PMT Test : Gain Scanning

- To adjust the gain for both PMT similarly, 5 PMTs are scanned for several HV Power

- 5 Candidates

  - Previous Week : RD4977, RD6161 (Will be replaced due to low gain)

  - This Week : RD4974, RD6224, RD6201, RD6160
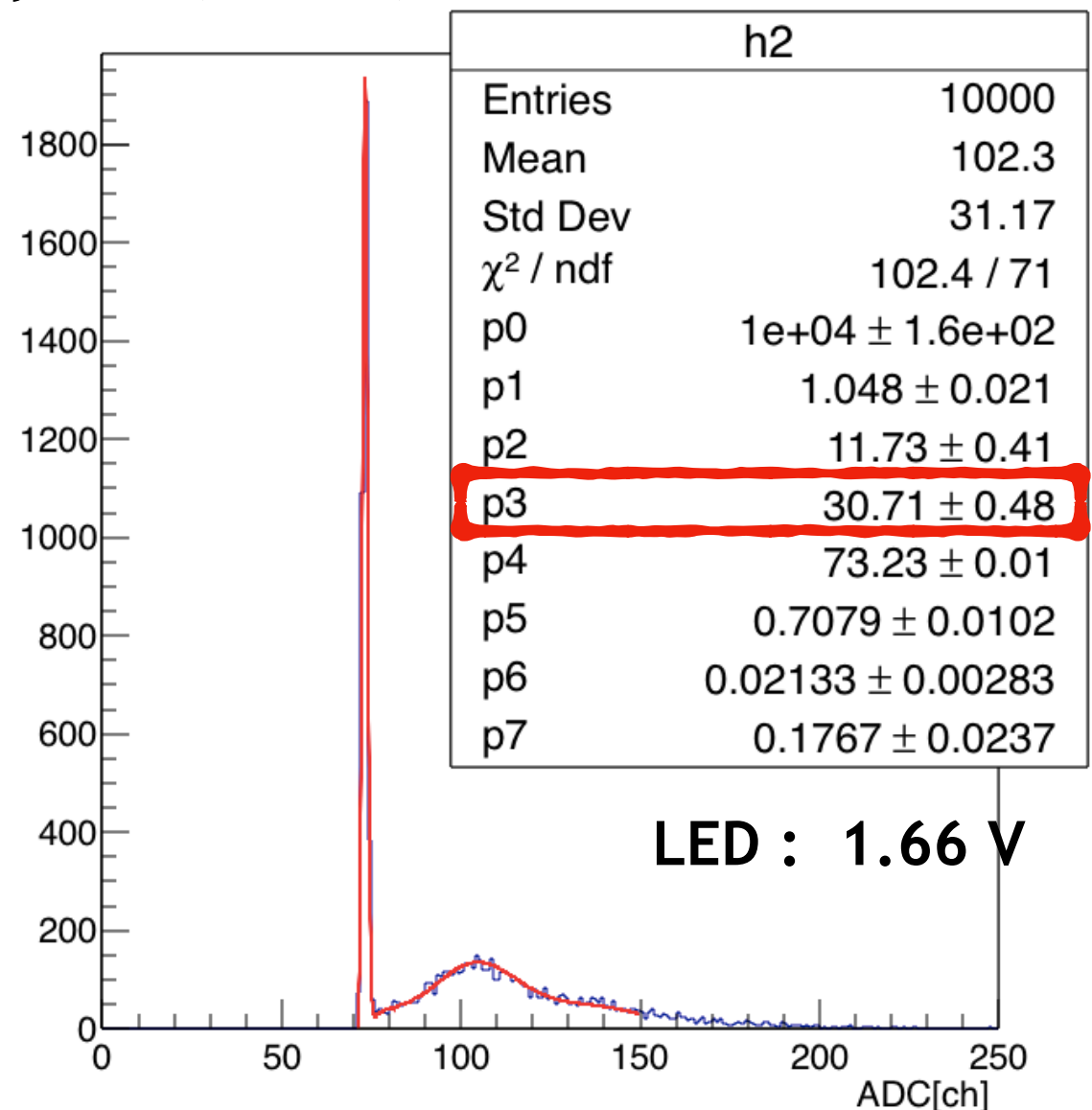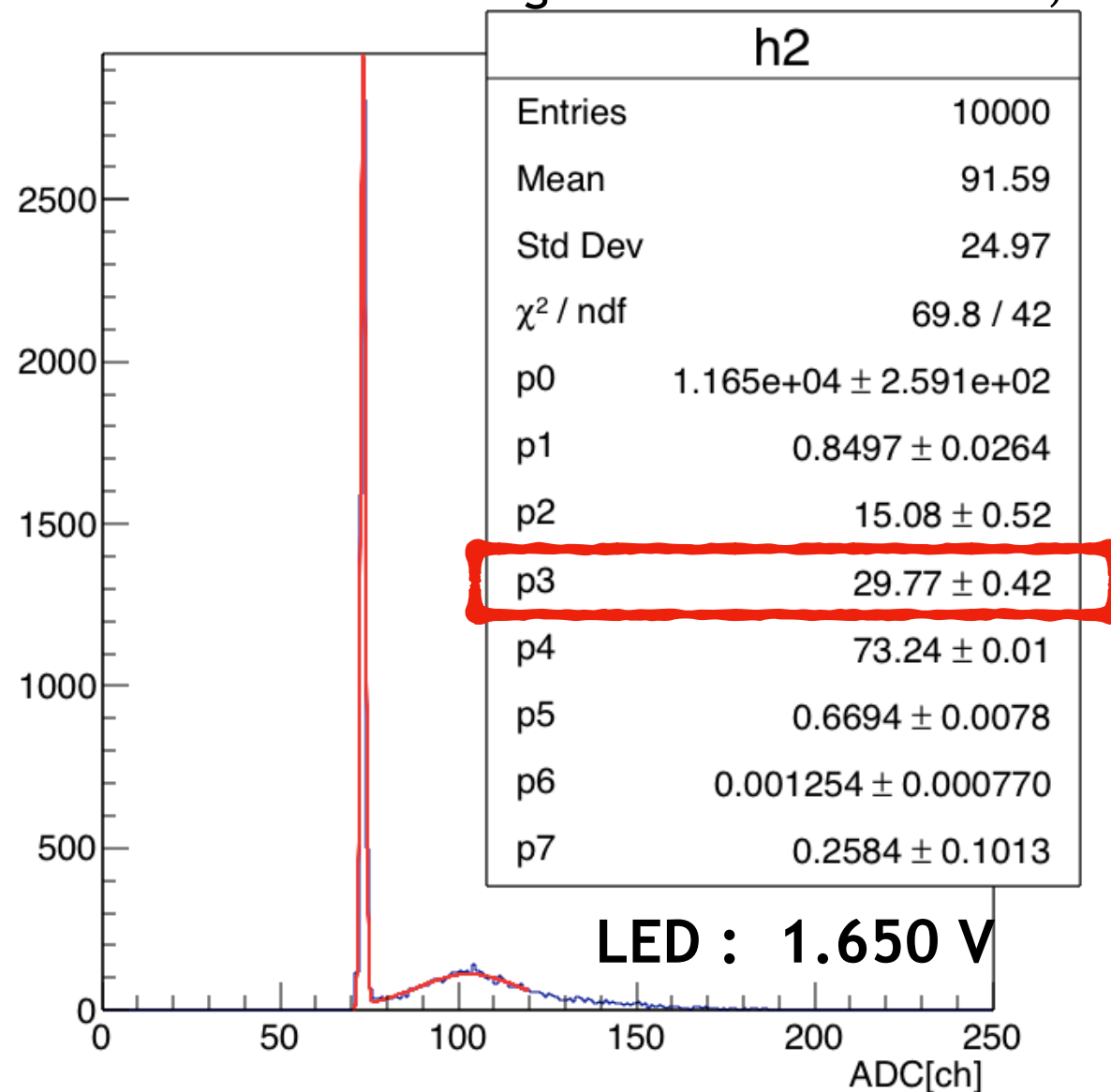
PMT Response Function

- Fitting Function for PMT Response

$$S_{real}(x) = const. \times \left[\left\{ \frac{1-w}{\sigma_0 \sqrt{2\pi}} exp\left(-\frac{(x-Q_0)^2}{2\sigma_0^2}\right) + w\theta(x-Q_0) \times \alpha exp\left[-\alpha(x-Q_0)\right] \right\} e^{-\mu} \right. $$

$$\left. + \sum_{n=1}^{\infty} \frac{\mu^n e^{-\mu}}{n} \times \frac{1}{\sigma_1 \sqrt{2\pi n}} exp\left(-\frac{(x-Q_0-nQ_1)^2}{2n\sigma_1^2}\right) \right]$$

Fitting Params.	Meanings	Params.
const.	Constant	p0
μ	Expectation Value of Poission Distribution	p1
σ_1	1st Peak's Standard Dev.	p2
Q_1	Gain	p3
Q_0	Pedestal	p4
σ_0	Standard Deviation of Pedestal	p5
w	Probability of Background Process	p6
α	Procedure of Background Procedure	p7

PMT Test with LED

- Serial No.RD6201

- Applied Voltage : -2100 V

- LED : Scanned starting from 1.65 V to 1.68V, every 0.05 V, 100 Hz, 20 ns

h2	
Entries	10000
Mean	91.59
Std Dev	24.97
χ^2 / ndf	69.8 / 42
p0	$1.165e+04 \pm 2.591e+02$
p1	0.8497 ± 0.0264
p2	15.08 ± 0.52
p3	29.77 ± 0.42
p4	73.24 ± 0.01
p5	0.6694 ± 0.0078
p6	0.001254 ± 0.000770
p7	0.2584 ± 0.1013

LED : 1.650 V

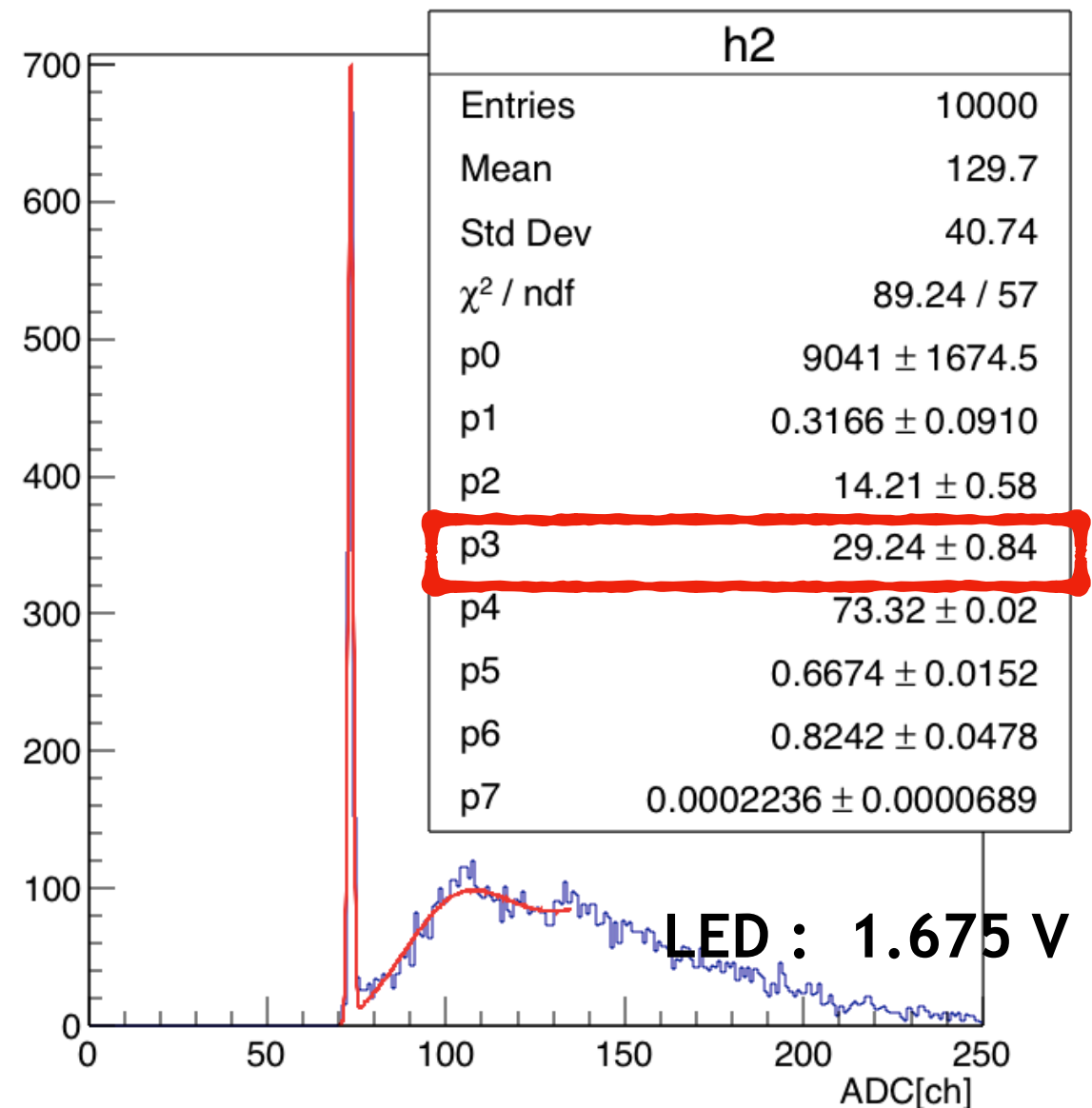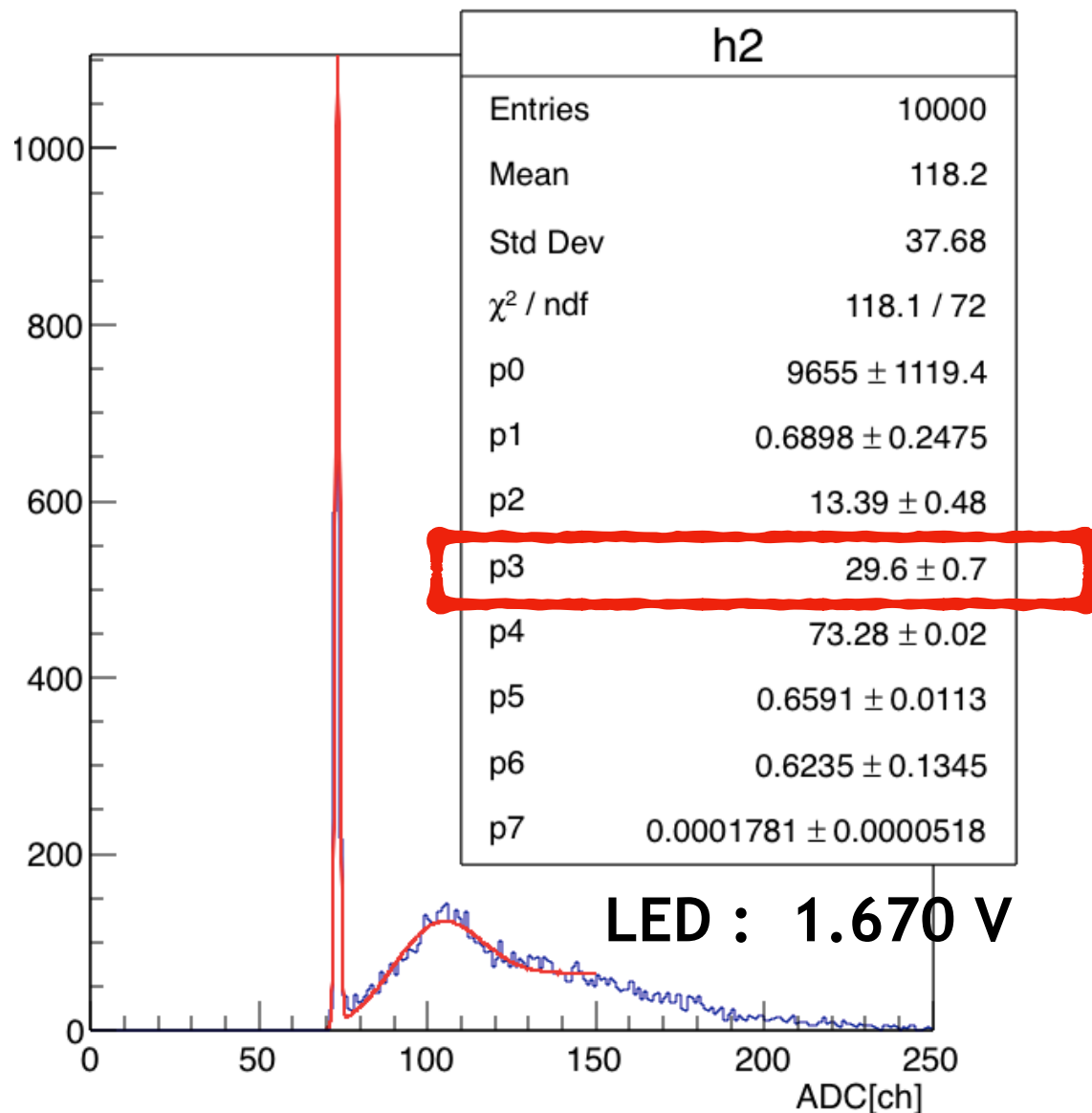| h2	
Entries	10000
Mean	102.3
Std Dev	31.17
χ^2 / ndf	102.4 / 71
p0	$1e+04 \pm 1.6e+02$
p1	1.048 ± 0.021
p2	11.73 ± 0.41
p3	30.71 ± 0.48
p4	73.23 ± 0.01
p5	0.7079 ± 0.0102
p6	0.02133 ± 0.00283
p7	0.1767 ± 0.0237

LED : 1.66 V

PMT Test with LED

- Serial No.RD6201

- Applied Voltage : -2100 V

- LED : Scanned starting from 1.65 V to 1.68V, every 0.05 V, 100 Hz, 20 ns

h2	
Entries	10000
Mean	118.2
Std Dev	37.68
χ^2 / ndf	118.1 / 72
p0	9655 ± 1119.4
p1	0.6898 ± 0.2475
p2	13.39 ± 0.48
p3	29.6 ± 0.7
p4	73.28 ± 0.02
p5	0.6591 ± 0.0113
p6	0.6235 ± 0.1345
p7	0.0001781 ± 0.0000518

LED : 1.670 V

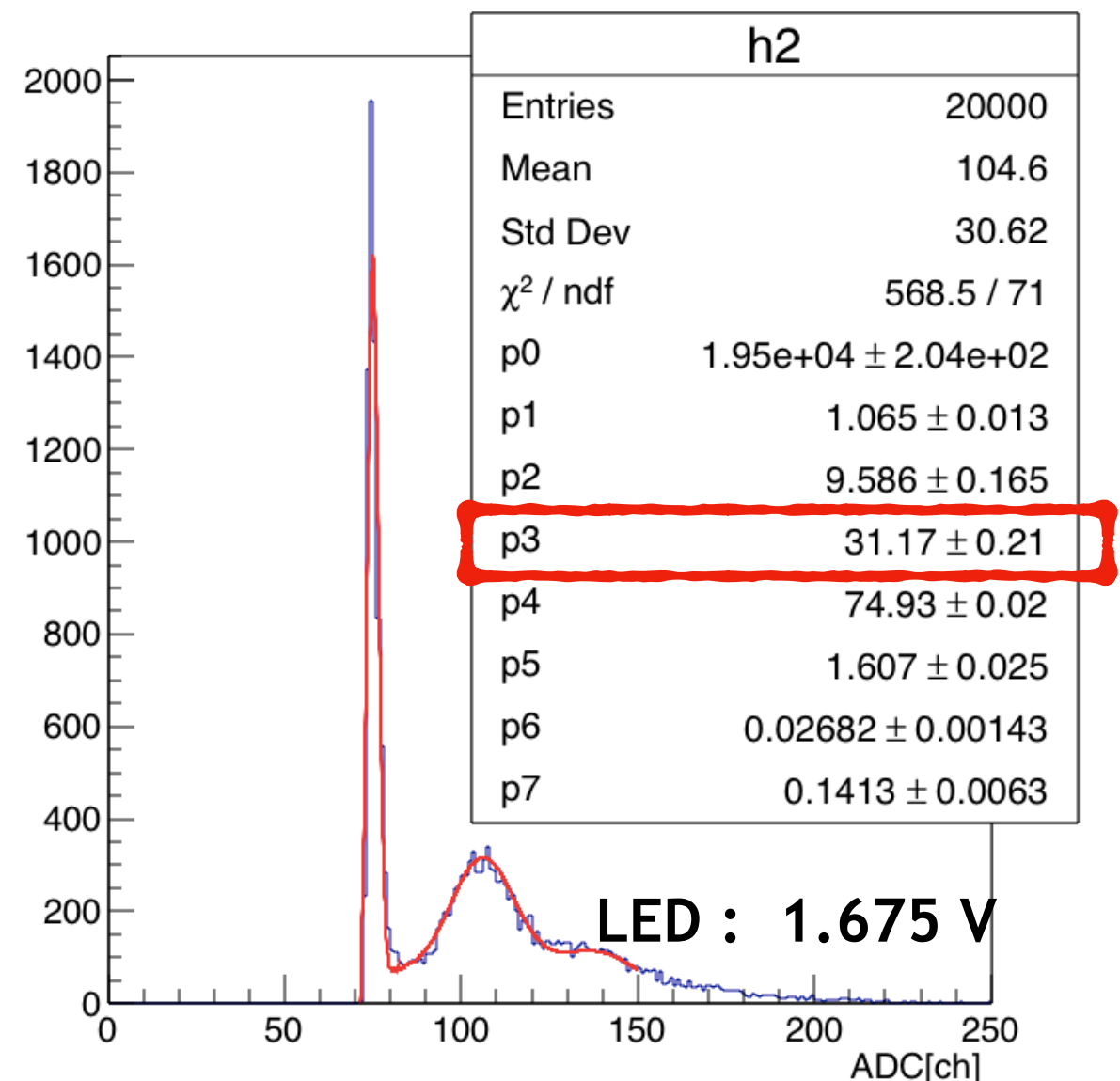| h2	
Entries	10000
Mean	129.7
Std Dev	40.74
χ^2 / ndf	89.24 / 57
p0	9041 ± 1674.5
p1	0.3166 ± 0.0910
p2	14.21 ± 0.58
p3	29.24 ± 0.84
p4	73.32 ± 0.02
p5	0.6674 ± 0.0152
p6	0.8242 ± 0.0478
p7	0.0002236 ± 0.0000689

LED : 1.675 V

PMT Test with LED

- Serial No.RD4974

- Applied Voltage : -2150 V

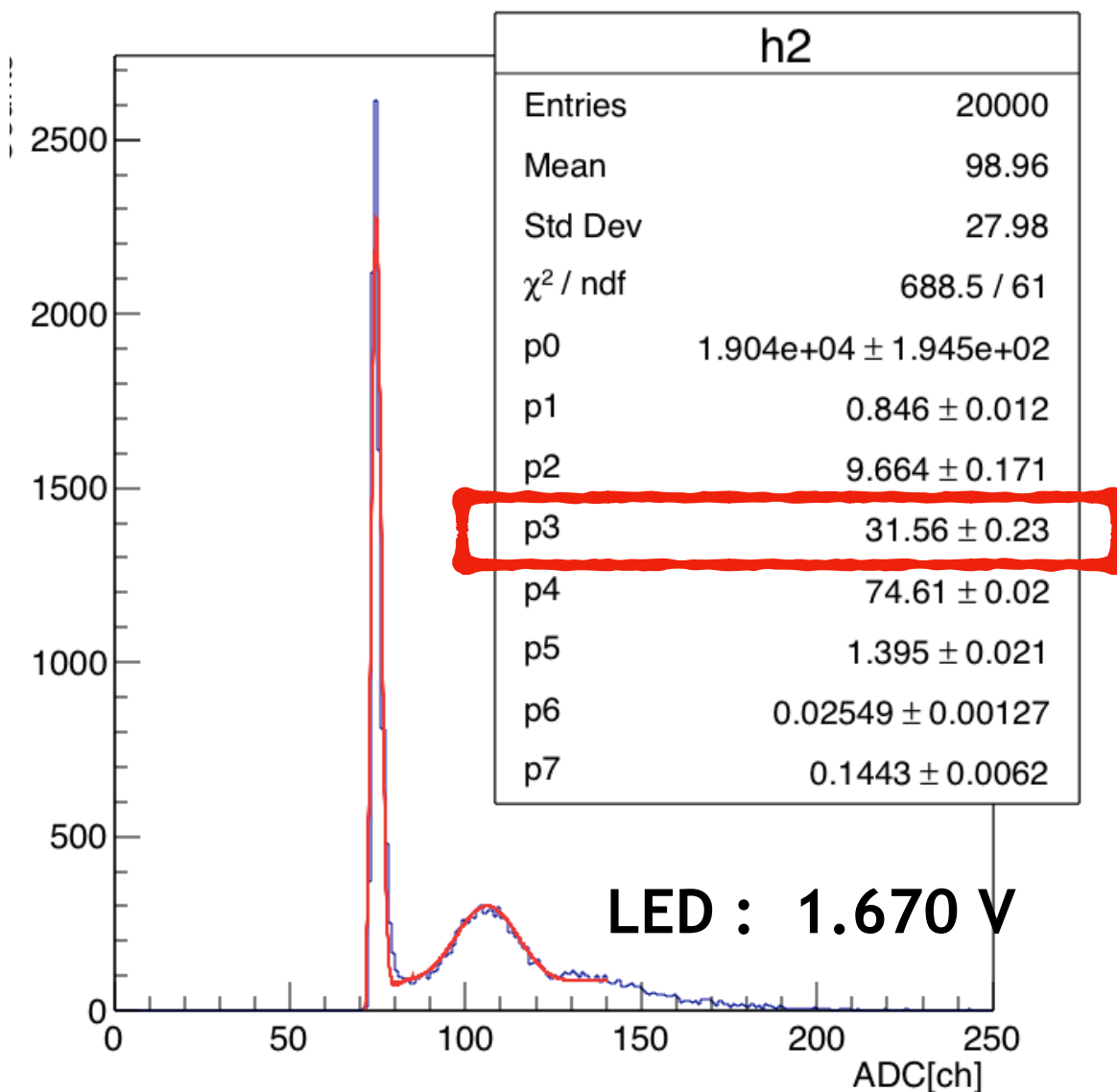- LED : Scanned starting from 1.65 V to 1.68V, every 0.05 V, 100 Hz, 20 ns

h2	
Entries	20000
Mean	98.96
Std Dev	27.98
χ^2 / ndf	688.5 / 61
p0	$1.904e+04 \pm 1.945e+02$
p1	0.846 ± 0.012
p2	9.664 ± 0.171
p3	31.56 ± 0.23
p4	74.61 ± 0.02
p5	1.395 ± 0.021
p6	0.02549 ± 0.00127
p7	0.1443 ± 0.0062

LED : 1.670 V

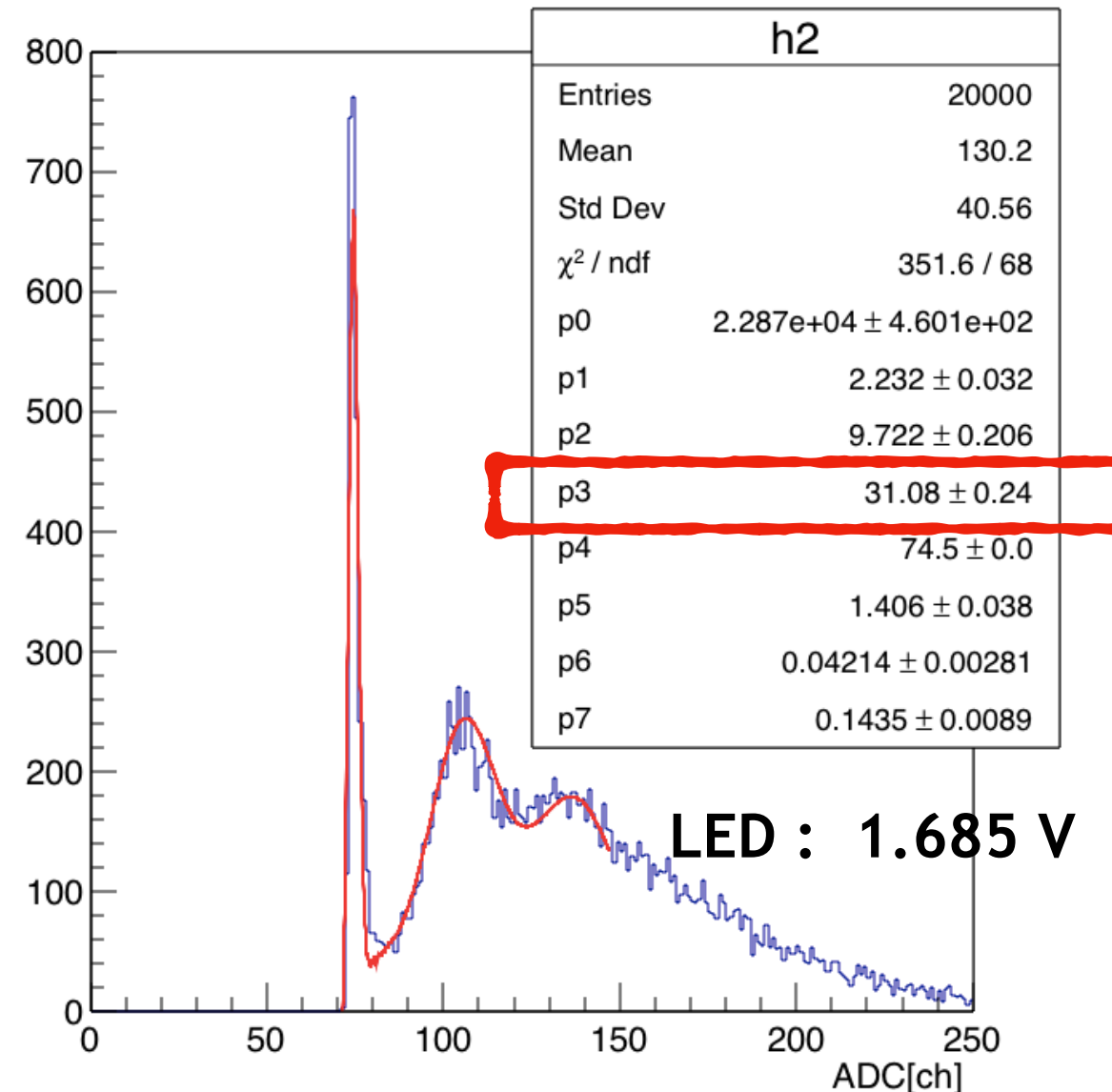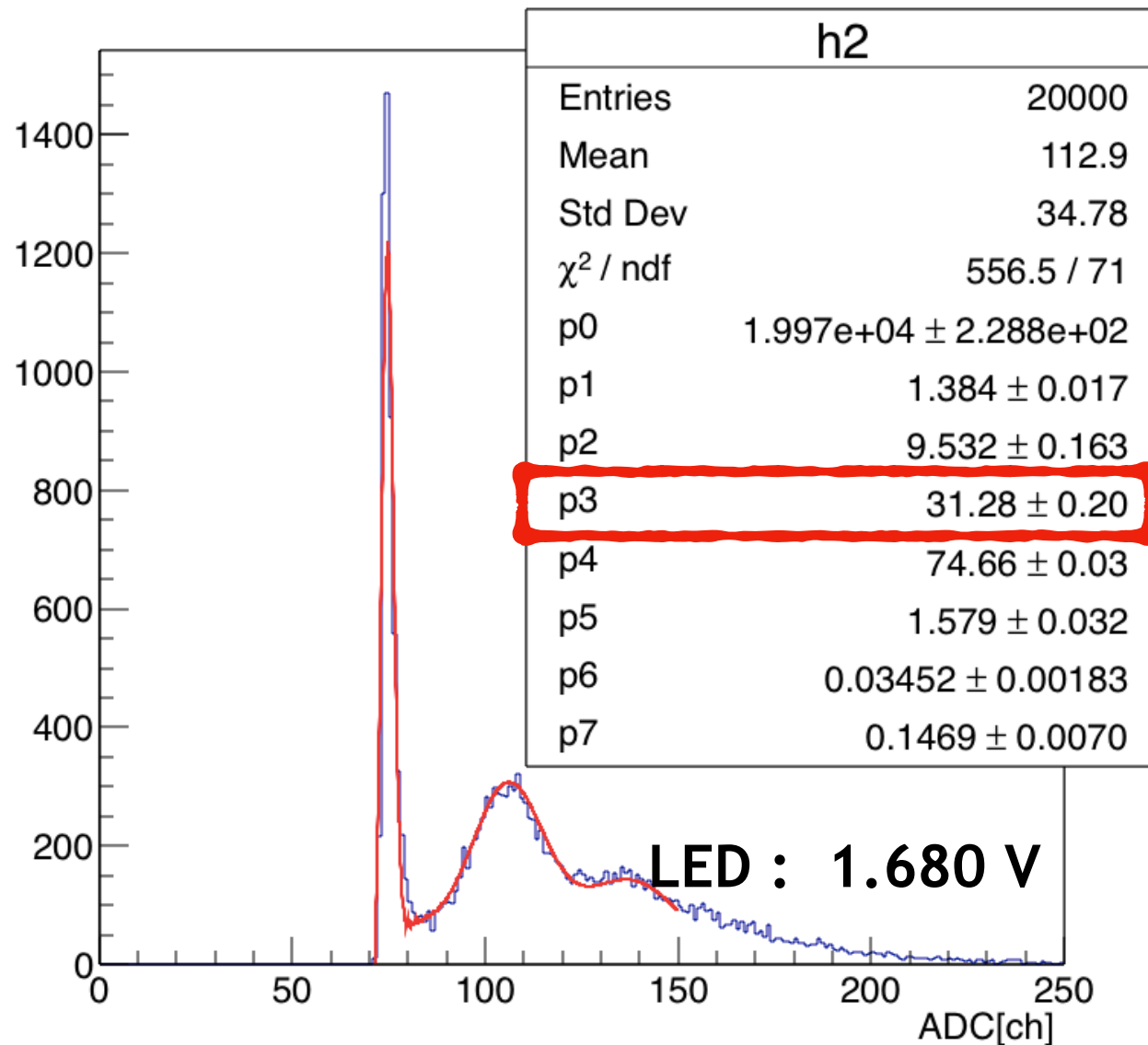| h2	
Entries	20000
Mean	104.6
Std Dev	30.62
χ^2 / ndf	568.5 / 71
p0	$1.95e+04 \pm 2.04e+02$
p1	1.065 ± 0.013
p2	9.586 ± 0.165
p3	31.17 ± 0.21
p4	74.93 ± 0.02
p5	1.607 ± 0.025
p6	0.02682 ± 0.00143
p7	0.1413 ± 0.0063

LED : 1.675 V

PMT Test with LED

- Serial No.RD4974

- Applied Voltage : -2150 V

- LED : Scanned starting from 1.65 V to 1.68V, every 0.05 V, 100 Hz, 20 ns

h2	
Entries	20000
Mean	112.9
Std Dev	34.78
χ^2 / ndf	556.5 / 71
p0	$1.997e+04 \pm 2.288e+02$
p1	1.384 ± 0.017
p2	9.532 ± 0.163
p3	31.28 ± 0.20
p4	74.66 ± 0.03
p5	1.579 ± 0.032
p6	0.03452 ± 0.00183
p7	0.1469 ± 0.0070

LED : 1.680 V

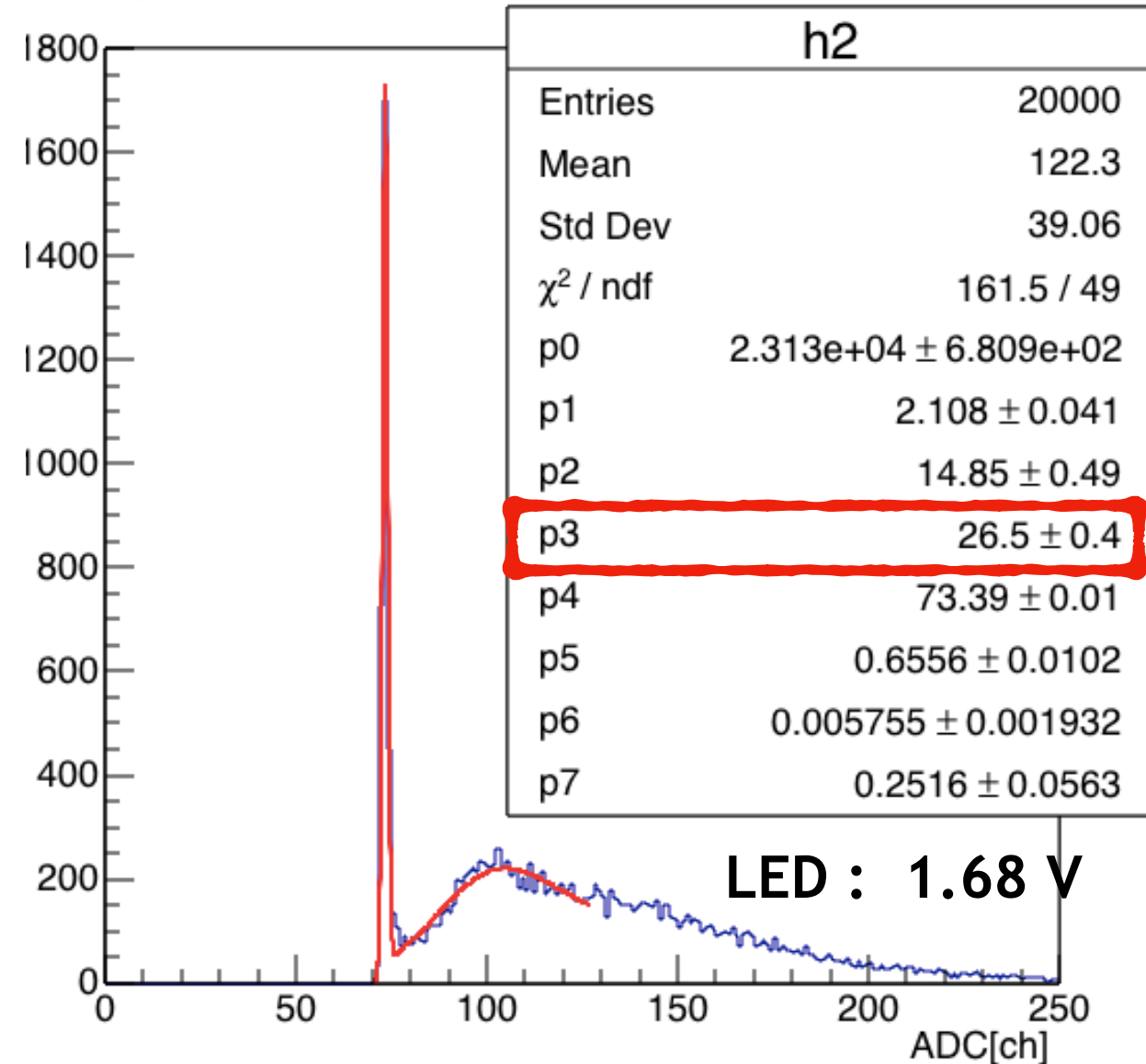| h2	
Entries	20000
Mean	130.2
Std Dev	40.56
χ^2 / ndf	351.6 / 68
p0	$2.287e+04 \pm 4.601e+02$
p1	2.232 ± 0.032
p2	9.722 ± 0.206
p3	31.08 ± 0.24
p4	74.5 ± 0.0
p5	1.406 ± 0.038
p6	0.04214 ± 0.00281
p7	0.1435 ± 0.0089

LED : 1.685 V

PMT Test with LED

- Serial No.RD6224

- Applied Voltage : -2400 V

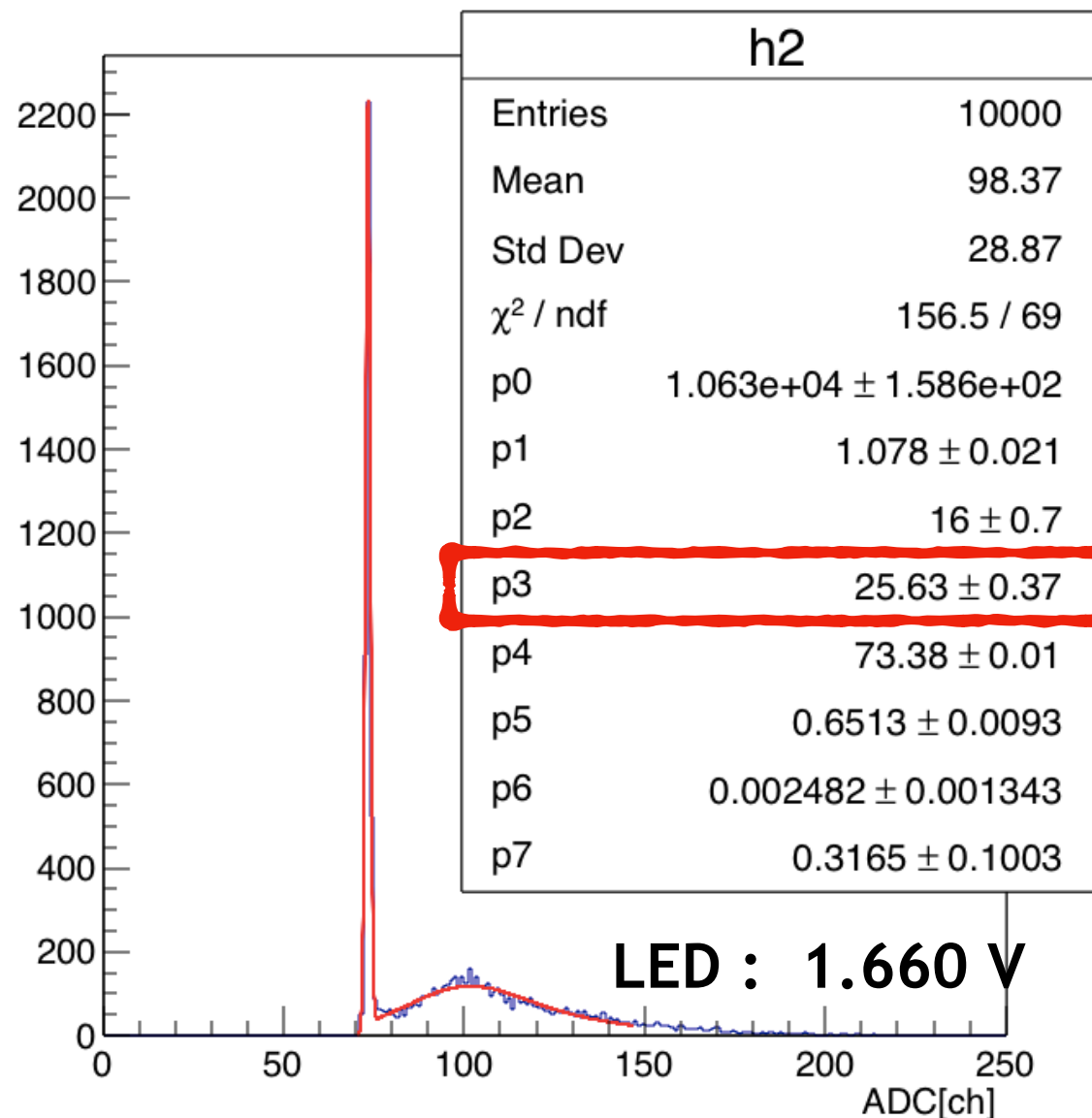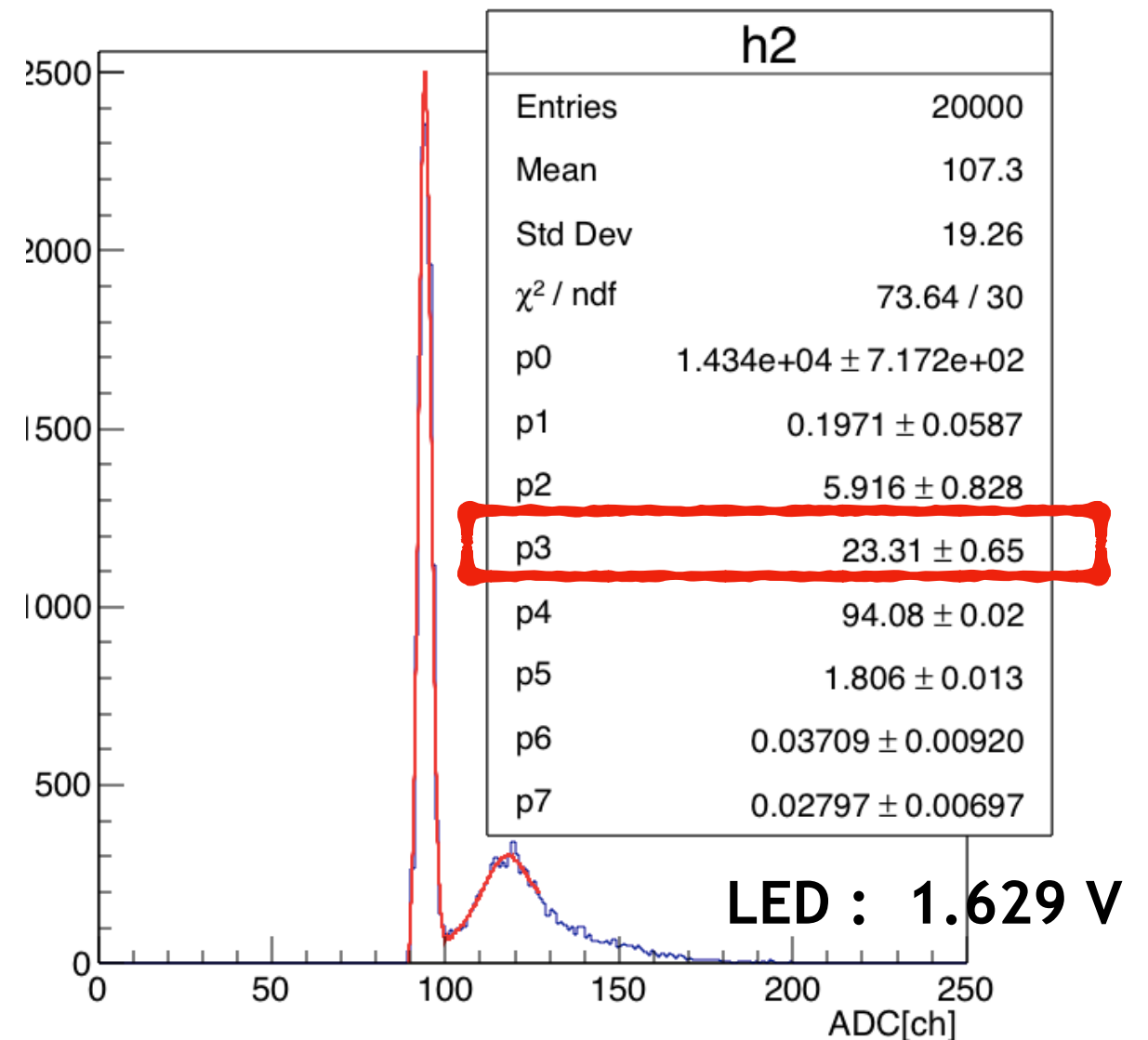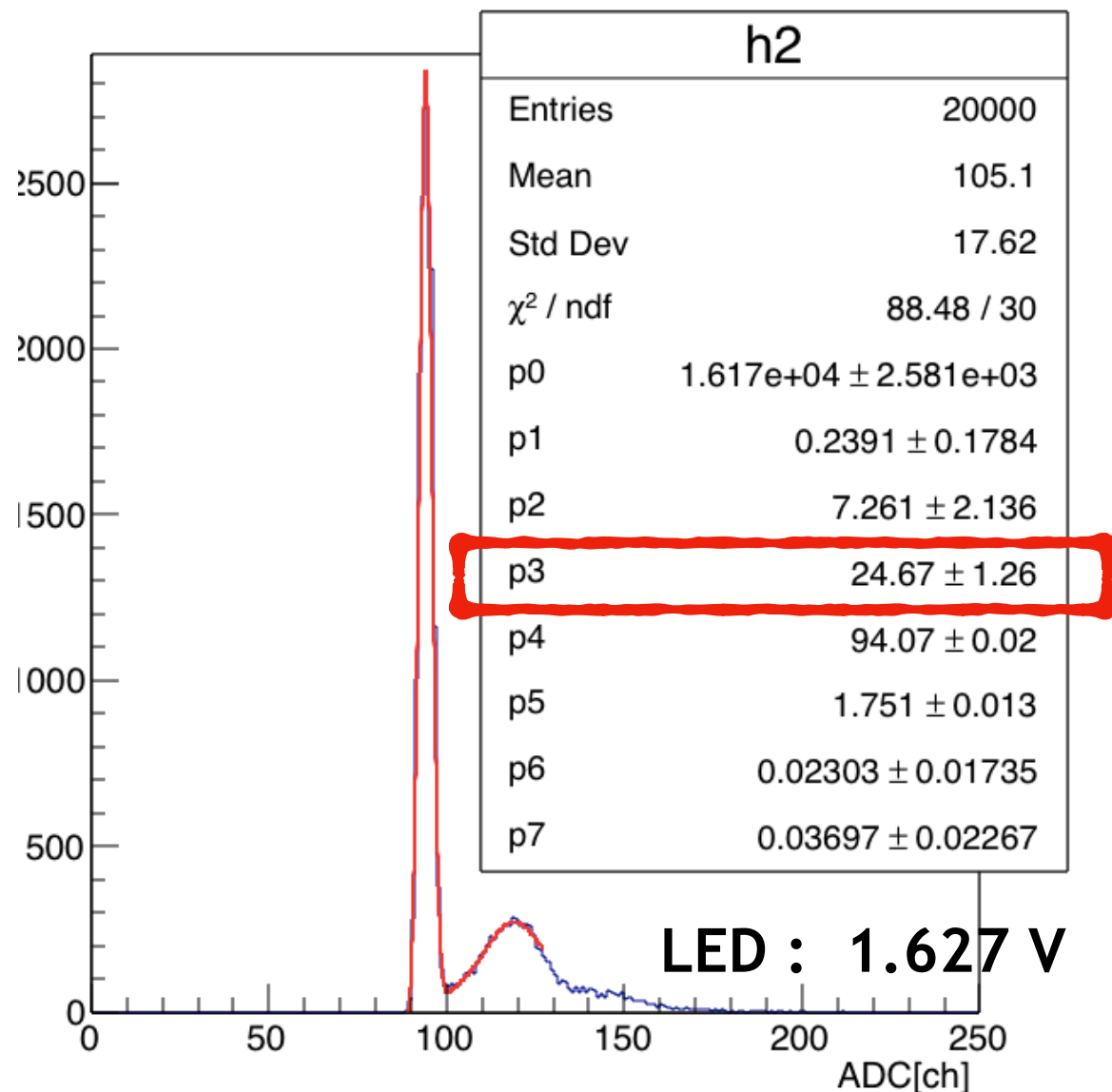- LED : Scanned starting from 1.65 V to 1.68V, every 0.05 V, 100 Hz, 20 ns

h2	
Entries	10000
Mean	98.37
Std Dev	28.87
χ^2 / ndf	156.5 / 69
p0	1.063e+04 ± 1.586e+02
p1	1.078 ± 0.021
p2	16 ± 0.7
p3	25.63 ± 0.37
p4	73.38 ± 0.01
p5	0.6513 ± 0.0093
p6	0.002482 ± 0.001343
p7	0.3165 ± 0.1003

LED : 1.660 V

h2	
Entries	20000
Mean	122.3
Std Dev	39.06
χ^2 / ndf	161.5 / 49
p0	2.313e+04 ± 6.809e+02
p1	2.108 ± 0.041
p2	14.85 ± 0.49
p3	26.5 ± 0.4
p4	73.39 ± 0.01
p5	0.6556 ± 0.0102
p6	0.005755 ± 0.001932
p7	0.2516 ± 0.0563

LED : 1.68 V

PMT Test with LED

- Serial No.RD6160

- Applied Voltage : -2300 V

- LED : Scanned starting from 1.62 V to 1.63V, every 0.01 V, 100 Hz, 20 ns

h2	
Entries	20000
Mean	105.1
Std Dev	17.62
χ^2 / ndf	88.48 / 30
p0	$1.617e+04 \pm 2.581e+03$
p1	0.2391 ± 0.1784
p2	7.261 ± 2.136
p3	24.67 ± 1.26
p4	94.07 ± 0.02
p5	1.751 ± 0.013
p6	0.02303 ± 0.01735
p7	0.03697 ± 0.02267

LED : 1.627 V

h2	
Entries	20000
Mean	107.3
Std Dev	19.26
χ^2 / ndf	73.64 / 30
p0	$1.434e+04 \pm 7.172e+02$
p1	0.1971 ± 0.0587
p2	5.916 ± 0.828
p3	23.31 ± 0.65
p4	94.08 ± 0.02
p5	1.806 ± 0.013
p6	0.03709 ± 0.00920
p7	0.02797 ± 0.00697

LED : 1.629 V

PMT Test with LED

- Summary of the test

Serial No,	Applied HV	Approx.Gain	Etc
RD 6201	-2100V	~ 30	Possible Candidate
RD 4974	-2150V	~ 31.2	Possible Candidate
RD 6224	-2400V	~ 26	Spare
RD 6160	-2300V	~ 24	Spare
RD 4977	-2300V	~ 30.8	Possible Candidate (Former Bottom PMT)

- RD 6201, RD 4974, RD 4977 are considered as possible candidates for the detector

- After the installation, another test will be performed.

Parametres Measurement

- For the most water cherenkov detectors, the main issue is 'attenuation length'

- Some groups studied about...

  - Change in attenuation length due to exposure to the plastic for long time

  - Change in attenuation length due to contamination due to glue

- Experimental Methods differs with the groups but constructing the system for measuring attenuation length using led seems important

  - **By plotting ADC mean (for several days) -> Exponential Fit**

  - Otherwise, data acquisition of Amplitude vs Time per each day (?)

Parametres Measurement
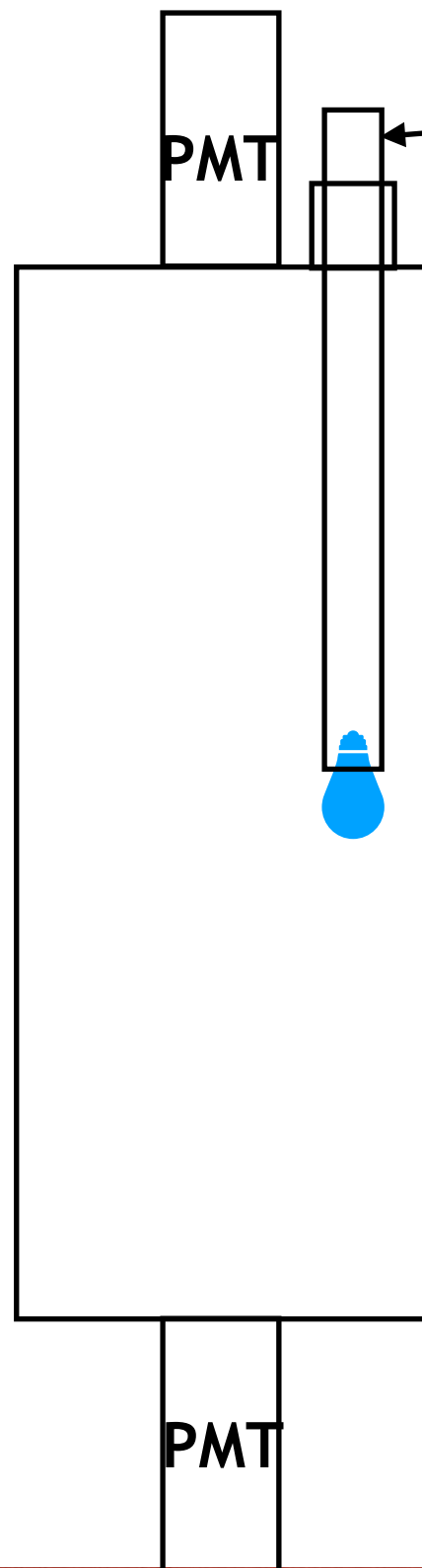
**Acrylic Cylinder
with ruler**

PMT

PMT

- Inserting an acrylic cylinder with length scale indicated

- Experimental Setup

  - With Pure water filled, obtaining ADC mean value while LED is turned on.

  - By differing the vertical position of LED, by every 5 ~ 10 cm, determine the attenuation length by fitting exponential.

  - Monitoring for several days

- For the possible contamination, using filters and circulator seems promising.

Backup

- Applied HV : -2300 V. (No. RD 4977)

- LED : Scanned starting from 1.63 V to 1.65V, every 0.05 V, 100 Hz, 20 ns

h1	
Entries	20000
Mean	111.8
Std Dev	23.48
χ^2 / ndf	185.6 / 43
p0	$1.705e+04 \pm 1.682e+02$
p1	0.5001 ± 0.0098
p2	9.468 ± 0.213
p3	31.05 ± 0.26
p4	93.7 ± 0.0
p5	1.574 ± 0.012
p6	0.01735 ± 0.00072
p7	0.05419 ± 0.00355

LED : 1.640 V

h1	
Entries	20000
Mean	121.3
Std Dev	27.51
χ^2 / ndf	147 / 83
p0	$1.194e+04 \pm 1.269e+02$
p1	0.5 ± 0.0
p2	7.663 ± 0.194
p3	31.16 ± 0.26
p4	93.62 ± 0.02
p5	1.655 ± 0.013
p6	0.04647 ± 0.00108
p7	0.03622 ± 0.00066

LED : 1.650 V