Building a new clustering algorithm

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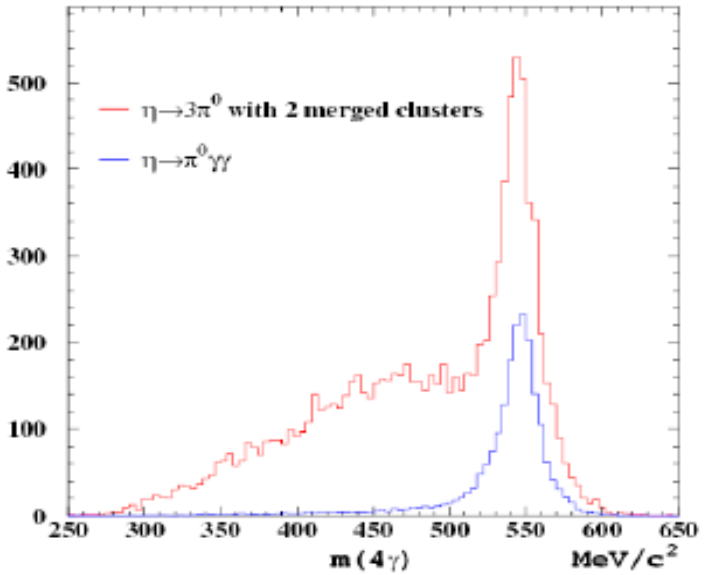
Motivation

Cluster merging effect: the $\eta \to \pi^0\gamma\gamma$ decay



After cutting on the kinematic fit χ^2 in the $\phi \to \eta\gamma \to \pi^0\gamma\gamma\gamma$ hypothesis, a huge background survives, entirely due to $\eta \to 3\pi^0$ decays with double merged clusters.

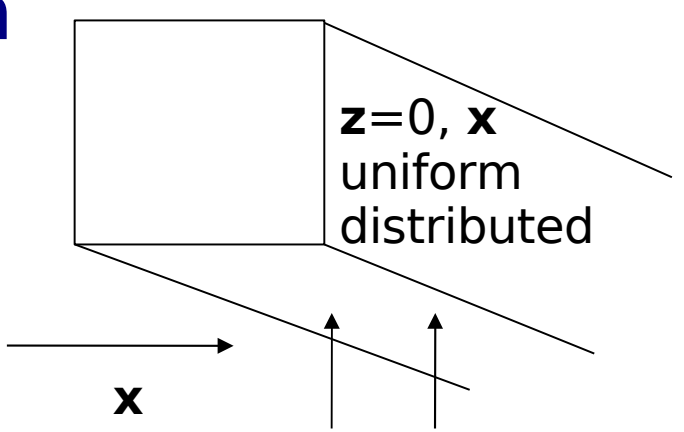
Due to the merging of two couple of photons the topology of $\eta \to 3\pi^0$ becomes equal to the $\eta \to \pi^0\gamma\gamma$. The invariant mass of the four photons peaks as the signal. The two plots are scaled according the real branching ratios:

By integrating only the mass peak region we get $\frac{signal}{background} = 0.35$

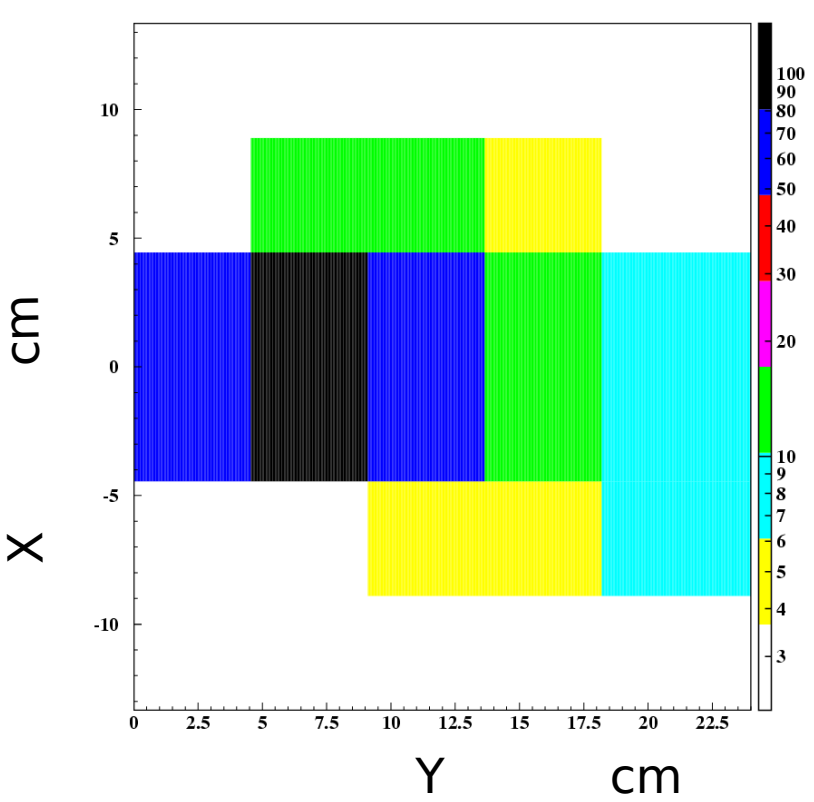
Interesting also for the interferometry measurement of the CP violating process:
$K_S \to \pi^+\pi^-$, $K_L \to \pi^0\pi^0$, huge background from $K_L \to 3\pi^0$

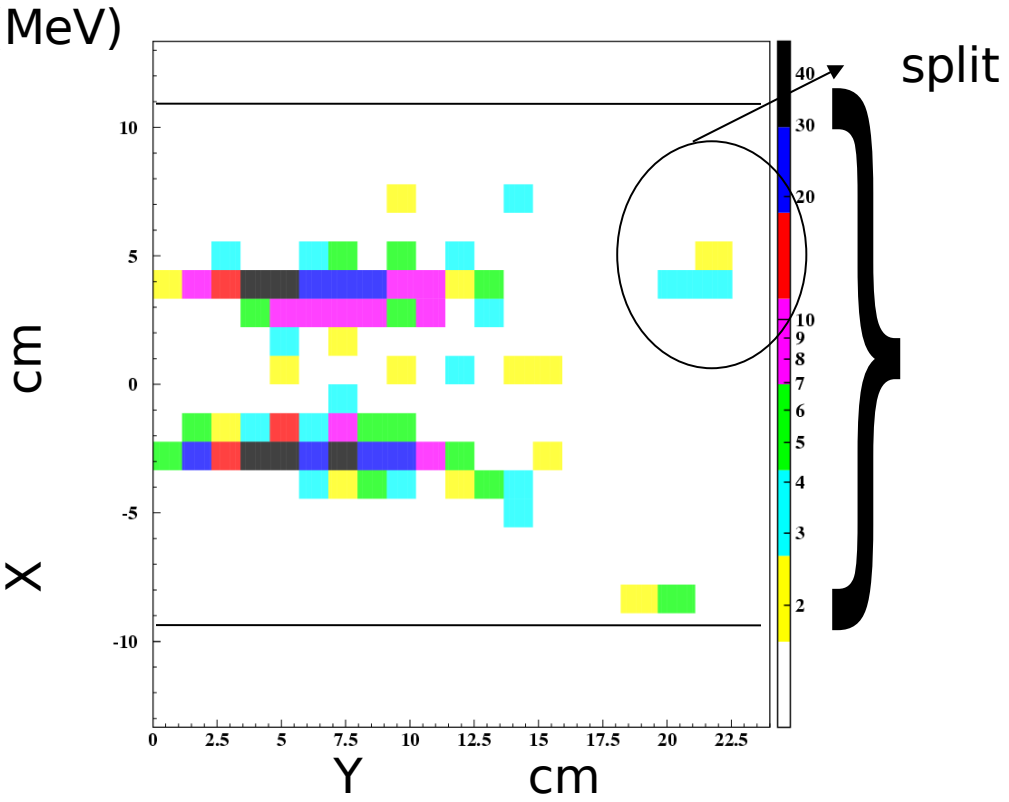
High granularity comparison

2 beams of photons are simulated.



Relevant improvement in merging, worsening of the splitting (clustering algorithm not optimized for high granularity!!)





At the beginning, no improvement was observed in merging reason: the algorithm merges everything in 20 cm.

The clustering algorithm

From the LNF meeting

The KLOE clustering algorithm cannot be easily adapted for high granularity read-out.

Merges everything is at 20 cm distance. → **4 cm in our modified version.**

All the rest is split.

NO CLUSTER SHAPE ANALYSIS

EFFORT IS NEEDED TO REDESIGN IT

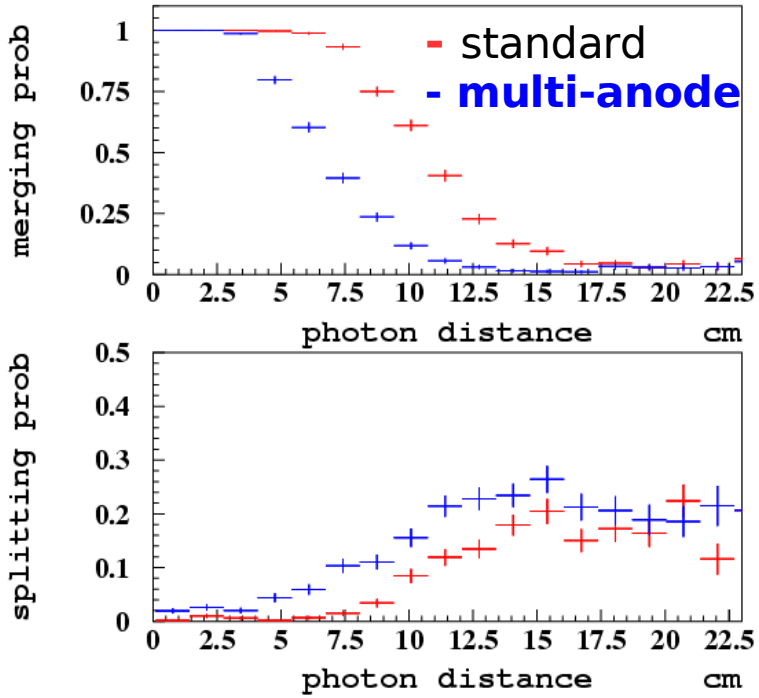
Merging and splitting (multianode case)

Events with one cluster give the merging probability
events > 2 clusters give the splitting probability.

Relevant improvement in merging, worsening of the splitting

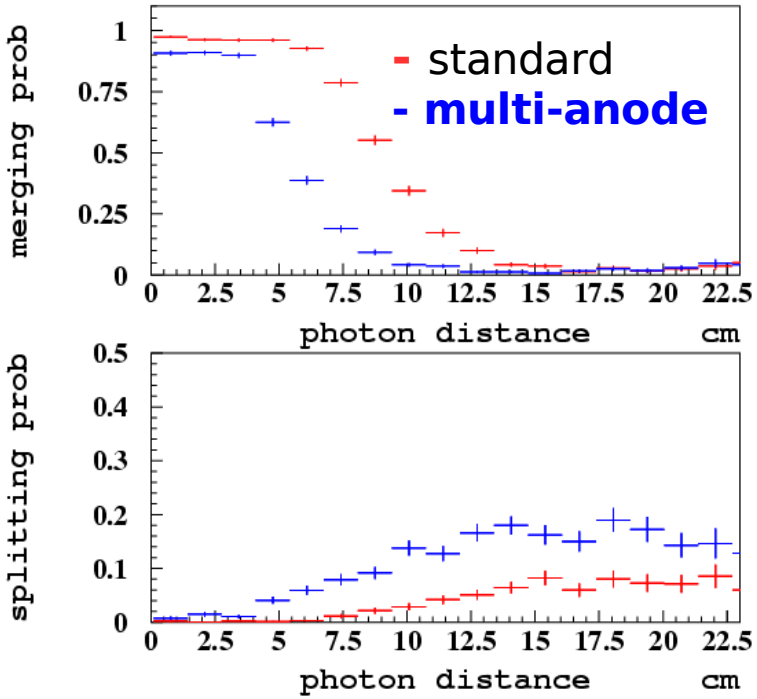
Standard algorithm lowering the cut at 4 cm
The splitting is out of control

$E_1 = E_2 = 300$ MeV



7 MeV cut on small clusters

$E_1 = 50$ MeV
$E_2 = 300$ MeV



How to increase granularity?

Improvement factor **4.5** **4**

Software granularity 20 cm → Hardware granularity 4.4 cm → Multi-anode 1.1 cm

New algorithm

new algorithm + hardware upgrade

Campana's proposal: “Let's give 10% of the money we need for the hardware upgrade to someone that rewrites the clustering”.

Barrel upgrade price:

24*12*5 cells = 1440*2 multianodes = 2880*1000 = 2880000/10 = 288000 € = 19 X my year fee
(IT IS WORTH TO TRY!!!)

Who is doing it?

Of course Pierluigi was joking, so we need people that collaborate in doing it.

The Polish group (Pawel + students) has expressed interest in doing it (the same day of the meeting while coming back to home)

I was in Poland in December to describe them the calorimeter and how to use the FLUKA simulation in order to study the clustering;

Two weeks ago they came here, and showed us the working principle of the algorithm. Then Erik Czerwinsky and me started to implement it.

New clustering algorithm development

Global redesign of the clustering

requirements

- improving the merging/splitting probability;
- easy to adapt at higher granularity (to make Branchini happy);

- Usable also in KLOE
  1) Graziano cannot complain that we use KLOE resources for KLOE2;
  2) It is a benefit for cluster merging dominated analyses (a_0, $\eta \to \pi^0\gamma\gamma$, ε'/ε)

Method

Old clustering

topological merging of the cells, cut based criteria:

1) distance (merge cells)

2) Time rms split clusters (rms)

New clustering

1) likelihood implementation of time, energy and multiplicity distributions, able to distinguish between 2 particles candidates and 1 particle candidate

2) Optimization of the clustering with different particle hypotheses (electron-photons, muons-pions)

Algorithm scheme step 1

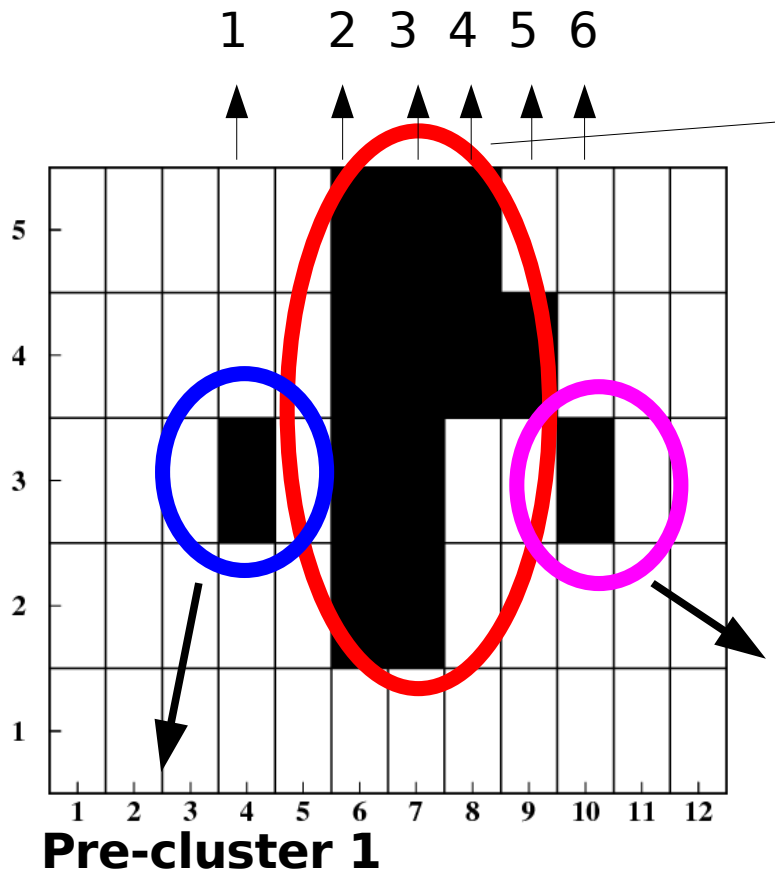
Build preclusters → Pre-cluster validation → Pre-cluster merging → Final cluster

Project cells of both sides on one side.

Group connec-ted cells on the same column.

Group column in pairs if they have at least one cell side connected.

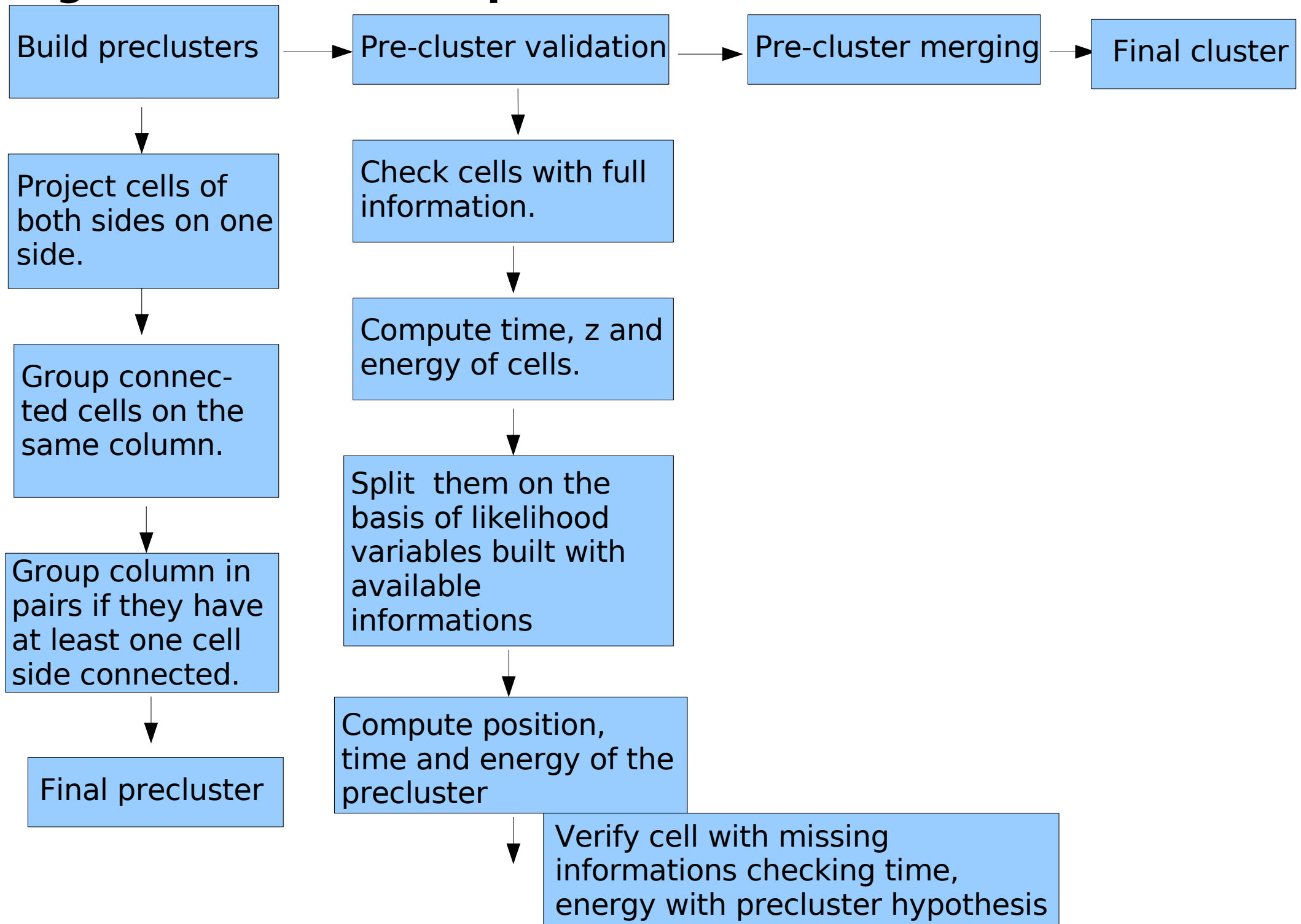
Final precluster



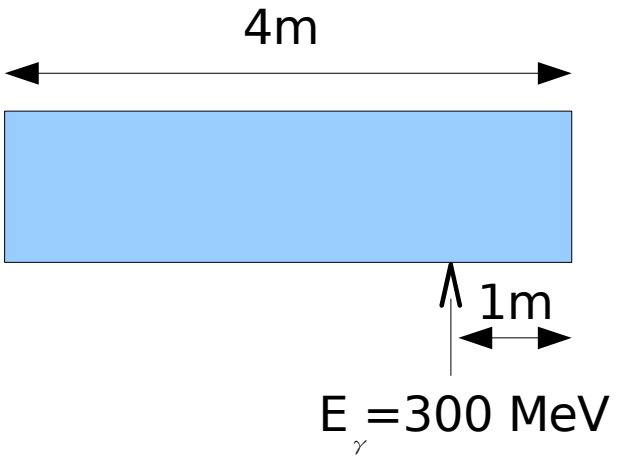
Two cells are connected if they touch on a full side

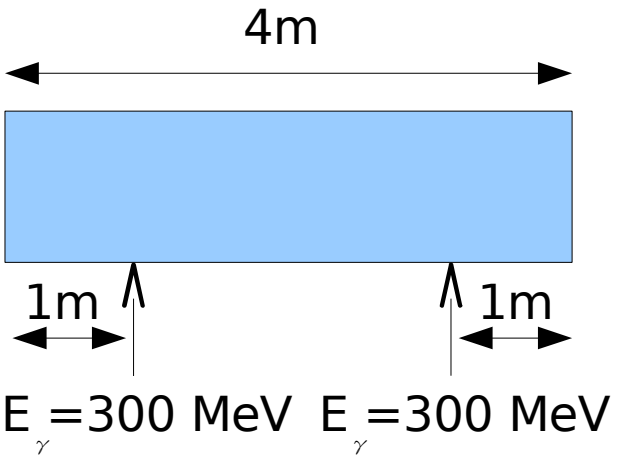
side A + B

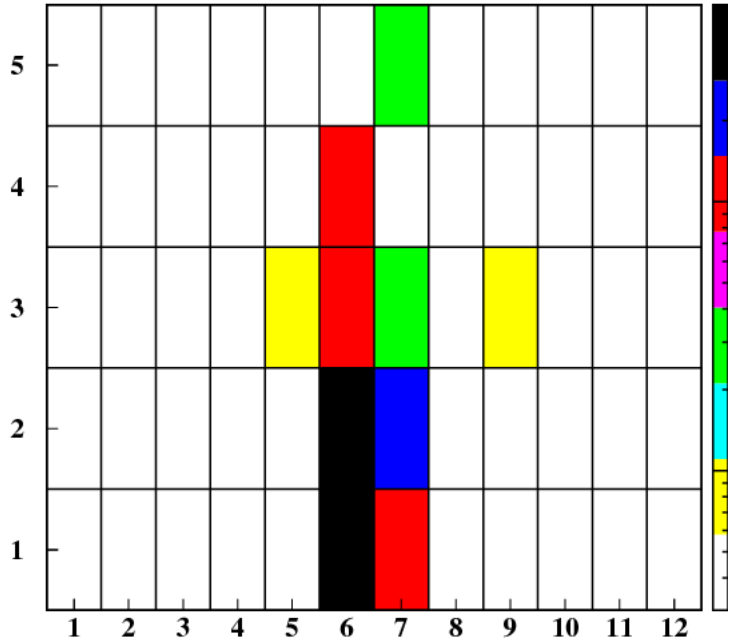
Algorithm scheme step 2

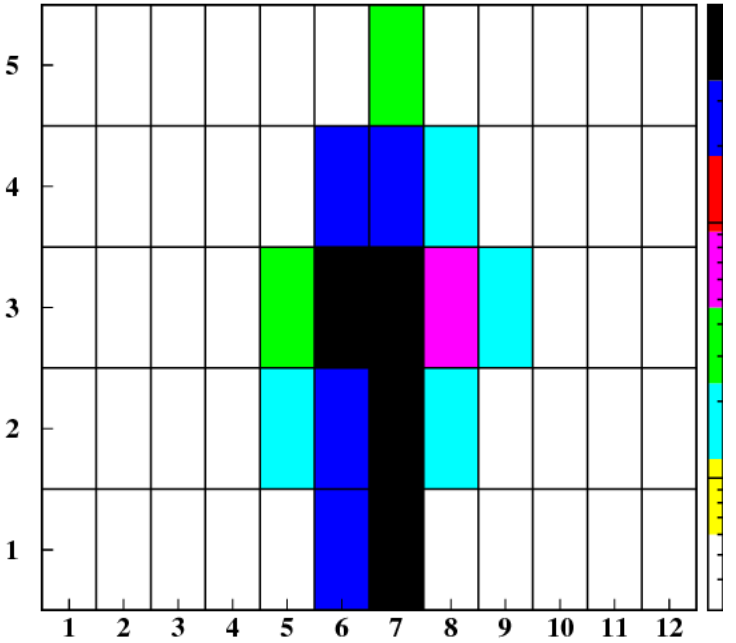


Possible topology identification

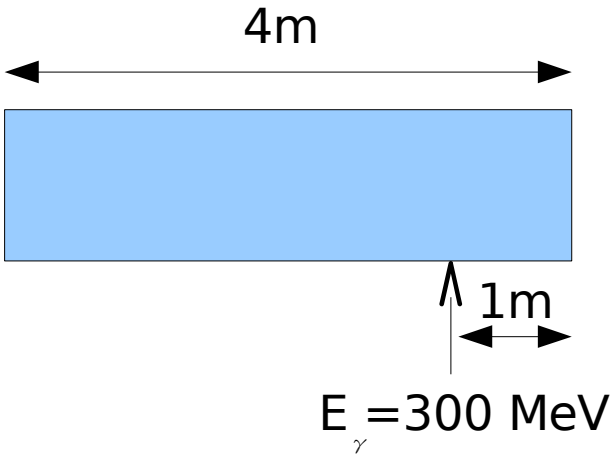


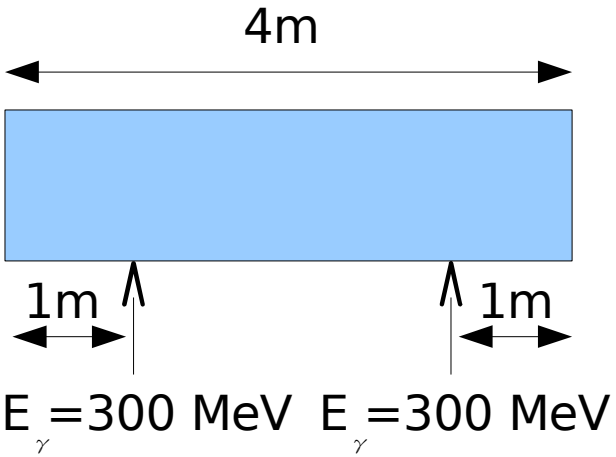






ΣE


4m
1m
E γ =300 MeV


4m
1m
1m
E γ =300 MeV
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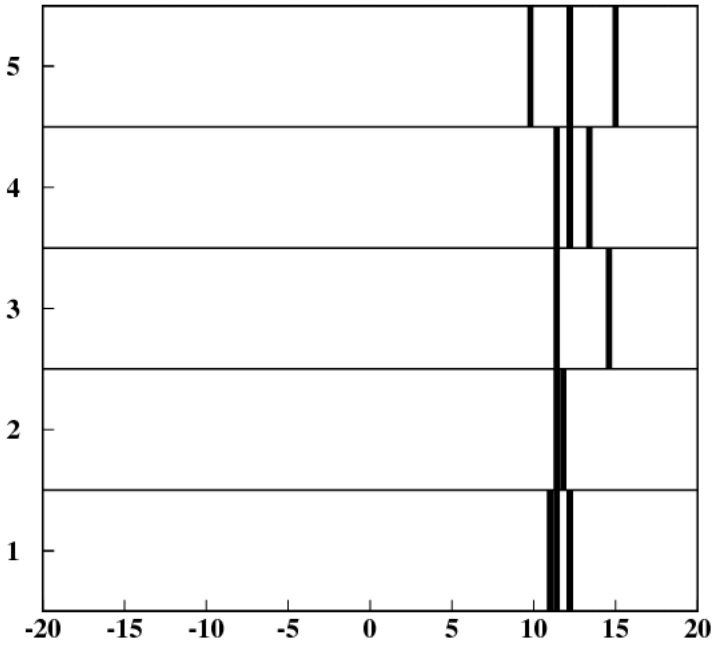
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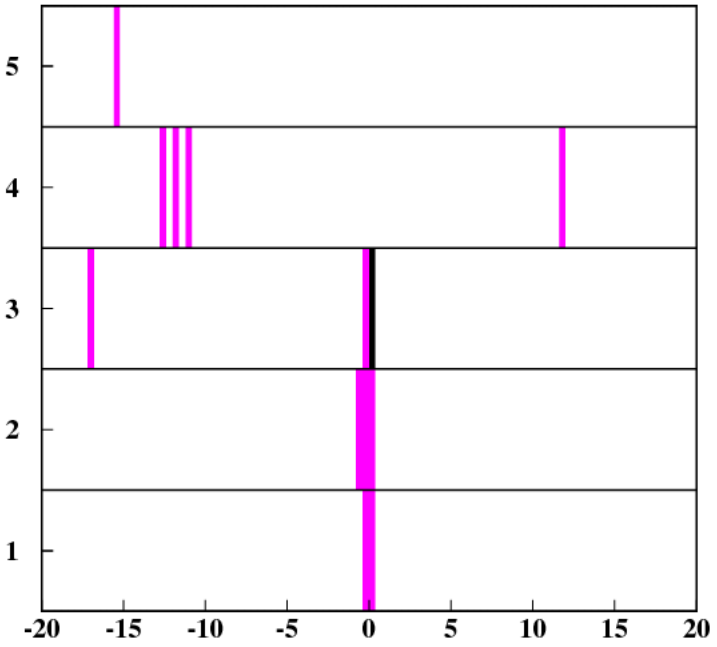
20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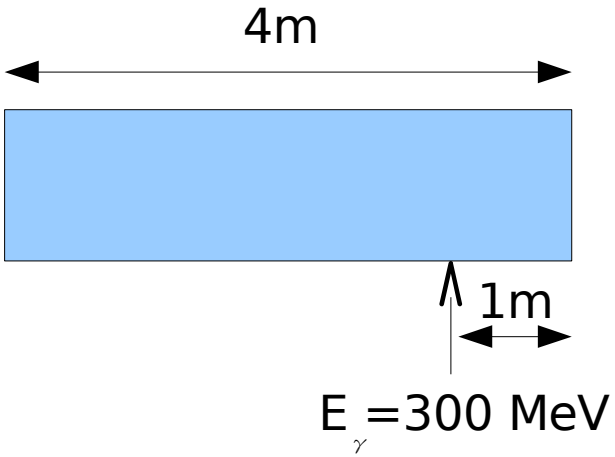
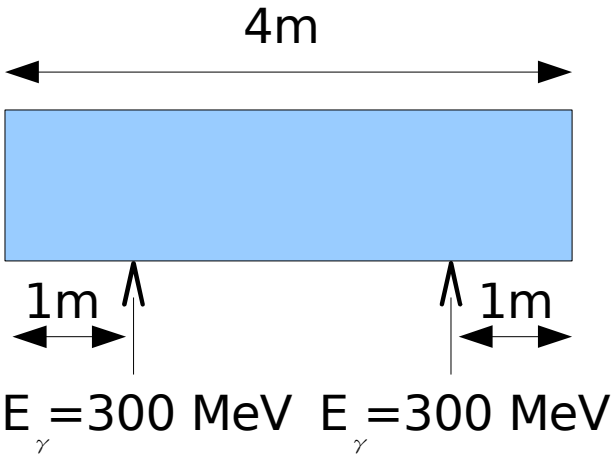
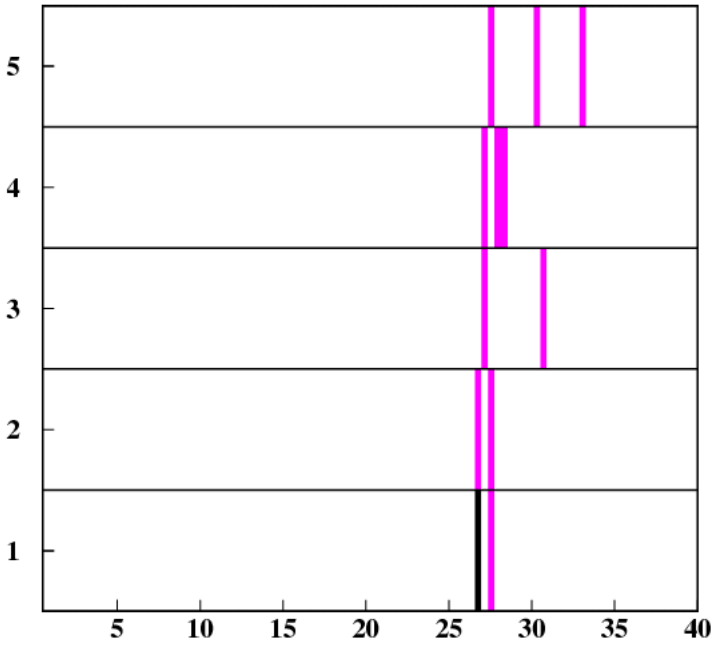
20

Δt


4m
1m
E γ =300 MeV


4m
1m
1m
E γ =300 MeV
E γ =300 MeV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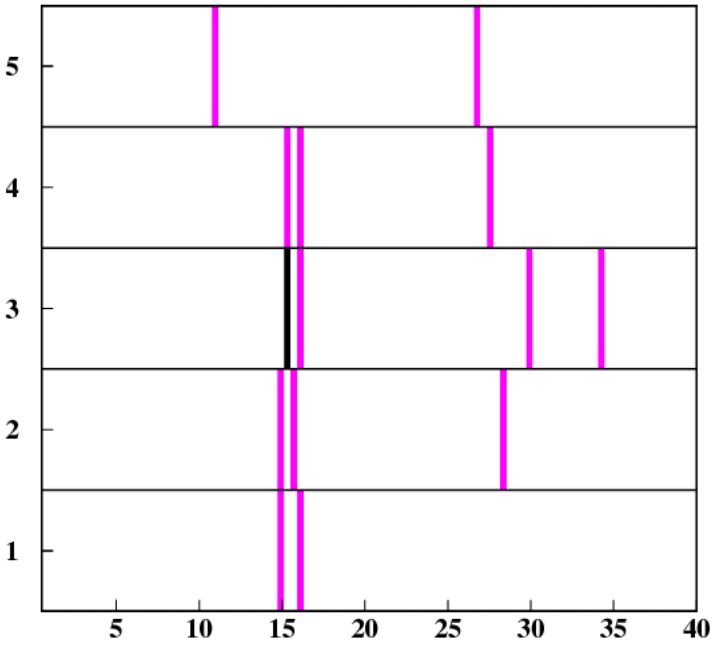
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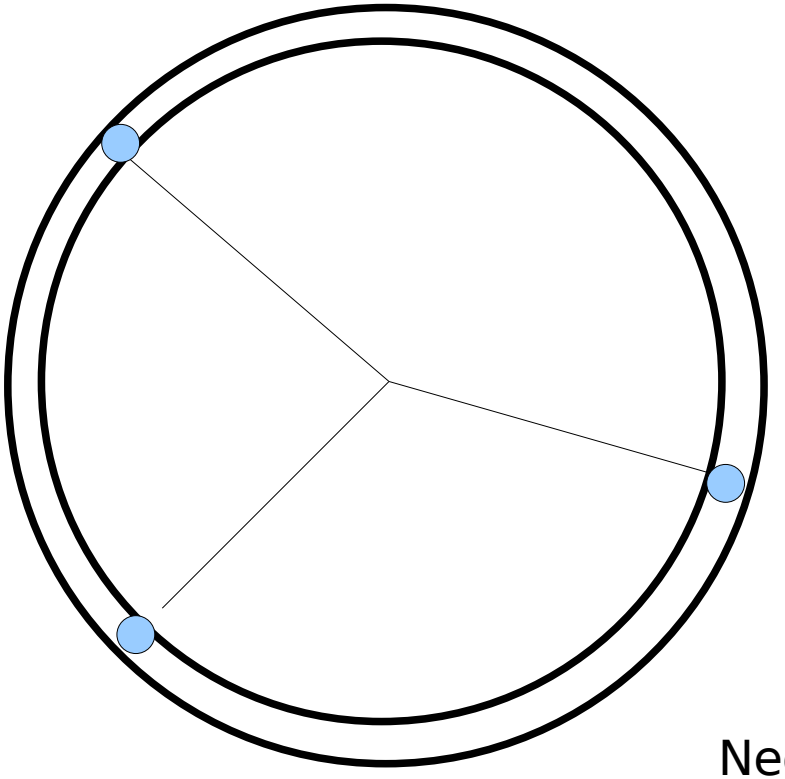
Σt

Control sample selection for likelihood tuning no merging case



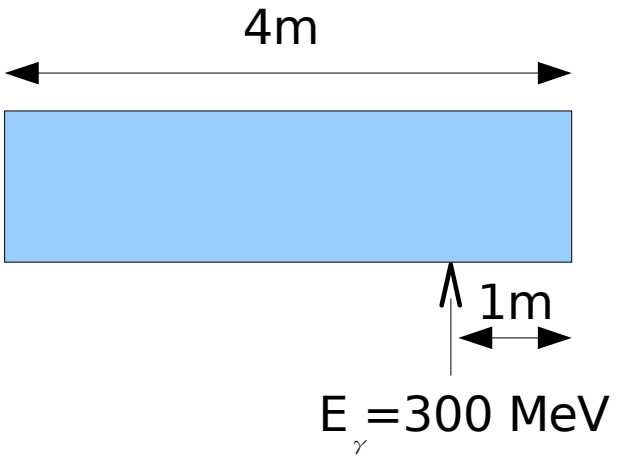
$$\phi \rightarrow \eta\gamma, \eta \rightarrow \gamma\gamma$$

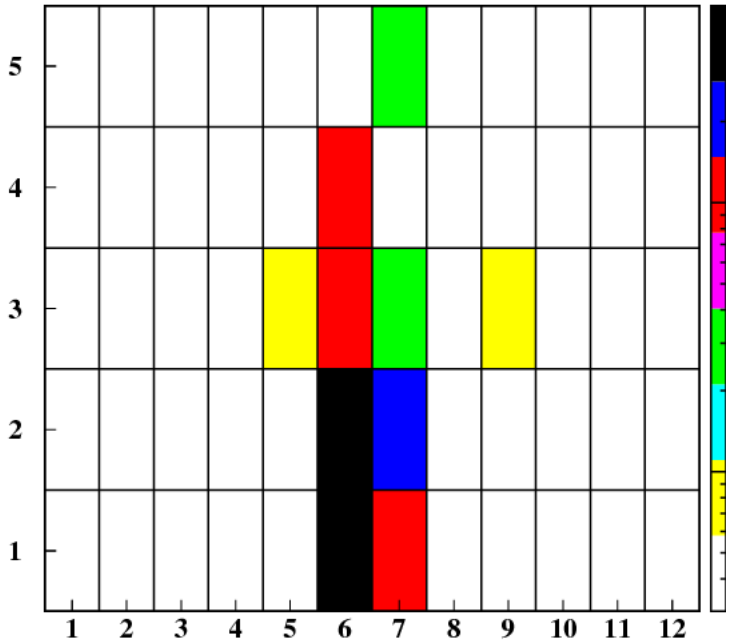
1) Very clean signal

2) The energy of the photons is given by the kinematic fit at 1 MeV level

Need to run on “rad” stream.
No cell information on 'drn' stream.
Average number of files 15 / run
Easy to load more than 100 files: 10 runs bunch.

MC


4m
1m
E γ =300 MeV


5
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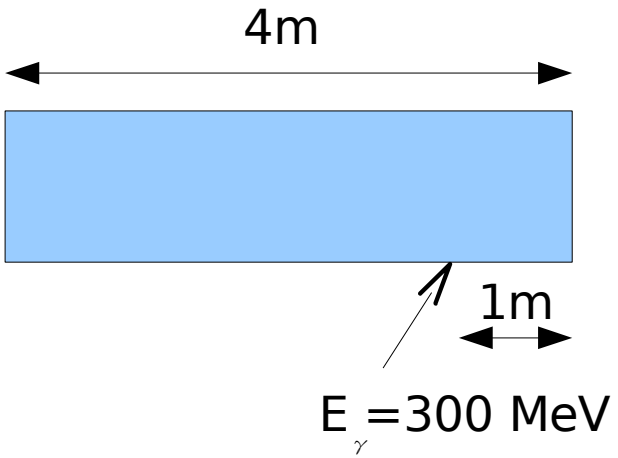
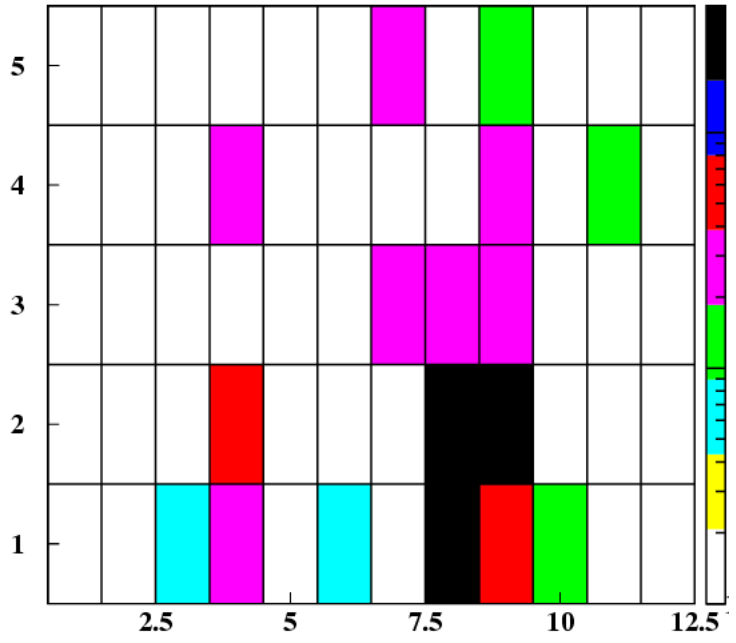
DATA


4m
1m
E γ =300 MeV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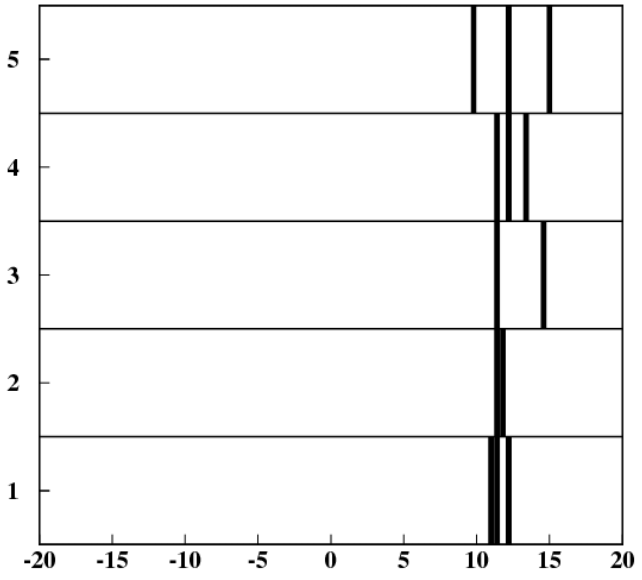
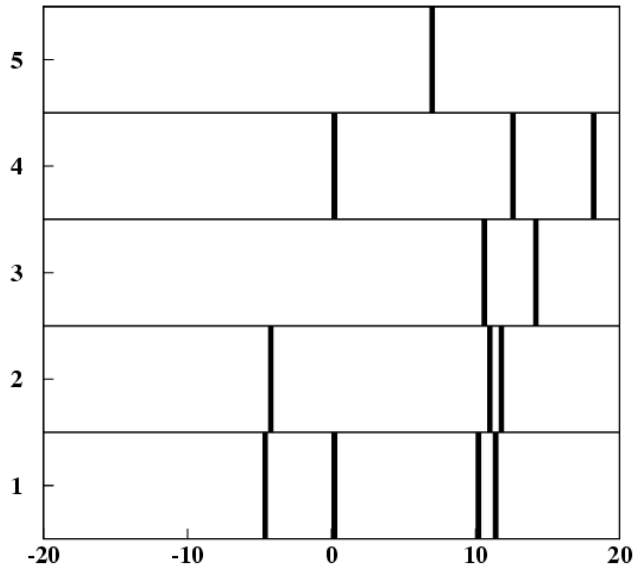
2.5
5
7.5
10
12.5

MC

DATA

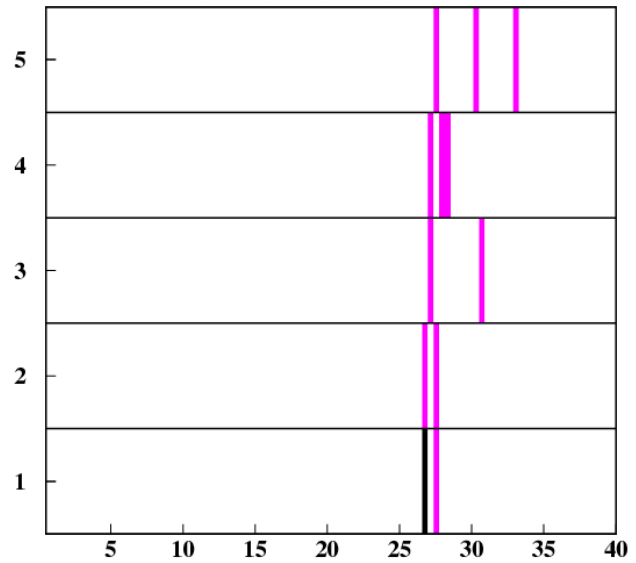
Δt

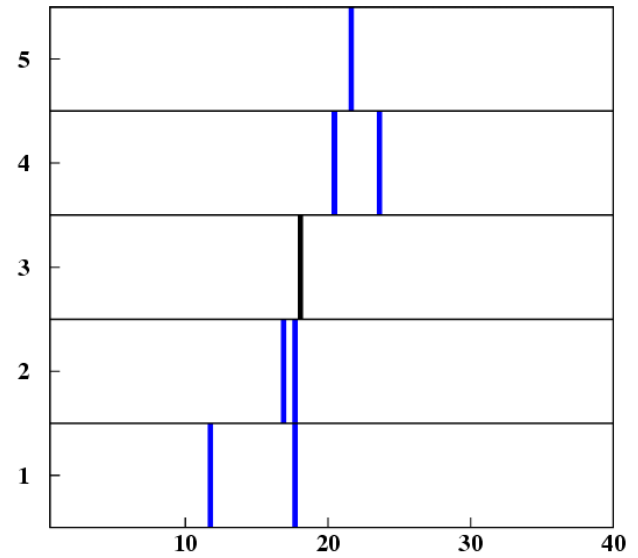




Possibility to reconstruct particle direction using hits pattern?

Σt

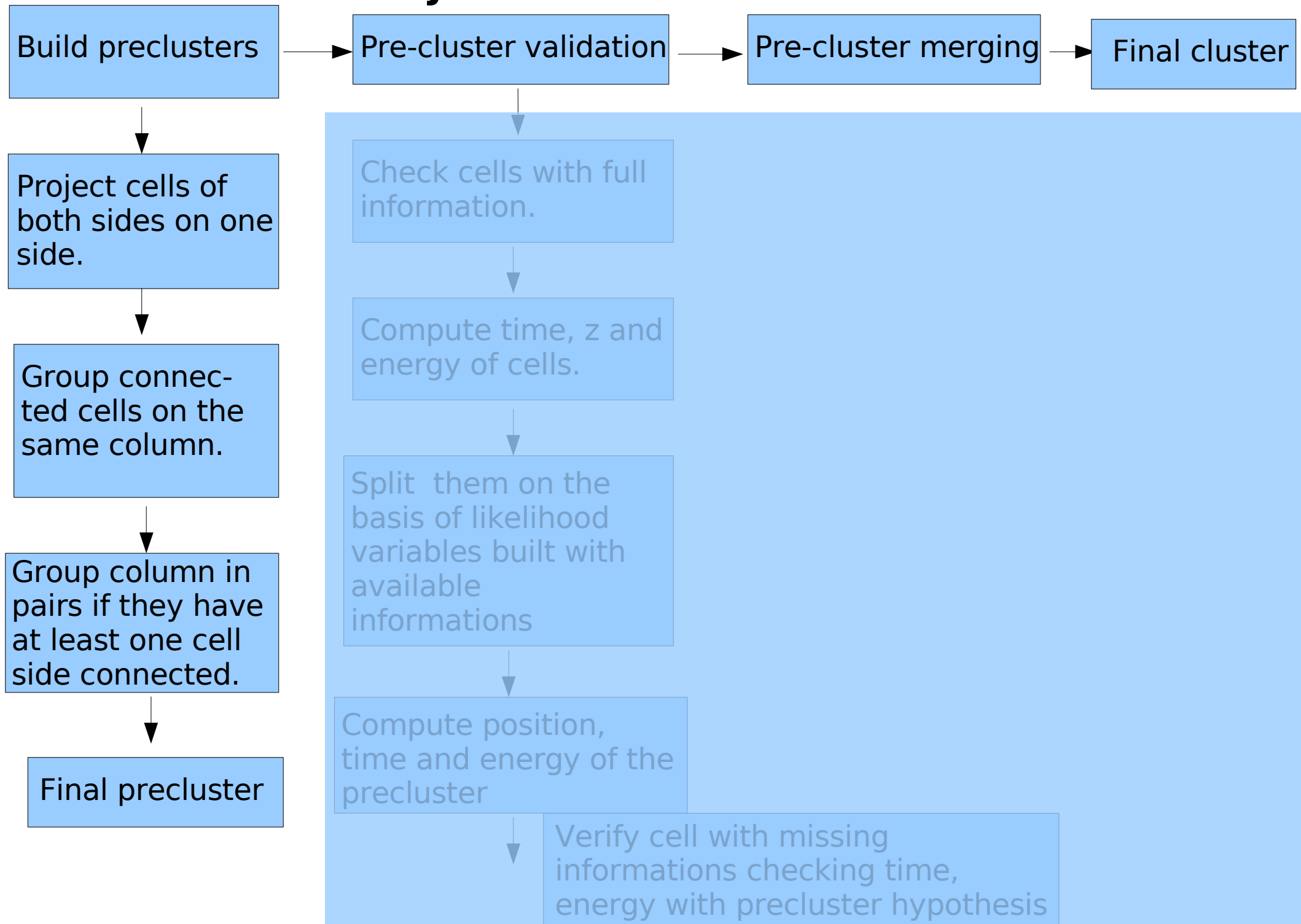




MC

DATA

Status of the job



Resources working on it

- Moskal + students 100% but the starting time is not known (students are still involved in exams);

- Czerwinski 10 % - 20 % (some hours for week but continuous work)

- B. Di Micco supervision and suggestions