
Photon Reconstruction Status

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OUTLINE

- **Framework**
- **Approaches**
 - TOWER
 - VICINITY
 - Photon FinDer
 - EMILE
- **Tests**
 - Isolated Photons
 - π^+/γ
- **Conclusions**

- GEANT 4
 - Projective Geometry (**LINEAIRE**)
 - Non-projective Geometry (**MOKKA**)
-
- Interface of the **CODES** with the non-projective geometry is on progress and no difficulty is foreseen
 - The informations are centralized on the **Web Site**
`http://lc-ecal.in2p3.fr`

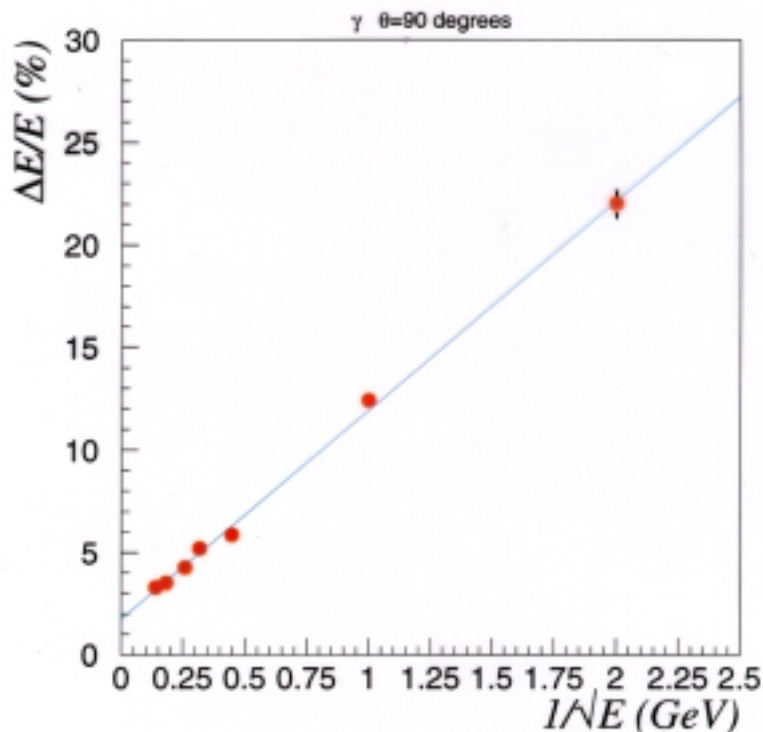
TOWER

- Projective Geometry
- **Clusterisation** is the collection of every pads in a $5 \times 5 \times 40$ ($\theta, \phi, layer$) **tower** around the most energetic pad if such a pad is not-isolated.

If no not-isolated pad exists, the zone is reduced to a $3 \times 3 \times 40$ tower around the most energetic pad.

- **Test**

Isolated Photons from 250 MeV up to 30 GeV



Resolution obtained as a function of E_γ
$$\Delta E/E = (10.3 \pm 0.3)\% / \sqrt{E} + (1.1 \pm 0.1)\%$$

- Acts as a benchmark
- Indicates the intrinsic performances of the Si/W ecal

VICINITY

- Projective Geometry
- Clusterisation is based on vicinity rule between the pads

Rule : 2 pads with at least a corner or/and a side in common are connected

- Clustering begins on the most energetic pad not already involved
- A cluster is the collection of all pads linked by the vicinity rule after iterative loop on all the pads already collected.
- goto i)

- Tests

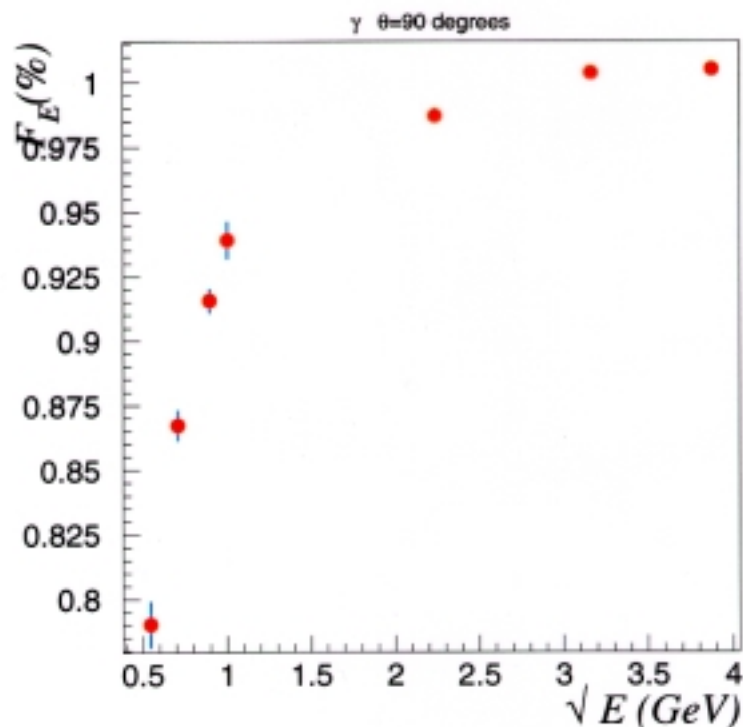
Isolated Photons from 250 MeV up to 15 GeV

Fraction of collected energy as a function of E_γ

→ → →

- Projective Geometry
- Isolated Photons from 250 MeV up to 15 GeV

Fraction of collected energy as a function of the energy



The cluster under consideration should have more than 5 pads involved.

The fraction of collected energy is less than 80% @ 250 MeV while it decreases to 60% when **only** the most energetic cluster is taken into account.

- A rule to connect the clusters has to be defined

Which pads to use ?

1 - reject from the list of pads, all pads within some distance to the extrapolation of a charged track (1cm)

VIRTUAL STACK 1

1 - Create a *virtual stack* by summing the first 10 layers
2- order by energy the *virtual pad(s)* of the virtual stack
3- Start a new *virtual cluster(s)* as soon as a pad is not a neighbour of the previous virtual pad in the energy ordered list.

(*GAMPEX - ALEPH photon package*)

CLUSTERING kernel

1 - Start from the *virtual cluster(s)* as entry point to clustering for all *real pad(s)*
2 - Use “equivalent distance” at the ECAL entry to declare 2 pads are neighbours
3 - Recover unassociated pads by the angle between the “direction” of a cluster and the “direction” of a pad.
see next transparency for the definition of the direction

- **What is 'direction'**

for a cluster

Vertex to COG of the cluster

for a pad

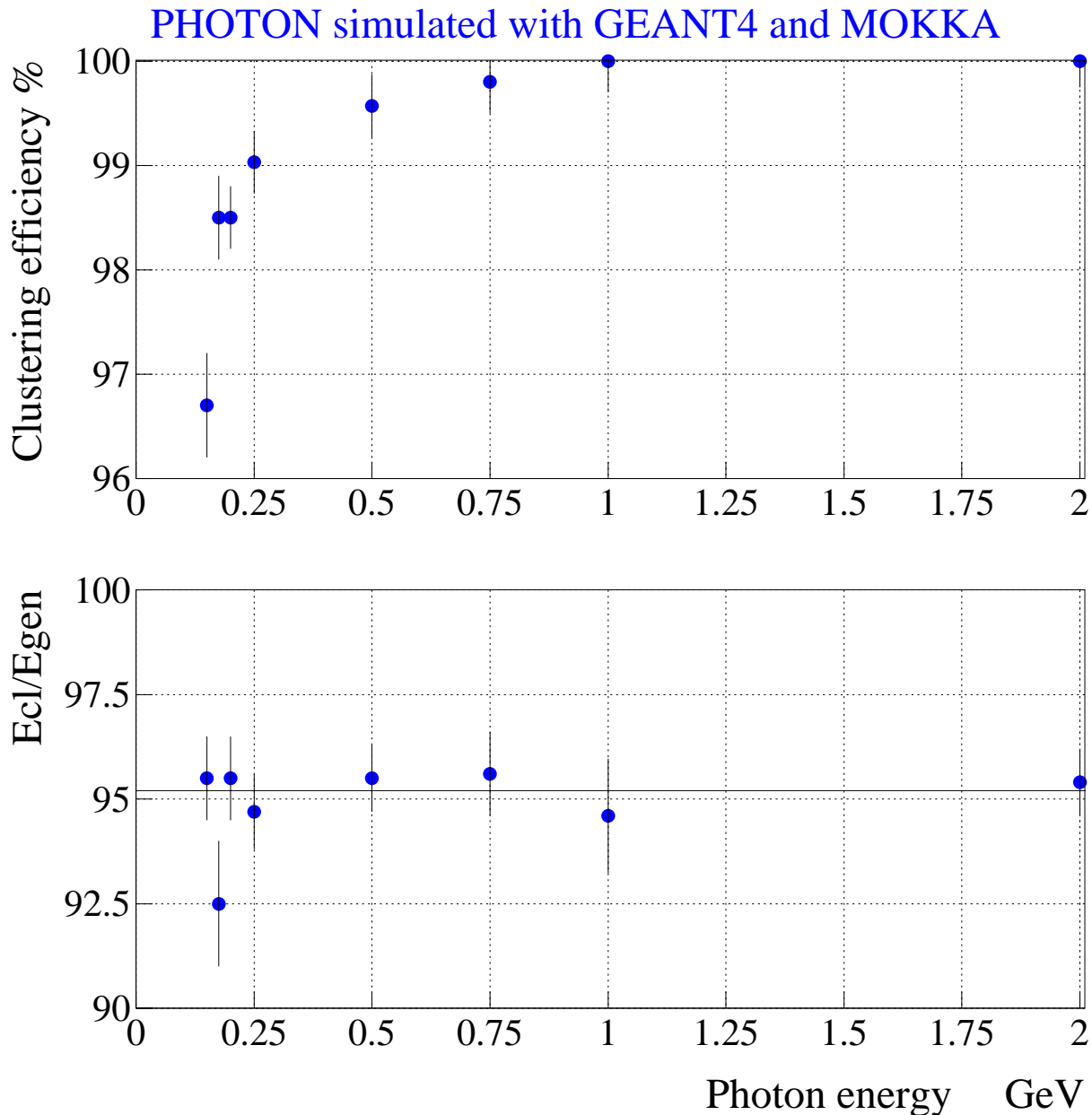
projected COG to entrance of the ECAL
to Pad position

- **Tests**

- Use of **MOKKA**

- Simulate photons from 0.15 to 100 GeV

RESULTS FROM SIMULATION



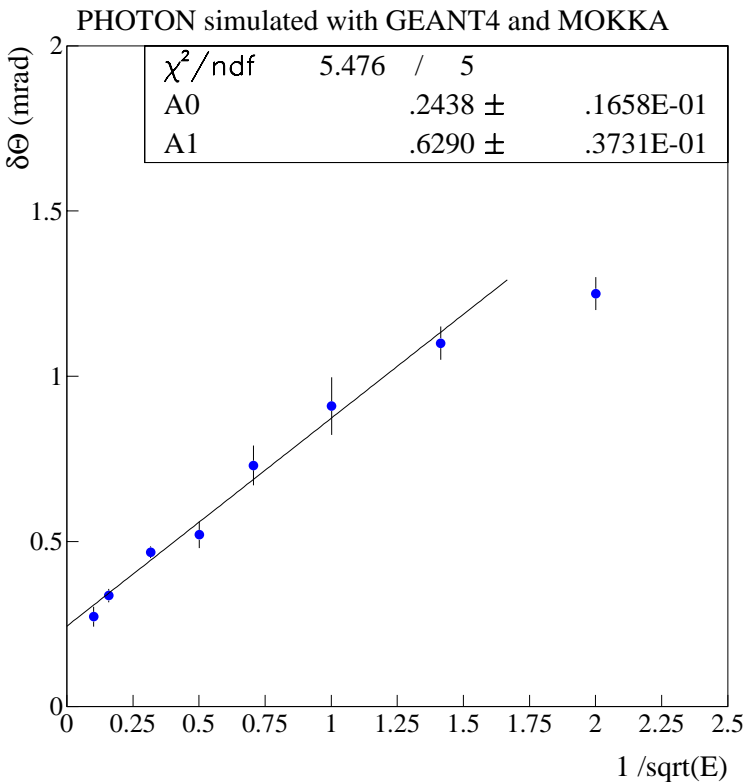
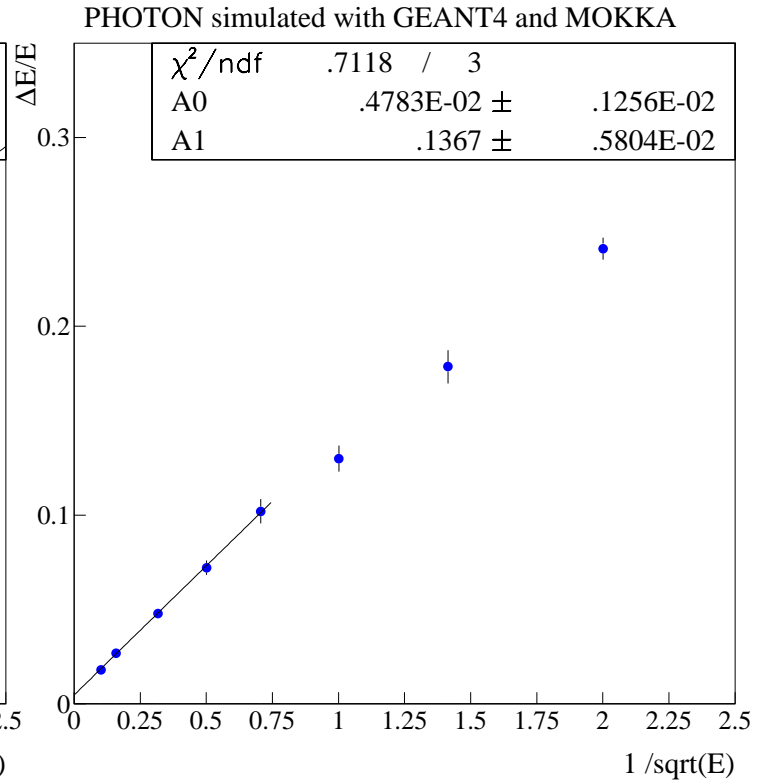
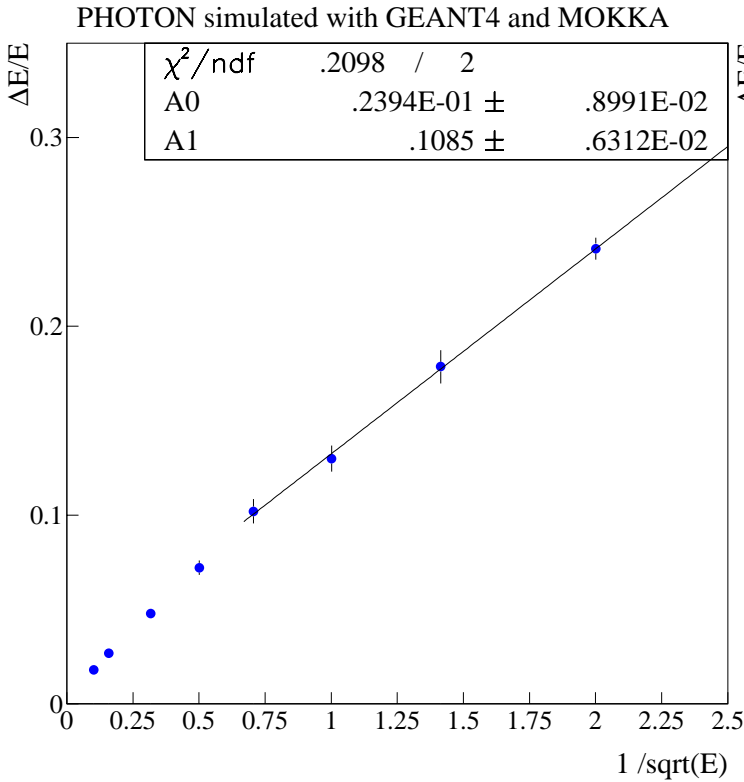
1 - PFD efficiency to find photon in the low energy region
About 99% above 0.25 GeV

2 - rate of fake electromagnetic cluster (created from fluctuation of an electromagnetic shower)
About few per mill - $4 \cdot 10^{-3}$ at 0.5 to $9 \cdot 10^{-3}$ at 100. GeV

3 - fraction of the total energy in the cluster

Stable and about 95 % up to 4 GeV then slowly going to 99.5% at 100. GeV

RESULTS FROM SIMULATION



4 - Energy and angular resolution
AFTER CLUSTERING
the stochastic term is $11.4\%/\sqrt{E}$
up to few GeV then about
 $13.7\%/\sqrt{E}$
 $\delta\theta(mrad) = 0.63/\sqrt{E} + 0.24$ down
to few hundred MeV

Beside the Standard approaches, new one is developed :

Energy **M**easurement **I**ntended for **L**ow **E**m showers

Main Directions

- 3D
- Democratic
- Physical insight
- No seed
- Long range

- Two pads (i and j) are connected according a link strength d_{ij} defined by terms which reflects the basic process ($e \rightarrow \gamma, \gamma \rightarrow e$)

Long distance interaction	$e^{-\rho_{ij}/X_o}$
Energy relation	E_i/E_j
Angular dependence	$1/(1-\beta \cos \theta_{ij})$

where

ρ_{ij} is the **3D distance** between the pads i and j ,
 X_o is the interaction length,
 θ_{ij} is the angle between the pad i and j
 $\beta = .99$

Thus d_{ij} is defined as

$$d_{ij} = e^{-\rho_{ij}/X_o} \times E_i/E_j \times 1/(1-\beta \cos \theta_{ij})$$

- d_{ij}
 - The d_{ij} terms are determined between every pair of pads in the event but pad j should be on a layer outer than the pad i i.e. follows the development of the e.m. shower
 - All pads are connected without any initiate pad (in contrast with maximal energy pad rule)
 - The energy from a pad could be shared by many objects

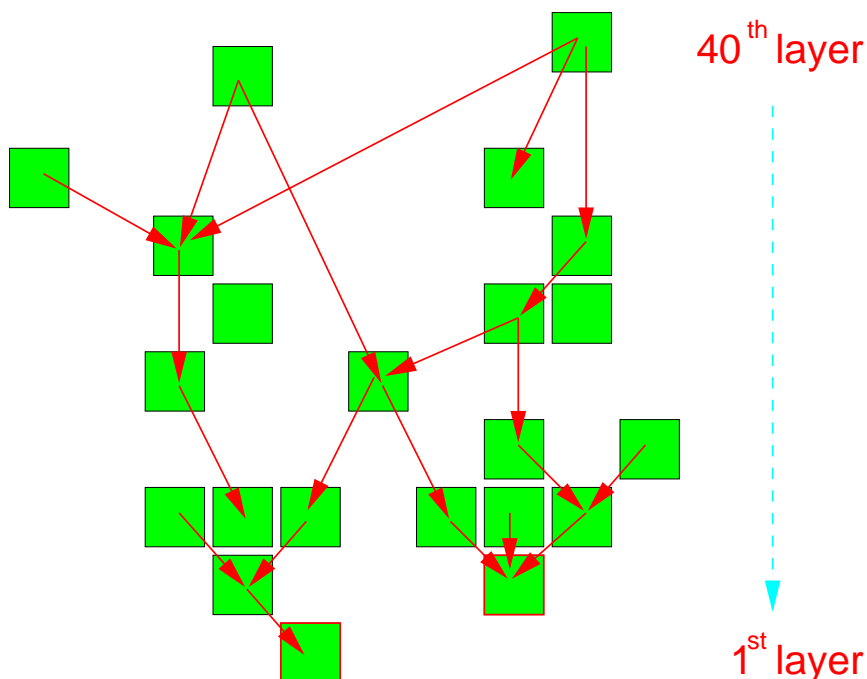
- An internal cut is applied

preliminary Version !

Cuts have to be tuned (or replaced by continuous function)

- Clustering

- **def** : Each pad j with $d_{ij}=0$ whatever i is a terminal pad
- **Rule** : From the outer layer (*i.e.* 40th) the energy is distributed on each pad according the d_{ij} down to each terminal pad.
 - **A terminal pad defines a cluster**
 - **Every characteristic of the cluster is built through the d_{ij} weighting from the 40th layer to the terminal pad.**



Examples : Energy, terminal pad coordinates, core cluster coordinates...

• Cluster association

Two clusters (a and b) are merged if

$$\|D_{entry}^a - D_{entry}^b\| \leq 1.73 \text{ or } \|D_{core}^{a,b}\| \leq 0.5$$

where D_{entry} stands for the Distance from the center of the detector and the terminal pad point, and $D_{core}^{a,b}$ is the distance between the barycenter of the cluster a and b .

Cuts have been tuned to ensure the best recovering of photon energy

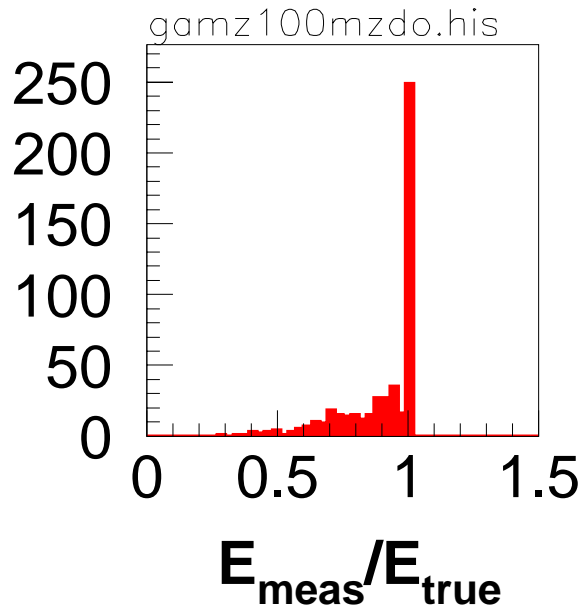
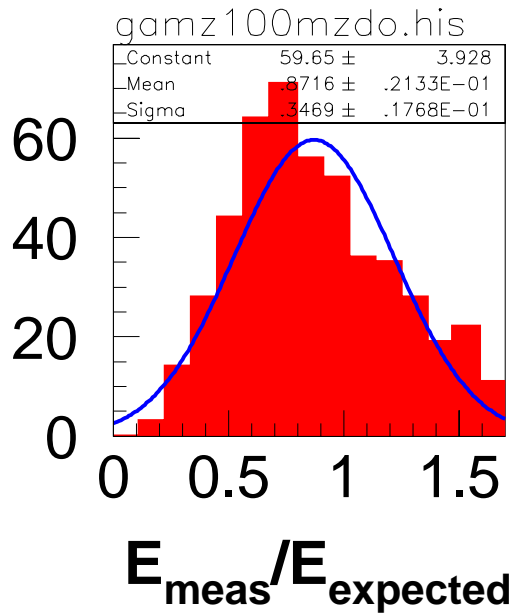
• Tests

Projective Geometry

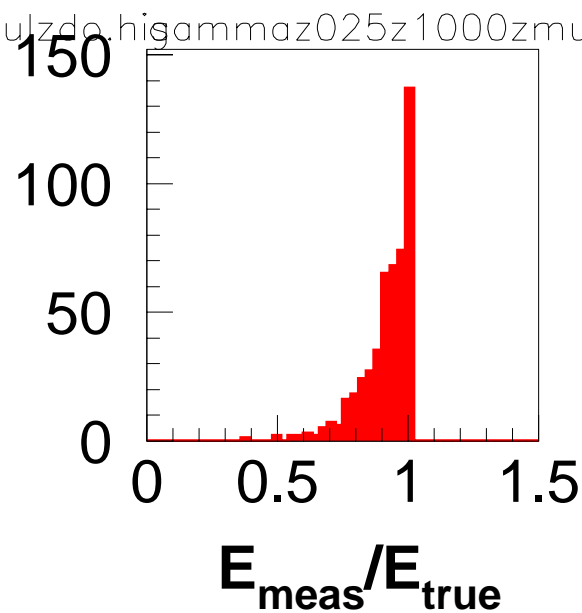
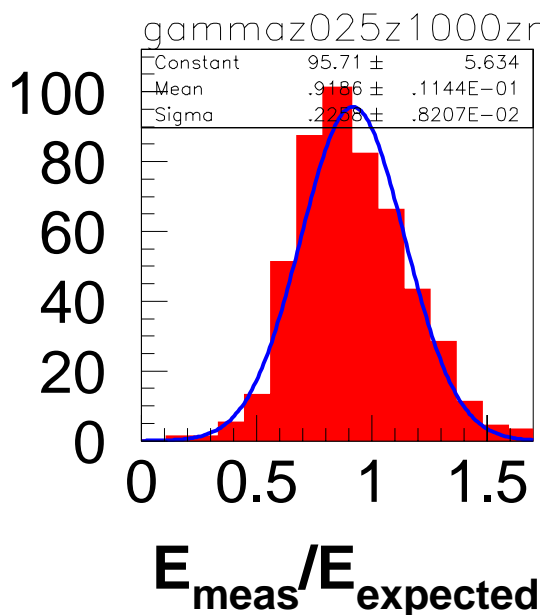
Isolated Photons from 100 MeV up to 15 GeV

EMILE: LOW PHOTONS

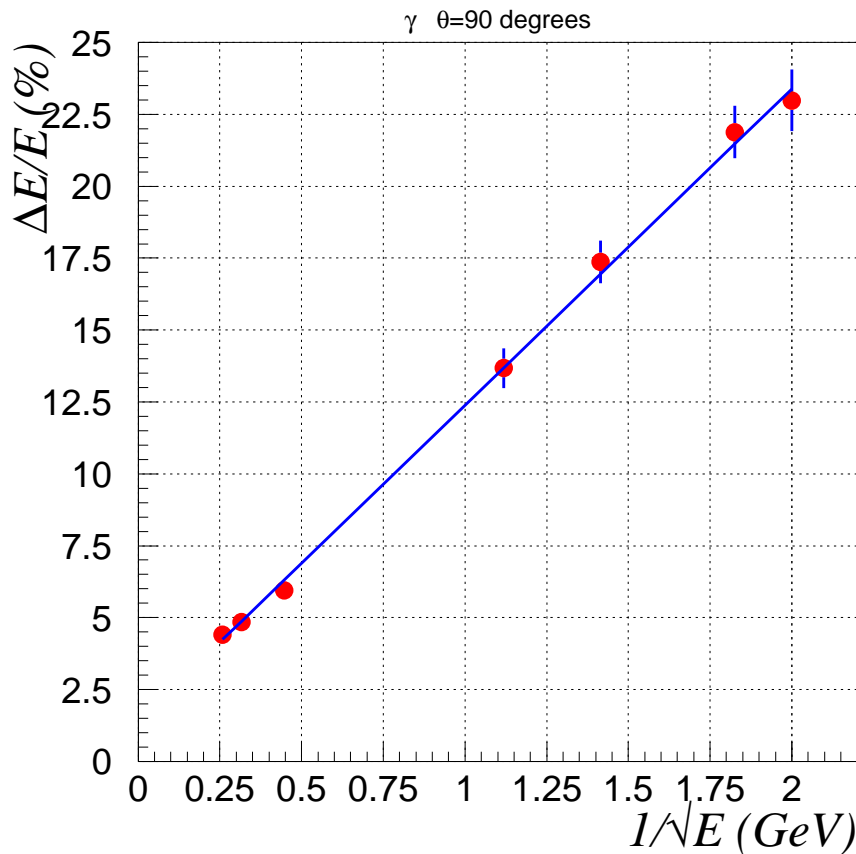
$E_\gamma = 100 \text{ MeV}$



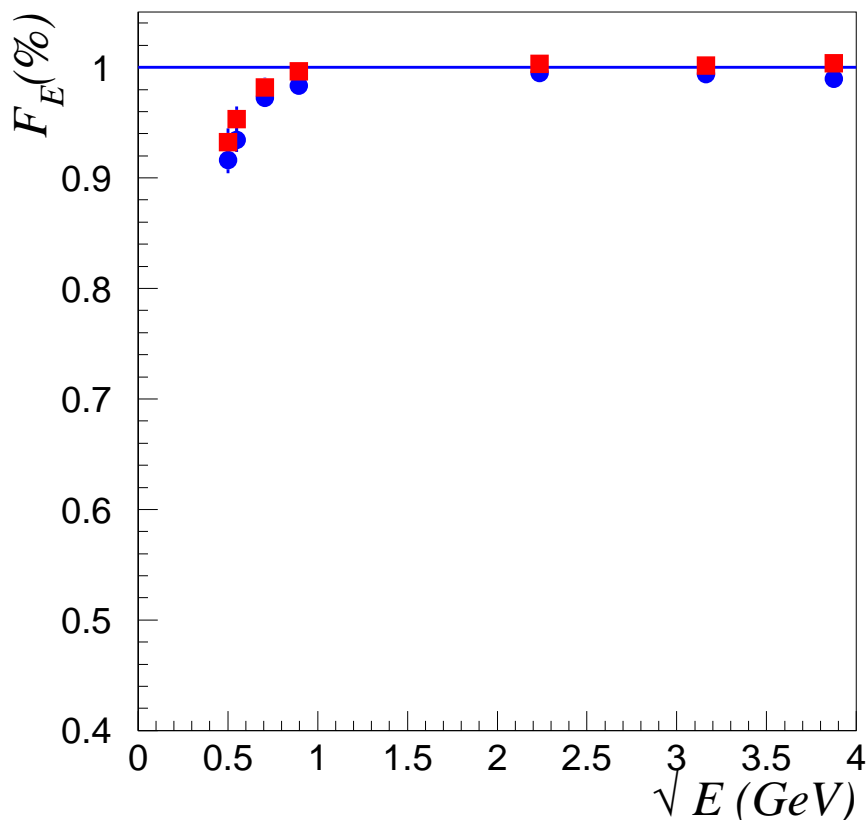
$E_\gamma = 250 \text{ MeV}$



FIRST PRELIMINARY RESULTS

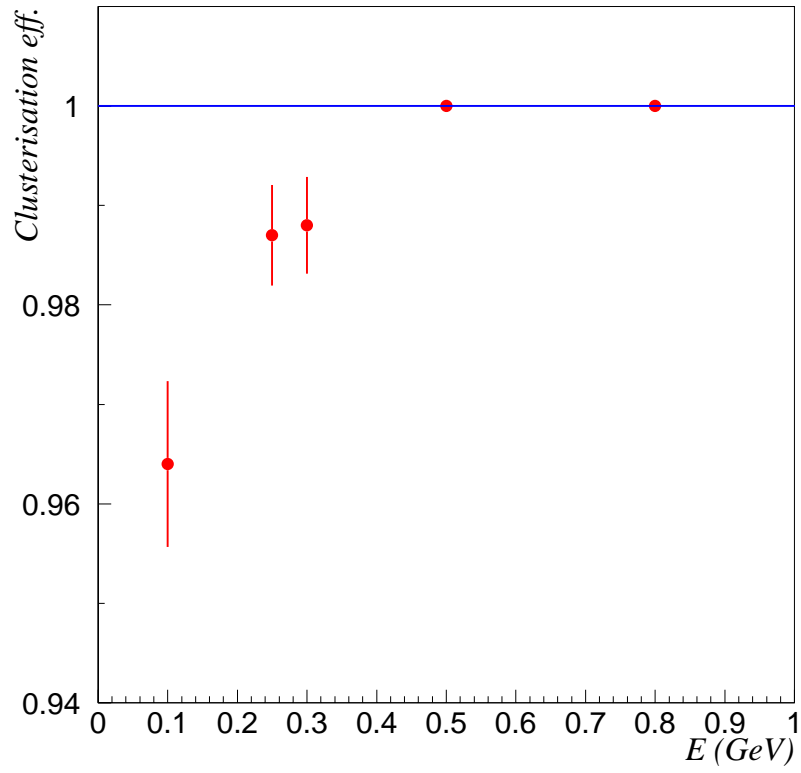


$$\Delta E/E = (11. \pm 0.3)\% / \sqrt{E} + (1.4 \pm 0.2)\%$$



Fraction of collected energy is never less than 92% even when only the most energetic cluster is taken into account

FIRST PRELIMINARY RESULTS



PHOTONS WITH PIONS

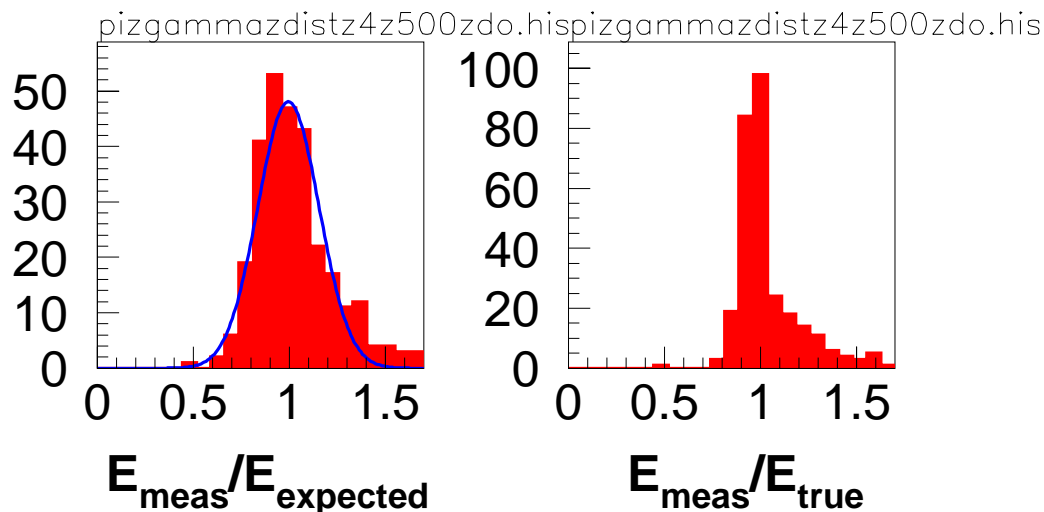
- Tests
- Photons with noise coming from π^+

Samples with different distances between the γ and the π^+

Typically $E_\gamma=1$ GeV and $E_\pi=10$ GeV
Distance is 4, 3 and 2 cm

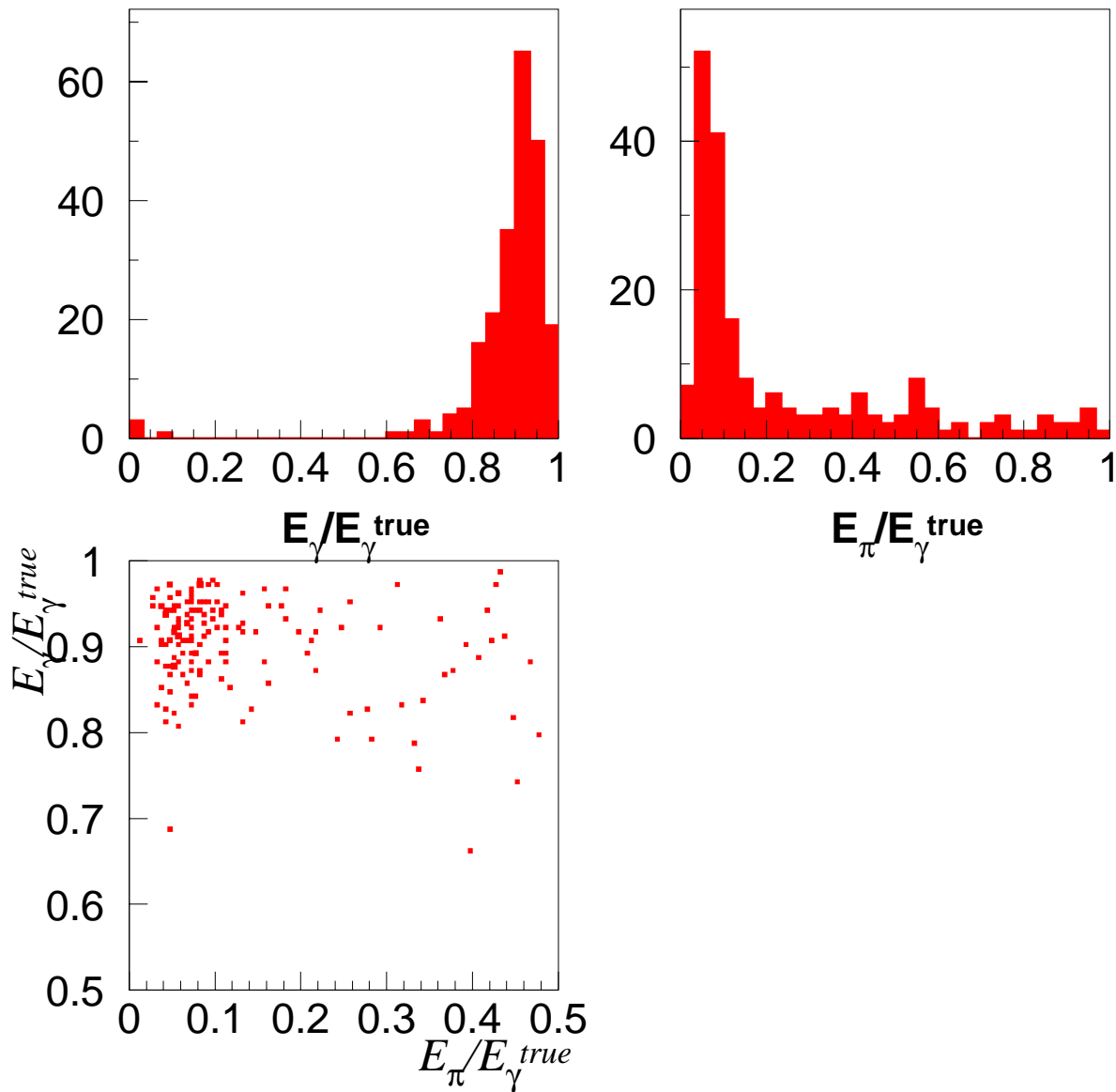
The clusters matching the MC photon direction are considered as photons

@ 4 cm



PHOTONS WITH PIONS

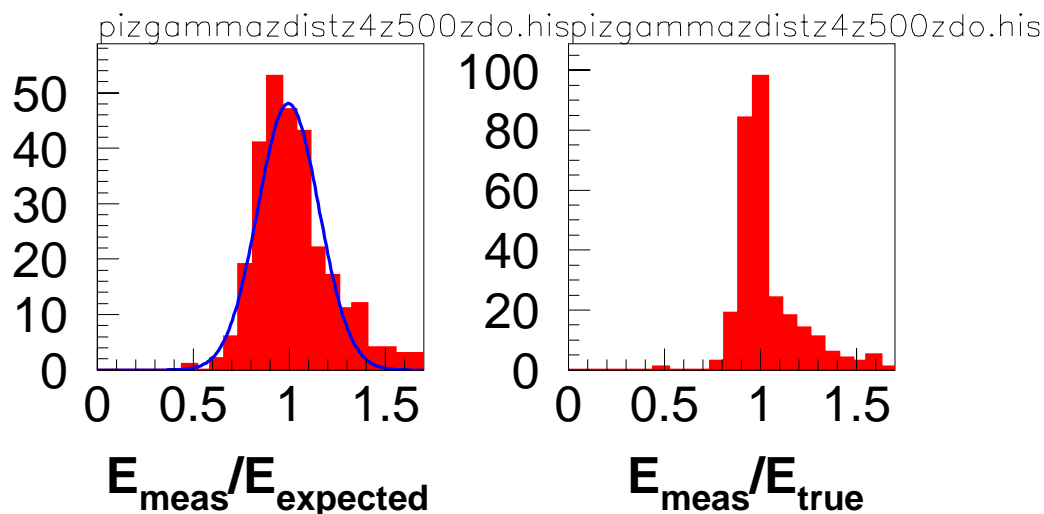
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PHOTONS WITH PIONS

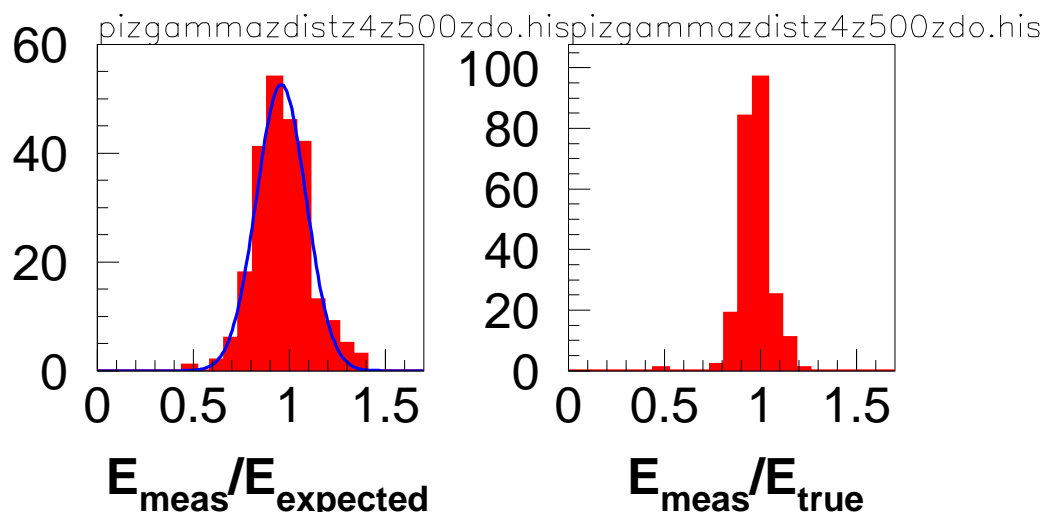
Photon with Pions

@ 4 cm



to Simulate the Photon-Id a cut on $(E_{\text{e.m.}}/E_{\text{meas}})_{\text{cluster}}$ is applied

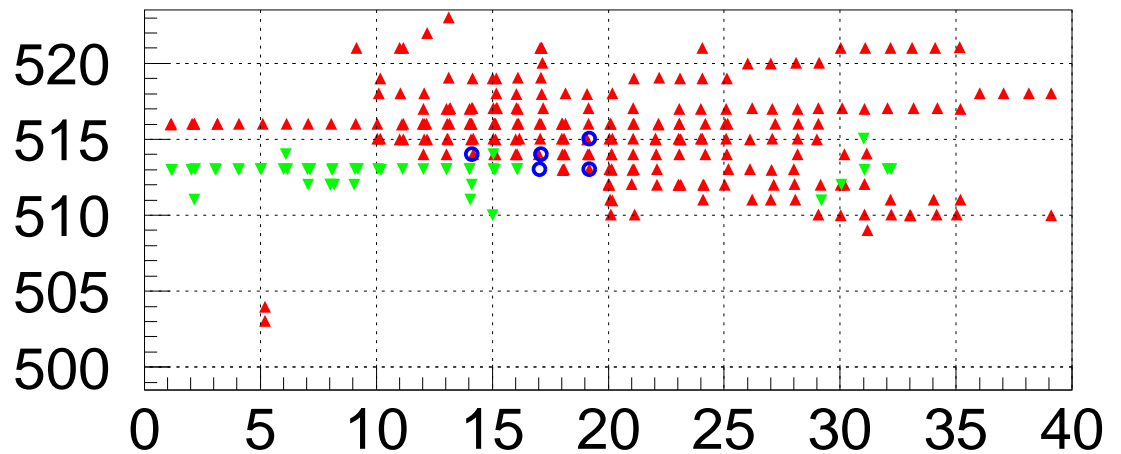
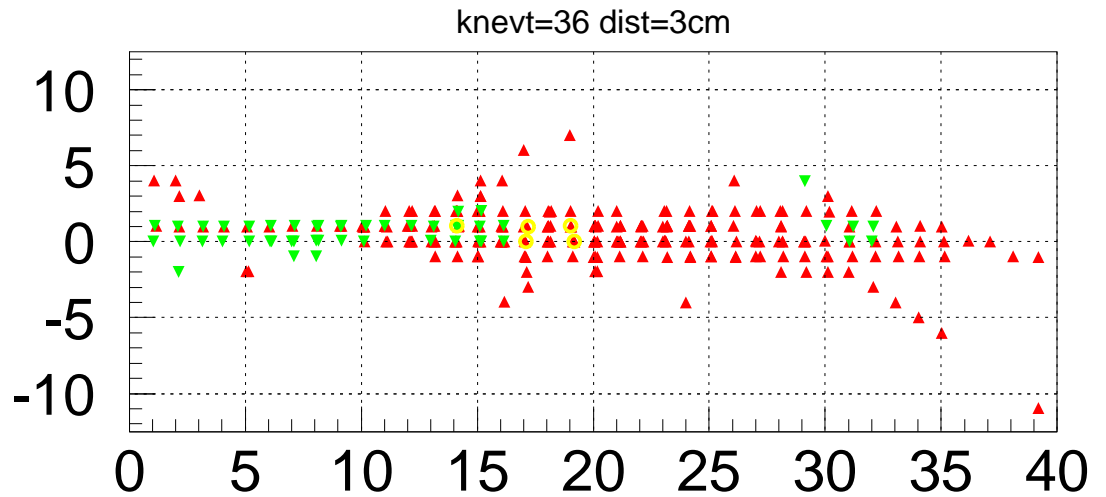
The cut is 'tuned'⁽¹⁾ to render the distribution gaussian



(1) typically .75

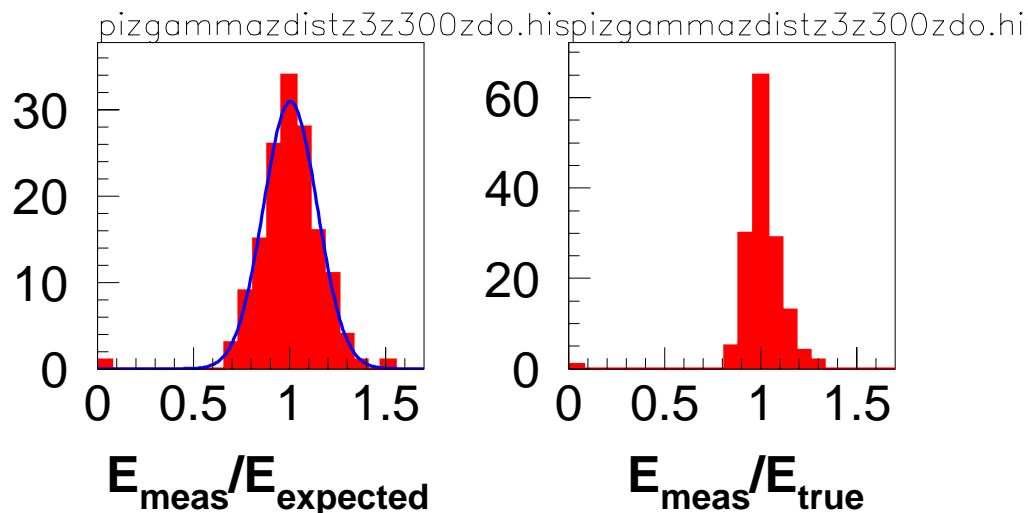
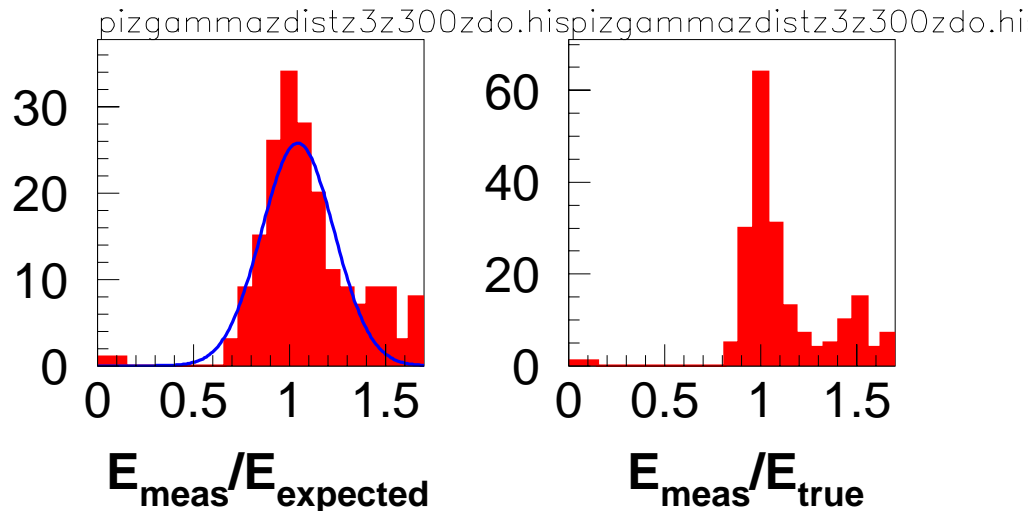
PHOTONS WITH PIONS

Display
@ 3 cm



knevt		E_{meas}	E_{π}	E_{γ}	the	phi	lay	E_{π}^{true}	E_{γ}^{true}
36	1	2.768	1.413	1.355	0	513	1	6.071	1.478
36	2	.014	.001	.013	-2	511	2	6.071	1.478
36	3	.265	.240	.025	0	510	15	6.071	1.478
36	5	2.870	2.785	.086	1	516	1	6.071	1.478
36	6	.033	.033	.000	-11	510	39	6.071	1.478
36	7	.403	.403	.000	-2	503	5	6.071	1.478
36	9	.795	.795	.000	1	521	9	6.071	1.478
36	10	.035	.035	.000	-3	519	17	6.071	1.478
36	11	.050	.050	.000	4	516	1	6.071	1.478
36	12	.013	.013	.000	-2	521	17	6.071	1.478
36	13	.029	.029	.000	-4	521	24	6.071	1.478
36	14	.009	.009	.000	-4	517	16	6.071	1.478
36	15	.015	.015	.000	6	521	17	6.071	1.478
36	16	.217	.217	.000	1	519	10	6.071	1.478
36	17	.034	.034	.000	7	517	19	6.071	1.478

Photon with Pions @ 3 cm



With such assumptions Preliminary Results are

@ 4cm $\epsilon_{\gamma}=80\%$

@ 3cm $\epsilon_{\gamma}=50\%$

@ 2cm $\epsilon_{\gamma}=22\%$

NB. No rejection of the π^+ shower nor Mip reconstruction

More realistic numbers will come with Photon-Id

CONCLUSION

1 Standard approaches

- Photon FinDer is an efficient photon finder
- It is a good starting point for photon
- Could play the Benchmark rôle, already interfaced w/ MOKKA

2 New approach with EMILE

- (3D, democratic, Physical insight, no seed, long range)
- Preliminary version
- Many switches have to be tuned

Next

- New Codes will be available from the Web Site
 - interfaced w/ MOKKA very soon
 - Included in BRAHMS
 - More investigation with noisy situation
 - Test the algorithms with jets, τ decays, etc.
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- Regular meeting are forseen (*last one 13th April 2000*)
 - KEK people are interested (*F. Le Diberder will visit them on july*)