Draft : Effective area on-orbit validation for Pass5

Reposeur[1] & Parent[1]

1. Introduction

This study presents a method of the effective area on-board validation for the Large Area Telescope(LAT), using the 55 day LEO interleave. We worked on the background rejection analysis called Pass5_v0, summarized in Table2. The studied sources are the Vela pulsar and the diffuse background. The final purpose is to determine whether the instrument responds on-orbit as the Monte Carlo simulations.

To validate the effective area depending on the energy and theta, we propose to compare the cut efficiencies at each stage of the analysis procedure for the real data, and for the simulated data which depend on Monte Carlo. The MC may include several biases : level of background, source models... Vela would be the best candidate as it is the brightest γ source and an identifiable pulsed source. However, it cannot be used to validate the high energy range.

The purpose is to obtain an analysis which doesn't depend on the source. We summarize in Tables 2, 3 and 4, the Pass5 cut efficiencies for different levels. A Pass5 summary added by Riccardo Rando is available on https ://confluence.slac.stanford.edu/display/SCIGRPS/Pass+5+summary.

The first step is to compare the efficiencies. We define the efficiency as $\epsilon = N_{evts}/N_0$, with N_{evts} the number of events after analysis cuts, and N_0 the number of raw events, that is, all events in the Merit file. As an example, for the Pass5 level 1 described in Table 2, the efficiency for the transient cut is given by :

$$\epsilon = \frac{N_{EvtTransient}}{N_0} \tag{1}$$

If the comparison fails, we will try to determine which variable(s) is(are) responsible of the difference. Hence, we will compare the efficiencies for the Pass5 Level 2, described in Table 3, down to the ACD, TKR and CAL variables.

We present two slightly different methods. We compared the bright pulsar Vela and the diffuse background, which have both a different spectral index and different flux, in order to determine if our method depends (or not) on the source.

[1]CENBG

2. Method 1 : integrated efficiency

We selected the 55 day LEO interleave data for the regions of interest of 1,3 and 5 deg centered on the pulsar position and an energy range from 30 MeV to 300 GeV. Especially, we used the MCSRCID variable in the Merit files to select the two sources (Vela MCSRCID = 21000, BG MCSRCID = 12000, 12001). Table 1 presents the Pass5 level 1 (integrated) efficiency with the statistical errors, for the three regions, that is, $\epsilon = N_{evts}/N_0$ integrated between 30 and 300 MeV, and between theta 0 and 90 deg and the ROI.

Table 1: Integrated efficiency for the Vela pulsar and the diffuse background.

Source	CutName	1 (°)	3 (°)	5 (°)
Vela	Transient	73.22 ± 0.76 (31723/43324)	65.49 ± 0.47 (63094/96339)	61.01 ± 0.38 (80660/132209)
	Source	69.65 ± 0.74 (30176/43324)	59.25 ± 0.44 (57081/96339)	53.14 ± 0.35 (70255/132209)
	Diffuse	65.88 ± 0.71 (28544/43324)	51.96 ± 0.40 (50073/96339)	44.10 ± 0.30 (58300/132209)
Diffuse	Transient	57.85 ± 2.98 (1165/2014)	57.9 ± 1.0 (10562/18234)	57.70 ± 0.60 (28515/49422)
	Source	48.7 ± 2.64 (981/2014)	49.52 ± 0.89 (9030/18234)	49.17 ± 0.54 (24302/49422)
	Diffuse	39.82 ± 2.29 (802/2014)	40.74 ± 0.77 (7429/18234)	40.61 ± 0.47 (20072/49422)

Note. The response function sets are preceded by the trigger and filter cuts : (GltWord&10)>0 && ((GltWord&7) !=3) && (FilterStatus_HI==0). In parenthesis are the number of events.

We note, that the level 1 efficiency for each cut and each ROI, is different for the Vela pulsar and the diffuse background. For a 5 deg ROI, the efficiencies tend towards a same result. The results depend on the ROI and the source properties. This method presents too many biases to be used as such. This is essentially dut to the different coverage of the (θ,E) phase space resulting in different average values. We will show in the next section that a more complete scan of (θ,E) is made possible using the galactic background.

3. Method 2 : ϵ(E,θ)

We selected the 55 day LEO interleave data for the region of interest of 10 deg around the Vela pulsar and the galactic plane between the latitude -6 and +6 deg (high statistics). We used the MCSRCID variable to select the two sources. We calculated the efficiency in 20 energy intervals and 20 theta intervals for the two sources and compared the efficiencies for each interval. The analysis validation requirements are :

- $\Delta\epsilon(\mathrm{E},\theta)/\epsilon(\mathrm{E},\theta) < 10\%$
- $\epsilon(E,\theta)_{vela} \pm \Delta\epsilon_{vela} = \epsilon(E,\theta)_{bg} \pm \Delta\epsilon_{bg}$

Figures 1, 2 and 3 present the results for the Pass5 level1. Figures 4, 5, 6, 7, 8, 9, 10 present the results for the Pass5 level2.

Description of figures :

[1] Top left : ϵ(E,θ) for the Vela pulsar.

[2] Top right : ϵ(E,θ) for the galactic plane.

[3] Bottom left : $\epsilon(E,\theta)_{vela}$ - $\epsilon(E,\theta)_{bg}$

[4] Bottom right : Efficiency verification :

0 : $\epsilon_{vela} \pm \Delta\epsilon_{vela} \neq \epsilon_{bg} \pm \Delta\epsilon_{bg}$

1 : $\epsilon_{vela} \pm \Delta\epsilon_{vela} = \epsilon_{bg} \pm \Delta\epsilon_{bg}$ and $\Delta\epsilon/\epsilon < 10\%$

2 : $\epsilon_{vela} \pm \Delta\epsilon_{vela} = \epsilon_{bg} \pm \Delta\epsilon_{bg}$, but $\Delta\epsilon/\epsilon > 10$ %.

3 : No statistics.

The results are promising, because the analysis validates the effective area for (only) a part of energy and theta intervals. The method requires large statistics in the energy and theta intervals. The Vela pulsar is limited by low statistics compared to the galactic plane, and a energy cutoff around 10 deg.

We demonstrated that computing ϵ(E,θ), rather than the averaged value, doesn't depend on the analyzed source. However, it will depend on the ratio between the charged particles and the γ-ray, especially in pointing mode where we will deal with the albedo. Moreover, to avoid the charged particle problem, Vela is still a good choice to scan a limited phase space.

4. Perspectives

We will use the galactic plane data of the 55 day LEO interleave to compare with the Science Ops 2.

Table 2: Pass5 level1

Cut name	Definition
Transient	CTBBestEnergyProb>0.1 && CTBCORE>0.1 && CTBBestEnergy>10 && CTBBestEnergyRatio<5 && CTBClassLevel>0
Source	CTBBestEnergyProb>0.1 && CTBCORE>0.1 && CTBBestEnergy>10 && CTBBestEnergyRatio<5 && CTBClassLevel>1
Diffuse	CTBBestEnergyProb>0.1 && CTBCORE>0.1 && CTBBestEnergy>10 && CTBBestEnergyRatio<5 && CTBClassLevel>2

Note. The response function sets are preceded by the trigger and filter cuts : (GltWord&10)>0 && ((GltWord&7) !=3) && (FilterStatus_HI==0).

Table 3: Pass5 level2

Cut name	Definition
TBBestEnergyProb	CTBBestEnergyProb>0.1
CTBBestEnergyRatio	CTBBestEnergyRatio<5
CTBBestEnergy	CTBBestEnergy>10
CTBCORE	CTBCORE>0.1
CTBClassLevel>0	CTBCalTkrComboCut>0.45 || CTBAllProb>Max(0.075,0.07*(CTBBestLogEnergy-1.))
CTBClassLevel>1	CTBCalTkrComboCut>0.85 || CTBAllProb>Min(0.95,Max(0.4,0.4*(CTBBestLogEnergy-1.)))
CTBClassLevel>2	CTBCalTkrComboCut>1.45 || CTBAllProb>Min(0.97,Max(0.8,0.4*(CTBBestLogEnergy-1.)))

Table 4: Pass5 level3

Cut name	Definition
CTBAllProb0	Max(0.075,0.07*(CTBBestLogEnergy-1.))
CTBAllProb1	Min(0.95,TMath : :Max(0.4,0.4*(CTBBestLogEnergy-1.)))
CTBAllProb2	Min(0.97,TMath : :Max(0.8,0.4*(CTBBestLogEnergy-1.)))
CTBCalTkrComboCut0	CTBCalTkrComboCut>0.45
CTBCalTkrComboCut1	CTBCalTkrComboCut>0.85
CTBCalTkrComboCut2	CTBCalTkrComboCut>1.45

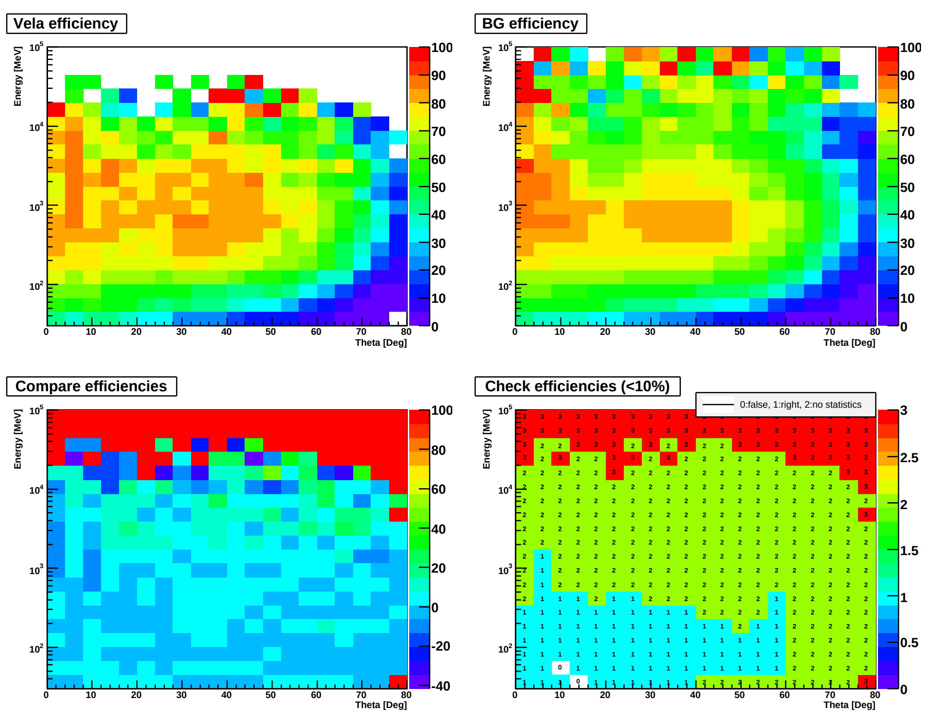

Fig. 1.— Transient

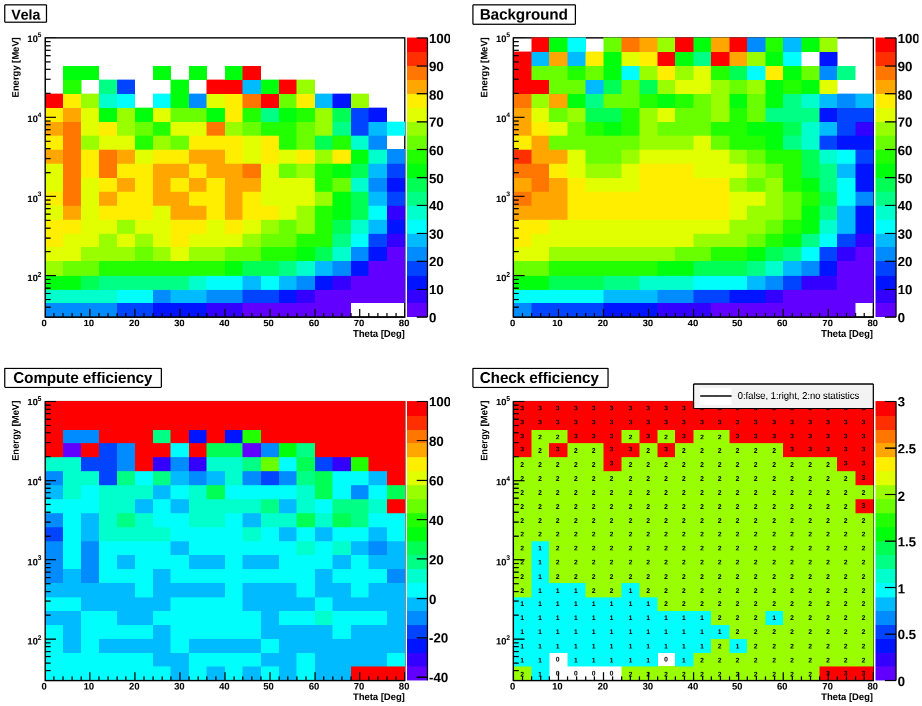

Fig. 2.— Source

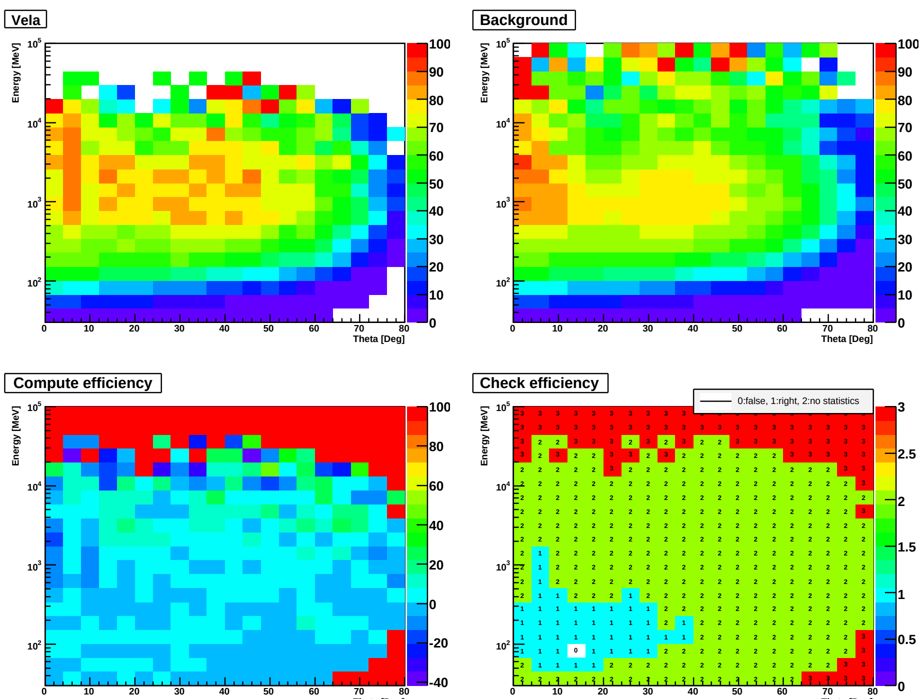

Fig. 3.— Diffuse

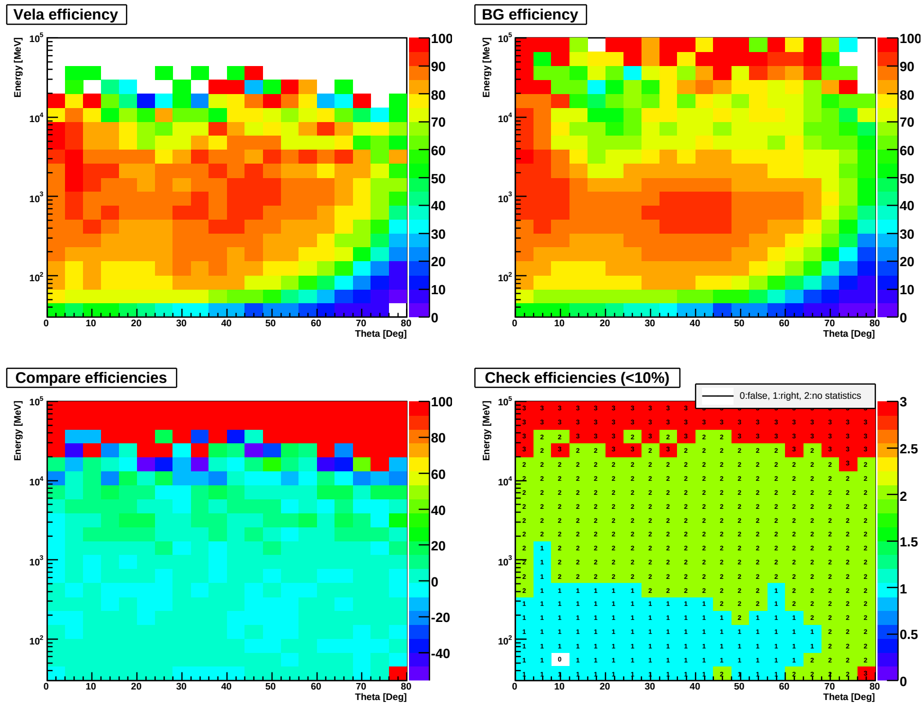

Fig. 4.— CTBBestEnergyProb

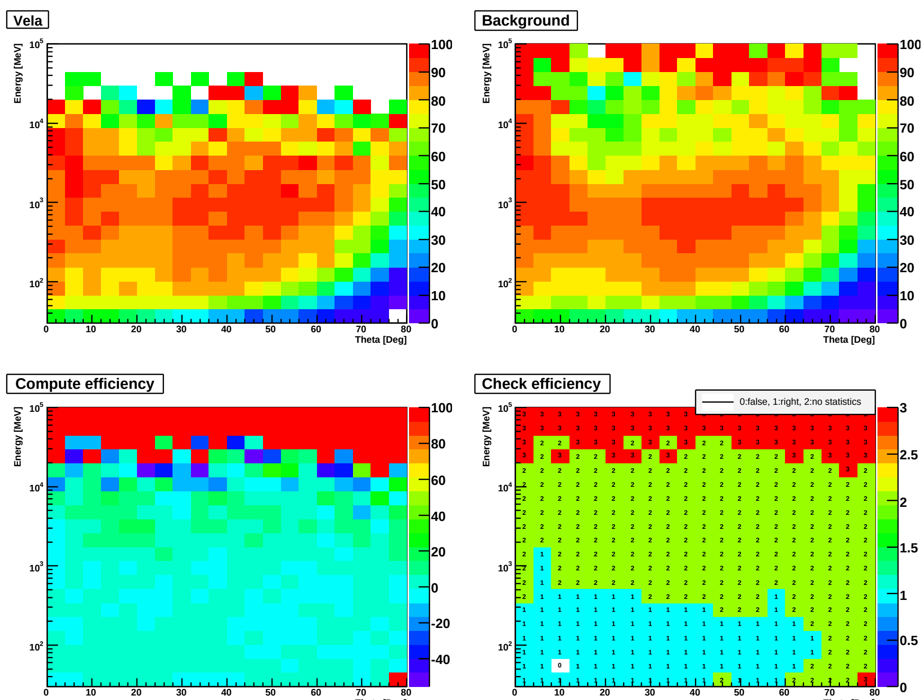

Fig. 5.— CTBBestEnergy

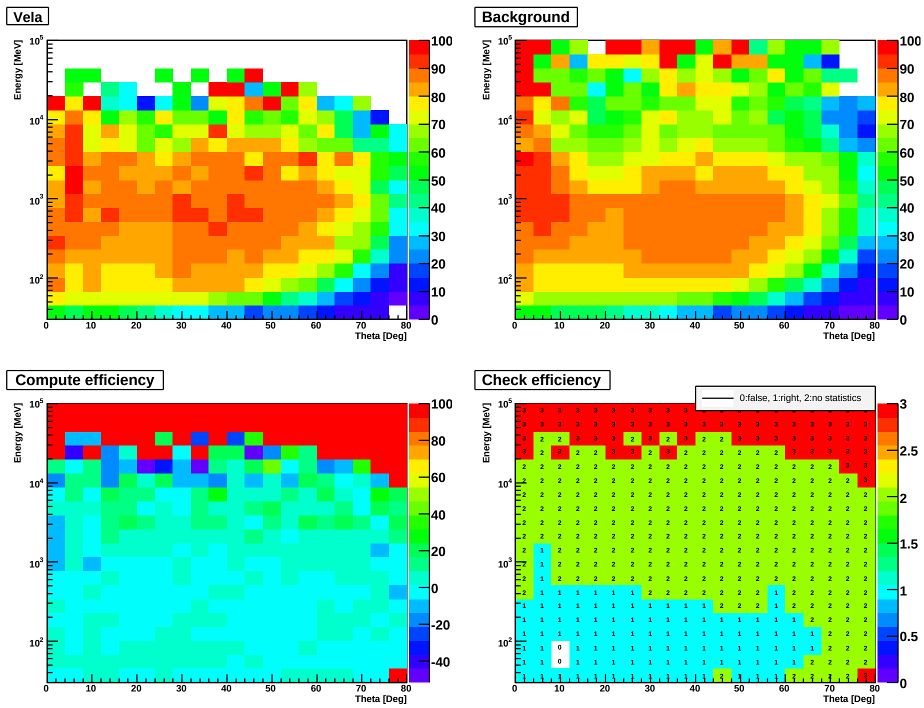

Fig. 6.— CTBCORE

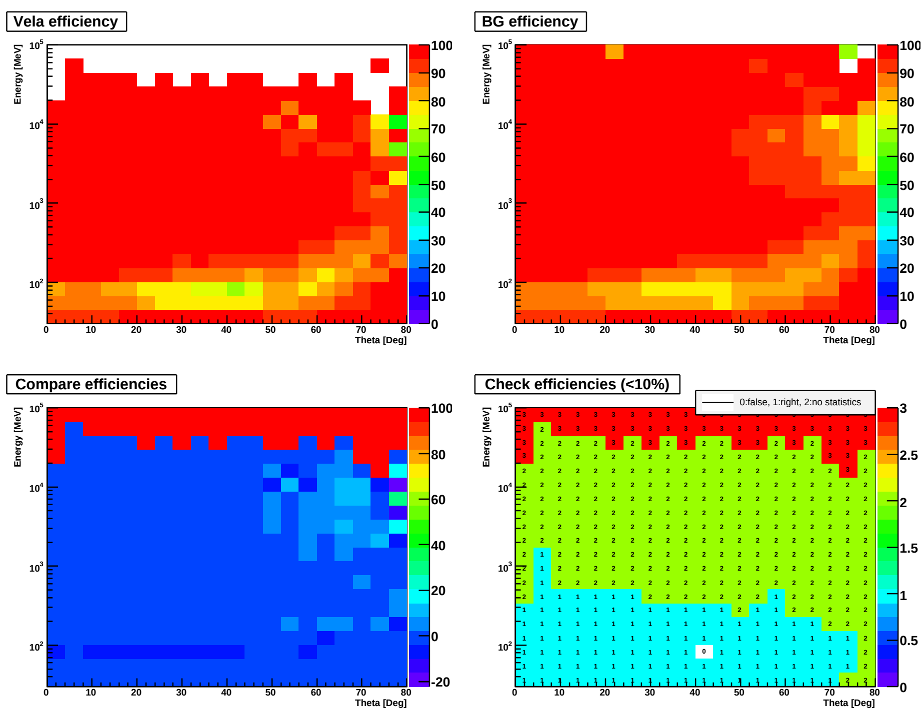

Fig. 7.— CTBBestEnergyRatio

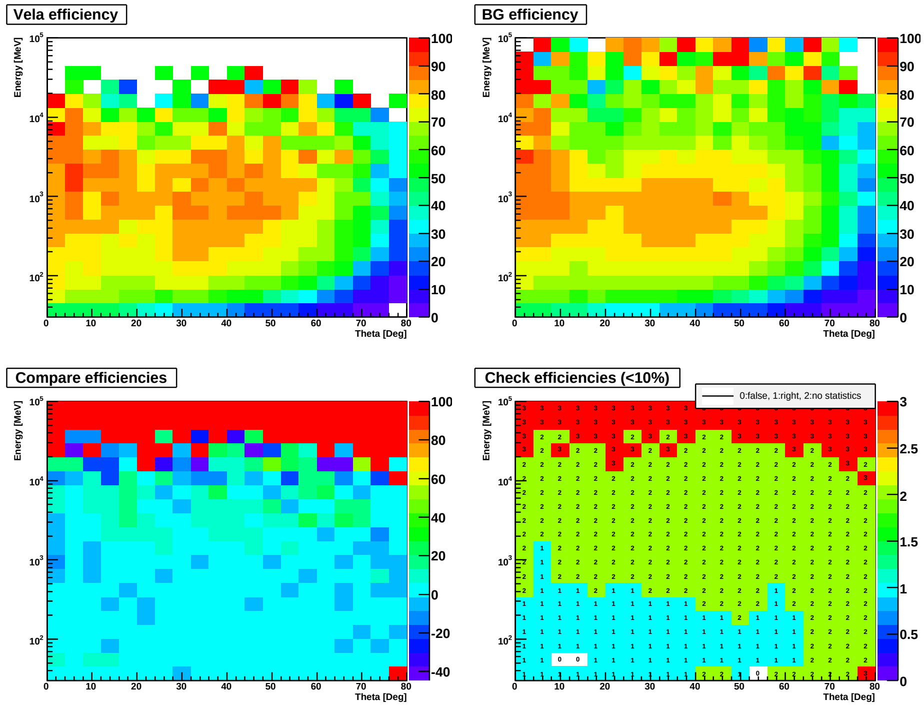

Fig. 8.— CTBClassLevel0

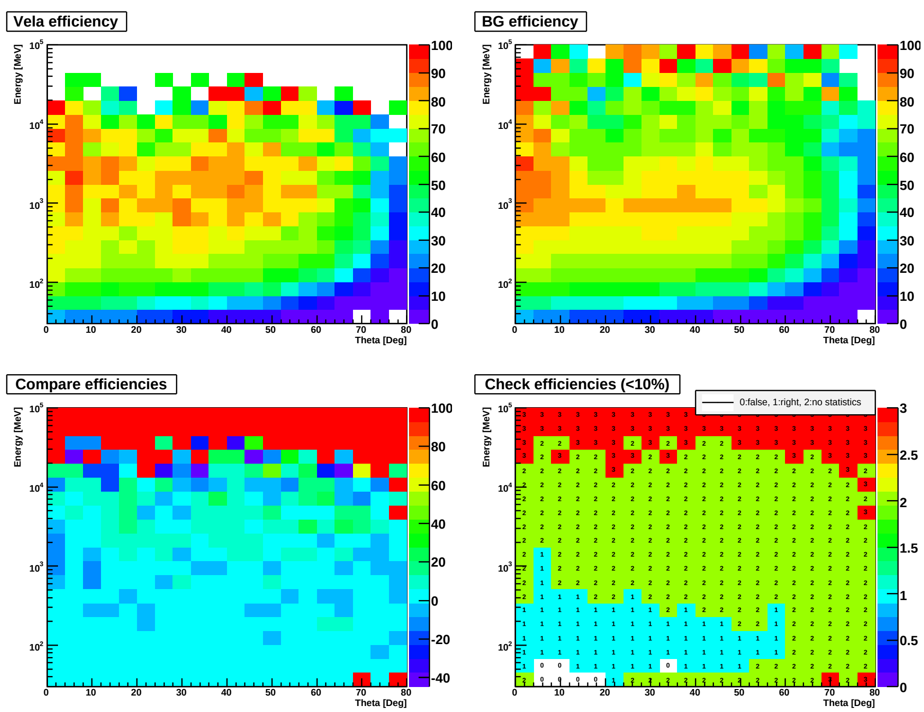

Fig. 9.— CTBClassLevel1

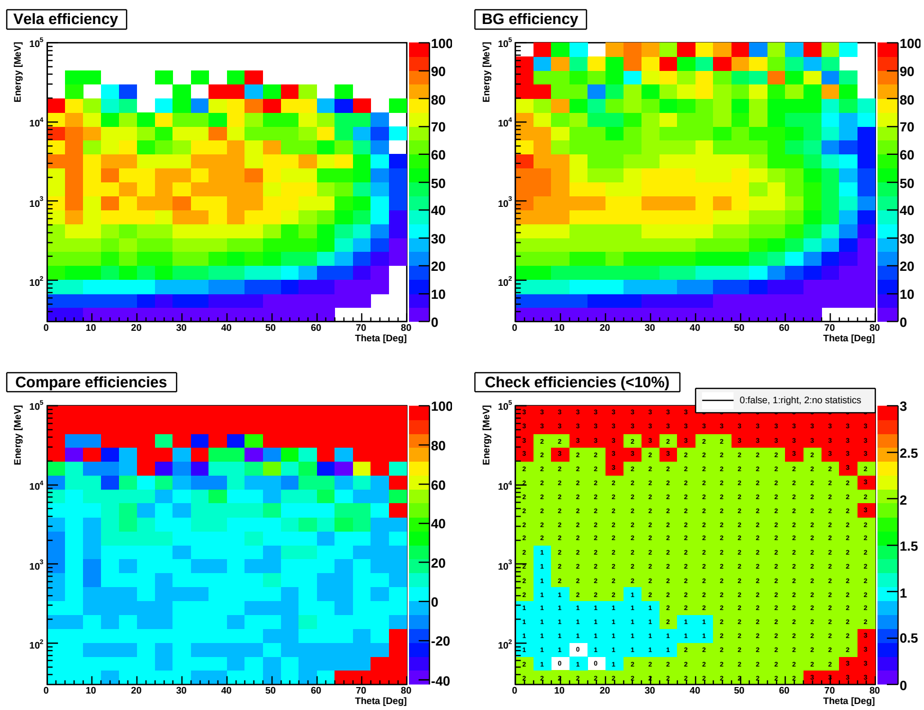

Fig. 10.— CTBClassLevel2