Ablative Laser Propulsion
(First Data)

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Acknowledgements

ALP Group

Andrew Pakhomov, Ph.D. (PI), Don A. Gregory, Ph.D., Mr. Younes Elkacimi, Mr. Wesley Swift, Jr.

And also:

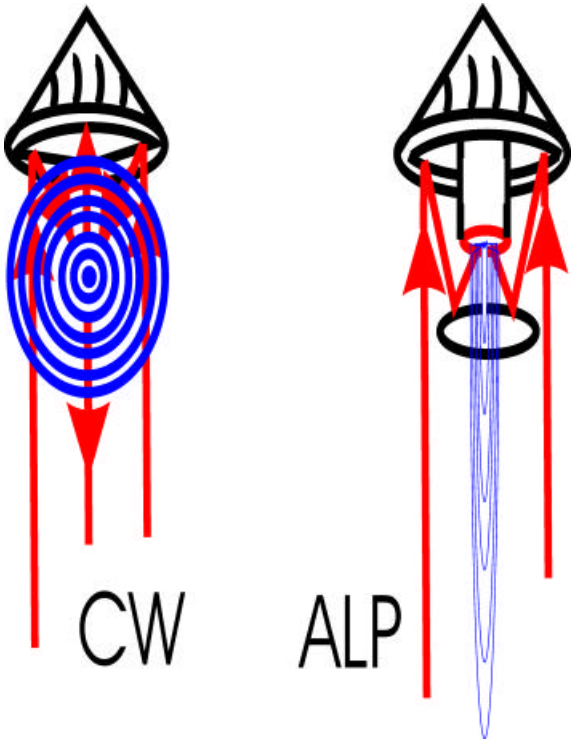
Dr. Lloyd Hillman, Dr. Matthew Smith, Dr. Gordon Emslie, Mr. Jeff Meier

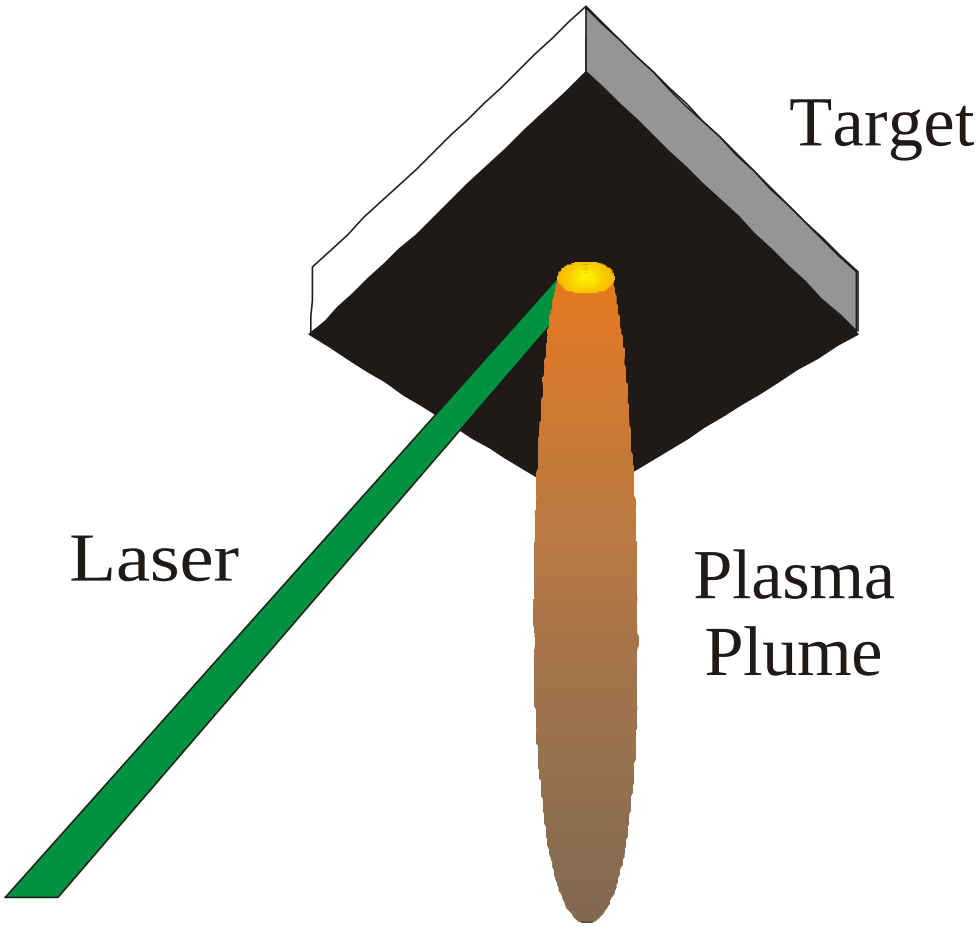
Outline

- **Introduction to ALP concept**
- **Experimental setup and techniques**
- **Results**
- **Future experiments and conclusion**

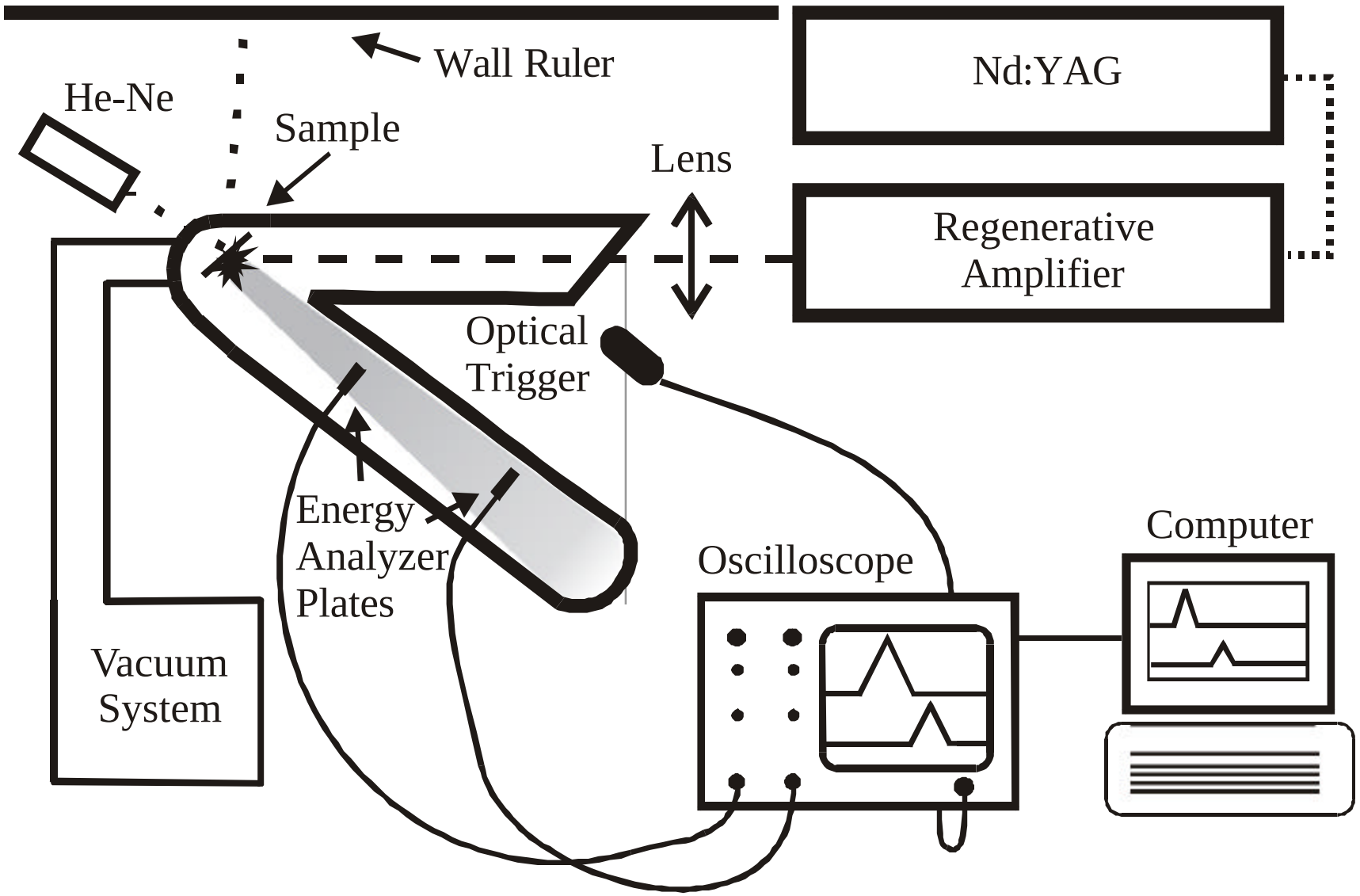
ALP: ABLATION DOMINATED MOMENTUM TRANSFER

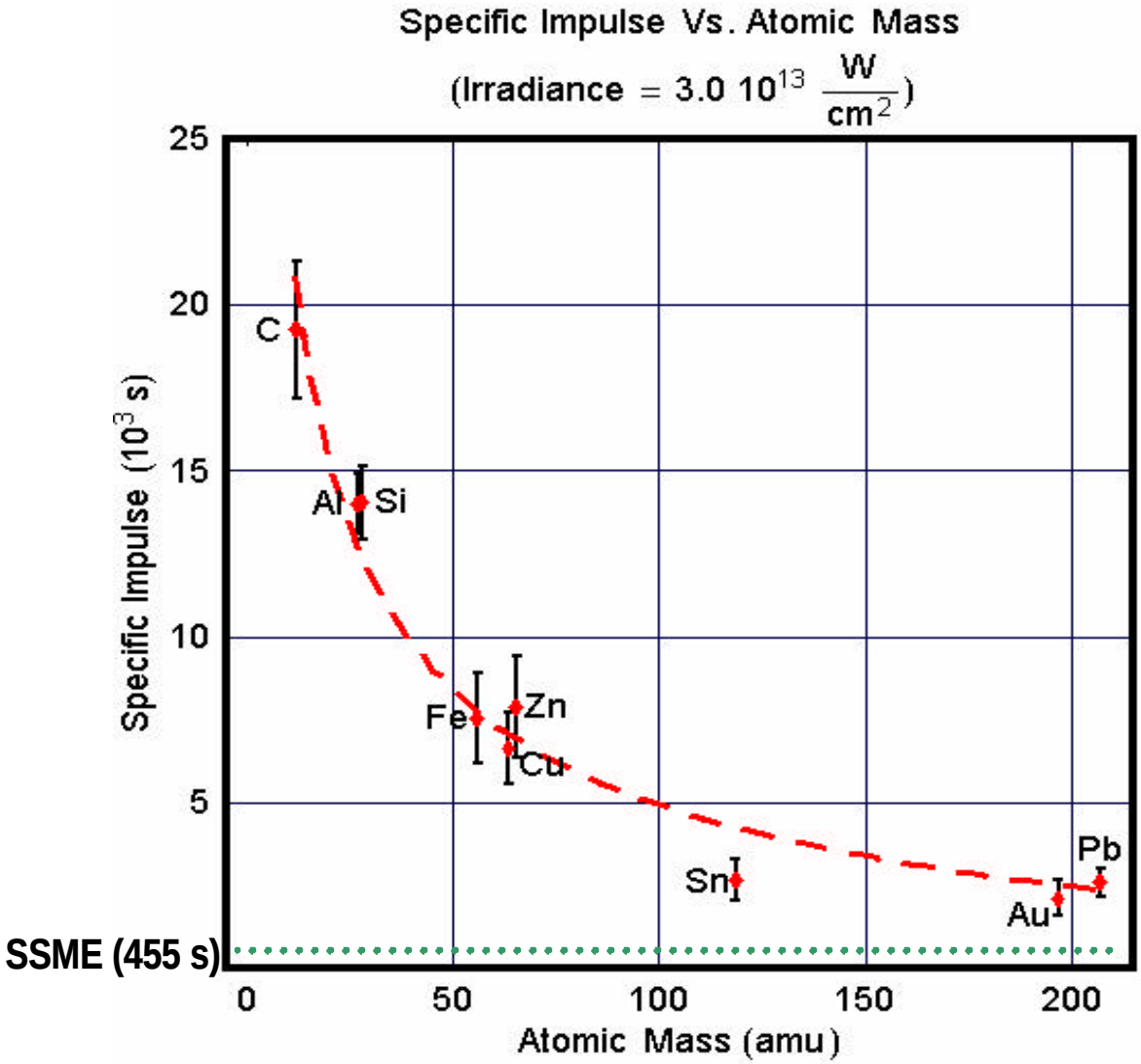
- Short, high-energy laser pulses
- Material dependent (I_{sp})
- Solid propellants (low breakdown thresholds)
- Ion collimation (no combustion chambers required)

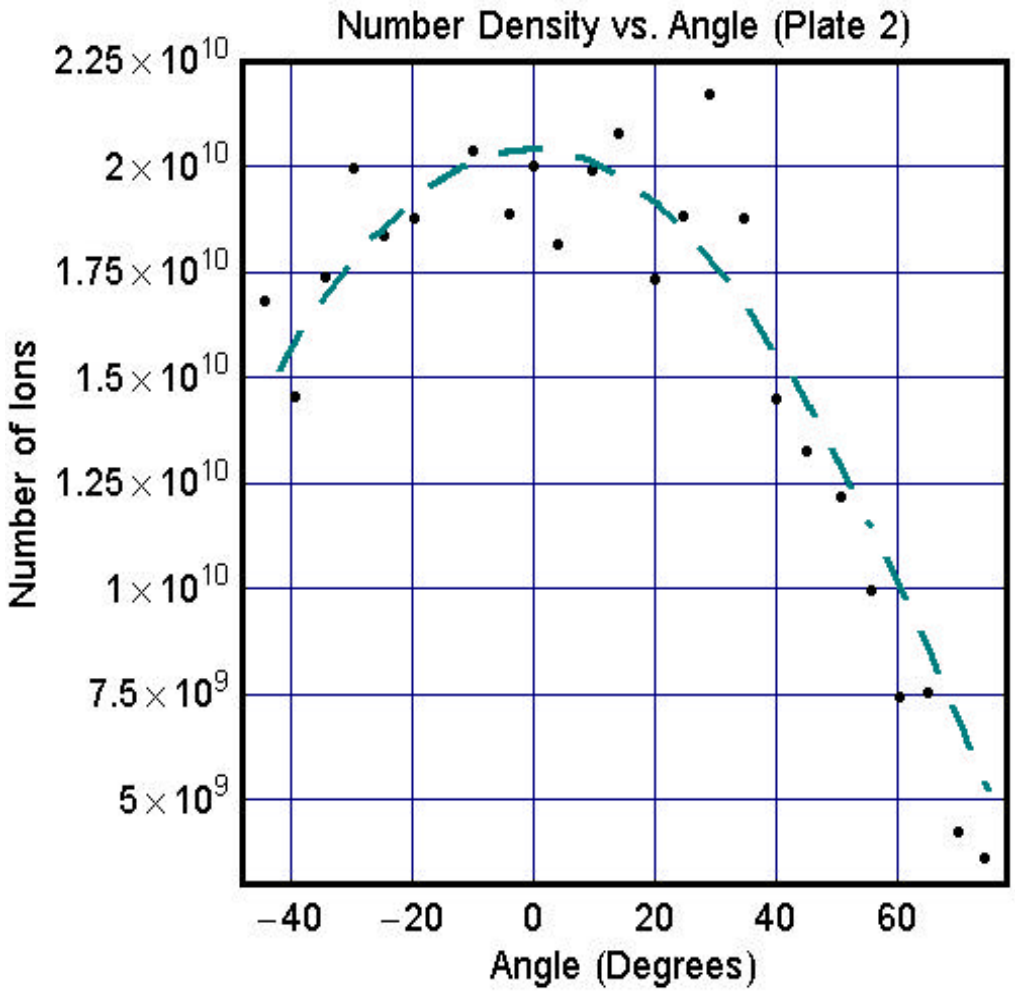


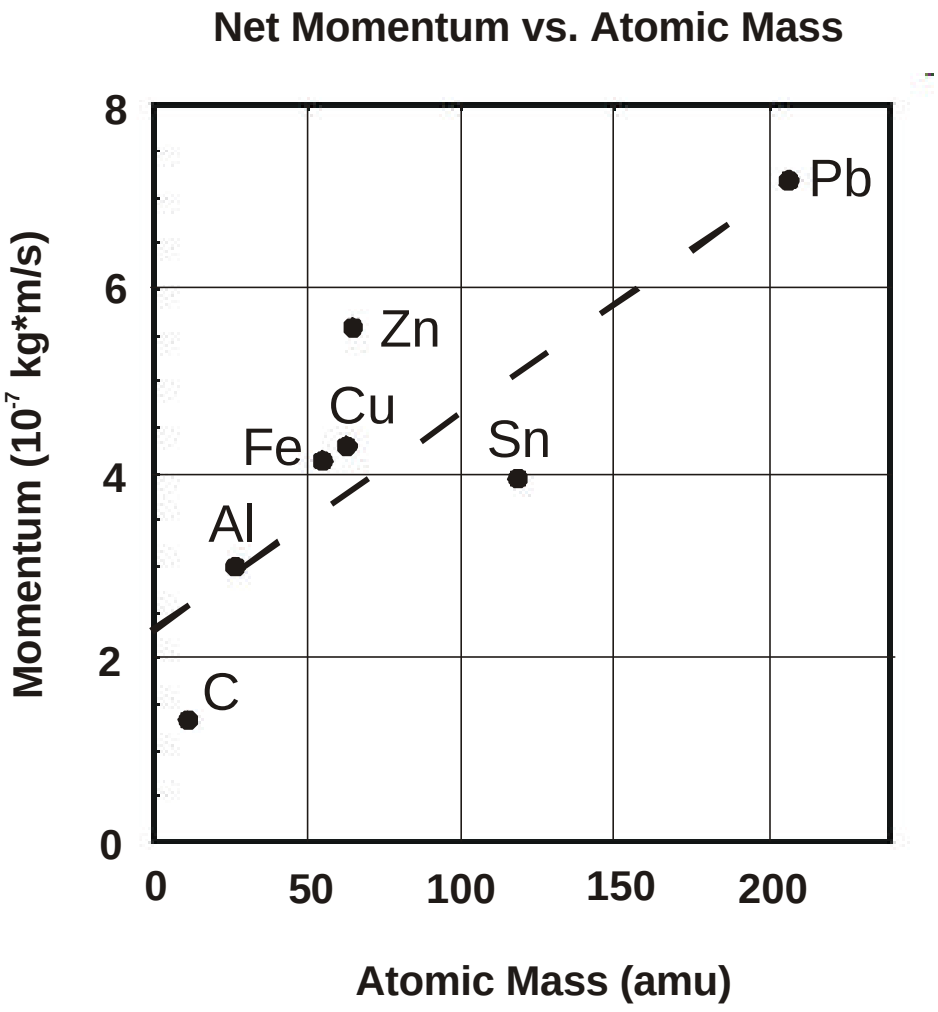

Target
Laser
Plasma
Plume

TOF Experimental Setup

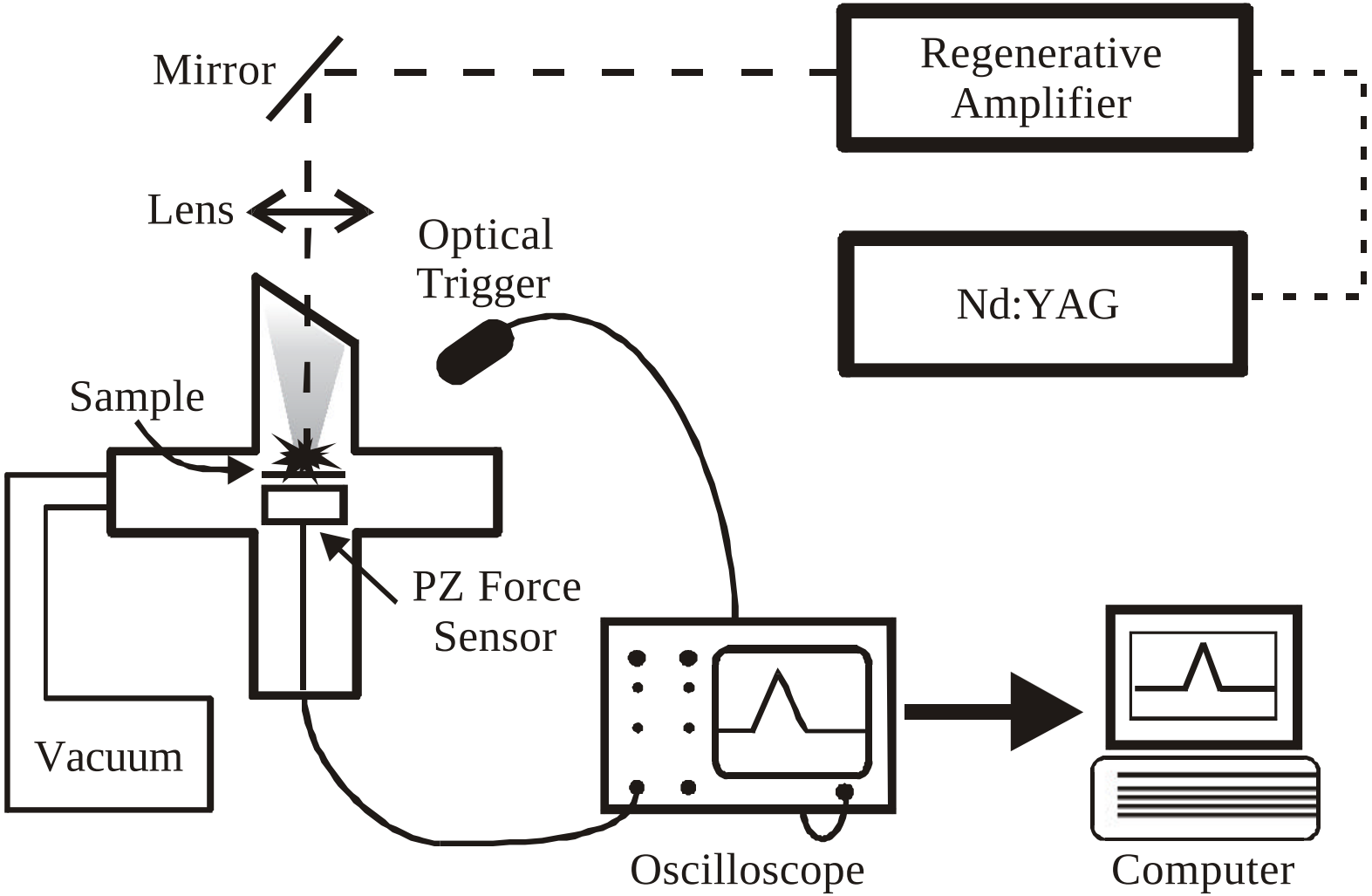



Specific Impulse Vs. Atomic Mass
(Irradiance = 3.0 10^13 W/cm^2)
Specific Impulse (10^3 s)
Atomic Mass (amu)
25
20
15
10
5
0
50
100
150
200
C
Al
Si
Fe
Zn
Cu
Sn
Au
Pb
SSME (455 s)

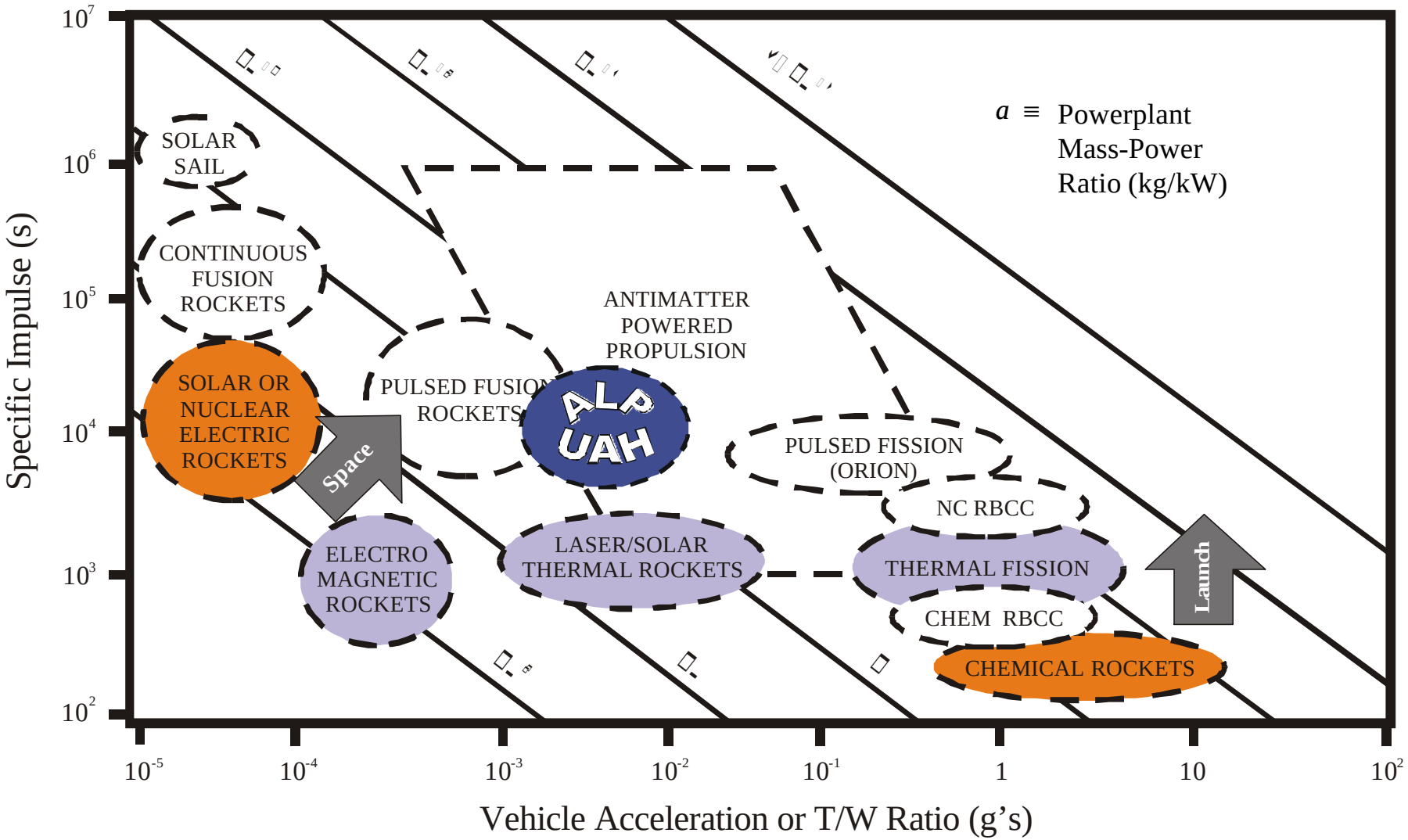

Number Density vs. Angle (Plate 2)
2.25 × 10^10
2 × 10^10
1.75 × 10^10
1.5 × 10^10
1.25 × 10^10
1 × 10^10
7.5 × 10^9
5 × 10^9
Number of Ions
−40
−20
0
20
40
60
Angle (Degrees)


Net Momentum vs. Atomic Mass
Momentum (10^{-7} kg*m/s)
Atomic Mass (amu)
0
2
4
6
8
0
50
100
150
200
Pb
Zn
Cu
Fe
Sn
Al
C

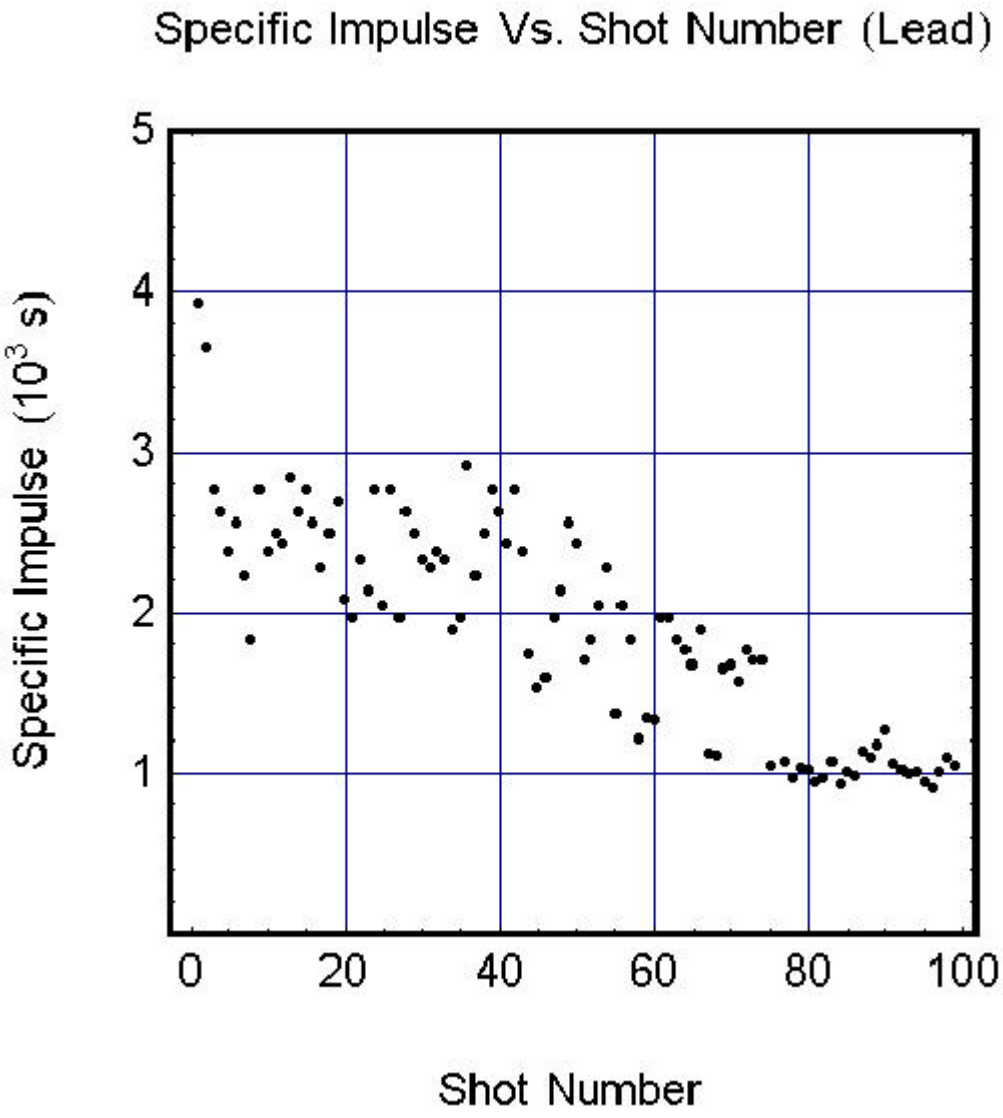
Impulse Measurement Setup

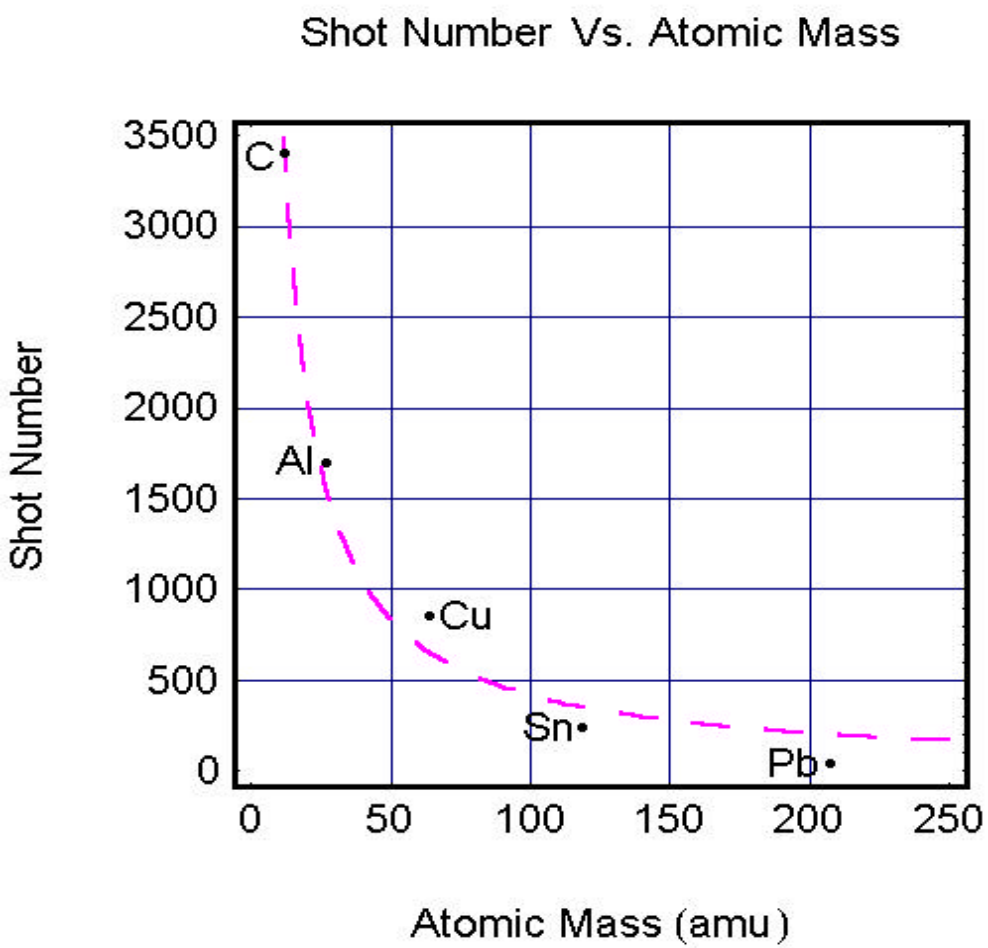


Propulsion System Concepts



Picture from: Schmidt, G. MSFC Propulsion Research, in *Proceedings of NASA/JPL/MSFC/AIAA 10th Annual Space Propulsion Workshop*, April 5-8, 1999, Huntsville, AL, Vol. 1, pp. 61.


Specific Impulse Vs. Shot Number (Lead)
Specific Impulse (10^3 s)
5
4
3
2
1
0
20
40
60
80
100
Shot Number


Shot Number Vs. Atomic Mass
Shot Number
3500
3000
2500
2000
1500
1000
500
0
C
Al
Cu
Sn
Pb
0
50
100
150
200
250
Atomic Mass (amu)

Critical Electron Density

$$N_{ec} = \frac{m_e e_0 w_{pc}^2}{e^2}$$

Electron “Growth” Rate

$$\frac{dN_e}{dt} = nN_e$$

Critical Pulse Length

$$t = \frac{\ln(N_{ec})}{n}$$