

# Liquid Xenon TPC for a gamma detector (LXeTPC)

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D\_RD\_06, FJPPL10 Workshop  
15-16 June 2010

# LXeTPC project

since 2007.4 as a KEKDTP project

Detection of KeV-MeV “gammas”  
with 3D positions and energy of  
high resolutions

**Applications** : Gamma ray astronomy;

Single Photon Emission Computed Tomography  
(SPECT), Positron Emission Tomography (PET) ;

Dark matter, Double  $\beta$  decay experiments

KEK : liquefaction & purification , PMT, TPC, DAQ

T.Tauchi, A.Maki, T.Haruyama, S.Tanaka, S.Mihara, T.Saeki  
K.Kasami, S.Suzuki

Saga univ. : TPC, simulation, FE ASIC chip, test

A.Sugiyama, T.Higashi(D4)

Tokyo univ. : TPC, PMT, simulation, test

T.Mori, Y.Fujii(M2), T.Chiba(M1)

National Institute of Radiological Science : PET

M.Kumada, T.Tomitani, C.Toramatsu

Yokohama National univ. : PMT, Xe-property

S.Nakamura, Y.Takagi (M1)

Cooperation : KEK electronics system group , DAQ

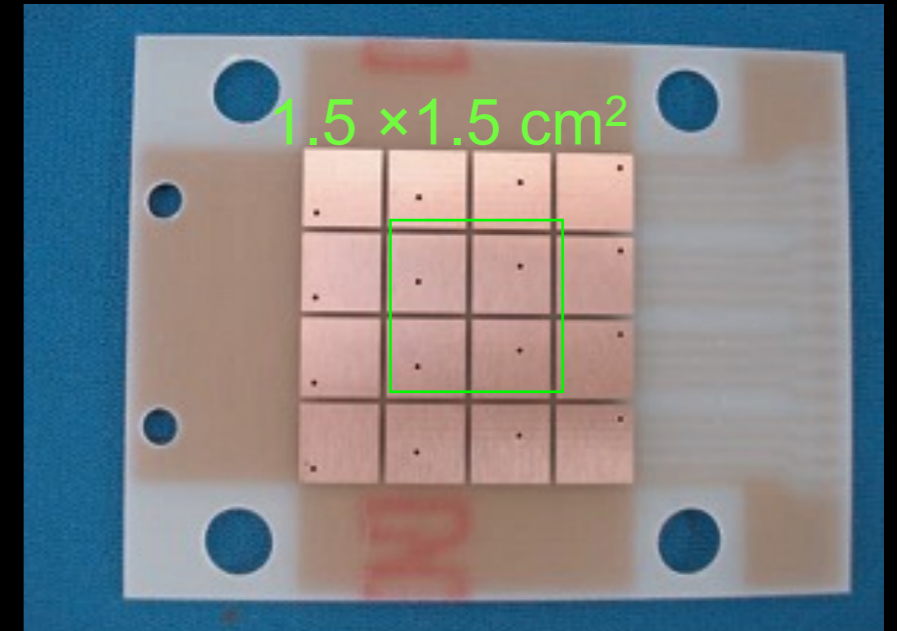
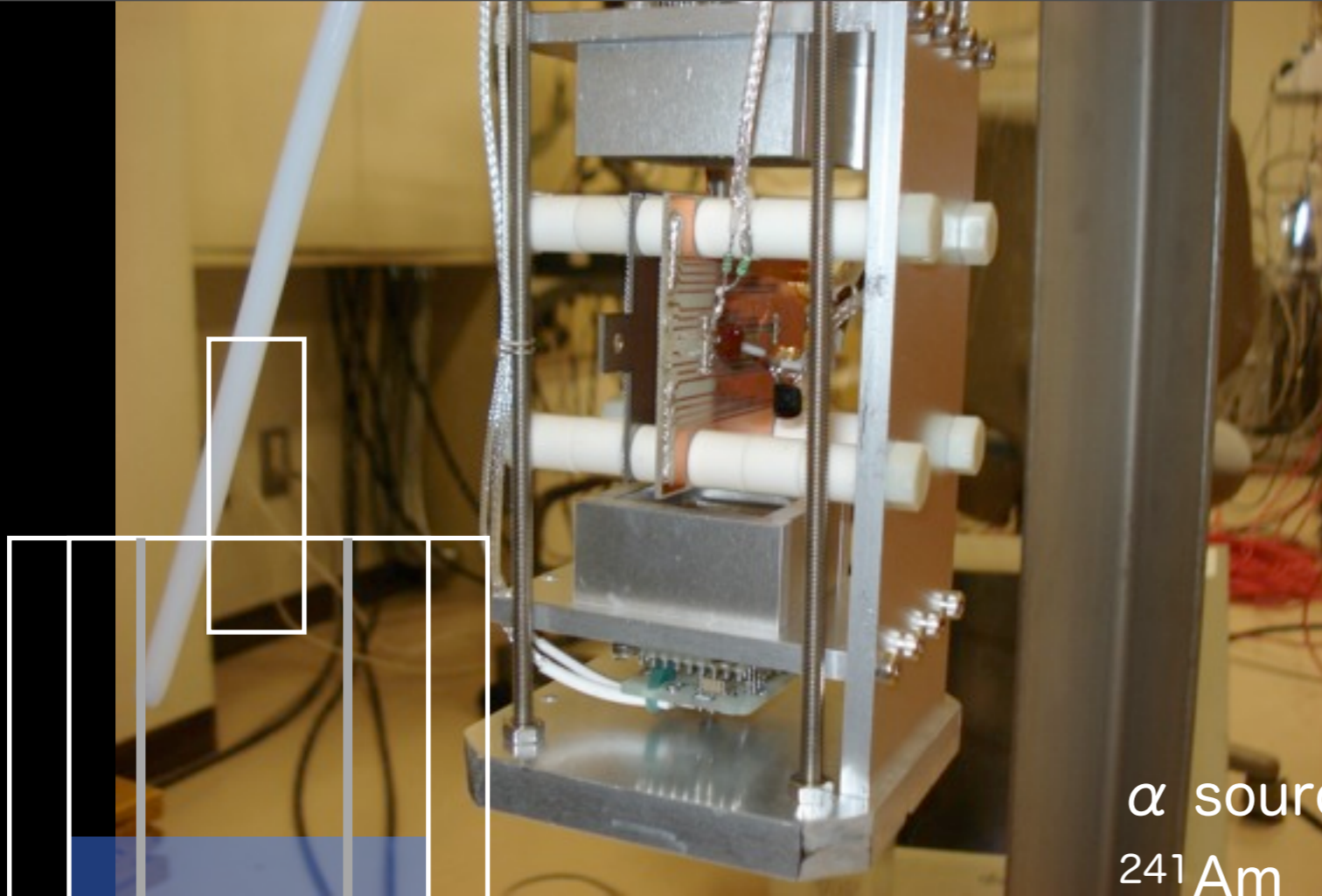
M.Tanaka et al.

# First Experiment in 2009

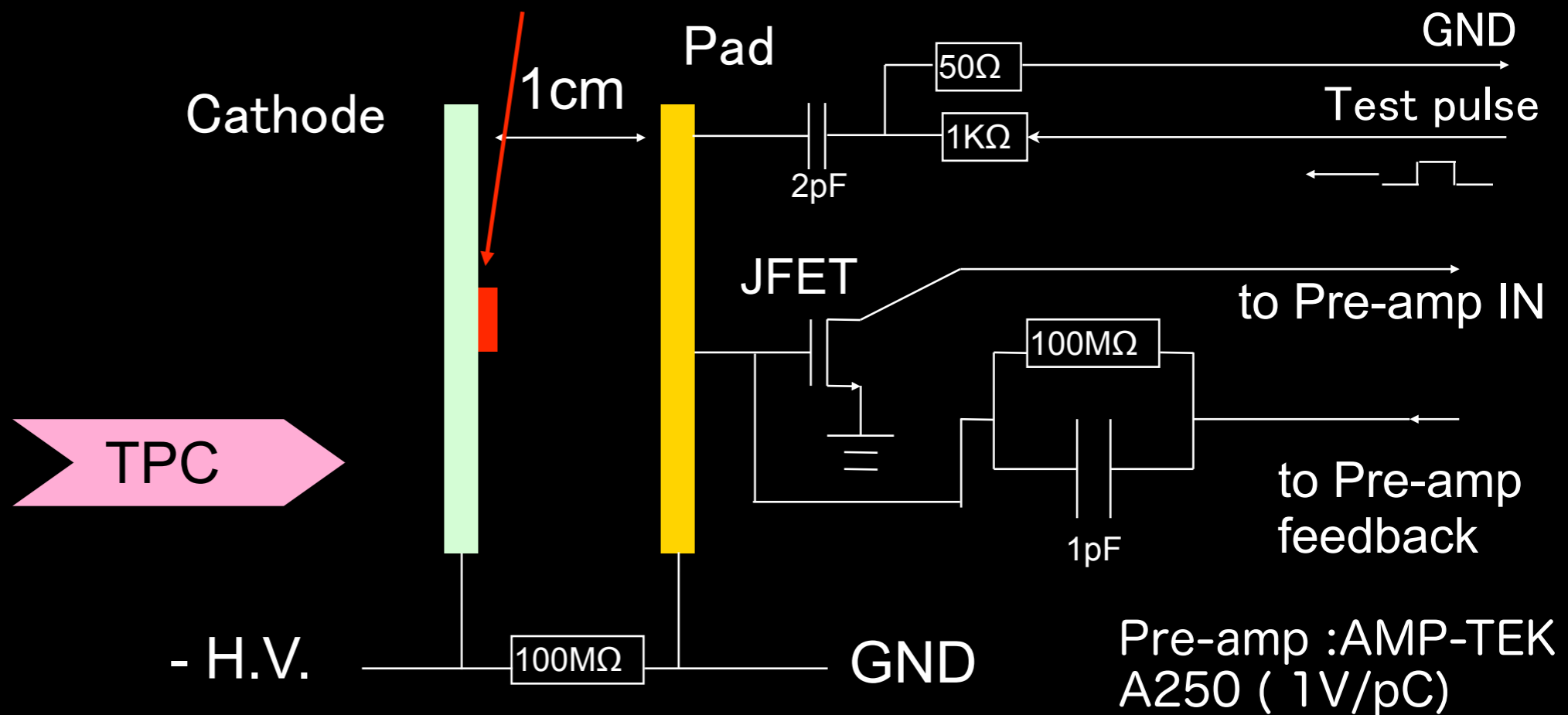
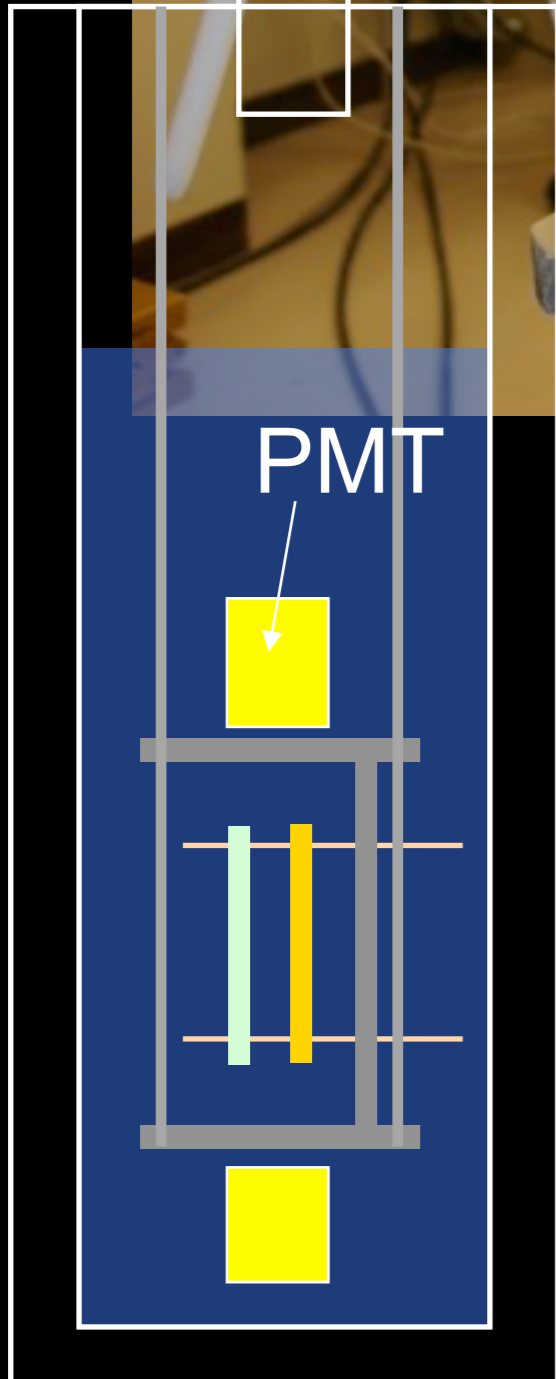
- 4/24 15:04 Start of evacuation in the chamber
- 4/27 -30 Vacuum build up tests in three times @  $1.4 \times 10^{-4}$ Pa
- 5/2 12:15 Gas phase purification/circulation with 4L/min
- 5/10 16:52 First observation of charge signals from cosmic rays(8)
- 5/20 17:40 Liquid phase purification/circulation with 1L/min
- 5/22 14:44 First observation of  $\alpha$  charge signals ( 20mV )(20)
- 6/29 17:15  $\alpha$  charge signals to 100mV w/o LPF
- 6/25 -7/9 Electric field dependence of charge and light signals
- 7/23 - 31 4ch Pre-amplifier setup and test
- 8/14 -17 Data taking with Cosmic ray trigger, about 1/min
- 9/10 Presentations at the JPS meeting by Y.Fujii (Tokyo univ.) and T.Higashi (Saga univ.) for ASIC-FE chip R&D

( days since purification/circulation )

# Experimental setup

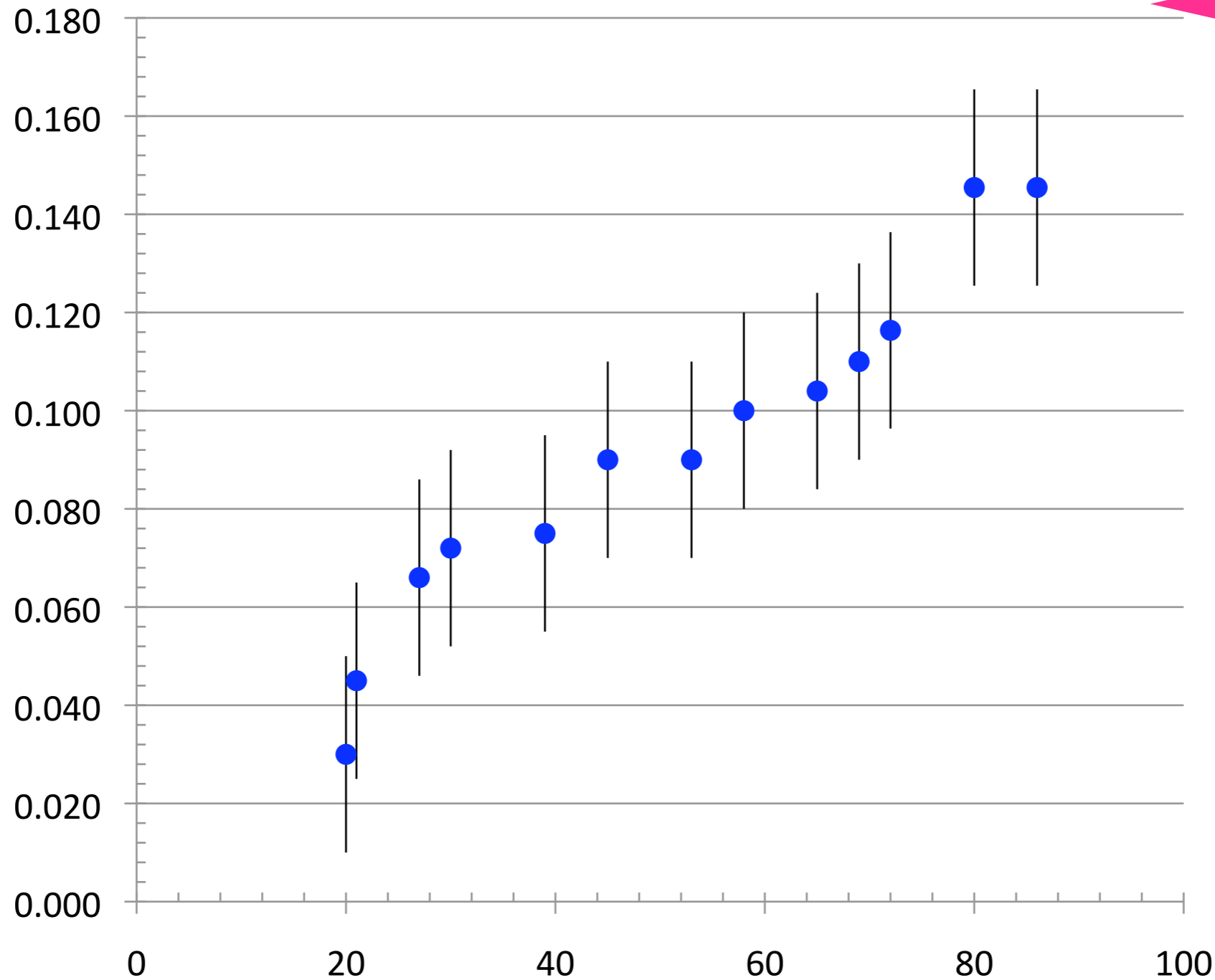


$\alpha$  source of  $^{241}\text{Am}$  (200Bq)



# $\alpha$ - signals (ch1, x80)

“Peak” Pulse Height at post-amp w/o LPF (V)



← < expectation >  
2.3fC  
assume  $Q/Q_0=4\%$   
at  $E=-2\text{kV/cm}$

5/2

5/22

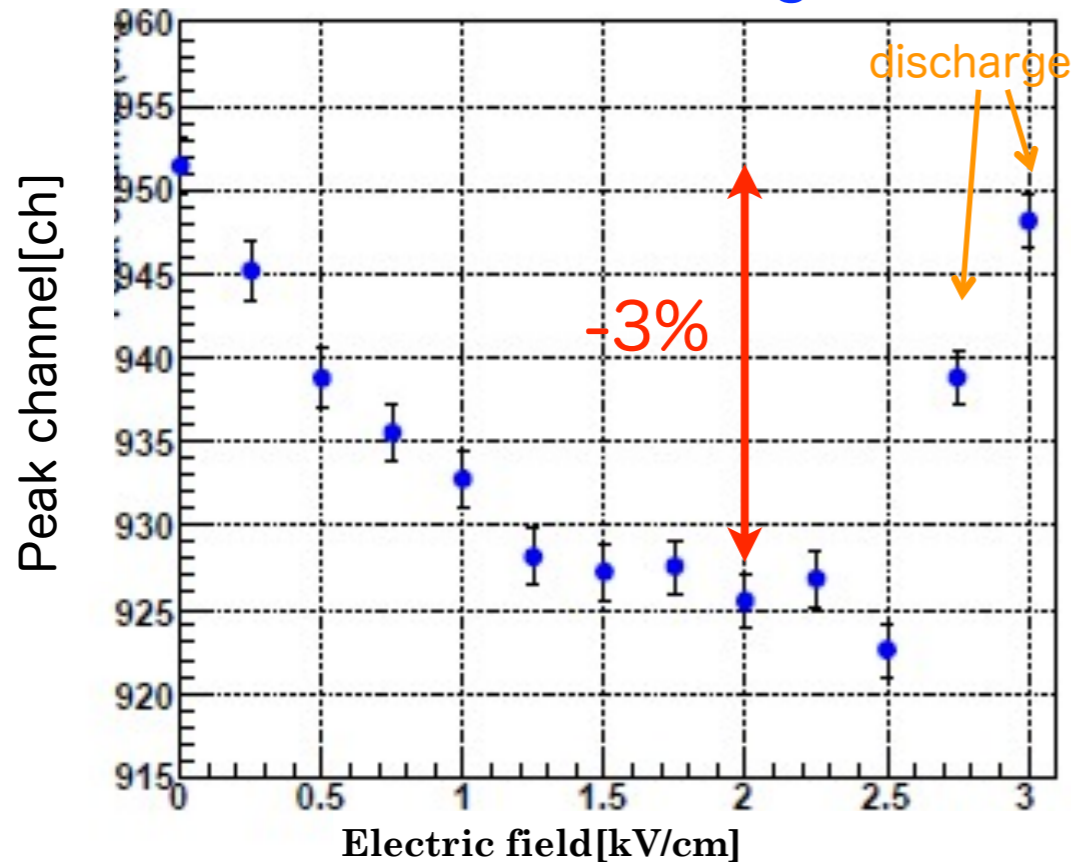
7/1

7/27

Days since 5/2

note - pulse height : w/o : w LPF = 1.5 : 1

## Scintillation Lights

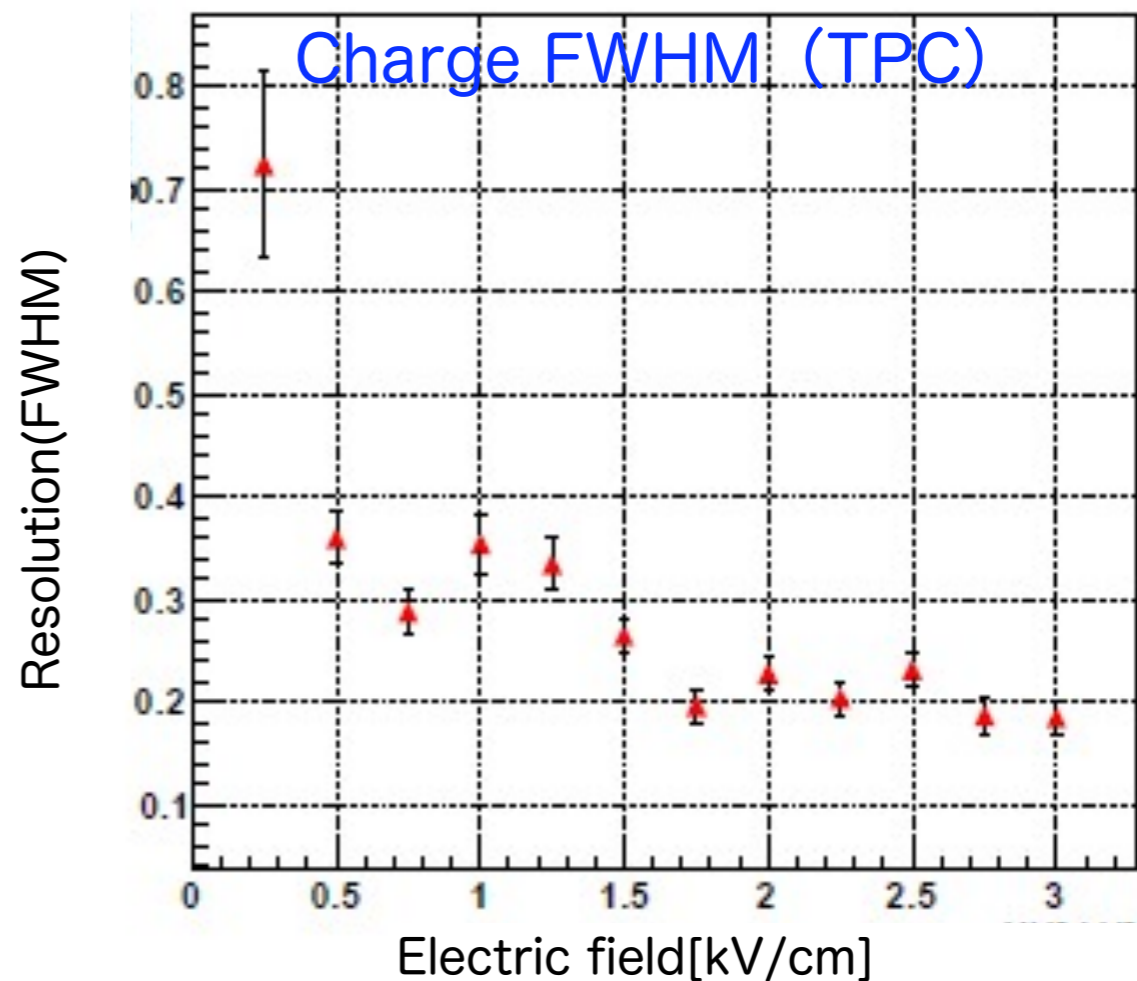
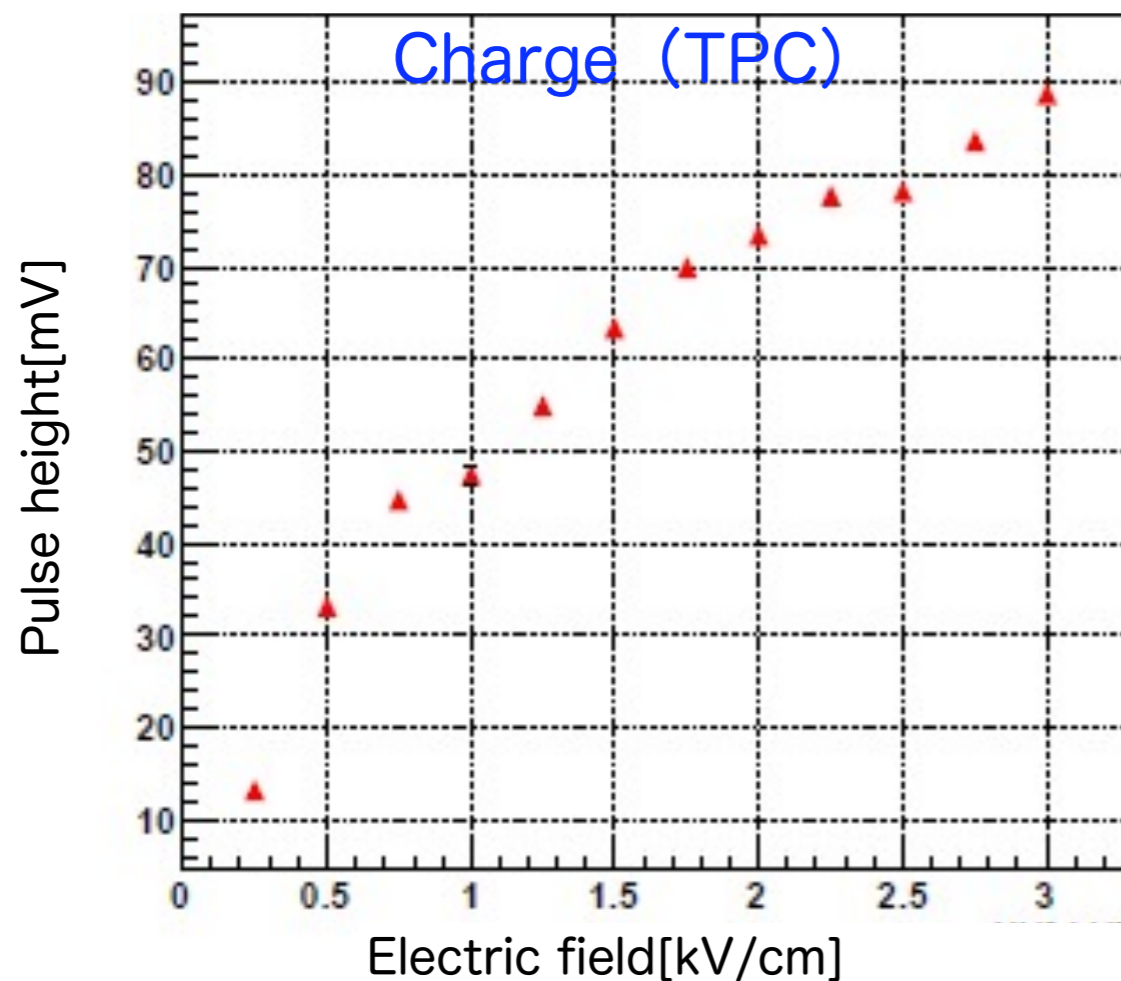


## Electric field dependence ( $\alpha$ )

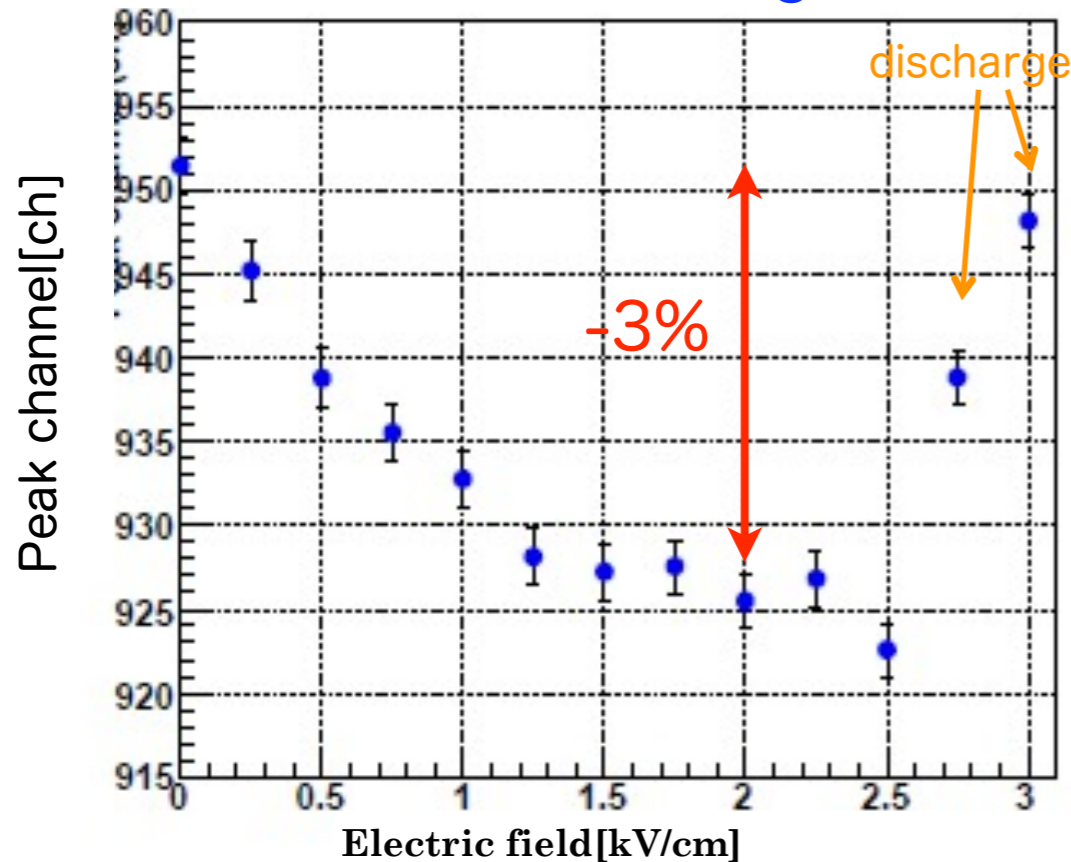
including attenuation due to impurity and drift time (E-field)

Electric field	2kV / 1kV
Scintillation lights	-3% / -2%
Charge	73mV / 46mV = 1.6
Charge res. FWHM	0.22 / 0.35 = 0.6

HV vs resolution



# Scintillation Lights

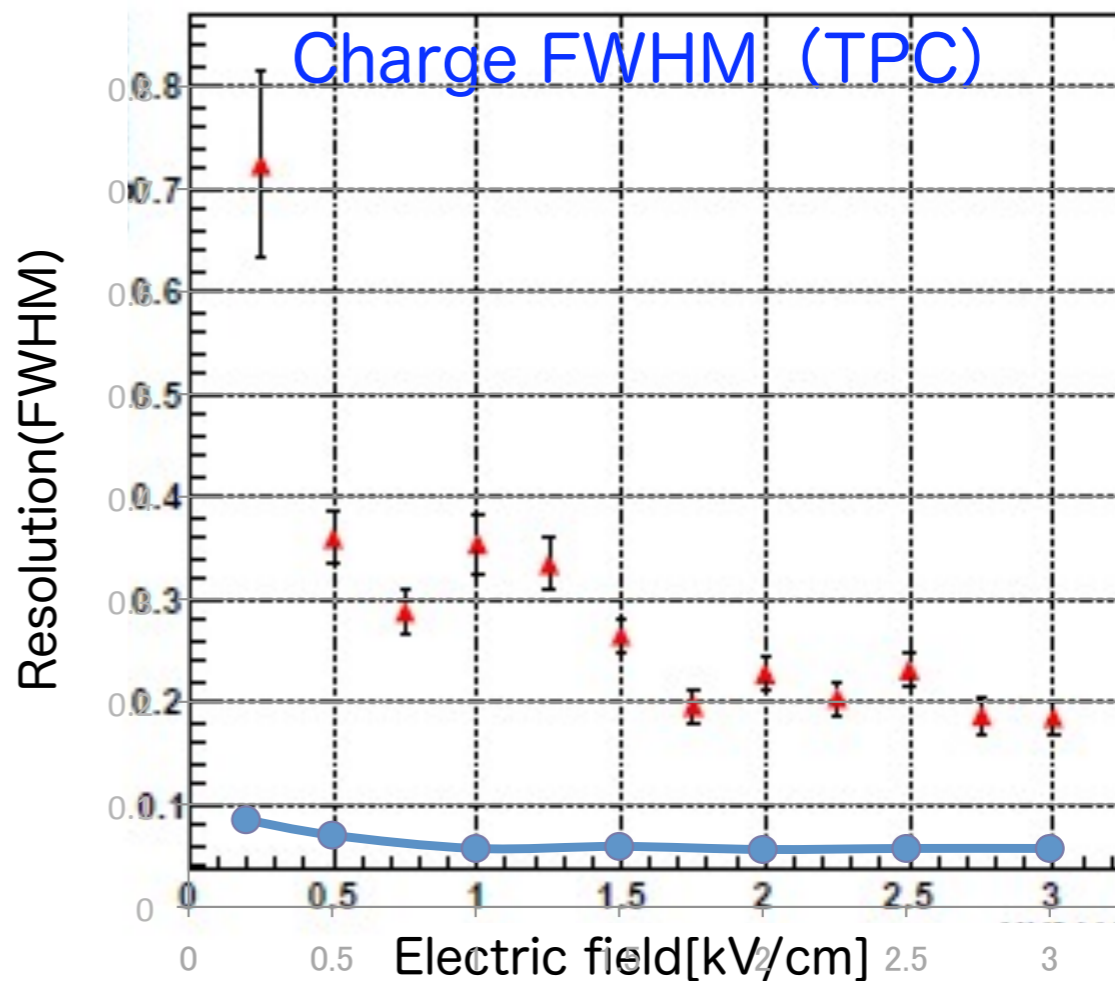
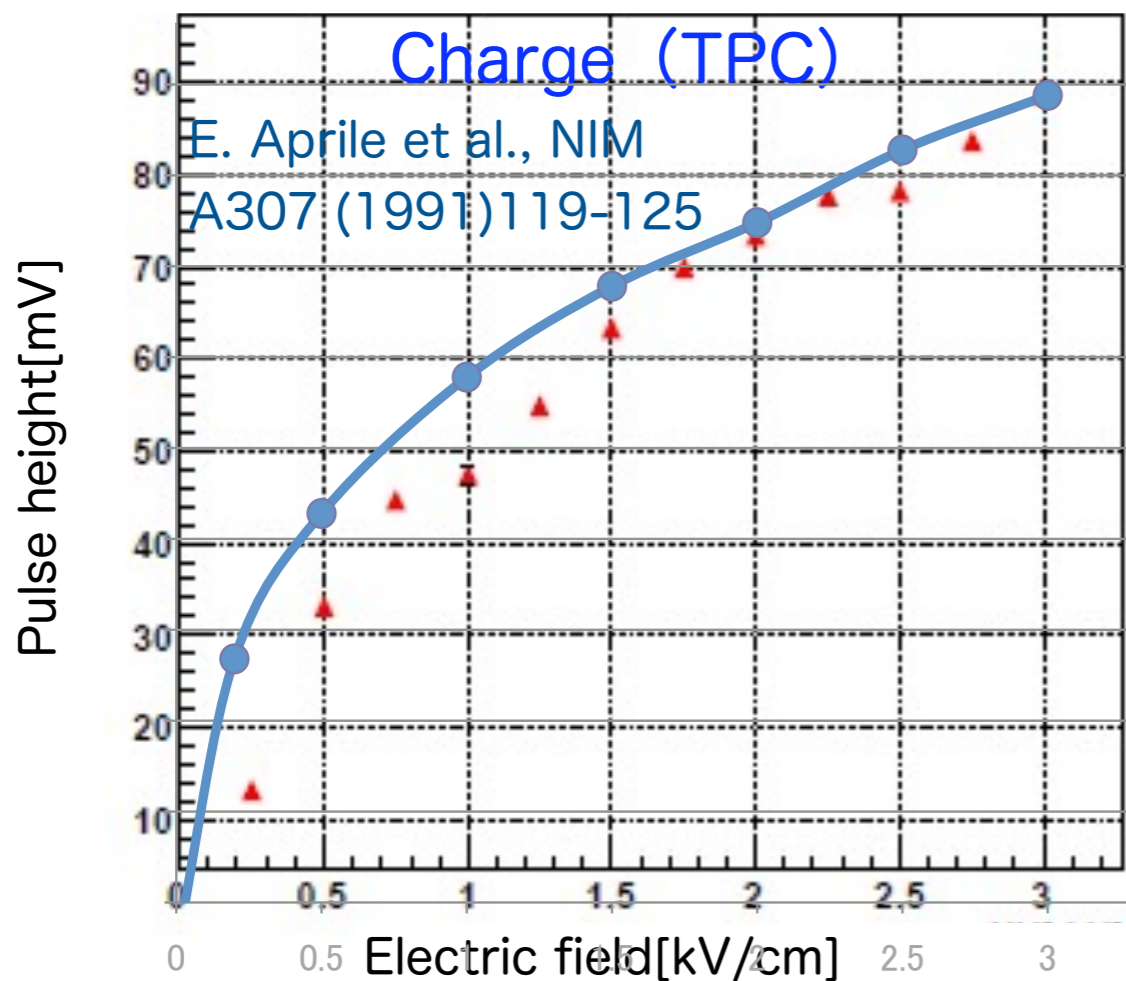


# Electric field dependence ( $\alpha$ )

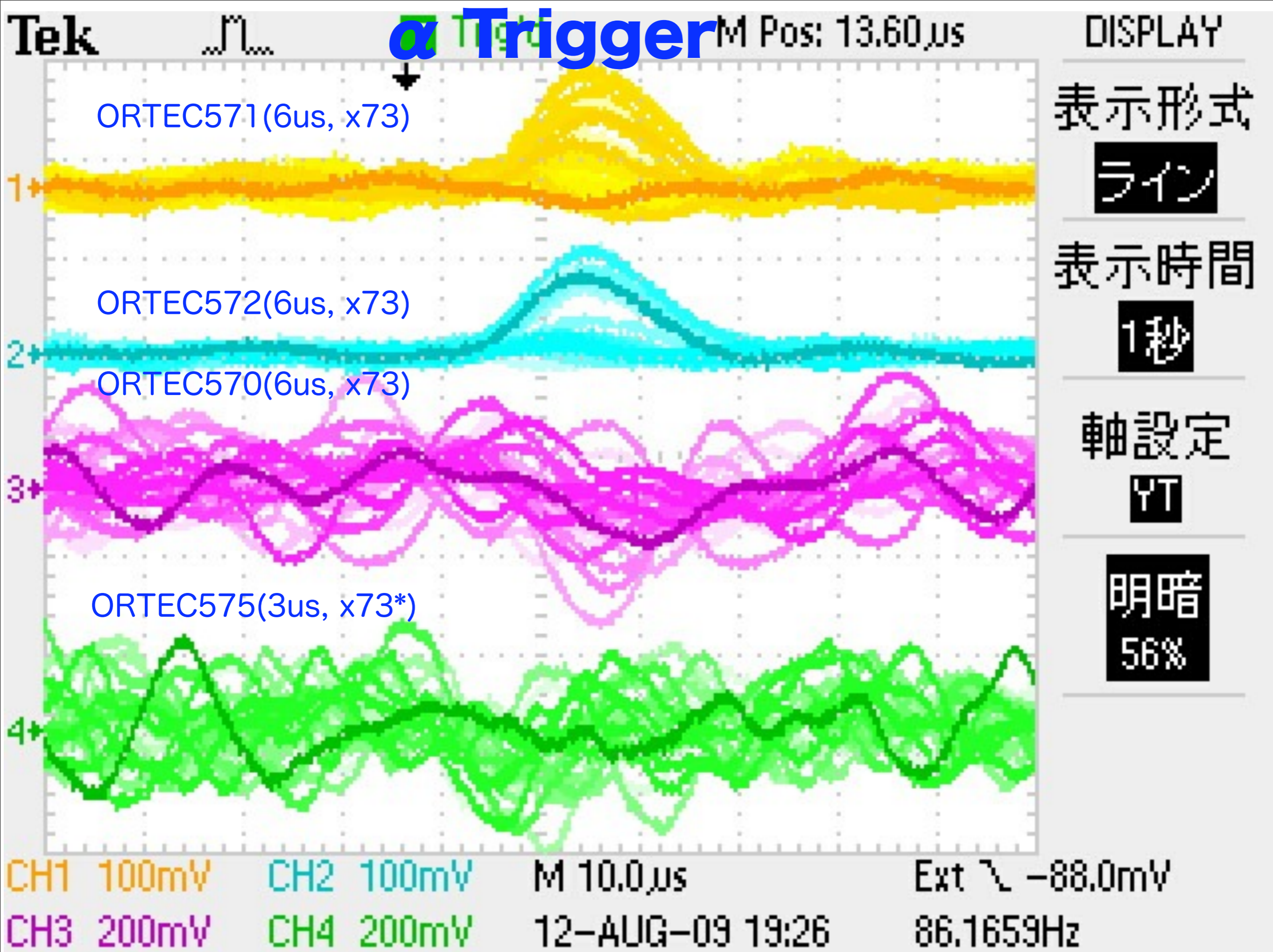
including attenuation due to impurity and drift time (E-field)

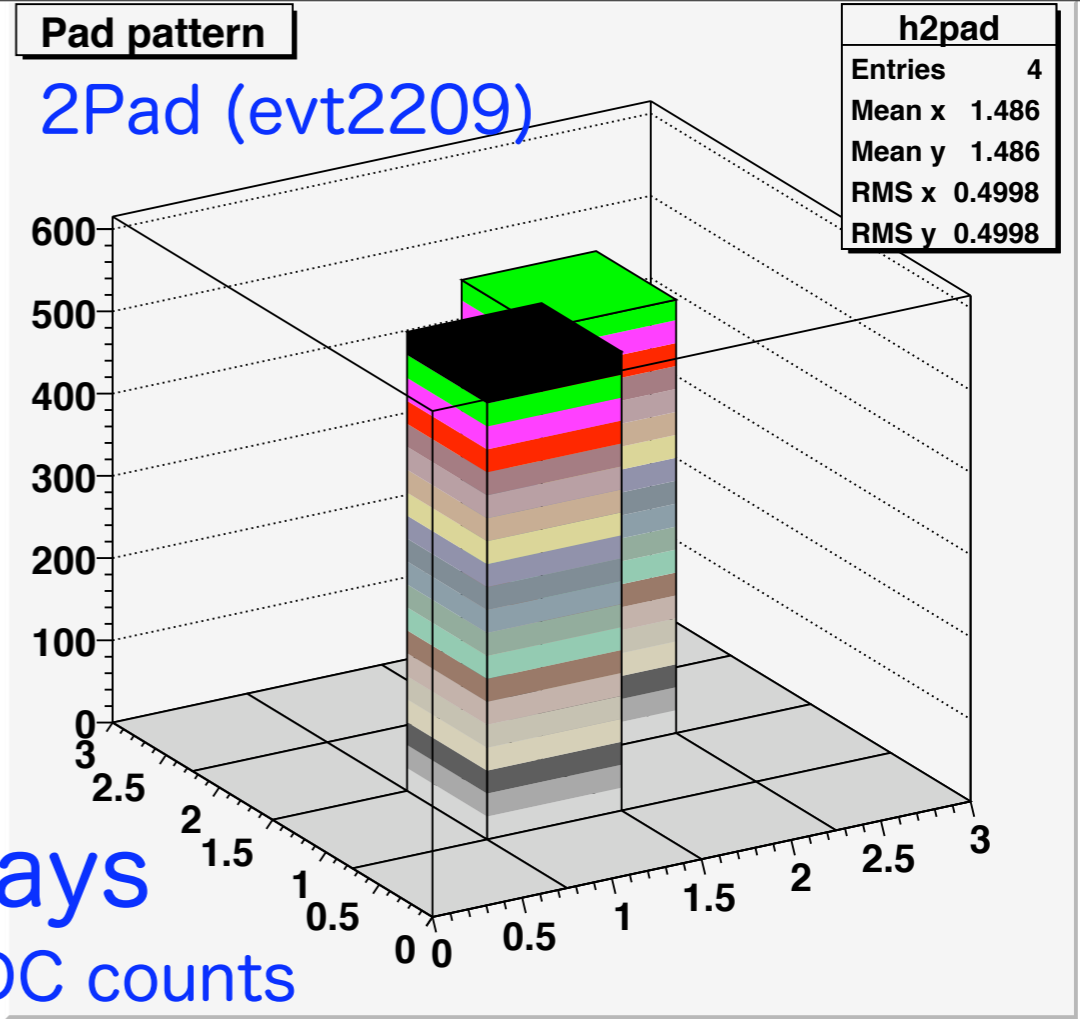
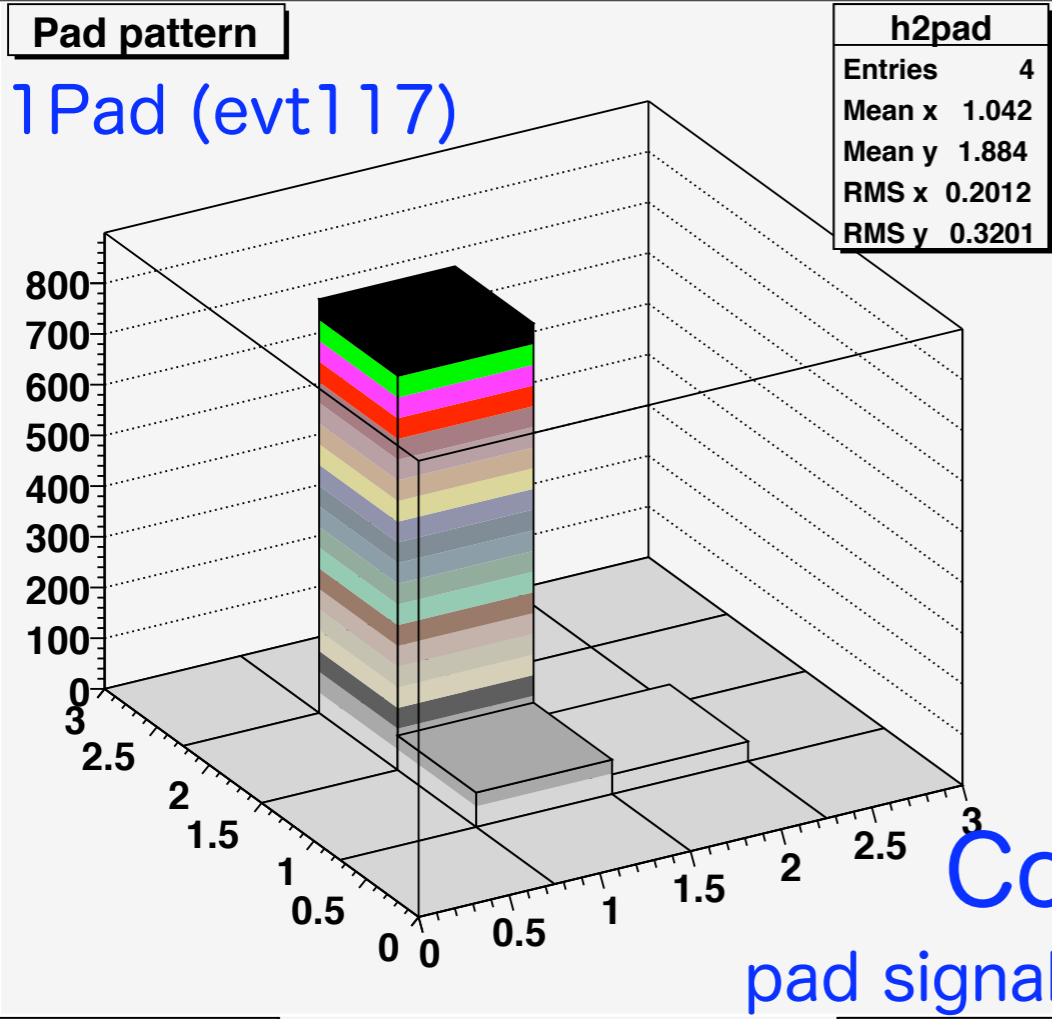
Electric field	2kV / 1kV
Scintillation lights	-3% / -2%
Charge	73mV / 46mV = 1.6
	1.27
Charge res. FWHM	0.22 / 0.35 = 0.6
	0.056/0.057 = ~1

HV vs resolution



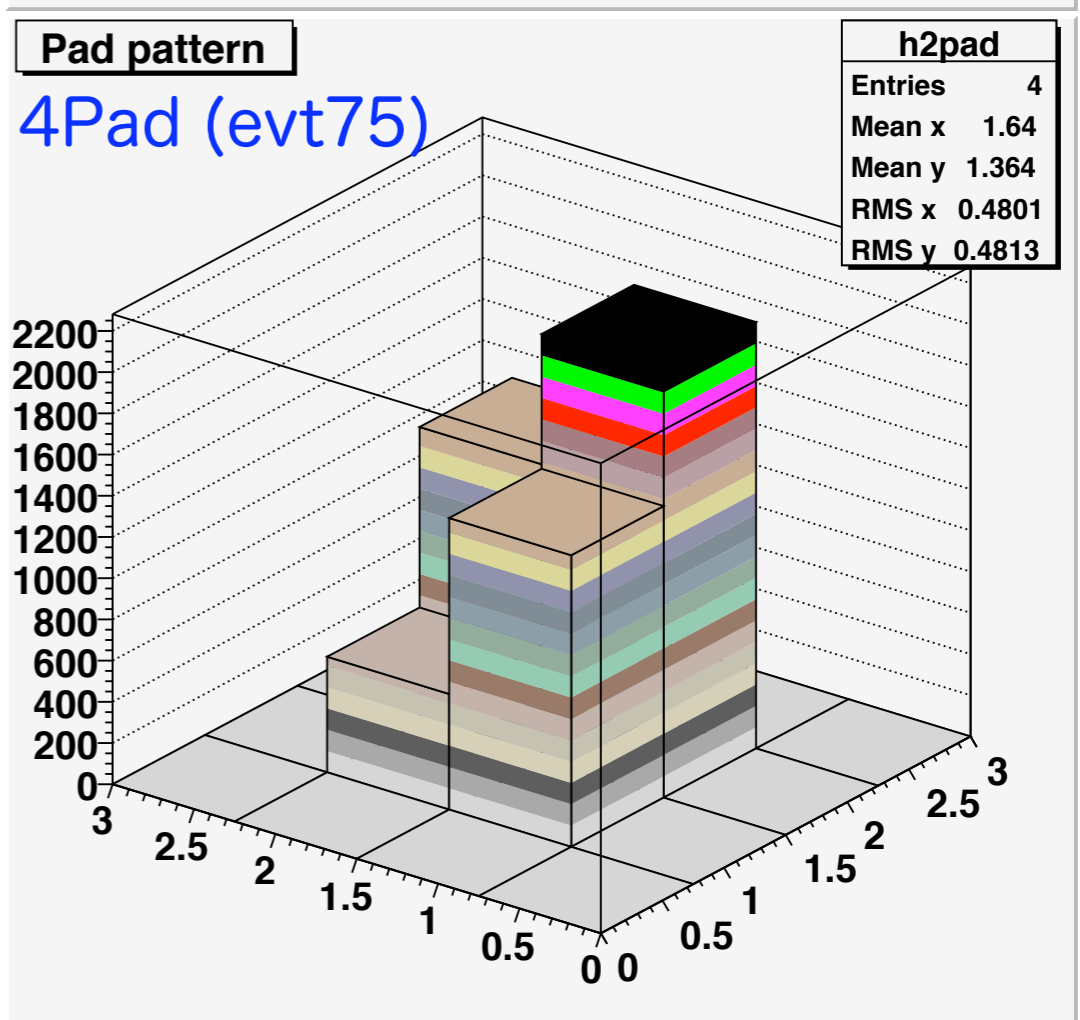
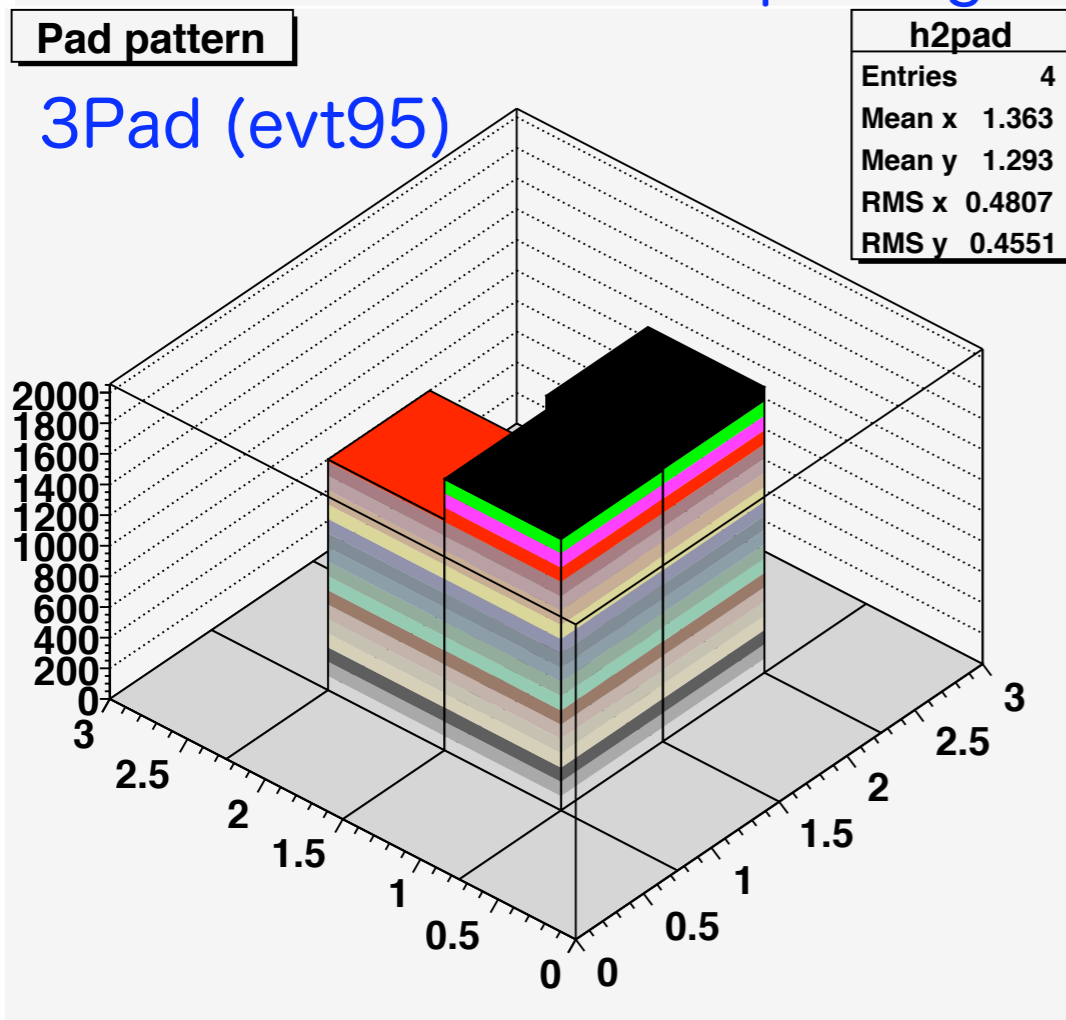






# Cosmic rays

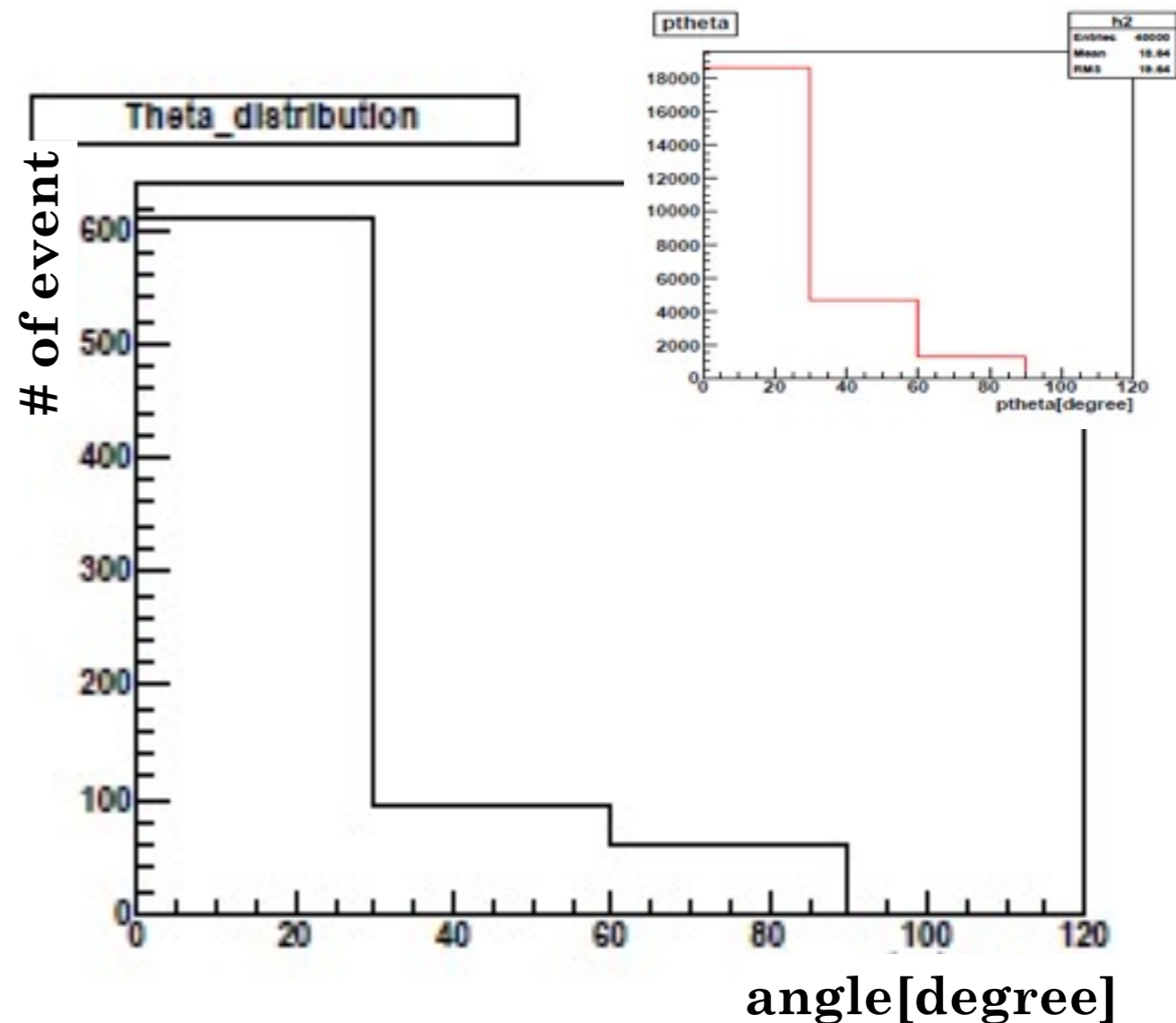
pad signal > 100 ADC counts



# ZENITH ANGULAR DISTRIBUTION OF CRM

## ○ Results

- Sum of charges  $> 20\text{fC}$
- Cosmic ray muons have the zenith angular distribution as a function of  $\cos^2 \theta$ 
  - Red histogram shows the distribution with  $\cos^2 \theta$  (Monte Carlo), where the azimuthal angles are integrated.
- Consistent distribution was obtained.



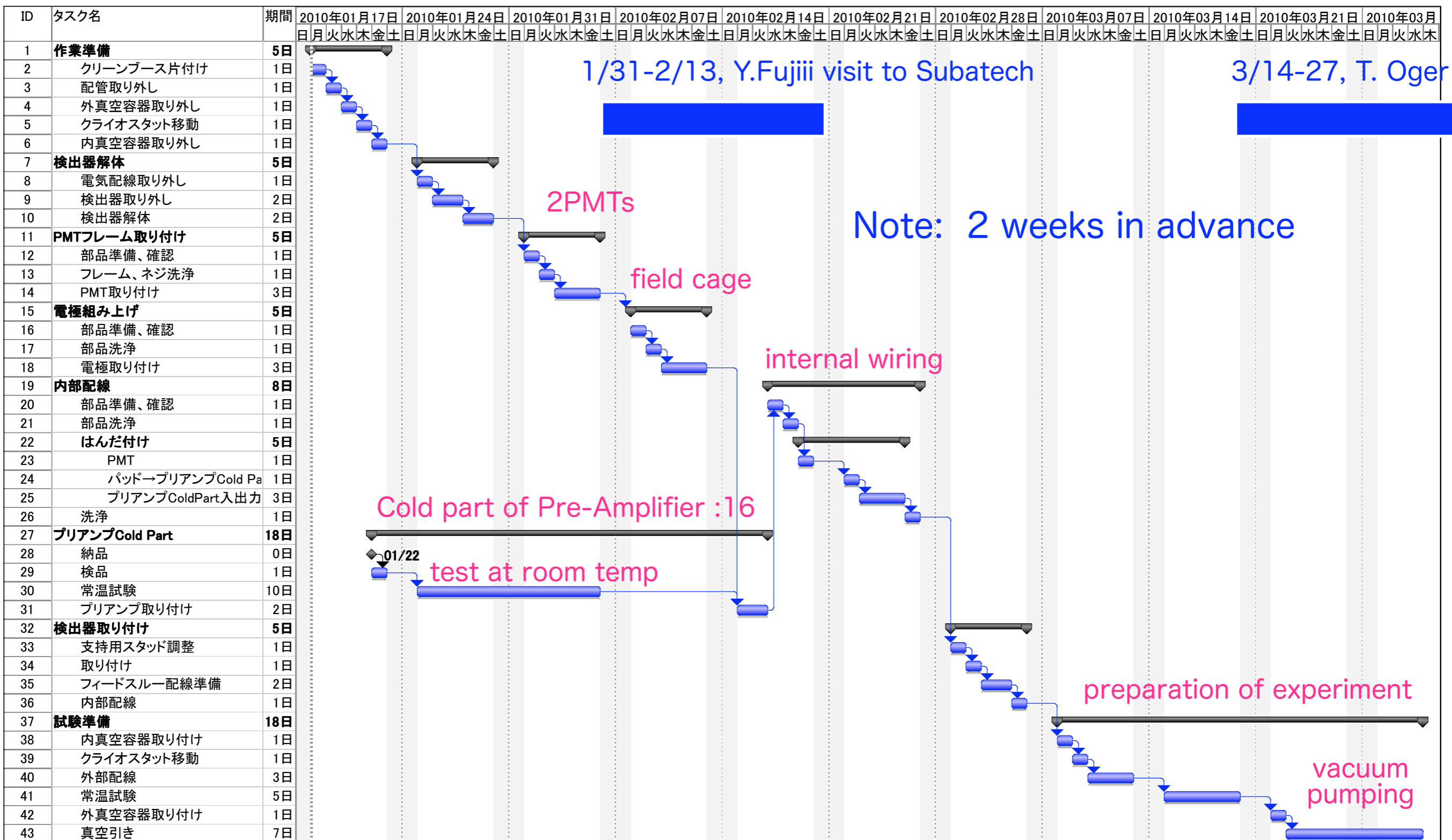
# Next exp. : 4cm drift with grid(mesh) & 16 pad readout

Jan.

Feb.

Mar.

2010



# Next Experiment

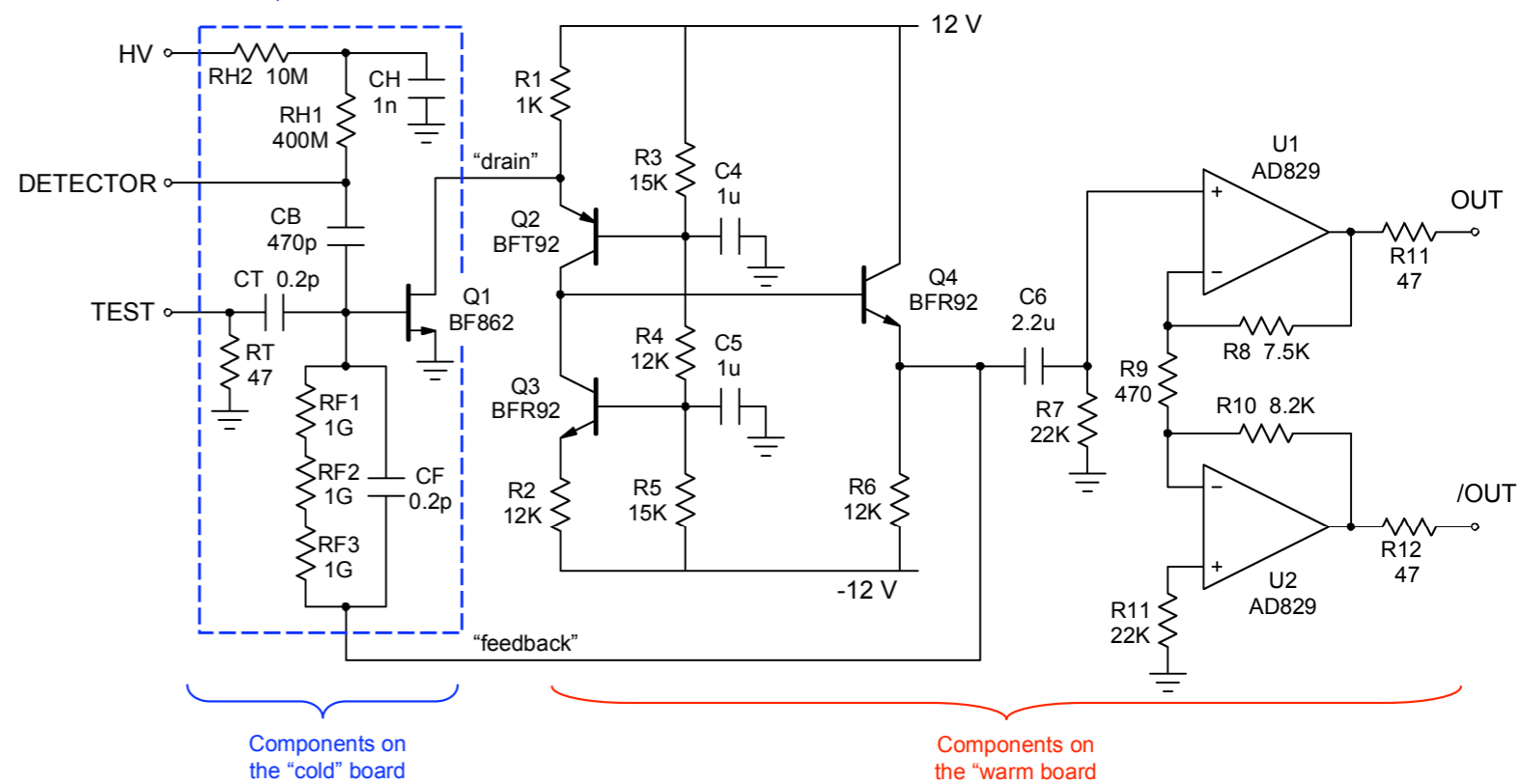
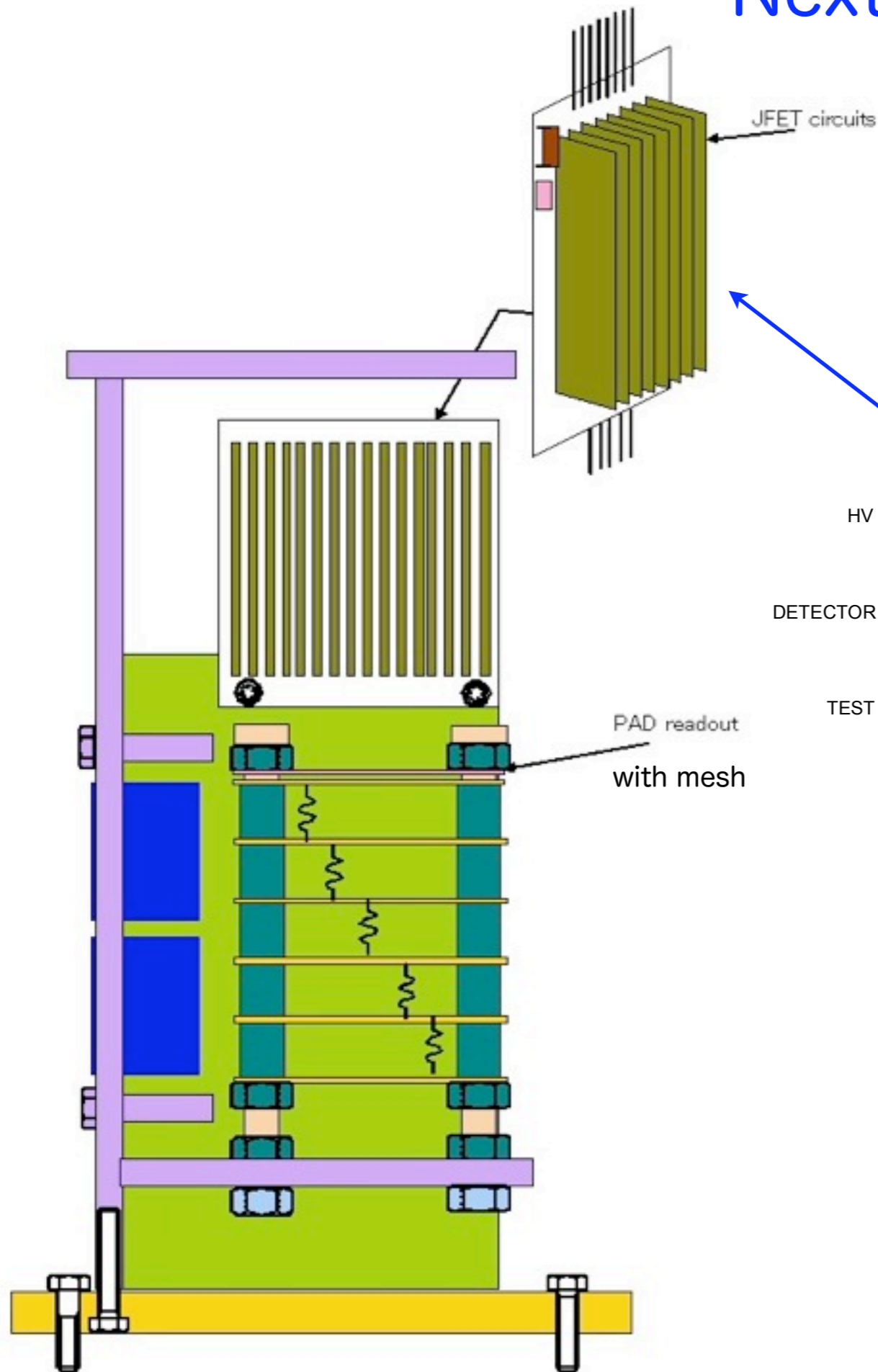
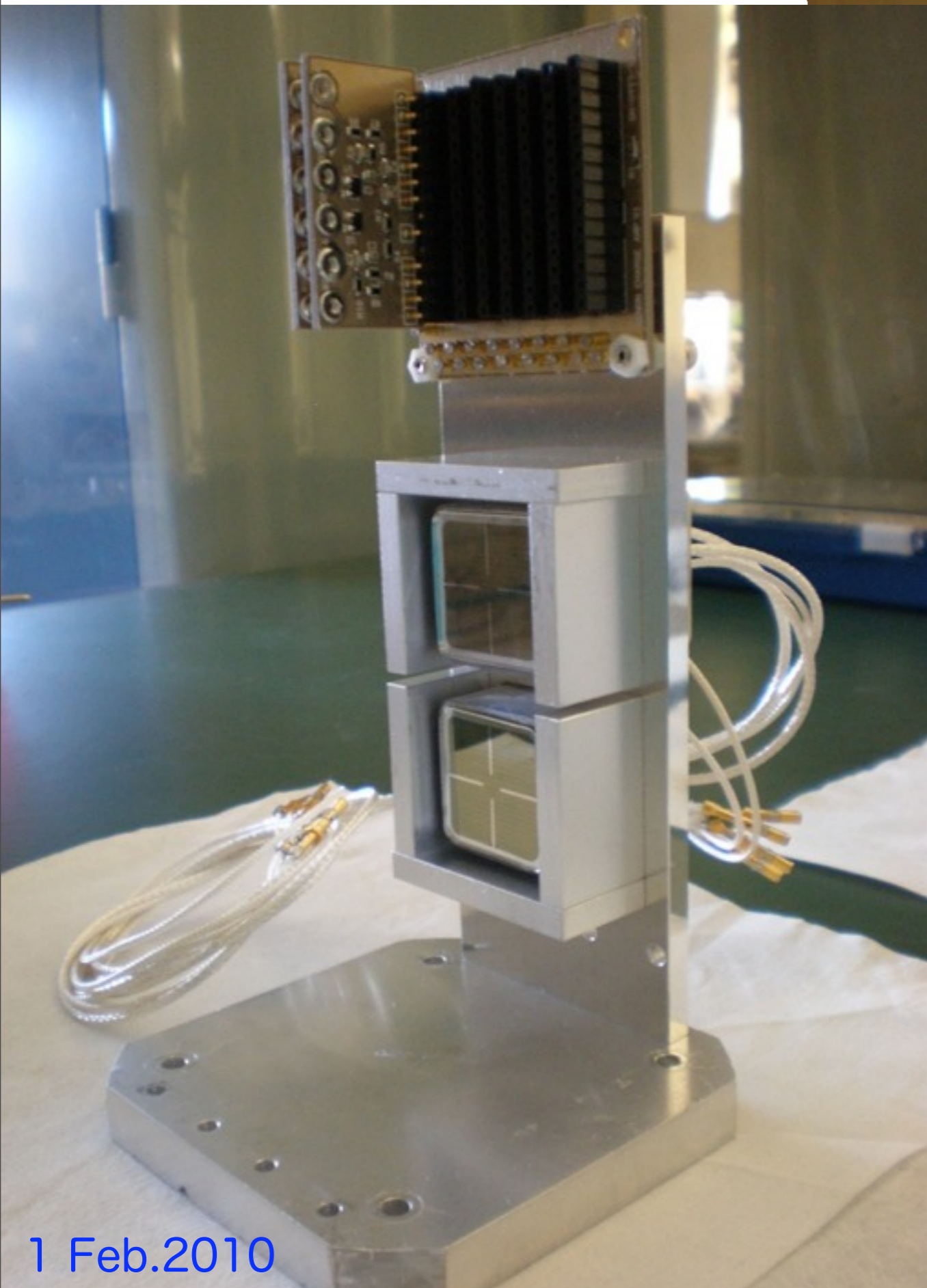


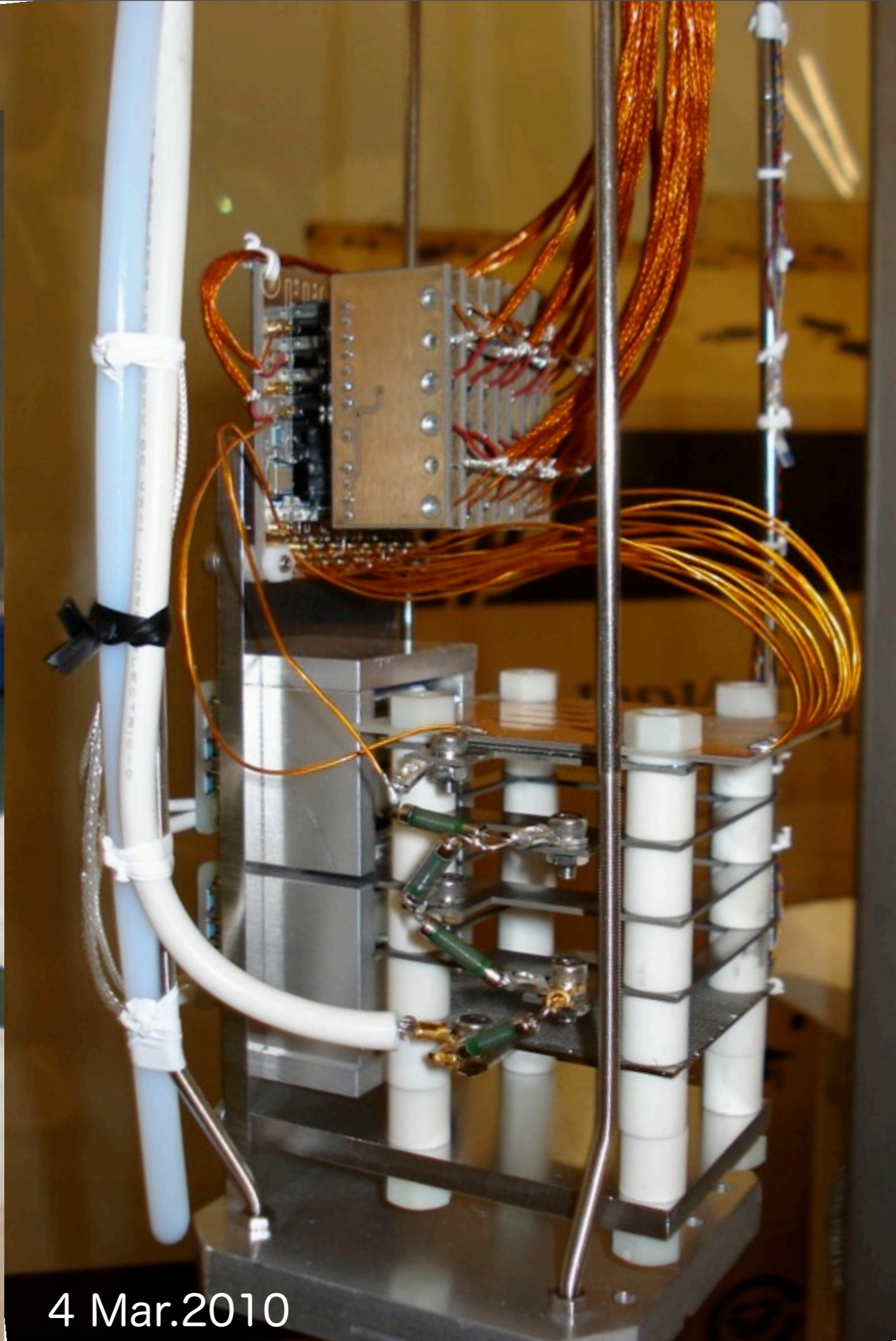
Fig. 3. Simplified schematic diagram of the charge sensitive preamplifier.

“A Cold Low Noise Preamplifier for Use in Liquid Xenon”, A. Pullia et al.

# 2nd Experiment

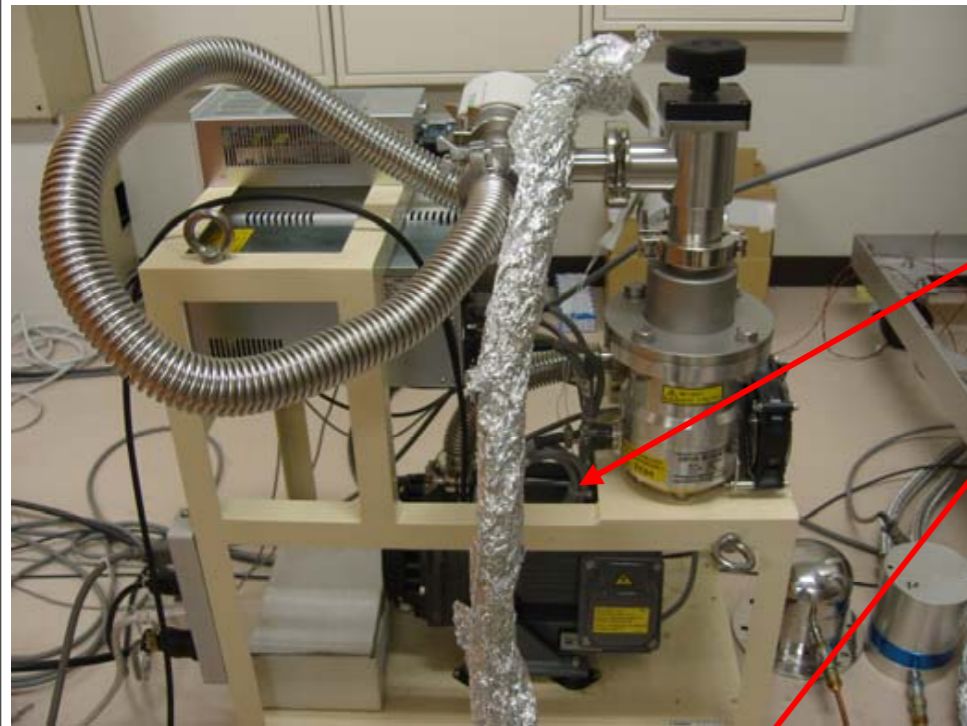


1 Feb.2010



4 Mar.2010

# Vacuum evacuation



Three pumps are used :

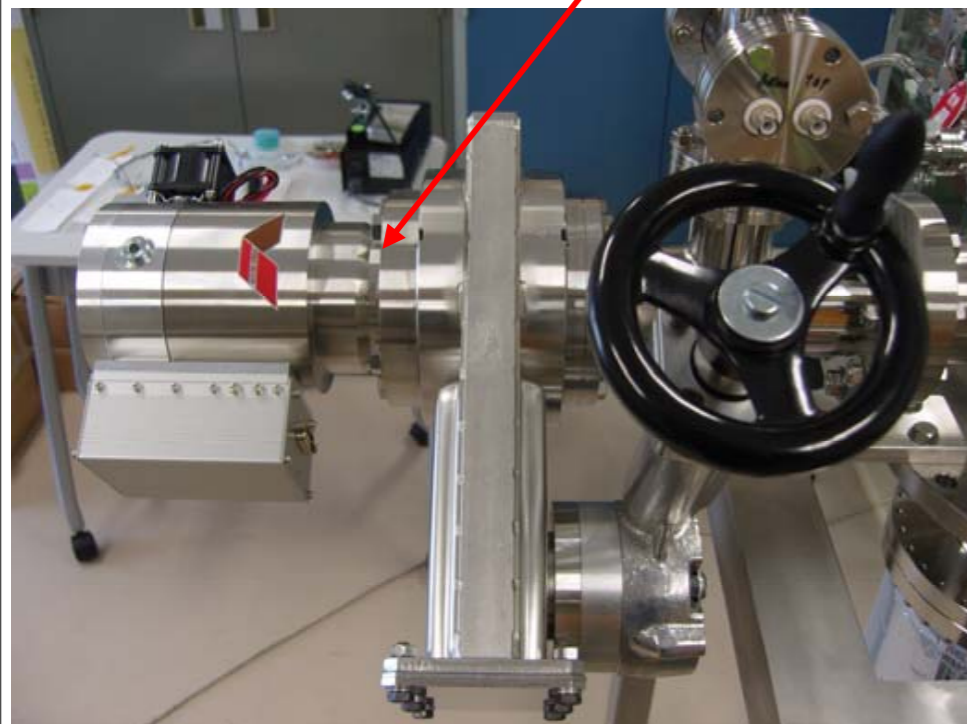
- A primary pump
- A turbomolecular pump
- A getter pump (CapaciTorr-D400-2)

Time of pumping : **6 days**

Result of the vacuum build-up test :  **$6 \cdot 10^{-3}$  Pa**  
after one hour of stopping pumping



Very good cleaning of the circuit



# Vacuum evacuation



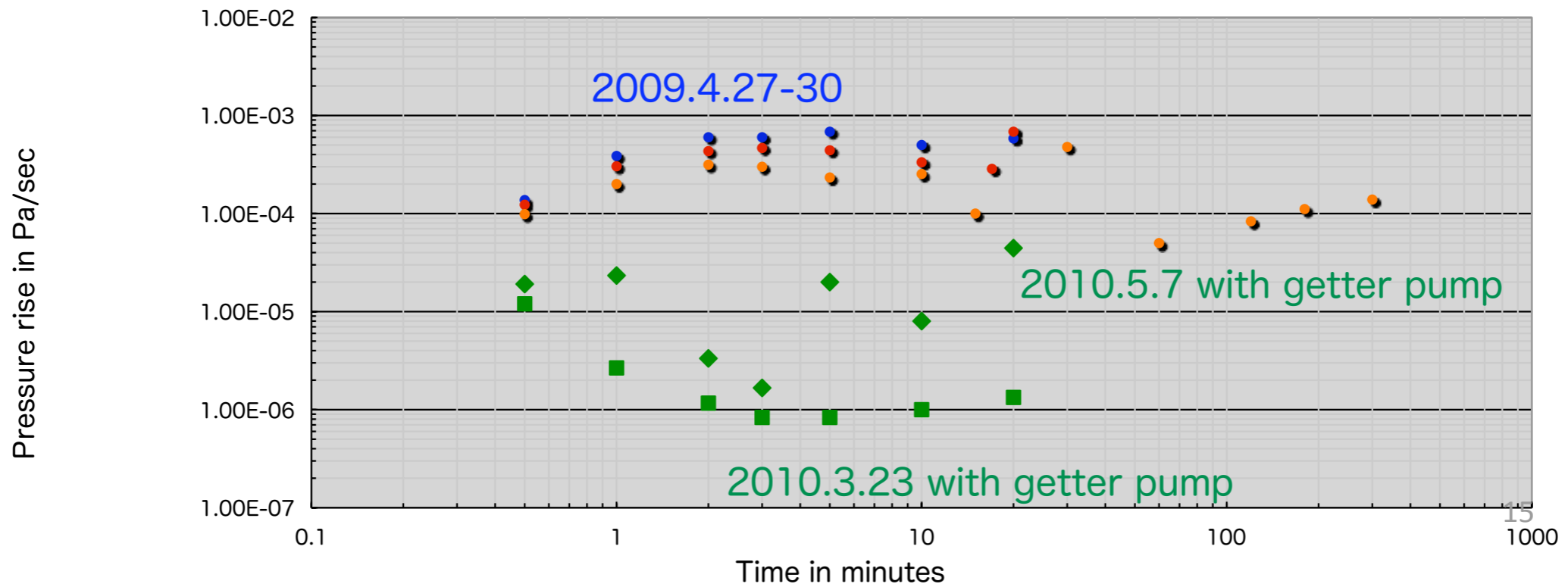
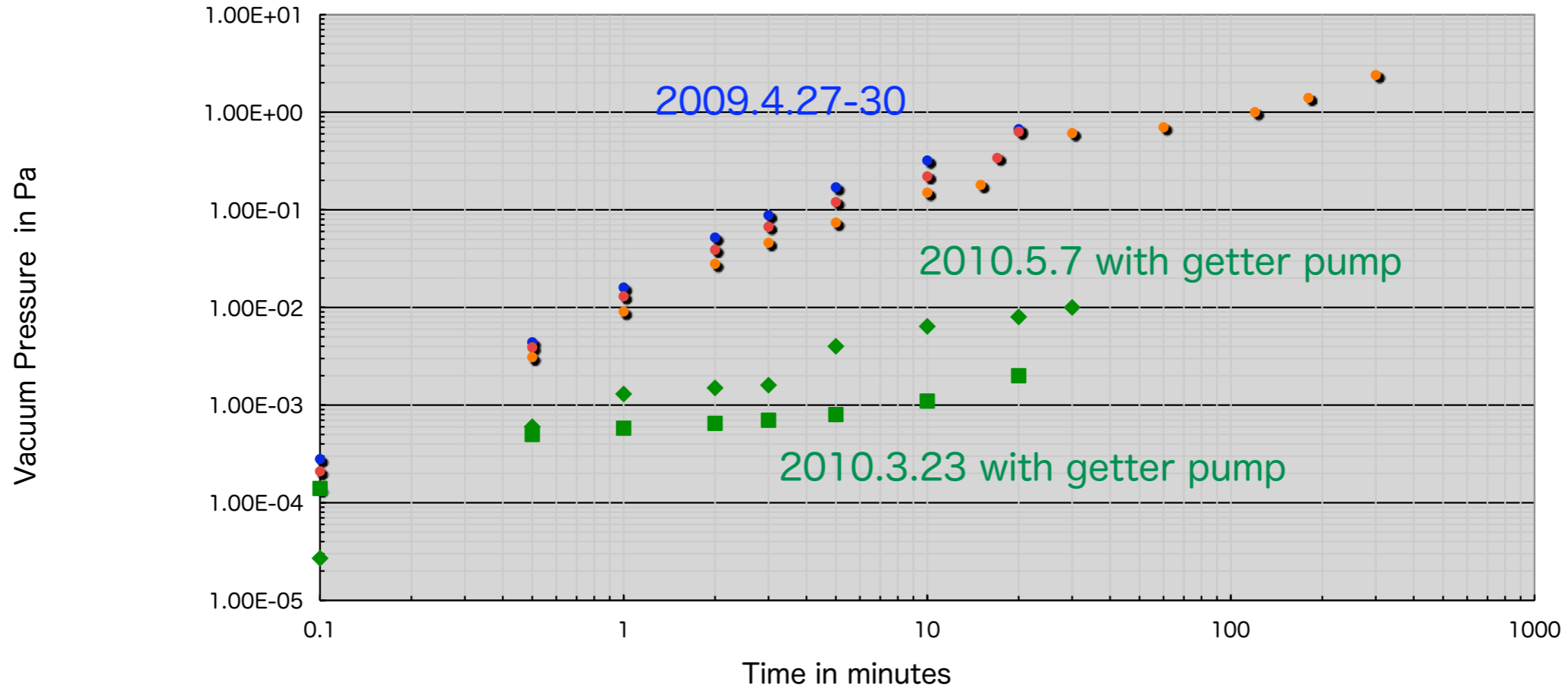
$10^{-3}$  Pa

circuit



# Vacuum Build Up Test

"Less than 1 Pa overnight", Doke's Golden rule



# Summary

1. Charge signals of both cosmic ray and  $\alpha$  sources were detected with a commercial pre-amplifier.
2. Purification process was monitored and understood by scintillation light and charge signals. The preliminary estimation is about 90 ppb ( $O_2$  equiv.) with circulation in 2 months, which will be improved in next time.
3. 2nd exp. : TPC with 16ch-pads, 4cm drift. significant improvement by a getter pump  
one accident - all JFETs were dead by discharge?  
After fixing, it is under purification.