Advanced Gamma-detector for CubeSats

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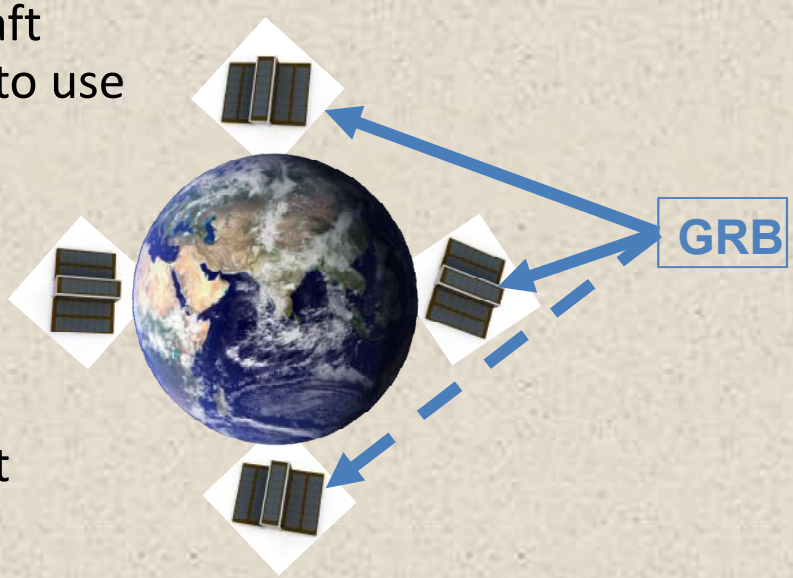
GRB detectors on board satellites of CubeSat class

A number of groups plan to launch the constellations of CubeSats with gamma-detectors for GRB study. They are also planned to be used for TGF and Solar flares

- The detector area sufficient for GRB registration is ~100 cm^2
- Installing gamma detectors on several spacecraft that are about 1000 km apart makes it possible to use triangulation
- Exact timing is needed.
- Orientation accuracy ~1^o is useful
- Fast telegrams are needed

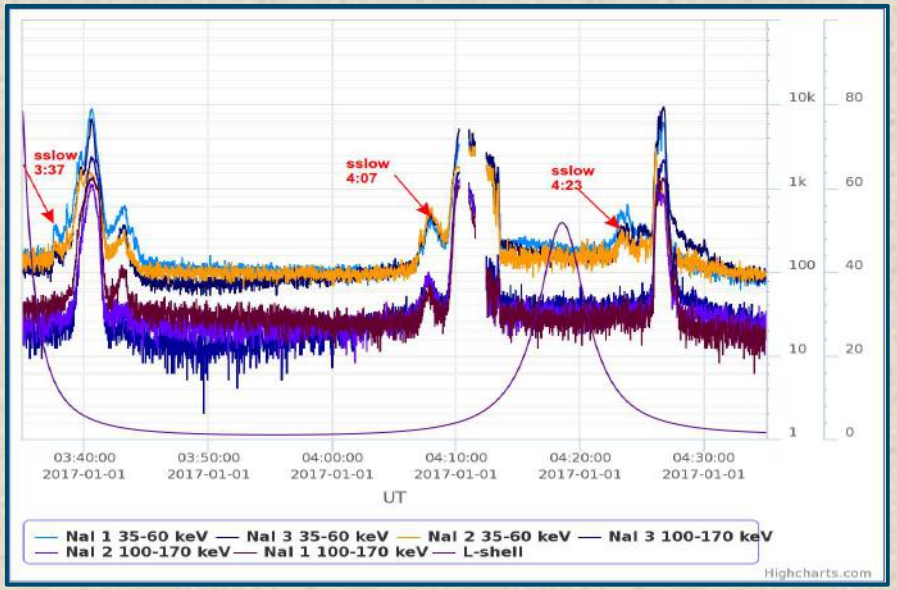


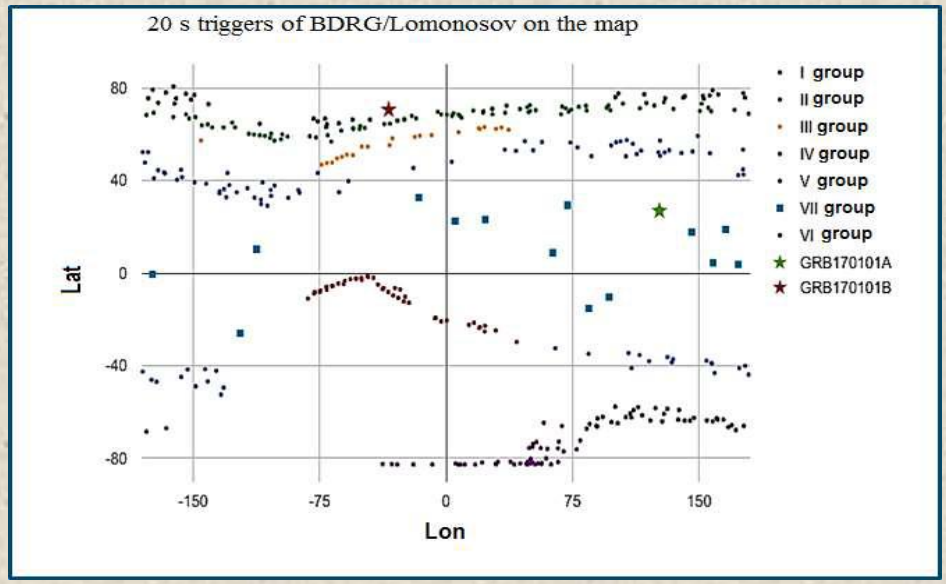
If the satellites are launched to the polar orbit the problem of false triggering by electron precipitation rises. It can be solved by monitoring of electron flux

Advantages of position sensitive detectors:

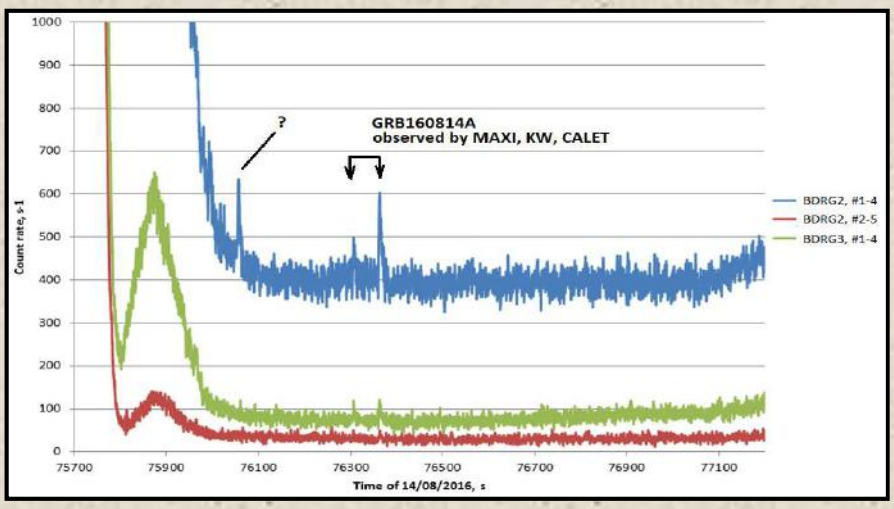
- Wide dynamic range (important especially for TGFs)
- Determine coordinates if combined with mask
- Polarization measurements

Problem of GRB triggering on low polar orbit: triggering on electron precipitation

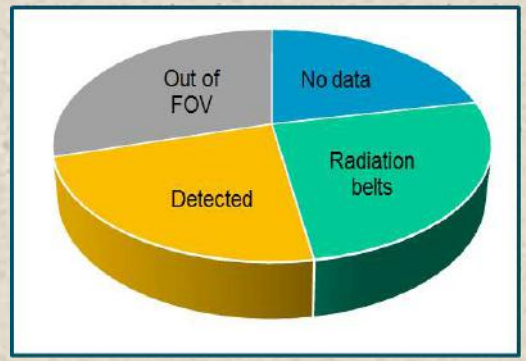




Geographic distribution of 20 s GRB triggers produced by BDRG/Lomonosov



Example of GRB observed by BDRG/Lomonosov near RB

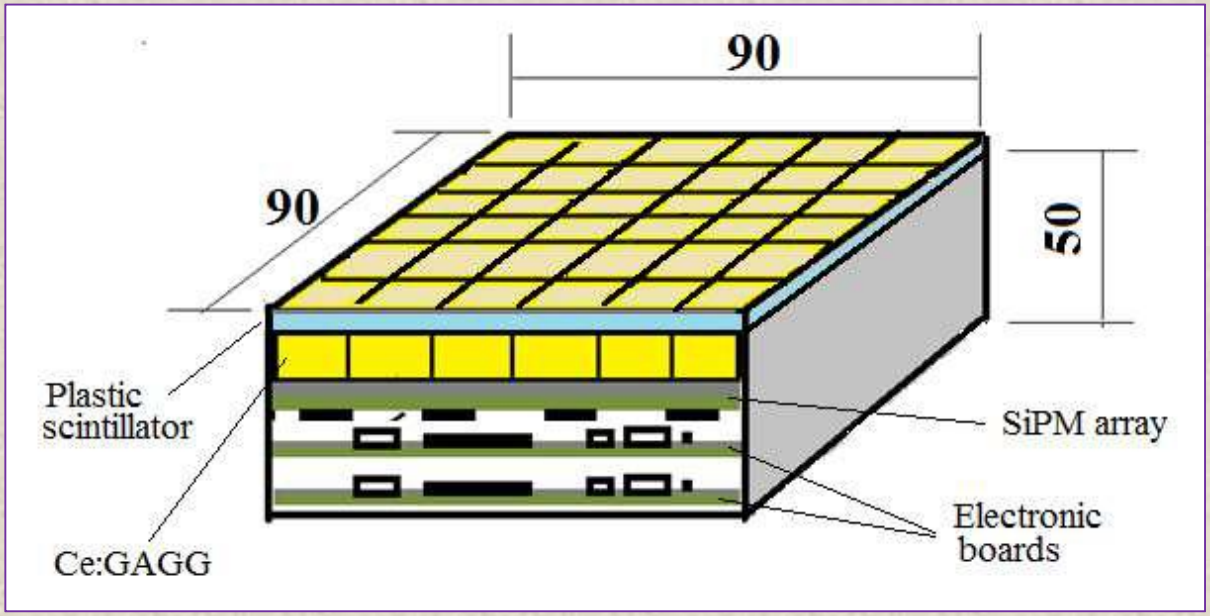


Statistics of GRBs observed by BDRG/Lomonosov

Configuration of proposed gamma-detector

The main detecting element is an assembly of small Ce:GAGG crystals with a thickness of 5 mm

The scintillators are viewed by the array of SiPM-type photodetectors.

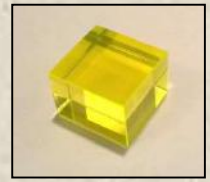


On the side of the input window, there is a layer of 4 mm thick plastic scintillator, which is in optical contact with Ce:GAGG elements and is viewed by the same photodetectors.

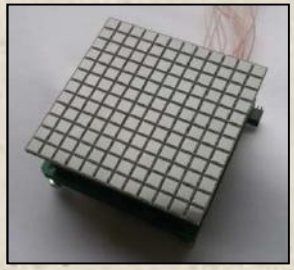
Electronic boards contain DC/DC converters, amplifiers, shapers, ADCs and MCU (from ST Microelectronics with Cortex L4 core)

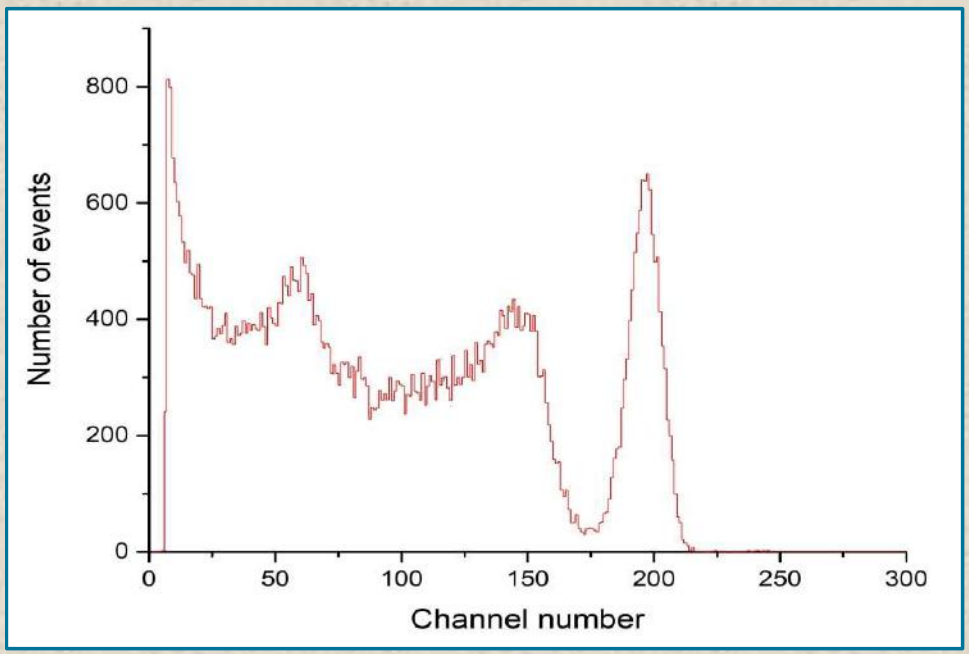
Results of laboratory tests of the detector prototype

Ce:GAGG crystals with different size from 3 mm to ~1 cm grown in the Research Institute for Nuclear Problems of the Belarusian State University were used.



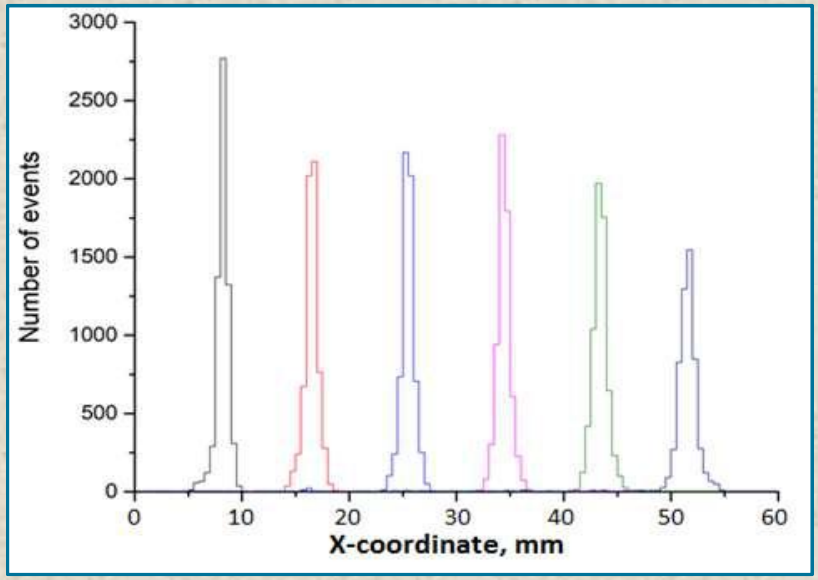
SiPM assembly produced by SensL company was used. It is a set of 144 elements of 3 mm x 3 mm each, grouped in a light-sensitive matrix of 12 x 12 pixels



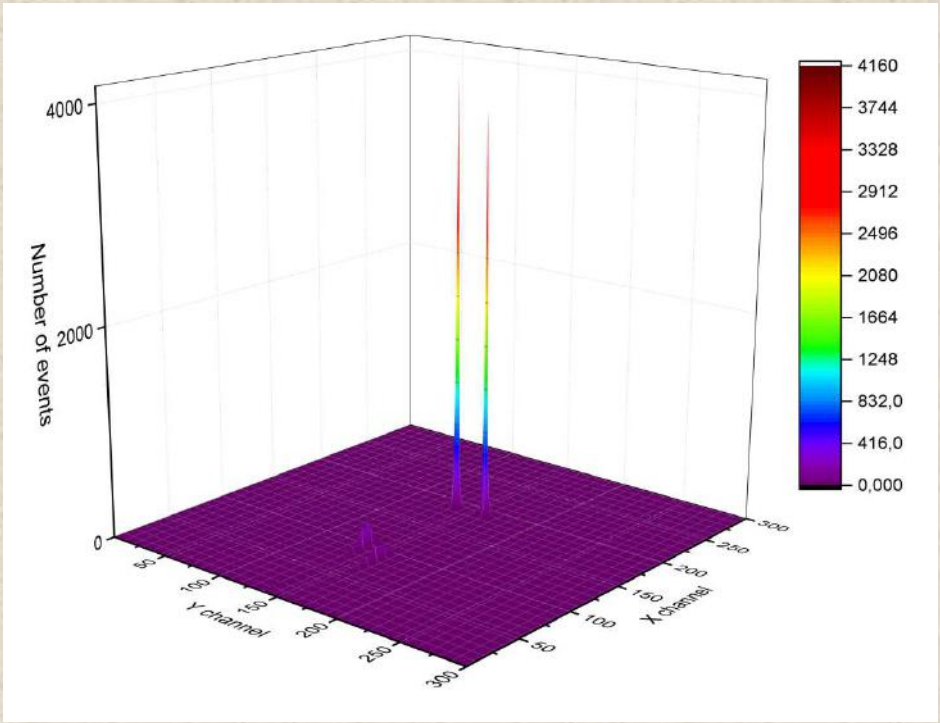


Energy spectrum of Cs-137 obtained with 3mm Ce:GAGG

Laboratory tests of the position resolution

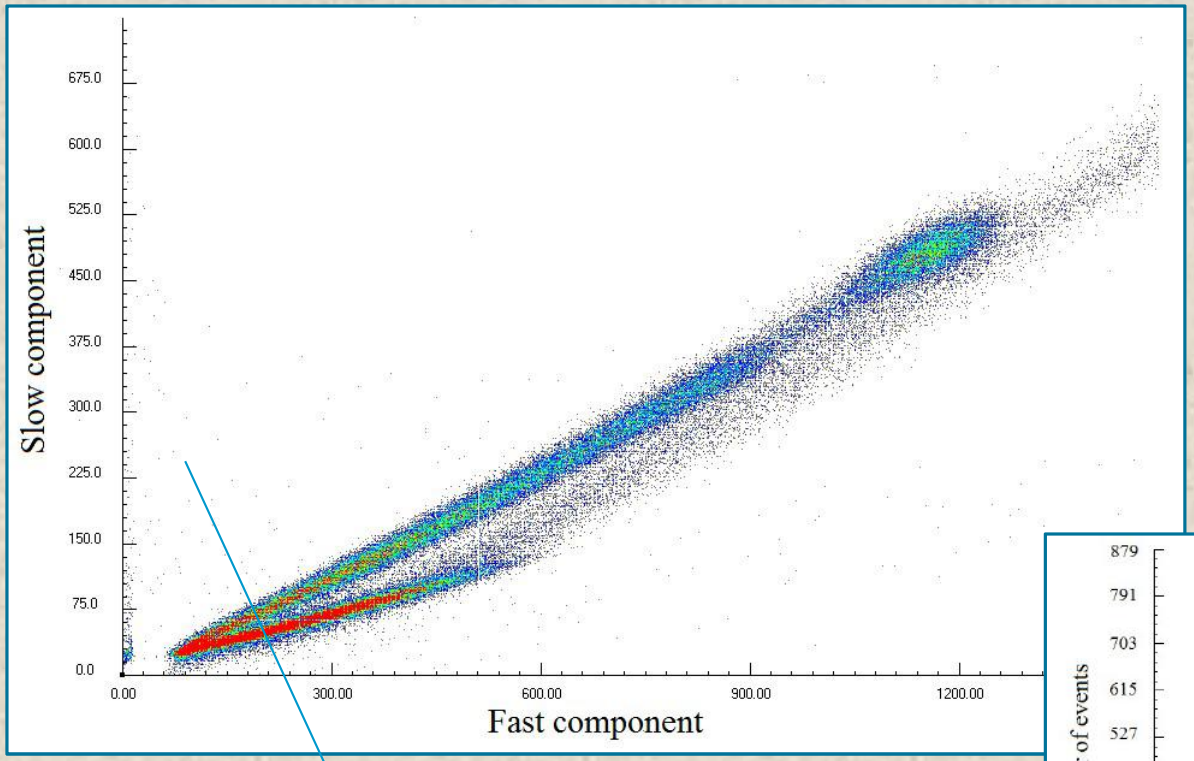


Test of position resolution with 8mm crystal

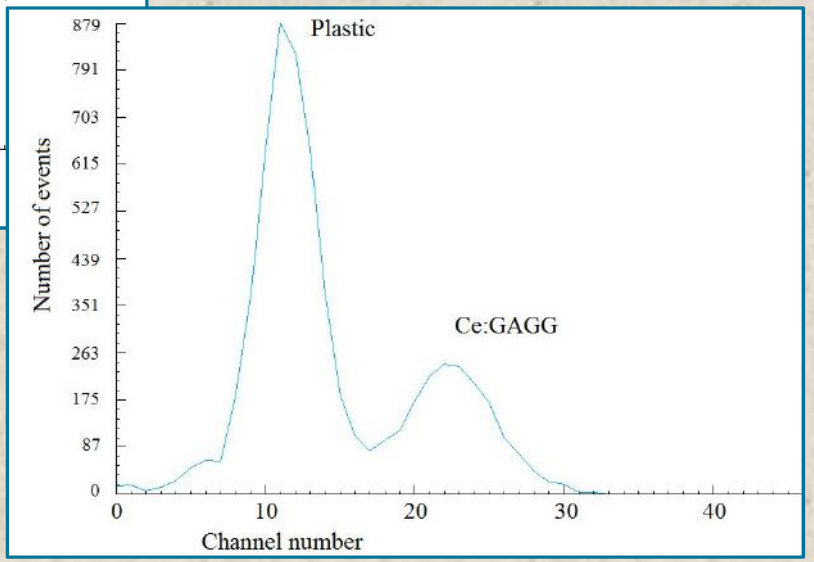


Response for 2 nearby 3mm crystal

Laboratory tests of the separation of the events in Ce:GAGG and plastic scintillators



2D-diagram fast component vs slow component taken for Ce:GAGG + plastic phosvich detector irradiated by gamma quanta from Cs-137 and electrons from Sr-90

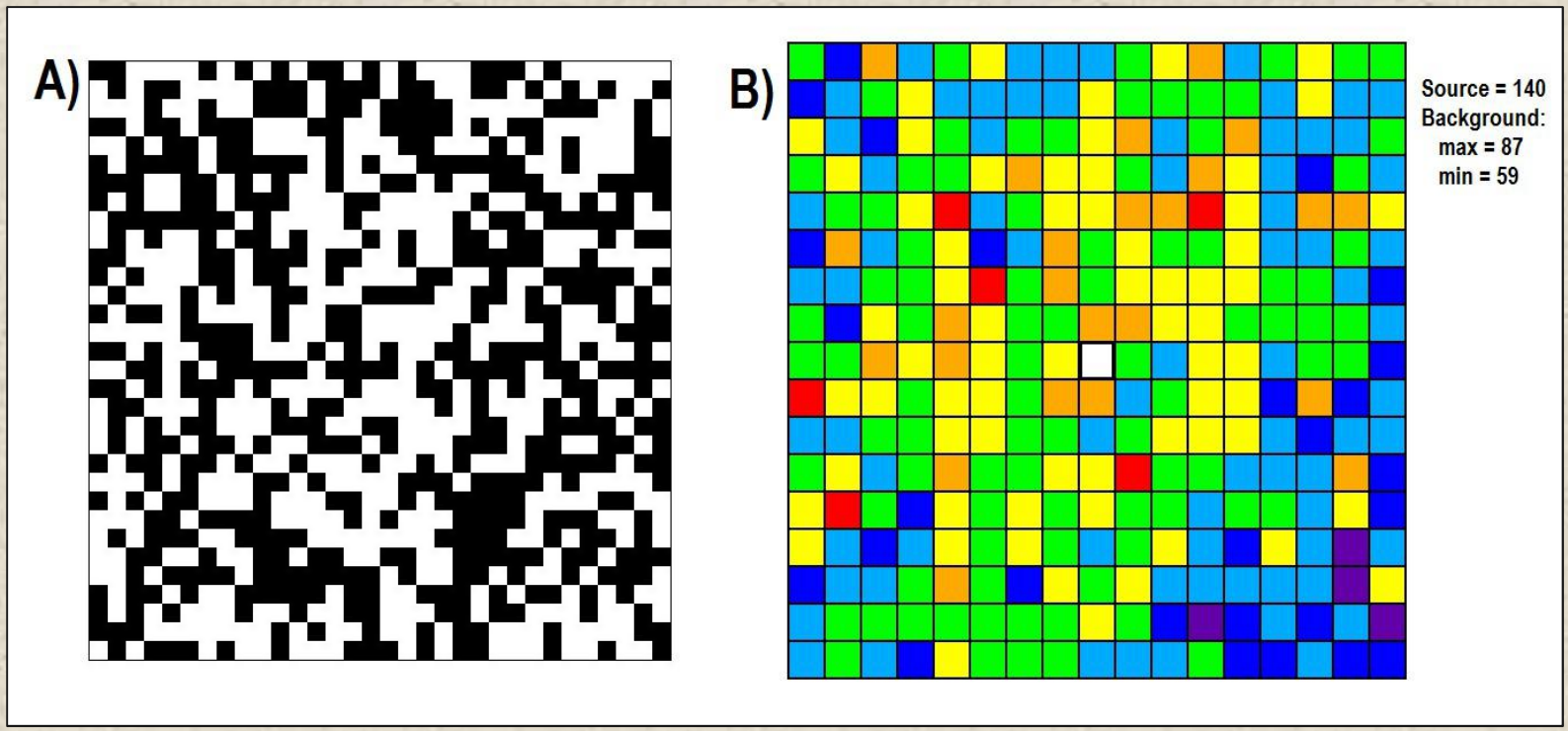


Cross section of 2D-diagram at 50 keV level

Coding mask telescope proposal for CubeSats

The coding mask telescope with low number of pixels allow to detect the point source of GRB and provide its coordinate measurements with ~2^{o} accuracy

The characteristics of the instrument for CubeSats: PSD size 70x70 mm, pixel size 3x3 mm, distance between PSD and mask 80 mm, FOV +/- 45^{o}



Coding mask pattern (A) and reconstructed image of a point source (B) for 16x16 pixel coding mask gamma telescope

CONCLUSION

The proposed gamma-ray detector makes it possible to conduct GRB studies when installing such detectors on one or more ultra-small satellites of the CubeSat class.

Characteristics:

- weight ~500 grams,
- dimension ~0.5 U,
- power consumption ~ 1 W.
- energy range from 20 Kev to 1 MeV or higher.
- Sensitive area ~ 80 cm^2
- Time resolution ~10 mcs in event-by-event mode

The experiment can be provided on any orbit including polar one because of the separate detection of gammas and electrons

The combination with coding mask allows to determine point source coordinates with ~2^o accuracy

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Thank You!