

Weekly Meeting

**Status of Gas Study with Test Chamber,
(DOLAMI CDC
and my M-Thesis)**

Yuto Kimura, 2024/12/2

Gas Study with Test Chamber

1. Gain from wave form and QDC
2. Frequency of 2nd, 3rd ... signal from TDC
- (3. Efficiency from TDC)

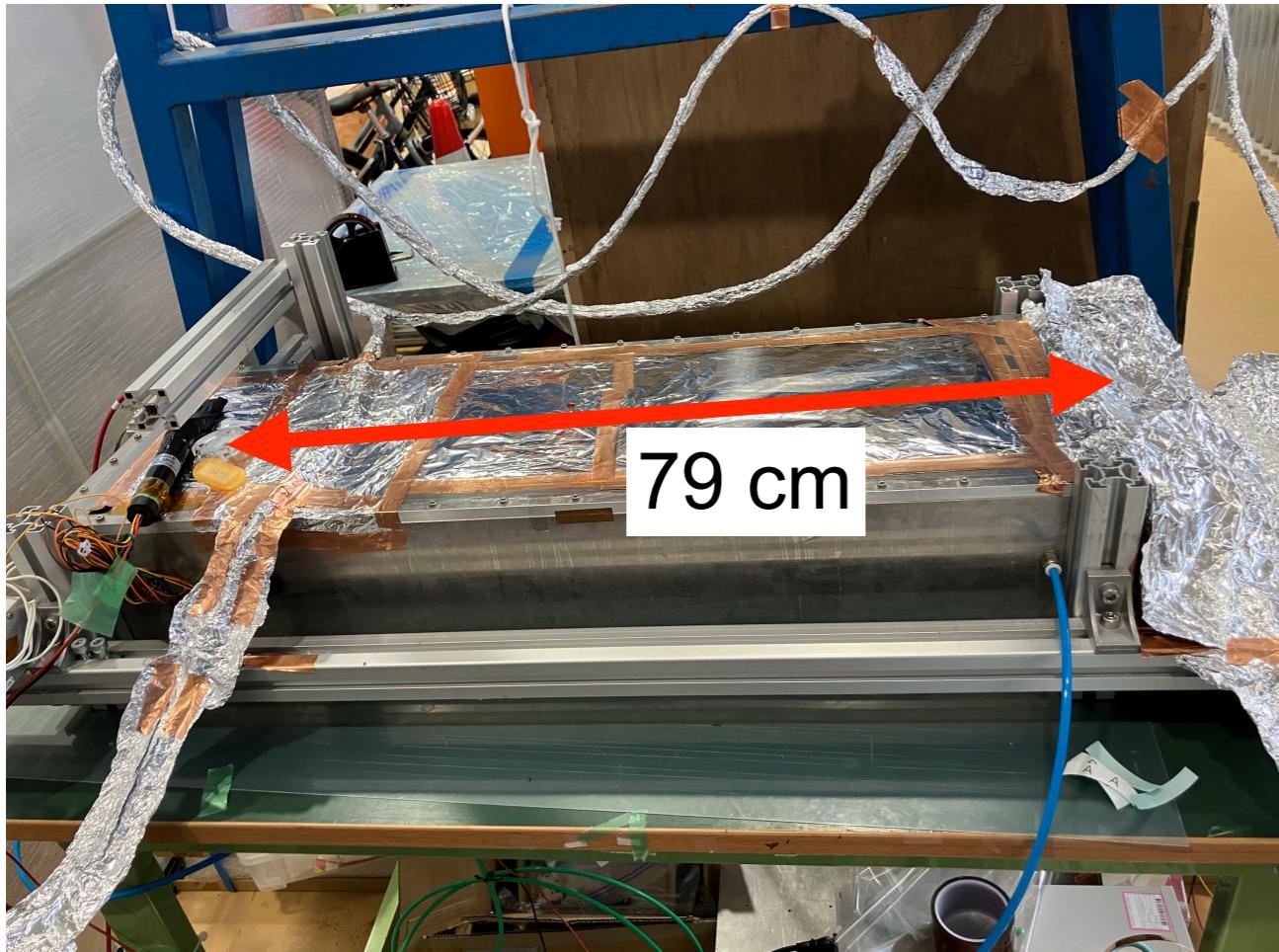
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Test Chamber ToDo			最後のは1目盛の時間										
2	Ratio	HV	Pos	Analog Before ASD					Analog After ASD				Digital	要した時間[min]
3	75-25	2300	79	noise	noise	noise	noise	noise	✓	✓	100 events	run195	no time to do	
4		2400	79	✓	✓	✓	✓	100 events	✓	✓	100 events	run196	run18	
5		2500	79	✓	✓	✓	✓	100 events	✓	✓	100 events	run197	run17	
6	11/27	2600	79	✓	✓	✓	✓	100 events	✓	✓	100 events	saturation	run16	
7		2700	79	✓	✓	✓	✓	100 events	✓	✓	100 events	saturation	run15	300
8		2800	79	✓	✓	✓	✓	100 events	saturation	saturation	saturation	saturation	no data	
9	80-20	2100	79	noise	noise	noise	noise	noise	✓	✓	1,000 events	run206	run19	
10		2200	79	✓	✓	✓	✓	1,000 events	✓	✓	1,000 events	run205	run20	
11		2300	79	✓	✓	✓	✓	1,000 events	✓	✓	1,000 events	run204	run21	
12		2400	79	✓	✓	✓	✓	1,000 events	✓	✓	1,000 events	run203	run22	
13	11/29	2500	79	✓	✓	✓	✓	1,000 events	✓	✓	saturation	saturation	run23	
14		2600	79	✓	✓	✓	✓	1,000 events	✓	✓	saturation	saturation	not needed	420
15	90-10	1900	79	noise	noise	noise	noise	noise	✓	✓	1,000 events			
16		2000	79	noise	noise	noise	noise	noise	✓	✓	1,000 events			
17		2100	79	✓	✓	✓	✓	1,000 events	✓	✓	1,000 events			
18	12/2	2200	79	✓	✓	✓	✓	1,000 events	✓	✓	1,000 events			
19		2300	79	✓	✓	✓	✓	1,000 events	✓	✓				
20		2400	79	itrip	itrip	itrip	itrip	itrip	✓	✓				
21	pre-mixed	1900	79	□	□	□	□	□	□	□	□	□		
22	90-10	2000	79	□	□	□	□	□	□	□	□	□		
23		2100	79	□	□	□	□	□	□	□	□	□		
24		2200	79	□	□	□	□	□	□	□	□	□		
25	12/4	2300	79	□	□	□	□	□	□	□	□	□		
26		2400	79	□	□	□	□	□	□	□	□	□		
27														

Before ASD

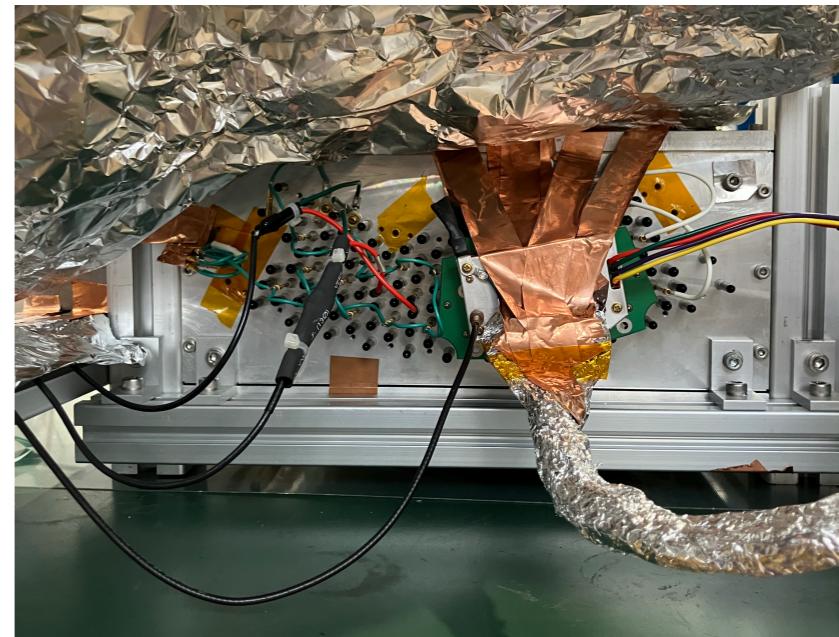
Analog signal Before ASD

Test Chamber
ArCO₂ (73⁺²₋₅ : 27₊₅⁻²)

Set-Up

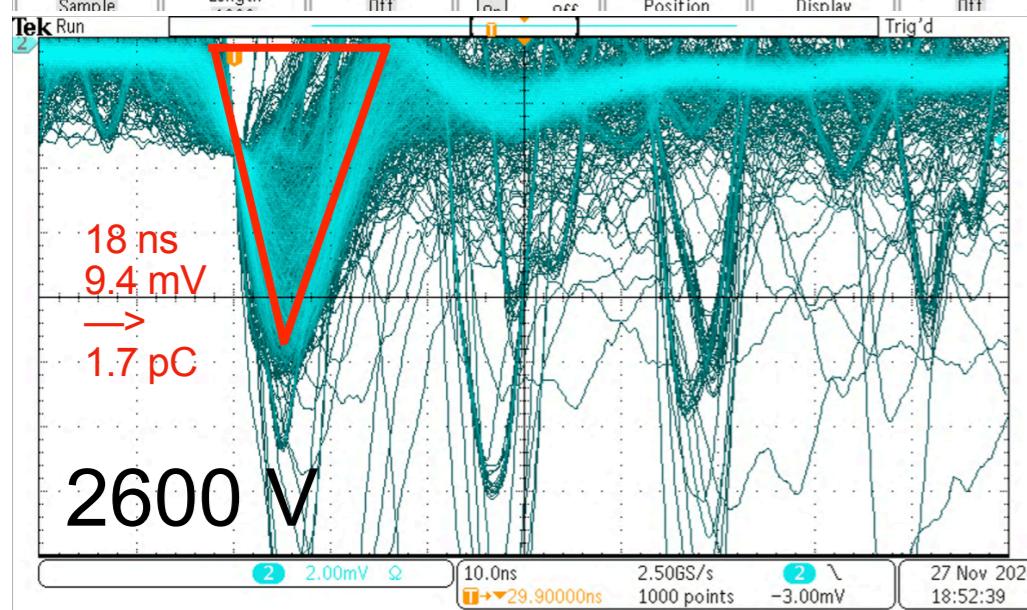
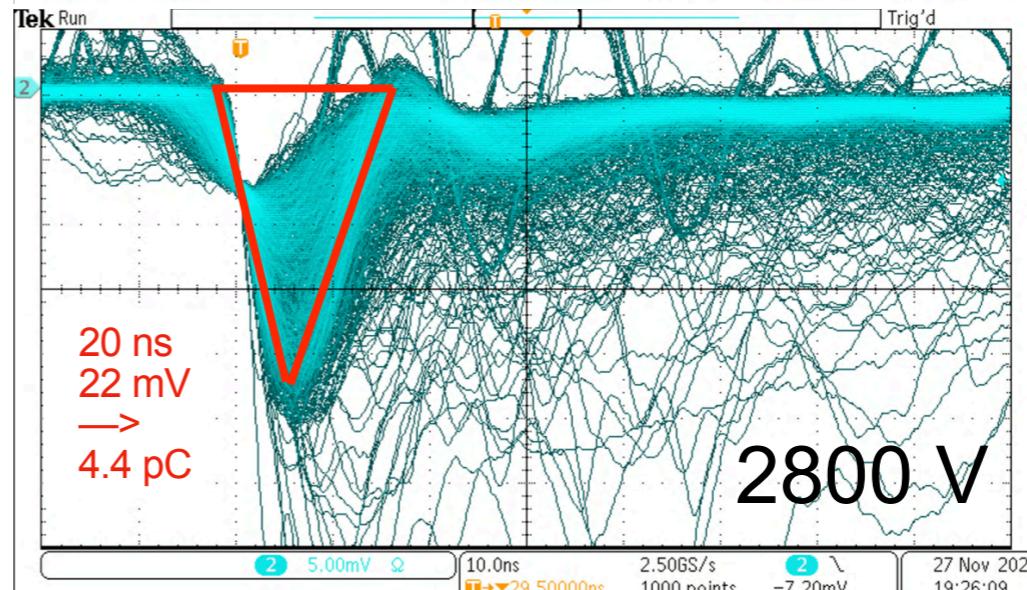
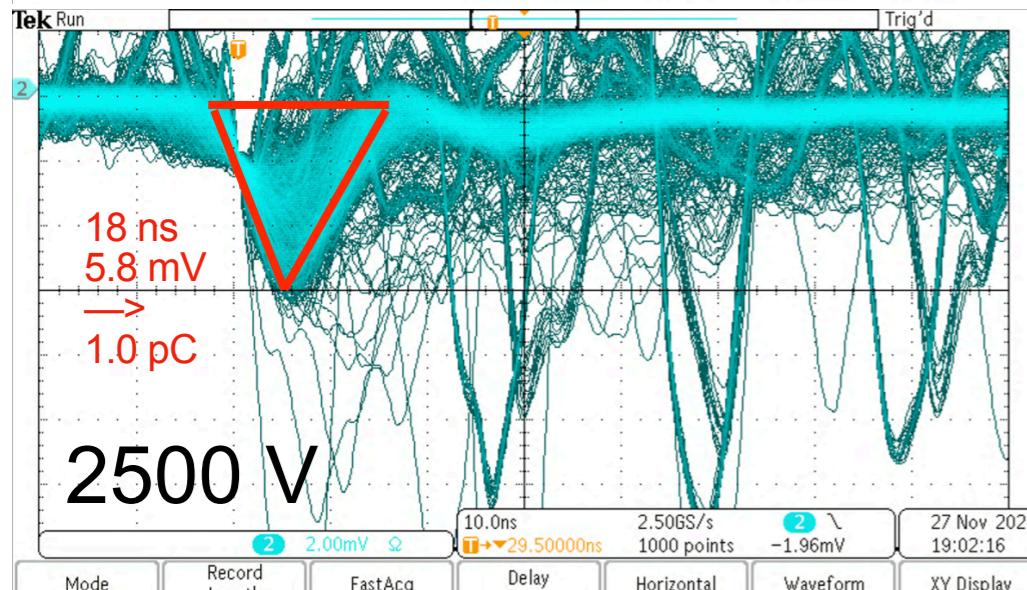
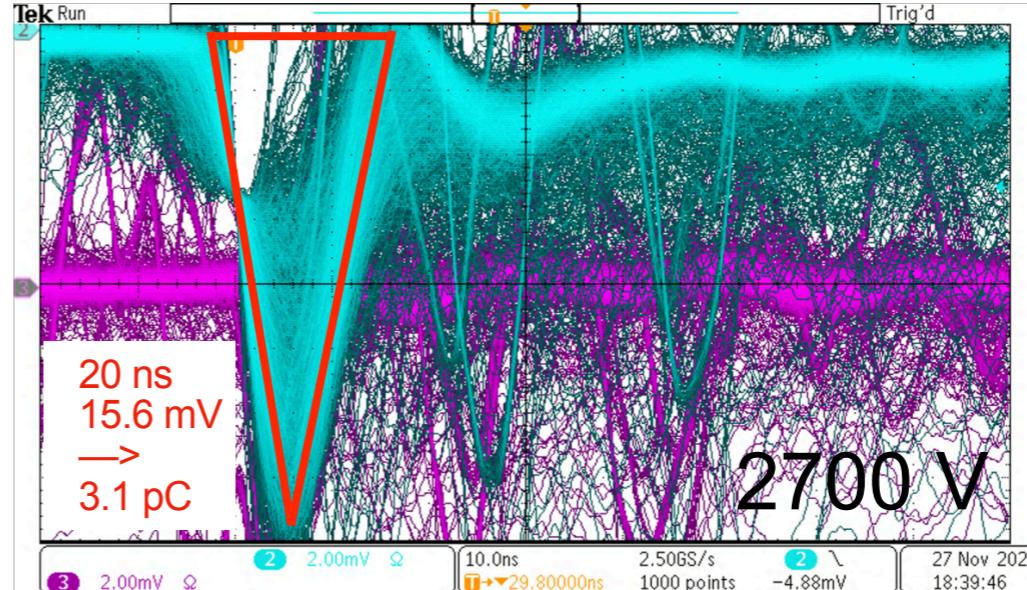
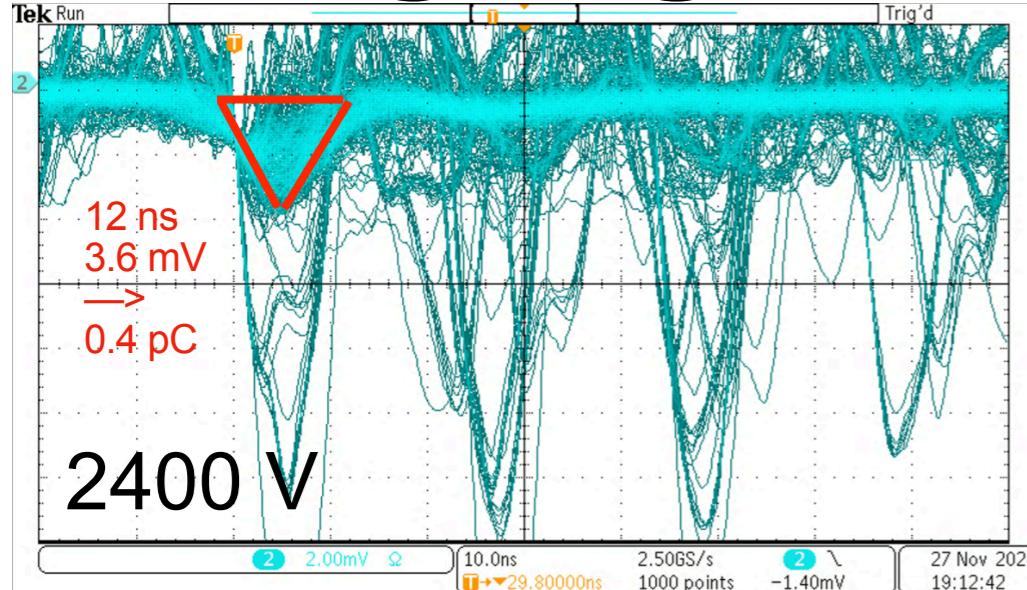


真ん中のレイヤー(2層目)の
2本をみている。
ASD、repeaterの電源はつけた状態。
PMT HVは落としている。



Analog signal Before ASD

Test Chamber
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)



Be Careful of this Range

2400 Vの場合、

$$Charge = - \frac{12 [ns] \times 3.6 [mV]}{2 \times 50[\Omega]} = - 0.4 [pC]$$

Analog signal Before ASD

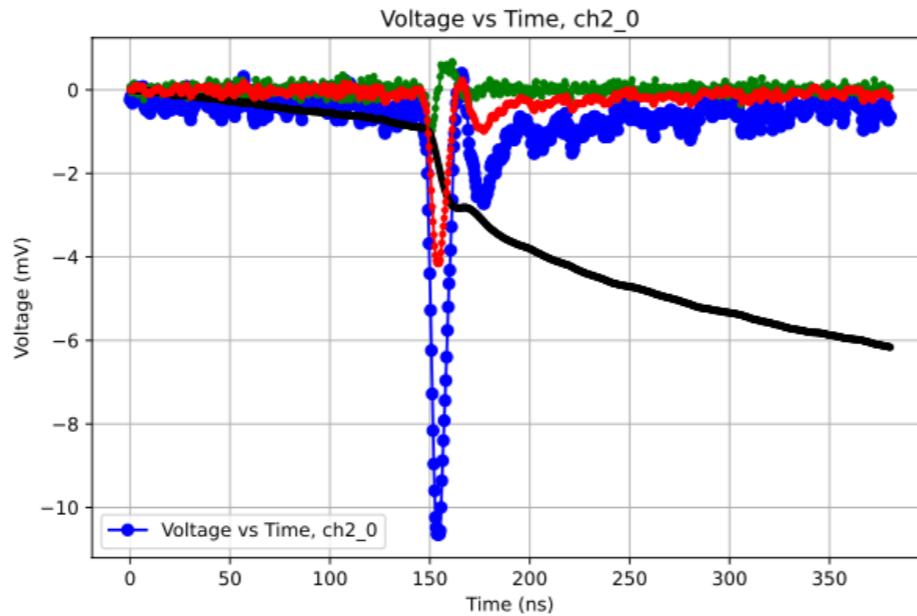
Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+5}_{-5})

Wave Form Analysis

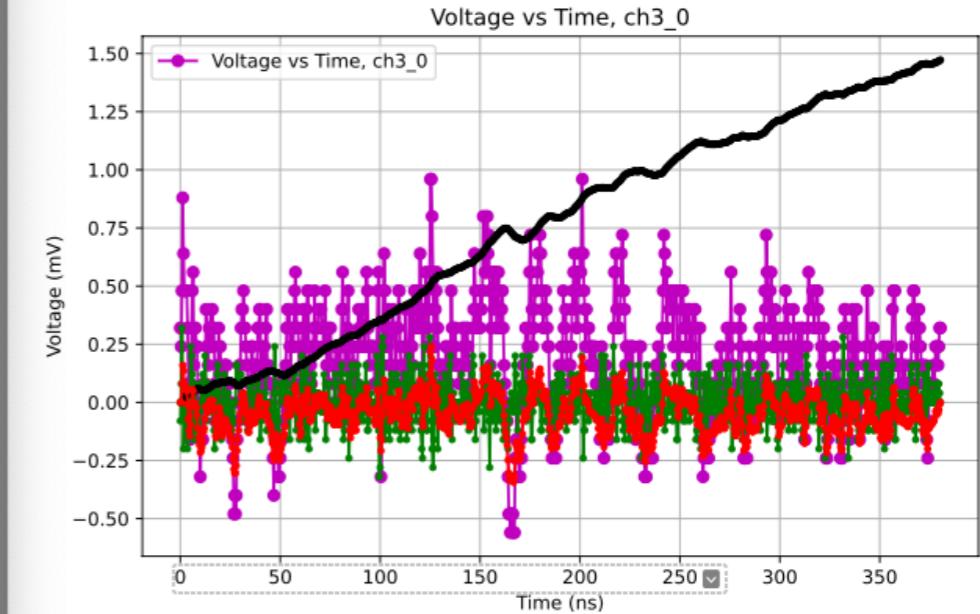
Some Types of Examples

blue(magenta) : real signal
black : integral of real signal
green : differential of real signal
red : integral of green

線源を当てるワイヤー

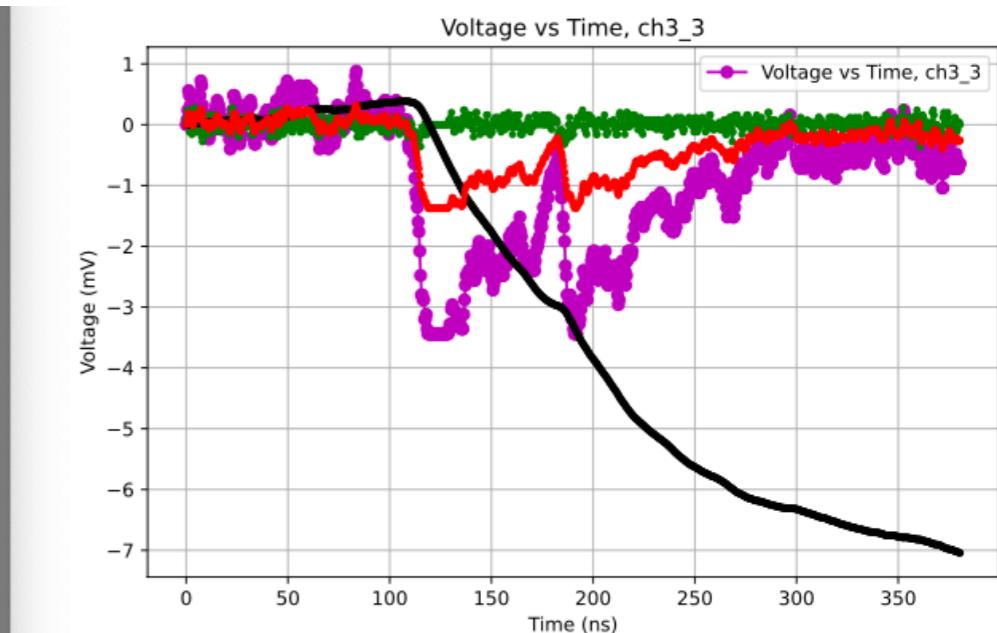
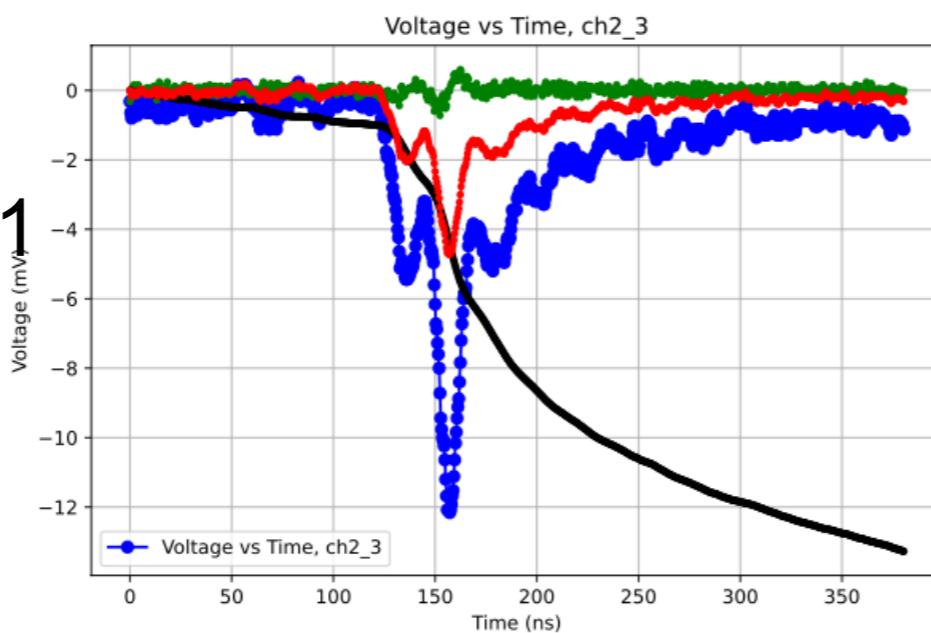


隣のワイヤー



Type 2.

Strange Signal 1
(pre-sig type)



Analog signal Before ASD

Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+5}_{-2})

Wave Form Analysis

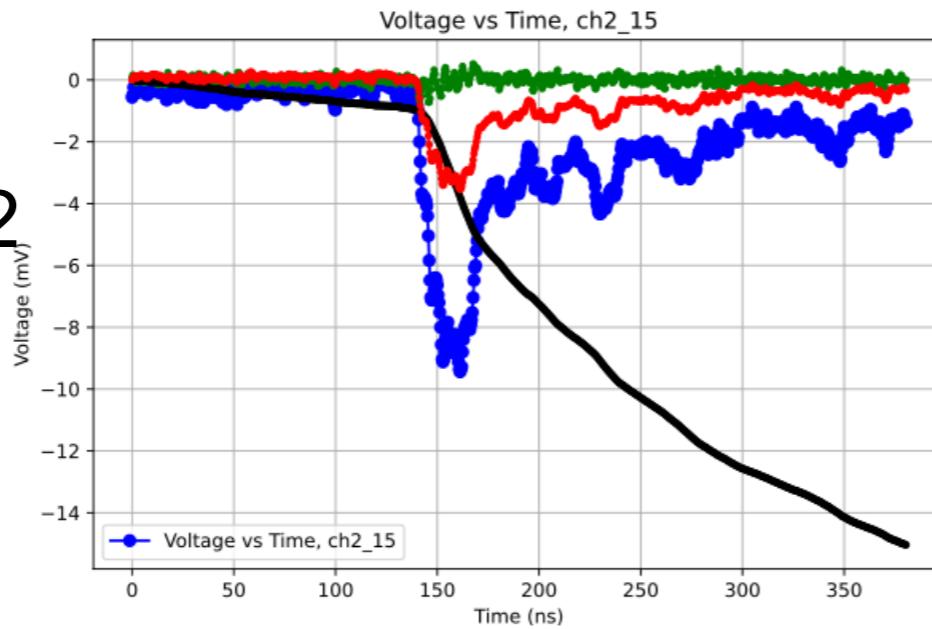
Some Types of Examples

blue(magenta) : real signal
black : integral of real signal
green : differential of real signal
red : integral of green

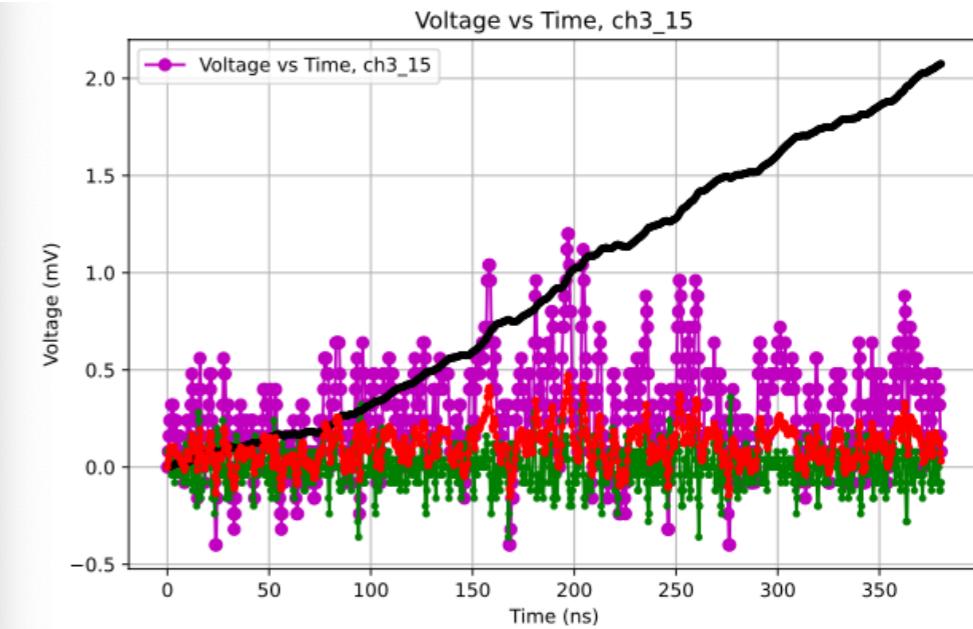
線源を当ててるワイヤー

Type 3.

Strange Signal 2
(broad-sig type)

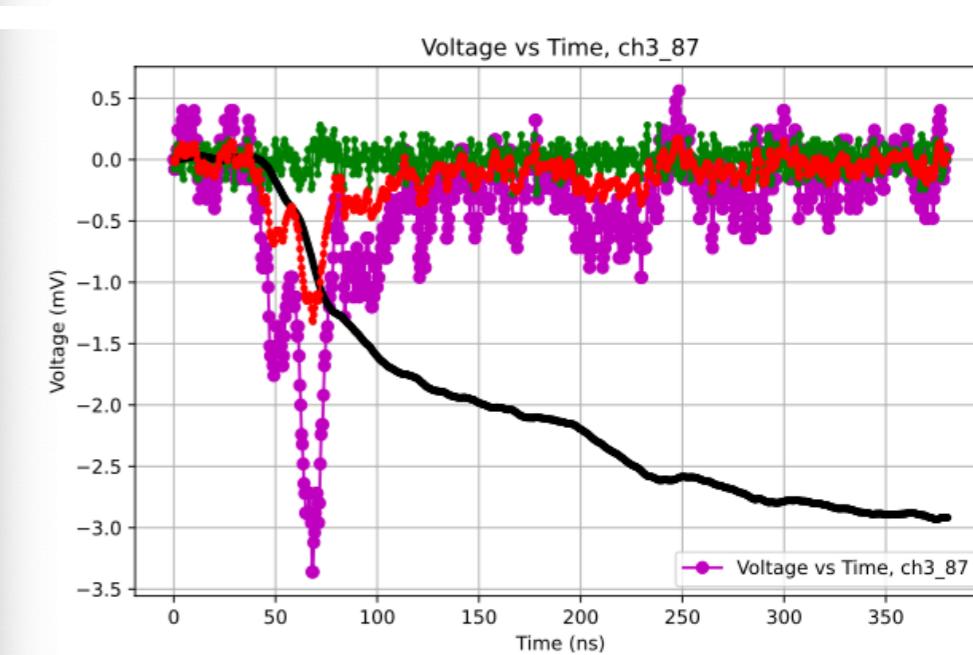
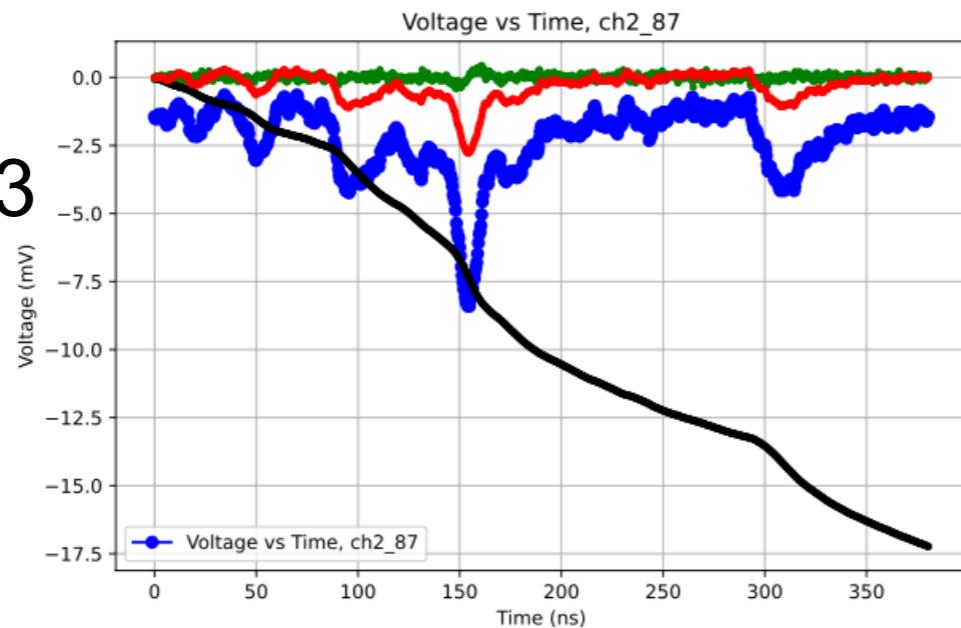


隣のワイヤー



Type 4.

Strange Signal 3
(dirty-sig type)



Analog signal Before ASD

Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+5}_{-2})

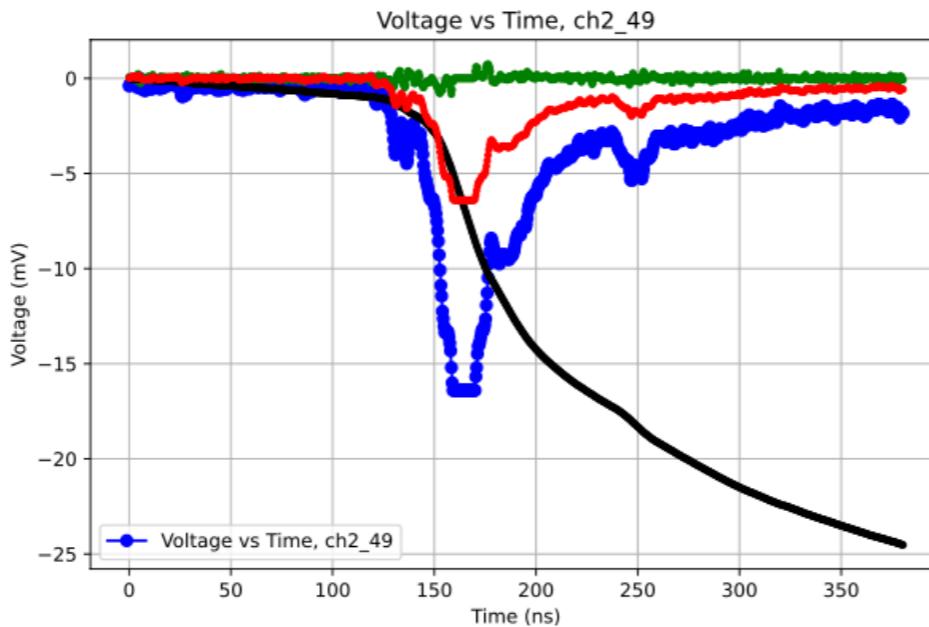
Wave Form Analysis

Some Types of Examples

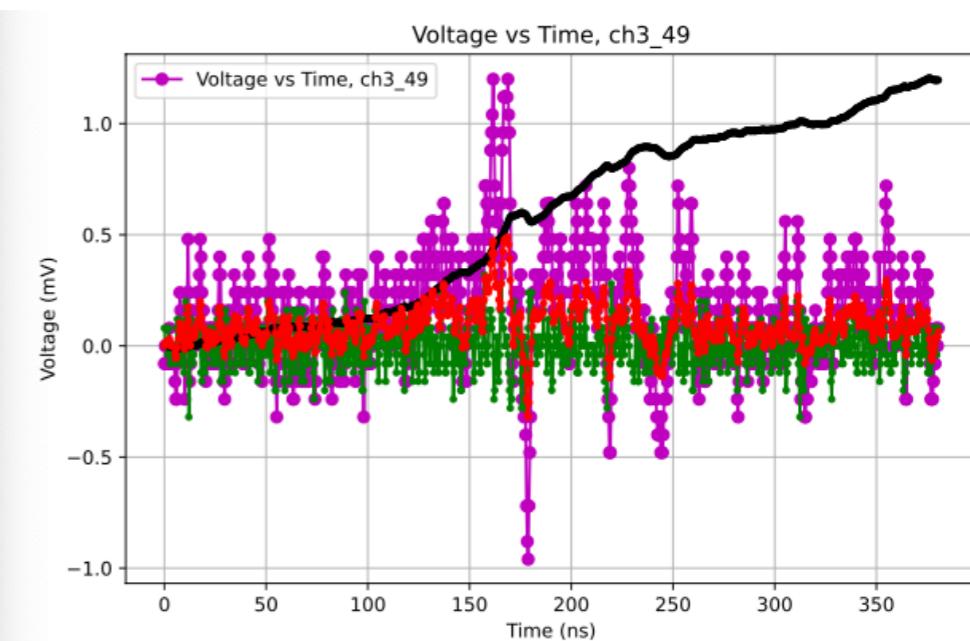
blue(magenta) : real signal
black : integral of real signal
green : differential of real signal
red : integral of green

線源を当ててるワイヤー

Type 5.

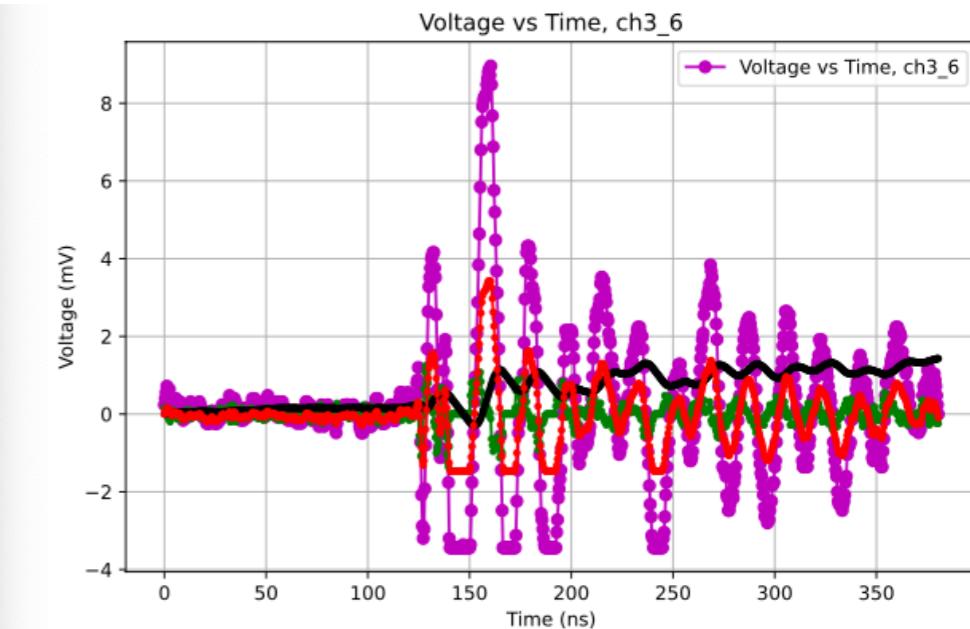
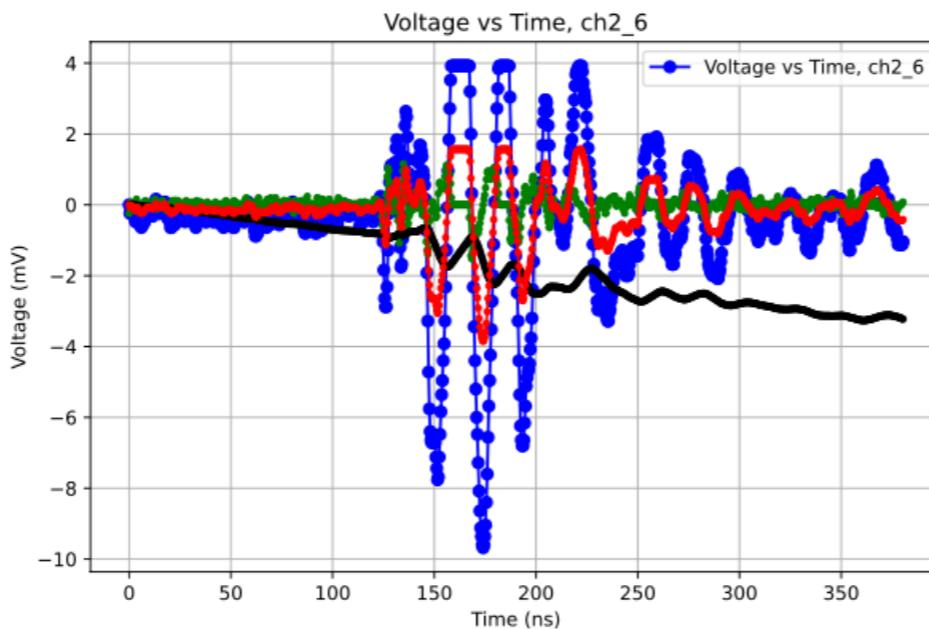


隣のワイヤー



Type 6.

Noise



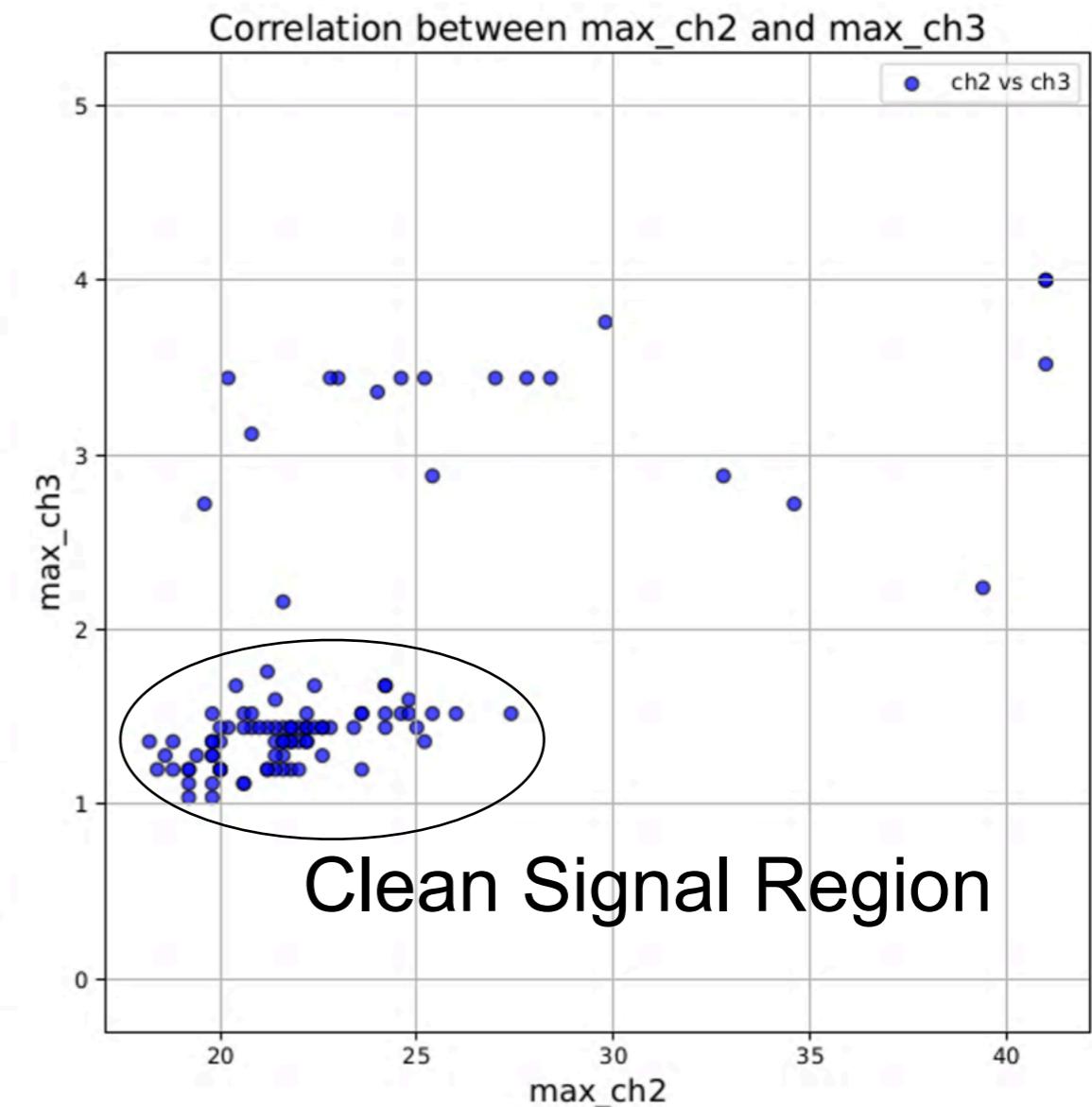
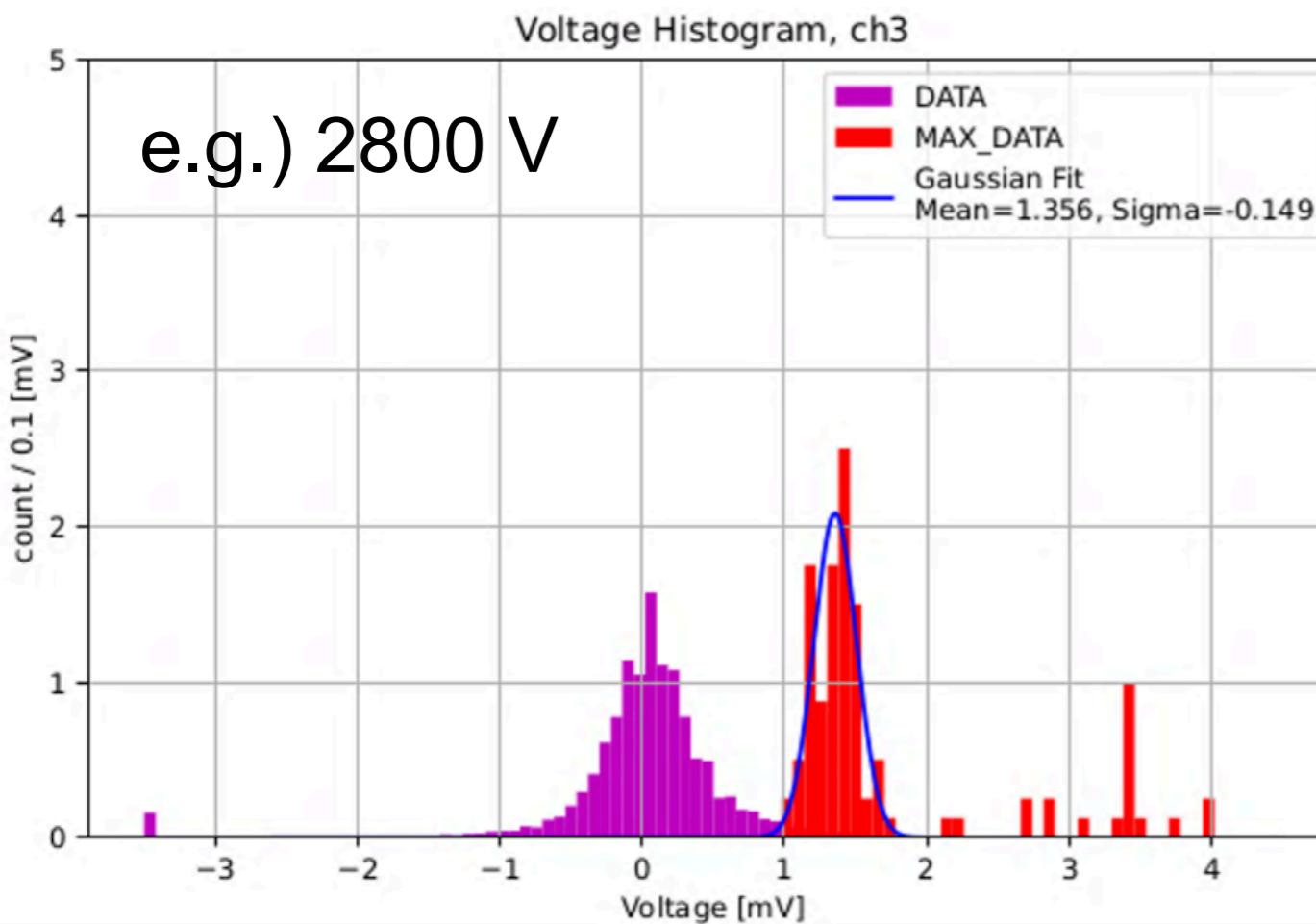
Analog signal Before ASD

Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+2}_{-5})

Wave Form Analysis

To choose clean signal only,
we can use information of the next wire (ch3).

magenta : all of voltage value (norm)
red : abs max value in each signal (norm)



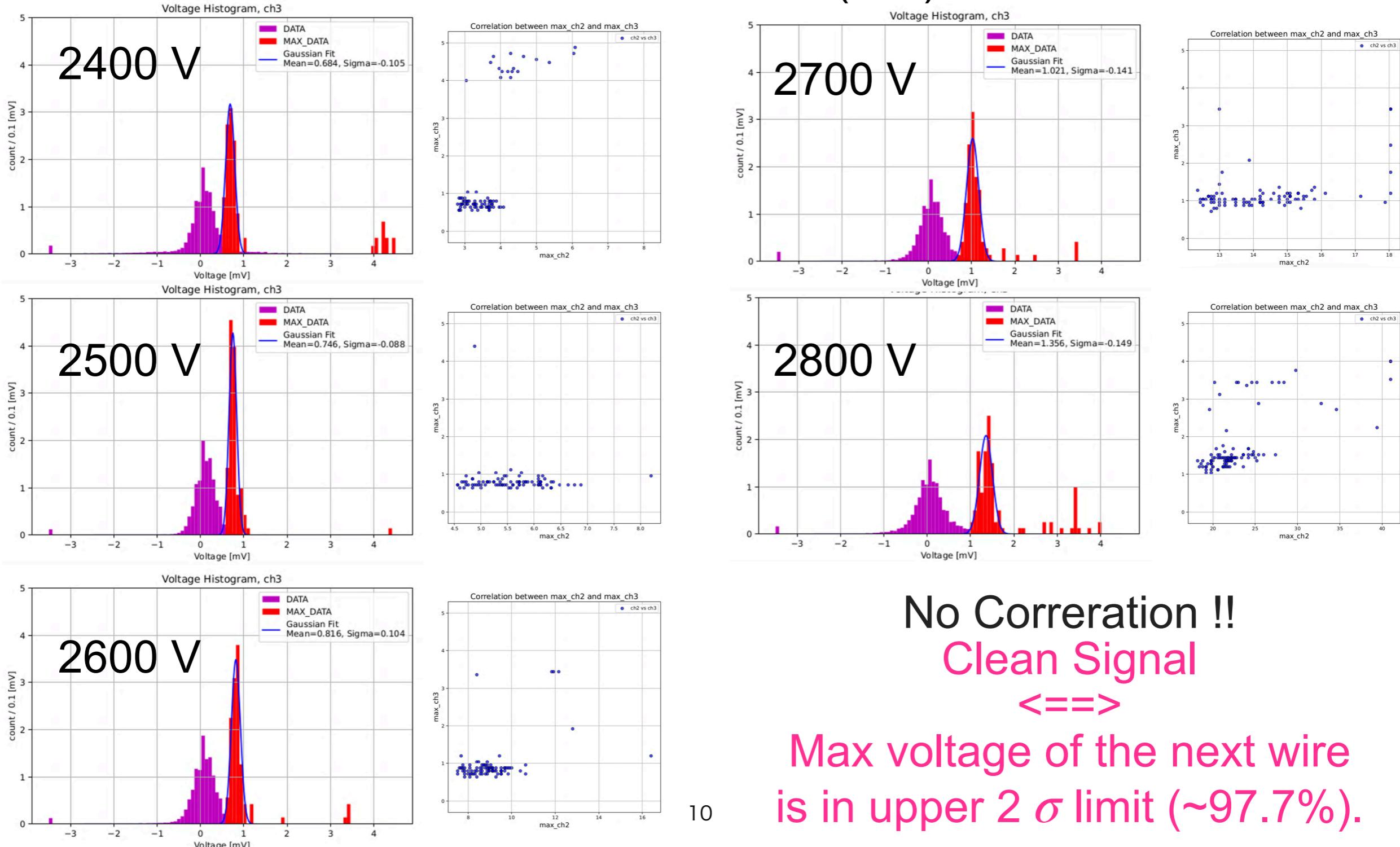
Analog signal Before ASD

Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+5}_{-5})

Wave Form Analysis

To choose clean signal only,
we can use information of the next wire (ch3).

magenta : all of voltage value
red : abs max value in each signal



Analog signal Before ASD

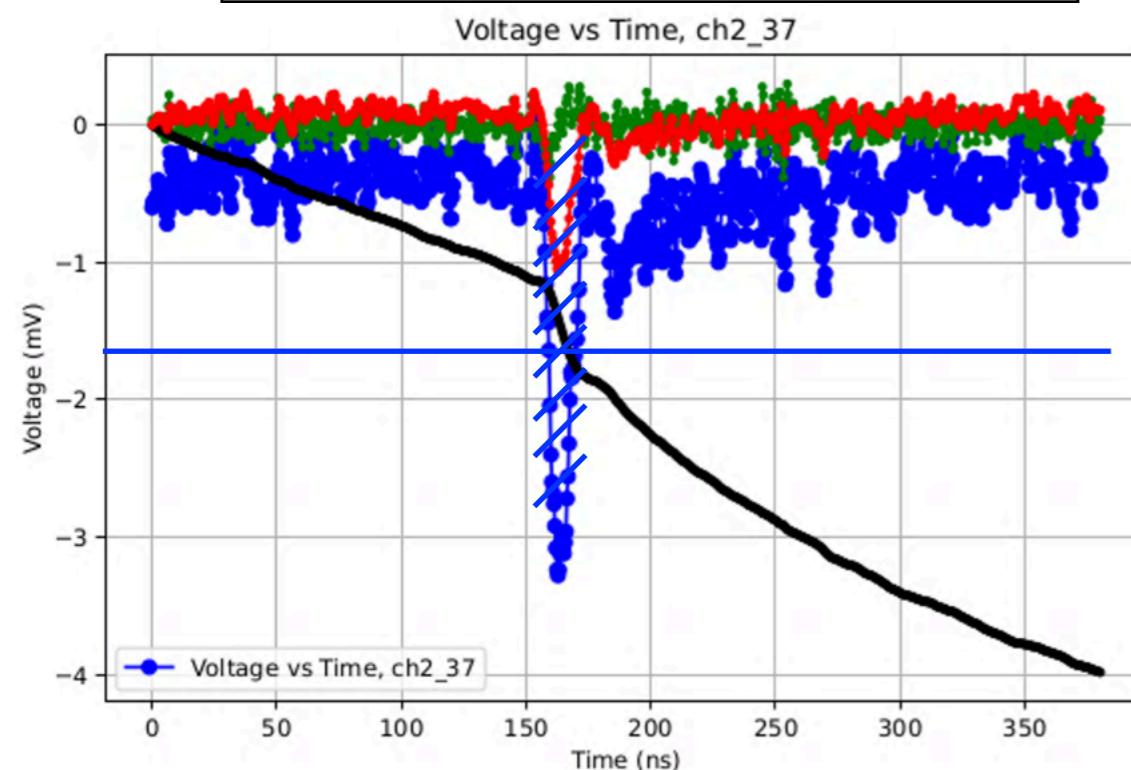
Test Chamber
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)

Wave Form Analysis

Calculation of Charges

e.g.) 2400 V

blue : real signal, v0
black : integral of real signal, q0
green : differential of real signal, dv
red : integral of green, v1



本当はv1がv0のベースラインを0にしたものになると期待していた(微分して積分しただけなので)。そうならない理由まで調査してる暇はない。

```
#####
### calculation of charges from waveforms
def Analize(pdf, channel, number, is_noise):
    try:
        data = np.loadtxt(DIR + f"Txt/ch{channel}_{number}.txt", skiprows=1)
        t = data[:, 0]
        v0 = data[:, 1]*1000
        q0 = cumulative_trapezoid(v0, t, initial=0) / 50
        dv = np.gradient(v0)
        v1 = cumulative_trapezoid(dv, t, initial=0)
        Vth = - np.max(np.abs(v1)) / 2

        q = 9999

        if channel == 2 :
            index_min = np.argmax(v1 < Vth)
            tmin = t[index_min]
            mask = t >= tmin
            index_max = np.argmax((v1 > Vth) & mask)
            tmax = t[index_max]

            q = q0[index_max + 10] - q0[index_min - 10] - q0[index_min - 10] * (tmax - tmin) / tmin
```

Signal $V_{th} = \text{Max Voltage of } v1 / 2 \rightarrow t_{\min}$ and t_{\max}

Charge q はこう計算

Analog signal Before ASD

Test Chamber
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)

Wave Form Analysis

Calculating the number of the primary electrons

Ar 平均電離エネルギー : 26 eV

CO₂ : 33 eV

$$W_{ave} = 26 \times \frac{73}{100} + 33 \times \frac{27}{100} = 27.89 \text{ eV}$$

$$N_{prime} = \frac{5.90 \text{ keV}}{27.89 \text{ eV}} = 212$$

気体	Z	A	(g/cm ³)	E _{ex} (eV)	E _i (eV)	I _o (eV)	W _i (eV)	(dE/dx) ₀ (MeV/g·cm ²)	(dE/dx) ₀ (keV/cm)	n _p (cm) ⁻¹	n _t (cm) ⁻¹
H ₂	2	2	8.38 × 10 ⁻⁵	10.8	15.9	15.4	37	4.03	0.34	5.2	9.2
He	2	4	1.66 × 10 ⁻⁴	19.8	24.5	24.6	41	1.94	0.32	5.9	7.8
N ₂	14	28	1.17 × 10 ⁻³	8.1	16.7	15.5	35	1.68	1.96	(10)	56
O ₂	16	32	1.33 × 10 ⁻³	7.9	12.8	12.2	31	1.69	2.26	22	73
Ne	10	20.2	8.39 × 10 ⁻⁴	16.6	21.5	21.6	36	1.68	1.41	12	39
Ar	18	39.9	1.66 × 10 ⁻³	11.6	15.7	15.8	26	1.47	2.44	29.4	94
Kr	36	83.8	3.49 × 10 ⁻³	10.0	13.9	14.0	24	1.32	4.60	(22)	192
Xe	54	131.3	5.49 × 10 ⁻³	8.4	12.1	12.1	22	1.23	6.76	44	307
CO ₂	22	44	1.86 × 10 ⁻³	5.2	13.7	13.7	33	1.62	3.01	(34)	91
CH ₄	10	16	6.70 × 10 ⁻⁴		15.2	13.1	28	2.21	1.48	16	53
C ₄ H ₁₀	34	58	2.42 × 10 ⁻³		10.6	10.8	23	1.86	4.50	(46)	195

クライン・クネヒトより

Errorの計算

$G(c, n)$, c: Total charge , n: The number of primary electrons

$$n = \frac{5.9 \times 10^3}{W_{av}(R(Ar))} , W_{av}: \text{平均電離エネルギー} -$$

$R(Ar): \text{The ratio of Ar gas } (\leq 1)$

$$\therefore G(c, n) = g(c, R(Ar)) = \frac{c \times 10^{-12}}{\frac{1.6 \times 10^{-19}}{n} \times \text{素電荷}}$$

$$= \frac{c \times 10^{-12}}{1.6 \times 10^{-19} \times \frac{5.9 \times 10^3}{W_{av}(R(Ar))}} = \frac{10^4}{9.44} \times c \times (26 \times R(Ar) + 33 \times (1 - R(Ar)))$$

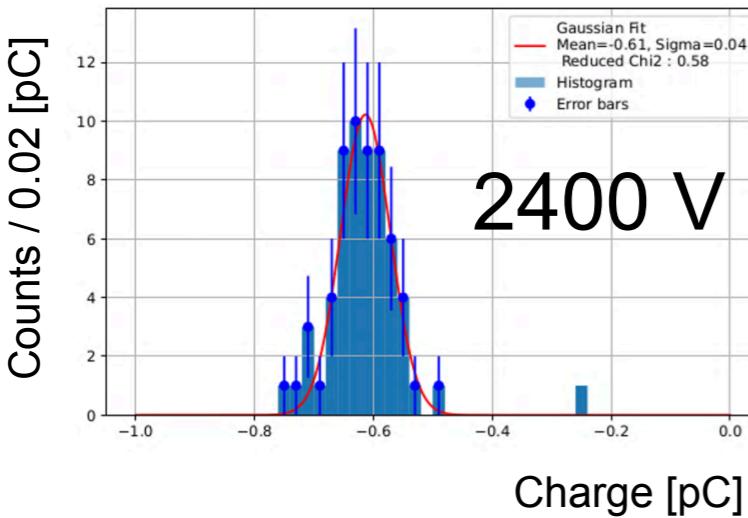
$$= \frac{10^4}{9.44} \times c \times (33 - 7 \times R(Ar))$$

$$\therefore G(c, n)^2_{err} = \left\{ \frac{10^4}{9.44} \times (33 - 7 \times R(Ar)) \times \Delta c \right\}^2 + \left\{ \frac{10^4}{9.44} \times c \times 7 \times \Delta R(Ar) \right\}^2$$

Analog signal Before ASD

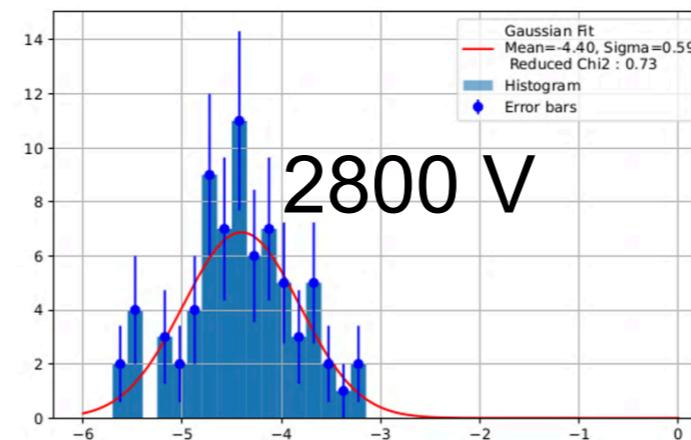
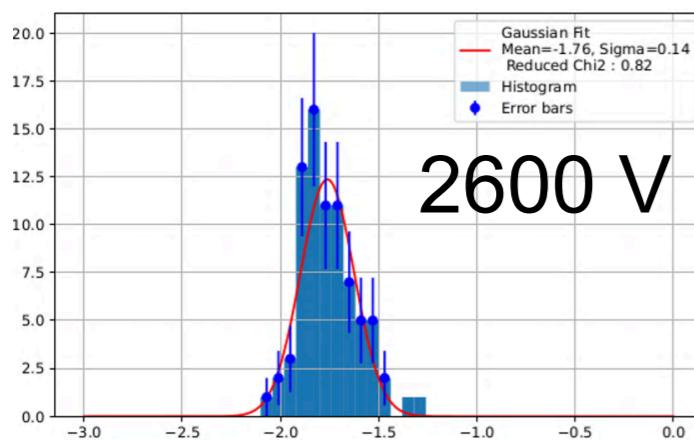
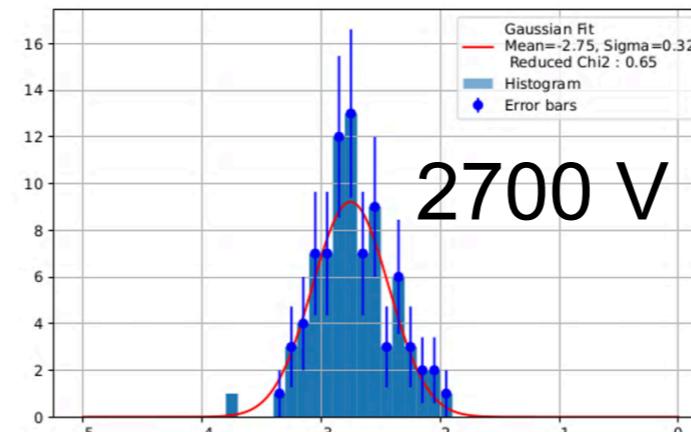
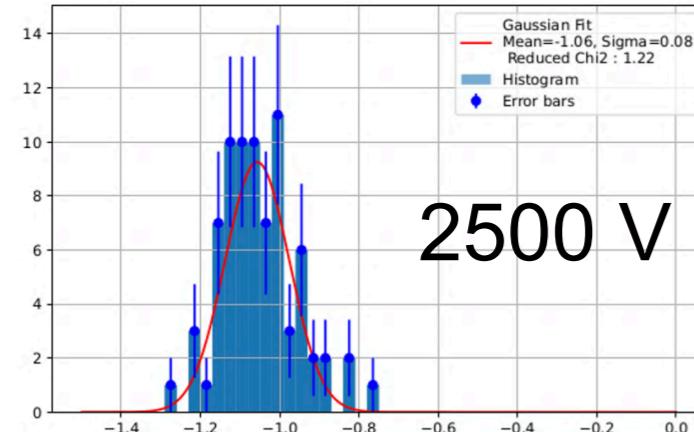
Test Chamber
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)

Wave Form Analysis ; Integrated Charge



e.g.) 2400 V

$$G = \frac{0.61 \text{ [pC]}}{1.60 \times 10^{-19} \text{ [C]} \times 213} = 1.79 \times 10^4$$



HV	Gain	Gain_err
2400 V	1.79×10^4	$+0.12 \times 10^4$ -0.12×10^4
2500 V	3.11×10^4	$+0.24 \times 10^4$ -0.24×10^4
2600 V	4.78×10^4	$+0.41 \times 10^4$ -0.42×10^4
2700 V	7.47×10^4	$+0.95 \times 10^4$ -0.95×10^4
2800 V	1.20×10^5	$+0.17 \times 10^5$ -0.18×10^5

Analog signal Before ASD

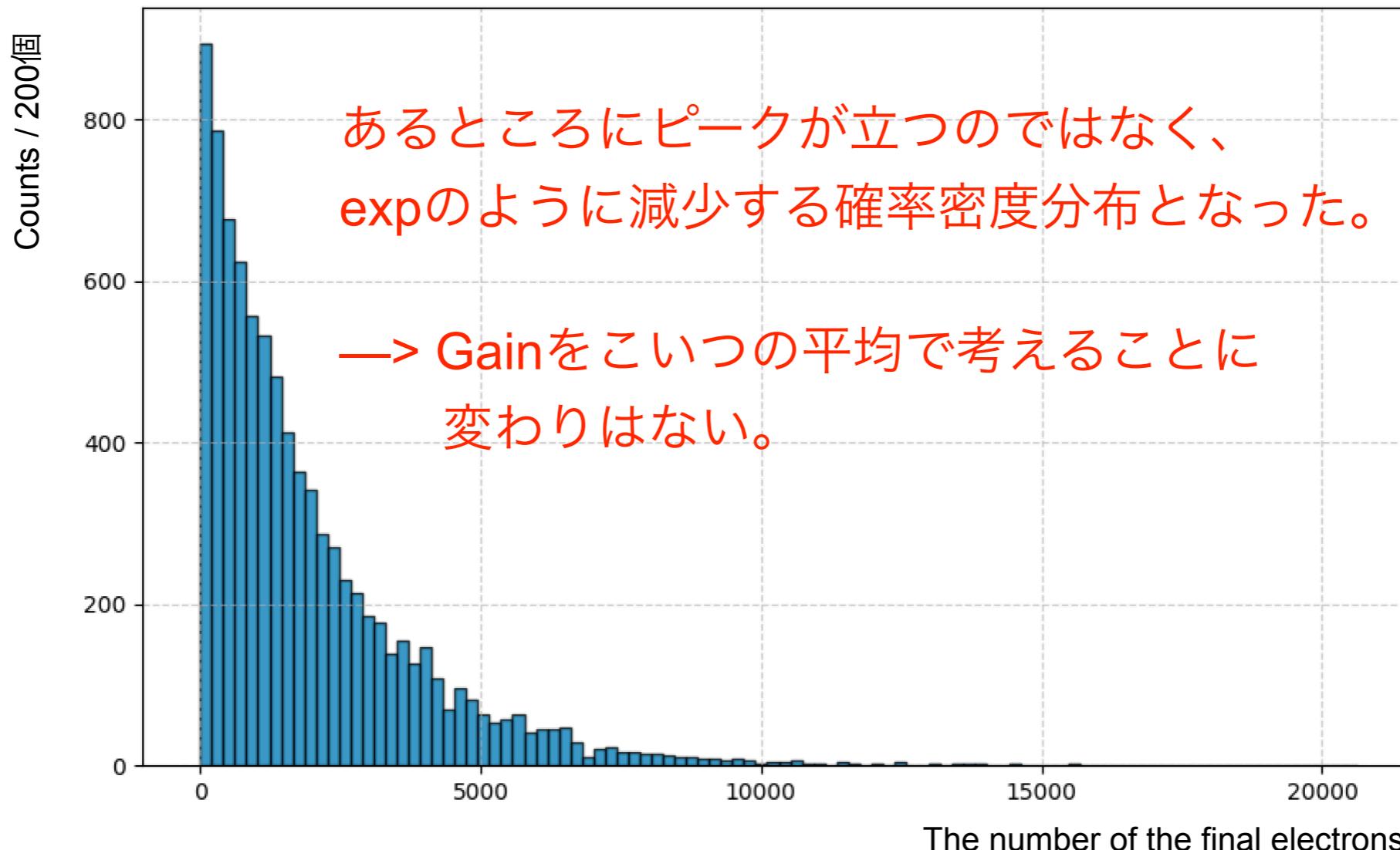
Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+2}_{-5})

Comparison with simulation

そもそも、あるHV、ある地点スタートの一次電子が最終的に何個になるのかの分布を見てみた。(70-30, 2000 V, r = 1 mm)

試行回数10,000回 (Garfield++)

Distribution of the number of the final electrons

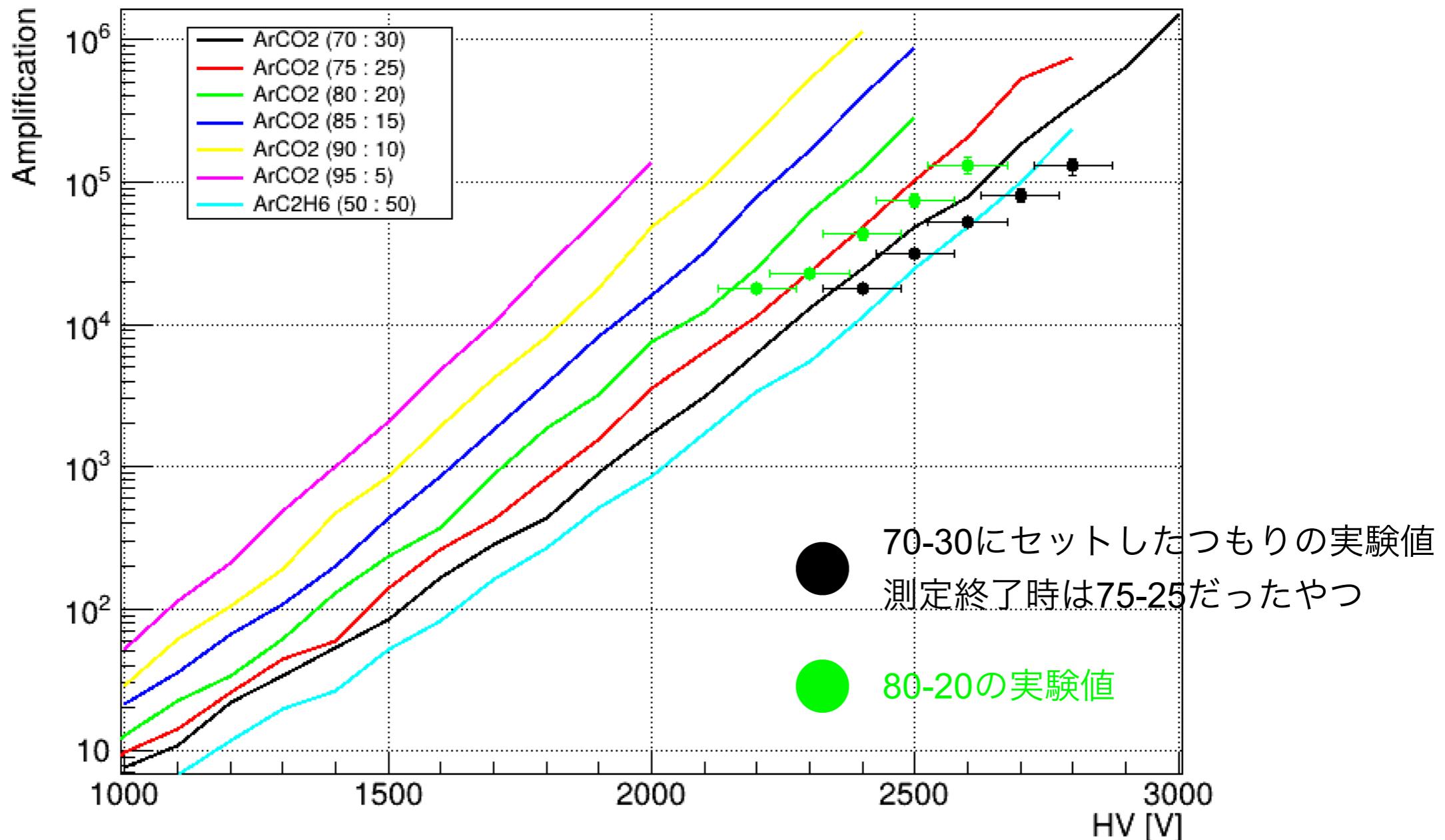


Analog signal Before ASD

Test Chamber
ArCO₂ (73⁺² : 27⁻²)

Gain Comparison with simulation

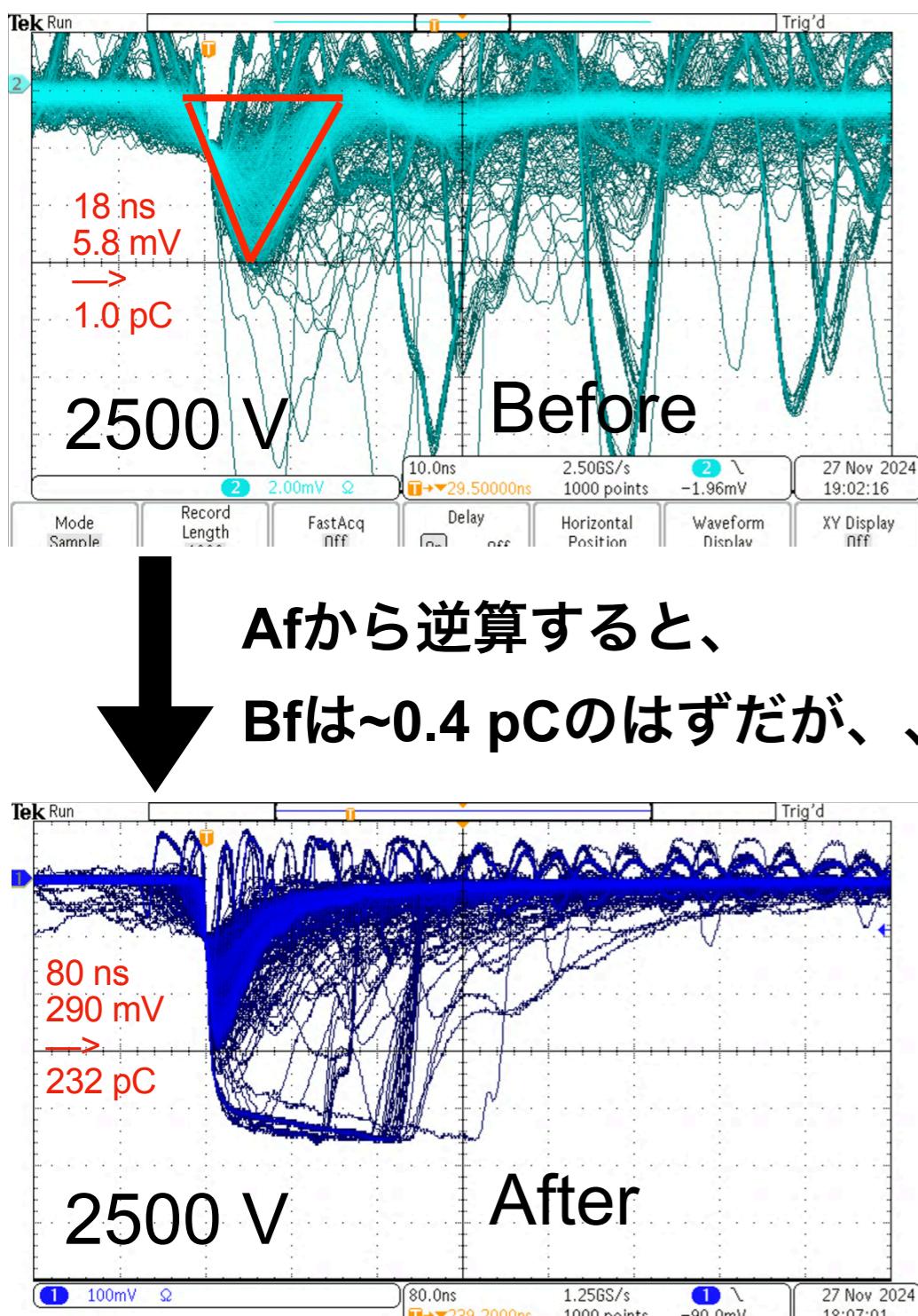
Amplification G vs HV



盛大にズれている。。。

After ASD

After ASD



Afから逆算すると、
Bfは~0.4 pCのはずだが、

Linear Fan-in Fan-outのinvを
経由していることに注意

Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+2}_{-5})

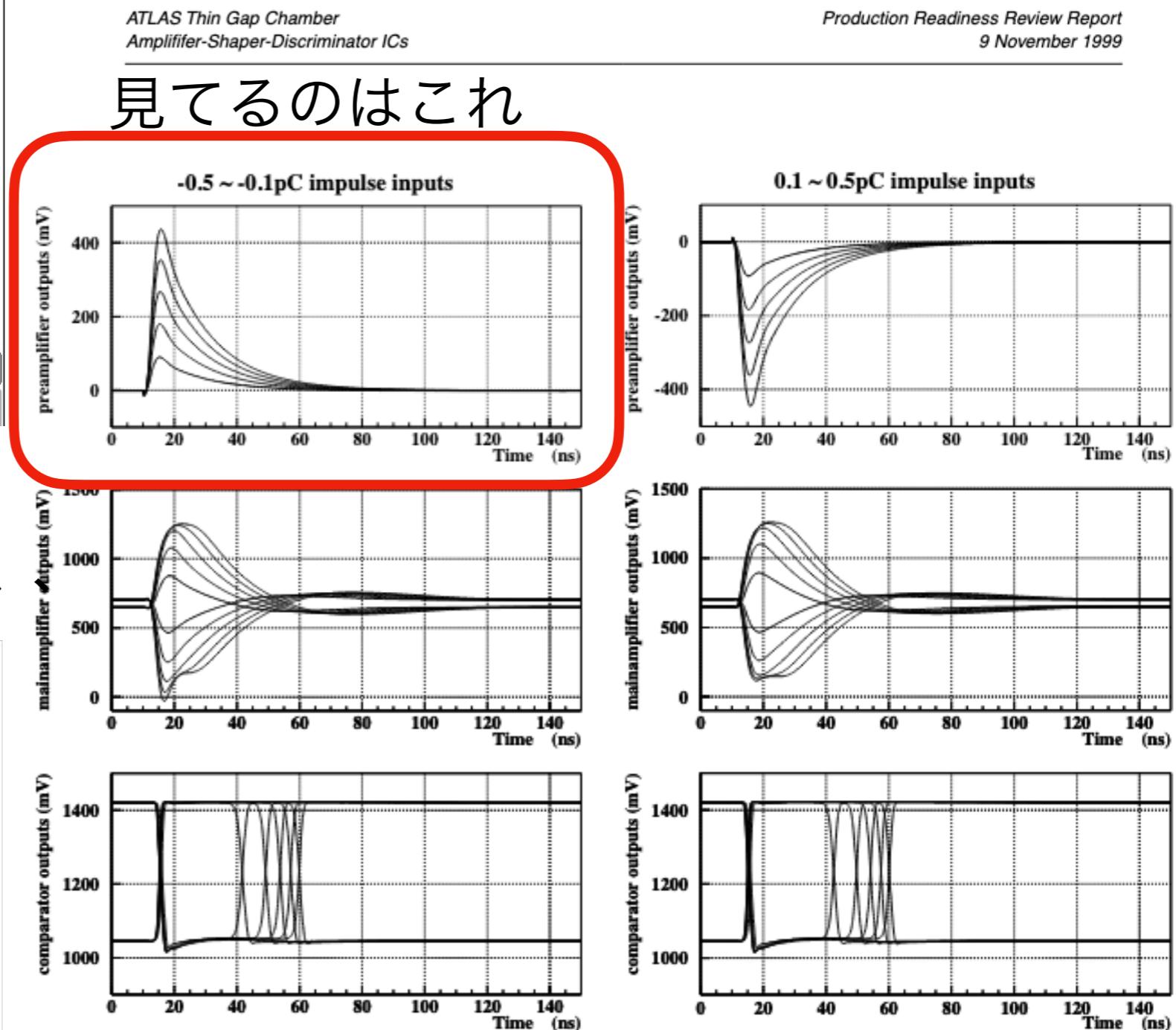
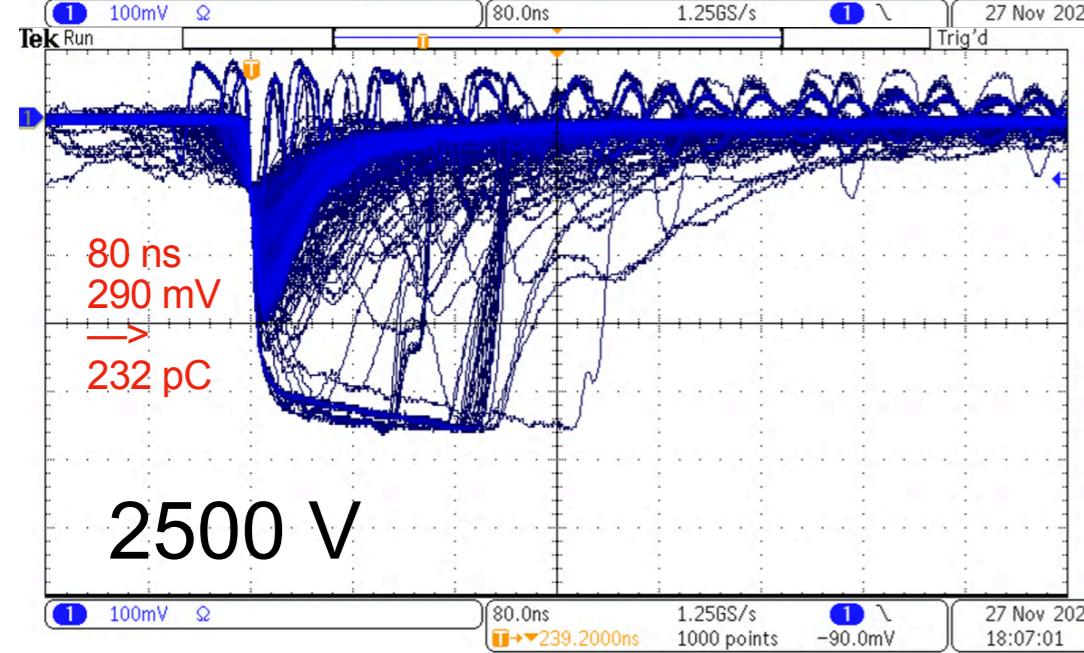
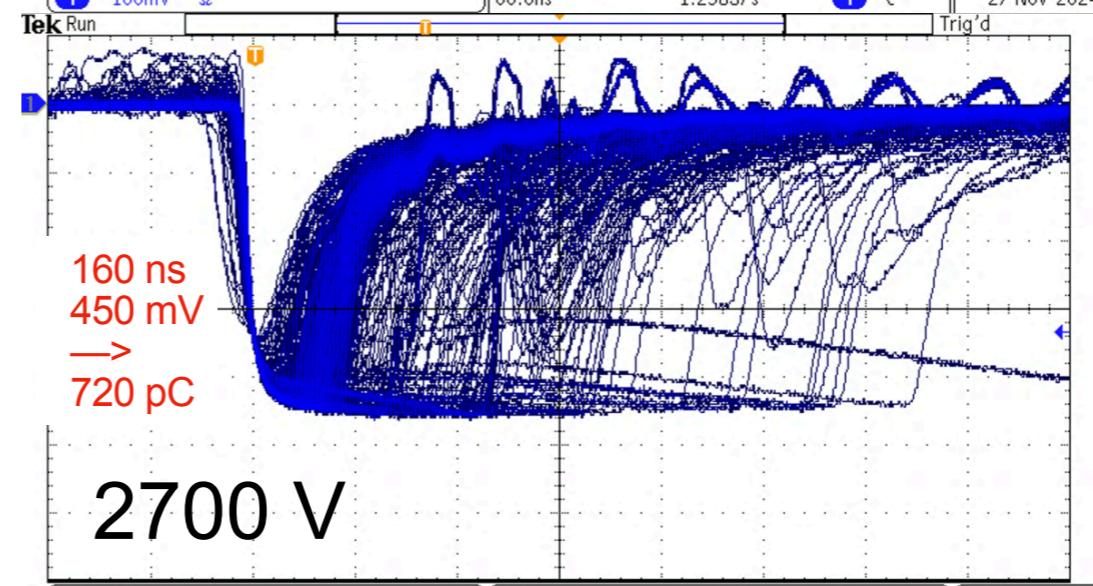
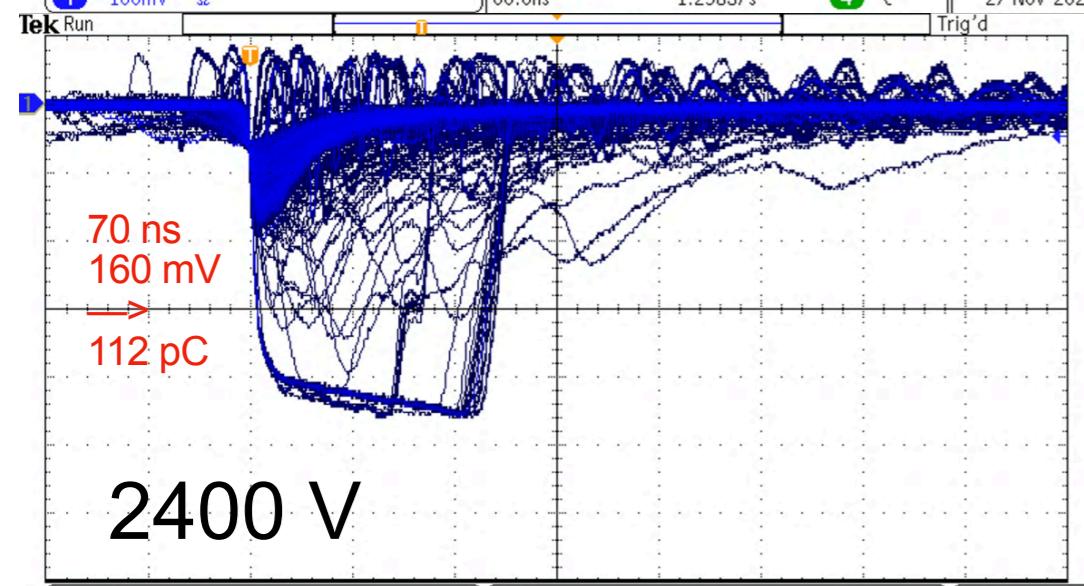
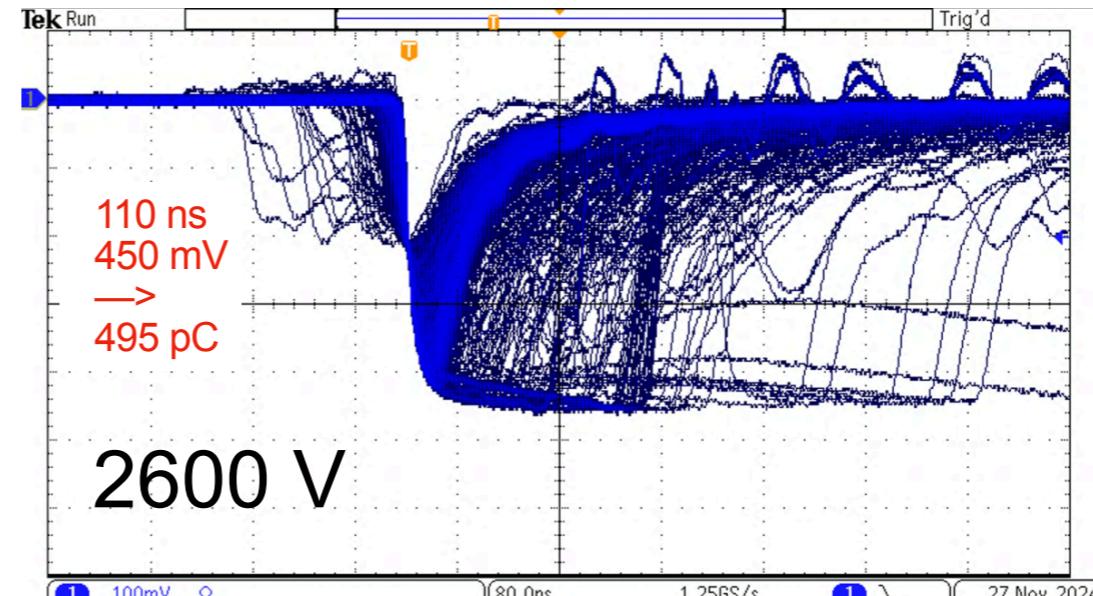
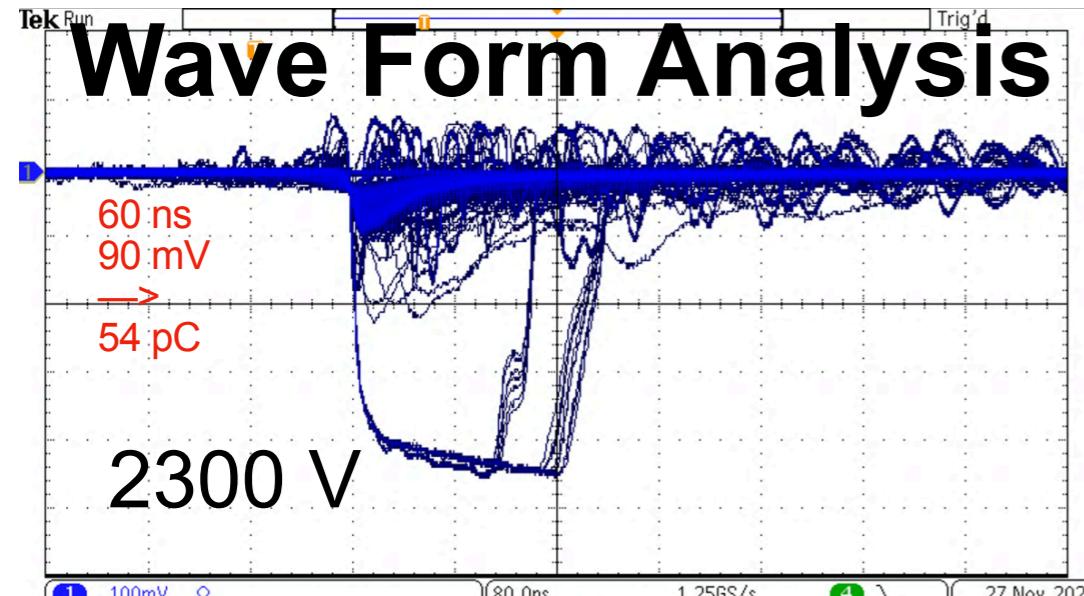


Figure 4-4 SPICE simulation of (1) the preamplifier output, (2) the two main-amplifier differential output signals, and (3) the two comparator differential output signals (LVDS).

Analog signal After ASD

Test Chamber
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)

Wave Form Analysis



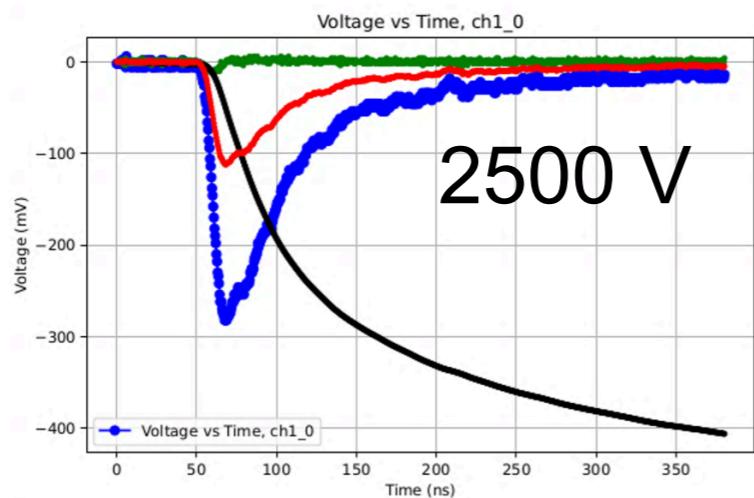
2600 ~ 2700 Vはさちってる。
→評価不能？

Analog signal After ASD

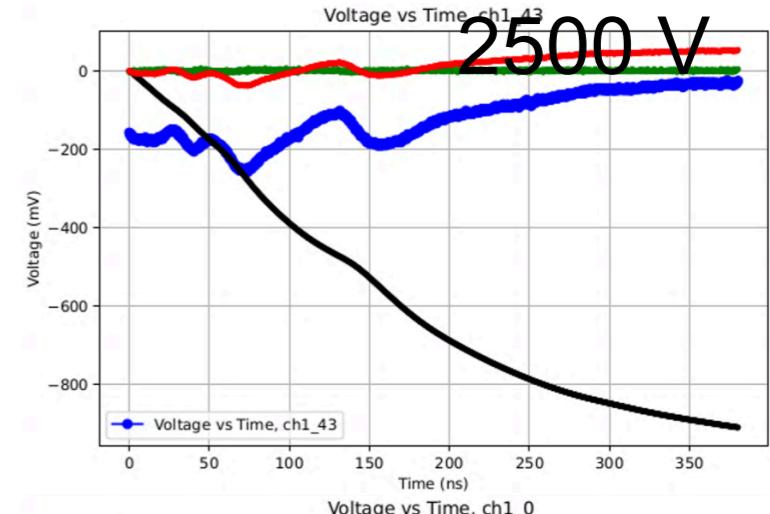
Wave Form Analysis

Test Chamber
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)

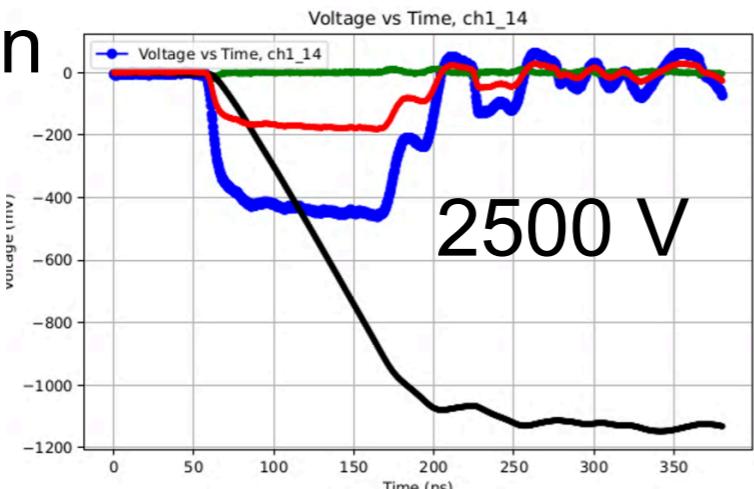
1. Clean



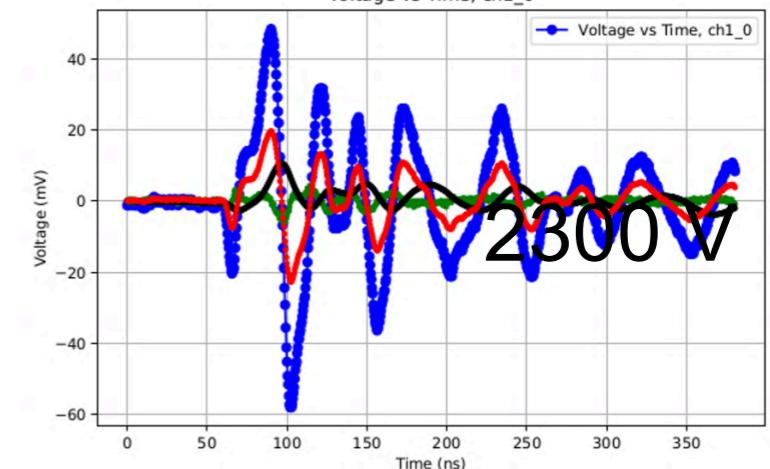
4. Float



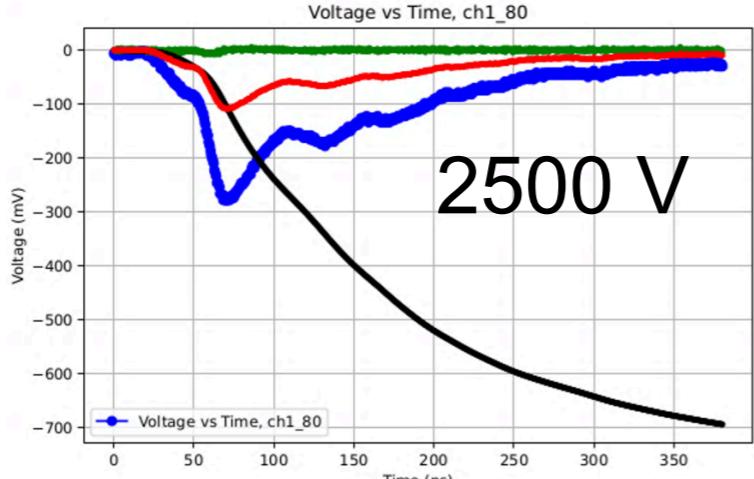
2. Saturation



4. Noise



3. Broad



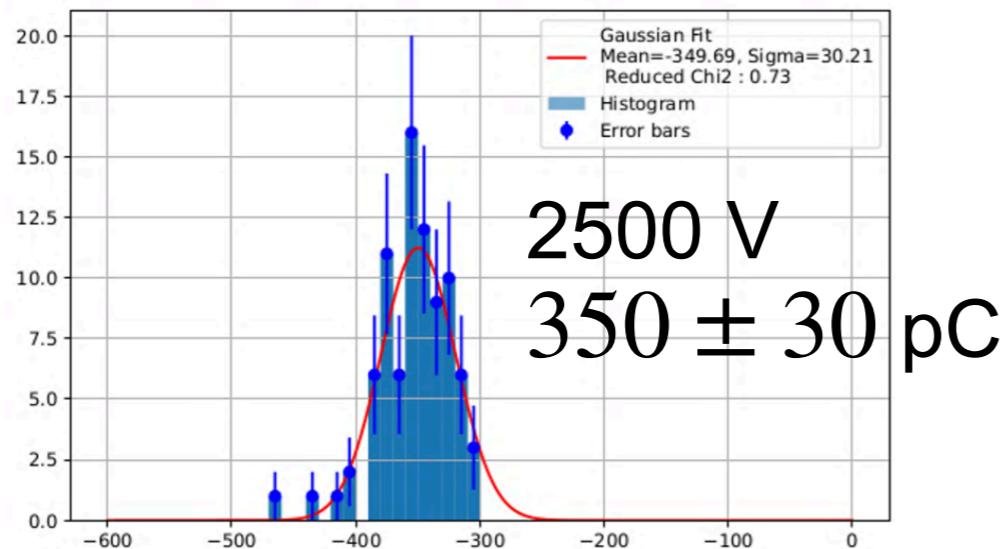
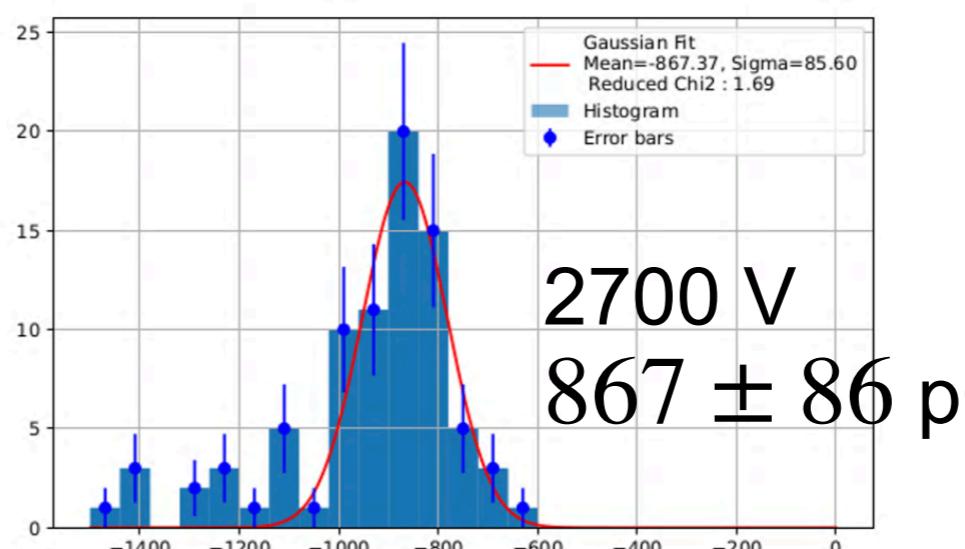
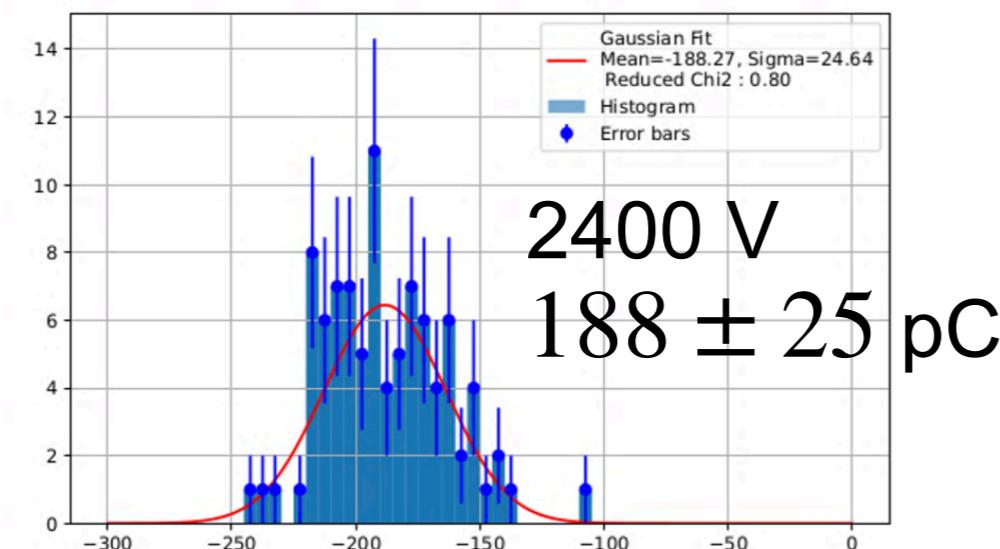
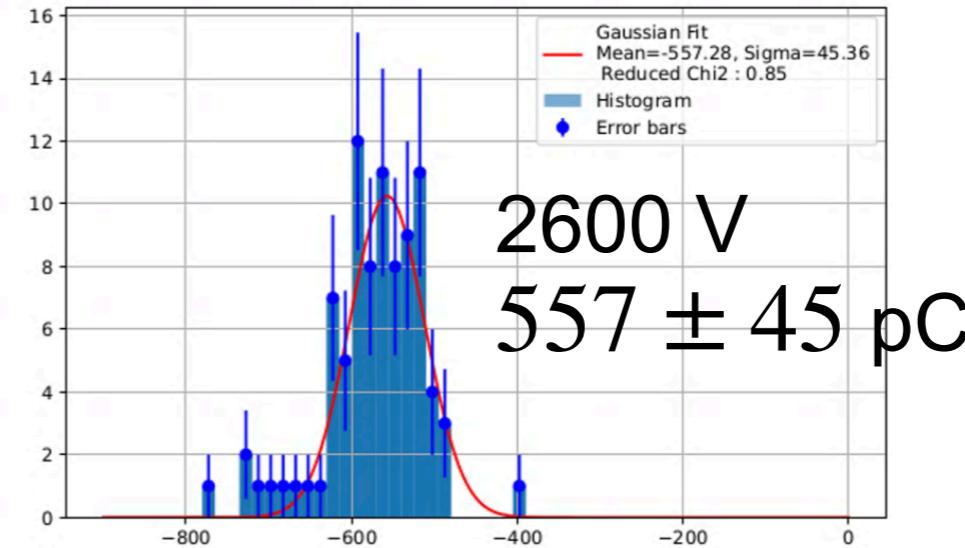
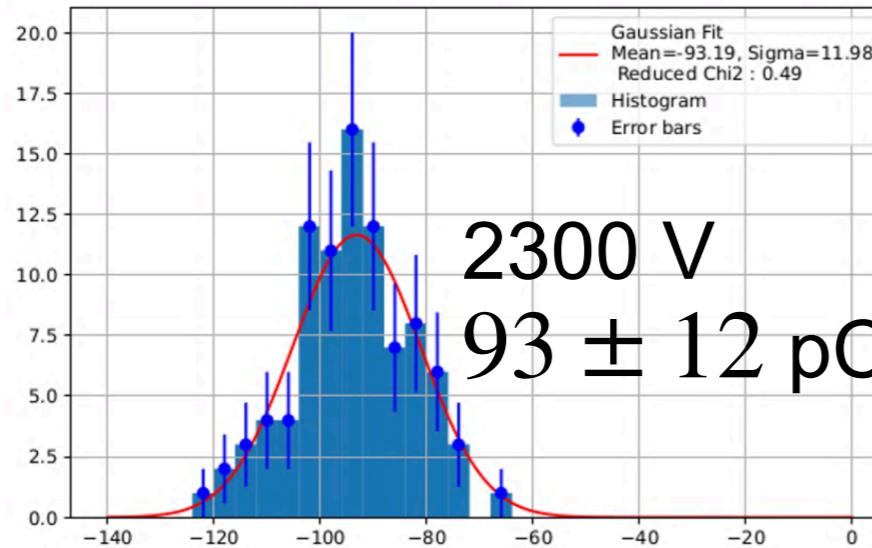
Vnoise, Tmin_th, Tmax_thとnp.max(v0)でCleanのみを選ぶ。

Run	Ar	HV	Vnoise	C_min	C_max	Bins	Tmin_th	Tmax_th
0	70	2300	13	-100	0	50	75	180
1	70	2400	14	-200	0	50	40	180
2	70	2500	15	-400	0	50	50	180
3	70	2600	16	-600	0	50	40	180
4	70	2700	17	-1000	0	50	50	180
5	80	2100	13	-100	0	50	40	180
6	80	2200	14	-200	0	50	40	180
7	80	2300	15	-400	0	50	100	240
8	80	2400	16	-600	0	50	100	240

Analog signal After ASD

Wave Form Analysis

Test Chamber
ArCO₂ (73⁺²₋₅ : 27₊₅⁻²)

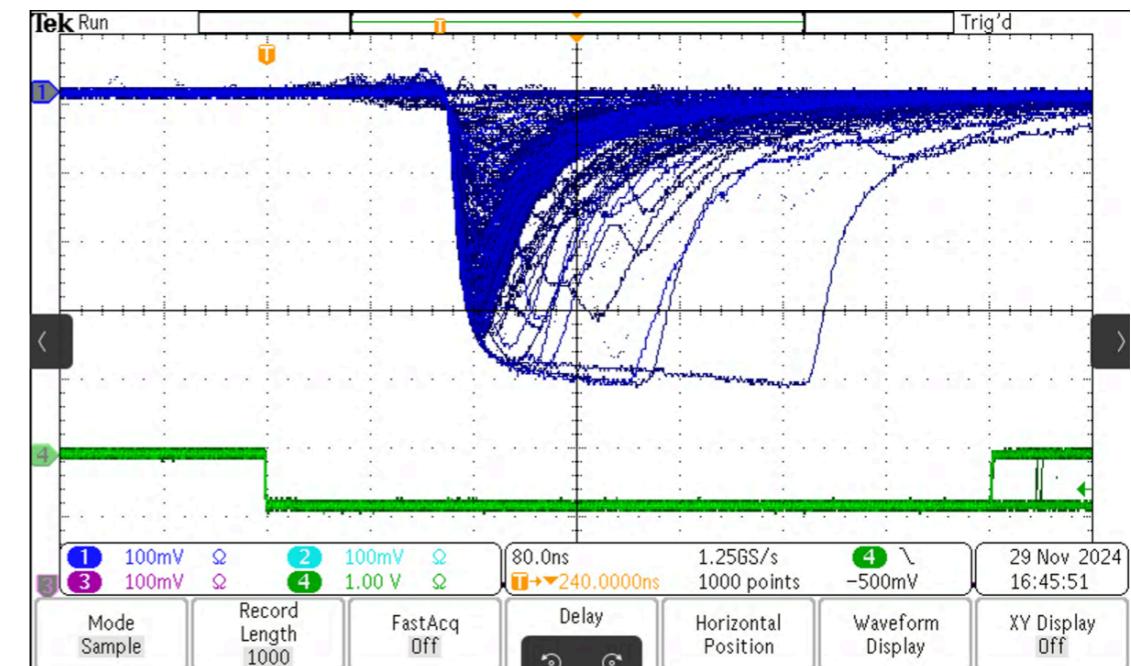
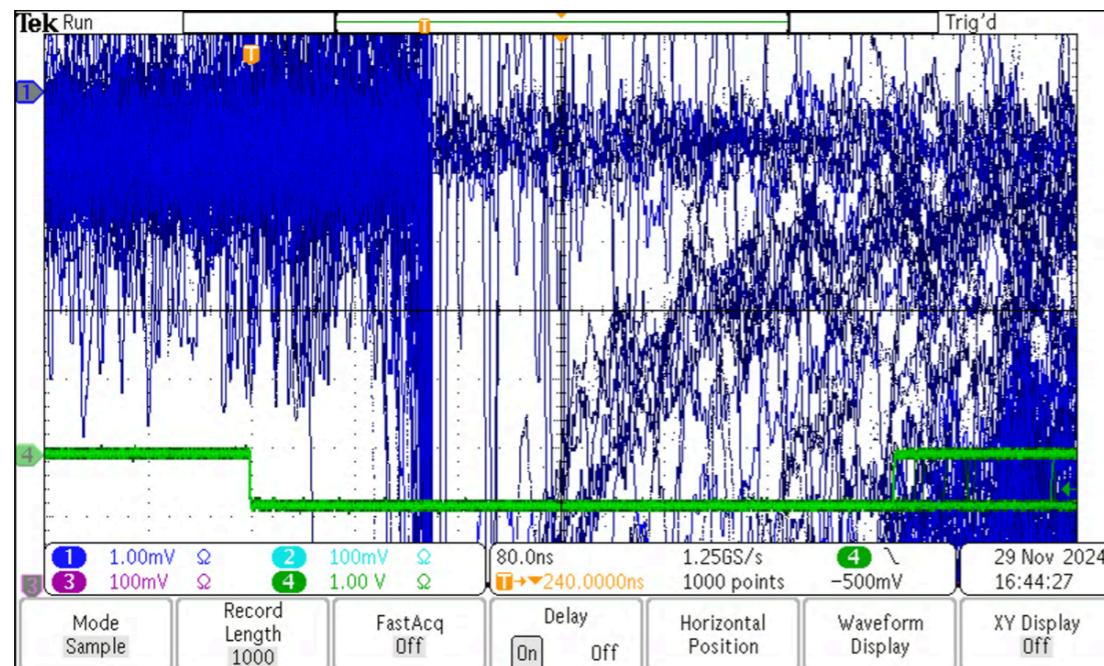
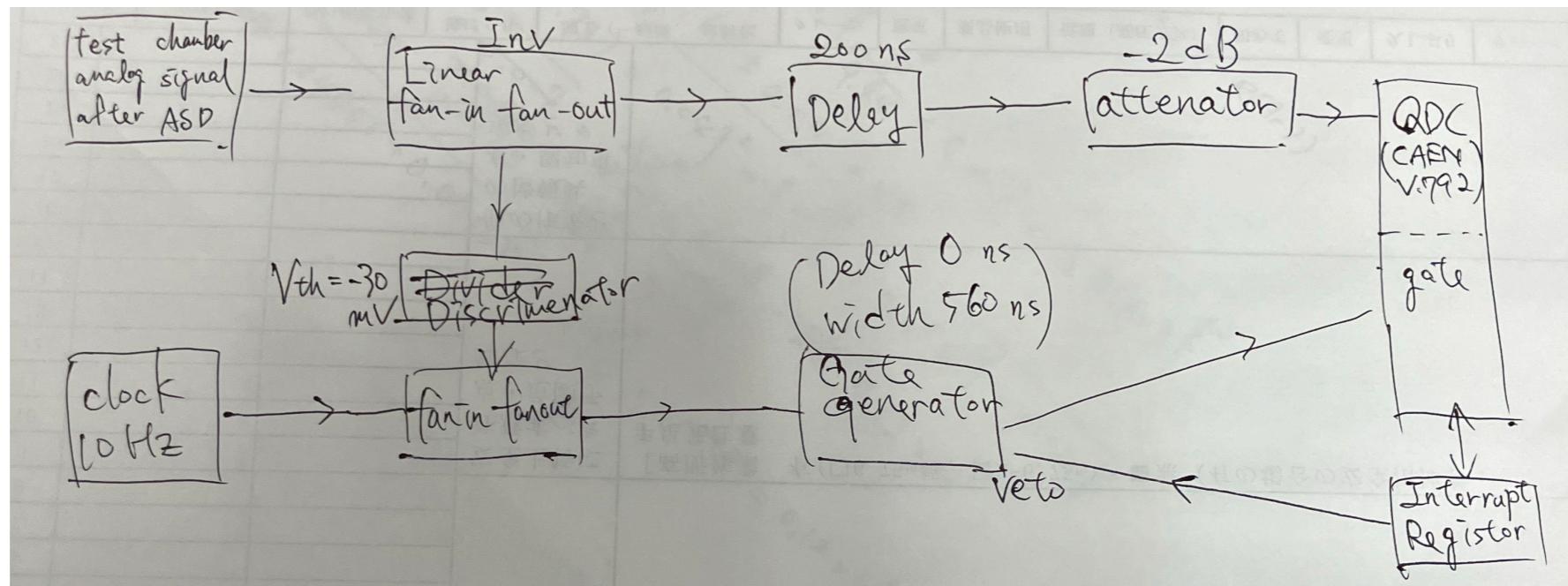


2600 ~ 2700 Vはさちってる。
→評価不能？
ASDの增幅率に決着をつけないと
Gainは出せない。。。。

Analog signal After ASD

Test Chamber
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)

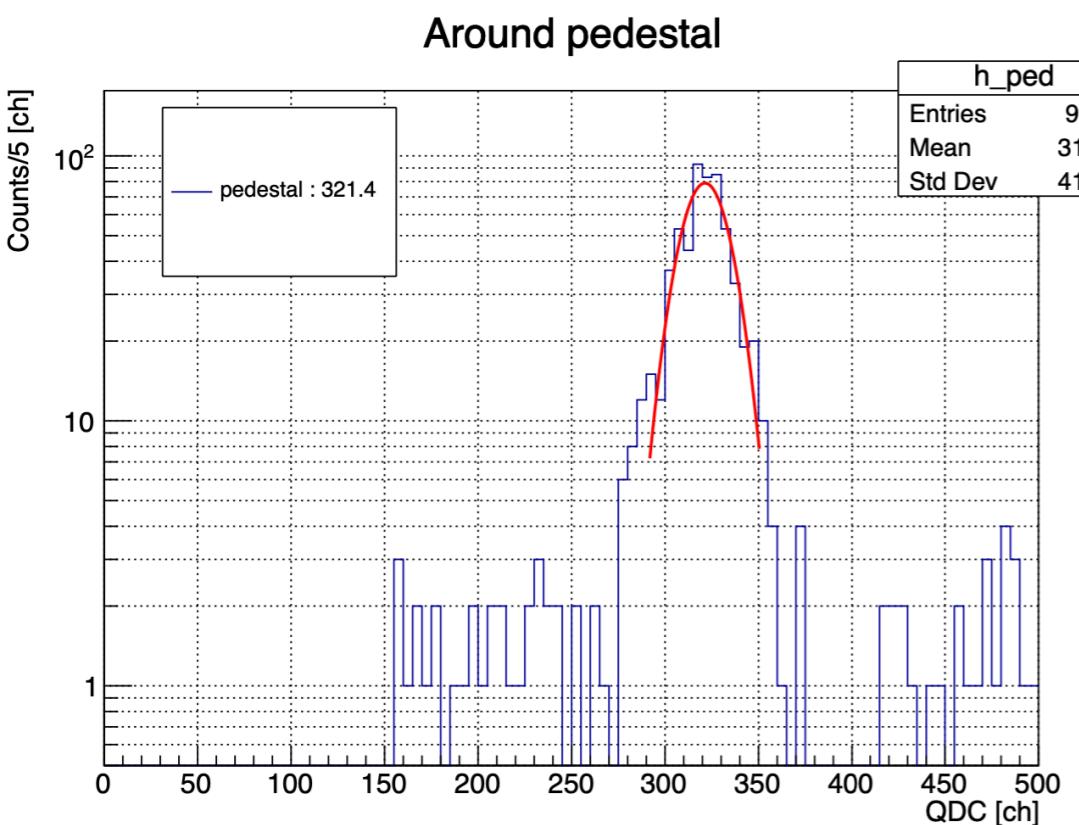
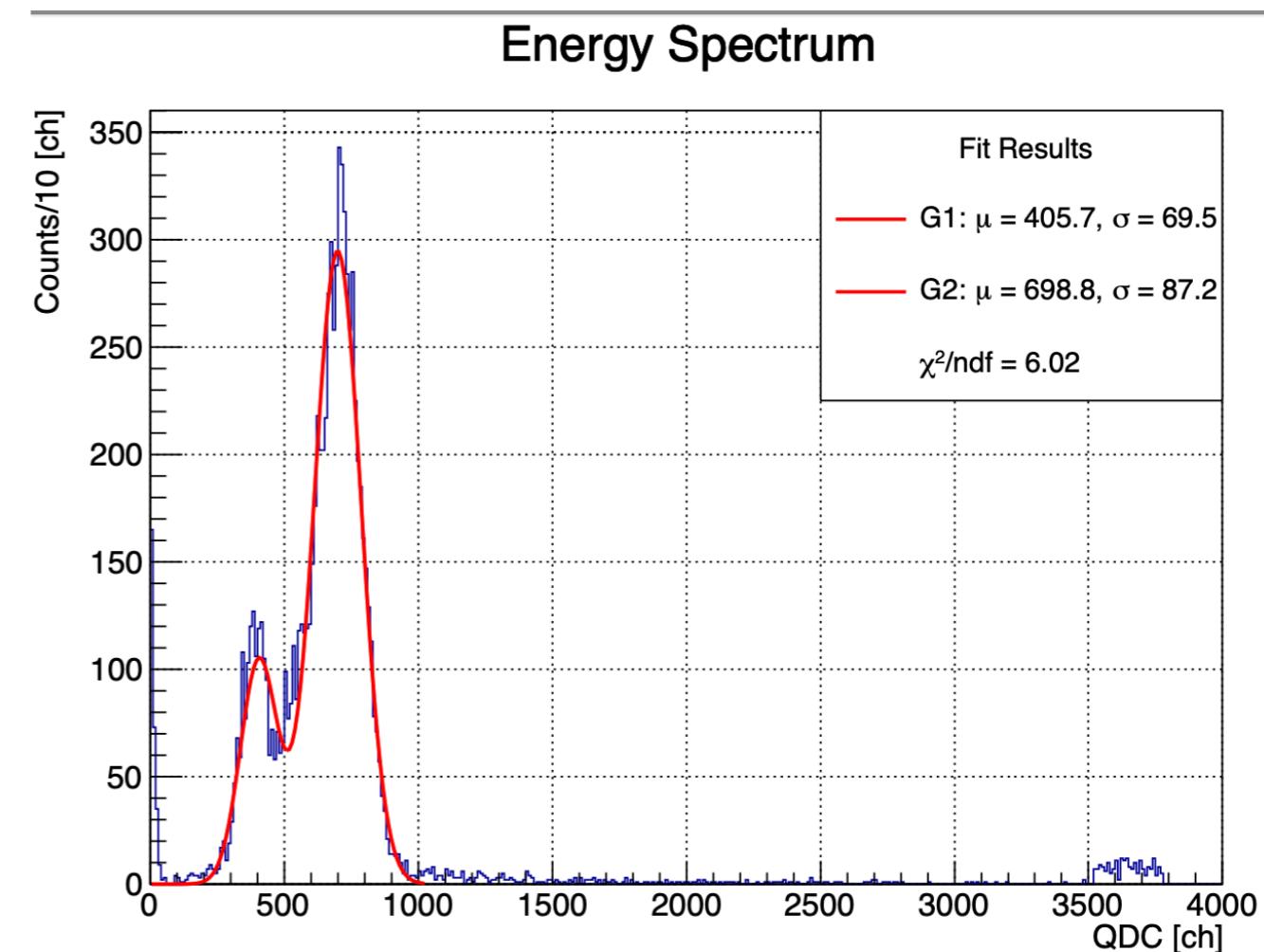
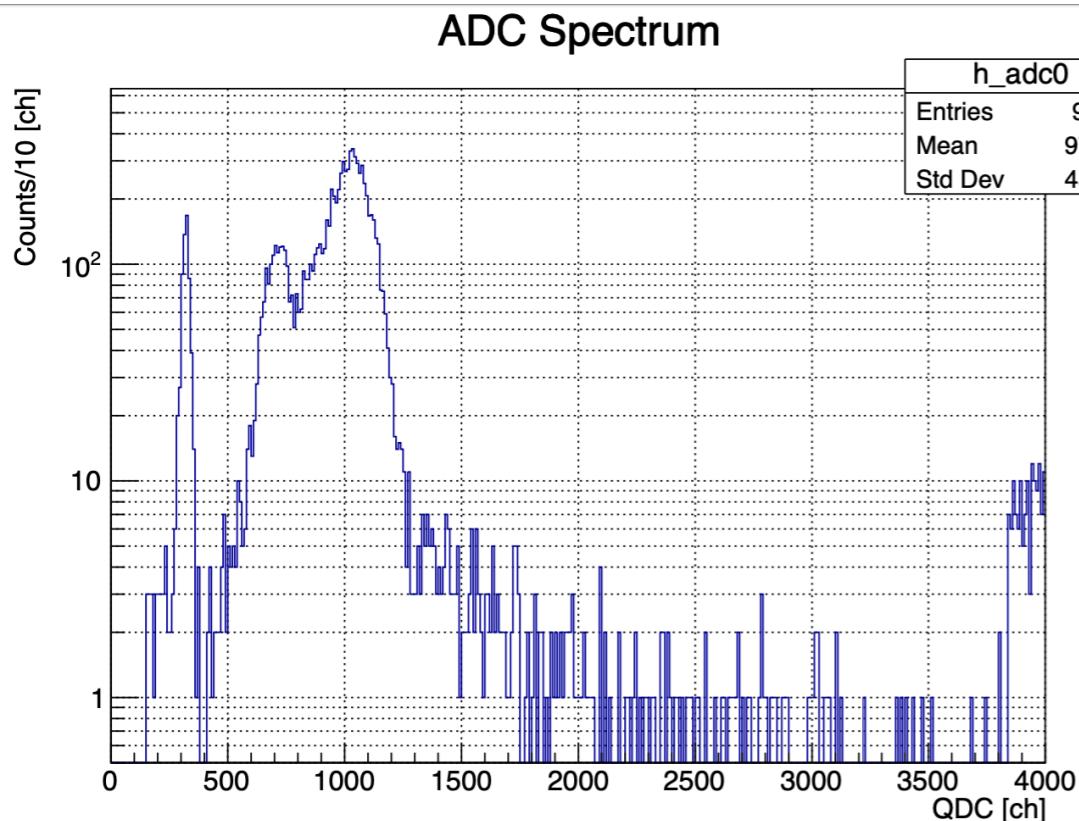
Self QDC by 55Fe, Set up



Analog signal After ASD

Test Chamber
ArCO₂ (73^{+2}_{-5} : 27^{+5}_{-5})

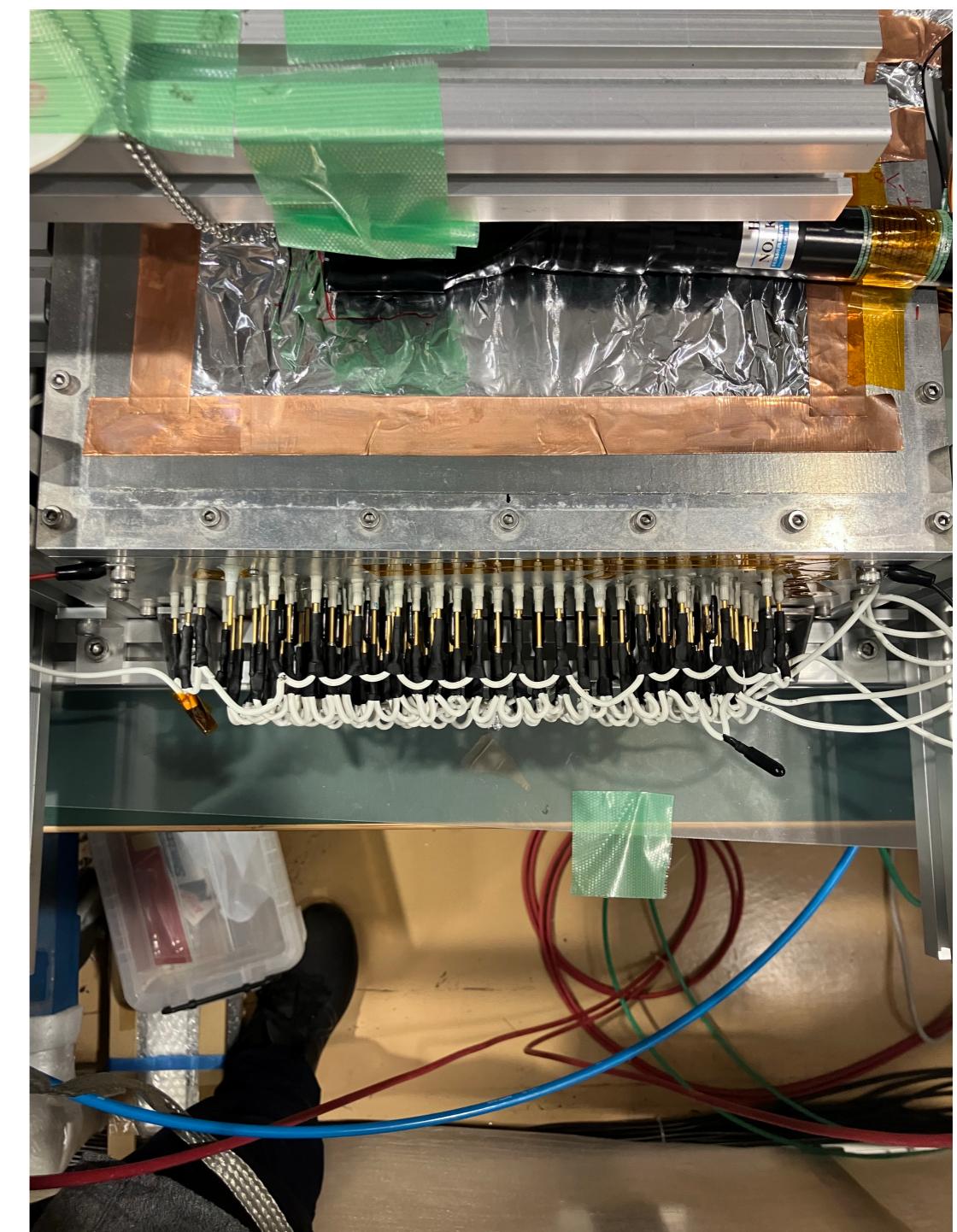
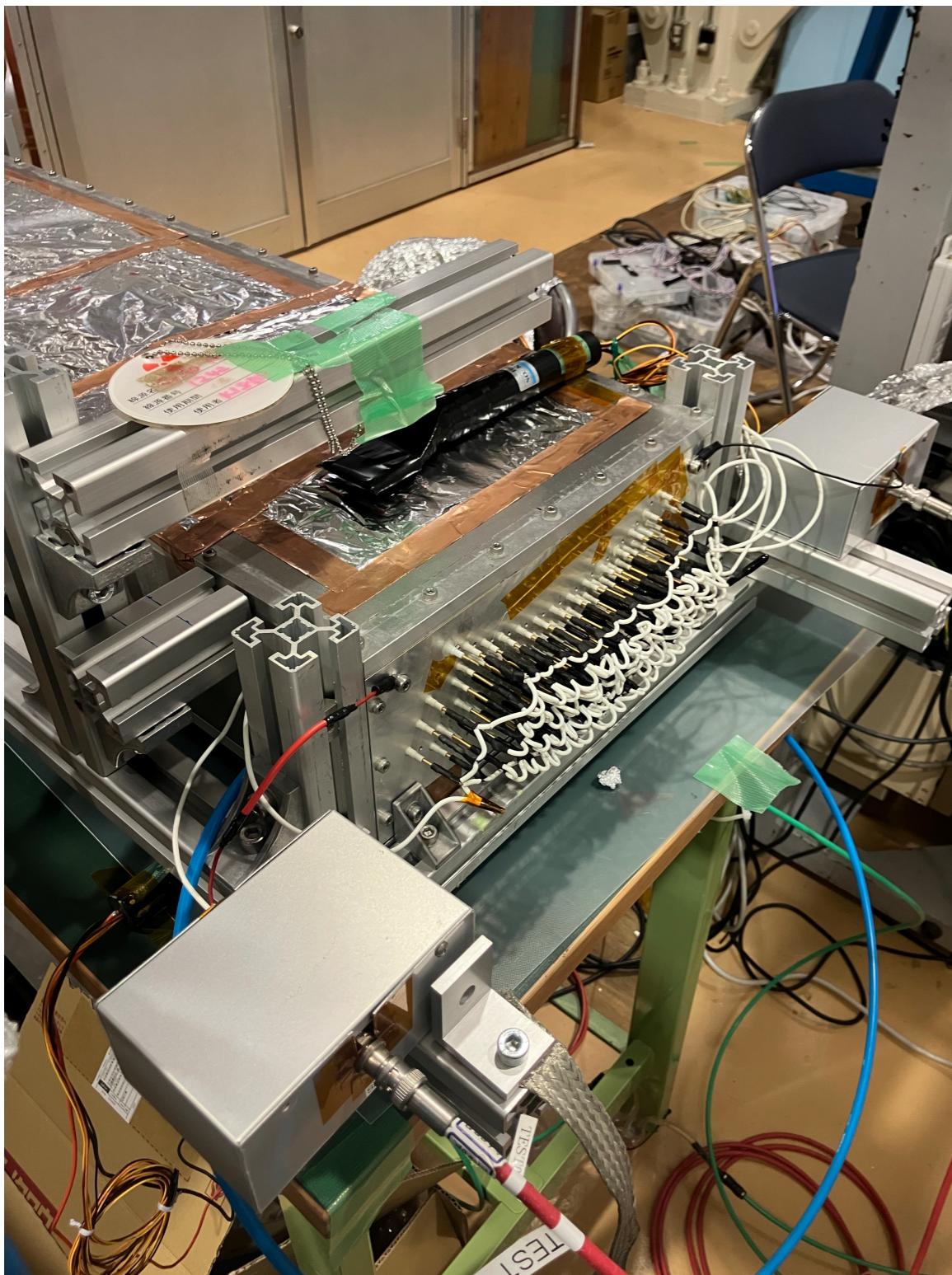
Self QDC by 55Fe, (e.g) 2300 V, 2dB attenuator



1 ch = 0.1 pC
→ Main Peak $\sim 69 \text{ pC} * 1.26 = 87 \text{ pC}$

前のページの2300 Vの電荷量と概ね一致

TDC



こんしゅう

Test chamber に関するデータ取得を終える。

TDCまで解析する。(子連れの評価。Effは厳しいかな。。。)

今週日曜日までに、第3章までまとまったものを作って

見てもらう。

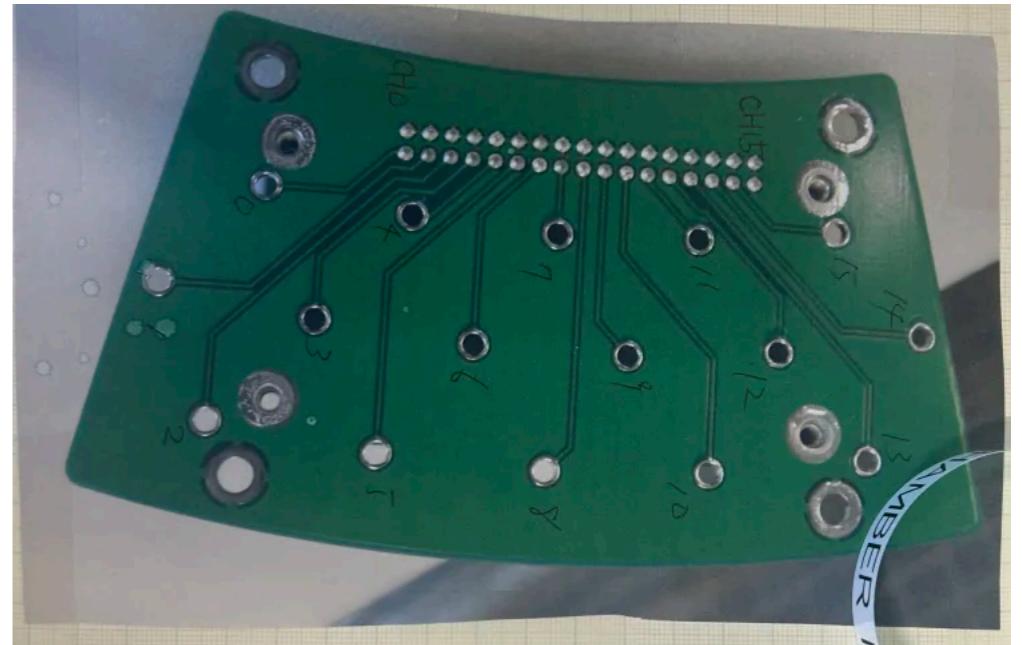
第1章 序章	1.1 反K中間子原子核 1.2 理論的研究 1.3 実験の歴史 1.4 J-PARC E15 実験 .
第2章 J-PARC E80 実験	.1 実験目的 .2 実験方法 .3 実験セットアップ 2.3.1 大強度陽子加速施設 J-PARC 2.3.2 K1.8BR ビームライン 2.3.3 ビームライン検出器 2.3.4 標的システム 2.3.5 円筒型検出器システム (Cylindrical Detector System, CDS) 2.4 崩壊粒子の検出
第3章 円筒型ドリフトチューブ	3.1 ワイヤードリフトチェンバーの動作原理 .2 開発目的 3.3 要求性能 .4 検出器の構成 3.4.0 全体的な構造 3.4.1 ワイヤー、セル構造 3.4.2 読み出し回路 3.5 CDC 製作
第4章 充填ガスについて	.1 Garfield++を用いたシミュレーション 4.1.1 電磁場 .1.2 諸性質 4.1.3 得られる電気信号 (Preamplifier 直前) 4.2 テストチャンバーを用いた実験 2.1 実験セットアップ 2.2 アナログ信号

Efficiency

7 && 8 && (no hit in the others)



6 or 9



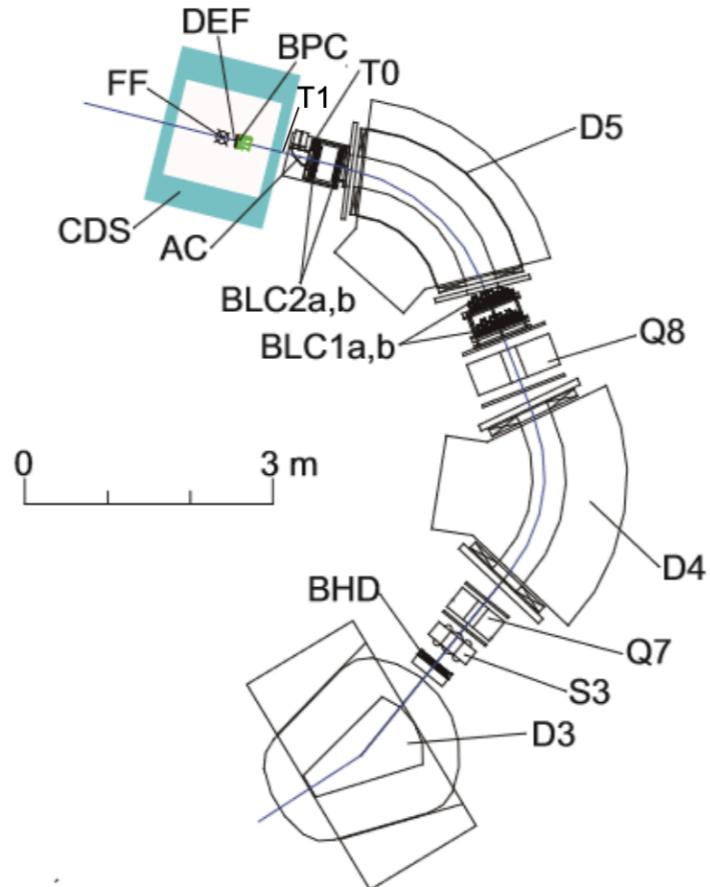


Figure 2.3: Schematic view of the beam line spectrometer setup, featuring a range of components including trigger counters (BHD, T0, T1, and DEF), beam line chambers (BLC1, BLC2, and BPC), and a counter specifically for identifying kaons (AC)[49].

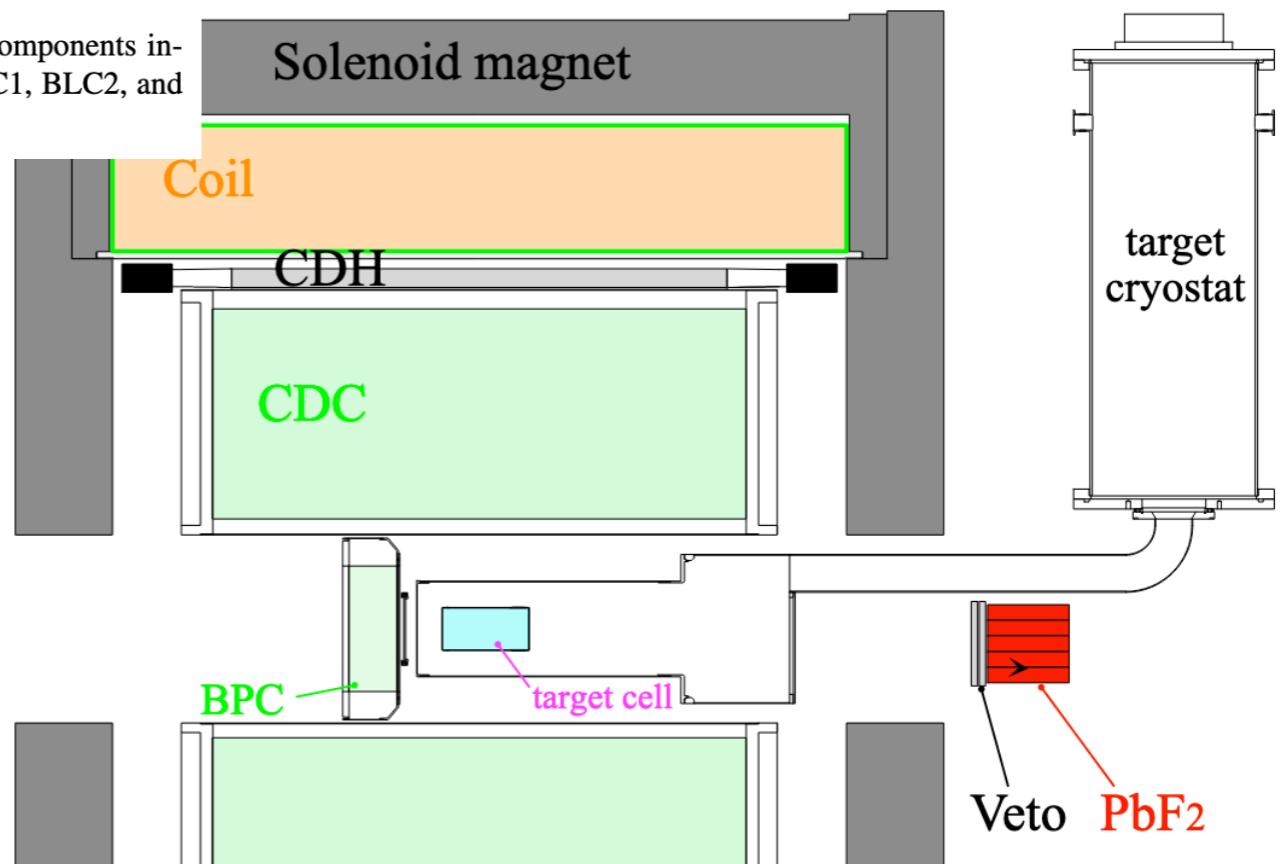


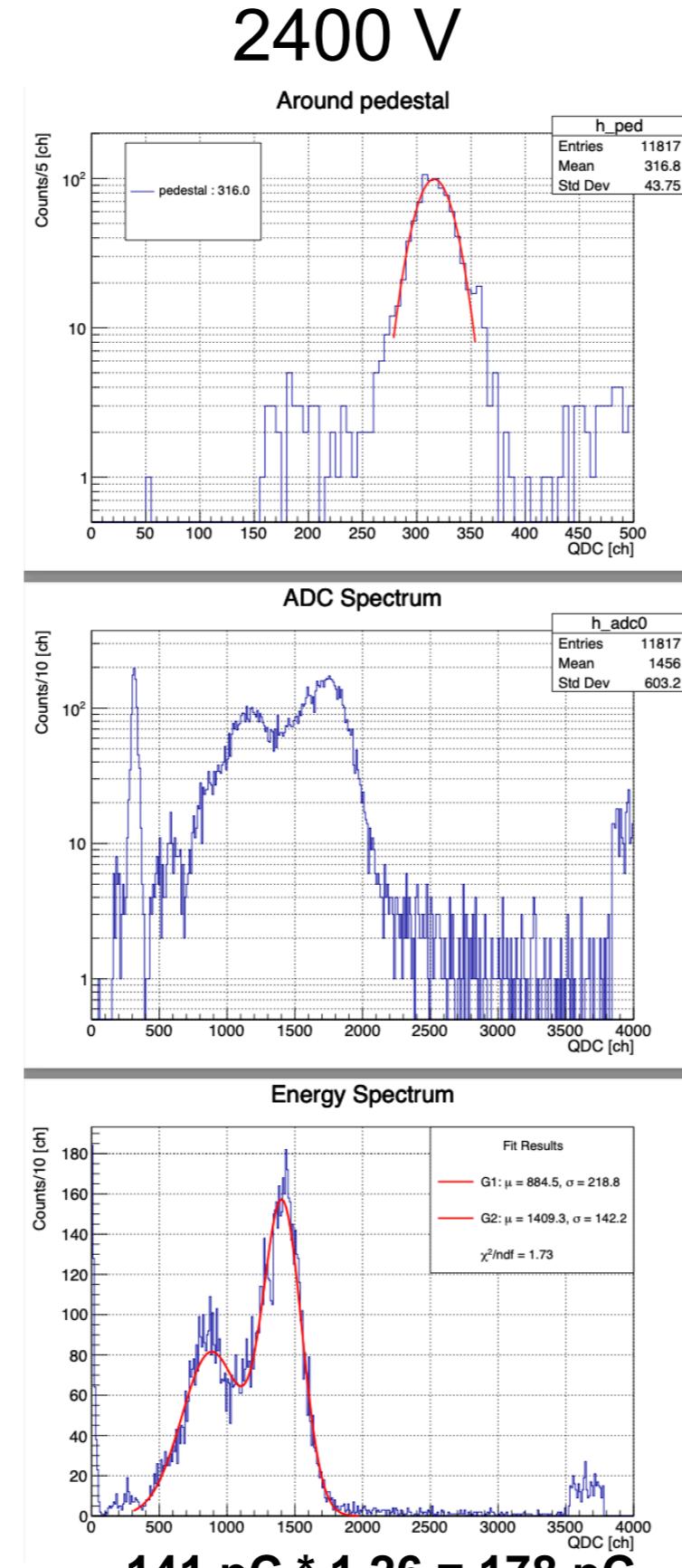
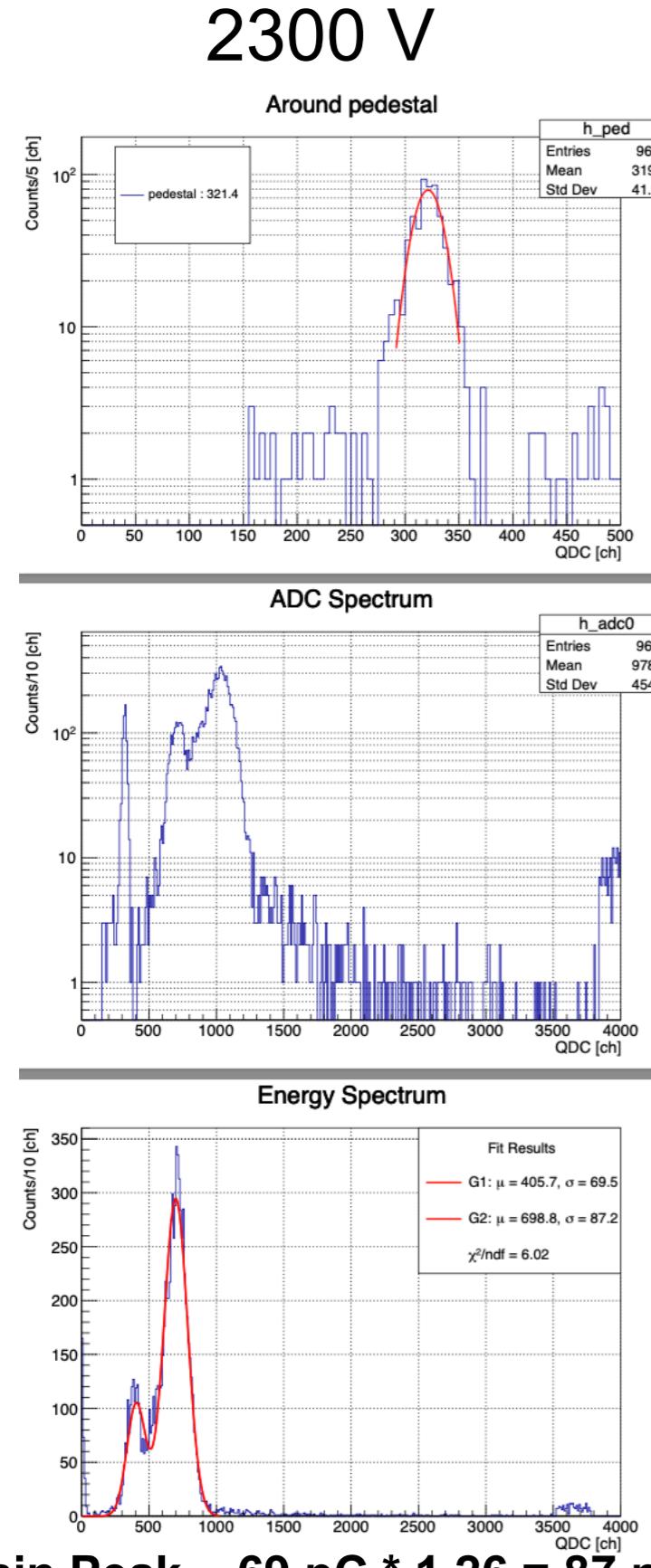
Figure 2.12: A schematic view of the Cylindrical Detector System (CDS) including the liquid helium target system[52].

Appendix

Test Chamber

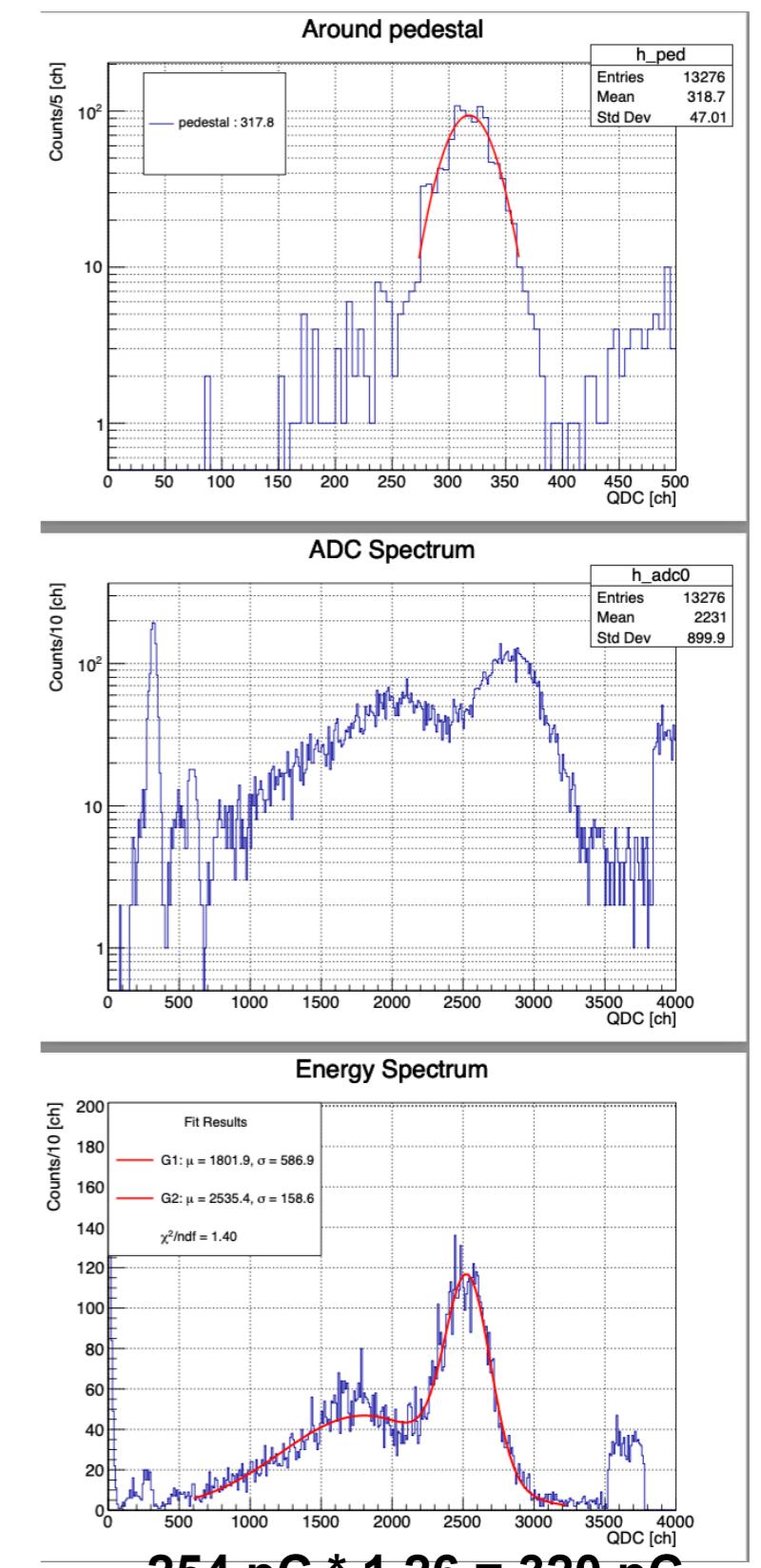
ArCO₂ (73⁺²₋₅ : 27⁻²₊₅)

2300 V 2400 V 2500 V



Main Peak ~ 69 pC * 1.26 = 87 pC

~ 141 pC * 1.26 = 178 pC

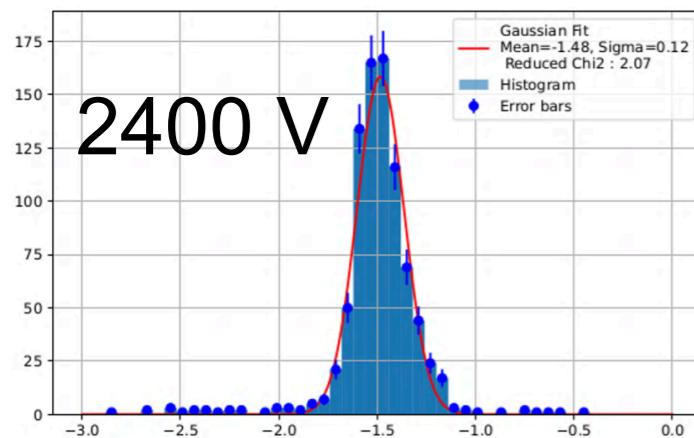
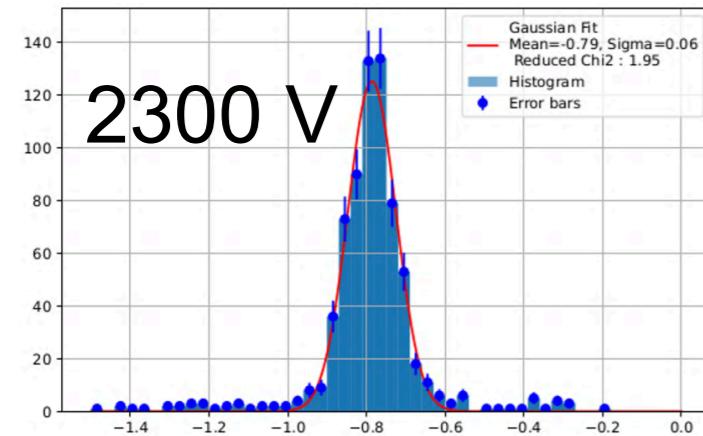
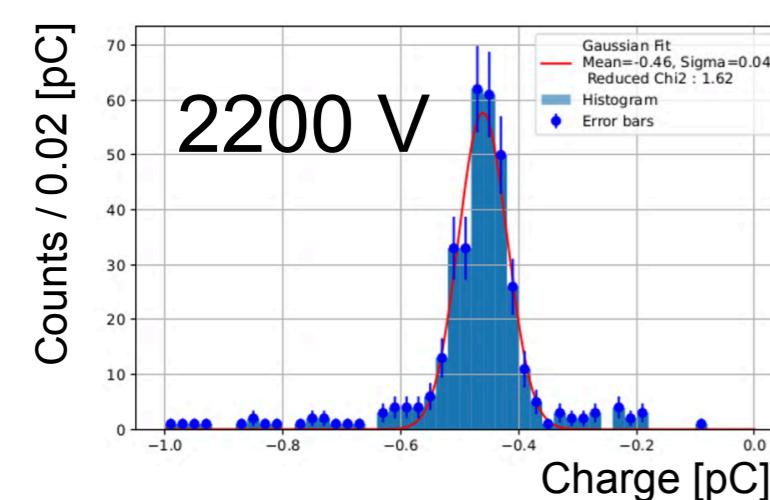


~ 254 pC * 1.26 = 320 pC

Analog signal Before ASD

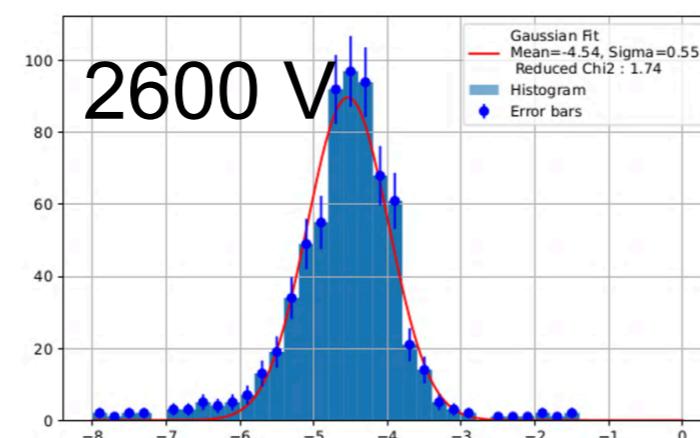
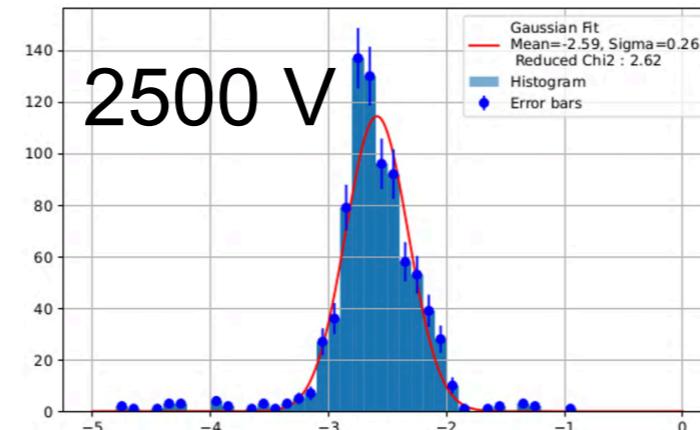
Test Chamber
ArCO₂ (80±2:80±2)

Wave Form Analysis ; Integrated Charge



統計10倍でそれなりのGaussianになった。

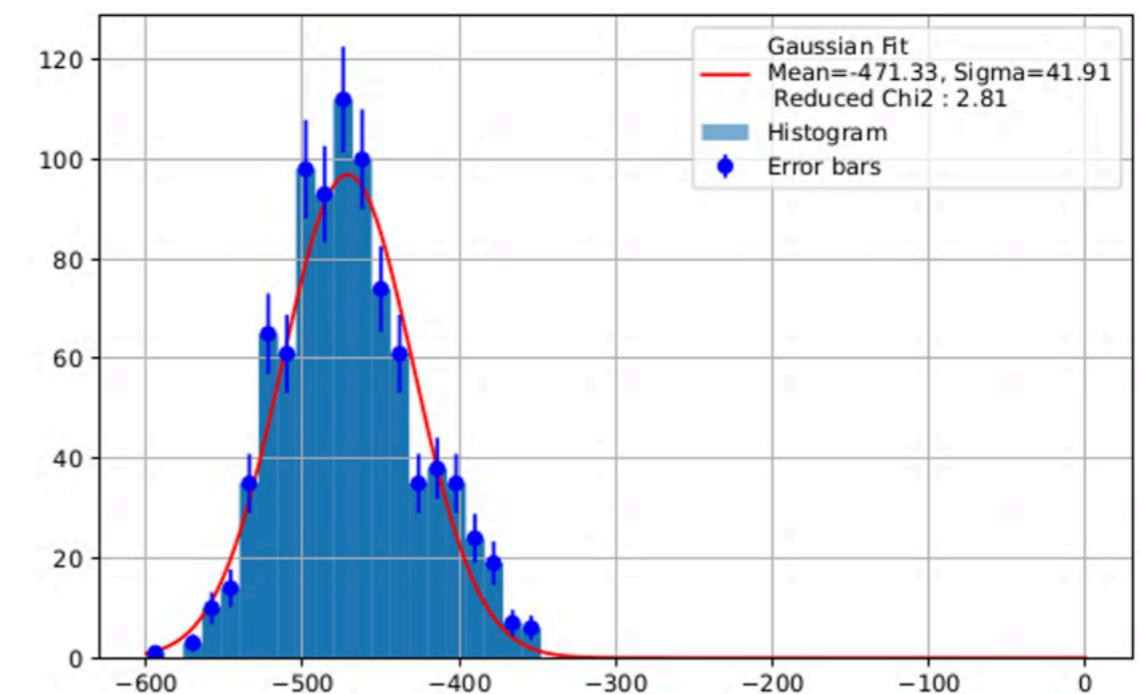
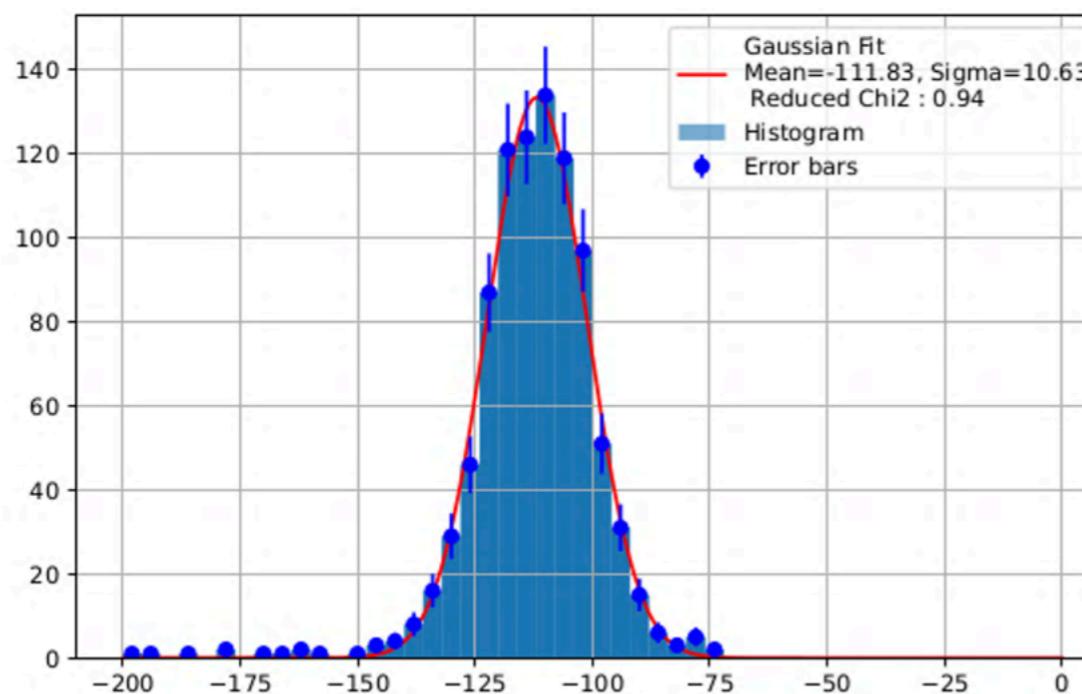
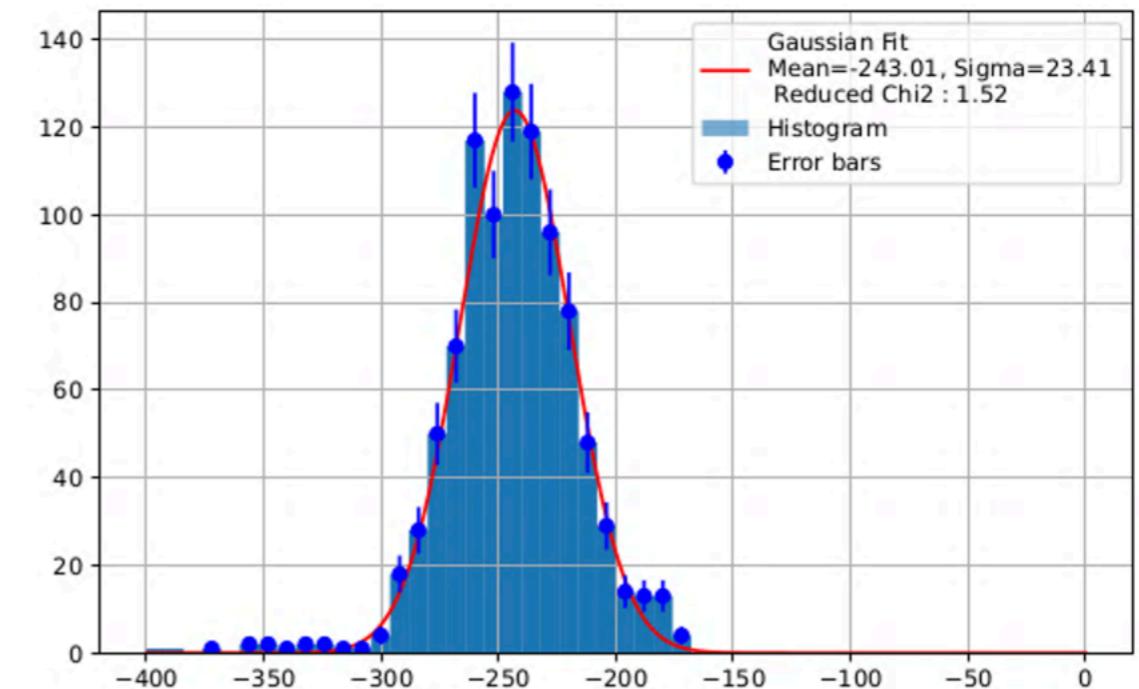
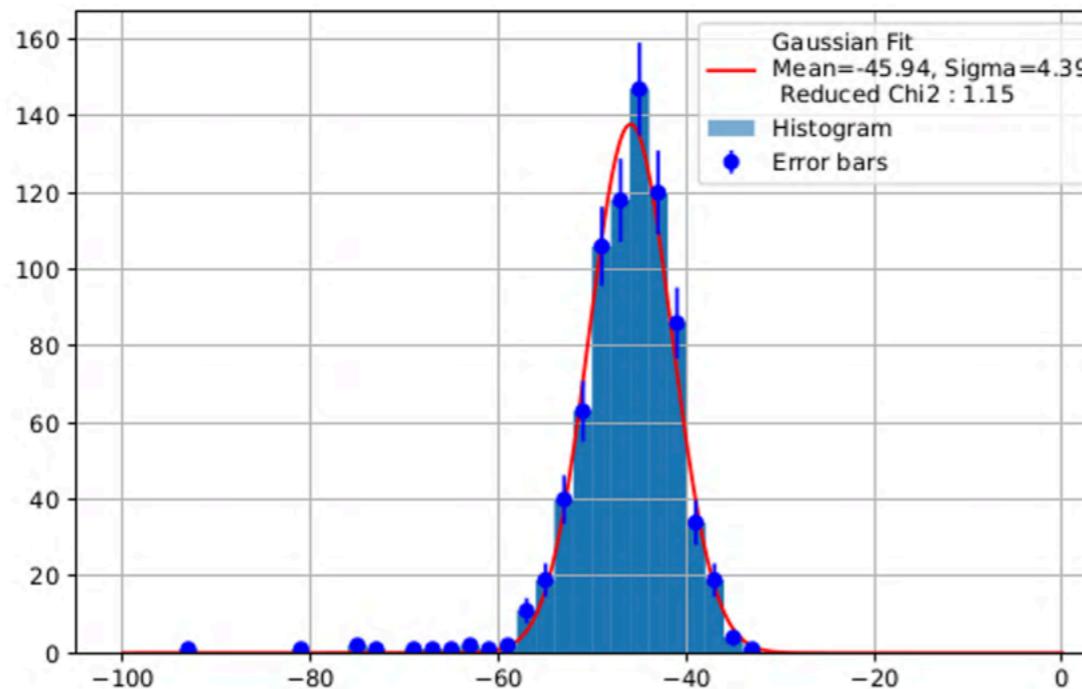
$$G = \frac{0.46 \text{ [pC]}}{1.60 \times 10^{-19} \text{ [C]} \times 230} = 1.25 \times 10^4$$



HV	Gain
2200 V	1.25×10^4
2300 V	2.15×10^4
2400 V	4.02×10^4
2500 V	7.04×10^4
2600 V	1.20×10^5

Analog signal After ASD

Test Chamber
ArCO₂ (80±2:20±2)



RARiS meeting 241203

目標

ガス比率ArCO₂を変えて、增幅率とefficiencyとmultiplicity評価

現在

テストチャンバーと線源

- オシロから波形取得して積分
- QDC、TDC解析

今週中にデータ取り終える。→ 解析、同時並行で修論