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GRBs by thin persistent precessing lepton Jets: the long life GRB110328 and the Neutrino signal

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Abstract. Gamma Ray Burst sources are apparently evolving around us in a harder and brighter samples at far and far redshift. The average output may range from a near Supernova (nearest events) output to a billion time that power for most distant events. Such a tuned evolution around us is not an anti-copernican signature. It is a clear imprint of a off-axis (nearest sources) beaming versus a rarest in-axis blazing (far redshift sources) by a thin relativistic beam (Lorentz factor up 10^4 or above, micro-nano steradian solid angle). The main consequence is the rarer and rarer presences of hardest gamma events (hundreds MeV, GeVs, tens GeVs), nearly one over a twenty, observed with difficulty at largest redshift inside their thinner beamed jets. For this reason these rarest tens GeV beamed events, even observed by EGRET and Fermi, are hardly seen at hundred GeV by Cherenkov telescope (Magic,Hess,Veritas) on Earth. For the same reason and because tens GeV neutrino energy is below Icecube thresholds (threshold to hundreds GeV) we have not been observed yet a neutrino GRB. However if the GRBs primaries contains tens GeV neutrino traces (at comparable GRB gamma rate) their presence may rise in few years at Deep Core (a more dense array inside ICECUBE) detector whose lower threshold, ranges just one or few tens GeV energy. Moreover the very recent X ray persistent GRB110328 or(J164449.3 transient event), whose understanding was first associated to a cannibal star AGN eating (Shao,2011), but now (Bloom,2011), (Zauderer et al,2011) , to a cannibal AGN feeding beamed jet, it is, more naturally consistent to our GRB (by few solar mass compact source, not an AGN) spinning, precessing and blazing model jet, whose geometry is more aligned and stable (than other GRBs) to us: its decay law and its average output is fully consistent with our earliest proposals.

Key words. Stars: Gamma Ray Burst – Inverse Compton– Synchrotron Radiation – Neutrino signal – Deep Core Detector

1. Introduction

The gamma ray burst apparent average isotropic power versus their red-shift of all known GRB has been published recently, see ref. (Fargion et al, 2010). As shown in Fig.1 this distribution calls for an unrealistic (or tuned) Gamma Ray Burst evolution around us or, better, it just probes the need of a very thin gamma precession-jet model for GRBs, where beaming geometry explain the puzzle. These precessing and spinning gamma jet are originated by Inverse Compton and-or Synchrotron Radiation at pulsars or micro-quasars sources, by their parent ultra-relativistic leptons and fi-

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nal electron pairs. These GRB jet sources are compact neutron stars or Black holes each of few solar masses born at peak activity during a Supernova spherical explosion. These Jets are most powerful at Supernova birth, blazing, once on axis, to us and flashing as GRB events, decaying their jet power in hours-day scale time and surviving as late dimmed SGRs Jets. The trembling of the thin jet (spinning, precessing, bent by magnetic fields and companion NS,BH or disk), its tiny aperture and solid angle (a part over a million-billion of a steradian) explains naturally the observed erratic multi-explosive structure of different GRBs, as well as its rare re-brightening or its precursors. In our model to make observed GRB-SN in nearly energy equipartition, the jet must be very collimated $\frac{\Omega}{\Delta\Omega} \simeq 10^8$-$10^{10}$ ((Fargion et.al,1995,F,F)) explaining why apparent (but beamed) GRB luminosity $\dot{E}_{GR-jet} \simeq 10^{53}$-$10^{54}$ erg s^{-1} coexist on the same place and similar epochs with lower (isotropic) SN powers $\dot{E}_{SN} \simeq 10^{44} - 10^{45} erg s^{-1}$. In order to fit the statistics between GRB-SN rates, the jet must have a decaying activity ($\dot{L} \simeq (\frac{t}{t_o})^{-\alpha}$, $\alpha \simeq 1$): it must survive not just for the observed GRB duration but for a much longer timescale, possibly thousands of time longer $t_o \simeq 3 \cdot 10^4\, s$. The late stages of the GRBs (within the same decaying power law) would appear as a SGRs: indeed the same law for GRB output at late time (thousand years) is still valid for SGRs. The jets are precessing (by binary companion or inner disk asymmetry) and decaying by a decay law estimated (Fargion,1999): $I_{apparent}$= $I_{jet} \cdot (\Delta\Omega(t))^{-1}$.

$$I_{jet} = I_1 \left(\frac{t}{t_0}\right)^{-\alpha} \simeq 10^{45} \left(\frac{t}{3 \cdot 10^4\, s}\right)^{-1} \; erg\, s^{-1} \qquad (1)$$

Where the beaming solid angle is $(\Delta\Omega(t))^{-1}$= $\theta_1(t)^{-2}$= $[\theta_{1m}^2 + \theta_{var}^2]^{-2}$, where the minimal average opening angle (main jet-observer) $\theta_{1m} \simeq \frac{1}{\gamma_e}$, $\gamma_e \simeq 10^4$ and the variable jet spinning-precessing angle θ_{var}, rules the whole erratic GRB variability. The huge apparent GRBs luminosity (up to $10^{53} - 10^{54}$ erg s^{-1}) may be due to highest collimated on-axis blazing jet (trembling and precessing) of the Jet (at SN output power). The relic pulsar (or BH) source of the Jet must reflect its spin (ω_{psr}) frequency in angle $\theta_1(t)$ evolution if his angular momentum axis is not in general coincident with the gamma jet axis. This fast spinning will, usually, imprint the "trembling" millisecond behavior of most in-axis structured rapid GRBs. Finally the possible anisotropy of the jet system (related for instance to its own different inertial momentum, orthogonal and parallel, to the spin axis $I_\perp$, $I_\parallel$) would modulate by nutation the beam-observer angle θ_1 by an angular velocity $\omega_N \sim \omega_{psr} \frac{I_\perp - I_\parallel}{I_\parallel}$. The combined multi-precessing and spinning beam angle will describe in the sky a multiple cycloidal (or epicycloidal) trajectory (almost stochastic) described (in present approximation) by $\theta_1(t) = \sqrt{[\theta_{1m} + \theta_{psr}\cos(\omega_{psr}t) + \theta_N \cos(\omega_N t)]^2 + + [\omega_b t + \theta_{psr}\sin(\omega_{psr}t) + \theta_N \sin(\omega_N t)]^2}$. Additional free parameters to be applied (to fit at best the GRB behavior) in both $\sin(\omega t)$, $\cos(\omega t)$ terms are their initial phase pulsar spinning ϕ_{psr}, and its nutation phase ϕ_N . Late GRBs jets are surviving hundreds year later after the SN-GRB birth as SGRs applying the same eq.1. GRB blazing occurs inside the observer thin cone of view only a fraction of seconds duration times because of the this spinning jet and its thin beam; because of relativistic synchrotron (or IC) laws the jet angle is thinner and thinner for harder and harder gamma spectra but the angle it is wider beamed for soft X band. This explain the longer and longer soft X afterglow and its eventual X precursor appearance. GRB apparent brightening is so well correlated with its hardness (the Amati correlation) because better in axis means more luminosity and harder photons. This explain the wider and longer X GRB afterglow life with respect to harder and fast gamma GRB structures. The jet peripherals casual blazing explains the (6 – 20%) rare presence of (otherwise mysterious) X-ray precursors, events well before the (apparent) main GRB explosion (for us, a better blazing alignment). The jet is fed by lepton pair jet (probably first PeVs muons and later on TeVs and tens GeVs electron secondaries). The absence of the PeV neutrino parent are related to the rarety of the inner harder beaming in analogy to GeV gamma rarety in Fermi, EGRET GRBs. The best detectable GRB neutrino events are therefore the most distant ones, (larger sample, more probable in axis alignment) whose gamma and X-OT afterglow might be even too diluted and red-shifted to be observed. TeVs neutrino might be too rare to be observed. Tens GeV neutrinos (within a Fermi like power GRB neutrino spectra) might rise in Deep Core in next few years. Because the vertical axis in Deep Core pointing to the North is the less noise area (Fargion,2011), these future correlated GRBs-Neutrino events maybe well recognized. The well probed Super-novae-GRBs connection since 1998, often forgotten in fountain fireball models, naturally requires a thin beaming whose softer external cone (as for nearest GRB980425) is explaining the huge diversity between spherical SN output and apparent coexisting beamed GRB. The presence of a huge population of active jets fit a wide spectrum of GRB morphology (Giovannelli et.al.,2003). Last GRB-XRF 080109 extreme vicinity and lowest output maybe understood as the external tail of an off-axis GRB jet. Indeed a similar lesson as earliest GRB980425 or recent GRB060218 tell us that Supernovas may often contain a Jet senn in different angles. The nearest jet persistent activity may shine a little off-axis as a soft GRBs or at largest volumes and largest sample as the brightest and hardest gamma GRB event. Because of GRB-XRF 080109 near location (z = 0.0065) it also calls for a huge population of such SN-XRF in far Universe, undetected because below the present Swift, Fermi threshold. Late stages of these jets may loose the SN traces and appear as a short GRB or a long orphan GRB (depending on jet angular velocity and view angle, time distance from the SN birth). XRF are just off-axis viewing of the persistent jets of GRBs whose old Supernova are too dim to be observed.

2. GRB 110328A: a new model tidal star-AGN cannibalism or just a persistent GRB beaming jet?

Sw 1644+57/GRB 110328A was discovered by the Swift satellite. Actually it rised earlier (25 March) as a precursor. It is coincident with an optical source at nearby redshift z = 0.353 as well as a radio source. The the luminosity of the flaring X-ray afterglow reaches 10^{48}erg s, well explained by a partial beaming of the jet and other GRBs map evolution, see Fig 1; GRB 110328A decayed by nearly 2.5 order of magnitude in nearly $10^7 s.$, well coexistent with our (old see eq. 1also in (Fargion,1999)) assumed as inverse linear decay power; the jet beaming increases the apparent luminosity by $3 - 5$ order of magnitude; for us this variability are due to partial geometry blazing in out axis. The GRB 110328 if it was full in axis it would shine four-six order of magnitude brighter. The time structure is at least tens sec. because the large impact parameter angle;an un-probable better collimation (the source is near , z= 0.3) would show a faster structures, harder spectra brighter flux. The common understanding of this event by many authors begun as a pure (Shao,2011) star cannibal eating (almost spherical radiation) to a more AGN-Jet feeding (Bloom,2011), (Burrows,2011), (Zauderer et al,2011) beamed blazing at fountain angle ($5^o - 10^o$). In analogy of the past GRB Fireball model evolving into to Fountain Jet Fireball model: from isotropy to a mild beaming. We disagree with both interpretation. These new GRB model (cannibal-AGN jet) are un-probable for different reasons: first the three day precursor followed by a silent stage, a very fast variability on 28 March at earliest stages in disagrement with any reasonable early tidal fragmentation process of a star (where one does expect a slow star disruption and a slow growing feeding of the star debris into accretion disk and-or AGN jet regime). The GRB 110328A shows huge variability are at very early time up to 3-4 order of magnitudes in days 2-18 April, unexpected in any feeding disk and wide angle jet. Secondly the repetitive oscillations are at short minute times, all along, and they are more reminiscent of sev-

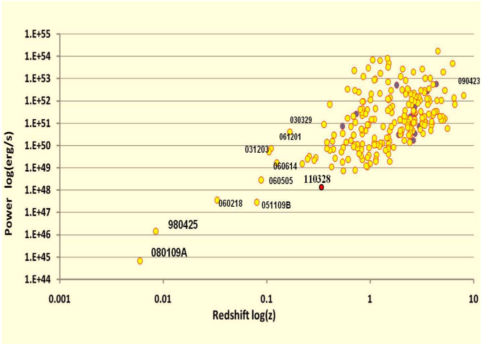

Fig. 1. The GRB X-ray luminosity with most events updated up to March 2011. The apparent GRBs Luminosity vs red-shift distribution bounded by a quadratic power, it is mostly due (in lower regions) to the quadratic distance threshold cut-off and (in higher regions) by the rarer beaming in axis occurring mostly by largest samples and widest cosmic volumes. The spread of nearly ten order of magnitude in Luminosity (iso) calls for a thin (0.001 − 0.0001 rad and a micro or nano-sr solid angle) beams. Note the well fit role of persistent GRB110328 recently found and understood as a new kind of AGN cannibalism (Shao,2011). More recent models call for a jet blazing by AGN, not precessing at all, (Bloom,2011), (Zauderer et al,2011), (Burrows,2011). On the contrary we believe that it is a persistent precessing GRB beamed jet,in stable partial ($\simeq 10^{-2}$ rad, or 0.5^o) collimation to us.

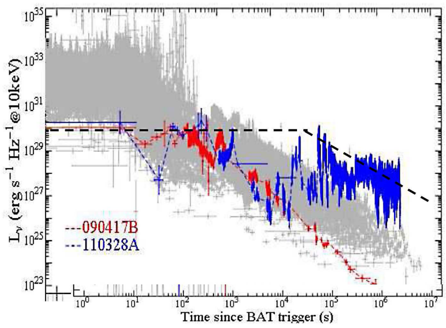

Fig. 2. The longest live GRB110328 whose X-ray luminosity survived up to day; adapted from (Shao,2011). The dot line describe an approximate average power jet (partially beamed,$\simeq 10^{-2}$ rad, or 0.5^o) collimation to us, as described by the time evolution in eq. 1. The event is probably not a stellar AGN cannibal eating, (Shao,2011), (Zauderer et al,2011), (Bloom,2011), (Burrows,2011), but just (the dimmed?) SN-GRB birth in a stable partial ($\simeq 10^{-2}$ rad, or 0.5^o) collimation, blazing to us.

eral long life GRBS structure; we explain it by a relative large impact angle θ_{min} shining and blazing to us. Our few solar mass thin, spinning and precessing jet GRB-SGR is quite common, their cannibal jet is an unique and rarest AGN beamed source, even centered within a kilo-parsec radius from the galaxy core. The very peculiarity of of this GRB, if any, is its stability, its (partial) alignment to us, its detection, within Swift threshold during a long observation life.

2.1. Blazing jets in GRBs and SGRs, Tens GeV or PeV electron sources? The SGR1806-20 flare

A key puzzle (or better to say, a lethal question), for one shot popular Magnetar-Fireball model (Duncan,1992), arises for the surprising giant flare from SGR 1806-20 that occurred on 2004 December 27th: if it has been radiated isotropically (as assumed by the Magnetar model (Duncan,1992)), most of - if not all - the magnetic energy stored in the neutron star NS, should have been consumed at once. This should have been reflected into sudden angular velocity loss (and-or its derivative) which was *never observed*. On the contrary a thin collimated precessing jet $\dot{E}_{SGR-jet} \simeq 10^{36}$-$10^{38}$ erg s^{-1}, blazing on-axis, may be the source of such an apparently (the inverse of the solid beam angle $\frac{\Omega}{\Delta\Omega} \simeq 10^{8}$-$10^{9}$) huge bursts $\dot{E}_{SGR-Flare} \simeq 10^{38} \cdot \frac{\Omega}{\Delta\Omega} \simeq 10^{47}$ erg s^{-1} with a moderate steady jet output power (X-Pulsar, SS433 like). See simulated gamma SGR1806-20 flare in Fig. 6; This explains the absence of any variation in the SGR1806-20 period and its time derivative, contrary to any obvious correlation with the dipole energy loss law.See Ref. (Fargion,2006b), (Fargion et.al,2006b), (Fargion et.al,2005). Such a spinning-precessing blazing may also explain the earlier precursor. The simplest way to produce the γ emission would be by IC of GeVs electron pairs onto thermal infra-red photons at Lorentz factor $\gamma_e \simeq 10^4$. Also electromagnetic showering of PeV electron pairs

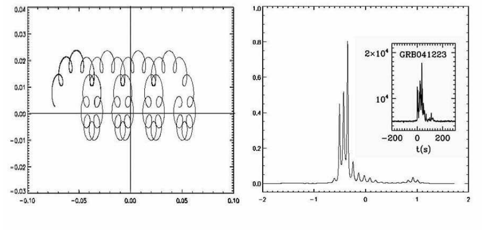

Fig. 3. The possible simple beam track of a precessing jet to observer located at origin. On the left, observer stays in (0.00 ; 0.00); the progenitor electron pair jet (leading by IC (Fargion et al,1998) to a gamma jet) has here a Lorentz factor of a thousand and consequent solid angle at $\sim \mu$ sr. Its consequent blazing light curve corresponding to such a similar outcome observed in GRB041223.We assumed nearly thousand Lorentz factor and IC radiation.

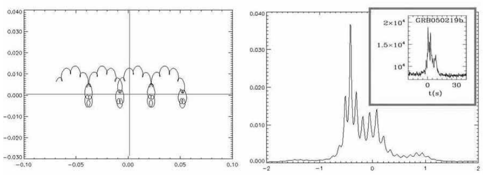

Fig. 4. Same as in Fig. 3: a precessing jet, as above, its consequent light curve versus a similar outcome observed in GRB050219b.

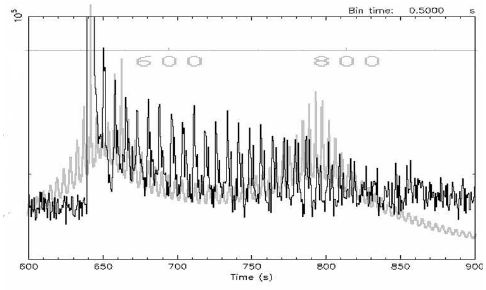

Fig. 5. Same as in Fig. 3: a precessing jet model by PeV muons, tens or hundred TeV electrons radiating via synchrotron radiations and the consequent light curve (by spinning and precessing jet) versus a similar outcome observed in huge flare SGR1806-20.We assumed a Lorentz factor near a billion by PeV electrons

$\gamma = 10^9$	$\theta_a = 0.2$	$\omega_a = 1.6 \cdot 10^{-8}$ rad/s
$\theta_b = 1$	θ_{psr}=$1.5 \cdot 10^7/\gamma$	θ_N=$5 \cdot 10^7/\gamma$
ω_b=$4.9 \cdot 10^{-4}$ rad/s	ω_{psr}=0.83 rad/s	ω_N=$1.38 \cdot 10^{-2}$ rad/s
$\phi_b = 2\pi - 0.44$	ϕ_{psr}=$\pi + \pi/4$	ϕ_N=$3.5\,\pi/2 + \pi/3$
$\phi_s \sim \phi_{psr}$	θ_s=$1.5 \cdot 10^6/\gamma$	ω_s = 25 rad/s

Fig. 6. The angular velocity, the spinning and precessing parameters able to fit the rarest and most puzzling SGR1806-20 event described in previous figure 5, occurred by SGR1806-20 on 2004

by synchrotron emission in galactic fields, ($e^{\pm}$ from muon decay) may be the progenitor of the γ blazing jet. However, the main difficulty for a jet of GeV electrons is that their propagation through the SN radiation field is highly suppressed. UHE muons ($E_{\mu} \geq$ PeV) instead are characterized by a longer interaction length either with the circum-stellar matter and the radiation field; thus they have the advantage to avoid the opacity of the star and escape the dense GRB-SN isotropic radiation field (Fargion et.al,2005,F). We proposed (Fargion et.al,2005) that also the emission of SGRs is due to a primary hadronic jet producing ultra relativistic $e^{\pm}$ (1 - 10 PeV) from hundreds PeV pions, $\pi \rightarrow \mu \rightarrow e$, (as well as EeV neutron decay in flight): primary protons can be accelerated by the large magnetic field of the NS up to EeV energy. By interacting with the local galactic magnetic field relativistic pair electrons lose energy via synchrotron radiation: $E_{\gamma}^{sync} \simeq 4.2 \cdot 10^6 (\frac{E_e}{5 \cdot 10^{15}\, eV})^2 (\frac{B}{2.5 \cdot 10^{-6}\, G})\, eV$ with a characteristic timescale $t^{sync} \simeq 1.3 \cdot 10^{10} (\frac{E_e}{5 \cdot 10^{15}\, eV})^{-1} (\frac{B}{2.5 \cdot 10^{-6}\, G})^{-2}\, s$. This mechanism would produce a few hundreds keV radiation as it is observed in the intense γ-ray flare from SGR 1806-20. The jet (in PeV synchrotron model) will be not just as the thin cone (of tens GeV IC model), but the jet is a much thinner wider layer of fan-structure. Indeed the electron pairs are spread by Larmor radius that it is about two orders of magnitude smaller than the synchrotron interaction length; this imply that the aperture of the showering jet is spread in a rare thin fan structure (Fargion et.al,1997,F) by the interstellar magnetic field, $\frac{R_L}{c} \simeq 4.1 \cdot 10^8 (\frac{E_e}{5 \cdot 10^{15}\, eV})(\frac{B}{2.5 \cdot 10^{-6}\, G})^{-1}\, s$. The solid angle ($\Delta\Omega(t)$) is in this situation, in almost mono-dimensional, of few degree wide and thin: as thin as the inverse of the Lorentz factor : $(\Delta\Omega(t))^{-1} = \theta_1(t)^{-1} = [\theta_{1m}^2 + \theta_{var}^2]^{-1}$, where the minimal average opening angle (between jet-observer) is: $\theta_{1m} \simeq \frac{1}{\gamma_e}$, $\gamma_e \simeq 10^9$, ($\theta_{1m} \sim 10^{-9} rad$). In particular a thin ($\Delta\Omega \simeq 10^{-9}$-$10^{-10}$ sr) precessing jet from a pulsar may naturally explain the negligible variation of the spin frequency $\nu = 1/P$ after the giant flare ($\Delta\nu < 10^{-5}$ Hz). Indeed it seems quite unlucky that a huge ($E_{Flare} \simeq 5 \cdot 10^{46}$ erg) explosive event, as the needed mini-fireball by a magnetar model (Duncan,1992), is not leaving any trace in the rotational energy of the SGR 1806-20, $E_{rot} = \frac{1}{2} I_{NS} \omega^2 \simeq 3.6 \cdot 10^{44} (\frac{P}{7.5\,s})^{-2} (\frac{I_{NS}}{10^{45} g\,cm^2})$ erg. The consequent fraction of energy lost after the flare is severely bounded by observations: $\frac{\Delta(E_{Rot})}{E_{Flare}} \leq 10^{-6}$. More absurd in Magnetar-explosive model is the evidence of a brief precursor event (one-second SN output) taking place with no disturbance on SGR1806-20 *two minutes before* the hugest flare of 2004 Dec. 27th. The thin precessing Jet while being extremely collimated (solid angle $\frac{\Omega}{\Delta\Omega} \simeq 10^8$-$10^{10}$ ((Fargion et.al,1995,F,F,F)) may blaze at different angles within a wide energy range (inverse of $\frac{\Omega}{\Delta\Omega} \simeq 10^8$-$10^{10}$). The output power may exceed $\simeq 10^8$, explaining the extreme low observed output in GRB980425 -an off-axis event-, the long late off-axis gamma tail by GRB060218 (Fargion,2006)), respect to the on-axis and more distant GRB990123 (as well as GRB050904).

3. Conclusions

The GRBs are not the most powerful explosions, but just the most collimated ones. Their birth rate is comparable to the SN ones (a few a second in the observable Universe), but their thin beaming (10^{-8} sr) make them extremely rare (10^{-8} perfect alignment up to 10^{-4}, partial beaming), and long life, to observe, pointing to us at their earliest (days-months after their SN birth) dates. Sometimes the observation delay makes the SN-GRB connection lost. Sometimes the dust obscuration may hide the SN. The link with SN is often guaranteed in long GRB, but the jet connection occurs also for Short GRBs XRF whose explosive supernova is faded away months or years earlier. In our Universe thousands of GRBs are shining at SN peak power, but they are mostly pointing else where. Only one a day might be blazing and detect at SWIFT, Agile, Fermi threshold level. Thousand of billions mini-jets are blazing (unobserved) as SGRs in the far Universe. The ones in our Galaxy, near enough, maybe revealed as SGRs. The GRB-SGRs connection with X-ray-Pulsars make a possible link to anomalous X-Ray pulsar. This GRB-SGR link to X and gamma pulsar is to be considered as a possible grand unification of the model. The nearest (tens-hundred Mpc) are observable mostly off-axis (because of probability arguments); the last peculiar GRB 110328A does fit the global GRB flux-redshift diagram: see Fig.1: therefore it is not a too rare AGN beamed star eating, but more probable a partial off-axis beaming GRB whose time evolution do confirm our old model. The most distant GRB are seen mostly on axis (because larger sample and detector threshold). Therefore the hardest GRB are often at highest redshift. But the IR cut-off makes this hundred GeVs gamma bounded. Last persistent GRB 110328A just probe the longevity of the jet,because lucky persistence directionality pointing to us. Hardest GRB at most distant redshift, corresponding to hardest hundreds GeV gamma are often obscured by cosmic or inter galactic photon-IR cut off opacity, making hard to observe them at MAGIC-VERITAS-HESS.*For same reasons neutrino GRBs at hundreds GeV up to PeV may be too rare to be observed in ICECUBE while at few ten GeV neutrino GRB event may be observed in Deep Core Detector in the near future. (If GRB neutrino spectra extends to tens GeV energy in equipartition with the gamma component.)*

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