Beam test @ELPH

Aerogel Cherenkov + MPPC

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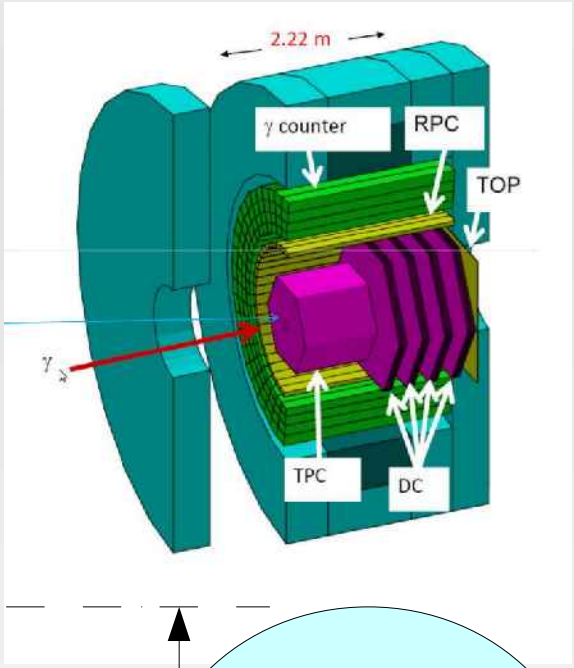
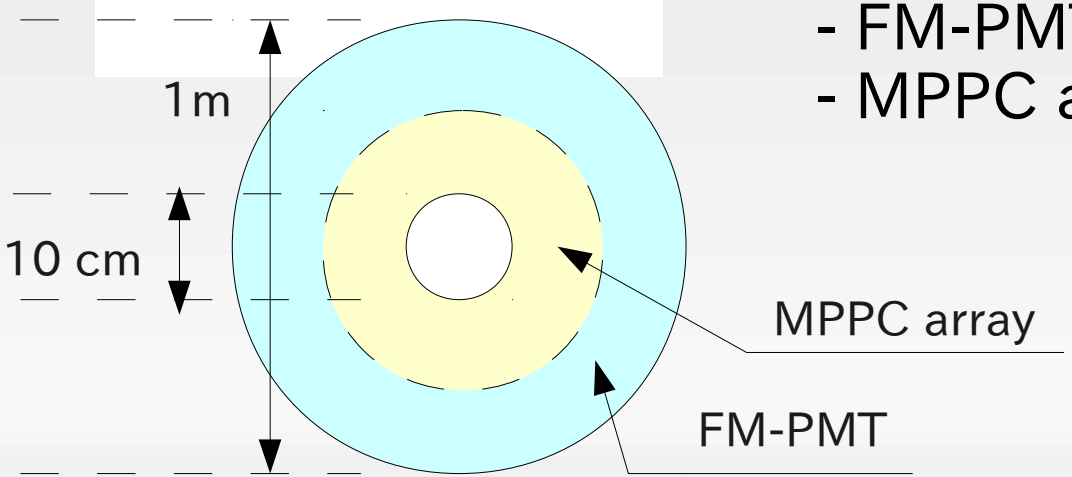
伊藤博士(千葉大)

Introduction: LEPS II AC Plan





Requirement

1. Installing AC into Dipole-Magnet
2. Thinner type for between TPC and DC
3. Lower density for Tracking
4. 1 – 2 GeV/c π /K Id

Recent Plan

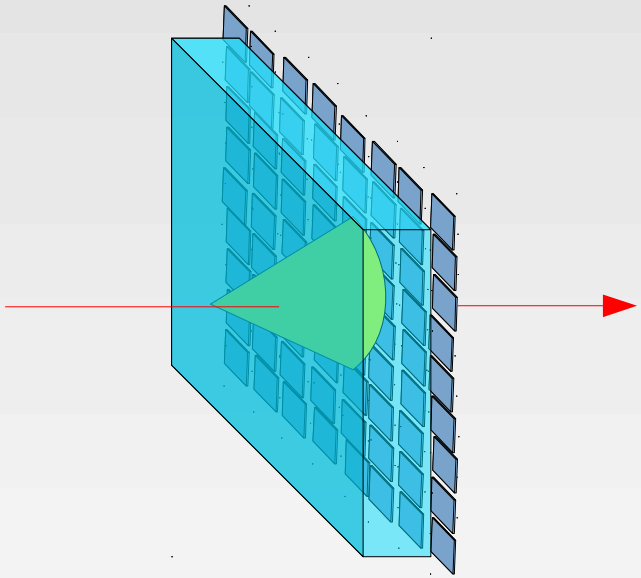
Development 2 types AC

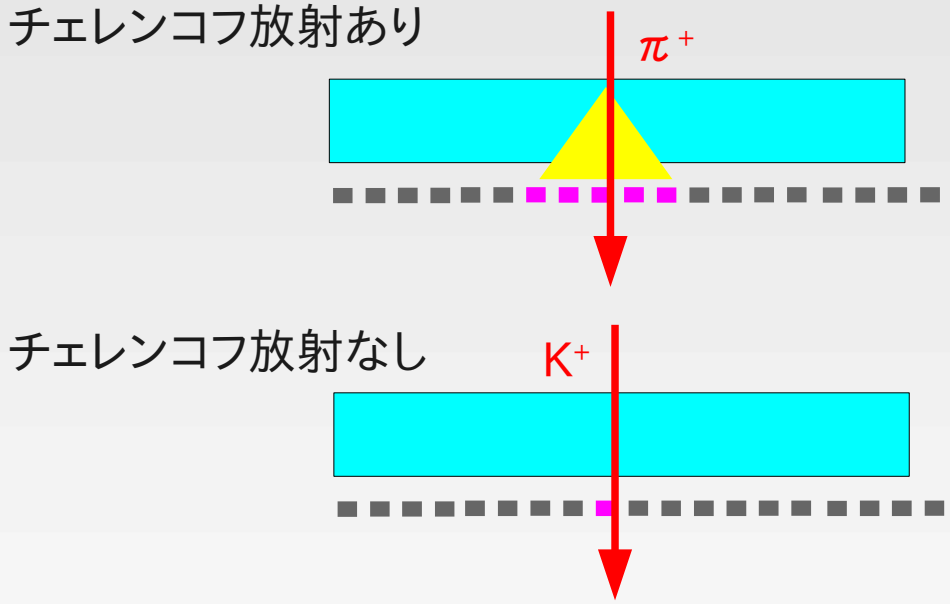
- FM-PMT type
- MPPC array type

Index: This Contents

- MPPC array type AC
- ELPH Beam test
- Discussion
- Production aerogel

MPPC Array type



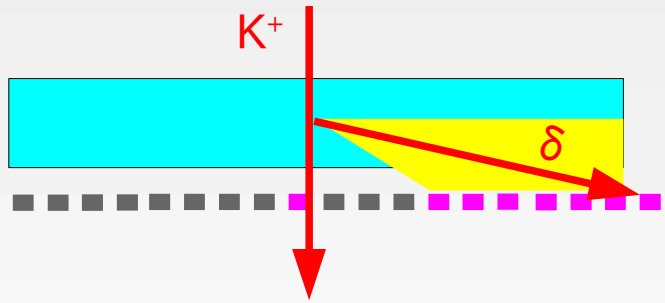


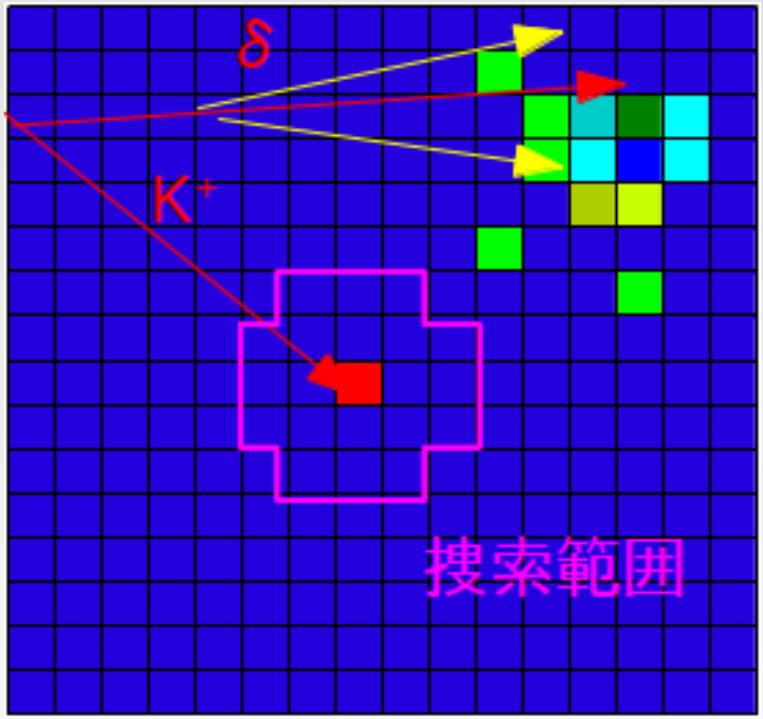
MPPC Array type

Knock on electron reject

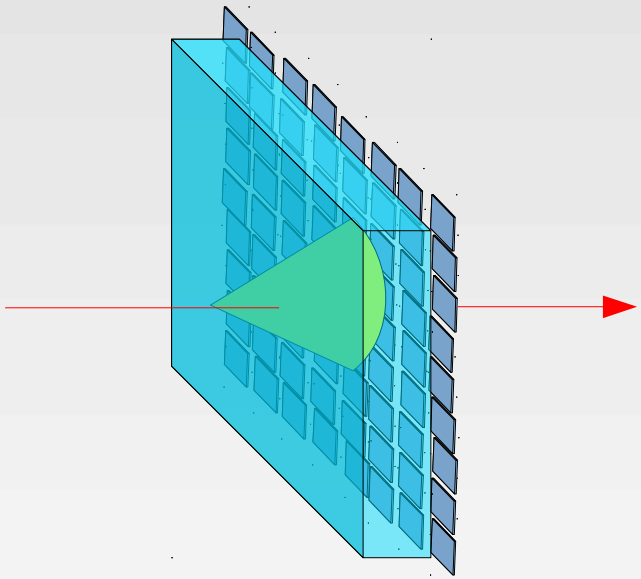
Knock on electron reject

- Limit of integral region of MPPCs.
- Cherenkov light from delta-ray perhaps far away out side of the region.
- PID 99% over more would be achieved.





MPPC Array type



MPPC HAMAMATSU K.K.

New S13360 Series

- Lower Cross Talk
- Lower After Pulse
- Lower Dark Current

KEK & Tohoku Unv.

New EASIROC module

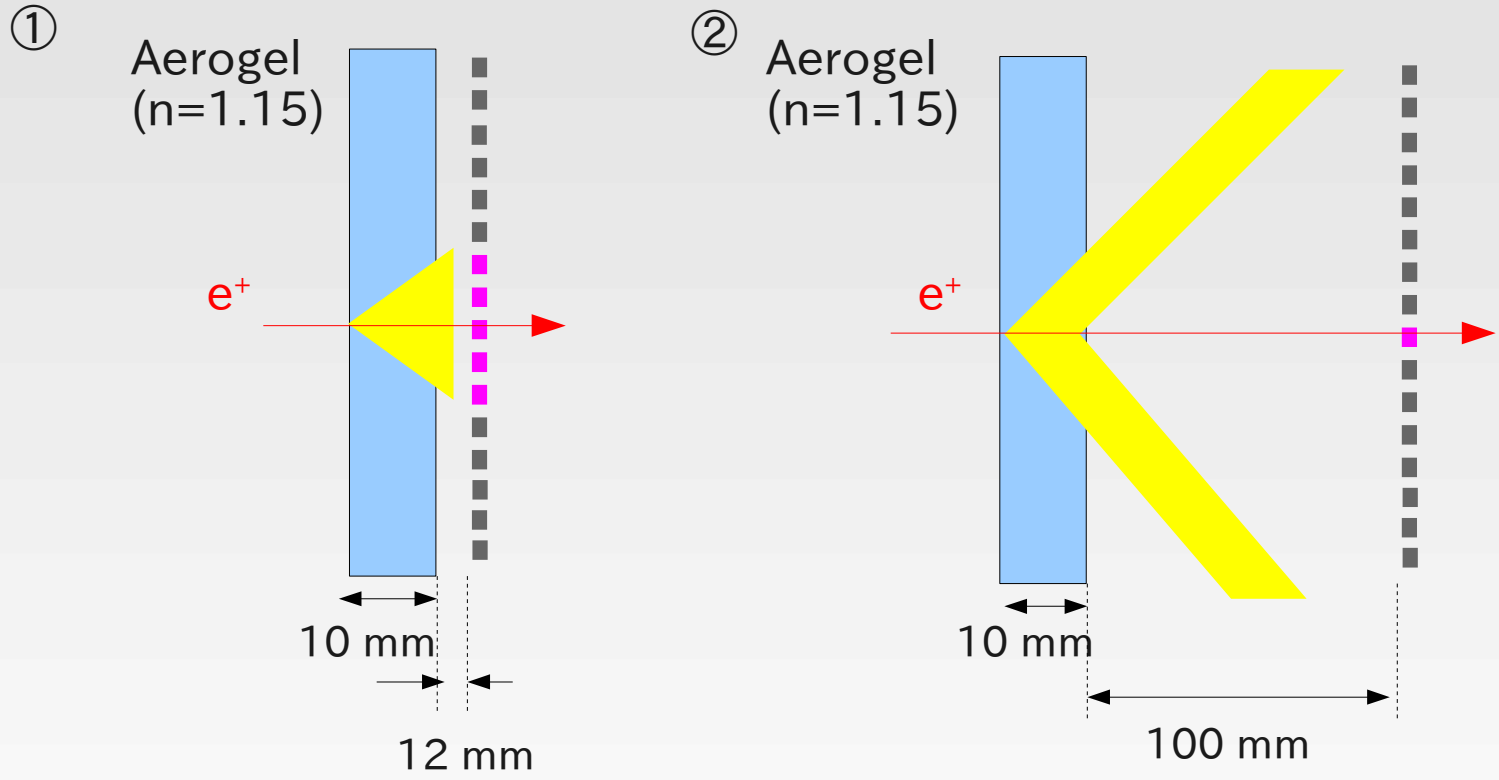
- Max 64 ch ADC+HV
- Cost: 300 – 400 kYen
- Ethernet Operation

新MPPCとEASIROCの詳細はBackupに載せとく

ELPH Beam test

ELPH: Research Center for Electron Photon Science, Tohoku Univ.
e^+ Beam line @ GeV Gamma room

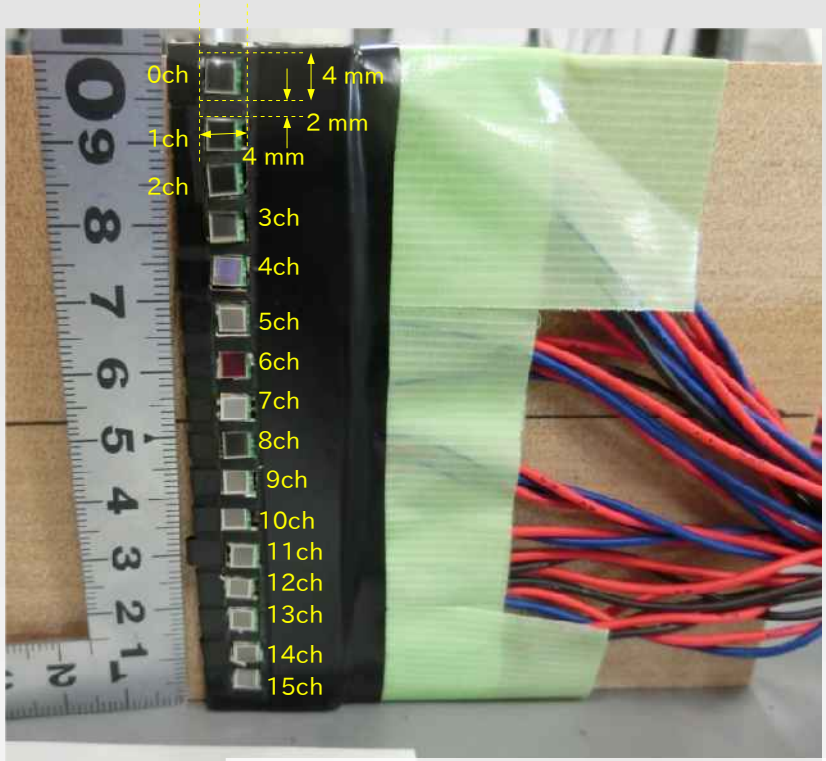
Setup: image



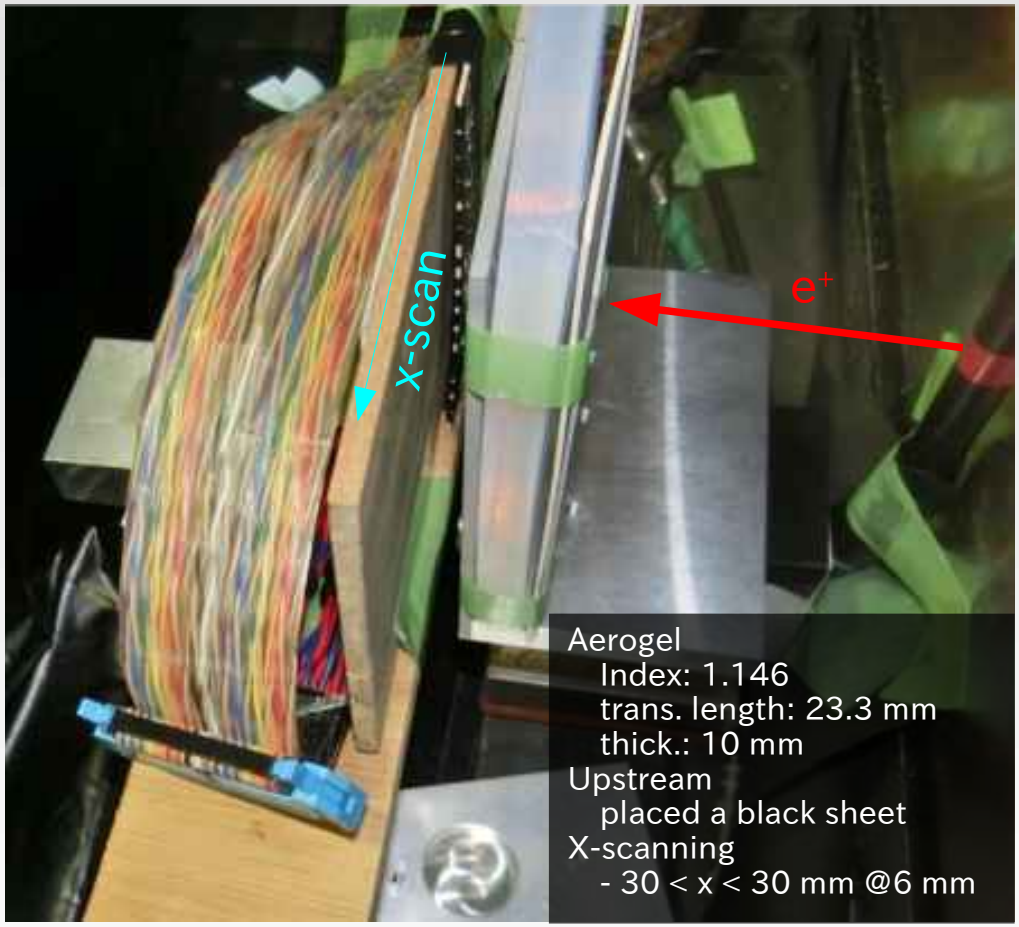
MPPC: S12572-100P, □3 mm, 16 ch
EASIROC module … readout MPPCs

ELPH Beam test

Setup: picture

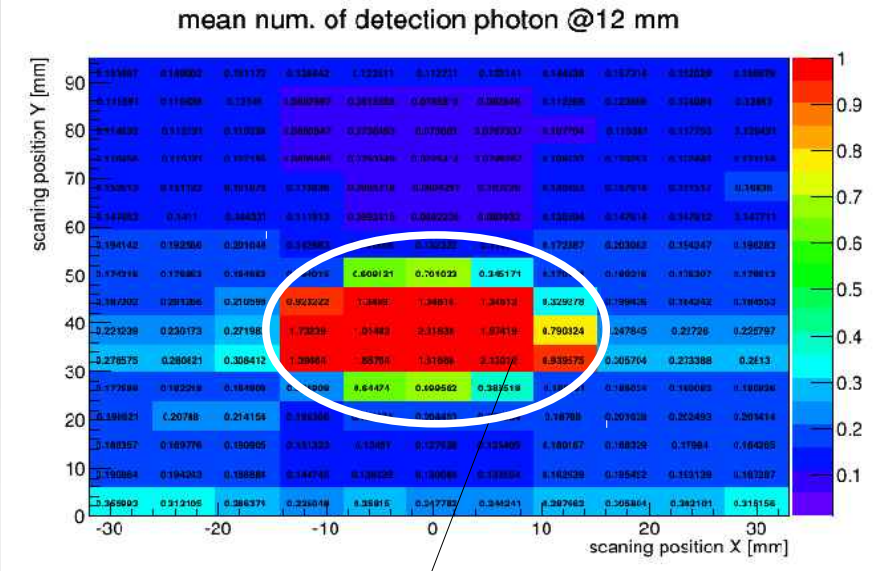


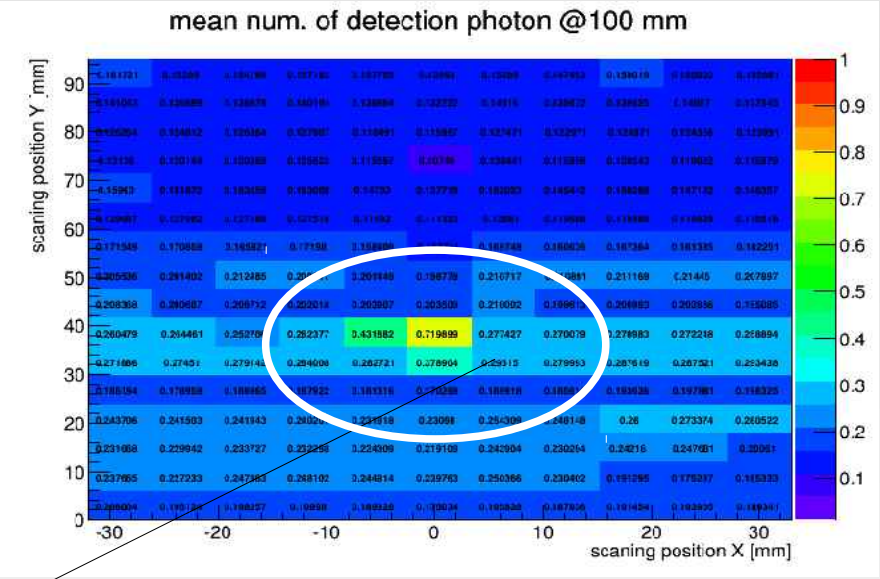
MPPC: S12572-100P
eff. area: □3 mm
Outside area: □4 mm
Scanning acceptance 0.25

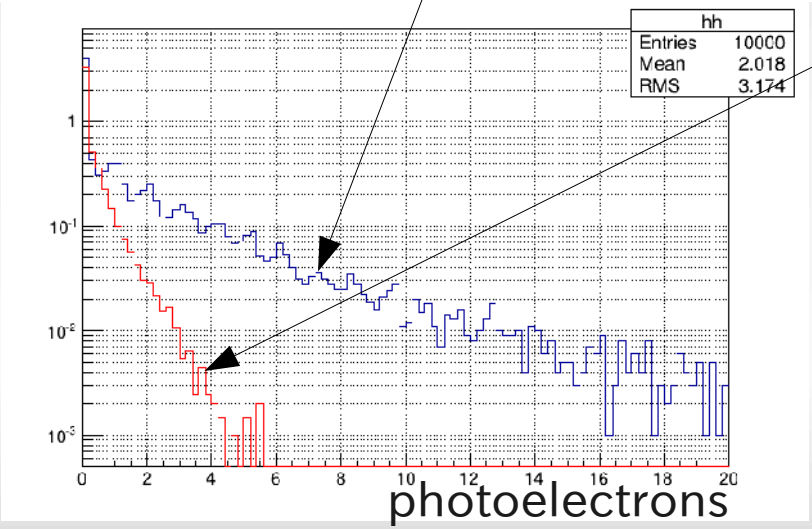


ELPH Beam test

Distribution mean p.e. of MPPCs







These distribution of Cherenkov are clearly.

In main Cherenkov region channels, total num. of p.e. is 23 and 6, respectively.

ELPH Beam test

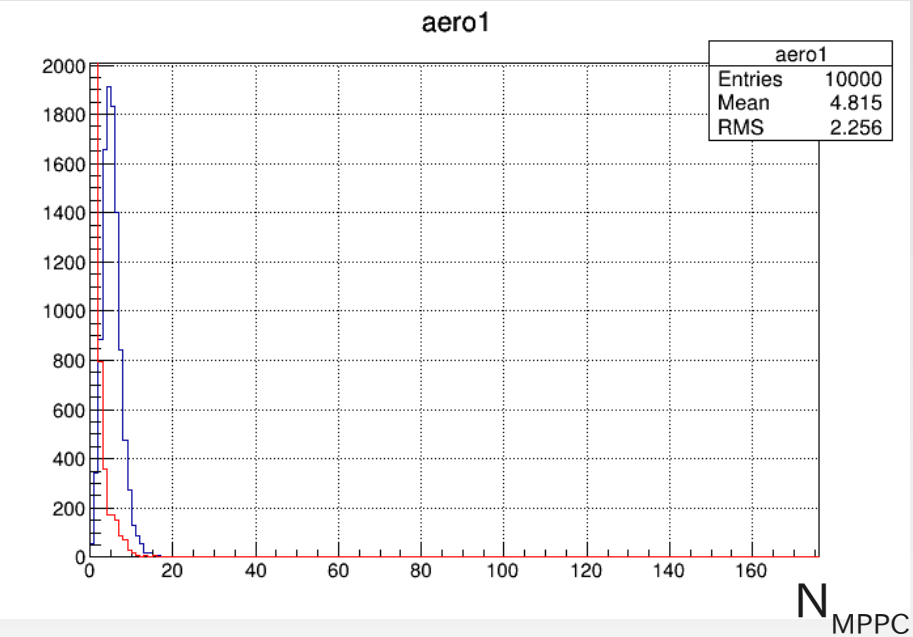
Analysis by force;
PID estimation but only Lines with non-synchronization

Consider
(1) Each MPPC Line has not synchronized in event.
(2) Cherenkov light is assumed random in the cone.
(3) MPPCs are arrayed 2-D virtually.

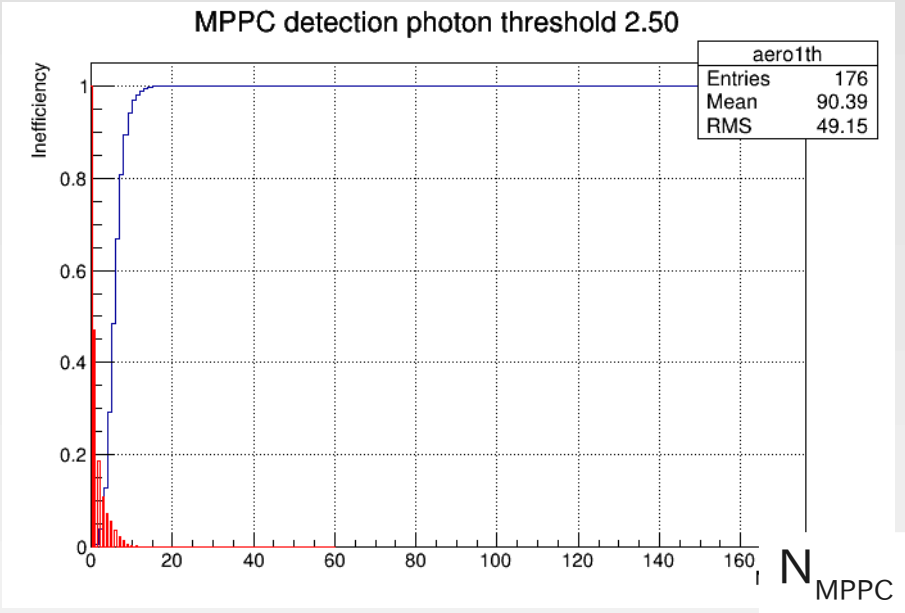
Analysis 1 … 176 MPPCs PID On-line PID model
2 … 21 MPPCs PID Off-line PID model

ELPH Beam test

176 MPPCs PID estimation



N_{MPPC} Distribution @ Nth = 2.5
Blue ⋯ 12 mm
Red ⋯ 100 mm

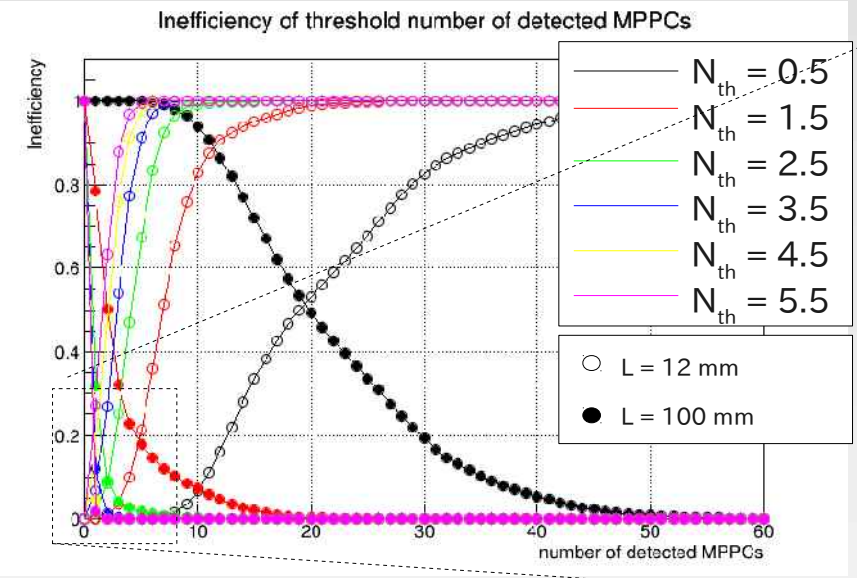


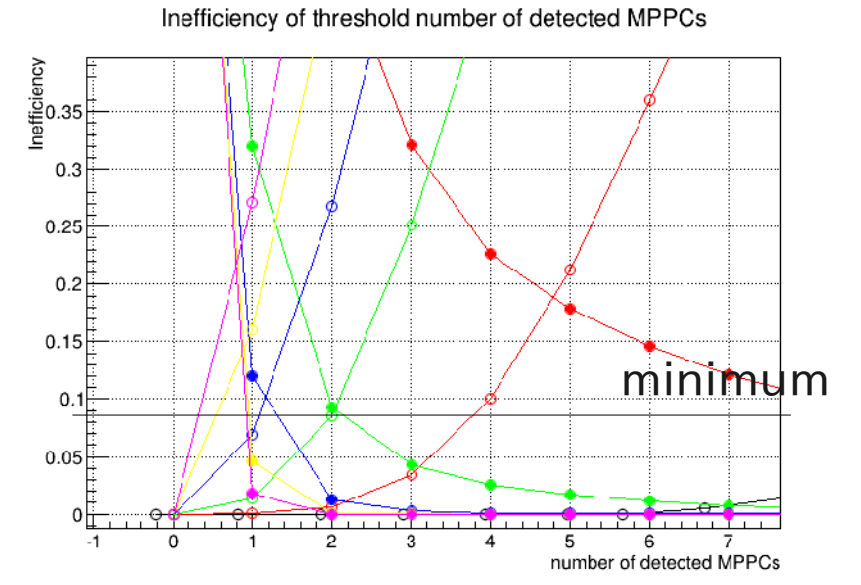
Miss-Id of Cherenkov @ Nth = 2.5
Blue ⋯ 12 mm
Red ⋯ 100 mm

N_{th}: threshold of detected number of MPPCs
N_{MPPC}: threshold of p.e. of each MPPC

ELPH Beam test

176 MPPCs PID estimation





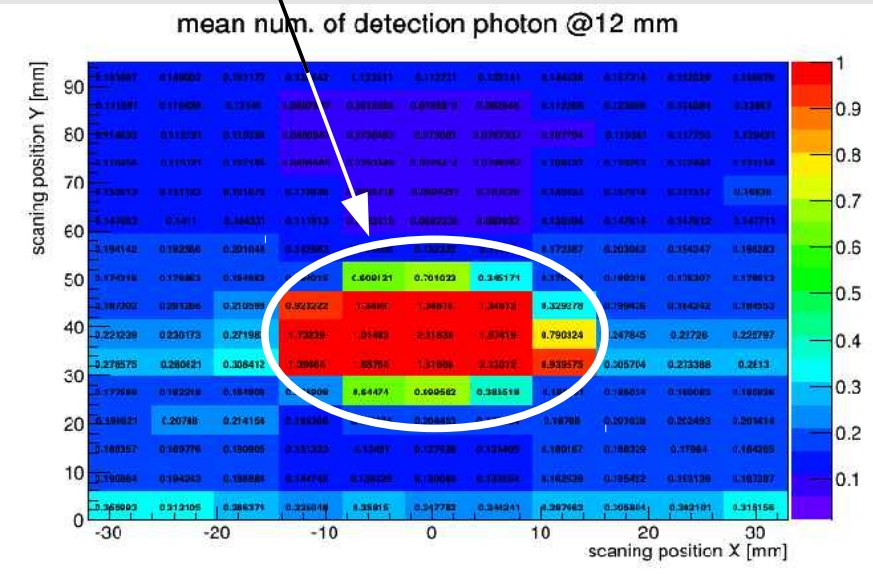
Minimum Mis-Id is 0.09
→ PID: 91% @ N_{th} = 2.5, N_{MPPC} = 2

N_{th}: threshold of detected number of MPPCs
N_{MPPC}: threshold of p.e. of each MPPC

ELPH Beam test

21 MPPCs PID estimation

the PID estimated from 21 MPPCs in the same way as 176 MPPCs PID analysis.



When the threshold of MPPC has been configured 3 or more, PID was estimated 90.2% as eff. and 7.2% as mis-id.

ELPH Beam test

Result & Considerable

Result

On-line ⋯ eff. 91%, mis-id 9%
Off-line ⋯ eff. 90.2 %, mis-id 7.8%

Considerable

Why the PID was estimated worse but 20 p.e. or more was detected by MPPCs?

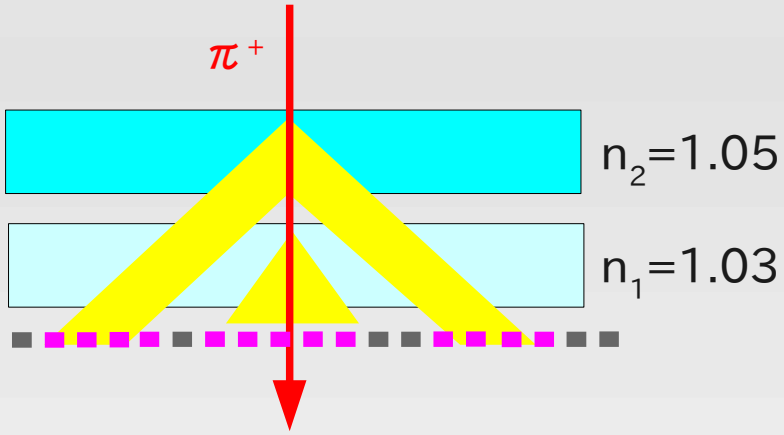
- MPPC has high noise and cross talk mainly
N(n=1.15, d=1cm) ～ 93, acceptance =0.25, $Q.E._{MPPC}$ ～ 0.35
Np.e. ～ 8.2, Nexp=17 ⋯ cross talk effect=17/8.2 ～ 2

Improvement: How should we do ?

1. MPPC array acceptance: 25% → 50%
2. N(n=1.15, d=1cm) ～ N(n=1.03, d=4.2)
3. new MPPC (S13360) would like to be used.
3. decided aptitude parameter for AC
    Aerogel thckness, index, TL, gel-MPPC distance,
    MPPC acceptance, ...

Discussion

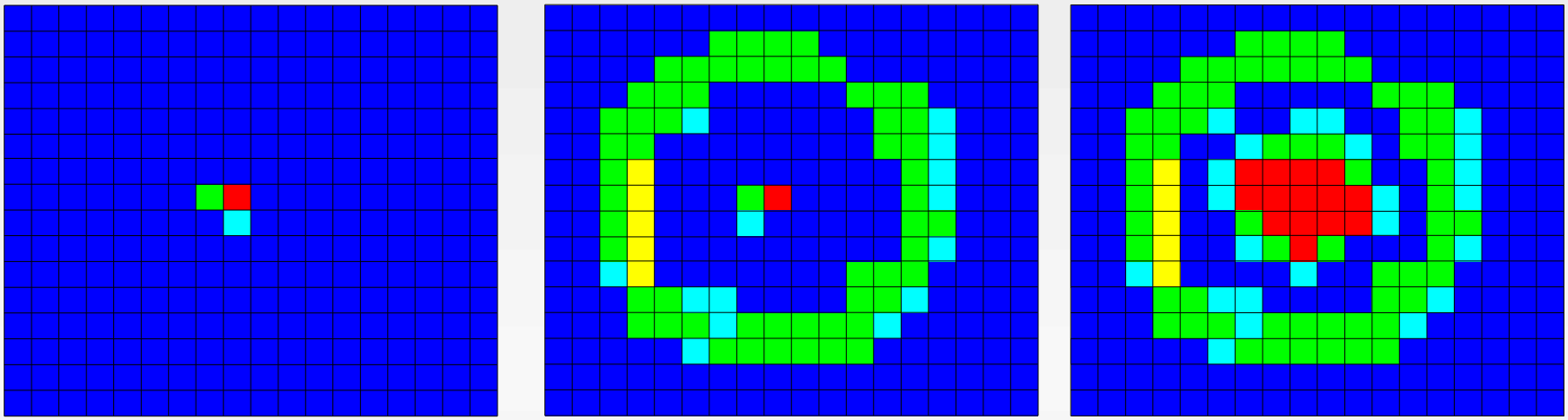
π /K/p identification



$$\beta_p < 1/n_1 < \beta_K < 1/n_2 < \beta_\pi$$

- 3 kinds PID (π /K/p)
- 2 kinds + Wide Range Momentum

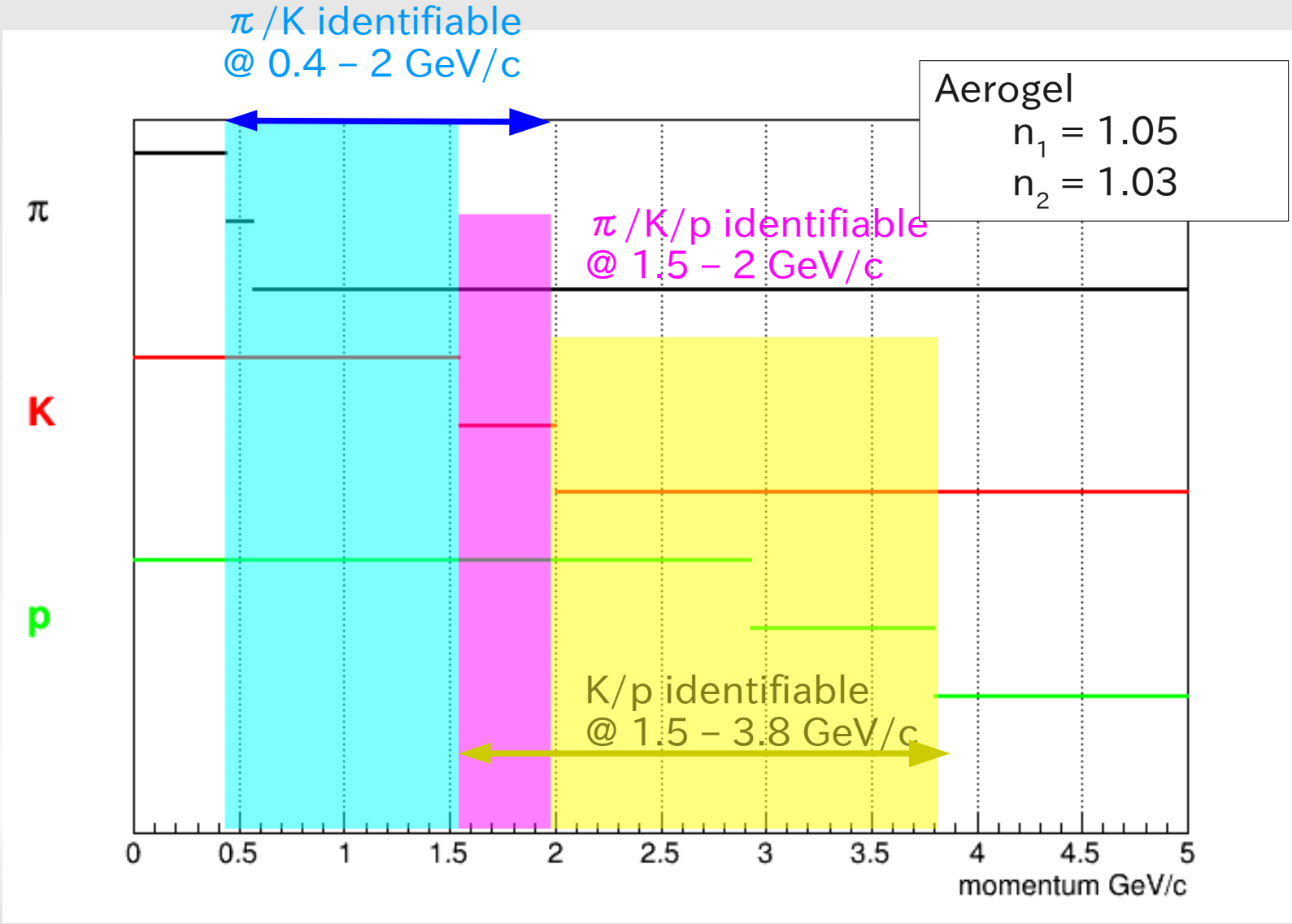
Image distribution



p K^+ π^+

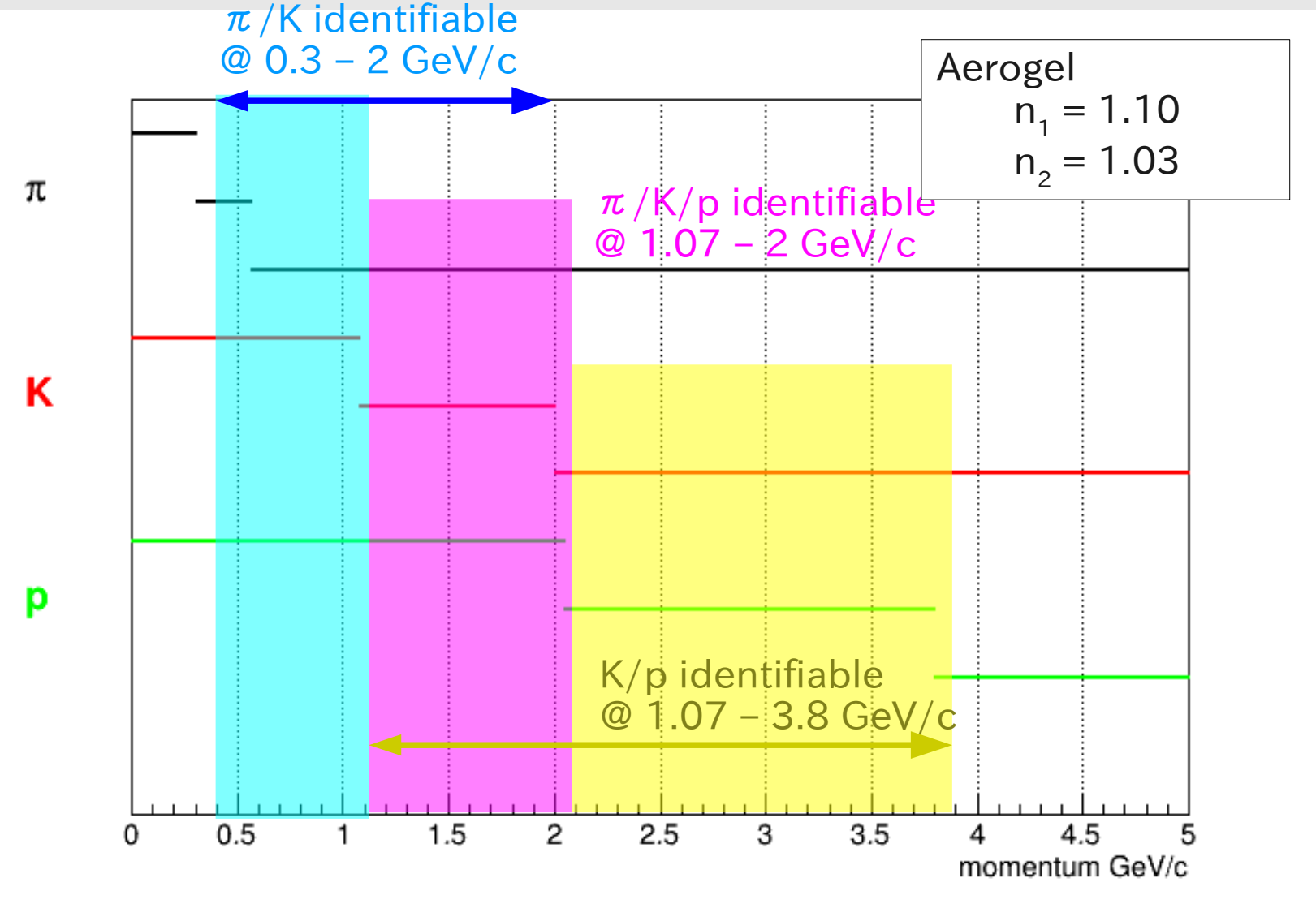
Backup

π /K/p identification



Backup

π /K/p identification



Conclusion

- MPPC type
  MPPC put on downstream aerogel directory.
  Noise is reducible by veto knock-on electron.

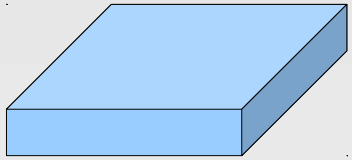
- MPPC Linear Scaning
  Aerogel n=1.15m, TL=23 mm
  MPPC □3 mm, 16 Linear, Acceptance 25%
  → *Cherenkov Distribution Clearly*
  → PID estimation **90% or more** by force
  MPPC noise & cross talk make break relation of **p.e.** and **eff.**

- New Idea
  3 kinds Particle Identifiable:
  π /K/p (1 – 2 GeV/c) @ n_1=1.10, n_2=1.03
  PID at Wide Range Momentum
  π /K (0.3 – 2 GeV/c)

Aerogel in Chiba Univ.

河合さんからの伝言

1バッチ = 2L



10 x 10 x 2 cm^3

× 10コ分

1週間で2バッチが限界
→ 1ヶ月で8バッチ
→ max 16 L / 月

3ヶ月目からの製作依頼では10万円/バッチ 引き

ピンホール	あり	なし
屈折率	1.03 – 1.26	1.003 – 1.08
製作期間	3ヶ月	2ヶ月
値段	40万円/バッチ	30万円/バッチ

Aerogel in Chiba Univ.

大学同士の契約ができる場合

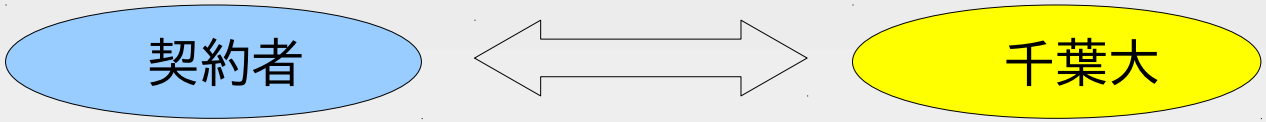
	間接経費
受託研究契約	+30%
共同研究契約	+10%
研究成果物有償譲渡契約	+0%

オススメ

大学同士の契約ができない場合

間に企業が入ってもらって、
契約する。
企業の手数料がいくらかかる

契約のながれ



4月		契約	
5月			エアロゲル製作
6月			納品(1)
7月	振込(1)		納品(2)
8月	振込(2)		納品(3)
9月	振込(3)		納品(4)
10月	振込(4)	⋮	
11月			

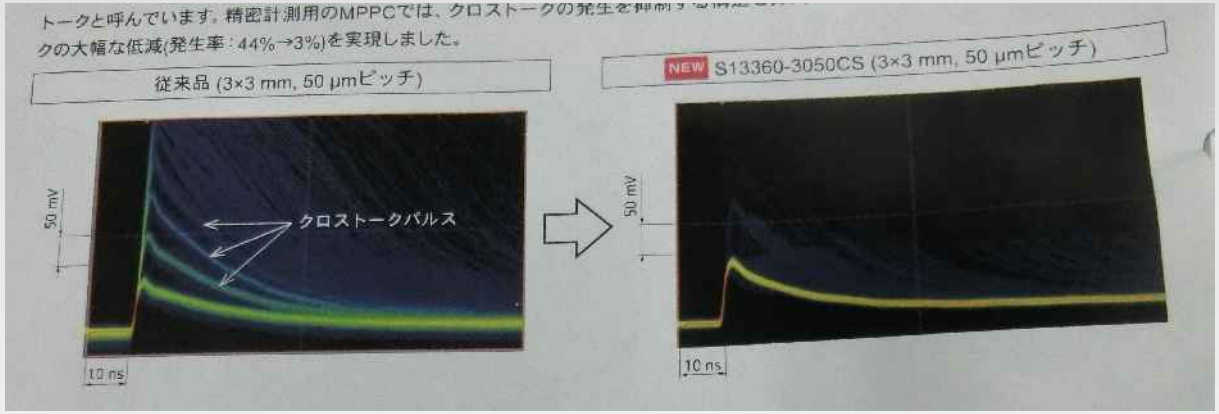
Backup

Backup

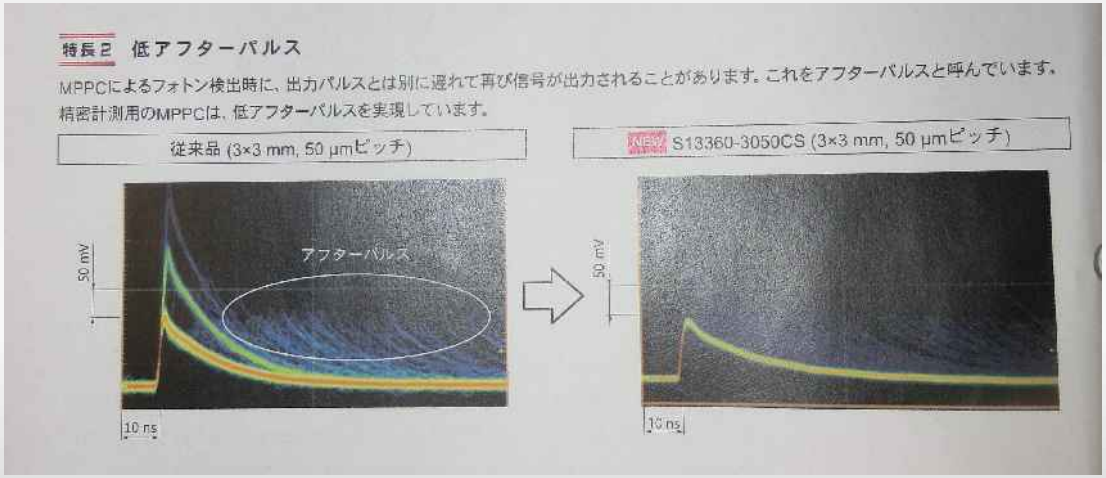
MPPC HAMAMATSU K.K.

NewS13360 Series

Lower Cross Talk



Lower After Pulse

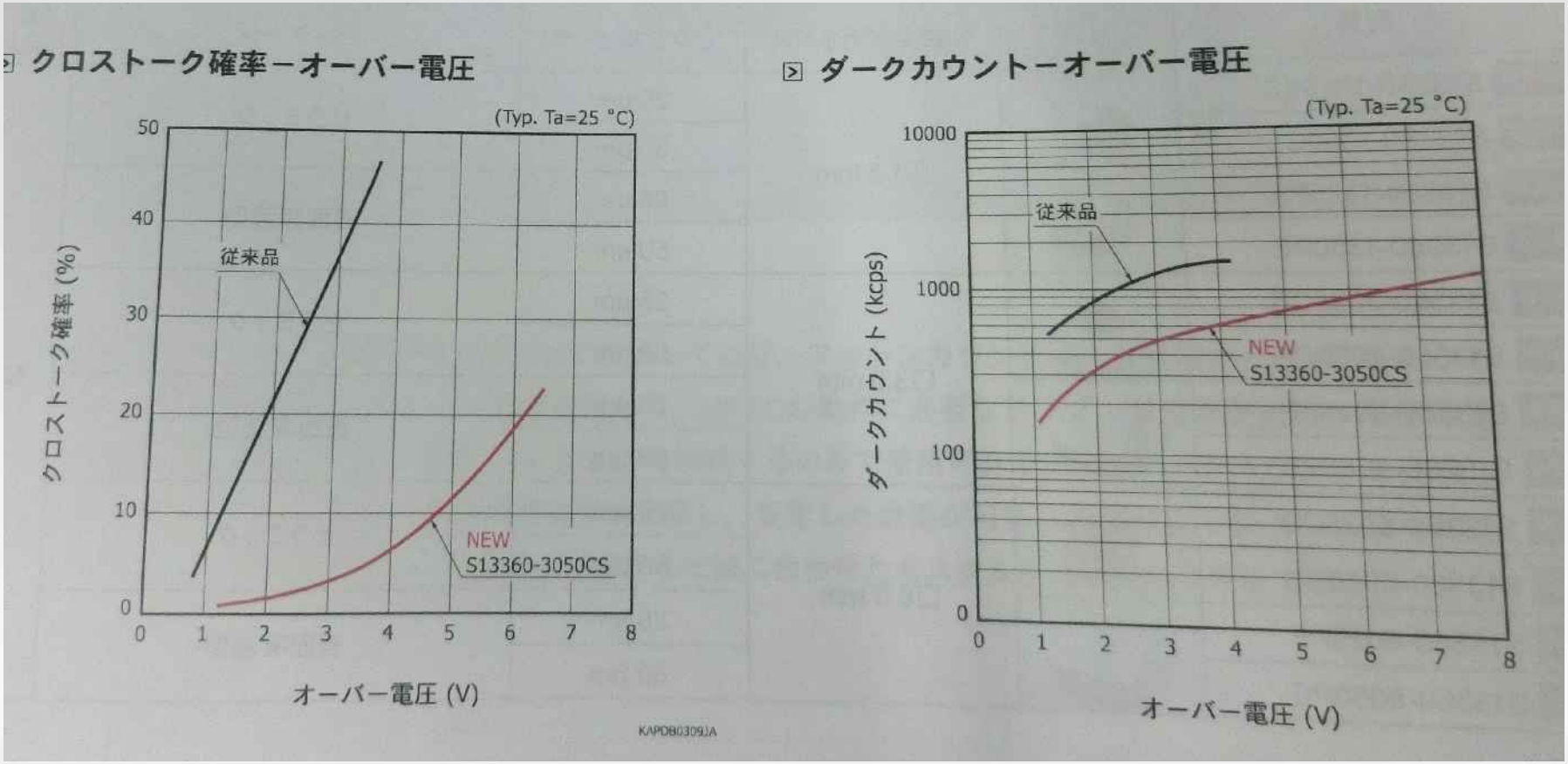


Backup

MPPC HAMAMATSU K.K.

NewS13360 Series

Contribution at Over Voltage



Backup

MPPC HAMAMATSU K.K.

New S13360 Series

	S12572	S13360	
	-100P	-3050PE	-6050PE
Effective photosensitive area	3 × 3 mm^2	3 × 3 mm^2	6 × 6 mm^2
Pixel pitch	100 μm	50 μm	50 μm
Number of pixels	900	3600	14400
Number of channels	1 ch		
Package	Surface mount type		
Cooling	Non-cooled		
Spectral response range	320 to 900 nm		
Peak sensitivity wavelength (typ.)	450 nm		
Dark count (typ.) 0.5 th	1000 kcps	500 kcps	2000 kcps
(Max.)	2000 kcps	1500 kcps	6000 kcps
Terminal capacitance (typ.)	320 pF	320 pF	1280 pF
Gain (typ.)	2.8 × 10^6	1.7×10^6	
Recommended operating voltage (typ.)	VBR +1.4	VBR + 3 V	
price	2 kYen/個 (100個)	7 kYen/個 (100個単位) 6 kYen/個 (100個単位)	11 kYen/個 (50個単位) 10 kYen/個 (100個単位)

HAMAMATSU Catalog data

Backup

KEK & Tohoku Unv.
New EASIROC module

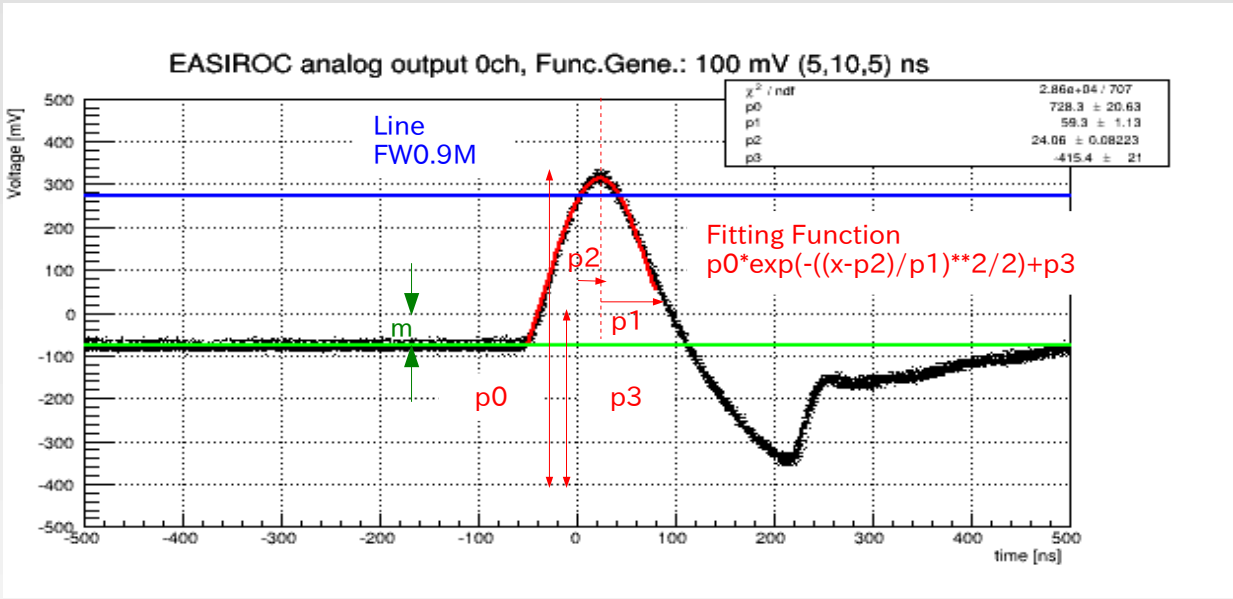
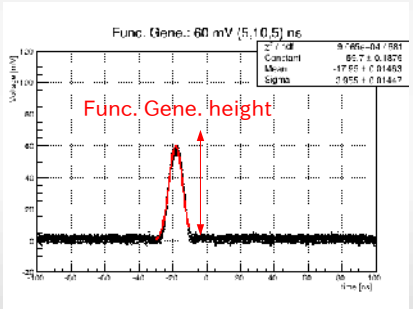


Fig. Analog output signal

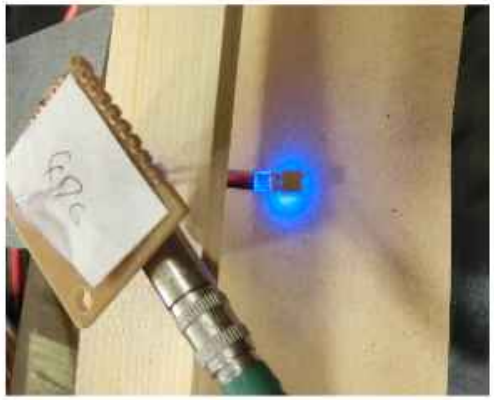
- EASIROC 2 chip
- Maximum 64ch ADC
  HV supply
- Trigger Logic
- PreAmp gain
- Slow Shaper time coefficient
- Lower Cost: 300 – 400 kYen

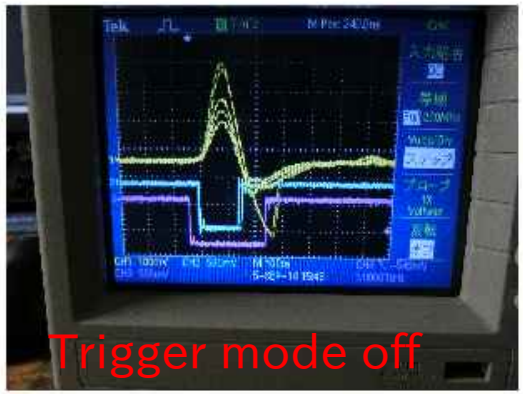


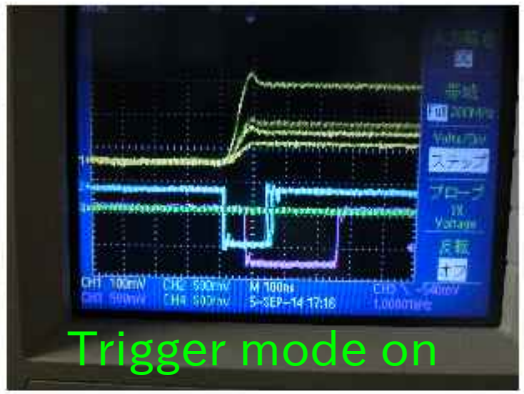
Input signal made from
Function Generator

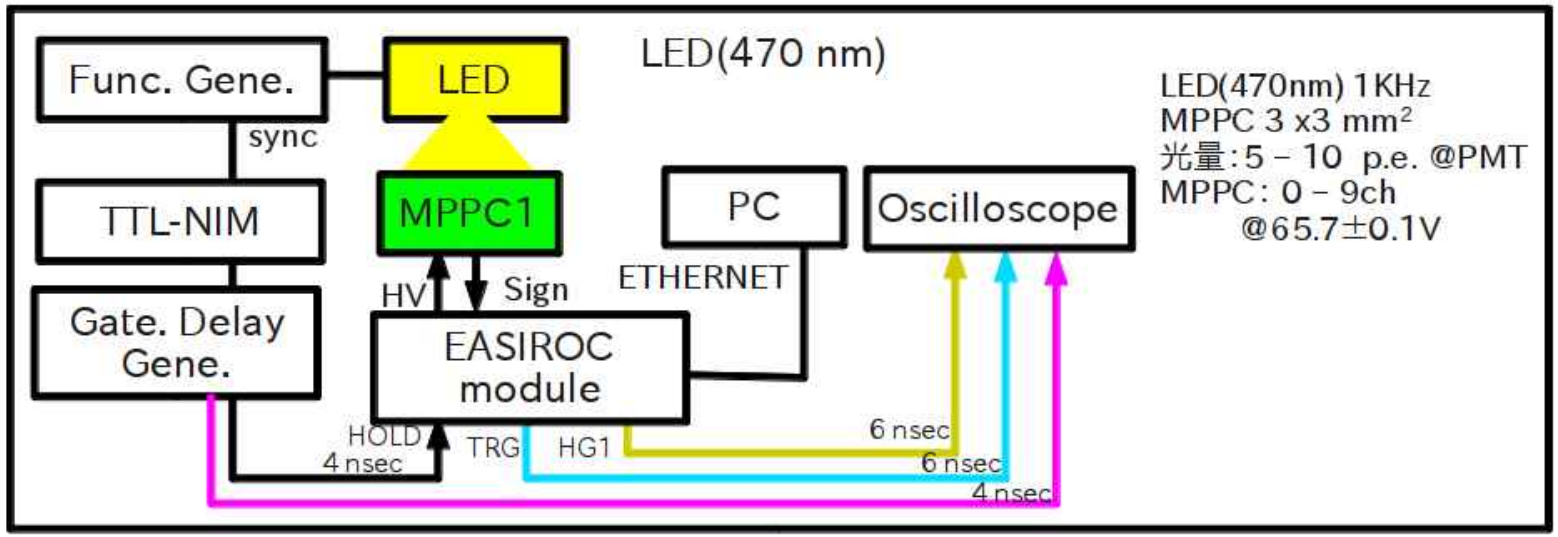
Backup

MPPC Calibration using EASIROC module



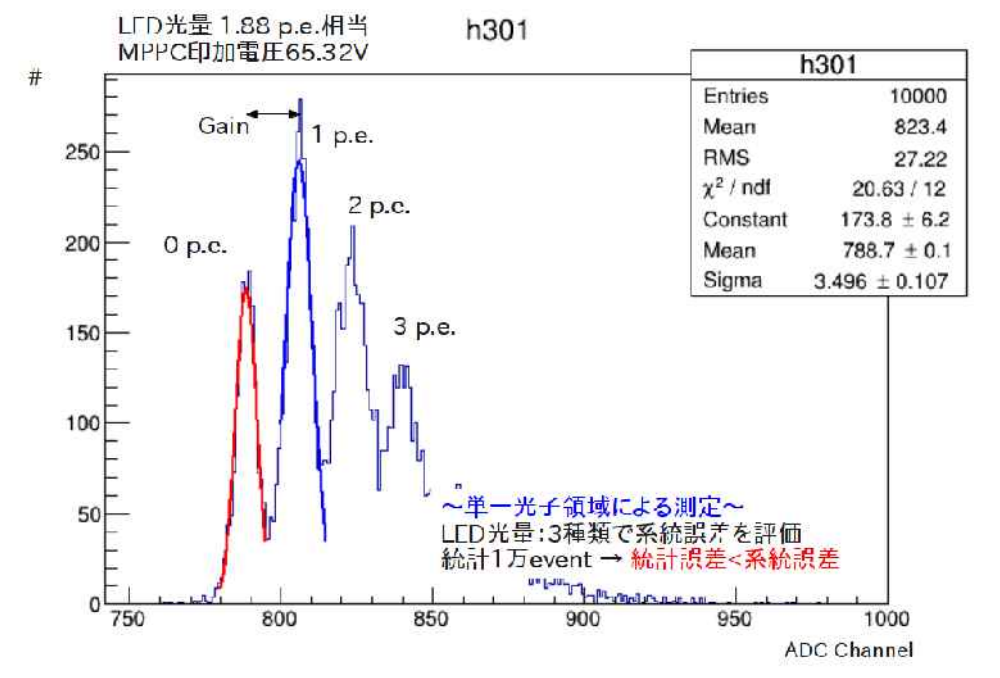


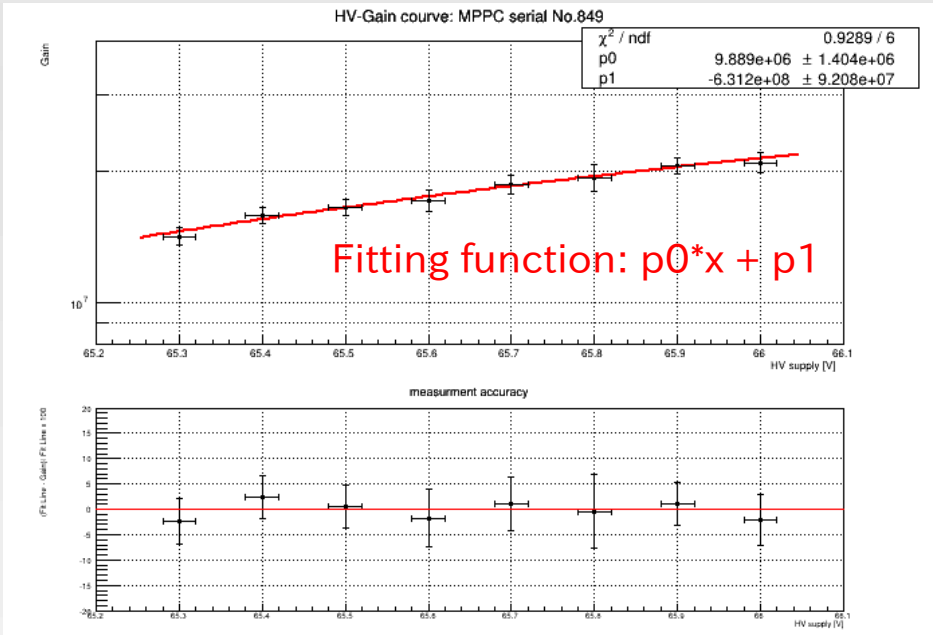




Backup

MPPC Calibration using EASIROC module





$$\mu(V) = \frac{(M_{n+1} - M_n)C_{MPPC}C_{ADC}}{e}, (n = 0)$$

M_n … ピークnの平均値
C_{MPPC} … MPPCの容量[pF]
C_{ADC} … ADCの変換係数[mV/ADC]

$$\mu = \frac{Q}{e}$$

$$Q = C(V_R - V_{BR}),$$

$$N_{photo} \propto Q = \sum_i Q_i$$

Backup

Caluclation number of Cherenkov photons

@ β =1, thickness=1cm, 400-600 nm

n	angle[deg.]	num.ph.
1.01	8.1	7.5
1.02	11.4	14.8
1.03	13.9	21.9
1.04	16.0	28.8
1.05	17.8	35.5
1.06	19.4	42.0
1.07	20.9	48.3
1.08	22.2	54.5
1.09	23.5	60.5
1.10	24.6	66.3
1.11	25.7	72.0
1.12	26.8	77.5
1.13	27.8	82.8
1.14	28.7	88.1
1.15	29.6	93.2
1.16	30.5	98.1
1.17	31.3	102.9
1.18	32.1	107.7
1.19	32.8	112.2
1.20	33.6	116.7

$$N \sim 2\pi\alpha L\left(1-\frac{1}{n^2\beta^2}\right)\int\frac{d\lambda}{\lambda^2}$$

Backup

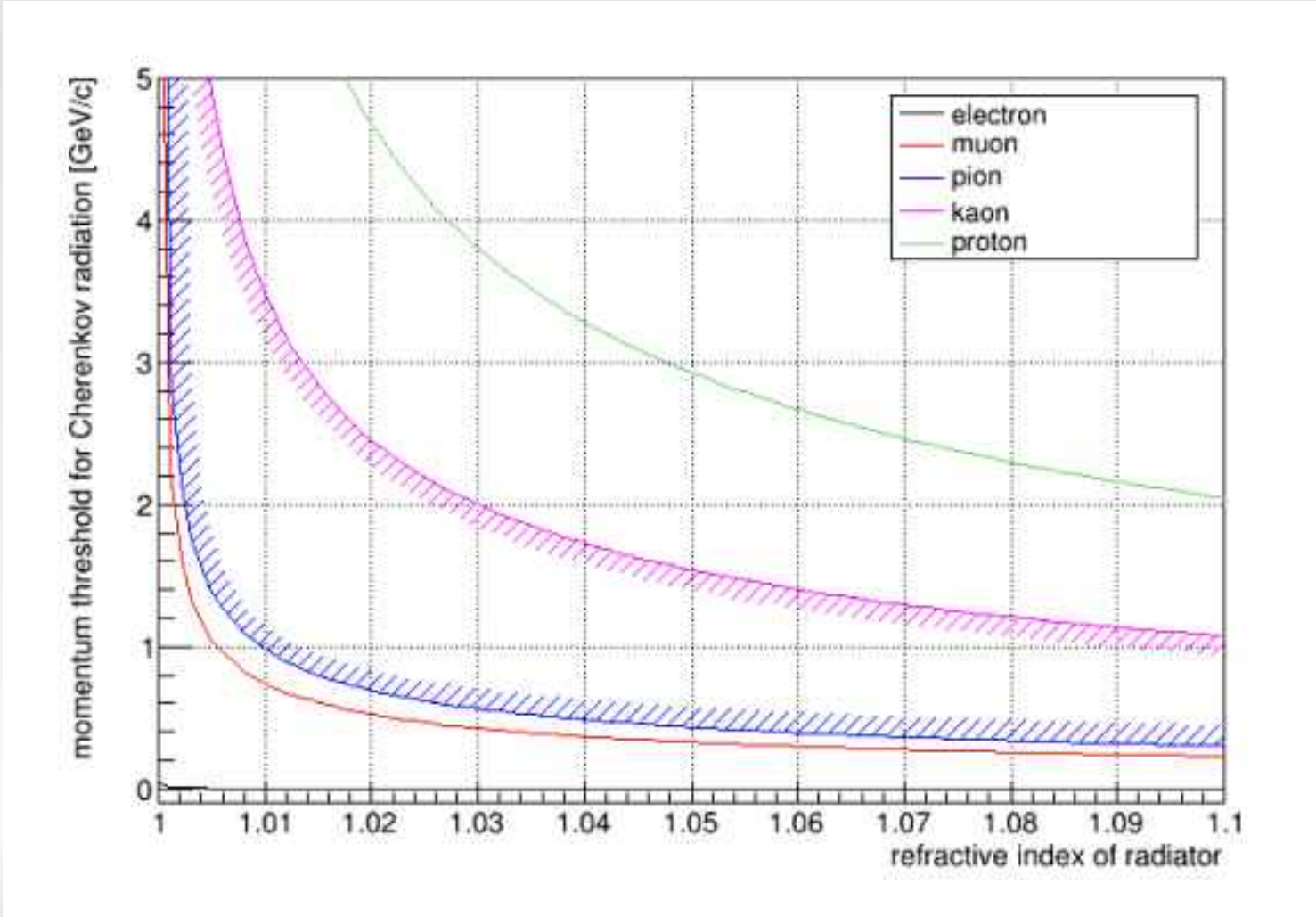
Caluclation number of Cherenkov photons in a case of π (1.5 GeV/c)
@ β =0.996, thickness=1cm, 400-600 nm

n	angle [deg.]	num.ph
1.01	6.1	4.3
1.02	10.1	11.7
1.03	12.8	18.8
1.04	15.1	25.8
1.05	17.0	32.5
1.06	18.7	39.1
1.07	20.2	45.5
1.08	21.6	51.7
1.09	22.9	57.7
1.10	24.1	63.6
1.11	25.2	69.3
1.12	26.3	74.8
1.13	27.3	80.2
1.14	28.3	85.5
1.15	29.2	90.7
1.16	30.0	95.7
1.17	30.9	100.5
1.18	31.7	105.3
1.19	32.5	109.9
1.20	33.2	114.4

$$N \sim 2\pi\alpha L\left(1-\frac{1}{n^2\beta^2}\right)\int\frac{d\lambda}{\lambda^2}$$

Backup

PID of threshold type Cherenkov Counter



Backup

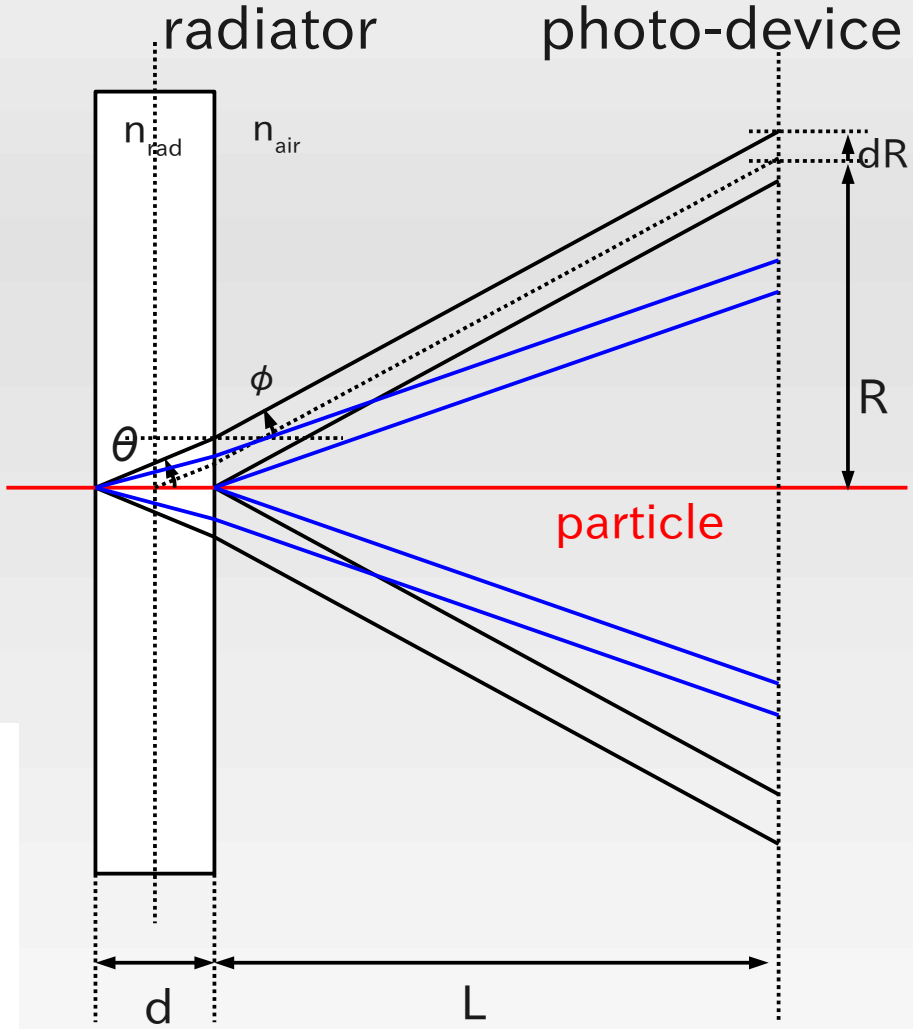
Cherenkov info.

屈折率nの媒質に荷電粒子が速度 $\beta = v/c > c/n$ で走った時、チェレンコフ放射する。チェレンコフ角は

$$\cos\theta_c = 1/n\beta$$

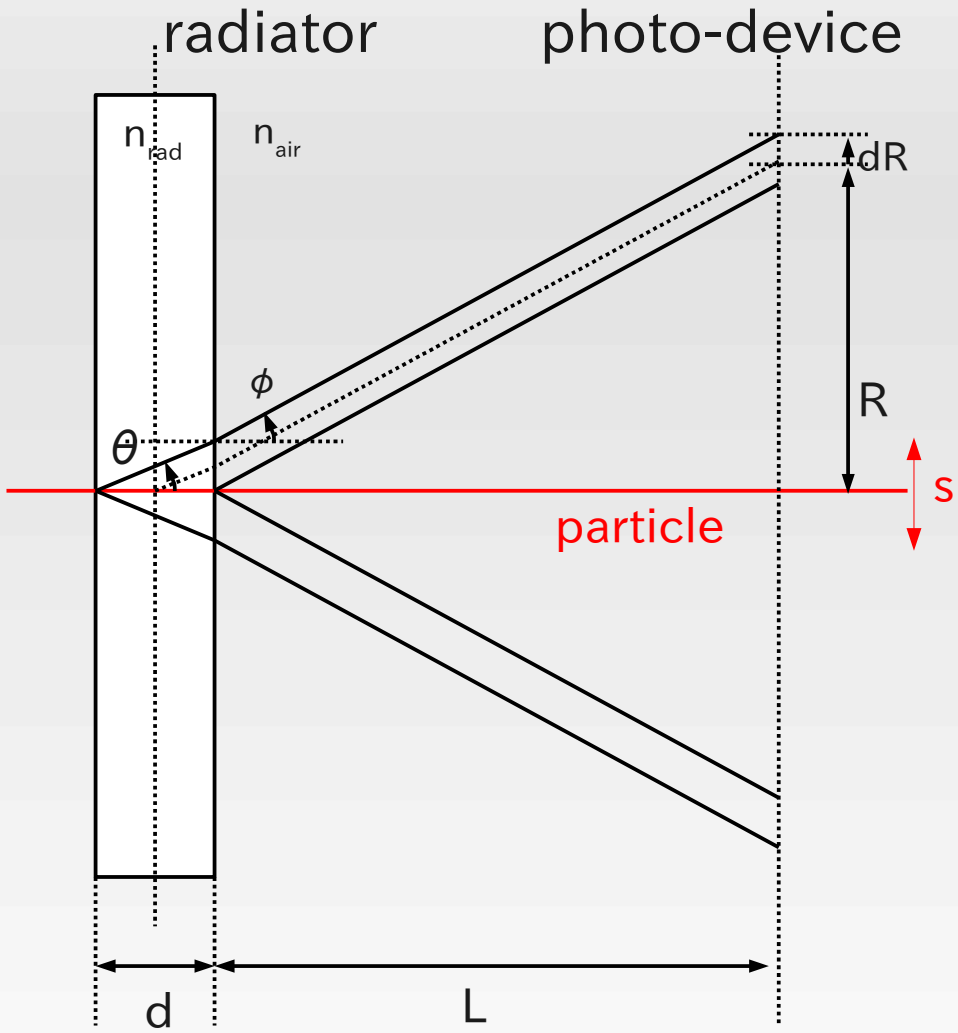
同じ運動量領域でチェレンコフ角を測定して粒子識別する方法をRICHという。

$$\begin{aligned} R &= \frac{1}{2} d \tan\theta_C + L \tan\varphi \\ \delta R &= \frac{1}{2} d \tan\theta_C \\ \theta_C &= \cos^{-1} 1/n\beta \\ \sin\varphi &= \frac{n_{rad}}{n_{air}} \sin\theta_C \end{aligned}$$



リングイメージングチェレンコフの模型

Backup



リングイメージングチェレンコフの模型

N=1.15, d=10 mm, L_1=12 mm,
L_2=100 mm

r_1～10.58 ± 2.74 mm
r_2～68.14 ± 2.74 mm

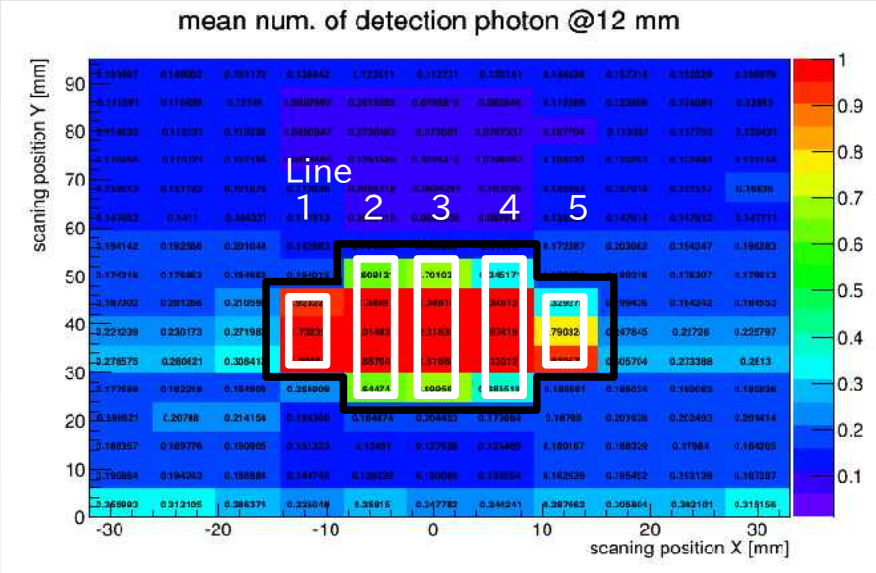
s=10 mm
R=s/2 + r

R_1 ～15 ± 3 mm
R_2 ～ 73 ± 3 mm

L=100 mmだとスキャン領域から外れる

ELPH Beam test

21 MPPCs PID estimation



Analysis Method

①Assumed 5 lines independence PID detector

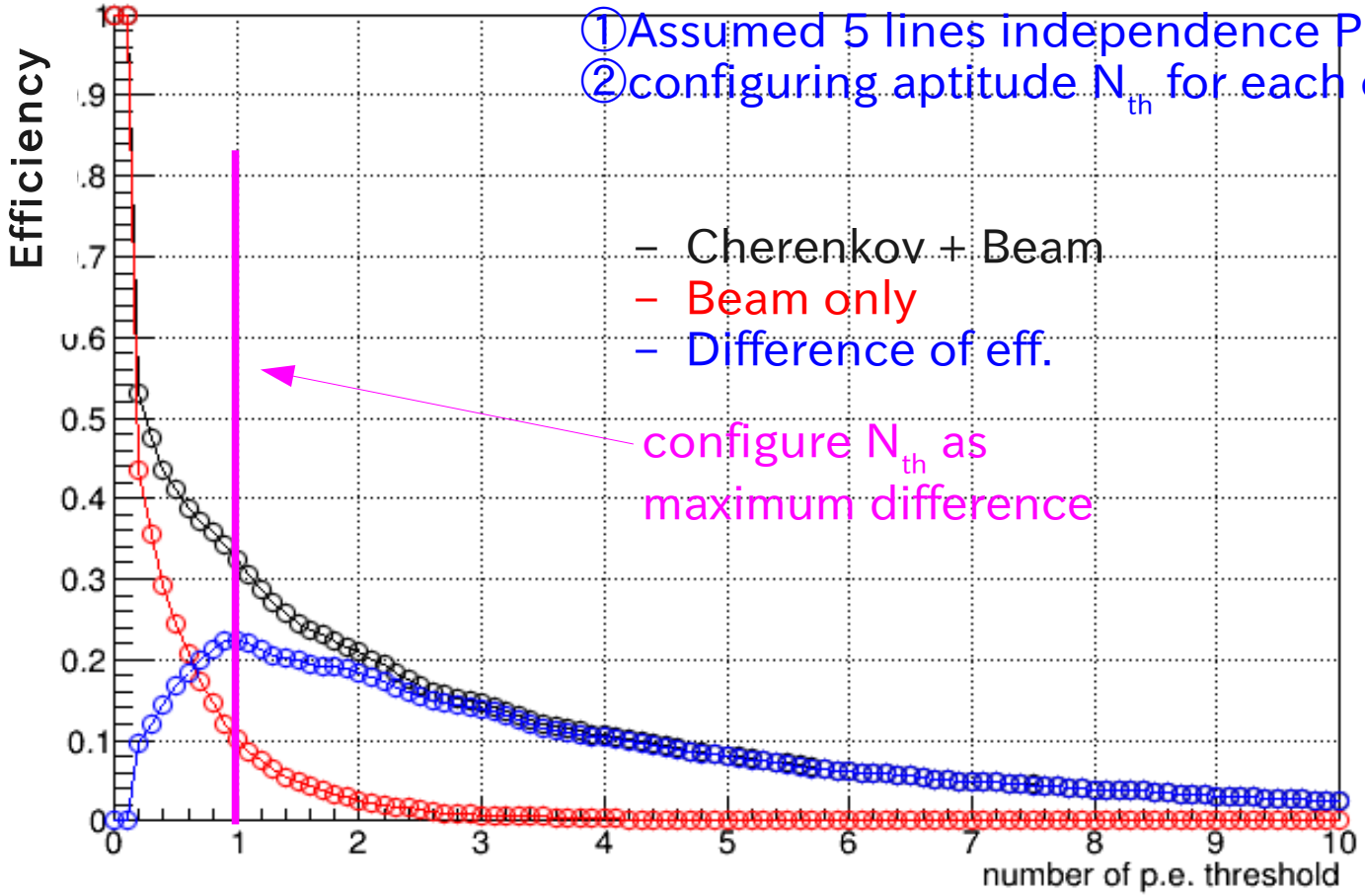
②configuring aptitude N_{th} for each channel

③configuring aptitude N_{MPPC} in each line

④estimation whole PID decided combination HIT event in 5 lines

ELPH Beam test

21 MPPCs PID estimation

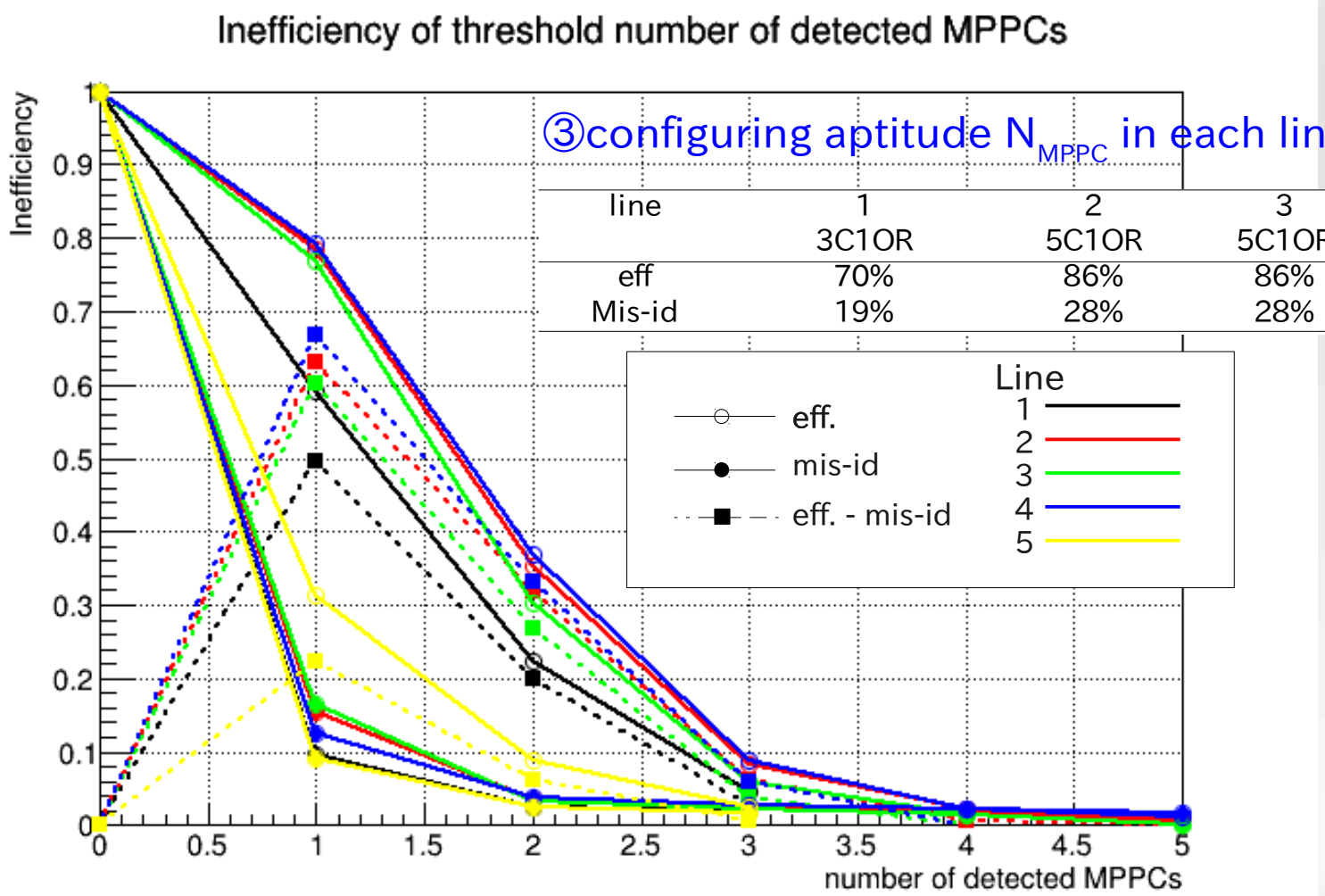


No	Nth	eff	Mis-id
1	0.9	0.34	0.12
2	1.0	0.48	0.12
3	1.0	0.33	0.09
4	1.0	0.28	0.11
5	0.9	0.47	0.12
6	2.0	0.19	0.08
7	0.9	0.44	0.11
8	1.0	0.29	0.11
9	0.9	0.34	0.13
10	0.9	0.36	0.12
11	5.1	0.19	0.03
12	1.0	0.32	0.12
13	1.0	0.31	0.10
14	1.7	0.11	0.04
15	0.9	0.48	0.13
16	0.9	0.46	0.14
17	0.9	0.48	0.12
18	1.8	0.11	0.04
19	2.0	0.07	0.03
20	1.1	0.24	0.10
21	1.0	0.24	0.09

各MPPCの分布データはBackupに載せとく

ELPH Beam test

21 MPPCs PID estimation



③configuring aptitude N_{MPPC} in each line

line	1 3C1OR	2 5C1OR	3 5C1OR	4 5C1OR	5 3C1OR
eff	70%	86%	86%	86%	38%
Mis-id	19%	28%	28%	21%	14%

ELPH Beam test

21 MPPCs PID estimation

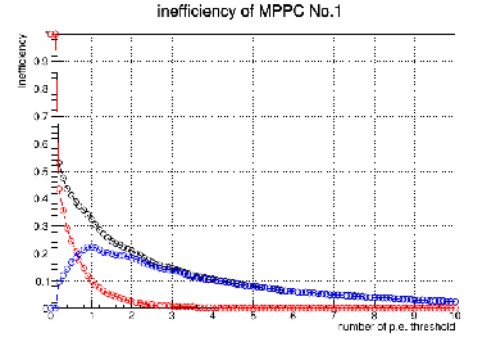
④estimation whole PID decided combination HIT event in 5 lines

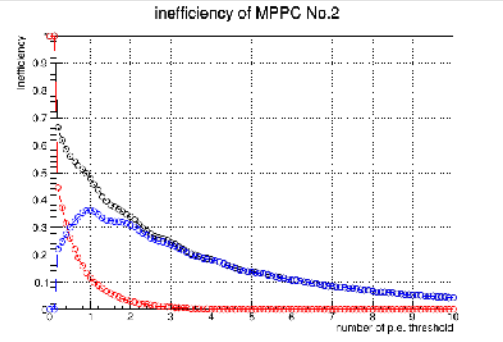
	5C5OR	5C4OR	5C3OR	5C2OR	5C1OR
π-eff	16.9%	60.0%	90.2%	98.6%	99.9%
Mis-π	83.1%	40.0%	9.8%	1.4%	0.1%
Mis-K	0.0%	0.9%	7.2%	28.2%	71.5%

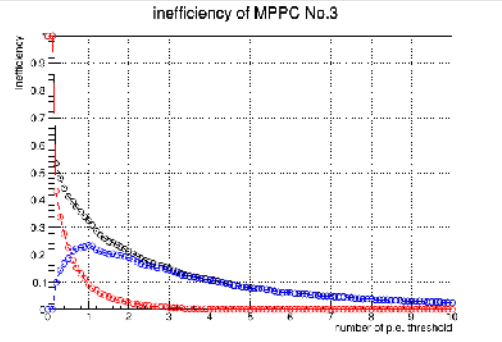
Therefor, when the threshold of MPPC has been configured 3 or more, whole PID was estimated 90.2% as eff. And 7.2% as mis-id.

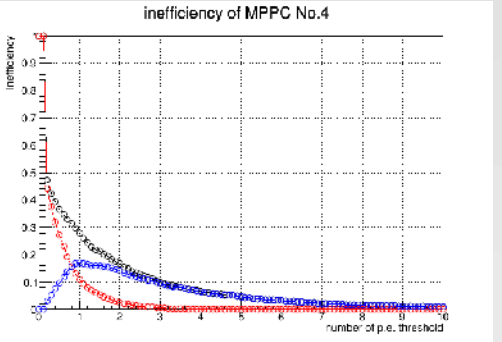
Backup

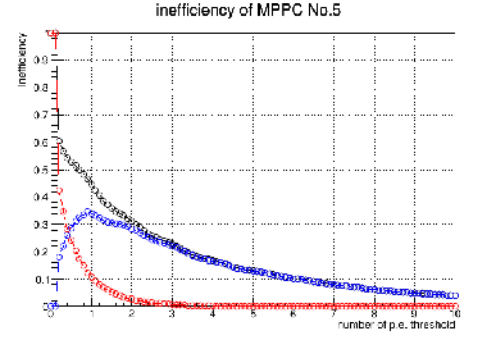
21 MPPCs PID estimation

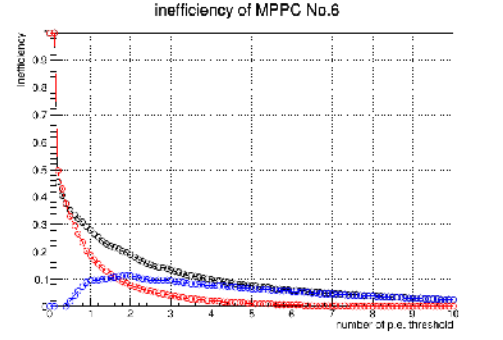


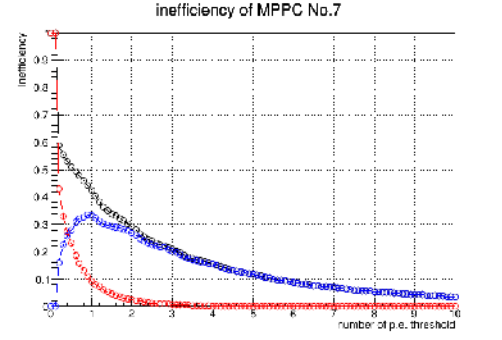


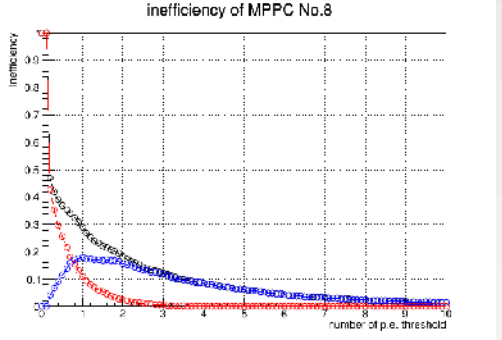


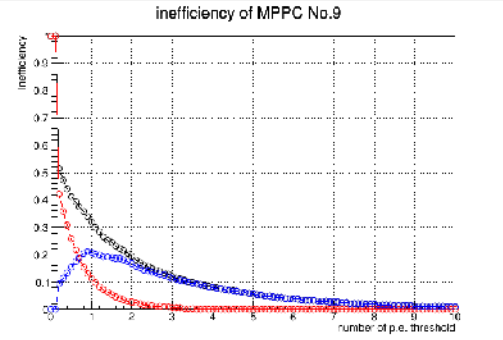


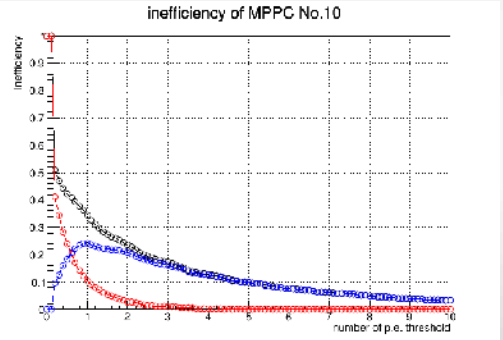


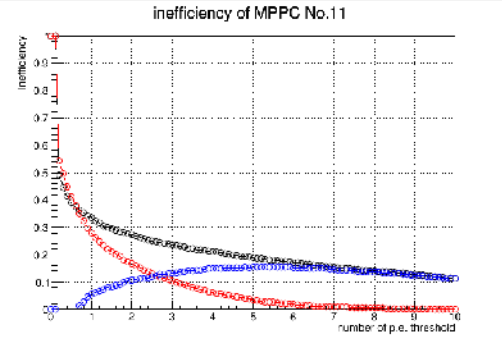












Backup

21 MPPCs PID estimation