Development of Hard X-ray/Gamma-Ray Polarimeters

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We are now developing the several types of hard X-ray/gamma-ray polarimeters to install on the future small satellite and the solar powered sail mission. The X-ray polarization measurement is one of the most important window left behind high-energy astrophysics. In this poster, we present mission plans and detector configurations as well as the KEK beam test and the balloon flight.

Solar Powered Sail Mission

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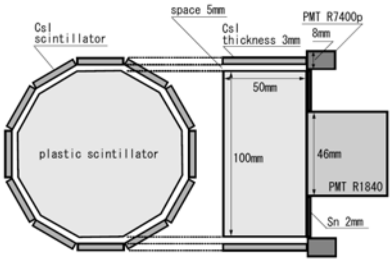
We are now developing the gamma-ray polarimeter for GRBs onboard the Solar Powered Sail satellite. The solar sail is a next Japanese engineering verification spacecraft planned to launch in 2013. Expanding the huge membrane of 50m diameter, it translates the radiation pressure from the sun to the thrust of the spacecraft. (also use the ion engine : hybrid)

Solar Powered Sail Satellite

Scientific Payloads

1. Near Infrared Cosmic Background (Cosmology)
2. Jupiter probe and orbiter (Planetary Science)
3. Trojan asteroid (Planetary Science)
4. **GRB polarization detecto and Inter Planetary Network (High energy astrophysics)**

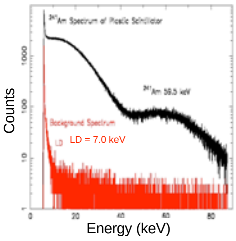
1. Design of Gamma-Ray Burst Polarimeter



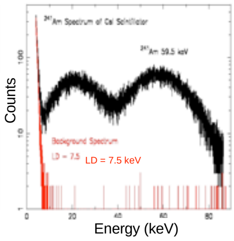
A dodecagonal plastic scintillator is placed at center, and 12 CsIs are set around it. This detector has high geometrical symmetry, so the FAKE modulation is kept under 1% level estimated by the EGS simulation.
Modulation factor = 0.30 and efficiency = 0.20 at 100 keV.

2. Detector Capability

Plastic scintillator

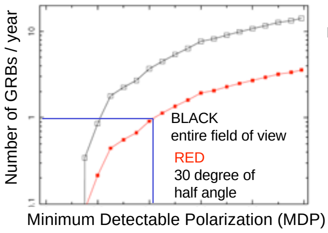


CsI scintillator



The lower discriminate level is 7.0 keV for the odecagonal plastic, and 7.5 keV for the CsI. We hope to improve the energy threshold of Plastic scintillators. For 90-deg scattering of 60 keV photons, the signal is 6.3 keV.
CsI scintillators satisfies our requirement : They work as IPN detector for 10 – 200 keV range.

3. Polarization Detectability



Using BATSE catalogue, we estimated the minimum detectable polarization for each event.

$$MDP = \frac{N(\eta_S)^{1/2}}{\alpha}\sqrt{\frac{\eta_F S + B}{T}}$$

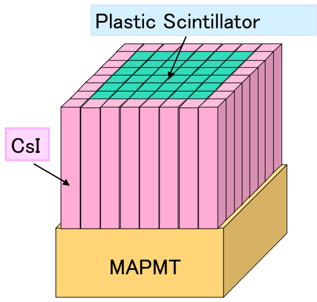
If the prompt emissions have the polarization degree of 40%, we have several chance to observe them within our field of view. We may enable to measure the polarization with the rate of a few events/yr.

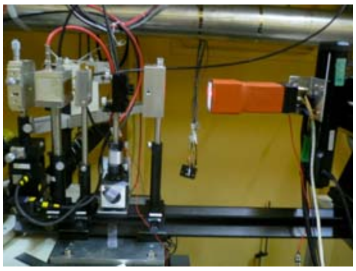
PHENEX – balloon mission –

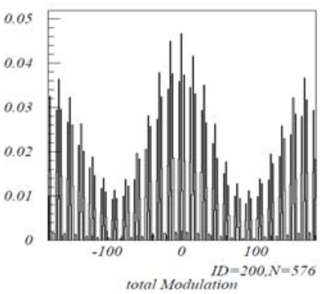
S. Gunji, F. Tokanai (Yamagata Univ.), T. Mihara (RIKEN), K. Hayashida (Osaka Univ.), and PHENEX team

KEK-PF beam test and Detector sensitivity

Using multi-anode PMT and the VA-TA ASIC, 8×8 matrix type polarimeter is developed. The plastic scintillators are placed at the central 6×6 parts and CsI scintillators are around them.
This detector was tested by the synchrotron beam, almost complete polarized radiation, at the KEK-PF to estimate the detector capability.





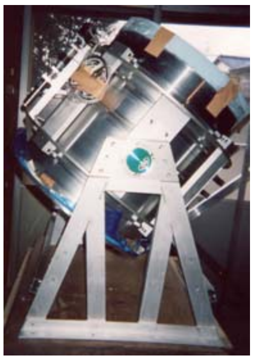


The left panel is the observed modulation curve with plastic – CsI coincidence events, irradiated with monochromatic 80 keV synchrotron radiation. This detector is rotated 360 degree along the beam axis with 15 degree step.

Modulation factor: 53%
Detection Efficiency: 20%

Balloon Fright to Observe Crab

PHENEX (polarimeter for high energy X-rays) was successfully launched on June 13, 2006 (just a week ago !!). We observed Crab pulsar and nebula with the exposure time of > 1 hours. The payload was safely recovered and we are now analyzing the data.



In this flight, we installed 4 units of 8×8 counters with a monitor counter (left panel). The right panel is the detector vessel which can be controlled for 3 axis. This vessel can be rotated along the observing direction. By the control of azimuth and elevation, the tracking of the Crab pulsar and nebula can be carried out. Observation was performed at the altitude of 38 km.

Balloon Flight Jun. 13, 2006