# AIAA High Lift Prediction Workshop - Wind Tunnel / Test Data

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AIAA
CFD High Lift Prediction Workshop

DLR

# Test Case Features and Validation Objectives

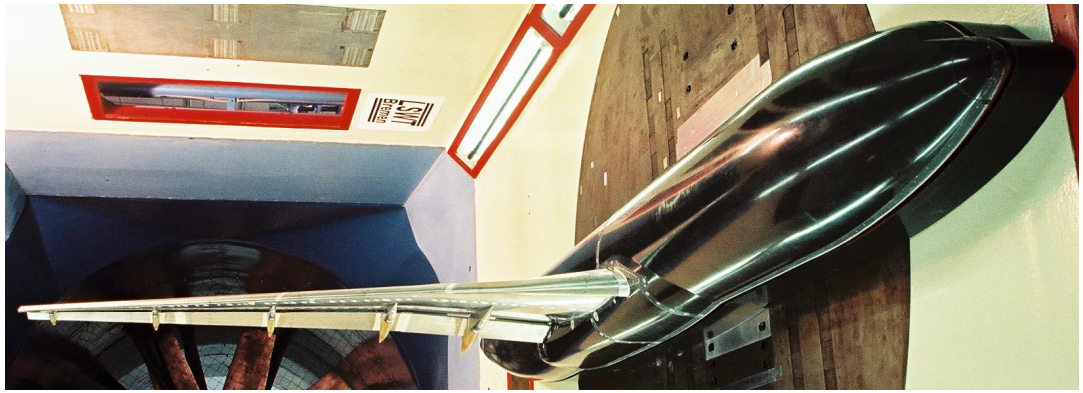


- Aircraft configuration fairly representative for commercial type high lift layout
  - typical plan form layout (twist, taper)
  - typical 3-element high lift system (slat / fixed wing / Flowler flap)
  - Full span slat and flap wing/body high lift configuration
- Major simplification compared to full real Aircraft configuration concerning
  - neglecting engine / pylon (important trigger for $C_{Lmax}$ on underwing configs.)
  - full span flap, no aileron
  - slat / fuselage intersection sealed ⇨ no slat side edge vortex interference effects
- Optional complexity increase
  - consideration of externally mounted pressure tube bundles of w/t model
- Validation Objectives:
  - ⇨ Simulation of maximum lift determining effect for configuration in landing setting
  - ⇨ Prediction of the Re-No. influence using LSWT and ETW test results

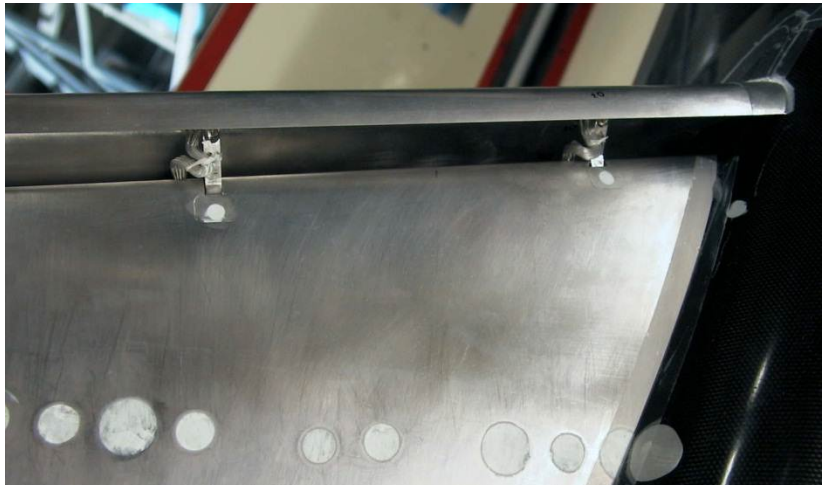
# EUROLIFT DLR-F11 Model Stage 0 - KH3Y Specification



- **Main dimensions and specification of DLR-F11 high lift model:**
  - **half span : $s = 1.4$ m**
  - **wing reference area: $A/2 = 0.42$ m$^2$**
  - **reference chord : $c_{ref} = 0.347$ m**
  - **aspect ratio : $\Lambda = 9.35$**
  - **taper ratio : $\lambda = 0.3$**
  - **¼ chord sweep : $\varphi_{25} = 30^o$**
  - **fuselage length : $l_{Fu} = 3.077$ m**



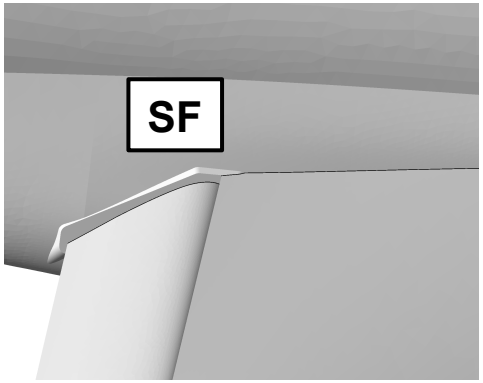
- **High lift system (landing, WP9)**
  - **full span slat and flap**
  - **slat deflection : $\delta_s = 26.5^o$**
  - **flap deflection : $\delta_f = 32.0^o$**
  - **no gap at WB junction**

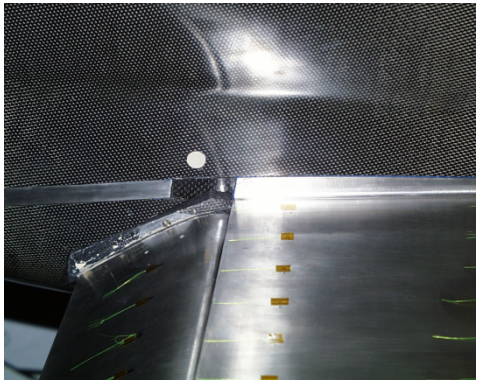


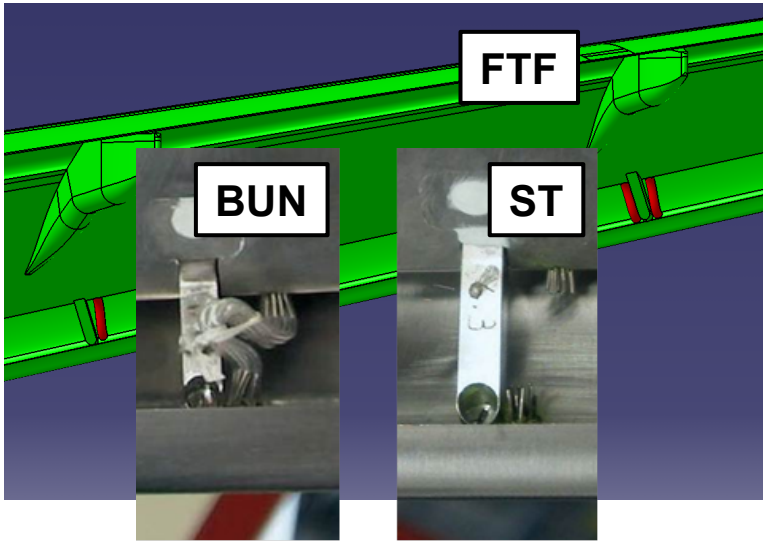
# EUROLIFT DLR-F11 Model Stage 0 – CAD Model Variants



- **5 variants with an increasing level of detail have been provided, each with and w/o farfield:**
  - **Stage 0-1 W/B:** **aiaa_hl_f11_wbsf.mod.v1_0m.igs**
  - **Stage 0-2 W/B/SF:** **aiaa_hl_f11_fsurf_wbsf.mod.v1_0m.igs**
  - **Stage 0-3 W/B/SF/FTF:** **aiaa_hl_f11_fsurf_wbsf_ftf.mod.v1_0m.igs**
  - **Stage 0-4 W/B/SF/FTF/ST:** **aiaa_hl_f11_fsurf_wbsf_ftf_st.mod.v1_0m.igs**
  - **Stage 0-5 W/B/SF/FTF/ST/BUN** **aiaa_hl_f11_fsurf_wbsf_ftf_st_bun.mod.ff.v1_0m.igs**





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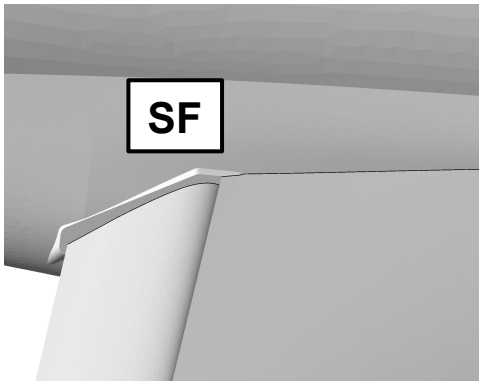
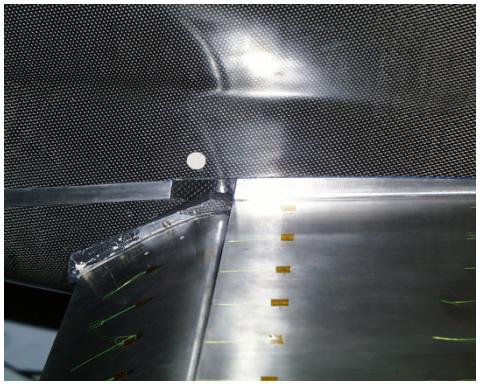
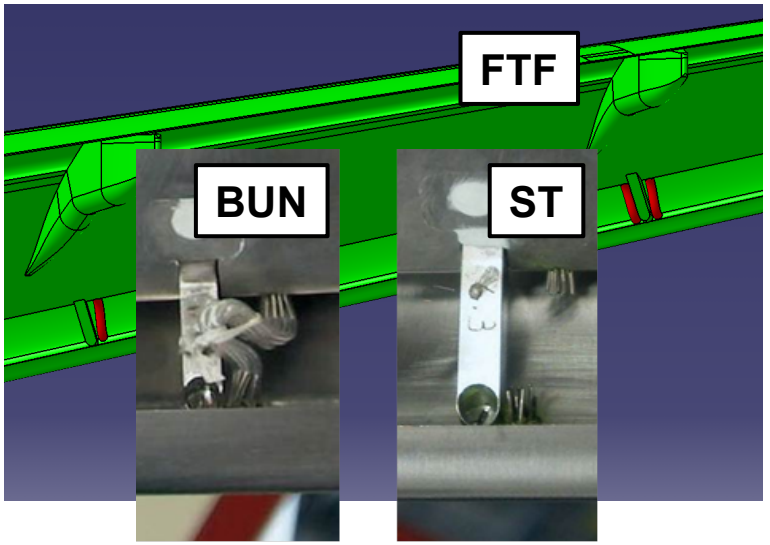
  - **Stage 0-1 W/B:** aiaa_hl_f11_wbsf.mod.v1_0m.igs
  - **Stage 0-2 W/B/SF:** aia ⇨ Case 1 surf_wbsf.mod.v1_0m.igs
  - **Stage 0-3 W/B/SF/FTF:** aiaa_hl_f11_fsurf_wbsf_ftf.mod.v1_0m.igs
  - **Stage 0-4 W/B/SF/FTF/ST:** aia ⇨ Case 2a and Case 2b st.mod.v1_0m.igs
  - **Stage 0-5 W/B/SF/FTF/ST/BUN** aia ⇨ Case 3a and Case 3b st_bun.mod.ff.v1_0m.igs





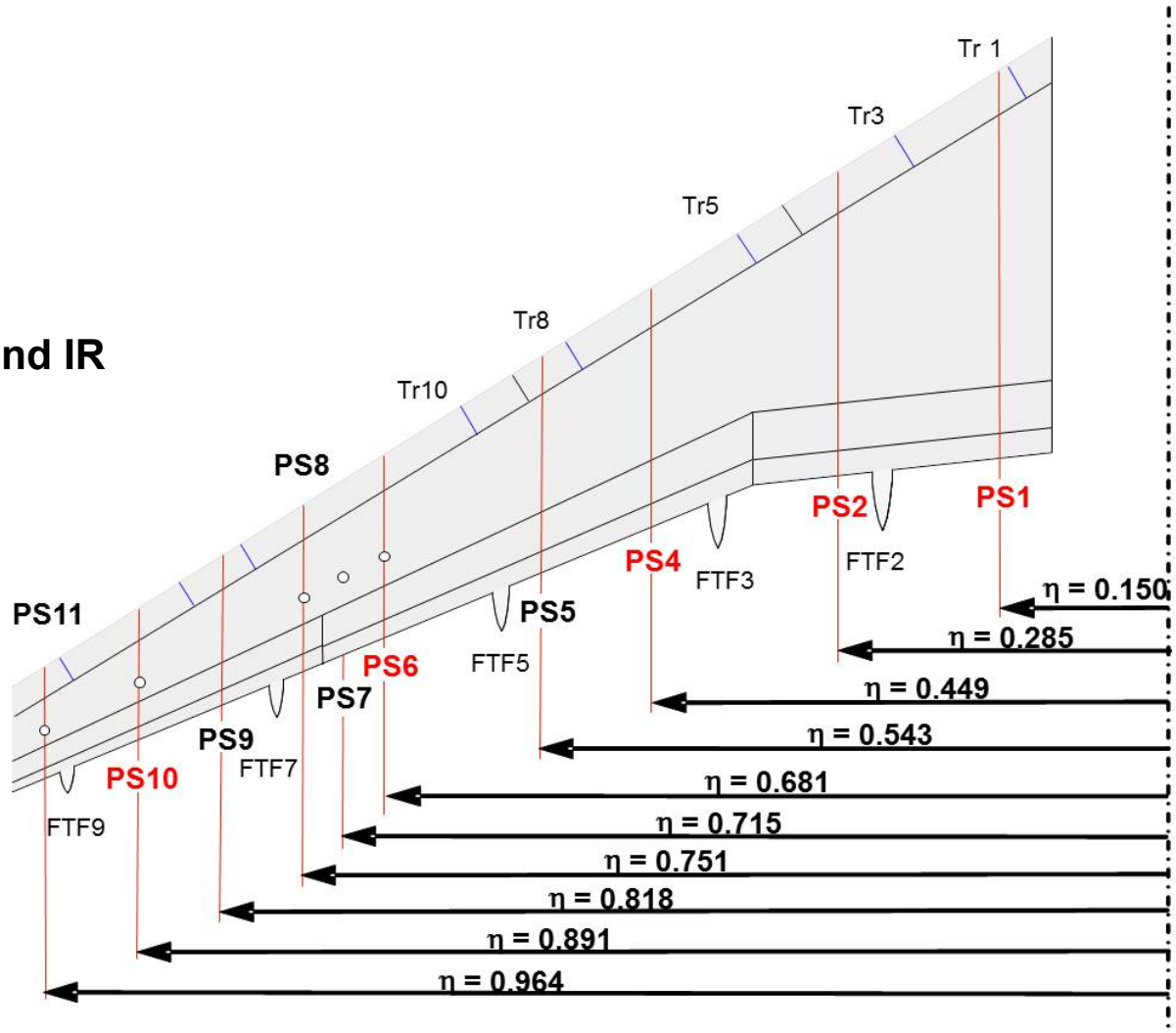
**Available experimental evidence:**

- Forces, Moments
- Pressure distributions, 10 PS
- Oil flow pictures
- PIV measurements
- Transition information by 4xHFA and IR
- Tuft videos

**Onflow conditions:**

- atmospheric
- M = 0.175
- Re = 1.35 x $10^6$
- $\alpha$ : 0.04° - 20.99°

**Test section dimension: 2.1 x 2.1 m**

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# EUROLIFT: Wind tunnel Test Campaign in B-LSWT



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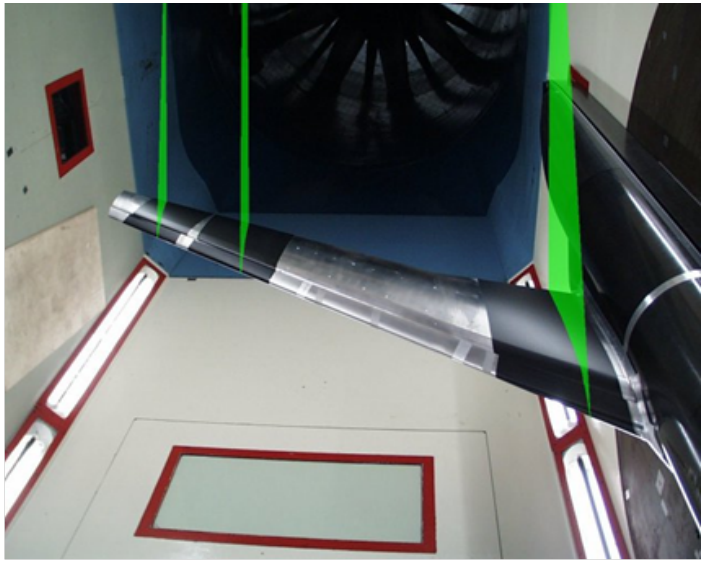
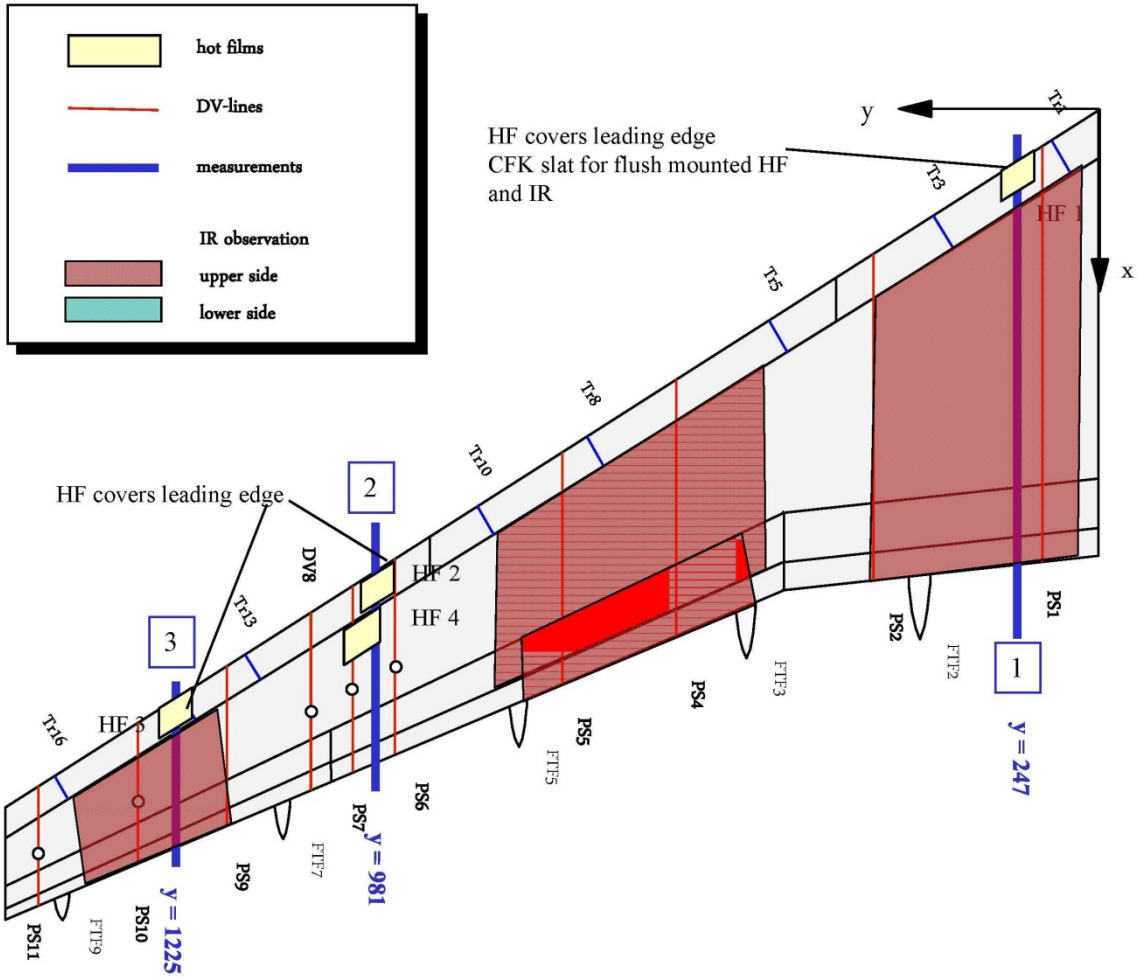




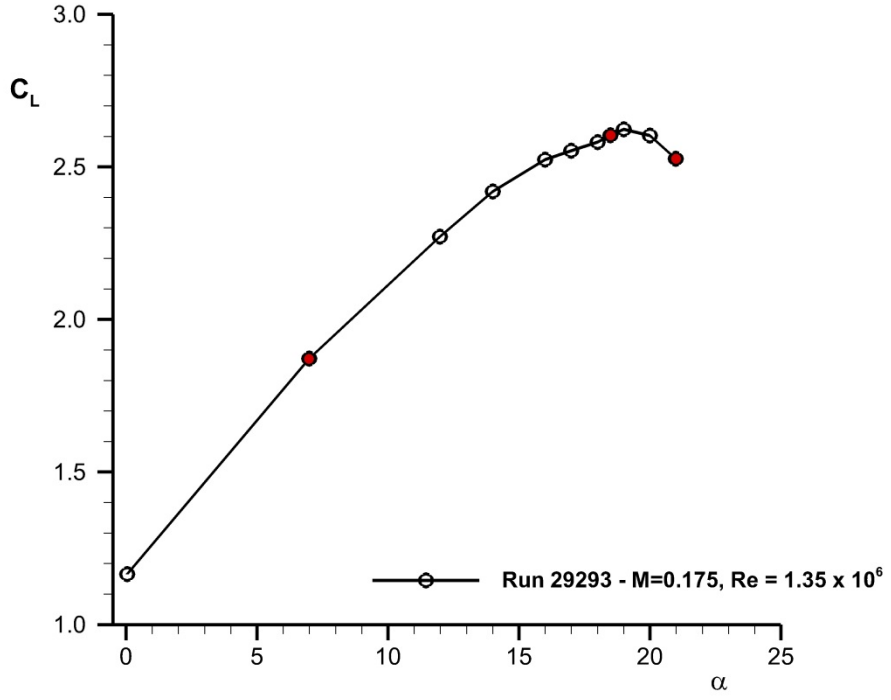
## Available experimental evidence vs angle of attack:

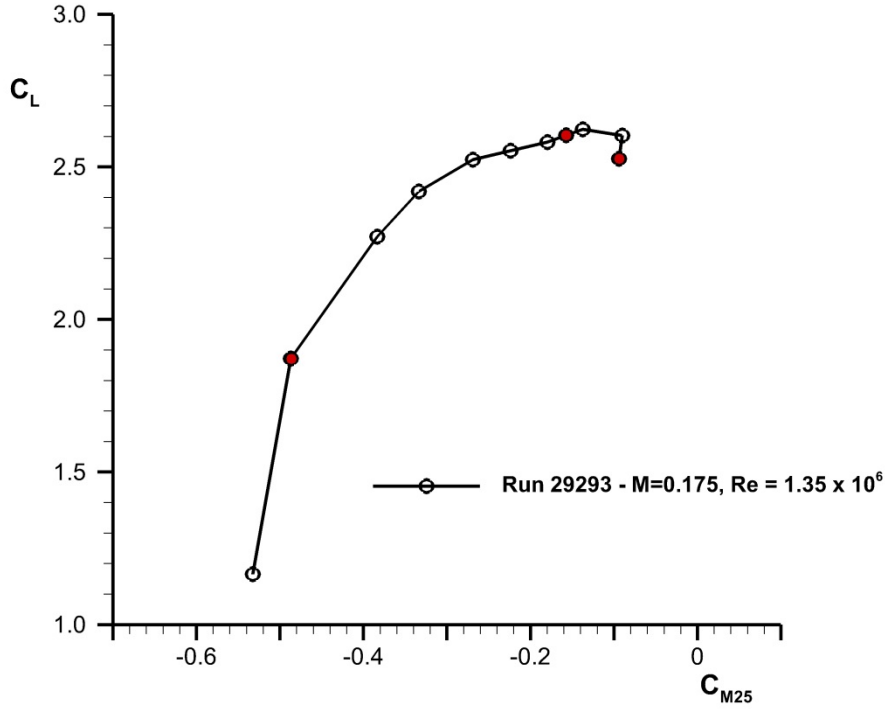
| $\alpha$ | F&M | $C_p$ | Oilflow | Hotfilm | IR | PIV | Tufts |
|---|---|---|---|---|---|---|---|
| 0.04° | x | x | | x | x | | Video Tape |
| 6.99° | x | x | x | x | x | x | |
| 11.98° | x | x | | x | x | x | |
| 14.00° | x | x | | x | x | | |
| 16.00° | x | x | | x | x | x | |
| 17.00° | x | x | | x | x | | |
| 18.00° | x | x | | x | x | | |
| 18.49° | x | x | x | x | x | x | |
| 19.00° | x | x | | x | x | | |
| 20.00° | x | x | | x | x | | |
| 20.99° | x | x | x | x | | x | |

**x: available** **x: provided** **x: to be provided**

## Lift and pitching moment curve:

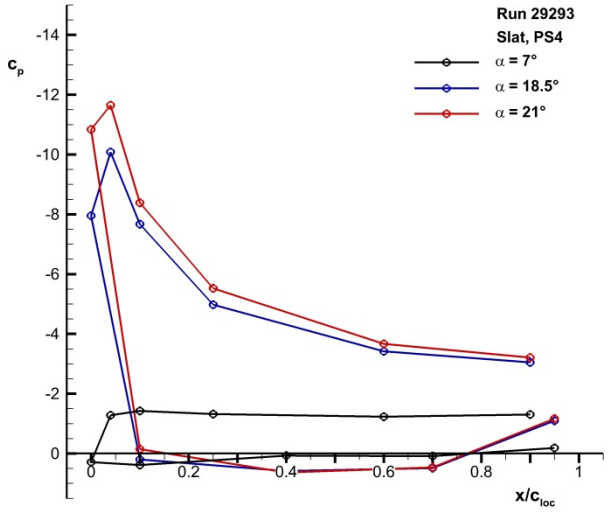
- **Reference angles of attack for lift breakdown analyis marked**

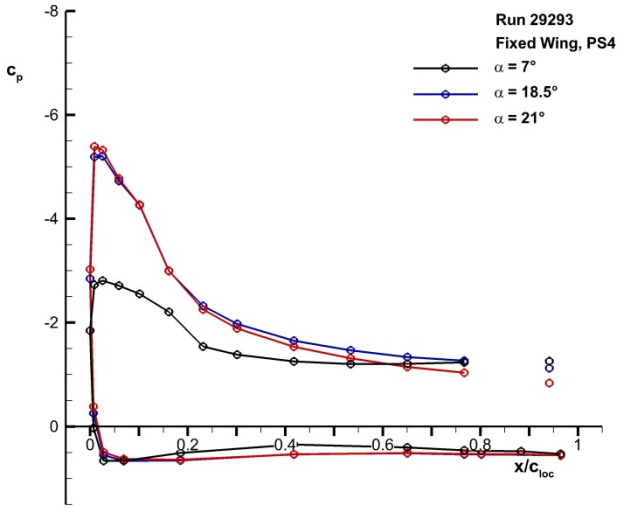


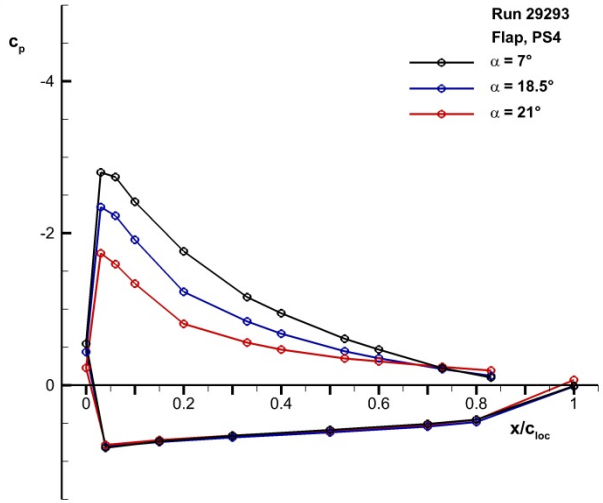



## Pressure distributions:

- **Reference angles of attack for lift breakdown**

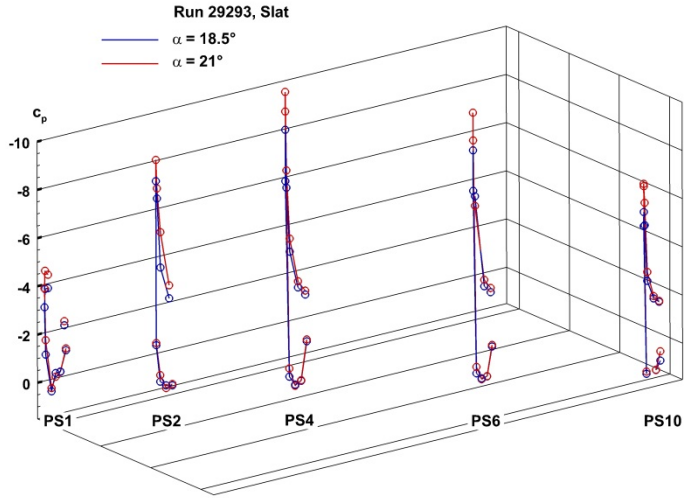


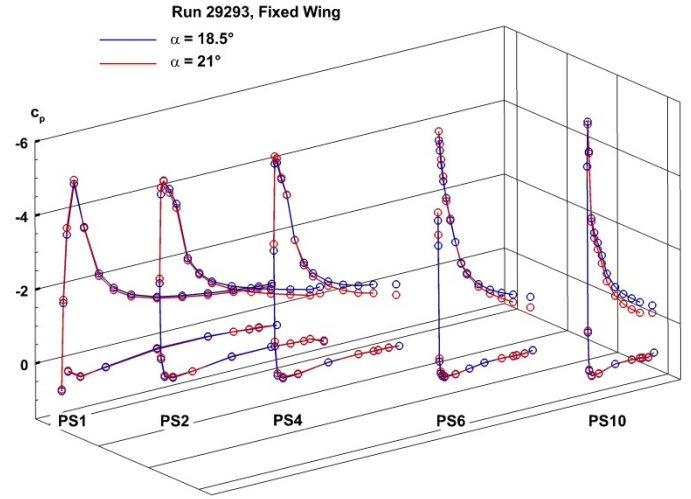



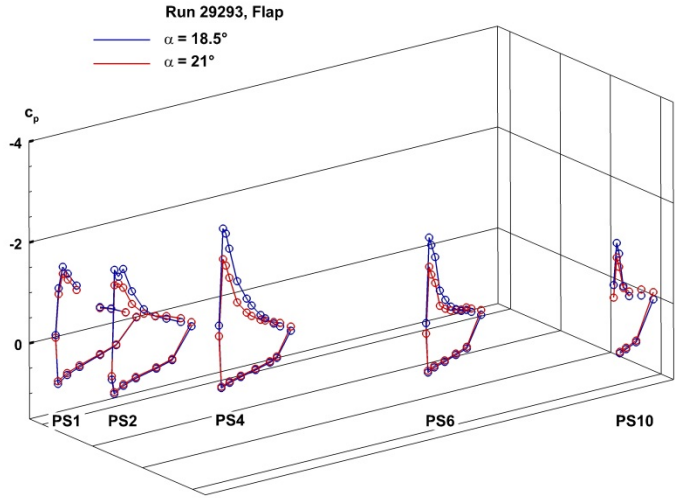



## Pressure distributions lined up along span:

- At $C_{Lmax}$ and beyond lift breakdown



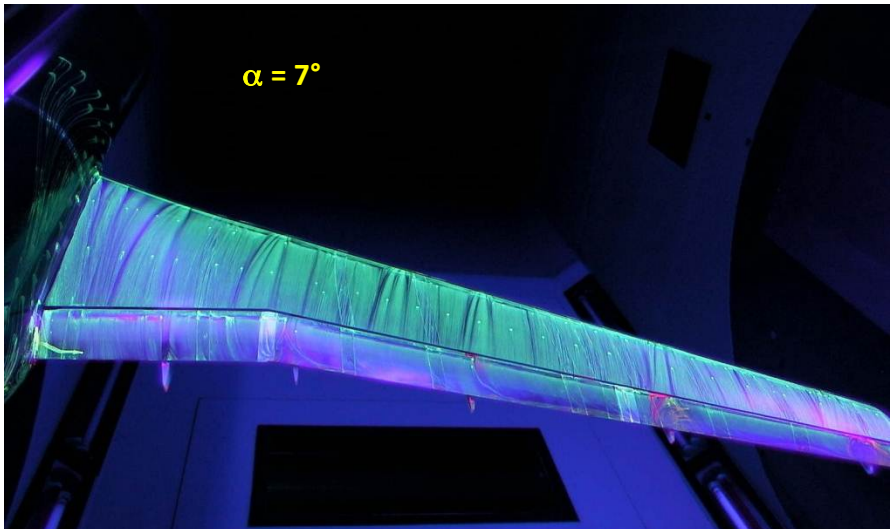
# EUROLIFT: Wind tunnel Test Campaign in B-LSWT

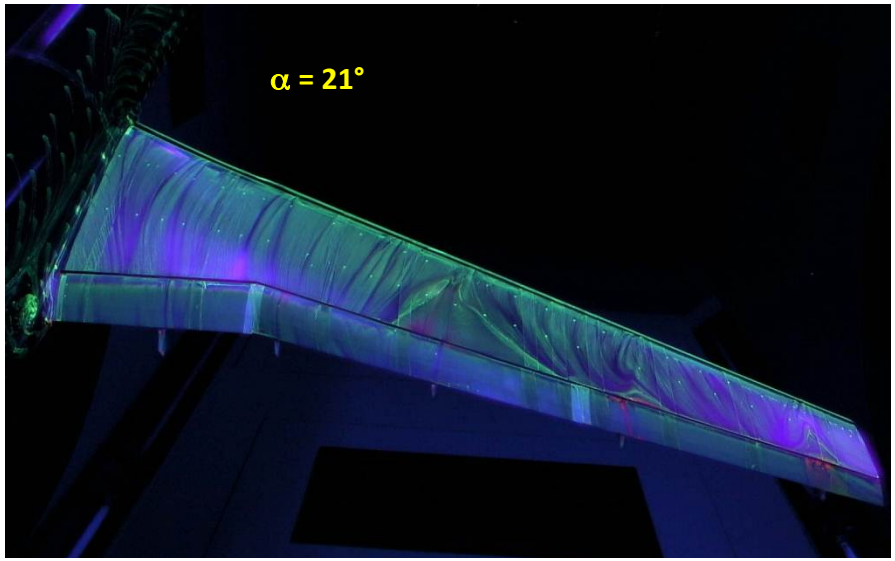


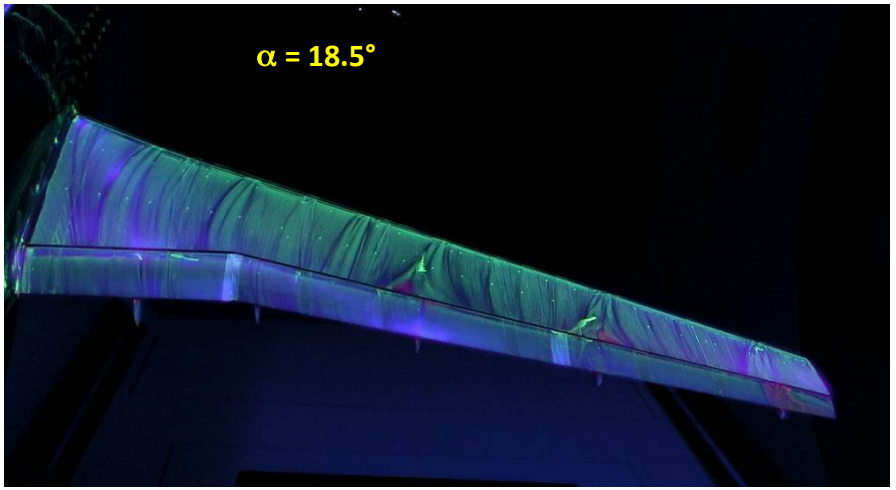
## Oil flow pictures:

- Reference angles of attack
- Separation starts midboard on aft part of wing

⇨ Influence of slat track wakes visible

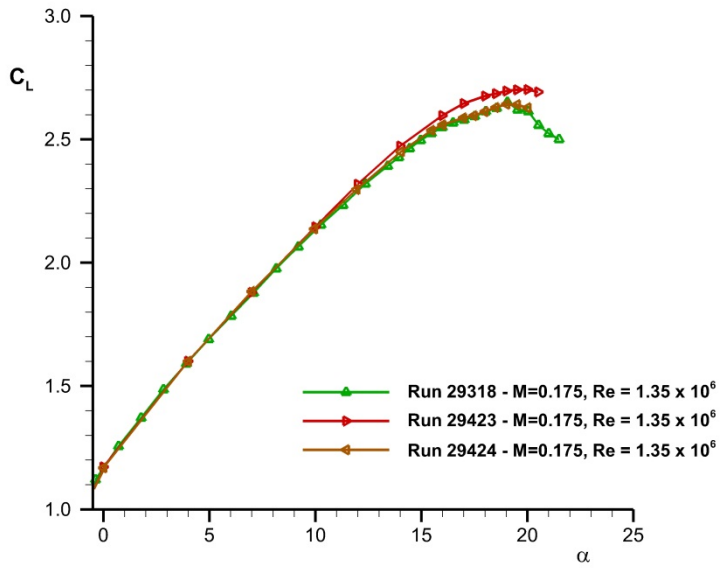


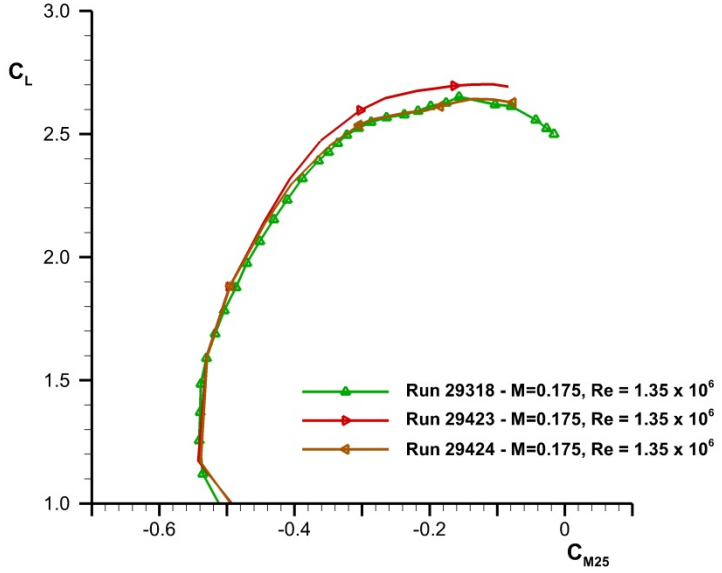



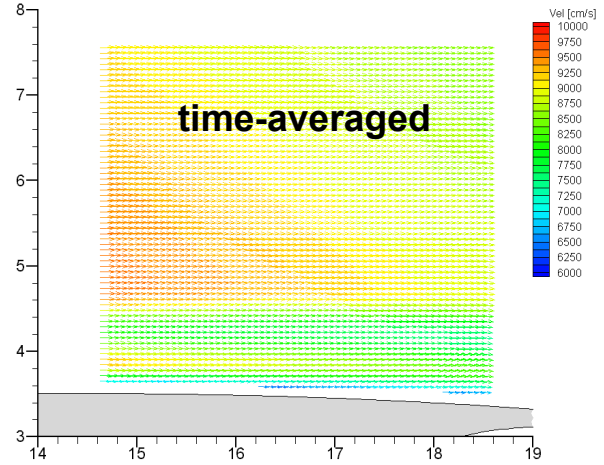
## Lift and pitching moment curve:

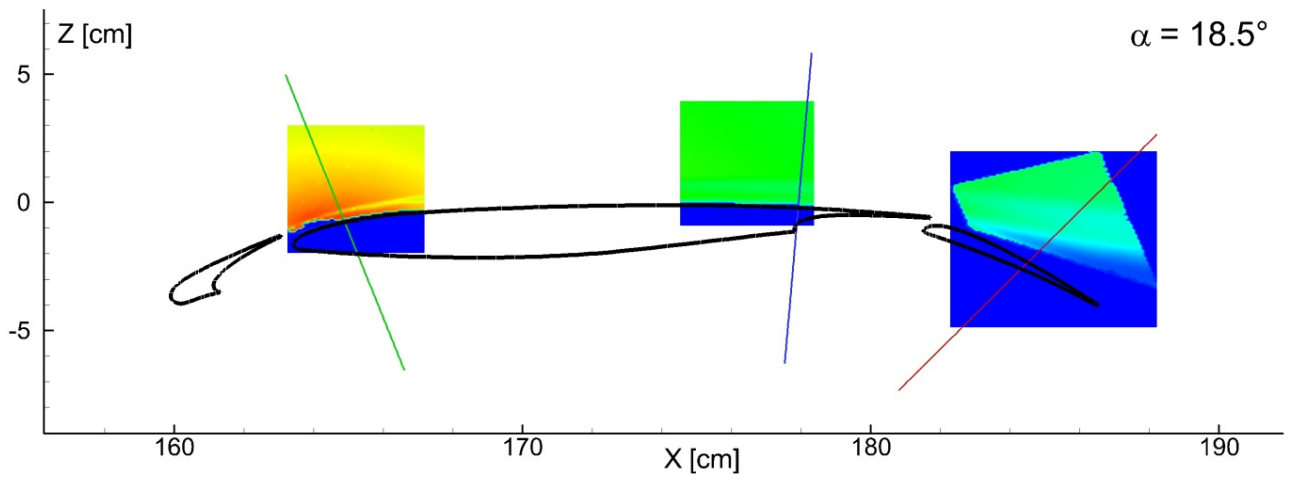
- **Pressure tube bundle influence**

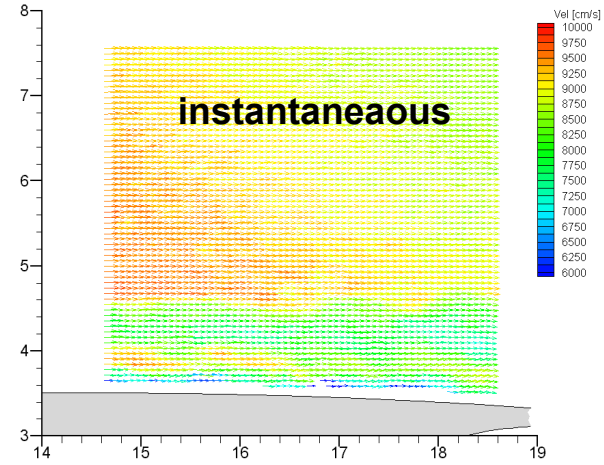


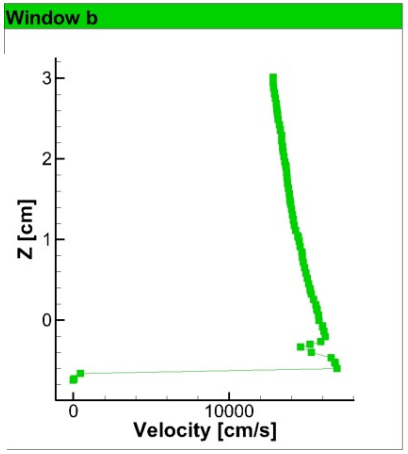



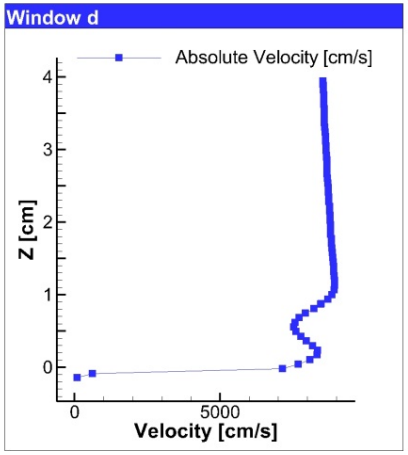
## PIV image refurbishment, plane 2:

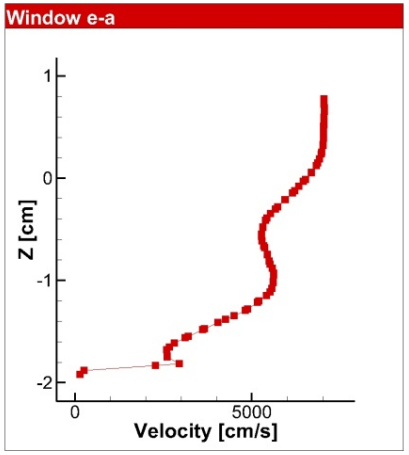
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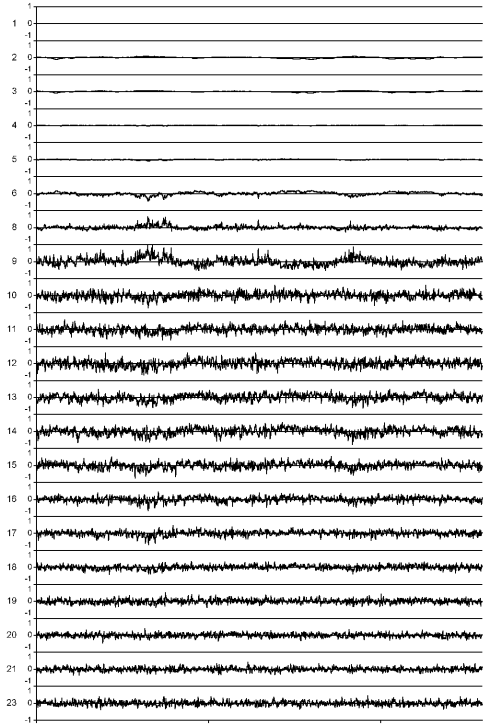
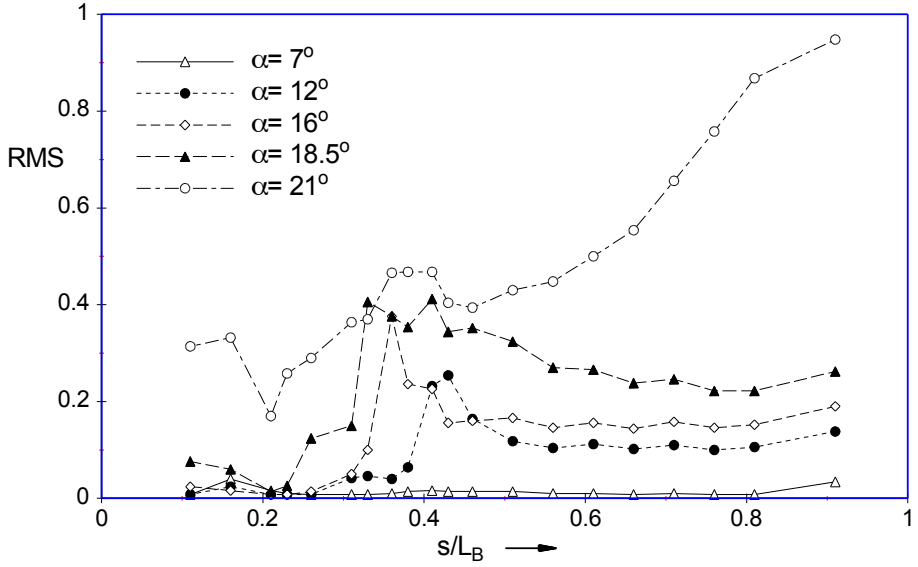
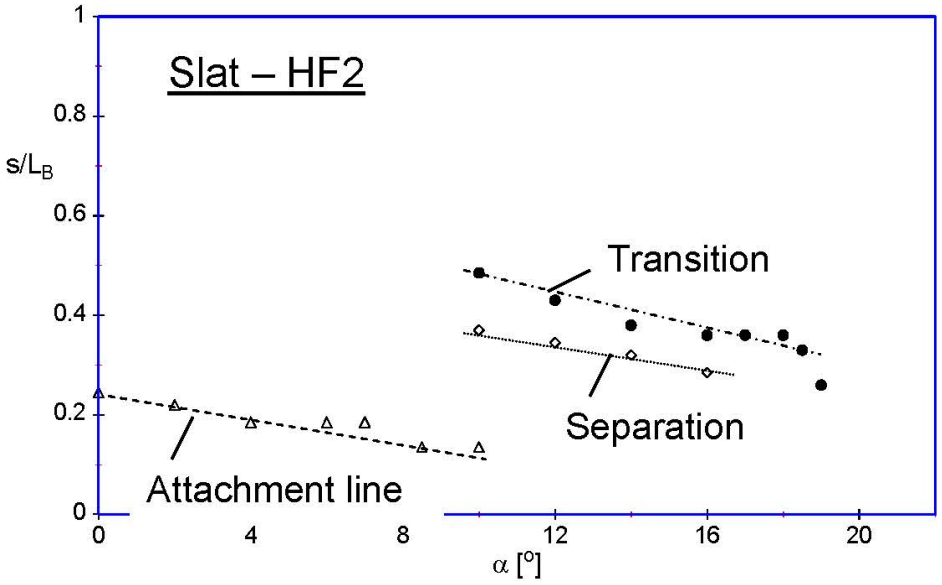
## HF data and analysis, section 2, slat:





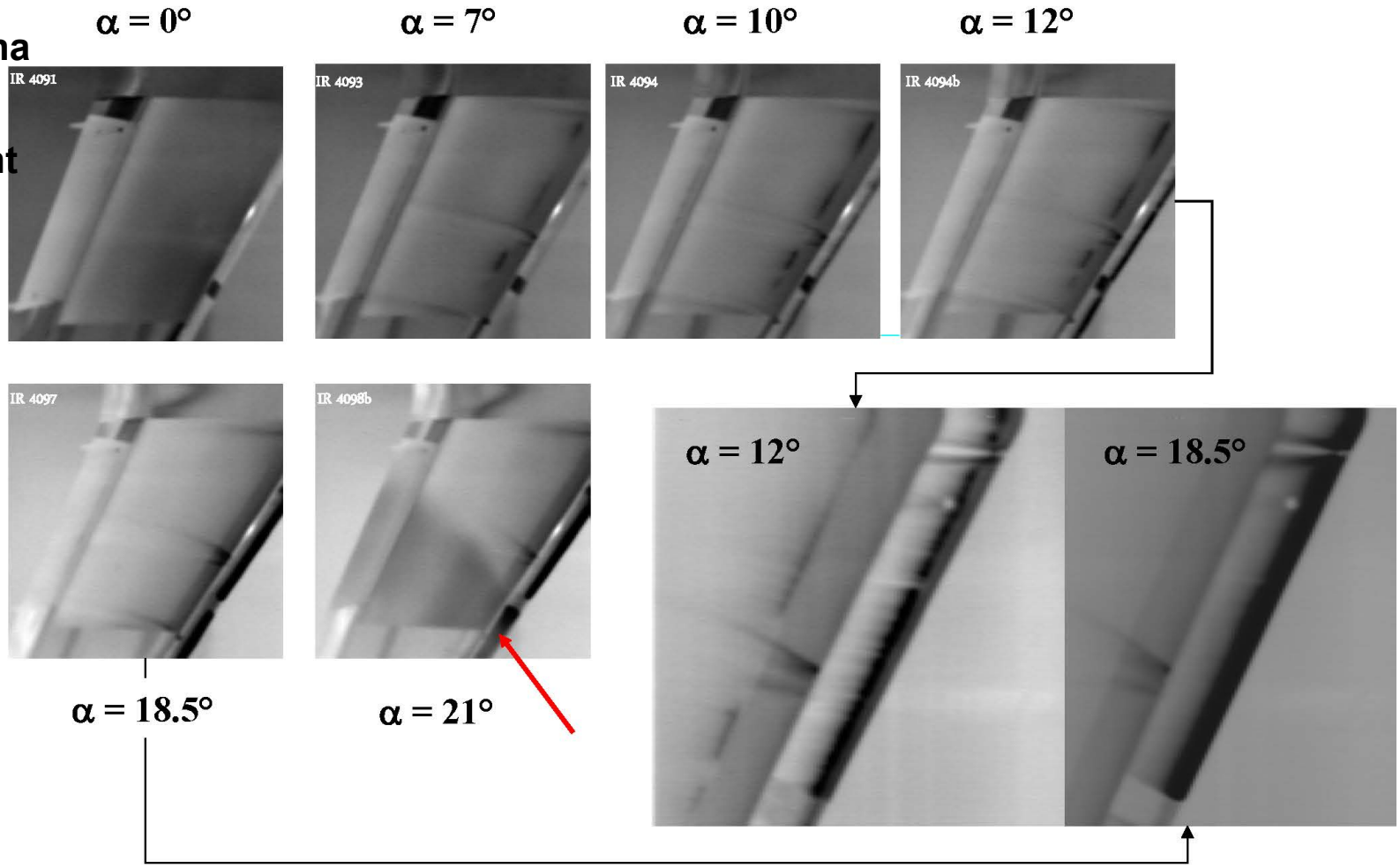



# EUROLIFT: Wind tunnel Test Campaign in B-LSWT

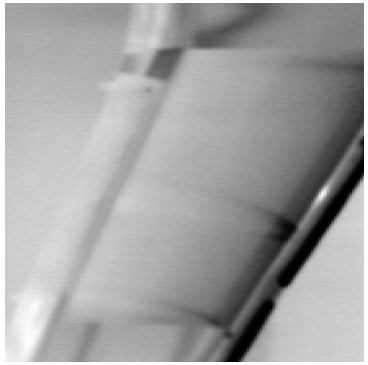


**IR images:**

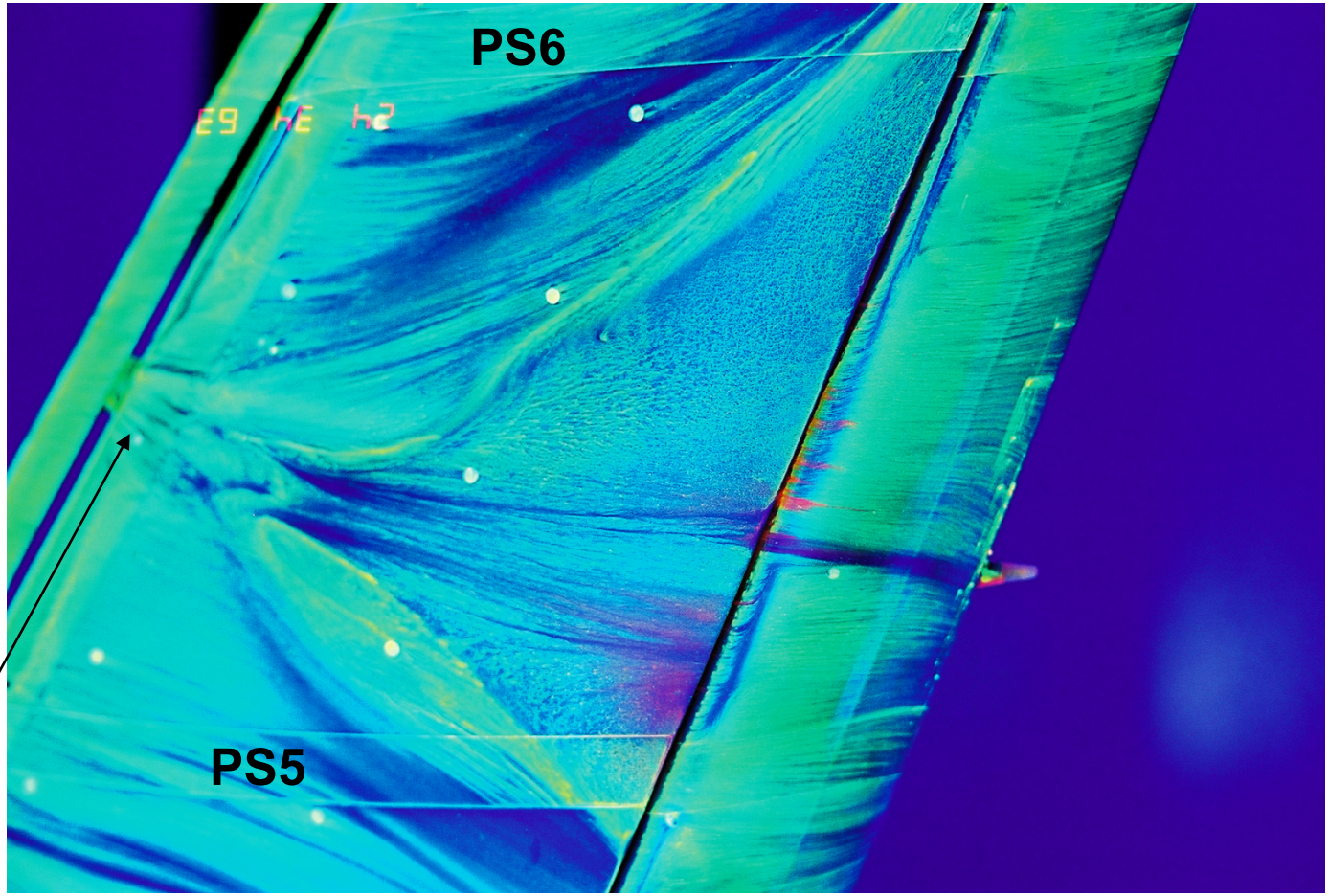
- different perspectives
- US and LS
- some phenomena identified
- needs consistent interpretation
- With HF, PIV



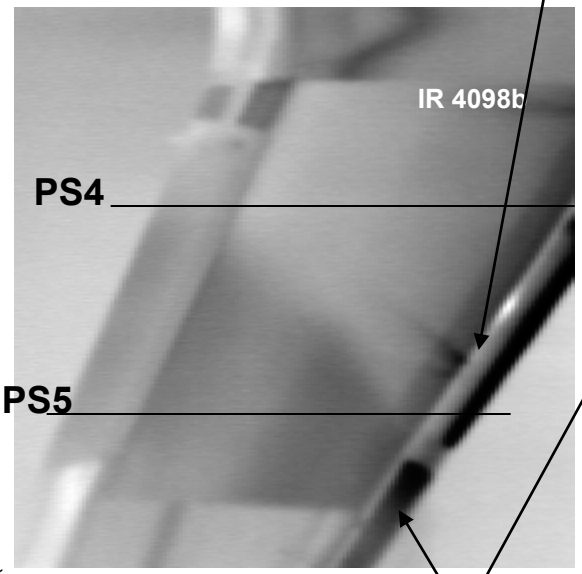
$\alpha = 18.5°$



Stall at $\alpha$ = 21° (post-stall) seen as IR and oil flow image




Track 8




$\alpha = 21°$

Track 10

# EUROLIFT: Wind tunnel Test Campaign in ETW



**Available experimental evidence:**

- **Forces, Moments**
- **Pressure distributions, 10 PS**

**Onflow conditions:**

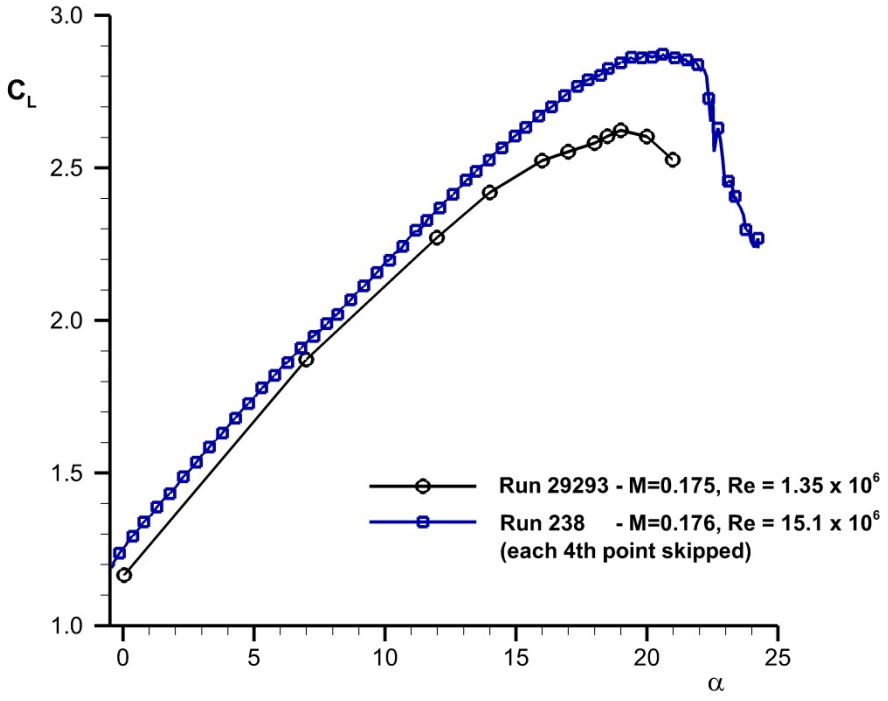
- **cryo and pressurized**
- **M = 0.176**
- **Re = 15.1 x $10^6$**
- **$\alpha$ : -3.2° - 24.24°**

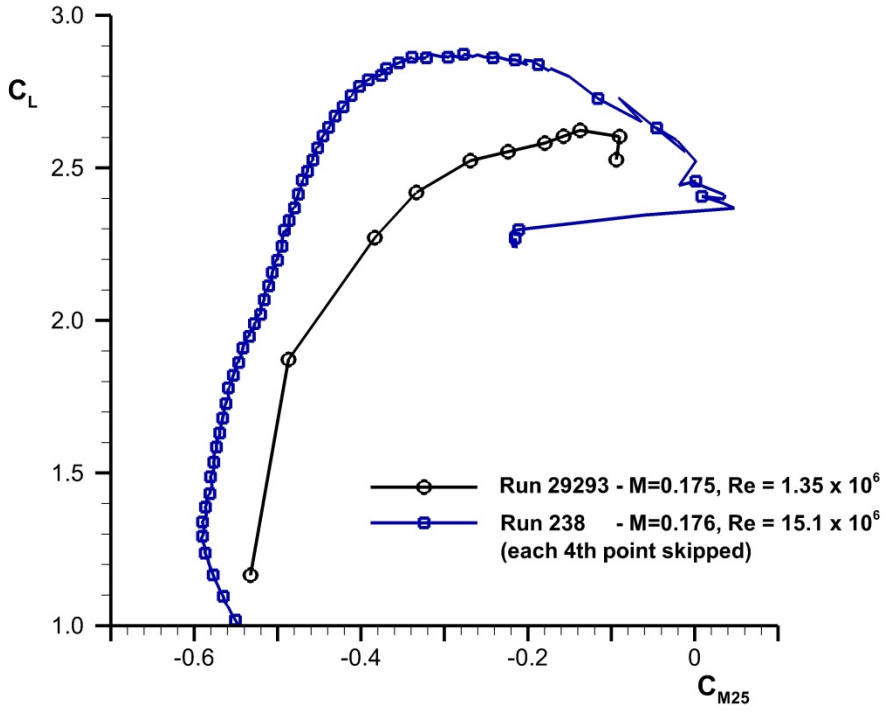
| $\alpha$ | F&M | $C_p$ |
|---|---|---|
| 0.01° | x | x |
| 7.04° | x | x |
| 11.97° | x | x |
| 13.98° | x | x |
| 15.99° | x | x |
| 16.98° | x | x |
| 18.00° | x | x |
| 18.49° | x | x |
| 19.00° | x | x |
| 20.02° | x | x |
| 20.95° | x | x |
| 22.40° | x | x |

**Test section dimension: 2.0 x 2.4 m**

## Lift and pitching moment curve:

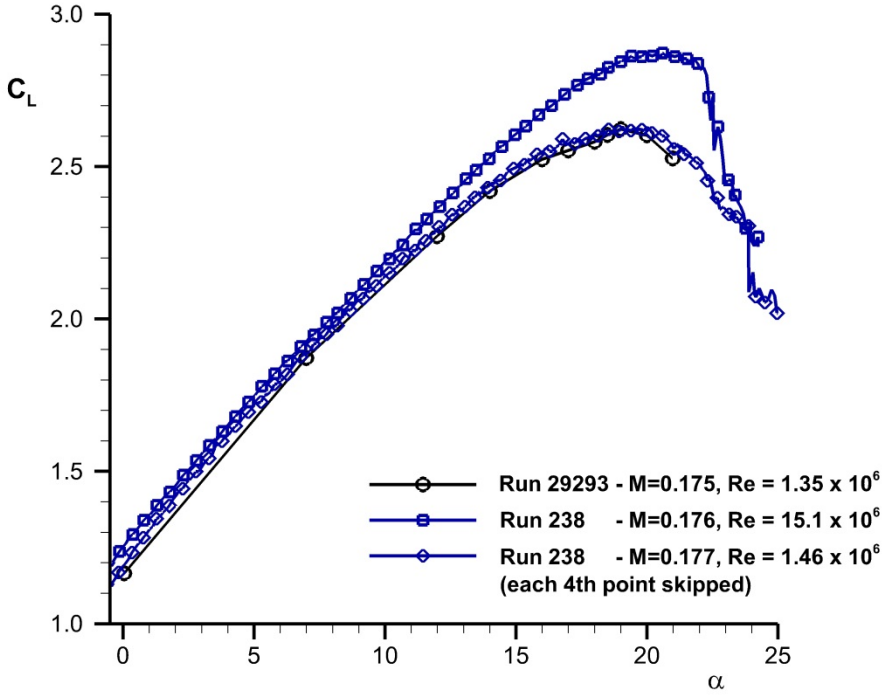
- **Comparison of low and high Re test data: B-LSWT - ETW**

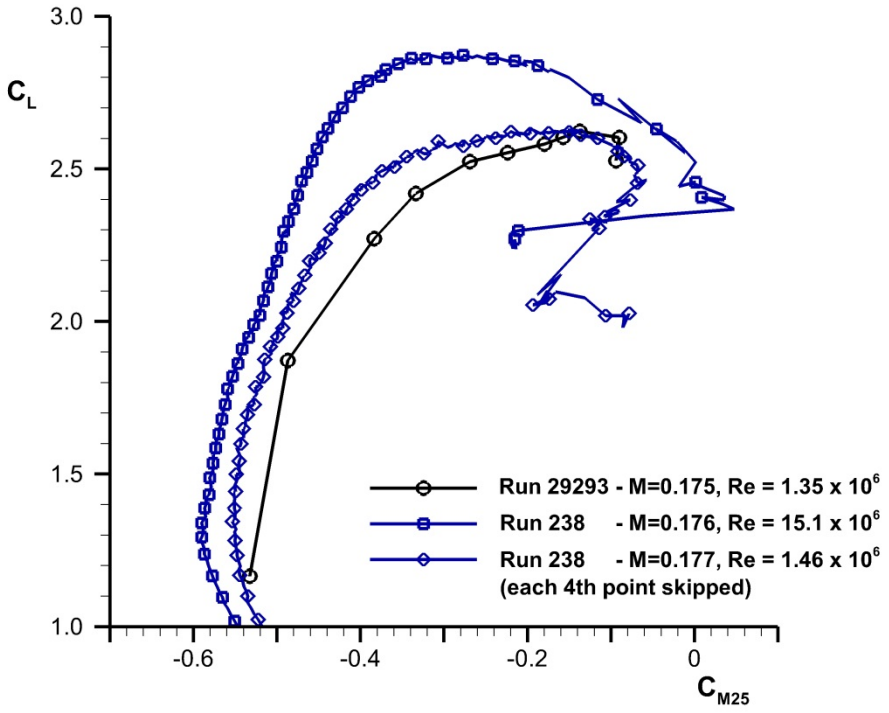


## Lift and pitching moment curve:

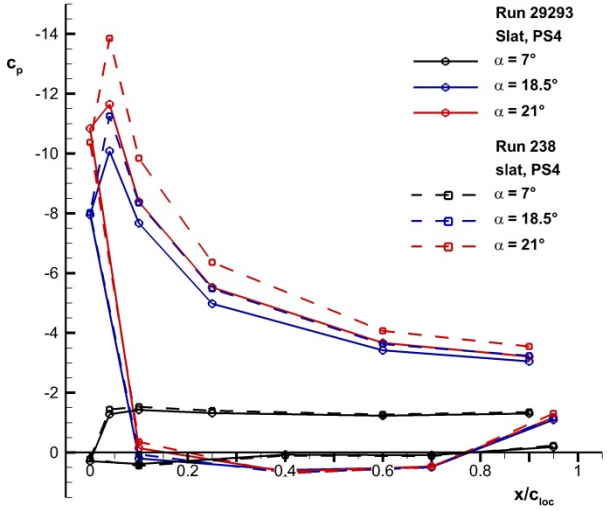
- **Comparison of low and high Re test data: B-LSWT - ETW - ETW**

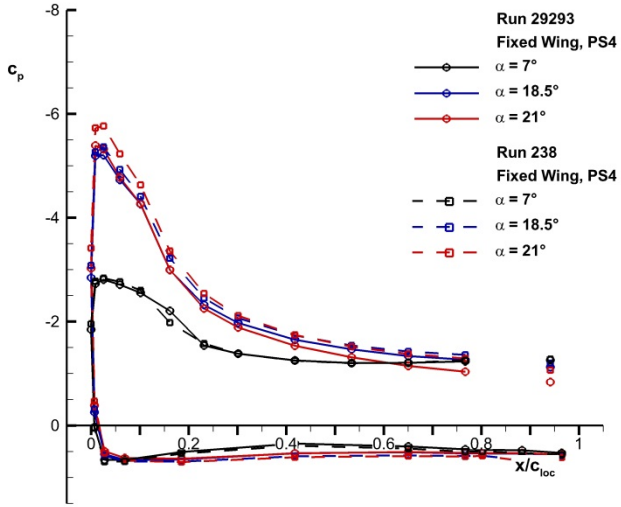


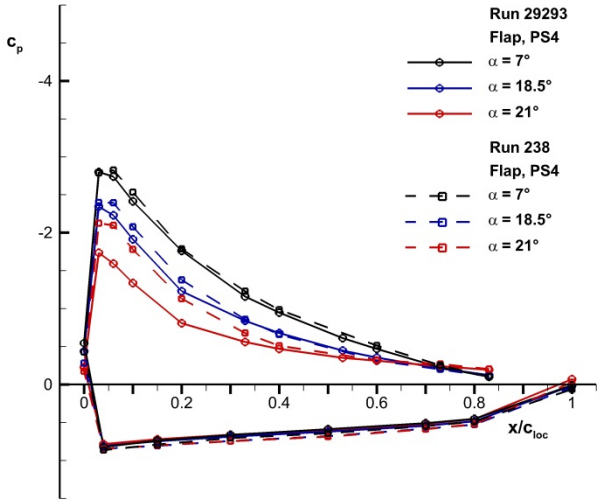



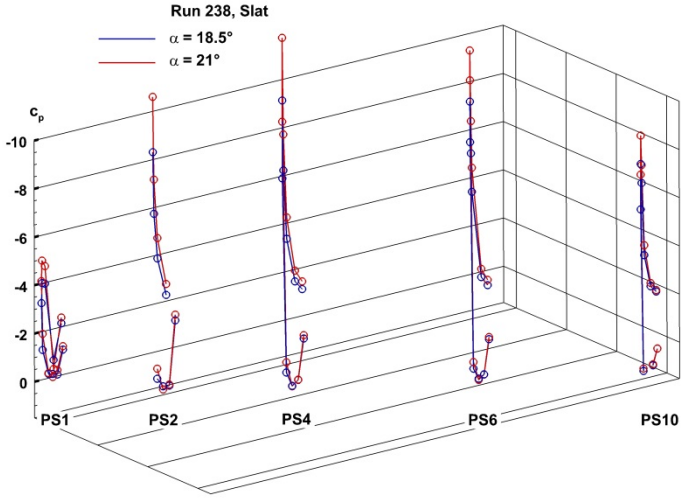
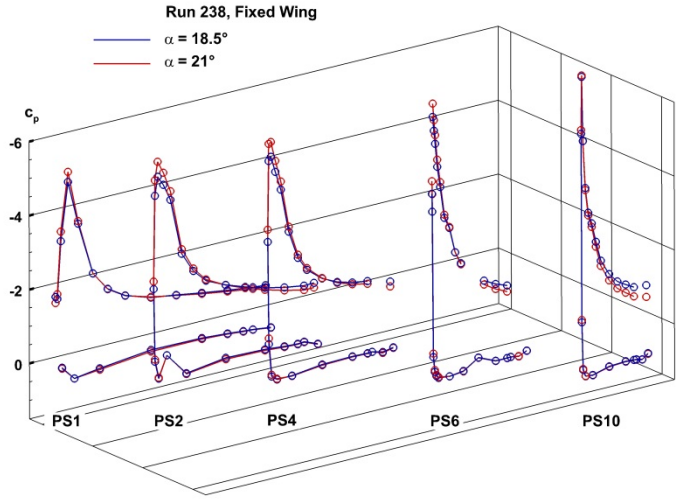
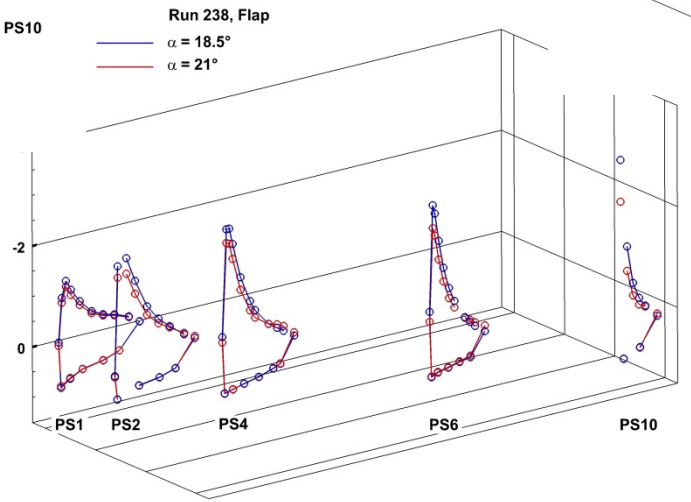
## Pressure distributions:

- Comparison of low and high Re test data, PS4



## Pressure distributions lined up along span:

- At $C_{Lmax}$ and beyond lift breakdown