

# Modular, ultra-compact Marx generators for repetitive high-power microwave systems

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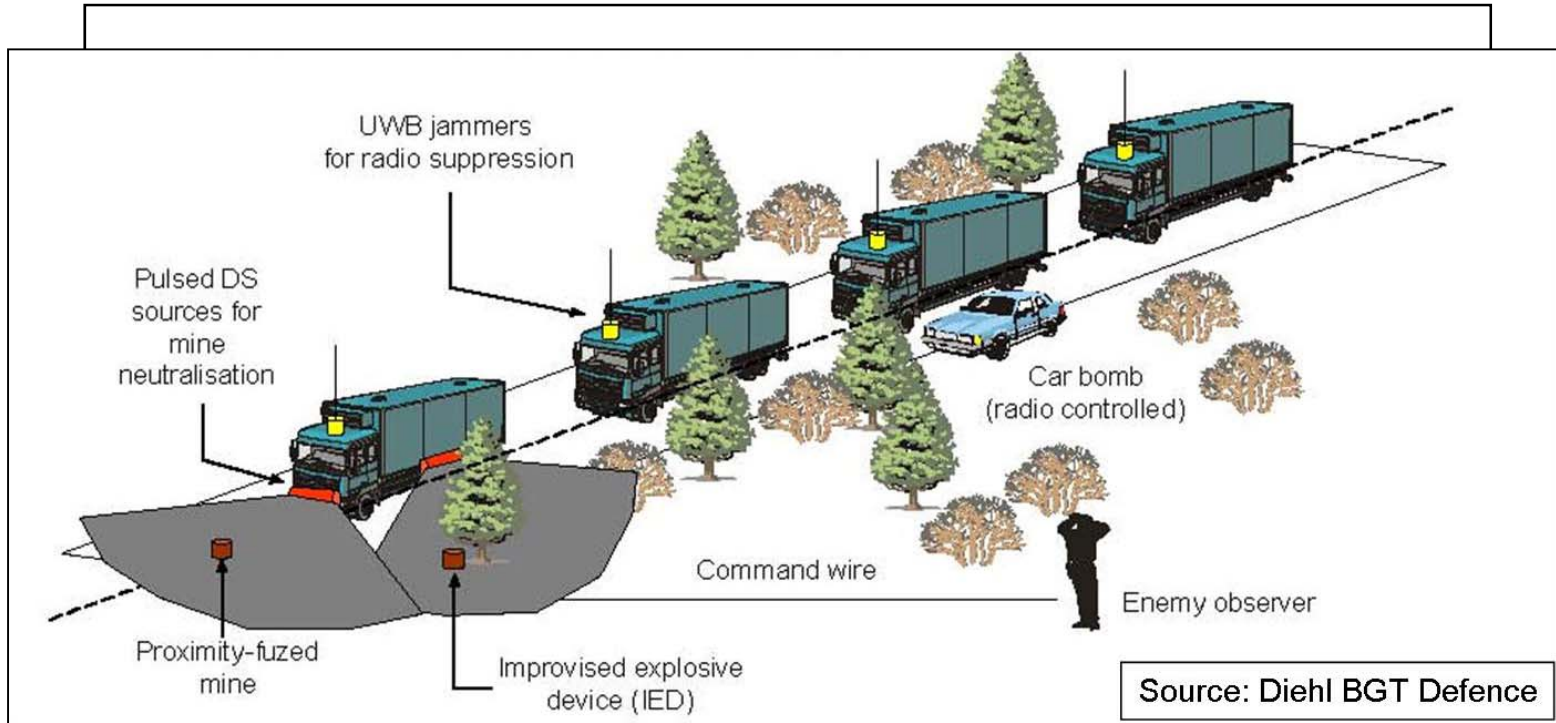
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# Outline

- Repetitive HPM systems: Fields of application
- Marx generator design
- Experiments
  - Single-shot
  - Burst-mode
- PSpice simulation
- Summary and Outlook



# Repetitive HPM systems: Fields of application



Destroyed ATF Dingo  
near Kunduz (Afghanistan) 26/03/2008  
approx. 10 kg explosive

Source: Bundeswehr

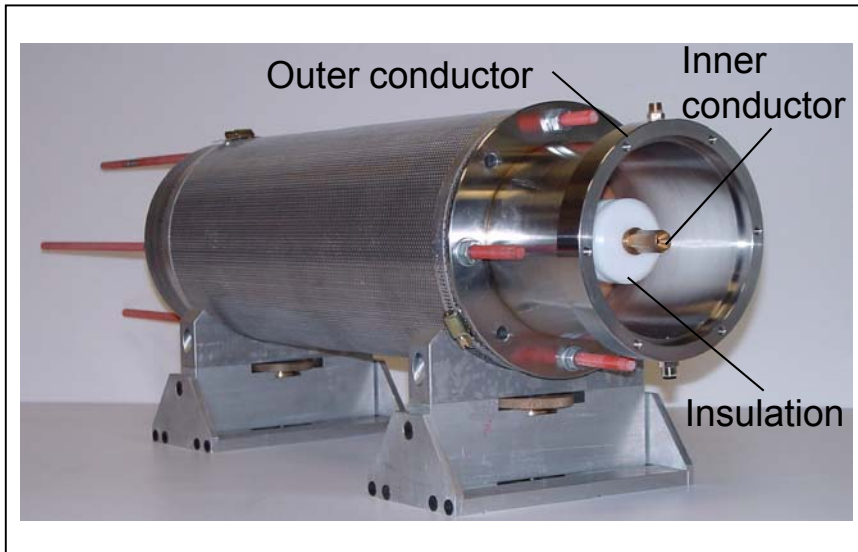
# Marx Generator Design: Elementary stage

- **Modularity & Scalability**
- **HV components**
  - 8 capacitors in parallel ( $C_{tot} = 8.8 \text{ nF}$ )
  - 2 charging coils
  - Custom-made contact sheets
- **Housing** ( $\varnothing = 200 \text{ mm}$ ,  $h = 47 \text{ mm}$ )
  - PVC
  - Insulation between stages and vs. ground
  - O-ring sealing
  - Different gas types and pressures  
(e.g. spark gaps : technical air,  $\text{N}_2$ ,  $\text{H}_2$ , ...  
HV-components :  $\text{SF}_6$ )
  - Hardened chromium steel electrodes, on-axis
- **Weight:**  $m_{Stage} = 2.86 \text{ kg}$



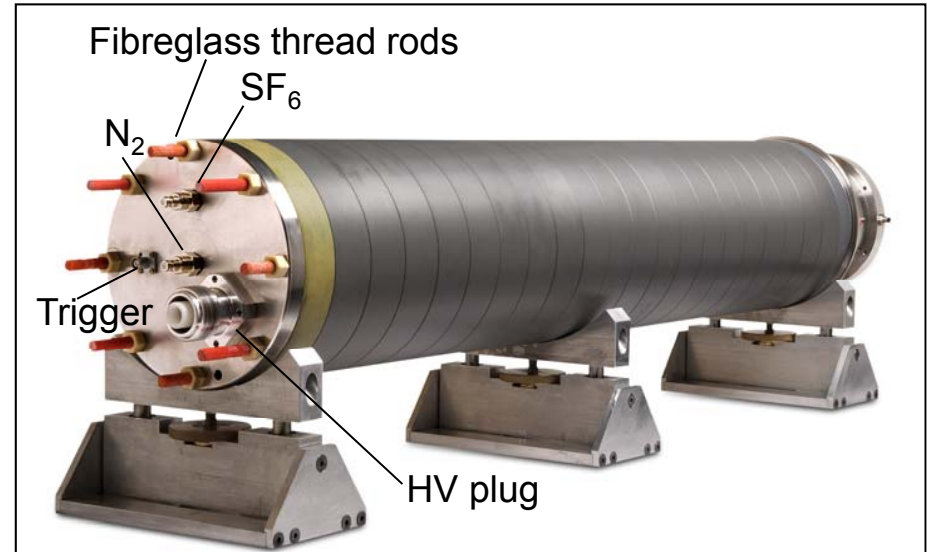
# Assembled Marx Generators

10 stages



$m_{10} = 34 \text{ kg}$   
 $l_{10} = 690 \text{ mm}$

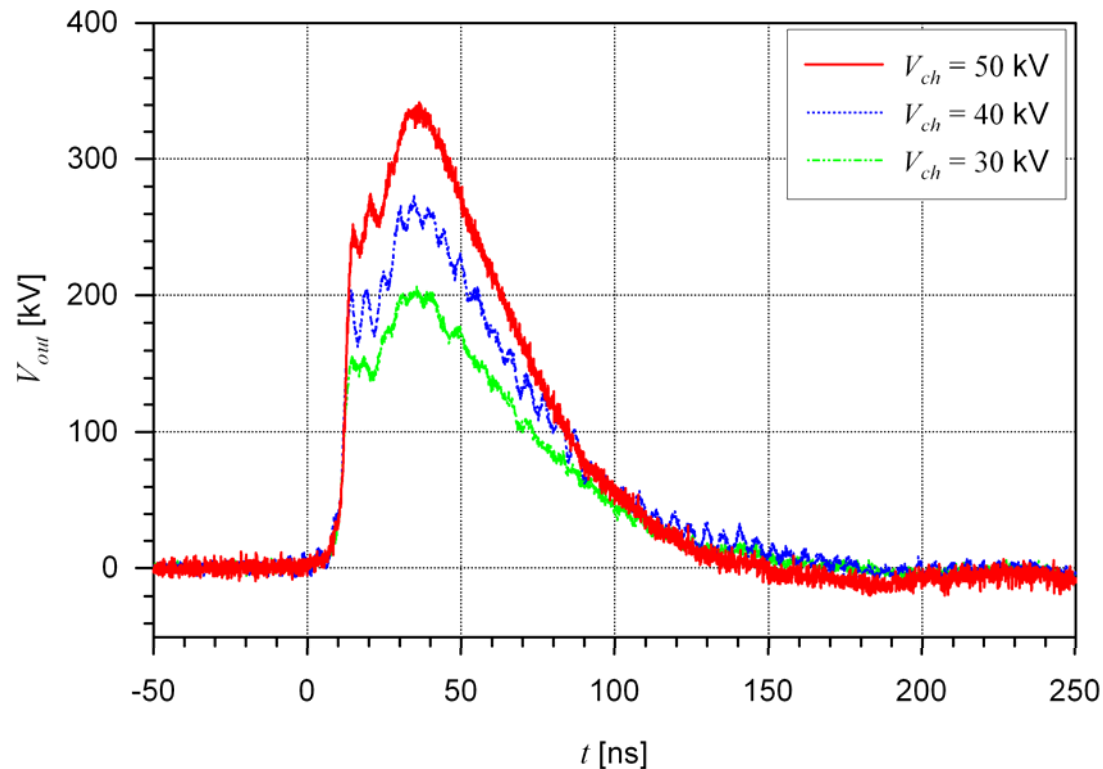
20 stages



$m_{20} = 62 \text{ kg}$   
 $l_{20} = 1160 \text{ mm}$

# Single-Shot operation: Efficiency

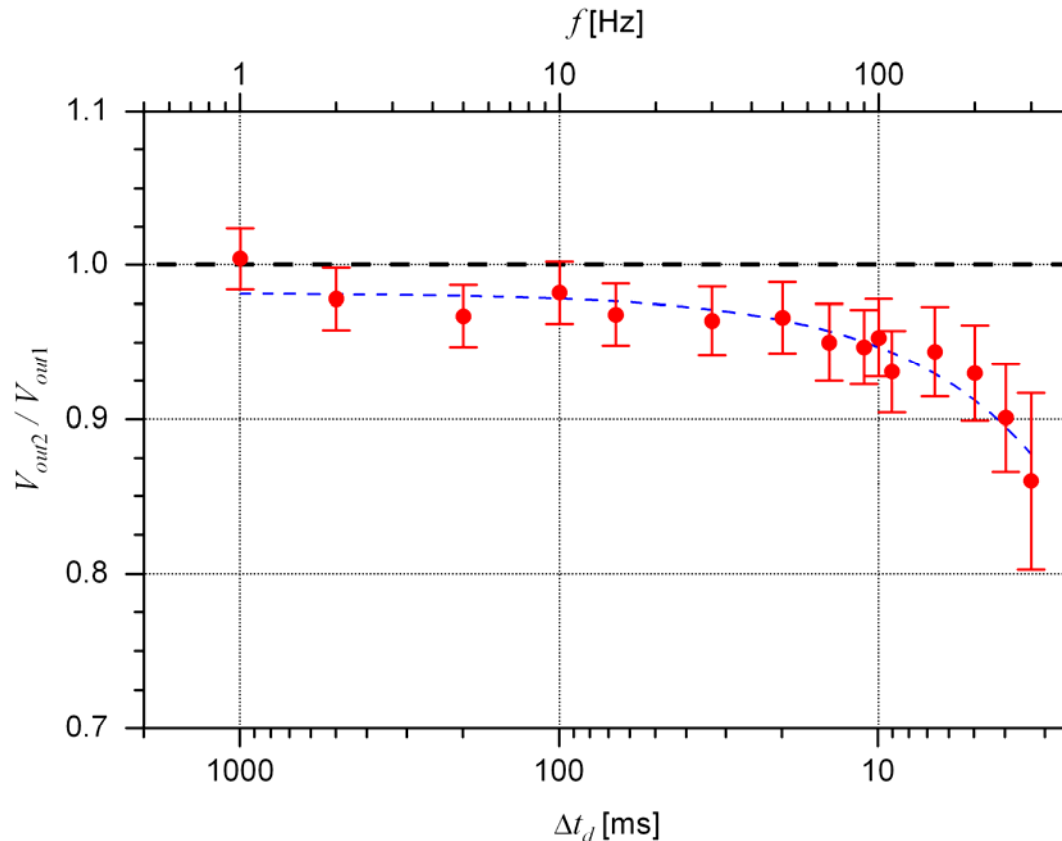
$N = 10$  stages -  $V_{ch}$  up to 50 kV - Nitrogen  $N_2$  -  $50 \Omega$  load



Efficiency 7 % higher than comparable resistive Marx generators

# Two-pulse experiments: Recovery time

$N = 4$  stages -  $V_{ch} = 40$  kV - Nitrogen  $N_2$  @  $p = 3.2$  atm

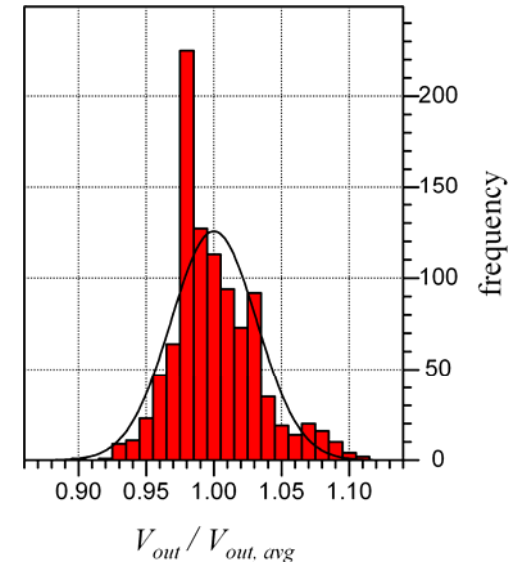
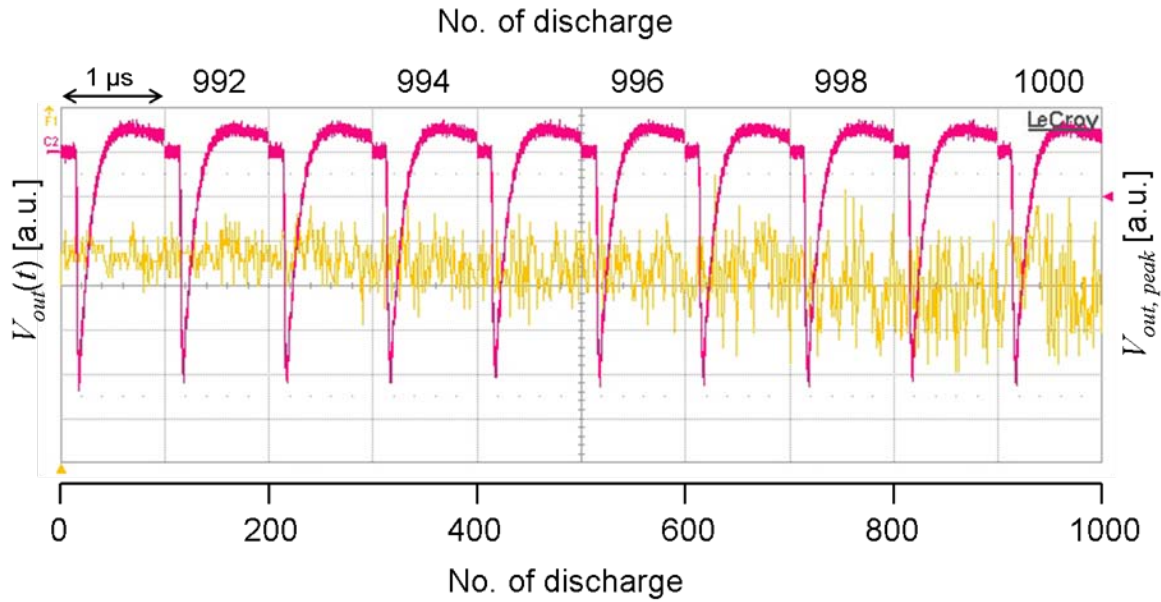


90 % recovery @  $f = 250$  Hz  $\leftrightarrow \Delta t_d = 4$  ms



# Burst-mode operation:

$\Delta t_B = 10 \text{ s @ } f = 100 \text{ Hz}$

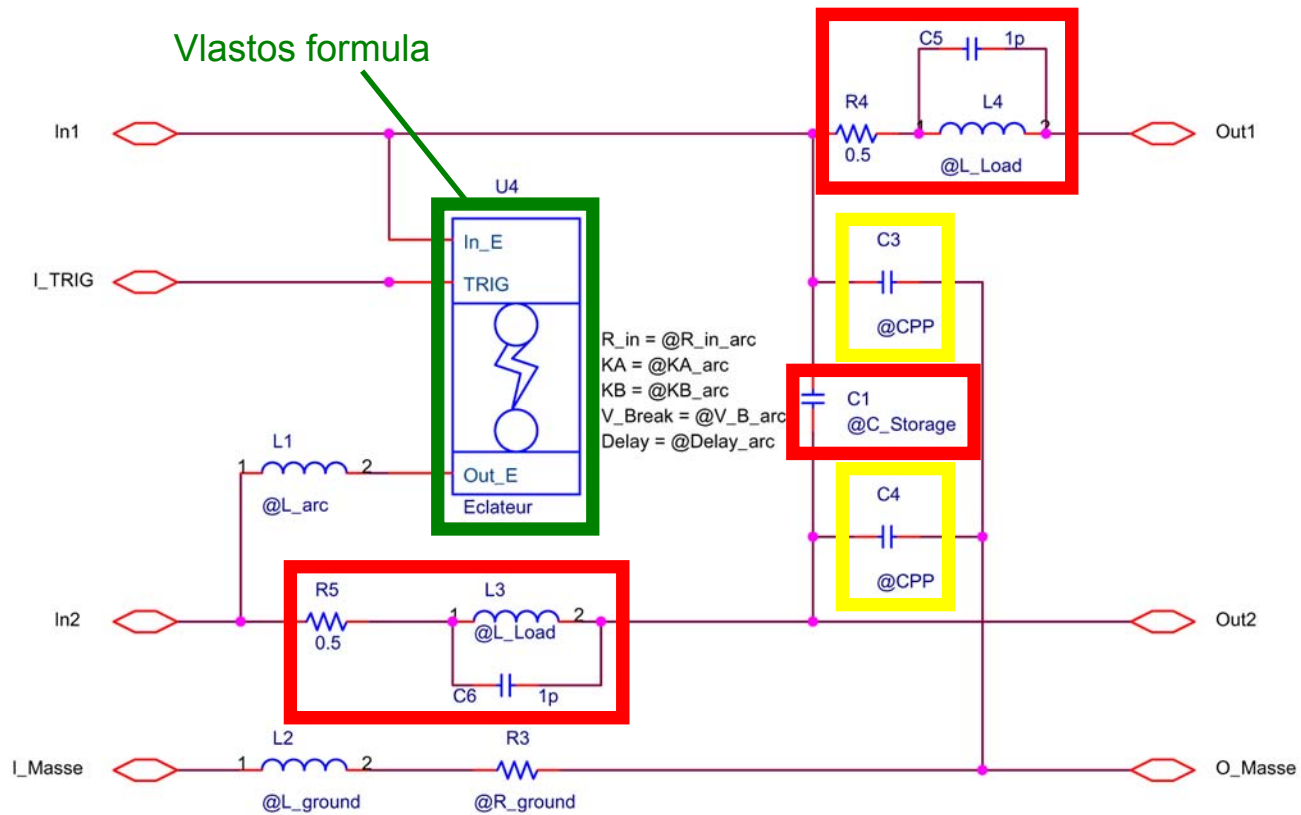


- $N = 8$
- $V_{ch} = 38 \text{ kV}$
- Self-breakdown
- No gas circulation

$\sigma = 0.032$

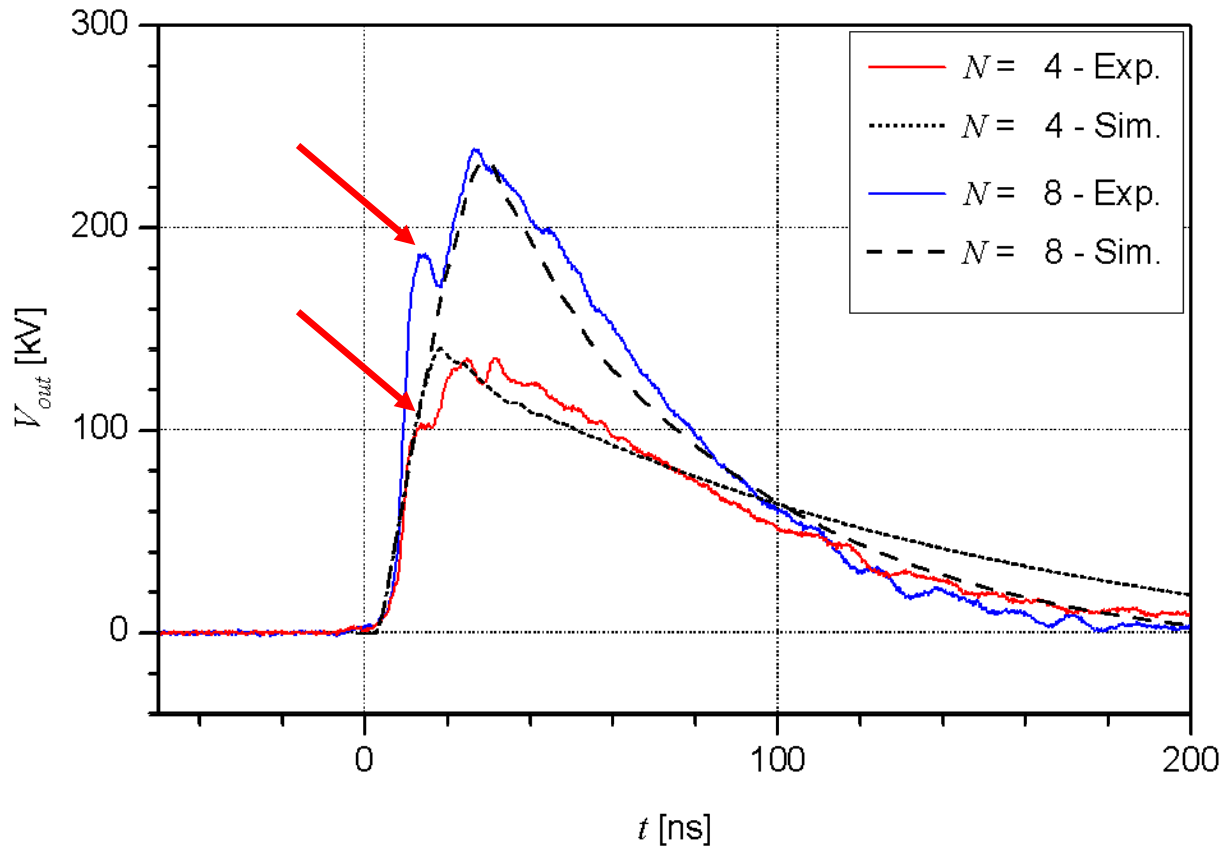


# PSpice Simulation: Model



Model of one single Marx stage

# Simulation results



Experiment and simulation in good agreement

# Summary & Outlook

- Summary
  - Redesign of ISL Marx generators
  - Successful burst-mode operation
  - Optimized PSpice model
- Outlook
  - Implementation of gas circulation
  - Testing of alternative electrode materials (CuNiSi) and electrode geometries (Ernst profile)
  - Long-term repetitive operation (e.g. 1h @ 20 Hz)
  - Portable HPM system (GIMLI pulse-shaper)



# Questions?



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