High-Speed Position Encoding System for the TPC with Micro Pixel Chamber Readout

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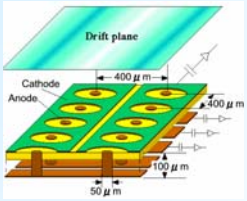
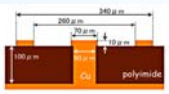
For the readout of the time projection chamber with our developed micro-pattern gaseous detector (μ-PIC), we have developed a high-speed position encoding system operated at 100MHz clock, by combination of an analog-ASIC preamplifier, a position encoding system with FPGA processors, a VME-bus memory-board, and a VME-bus CPU.

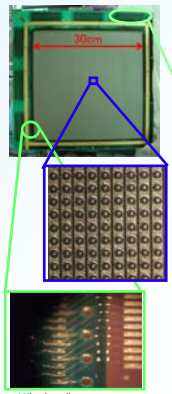
1. μ-PIC (Micro Pixel Chamber)

μ-PIC [1]

- A gaseous 2D imaging detector with strip readout
- 768×768 (=589,824) pixels with a pitch of 400μm
- Cu electrodes and polyimide substrate
- based on the Print Circuit Board technology
- maximum gas gain ~15,000
- fine position resolution (RMS ~120μm)
- large detection area ~944 cm^2
- good gas gain uniformity (RMS ~5%) at the whole area
- stable operation for ~1000 hours with gas gain ~6,000

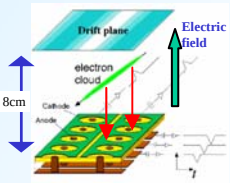


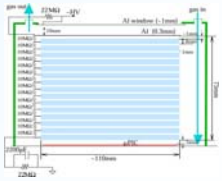


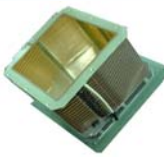


Wire-bonding to the read-out board

TPC with μ-PIC readout [2]







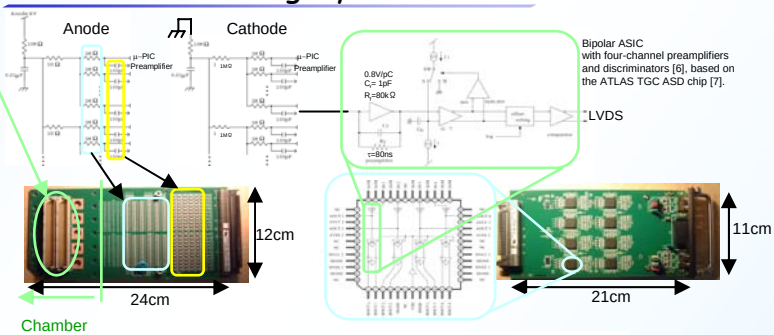
- ✓ μ-PIC ⇒ 2D hit position
- ✓ 8cm drift cage ⇒ electron drift time ⇒ Z position

3D track of a charged particle is measured

Applications of μ-PIC

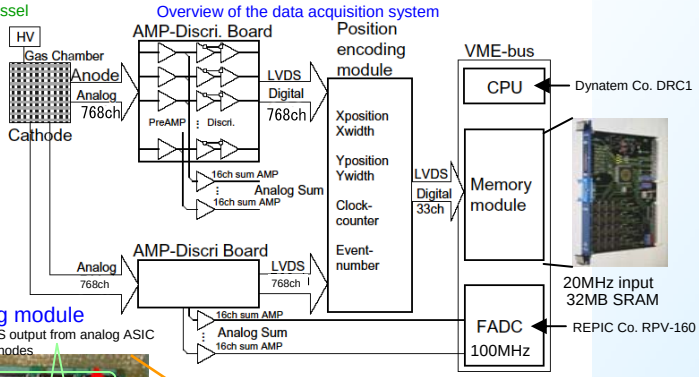
- MeV gamma-ray Compton Camera [3]
  R.Orito, et al. poster N14-53, T.Tanimori, et al.,poster J03-62
- Dark Matter search [4]
- X-ray crystallography [5]

2. Position Encoding System

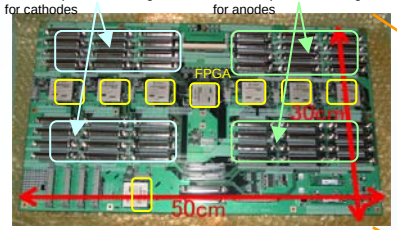


Chamber vessel

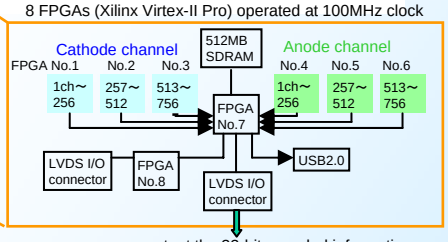
Overview of the data acquisition system



Position Encoding module



8 FPGAs (Xilinx Virtex-II Pro) operated at 100MHz clock

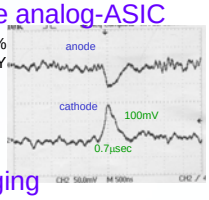


output the 32-bit encoded information to VME memory board

3. Performance

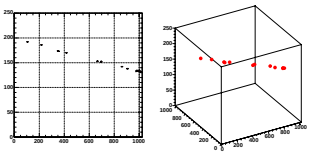
Output from the analog-ASIC

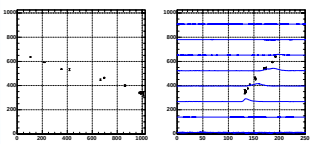
- Gas : Ar 90% + C_2H_6 10%
- signal of β-ray from ^{90}Sr/Y
- V_{anode}=500V



3D tracking with the TPC

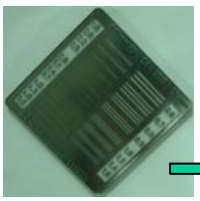
Cosmic muon track



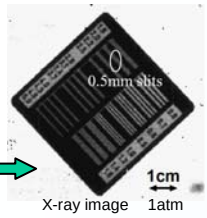


Pulse shape of output from the preamplifier

2D X-ray imaging



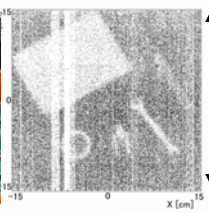
Photograph



X-ray image

1atm Xe 80% + C_2H_6 20%

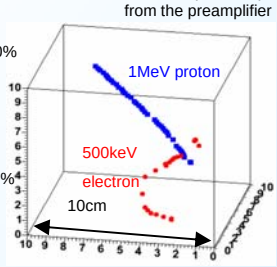
Photograph



X-ray image

30cm

- Ar 90%+C_2H_6 10%
- gas depth ~1cm
- ^{109}Cd (22.2keV)



Operation mode of Position Encoding

2D X-ray imaging

(2D-1) LVDS signal outputs from analog ASICs for cathodes and anodes are synchronized with the FPGA No.1~6 at 100MHz clock
(2D-2) Maximum and Minimum Hit (X, Y) Positions are sent to FPGA No.7, and the 512MB SDRAM
(2D-3) After the X-ray irradiation, the positions are read via the VME-bus memory board or the USB2.0 interface.

3D tracking

- Trigger from the scintillator ⇒ FPGA No.7
- (2D-1), (2D-2), (2D-3)
- Drift time = elapsed time from the trigger, measured at 100MHz clock
- Drift Z position of a charged particle = drift velocity of electrons × drift time

References

[1] A. Ochi, et al., *NIM A*, **478** (2002) 196;
T. Nagayoshi, et al., *NIM A*, **525** (2004) 20.
[2] H. Kubo, et al., *NIM A*, **513** *(2003) 94*
[3] T. Tanimori, et al., *New Astro. Rev.*, **48** (2004) 263.
[4] T. Tanimori, et al., *Phys. Lett. B*, **578** (2004) 241.
[5] A. Takeda, et al., *J. of Synchrotr. Radi.*, in press.
[6] R. Orito, et al., *IEEE Trans. Nucl. Sci.*, **51** (2004) 1337.
[7] O. Sasaki & M.Yoshida, *IEEE Trans. Nucl. Sci.*, 46 (1999) 1871

http://www-cr.scphys.kyoto-u.ac.jp/research/mu-PIC/index.html