Development of a pixel-readout µ–PIC for X-ray polarimetry

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Motivation of X-ray polarymetry

Physics which can be solved only by X-ray polarimetry. Identification of the mechanism of the accelerated electrons. Direct measurement of space-time structure around compact X-ray sources.

But only detected from Crab nebula because of technology.

1012

134 133 132 131 Right Ascension (J2000, degree)

Before pixel-readout µ-PIC

 X-ray polarimetry => To use photo-electric effect (most dominant process)
 Polarization? =>Track of the photo-electrons (<=mm even in gas)
 =>MPGDs

 $=>\mu$ -PIC?

- Transmitting hard X-rays => with hard X-ray polarimeter
- The performances have been already demonstrated.
 Detected polarization in the lab. (Ueno et al. 2004)
 A long-term stability (over 1000h at a gas gain of 5000 without any critical discharge) (Nagayoshi et al. 2004)

Strip-type µ-PIC

Cannot determine the track of photo-electrons event by event.



Not sensitive to 45° polarization angle => Need the rotation of the detector.

Pixel-readout µ -PIC for X-ray polarimetry

="Very thin and small multi-anode proportional counter" + pixel-readout



Measurement of polarization angle (photo-electron direction)



Data acquisition system

TKO32ch CS-ADC 32ch delay (200ns) 64ch preamplifier board **HOSHIN T004** HOSHIN HEP2846 board ~ 400ns ~ 100mV Anode signals $\times 256$ Trigger Cathod (strip) signals $\times 16$ Summing & **Discriminator &** amplifier Gate circuit Generator(NIM) μ-PIC



Energy spectrum & gas gain

Gain v.s. HV



Uniformity on detector plane

Integral of ADCs



Less than 1/10 times on the edge...

Study of non-uniformity

3. Gain



1. Readout = > x? no correlation between pixel position and readout

2. Electric field of drift space





Electric field of drift space



Uniformity of gain



Experiment in synchrotron facility

Sensitivity to polarization depends on energy.

Need monochromatic and polarized X-rays. Scattered by acrylate

Rotation

X-ray beam

Image orientation angle of electron cloud



Modulation factor vs energy



Summary

Development of pixel-readout μ-PIC and first measurement of X-ray polarization. => Further simulation study, fine-pitch, etc. Problems Difference of modulation factors between the experiment and the previous simulation. Non-uniformity. Further study Detailed simulation study (GEANT4?). 400um pitch detector. More elegant readout ???



Satellite for X-ray polarimetry "Polaris"



Structure of pixel-readout µ-PIC



Hitmap vs hit threshold





Not-corrected image orientation angle of electron cloud

Polarized to 90degree

Polarized to Odegree



Not flat even for unpolarized X-rays...

Simulated sensitivity vs energy



Sensitivity to X-ray polarization

