Detailed feasibility study of a gamma ray detector system for nanosatellites using GEANT4 simulations

Galgóczi Gábor**, Fizikus MSc szak, 2. évfolyam

Eötvös Loránd Tudományegyetem, Természettudományi Kar

WIGNER Fizikai Kutatóközpont - MTA

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Introduction

High energy astrophysics

Aim of the simulation

The main aim of the paper, therefore this thesis is to optimize the scintillators of the CubeSats (miniaturized satellites) in the Constellation Gamma satellites. The second aim is to understand how the material of the CubeSat would affect the gamma photons that the satellite is meant to detect.

The Constellation Gamma (ConGa) fleet

The simulated setup

HAMAMATSU S13360-6050CS

datasheet of QE:

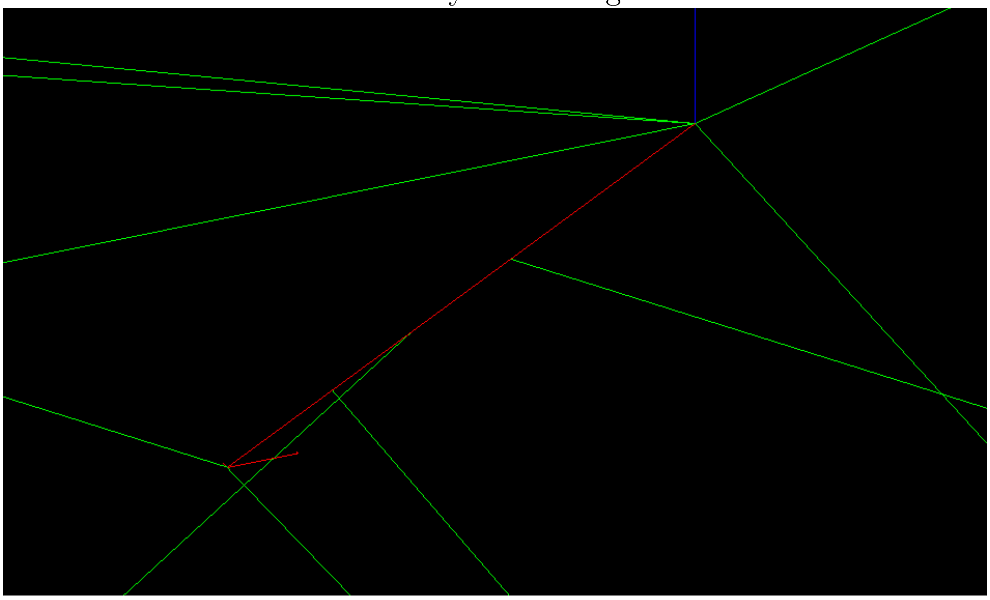
esr foil: Please check "ESR from 3M" company. e.g.,

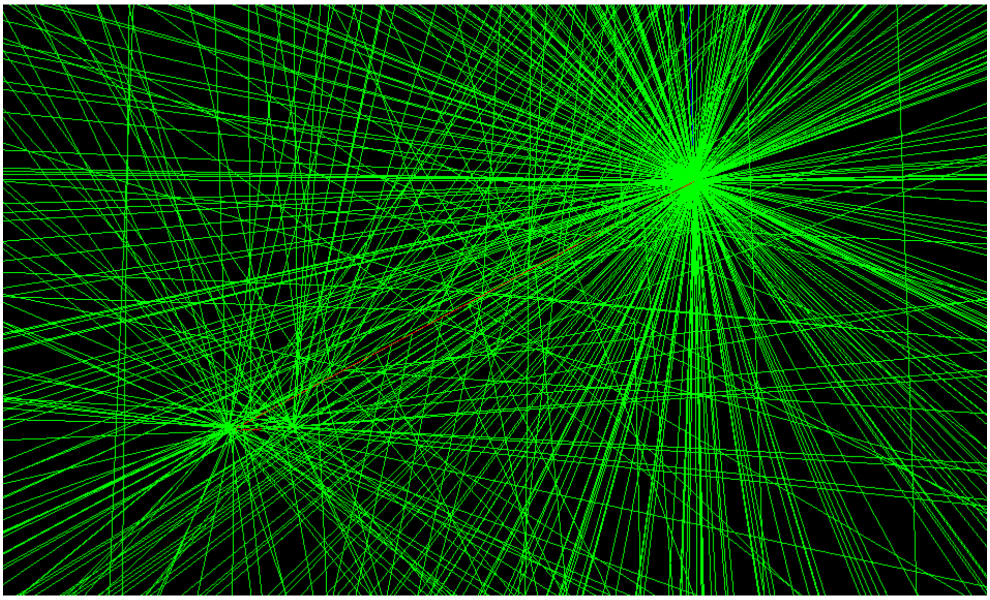
Simulation

In order to understand how the γ photons – that the CubeSat is meant to detect – interact with the matter of the satellite simulations are needed. In a simulation it is also possible to determine the optimal geometry that would lead to the best GRB detection.

The Geometry... XXX TRacking (Geant4)

The cross section for photoeffect is far the largest by far for low energy gamma photons. The ionized nuclei and the secondary electrons generates scintillation.





Also the nuclei that is ionized by the gamma produces photons.

Fine tuning the optical parameters

Most relevant parameters:

- absoprtion length of the scintillator material
- scintillation yield

Setup

Size of the scintillator is, the aluminium housing thickness is, the size of the SiPM is... Parameters of the CsI(Tl) scintillator REF

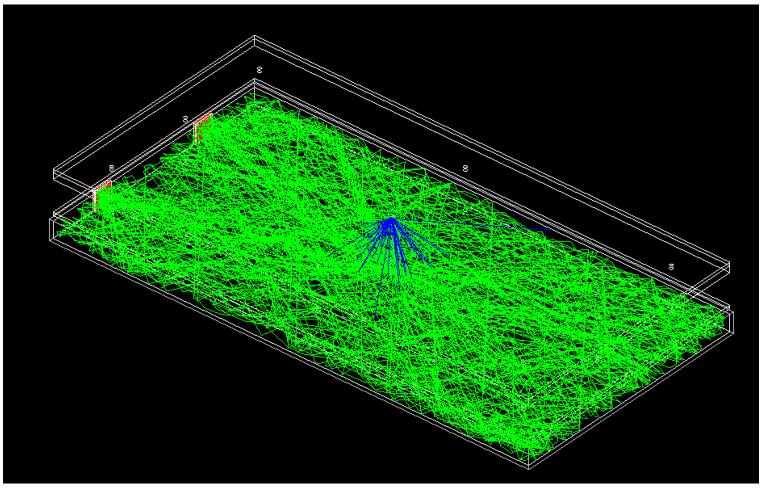
- Scintillation yield (Number of photons produced by given keV depleted in the scintillator)
- The energy spectra of the produced scintillation
- The time constant of the scintillation photon creation
- The absorbtion length of the optical photons
- Birks constant?

Optical parameters of the materials and surfaces:

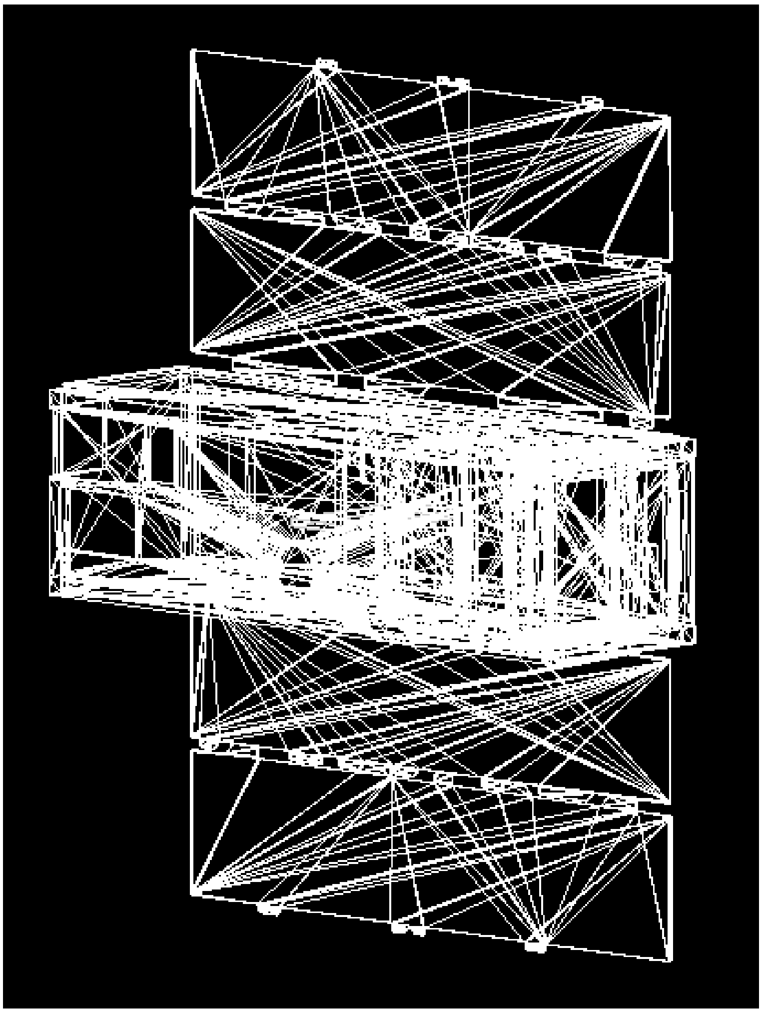
- Refractive indices of all relevant materials
- Reflection
- The detection efficiency of the SiPM detectors

1 channel setup

2 channel setup



The satellite



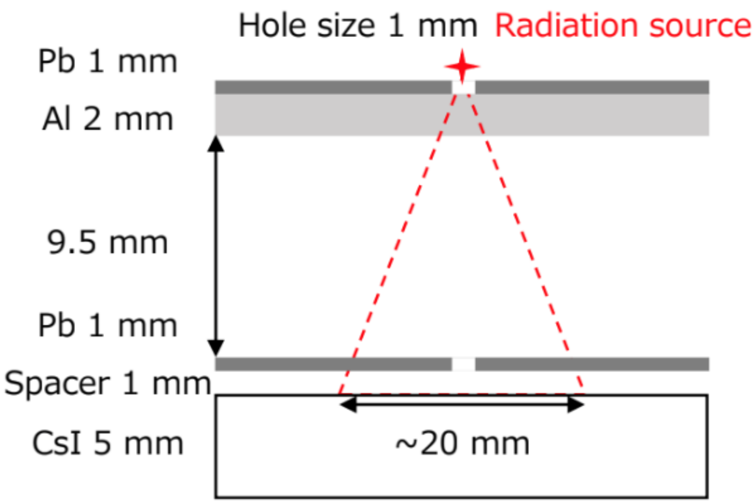
Name of module	mass [g]	Type of material	Mass ratio [%]
ADCS	710	Aluminum 6061-T6	50
		Copper Electric	25
		Glass Borosilicate	25
ANT	110	Stainless Steel	50
		FR4 Glass-Epoxy sheet	50
AUX	100	FR4 Glass-Epoxy sheet	100
COM	90	Stainless Steel	2
		Brass Generic	25
		Aluminum 7075-T73	40
		FR4 Glass-Epoxy sheet	33
EPS	750	FR4 Glass-Epoxy sheet	25
		Aluminum 6061-T6	75
OBC	50	FR4 Glass-Epoxy sheet	100
STRU	980	Aluminum 6061-T6	100
SP	570	Solar Panel	100
Payload	1100	As you wish	100

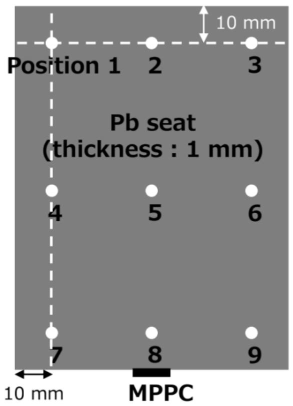
Material name												
Aluminum 6061-T6	Al	96.90	Mg	1.20	Si	0.80	Fe	0.70	Cu	0.40		
Aluminum 7075-T73	Al	88.60	Zn	6.10	Mg	2.90	Cu	2.00	Si	0.40		
Stainless Steel	Fe	66.50	Cr	20.00	Ni	10.50	Mn	2.00	Si	1.00		
Copper Electric	Cu	100.00										
Glass Borosilicate	Si	42.10	O	54.80	B	3.10						
FR4 Glass-Epoxy	Si	23.39	O	36.02	C	37.04	H	3.55				
Brass Generic	Cu	85.00	Zn	15.00								
Solar Panel	Ge	38.00	Si	24.00	O	20.00	C	13.00	H	4.00	B	1.00

Results of the simulation

Comparison of the results of the simulation with experiments

1 channel read out:





The experimental results:

Pos. of source	1	2	3	4	5	6	7	8	9
Pos. of main peak	0.642	0.664		70.7	0.743		0.598		

The parameters set in the simulation: reflectivity: 0.995 and absoprtion length of 40 cm:

Pos. of source	1	2	3	4	5	6	7	8	9
Pos. of main peak	0.3389	0.3256	0.3355	0.3521	0.3555	0.3522	0.2060	1	0.203

The parameters set in the simulation: reflectivity: 0.995 and absoprtion length of 50 cm

Pos. of source	1	2	3	4	5	6	7	8	9
Pos. of main peak	0.4013	0.3917	0.3981	0.4045	0.4172	0.4140	0.2580	1	0.2739

Reflectivity of 0.997 and abs. length of 60 cm

Pos. of source	1	2	3	4	5	6	7	8	9
Pos. of main peak	0.4588	0.4587	0.4697	0.4734	0.4700	0.4737	0.3388	1	0.3365

X-ray fluorescence

Histogram without fluorescence, turned out in LXeEMPhysics line 140-159

Histogram with flo

Simulation of background in space

Optimalization of the scintillator detectors

Conclusion

Acknowledgment

References

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Advances in Thick GEM-like gaseous electron multipliers—Part I: atmospheric pressure operation,
Nuclear Instruments and Methods in Physics Research A, vol. 558, page 475-489, 2006