# Kobe Activities on SF6

Note: Some results are unpublished

2016 Sep 8th

work by Tomonori Ikeda
report by Kentaro Miuchi

## Kobe SF6 related activities

- Started 2015 summer
- First report @ MPGD2015
  (including CS2 study @ OXY)

- Today
  - –detector study
  - –electronics R&D

Study of Negative-Ion TPC using μ-PIC
for Directional Dark Matter search

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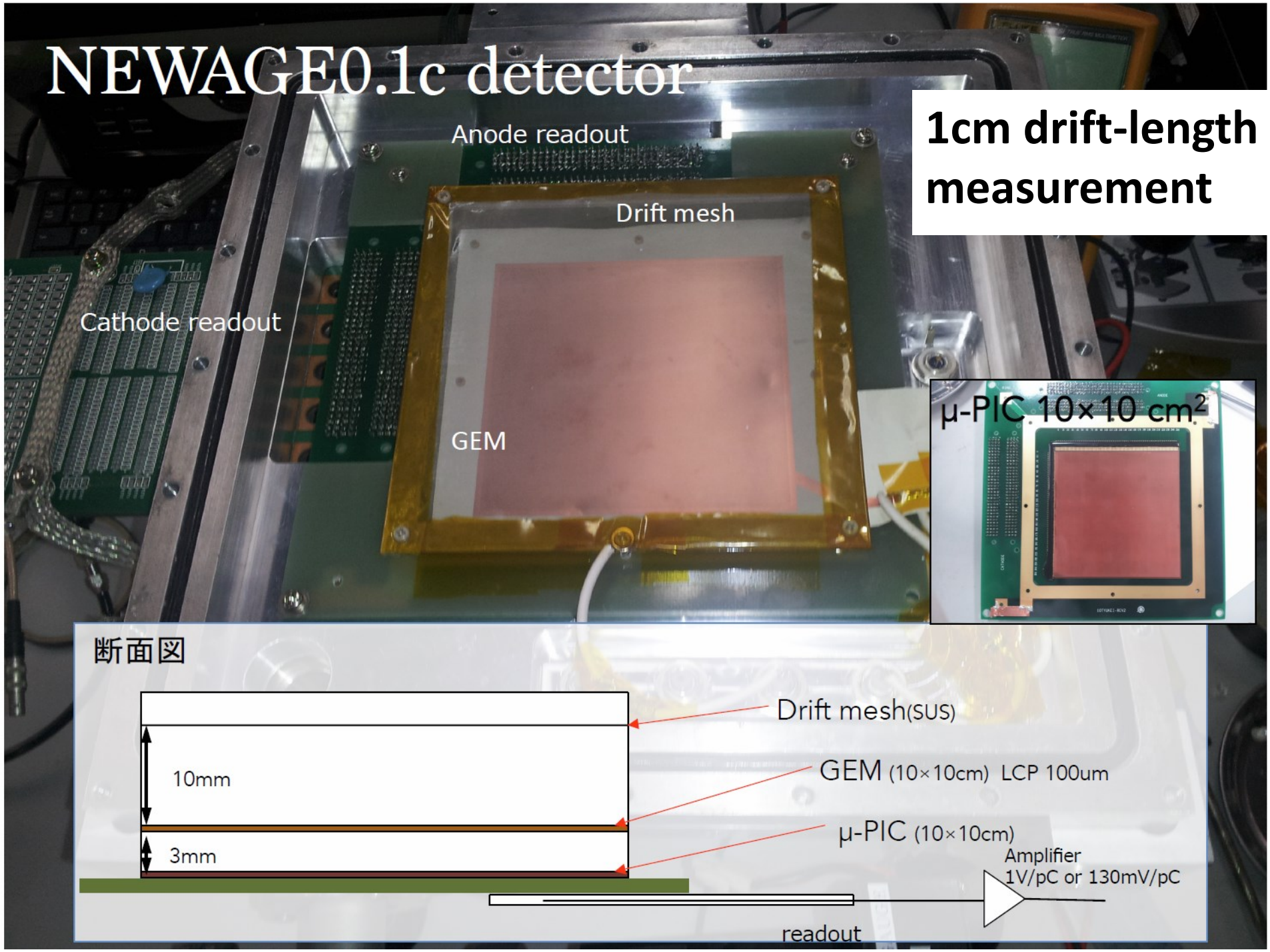
+NEWAGE Group

1. DM Experiments with MPGD
2. NEWAGE
3. Motivation
4. Measurement
5. Summary

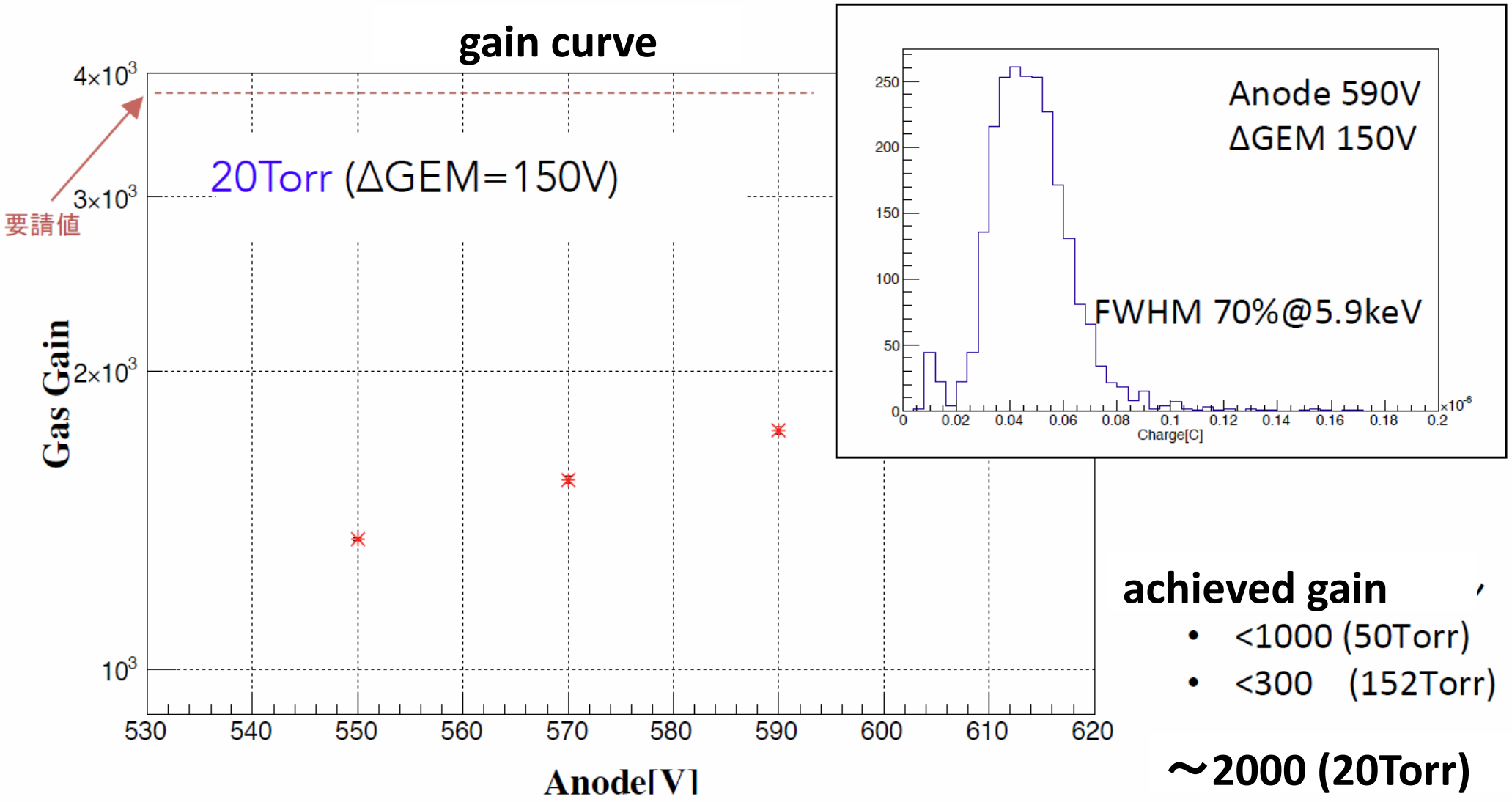
# Detector Study

# NEWAGE0.1c detector

**1cm drift-length for gain measurement**



# gas gain

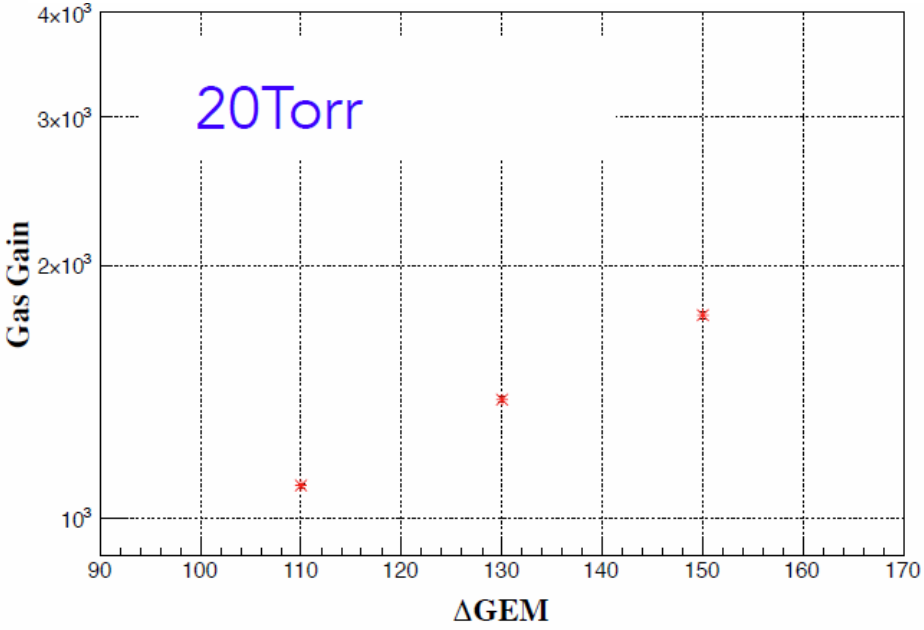


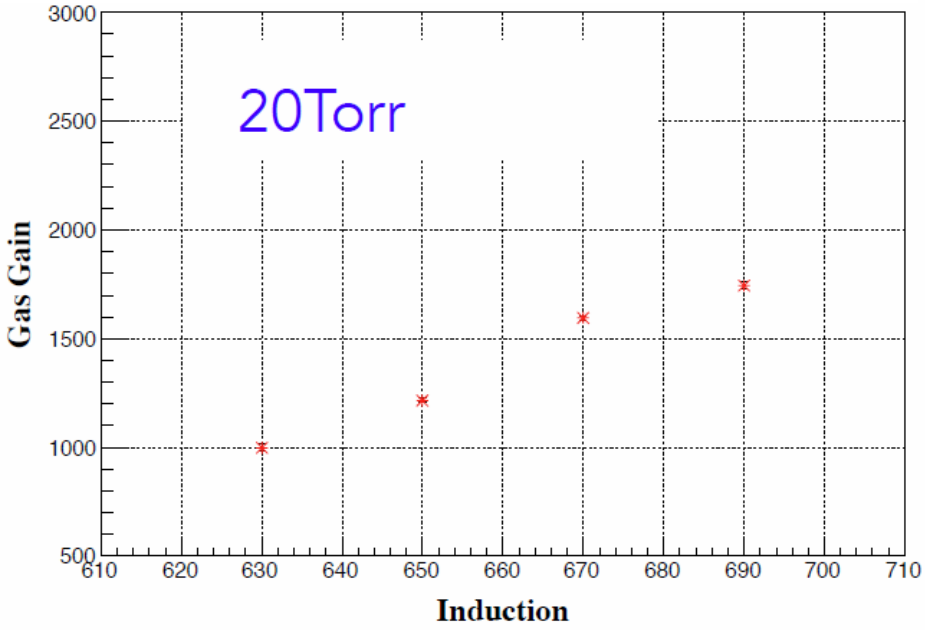

**achieved gain**

- <1000 (50Torr)
- <300 (152Torr)

**～2000 (20Torr)**

# gas gain (ΔGEM, induction dependence)




**gas gain 2000 @ 20Torr**

**(current operation: gain 3000with 76Torr CF4)**

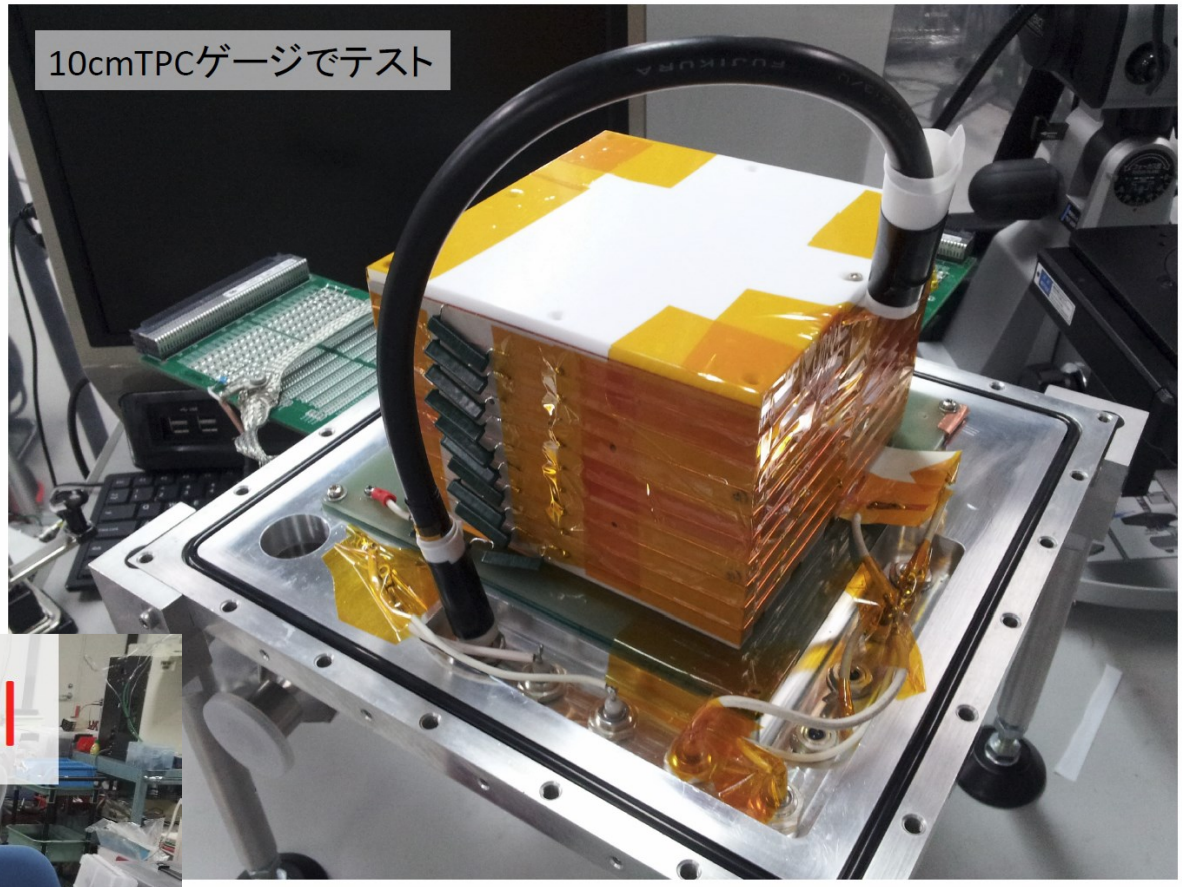
**longer tracks are expected with better S/N amplifiers**

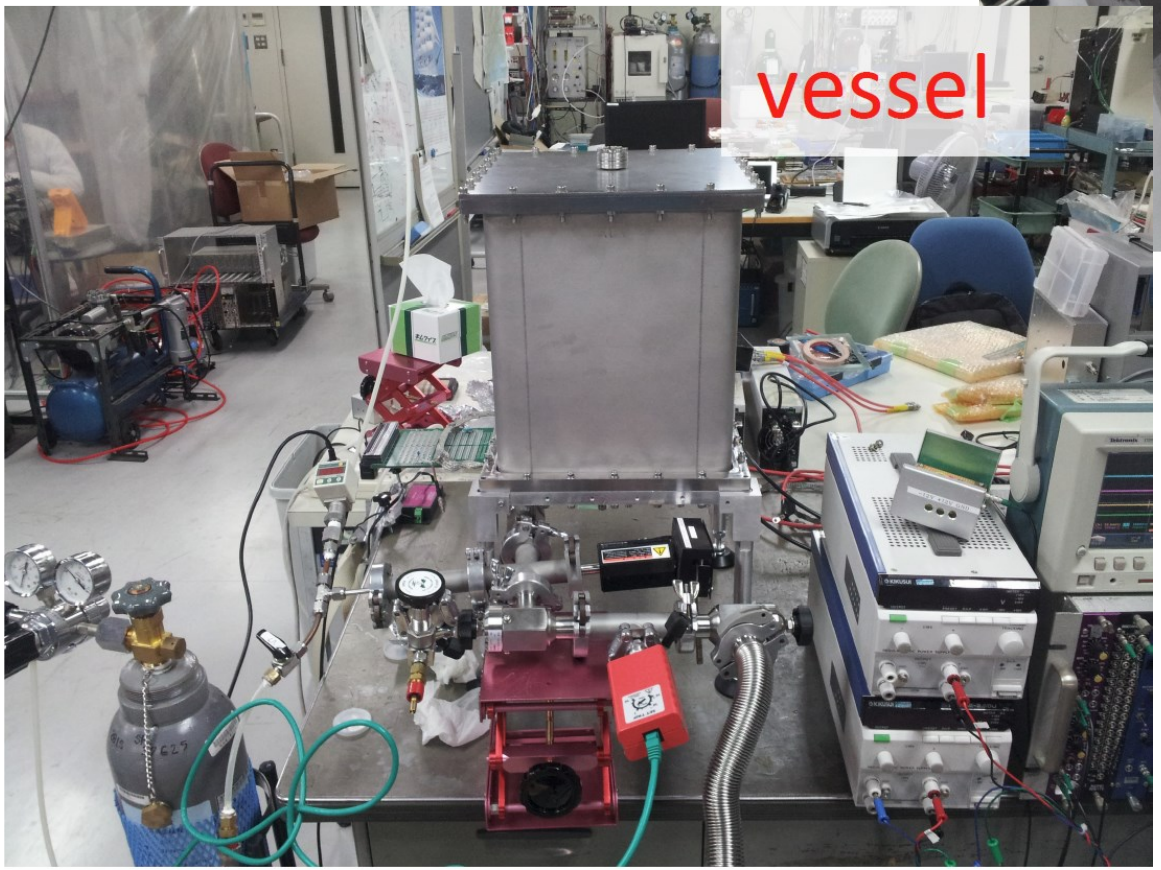
**Ongoing study**

- **uPIC/GEM individual gains**
- **Observe minority signals with TPC**

# TPC

10cm drift length
alphas/252Cf
taking data
vessel is for upto 30cm



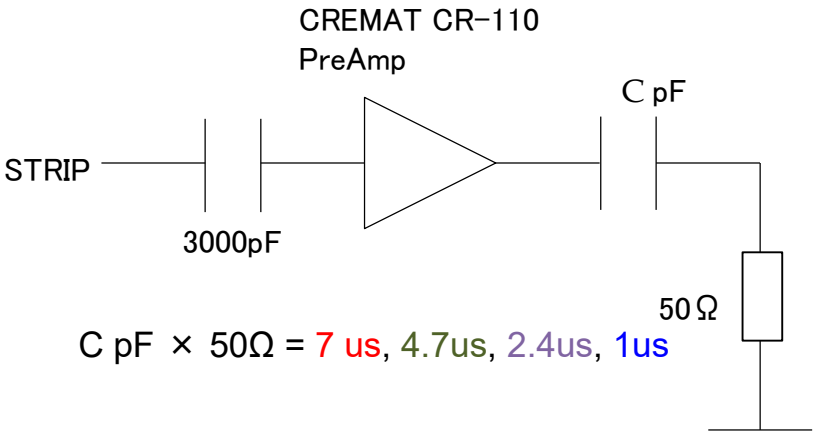



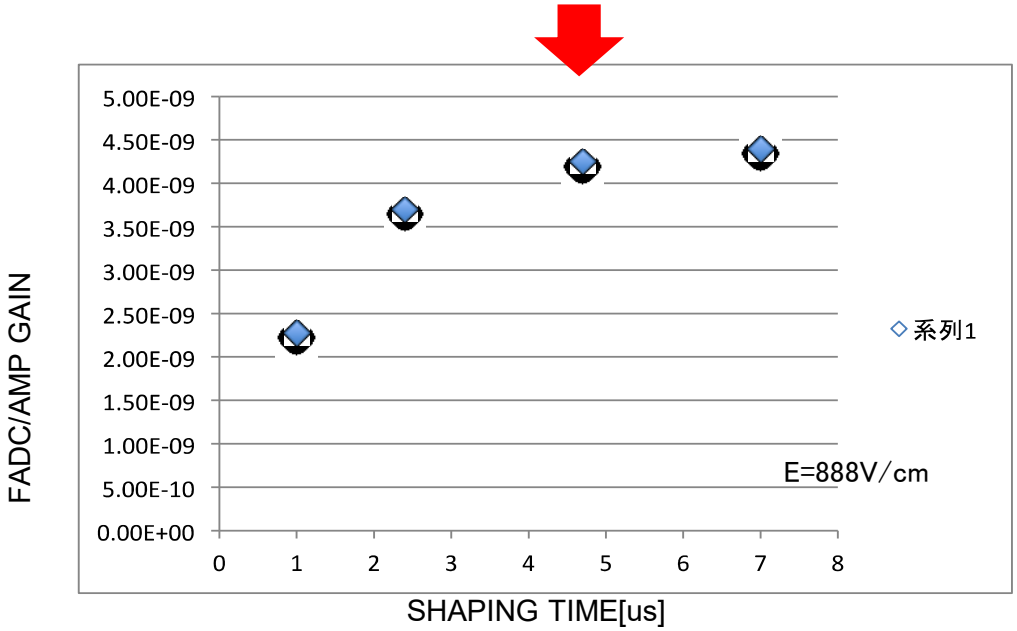
# Electronics Development

# μTPC VS NIμTPC

| | μTPC(NEWAGE0.3b') | NIμTPC |
|---|---|---|
| Gas | $CF_4$ (76Torr) | $SF_6$ (20Torr) |
| Gas gain | ~6000 | ～1000 |
| Ionization energy | 16eV | 16 eV |
| Drift electric field | 100V/cm | ～1000V/cm |
| Drift velocity | ～cm/μs | ～$10^{-2}$cm/μs |
| Deposit energy / 1strip(400um) | ～30keV (～2pC) | ～10keV (～0.1pC) |
| pre-amp shaping time | ATLAS TGC ASD (T=16ns and 80ns) | Wanted |

- Measured 55Fe signals from uPIC signal
  with several shaping time constants




- At ～5us, output voltage
  of the charge amplifier reached its maximum.

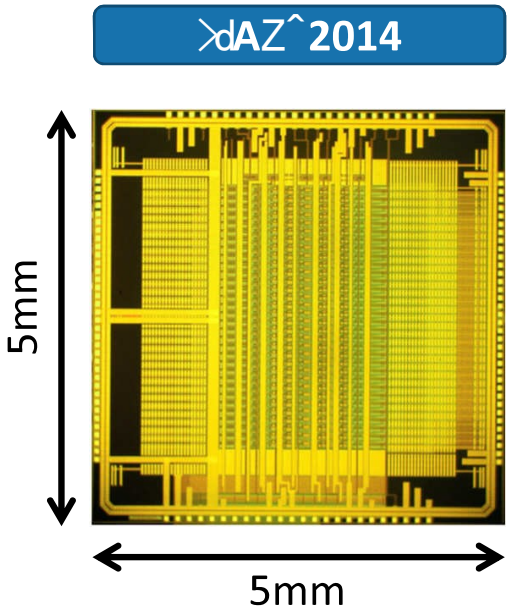
# Specification requirements for NITPC ASICS

| Specificatioin(2016/6/27) | | |
|---|---|---|
| | Minority Charge | Main Charge |
| Detector Cap | 300pF | |
| Minimum signal | 3fC(ENC × 10) | 80fC |
| ENC | 2000(0.3fC)以下 | 5 × $^{4}$(8fC)以下 |
| Dynamic range | 80fC | 1600fC |
| Conversion gain | 10mV/fC | 0.5mV/fC |
| Shaping time | 4us | |
| power | <50mW/32ch | |
| etc | 16ch input | |

**Key values: dynamic range and time constant**

# designed by KEK for Liq Ar TPC

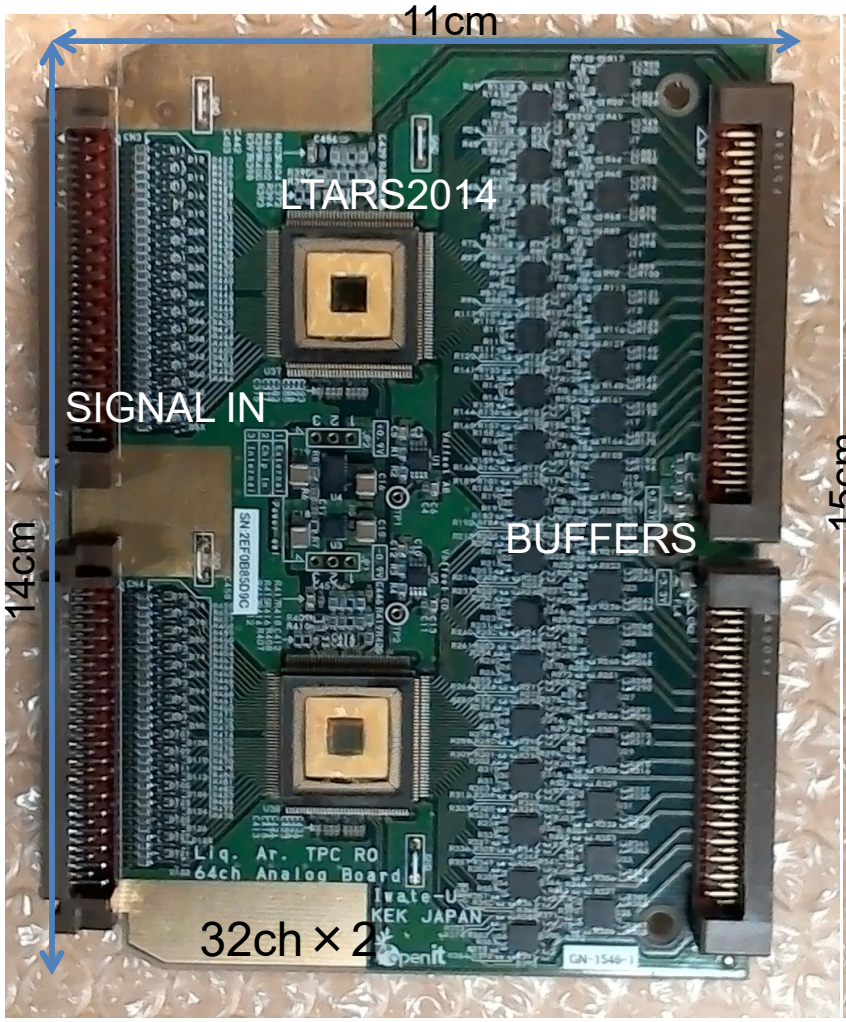
| | Design |
|---|---|
| Minimum signal | 1fC |
| ENC | 1950 (0.3fC) |
| Max detector Cap | 300pF |
| Dynamic range | 80fC～500fC |
| Conversion gain | 8mV |
| Shaping time | 1us |
| PSD/ch | 1.25mW |
| Total number of channels | 32 |
| Total | <50mW |

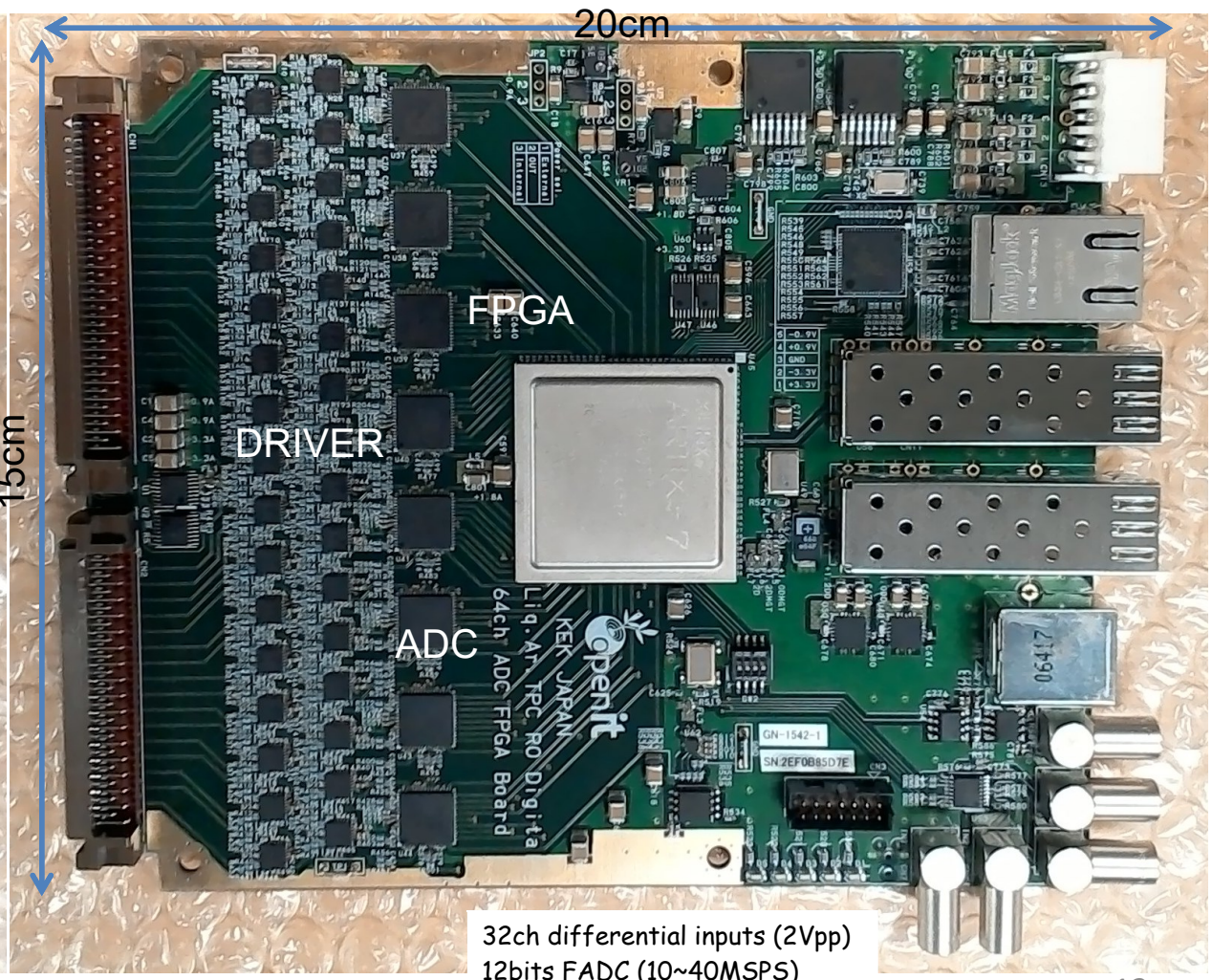



→ **3fC ~ 1600fC**

→ **4us**

**FY 2016 single-channel test chip development**
**FY 2017 multi-channel chips**



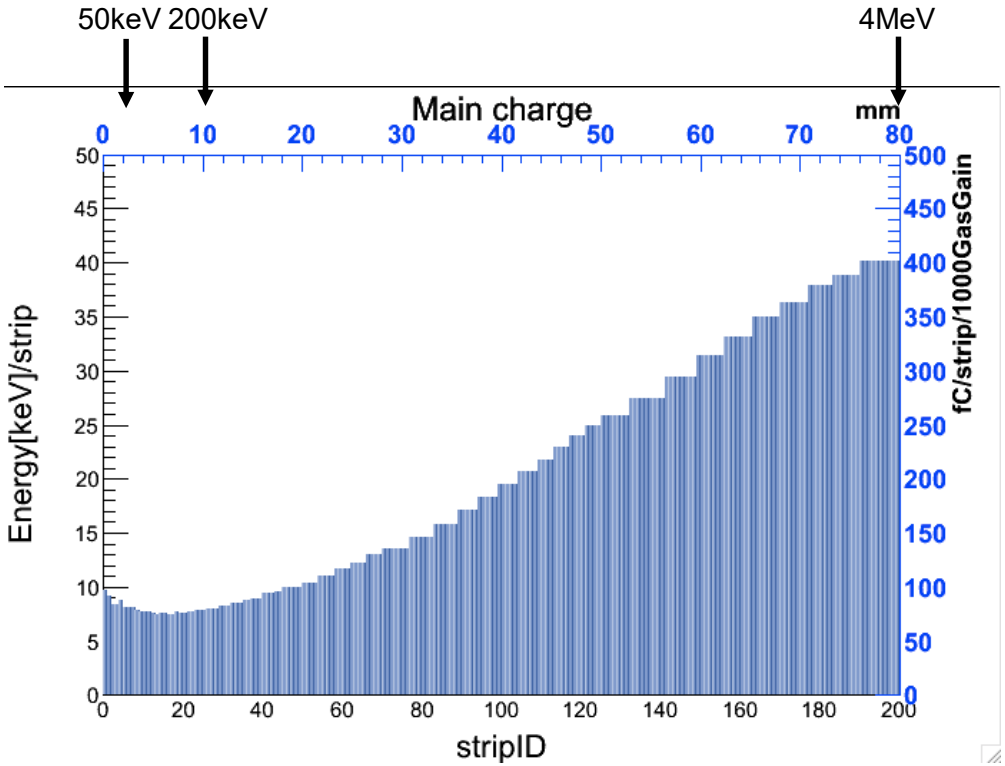

32ch differential inputs (2Vpp)
12bits FADC (10~40MSPS)
Airtix-7 FPGA
Ethernet (RJ45 or SFP)

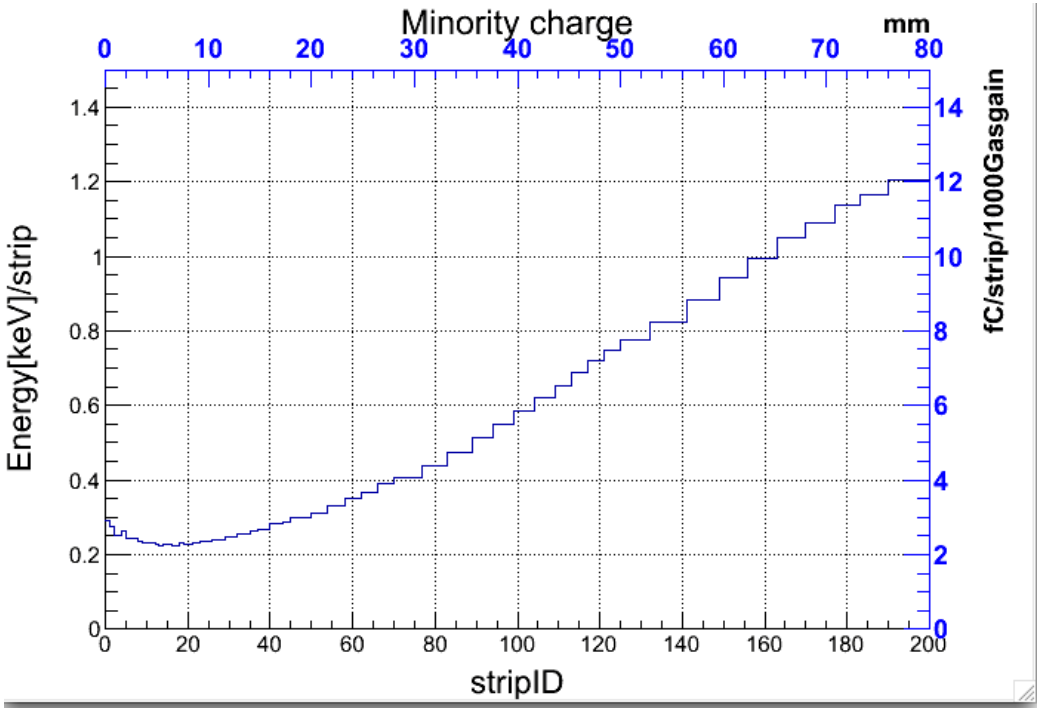


# 10cm TPC readout by these system is on-going

# Backups

- Using SRIM&TRIM
- F nucleus at SF6(20Torr)
- Minority charge: 0.03 × Main charge [Ref: N.Phan talk at CYGNUS2015]



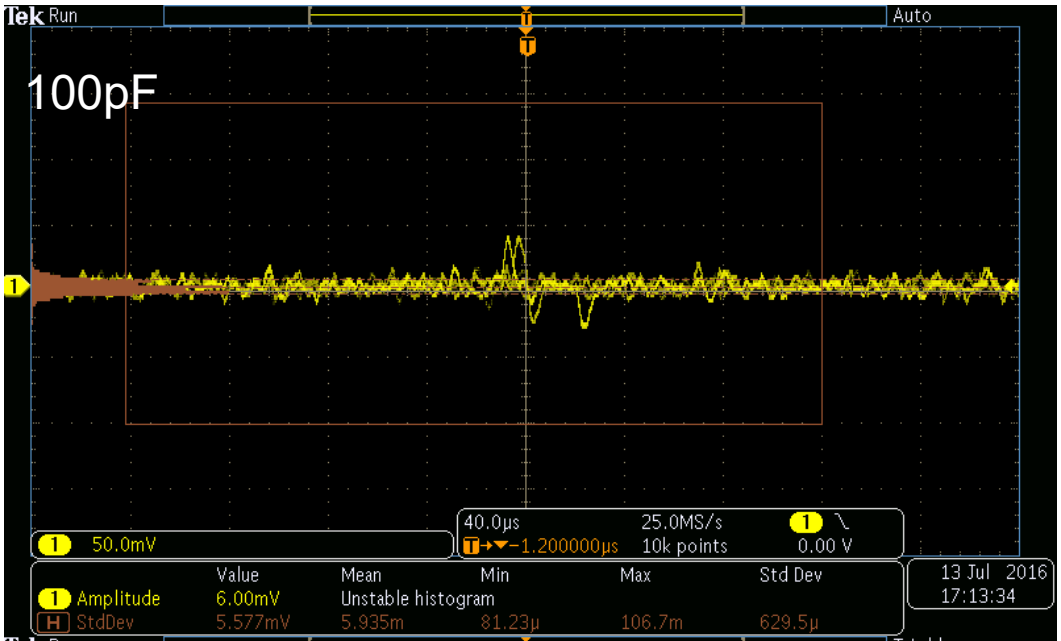



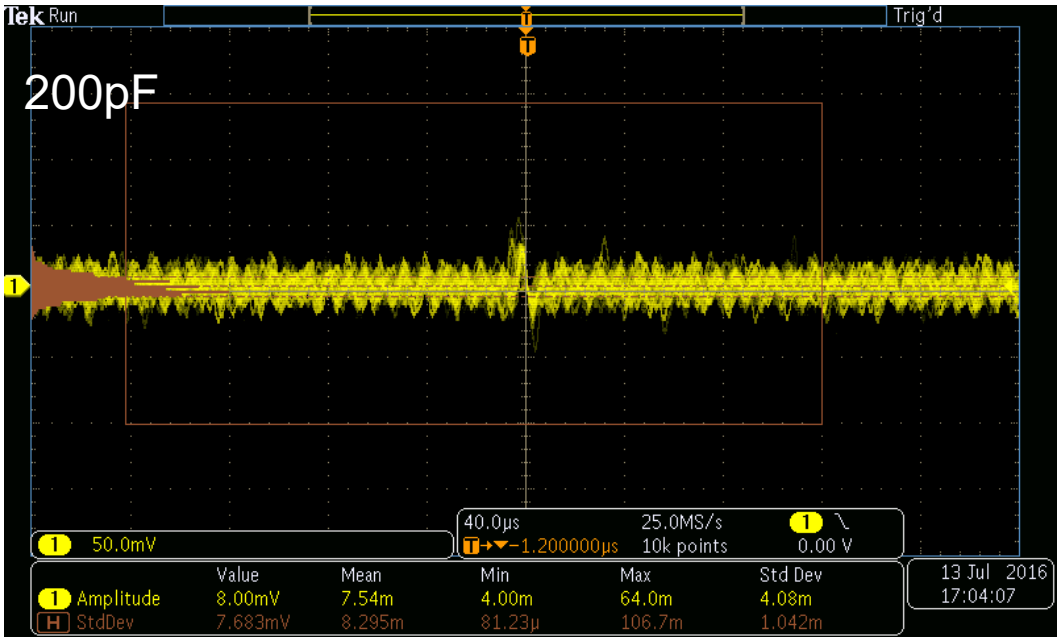

- Minimum energy deposit is about 2fC at gas gain 1000.

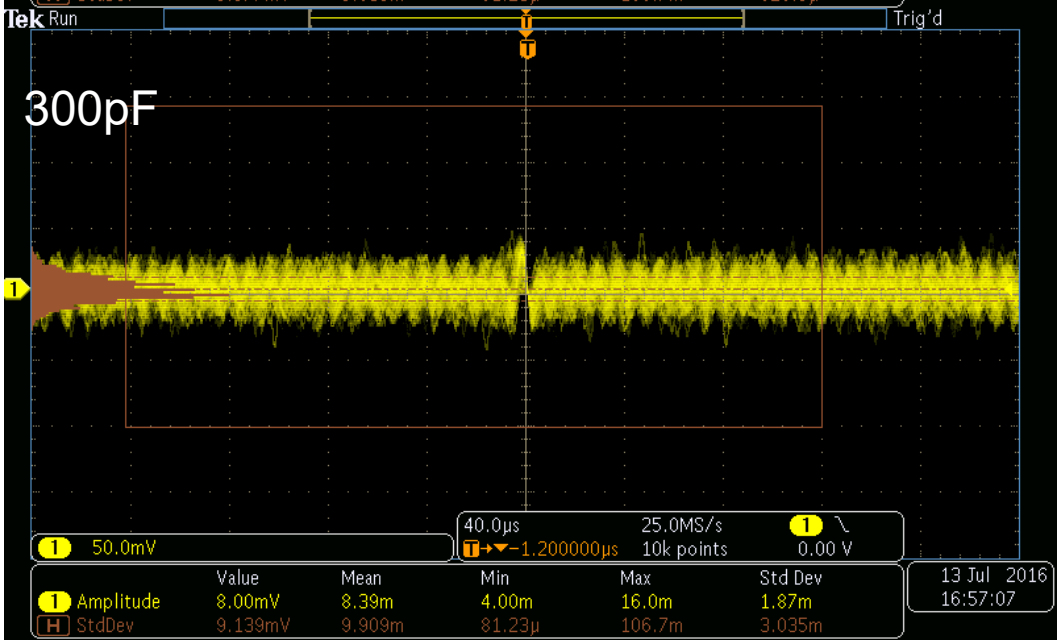
# Dynamic Range

| | | F | Alpha |
|---|---|---|---|
| Main | Max(1strip) | 800fC | 40fC |
| | Min | 80fC | 10fC |
| Minority | Max | 24fC | 0.6fC |
| | Min | 2fC | O($10^{-1}$) |

Max = maximum charge × gas gain 2000
Min = minimum charge × gas gain 1000



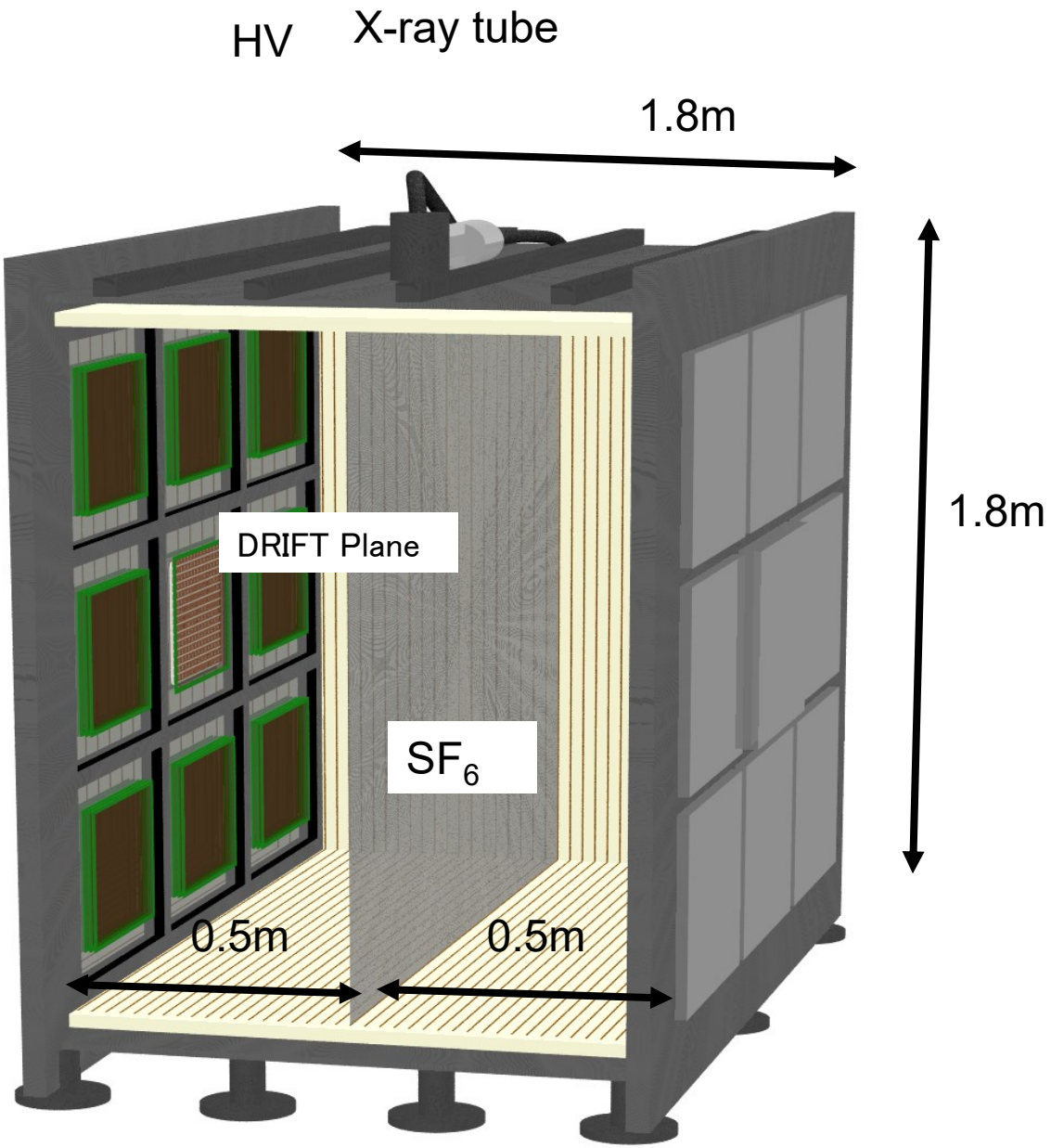




At 300pF(3strips), σ9mV=5000electrons.

# CYGNUS/NEWAGE “observatory”, or test bench

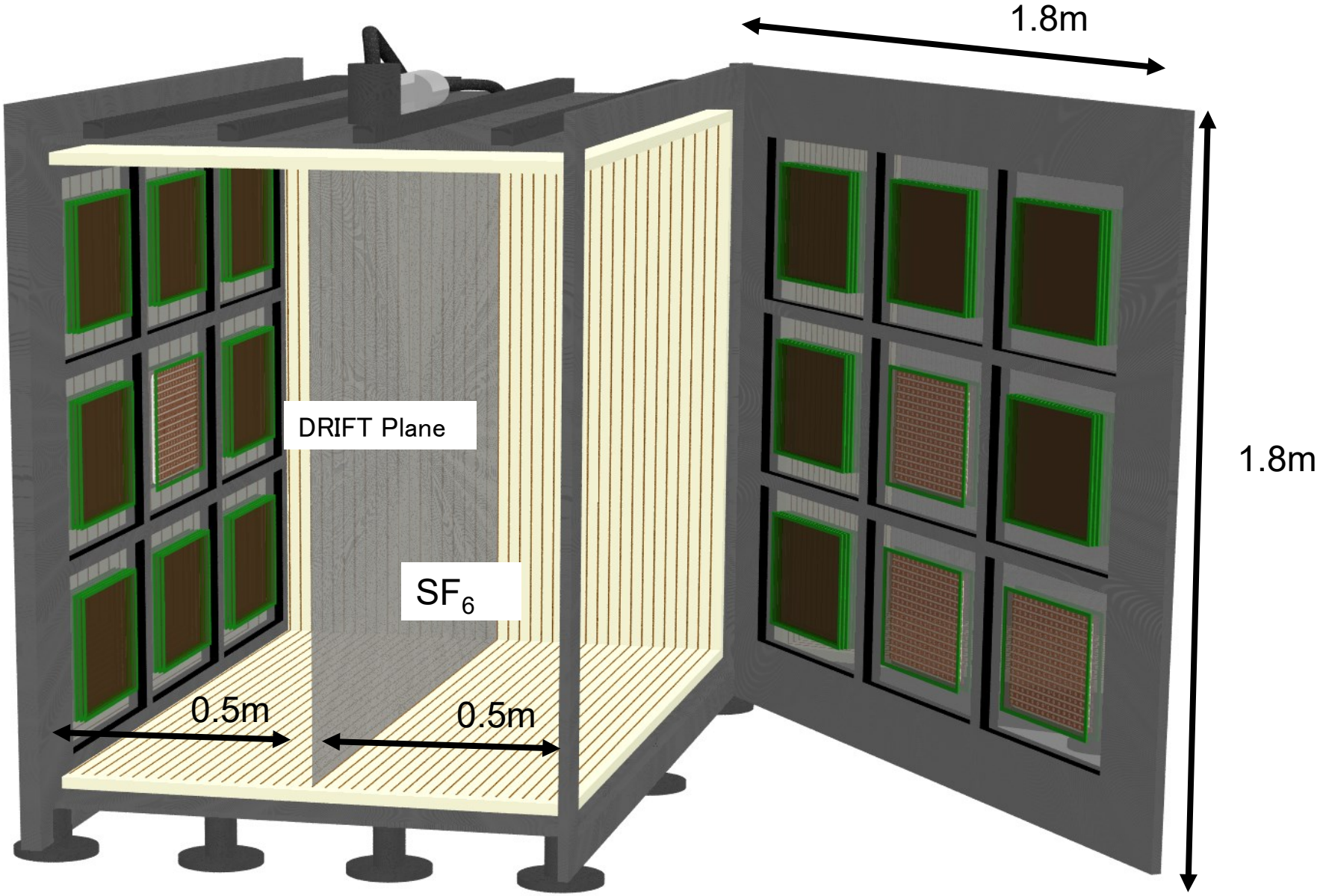
- SPECS
  - Vessel material: steel (baseline) or plastic (as a future R&D)
  - Vessel shape: cube (baseline) or cylinder (cheaper option )
  - 50cm polyethylene shield
  - Equipped with 18 modules



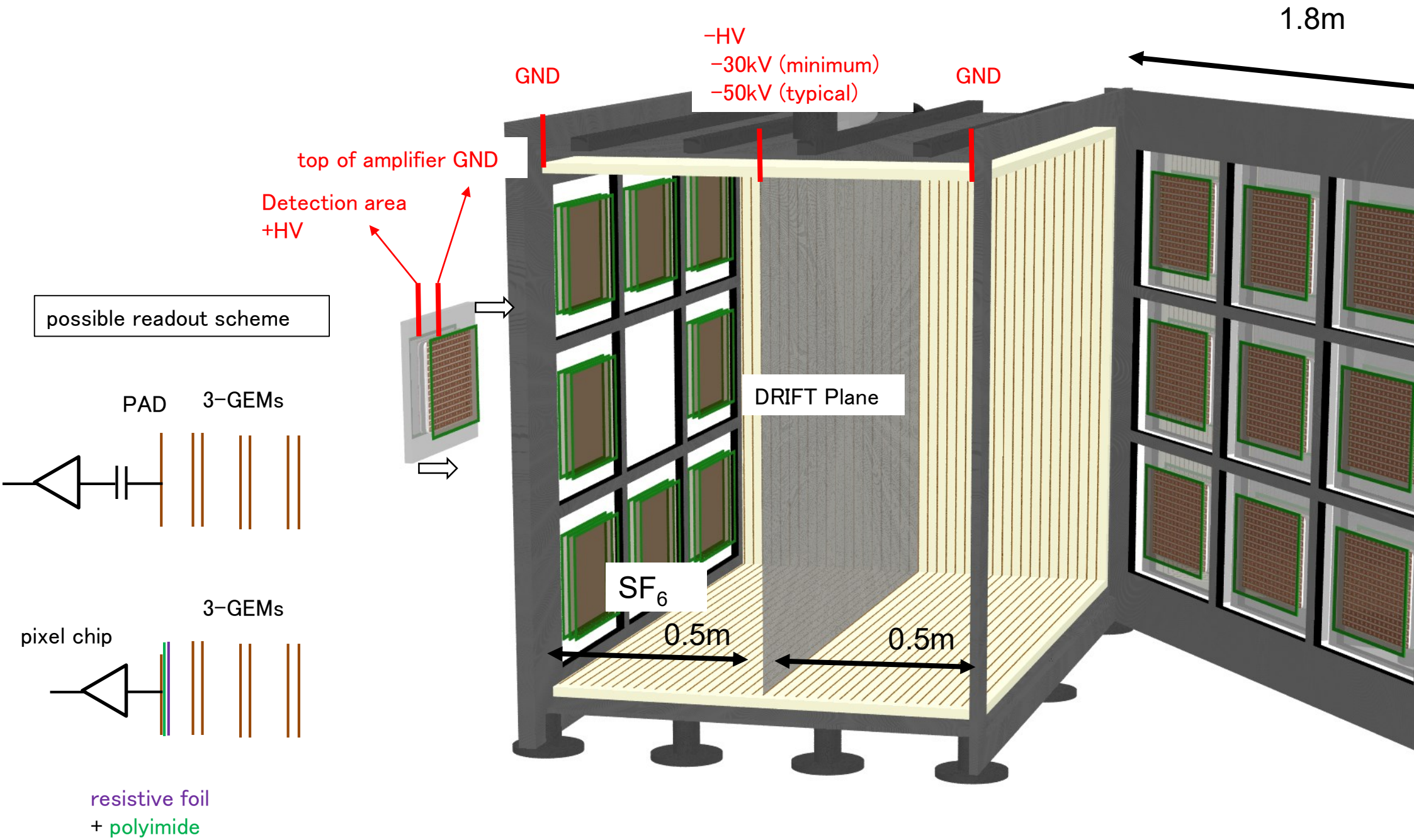

detector modules
(50 × 50cm$^2$)

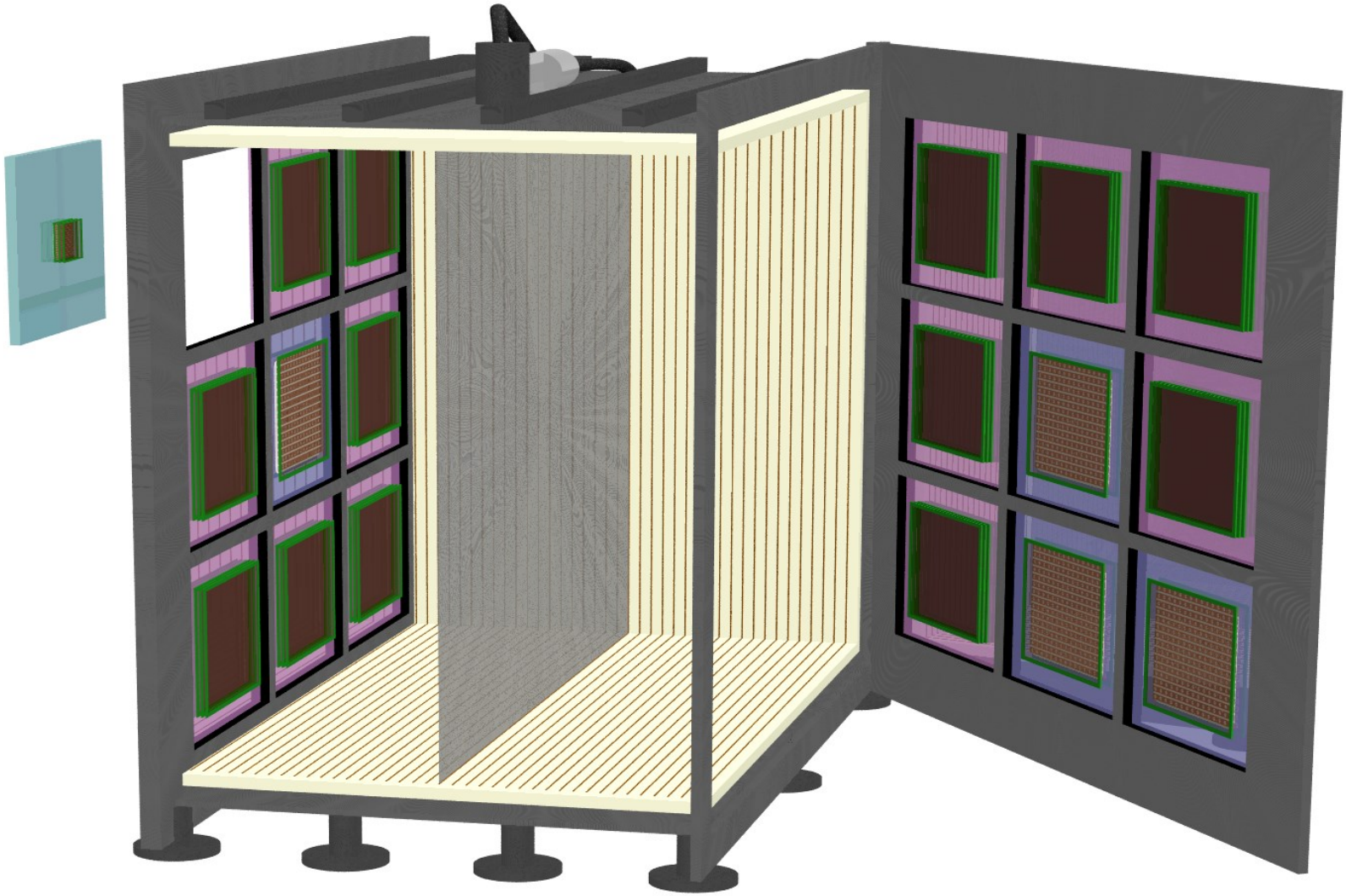
- Schedule
  - 2016–2017 construction
  - 2018–2019 commissioning: 14 × GEM modules + 4 × uPIC modules –> confirm low BG environment
  - 2020– open to other readouts: pixel chips, optical…. (Radon emanation screening prior to the installation)

detector module
(50 × 50cm$^2$)



- Design discussion
  - Drift field for hybrid-system
  - gain voltage would vary among detectors





- AC-coupled readout

2012 JINST 7 C02021

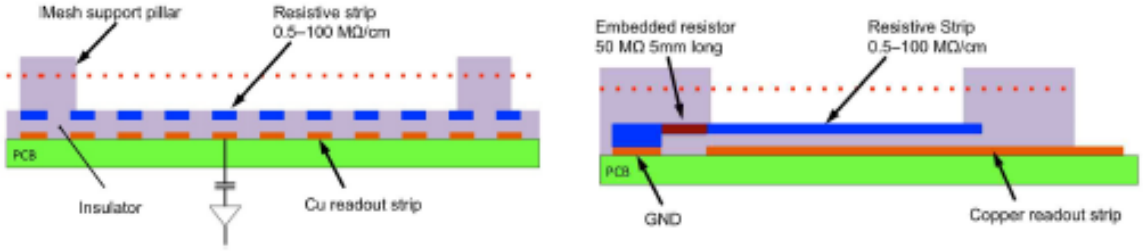
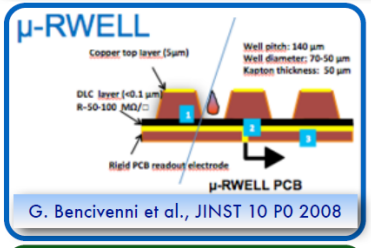


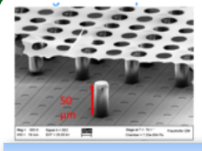

**Figure 1.** Sketch of the detector principle (not to scale), illustrating the resistive protection scheme; (left) view along the strip direction, (right) side view, orthogonal to the strip direction.

# NITEC possible future: CYGNUS-RD

**CYGNUS-RD: development and characterization of a Negative Ion TPC with MPGDs readouts (charge/optical)**




G. Bencivenni et al., JINST 10 P0 2008




GridPix

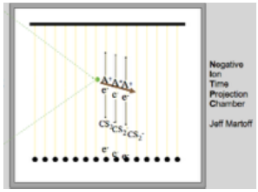
W. Koppert et al., NIM A 732, 245-249

Orange

M. Marafini et al, JINST 10 No 12 P12010

+

**Negative Ions (SF6)**




**Total budget asked:**
**~50k EUROS / 2 years**
**(answer by Sep 2016)**

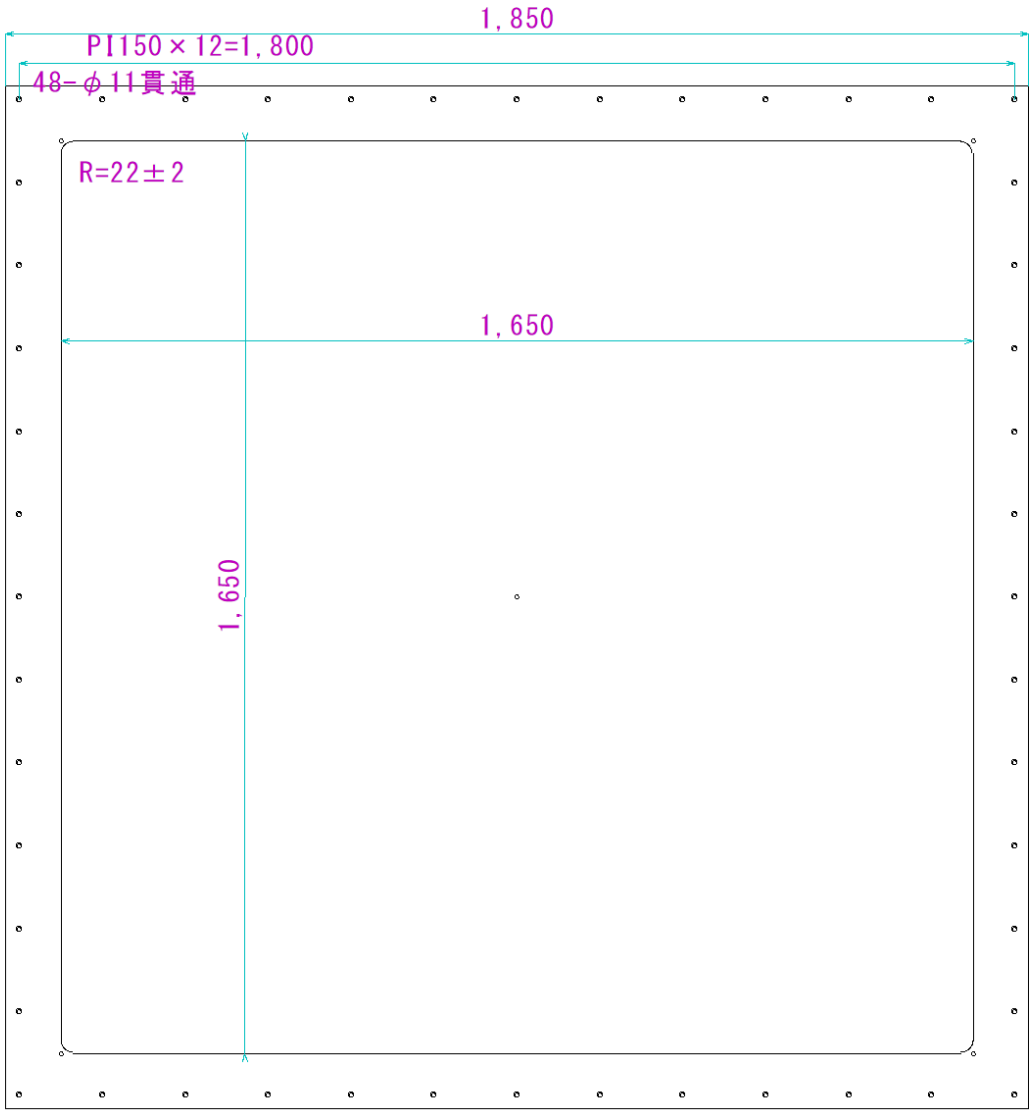
**Team ~ 3 FTE**
**(LNF + Roma1)**

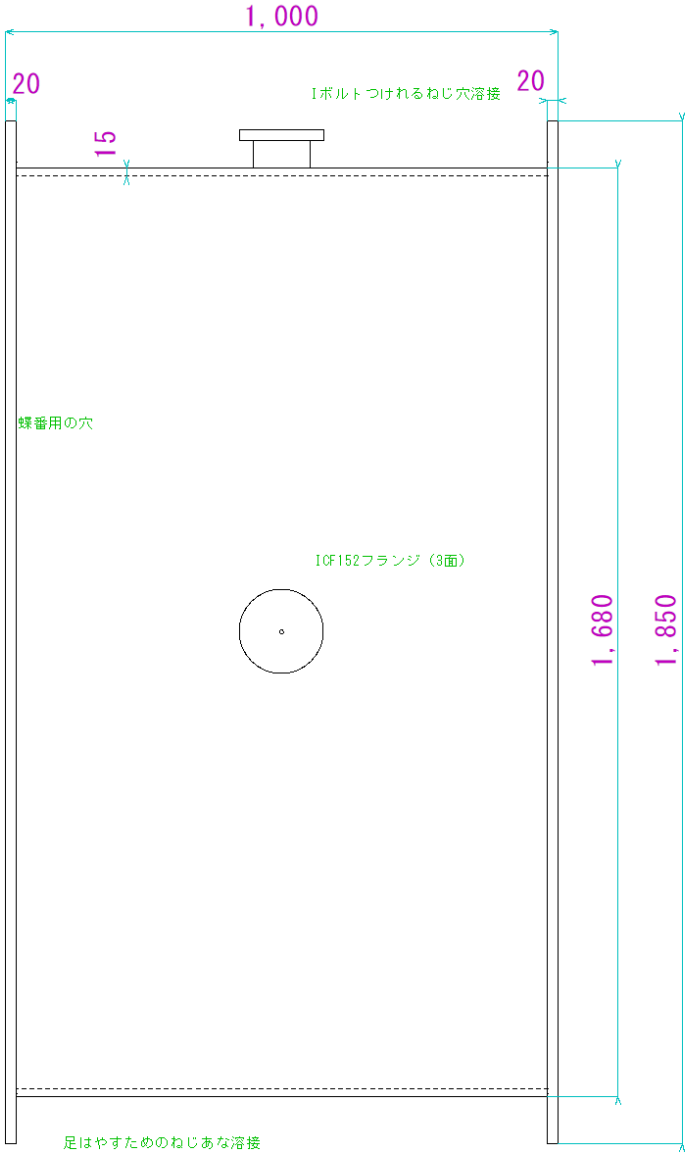
In the context of the **CYGNUS-TPC project**


**...CAVEAT me finding a position (my contract ending 05/17)**

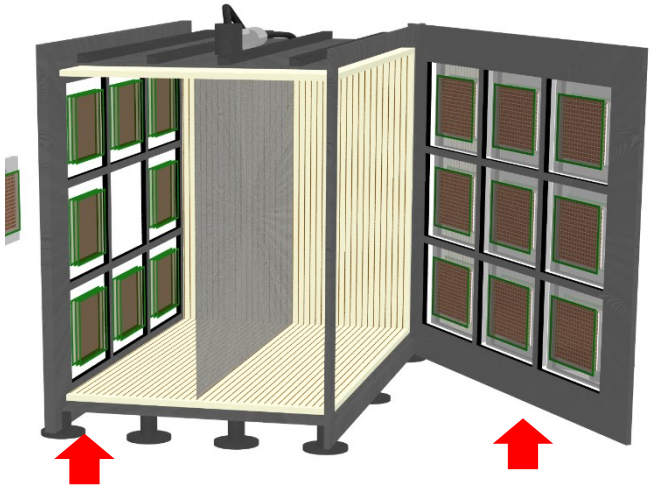
# plans(unit: mm)

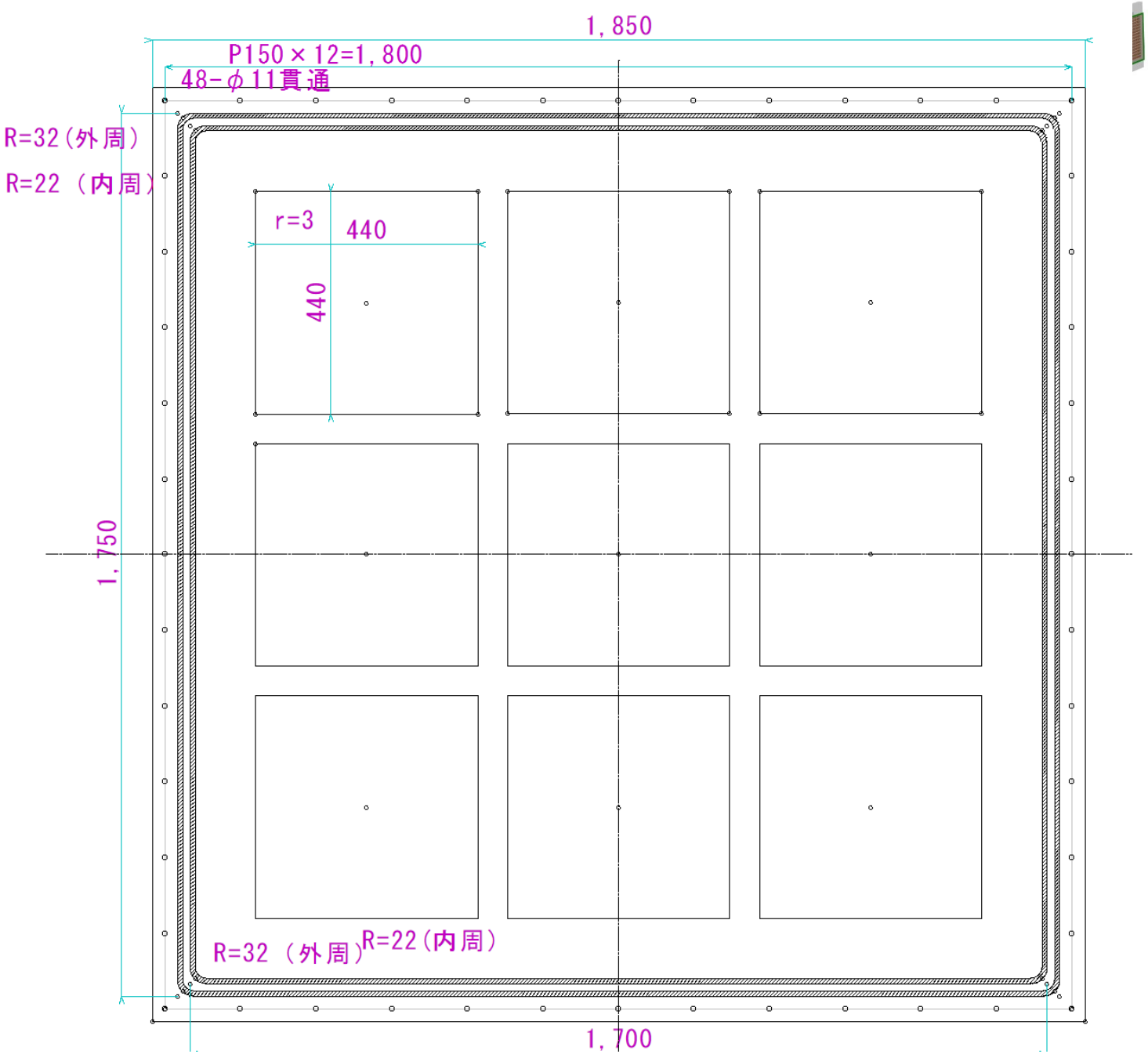
## VESSEL



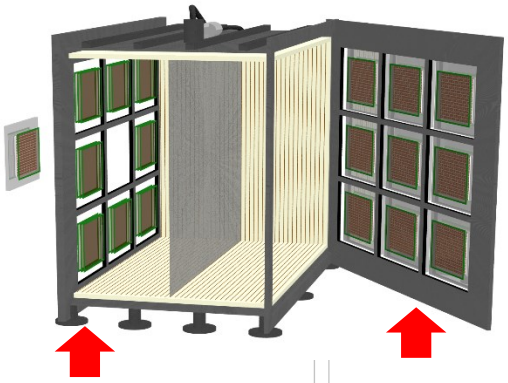



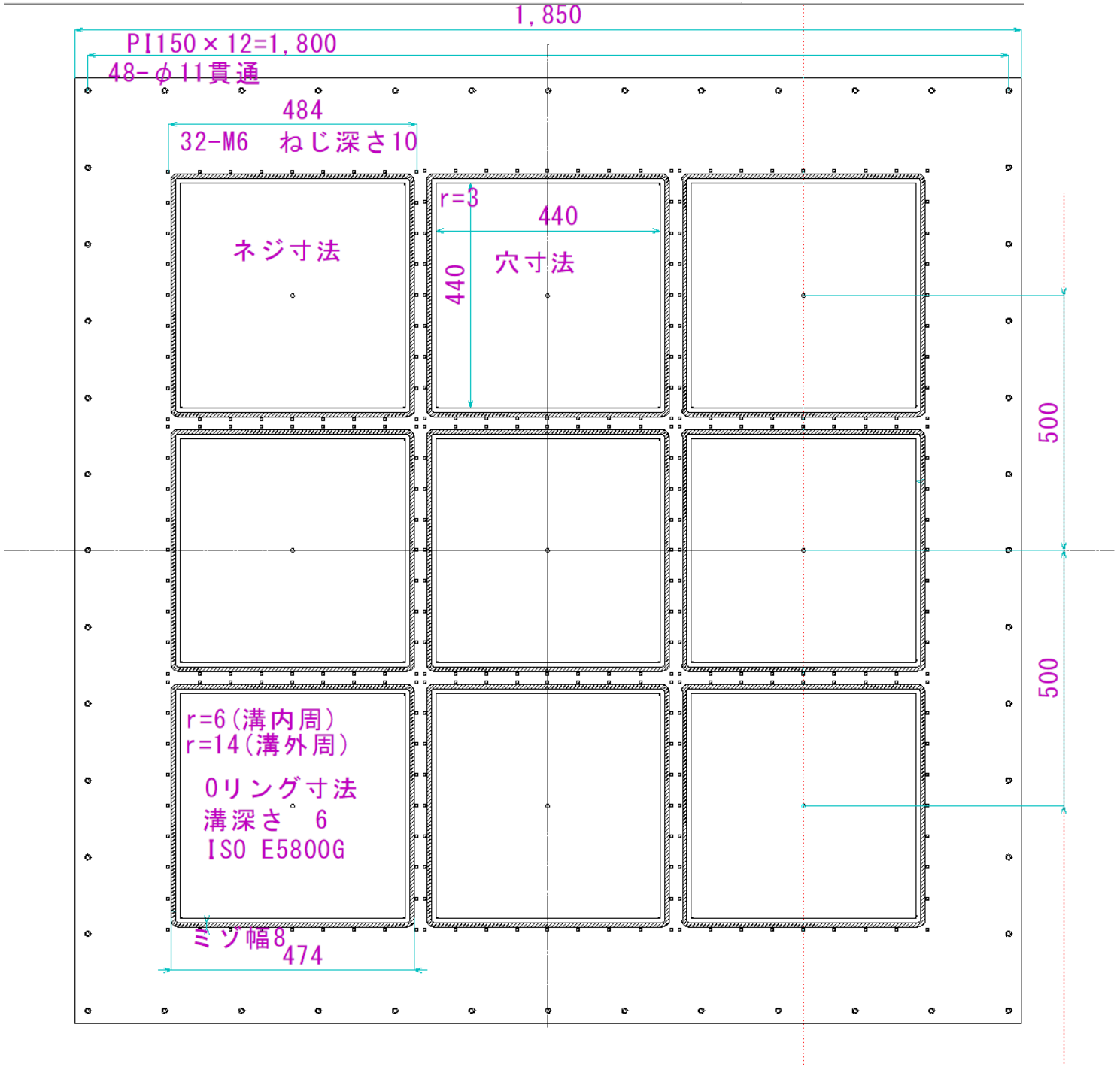
# endcap plate（inside）



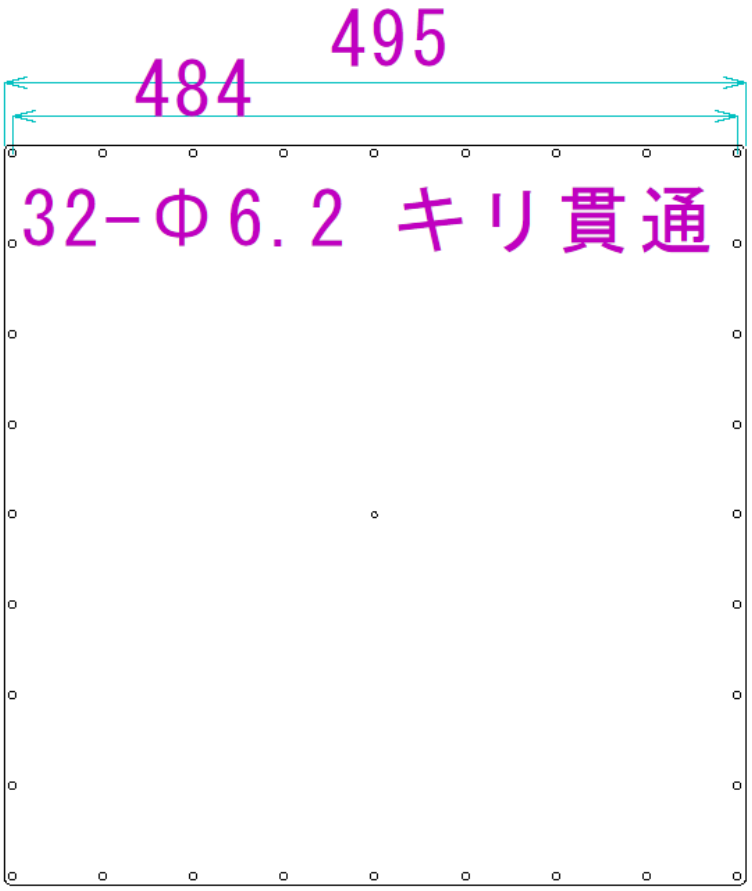


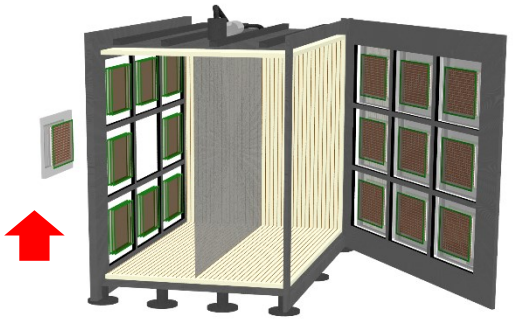
# endcap（outside）

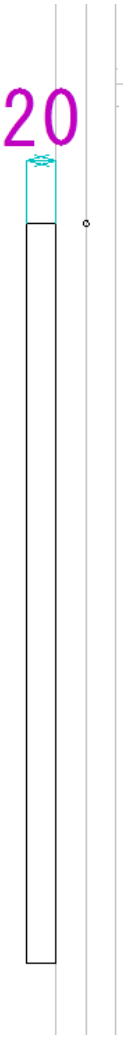




# module base





# TPC