University of Connecticut

Study of BB Trigger rate reduction using GRINCH in SIDIS/GEn experiments : Example of SIDIS

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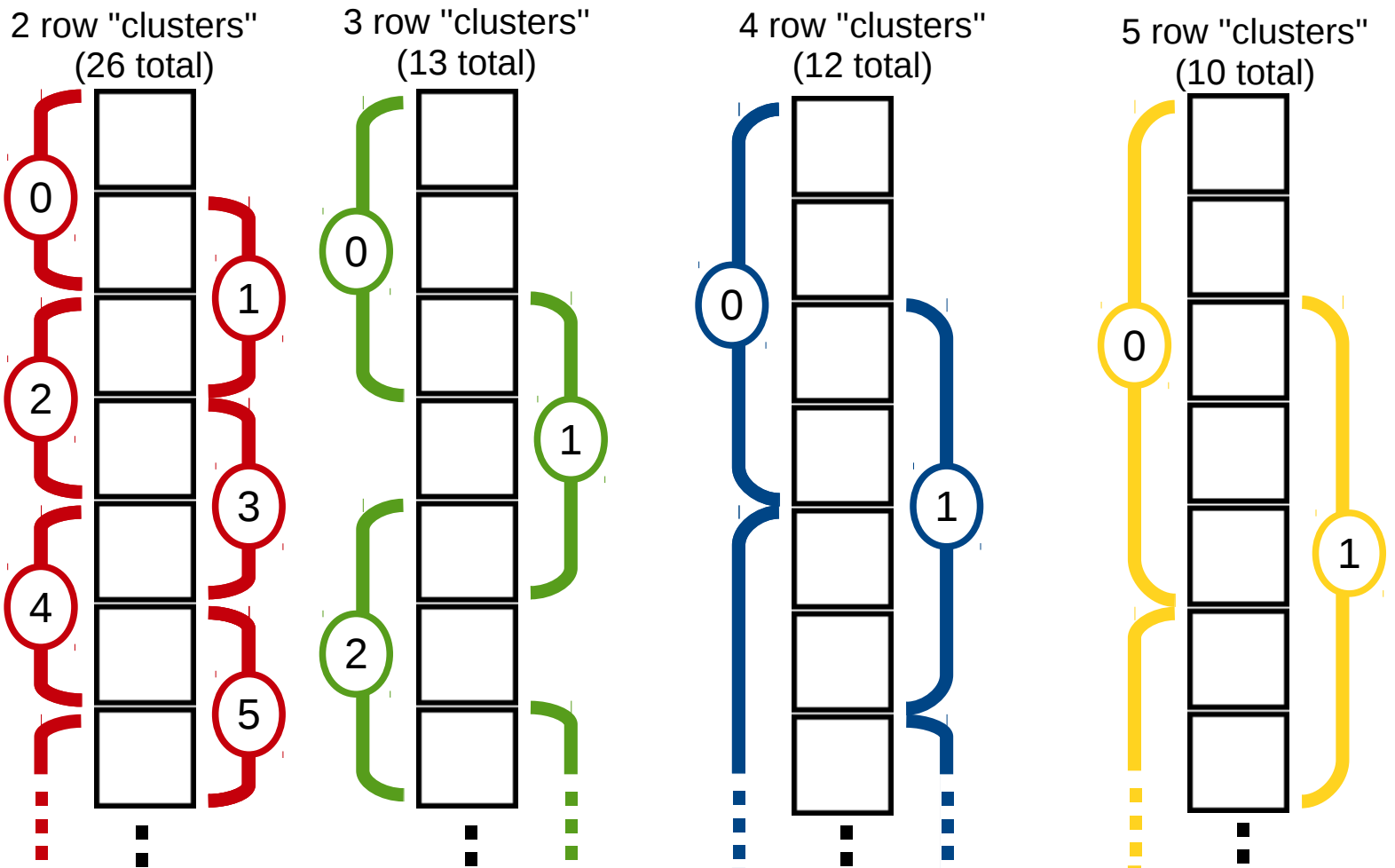
To reduce the rate for SIDIS and GEn experiments, we want to use the GRINCH detector. However, the total rates in the full detector is R_{Grinch} = **450MHz**, which is still too high.

To "plug" the GRINCH in the online trigger for SIDIS, GEn requires to use the correlation between the signal position in the calorimeter and the signal position in the GRINCH to clean a significant fraction of accidentals.

Step 1 : Segment the calo : 4 segmentations (tested in parallel) with different overlap fractions: Each of these clusters would trigger if energy deposit > 1 GeV.



Step 2 : Evaluation of efficiency drop / multiple countings :

If total Energy deposit on calo > 1 GeV but no subclusters is above threshold event is missed (efficiency drop).
If, on the other hand, many have a threshold > 1 GeV, we have multiple counting.

To evaluate these quantities:

Generated 400000 DIS evts in SIDIS configuration with :
$0 < e' < 6$ GeV ; 22 deg $< \theta <$ 42 deg ; -35 deg $< \phi <$ 35 deg
BB angle = 30 deg;
BB dist = 1.55 m;

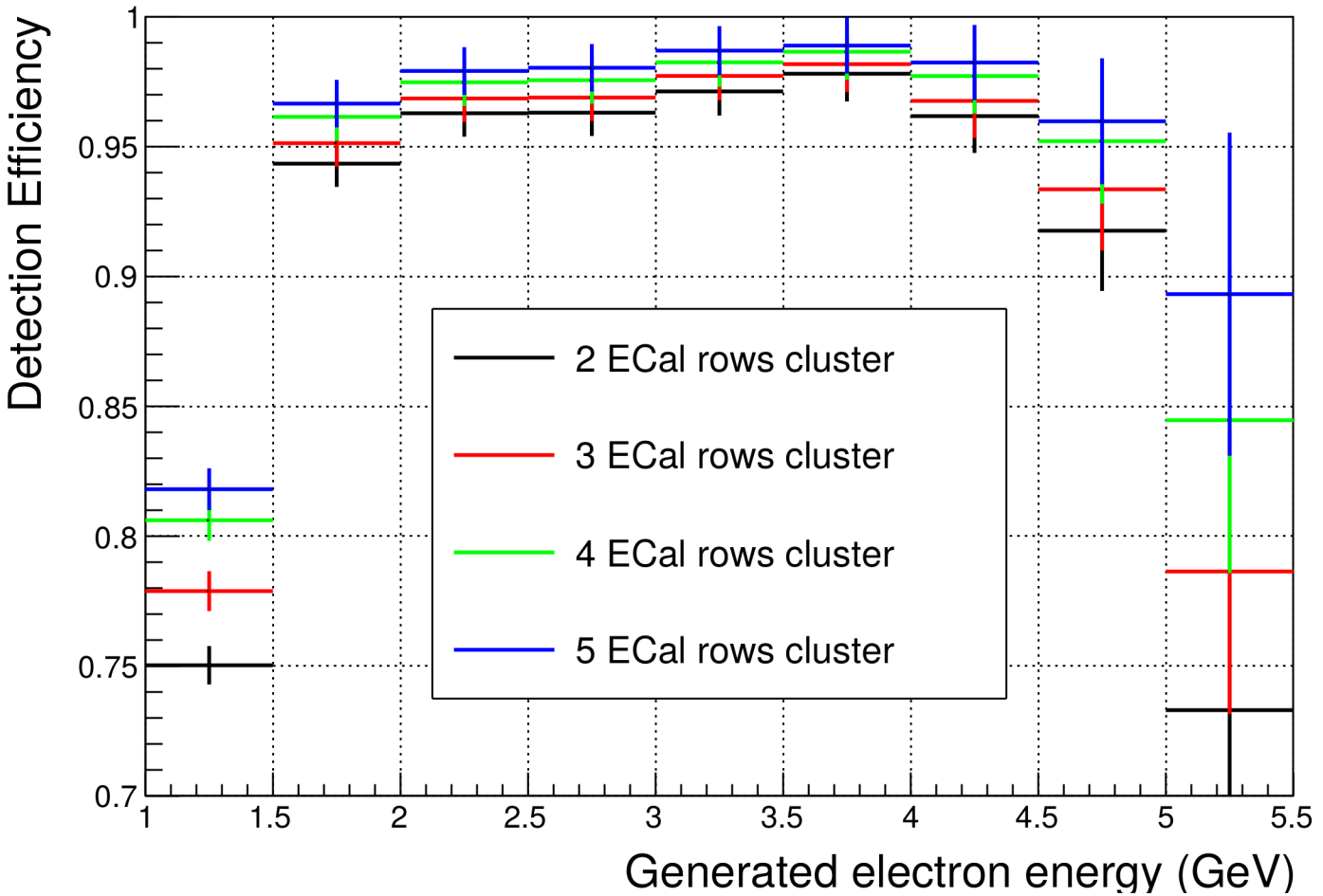
- Selection, (w/ MC truth), of all events in the spatial acceptance of the BB magnet ;
- 1 GeV threshold applied on sum of energy deposit in all Ecal elements (PS+SH) ;
=> *Denominator for efficiency.*

1 GeV threshold applied on sum of energy deposit in each of the calo "cluster" defined on previous slide ;

If *at least* one cluster beyond threshold, event counted. Else, event rejected.

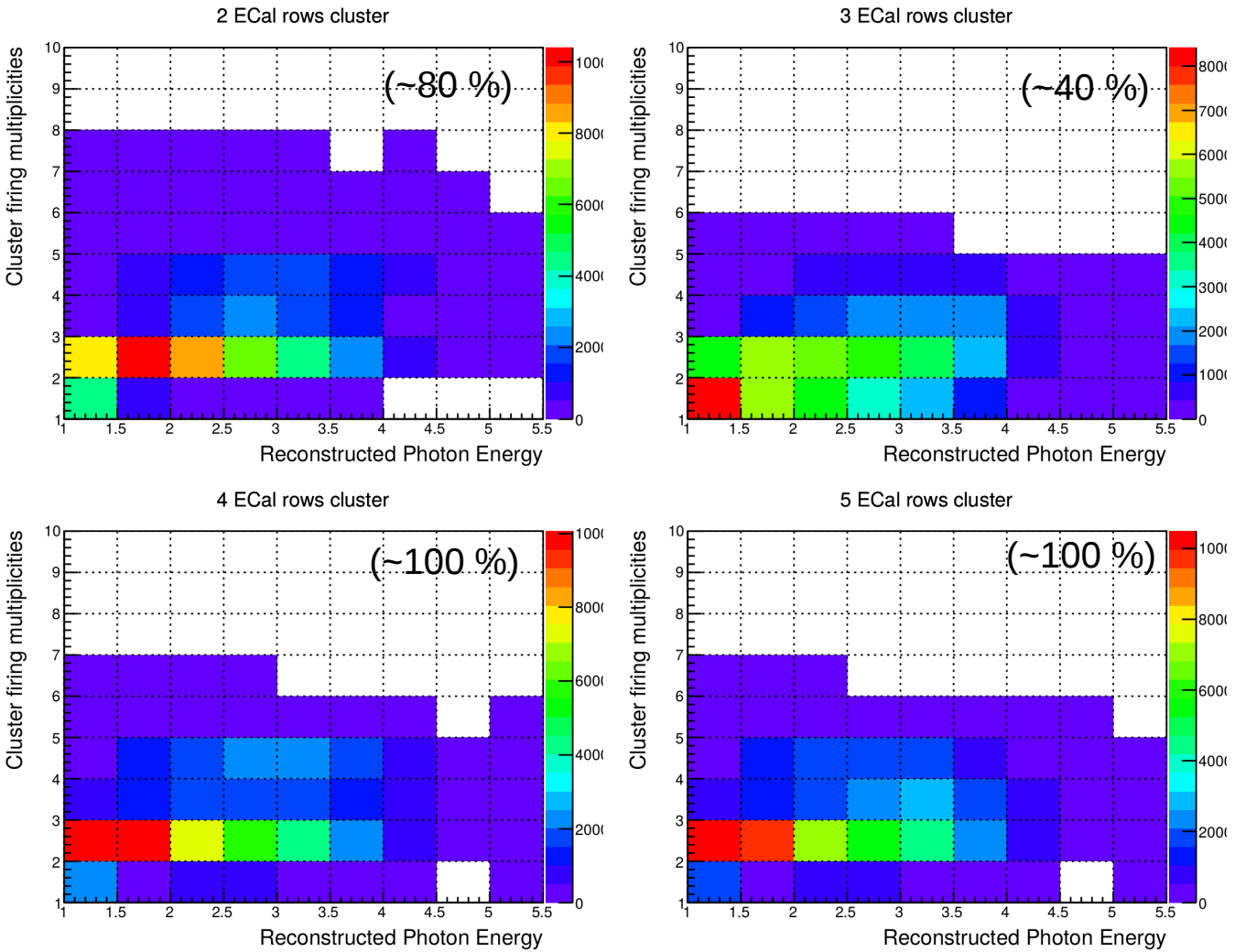
Number of clusters firing for this event gives trigger multiplicities.

Detection efficiency drop as function of the energy.



Efficiency is mostly reduced at lower energy.
Increasing cluster size does not significantly increase efficiency, even with large overlap.

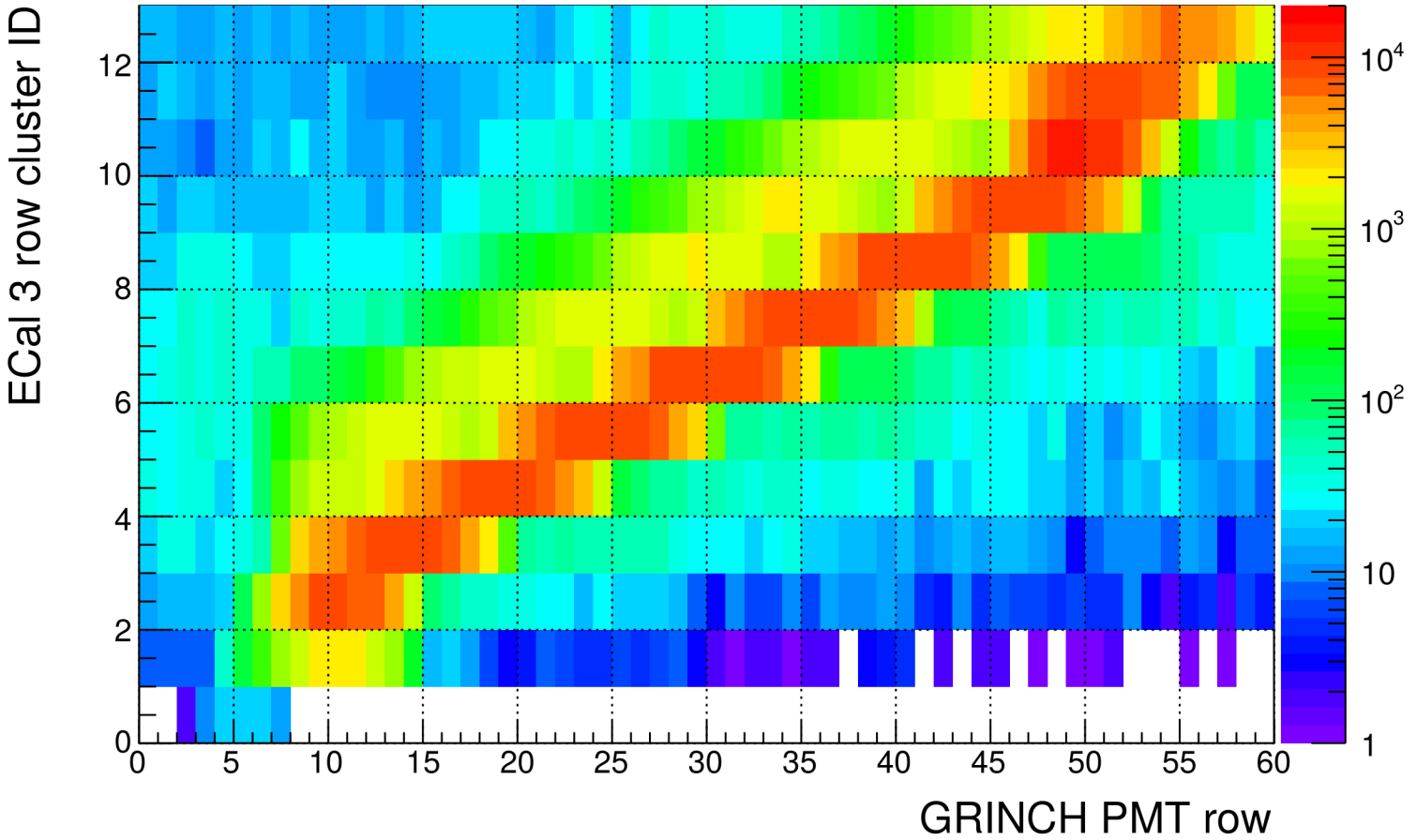
Trigger multiplicity: as function of the energy :



*Optimum multiplicity reached with **3 row clusters** segmentation*

Number in parentheses indicate estimated background increase due to multiplicities (see backup)

GRINCH PMTs / ECal segments correlation with 3 row clusters segmentation



Each Ecal "3-row cluster" segment is correlated with >= 10 PMTs.
(systematics study next slide).
Side remarks : Sector 0 (top) almost empty (no statistics);
Sectors 1-2 and 10-11 pretty much overlapping due to the mirror shapes
(GRINCH mirrors : 2 cylindrical in the middle, 2 spherical in the sides)

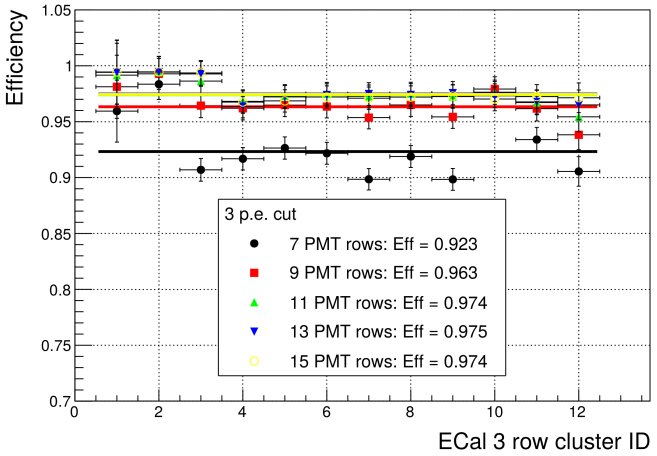
Systematic study of number of PMTs to "hook-up" to each 3 row clusters :

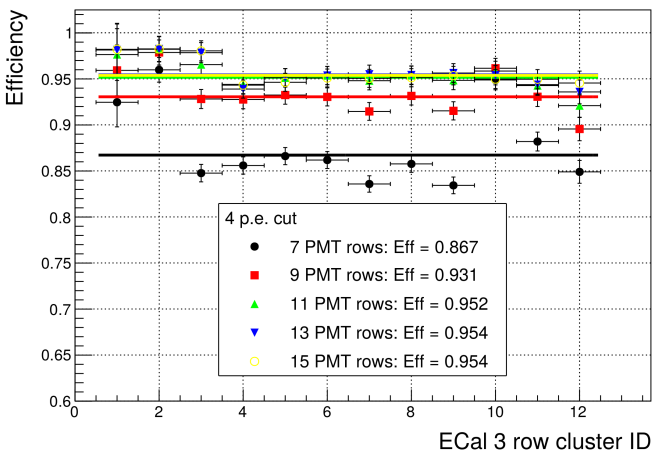
- Estimation of "central" PMT row
- Systematic study including ± 3, 4, 5, 6, 7 PMTs rows around this row

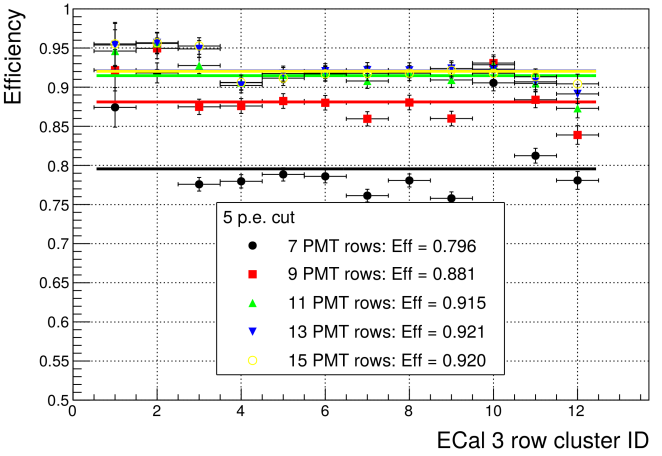
(7, 9, 11, 13 15 PMT rows total).

=> Hit multiplicity (i.e. N p.e.) in this PMT group → convolute with Poisson * gaus(σ = 1 p.e.)

=> *Apply p.e. threshold on these distributions : 3, 4, 5 p.e.*





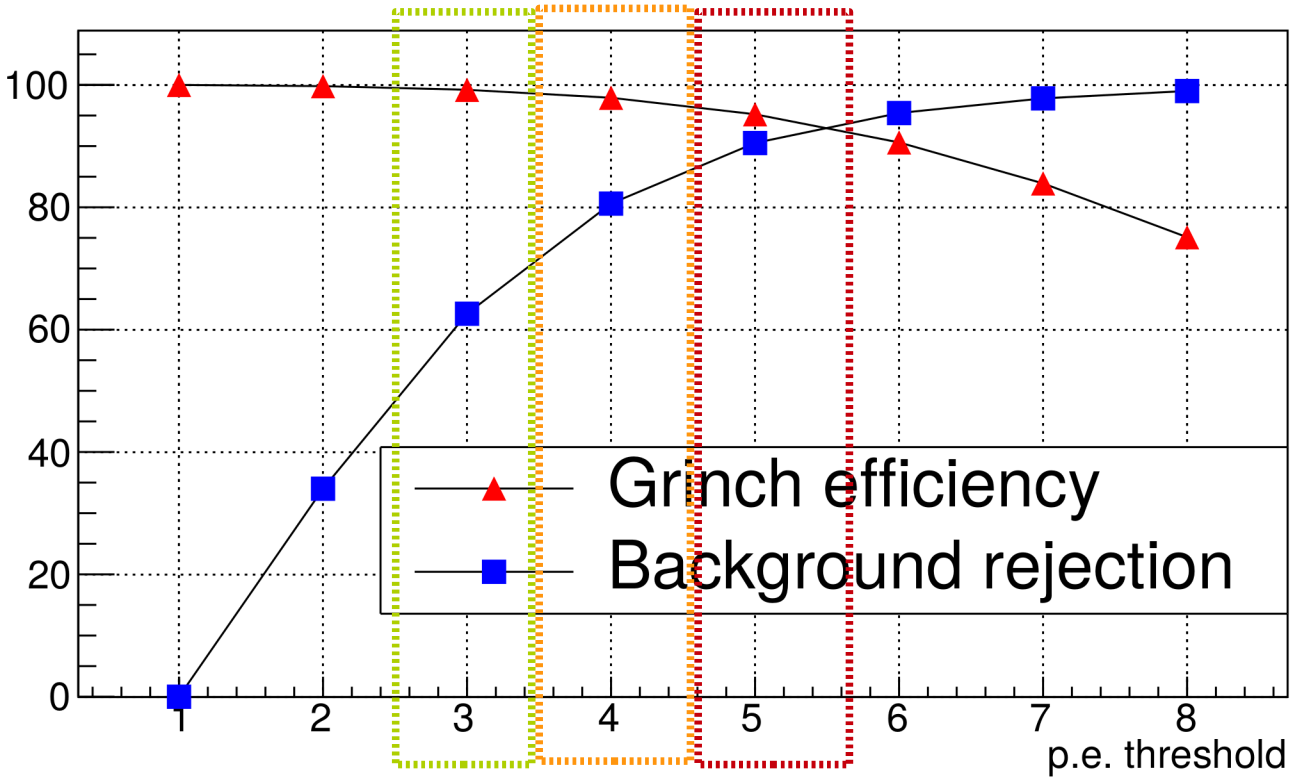


Global efficiency stable past 11 PMT rows ; larger PMT groups add more noise than signal.

Reminder : Total GRINCH rate = 450 MHz (*w/o threshold*) divided ~uniformely on all PMTs

=> a single group of 11 PMT rows will receive only ~ 18% of this background i.e. **80MHz**

Previous (very short) study on the full GRINCH detector provided the following efficiency and background rejection curves as a function of the p.e. threshold:



=> 3 p.e. threshold removes 2/3 background
=> 4 p.e. threshold removes 4/5 background
=> 5 p.e. threshold removes 9/10 background
→9 MHz on a 11 PMT row group

Recap :

"3 row cluster" segmentation seems reasonable for the BB ECal :
Keeps **90 % signal** overall and introduces "reasonable" multiple counting (+20%).

ECal clusters well correlated with defined sets of 11 GRINCH PMT rows
(slighty less than 20 % of the total number of PMTs in the GRINCH).
Divides GRINCH background (450MHz) by >5 for each of these groups => **80MHz**

5 p.e. threshold applied on each of these PMT groups :
cuts **90 % of remaining background**, => **8MHz**
preserves **92 % signal**.

Combined with ECal rates (**280kHz** for SIDIS*) with a coincidence window Δt = 30ns :

Total BB rate (GRINCH + ECal) = 68 kHz

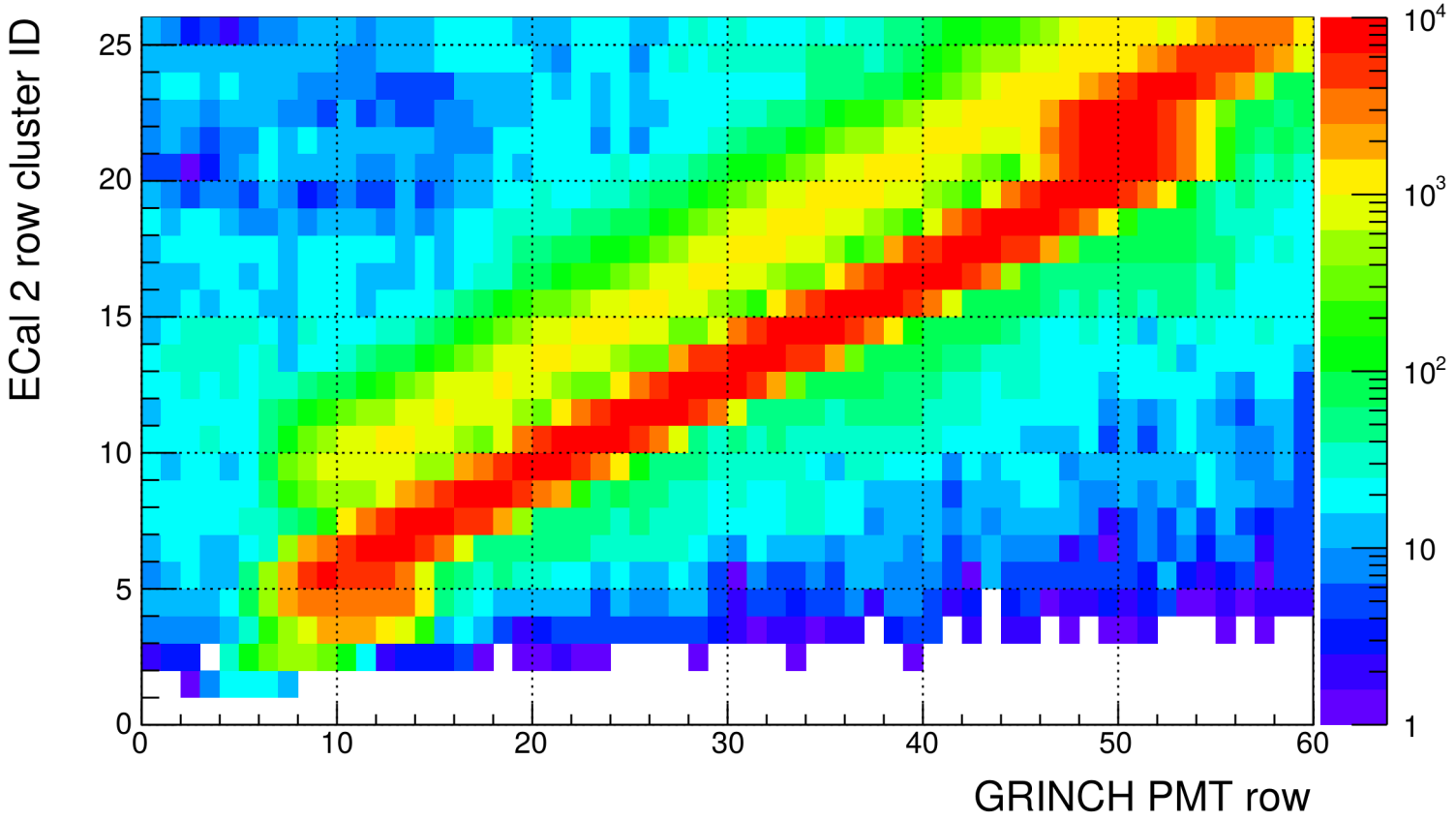
Combination with other detectors (Ex SIDIS : HCal singles = **3kHz**) with same Δt

Total DAQ rate (SIDIS) = 6.1 kHz (for the price of ~18 % signal, mostly at lower e')

*=> Rates from the proposal x 1.40 for multiplicities induced by segmentation (slide 5)

TODO : from SBS software meeting brief discussion

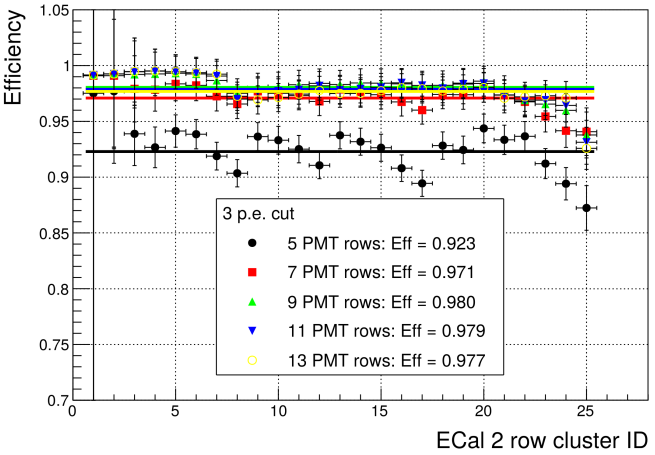
- Do the same work for "2-row cluster" segmentation (following Bogdan's remark)
  => those will be correlated with smaller subsets of PMTs;
  => however, background increase from multiplicities by 80 %;

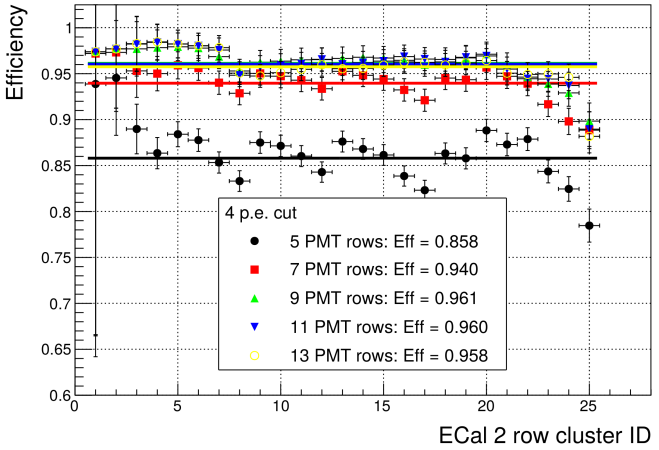


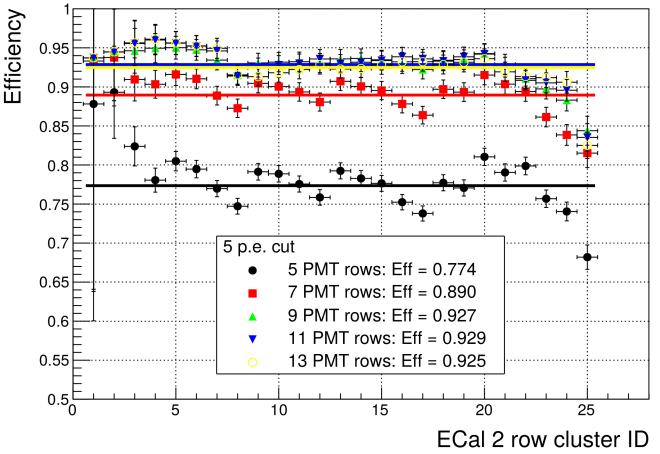
Each Ecal "2-row cluster" segment is correlated with <= 10 PMTs.
(less than 3-row cluster ; systematics study next slide).
Side remarks: Again, sectors 0,1 (top) almost empty (no statistics);
Sectors 3-5 and 21-23 overlapping due to mirror shapes

- Systematic study including ± 2, 3, 4, 5, 6 PMTs rows around this row (5, 7, 9, 11, 13 PMTs rows total).

=> Hit multiplicity (i.e. N p.e.) in this PMT group → convolute with Poisson * gaus(σ = 1 p.e.)
=> Apply p.e. threshold on these distributions : 3, 4, 5 p.e.







Global efficiency stable past 9 PMT rows
=> 15% of GRINCH background i.e. **67.5 MHz**
=> p.e. cut → **6.75 MHz**
=> 30ns coincidence with Ecal (**360 kHz***) => **90 kHz**
=> 30ns coincidence with HCal singles (**3kHz**) => **8.1kHz**
(for the price of ~18 % signal, again mostly at lower e')

*=> Rates from the proposal x 1.80 for multiplicities induced by segmentation (slide 5)

Conclusions :

- GRINCH may be included in trigger, using ECal-GRINCH signal correlation, with the relevent ECal Segmentation.

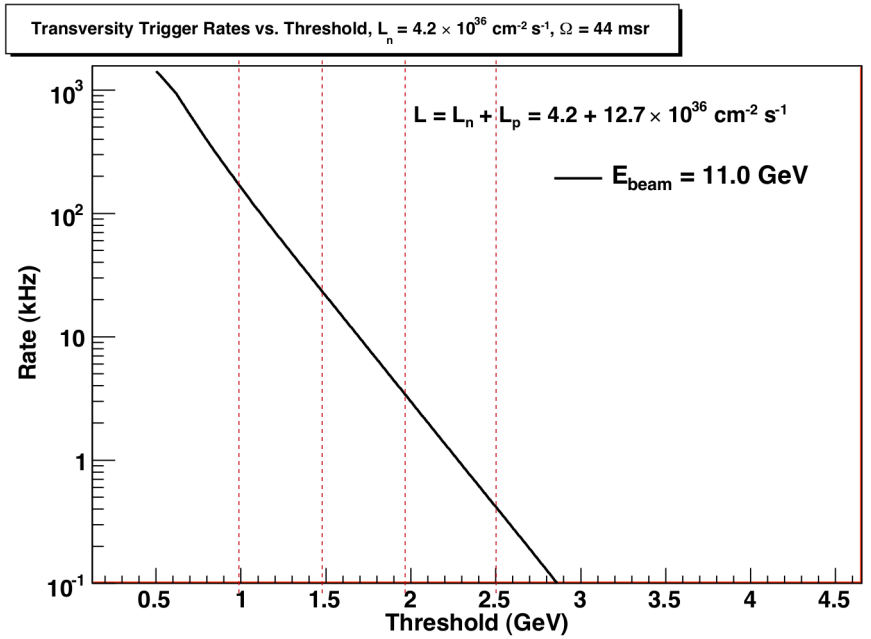
- In absolute, this segmentation may reduce the trigger rates by a factor 5.

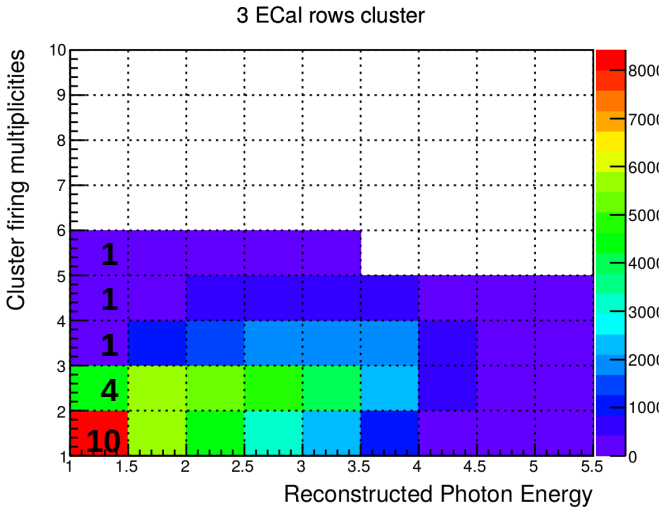
- As a side effect of segmentation, ECal background rates are also increased (by less than a factor 2 for the considered segmentations), but it is well compensated by the trigger rate reduction.

Thank you for your attention

Evaluation of additionnal ECal background induced by segmentation/ multiplicities : (fast method).

Use BB Ecal rates for SIDIS as available in the proposal :
From this figure, extrapolate a simple function for the background (exp), to be integrated on the indicated E bins





For each E bin, multiply integrated background obtained from the left plot by the "multiplicity factor" (= ∑ Events*Multiplicity / ∑ Events) obtained form right plot.

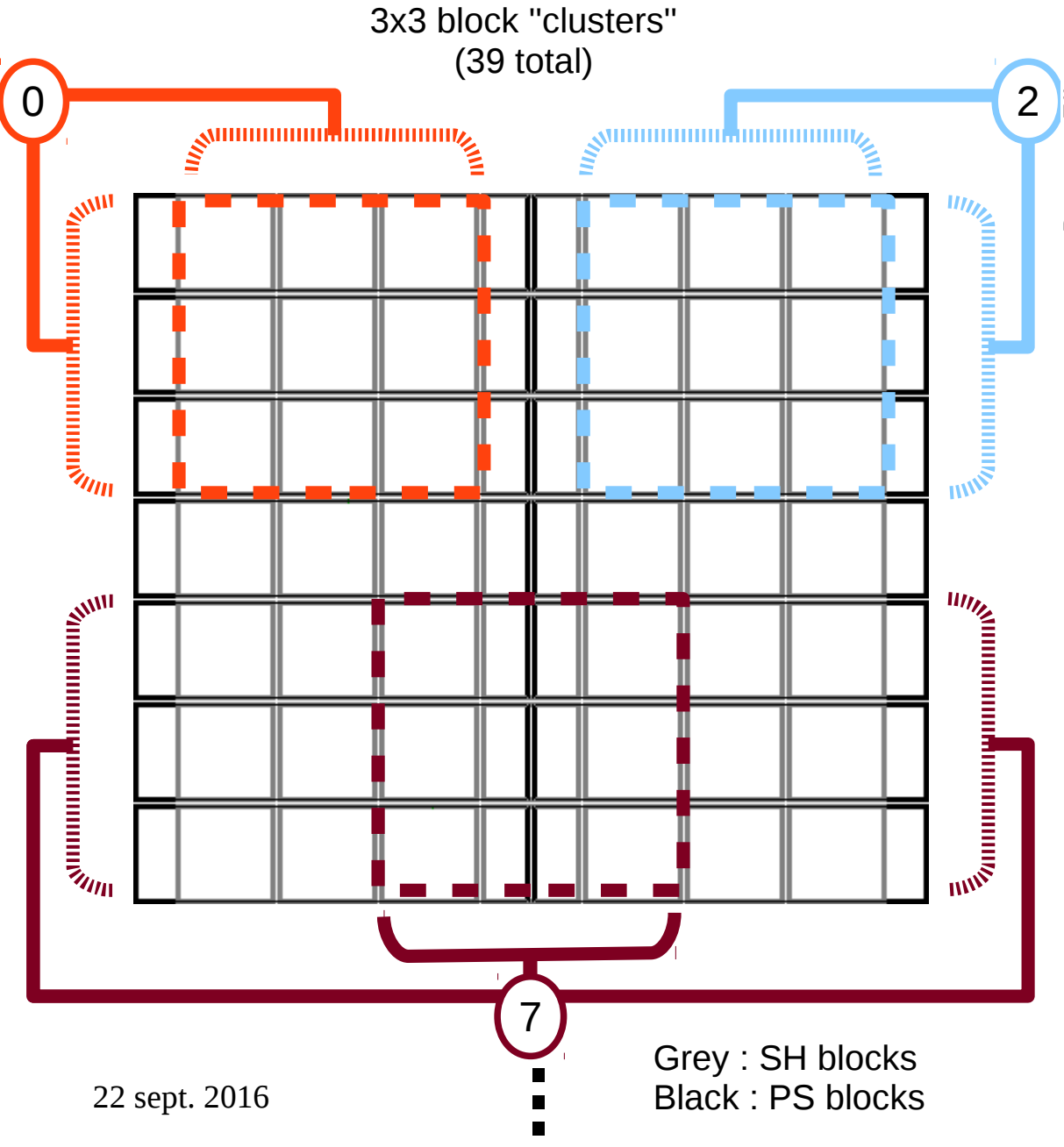
Ex : first column right plot (*written numbers not actual ones*):

∑ Events = 10+4+1+1+1 = 17

∑ Events***Multiplicity** = 10***1**+4***2**+1***3**+1***4**+1***5** = 30

=> "multiplicity factor" = 30/17 ~ 1.76

Horizontal + vertical ECal segmentation :



Grey : SH blocks
Black : PS blocks

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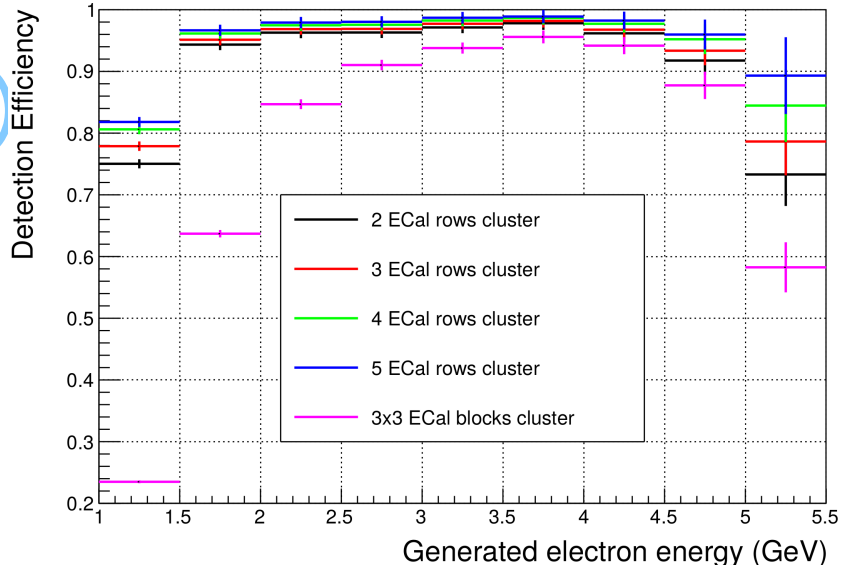
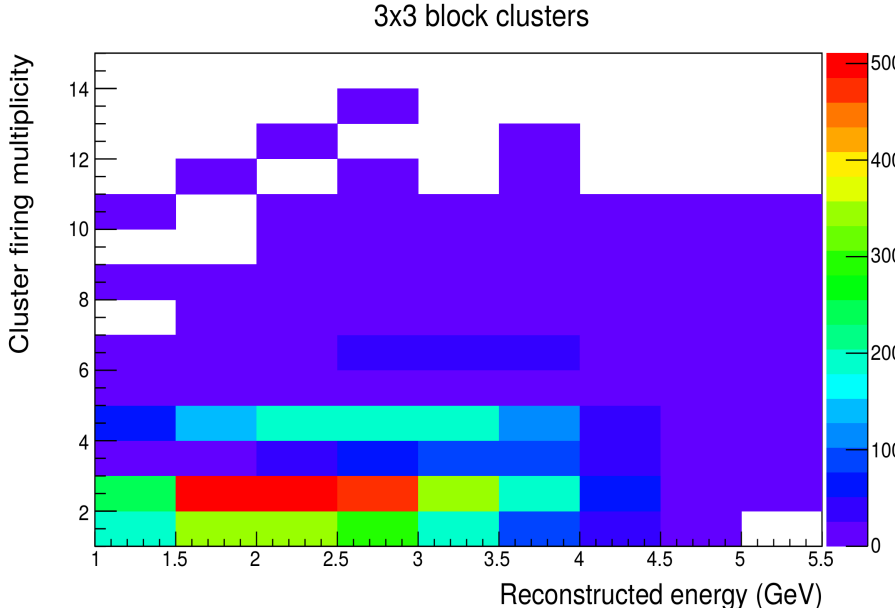
Huge efficiency drop :

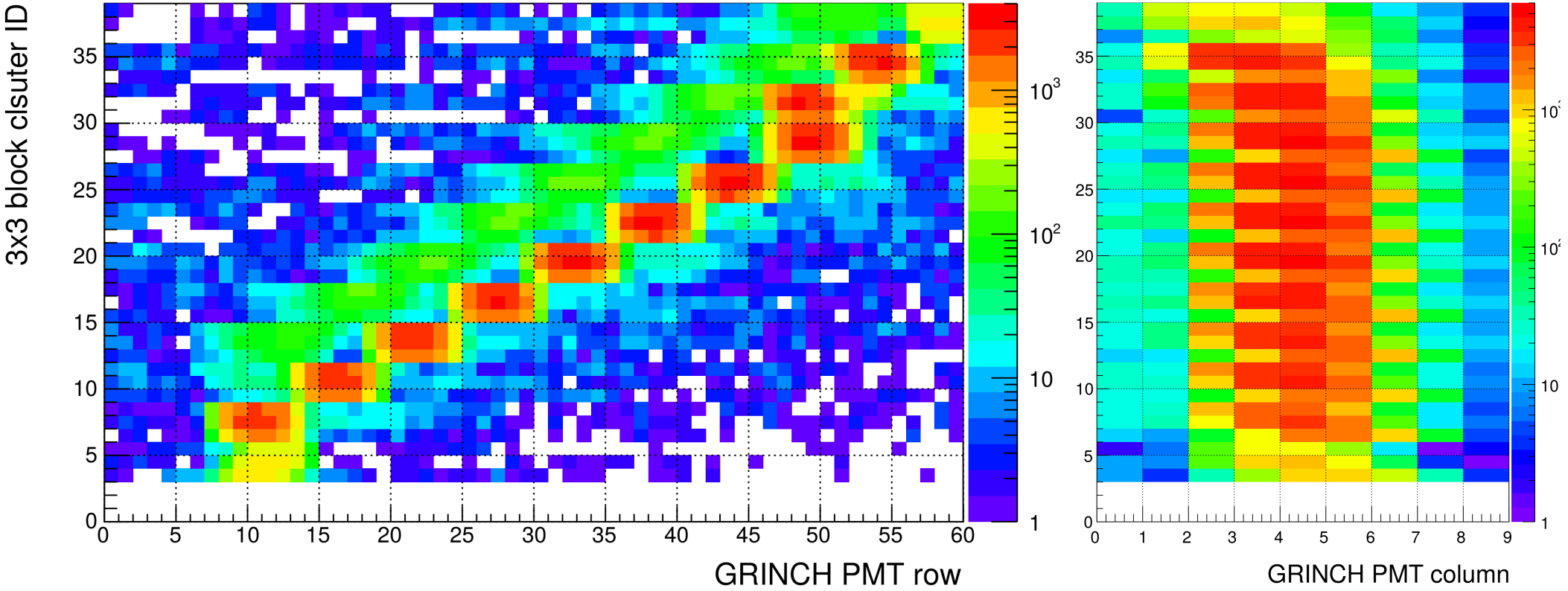


Multiplicity: *much more important than with vertical divisions only*



Horizontal + vertical ECal segmentation :

In regard of the much lower efficiency and the higher multiplicity, the possible reduction of corresponding GRINCH PMT subsets might not be so determinant.
(although it cannot be denied that correlations between Ecal clusters and GRINCH PMTs look cleaner).

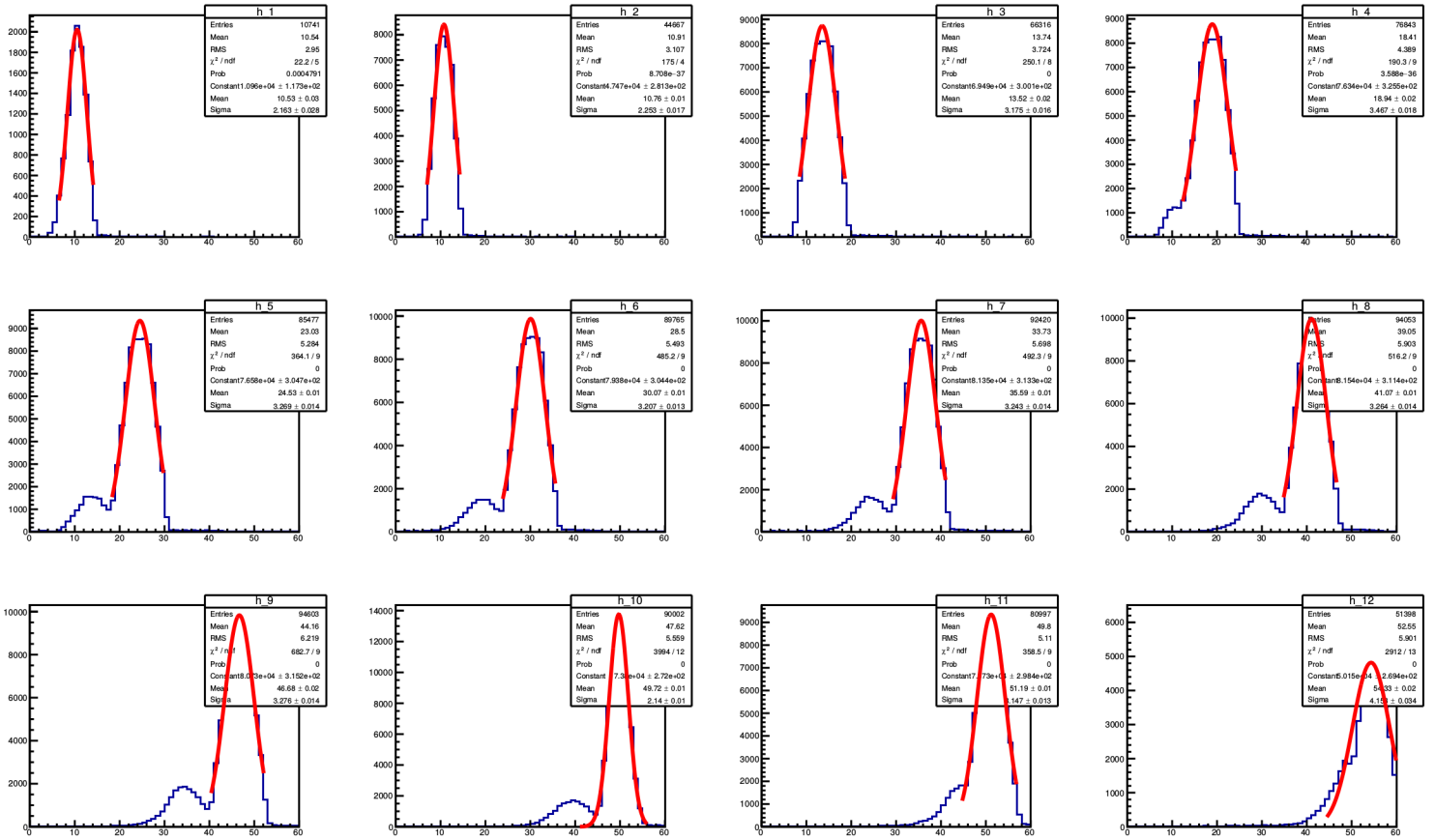


=> Form now on, we stick to the "3-row cluster" configuration

Systematic study of number of PMTs to "hook-up" to each 3 row clusters :

- Estimation of "central" PMT row

- Systematic study including ±3, 4, 5, 6, 7 PMTs rows around this row (7, 9, 11, 13 15 PMT rows total).



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