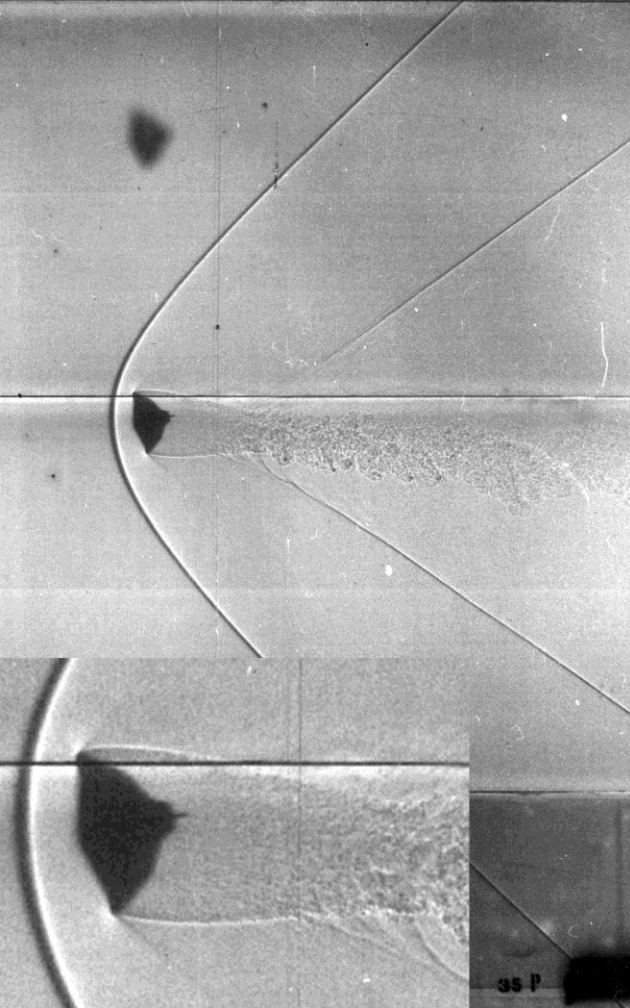




PRELIMINARY Results of a Ballistic Range Test of a 2% Scale Mars 2020 Entry Capsule with Onboard Pressure Measurement

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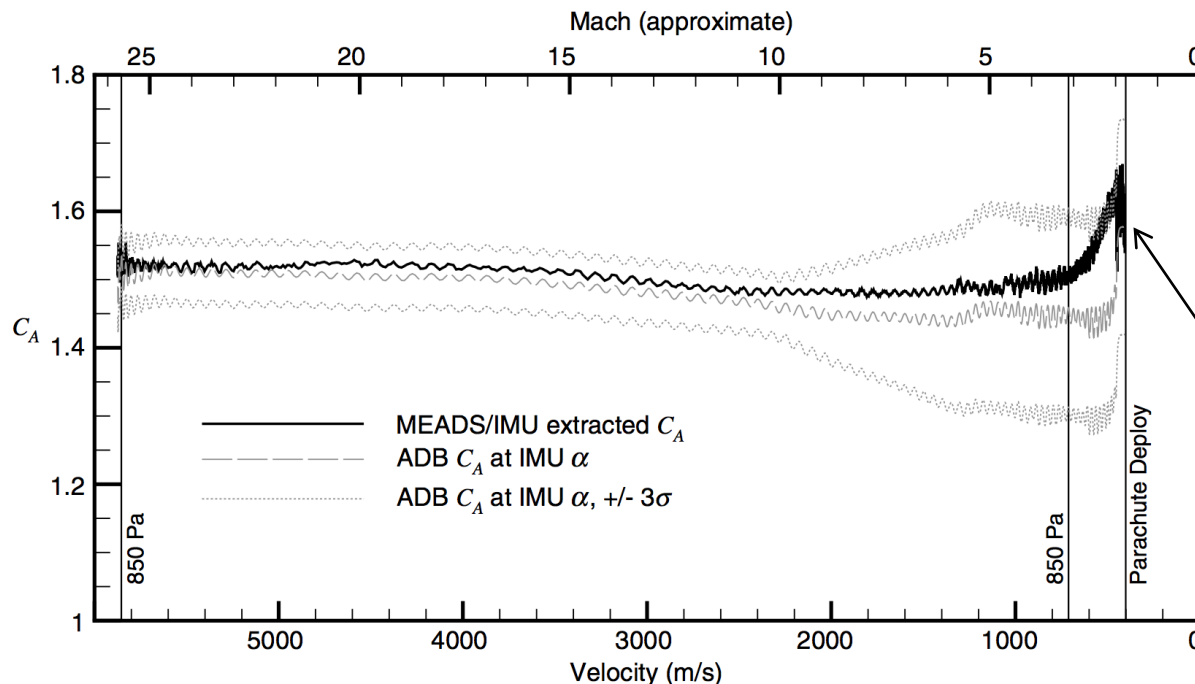




Introduction



- MEDLI2 will be flying 1-2 backshell pressure transducers on Mars 2020 entry capsule
 - Base pressure will validate reconstructed supersonic drag coefficient
- NESC/MEDLI2 funded a ballistic range test to verify that a single transducer is sufficient to resolve backshell drag contribution (is pressure ~constant over backshell?)
- Tests designed in partnership with and conducted at United States Army Research Laboratory, Aberdeen MD
 - Tests completed in March/April 2016

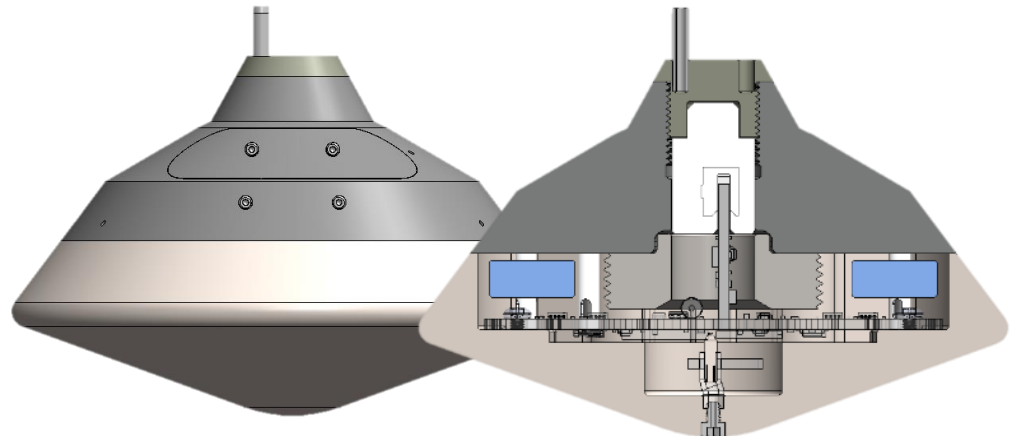
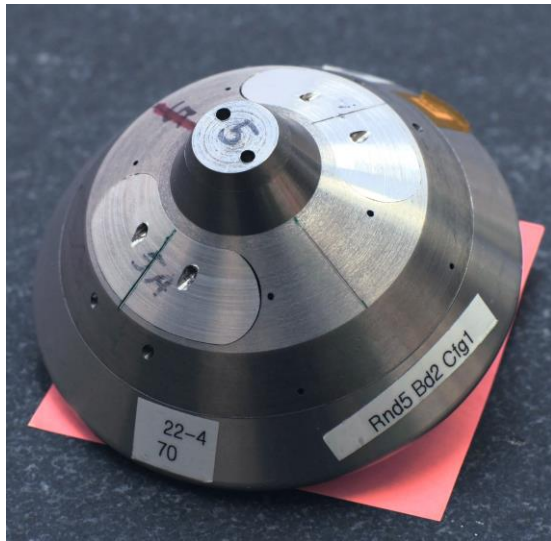


Mars Science Laboratory
MEDLI-1 Flight Data

Reconstructed supersonic C_A
(accelerometer-based)
exceeded 3σ preflight
dispersions

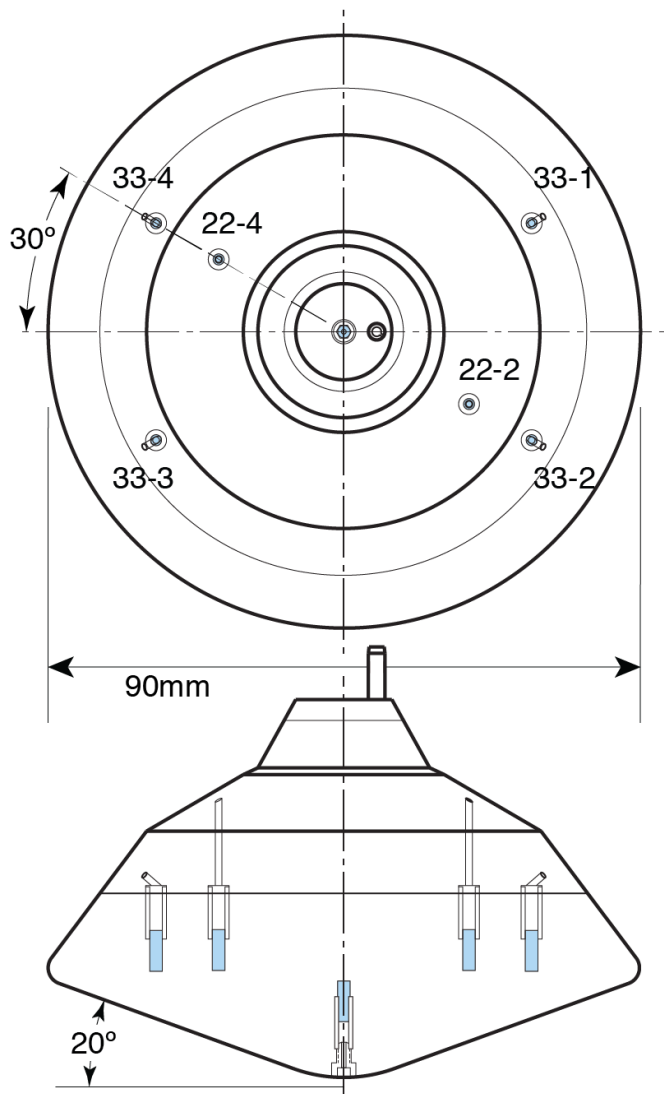
Introduction (concluded)

- Models were instrumented with Kulite XCEL-072 0-500psi and 0-25psi (backshell) transducers to resolve wake pressure and confirm Mach number. Pressure recorded at (62.5kHz)
- Launch Conditions
 - Initial Mach = 3.0 (designed to be at Mach = 2.5 at station 1 and remain supersonic at end of range)
 - Initial angles-of-attack: 0 deg, 10 deg (set within launch sabot)
- Models also recorded rates, accelerations and orientation relative to local magnetic field. This data was part of ARL technology development and is still being processed



Model Design/Development

- Model designed with options for 6 backshell port locations
- 4 models populated different combinations of 3 locations



Model Backshell Port Layouts

Model #1



Shots
40021, 40022

Model #2



Shots
40023

Model #3 (22-4 blind)



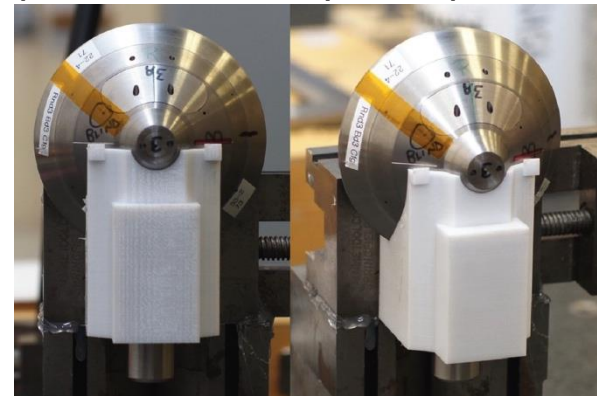
Shots
40017, 40018, 40024

Model #5

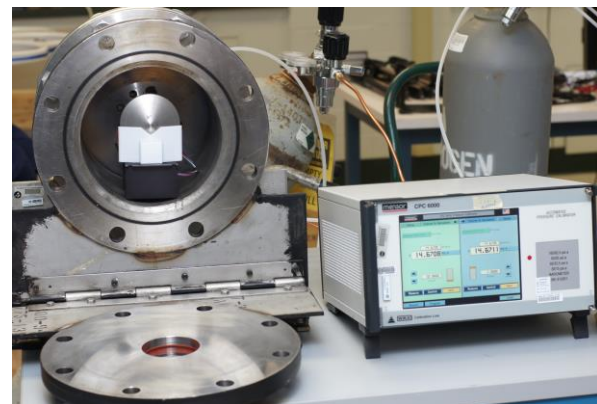


Shots
40019

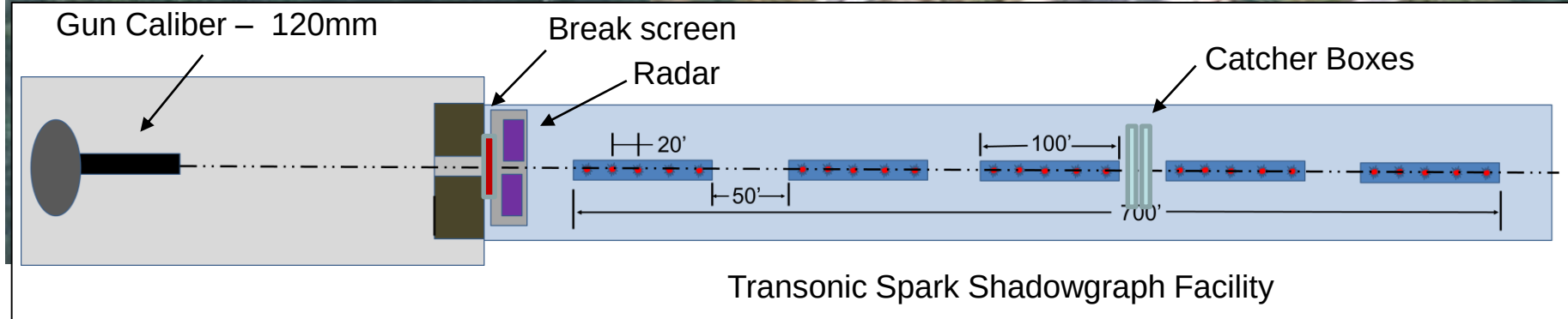
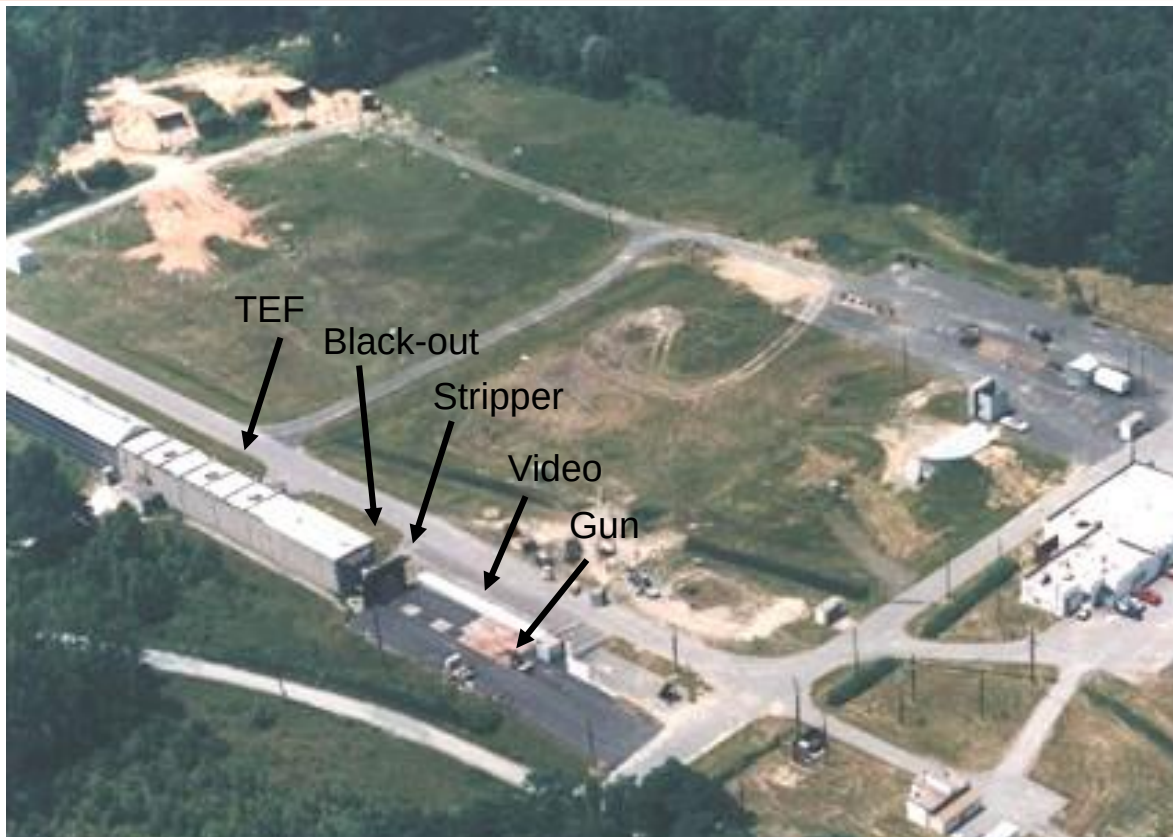
Geometries of models measured (OML, Mass Properties)



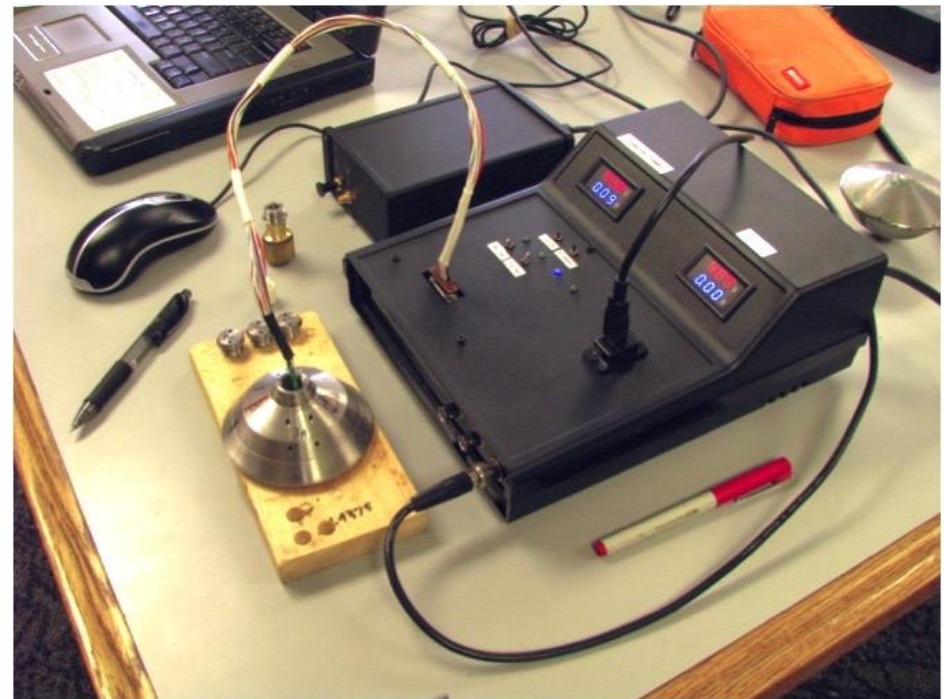
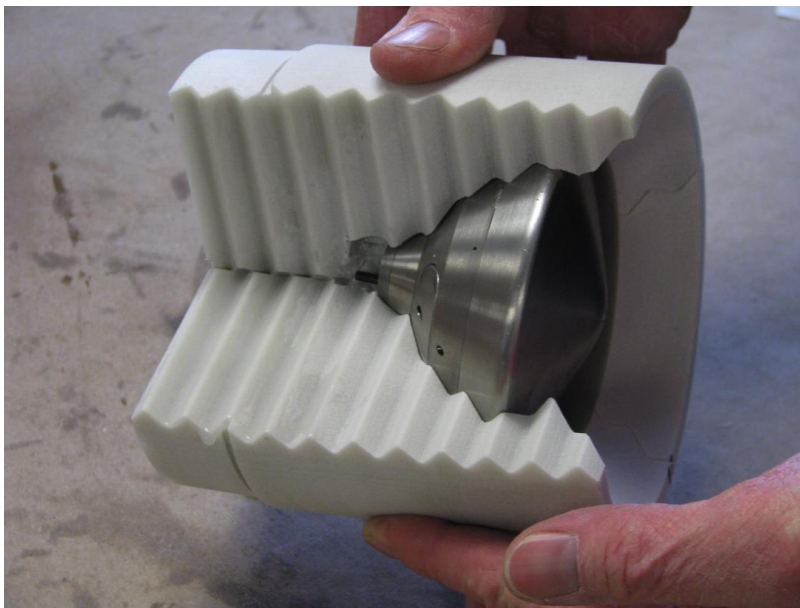
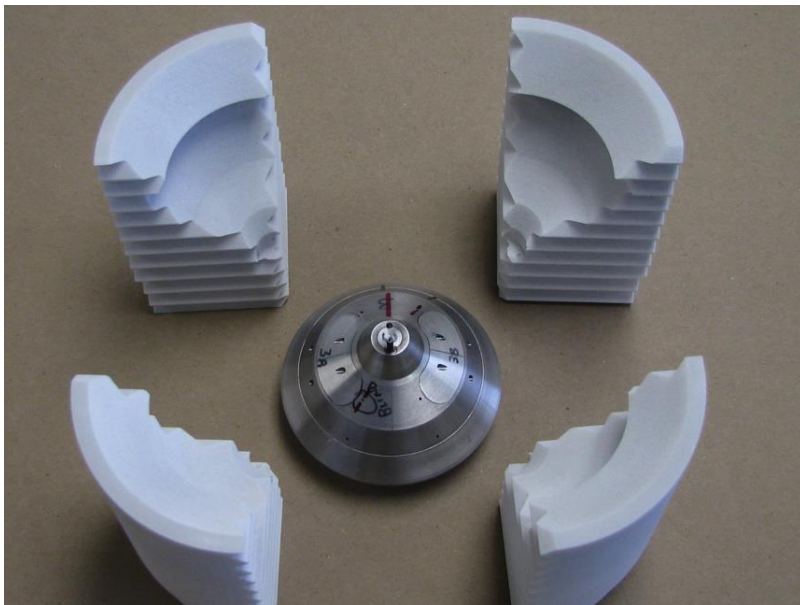
Transducers calibrated (0.5 – 160 psi)



Transonic Experimental Facility (TEF)



Preparing Launch Package



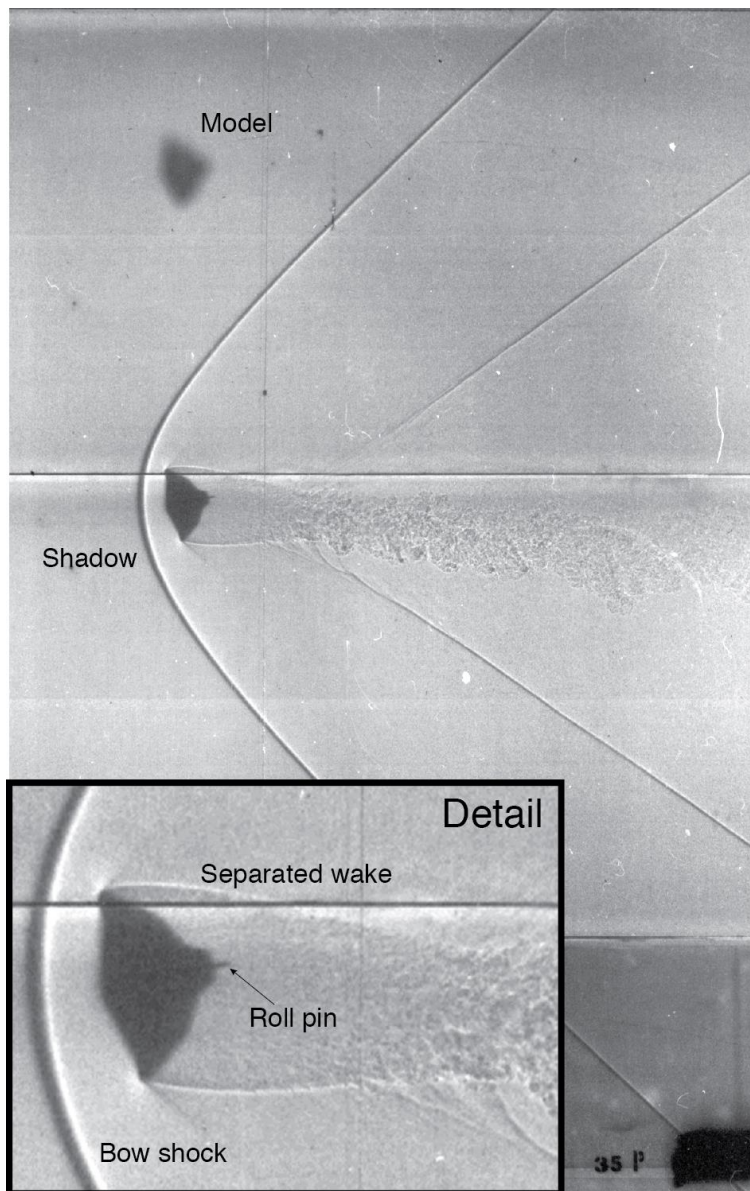
Onboard batteries power instrumentation package

Timer started before loading: After 10min expires, g-trigger looks for acceleration to initiate data recorder

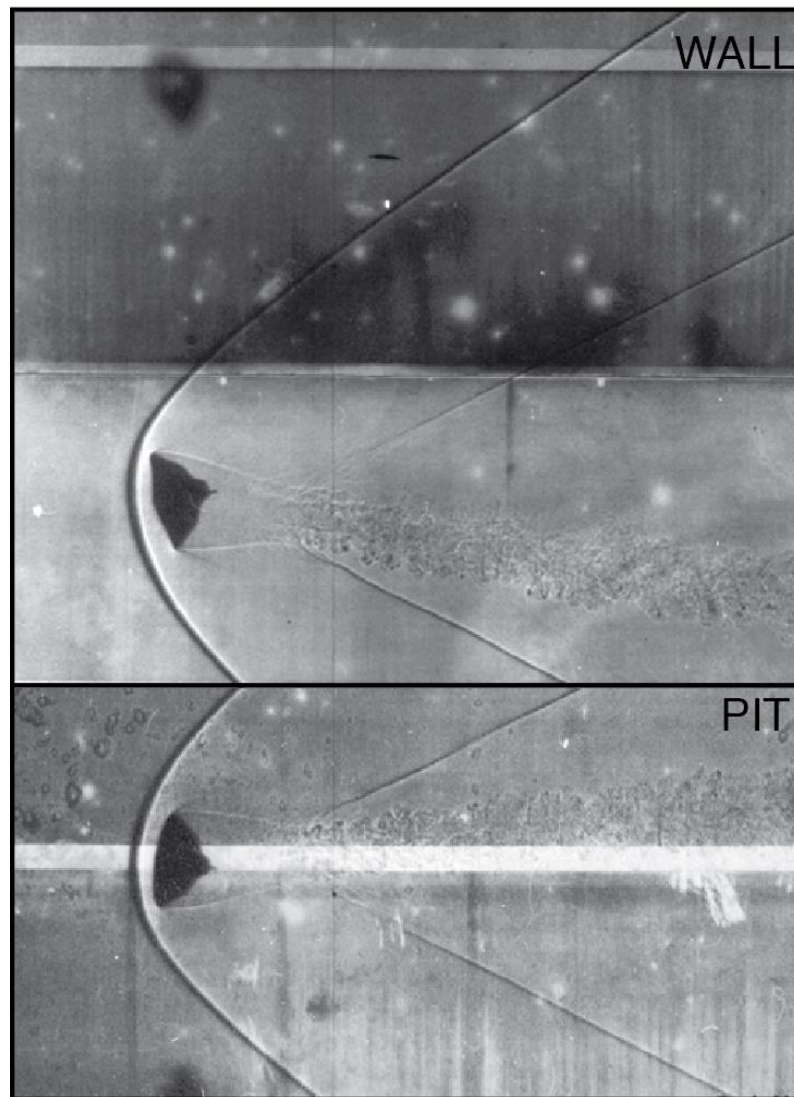
Model packaged in sabot (0 or 10 deg cant angle) and loaded in gun to fire

Launch acceleration triggers data recording.

Shadowgraph Example: Shot 40021 (anchor pressures to trajectory)



Group 2, Station 4



Model Retrieval

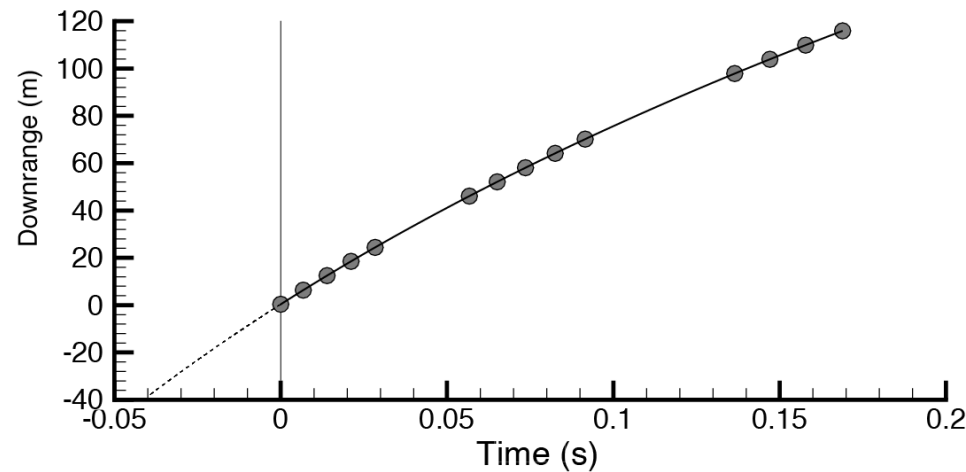
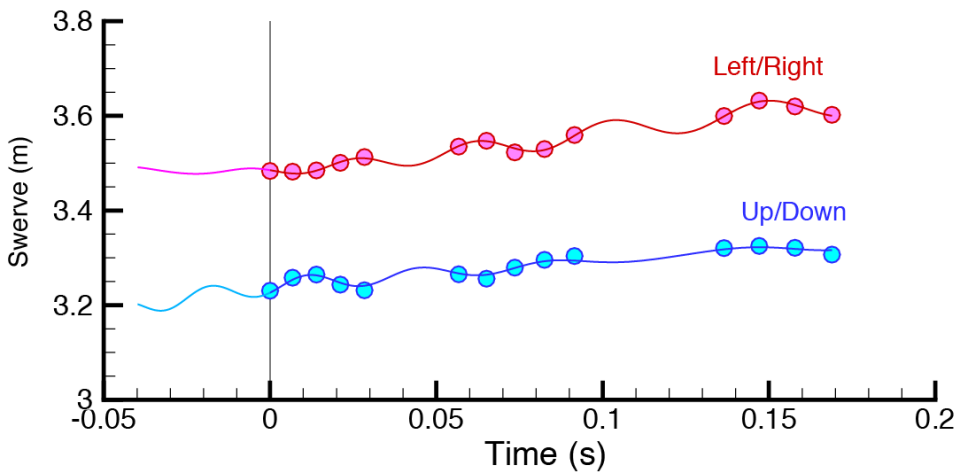
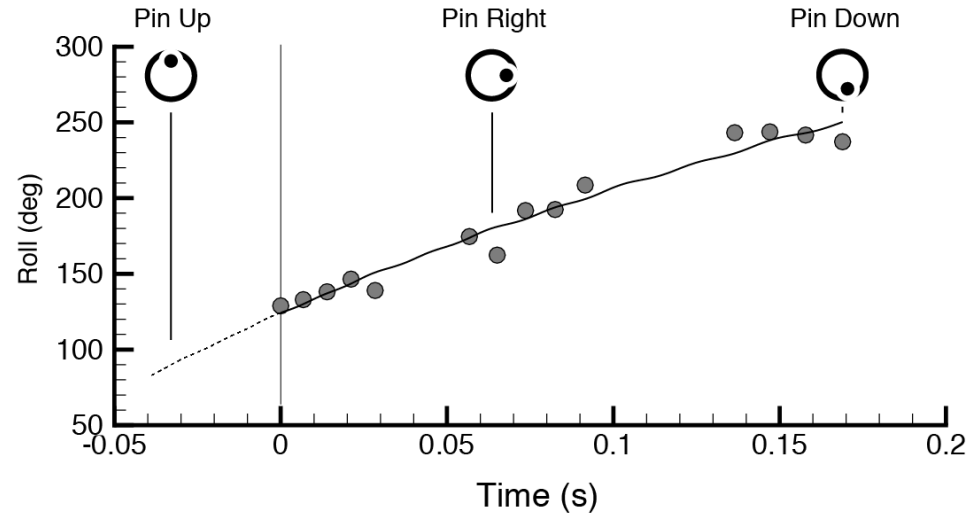
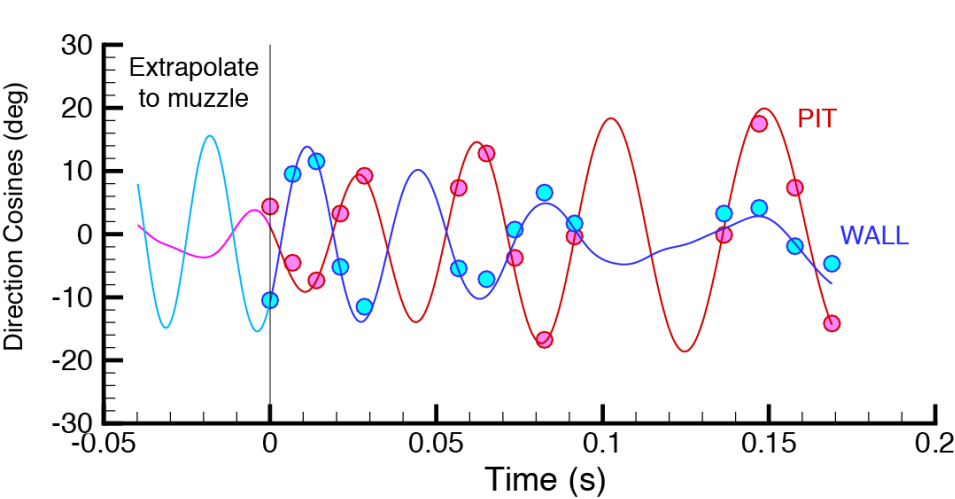


Model flight arrested in plywood boxes filled with homasote fiberboard and cardboard bundles

Model must be retrieved intact (and electronically functional) to download data.

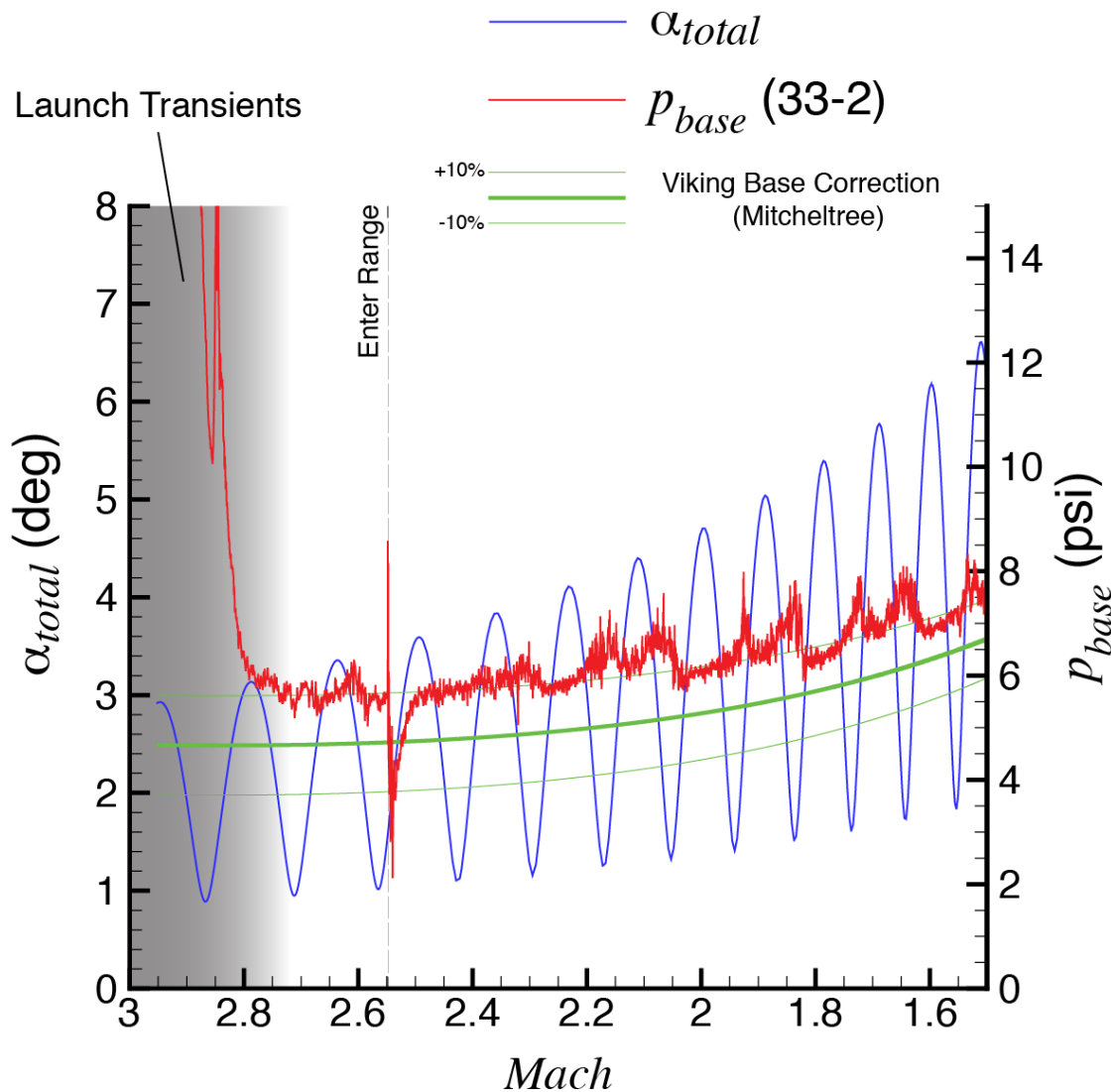


Shot 40021 Trajectory Fit



Excellent fit to data using pre-test ballistic range aerodynamics
 Data can be extrapolated upstream back to muzzle to compare with pressures

Shot 40018 Backshell Pressure



Shot 40018 (2nd shot of model #3) recorded one backshell pressure past last shadograph station

- 0 deg sabot
- Mach =2.5 at station 1

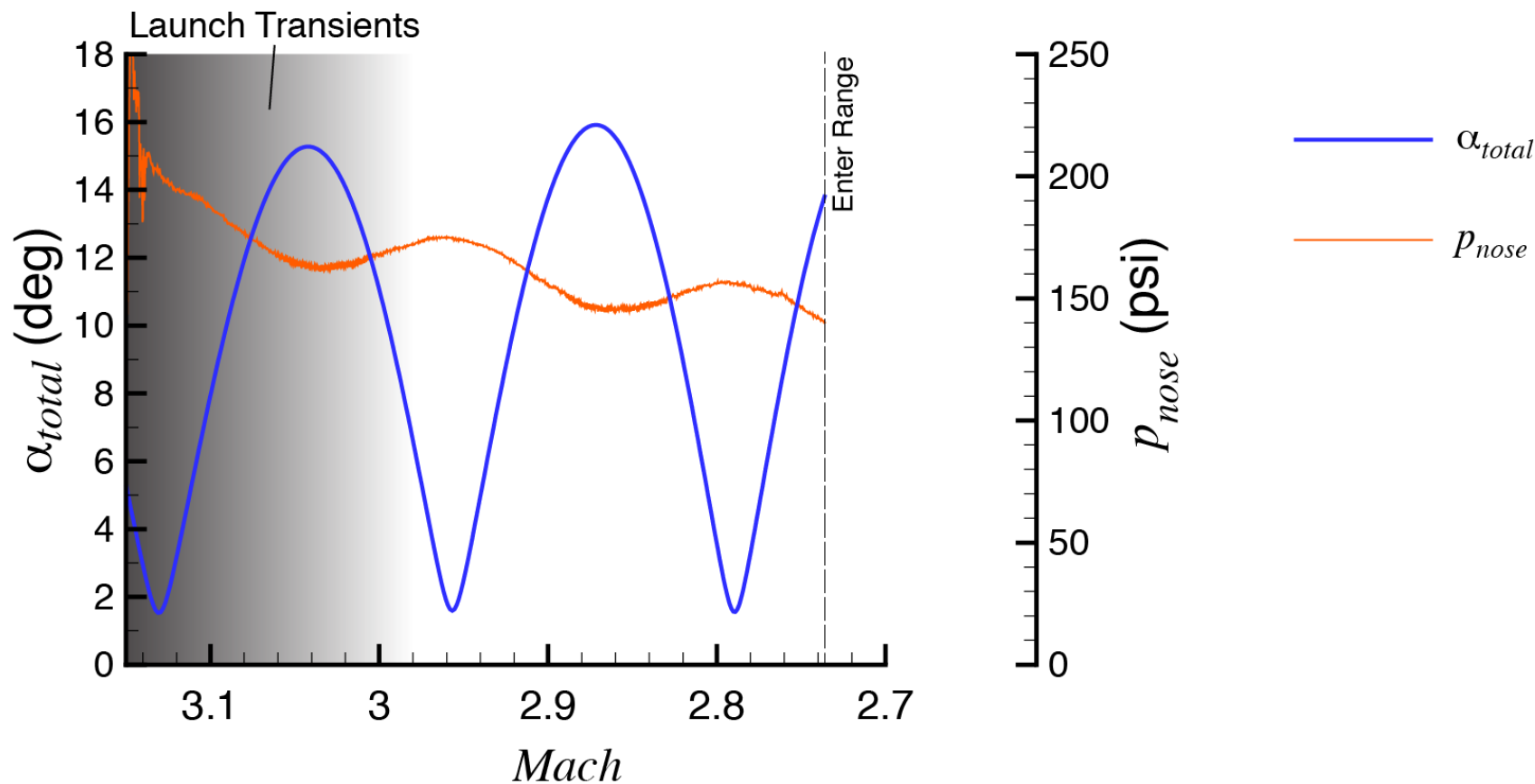
Variation with Mach follows empirical data (Viking derived)

Wake pressure appears to be higher than Viking model (lower drag?)

Small variations in pressure signal appear to be correlated with small angle-of-attack oscillations

Shot 40021 Pressures

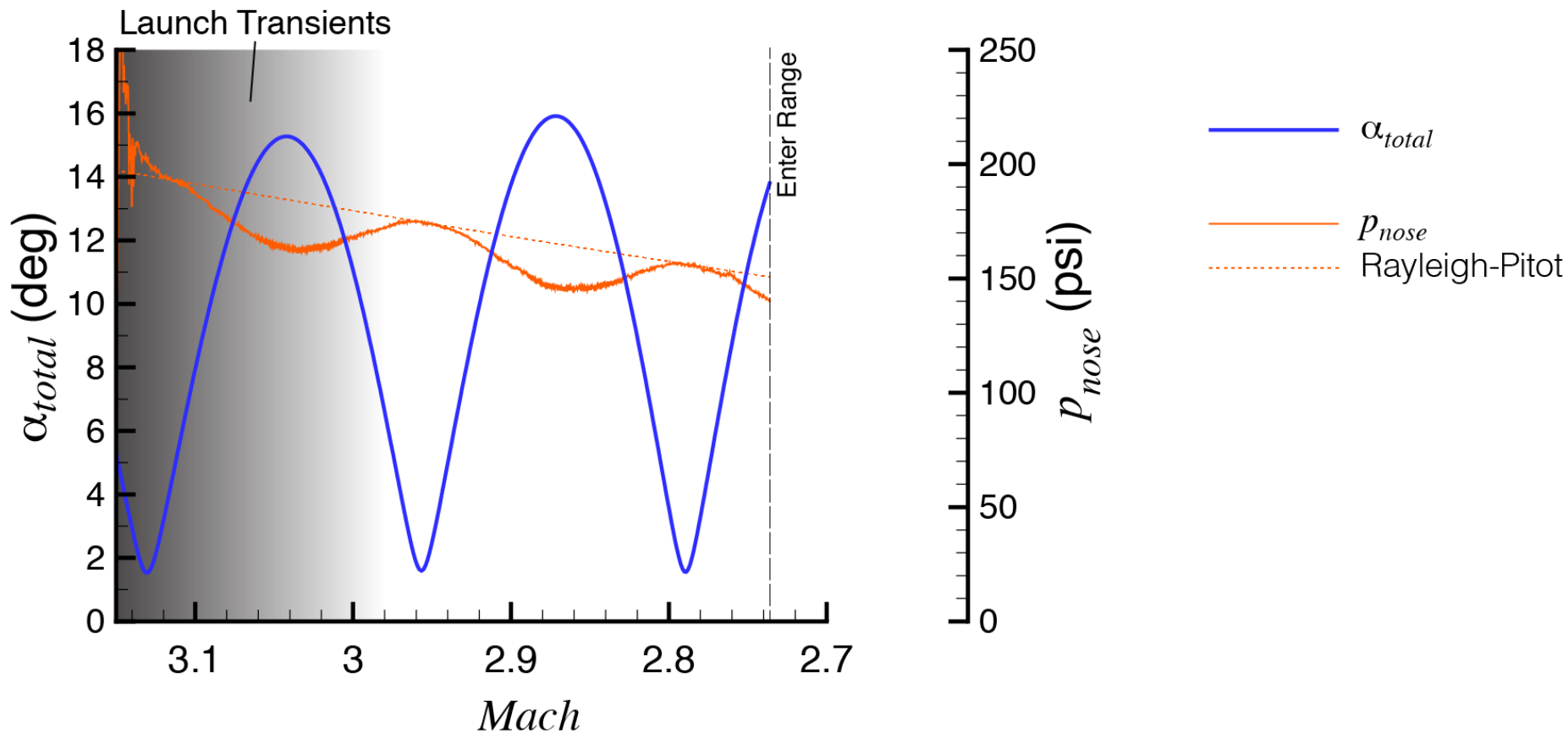
10 Deg Sabot, First shot of Model #1



- ANOMALY: Shot 40021 stopped recording at break screen.
- Pressure variation at nose consistent with large angle oscillations

Shot 40021 Pressures

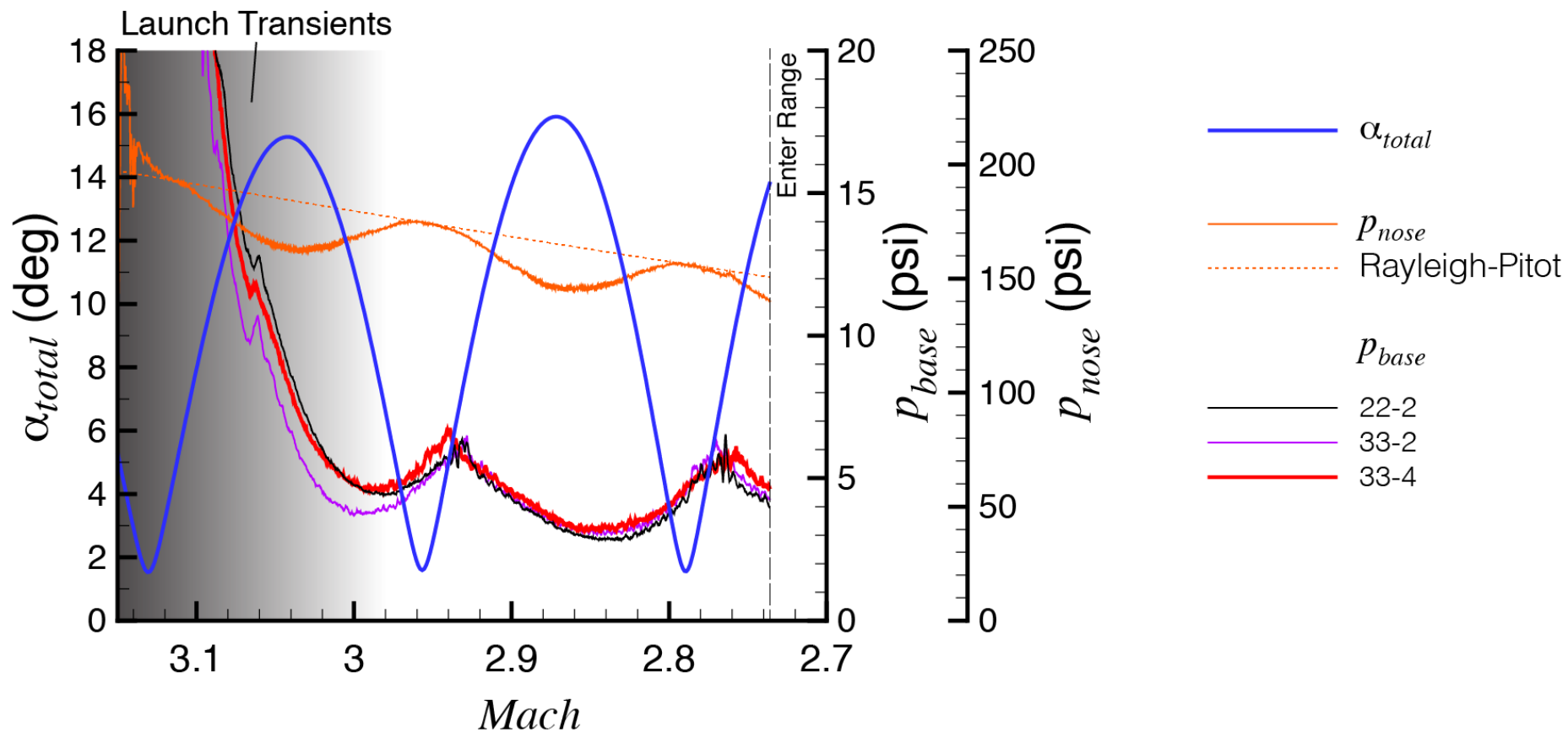
10 Deg Sabot, First shot of Model #1



- Pressure at nose in close agreement with Rayleigh-Pitot eqn (at reconstructed Mach number)
- Good indication that pressure measurements and trajectory data are good, and synched

Shot 40021 Pressures

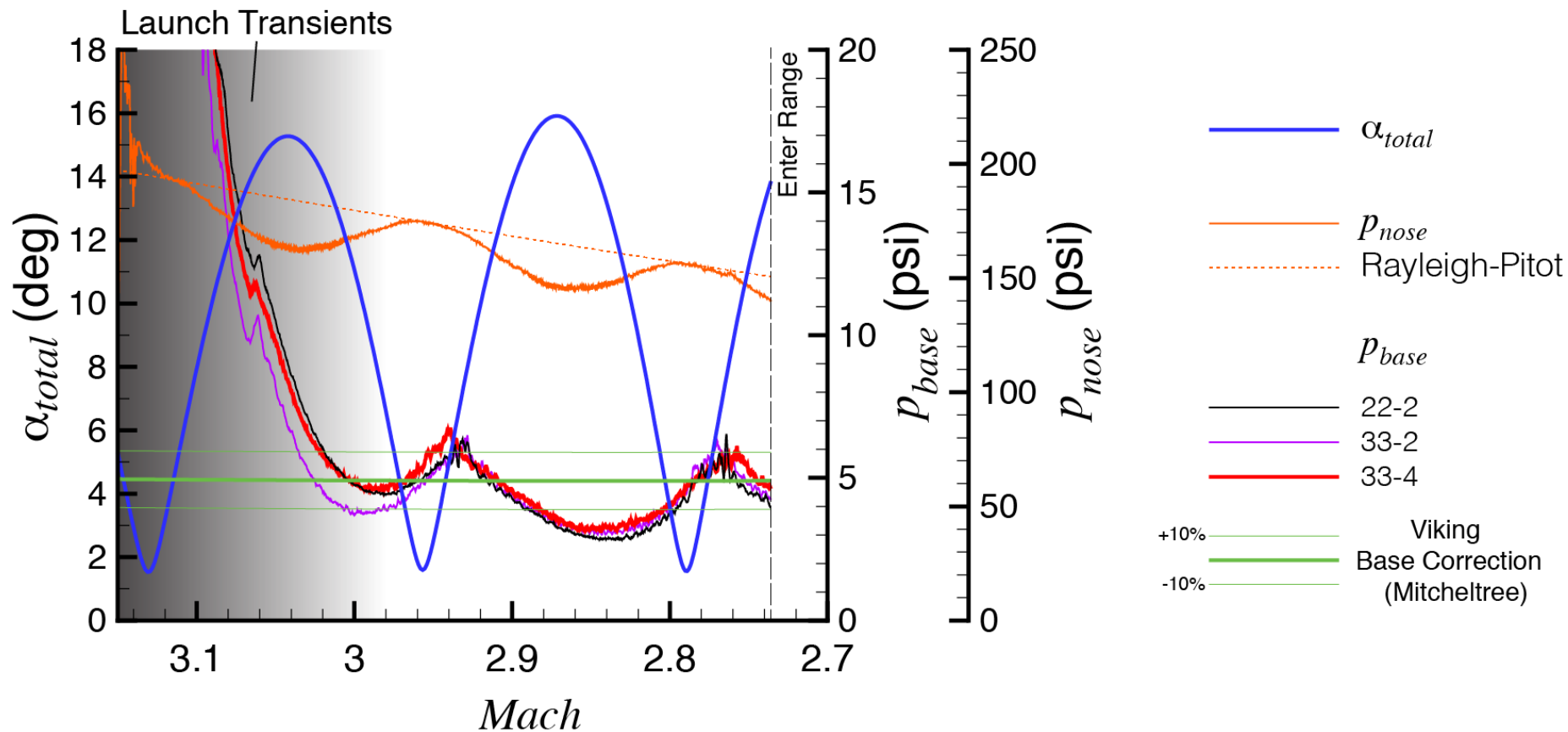
10 Deg Sabot, First shot of Model #1



- Wake pressures (1st & 2nd backshell cones, opposite sides of the model) vary with oscillations
- To first order wake pressure appears to vary in bulk across backshell (no large local changes)

Shot 40021 Pressures

10 Deg Sabot, First shot of Model #1



- Wake pressure variation greater than base correction uncertainty band
- Trim angle-of-attack may be significant influence on overall wake pressure
- Dynamic history of pressure looks very interesting: More work required.



Conclusion



- Test successfully measured backshell surface pressures in a quiescent environment
- Data recording anomalies limited the amount of useful data, but recorded data is very useful
- Pressure variations appear to be driven by angle of attack and to first order are constant across entire backshell
- Dynamic variation of backshell pressures warrant further investigation
- The root cause of the data recording anomaly must be identified and corrected. When corrected, this test technique can be used to measure high quality validation data for CFD wake predictions and could help reveal the driving mechanisms behind blunt body dynamic instabilities.



Muzzle Exit View



18m downrange from Muzzle