

Geant4, Gain

2019. 10. 2. Oh Sora

Shot Muon into scintillator with 2 GeV/c

- Determine the volume of the scintillator at 1cm^3
- Energy unit is MeV
- Length unit is cm
- Use table 2.1 in Techniques for Nuclear and Particle Physics Experiments

Bethe-Bloch formula

$$\bullet \frac{dE}{dx} = 2\pi N_a r_e^2 m_e c^2 \rho \frac{Z}{A} \frac{z^2}{\beta^2} \left[\ln \left(\frac{2m_e \gamma^2 v^2 W_{max}}{I^2} \right) - 2\beta^2 - \delta - 2 \frac{C}{Z} \right]$$

- r_e : *classical electron*
- m_e : *electron mass*
- N_a : *Avogadro's number*
- I : *mean excitation potential*
- Z : *atomic number of absorbing material*
- A : *atomic weight of absorbing material*
- ρ : *density of absorbing material*

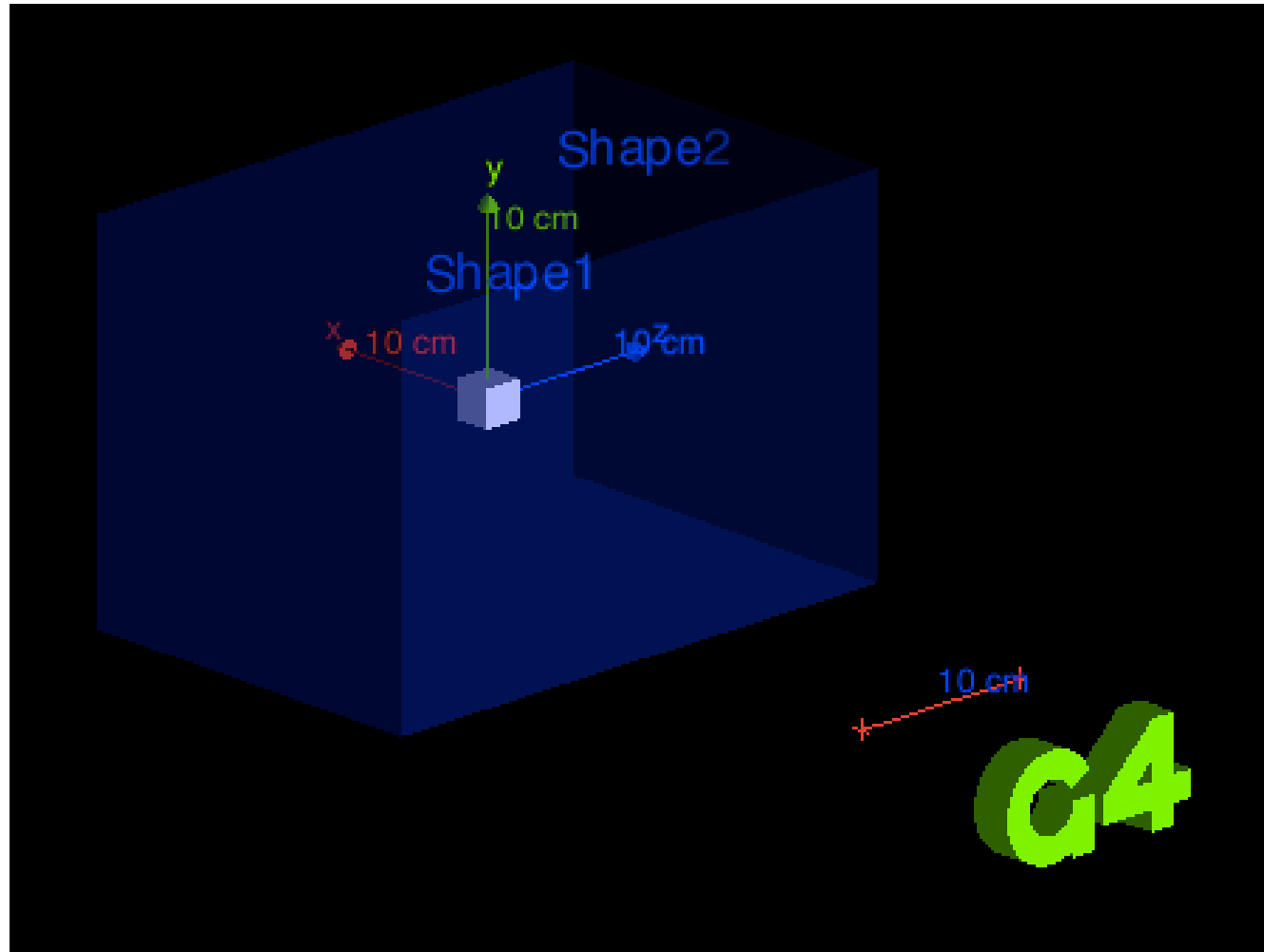
- z : *charge of incident particle in units of e*
- $\beta = \frac{v}{c}$ *of the incident particle*
- $\gamma = \frac{1}{\sqrt{1-\beta^2}}$
- δ : *density correction*
- C : *shell correction*
- W_{max} : *maximum energy transfer in a single collision*
- $I = 64.7 * 10^{-6}$
- $C_0 = -3.2$
- $a = 0.1610$
- $X_1 = 2.49, X_0 = 0.1464$
- $m = 3.24$
- $\eta = \beta\gamma$

- $W_{max} \cong 2m_e c^2 \eta^2 \quad (\because M \gg m_e) = 364.234$
- $\delta = 4.6052X + C_0 + a(X_1 - X)^m \quad (\because X_0 < X < X_1), X = 1.27596$
- $p = \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \quad \therefore v = 0.9986c$
- $Z_{eff} = \sum a_i Z_i = 33.1$
- $A_{eff} = \sum a_i A_i = 61.5429$
- $-\frac{dE}{dx} = 2.22579$

Scintillator

PROPERTIES	EJ-200	EJ-204	EJ-208	EJ-212
Light Output (% Anthracene)	64	68	60	65
Scintillation Efficiency (photons/1 MeV e ⁻)	10,000	10,400	9,200	10,000
Wavelength of Maximum Emission (nm)	425	408	435	423
Light Attenuation Length (cm)	380	160	400	250
Rise Time (ns)	0.9	0.7	1.0	0.9
Decay Time (ns)	2.1	1.8	3.3	2.4
Pulse Width, FWHM (ns)	2.5	2.2	4.2	2.7
No. of H Atoms per cm ³ (x10 ²²)	5.17	5.15	5.17	5.17
No. of C Atoms per cm ³ (x10 ²²)	4.69	4.68	4.69	4.69
No. of Electrons per cm ³ (x10 ²³)	3.33	3.33	3.33	3.33
Density (g/cm ³)	1.023	1.023	1.023	1.023
Polymer Base	Polyvinyltoluene			
Refractive Index	1.58			
Softening Point	75°C			
Vapor Pressure	Vacuum-compatible			
Coefficient of Linear Expansion	7.8 x 10 ⁻⁵ below 67°C			
Light Output vs. Temperature	At 60°C, L.O. = 95% of that at 20°C No change from 20°C to -60°			
Temperature Range	-20°C to 60°C			

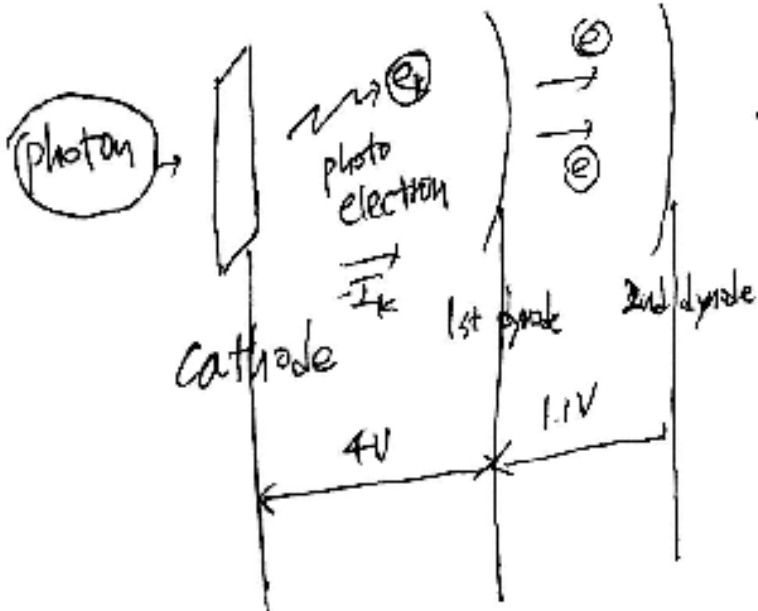
Scintillator(1 cm*1 cm*1 cm)



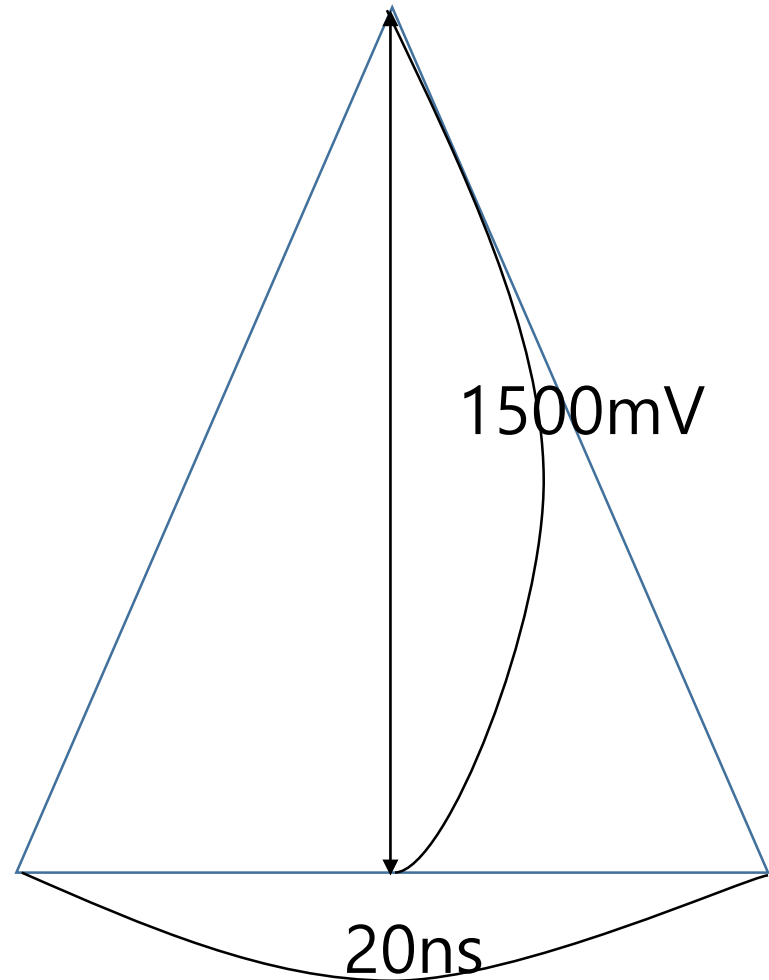
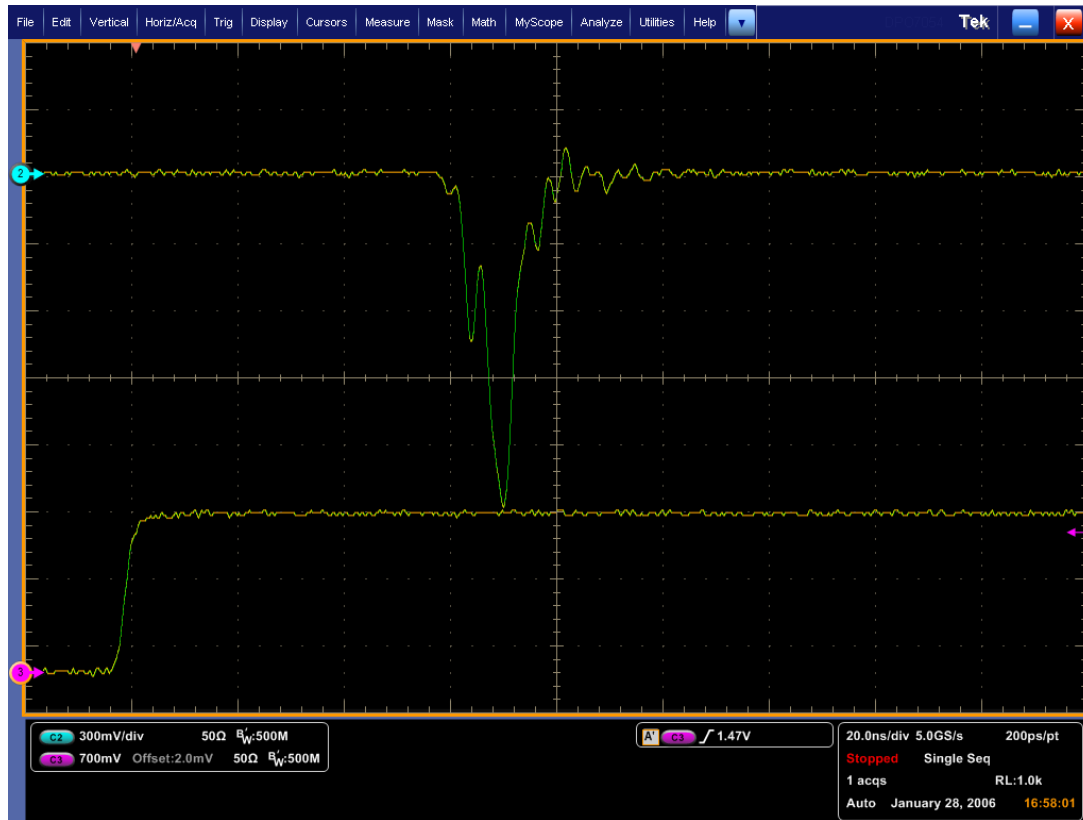
of Photons

- $QE = \frac{\text{\# of photoelectrons}}{\text{\# of photons}}$
- $\text{\# of photons} = \frac{\text{\# of photoelectrons}}{QE}$
- $Gain = \frac{I_p}{I_k} = \frac{e_p/t}{e_k/t} \frac{\text{\# of } e_p}{\text{\# of photoelectrons}}$
- $\text{\# of photons} = \frac{\text{\# of } e_p}{QE * gain}$
- I_p : anode current
- I_k : cathode to 1st dynode current

PMT



Number of photon entering PMT



Charge

- $I = q/t$

- $V = IR$

- $q = \frac{V * t}{R}$

- $q = \frac{1}{2} * \frac{1500mV * 20ns}{50\Omega} = 3 * 10^{-10} C$ $e = -1.602176634 * 10^{-19} C$

- # of $e_p = 1.87 * 10^9$

QE

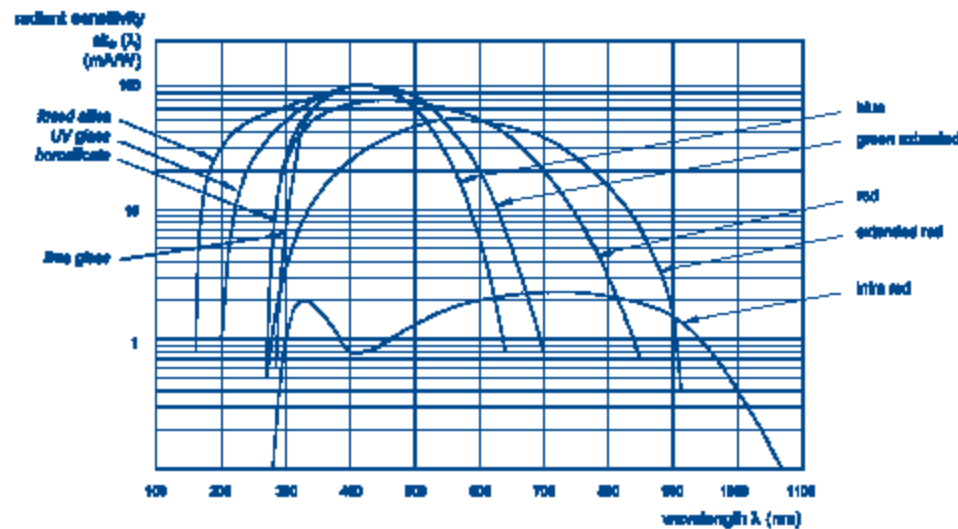


Fig.2 Typical spectral sensitivity characteristics of standard photocathodes with associated window materials.

- $QE(\%) = \frac{124}{\lambda} \times$
radiant sensitivity $\left(\frac{mA}{W}\right)$
- *radiant sensitivity* = 90 $\left(\frac{mA}{W}\right)$
- $\lambda = 400nm$
- $QE=27.9\%$

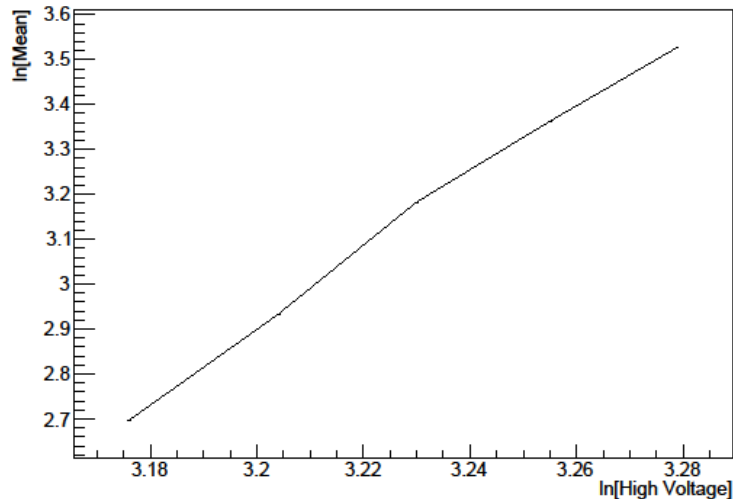
of Photons

- $\# \text{ of photons} = \frac{\# \text{ of } e_p}{QE * \text{gain}}$

- $\# \text{ of photons} = \frac{1.87 \times 10^9}{27.9\% * 3 \times 10^7} = 2.23 * 10^2$

Gain(μ) 측정

- $\mu = A * V^{kn}$
- V : supply voltage n : # of dynodes A : const
- $\frac{\mu_1}{\mu_2} = \left(\frac{V_1}{V_2}\right)^{kn}$ kn : slope of the straight line, graph of $\ln(\text{mean}) - \ln(V)$

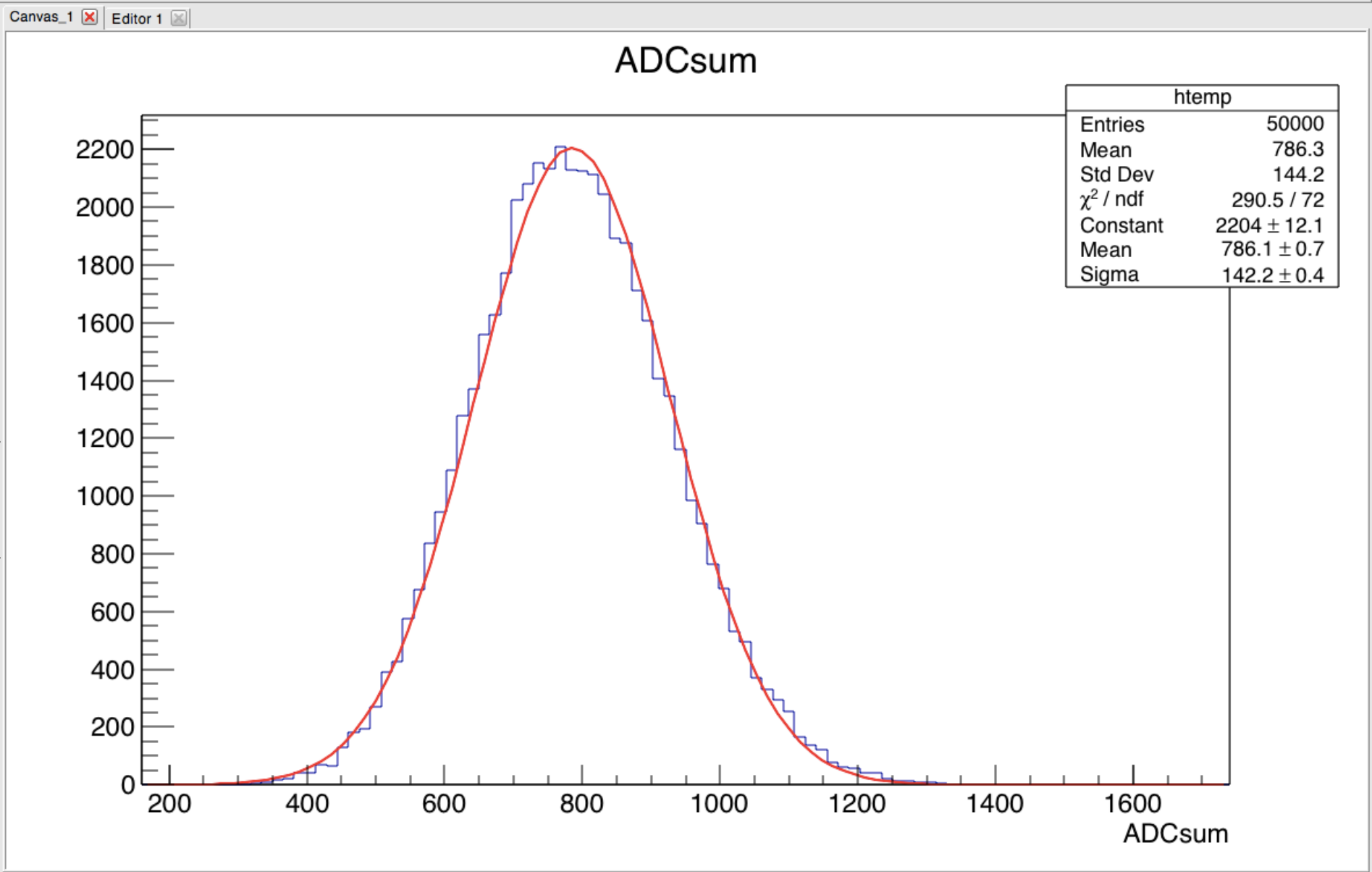


Files

Draw Option:

- T1_dst.root
 - tree;1
 - nch
 - Pedestal
 - Pedestal_rm:
 - ADCsum
 - ymax
 - Time
 - hped;1
- T2_dst.root
- TR0_dst.root
 - tree;1
 - nch
 - Pedestal
 - Pedestal_rm:
 - ADCsum
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 - Time
 - hped;1
- TR1_dst.root
- TR2_dst.root
- TR3_dst.root
- TR4_dst.root
- TR5_dst.root
- TR6_dst.root
- example
- f1.C
- fit_graph.C
- gain_histogram
- gain_hv_mean
- gain_inhv_inmean.C
- hv1500_dst.root
- hv1600_dst.root
- hv1700_dst.root
- hv1800_dst.root
- hv1900_dst.root
- Inhv_inmean.pdf
- CMakeLists.txt
- get.C
- hv1500.pdf
- Inhv_inmean.pdf
- nano_save

Filter: All Files (*.*)



Command

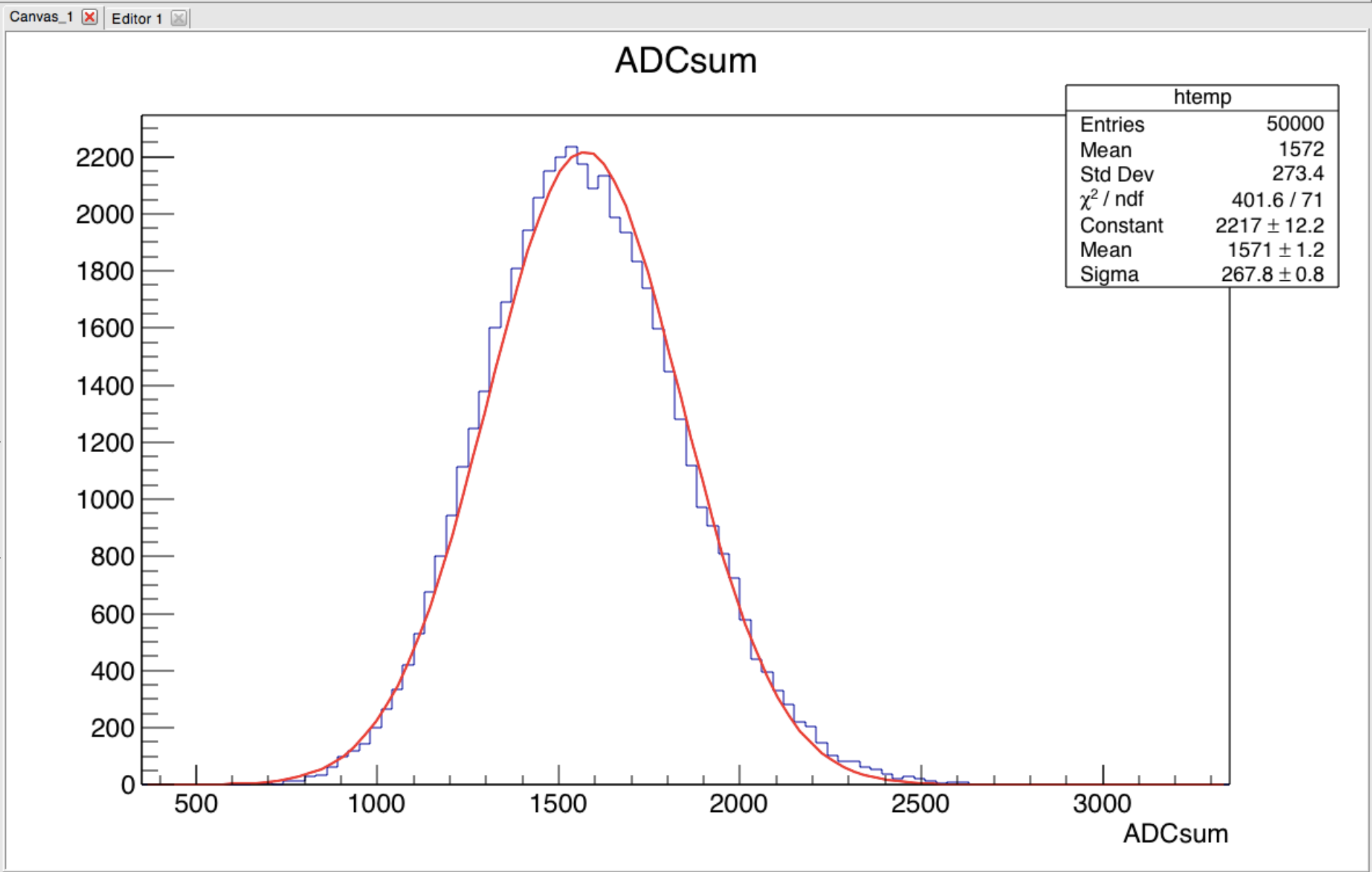
Command (local):

Files

Draw Option: [v]

- tree;1
 - nch
 - Pedestal
 - Pedestal_rm:
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- hped;1
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 - Time
 - hped;1
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 - tree;1
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Filter: All Files (*.*)



htemp	
Entries	50000
Mean	1572
Std Dev	273.4
χ^2 / ndf	401.6 / 71
Constant	2217 \pm 12.2
Mean	1571 \pm 1.2
Sigma	267.8 \pm 0.8

Command

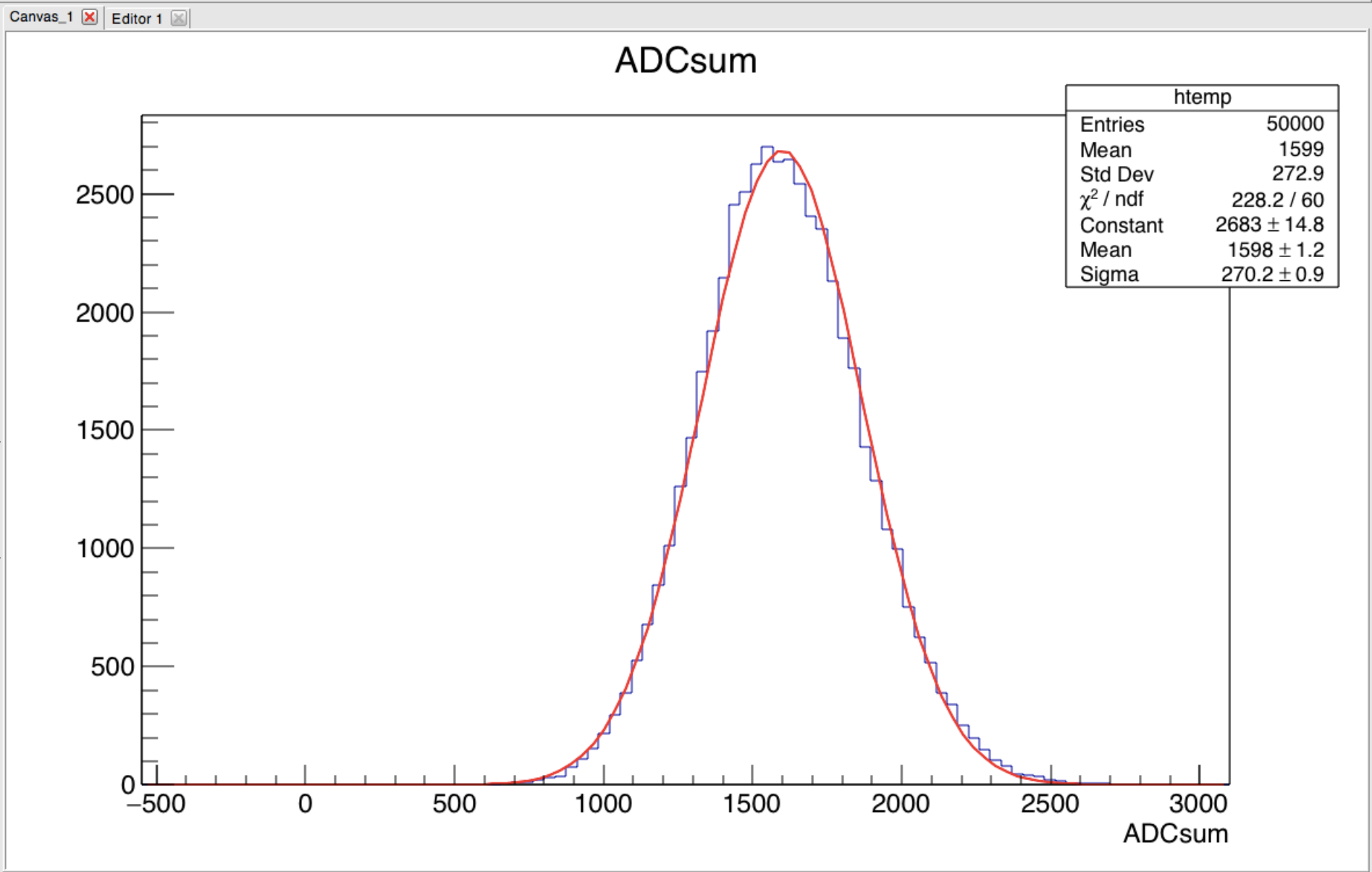
Command (local): []

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- TR3_dst.root
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- TR5_dst.root
- TR6_dst.root
- example

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Command

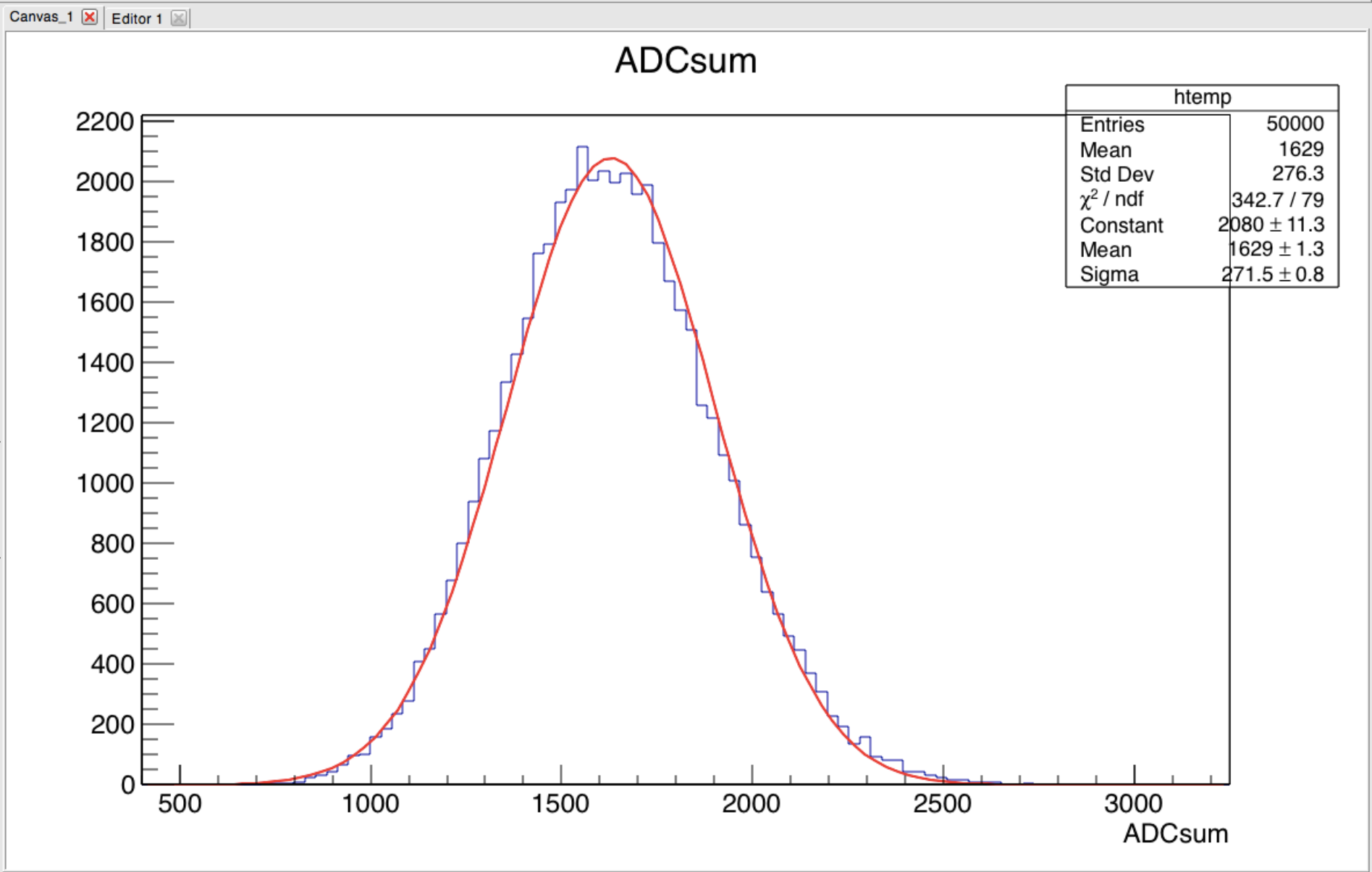
Command (local):

Files

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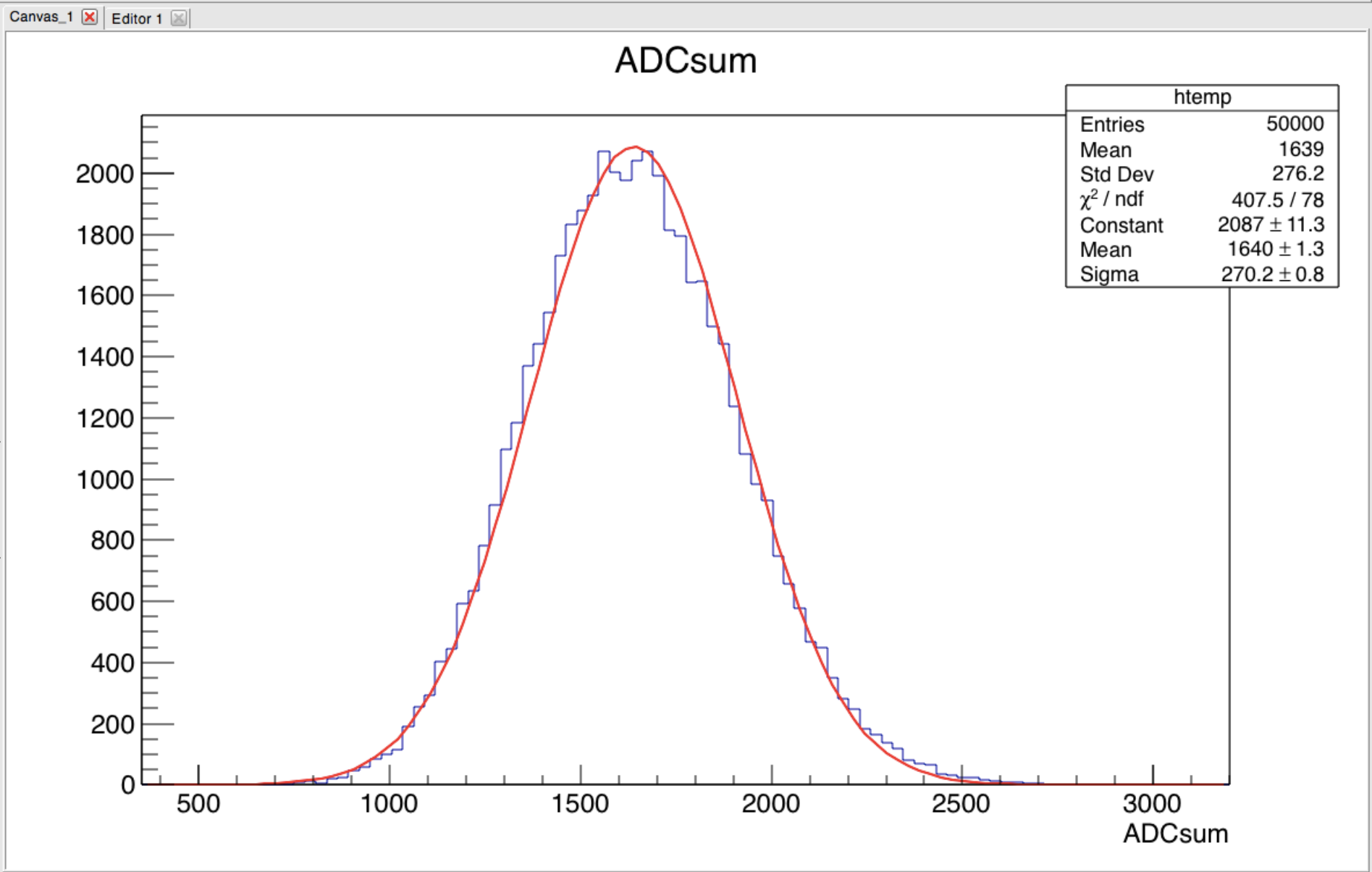
Command (local):

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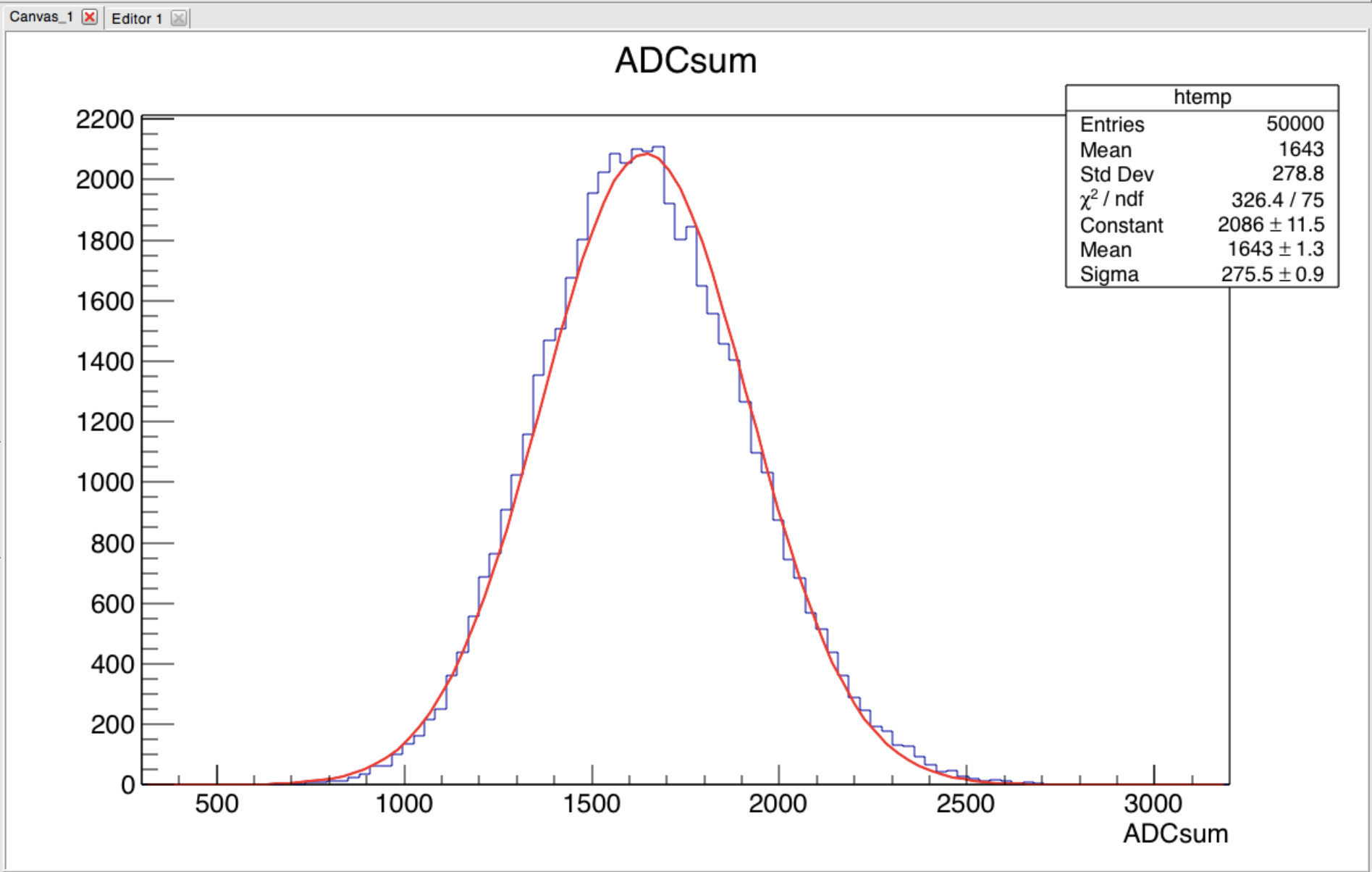
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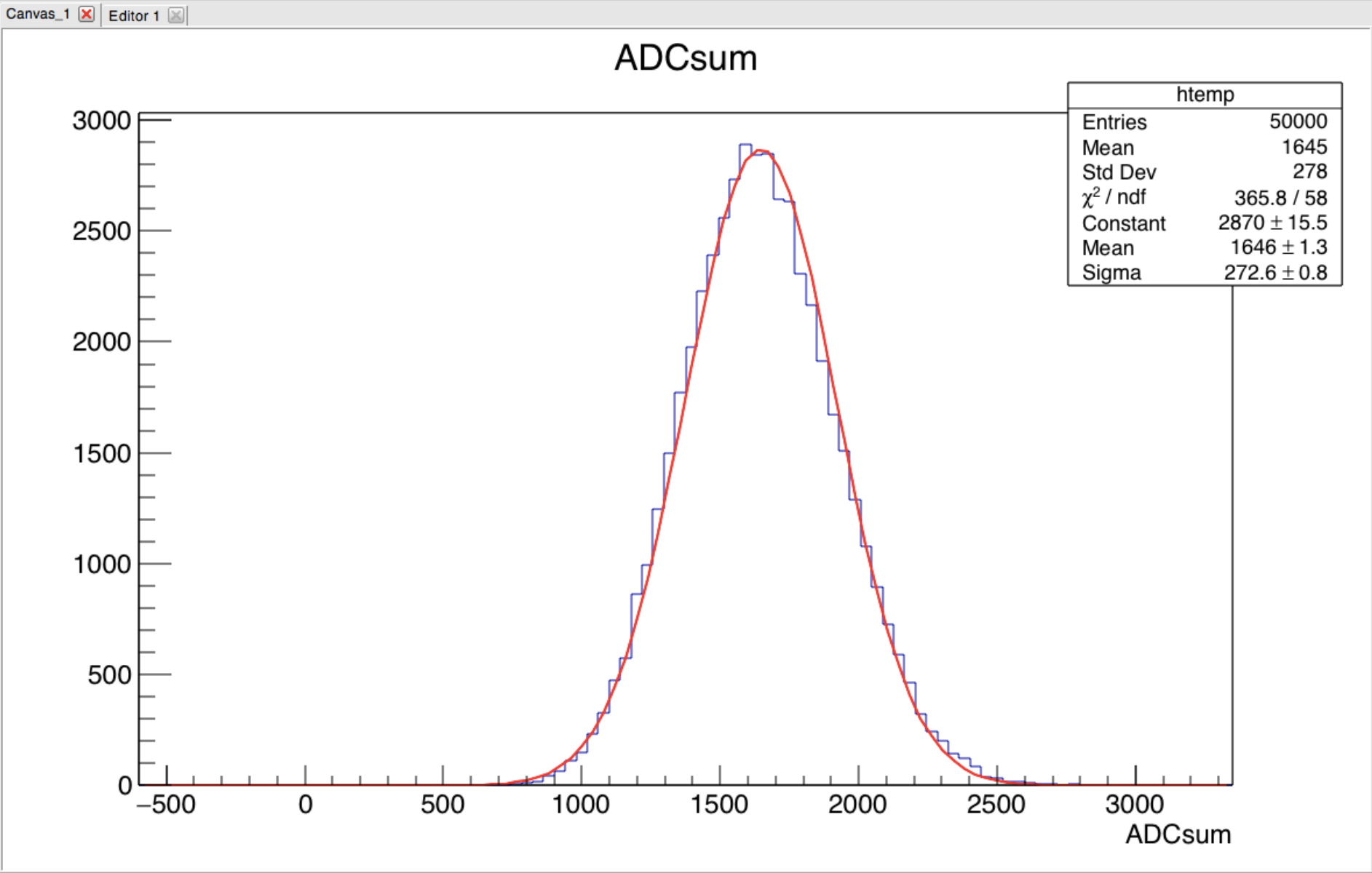
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Command

Command (local):

Times

Time	High voltage	Mean	Sigma
0 hour	1588-1603	786.1	142.2
1 hour	1601-1616	1571	267.8
2 hour	1635-1640	1598	270.2
3 hour	1557	1629	271.5
4 hour	1562, 1564	1640	270
5 hour	1565	1643	275.5
6 hour	1558-1570	1646	272.6

To do list

- Need to draw and fit histogram : $\ln(\text{mean}) - \ln(V)$ for get k_n
- Draw graph of gain ratio
- Study bethe-bloch formula
- Study of Geant4 and simulate