Ceramic GEM

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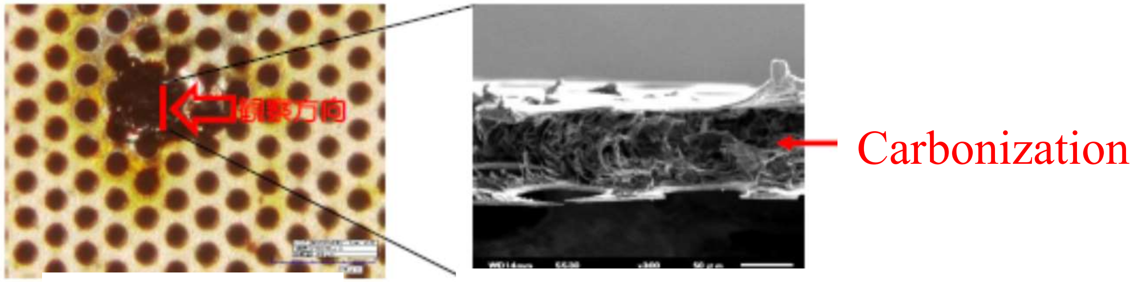
New GEM

- One big issue is that serious damage occurs in GEM foils.
  - Large charge stores in large capacitance of GEM foil.
  - Small discharge (trigger)

    —> Large discharge —> Serious damage (Carbonization)



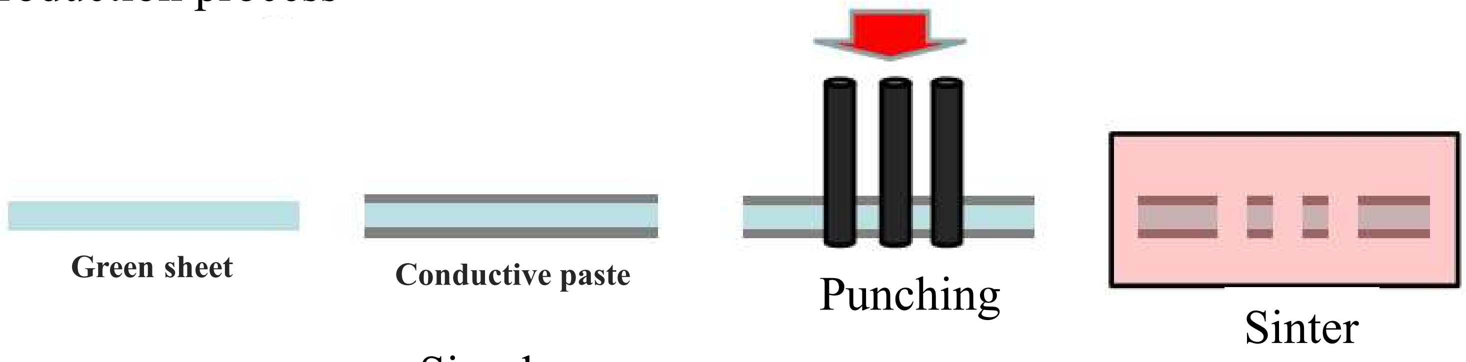
Broken GEM Image with SEM

- To avoid serious damage
  - Resistive GEM (RE-GEN)
    - Resistive electrode instead of Cu → Sacrifice rate capability
  - Teflon (PTFE, polytetrafluorethylene) GEM

    → Some difficulty in production
  - Ceramic GEM

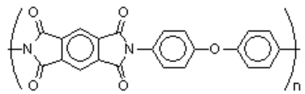
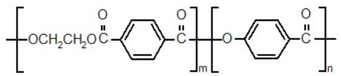
2. Low Temperature Co-fired Ceramic (LTCC) GEM

（1）Production process



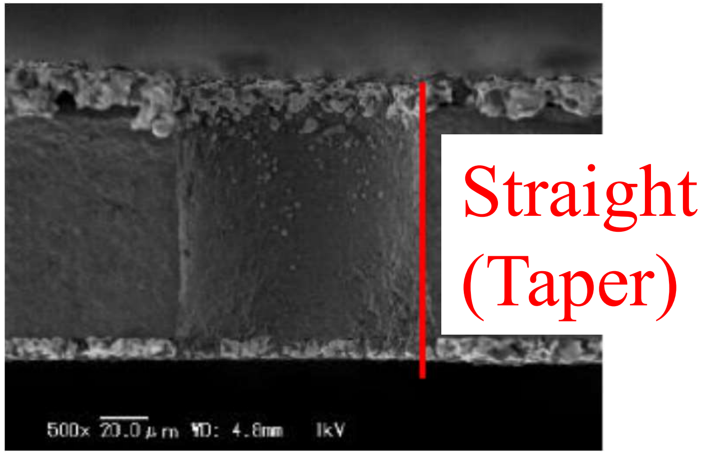
- Simple
- Mask-less

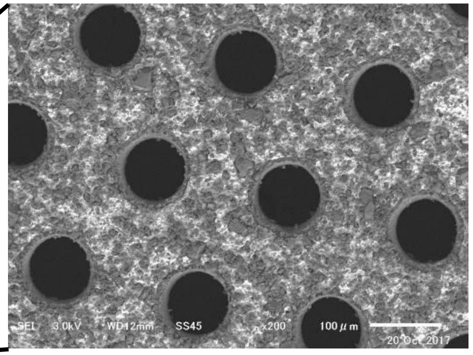
(2) Strong against discharge

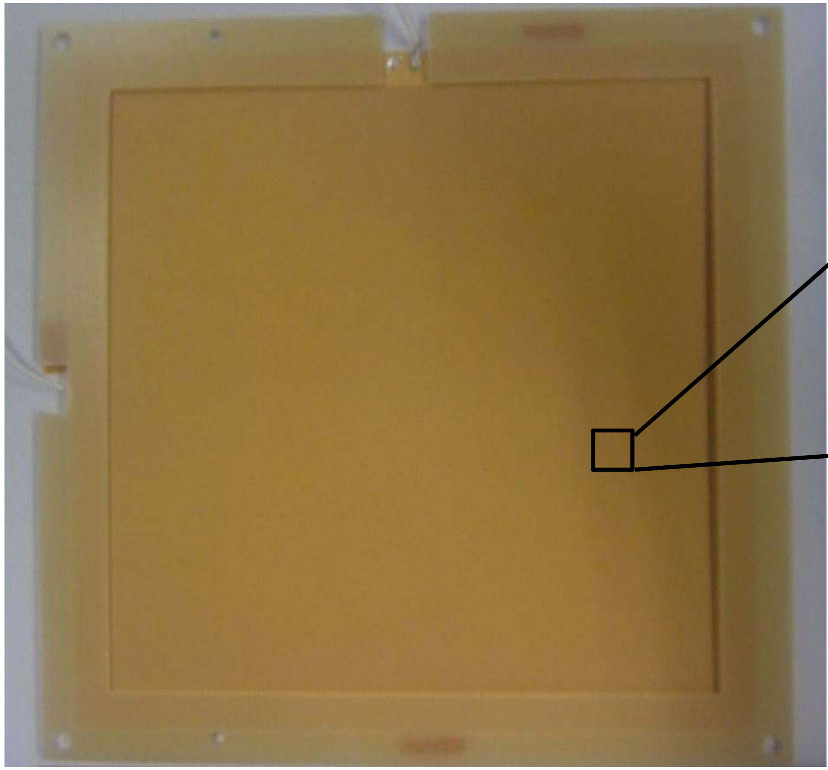
		Past		New
		Foil GEM		Ceramic GEM
		polyimide	LCP	LTCC
Material				CaO Si_2 + Al_2O B_2O_3
Voltage registance	kV・mm^{-1}	22	26-40	＞15
Ark discharge	Sec	135	186	＞300
Melting point	℃	＜800	＜450	＞800

No carbon and no hydrogen in ceramic

LTCC-GEM





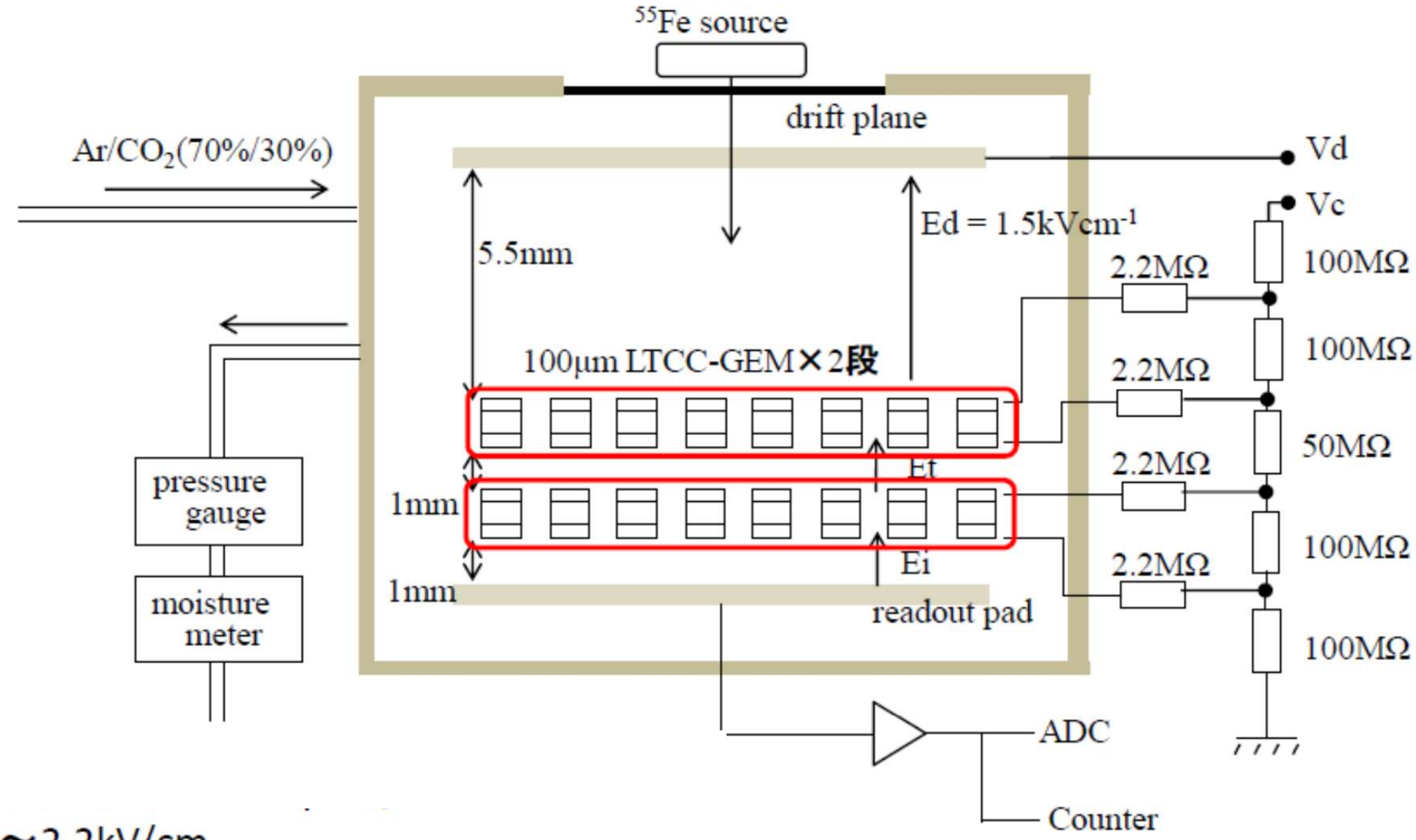


LTCC-GEM

LTCC GEM (normal GEM)

- Size : 100 mm×100 mm
- Hole diameter : 100 μm (70 μm)
- Hole pitch : 200 μm (140 μm)
- Thickness : 100 μm (50 μm)
- Material of Electrode : Au (Cu)

Setup for double GEM structure

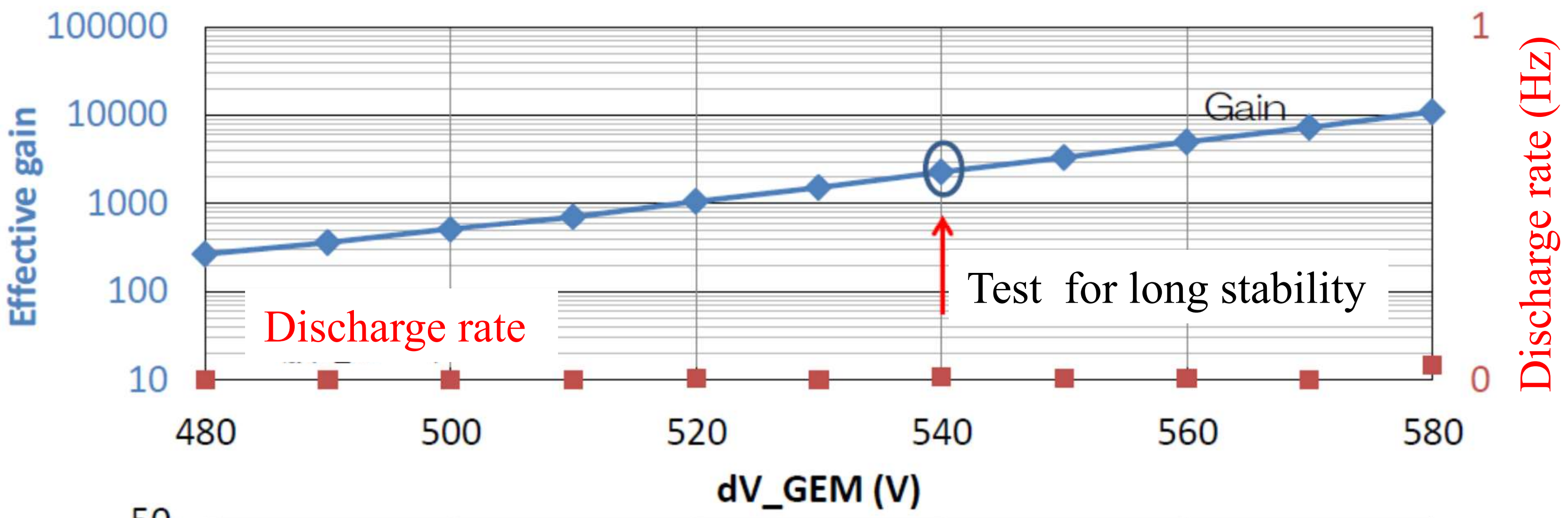


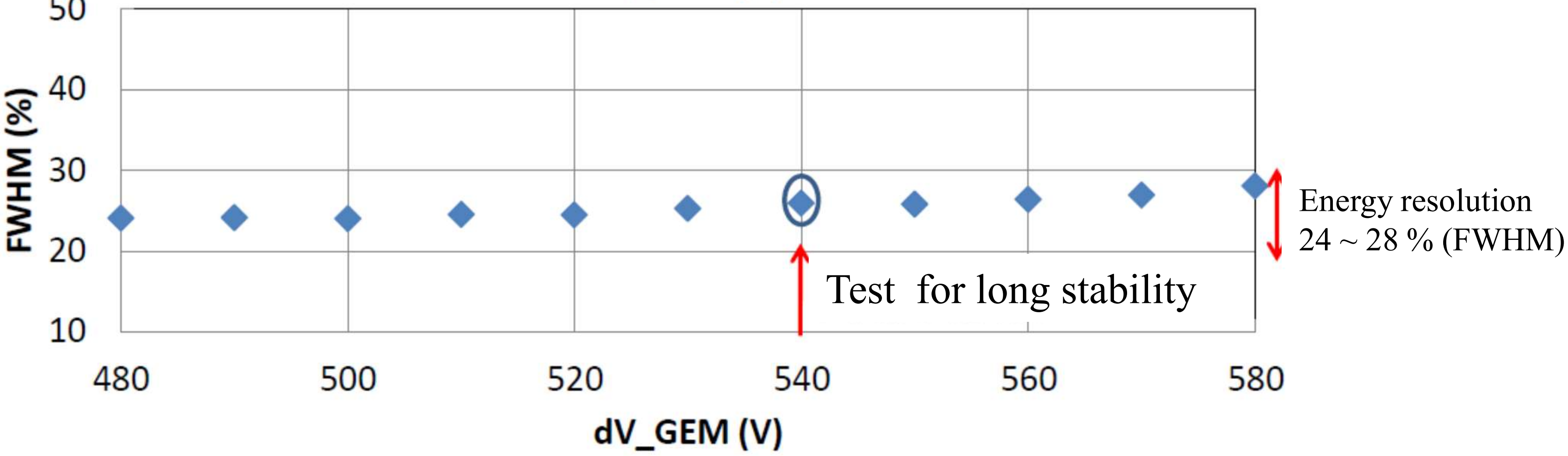
Ed= ～2.2kV/cm

Et= ～3.3kV/cm

Ei= ～ 6.4kV/cm

Gas gain and energy resolution with double GEM structure





Performance tests
with Pulsed Neutron Beam

RANS in RIKEN

(Compact pulsed neutron source)

Experimental setup

RANS in RIKEN

Compact accelerator within one room

Proton beam and Neutron source

Neutron detector

HV cables

All cables and pipes
can be connected
from one side.

One Ethernet cable
for digital data transfer

Two gas pipes
for inlet and outlet

Electronics aria

Active aria

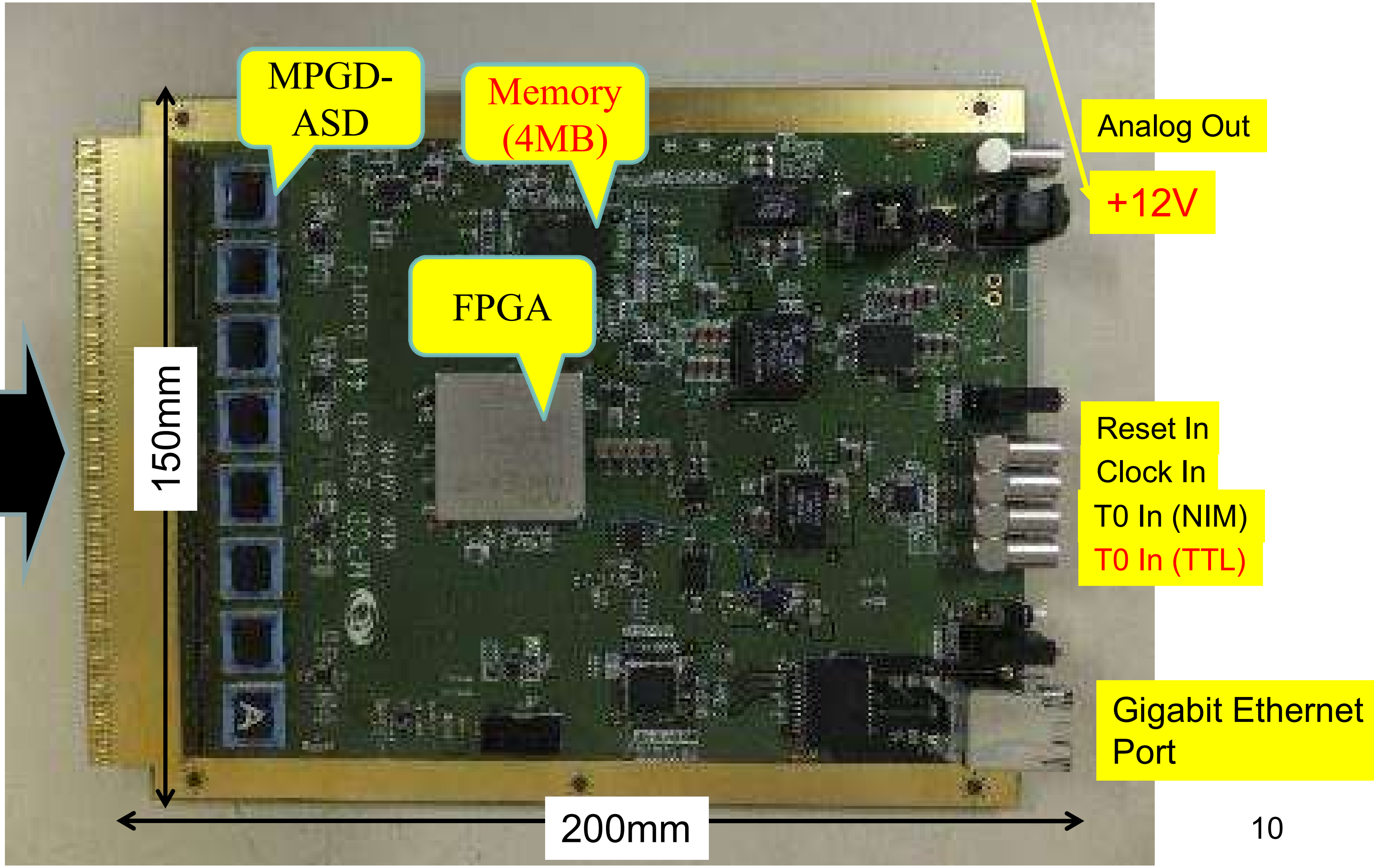
Aluminum cathode with 2μm^t boron

Electronics board

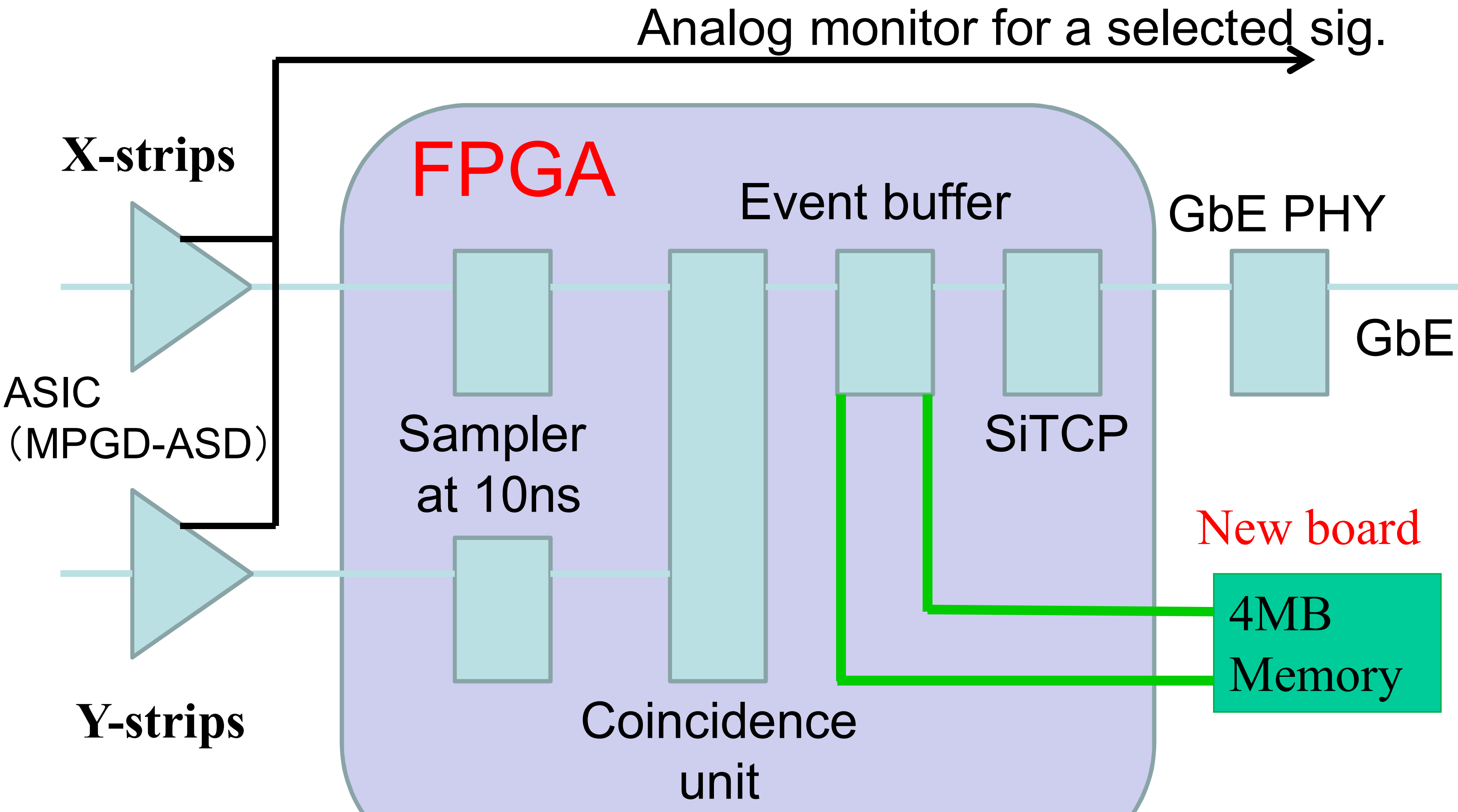
Commercial AC adapter can be used.

ASD 32ch/chip with analog monitor

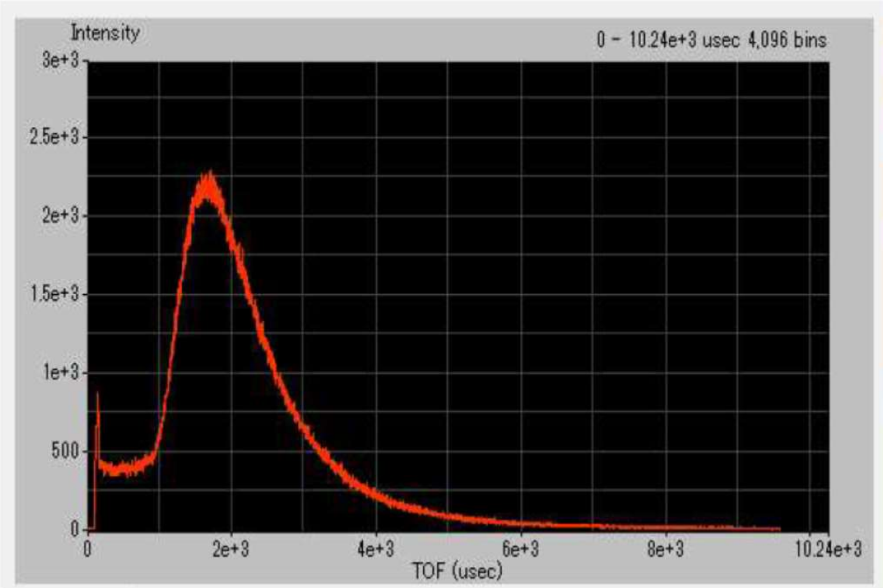
256 signal inputs



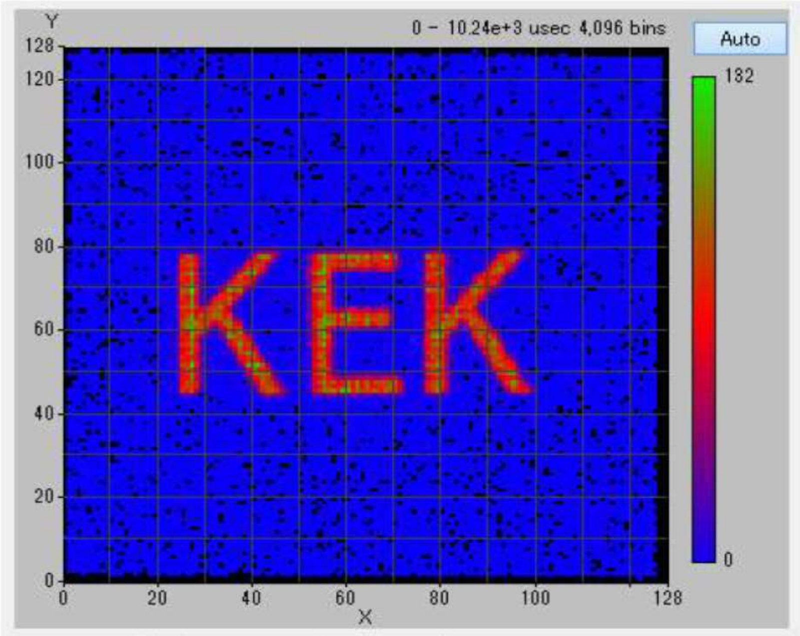
Block diagram



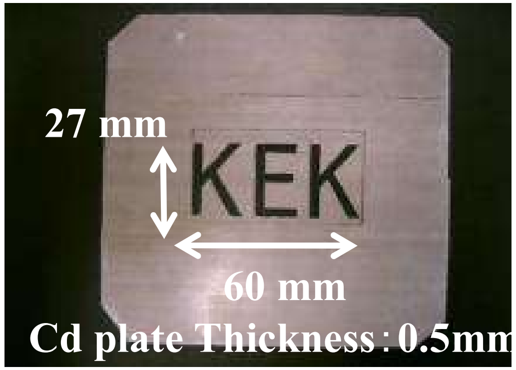
Results



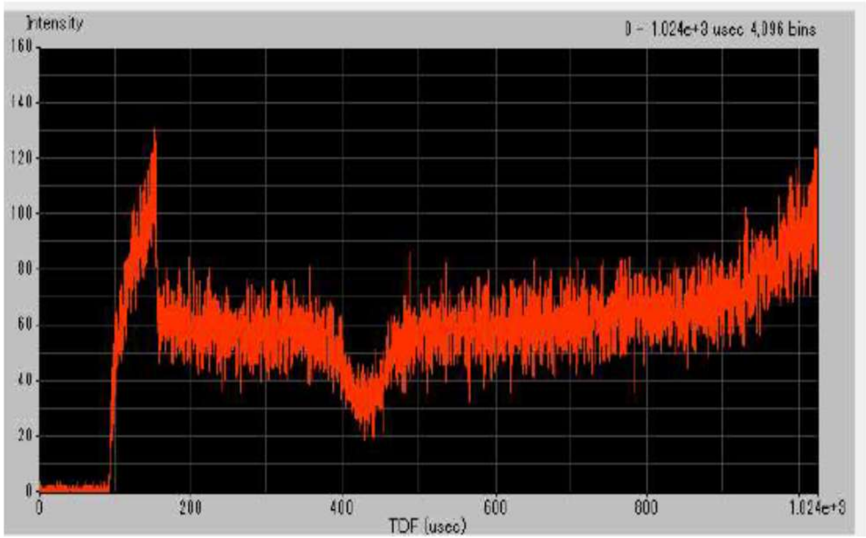
Time of Flight distribution for 0-10 msec.
Flight length : ~4m
Thermal neutron peak : ~1.7msec



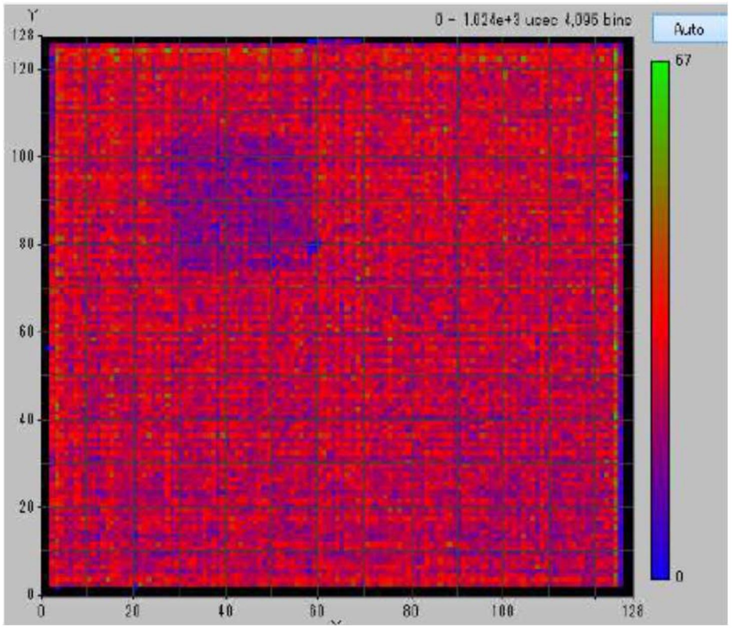
Two-dimensional image (10cmx10cm)
with ToF cut (Cd cut off)



Resonance absorption



ToF distribution with In sample for 0-1msec
Time offset : 100μsec
Beam spread : 60μsec
Dip around 450μsec corresponds to the resonance absorption of In.



Two-dimensional image for In sample with ToF cut around 450μsec, which corresponds to the resonance energy of In.

Summary

- We are developing new GEM in order to get a stable operation without breaking caused by large discharges.
- Ceramic GEM is one of promising candidates.
  - No carbon → no Carbonization
  - No hydrogen → Good for neutron detector
  - Simple production process without masks
- Prototype GEM with 10cmx10cm size was fabricated and was tested.
  - High gas gain (10^4) with reasonable resolution was obtained for X-ray from the Fe-55 radioactive source using double GEM structure.
  - Neutron detector with the ceramic GEM is also working well.