Summary of PHENEX Balloon-borne Experiment in 2009

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Abstract

We have been developing a hard X-ray polarimeter with high sensitivity, called as a PHENEX (Polarimetry for High ENErgy X rays) polarimeter. We constructed prototype PHENEX polarimeter and carried out a preliminary observation of the Crab Nebula on June 13th, 2006 as a balloon-borne experiment. Though we confirmed from the data that PHENEX polarimeter detected hard X rays from the Crab Nebula with a significance of 8 σ, the degree and the direction of polarization with high accuracy could not be determined because of the trouble for attitude control system (ACS) and the small detection area of the prototype polarimeter. We improved the PHENEX polarimeter and carried out a balloon-borne experiment in June 2009 launching from Taiki Aerospace Research Field to observe the polarization of the Crab Nebula with higher accuracy. In this paper, we will report the summary of this experiment.

Key words: Hard X ray, Polarimetry, PHENEX, Crab Nebula

1. Instrument

The PHENEX polarimeter is constructed in a modular fashion with an array of "unit counters". The unit counter is Compton-scattering-type polarimeter sensitive to the energy range from 40 keV to 200 keV and it has a modulation factor of 53% and a detection efficiency of 20% at 80keV(Y. Kishimoto et al. 2007). We have constructed the PHENEX polarimeter with eight unit counters as a flight model. The instrument configuration for this flight is shown in Fig. 1. In the center of the PHENEX polarimeter, a CsI(Tl) scintillation counter is installed and it is called as "monitor counter". It is used to monitor the flux from the Crab Nebula and thus to confirm the pointing. The monitor counter and the eight unit counters are installed inside CsI(Tl) active shields.

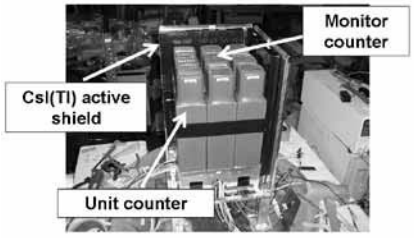

Fig. 1. Flight model of PHENEX polarimeter. Eight unit counters and one monitor counter are installed in CsI(Tl) active shields.

2. Summary of the Balloon Experiment in 2009

Installing the PHENEX polarimeter to a gondola for balloon-borne experiment, we have launched it from Taiki Aerospace Research Field on June 18th, 2009. Fig. 2 shows the flight route of the balloon. From 12:08 to 14:45, we obtained a level flight for 2.5 hours at an altitude of about 39 km. The detector system operated well over the duration of the flight. Then, the gondola was separated from the balloon and parachuted into the sea. The polarimeter was subsequently recovered safely without any serious damage and the data storage on the detector was also recovered safely. Fig. 3 shows the trigger rates of the unit counters and the monitor counter. It is recognized that these rates change drastically at the time which corresponds to launching and reascending. The bump of the trigger rate around 10:00 corresponds to Pfotzer maximum. During the level flight, the trigger rates of the unit counters and the monitor counter were about 1kcps and 300cps, respectively. Though the gap of the trigger rates is observed around 13:55, it corresponds to the matter that we had lowered the voltage for the PMTs because of wrong information on the time for the cutting from the balloon. Hence, the data from

13:49 to 14:10 was not used for the further analysis of the counting rates.

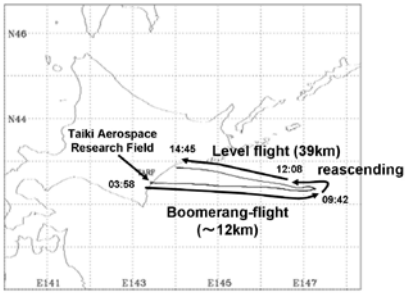

Fig. 2. Flight route of balloon. We obtained a level flight for 2.5 hours at an altitude of about 39km.

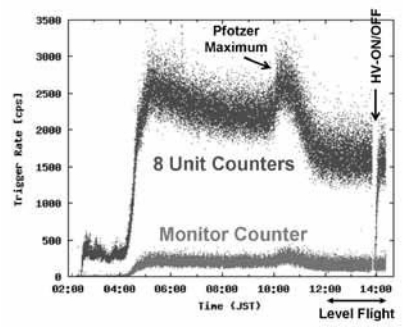

Fig. 3. Trigger rates of the 8 unit counters and the monitor counter. These rates change drastically at the time which corresponds to launching and reascending.

We carried out the OFF-observation from 12:10 to 13:26 and ON-observation from 13:26 to 14:22. However, unfortunately the azimuthal ACS (attitude control system) for the PHENEX polarimeter did not function correctly though the elevation can be controlled at the accuracy of 0.2 degrees. Then the line of the sight could not be stabilized as shown in Fig. 4 though the line of the sight can be monitored. Fig. 5 also shows the azimuth offset during ON-observation. The distribution of the azimuth offset from Crab Nebula is shown in Fig. 6. The x axis and y axis correspond to the azimuthal offset angle from the Crab Nebula and the observation time, respectively. For the data, we used only the data from 13:36:00 to 13:48:40 and from 14:10:00 to 14:20:00 (boxed regions in Fig. 5) to avoid the duration affected by shutoff of high voltage supplies. The boxed region in Fig. 6 corresponds to the field of view of the PHENEX polarimeter. Calculating the integral time in this region, the time of ON-observation is estimated to be 572 seconds. So, we are analyzing the data of the PHENEX polarimeter and trying to confirm increase of event rate due to the flux of the Crab Nebula.

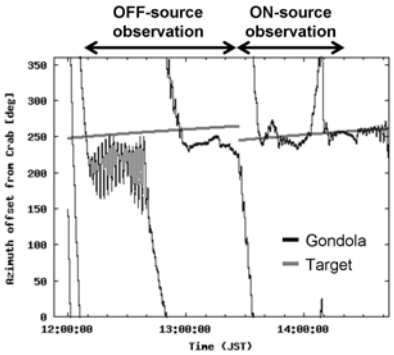

Fig. 4. Azimuthal angle of the gondola during level flight is drawn. Unfortunately, the duration which the Crab remains at the field of view of the PHENEX polarimeter was about 10 minutes because the ACS did not function correctly

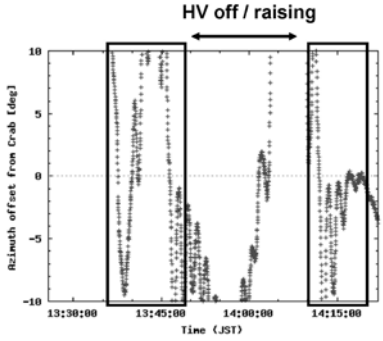

Fig. 5. The azimuth offset from Crab Nebula is drawn. The boxed regions around 13:40 and 14:15 show the durations in which we used the data for estimation of ON-observation time.

3. Conclusions

We have developed the PHENEX hard X-ray polarimeter and have carried out the balloon-borne experiment in June 18th, 2009. Though the polarimeter operated well, unfortunately the azimuthal ACS did not function correctly. From the quick analysis on the line of the sight, we recognized that it observed the Crab Nebula for 10 minutes. We will analyze the data in detail.

References

Y. Kishimoto et al. 2007 IEEE TNS., 54, 561-566

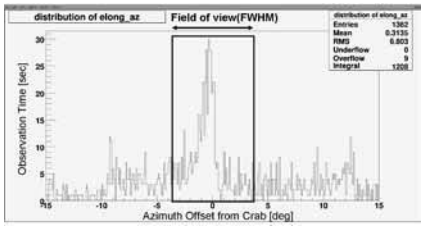

Fig. 6. The distribution of azimuth offset from Crab Nebula.