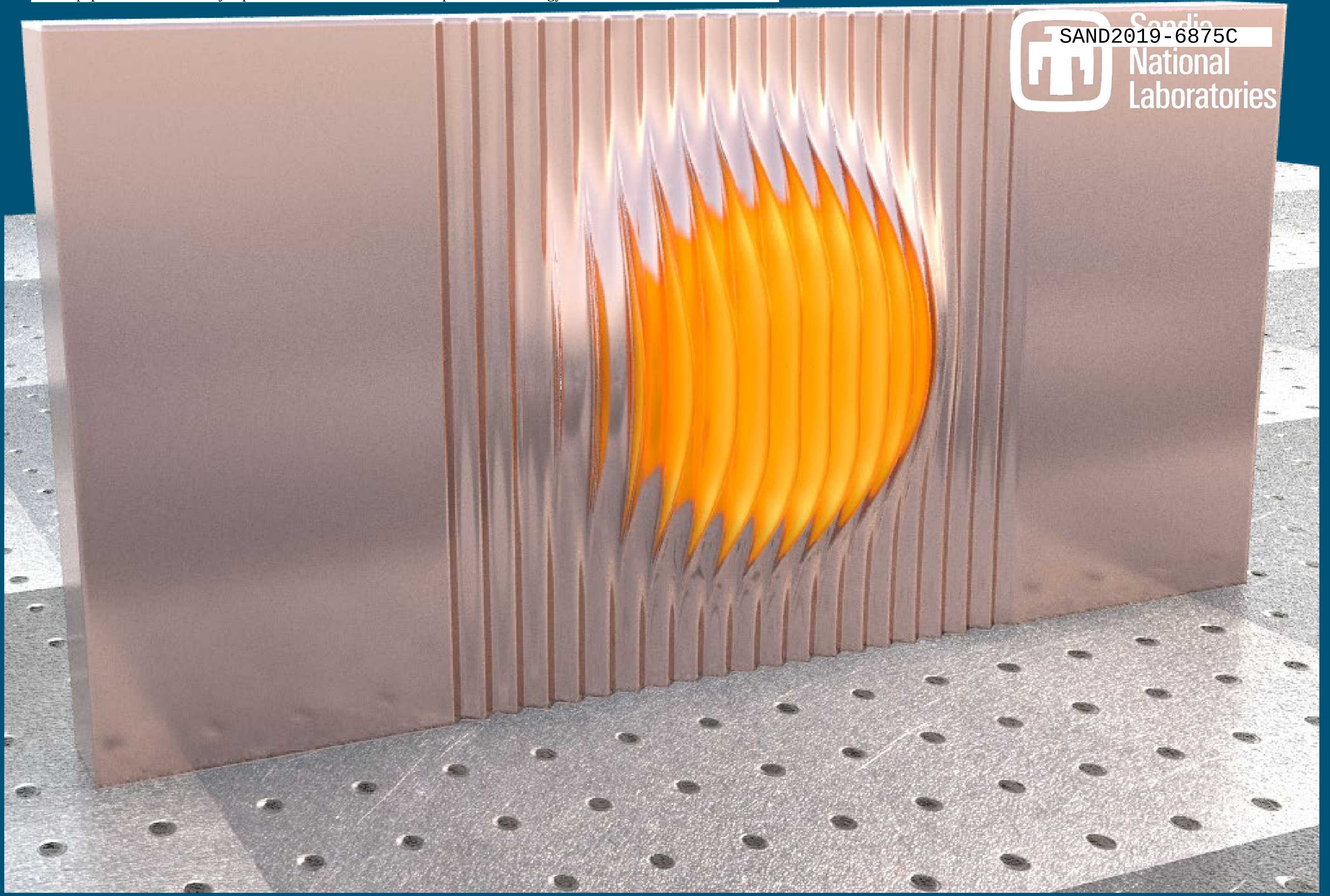
SAND2019-6875C

Validation and Calibration of Metal Strength Models Using Richtmyer-Meshkov Instability Measurements & Simulations



PRESENTED BY

Christopher Garasi

IN COLLABORATION WITH

Joseph Olles, Ryan Coleman

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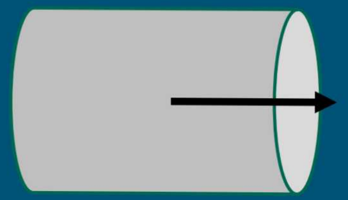
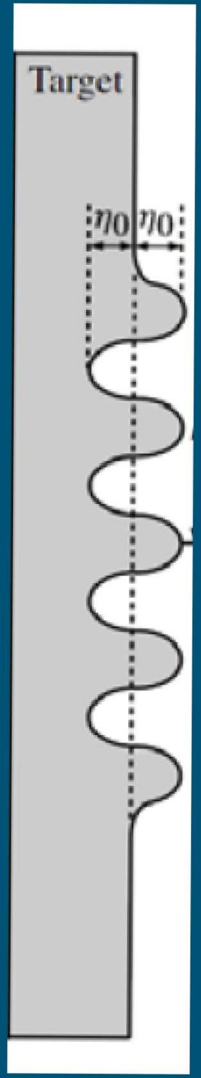
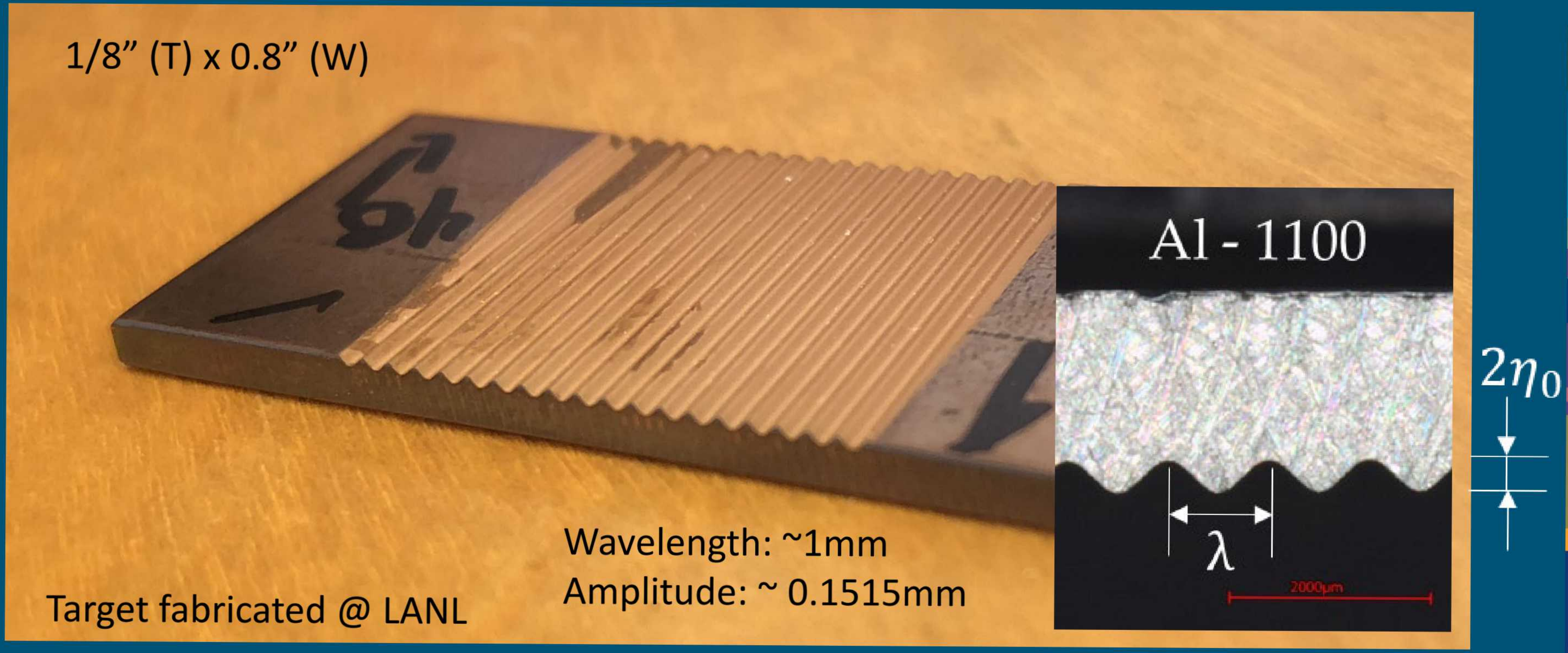
Richtmyer-Meshkov Metal Target Experiments @ APS

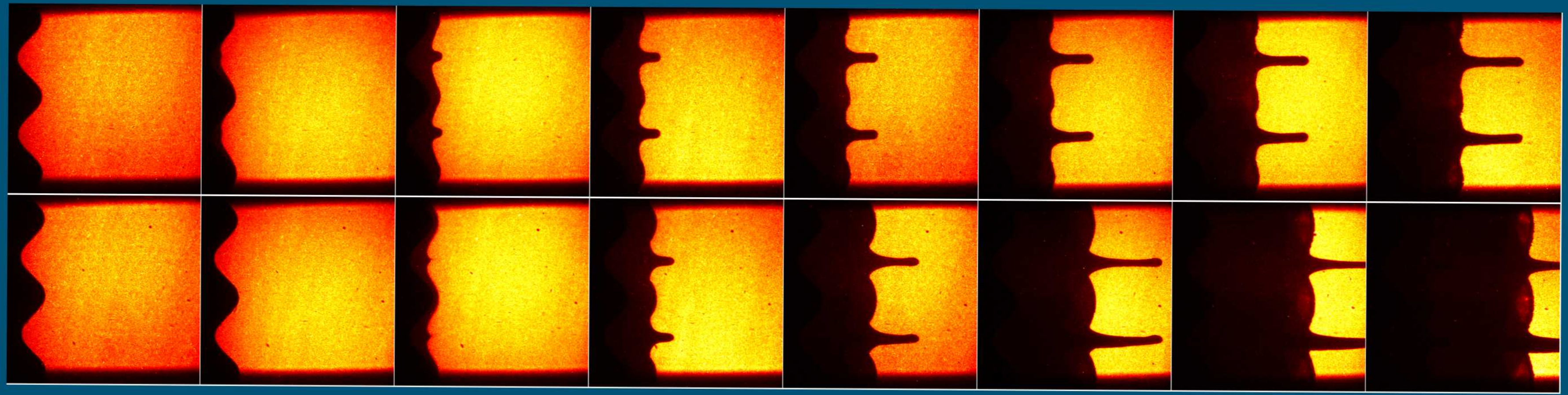
0.4” (D) x 4” (L)



Al on Al
Cu on Cu

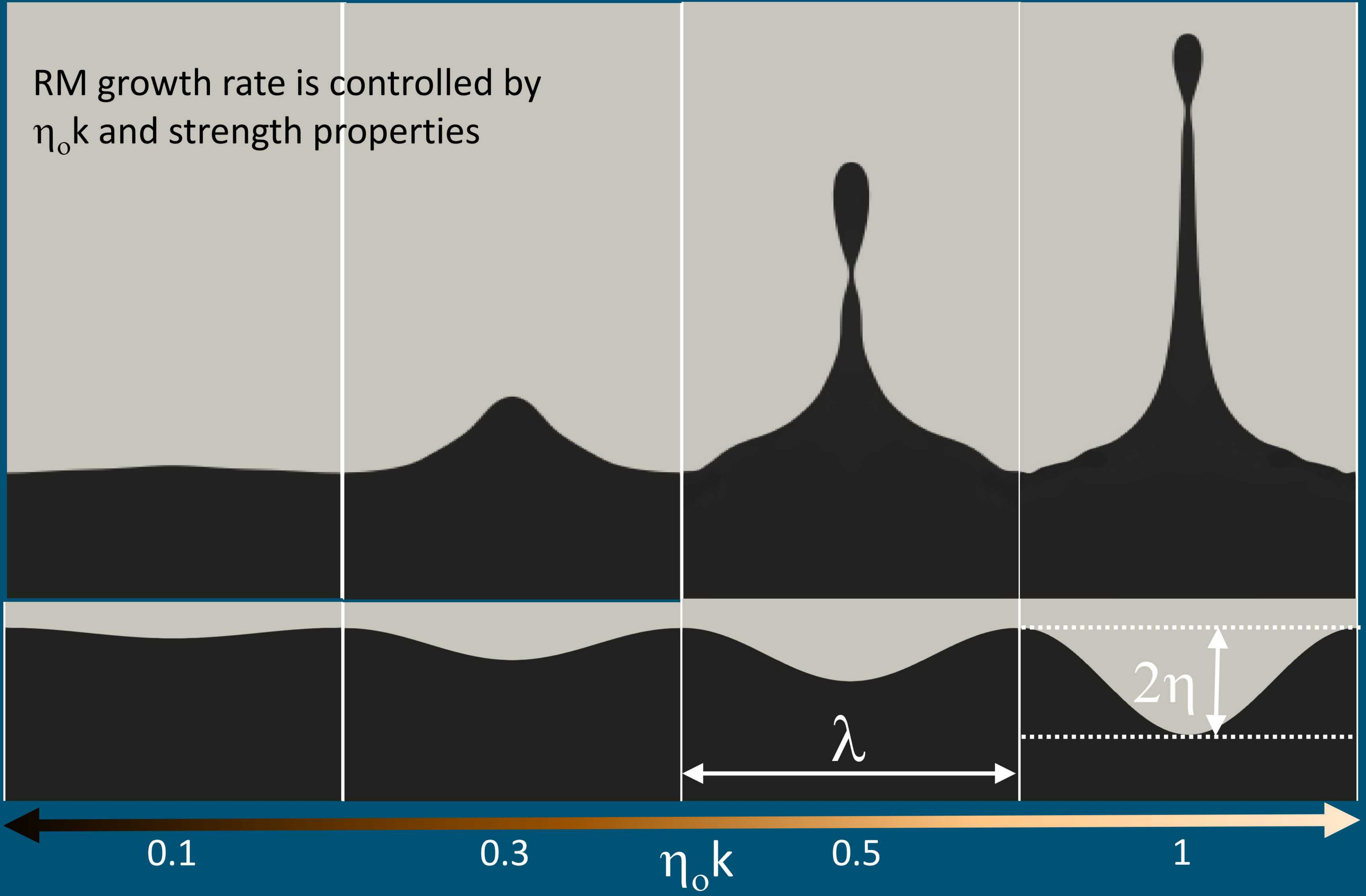




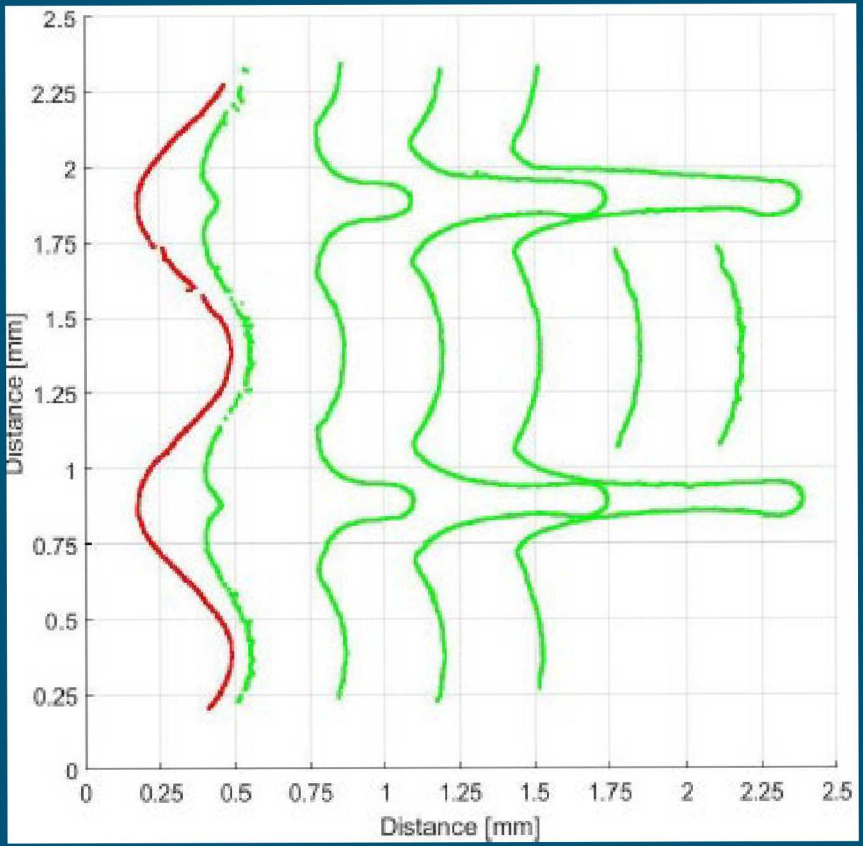


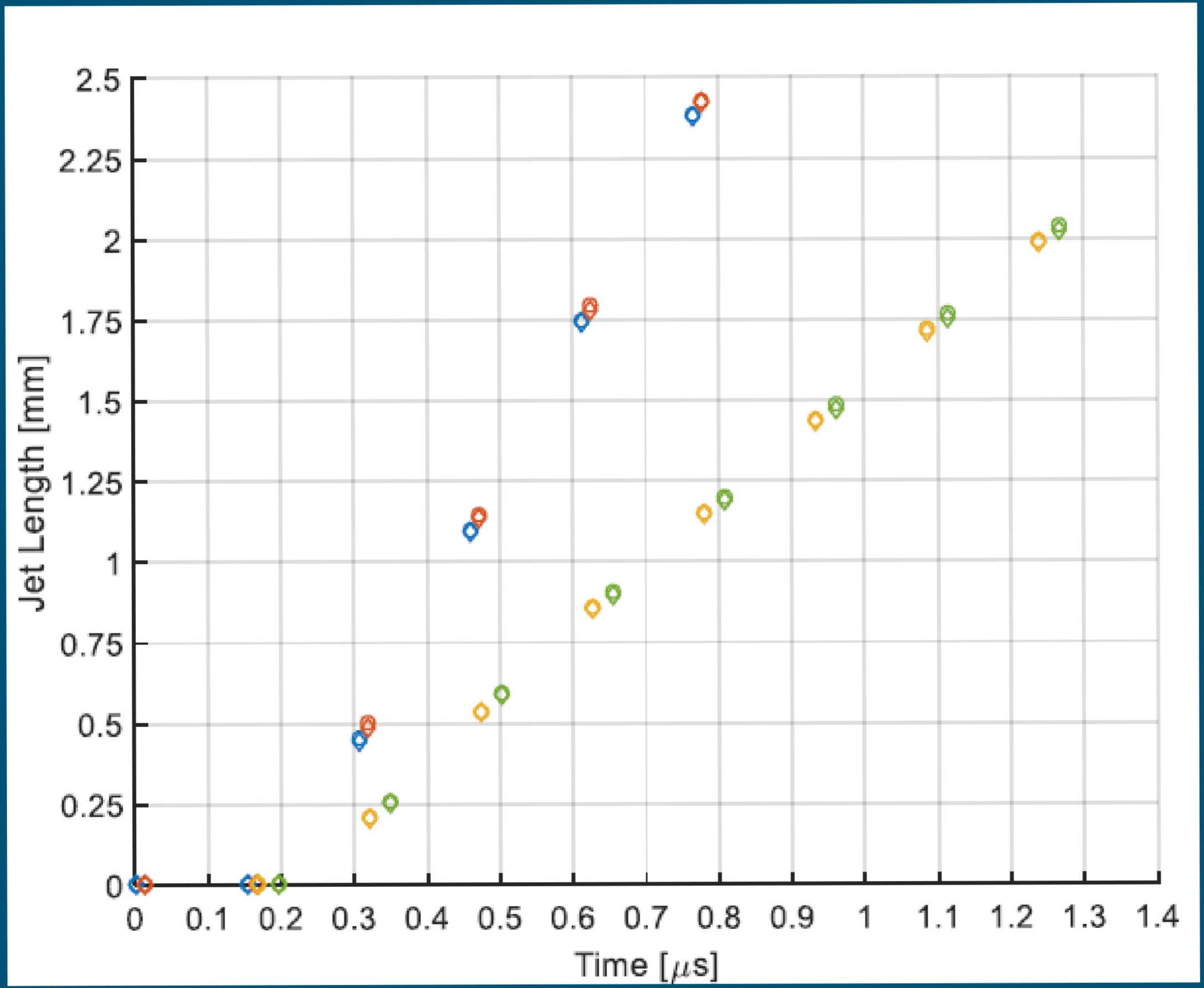
Experiments by Joseph Olles

RM growth rate is controlled by $\eta_o k$ and strength properties



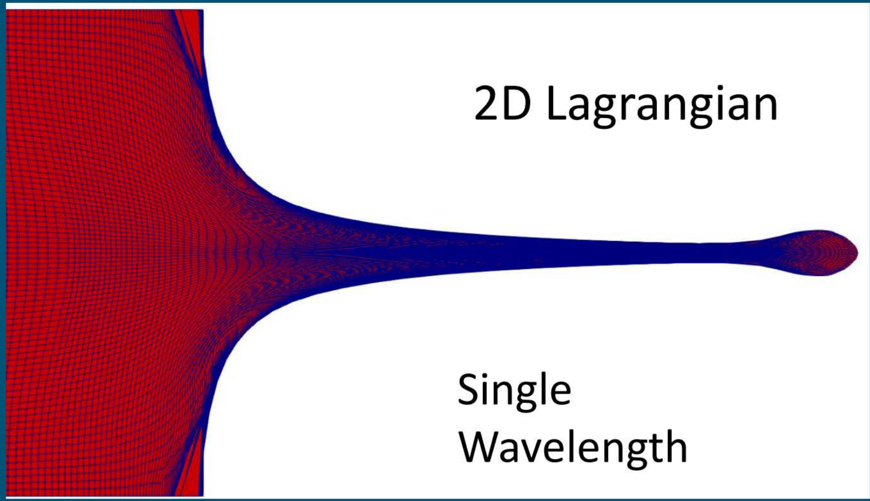
RM Copper Target Experiment Measurements

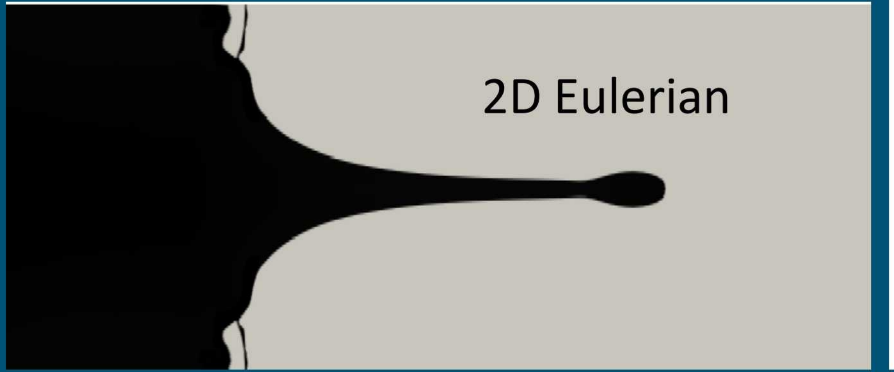




Experiments by Joseph Olles

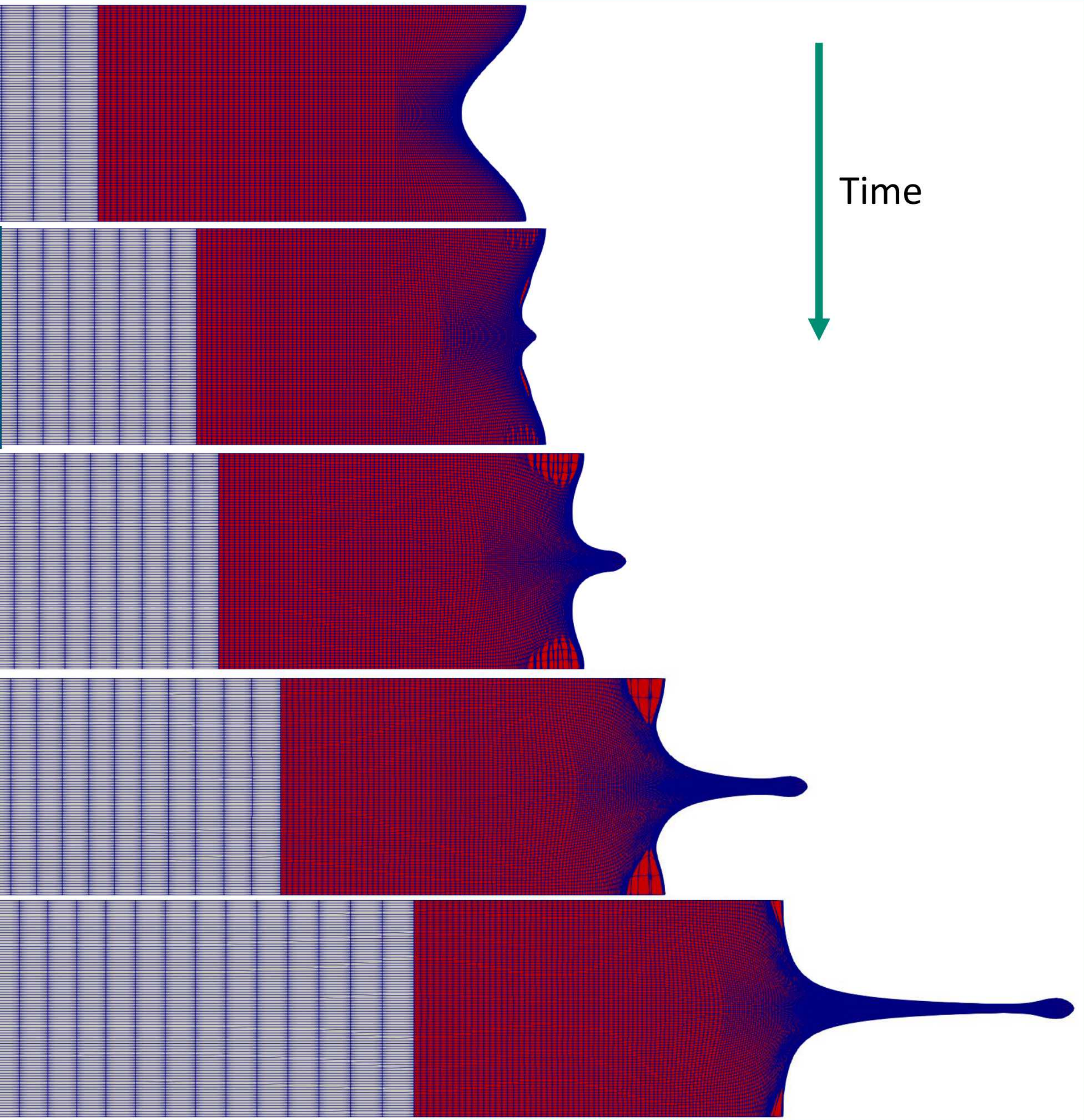
ALEGRA RM Simulation Variations



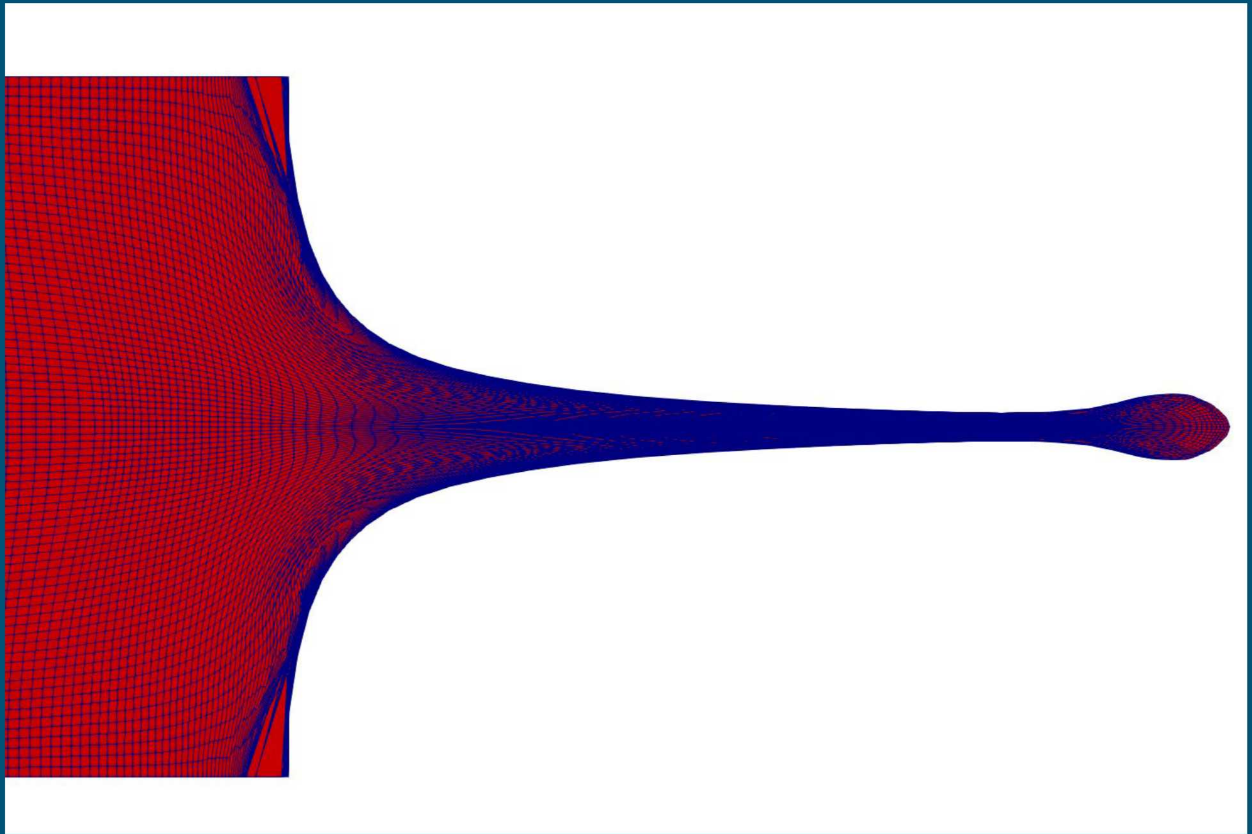


Elastic Perfectly Plastic
Johnson-Cook
Zerilli-Armstrong
Steinberg Guinan Lund
Preston Tonks Wallace

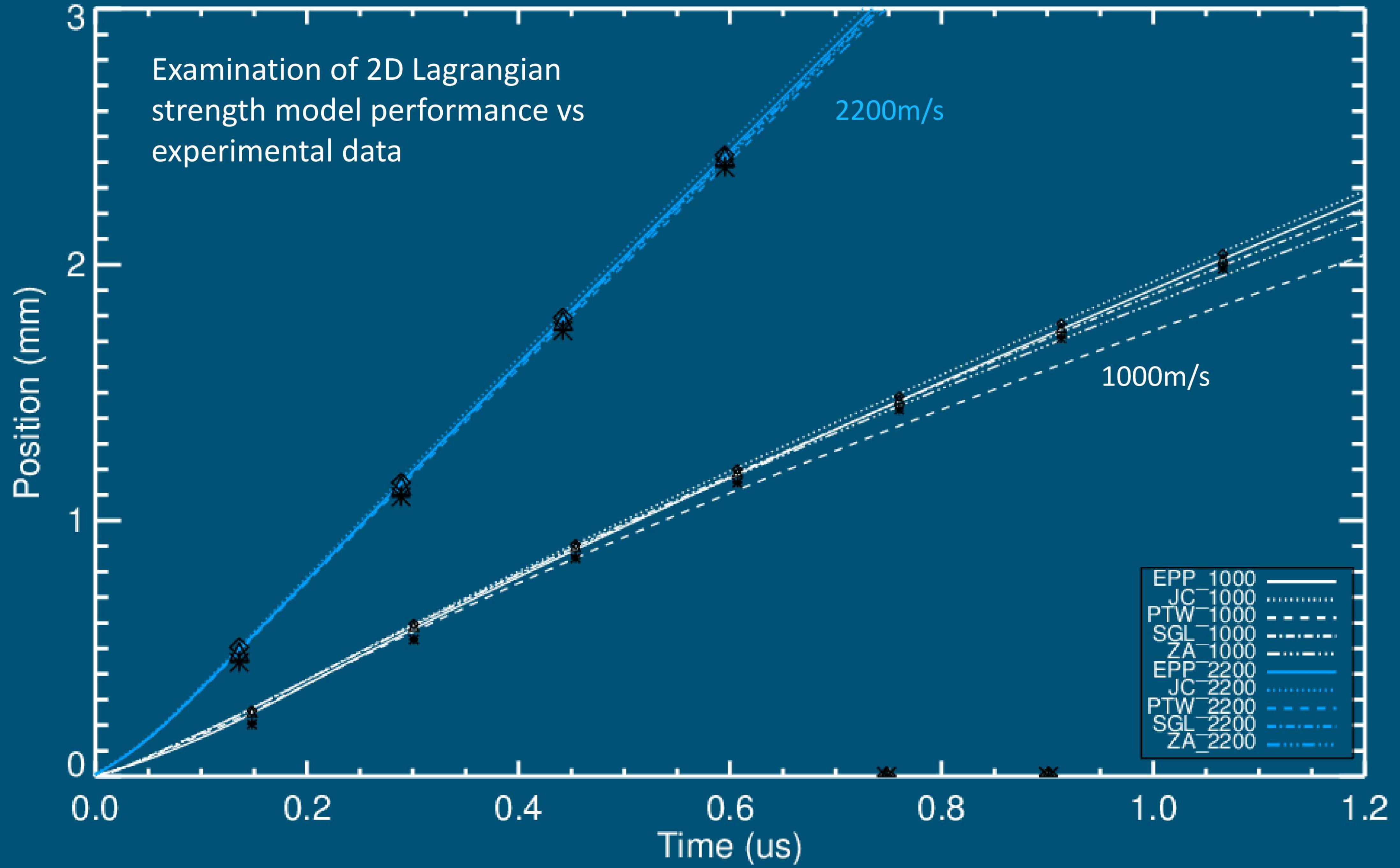
How well do the strength model results compare to the experimental data?



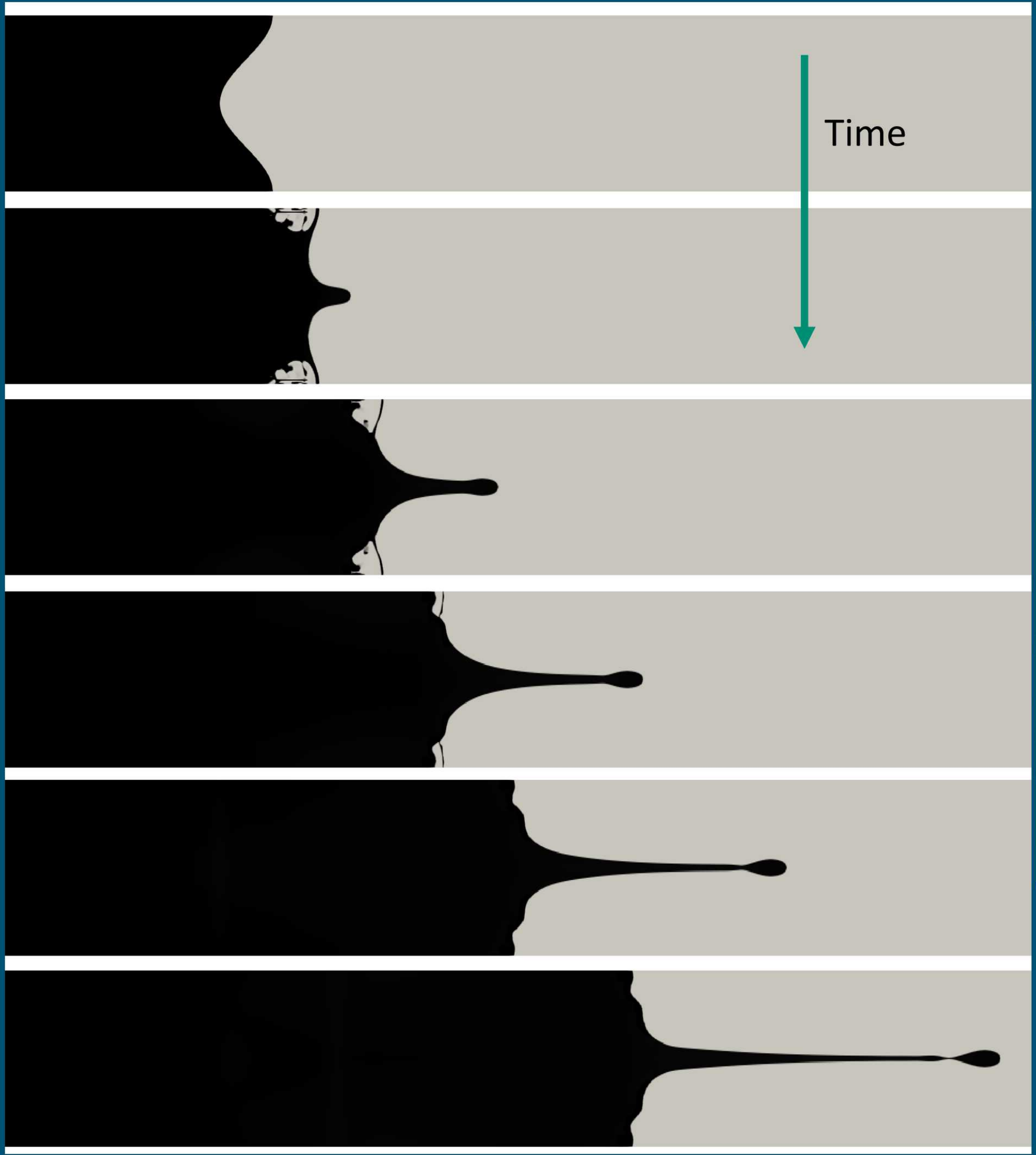
2D Lagrangian Simulation



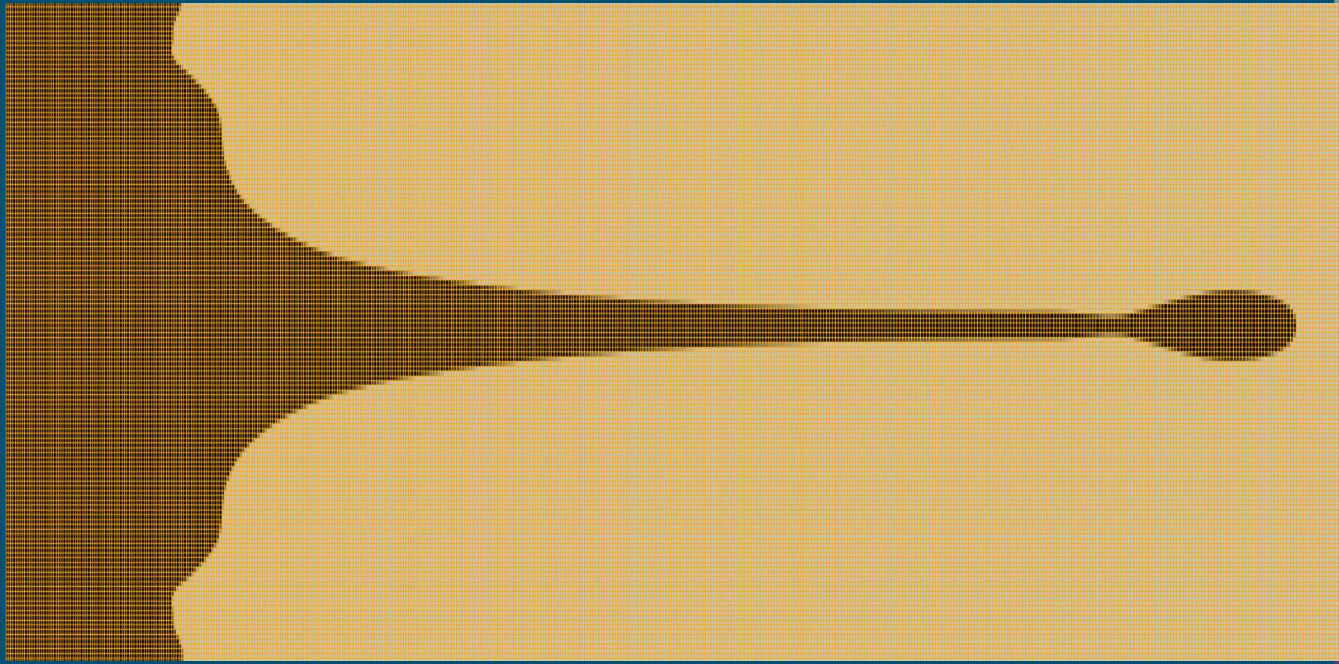
Simulations of increasing resolution were run to demonstrate jet growth convergence



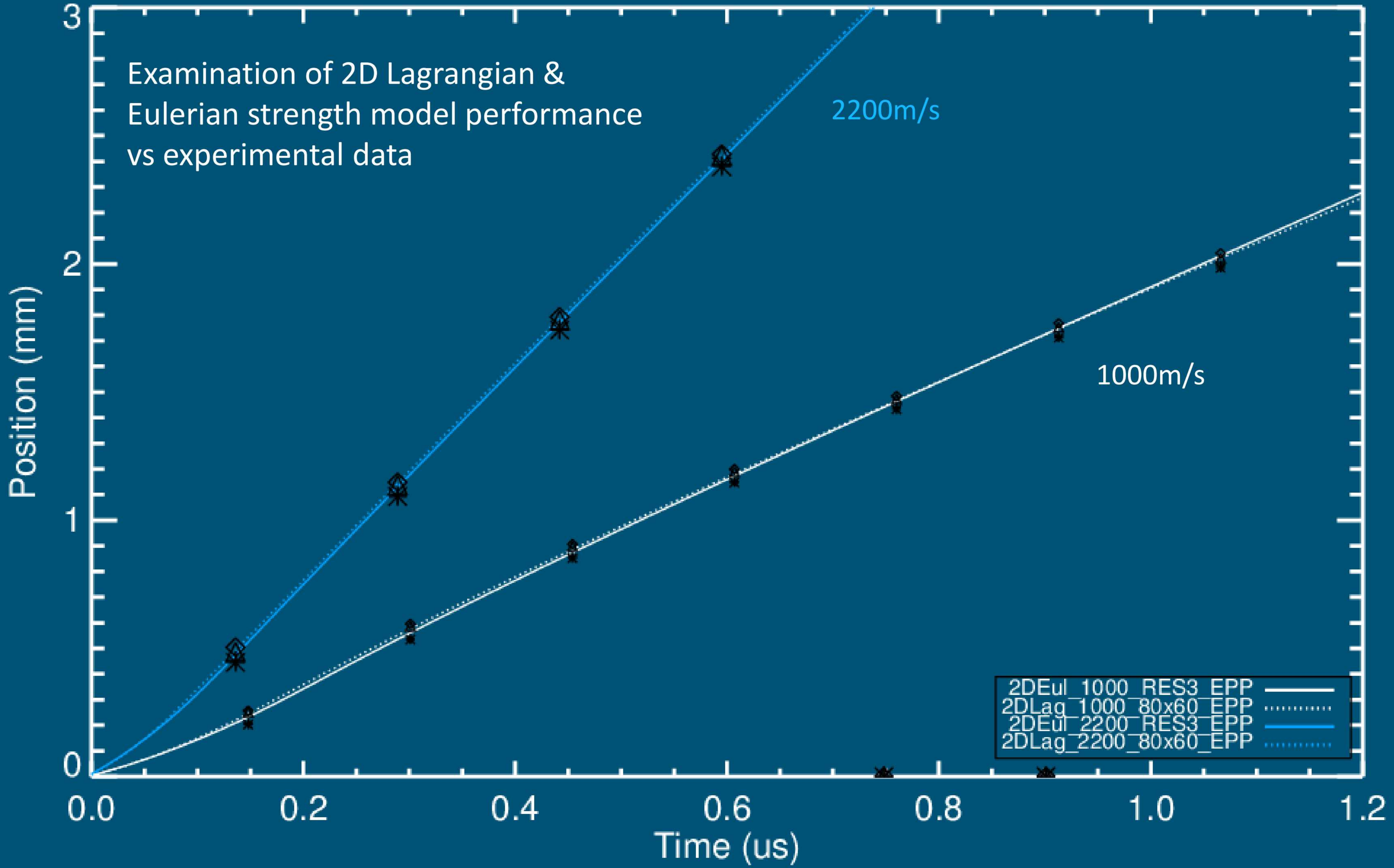
Examination of 2D Lagrangian strength model performance vs experimental data
2200m/s
1000m/s
Position (mm)
Time (us)
0
1
2
3
0.0
0.2
0.4
0.6
0.8
1.0
1.2
EPP_1000
JC_1000
PTW_1000
SGL_1000
ZA_1000
EPP_2200
JC_2200
PTW_2200
SGL_2200
ZA_2200



2D Eulerian Simulation

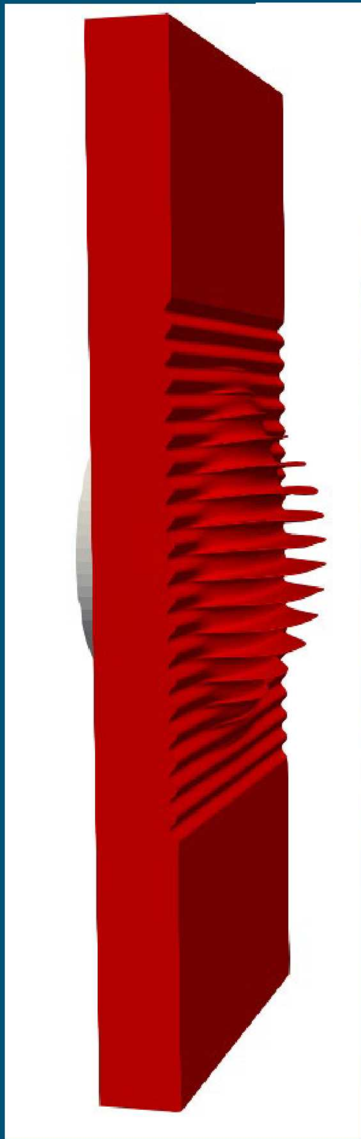


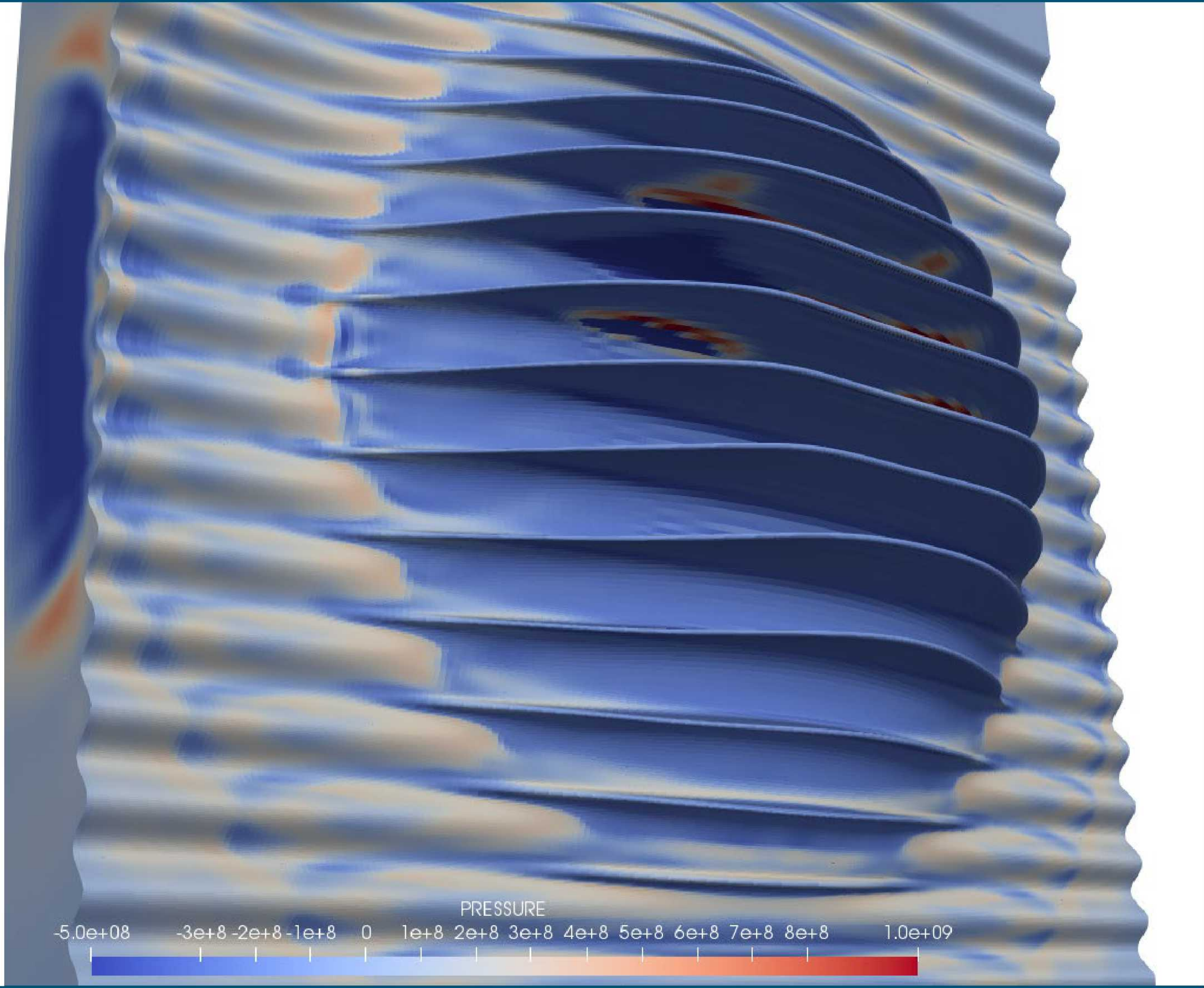
Simulations of increasing resolution were run to demonstrate jet growth convergence



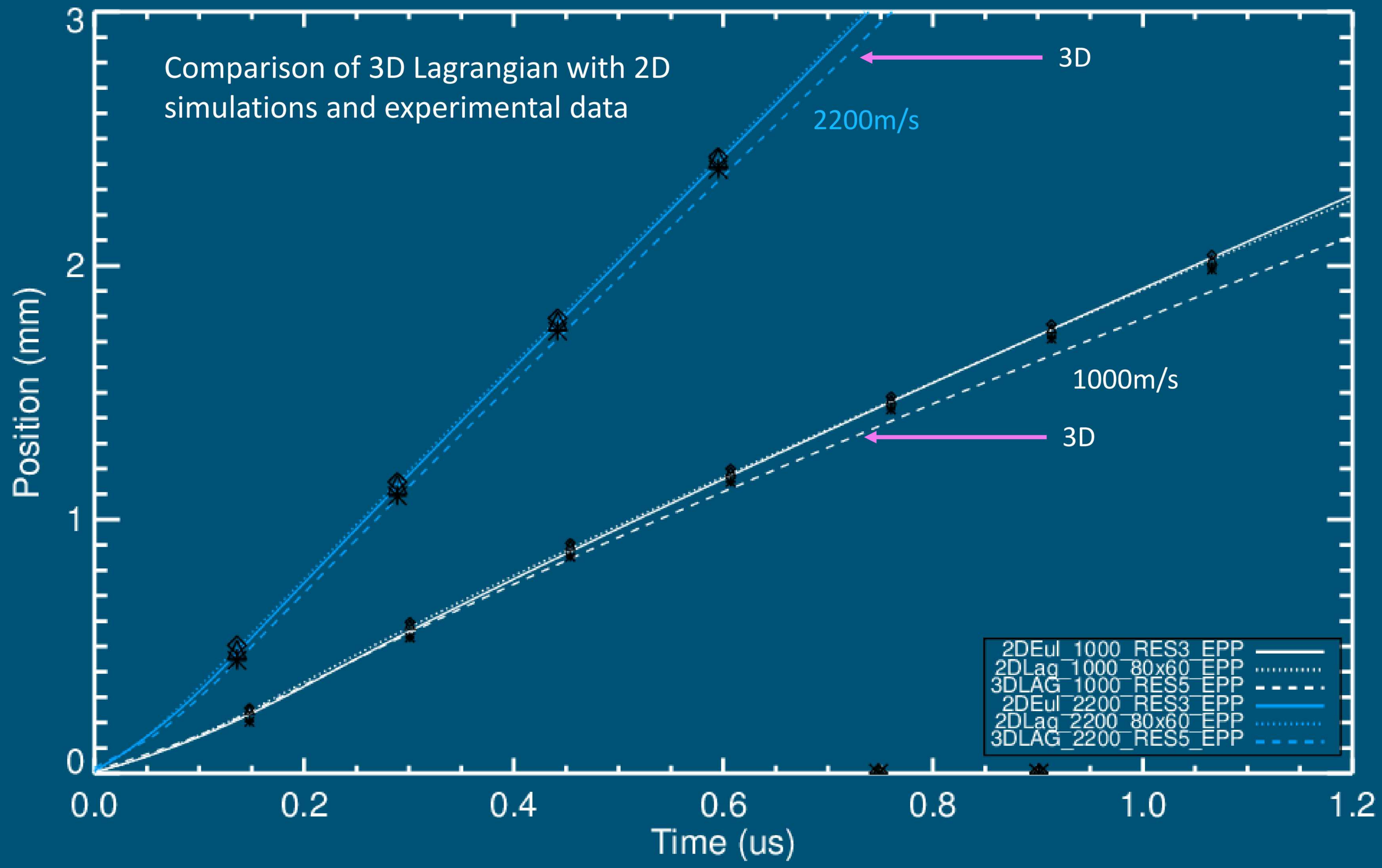
Examination of 2D Lagrangian &
Eulerian strength model performance
vs experimental data
2200m/s
1000m/s
Position (mm)
Time (us)
0
1
2
3
0.0
0.2
0.4
0.6
0.8
1.0
1.2
2DEul_1000_RES3_EPP
2DLag_1000_80x60_EPP
2DEul_2200_RES3_EPP
2DLag_2200_80x60_EPP

3D Lagrangian Simulation

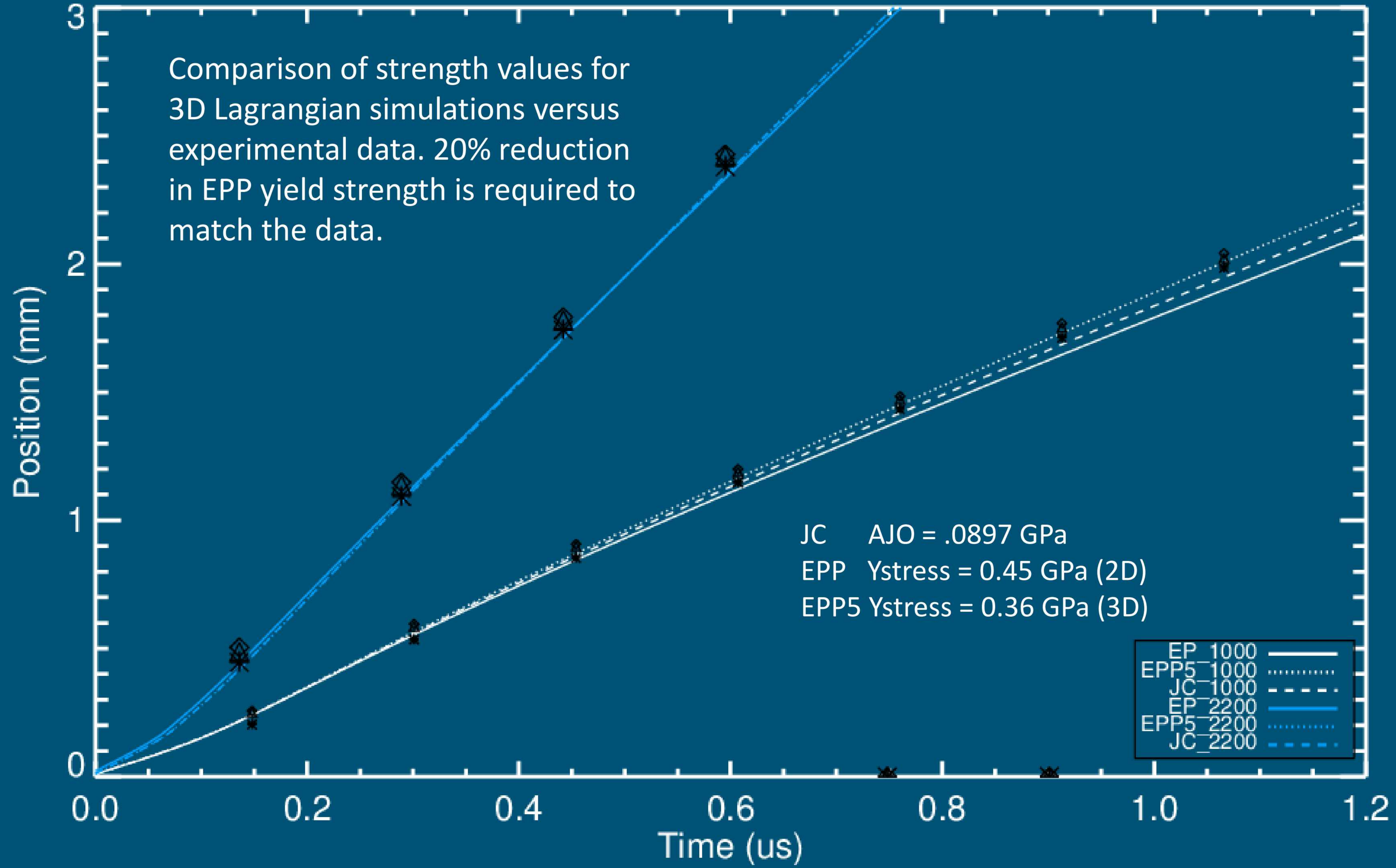




Simulations of increasing resolution were run to demonstrate jet growth convergence

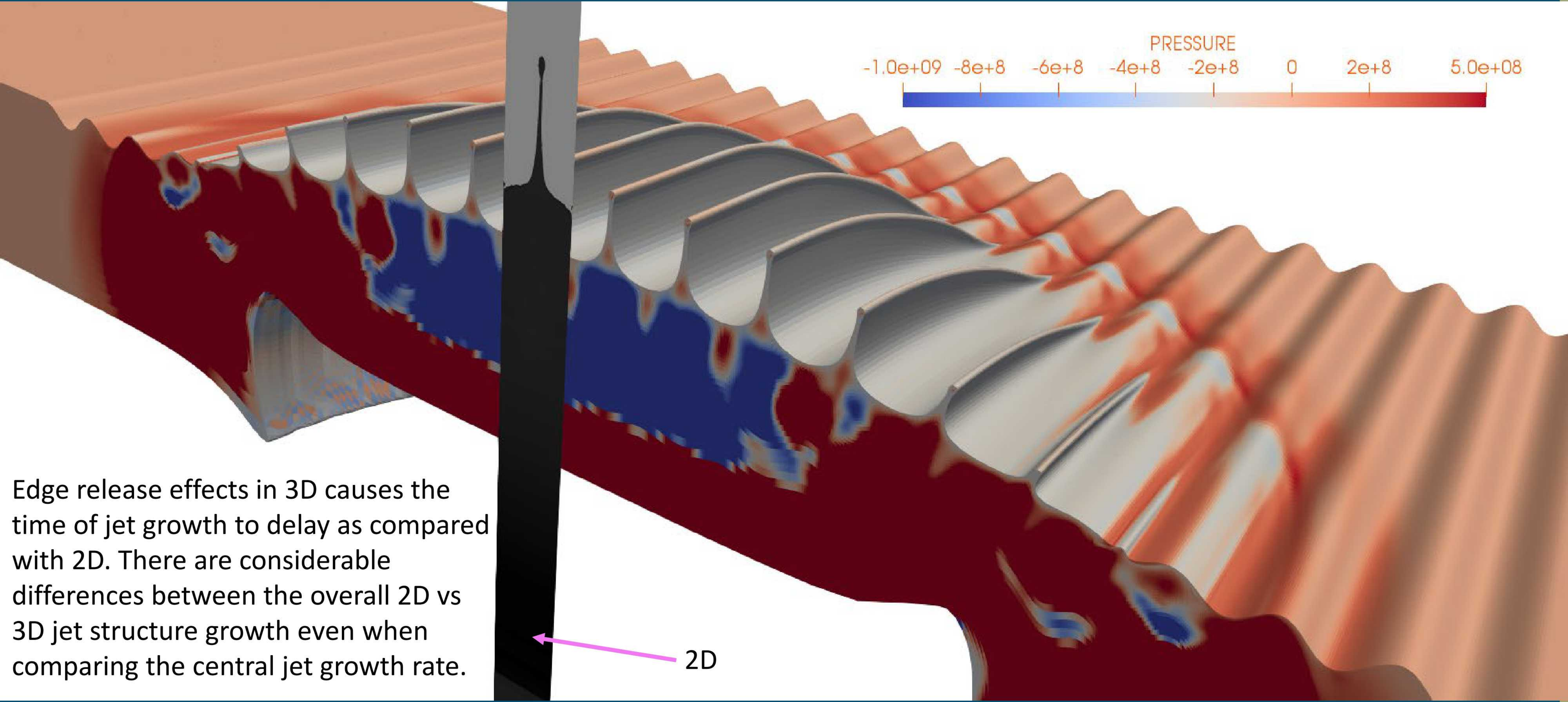


Comparison of 3D Lagrangian with 2D simulations and experimental data
3D
2200m/s
1000m/s
3D
Position (mm)
Time (us)
0
1
2
3
0.0
0.2
0.4
0.6
0.8
1.0
1.2
2DEul_1000_RES3_EPP
2DLag_1000_80x60_EPP
3DLAG_1000_RES5_EPP
2DEul_2200_RES3_EPP
2DLag_2200_80x60_EPP
3DLAG_2200_RES5_EPP

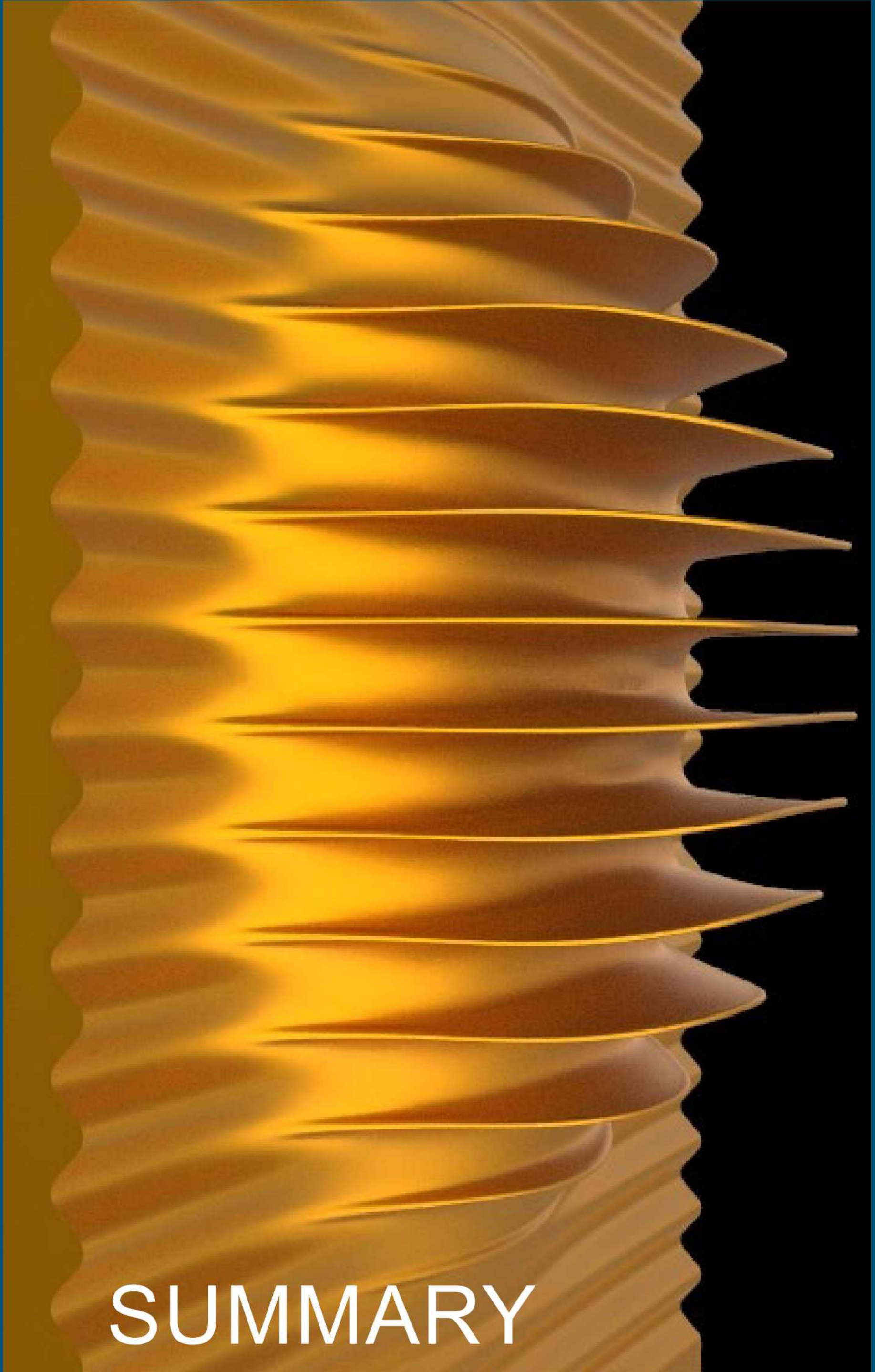


Comparison of strength values for
3D Lagrangian simulations versus
experimental data. 20% reduction
in EPP yield strength is required to
match the data.
JC AJO = .0897 GPa
EPP Ystress = 0.45 GPa (2D)
EPP5 Ystress = 0.36 GPa (3D)
EP_1000
EPP5_1000
JC_1000
EP_2200
EPP5_2200
JC_2200
Position (mm)
Time (us)
0
1
2
3
0.0
0.2
0.4
0.6
0.8
1.0
1.2

Can a 2D Single Wavelength Simulation Accurately Capture the Experiment?



Edge release effects in 3D causes the time of jet growth to delay as compared with 2D. There are considerable differences between the overall 2D vs 3D jet structure growth even when comparing the central jet growth rate.



SUMMARY

Successfully demonstrated resolution convergence for 2D & 3D *single-wavelength* RM simulations.

Of the five strength models tests (EPP, JC, PTW, ZA, SGL) the PTW 2D simulation was an outlier compared with the experimental data. Although EPP is a very simplistic model it could be calibrated to match the RM data within the experiment uncertainty.

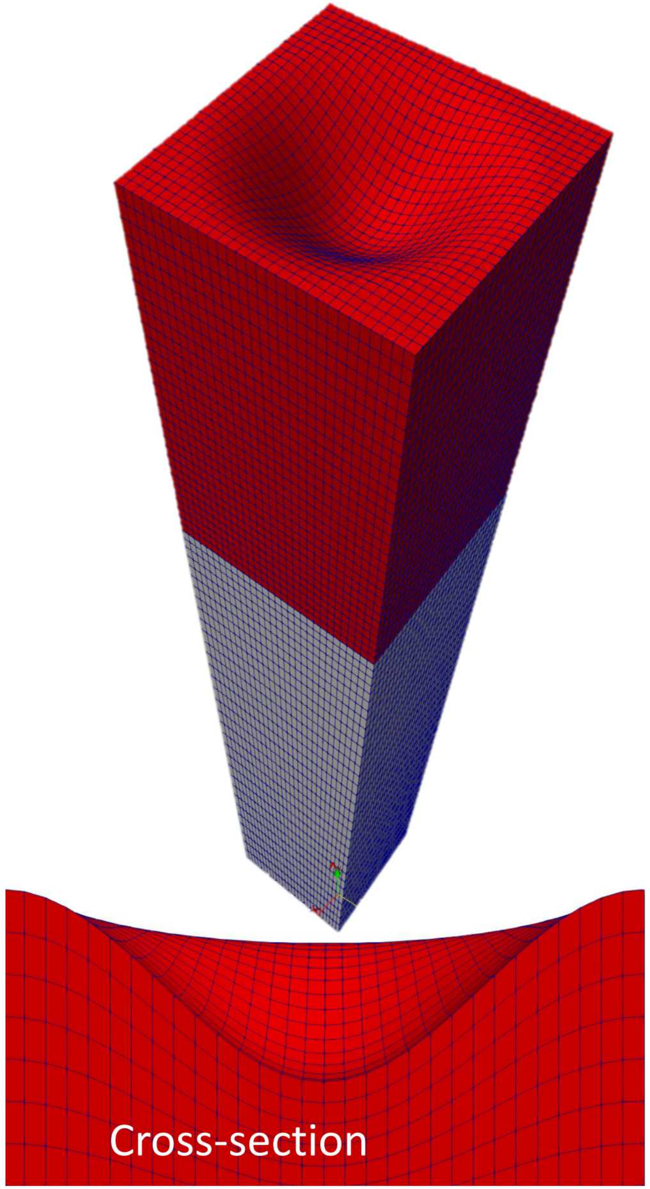
3D Lagrangian simulations of the entire target demonstrate a jet growth behavior different than 2D simulations due to edge effects. A 20% reduction of the EPP model yield strength (vs 2D) was required to match the experimental data. 3D results with JC strength model fell outside of the experimental uncertainty.

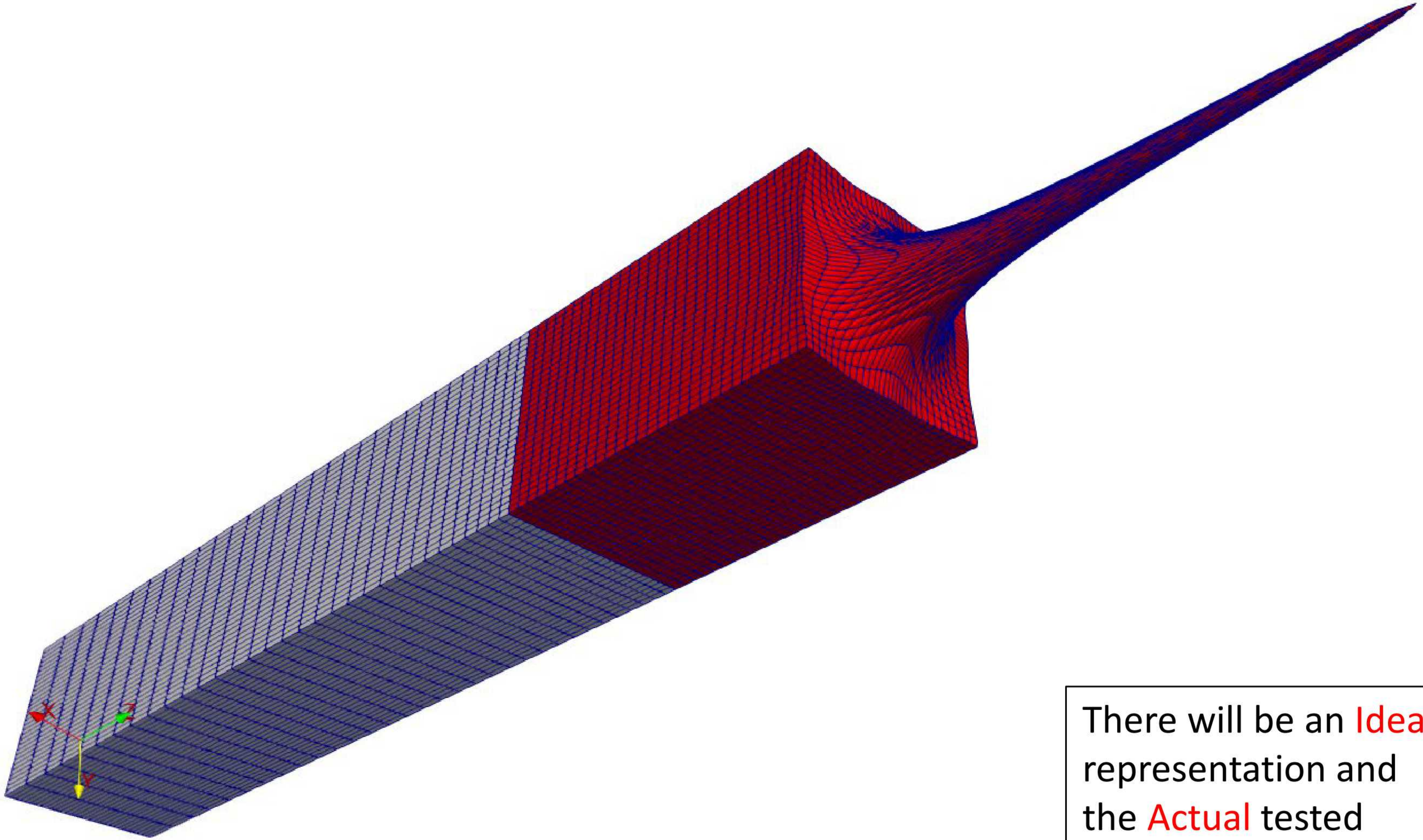
LESSON LEARNED

RM experiments can be used to calibrate strength models however one must be aware of the true 3D nature of the experiment and the impact on calibration for 2D vs 3D simulations.

Metal-on-Metal ALEGRA Lagrangian Meshing

Axisymmetric Sinusoidal Perturbation Initialization





There will be an Ideal representation and the Actual tested configuration

Copper Material Models

JOHNSON-COOK EP

AJO	8.9700e+07
BJO	2.9187e+08
CJO	2.5000e-02
MJO	1.0900e+00
NJO	3.1000e-01
TJO	1.3807e+03
POISSON	3.3300e-01

ZERILLI ARMSTRONG

C1ZE	0.0000e+00
C2ZE	8.9000e+08
C3ZE	2.8001e-03
C4ZE	1.1500e-04
C5ZE	0.0000e+00
AZE	6.5000e+07
NZE	1.0000e+00
POISSON	3.3000e-01

EPP

Yield Stress	(2D) 4.485e+08 (5x) (3D) 3.588e+08 (4x)
POISSON	0.33

Copper Material Models

STEINBERG GUINAN LUND

R0ST	8.9300e+03
TM0ST	1.7899e+03
ATMST	1.5000e+00
GM0ST	2.0200e+00
AST	2.8300e-11
BST	3.7702e-04
NST	4.5000e-01
C1ST	0.0000e+00
C2ST	0.0000e+00
G0ST	4.7700e+10
BTST	3.6000e+01
EIST	0.0000e+00
YPST	0.0000e+00
UKST	0.0000e+00
YSMST	0.0000e+00
YAST	0.0000e+00
Y0ST	1.2000e+08
YMST	6.4000e+08
POISSON	3.3300e-01

PRESTON TONKS WALLACE

ALPHA	2.0000e-01
THETA	2.5000e-02
P	2.0000e+00
S0	8.5000e-03
SINF	5.5000e-04
KAPPA	1.1000e-01
GAMMA	1.0000e-05
Y0	1.0000e-04
YINF	1.0000e-04
Y1	9.4000e-02
Y2	5.7500e-01
BETA	2.5000e-01
TMELT	1.3564e+03
G0	5.1800e+10
AM	1.0552e-25
RAD	1.0000e+00
POISSON	3.3300e-01