INTERNAL REPORT SDL-87-02

IMPACT EXPERIMENTS TO DETERMINE THE FEASIBILITY OF USING DOW CORNING PYROCERAM 9606 AS A RAMP WAVE GENERATOR

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INTRODUCTION

It is desirable to have a ramp wave generator that extends beyond the 40 kbar stress limit of fused silica. Data from Sandia Labs on Pyroceram 9608 indicates that this may be a suitable material. However, 9608 is not available in required sizes. A very closely related material is 9606 which is available. Two particle velocity experiments, at 87.5 and 77 kbar, were performed to determine the suitability of Pyroceram 9606 as a ramp wave generator.

EXPERIMENTS

Material properties for the Pyroceram 9606 and details of the experimental parameters are given in Table I. Both targets were built exactly the same. Only the impact velocity, and therefore the peak stress, was changed. This allowed for direct comparison between the two shots. Gauges were placed on the impact surface and at a depth of 5.61 mm into the sample. Gauges were of the vapor-deposited/electroplated type. Two gauges with different lead configuration were placed at the internal location for comparison. Initial stress was determined from the measured projectile velocity, measured particle velocity and the hugoniot for sapphire. Hall probes were mounted directly behind the sample to measure the magnetic field, and the particle velocity was determined from the relation $\vec{E} = \vec{l} \cdot (\vec{u} \times \vec{B})$. By having gauges on two planes, the wave speed could be measured. The experiments were done using the 63.5 mm gas gun at our laboratory. Gauge layout and the profiles from all of the oscilloscopes are shown in the Appendix.

RESULTS

The profiles from experiment No. 1 (87-529) are shown in Figure 1. The key result here is the significant attenuation between gauges 1 and 2. Gauge 2 also shows the rise to the peak value to be non-linear (almost bilinear). The nonlinear rise by itself is not a serious problem.

Profiles from the second experiment (Figure 2), performed at a peak stress of 77 kbar show no attenuation between the profiles at the two gauge locations. The ramping at the second gauge is nonlinear and is reminiscent of a visco-elastic material.

In Figure 3, the interior gauge profiles from the two shots are shown and up to about 0.35 mm/μs, they overlay almost exactly. This result suggests that the loading path is identical to this value. This result is expected from a material with a convex, upward compression curve.

On the basis of these two shots it appears that Pyroceram 9606 may be a useful material producing ramp waves (with nonlinear sample) up to a stress of 77 kbar. Beyond this value, the material response is complicated by time-dependence and attenuation.

The present set of results, on the basis of 2 experiments, should be considered as preliminary. The low wave speed in the first experiment is puzzling and of some concern.

TABLE I

MATERIAL PROPERTIES

Knoop hardness:	657	
Young's modulus (E):	12 (10^3) kg/mm^2	
Poisson's ratio (υ):	0.24	
Rigidity modulus:	4.84 (10^3) kg/mm^2	[G = E/2(1-υ)]
Bulk modulus:	7.69 (10^3) kg/mm^2	[K = E/3(1-2υ)]
Density:	2.61 gm/cm^3	(buoyancy method)
Sound speed:	7.57 mm/μs	(ultrasonic method)

EXPERIMENTAL SUMMARY

	Shot 87-529	**Shot 87-530**
Projectile velocity, mm/μs:	0.883	0.600
Impactor, 6.4 mm:	sapphire	sapphire
Impact stress, kbar:	87.55	76.96
Magnetic field, gauss:	2919	2455
Wave speed, mm/μs:	7.14	7.64
Impact particle velocity, mm/μs:	0.69	0.43
Interface particle velocity, mm/μs:	0.56	0.43

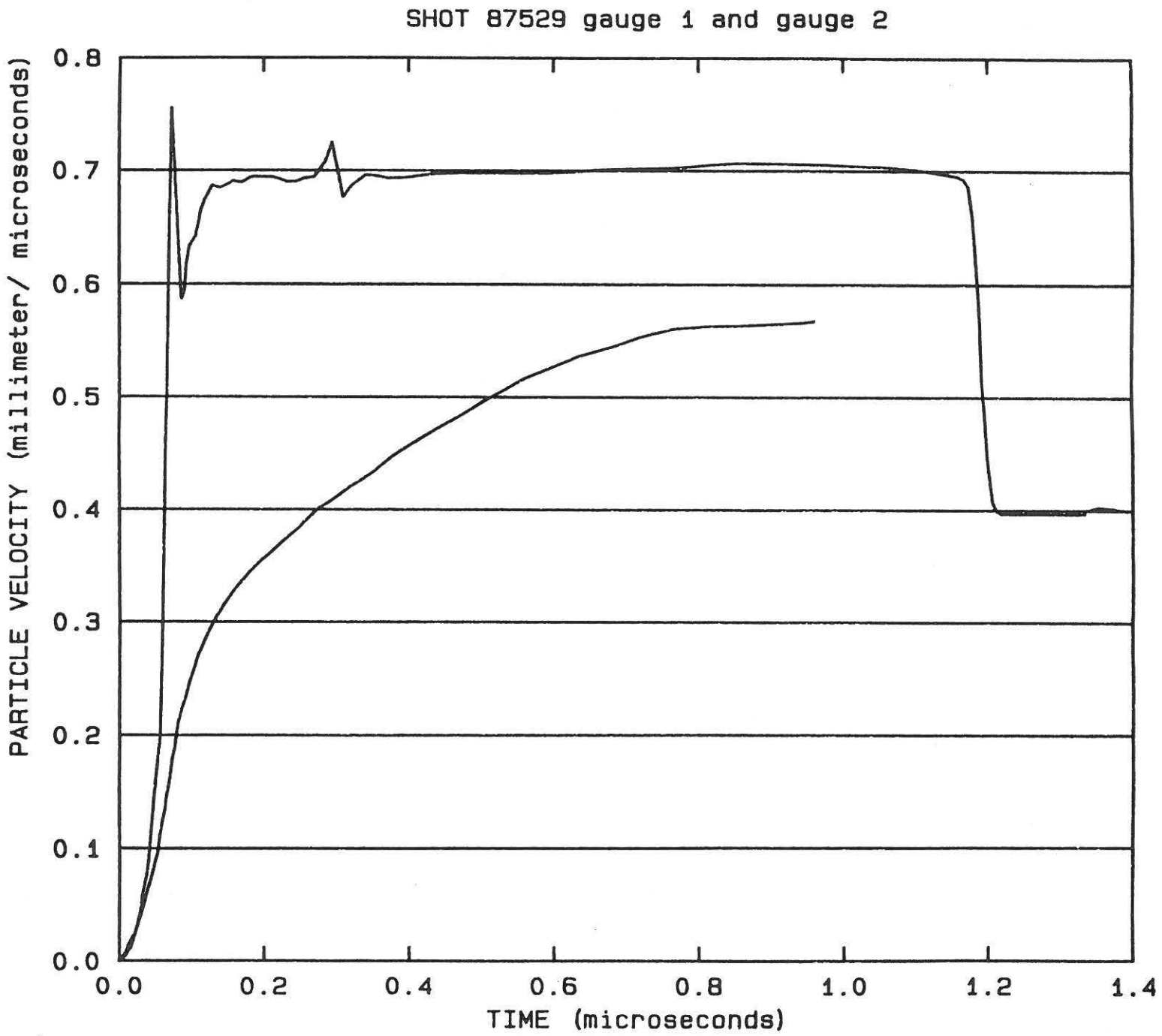
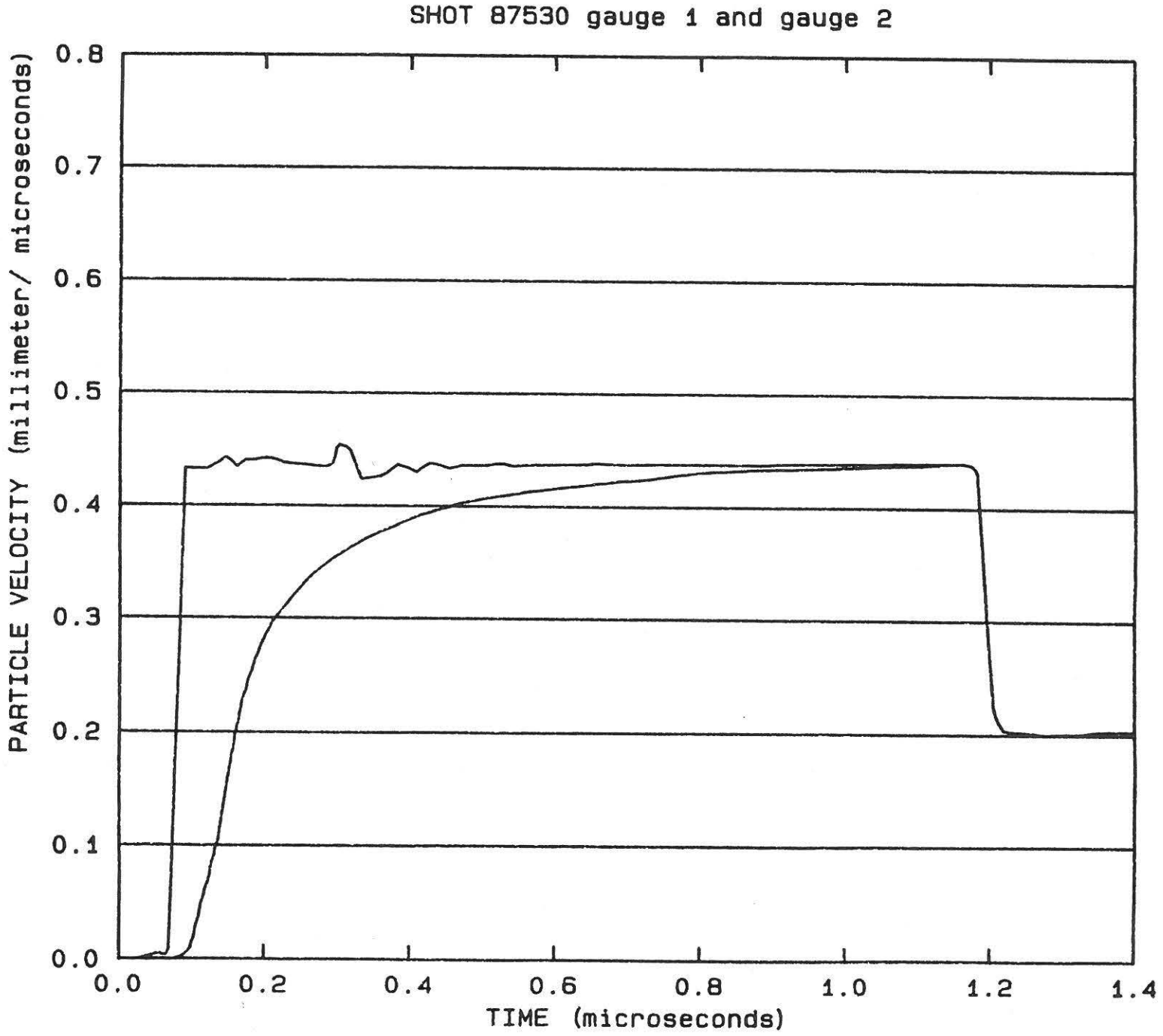
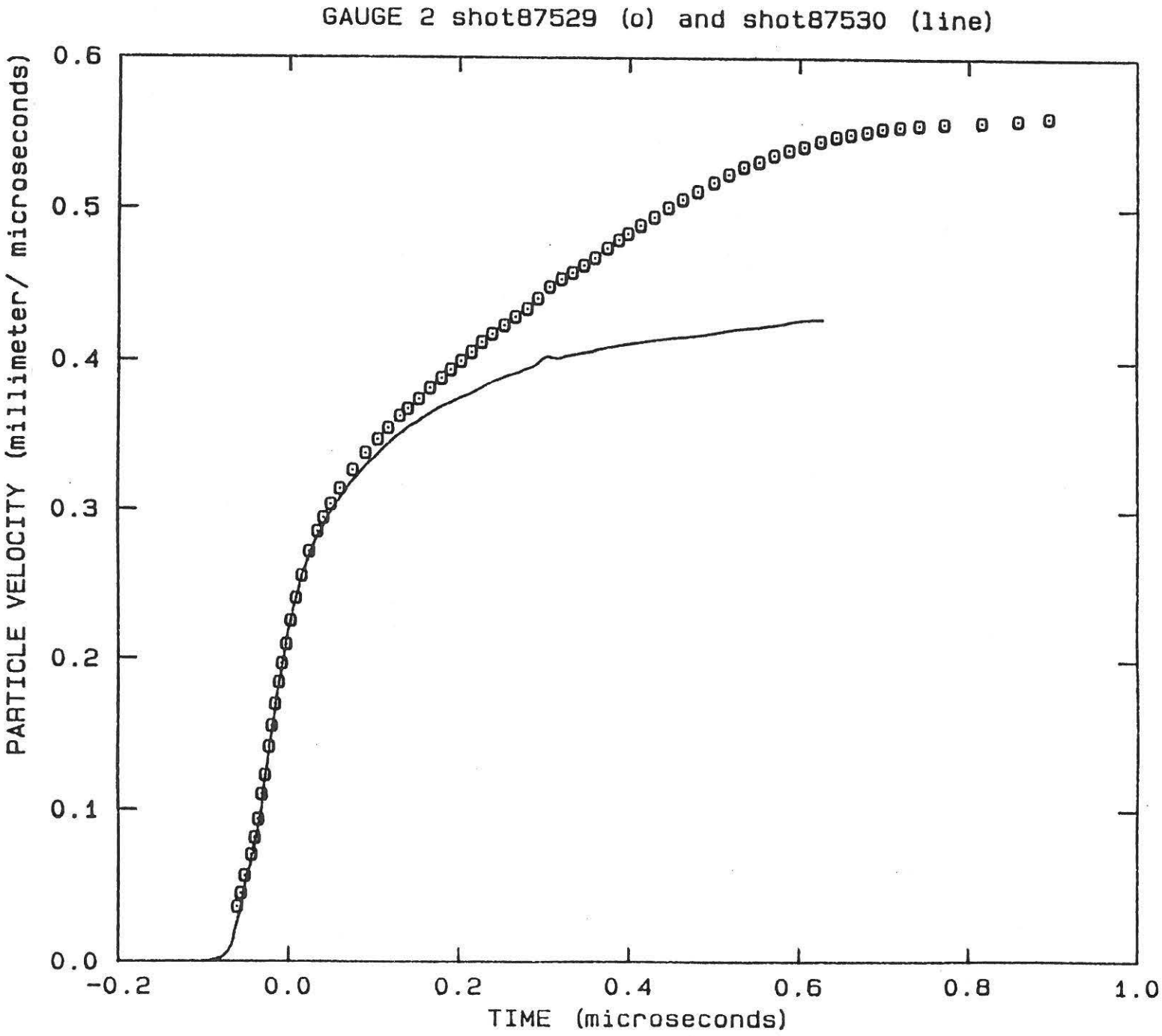

SHOT 87529 gauge 1 and gauge 2
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
TIME (microseconds)

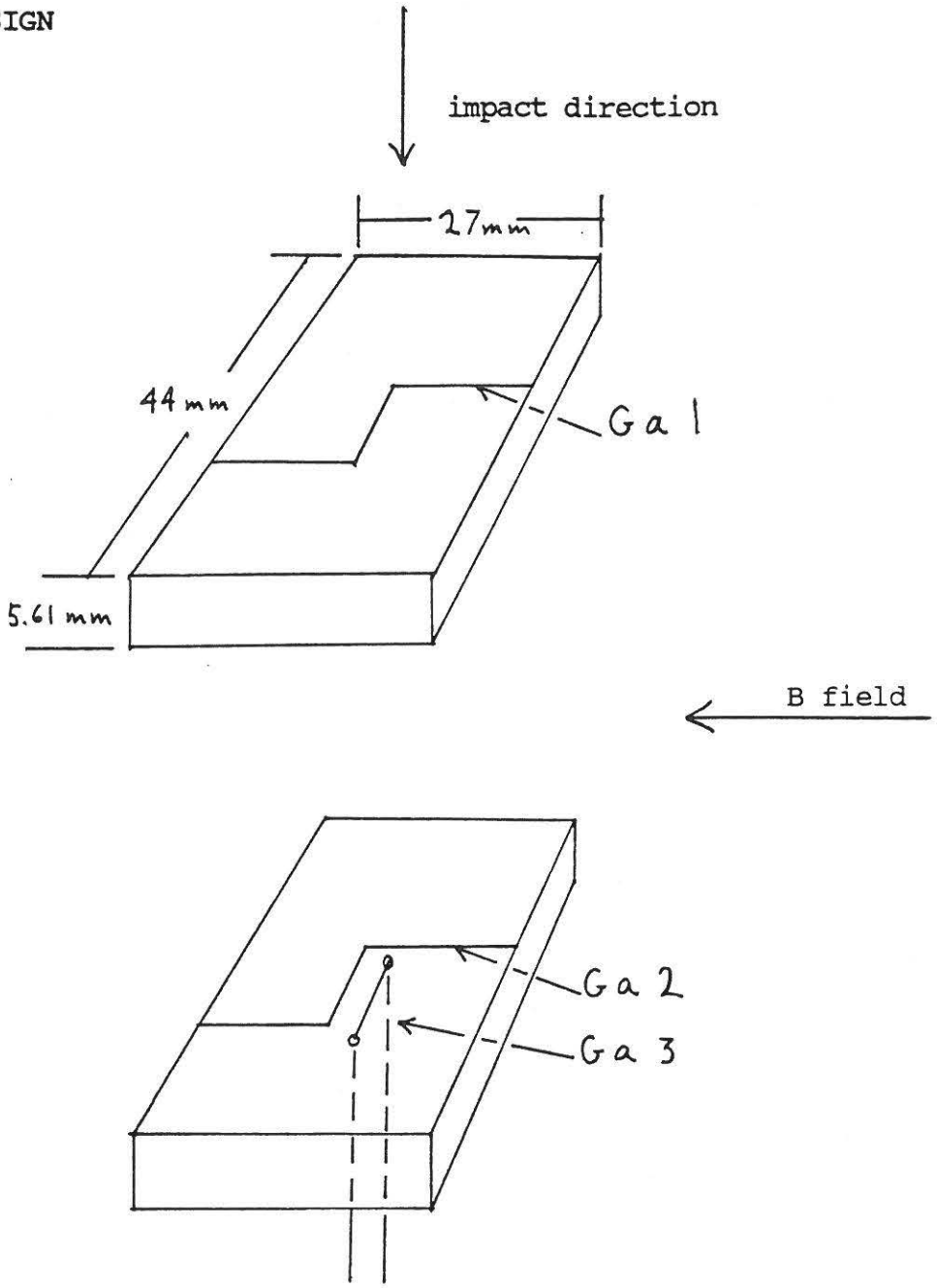
Fig.


SHOT 87530 gauge 1 and gauge 2
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
TIME (microseconds)

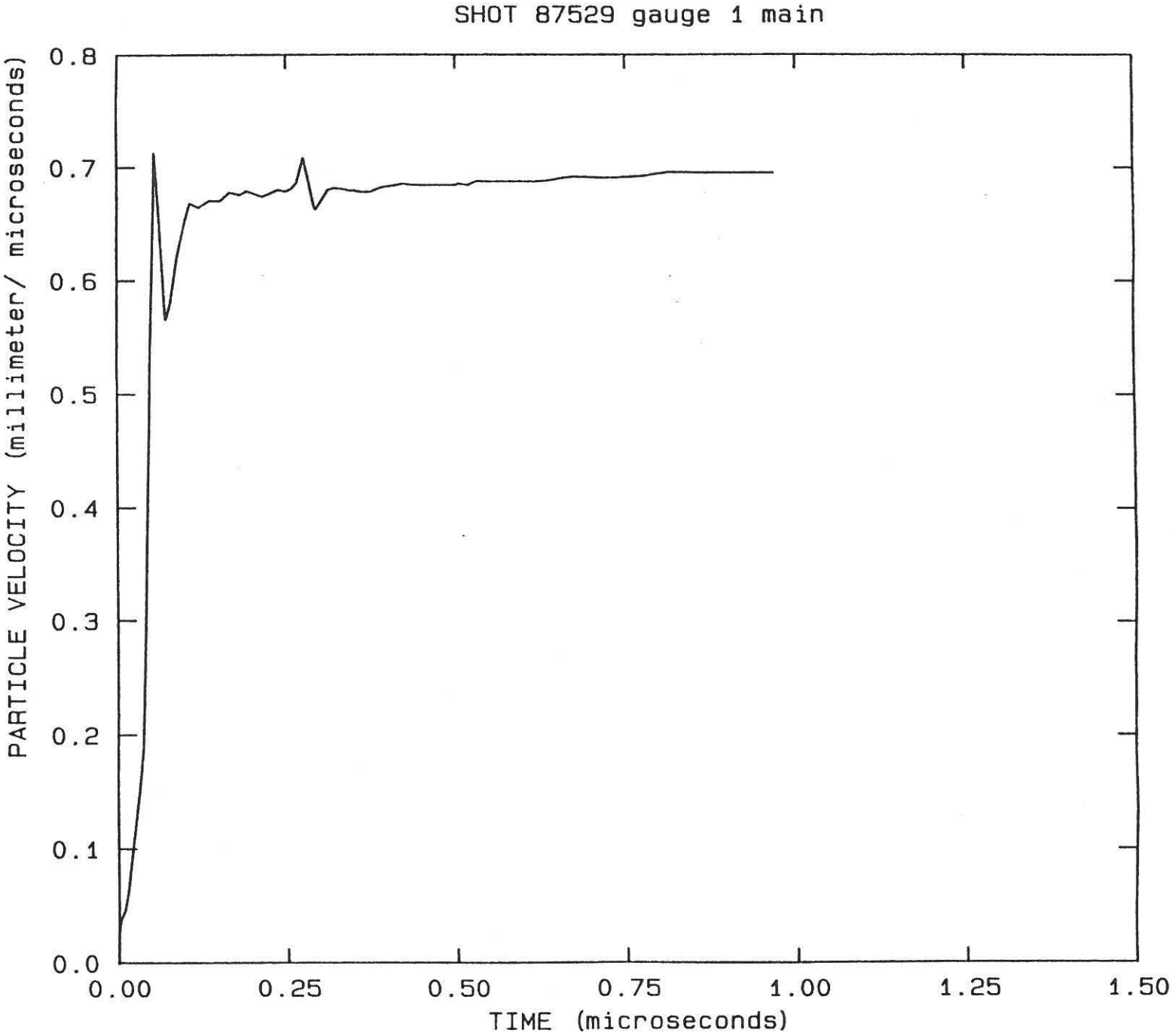

GAUGE 2 shot87529 (o) and shot87530 (line)
PARTICLE VELOCITY (millimeter/ microseconds)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
TIME (microseconds)

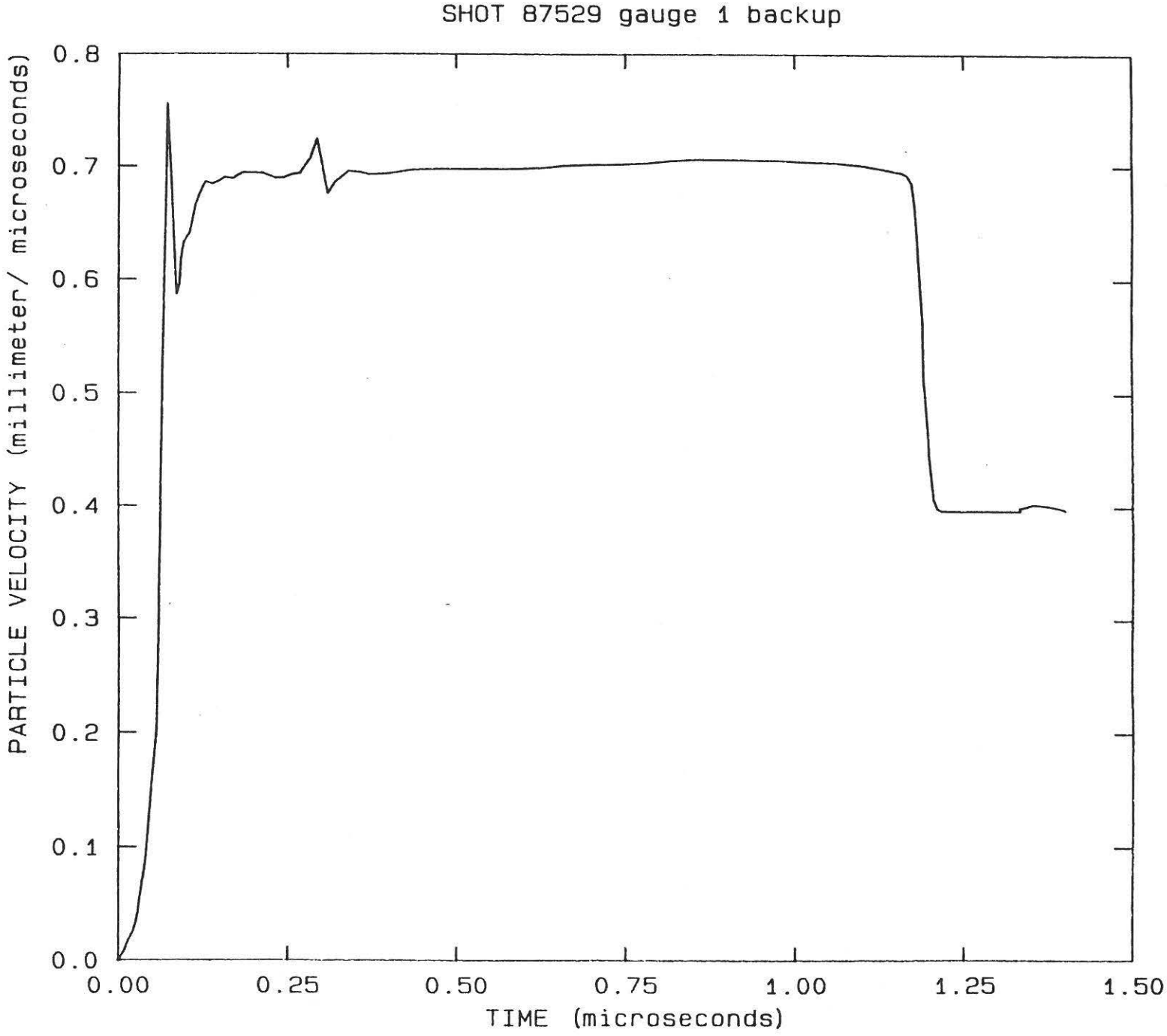
APPENDIX

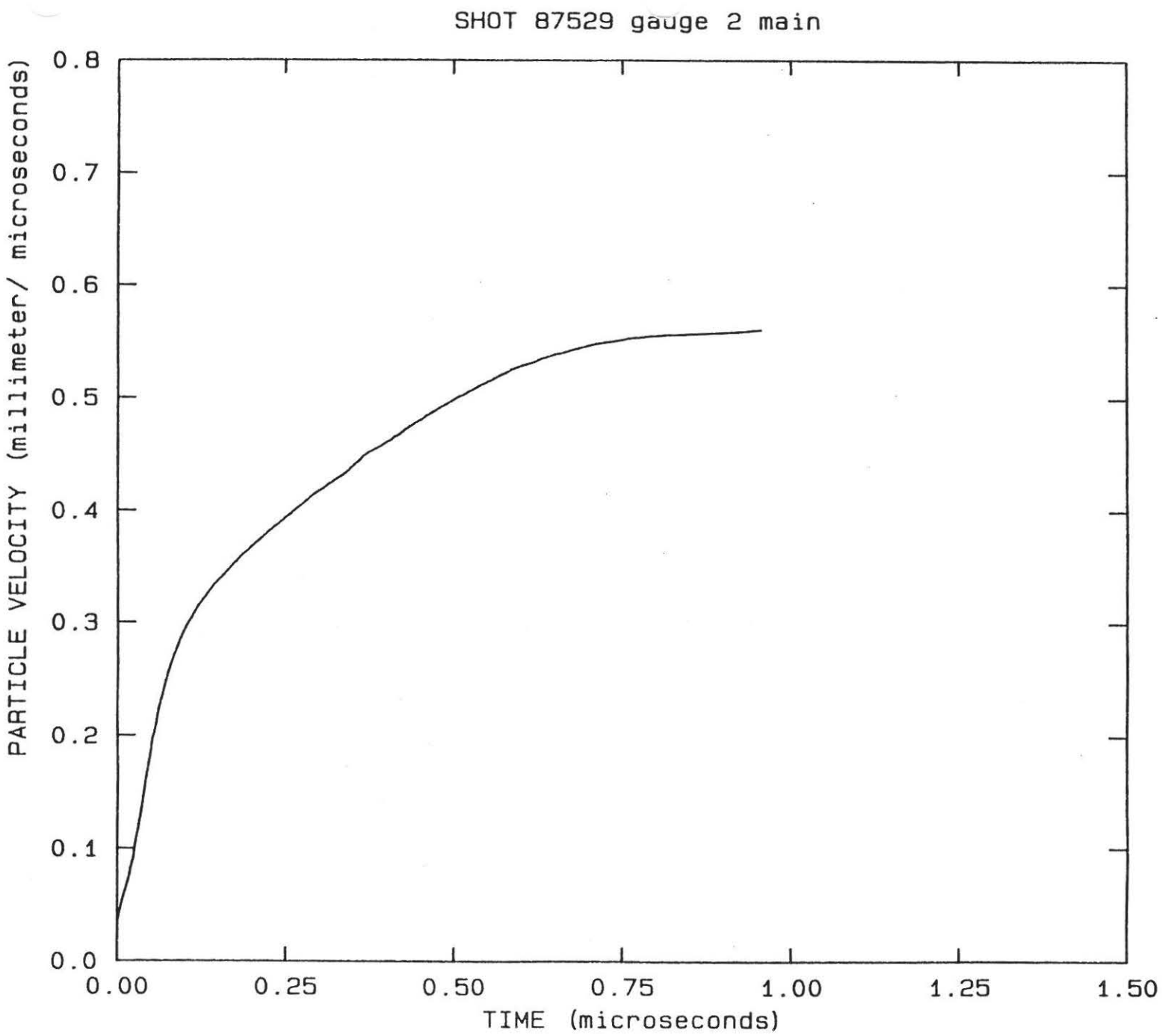
TARGET DESIGN

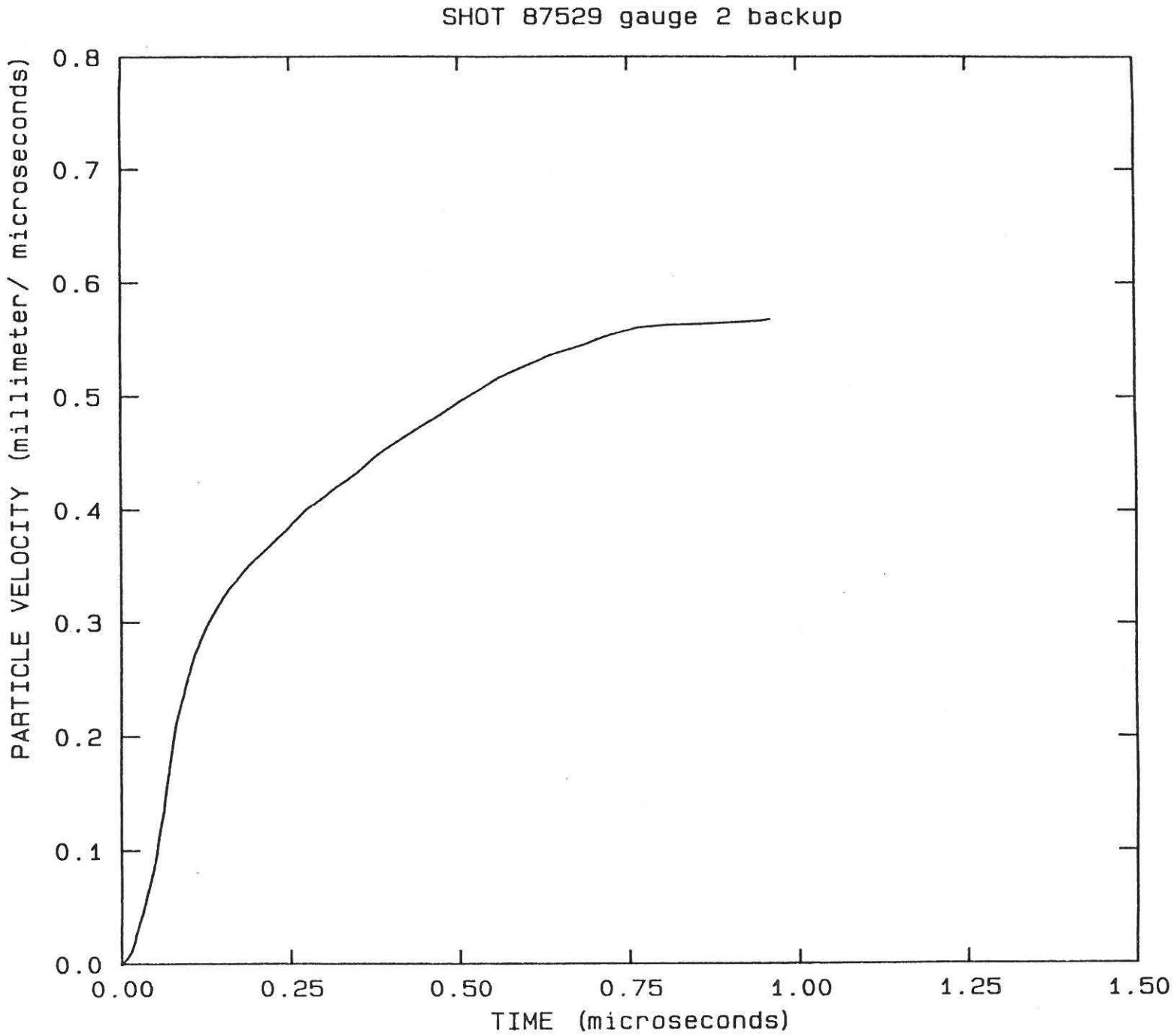


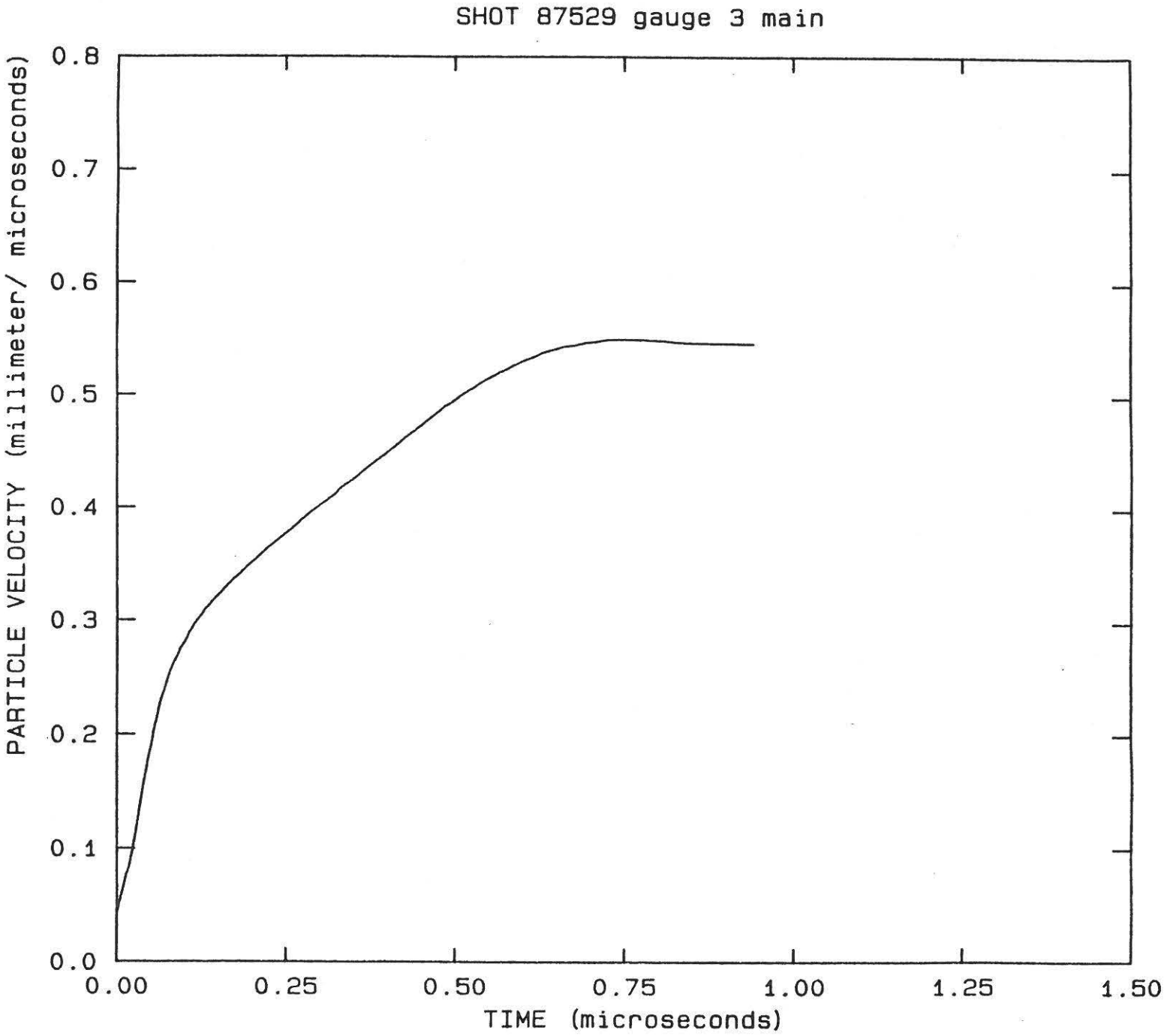
All gauges were 1mm wide by 0.020 mm deep by 10.16 mm long. Gauge 3 was made with the wire leads coming out of the back of the sample for comparison.

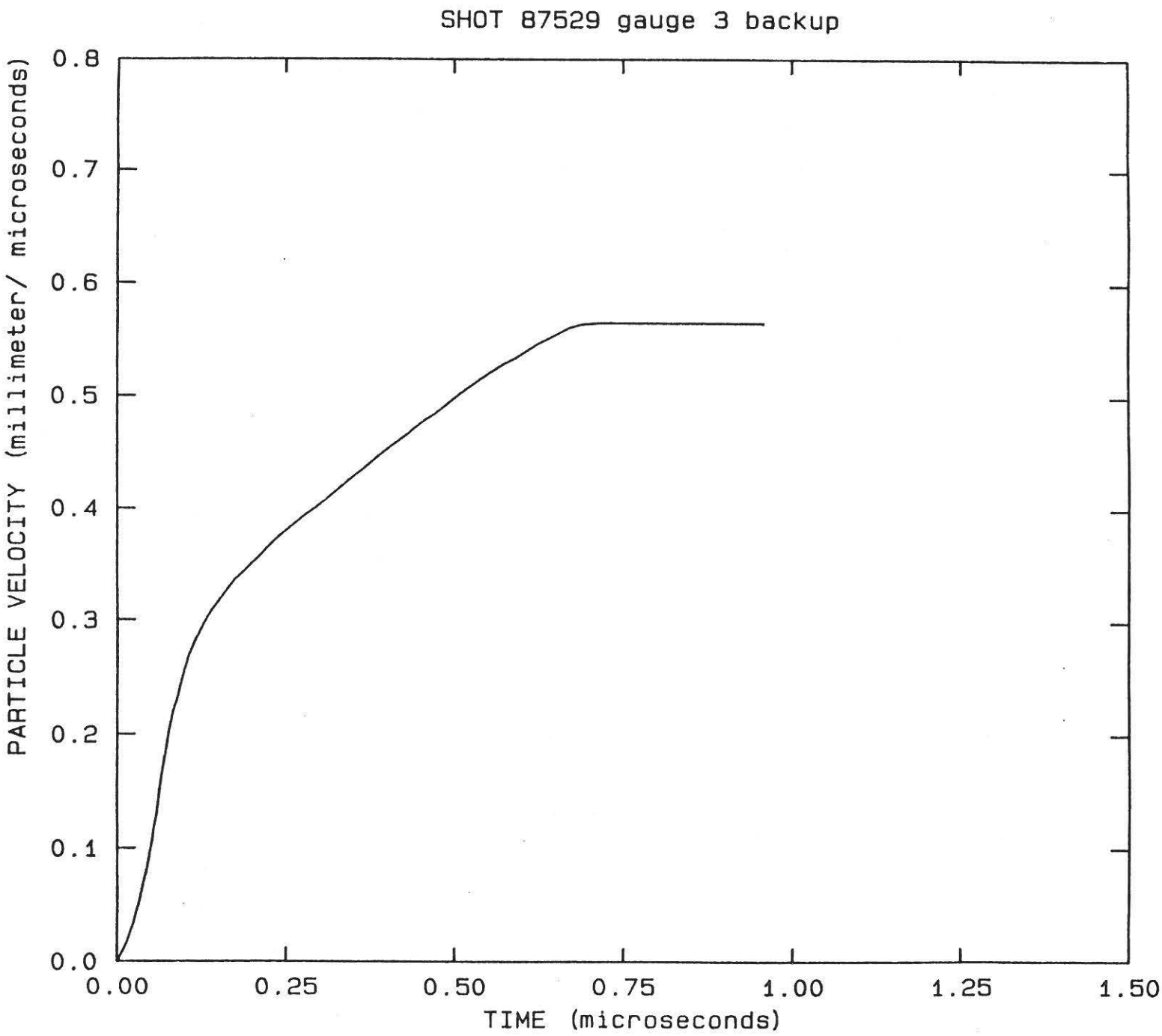

SHOT 87529 gauge 1 main
PARTICLE VELOCITY (millimeter/ microseconds)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87529 gauge 1 backup
PARTICLE VELOCITY (millimeter/ microseconds)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87529 gauge 2 main
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87529 gauge 2 backup
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87529 gauge 3 main
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87529 gauge 3 backup
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
0.1
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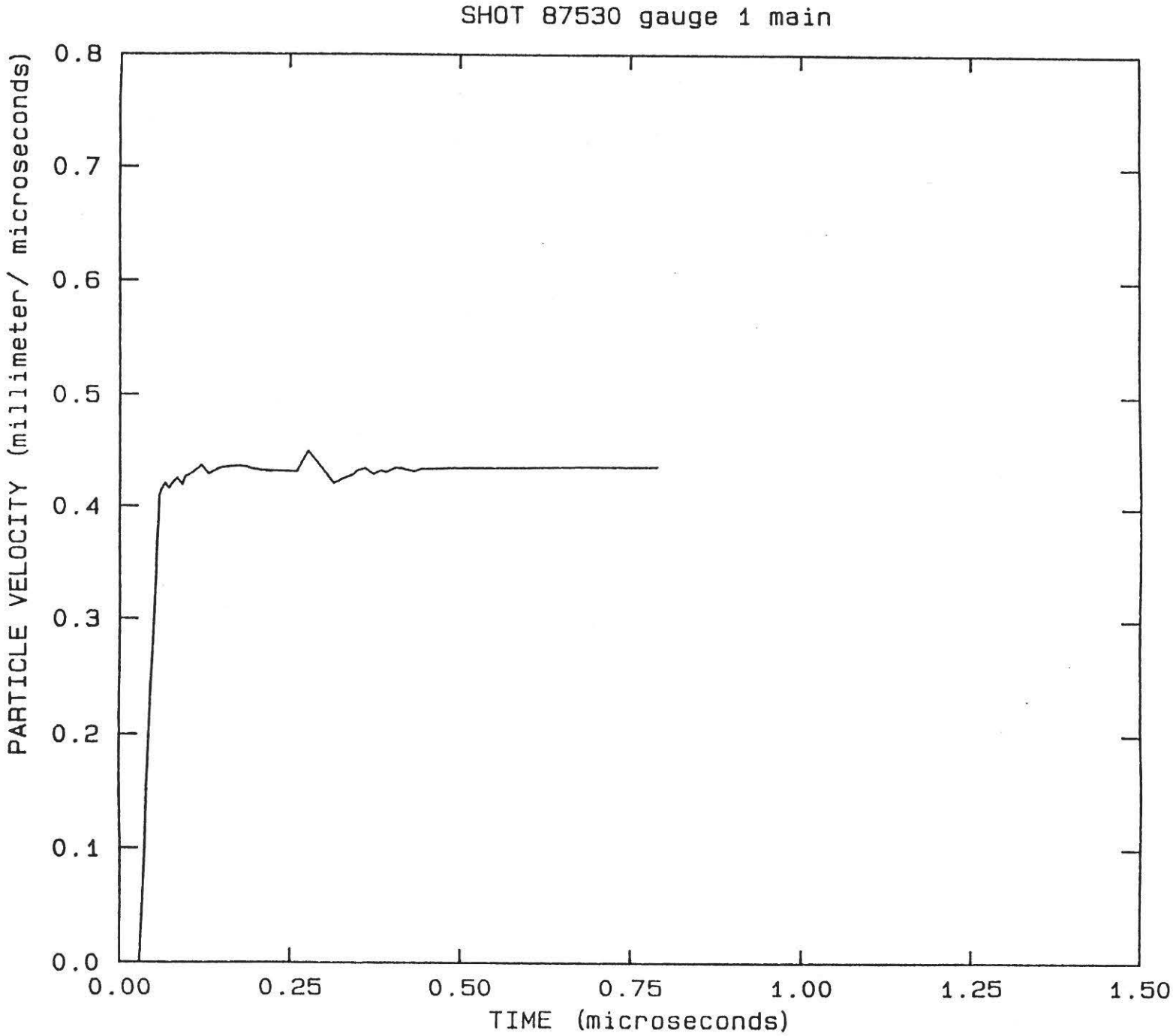
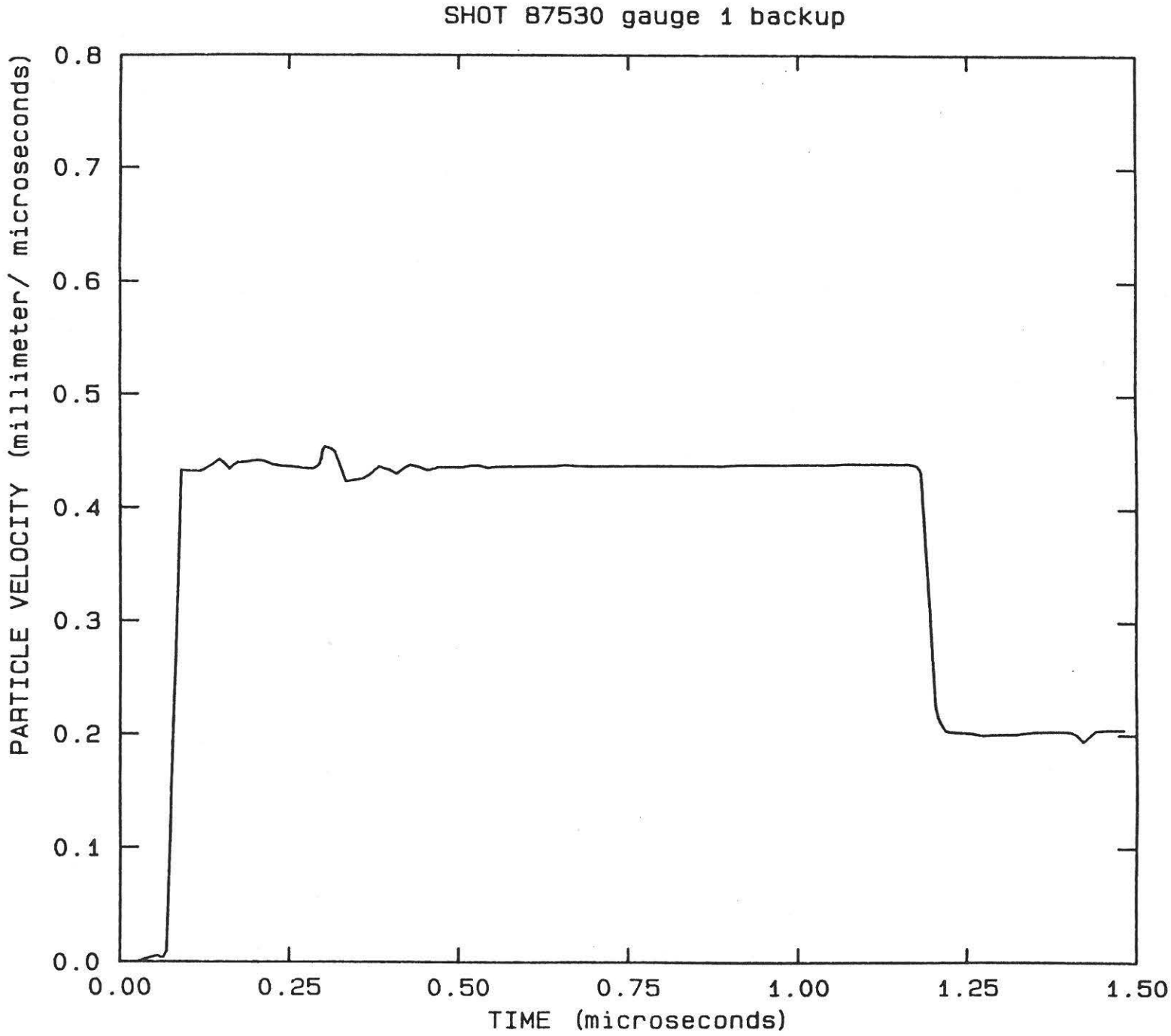
0.3
0.4
0.5
0.6
0.7
0.8
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87530 gauge 1 main
PARTICLE VELOCITY (millimeter/ microseconds)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)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PARTICLE VELOCITY (millimeter/ microseconds)
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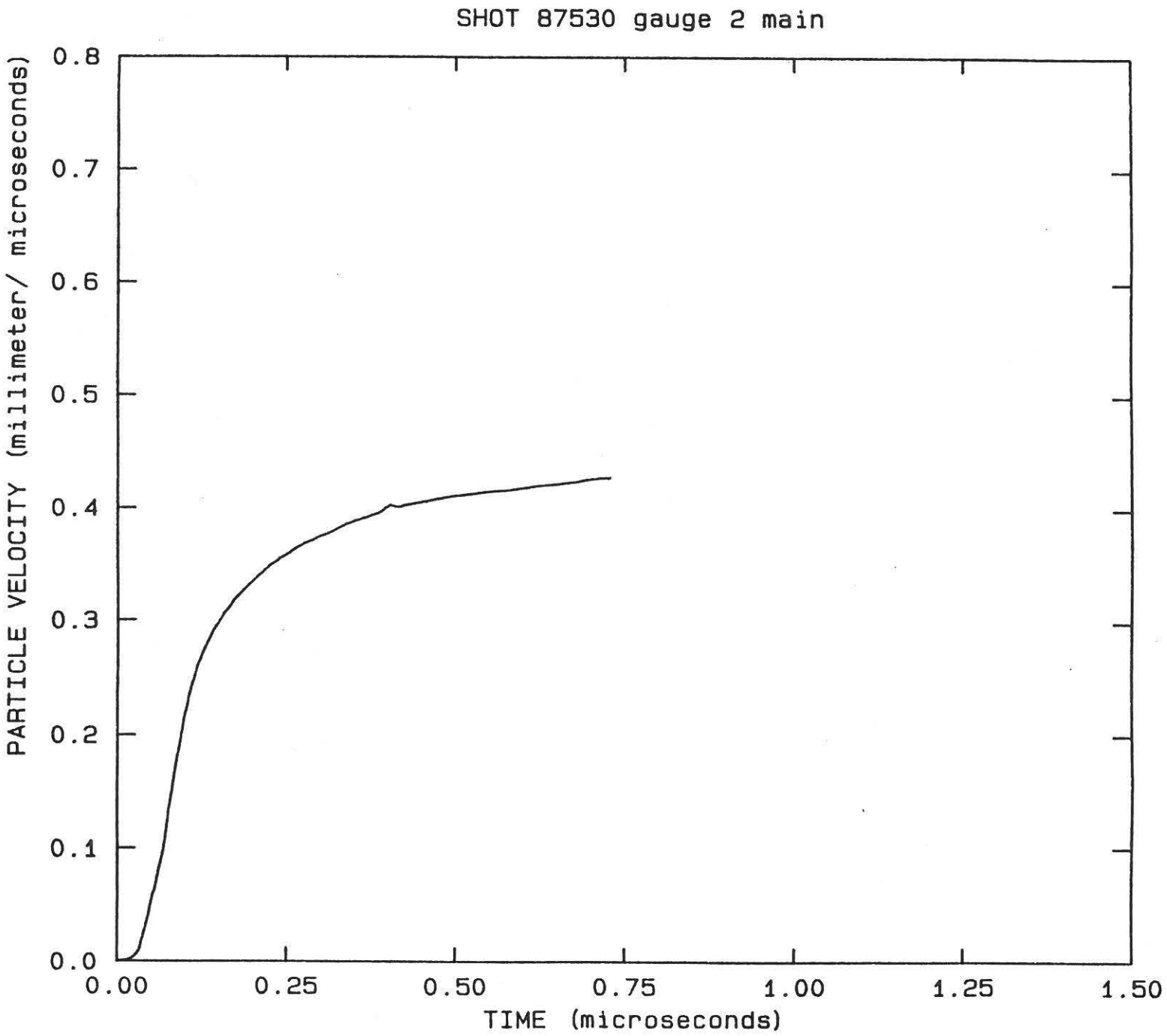
0.4
0.3
0.2
0.1
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87530 gauge 2 main
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
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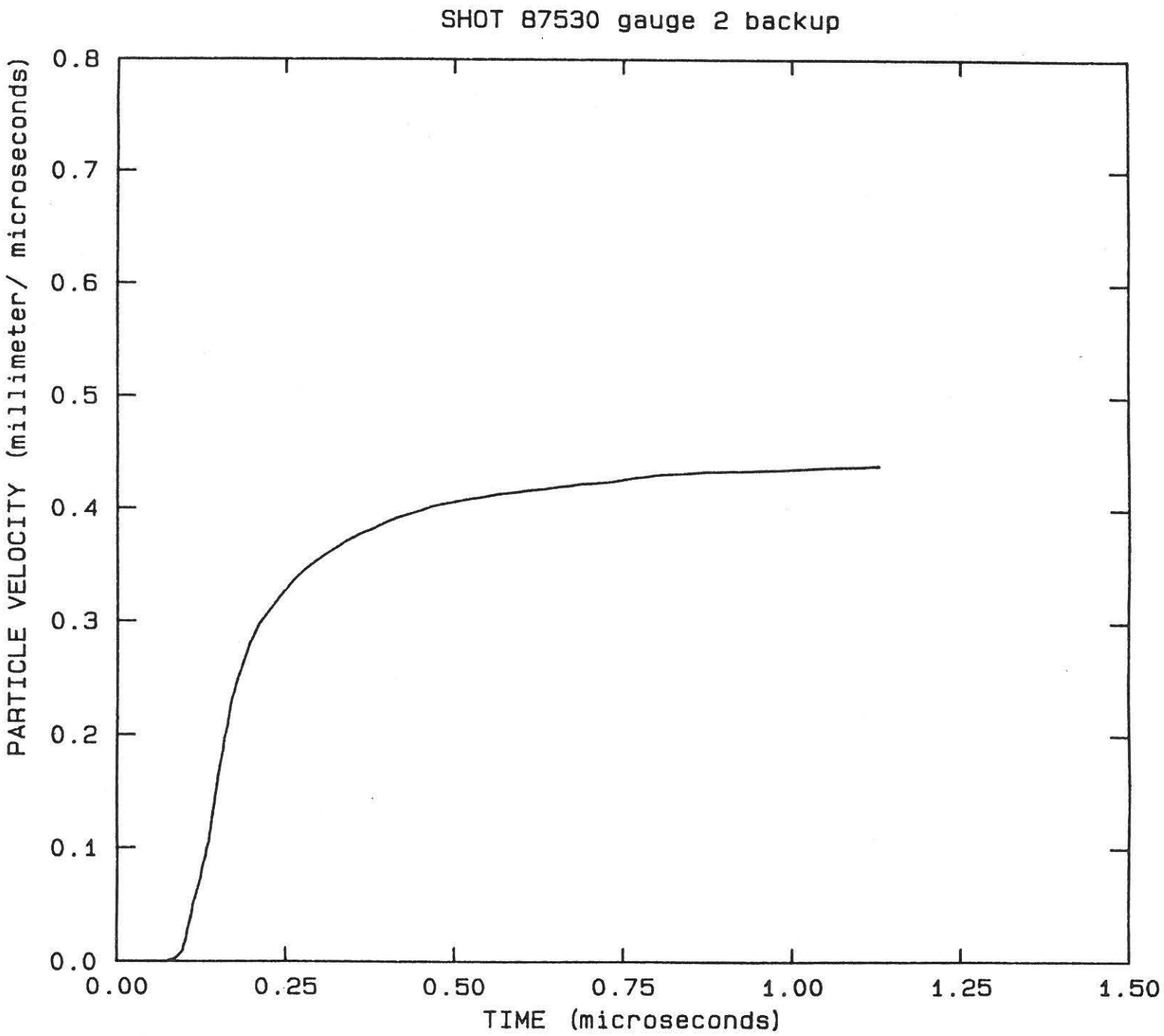
0.4
0.5
0.6
0.7
0.8
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)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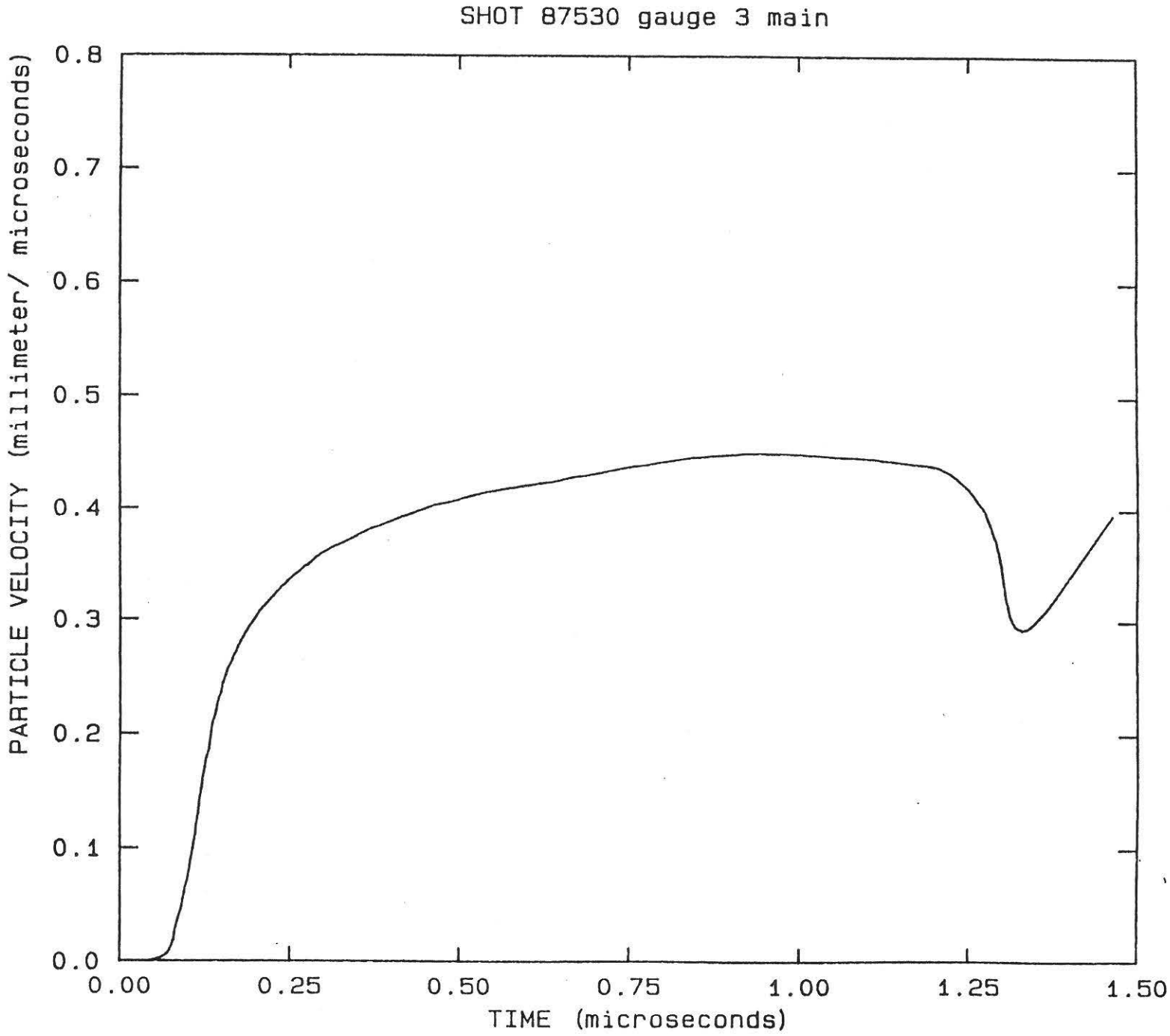
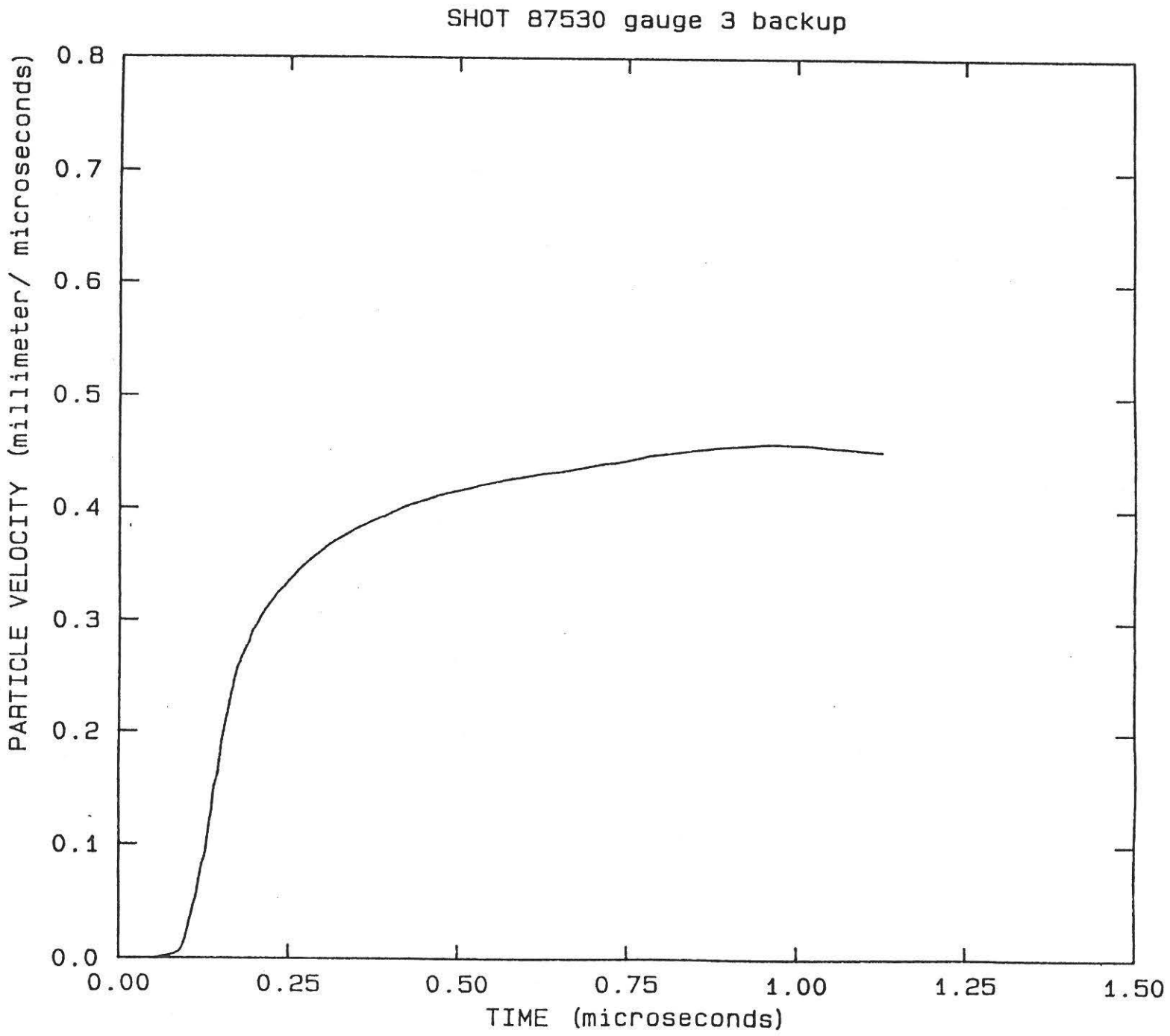
PARTICLE VELOCITY (millimeter/ microseconds)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)


SHOT 87530 gauge 3 main
PARTICLE VELOCITY (millimeter/ microseconds)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
TIME (microseconds)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0.25
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TIME (microseconds)