Study of Converging Reflected Shock Waves and Richtmyer-Meshkov Instability in Spherical Geometry

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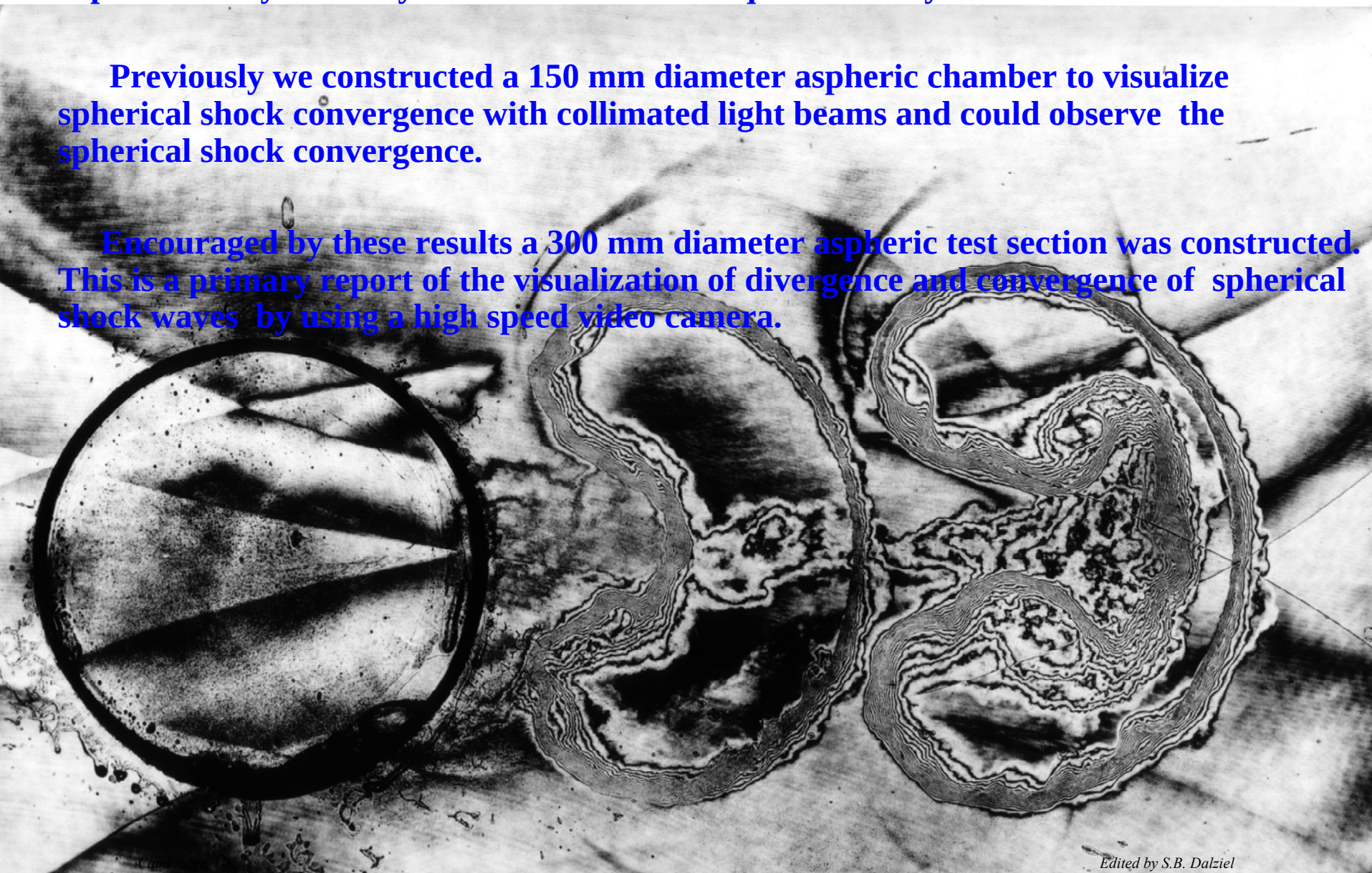
Introduction

Convergence of spherical shock waves is not easy to generate experimentally and very hard to be visualized quantitatively.

Previously we constructed a 150 mm diameter aspheric chamber to visualize spherical shock convergence with collimated light beams and could observe the spherical shock convergence.

Encouraged by these results a 300 mm diameter aspheric test section was constructed. This is a primary report of the visualization of divergence and convergence of spherical shock waves by using a high speed video camera.

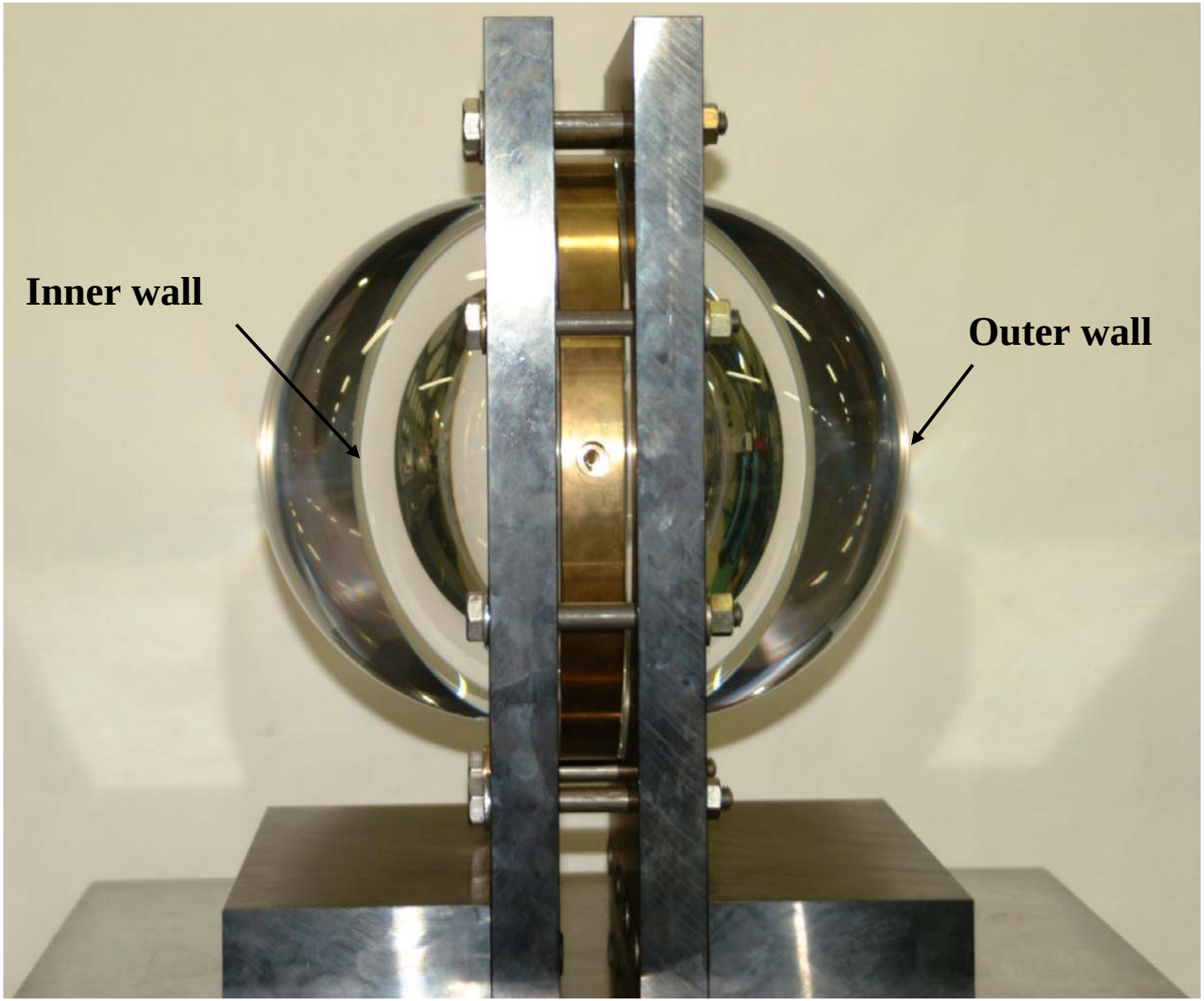


Previous Works

G. Guderley	(1942)
R. W. Perry and A. Kantrowitz	(1951)
K. P. Stanyukovich	(1960)
I. I. Glass and S. P. Sharma	(1976)
T. Saito	(1982))
H. Matsuo	(1983)
Y. Hoshizawa	(1986)
M. Watanabe	(1994)
Z. Jiang and K. Takayama	(1998)
S. H. R. Hosseini and K.Takayama	(1999)

CFD, experiments, analysis, converging cylindrical shock

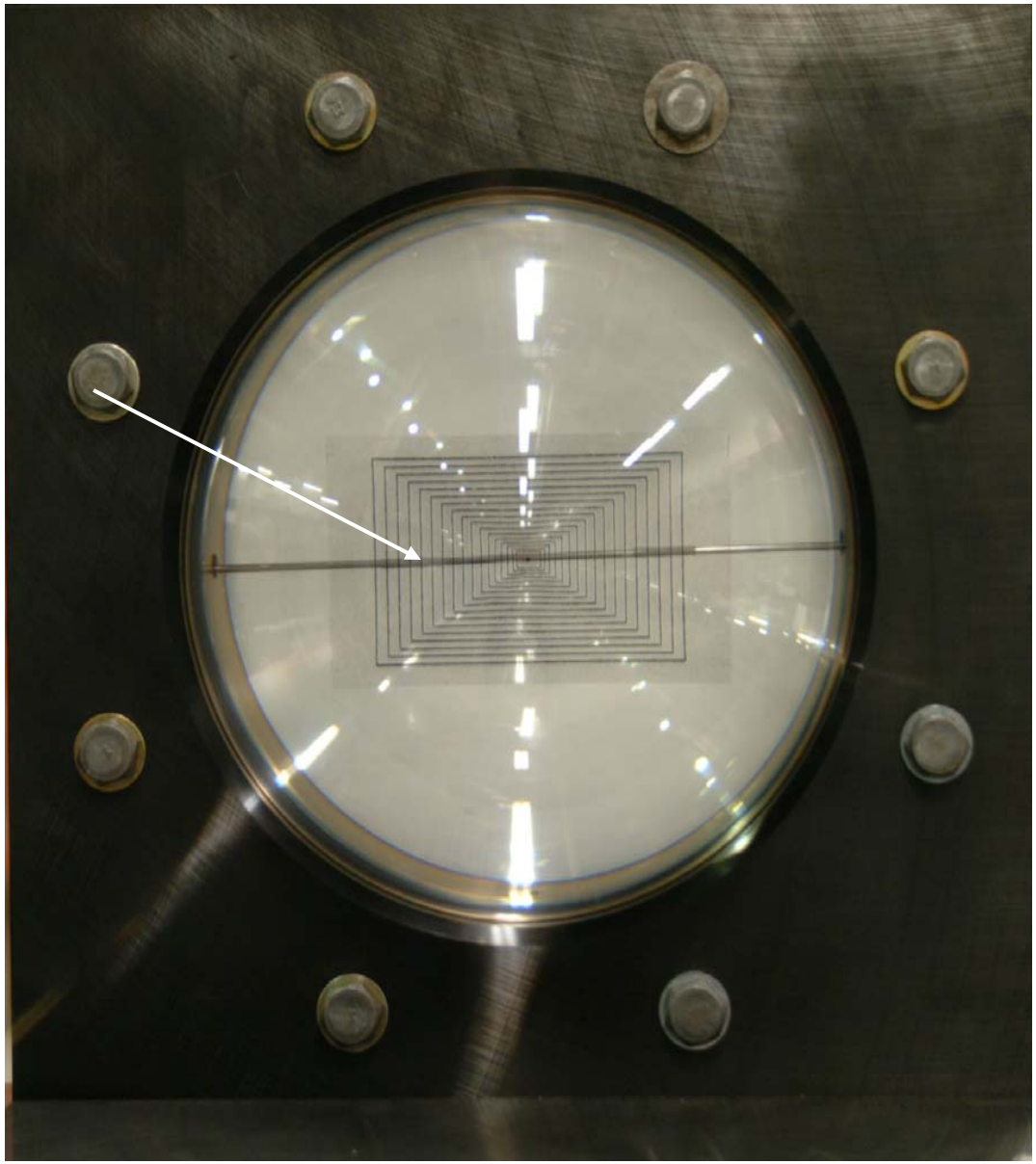
Previous 150mm dia. Aspheric Test Section



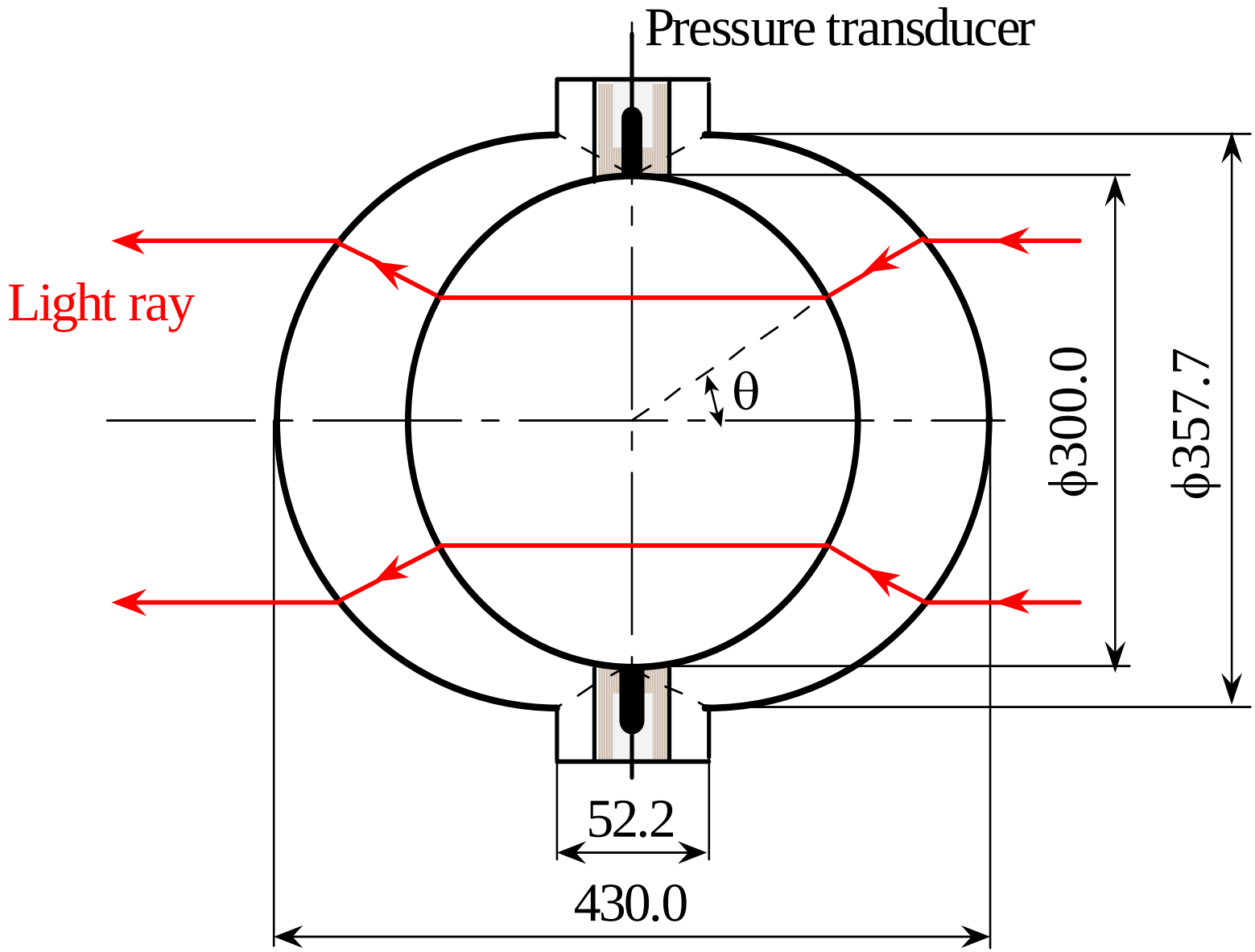
This was constructed to ensure whether or not the design concept worked.

Frontal View of the Test Section

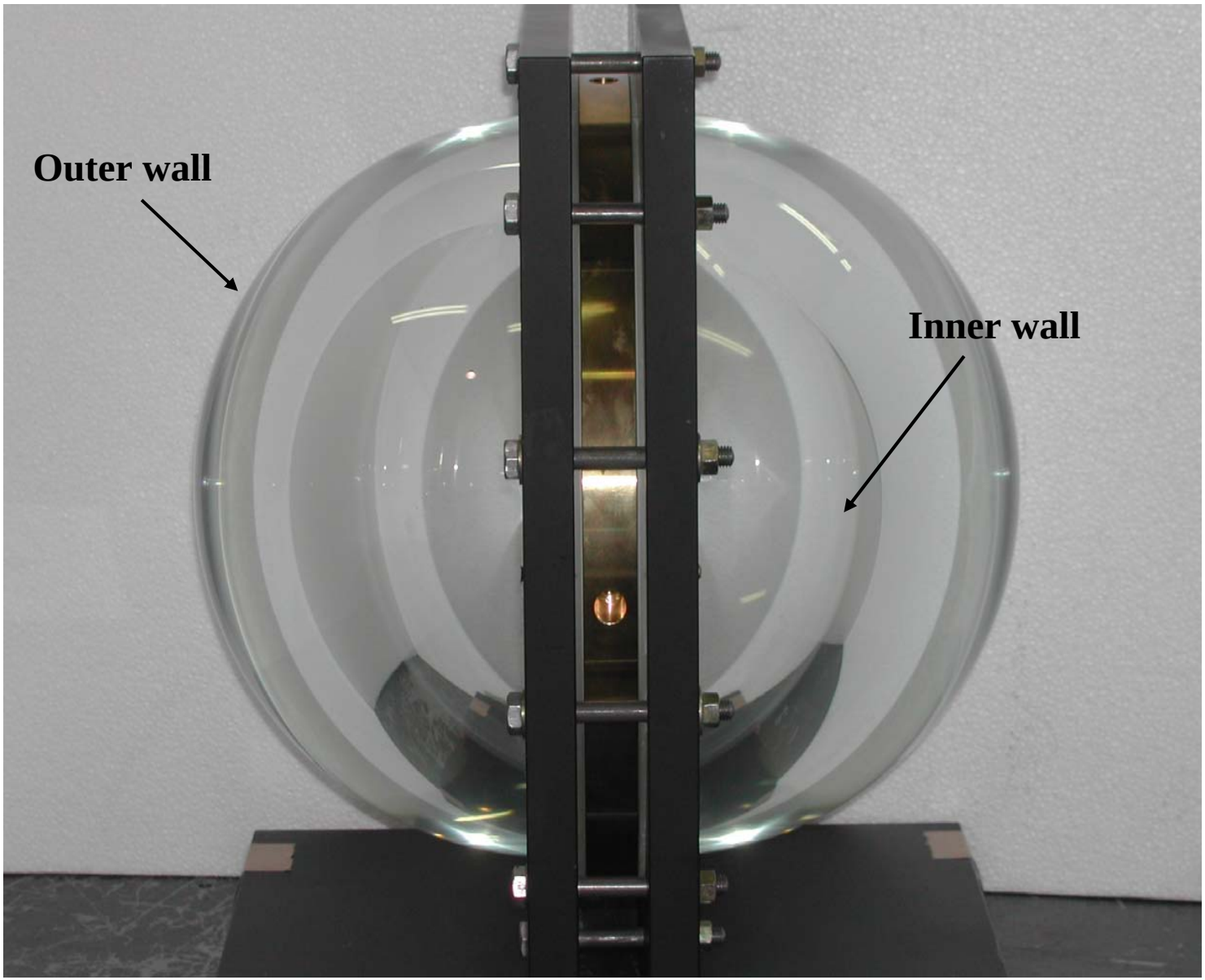
Test chart



Ray Tracing across Aspheric Test Section

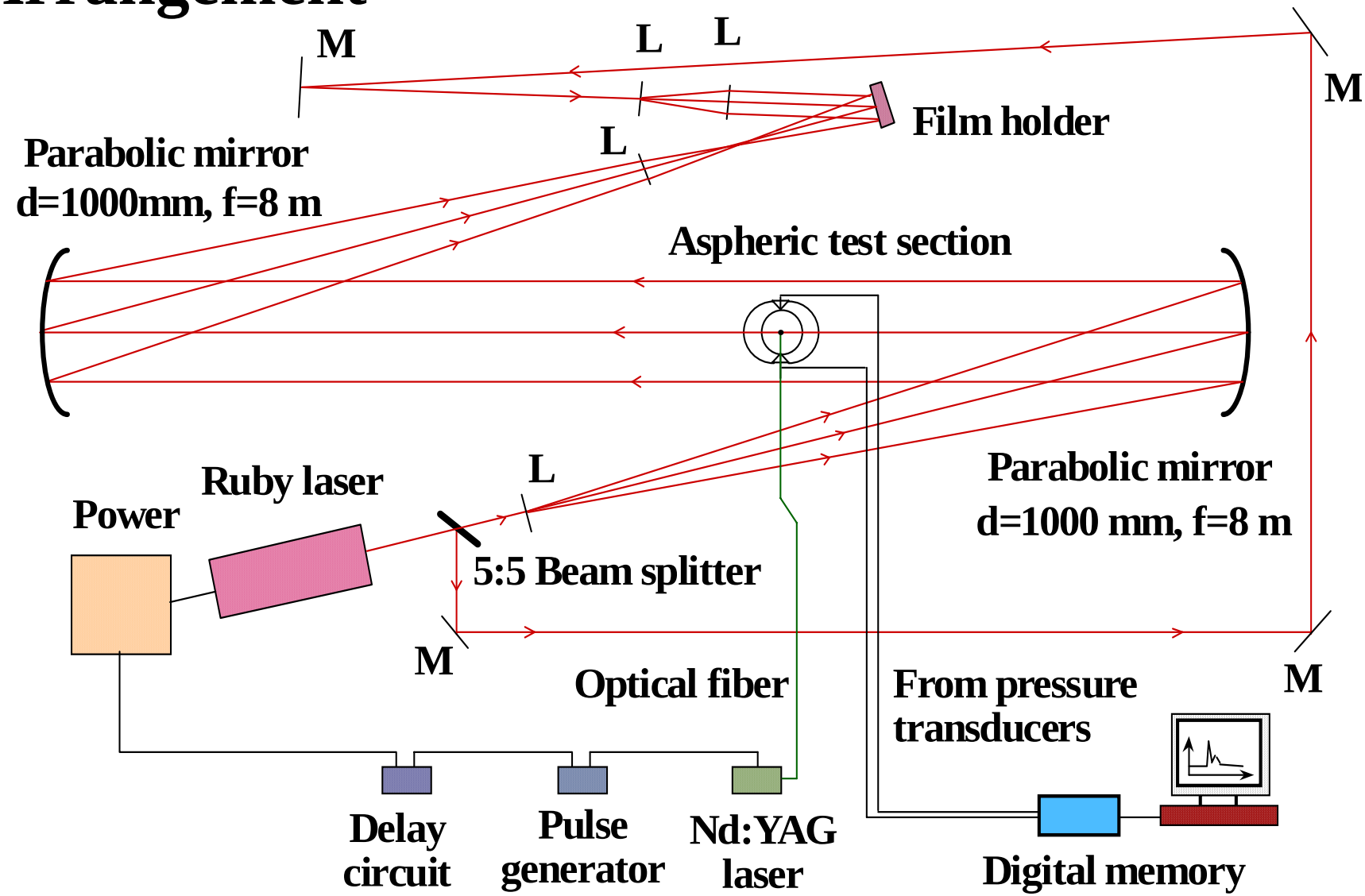


300 mm dia. Aspheric Test Section

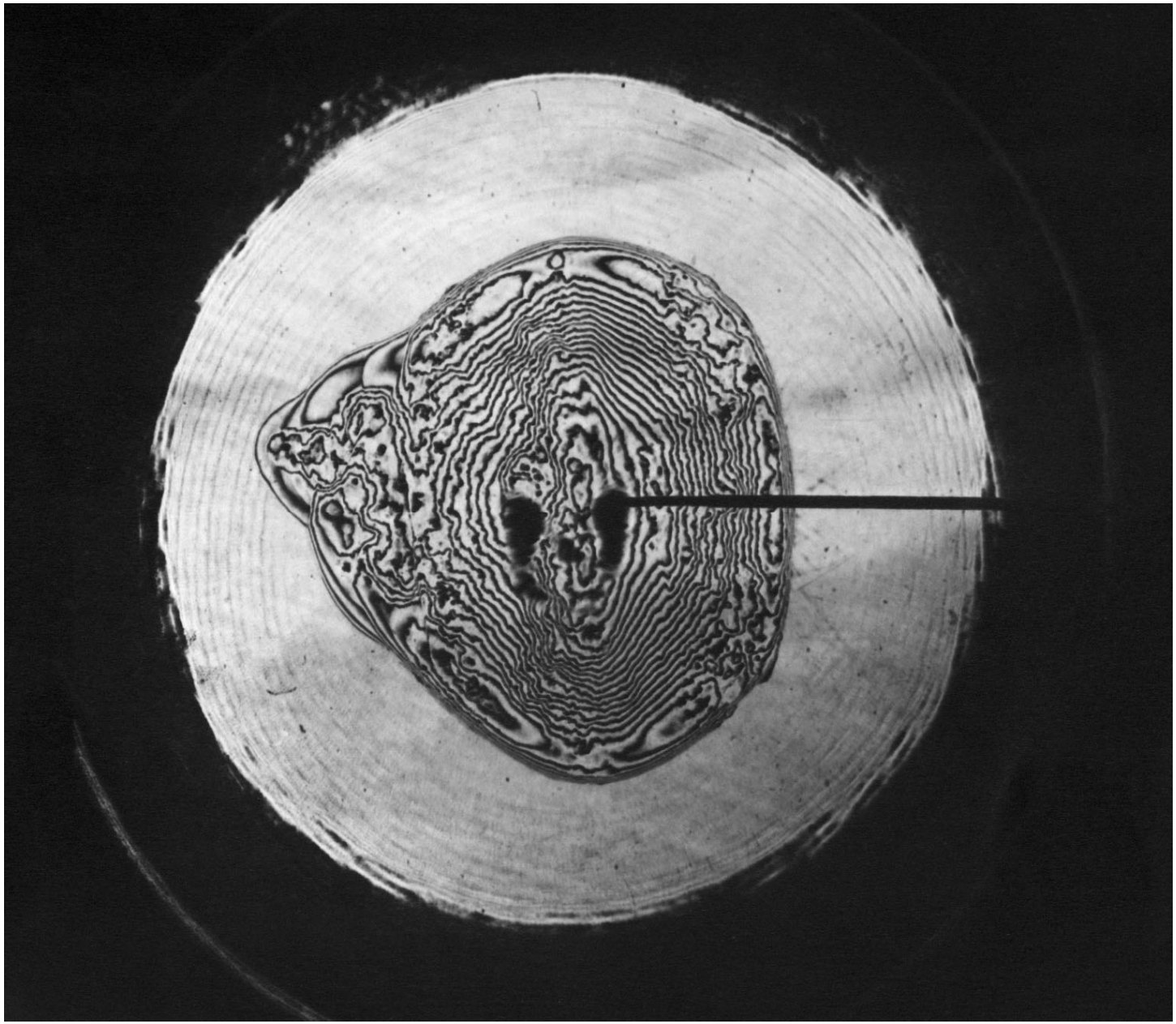


To achieve imploding shock/gaseous interface interaction a large diameter is needed.

Holographic Interferometric Arrangement

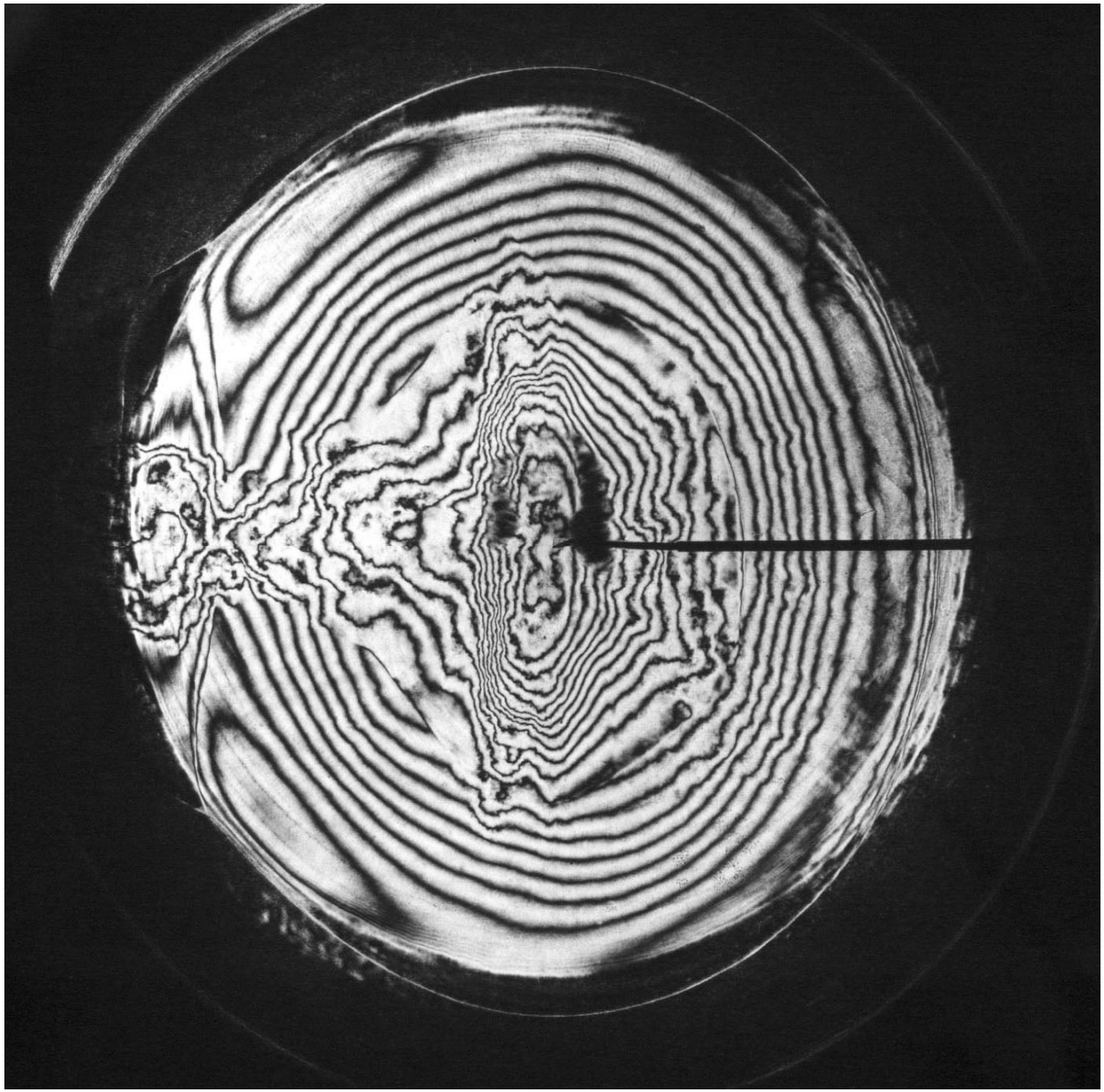


Micro-Explosion Ignited by Laser Beam Irradiation

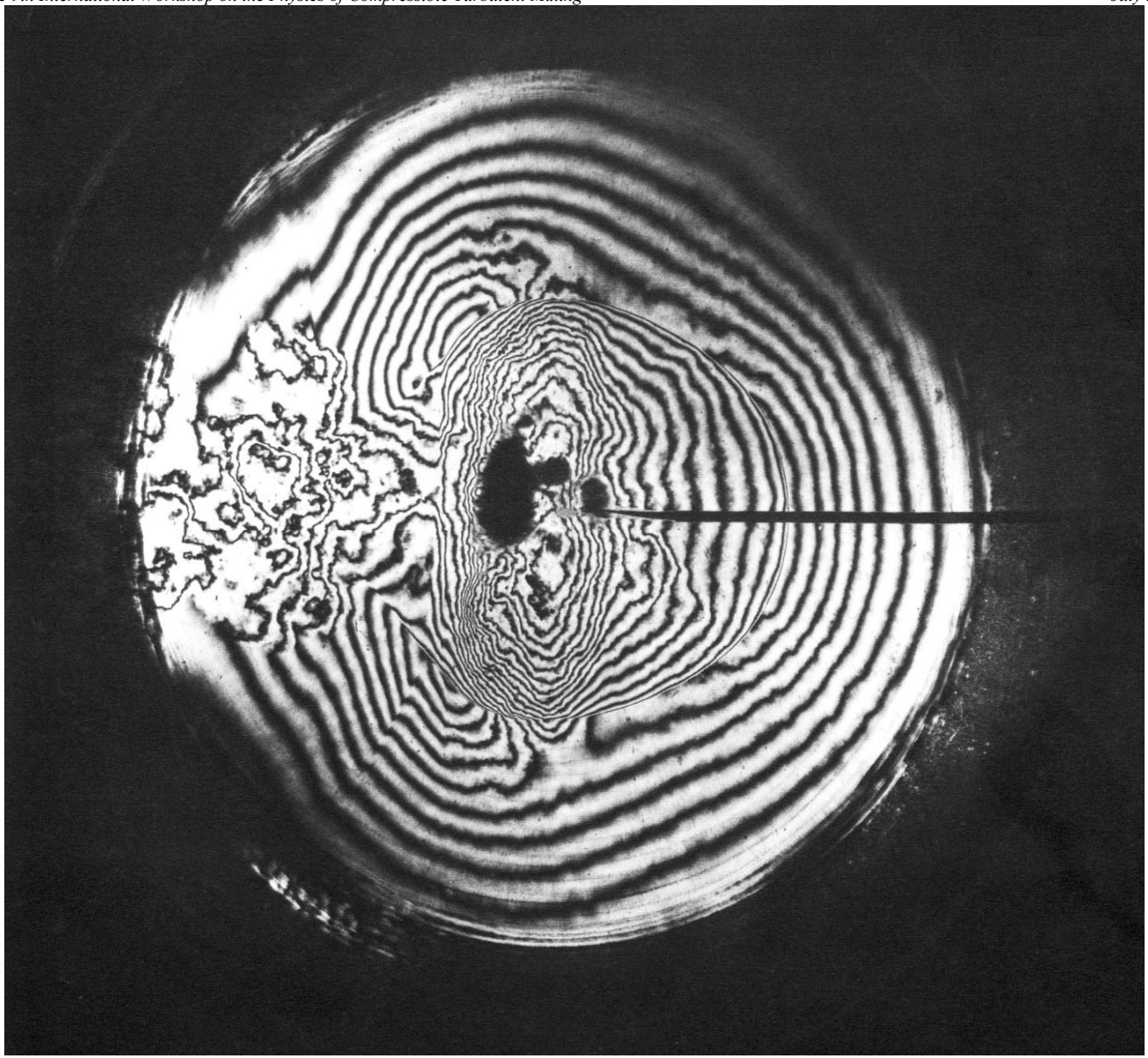


50 μs

Holographic interferometry can describe material interface.



100 μs

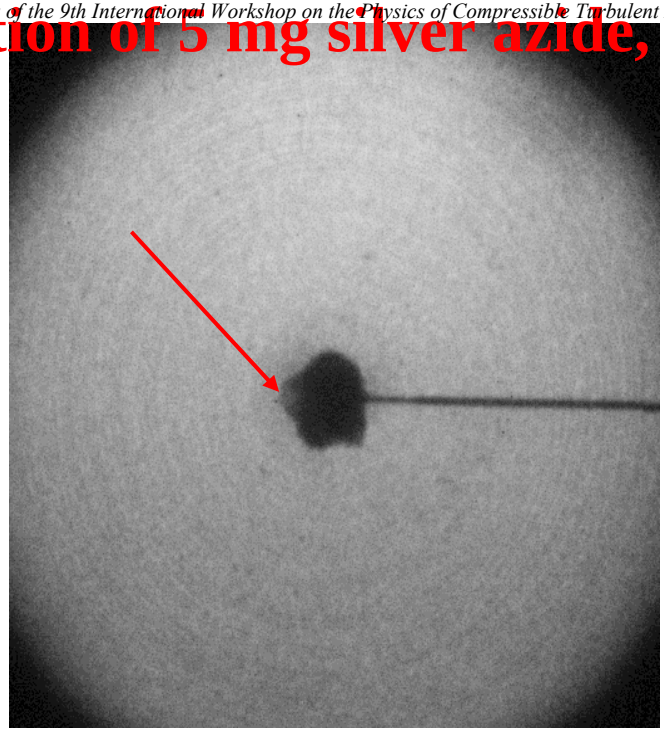


260 μs

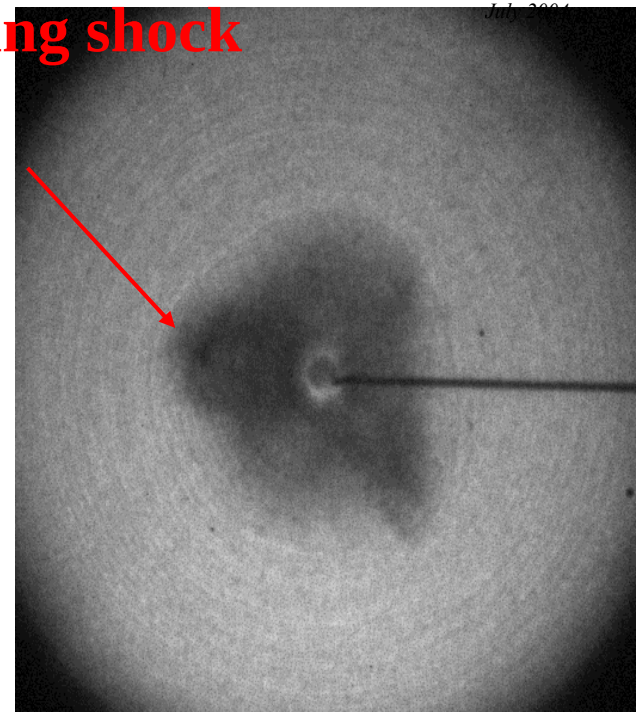
Laser ignition not necessarily produces spherical shock and then the shape of charges should be modified so as to initiate spherical shock. Base ignited conical shape can produce, at the moment, relatively spherical shock shapes.

Base ignition of 5 mg silver azide, diverging shock

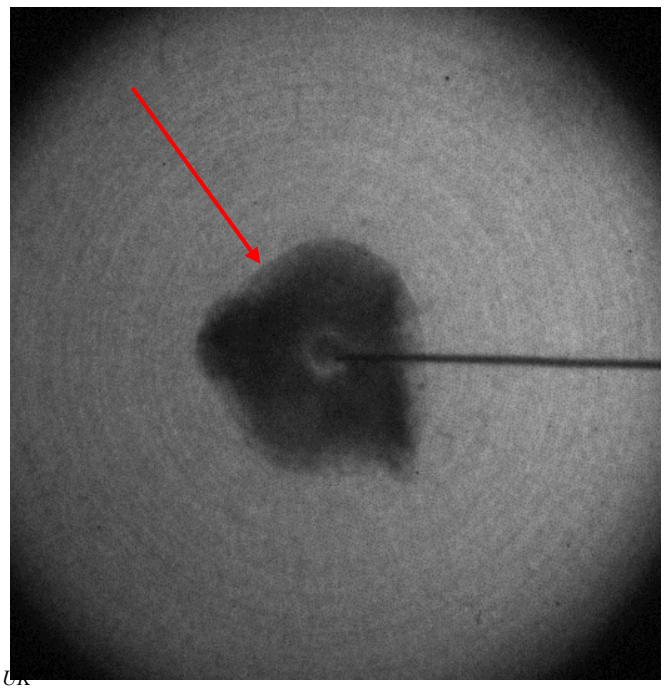
6 μs



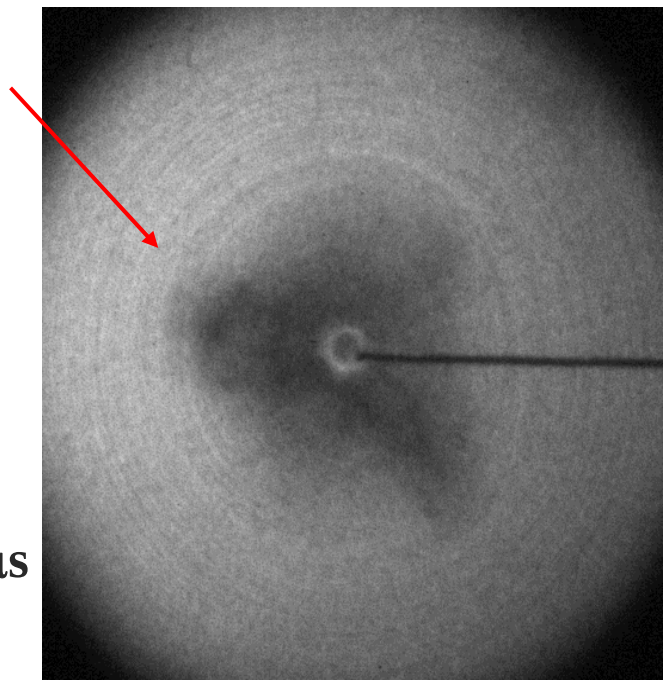
38 μs



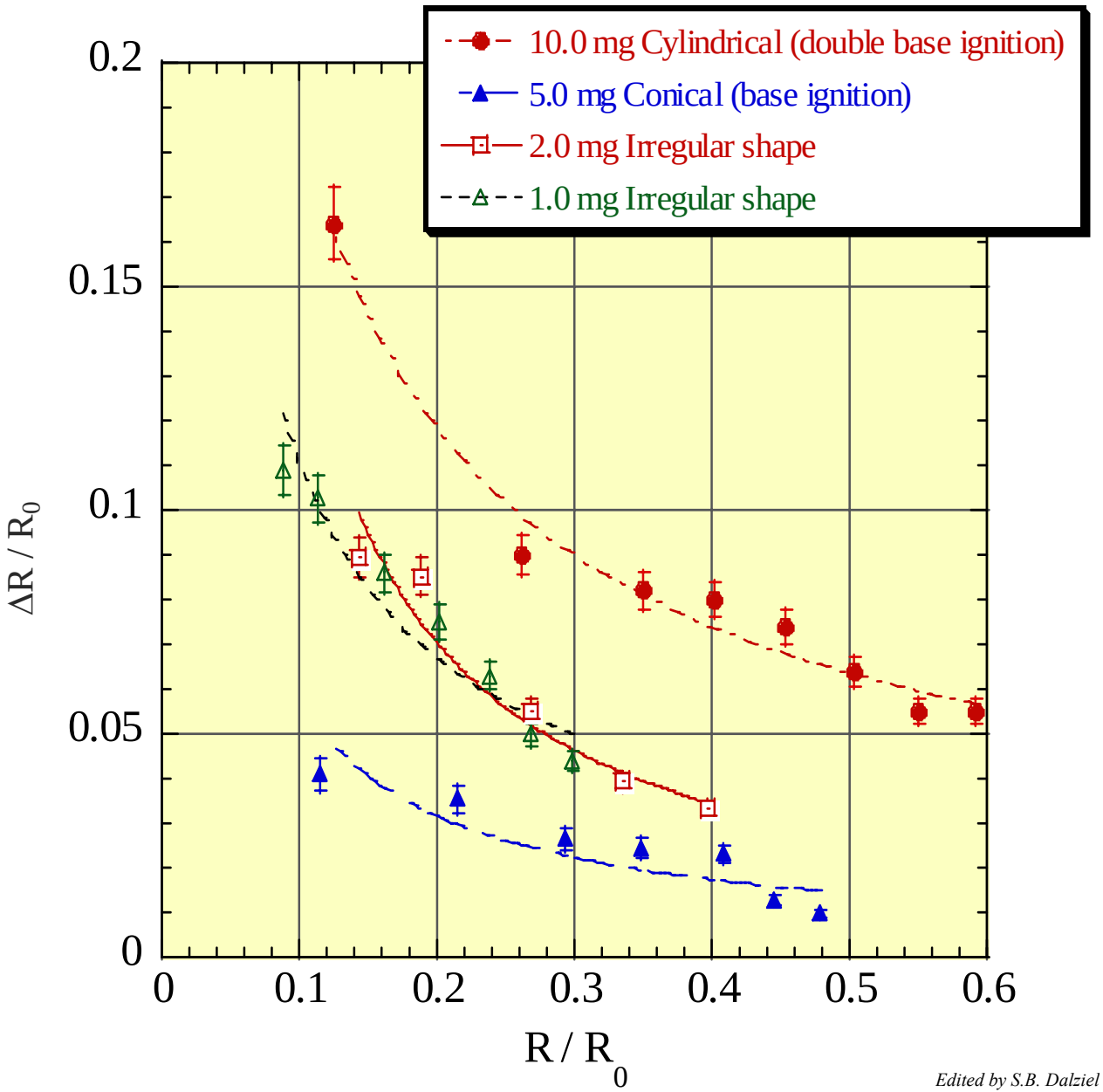
22 μs



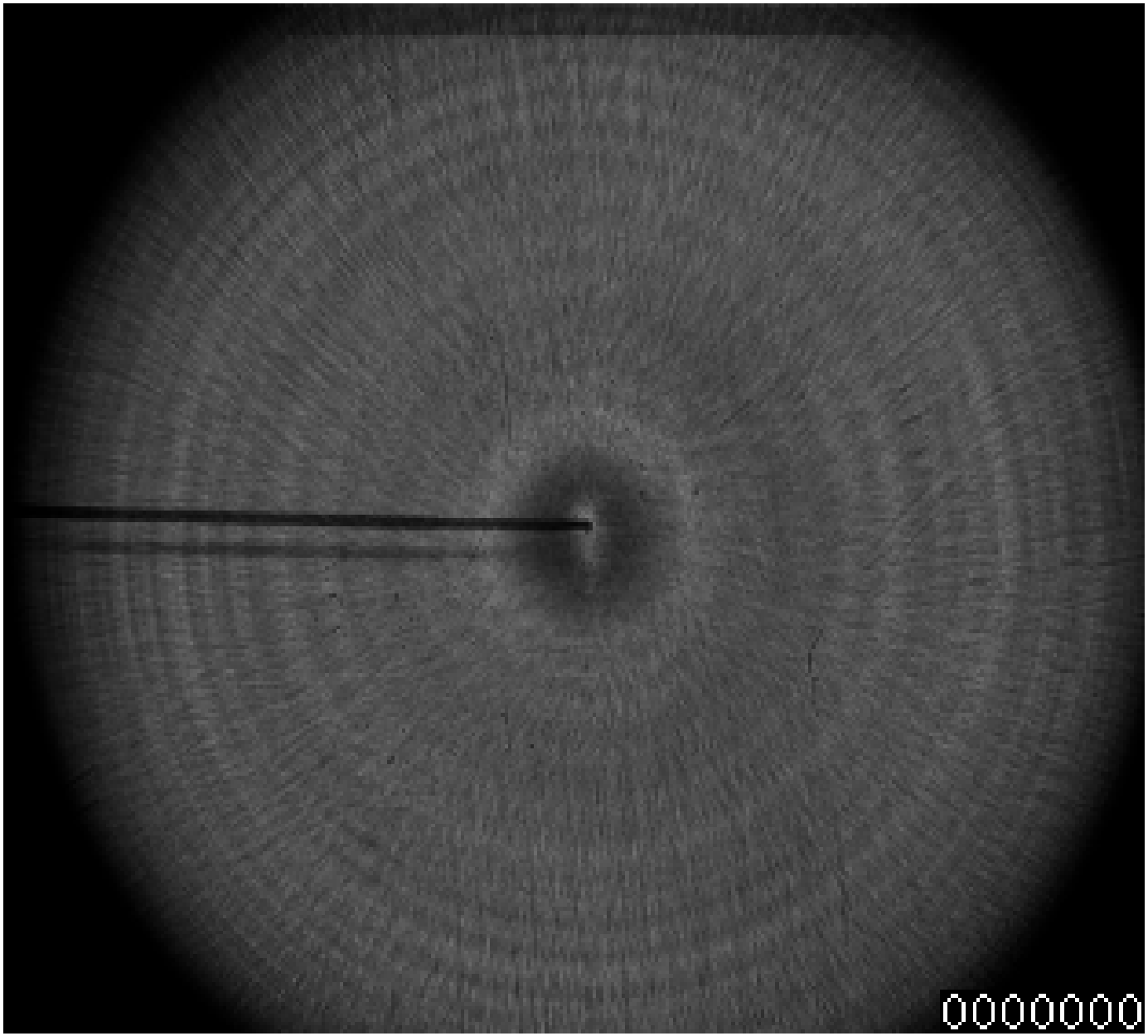
54 μs



Deviation of Shock Shape from Sphere

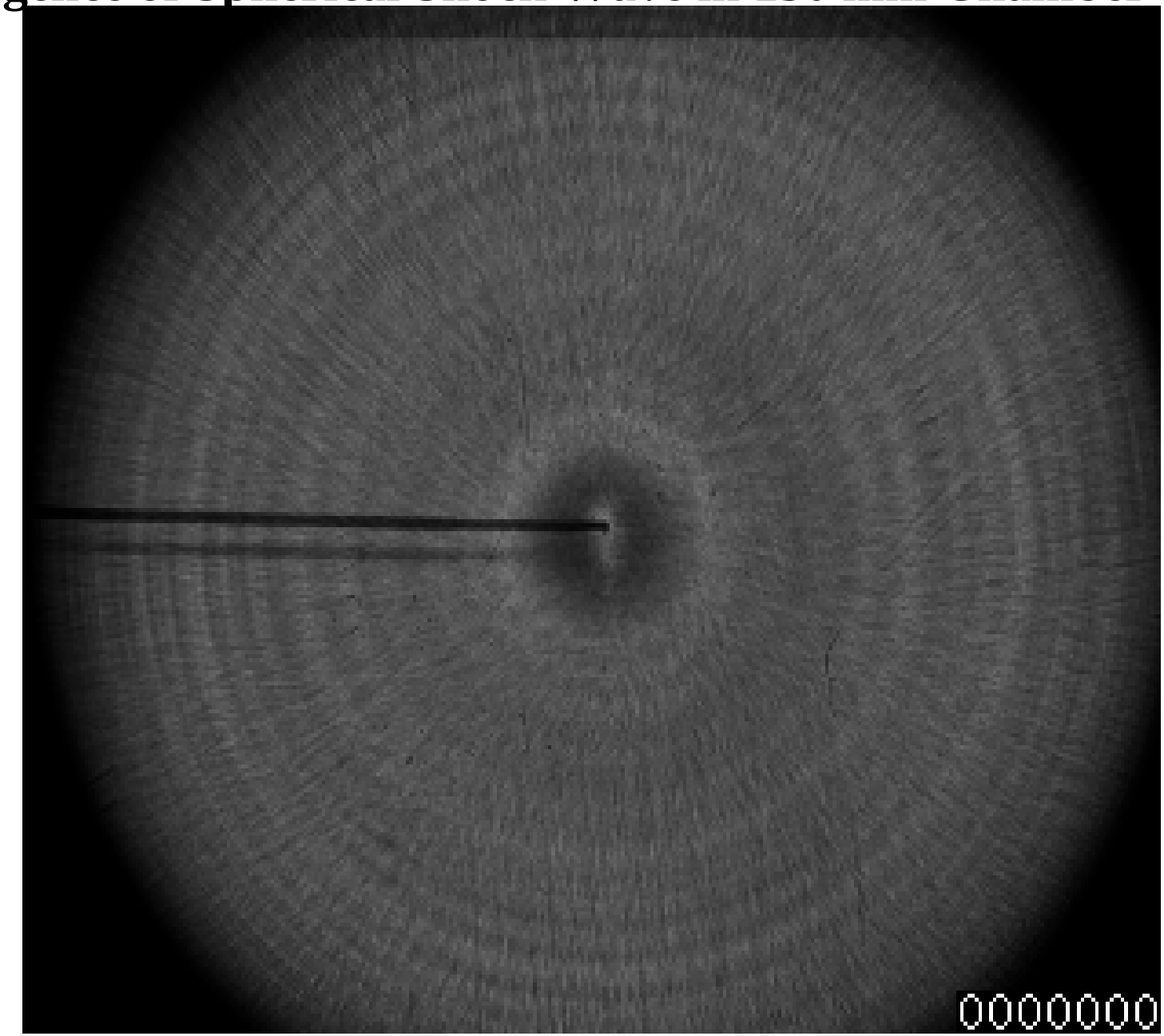


Diverging Spherical Shock Wave in 150 mm Chamber



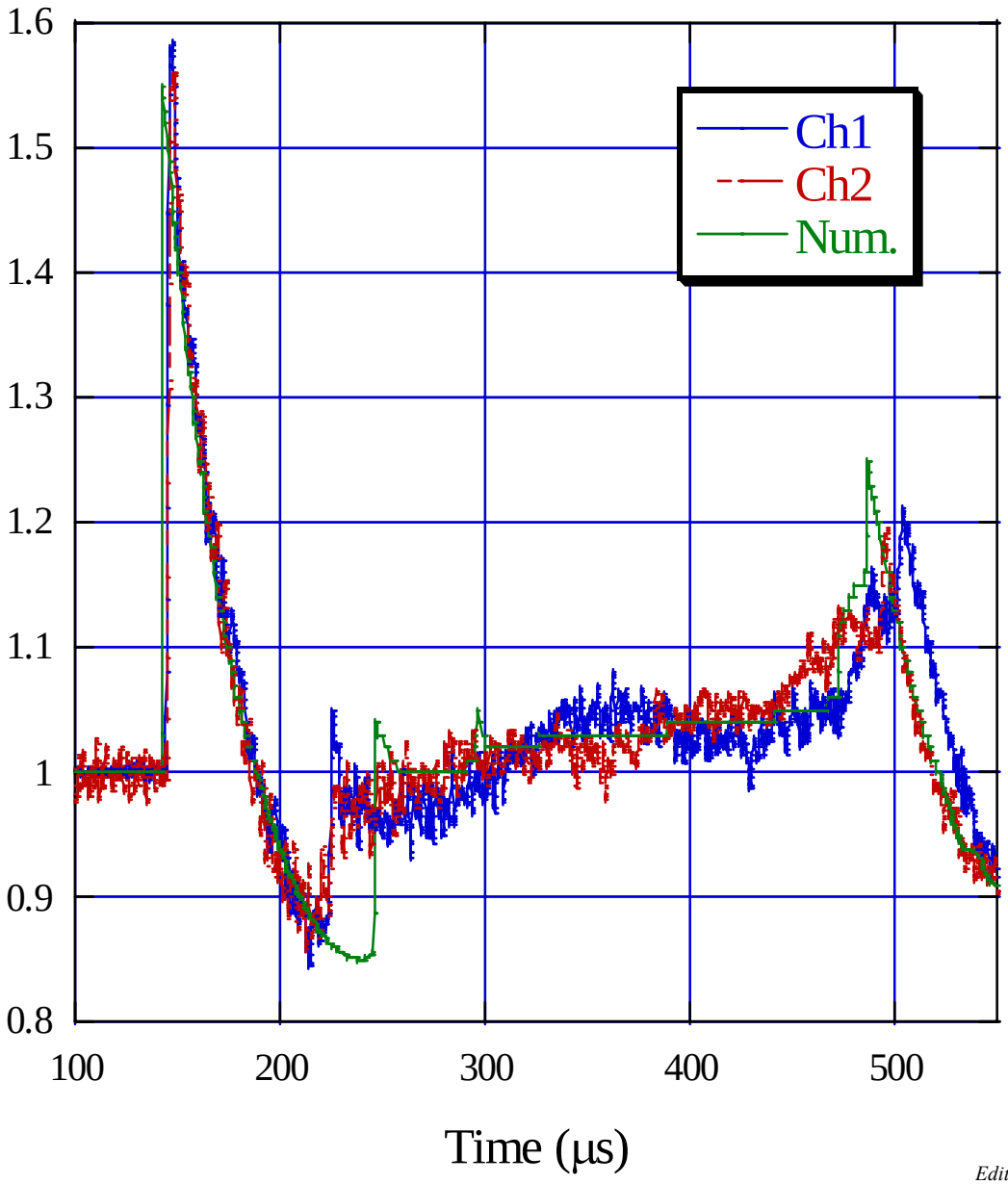
5.0 mg conically shaped AgN_3, 2 μs inter-frame time, 250 ns exposure time

Convergence of Spherical Shock Wave in 150 mm Chamber

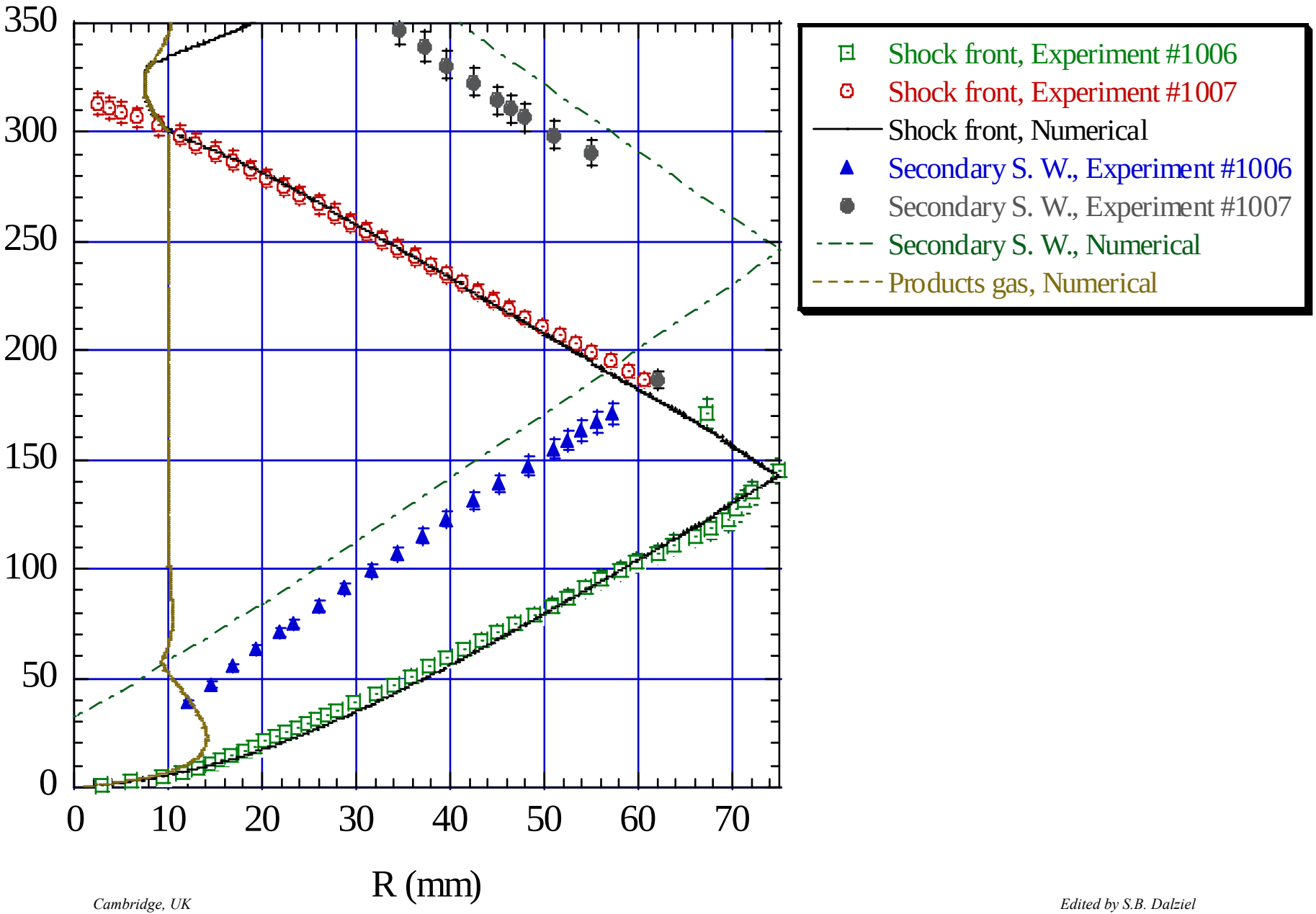


5.0 mg conically shaped AgN_3 , 2 μs inter-frame time, 250 ns exposure time

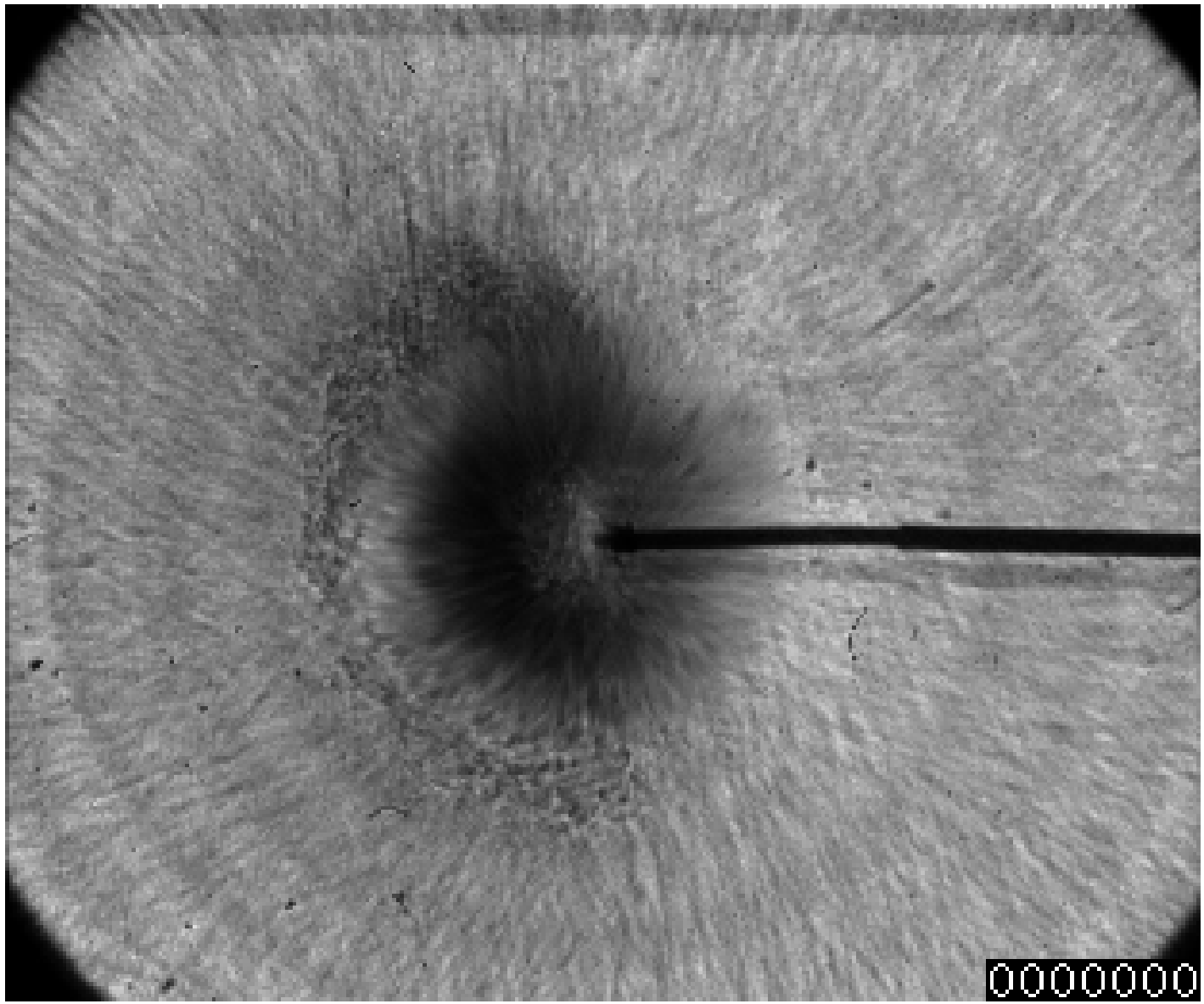
Comparison of Pressure Measurements with CFD Using Revised Kihara-Hikita EOS for AgN_3 Detonation



Shock Wave Trajectory in r-t Diagram

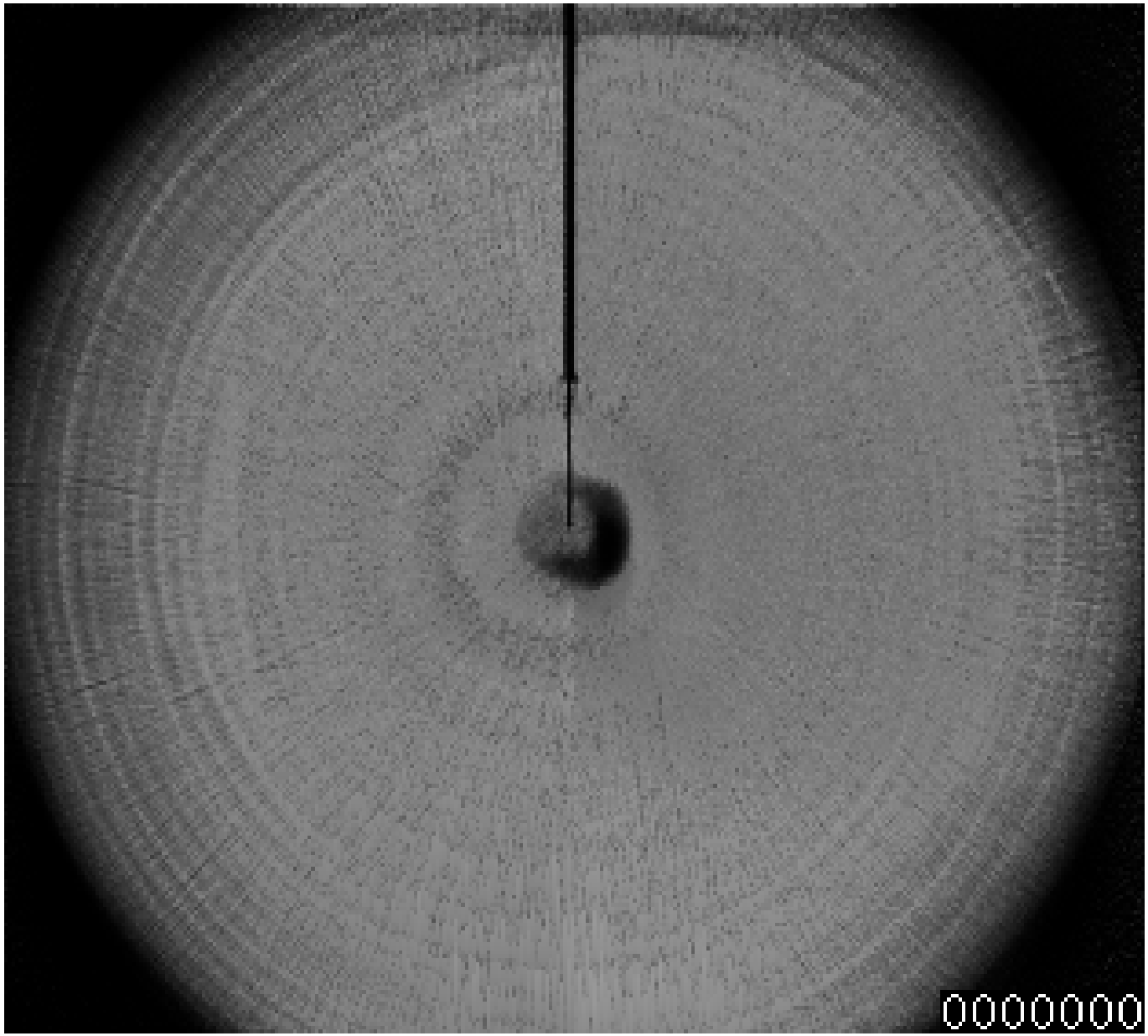


Converging Spherical Shock Waves in 150 mm dia. Chamber



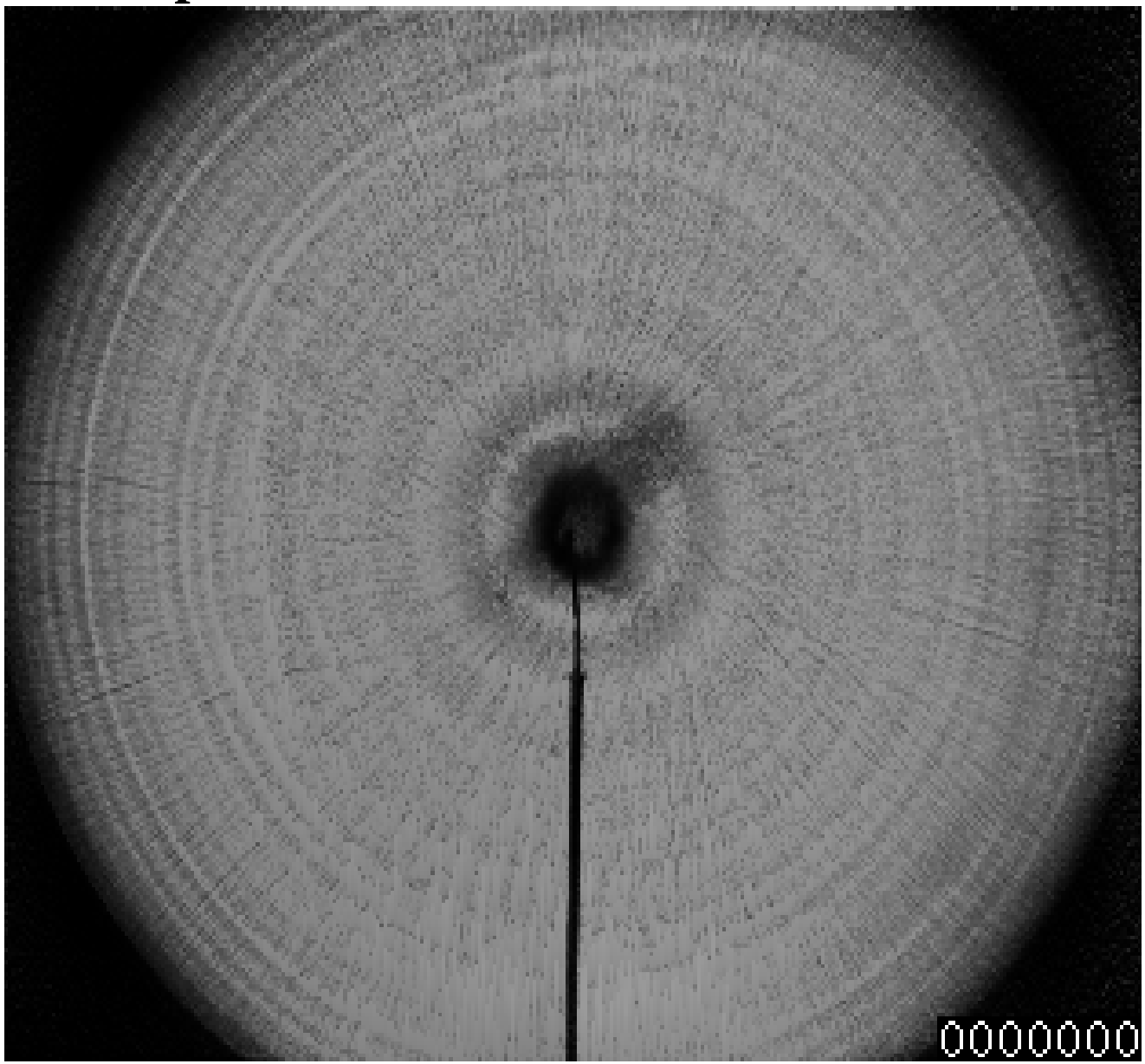
2.0 mg conically shaped AgN_3 2 μs inter-frame time, 250 ns exposure time

Diverging Shock Waves in 300 mm Diameter Chamber



5.0 mg conical shape AgN_3 2 μs inter-frame time, 250 ns exposure time

Convergence of Spherical Shock Waves in 300 mm dia. Chamber



5.0 mg conical shape AgN_3 2 μs inter-frame time, 250 ns exposure time

Summary

Constructed 150 mm and 300 mm aspheric shape test sections and visualized diverging and converging spherical shock waves.

Optimized the shape of silver azide pellets with combination of a laser ignition system for creating spherical shock waves.

Obtained a relatively undisturbed spherical shock waves.

Found that a 300 mm diameter test section was helpful in performing R-M instability occurring spherical shock implosion.

Future Works

Improve charge shapes and their ignition.

CFD of silver-azide explosion.

Achieve higher degree of reproducibility.

Develop time-resolved real time holographic interferometry or combination of laser light sheet technique.

Develop a high-speed camera of 3 x 10^6 f/s, 104 frames and color images.

Observe shock/gaseous interface interaction by creating co-axial soap bubbles filled with foreign gases.