Experimental Study of Shock-accelerated Liquid Layers for IFE Reactors

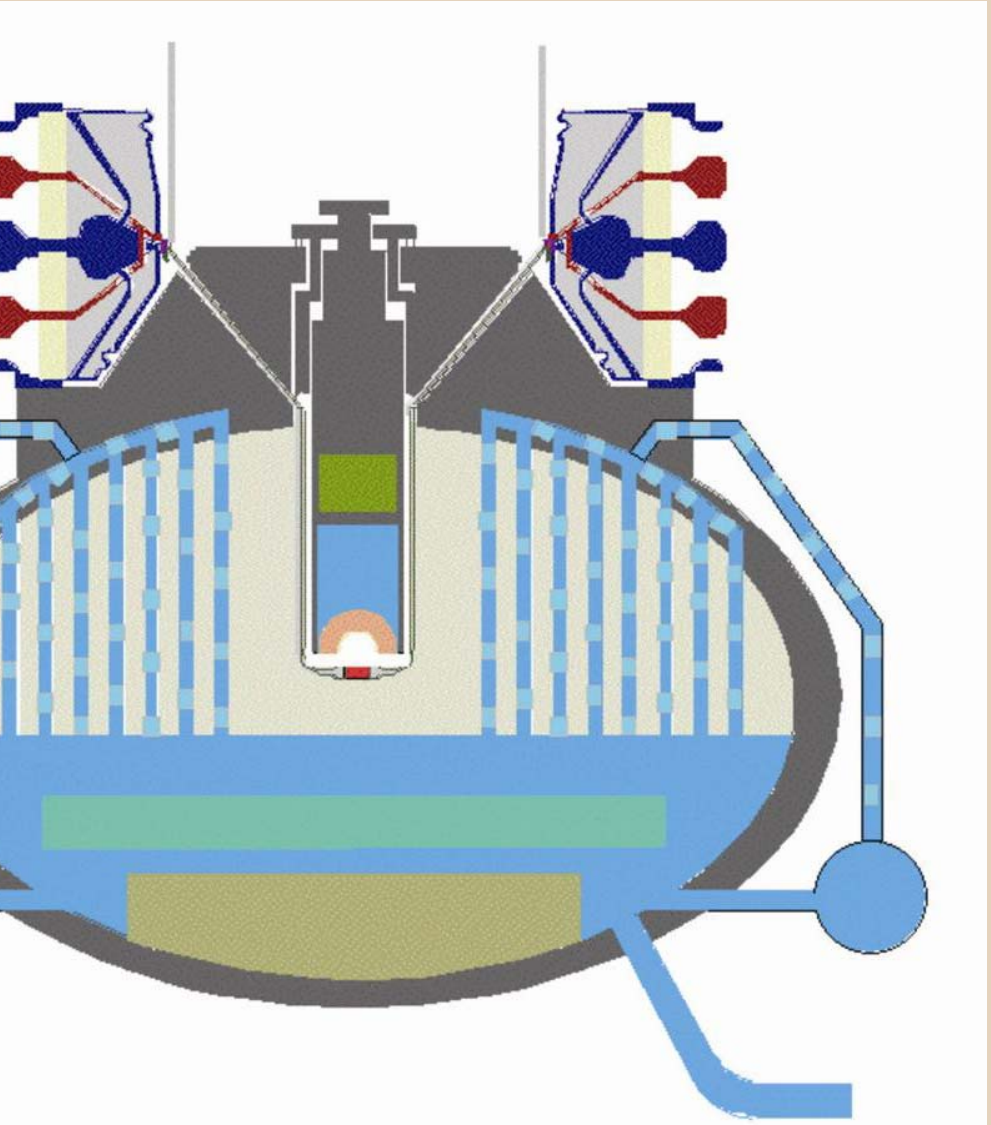
Mark Anderson, Phongsan Meekunnsombat, Jason Oakley
Riccardo Bonazza

Department of Engineering Physics

Fusion Technology Institute

University of Wisconsin-Madison

ctors



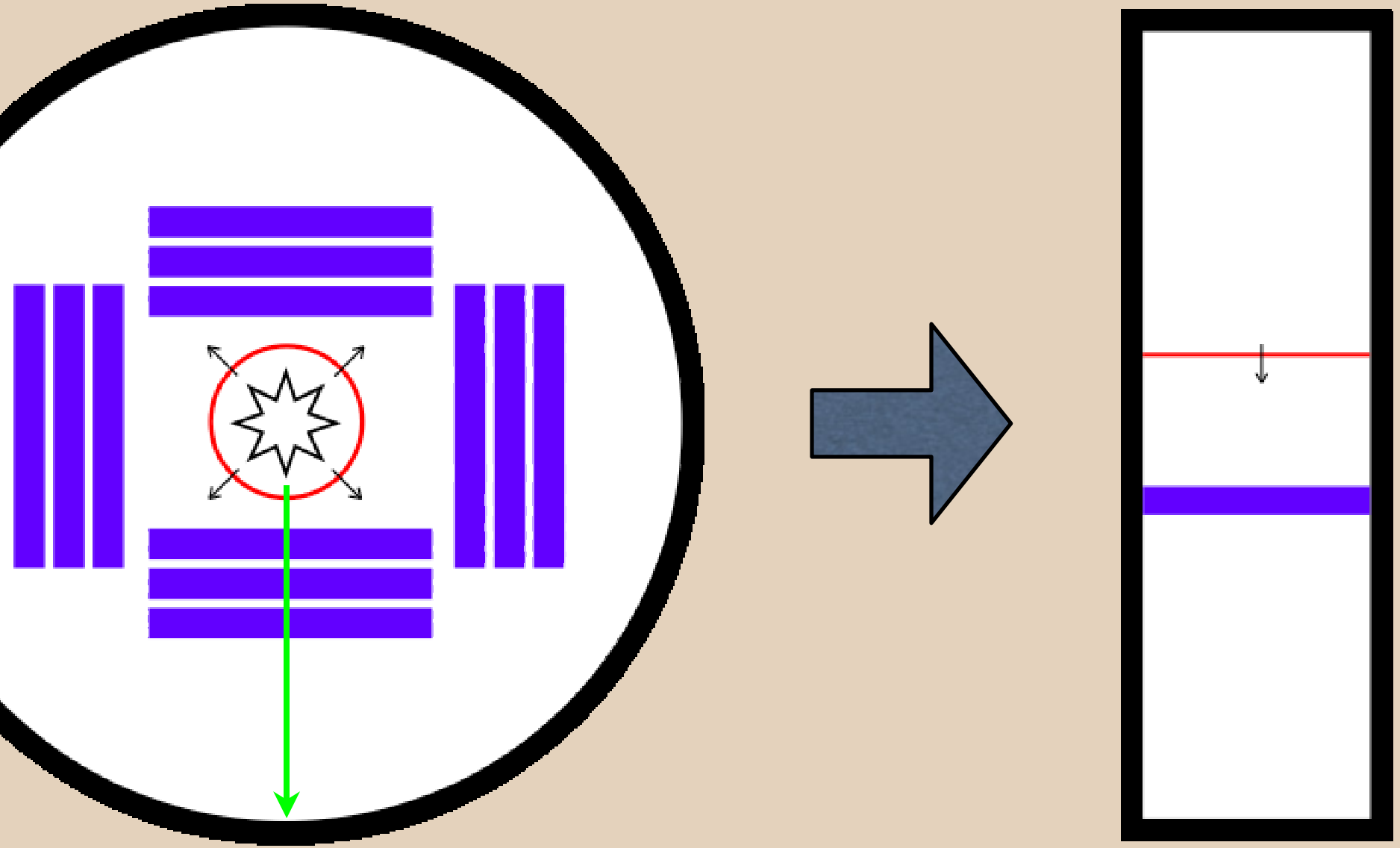
- High density energy pu
compresses the fuel

- Very strong shock wav
propagates outward

- Cyclic process

- Liquid wall absorb the
and protect the chamber v

Motivation

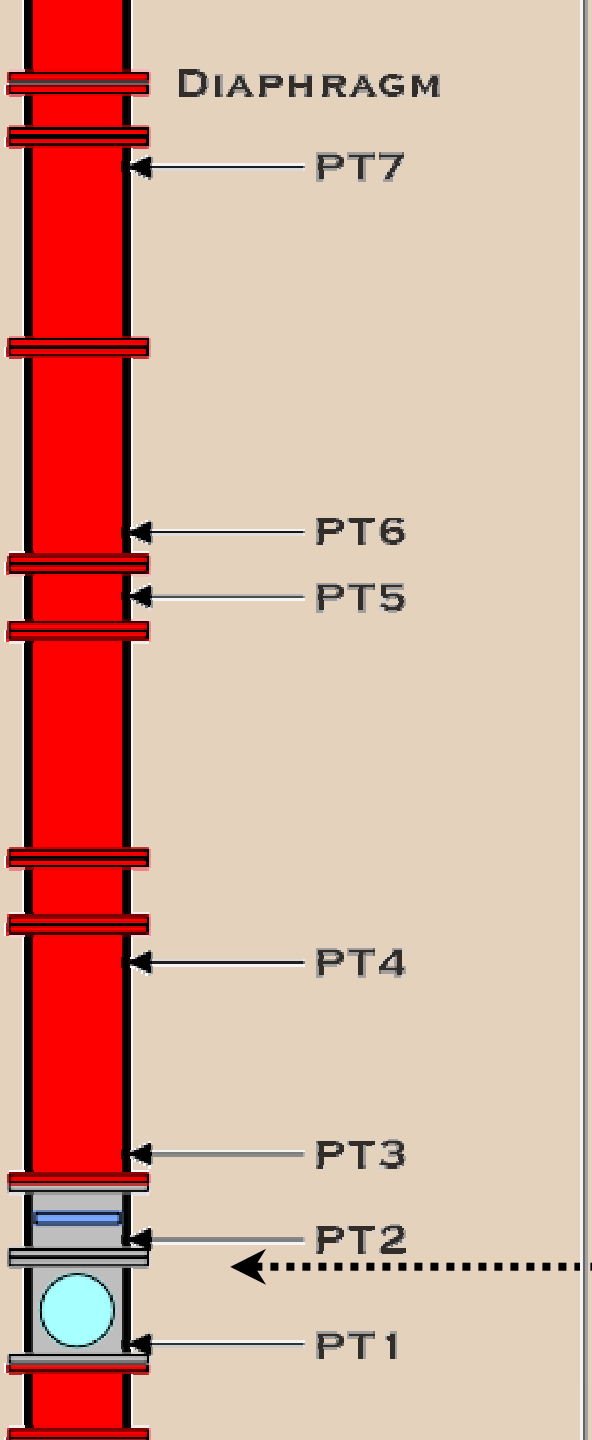


Objectives

To study the fragmentation of the liquid layer(s) when subjected to a shock wave

To study the effect of the shocked liquid layer(s) to the end-wall impulse loading

To provide benchmark data for future numerical simulations

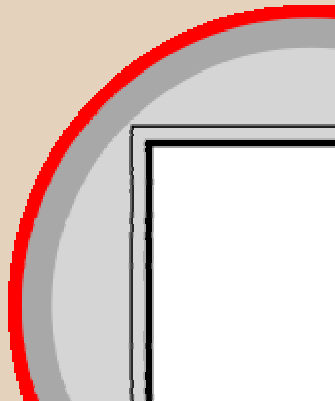


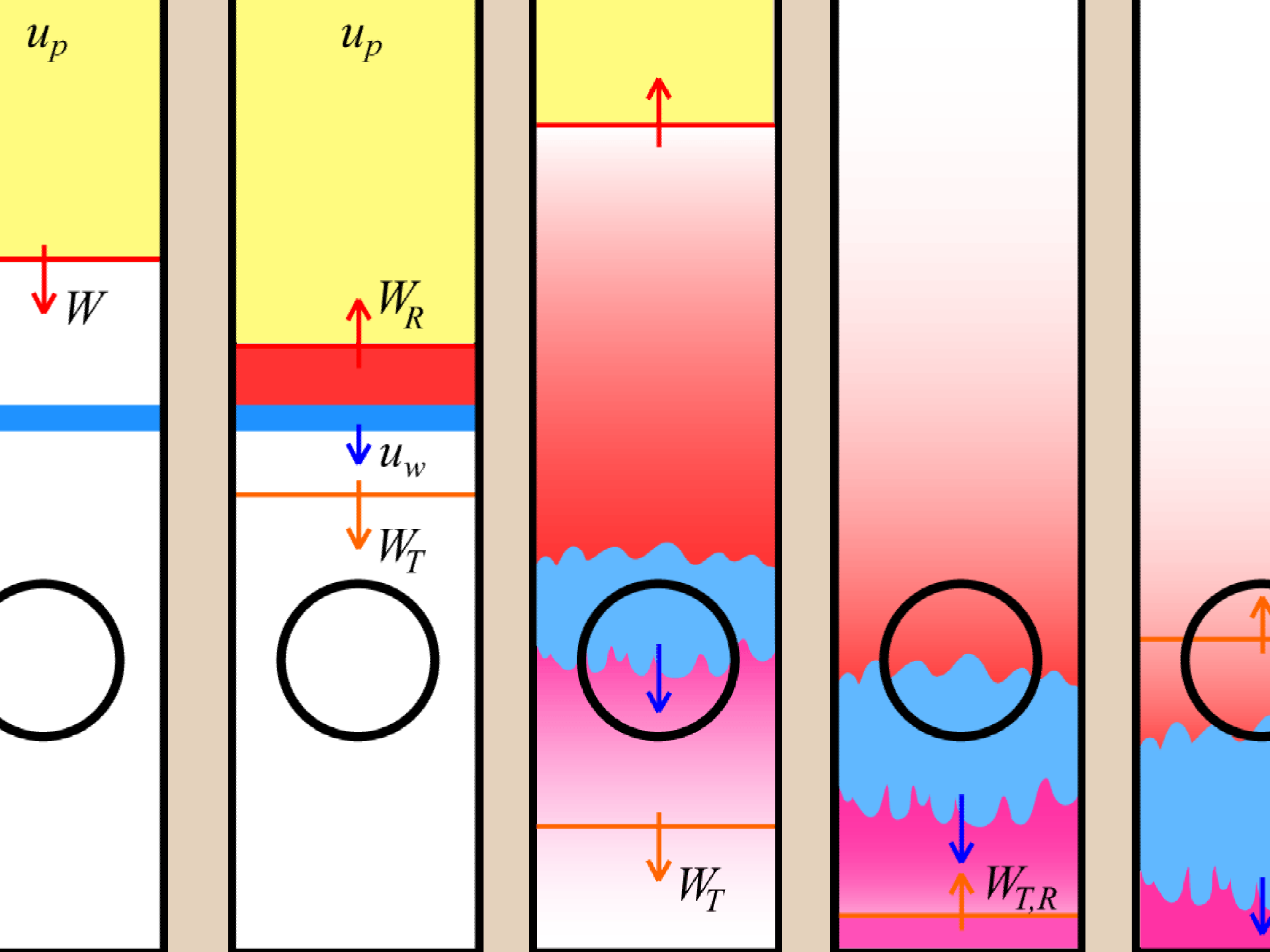
• Square internal cross secti
x 25 cm

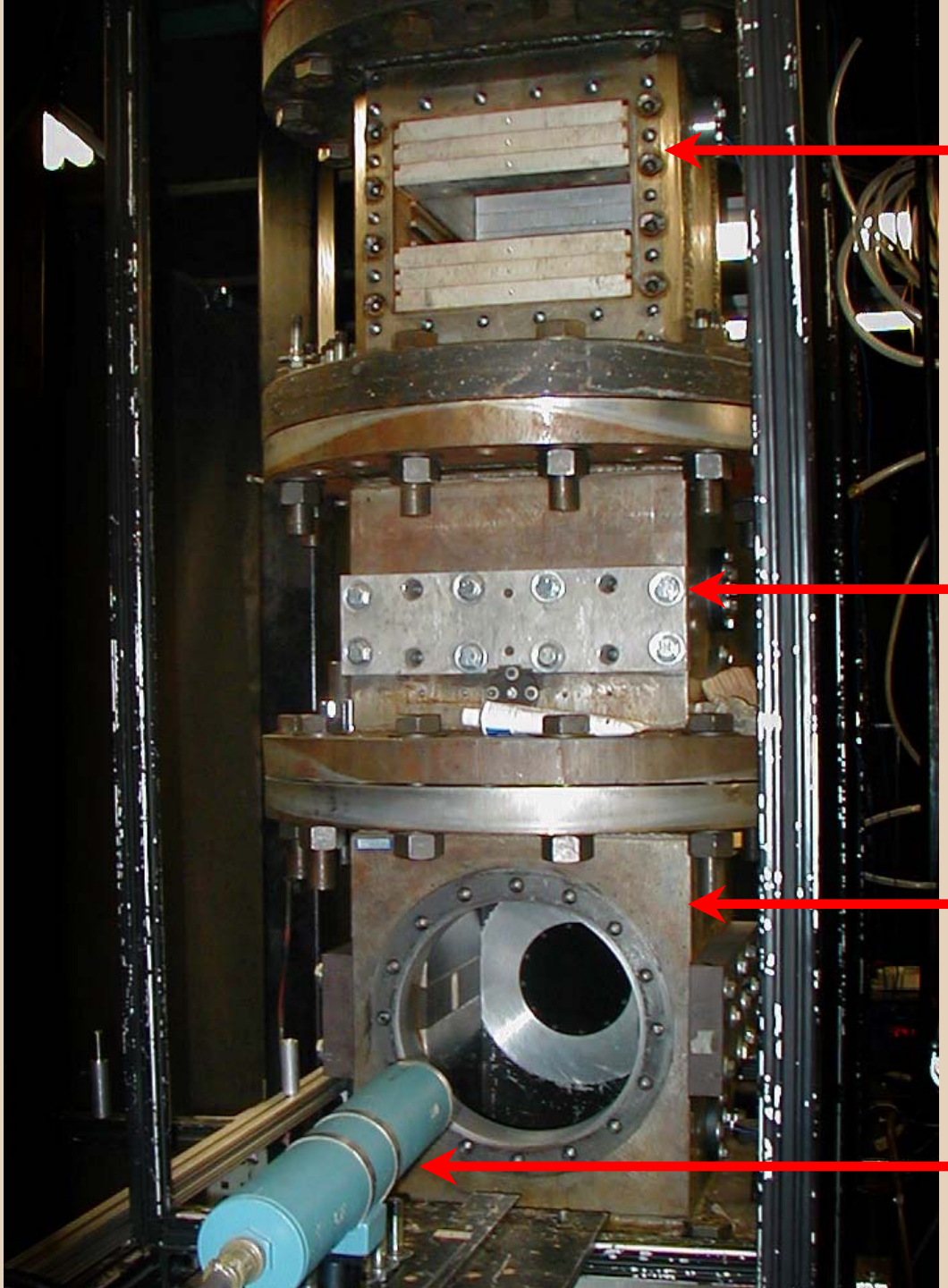
• Up to Mach 5 into atmosp
air

• 7 pressure transducers alo
tube

• 9 pressure transducers at t
wall




u_p
W
u_p
W_R
u_w
W_T
W_T
$W_{T,R}$

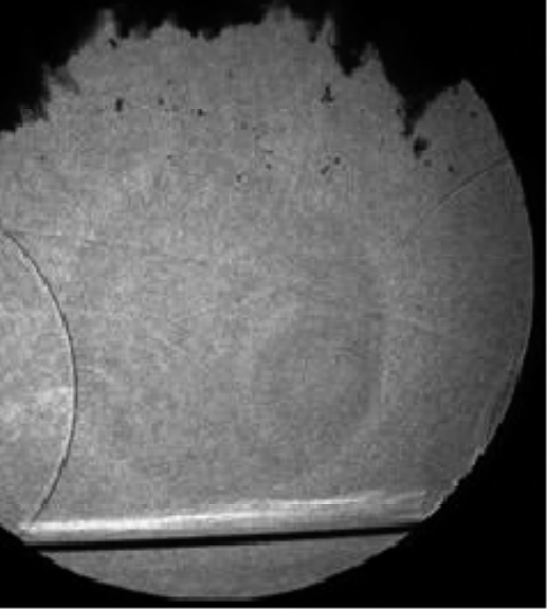


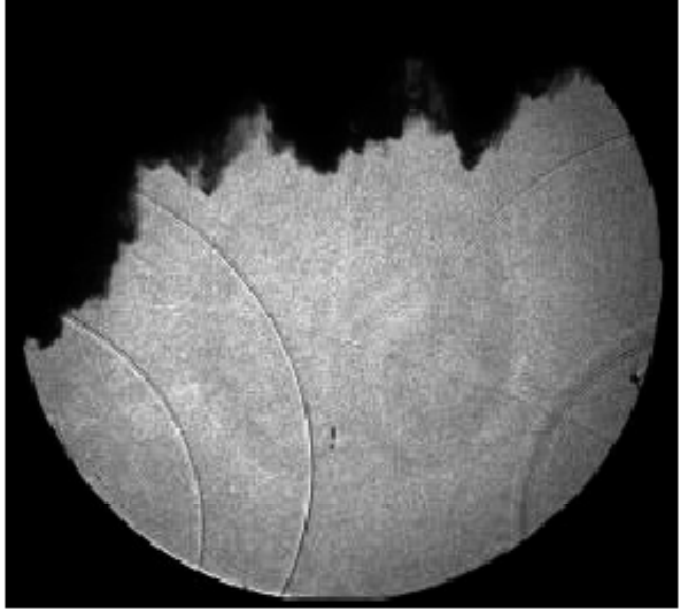
Multip
Inte

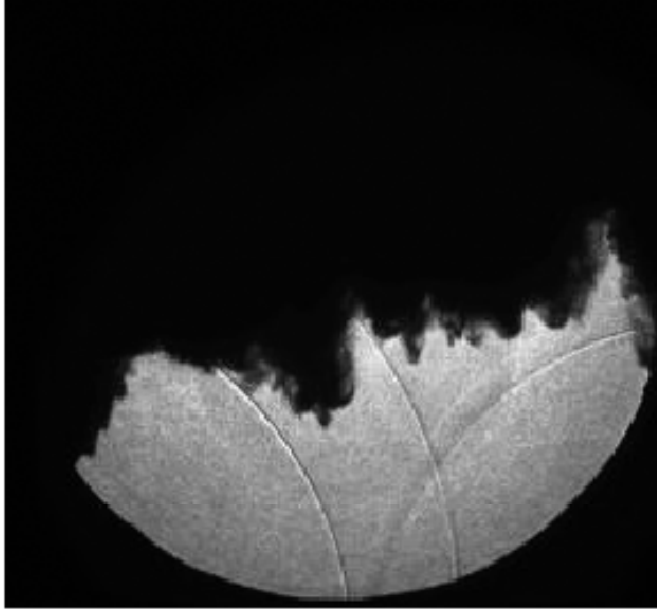
Sing
Int

Test

X-ra

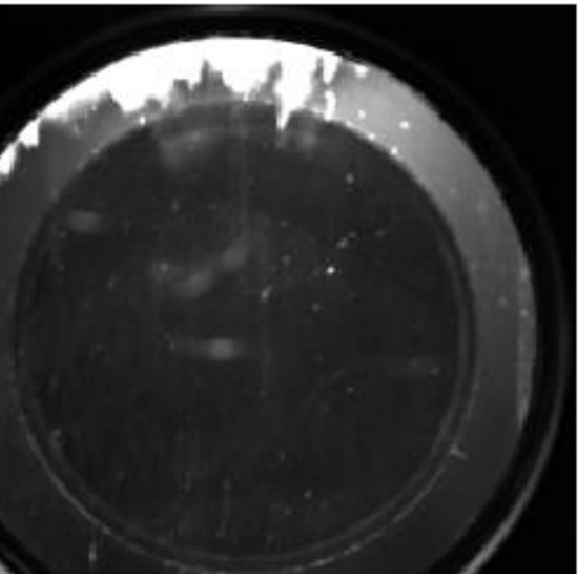


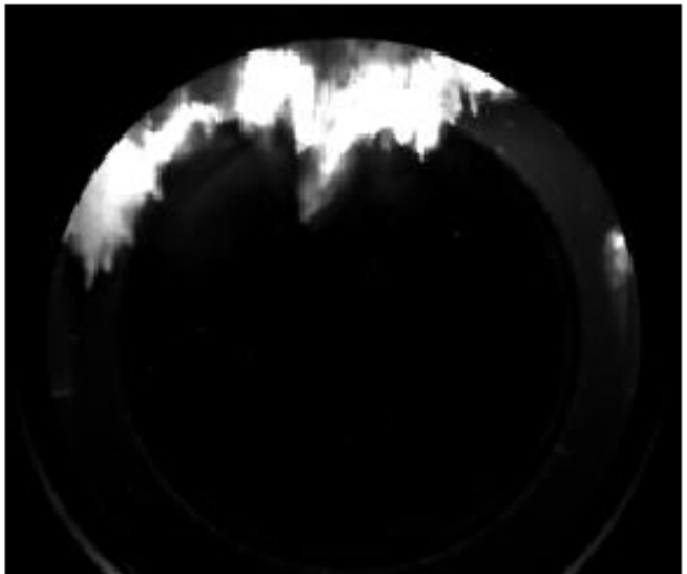


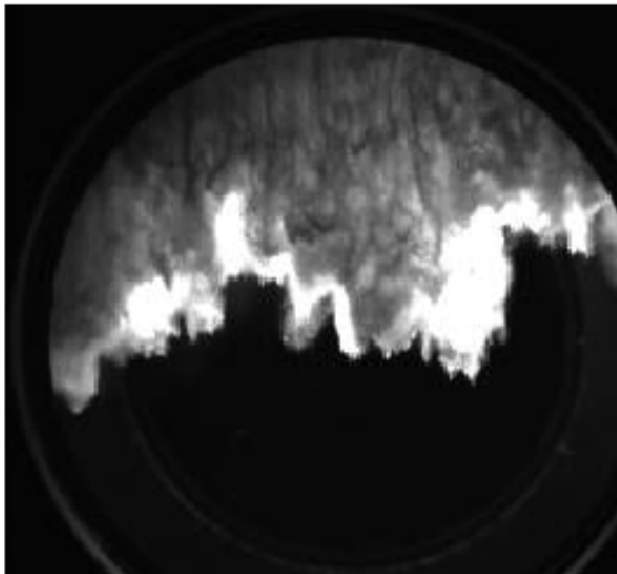


1.32 ms 1.43 ms 1.47 ms

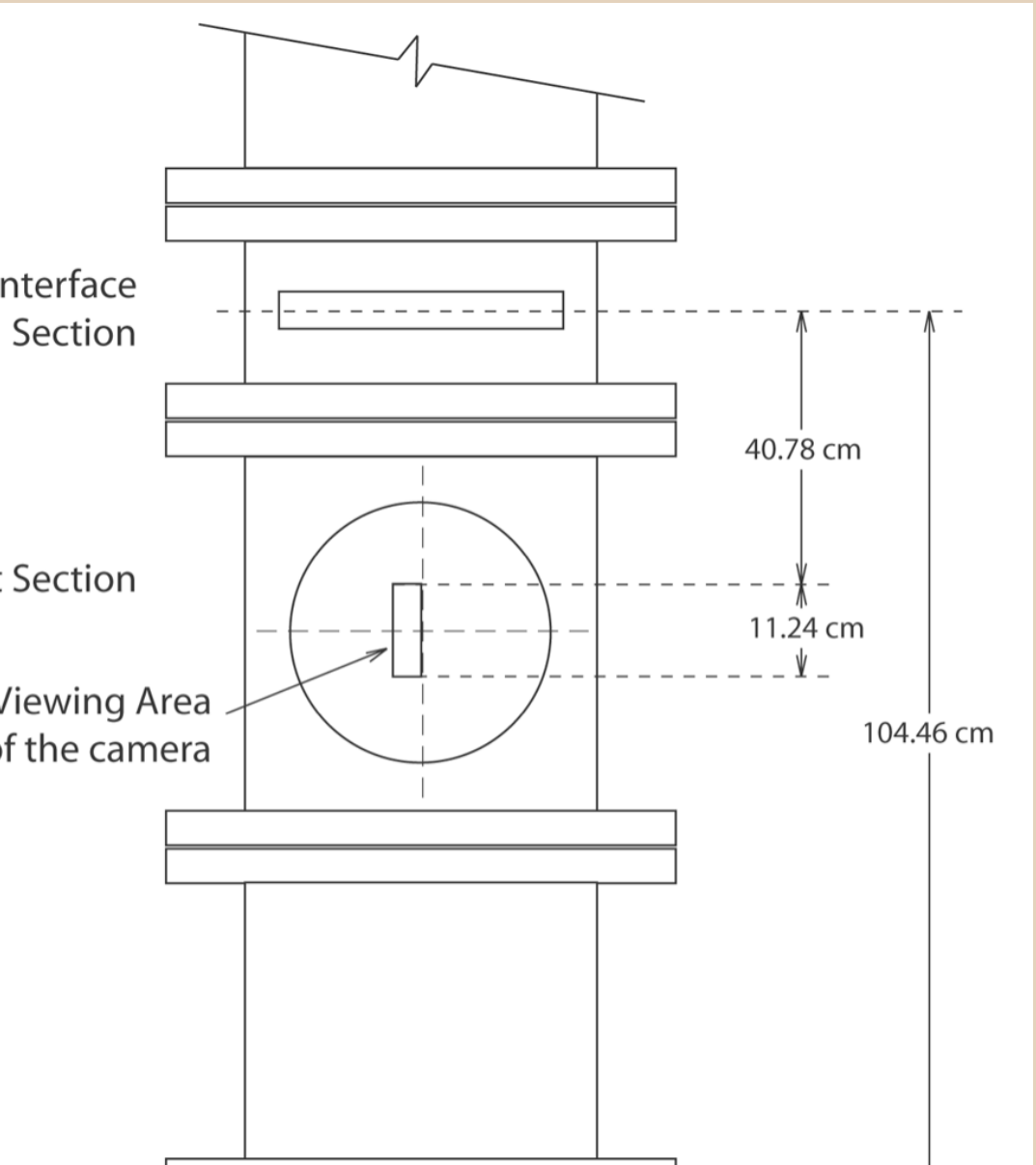
2.14, initially 12.8 mm thick



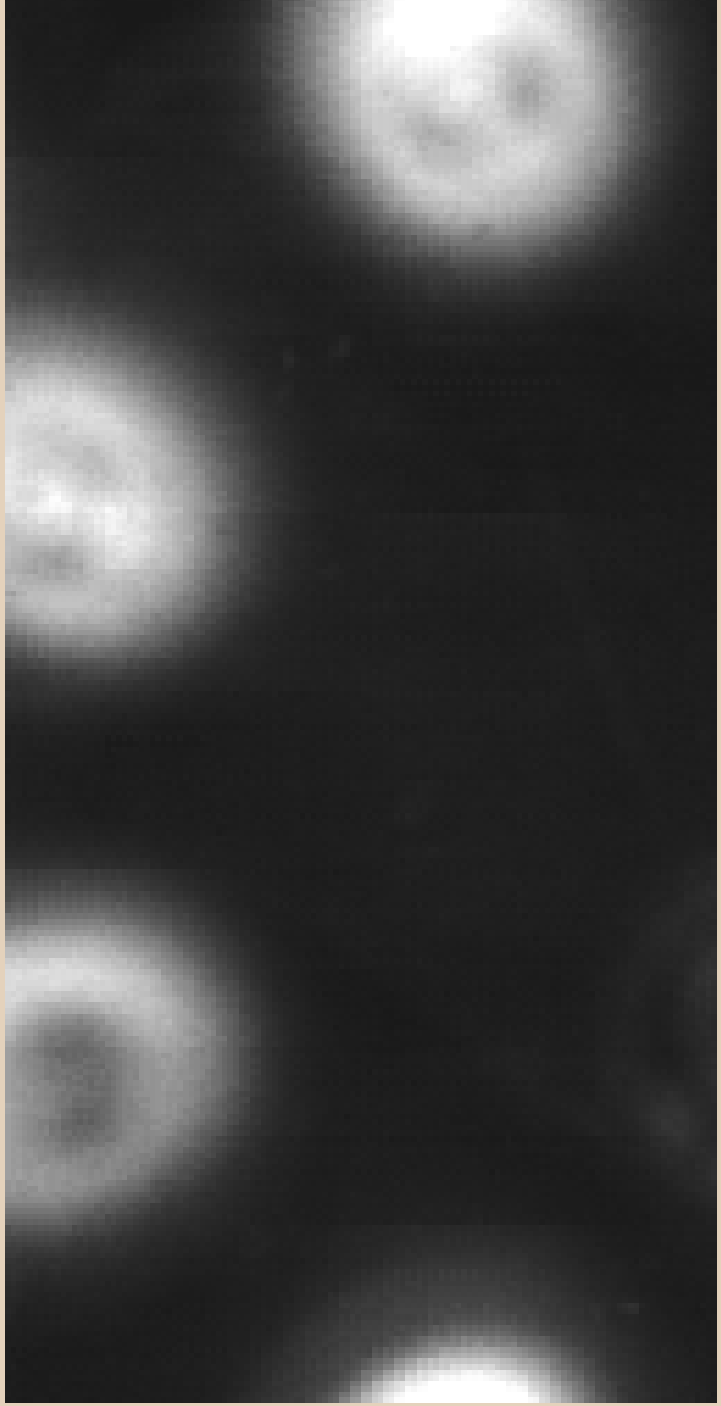




High speed Cinematography



- 128 x 256 p
(FASTCAM)
- 5.6 x 11.2 c
viewing area
- 30,000 fps



ng Edge

(u_p = 65

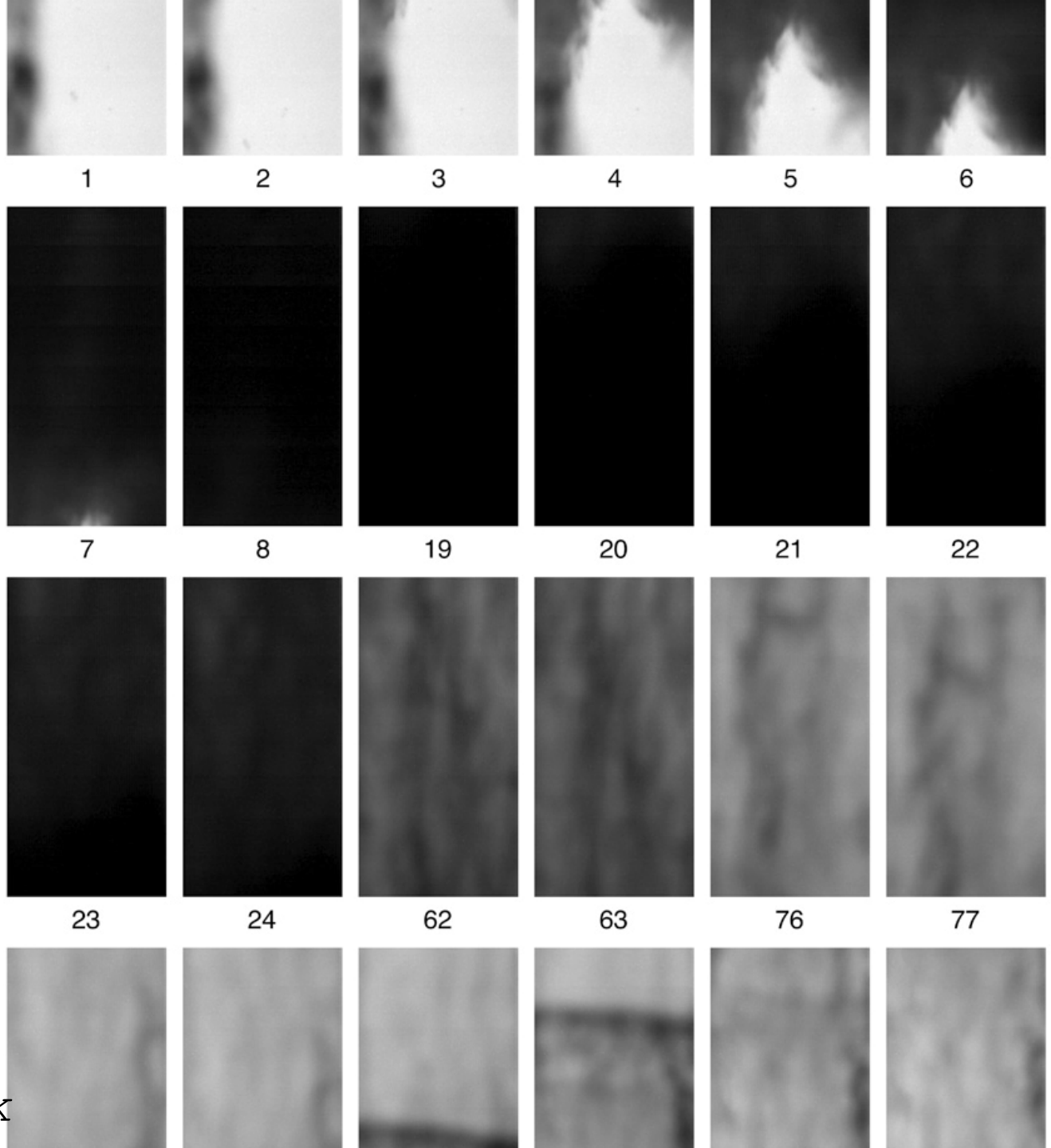
ody

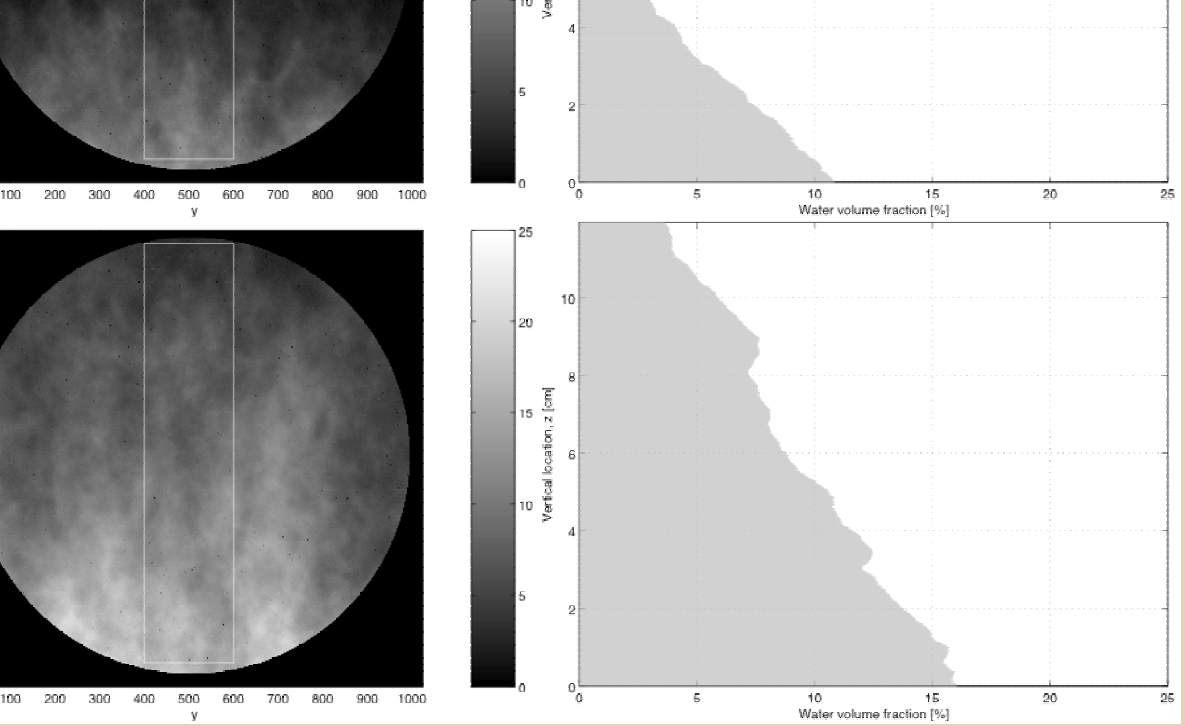
ing Edge

ted Shock

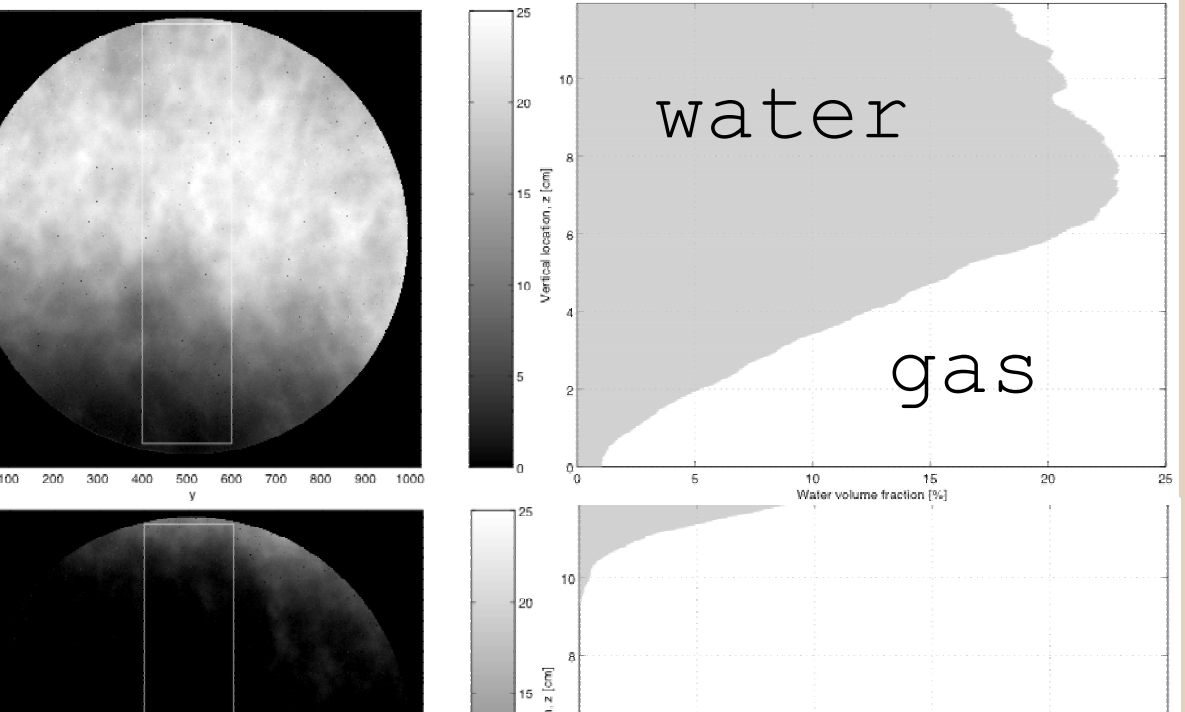
1,243

(W = 98

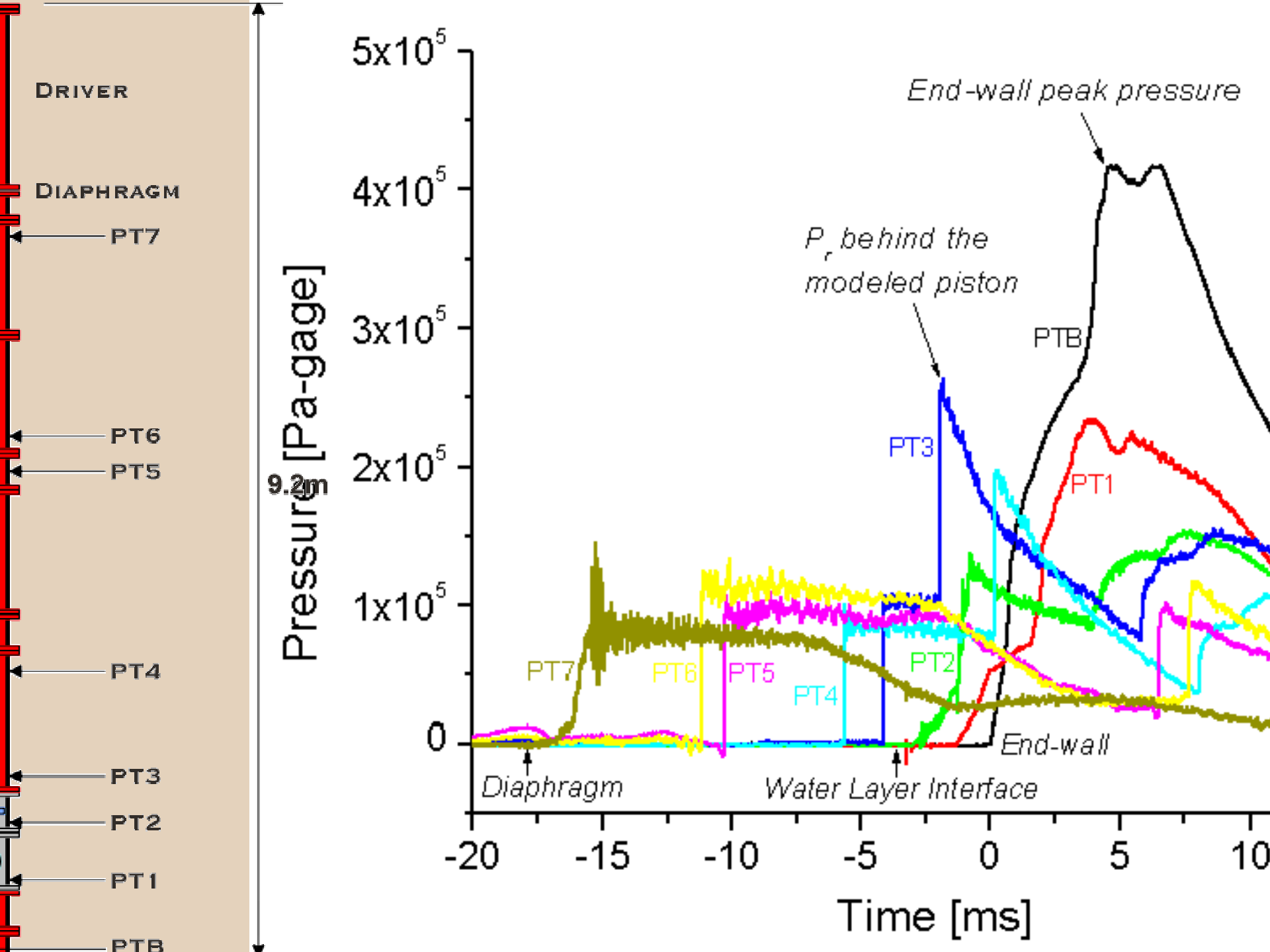


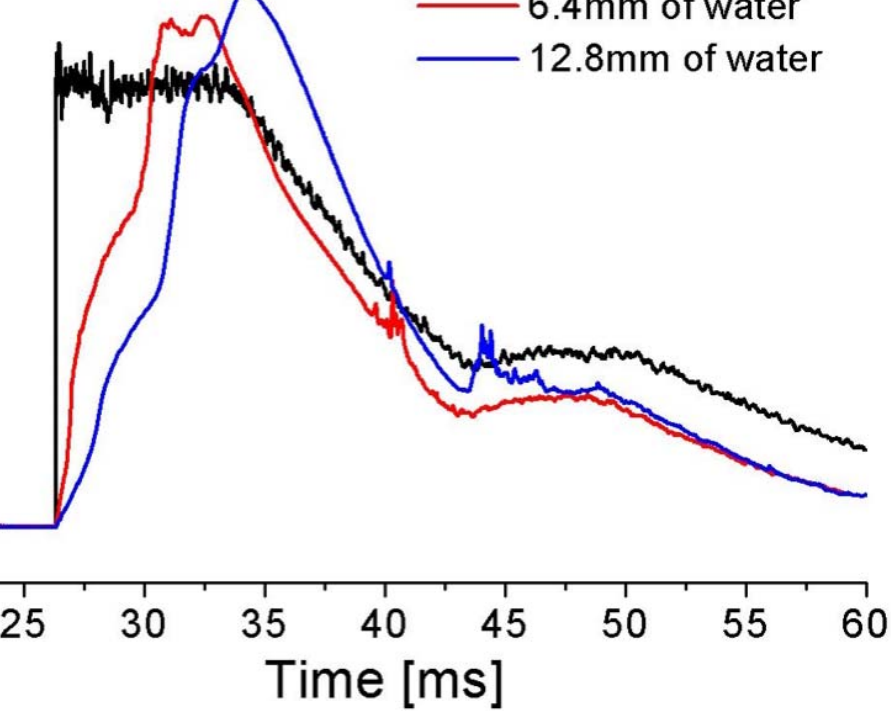


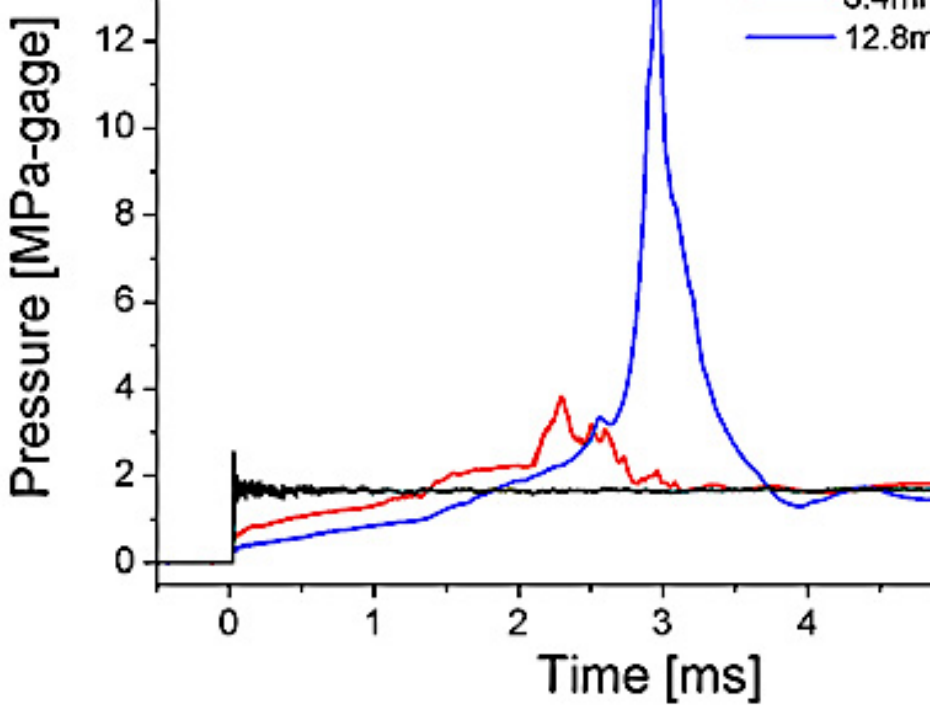
3.40 ms "Middle



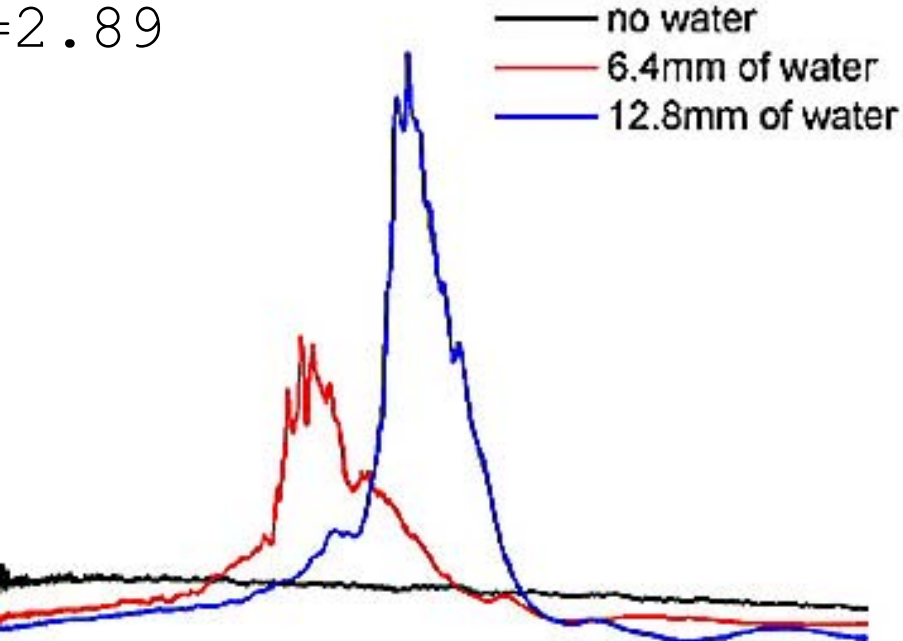
3.19 ms "Front"


DRIVER
DIAPHRAGM
PT7
PT6
PT5
PT4
PT3
PT2
PT1
PTB
9.2m
Pressure [Pa-gage]
5x10^5
4x10^5
3x10^5
2x10^5
1x10^5
0
-20
-15
-10
-5
0
5
10
Time [ms]
End-wall peak pressure
P_r behind the modeled piston
PTB
PT3
PT1
PT7
PT6
PT5
PT4
PT2
End-wall
Diaphragm
Water Layer Interface

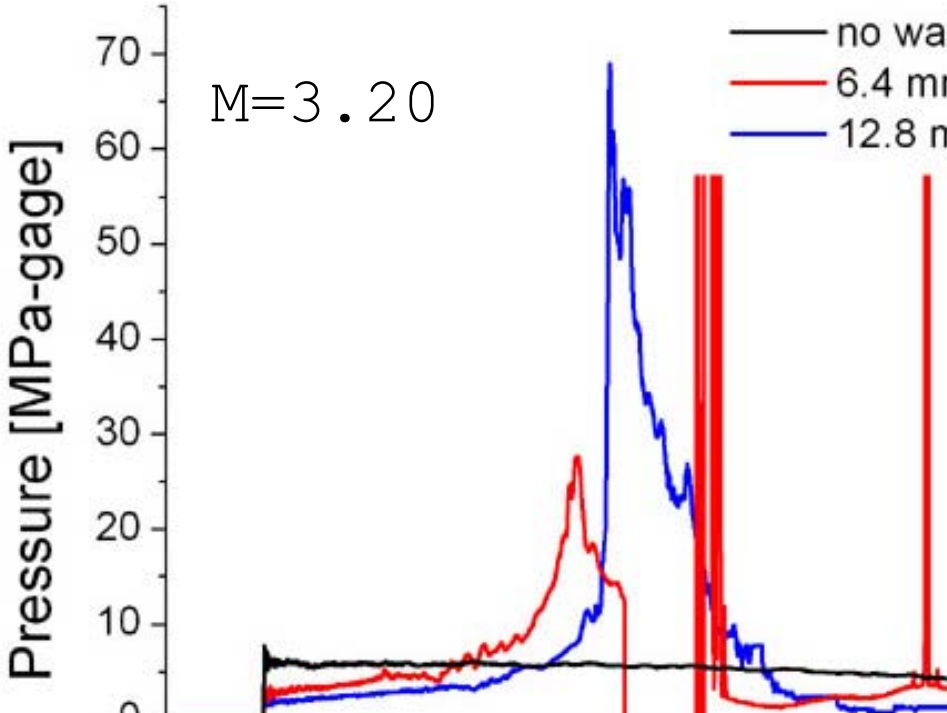

6.4mm of water
12.8mm of water
25
30
35
40
45
50
55
60
Time [ms]

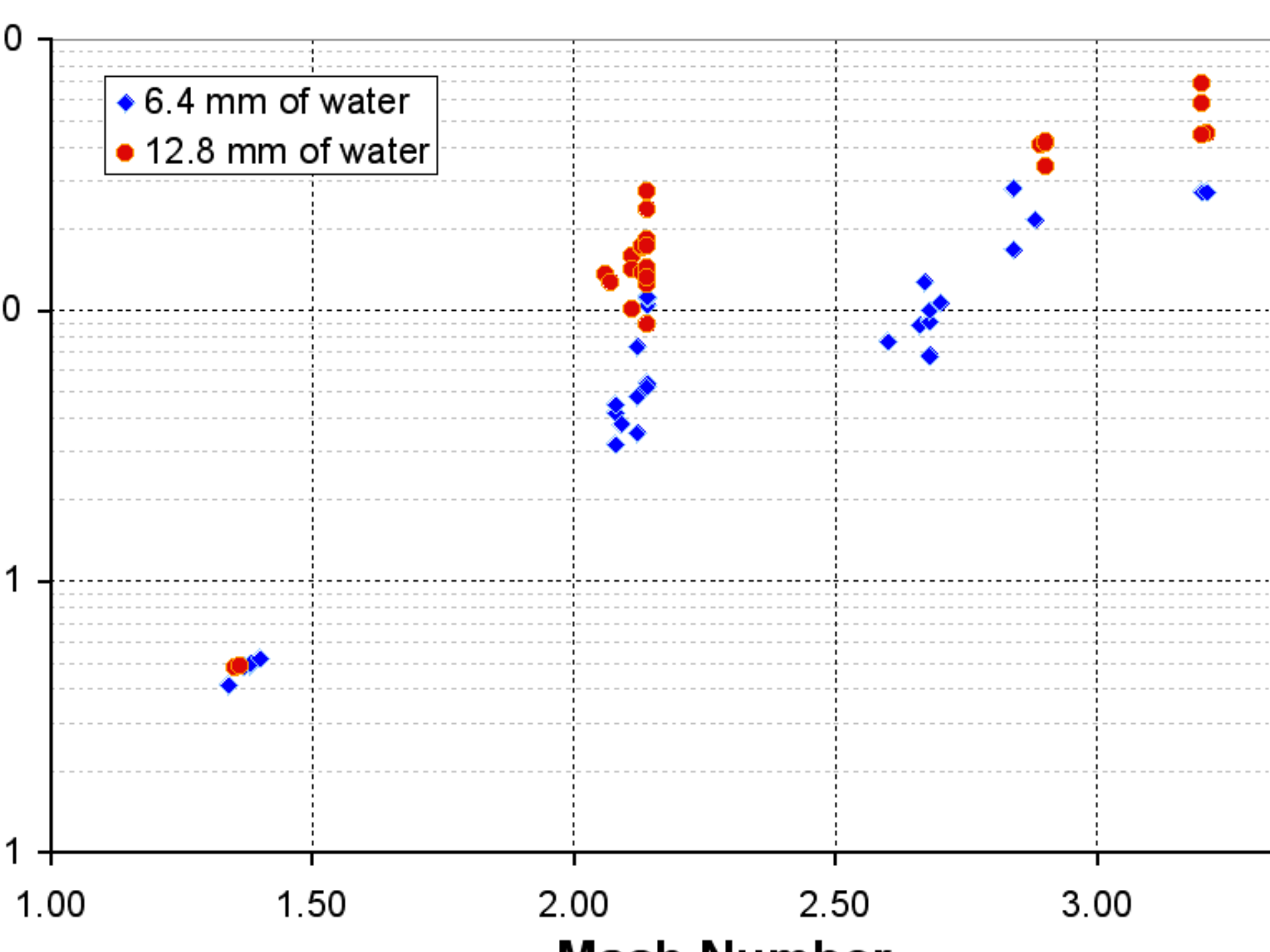

12
10
8
6
4
2
0
Pressure [MPa-gage]
0
1
2
3
4
Time [ms]

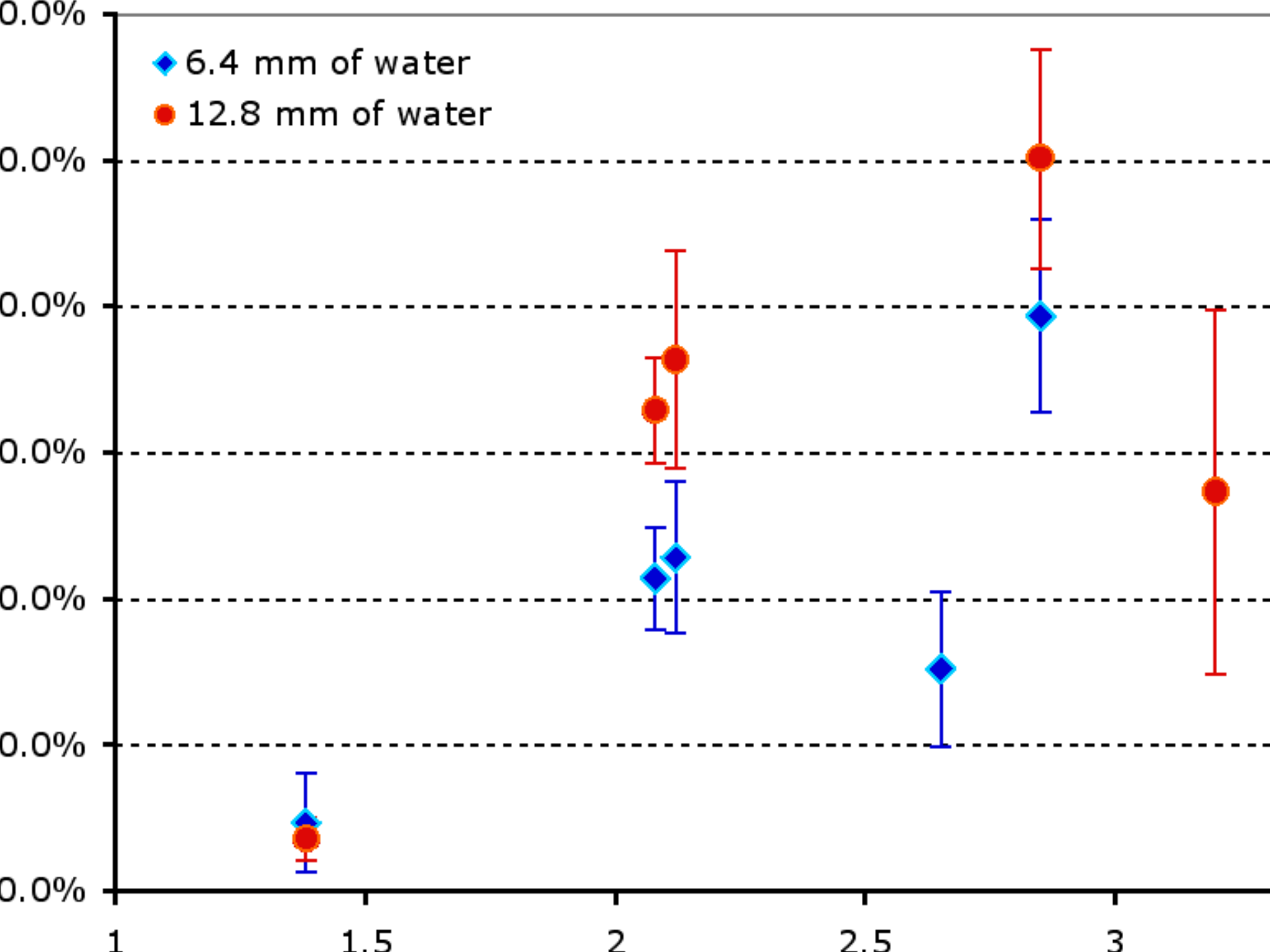
=2.89

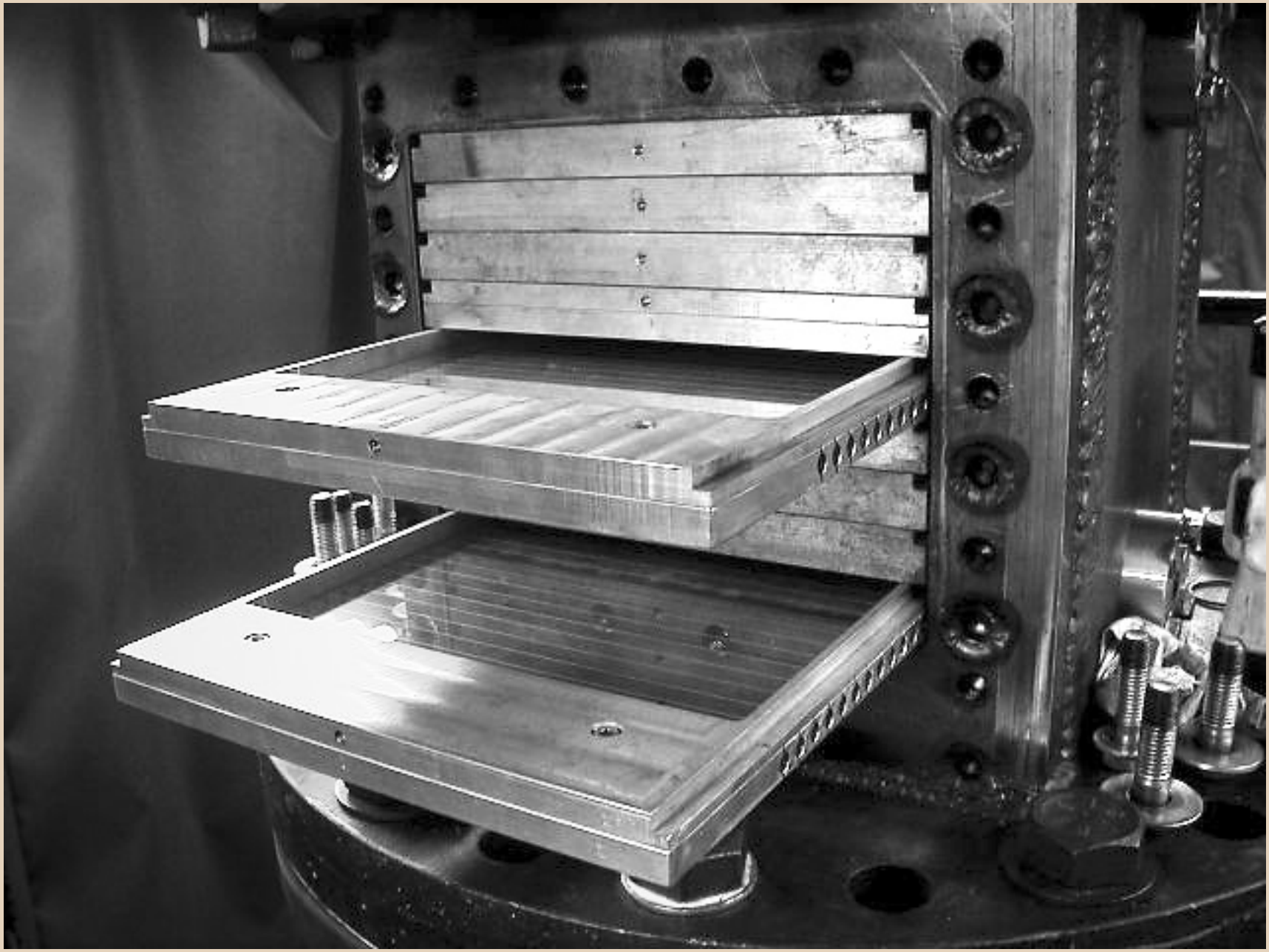

no water
6.4mm of water
12.8mm of water

M=3.20

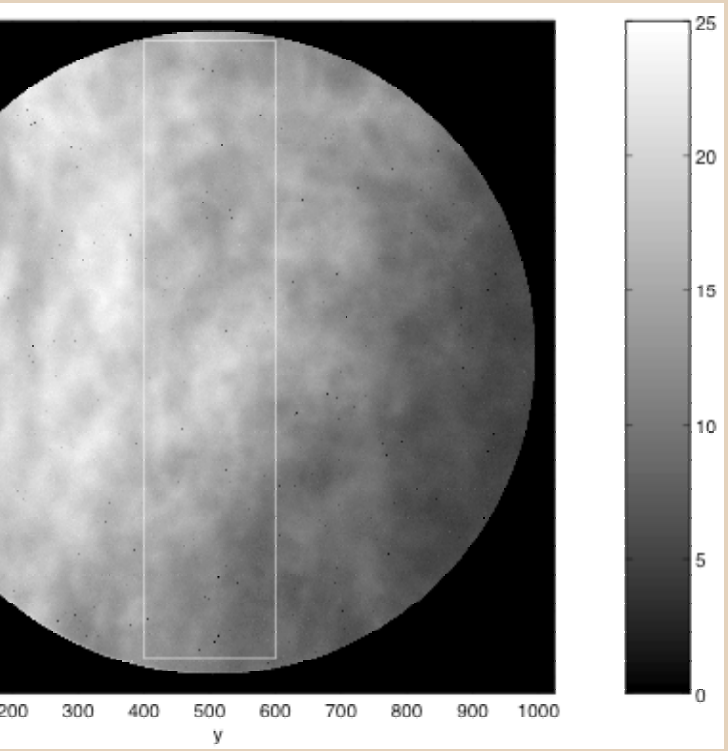

70
60
50
40
30
20
10
Pressure [MPa-gage]

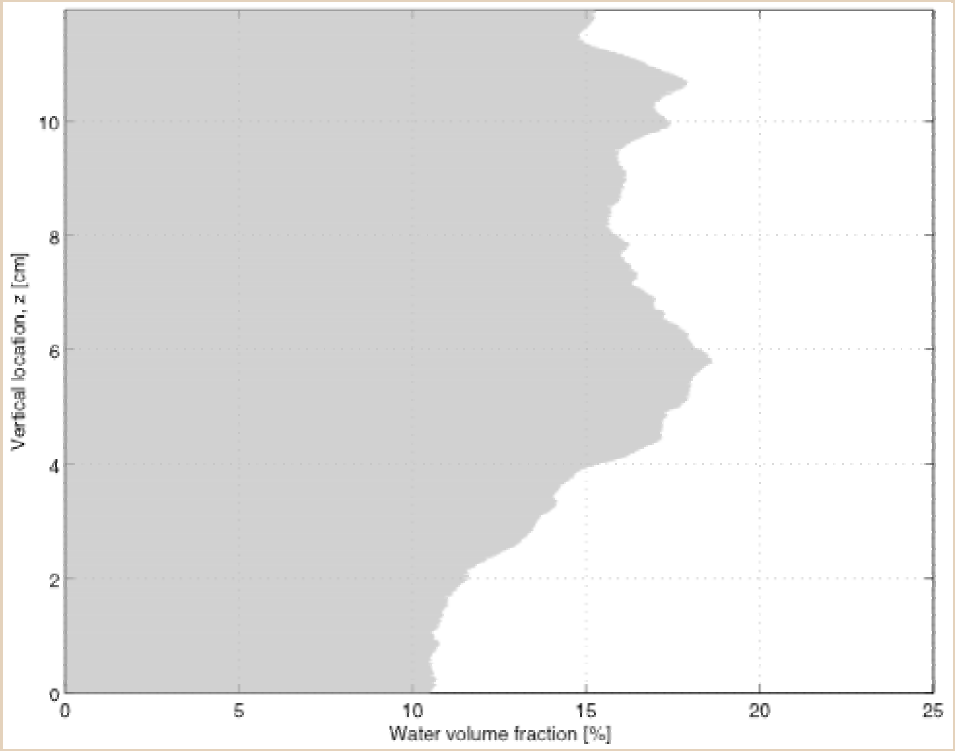

6.4 mm of water
12.8 mm of water
0
0
1
1
1.00
1.50
2.00
2.50
3.00


6.4 mm of water
12.8 mm of water
0.0%
0.0%
0.0%
0.0%
0.0%
0.0%
1
1.5
2
2.5
3

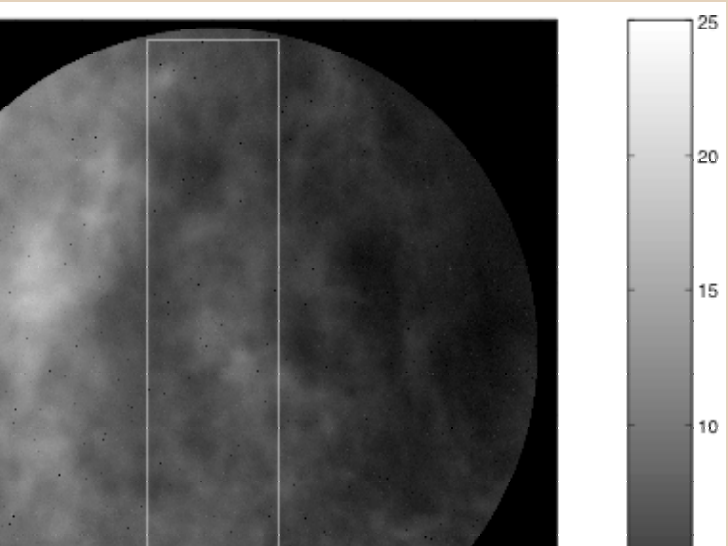


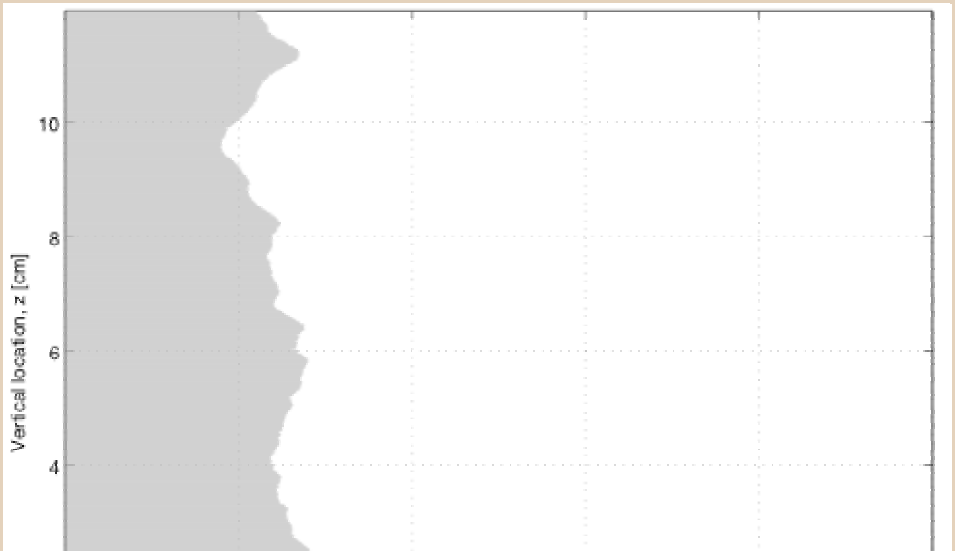
e and multi-layer



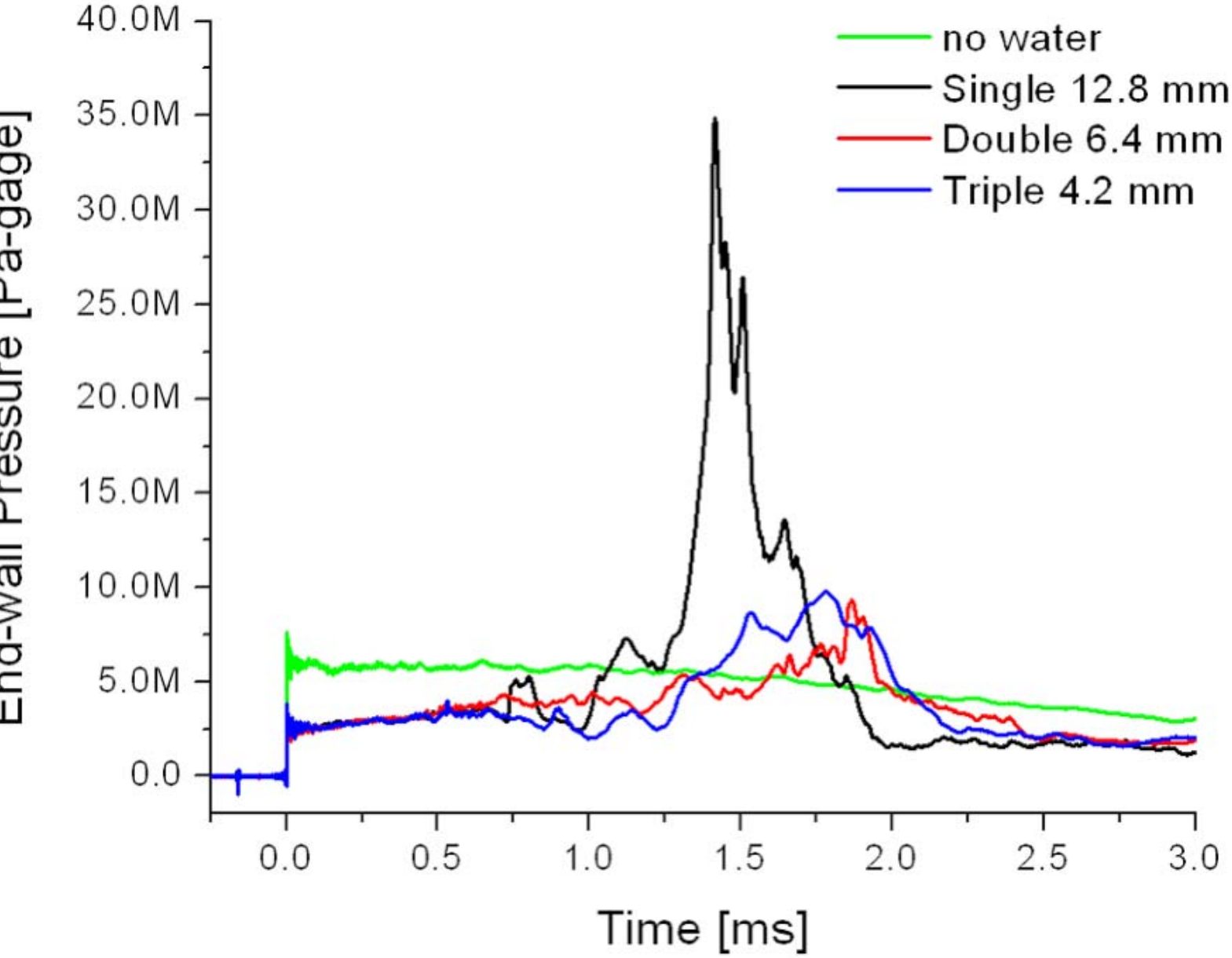


Sing
12.8
M=2.
4.93

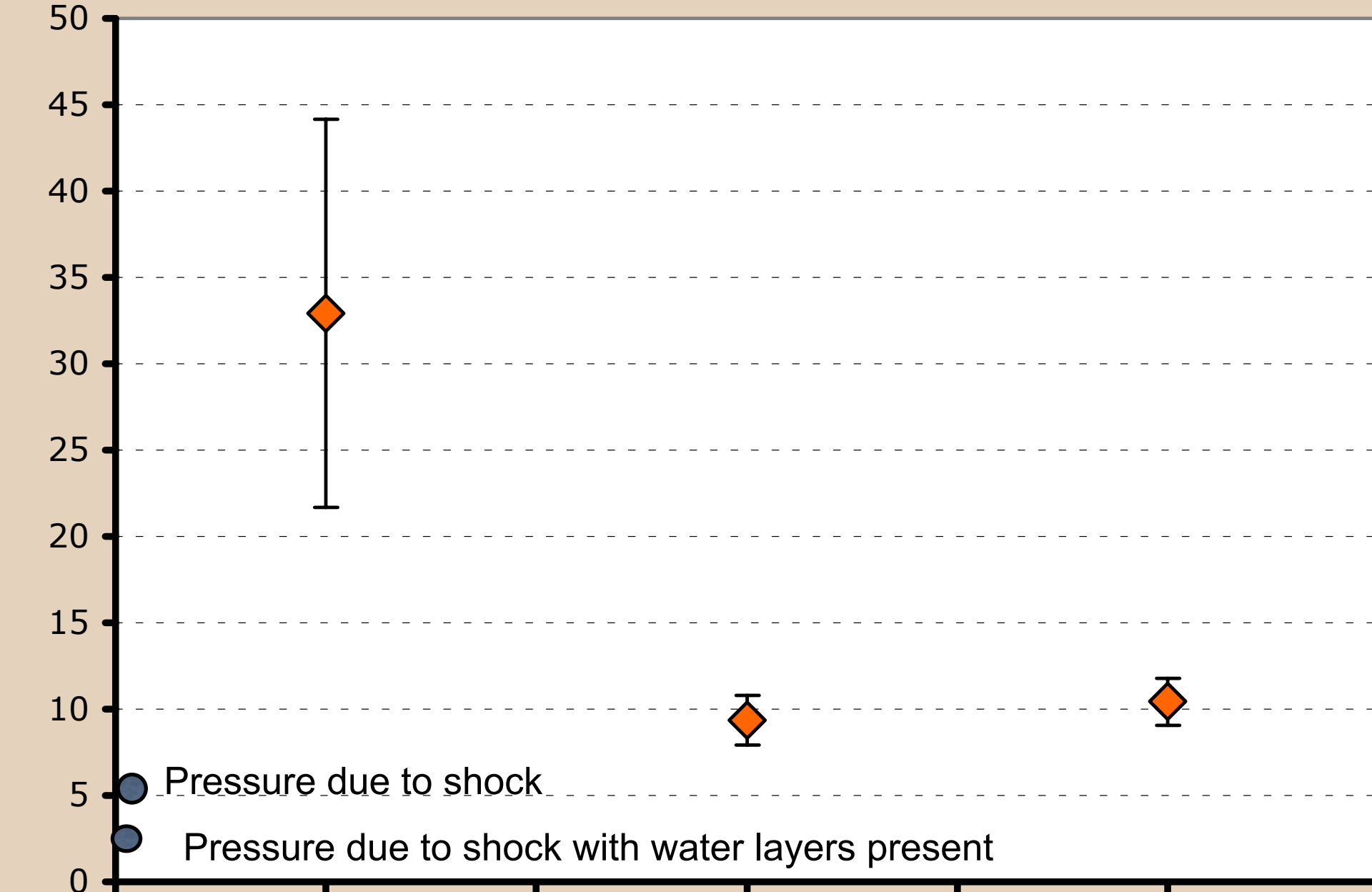




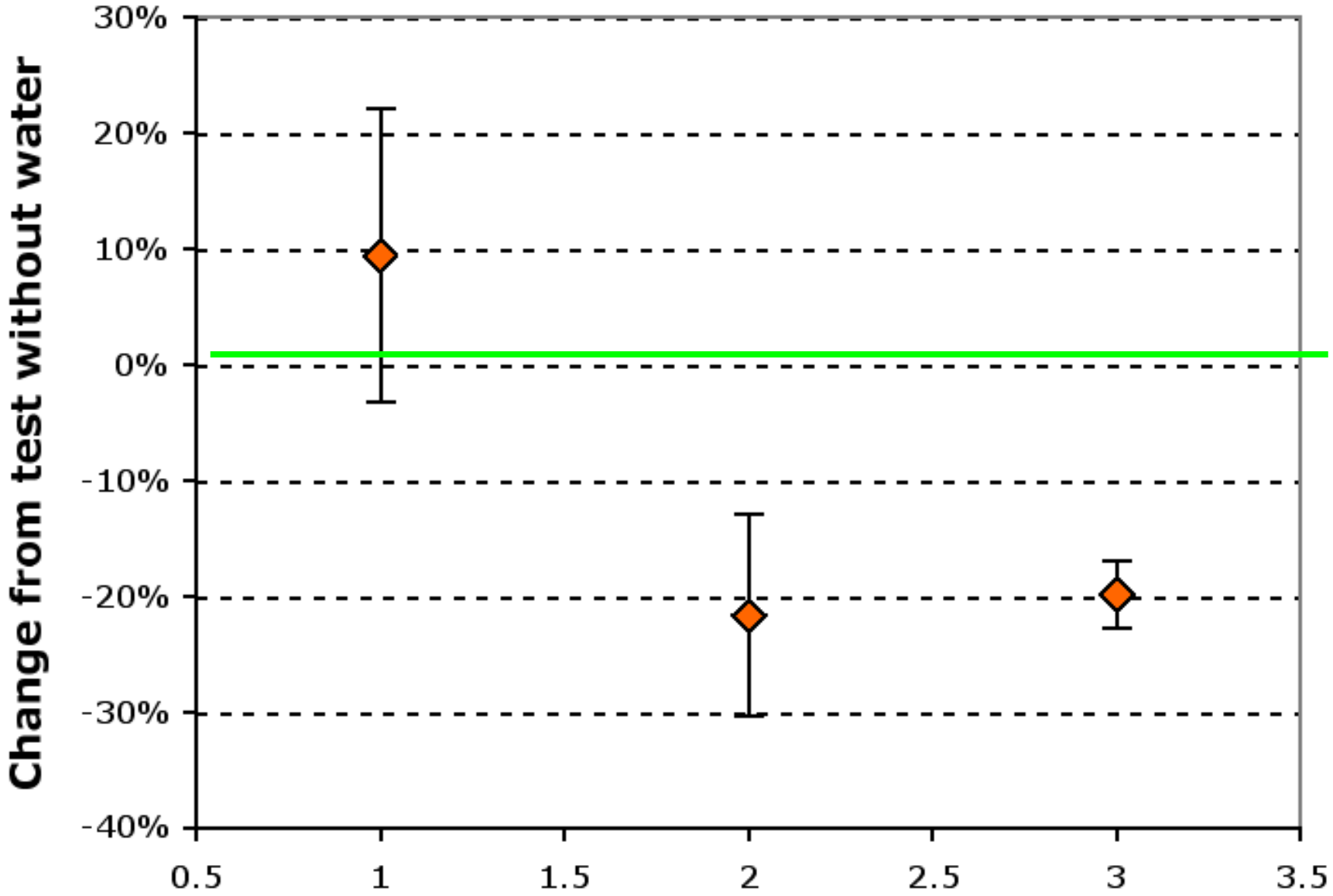
Two
6.4
smal
M=2.
5.18


40.0M
35.0M
30.0M
25.0M
20.0M
15.0M
10.0M
5.0M
0.0
End-wall Pressure [Pa-gage]
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Time [ms]
no water
Single 12.8 mm
Double 6.4 mm
Triple 4.2 mm

r of layers constant water volume, S=1.8



S 1.8 cm


30%
20%
10%
0%
-10%
-20%
-30%
-40%
Change from test without water
0.5
1
1.5
2
2.5
3
3.5
No

- Shock wave strength reduced by about fact
  two
- End-wall peak pressure with liquid layer is
  gnificantly higher (up to 7 times with
  essures of 70MPa) than without water
- Thicker layers, stronger shocks result in
  gher impulses
- Shock-induced spread of the liquid layer
  velops very rapidly

Multiple layers decrease the end-wall peak
ssure by more than 50% compared to single laye

Shockwave peak pressure reduced by 50%

End-wall impulse decreases to less than that for
case with no water

Number of layers has little effect on the
nsmitted shock

Separation of layers has an effect on results and
ld be optimized to reduce impulse