Development of HPD

A position sensitive photon detector is an essential ingredient for the Aerogel-RICH detector. Requirement for the photon detector is summarized as follow:

a) Should be immune to the 1.5 Tesla high magnetic field, ,

b) Should have single-photon sensitivity with high resolution and high detection efficiency,

c) Should have position resolution less than 2 mm,

d) Should have high sensitivity for photons of $\lambda = \sim 400$nm.

The last item comes from the following reasons: due to Rayleigh scatterings in the aerogel radiator, shorter wave length photons easily lose directional information, therefore, photons of $\lambda = \sim 400$ nm are most important for this Aerogel RICH.

There may be some candidates for such photon detector. For instance, a Micro-Channel-Plate PMT (MCP-PMT) has excellent timing property and single-photon resolution in high magnetic field, but the collection efficiency of photoelectron is 65 % at most. A Fine-mesh-PMT is operative in a high magnetic field, but has very poor single-photon resolution: hard to observe a single-photon peak. Currently we take a proximity-focusing-type Hybrid Photo-Diode (HPD) or a Hybrid-Avalanche-Photo-Diode (HAPD) as the best candidate, since those have excellent single-photon resolution and high detection efficiency even in high magnetic field. An operation concept of HPD can be seen in the figure++ (Peters figure).

Some kinds of HPD's are already commercially available [ref. DEP catalog], however, we can not use a focusing type HPD in a high magnetic filed and the effective area of the current proximity focusing type HPD is less than 50%. In order to enlarge the detection area of a HPD, we decided to develop a new HPD having pixel size of 5 mm square with Hamamatsu Photonics K.K. (HPK). Figure * shows a schematic drawing of the H(A)PD, which has 72x72 mm^2 in outer size and 59x59 mm^2 of sensitive area. This means 65% of the total area is covered by photo-diodes (PD) or avalanche PDs (APD).

Four PD's or APD's having 6x6 arrays are installed in a ceramic vessel as shown in the figure, which leads 12x12 arrays in total. The window is made of quartz and the photocathode material is a multi-alkali.

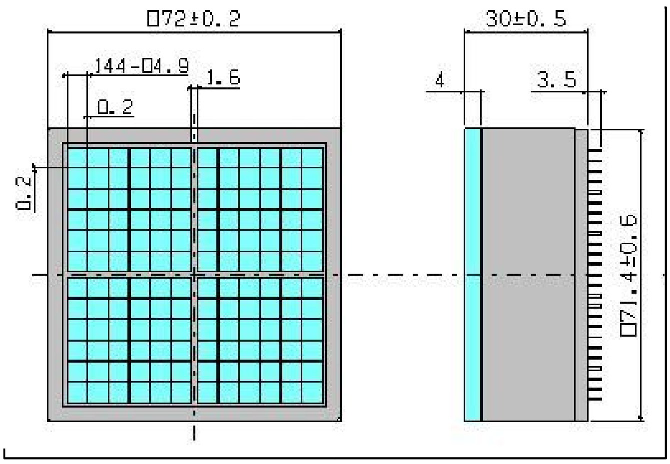


Fig.* Shematic drawing of the H(A)PD which is under development.

In order to confirm the performance of H(A)PD , a single channel HPD and a 3x3 multi-channel HAPD are tested by using a laser diode light pulser (λ = 850 nm). Figure* shows a multi-photon spectrum obtained by a HPD, which was operated at 8 kV for electron bombardment (EB) (typical EB gain was 1500) and 80 V for bias. The leak current was 4nA and the detector capacitance was 20pF.

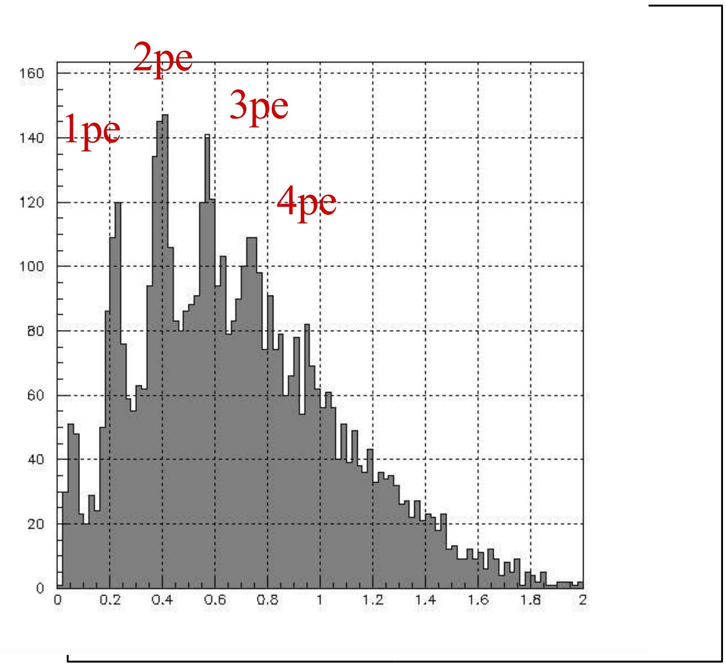


Fig.*. Multi-photon spectrum obtained by the single-channel HPD.

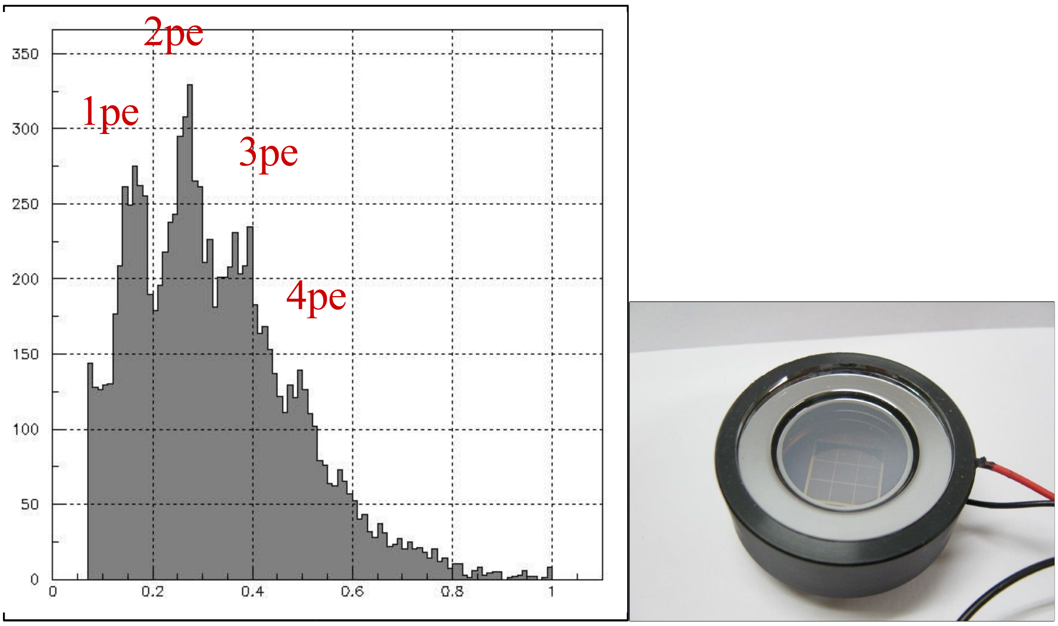


Fig. * Multi-photon spectrum obtained by the 3x3 multi-channel HAPD and a photo of the HAPD.

Multi-photon spectrum was obtained by the HAPD either. The gain was high (x 26000) for HAPD, due to an avalanche gain of about 15, however, the detector capacitance was 73 pF and the leak current was 14 nA, that brought worse signal to noise ratio than HPD. Although both the

HPD and the HAPD have shown the excellent performance, the HPD gives slightly better resolution.

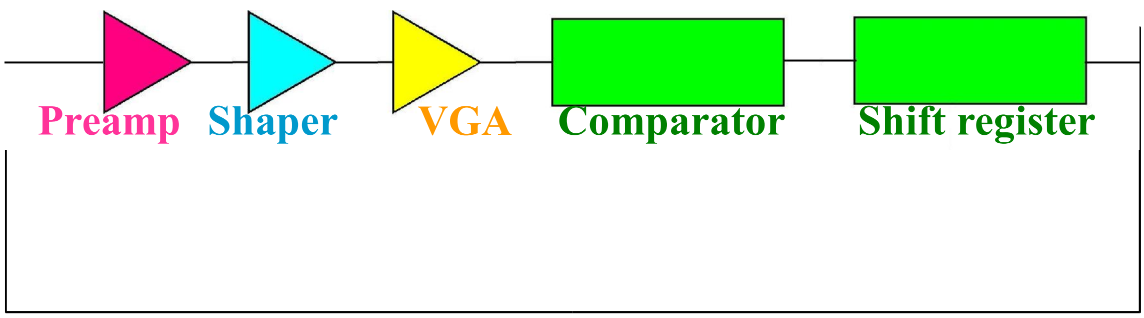
Prototype production of APD's and PD's is going on in HPK and evaluation of them have been curried out for some portion. So far there are no serious problem for PD's except for slightly worse timing response, however, a large leak current was observed for APD's after activation of photocathode. Futhermore larger noise than expected is seen in APD's. HPK people are investigating the APD's to solve this problem in the next batch.

Anyway we will have some prototype 12x12 HAPD's in January 2004, which will be tested at the next beam time in February.

In parallel to the development of the photon detector, we are developing a readout electronics. Since in a real detector the number of readout channels amounts to more than 120k in total, we need special readout scheme to treat them. For this end, we have developed an ASIC which has following properties:

a) High gain with short shaping times, 5V/pC and 150 ns,
b) Variable gain amp to adjust the threshold, x 1~16,
c) Pipeline readout scheme with shift register,
d) Low power consumption, 5 mW/ch.
e)

A schematic of the ASIC and a photo through microscope are shown in fig. *
Only on/off information through the comparator are registered in the shift register.
When a trigger signal is accepted the last 4 bits of the shift register is duplicated in a 4-bits register, which is readout in serial.



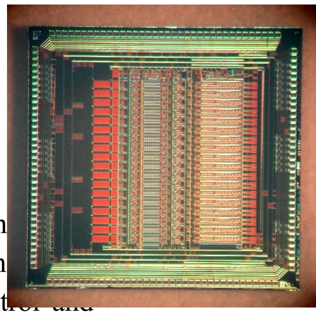


Fig. * Schematic and photo of the ASIC (4.9x4.9 mm^2).

Although unexpected large noise is observed in some channels, basic functioning of th was confirmed by using a test pulse. We will make minor reworks to improve th performance in the next production. This ASIC is controlled by LVDS signals. A control and readout board is under development with Meisei Co.Ltd, which will be ready in January 2004.