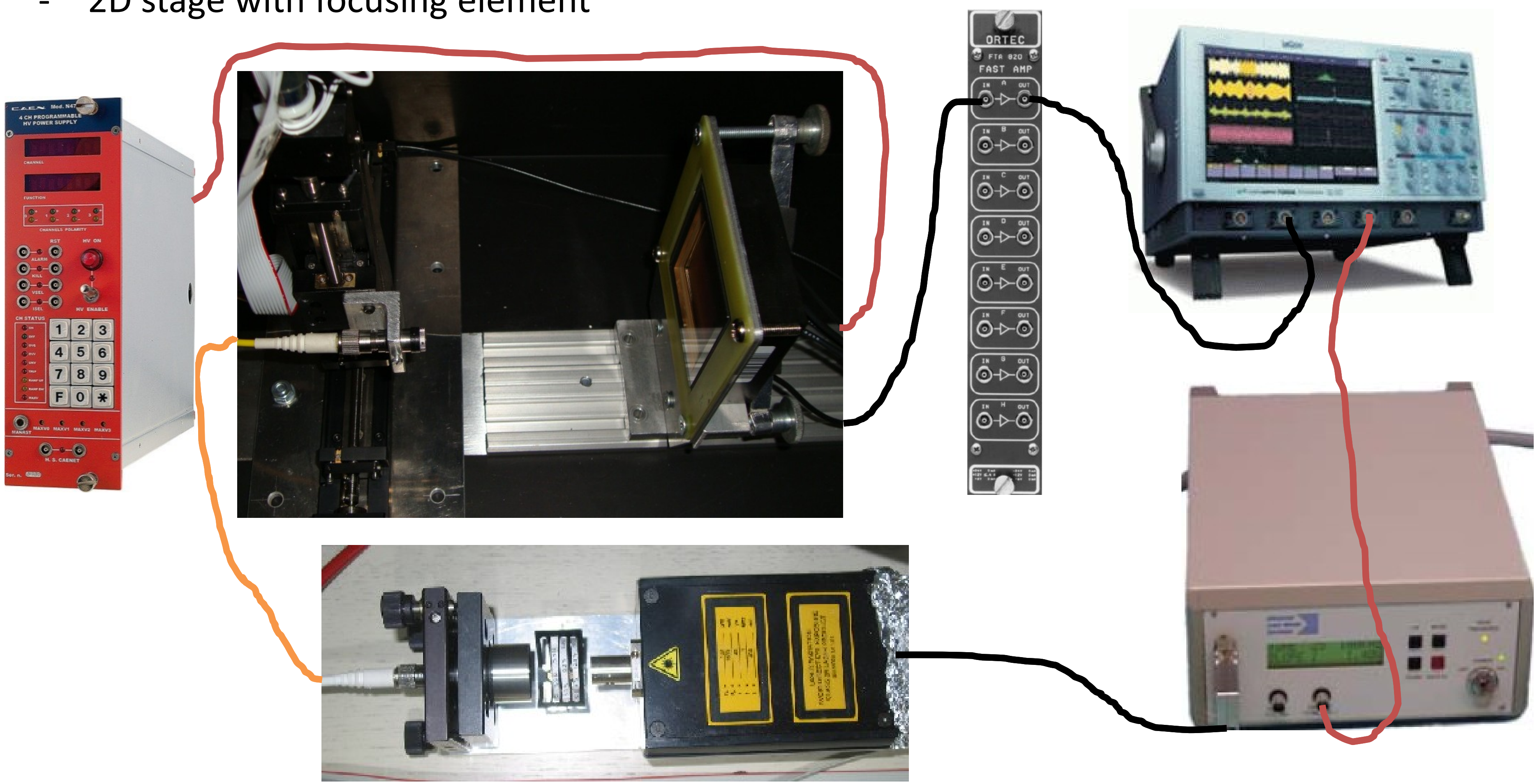
Characterization of the MCP-PMT

The aim of the exercise is to study the timing properties of the MCP-PMT and to observe effects of photoelectron backscattering and charge sharing.

- First check the connections in the set-up
- Apply the height voltage (-2400V) and setup the oscilloscope to observe the PiLas trigger signal and signals from two lower channels of the MCP-PMT. Adjust the light intensity to single photon level.
- Set-up the charge and delay measurement (leading edge and constant fraction) on one of the MCP-PMT signals with respect to the PiLas trigger signal.
- Estimate the gain and single photon timing resolution.
- From the measured timing distribution determine the distance between the photocathode and MCP entrance surface.
- Observe the signals when you move from one channel to the other
- Measure the timing distribution for multiphoton pulses

Set-up for MCP-PMT study:

- MCP-PMT, Photonis(BURLE) 10 um, 4 channel prototype
- HV power supply CAEN
- Amplifier ORTEC FTA820A: gain 200, bandwidth 350MHz, neg./neg.
- LeCroy WawePro 7300A oscilloscope
- PiLas laser with 630 nm laser head
- 2D stage with focusing element



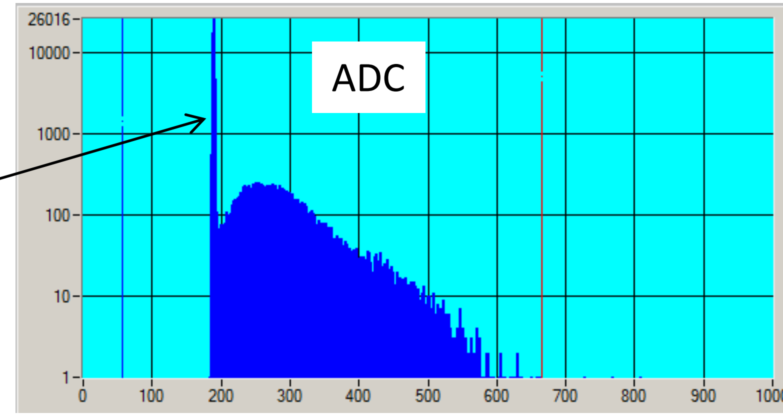
Single photon level – large fraction of single photoelectron signals

$$P(N)=\frac{\overline{N}^{N}}{N!}e^{-\overline{N}}$$

Number of photoelectrons follows Poisson distribution

$$P(0)=e^{-\overline{N}}$$

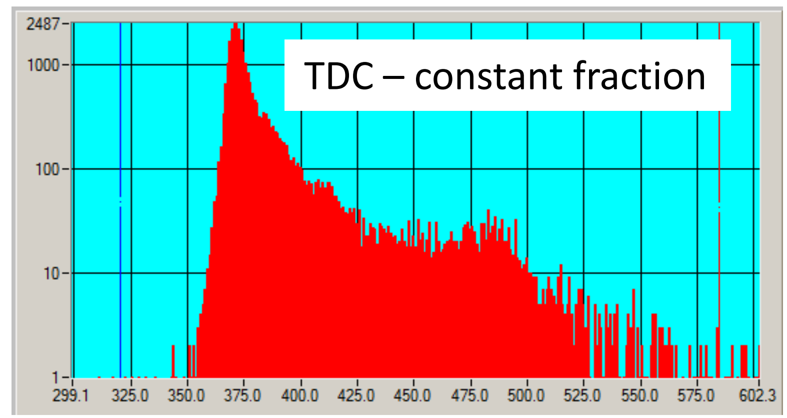
Fraction of pedestal events



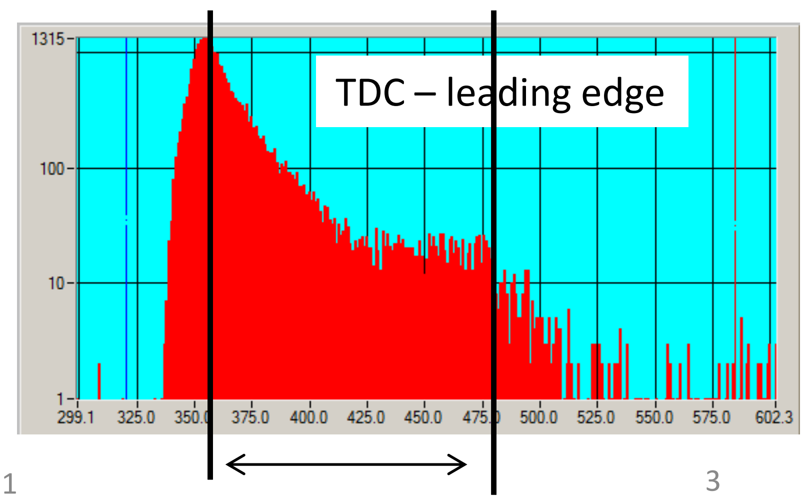
Fraction of single photoelectron signals

$$\eta=\frac{P(1)}{1-P(0)}=\frac{-\ln P(0)\bullet P(0)}{1-P(0)}$$

P(0)	η
0.5	0.7
0.8	0.9
0.9	0.95



Maximal travel time of a backscattered photoelectron can be estimated from the timing distribution of single photoelectron signals.



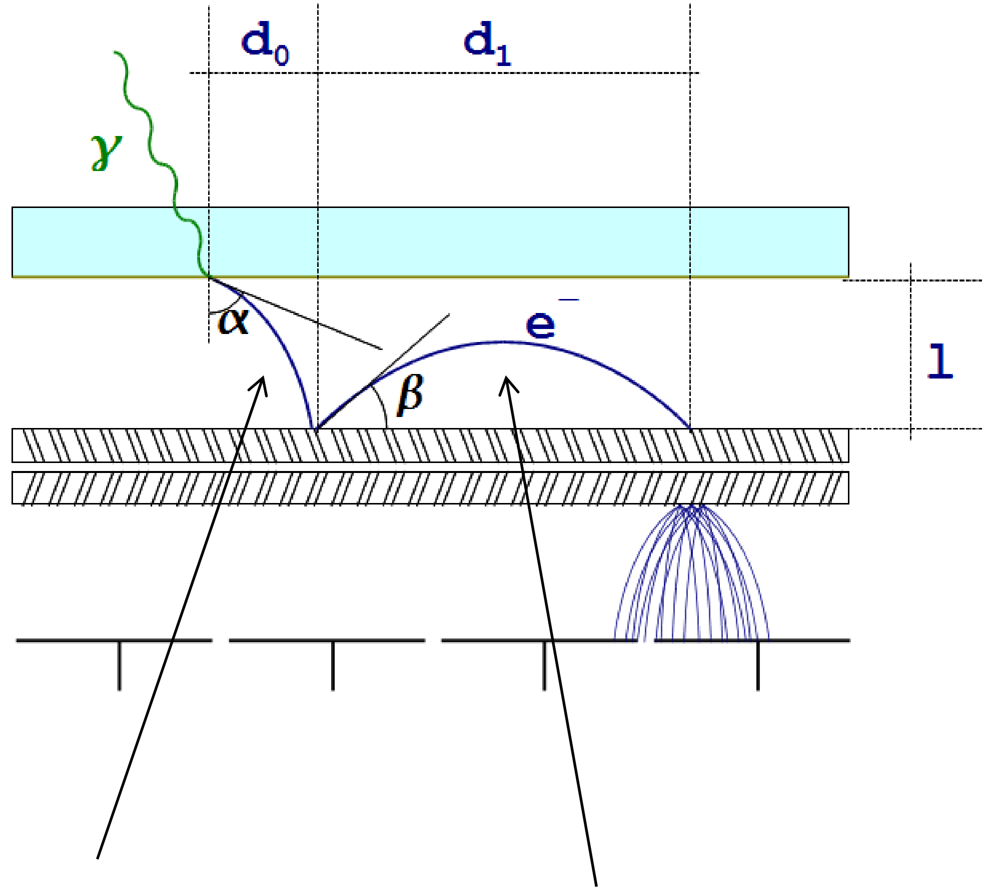
Travel time and range of photoelectron

$$t_0 \approx \sqrt{\frac{2m_e l^2}{Ue_0}}$$

$$d_0 \approx 2l\sqrt{\frac{E_0}{Ue_0}}\sin(\alpha)$$

Delay and range of backscattered photoelectrons

$$t_1 \approx 2t_0 \sin(\beta) \qquad d_1 \approx 2l\sin(2\beta)$$

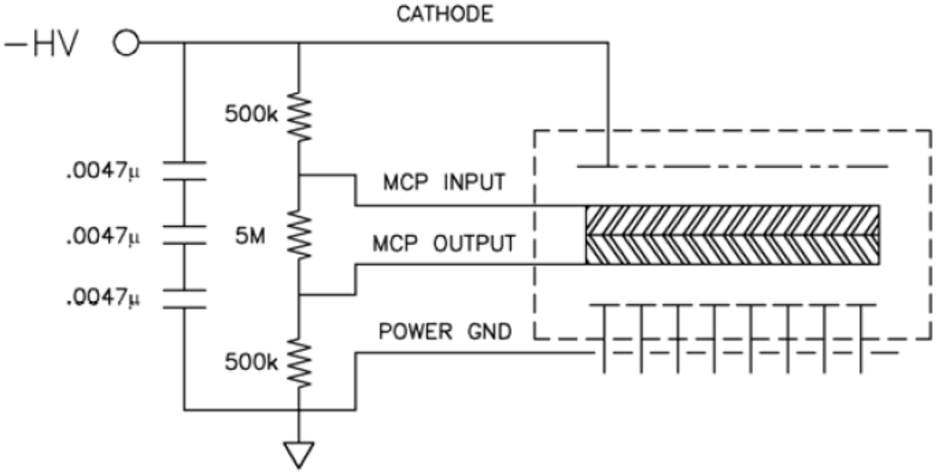


Parameters used:
- $U = 200$ V
- $l = 6$ mm
- $E_0 = 1$ eV
- $m_e = 511$ keV/c^2
- $e_0 = 1.6\ 10^{-19}$ As

Photoelectron:
- $d_{0,max} \sim 0.8$ mm
- $t_0 \sim 1.4$ ns
- $\Delta t_0 \sim 100$ ps

Backscattering:
- $d_{1,max} \sim 12$ mm
- $t_{1,max} \sim 2.8$ ns

MCP-PMT characteristics:



GENERAL

Parameter		Value	Unit
Spectral Response		185 to 660	nm
Wavelength of Maximum Response		400	nm
Photocathode Material		Bialkali	--
Window	Material	UV Grade Fused Silica	--
	Thickness	2.0	mm
Multiplier	Structure	MCP (10 µm pore, 40:1 L:D)	--
	Number of Stages	2	--
Anodes	Number	4 (2 × 2)	
	Size / Pitch	24.4 / 25.4	mm
Voltage Divider Resistance		6	MΩ

Maximum Ratings (Absolute Maximum Values)

Parameter	Value	Unit
Supply Voltage	-2400	VDC
Average Anode Current, sum of all anodes	3	µA
Ambient Temperature	- 15 to + 50	C