NEW DEVELOPMENTS OF LORENTZ DRIFT SWITCHES FOR HIGH CURRENT AND HIGH VOLTAGE APPLICATIONS

rler, K. Esser, C. Hock, J. Jacoby, B. Koubek, B.-J. Lee, J. Otto, Pfaff, B. Klump,T. Rienecker, A. Schoenlein, J. Wiechula

Ins for Applied Physics, Goethe University, Max von Laue Str. 1, D-60438 Frankfurt

(Founded by BMBF)

Content

- Introduction and Motivation
- Basics of the Lorentz-Drift-Switch (LDS)
- Trigger Concept
- Experimental Results
- Related Experiments
- Summary
- Outlook

Introduction

- Requirements for high power switches

- High hold-off-voltage
- Capability for switching high currents
- Long life time (low erosion)
- High dynamical range for the voltage
- Precise triggering
  (Delay, Jitter)
- High current rise rate (low inductive)

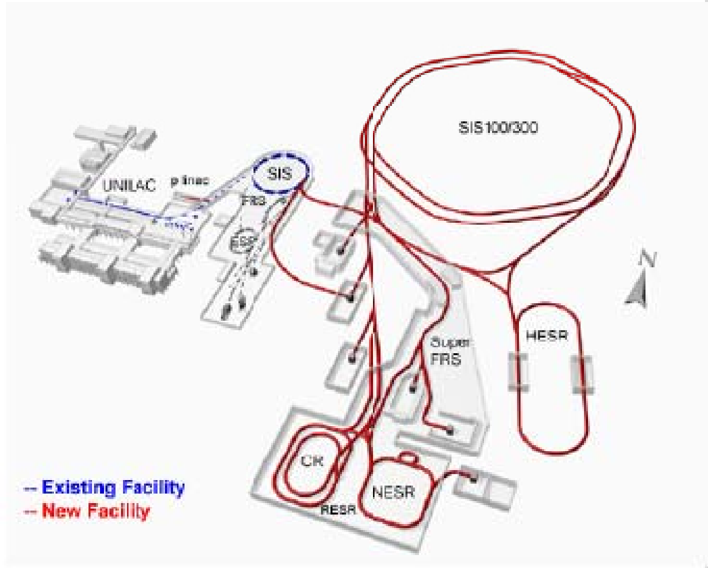
Motivation

1. Accelerator Laboratories (GSI/FAIR-Darmstadt)

a) Beam dump systems

b) Injection- and extraction- magnets

PFN of kicker magnets: SIS 100/300



Voltage:	> 70	kV
Current:	~ 8	kA
Repetition rate:	4	Hz
Pulse length:	6-8	µs
Current rise time:	< 250	ns
Pulse energy:	~ 6	kJ
Peak power:	~ 800	MW
Charge transfer/pulse:	~ 60	mC

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2. High Power Laser Facilities (GSI, PHELIX-Laser)

Switches for the flash lamps of laser

340 Capacities, 12 Ignitrons

Voltage:	20 kV
Pulse energy:	3,5 MJ
Pulse width:	~100 µs

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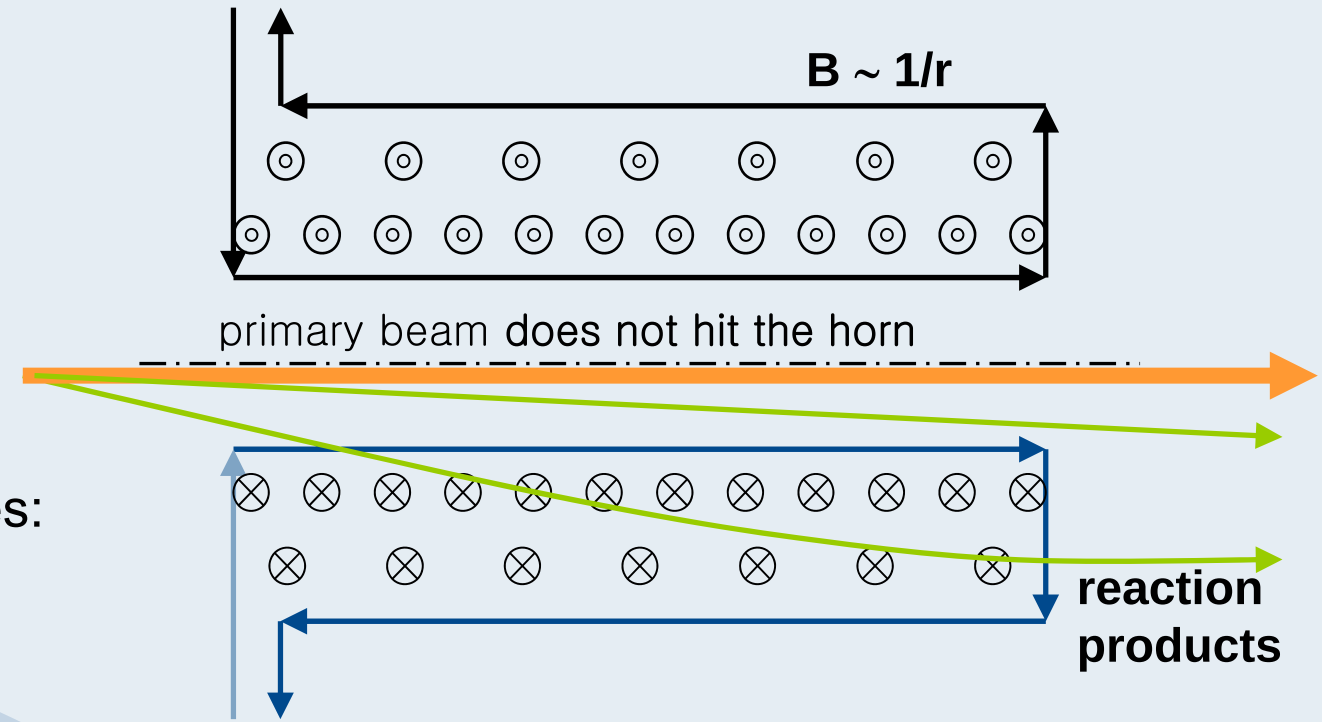
3. Magnetic horn for the FAIR-facility

Focusing Anti Protons

Requirements:
~ 10 kV
~ 400 kA
~ 100 µs

Favorit Switches:
Ignitrons?



Basics of the LDS

Gas filled tube

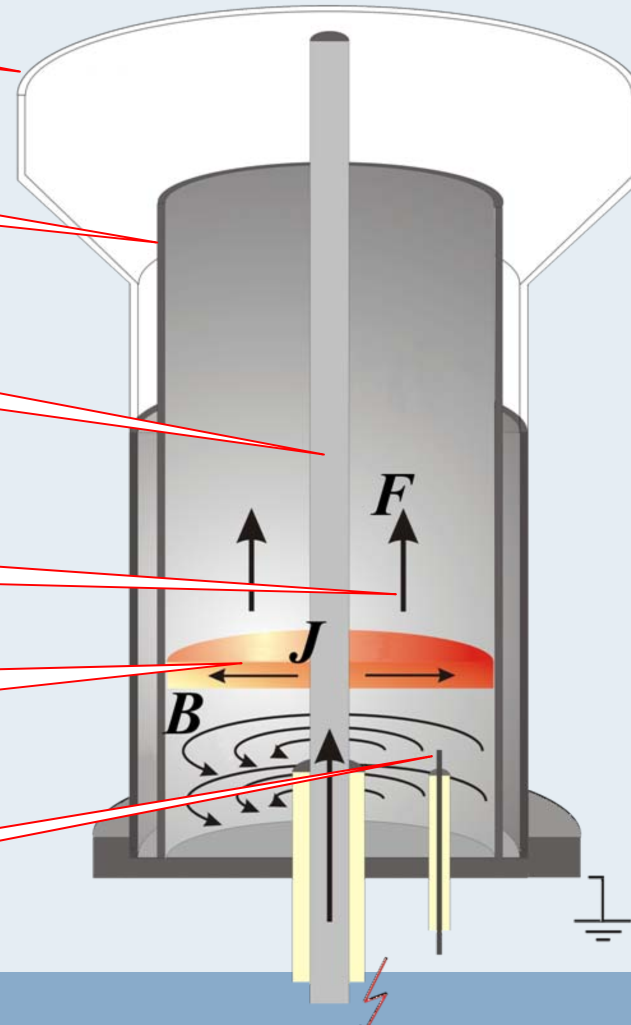
Grounded electrode

High voltage electrode

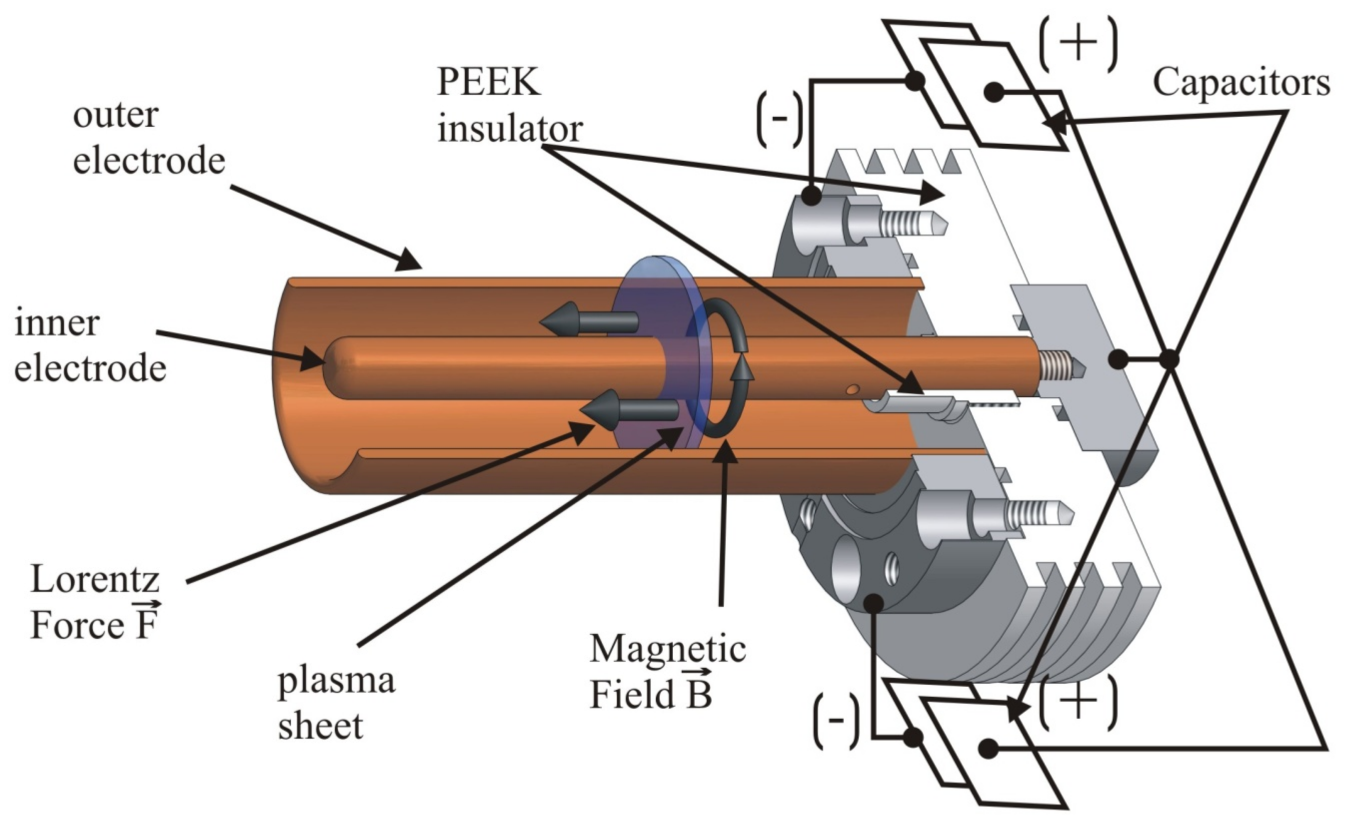
$$F = \int dV\ J x B$$

Discharge plasma
J = current density

Trigger unit



Principle of the moving arc

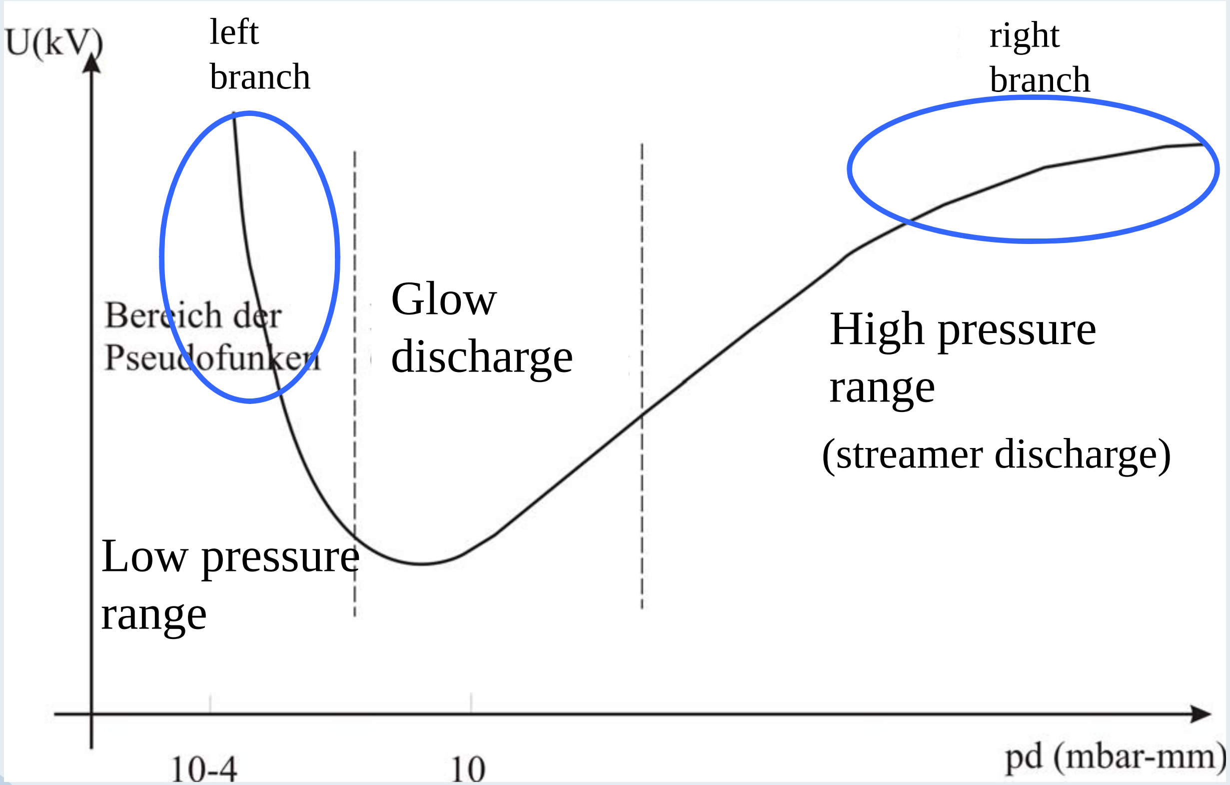


Consideration of the working parameter

<u>High pressure</u>
(short distance)
- delay
- large jitter
- high energy for triggering
- erosion of the trigger unit
- noisy operation

<u>Low pressure</u>
(far distance)
- effective triggering
- silent discharge
- high dynamical range

Paschen curve



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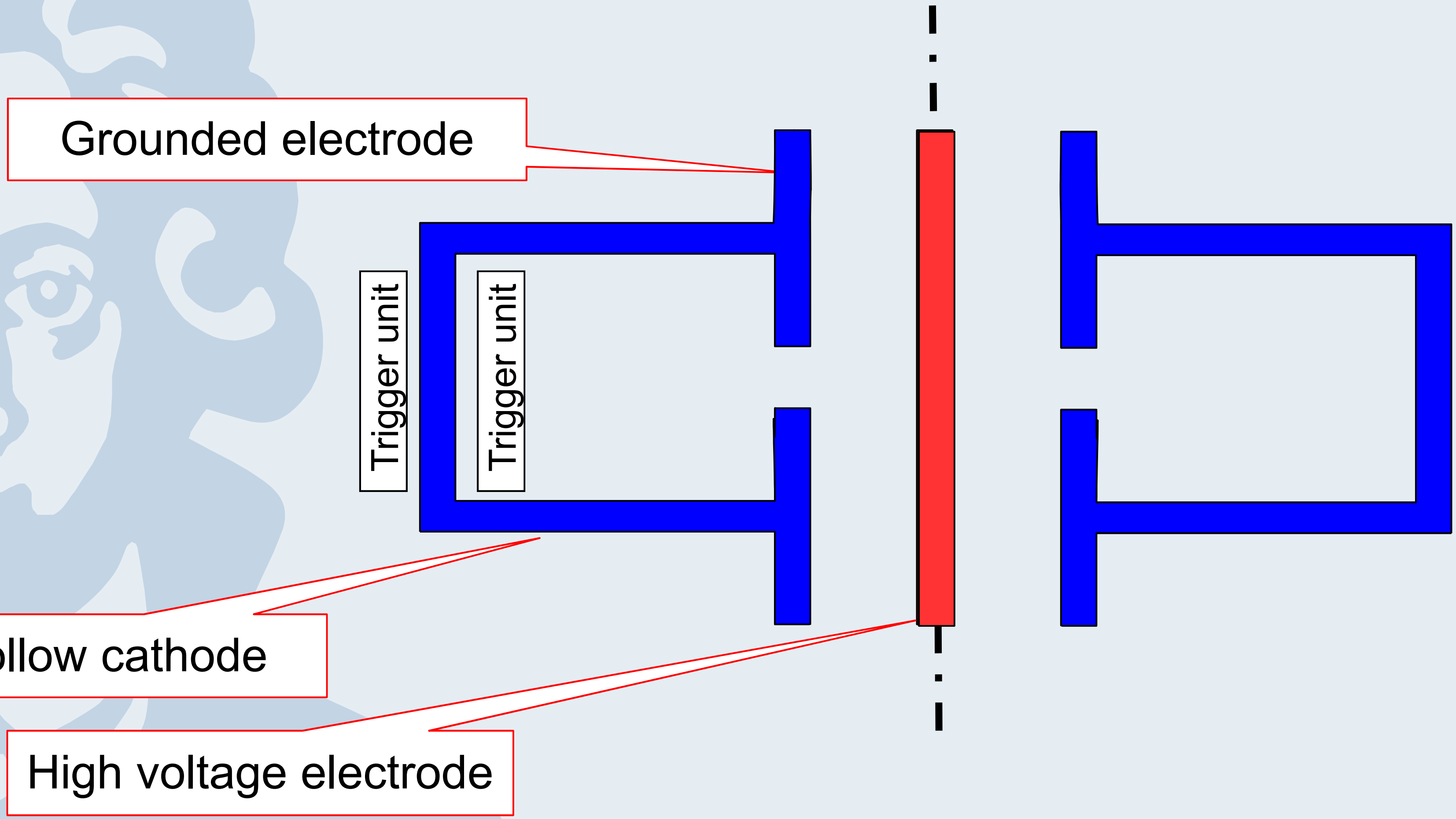
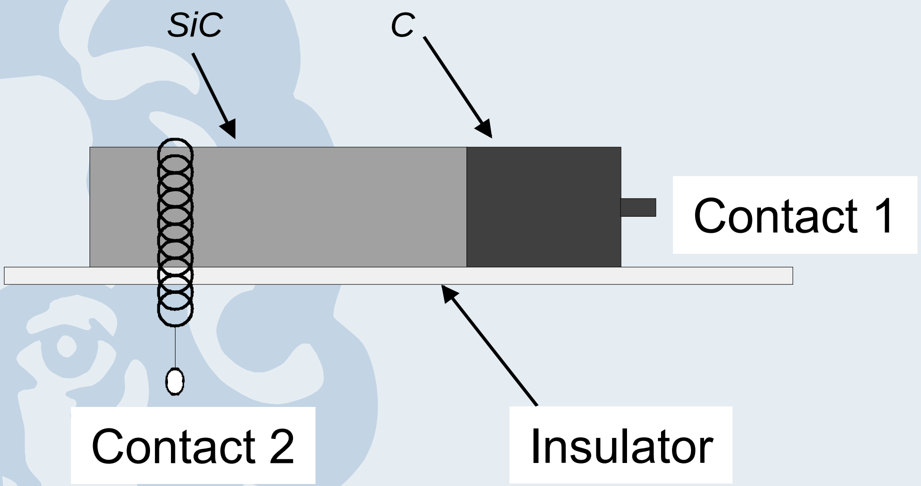
Solution for the low pressure range

Advantage: Protected trigger system



Trigger unit

Semiconductor surface flashover trigger



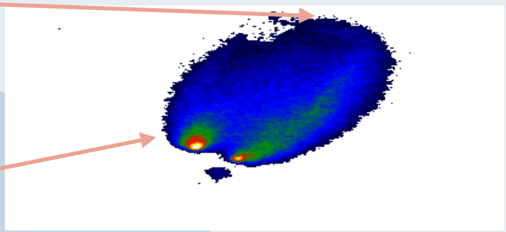
consists of:

- copper spring (contact 2)
- SiC-cylinder
- C-cylinder
- insulator

Example of a discharge:

contact 1

copper-spring



Discharge over a long path

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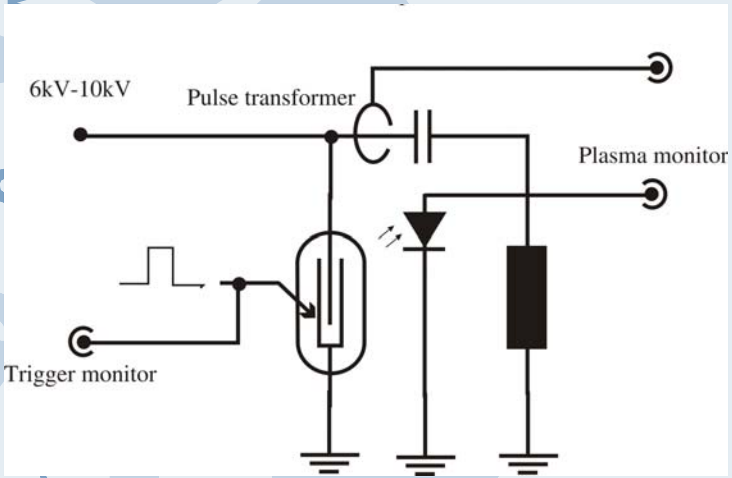
Electrical test set-up



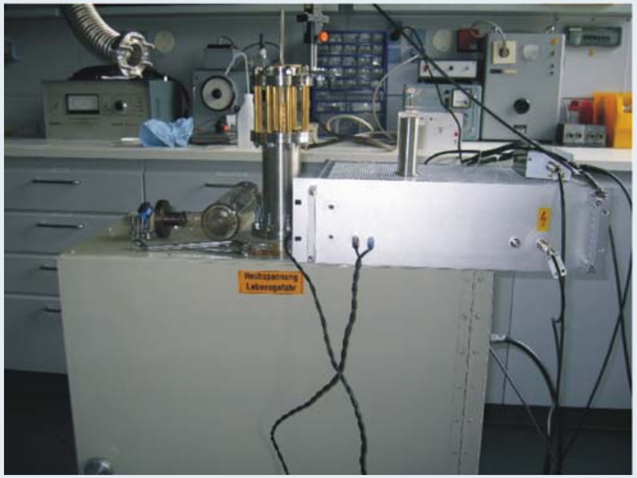
$C \sim 5\ \mu F$

$U = 0.1\ kV – 20\ kV$

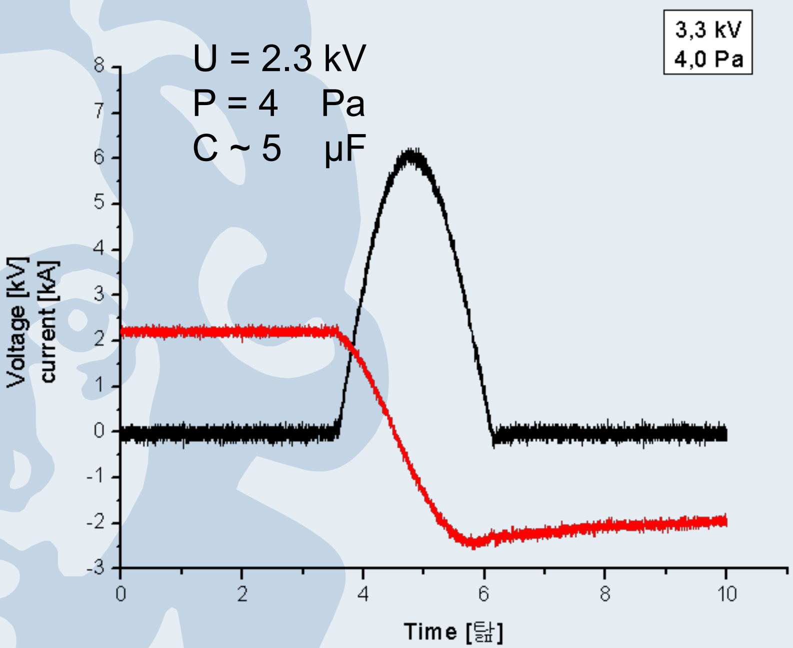
$W_{max.} \sim 1000\ J$

Working gas:

N_2 or Ar



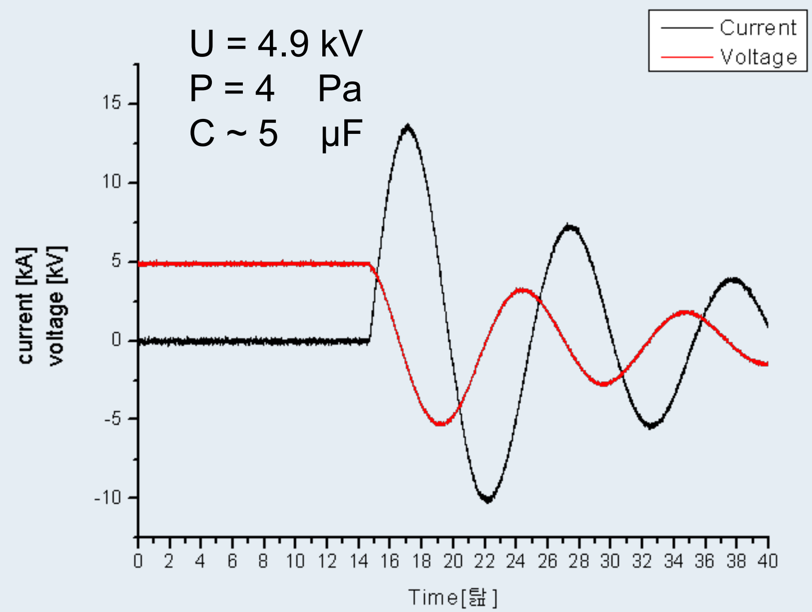
Current and voltage behaviour for a single gap LDS



Effect of a diode

Stop of the discharge at the top of the electrodes

(behaviour of a opening switch)



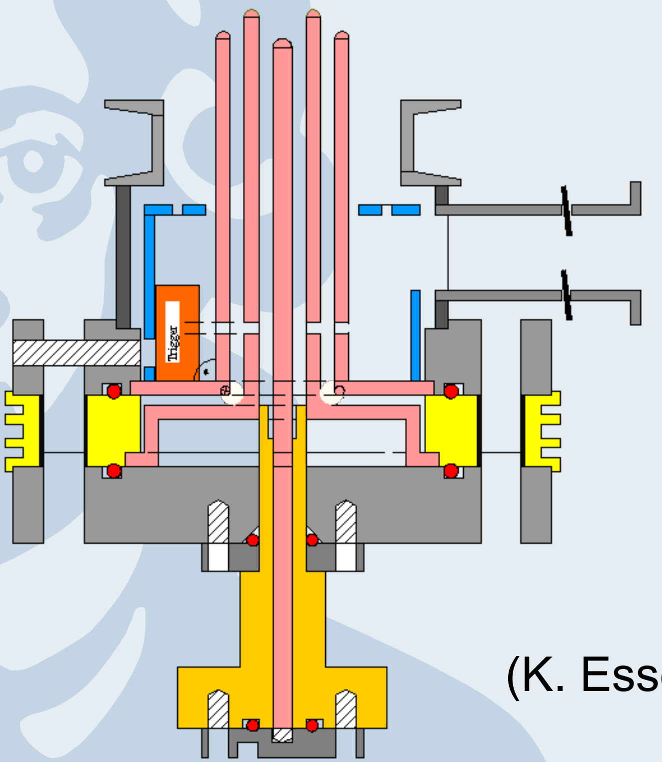
Damped oscillation

Continuous moving discharge, reignition of the Discharge at the bottom of the electrode system

Multi-Gap-LDS for high voltage

Two-Gap LDS

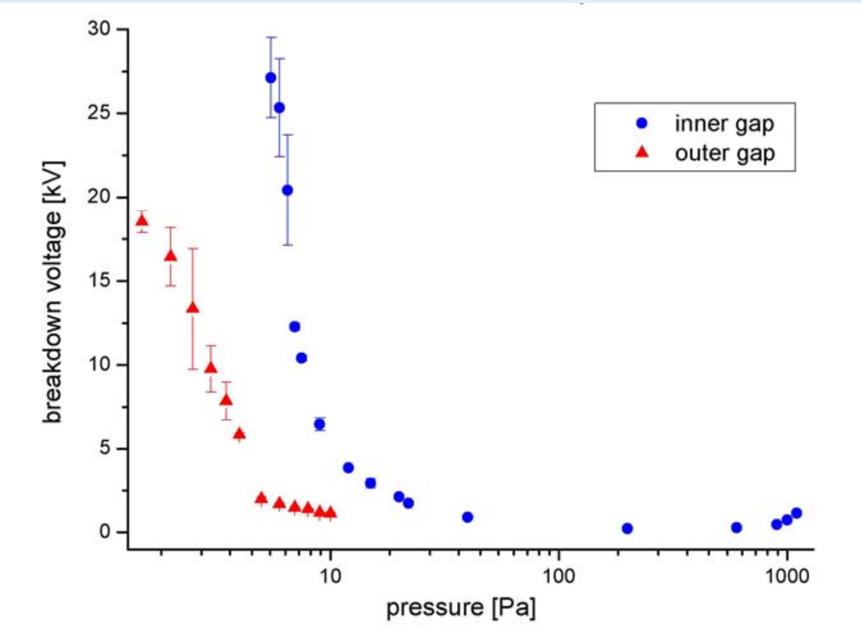
Injection and Extraction
Kicker Magnets



(K. Esser)

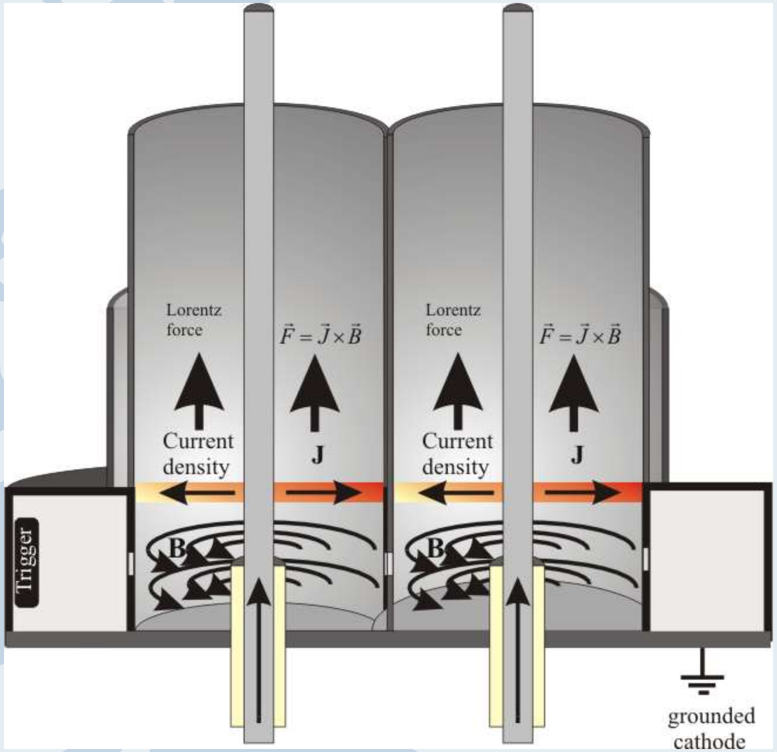
Break-Down Voltage

Limited by the outer gap



Multi-Electrode-LDS for high current (MELDS)

Application: Magnetic Horn



(Schematic drawing of the MELDS)

Requirements for high current switches

- High charge transfer
- Homogenous electrode erosion
- Simple in triggering
- Low jitter and delay

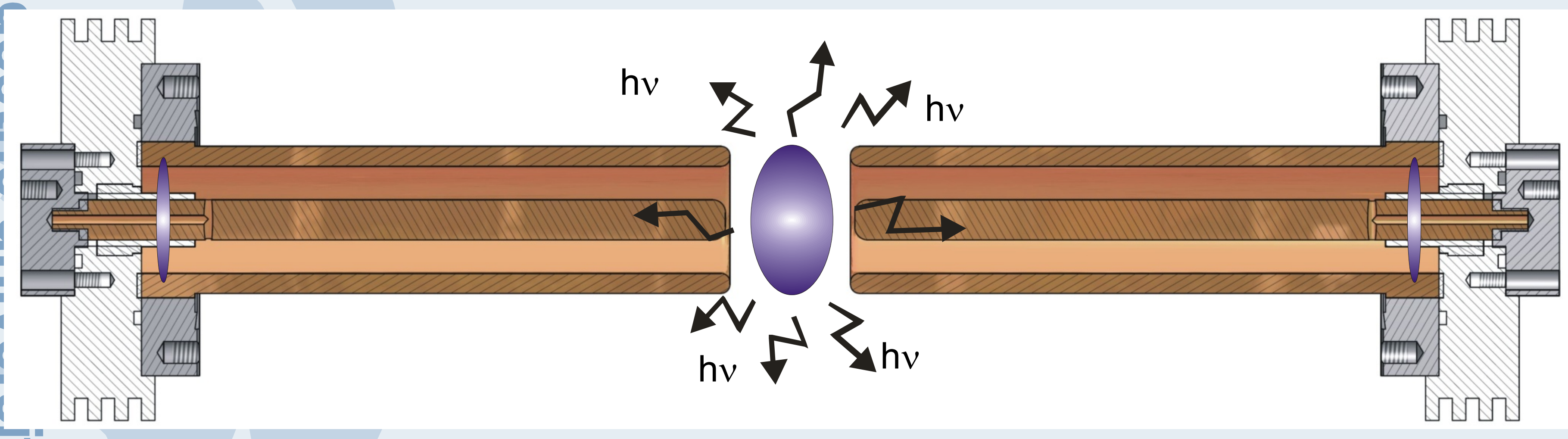
Realising

- Parallel arranged electrodes
- One triggersystem
- Plasma coupling due to holes

(now under construction)

Further Experiment based on Lorentz Drift

VUV-Radiation source



I. Electron temperature
II. Electron density
III. Degree of Ionisation
IV. Heating from Shockwave

Advantages of the LDS

• moving arc	→	low electrode erosion
• blow out (at the open end)	→	defined pulse length
• coaxial set up	→	low inductivity
• simple in manufacturing	→	low cost

Outlook

Set up and Test of the Multi Electrode LDS
(GSI-flash lamp labaratory)

Development of a multi gap system (high voltage applications)

Theoretical evaluation of the discharge (Colliding Experiment)

Snow blow model

Spectroscopic investigations

Time resolved

Spatial resolved