Systematics on cluster's counting

S. Miscetti
LNF - INFN

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Talk's Layout:

- Reconstruction efficiency
- Splitting/Splitting Recovery
- Merging/Merging statistics
- Photons' counting in $\phi \to \eta\gamma \to 7\gamma$
- Conclusions ....

ϵ_γ: methods of measurement

Two independent data samples have been used to extract the γ's reconstruction efficiency: **radiative Bhabha's and $\pi^+\pi^-\pi^0$ events**. In both cases the tracking system and the momentum conservation allow to determine the γ's direction. The requirements on the clusters have been always kept very loose in order to reduce the biases in the measurement.

Radiative Bhabha's

- good vertex + 2 high Pt tracks;
- $|P1|, |P2| > 490$ **MeV**;
- exclusion region around the charged clusters;
- $\overline{P}$ (Dch) is our best estimate of γ's momentum;

$\boldsymbol{\pi^+\pi^-\pi^0}$ events

- good vertex with 2 tracks;
- $\overline{\mathbf{P}}_{\mathbf{miss}}(\mathbf{dch}) = \overline{\mathbf{P}}_{\pi^0}$
- exclusion region around the charged clusters;
- Use one very well defined photon's cluster (high χ^2_γ) to estimate the γ_2's direction.

Altough in both methods the efficiency depends on the opening angle of the cone around the extimated direction the second sample offers a better behaviour of the efficiency as a function of θ_γ since is NOT RELATED TO γ_1, γ_2 directions.

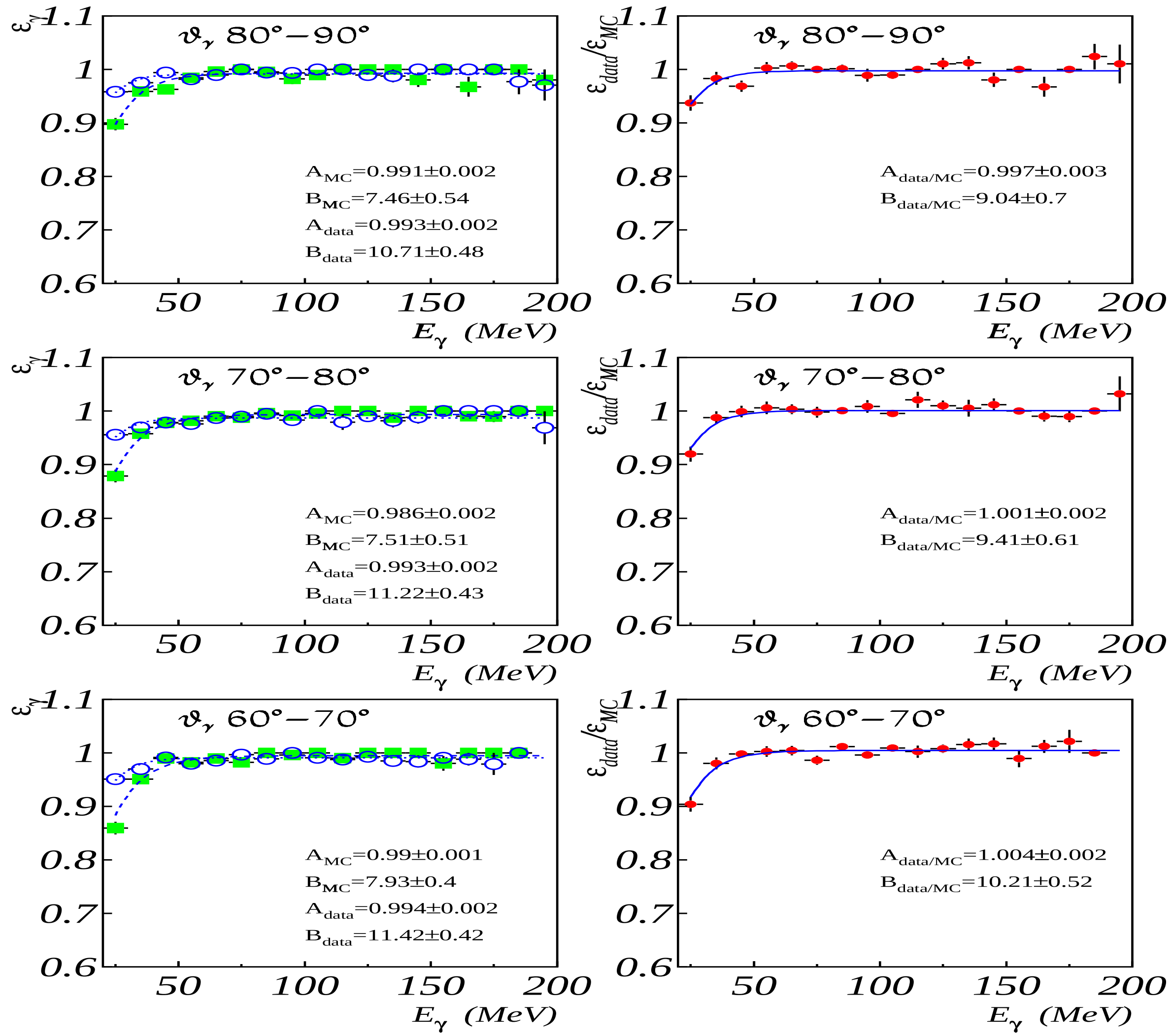
ϵ_γ's measurement: Radiative Bhabha's

Runs with HV-old

Left plots: Data vs MC comparison of ϵ_γ vs E_γ for different θ_γ.

Right plots: ratio of efficiencies Data/MC vs E_γ for different θ_γ.

The fit is: $A \times e^{1-E_\gamma/B}$

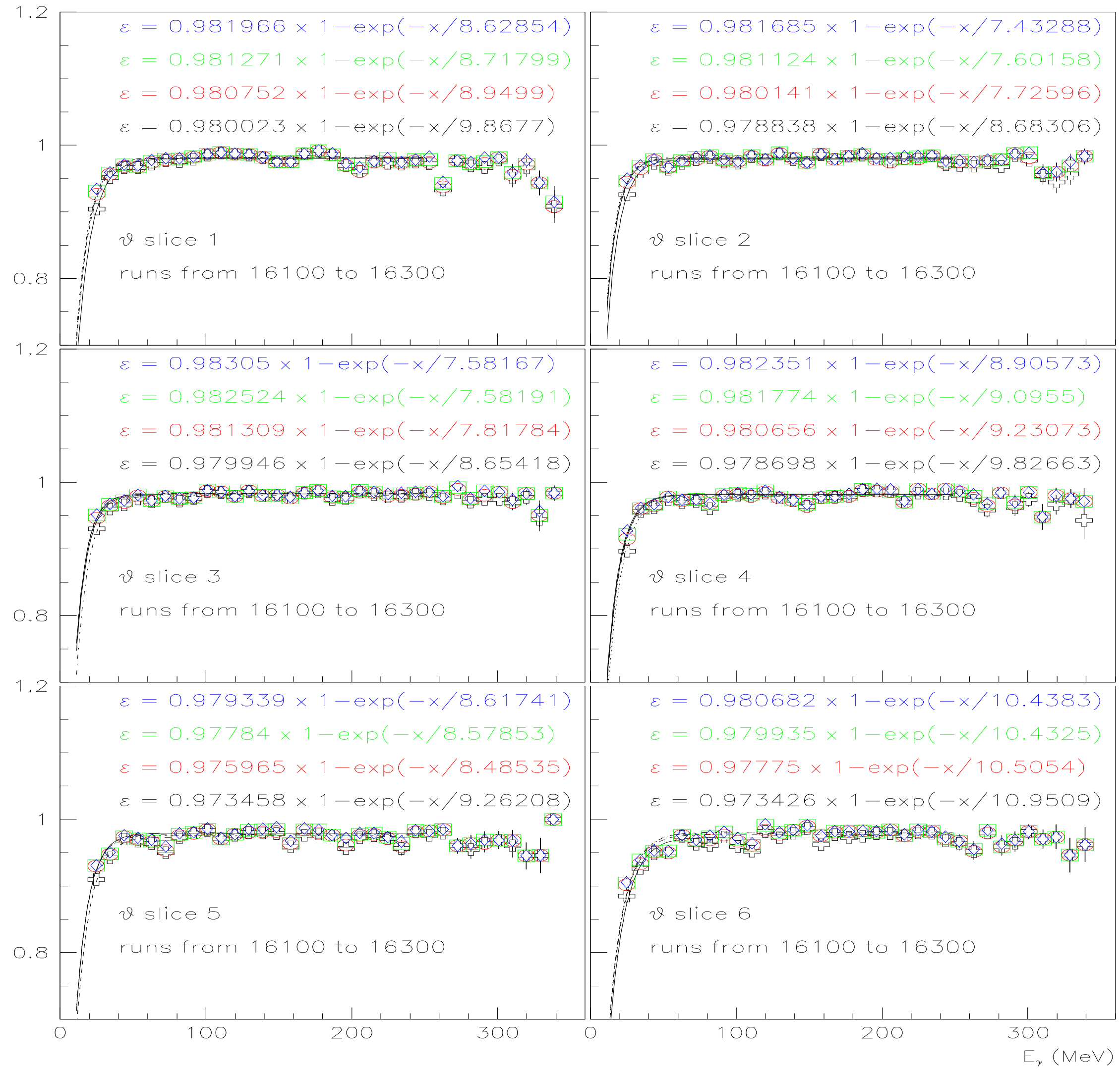


ϵ_γ's measurement: $\pi^+\pi^-\pi^0$ sample

Runs 16100-16200

HV New (+20%)

Data ONLY



Overlook on the measurements of efficiency:

The two methods reasonably agrees for $\theta_\gamma > 60^\circ$ but the the second method better describes the situation at low angles.

The efficiency drop observed in the data respect to the simulation is practically due to the cutoff of the effective threshold which is missing in the simulation $\longrightarrow$ see next plots

During the KLOE running in Nov-Dec 2000 we have tried different working operation of the calorimeter to try to reduce this drop, namely:

- We have increased High Voltage setting of 20 %
- We have lowered the ADC thresholds (**this introduced an overload of 1KB/event in the builder data output**).
- We have lowered the TDC thresholds (**this sligthly deteriorated our timing resolution**).

Only the 3-p method has shown some little improvement in the efficiency but we have never recovered the loss below 50 MeV! The EMC group decided not to play around with this problem anymore and just try to tune the effective threshold on the simulation.

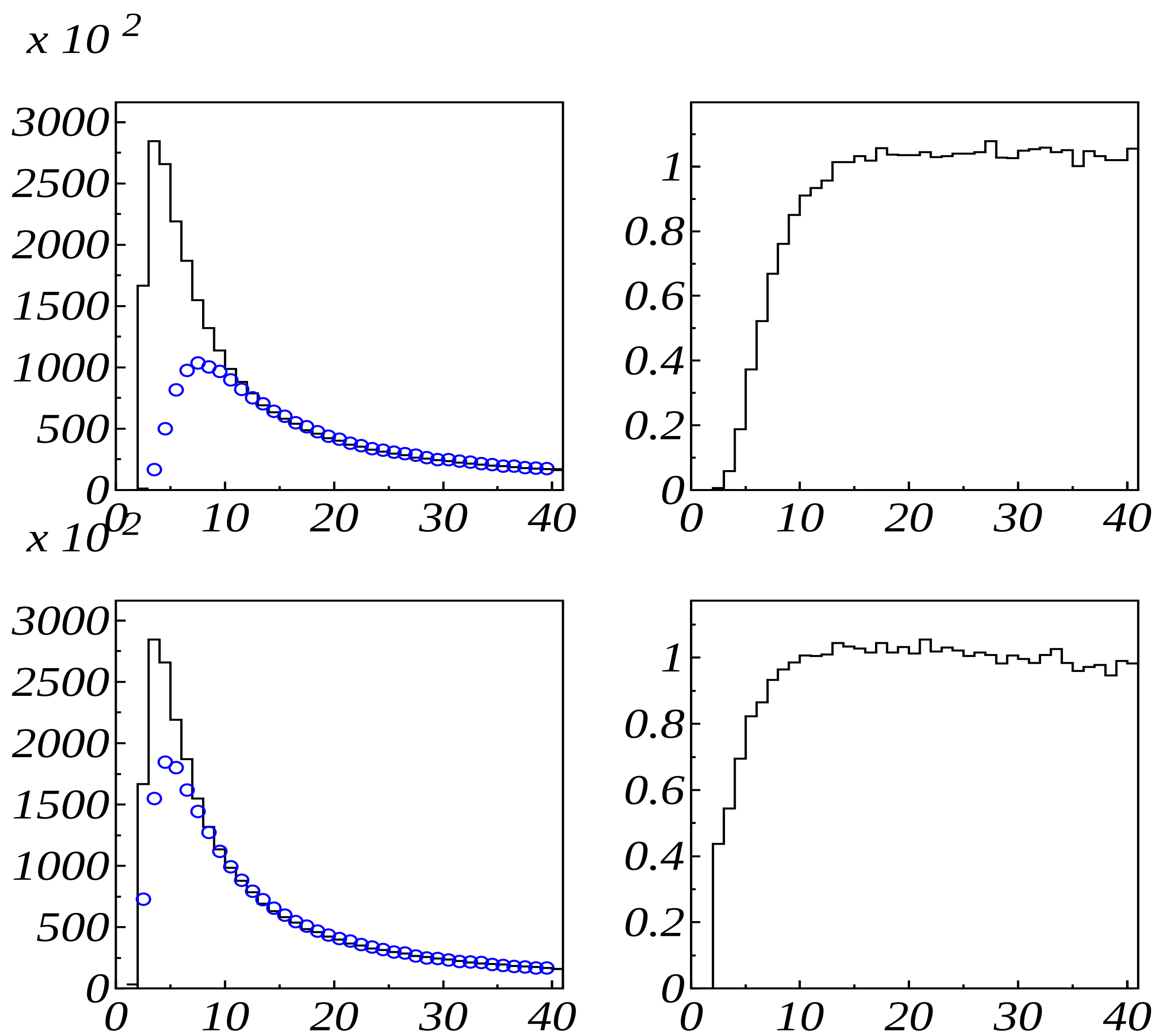
Effective Threshold on data

Data (open circles)
MC (solid-line):

TOP-PLOTS:
Hv Old

BOTTOM PLOTS:
(Hv New) with lowered TDC threshold

- Left: Distribution of cells energy.
- Right: Distribution of cells energy DATA/MC



DATA/MC comparison with THR simulation (1)

The measured effective threshold has been applied to the cells'simulation via hit or miss and then the cluster's energy is rebuilt:

- If this new energy is below the used clurec threshold the cluster disappears from the counting!
- If used directly on CELE/CWRK bank this creates a necessity to recalibrate CLUFIXENE in the MC (i.e. our energy scale). Indeed the application of the threshold clarifies also the observed calorimeter non-linearity at low energies.
- For the moment we apply the threshold only at PAW level, we will release an AC version after recalibration of Clufixene is completed.

As you will see in the next slides the agreement DATA/MC is excellent whenever we use the measured threshold moving up the cells energy scale of $+$ 1MeV (Are we missing the PM gain smearing??).

DATA/MC comparison with THR simulation (2)

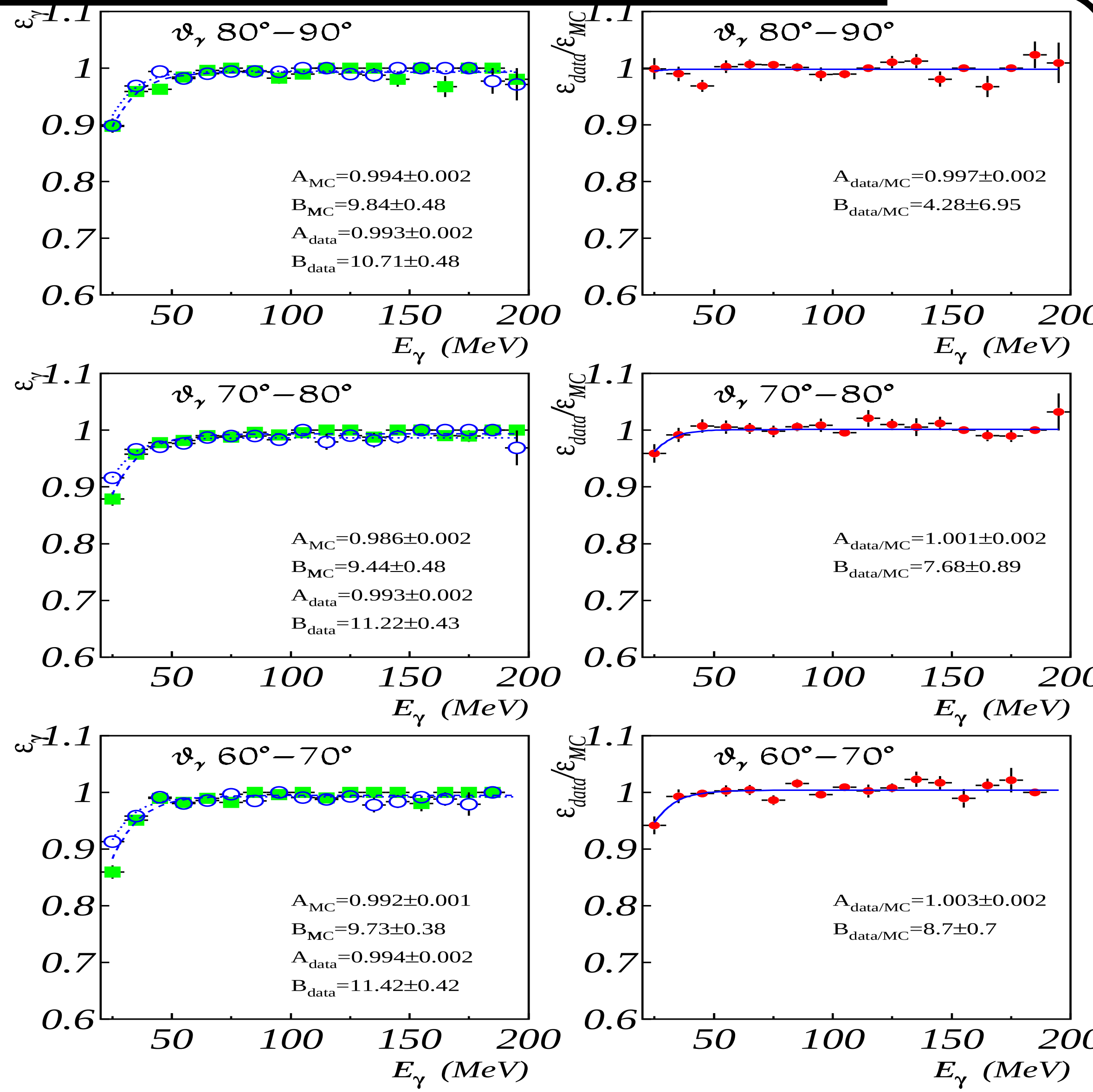
$e^+e^-\gamma$ sample

Runs with HV-old

Threshold Simulation ON

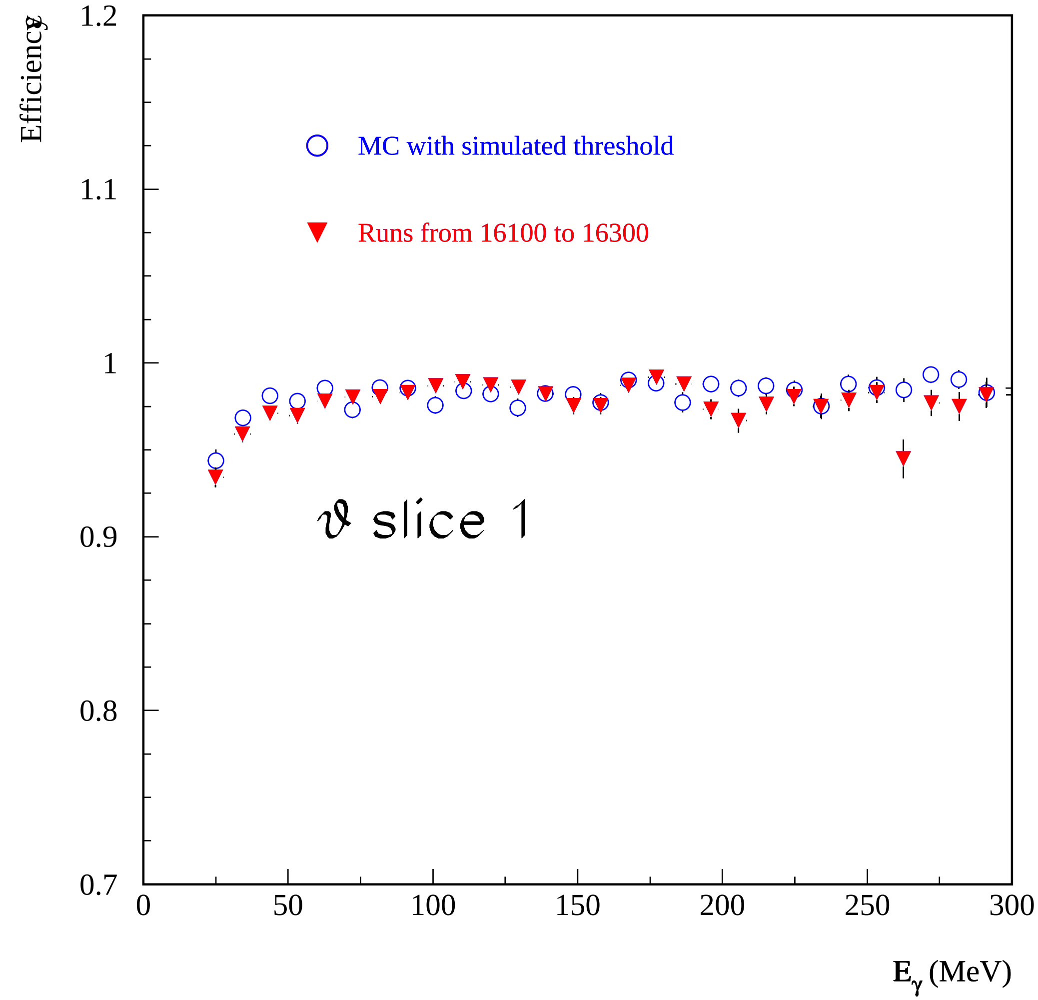
Left plots: Data vs MC comparison of ϵ_γ vs E_γ for different θ_γ.

Right plots: ratio of efficiencies Data/MC vs E_γ for different θ_γ.



DATA/MC comparison with THR simulation (3)

- $\pi^+\pi^-\pi^0$
- Runs 16100-16200
- HV-NEW
- Threshold Simulation ON



Splitting and Splitting recovery:

As shown at the Emc Review, even for events without pions in final state (e.g n γ's), we observe a lot of unwanted clusters in the events which satisfy our definition of proper time window.

This clusters are usually originated by shower fragments which fly and release energy in a region closer or not to the main cluster.

Depending upon the tightness of the Merging Cuts in clurec we can reduce this origin of overcounting.

We know for sure that:

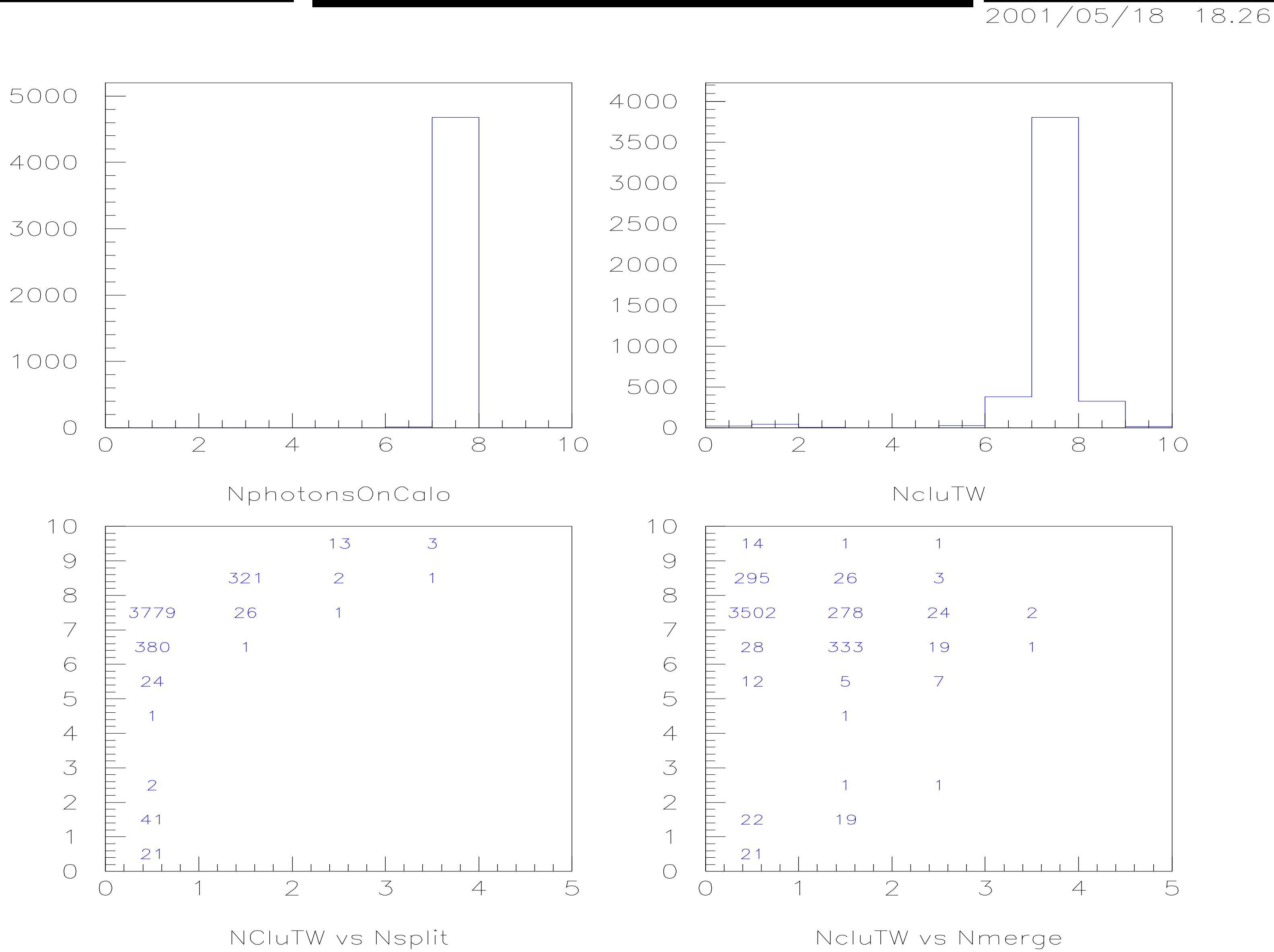
- This photons are soft (higher threshold helps .. see for istance M.Palutan presentation);
- This photons are often close enough to the original main clusters;
- A smart time window should use also a reasonable upper cutoff (**i.e. TW** $= min(5 * \sigma_t, 3.0)ns$) to reduce both the fraction of In-Time fragments flying far away and machine background accidentals.

γ's counting in MC : Clurec

To test by montecarlo if this is possible, we have first tried to learn how to count correctly the photons. Here an example follows for $\phi \rightarrow 7\gamma$:

1. Require **BY KINE** all 7 γ's in angular acceptance!!
2. Since GEANFI does not have any conversion or compton flags we use the stored hits on the calorimeter surface to obtain a sample of γ's with no interactions wherever.
3. Count the clusters in TW (Ntw);
4. Count the number of times/event the same KINE appears in more than one cluster (Splitting);
5. Count also the number of times/event we find more than one KINE in the same cluster (Merging).

γ's counting in MC : CLUREC



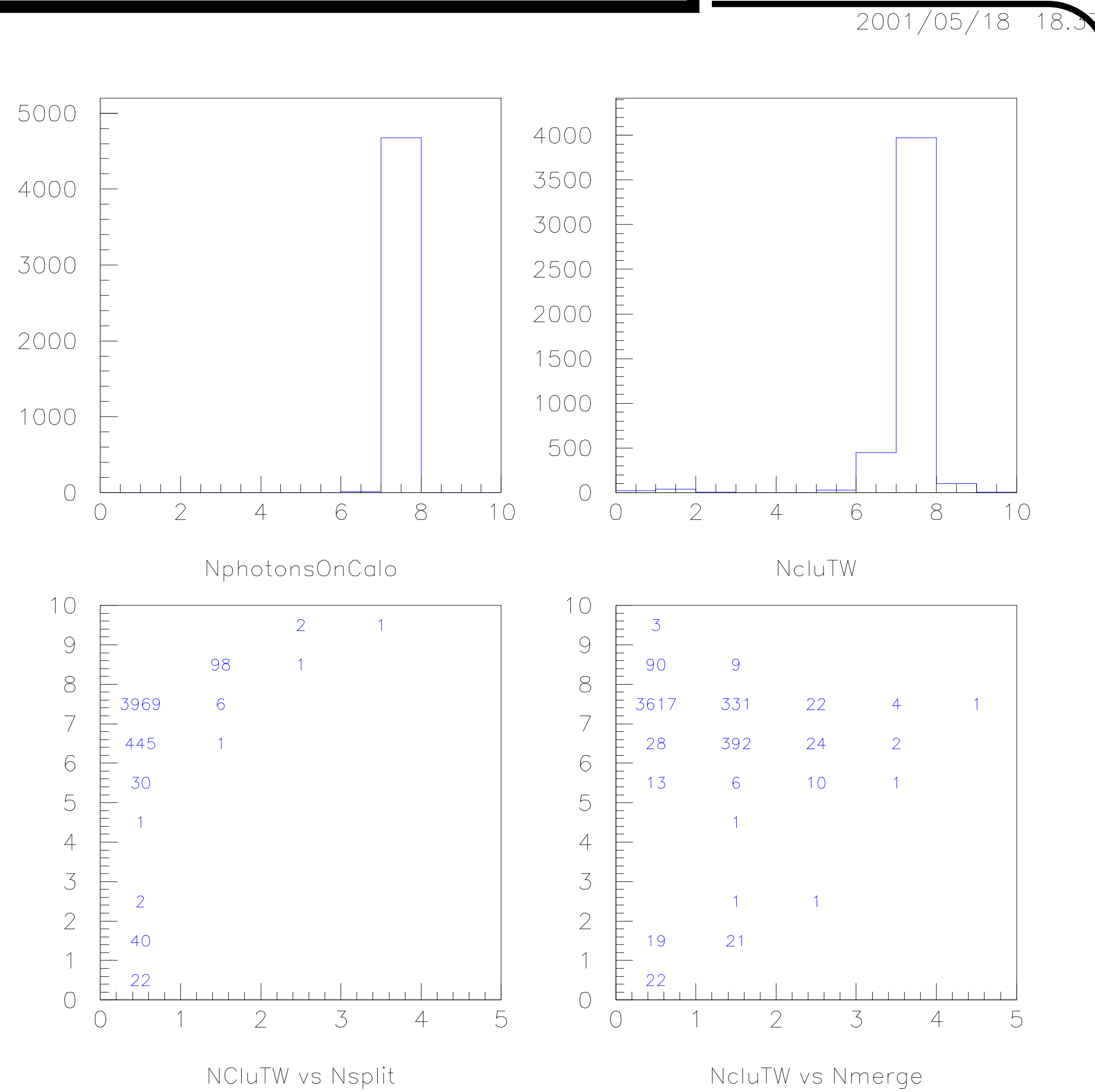
γ's counting in MC : RECSPLIT

Given a cluster "i" we join a cluster "j" if:

- Energy of cluster "j" is below 100 MeV
- ΔR, ΔZ, ΔR_t are below 6.0 cm$/\sqrt{(E/GeV)}$
- $\Delta T < 3.5ns$

If clusters are joined we recompute the centroid variables.

In the case of Barrel-Ecap clusters we use only ΔR and ΔT cuts.



Merging of clusters (1)

Definition of the problem :

- The overlap of different particles in the same region of the detector will confuse reconstruction of energy, timing and position.
- Troubles can be created not also by different primary particles but also by their "fragments" (both from π's or showers)
- In the real life we can have troubles also with overlapping machine background clusters;
- If the overlap is $\sim$ complete, it will deteriorate not only the calorimeter performance but also the clusters' counting!! This can be relevant both for precise measurement of multi-photons final states and/or background rejection of events with more photons in final state (e.g. $K_L \rightarrow 3\pi$ vs 2π decays).

Merging of clusters (2): algorithms

- Clurec works in two steps:

1. At precluster level uses two coordinates (i.e. the cells' coordinates in the transverse plane) to join only "contiguous" cells;
2. Before starting with the merging procedure a breaker algorithm looks for structures of clumps along the longitudinal coordinate (Z in the following).

- The breaking Technique:

1. It proceeds using the timing information in A,B side separately. As a function of the timing RMS in the two sides reclusters along Z by dividing the detector in 4 possible sub-regions;
2. It works independently from the vertexing since compares the timing of each cell with the average of the pre-cluster. It is not sensible to trigger rephasing of the timing (t0step0,t0step1 ..)
3. IT DOES NOT SOLVE by construction the cases where two different particles shower in the same cells.

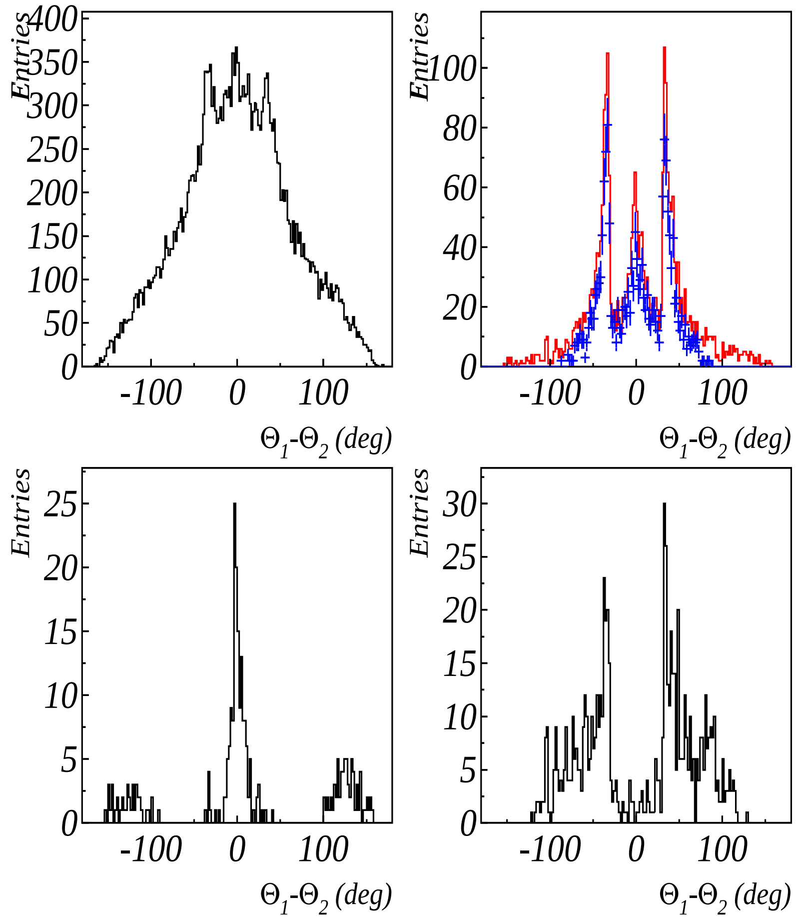
... continue

Merging of clusters (3): algorithms

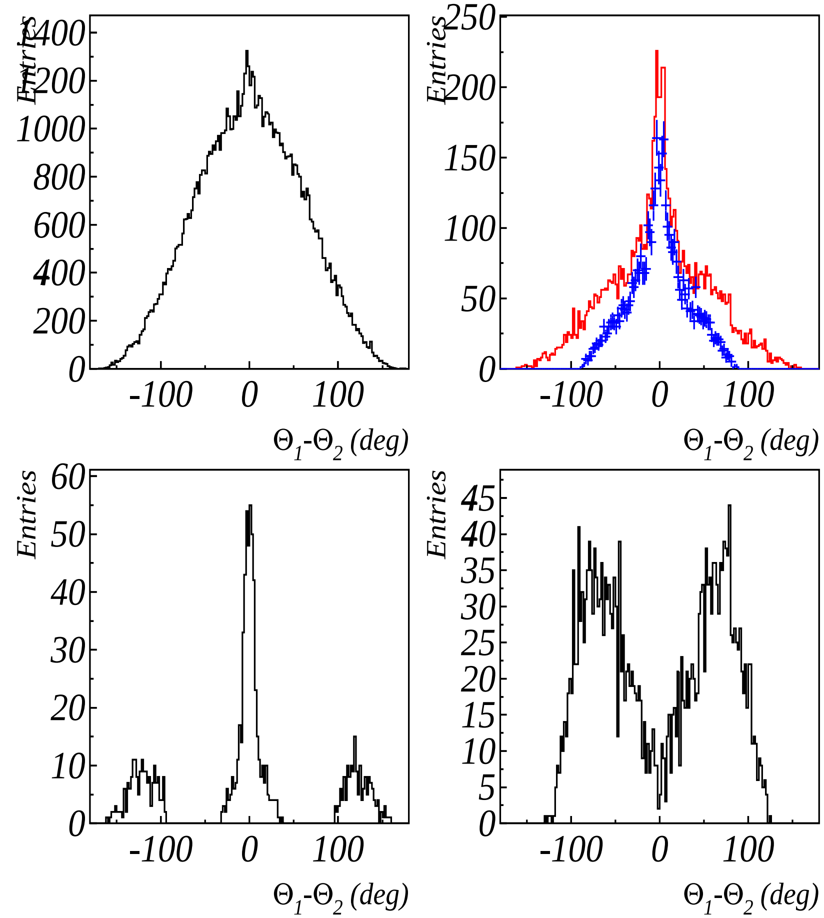
- By assuming a vertex it is possible “in principle” to try to disentangle the composition of the clusters by fully reconstructing the hits and then reclustering.
- Before discussing about developing/changing the existing algorithms let us investigate by MC the entity of the problem (if any!).

MERGING (a): Kinematics $\phi_{\gamma i} - \phi_{\gamma j} <= 15^\circ$

- $\phi \to f0\gamma \to 5\gamma's$

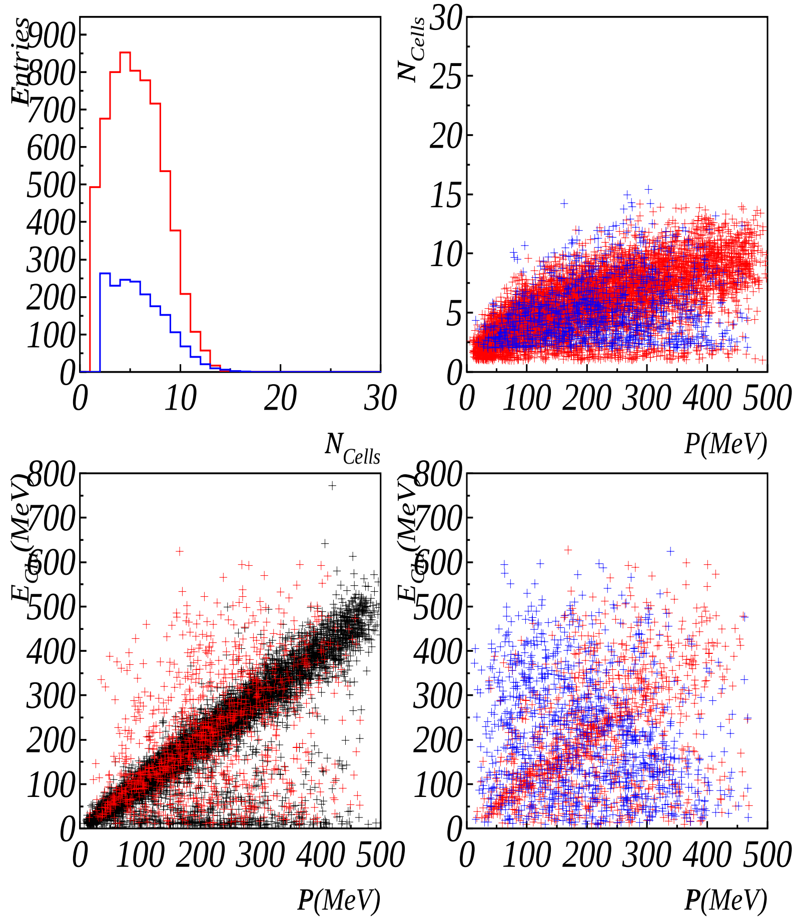


- $\phi \to \eta\gamma \to 7\gamma's$

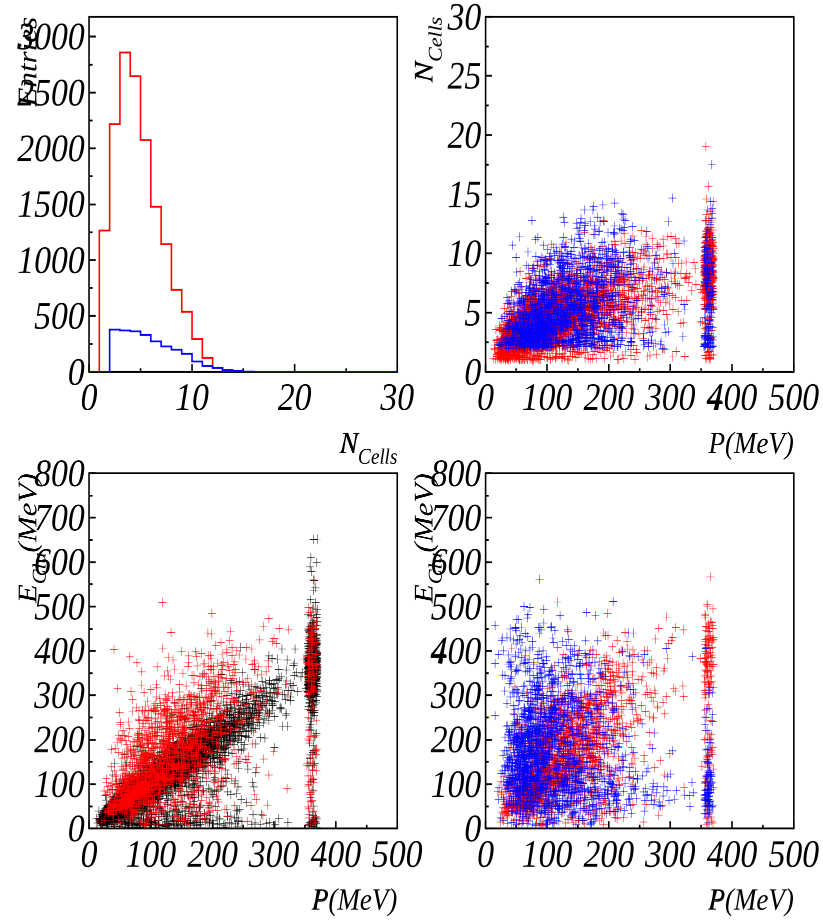


MERGING (b) : clustering

- $\phi \to f0\gamma \to 5\gamma's$ Clurec

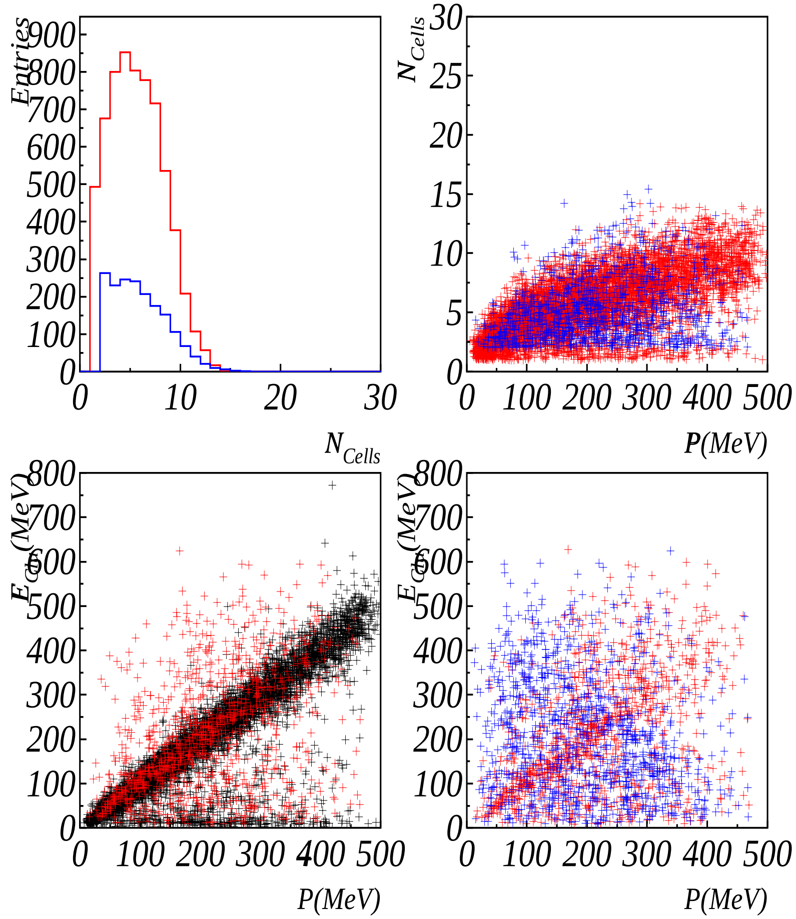


- $\phi \to \eta\gamma \to 7\gamma's$ Clurec

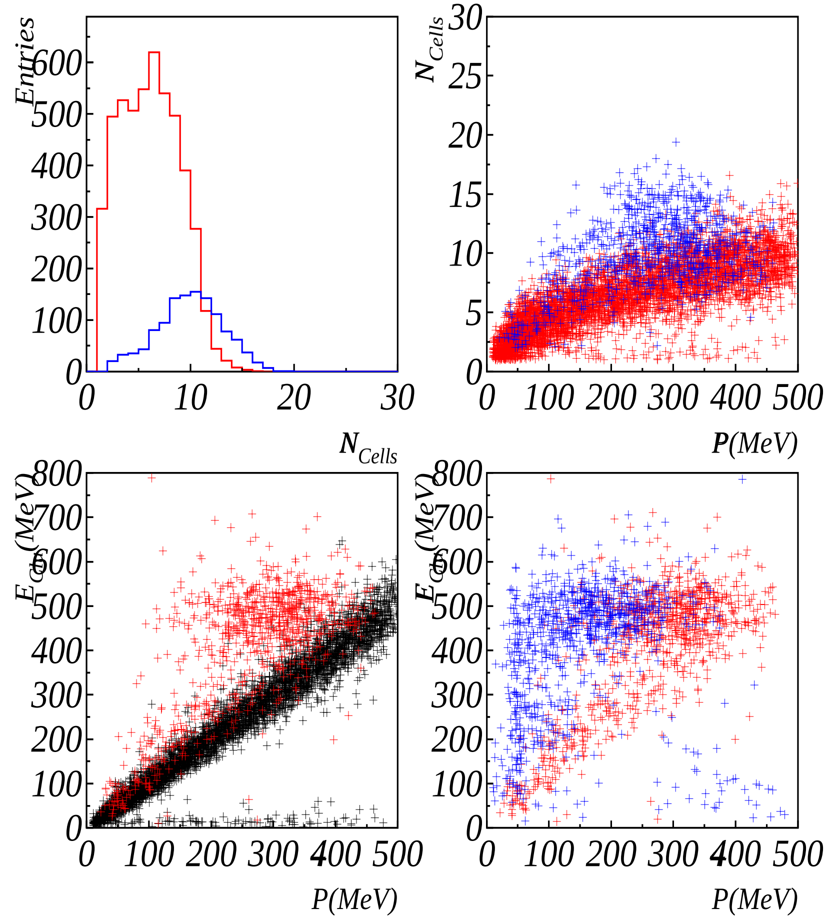


MERGING (b2) : clustering with/without breaking

- $\phi \to f0\gamma \to 5\gamma's$ Clurec



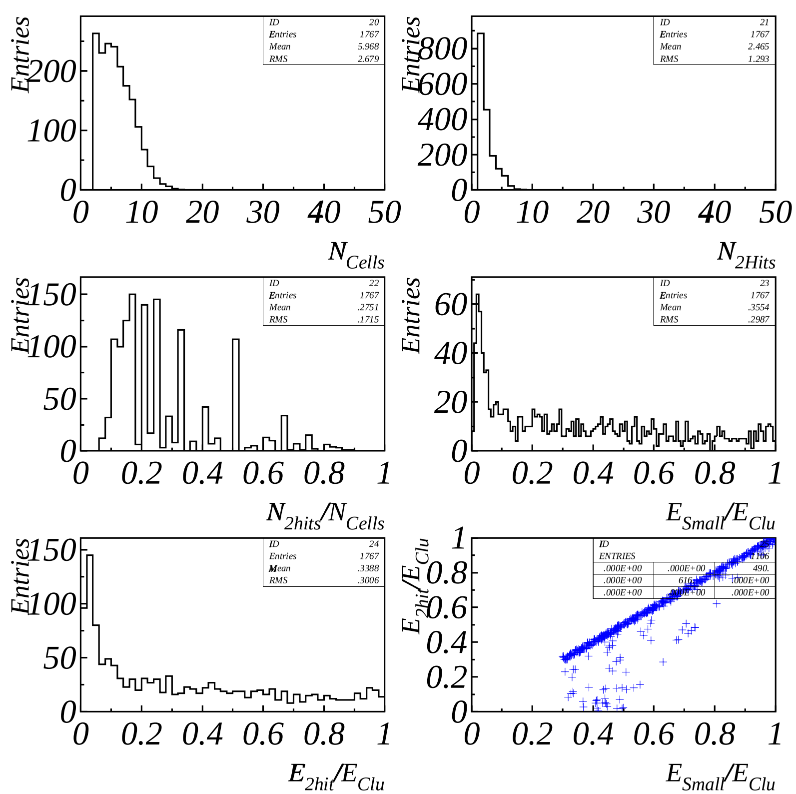
- $\phi \to f0\gamma \to 5\gamma's$ NoBreaker



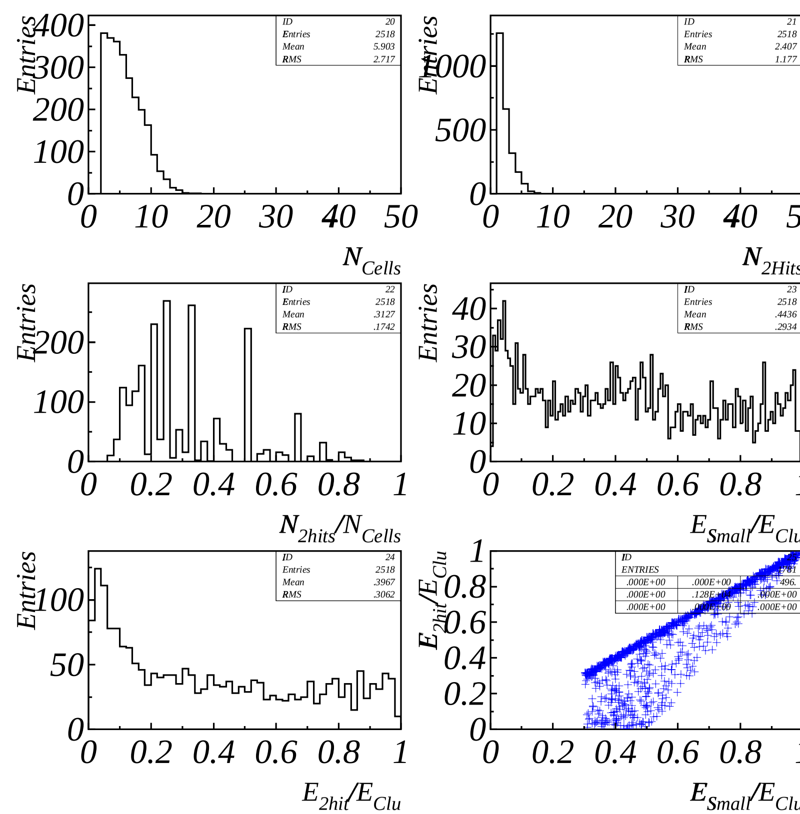
MERGING (C) : Cells composition of the cluster

To classify the possible overlaps in the cluster we use two variables: **E2HIT** is the energy sum of all cells with two hits and **Esmall** which is the energy sum of all cells belonging to the smallest contributor.

- $\phi \rightarrow f0\gamma \rightarrow 5\gamma's$ Clurec

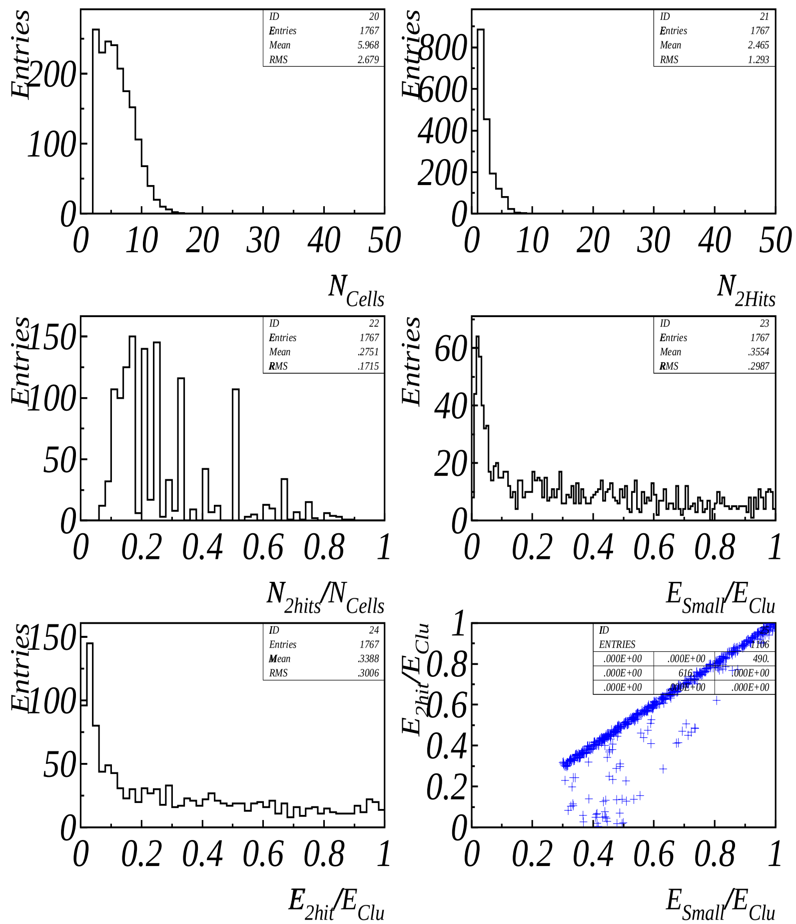


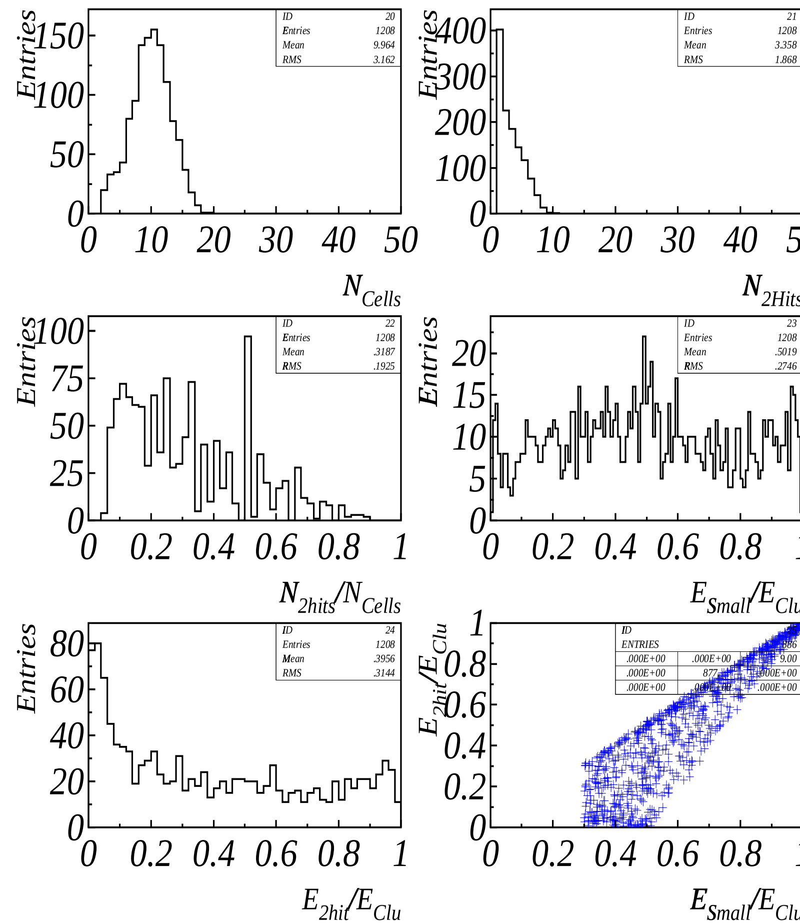
- $\phi \rightarrow \eta\gamma \rightarrow 7\gamma's$ Clurec



MERGING (C2) : Cells composition of the cluster

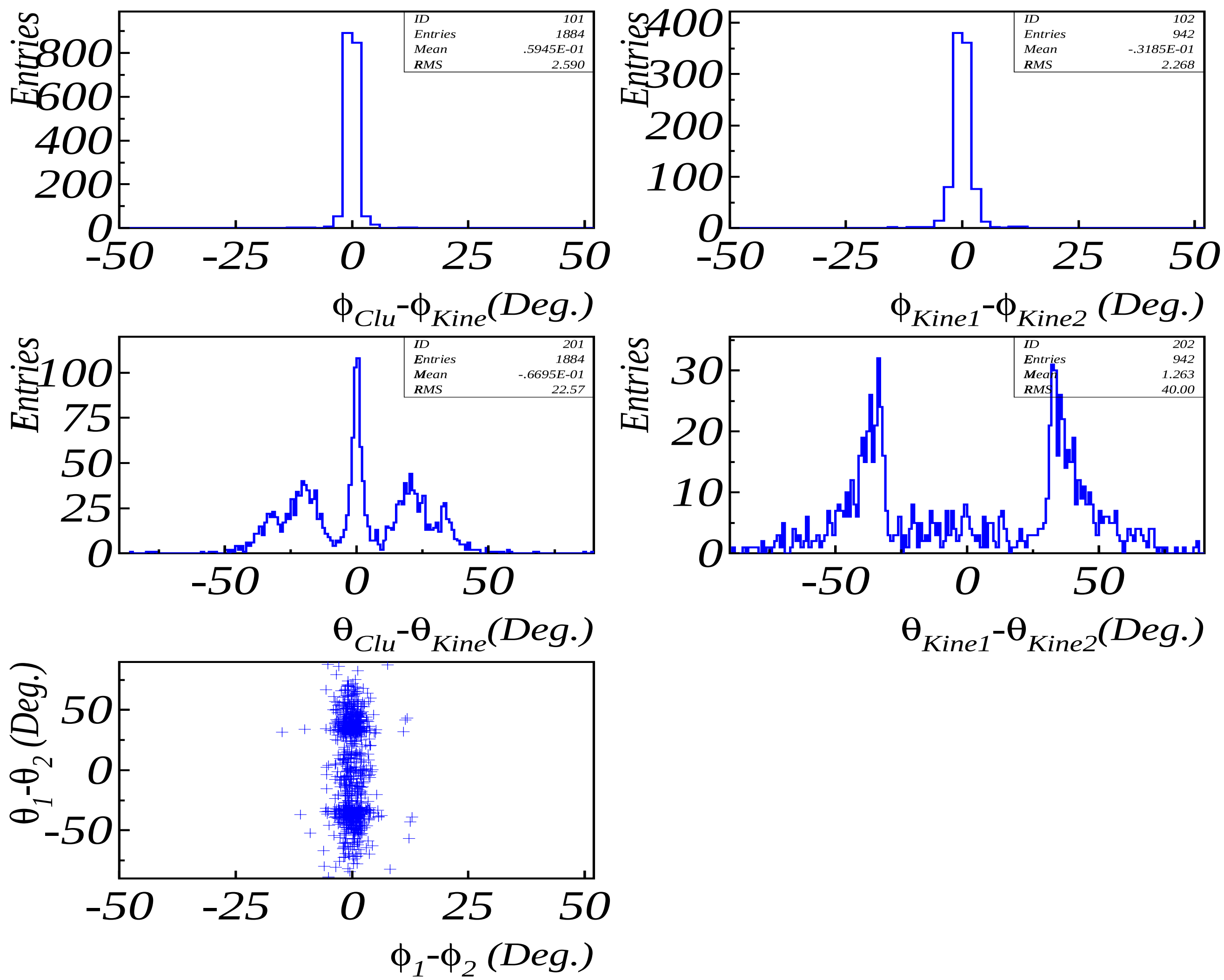
Comparing with/without breaker f0 γ events





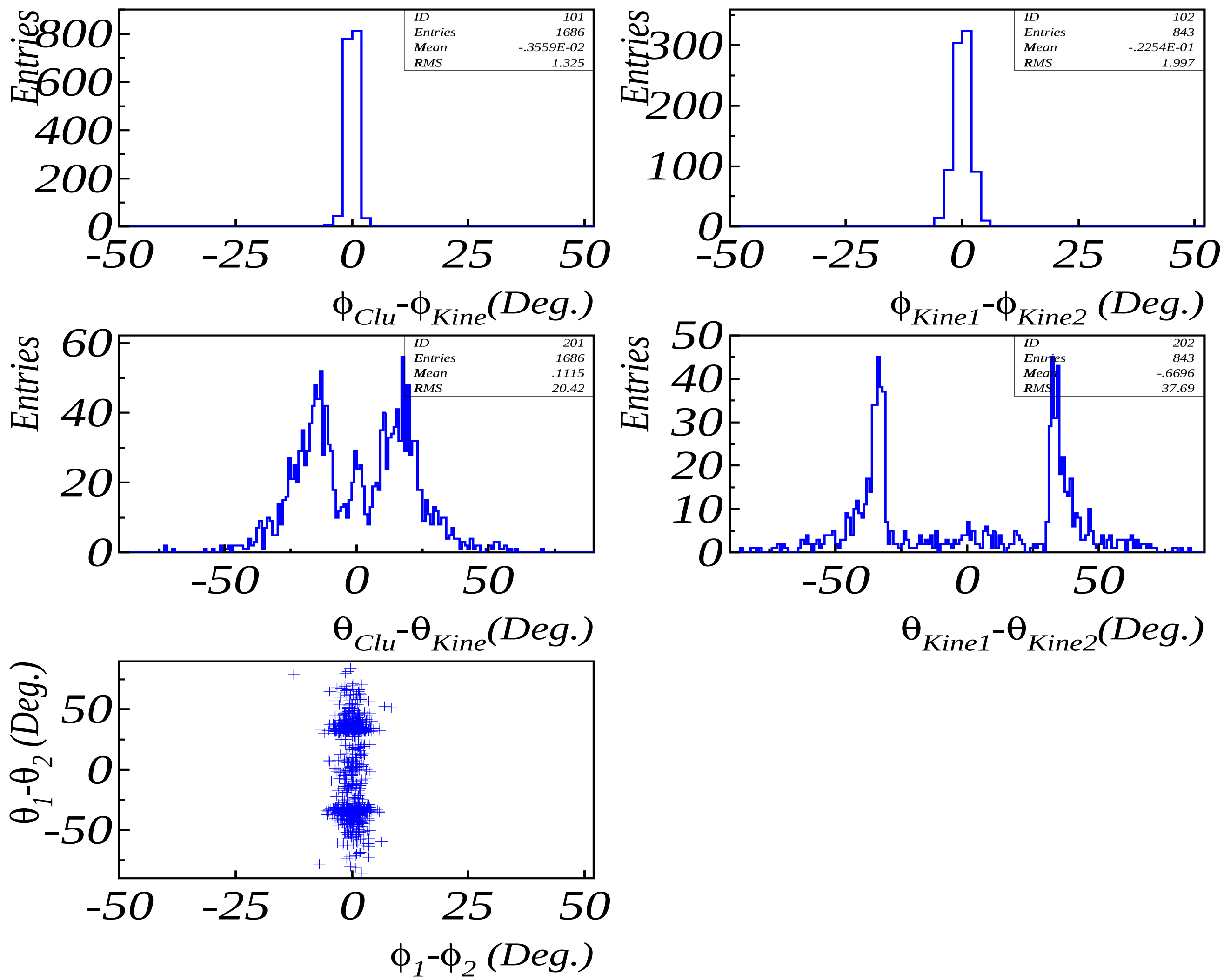
MERGING (D1) : composition f0γ

Kine-Particle composition of a cluster "without" fragments



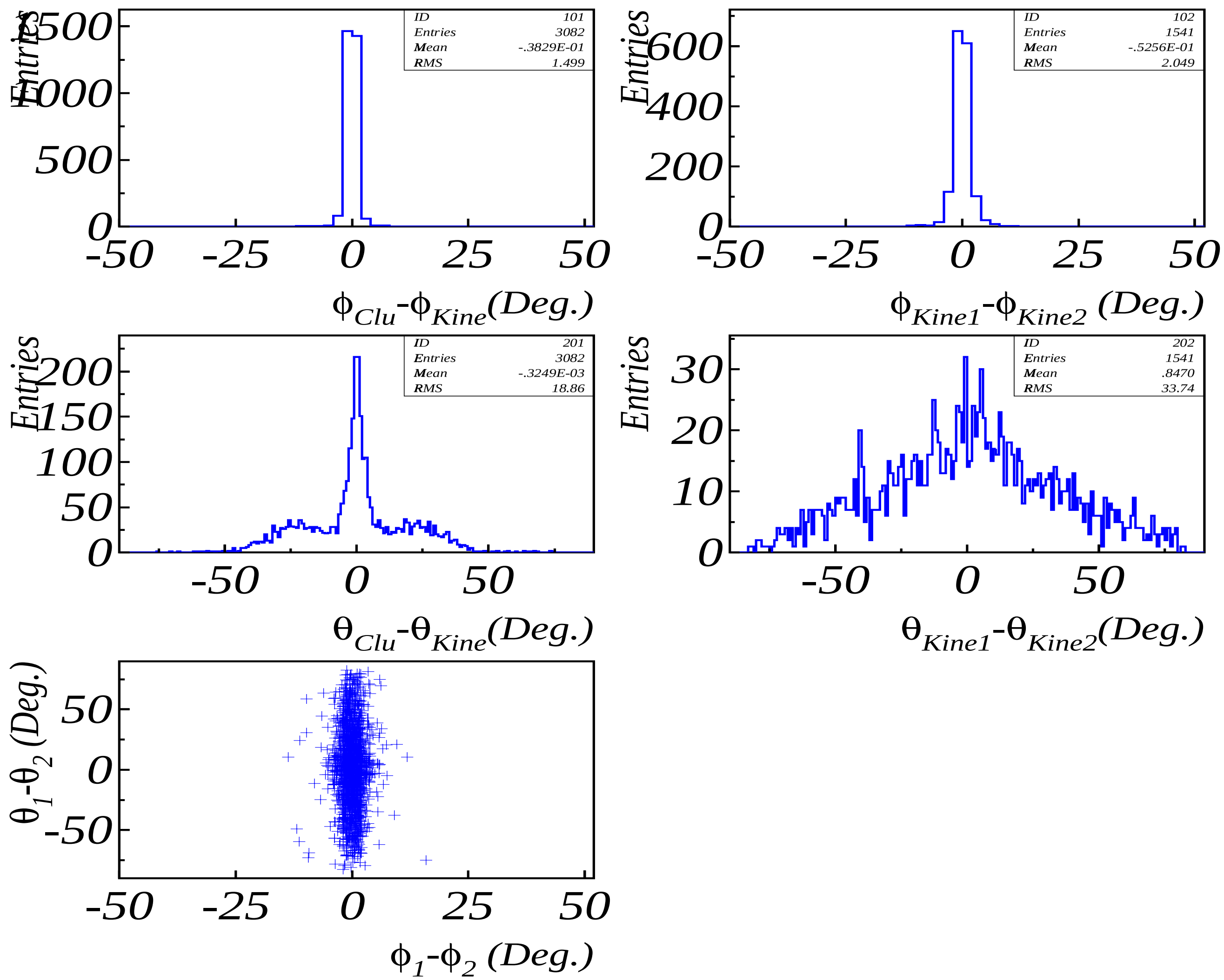
MERGING (D2) : composition f0γ NoBreaker

Kine-Particle composition of a cluster "without" fragments

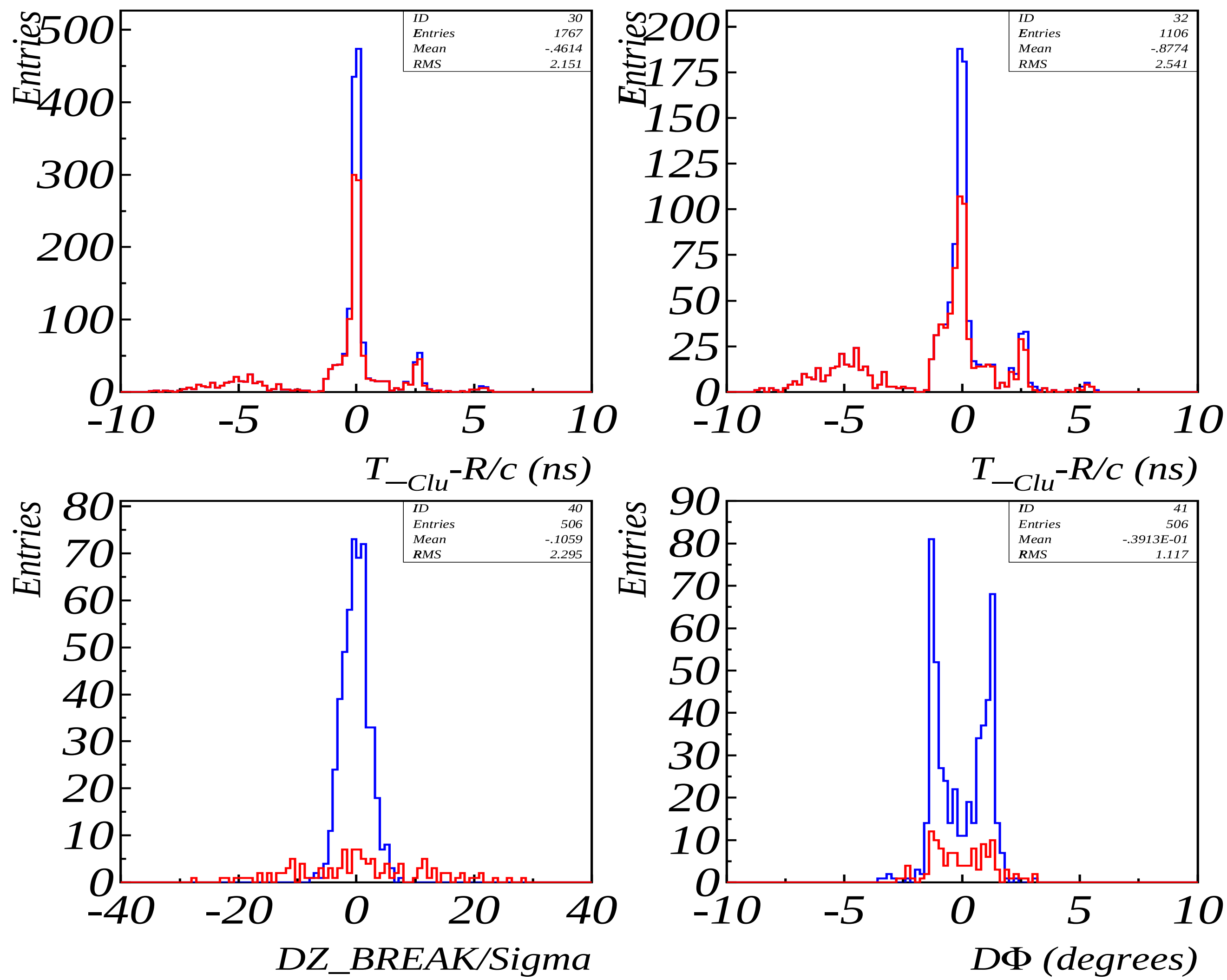


MERGING (D3) : composition $\eta\gamma$

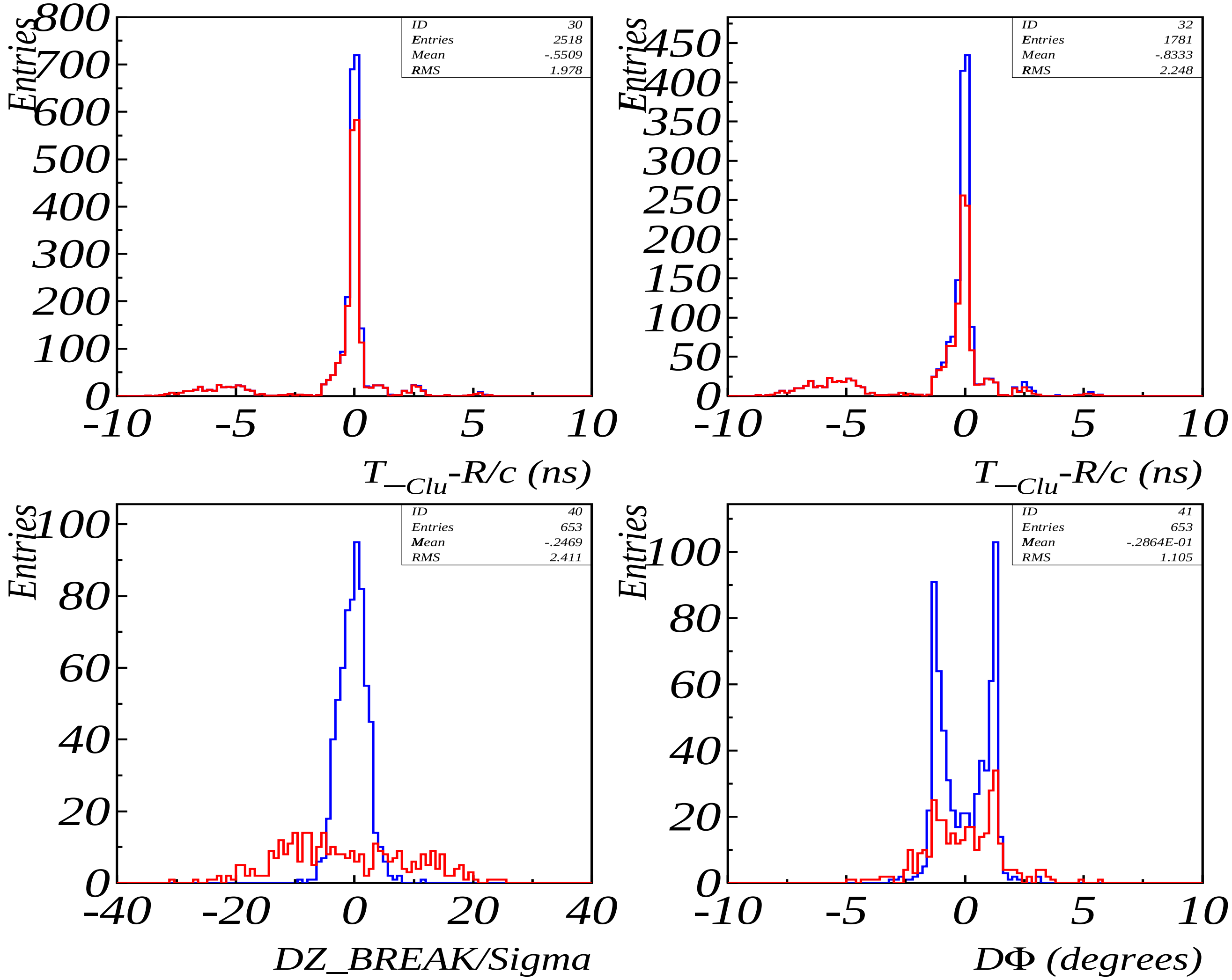
Kine-Particle composition of a cluster "without" fragments



MERGING (E) : Timing and Chi2Breaker, f0 γ



MERGING (E2) : Timing and Chi2Breaker, $\eta\gamma$



Merging of clusters: statistics

Out of 25 K events ($\eta\gamma, f0\gamma$) assuming as merging clusters only that ones with at least 30% in Esmall/Ecluster:

- 1751 (1420) events with at least one merging;
- 1540 (950) events with merging not coming from fragments;
- 750 (280) with $|\theta_{clu} - \theta_{kine}| < 10^\circ$
- 560 (240) with $10 < |\theta_{clu} - \theta_{kine}| < 20^\circ$
- 230 (430) with $|\theta_{clu} - \theta_{kine}| > 20^\circ$
- 1000 (600) with $|\theta_1 - \theta_2| < 40^\circ$
- 500 (350) with $|\theta_1 - \theta_2| > 40^\circ$

As a short summary and without considering acceptance:

- around 7% (5%) of clusters are merged
- 1.3% (1%) gives problems of timing.
- Around 1/3 of the total are too well matched photons, nothing to do!
- Around 1/3 of the total can possibly be solved if cells are broken .. but..

Merging of clusters: development/plans

We have developed a CELLS breaking technique as follows:

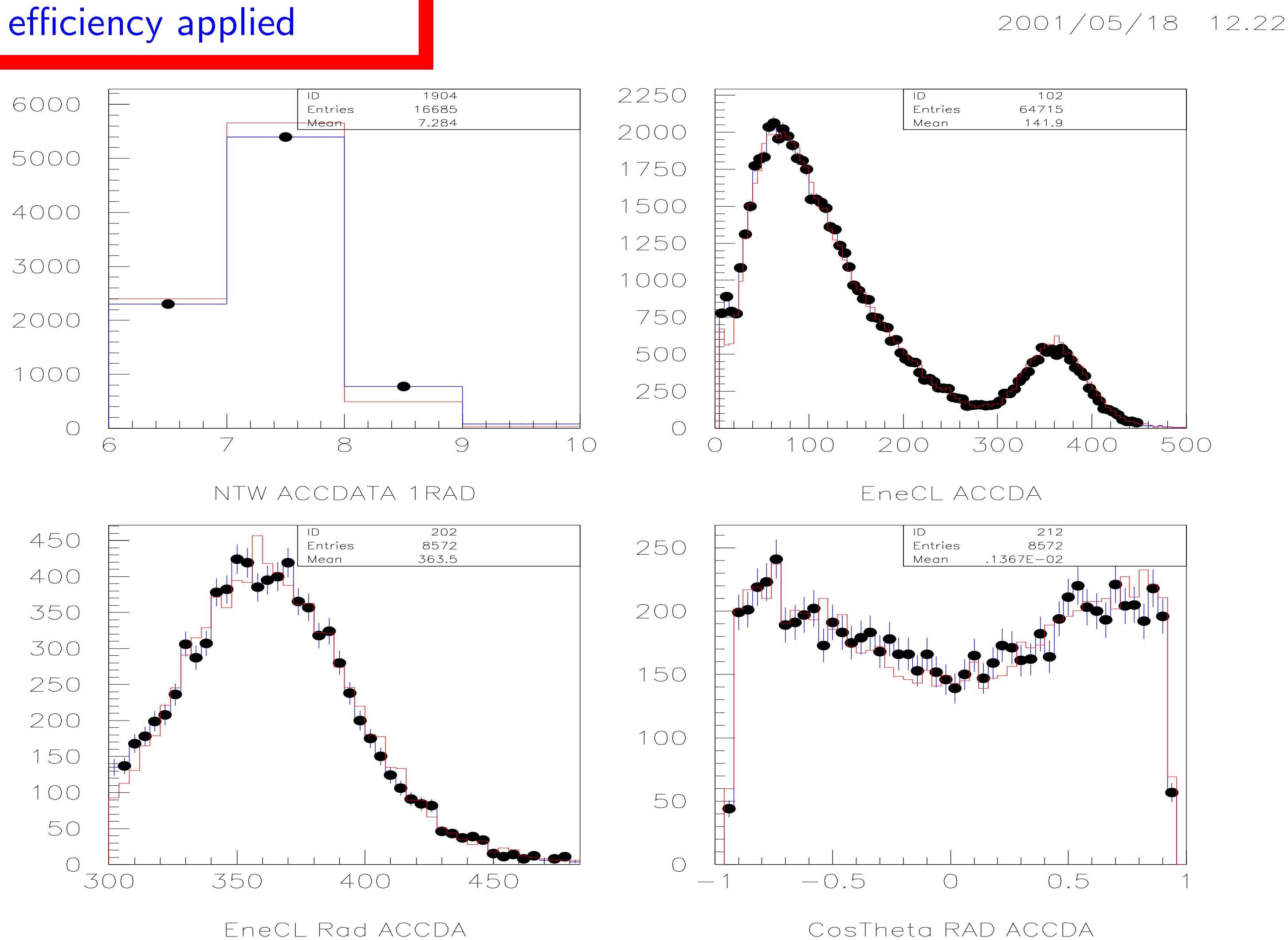
- Create a new CSPS data structure able to handle multiple hits/cell;
- Assume a vertex for the cluster (i.e. for the hit);
- Break cells along Z to originate double hits USING VTX + Ta,Tb absolute timing! (here trigger rephasing COUNTS).
- If cells is broken solve E_{hit1},E_{hit2} using Ea,Eb;
- Reconstruct CSPS again;
- Recluster;

After doing all this we have found a lot of troubles:

1. there is a tendency to break one single late hit in two very nice "prompt" hits
2. the endcap curve section does not respond properly
3. each wrong t0step0 creates a trouble for breaking cells ...
   THIS IS STILL WORK IN PROGRESS

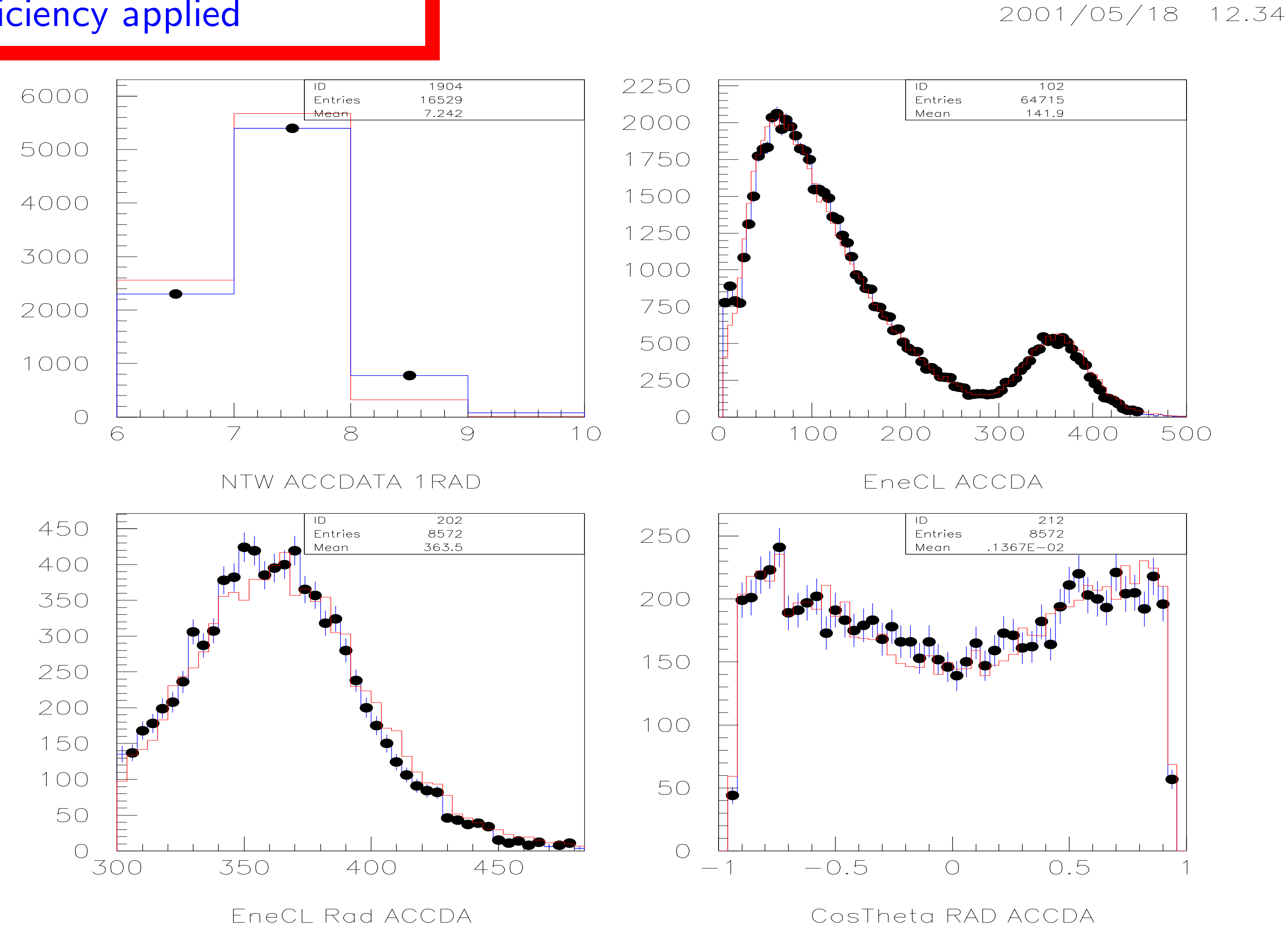
Counting $\phi \to \eta\gamma \to 7\gamma's$:

Clurec
No efficiency applied



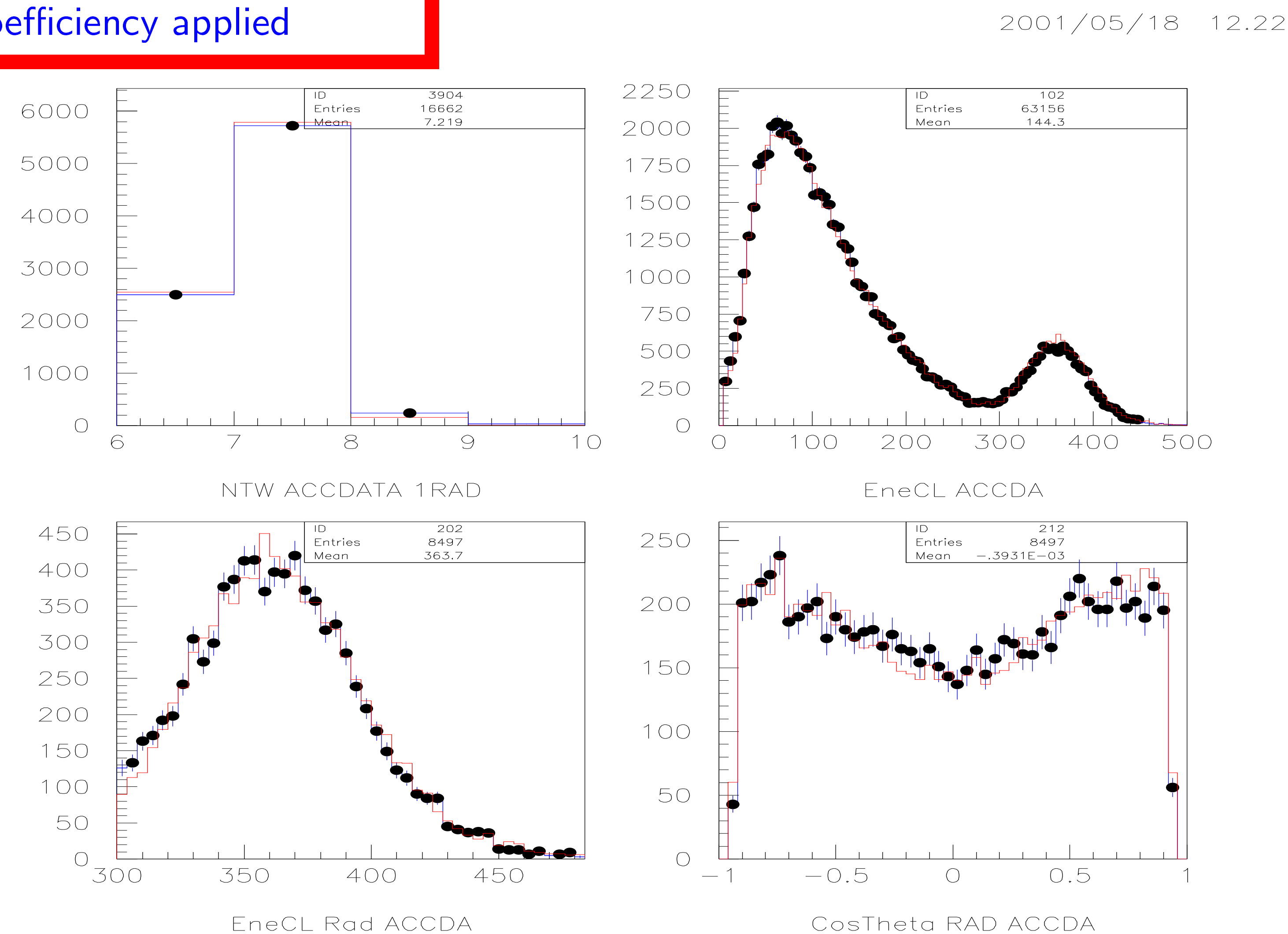
Counting $\phi \to \eta\gamma \to 7\gamma's$:

Clurec
efficiency applied



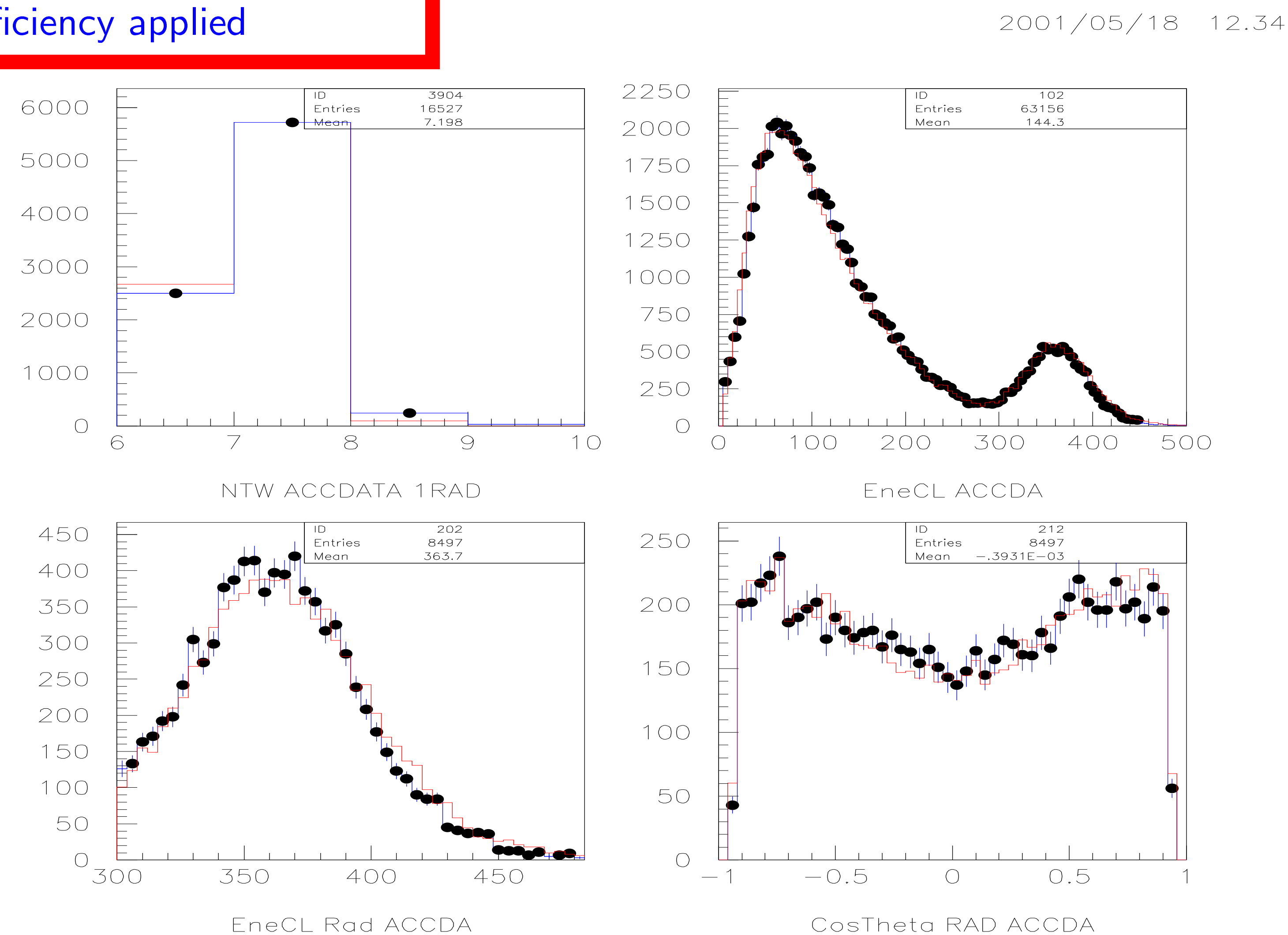
Counting $\phi \rightarrow \eta\gamma \rightarrow 7\gamma's$:

RecSplitting
Noefficiency applied



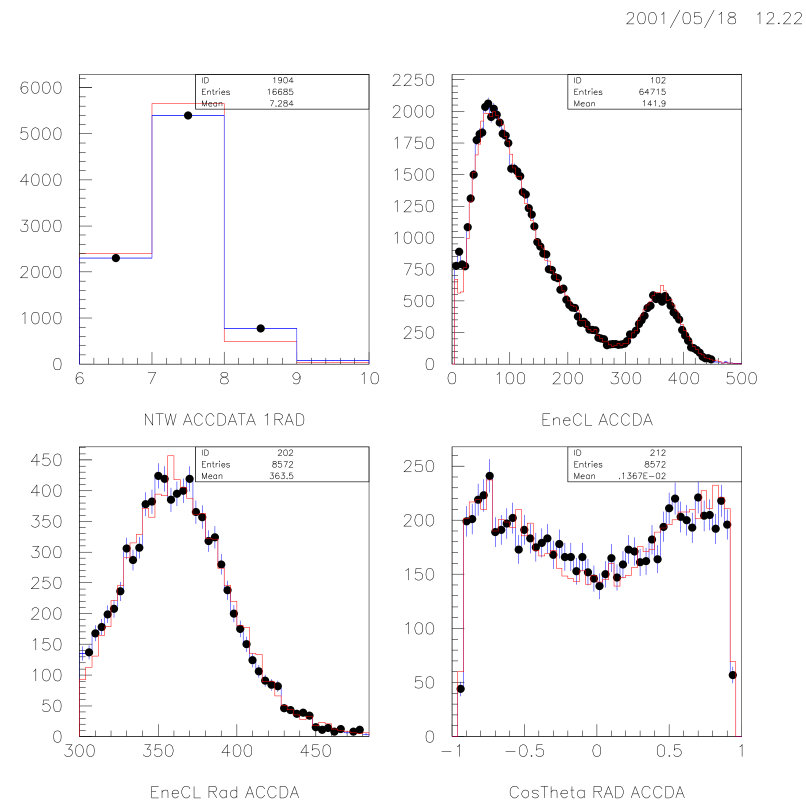
Counting $\phi \to \eta\gamma \to 7\gamma's$:

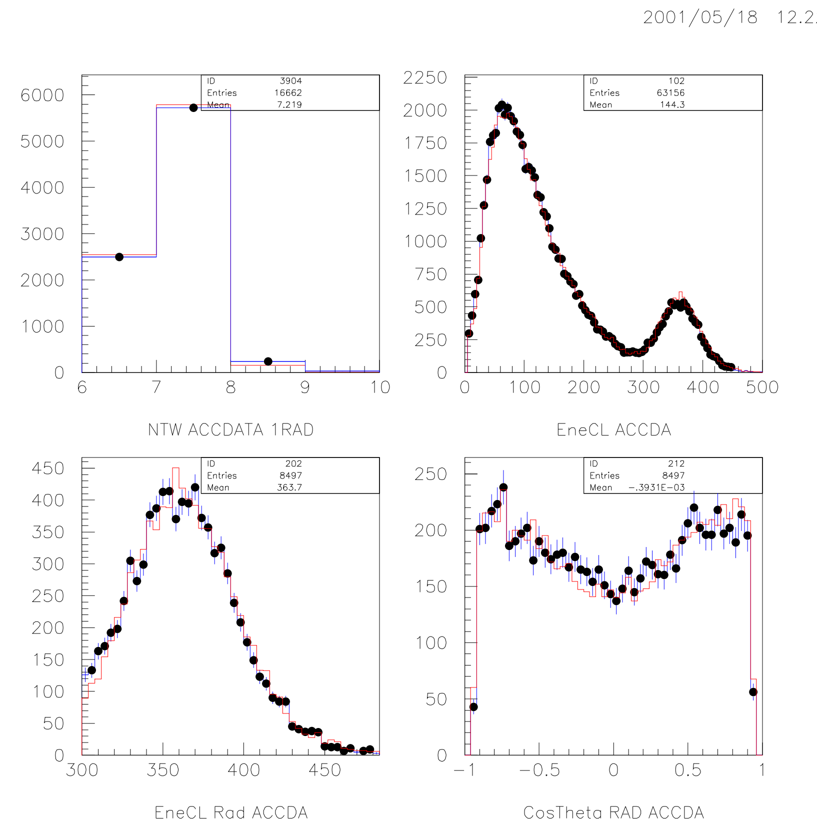
RecSplitting
Efficiency applied



Counting on MultiPhotons final state:

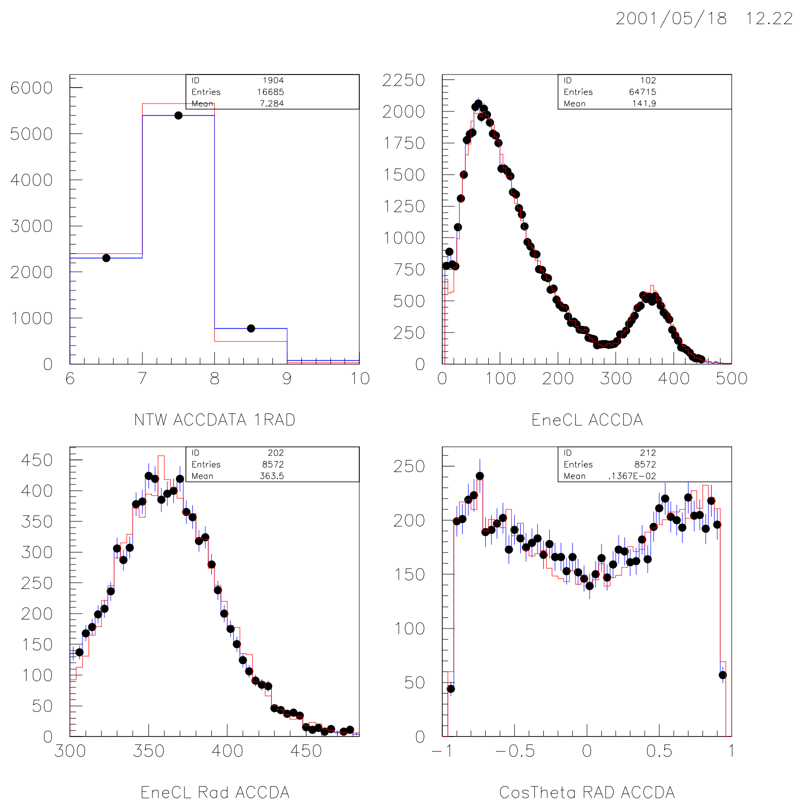
A realistic case: $\eta\gamma$ with NO EFFICIENCY applied

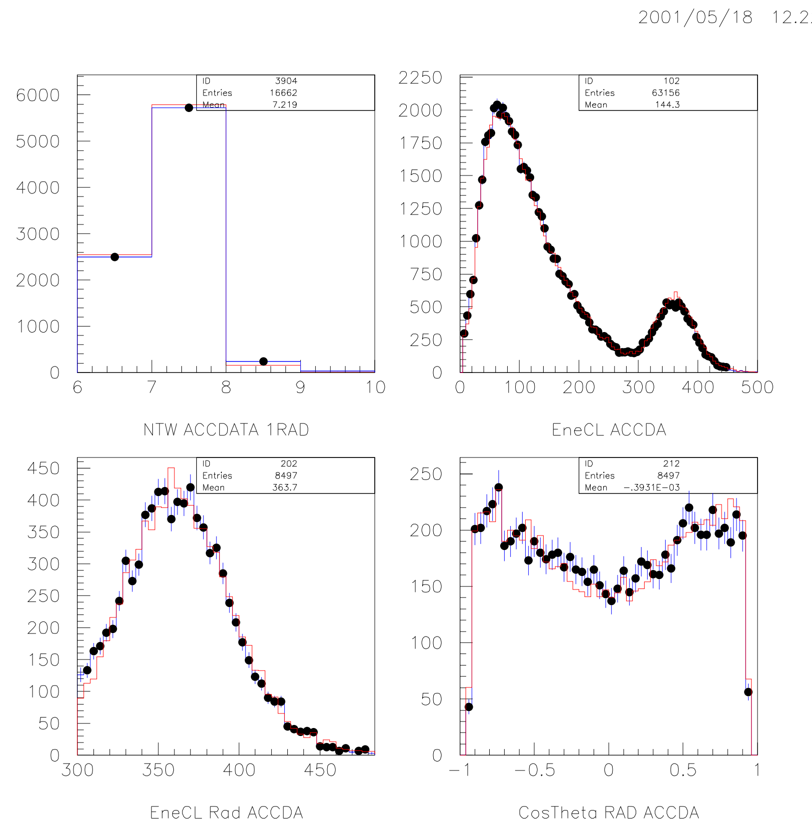




Counting on MultiPhotons final state:

A realistic case: eta7 with EFFICIENCY applied





Counting $\phi \rightarrow \eta\gamma \rightarrow 7\gamma's$:

Clu	VAR	6 RAD	7 RAD	6+7 RAD	8 RAD
old	Nev	2302	5399	7798	777
old	Nev/ϵ	12342	12261	12437.	20470
old	Nev/ϵ(2)	11652	12335	12261.	31179
old	ϵ	0.187 ± 0.003	0.440 ± 0.004	0.038 ± 0.001	0.627
old	ϵ(2)	0.198 ± 0.003	0.438 ± 0.004	0.025 ± 0.001	0.636
old	Ratio	0.268 ± 0.008	.630 ± 0.005	0.898± 0.008	.091 ±0.003
old	Ratio(1)	0.281 ± 0.005	.662 ± 0.003	0.943± 0.006	.057 ±0.002
old	Ratio(2)	0.300 ± 0.005	.663 ± 0.003	0.963± 0.006	.038 ±0.002
old	AC/PI	0.008(0.019)	0.007(0.020)	0.006(0.012)	
new	Nev	2499	5719	8218	242
new	Nev/ϵ	12495.	12590.	12566.	20167.
new	Nev/ϵ(2)	12014.	12857.	12585.	31026.
new	ϵ	0.200 ± 0.003	0.454 ± 0.004	0.654 ± 0.005	0.012 ± 0.001
new	ϵ(2)	0.208 ± 0.003	0.445 ± 0.004	0.653 ± 0.005	0.008 ± 0.001
new	Ratio	0.295 ± 0.008	0.676 ± 0.005	0.971 ± 0.002	0.029 ± 0.002
new	Ratio(1)	0.300 ± 0.005	0.682 ±0.003	0.982 ± 0.001	0.018 ± 0.001
new	Ratio(2)	0.315 ± 0.005	0.673 ±0.003	0.988 ± 0.001	0.012 ± 0.001
new	AC/PI	0.007(0.017)	0.009(0.022)	0.029 (0.047)	

$\phi \to \eta\gamma \to 7\gamma$: X-sec and Ratios

Using clurec or recover splitting the cross-section measurement does not change more than 1 %

Variation of cross section as a function of an exclusive photons'counting (6 or 7) is contained in within 6 %.

Cross section is stable at $1 \div 2$ % level if we count 7 or $6+7$.

The data/mc difference of the ratios between the counting of Nphotons/Nall improves with RecoverSplitting.