# TXePET and Readout/Electronics

# General Property of Liquid Xenon

http://www.pd.infn.it/~conti/LXe.html

Rich detection media : Scintillation and Ionization

| Scintillation | Ionization |
| --- | --- |
| energy | position |
| photomultipliers | ionization chamber with low noise amp. 300e |
| GEM/photocathod | GEM in 2 phase Xe |
| Avalanche Photodiodes | |

22,000 VUV photons/511KeV with 3ns, 27ns and 45ns

30,000 electron-ion pairs/511KeV
electron drift at 2.3mm/us with 2kV/cm

At 511 keV, 22% photoelectric, 78% Compton with xenon
half a mm for 511 keV photoelectron

Primary ionization signal is weak: of the order of 1, 10, 100 and 500 keV for coherent neutrino, dark matter, solar neutrino and PET respectively.

# TXePET： 液体キセノンTPC-PET

液体Xe：140ℓ,88cm内径,48cm FOV,9cm DOI (93%γ線検出)

光電子増倍管: 8x112x2=1792本

位置分解能(FWHM) = 2cm

同時計測時間 = 10 nsec

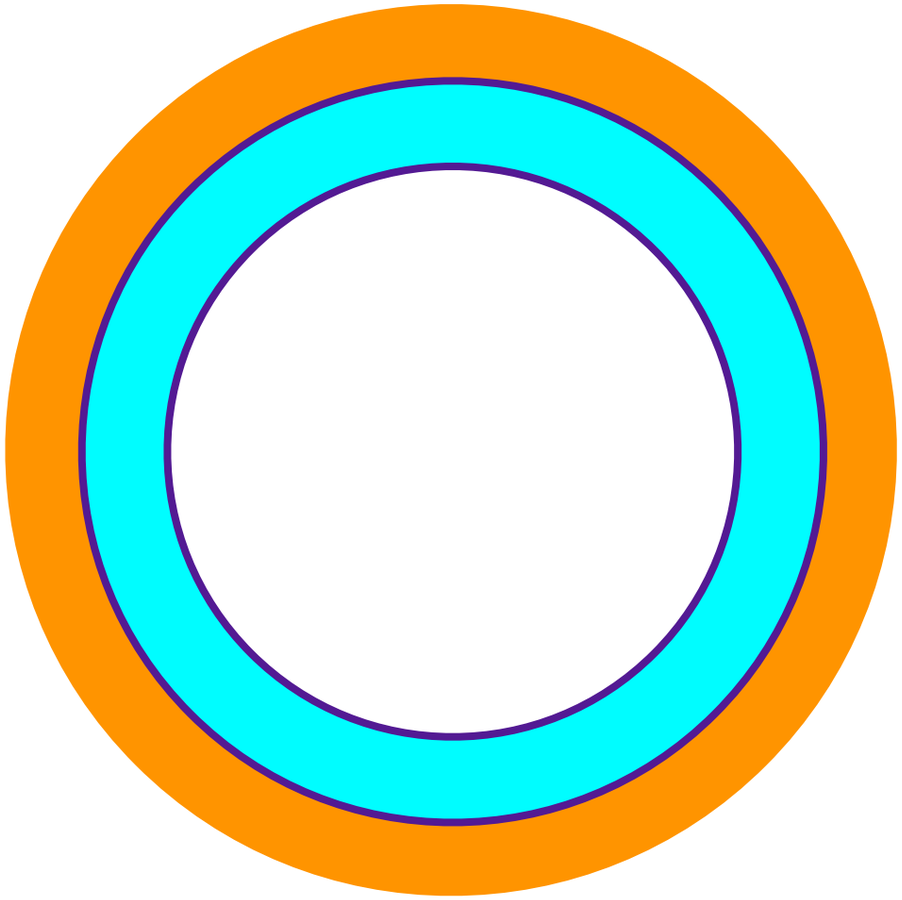
TPCへのタイムスタンプ

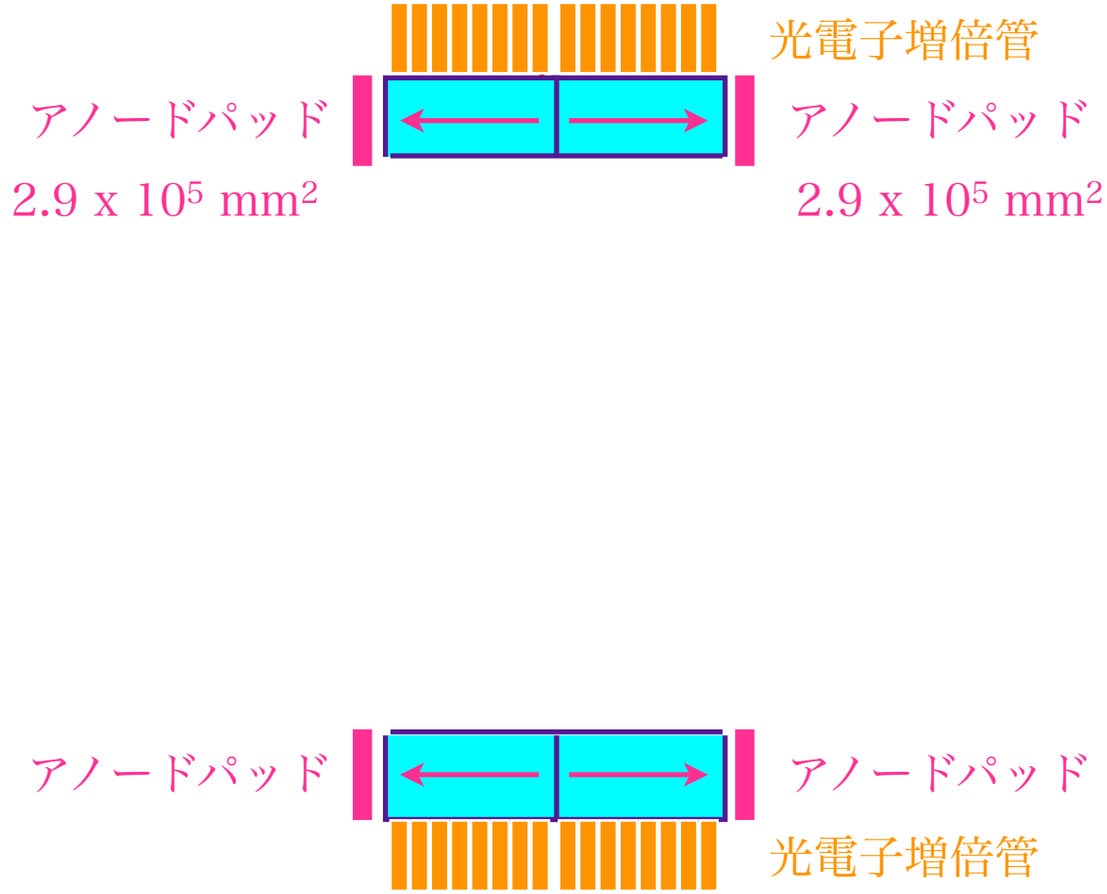
TPC：電場 48kV/24cm

ドリフト時間：104 μsec/±24cm

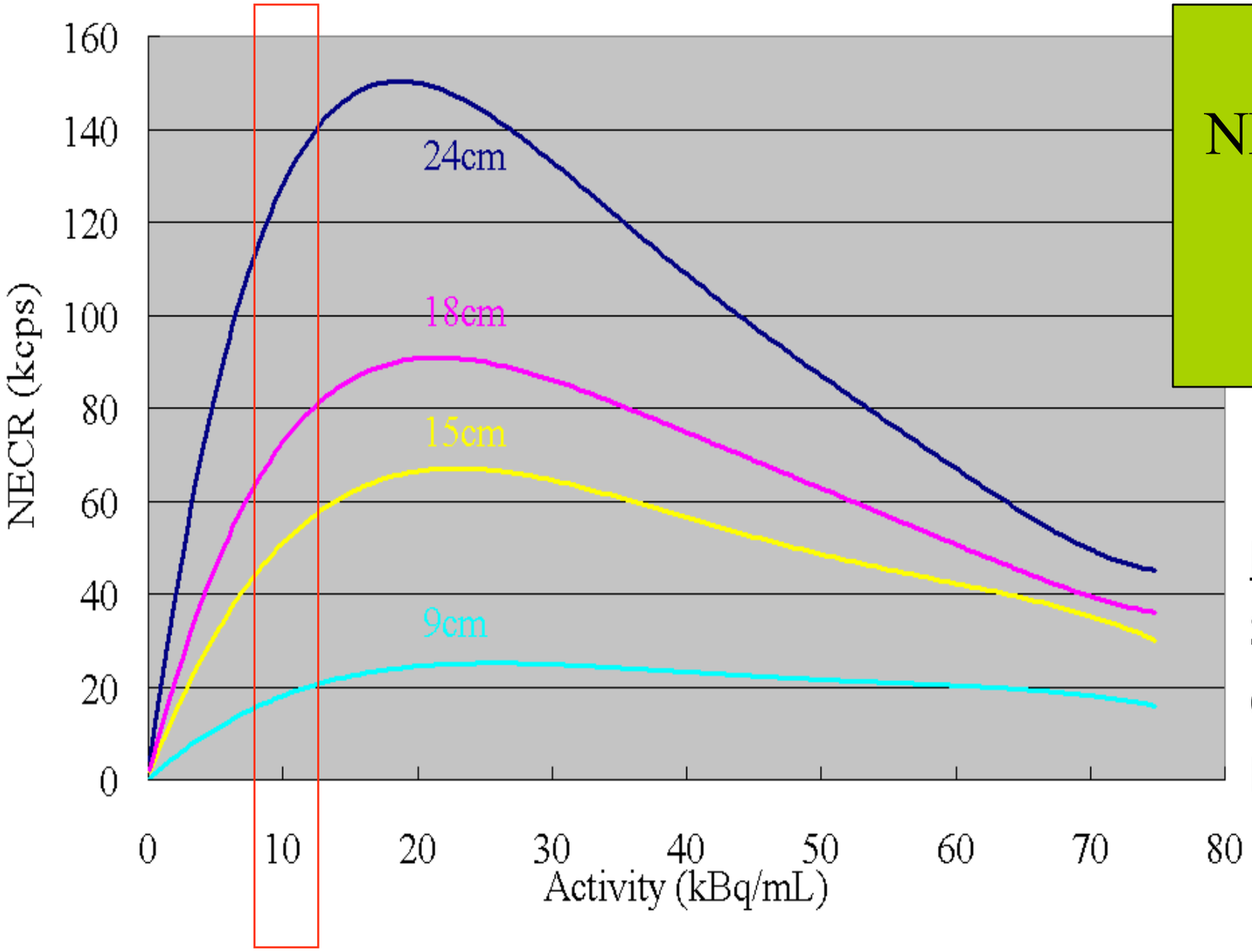
(ドリフト速度：2.3mm/μsec)

不感時間のない読み出し





# NECR




$$NECR = \frac{T^2}{T+S+R}$$

T：真の同時計数イベント
S：散乱同時計数イベント
R：偶発同時計数イベント

NEC simulation

System dead time:200ns

Coincidence window:4ns

Energy window:450-550keV

# Counting Rates

jPET-D4

solid angle = 0.713

segmentation 24 (ring) x 5 (axis) = 120

maximum NECR = 150kcps / 10kBq/ml

single count = 15Mcps / 10kBq/ml

total count = 2Mcps / 10kBq/ml

true+scatter = 1Mcps / 10kBq/ml

random = 1Mcps / 10kBq/ml

Nishikido LXeTOF PET

solid angle = 0.287

segmentation of "PMT" 103 (ring) x ( 8 (axis) +2 (DOI) ) = 1030

maximum NECR = 150kcps / 20kBq/ml , 100kcps / 10kBq/ml

TXePET

solid angle = 0.514

segmentation of "PMT" 112 (ring) x 16 (axis) = 1792

General PET ( Shimizu SET 3000GCT )

solid angle = 0.352

segmentation of "PMT" 88 (ring) x 10 (axis) = 880

maximum NECR = 60kcps / 9.8kBq/ml

Assume single count is one of jPET-D4;

single count/total PMTs =15MHz/total PMTs
=15MHz/1792 PMTs
= 8370Hz/PMT

1/8370= 119μsec/PMT

# PMT Readout

1792 PMTs

128 PMTs
1/14 of ring

x 14
FADC

300MHz
8bit
128ch

128 x8

x 14
FPGA

300MHz
BS, $\Sigma p_i > E_{min}$
x, y, z
$t_o$

Coincidence

SRAM

corrections:
random,
dead time, etc

x, y, z (DOI)
$t_o$ , $E_{PMT}$

300MHz
BS, $\Sigma$
x, y, z
$t_o$

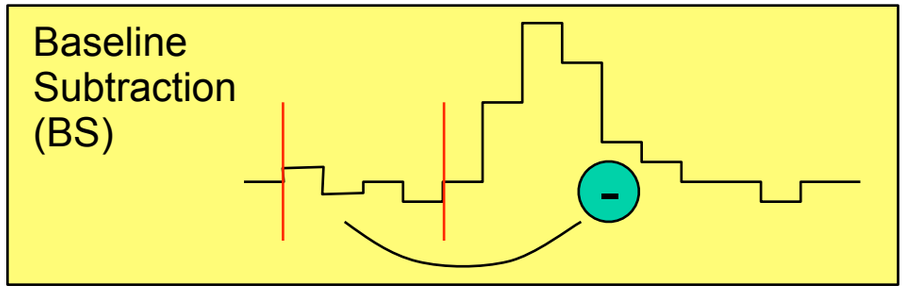
SRAM

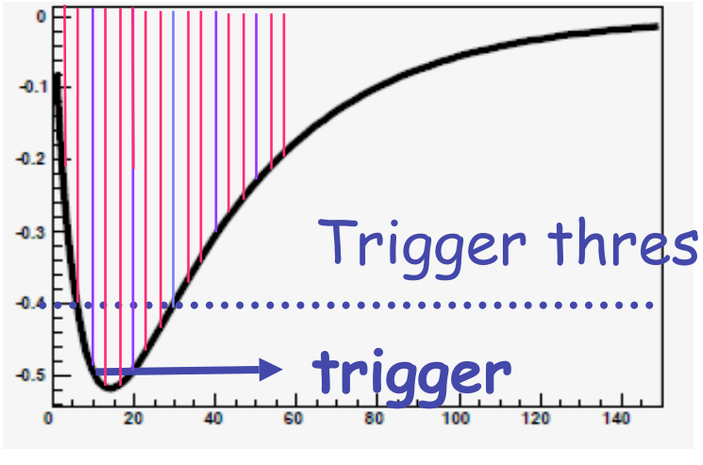
128 PMTs
1/14 of ring

$x_{PMT} = \Sigma x_i p_i / \Sigma p_i$
$y_{PMT} = \Sigma y_i p_i / \Sigma p_i$
$z_{PMT} = Z(D)$
$n_{pe} = p_i$

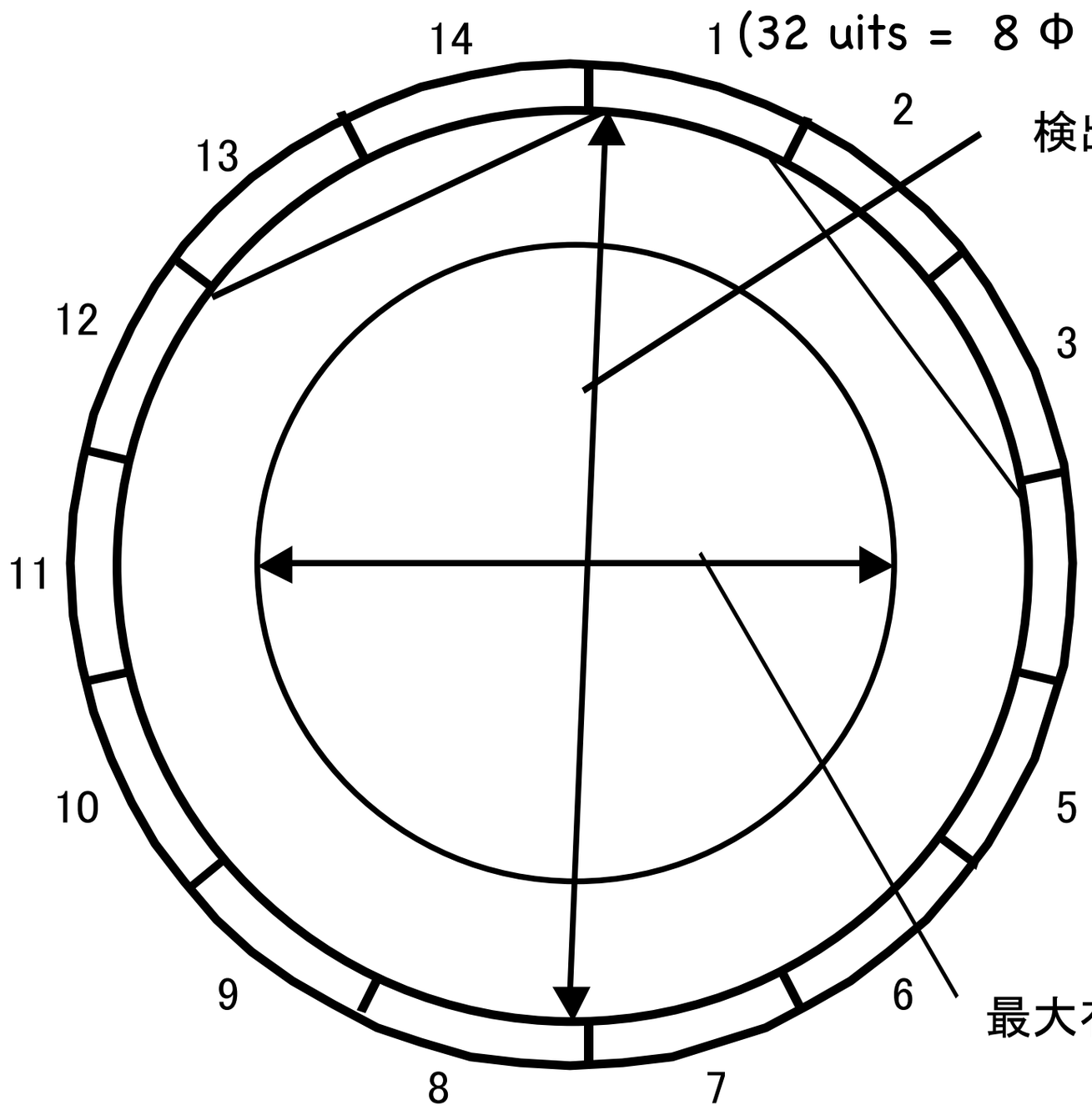
$$D = \frac{\sum n_{pe}(i)x(i)^2 + n_{pe}(i)y(i)^2}{\sum n_{pe}(i)} - \left(\frac{\sum n_{pe}(i)x(i) + n_{pe}(i)y(i)}{\sum n_{pe}(i)}\right)^2$$

## MEG experiment



# Coincidence processor (SET-2400W)




(32 uits = 8 Φ x 4 z )

検出器間距離= 850mm

14 groups in total

1 coincidence group (15ns) :
1 group and 9 groups
(1) (4-12)

63 coincidence circuits
9 groups x 7 (angles)

最大有効視野= 595mm

total PMTs =32 x 14 x 4= 1792

図 3-14 有効視野と同時計数グループの関係

# TPC Readout

x 2 | x 2,014 x 2 | x 2,014 x 2 | x 48 x2

3.2 x $10^4$ pads
2.9 x $10^5$ $mm^2$
3x3$mm^2$/pad

anode pads

anode pads

anode pads

anode pads

anode pads

## ASIC

CMOS Front End

16 pads

1.2x1.2$cm^2$/ASIC

## FADC

$\Sigma p_i$

300MHz 8bit

16 LVDS

pulse height($p_i$) is proportional to pulse width($w_i$) of LVDS.

## FPGA

300MHz
I/O >1024
BS, $\Sigma p_i > E_{min}$
x, z
t

(42 ASIC)

300MHz
BS, $\Sigma$
x, z
t
(42 ASIC)

SRAM

x, z (DOI)
t , $E_{TPC}$

$x_{TPC} = \Sigma x_i w_i / \Sigma w_i$

$z_{TPC} = \Sigma z_i w_i / \Sigma w_i$

$y_{TPC} = v(t - t_o)$:FOV

$|x_{TPC} - x_{PMT}| < 0$(cm)

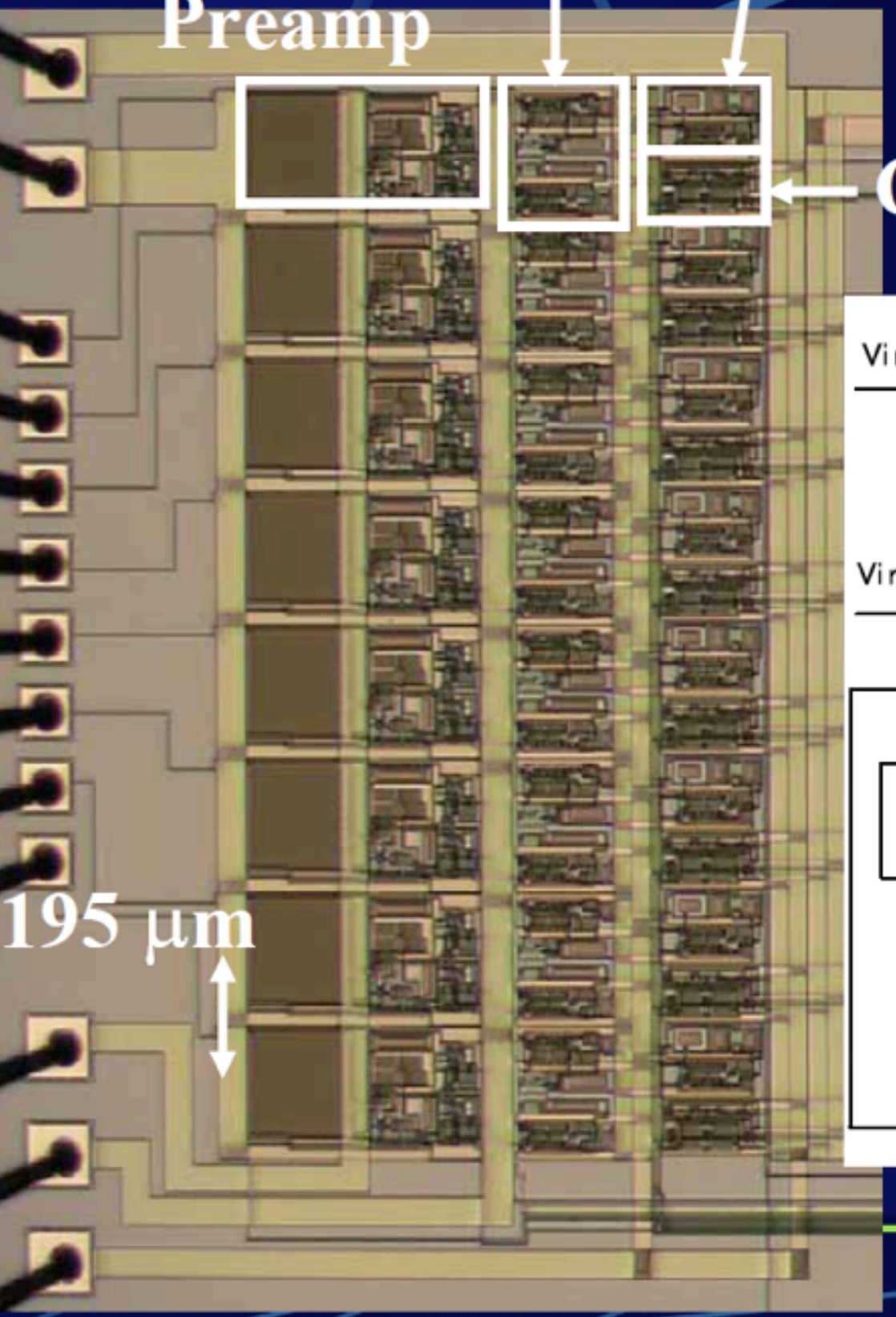
$|y_{TPC} - y_{PMT}| < 0$(cm)

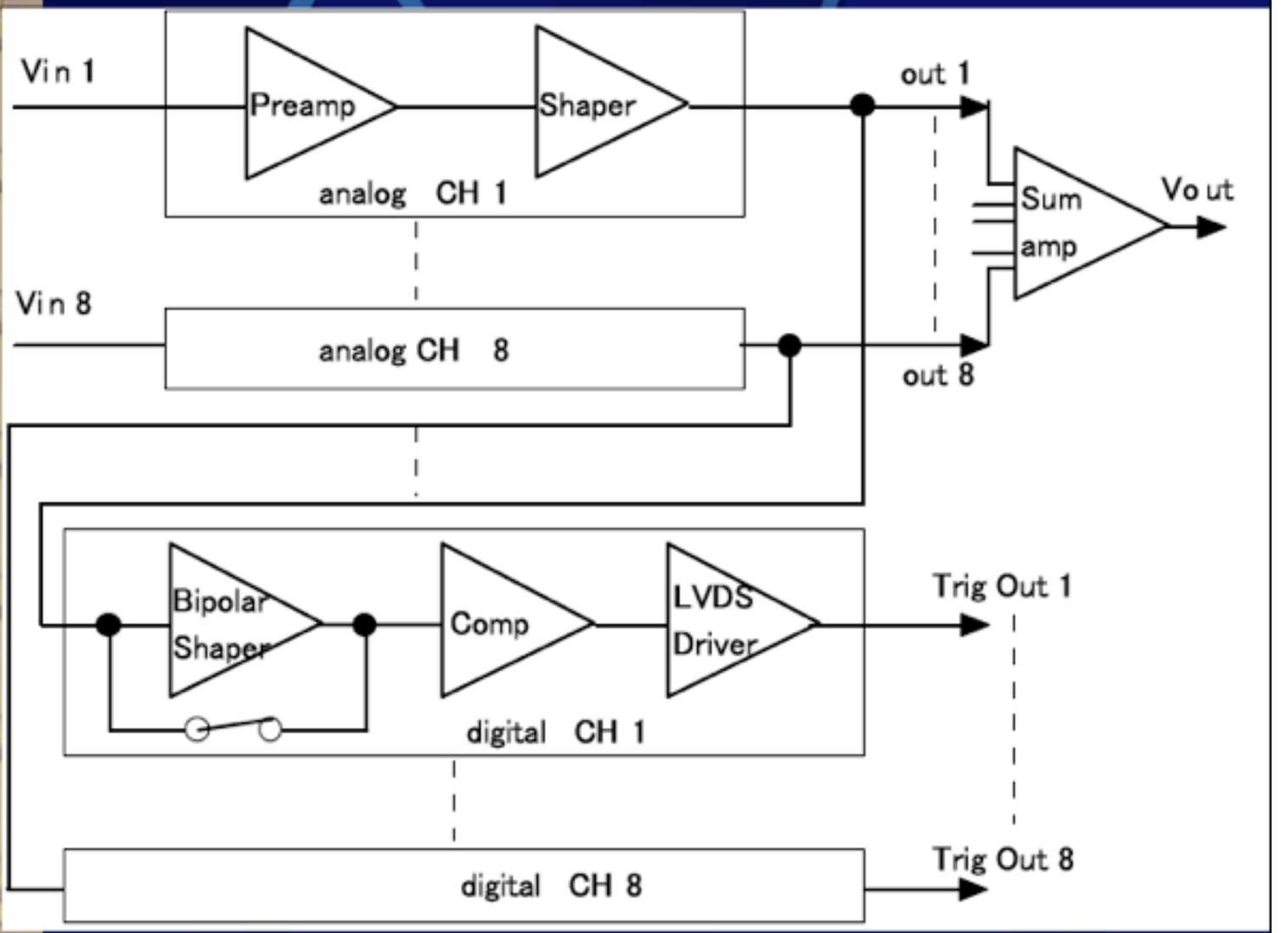
$|z_{TPC} - z_{PMT}| < 0$(cm)

# CMOS Front End

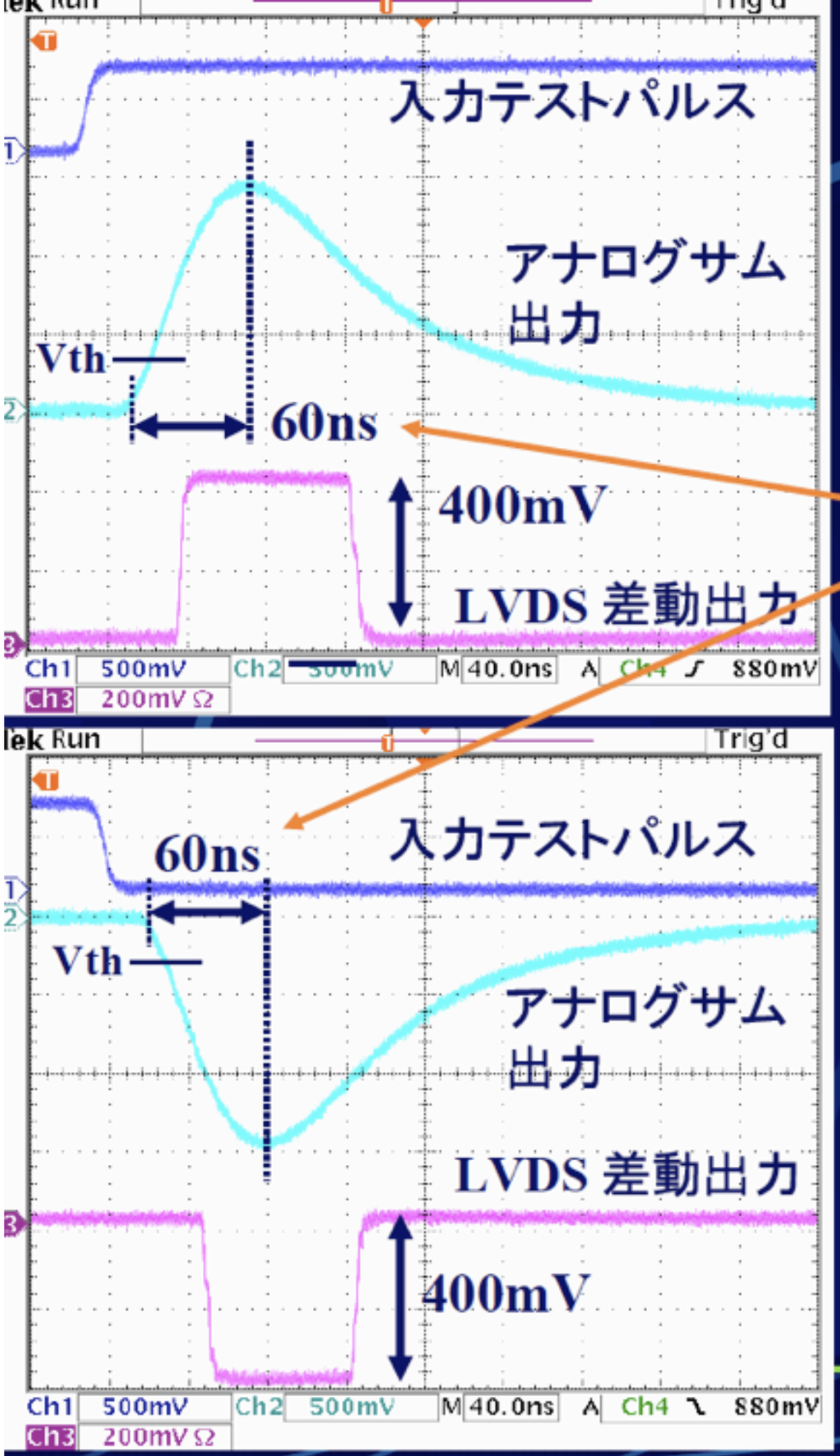
# レイアウト

藤田陽一



# パルス応答




目標仕様

- ピーキングタイム 30ns
- 出力
  - LVDS（チャネル毎）
  - アナログサム（全チャネル）

- ピーキングタイムが予定より大きいのは、抵抗が一律に 70%増で製造されたことによると考えられる