MEG実験用光電子増倍管の液体キセノン中における LED を用いた利得解析と現状

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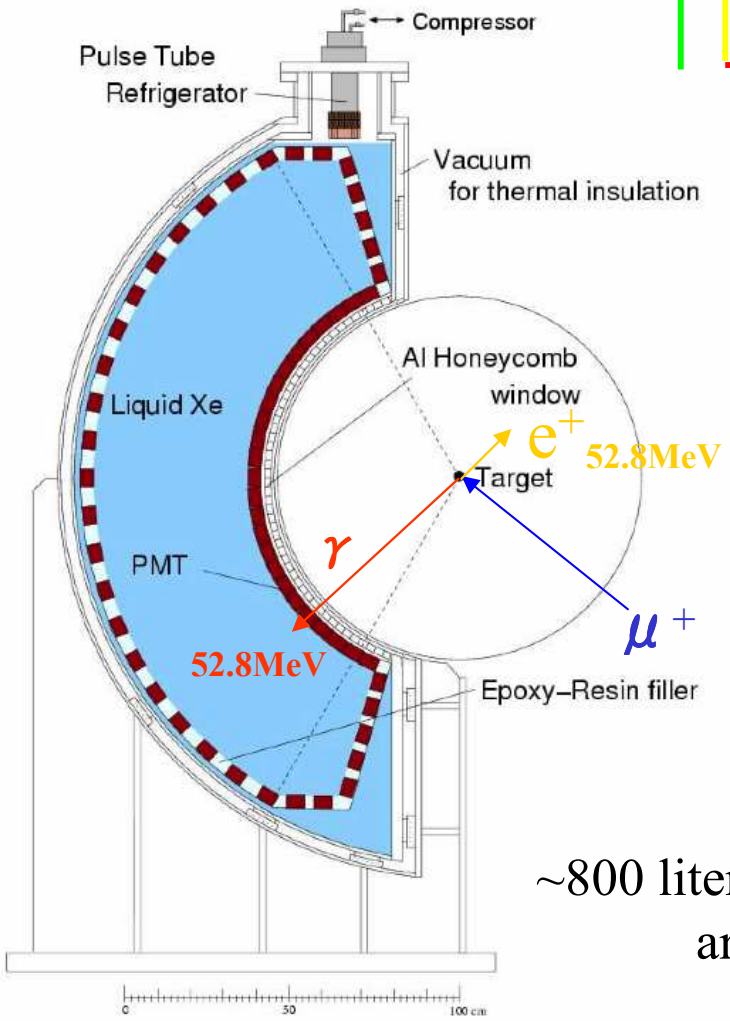
Abstract

- Overview of the Liquid Xenon Calorimeter
  Why do we need some pretests at the Prototype Calorimeter?
- Report over 4 tests in the LXe detector @ PSI
  Measurements have been completed.
- What measured in these 4 tests?
  - Rate dependence tests by 6LEDs (2 are signal, 4 are B.G.)
  - Q.E. measurements in gas/liquid by alpha source (^{241}Am)
  - Wave form measurements by DRS (talking next)
  - Cosmic ray analysis (not mentioned now in this talk)
  - gain calibration
- characteristic of the fluctuation
  from LED Driver and LEDs in these tests
  - estimation of gain and how to remove it

Liquid Xe Photon Detector

μ^+からのγ線をとらえる検出器



~800 liters LXe
are used

total **846** PMTs
are needed!!

液体Xe中で動作するPMTの開発

- 低温でも高感度な光電面の選択 (K-Cs-Sb)
- 高いbeam rateでも動作する (Zener diodeの採用)
- 紫外領域のシンチレーション光(~178nm)を受光可

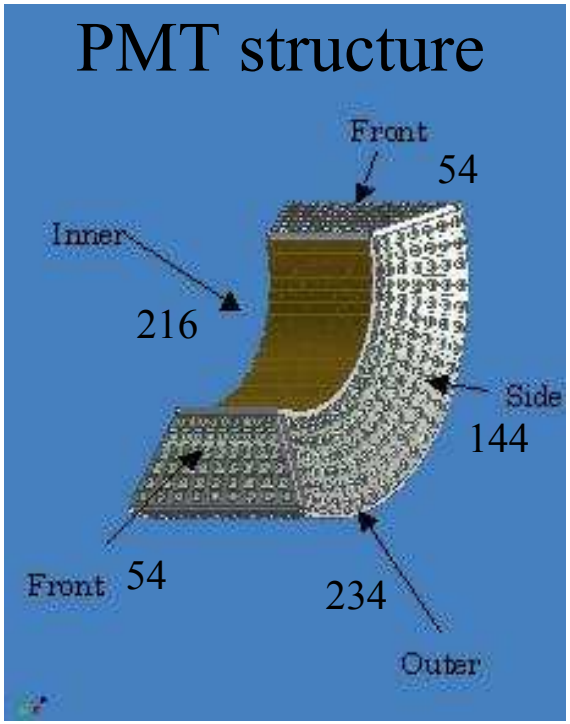
液体 Xeシンチレータに必要な技術

- 安定した低温の維持(~165K)　→パルス管冷凍機
- 不純物を取り除く　液相/気相純化装置の構築

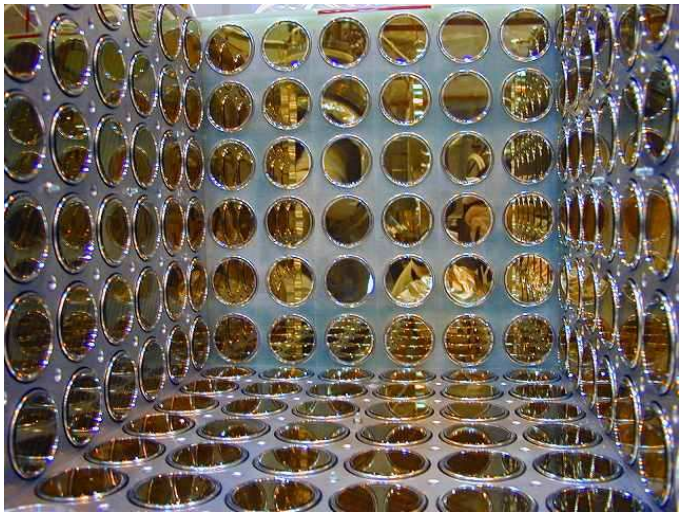
Prototype Detectorを用いて実証済み

PMT性能測定の
結果により配置決め

next



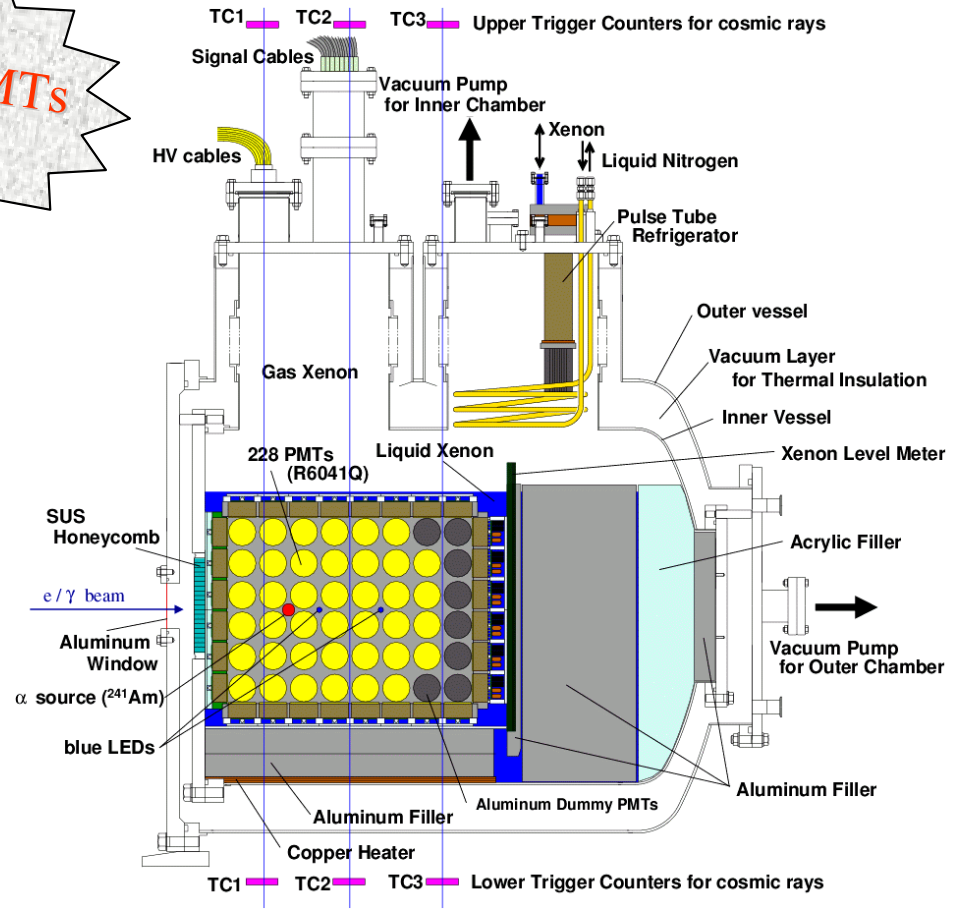
Prototype of liquid Xe Photon Detector



37cm x 37cm x 50cm (67liters) + others ~ 120liters LXe

一度の測定で
真空引き、Xe液化などを含め
数週間を要する

total 238 PMTs
in 6faces



4 tests completed in 2005, 2006

**4回のテスト(8/2005~3/2006)で
実機に使われるPMTを評価**

	1st	2nd	3rd	4th
new PMTs	188	184	144	100
+PMTs tested before	20	35	64	100
+PMTs tested in other group(PISA)	30	19	30	38
				238

一度に238本のPMTをテスト

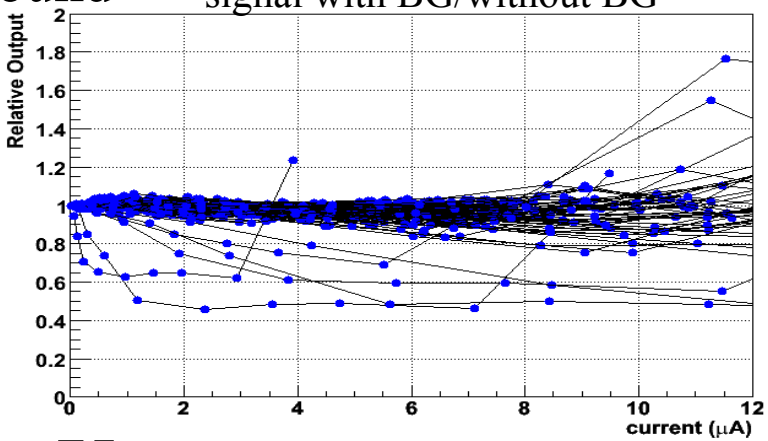
107 PMTs returned to HAMAMATSU

741(+78 LP +73 PISA soon)本の PMTが測定済み

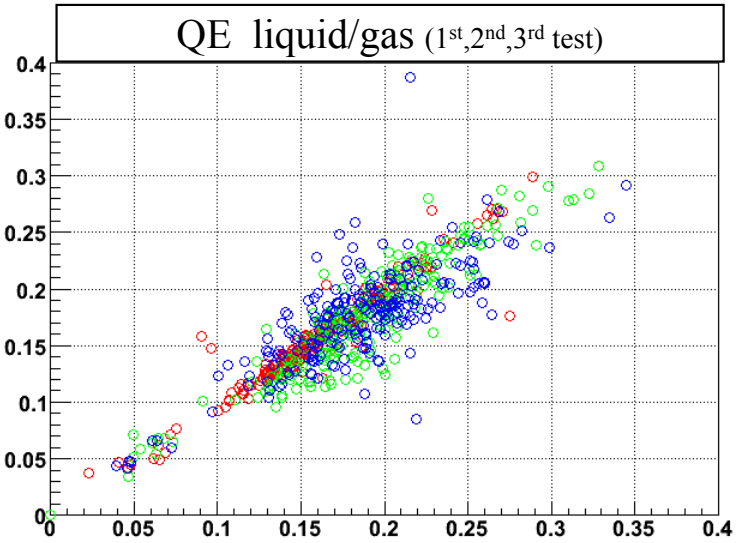
What is measured over 4tests

- gain calibration ⟶ later
- rate dependence with ~1~100kHz background
  - signal with 2 LEDs, background with 4 LEDs
  - estimated BG from gamma rays ~ 0.4 μ A
  - estimated BG from a neutron ~ 2 μ A
  - good up to 4 μ A

signal with BG/without BG

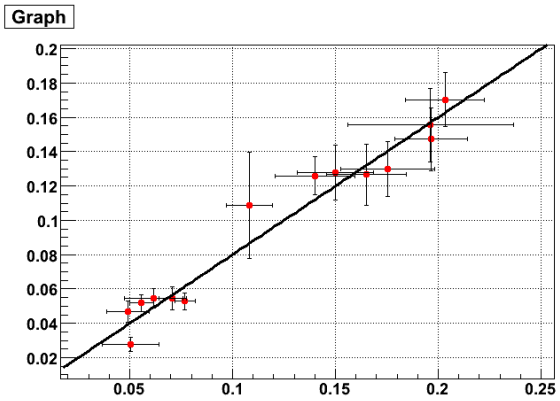


- Q.E. measured in liquid Xe and gas Xe
  - How to analyze Q.E.?
    - ADC values from α source (^{241}Americium) 2point by 4wires now
    - result of Monte Carlo simulation
    - gain used by LED
  - liquid/gas ~ 1

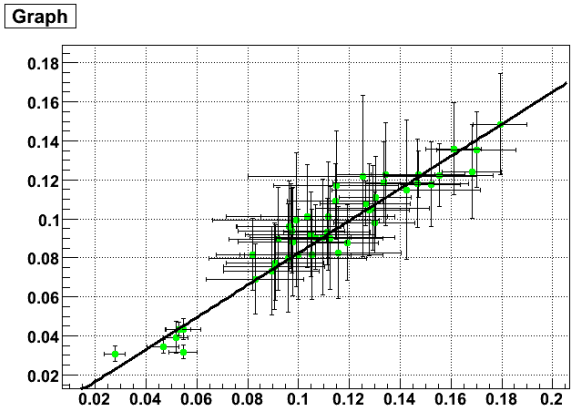


Q.E. comparison over 4tesets

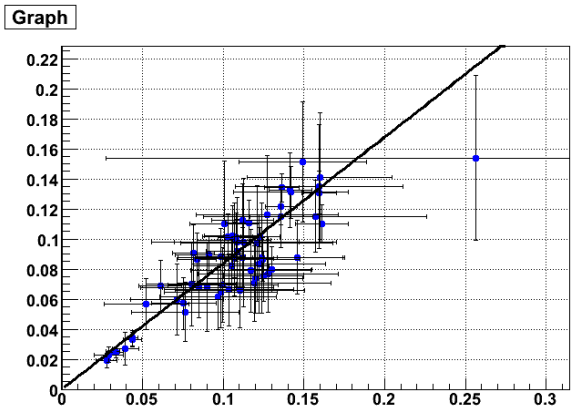
- Q.E. compared by the same PMT over tests
  - in liquid
    - $2^{nd}/1^{st} \sim 0.80$



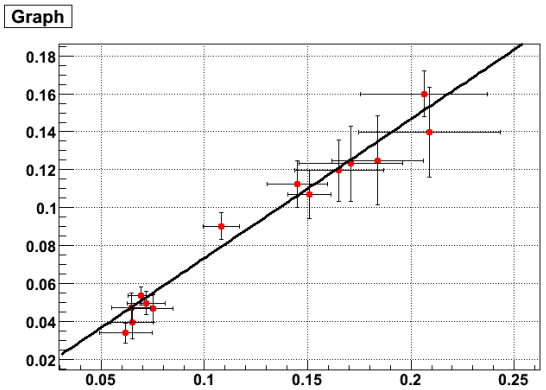
$3^{rd}/2^{nd} \sim 0.83$



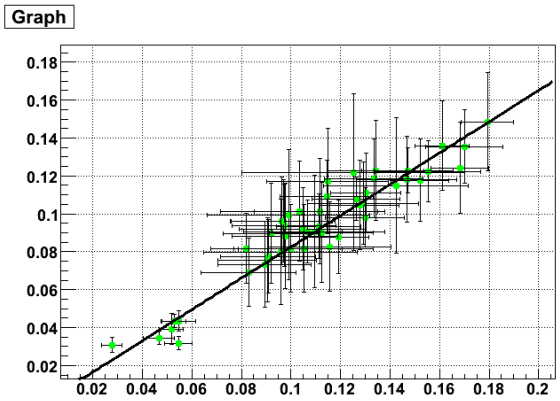
$4^{th}/3^{rd} \sim 0.84$



  - in gas
    - $2^{nd}/1^{st} \sim 0.73$



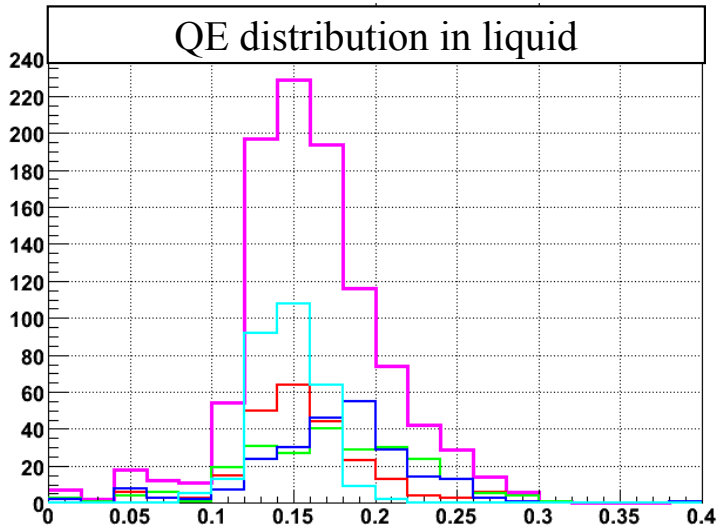
$3^{rd}/2^{nd} \sim 0.99$

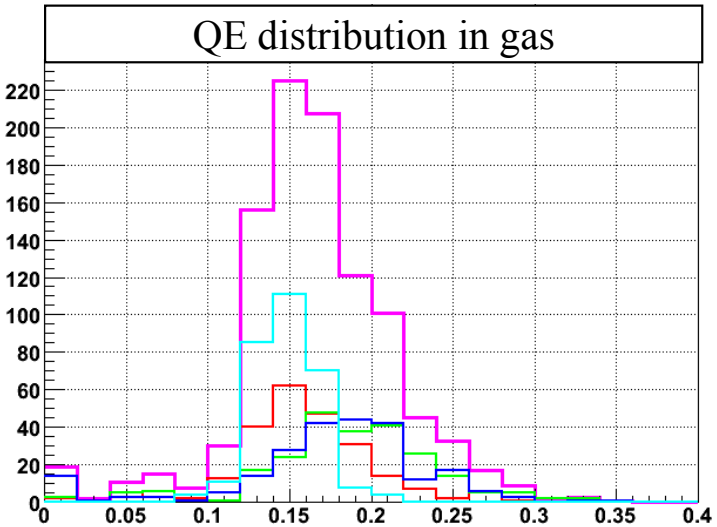


normalize Q.E.
over different test
using these factors

Q.E. distribution

➡ All data 1st test 2nd test 3rd test measurement in PISA (/0.136, /0.134)



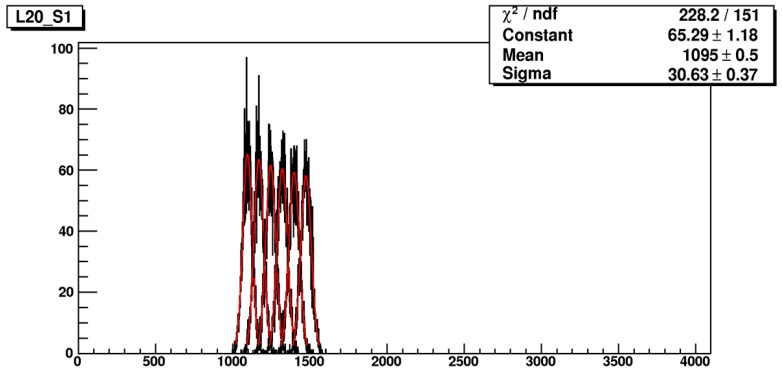


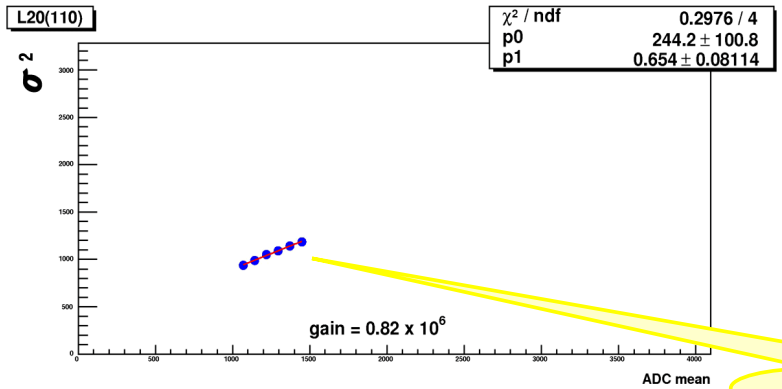
➡ determination of the location

Side face PMTs	Inner face PMTs
0.3×10^6<Relative gain<10×10^6 0.04<RelativeQE<0.4 0.25mm≤D ≤ 0.35mm some PMTs replaced after one year operation	0.5×10^6<Relative gain<2×10^6 Relative QE mean : 0.133 with smaller difference with QE mean will be selected. Slope < 0.25mm 303 PMTs are selected

Outer : high Q.E. & normal gain Front : others

Gain analysis by LEDs

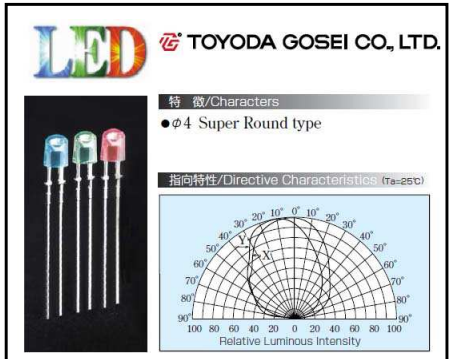




6plots by 5000 counts

set the pulse heights(6steps)
and the width (mainly ~7ns)

slope = gain

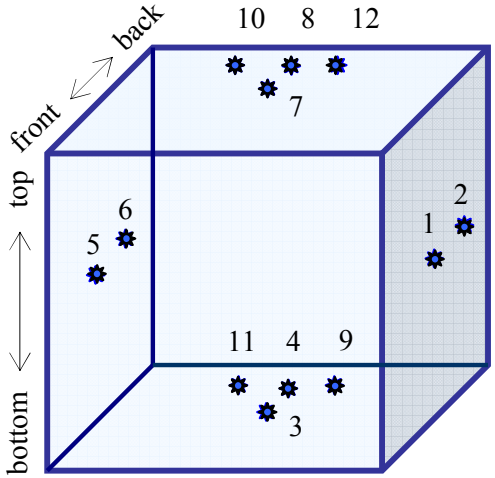


used pairs

(#1,#5) (#2,#6)
(#3,#7) (#4,#8)
(#9,#10) (#11,#12)

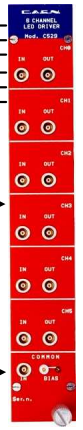
to illuminate uniformly

LXe Calorimeter
Labeling LEDs



LED #1~#12

Attenuator(10dB)



LED Driver
CAEN (C529) -2 ~ -20V

Frontend
set (width, height0~5) x steps

100Hz

$$I_{sig} = Gain \times e \times N_{p.e.} = M_{ADC} \times C$$

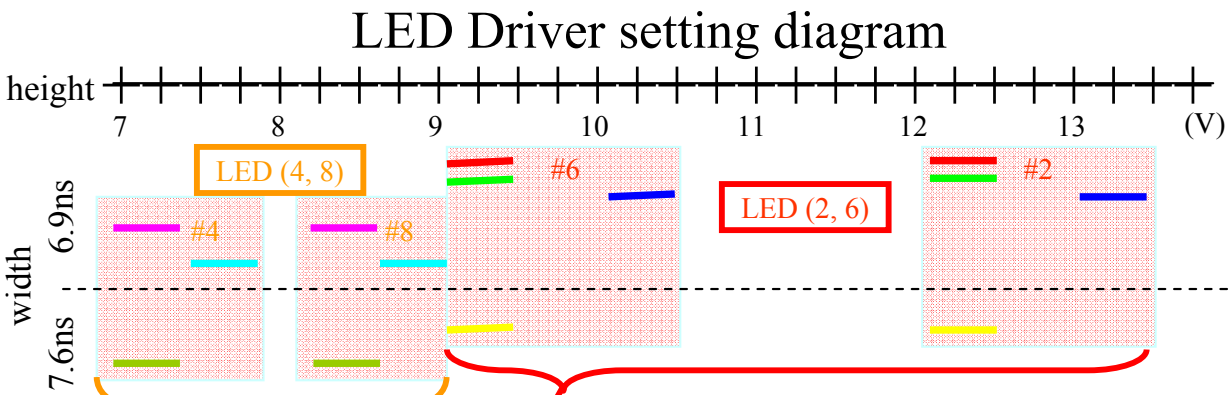
$$\sigma_{N_{p.e.}}{}^2 = \overline{N}_{p.e.} \rightarrow \sigma_{ADC}{}^2 = Gain \times \overline{M}_{ADC} \times e / C$$

(poisson)

Problem about the gain by LEDs

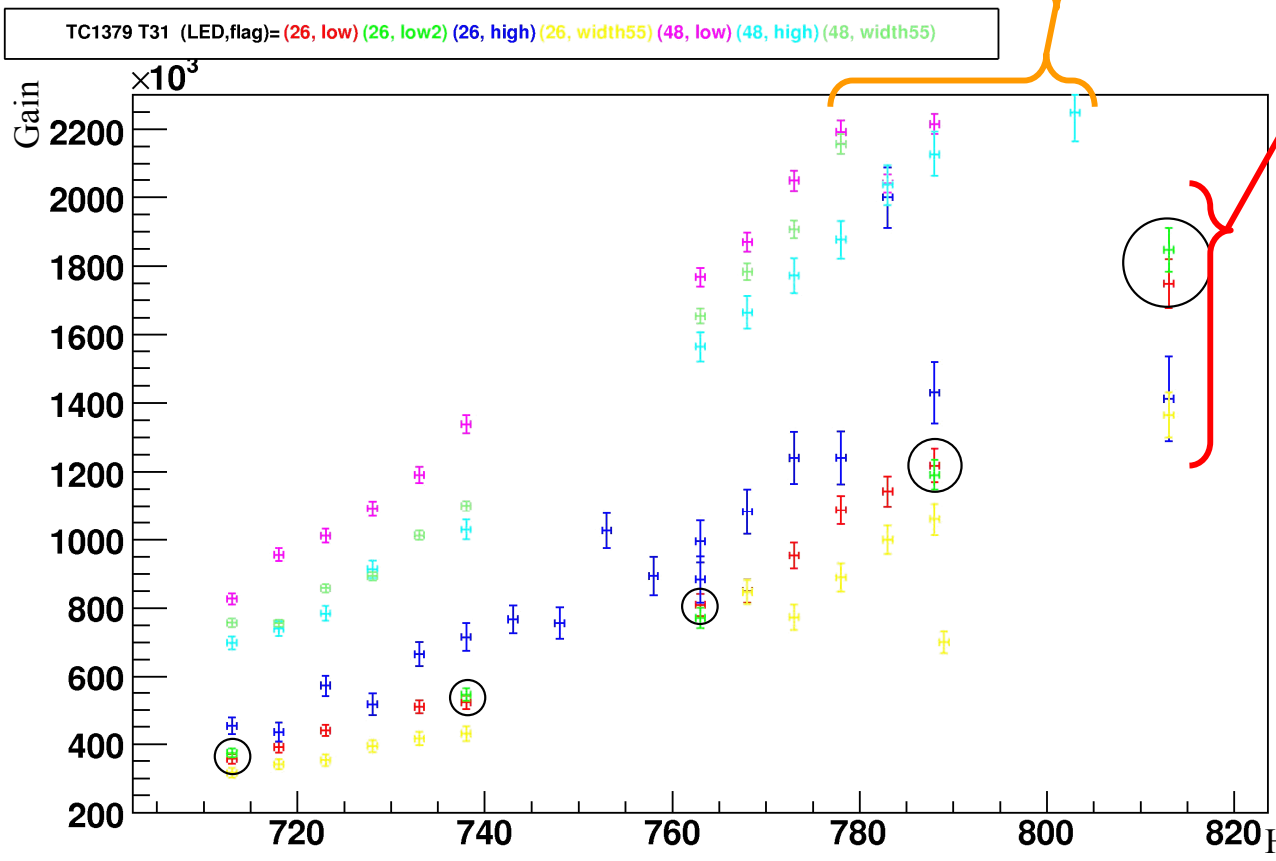
Gain gap exists !

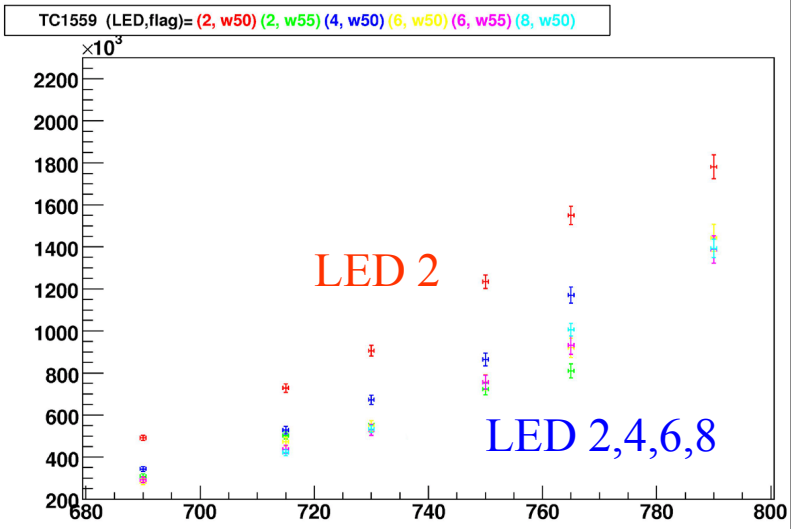
LEDやそのsettingの違いによって
Gainのシフトが見られる
LED Driver からのパルス幅、
高さを変えても違いが出ている



using 2pairs of LEDs

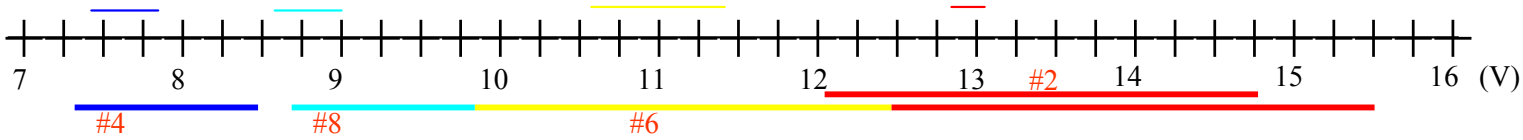
using 1LED





fluctuation from LED Driver

height setting

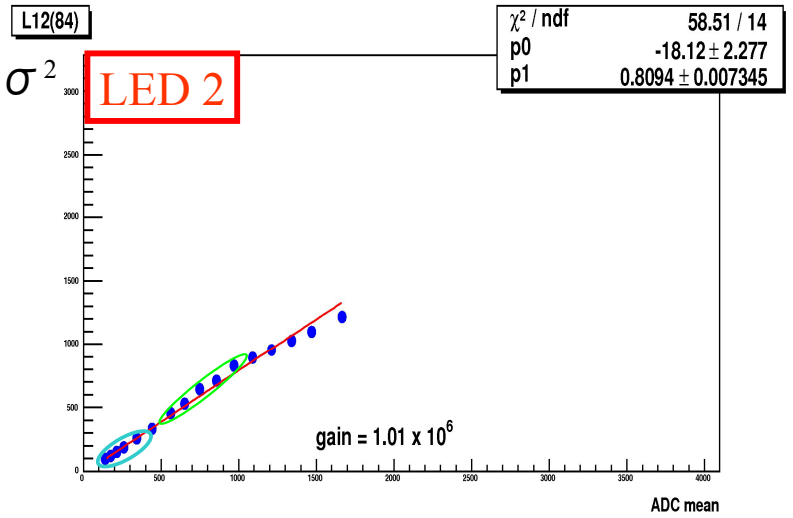


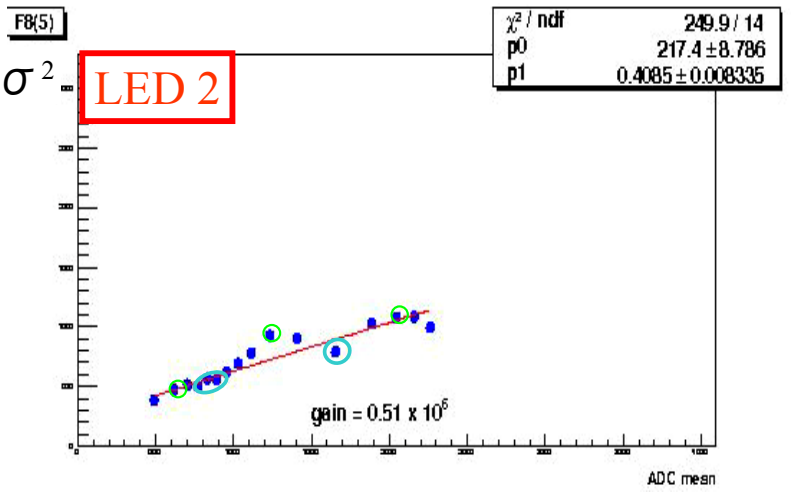
6 steps (previous slide)

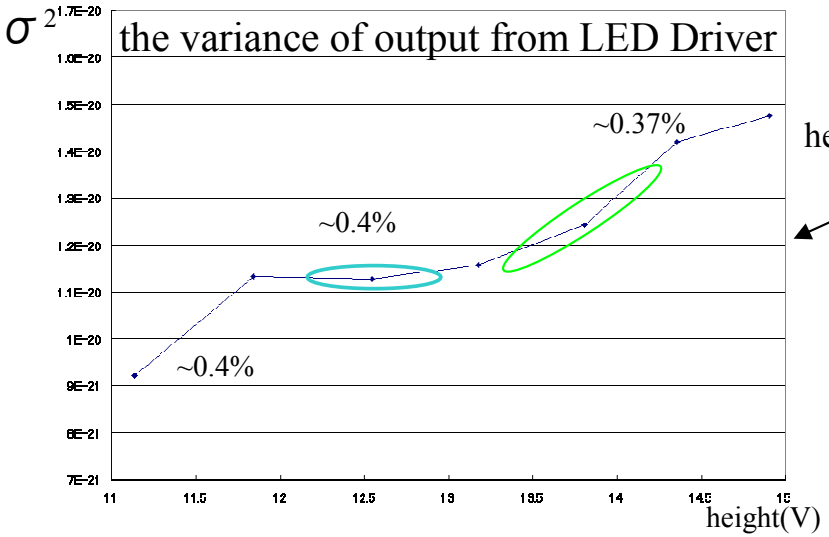
to 16 steps

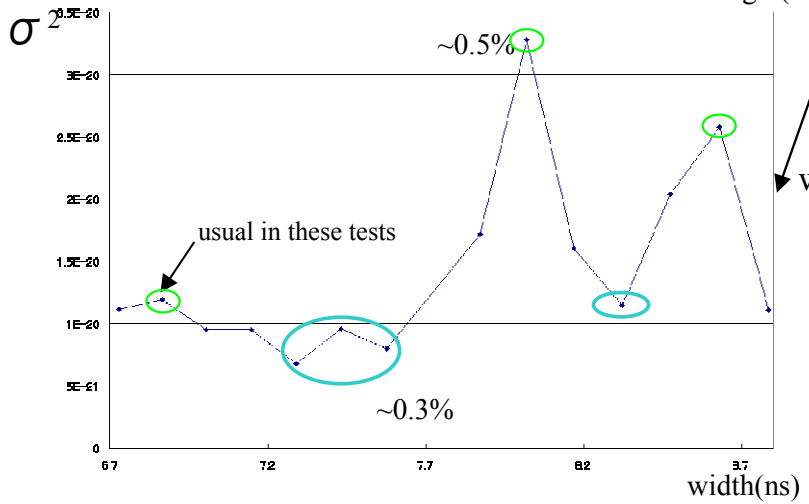
changing by height

changing by width









height scan

width scan

Attenuator

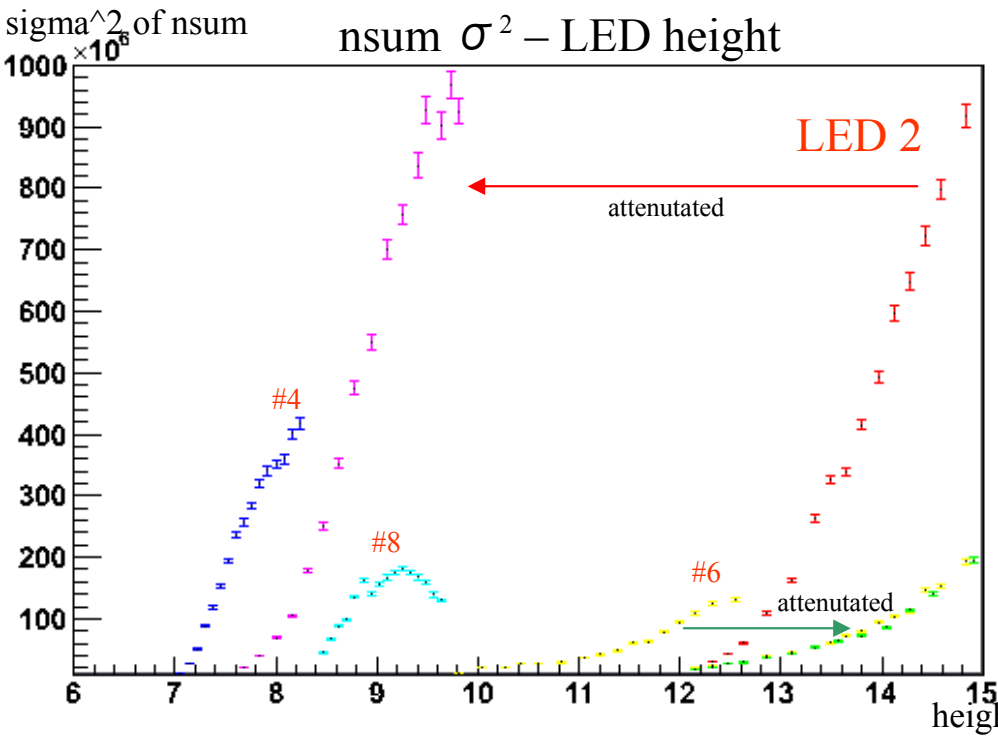
LED Driver
CAEN (C529) -2 ~ -20V

LED2ではLED Driverからのσ^2でGainが大きめに出る傾向がある.

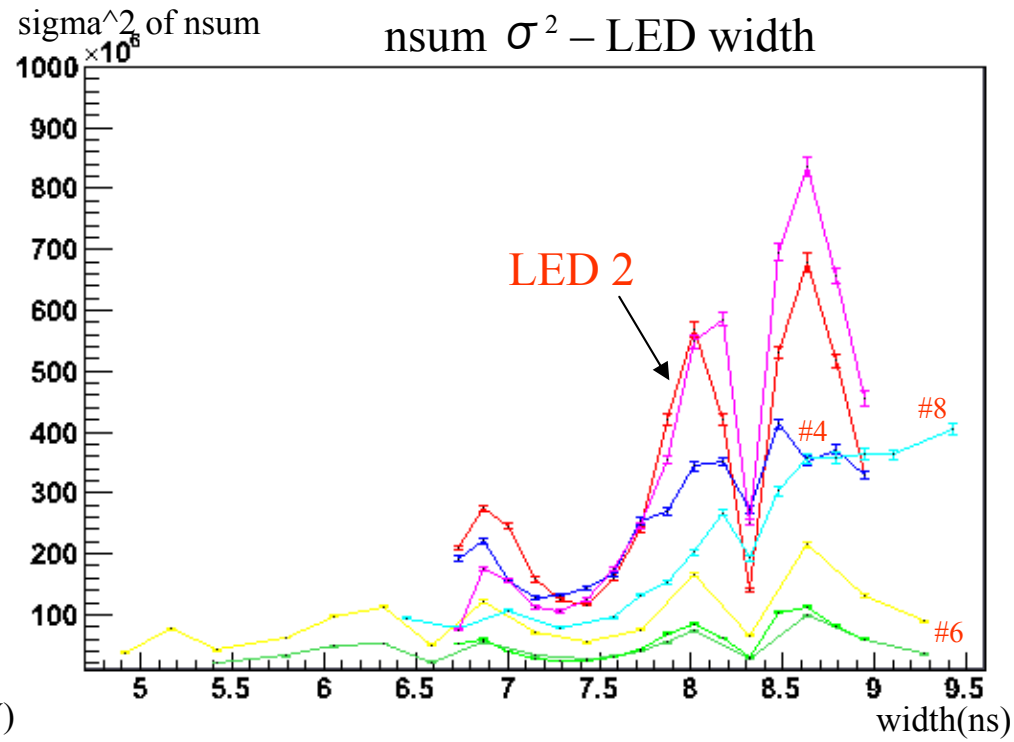
他のLEDとの違い

the variance of total photon

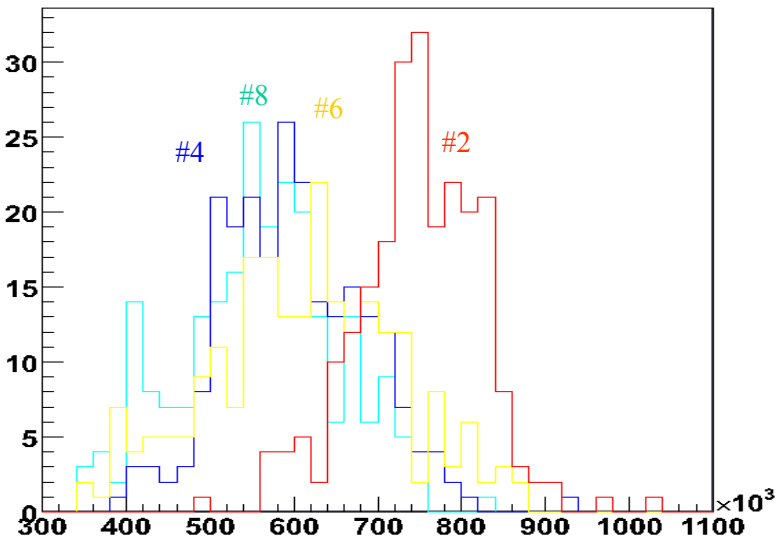
nsum σ^2 – LED height



nsum σ^2 – LED width



gain distribution of each LED



summary

- 液体Xe中で4回のテストを行い、
  必要な846本を上回るPMTが評価終了
- high rate BG における耐性が確かめられた
- Q.E.の解析を終え、PMTの位置決めが可能な状態
  - gas中liquid中で一致、各テスト間では同じPMTで較正
- gainは同じLED setupならerror程度の再現性を持つ
  - 今回用いたLED Driver 出力の分散が揺らぎを持つ
    ⇨ 補正、交換で精度が上がる可能性
  - LEDによりGainがshiftする
    ⇨ LEDを選択すれば影響を小さくできる

Liquid Xe detector (Prototype) での半年以上に渡る測定を終了

MEG実験(2006年後半から測定開始)に用いるPMTが既に供給可能

End of Slides

MEG最初の一年，その展望
三原智 (27aWK-7)

MEG実験用液体キセノン検出器の波形解析による性能評価
内山雄祐 (27pWL-6)

MEG実験におけるビームチューニング
森田裕一 (29pWL-9)

汎用データ解析ソフトウェア生成ツールROME&ARGUS
澤田龍 (30pWK-11)