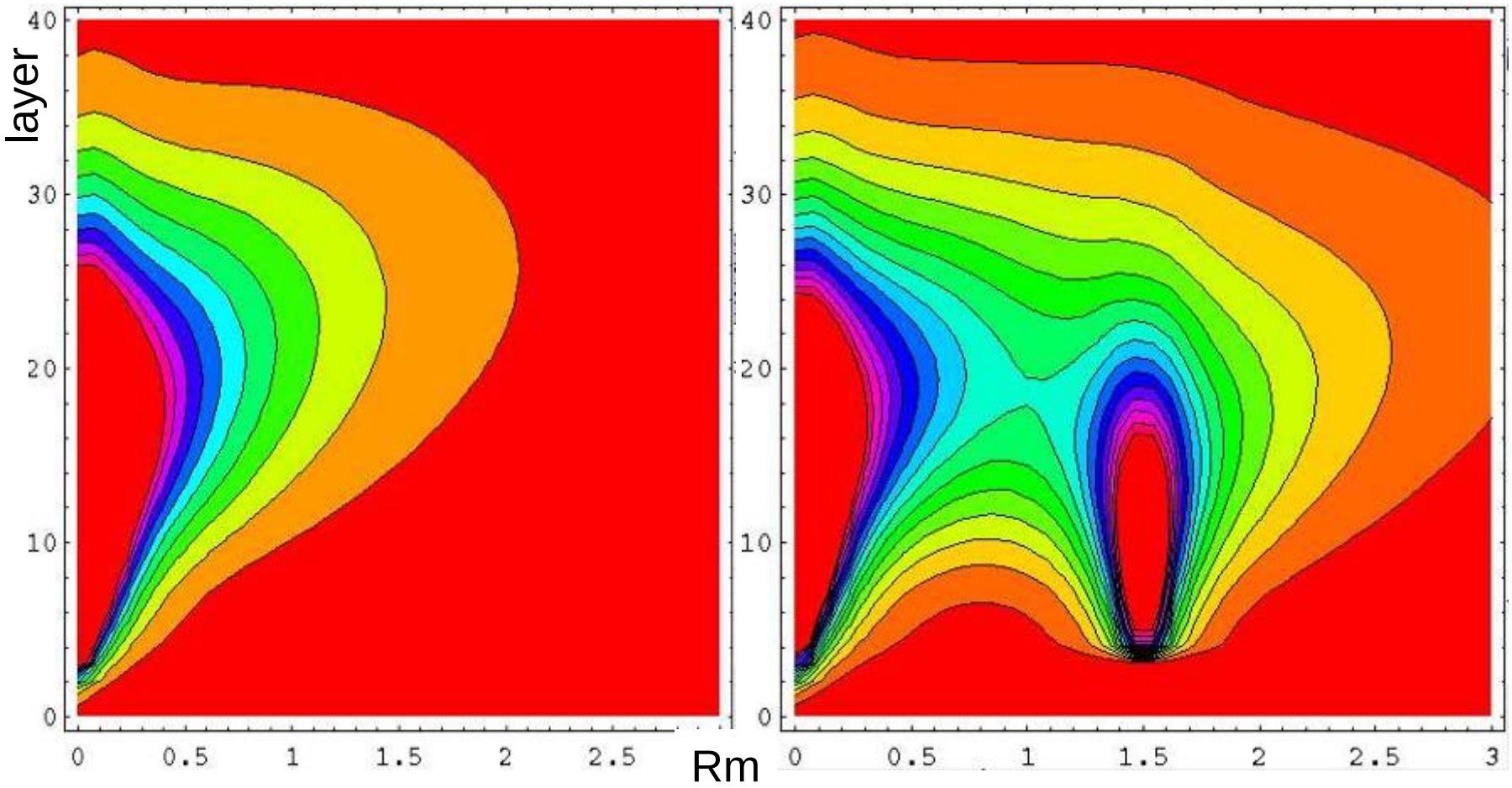
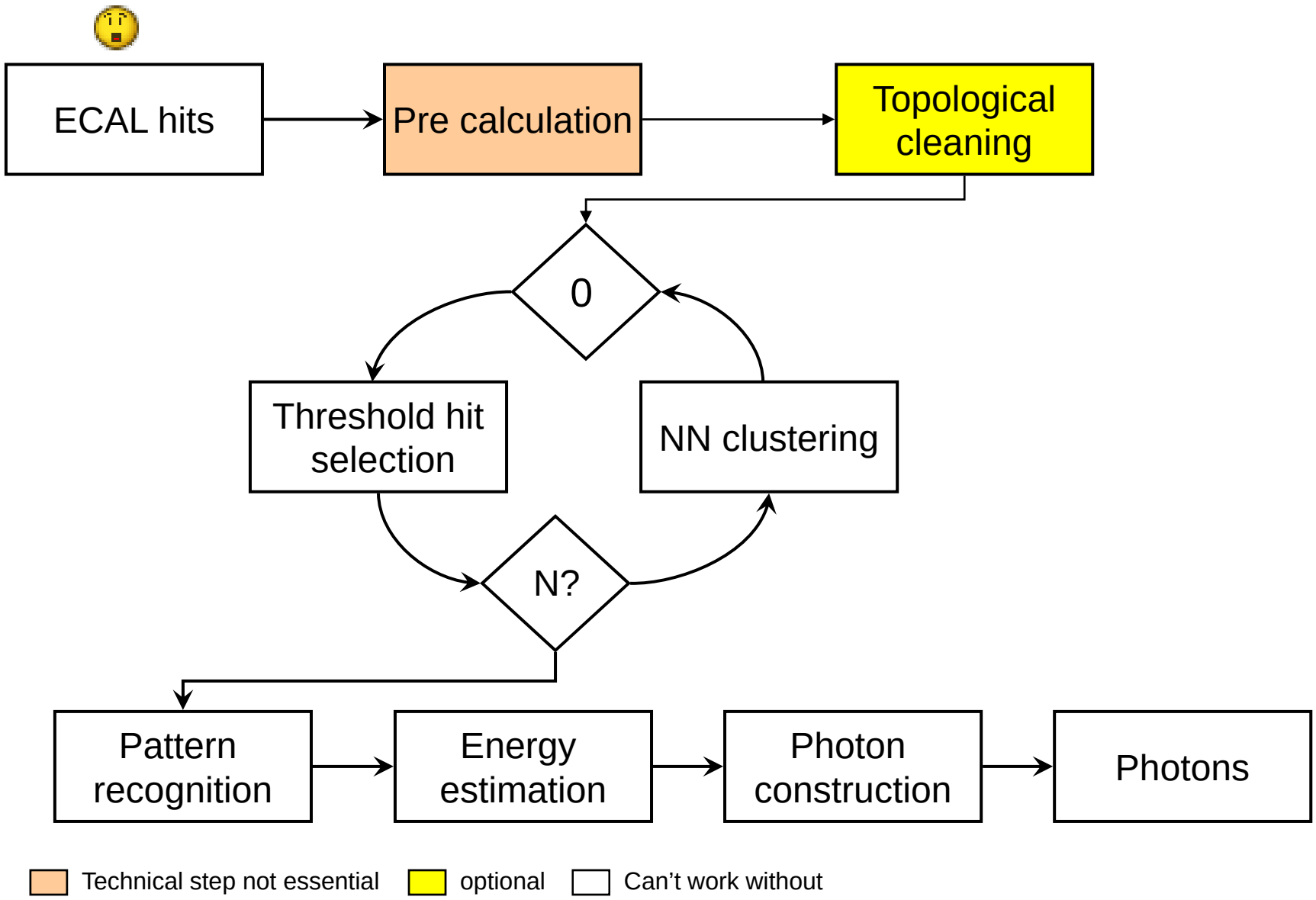
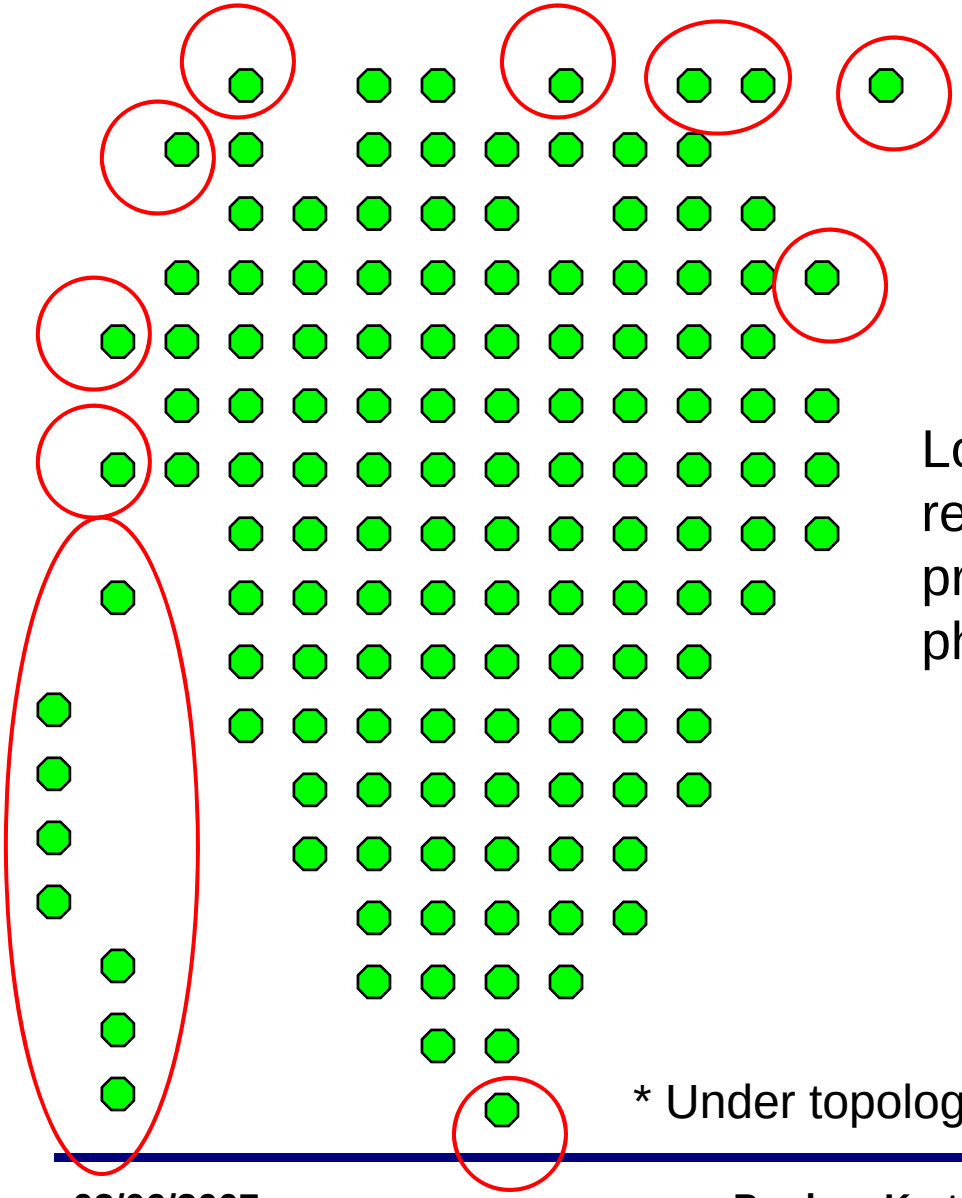
Photon Reconstruction

3D photon shower profile



Integral over the ring with dr=cell size (10mm) for photon shower profile , left single 10GeV photon, right 10GeV and 4GeV photon

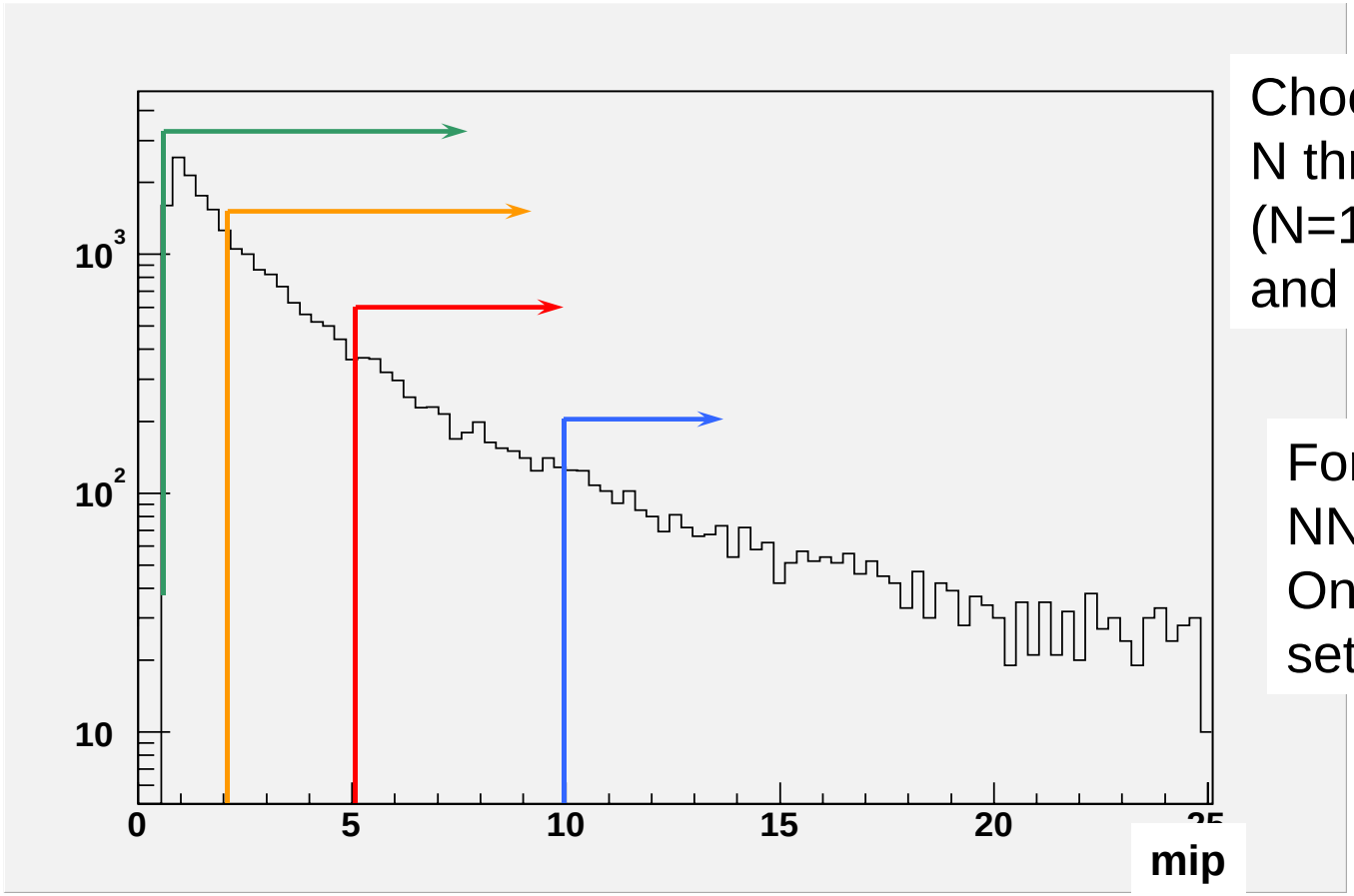

ECAL hits
Pre calculation
Topological cleaning
0
Threshold hit selection
NN clustering
N?
Pattern recognition
Energy estimation
Photon construction
Photons
Technical step not essential
optional
Can't work without



Hits are divided
Into two classes
$N_{neighbors} <= X$
and $N_{neighbors} > X$
(at the moment X=4)

Low topology* hits are then removed from further steps of procedure till the final one photon construction

* Under topology one means number of neighbors

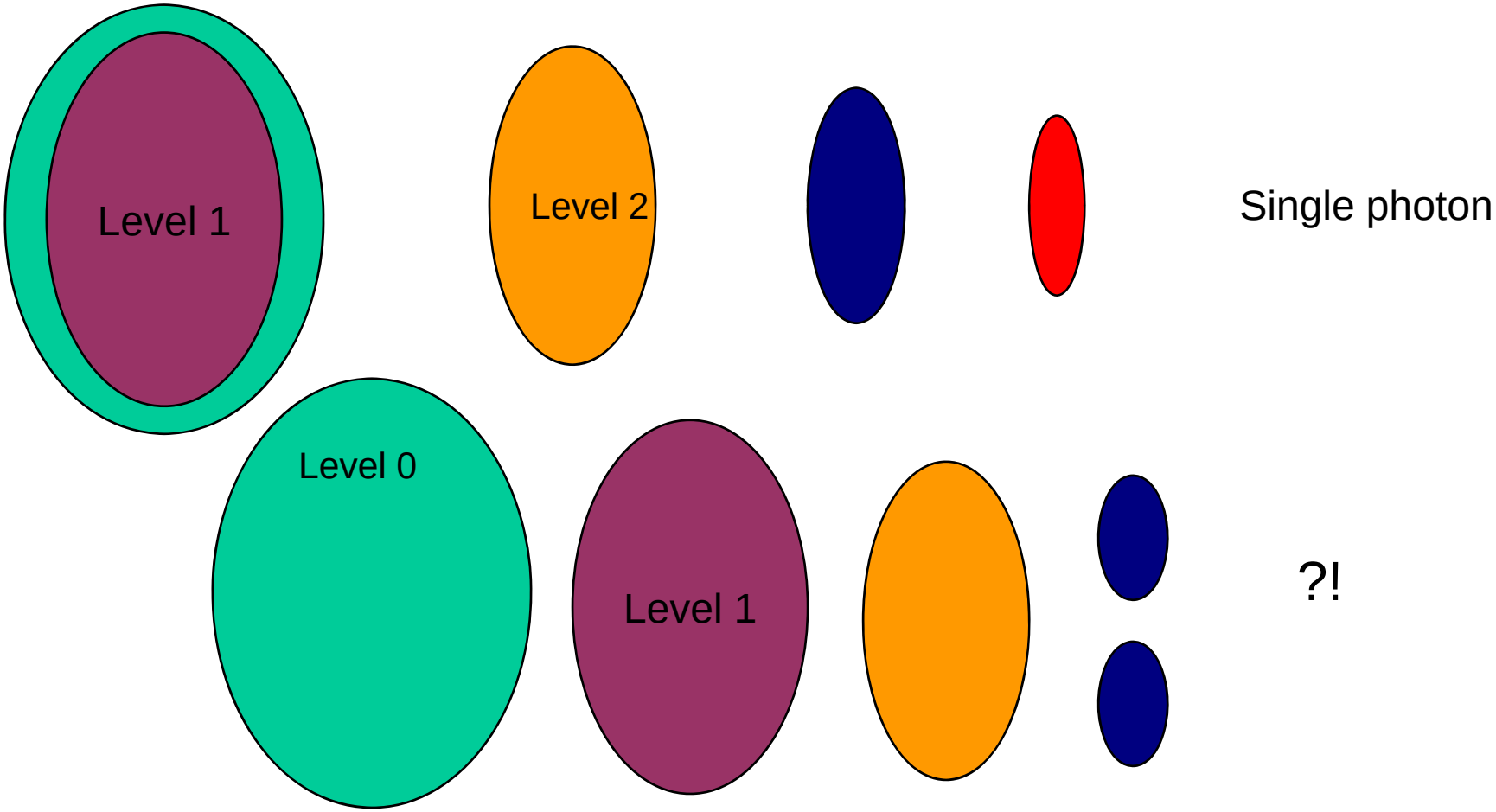


Choose
N threshold levels
(N=10 at the moment)
and get N sets of hits

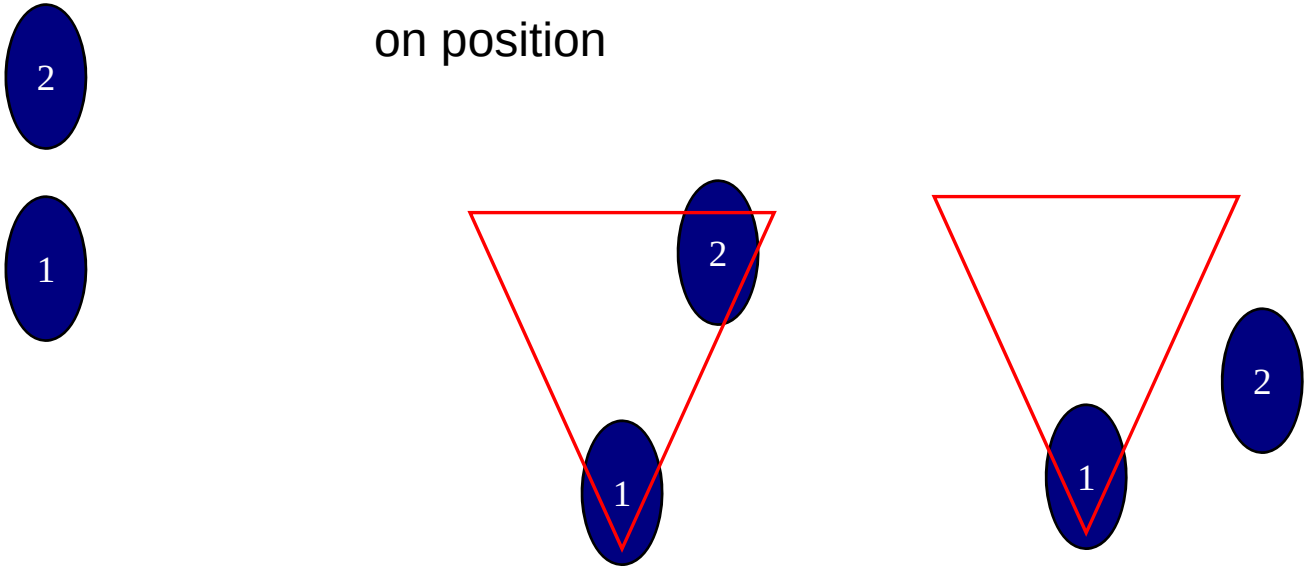
For each set do a
NN clustering
Only in particular
set!!

- Exponential distribution of the energy in hits
- don't' forget that full energy range of the photons is from detection threshold till CMS Energy/2.0

At this stage you have set of NN clusters for different thresholds levels
What would one expect in case of no fluctuation



Decision when to split
on size
on position



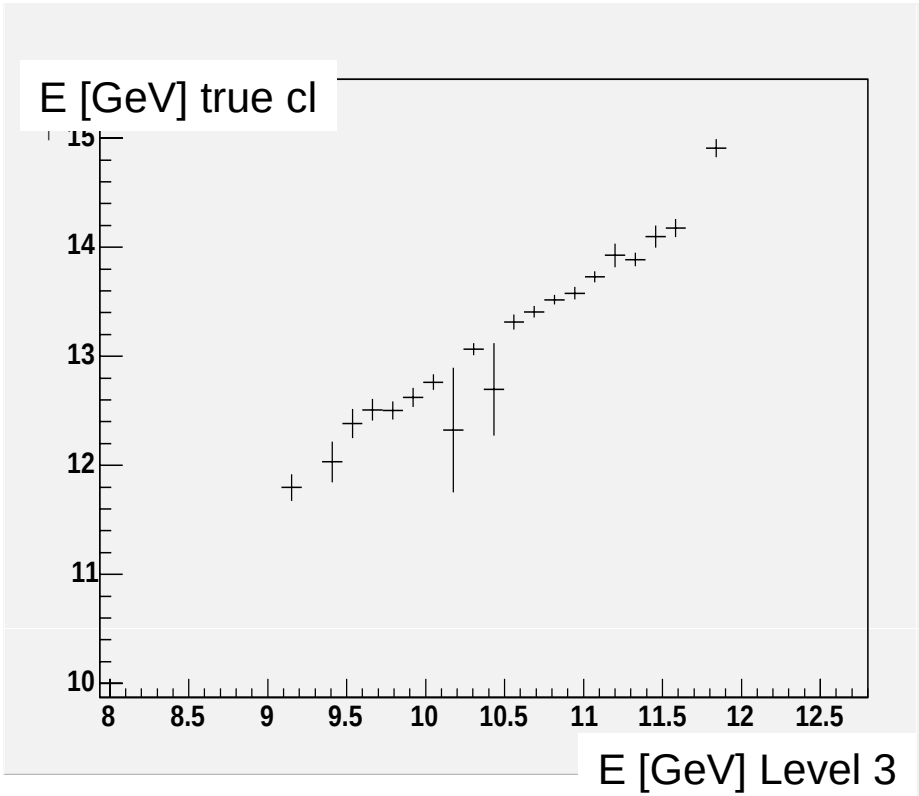
No split Split

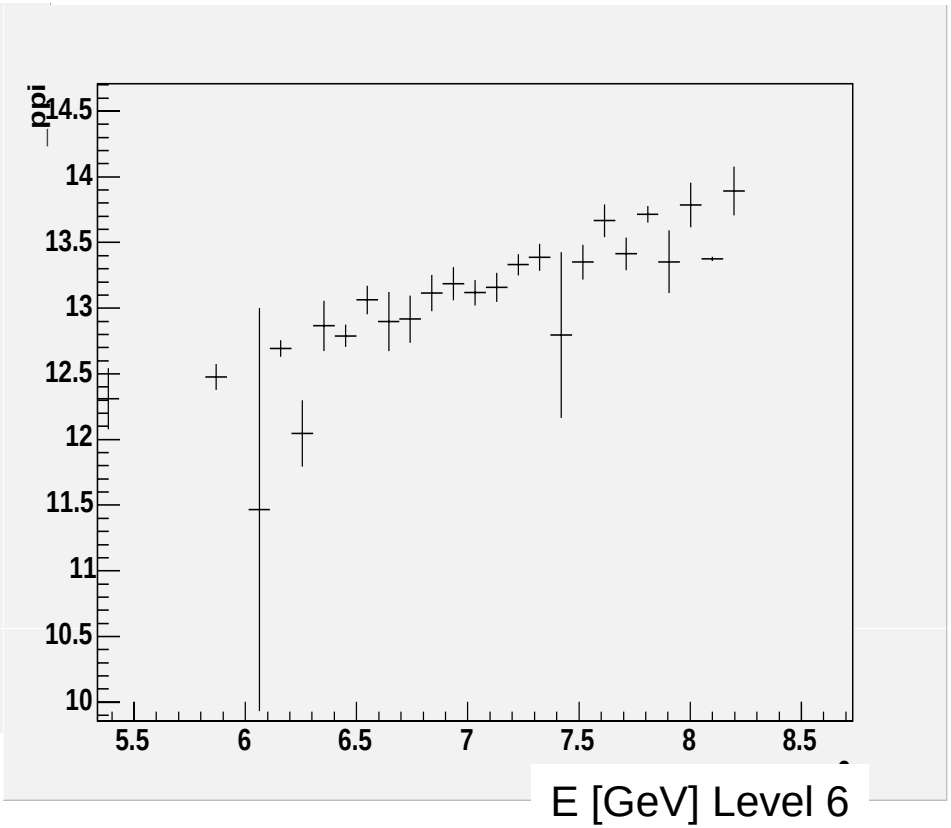
“Split” means that each of the clusters is now considered as a photon core

At the end of procedure we have a set of clusters with their level that are considered **“cores”** of EM shower

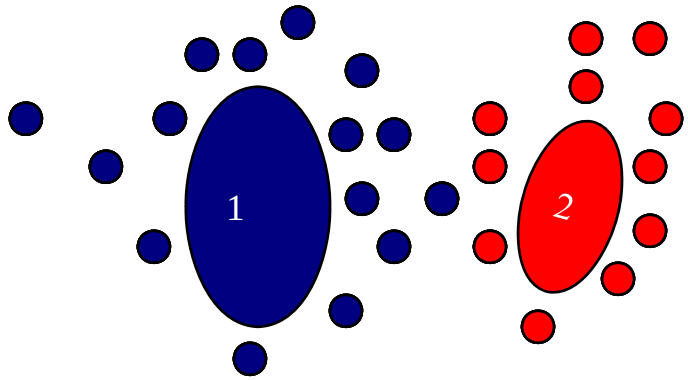
• Energy estimation in terms of algorithm means procedure to get an estimate of incoming photon energy based on the core energy and the cluster level

•linear parameterization was chosen as appropriate





• At this stage you have a set of Energies, directions and starting points
• now it's possible to apply full 3D model for the photon
• now the we take into account all the hits !! (irrespective of number of neighbors)
• material parameters for the model must be provided from geometry package



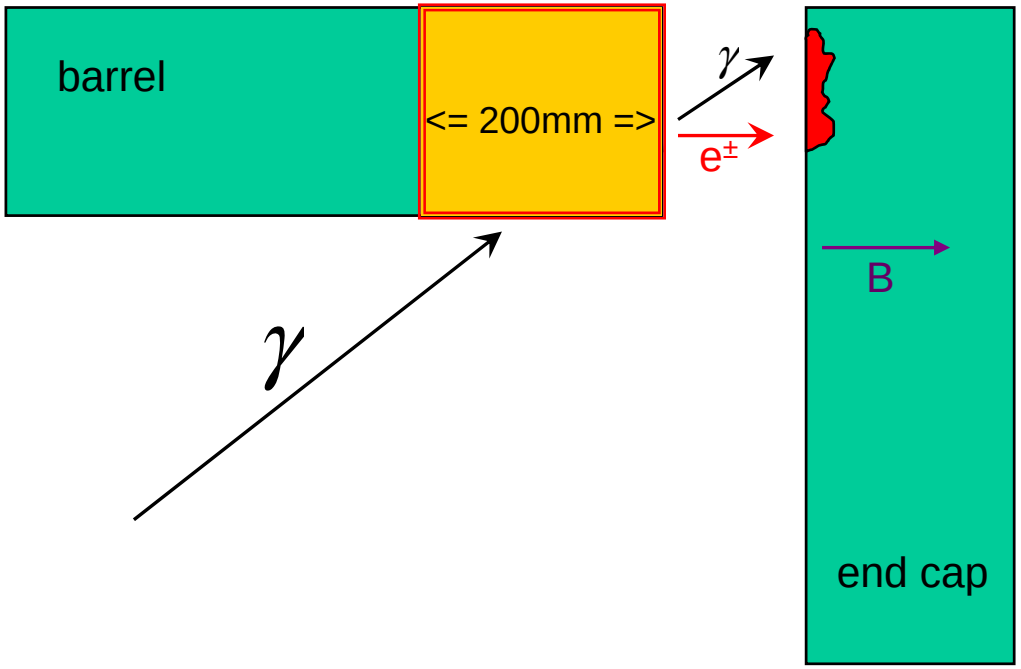
• spread the probabilities for first

• spread the probabilities for second

• if more then one contribution in hit pick the larger one

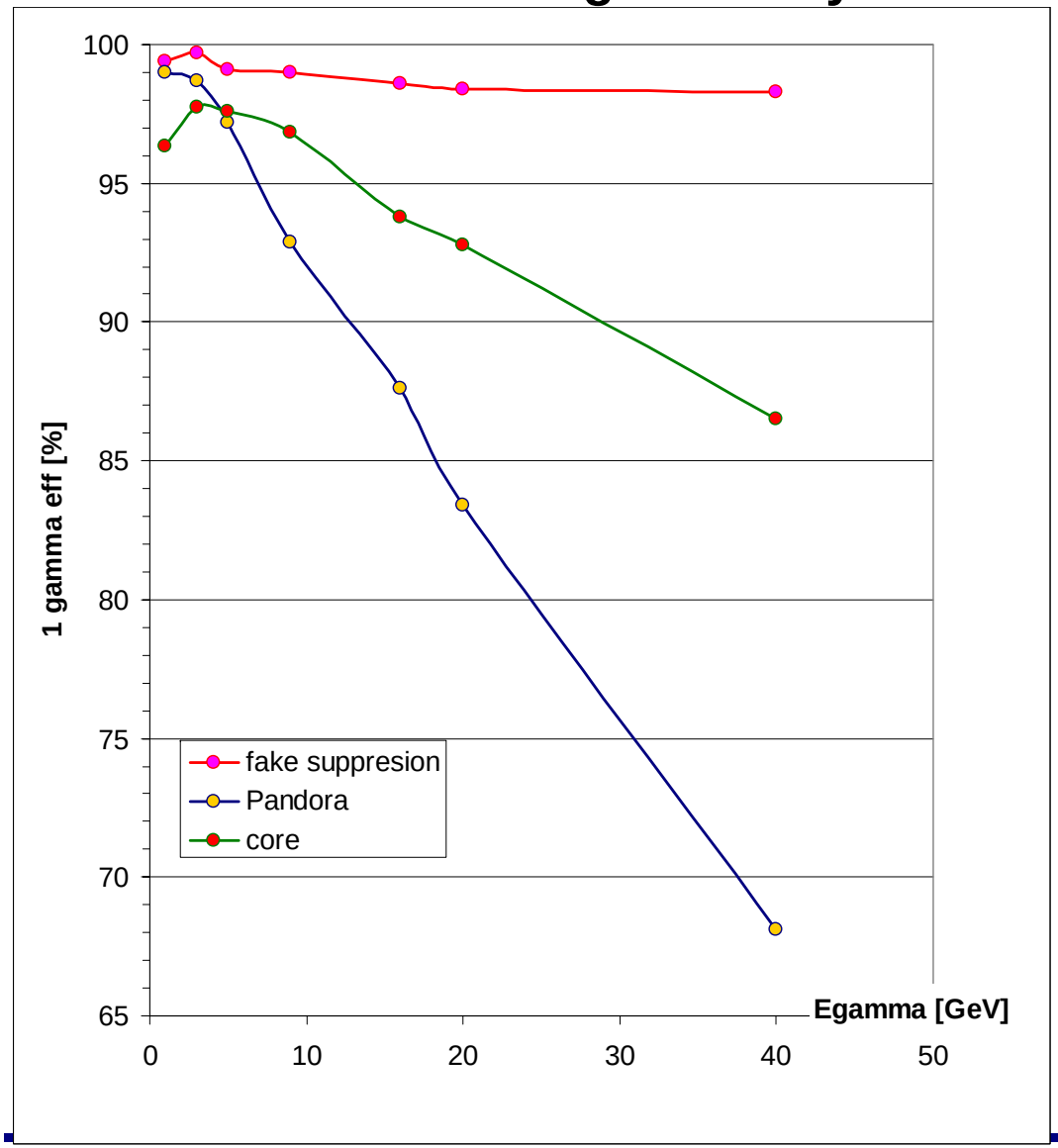
• now assign

“Corner” problem

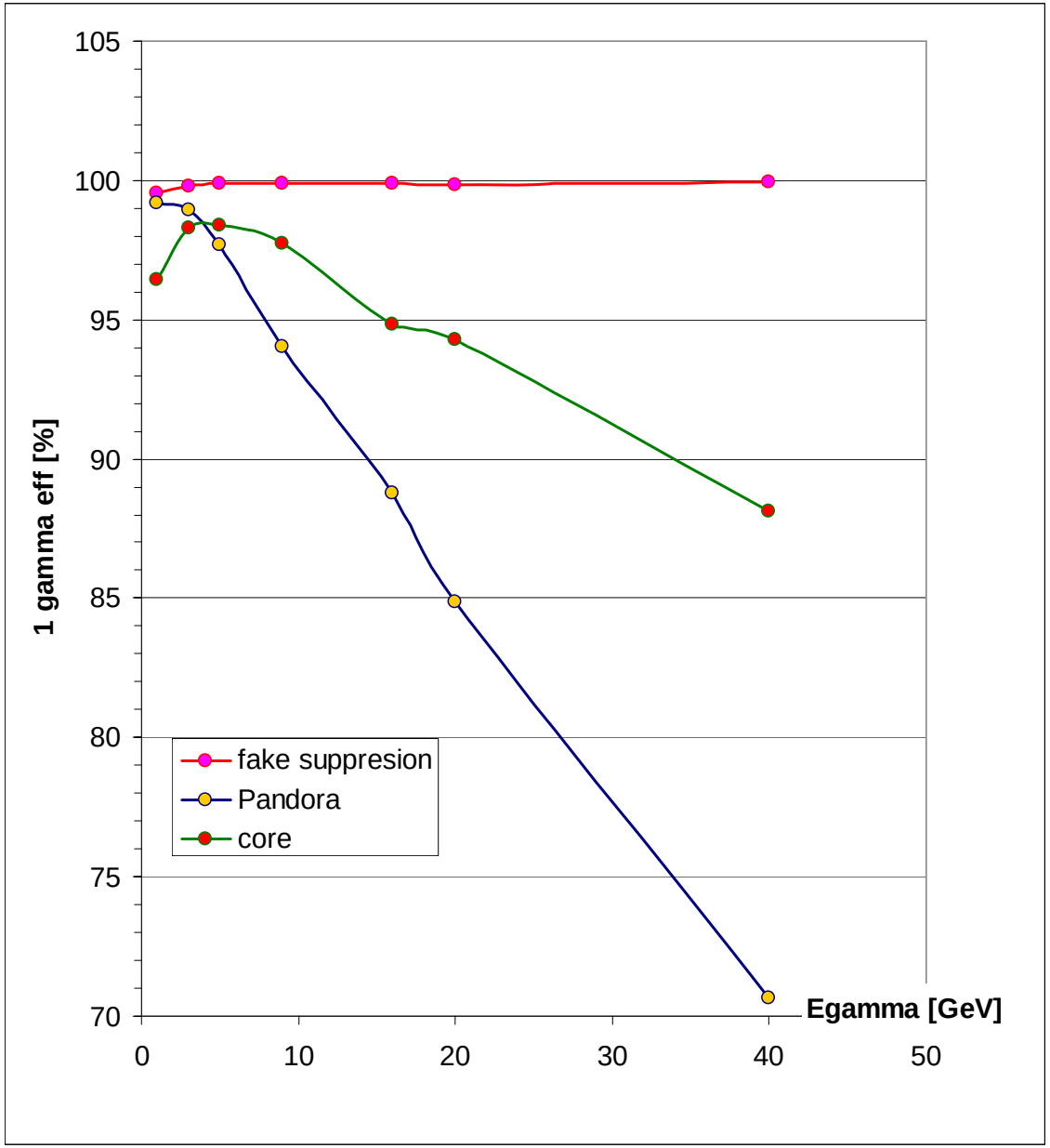


Two selection criteria : photon end in ECAL
photon end in ECAL + corner region excluded

Single photon efficiency ≡ **shoot one** in ECAL
get exactly one from reconstruction



For full sample of photons



Sample with corner excluded

Key words to remember

- **WYSWYG** principle i.e. use imaging calorimeter as you should

- **Inverse engineering** - calorimeter gives enough information to enable photon construction using EM shower model. (good estimator of starting point , incoming energy and direction)
- **99+** efficiency for 1 in 1 out - proven for 1-40GeV (no upper limit expected)

- **Fast** - look at appendix

- **Available** - easy download from cvs

- **Supported** - you can always ask me

- **Don't put yourself into the corner**

Appendix beyond this page - all that you wanted to ask but didn't dare

appendix

Event generation and selection

Model - LDC00_02ScP – same as one from the central database if you exchange vtx to cylindrical one.

Generation - single photons - particle gun - uniform smearing over theta phi

List - QGSP

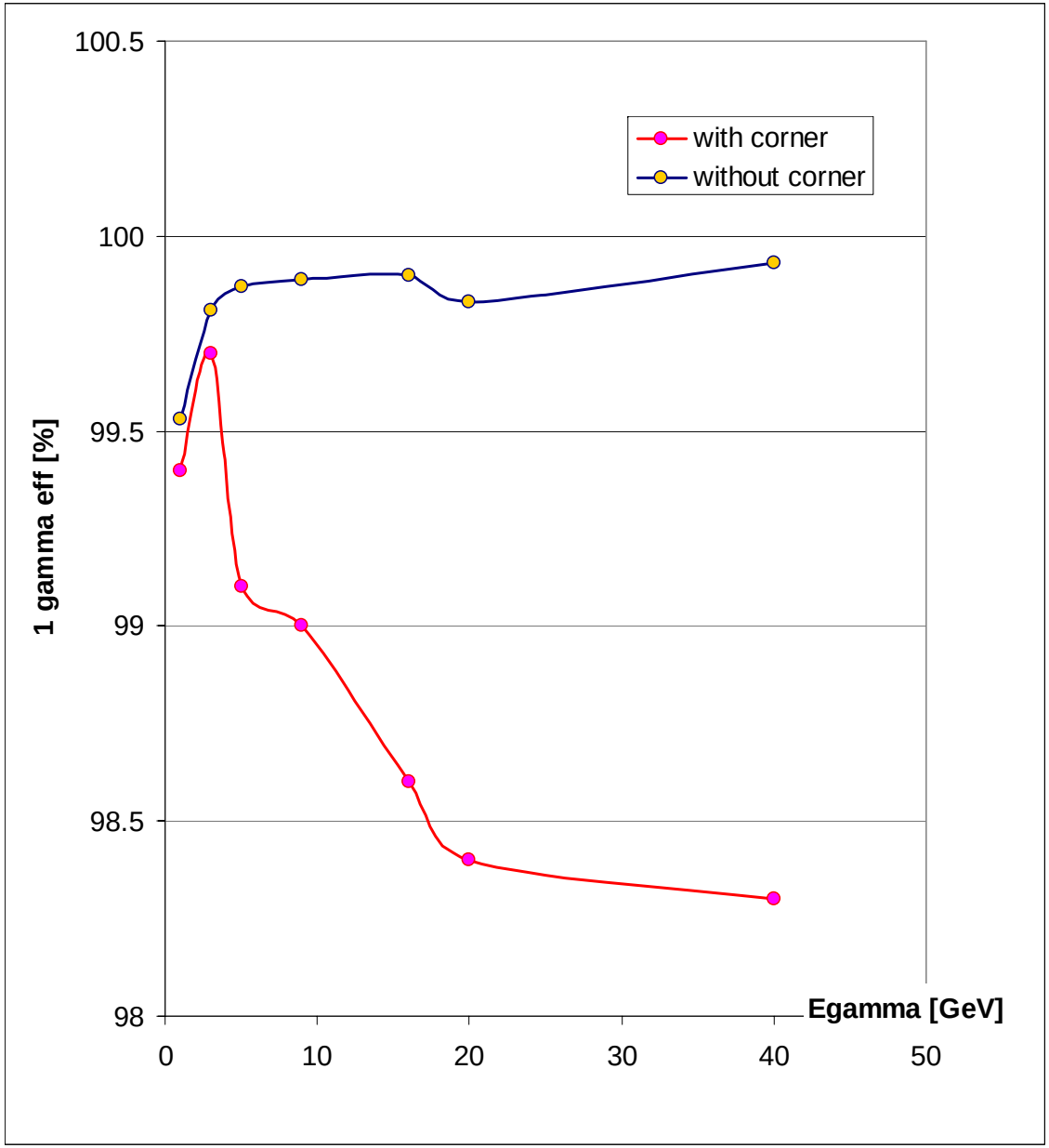
Event selection – to suppress events with conversion in any part of detector before calorimeter only events with photon ending in ECAL are considered , sub sample with excluded barrel end cap transition region (“corner”)

5 or 10k events at 1,3,5,9,16,20 and 40GeV (look at the tables)

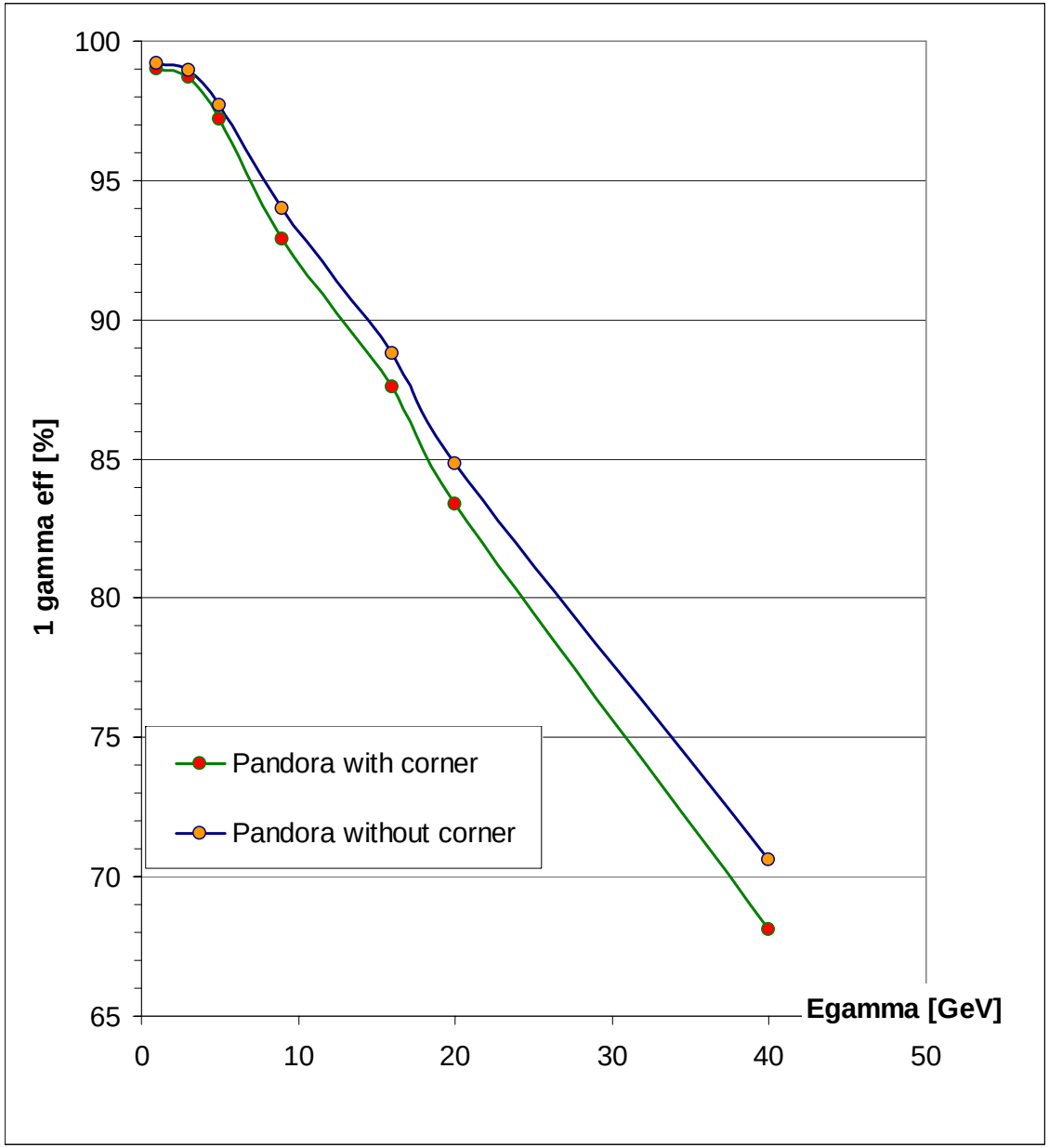
Two stages of the procedure checked

find cores => Ncore => x => photons

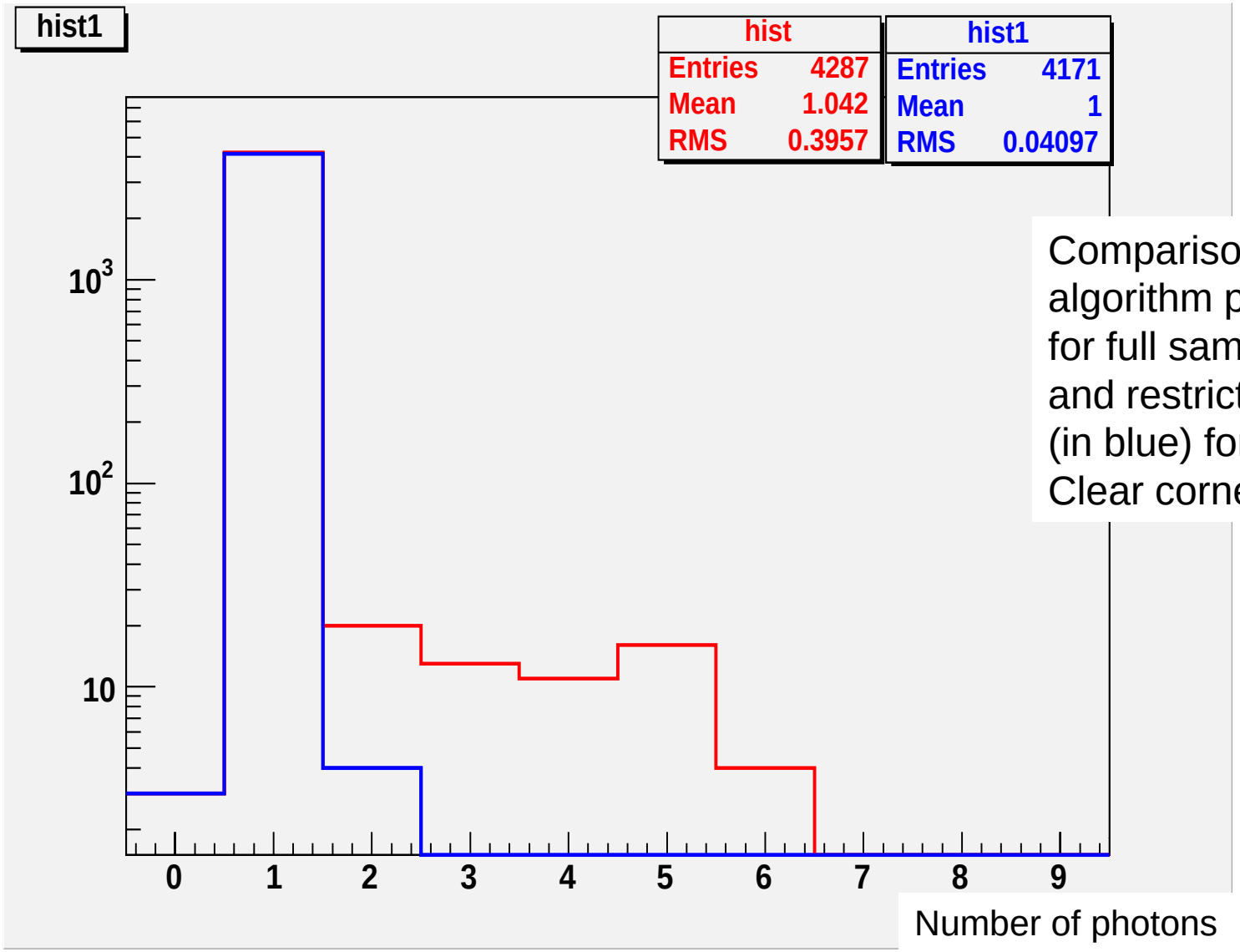
Ncore => fake suppression => photons



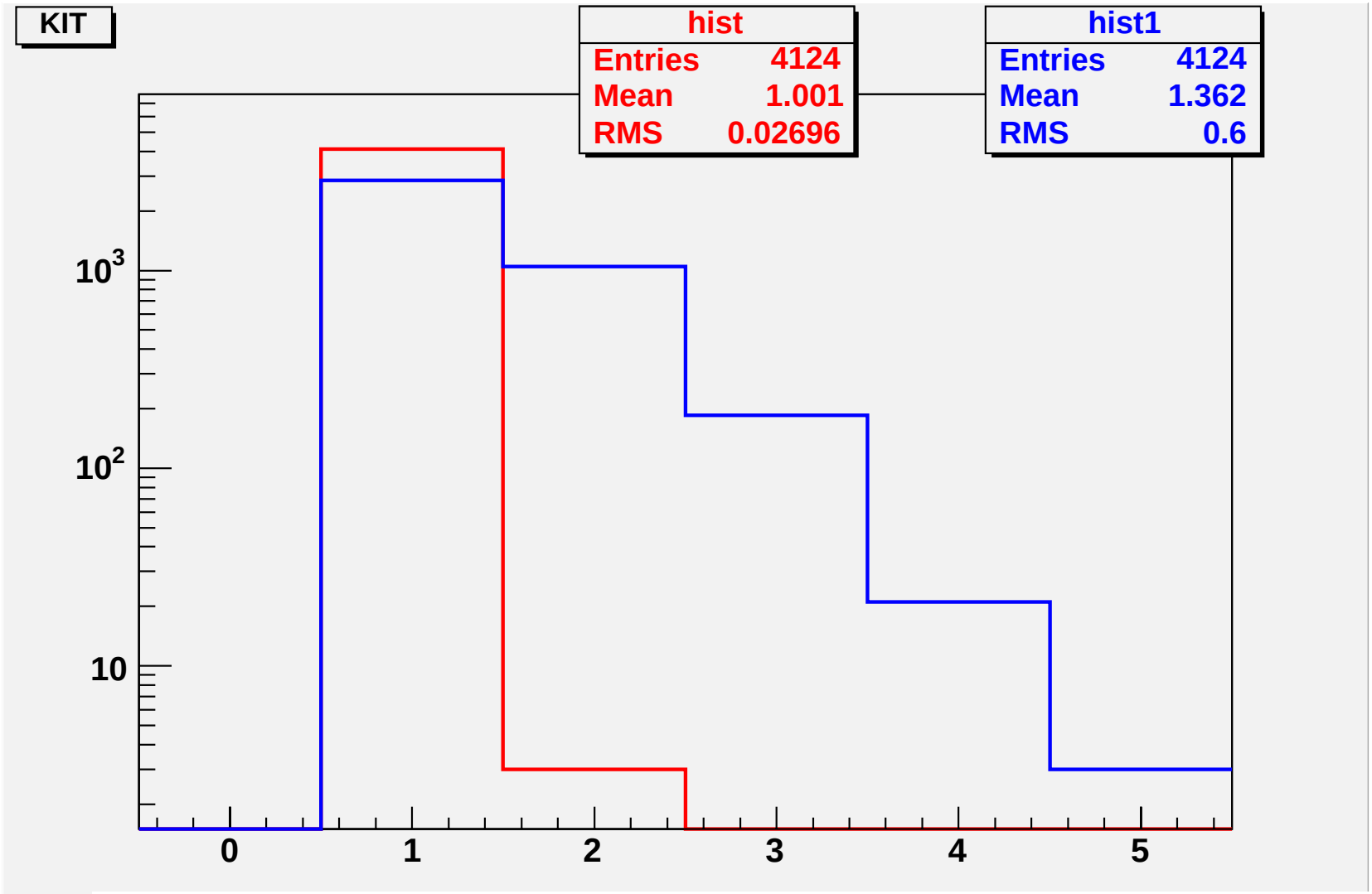
Comparison of algorithm performance for full sample (with corner) and restricted one (without corner)



Comparison of Pandora performance for full sample (with corner) and restricted one (without corner)



Comparison of algorithm performance for full sample (in red) and restricted one (in blue) for 20GeV
Clear corner effect !



Number of reconstructed objects distribution for photons sample at 40GeV (corner excluded) , in red algorithm, in blue Pandora.

1 GeV

N per event	Nevt	Ncore	%	Nrec	%	Npan	%
0	4267	2	0.046871	3	0.070307	0	0
1	4267	4110	96.3206	4242	99.41411	4224	98.99227
2	4267	152	3.562222	21	0.492149	40	0.937427
3	4267	3	0.070307	1	0.023436	3	0.070307

1 GeV cut

N per event	Nevt	Ncore	%	Nrec	%	Npan	%
0	8311	5	0.060161	6	0.072193	1	0.012032
1	8311	8015	96.43846	8272	99.53074	8244	99.19384
2	8311	286	3.441222	32	0.385032	65	0.782096
3	8311	5	0.060161	1	0.012032	1	0.012032

If Ncore is 0 this is pure inefficiency of the method , difference Nrec(0)-Ncore(0) is just a technical problem of the energy estimation procedure (easy solvable) !

Upper table is for full ECAL , lower one (labeled with cut) without corner !
Nevt – Number of processed events
Ncore – number of cores of EM shower found
Nrec – number of photons reconstructed
Npan – number of reconstructed particles from Pandora (with default settings !)

3 GeV

N per event	Nevt	Ncore	%	Nrec	%	Npan	%
0	4245	0	0	3	0.070671	0	0
1	4245	4150	97.76207	4233	99.71731	4190	98.70436
2	4245	81	1.908127	5	0.117786	53	1.248528
3	4245	11	0.259128	2	0.047114	2	0.047114
4	4245	3	0.070671	2	0.047114	0	0

3 GeV cut

N per event	Nevt	Ncore	%	Nrec	%	Npan	%
0	8276	0	0	3	0.036249	0	0
1	8276	8133	98.27211	8260	99.80667	8188	98.93668
2	8276	136	1.643306	11	0.132914	87	1.051232
3	8276	5	0.060416	1	0.012083	1	0.012083
4	8276	2	0.024166	1	0.012083	0	0

5 GeV

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4245	0	0	3	0.070671	0	0
1	4245	4143	97.59717	4207	99.10483	4125	97.17314
2	4245	84	1.978799	17	0.400471	110	2.591284
3	4245	8	0.188457	12	0.282686	10	0.235571
4	4245	8	0.188457	6	0.141343	0	0
4	4245	2	0.047114	6	0.141343	0	0

5 GeV cut

	Nevt	Ncore	%	Nrec	%	Npan	%
0	8299	0	0	3	0.036149	0	0
1	8299	8164	98.3733	8288	99.86745	8109	97.71057
2	8299	132	1.590553	6	0.072298	188	2.265333
3	8299	2	0.024099	2	0.024099	2	0.024099
4	8299	1	0.01205	0	0	0	0

9 GeV

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4271	0	0	0	0	0	0
1	4271	4137	96.86256	4228	98.99321	3967	92.88223
2	4271	98	2.294545	13	0.304378	279	6.532428
3	4271	18	0.421447	17	0.398033	16	0.37462
4	4271	9	0.210723	10	0.234137	7	0.163896
5	4271	5	0.117069	1	0.023414	2	0.046827
6	4271	2	0.046827	1	0.023414	0	0
7	4271	2	0.046827	1	0.023414	0	0

9 GeV cut

	Nevt	Ncore	%	Nrec	%	Npan	%
0	8316	0	0	1	0.012025	0	0
1	8316	8130	97.76335	8307	99.89177	7818	94.01154
2	8316	179	2.152477	5	0.060125	485	5.832131
3	8316	6	0.07215	2	0.02405	12	0.1443
4	8316	1	0.012025	1	0.012025	1	0.012025

16 GeV

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4289	0	0	2	0.046631	0	0
1	4289	4023	93.79809	4227	98.55444	3756	87.57286
2	4289	215	5.012824	20	0.466309	466	10.865
3	4289	20	0.466309	13	0.303101	51	1.189088
4	4289	14	0.326416	14	0.326416	9	0.209839
5	4289	7	0.163208	6	0.139893	5	0.116577
6	4289	5	0.116577	4	0.093262	1	0.023315
7	4289	5	0.116577	3	0.069946	1	0.023315

16 GeV cut

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4135	0	0	1	0.024184	0	0
1	4135	3922	94.84885	4131	99.90326	3672	88.8029
2	4135	196	4.740024	3	0.072551	432	10.4474
3	4135	6	0.145103	0	0	30	0.725514
4	4135	0	0	0	0	1	0.024184
5	4135	1	0.024184	0	0	0	0

20 GeV

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4287	0	0	2	0.046653	0	0
1	4287	3979	92.81549	4220	98.43714	3577	83.4383
2	4287	247	5.761605	20	0.466527	622	14.50898
3	4287	26	0.606485	13	0.303242	63	1.469559
4	4287	11	0.25659	11	0.25659	19	0.4432
5	4287	15	0.349895	16	0.373221	4	0.093305
6	4287	6	0.139958	4	0.093305	2	0.046653
7	4287	0	0	1	0.023326	0	0
8	4287	2	0.046653	1	0.023326	0	0
9	4287	0	0	1	0.023326	0	0
10	4287	1	0.023326	0	0	0	0

20 GeV cut

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4171	0	0	3	0.071925	0	0
1	4171	3932	94.26996	4164	99.83217	3539	84.84776
2	4171	230	5.514265	4	0.0959	586	14.04939
3	4171	9	0.215776	0	0	44	1.054903
4	4171	0	0	0	0	2	0.04795

40 GeV

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4240	0	0	2	0.04717	0	0
1	4240	3666	86.46226	4167	98.2783	2888	68.11321
2	4240	476	11.22642	15	0.353774	1084	25.56604
3	4240	47	1.108491	13	0.306604	216	5.09434
4	4240	10	0.235849	11	0.259434	41	0.966981
5	4240	14	0.330189	18	0.424528	9	0.212264
6	4240	13	0.306604	10	0.235849	2	0.04717
7	4240	11	0.259434	4	0.09434	0	0
8	4240	1	0.023585	0	0	0	0
9	4240	2	0.04717	0	0	0	0

40 GeV cut

	Nevt	Ncore	%	Nrec	%	Npan	%
0	4124	0	0	0	0	0	0
1	4124	3635	88.14258	4121	99.92726	2913	70.63531
2	4124	453	10.98448	3	0.072745	1049	25.43647
3	4124	35	0.848691	0	0	185	4.485936
4	4124	1	0.024248	0	0	21	0.509214
5	4124	0	0	0	0	3	0.072745

“Speed is not an issue ” - for those that it is here is what you can expect

E [GeV]	Nevt	Time [s]*	Per evt [ms]*
1	8311	14	1.7
3	8276	19	2.3
5	8299	22	2.6
9	8316	29	3.5
16	4135	20	4.8
20	4171	22	5.3
40	4124	33	8.0

* Together with reading the file and calorimeter digitization on P4 at 3GHz

FAQ

Where to obtain the code ?

Code is in MarlinReco in Clustering under PhotonFinderKit

How to use it ?

There is a example processor that leads you up to the stage after pattern recognition . After that cores are written out in LCIO to be used at later stage. All the necessary tools to perform later steps are also provied

Whom to ask ?

Support is organized (free of charge and registration) via e-mail krstonos@ifh.de

Additional material ?

Orsey_workshop

ECFA_Valencia