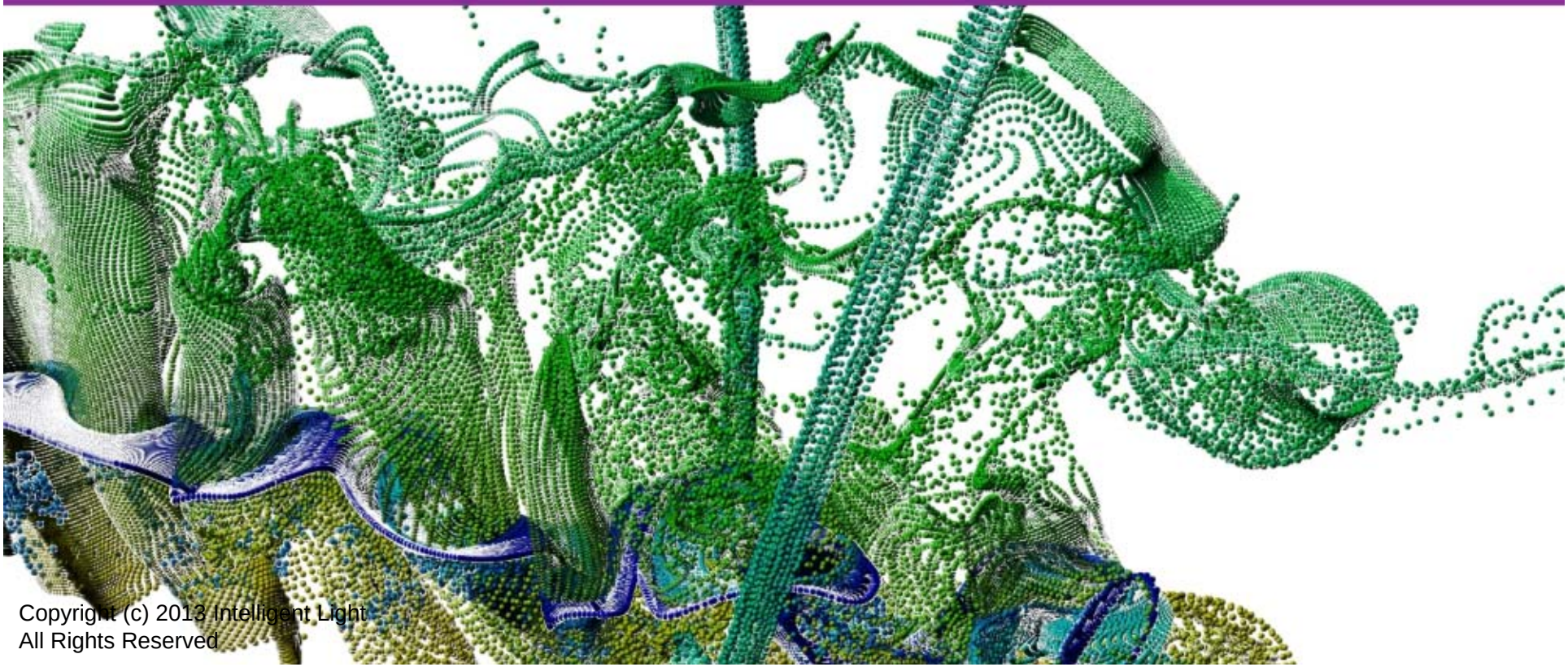
Applied Research Group

Seeking Answers, Deploying Solutions

Intelligent Light

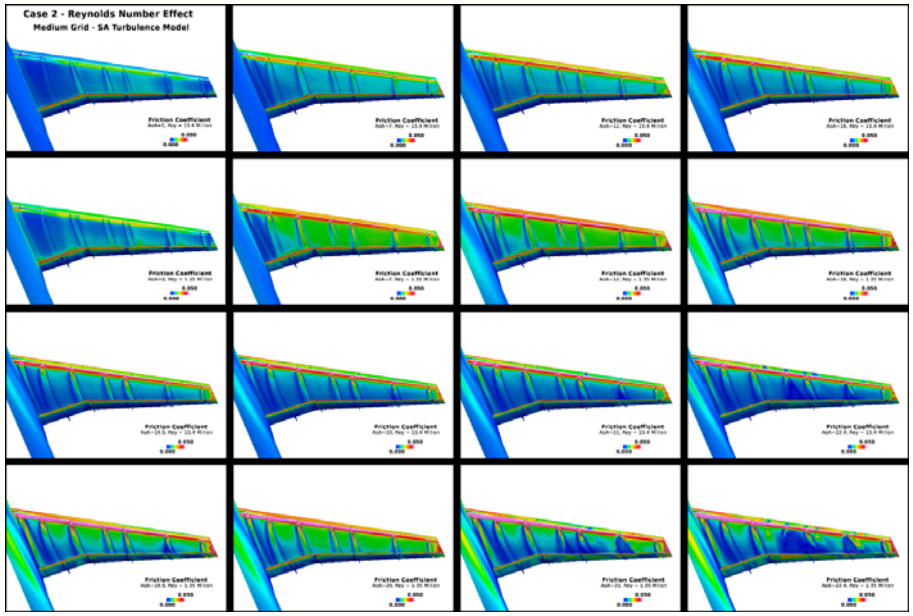


Earl P.N. Duque
Manager of Applied Research
Intelligent light

HI LIFT PREDICTION WORKSHOP 2

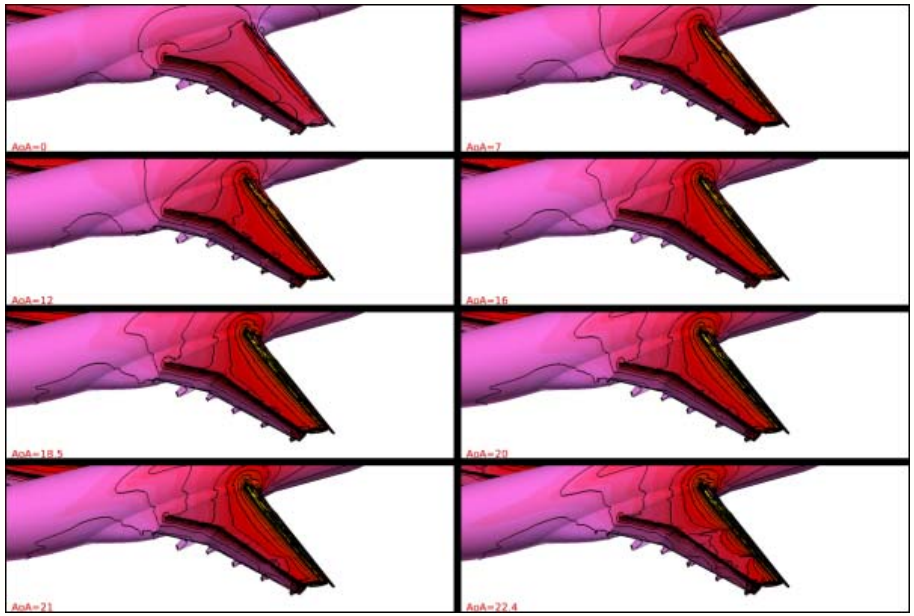
Outline

- Purpose
  - IL's contribution to the knowledge base
  - Get current with OVERFLOW and CFD pain (I've been in management & teaching too long …)
  - Create demonstration cases for our own Applied Research Group projects
- Demonstrate Large scale big data post processing and effective workflow processes
- Provide a different method to the community



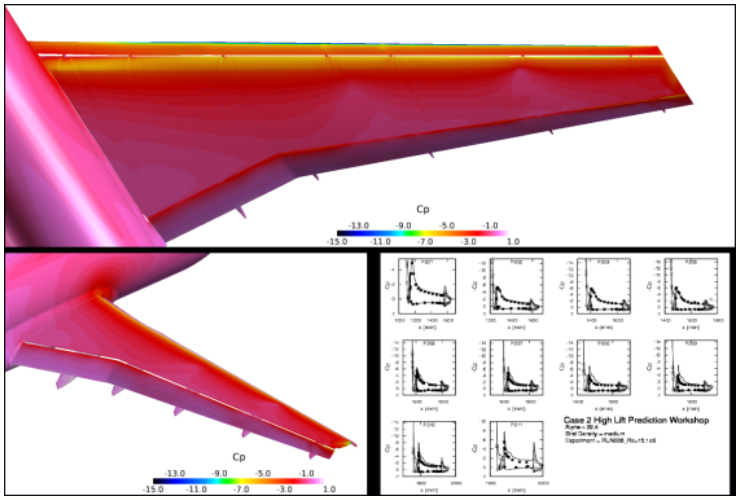
AIAA High Lift Prediction Workshop

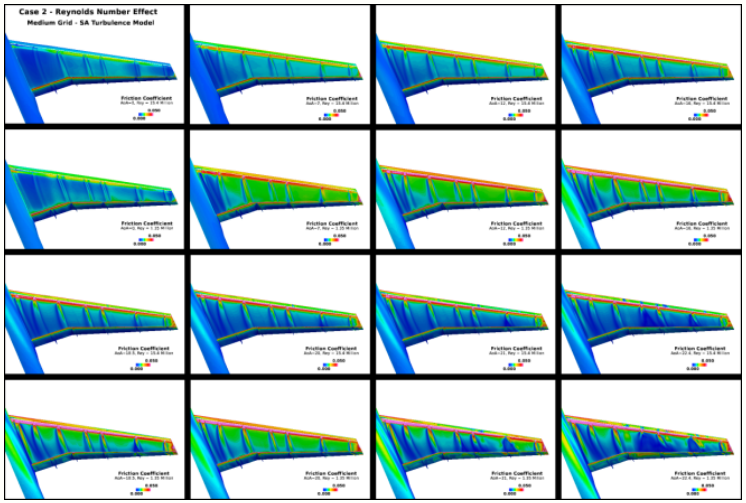
- Case 1
  - Coarse, medium, fine and extra fine grid
  - SA Turbulence model
  - Alpha – 7, 16, 18.5, 20, 21, 22.4
  - Steady
  - Blind Run up to 2600 Steps (Still Running…)
- Case 2
  - Medium grid
  - High Reynolds
    - Alpha – 0, 7, 12, 16, 18.5, 20, 21,22.4
    - SA Turbulence Model
    - Fully Turbulent
    - Blind Run Up to ~10k Steps
  - Low Reynolds
    - SA Turbulence Model
    - Fully Turbulent (Blind Run Up to ~10k Steps)
    - Transition (Menter-Langtry) (In progress)
    - k-W-SST (In progress)
    - k-W-SST Unsteady (In progress)



OVERFLOW and FV Workflows

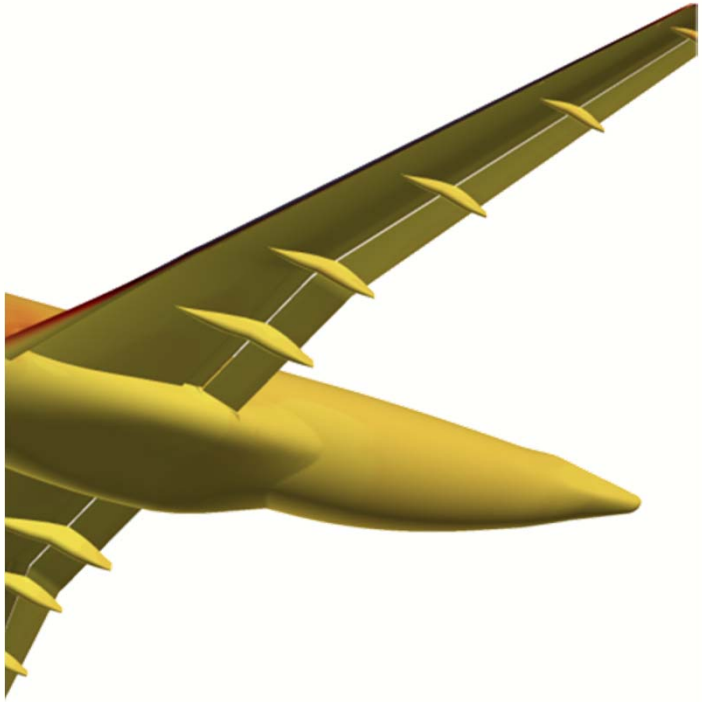
- Solver - OVERFLOW-2.2e
  - Cray XE6
  - 128-1024 cores (75-85% // Efficiency)
  - Methodologies
    - RHS - Roe upwind
    - LHS – Scalar Penta
    - Full Multi-Grid
    - Full Viscous Terms
- FieldView 13.2 & 14-beta
  - Cray XE6 – 16 cores
  - Automated Batch Post-Processing
  - XDB workflow for surface data extraction
  - FVX + gnuplot for 2D plotting
  - Multi-Window Comparisons



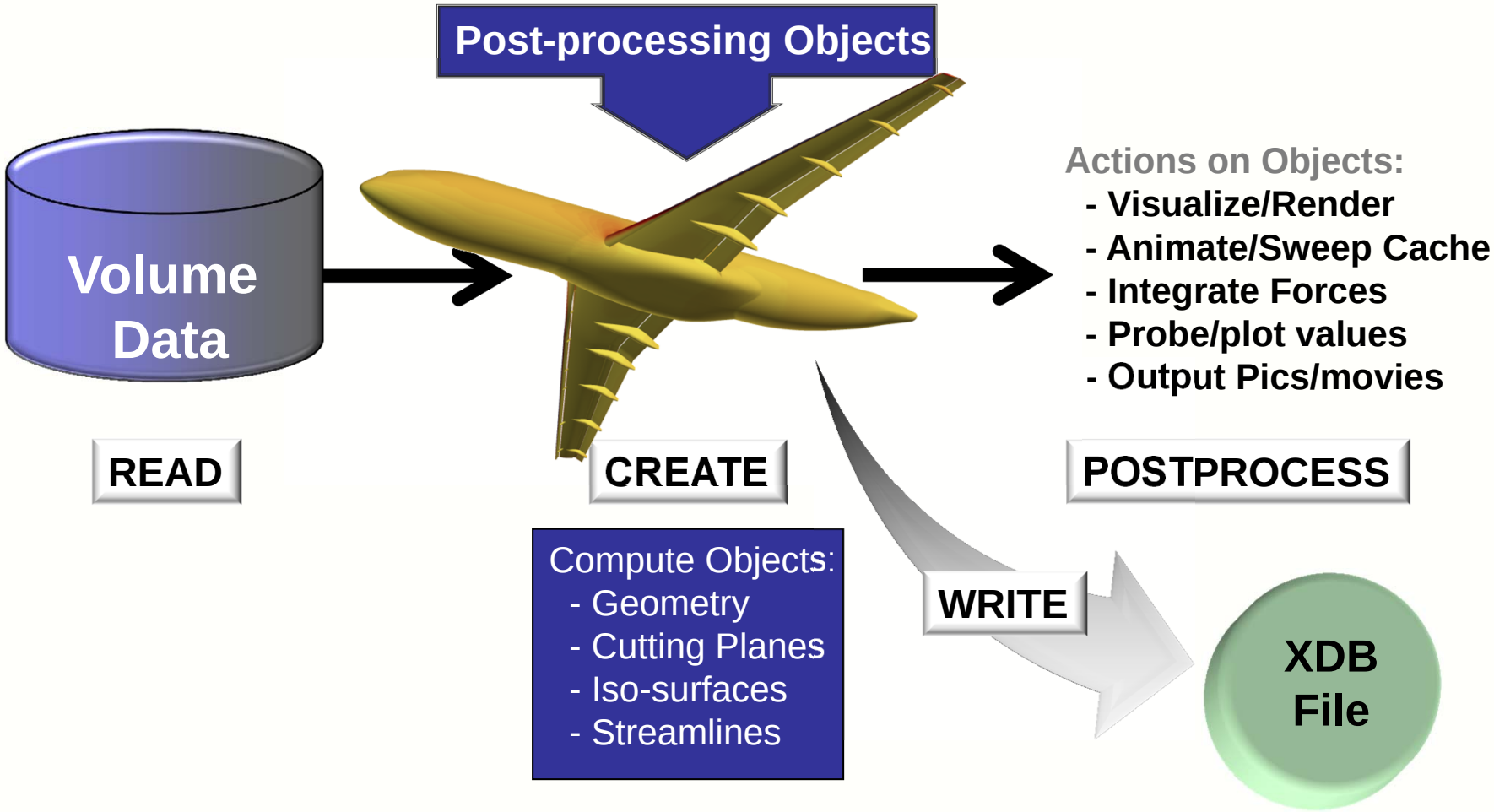


Issue with Large Scale Post-Processing

- Writing, reading or copying **large** results files takes a **long time**
  - Wastes engineering time
  - Important data is quite small
- **Slow** network speed
  - Performance is often unpredictable
- **Sharing** large results files takes **much space** and **time**
- Analyzing many datasets requires **repeating many steps**
- Graphics hardware **outpacing** software development
- Data Extracts – XDB Workflows



Volume Data Processing…



…to XDB Workflows

XDB File

XDB File

Post-processing Objects

Actions on Objects:
- Visualize/Render
- Animate/Sweep Cache
- Integrate Forces
- Probe/plot values
- Output Pics/movies

READ/APPEND

CREATE

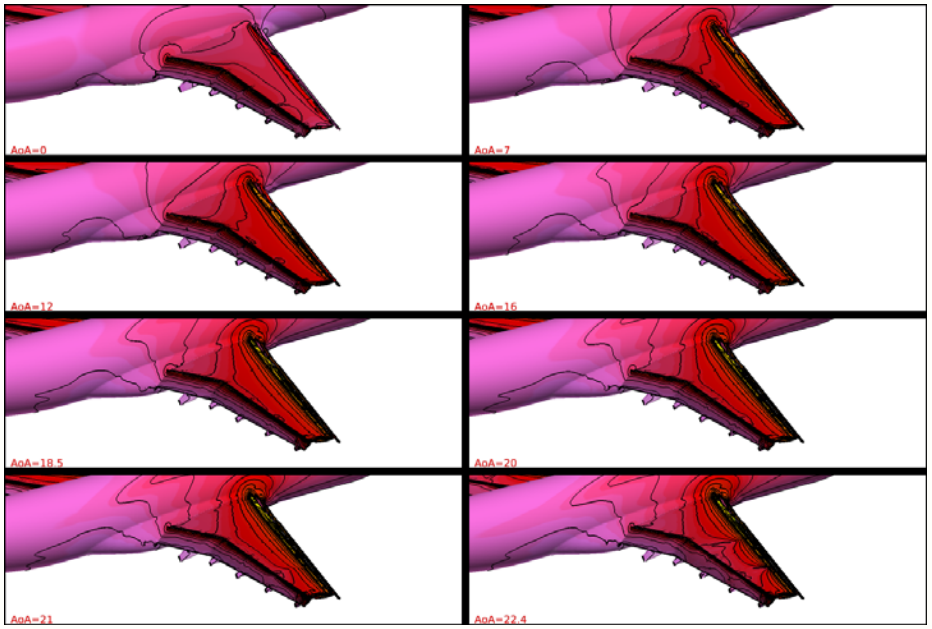
POSTPROCESS

- Full Numerical Fidelity
- Normals included
- Smaller files (10X-100X)
- Lower memory (10X-100X)

Compute Objects:
- Geometry
- Cutting Planes
- Iso-surfaces
- Streamlines

HiLiftPW 2 General Workflow

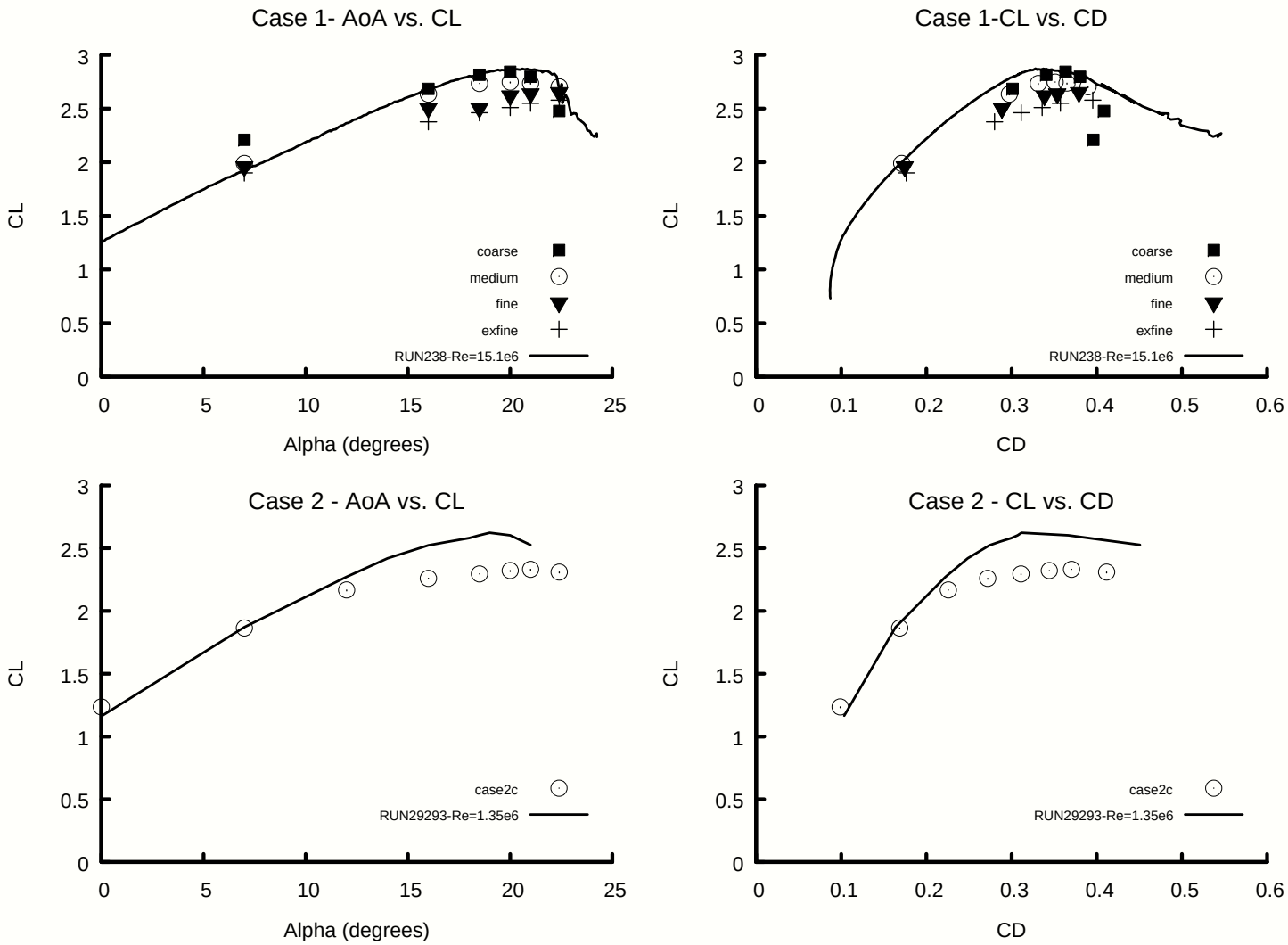
- Run the OVERFLOW2 case 128 – 1056 processors
- Submit post processing job, 16 procs in batch directly on remote Cray XE6 system
  - Boundary Surface Extracts
  - Coordinate cut planes
  - Velocity Profiles
  - Surface Streamlines
- Create images, tables and 2D plots
  - Perform all on the big iron especially if good graphics connected to system or …
  - Move extracts and solver output to local workstation



XDB Data reduction

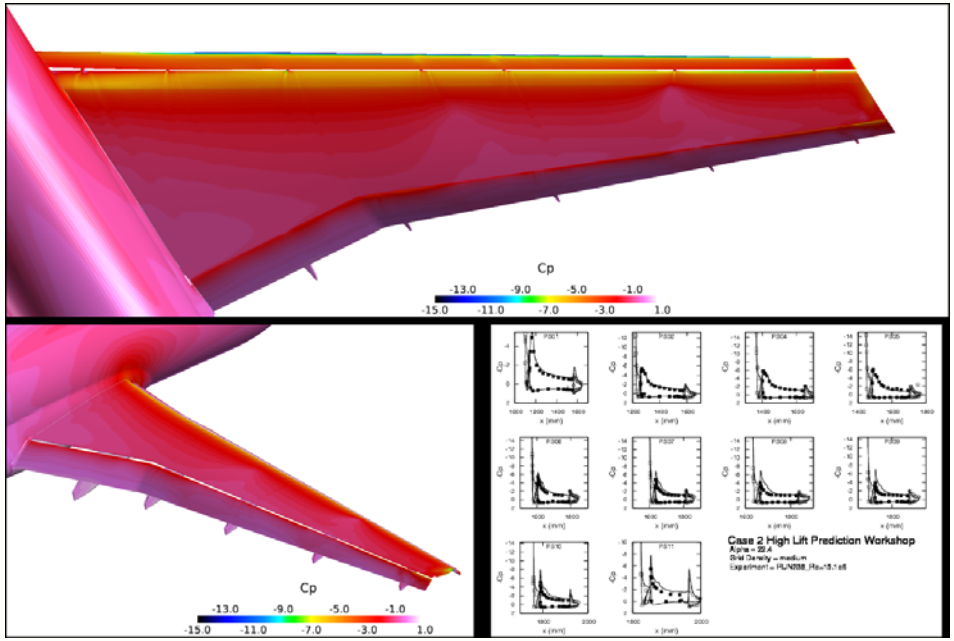
Case 1							
Grid Size	**# Overset Grids**	**Grid Points (10^6)**	**Grid File Size**	**Soln File Size**	**Coordinate Cut Plans (3 planes) 7 scalars**	**Boundary Surface 12 scalar variables**	**Surface Streams Medium seed density, 2 varables**
Coarse	44	29.4	758M	1.6G	14.1M	24M	435M
Medium	44	69.0	1.8G	3.6G	25.8M	41M	411M
Fine	44	230.7	6.1G	13G	58M	92M	524M
Extra-Fine	44	544.5	15G	29G	98M	160M	530M

Force and moments

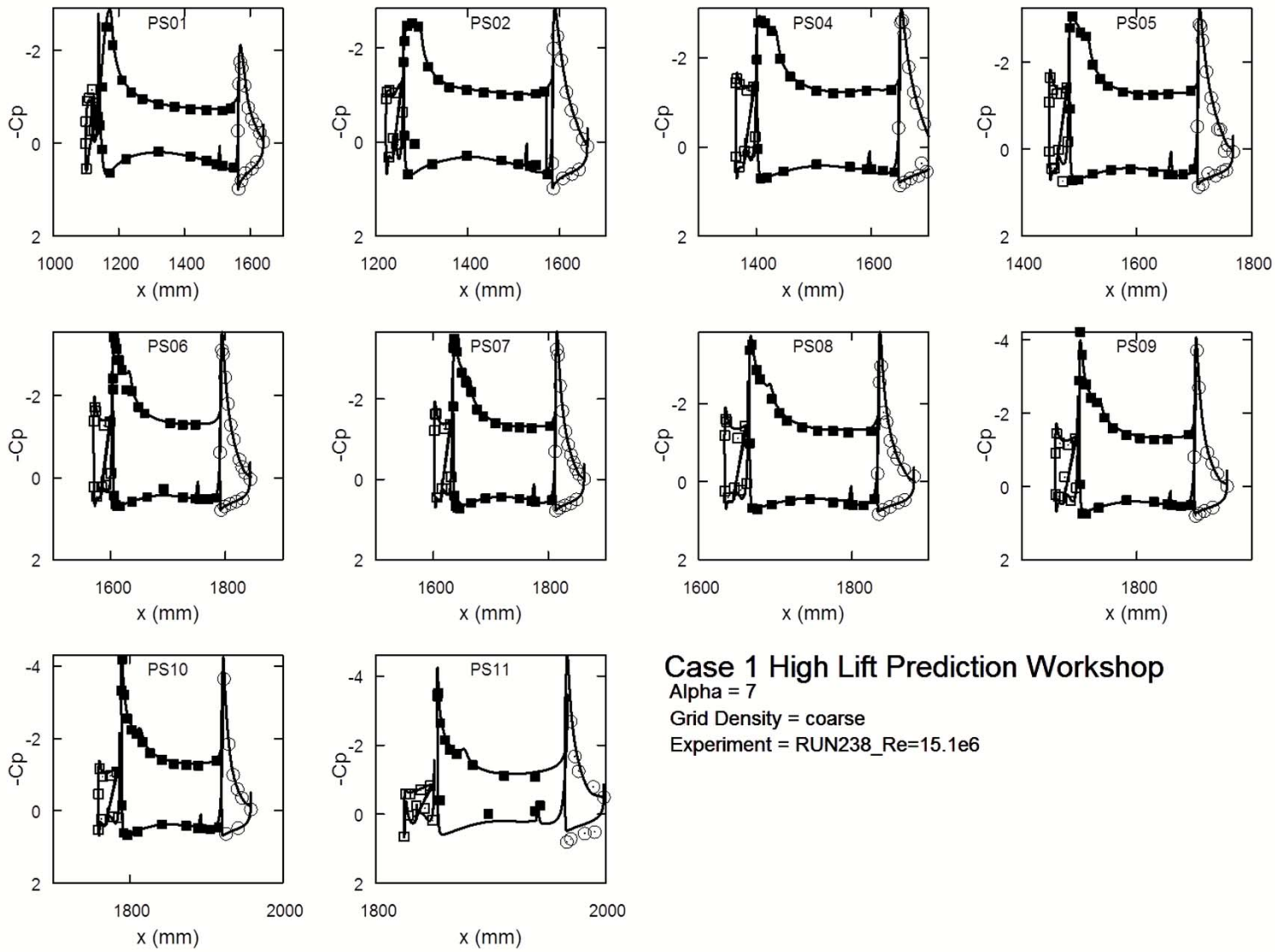


Surface Coefficients

- Extract - Boundary Surface
  - Slat, Main, Flap, Body
  - Cp, Cf, Cfx, Cfy, Cfz, Surface Normals
- Further processed on local workstation
- Take slices at the pressure stations
  - Use thresholding on the provided workshop equations and find cell center of resulting polygon
  - Output 2D plot data to standard formats
- Automatically create multi plot comparisons using your favorite 2d Plot program (i.e. Gnuplot)



Case 1 – Grid Refinement Effect @ 7, 18.5, 21, 22.4 Degrees

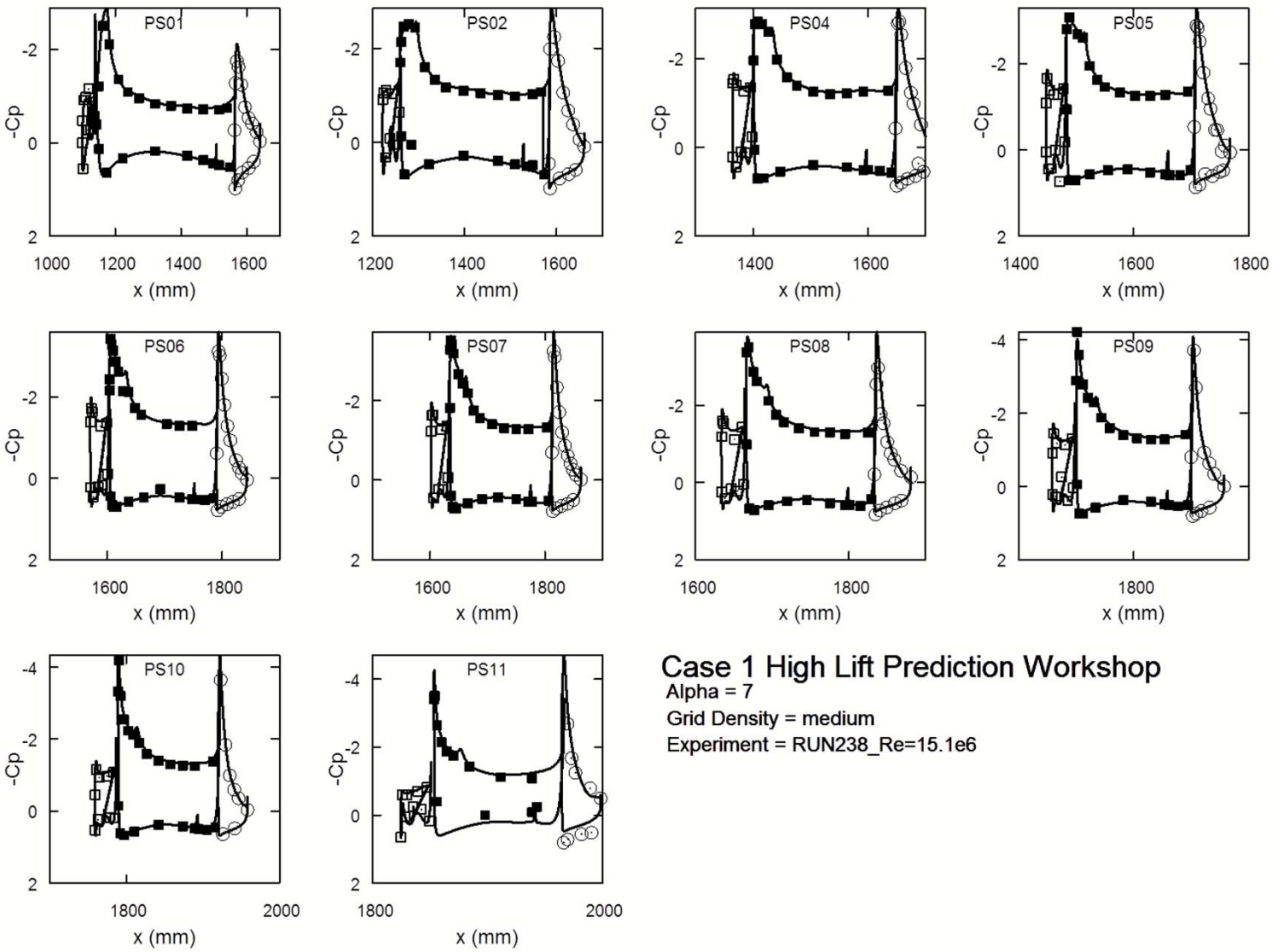


Case 1 High Lift Prediction Workshop

Alpha = 7

Grid Density = coarse

Experiment = RUN238_Re=15.1e6

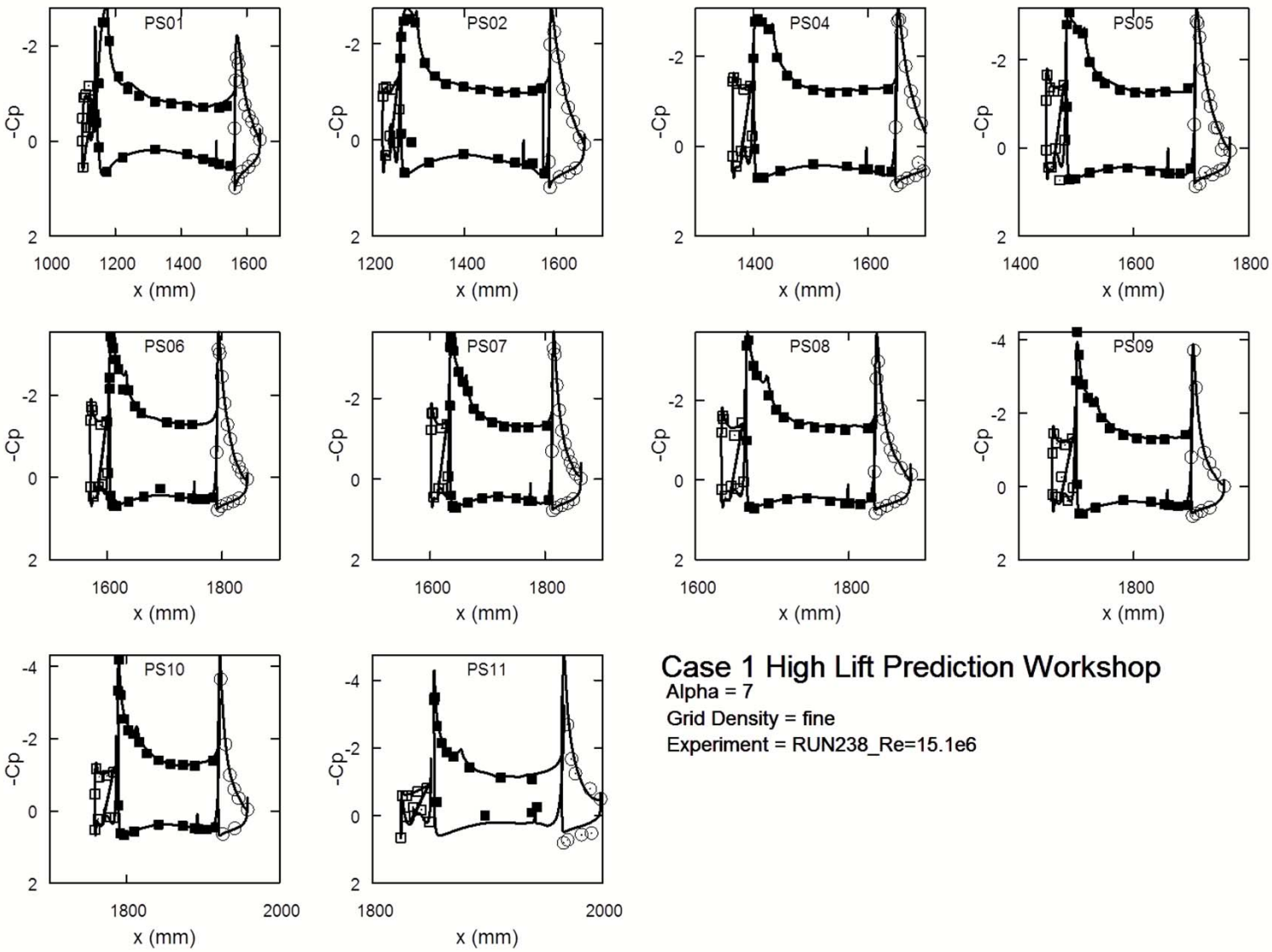


Case 1 High Lift Prediction Workshop

Alpha = 7

Grid Density = medium

Experiment = RUN238_Re=15.1e6

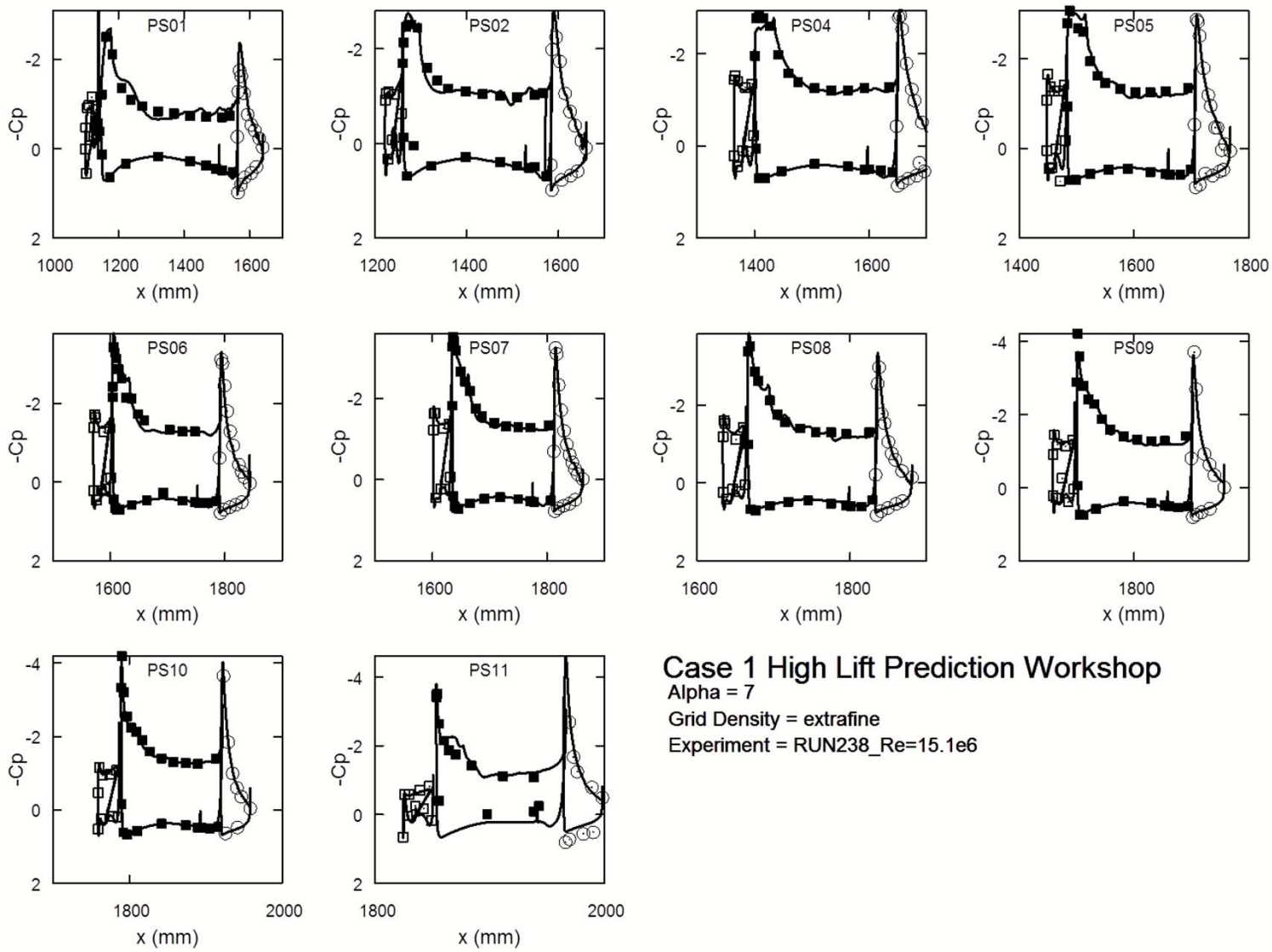


Case 1 High Lift Prediction Workshop

Alpha = 7

Grid Density = fine

Experiment = RUN238_Re=15.1e6

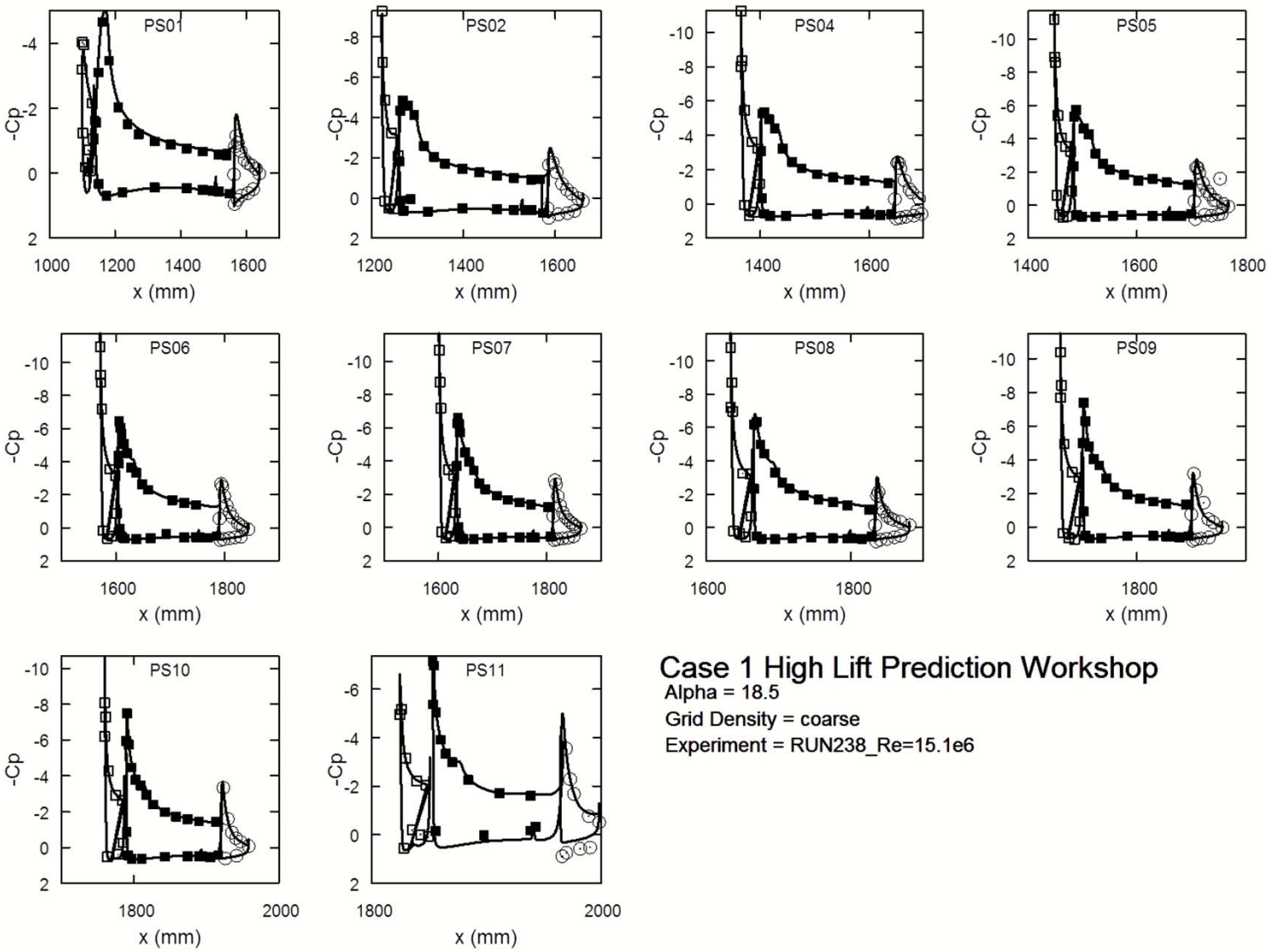


Case 1 High Lift Prediction Workshop

Alpha = 7

Grid Density = extrafine

Experiment = RUN238_Re=15.1e6

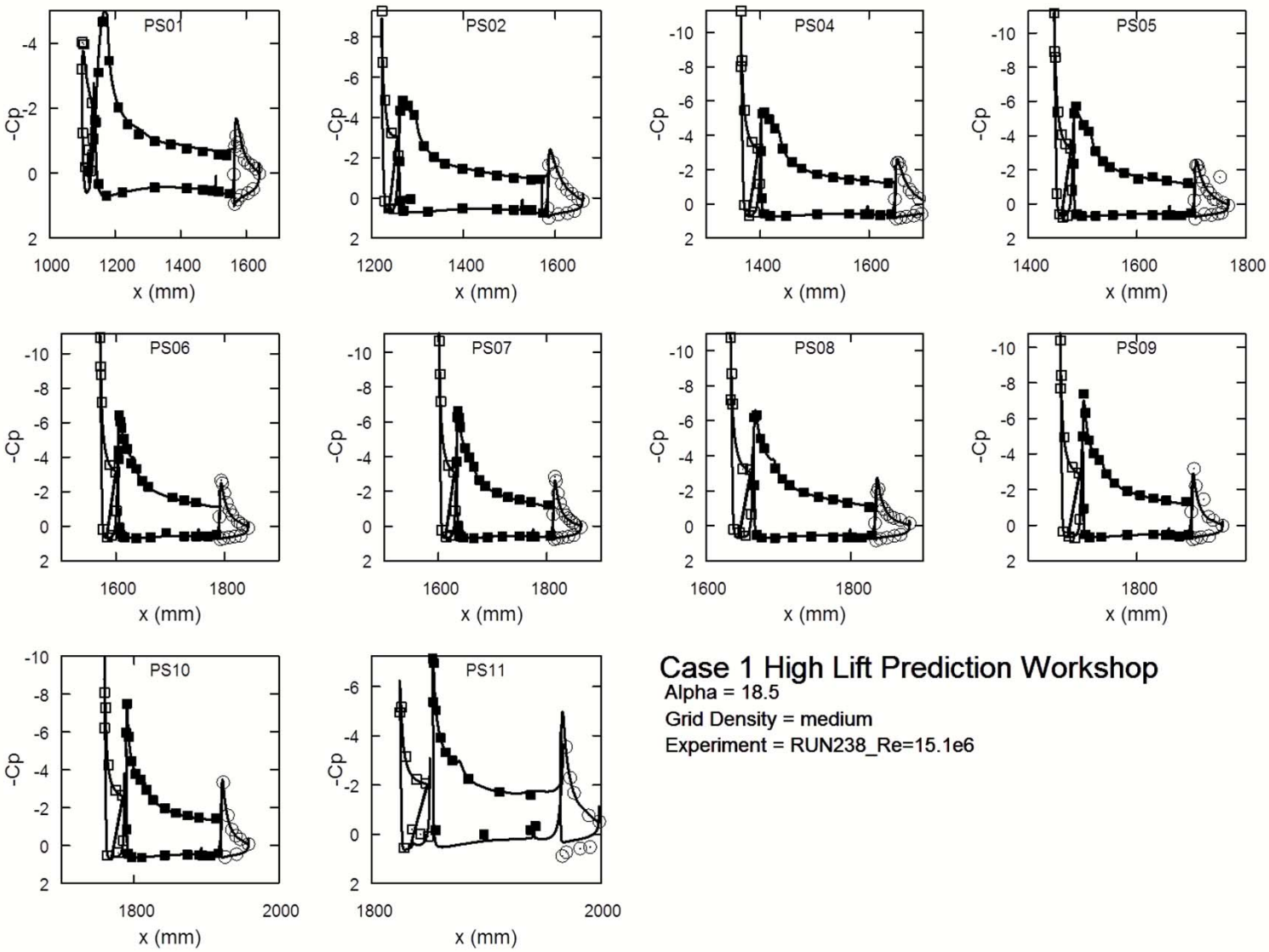


Case 1 High Lift Prediction Workshop

Alpha = 18.5

Grid Density = coarse

Experiment = RUN238_Re=15.1e6

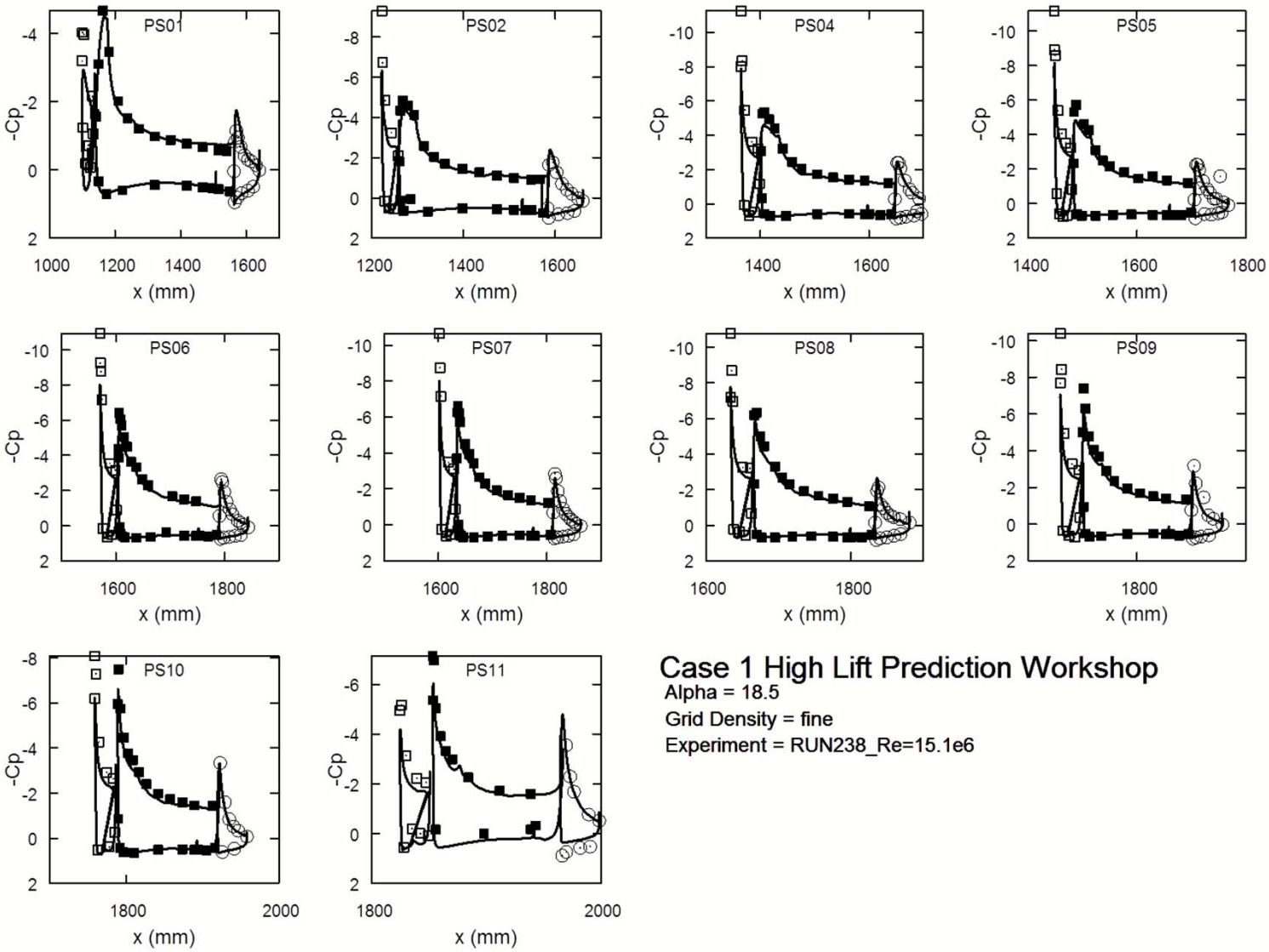


Case 1 High Lift Prediction Workshop

Alpha = 18.5

Grid Density = medium

Experiment = RUN238_Re=15.1e6

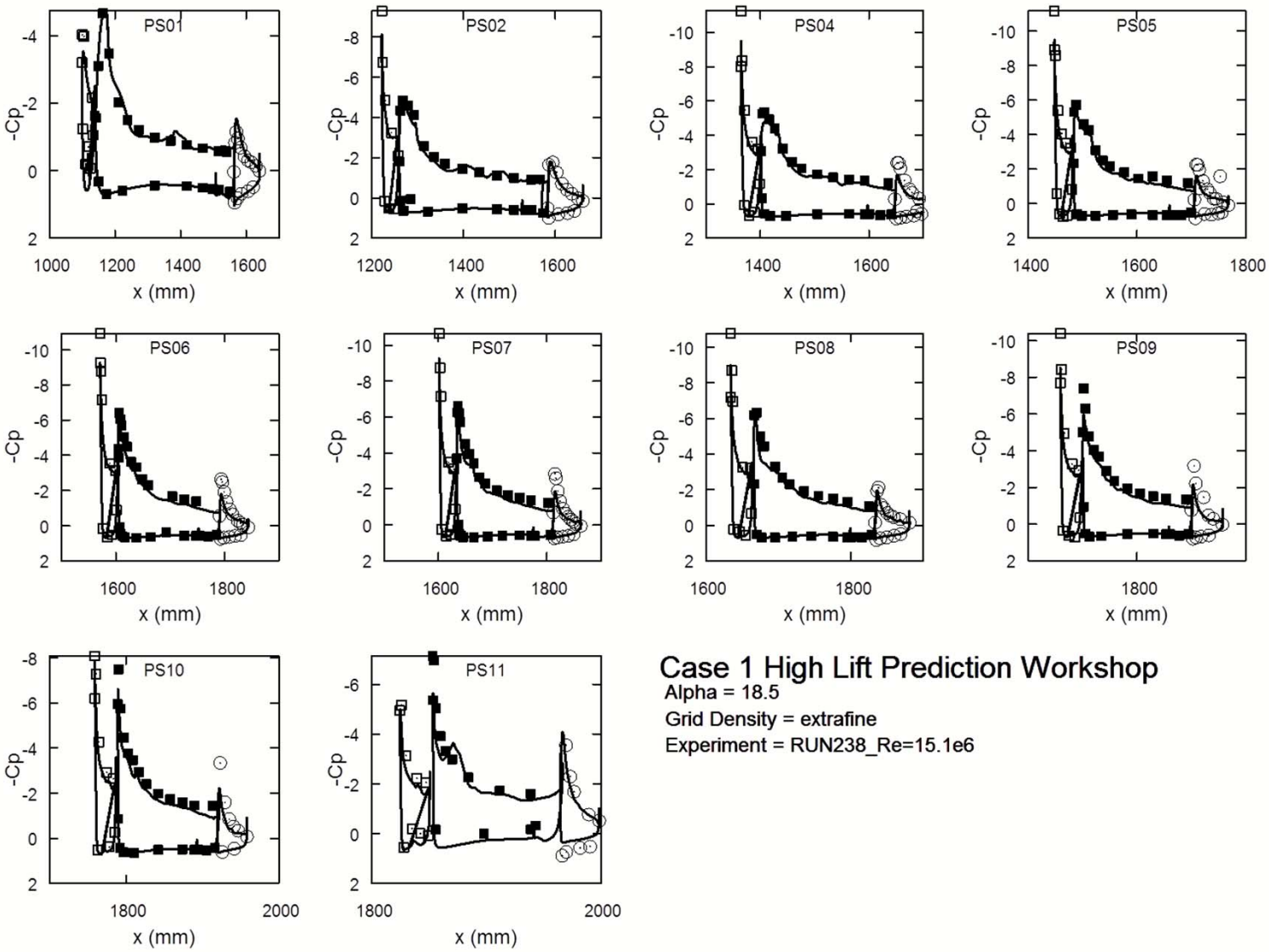


Case 1 High Lift Prediction Workshop

Alpha = 18.5

Grid Density = fine

Experiment = RUN238_Re=15.1e6

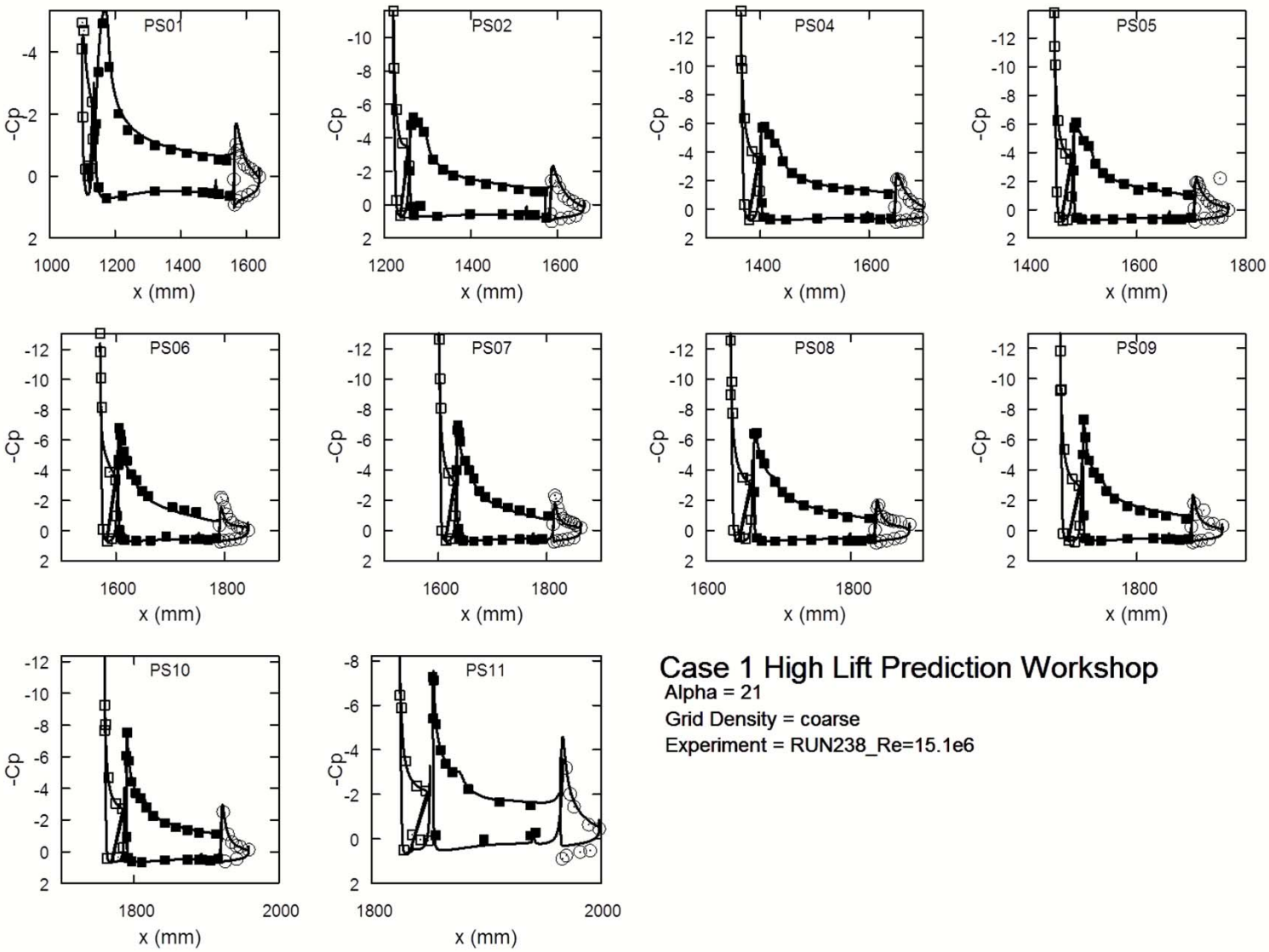


Case 1 High Lift Prediction Workshop

Alpha = 18.5

Grid Density = extrafine

Experiment = RUN238_Re=15.1e6

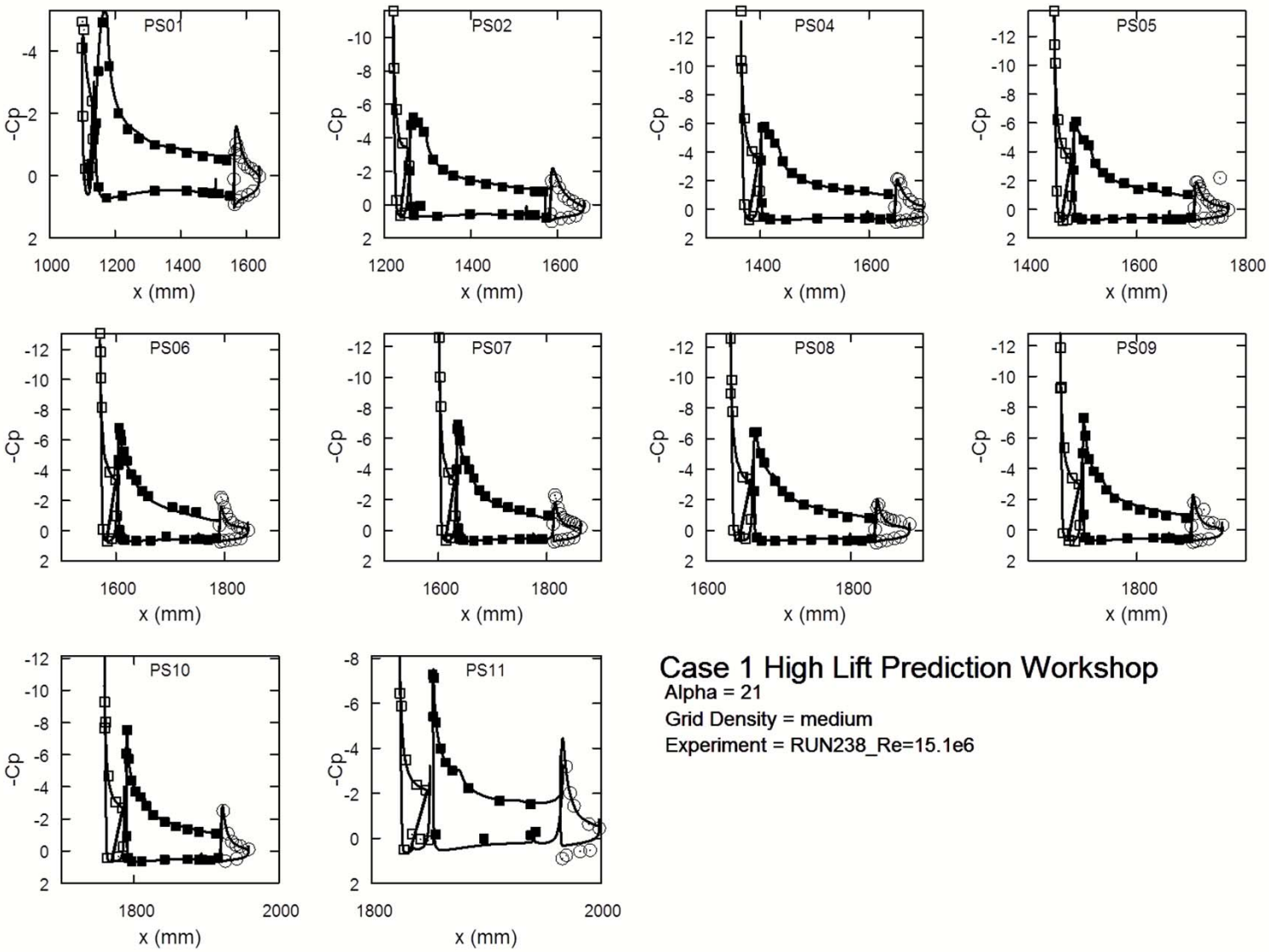


Case 1 High Lift Prediction Workshop

Alpha = 21

Grid Density = coarse

Experiment = RUN238_Re=15.1e6

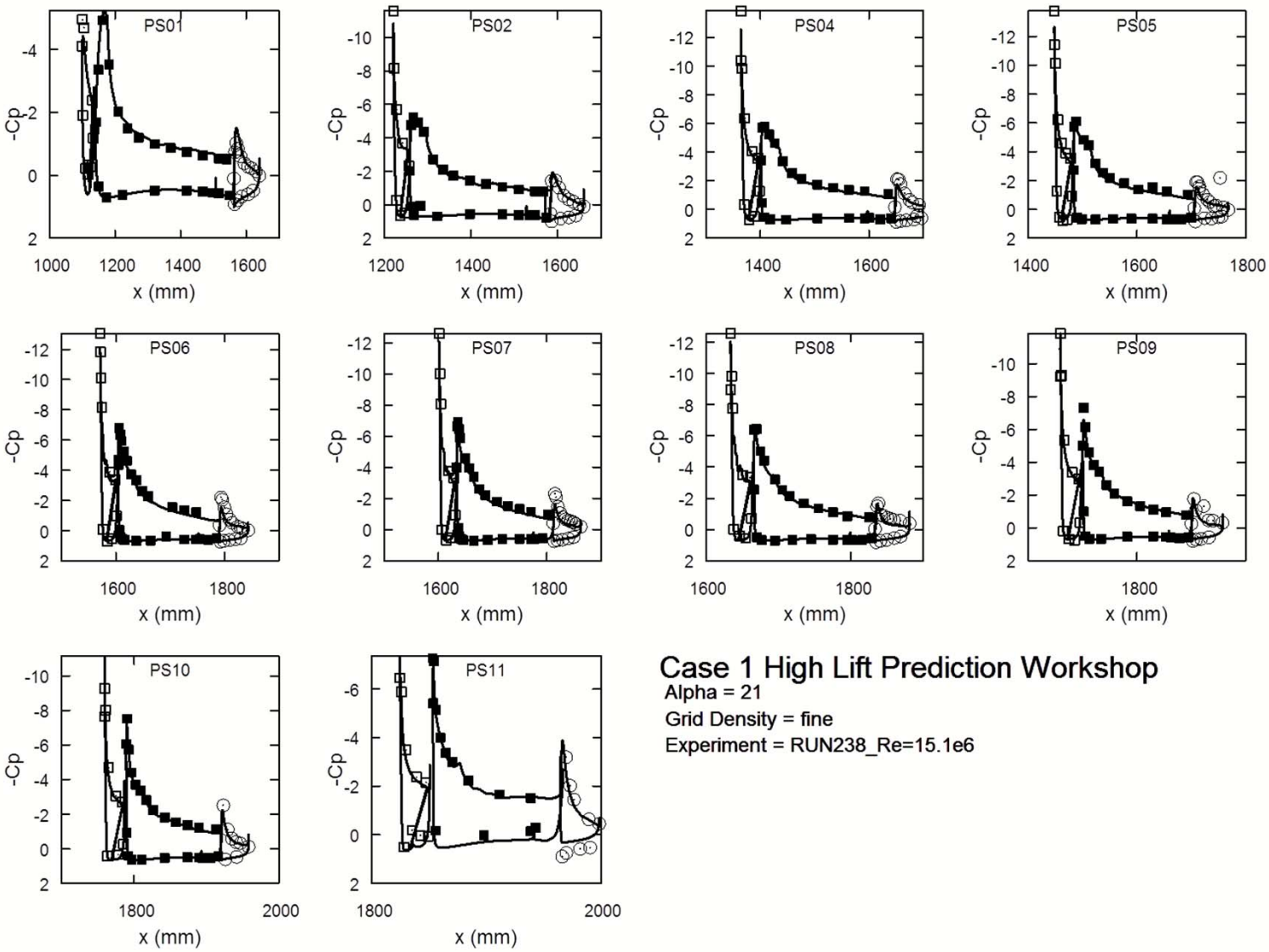


Case 1 High Lift Prediction Workshop

Alpha = 21

Grid Density = medium

Experiment = RUN238_Re=15.1e6

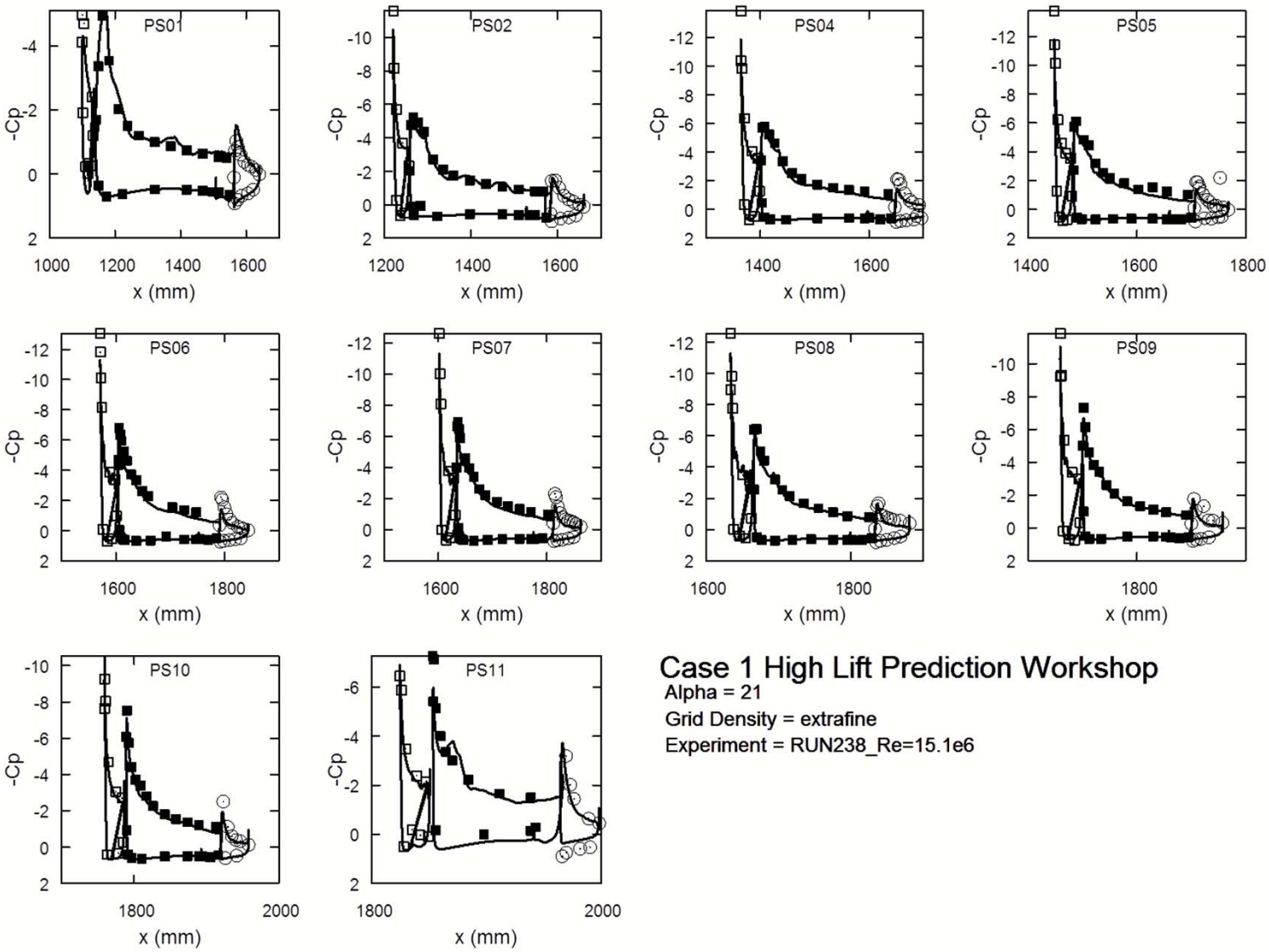


Case 1 High Lift Prediction Workshop

Alpha = 21

Grid Density = fine

Experiment = RUN238_Re=15.1e6

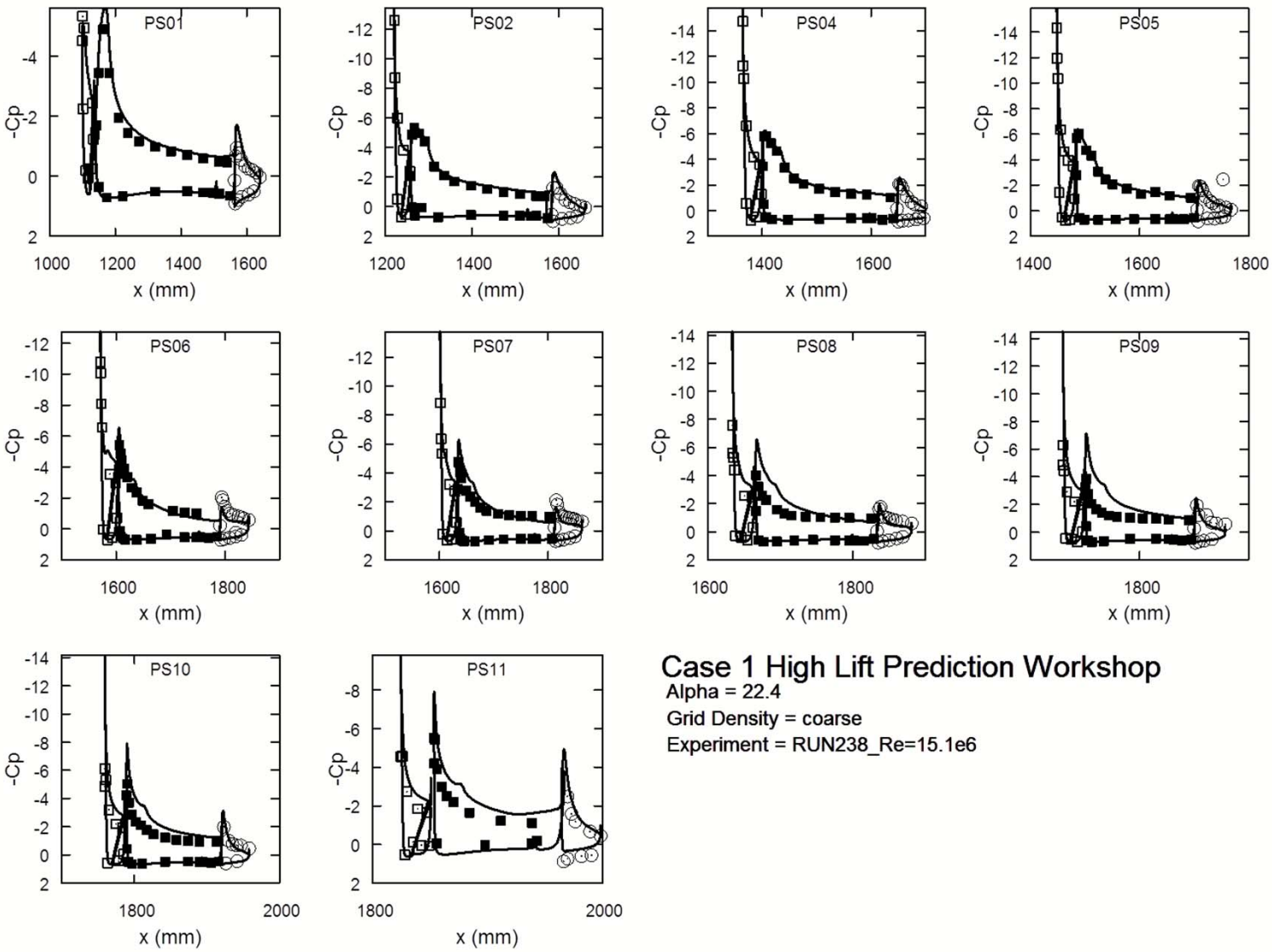


Case 1 High Lift Prediction Workshop

Alpha = 21

Grid Density = extrafine

Experiment = RUN238_Re=15.1e6

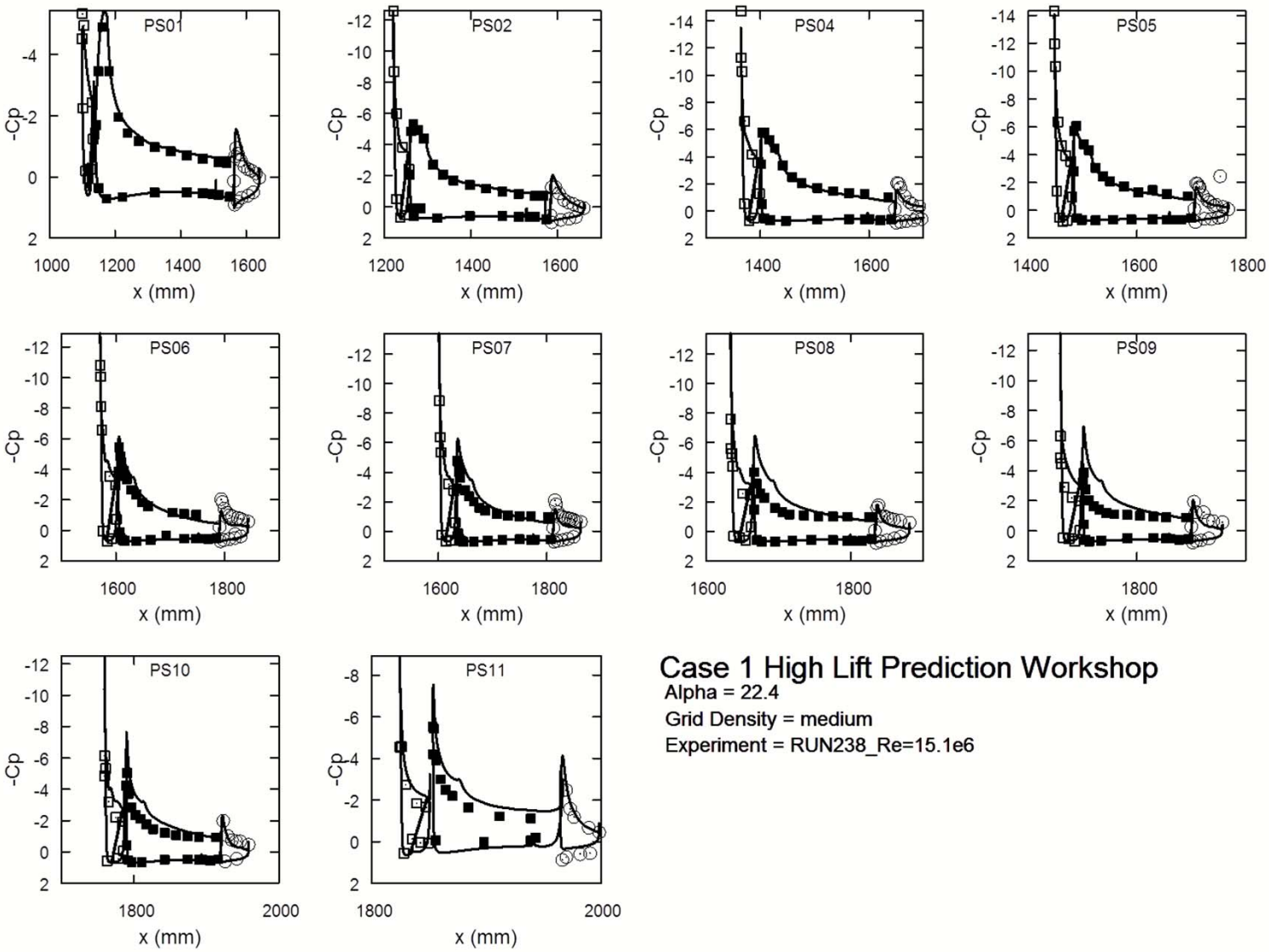


Case 1 High Lift Prediction Workshop

Alpha = 22.4

Grid Density = coarse

Experiment = RUN238_Re=15.1e6

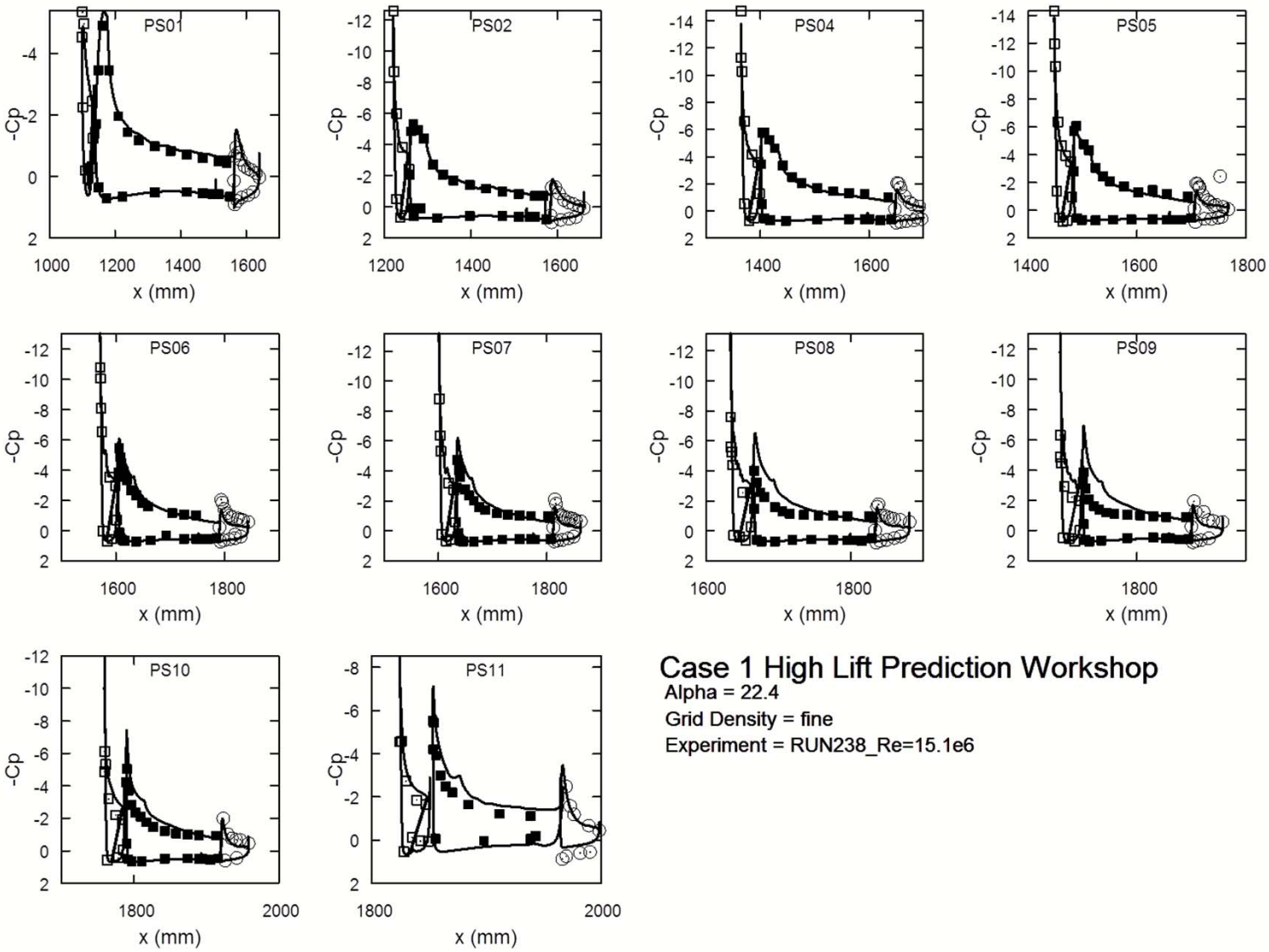


Case 1 High Lift Prediction Workshop

Alpha = 22.4

Grid Density = medium

Experiment = RUN238_Re=15.1e6

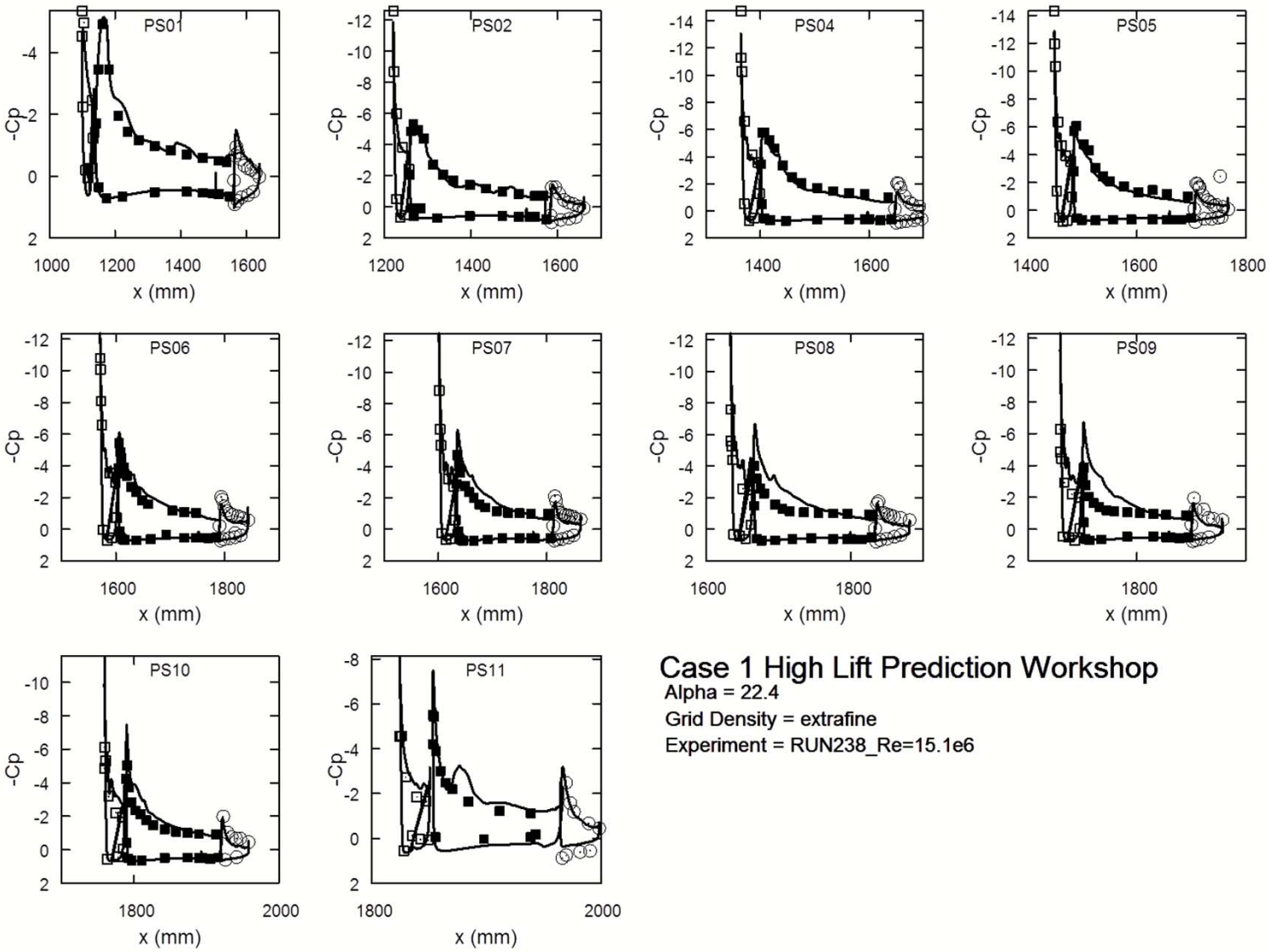


Case 1 High Lift Prediction Workshop

Alpha = 22.4

Grid Density = fine

Experiment = RUN238_Re=15.1e6



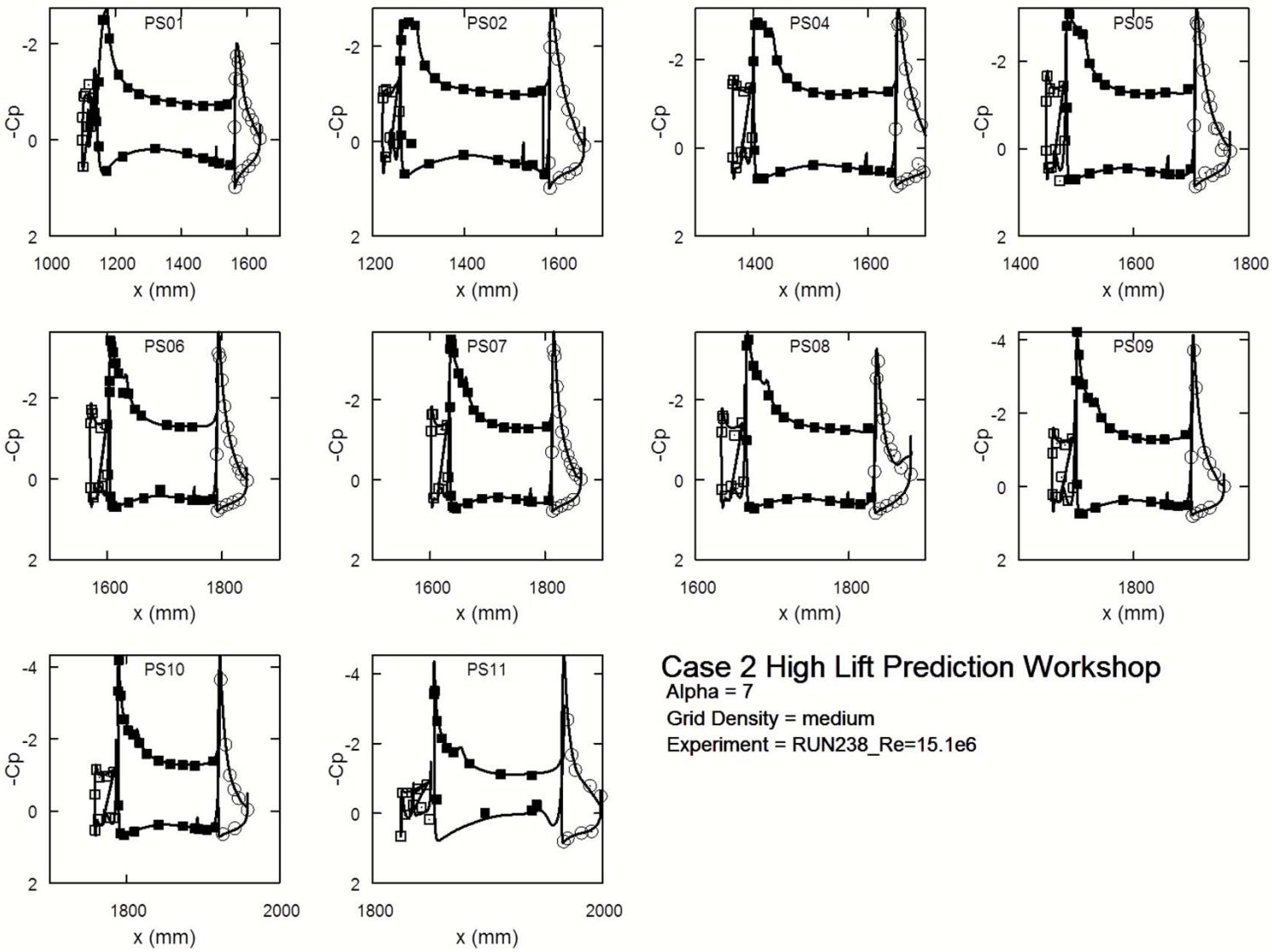
Case 1 High Lift Prediction Workshop

Alpha = 22.4

Grid Density = extrafine

Experiment = RUN238_Re=15.1e6

Case 2 – High and Low Reynolds Number Effect @ 7, 18.5 & 21 Degrees

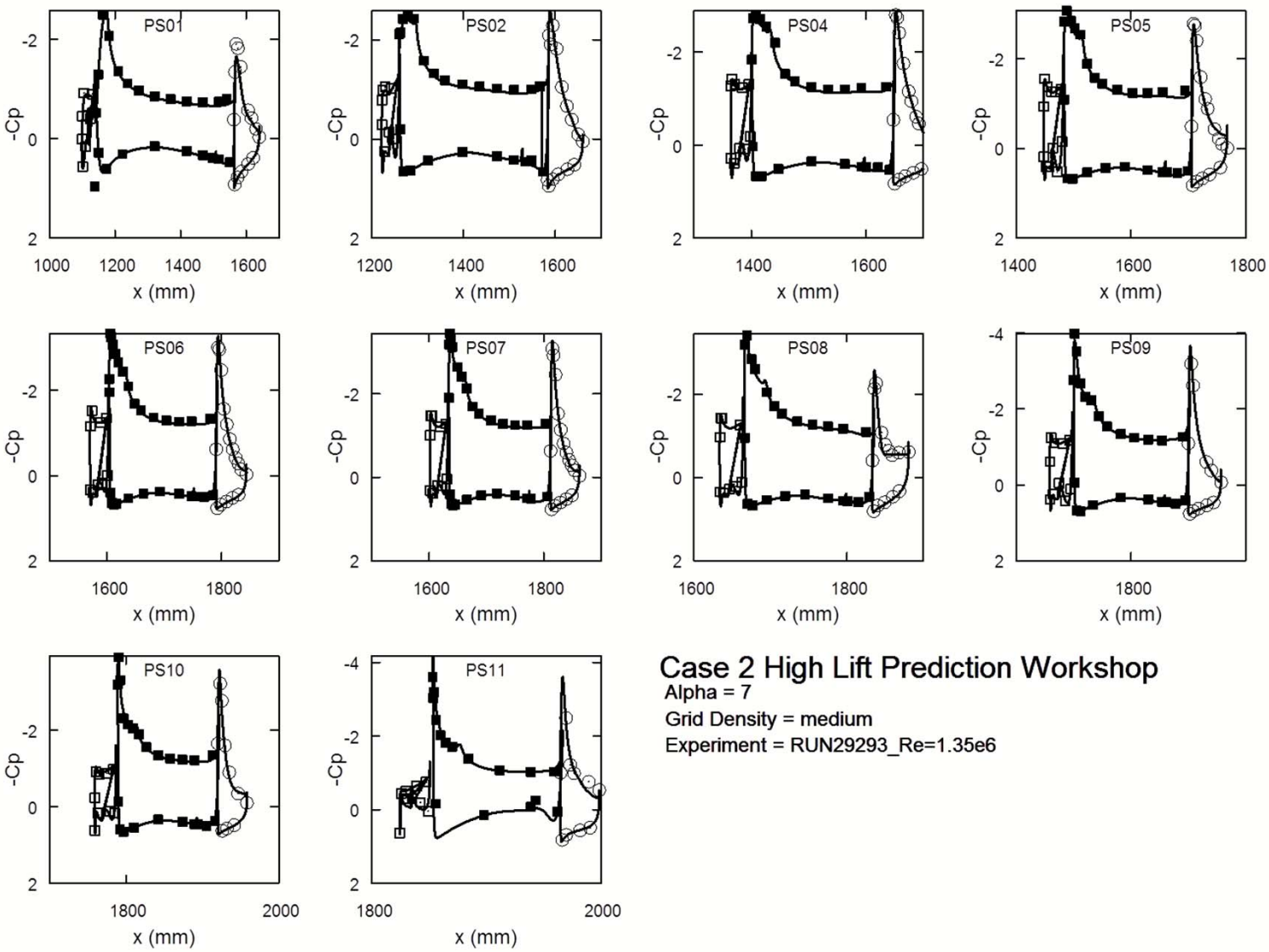


Case 2 High Lift Prediction Workshop

Alpha = 7

Grid Density = medium

Experiment = RUN238_Re=15.1e6

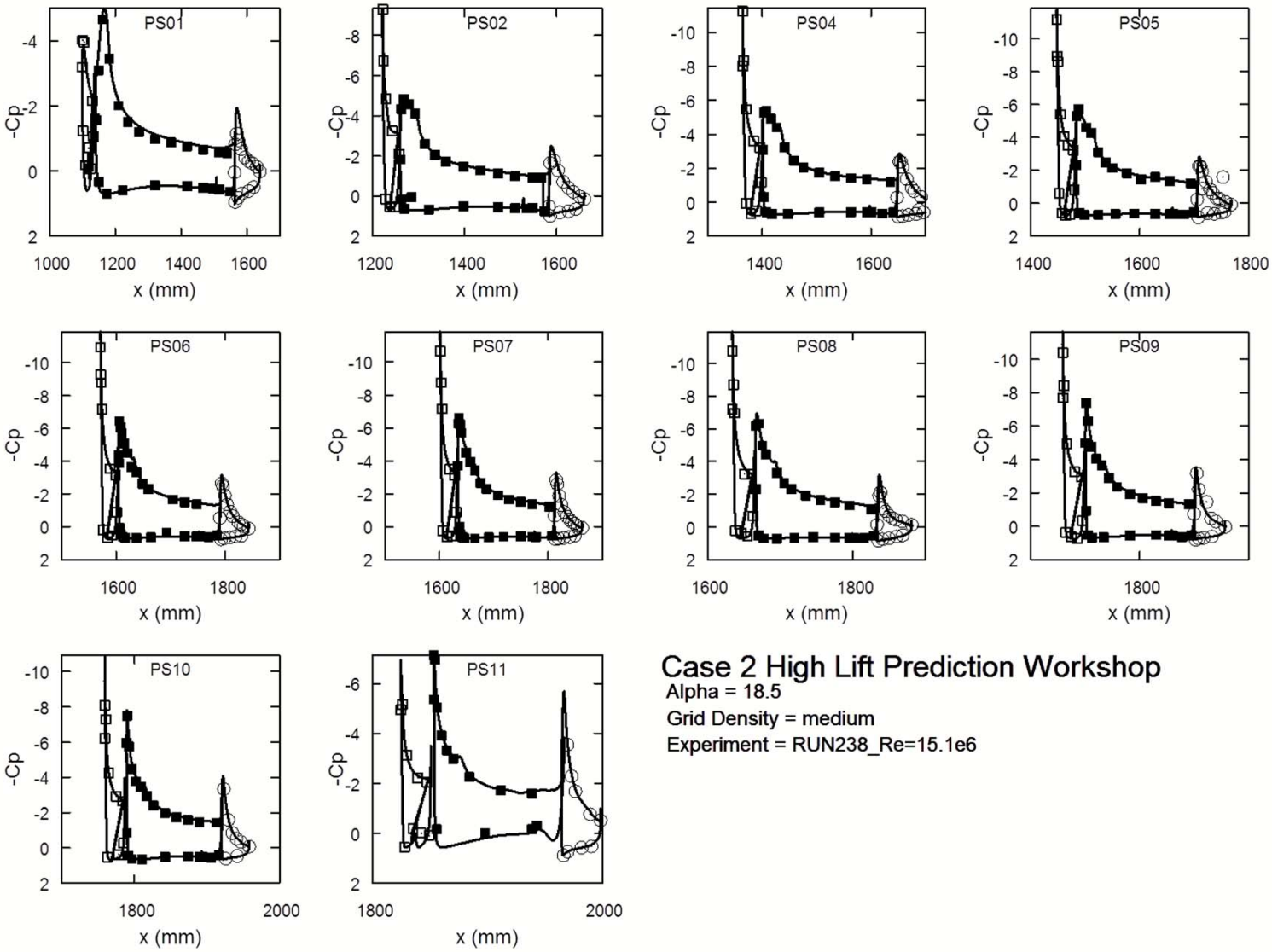


Case 2 High Lift Prediction Workshop

Alpha = 7

Grid Density = medium

Experiment = RUN29293_Re=1.35e6

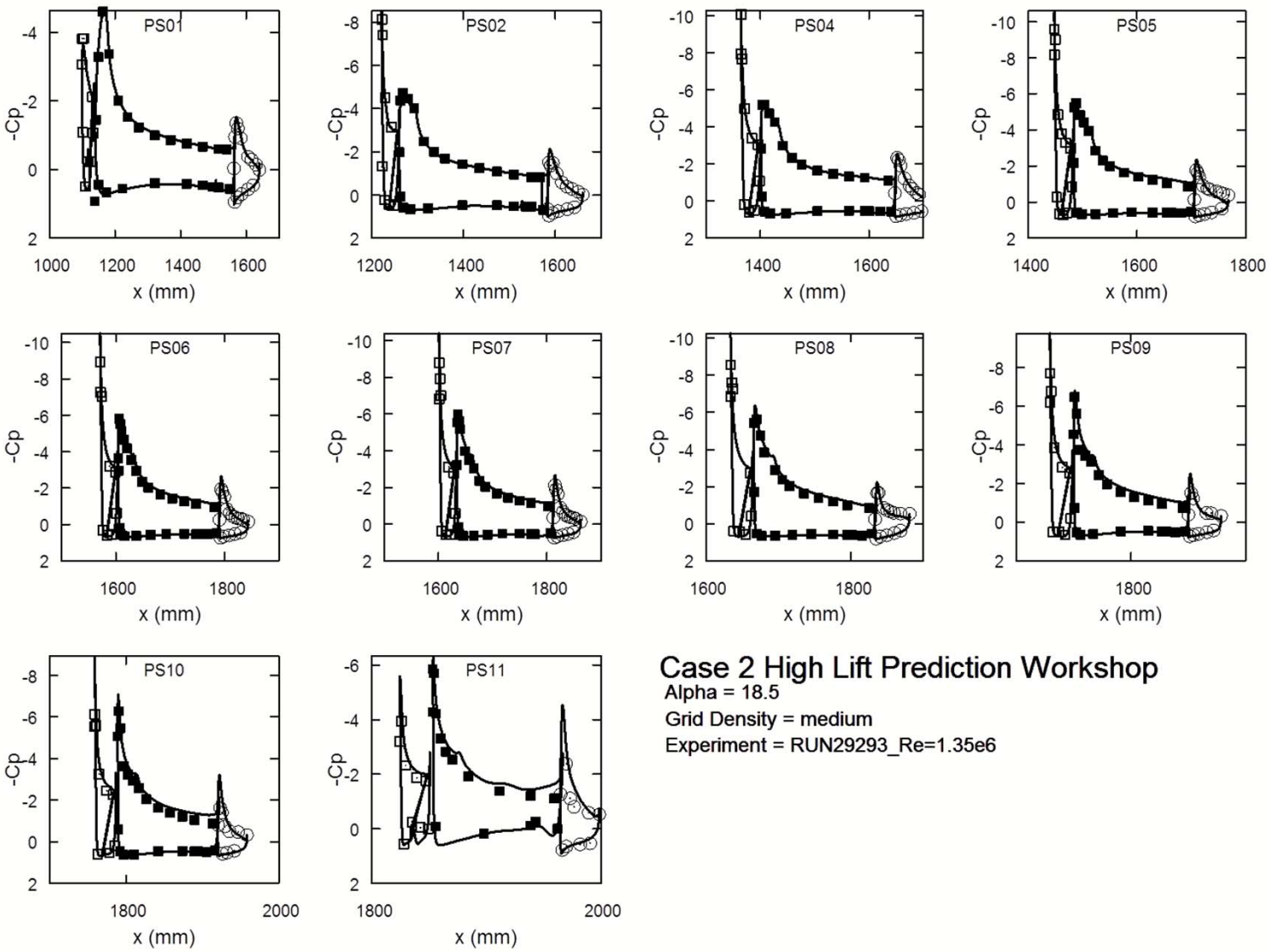


Case 2 High Lift Prediction Workshop

Alpha = 18.5

Grid Density = medium

Experiment = RUN238_Re=15.1e6

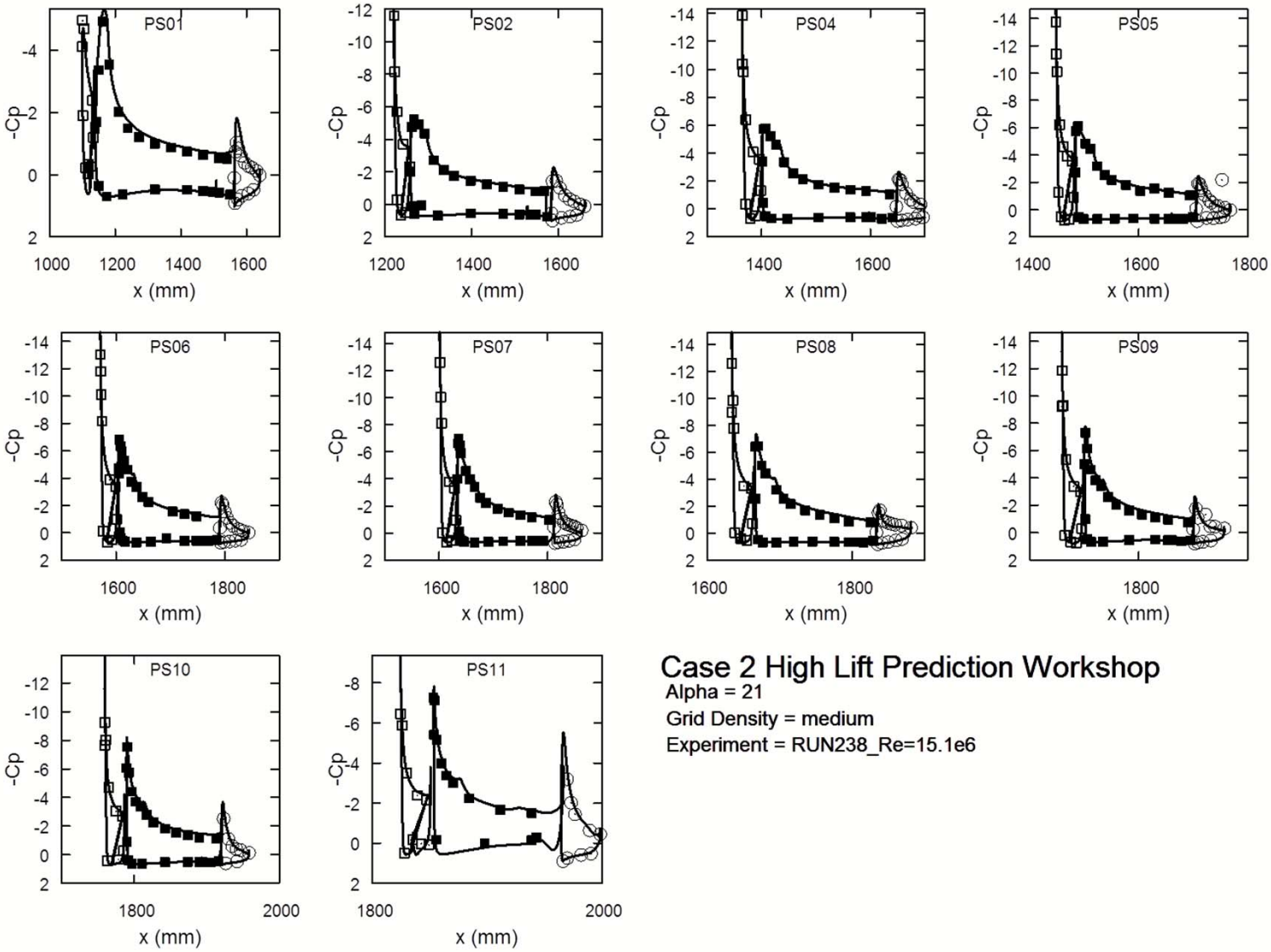


Case 2 High Lift Prediction Workshop

Alpha = 18.5

Grid Density = medium

Experiment = RUN29293_Re=1.35e6

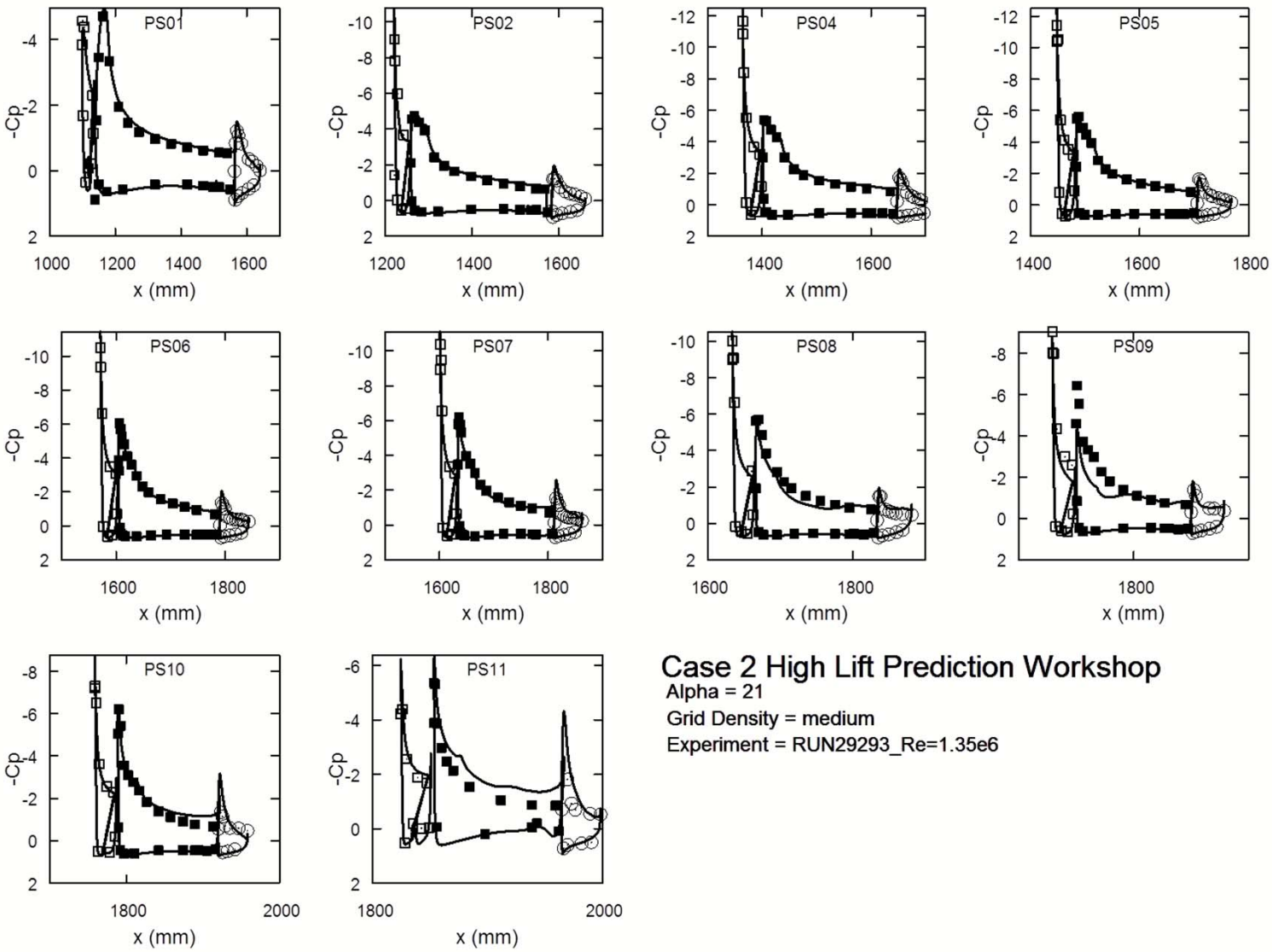


Case 2 High Lift Prediction Workshop

Alpha = 21

Grid Density = medium

Experiment = RUN238_Re=15.1e6



Case 2 High Lift Prediction Workshop

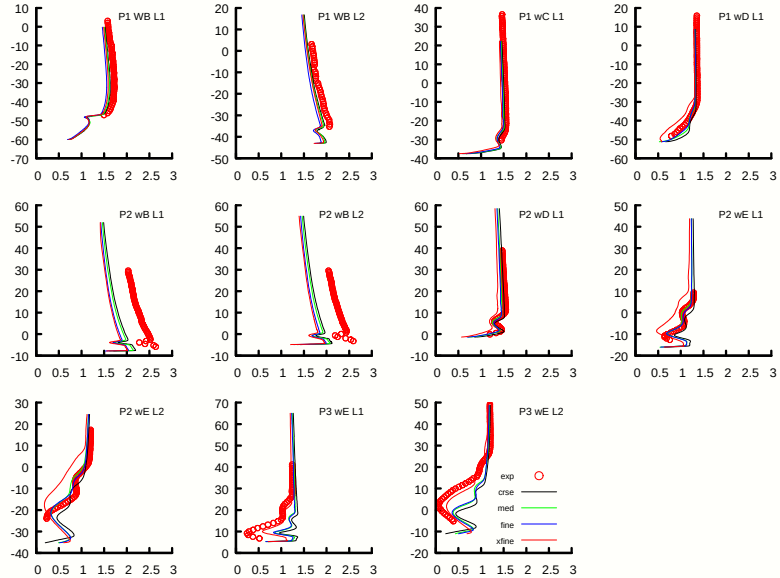
Alpha = 21

Grid Density = medium

Experiment = RUN29293_Re=1.35e6

Velocity comparisons

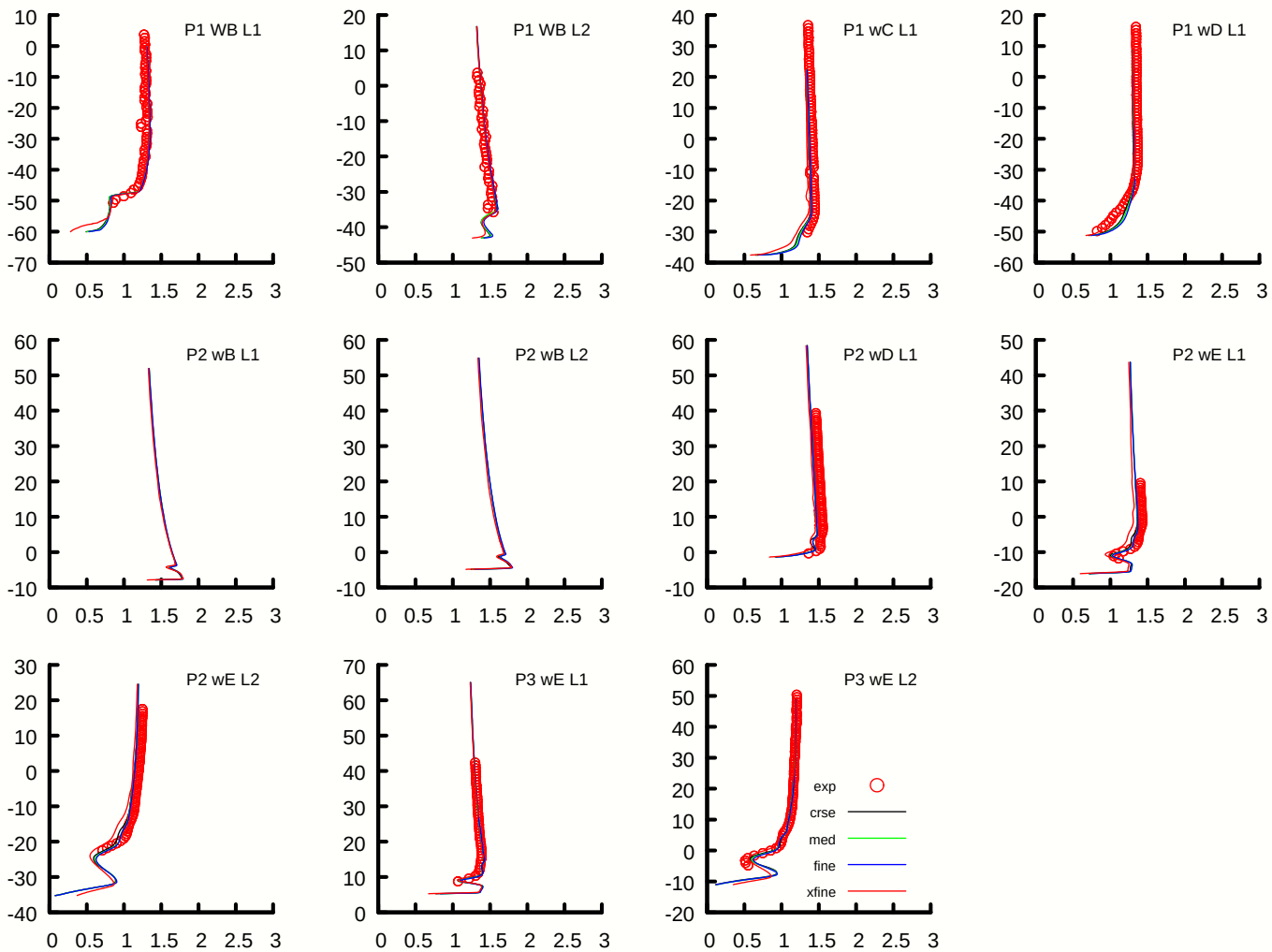
- Line Plot Extractions
- Directly sample and export velocity plot data to disk
  - Experiment vs Case 1 coarse to exfine
  - Experiment vs Case2 Reynolds number



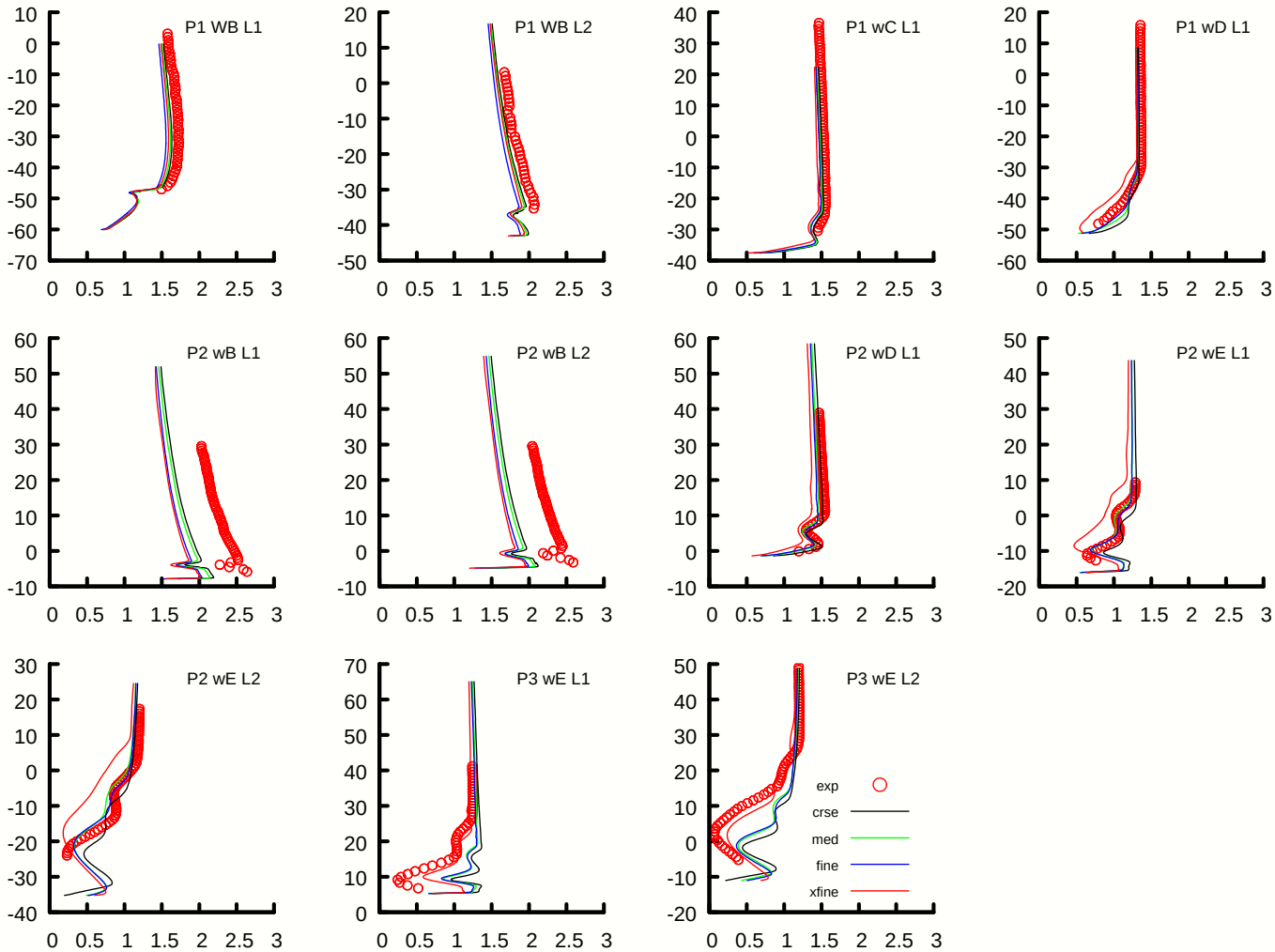
Experiment vs Case 1

Velocity Profiles
Hi Reynolds
7, 18.5, 21 Degrees
Effect of Grid Refinement coarse, medium, fine, extra-fine

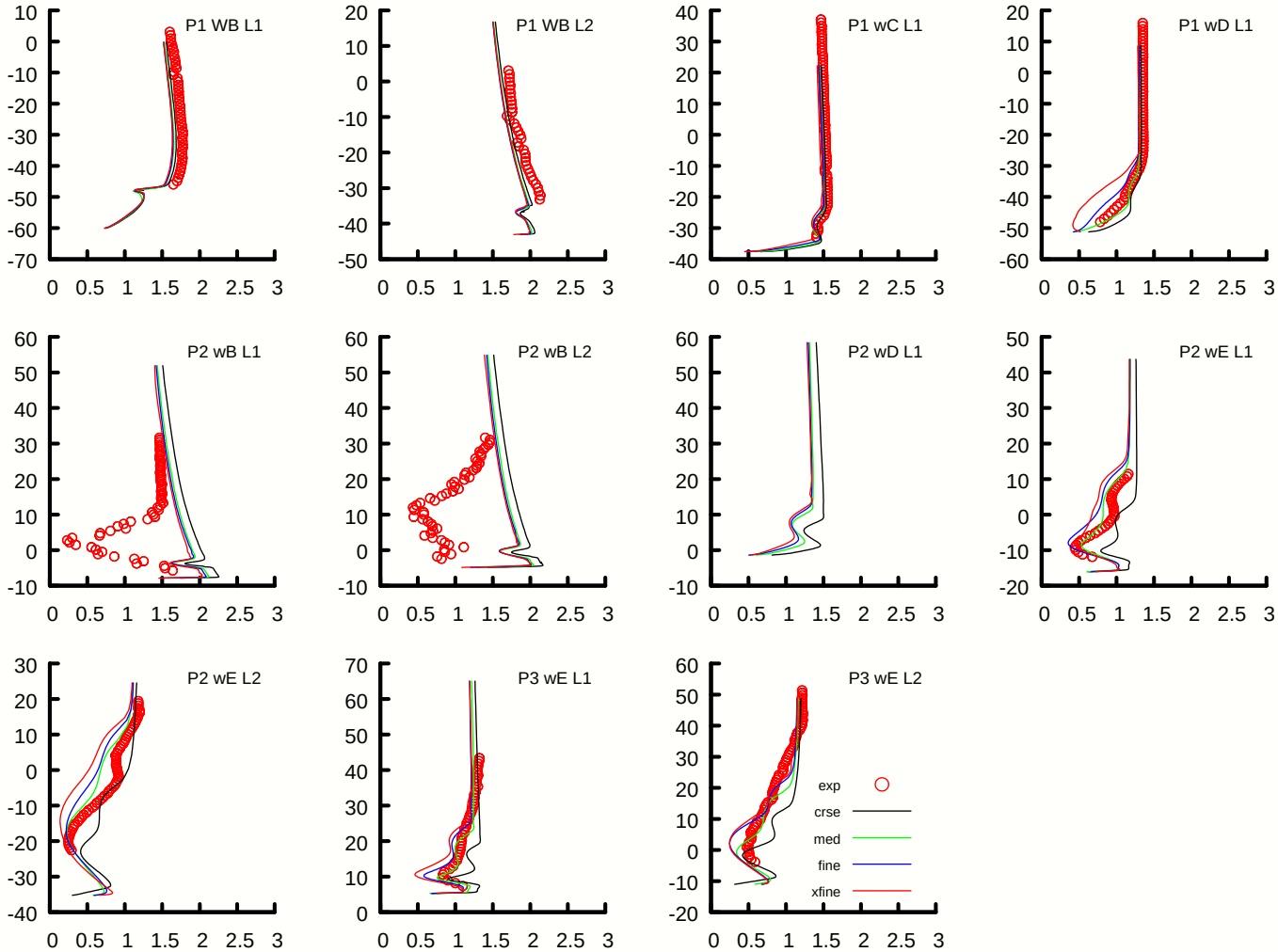
Velocity profiles 7 Deg. – Hi Rey



Velocity profiles 18.5 Deg. – Hi Rey



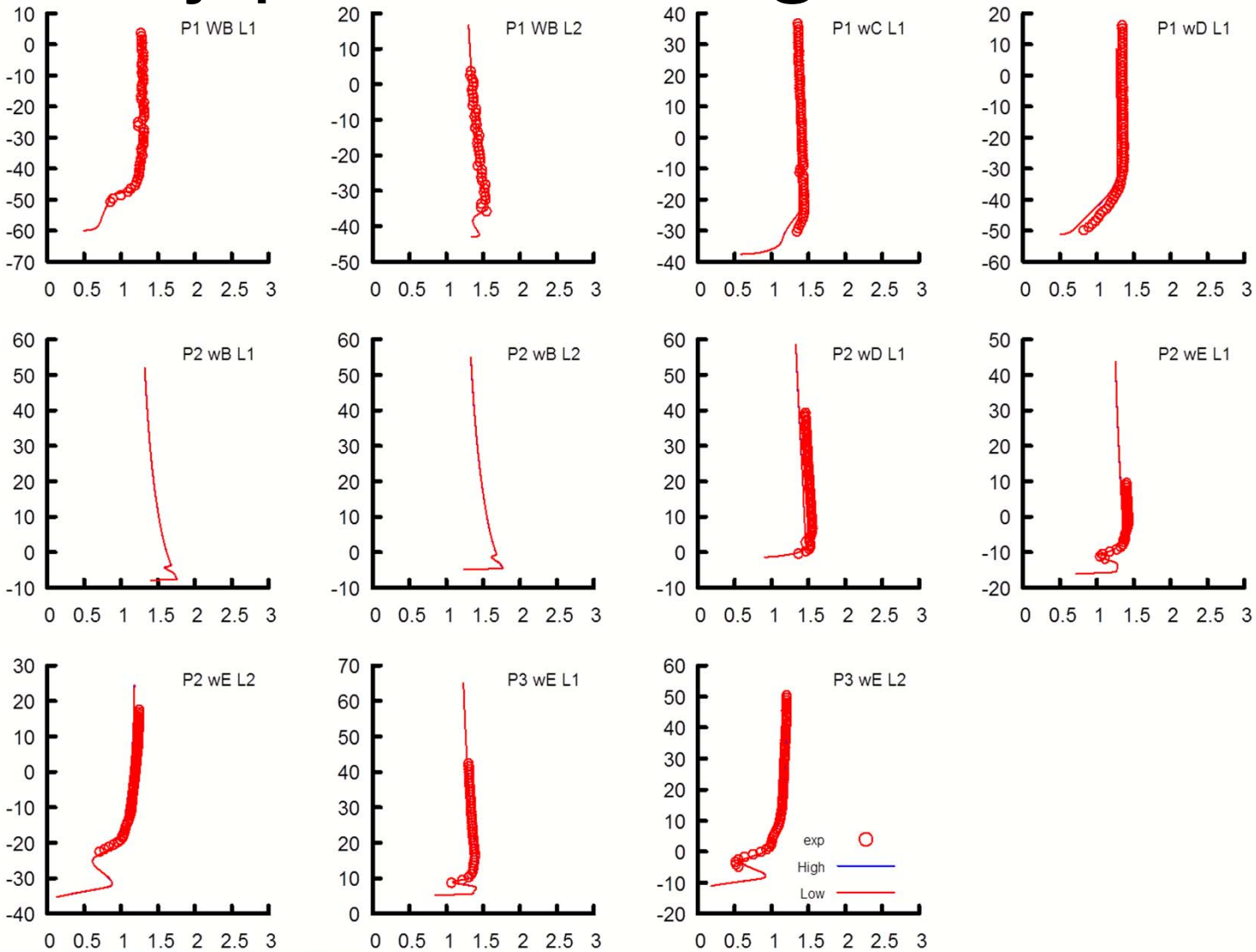
Velocity profiles 21 Deg. – Hi Rey



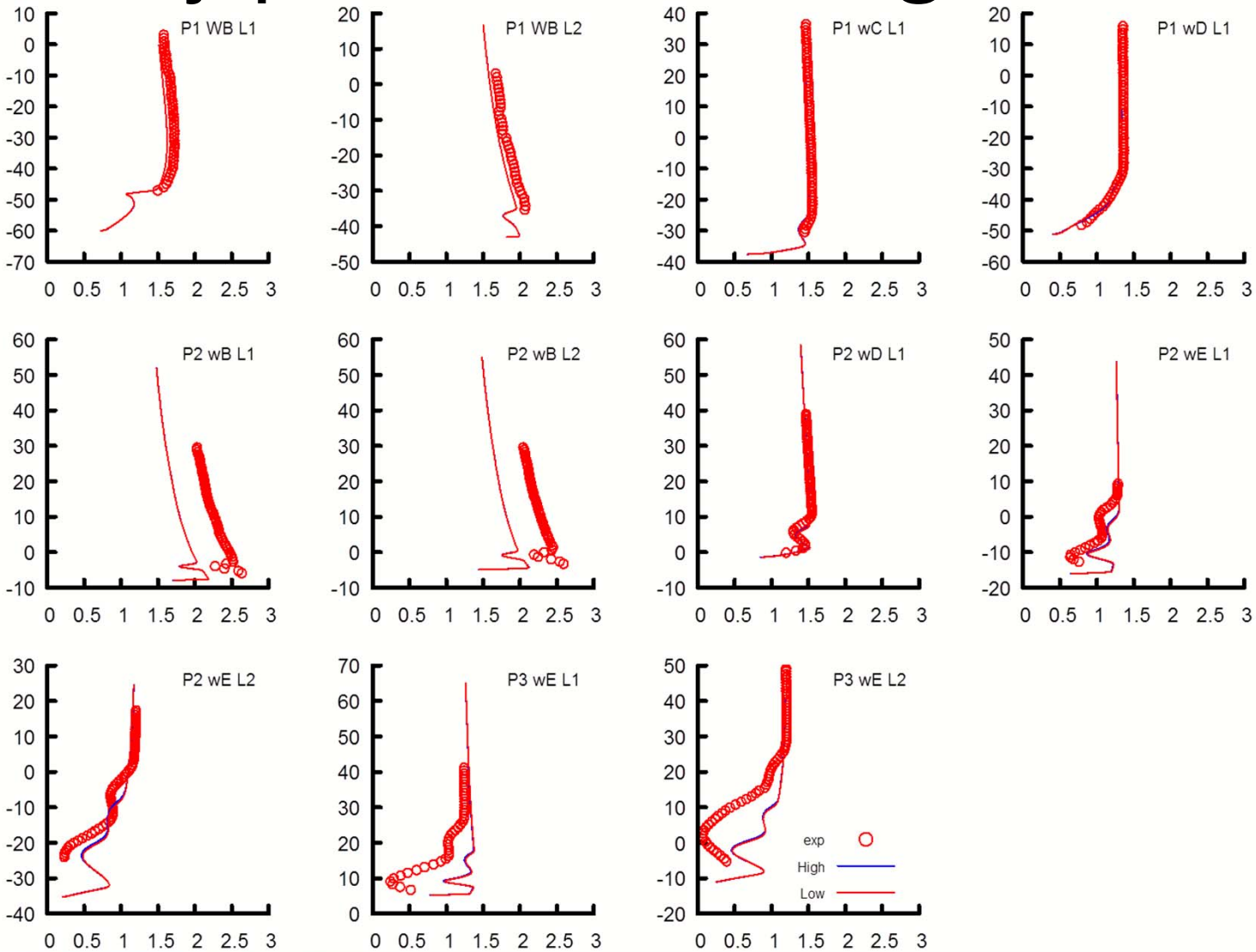
Experiment vs Case 2

Effect of Reynolds Number
7, 18.5, 22.4 m/s

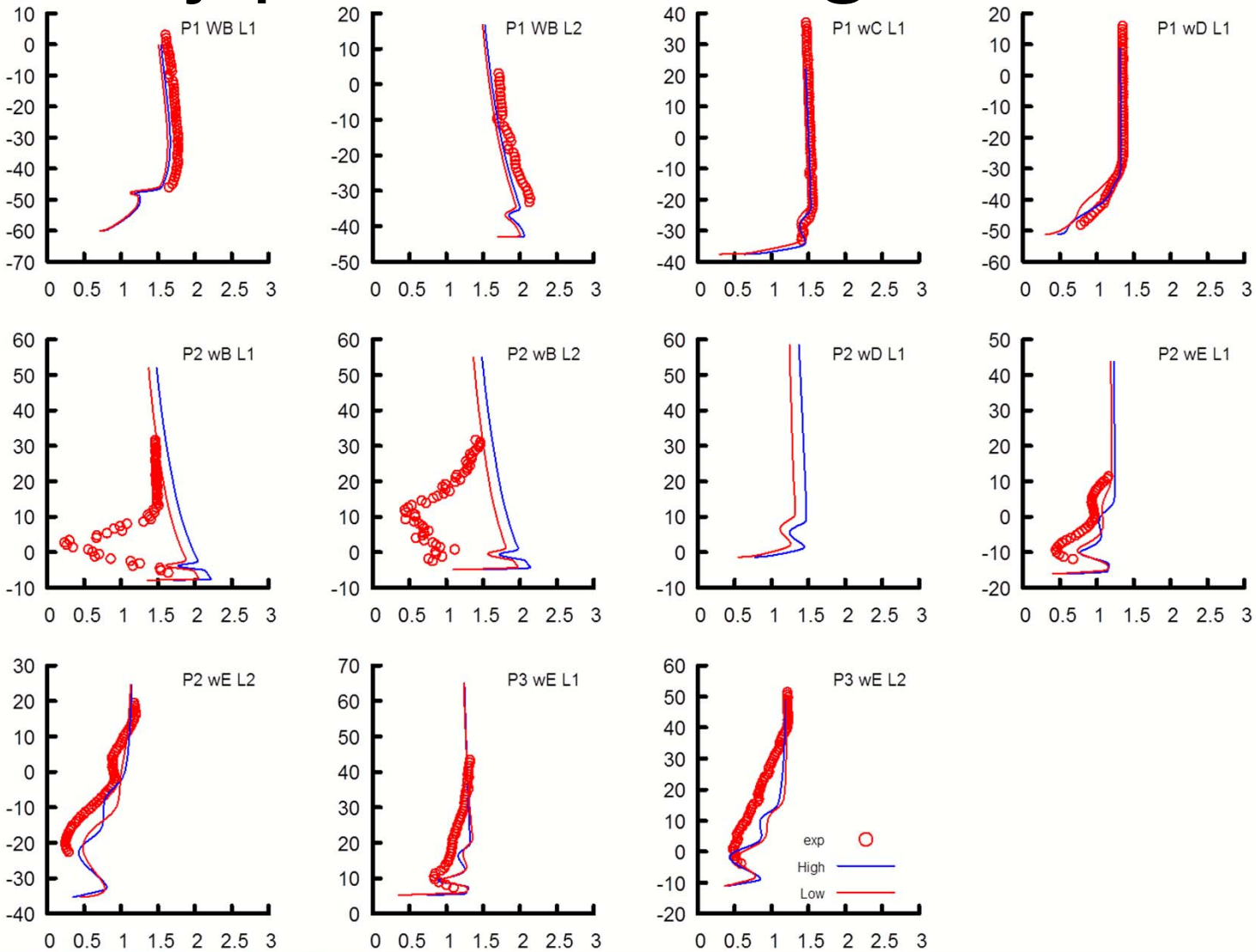
Velocity profiles 7 Deg. – Case 2



Velocity profiles 18.5 Deg. – Case 2

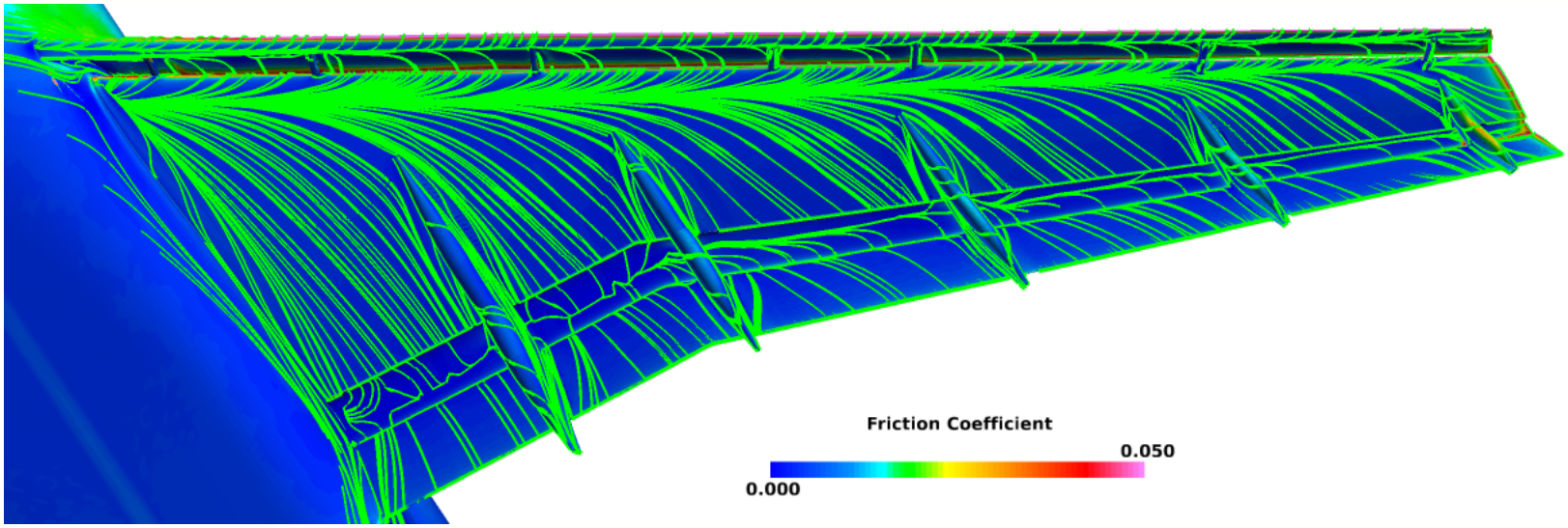


Velocity profiles 21 Deg. – Case 2

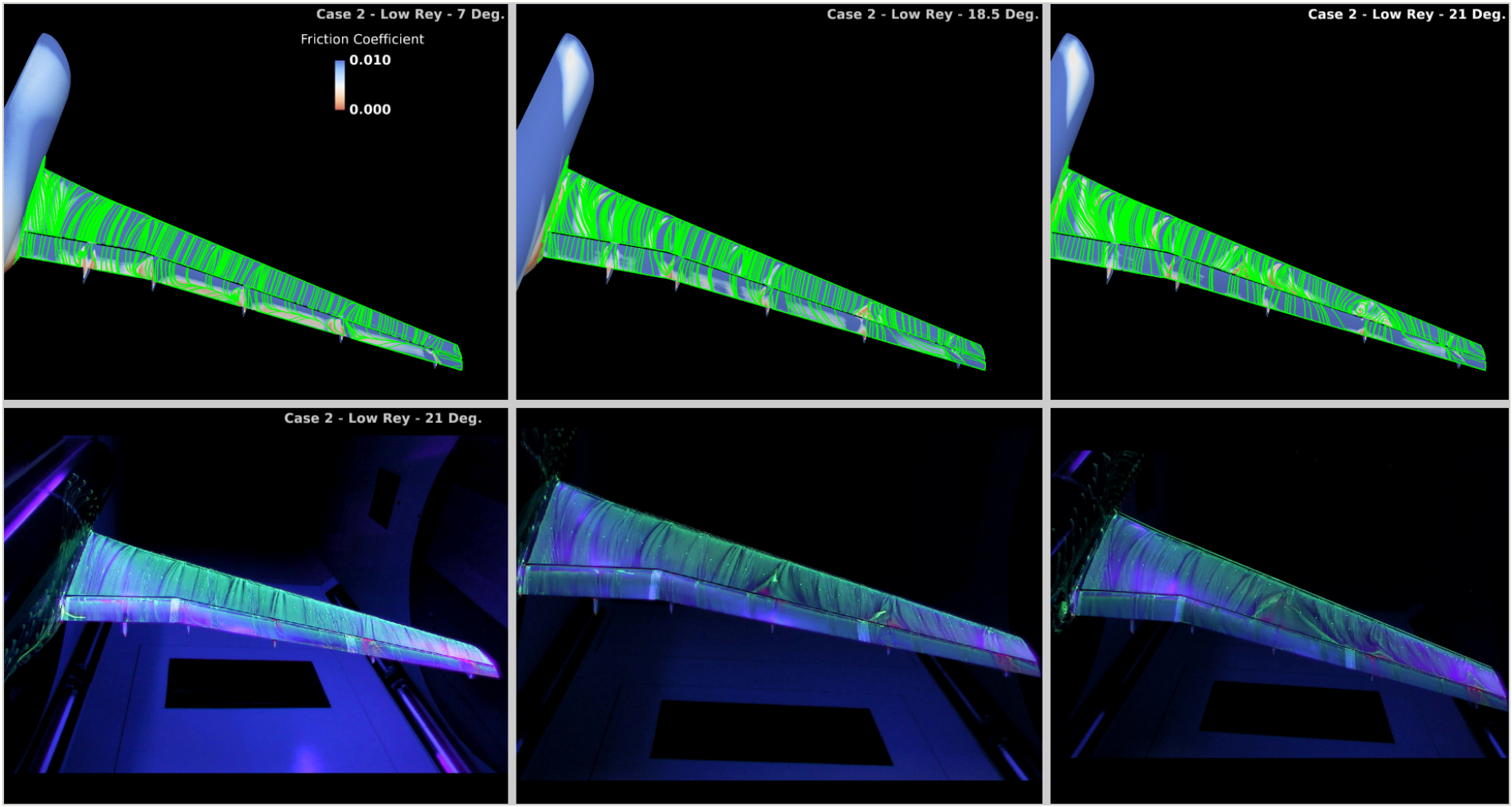


Surface streamlines

- Create surface streamlines using Surface Flow Tool
- Execute script based upon FVX -> .fvp files
- Download the resulting pathline file
- Load in to interactive session for exploration or batch process direct to images

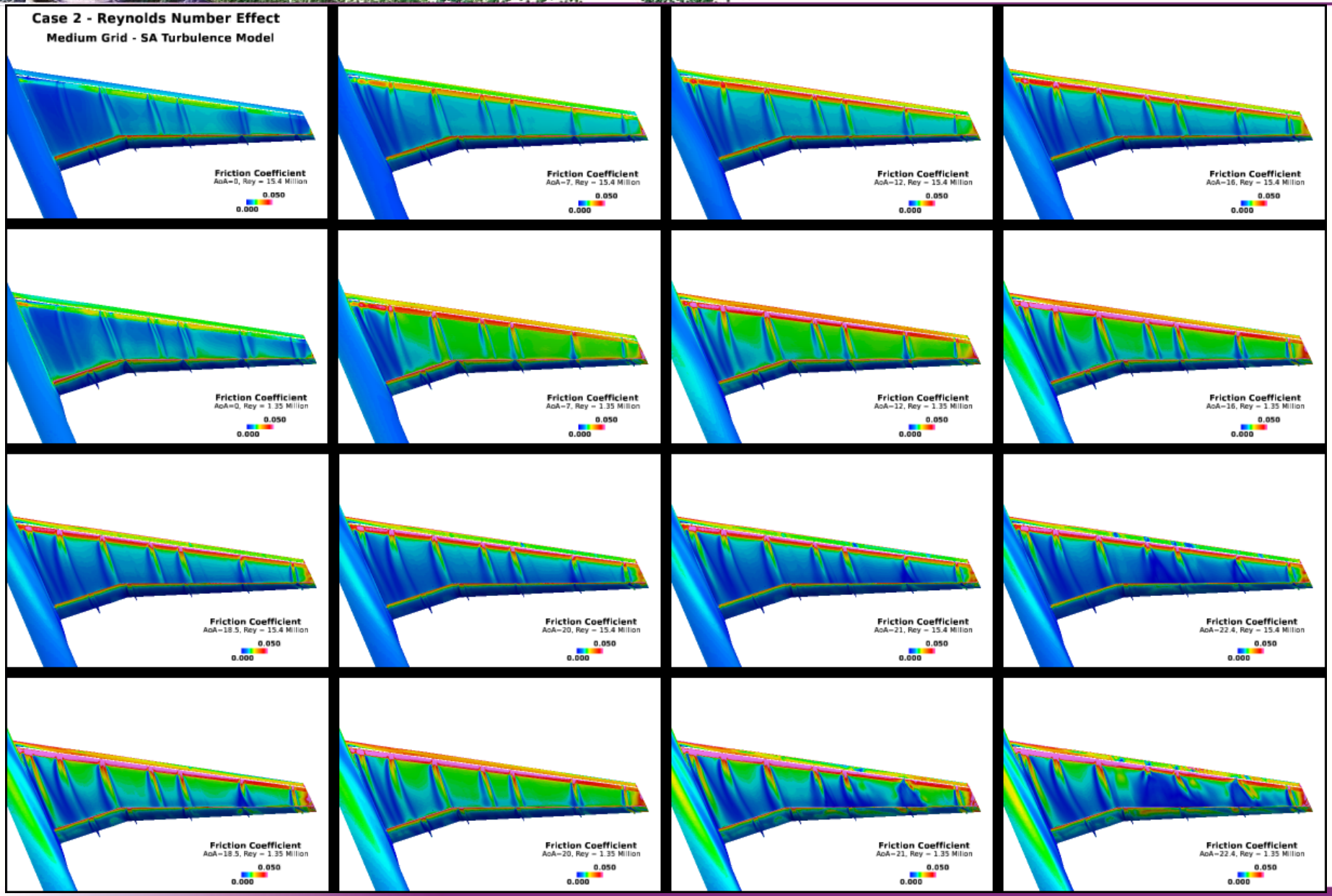


Case 2 Low Reynolds



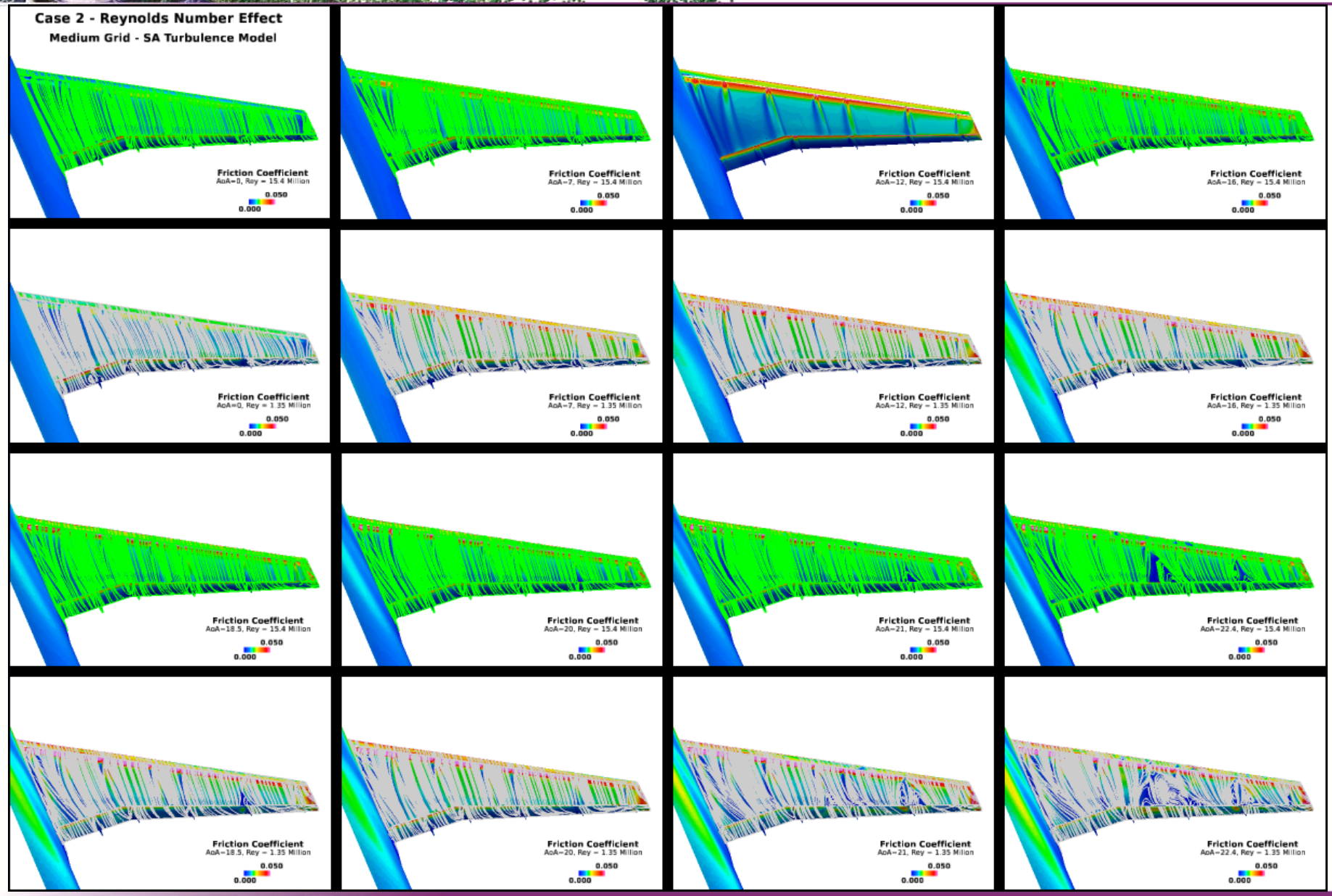
Case 2 - Reynolds Number Effect

Medium Grid - SA Turbulence Model



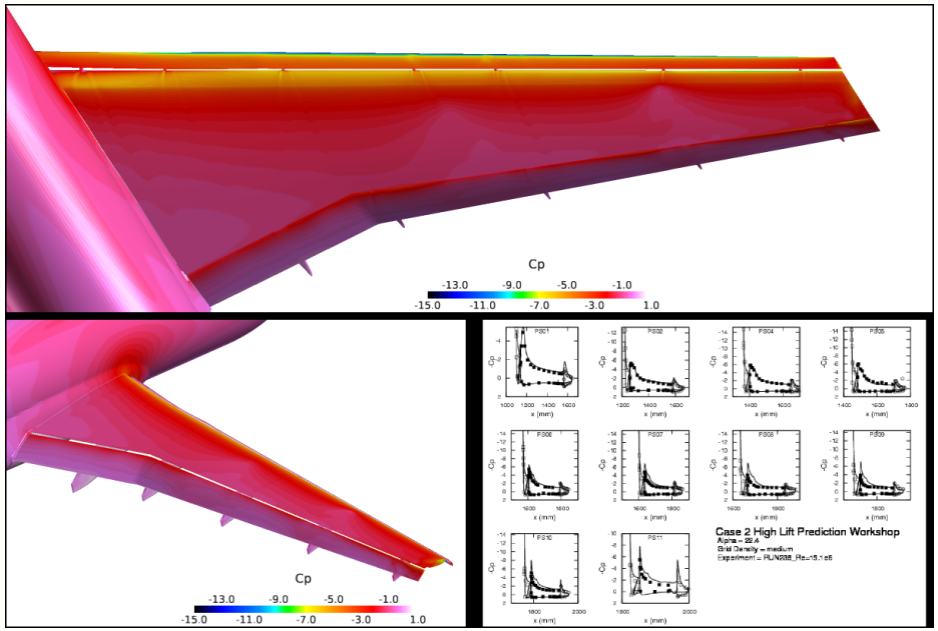
Case 2 - Reynolds Number Effect

Medium Grid - SA Turbulence Model



Summary

- Trending similar to others
- Flow separation of interest
- Unsteady, Turbulence, Convergence ?
- Saga Continues
  - Continuing to “run out” solutions across the board
  - Look at transition and unsteady cases more carefully
  - Would like to do AMR
- What have I (re)learned
  - Pay attention to Convergence
  - May be use pre-conditioning
  - Need a structured grid that to enables better load balancing (AMR?)
  - Unsteady needs attention



Future Work

- Run out Case 1
- Run out Case 2
  - High Reynolds
    - Run to Convergence
    - Off Body Flows
  - Low Reynolds
    - Transition (Menter-Langtry) (Finish)
    - k-W-SST (finish)
    - k-W-SST Unsteady (finish)
- XDB Workflow Case Study – July 2013
- AIAA Summer 2014 Paper