Selecting and Designing the Front-end Amplifier for High-gain **Photomultiplier Detectors with Optimal Timing Performance**



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Timing applications of high gain photo-detectors

PMT

SiPM

Timing resolution entails the accurate identification of the arrival time of single photons or the difference in the arrival times of a pair of photons



- high energy physics experiments
- medical imaging (ToF-PET)
- astro-particle physics
- mass spectroscopy
- meteorology (LIDAR) and many more



Timing accuracy required: hundreds of ps or possibly less

Single-photon timing resolution

Large-gain (10⁶) and fast-response detectors are used for time measurements: PMT, APD, SPAD, SiPM



hiah field

region

low field.

back contact

drift region





Signal pulse characteristics (PMT):

- the fast leading edge is determined by the charge multiplier process (avalanche,..)
- the trailing edge is related to the detector characteristics and to the amplifier input resistance

Front-end electronics: commonly used approaches

avalanche 📥



____R_in=5 Ω

— R_{in}=7.5 Ω — R_{in}=10 Ω

___R_=**25** Ω

10⁹

____R____R_____R____

Rin=7.5 Ohm Rin=10 Ohm

-Rin=25 Ohm

Rin=35 Ohm

10

BW [Hz]

pair can be identified for a given detector

SiPM from

FBK-IRST

 $\sigma_t \approx \frac{C_{eq}}{Q_{eff}} \frac{2L}{R_{in}} e_n \sqrt{BW}$

Hamamatsu

H8500 PMT



timing performance as compared to the VA

VA vs CB: main performance parameters as a function of L