DIEHL & EAGLE PICHER
Batterie-Systeme

„The Power of the Fuze“

60th Annual Fuze Conference
May 11th, 2017
Harald Wich
Diehl & Eagle Picher GmbH

Overview

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- History, the large Calibre Fuzes
- Requirements
- Challenges
- Miniaturised Fuze Batteries
- New Test Equipment
- Conclusions

Legacy Fuze Batteries

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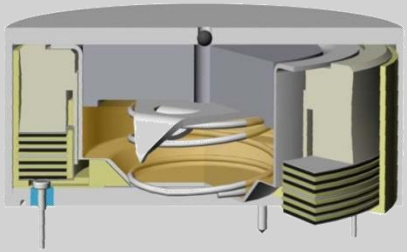
- PS115 (lead)
- MOFA post launch
- DEP 1400x series



- Requirements
  - Power 1 – 5 W
  - Energy 200 – 500 J
  - Life time < 200 s
  - Rise time > 100 ms

The “Onset”

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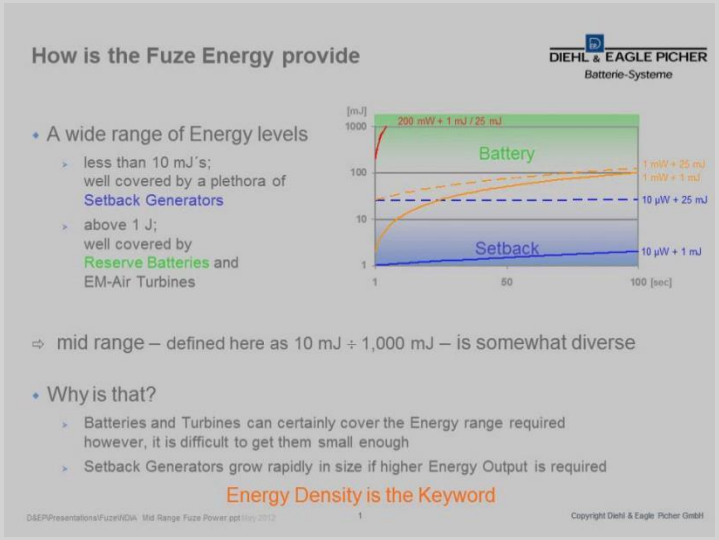
- In our 2011 presentation …



we have analysed the requirements …

… and proposed a small Fuze battery

The Start

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- Naively we thought …
  - substitute a 5 – 10 mJ set-back-generator
  - with a 100 mJ fuze battery
  - ¼ the size of the generator

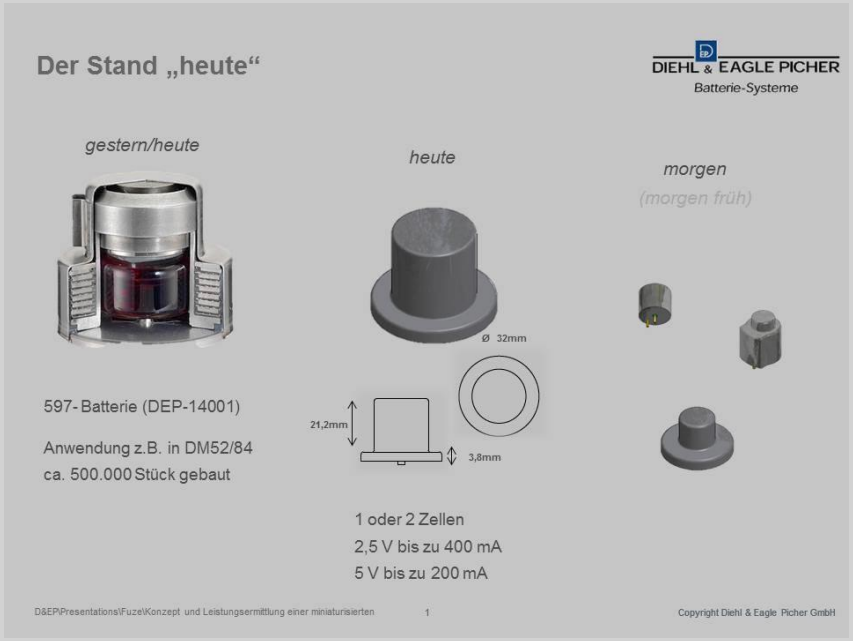
is not a big issue

we used to build Artillery/Mortar-Fuze Batteries
with 10,000 times more Capacity

just reduce the diameter by a factor of 3

and

the height by factor of 2.5



Customers Challenge

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- Our 2014 presentation …

Power Supply

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- All new electronic Subsystems are
  - Low voltage 1.7 - 8.5 V*
  - Low current 5 - 110 mA*
  - ⇨ Low power 10 - 300 mW*
- Typical combinations for medium caliber

P_{Peak} = 50 - 500 mW

flight times of 10 - 20 sec sum up to E = 0.5 - 10 J

- Sophisticated Power management is required to lower Energy

* for the examples shown

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Electrical data

Voltage: As high as possible to reduce current. We are thinking 3-4 cells in series (if possible).
Minimum voltage level TBD

Energy: Shall 0,5 Joule, Should 1 Joule

Activation Should 50 msec, Shall 100 msec (min 300 mJ delivered at this time to capacitor)

Type of load: DC/DC converter (switching type). Up to 10 W can be consumed by the converter for a short time.

supplemented by DoD 2014.1 SBIR

rise time	< 10/100 ms
current	> 2/40 mA
voltage	> 2.9 V

our customer survey

Anforderungen/Randbedingungen

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		I		II		III		IV		V		VI		VII		VIII		IX		X	
Spannung	[V]	1 s	3,3	1-2 s	5,5		3,6		(3,6)	25	5	k. A.				> 2,4		> 10		> 2,9	
Strom	[A]	<	20 m		250 m		(3,3)		(280 m)		100 m	k. A.				16 m				40 m	
Leistung	[W]	<	40 m		875 m		(12)		1		(500 m)		500 m					5 - 10		(120 m)	
Energie	[J]	k. A.	(200 m)		5,3		144		10		(303		(15)					500 m		(2,4)	
Laufzeit	[s]	<<	5	<	12	k.A.	(12)		10		60		30			15		15		20	
Anstiegszeit	[ms]	<<		<<	8	k. A.		k. A.			10	k. A.				6	<<			10	
Abmessungen	[mm]	k. A.		k. A.			ϕ 20 h 25		ϕ 25 h 10-20		ϕ 21 / 16 h 11		ϕ 22 h 14 / 19			ϕ 11 h 10	k. A.			ϕ 6,5 h 7	
Beschleunigung	[g]	>>		>>		k. A.		k. A.		>>		k. A.		65000		12000		12000		100000	
Drall	[1/s]	>>		>>		k. A.		k. A.			100 - 500	k. A.		10		1 - 120		1 - 120		1000	
Kaliber	[mm]		30		30	k. A.		k. A.			40		40 57	40 100		84		84			

D&EP\Presentations\Fuze\Konzept und Leistungsermittlung einer miniaturisierten 1 Copyright Diehl & Eagle Picher Konzept und Leistungsermittlung einer miniaturisierten 2 Copyright Diehl & Eagle Picher GmbH

Bottom Line

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- Requirement “Challenges/Highlights” *

Voltage	as high as possible
Energy	hundred´s of mJ
Power	most of the Energy within ms some W´s
Current	hundred´s of mA
Rise time	almost instantaneously t_r = close to zero
Life time	up to 60 s
Environment	spinning and none spinning

* fortunately not all cumulative

Our first small Battery

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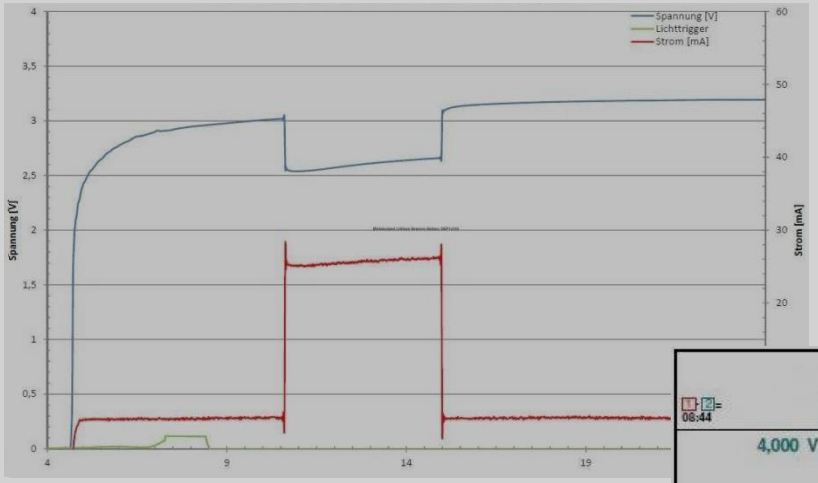
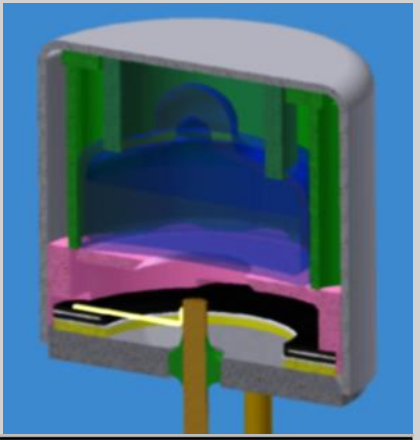
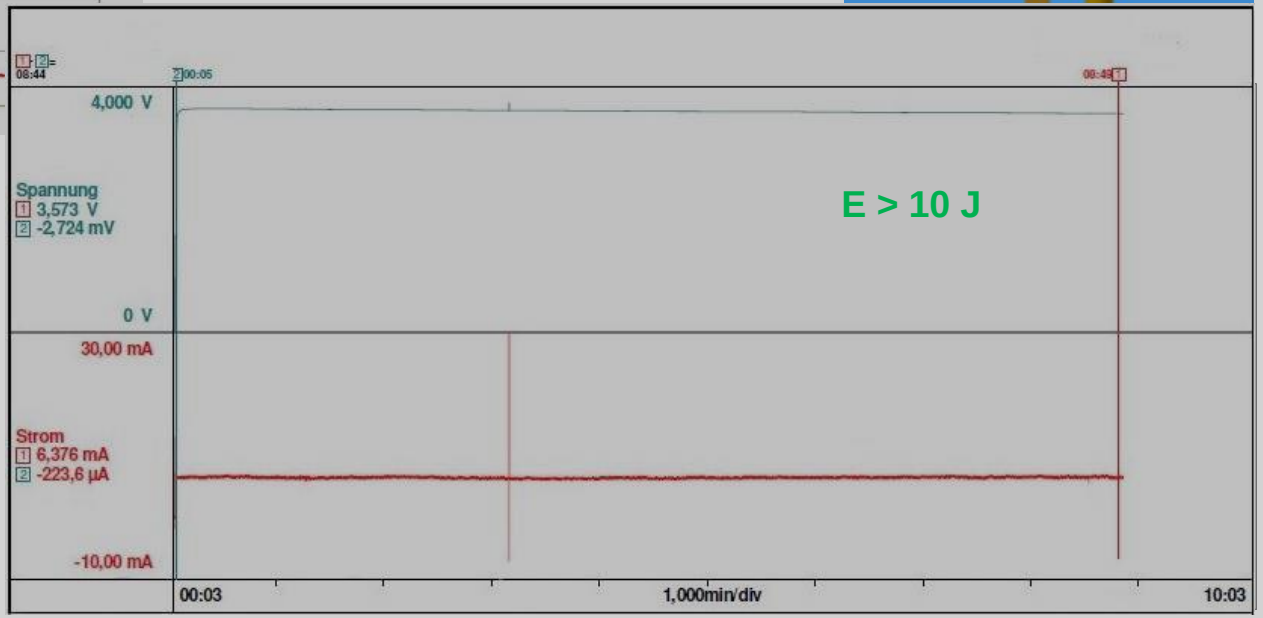
- High Acceleration (no/low spin)



DEP 14103
at -46°C





The next small Battery

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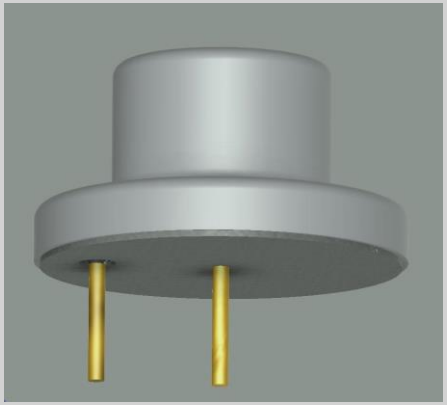
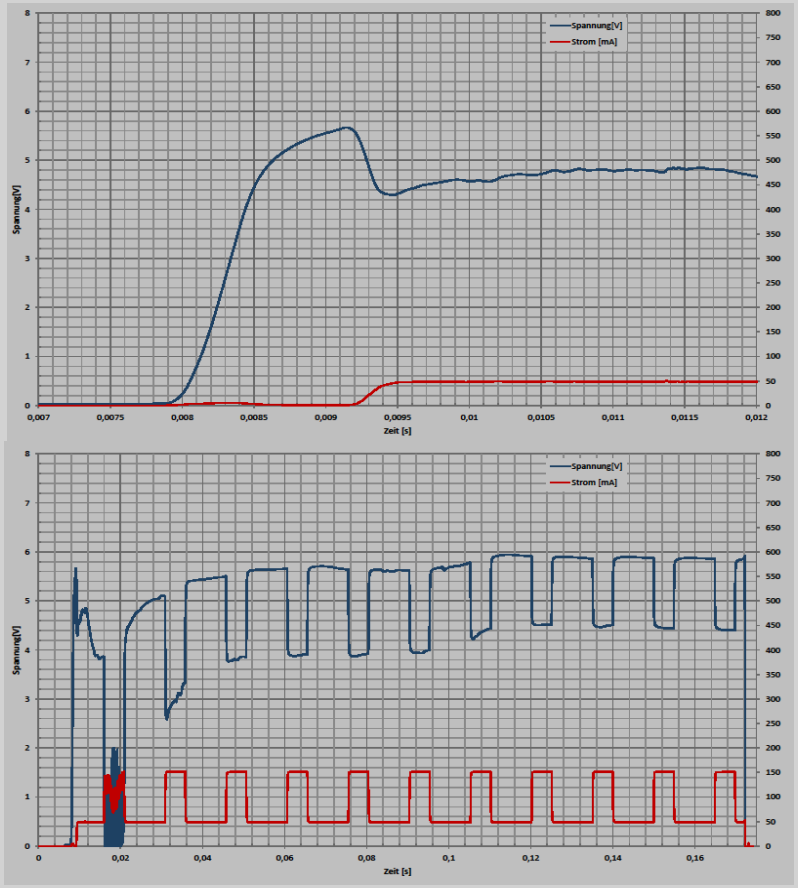
- DEP14202.01





reflecting new customer requirements

DEP14202.z; -46°C, spin

Early Voltage/Power Capability

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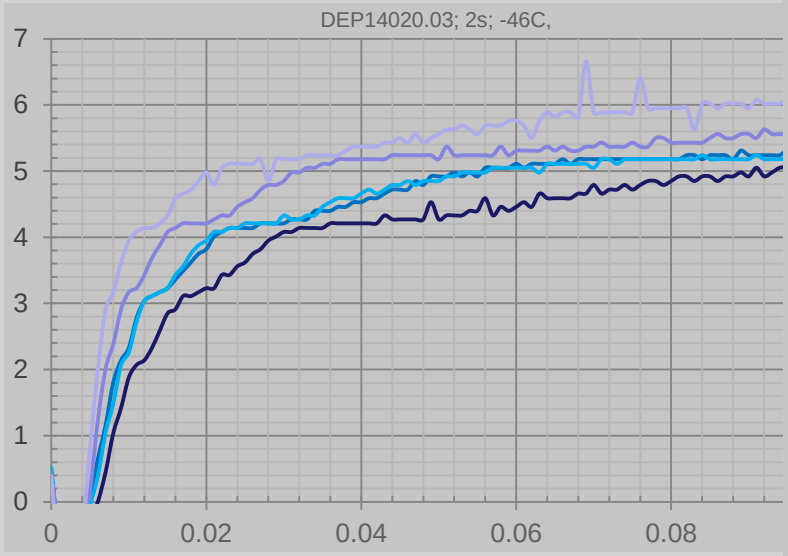
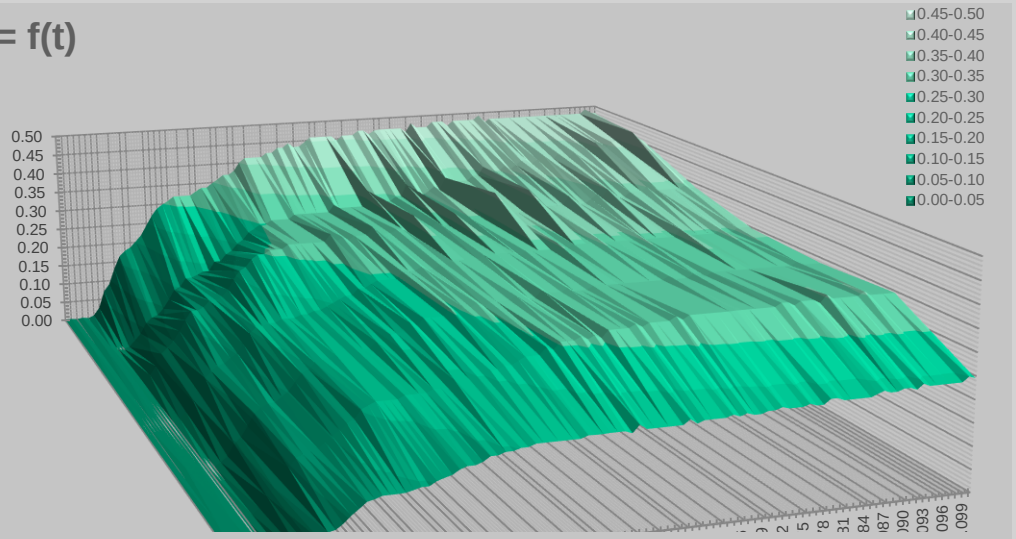
- Load-Test



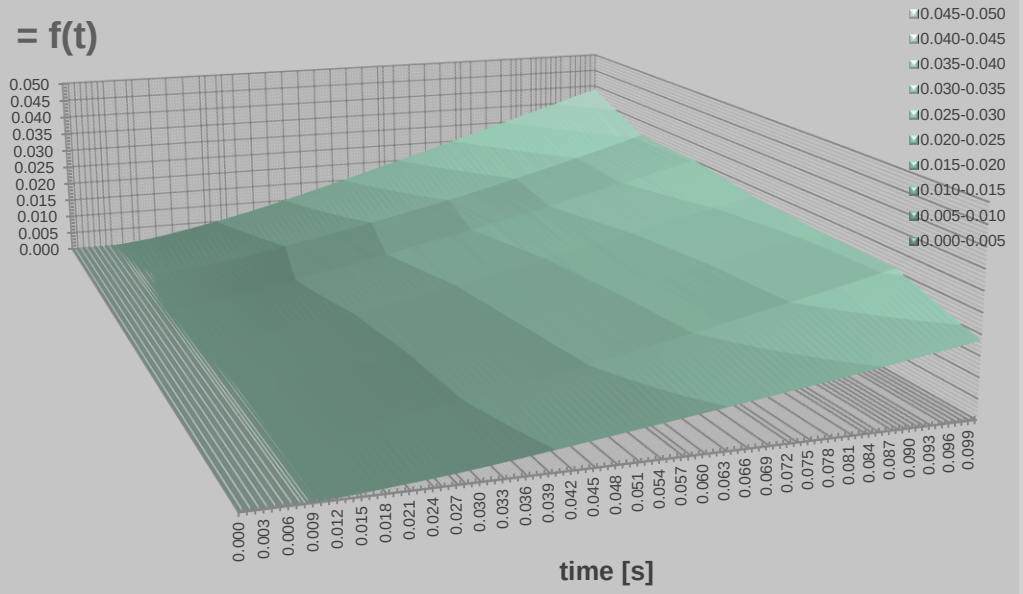
2s Battery

P ≈ 500 mW/cm^2 @ 100 ms
E ≈ 40 mJ/cm^2 until 100 ms

Power = f(t)



Energy = f(t)



Load Management

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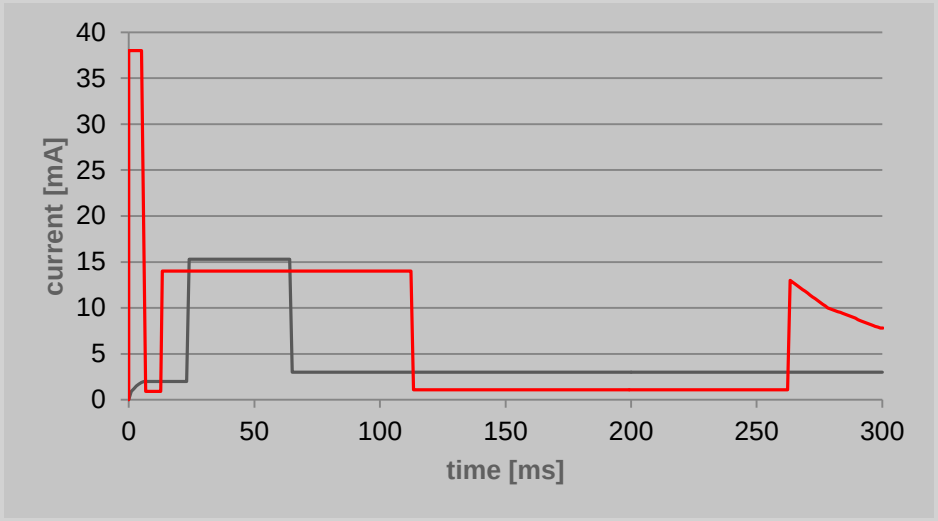
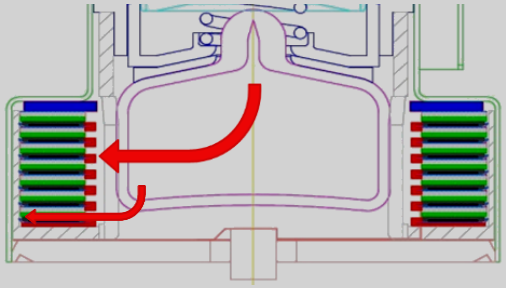
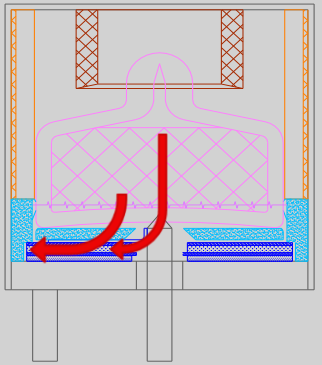
- Load Profile







- avoid (delay) high current until battery is sufficiently activated
  (electrolyte has reached the place where it is supposed to be)
- high capacitive load can be even worse
  (remember: empty capacitor is a “short circuit”)

New Lab-Test-Equipment

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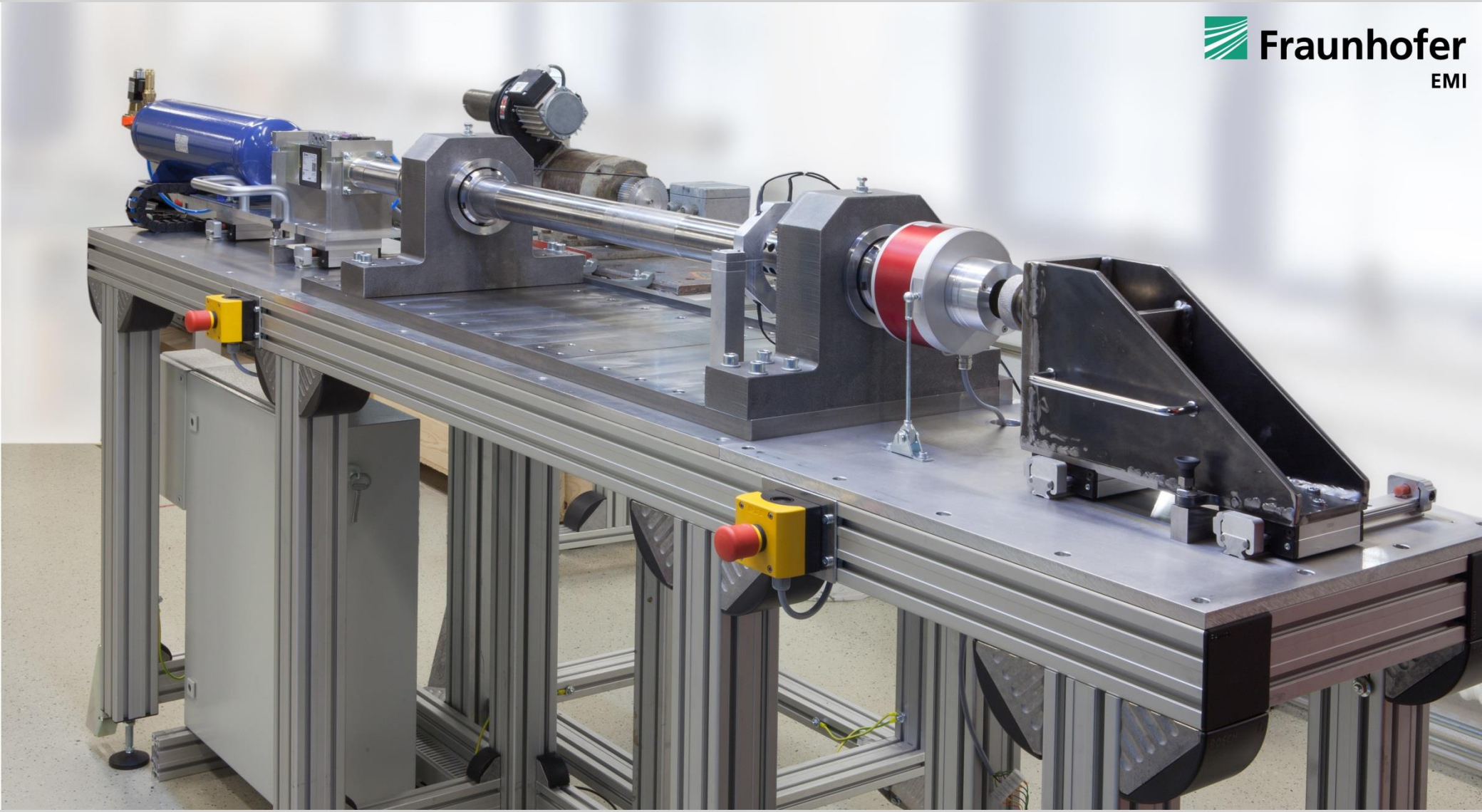
Fraunhofer
EMI



New Lab-Test-Equipment

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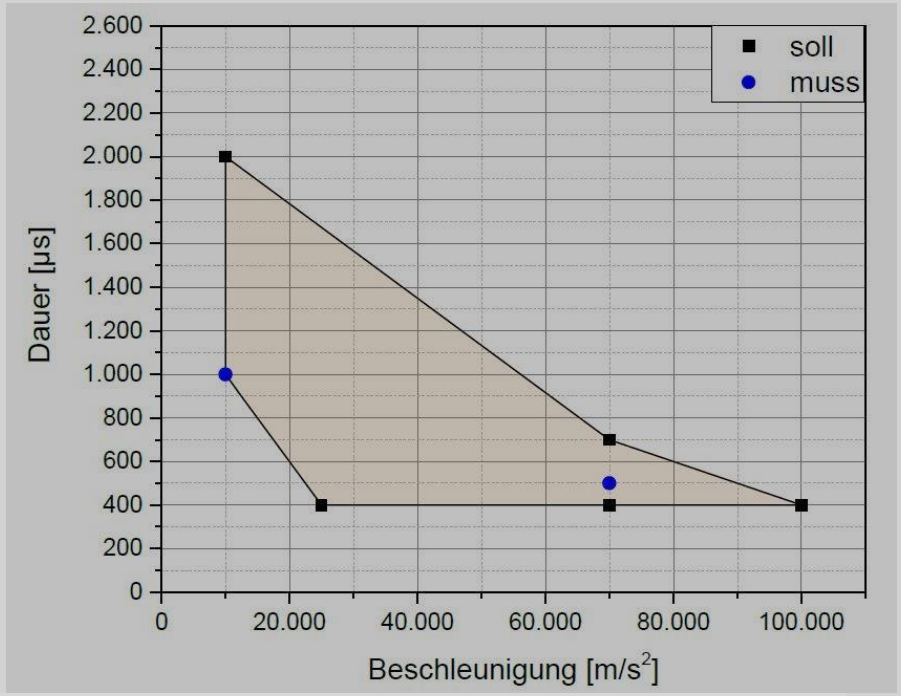
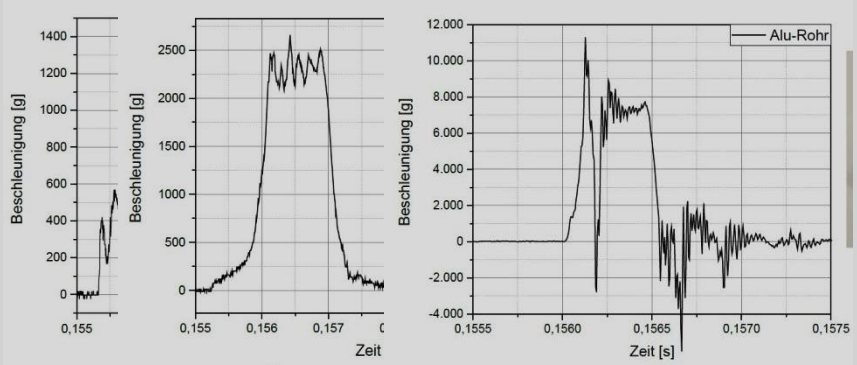
- External Load Panel (e.g. Maccor) or Customer Breadboard
- Synchronised Load and Data Recording
- Spin Rate up to 18,000 rpm
- Test-Time up to 500 s
  (actually unlimited)





First Results

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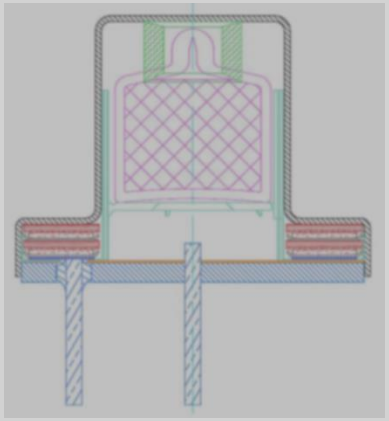
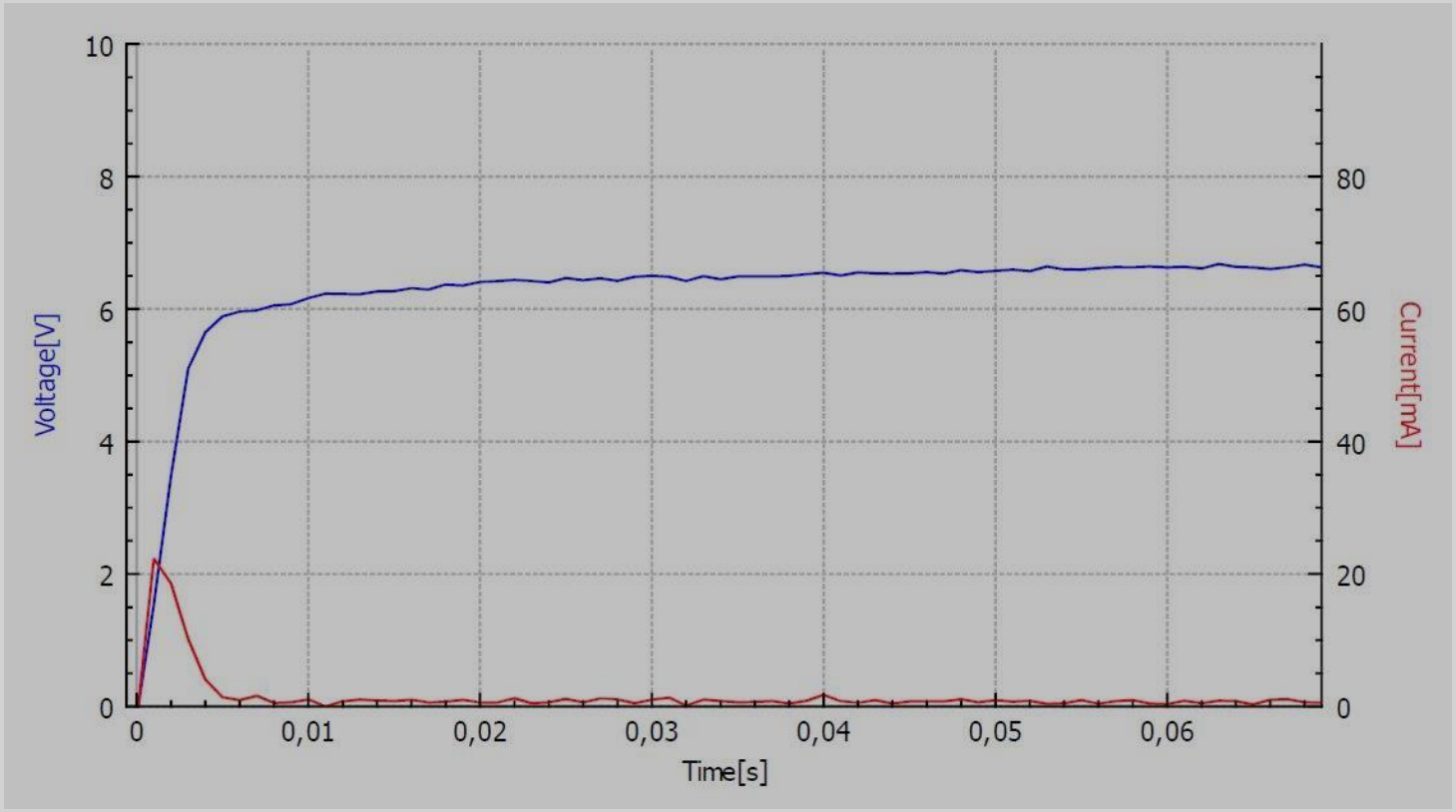
- DEP14202.**02**
  = none spinning mod of DEP14202.01





Conclusion

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- Lithium Reserve Batteries provide very short Activation Time
  - under high forces
    - Acceleration
    - Spin
  - if properly designed
  - under proper load management

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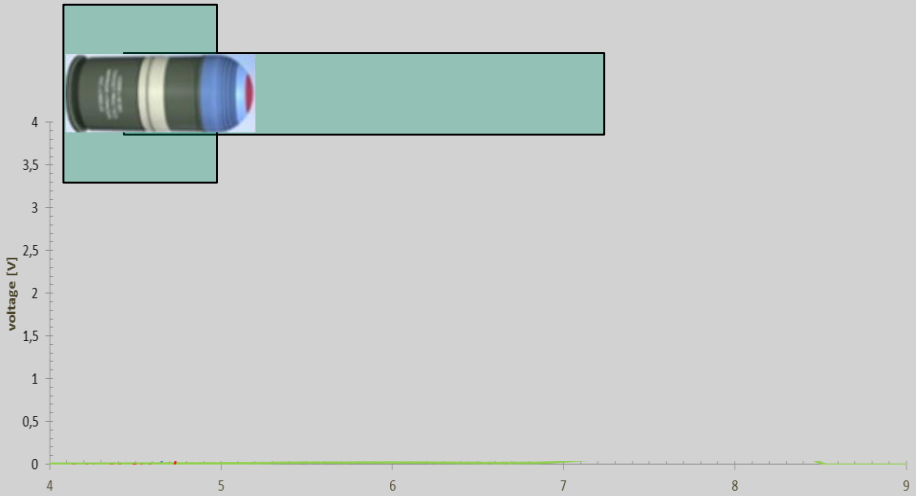

Lithium Reserve Batteries are able to provide “In-Barrel” Power!

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Thank you for your attention!

Questions?

… and don´t forget talk to us about YOUR requirements!

Diehl & Eagle Picher Contact

DIEHL & EAGLE PICHER
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