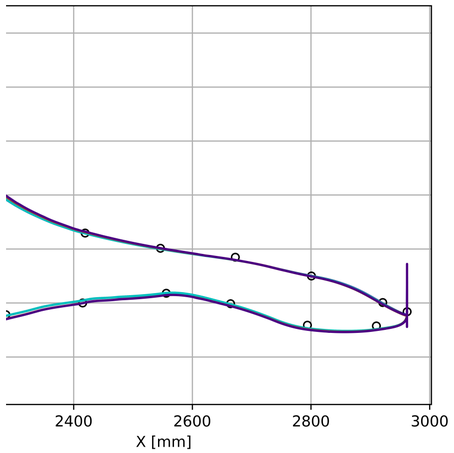
Wing Pressures, AOA = 5.0 deg



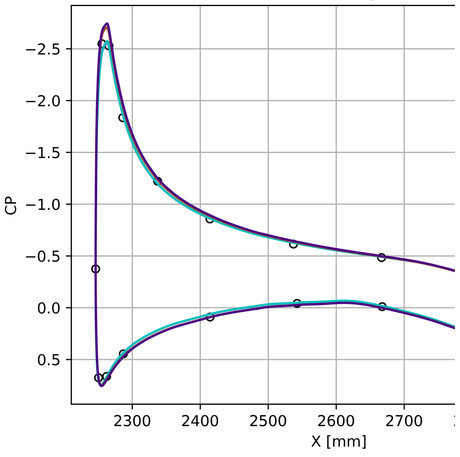
Wind Tunnel peak
is higher than free air,
but still lower than Exp.



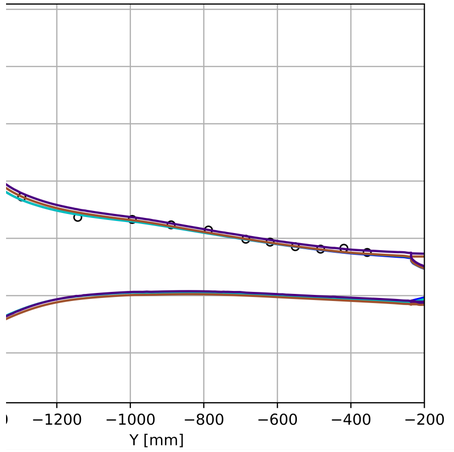
y=482.6 mm



y=685.8 mm

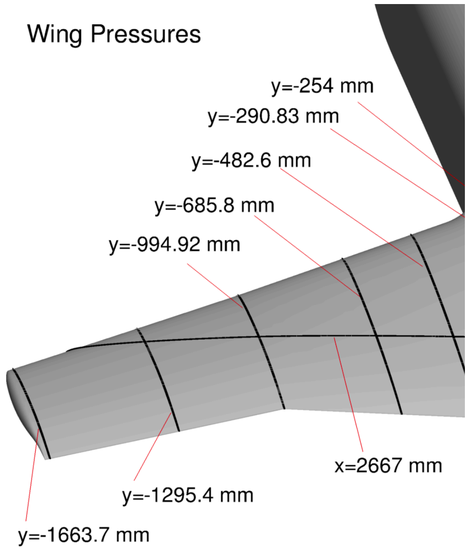


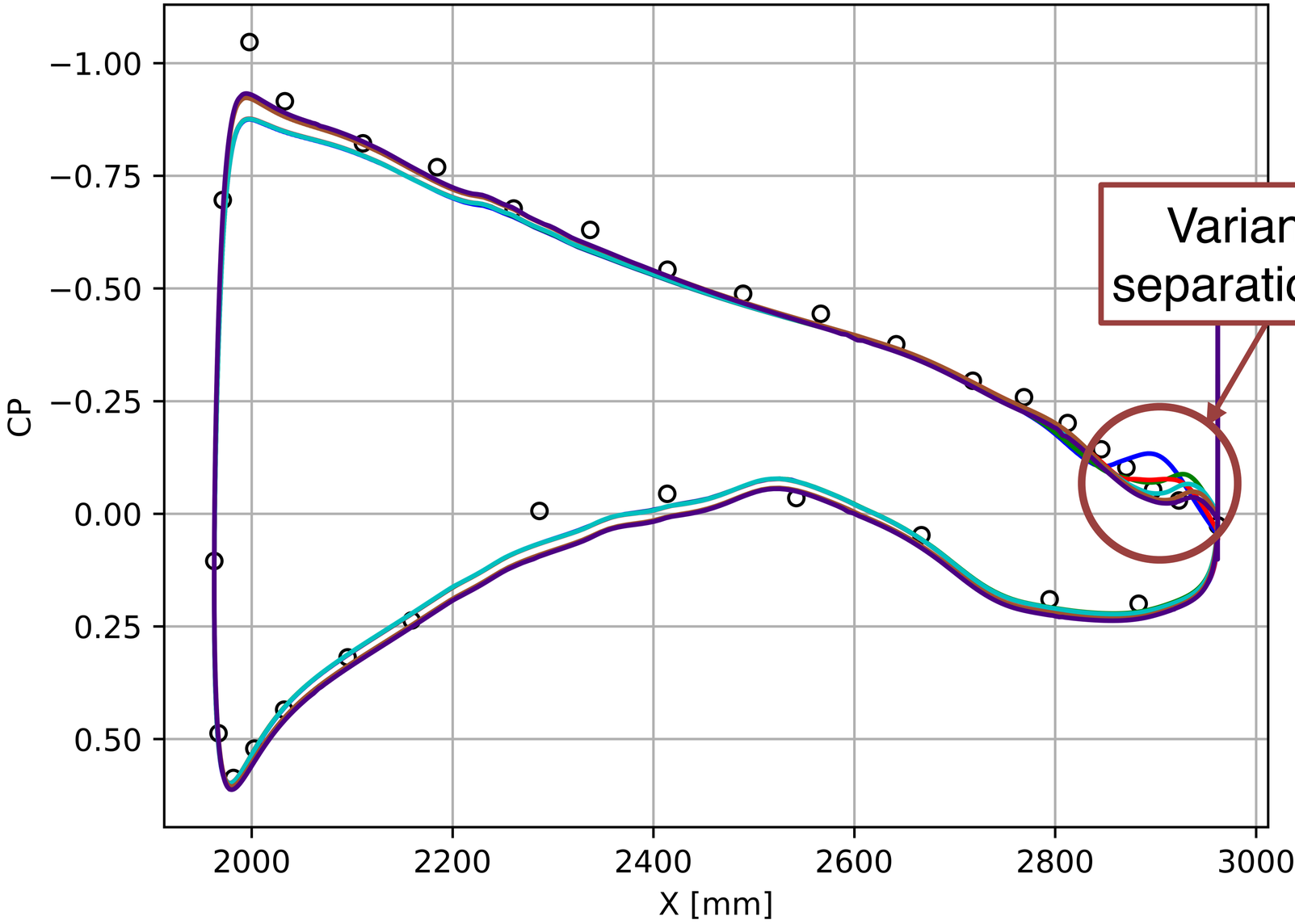
x=2667 mm



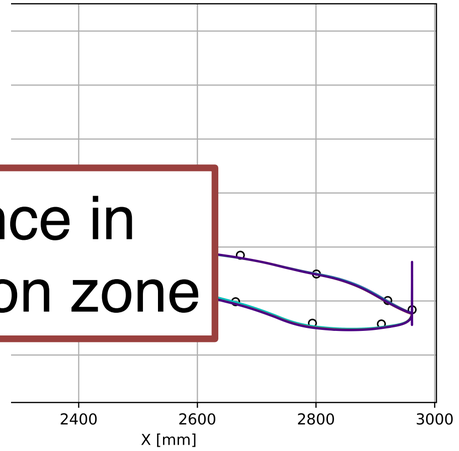
Experiment
CFD Coarse
CFD Medium
CFD Fine
CFD ExtraFine
CFD-WT+SM Medium
CFD-WT+SM Fine

Wing Pressures, AOA = 5.0 deg

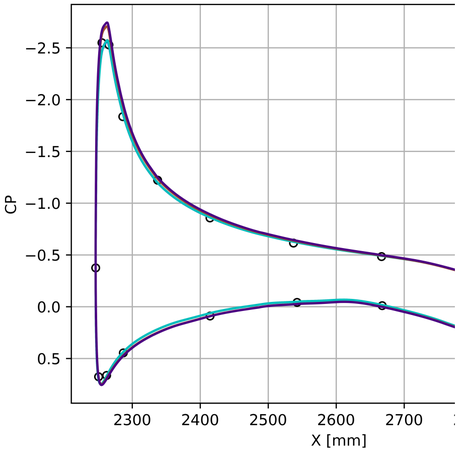




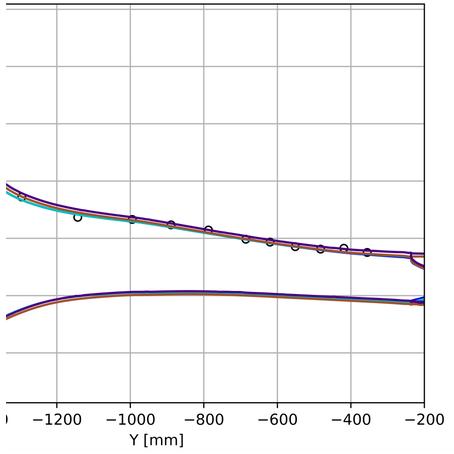
y=482.6 mm



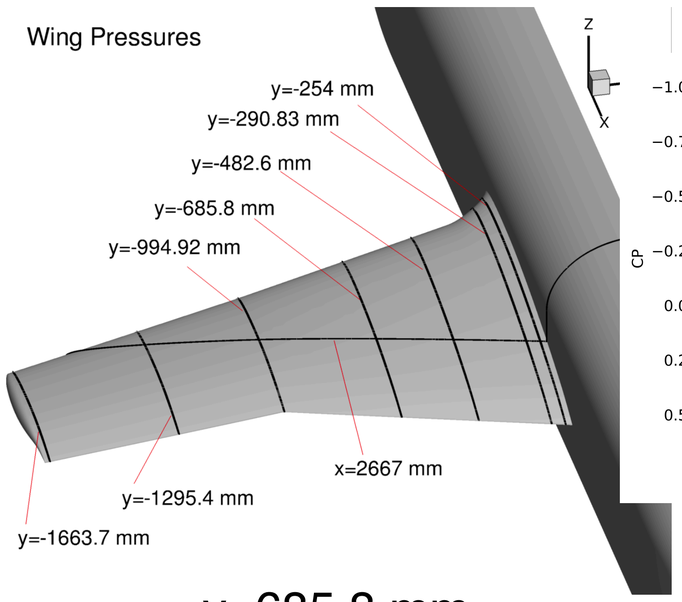
y=685.8 mm



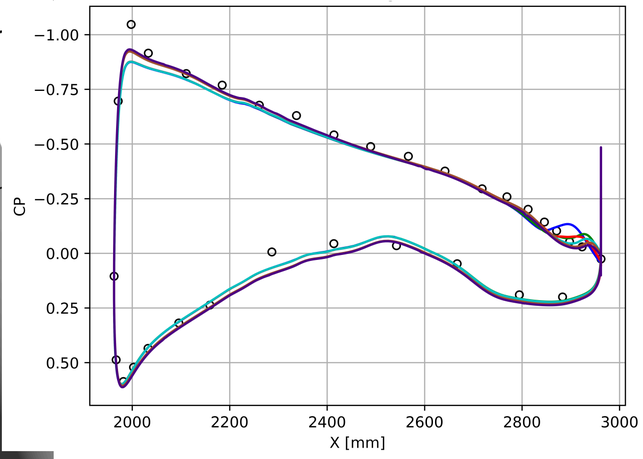
x=2667 mm



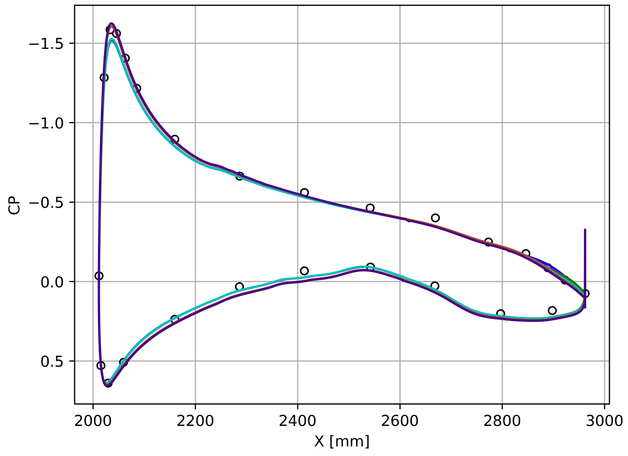
Wing Pressures, AOA = 5.0 deg



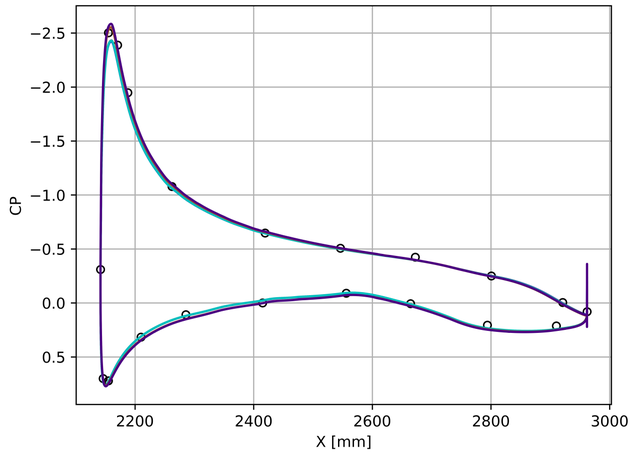
y=254.0 mm



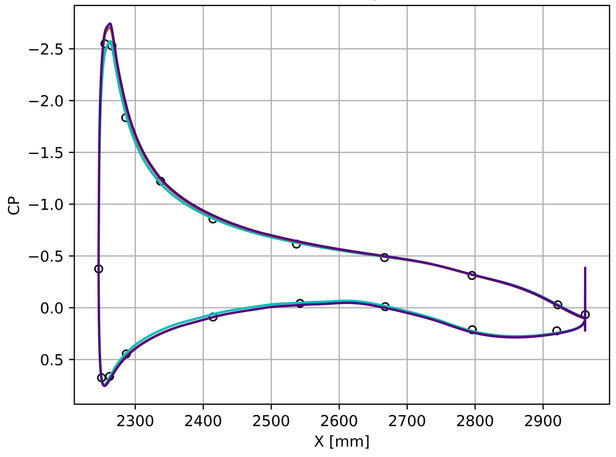
y=290.83 mm



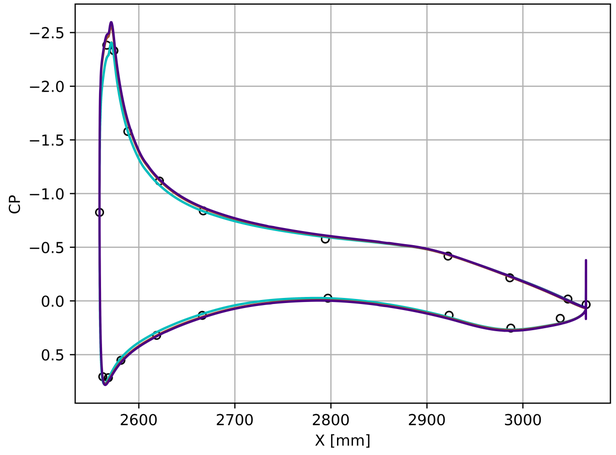
y=482.6 mm



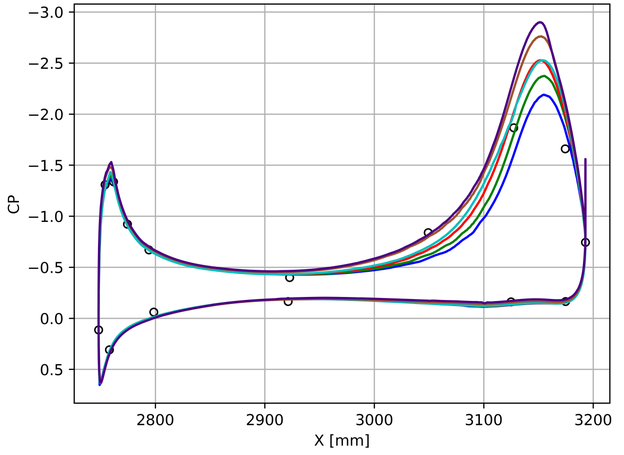
y=685.8 mm



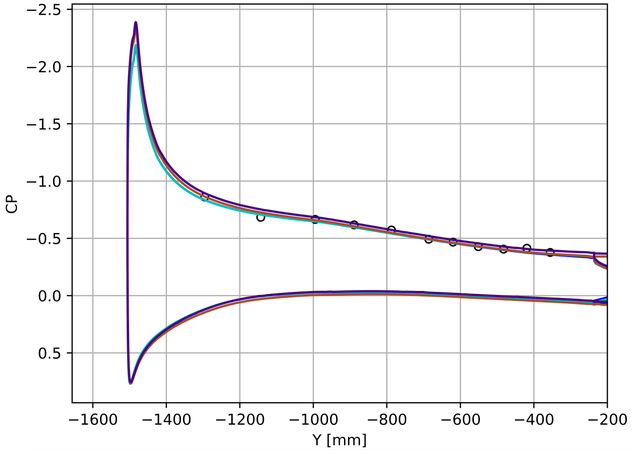
y=1295.4 mm



y=1663.7 mm

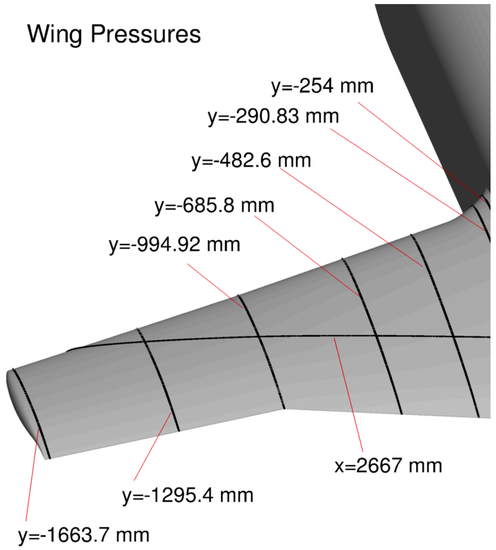


x=2667 mm

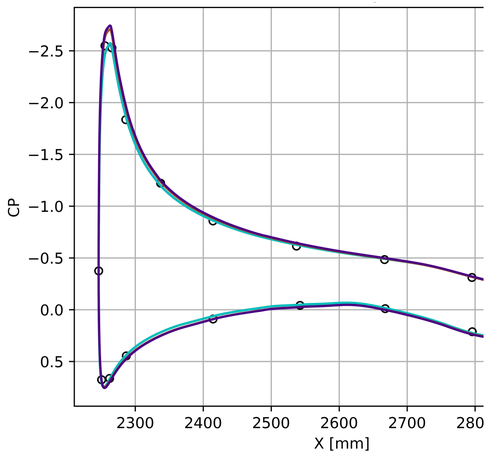


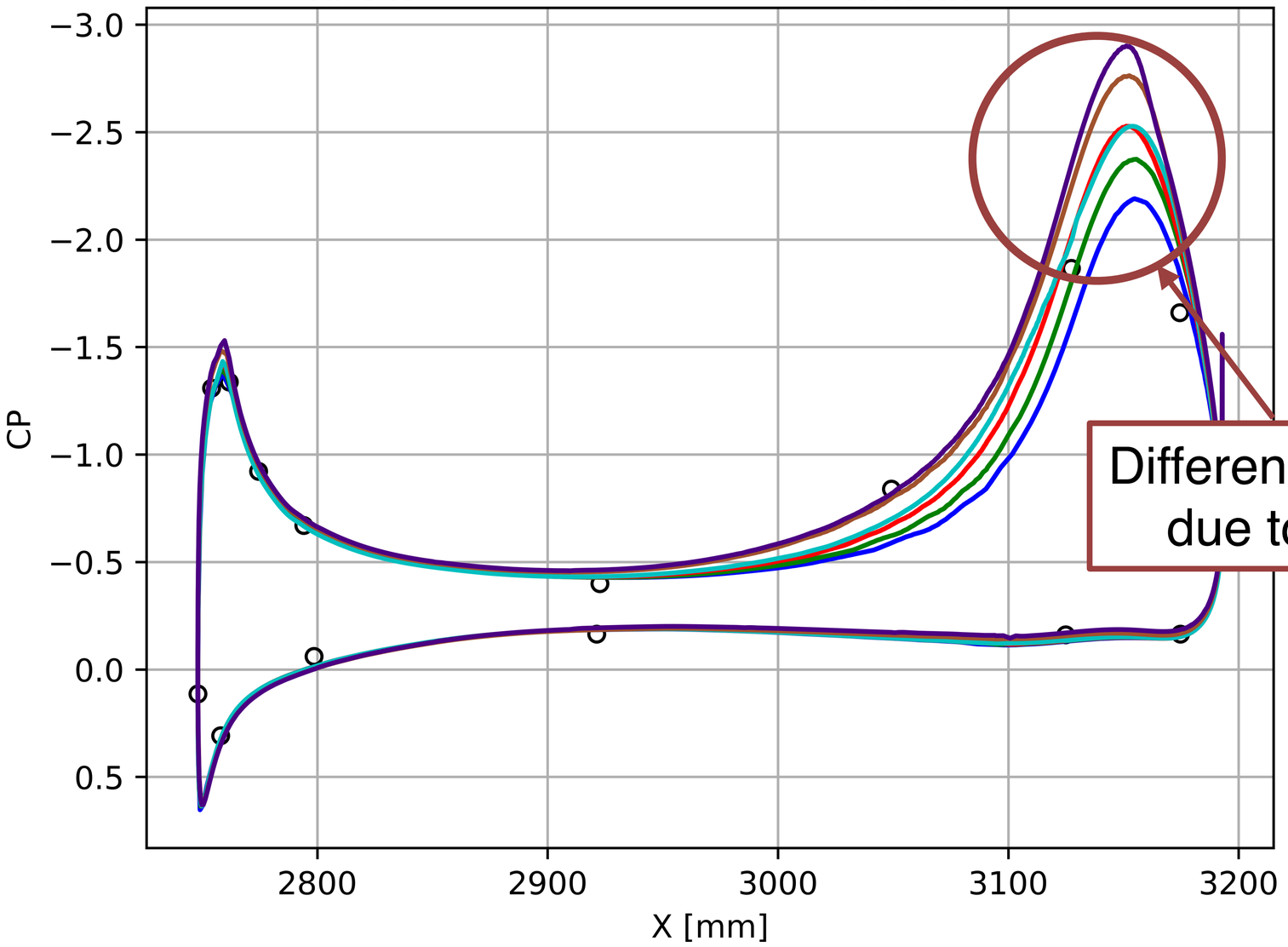
Experiment
CFD Coarse
CFD Medium
CFD Fine
CFD ExtraFine
CFD-WT+SM Medium
CFD-WT+SM Fine

Wing Pressures, AOA = 5.0 deg

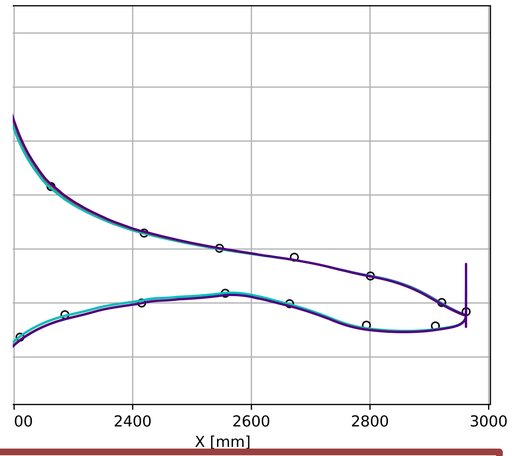


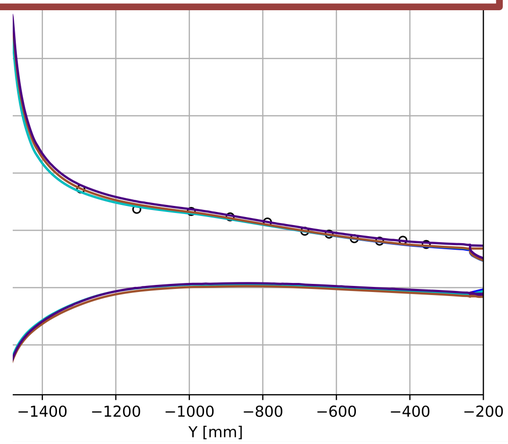
y=685.8 mm





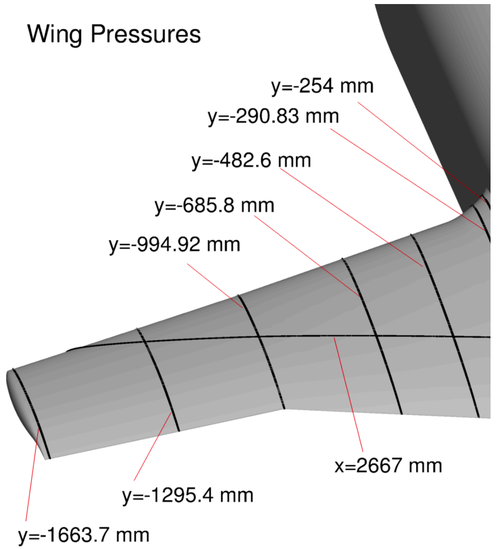
y=482.6 mm

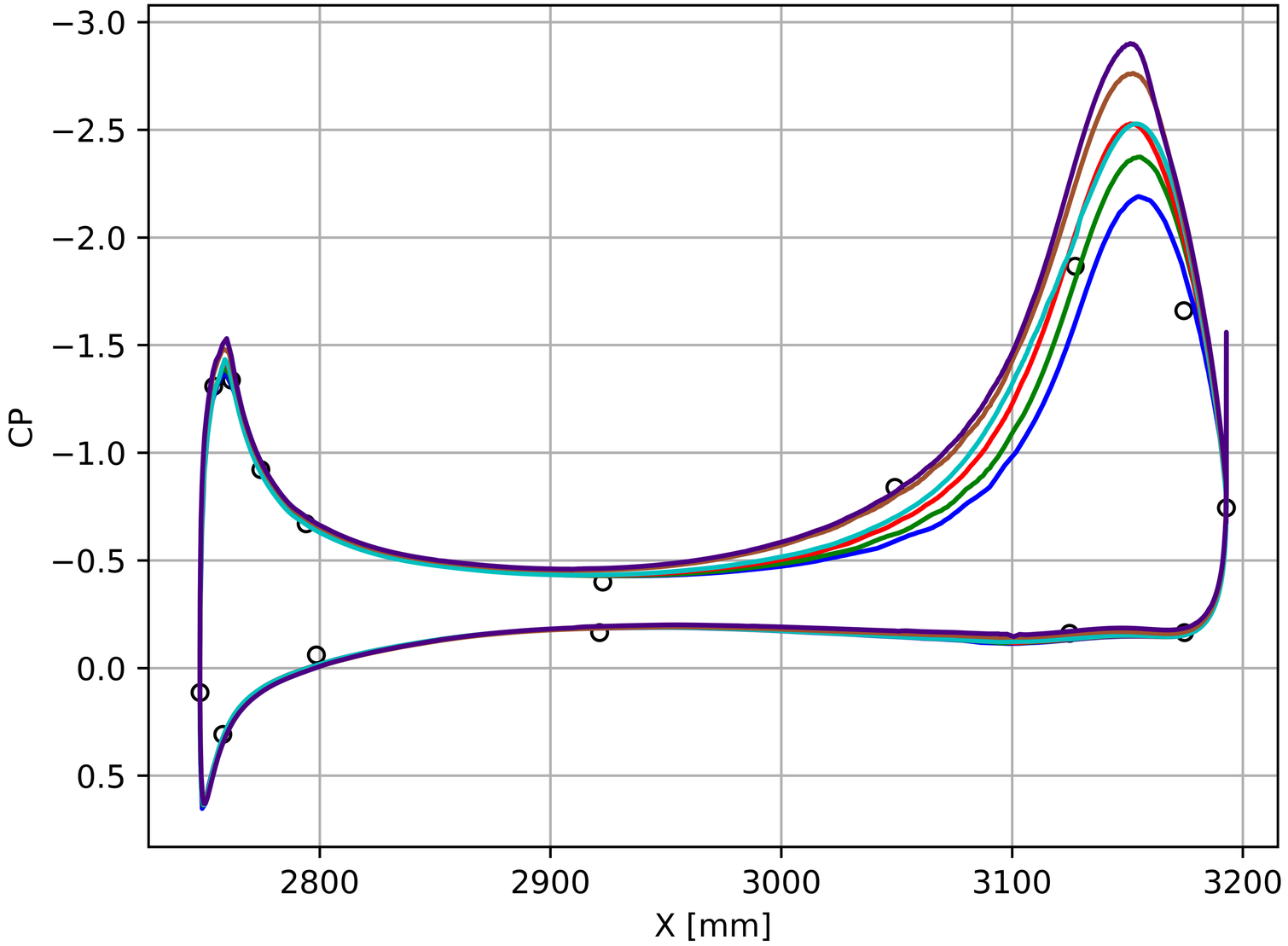




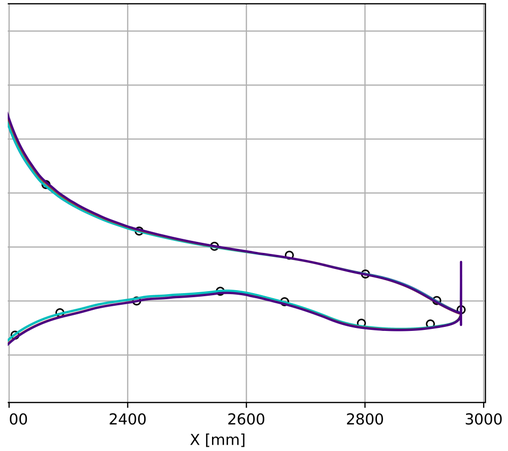
Differences in tip pressure due to grid resolution

Wing Pressures, AOA = 5.0 deg

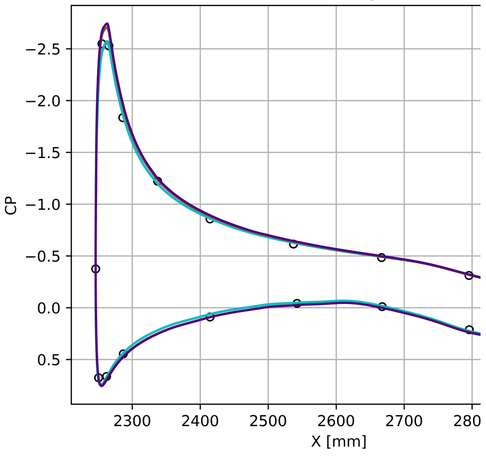




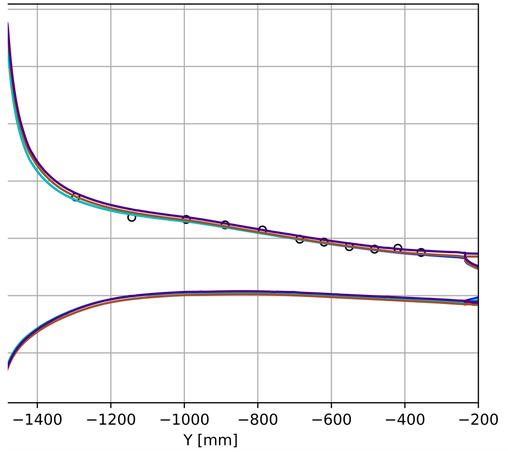
y=482.6 mm



y=685.8 mm

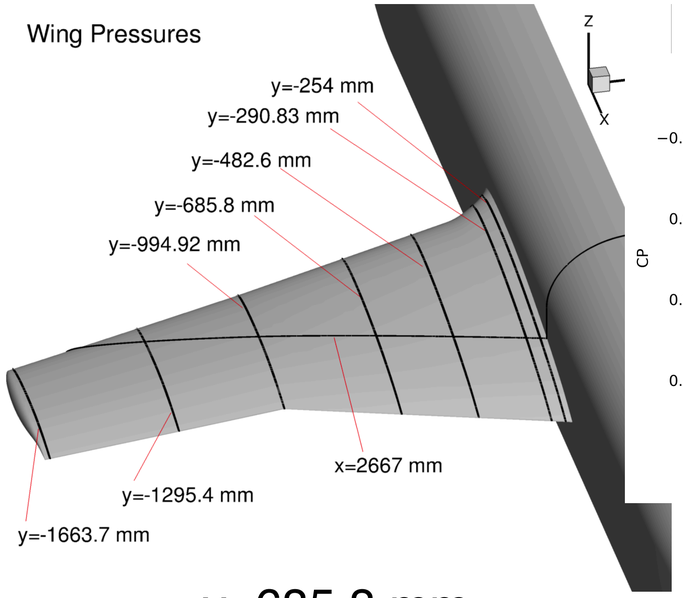


x=2667 mm

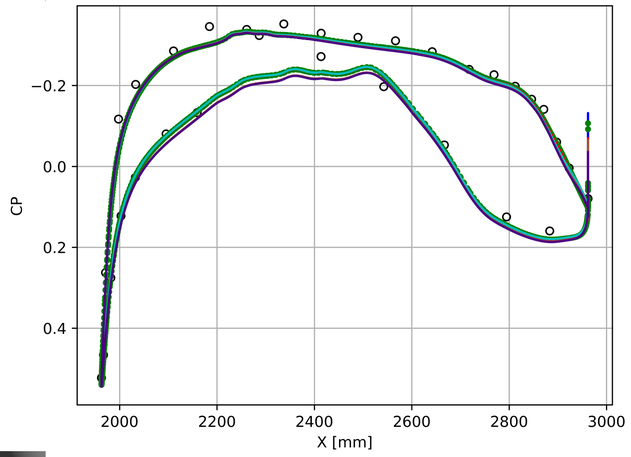


Experiment
CFD Coarse
CFD Medium
CFD Fine
CFD ExtraFine
CFD-WT+SM Medium
CFD-WT+SM Fine

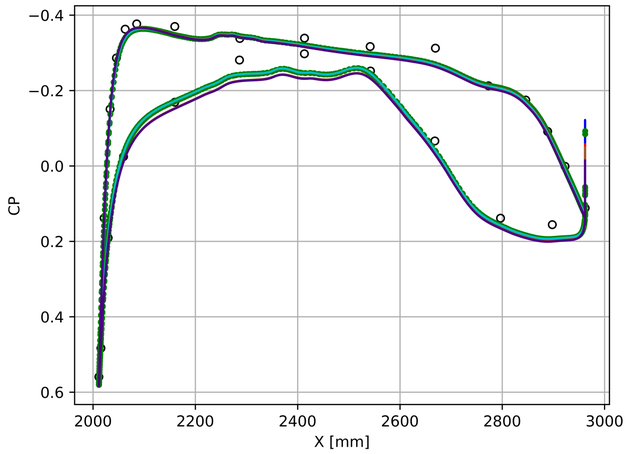
Wing Pressures, AOA = -2.5 deg



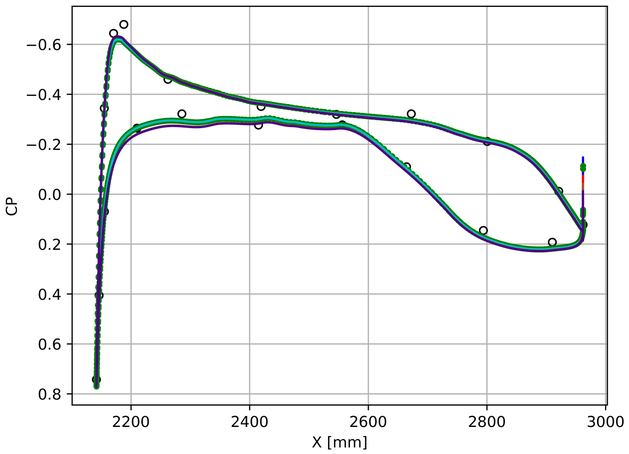
y=254.0 mm



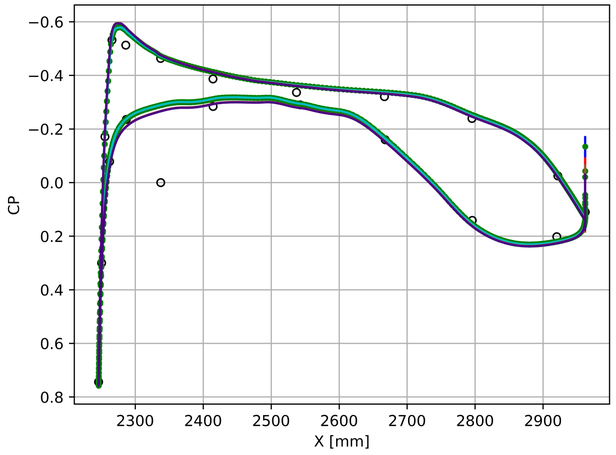
y=290.83 mm



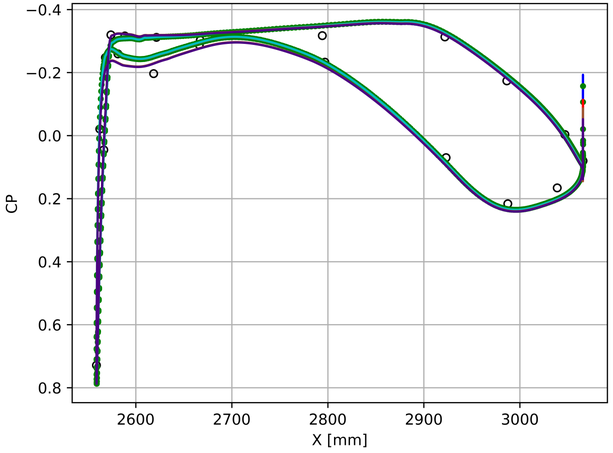
y=482.6 mm



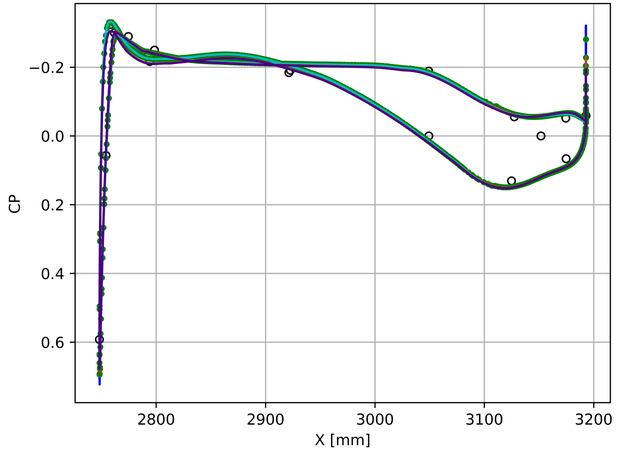
y=685.8 mm



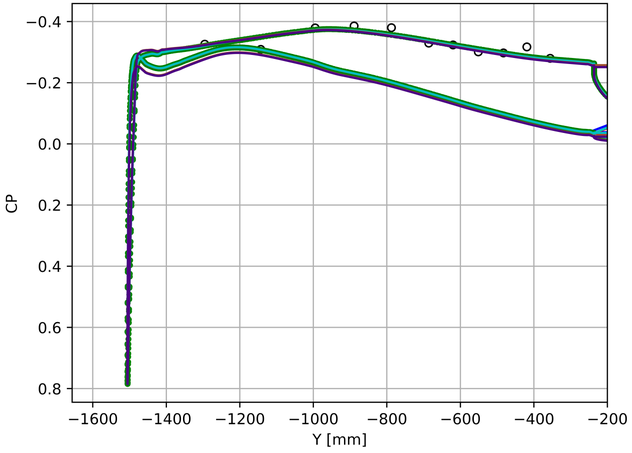
y=1295.4 mm



y=1663.7 mm



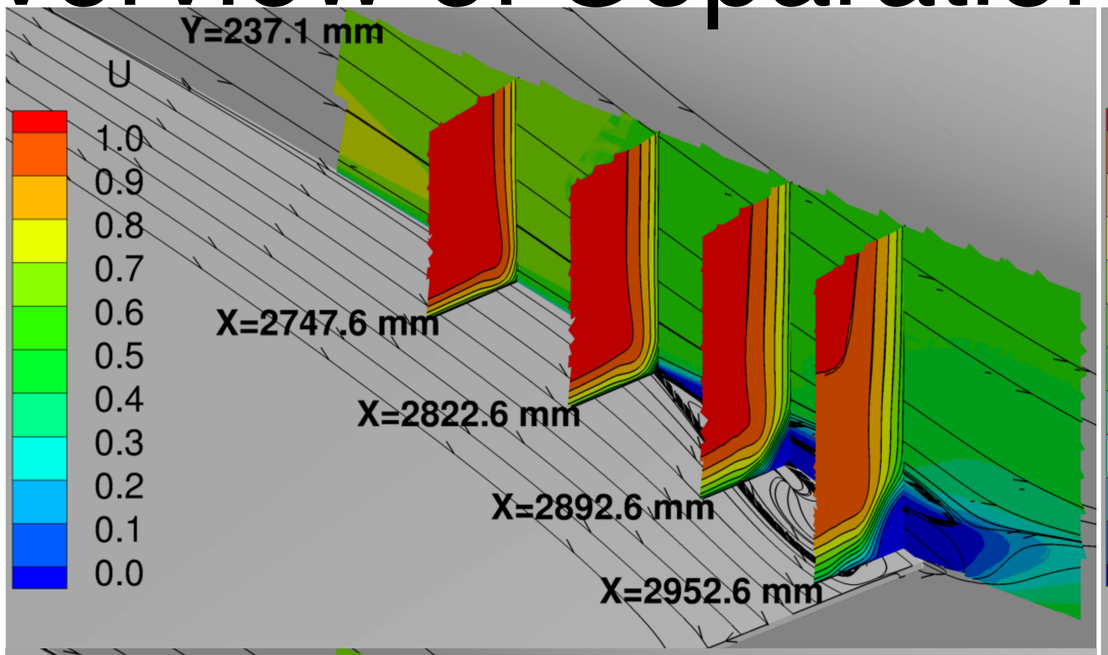
x=2667 mm

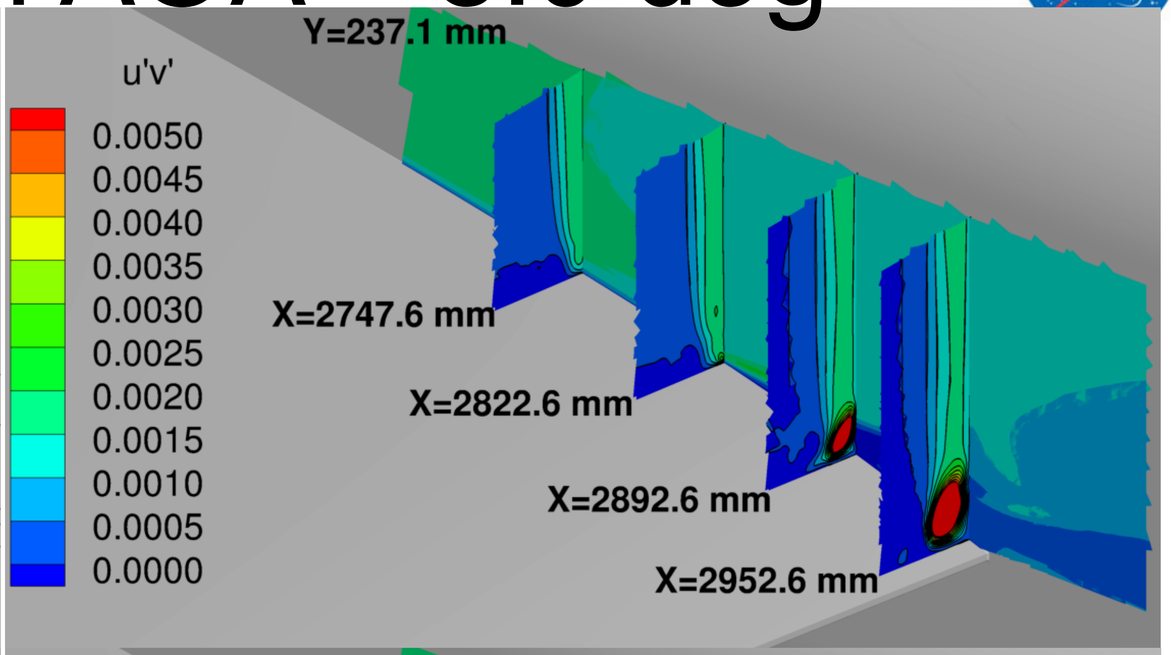


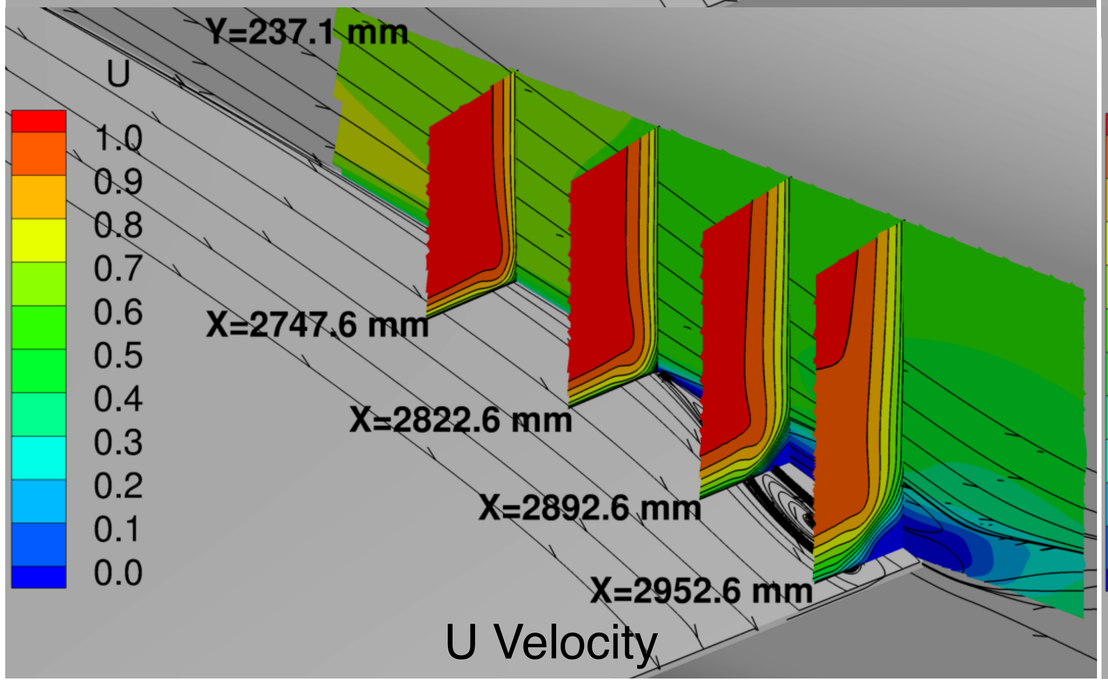
Overview of Separation AOA = 5.0 deg

Medium Grid (Air)

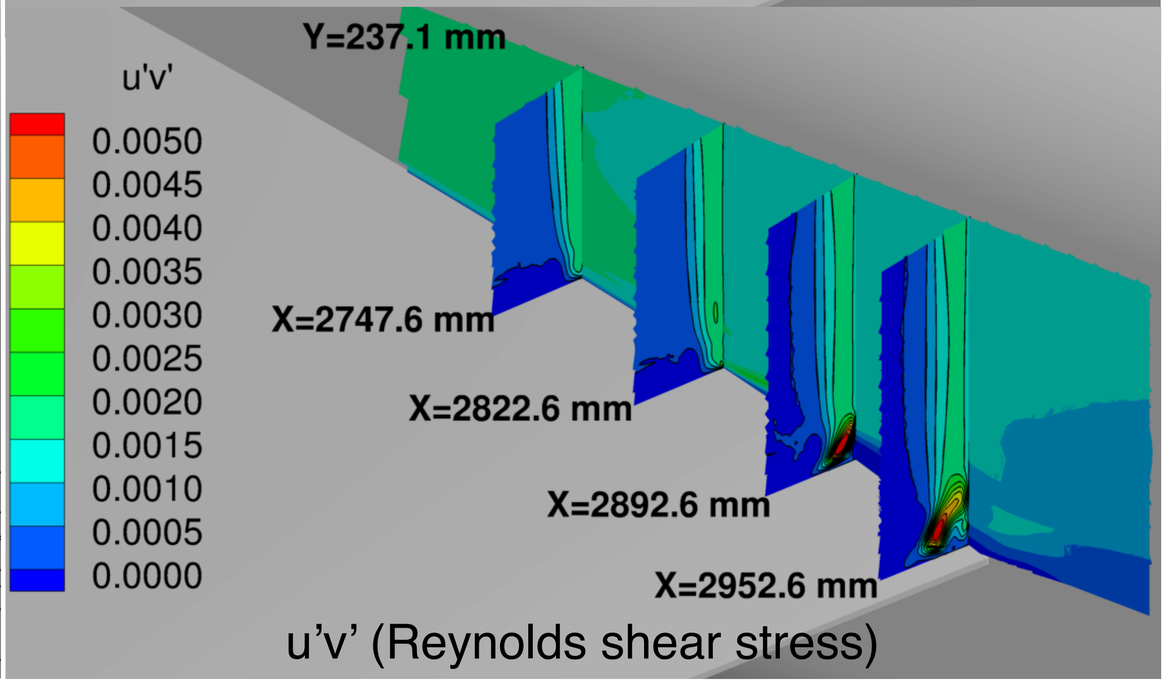
Fine Grid (Air)





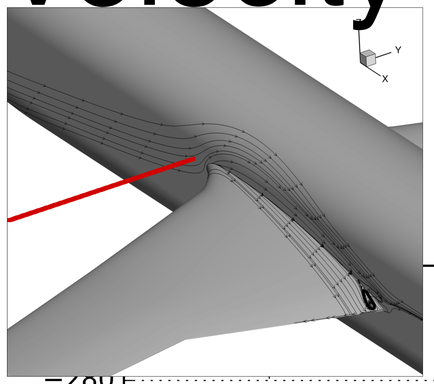


U Velocity

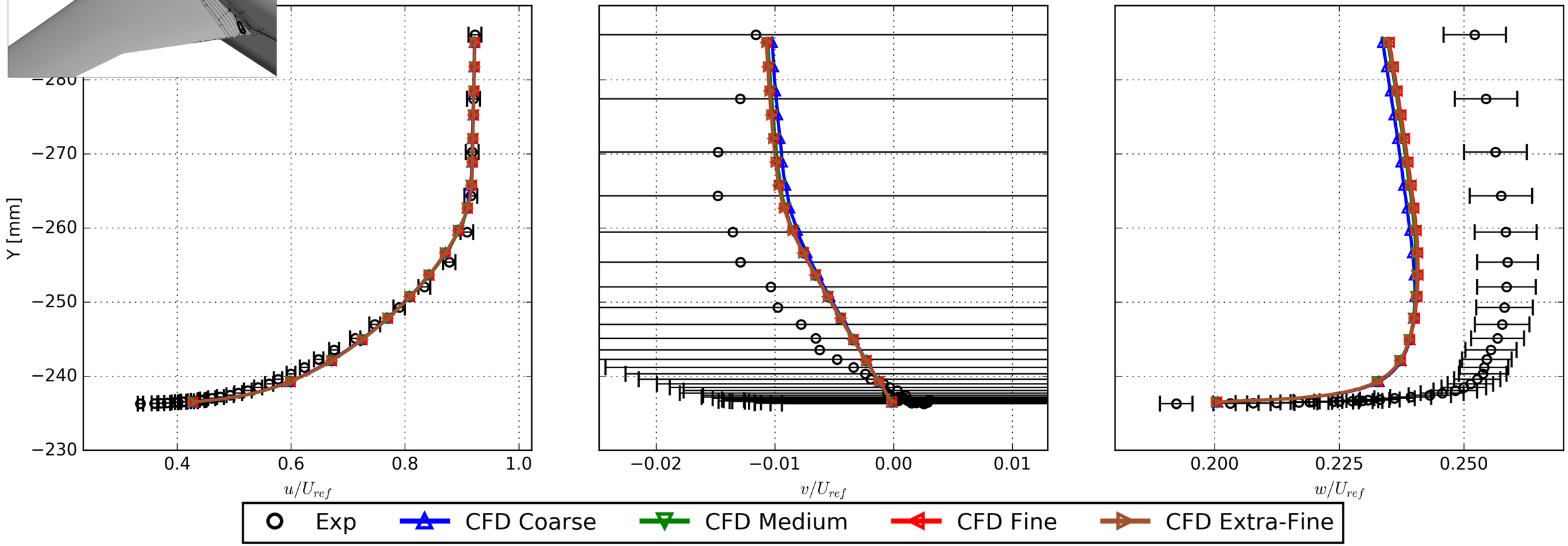


u'v' (Reynolds shear stress)

Velocity Profiles: Grid Resolution (Free Air)



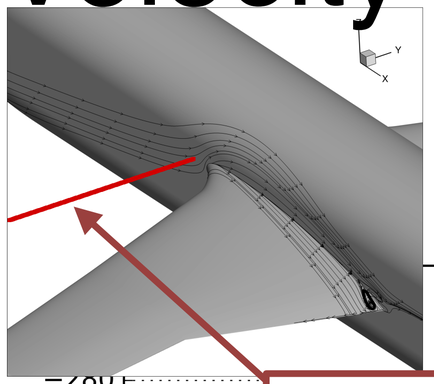
Before LE of wing

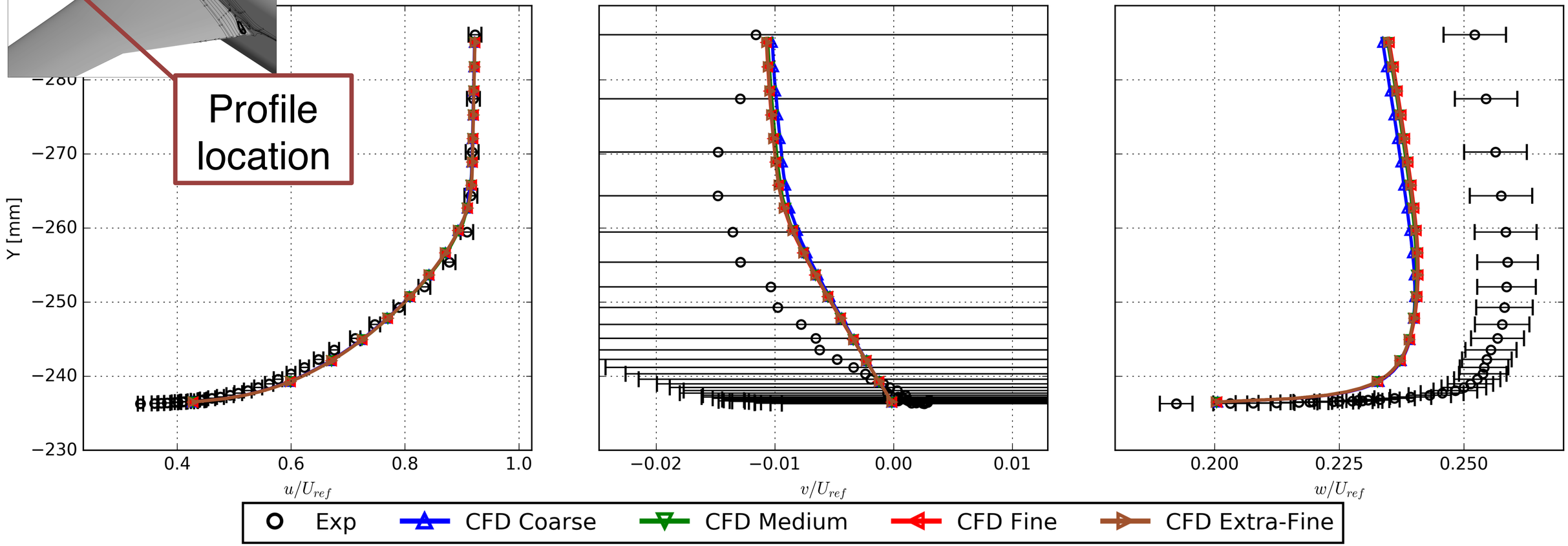


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)

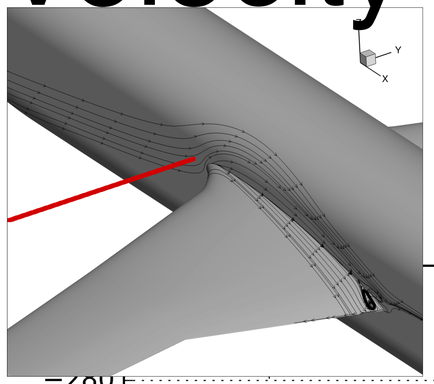
Before LE of wing



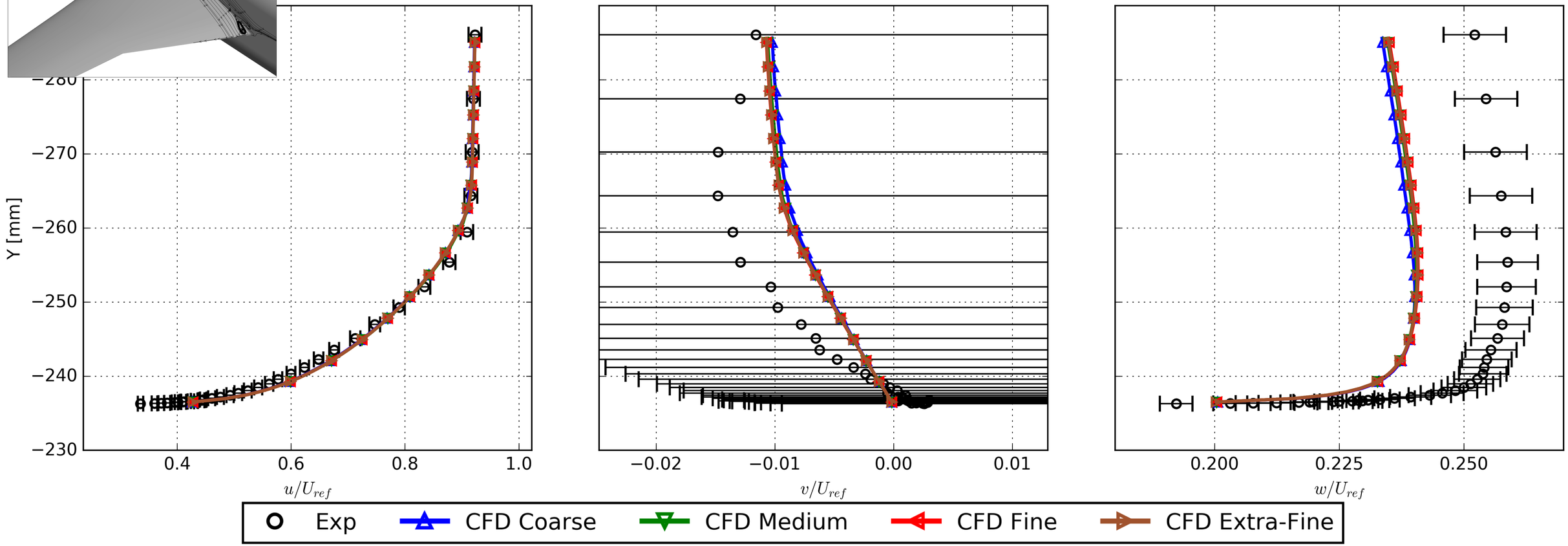


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)

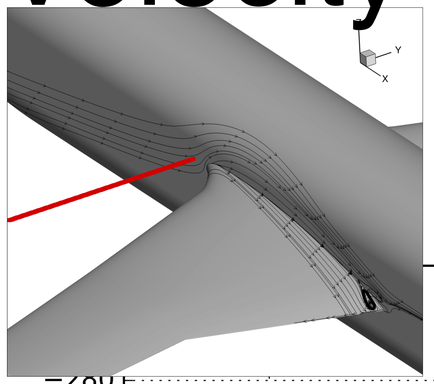


Before LE of wing



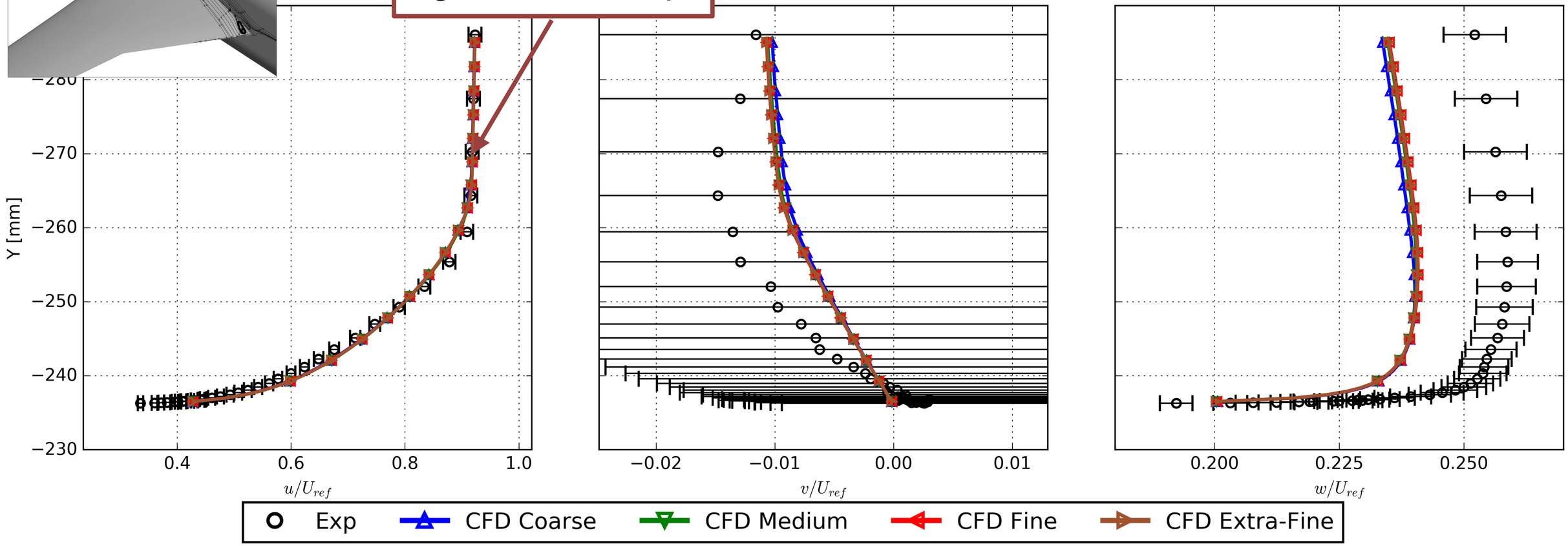
AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)



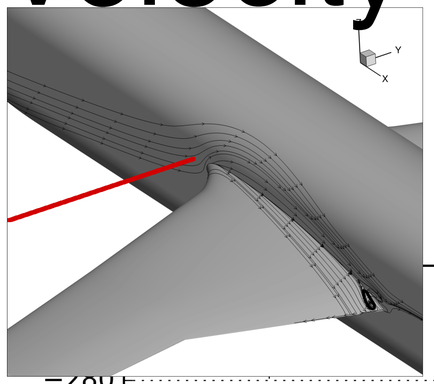
Before LE of wing

u-component agrees with Exp.

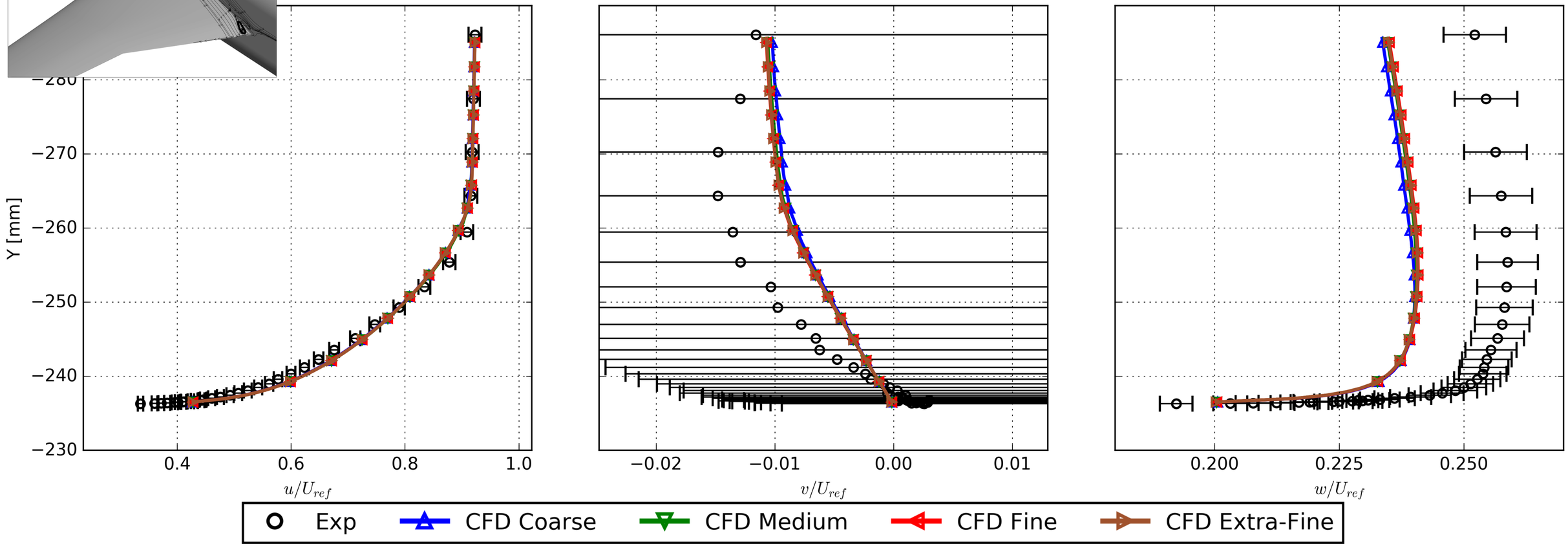


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)

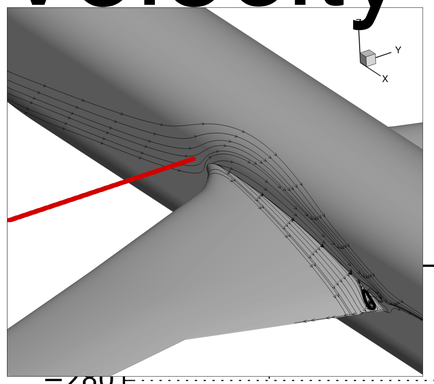


Before LE of wing



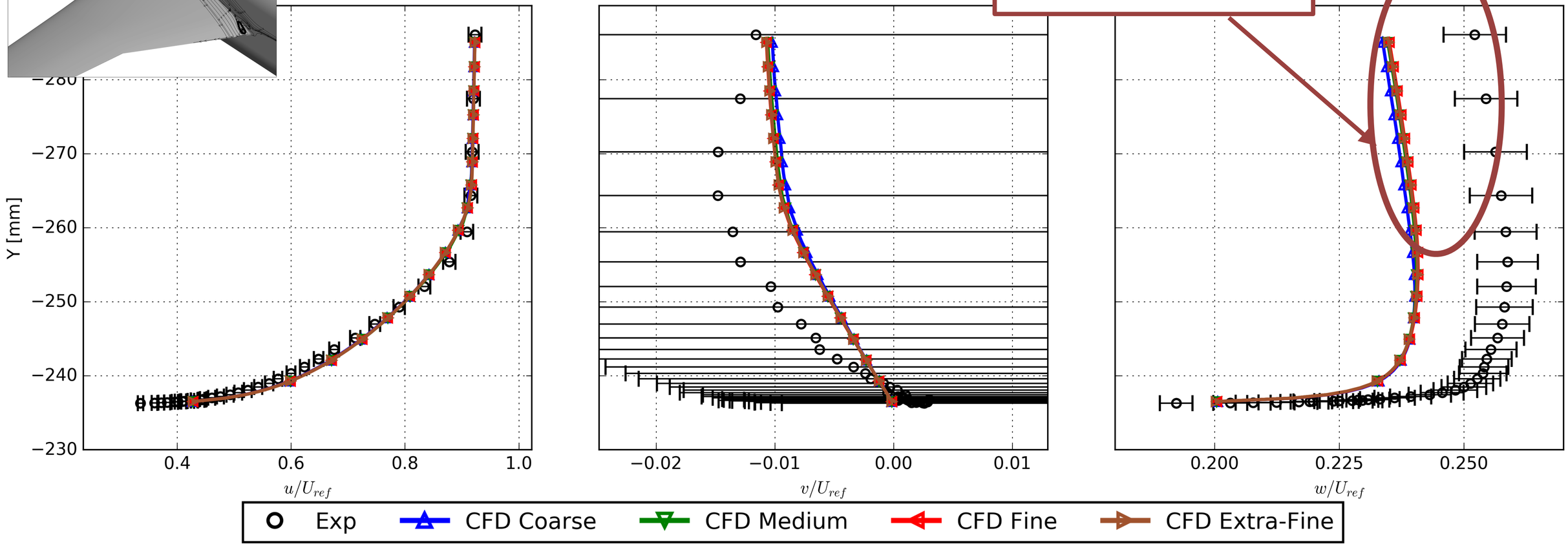
AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)



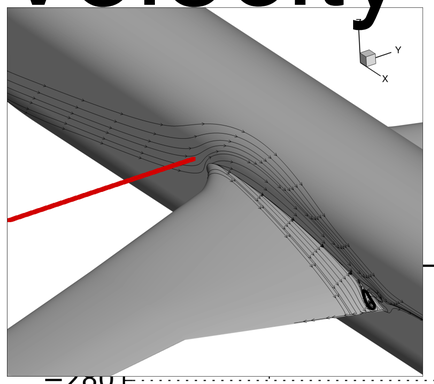
Before LE of wing

w-component is lower than Exp.

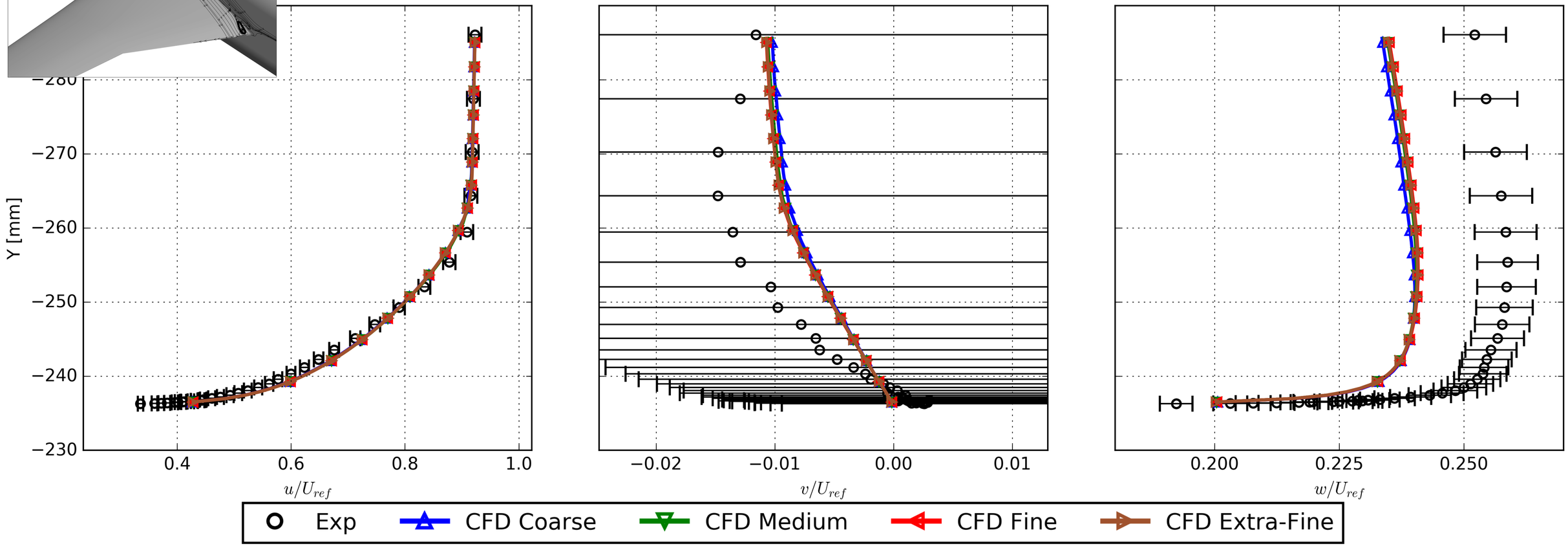


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)



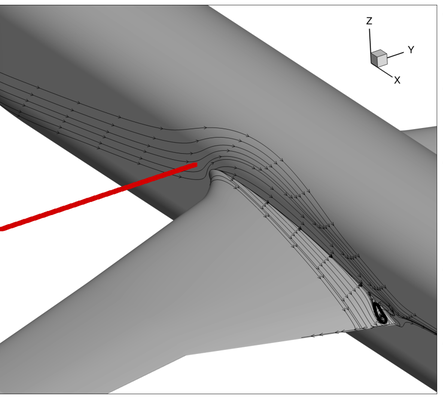
Before LE of wing



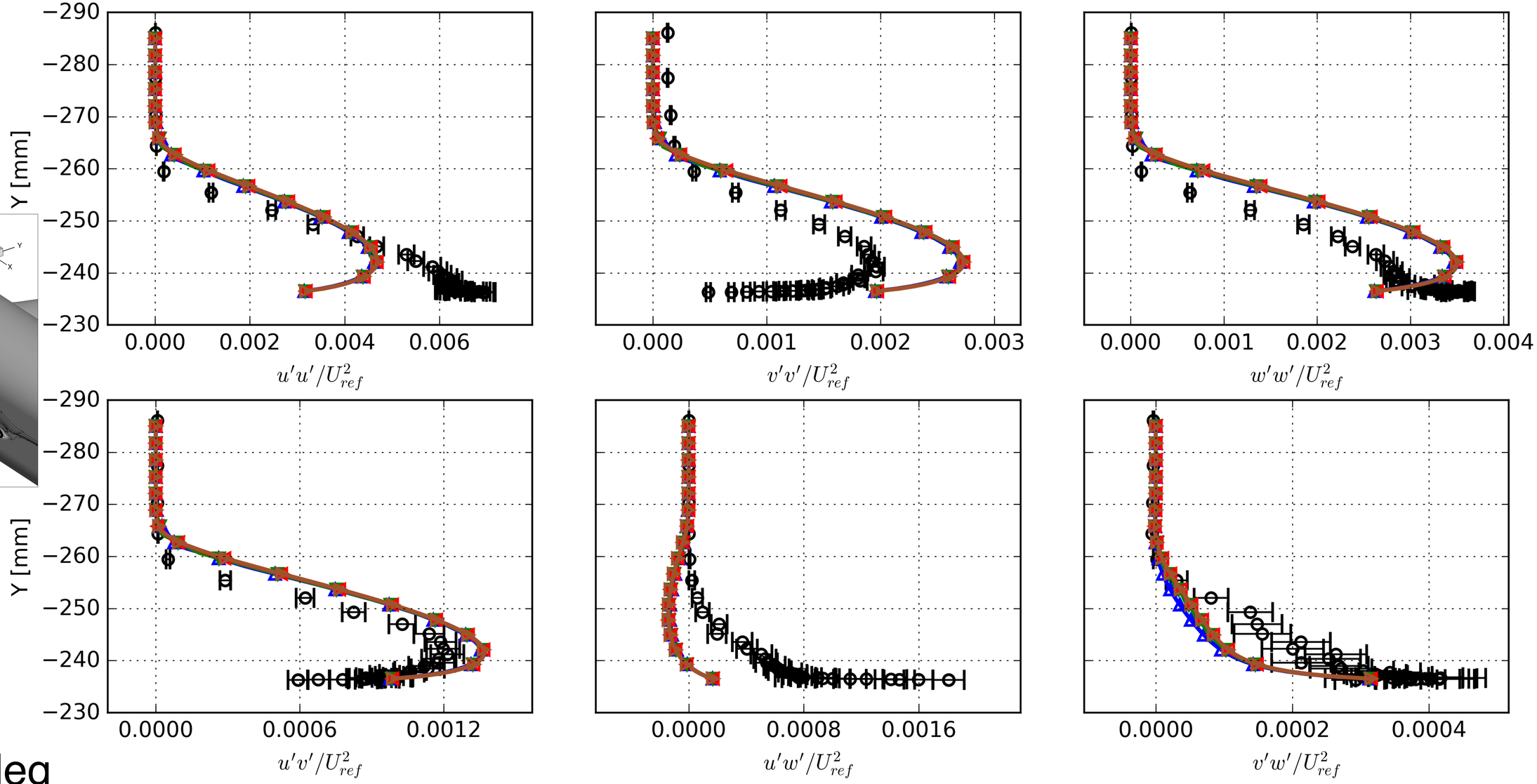
AOA = 5 deg

Reynolds Stress Profiles: Grid Resolution (Free Air)

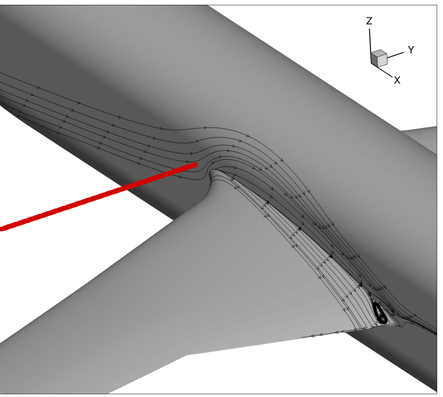
Before LE of wing



AOA = 5 deg

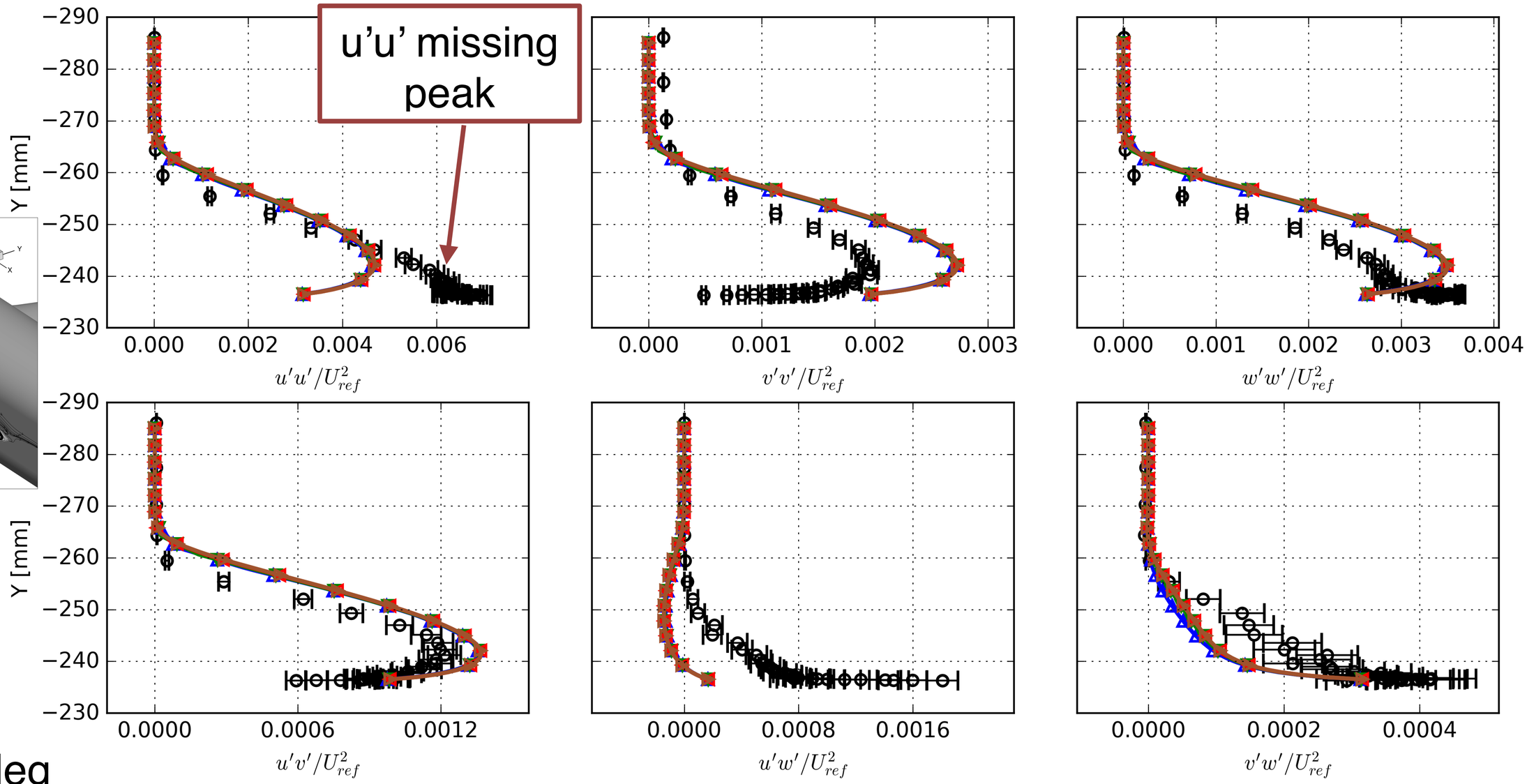


Reynolds Stress Profiles: Grid Resolution (Free Air)



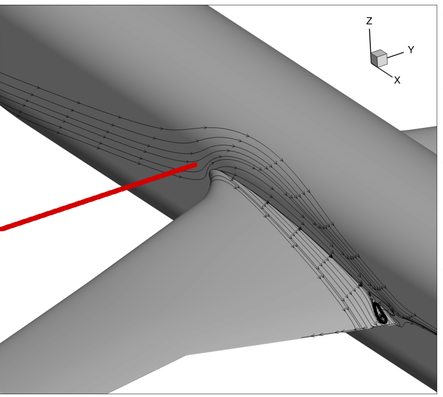
AOA = 5 deg

Before LE of wing

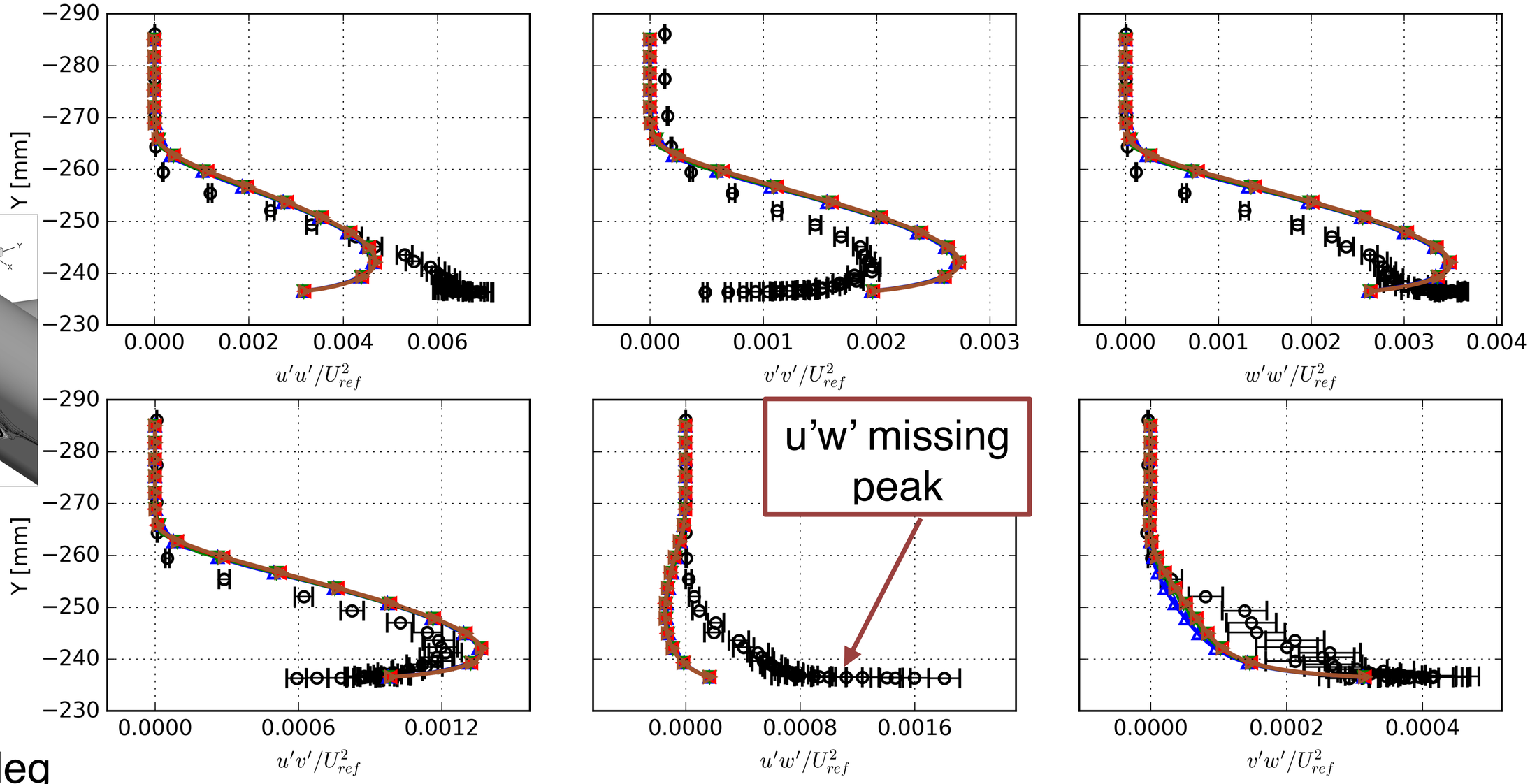


Reynolds Stress Profiles: Grid Resolution (Free Air)

Before LE of wing

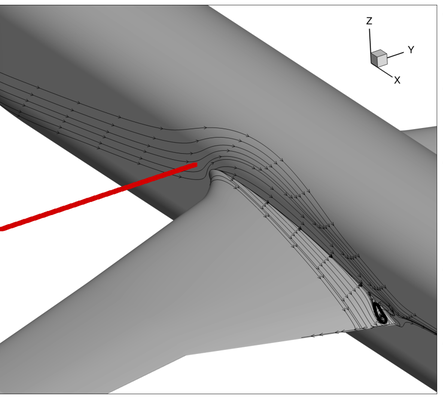


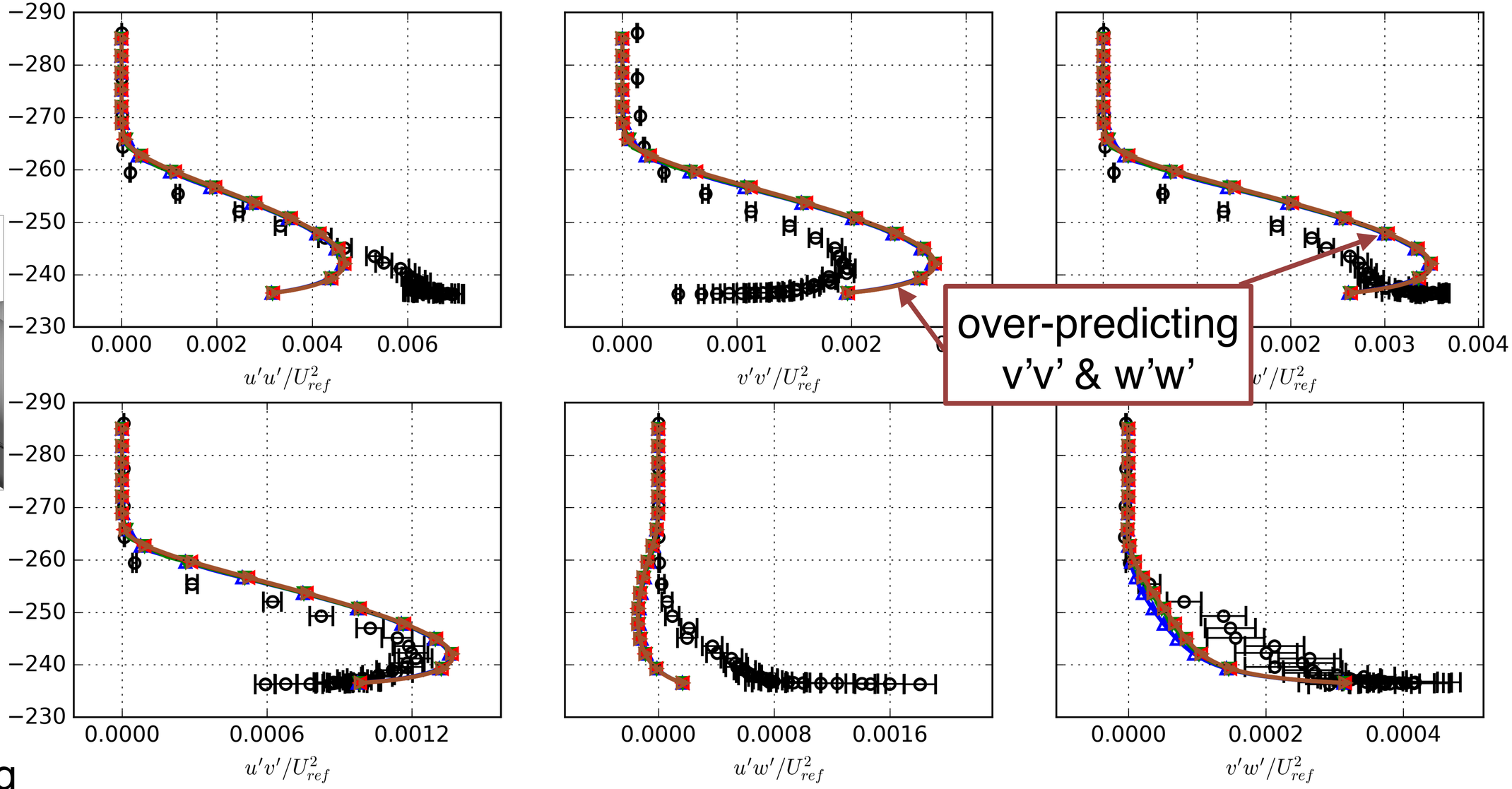
AOA = 5 deg



Reynolds Stress Profiles: Grid Resolution (Free Air)

Before LE of wing

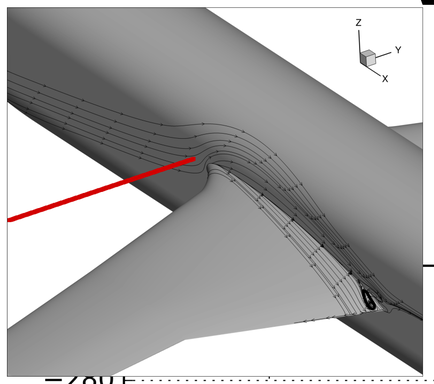


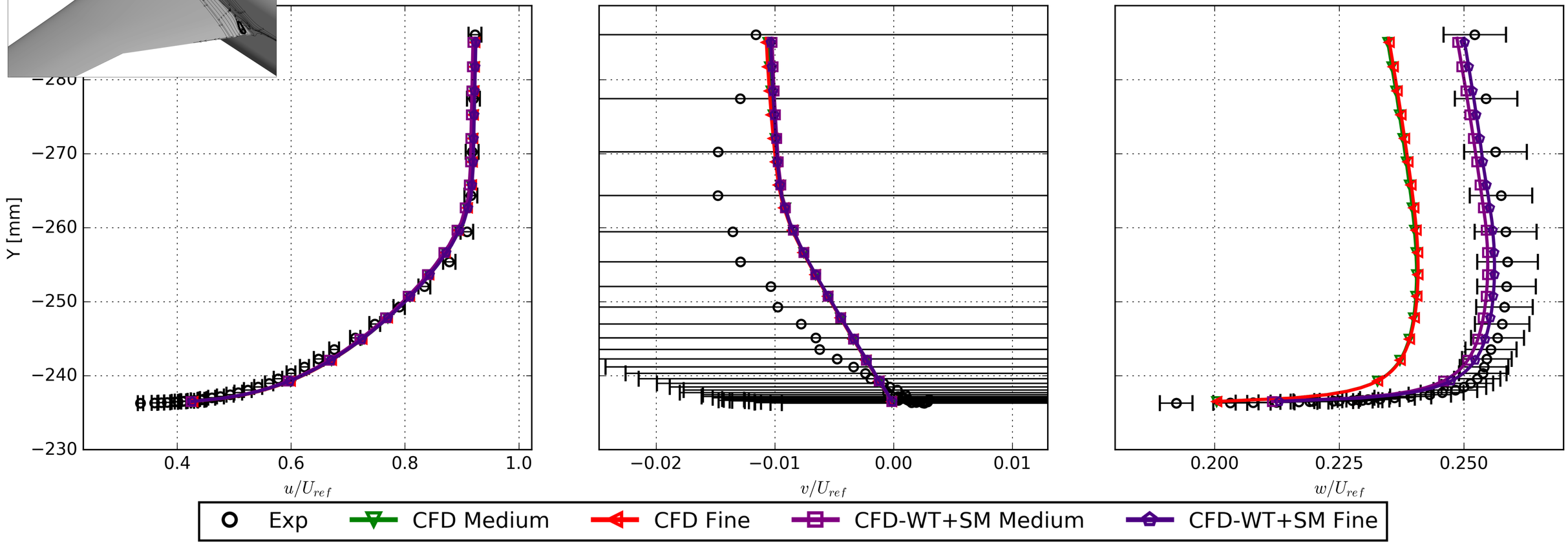


AOA = 5 deg

Velocity Profiles: Wall Effect

Before LE of wing

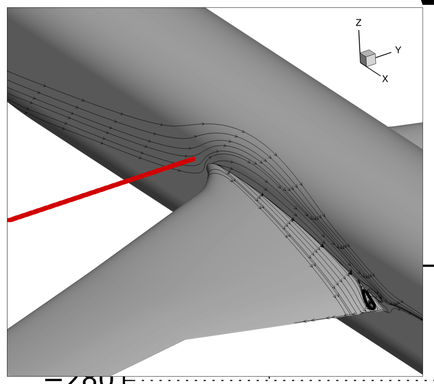


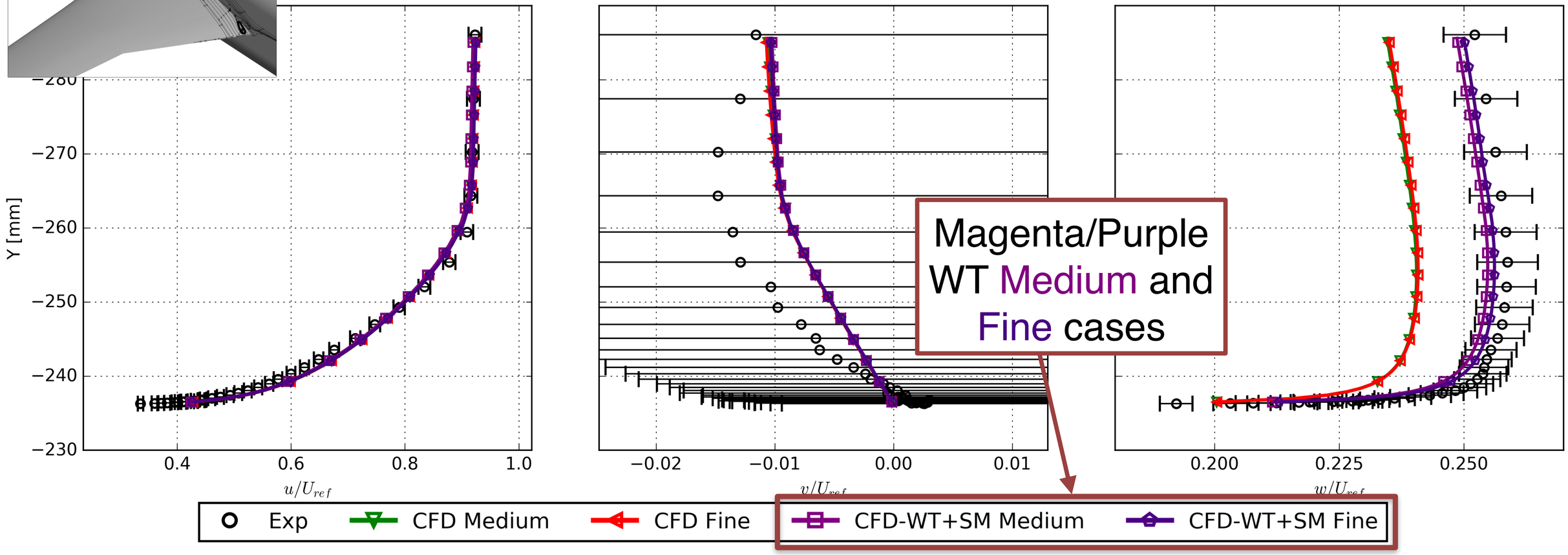


AOA = 5 deg

Velocity Profiles: Wall Effect

Before LE of wing

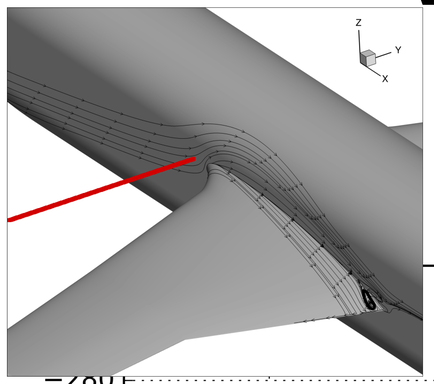




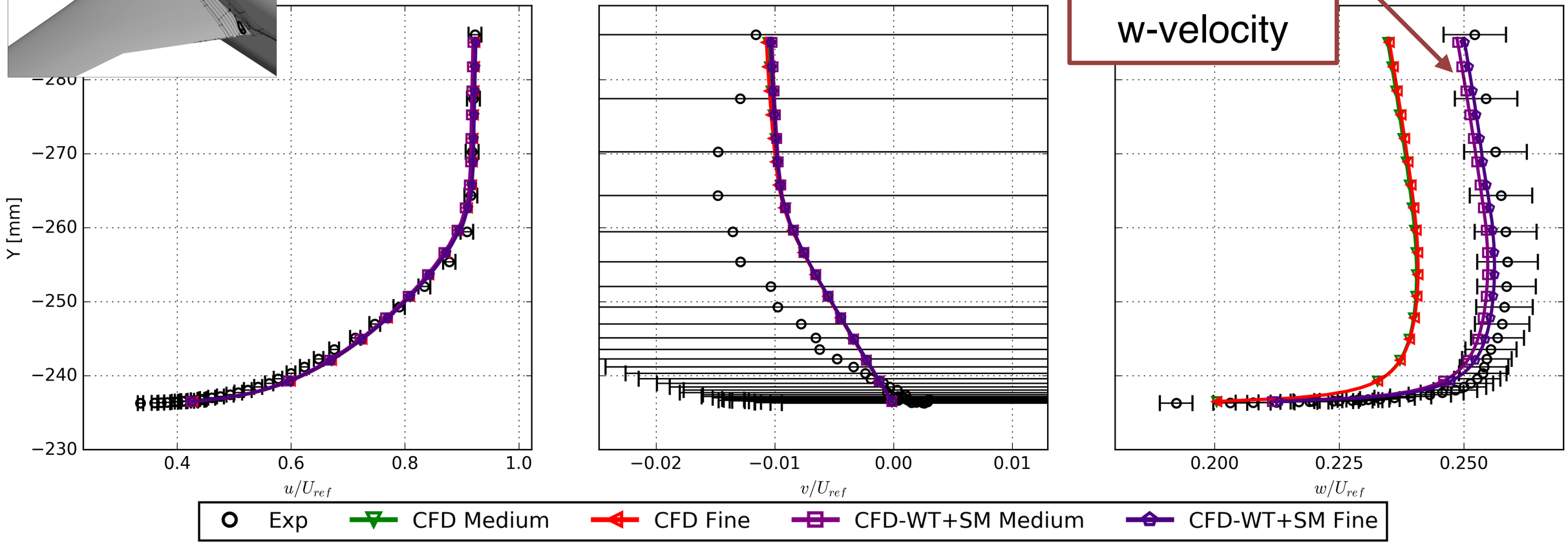
AOA = 5 deg

Velocity Profiles: Wall Effect

Before LE of wing



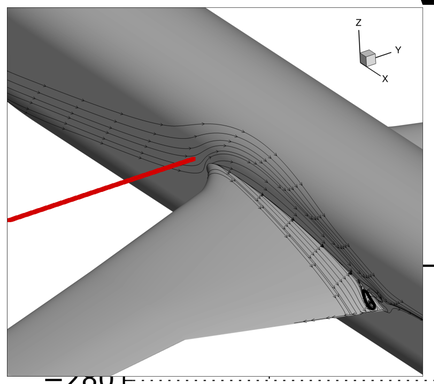
Adding WT walls recover w-velocity

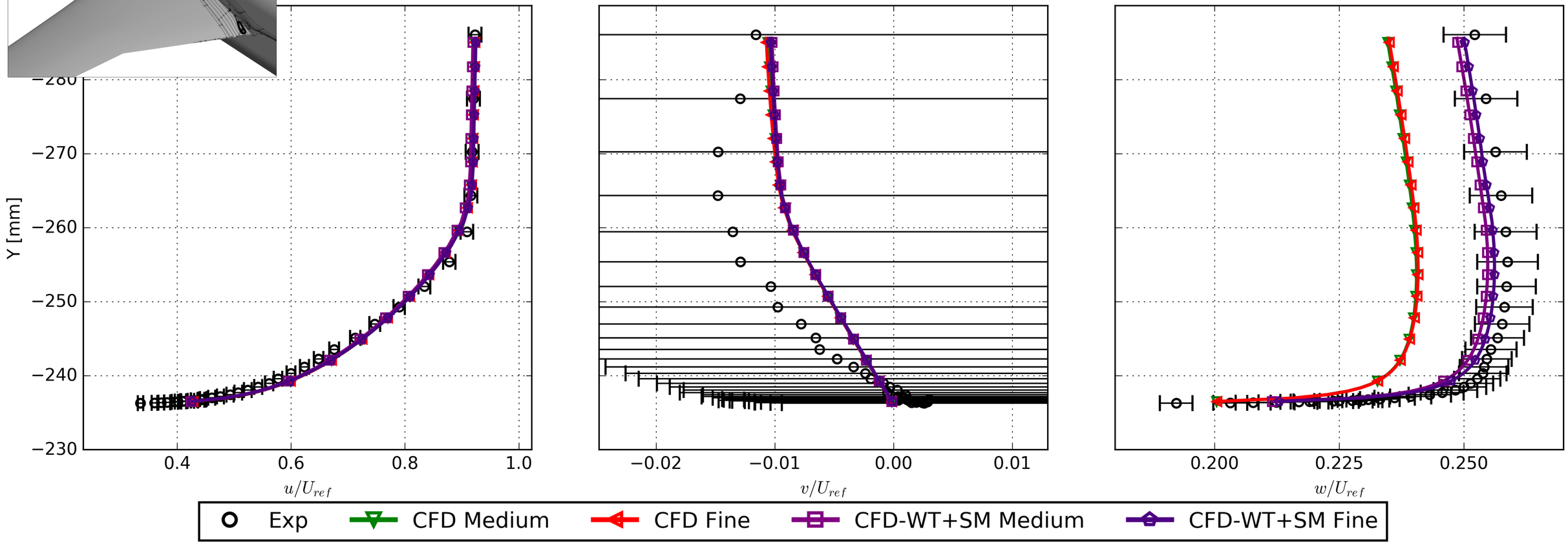


AOA = 5 deg

Velocity Profiles: Wall Effect

Before LE of wing

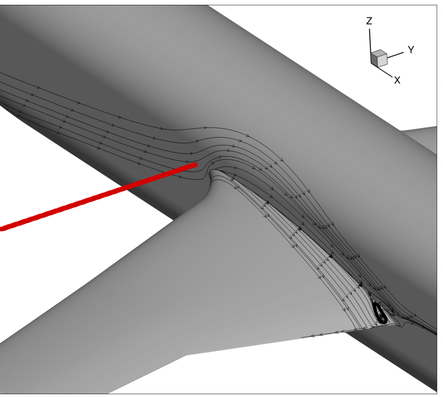




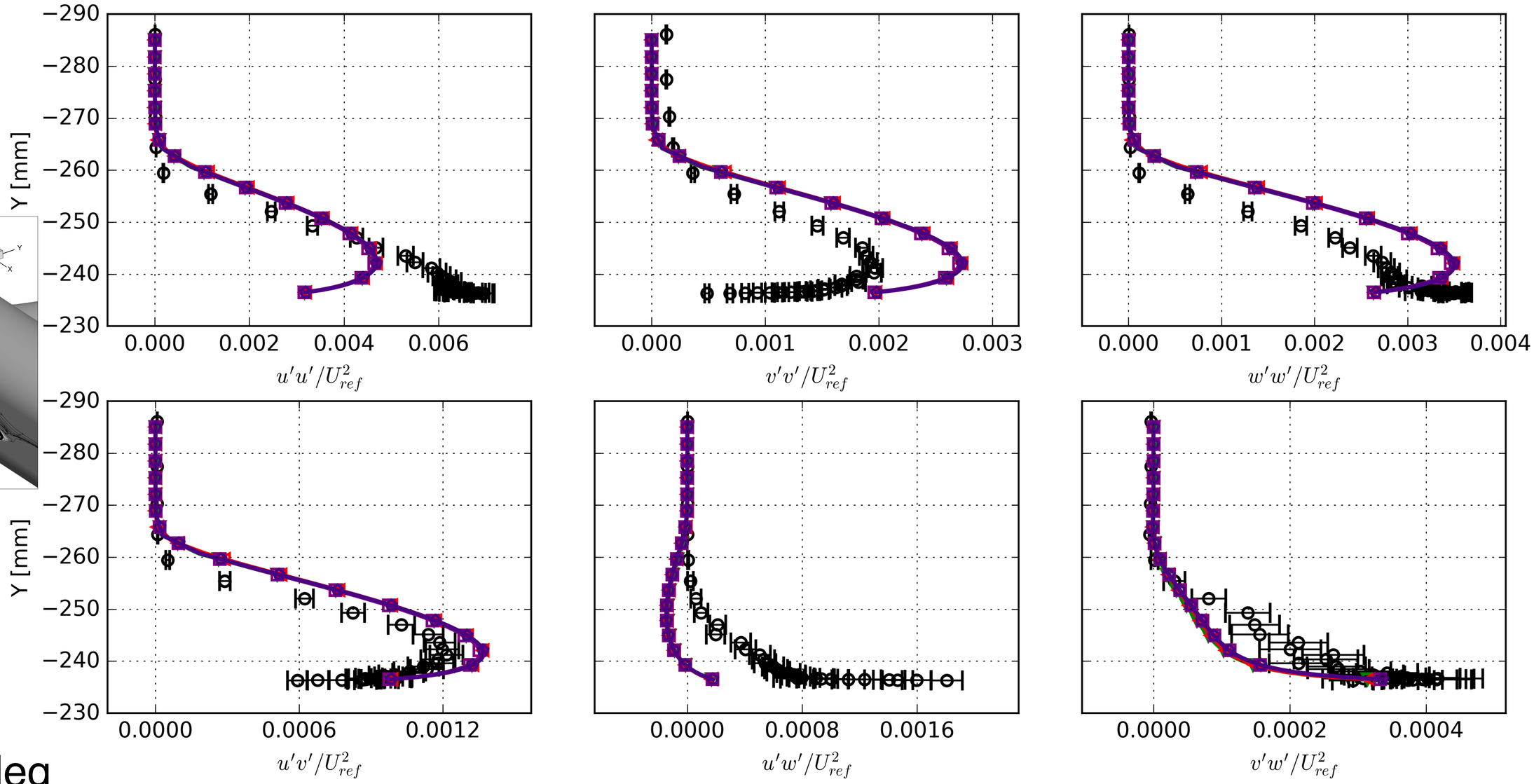
AOA = 5 deg

Reynolds Stress Profiles: Wall Effect

Before LE of wing



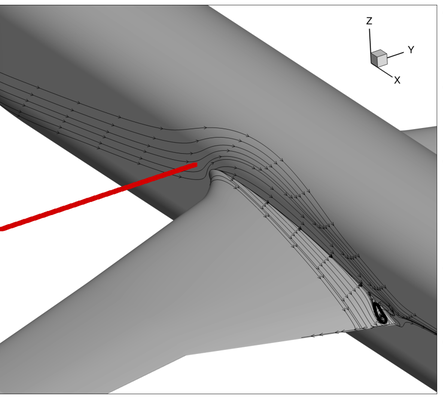
AOA = 5 deg

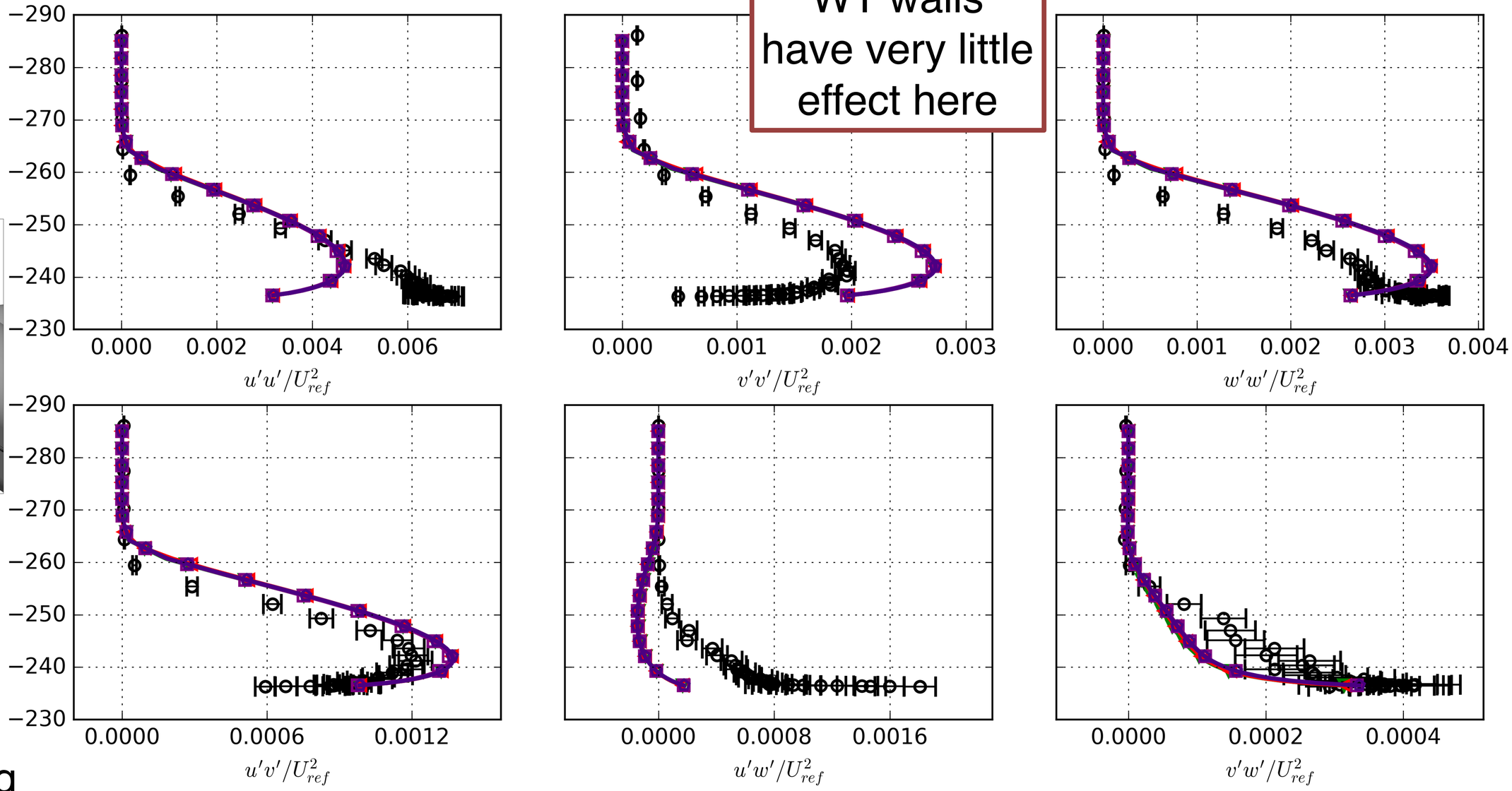


Reynolds Stress Profiles: Wall Effect

Before LE of wing

WT walls have very little effect here

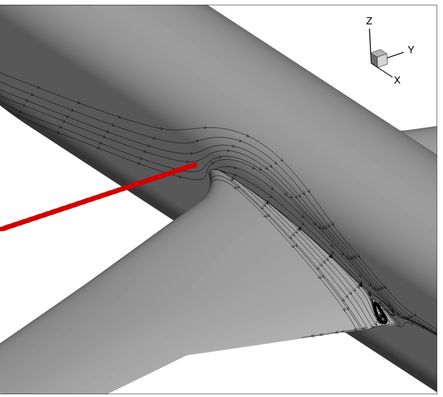




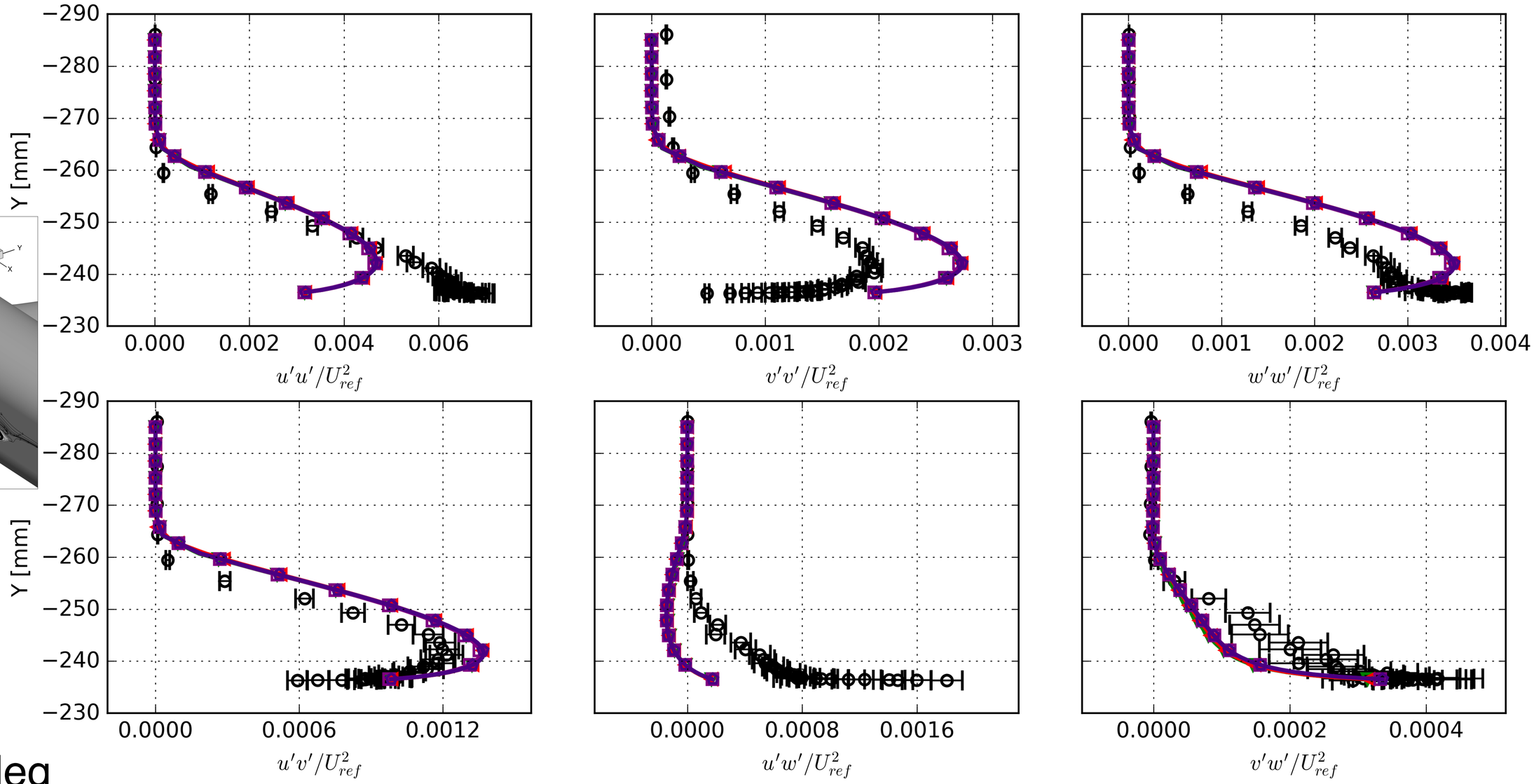
AOA = 5 deg

Reynolds Stress Profiles: Wall Effect

Before LE of wing

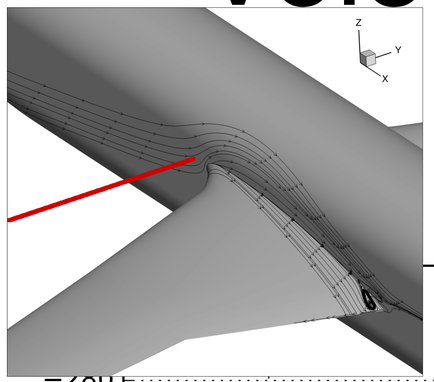


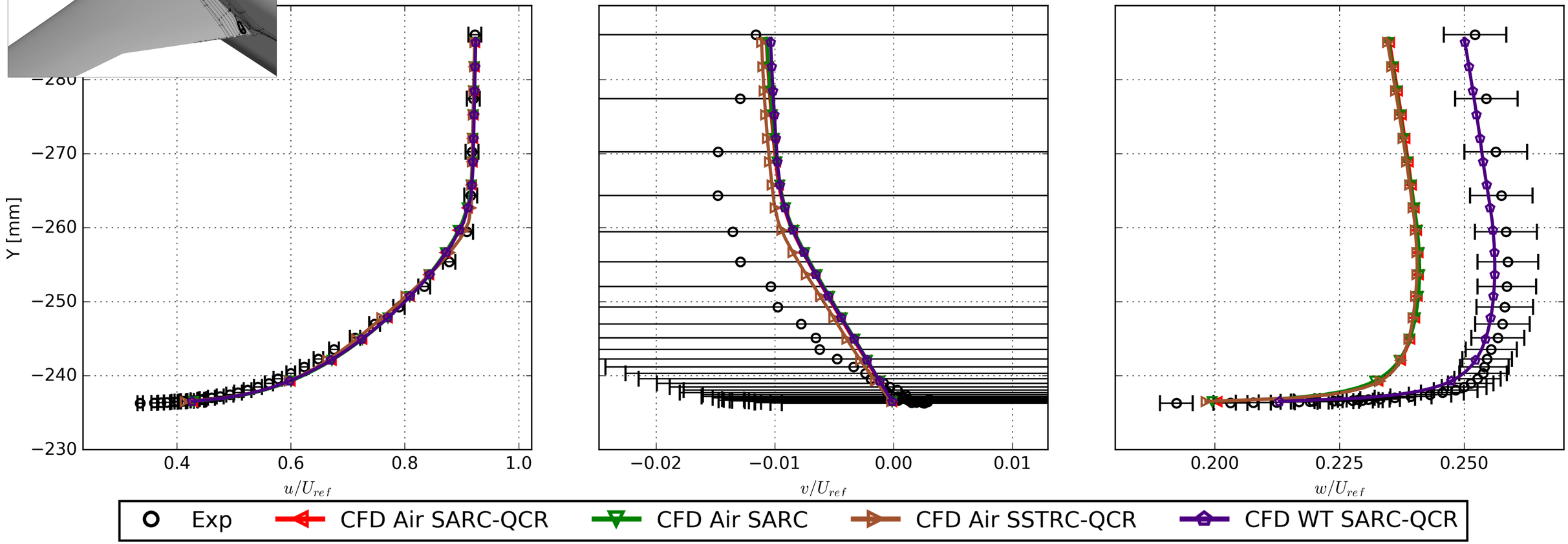
AOA = 5 deg



Velocity Profiles: Turbulence Model

Before LE of wing, Fine Grid

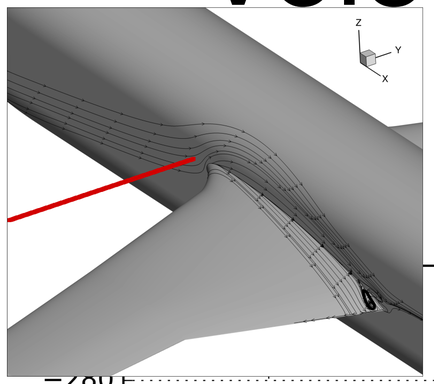


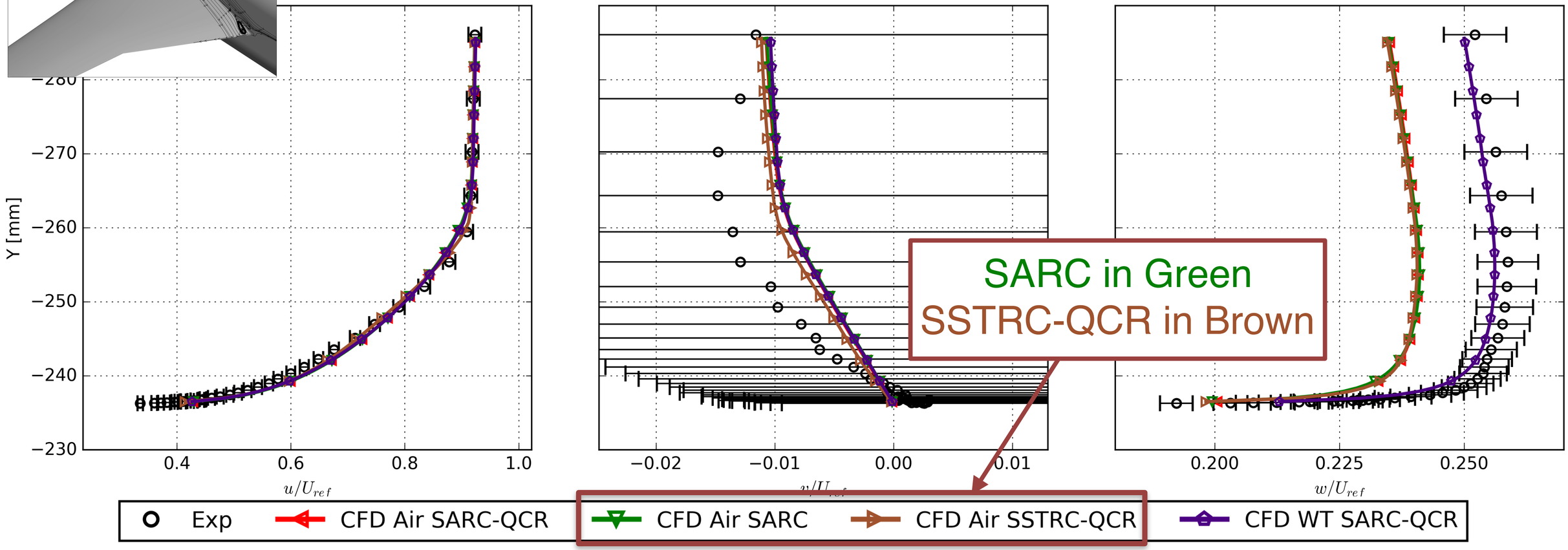


AOA = 5 deg

Velocity Profiles: Turbulence Model

Before LE of wing, Fine Grid

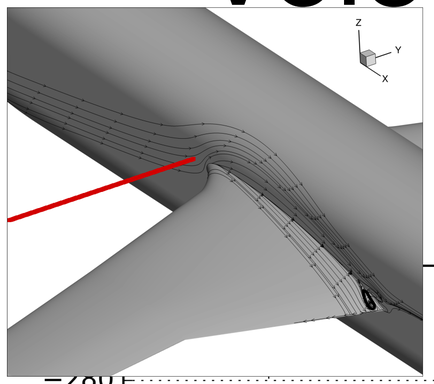




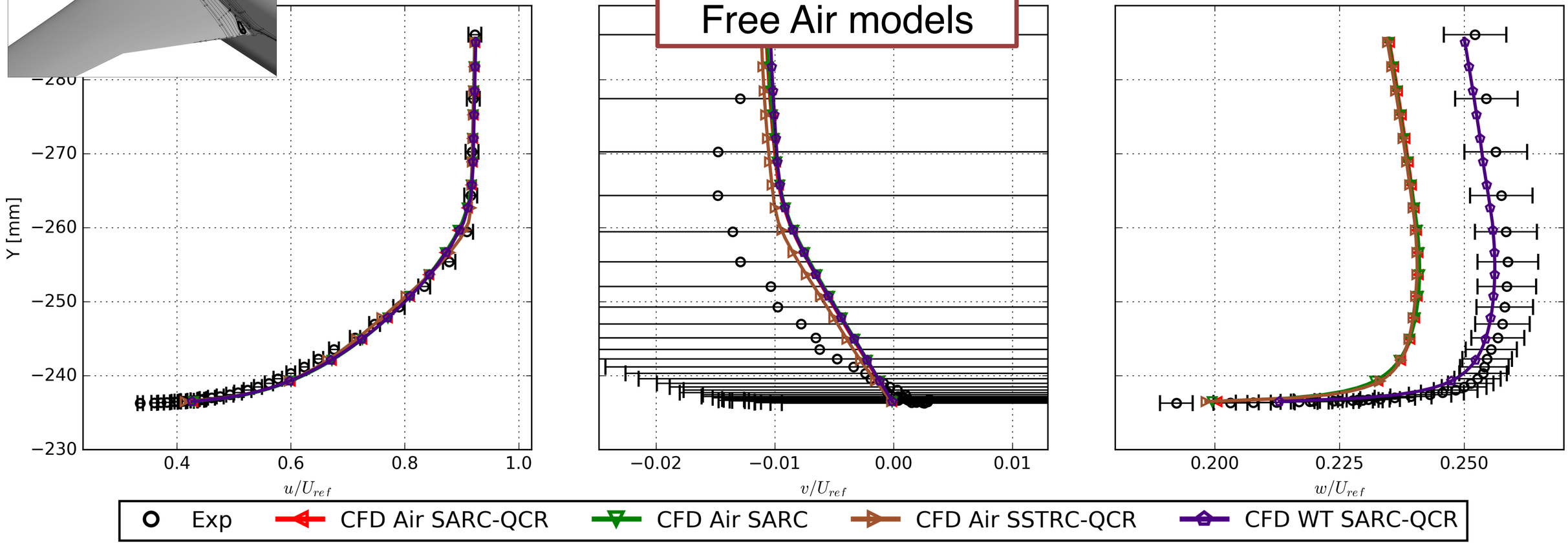
AOA = 5 deg

Velocity Profiles: Turbulence Model

Before LE of wing, Fine Grid



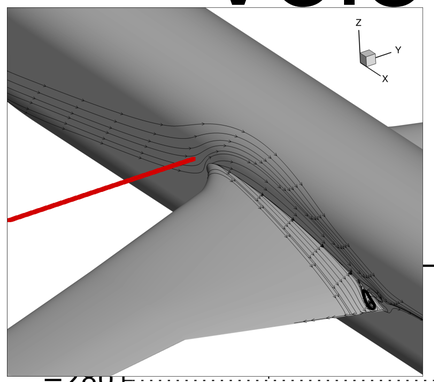
Profiles look similar between all Turb. Free Air models

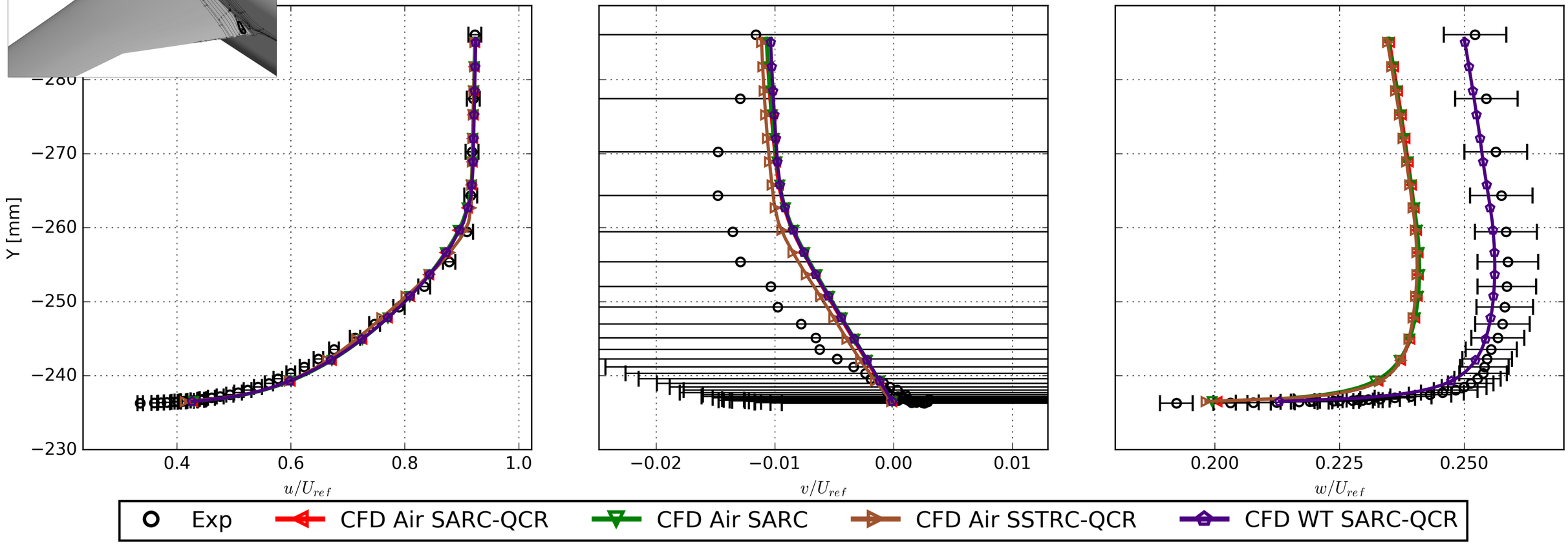


AOA = 5 deg

Velocity Profiles: Turbulence Model

Before LE of wing, Fine Grid

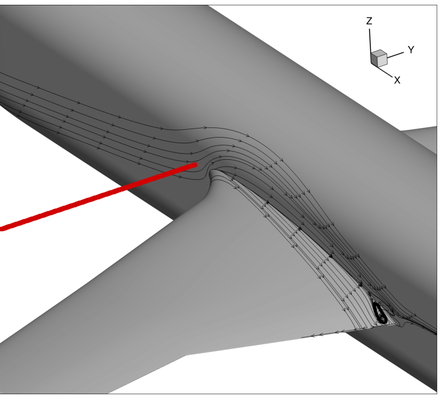




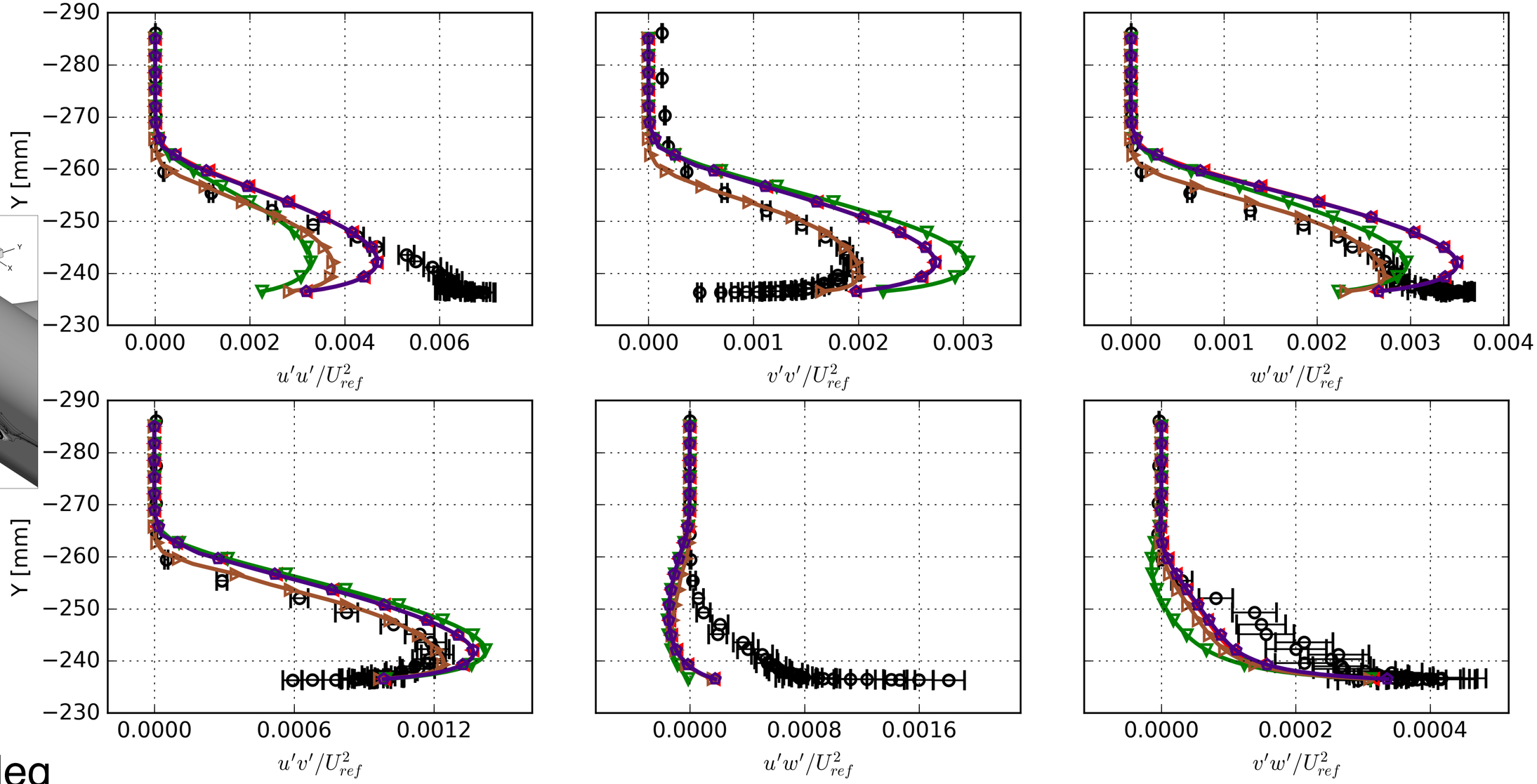
AOA = 5 deg

Reynolds Stress Profiles: Turbulence Model

Before LE of wing, Fine Grid



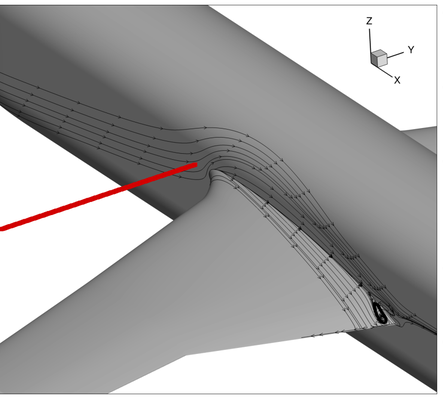
AOA = 5 deg

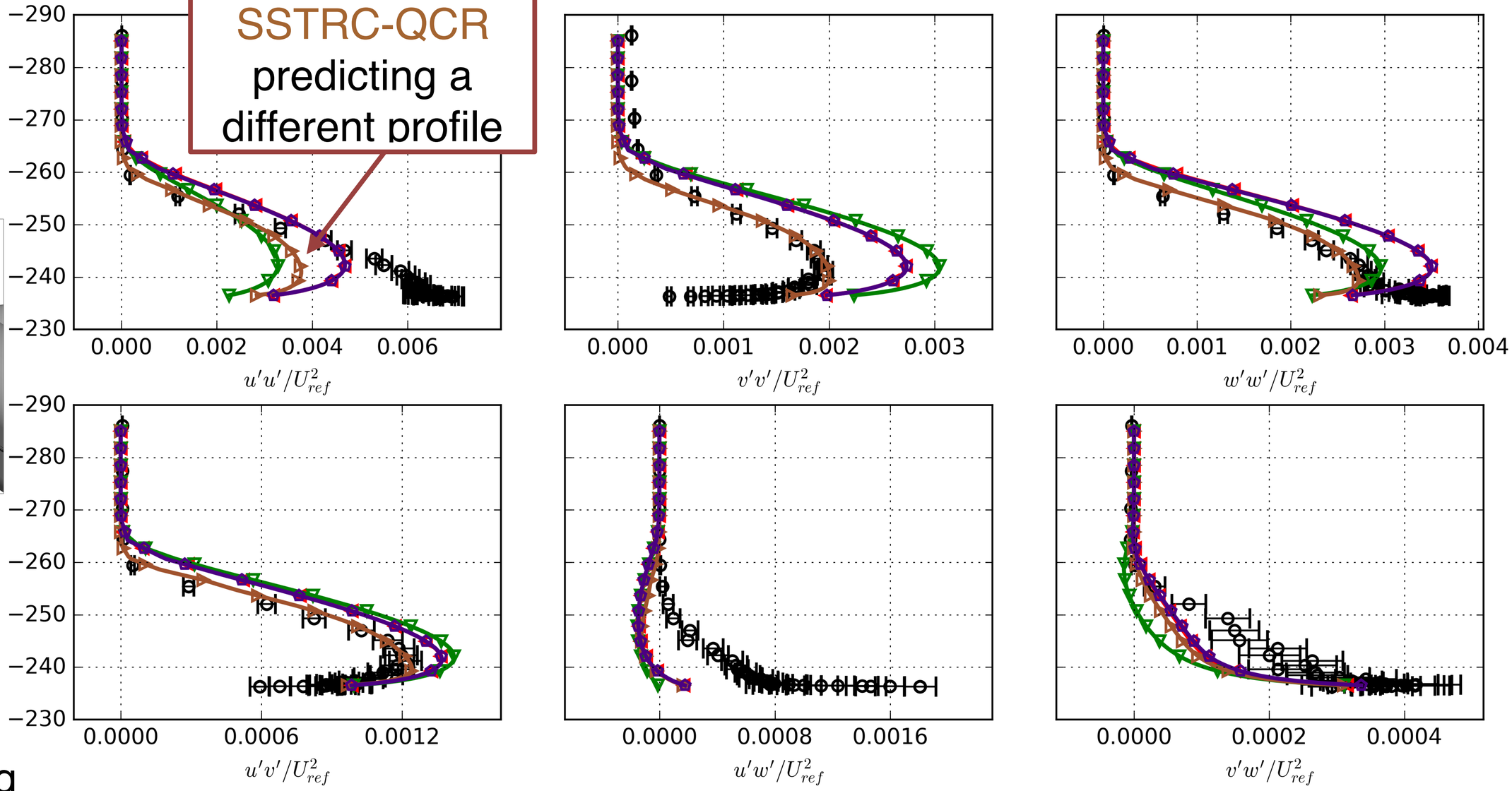


Reynolds Stress Profiles: Turbulence Model

Before LE of wing, Fine Grid

SSTRC-QCR predicting a different profile

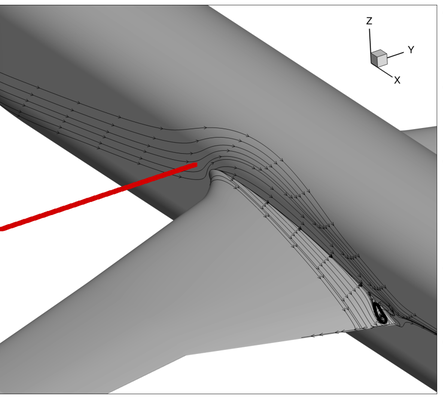




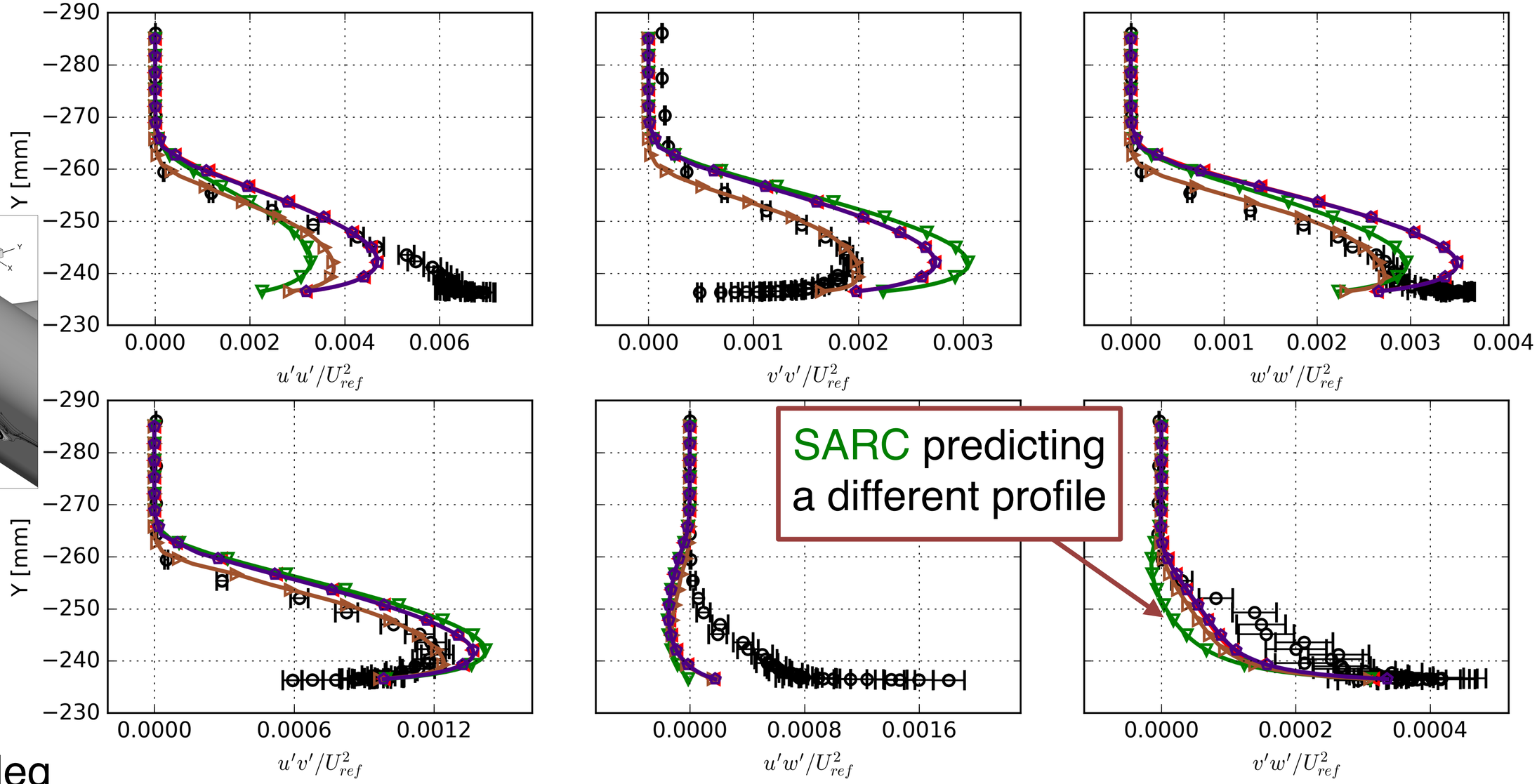
AOA = 5 deg

Reynolds Stress Profiles: Turbulence Model

Before LE of wing, Fine Grid



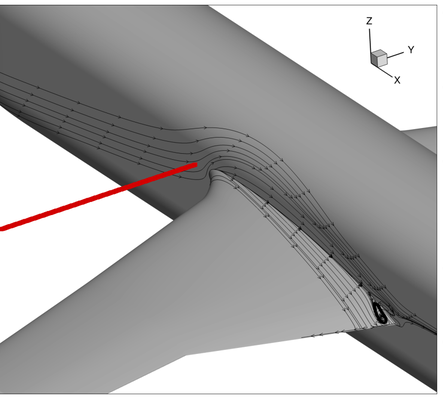
AOA = 5 deg

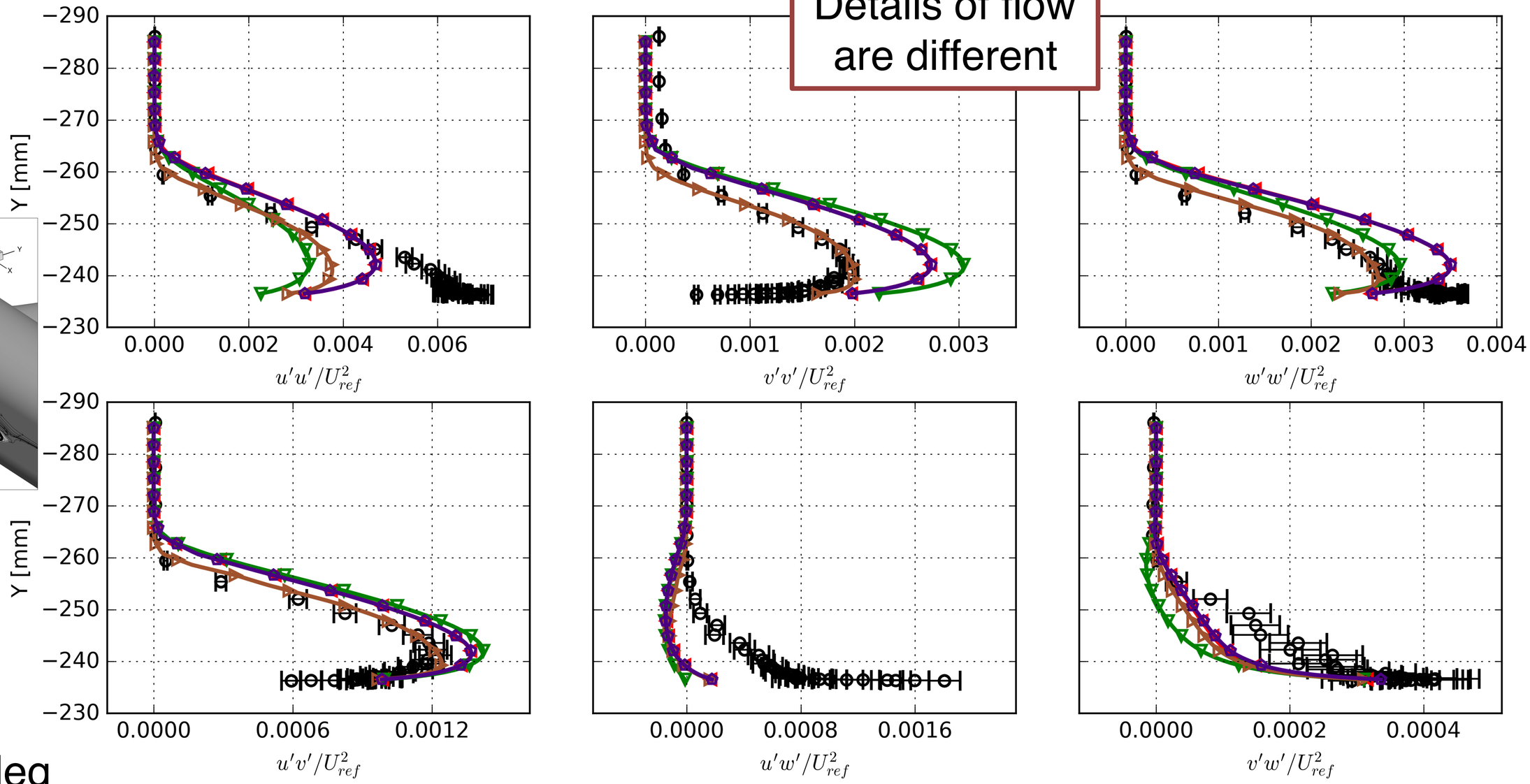


Reynolds Stress Profiles: Turbulence Model

Before LE of wing, Fine Grid

Details of flow are different



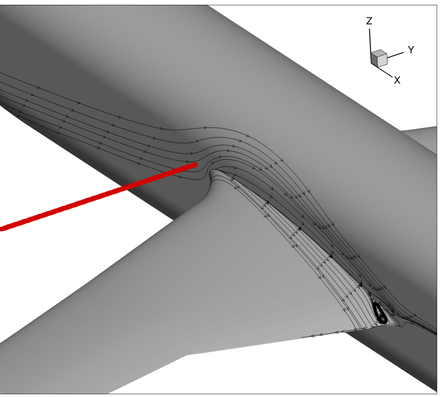


AOA = 5 deg

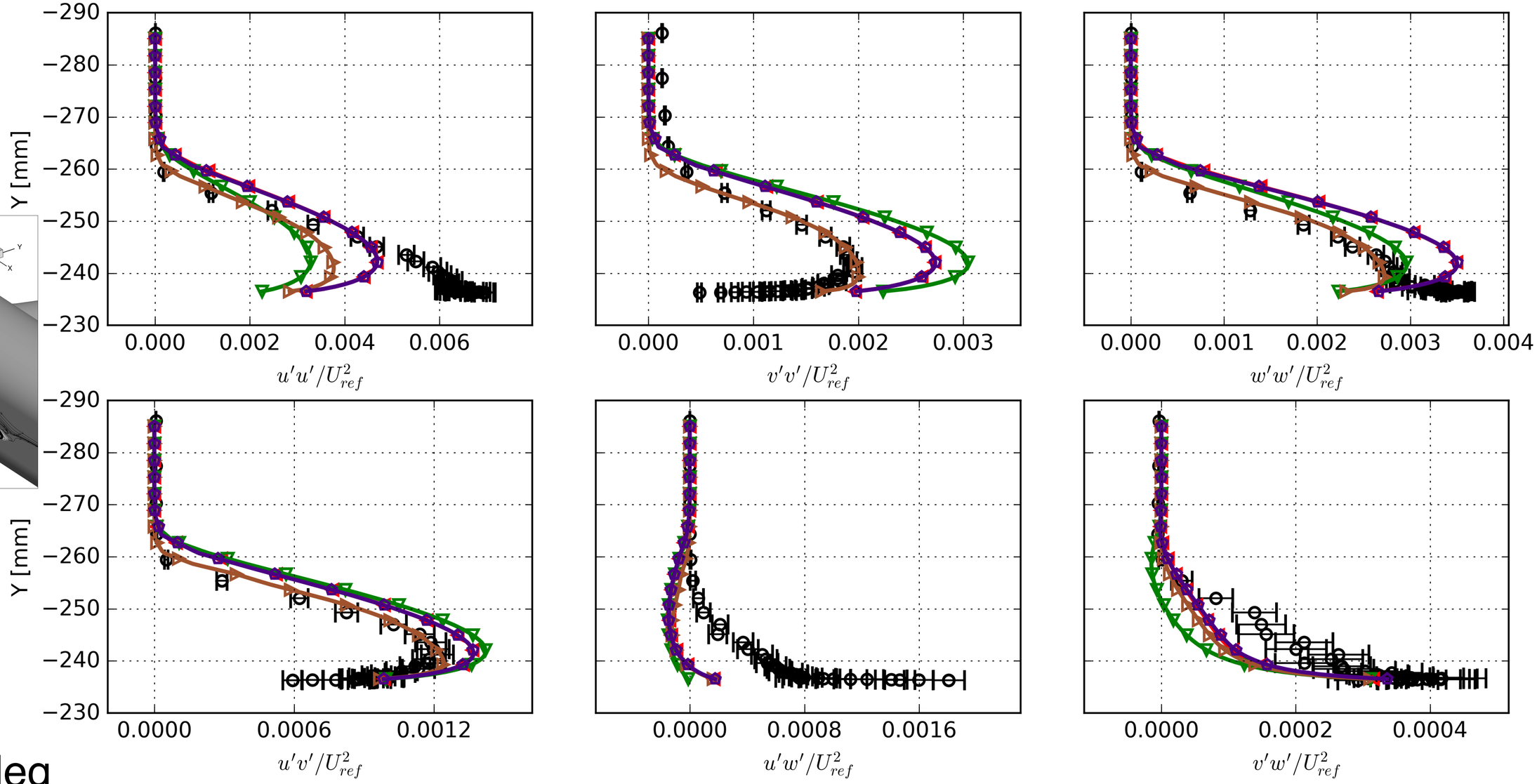
Exp | CFD Air SARC-QCR | CFD Air SARC | CFD Air SSTRC-QCR | CFD WT SARC-QCR

Reynolds Stress Profiles: Turbulence Model

Before LE of wing, Fine Grid

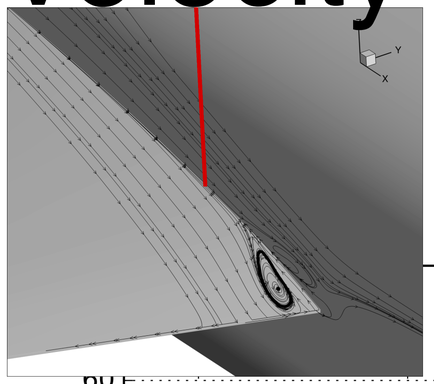


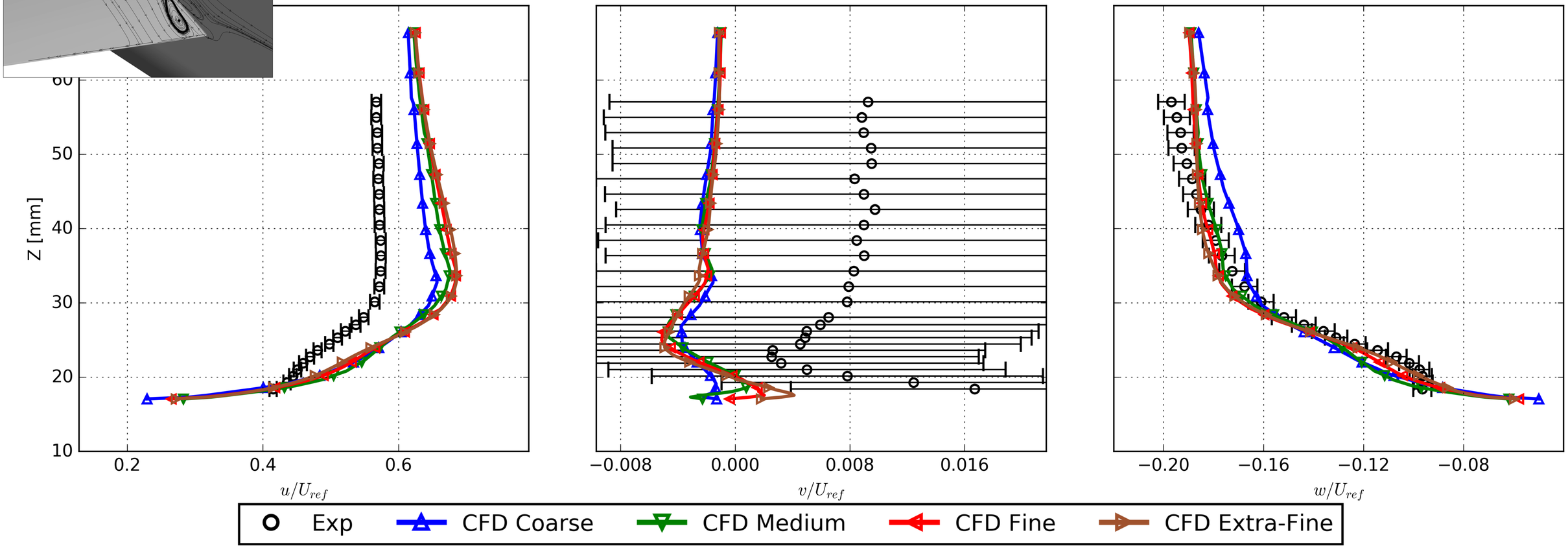
AOA = 5 deg



Velocity Profiles: Grid Resolution (Free Air)

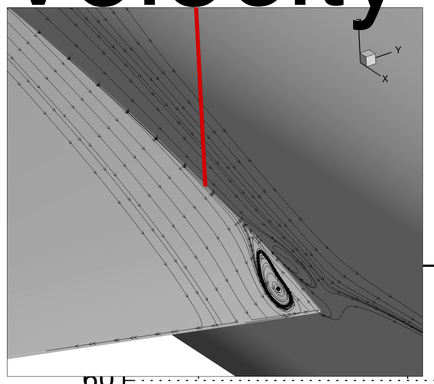
Upstream of Separation, 1 mm from fuselage





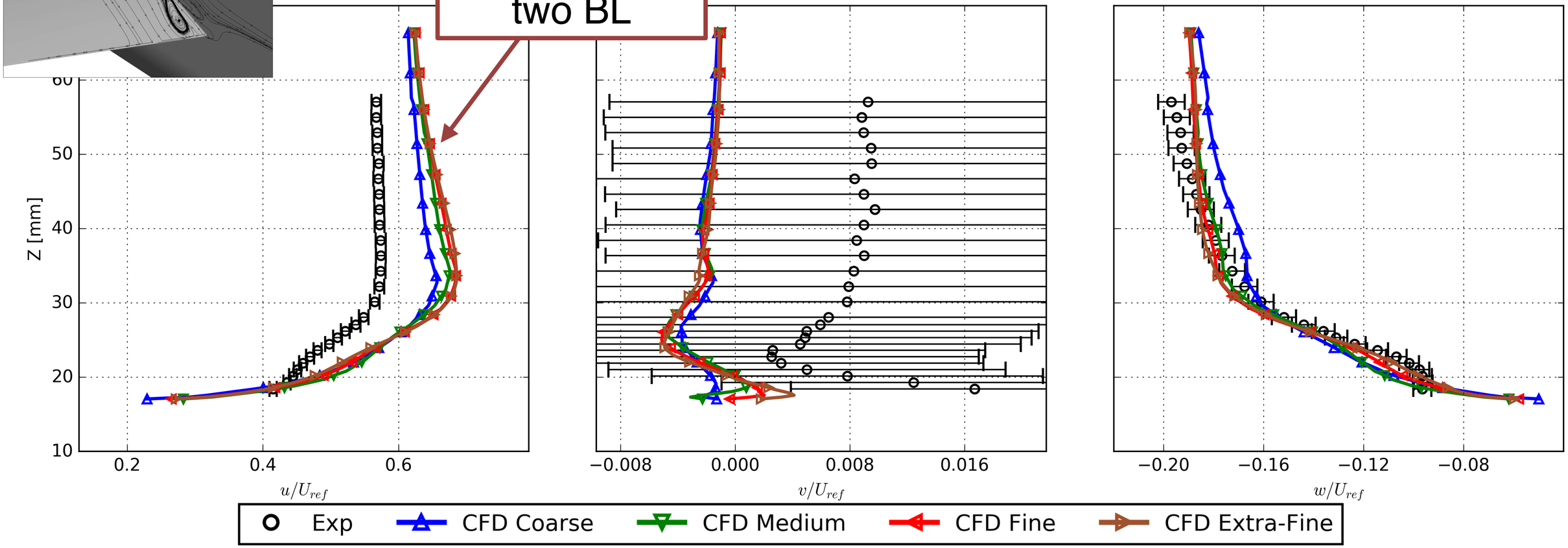
AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)



Upstream of Separation, 1 mm from fuselage

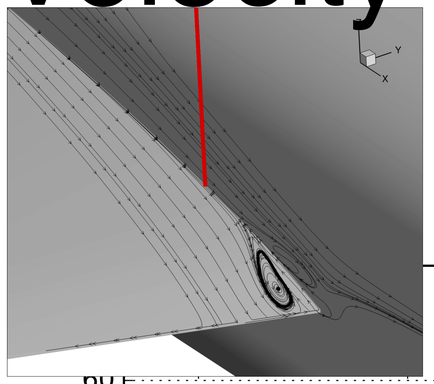
Shift may be caused by the two BL

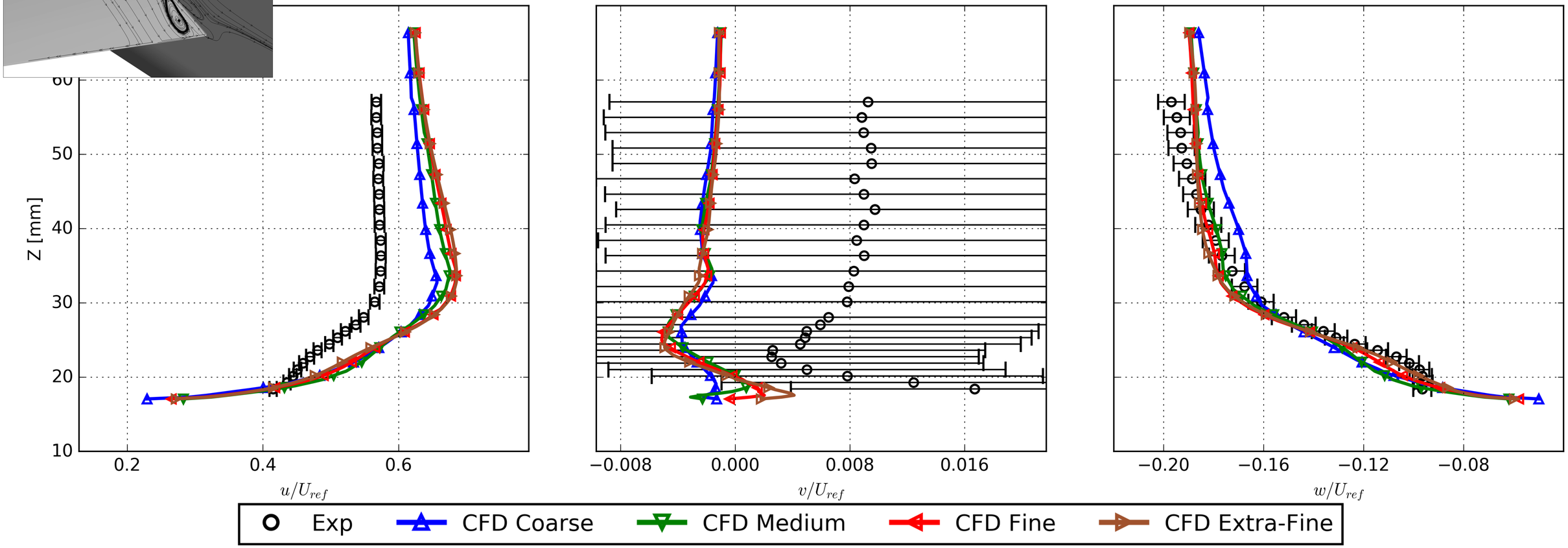


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)

Upstream of Separation, 1 mm from fuselage

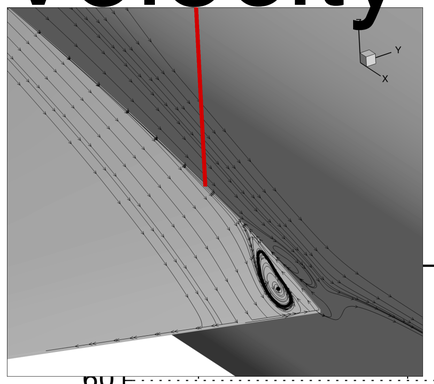


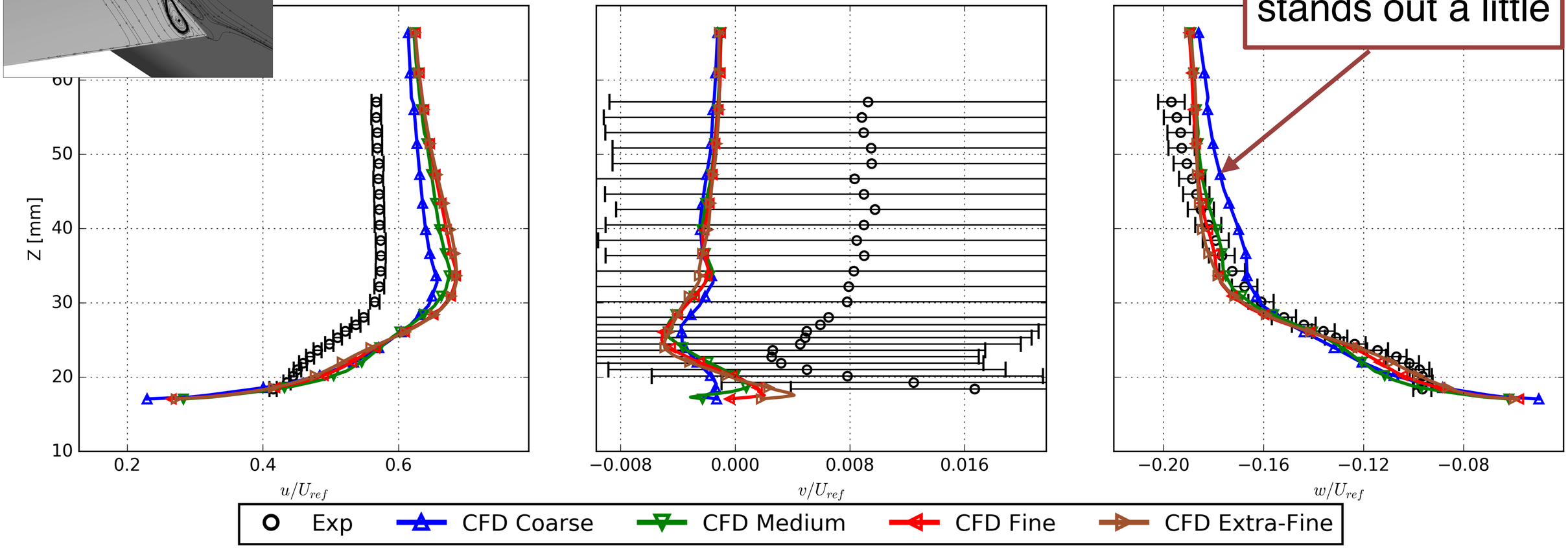


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)

Upstream of Separation, 1 mm from fuselage

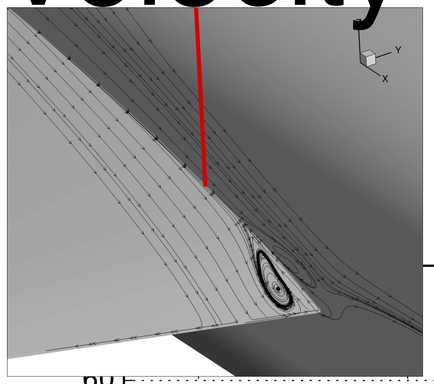


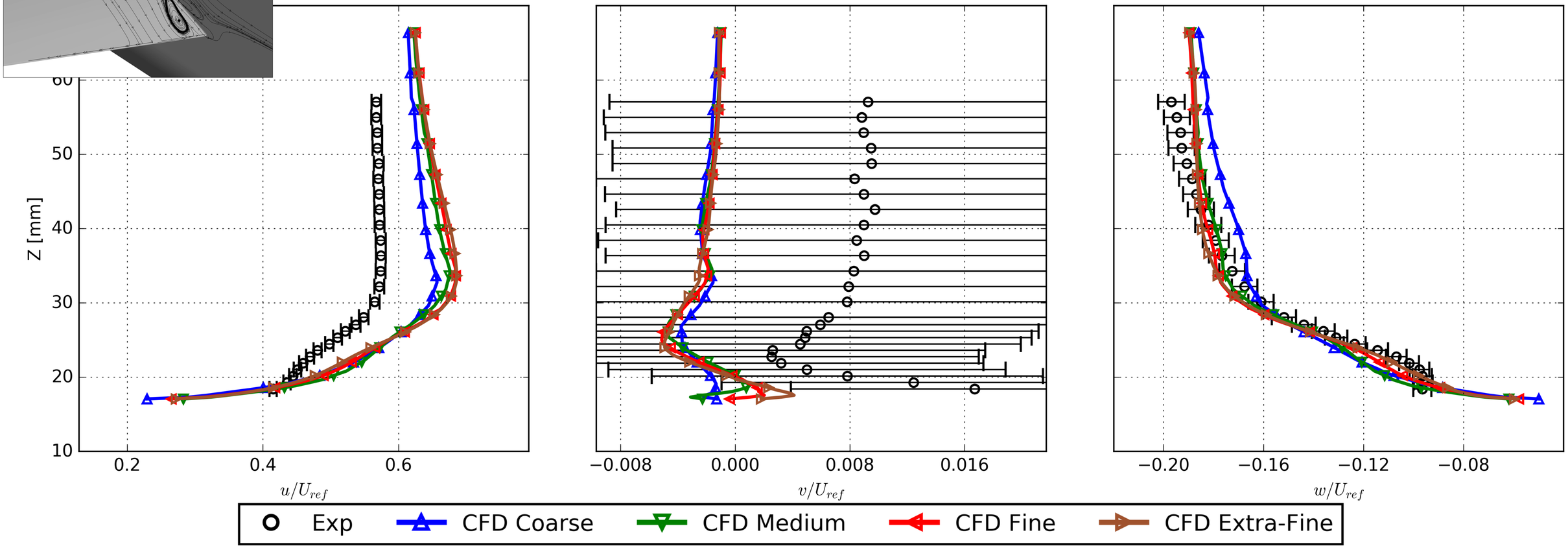


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)

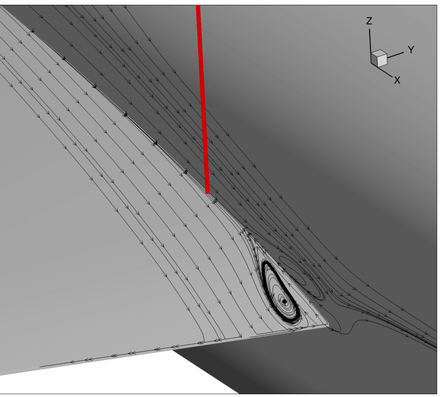
Upstream of Separation, 1 mm from fuselage





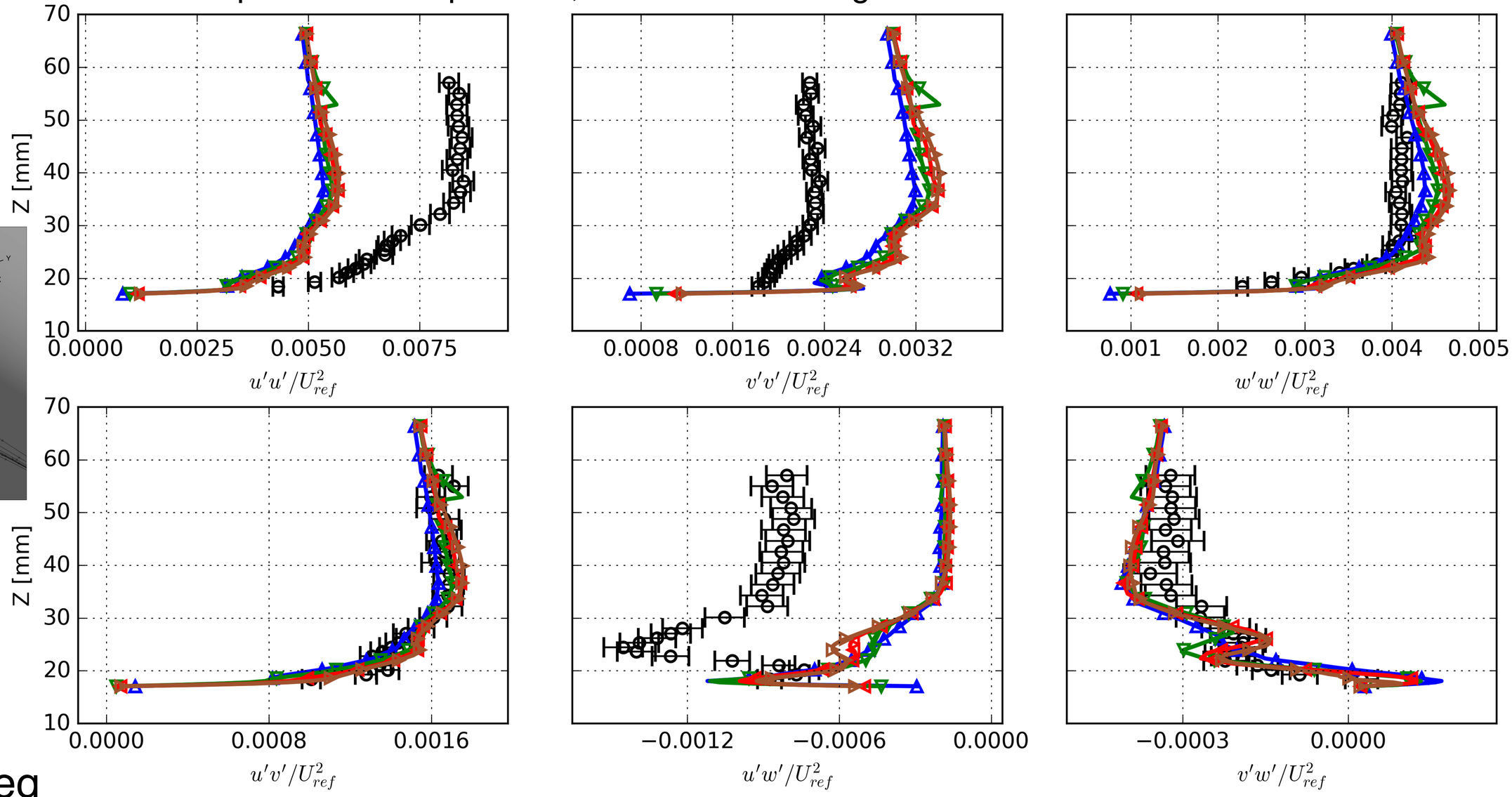
AOA = 5 deg

Reynolds Stress Profiles: Grid Resolution (Free Air)



AOA = 5 deg

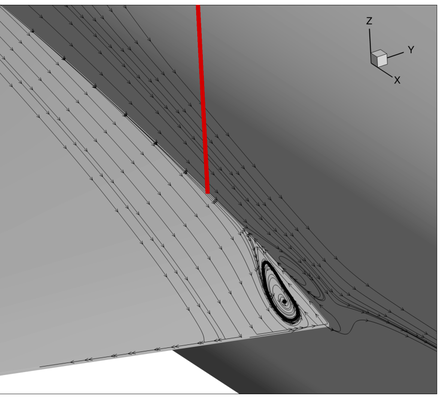
Upstream of Separation, 1 mm from fuselage



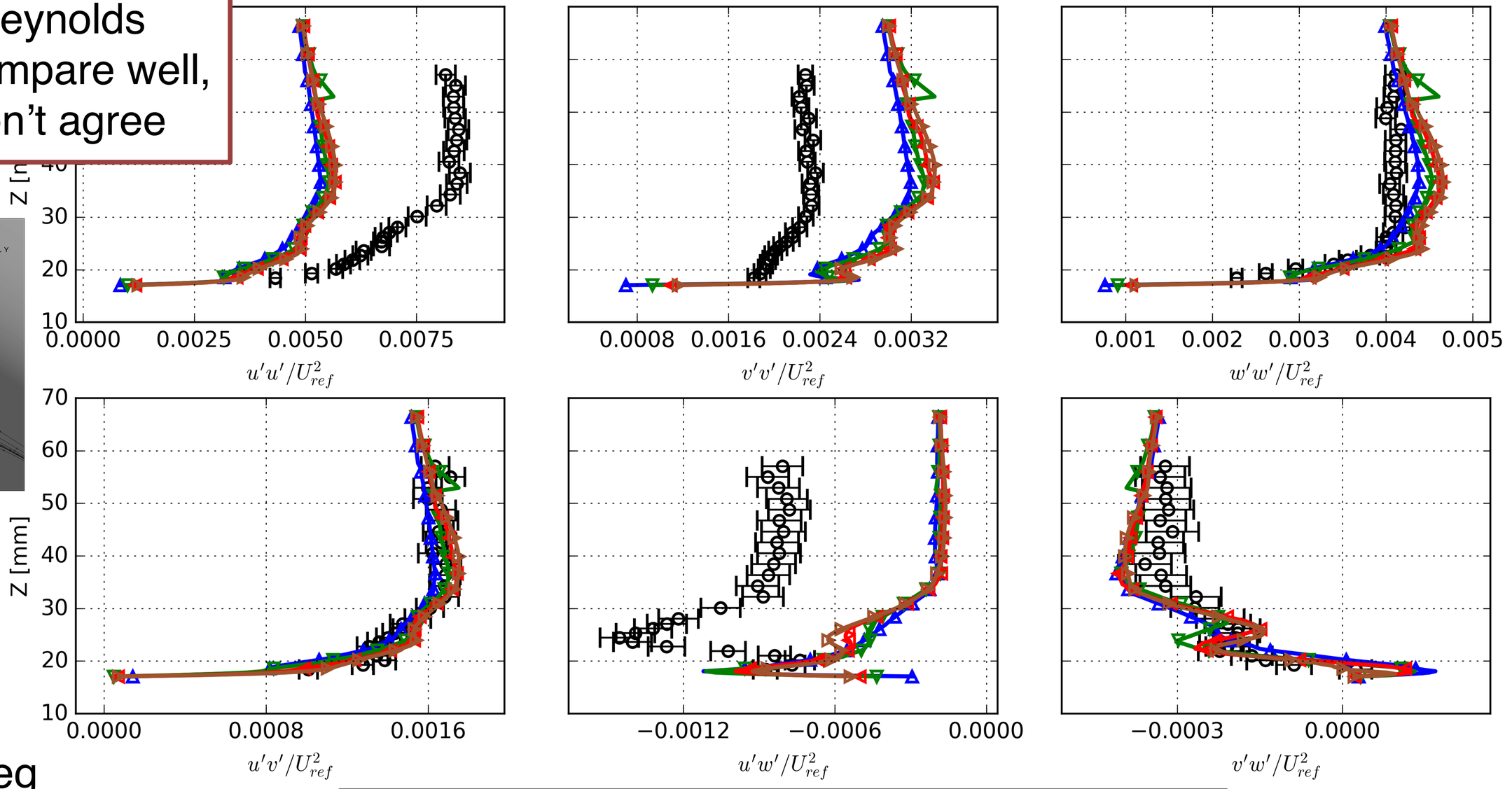
Reynolds Stress Profiles: Grid Resolution (Free Air)

Upstream of Separation, 1 mm from fuselage

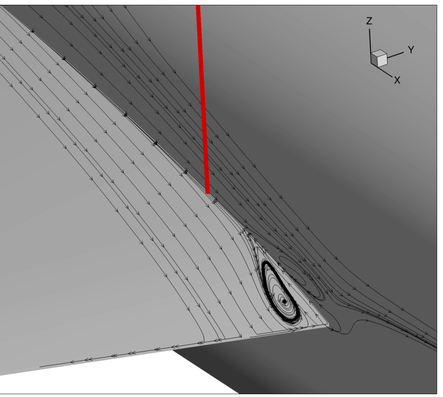
Some Reynolds stresses compare well, others don't agree



AOA = 5 deg

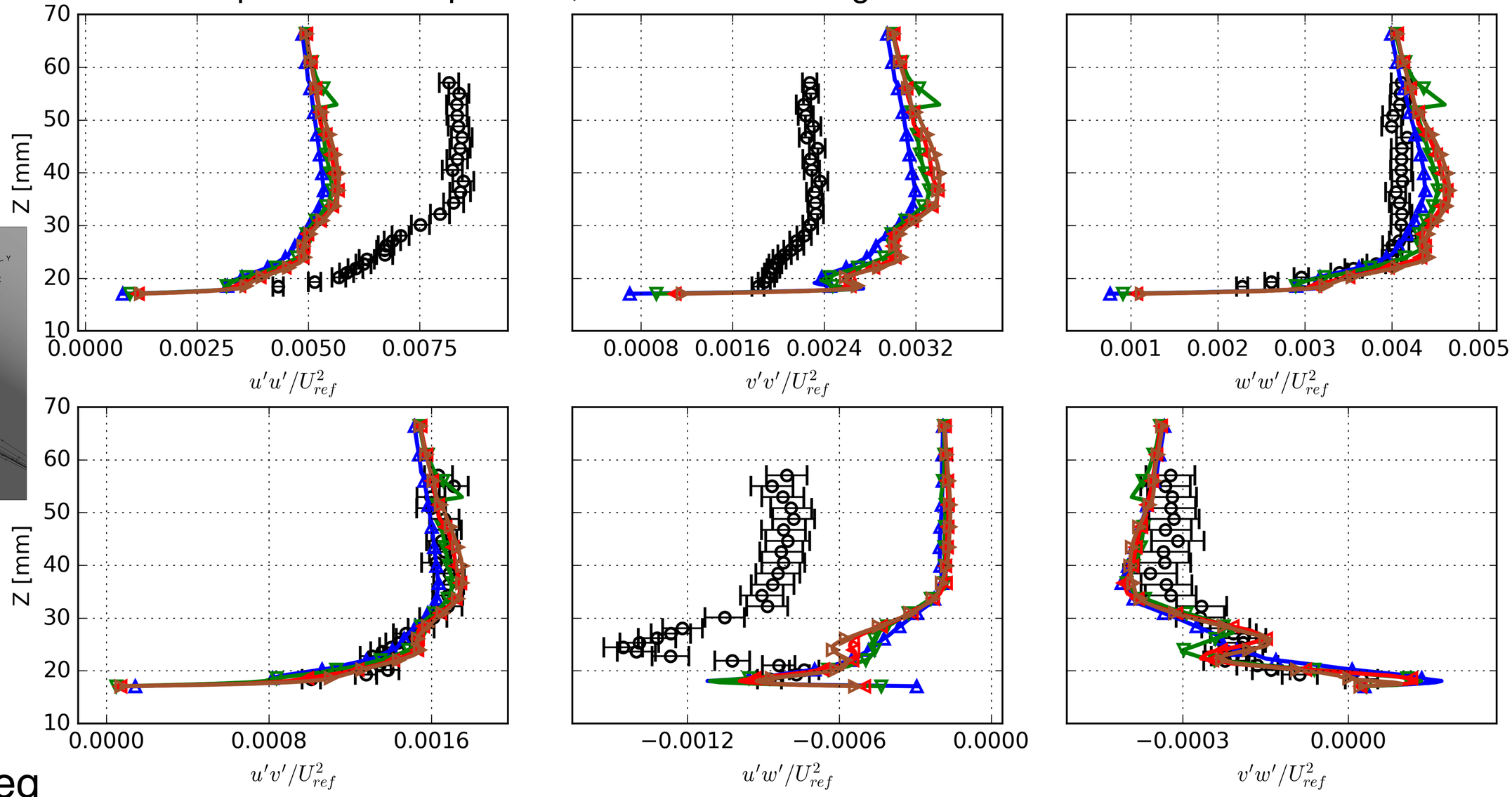


Reynolds Stress Profiles: Grid Resolution (Free Air)



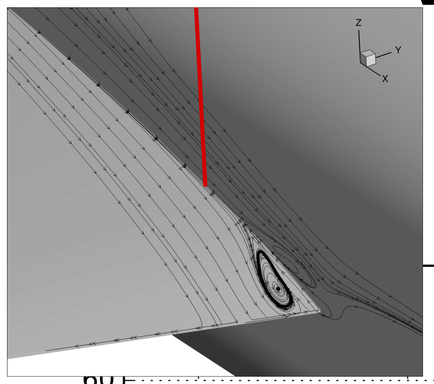
AOA = 5 deg

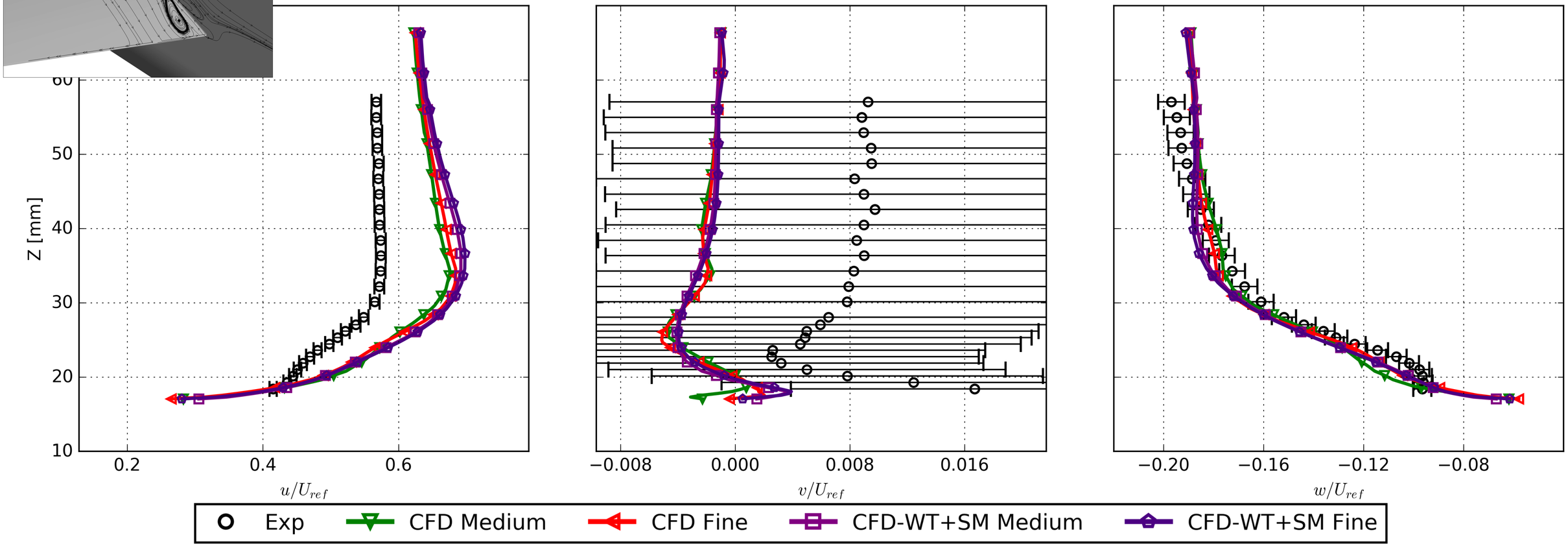
Upstream of Separation, 1 mm from fuselage



Velocity Profiles: Wall Effect

Upstream of Separation, 1 mm from fuselage

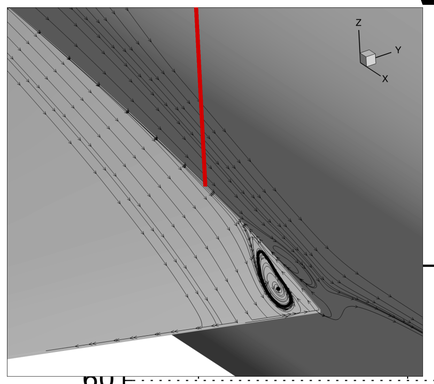




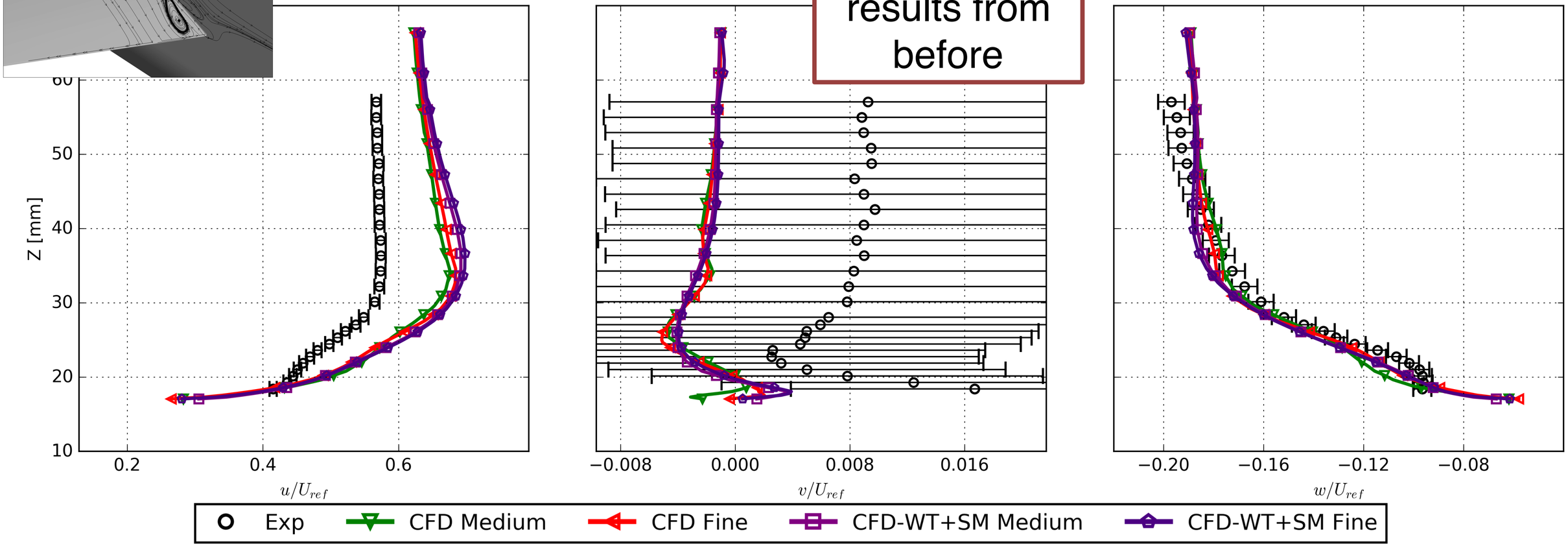
AOA = 5 deg

Velocity Profiles: Wall Effect

Upstream of Separation, 1 mm from fuselage



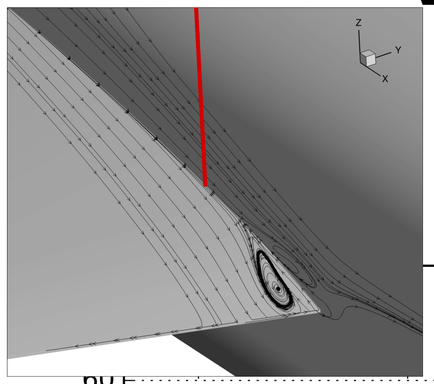
Very similar results from before

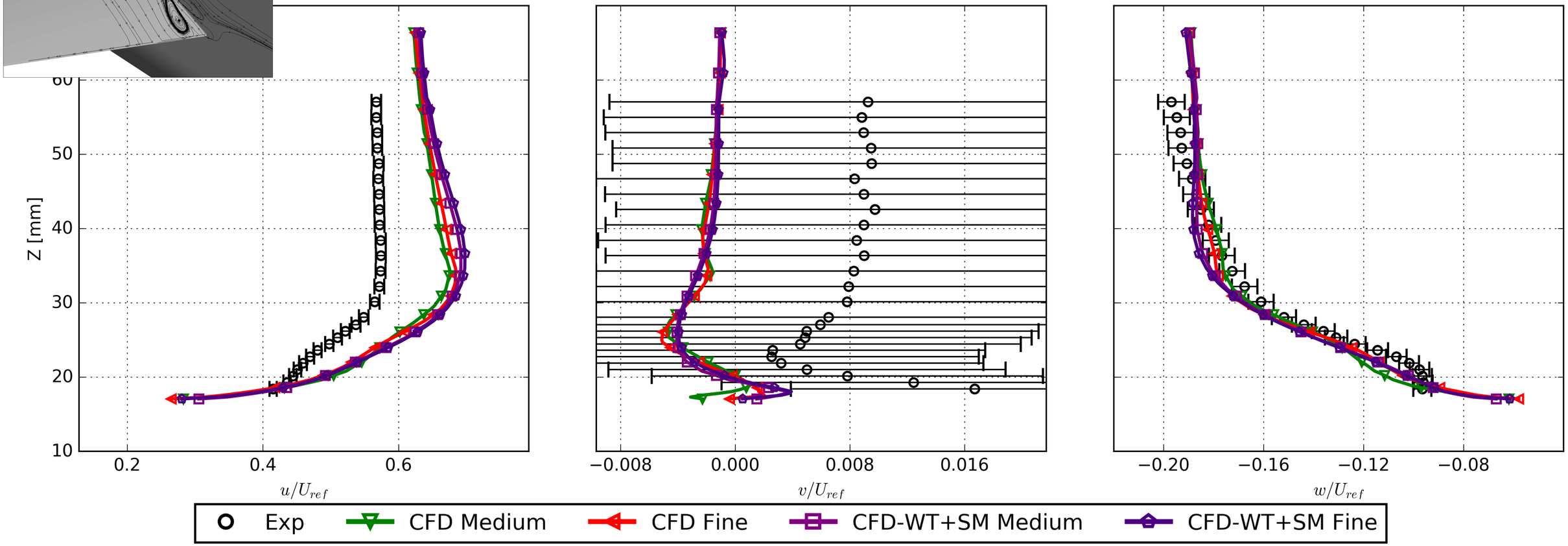


AOA = 5 deg

Velocity Profiles: Wall Effect

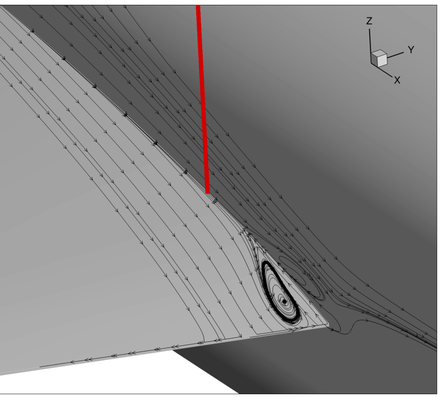
Upstream of Separation, 1 mm from fuselage





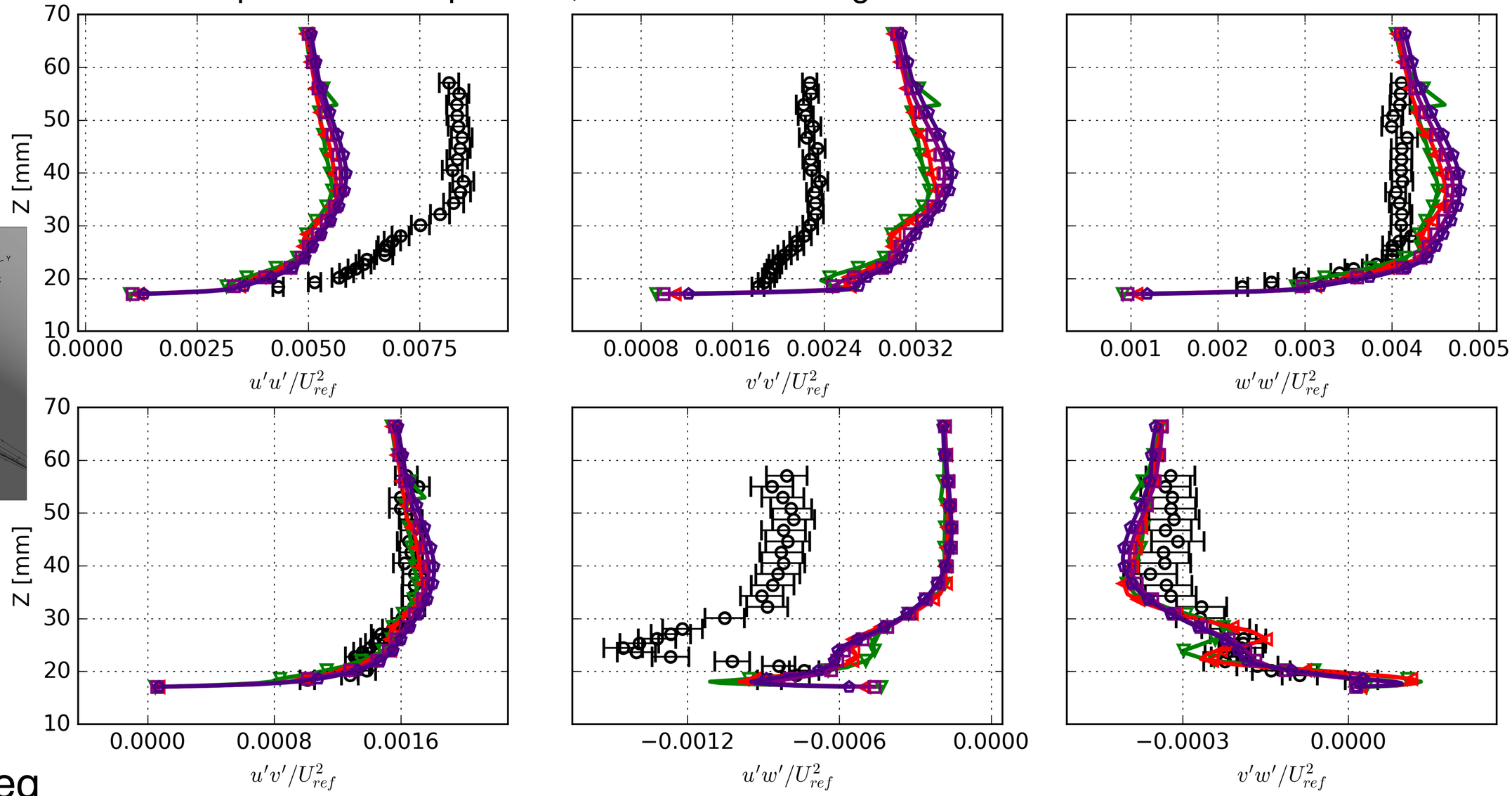
AOA = 5 deg

Reynolds Stress Profiles: Wall Effect

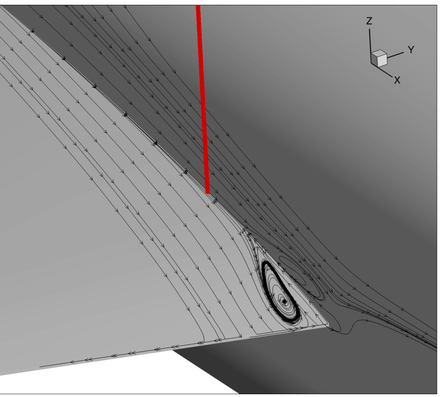


AOA = 5 deg

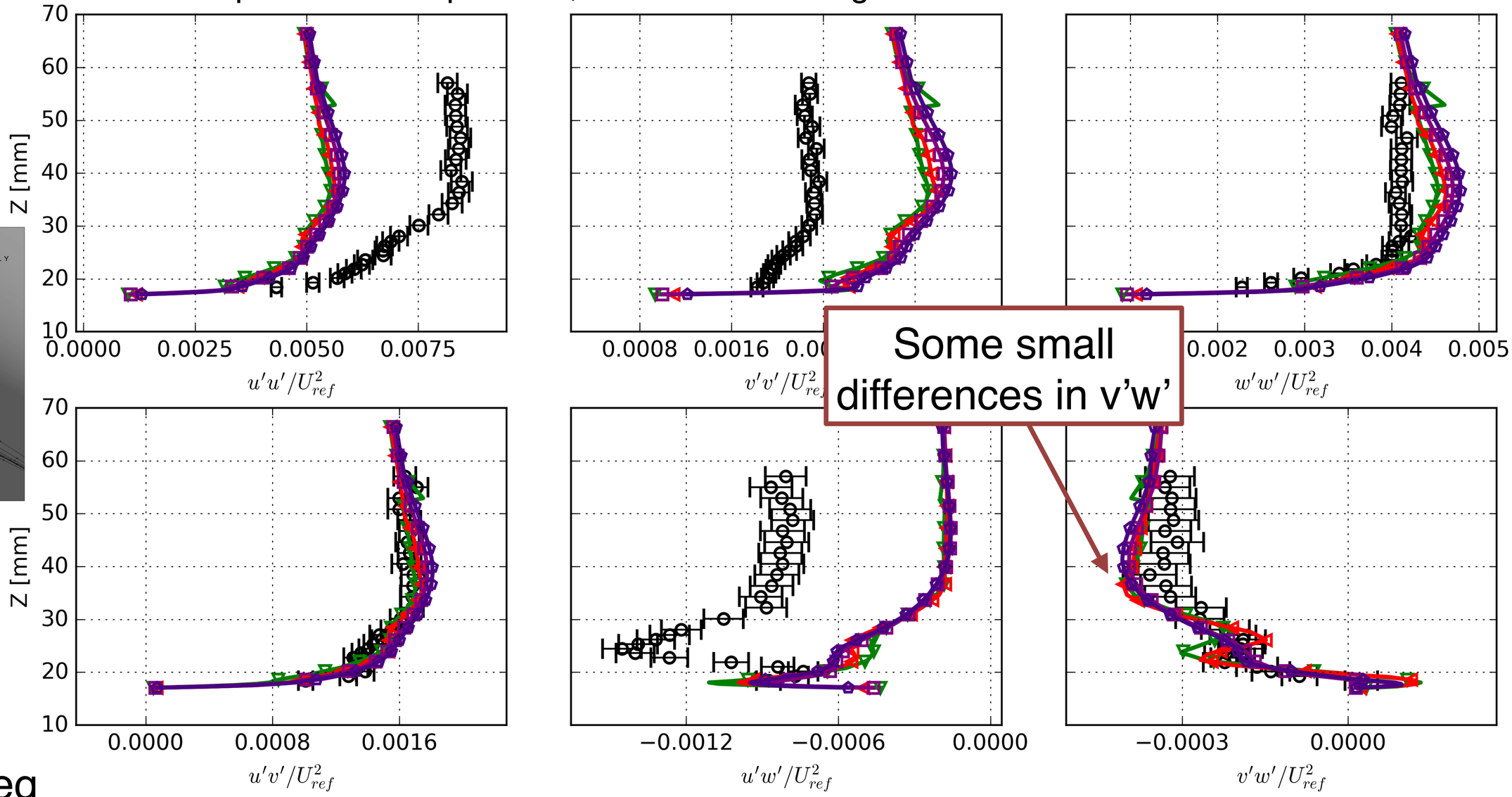
Upstream of Separation, 1 mm from fuselage



Reynolds Stress Profiles: Wall Effect

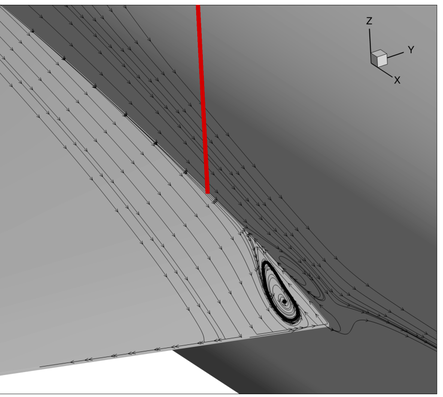


Upstream of Separation, 1 mm from fuselage



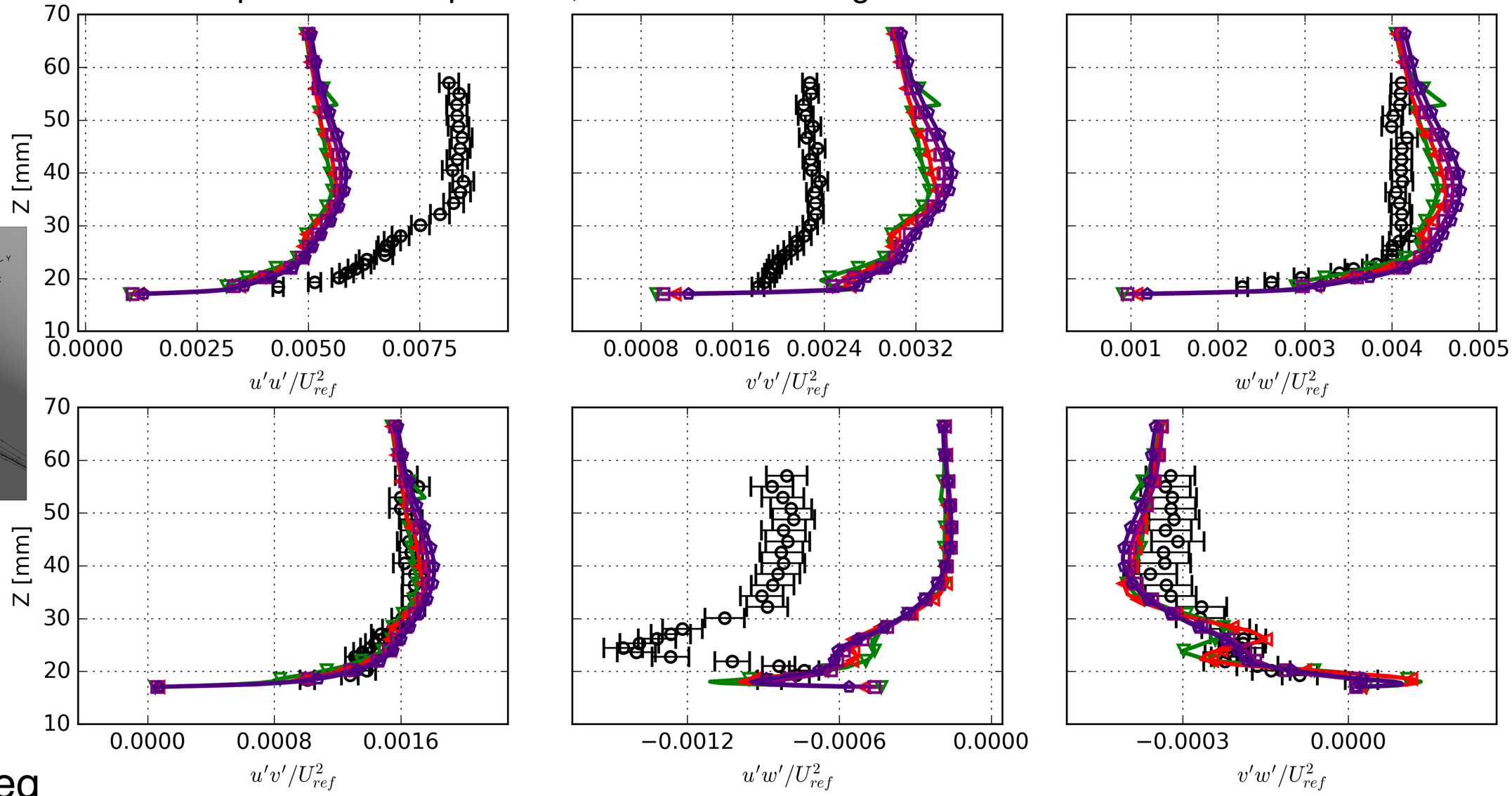
AOA = 5 deg

Reynolds Stress Profiles: Wall Effect



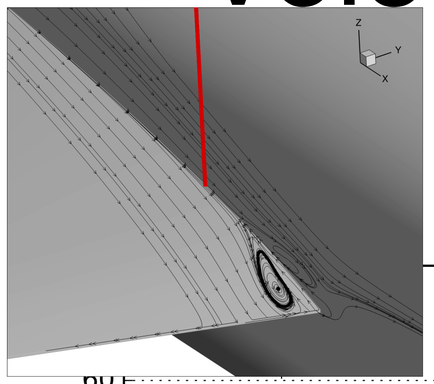
AOA = 5 deg

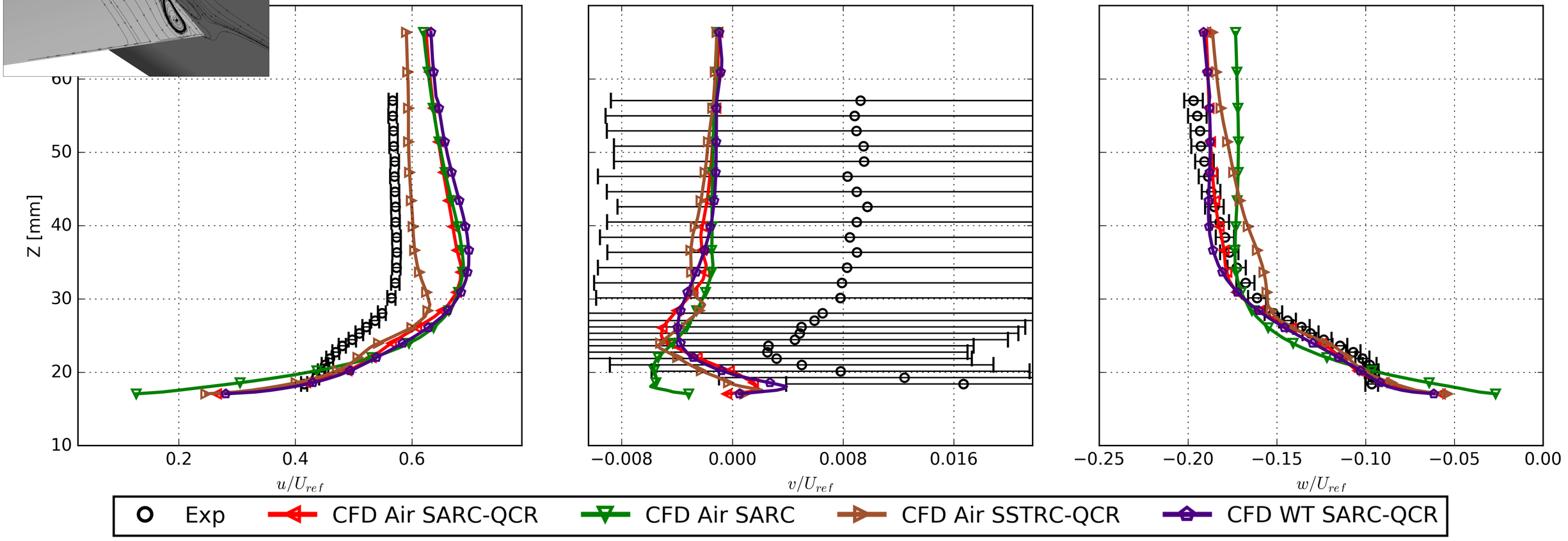
Upstream of Separation, 1 mm from fuselage



Velocity Profiles: Turbulence Model

Upstream of Separation, 1 mm from fuselage, Fine Grid

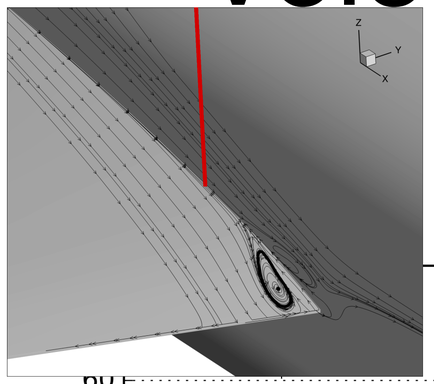




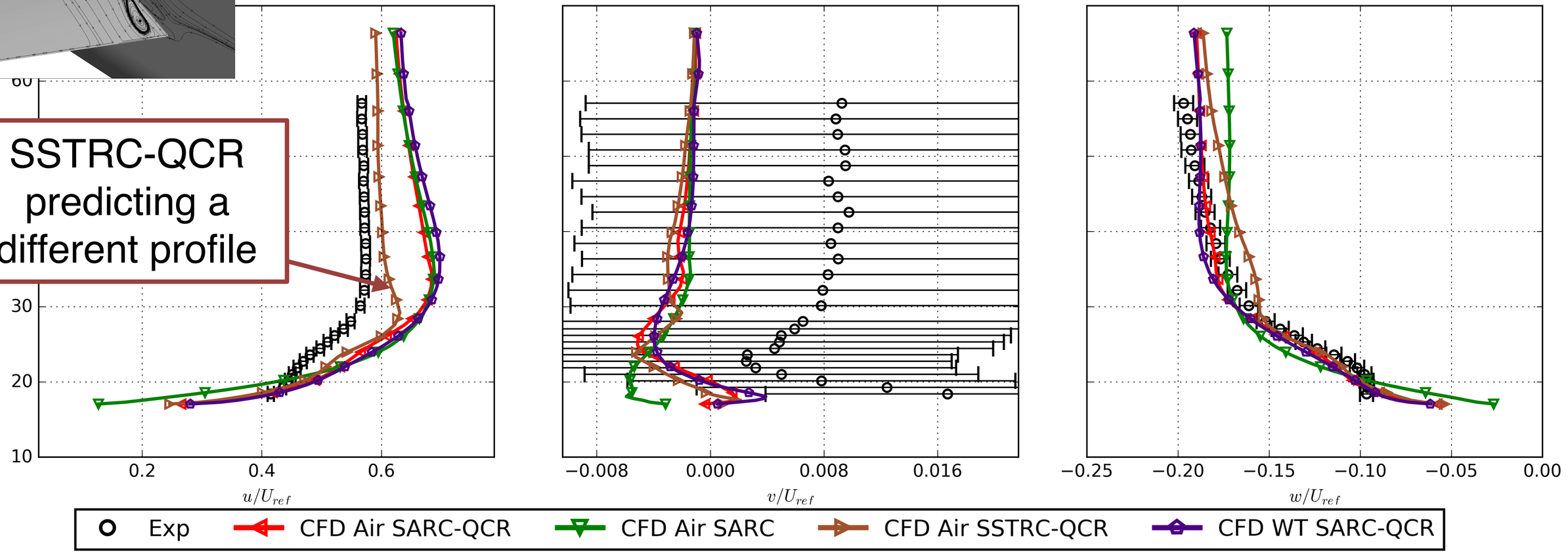
AOA = 5 deg

Velocity Profiles: Turbulence Model

Upstream of Separation, 1 mm from fuselage, Fine Grid



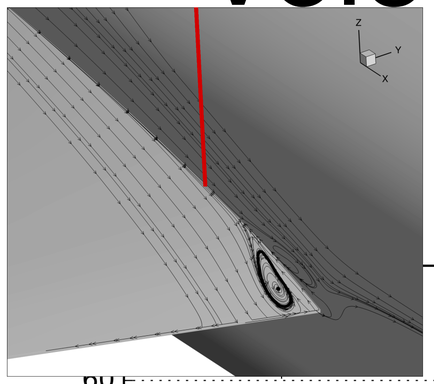
SSTRC-QCR predicting a different profile



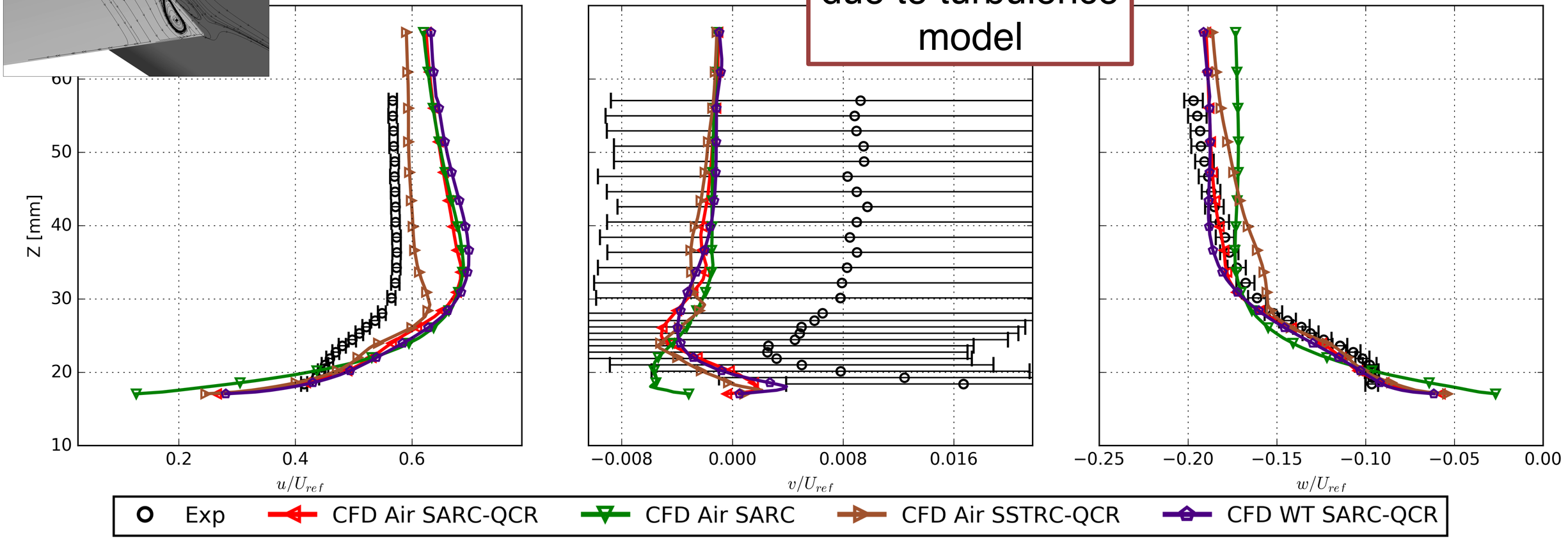
AOA = 5 deg

Velocity Profiles: Turbulence Model

Upstream of Separation, 1 mm from fuselage, Fine Grid



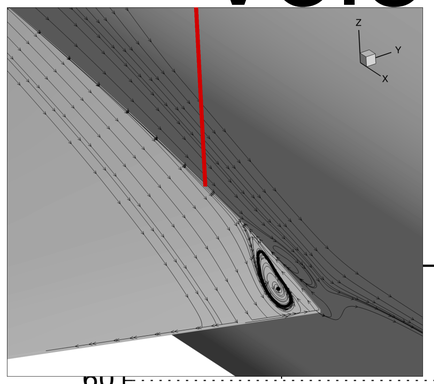
More variation due to turbulence model

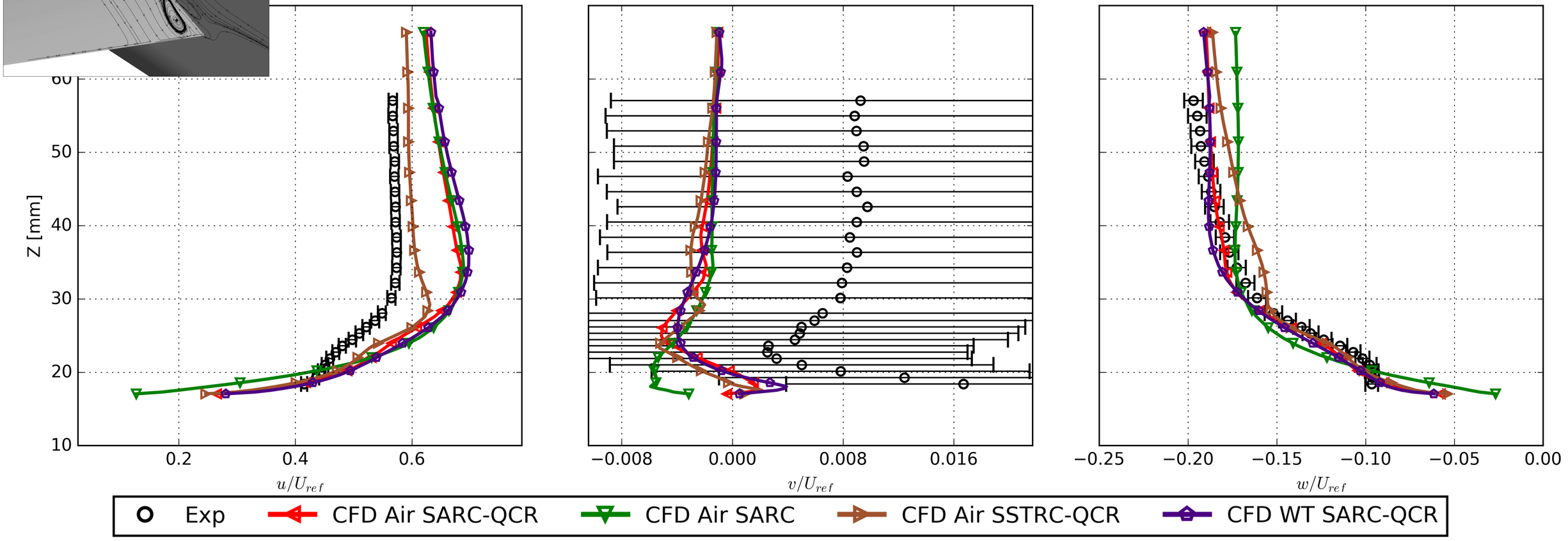


AOA = 5 deg

Velocity Profiles: Turbulence Model

Upstream of Separation, 1 mm from fuselage, Fine Grid

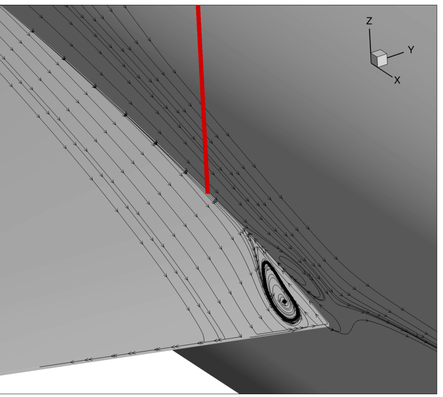




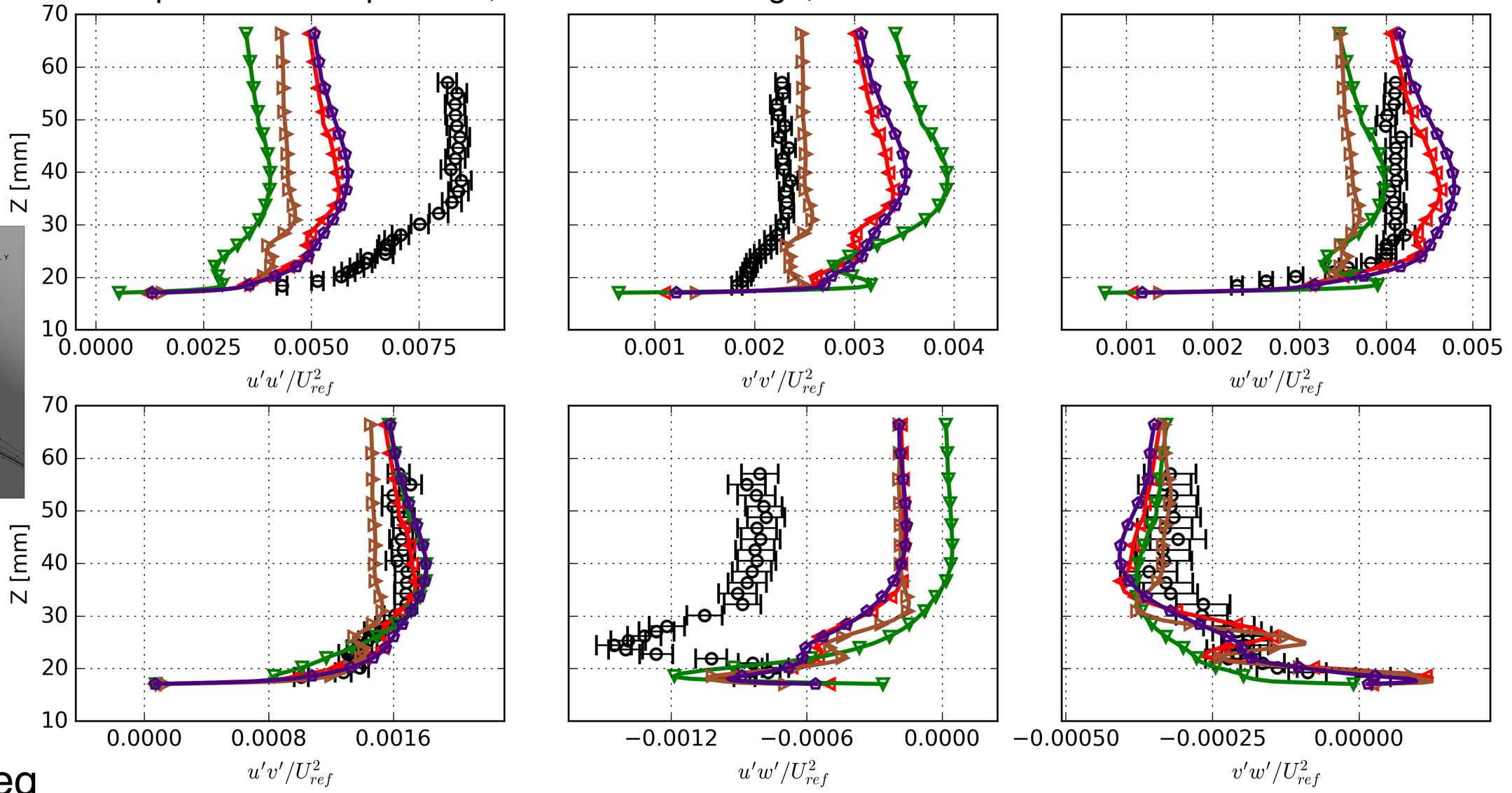
AOA = 5 deg

Reynolds Stress Profiles: Turbulence Model

Upstream of Separation, 1 mm from fuselage, Fine Grid



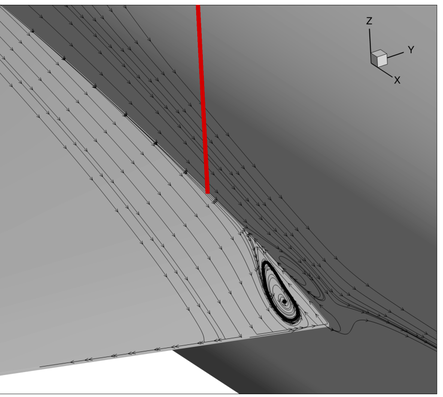
AOA = 5 deg



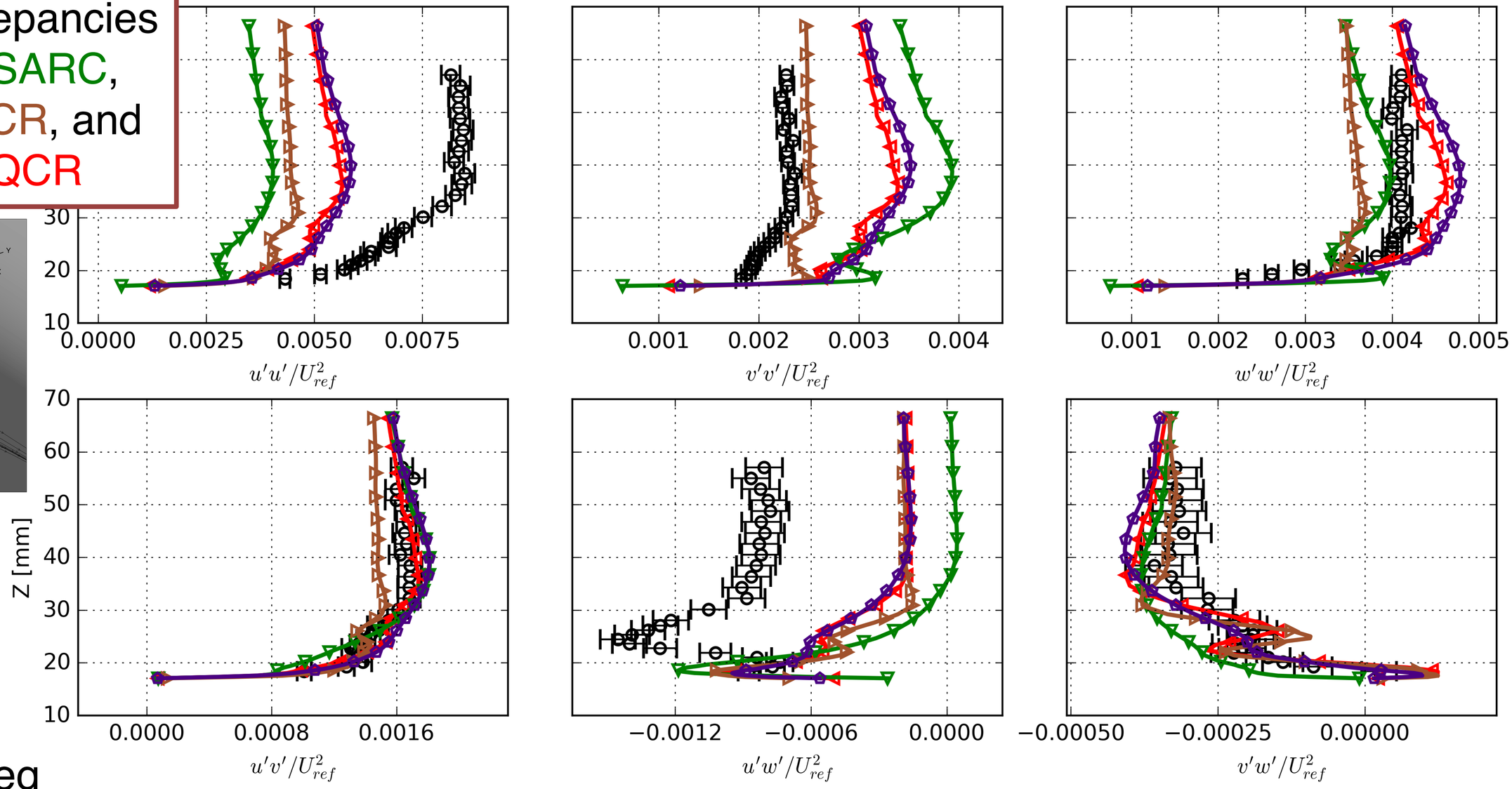
Reynolds Stress Profiles: Turbulence Model

Upstream of Separation, 1 mm from fuselage, Fine Grid

Large discrepancies between SARC, SSTRC-QCR, and SARC-QCR

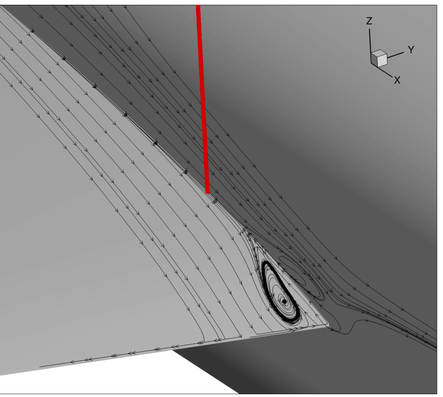


AOA = 5 deg

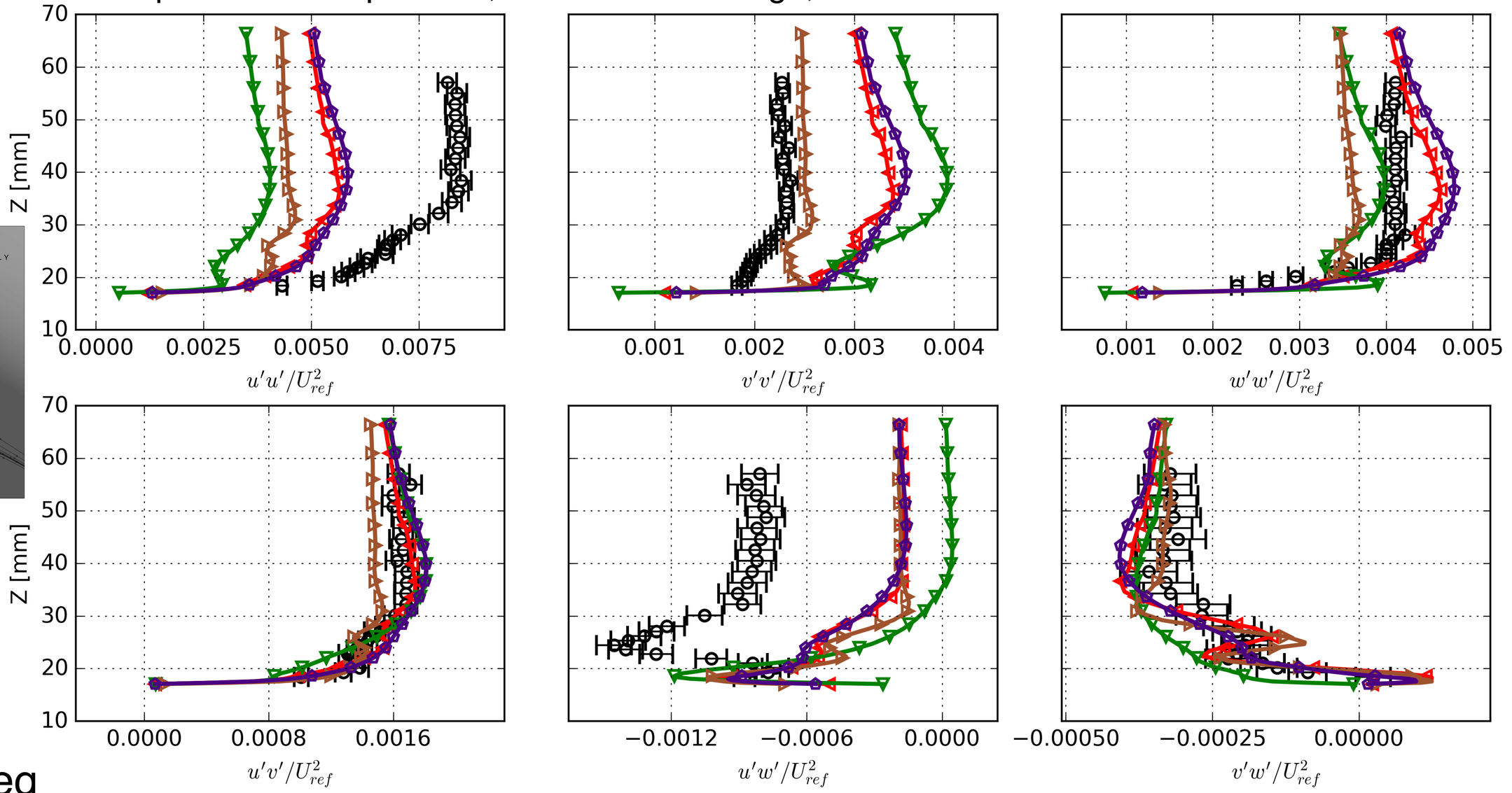


Reynolds Stress Profiles: Turbulence Model

Upstream of Separation, 1 mm from fuselage, Fine Grid

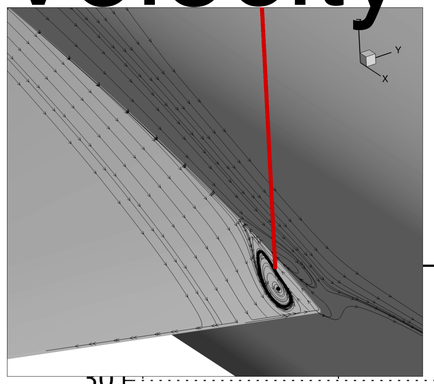


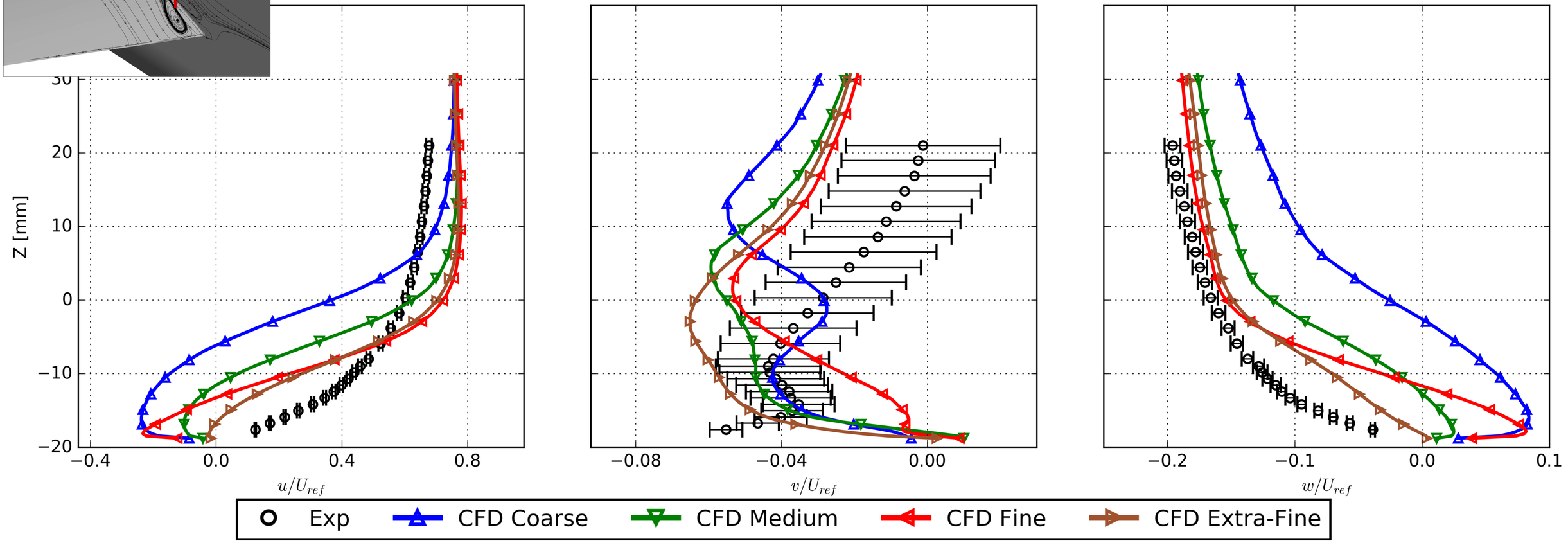
AOA = 5 deg



Velocity Profiles: Grid Resolution (Free Air)

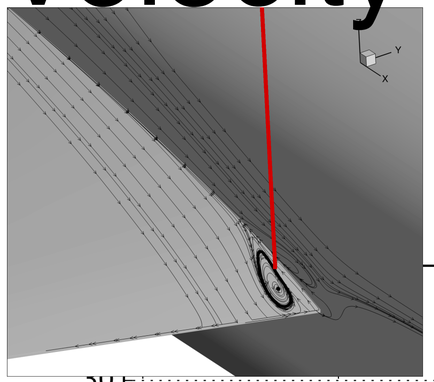
In the Separated Region, 10 mm from fuselage





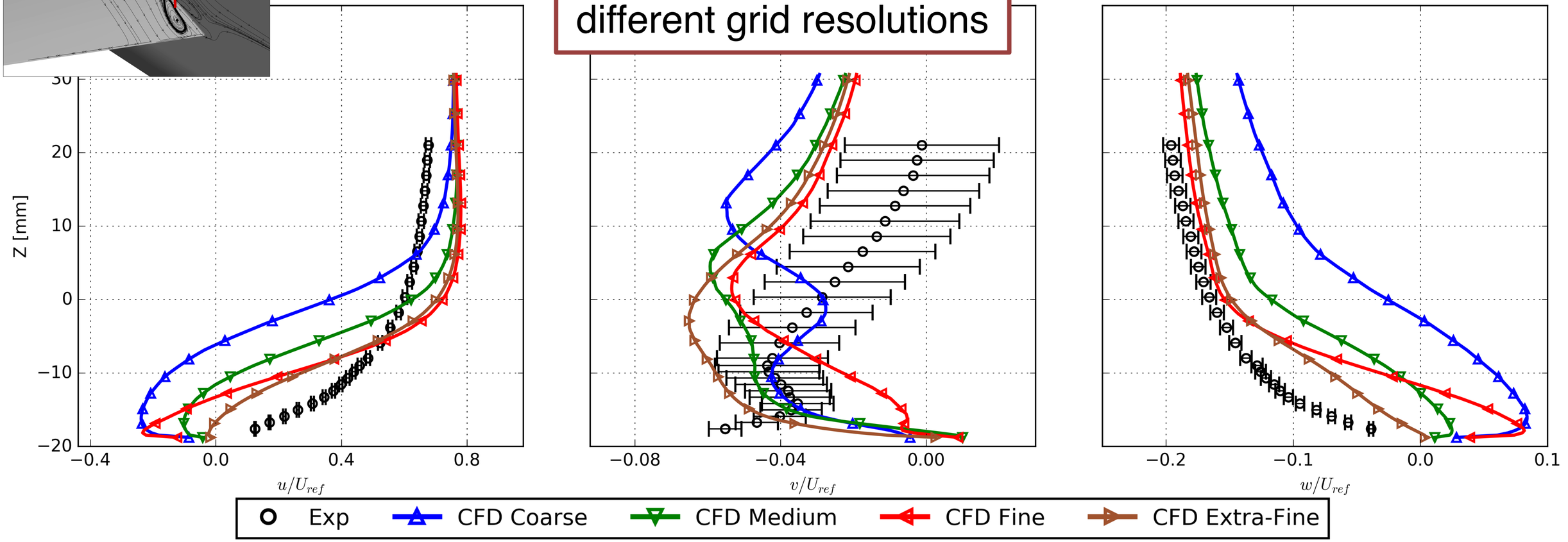
AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)



In the Separated Region, 10 mm from fuselage

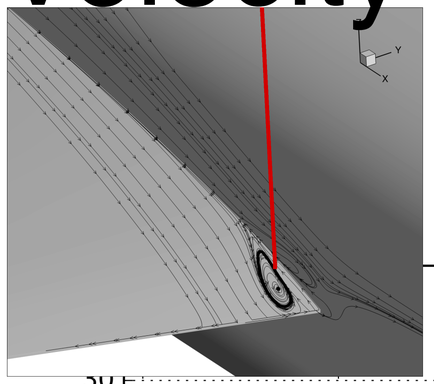
Large variation in velocity profiles across different grid resolutions

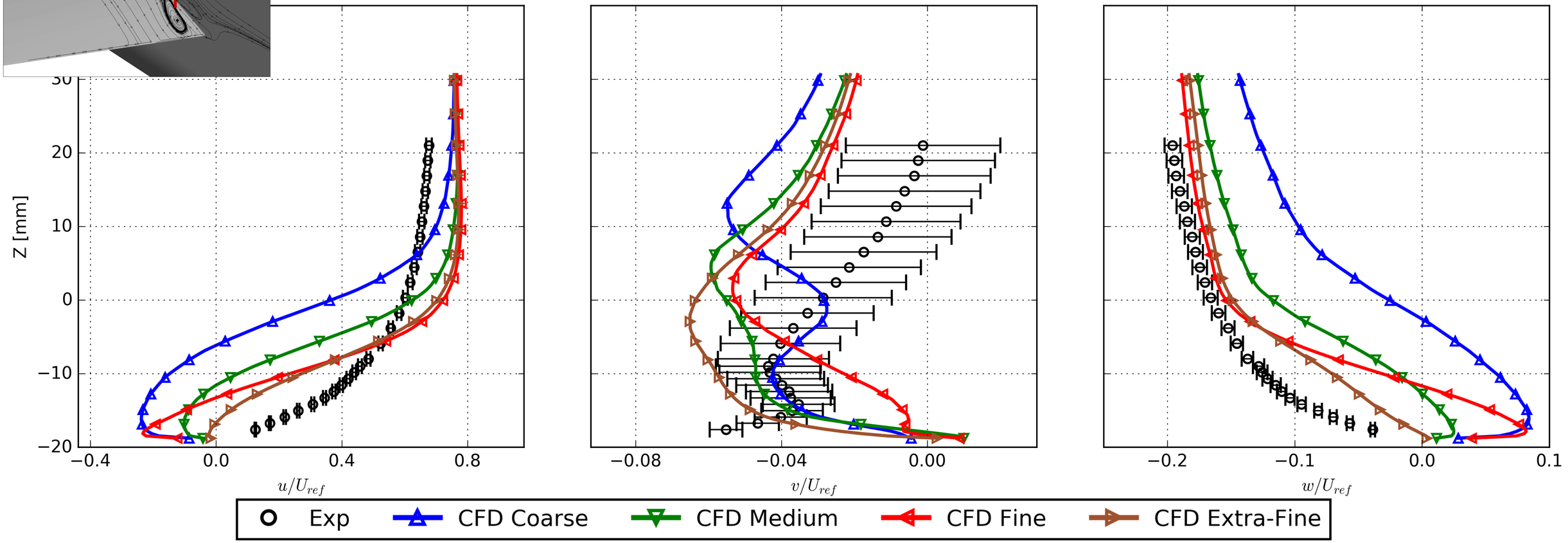


AOA = 5 deg

Velocity Profiles: Grid Resolution (Free Air)

In the Separated Region, 10 mm from fuselage

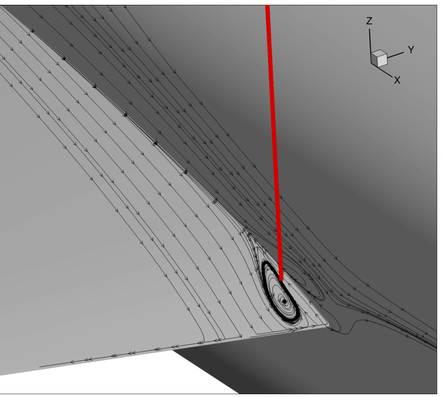


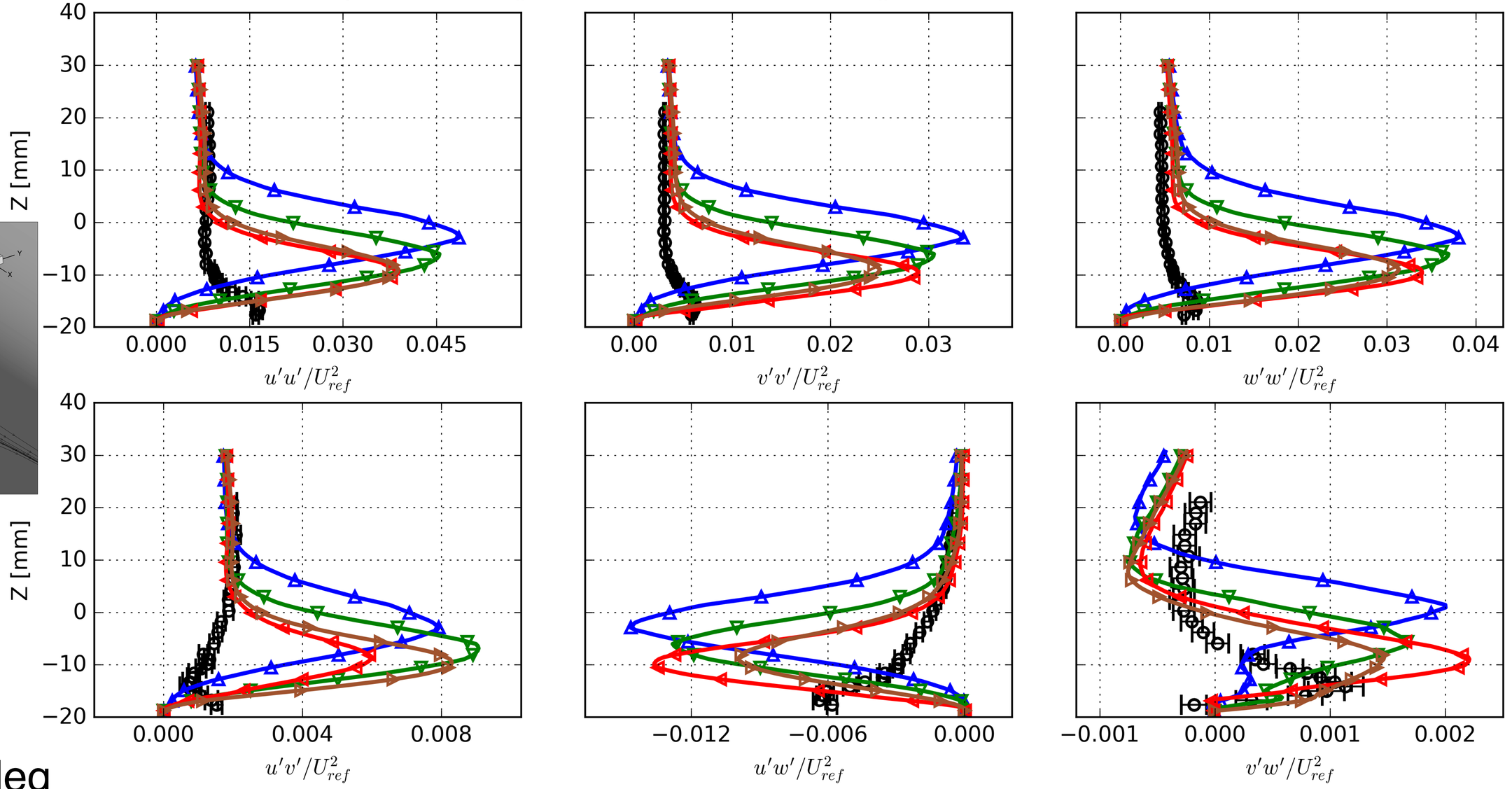


AOA = 5 deg

Reynolds Stress Profiles: Grid Resolution (Free Air)

In the Separated Region, 10 mm from fuselage



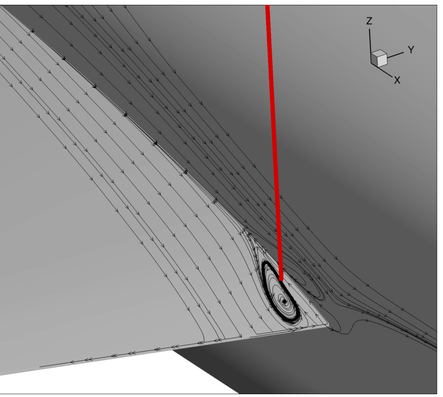


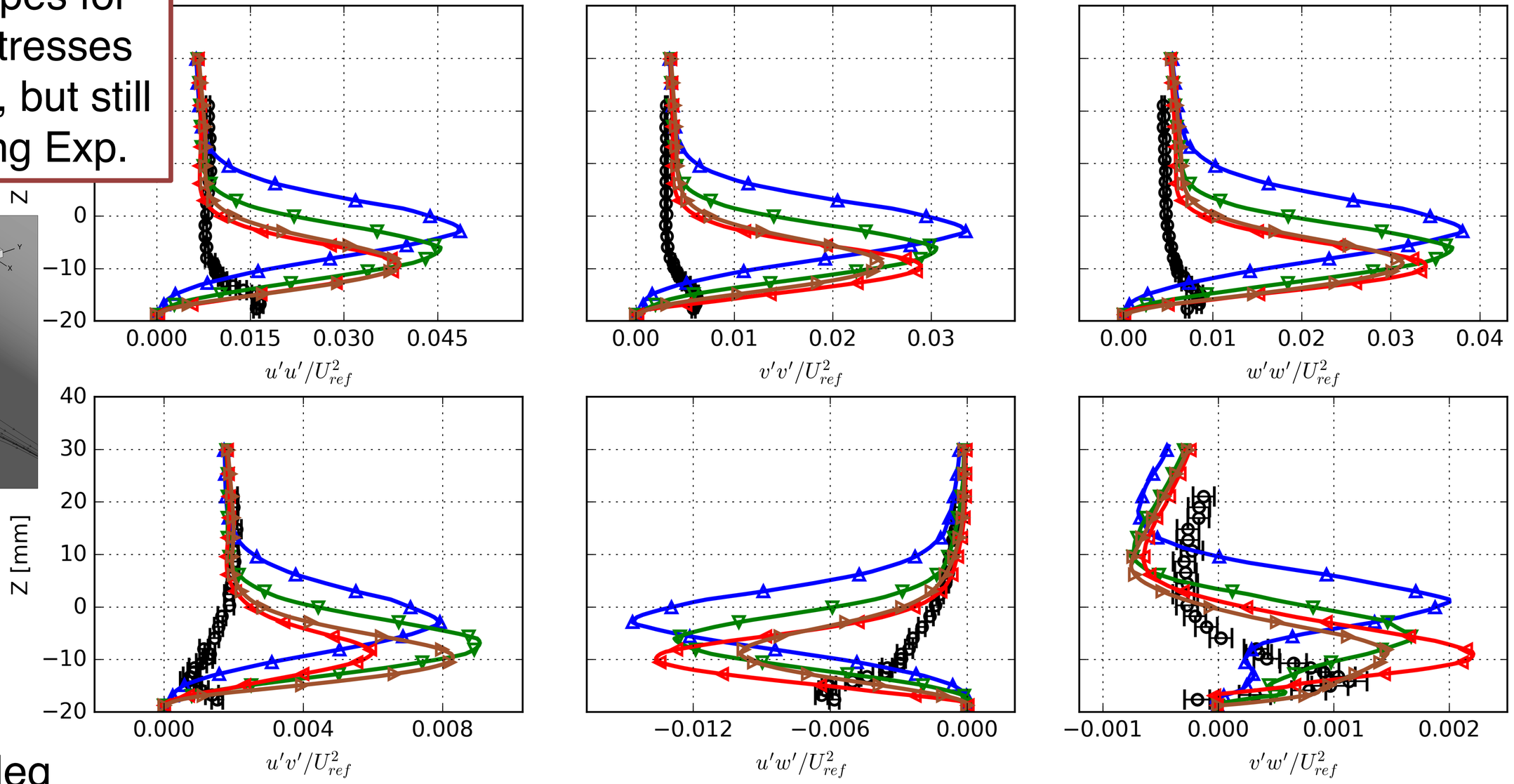
AOA = 5 deg

Reynolds Stress Profiles: Grid Resolution (Free Air)

Similar shapes for Reynolds stresses across grids, but still not matching Exp.

In the Separated Region, 10 mm from fuselage

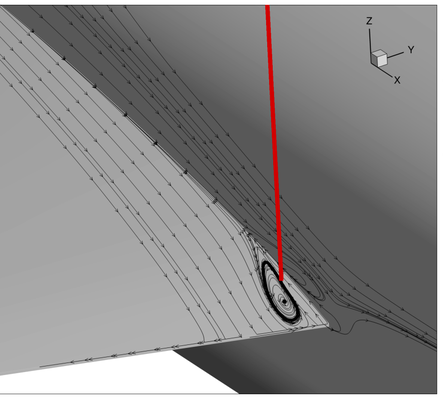


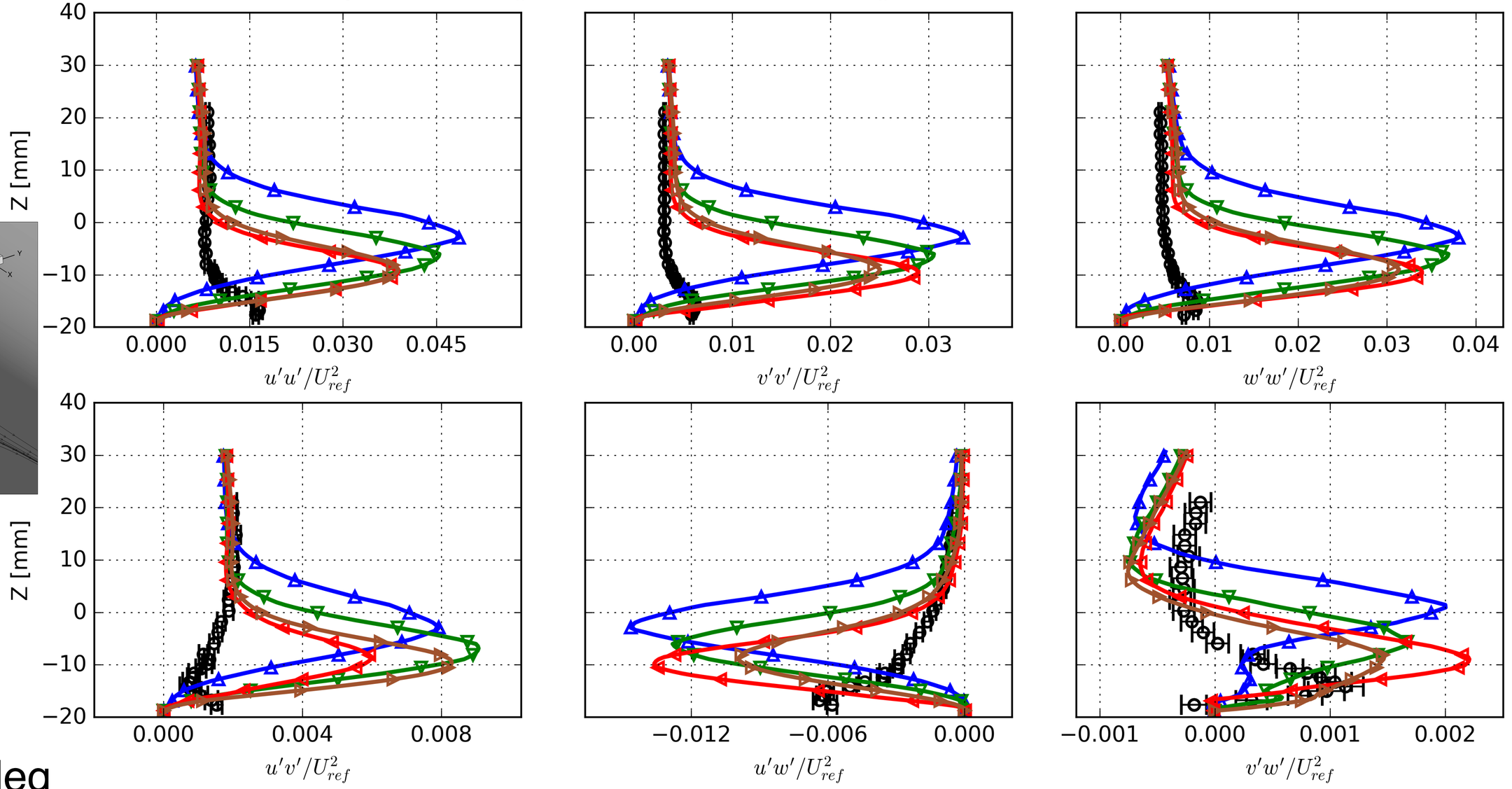


AOA = 5 deg

Reynolds Stress Profiles: Grid Resolution (Free Air)

In the Separated Region, 10 mm from fuselage

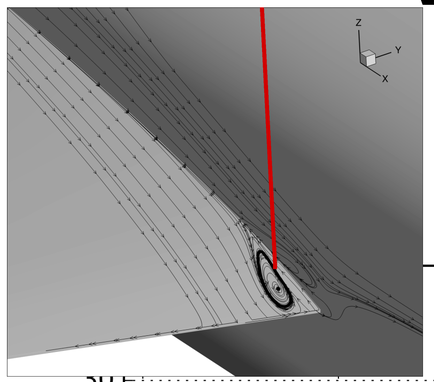


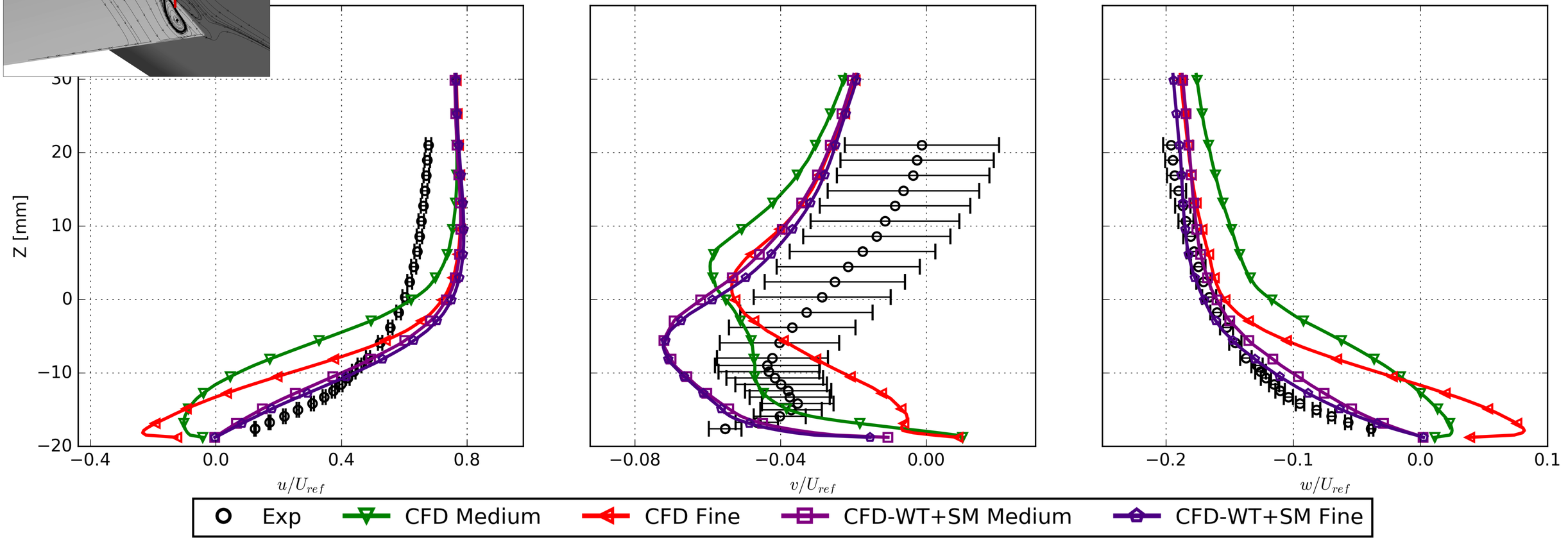


AOA = 5 deg

Velocity Profiles: Wall Effect

In the Separated Region, 10 mm from fuselage

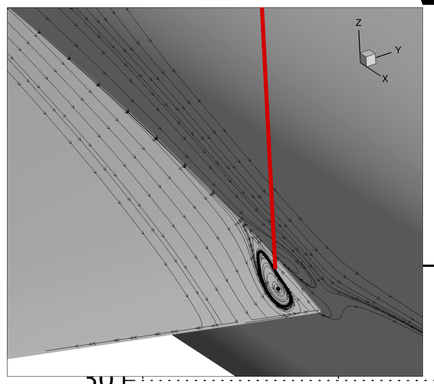


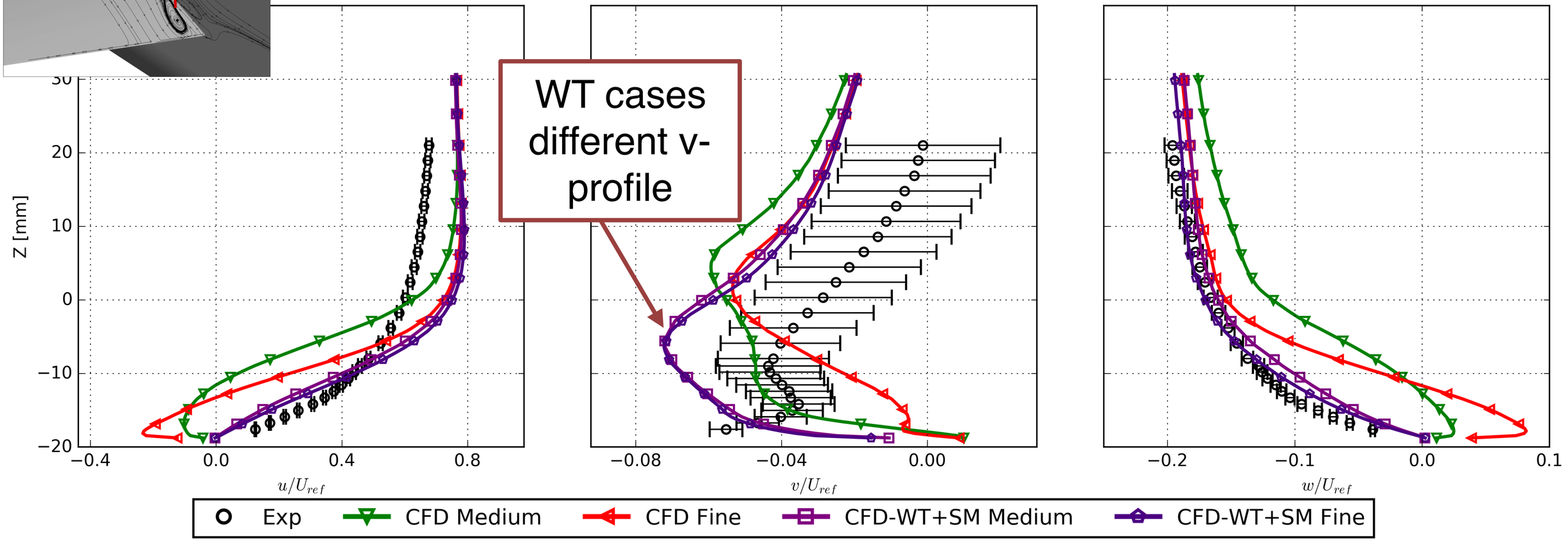


AOA = 5 deg

Velocity Profiles: Wall Effect

In the Separated Region, 10 mm from fuselage

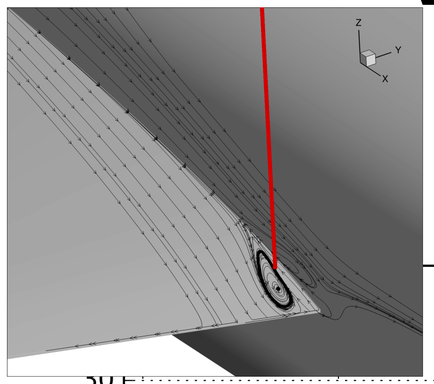




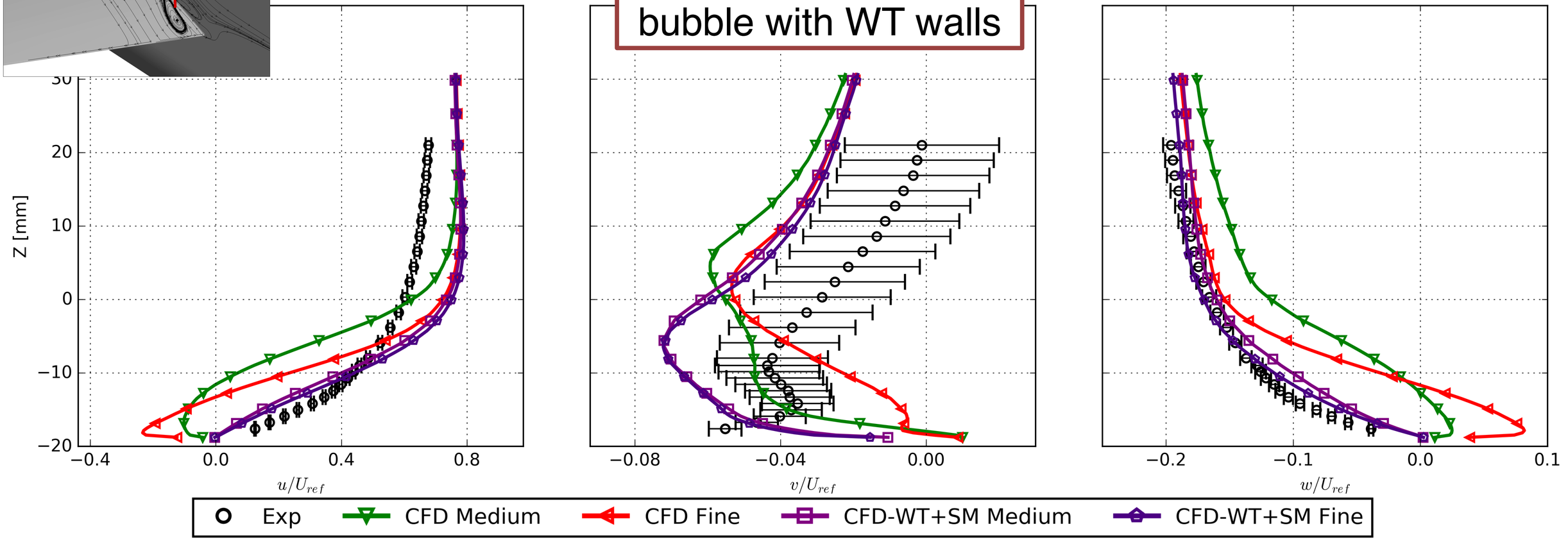
AOA = 5 deg

Velocity Profiles: Wall Effect

In the Separated Region, 10 mm from fuselage



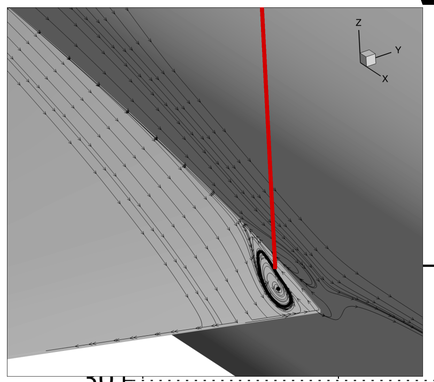
Separated flow predictions different in bubble with WT walls

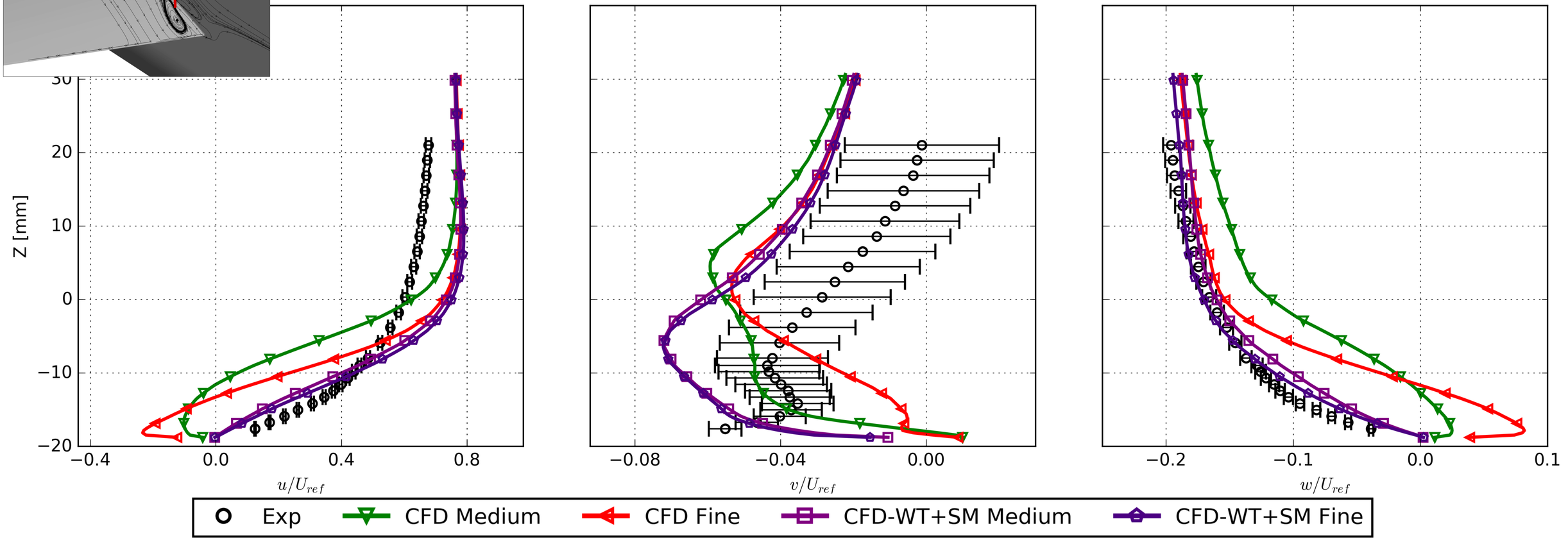


AOA = 5 deg

Velocity Profiles: Wall Effect

In the Separated Region, 10 mm from fuselage

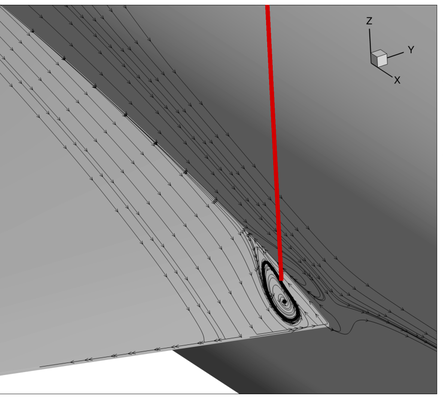




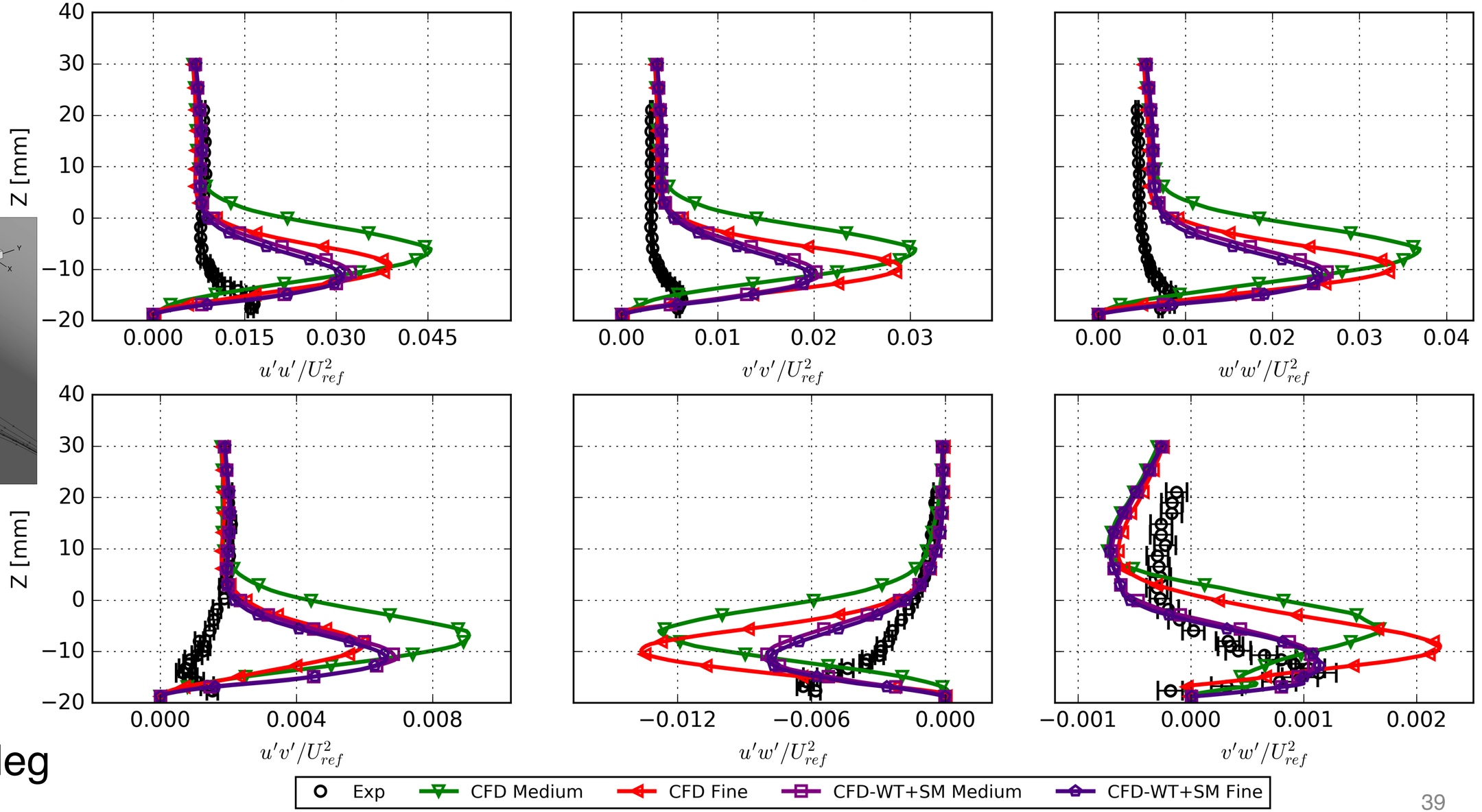
AOA = 5 deg

Reynolds Stress Profiles: Wall Effect

In the Separated Region, 10 mm from fuselage

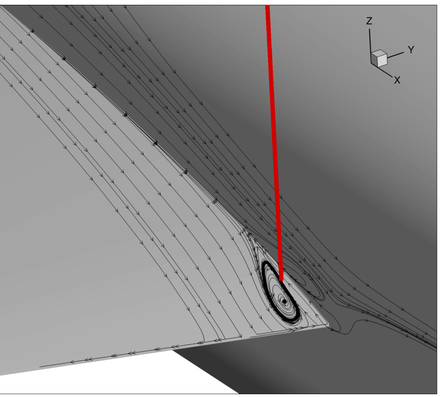


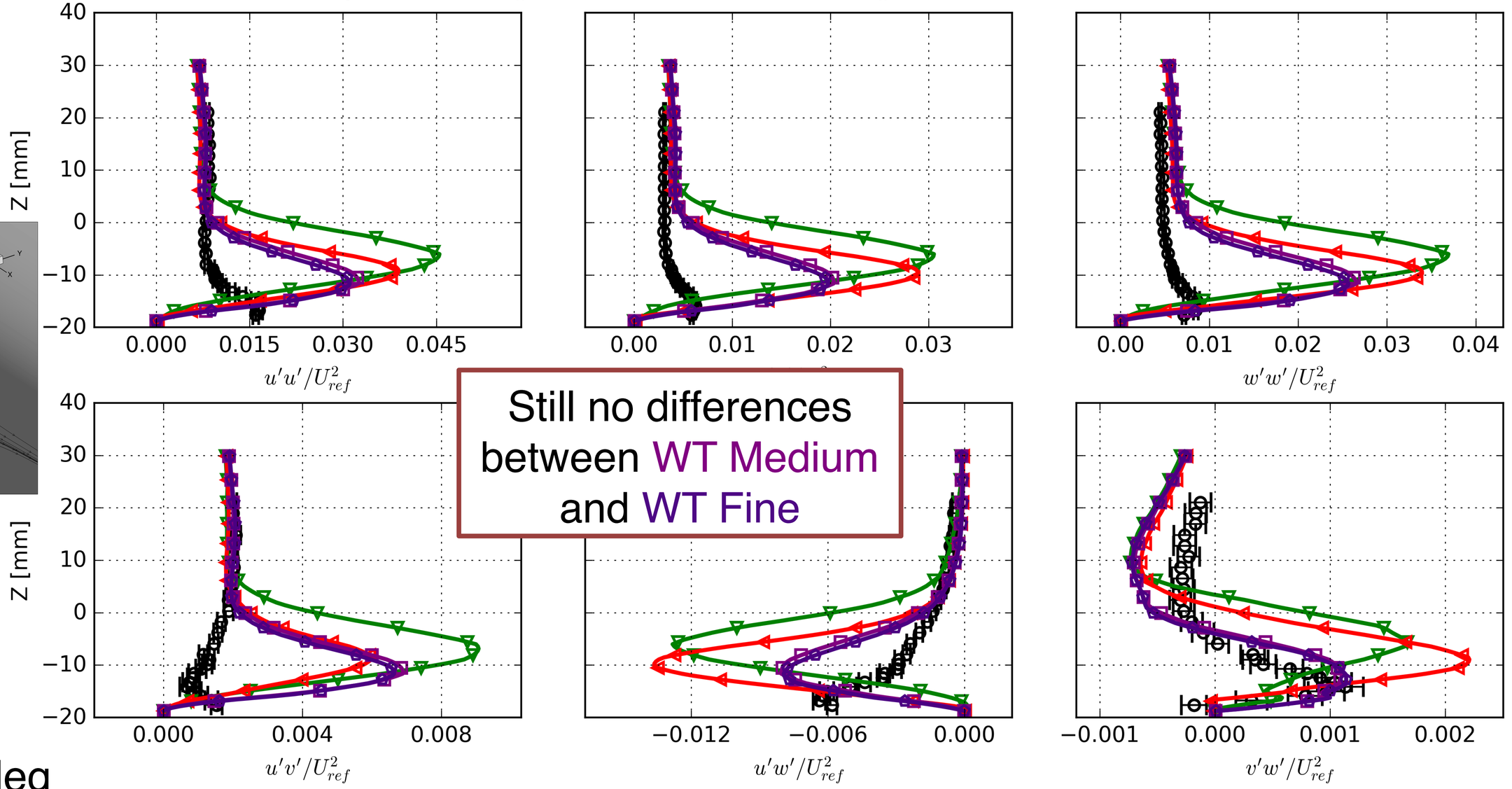
AOA = 5 deg



Reynolds Stress Profiles: Wall Effect

In the Separated Region, 10 mm from fuselage



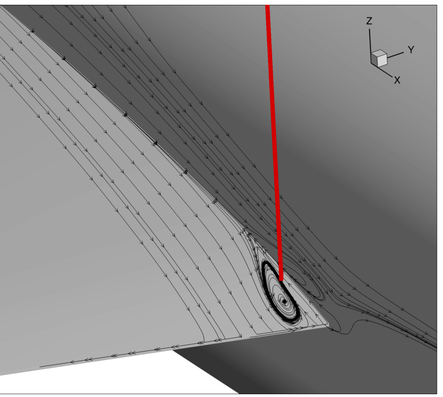


Still no differences between WT Medium and WT Fine

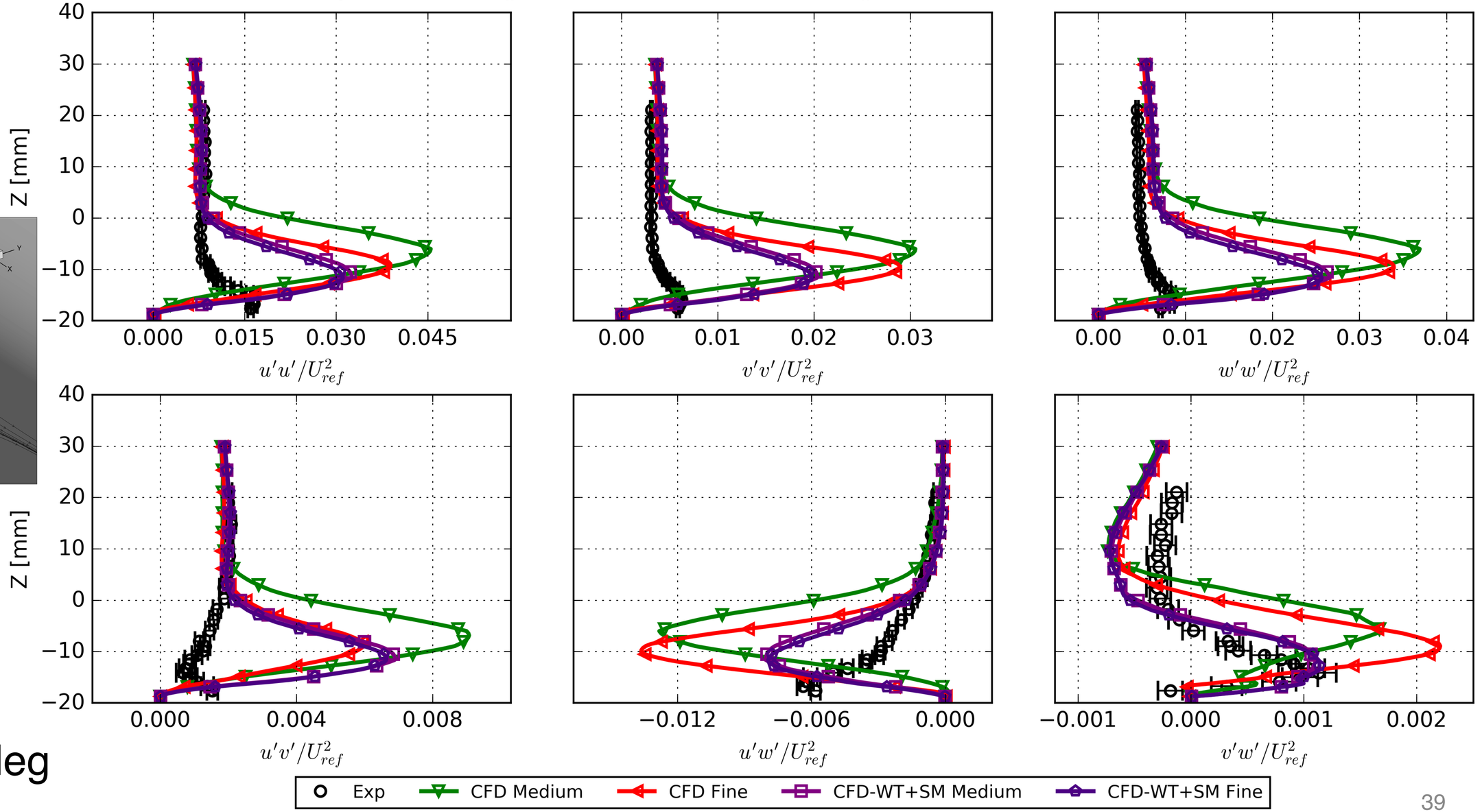
AOA = 5 deg

Reynolds Stress Profiles: Wall Effect

In the Separated Region, 10 mm from fuselage

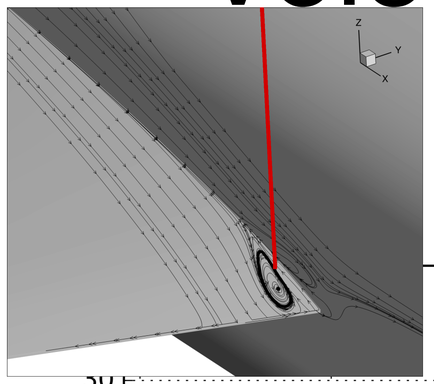


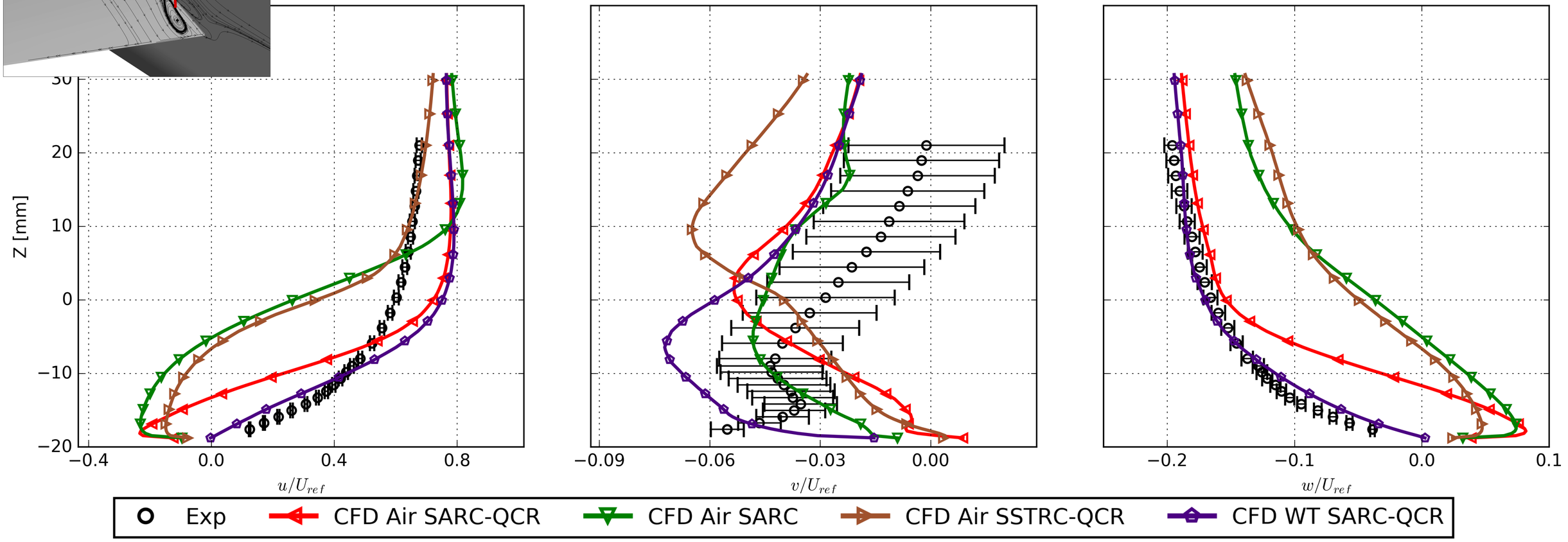
AOA = 5 deg



Velocity Profiles: Turbulence Model

In the Separated Region, 10 mm from fuselage, Fine Grid

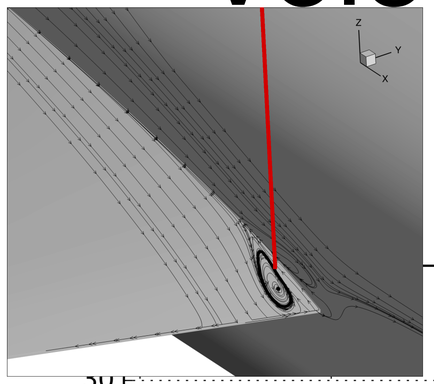




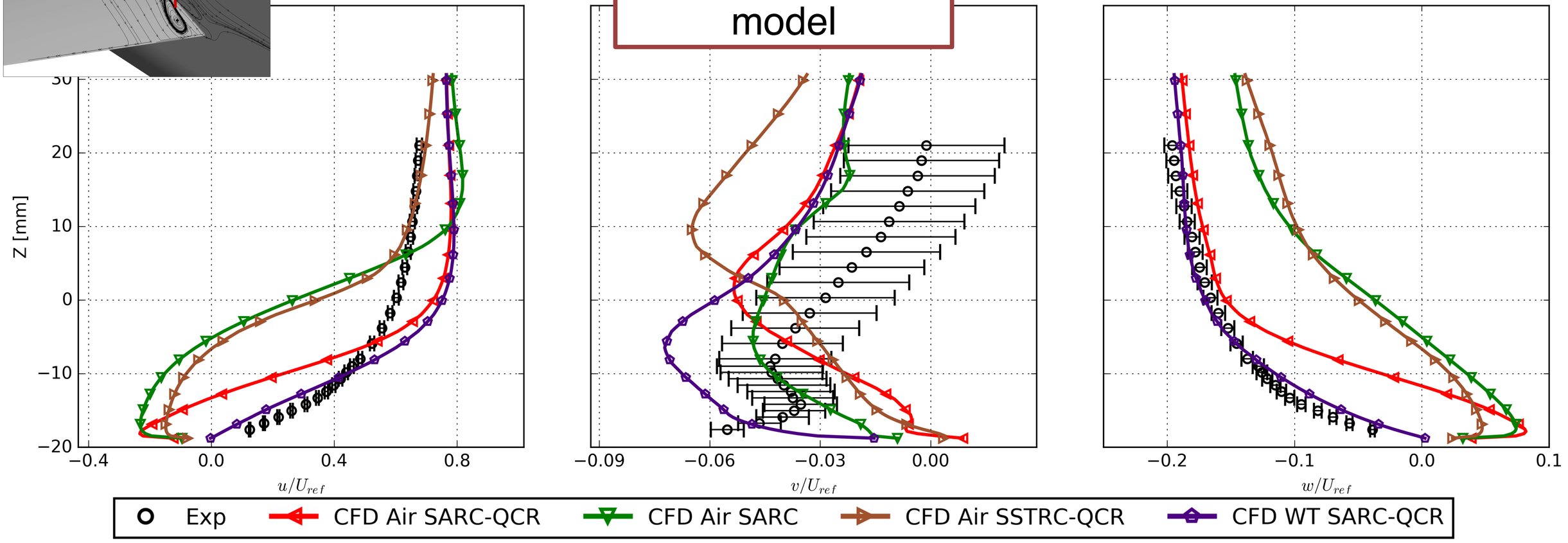
AOA = 5 deg

Velocity Profiles: Turbulence Model

In the Separated Region, 10 mm from fuselage, Fine Grid



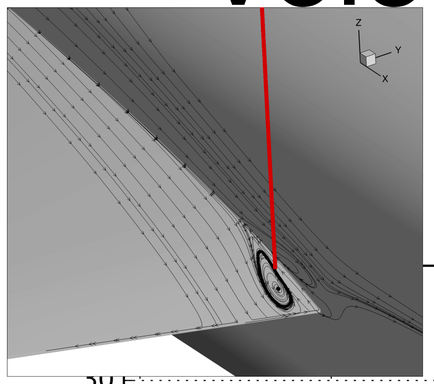
Large variation for each turbulence model

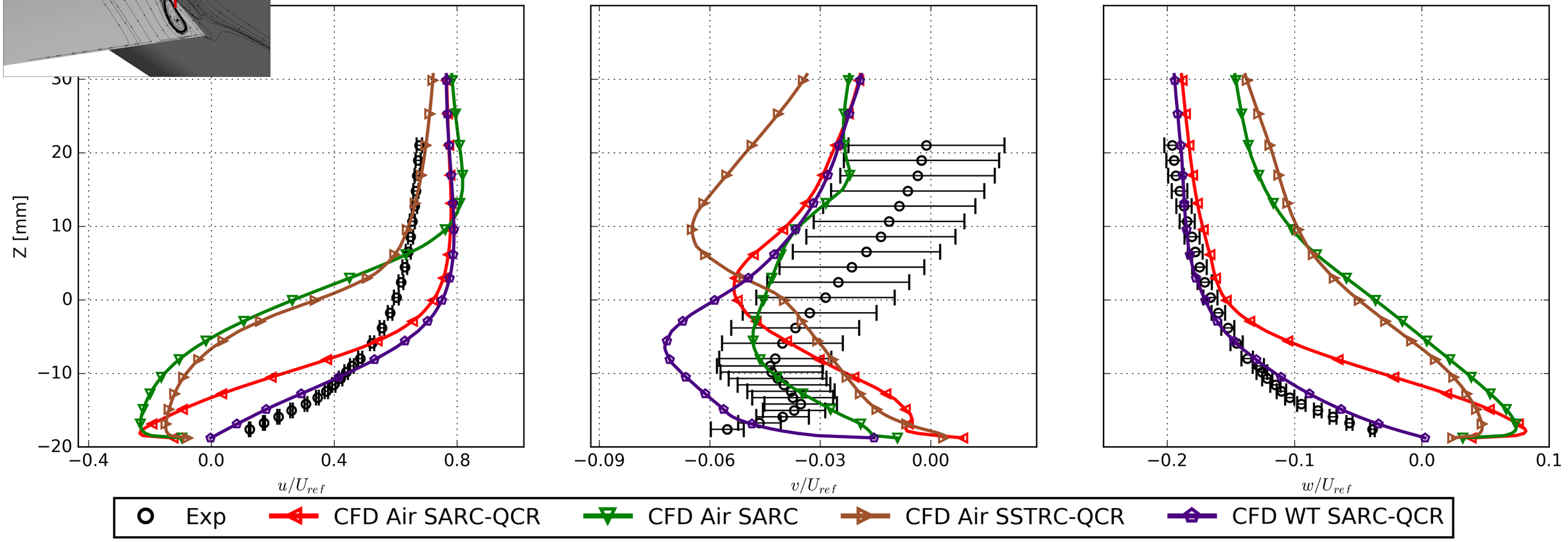


AOA = 5 deg

Velocity Profiles: Turbulence Model

In the Separated Region, 10 mm from fuselage, Fine Grid





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Reynolds Stress Profiles: Turbulence Model

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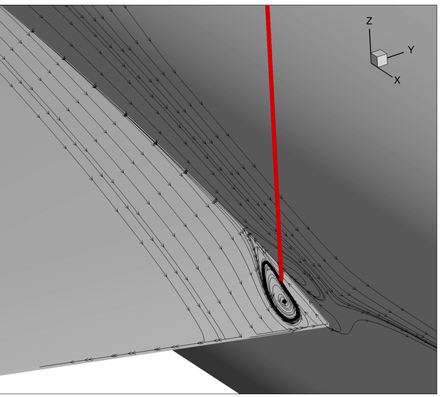

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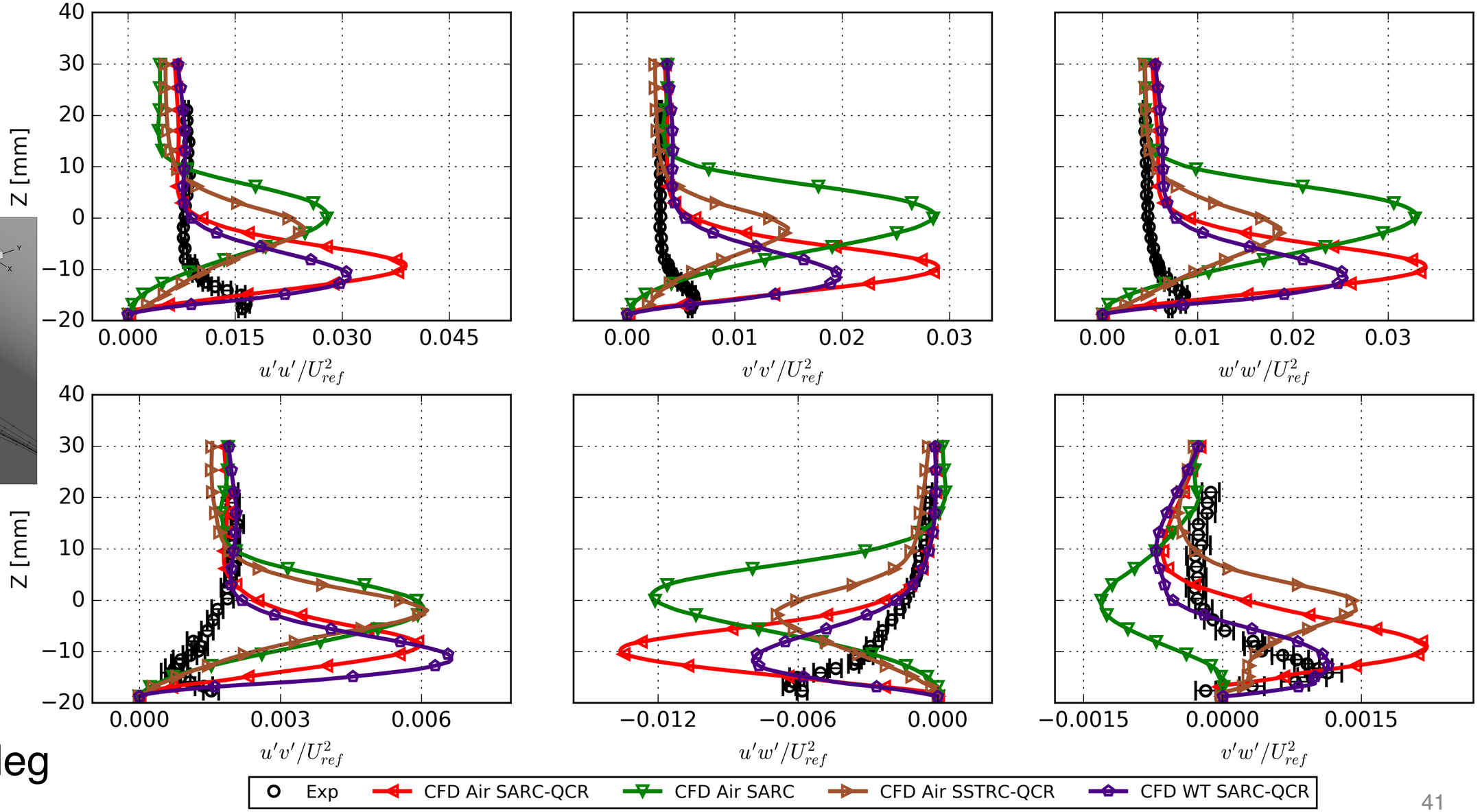
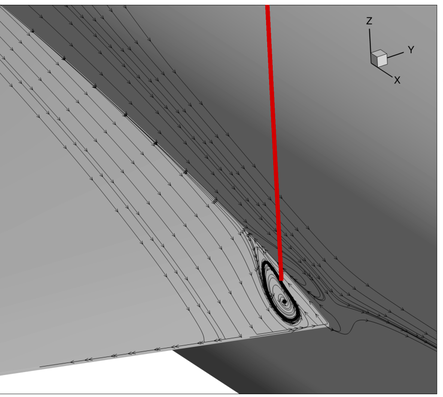
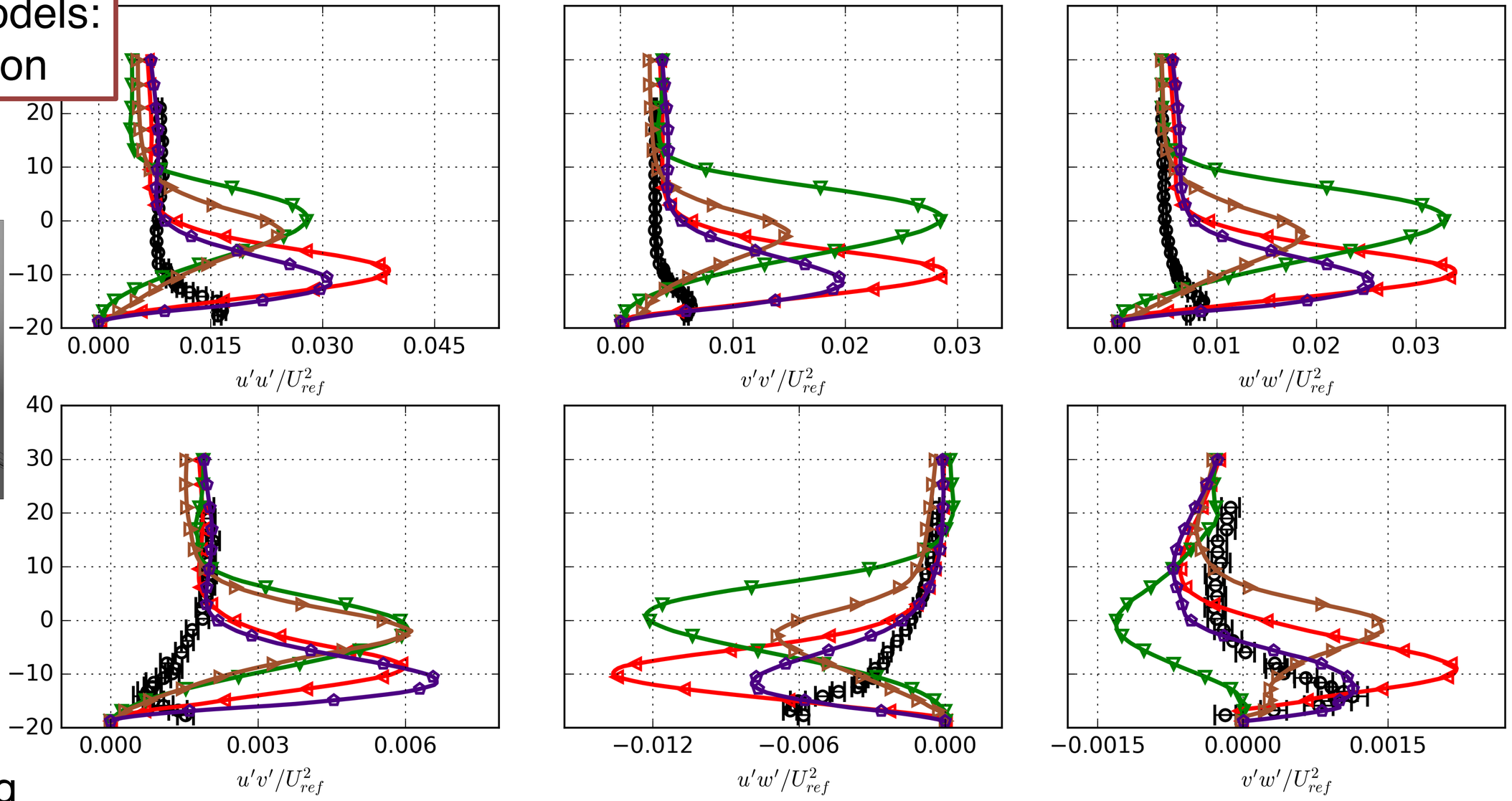


Reynolds Stress Profiles: Turbulence Model

In the Separated Region, 10 mm from fuselage, Fine Grid

Turbulence models: large variation

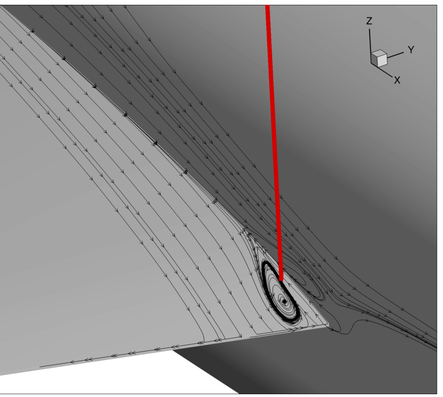




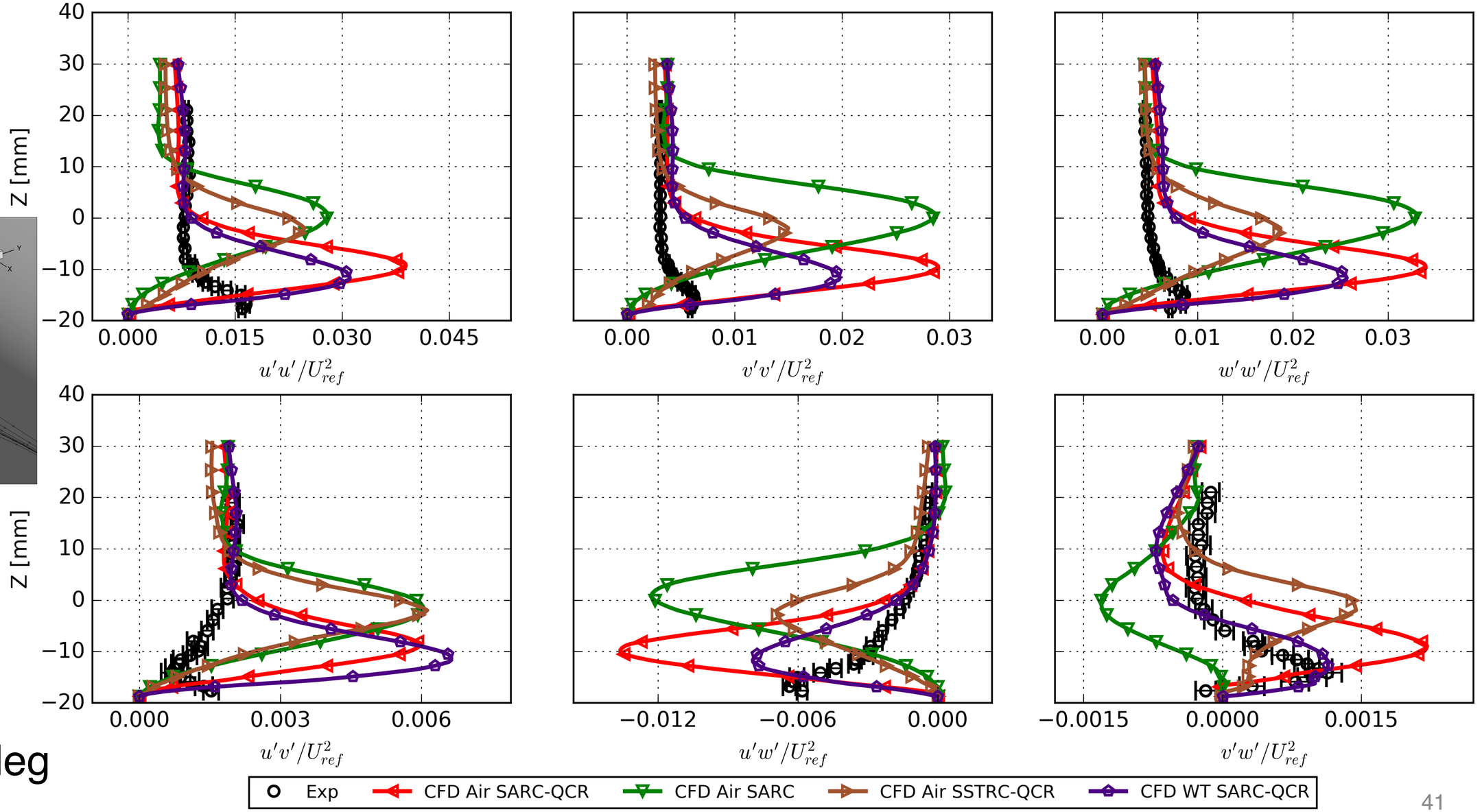
AOA = 5 deg

Reynolds Stress Profiles: Turbulence Model

In the Separated Region, 10 mm from fuselage, Fine Grid



AOA = 5 deg



Summary

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- Preliminary evaluations of OVERFLOW CFD “RANS” on Juncture Flow region
  - Solutions compare well before separation
  - Some sensitivity to grid resolution in free air
  - Less sensitive to grid resolution with wind tunnel walls
  - CFD in tunnel simulations predicted smaller separations
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- CFD is doing a decent job at the broader quantities (pressures, velocities), but predictions break down in the separated regions.

Future Work

- No significant indication in the computation of unsteady nature to the flow
  - Preliminary time accurate computations do not show any major effects of unsteadiness
  - Need a bit more guidance about the time scales
- Possible corrections for AOA?
- Website: https://turbmodels.larc.nasa.gov/Other_exp_Data/juncture flow_exp.html

Acknowledgements

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Bill Oberkampf

Questions?