Development of a MPPC Signal Amplifier Circuit

2016/3/8

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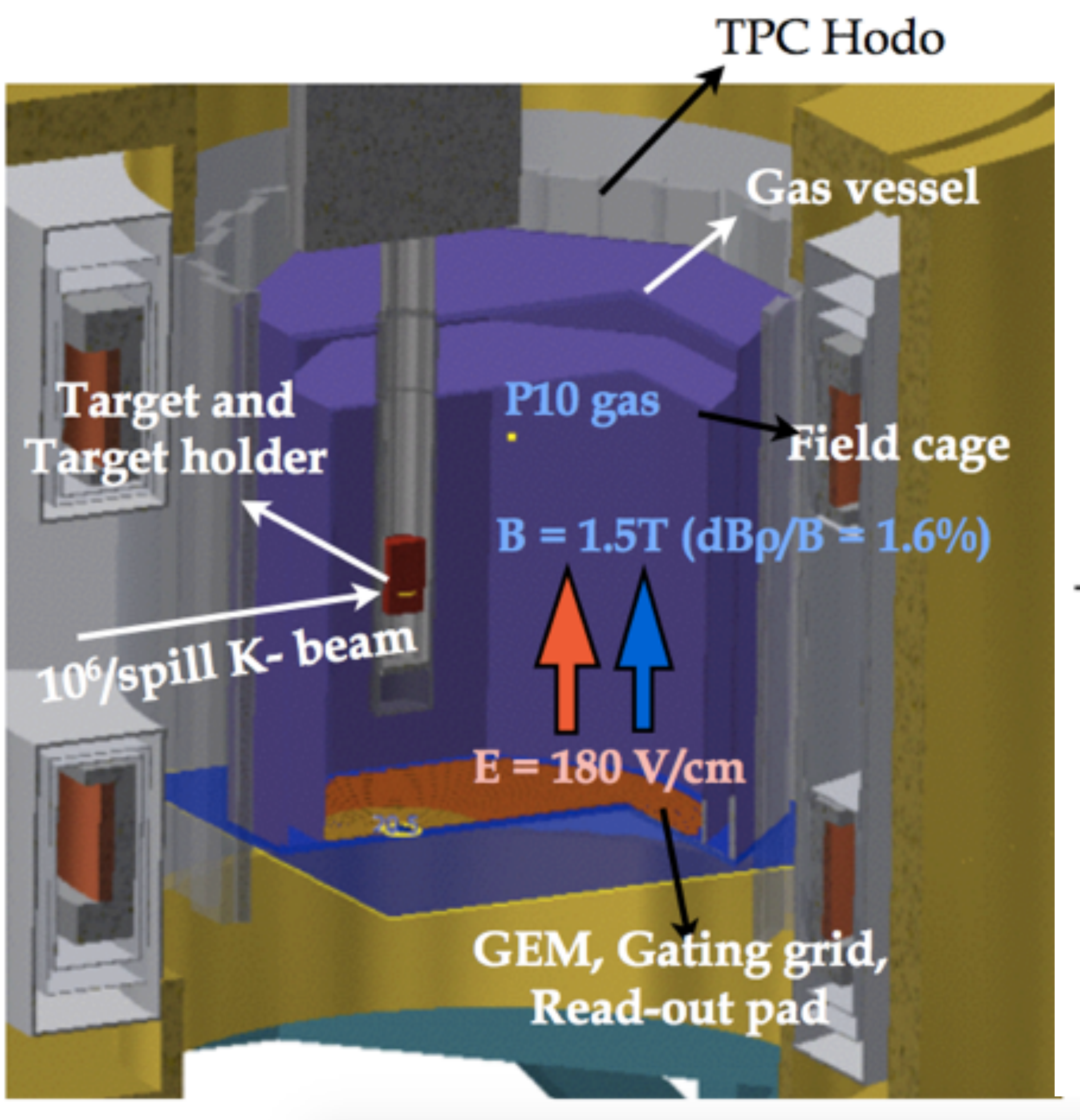
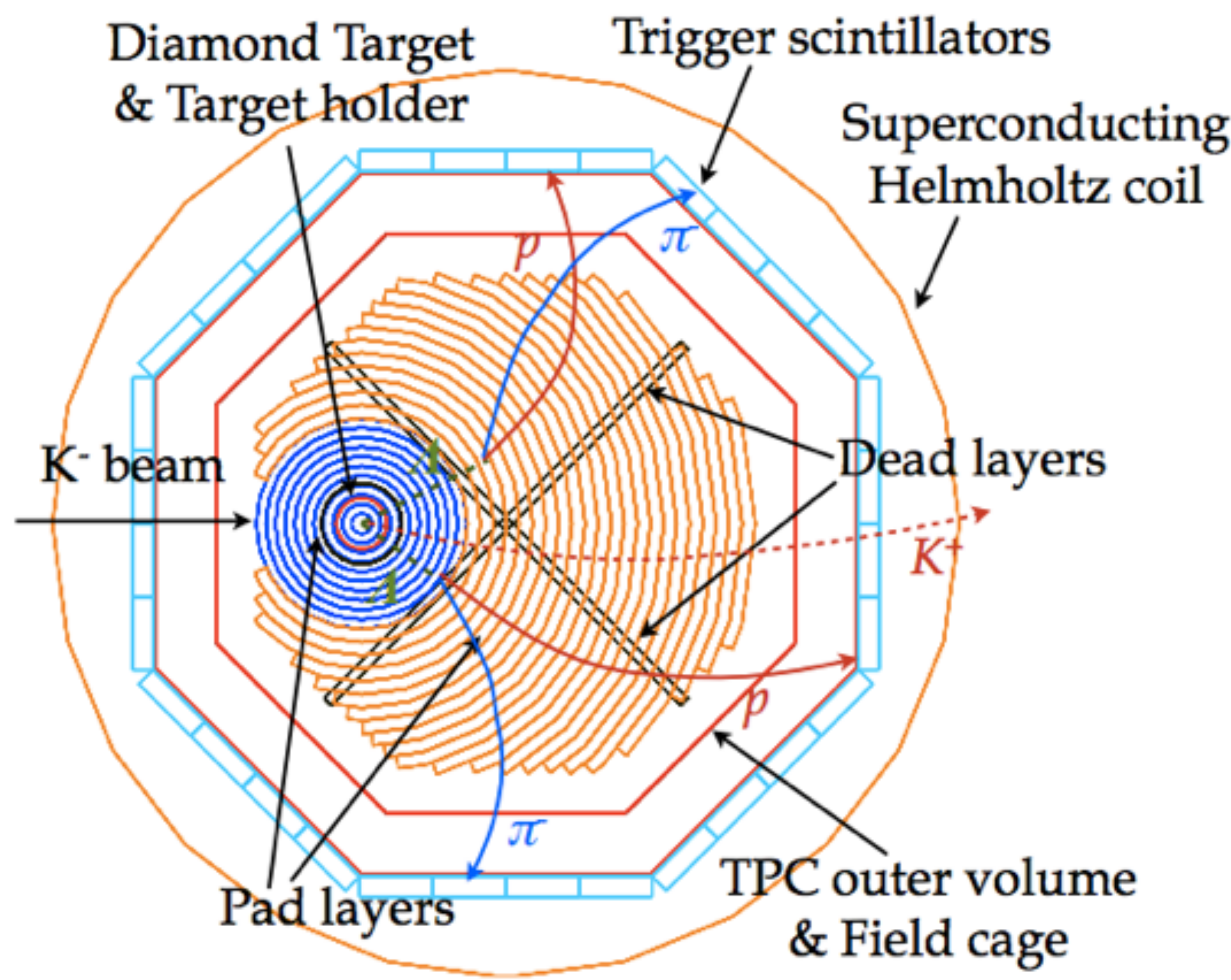
Hadron & Nuclear Physics Lab

E42 hypTPC


TPC Hodo
Gas vessel
Target and
Target holder
P10 gas
Field cage
B = 1.5T (dBρ/B = 1.6%)
10⁶/spill K- beam
E = 180 V/cm
GEM, Gating grid,
Read-out pad


Diamond Target
& Target holder
Trigger scintillators
Superconducting
Helmholtz coil
K⁻ beam
Dead layers
K⁺
p
π
Λ
Pad layers
TPC outer volume
& Field cage

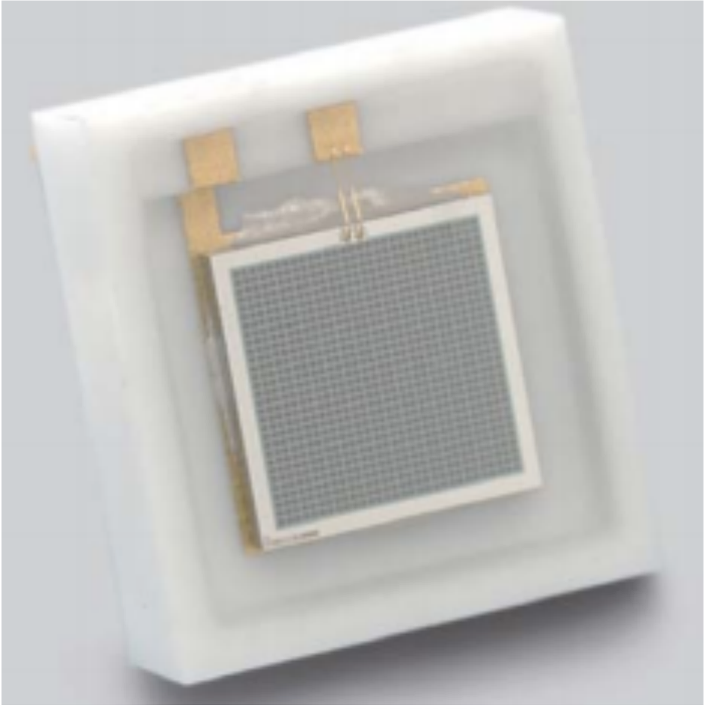
MPPC?

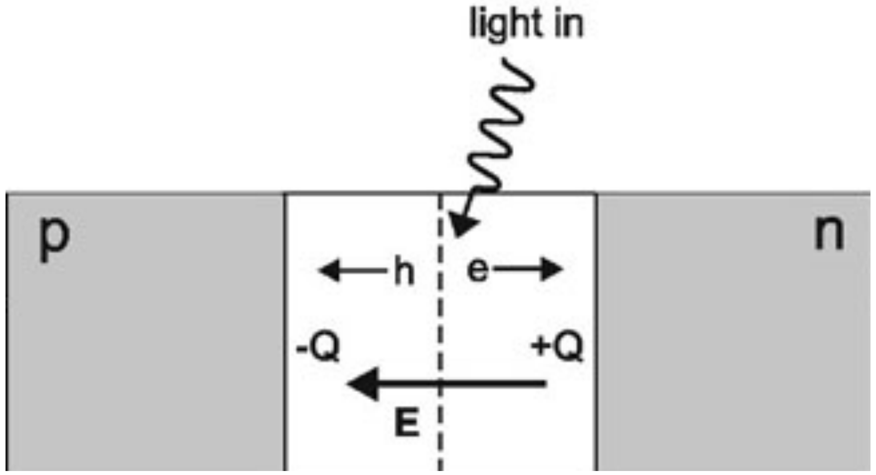
MPPC

- multi-pixel photon counter
- photodiode pixels

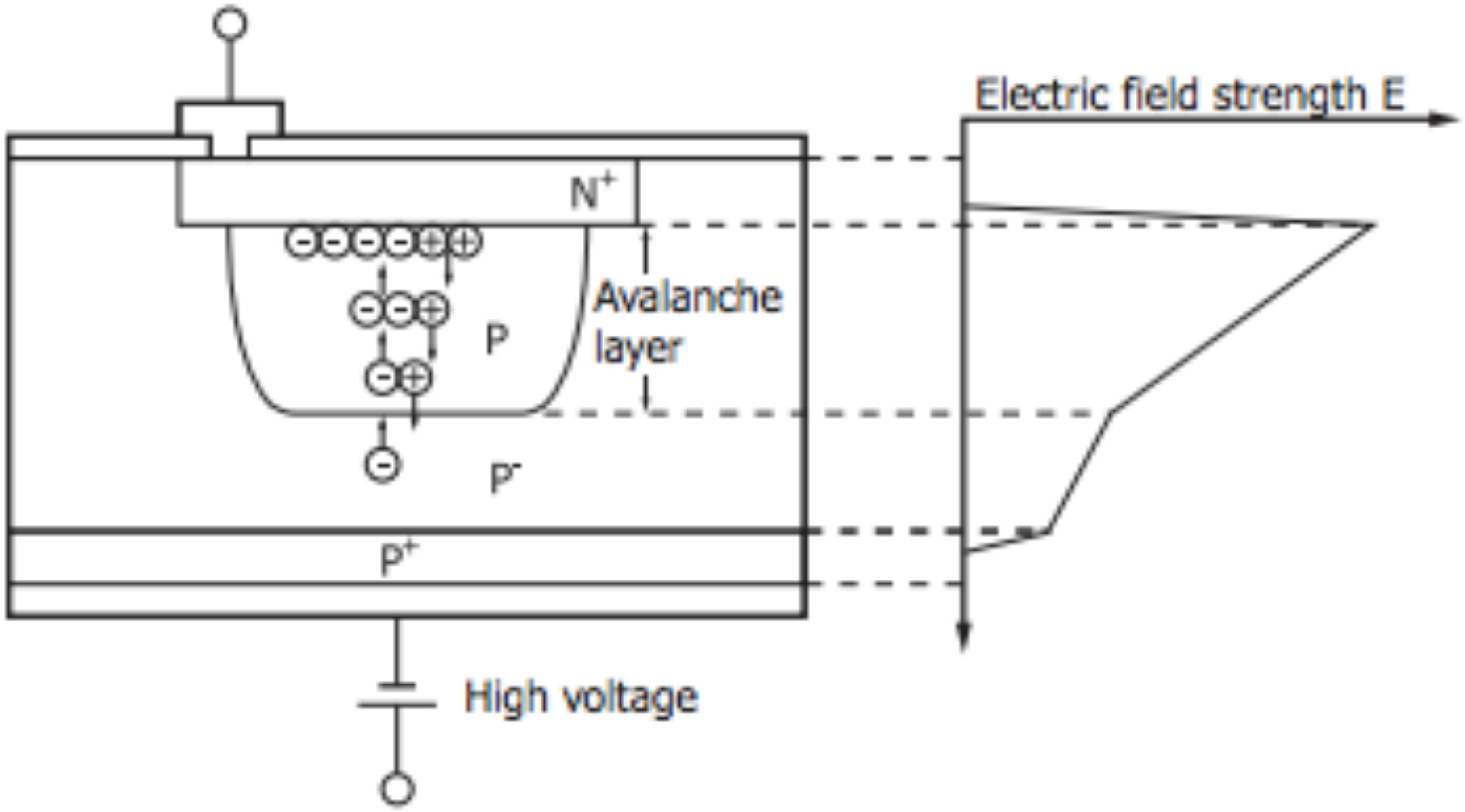
Photodiode

- photoelectric effect



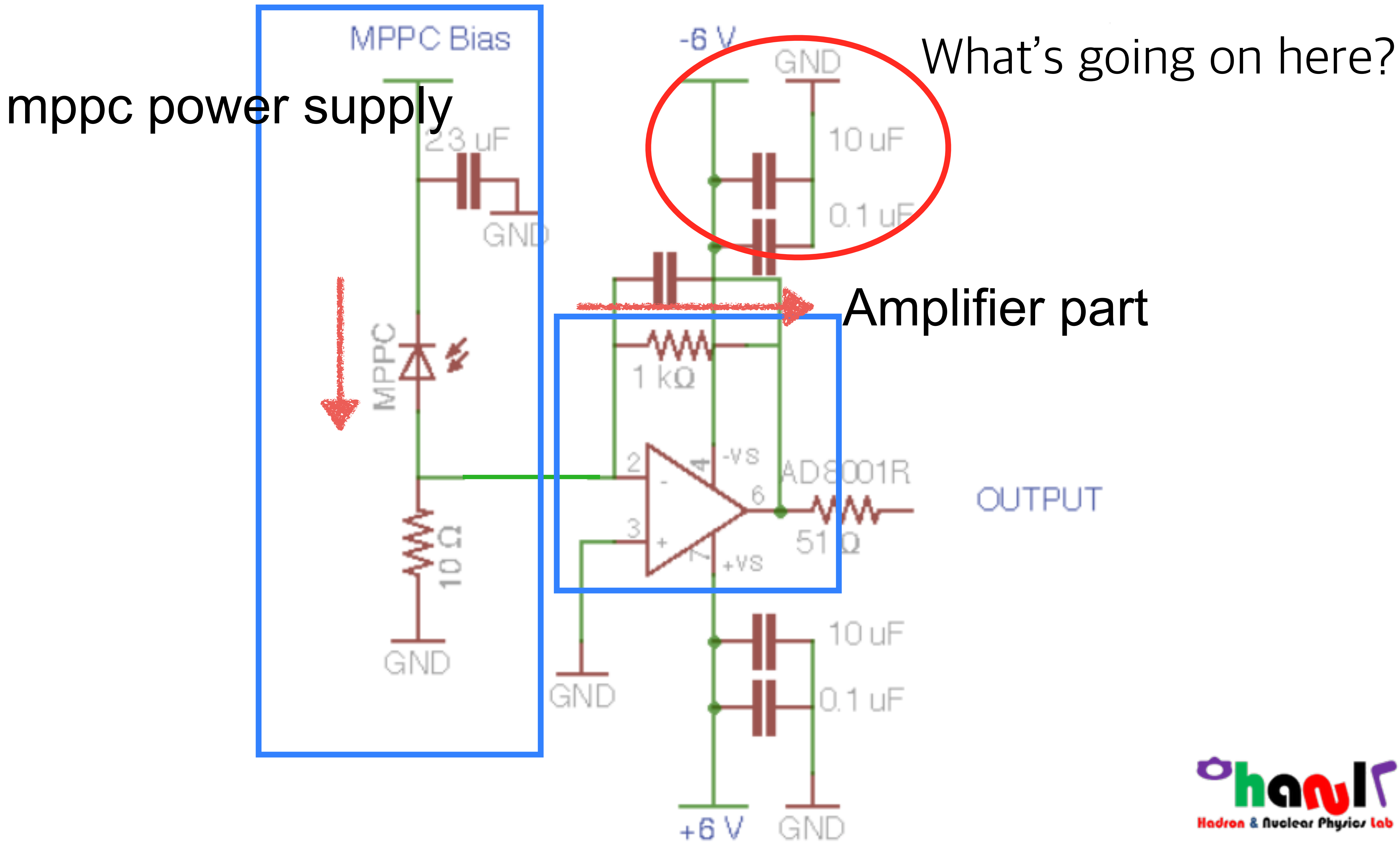


Si APD

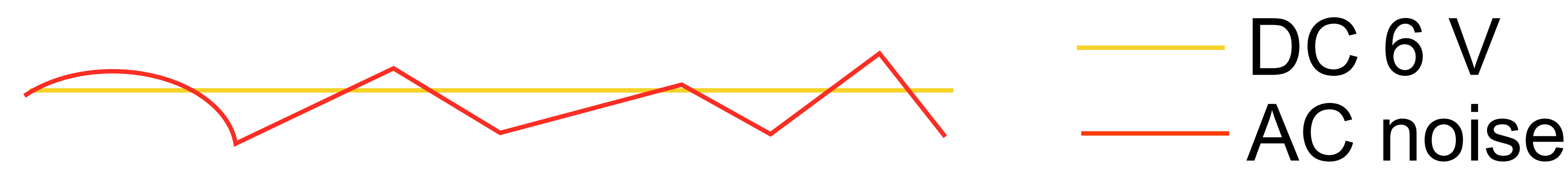


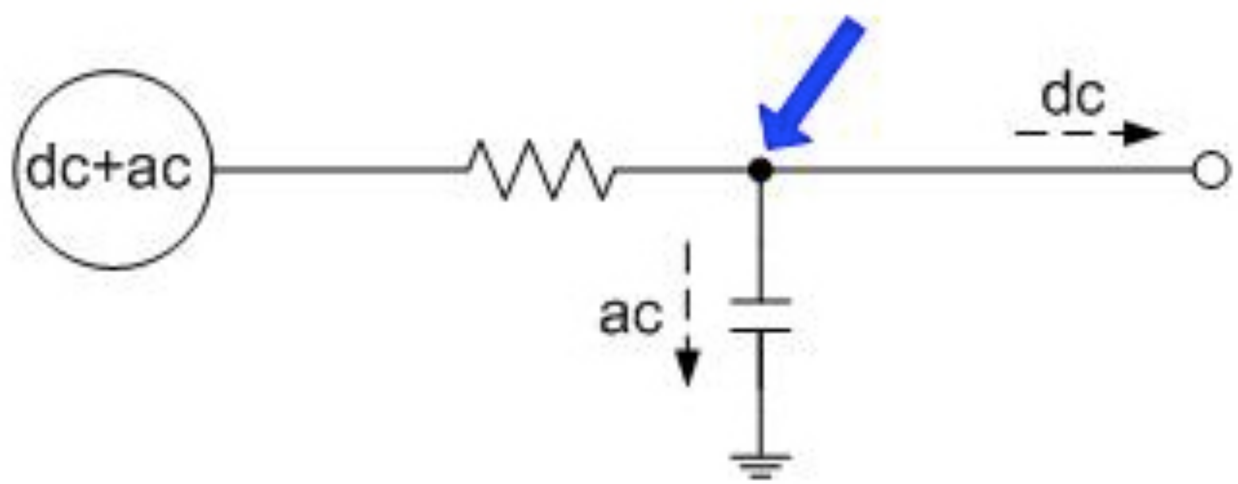
- Avalanche multiplication

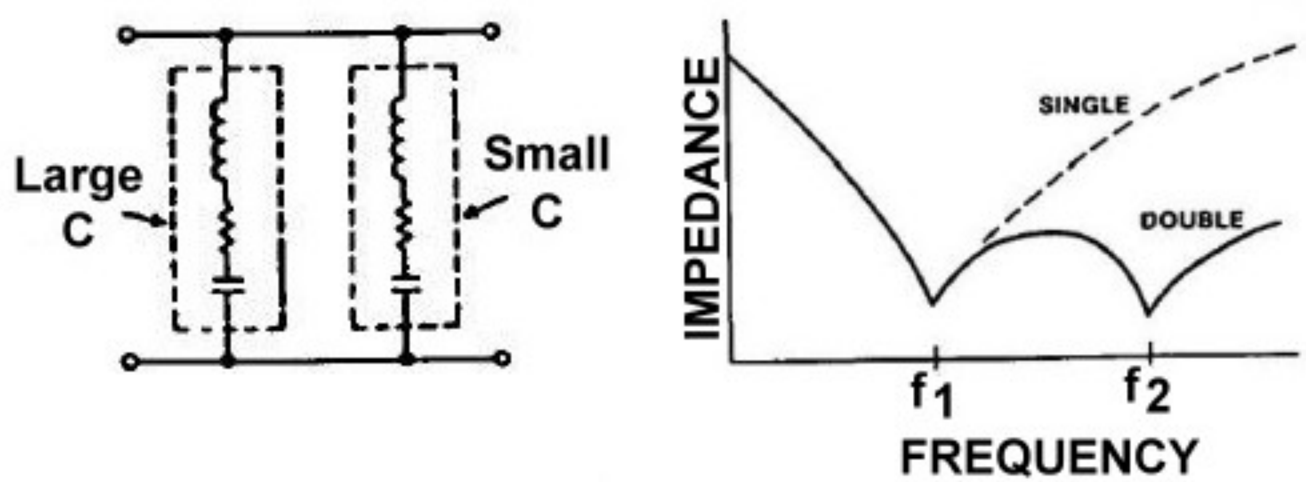
Circuit Design



Bypassing



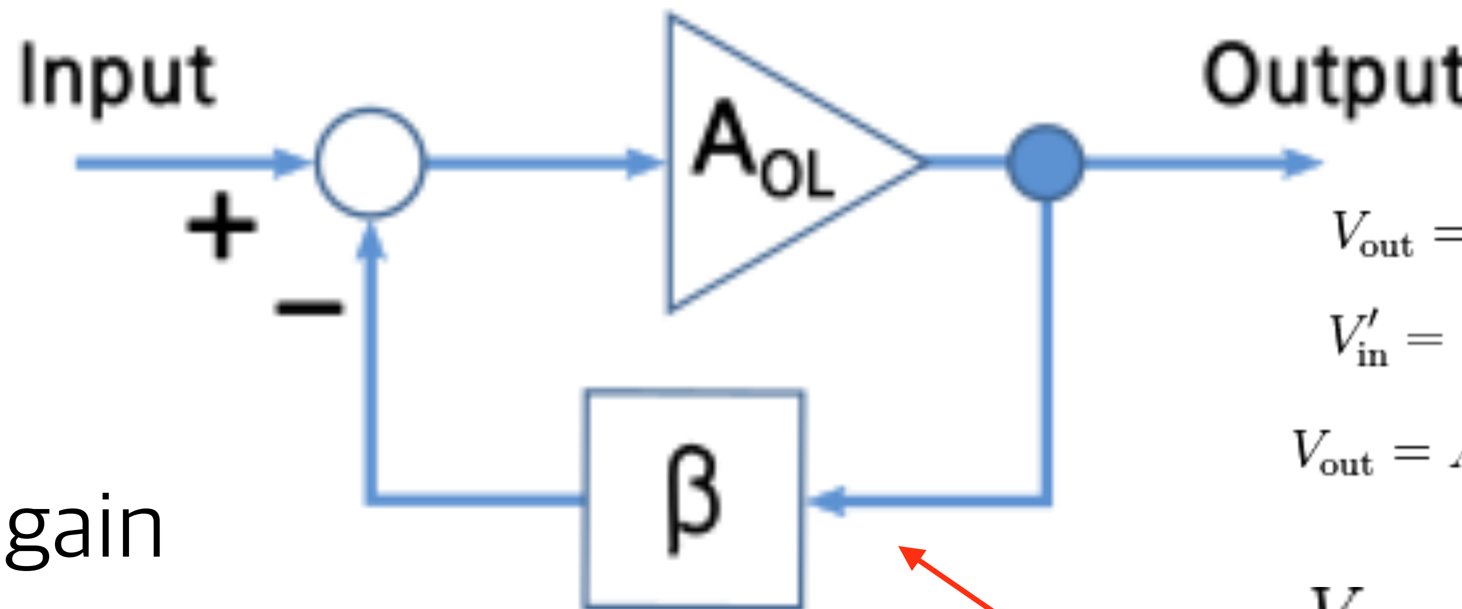




Parallel Capacitor Frequency Response

$$X_C = \frac{1}{2\pi f C}$$

Negative Feedback Amplifier



$$V_{\text{out}} = A_{\text{OL}} \cdot V'_{\text{in}}$$

$$V'_{\text{in}} = V_{\text{in}} - \beta \cdot V_{\text{out}}$$

$$V_{\text{out}} = A_{\text{OL}}(V_{\text{in}} - \beta \cdot V_{\text{out}})$$

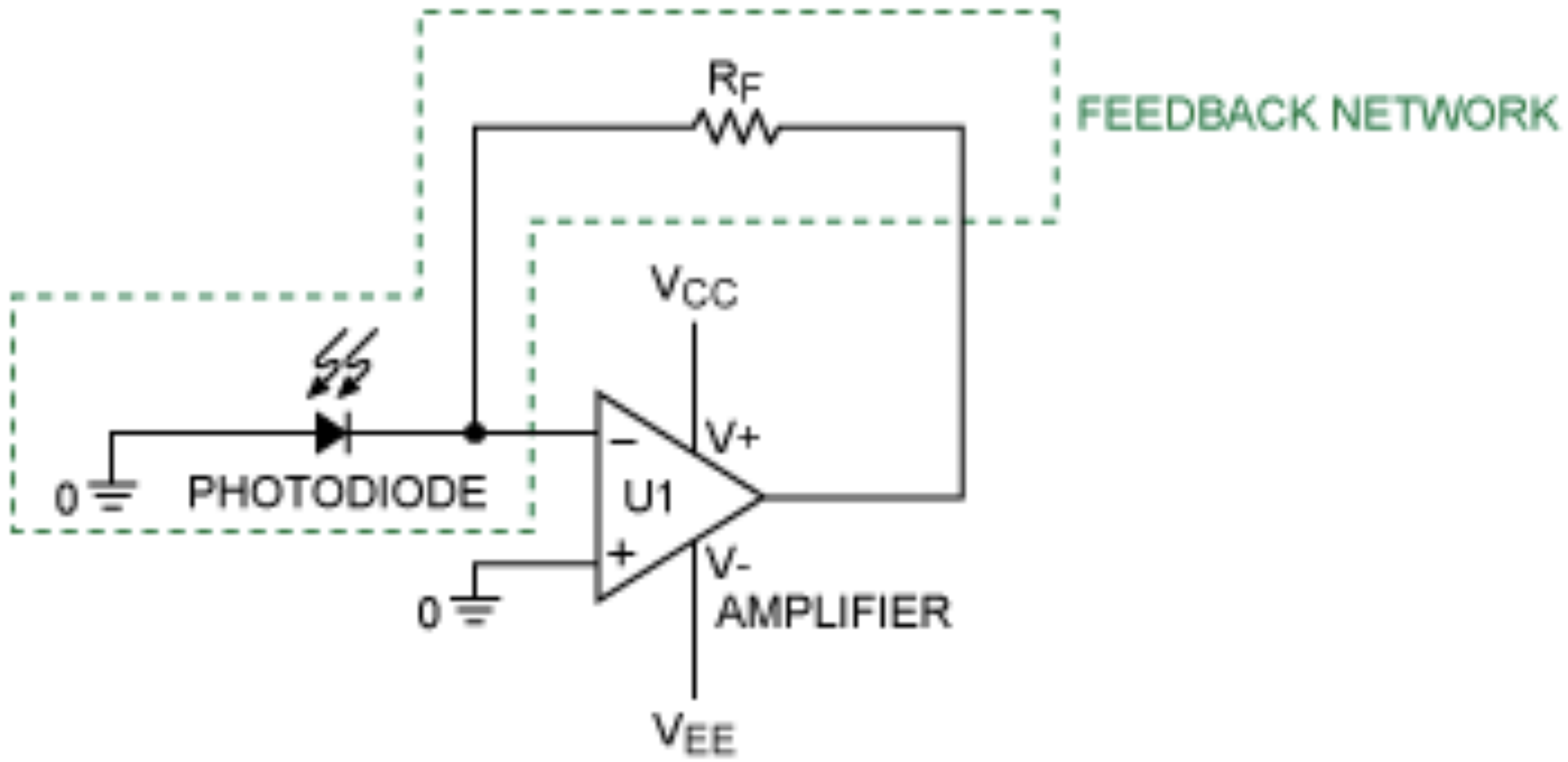
$$\frac{V_{\text{out}}}{V_{\text{in}}} = \frac{A_{\text{OL}}}{1 + \beta \cdot A_{\text{OL}}}$$

A_{OL}:open loop gain

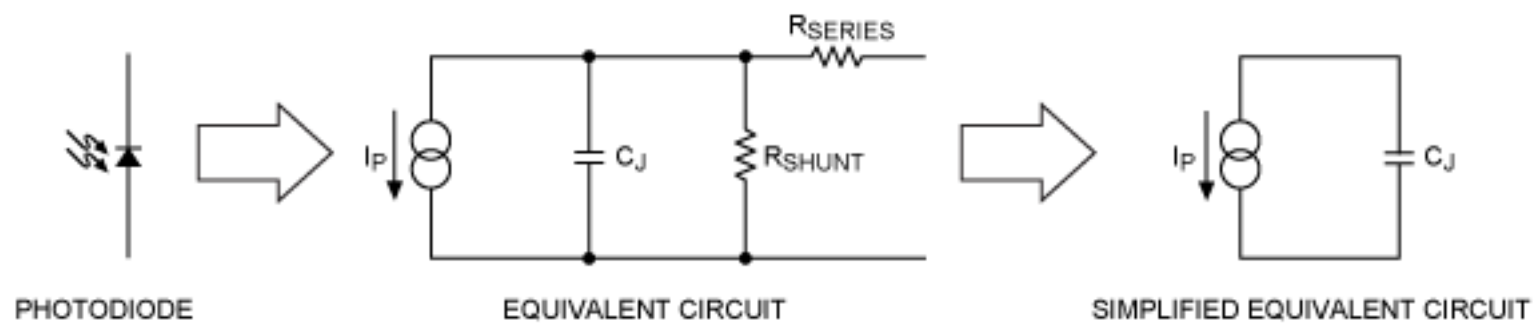
β:feedback factor

Phase upside down

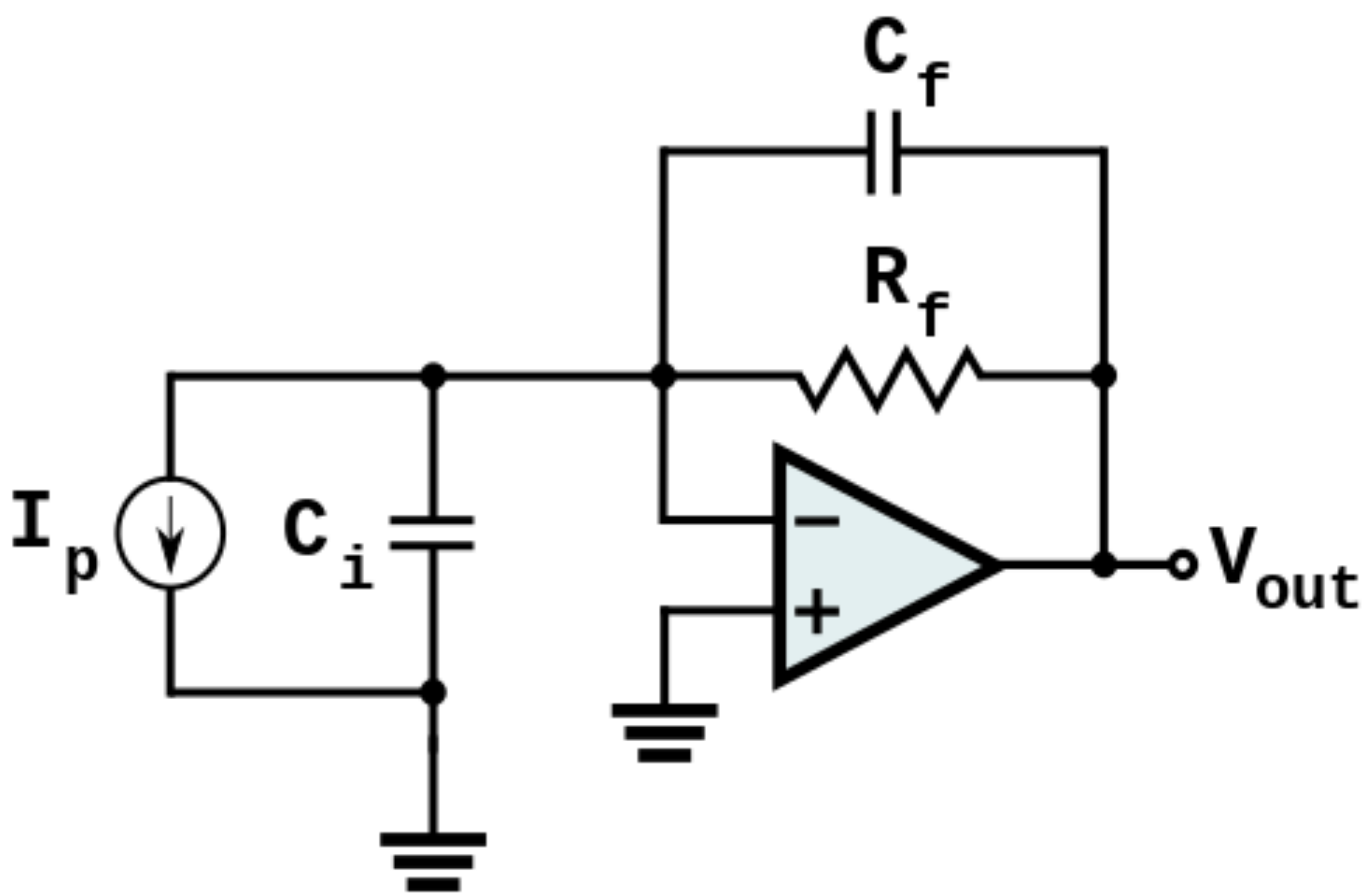
Transimpedance Amplifier



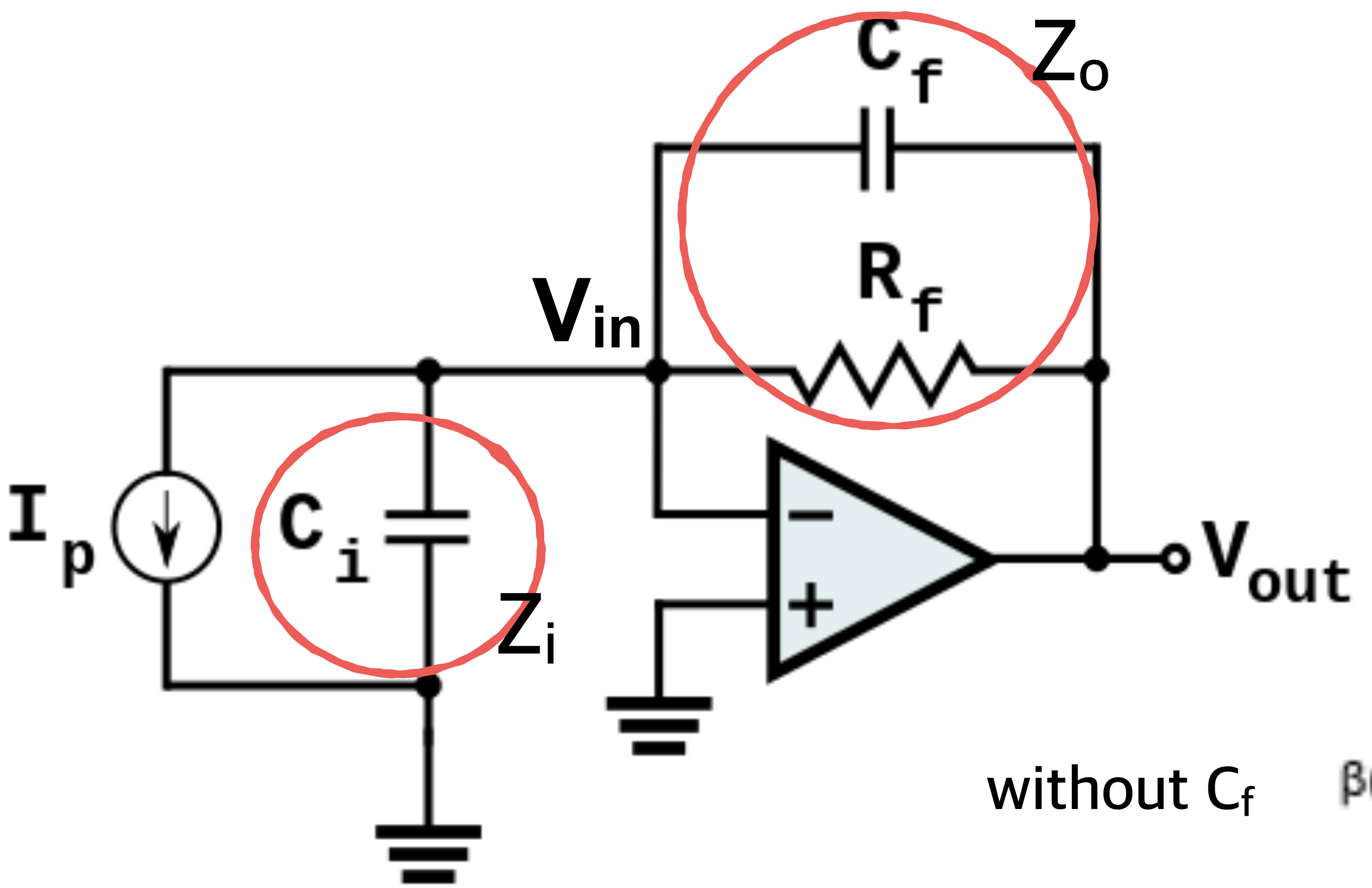
Equivalent Circuit



RSERIES = 0
RSHUNT = Infinity



Feedback Network



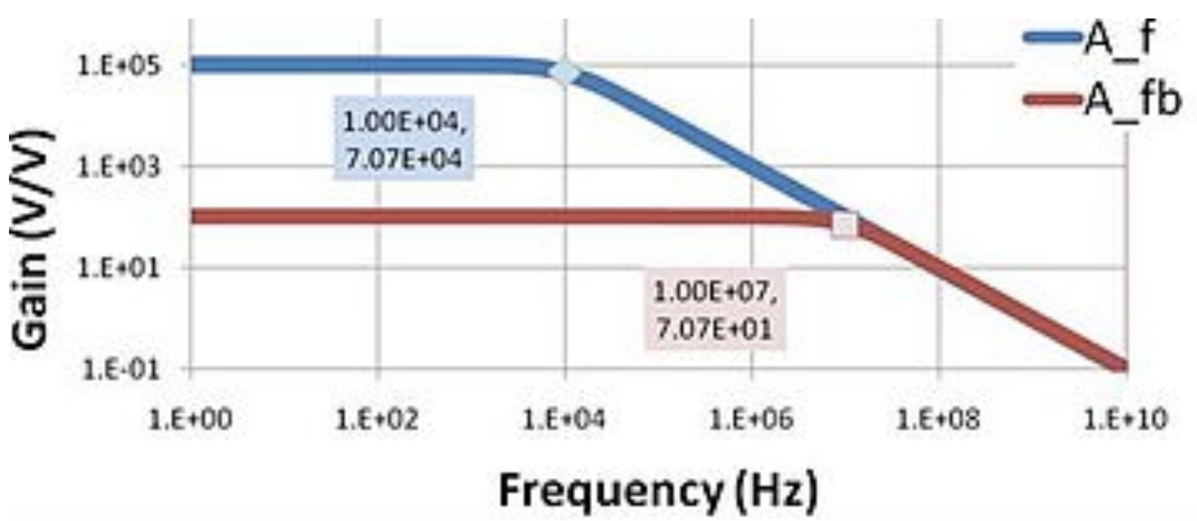
feedback factor

$V_{in}/V_{out}=Z_o/(Z_i+Z_o)$

without C_f $\beta(j\omega) = \frac{X_{Ci}}{Z_F + X_{Ci}} = \frac{1}{1 + j\omega R_F C_i}$

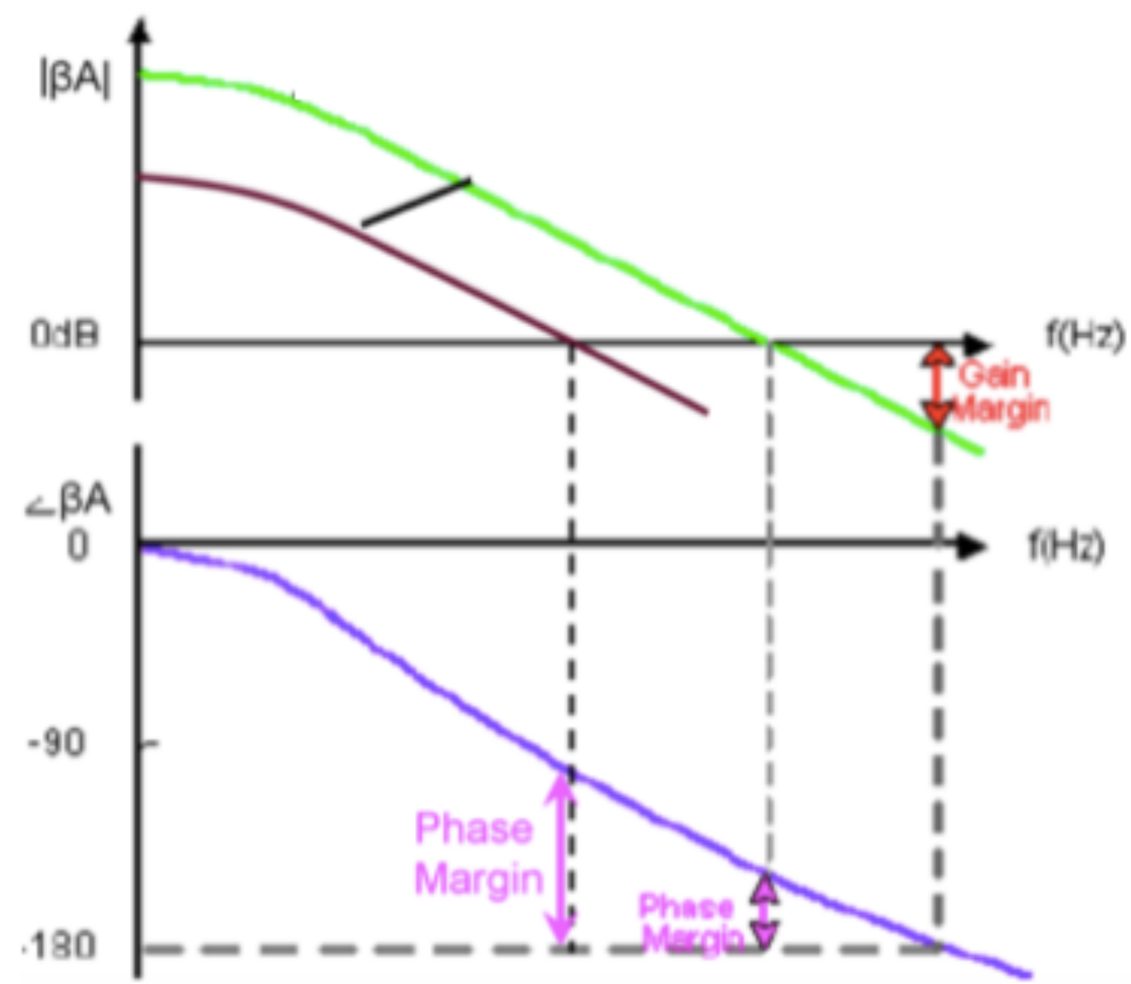
with C_f $\beta(j\omega) = \frac{X_{Ci}}{R_F||X_{CF} + X_{Ci}} = \frac{1 + j\omega R_F C_F}{1 + j\omega R_F (C_i + C_F)}$

High Frequency Response



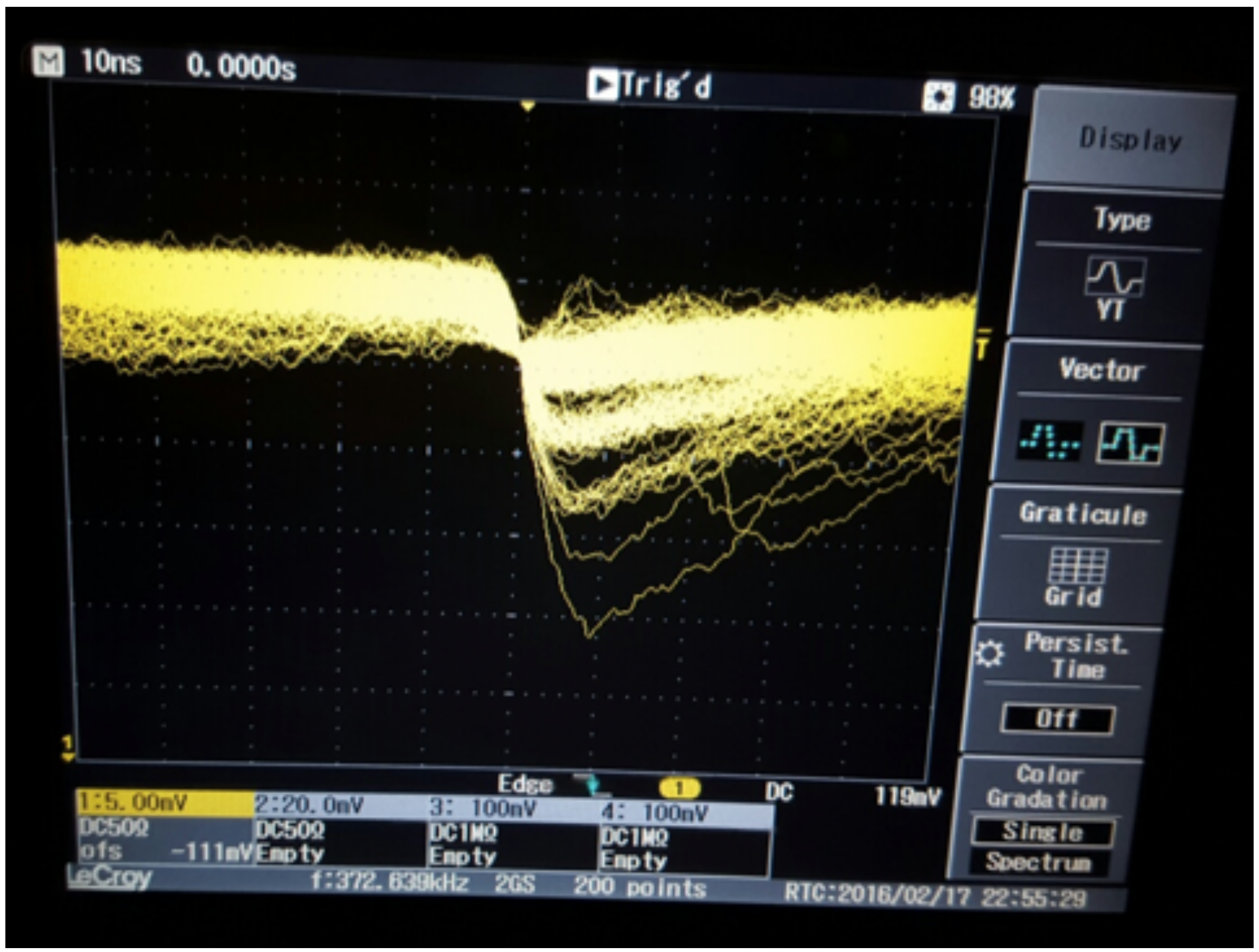
$$A_{\mathrm{OL}}(f) = \frac{A_0}{1 + jf/f_{\mathrm{C}}}$$

$$\begin{aligned} A_{\mathrm{FB}}(f) &= \frac{A_{\mathrm{OL}}}{1 + \beta A_{\mathrm{OL}}} \\ &= \frac{A_0/(1 + jf/f_{\mathrm{C}})}{1 + \beta A_0/(1 + jf/f_{\mathrm{C}})} \\ &= \frac{A_0}{1 + jf/f_{\mathrm{C}} + \beta A_0} \\ &= \frac{A_0}{(1 + \beta A_0)\left(1 + j\frac{f}{(1+\beta A_0)f_{\mathrm{C}}}\right)} \end{aligned}$$

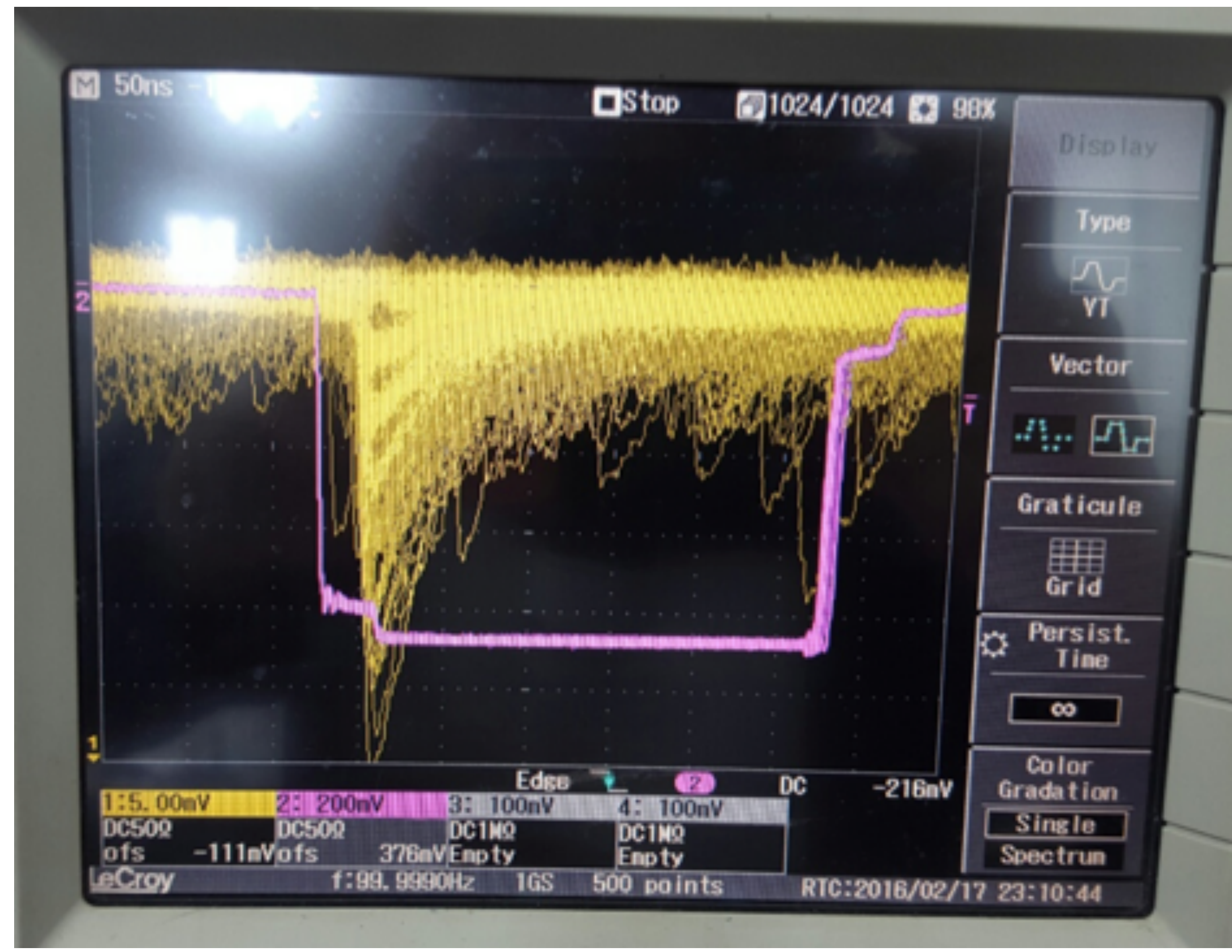


LED test

Results



Dark current



LED signals

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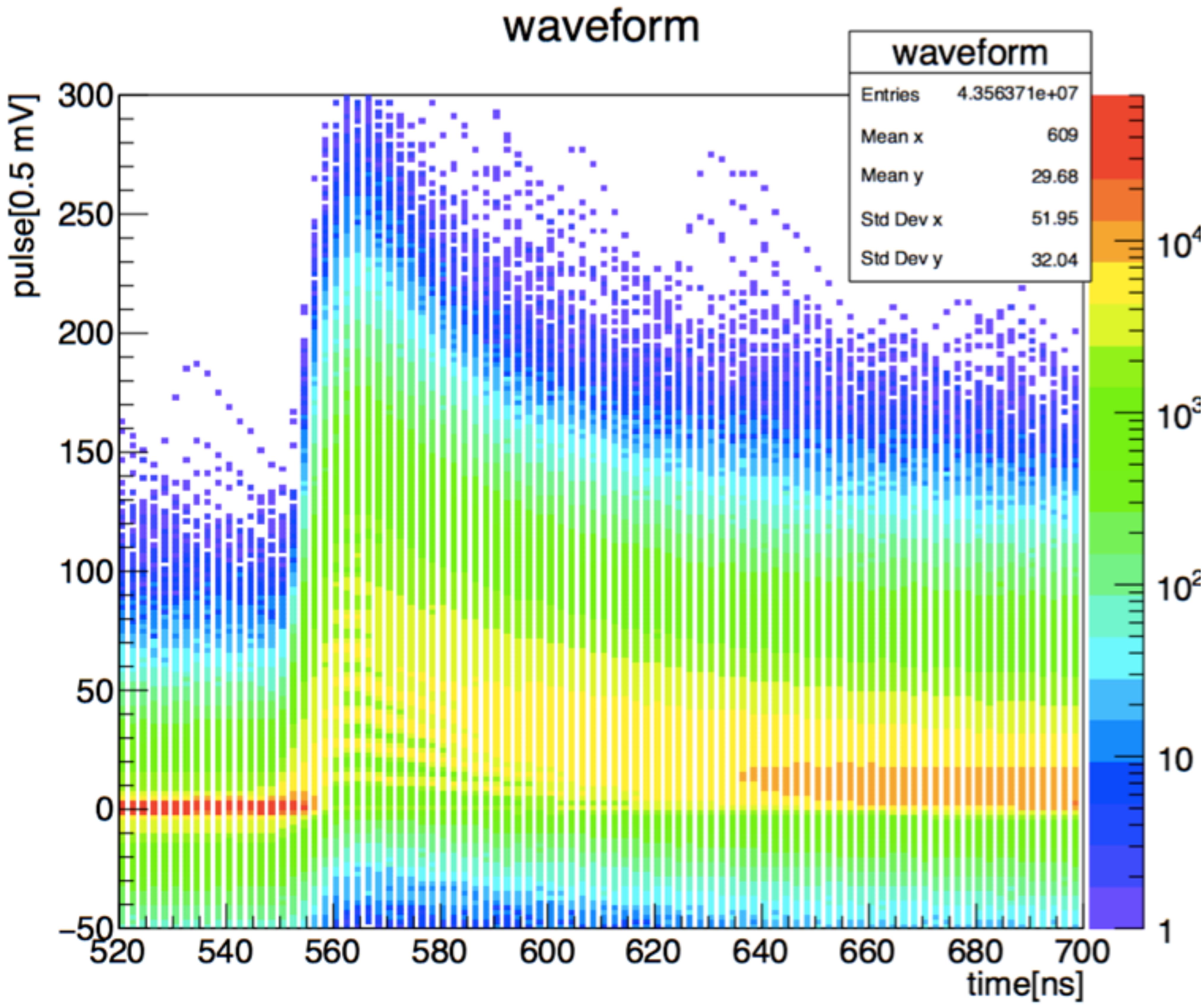

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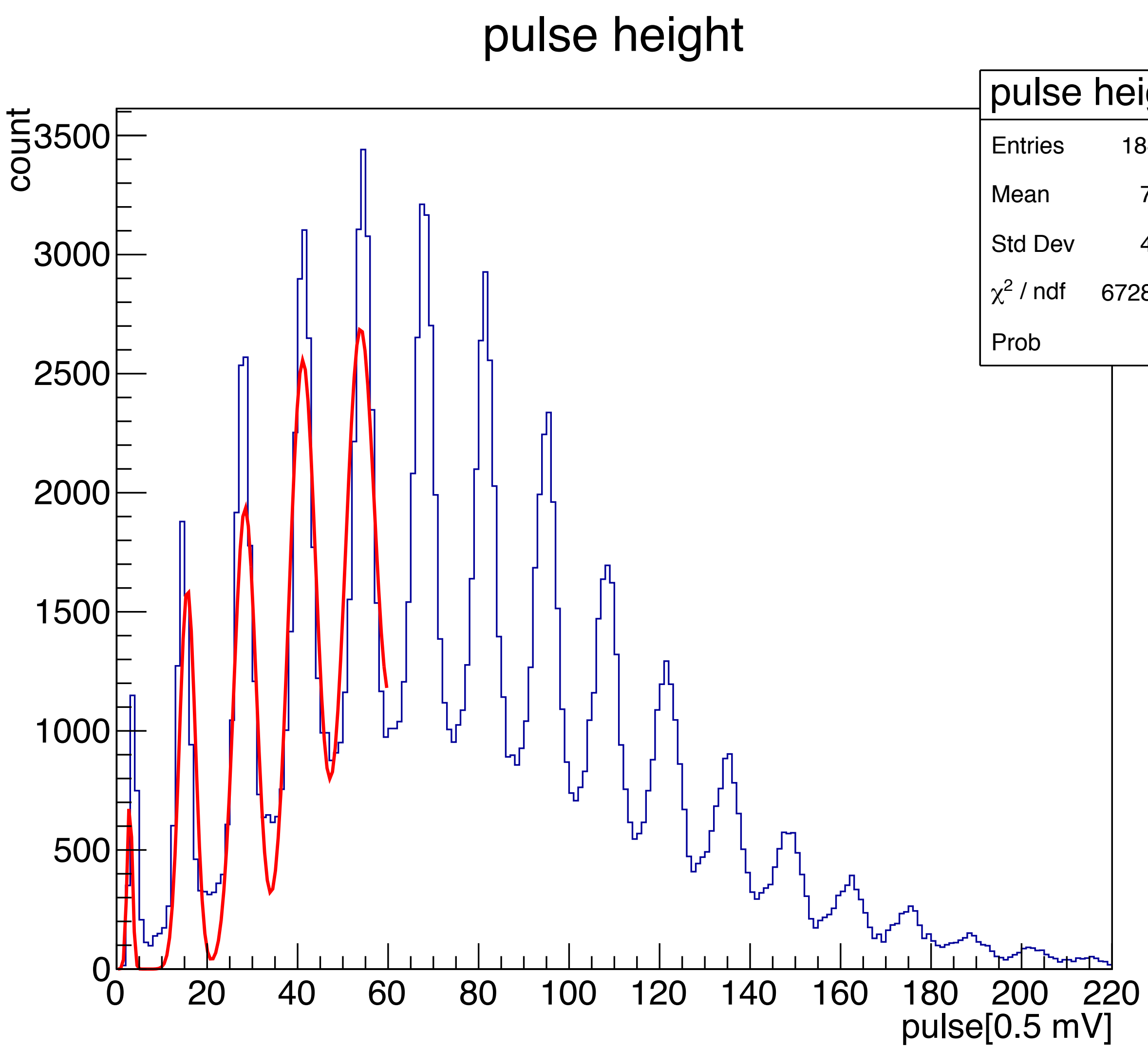
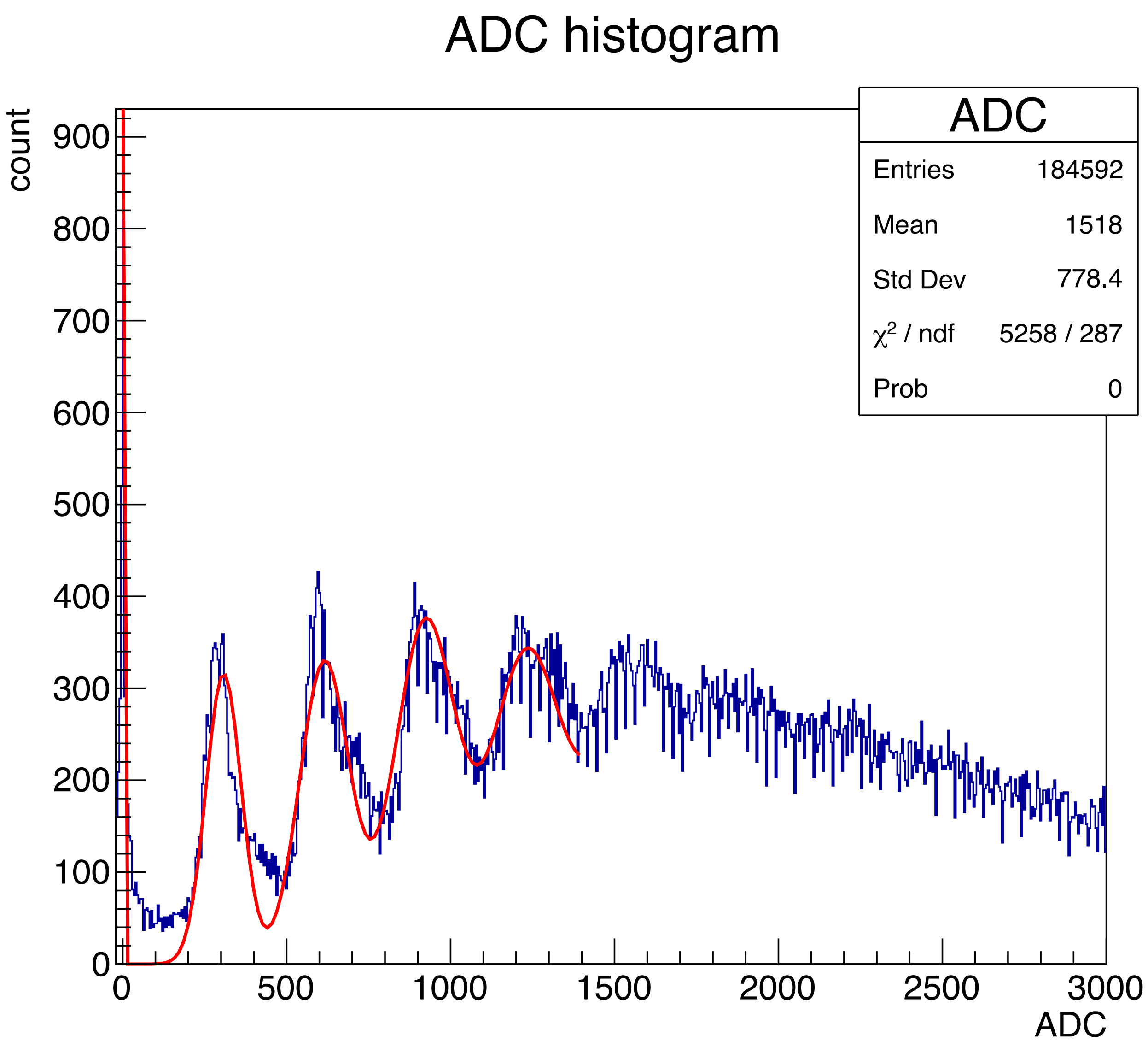


pulse height
pulse height
Entries 184592
Mean 77.66
Std Dev 40.88
χ2 / ndf 6728 / 52
Prob 0
count
pulse[0.5 mV]



ADC histogram
ADC
Entries 184592
Mean 1518
Std Dev 778.4
χ2 / ndf 5258 / 287
Prob 0
count
ADC