**ECLAIRs: A microsatellite to observe the prompt optical and X-ray emission of Gamma-Ray Bursts**

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**Abstract.** The prompt $\gamma$-ray emission of Gamma-Ray Bursts (GRBs) is currently interpreted in terms of radiation from electrons accelerated in internal shocks in a relativistic fireball. On the other hand, the origin of the prompt (and early afterglow) optical and X-ray emission is still debated, mostly because very few data exist for comparison with theoretical predictions. It is however commonly agreed that this emission hides important clues on the GRB physics and can be used to constrain the fireball parameters, the acceleration and emission processes and to probe the surroundings of the GRBs. **ECLAIRs** is a microsatellite devoted to the observation of the prompt optical and X-ray emission of GRBs. For about 100 GRBs yr$^{-1}$, independent of their duration, **ECLAIRs** will provide high time resolution high sensitivity spectral coverage from a few eV up to $\sim$ 50 keV and localization to $\sim$ 5" in near real time. This capability is achieved by combining wide field optical and X-ray cameras sharing a common field of view ($\geq$ 2.2 steradians) with the coded-mask imaging telescopes providing the triggers and the coarse localizations of the bursts. Given the delays to start ground-based observations in response to a GRB trigger, **ECLAIRs** is unique in its ability to observe the early phases (the first $\sim$ 20 sec) of all GRBs at optical wavelengths. Furthermore, with its mode of operation, **ECLAIRs** will enable to search for optical and X-ray precursors expected from theoretical grounds. Finally **ECLAIRs** is proposed to operate simultaneously with **GLAST** on a synchronous orbit. This combination will ensure broad band spectral coverage from eV to GeV energies for the GRBs detected by the two satellites, **ECLAIRs** further providing their accurate localization to enable follow-up studies. **ECLAIRs** relies upon an international collaboration involving theoretical and hardware groups from Europe and the United States. In particular, it builds upon the extensive knowledge and expertise that is currently being gained with the **HETE-2** mission.

**INTRODUCTION**

GRBs occur at cosmological distances and are the most violent explosive phenomena presently observed in the Universe. For the strongest GRBs, up to $\sim$ $10^{54}$ erg (assuming isotropic emission) can be radiated in the $\gamma$-ray domain on a very short timescale (from milliseconds to $\sim$ 100 seconds). In the currently favored models, GRBs are associated with the collapse of massive stars (collapsar, [35, 24]) or mergers of two compact stars (two neutron stars or a neutron star and a black hole, e.g., [13]) (see e.g., [23, 3] for recent reviews). Since GRBs are observable across the whole Universe, if they are indeed linked to the ultimate stages of massive star evolution, their redshift distribution should reveal the formation rate of massive stars up to very high redshifts, thus making GRBs effective cosmological probes (see e.g., [29, 18]).

In both the collapsar and the merger models, the final product is a stellar mass black hole and a rapidly rotating torus, from which the energy can be extracted via magnetohydrodynamic processes. The energy release in a very small volume produces a relativistic fireball with a Lorentz factor of at least a few hundred (e.g., [22]). When the relativistic flow decelerates in the interstellar medium (ISM), a forward and a reverse external shock are produced. The forward external shock can account for the afterglow emission observed at radio, optical and X-ray wavelengths ([12] for a recent review).

Whereas the physics of the afterglow is relatively well understood, the origin of the prompt emission is still debated, especially in X-rays and optical. In the relativistic fireball model, the Lorentz factor of the wind is supposed to be variable so that successive shells of plasma have large relative velocities leading to the formation of internal shocks ([23, 4]). In that model, the non-thermal $\gamma$-ray emission is associated with either synchrotron or inverse Compton emission of electrons accelerated in these shocks. In X-rays and optical, the picture is not as clear, mostly because there are not as many high quality observations available in that energy range compared to the $\gamma$-ray domain. There is however growing observational and theoretical evidence that this energy domain contains
critical information on the GRB physics, the nature of the progenitors, the way the initial bulk energy is converted into electromagnetic radiation. A better understanding of the GRB physics is required to test models predicting that GRBs may be sources of ultra high-energy cosmic rays, neutrinos, gravitational waves (see [2] for a recent review). This understanding is also required if one intends to make GRBs a reliable tool for cosmology and for the study of the Universe at very high redshifts.

**ECLAIRs** is a microsatellite proposed to the French Space Agency (CNES). It is specifically devoted to the observation of the prompt optical and X-ray emission of GRBs. In the next section, we briefly describe the main scientific objectives of **ECLAIRs** emphasizing on the area where it will bring an outstanding contribution. We then present the science payload and mission concept. Finally we emphasize on the complementarity of **ECLAIRs** with two other missions (**GLAST** and **SWIFT**) supposed to fly simultaneously with **ECLAIRs**.

**SCIENTIFIC OBJECTIVES**

With **ECLAIRs** we wish to use, for the short and long duration GRBs, the prompt optical and X-ray emission to probe 1) the physics at work during the event and 2) the surrounding of the burst to get insights on their origin. In addition, thanks to its instrumental capabilities, with **ECLAIRs**, we will investigate the existence of optical and X-ray precursors expected from theoretical grounds, and whose presence would put unprecedented constraints on any GRB models.

As far as the prompt emission is concerned, as discussed above, very few data exist in optical and X-rays in contrast to the γ-ray domain. In the optical, so far only one GRB has been detected (by the ROTSE automated telescope; GRB990123, [1]), and for a few others, upper limits are available for the late part (≥ 10 – 20 second after the onset) of the events (e.g., [3]). In X-rays, the situation is slightly better, mostly thanks to the **GINGA** (e.g., [2]) and **Beppo-SAX** satellites [13].

**What can be learned from the prompt optical emission?**

It has suggested that the prompt optical emission as the one observed in GRB990123 may be associated with electrons accelerated in the reverse external shock [33]. The strength of the optical emission depends on various parameters, but can in principle yield constraints on the wind initial Lorentz factor and the interstellar medium density [33, 17]. Alternatively, the prompt optical emission could arise from the forward shock of the blast wave when it propagates in the pre-accelerated and pair-loaded environment [3]. This emission can also give constraints on the radiation process itself; i.e., synchrotron versus Inverse Compton emission; a much stronger optical flash is expected in the Inverse Compton scenario (e.g., [11]).

The reasonable question to ask is why the prompt optical emission has so far been observed from only one GRB (GRB990123, [1]). The poor location accuracy of GRB detectors (e.g., BATSE), the delays in getting the finalized positions to the ground, the limited observing efficiency of automated optical telescopes, their response time, all conspire to make sensitive (below mag ∼ 14) and truly simultaneous observations of GRBs over the whole event almost impossible. For **ROTSE**, the shortest response time that has been achieved is ∼ 10 seconds [1]. **ECLAIRs** will not face any of these problems as the optical and X-ray cameras will operate continuously over a common field of view. Optical coverage will thus be granted for all types of bursts, independently of their duration, before, during and even after the event. This unique capability will also offer the opportunity to study the transition between the prompt and early afterglow phases at similar wavelengths.

Extinction by dust in the host galaxy may naturally prevent the detection of the prompt optical emission. This is the argument used to explain the lack of optical emission in some afterglows, otherwise detected in X-rays and in radio. Dust extinction is not unexpected if GRBs are associated with massive star formation. Djorgovski et al. (2001) have however found that the maximum fraction of optical afterglows hidden by dust is ∼ 50%. This is an upper limit, as some optical afterglows may have been missed for various reasons: very high redshifts, rapid decline rate, intrinsic faintness.

**ECLAIRs** will seek optical emission down to magnitude ∼ 15 (R band, 8 sec) for all GRBs. The properties of the prompt optical emission will be correlated with the properties of the afterglow optical emission, thus providing complementary constraints on the relativistic flow parameters and the surroundings of the event.

**What can be learned from the prompt X-ray emission?**

Let us now consider the prompt X-ray emission. The good correlation between the temporal behaviour of the prompt X-ray and γ-ray emissions suggests that it is also produced in internal shocks. In X-rays however, there might be additional contributions from the reverse shock [9], the forward shock [3] or from the photosphere of the fireball [19]. With its excellent sensitivity, **ECLAIRs** will observe the prompt X-ray emission of all GRBs, allowing detailed time-resolved X-ray spectroscopy to be per-
formed. These studies will set constraints on the Lorentz factor of the wind, its baryon loading, the emission mechanism and the relative contribution of the various shock regions in the overall emission.

The importance of observing the prompt X-ray emission has recently been reinforced by the discoveries of X-ray spectral features in Beppo-SAX observations: e.g., a transient absorption edge in GRB990705 and a transient emission feature in GRB990712 (spectral features are also observed in the X-ray afterglows, e.g., ECLAIRs). Well before these discoveries, it was predicted that effects of photo-electric absorption and Compton scattering from the circum-burst material should lead to observable changes in the intrinsic GRB spectrum, with the introduction of absorption cutoffs and features such as K-edges and emission lines. In principle, these features can be used to determine the density and composition of the ISM in the immediate vicinity of the GRB, the GRB redshift and possibly the nature of the GRB progenitor. For instance, the transient absorption edge observed from GRB990705 was satisfactorily modeled with photo-electric absorption by a medium with a large iron abundance, which could have been left there by a supernova event which occurred about 10 years before the burst. Similarly the transient emission feature seen in GRB990712 was shown to be consistent with thermal emission of a baryon-loaded expanding fireball when it becomes optically thin. The above interpretations are however made difficult by the limited statistical quality of the data. With its improved sensitivity and good time and spectral resolution, ECLAIRs will be able to observe the prompt emission of GRBs over the whole event and for all types of events.

What are the short bursts? What about the X-ray precursors?

GRBs display a bimodal distribution in durations; the border is around 2 seconds with about 25% of the GRBs with durations less than that value. This distribution seems to correlate with spectral hardness; the shortest GRBs have on average harder spectra. It seems therefore plausible that the two distributions represent two distinct, although quite similar, physical phenomena. Extremely short GRBs may be due to primordial black hole evaporation, short GRBs to merging neutron stars, and the long ones to collapsars (see e.g., ECLAIRs). So far, due to observational limitations, afterglows have only been identified for the long duration GRBs and very little is known about the short GRBs. ECLAIRs will have the unique capability to observe both short and long duration GRBs. These observations will thus provide clues to the following questions: How does the multi-wavelength prompt emission of the short GRBs compare with those of the long GRBs? How does the prompt emission relate to the afterglow properties? What is the redshift distribution of short GRBs? Answering these questions will help in assessing whether the short duration GRBs are of different nature than the long ones.

By its mode of operation, ECLAIRs will also enable us to search and study X-ray and optical precursors. X-ray precursors have already been observed (ECLAIRs), arising between 10 and 100 seconds before the main event. Several models have been put forward to explain these X-ray precursors (or soft excesses) (e.g., Paczyński (2001) recently pointed out that there are theoretical reasons to expect strong optical flashes preceding GRBs (e.g., ECLAIRs), the detection of which would put stringent constraints on the range of parameters for GRB models.

THE ECLAIRs MISSION CONCEPT

The ECLAIRs mission concept results from the scientific goals described above and is optimized under the stringent constraints of a microsatellite: 50 kilos, 50 Watts and a total volume of ~ 60 cm × 60 cm × 30 cm (length, width, height) available for the science payload. A technical assessment study of ECLAIRs was carried out by CNES in December 2001. This study showed that ECLAIRs was feasible as a microsatellite, albeit with not much margins. ECLAIRs is now lining up for a selection at the end of 2002. This clearly leaves some time to work on the optimization of the science payload. To help us in this task, an international Science Advisory Committee (SAC) was set up for the mission. The science payload described below accounts for the results from the CNES study and for the advises received from the SAC.

The science payload

The science payload consists of three sets of instruments (see Table 1). The Large Area X-ray Telescope (E-LAXT), the Soft X-ray Cameras (E-SXC), and the Wide Field Optical Cameras (E-WFOC) (see Fig 1). It will be provided by a consortium of institutes which have developed a considerable expertise along the preparation and operation of missions, such as HETE-2 and INTEGRAL. The US contribution to ECLAIRs will be the subject of a SMEX/MOO proposal to NASA in 2002.
TABLE 1. The ECLAIRs science payload consisting of three instruments: the ECLAIRs Large Area X-ray Telescope (E-LAXT), the ECLAIRs Soft X-ray Cameras (E-SXC), the ECLAIRs Wide Field Optical Cameras (E-WFOC). Two options are considered for E-LAXT: Silicon and higher density detectors (e.g., CdZnTe). Si would cover the energy range 3-50 keV whereas CdZnTe would cover from 5 keV to 150 keV.

|                      | E-LAXT | E-SXC | E-WFOC |
|----------------------|--------|-------|--------|
| Band pass            | ∼3-50/5-150 keV | 0.4–15 keV | 500-700 nm |
| Number of units      | 2      | 6 (3 pairs)  | 4      |
| Offset angle         | ±10⁰   | -28⁰,0,+28⁰ | ±25⁰   |
| Mass (kg)            | 14     | 16     | 14     |
| Power (instrument + electronics) (W) | 18 | 8 | 16 |
| Field of view (one unit, FWZR) | ∼120⁰ × 120⁰ | ∼53⁰ × 53⁰ | ∼50⁰ × 50⁰ |
| Positioning accuracy | ∼0.5⁰ | 5”    | 5”    |
| Number of GRBs yr⁻¹ (total) | ∼100 | ∼100 | ? |
| Limiting mag. (R) (S/N=8) | ... | ... | 14.8, 17.4 (8, 1000 sec) |

ECLAIRs - Large Area X-ray Telescope

The Large Area X-ray Telescope (E-LAXT) is made of two identical conventional 2D coded-mask imaging telescopes, with offset looking directions. The mask is located 15 cm above the detector. The detector is a pixel semiconductor detector. In the baseline, each pixel was a 2 mm thick Si PIN diodes of 1 cm². The mask cells match the pixel size. Large area Si PIN detectors with their associated low-noise low-power front-end electronics are currently developed at CESR as part of an R&T program funded by CNES. At low power, the expected noise level should result in an energy resolution of ∼1 keV (at 6 keV, -40C) making possible a low energy threshold of ∼3 keV. The thickness of the diodes ensures an energy coverage up to ∼40 keV: matrix of Si PIN diodes are therefore a possible detector solution for ECLAIRs.

However, as suggested by the SAC, there are alternatives to Silicon for the E-LAXT detector: CdTe, CdZnTe. Both would extend the energy range of ECLAIRs in the hard X-ray range, which would help for the detection of GRBs. CdZnTe, as the ones developed for SWIFT or AXO have excellent performances for a mW/cm² ratio similar to Silicon. In addition, using strip readout techniques they have been demonstrated to work down to 5 keV (e.g. [3]). Considering CdZnTe, the detector of one E-LAXT could have an effective area of 25 × 25 cm², covered with pixels of 5 × 5 mm² and 2 mm thickness. The imaging system would have an angular resolution of 2 degrees and a positioning accuracy of ∼0.5 degree. Due to the stringent mass constraints on a microsatellite, the mask and shielding will be effective only below ∼50 keV. Whereas the trigger will be obtained at energies above ∼50 keV, the position of the GRB will be derived from the images reconstructed below that energy. Using a simplified model for the E-LAXT and the Log(N)/Log(P) curve derived from the BATSE 4B catalog [2], we have estimated the rate of GRBs localized by the two E-LAXT units to be larger than 100 GRB yr⁻¹.

ECLAIRs - Soft X-ray Cameras

The Soft X-ray Cameras (E-SXC) for ECLAIRs are based upon the successfully flown HETE-2 [30] (see also these proceedings). The operating principle is that of a coded-mask imager, in which a 1-D coded mask is rigidly suspended above an X-ray charge-coupled device (CCDID-34). The E-SXC assembly is made of 6 camera modules, covering a field of view of 2.7 sr. The CCDID-34 (3K × 6K array; 10μm square pixels, 20”) has an overall size of 30 mm × 60 mm and is currently in production at MIT Lincoln Laboratory. It improves over the CCID-20 used for HETE-2 by a greater energy coverage (0.4-15 keV versus 0.8-10 keV), a better time resolution (0.25 sec versus 1 sec), and a better quantum efficiency (sensitivity of ∼400 mCrab, 1 sec, 4σ). The E-SXC will provide 5” burst localizations (at S/N=8). About 100 GRBs yr⁻¹ should be detected in the 6 units.

ECLAIRs - Wide Field Optical Cameras

The Wide-Field Optical Cameras (E-WFOC) for ECLAIRs are derived from the star camera units successfully flown on HETE-2 [30]. The large field of view is achieved by four such cameras. The limiting magnitude in R is 14.8 (8 s at S/N=8) for one E-WFOC. Each of the four modules utilizes a moderately fast, well-corrected optical lens (focal length of 80 mm, f/0.9) coupled to a 2×2 array of MIT CCID-34 sensors, resulting in a hybrid focal plane with 6K × 6K pixels; each pixel is 10μm × 10μm (25.8”). The integration time is 2 seconds.

To achieve the light weight and low power required for ECLAIRs, the drive and readout electronics, as well as the digital frame buffer memory, for the E-SXC and E-WFOC instruments will be combined to the maximum degree possible.

The operating mode for the E-WFOC relies upon digitizing and storing successive 300 MB image frames in a four stage deep buffer, requiring a total of 1.2 GB SRAM.
In response to triggers from the E-LAXT or E-SXC, we will select 4' × 4' regions-of-interest (ie 512 x 512 sub-arrays) from this large buffer, centered on the suspected burst coarse localization, for transfer into an optical burst memory. In addition, neighborhoods of twenty-five stars, extending out to 64×64 pixels (27' × 27'), will also be stored as astrometric and photometric references. The accumulation of 500 frames (=1000 sec), each with burst and reference star data, will reside in 377MB of SRAM, and require 3 minutes to downlink during an X-band contact with an ECLAIRs ground station. Shift-and-add summation of the digitized, two-second resolution CCD data in ground processing will permit the E-WFOC to achieve an ultimate limiting sensitivity of R=17.4 (1000s at S/N=8). Centroiding will result in bright optical transient localizations accurate to ± 2'', even in the presence of spacecraft pointing drift (assumed to be 47''/s, 3σ, as specified for the Myriade spacecraft). For long term optical monitoring, we will also be able to downlink 45 full image frames per day (whole field of view at full angular resolution, every ∼ 30 minutes), each containing more than 2.5 million star images. Downlinking of the full frame data will require 13 GB/day.

We are currently investigating near-infrared cameras (NIRC, 1-2 microns) as an alternative to the E-WFOC. There are three main advantages of considering NIRC. First, in NIR, the extinction is smaller than in the optical. This means that GRBs produced in dusty regions and not visible in the optical might become detectable in NIR. Second, NIRC would have the potential to observe higher z events, due to the Lyman alpha break. Finally, the discovery space is much larger in NIR than in the optical, as the NIR sky has never been searched for variability so far.

A detailed study is now required to determine whether cooled NIRC with good sensitivity, large field of view can be accommodated on ECLAIRs under the stringent constraints on power, mass, etc. of a microsatellite.

**Implementation of the mission**

The baseline for ECLAIRs is an equatorial 550 km (low inclination) orbit for a low, stable background, low radiation damage to the CCD, and for the download of the science data to be possible with a single ground station. This orbit could be achieved by various launchers, as for example a PEGASUS from the Marshall Island or from Alcantara. We plan to reuse the HETE-2 ground segment. In particular, one of the 3 S band stations (Singapore, Kwajalein, or Cayenne) will be converted to X band. For the alert system, we plan to use the HETE-2 network of 12 VHF stations located along the equator. As will be discussed below, ECLAIRs is proposed to fly simultaneously with GLAST; therefore an ideal launch date would be around the end of 2006. The lifetime of the mission is foreseen for 5 years for a maximum synergy with GLAST.

**Operational considerations**

As far as the attitude control is concerned, the instruments will point in the anti-earth direction during night time, and look at the pole during day time. This way the operating temperature of the instruments will be kept low (below -50 C). The triggering system of ECLAIRs is relatively simple. The on-board computer monitors continuously the count rates in E-LAXT. When a transient event is detected, a signal is sent to the E-SXC and E-WFOC for the most recent data to be stored in a dedicated memory. Two images from E-LAXT are then reconstructed before and during the event. From the difference of the two images, the rough position (∼ 0.5 deg accuracy) of the event is obtained and sent out to the ground and to the secondary instruments which use this position to obtain the final more accurate position. After ∼ 30 seconds, the final position (5” accuracy) is transmitted to the ground. During the next passage to the ground station a high rate X-band communication (16 Mbits/s) allows the whole data set associated with the event to be downloaded.

The mission and science operations will be performed with the help of CNES control center in Toulouse. The mission and operation center which may be combined will be responsible for receiving the data from CNES, generating the spacecraft commands on a weekly basis, monitoring the health of the spacecraft and science payload, recovering the attitude, and for the quick-look anal-
ysis of the data for rapid distribution of the GRB final positions. In addition it will be responsible for the data archives and the education and public outreach program. The center will likely be provided by a consortium of institutes including the Geneva observatory, the Strasbourg observatory and the Leicester University X-ray group.

A MISSION COMPLEMENTARY TO GLAST AND SWIFT

GLAST is scheduled to be launched in March 2006 into a low earth orbit. The satellite will carry 2 instruments: the Large Area Telescope (LAT), which will observe emission from 20 MeV to 200 GeV, and the Gamma-ray Burst Monitor (GBM), which will detect transients from 20 keV to 20 MeV. The LAT detector is 50 times more sensitive than its predecessor, EGRET. While only a few GRBs were detected by EGRET, GLAST is expected to observe nearly 200 GRBs per year. These bursts will also be detected by the GBM, so that the spectrum will be measured over 7 orders of magnitude. Unfortunately, only for the brightest bursts the positions derived by the LAT will be accurate enough to be used for follow up observations. Provided that ECLAIRs and GLAST can remain on a similar orbit (adjustment and maintenance of the orbit can indeed be achieved through the chemical propulsion system of the microsatellite) ECLAIRs would greatly enhance the GLAST science, by both extending the spectra to lower energies (down to \( \sim 2 \text{ eV} \)) and by improving the localizations in near real-time to enable follow-up observations in the afterglow regime. Given that the GBM has a FOV much larger than ECLAIRs, all GRBs seen by ECLAIRs will be also detected by the GBM, thus providing for \( \sim 100 \text{ GRB yr}^{-1} \), spectral coverage from about 7 decades in energy, and for those detected by the LAT (\( \sim 80 \)) over 11 decades in energy! This broad band spectral coverage will enable discrimination between the various radiation processes proposed for the multi-wavelength GRB emission, including those, yet to be tested, put forward for the GeV emission (inverse Compton, Synchrotron emission, see e.g., \([53,54]\)). This will open a completely new window on the GRB physics, setting for the first time real constraints on models predicting that GRBs are sources of ultra-high energy cosmic rays and neutrinos. Furthermore, the ability to locate the GLAST-GRBs precisely, making possible the identification of the host galaxies and the measure of the redshifts will enable the systematics of the GeV emission to be studied, and the GLAST-GRBs to be compared, as a class of events, to the GRBs detected by satellites operating at lower energies (Beppo-SAX, HETE-2 and SWIFT). Finally, for those GRBs for which the redshift will be determined, cut-offs in the observed GeV spectrum can be used to infer the level of ultra-violet to infra-red background light which is a direct tracer of star and Galaxy formation in the early Universe \([31]\). The complementarity between GLAST and ECLAIRs is best illustrated in Fig. 2 where the observing energy range is plotted against the observing time window of the events. ECLAIRs was presented at the last GLAST GRB working group and received strong support.

SWIFT is a NASA mission dedicated to the study of the GRB afterglows. It should be launched in Fall 2003, with a nominal on-orbit lifetime of 3 years. It will carry three instruments: The Burst Alert Telescope (BAT) covering the 10 to 150 keV range, and two Narrow Fields Instruments (NFIs); the X-Ray Telescope (XRT, 0.2-10 keV) and the UV Optical Telescope (UVOT, 170-650 nm). The observing strategy of SWIFT is to point

\[ \text{FIGURE 2. Comparing ECLAIRs (filled regions) with GLAST (horizontal lines) and SWIFT (tilted lines). The time window of the observations is given on the X axis whereas the Y axis represents the energy range of the instruments. As can be seen, the combination of ECLAIRs and GLAST would provide spectral coverage over 11 decades in energy. Note also the complementarity between ECLAIRs and SWIFT: ECLAIRs is focused on the prompt optical/X-ray emission whereas SWIFT is designed for the afterglow emission in the same energy range. The mean GRB duration is also shown for indication (vertical box).} \]

1 http://www-glast.stanford.edu/

2 http://swift.sonoma.edu/
the NFI after the detection of a GRB in the BAT. This strategy clearly means that SWIFT will miss the early X-ray and optical emission of all GRBs. The time to point the NFI to the direction of the GRB should range between 20 and 70 seconds, with a mean value of 50 sec. Its ability to observe the precursors and activity during the burst will thus make ECLAIRS a very complementary mission to SWIFT (see Fig. 2).

CONCLUSIONS

Fortunately GRBs are extremely bright events which can easily be detected and studied with an instrumentation matching the stringent mass and power constraints of a microsatellite. GRBs have been proved to be highly complex phenomena whose understanding requires multi-wavelength observations of the prompt and afterglow phases and follow-up ground-based observations to determine their host galaxies and their redshifts. ECLAIRS will thus bring a significant contribution to a better understanding of GRBs by providing high sensitivity observations of the prompt optical/X-ray emission and accurate localization of more than 100 gamma-ray burst per year.

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