TEST BENCH FOR ACTIVATABLE BATTERIES

Development of Customized Dynamic Test Systems

60th Annual NDIA
Fuze Conference
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Fraunhofer
EMI

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AGENDA

- Introduction
- Fraunhofer EMI as an engineer for customized dynamic test systems exemplified by a test bench for activatable batteries
  - Project definition and requirement specification
  - Concept and technical approach
  - Realization and first measurements
- Summary

Introduction

Methods for generating defined shock loads

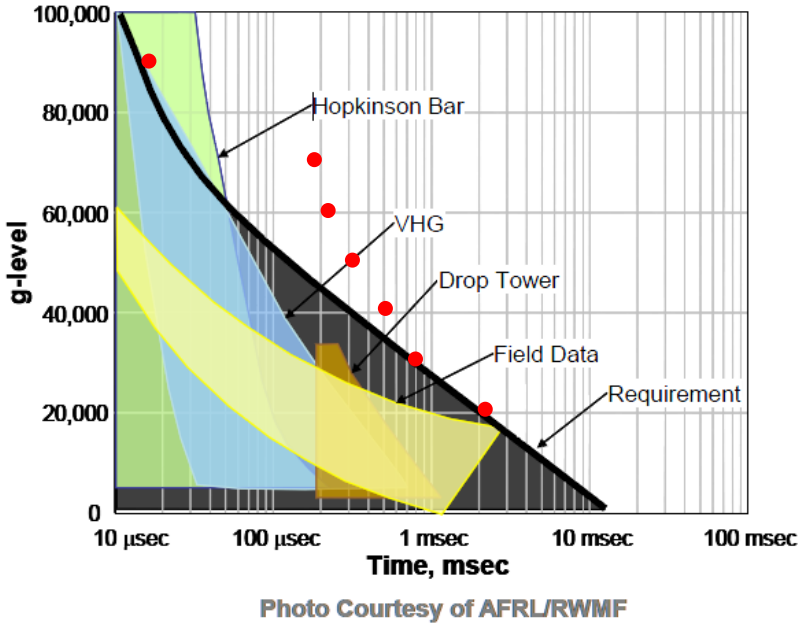
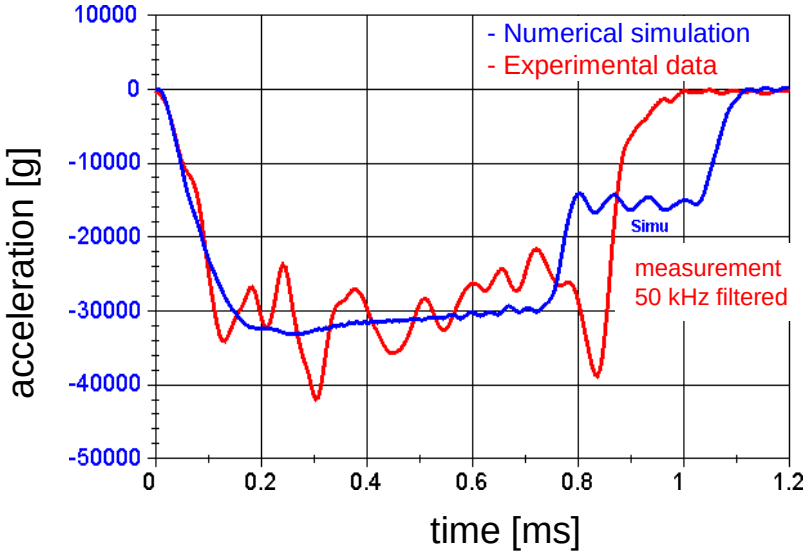


Photo Courtesy of AFRL/RWMF

Example: 30.000 g, 800 µs



D. Hayles, DTRA, Fuze Conference 2010

Nau et al. „Generation and Measurement of Long Duration High-g Accelaration Profiles“, 55th Annual Fuze Conference, Salt Lake City, 2011

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Introduction

Methods for generating defined shock loads

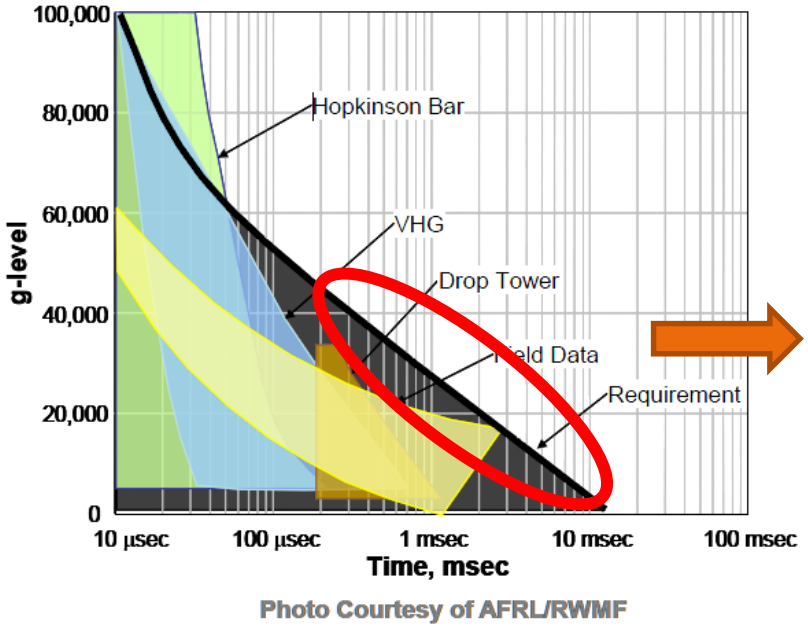


Photo Courtesy of AFRL/RWMF

required velocity: $v_0 > 100$ m/s

D. Hayles, DTRA, Fuze Conference 2010

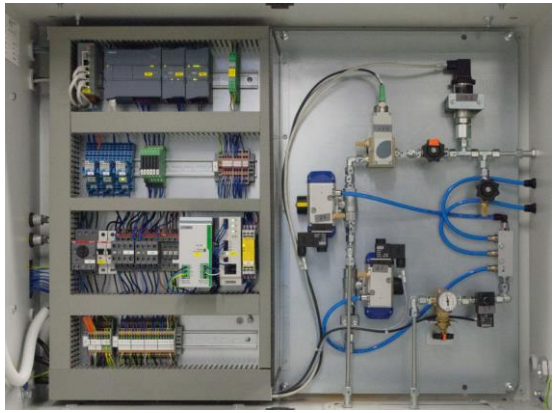
Nau et al. „Generation and Measurement of Long Duration High-g Accelaration Profiles“, 55th Annual Fuze Conference, Salt Lake City, 2011

Introduction
Pressurized air gun

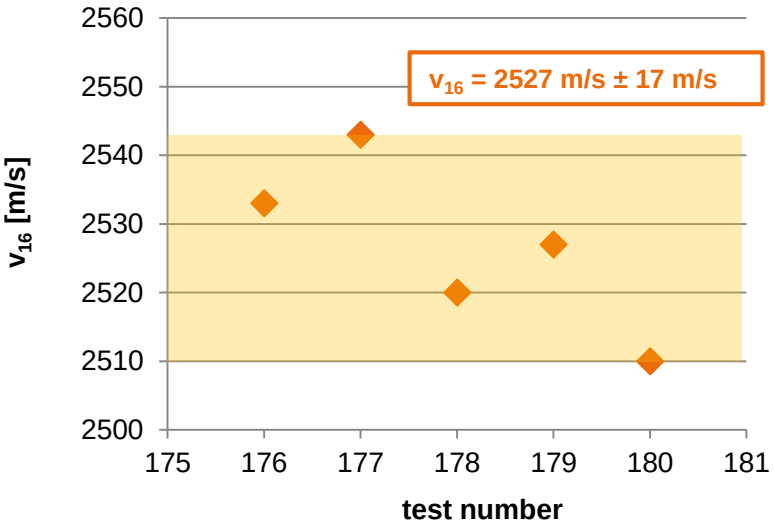
- Working pressure: max. 30 bar, vessel volume: 10 l
- Caliber: 45 mm, barrel length: 2 m
- Muzzle velocity: up to 175 m/s with m = 130 g

control panel

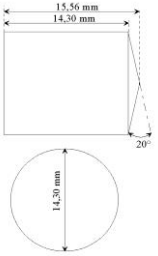
Inner view to control cabinet

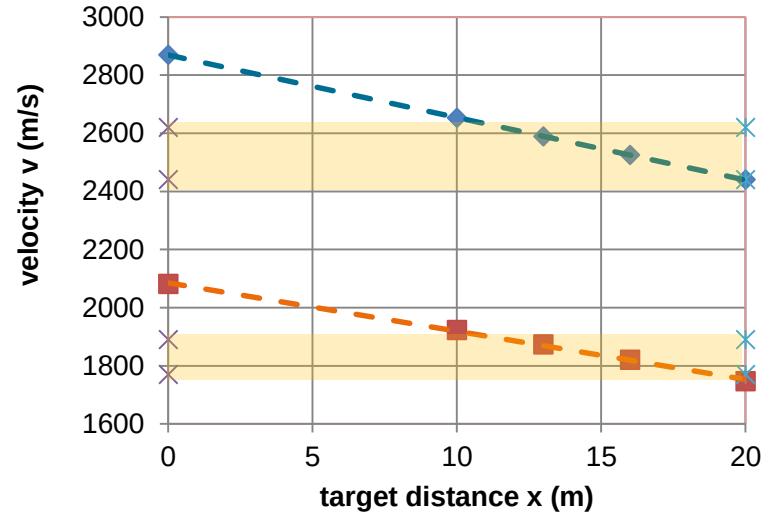


Introduction
High-velocity powder gun HVPG



Caliber:	60 mm (Smoothbore)
Barrel length:	6 m
$v_{0,max}$:	2850 m/s (m = 180 g)
p_{max}:	650 MPa
Features:	use of conventional propellants
	One of the fastest powder guns in Europe!





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Developing dynamic test systems
Test bench for activatable batteries

- Expertise in generation of defined acceleration profiles
  - Defined-Long-Duration (DLD) Shock Test
- Expertise in design and construction of dynamic test systems
  - Several commercialized accelerator systems

Diehl & Eagle Picher needs a:

- Flexible laboratory test bench
  - Various g-loads combined with
  - Various rotational speeds
  - Adaptable for different battery types
  - Withstand thousands of tests per year

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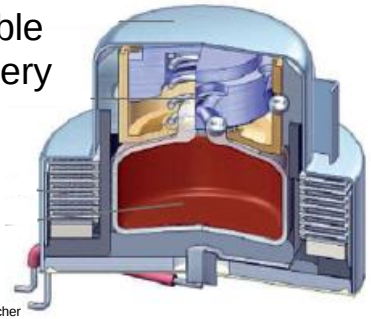
Developing dynamic test systems
Test bench for activatable batteries

Activatable fuze batteries, a short introduction:

- Used in fuzes for artillery, mortar and naval gun ammunition
- Long shelf-life

activatable fuze battery



© Diehl & Eagle Picher

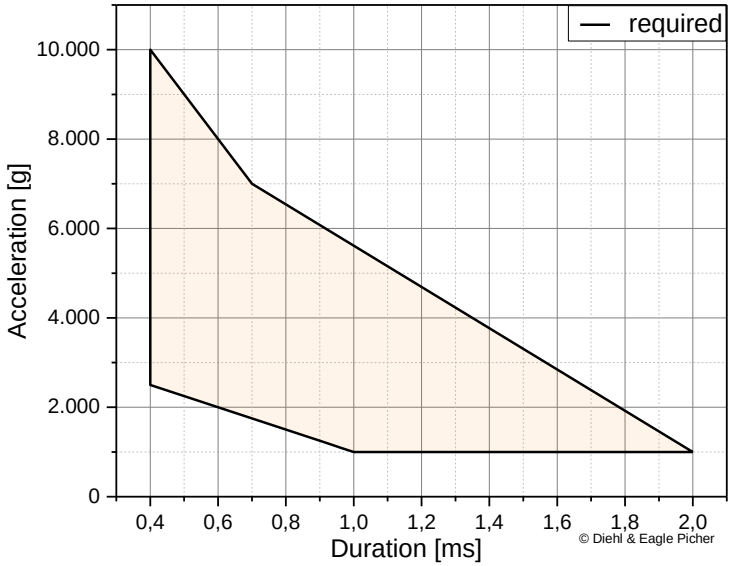
- Separation of electrolyte and cell stack during storage
- During gun launch the electrolyte is released by an activation mechanism and wetted the cell stack
- The activation mechanism is driven by the acceleration
- Wetting is mainly driven by the angular velocity

© Diehl & Eagle Picher

Test bench for activatable batteries
From requirement specification to realization

- Electrical connection during activation
  - Voltage and current measurement
  - External electric load
- Compliance to European law (CE conformity)

- Physical conditions for battery activation:
  - Linear acceleration for activation:
    Amplitude: 1’000 g to 10’000 g
    Duration: 0.4 ms to 2 ms
    (real ammunition, e.g. PzH2000: 12’000 g)
  - Simultaneously:
    variable rotation speed
    from 0 rpm up to 18’000 rpm
    (buzz saw: 7’500 U/min)



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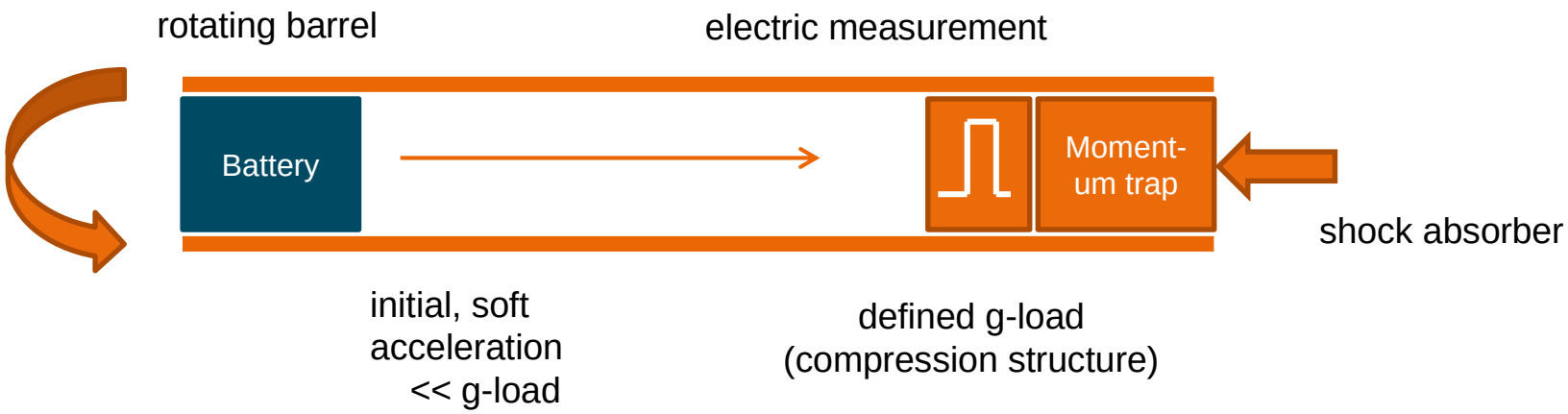
Test bench for activatable batteries
From requirement specification to realization

Approach (developed in cooperation with D&EP):

- Generation of g-load for activation by a defined deceleration during impact
- Independent generation of rotation (1st) and axial acceleration (2nd)
  - Use of a rifled barrel is not possible
- Keep axial g-load from the ball bearing by a momentum trap
- Transmission of the electric signals during the activation process (4-wire)



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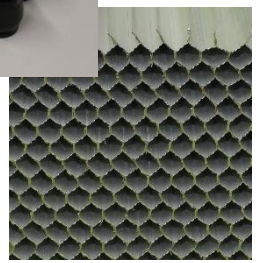
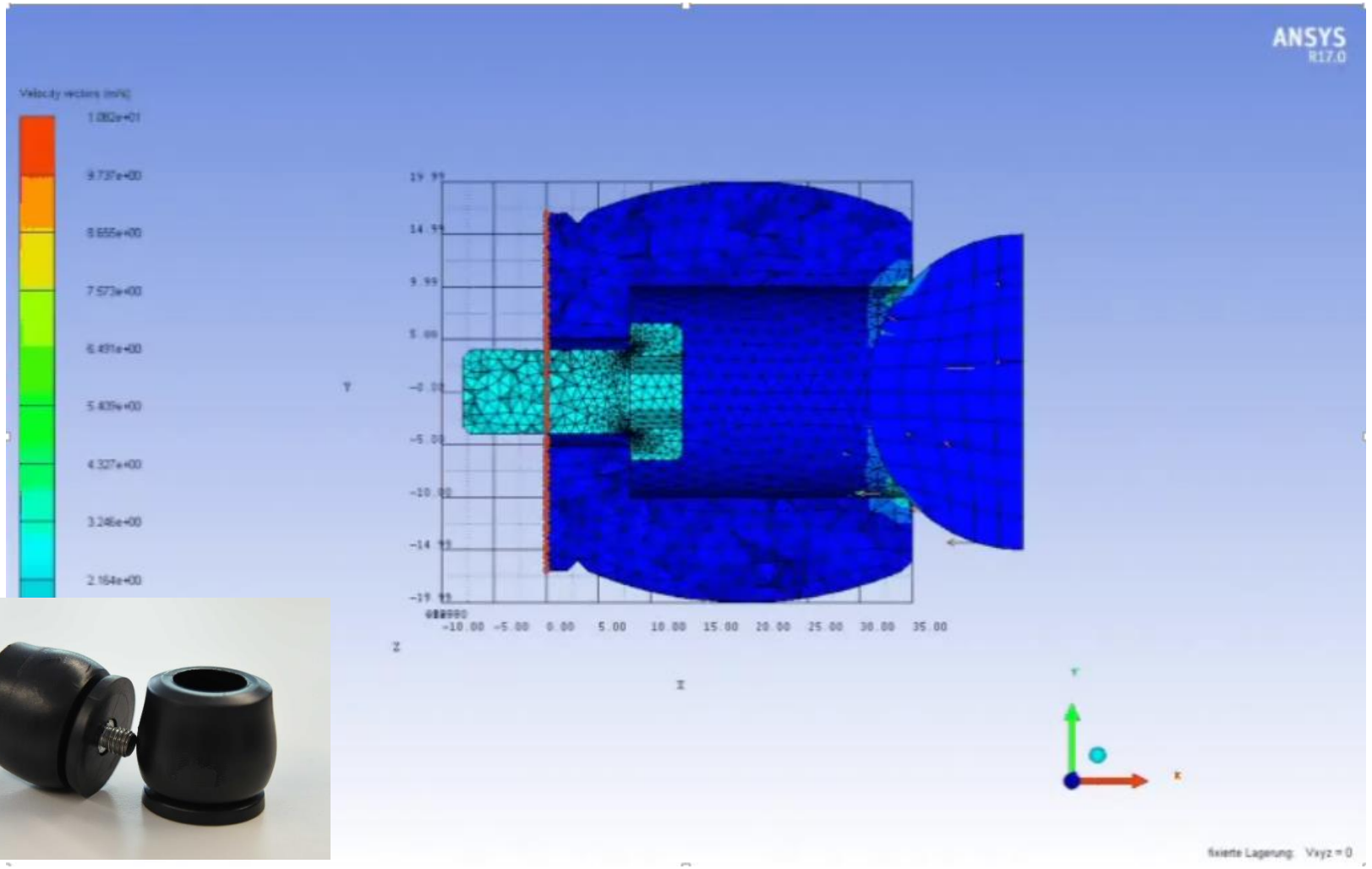
Test bench for activatable batteries
Experimental and numerical analysis of damping elements

- Experimental characterization of different damping elements
  - Compressive elements
    - Foams (metal and glass)
    - Honeycombs
    - Crashtubes
  - Damping pads (viscoelastic)
  - Profile dampers



- Numerical design and characterization of damping elements – if appropriate material model is available

Numerical design and characterization of damping elements



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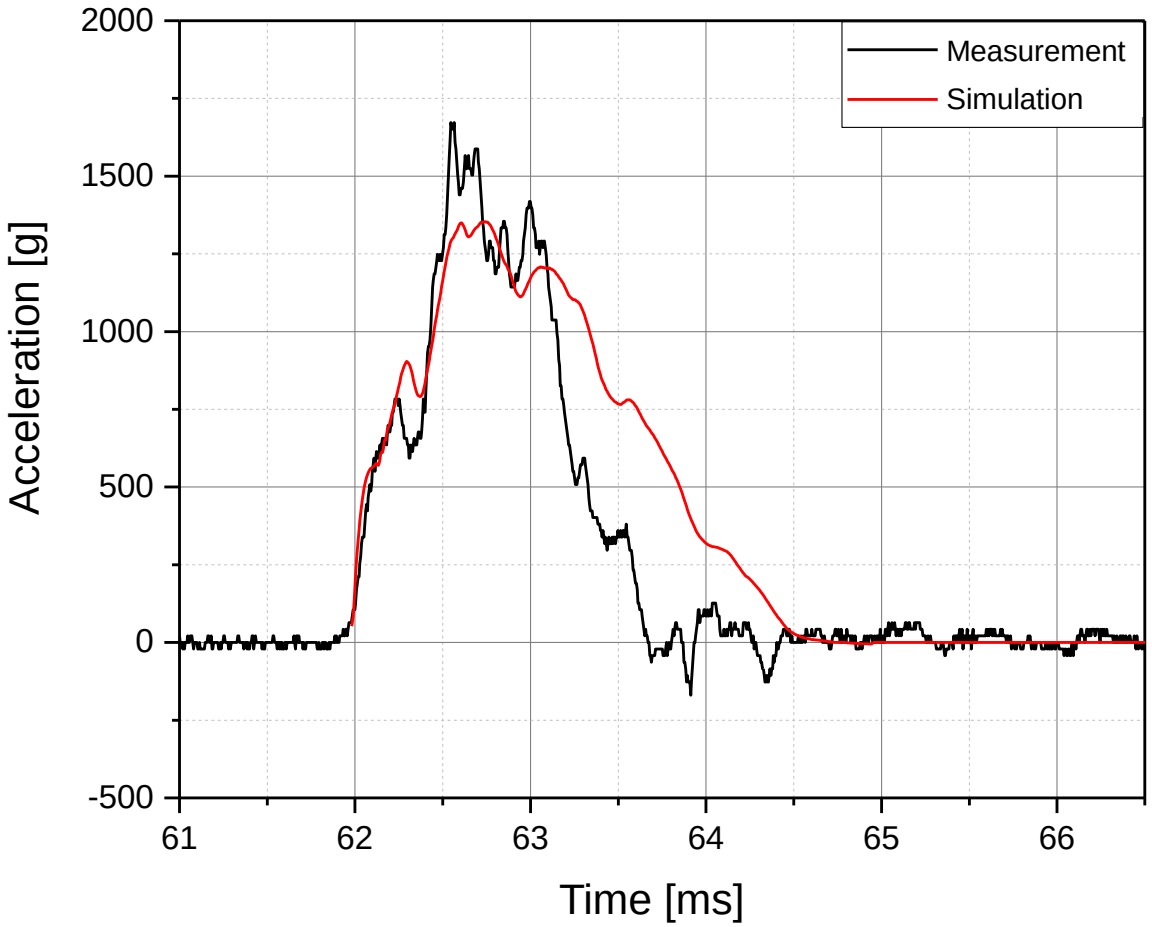
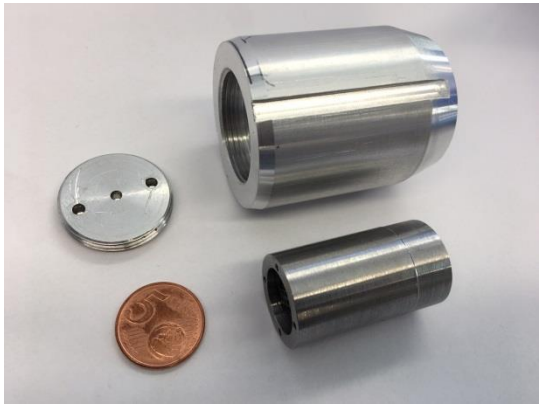
Characterization of damping elements



g-rec and test-projectile



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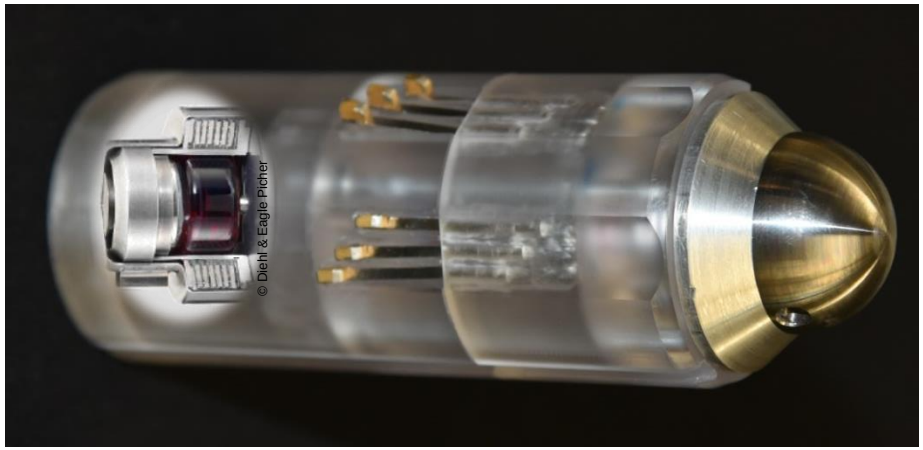
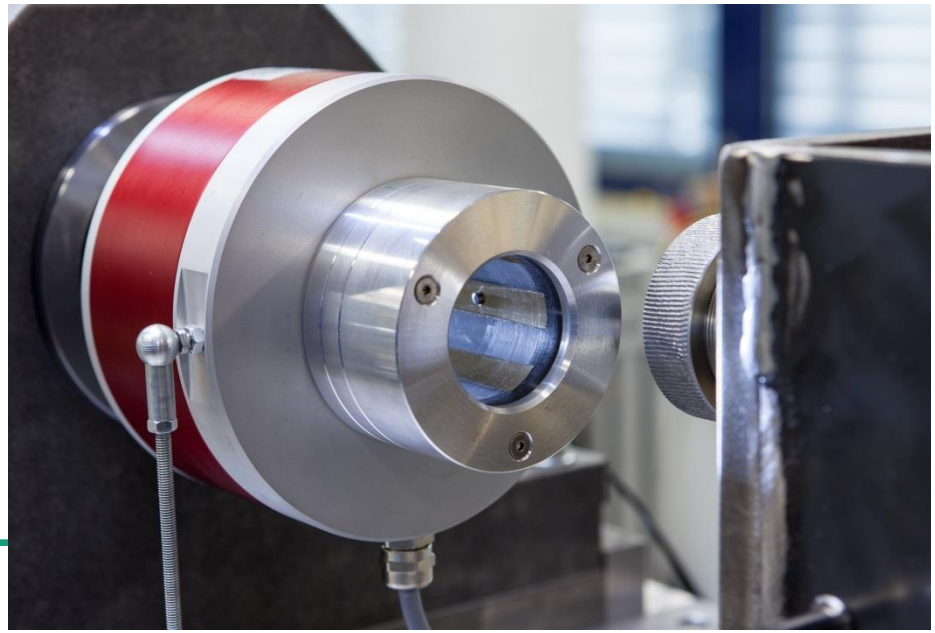
Test bench for activatable batteries

Galvanic connection between battery and electric load

insolation tube with
inserted sliding contact



Sabot with battery
with sliding contacts

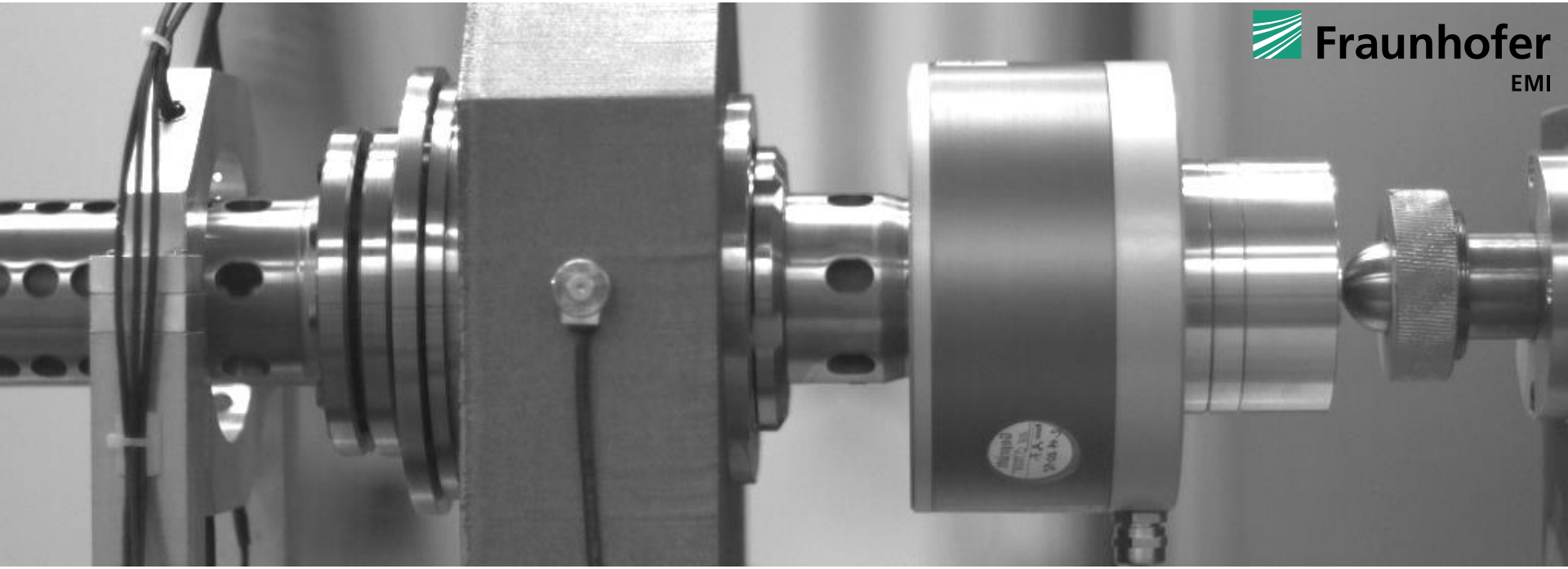


High-speed slip ring for signal
and power transmission

Test bench for activatable batteries

Test bench for activatable batteries

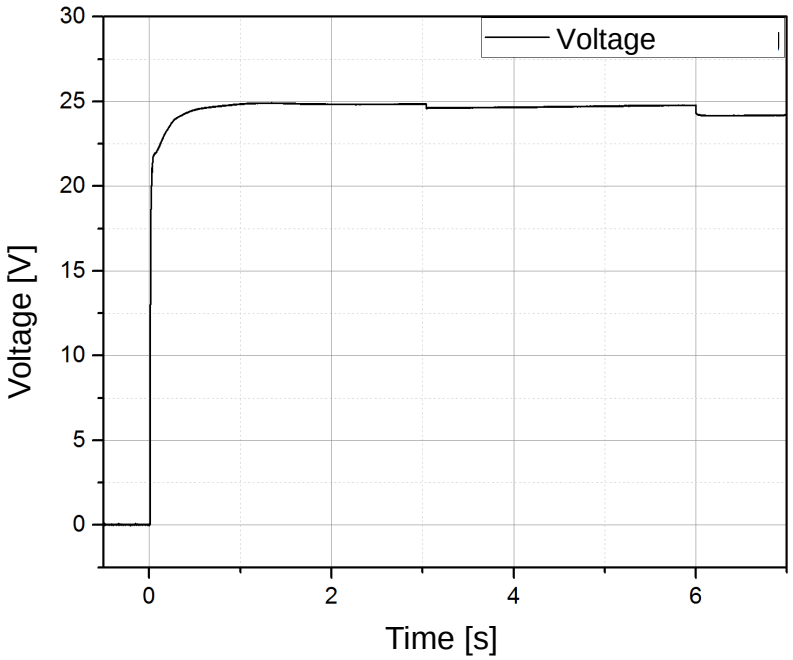
Realization and first tests

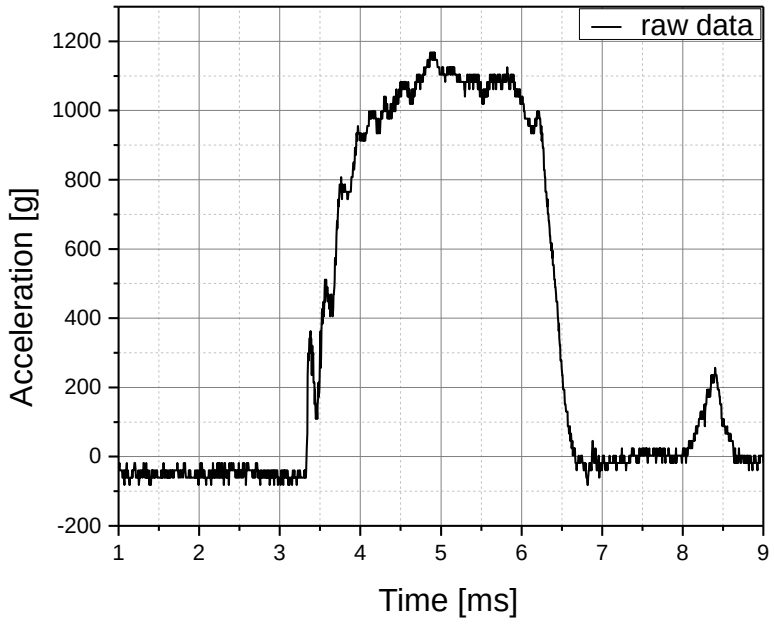


Rotational speed: 6.000 U/min
Frame rate: 10.000 fps

Test bench for activatable batteries

Realization and first tests





Battery voltage vs. time

- external measurement with variable load
  ⇒ steps in voltage plot

g-load for activation

(recorded with g-rec at same test setup)

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Summary

Developing test benches for defense technology application

- Fraunhofer EMIs expertise in:
  - Generating defined acceleration profiles
  - Construction of dynamic test benches
- Tailor made test bench for activatable batteries
  - Basic concepts of the test bench
  - Numeric simulations
  - First test results

If you need a customized test bench for your lab, feel free to contact us.

Thanks for your Attention!

Questions?

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