液体キセノングループ報告

前回（2013年5月21日)以降

KEKDTP重点レビュー、2013年12月2日、KEK

田内利明

KEK：冷凍・純化システム、PMT、エンドプレート

田内利明、真木晶弘、田中秀治、三原智、佐伯学行

笠見勝裕(冷凍システム構築)、鈴木祥仁（モニター:Labview)

佐賀大：TPC

杉山 晃

東大：DAQ、TPCテスト

森俊則

放医研： PETとしての性能仕様とシミュレーション

熊田雅之、富谷武浩、寅松千枝

横浜国大：液体キセノン基本特性、APD、ASICチップ

中村正吾、 濱西 亮（M1)、 岩崎 裕也 (M1)

協力支援：KEK素核研回路室、田中真伸氏

レビュワー：海野義信（KEK)、 柴村英道（埼玉県立大)

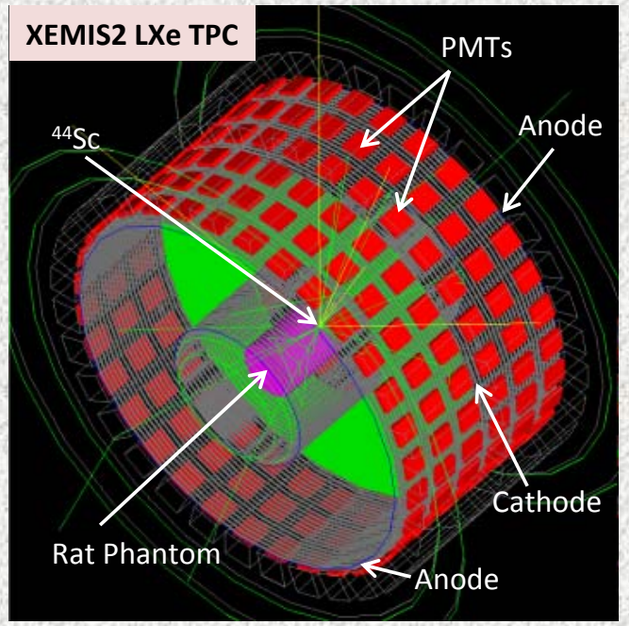
2013年度

2013年度

5/14　ガス循環再開（1.4L/分, 電荷量など7日後復帰
6/13-27 電荷検出の液体キセノンの液面依存性の測定; 14 to 9cm
7/4 He圧縮機を10m遠ざけ “2.5ms” ノイズ効果; 再現できず
7/8 冷凍機停止
7/1-8/30 ASICボード試験 (GN-1294-1,FR4) - OK w/ and w/o loads
9/5-9/21 Chamber内設置のLTCC-ASICボード試験 - NO w/ loads
9/11 - , LTspice simulation for this problem
10/5　固体タンタルコンデンサ（300uFx2) 試験 - 失敗
10/18 積層セラミックコンデンサ（300uFx2)試験 - 成功
10/21　冷却準備開始

日仏協力:9/17-9/19 D.Thers, E.Morteau, O.Lemaireの３氏 KEK滞在
[KEK-Subtech間の日仏交換学生プログラム]
7/1-9/27 Abder Merakeb (Ecole def Mines de Nantesの大学院生 M1)滞在-TPCFEによるFE-electronicsと新PMTの試験研究
10/1-12/29 横浜国大 濱西亮 (M1) Subatech滞在-Simulation study by GATE, PMT tests for XEMIS2 (small animal PET)

XEMIS2 pre-design study for small animal imaging with GATE



Cylindrical camera XEMIS2 (~ 100 kg LXe)

- radial 8 < r < 20 cm
- axial (z) Length = 2×12 cm
- Electric Field in z direction 2 kV/cm
- 192 PMTs
- Micromegas ionization read-out
- FEE Idef-X, pixels 3.175x3.175 mm^2 (~25k channels)

TPC characteristics

- Intrinsic energy resolution: 5% @ 511 keV
- Spatial resolution: 0.5 mm (X, Y and Z)

Performances (simulation in progress, *PhD student: A.F. Mohamad Hadi*

- Efficiency to measure LOR: 30%
- Efficiency to measure 1.157 MeV γ-rays: 43%
- 3 photons efficiency (after selection): ~5 %
- Precision on localization along LOR ~ 1 cm (FWHM)

Simulation status:

- LXe Compton Telescope already implemented in GATE
- Future => Simulation of test Phantoms (NEMA, Derenzo…) wit

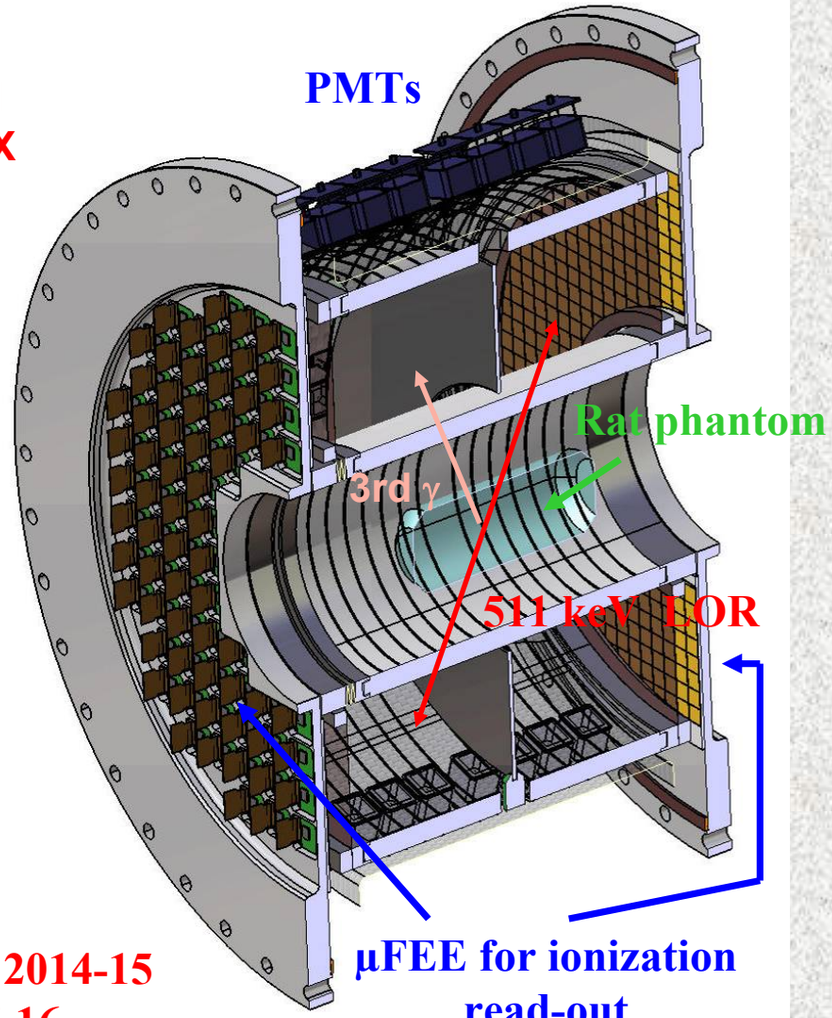
R&D on liquid Xenon detector technology, presented by Wan-Ting Chen, FJPPL2012, Clemond-Ferrand, France, 28-29 May, 2012

Funding issues almost adressed with the ARRONAXPLUS EQUIPEX

Improved reliability and safety : ReStoX (liquid xenon station)

Subatech

AIR LIQUIDE TECHNIQUES AVANCEES

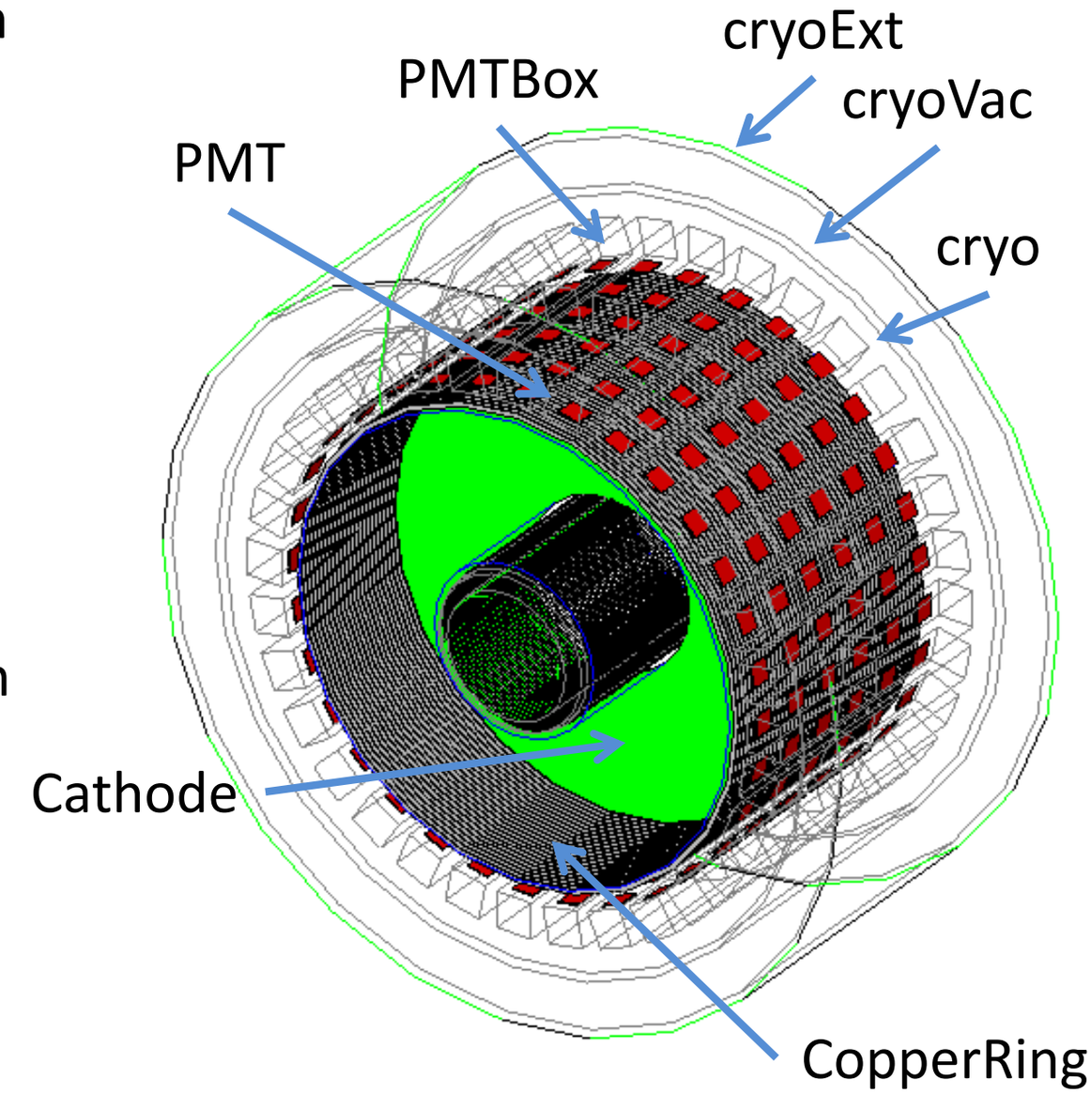


Expected to run at Subatech in 2014-15
→ Nantes Hospital in 2015-16

Improvement of geometry

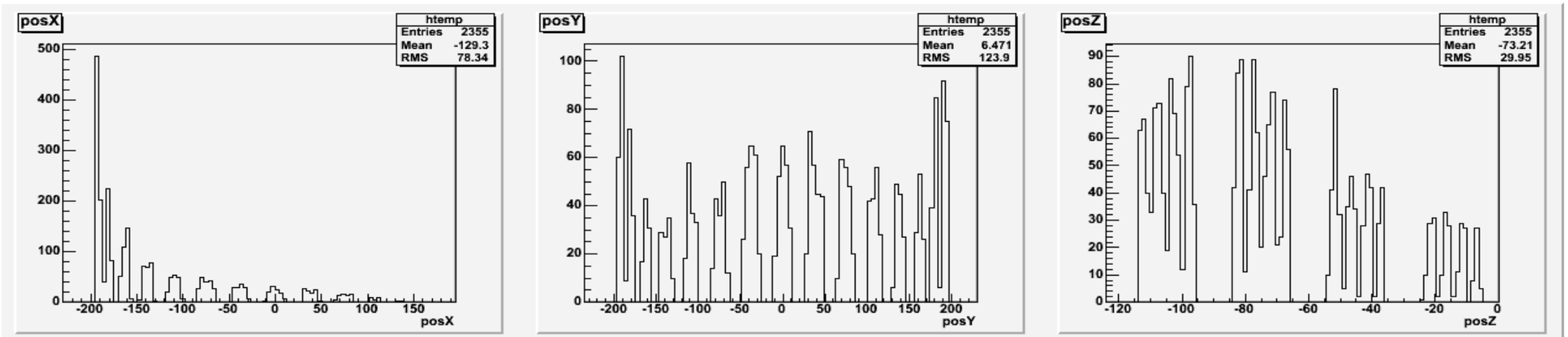
- Component of cylindricalPET.mac

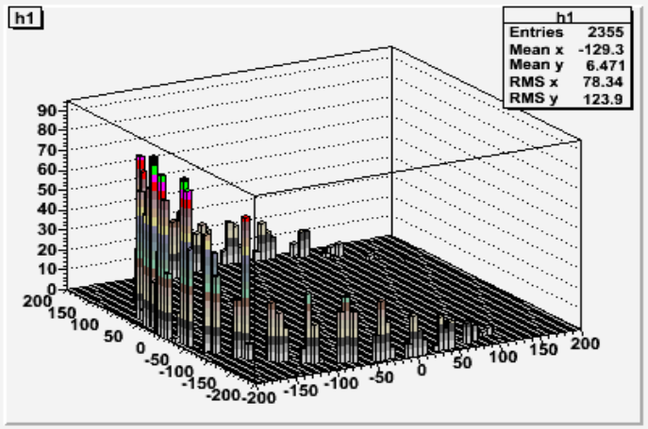
```
cryoExt          ------------------------Aluminium
  -cryoVac       ------------------------Vacuum
    -cryo        ------------------------SS304
      -xenon     ------------------------LXe
        -CopperRing1   ------------Cu
          -linear      //repeaters
        -CopperRIng2   ------------Cu
          -linear      //repeaters
        -ActiveZone    ------------LXe
          -Cathode     ------------Aluminium
        -PMTBox1       ------------Quartz
          -PMT1        ------------Bialkali
          -ring        //repeaters
        -PMTBox2       ------------Quartz
          -PMT2        ------------Bialkali
          -ring        //repeaters
```



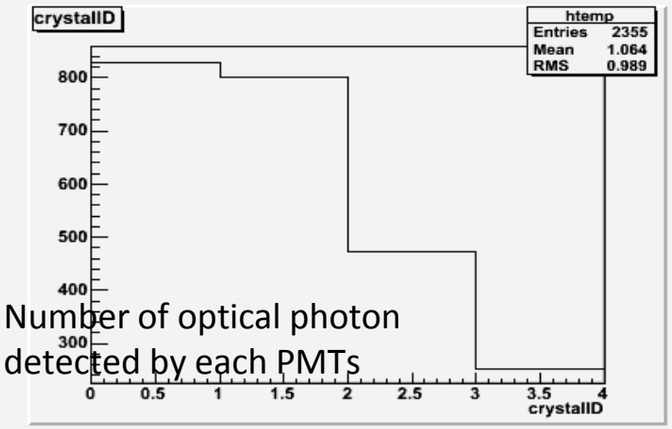
Distribution of optical photons

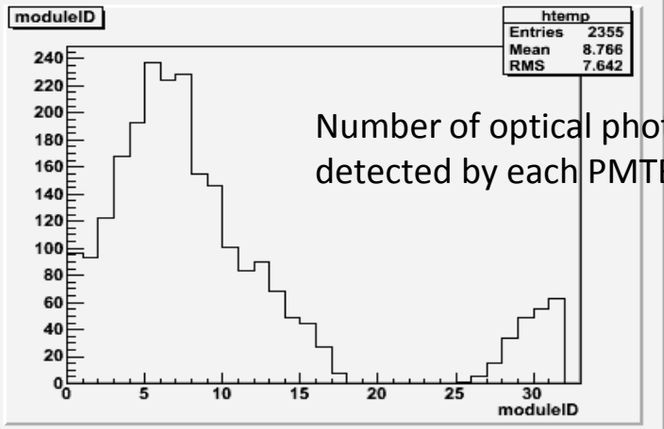
Number of PMTs is 256.



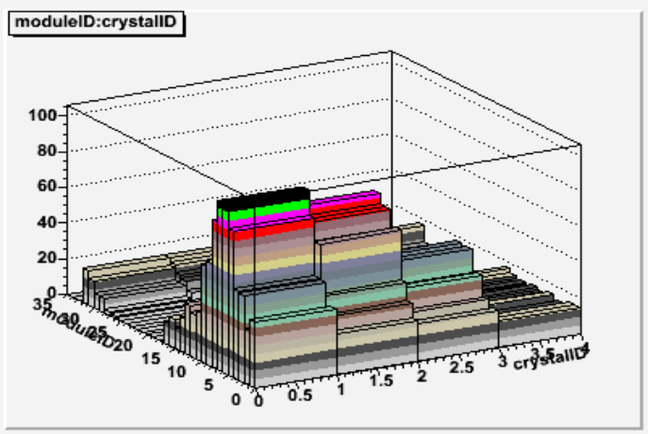


Number of optical photon detected by each PMTs

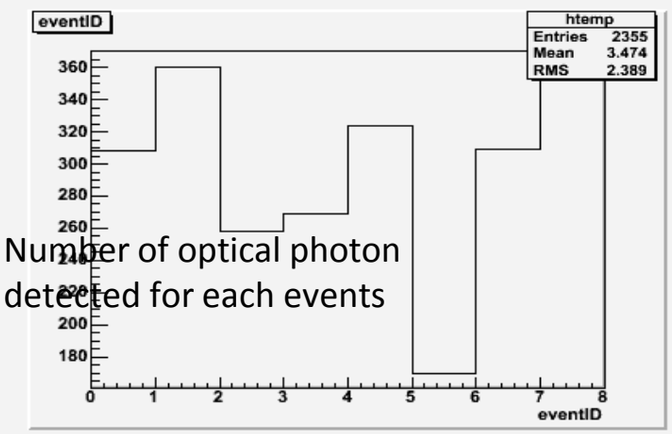


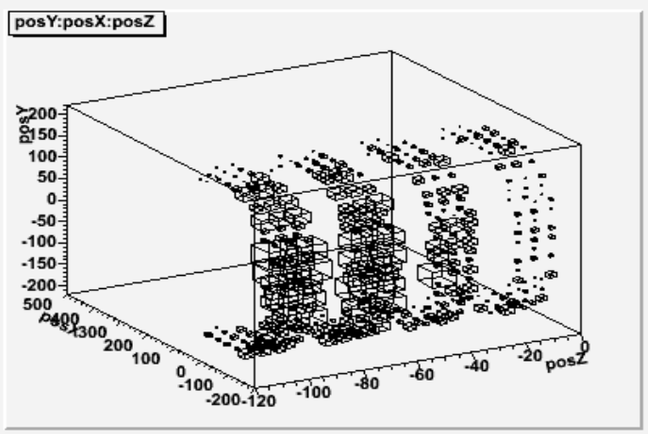


Number of optical photon detected by each PMTBox



Number of optical photon detected for each events

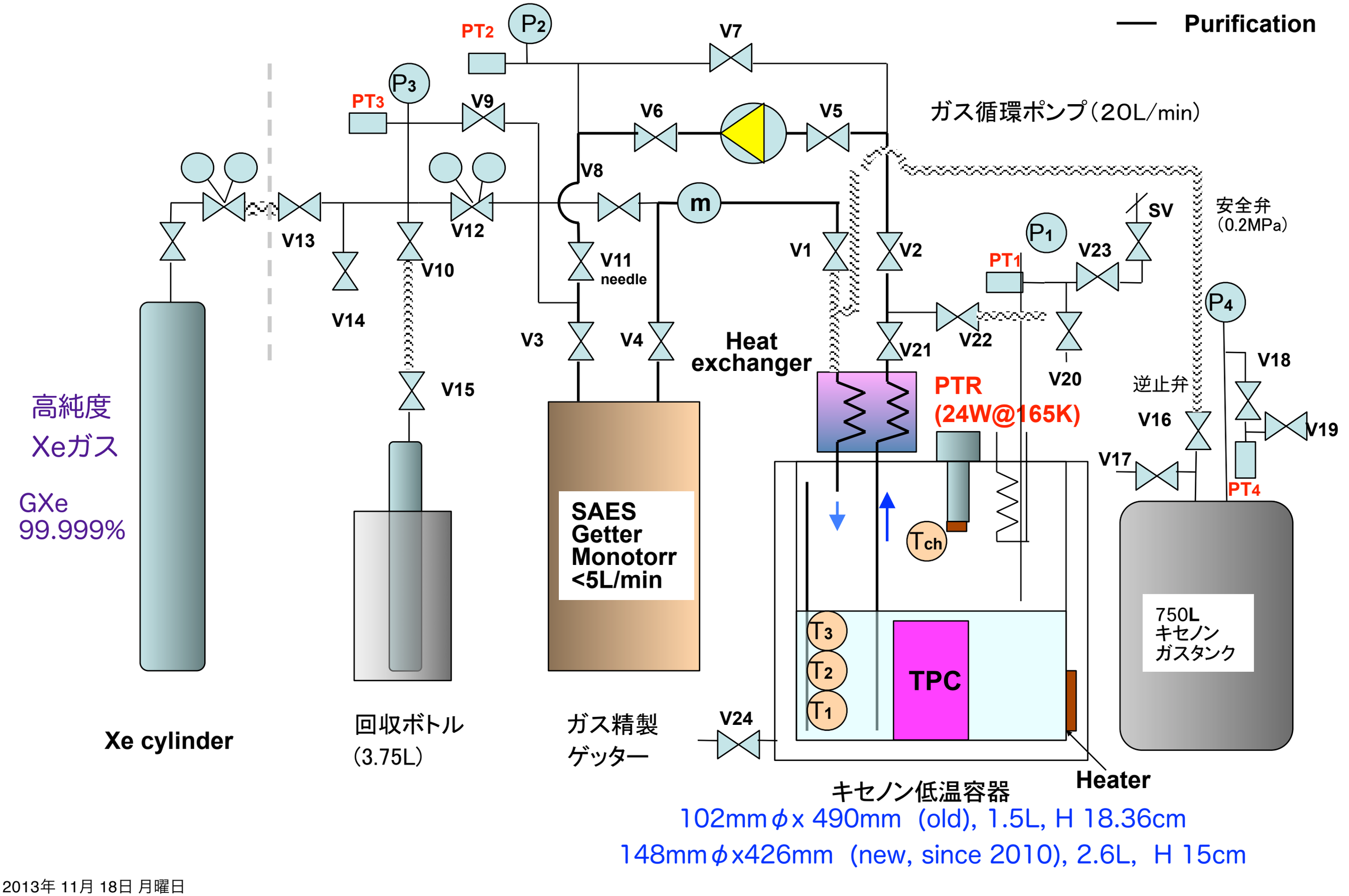


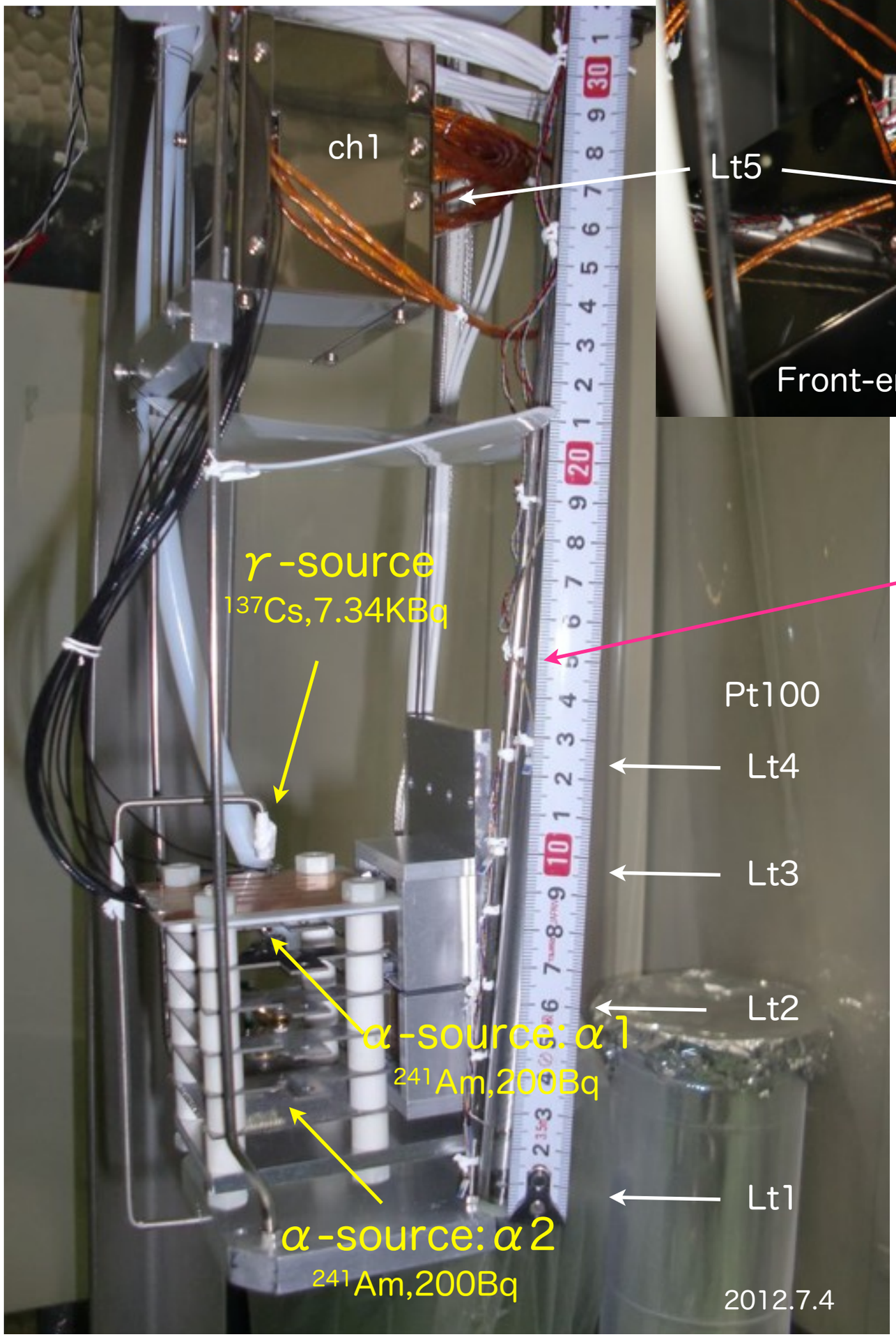


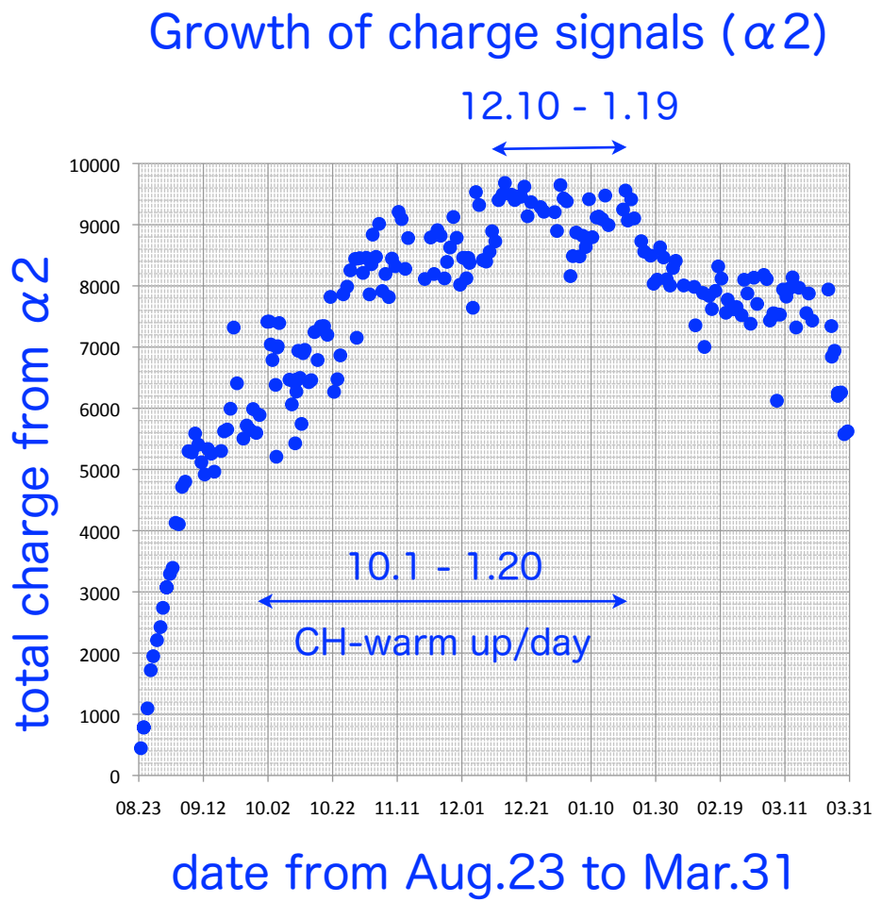
液化・純化システム

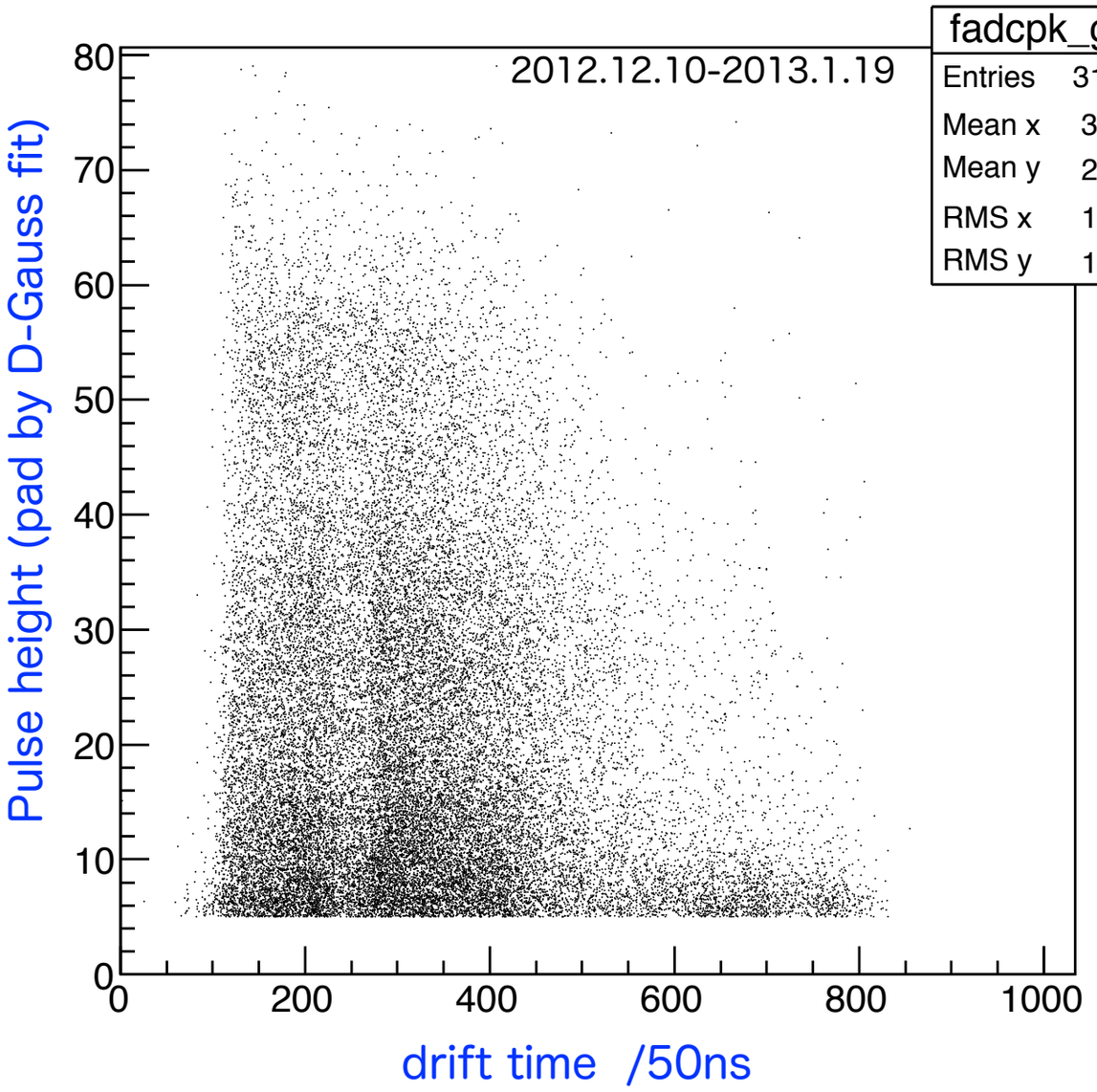
since June 2008

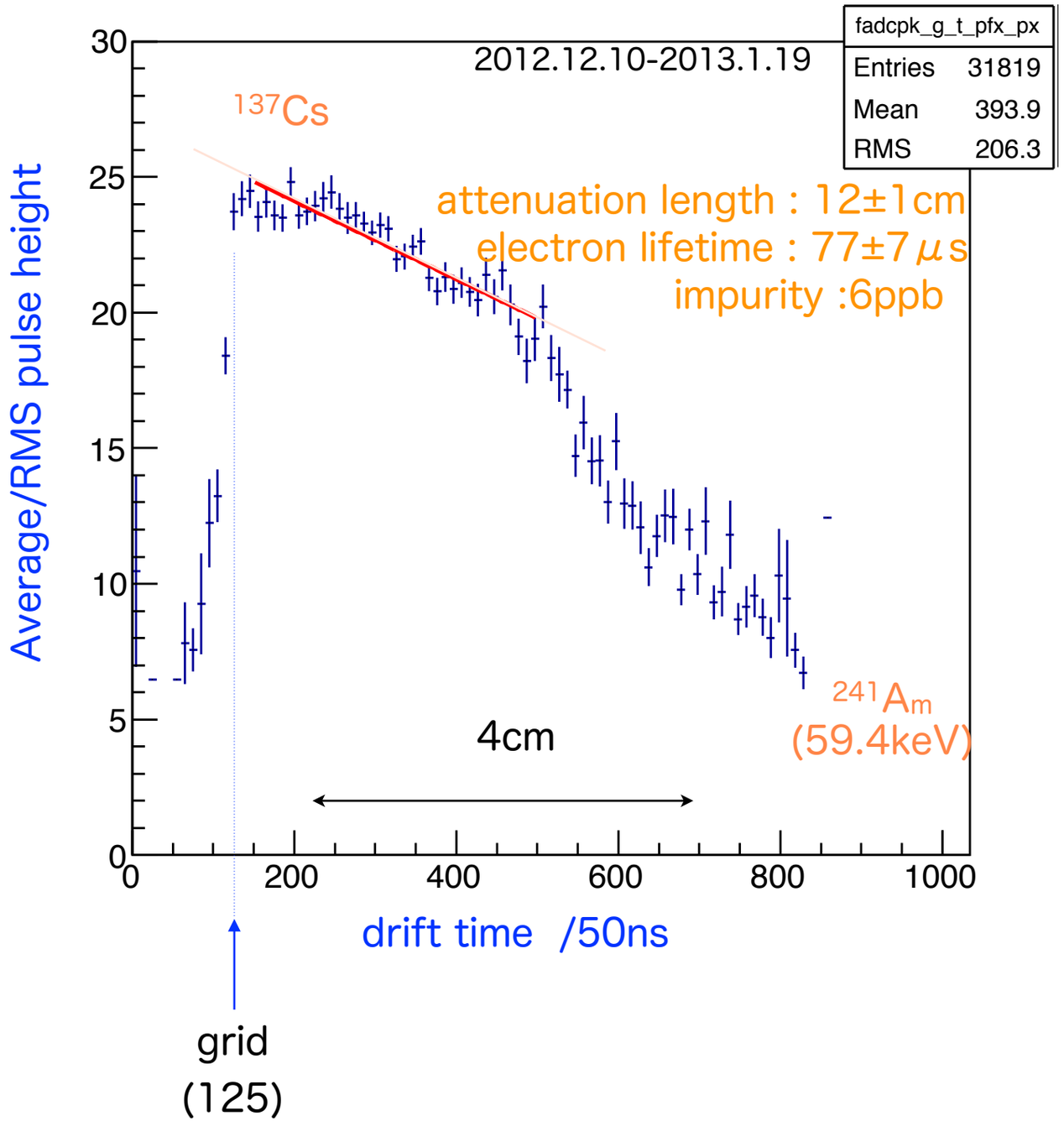
オイルフリー・ダイアフラムポンプ（エノモト）によるガス循環精製




ch1
Lt5
Front-end electronics
γ-source
137Cs,7.34KBq
Liquid level
gauge (15cm)
Pt100
Lt4
Lt3
Lt2
α-source: α1
241Am,200Bq
Lt1
α-source: α2
241Am,200Bq
2012.7.4


Growth of charge signals (α2)
12.10 - 1.19
10.1 - 1.20
CH-warm up/day
total charge from α2
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
08.23
09.12
10.02
10.22
11.11
12.01
12.21
01.10
01.30
02.19
03.11
03.31
date from Aug.23 to Mar.31

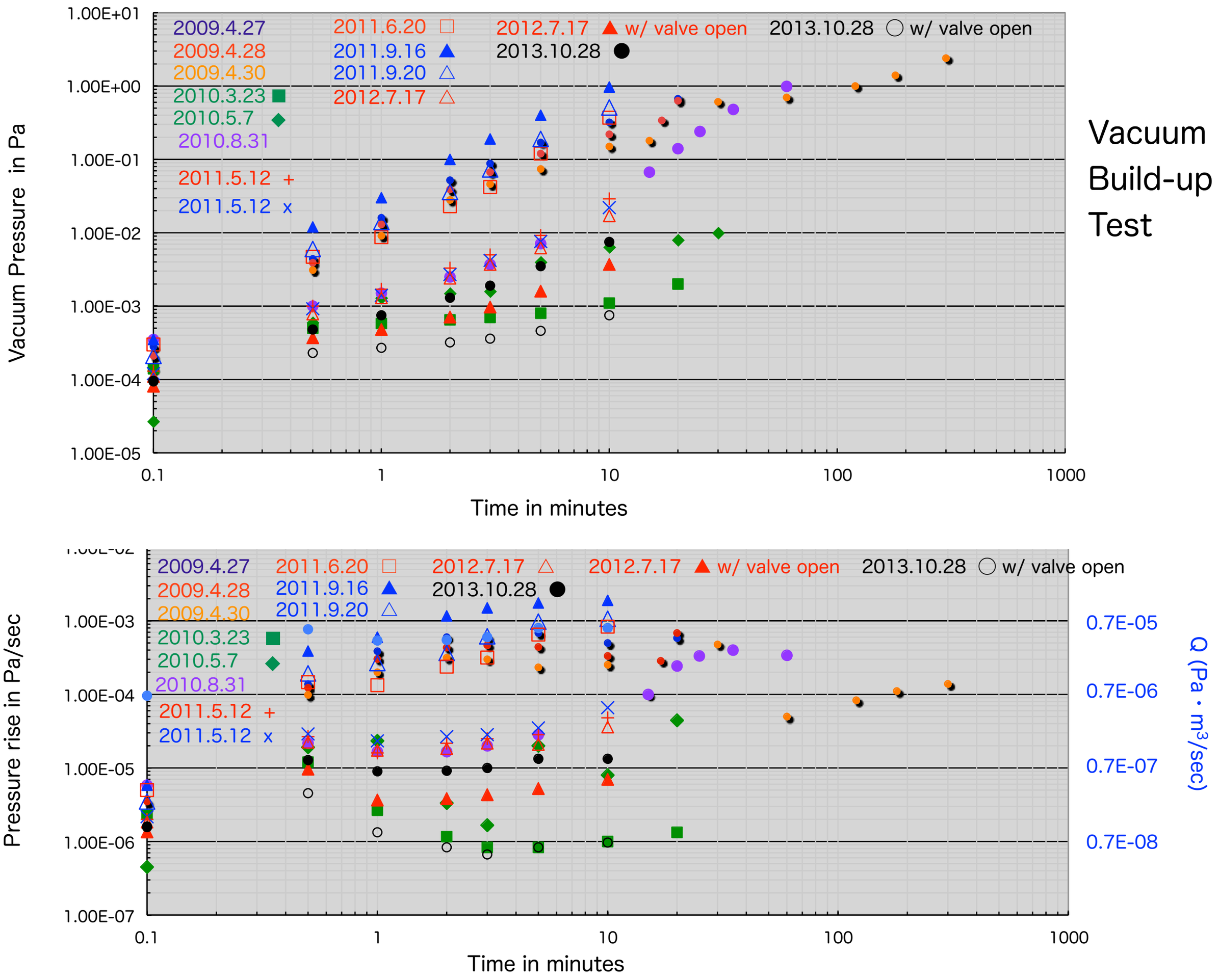




note : the anode plane at 125

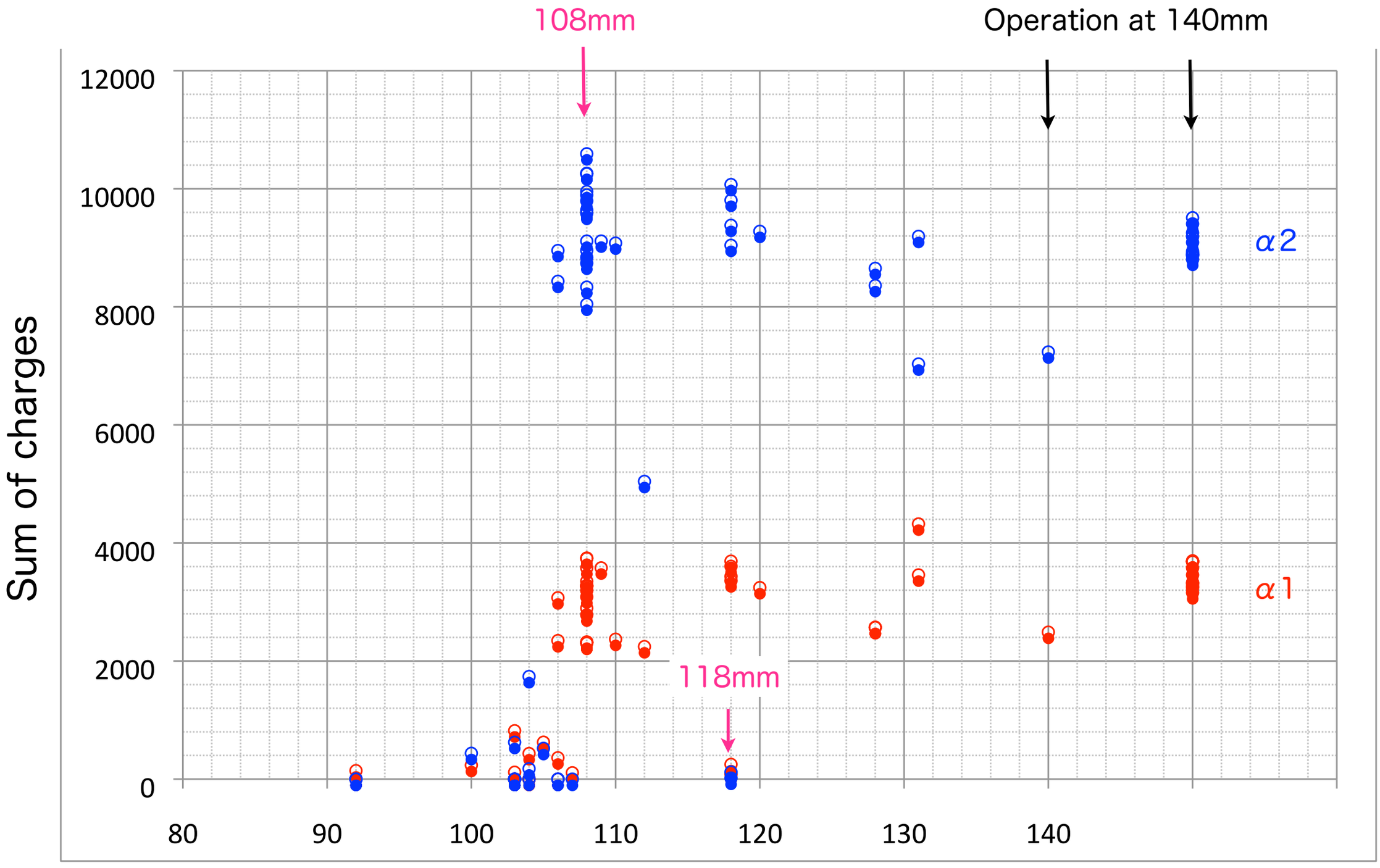
ビルトアップテスト

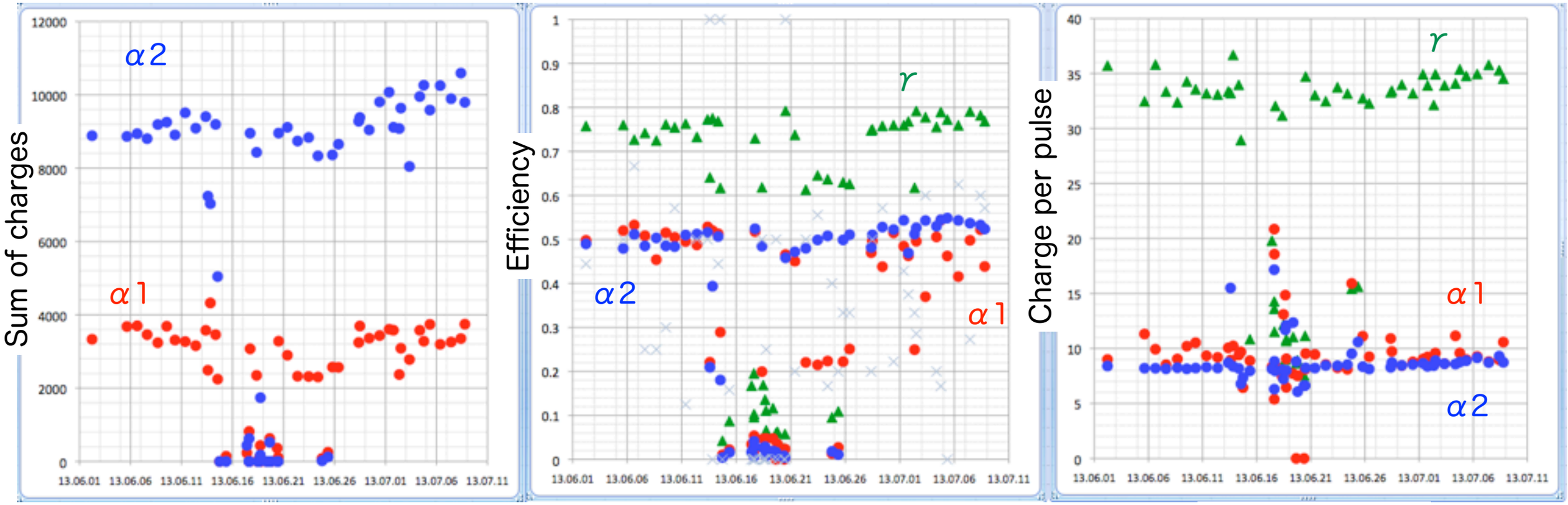
Vacuum Build-up Test

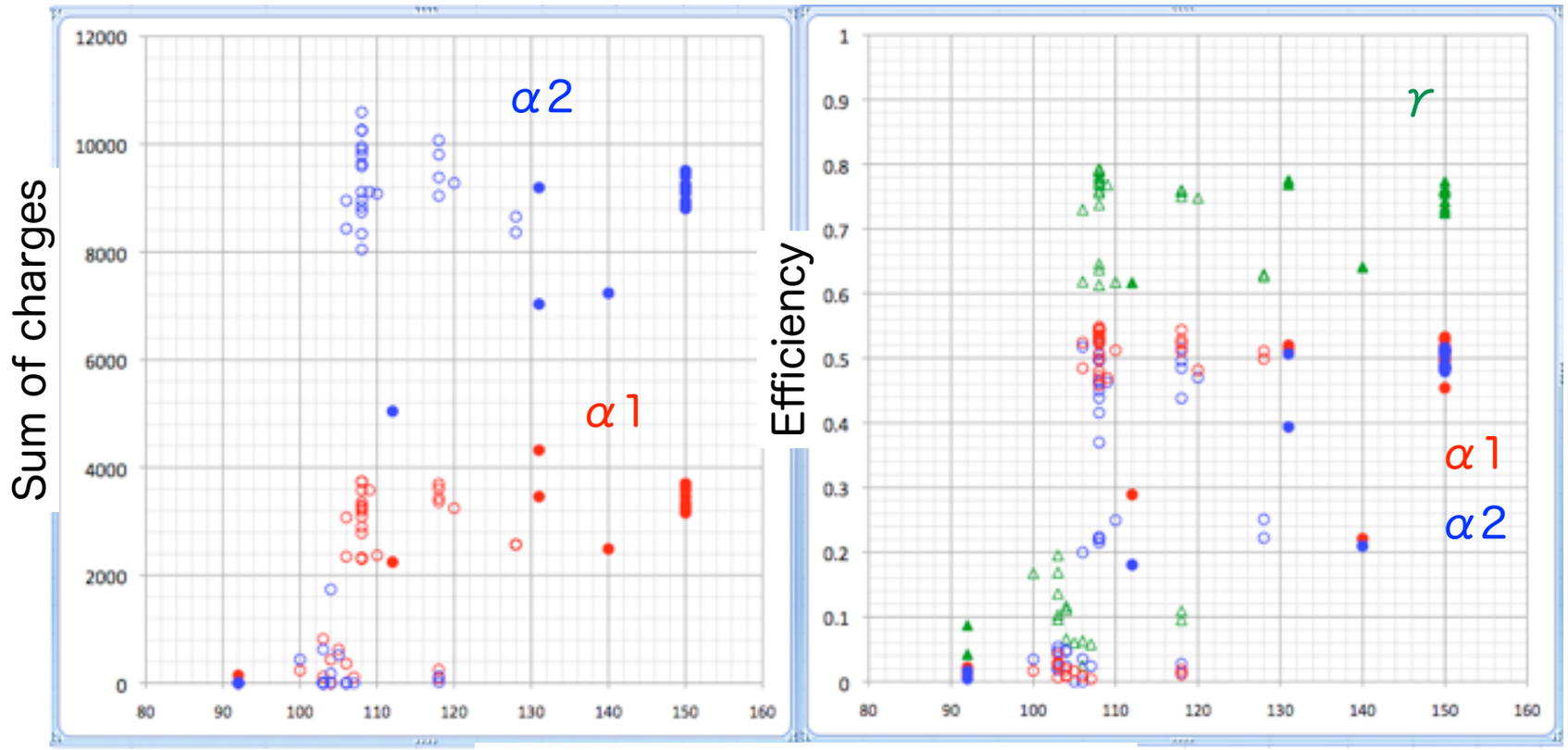


液面確認

Surface level of liquid Xe,　June, 2013




Sum of charges
α2
α1
Year.Month.Day
Efficiency
γ
α2
α1
Year.Month.Day
Charge per pulse
γ
α1
α2
Year.Month.Day


Sum of charges
α2
α1
Efficiency
γ
α1
α2
Surface level of liquid Xe (mm)

ノイズ対策

2012.8.9 Runlog 292からの引用：『(He compressor) ON時の主なノイズは周期2.5msecのもので、OFF時にはほぼなくなる。』

2013.7.4 He compressorをflexible tubesを用いて、chamberより約10m離れたところに設置し直して、その前後でのノイズを preamp出力後（pad1,2,3,4) で調べた。

Tek Trig'd M Pos: 400.0µs

Compressor ON

CH4 Coupling AC BW Limit Off 200MHz Volts/Div Coarse Probe 1X Voltage Invert Off

CH1 5.00mV CH2 5.00mV M 10.0ms Ext ⎿ −304mV
CH3 100mV CH4 100mV 9−Aug−12 16:39 49.9993Hz

Tek Trig'd M Pos: 2.600µs

Compressor OFF

CH4 Coupling AC BW Limit Off 200MHz Volts/Div Coarse Probe 1X Voltage Invert Off

CH1 5.00mV CH2 5.00mV M 10.0ms Ext ⎿ −304mV
CH3 100mV CH4 100mV 9−Aug−12 17:26 49.9996Hz

Tek Trig'd M Pos: 400.0µs

Compressor ON

CH4 Coupling AC BW Limit Off 200MHz Volts/Div Coarse Probe 1X Voltage Invert Off

CH1 5.00mV CH2 5.00mV M 2.50ms Ext ⎿ −304mV
CH3 100mV CH4 100mV 9−Aug−12 16:39 49.9998Hz

Tek Trig'd M Pos: 2.600µs

Compressor OFF test pulse

CH4 Coupling AC BW Limit Off 200MHz Volts/Div Coarse Probe 1X Voltage Invert Off

CH1 5.00mV CH2 5.00mV M 5.00µs Ext ⎿ −304mV
CH3 100mV CH4 100mV 9−Aug−12 17:25 49.9991Hz

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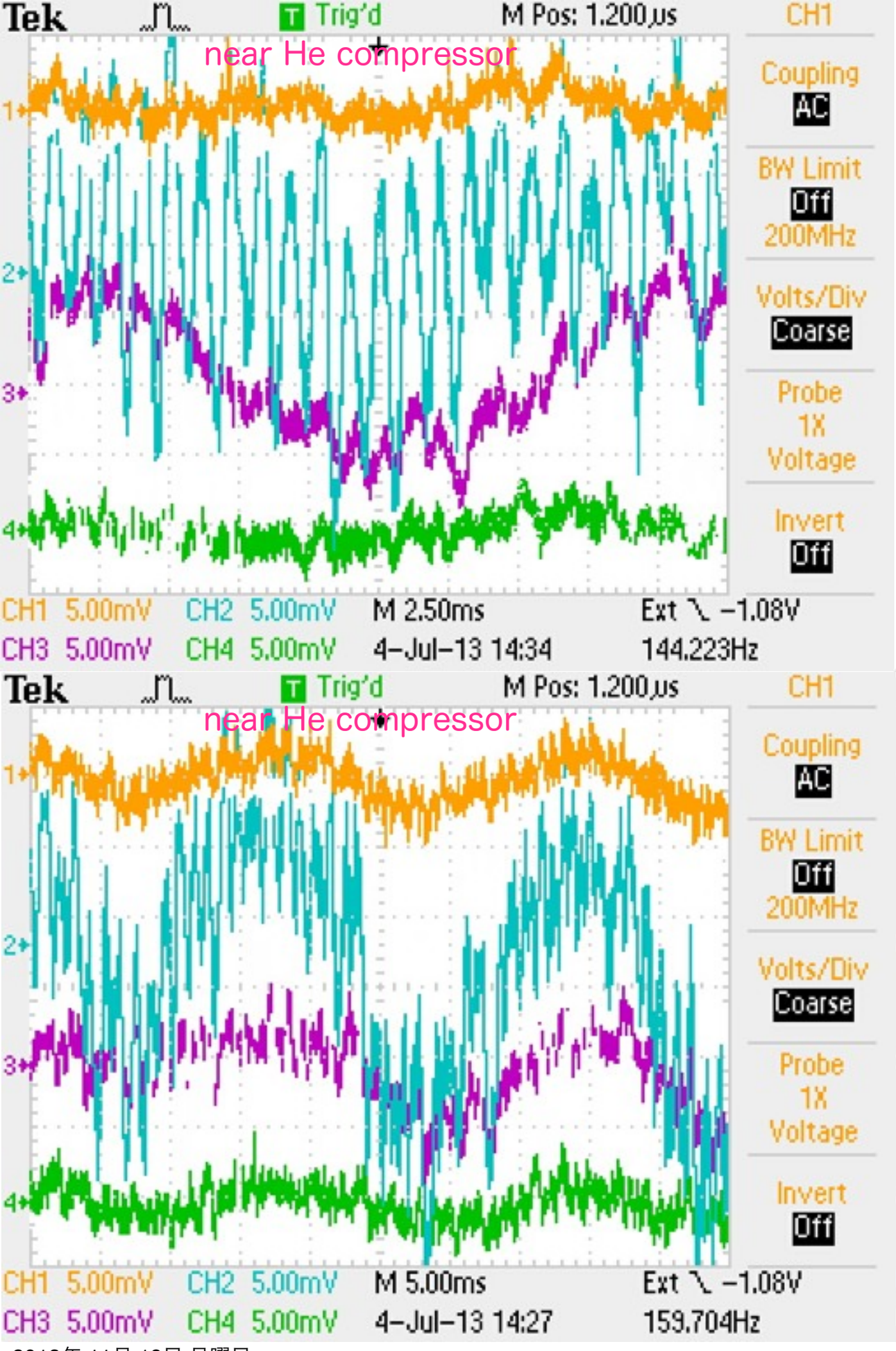

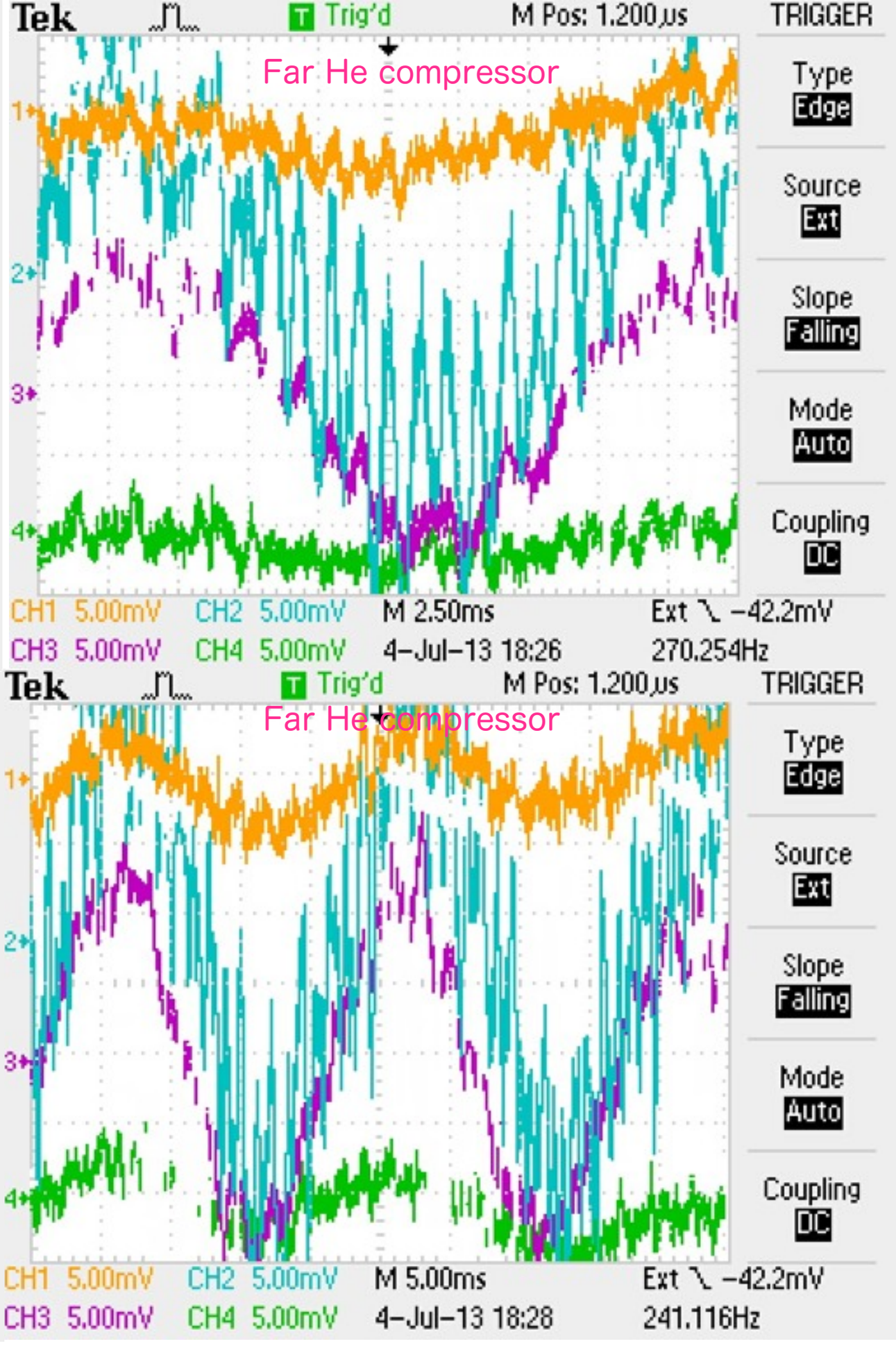

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TPCFE09 : 2nd version of FEXE09

Designed by Open-IT ;
Yuta Takagi (Yokohama N. univ.) ,
Takatoshi Higashi (Saga univ.),
Takahiro Fusayasu(NIAS) , Hirokazu Ikeda(JAXA) , Manobu Tanaka(IPNS)

Open-It (Open source consortium for detector instrumentation) collaboration

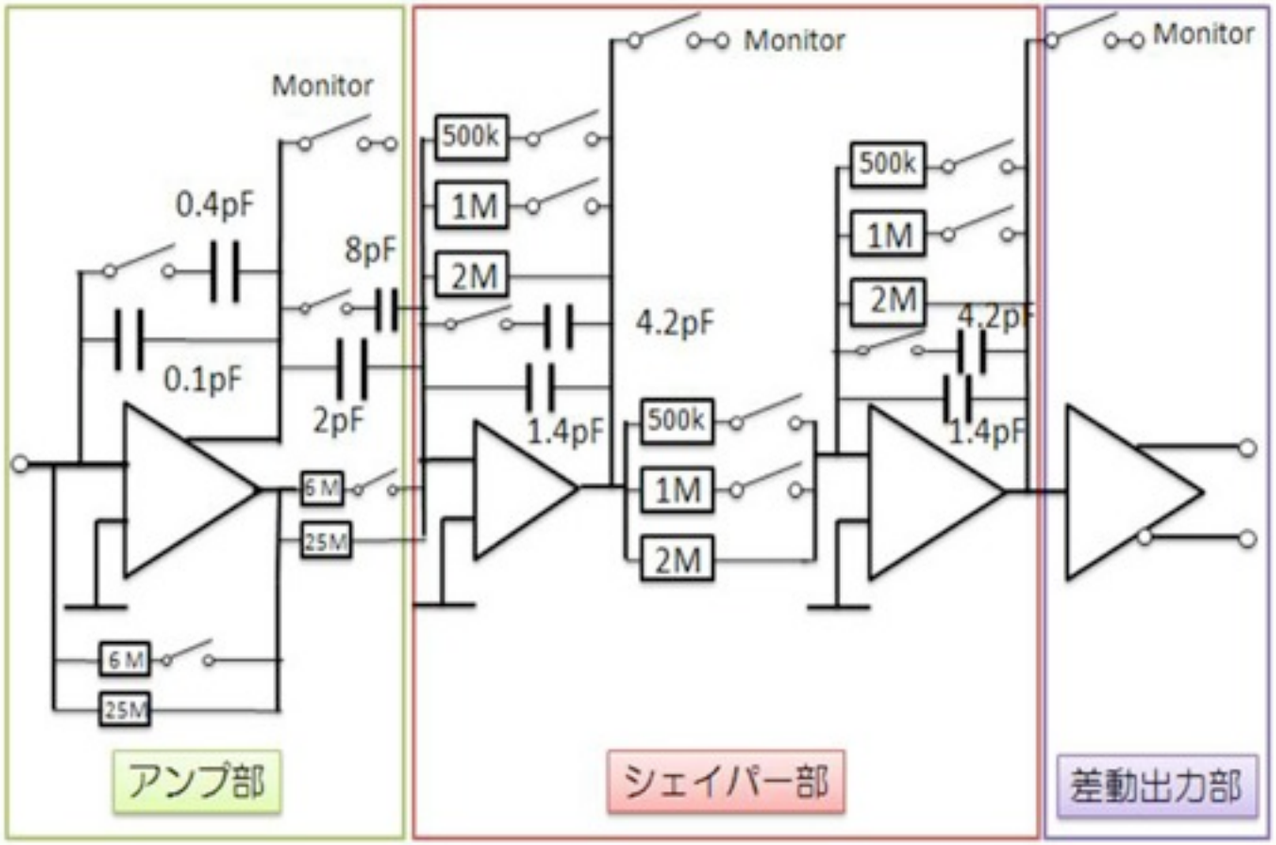
together with the neutron group

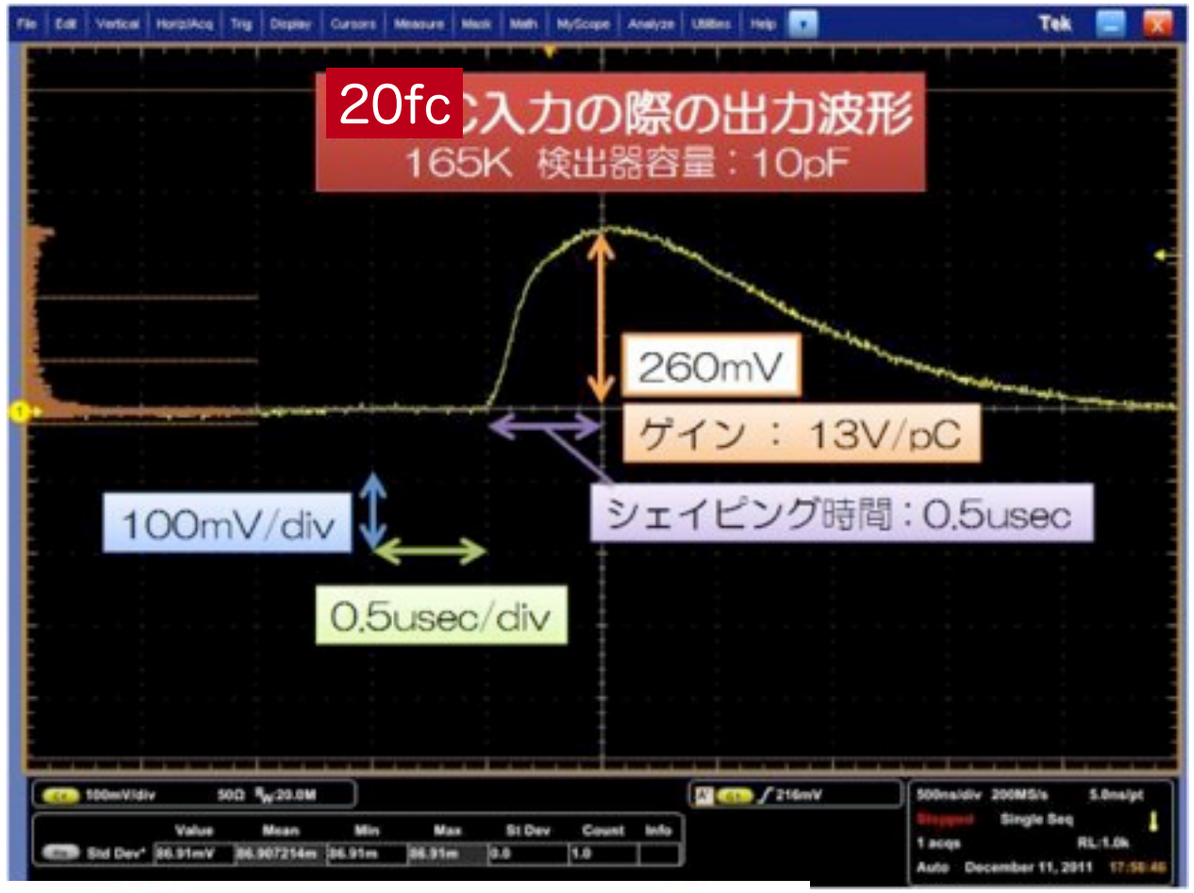
Parameters	TPCFE09(TPCFE1x)
dynamic range	-75fC~+25fC -500fC ~ -5fC
gain	2V/pC 10V/pC
gain tolerance	~1%
ENC	400+25/pF@0.5us
cross talk	~1%
peaking time	0.5, 1 and 2 us
power dissipation	<10mW/ch
Temperature range	-110 ~ + 25℃
# of channels	16ch
ADC	none (10bit/10MHz)

UMC 0.25um process

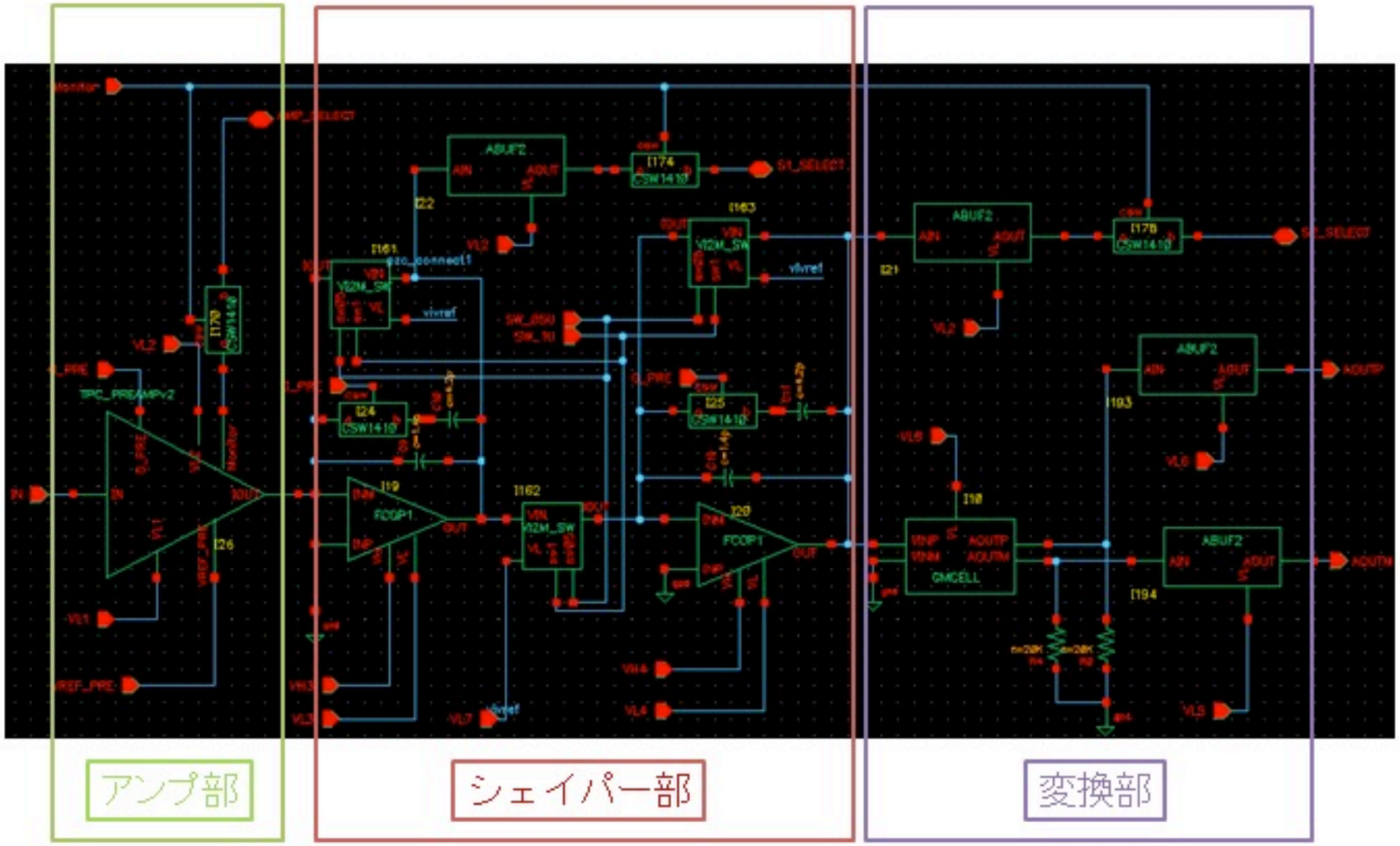
Schedule

1. Circuit design was completed, Mar.2010
2. Simulation was completed
3. Layout design was passed to the company on 24 Nov.2010
4. Tape out was(?) submitted by end of January 2011
5. Delivery in Summer 2011
6. Test in Autumn 2011


Monitor
0.4pF
8pF
0.1pF
2pF
6 M
25M
6 M
25M
アンプ部
Monitor
500k
1M
2M
4.2pF
1.4pF
500k
1M
2M
シェイパー部
Monitor
500k
1M
2M
4.2pF
1.4pF
差動出力部


20fC入力の際の出力波形
165K 検出器容量：10pF
260mV
ゲイン ： 13V/pC
シェイピング時間：0.5usec
100mV/div
0.5usec/div

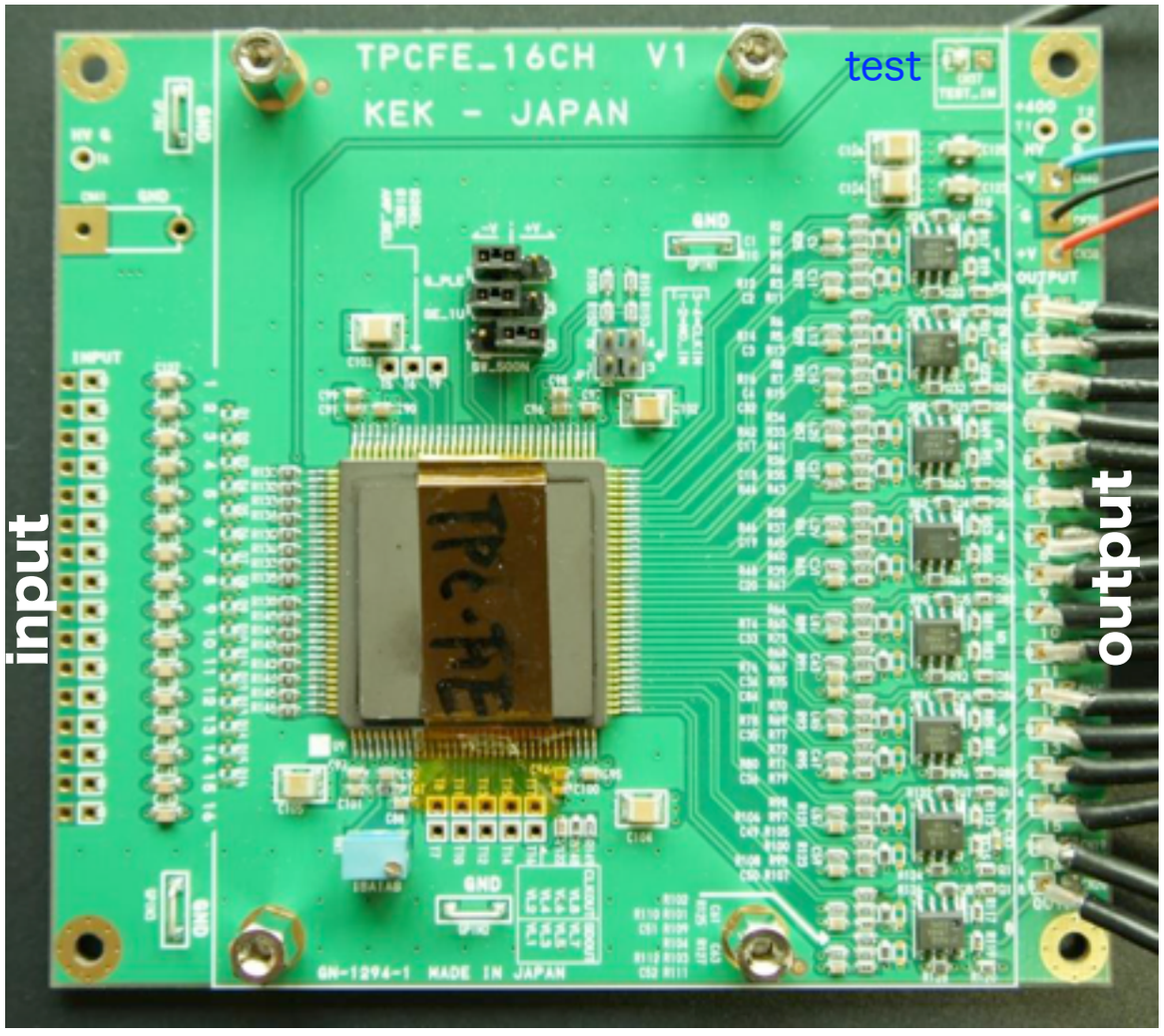
TPC-FE09
1 ch

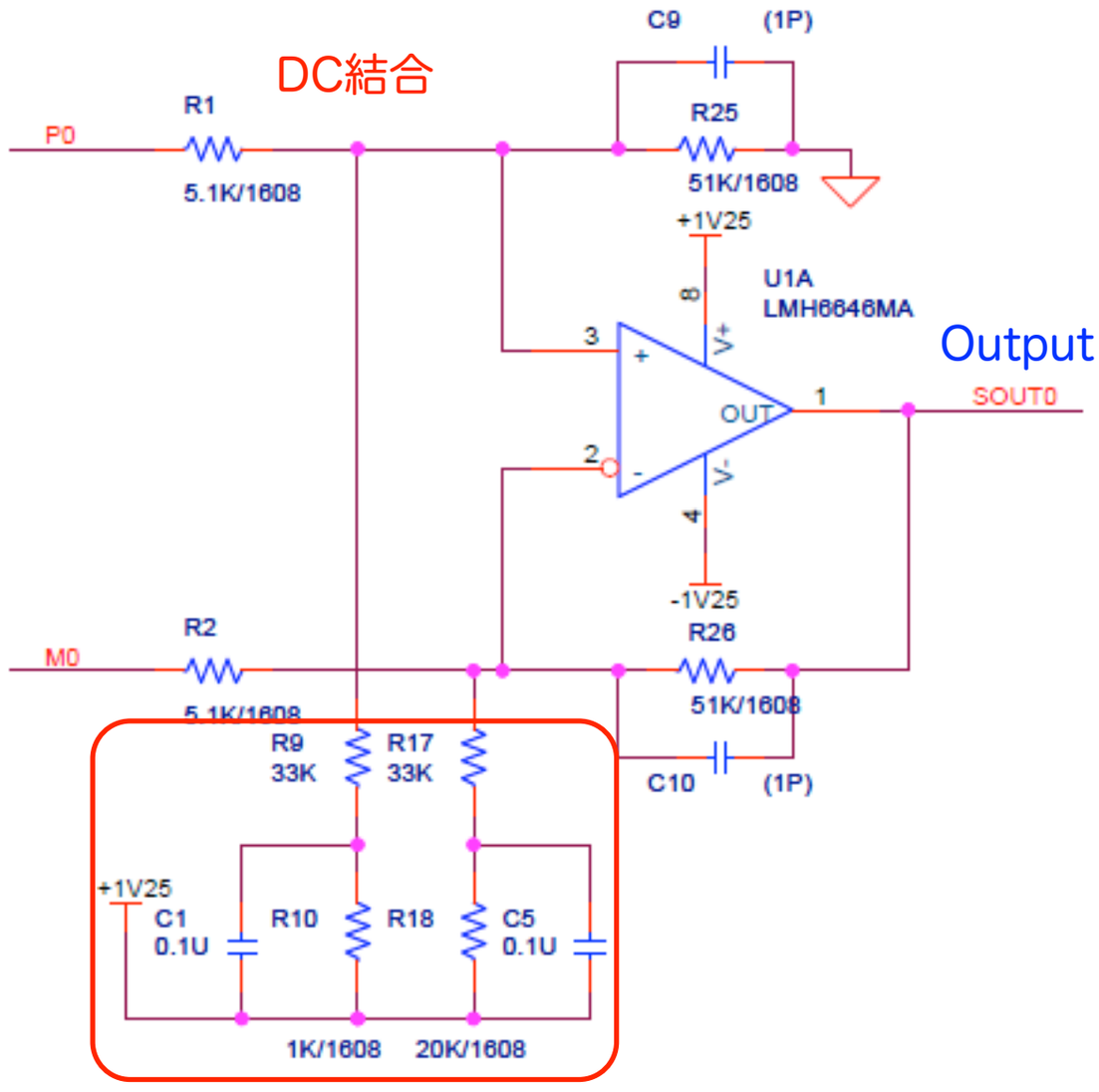

アンプ部
シェイパー部
変換部

Mother board of TPCFE (16ch), version -1, for test, Jan-Mar 2013

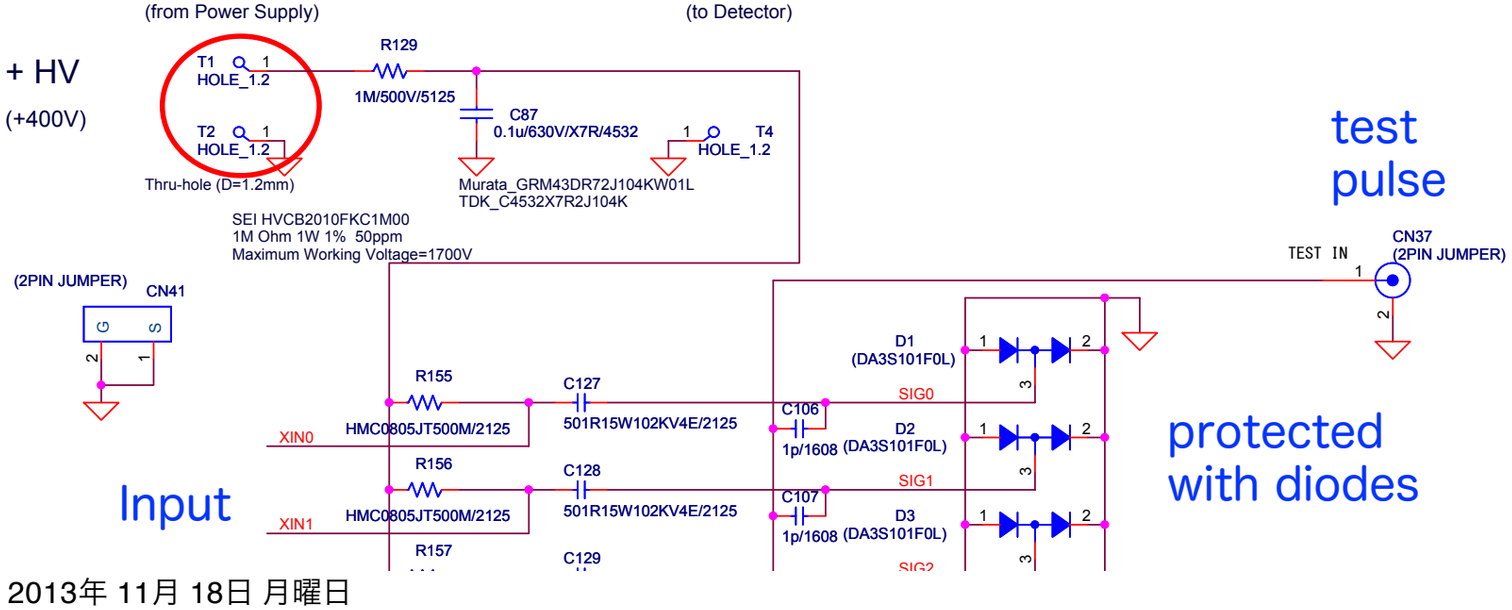
studied by Yuya Iwazaki, Yokohama National University

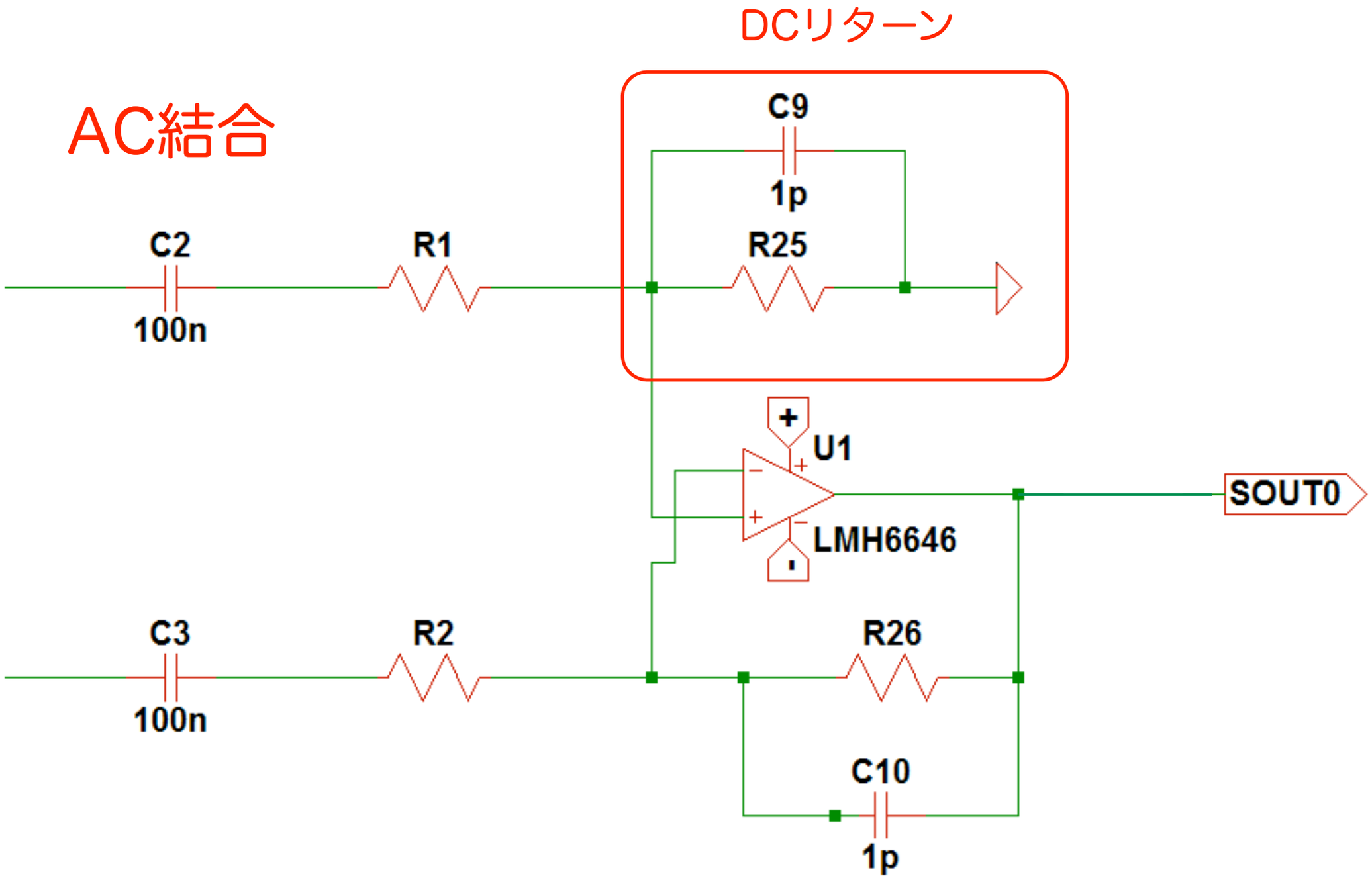
GN-1294-1(FR4), based on Takagi's M thesis





DC offset tuning circuit





R1=R2=5.1kΩ　：　R25=R26=100kΩ　Gain=19.6 → GN-1294-2(LTCC)

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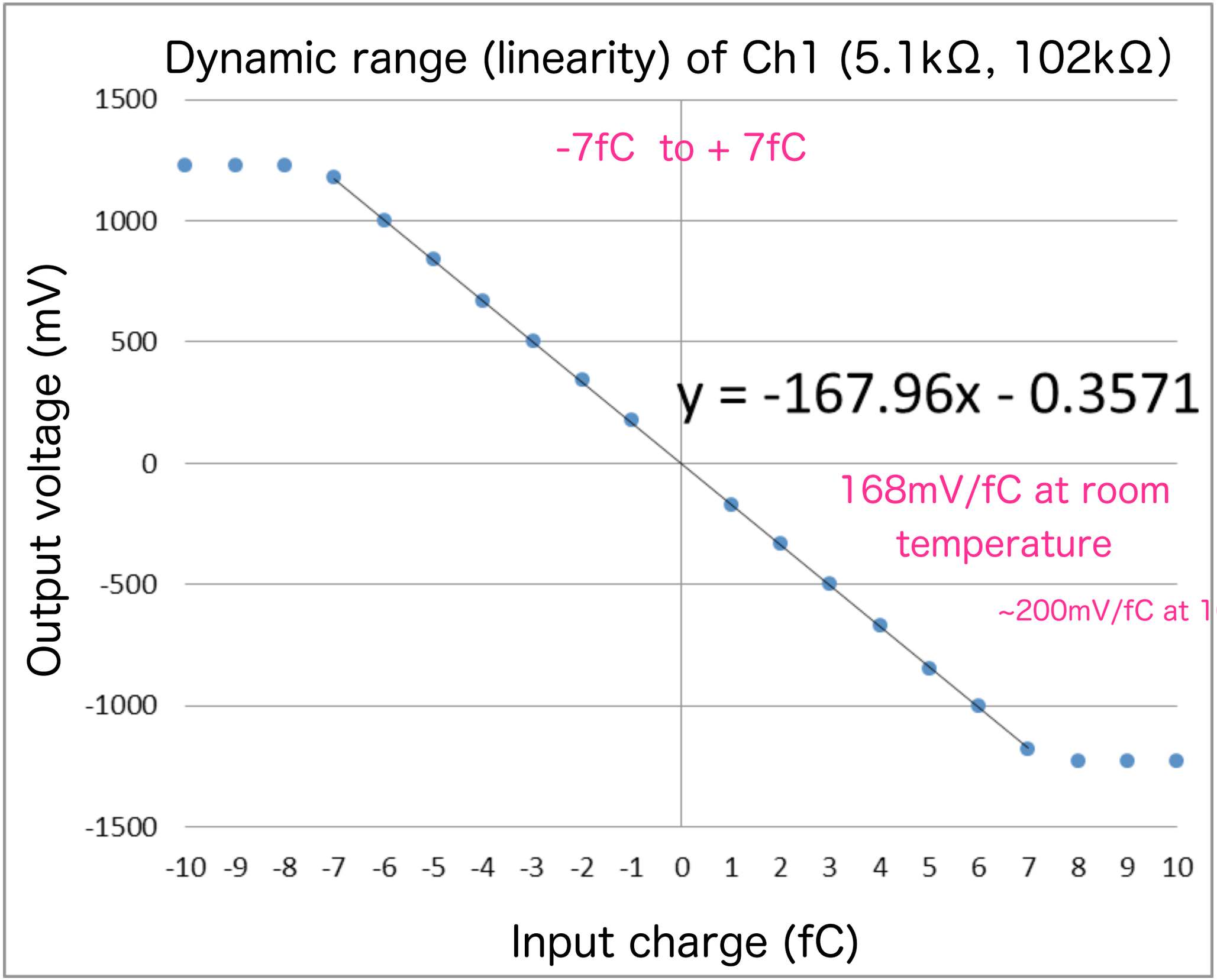
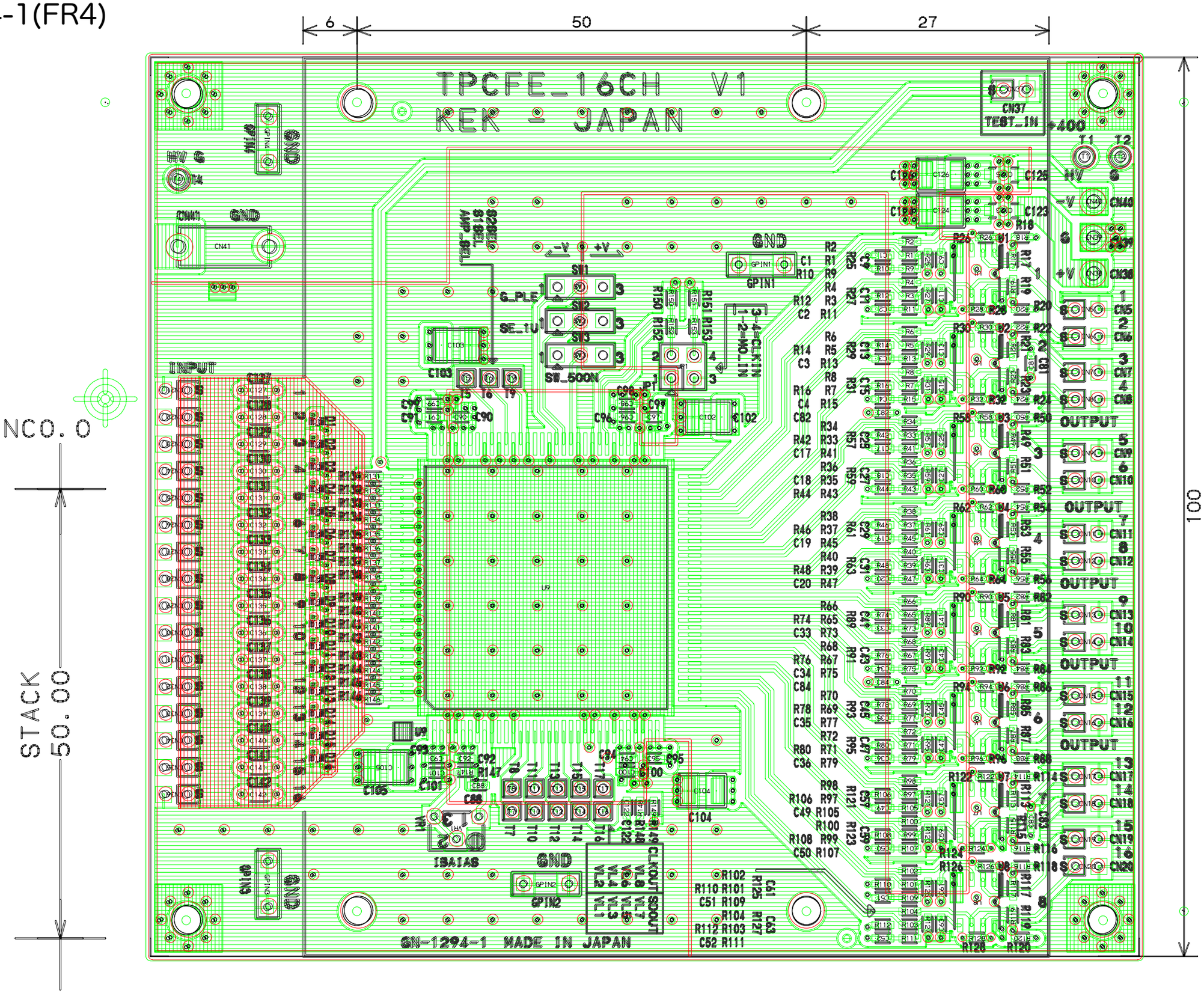
GN-1294-2(LTCC)



GN-1294-1(FR4)



L1 L3　　L1 SILK

GN-1294-1　　**部品面パターン**　　**縮尺： 1 倍**　　**2012/10/05 2:46:46**

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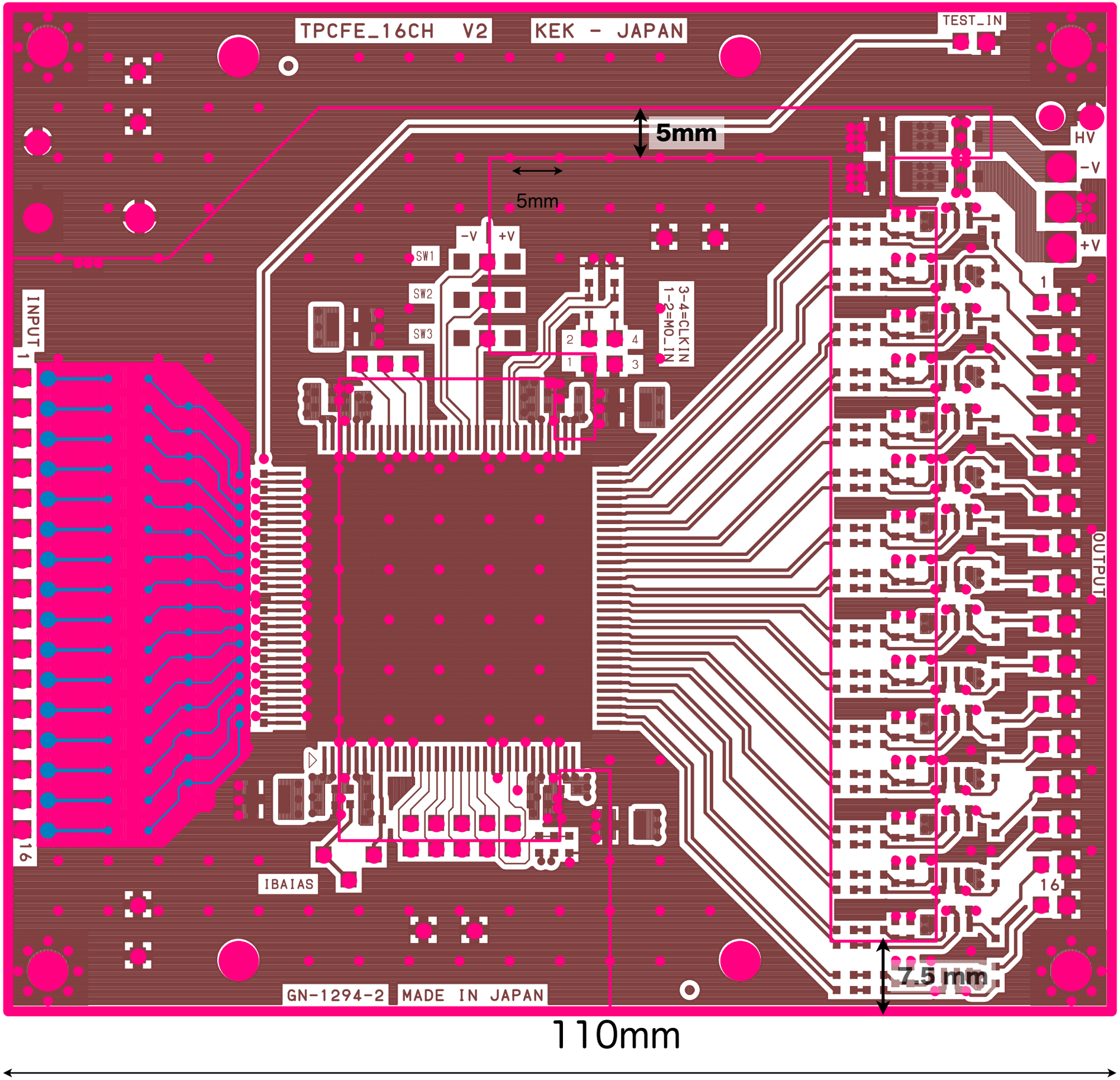
GN-1294-2(LTCC)



L1L3
L3+

KEK GN-1294-2 2013/04

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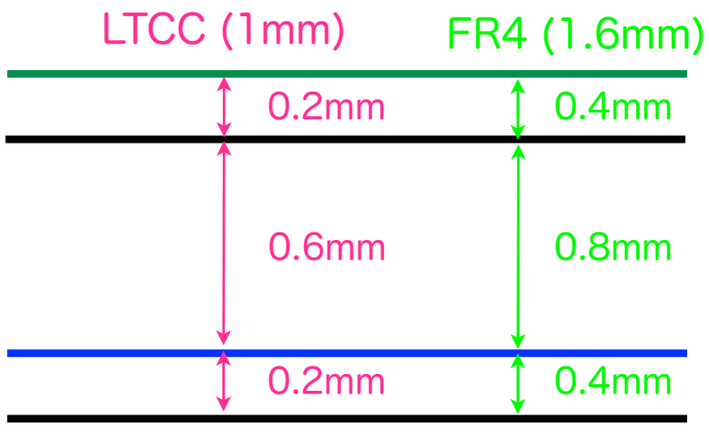
基板層構成

GN-1294-2基板データ

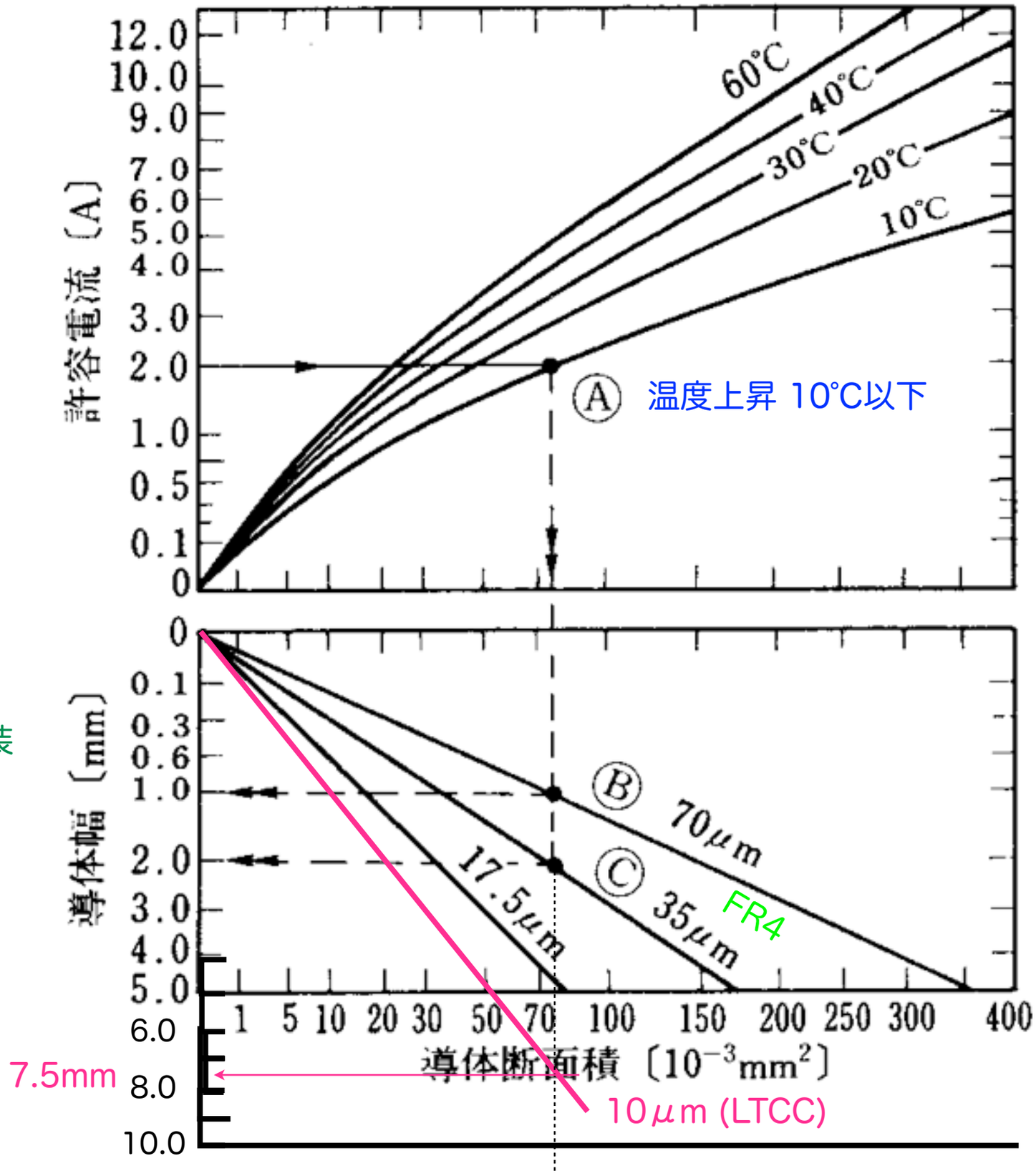
材料:LTCC　　単位[mm]

層	Via+NTH	基板厚み
L1&M1		
	Via+NTH	0.2
L2		
	Via+NTH	0.6
L3		
	Via+NTH	0.2
L4&M4		
板厚		1.0

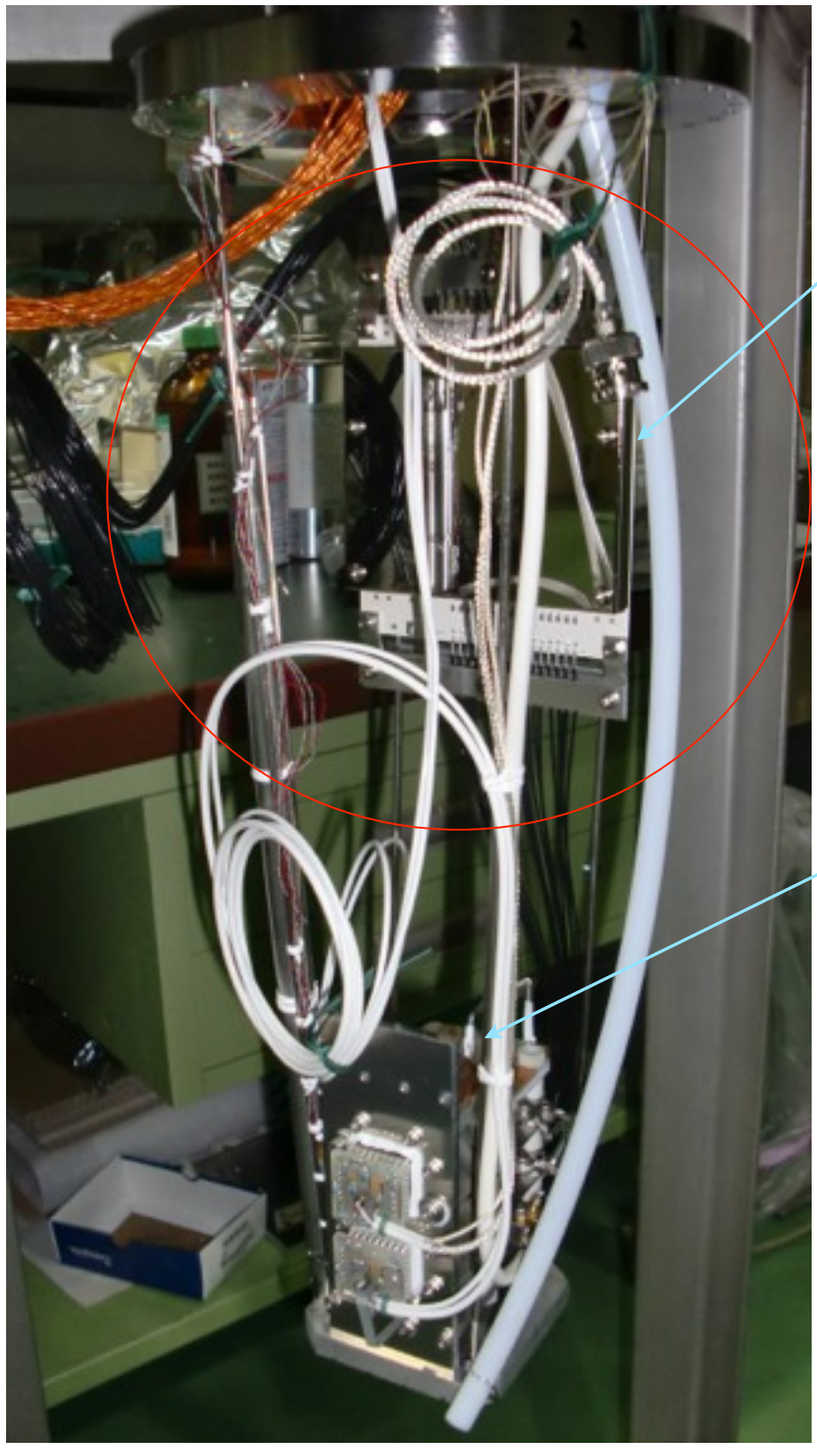


テストパルス,実装
GND

±1.25V
HV, GND, 実装



New Setup with the FETPC (ASIC-chip) , September 2013



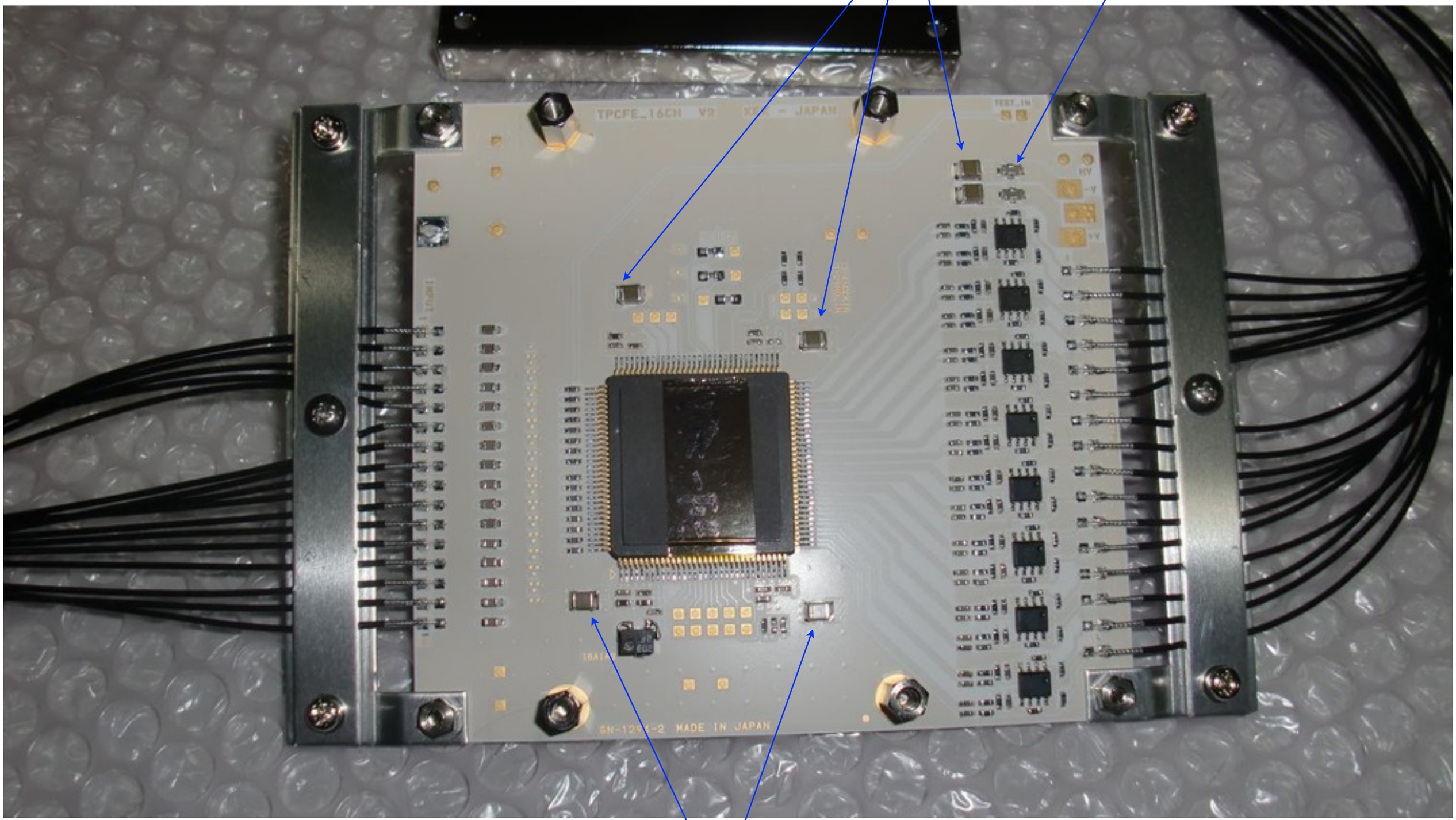
LTCC board

^{22}Na
(100kBq)

Decoupling Capacitor or Bypass Capacitor

Filter (60-80dB/0.4-200MHz, 27uF)

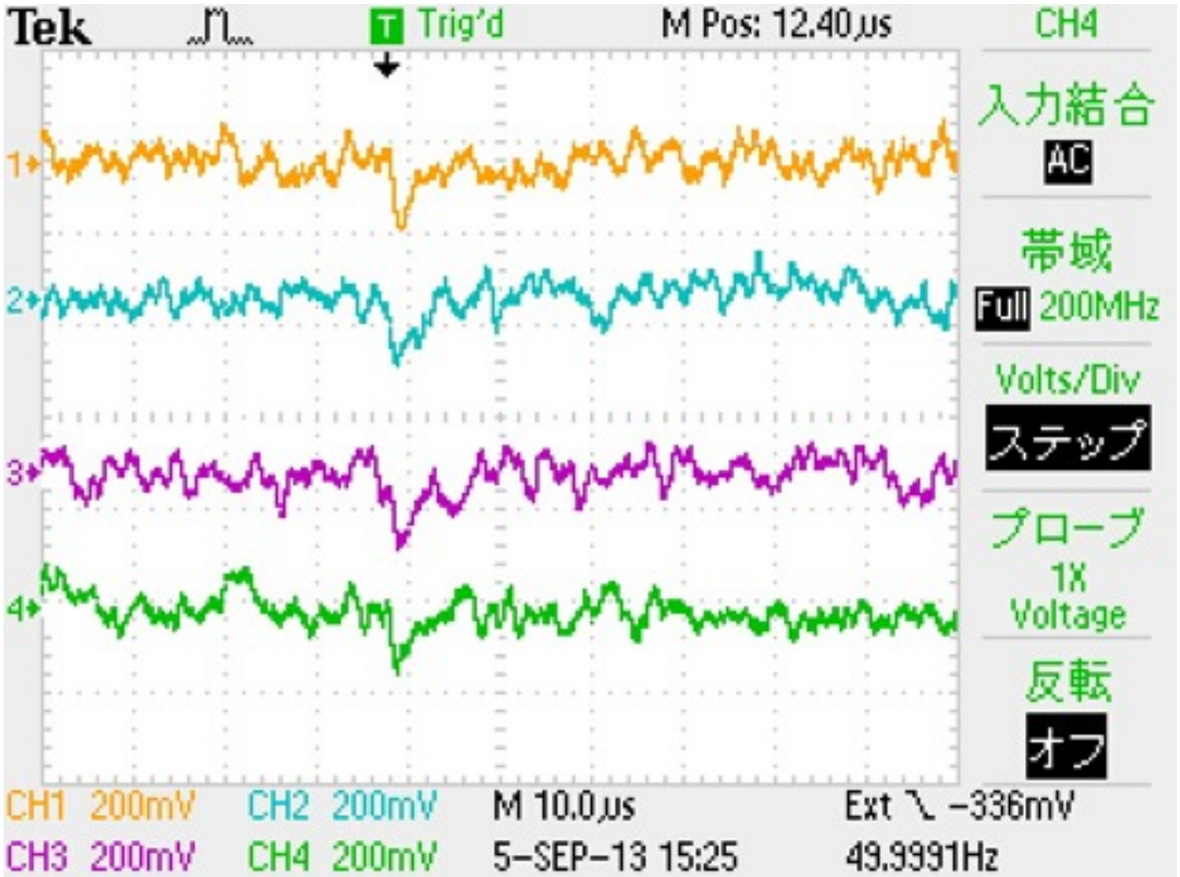
Multilayer Ceramic (JMK325AC6107_M,100uF)



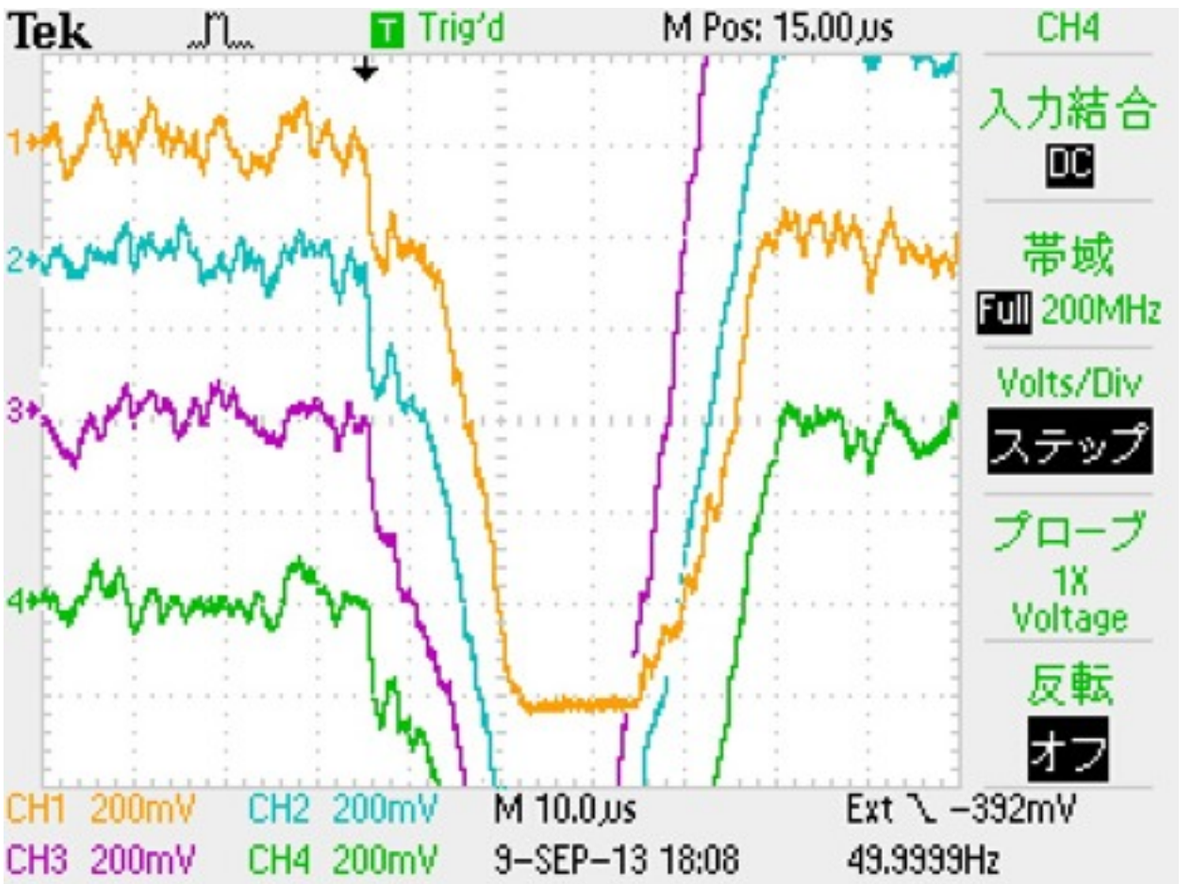
Multilayer Ceramic (JMK325AC6107_M,100uF)

2013年 11月 18日 月曜日

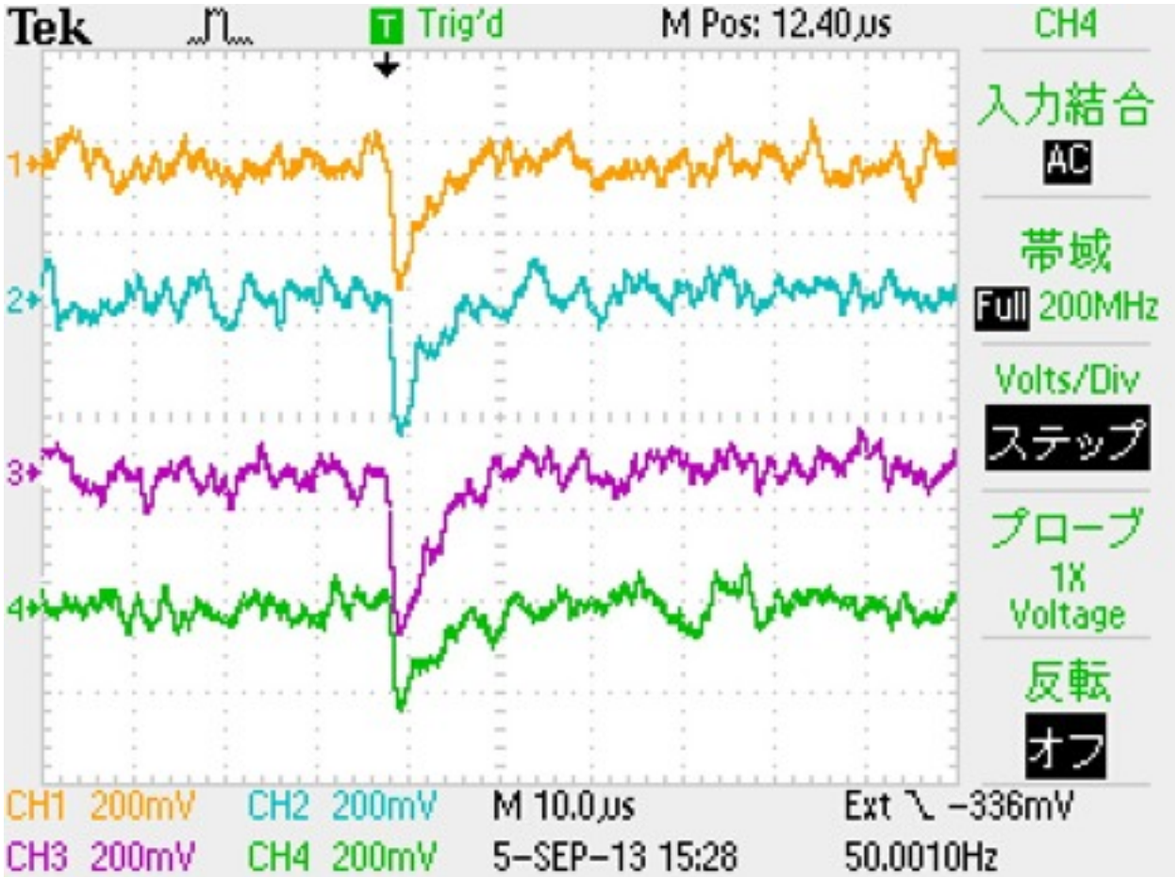
Test pulse, square, 50Hz, 0.025V, 31dB



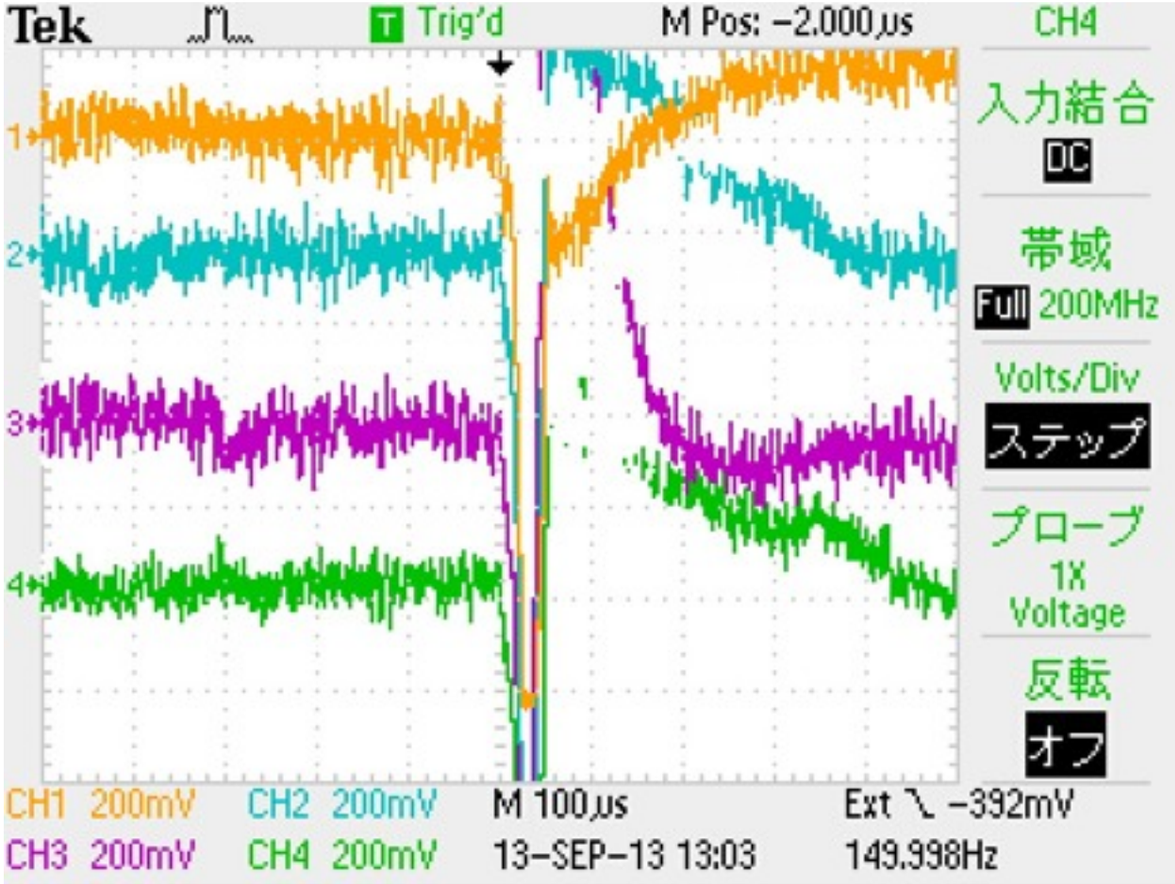
> 12ch of outputs terminated with 50 Ohm



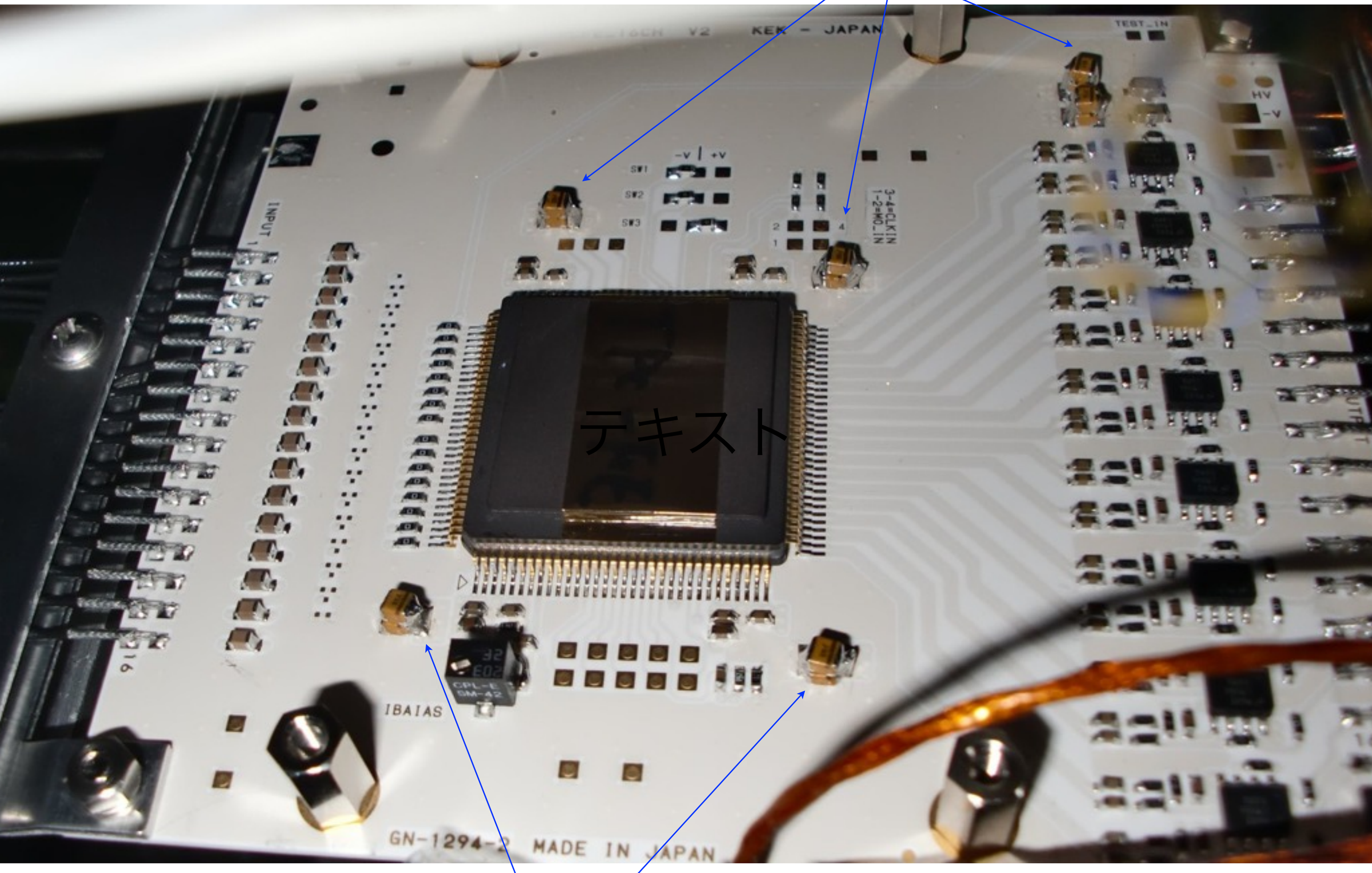
Test pulse, square, 50Hz, 0.025V, 25dB



> 12ch of outputs terminated with 50 Ohm



Solid-Tantalum (F950G337MBAAQ2, ESR=0.6Ω, 330uF x 2)

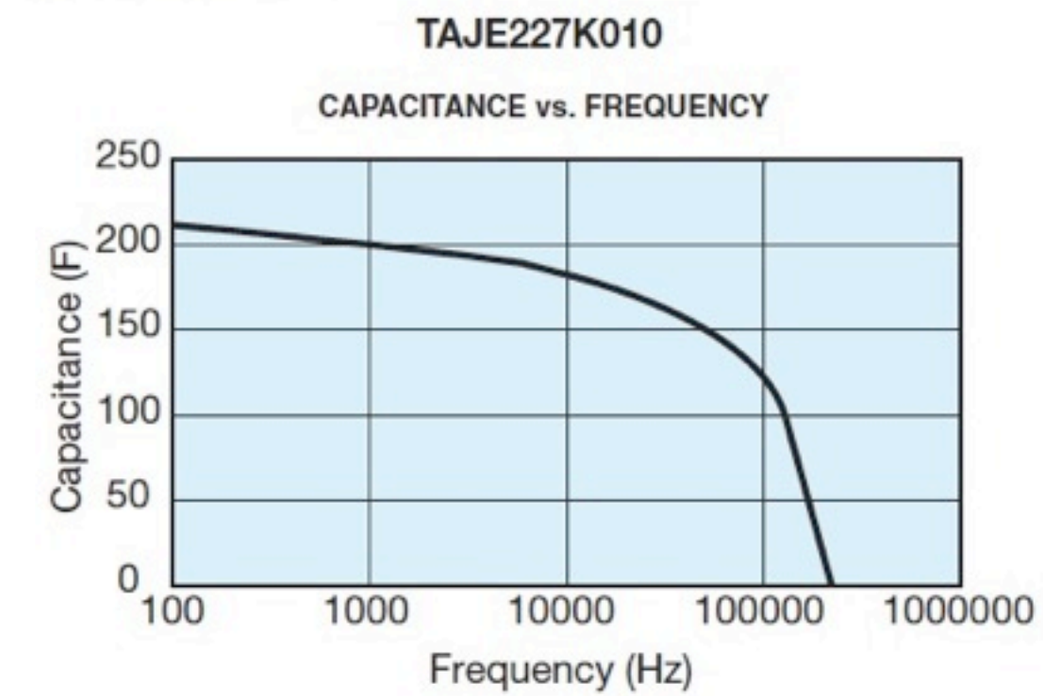


Solid-Tantalum (F950G337MBAAQ2, ESR=0.6Ω, 330uF x 2)

2013.9.24

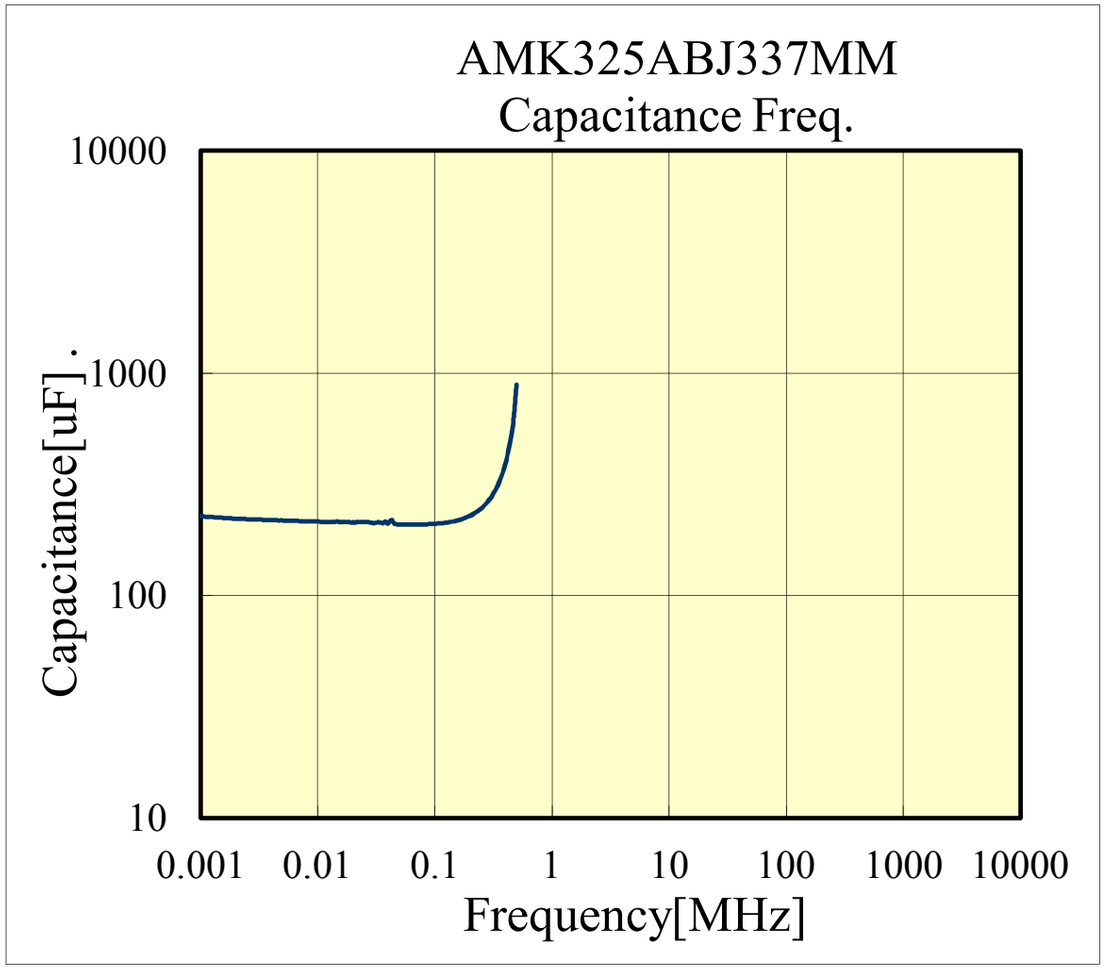
Solid-Tantalum

1.1.4 Frequency dependence of the capacitance.
The effective capacitance decreases as frequency increases. Beyond 100kHz the capacitance continues to drop until resonance is reached (typically between 0.5 - 5MHz depending on the rating). Beyond the resonant frequency the device becomes inductive.

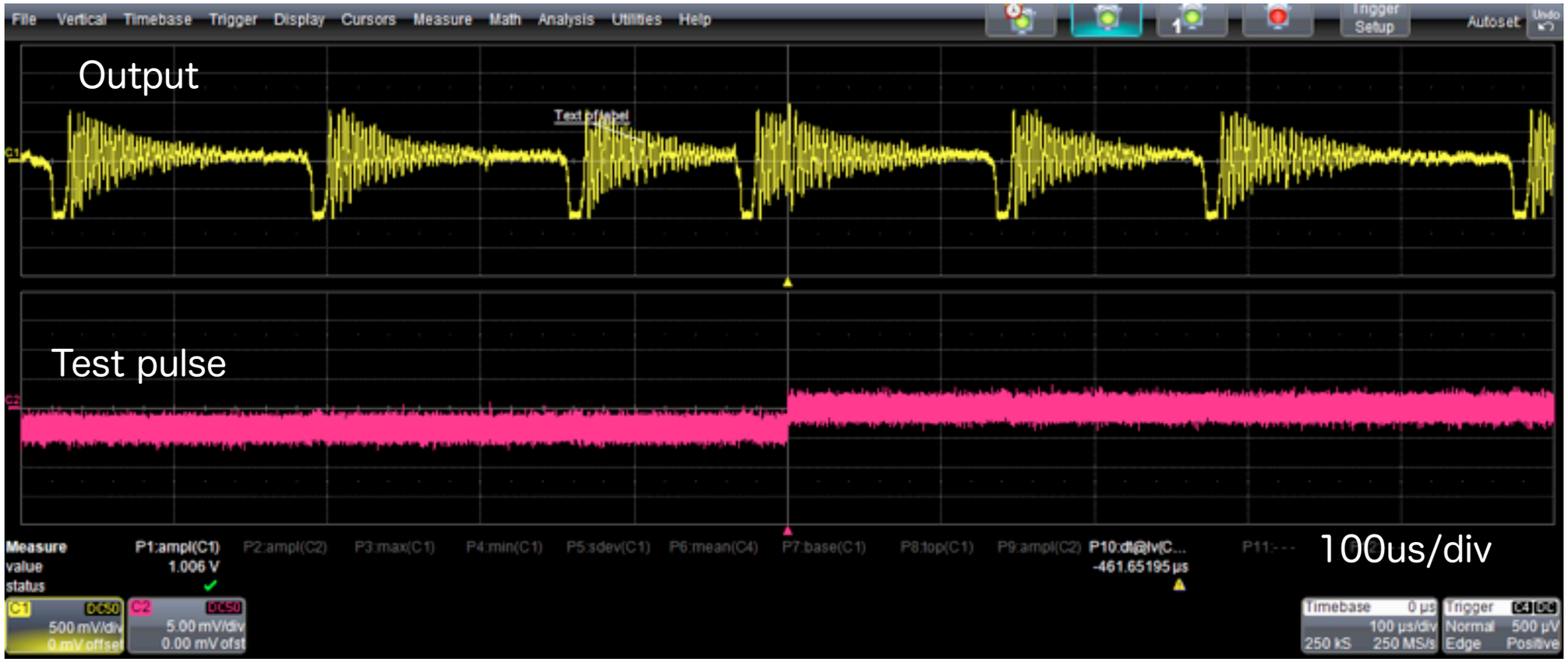


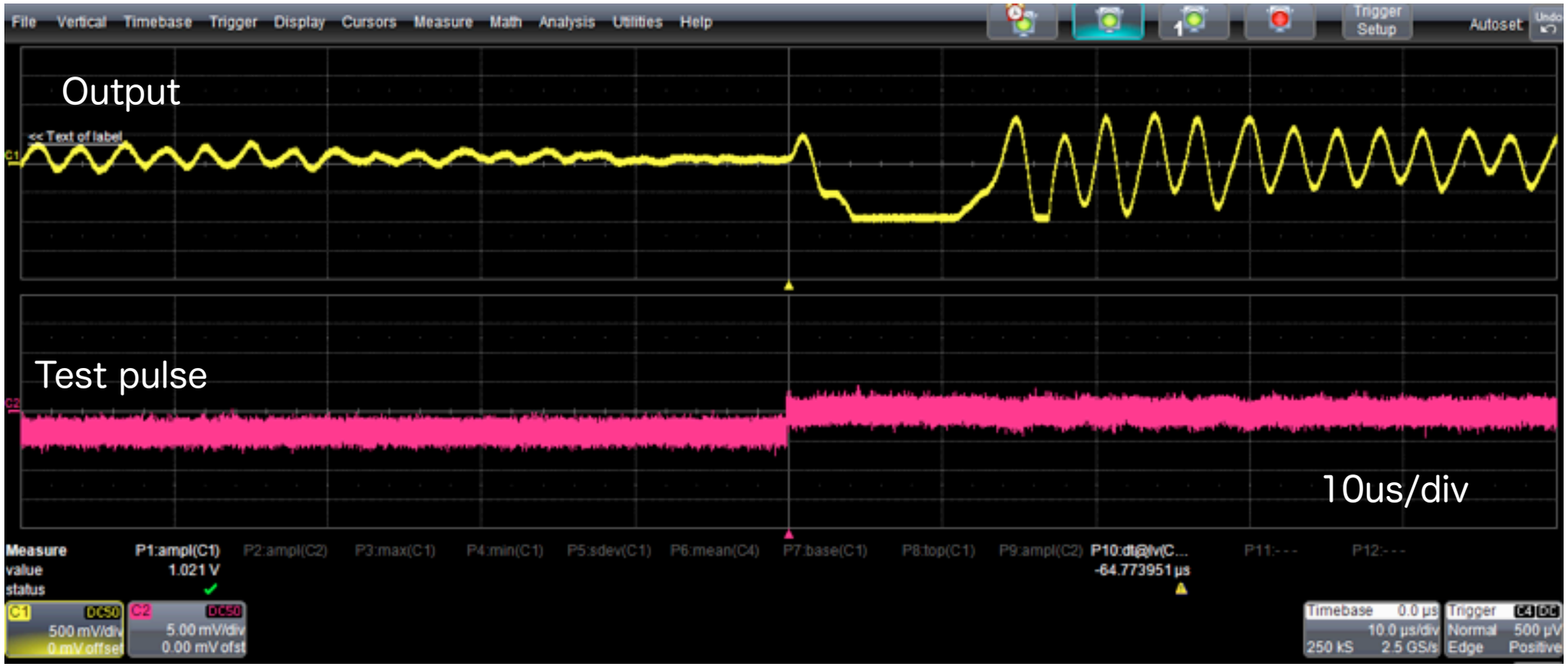
For individual part number please refer to SpiTan Software for frequency and temperature behavior found on AVX Corporation website.

Multilayer Ceramic

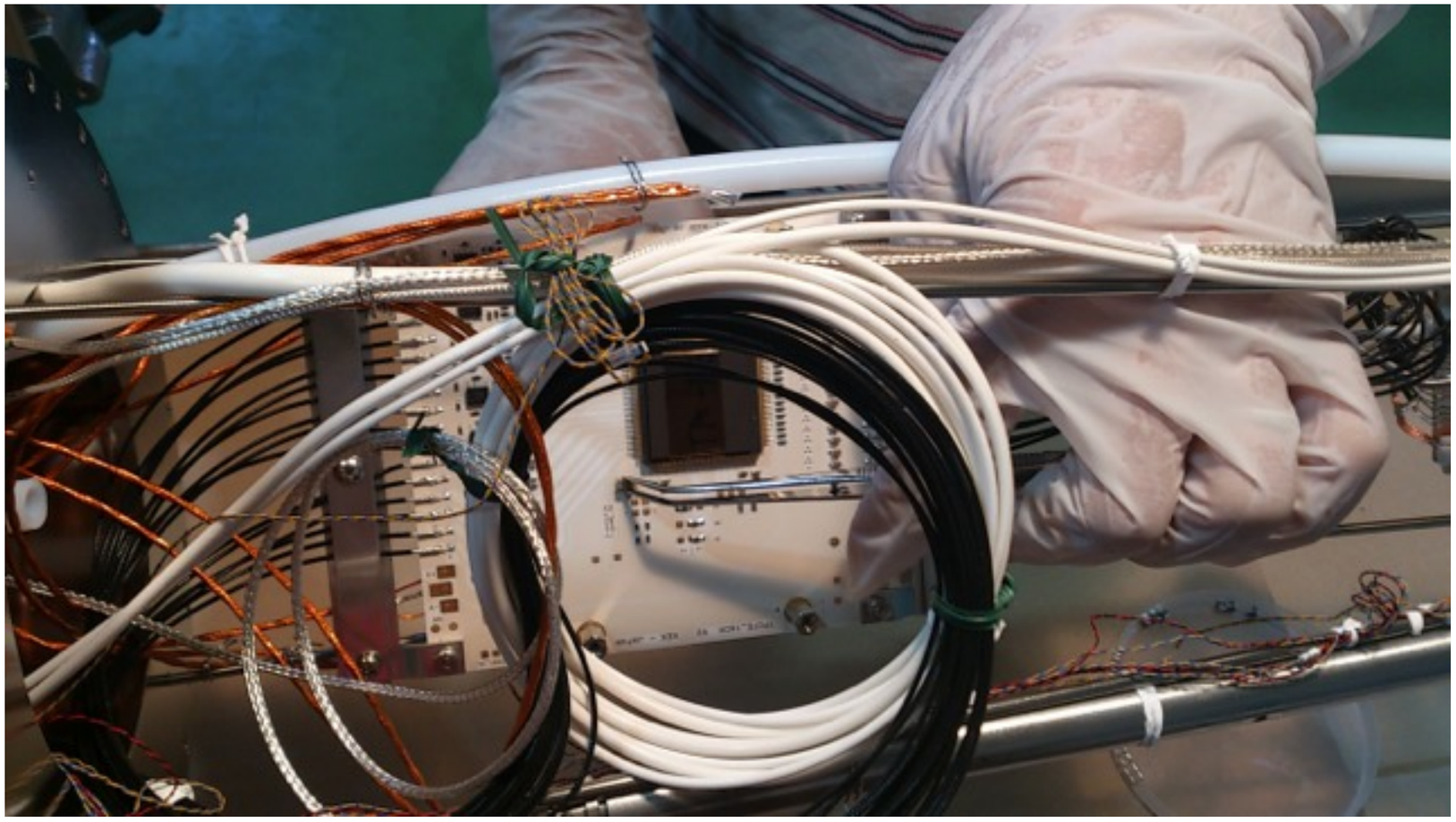


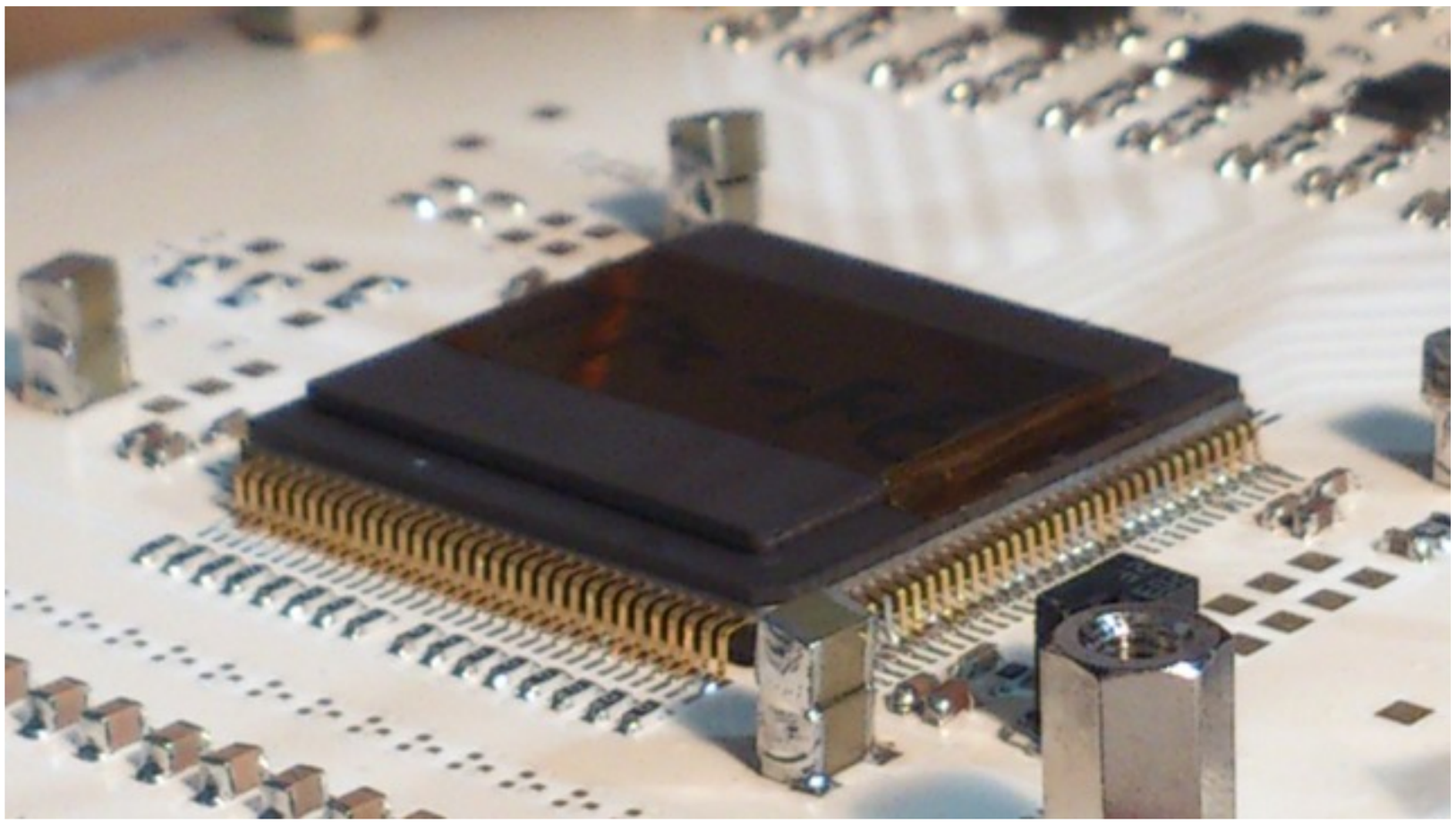
Solid-Tantalum (F950G337MBAAQ2, ESR=0.6Ω, 330uF x 2)





2013年 11月 30日 土曜日





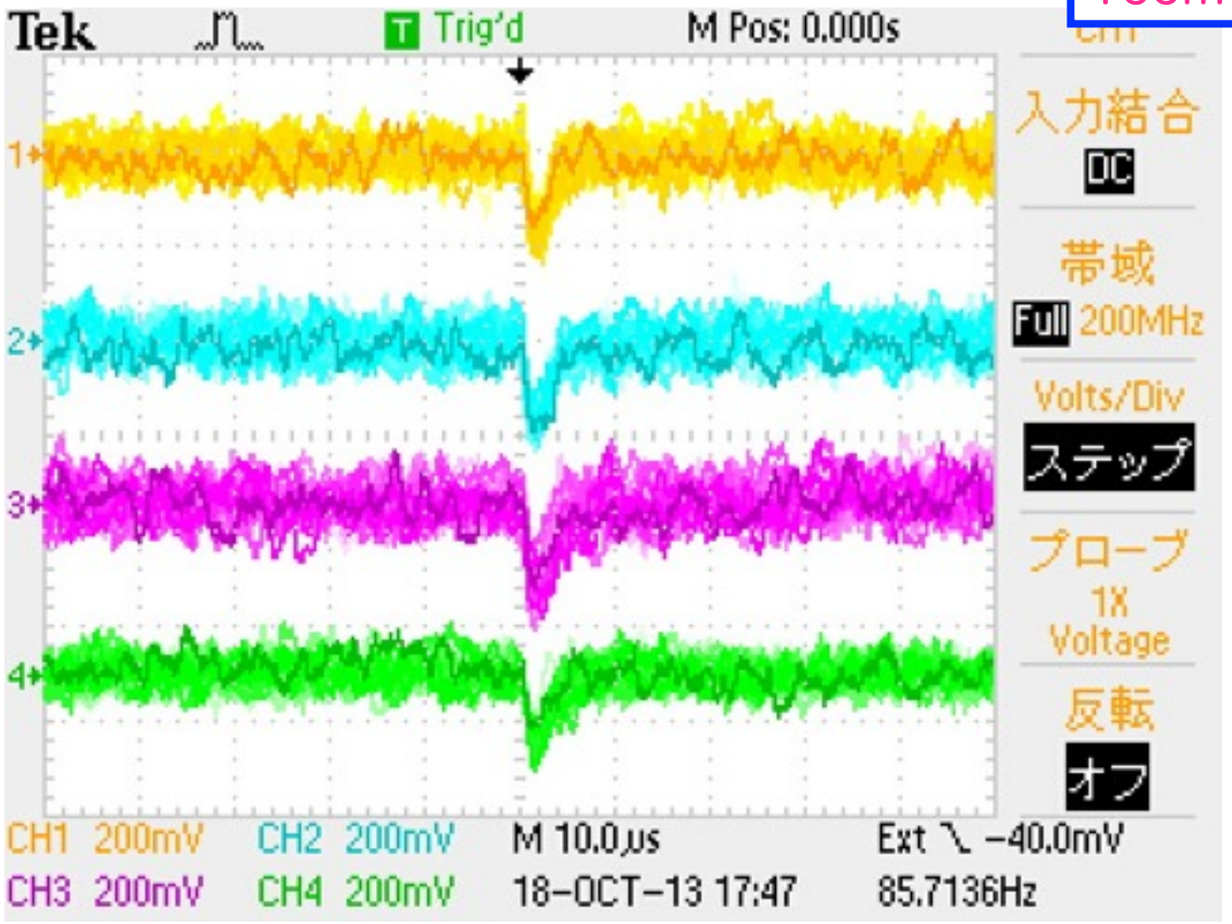
Multilayer Ceramic (
AMK324ABJ337MM,
330uF x 2, ESR=0.002Ω)
at each ±1.25V ,
i.e. 6 points in total

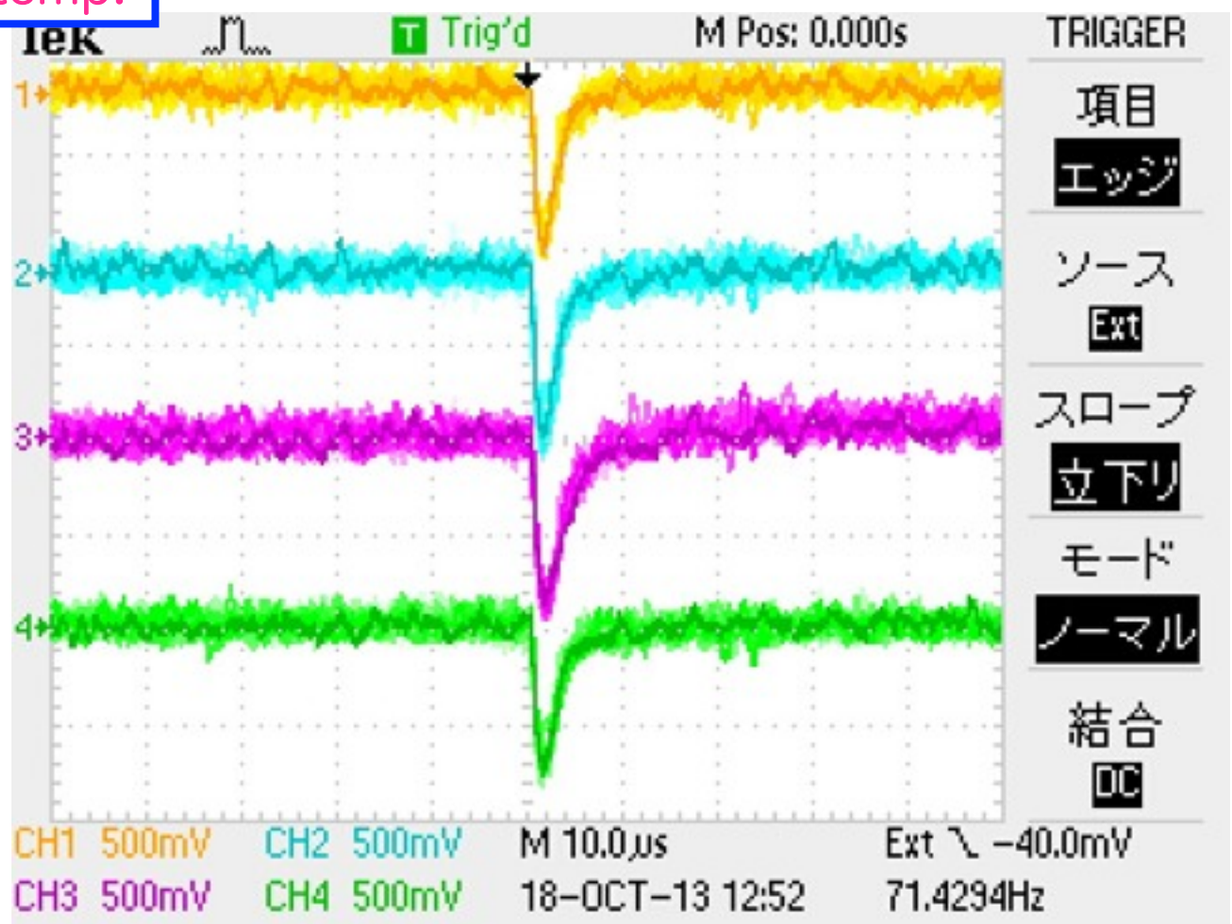
2013.10.18

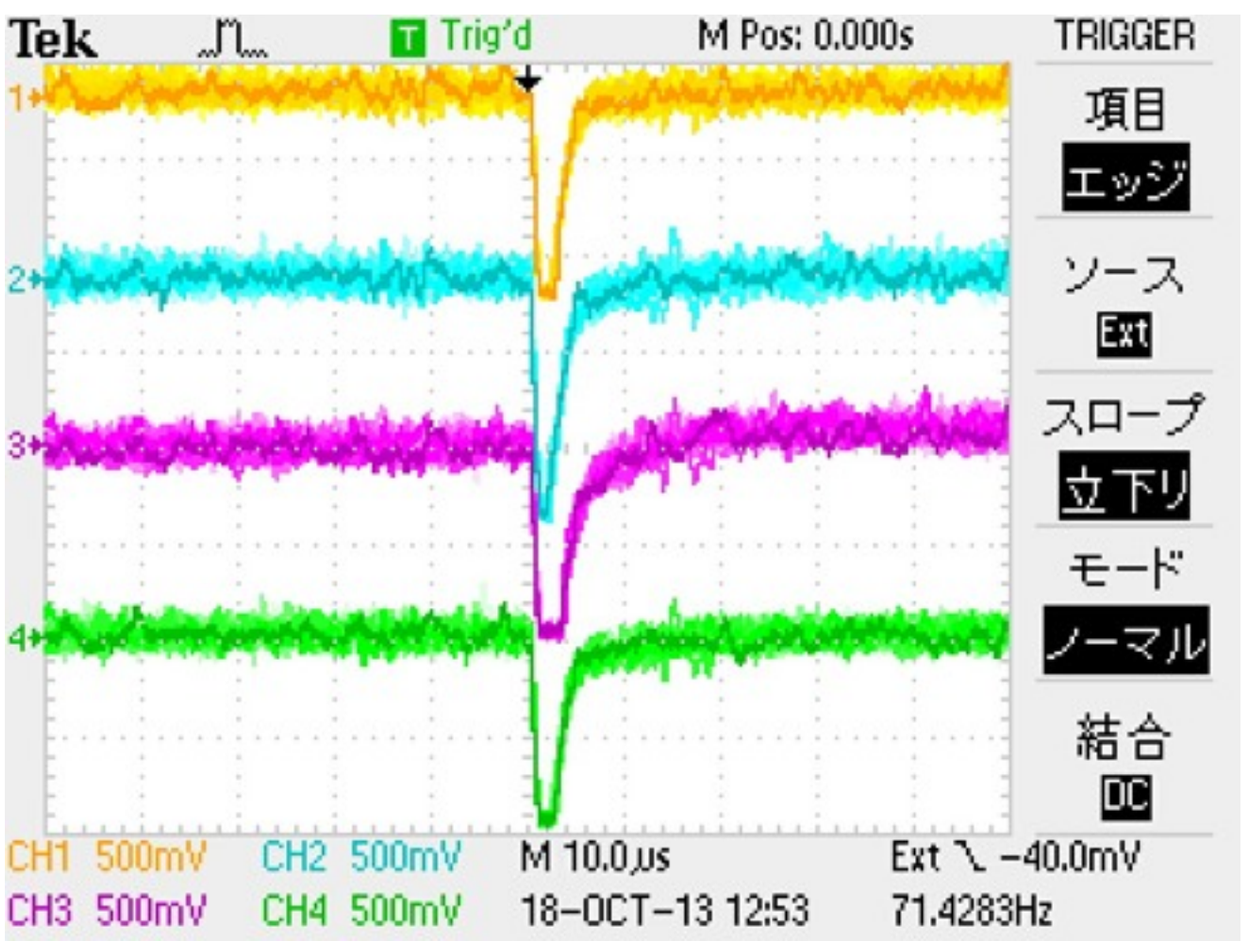
Test pulse, square, 50Hz, 0.025V, 31dB

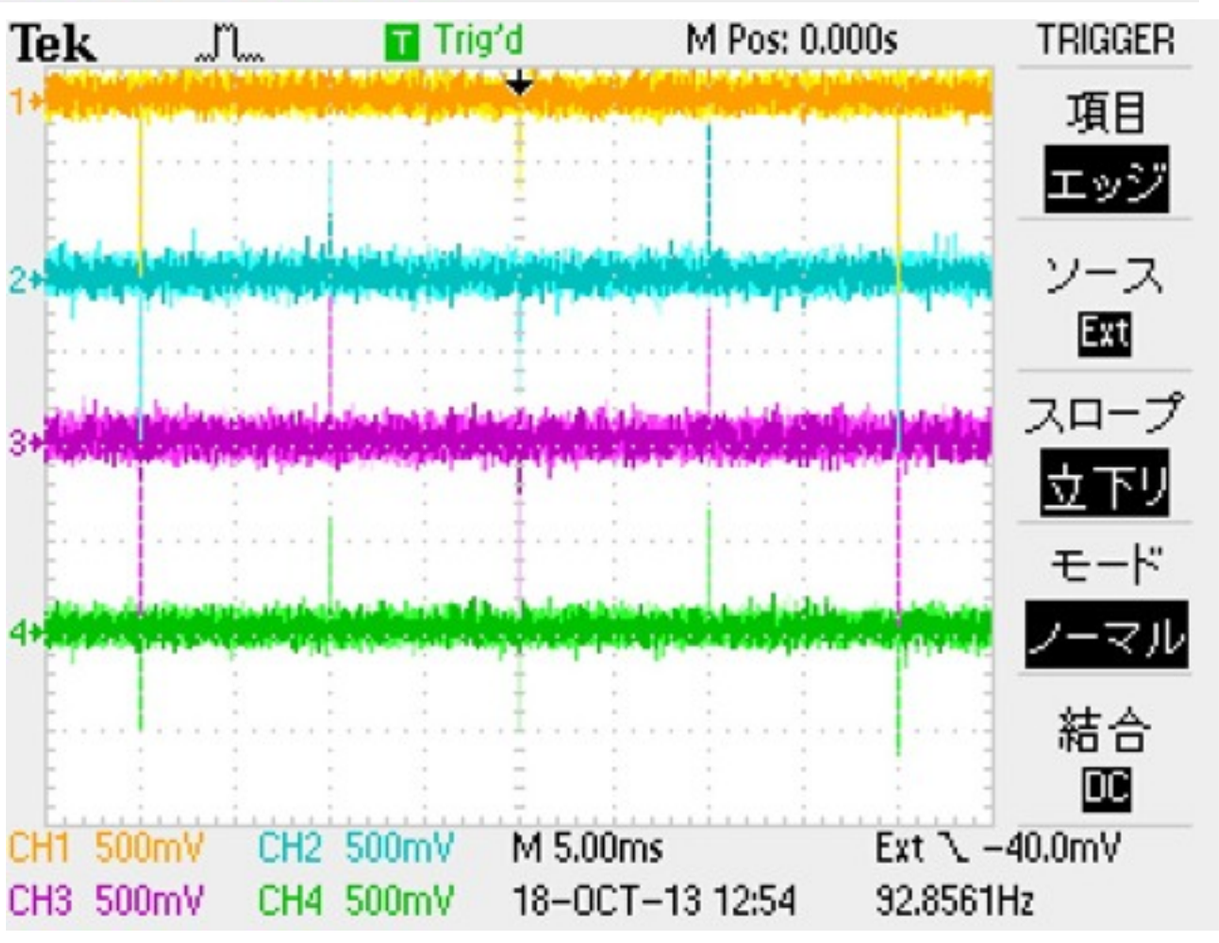
room temp.

Test pulse, square, 50Hz, 0.025V, 25dB



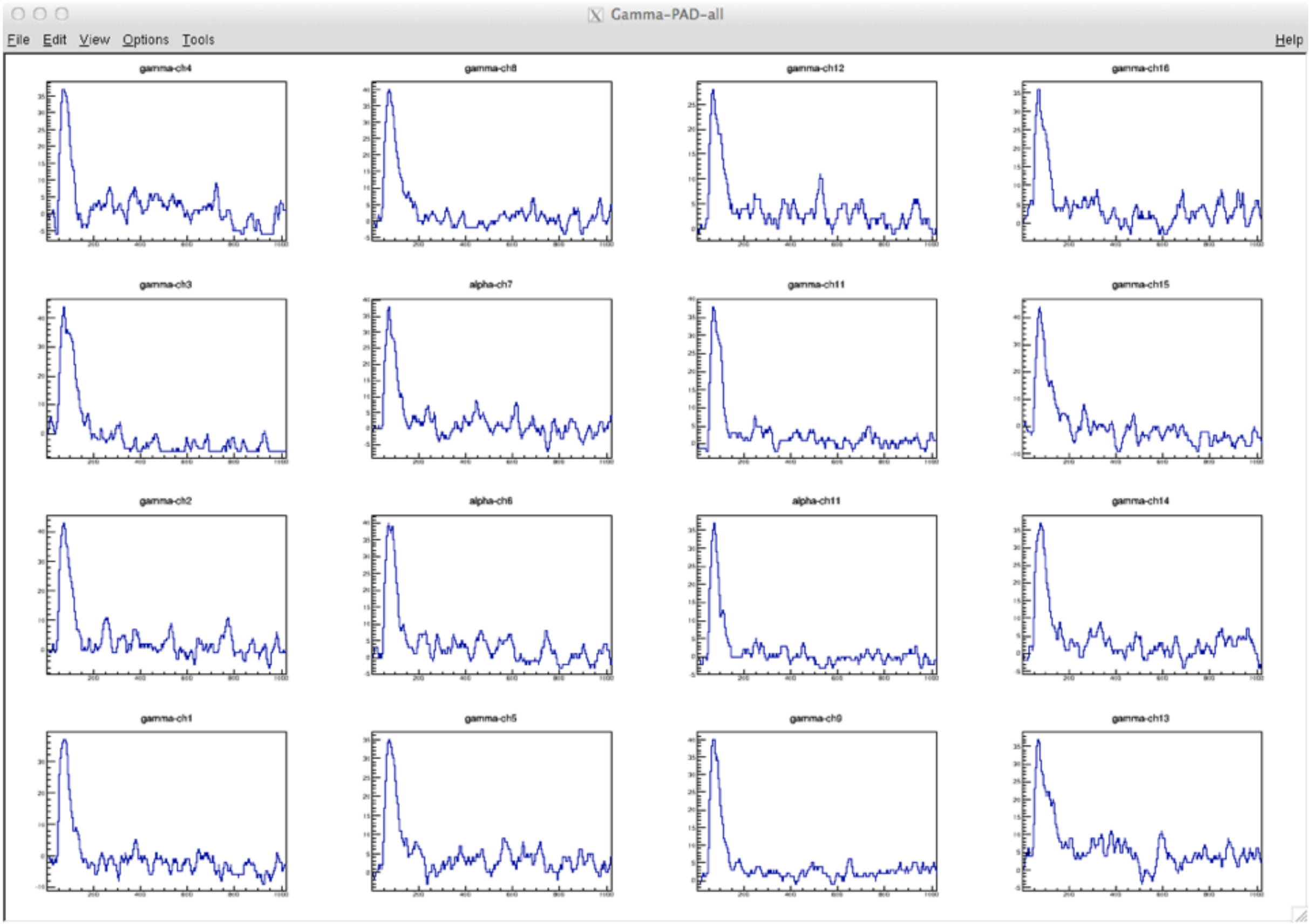




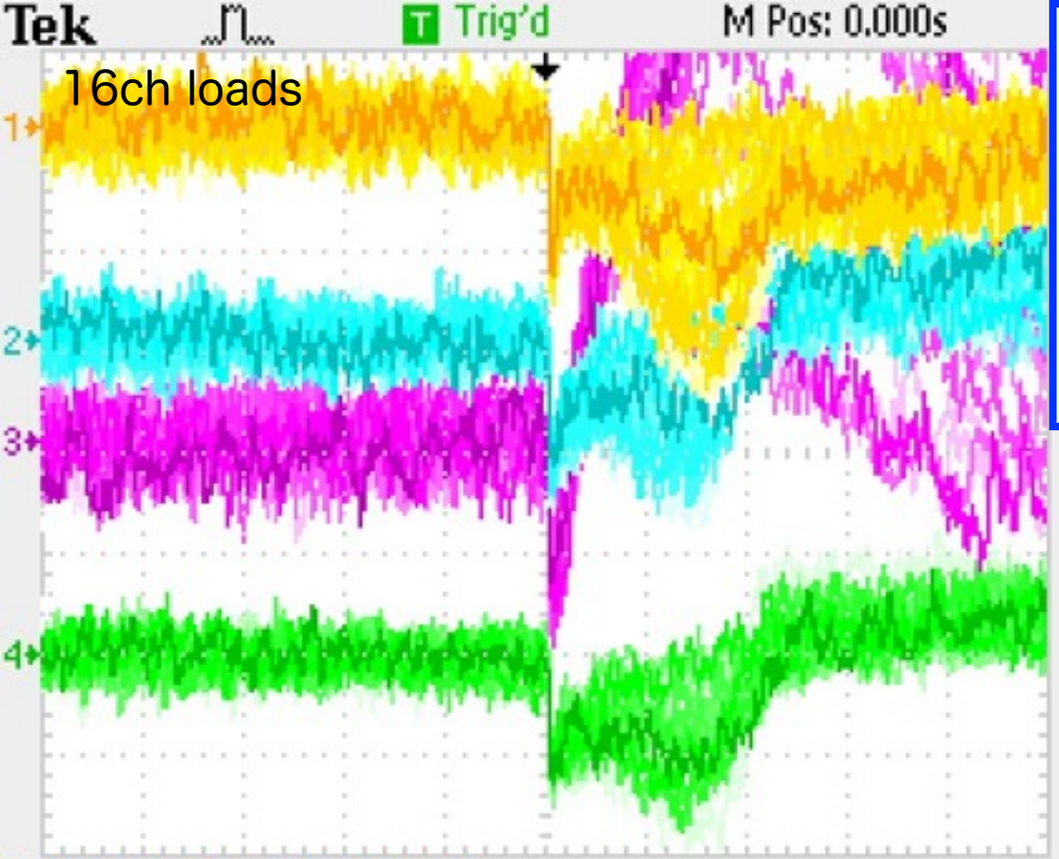


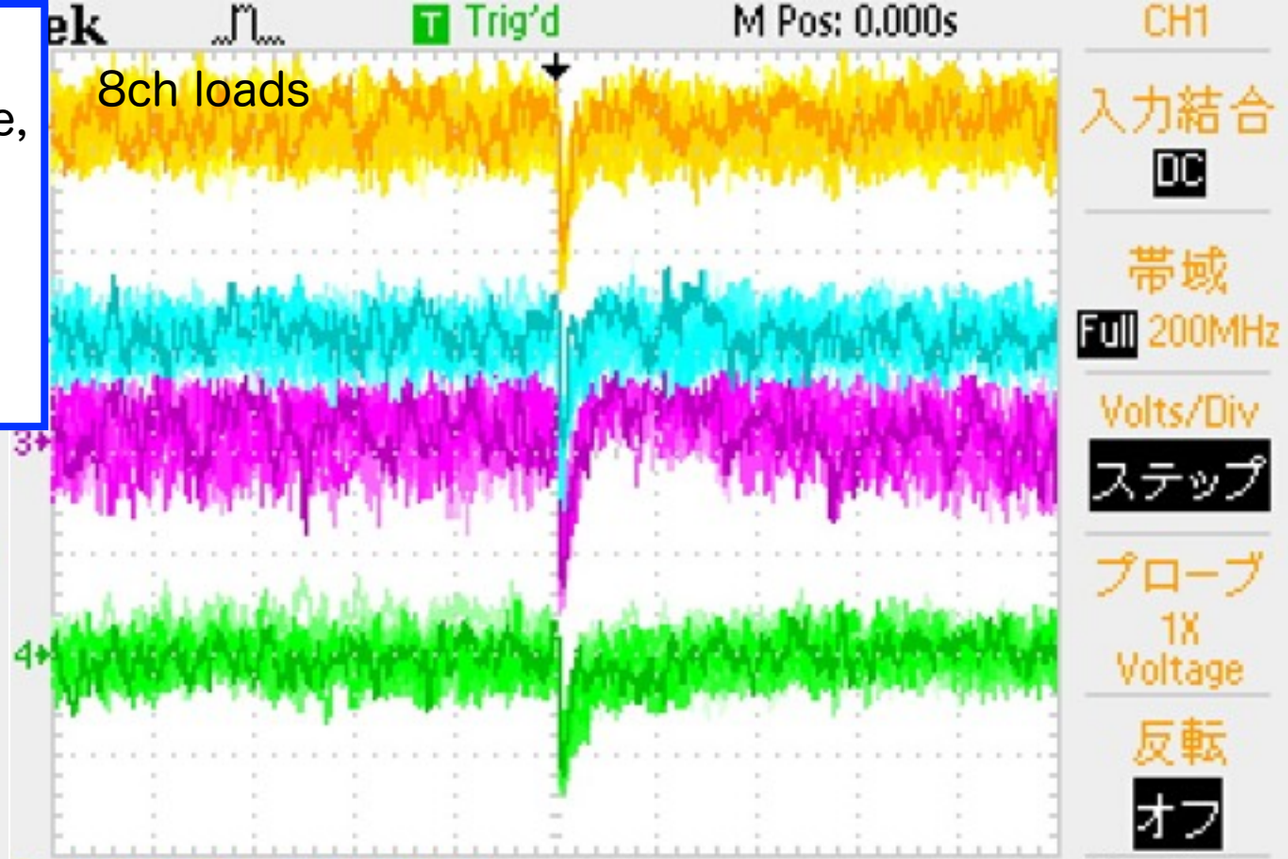
2013年 11月 18日 月曜日

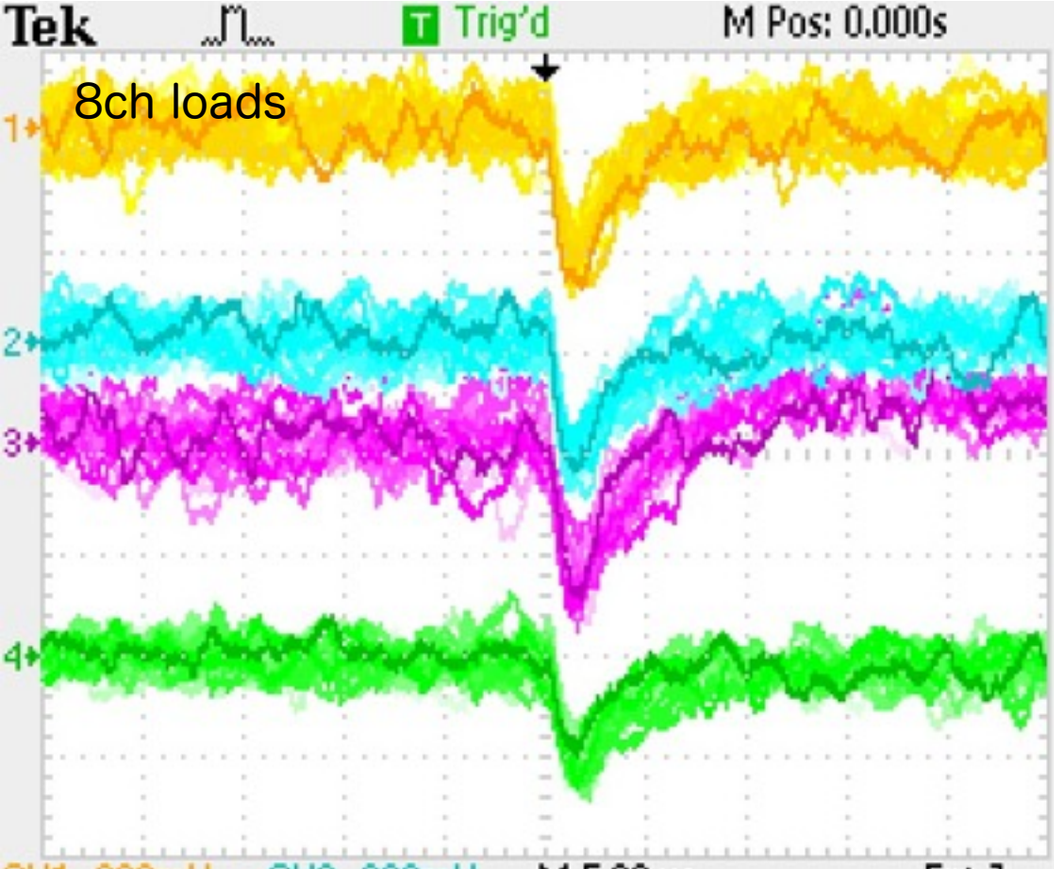
Test pulse : oct13/181746, event no.=4, no baseline subtraction, room temperature

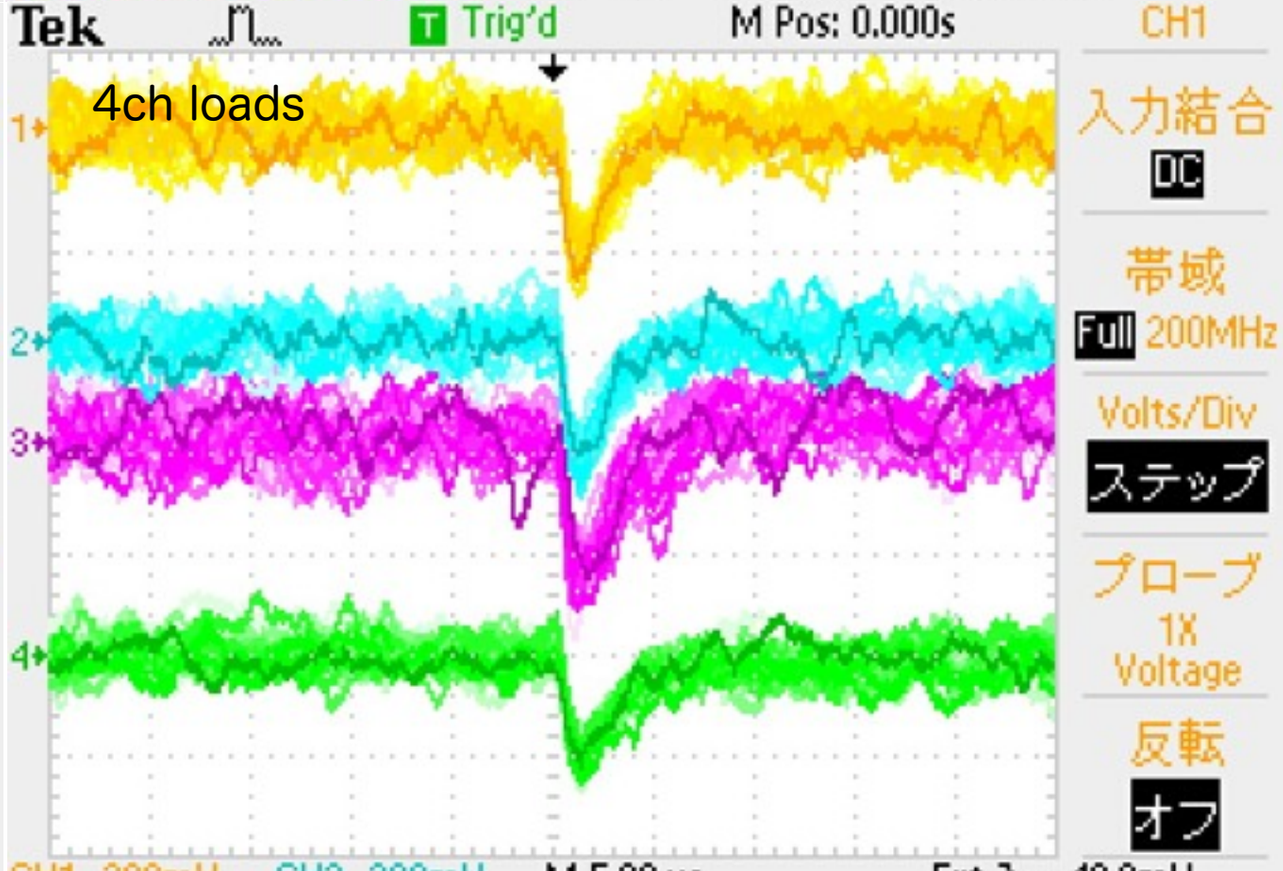


Liq.Xe
Test pulse,
square,
50Hz,
0.025V,
31dB



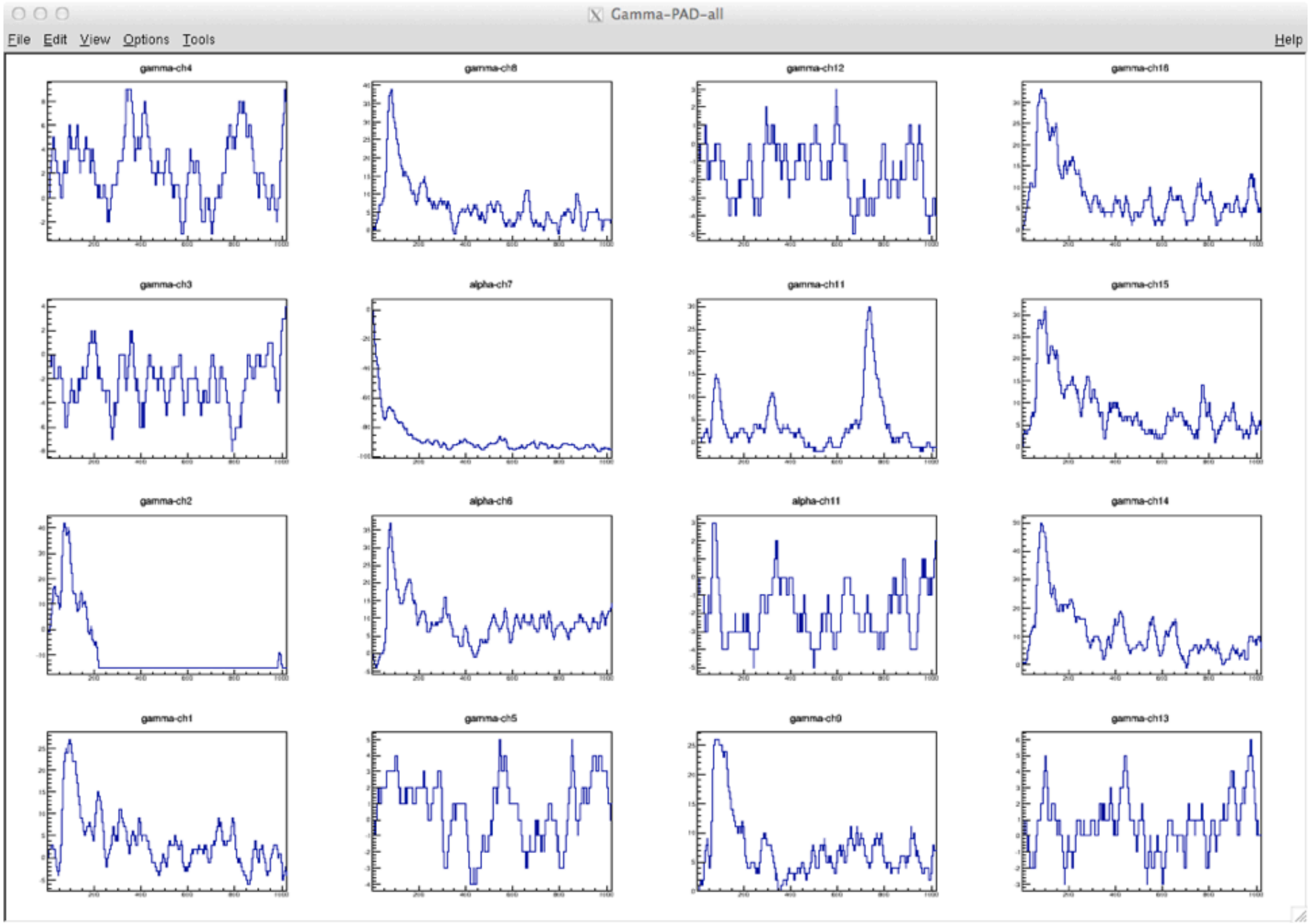






2013年 11月 18日 月曜日

Test pulse : nov13/081625, event no.=4, no baseline subtraction, Liq.Xe temperature



LTspiceによる回路シミュレーション

再現できず

ただし、TPCFE09以外のシミュレーション

まとめ

1．液面と電荷シグナルの関係
　液面計による電荷シグナルの消える液面：108mm, 118mm ?
　液面 > 120mm（ アノード面=約90mm ）

2．コンプレッサーからのノイズ対策
　TPCプロトタイプから約10m離したが、ノイズの軽減は見られなかった。

7．ASICのTPCFE09用の基板（FR4, LTCC）の製作:
　回路シミュレーション + TPCFE09/FR4の試験で最適化
　168mV/fC, -7fC<入力<+7fC　(バッファーアンプへAC結合でゲイン20倍)
　液体Xe温度でのゲイン期待値（実測)：0.2V/fC　(peaking time = 1μsec)

8．TPCFE09/LTCCの常温試験
　テストパルス入力ですべての出力に50Ω負荷を与えると、大きくリンギングする。
　対策として、電源±1.25V用の６カ所のパスコンを100uF（積層セラミック）から
　330uF x 2 (積層セラミック）に交換。　動作OK。
　（注意：同容量の固体タンタルは逆効果であった。）

9．TPCFE09/LTCCの液体キセノン温度での動作
　8ch以上の出力を50Ω負荷すると、リンギングが現れる。

10．γ線源から8ch以上同時に電荷シグナルが発生することはまれで、低温試験を続行中。
　TPCFE09も含んだ回路シミュレーションによる再現を試み，抜本対策を練る。

TPCX : Plan in 2013

(1) Noise reduction by isolation of He compressor as much as possible

(2) Readout of 16ch with TPCFE09

radiation sources: ^{22}Na above the anode, α2@cathode

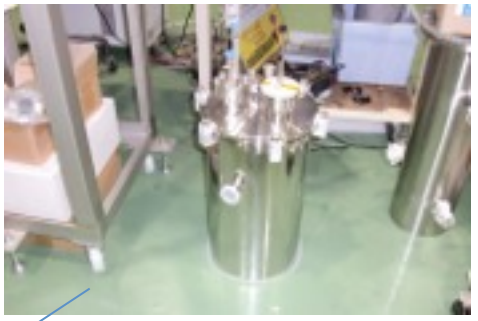
(3) Increase of gas circulation by adding a PTR

(4) In addition, heat exchanger with vacuum insulation will be used

ガスハンドリングパネル

ガス循環サーキュレーター

真空断熱・熱交換器



LXeクライオスタット

冷凍機インバーターノイズ大?。

TWINBIRD SC-UE15
173K@30W