Summer 2017 High-B Run
Gain Evaluation of Planacon XP85112
10-μm pore size

Progress Report

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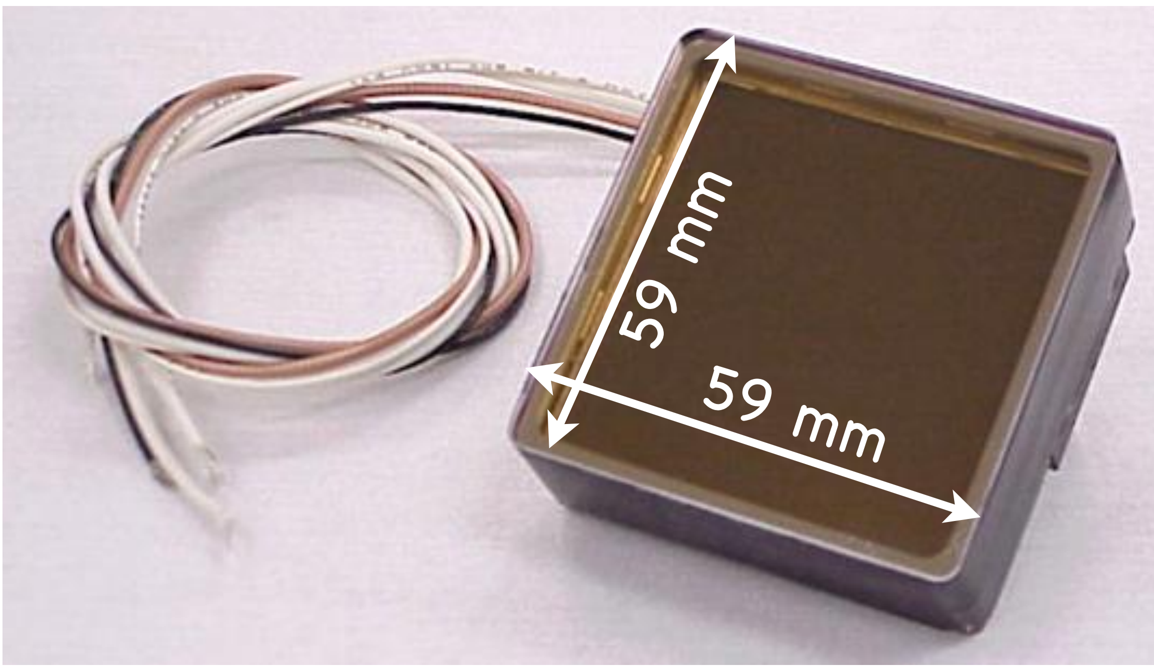
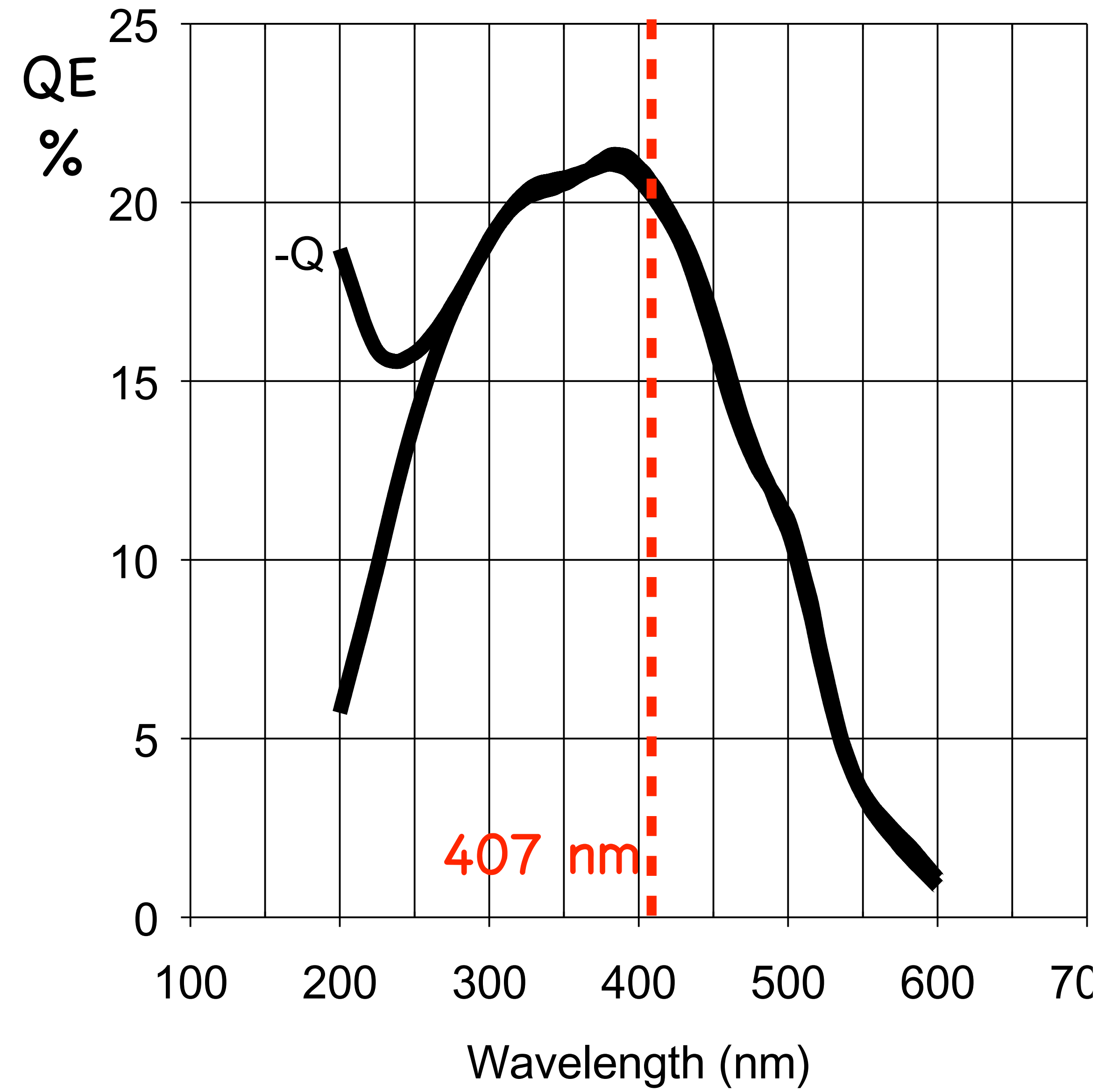
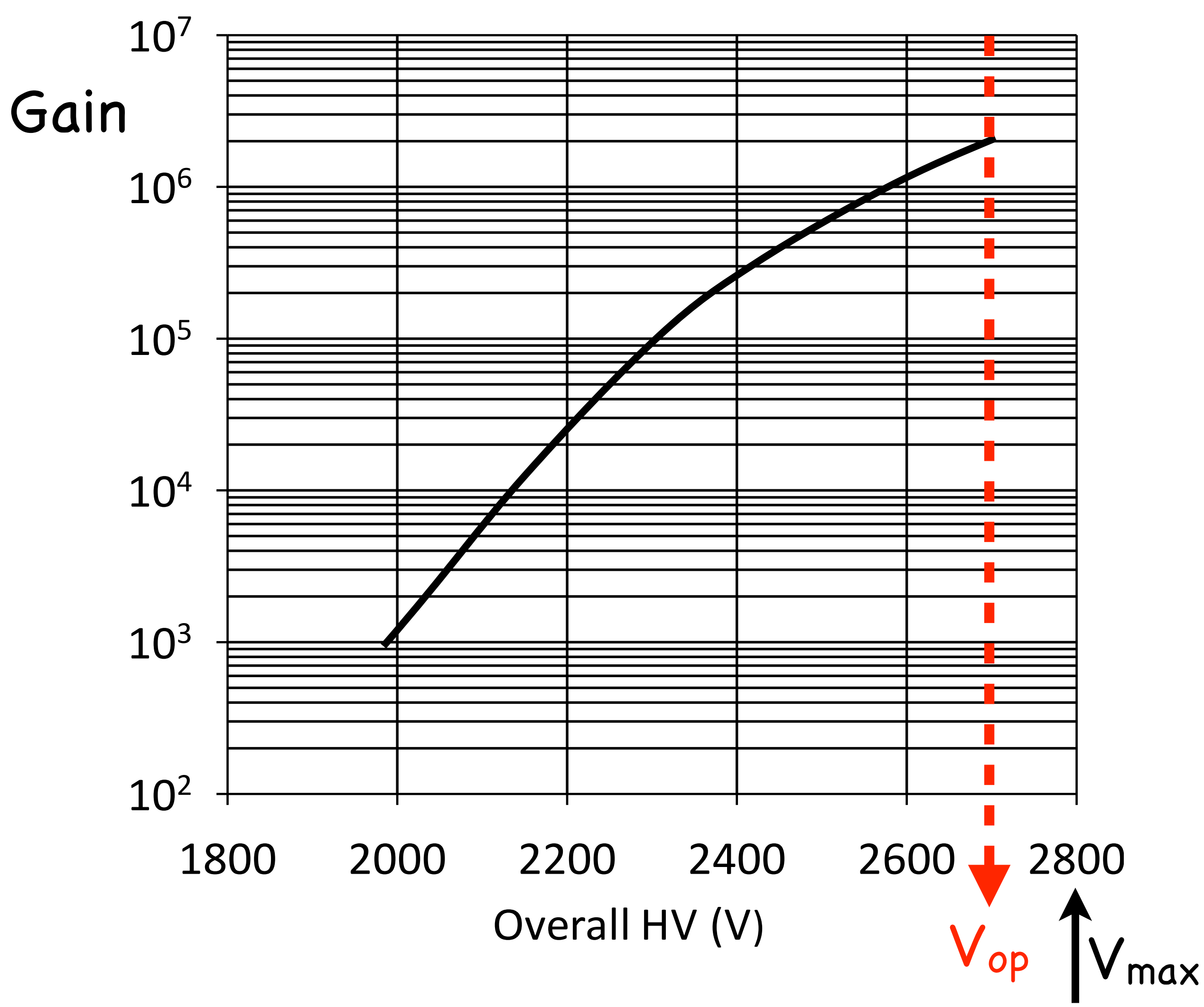
EIC-PID Consortium Meeting, 14 August 2017

Main Characteristics of the Sensor







Operational Parameters

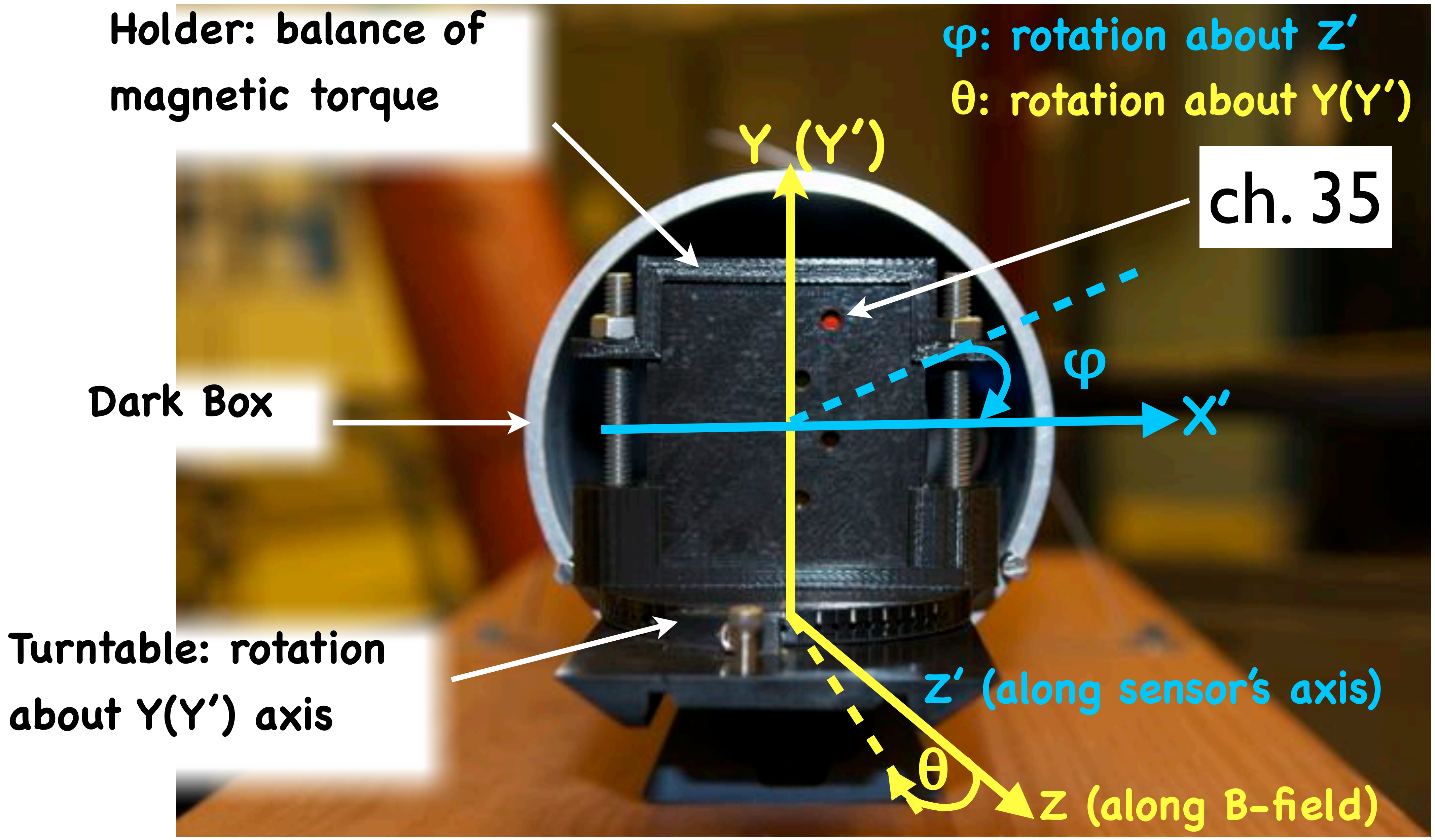
V_{op} = –2.7 kV

QE ~ 20%

8x8 channels

53x53 mm^2 active area

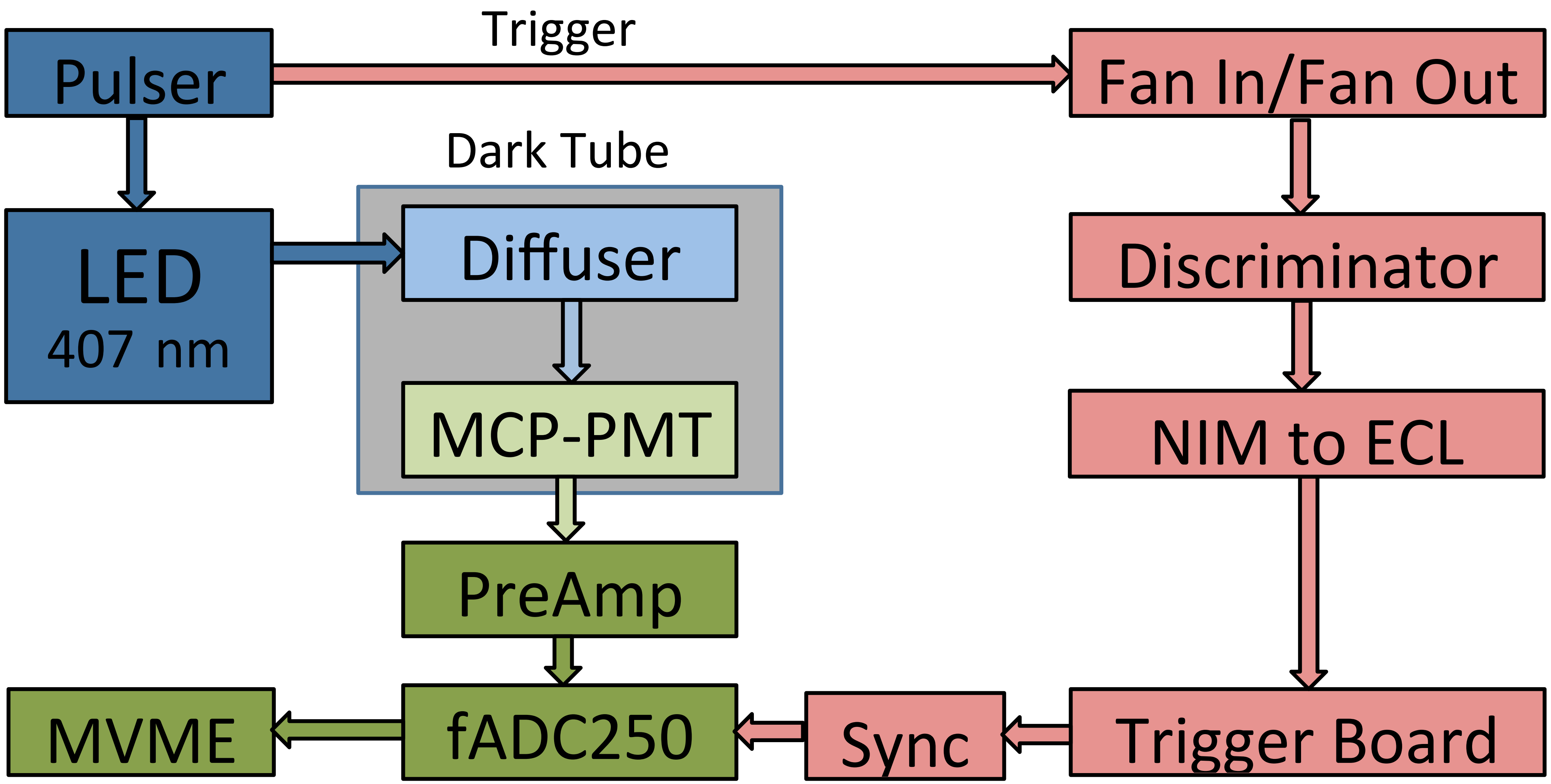
Test Setup



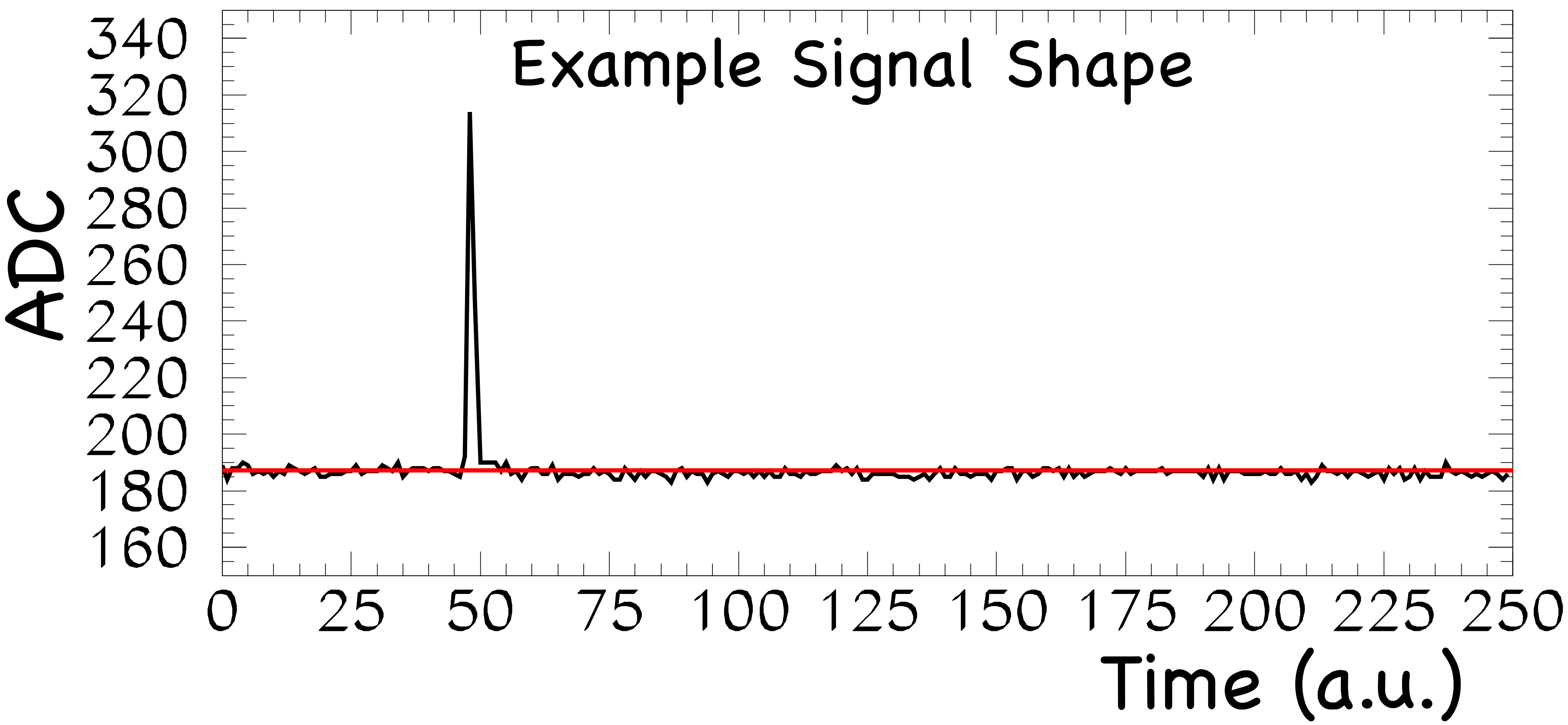
θ rotation: [0°, 20°], [0°, -20°]

φ rotation: fixed values of 0°, 90°, 180°, and 270°.

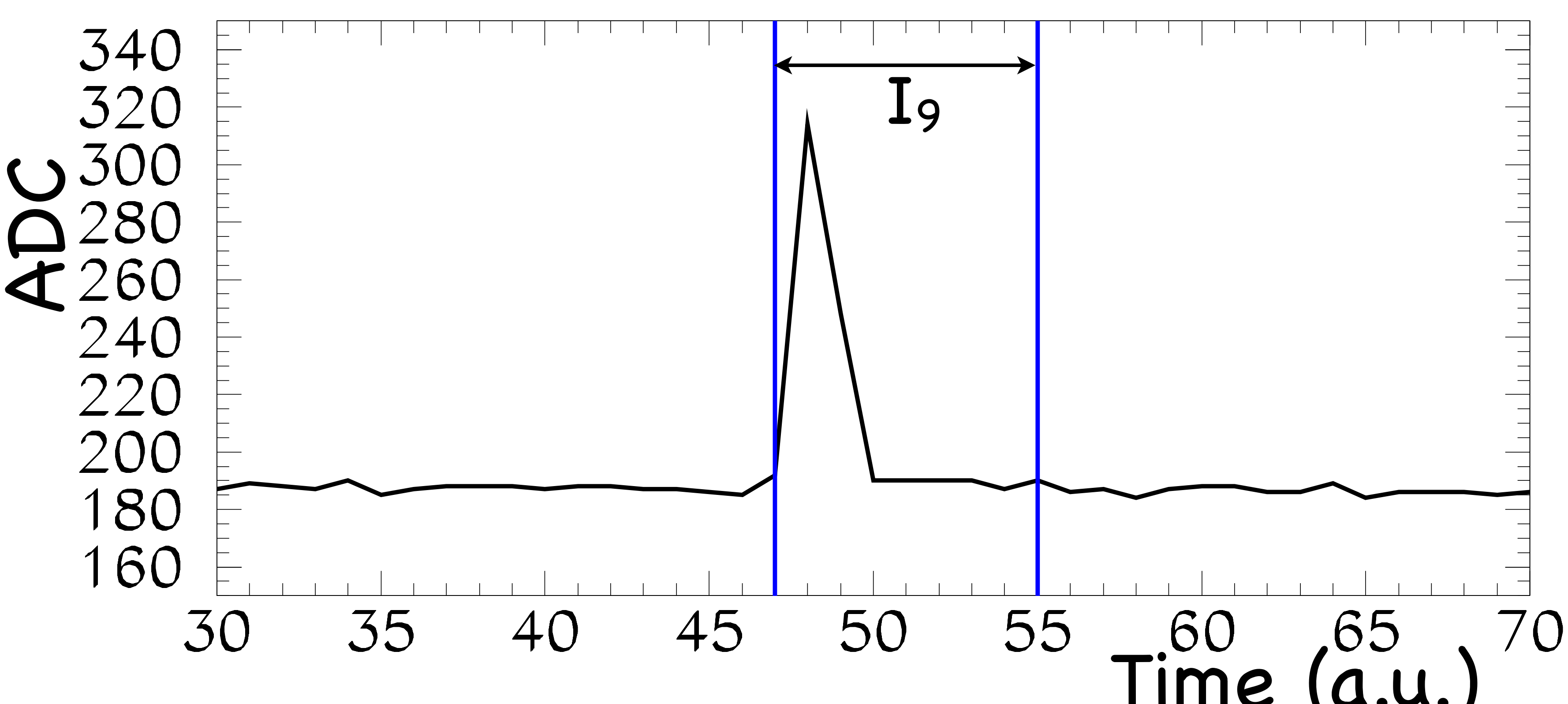
Read-Out and Light Source



Gain Determination (Part 1)



- high voltage: -2.7 kV
- B=0 T, θ=0°, φ=0°
- narrow peak with a very long tail
- max. ADC value at sample s_{max} = 48
- $I_9 = \sum_{i=s\max-1}^{s\max+7} ADC_i$



Gain Determination (Part 2)

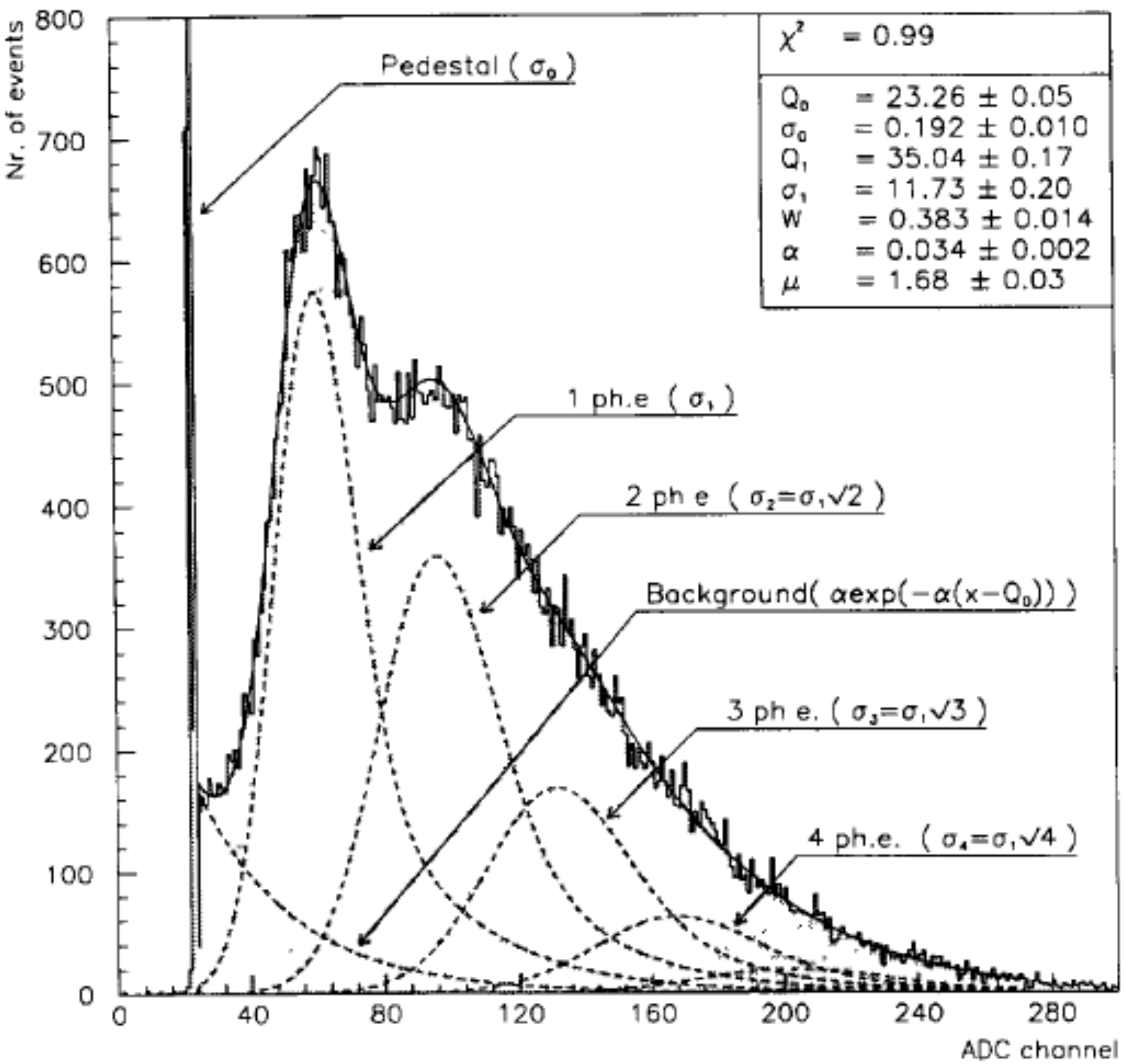


Fig. 2. Typical deconvoluted LED spectrum (EMI-9814B photomultiplier).

$$S_{Real}(x) = \int S_{Ideal}(x')B(x-x')dx' = \sum_{n=0}^{\infty} \frac{\mu^n e^{-\mu}}{n!} * \left[(1-w)G_n(x-Q_o) + wI_{G_n\otimes E}(x-Q_o)\right],$$

$$I_{G_n\otimes E}(x-Q_o) = \int_{Q_o}^{x} G_n(x'-Q_o)\alpha\exp[-\alpha(x-x')]dx$$

$$= \frac{\alpha}{2} exp[-\alpha(x-Q_n-\alpha\sigma_n{}^2)]$$

$$* \left[\mathrm{erf}\left(\frac{|Q_0-Q_n-\alpha\sigma_n{}^2|}{\sigma_n\sqrt{2}}\right) + sign(x-Q_n-\alpha\sigma_n{}^2) * \mathrm{erf}\left(\frac{|x-Q_n-\alpha\sigma_n{}^2|}{\sigma_n\sqrt{2}}\right)\right]$$

$$Q_n = Q_o + nQ_1$$

$$\sigma_n = \sqrt{\sigma_o{}^2+\sigma_n{}^2} \approx \begin{cases} \sigma_n = 0, n = 0 \\ \sigma_n = \sqrt{n}\sigma_o, n > 0 \end{cases}$$

$$Q = \frac{f}{A}\cdot Q_1$$

$$G = \frac{Q}{q\cdot N_{phe}} = \frac{f}{A\cdot q}Q_1$$

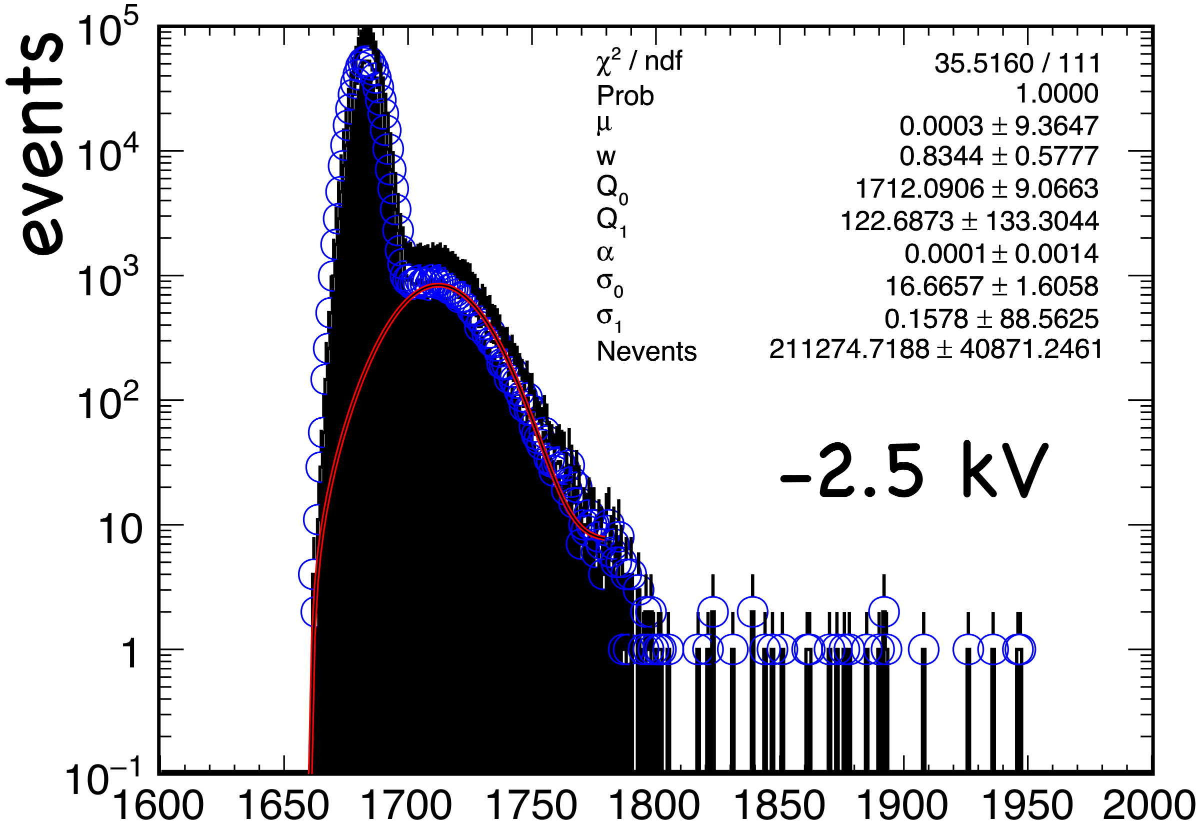
Q_1 : position of single phe peak above the pedestal Q_0

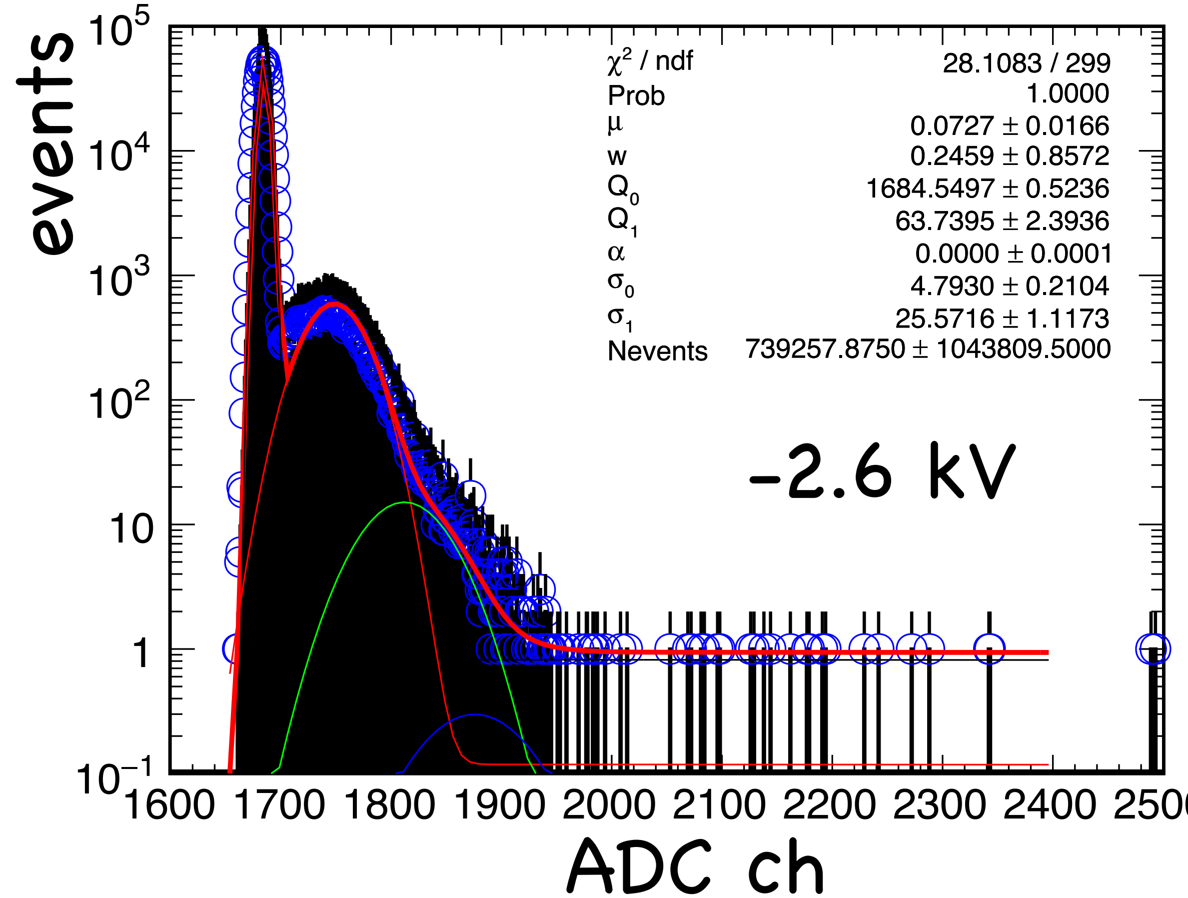
μ : average number of ph.e.

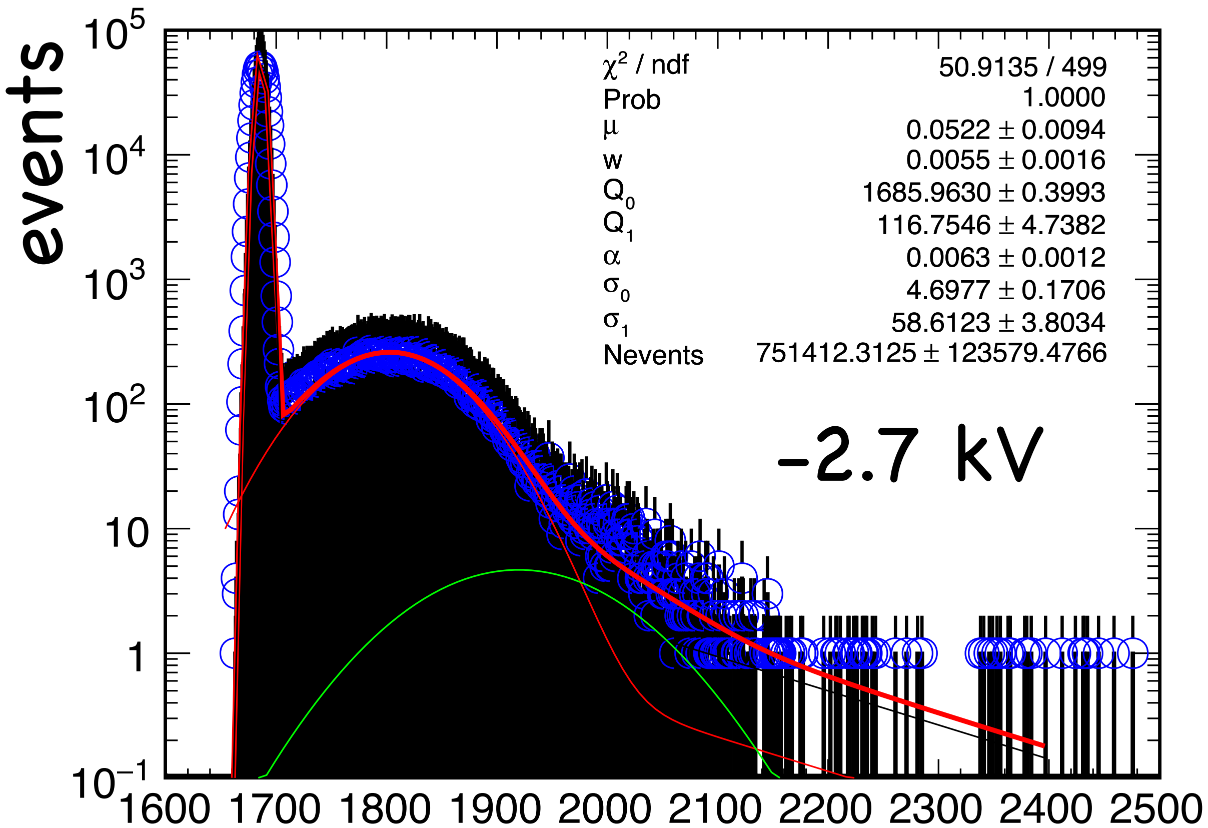
E.H. Bellamy et al. *Nucl. Instr. and Meth in Phys . Res. A* 339 (1994) 468-476

Gain Determination (Part 3)

θ=0°, φ=0°



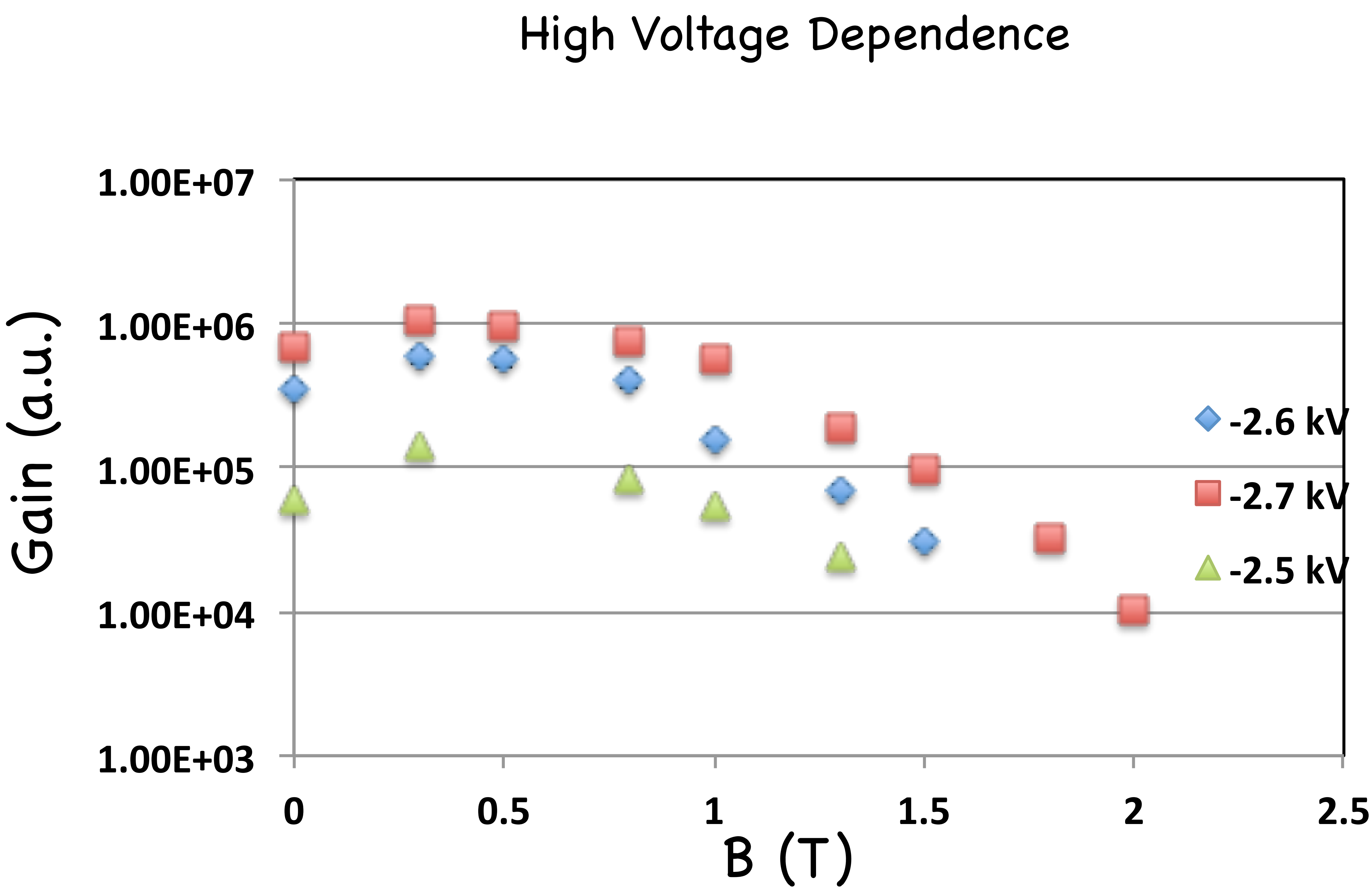




- Unambiguous fits when single ph.e. peak is well separated from pedestal.
- Gain fits work well up to 1 T. Above 1 T, gain is prorated from average signal area.
- 19.1±0.2 fC/ADCch.

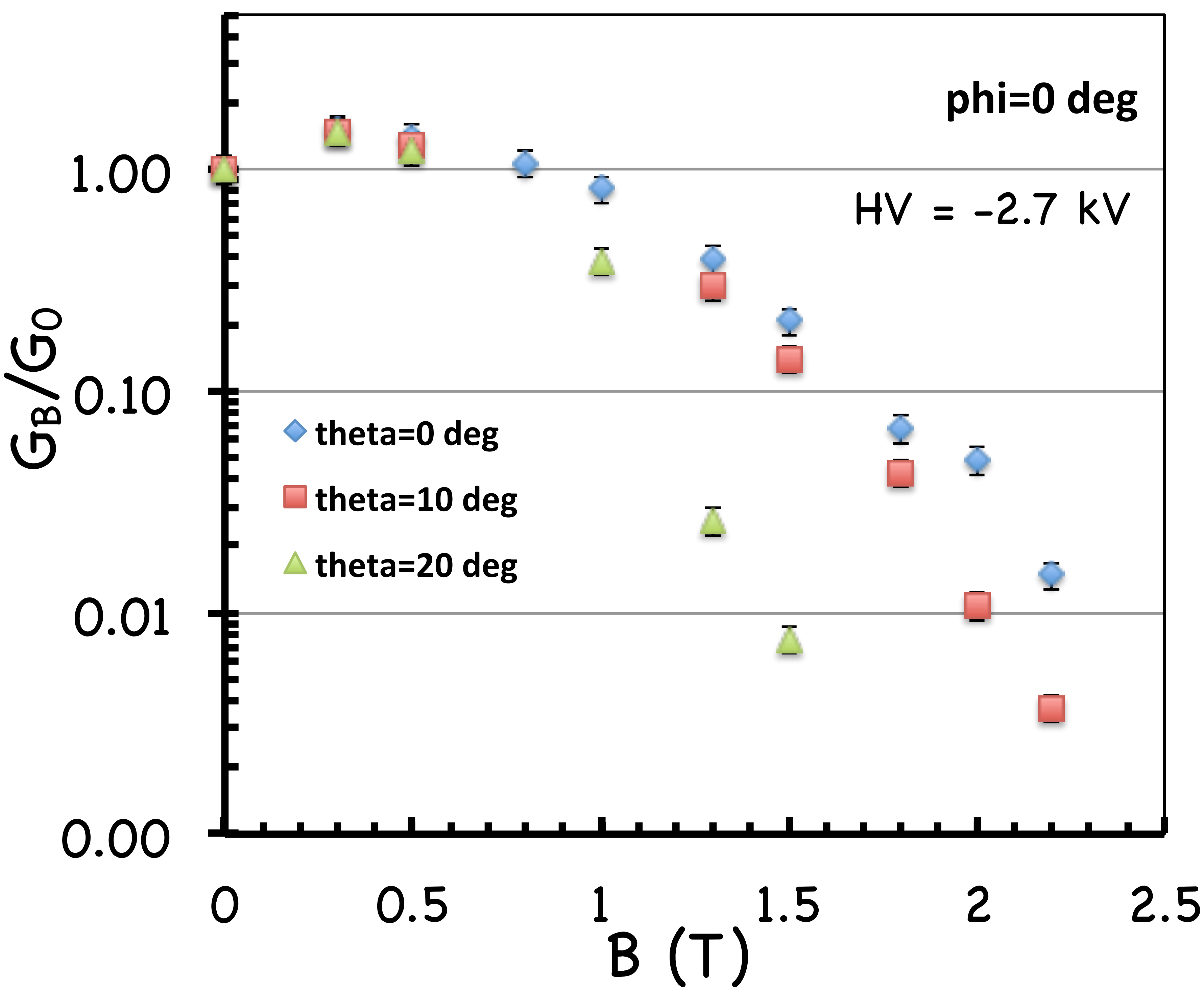
Gain Determination (Results)

θ=0°, φ=0°



Gain Evaluation of 10-μm Pore-Size MCP-PMT

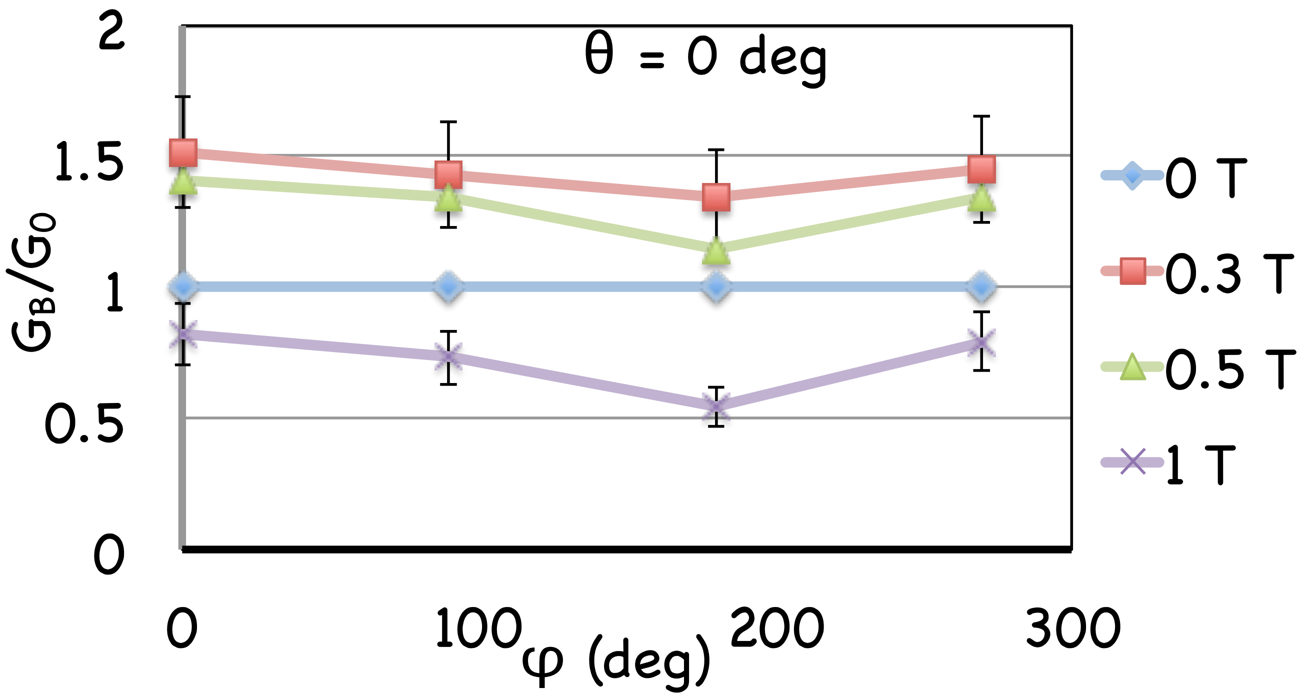
Photonis Planacon XP85112

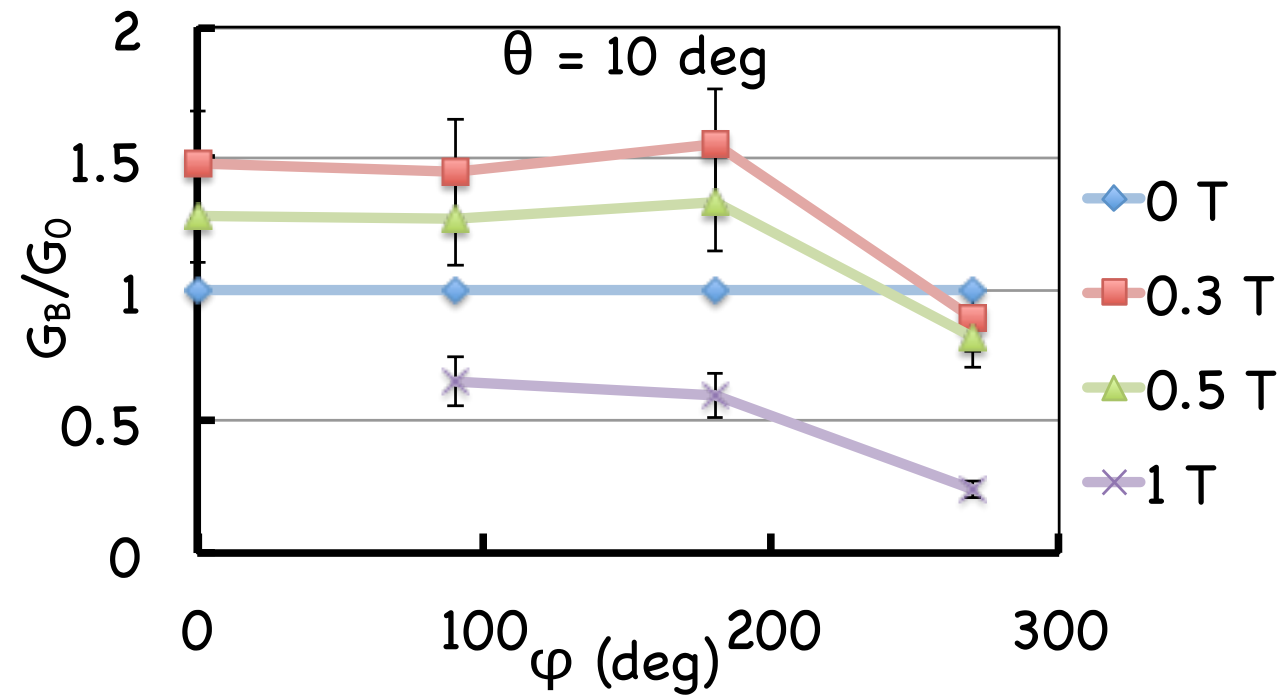


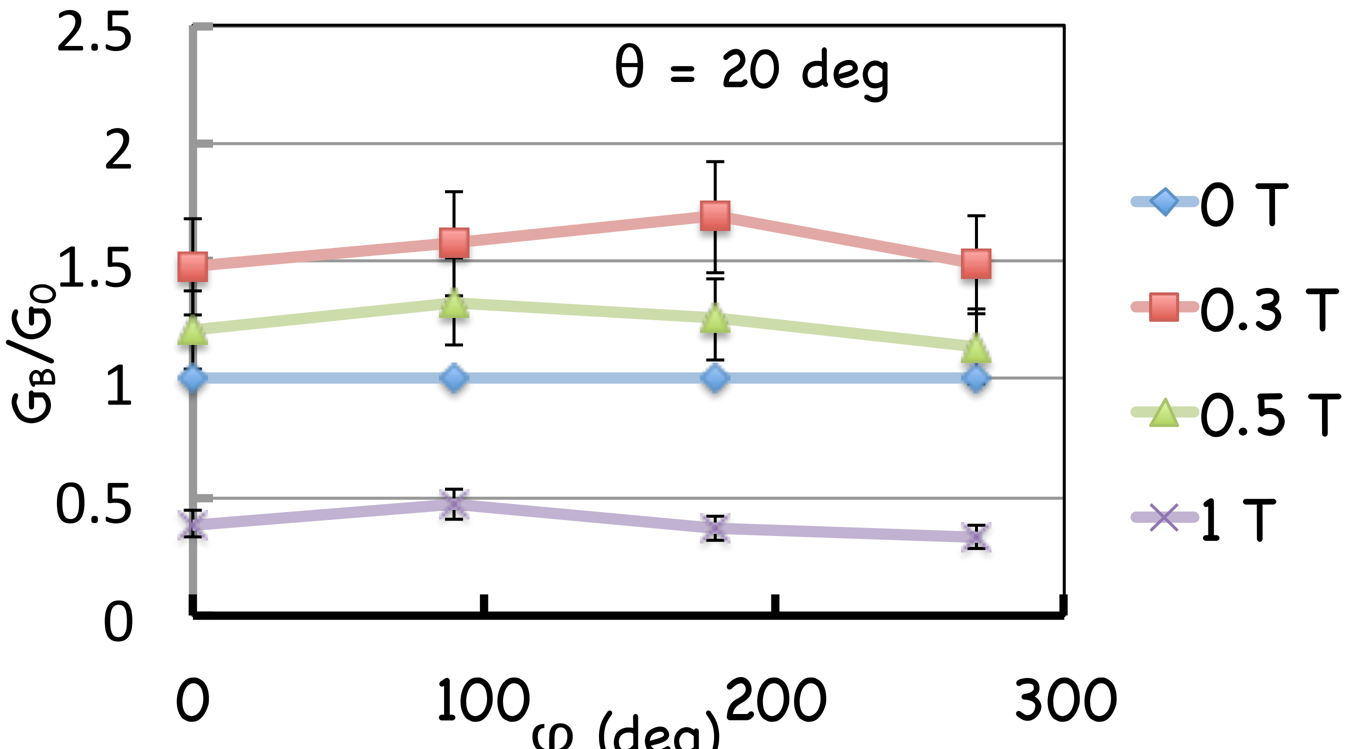
- Measurements performed at 96% of maximum allowed high voltage.
- Data
  - Maximum gain at 0.3 T.
  - B_{max} = 2.2 T.
  - Value of B_{max} strongly depends on orientation.
  - The larger the polar angle, the lower B_{max}.

Gain Evaluation of 10-μm Pore-Size MCP-PMT

Photonis XP85112







Azimuthal-angle dependence is correlated with the polar angle

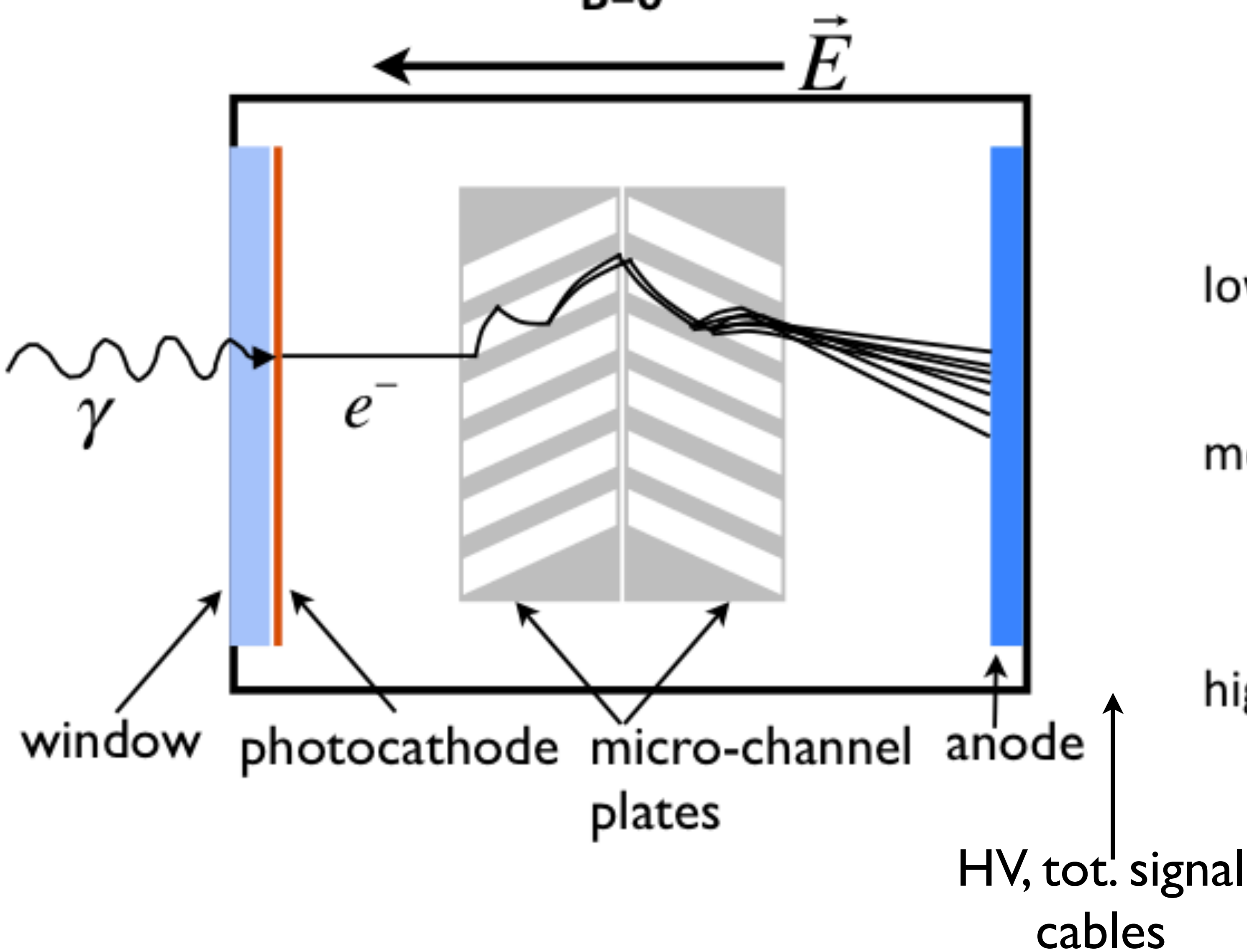
- θ = 0° – minimum at φ = 180°
- θ = 10° – minimum at φ = 270°
- θ = 20° – no characteristic features

Gain Evaluation of 10-μm Pore-Size MCP-PMT

Photonis XP85112

Schematic Diagram of MCP-PMT

B=0



Trajectory of Photoelectrion

B≠0

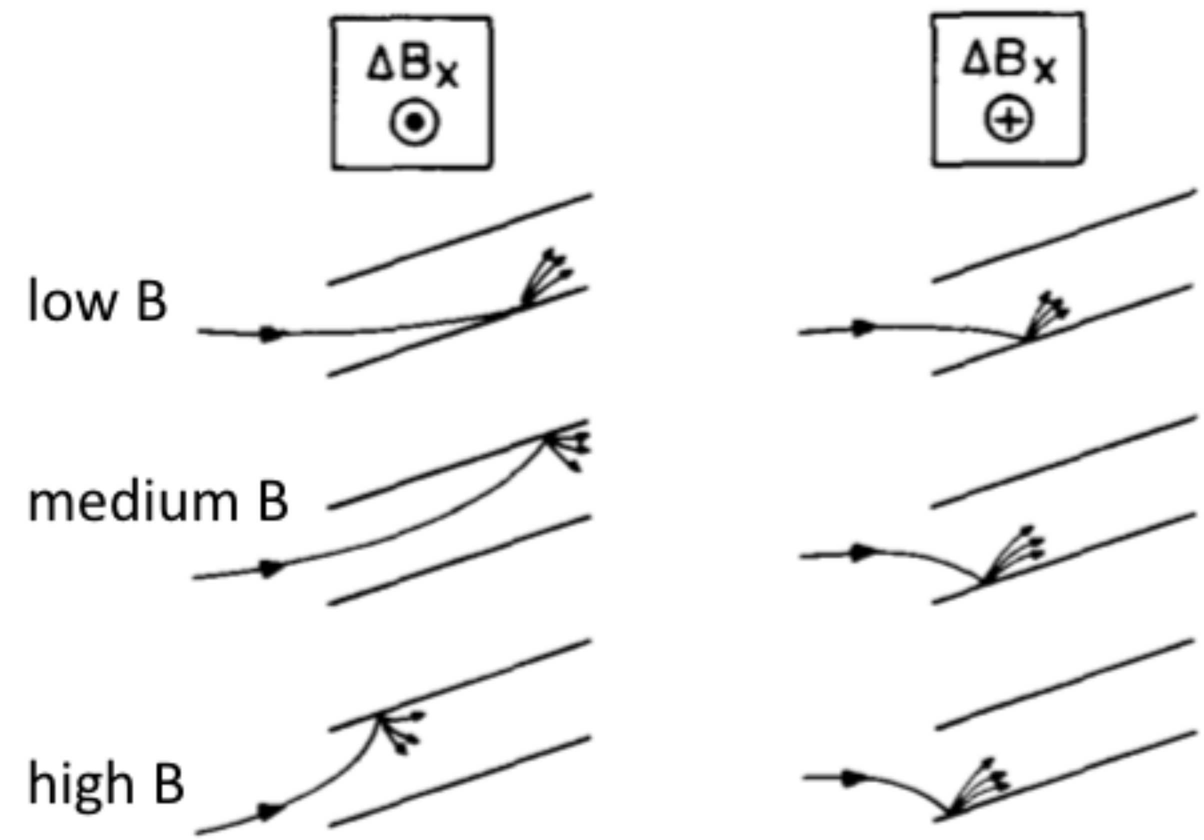


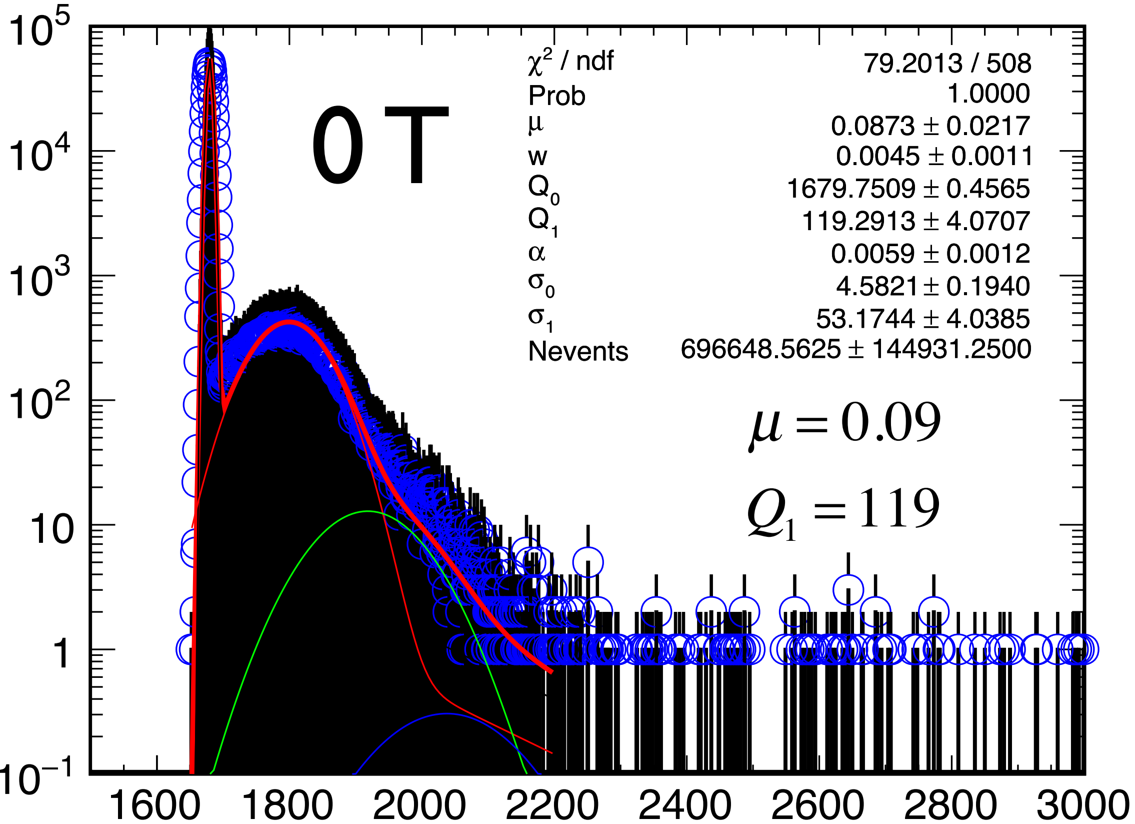
Figure from Ref. [2]

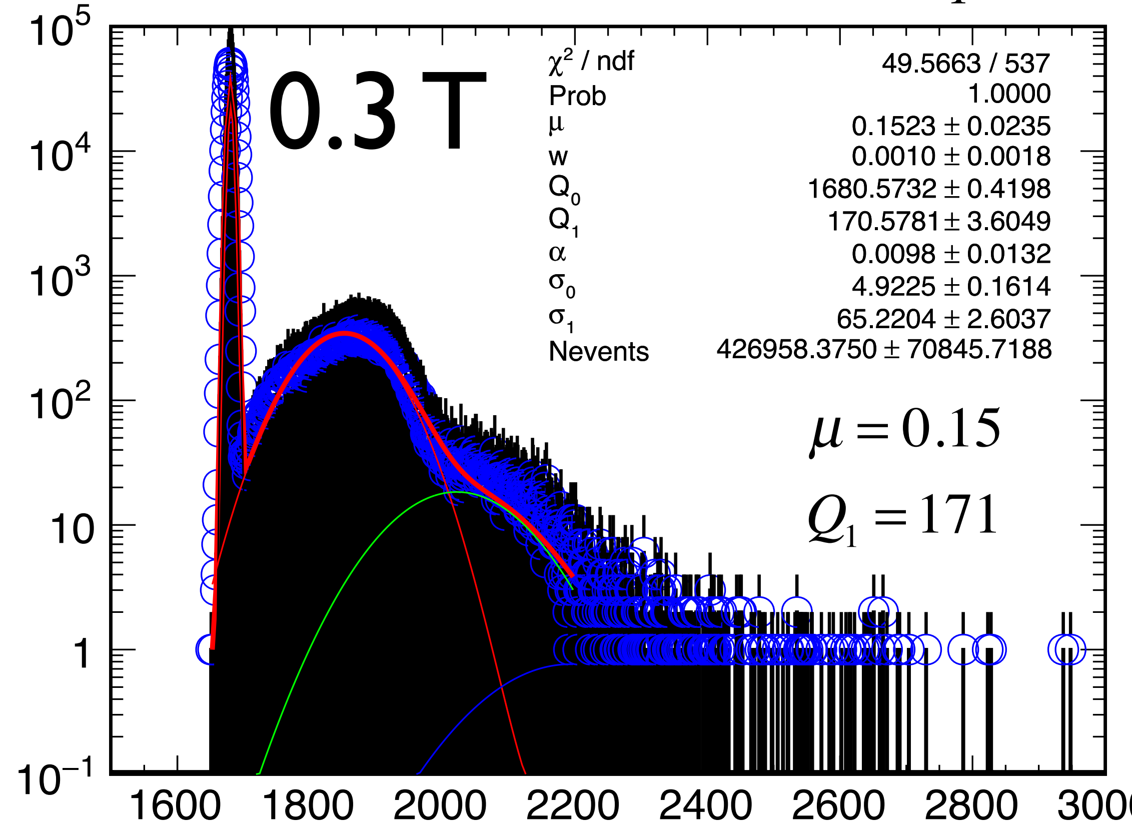
[2] C.I. Coleman, Rev. Sci. Instrum. 53 (1982) 735-748.

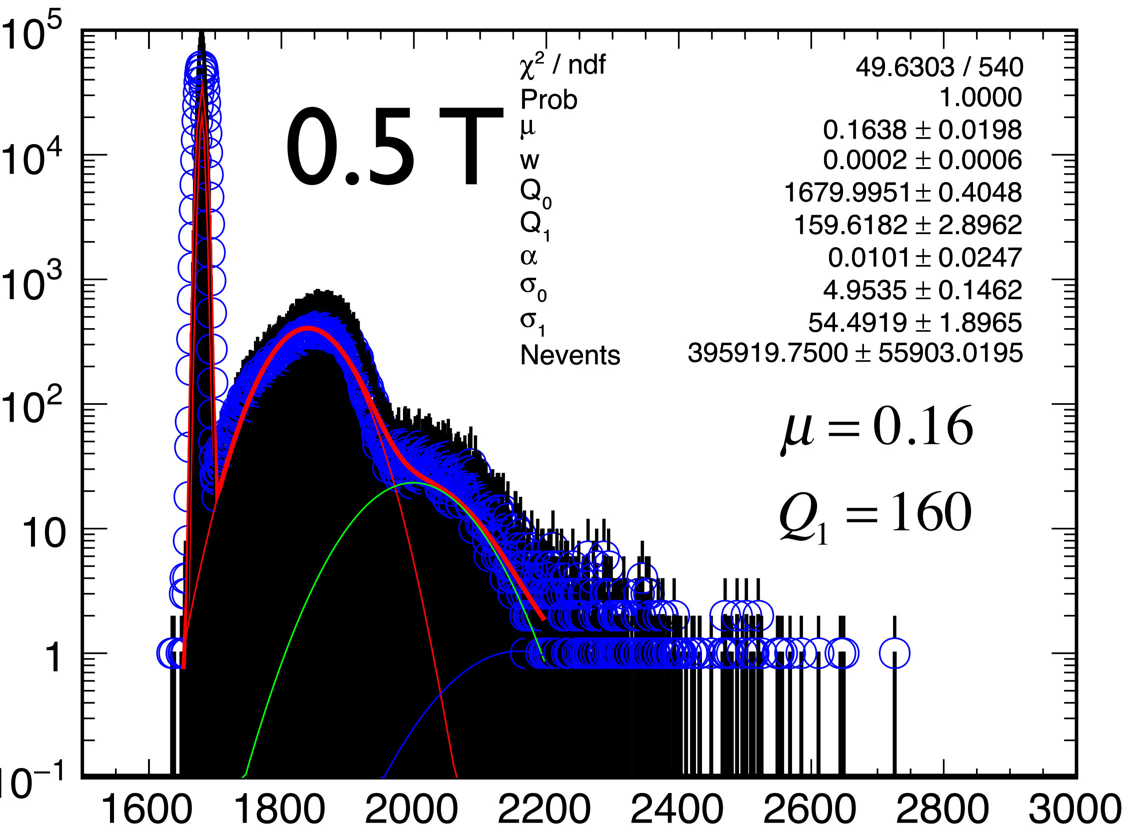
Gain and Efficiency Changes with θ

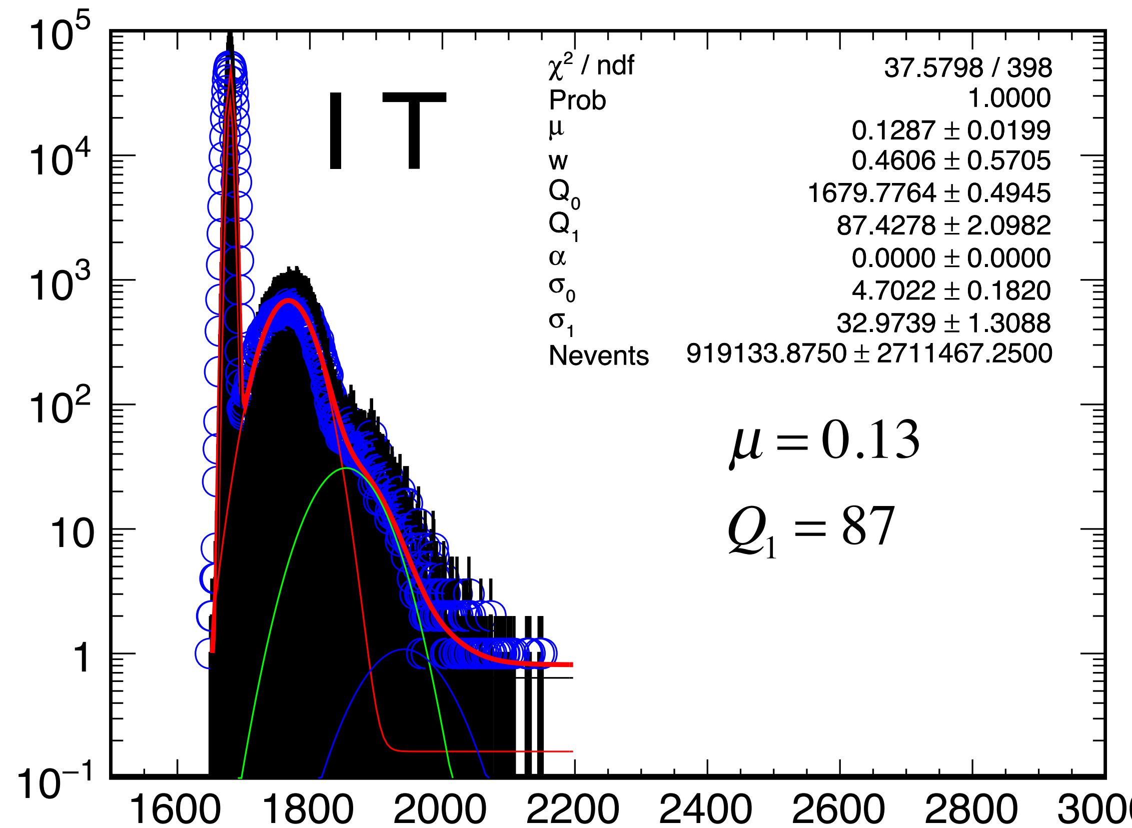
θ=0°, φ=90°, HV=-2.7 kV

$$G = \frac{f}{A \cdot q} Q_1$$





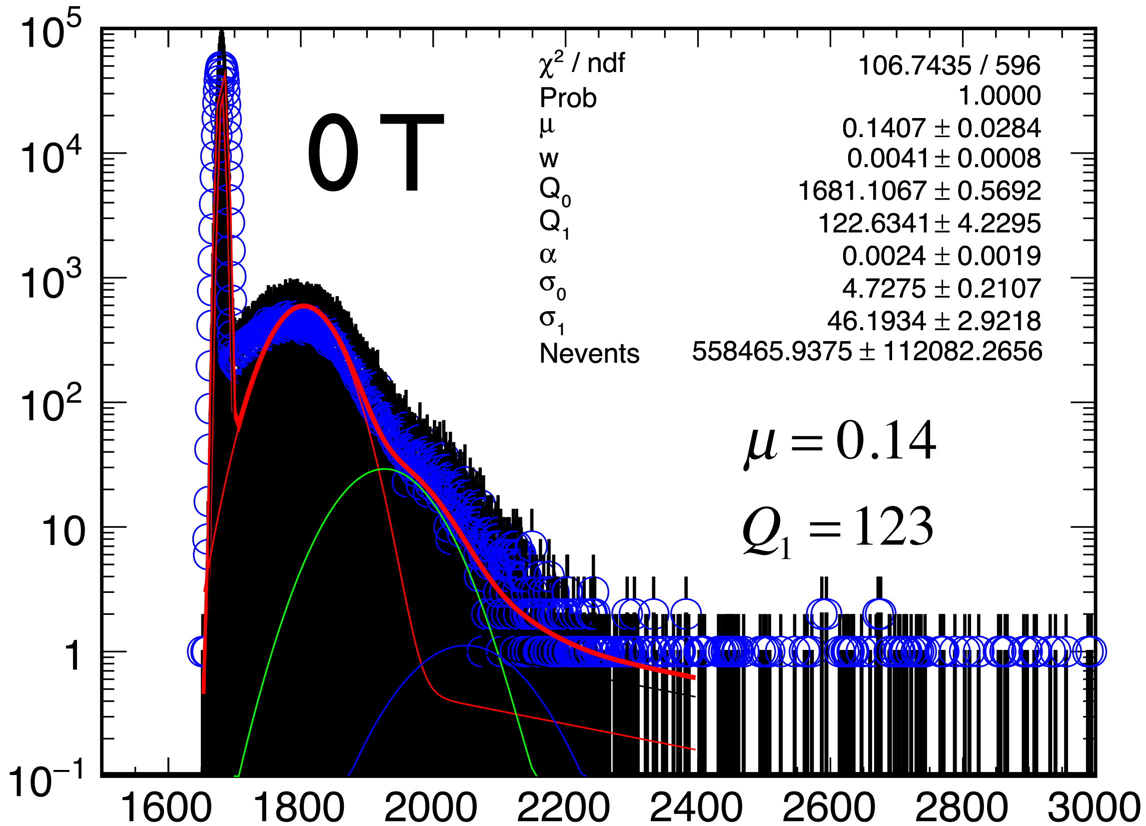


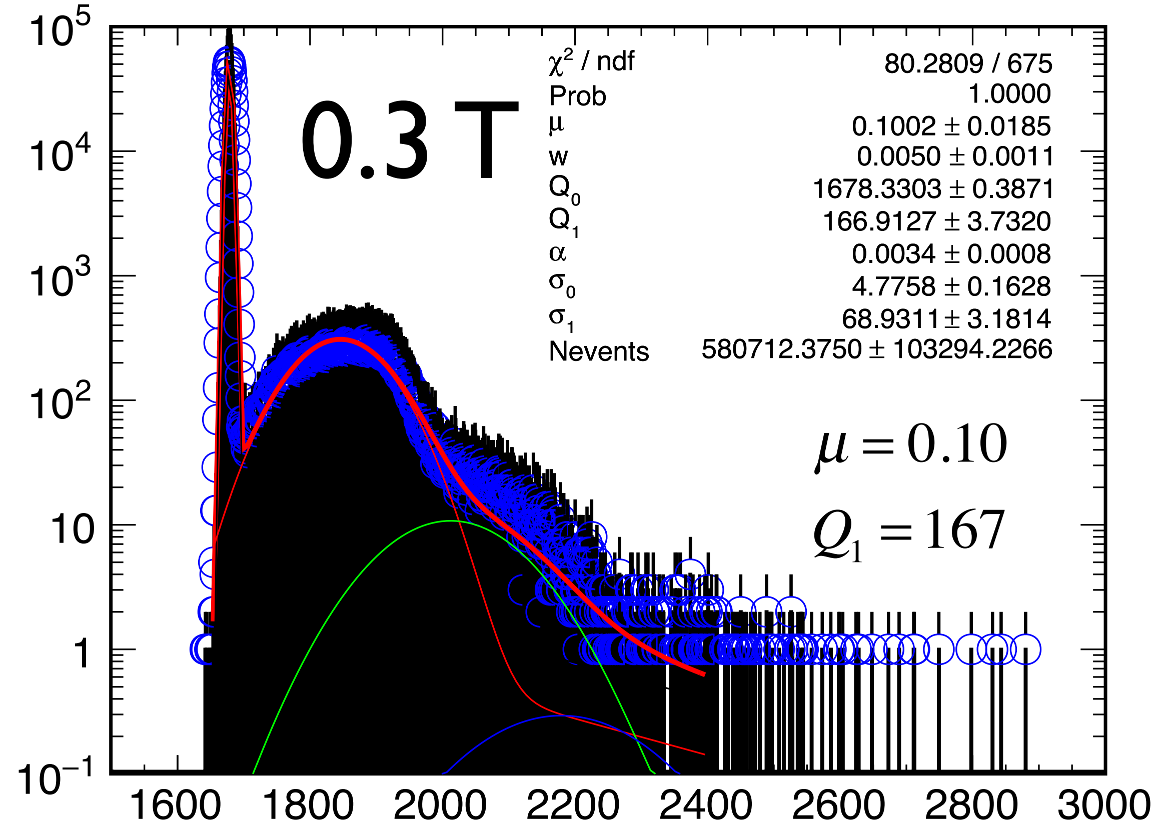


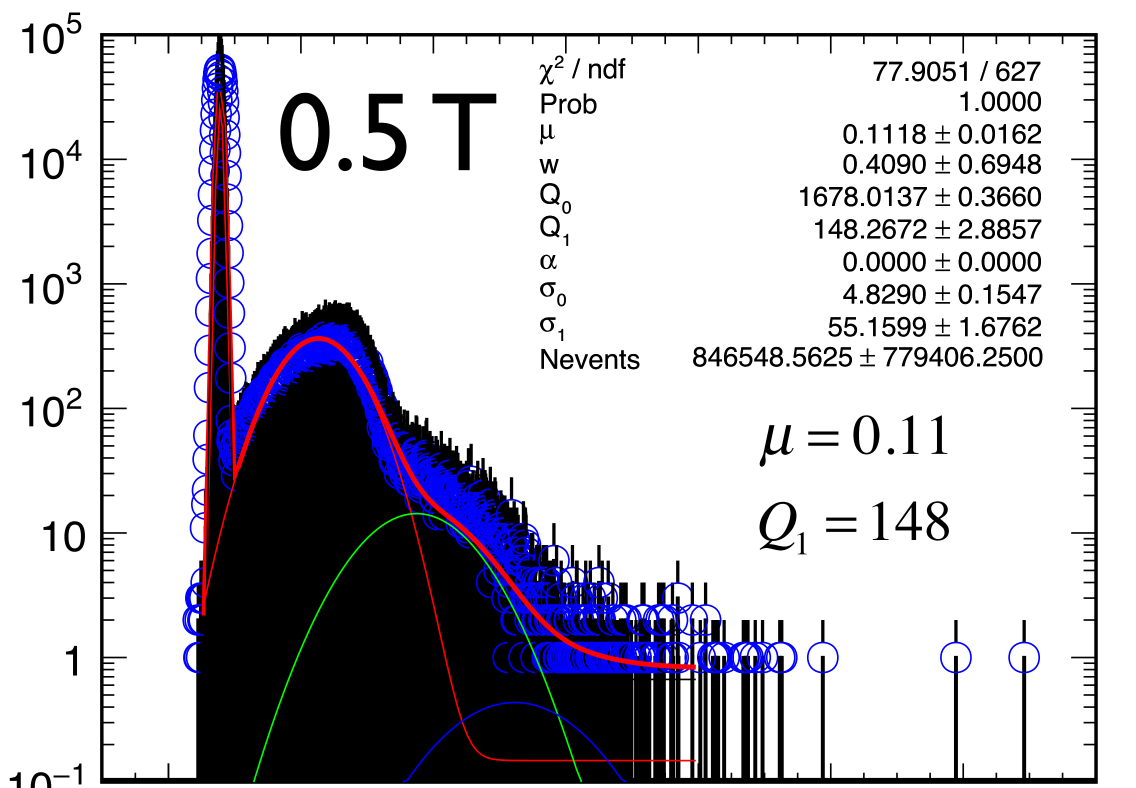
Gain and Efficiency Changes with θ

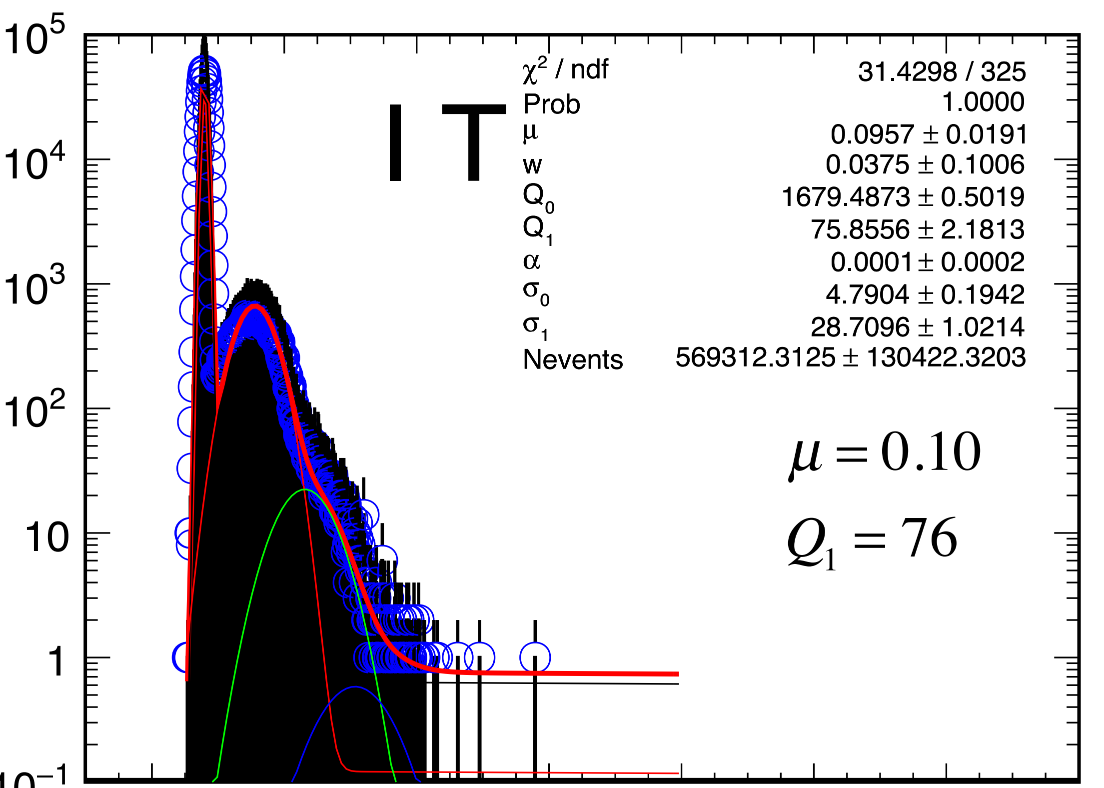
θ=10°, φ=90°, HV=-2.7 kV

$$G = \frac{f}{A \cdot q} Q_1$$





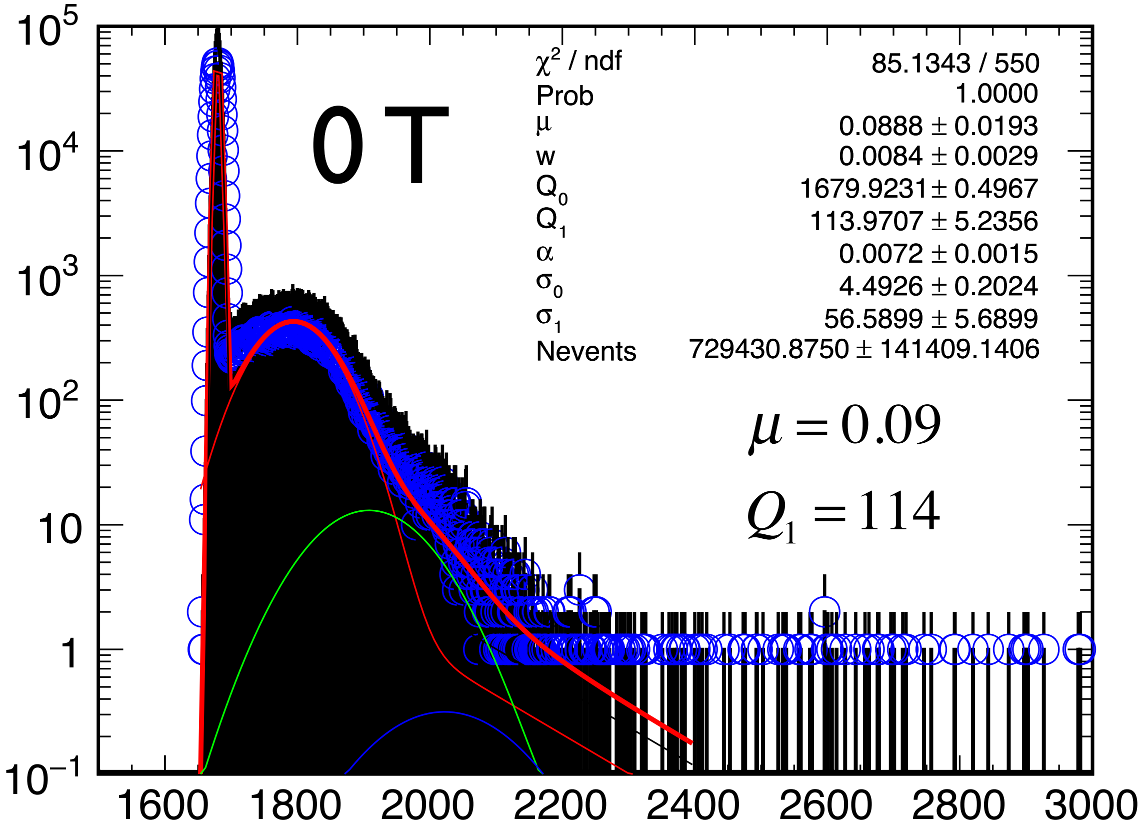


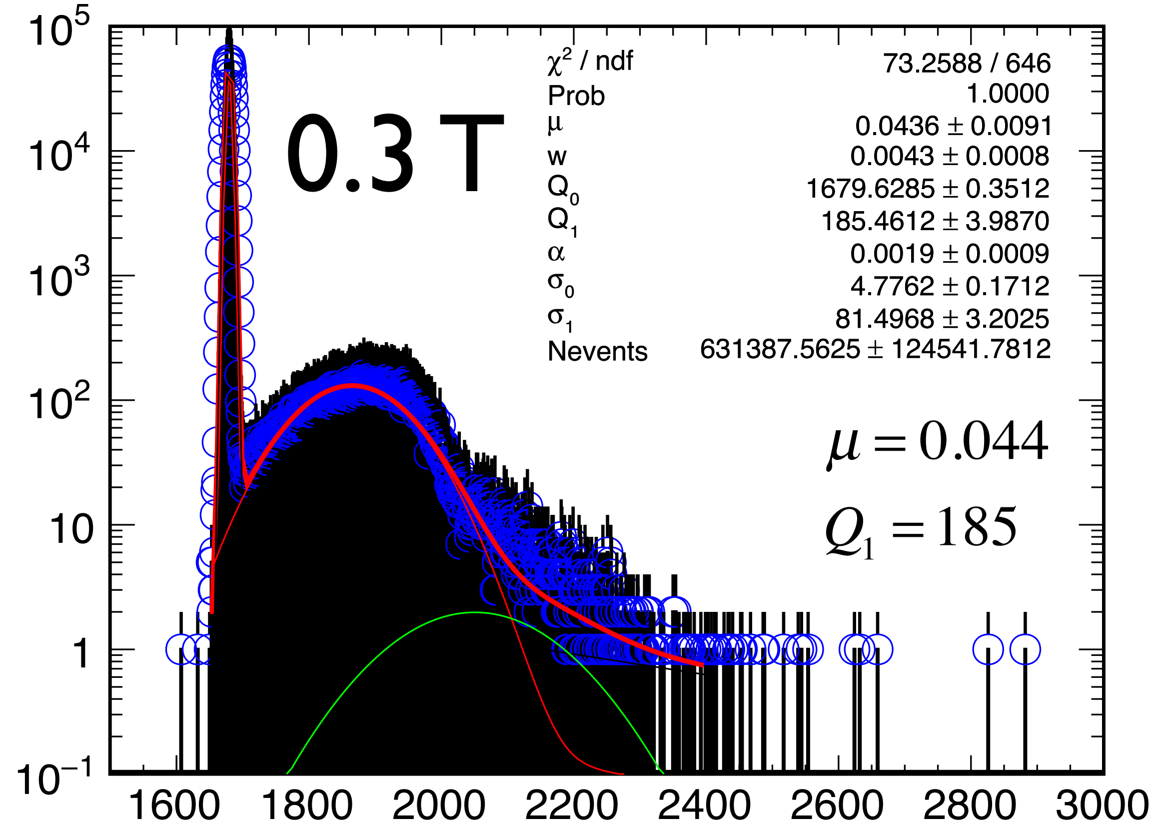


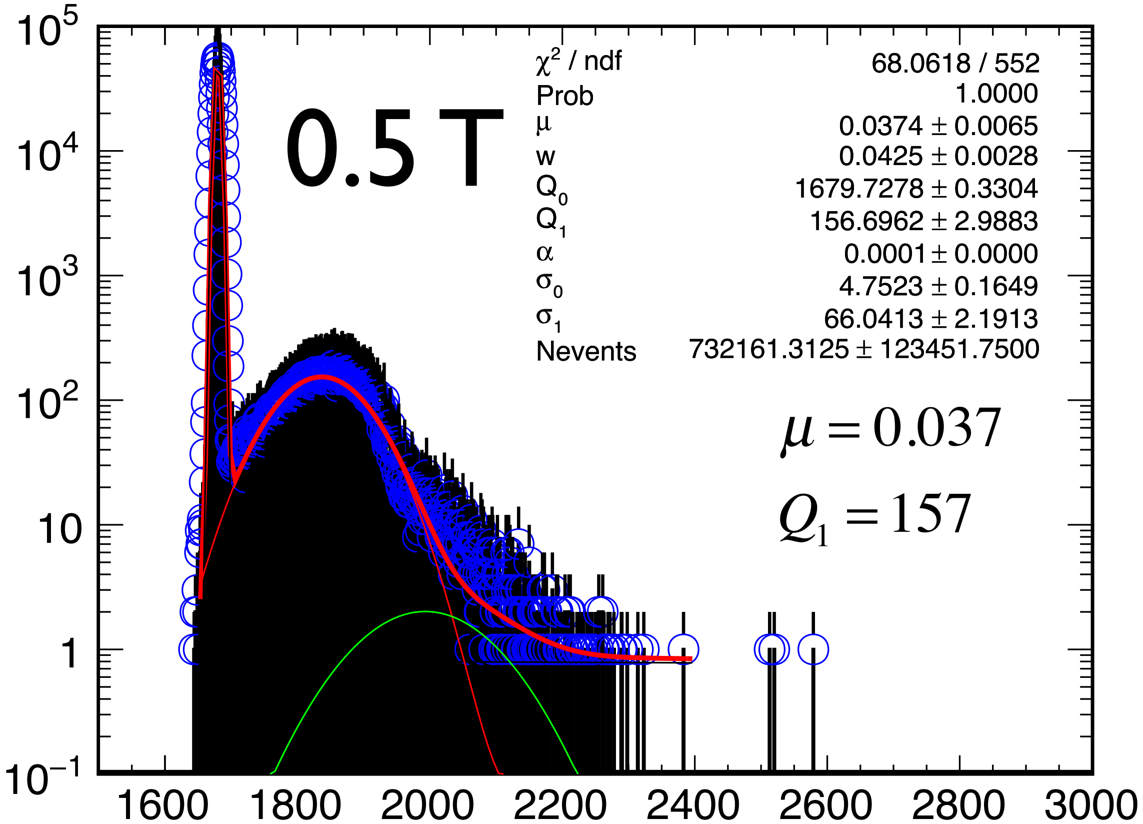
Gain and Efficiency Changes with θ

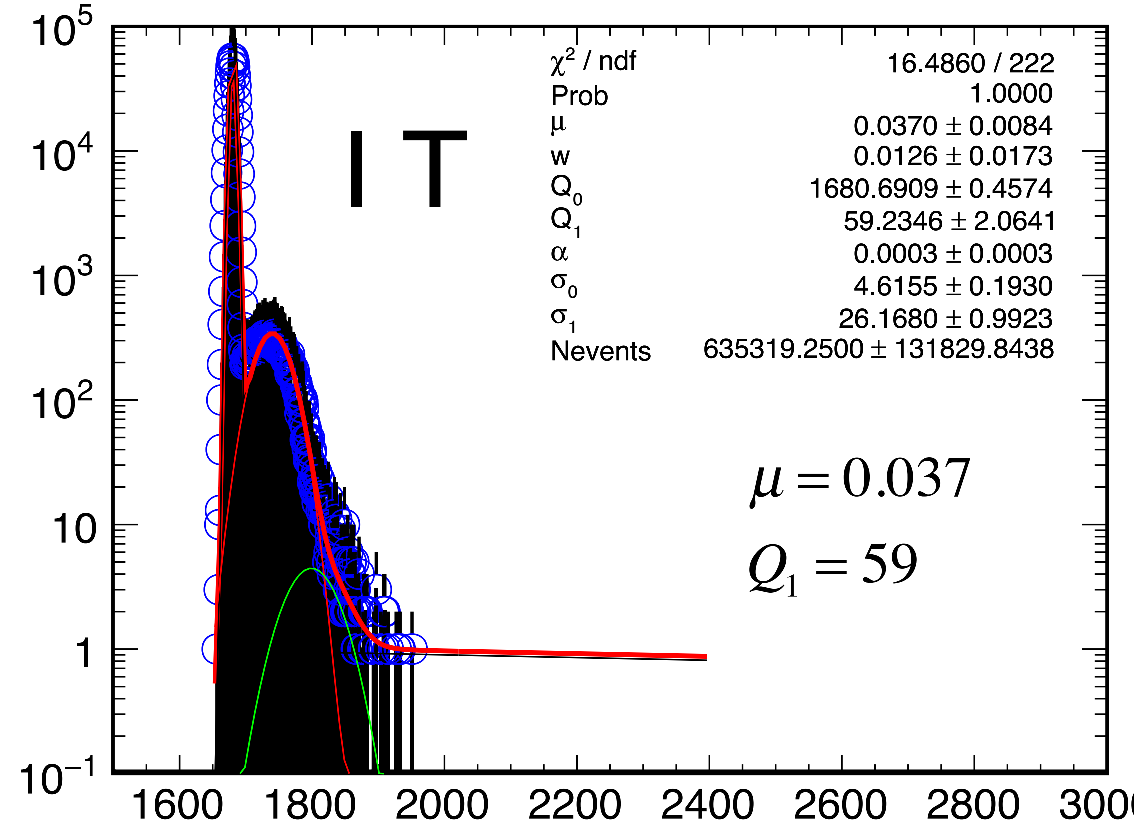
θ=20°, φ=90°, HV=-2.7 kV

$$G = \frac{f}{A \cdot q} Q_1$$



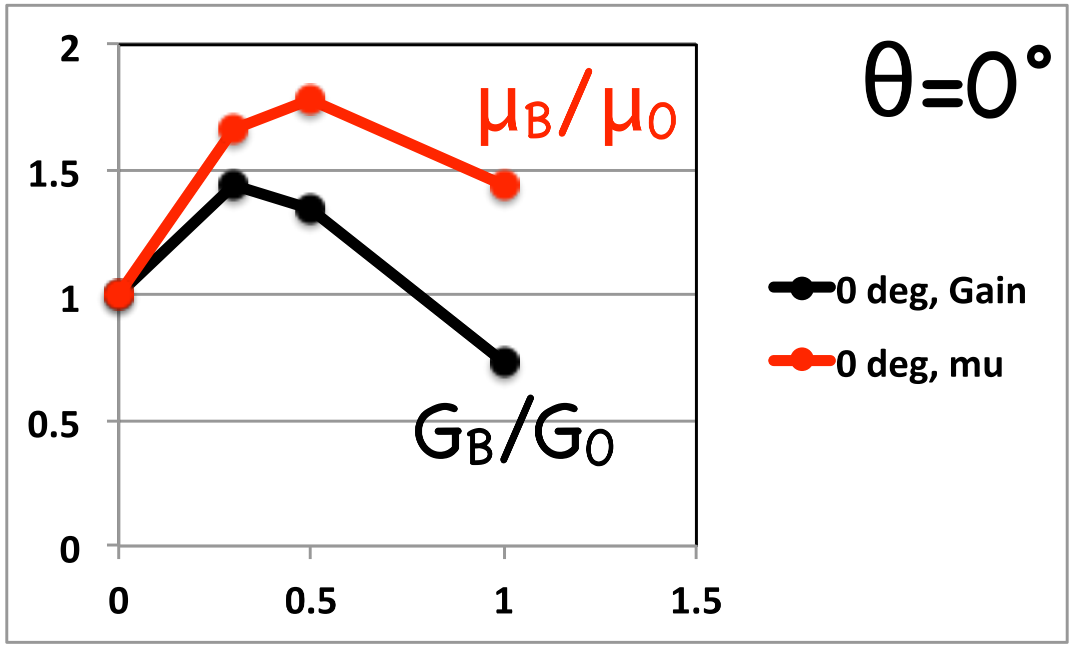


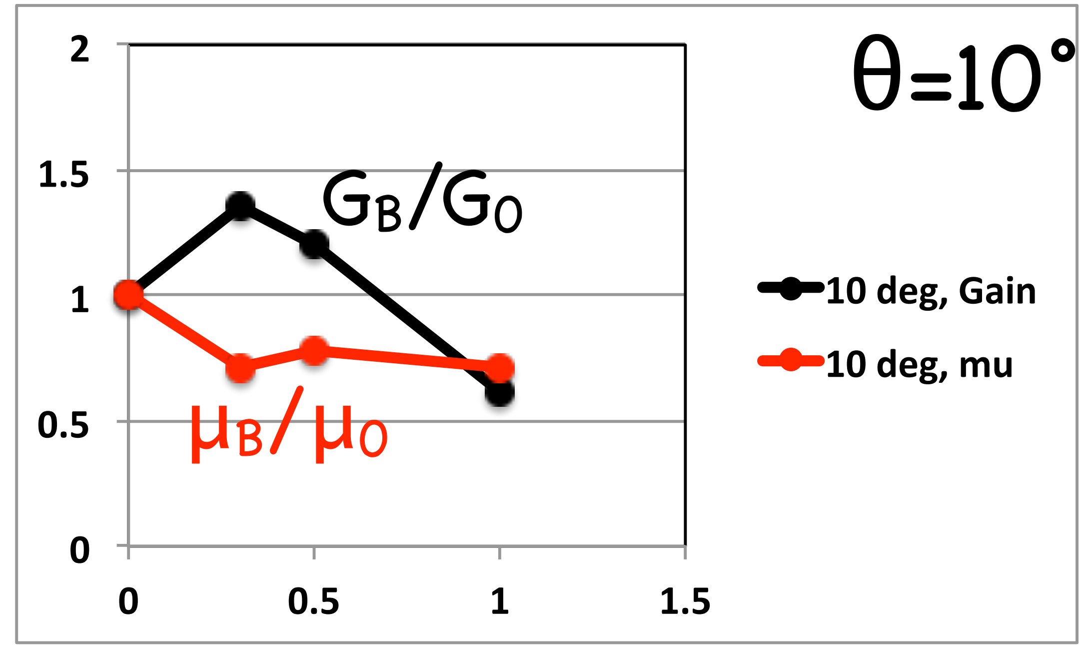


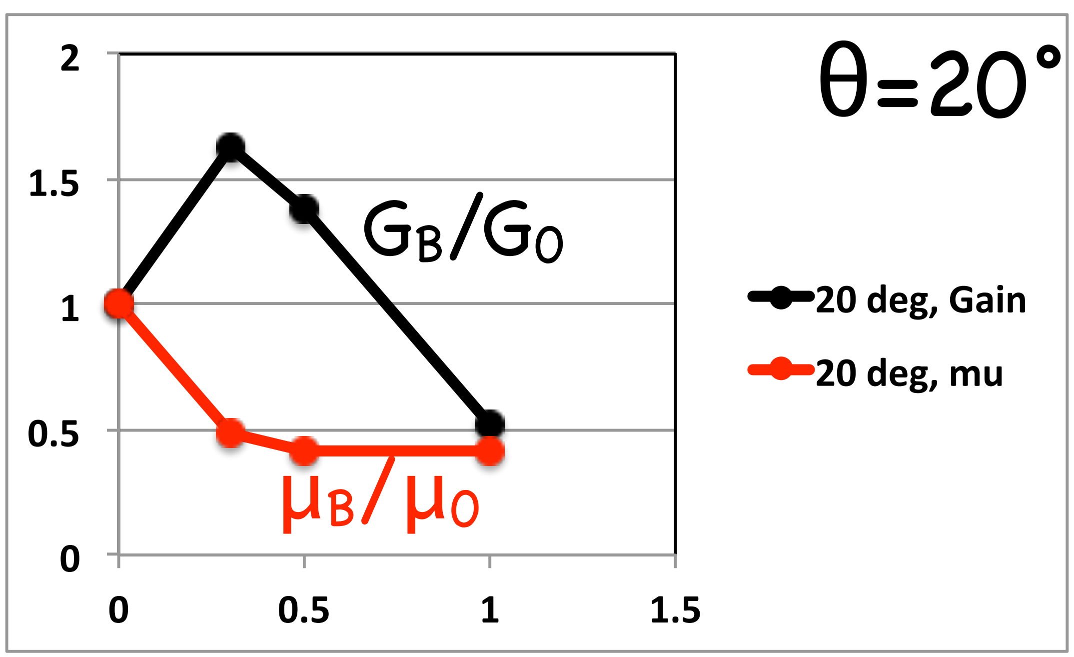


Gain and Efficiency Changes with θ

HV=-2.7 kV







$$P(n) = \frac{\mu^n e^{-\mu}}{n!};\ P(0) = e^{-\mu} = \frac{N_{ped}}{N_{trig}}$$

$$P(1) = \frac{\mu e^{-\mu}}{1!} = \frac{N_{1phe}}{N_{trig}};$$

$$\mu = \frac{P(1)}{P(0)} = \frac{N_{1phe}}{N_{ped}}.$$

The End

fADC Calibration

Charge Generator PS7120
Q(t)

fADC250
ADCch

$$Q\ (\mathrm{pC}) = (-0.4 \pm 1.2) + (0.0191 \pm 0.0002) \cdot \mathrm{ADCch}$$