# Investigations of the long-term stability of a GEM-TPC

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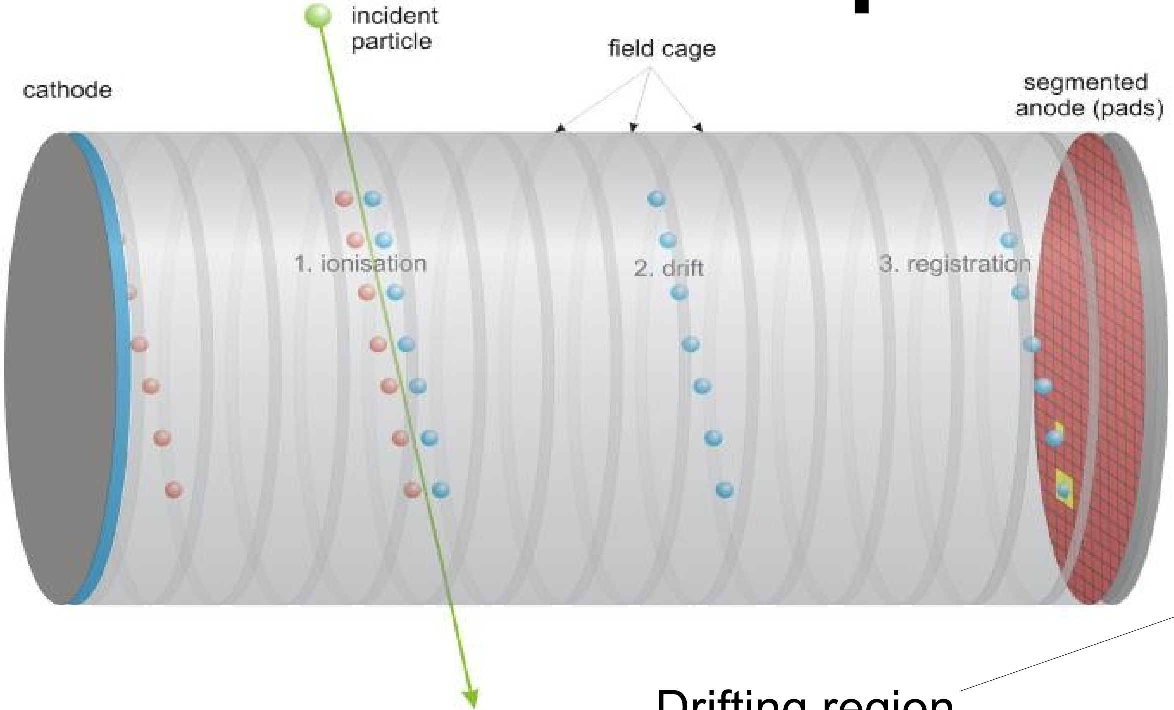
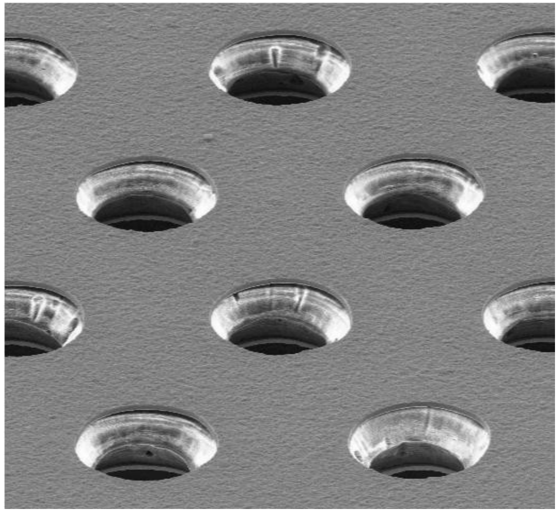
DESY

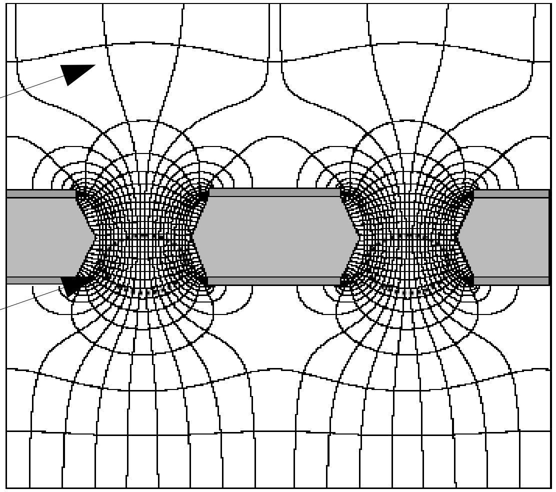
# Time Projection Chamber and GEMs

## TPC concept




## GEM holes

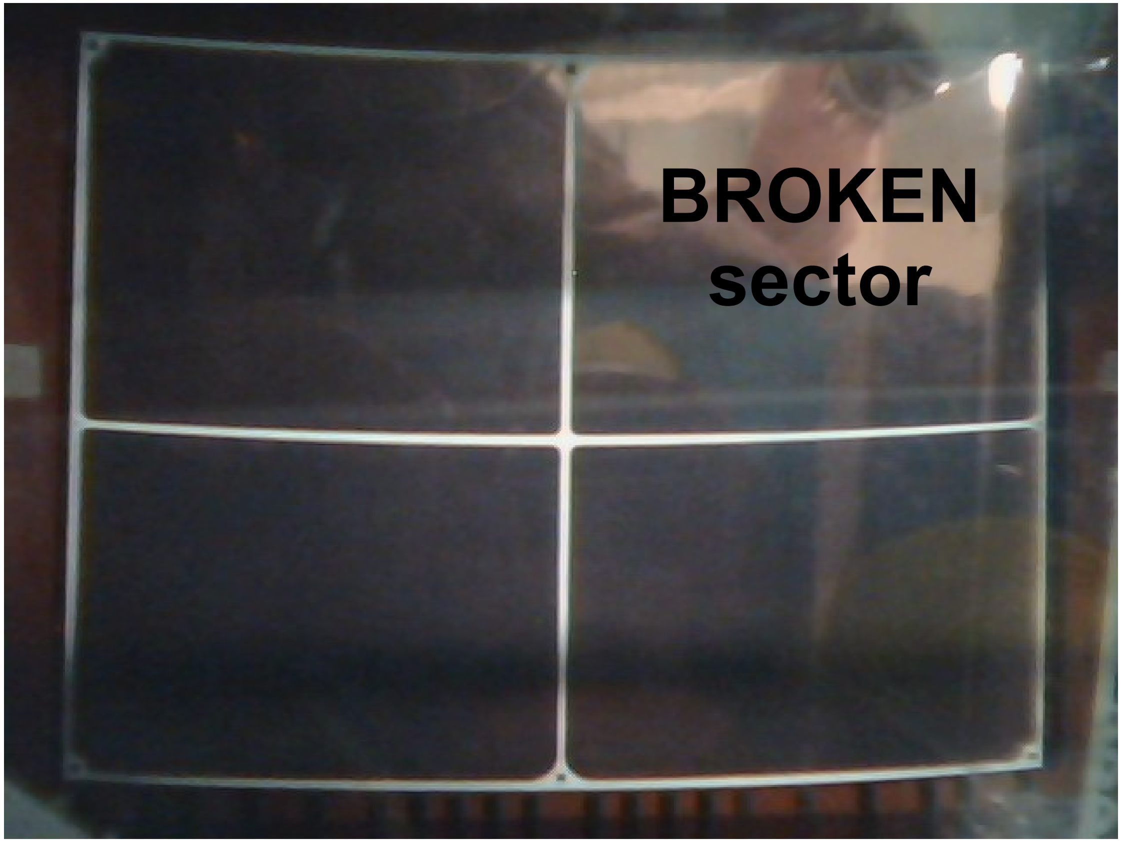




Drifting region

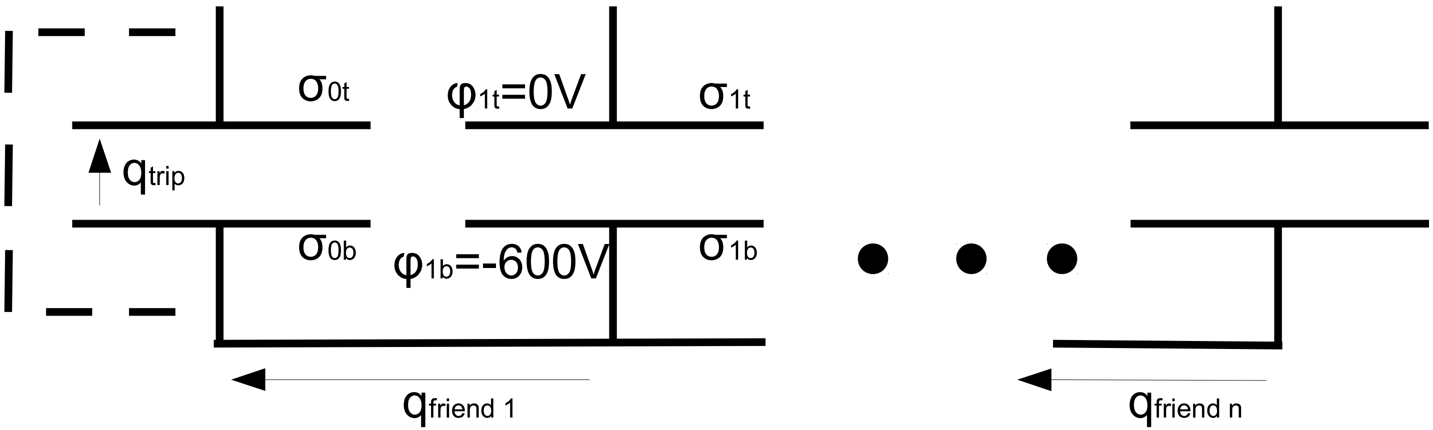
Gas amplification region

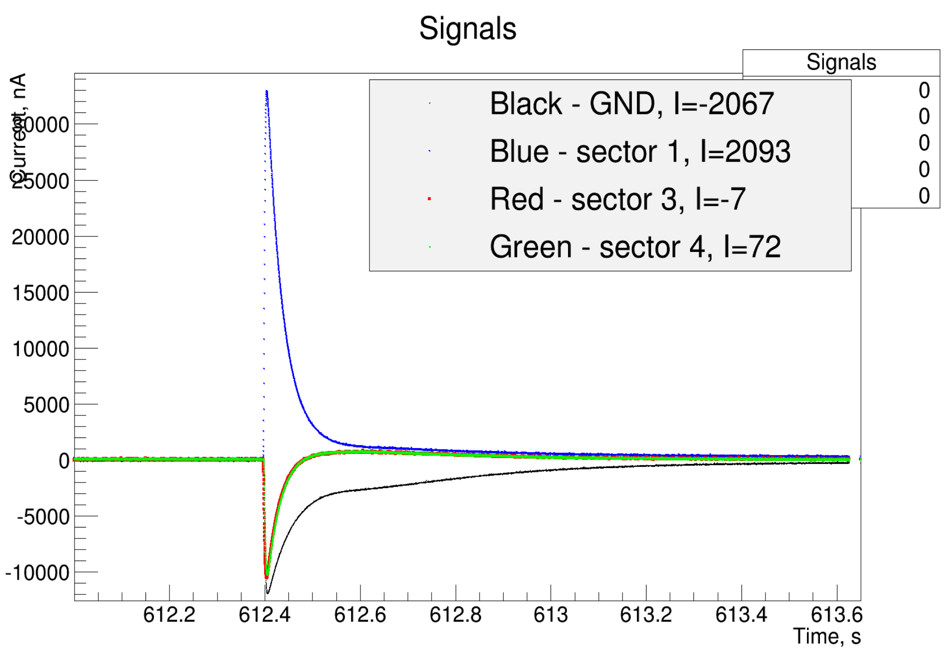
# Problem definition




- GEM is a main signal amplification part that is kept under HV.
- Due to HV environment from time to time we observe discharges between two plates.
- Some of them break our GEMs
- WHY?
- HOW TO AVOID THIS?

# Usual trips

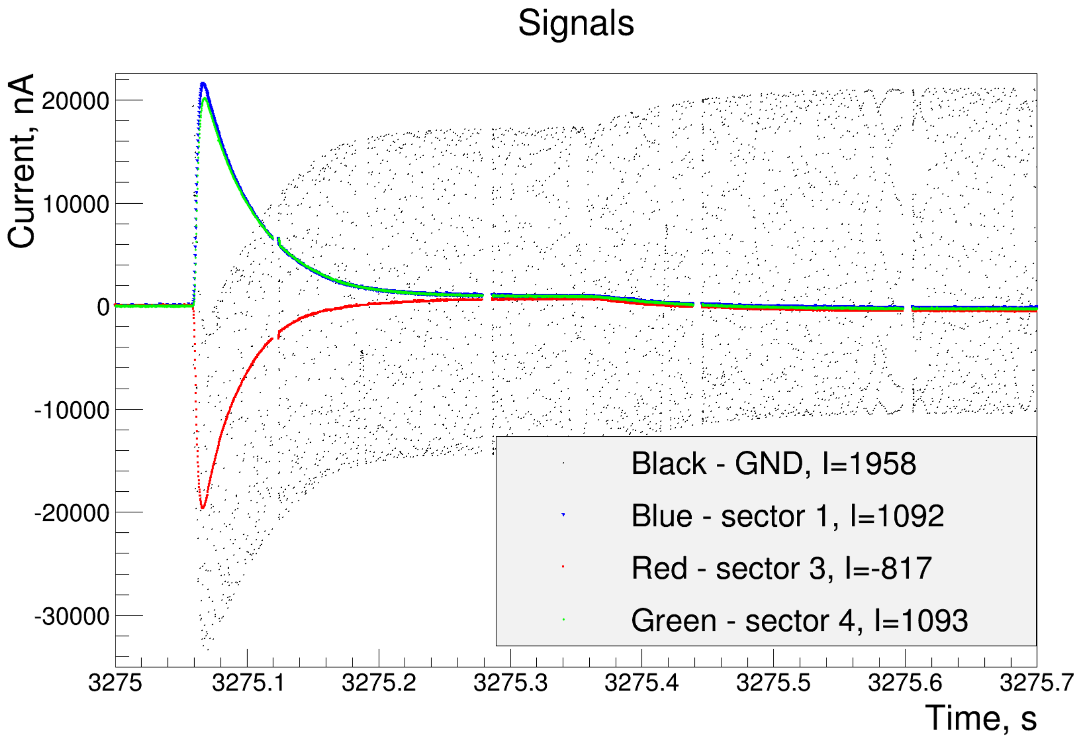


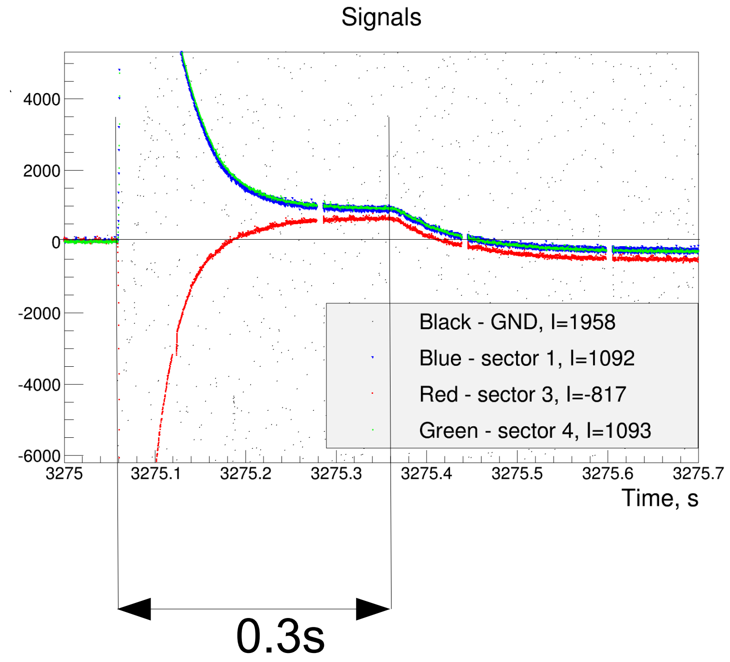




- Electrode spectators shows total zero current
- Splash and tripped electrode has opposite sign and equal value of charge exchanging

# Double trip

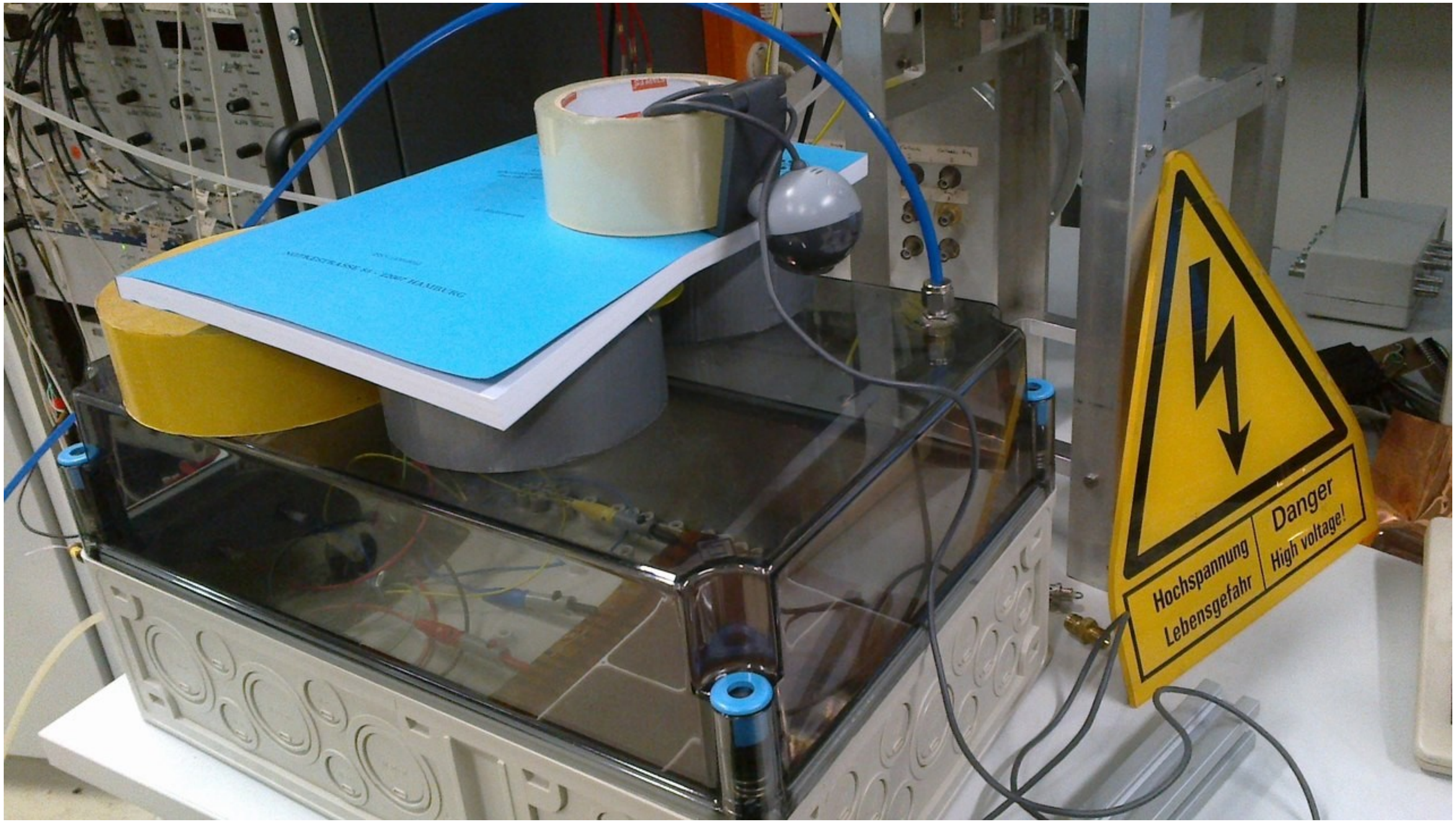
- Here we can well observe the two trip at the same time
- The common electrode has some problems with readout
- We also can see the trip killing time = 0.3s. That is equal to HV supply settings.



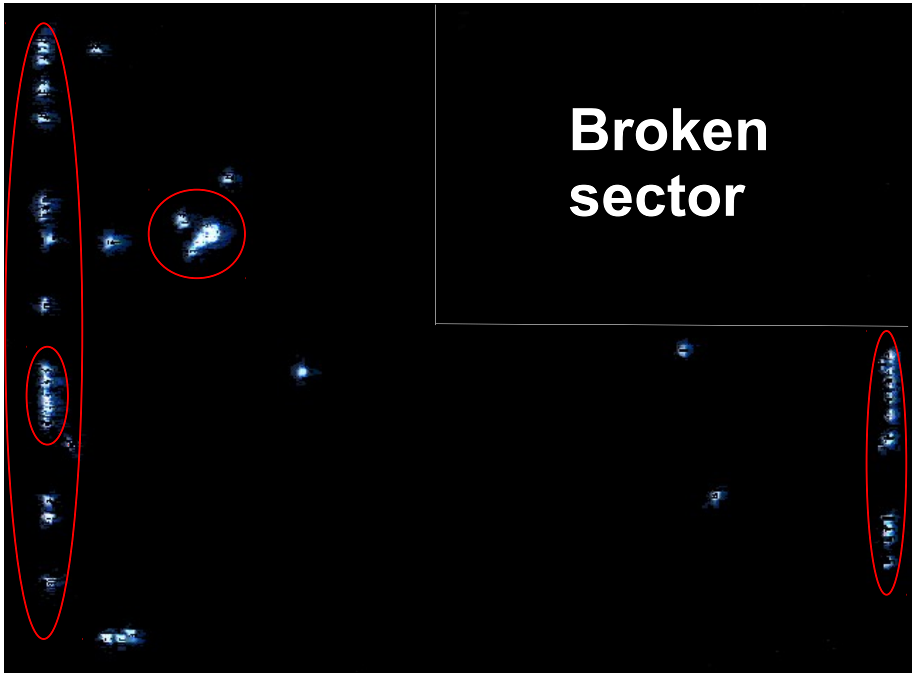

- Integration time = 1s

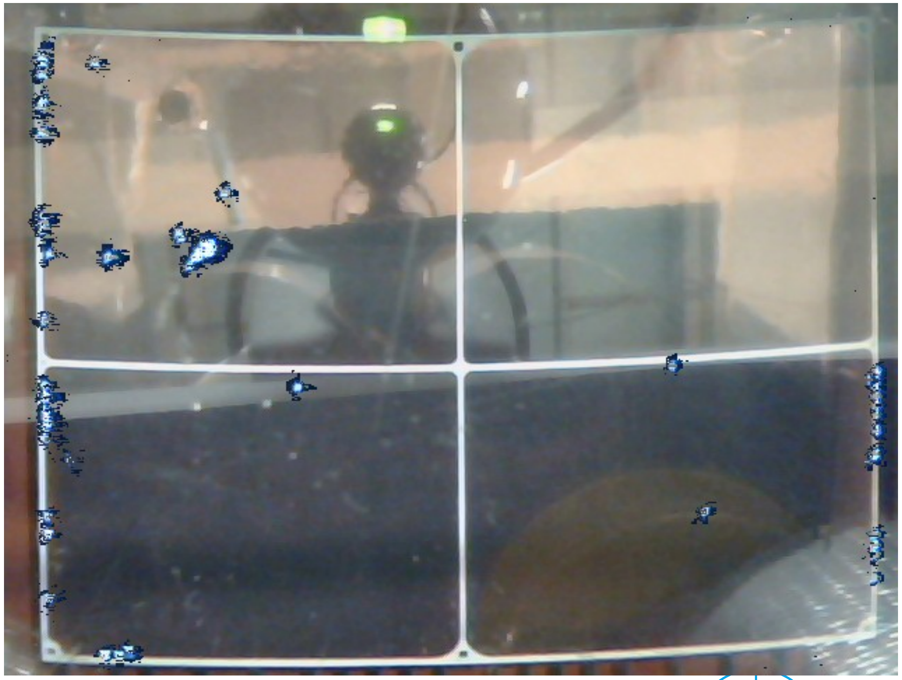
# Experimental setup: Support structure



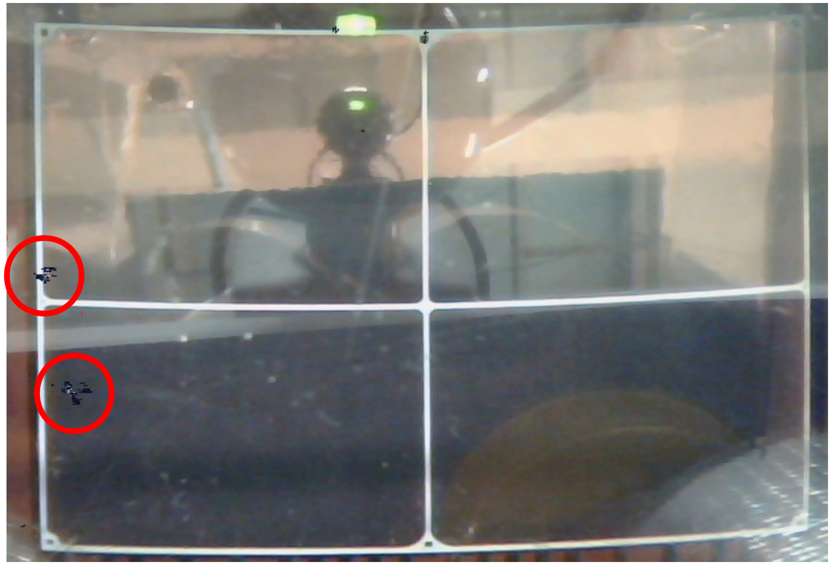
# Overlay of about 100 trips

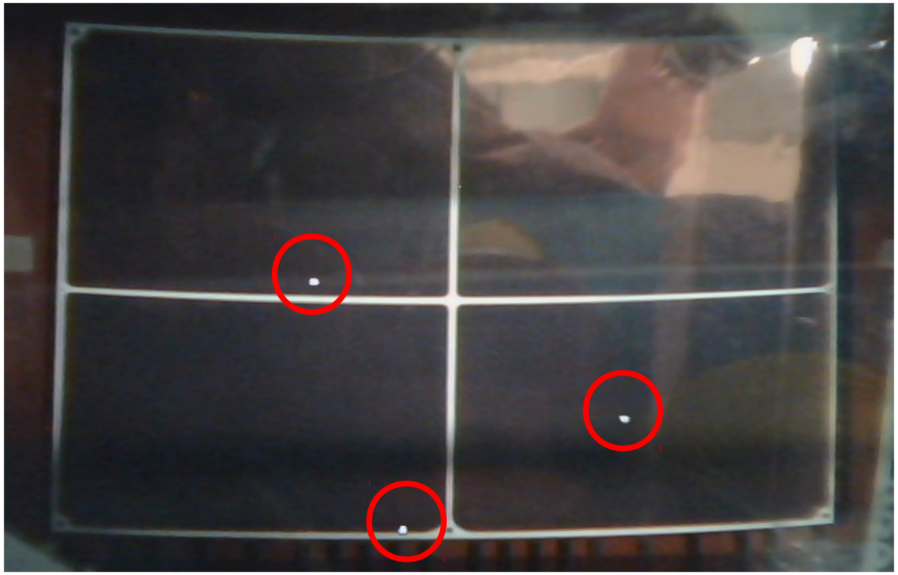
- We can see the groups of trips at the "weak" places
- Some trips occurs in the same very place

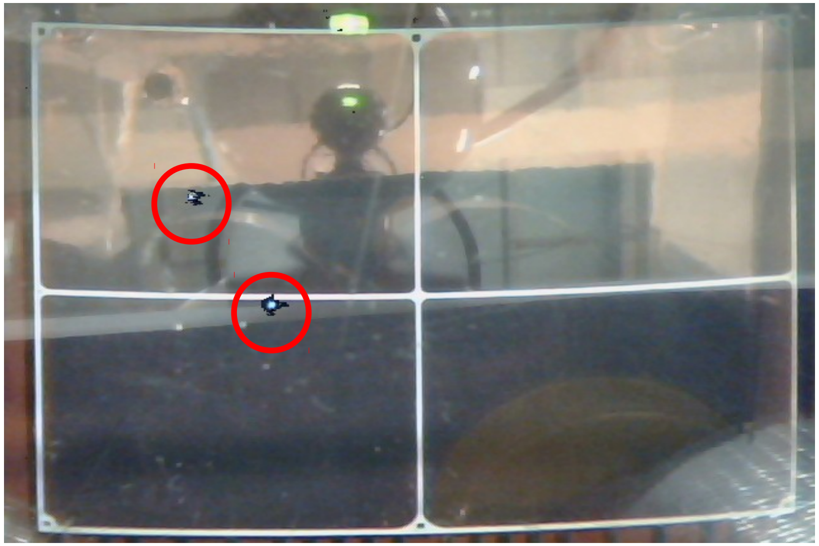


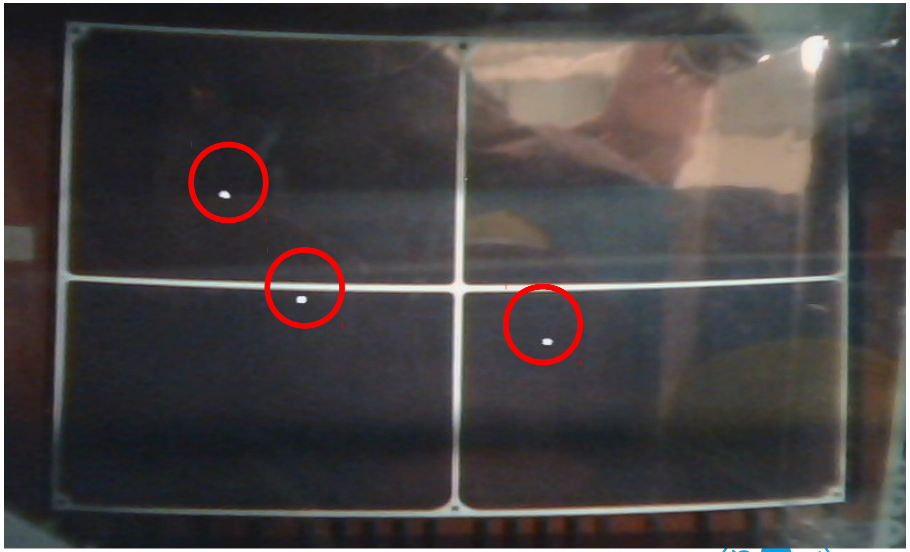



# Double and triple trips have been observed

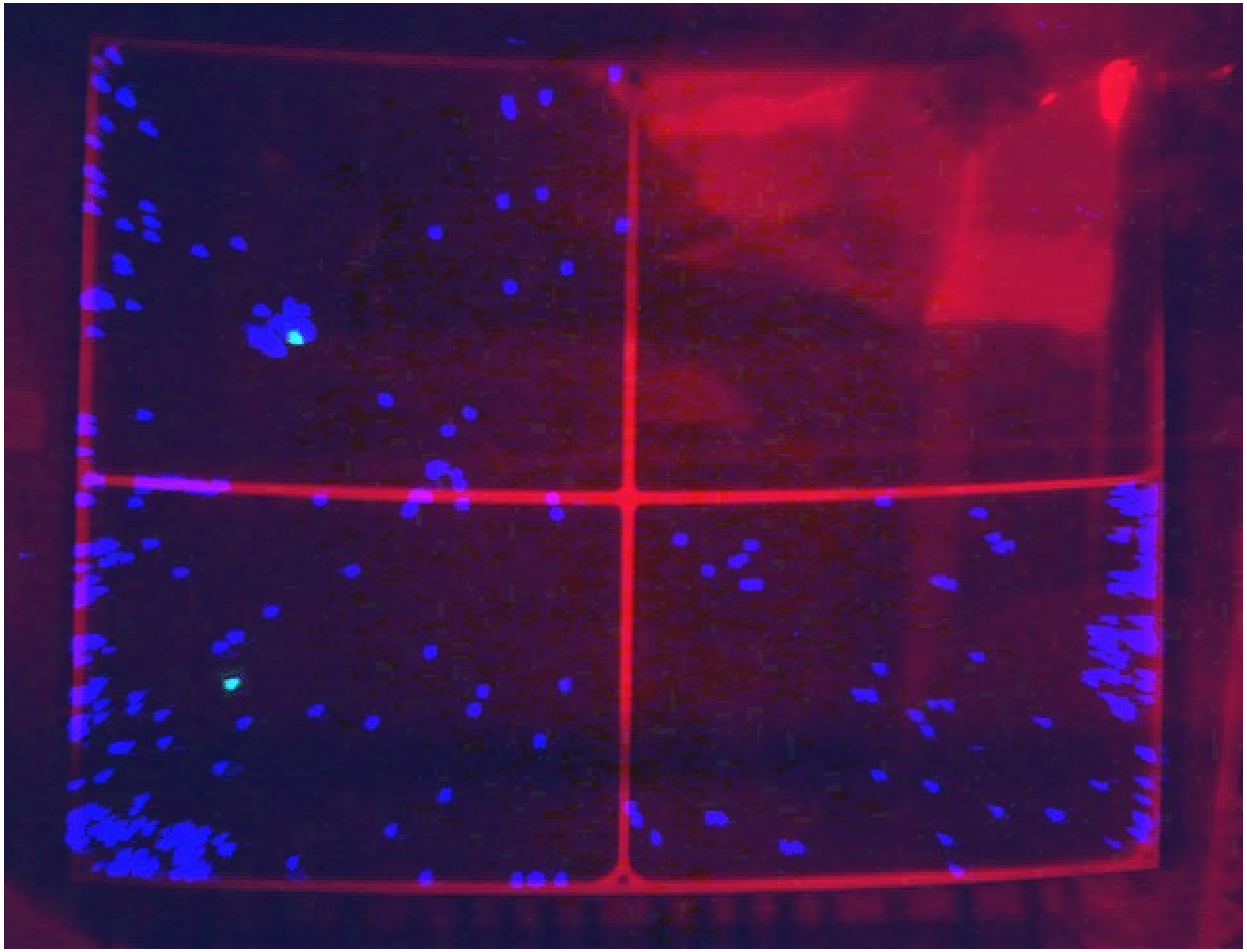








# Photo of the fatal trip

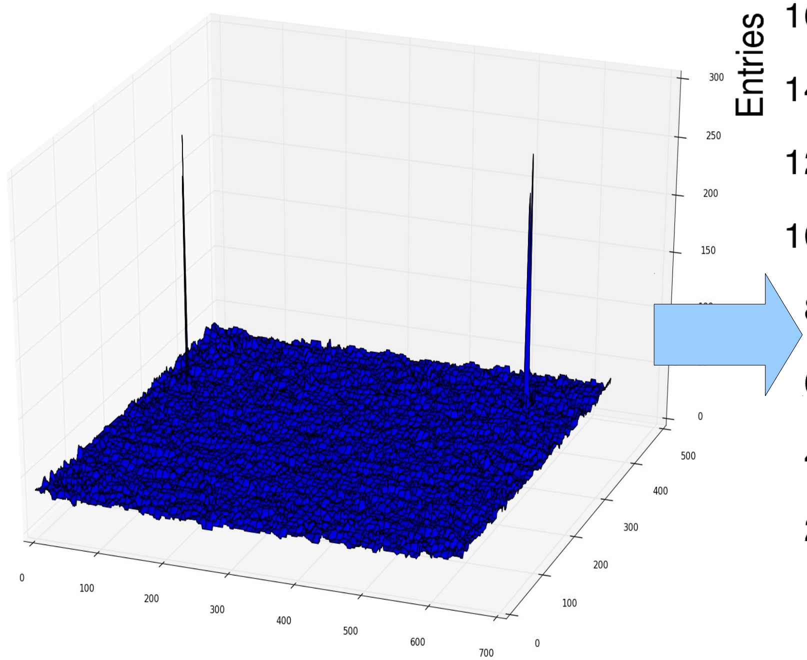


- Bottom left sector (3) has been broken

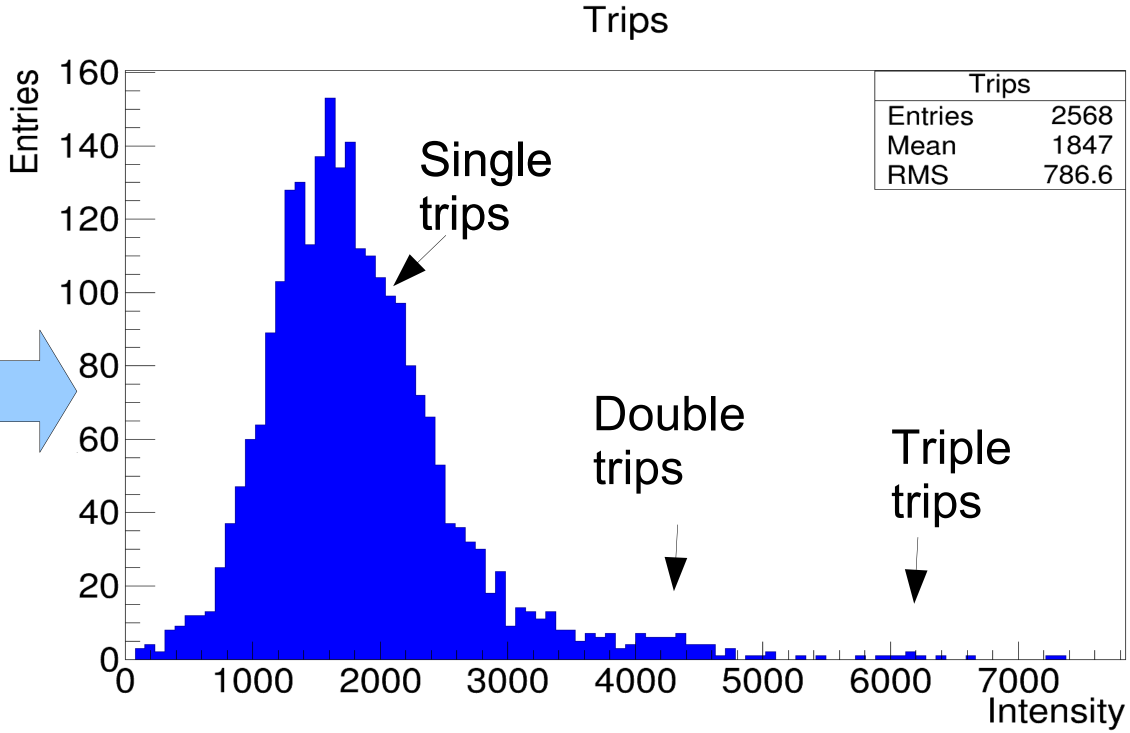
- The discharges appeared sequentially: in sector 4 (top), than sector 3 (bottom). This received from fact that discharges appears in the neighborhoods frames of camera (30 rps = 33 ms)

# Intensity distribution from WebCam

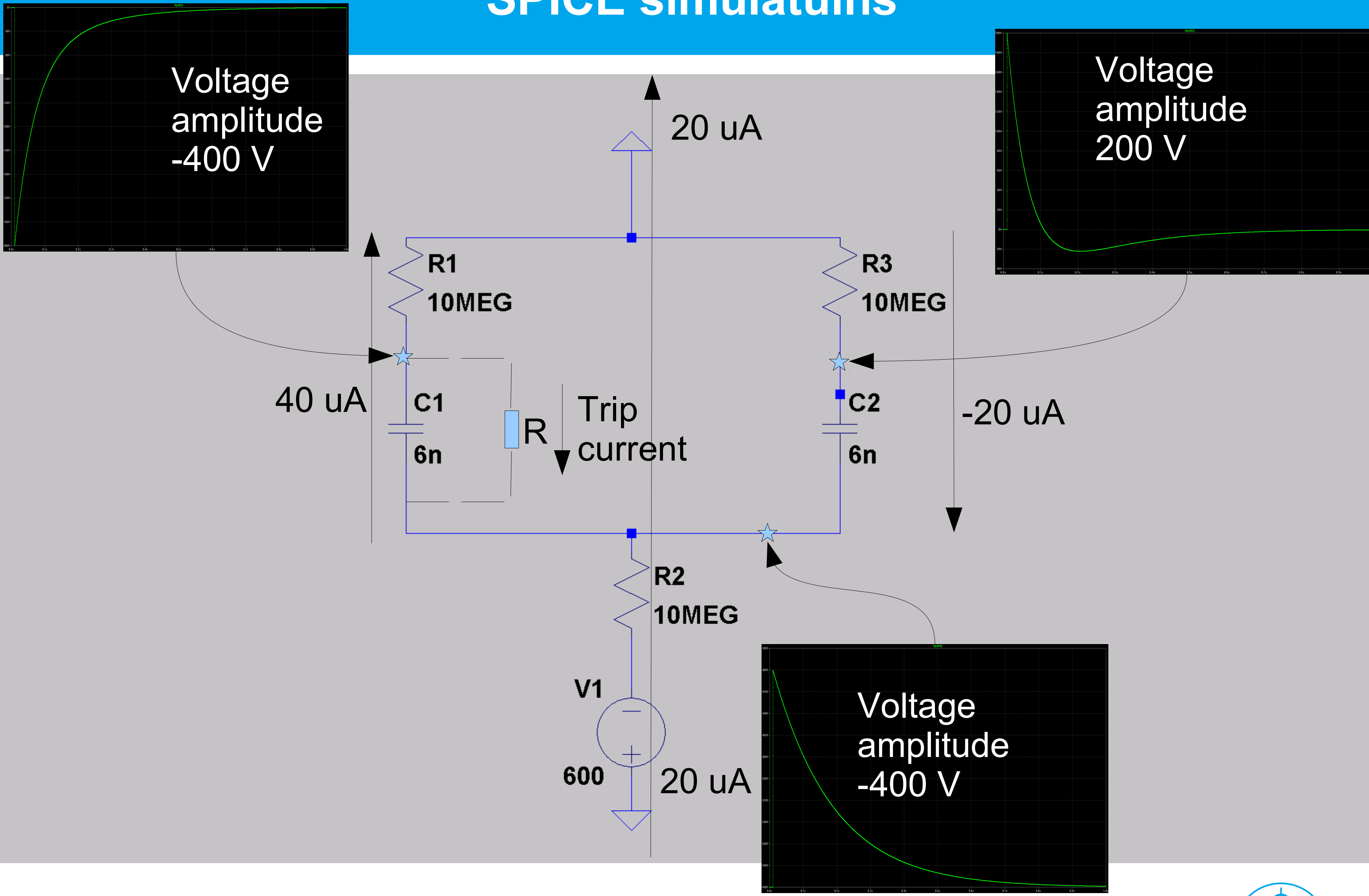
Blue color intensity



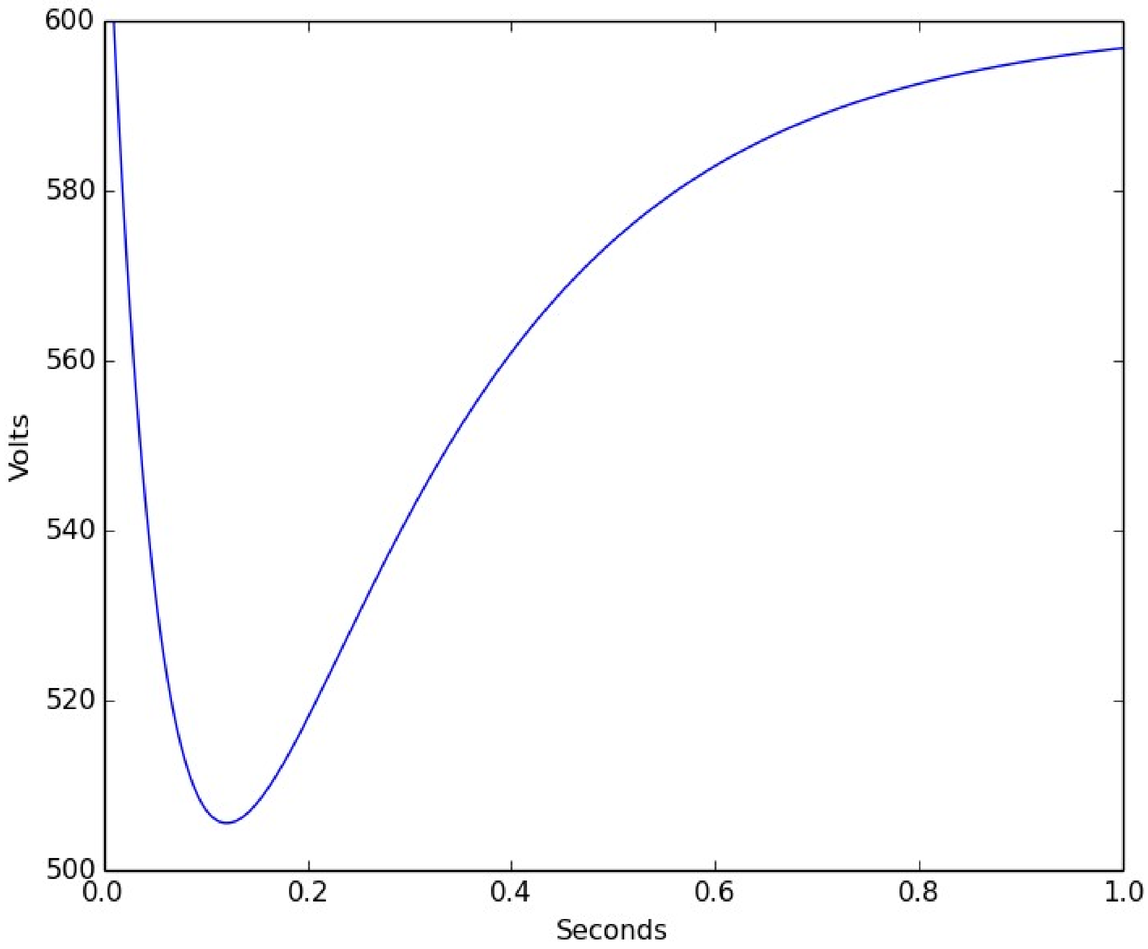
Blue color intensity
trip distribution



# SPICE simulatuins



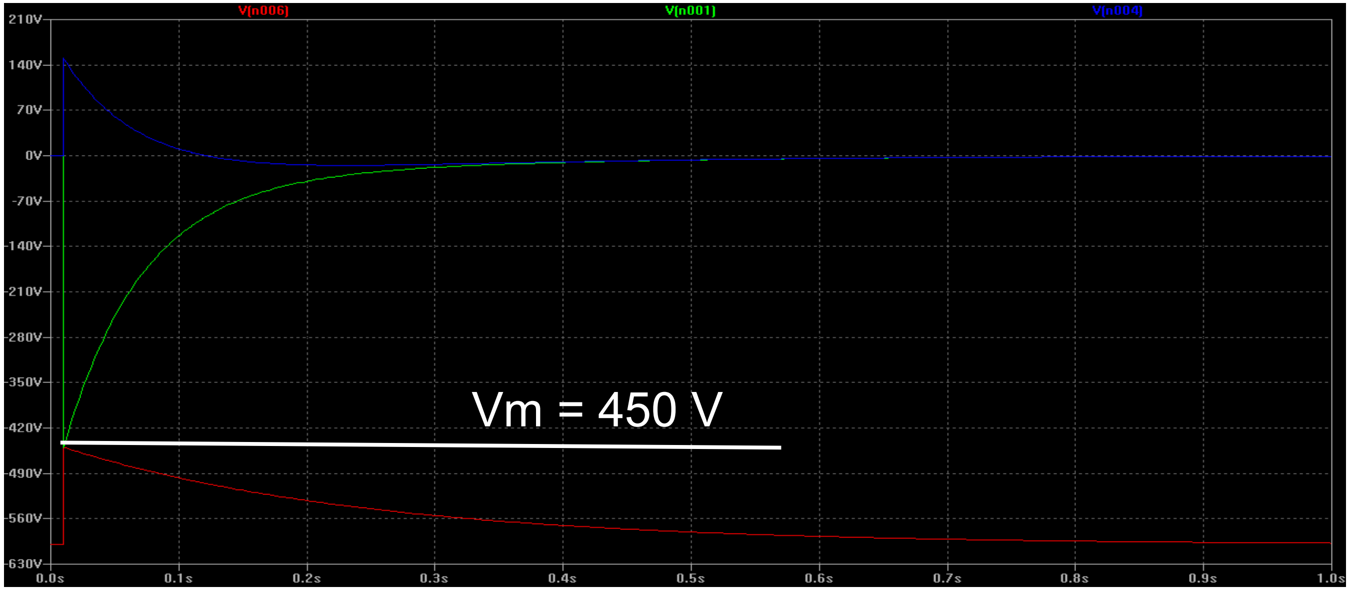
# Voltage on the spectator capacitor after the trip




The fast ramping up or down may cause trip.

May explain delayed and simultaneous double trips.

# Single trip




Green – tripped sector

Blue – sector spectator

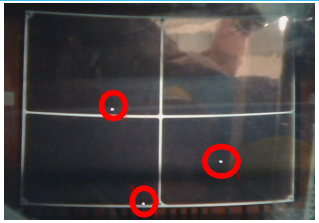
Red - GND

| N sectors | Vm, V | Q trip, Qsec*% | ΔQ trip, (Q trip-Q trip1)*% |
|---|---|---|---|
| 1 | -300 | 50% | 0 |
| 2 | -400 | 66% | 33% |
| 3 | -450 | 75% | 50% |
| 4 | -480 | 80% | 60% |

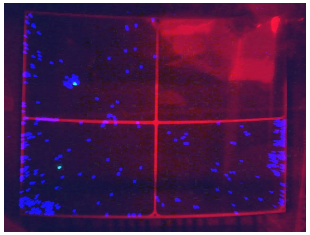
$$Q_{trip} = \frac{n}{(n+1)} Q_{sector}$$

# Summary

- Double and triple trips has been discovered.



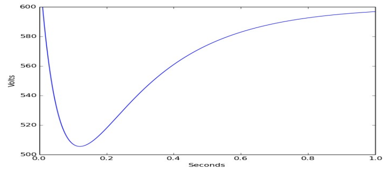
- One sector breaking has been observed. The “killer” is the sequential double trip.



- The trip charge is increasing with increasing sector number.

$$Q_{trip} = \frac{n}{(n+1)} Q_{sector}$$

- We can observe fast potential changing on spectator sectors.

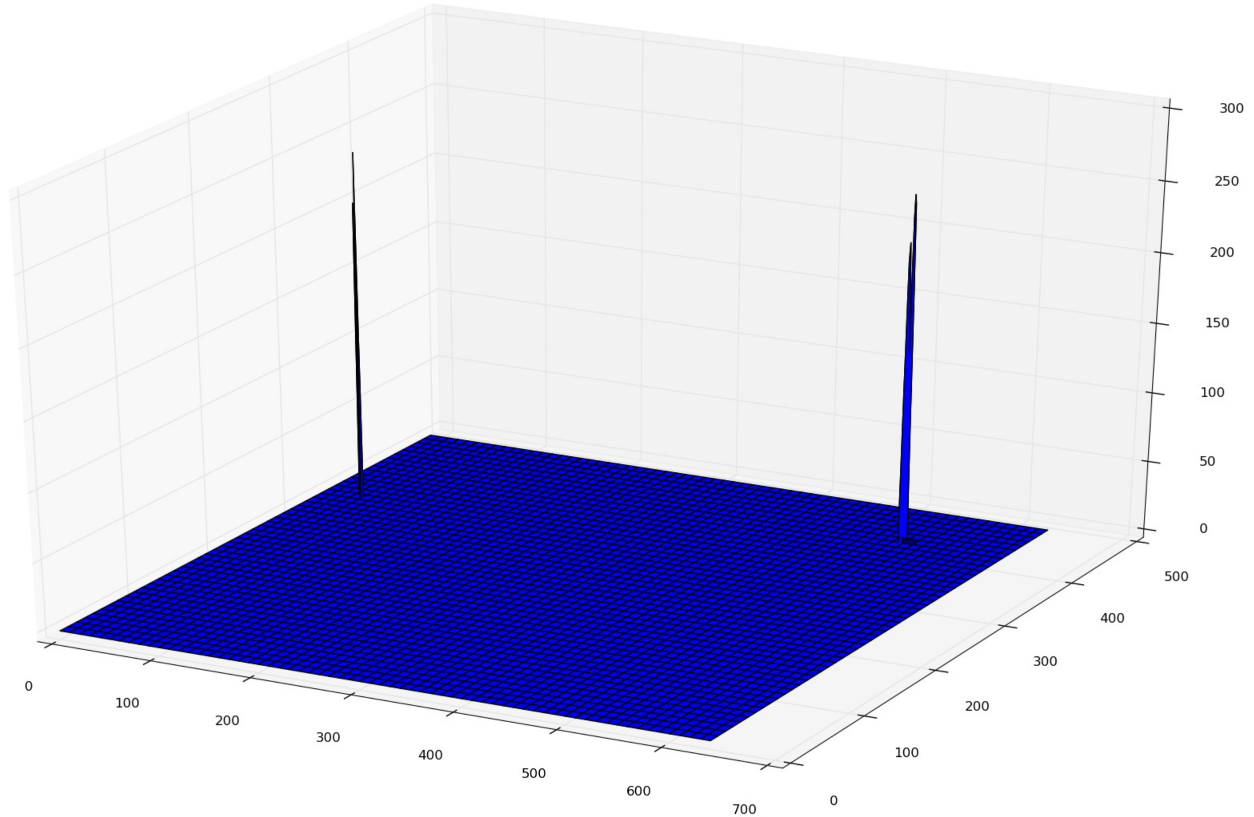



- We may consider the rescue system with additional power supply based on avalanche transistors.

# Back UP

# Using brightness distribution

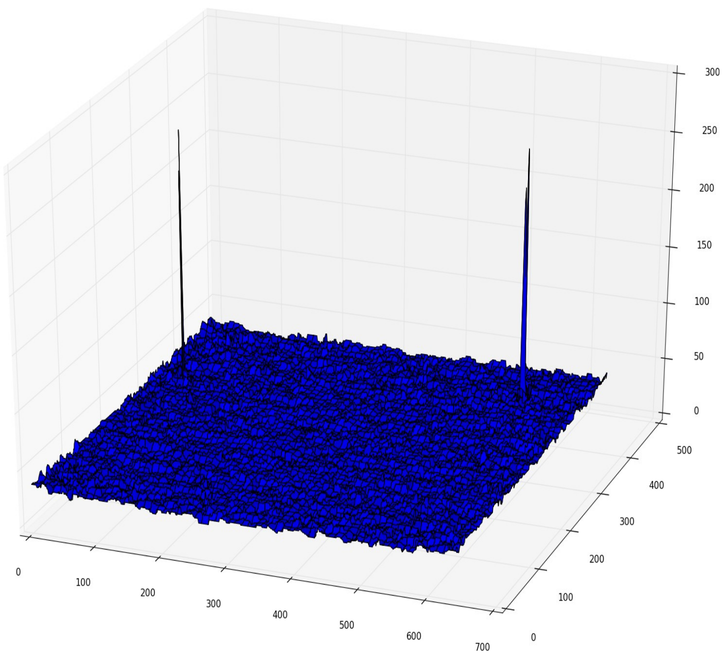
After applying a threshold



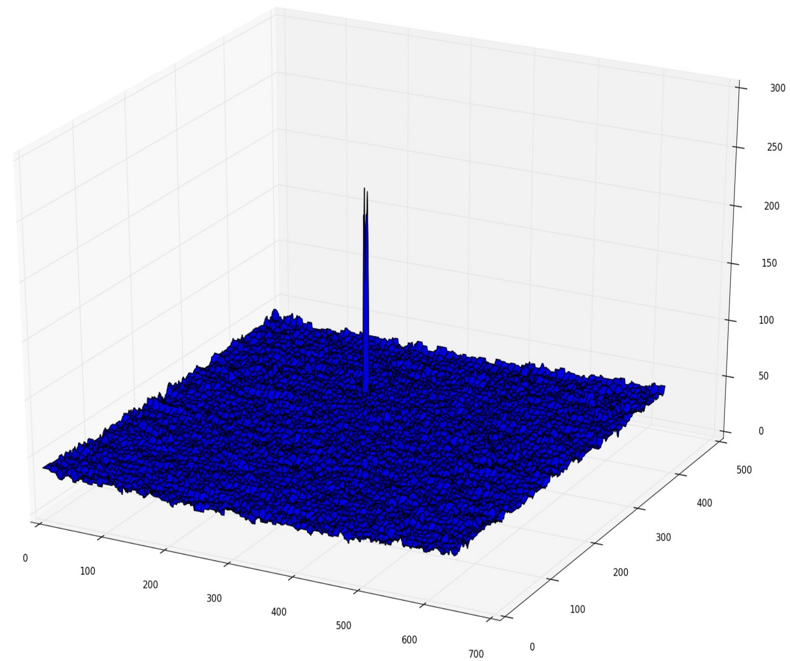
# Using brightness distribution

Trip brightness spikes response for trip light

Double trip

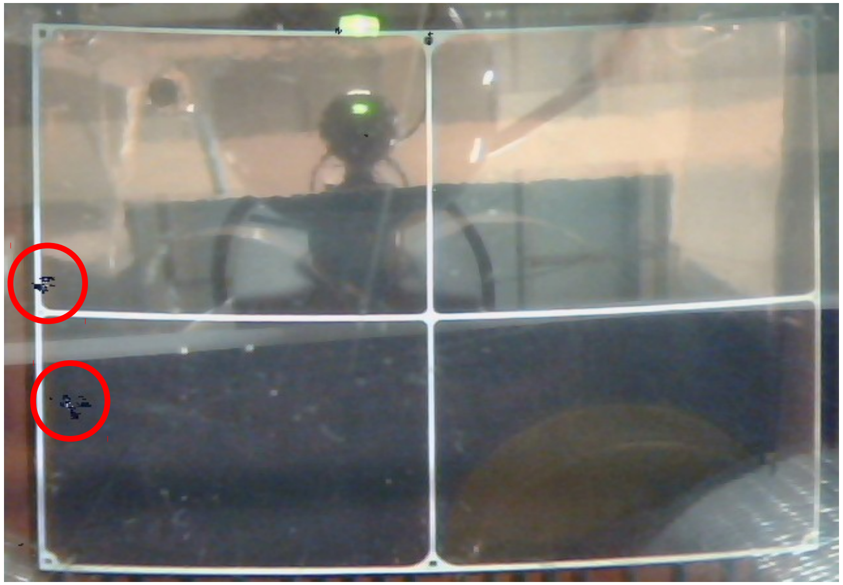


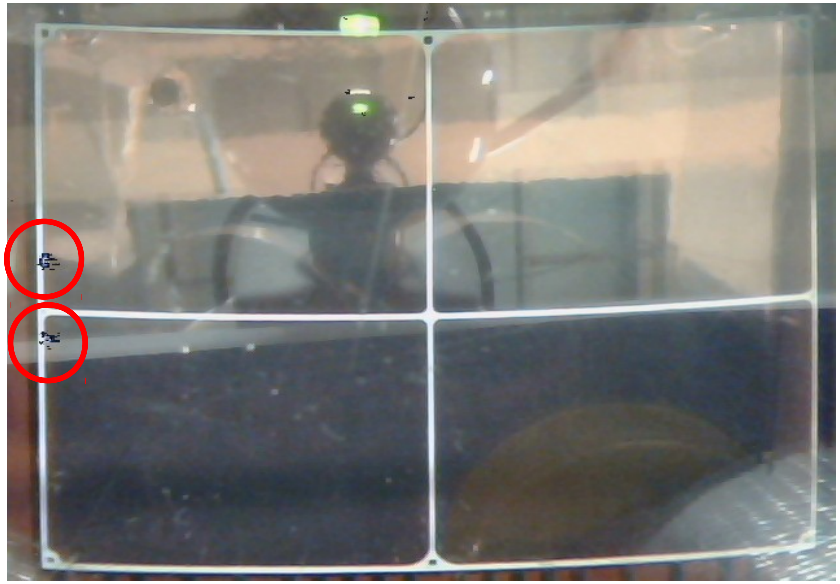

Single trip

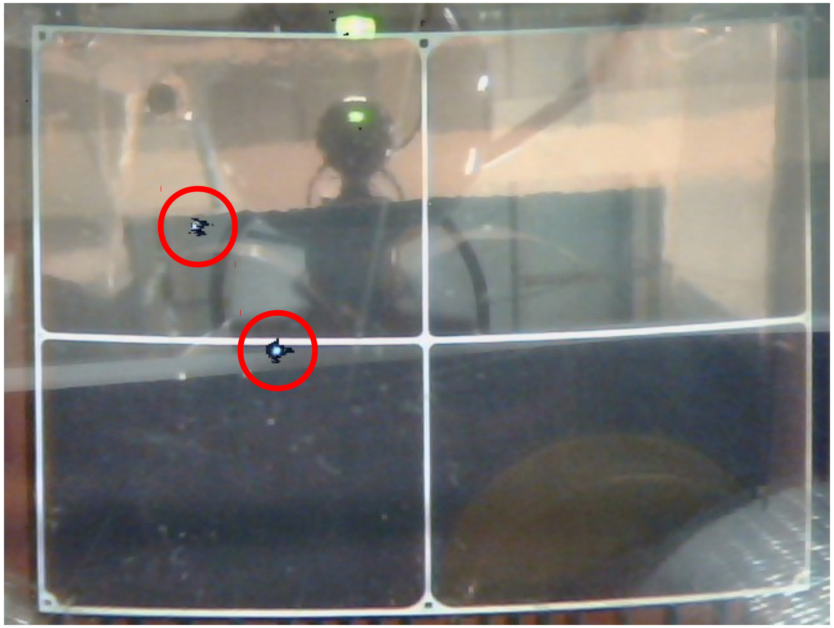


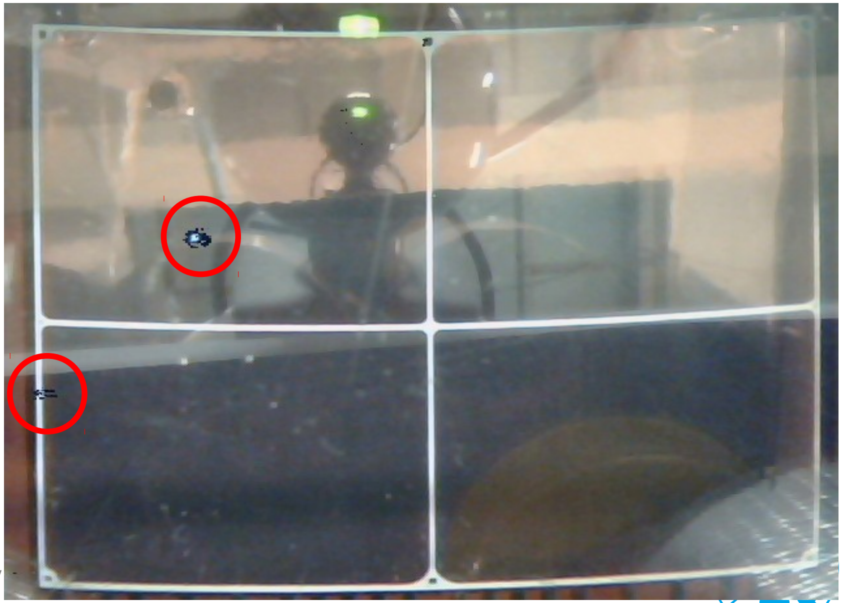
# No comments

# Double trips have been observed









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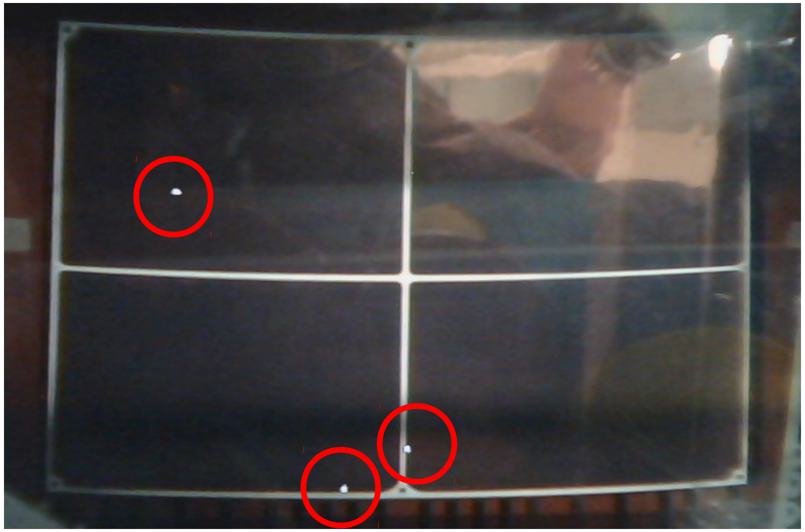
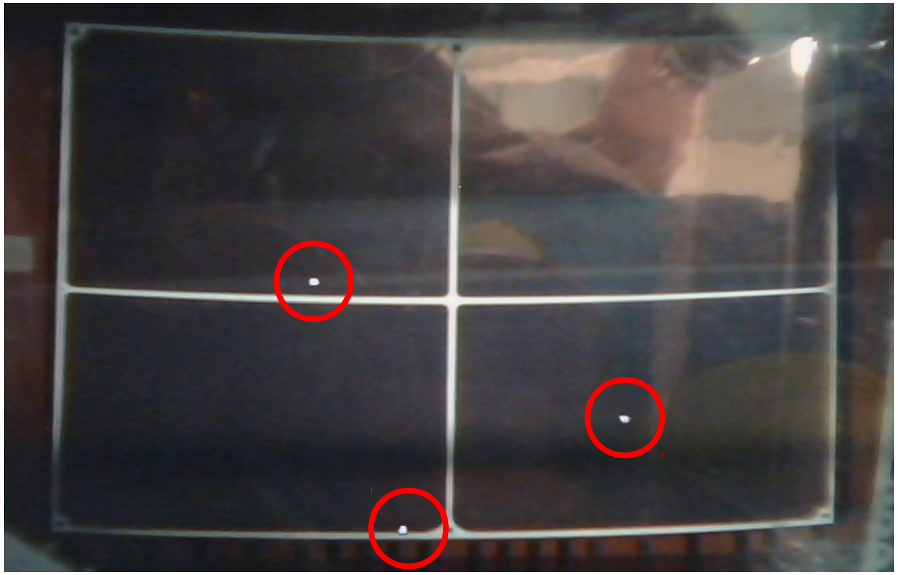
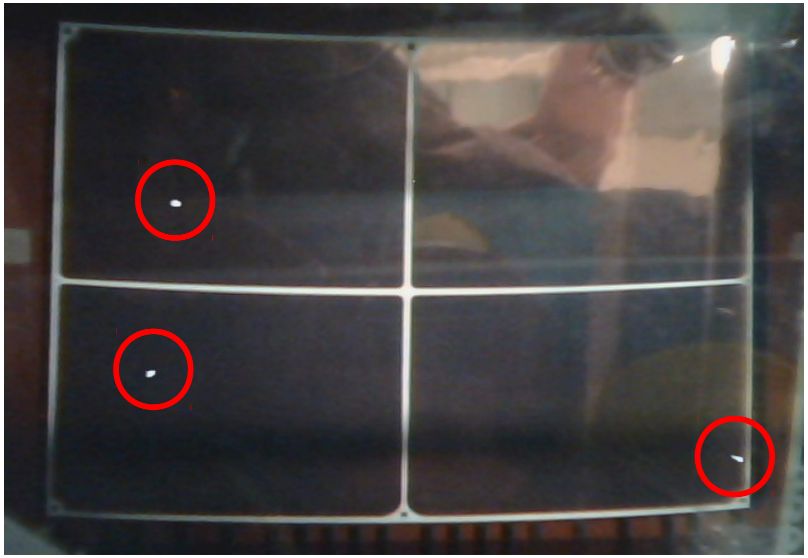
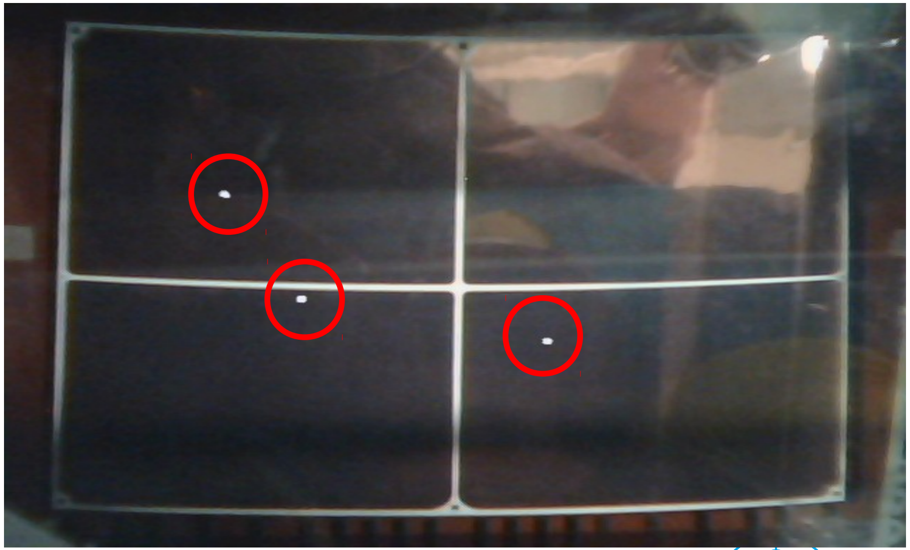
# Triple trips have been observed

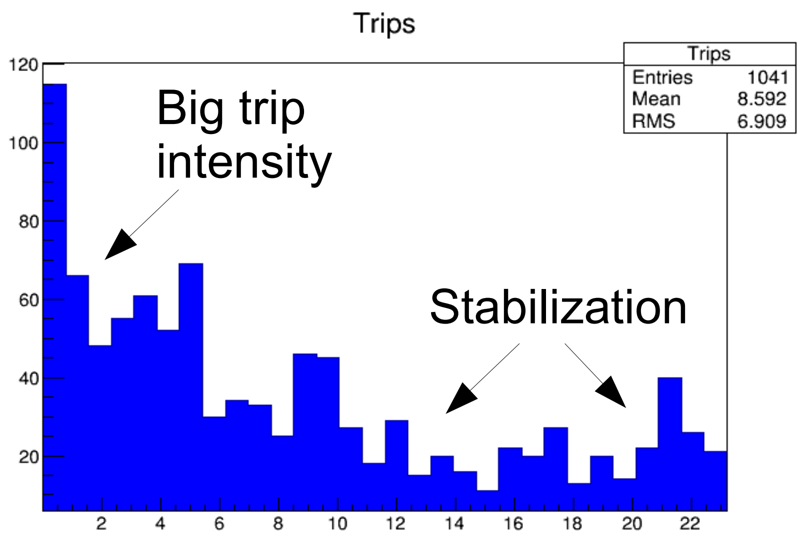


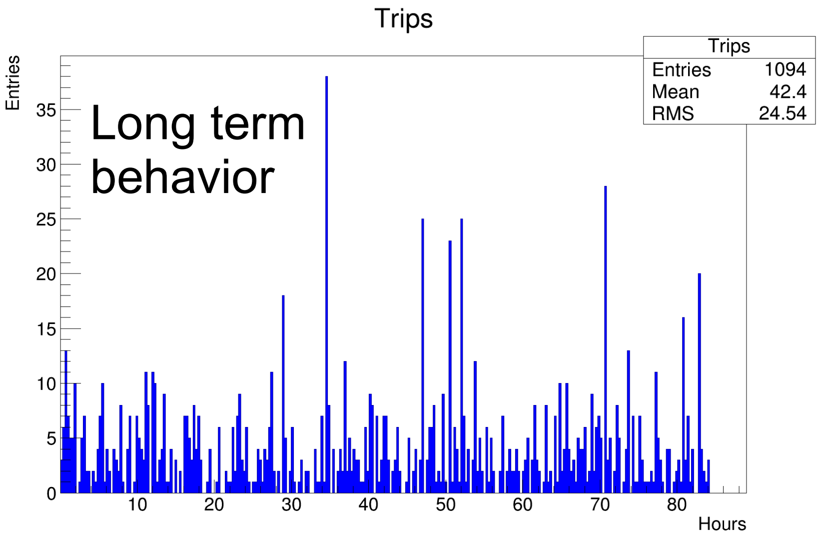






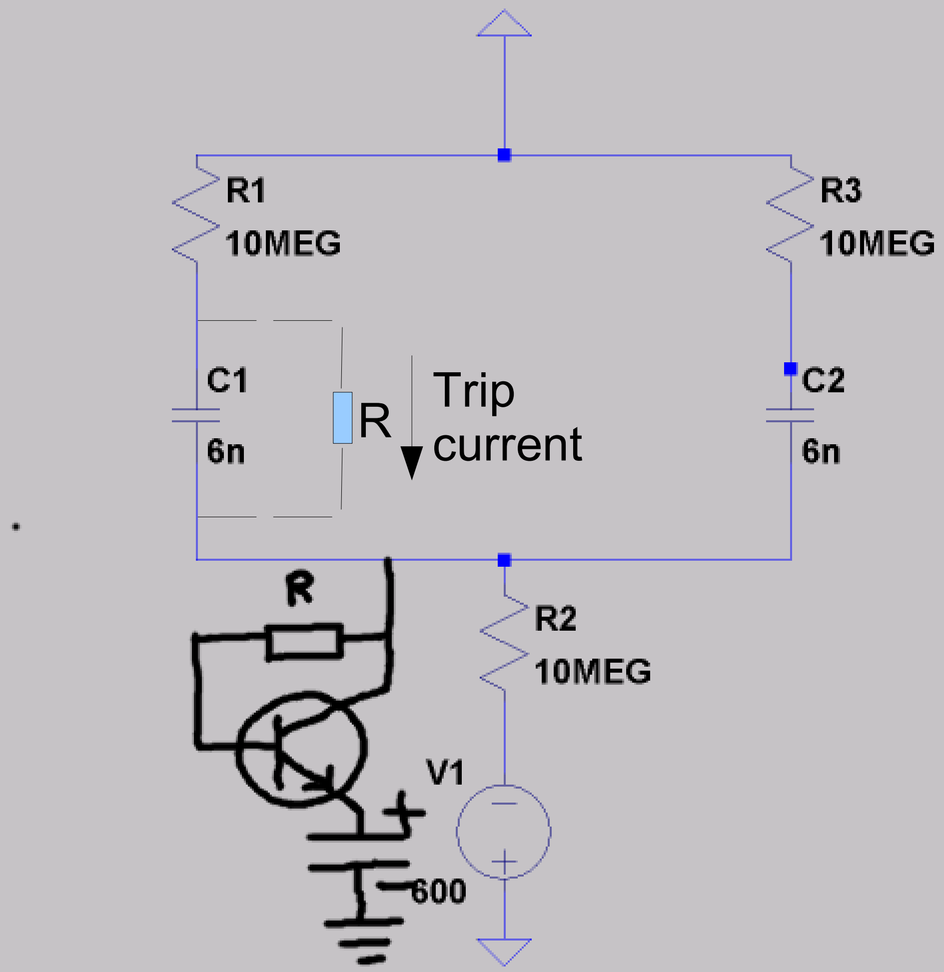
# Trip time occur dependence



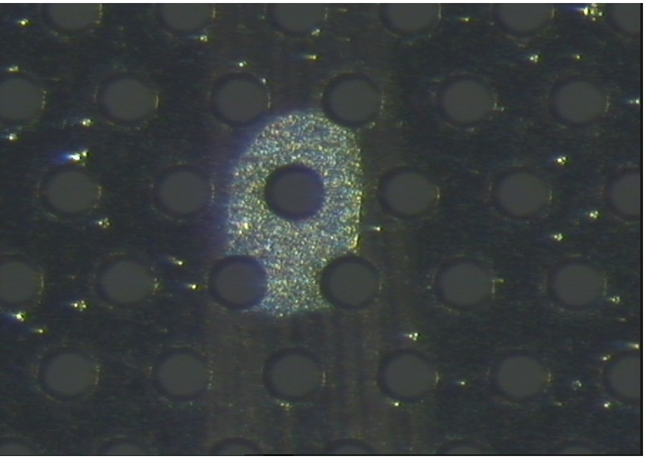



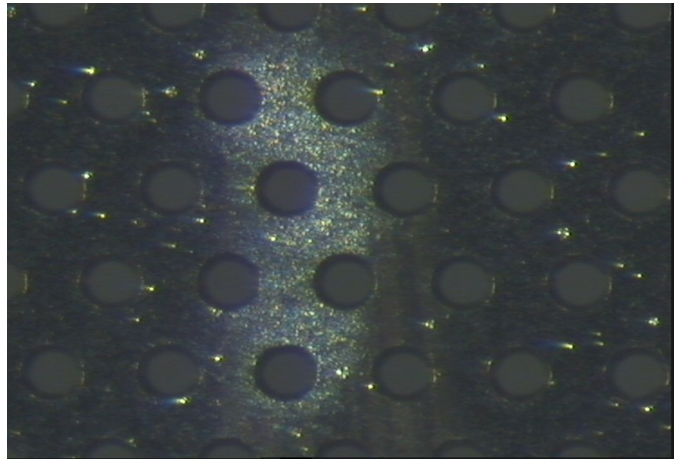

1 Bin = 20 minutes

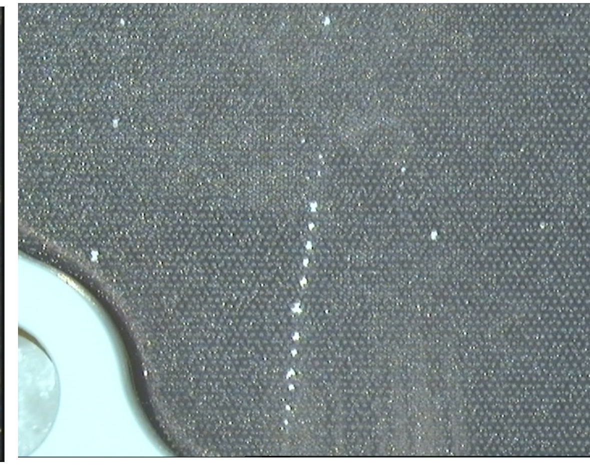
# Possible rescue system

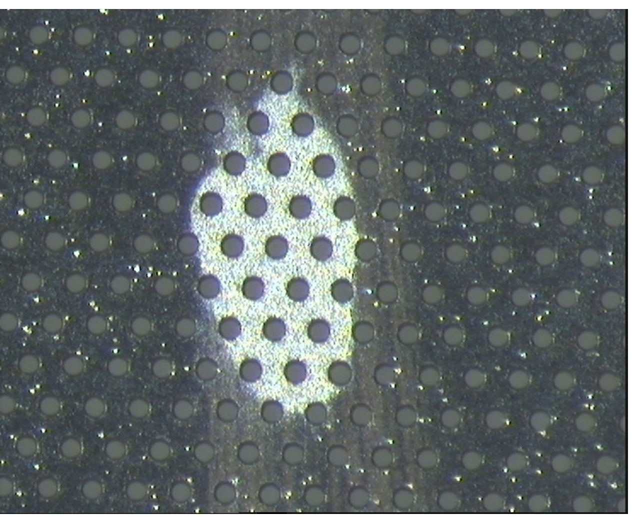


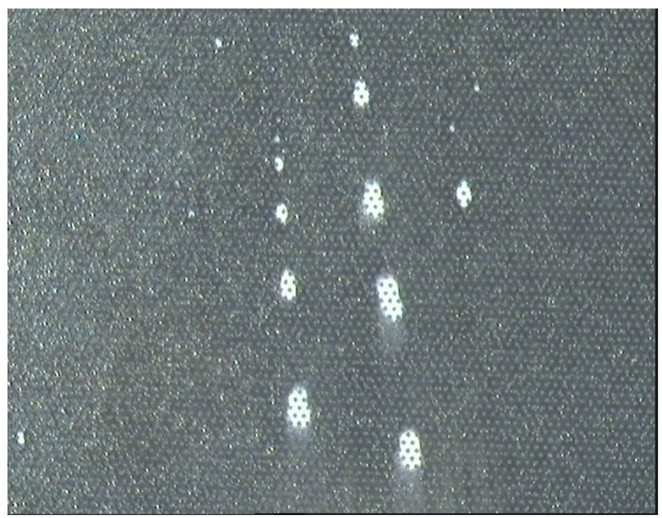
# Bright spots

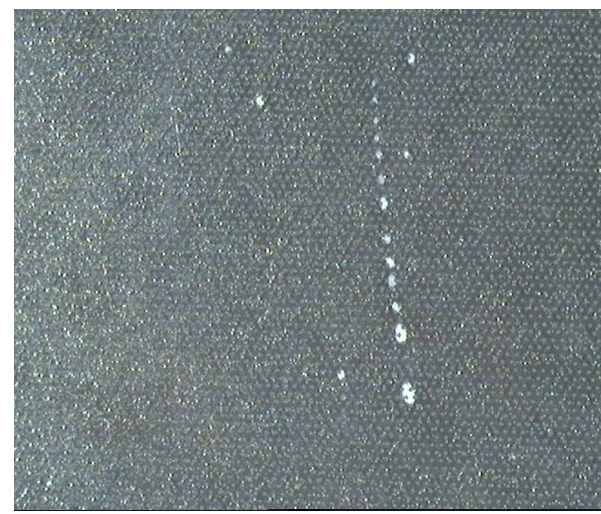




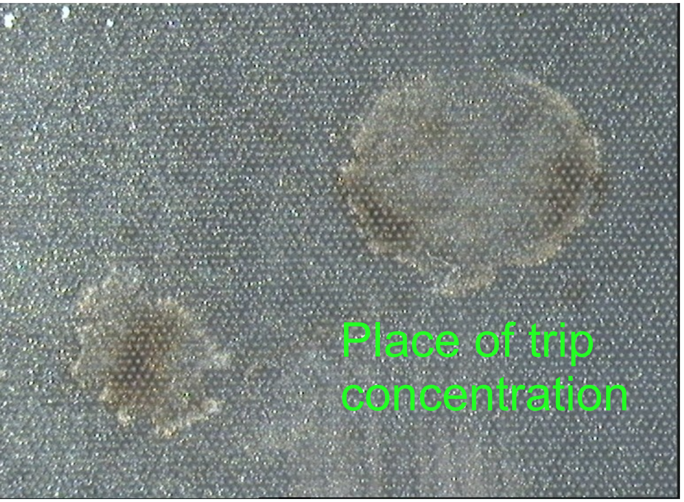


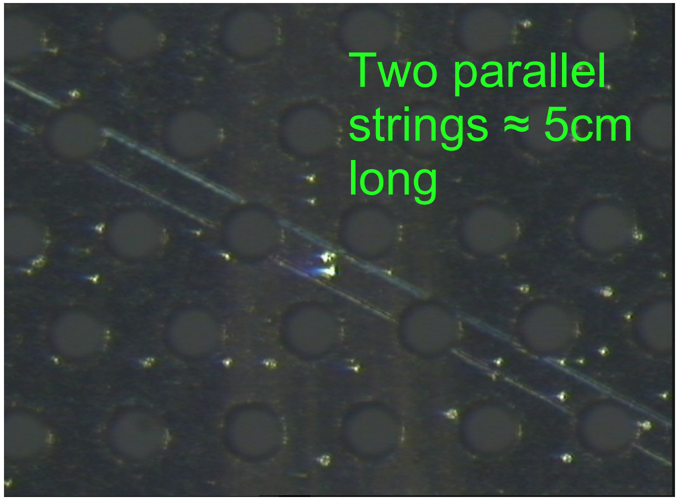


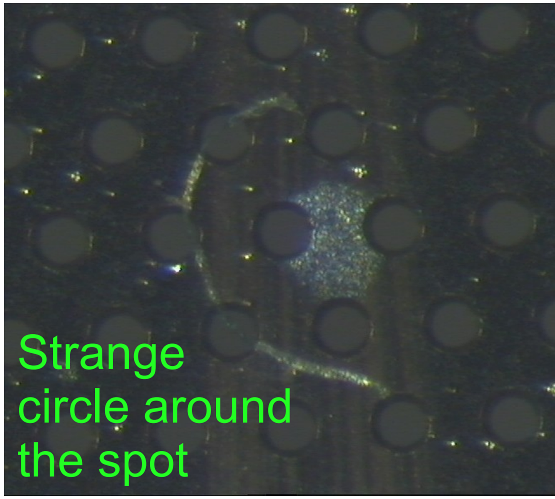


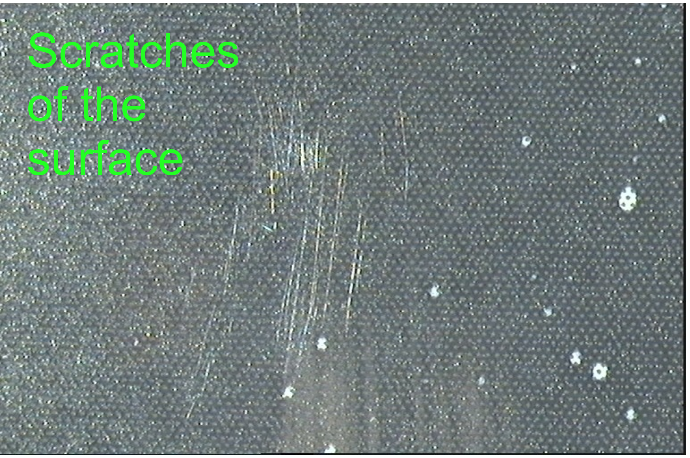


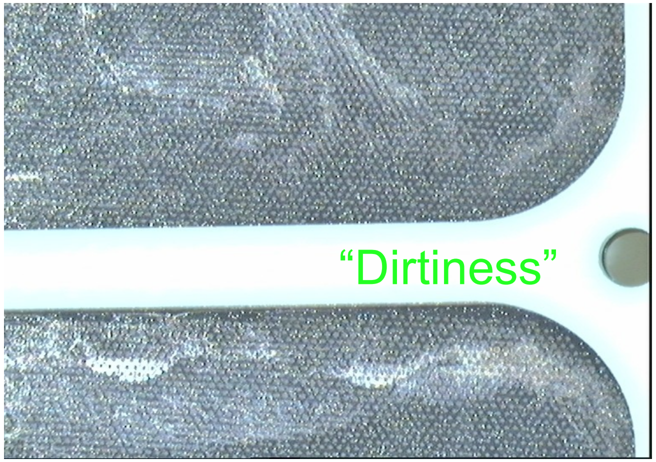
# Other imperfections

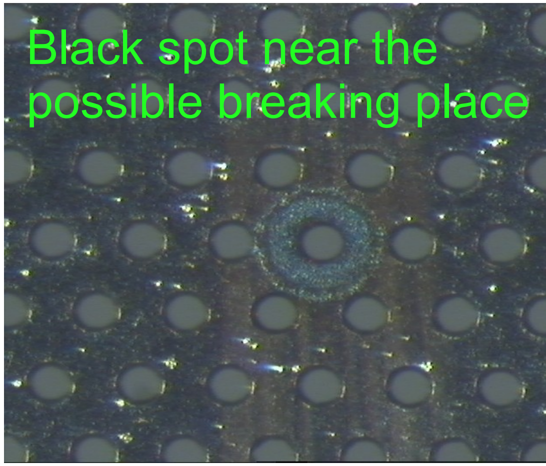


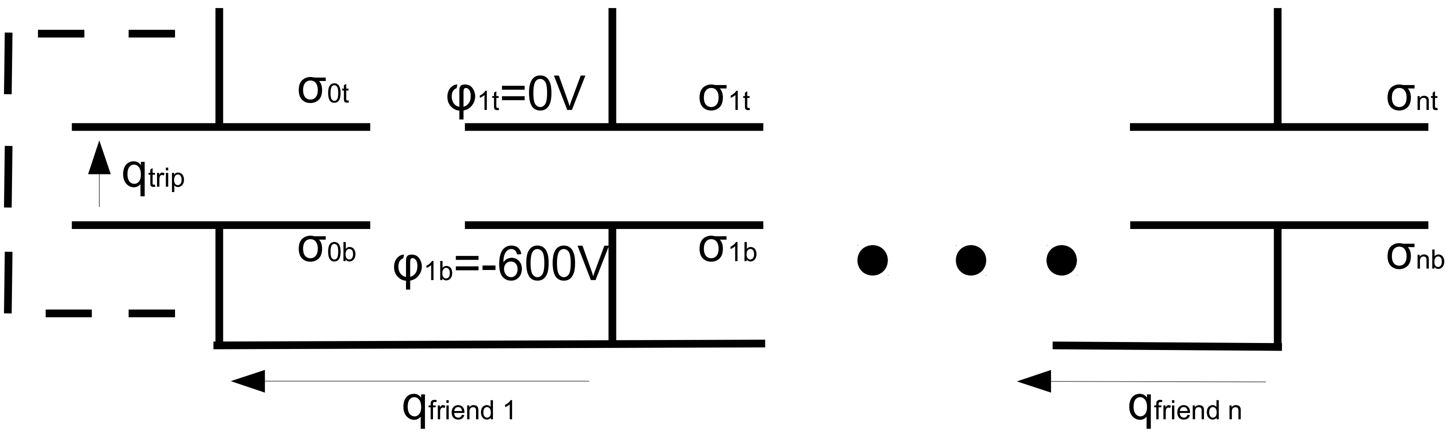



# Analytical proving of the empirical formula




For parallel plate: $\phi(z) = -E\cdot(z - z_0) = \frac{-\sigma}{2\cdot\varepsilon}\cdot(z - z_0) = C(z)\cdot\sigma$

$We\ choose: \phi_{nt} = 0;\ \sigma_{nt} = 0$

$\phi_{nb} = C\cdot -\sigma_{nb} = -600$

After trip:

$\phi_{0t} = \phi_{0b} = \phi_{nb} \rightarrow -\sigma_{trip} = C\cdot(\sigma_{0b} - \sigma_{trip} - (n-1)\sigma_{friend}) = C\cdot(-\sigma_{bt} + \sigma_{friend})$

# Analytical proving of the empirical formula

$$\phi_{0t}=\phi_{0b}=\phi_{nb}\rightarrow-\sigma_{trip}=C\cdot\left(\sigma_{0b}-\sigma_{trip}-(n-1)\sigma_{friend}\right)=C\cdot\left(-\sigma_{it}+\sigma_{friend}\right)$$

$$\sigma_{trip}=\frac{n}{n+1}\cdot\sigma_{ib}\rightarrow q_{trip}=\frac{n}{n+1}\cdot q_{ib}\rightarrow V_{splash}=\frac{n}{n+1}\cdot V_{0}$$

| N sectors | Vm, V | Q trip, Qsec*% | ΔQ trip, (Q trip-Q $trip_1$)*% |
|---|---|---|---|
| 1 | -300 | 50% | 0 |
| 2 | -400 | 66% | 33% |
| 3 | -450 | 75% | 50% |
| 4 | -480 | 80% | 60% |

Number of sectors move the voltage of equilibrium. For this GND need to spend more charge during a trip to move it to the lower voltage.