UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES

cta
cherenkov telescope array

Pre-selection of possible muon events at level of the SST-1M camera server

M. Della Volpe on behalf of the SST-1M muon team
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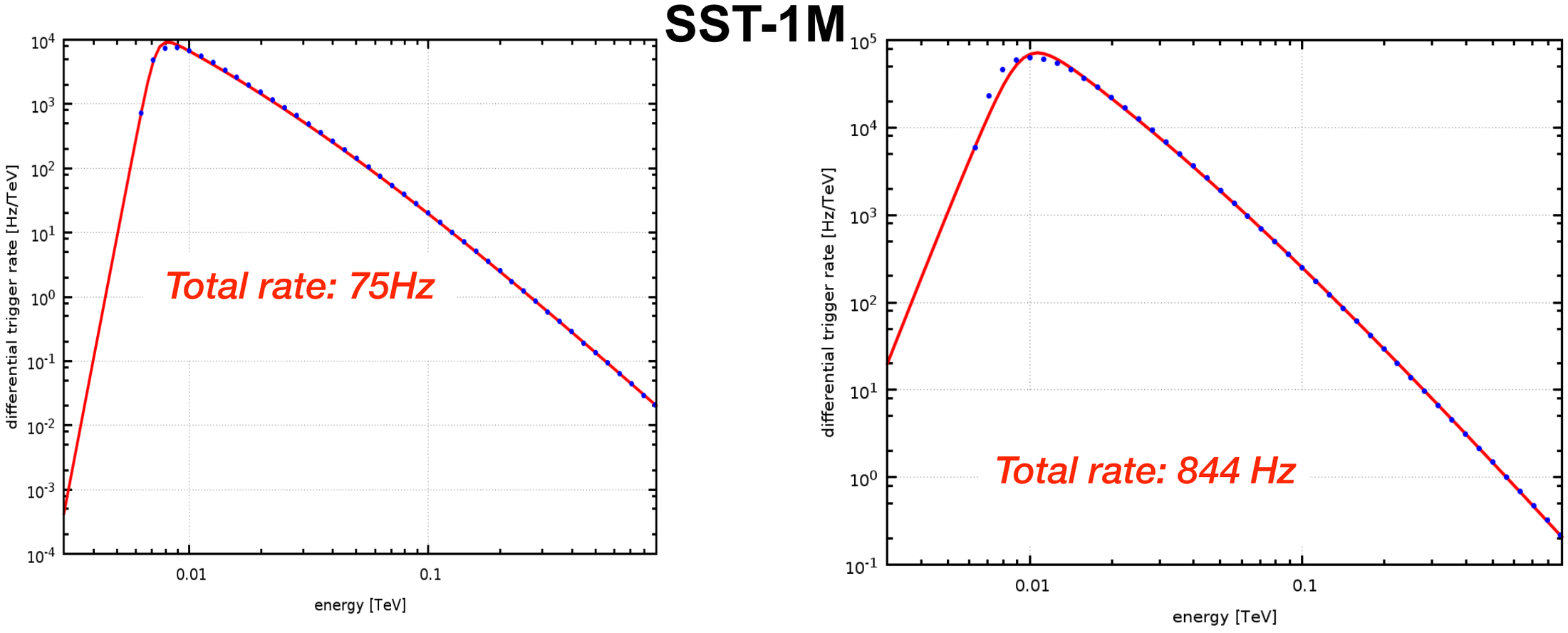
Outlook

- **Methods** for the pre-selection
  - Dedicated trigger at Camera Level
  - Fast analysis at the Camera Server Level
    - Hough transform
    - Demonstrator

Muon total rate

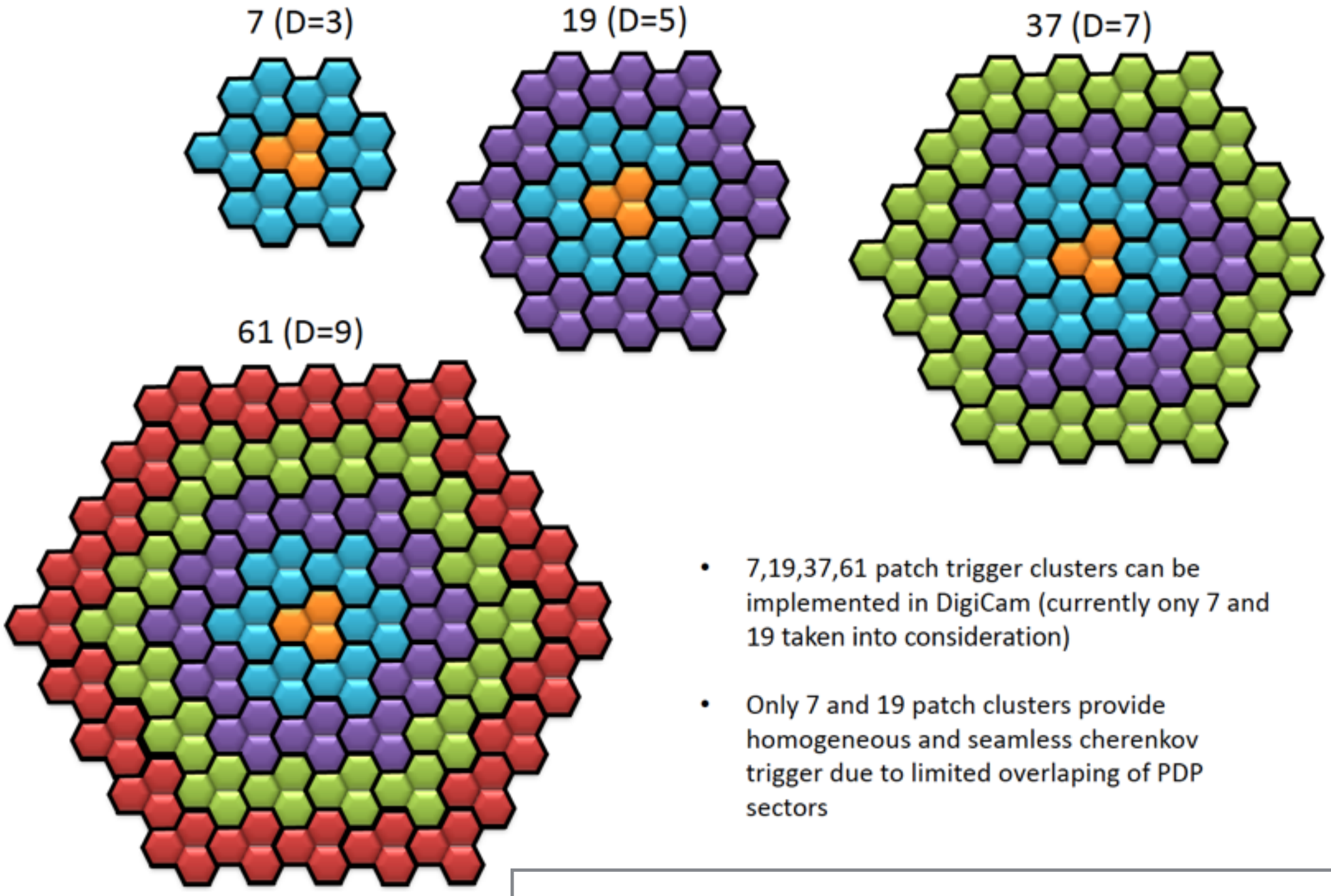
Trigger threshold **344 ADC** counts

Trigger threshold **127 ADC** counts



In principle, the rate of muons will be sustainable by our camera server, we can save everything (at least during commissioning)

Muon selection pre camera server: Dedicated muon trigger

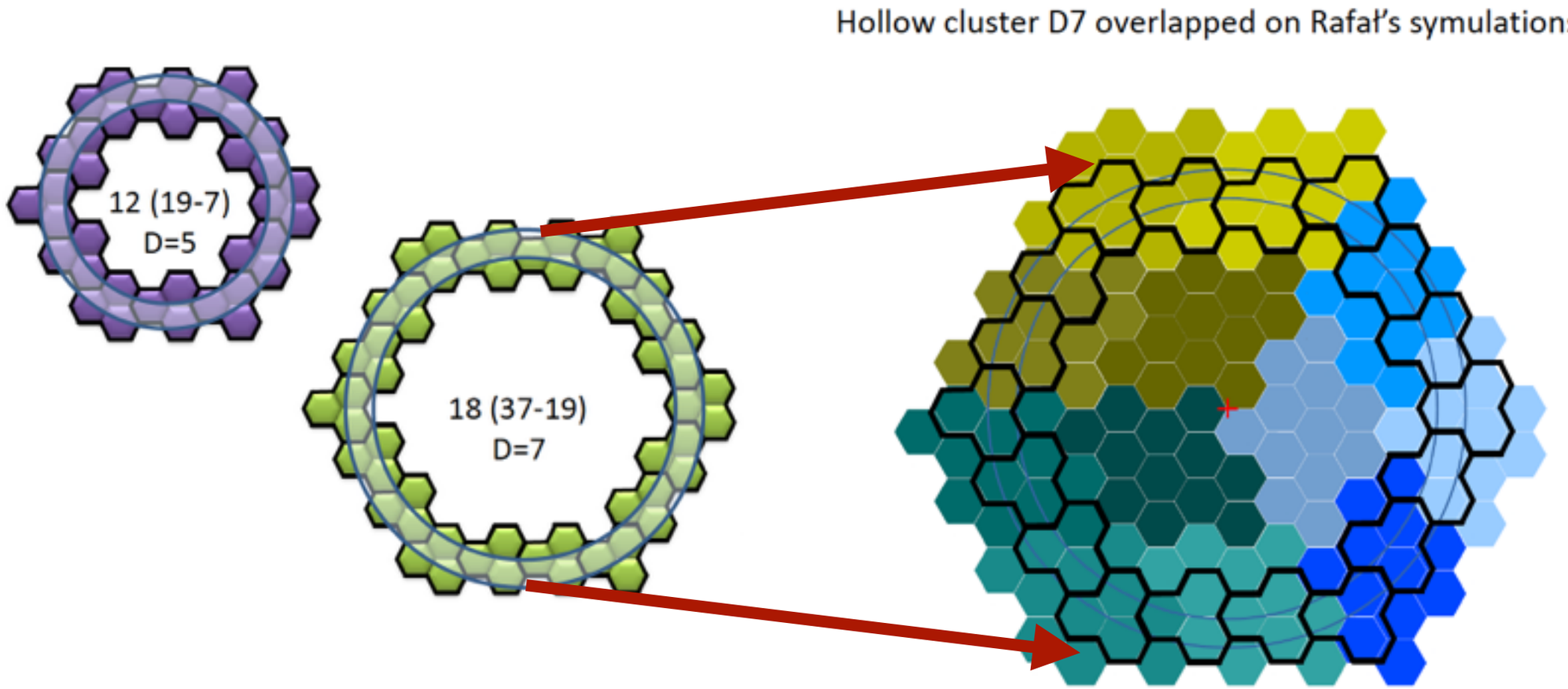


- 7,19,37,61 patch trigger clusters can be implemented in DigiCam (currently ony 7 and 19 taken into consideration)
- Only 7 and 19 patch clusters provide homogeneous and seamless cherenkov trigger due to limited overlaping of PDP sectors

DigiCam standard stereo trigger clusters

Work done by K. Zietara

Dedicated muon trigger



"hollow" muon trigger cluster for muon energies > 10 GeV size of rings 1.1-1.25 deg - perfect match!

Work done by K. Zietara

Conclusion on dedicated trigger

- Proposal: DigiCam offers a simple way to flag most of the “good” muons hitting our camera
- Simulations will be soon done (Vasyl)
- Advantage:
  - very elegant solution
  - does not requires any analysis
    - flag done at trigger card level, no action is needed from camera server
- Disadvantages:
  - solution works only for SST-1M;
  - the efficiency is not uniform of the camera but depends on muon ring position

Muon selection in Camera Server

- ASTRI method will be investigated by SST-1M team
- Hough transform (VERITAS method) : Based on a work done on FACT data (we are going to implement it on SST-1M data/geometry if we agree that it is promising)

33ND INTERNATIONAL COSMIC RAY CONFERENCE, RIO DE JANEIRO 2013
THE ASTROPARTICLE PHYSICS CONFERENCE

ICRC 2013

Muon Identification with VERITAS using the Hough Transform

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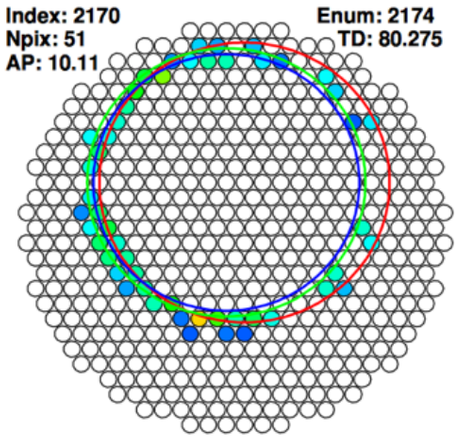
Hough Transform

http://lanl.arxiv.org/pdf/1307.8361v1.pdf

- In VERITAS is a very efficient way to select a pure muon sample



Muon ring in VERITAS camera

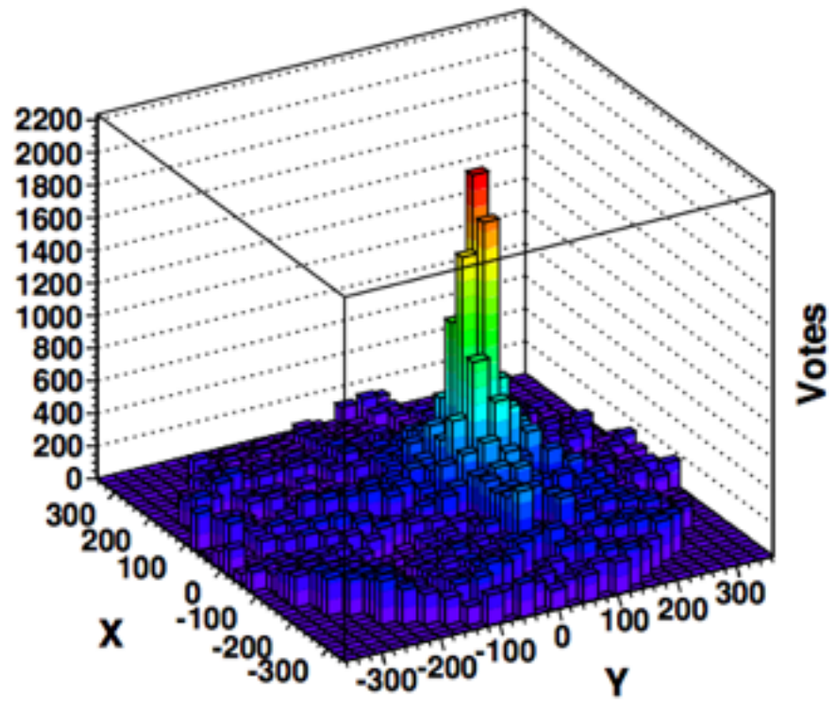
Muon = **ring**
center (x,y)
radius (R)

Hough Transform

Point in the (x,y,R) parameter space

Weight of the point: accumulator array

Accumulator array: sum of the intensity values of each pixel along the ring

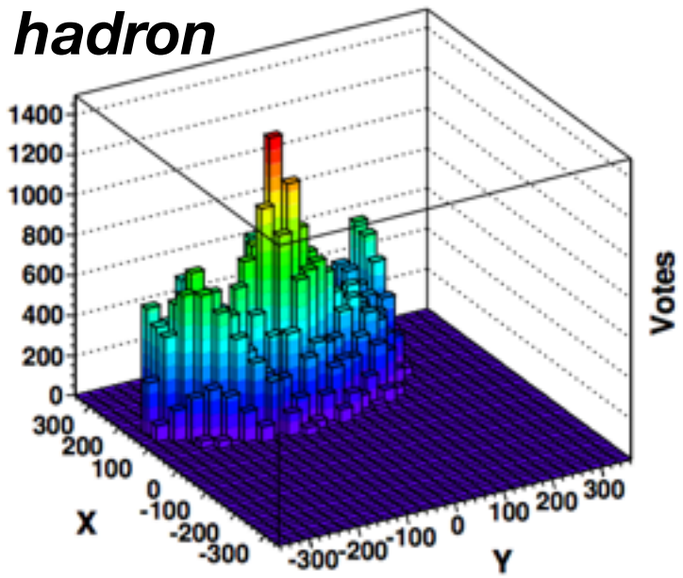


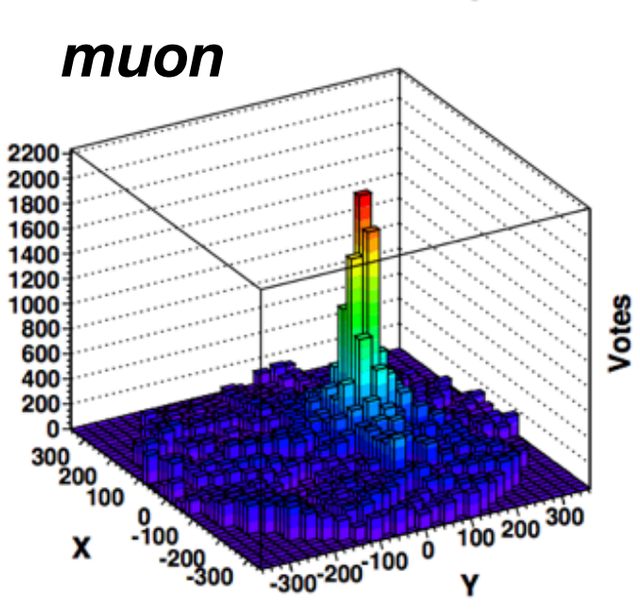
Muon ring projected on R parameter space

Best circular parametrization: coordinates of the bin (parameter space) with largest weight

Muon identification with Hough transform

Each event → Particular pattern in the 3D parameter space





- Muon selection: Set of cuts on identification parameters
- 1. Strength (signal to noise ratio) of the best parametrisation

$$AP = \frac{Largest\ bin\ value}{\left(\frac{Sum\ of\ all\ bin\ values}{Number\ of\ non-zero\ bins}\right)}$$

- 2. Sum of the distances in the parameter space between the three best parametrizations of the event

$$TD = D_{12} + D_{13} + D_{23}$$

$$D_{12} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (r_1 - r_2)^2}$$
$$D_{13} = \sqrt{(x_1 - x_3)^2 + (y_1 - y_3)^2 + (r_1 - r_3)^2}$$
$$D_{23} = \sqrt{(x_2 - x_3)^2 + (y_2 - y_3)^2 + (r_2 - r_3)^2}$$

- 3. Number of pixels with non-zero values

Muons: Large AP + Small TD

Hough transform: VERITAS Results

- By applying an optimised set of cuts, VERITAS obtains a **pure muon sample with a 29% efficiency**

	Total	Muons	Non-muons	Ambiguous
Before	11853	721	9109	2023
After	228	210	0	18

- The Hough transforms is performed with lookup tables for the possible rings (12475 circles)

Run	Events	Passing cuts	False positives
47511	274991	1617	5
40839	184048	1105	2
40840	166224	730	4
40841	184451	1101	3

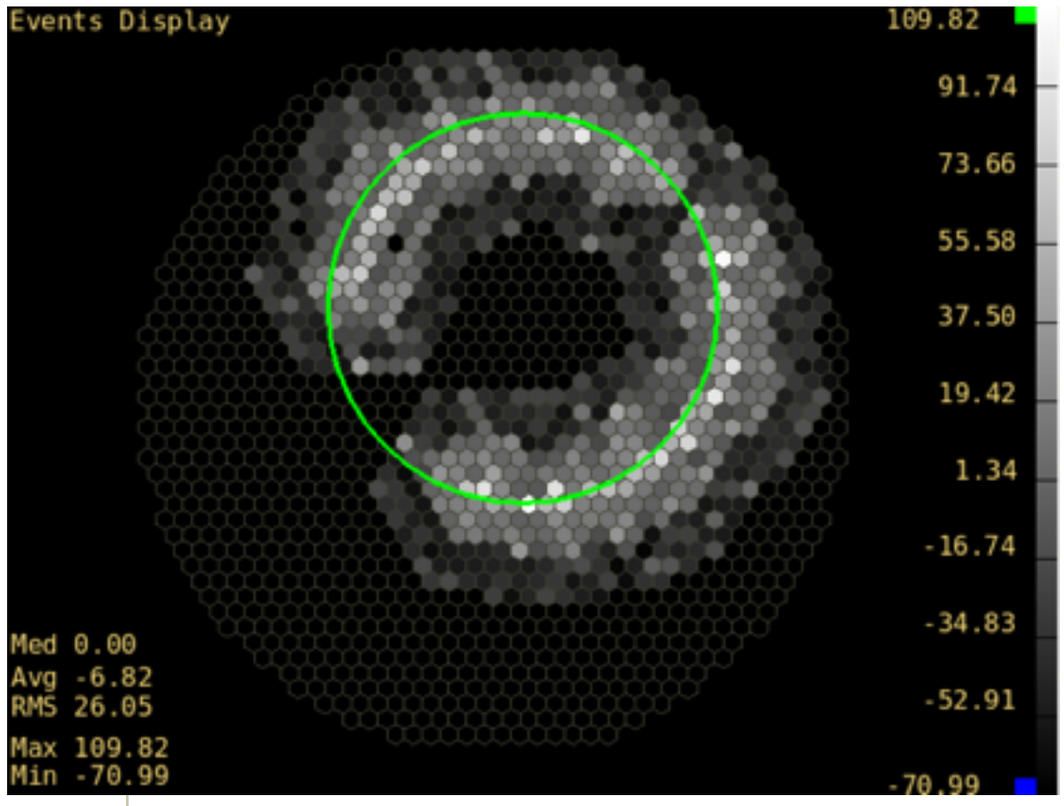
- We will try this approach on SST-1M

CAVEAT:

In SST-1M the number of possible circles is much larger, since circles are smaller.

DAQ Demonstrator and Hough transform

- A demonstrator based on google protocol buffers was developed by E. Lyard for the DAQ
- The code could be adapted to the Camera Server and to every kind of telescope
- The demonstrator:



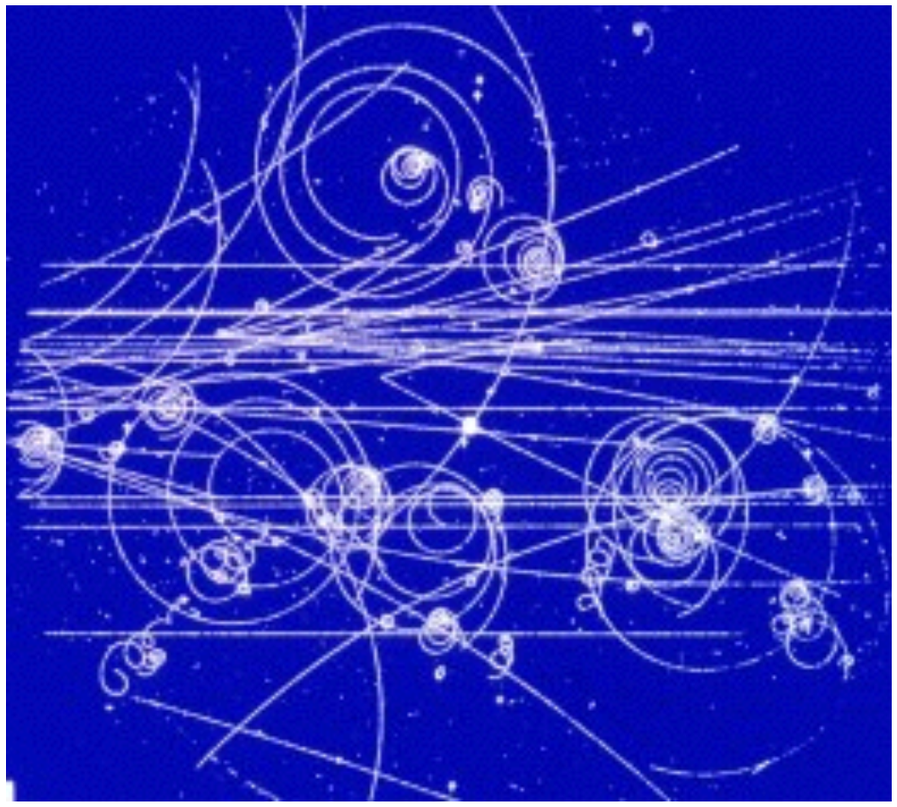
- muon selection (Hough transform) —> we already have the code to test

Conclusions on flagging muons

- Pre-camera server:
  - trigger card (digicam), using the trigger geometry
- At camera server level:
  - ASTRI method
  - Hough transform
  - Other methods?

Best method, fast and precise, to be found

Off-topic comment:Muons during cloudy nights



- Muons develops in the lowest part of the atmosphere
- Full rings are generated just above the telescope
- Proposal: can we take dedicated muon runs (i.e. with lower DT) during **cloudy nights**?

backup

Demostrator (developed for DAQ, could be adapted to our CS)

- Generic computing facility
- Want to add a new processing to the pipeline ?
  - Derive from base worker class and implement the message* doWork(message*) method
  - Discard events by returning NULL
- Two proof-of-concept processing's
  - Image cleaning
  - Muons extraction
    - Uses Hough transform + cut thresholds
- Laptop performances are ~ ±6kHz for 110kB event size
- Code not optimised
- Only obvious muons are extracted
- Missing precise data calibration