



HAL
open science

Photon reconstruction status

Pascal Gay, J.C. Brient, F. Le Diberder, S. Monteil, F. Yermia

► **To cite this version:**

Pascal Gay, J.C. Brient, F. Le Diberder, S. Monteil, F. Yermia. Photon reconstruction status. Workshop of the 2nd ECFA/DESY Study on Physics and Detectors for a Linear Electron Positron Colliders 6, May 2000, Padova, Italy. in2p3-00013854

HAL Id: in2p3-00013854

<https://hal.in2p3.fr/in2p3-00013854>

Submitted on 22 Jul 2003

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Photon Reconstruction Status

J.C. Brient, P. Gay, F. Le Diberder, S. Monteil, F. Yermia

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`

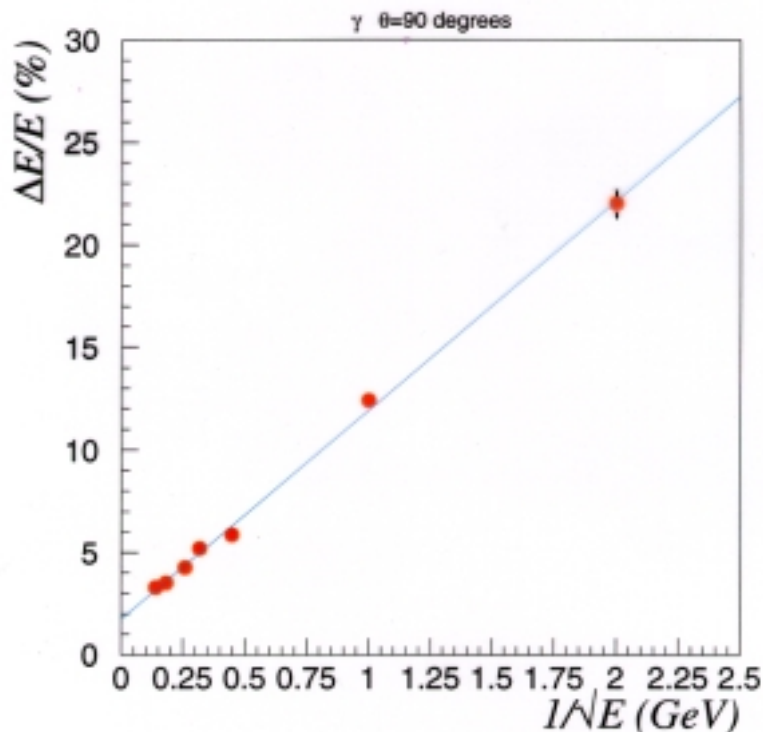
TOWER

- 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

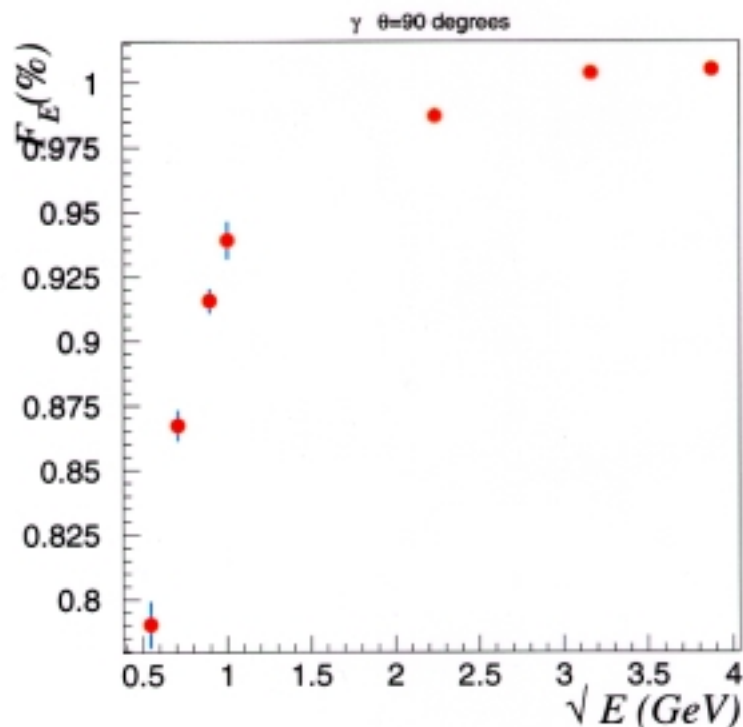
Isolated Photons from 250 MeV up to 15 GeV

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

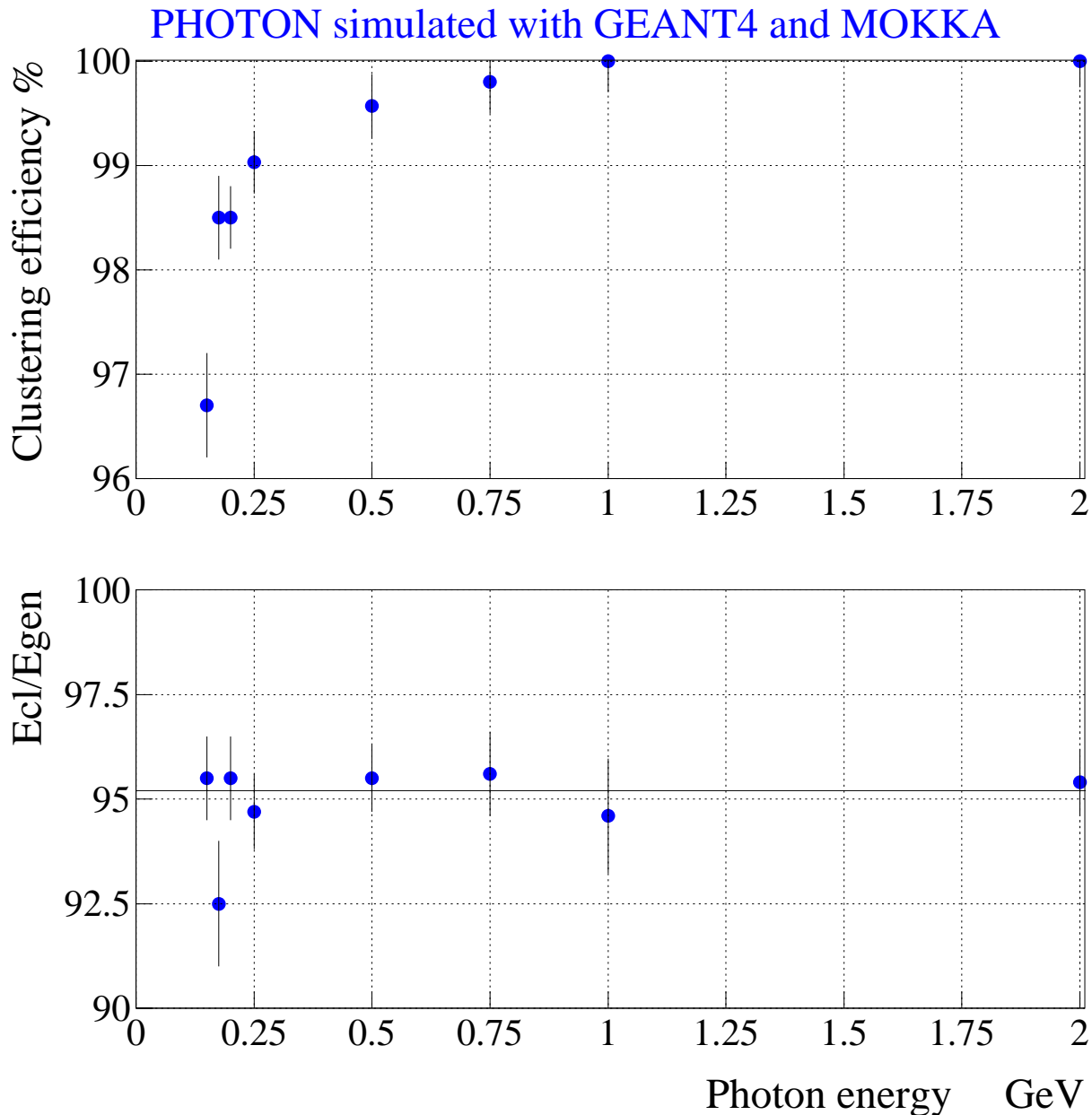
projected COG to entrance of the ECAL
to Pad position

- **Tests**

- Use of **MOKKA**

- Simulate photons from 0.15 to 100 GeV

RESULTS FROM SIMULATION



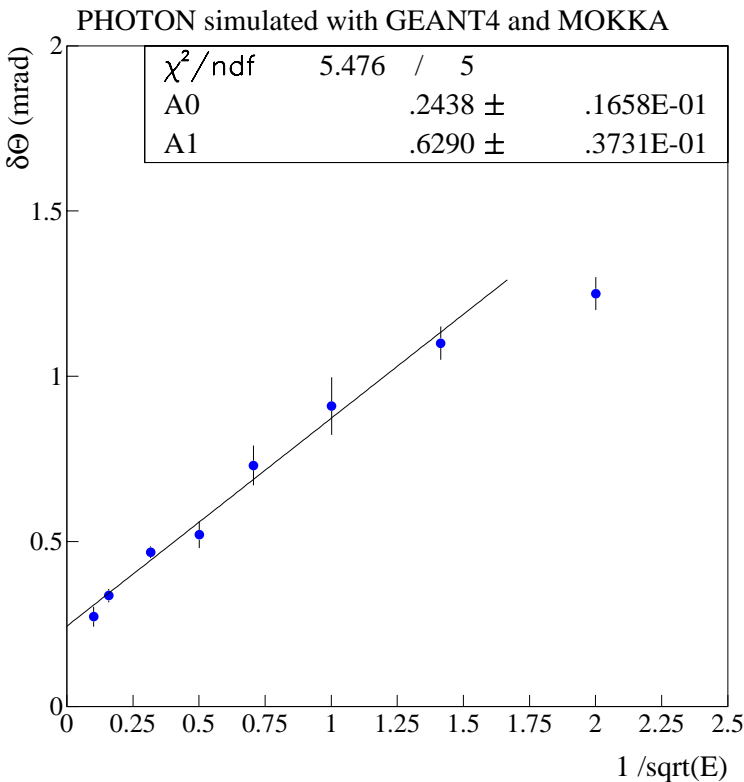
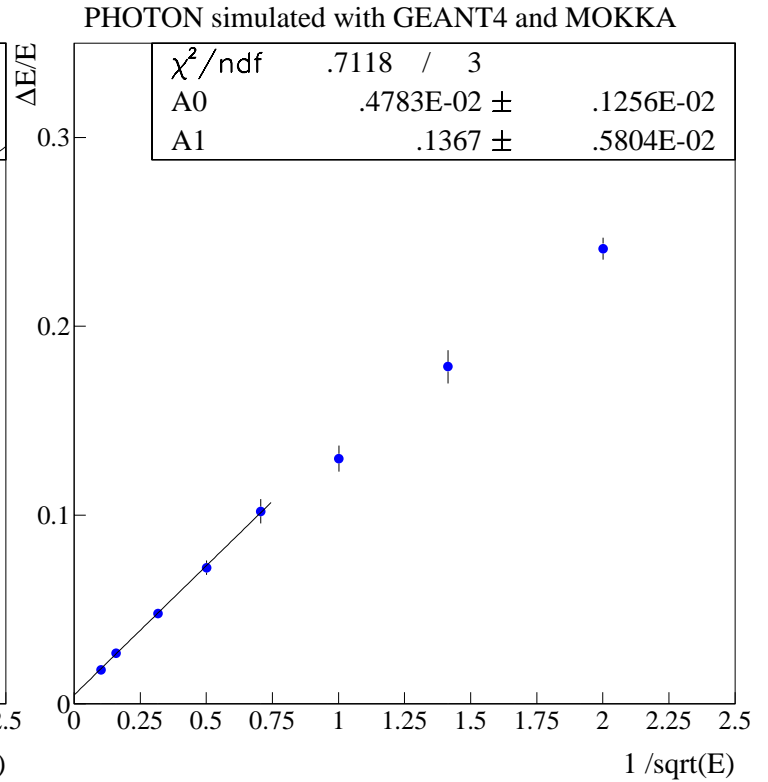
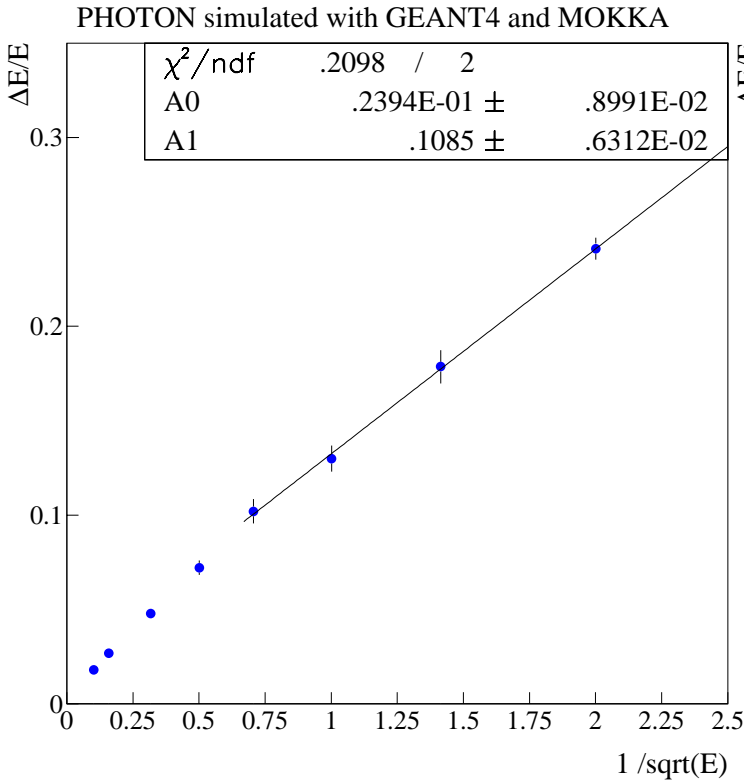
1 - PFD efficiency to find photon in the low energy region
About 99% above 0.25 GeV

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
 $13.7\%/\sqrt{E}$
 $\delta\theta(\text{mrad}) = 0.63/\sqrt{E} + 0.24$ down
to few hundred MeV

Beside the Standard approaches, new one is developed :

Energy Measurement Intended for Low Em 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

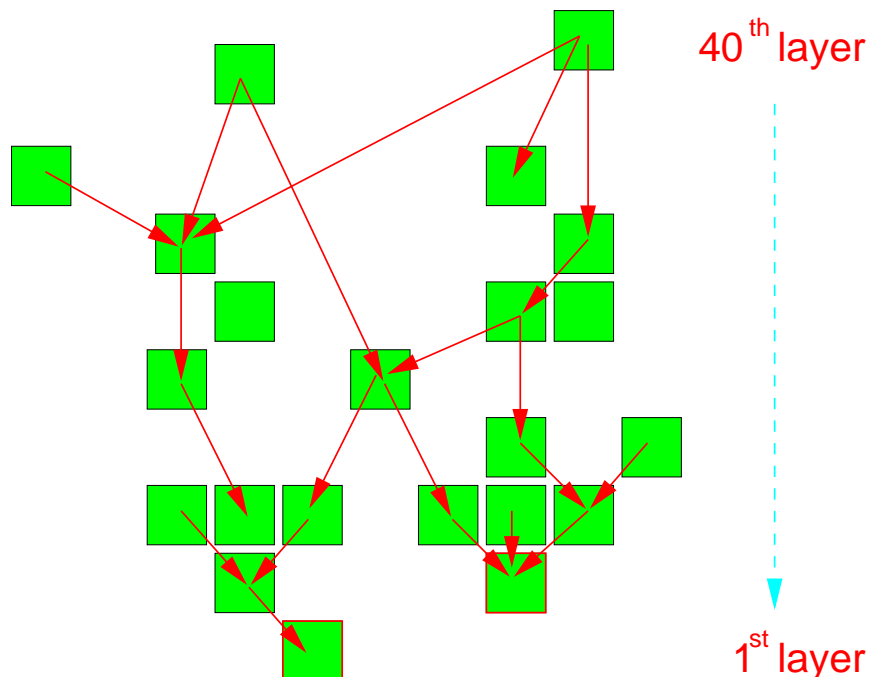
- An internal cut is applied

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

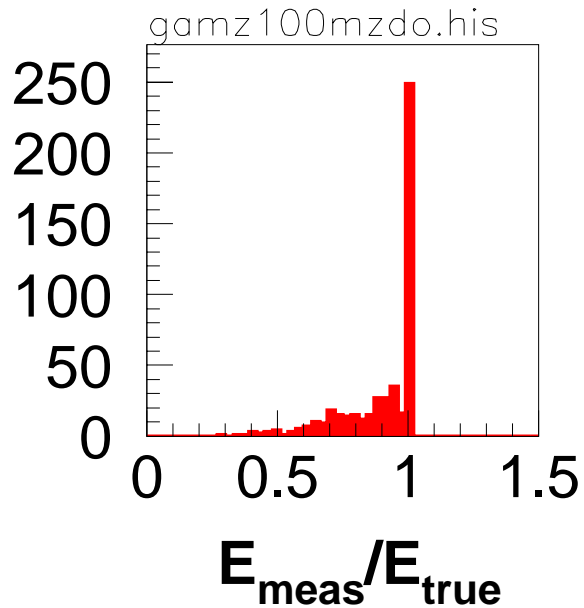
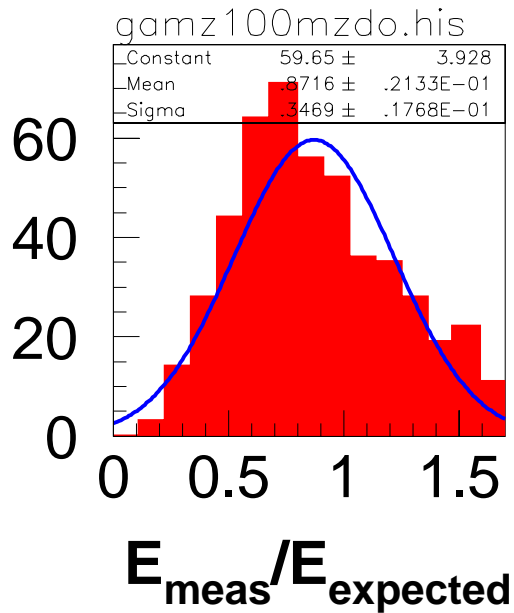
• Tests

Projective Geometry

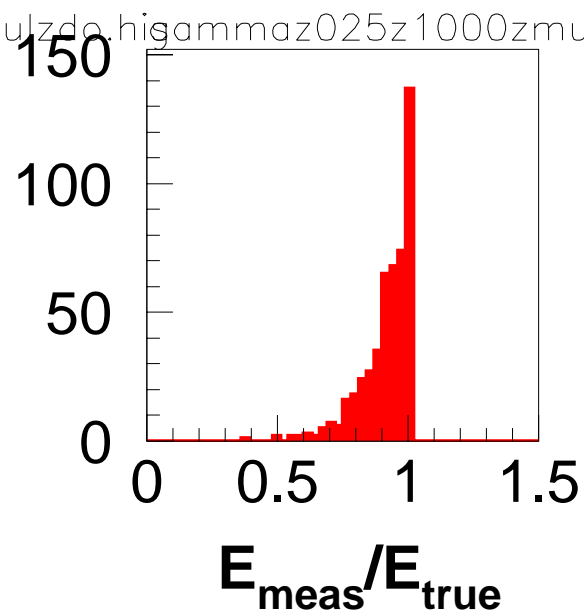
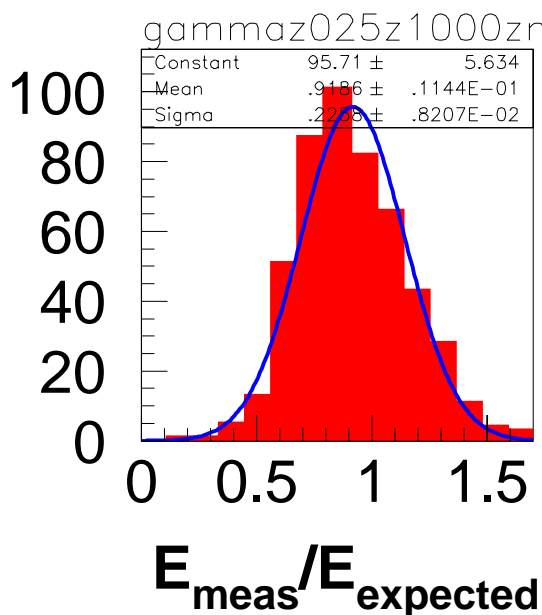
Isolated Photons from 100 MeV up to 15 GeV

EMILE: LOW PHOTONS

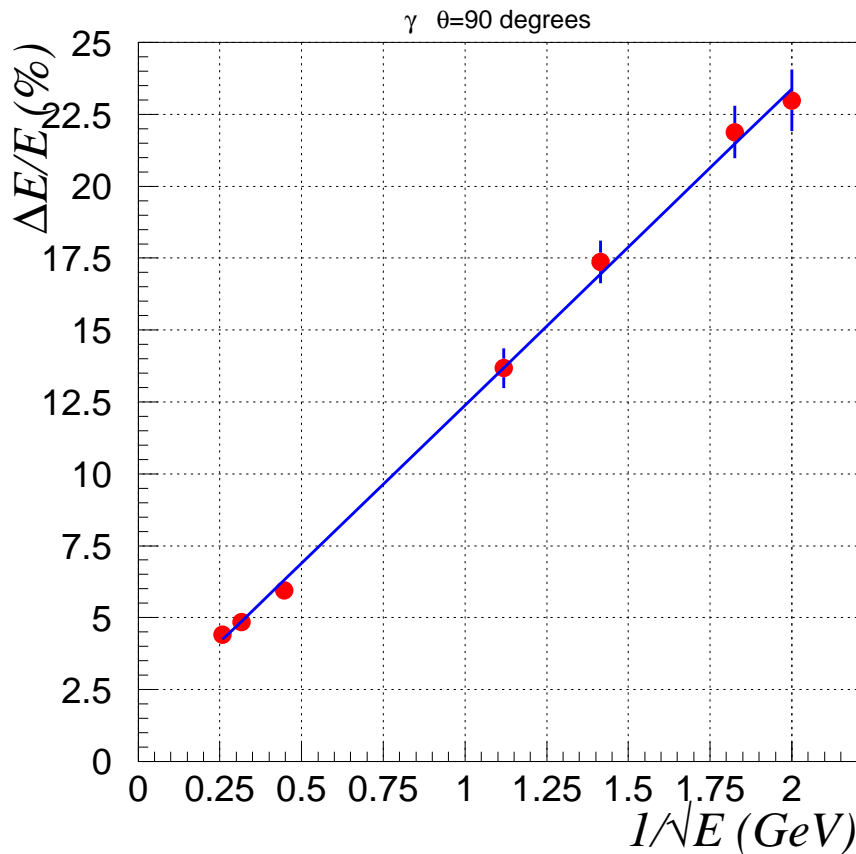
$E_\gamma = 100 \text{ MeV}$



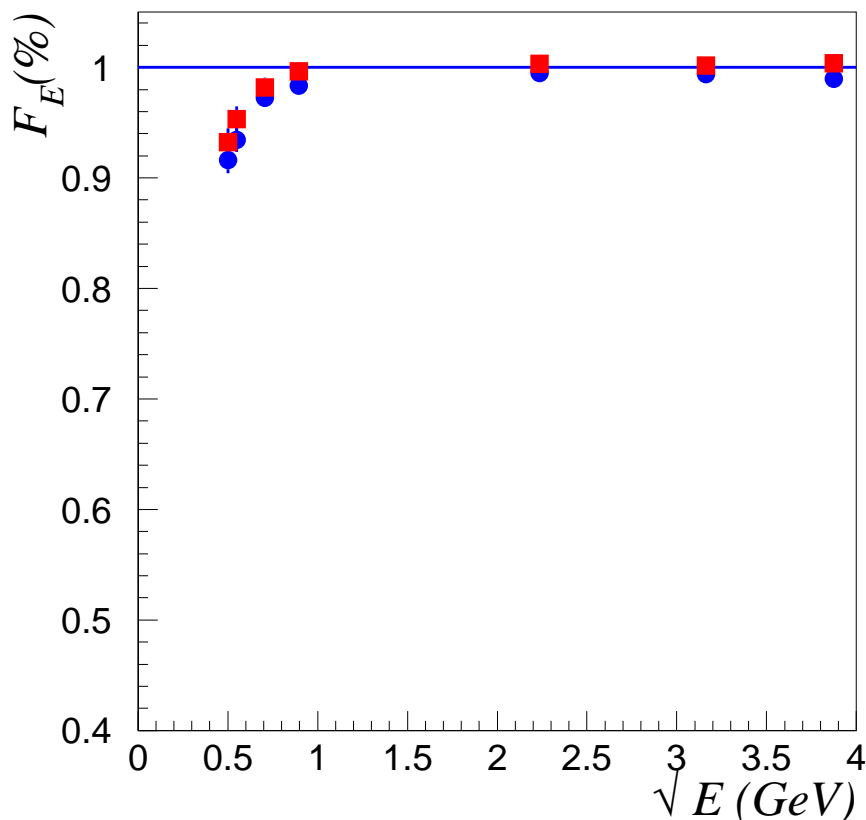
$E_\gamma = 250 \text{ MeV}$



FIRST PRELIMINARY RESULTS

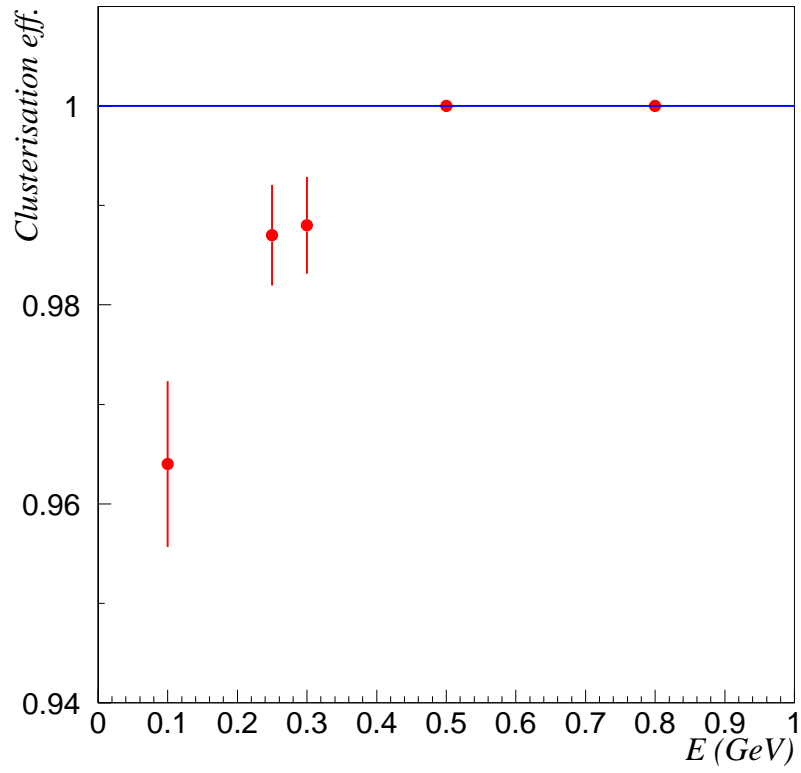


$$\Delta E/E = (11. \pm 0.3)\% / \sqrt{E} + (1.4 \pm 0.2)\%$$



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

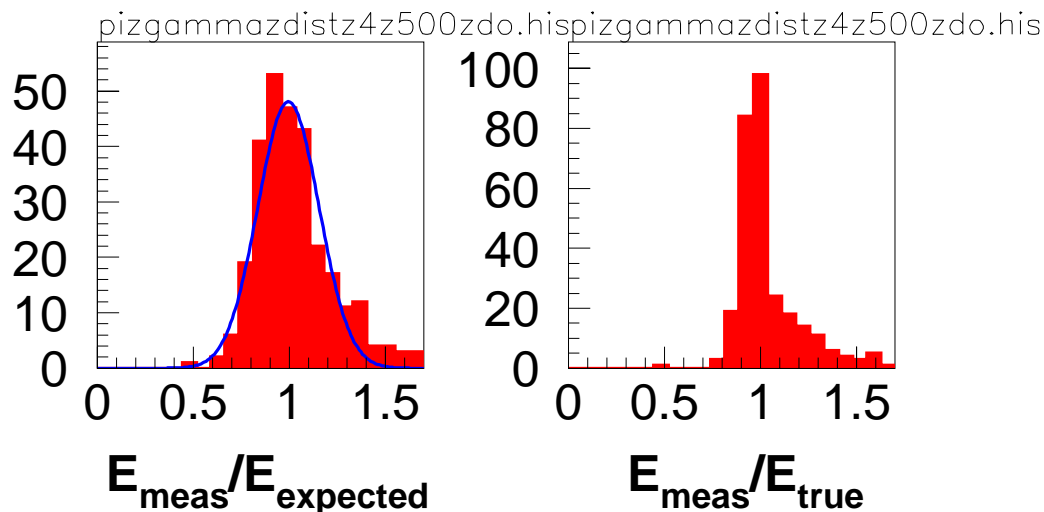
- Tests
- Photons with noise coming from π^+

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

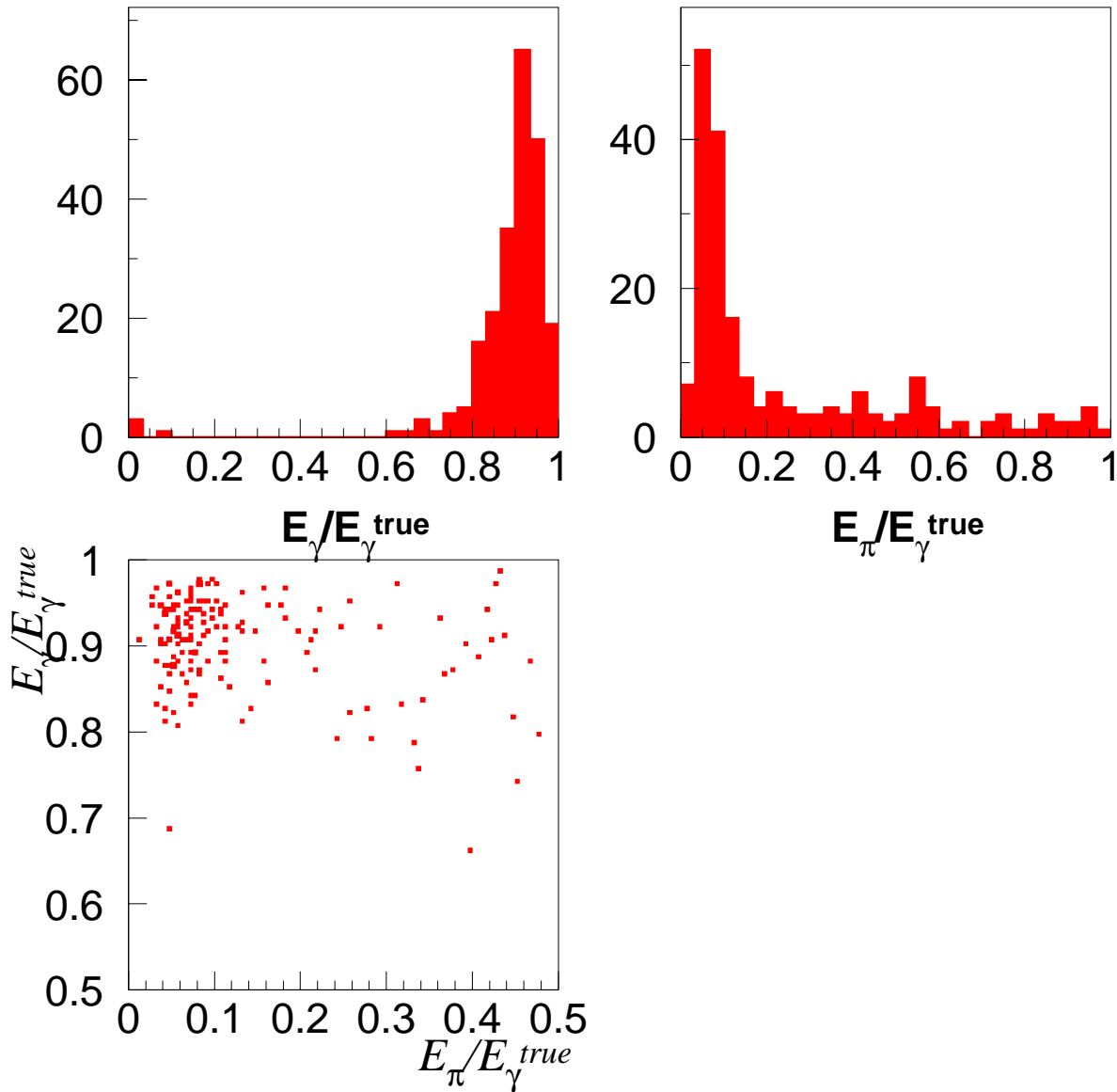
The clusters matching the MC photon direction are considered as photons

@ 4 cm



PHOTONS WITH PIONS

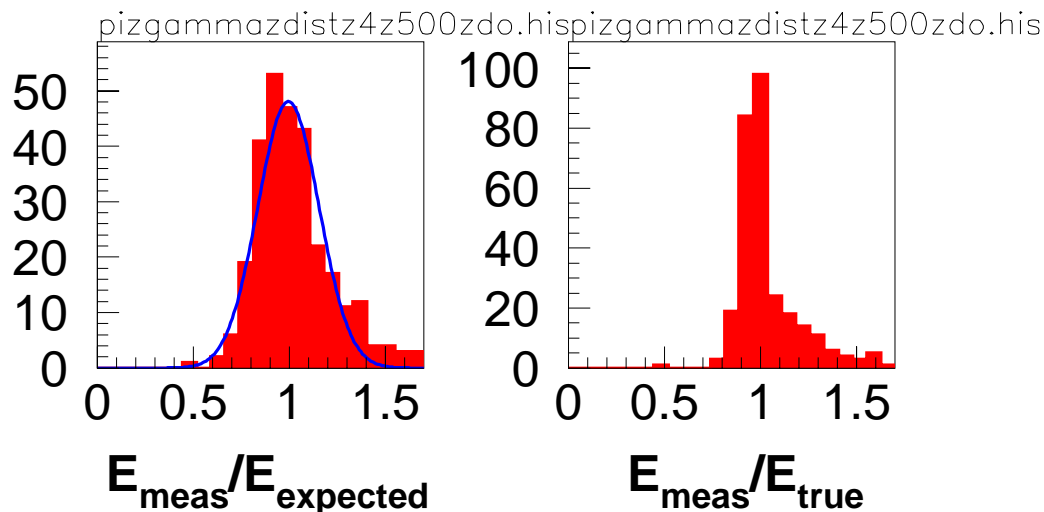
The clusters matching the MC photon direction are considered as photons



PHOTONS WITH PIONS

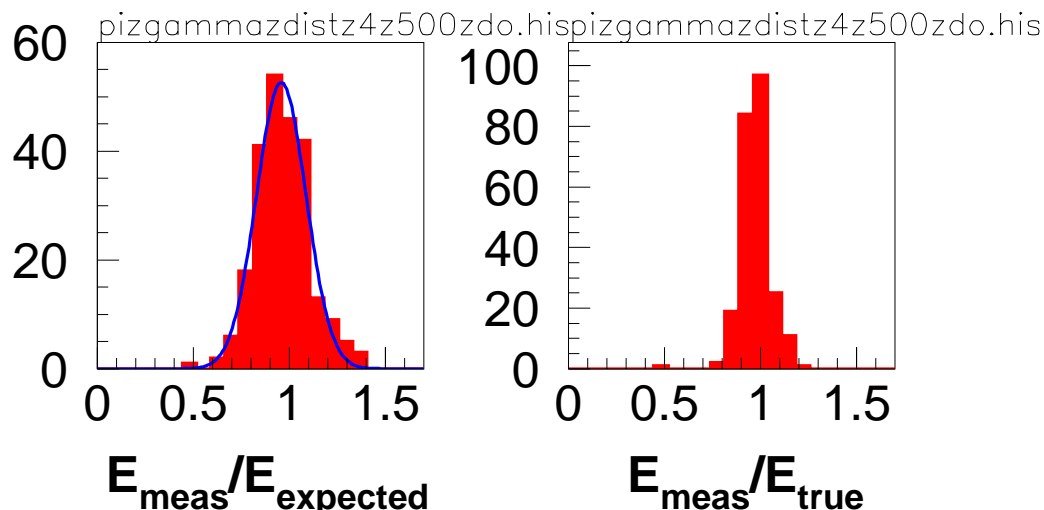
Photon with Pions

@ 4 cm



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

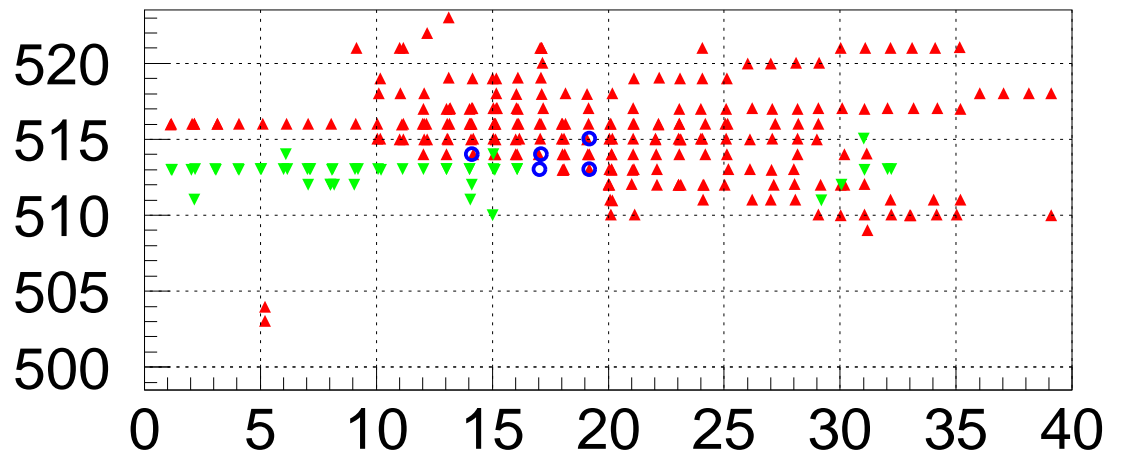
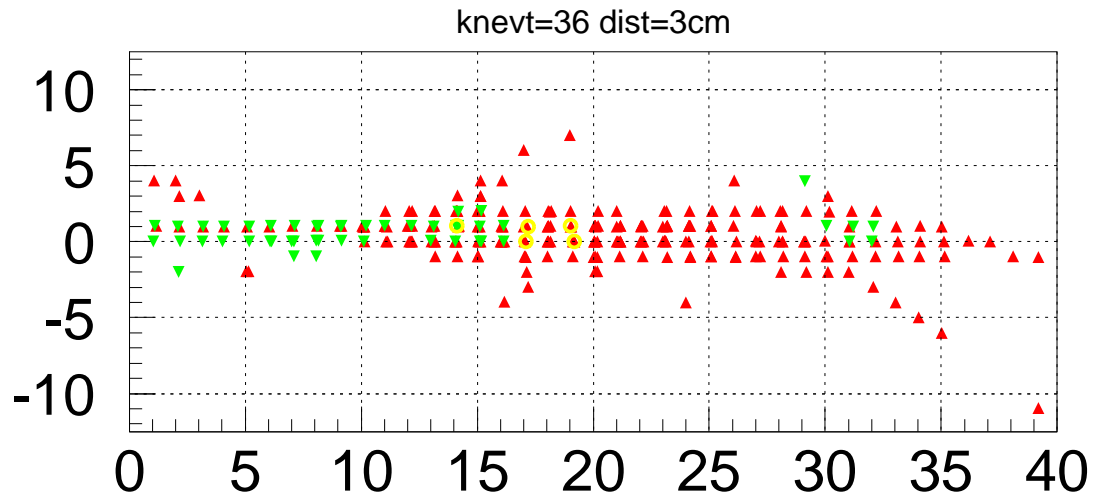
The cut is 'tuned'⁽¹⁾ to render the distribution gaussian



(1) typically .75

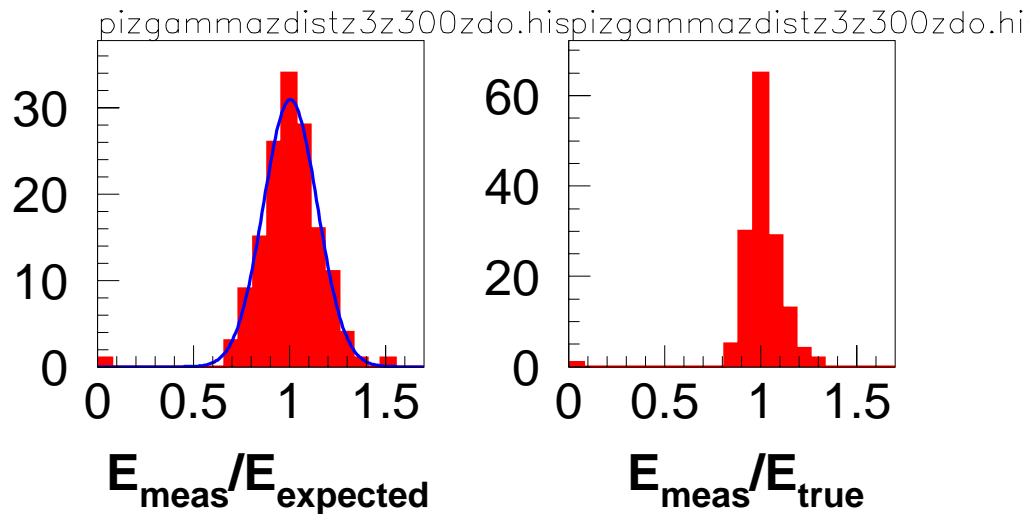
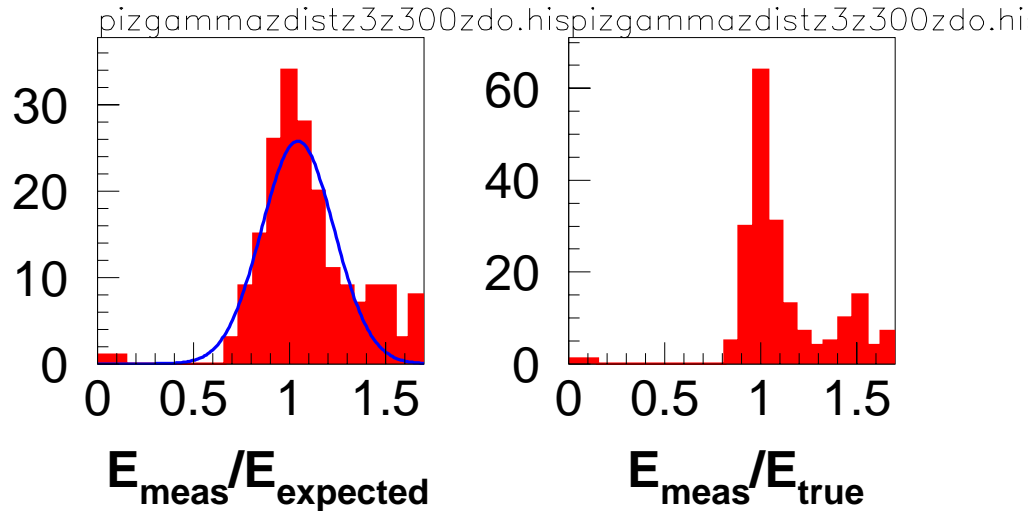
PHOTONS WITH PIONS

Display
@ 3 cm



<i>knevt</i>		E_{meas}	E_{π}	E_{γ}	<i>the</i>	<i>phi</i>	<i>lay</i>	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.
-
- Regular meeting are forseen (*last one 13th April 2000*)
 - KEK people are interested (*F. Le Diberder will visit them on july*)