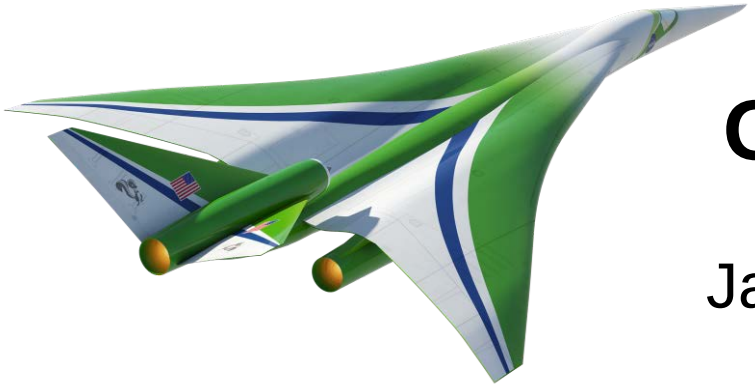
AIAA SCI-TECH 2014
1st Sonic Boom Prediction Workshop



OVERVIEW

January 11, 2014

John Morgenstern

Advanced Development Programs
LOCKHEED MARTIN

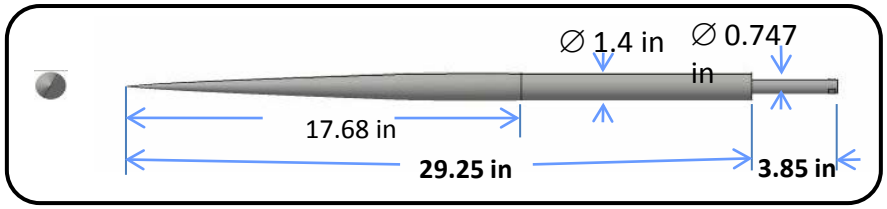
Objective

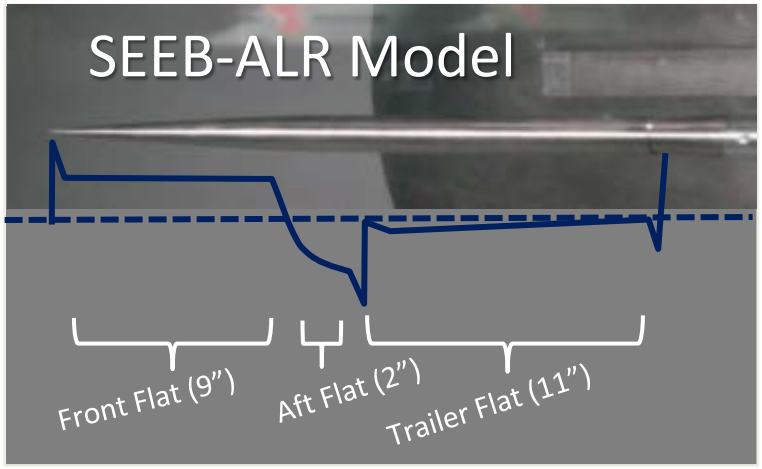
- **The objective of the First Sonic Boom Prediction Workshop is to assess the state of the art for predicting signatures suitable for sonic boom propagation.**
  - **Prediction resolution sufficiently far for propagation**
  - **Off track prediction resolution**
  - **Prediction resolution versus test data**

  Assessing the state of the art and identifying areas requiring additional research and further development.

Test Case 1

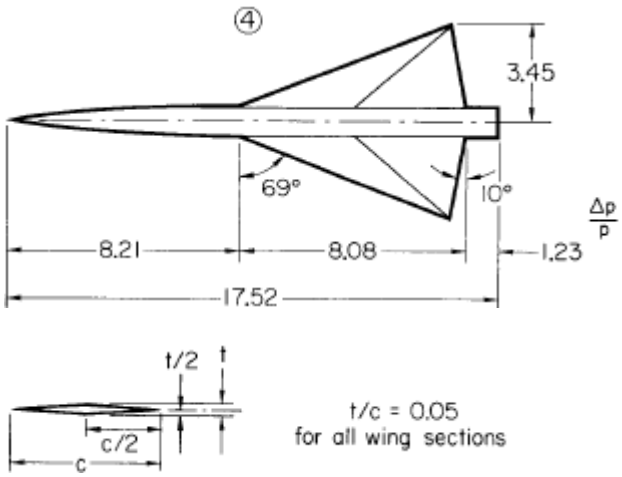
- **SEEB-ALR "Flat-Top" Signature (B)**
  - **Axi-symmetric geometry re-created "as-built" from average of inspection measurements around it**

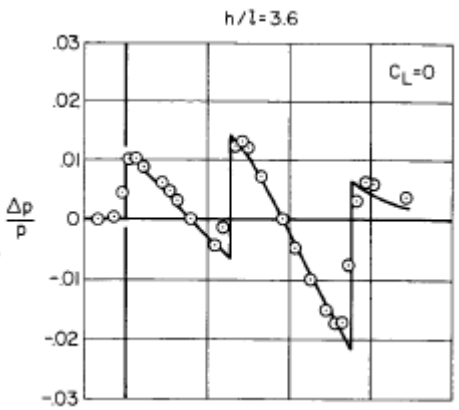


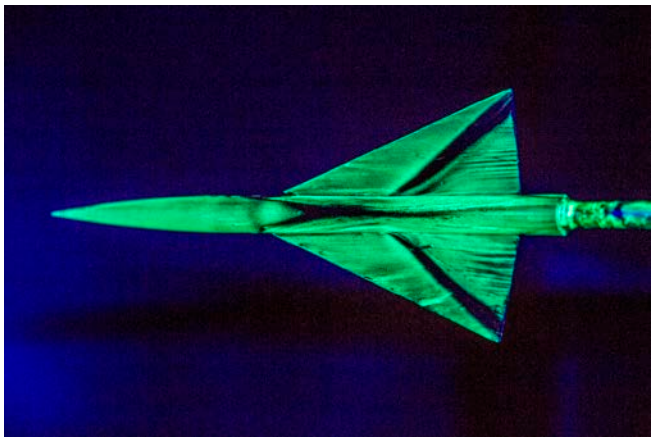


Test Case 2

- **NASA 69deg Delta Wing (WB)**
  - **CAD geometry based on limited definition in report**
  - **Un-cambered x-y plane symmetry, 5% thick diamond airfoil**
  - **Parabolic nose definition $r = 0.540 - 0.011 (x - 7.01)^2$ ($r = 0$ @ $x = 0.0035$)**

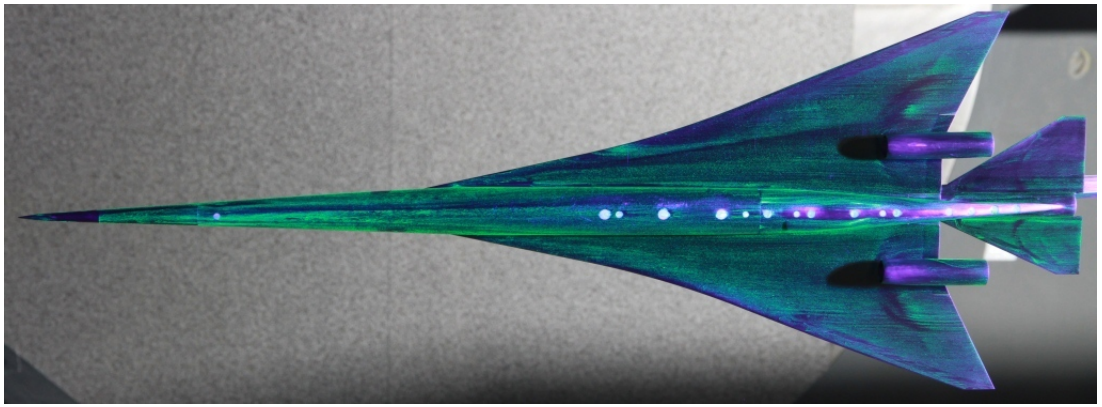




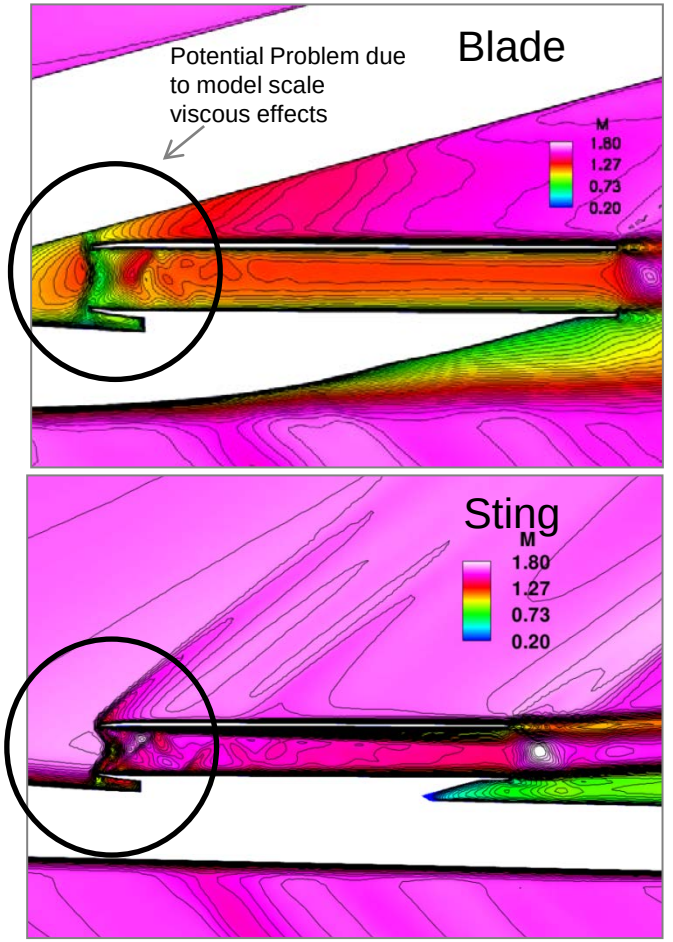


Test Case 3

- **NASA N+2 LM 1021-01 Configuration (WBNV)**
  - **Propagation Refinement**
  - **Off Track Refinement**
  - **Aeq/Lift Signature Level Matching**
  - **Viscosity effect on Nacelles Internal Flow, External Flow and Vehicle Lift**



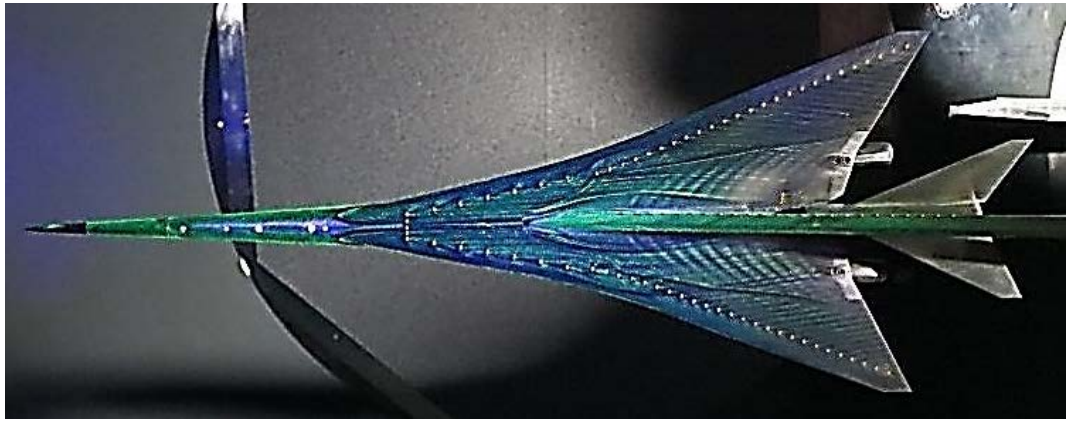
Attached lower surface flow with shock wave interactions on wing and tail from nacelles



Viscous CFD Predictions Indicate the Potential for an Interaction Between the Blade Mount and the Centerline Nacelle.

REFS: AIAA2012-3215 (Measurement Procedure) -3216 (Measurement Challenges) -3217 (Model Design)

Prediction Comparisons

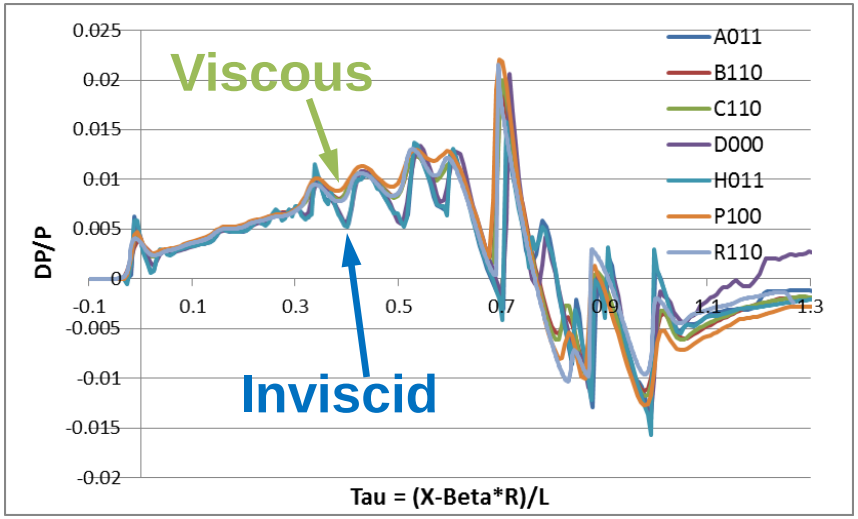


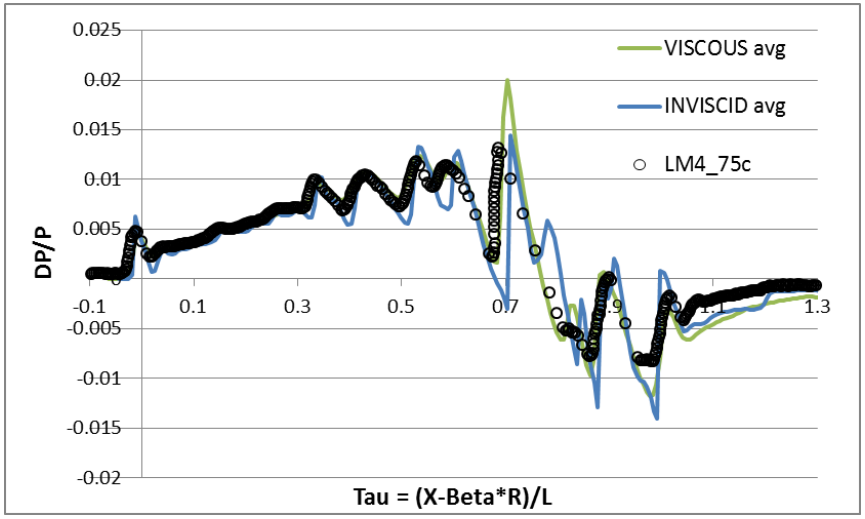
Prediction Methodologies

- **Key to Prediction Methodology, A # # #**
  - **Designation – solver, grid:**
    - **A011 – Cart3D, Cartesian grid 57M**
    - **B110 – CFD++, hybrid 24M**
    - **C100 – USM3D(sst, laminar), provided (hybrid) 14M**
    - **C110 – USM3D(SArn375), Pointwise/MCAP (hybrid)**
    - **D000 – Eugenie, provided (hybrid) 14M**
    - **H011 – Cart3D/Ovrflow, Cartesian/structured hybrid 39M+35M**
    - **P100 – FUN3D/CFL3D, provided (hybrid) 2M(nodes)+3M(cells)**
    - **R110 – FUN3D, VGRID unstructured 164M**
  - **1st #: 1 – Viscous BL, 0 – Inviscid**
  - **2nd #: 1 – New grid, 0 – Provided grid**
  - **3rd #: 1 – Solution adapted grid, 0 – Fixed grid (swept)**

Boundary Layer Induced Sonic Boom Level Variation

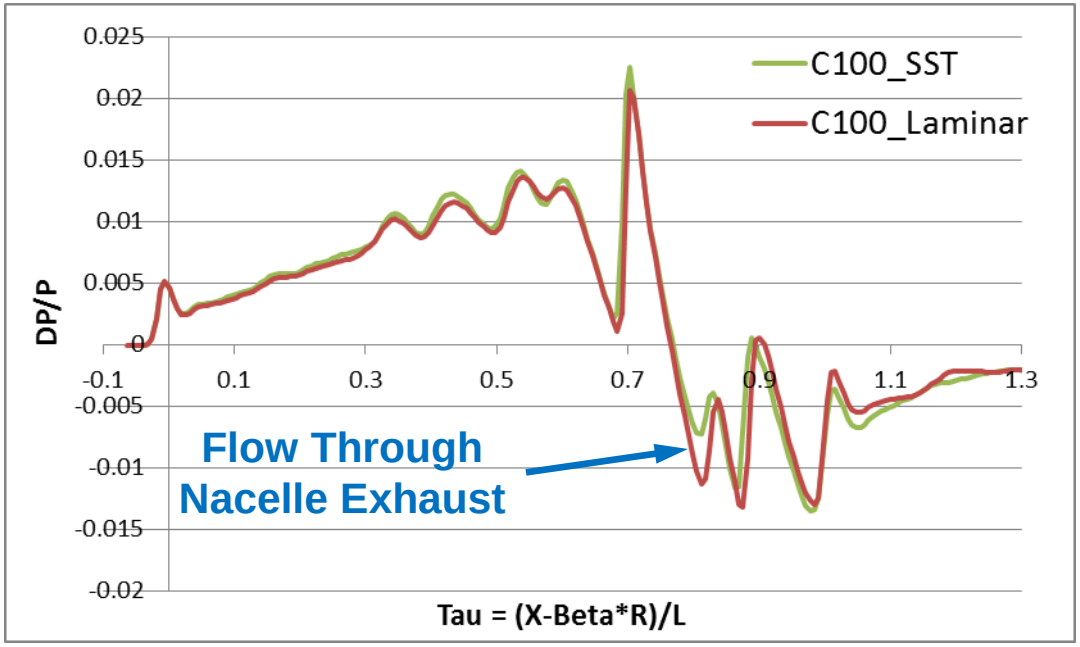
- **Two Solution Groupings: BL and No BL (Boundary Layer)**





Boundary Layer Required to Match Measurements
(at Wind Tunnel Reynolds Number)

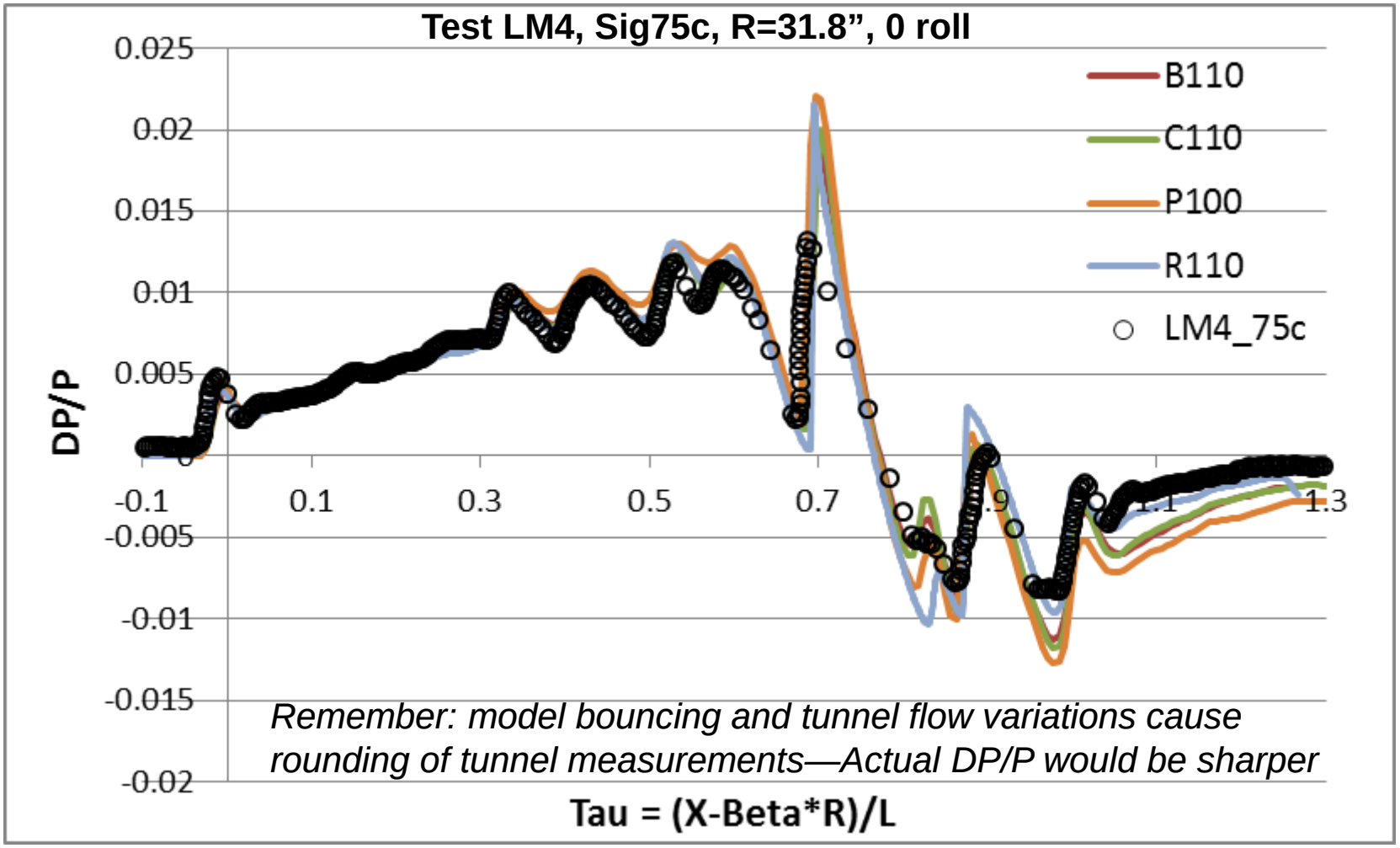
Turbulent vs. Laminar Sonic Boom Level Variation (Tunnel Re#)



Wind Tunnel Model Boundary Layer has a Mix of Laminar and Turbulent Flow *(not Significant at Full Scale)*

Matching Test Under Track

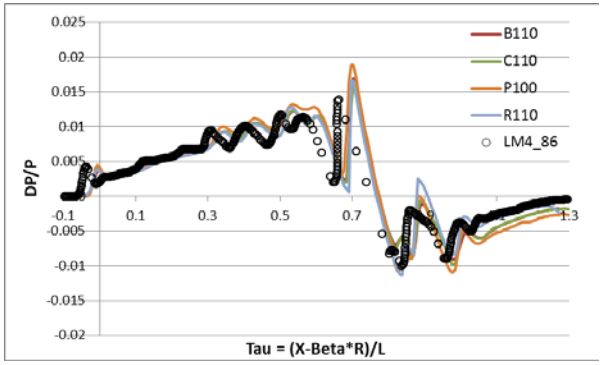
(Data has not been interpolated to match CL of CFD yet)



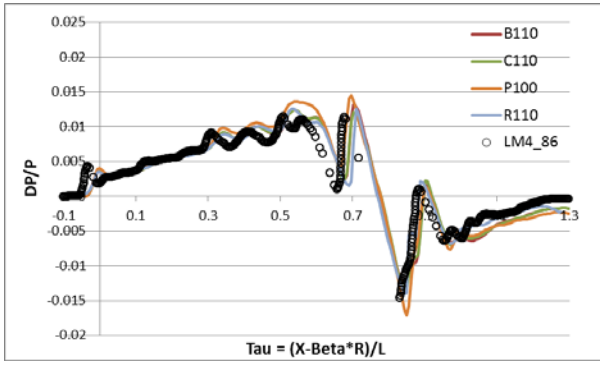
Matching Test Off Track

Test LM4, R=31.8”

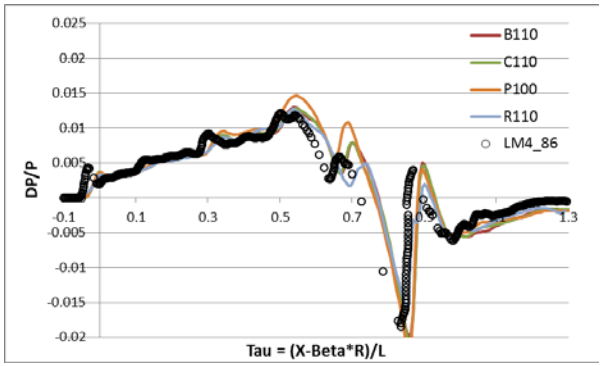
10 roll (Sig86)



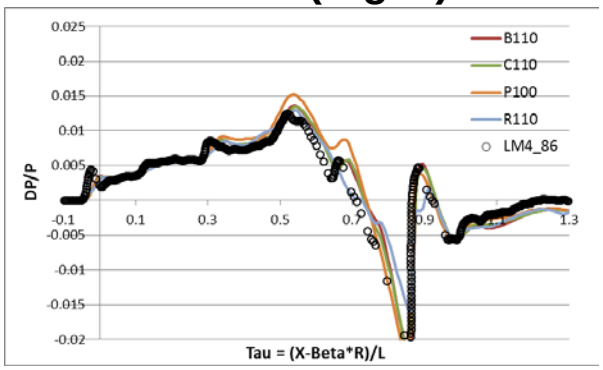
20 roll (Sig85)



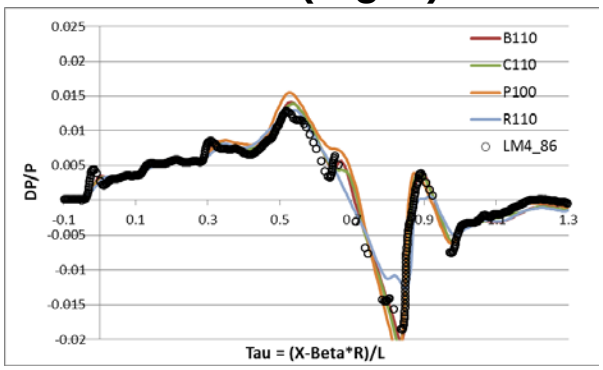
30 roll (Sig84)



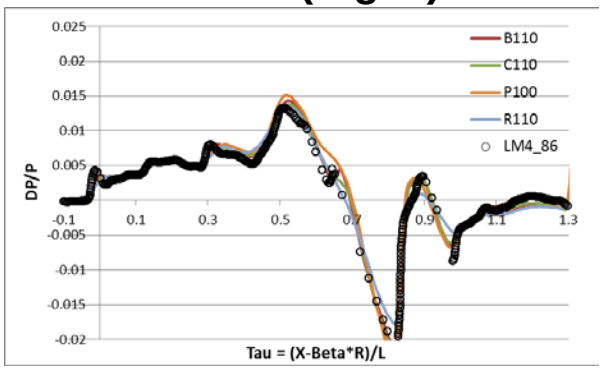
40 roll (Sig80)



50 roll (Sig82)

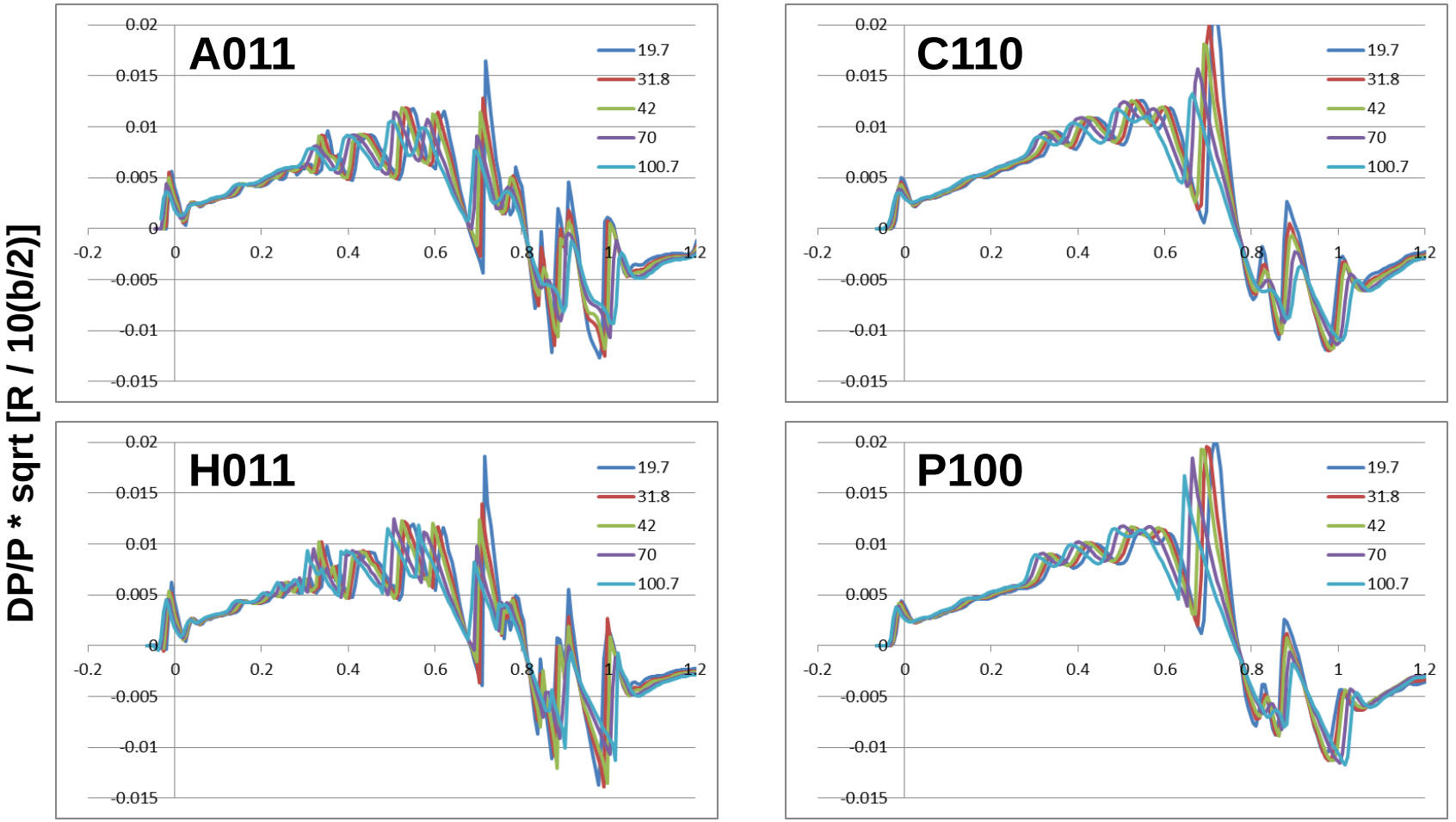


60 roll (Sig83)



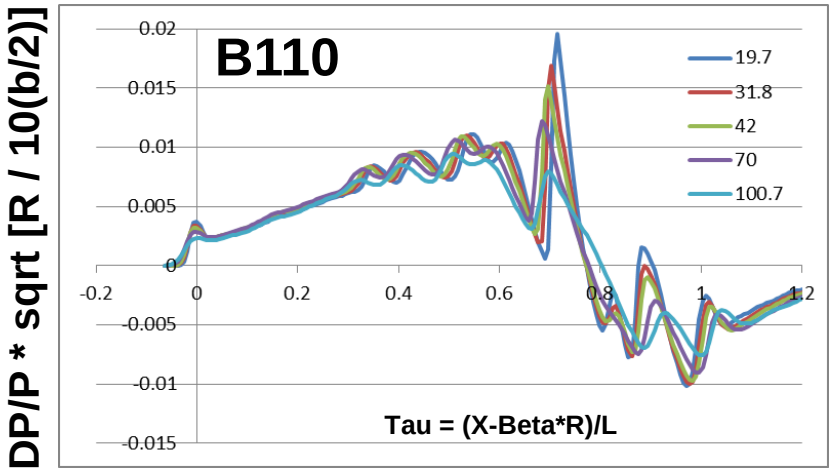
Propagation Resolution

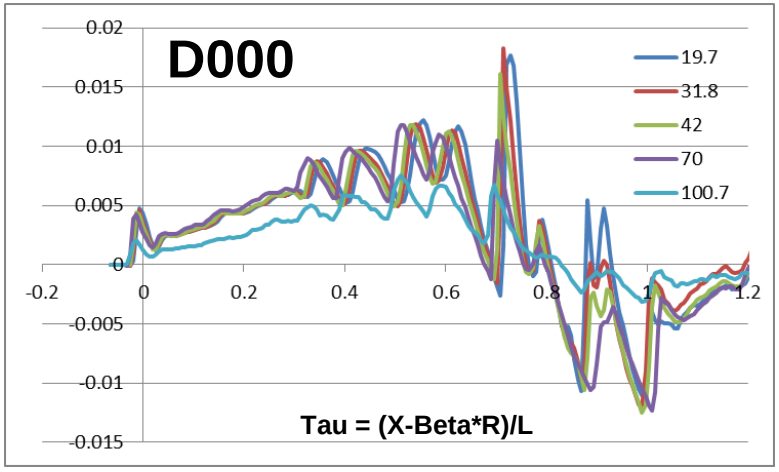
- **To 100.7 inches: A011, C110, H011, P100**



Propagation Resolution

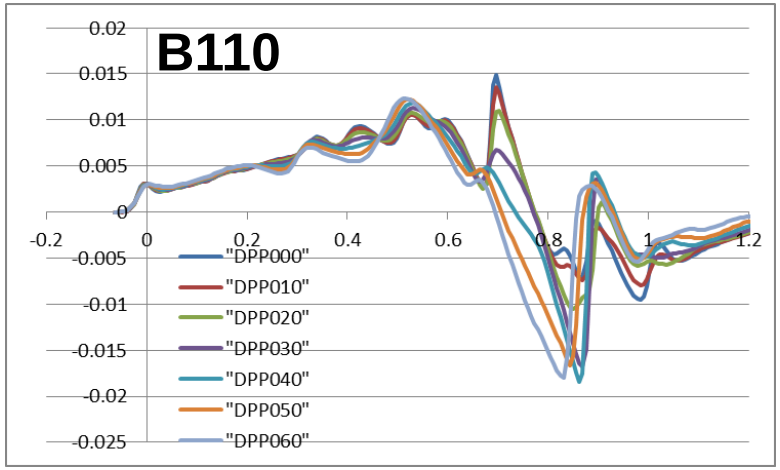
- **Less than 100.7 inches: B110, D000**

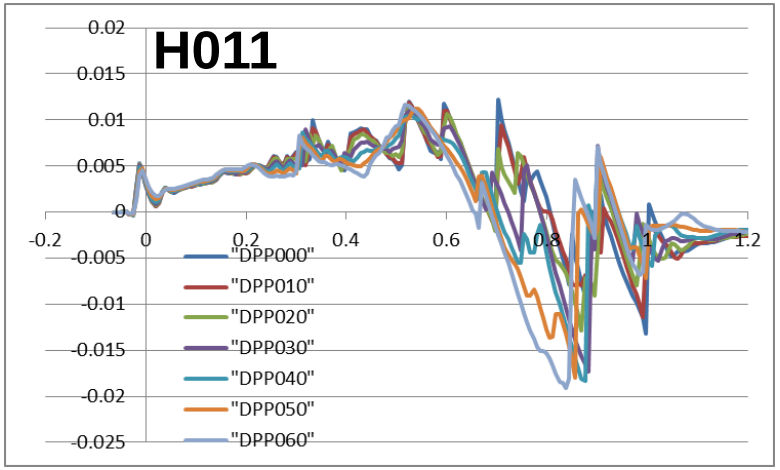




Off Track Resolution

- **To 60 degrees Roll Angle: B110 and H011**





Off Track Resolution

- **Less Sharp Off Track than Under Track: A011, C110, D000, P100** (though may still be sharper than B110)