

Comparison of Fermi-LAT and CTA in the region between 10–100 GeV



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ABSTRACT

The past decade has seen a dramatic improvement in the quality of data available at both high (HE: 100 MeV to 100 GeV) and very high (VHE: 100 GeV to 100 TeV) gamma-ray energies. With three years of data from the Fermi Large Area Telescope (LAT) and deep pointed observations with arrays of Cherenkov telescope, continuous spectral coverage from 100 MeV to ~ 10 TeV exists for the first time for the brightest gamma-ray sources. The Fermi-LAT is likely to continue for several years, resulting in significant improvements in high energy sensitivity. On the same timescale, the Cherenkov Telescope Array (CTA) will be constructed providing unprecedented VHE capabilities. The optimisation of CTA must take into account competition and complementarity with Fermi, in particularly in the overlapping energy range 10–100 GeV. Here we compare the performance of Fermi-LAT and the current baseline CTA design for steady and transient, point-like and extended sources.

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1. Introduction

The energy range between 10 GeV and 100 GeV is the range where space-based satellites such as the Fermi-LAT (~ 20 MeV to ~ 300 GeV) and ground-based instruments such as the next-generation Cherenkov Telescope Array (CTA) overlap. While they have vastly different effective areas, their sensitivity in this overlapping region is similar (differential flux $\sim 10^{-12}$ erg cm⁻² s⁻¹ for a typical 100 h observation and a 10-year Fermi-LAT mission) since the Fermi-LAT is close to background-free at those energies. This energy range is of great importance for a wide range of scientific topics:

- the Universe goes from being transparent to gamma-rays to having a pronounced horizon at a redshift < 1 [1–3], limiting the number of bright very distant objects (such as e.g. Gamma Ray Bursts, or GRBs) that can be studied, but providing information on the cosmological evolution of the infrared-ultraviolet background light [4–9].
- the brightest Fermi-LAT sources [10] have spectra that steepen in this energy range. Examples for this behavior are flat-spectrum radio quasars [11], and mid-aged supernova remnants interacting with molecular clouds [12,13]
- the diffuse Galactic background has a steeper spectrum than most detected Fermi-LAT sources and therefore goes from being the dominant γ -ray emitter below this energy range (at ~ 100 MeV) to being sub-dominant to individual sources in the TeV band [14–18].

- the spectra of a large number of Galactic object source classes exhibits rising components (in energy flux) and the emergence of additional components. Examples for such spectral properties are LS 5039 [19], Eta Carinae [20,21], the Supernova remnant RXJ1713.7–3946 [22] or the Pulsar Wind Nebula HESSJ1825–137 [23,24]. For this reason simple extrapolations of the energy spectra into this region from above or from below are often expected to be wrong (see e.g. [25] for a more detailed study of this topic in the pre-Fermi-LAT era).

In addition, to these scientific topics, cross-calibration between the Fermi-LAT and ground-based instruments might be interesting [26,27]. The increased overlap in energy coverage between CTA and Fermi-LAT compared to current instruments might render this important and might provide an cross-calibration for ground-based instruments.

Fig. 1 shows the sensitivity curve of the Fermi-LAT, H.E.S.S., and CTA for an E^{-2} type power-law spectrum of a source for several different observation lengths. Here and in the following the altitude of CTA is assumed to be 2000 m. Different altitudes will change the CTA sensitivity curves slightly but we do not expect the results described here to change in any significant way. The exact details of the sensitivity for CTA in general depend on the as of yet unknown parameters like the array layout and analysis technique of CTA. However, we don't expect the sensitivity of CTA or the lifetime of the Fermi-LAT to change by a significant factor compared to what is assumed here (unless there is a significant increase in the number of telescopes for CTA). As the differential sensitivity curves for these instruments are usually only provided for 1-year of Fermi-LAT and for 50 h of H.E.S.S./CTA, we had to make use of a sensitivity model which will be described in Section 2. Generally,

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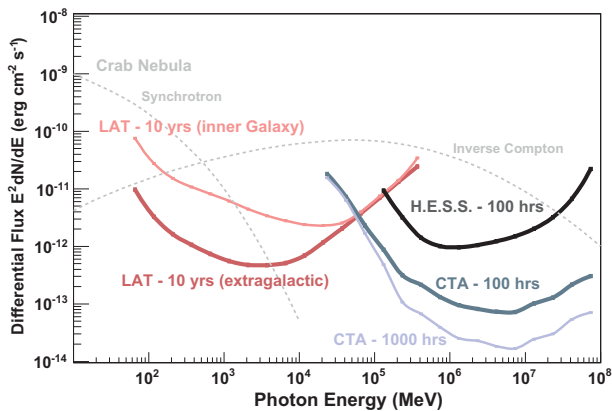


Fig. 1. “Differential” sensitivity (integral sensitivity in small energy bins) for a minimum significance of 5σ in each bin, minimum 10 events per bin and 4 bins per decade in energy. For Fermi-LAT, the curve labeled “inner Galaxy” corresponds to the background estimated at a position of $l = 10^\circ$, $b = 0^\circ$, while the curve labeled “extragalactic” is calculated using the isotropic extragalactic diffuse emission only. For the ground-based instruments a 5% systematic error on the background estimate has been assumed. All curves have been derived using the sensitivity model described in Section 2. For the Fermi-LAT, the *pass6v3* instrument response function curves have been used. As comparison, the synchrotron and Inverse Compton measurements for the brightest persistent TeV source, the Crab Nebula are shown as dashed grey curves.

the sensitivity information provided is insufficient to make a detailed comparison of the performance in the overlapping region which motivates this study.

As can be seen from the figure, the Fermi-LAT is photon starved in the overlapping energy range and therefore the νF_ν (which is equivalent to $E^2 dN/dE$) sensitivity worsens with increasing energy proportional to E^1 . The Fermi-LAT 10-year sensitivity is extremely uneven across the sky, due to the bright diffuse gamma-ray emission from cosmic-ray interactions in our Galaxy in that energy range [17]. We show two positions, one labeled “inner Galaxy” at $l = 10^\circ$, $b = 0^\circ$ Galactic coordinates and one at high latitudes labeled “extragalactic”, taking into account only the isotropic diffuse emission [28]. The Galactic diffuse emission has a steeper spectrum than E^{-2} and is therefore increasingly less dominant with higher energies in the Fermi-LAT [17]. For our study we will ignore the Galactic diffuse background in the following. This has negligible effect on the energy at which the Fermi-LAT and CTA differential sensitivity curves overlap as seen in Fig. 1. It should be noted that in the very inner parts of the Galaxy diffuse emission can become an issue, even for CTA as shown in [16]. Contrary to the Fermi-LAT, CTA is systematic error dominated in the overlapping energy range. Therefore longer observations do not help the CTA sensitivity in this range as can be seen from Fig. 1. Unless otherwise noted, we have assumed that the source counts need to be at least 5% above the background to be significantly detected (i.e. we assumed that we can determine our background level to 5% accuracy). While this is a reasonable assumption, for special observations, such as for pulsars (where the background can be determined by the off-phase), this might be overly conservative. Due to the dominance of systematic errors for CTA in the overlapping energy range, longer observation times do not significantly shift the energy at which the Fermi-LAT and CTA sensitivity curves cross as can be seen in Fig. 1.

Differential sensitivity is clearly not the only relevant factor when comparing instruments in the overlapping range. The integral sensitivity is relevant when aiming to detect a new source, and the angular and energy resolution are clearly critical for imaging and spectroscopy. Fig. 2 shows the angular resolution and the energy resolution for the instruments operating (or planned) in the ~ 100 GeV range. As can be seen there are orders of magnitudes

differences between instruments in both quantities. Below 100 GeV the Fermi-LAT outperforms all ground-based instruments in both angular and energy resolution. This is due to inherent fluctuations in those particles above the Cherenkov threshold high in the atmosphere for showers initiated by low energy primaries. So even if the differential sensitivity of the Fermi-LAT and CTA is the same at a given energy, the Fermi-LAT will be able to do a better measurement of a source. While HAWC’s performance in these quantities is rather modest, its main goal is to detect new sources and study variability and find transients. HAWC is not shown in Fig. 1 as differential sensitivity curves has not been provided by the HAWC collaboration and indeed, it is not the relevant quantity for the aforementioned goals. In the energy range at which this study is focused, HAWC is not competitive with the Fermi-LAT and CTA except perhaps for the detection of very short timescale transients such as GRBs.

2. The sensitivity model

The sensitivity of gamma-ray detectors is determined by three basic characteristics: the effective collection area, residual background rate and angular resolution, all of which are typically a strong function of gamma-ray energy. For Fermi-LAT the relevant curves are taken from [29] for instrument response function *pass6_v3*, and for CTA from [30]. It should be noted that the usage of the enhanced *pass7* response-functions for the Fermi-LAT will not substantially change the presented results. The difference in effective area above 1 GeV is $\sim 10\%$. We also note that the CTA performance is very likely to improve relative to that shown here, due to analysis improvements and hardware performance and telescope layout optimization. For a detailed description of the CTA instrument response function, see [?] in this issue. Detection sensitivity may be limited by statistical fluctuations of the background, by background systematics or by the number of detected signal photons. The statistical limit is calculated using a maximum likelihood approach, background systematics in CTA are assumed to have a 1% rms [30], and a minimum of 10 photons is always required for a detection. The instrument point-spread functions (PSFs) are assumed to be Gaussian for simplicity, with the 68% containment radius (θ_{68}) matched to that of the simulated instrument response. This study builds on that presented in [34] but is more precise in that it uses Monte-Carlo estimated background rates and collection areas for a baseline CTA design (*layout “E”*) [30] rather than inferred values, derived for an idealized future Cherenkov array [35]. Array layout *E* is used as an example. This particular configuration uses three telescope types: four 24 m telescopes with 5° field-of-view, 23 telescopes of 12 m diameter with 8° field-of-view, and 32 telescopes of 7 m diameter with a 10° field-of-view. The telescopes are distributed over ~ 3 km² on the ground. The study presented here uses the curves for an altitude of 2000 m and a zenith angle of 20° . The residual background rate adopted for Fermi (unless otherwise stated) is taken from [29] and is representative of the isotropic diffuse emission relevant for high Galactic latitude sources. As previously stated we ignore the Galactic diffuse emission which is justified, given its diminishing importance in the Fermi-LAT data above 10 GeV. The likelihood method adopted is a simplified version of that used for data analysis: events are binned in energy but counted (rather than fit) within an energy-dependent aperture. To match the sensitivity achieved using the standard method a background scaling factor of 0.6 is applied. This approach is used throughout except for the case of the source extension studies described in Section 5, where a full treatment is used.

In Fig. 3 we compare the sensitivity model to published curves for the differential sensitivity of CTA and Fermi, agreement exists

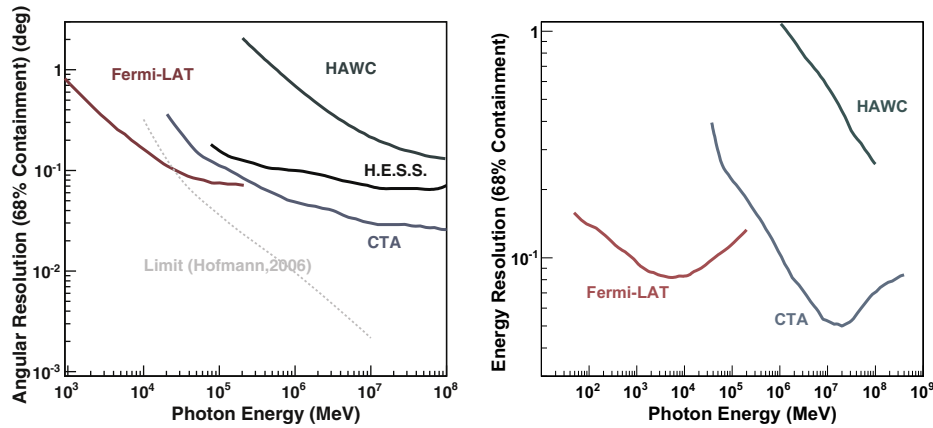


Fig. 2. **Left:** Angular resolution for Fermi-LAT [29] and CTA [30]. H.E.S.S. [31] and HAWC [32] are shown as examples for a current-generation IACT and for a next-generation water Cherenkov detector. Also shown is the limiting angular resolution that could be achieved if all Cherenkov photons emitted by the particle shower could be detected [33]. The CTA curve has not been optimized for angular resolution and enhanced analysis techniques are expected to improve this curve. **Right:** Energy resolution for Fermi-LAT and CTA. Shown is the 68% containment radius around the mean of the reconstructed energy. It is evident that the energy resolution of Fermi-LAT in the overlapping energy range is significantly better than the CTA resolution.

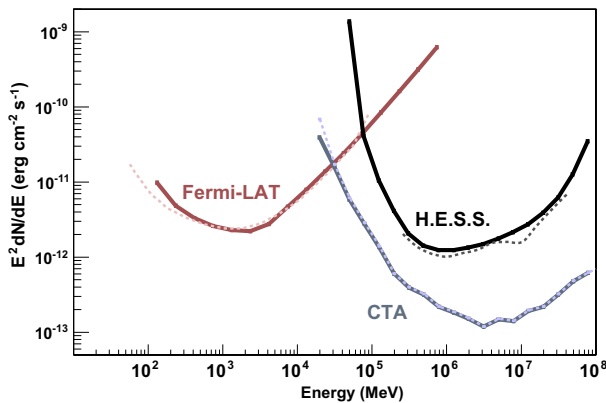


Fig. 3. Comparison of sensitivities derived with our model to the official sensitivity curves available in the literature [29,31,30]. Dotted curves are official curves, solid curves are derived with the model described in the text.

at the 10–20%, adequate for the purposes of our study, in particular considering the provisional nature of the CTA curves.

3. Differential sensitivity

It is interesting to compare differential sensitivities since this is the relevant quantity when comparing the quality of spectral measurements, in particular of features such as cutoffs and breaks. For the differential sensitivities we used a source with spectral index of $dN/dE \propto E^{-2}$, and required a significance of 5σ in each energy bin. In addition we required the source flux to be a factor of 5 above the background systematics (which we assumed to be 1%). Unless otherwise noted we calculated the differential sensitivity for 4 bins per decade in energy. In the energy range under study, both instruments suffer from drawbacks in spectroscopy: the Fermi-LAT is unable to exploit its good energy resolution due to a lack of photon statistics, but CTA is unable to make use of its large collection area due to limited energy resolution. Given the 30% energy resolution of CTA, see Fig. 2 (right), only 4 independent bins per energy are possible, assuming separation of the centers of the bins by the full-width half max of the energy resolution. This should not pose severe problems, since extremely sharp features are rather rare (apart from super-exponential cutoffs or dark matter annihilation signals).

When comparing the differential sensitivity in energy bins, clearly the motivation is to be able to perform spectral measurements. The energy E_{cross} at which the differential sensitivity curves of CTA and Fermi-LAT intersect is the energy below which Fermi-LAT and above which CTA is better suited to perform spectral measurements. However, it should be noted that the underlying motivation is to find the energy at which the Fermi-LAT and CTA spectral points of a source have similar statistical error bars. For CTA, being dominated by background systematics in this energy range, a 5σ detection requirement in each bin translates (in the Gaussian limit that applies here) into a 20% flux error for the point. For the Fermi-LAT, however, this is not true, since neither the signal nor the background of a threshold source are in the Gaussian limit in the energy range under study. Being signal-limited, we estimate that to get the same flux error, we need $N = 25$ signal events in the energy bin, significantly larger than what is usually applied when comparing differential sensitivity curves. If this requirement is fulfilled the Fermi-LAT should have a comparable error on its spectral measurement.

Fig. 4 shows the energy E_{cross} at which the error on the flux measurement in the energy bin should be equal between H.E.S.S. (left)/CTA (right) and the Fermi-LAT as a function of the observation times in both instruments. Given our assumptions about the systematic error on the background level, there is typically no large benefit in the overlapping energy range for CTA to spend significant amounts of observation time as can be seen from the fact that E_{cross} does change very weakly for a given Fermi-LAT observation time when increasing the CTA observation time. Also, it can be seen that for an expected 10-year lifetime of the Fermi-LAT mission $E_{\text{cross}} \sim 40$ GeV for the assumed parameters and for a typical 100 h CTA observation. That means at that energy the Fermi-LAT will be doing measurements (within the 10-year mission) that are comparable in quality to the measurements that will be done in a 100 h CTA observation.

Clearly, CTA has a huge discovery potential over the Fermi-LAT in the overlapping energy range for short-transient phenomena (provided they occur in the field of view), due to the large collection area. To demonstrate this, we show in Fig. 5 the differential sensitivity (or more precisely the integral sensitivity in the energy bin) for selected energies (25, 40, 75 GeV) as a function of observation time. Since the Fermi-LAT is signal-limited at these energies, the sensitivity improves rapidly with increasing observation time. For short-duration transient objects such as GRBs, it is evident that CTA has an advantage over the Fermi-LAT by many orders of

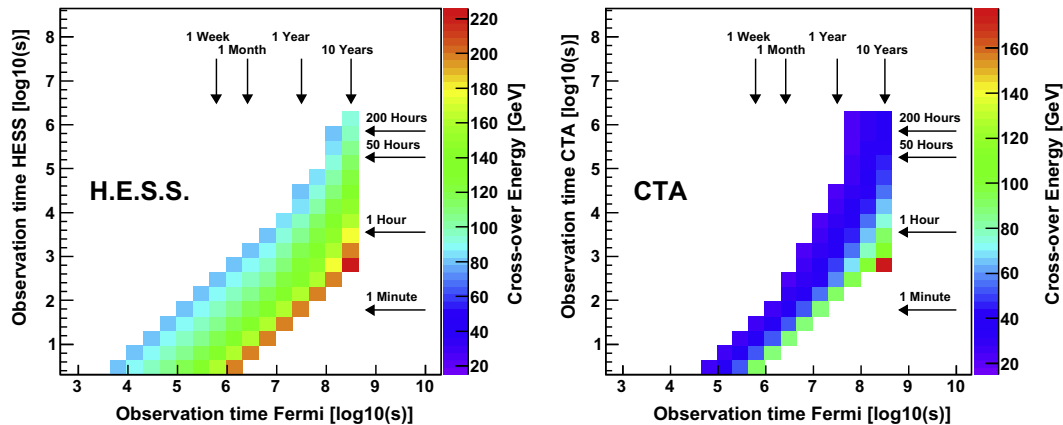


Fig. 4. Cross over energy E_{cross} as a function of Fermi-LAT and H.E.S.S. (left) or CTA (right) observation time. Here we required a detection significance in each energy bin of 5σ and a minimum number of 25 events in each bin (to get comparable errors on the flux measurement in the bin (see text for a discussion). No optimization for loosening the cuts at short observation times has been performed (the Fermi-LAT *pass6_v3* diffuse response function was used), therefore in principle the Fermi response could be somewhat better - but not by much, given the limited physical area of the instrument. Also for CTA, the curves could be improved if the systematics are brought under control and there was a smaller systematic error on the background estimate.

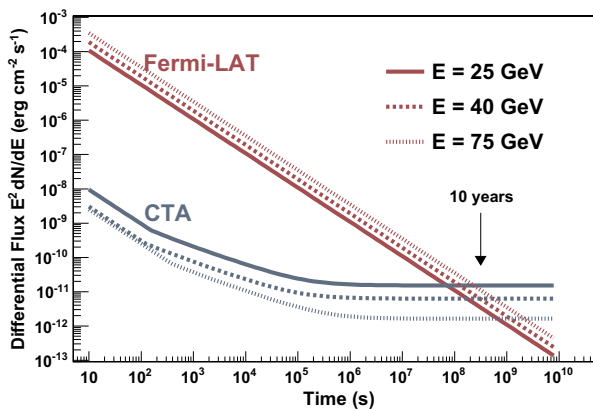


Fig. 5. Differential sensitivity at selected energies as a function of observation time. These plots were generated for a detection significance of 5σ in the relevant energy bin and a minimum number of 25 events.

magnitude which constitutes a large discovery potential. It should however be said that for transient sources the Fermi-LAT has the advantage of a 2.4π sr field of view which makes catching transients much more likely. In addition, the Fermi-LAT can view out gamma rays to much larger redshifts due to the $\gamma\gamma$ pair production opacity of the Universe at higher gamma-ray energies. The exact position of the kink in the graphs for CTA depends on the exact assumptions on the background systematics as discussed above. Again, it can be expected, that the CTA sensitivity for short-duration events can be significantly improved compared to the current instrument response function.

In addition to faint sources, it is also interesting to consider bright sources. Recent measurements have established pulsed emission from the Crab Pulsar in the > 25 GeV range [36,37]. For such observation the systematic error on the background level can be significantly reduced, since the local background can be determined from the off-phase of the pulsar. In this case the aim is no more the detection in each energy bin, but rather a very small error on the measured flux. In Fig. 6 we illustrate the effect of requiring 10σ per energy bin (and correspondingly 100 events) to get the same error on the flux in the signal-limited regime) and the suppression of the systematic error on the cross-over energy E_{cross} . For the special case of the pulsar observations, the cross-over energy can be significantly reduced and will be close to ~ 25 GeV

(compared to ~ 40 GeV in the standard case of 5σ and 10 events and 1% systematic error on the background flux).

4. Integral sensitivity

The potential of an instrument to discover new sources, or events, is related to its integrated performance over the relevant energy range. Unfortunately estimates of integral flux sensitivity are always strongly dependent on the assumed spectral shape. The most common approach assumes a power-law spectrum of a given spectral index (Γ) and calculates the minimum flux (F_{min}) above a given energy (E_0) that is required for detection. As the minimum flux in terms of photon rate per unit area is often a rapidly falling function of energy $E \times F_{\text{min}}$, a quantity with the same units as νF_{ν} , is often plotted. Implicit in this method is that the source spectrum starts abruptly at E_0 (or that all information below E_0 is disregarded) and that the source spectral power-law extends to infinity. Both of these assumptions are highly unrealistic in practice. Here we adopt an alternative approach to estimate minimum detectable flux, based on a characteristic energy in the source spectrum: either a spectral energy distribution (SED) peak or a cut-off energy. We define $\phi(E_c)$ as the minimum detectable integrated energy flux over the full energy range of a source with a spectrum $dN/dE \propto E^{-\Gamma} \exp -E/E_c$. A significance of 5σ and a minimum number of 10 events were requested (this section deals mostly with the detection of sources, not so much with the measurement of spectra). Fig. 7 shows this quantity for Fermi and CTA for two choices of Γ , 1.5 and 2.0. In the case $\Gamma = 1.5$, E_c corresponds roughly to the SED peak energy. The minima in ϕ seen for Fermi at ~ 3 GeV and CTA at ~ 10 TeV in the left panel of Fig. 7 can be interpreted as the energies at which these instruments are most sensitive for source detection. The cross-over between Fermi and CTA is at a cutoff energy of ~ 90 GeV. The case $\Gamma = 2$ is also interesting, demonstrating how dramatic the impact of a cut-off in the source spectrum is on the detection probability: for CTA a cut-off at 100 GeV raises the minimum required source power by an order of magnitude with respect to a > 1 TeV cut-off and a detection of such a source with Fermi is much more likely for the observation times assumed (10 years for Fermi and 100 h for CTA). The cross-over between Fermi-LAT and CTA in this curve is at a cutoff energy of ~ 370 GeV.

To help relate these curves to detection sensitivity for astrophysical objects, the right-hand axis of Fig. 7 gives the corresponding source luminosity at 1 kpc. For reference a canonical proton

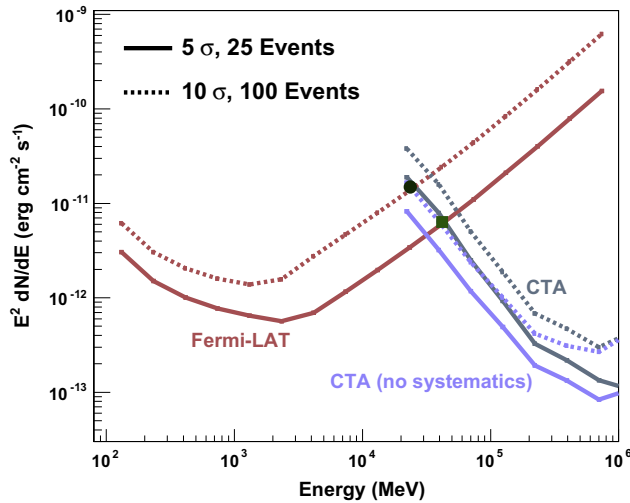


Fig. 6. Differential sensitivity for the case of no background systematic errors (e.g. in pulsar observations) in CTA (light blue) and with the standard 1% systematic error on the background for comparison (dark blue). In such cases the aim is to measure the spectrum at high precision, therefore 10σ per energy bin and a minimum of 100 events (resulting in an error on the flux of $\sim 10\%$) are shown as well (dashed lines). The markers indicate the points at which the 10σ , 100 events, no CTA background systematics intersect (dark green circle, 24.2 GeV) and for comparison the standard 5σ , 25 events, 1% background systematics (light green square, 41.8 GeV). The curves are shown for 10 years of Fermi-LAT and 100 h of a CTA observation. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

accelerating SNR at this distance with an ambient density of 1 hydrogen atom per cubic centimetre would have a luminosity of $\sim 10^{50}$ erg/ $t_{pp-\gamma} \sim 2 \times 10^{34}$ erg/s, suggesting that CTA should see such objects over most of the volume of the Galaxy. As can be seen from this figure: for hard-spectrum ($\Gamma = 2$) low-integrated luminosity sources such as SNRs, CTA will ultimately perform better than Fermi unless the cutoff is below ~ 1 TeV. We note that the case $\Gamma = 1.5$ is close to the expectation for dark matter annihilation spectra, (see e.g. [38,34]), or for a cut-off inverse Compton spectrum from an uncooled electron spectrum (see e.g. [39]). In the dark matter case the cut-off occurs at a factor of up to a few (e.g. in the case of annihilation into $b\bar{b}$) below the mass of the annihilating particle: Fig. 7 therefore suggests that Fermi may be more effective than CTA in searches for point-like dark matter annihilation signatures for particle masses below ~ 300 GeV.

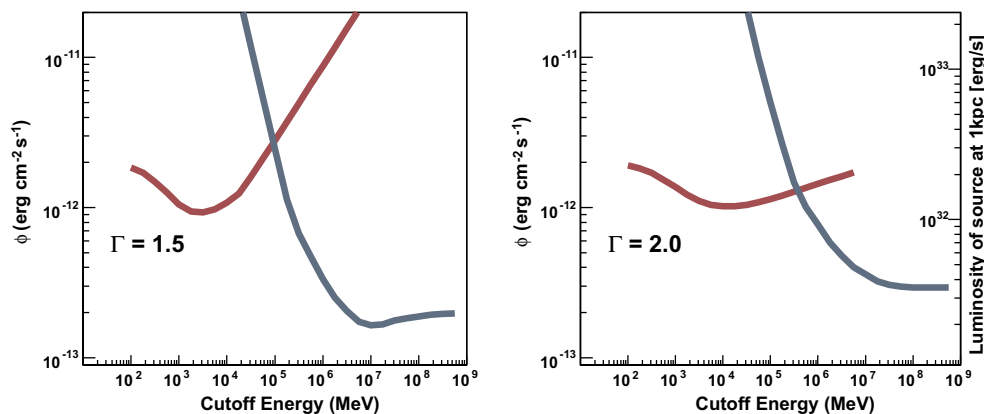


Fig. 7. Minimum detectable integrated (from 100 MeV to 100 TeV) energy flux, $\phi = \int E dN/dE dE$, as a function of cut-off energy E_c for spectra of the form $dN/dE \propto E^{-\Gamma} \exp(-E/E_c)$. Estimated CTA performance for 100 h of on-axis observations of a point-like source (dark blue curves) are compared to a 10 year Fermi all-sky survey (red curves). The left hand plot shows the case of photon index $\Gamma = 1.5$ and the right hand plot $\Gamma = 2.0$. The equivalent luminosity for a source at 1 kpc distance is shown for reference. At least 10 detected photons, a 5σ detection and a signal to noise of better than $1/20$ are required in all cases. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

5. Sensitivity for extended sources

The power to detect regions of extended emission and to image/resolve such regions is a key performance criterion for a gamma-ray detector. A substantial fraction of the sources visible above 100 GeV are significantly spatially extended, with a typically rms angular size of $\sim 0.2^\circ$ for Galactic objects [14]. Whilst relatively fewer extended objects are known at GeV energies, this may be, at least in part, a selection effect [40]. In addition to the dominant class of extended Galactic objects, extended emission is expected from extragalactic objects for some of the most important targets for CTA and the Fermi-LAT, in particular for cosmic-ray and/or dark matter annihilation signatures in clusters of galaxies and nearby galaxies. For an extended object, at least 3 flux levels are of interest: a minimum detectable flux F_d , the minimum flux F_e at which statistically significant extension can be demonstrated and the flux level F_i at which substructure on the scale of the PSF can be detected. Whilst F_i can be readily estimated from the point-source detection sensitivity F_{ps} : $F_i \approx F_{ps} \Omega_s / \Omega_{psf}$ (Ω being the solid angle), the remaining quantities are more subtle. An extended-source must be detected above the fluctuations of an increased background level $N_{bg,ext}(E) = N_{bg}(E) \sqrt{\theta_{psf}(E)^2 + \theta_s^2}$ where θ_s is the rms source size and θ_{psf} is the energy-dependent rms of the PSF, F_d is therefore close to F_{ps} for $\theta_s < \theta_{psf}$. In contrast the ability to detect the extension of a source improves dramatically for $\theta_s > \theta_{psf}$. Fig. 8 shows these two flux levels for both Fermi and CTA for nominal observation lengths and assuming an E^{-2} spectrum source with no cut-off. In the Fermi case the calculation of the Fermi collaboration for F_e is shown in solid green for comparison [40]. Fig. 8 shows that the deterioration of source detection power for larger angular size sources is much more dramatic for CTA than for Fermi, due to the superior angular resolution of the former. Conversely, CTA can detect modest source extension (at the $\sim 0.1^\circ$ level) for order of magnitude dimmer objects. Note that the arguments given here apply only to objects much smaller than the FoV of CTA (i.e. less than $\ll 4^\circ$ rms) for which the on-axis response can legitimately be assumed.

6. Summary and outlook

This paper presents the first in-depth comparison of the sensitivities in the overlapping energy range between 10 GeV and 100 GeV for the Fermi-LAT and CTA. This is an important energy range due to the fact that the Universe goes from being transparent

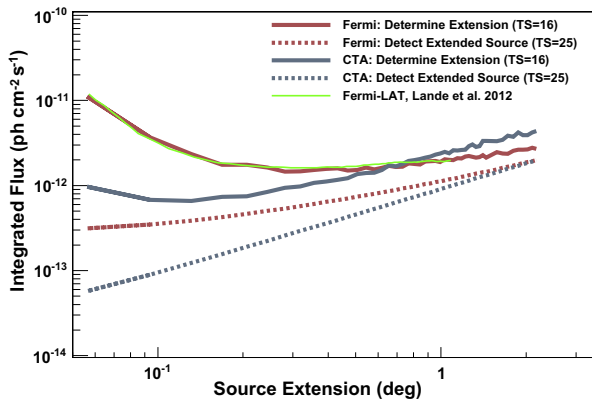


Fig. 8. Sensitivity for detecting extended sources as a function of the RMS (68% containment) source extension. Shown is the integral flux F_d at which an extended source is detectable at the 5σ -level (dashed) and the integral flux at which extension can be demonstrated (solid) at the 4σ -level. See text for details of these quantities. Shown as a solid green line is the sensitivity estimate for extended sources given by the Fermi-LAT collaboration [40]. It can be seen that the detection sensitivity F_d deteriorates more rapidly for CTA than for the Fermi-LAT due to the superior angular resolution. It can also be seen from the solid lines: up to sources of $\sim 0.7^\circ$ CTA will perform significantly better in resolving sources.

to being opaque to gamma-rays at these energies. It also is the range at which many Fermi-LAT sources show interesting features in their spectra, such as cutoffs and breaks or new components. When comparing the differential sensitivity of a 10-year sky-survey with the Fermi-LAT with a typical 100 h exposure of CTA we find that CTA will be better for measuring spectra (taking into account systematic errors) for an E^{-2} source above ~ 40 GeV. In terms of detecting sources, CTA will work better for sources with an E^{-2} spectrum and an exponential cutoff above ~ 370 GeV. For short-term phenomena (order of minutes) CTA will perform orders of magnitude better than the Fermi-LAT in the overlapping area, although the Fermi-LAT obviously has a huge advantage in terms of field of view. Given the large overlap in energy range, an ideal scenario is one where both the Fermi-LAT and CTA operate simultaneously during some (albeit brief) period of time. In fact, CTA would benefit tremendously from a simultaneous operation with the Fermi-LAT. Therefore, the ground-based gamma-ray community is strongly in favor of extending the lifetime of the Fermi-LAT mission over the currently planned 5–7 years.

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