Liquid Xenon TPC for a gamma detector (LXeTPC)

T.Haruyama, T. Tauchi, et al., (KEK)

H.Carduner, J-P.Cussonneau, S.Duval,
J.Lambin, E.Morteau, P.LeRay, T.Oger,
JS.Stutzmann, D.Thers(Subatec)

D_RD_06, FJPPL09 Workshop
20-21 May 2009

LXeTPC 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 β 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, test

A.Sugiyama, T.Higashi(D3)

Tokyo univ. : TPC, PMT, simulation, test

T.Mori, Y.Fujii(M1)

National Institute of Radiological Science : PET

M.Kumada, T.Tomitani, C.Toramatsu

Yokohama National univ. : PMT, Xe-property

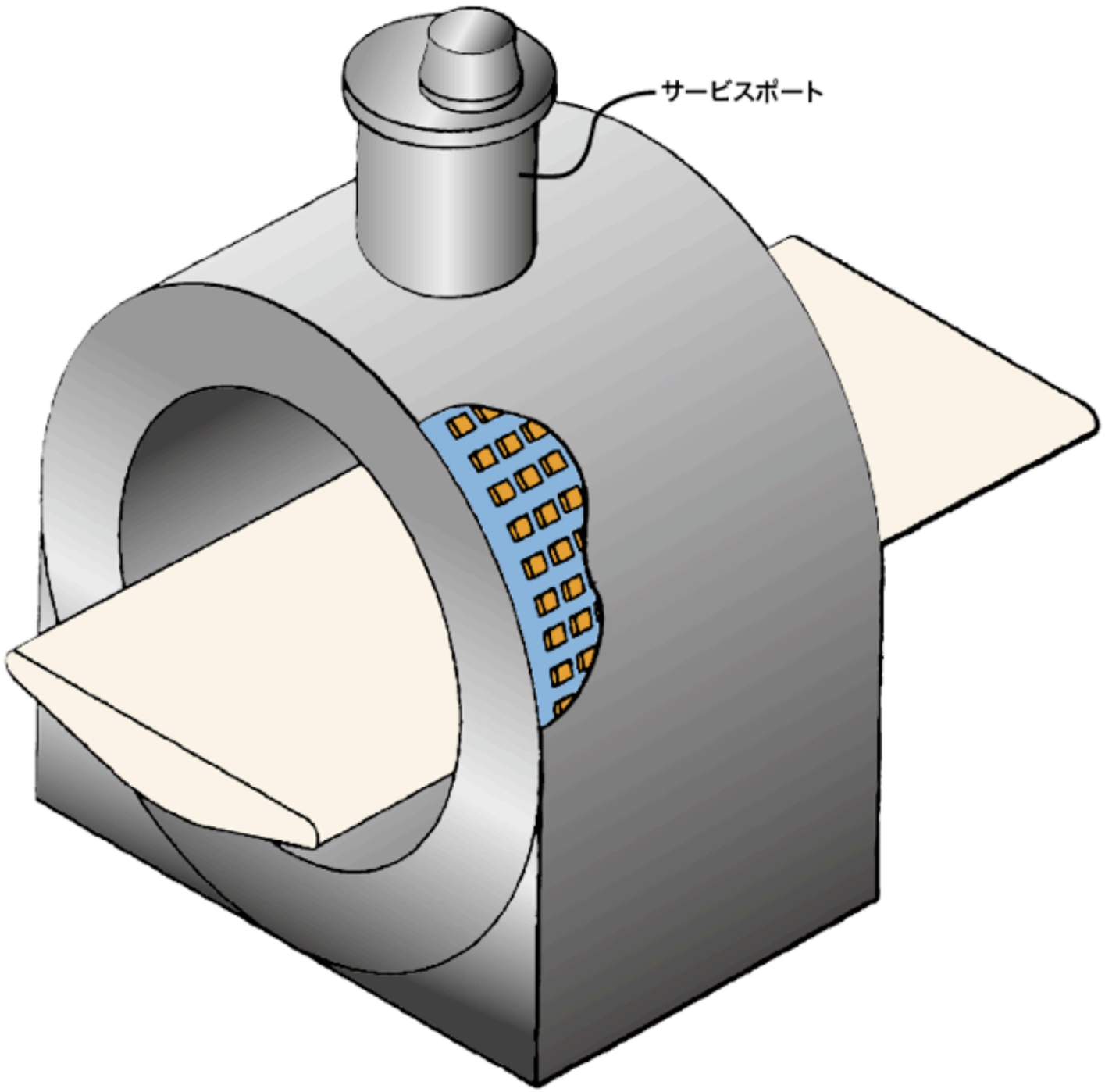
S.Nakamura

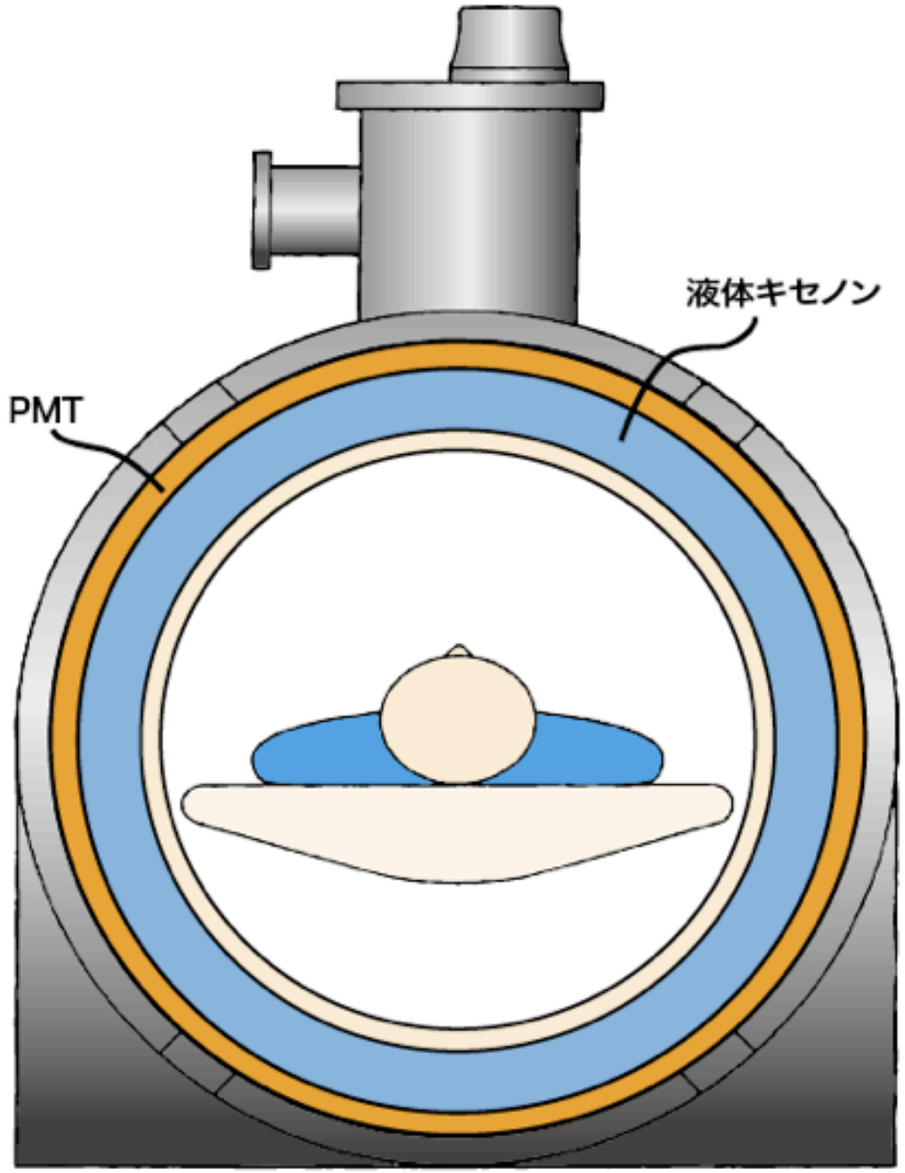
Cooperation : KEK electronics system group , DAQ

M.Tanaka et al.

Next-generation PET with LXeTPC

TXePET





LXe Cryogenic system at KEK , operation since May 2008

Gas handling panel

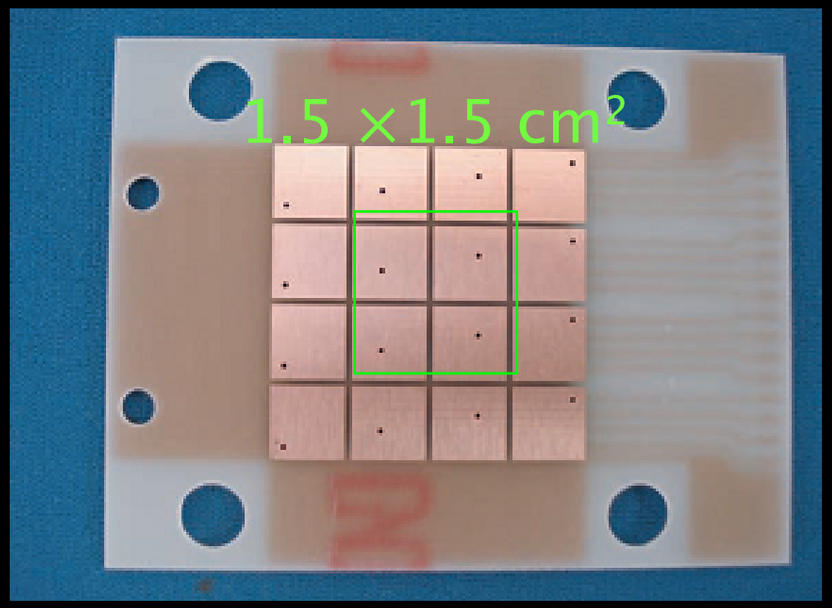
PTC (8W@77k)

0.75m^3 Tank

Test chamber

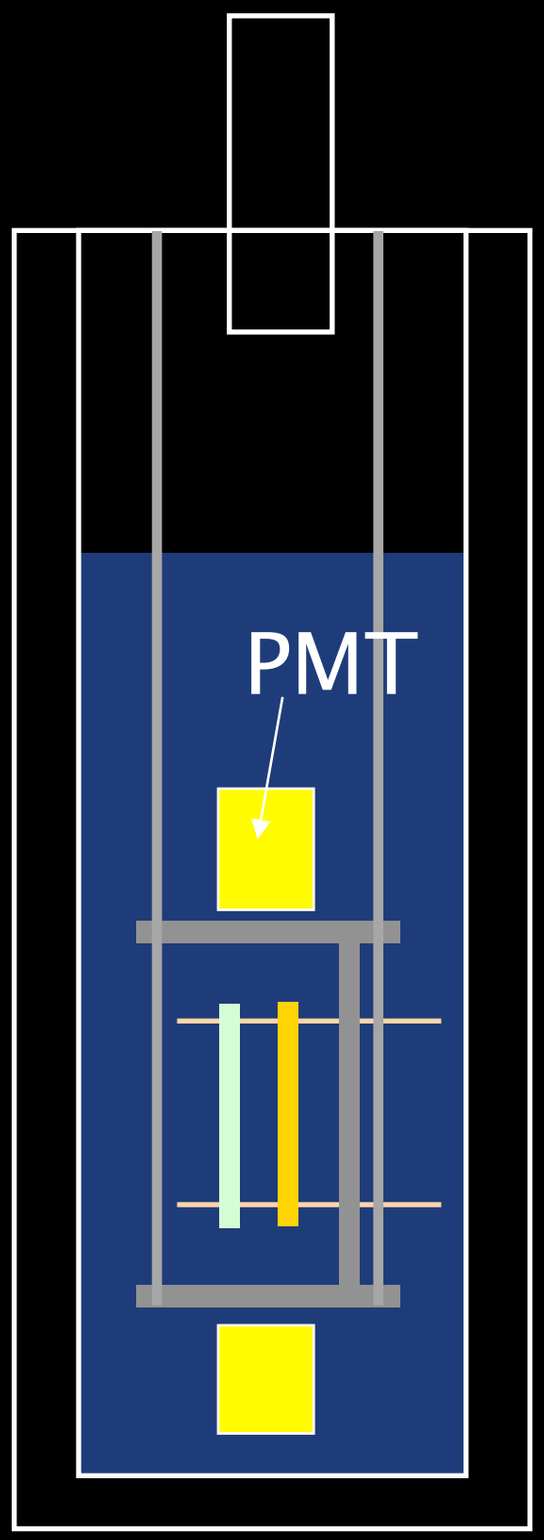
700W compressor

Experimental setup in Feb.- April, 2009

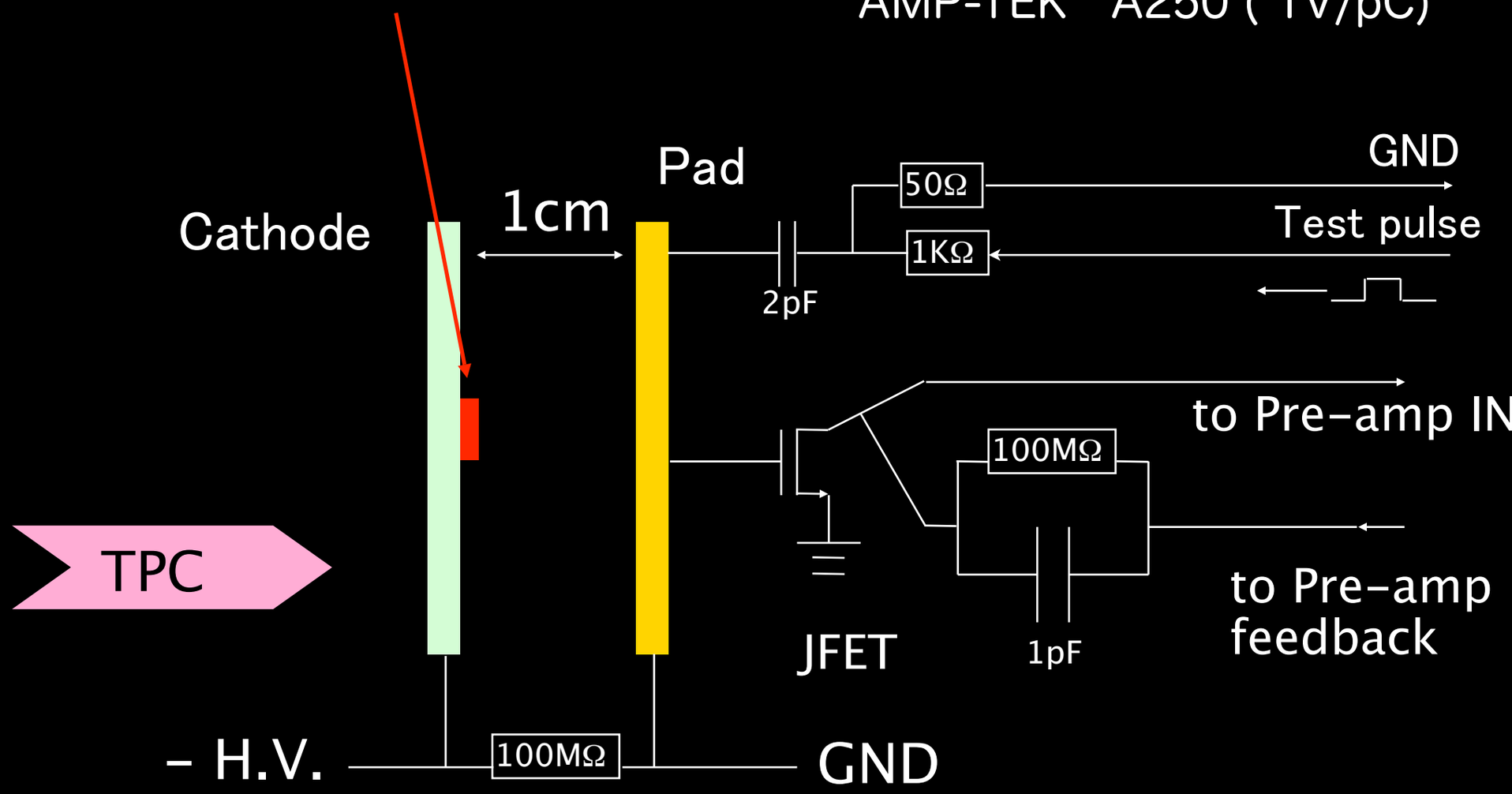


Pre-amp :

AMP-TEK　A250 (1V/pC)



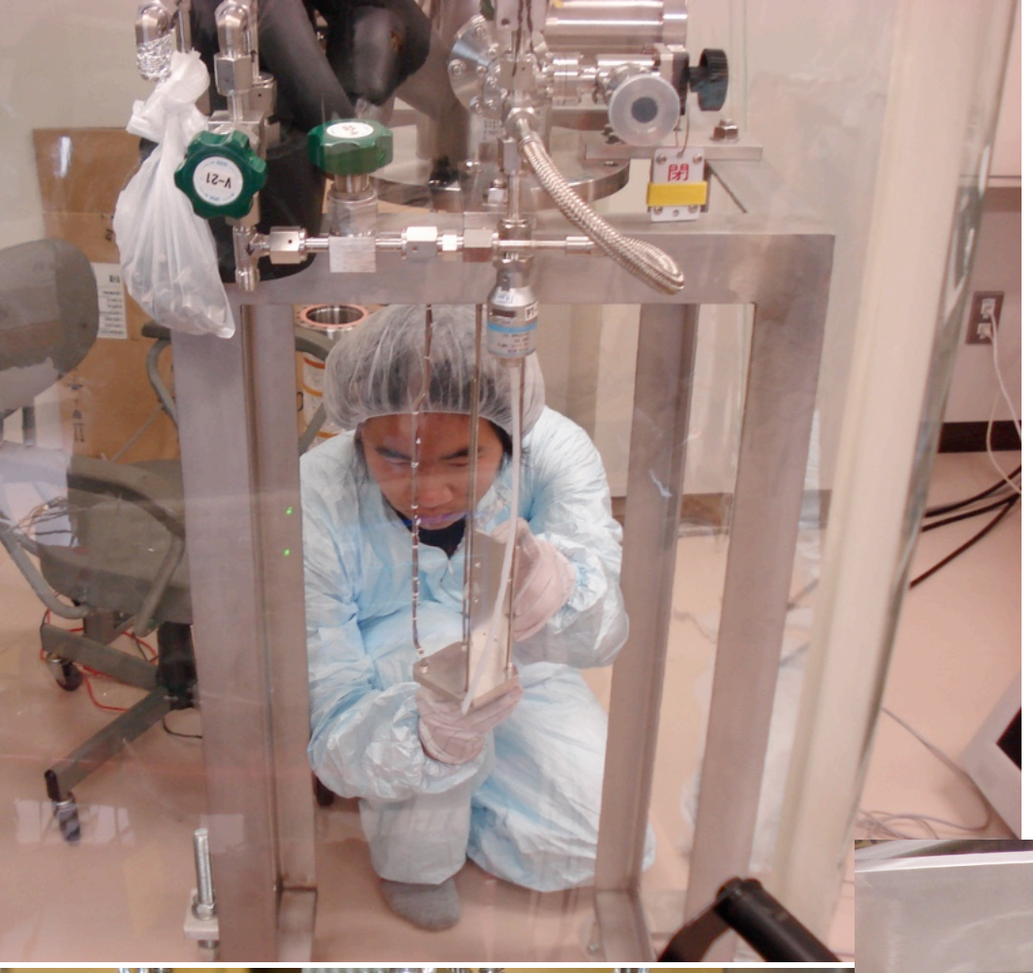
α source of ^{241}Am
(200Bq) on the cathode

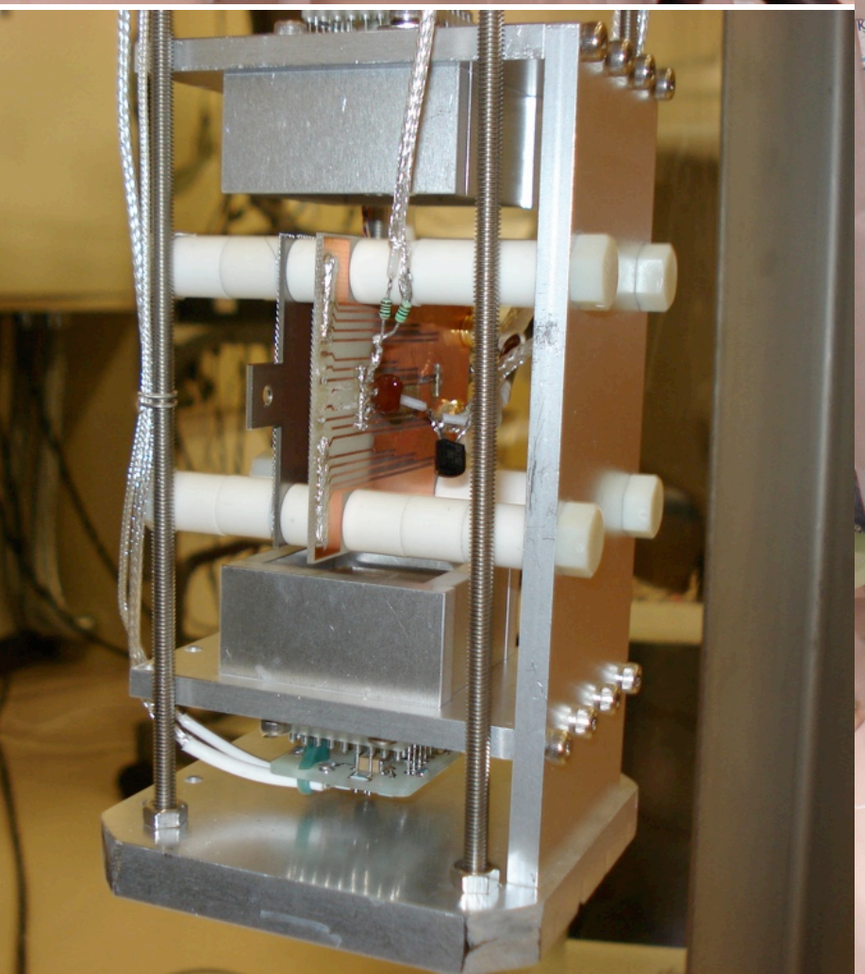


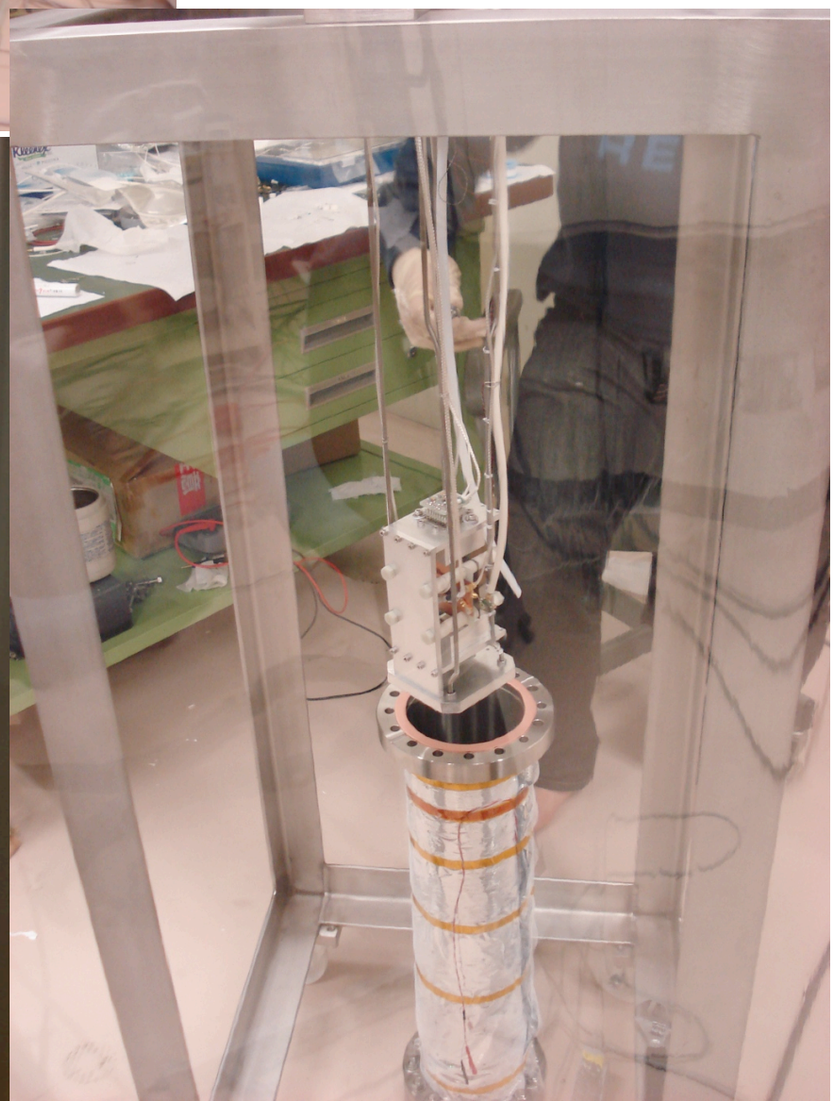
Preparation for Feb.-Mar.2009

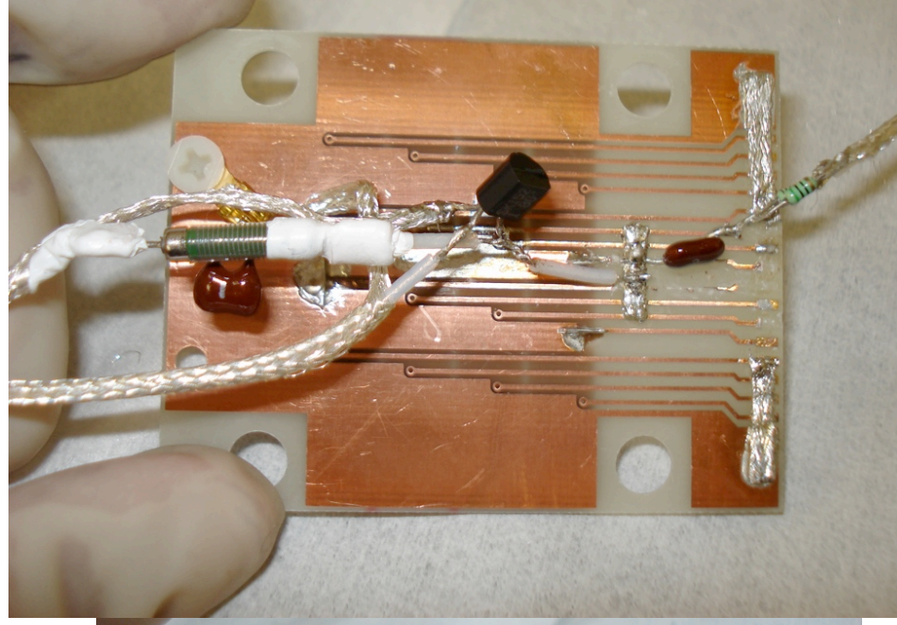
1cm drift w/o grid

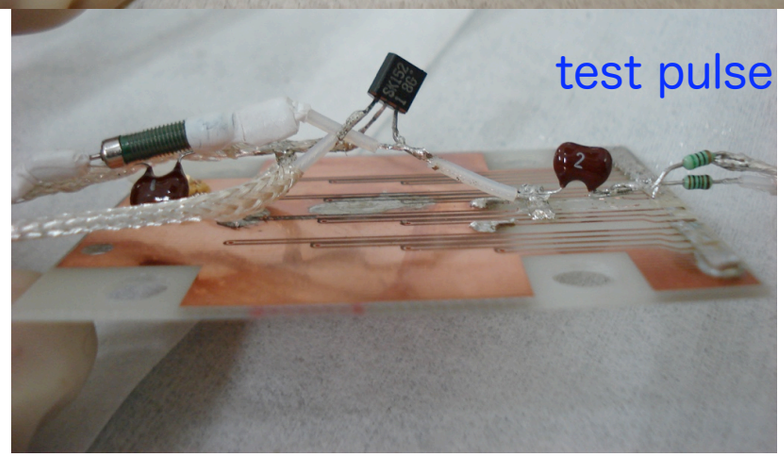
1. JFET, feedback C (1pF) & R(100MΩ) inside
2. Pre-amp (A250) outside
3. 1 ch (PAD) readout

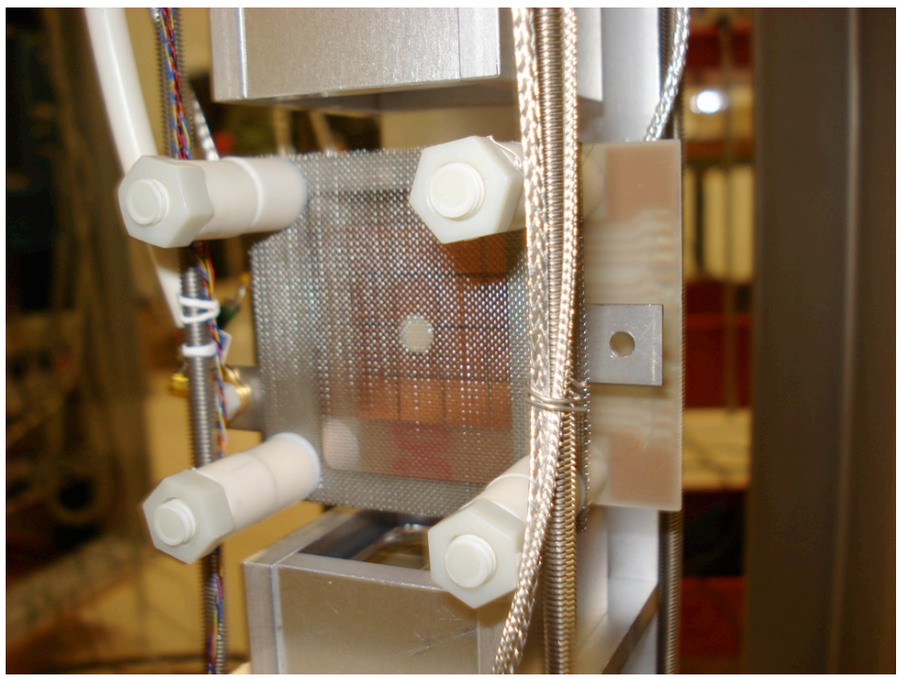






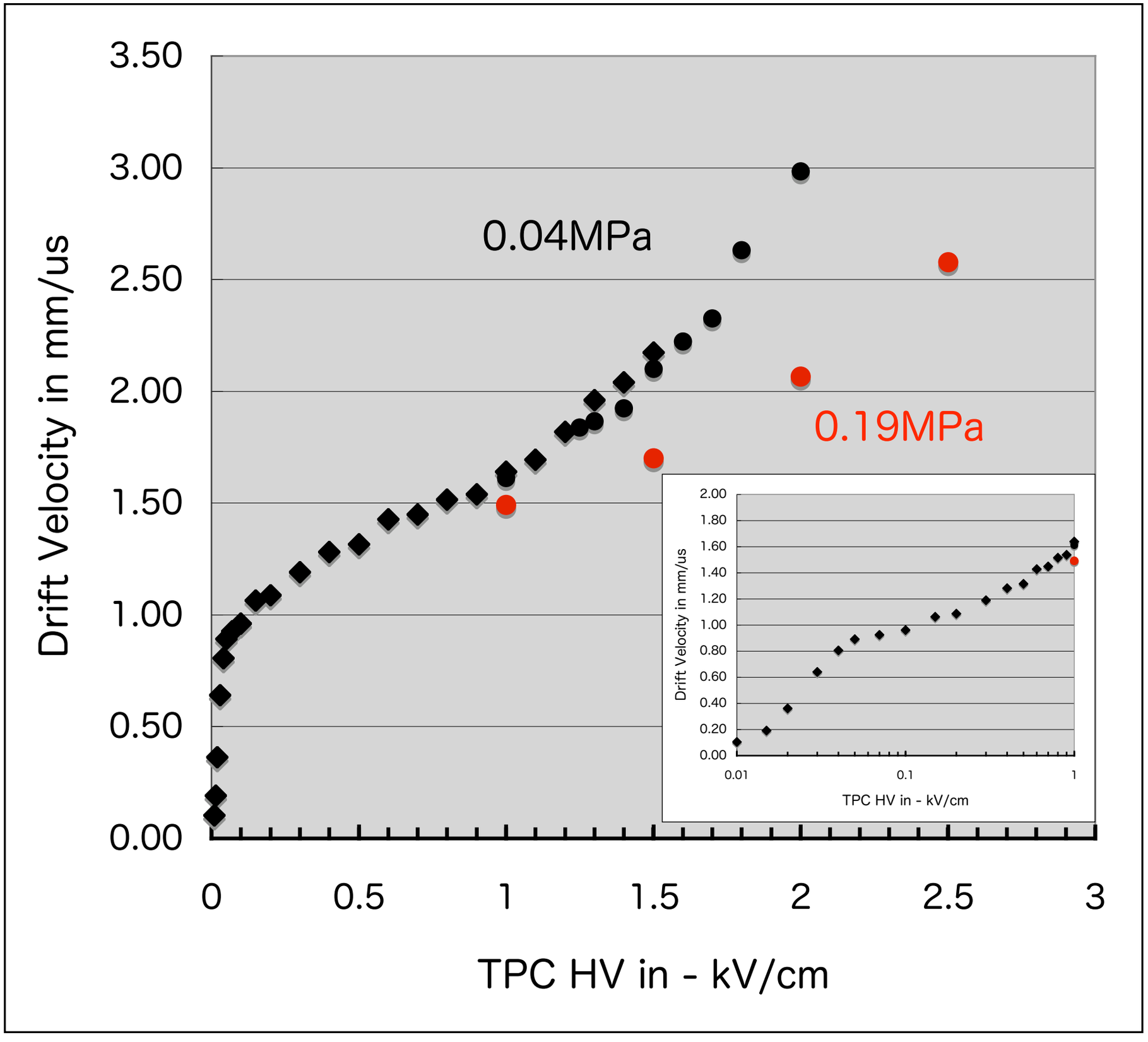




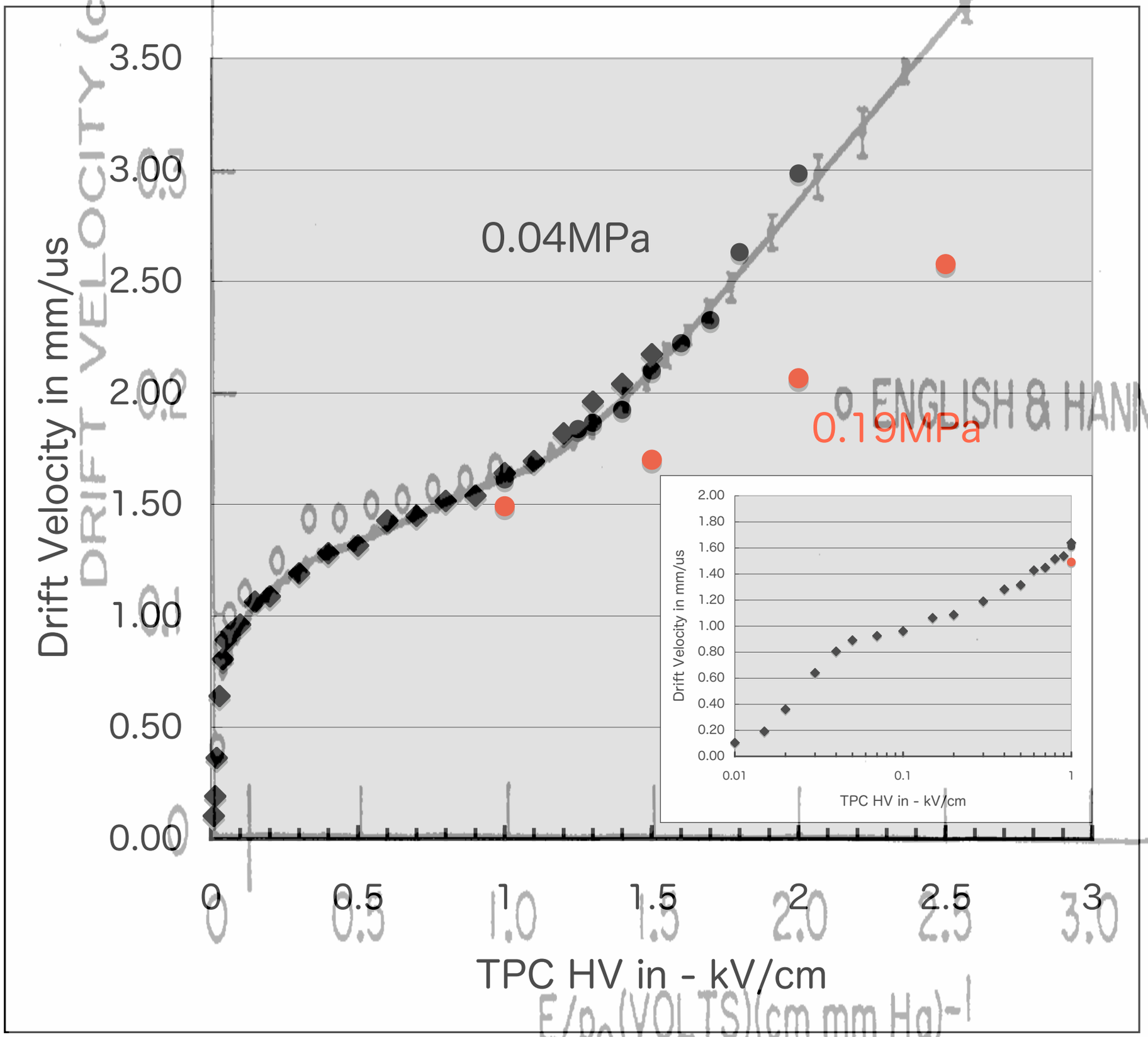


α線ソース(^{241}Am, 20Bq)

Drift velocity in Xe gas for drift in 10mm



Drift velocity in Xe gas for drift in 10mm



Scintillation light signals

Pulse Height (V)

1400
1200
1000
800
600
400
200
0

PMT1(700V)

PMT2(700V)

4 L/min

Gas to Liquid purification

AC down

1.1 L/min

0
10
20
30

2/14(0)

2/25(11)

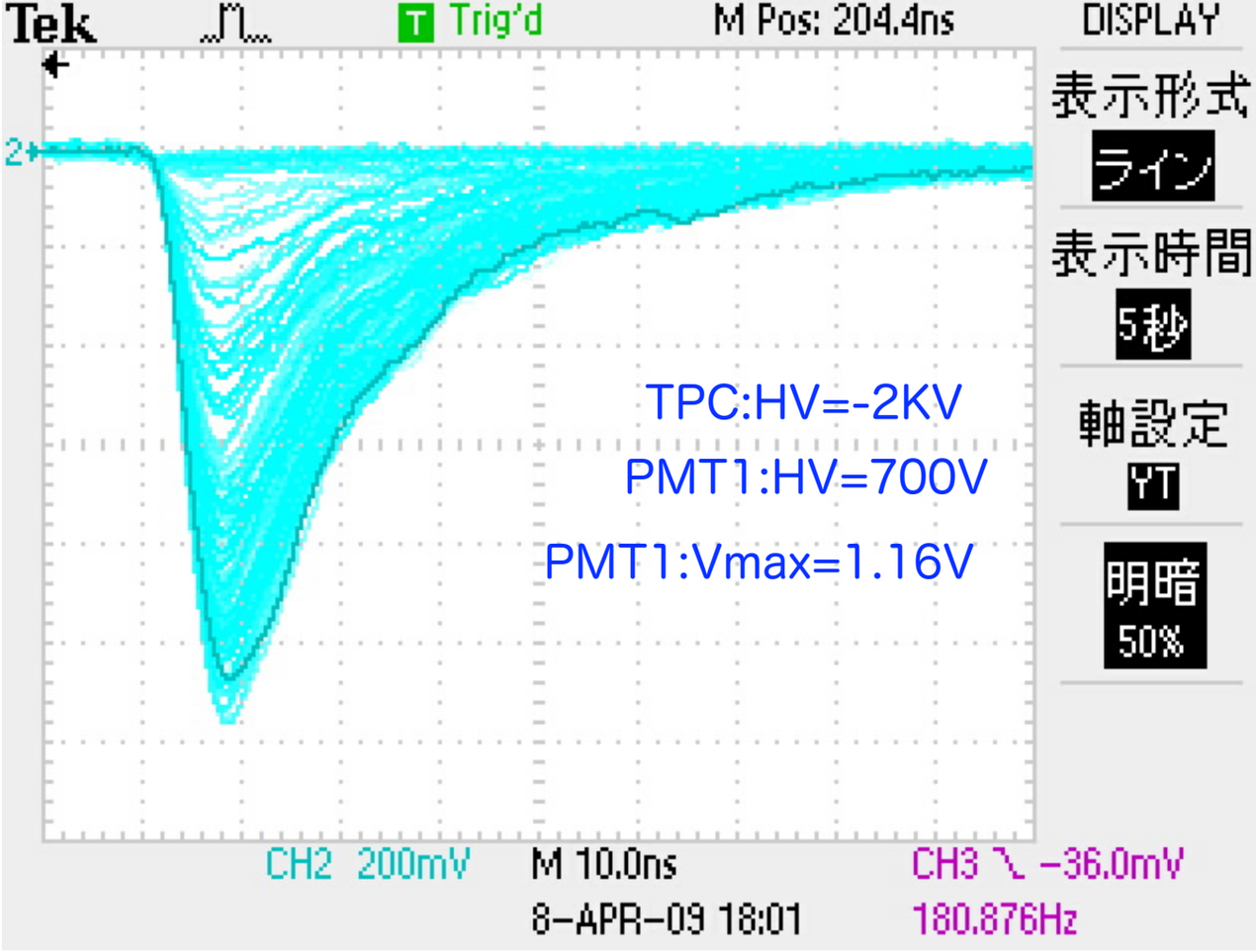
Days since circulation (purification)

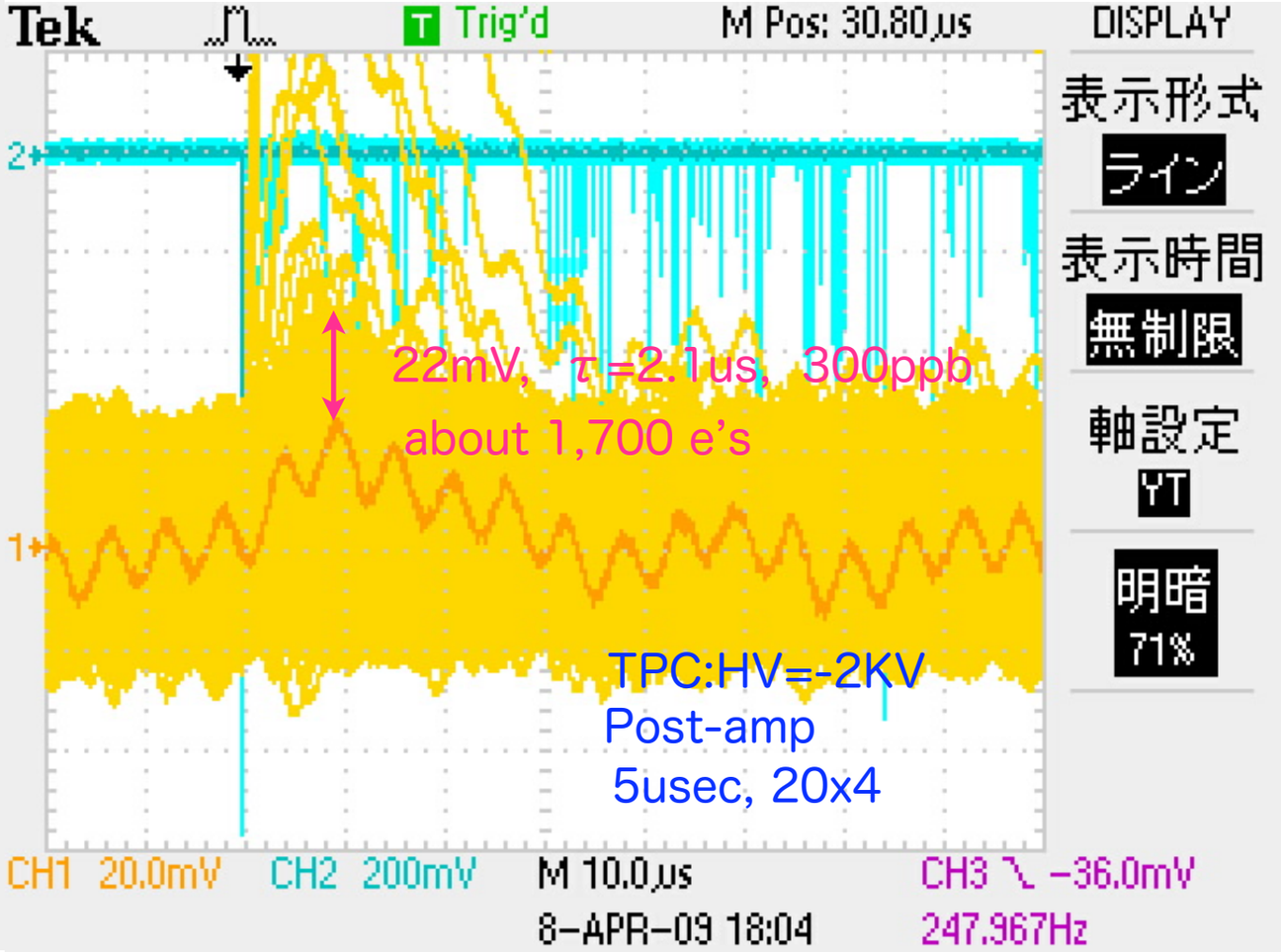
3/31(45)

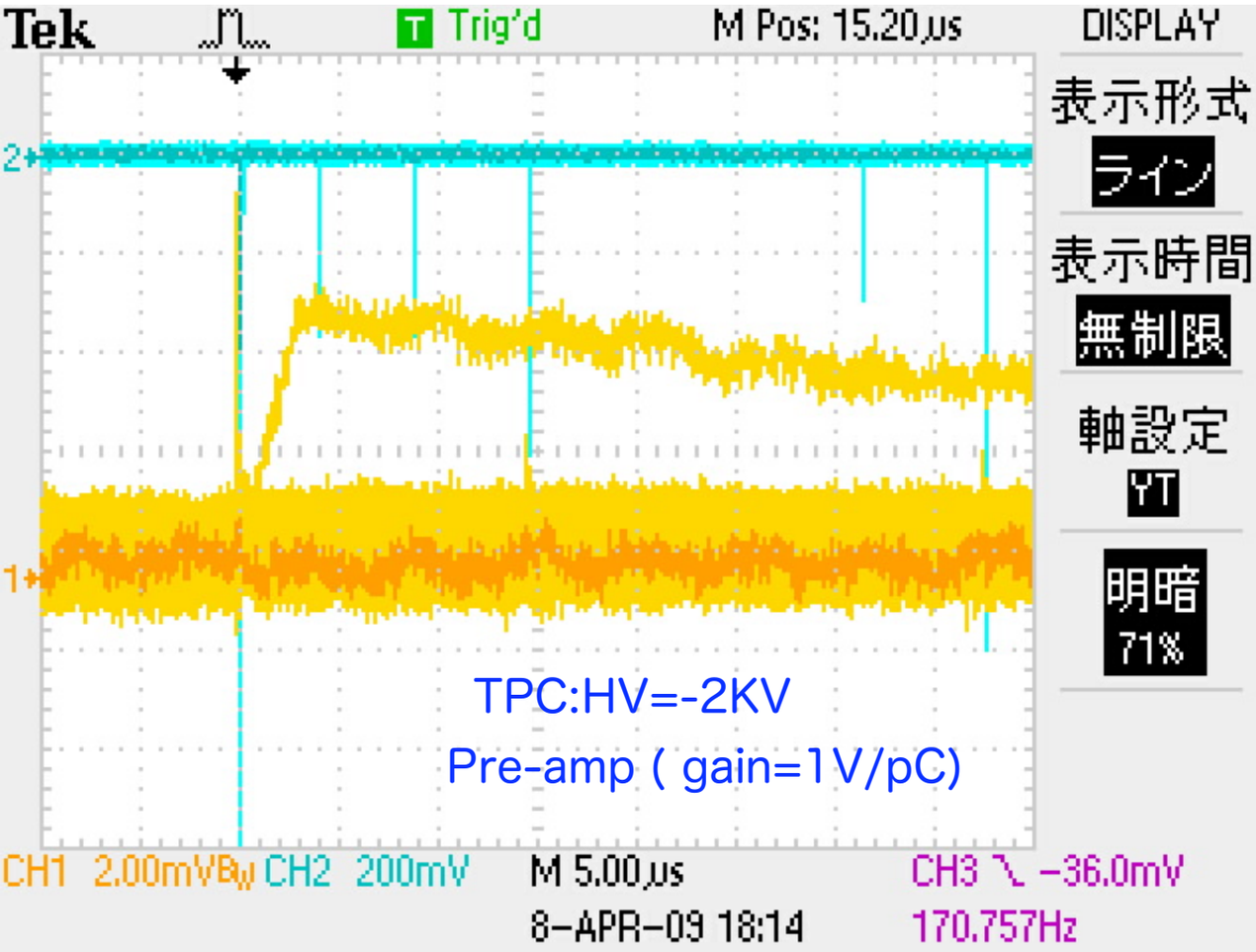
Charge signals

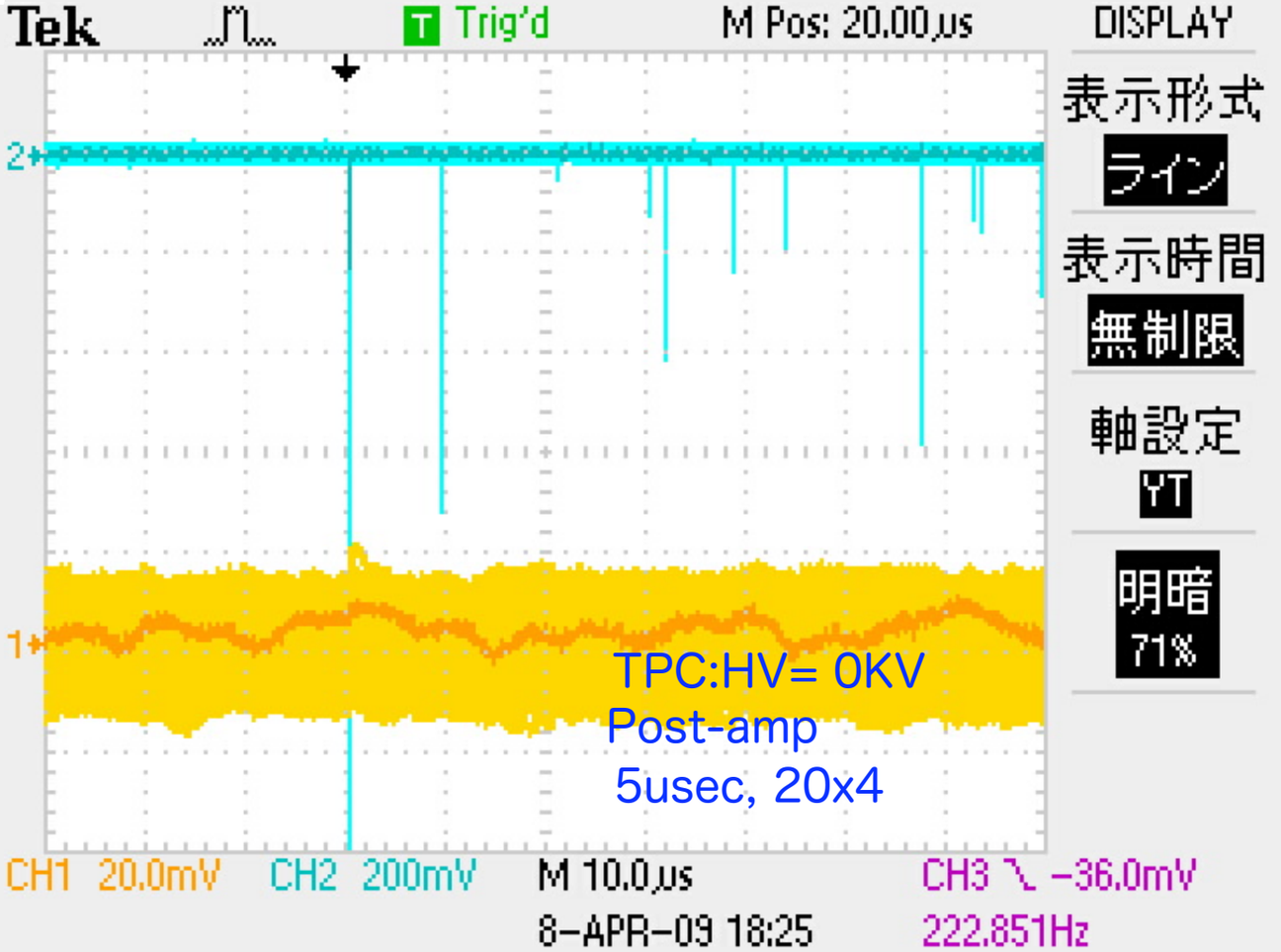
cosmic rays

α source


Tek
Trig'd
M Pos: 204.4ns
DISPLAY
表示形式
ライン
表示時間
5秒
軸設定
YT
明暗
50%
TPC:HV=-2KV
PMT1:HV=700V
PMT1:Vmax=1.16V
CH2 200mV
M 10.0ns
8-APR-09 18:01
CH3 ∖ -36.0mV
180.876Hz


Tek
Trig'd
M Pos: 30.80µs
DISPLAY
表示形式
ライン
表示時間
無制限
軸設定
YT
明暗
71%
22mV, τ=2.1us, 300ppb
about 1,700 e's
TPC:HV=-2KV
Post-amp
5usec, 20x4
CH1 20.0mV
CH2 200mV
M 10.0µs
8-APR-09 18:04
CH3 ∖ -36.0mV
247.967Hz

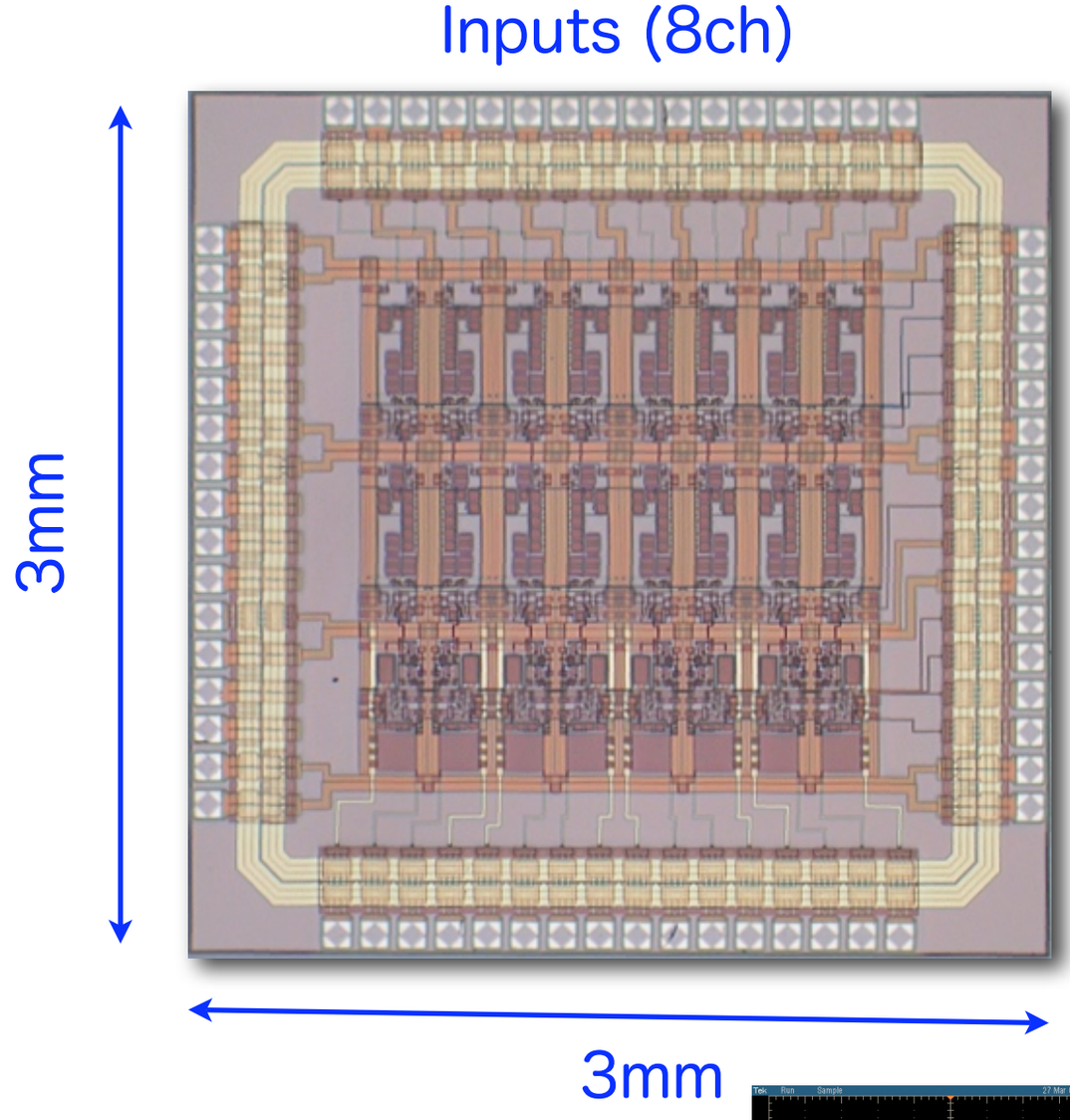

Tek
Trig'd
M Pos: 15.20µs
DISPLAY
表示形式
ライン
表示時間
無制限
軸設定
YT
明暗
71%
TPC:HV=-2KV
Pre-amp (gain=1V/pC)
CH1 2.00mVBw
CH2 200mV
M 5.00µs
8-APR-09 18:14
CH3 ∖ -36.0mV
170.757Hz


Tek
Trig'd
M Pos: 20.00µs
DISPLAY
表示形式
ライン
表示時間
無制限
軸設定
YT
明暗
71%
TPC:HV= 0KV
Post-amp
5usec, 20x4
CH1 20.0mV
CH2 200mV
M 10.0µs
8-APR-09 18:25
CH3 ∖ -36.0mV
222.851Hz

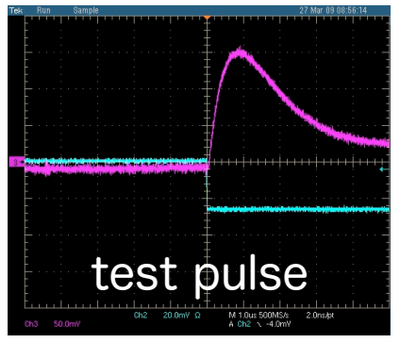
Front-end ASIC chip R&D

Pre-amp. to PZC to shaper - output all analog channels

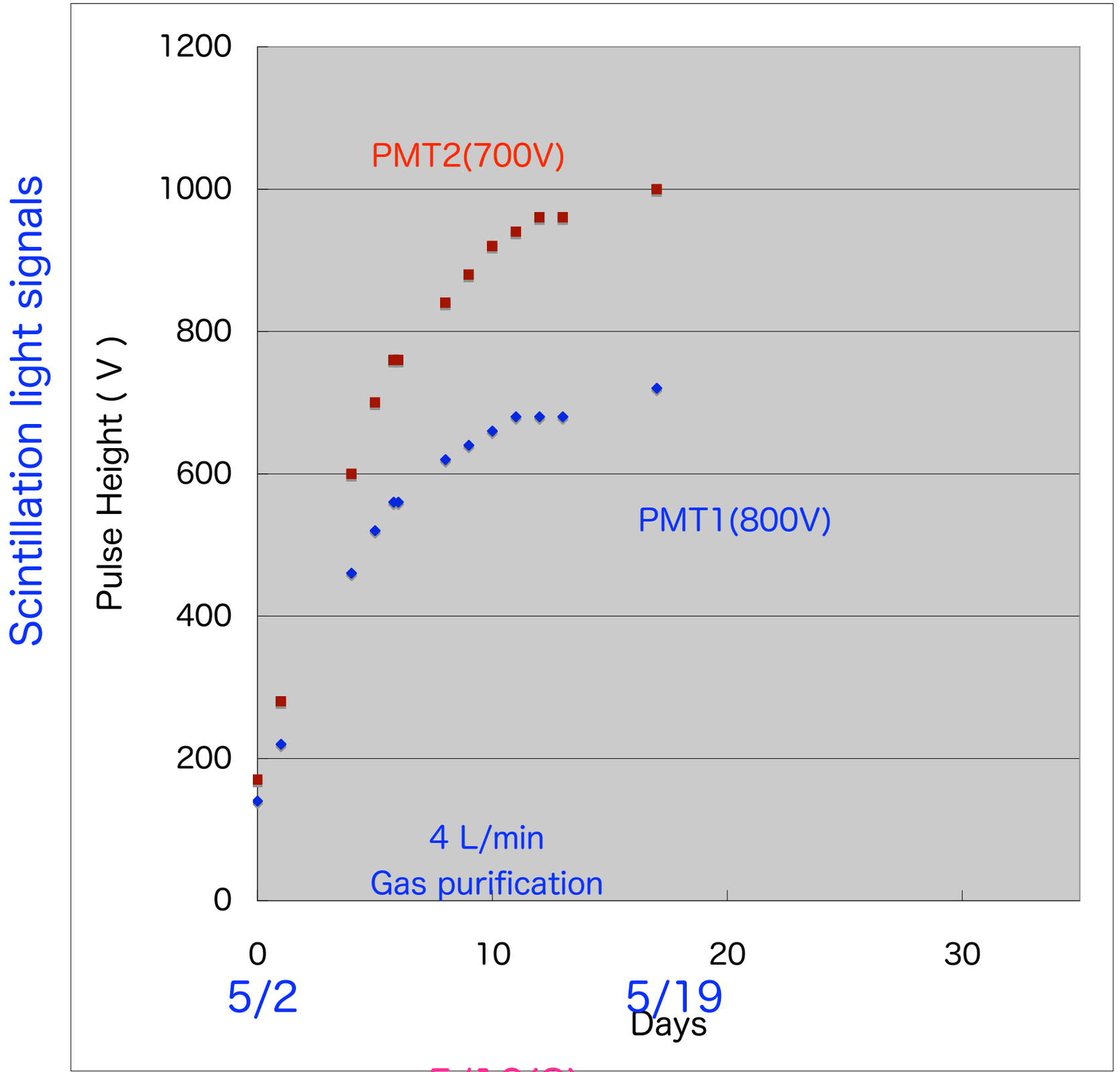
PARAMETER	SPECIFICATION
chip size	3mm x 3mm
channel number	8
power supplies	±2.5V
dissipation power	<10mW/ch
gain	8.2V/pC
Input charge	±25fC
peaking time	0.5, 1us, variable(>1us)
prod. process	0.5um CMOS



We are preparing the cooling test at -100°C.



Present status of prototype study (4 pads readout)

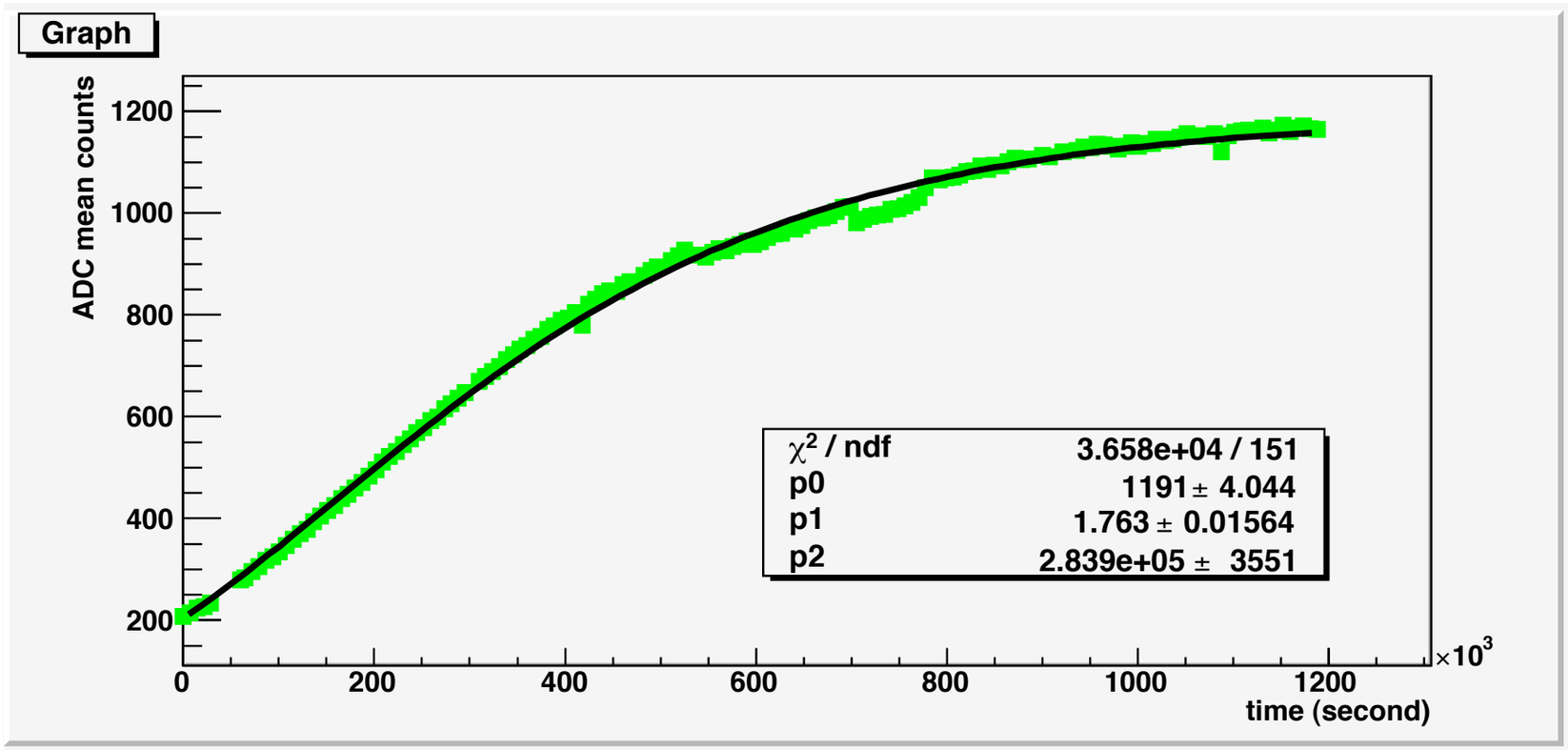


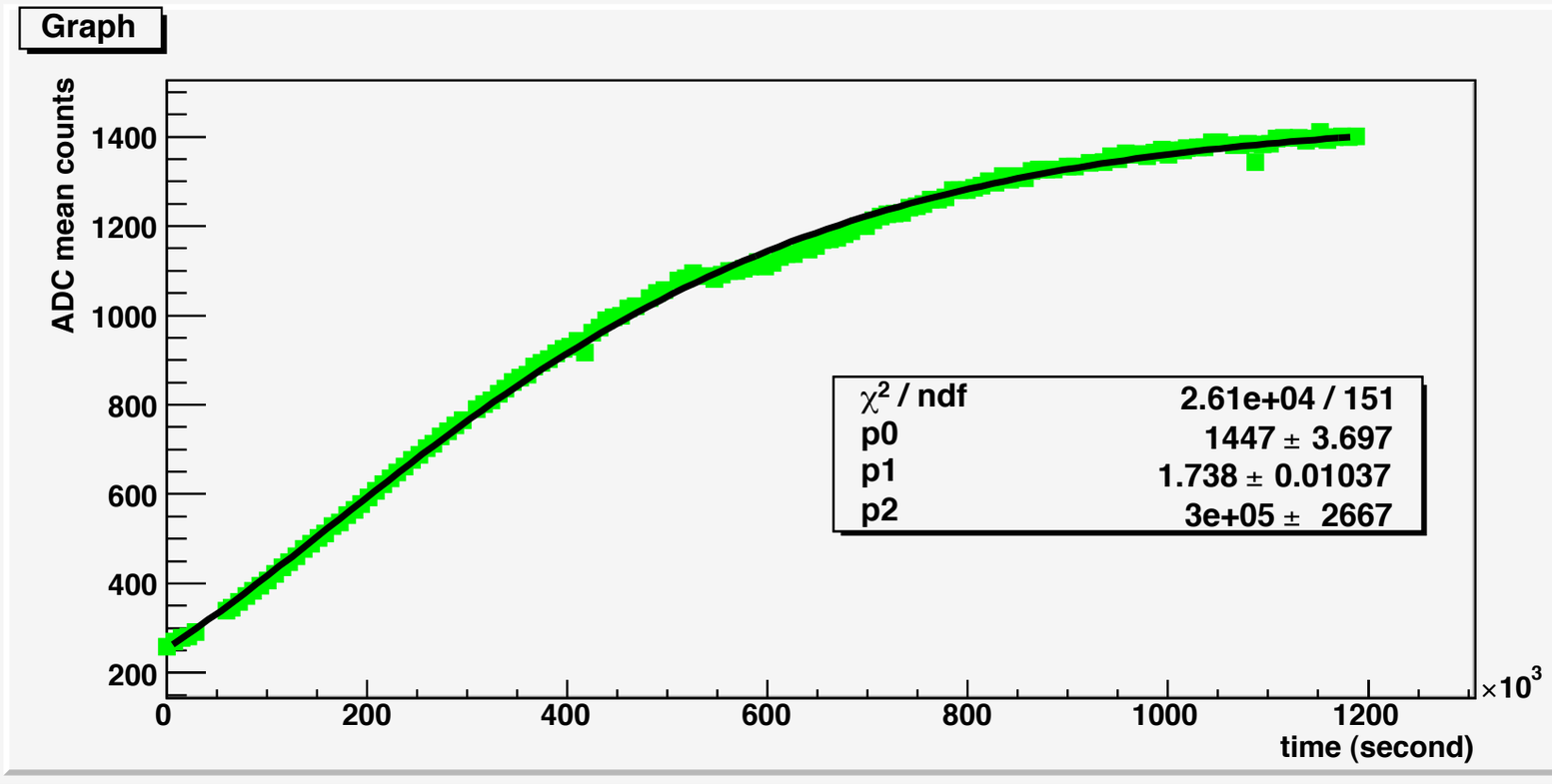
Charge signals

5/10(8)
cosmic rays

since circulation
(purification)

Purification process by scintillation lights





fitted by

$p(d,t) = p_0 e^{-d/\lambda}$

$\lambda = \lambda_0 e^{t/\tau}$

,where

λ_0 = initial attenuation length and τ = time constant of purification

$p_1 = d/\lambda_0 = 1.75$

$p_2 = \tau = 2.9 \times 10^5$ sec

τ = 3.4 days

put d = 5 cm

λ_0 = 2.9 cm

λ =160cm at 14days

Conclusions

1. Charge signals of both cosmic ray and α 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 300ppb (O_2 equiv.) with circulation in 50 days, which will be improved in the present run.
3. We will confirm the purification and measure the 4ch charge signals (pads).
4. Next, we will measure 16ch-pads with 5cm drift in TPC .