Status of fake trigger events simulation and analysis

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Outline

- Motivation
- SW and configuration
- Accumulated information
- Analysis, pattern recognition

Motivation

The goal of the trigger system is to detect the occurrence of scientifically valuable signal among very huge background noise detected by JEM-EUSO. The UV background registered is randomly distributed. We study if these random processes produce fake pattern, which could be mistakenly interpreted as EECRs events. We are simulating huge amount of measurements on PDM with only detector noise. To distinguish between such simulated fake events and real ECCRSs events and find the probabillity of registration fake event we are applying and developing pattern recognition methods

- detect the signal from real event among extremely high background (~10^{11} counts/s/FS)
- signal filtered on several levels reducing the trigger rate
- organized in 2 main levels, basing on positions and time correlations of physical events compared to background

Outline of noise reduction capability.

Level		**Rate of signals/triggers at PDM level**	**Rate of signals/triggers at FS level**
PDM level trigger	Photon trigger	$\sim 9.2 \times 10^{8}$ Hz	$\sim 1.4 \times 10^{11}$ Hz
	Counting trigger	$\sim 7.1 \times 10^{5}$ Hz	$\sim 1.1 \times 10^{8}$ Hz
	Persistency track trigger (PTT)	~7 Hz	$\sim 10^{3}$ Hz
PDM cluster level trigger (FS=144 PDM's)	Linear track trigger (LTT)	$\sim 6.7 \times 10^{-4}$ Hz	~0.1 Hz
Expected rate of cosmic ray events		$\sim 6.7 \times 10^{-6}$ Hz	$\sim 10^{-3}$ Hz

Motivation

- Very high statistics of simulated background needed
  → 10^5 events →10^{14} GTU's
- Impossible to simulate by ESAF:
  → 10^3 slower then used code
  → cannot be computed parallely (mem. share)
- Fast standalone code written in C++ was developed

The code

- Trigger algorithm implemented (as in ESAF)
- One PDM simulated
- Persistency Track Trigger algorithm → 1st level → 1Hz/PDM
- Linear Track Trigger algorithm → 2nd level → 1 mHZ/PDM
- Background source → Poisson distribution of average 500 photons (m^{-2} s^{-1} sr^{-1}) = 2.1 photons/pixel/GTU
- Code fast but since to produce huge statistics has to be run in parallel (on Kosice cluster)
- Minimal needed statistics obtained by a year of continuos computing on full PC cluster, optimally several years (not possible to run continuosly)
- Improved random number generation
- Fixed the bugs
- Interactive/batch mode

JEM-EUSO Kosice cluster

- Actually used (available for also for collaboration)
  7*32 + 24 cores @ 2.3 Ghz; 25 TB
- upgrade and RAID configuration done
- OS FC16
- ROOT v34.00, ESAF trunk, GEANT4 9.4

M36 Configuration

M36

BG = 2.1 ph/pix/GTU

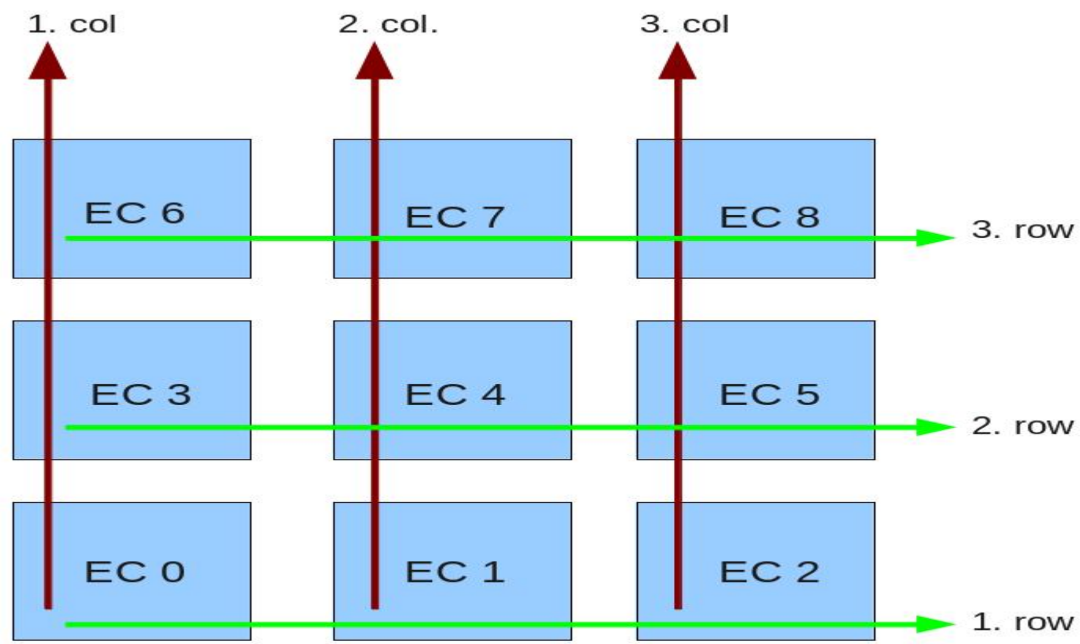
PTT_integr = 43

LTT integration = 145

Consecutive GTU = 5

Yellow pixel th = 4

- **Accummulated:**
- 10^{12} GTU's → 3months CPU time on part of PC cluster
- 12000 LTT triggers → 1mHz/PDM
- 750000 PTT triggers → 0.1 Hz/PDM

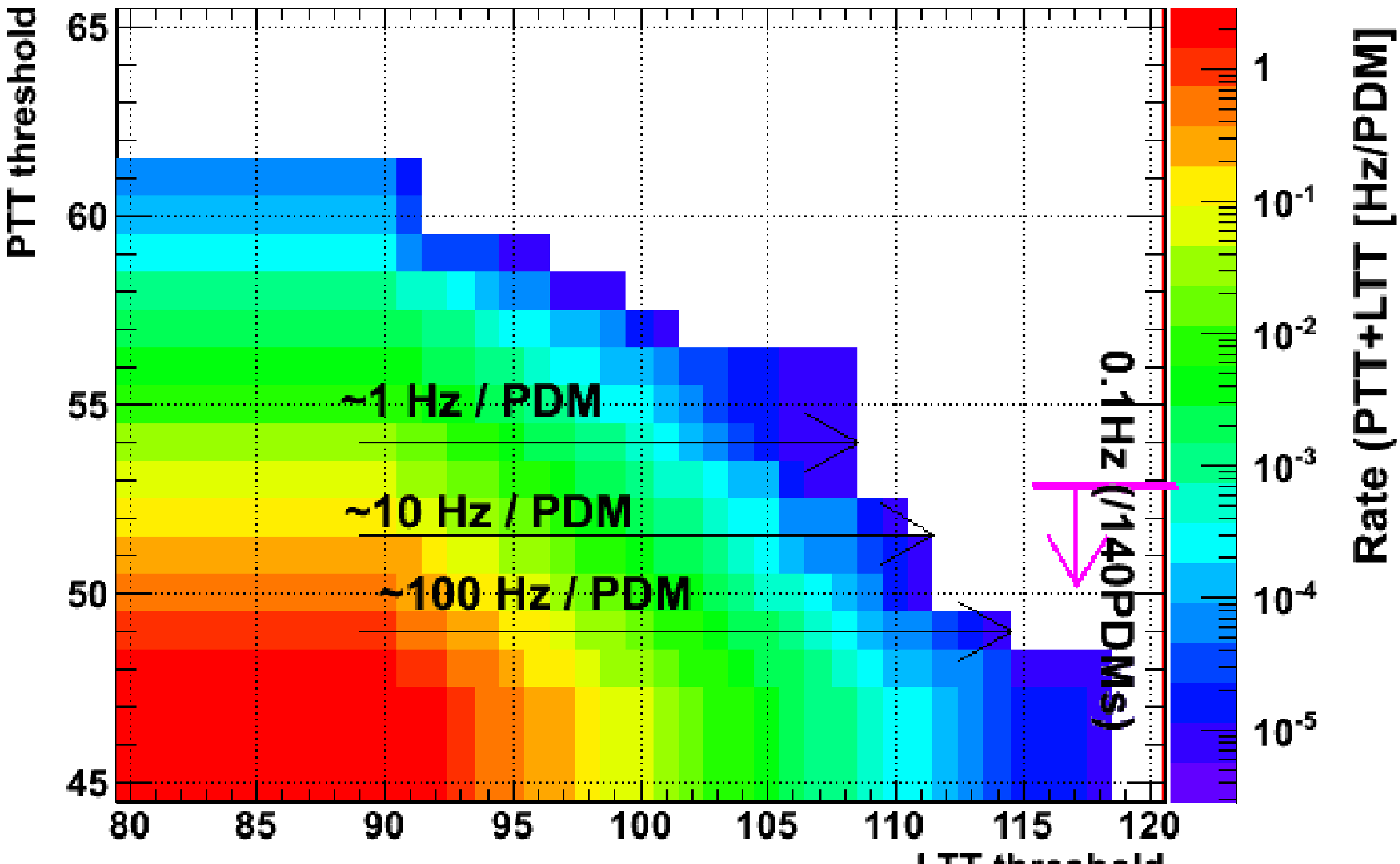


1 PDM = 9 EC = 1296 pixel

1 EC = 4 x PMT = 144 pixel

1 PMT = M 36 = 36 pixel (6 x 6)

M64 rates


PTT threshold
65
60
55
50
45
80
85
90
95
100
105
110
115
120
~1 Hz / PDM
~10 Hz / PDM
~100 Hz / PDM
0.1Hz (/140PDMs)
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Rate (PTT+LTT [Hz/PDM]

M64 Configuration

- Modification of BG →scaled according $(36/64)^2$
- PTT and LTT integration thresholds modification following obtained background rates for M64

M64

BG = 0.4 cts/ms

PTT_integr = 52

LTT integration = 115

Consecutive GTU = 5

Yellow pixel th = 2

- **Accummulated:**
- still running
- at present 5×10^{11} GTU's → 2 months CPU time on part of PC cluster
- 5000 LTT triggers → 1 mHz/PDM
- 300000 PTT triggers → 0.1 Hz/PDM

Information saved

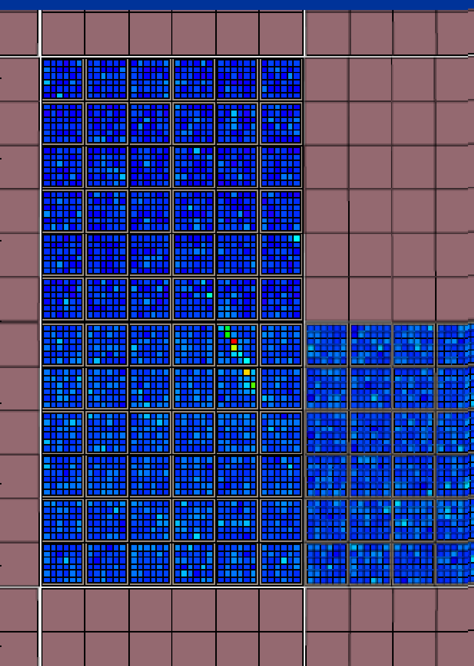
- Stored are events filtered on PTT and LTT levels
- 2 files written when thresholds reached:
  PTT_SECOND_OUT → (x,y,pers, ecid,counts)
  12x12x5 = 720 lines/PDM for M36 configuration
  16x16x5 =1280 lines/PDM for M64 configuration
- LTT_SECOND_OUT → (x,y,time,counts)
  36x36x31 = 40196 lines/PDM for M36 configuration
  48x48x31 = 71424 lines/PDM for M64 configuration
- stored information for which PPT, LTT dumped
- Average size of the LTT output : 250 MB/ 1.e9 GTU's,
  so we reprocessed it to store like root ntuples: 10 MB/1.e9 GTU's9,
  it is also suitable for the following analysis in ROOT framework

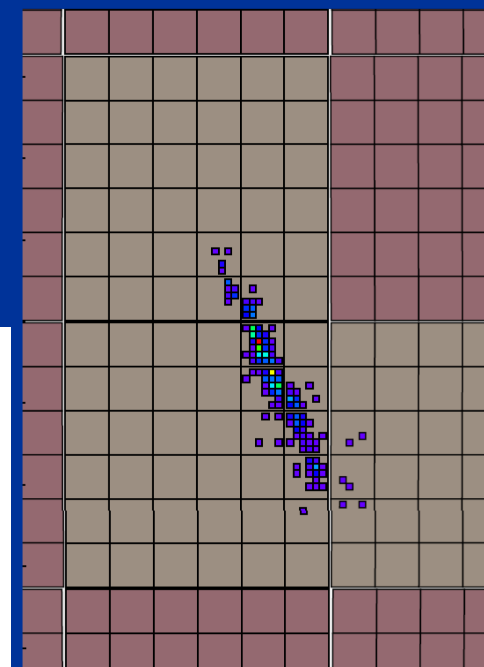
Analysis

- On the obtained result we parallely study by **pattern recognition** methods fake patterns
- A) Looking for fake patterns in purely randomly produced noise in 8x8 matrices
- B) Adaption of **RobustModule.cc** code which was prepared and is used in ESAF

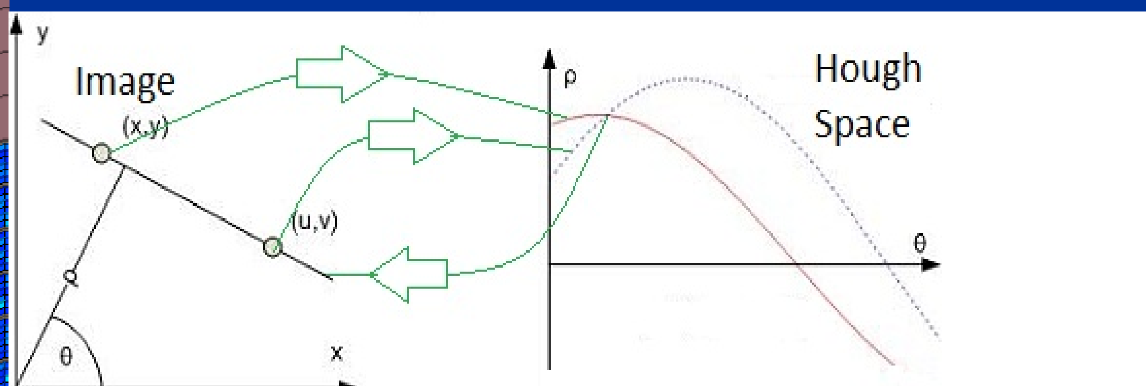
Pattern Recognition

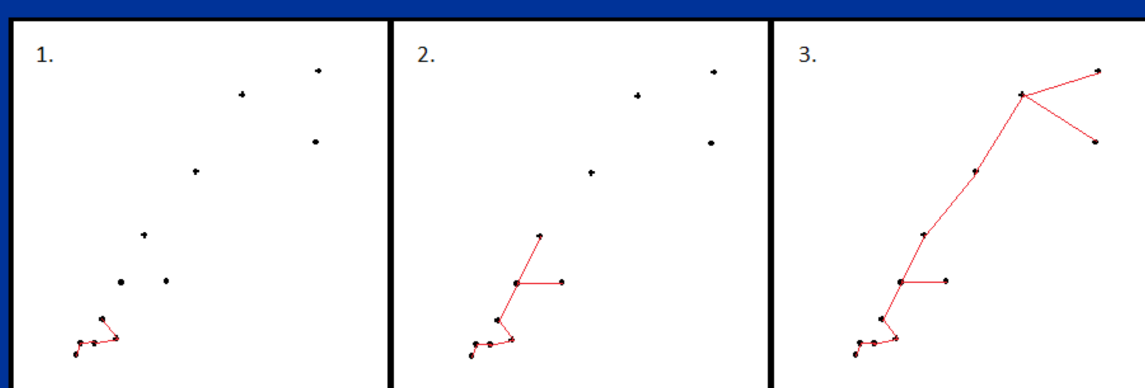
Hough transformation or clustering to disentangle signal from background…

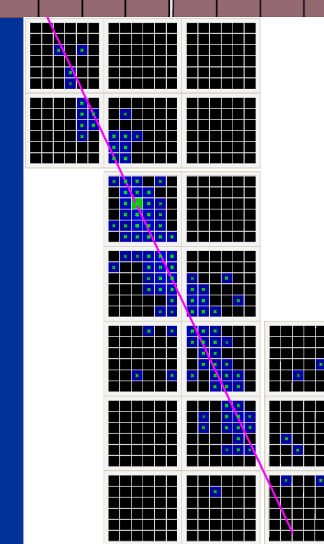




Finding points on line → parallel curves in Hough space







Static pattern

Generated N matrix 8 x 8 pixels (like PMT) with values on pixels 0-7 uniformly distributed random values

Pattern characteristics

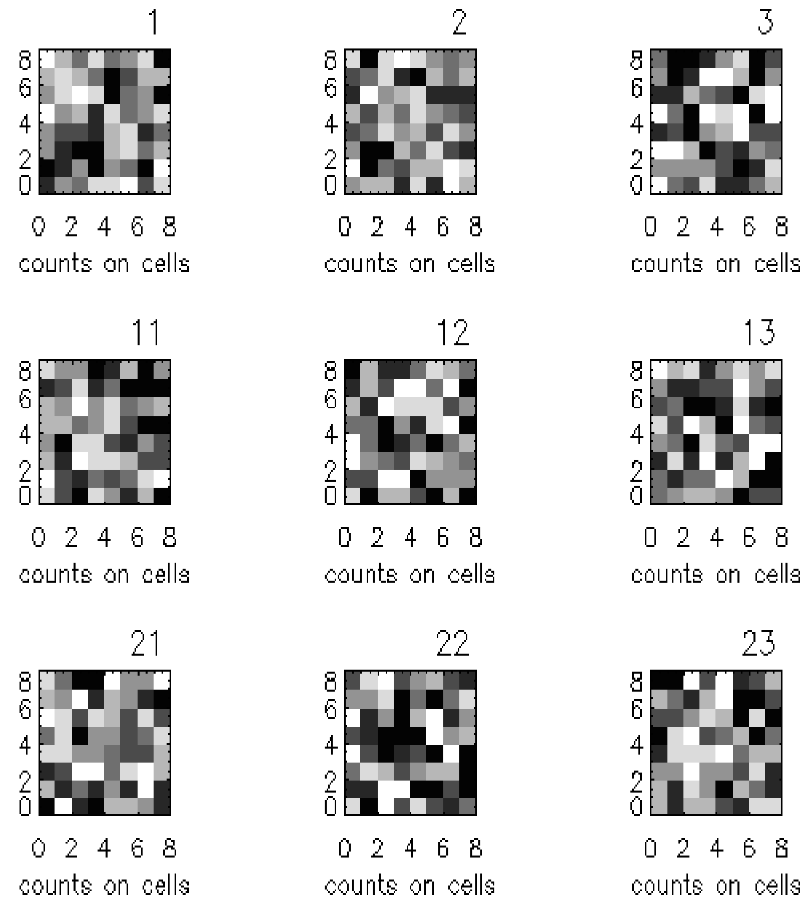
pattern length = number of pixels over threshold (here 3)

average pattern value = (sum of pixel values) / (pattern length)

Looking for at least 7 point lines with average pixel value > 6.9

Method firstly tested by putting by hand small amount of patterns to huge amount of generated background. The method reliably detected artificial patterns

EXAMPLE OF GENERATED MATRIXs



Static pattern

The number of detected patterns dependence on avg. pattern value for several pattern lengths (4 - 8)

E.g.:

If generated 1.E7 8x8 matrices, around **20** matrices with fake pattern with the length of 8 pixels with avg. pixel value (all pixels at maximum) found.

Verification:

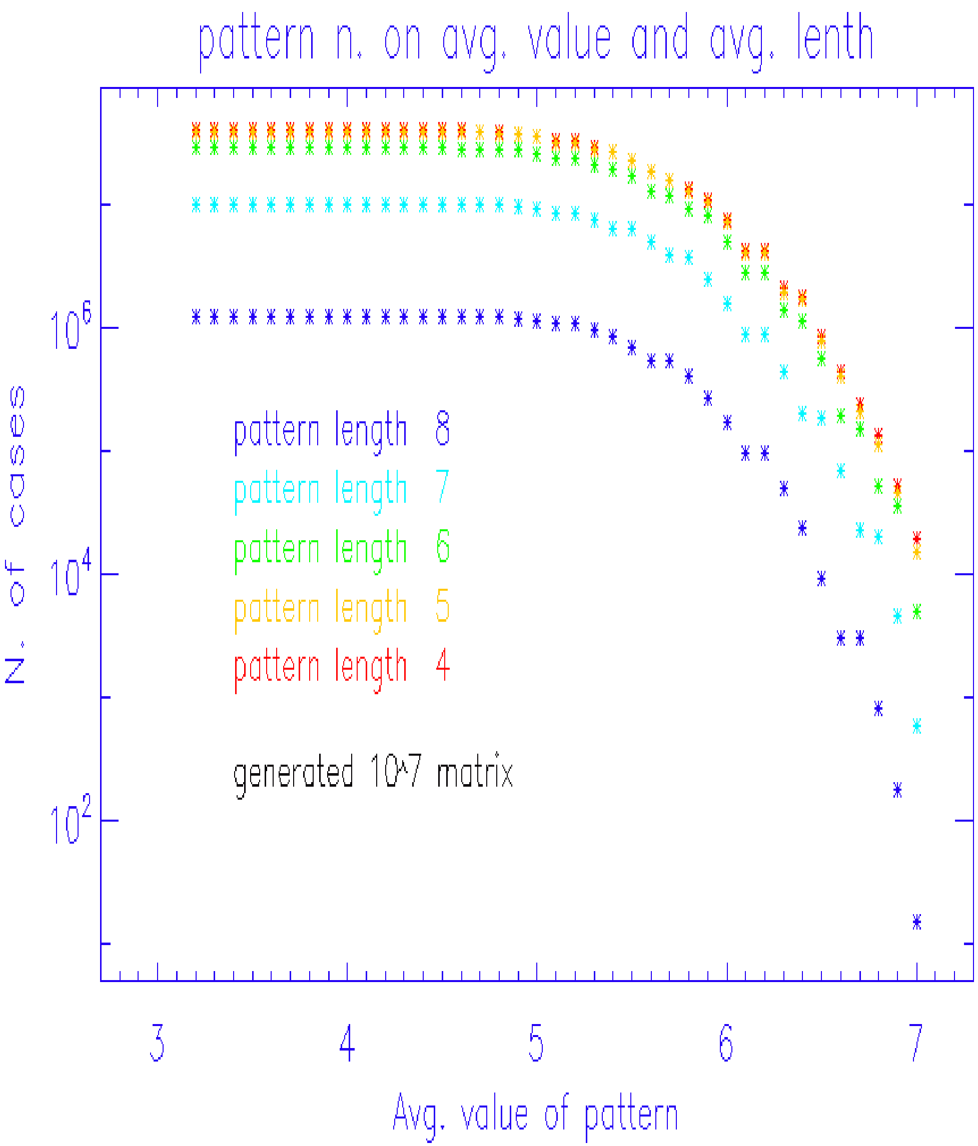
The probabillity that matrix pixel has some value is **1/8**

Any 8 pixel configuration – lineal pattern 8 pixel long appears with probability

$$\mathbf{(1/8)^8 = 5.96.10^{-8}}$$

Such lineal patterns are 32 , then the result is: **5.96.10-8 x 32 x 107 = 19.07**

Compatible with simulation result



Moving pattern

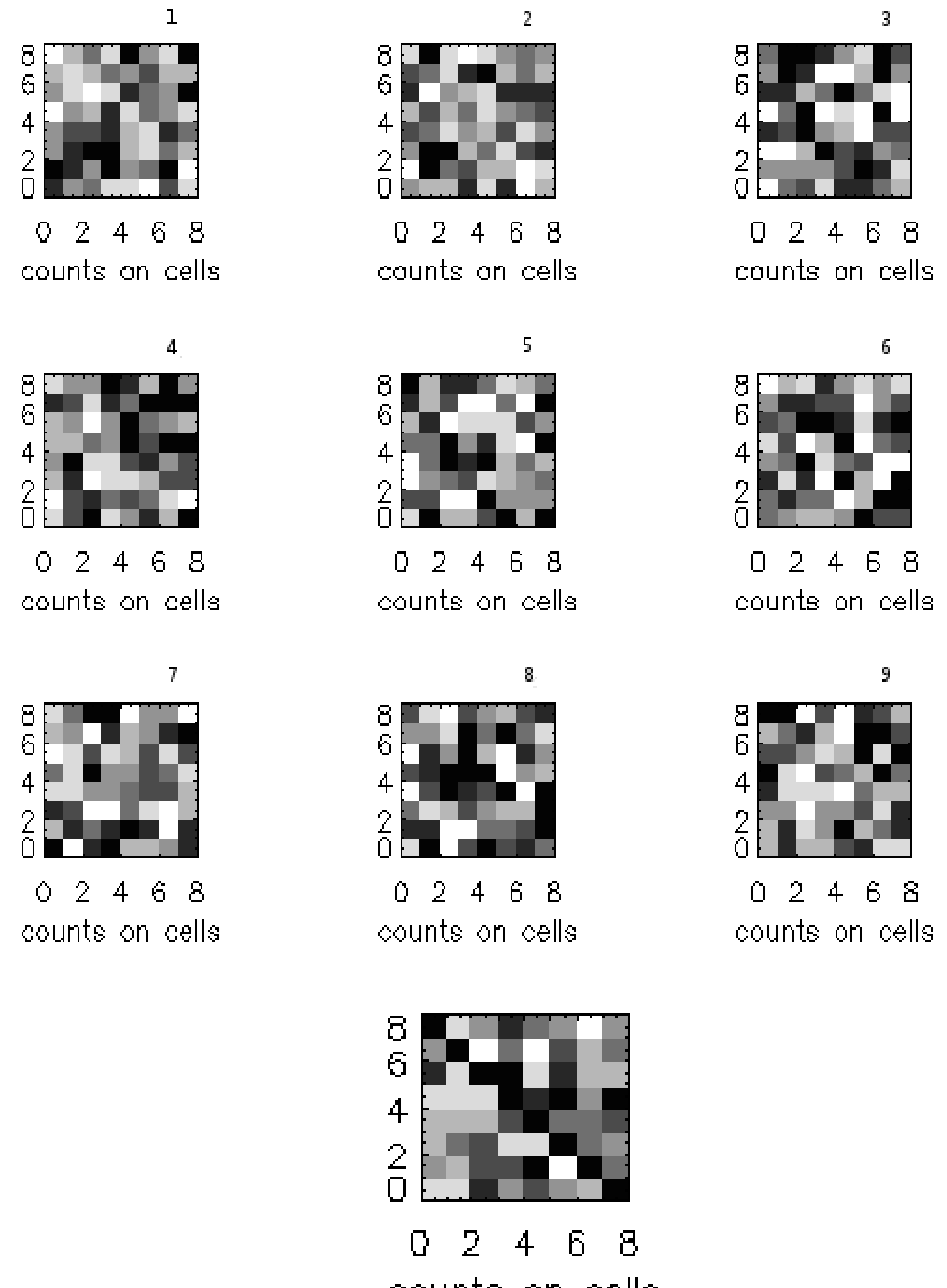
Particle moving with speed of light will is moving by 1 pixel/GTU.

To find moving pattern we have composite summary matrix from matrices for different times.

On such matrix applied Hugh transform

Works well

Next step – application to our obtained result from simulation with Poisson ditributed bckg filtered by 2 levels of trigger



Summary

- Checked trigger rates obtained from the code compatible with expectation
- Optimization for M64 configuration massive simulation running
- Pattern recognition of the obtained data continuing

•Poster on XXXII Physics in Collision 2012

- XXXII Physics in Collision 2012
- The international symposium on Physics in Collision (PIC) is a conference whose focus is to update key topics in elementary particle physics in which new results have been published in the last year or are reasonably expected to be so before the next symposium. The topics at the symposium cover a wide range of physics subjects from experimental and theoretical accelerator-based particle physics to astroparticle physics.

JEM-EUSO experiment for extreme energy cosmic rays observation

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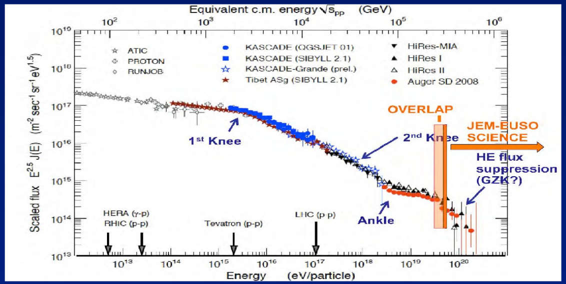
INSTITUTE OF EXPERIMENTAL PHYSICS, SAS, Košice

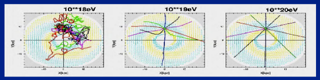
EXTREME UNIVERSE RESEARCH

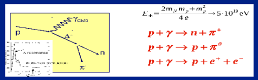
The astrophysical origin of the extreme energy cosmic rays (EECRs) and the physical mechanism of their acceleration to very high energies are of great interest. The highest observed cosmics rays energy is about $3x10^{20}$ eV - exceeds 10^8 times CERN LHC energy scale – is above so called GZK cuttof, which is due to interactions of cosmic rays with the cosmic microwave background. The registration of EECRs at the earth implies that the sources are up to several tens Mpc far. Possible EECRs sources are supernovas, pulsars, gamma ray bursts, active galactic nuclei and recent collisions of radiogalaxies. But most of these candidates are incapable of accelerating particles beyond 10^{20} eV by any known acceleration mechanism.

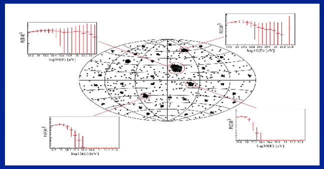
Low energy charged particles are bent by magnetic field in intergalactic and galactic space. The directional information of their origin is lost. The highest energy particles are barely bent, so retain the information of the direction to the origin.

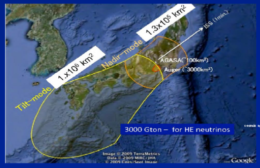
Very large area for observation is necessary to observe the rare EECRs events. Ground based observatories have nearly reached the maximum extent possible on earth. Space observatory makes a giant leap in the area size observed. JEM-EUSO mission explores the origin EECRs and explores the limits of the fundamental physics, through the observations of their arrival directions and energies.









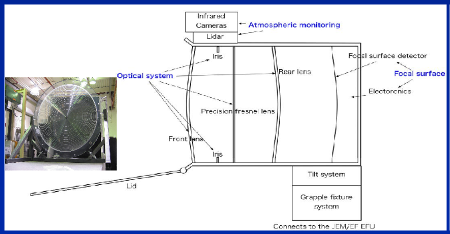


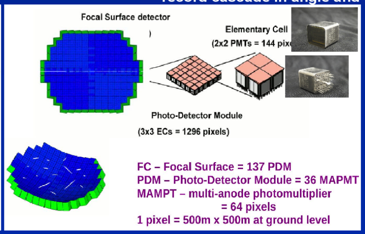
JEM-EUSO EXPERIMENT

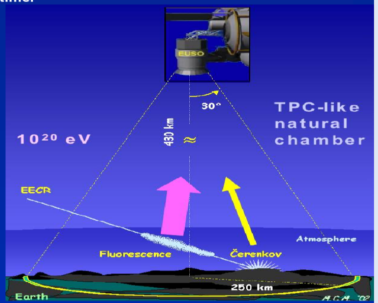
is common project of cosmic agencies JAXA, NASA, ESA, Roskosmos and 13 collaborating countries (77 institutions, over 250 researchers). The leading country is Japan, which provides the basic infrastructure including a vehicle HII-B, a spaceship HTV and the position for detector emplacement onboard the ISS Japanese Experimental Module Kibo. Minimum 3 years of operation starting from January 2017.

JEM-EUSO would measure the energy spectra of cosmic rays up to 10^{21} eV and would search for direction to their sources. It would observe extensive air showers (EAS) generated in the atmosphere by high energy cosmic ray primary particle. By observing from space the fluorescence and Cherenkov light emitted by EAS, the species, energy and direction of the primary could be well determined. Due to altitude of 400 km the instantaneous aperture of the telescope will exceed significantly the aperture of the largest ground EECRs detector Auger.

Technically JEM-EUSO is a large telescope with a diameter 2.5 m with fast UV camera. Camera takes 400000 frames/s. It defines the basic time unit of detector operation (GTU). Telescope on Focal Surface consists of more than 300000 pixels. It implies 500mx500m resolution at the ground. These allow to record cascade in angle and time.







OUR CONTRIBUTION

In Slovakia the Institute of Experimental Physics is participating in JEM-EUSO experiment preparation. We are responsible for several tasks. The main are:

1) **The estimation of the UV background on the night side of the Earth**

Sources of the backgound are reflections from sky (Moon, stars, planets), man made lights, lightnings, airglow, aurora, meteorites.

2) **The determination of the JEM-EUSO operational effiiciency**

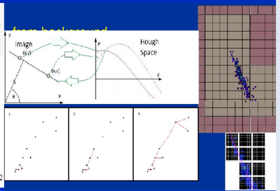
fraction of time when monitoring UV compared to full time on orbit. Above mentioned UV background sources together with ISS operation schedule had to be taken into account in the model of JEM-EUSO operational efficiency

3) **The fake trigger event simulations and analysis**

The goal of the trigger system is to detect the occurrence of scientifically valuable signal among very huge background noise detected by JEM-EUSO. The UV background registered by JEM-EUSO is randomly distributed. We study if these random processes produce fake pattern, which could be mistakenly interpreted as EECRs events. We are simulating huge amount of measurements on PDM with only detector noise. To distinguish between such simulated fake events and real ECCRSs events and find the probability of registration fake event we are applying and developing pattern recognition methods.

$I_{Allowed}$ [ph/(m^2 ns sr)]	I_{SUN} > 109.18°	I_{MOON} only [%	Cities only [%	I_{SUN} + I_{MOON} [%]	I_{SUN} + I_{BG} + I_{MOON} [%	I_{SUN} + I_{BG} + I_{MOON} + Cities [%]
1		50.00	90.14	17.83	0.00	0.00
10		50.11	90.14	17.85	0.00	0.00
100		51.14	90.18	18.14	0.00	0.00
300		53.45	90.18	18.72	0.00	0.00
500		55.92	90.26	19.25	0.00	0.00
1000	34.84	62.06	90.26	20.41	19.25	17.46
1500		**68.08**	**91.06**	**21.43**	**20.41**	**18.51**
5000		89.73	95.97	26.73	26.07	23.61
10000		97.85	98.81	32.69	32.20	29.15
15000		99.99	100.00	34.83	34.80	31.55
30000		100.00	100.00	34.84	34.84	31.58

Level		Rate of signals/triggers at PDM level	Rate of signals/triggers at FS level
1st level trigger (PDM)	Photon trigger	~9.2×10^8 Hz	~1.4×10^{11} Hz
	Counting trigger	~7.1×10^5 Hz	~1.1×10^8 Hz
	Persistency trigger	~7 Hz	~10^3 Hz
2nd level trigger (PDM cluster)		~6.7×10^{-4} Hz	~0.1 Hz
Expected rate of cosmic ray events		~6.7×10^{-6} Hz	~10^{-3} Hz



EVO Transitions to SeeVogh Research Network

- Starting in January 2013 the current EVO service will transition to a commercial service (managed by Evogh, Inc.) named the SeeVogh Research Network. Access to the new service will be provided only to authorized organizations/experiments within the research community, with subscription fees based on the usage and community.

- Note that for those organizations/experiments subscribed to the SeeVogh Research Network, full access to EVO will remain open, and the EVO service will be fully operational as needed to facilitate the transition.

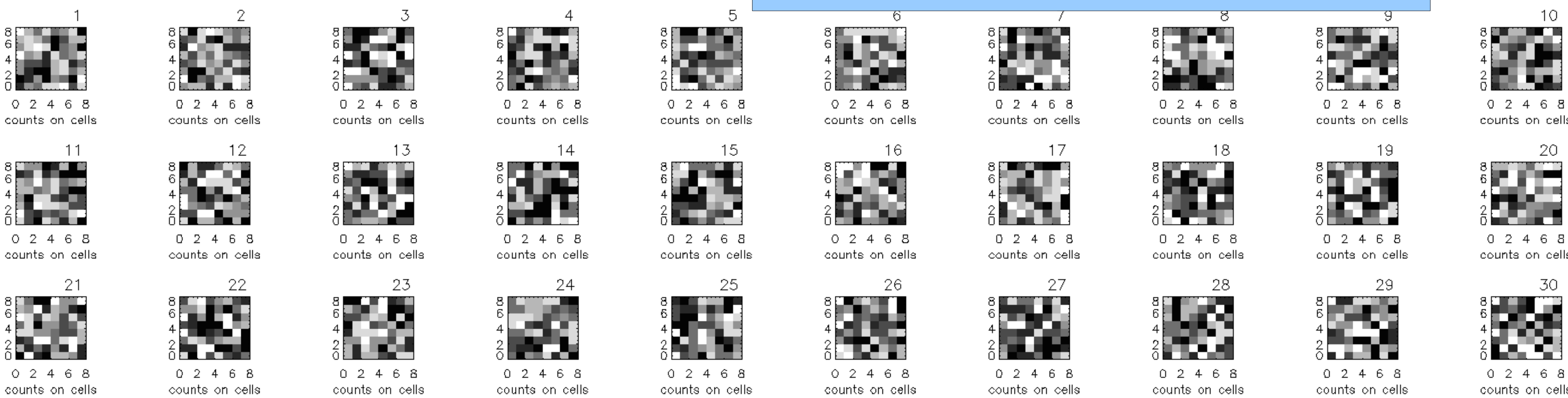
- The SeeVogh Research Network service is now open to current EVO users at no cost, for the remainder of 2012. See **http://research.seevogh.com**

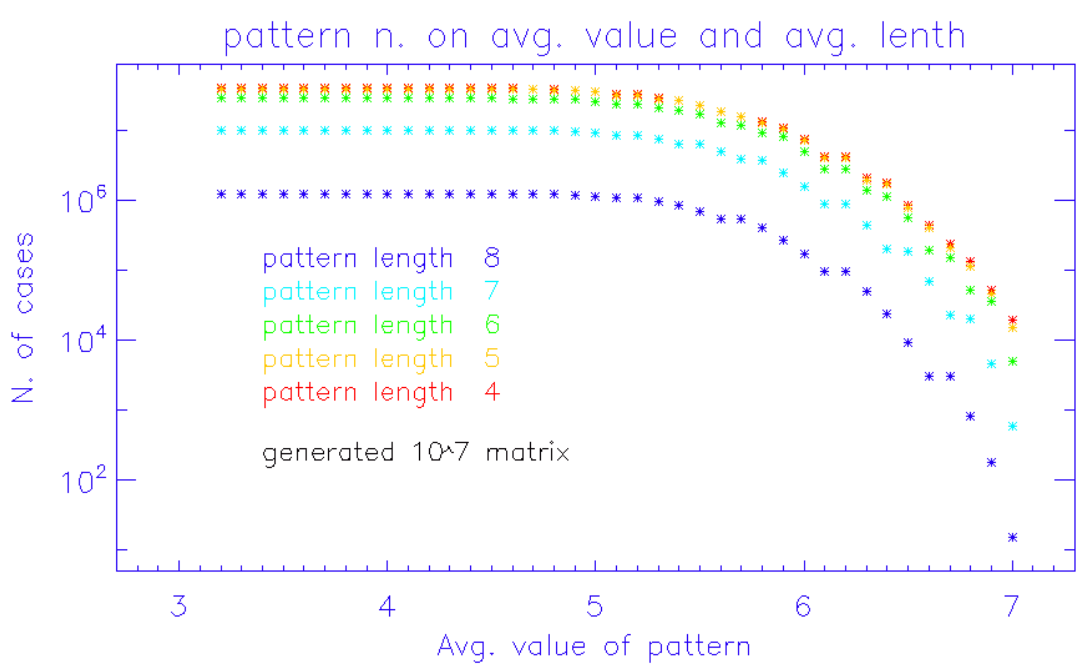
  The EVO and SeeVogh Research Network services are fully compatible: they share the same database for user authentication and meeting access, and interwork seamlessly. One can already join EVO meetings using SeeVogh. A parallel offering called the SeeVogh Hybrid Cloud is also now available to anyone.

  SeeVogh's new features include:
  - Updated and simplified user interface
  - Single window interface in a meeting
  - Compatibility with iOS (iPad, iPhone) and Android (tablets and smartphones)

Pattern recognition - Hough transform

EXAMPLE OF GENERATED MATRIXs





- M. Staroň diploma work - started work

- generated N matrix 8 x 8 pixels (like PMT) with values on pixels 0-7 (uniformly distributed random values)

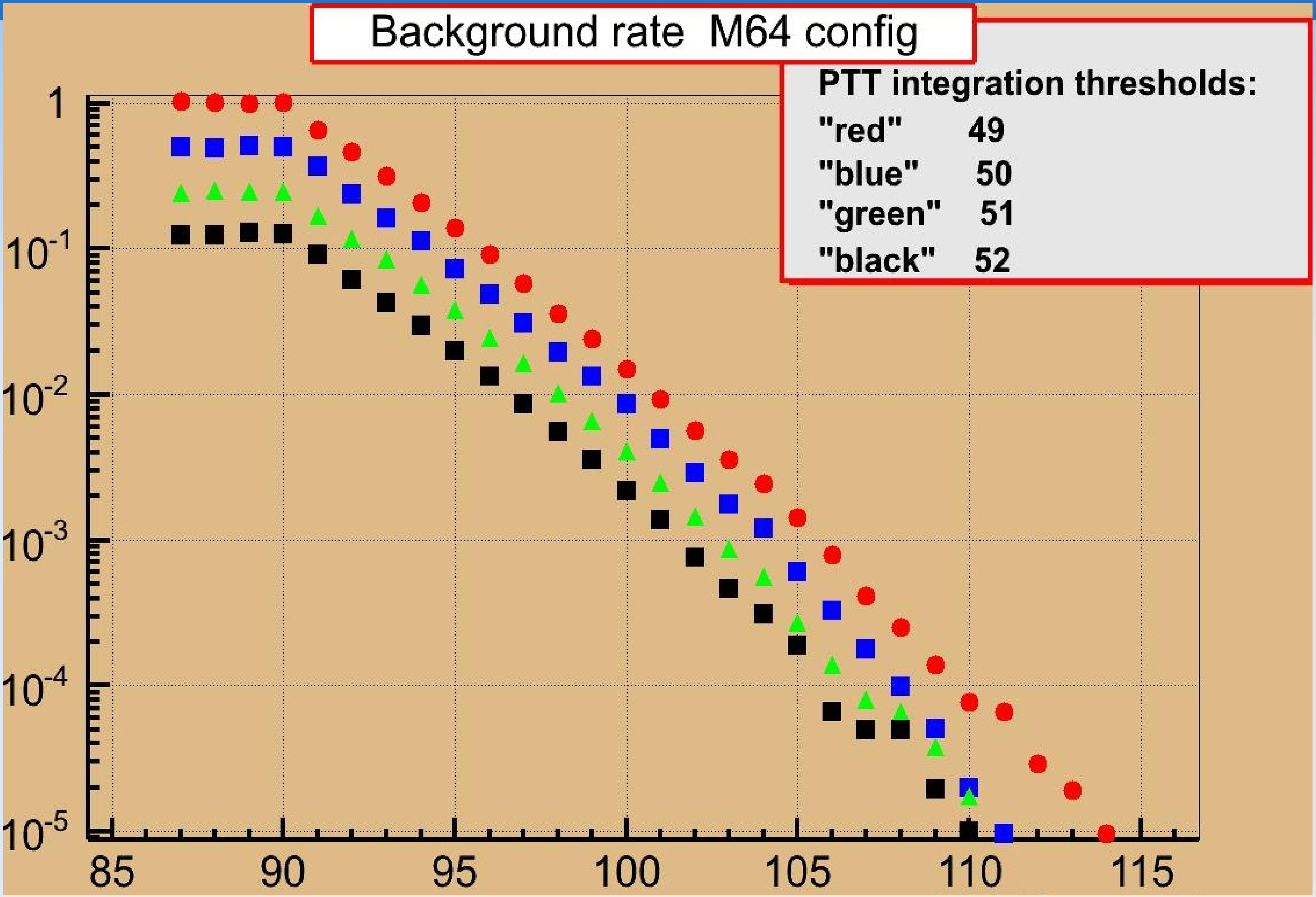
- **Hough transform** applied
  - static pattern - work well
  - moving pattern - work well

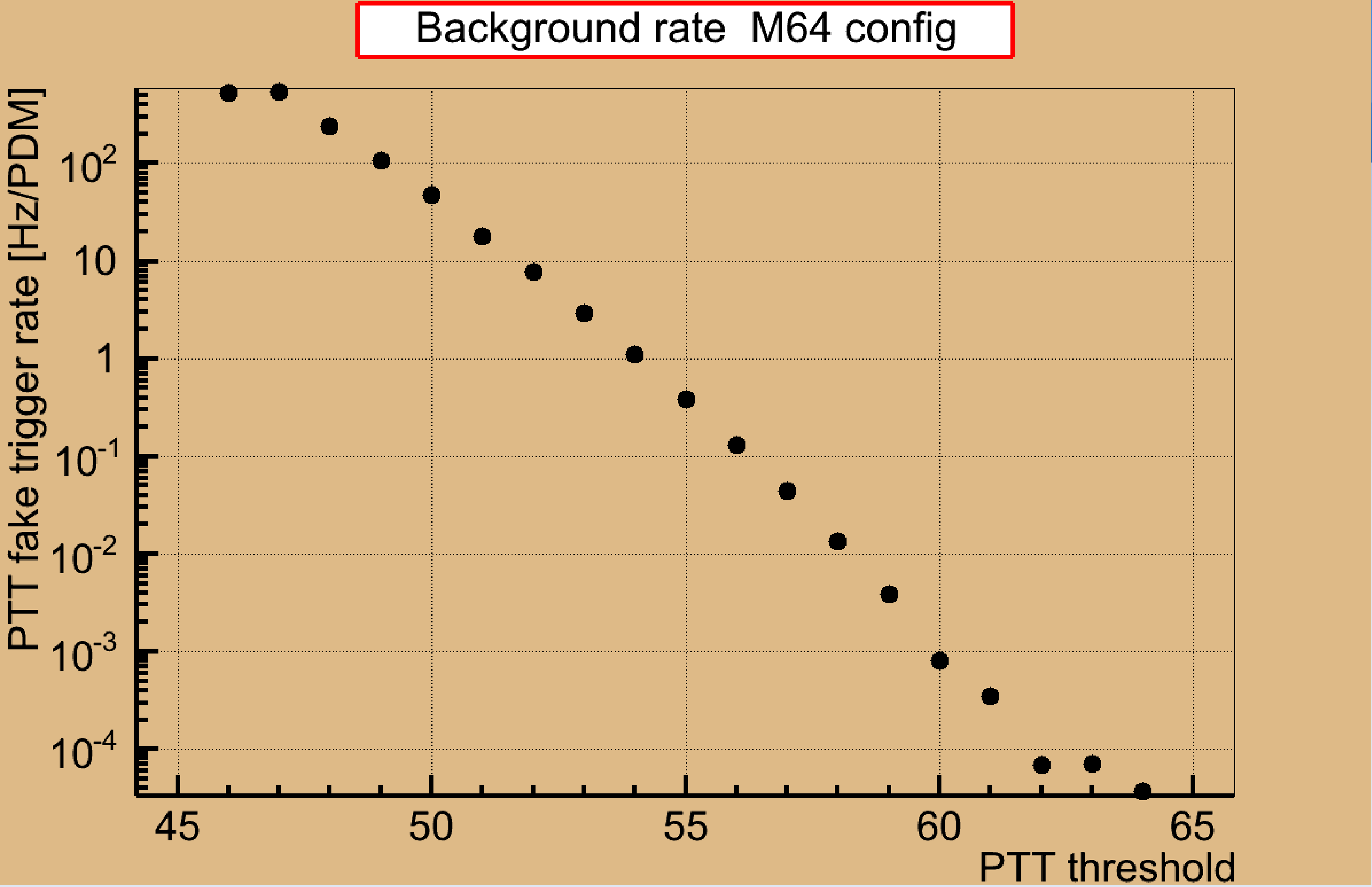
- fake patterns in generated matrix
  - seems in range predicted by theory

- pattern characteristics
  – average patter value, pattern length

- direction of work – Hough transform verification for JEM-EUSO fake trigger simulations

LTT threshold for M64





Background rate M64 config
PTT fake trigger rate [Hz/PDM]
10^2
10
1
10^-1
10^-2
10^-3
10^-4
45
50
55
60
65
PTT threshold