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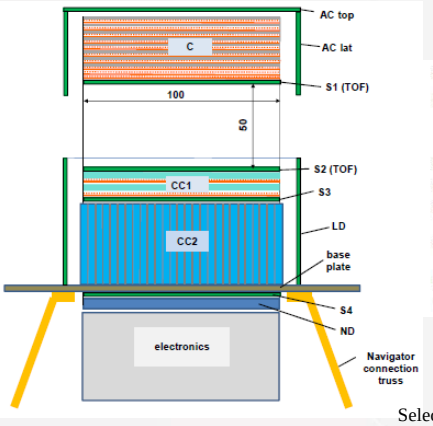
Electrons and protons separation in the GAMMA-400 experiment

GAMMA-400 SCIENTIFIC GOALS:

- study of the origin of the dark matter by means of gamma-ray astronomy;
- precise measurements of Galactic and extragalactic discrete astrophysical sources;
- research of high-energy gamma-ray bursts;
- study of the energy spectra of Galactic and extragalactic diffuse emission;
- research of high energy electron + positron fluxes;
- research of high-energy nuclei fluxes.

GAMMA-400 PHYSICAL SCHEME



AC - anticoincidence detectors (AC top , AC lat)

C - Converter-Tracker - total 1 Xo
8 layers W 0.1 Xo +Si (x,y) (pitch 0.1mm)
2 Si(x,y) no W

S1, S2 - TOF detectors

S3, S4 calorimeter scintillator detectors

CC1 - imaging calorimeter (2Xo)
2 layers: CsI(Tl) 1Xo + Si(x,y) (pitch 0.1 mm)

CC2 - electromagnetic calorimeter
CsI(Tl) 23 Xo 3.6x3.6x43 cm^3 - 28x28 = 784 crystals

LD - 4 lateral calorimeter detectors

ND - neutron detector

The neutron number cutoff to separate protons is equal 60.

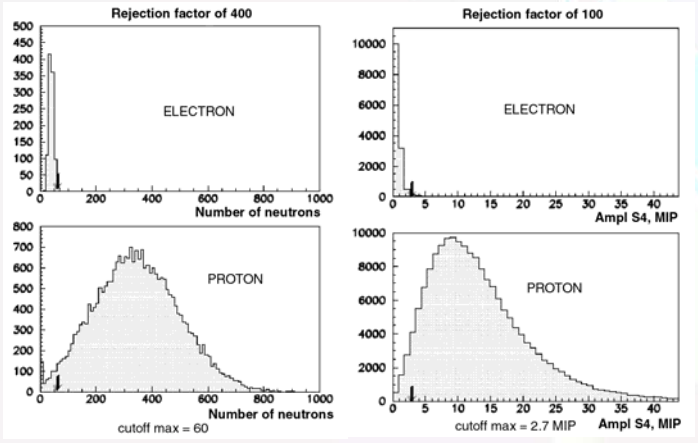
Simulation environment: GEANT4 (4.9.4p02)
GLAST physical list (http://www-glast.slac.stanford.edu/software/PDR/SAS/g4prot.htm)
Crosscheck with QGSP_BIC_HP physics list

Protons produce the main background, when detecting electrons in cosmic rays. The main trigger of the gamma-ray telescope includes the signals from time-of-light scintillation detectors S1 and S2, at that the signal in S1 has to be generated before the signal in S2. To reject protons from electrons the GAMMA-400 instrument information from ND, S4, S3, S2, CC1, C, and CC2 is used. The rejection factor for protons is calculated as the ratio of number of initial protons with energy more than 100 GeV, assuming that the proton energy spectrum power is -2.7, to the number of events identified as electrons with energy 100±2 GeV. Firstly, the rejection factor for vertical incident protons is evaluated. All processed criterions to suppress protons are based on selecting cutoffs to distinguish proton and electron events. **The location of the cutoff for each criterion is selected in order to retain 98% of electrons.** Totally 25 cutoffs are used to reject protons. With presented selection also ~30% of electrons are lost due to proton rejection.

Detector system, number of cutoffs	Own rejection factor for each cutoff	Total rejection factor
ND (1 cutoff)	400	2
CC2 (2 cutoffs)	30	2.6
S4 (2 cutoffs: 1 cutoff for each scintillation layer)	100	1.7
Strips in CC1 (4 cutoffs: 2 cutoffs for each X or Y silicon strip)	6	1.2
CsI(Tl) from CC1 (2 cutoffs: 1 cutoff for each CsI(Tl) crystal)	3	1.3
S2, S3 (4 cutoffs: 2 cutoffs for each detector)	2	1.3

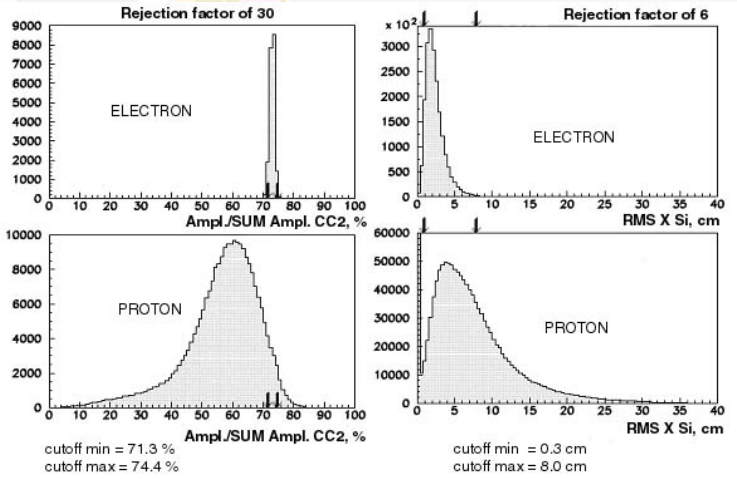
The information about own rejection factor of each criterion (without other) and the values of total rejection factor decreasing in the case of refusal of given criterion. Using all criteria in the combination, it is possible to obtain the rejection factor for protons equal to $(4.0\pm0.7)\times10^5$. The results of calculation for 30^0 incident angles of protons give the total rejection value equal $(3.0\pm0.4)\times10^5$.

Selecting events with signals in S4 less than 2.7 MIP (MIP is minimum ionizing particle, 1 MIP is ~ 2 MeV for S4), it is possible to suppress protons with a factor of 100.

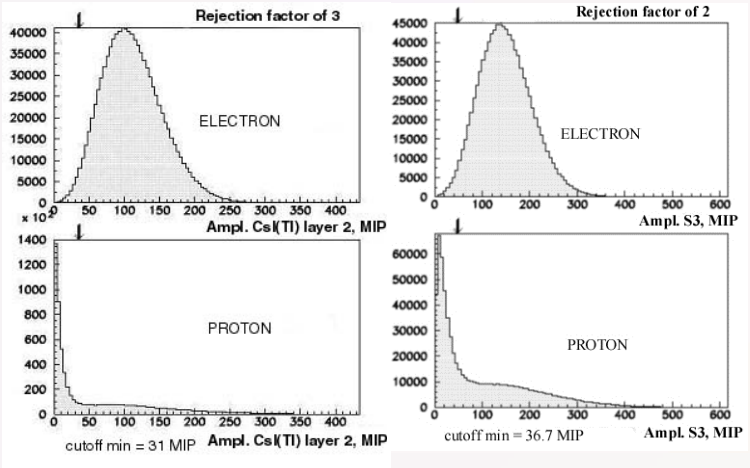


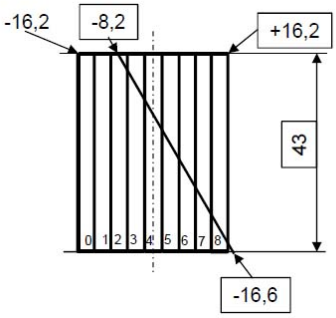
The criterion is based on the difference of the transversal size for hadron and electromagnetic showers. Applying this rejection in calorimeter provides the rejection factor of ~30.

The differences in proton and electron cascade transversal size are also used when analyzing information from silicon strips in CC1 for the distributions of RMS of coordinates in strips with signals for initial electrons and protons. Applying this rejection provides the rejection factor of ~6.



To take into account the fact that the hadron cascade begins to develop deeper inside the instrument, than the electromagnetic shower, the signals in detector systems CC1, S2 and S3 are considered. For proton-induced cascades, there are a lot of events with small signal amplitude.





E_e, GeV	rejection factor
50	$(12.8\pm2)\times10^5$
100	$(4.0\pm0.7)\times10^5$
200	$(5.0\pm0.7)\times10^5$
1000	$(4.1\pm0.7)\times10^5$