2nd AIAA Sonic Boom Prediction Workshop

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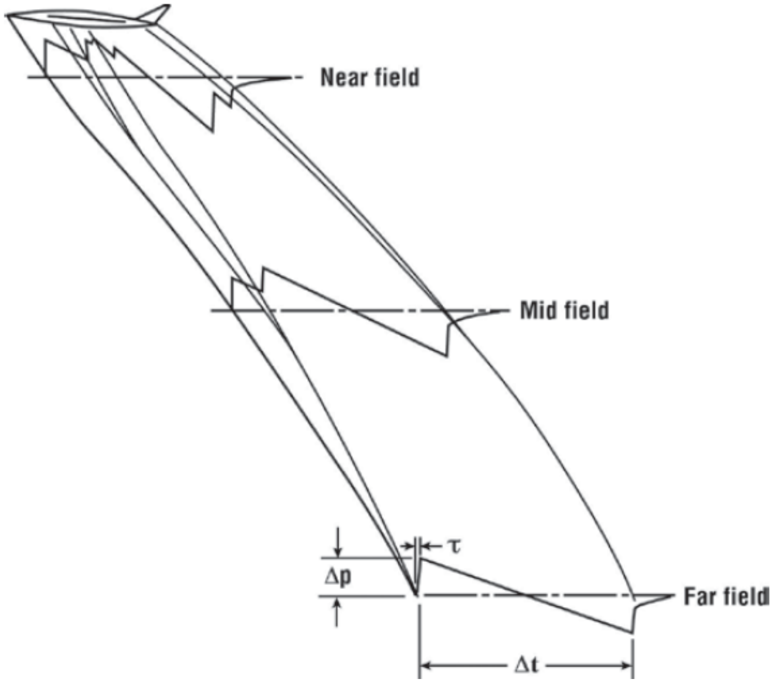
Outline

- Case Summary
- Propagation Prediction Code
- Prediction Code Discretization
- Case Analysis
- Highlights & Observations



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Case Summary

- Axisymmetric body of revolution
  - Propagation of all available roll angles [-60:05:60]
    - Standard Atm.
    - Standard Atm. (fixed 70% RH)
    - Realistic Atm. Profile 3
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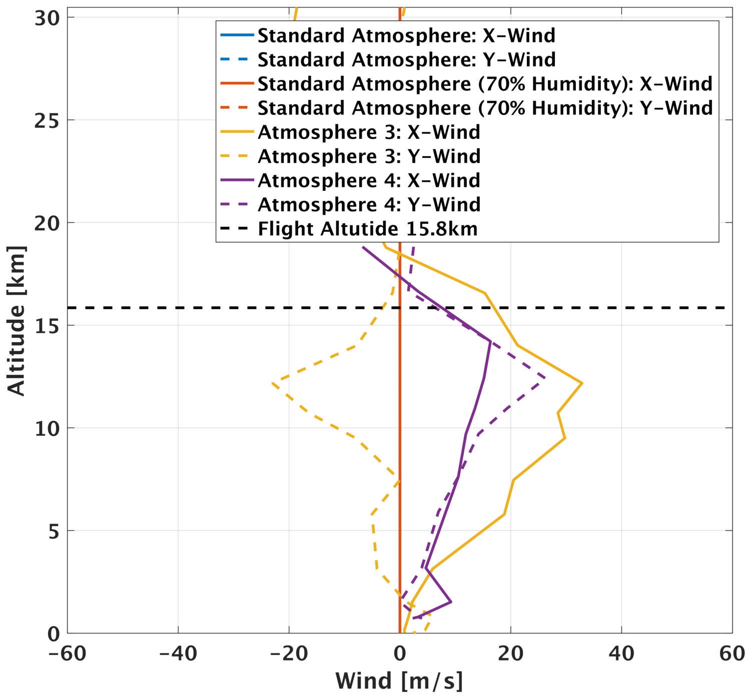

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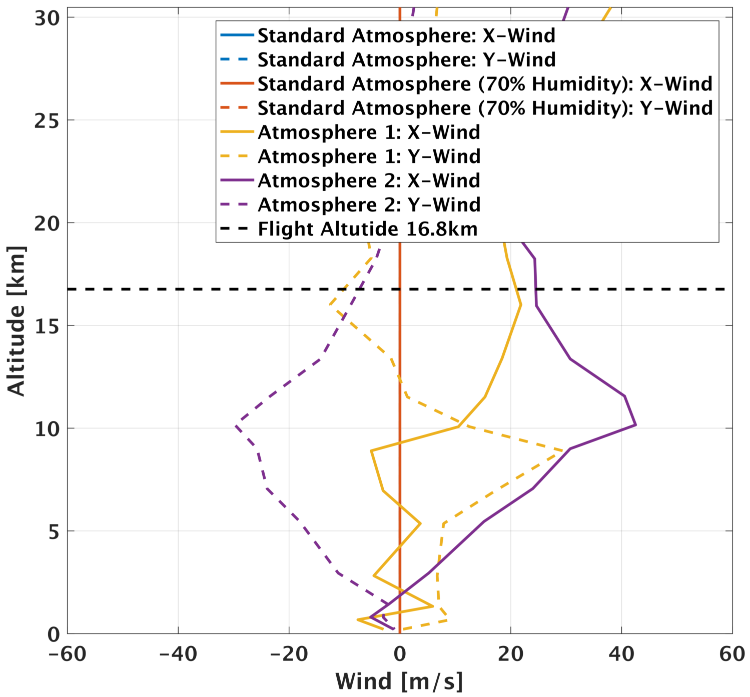
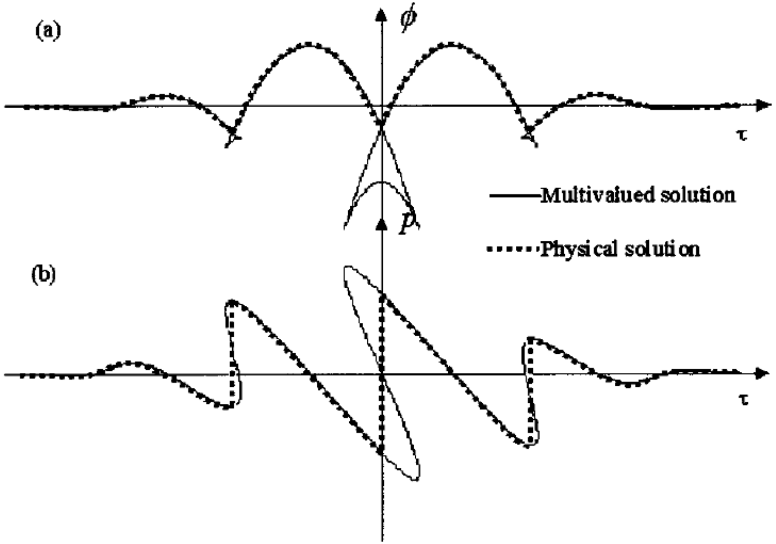


Propagation Prediction Code

- Prediction code: GACBoom
  - Time domain algorithm based on work by R.O. Cleveland
    - GAC code by J.A. Salamone
  - Augmented with Acoustic Potential method
  - Signature evolution calculated using operator splitting method
  - Multiple relaxation processes
    - Oxygen and Nitrogen

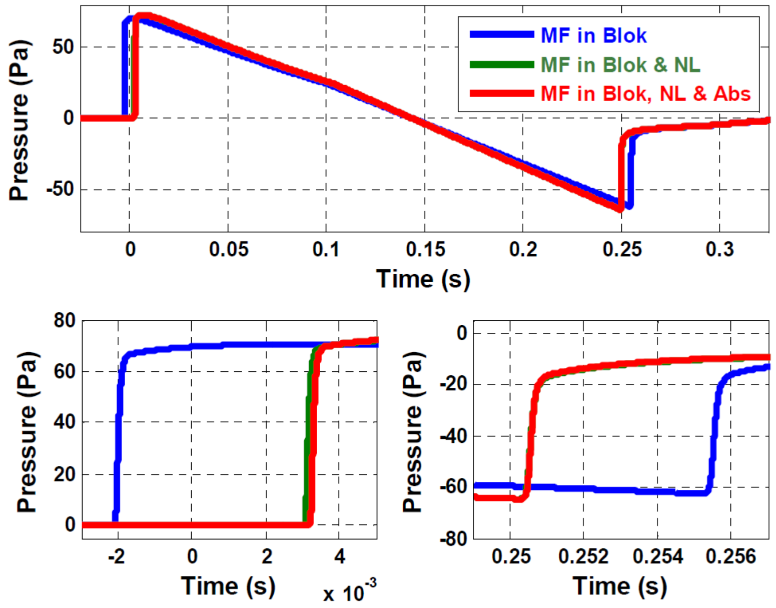
"…From a numerical point of view, finding the maximum of several values is much more efficient than solving the differential equation governing the position of the shocks according to weak shock theory, or determining the position that makes the surface of the two lobes equal, as for the law of equal areas. The only numerical cost is due to the discretization"



R. Marchiano, F. Coulouvrat, R. Grenon, "Numerical Simulation of Shock Wave Focusing at Fold Caustics, with application to Sonic Booms"

Propagation Prediction Code

- Prediction code: GACBoom
  - Mean flow accounted for in Blokhintzev, nonlinearity and absorption/dispersion terms
  - Logarithmically interpolated pressure stratification
  - Loudness code based on NASA Langley methodology
    - Custom coded time domain filters to calculate 1/3 octave
  - Unsteady trajectory capability



J. Salamone and V. Sparrow, "A Sonic Boom Propagation Model Including Mean Flow Atmospheric Effects"

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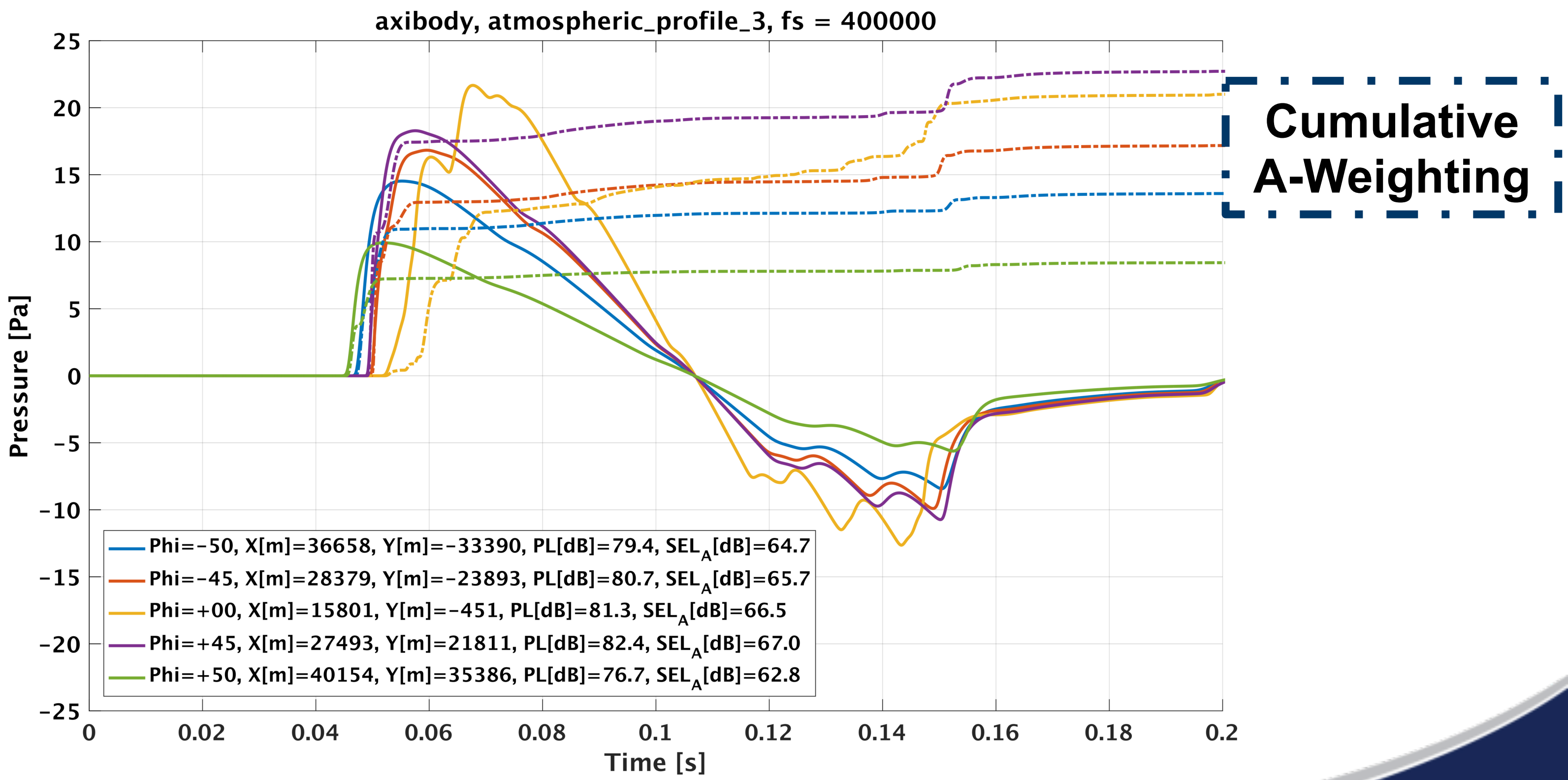
Prediction Code Discretization

- Temporal Discretization
  - Sample rate selection influenced by, semi-discrete, Fourier analysis presented by Cleveland. Minimize numerical absorption and dispersion
  - 50kHz, 100kHz, 200kHz, 400kHz, 800kHz
- Spatial Discretization
  - Nonlinearity
  - Absorption: Relaxation & Thermoviscous
  - Dispersion: Relaxation
  - Atmospheric property gradient: speed of sound, Blokhintzev invariant, relaxation time, density and pressure
- Acoustic Potential to full lossy method handoff is dynamically selected based on ratio of dispersion to nonlinearity

Case Analysis: Axisymmetric



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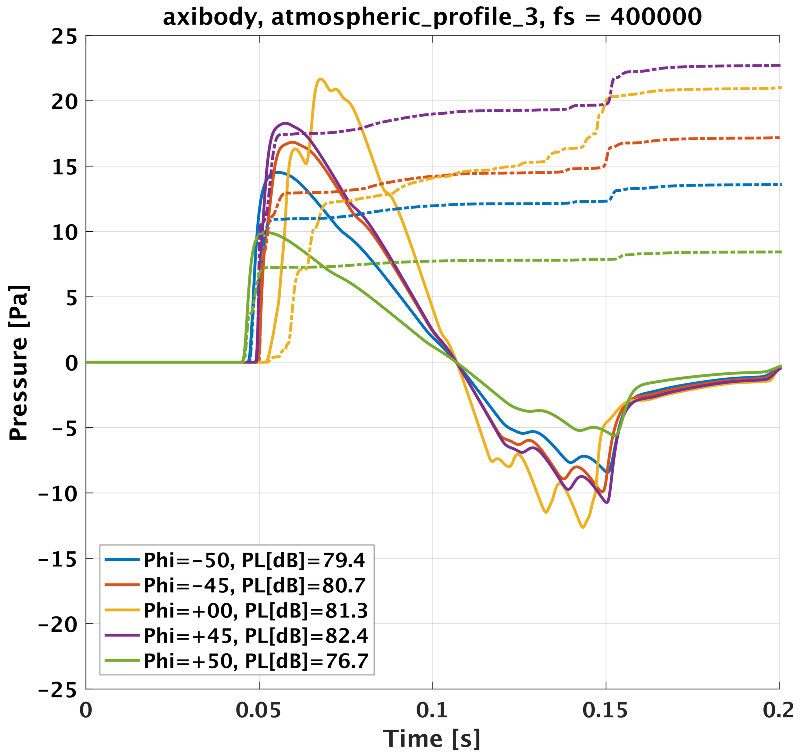
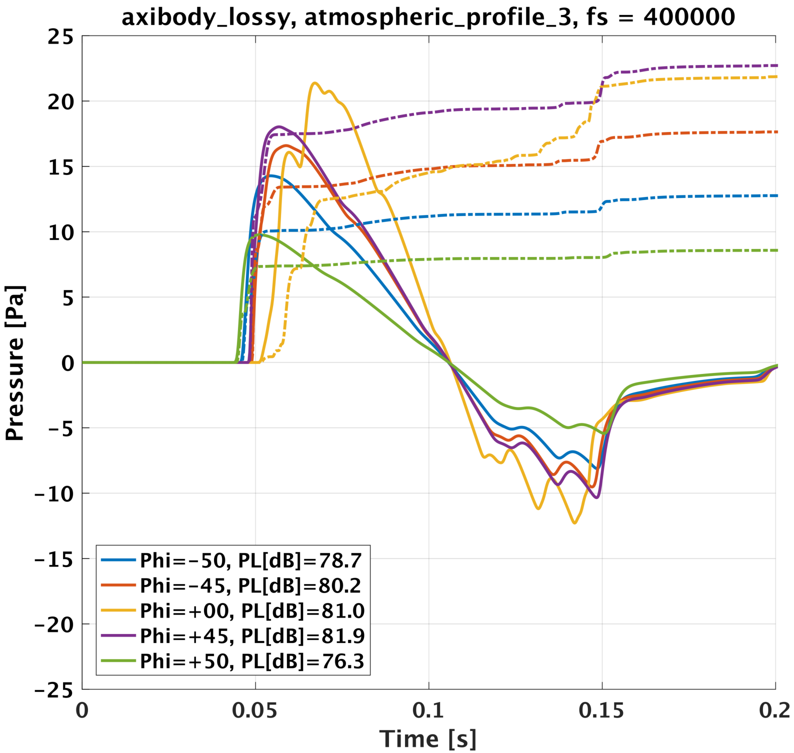
Case Analysis: Axi-Symmetric



Acoustic Potential + Lossy Propagation



Lossy Propagation

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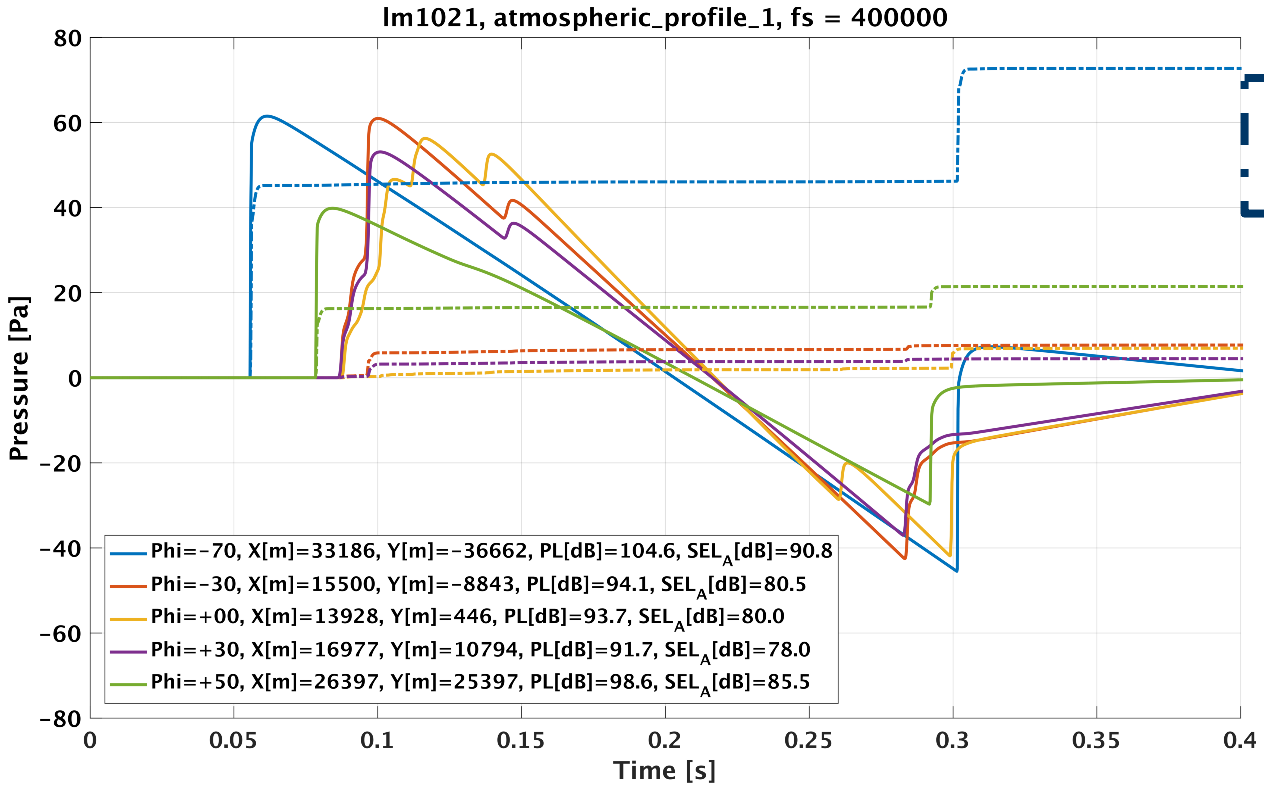
Case Analysis: LM1021



Cumulative A-Weighting

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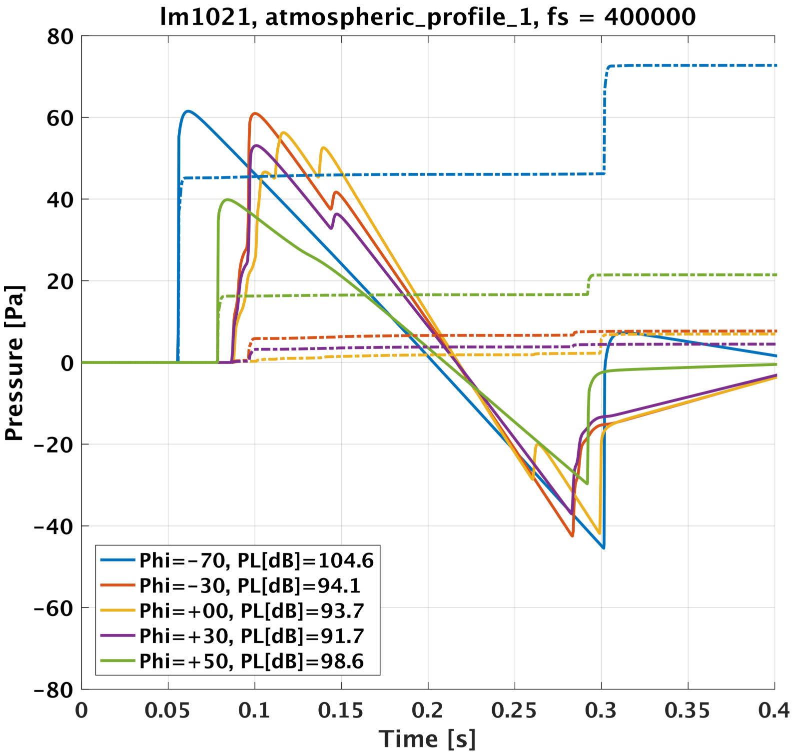

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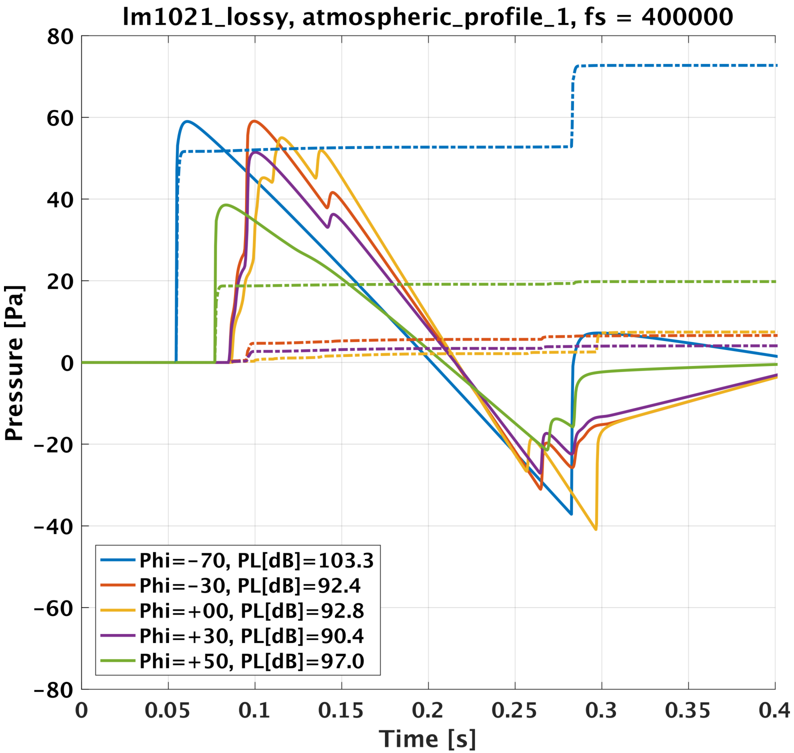

Lossy Propagation

Highlights & Observations

- Signature Observations
  - Axisymmetric signatures loudness driven by bow shock. Tail shock fairly benign
  - LM1021 signatures loudness driven by discrete bow & tail shock features
  - Signatures with strong near-field shocks present themselves as N-waves off-track. Nonlinearity not negated by propagation distance or rounding due to absorption
- GACBoom Unique Functionality
  - Acoustic Potential method used where nonlinearity dominates dispersion
    - Absorption contributes little when shocks are strong
    - Relaxation terms may induce Gibbs like oscillations where humidity is low with insufficient sample rate
  - Mean flow terms included
  - Dynamic step size controlled by many parameters both acoustic and atmospheric
  - Typically executed with high sample rate (200kHz)

Questions?

Backup Slides

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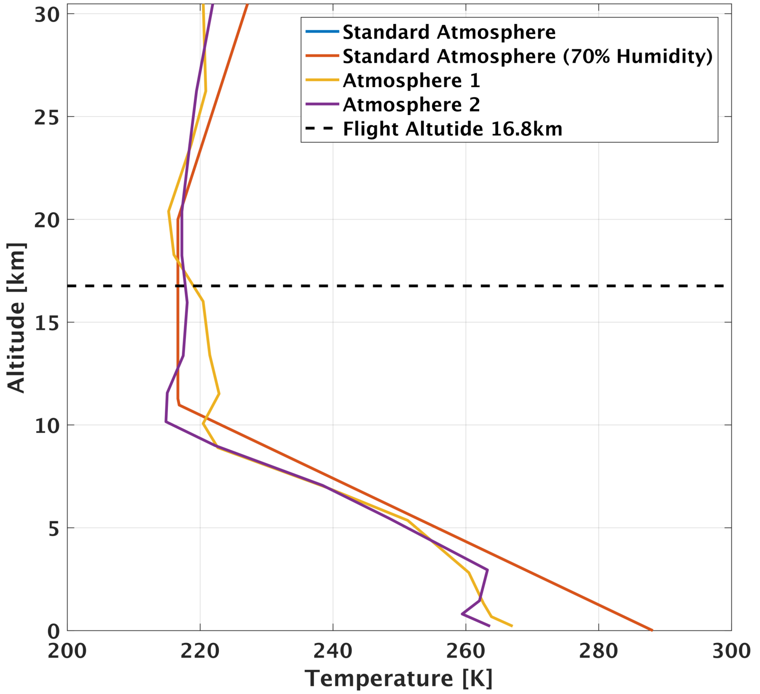

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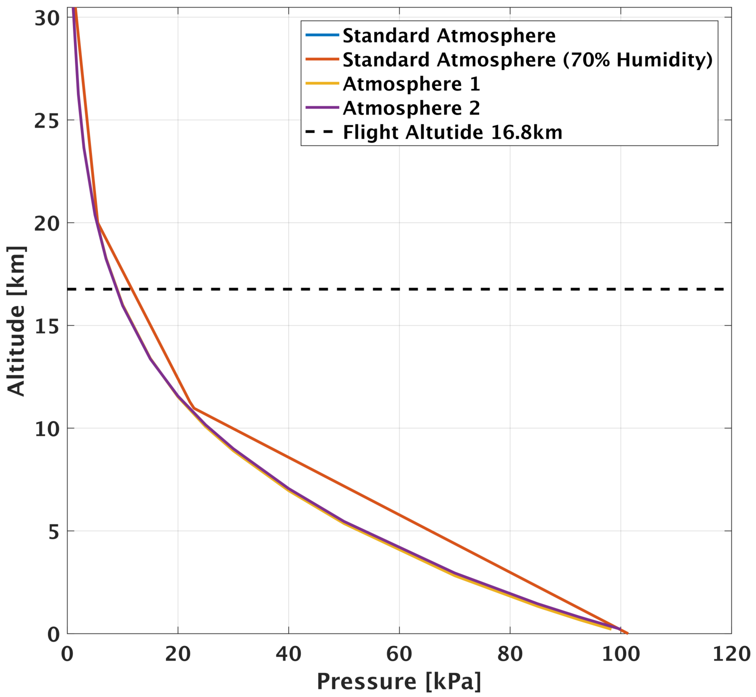

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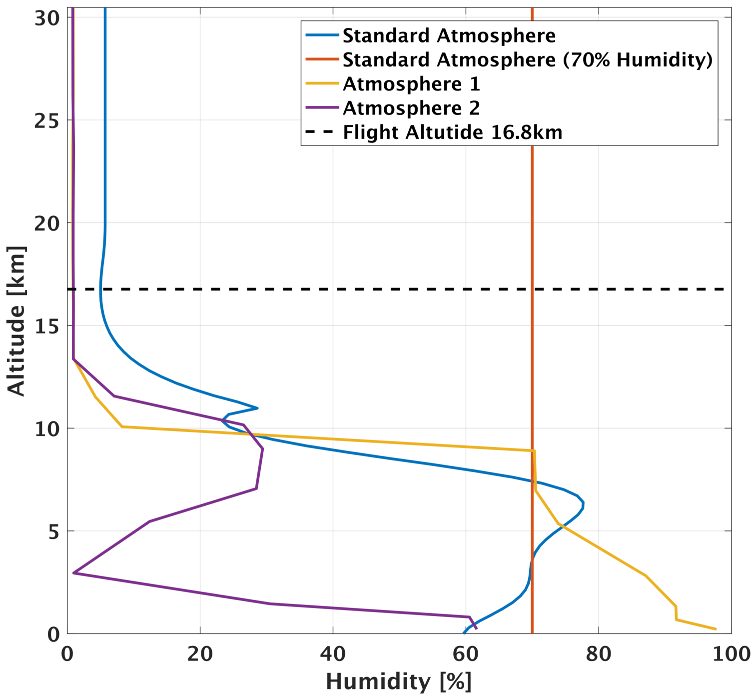

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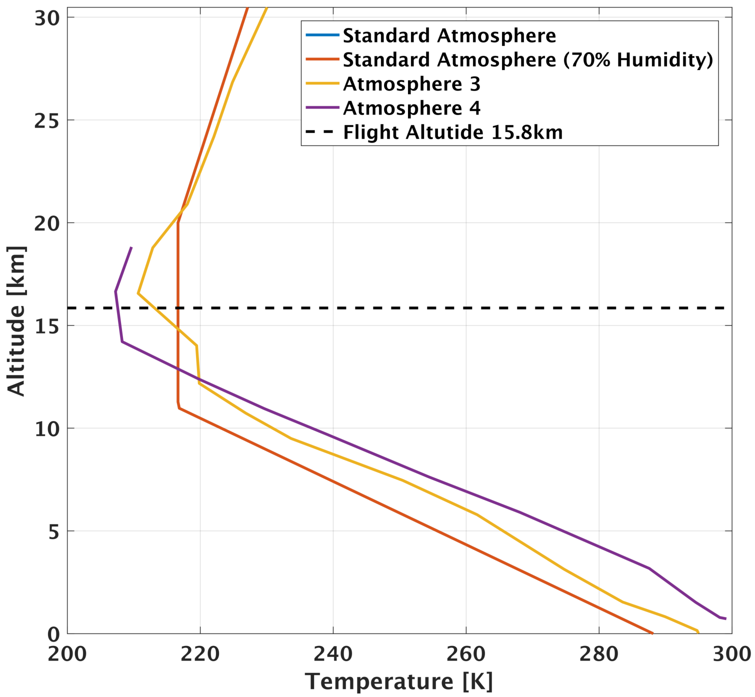

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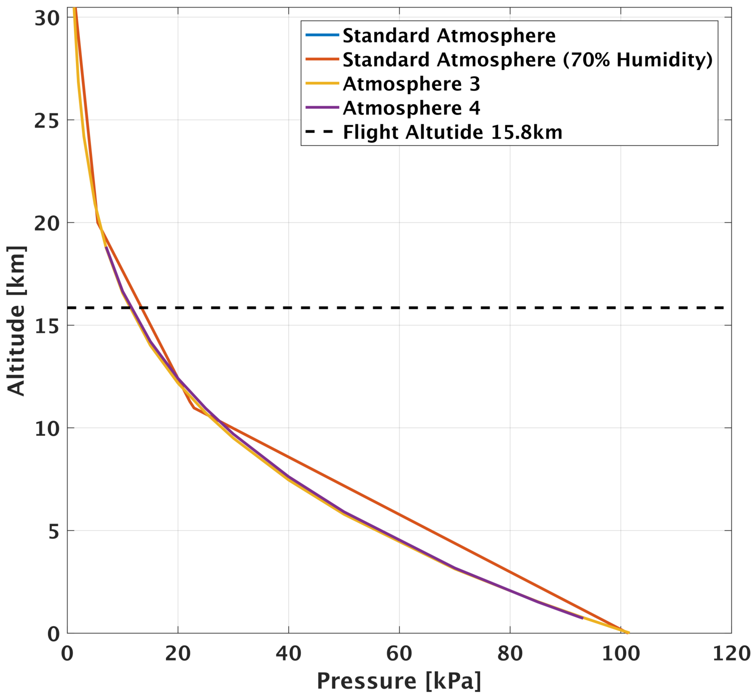

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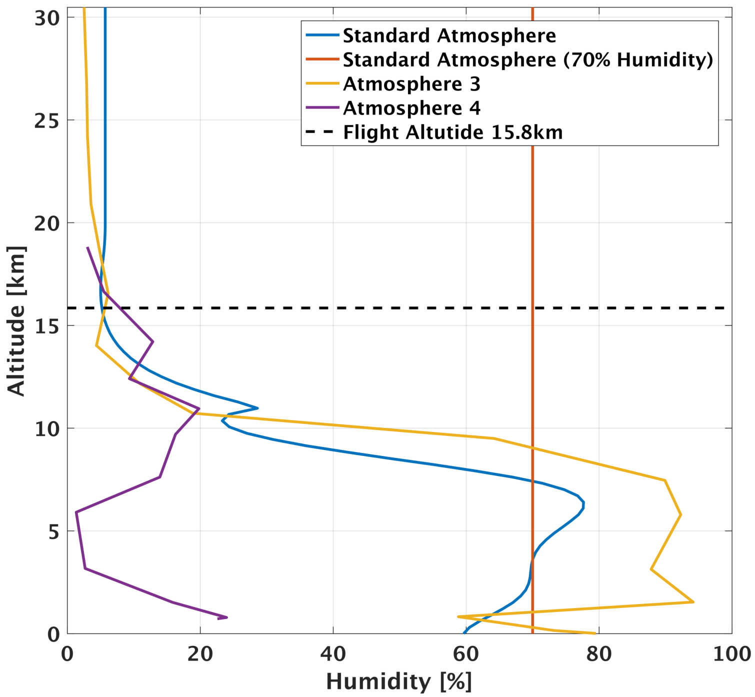
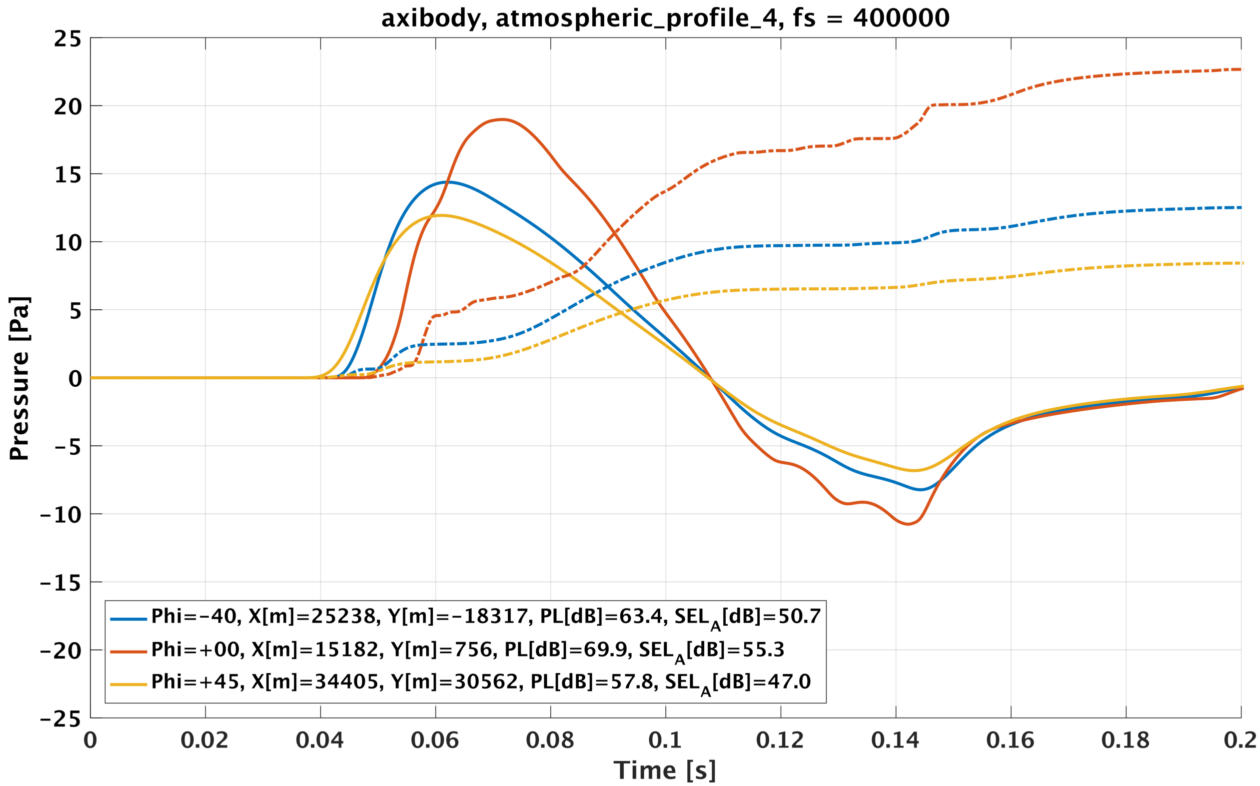


Case Analysis: Axisymmetric



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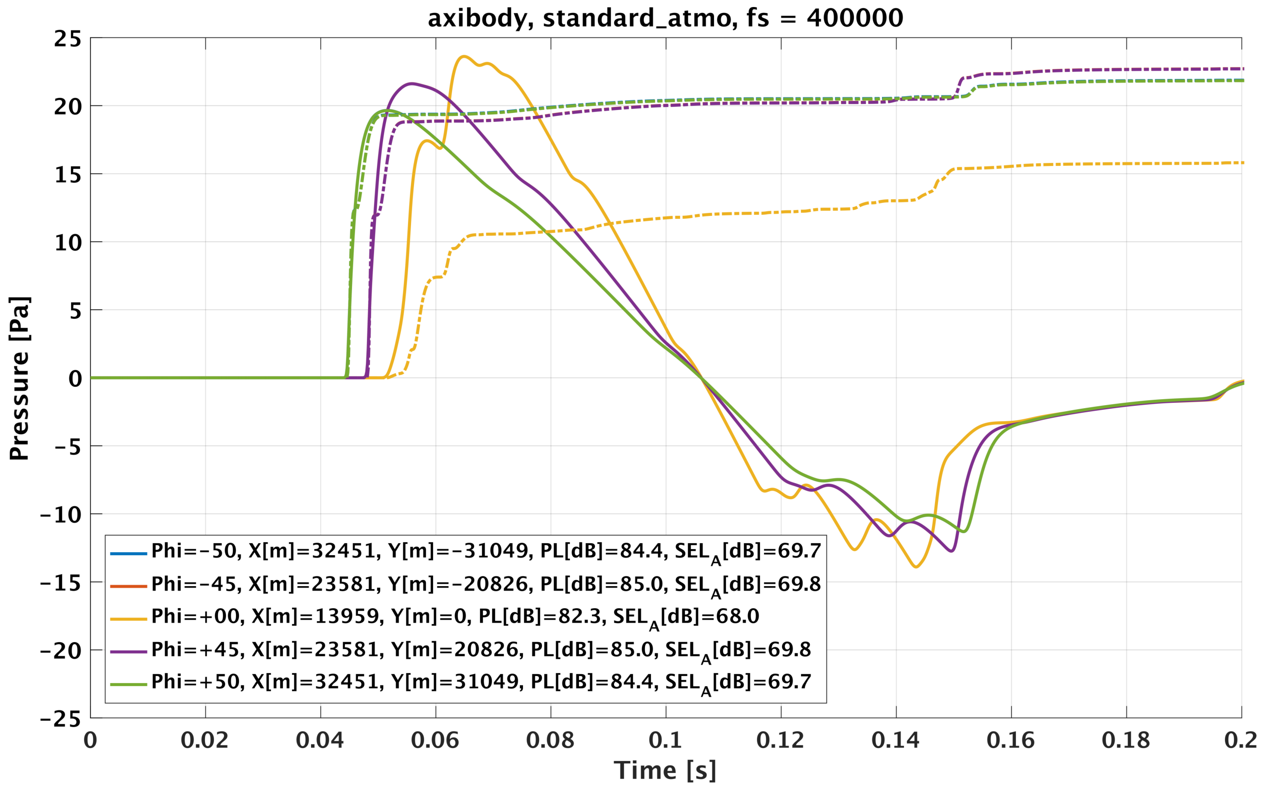

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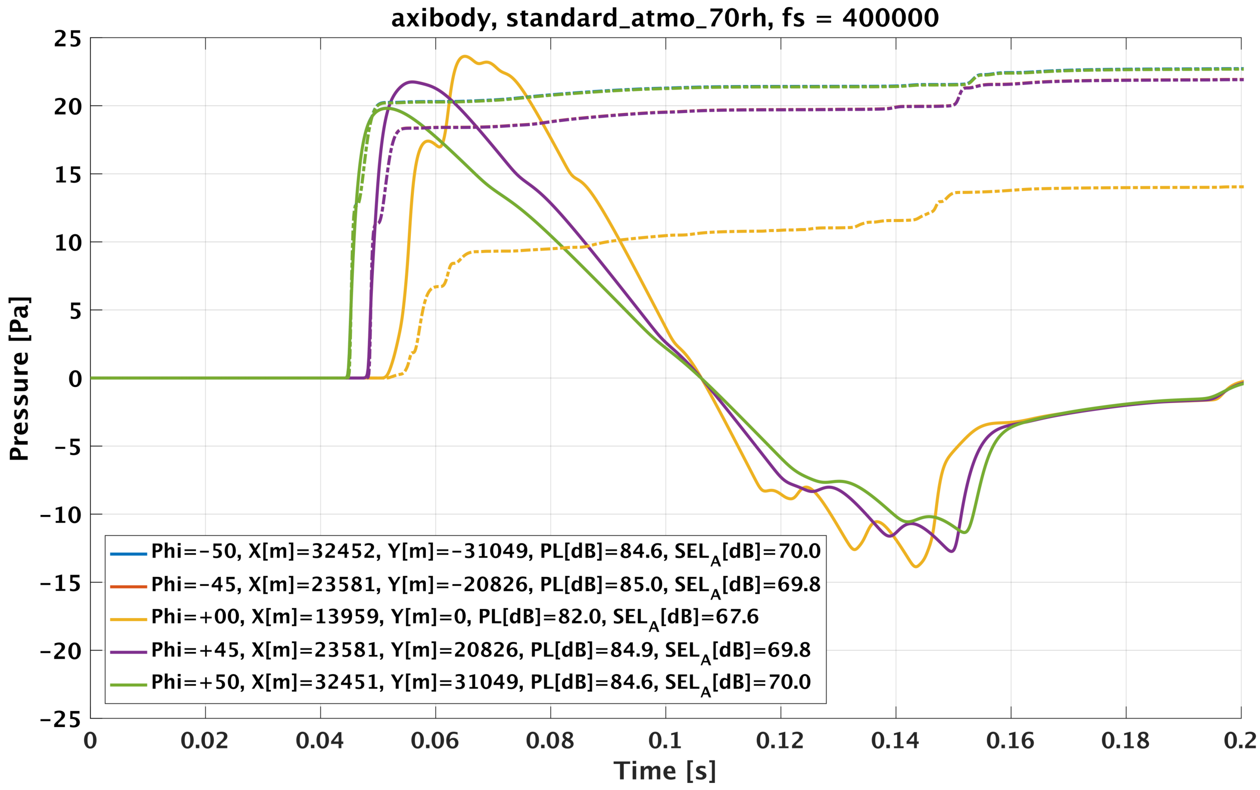

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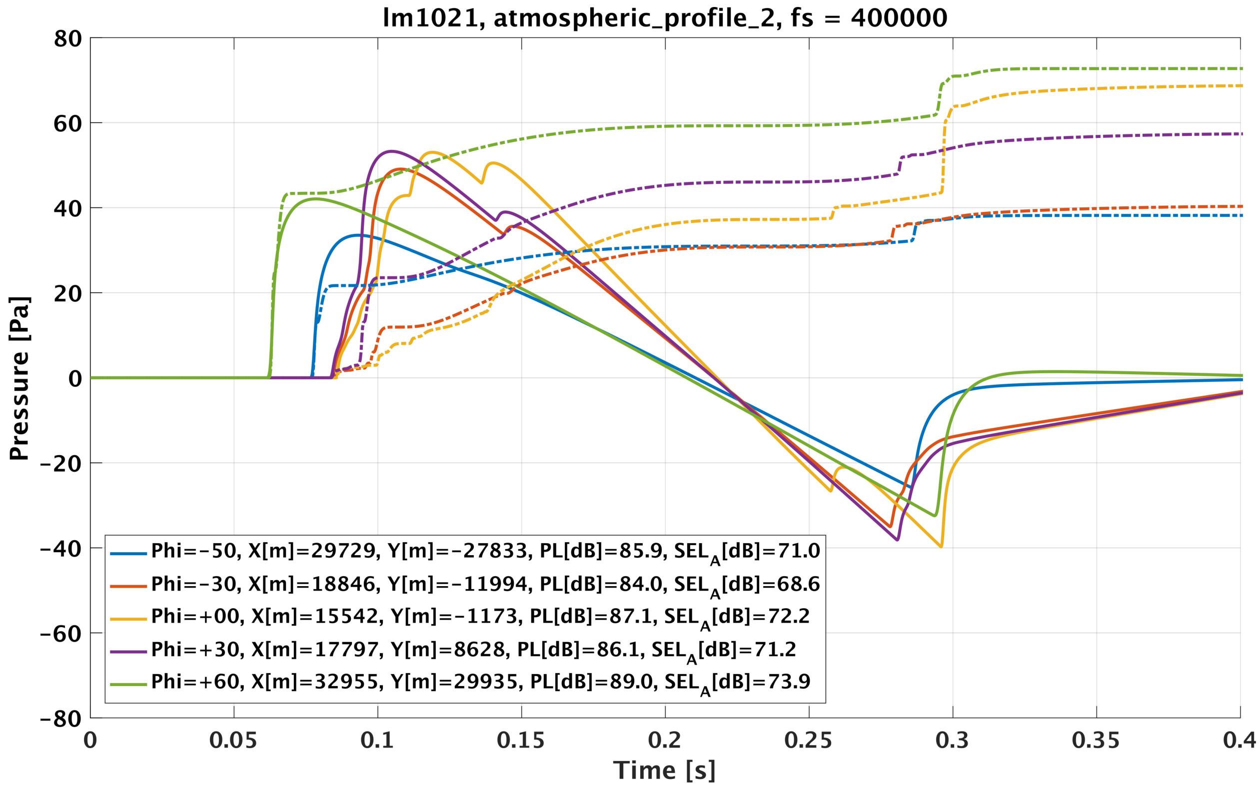

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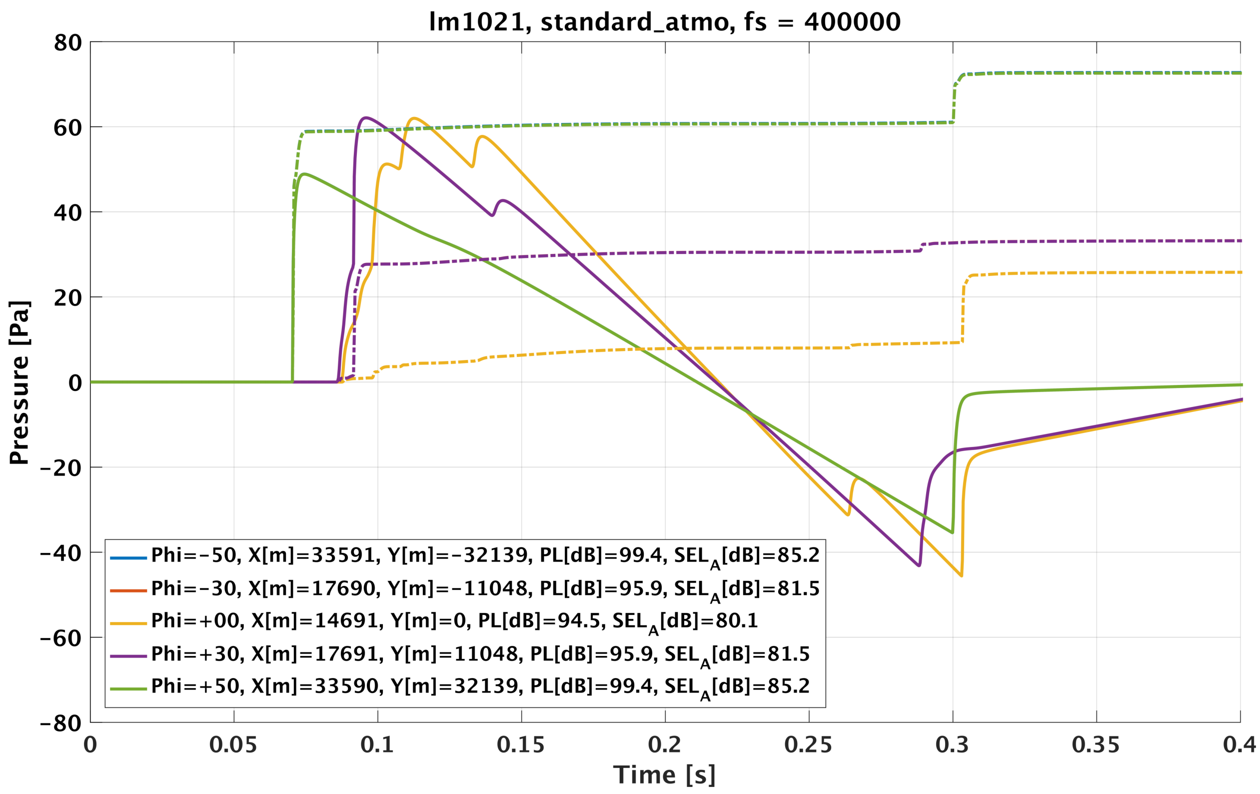

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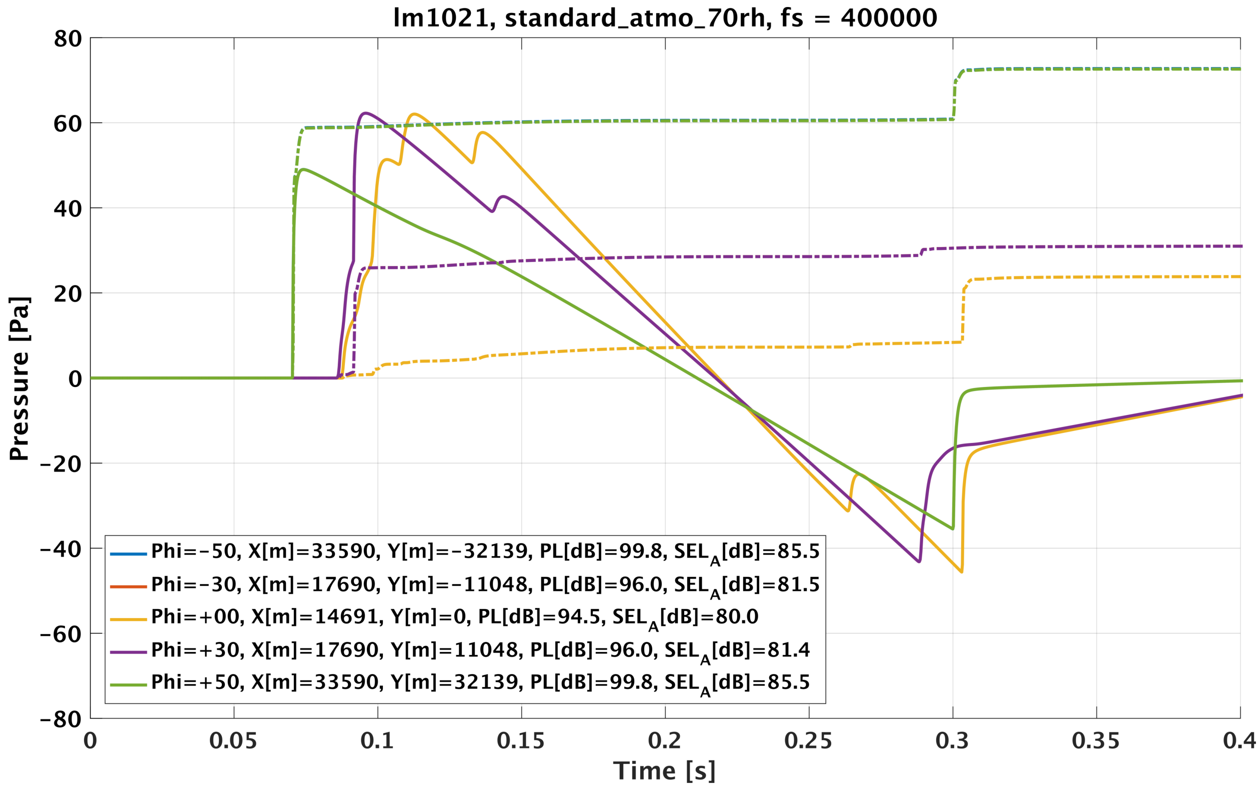

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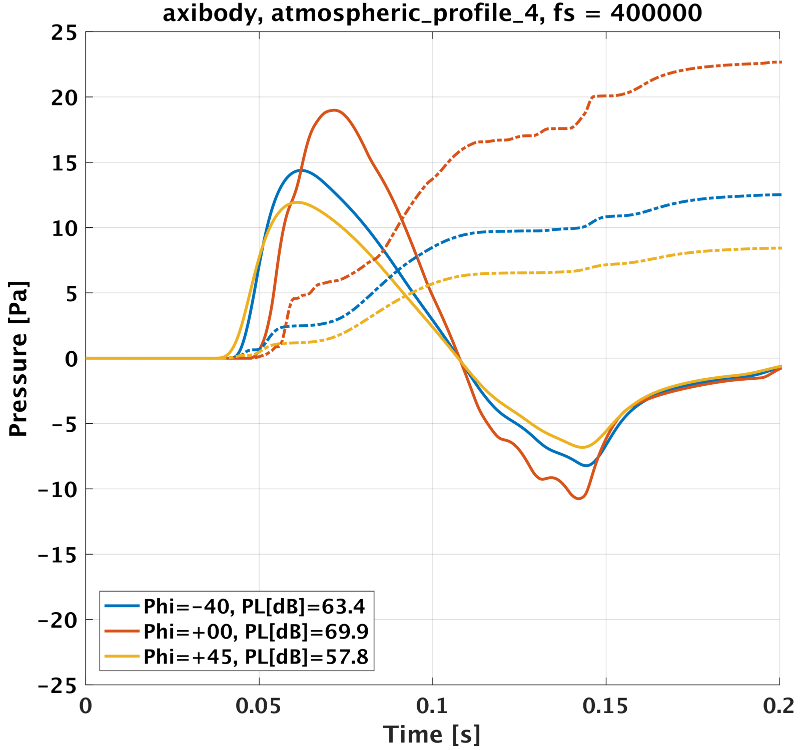

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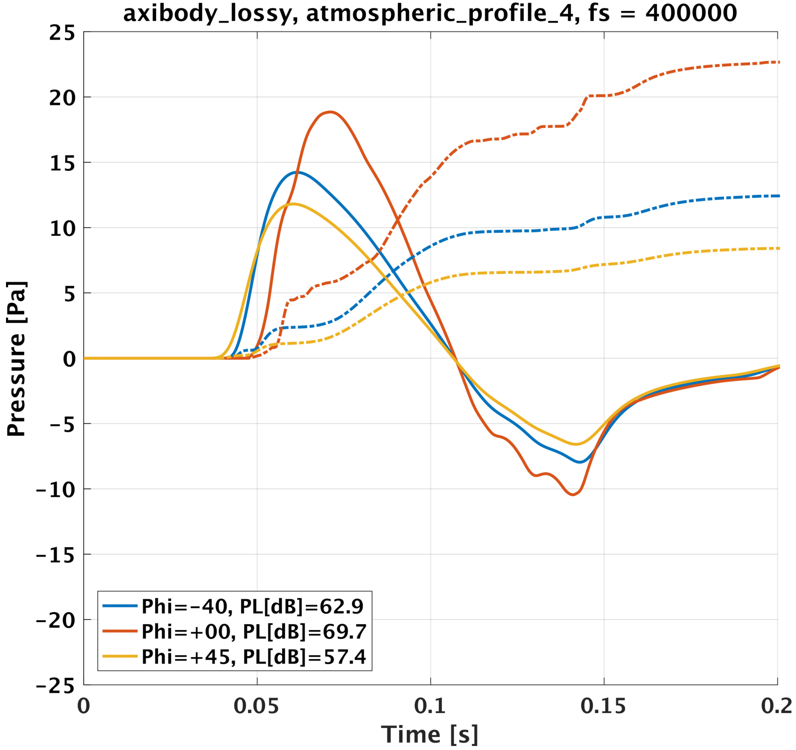

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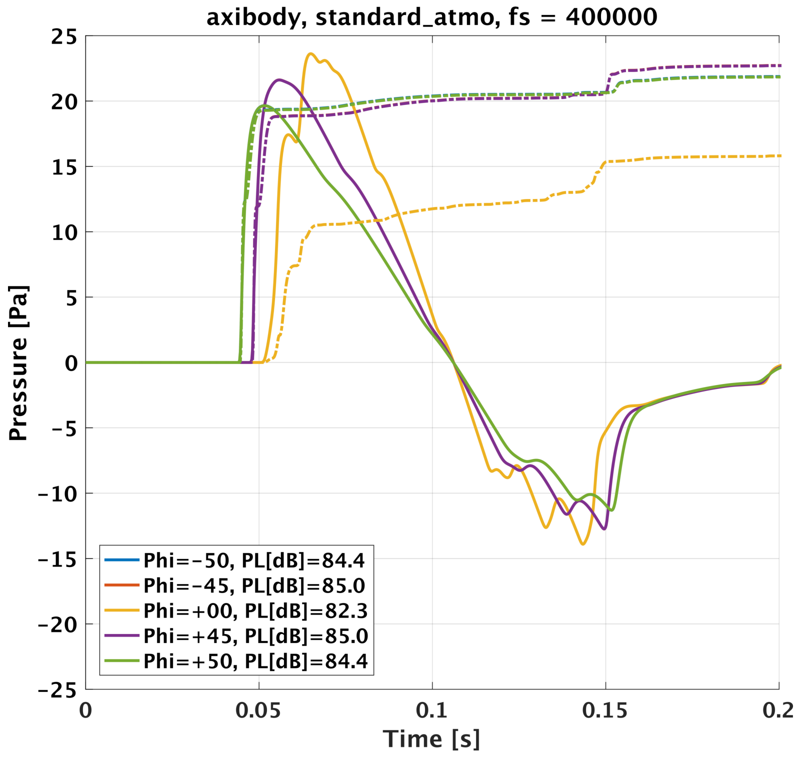

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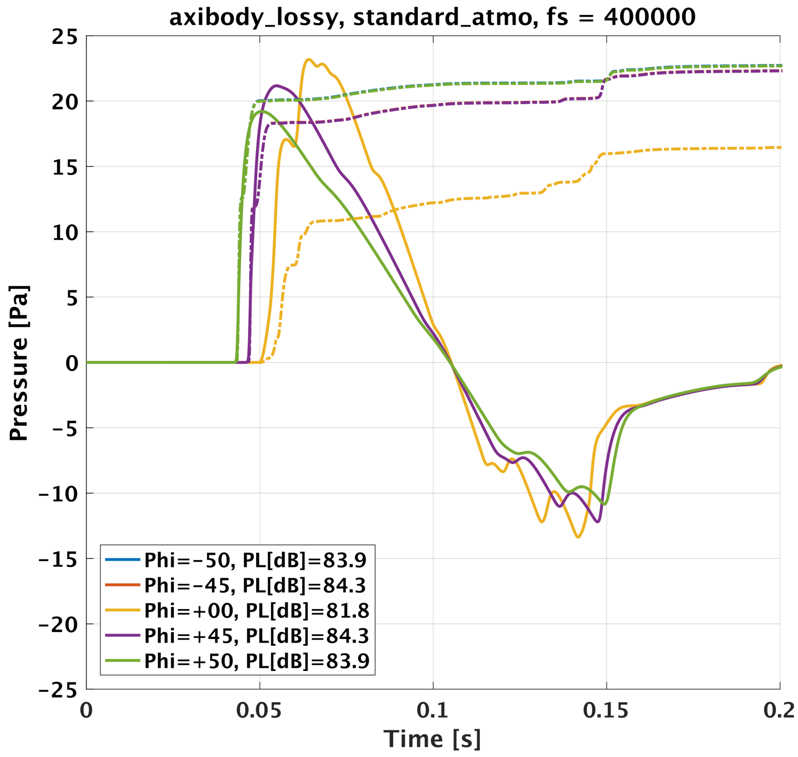

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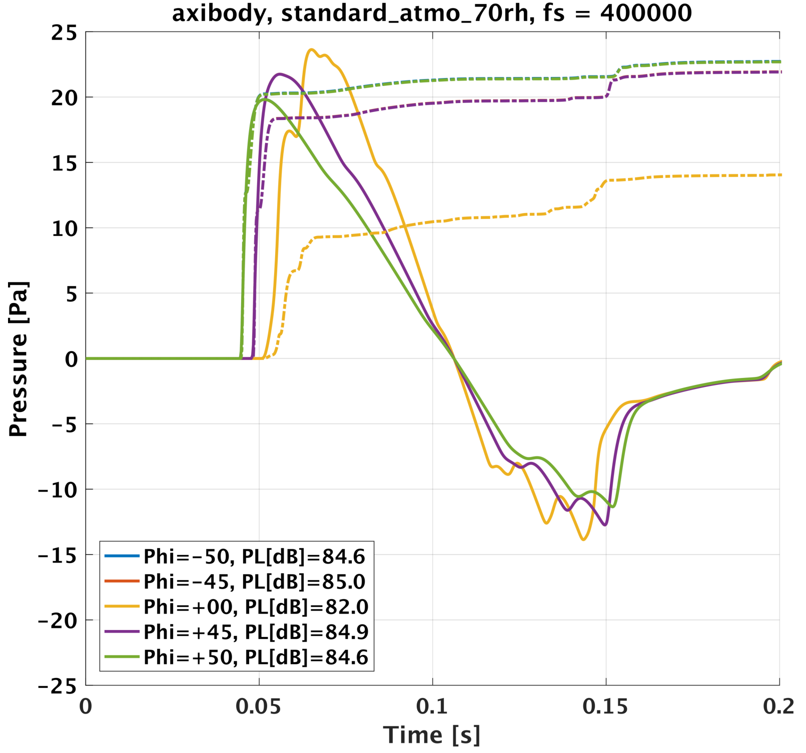

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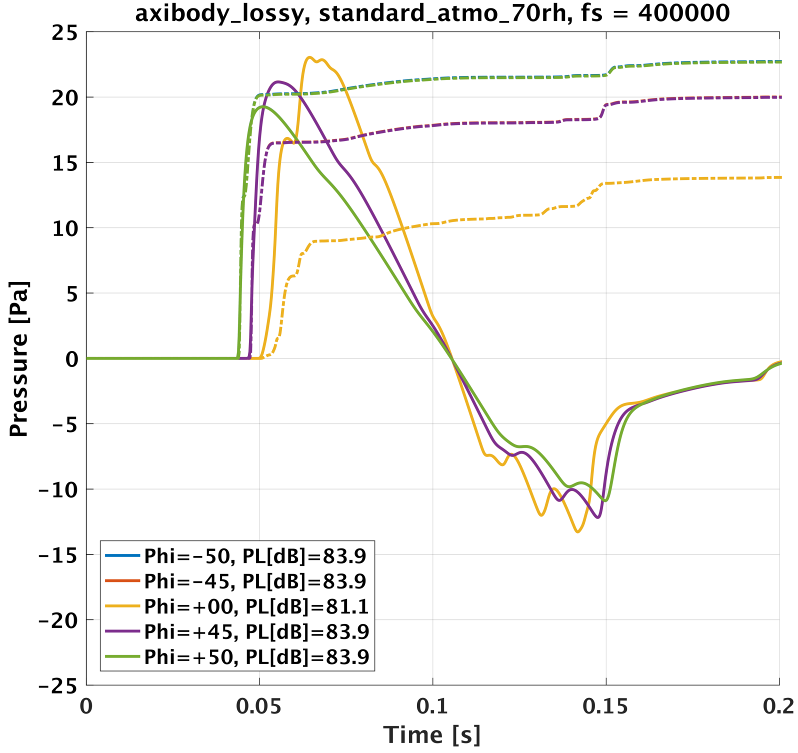

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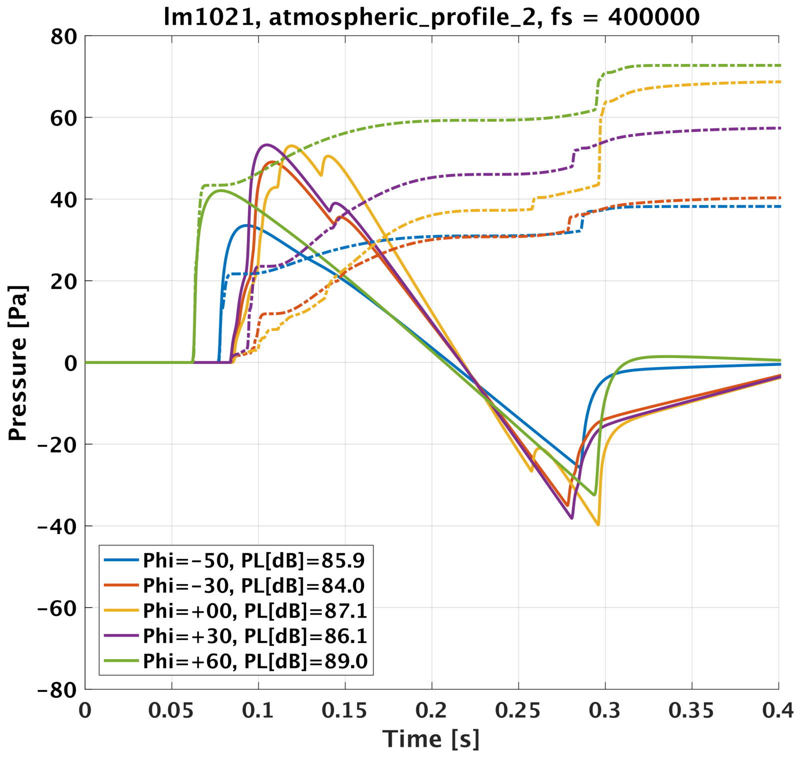

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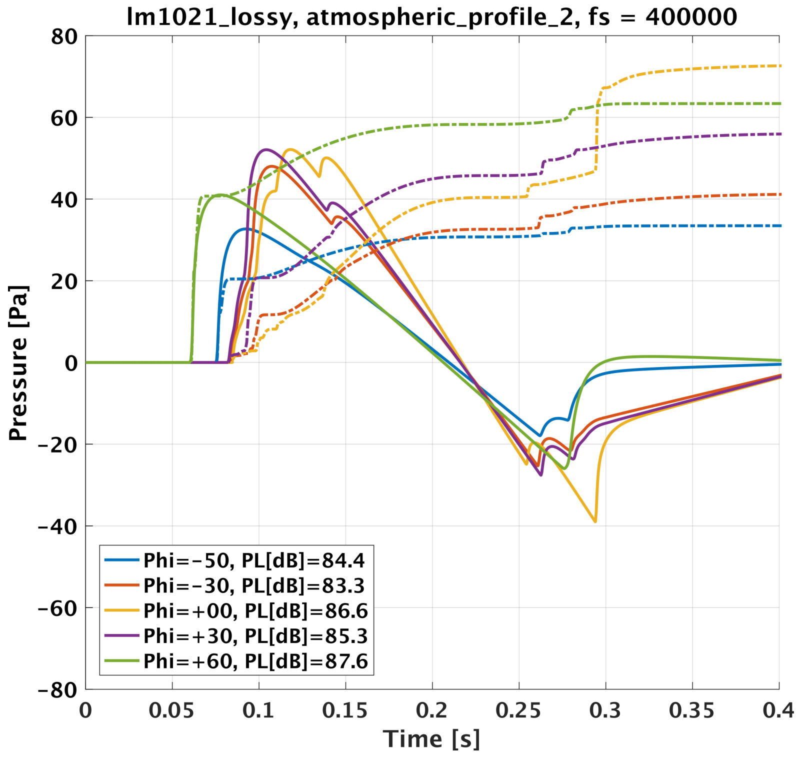

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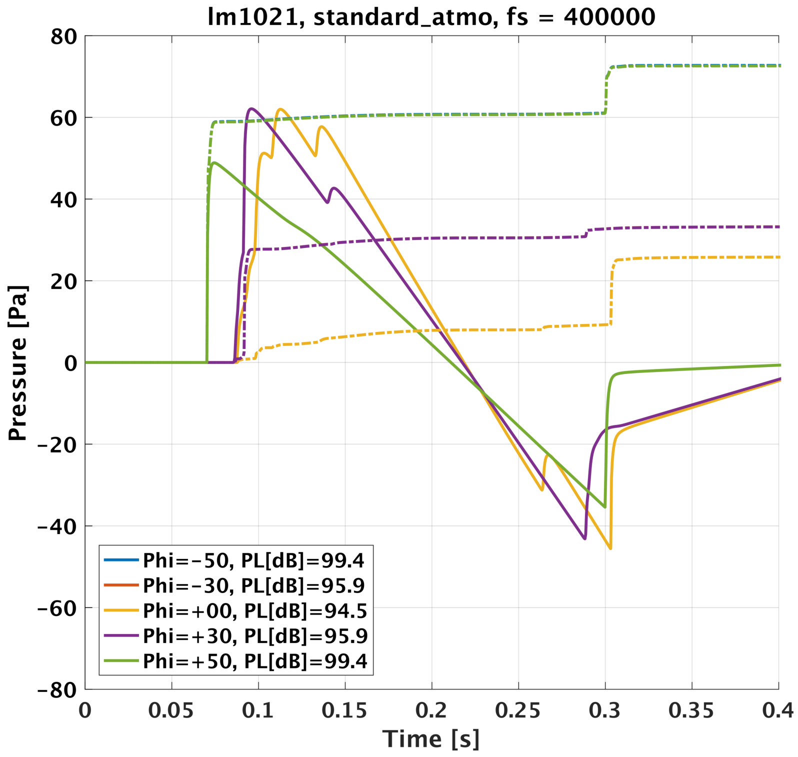

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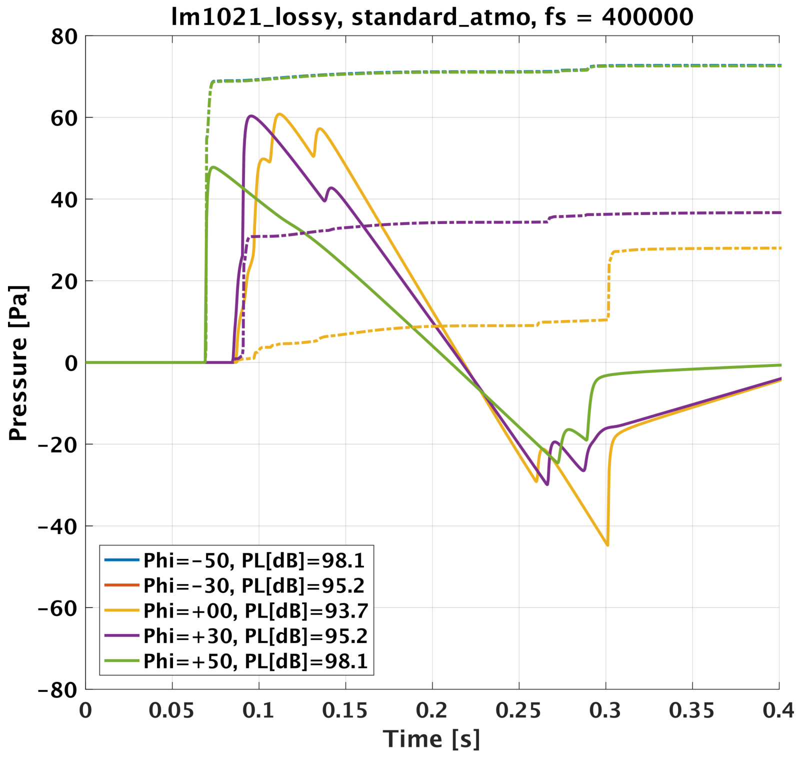

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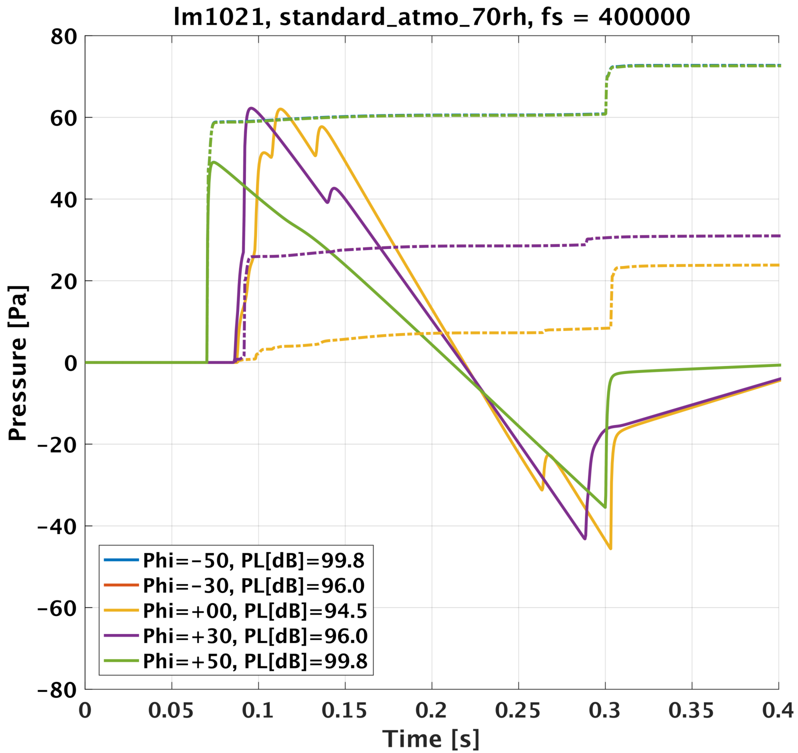

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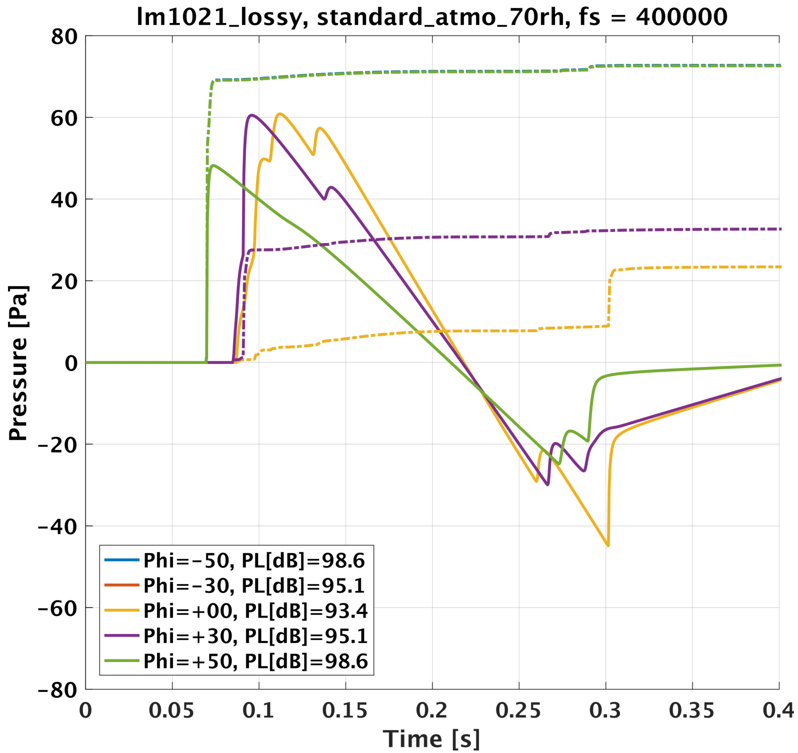

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