Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics B (Proc. Suppl.) 246–247 (2014) 29–33

NUCLEAR PHYSICS B
PROCEEDINGS
SUPPLEMENTS

www.elsevier.com/locate/npbps

The Status of the Ultra Fast Flash Observatory - Pathfinder

J.W. Nam[a], S. Ahmad[d], K.B. Ahn[b], P. Barrillon[d], S. Brandt[e], C. Budtz-Jrgensen[e], A.J. Castro-Tirado[f], C.-H. Chang[g], C.-Y. Chang[g], Y.Y. Chang[a], C.R. Chen[g], P. Chen[a], M. Cho[c], H.S. Choi[h], Y.J. Choi[i], P. Connel[j], S. Dagoret-Campagne[d], C. Eyles[j], B. Grossan[c], J.J. Huang[a], M.H.A. Huang[k], S. Jeong[c], A. Jung[c], J.E. Kim[c], M.B. Kim[l], S.-W. Kim[b], Y.W. Kim[l], A.S. Krasnov[m], J. Lee[l], H. Lim[l], E.V. Linder[c], T.C. Liu[a], N. Lund[e], K.W. Min[i], G.W. Na[c], M.I. Panasyuk[m], I.H. Park[l], V. Reglero[j], J. Ripa[l], J.M. Rodrigo[f], G.F. Smoot[c], J.E. Suh[c], S. Svertilov[m], N. Vedenkin[m], M.-Z. Wang[a], I. Yashin[m], and on behalf of the UFFO Collaboration

[a] *National Taiwan University, Taipei, Taiwan*
[b] *Yonsei University, Seoul, Korea*
[c] *Ewha Womans University, Seoul, Korea*
[d] *LAL, University of Paris-Sud 11, Orsay, France*
[e] *Technical University of Denmark, Copenhagen, Denmark*
[f] *Instituto de Astrofsica de Andaluca - CSIC, Granada, Spain*
[g] *National Space Organization, Hsinchu, Taiwan*
[h] *Korea Institute of Industrial Technology, Cheonan, Korea*
[i] *Korea Advanced Institute of Science and Technology, Deajeon, Korea*
[j] *University of Valencia, Valencia, Spain*
[k] *National United University, Miao-Li, Taiwan*
[l] *Sungkyunkwan University, Suwon, Korea*
[m] *Moscow State University, Moscow, Russia*

Abstract

The Ultra Fast Flash Observatory (UFFO) is a project to study early optical emissions from Gamma Ray Bursts (GRBs). The primary scientific goal of UFFO is to see if GRBs can be calibrated with their rising times, so that they could be used as new standard candles. In order to minimize delay in optical follow-up measurements, which is now about 100 sec after trigger from the *Swift* experiment, we rotate a mirror to redirect light path so that optical measurement can be performed within a second after the trigger. We have developed a pathfinder mission, UFFO-pathfinder to launch on board the *Lomonosov* satellite in 2012. In this talk, I will present scientific motivations and descriptions of the design and development of UFFO-pathfinder.

Keywords: Gamma Ray Bursts, Early Light Emissions, Ultra Fast Flash Observatory

1. Introduction

Now we are savoring the renaissance of the GRB science by virtue of wonderful data obtained by various experiments such as *Swift* [1] and *Fermi* [2]. However, a regime of early time in UV-optical wavelengths still remains an unexplored region in parameter space. Although a great improvement of early photon measurement from GRB was carried out by *Swift* using the fast in-site follow-up capability, only a handful of optical light curves have been observed in sub-minute domain due to an intrinsic limitation on its response time. *Swift* first determines a GRB position using the Burst Alert Telescope (BAT) which has a large field of view. After that, the space craft slews to point its UV-Optical Telescope (UVOT) to the position of the GRB. The minimum response time of *Swift* is about 60 seconds arising from computational latency in determination of the location, and slewing method of rotating the entire space

Email address: jwnam@phys.ntu.edu.tw (J.W. Nam)

http://dx.doi.org/10.1016/j.nuclphysbps.2013.10.061

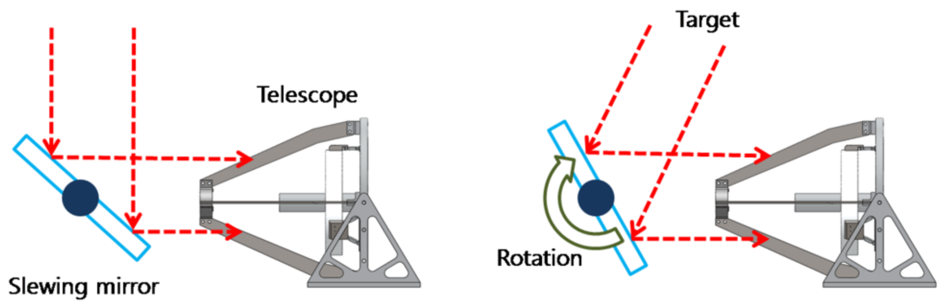

Figure 1: Fast Slewing Concept of UFFO

craft.

UFFO approach is to reduce the response time by 1) employing a fast localization and 2) a new slewing method which rotates only a small mirror to redirect the optical path of the incoming GRB beam instead of the entire spacecraft (see Figure 1) [3]. We have successfully developed a rapid response space observatory with a fast localization capability based on the Field-Programmable Gate Array (FPGA) technology which can calculate localization within 1 sec after the trigger, and a gimbal mirror system moving a target in our entire field of view to the focal point within 1 sec. An advanced slewing mirror system has been proposed to achieve sub-millisecond slewing time using Electro Mechanical System (MEMS) Micro Mirror Array [4]. But the implementation of a large area mirror array and a precise angle control to obtain uniform distribution of micro mirror surfaces are still technically challenging.

As the first step, we have developed a pathfinder mission, to be named the UFFO-pathfinder [5], with a mass of 20 kg and launched in 2013. Even though it has a limited size, UFFO-pathfinder will demonstrate its concept and may bring great scientific results from successful detection of early optical emissions from GRBs. In parallel with the pathfinder mission, we plan a bigger scale mission with 100 kg mass (UFFO-100) [3] and 600 kg mass (UFFO-600) to obtain competitive sensitivity and statistics with $Swift$ for future observations.

There are many scientific topics with great interests in the sub-minute regime where we could find great hints to understand intrinsic properties of GRBs. For instance, examinations of prompt optical emission from short-hard GRBs and dark bursts are unique scientific subjects of UFFO project. Measurements of peak emission times in early light curves can lead to determine the bulk Lorentz factor [6]. Furthermore, rising times of light curves are possibly correlated with optical luminosity so that it could be calibrated [7]. Once the intrinsic properties of GRBs are fully understood, GRBs would serve as a reliable cosmological standard candle which extends the Hubble diagram up to much larger redshift than SN-Ia supernovae [8]. Fast transient emissions such as primordial black holes [9] are also exciting topics for UFFO with the fast response [3].

2. The UFFO-Pathfinder Instrument

The payload of the UFFO-pathfinder consists of two telescopes; one is the UFFO Burst Alert Telescope (UBAT) [10] for event trigger and its localization in a wide Field of View (FOV) of 90×90 arcdeg^2, and the other is the Slewing Mirror Telescope (SMT) [11, 12] for UV-optical follow-up measurement in a narrow FOV of 17×17 armin^2. Figure 2 shows schematic views as well as the manufactured flight model of the UFFO-pathfinder.

UBAT is a coded mask aperture camera which is conceptually similar to the $Swift$ BAT system. By analyzing the shadow image of the coded mask on the imagine sensor, directions of the x-ray source can be determined. The UBAT system consists of three major components: a coded mask, detectors and electronics. The coded mask made of Tungsten Alloy has randomized rectangular hole patterns with 50% open fraction. The detector is formed by 48×48 pixels YSO crystal array which is attached on 36 Multi Anode Photo Multipliers (MAPMT) with 8×8 pixels. The MAPMT is highly sensitive while having low thermal noise, so that energy threshold can lower down to 10 eV. Since the coded mask loses opacity for high energy x-rays, energy range for UBAT is limited to the 200 eV. All electronics including the analog readout board, the digital processing boards, the trigger board, and the high voltage board are located under MAPMT array, forming a compact structure of the UBAT detector module located at the bottom of the UBAT. We implemented all digital processes