Status of Escalation Measurements

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

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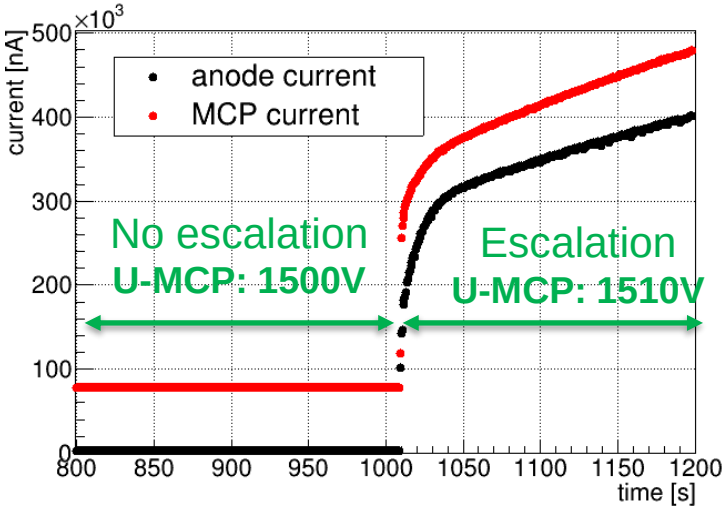
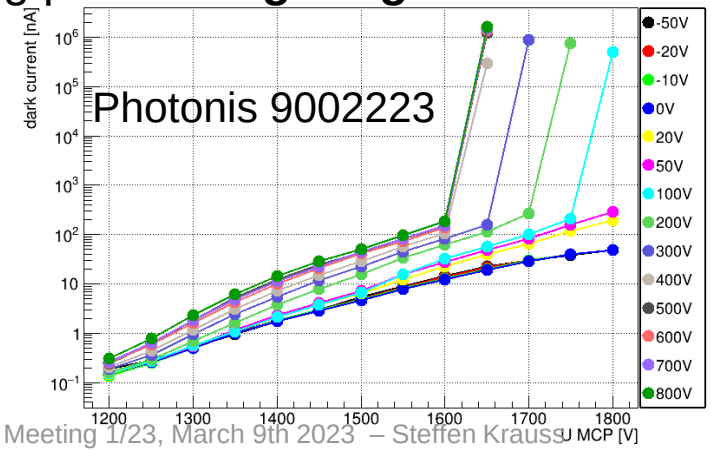
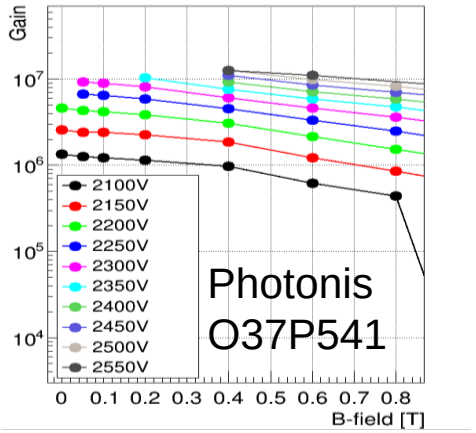
Summary of effects seen in escalation mode

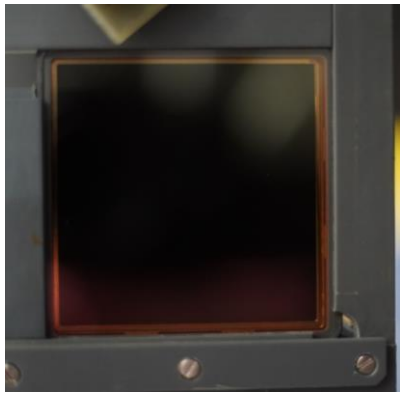
- B-field measurements showed strange effects (“escalation“) when decreasing field to 0 T, first observed in fall 2020
- Start of “escalation“ depends on gain and/or illumination conditions
- List off effects seen during “escalation“:
  - Higher current across the MCPs (factor >3) → resistivity drop
  - Seems to have no equilibrium state, steady increase of currents
  - High (dark) count rate and high anode current
  - Smaller signals → gain drop
  - **Photon creation**
  - Effects appear to be less serious inside magnetic field
- Escalation behaviour only appears with latest Photonis tubes
- By optimizing the ALD process Photonis was able to **shift** the ”escalation” starting point **to higher gains for newest MCP-PMTs**



Reason: photon creation inside the MCP-PMT, can be seen with camera or even bare eyes







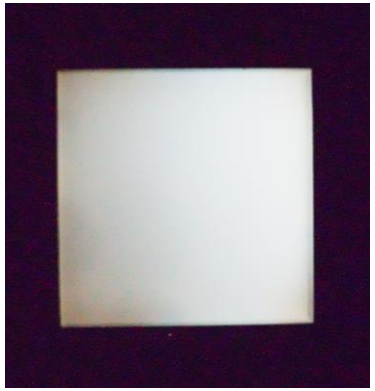
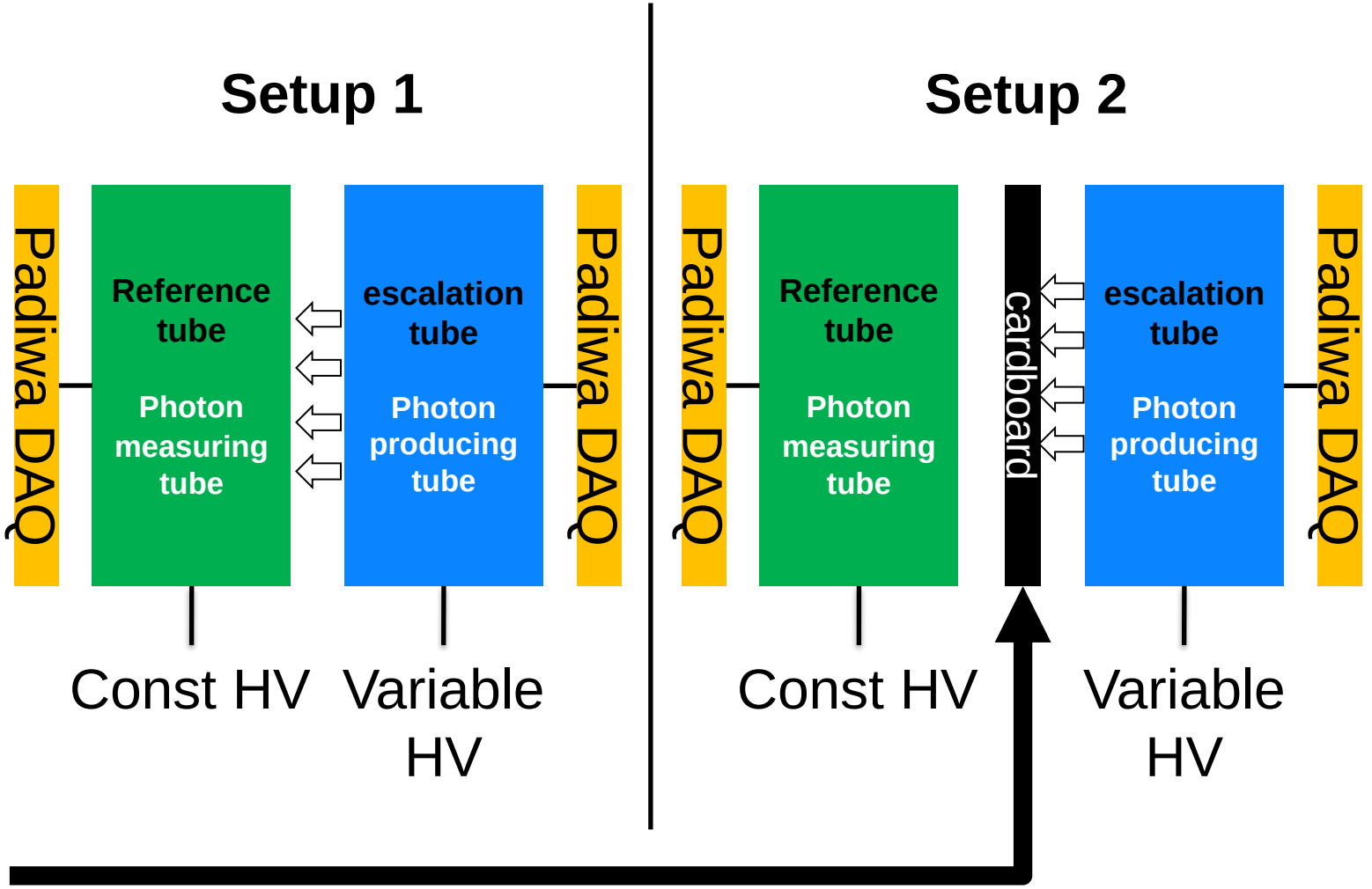


photo of PMT before operation and during escalation mode

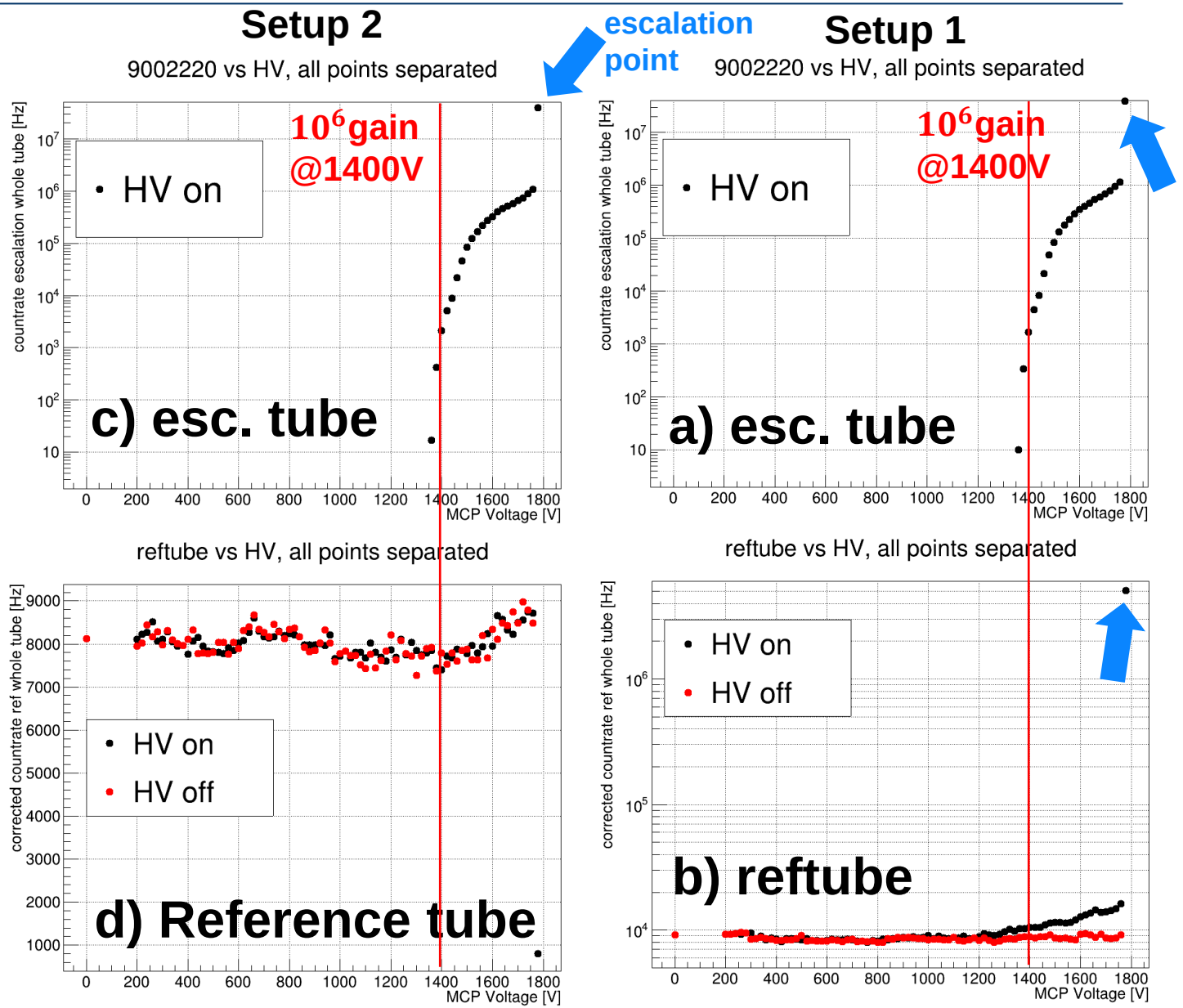
Scheme of countrate measurement

- Goal is to measure the rate of produced photons close to & during escalation mode
- Two MCP-PMTs oppositely placed with few cm distance
- **Reference tube** operated at constant HV as **photon counter**
- **Escalation tube** operated at different voltages/gain to create photons (**photon generator**)
- Both tubes read out via Padiwa DAQ to measure countrates
- **Setup 2 has cardbord in between both tubes as “photon stopper“ to obtain reference measurement**
- No illumination in these setups



Measurement results, Photonis 9002220

- In all plots the **countrate** is drawn over **MCP voltage of escalation tube**
- Upper row countrates of **escalation tube**
- Lower row countrates of **reference tube**
- Fig **a** and **c** show expected behavior; for higher gain the countrate increases
- Fig **d:** countrates of reference tube with cardboard in between → statistical fluctuation of darkcount rate of reference tube
  - As expected, no “generated“ photons are measured
- Fig **b**: @1200V MCP-voltage, the reference tube detects more signals when escalation tube is on HV, compared to HV off
- **Generation of photons starts already well below escalation & 10^6 gain**



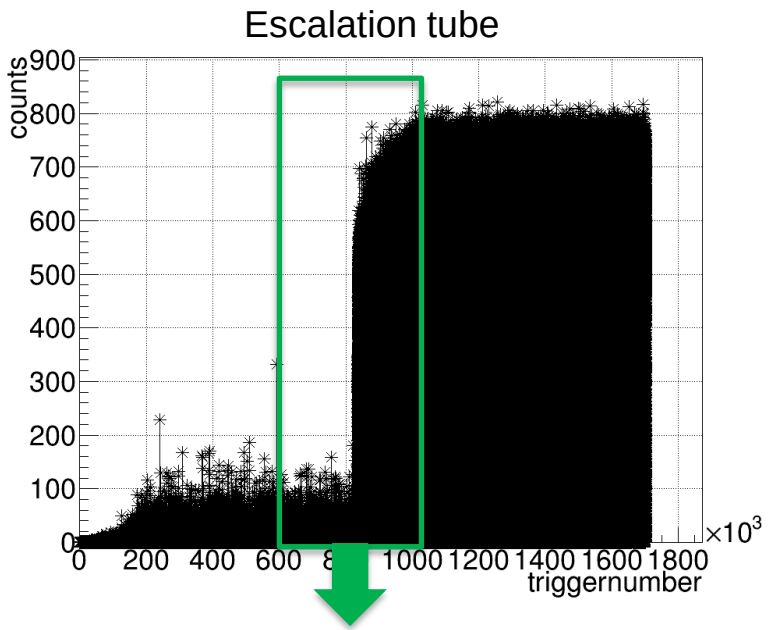
Further investigation of escalation point

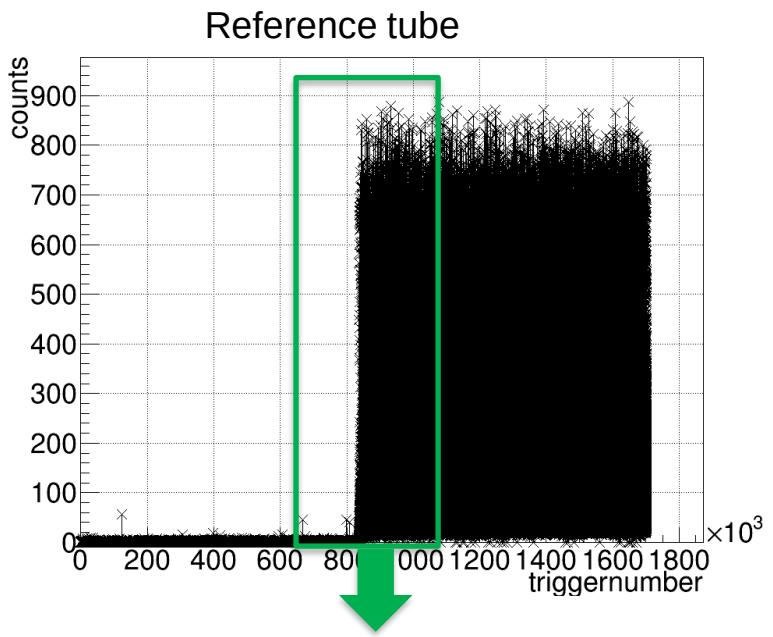
- Zooming into escalation point of last slide
- Counts vs triggernumber
- Trigger rate of 20 kHz → 50 µs binning
- Sudden increase of counts → start of escalation, visible in escalation & reference tube at same time

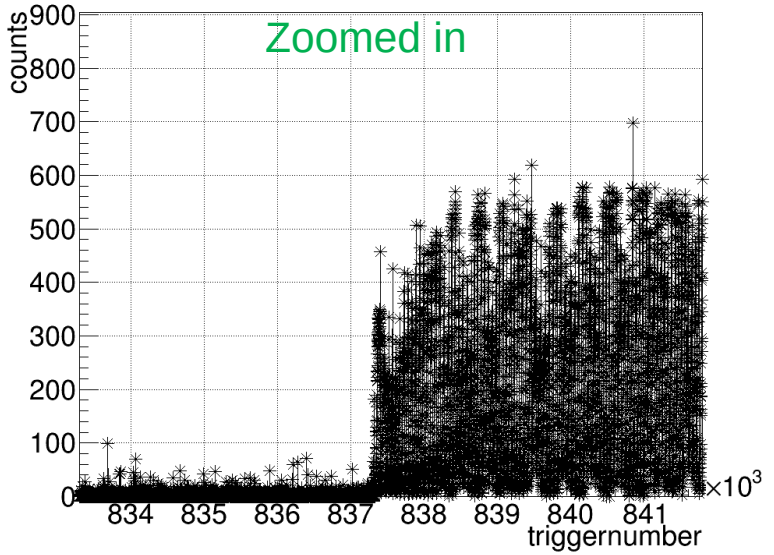
➢ Increase of counts within one trigger, as seen in bottom row plots

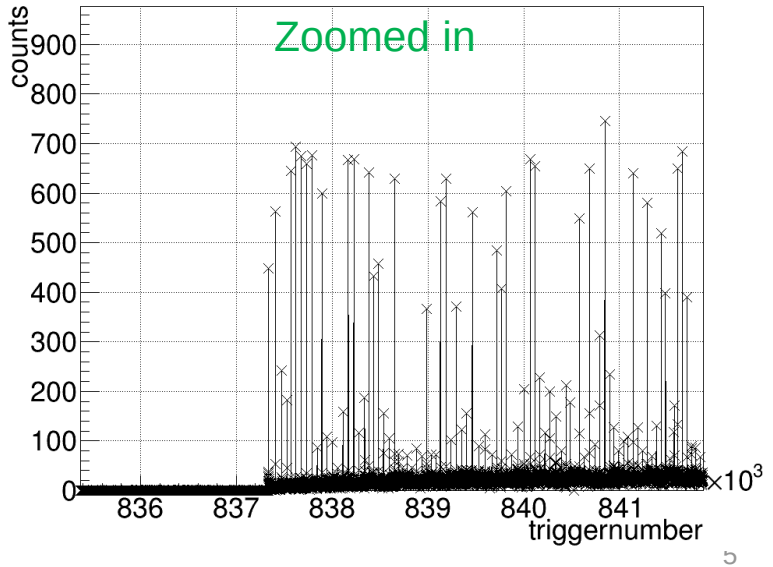
➢ Very fast switching from normal mode to escalation mode

- During escalation Padiwa DAQ saturates due to too many counts within one trigger



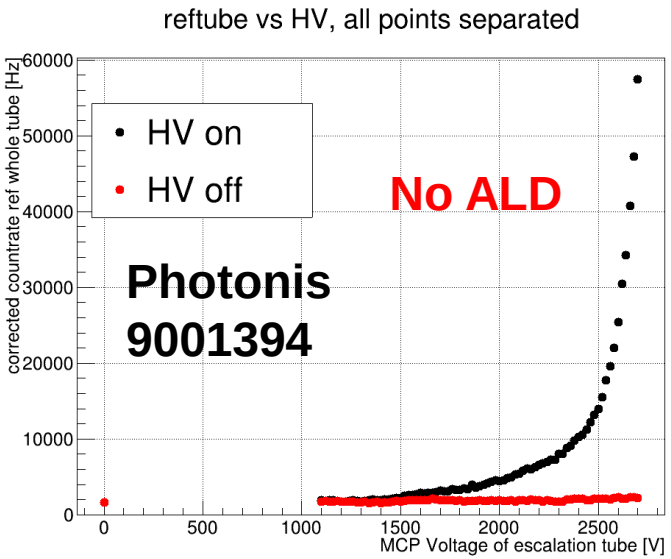


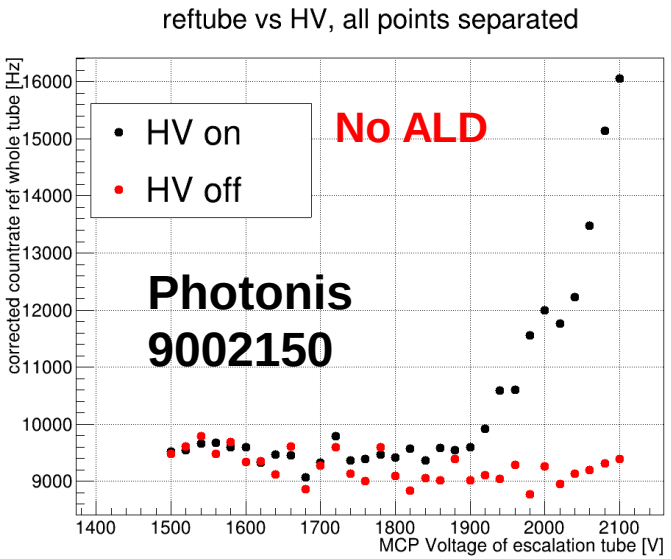


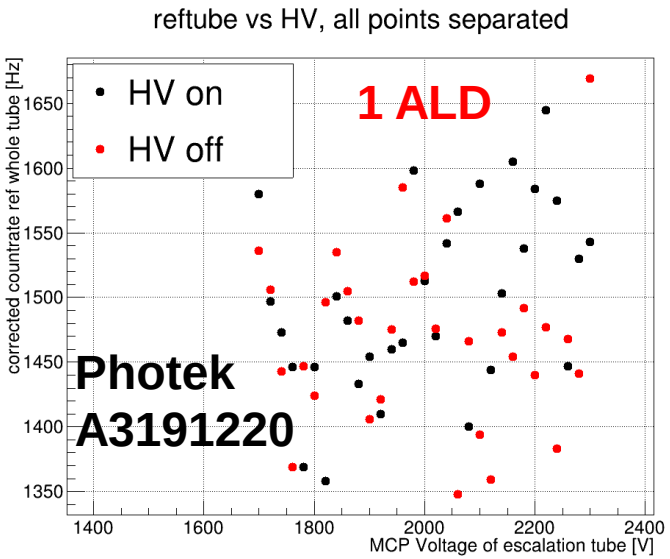


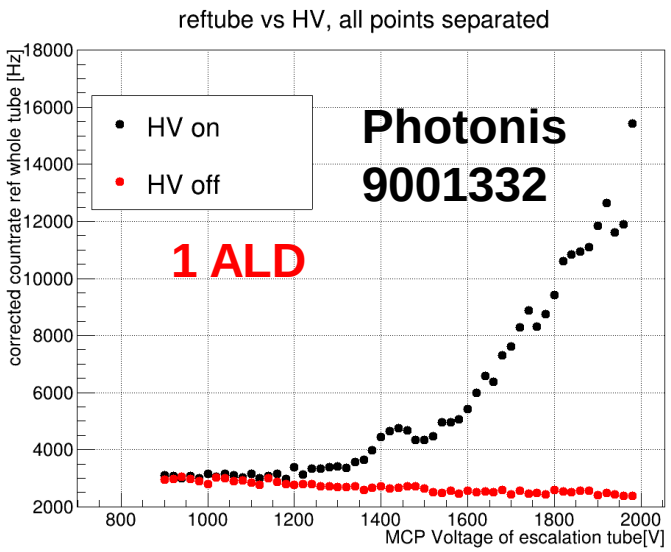
Investigation of photon creation in various MCP-PMTs

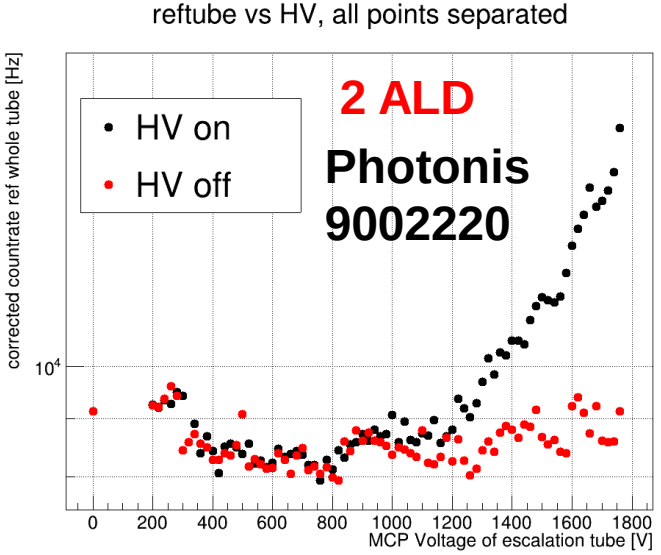
- Photon generation in Photonis MCP-PMTs always happens (No ALD, 1 ALD & 2 ALD)
- ➢ Only 2 layer ALD tubes enter escalation mode
- Photek and Hamamatsutubes don‘t generate photons in this measurement

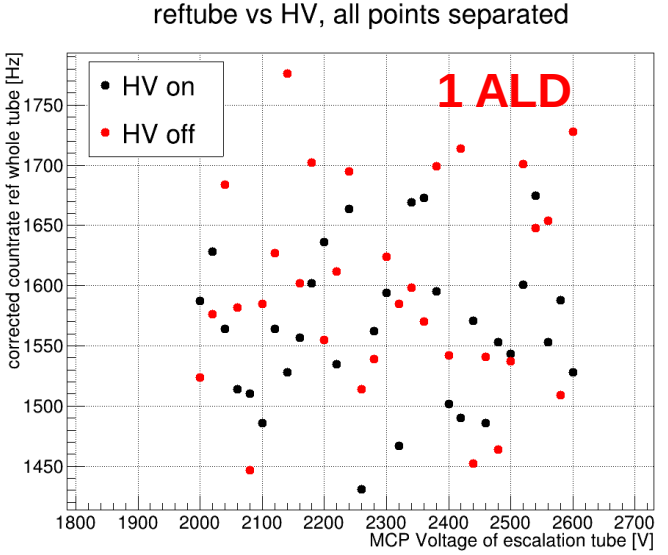












Hamamatsu YH0250

Summary of photon creation and escalation behavior

- Photonis:
  - Photon creation starts in all types of tubes (No ALD, 1 ALD & 2 layer ALD MCPs) already well below 10^6 gain
  - Just MCP-PMTs with 2 layer ALD-MCPs enter escalation stage
- Photek & Hamamatsu tubes do not have this photon creation effect at all
- Dark count behavior seen in LAPPD tubes look very familiar to escalation effect from Photonis