



NEW METHODOLOGY FOR SIMULATING FRAGMENTATION MUNITIONS

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Fragmentation Modeling

Outline

- Introduction
- Background
- Modeling Methodology
- Natural Fragmentation
- Preformed Fragmentation
- Conclusions



Fragmentation Modeling

Introduction

- **TACOM-ARDEC Warheads**
 - Long history of warheads design
 - Technology development
 - Application
- **Fragmentation Ammunition Requirements**
 - ALACV, OCSW, OICW, M203 upgrade
 - Lightweight ammunition
 - Lethal fragmentation, various approaches



Fragmentation Modeling

Background



- **Natural Fragmentation**
 - Limited lethality due to poor size distribution
 - Good structural characteristics (G load)
- **Preformed and Scored Fragmentation**
 - High lethality potential
 - Reduced structural integrity, efficiency issues
- **Combined Fragmentation**
 - Natural AND preformed/scored fragmentation
 - Multiple materials (eg: steel and tungsten)
 - Maintain structural integrity where required, use preformed/scored fragmentation elsewhere
 - Require new modeling methodology



Fragmentation Modeling

Modeling Methodology

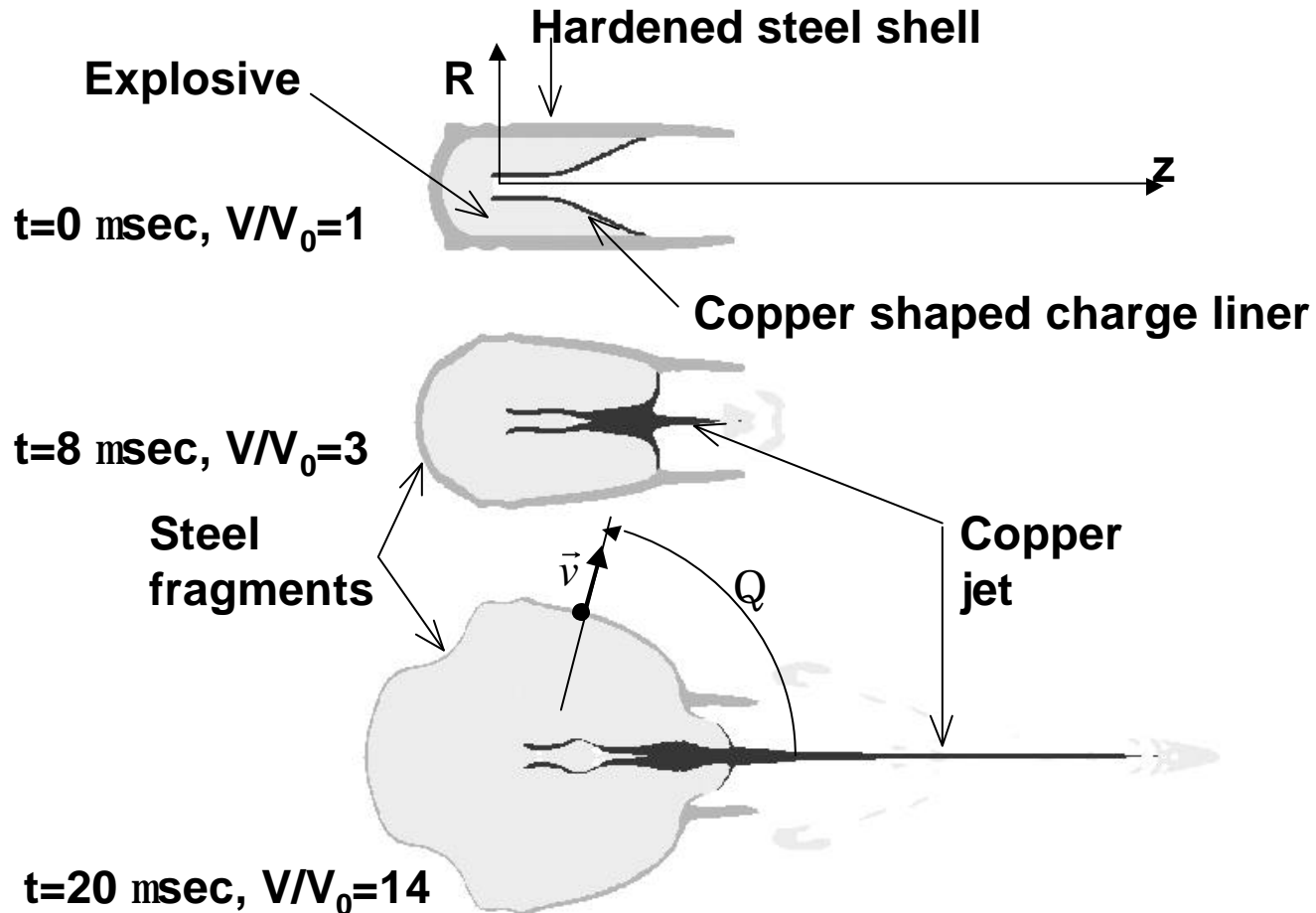


- **Warhead Mechanics (early time)**
 - Arbitrary Lagrangian/Eulerian High Rate Continuum Modeling: CALE (LLNL) finite difference program
 - Velocity and Mass Distributions
- **Fragmentation Modeling**
 - Hybrid Analytical and Empirical Approach
 - Natural Fragmentation: Mott based model
 - Preformed/Scored Fragmentation: Experimentally based size distribution



Fragmentation Modeling

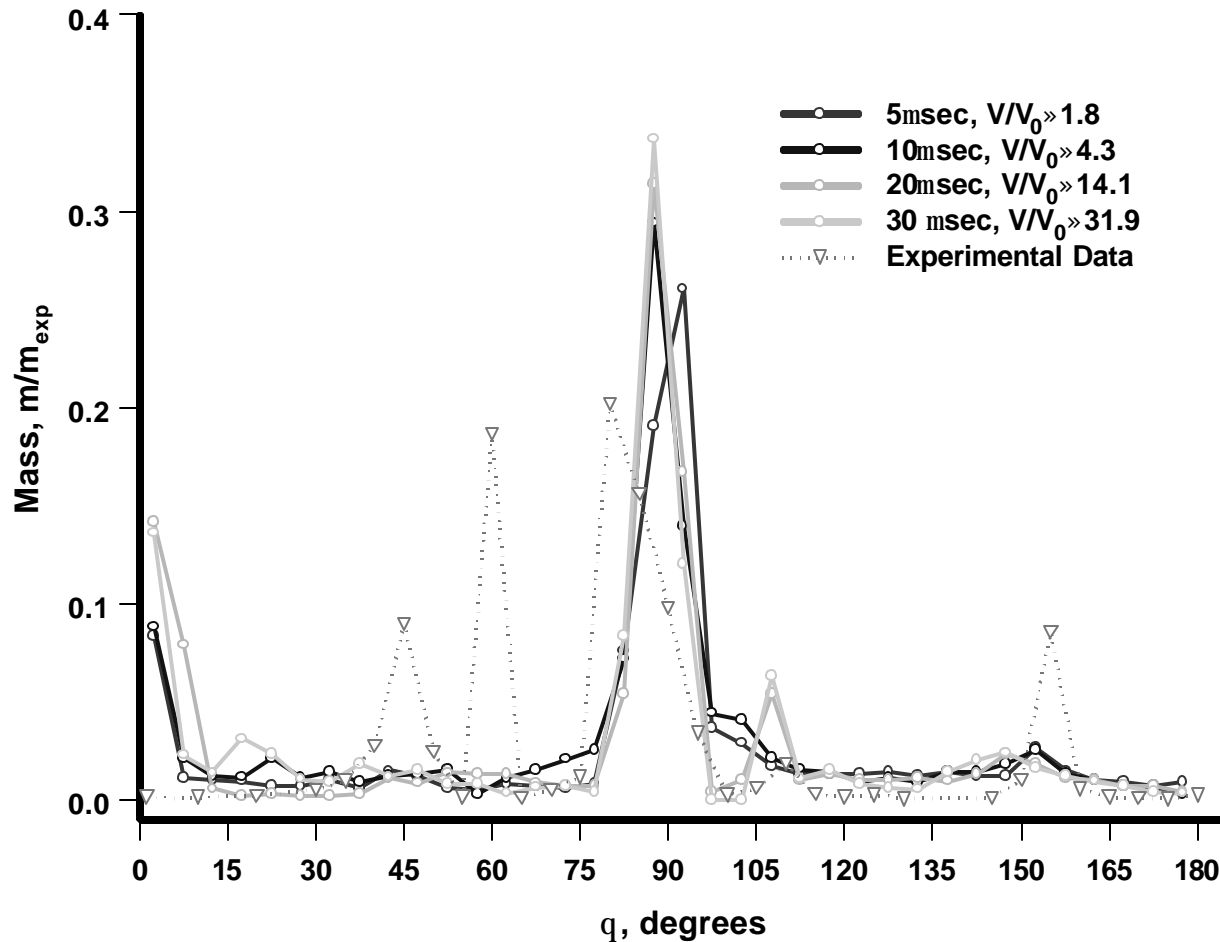
Natural Fragmentation: CALE





Fragmentation Modeling

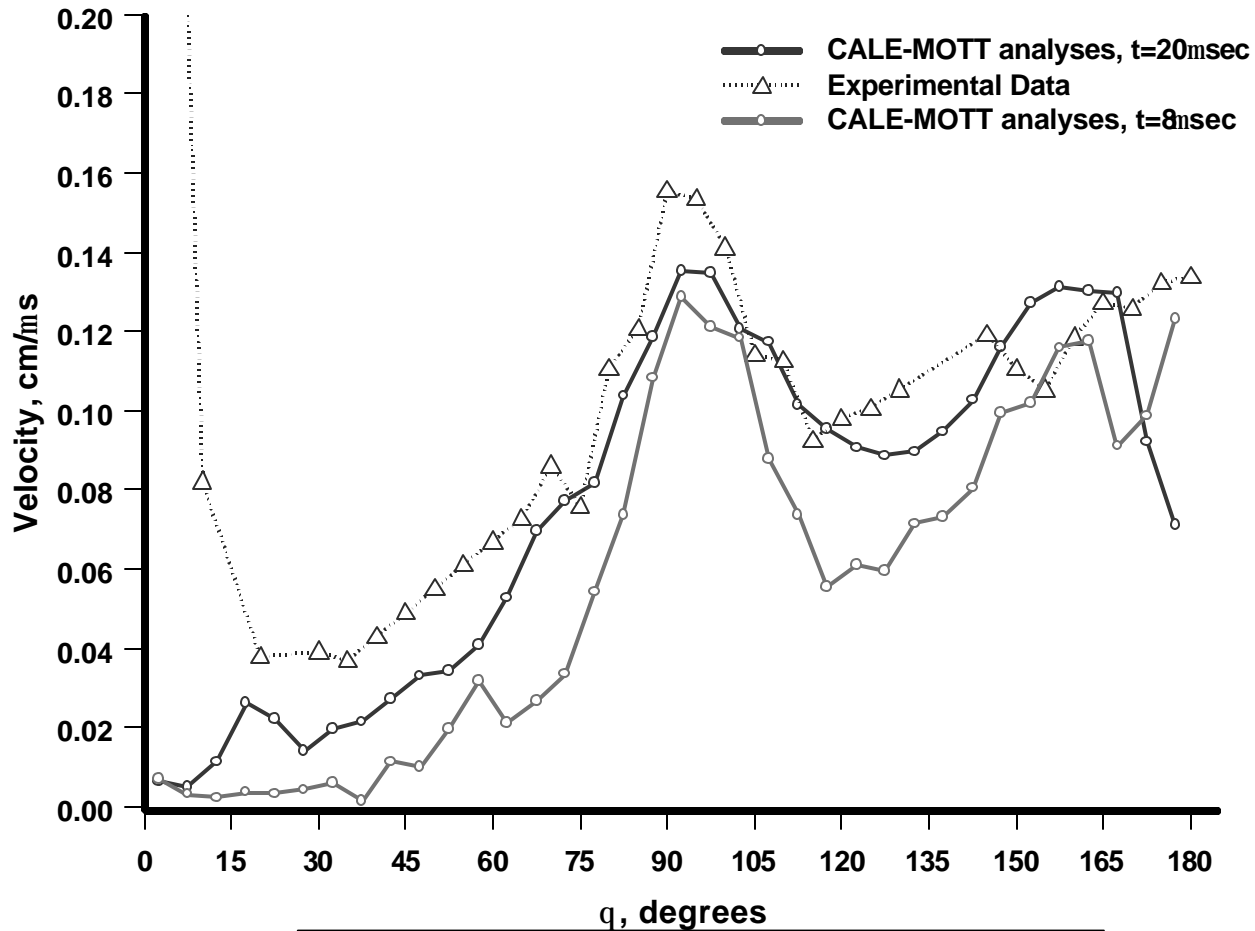
Natural Fragmentation: CALE





Fragmentation Modeling

Natural Fragmentation: CALE

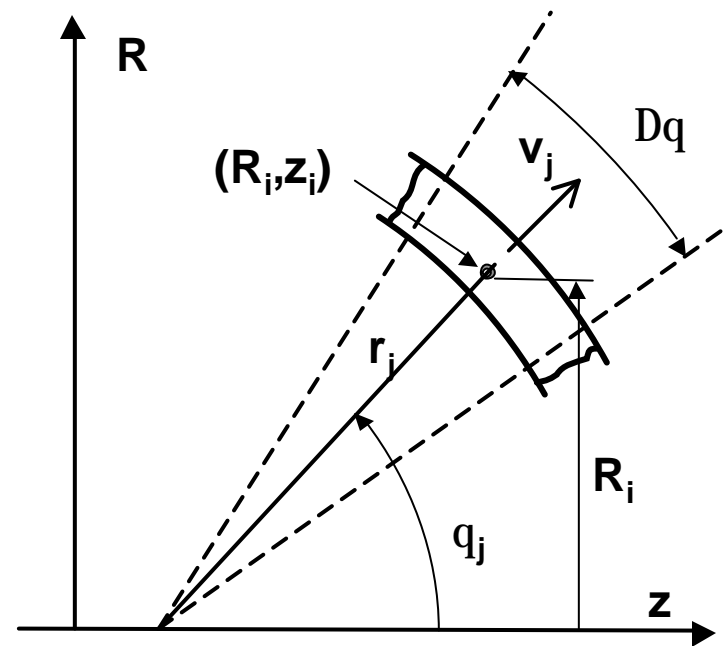
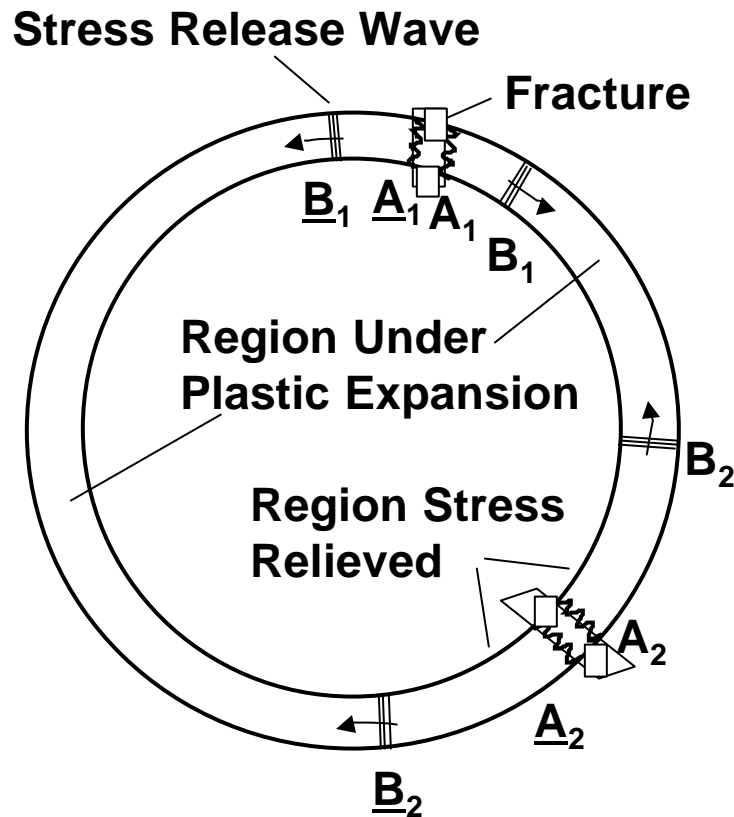


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Fragmentation Modeling

Natural Fragmentation: Mott





Fragmentation Modeling

Natural Fragmentation: Mott



Fragment Size Distribution:

$$N_j(m) = N_{0j} e^{-\left(\frac{m}{m_j}\right)^{1/2}}$$

$$m_j = \sqrt{\frac{2}{r}} \left(\frac{P_F}{g}\right)^{3/2} \left(\frac{r_j}{V_j}\right)^3$$

Total Number of Fragments:

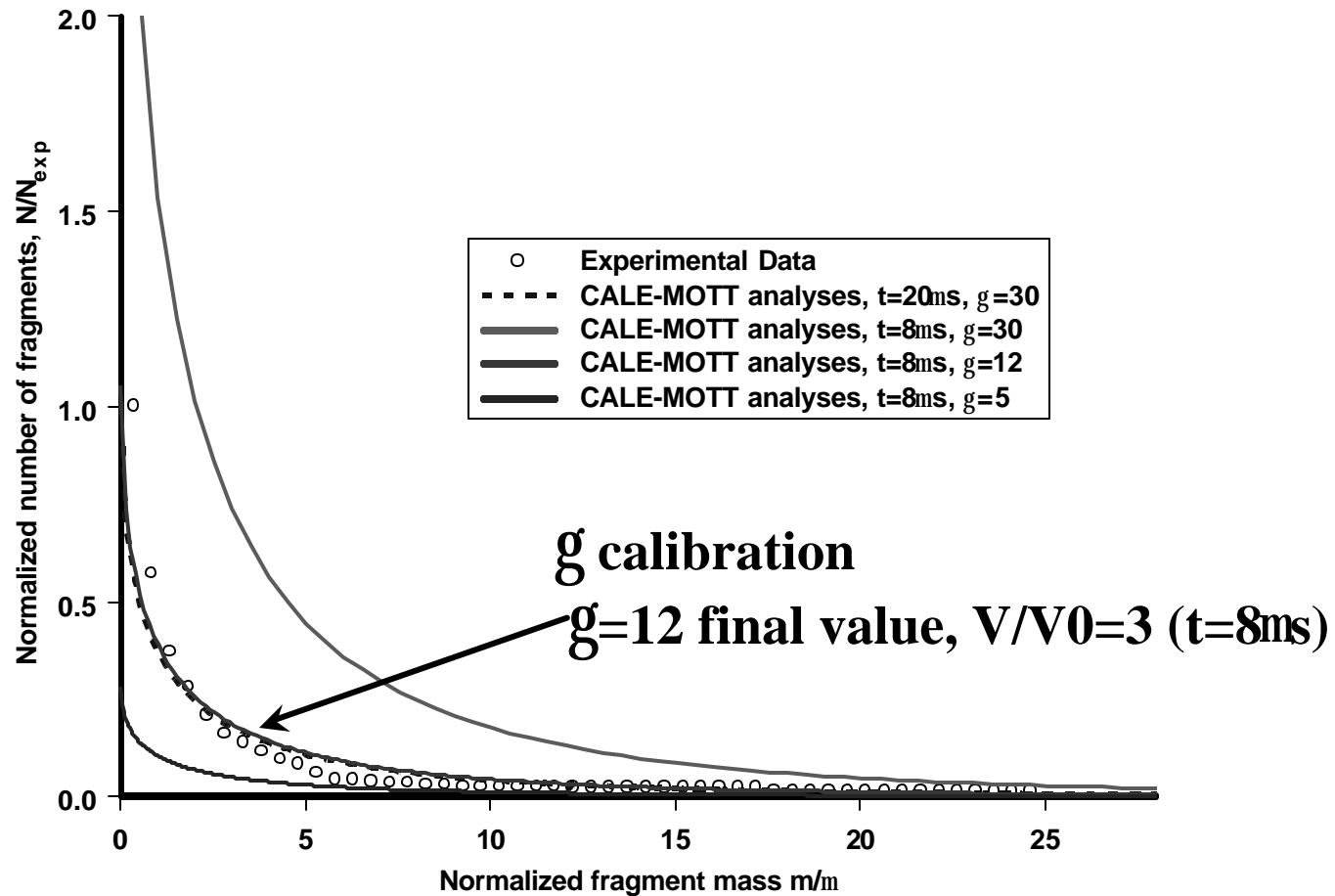
$$N_{0j} = \frac{m_j}{m_j}$$

g is a statically based material dependant constant



Fragmentation Modeling

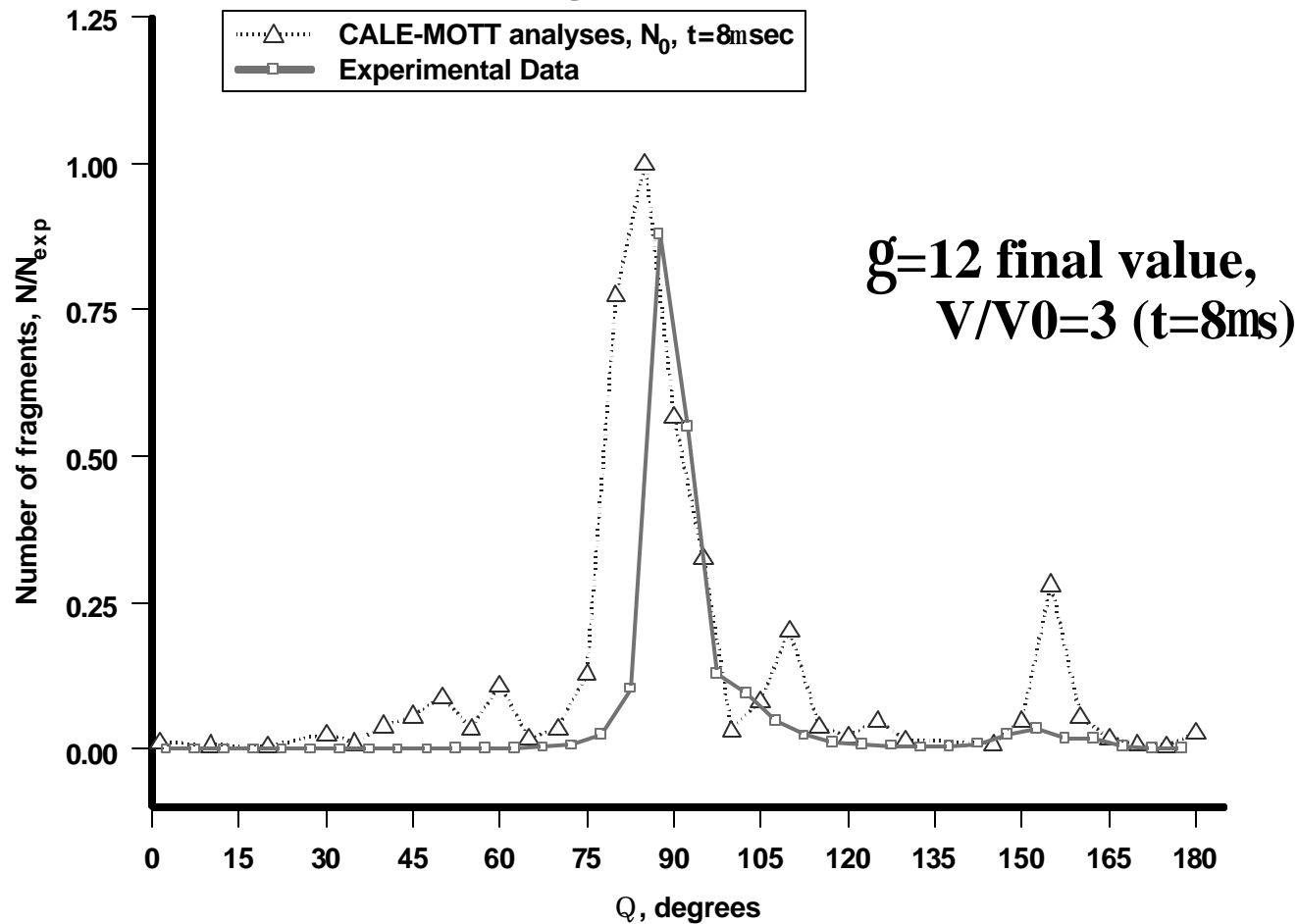
Natural Fragmentation: Mott





Fragmentation Modeling

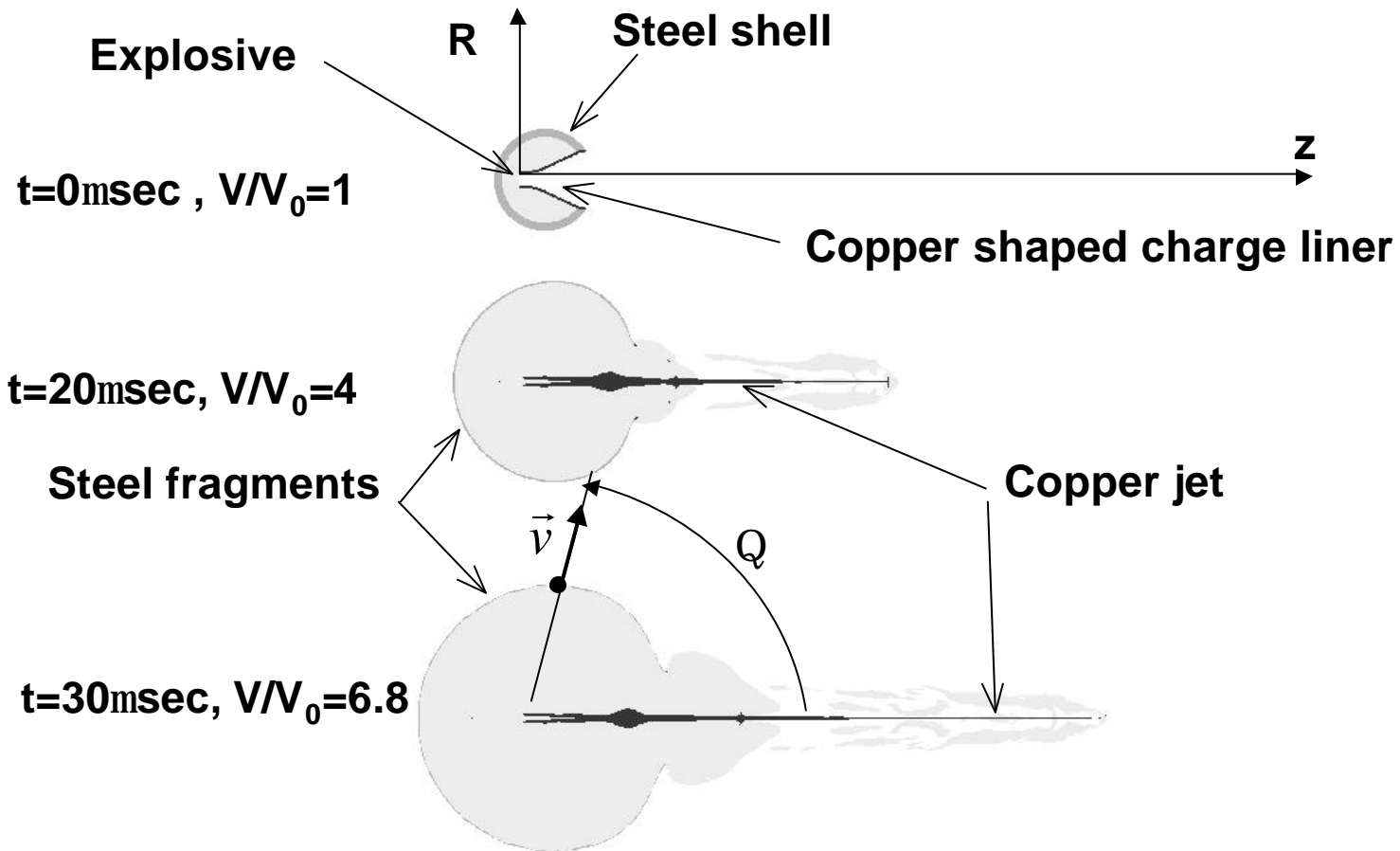
Natural Fragmentation: Mott





Fragmentation Modeling

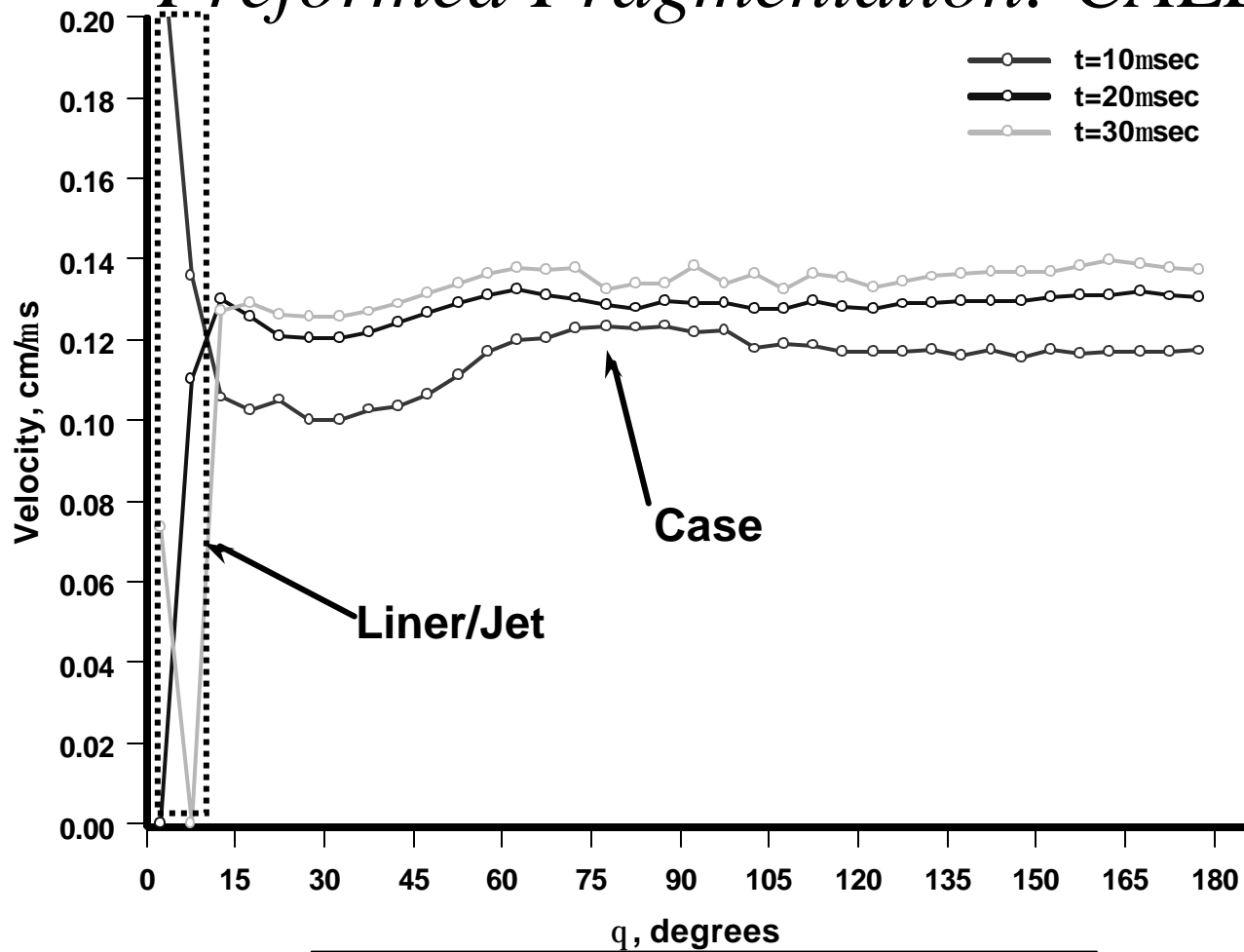
Preformed Fragmentation: CALE





Fragmentation Modeling

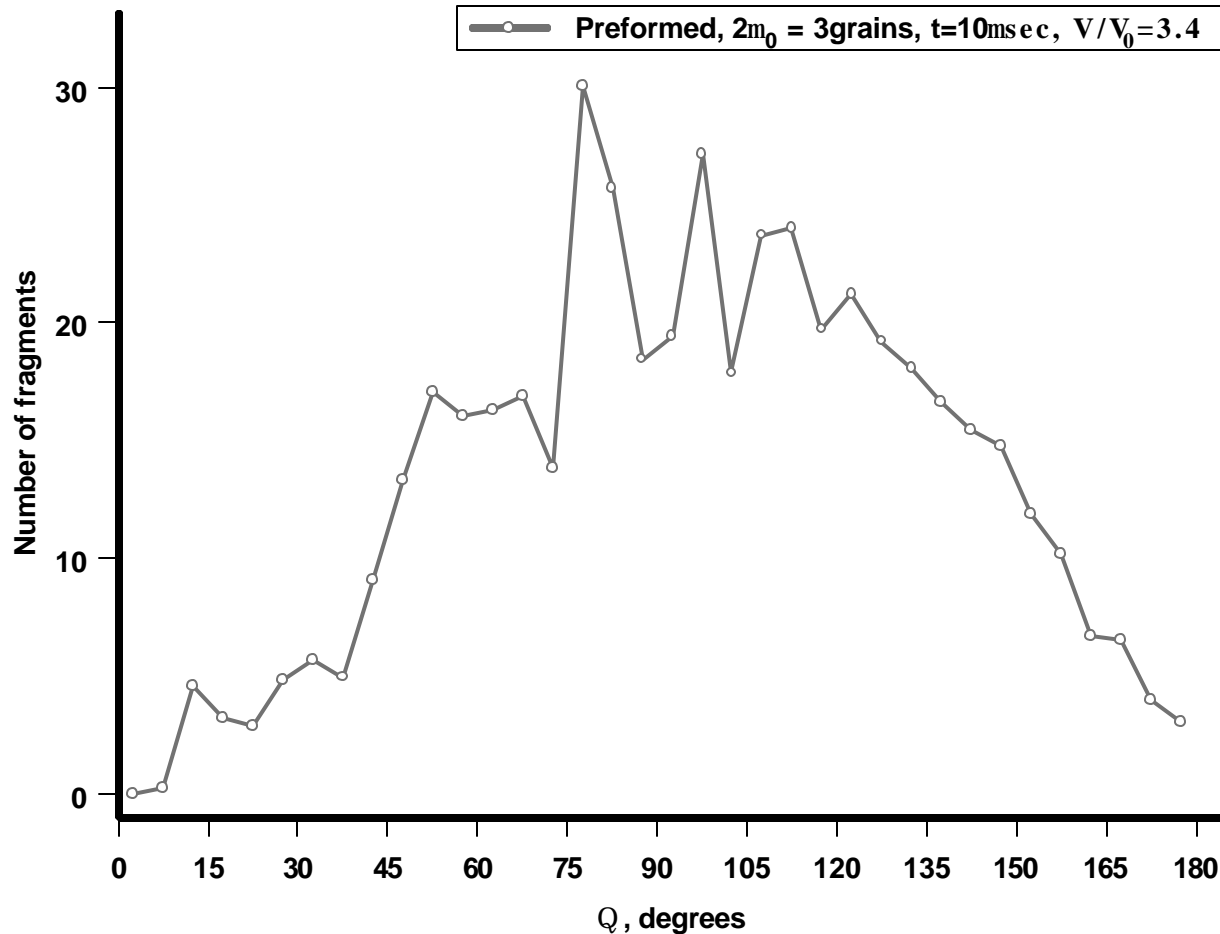
Preformed Fragmentation: CALE





Fragmentation Modeling

Preformed Fragmentation: Analysis



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Fragmentation Modeling

Summary



- **New Fragmentation Simulation Capability**
- **Natural Fragmentation**
- **Preformed and Scored Fragmentation**
- **Combined Fragmentation**
 - Required new modeling methodology
 - Natural/Scored/Preformed, multiple materials
 - Currently being applied on the ALACV program