SYNCHRONIZABLE HIGH VOLTAGE PULSER WITH LASER-PHOTOCATHODE TRIGGER

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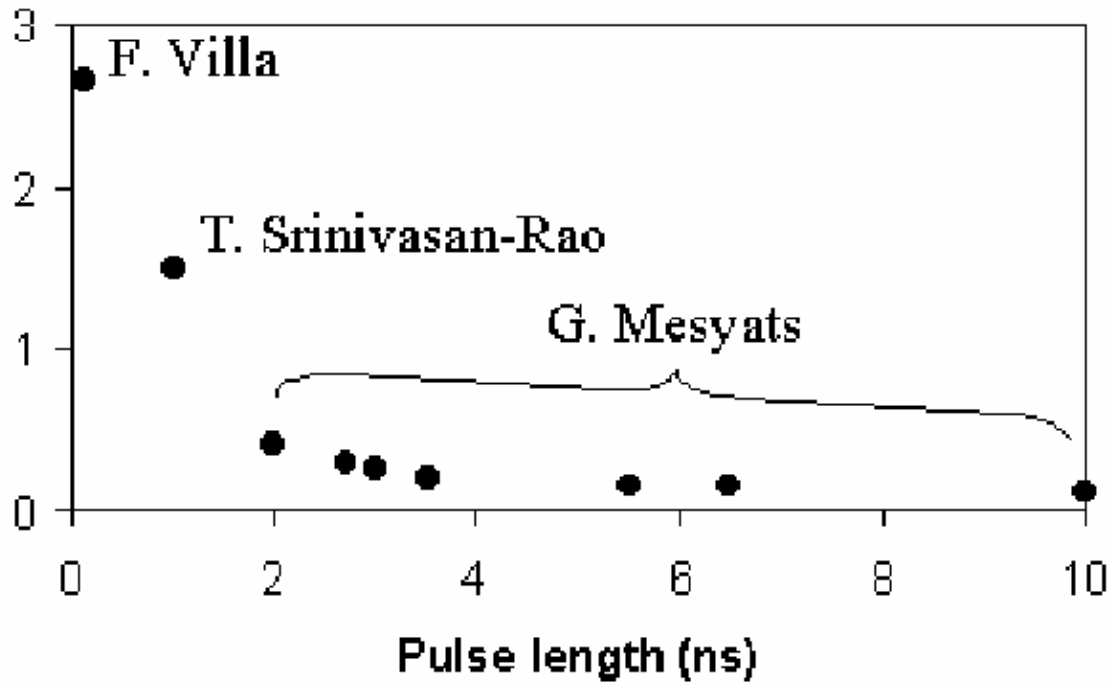
Outline

1. Introduction
2. Marx Generator
3. Main Switch
4. Transmission Line
5. Summary

1. Introduction

High Gradient Electron Gun Requires a synchronizable Pulser



- Electric field breakdown limit (GV/m) versus pulse length (ns) for copper electrodes.

1. Introduction

High Gradient Electron Gun Requirements for a synchronizable Pulser

- Low jitter (< 500 ps)
- Fast rise time (<500 ps)
- Short pulse width (< 2 ns, 1~1.5 ns)
- Fall time (<1 ns)
- Pulse amplitude (~ hundreds of kV, MV)
- Repetition rate (Low:1~5 Hz)

1. Introduction

Critical issues in a Pulser: reducing jitter, caused mainly by switch devices

- Fast switch in accelerators: semiconductor switch, spark gap (electrical or laser trigger), etc.
- Limitations: technical problems, cost, size, complications, etc.
  - Short pulse, high voltage: spark gap is often used (simple structure)
  - To improve jitter: laser-triggered spark gap

1. Introduction

Conventional laser-triggered switch

- **Jitter relatively low:** Compared with gas gap switch
- **Low optical energy utilization ratio**
  - For SF_6 and N_2, absorption rate<0.002/cm
  - 30 cm gas channel, total photons absorbed < 6 %
  - Result: Cost increases greatly as high energy lasers are expensive

1. Introduction

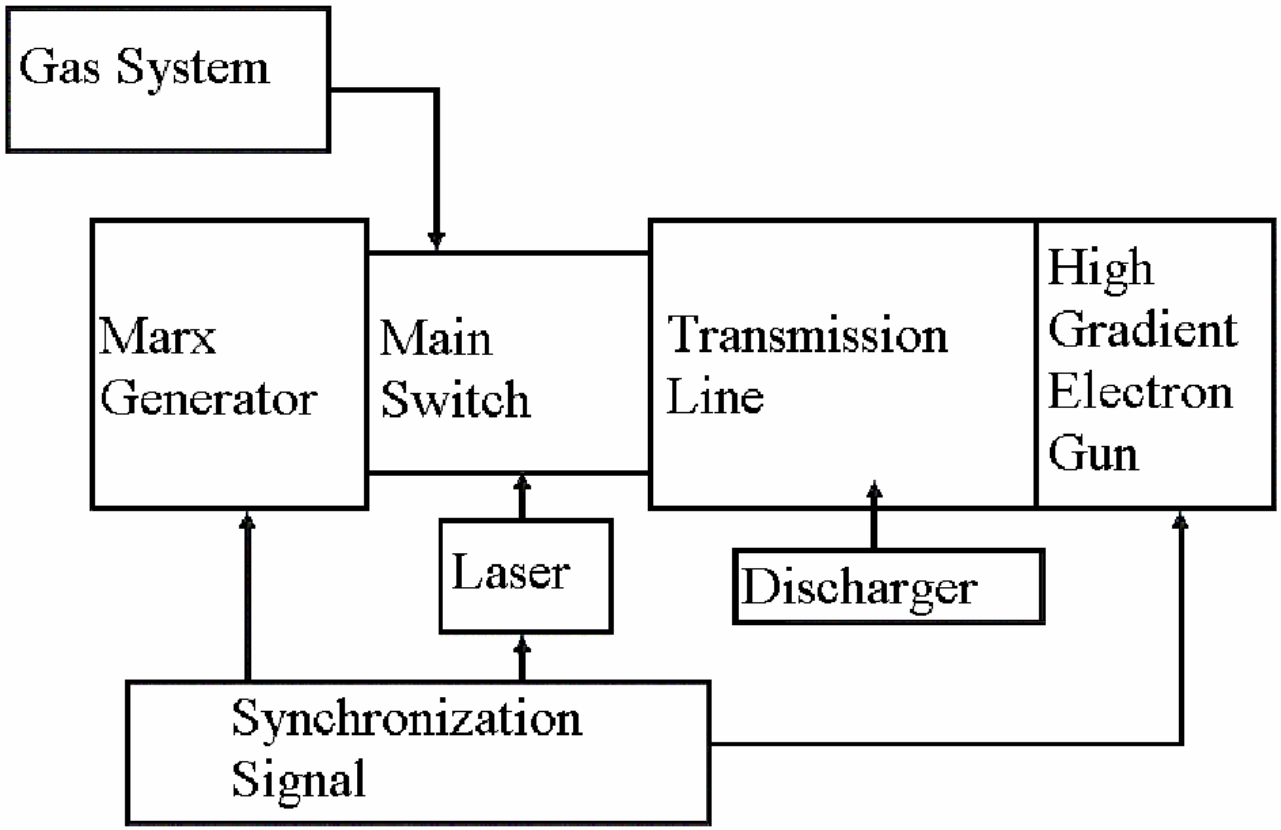
Novel Switch designed by DULY in rf/dc electron gun project

Gas spark gap switch

- Triggered by laser photoelectrons
- Goals:
  - Minimize the jitter of the switch
  - Raise the utilization ratio of the laser beam energy
  - Make the pulser synchronizable

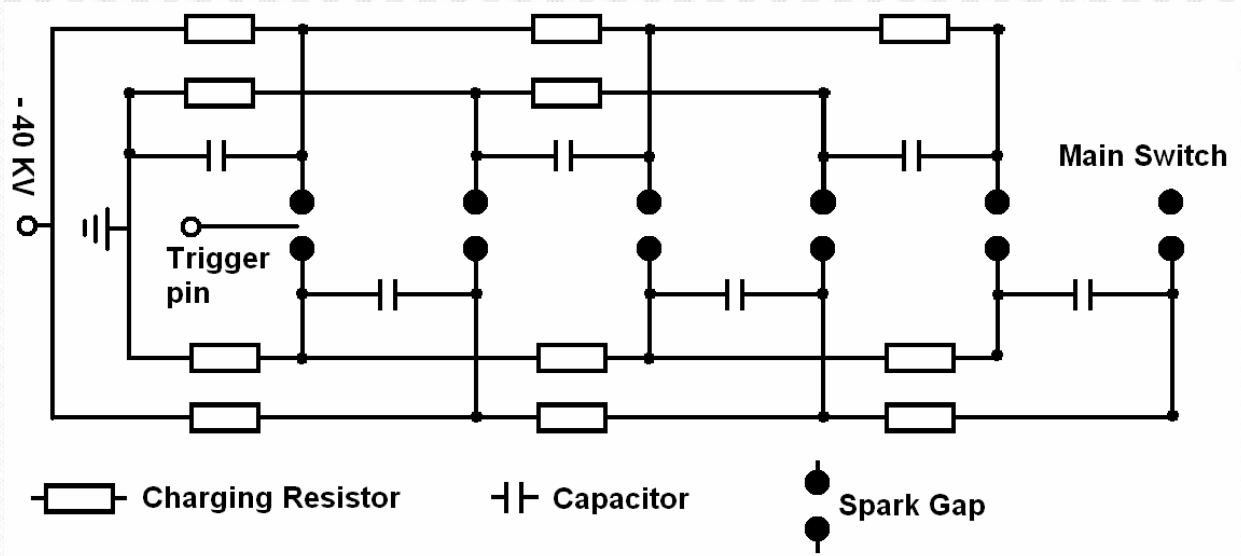
1. Introduction

Pulser Designed for the DC/RF Gun



2. Marx Generator

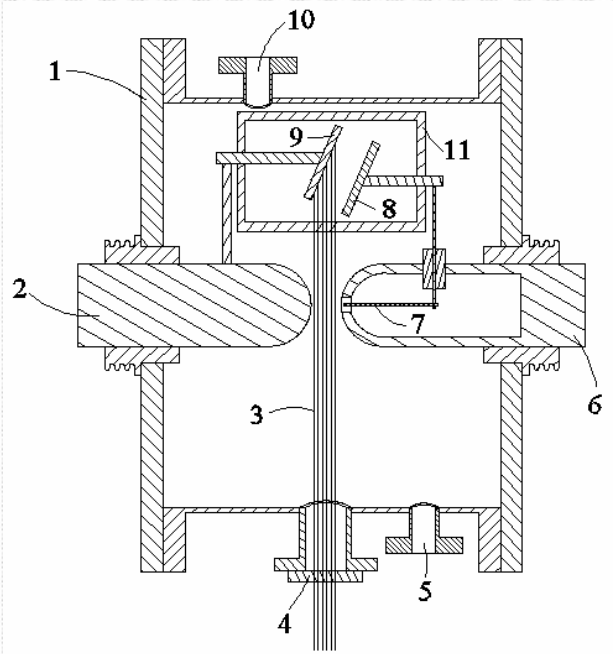
Energy storage device for dc/rf gun



- Advantage: Easy to realize voltage multiplication
- Drawback: Large jitter at erection
- Main switch to control jitter

3. Main Switch

Connected with Marx generator and control the pulse transmit

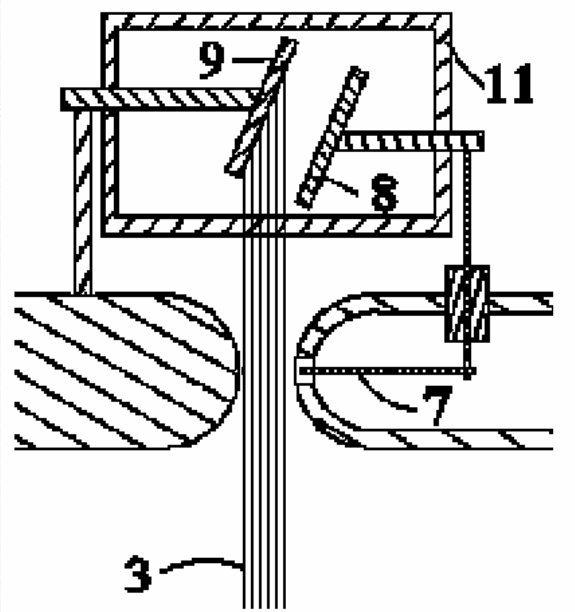


Trigation
Type switch

- Trigger: Laser-Photocathode sub-system
- Connection: main electrode 2 at low potential
  main electrode 6 at high potential
- Properties: A. Make use of the leftover laser optical energy; B. Input more activation energy to spark gap

3. Main Switch

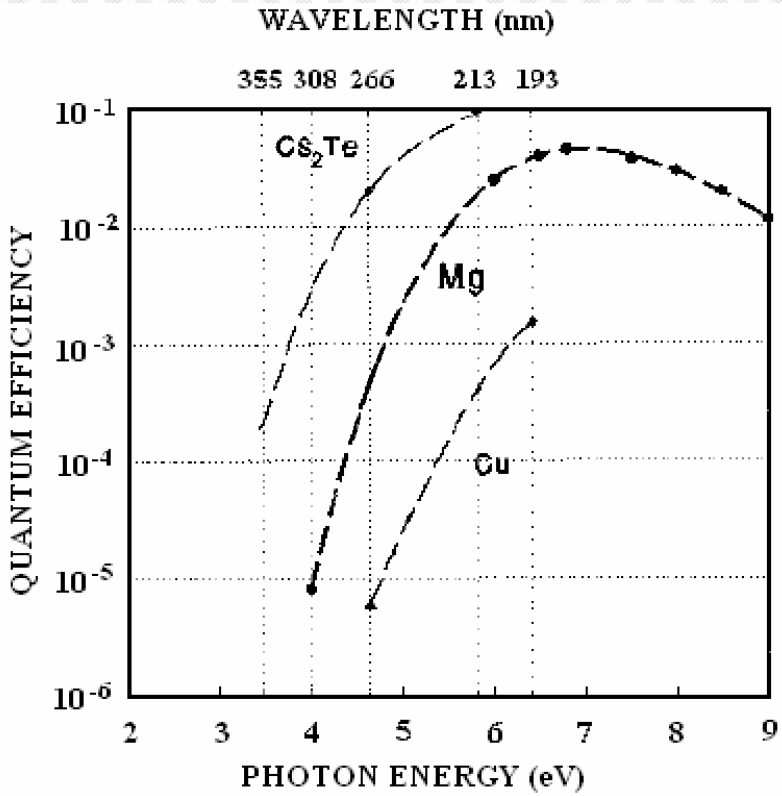
High vacuum cell with a transparent wall



- Purposes: (1) high quantum efficiency (2) long lifetime of the photocathode
- Triggering mode: double triggering
- Properties: delay acceptable and very low jitter

3. Main Switch

Photocathode quantum efficiency data (F. Zhou et al., Phys. Rev. Special Topics-Accelerators and Beams, Vol.5, 2002)



- Photocathode: Magnesium
- Quantum efficiency: 5×10^{-4} (Moderate)

3. Main Switch

Switch calculations

- Assumptions:
  - UV Laser: pulse length=100ps, pulse jitter~sub-ps, pulse energy=4 mJ
  - Model: radius of anode~1.5 cm, gap between photocathode and anode~1.5 cm, separation between anode and main electron adjacent > 1 cm, length of trigger electrode ~4 cm
- Photoelectron charge: -3.43×10^{-7} Coulomb
- Capacitance between trigger circuit and adjacent main electrode: 2.07×10^{-12} F
- Voltage across the gap between trigger and adjacent main electrode: 165.7 kV (very high)
- Electrical energy stored: 28.4 mJ>> 4 mJ (laser energy)

3. Main Switch

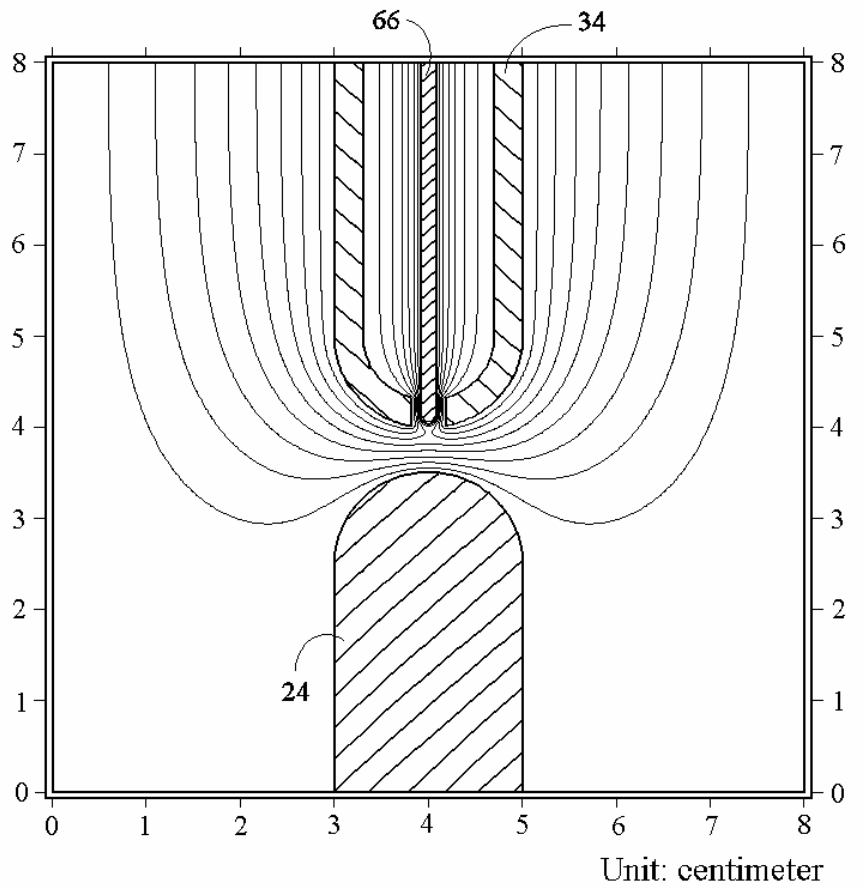
Switch calculations (Cont'n)

- Transit time for photoelectron across the gap between photocathode and anode:

$$t = \frac{m_0 c}{eE} \arccos\left(1 - \frac{eEl}{c^2 m_0}\right)$$

  - t is the transit time; m_0: rest mass of electron; e: electron's charge; c: the light speed in vacuum; E: the electric field; and l: distance between photocathode and anode
- Transit time: 276 ps
- Delay: Laser pulse length+transit time+ photocurrent conduction time in metal wire<609 ps (Wire length < 10 cm)

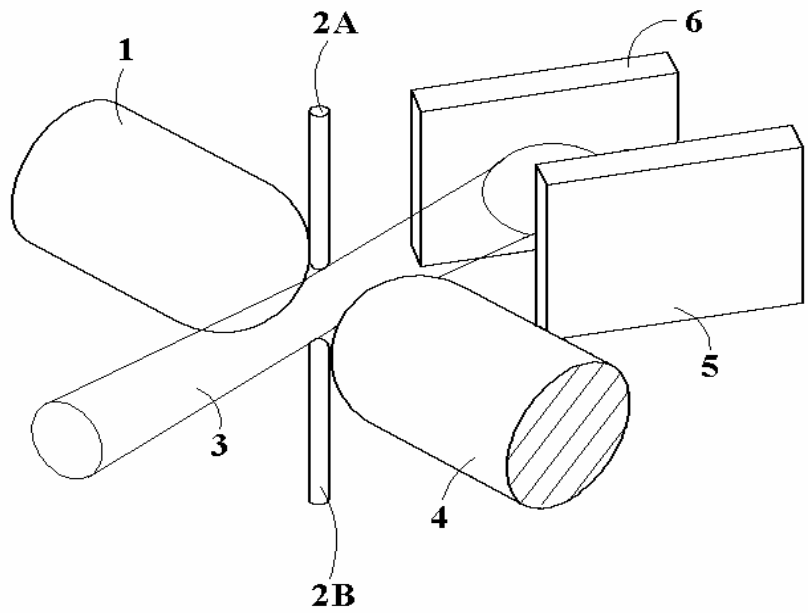
3. Main Switch



- Equal potential lines calculated by SUPERFISH /POISSON code around the electrodes

3. Main Switch

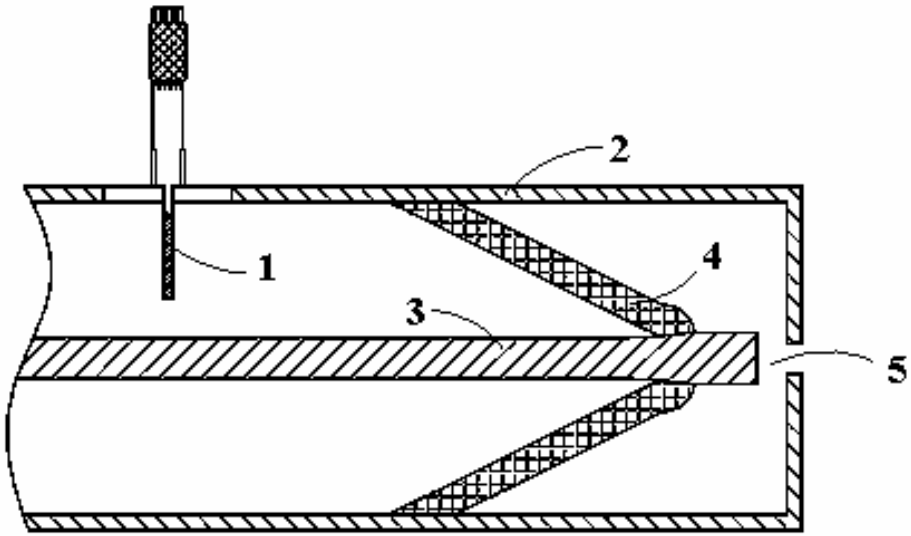
Field distortion type switch



- Advantage: multi-point ignition,
  easy adjustment of trigger gap distance
- Drawback: one more trigger circuit connection

4. Transmission Line and Discharger

Discharger on the transmission line:



Impedance of the coaxial transmission line 75 ohm

Discharger breakdown caused by: incident wave+reflection wave

Pulse length: adjustable

5. Summary

- Propose a new trigger mechanism
- Double triggering mode
- Switch having very low jitter

6. Last Page

Thank you!

Questions?