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SiPM Geiger discharge for high intensity light registration

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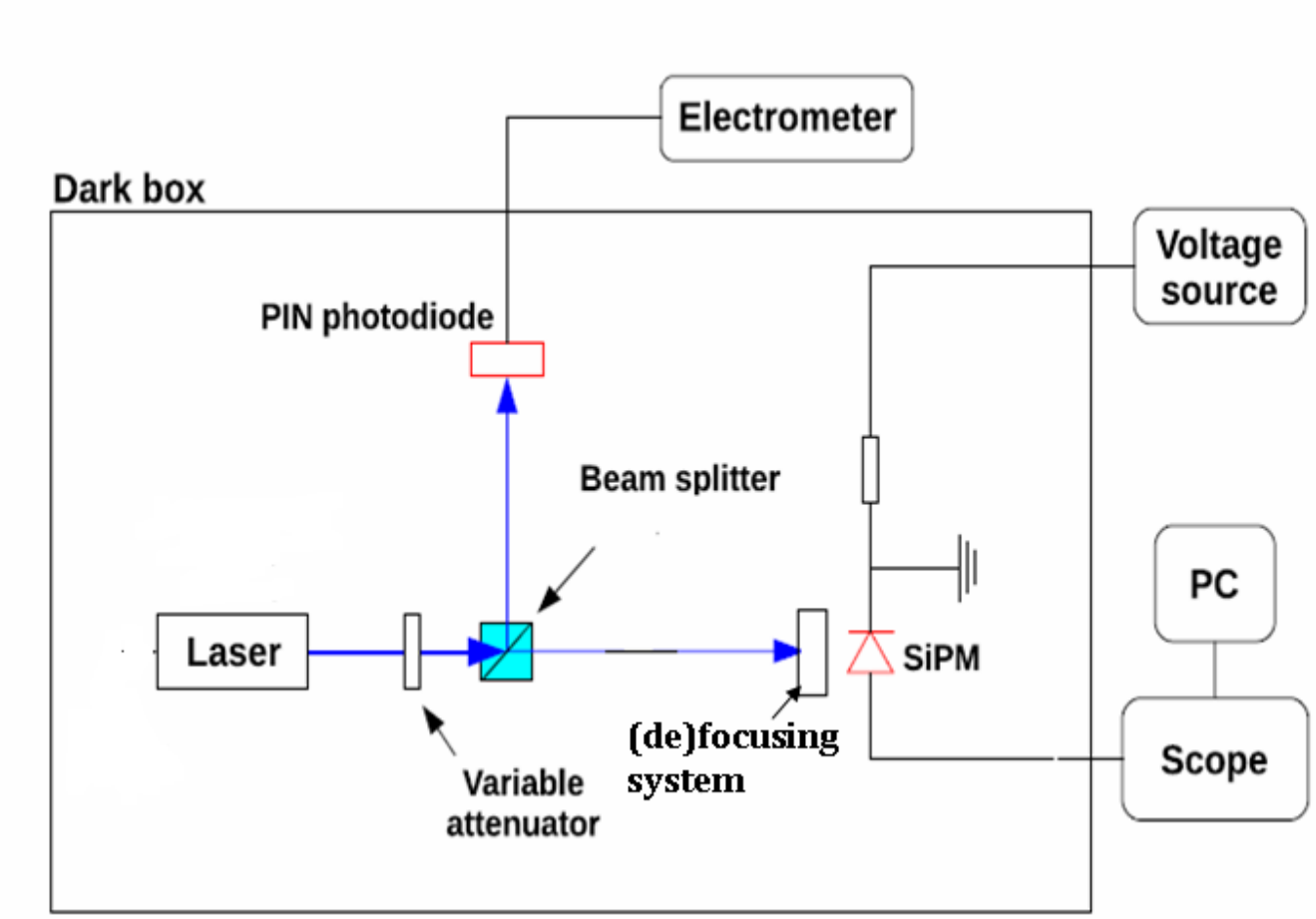
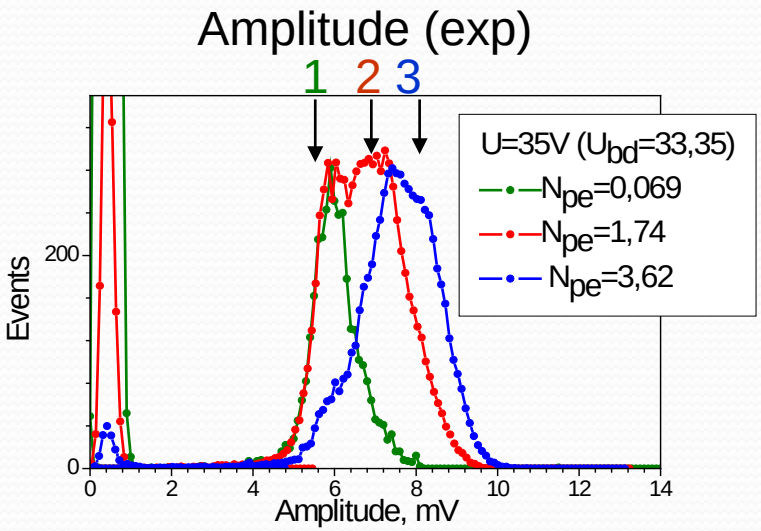
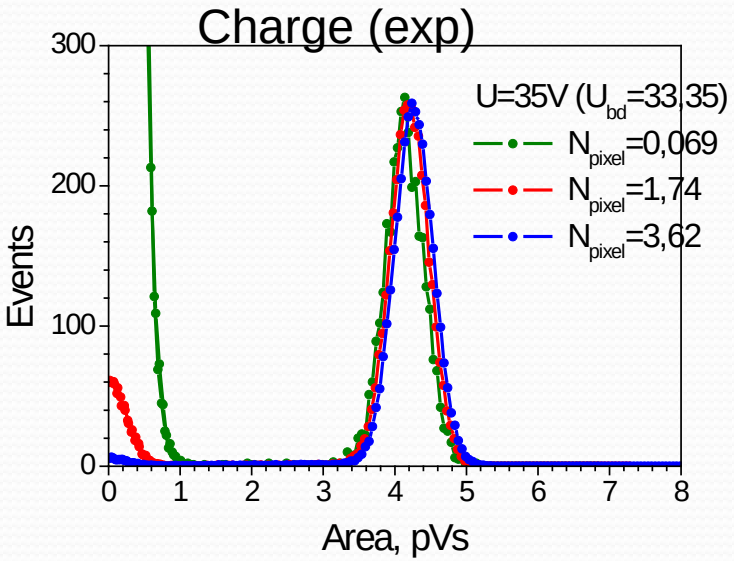
Measurement setup with 40ps laser 405nm, digital scope 2GHz with light intensity control



Signals from stand alone cell

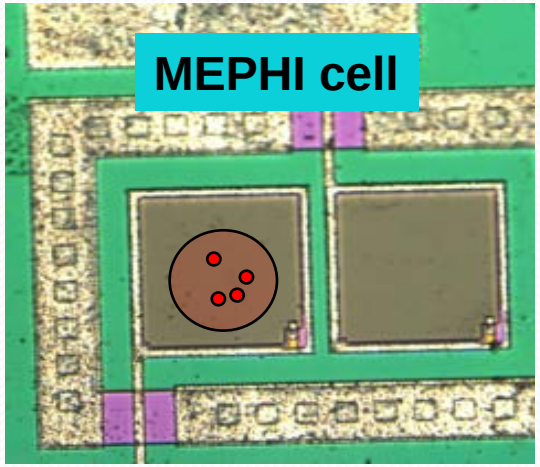
Fixed overvoltage ΔU=1.65V, different light intensity



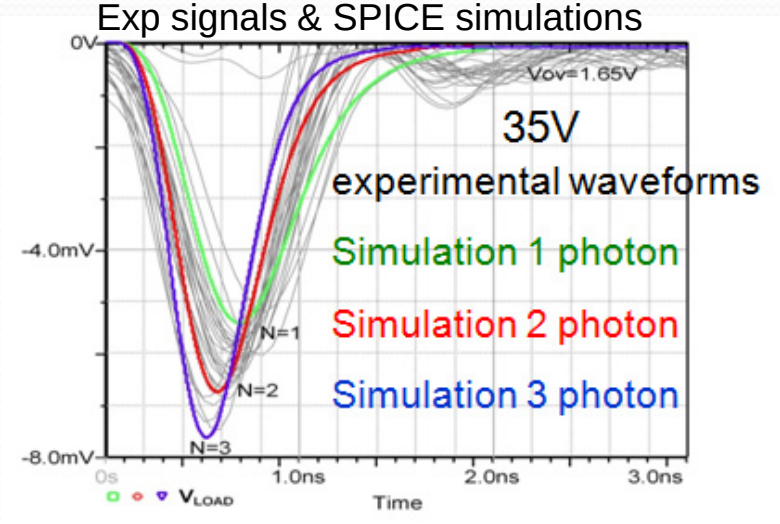


We have developed a SPICE model of Geiger discharge propagation

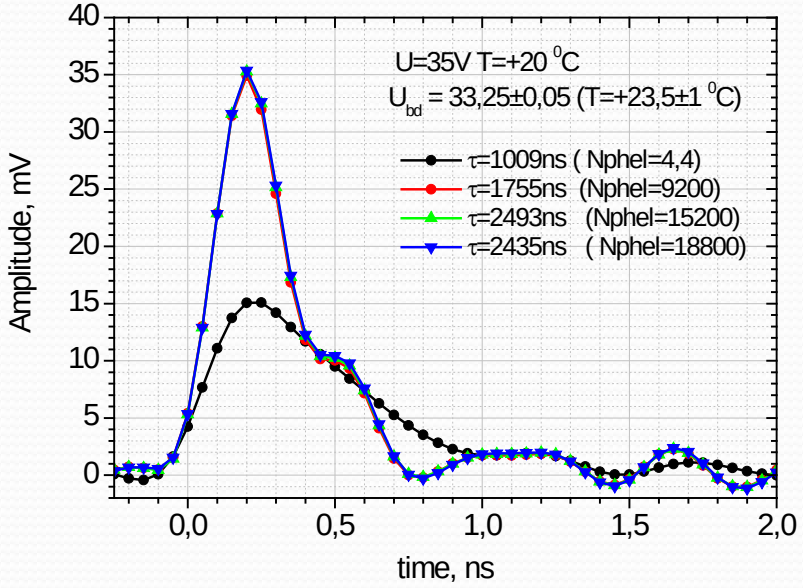
NIM A787, 1 July 2015, 270–274



Exp signals & SPICE simulations

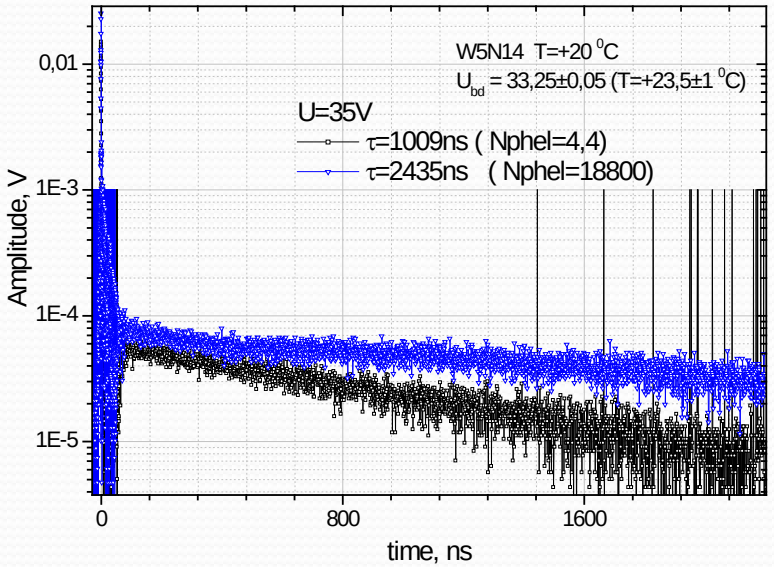


Single cell pulses for different intensity light but for fixed overvoltage. MEPHI cell (100x100 μm^2)



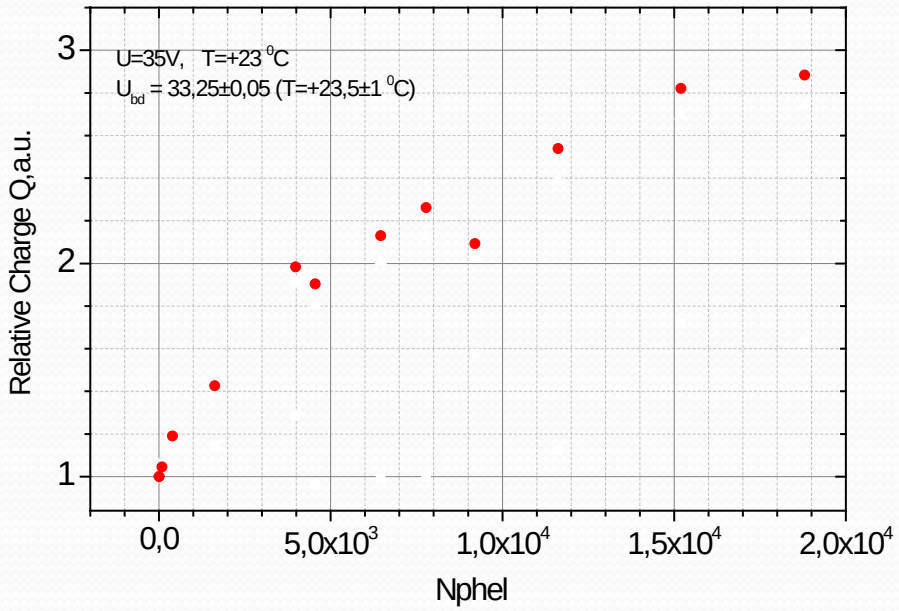
$$Q = (C_{fast} + C_{slow}) * (U - U_{br})$$ **Total charge**

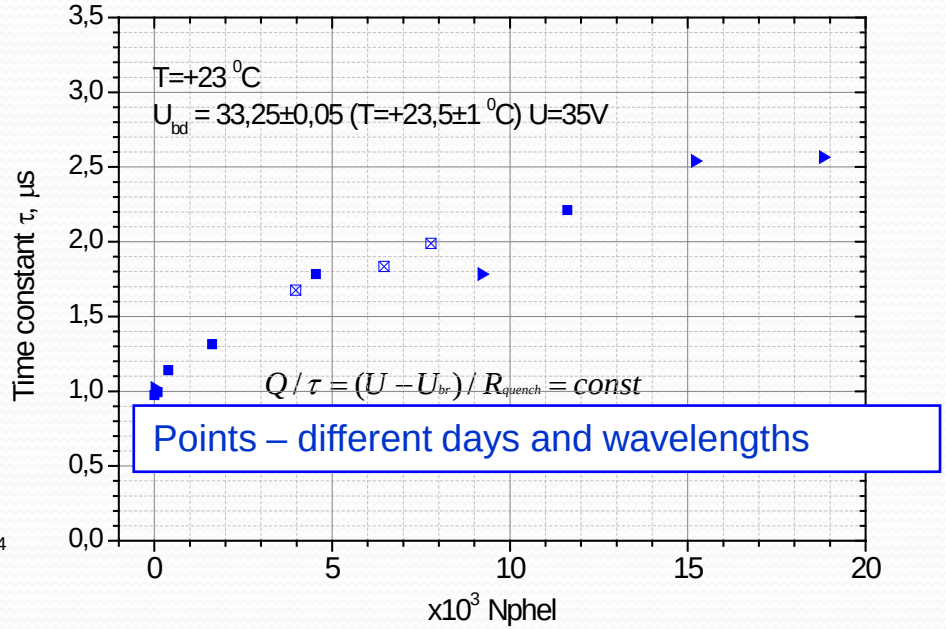
$$\tau = R_{quench} * (C_{fast} + C_{slow})$$

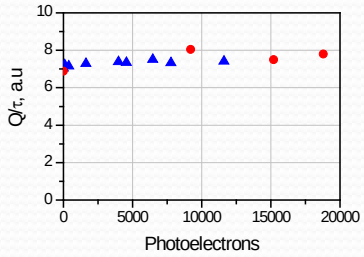


$$Q / \tau = (U - U_{br}) / R_{quench}$$

MEPHI cell.





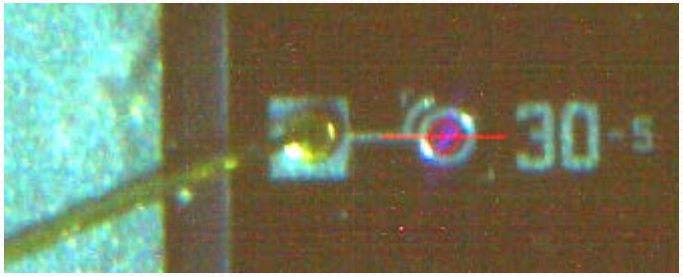


$$U - U_{br} = const$$

U-Ubreakdown doesn't change

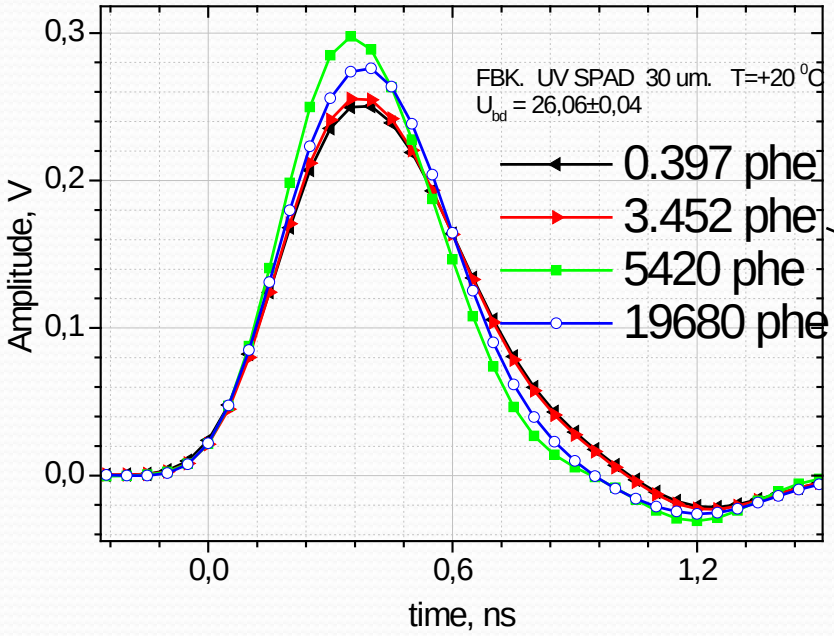
Q increases due to increasing of $C_{fast}+C_{slow}$

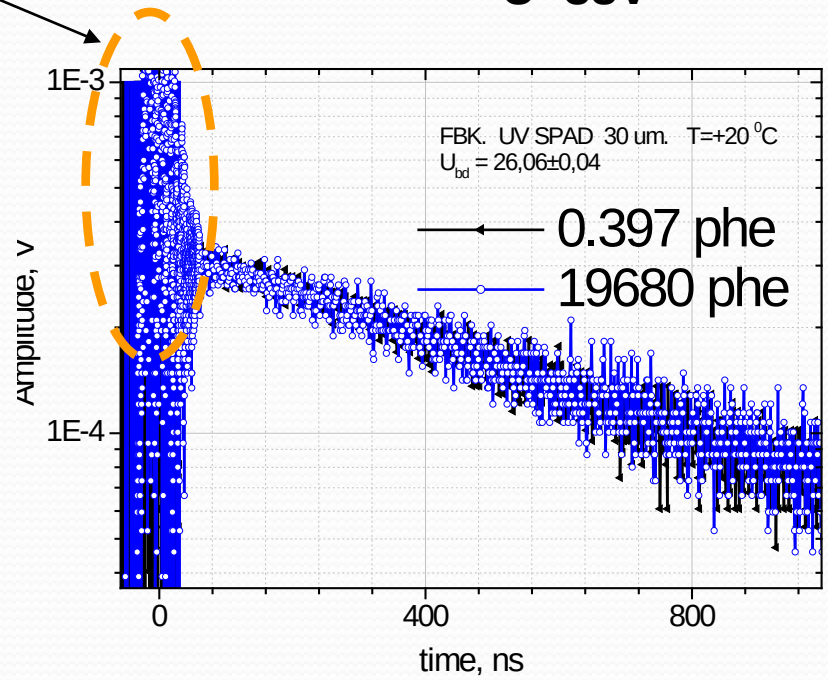
Single cell pulses for different intensity light. FBK cell



FBK cell. Dia 30 μm

U=38V

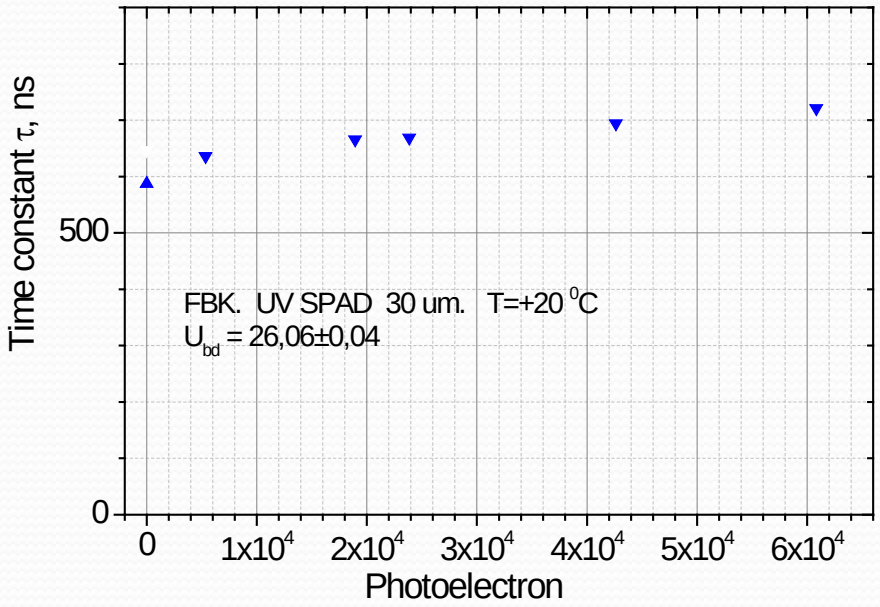


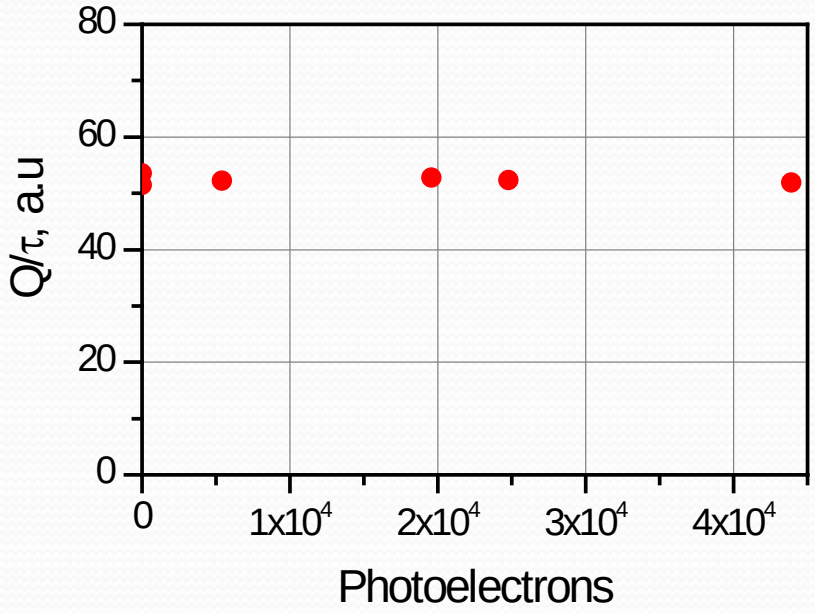


Very small difference in pulse shapes for different light intensities

Single cell pulses for different intensity light. FBK cell

U=38V

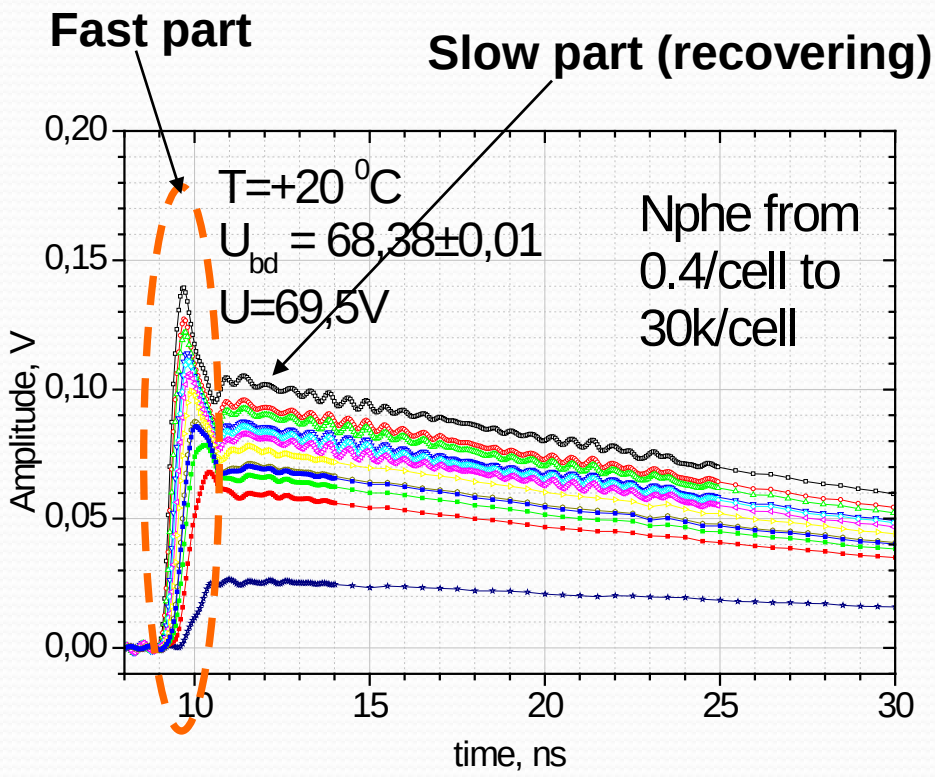


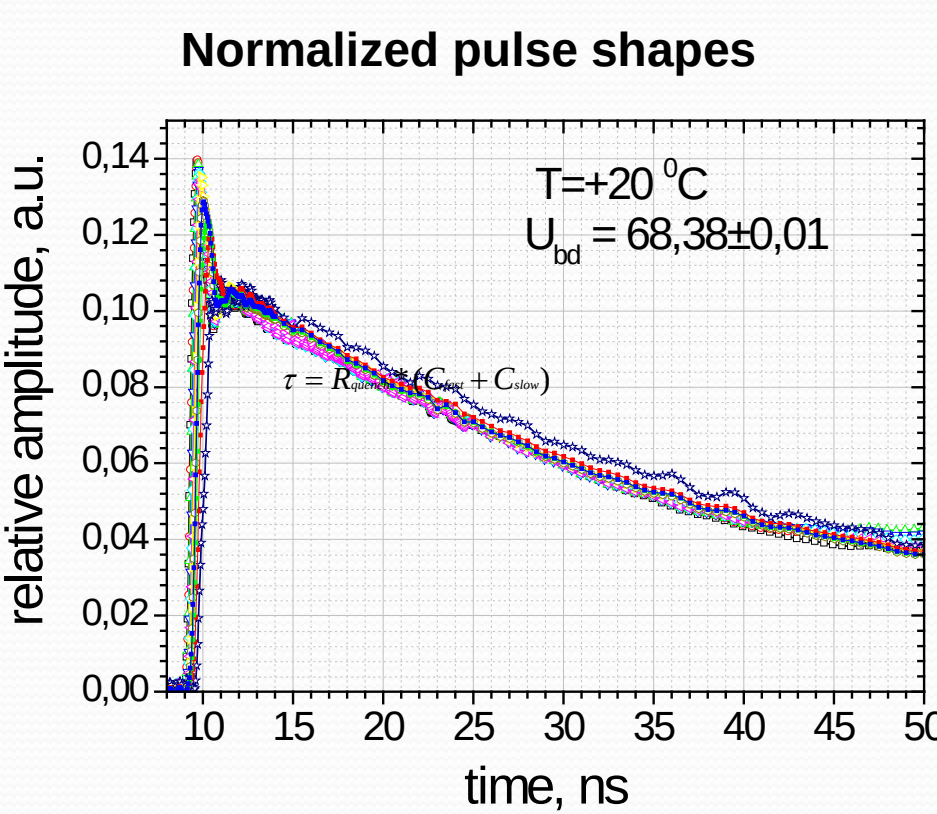


$U-U_{breakdown}$ doesn't change
Q increases due to increasing of $C_{fast}+C_{slow}$

Pulse shape for different light Intensities. MEPHI data

Hamamatsu S10362-11-100U No.50





$$Q = (C_{fast} + C_{slow}) * (U - U_{br})$$ **Q changes with intensity**

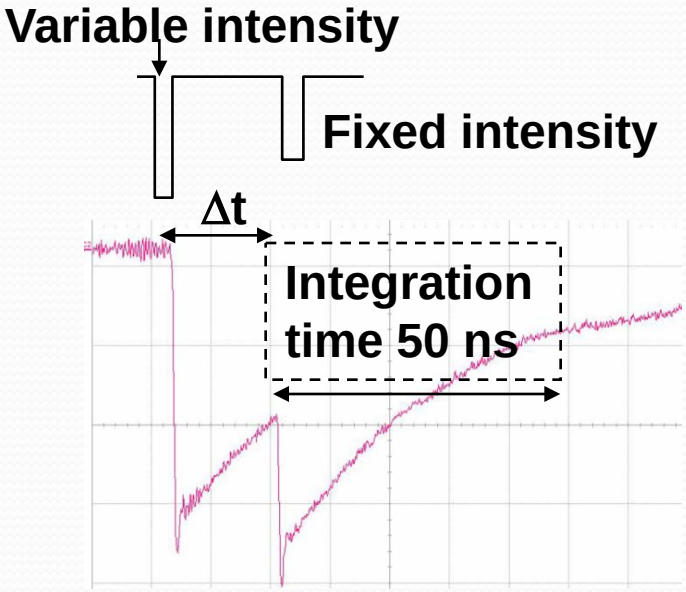
τ doesn't change with intensity

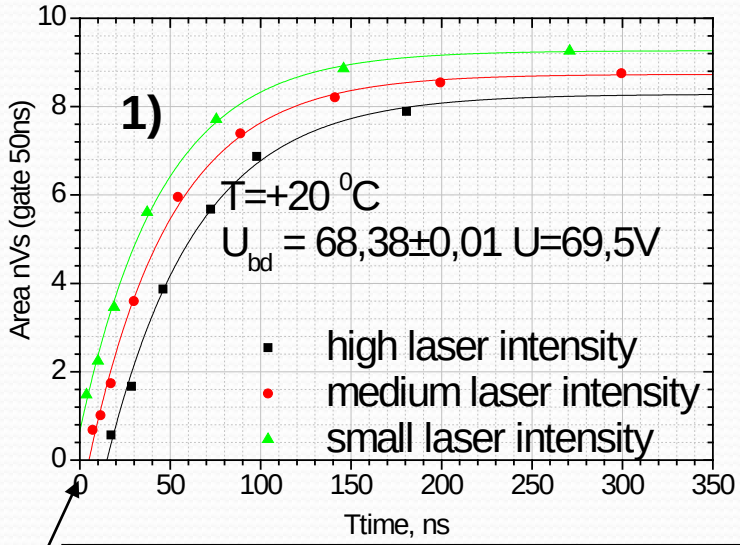
A=N_cell*ΔU/R_quench

ΔU changes with intensity – voltage drops on cell p-n-junction below U_breakdown

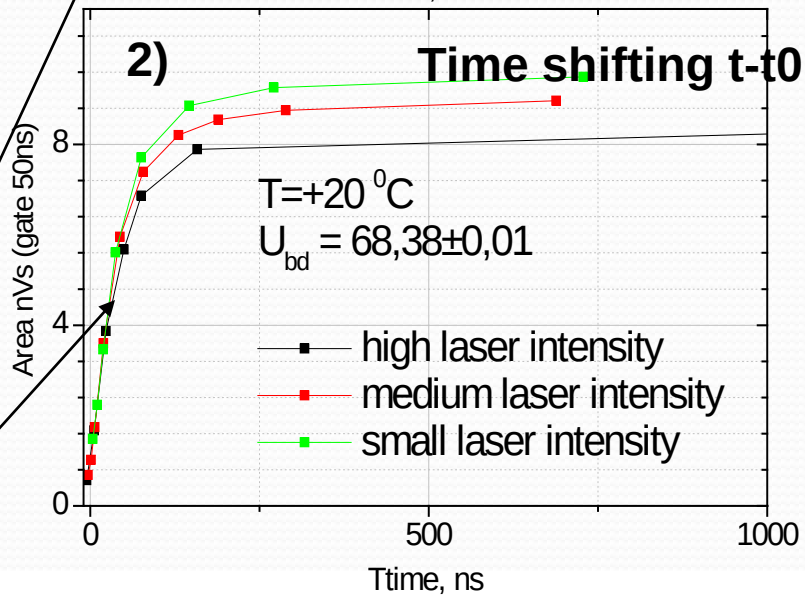
Recovery time for different light Intensities. Double pulses

Hamamatsu S10362-11-100U No.50





Voltage on p-n-junction

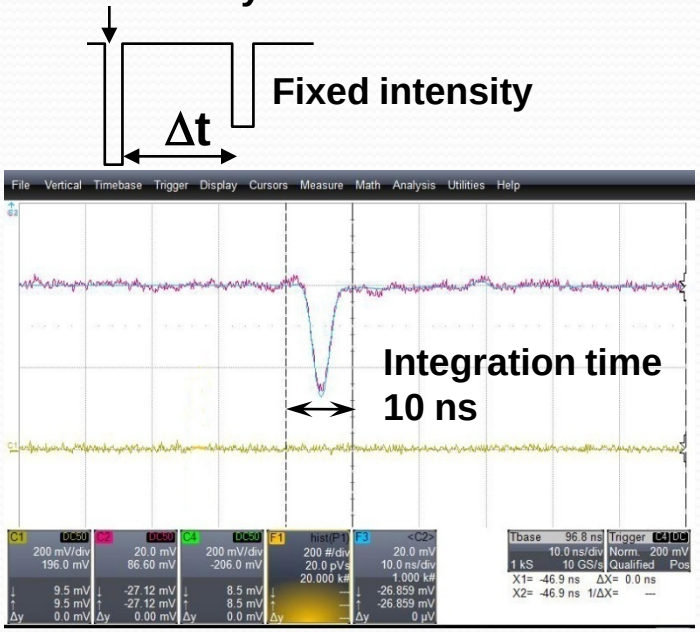


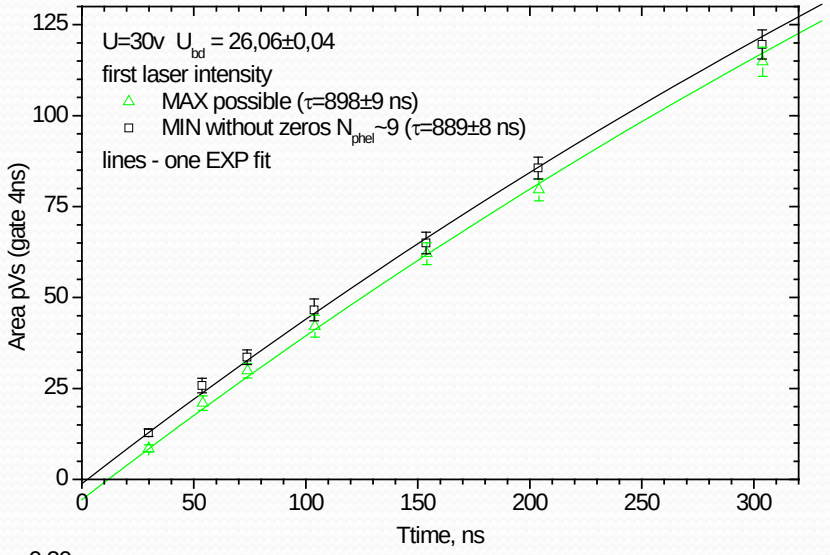
As higher first pulse intensity as longer time Δt before second pulse starts to initiate Geiger discharge (1); But recovery constant is the same (2)

Recovery time for different light Intensities. Double pulses

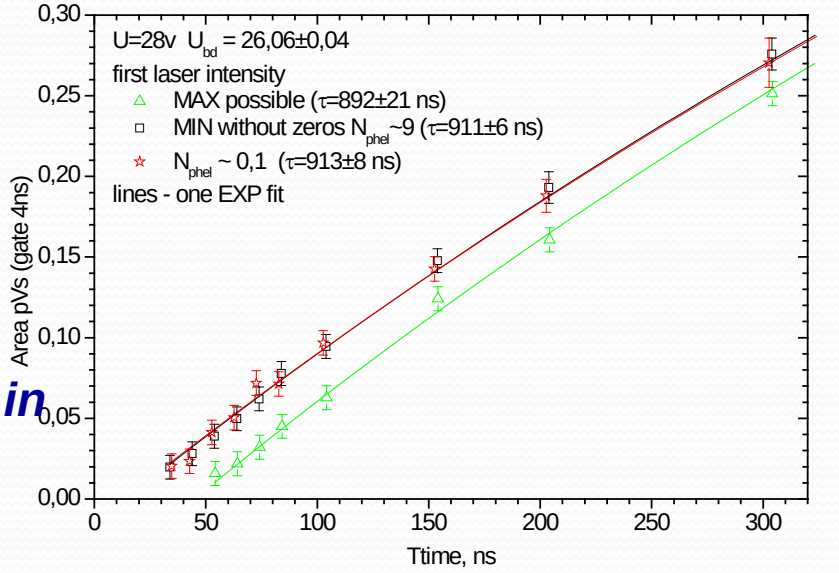
FBK cell

Variable intensity





Voltage on p-n-junction



The lower overvoltage the grater a shift in start of the restoration

Summary:

- **SiPM cell**
  - **recovery time**
  - **amplitude**
  - **charge**

for Geiger mode operation in oversaturation conditions (>>1 phe/cell) depends on light intensity due to extremely fast developing of the Geiger discharge

- **Depending on SiPM cell construction (technology used) high light intensity may affect cell capacity or/and voltage drop on cell pn-junction below $U_{breakdown}$**
- **The lower overvoltage the grater a shift in start of the SiPM cell restoration**

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