Photon reconstruction status

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Outline

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

Framework

– **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`

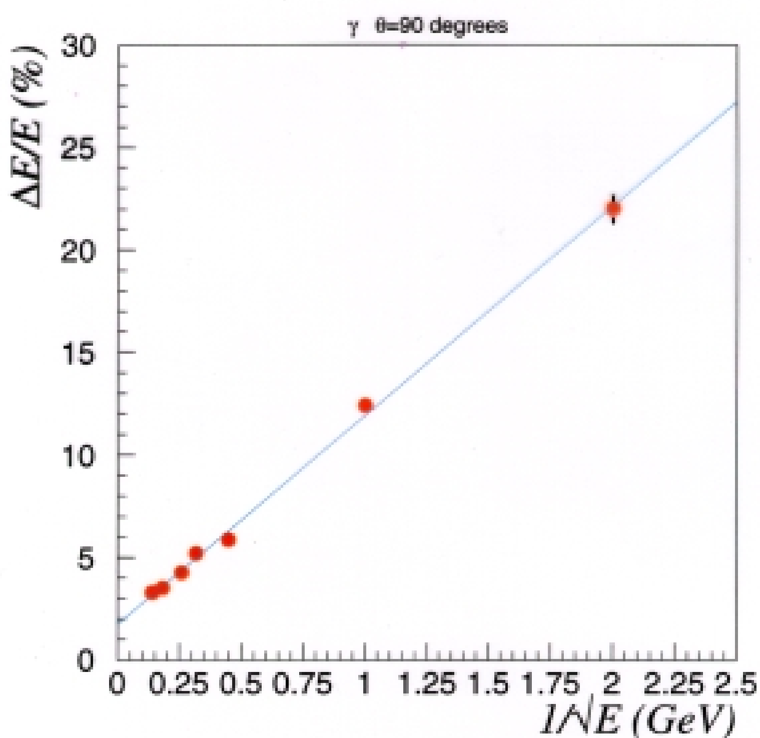
TOWER

- **Projective Geometry**
- **Clusterisation is the collection of every pads in a 5x5x40 ($\theta, \phi, layer$) tower around the most energetic pad if such a pad is not-isolated.**

If no not-isolated pad exits, the zone is reduced to a 3x3X40 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

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

- **Tests**

Isolated Photons from 250 MeV up to 15 GeV

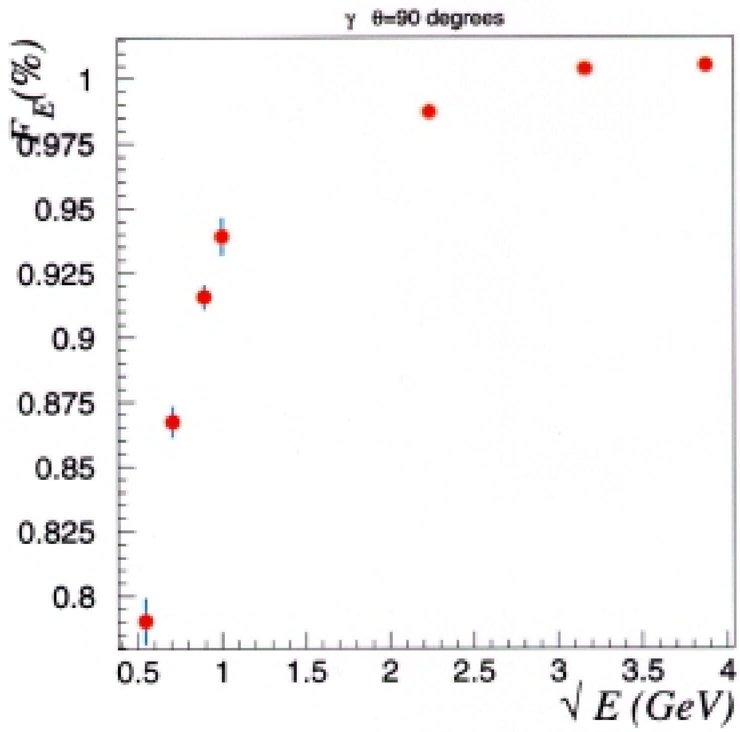
Fraction of collected energy as a function of E$_\gamma$

$\longrightarrow\longrightarrow\longrightarrow$

VICINITY

- 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 unassiocated pads by the angle between the " direction " of a cluster and the "direction" of a pad.
see next transparancy for the definition of the direction

- **What is 'direction'**

for a cluster

Vertex to COG of the cluster

for a pad

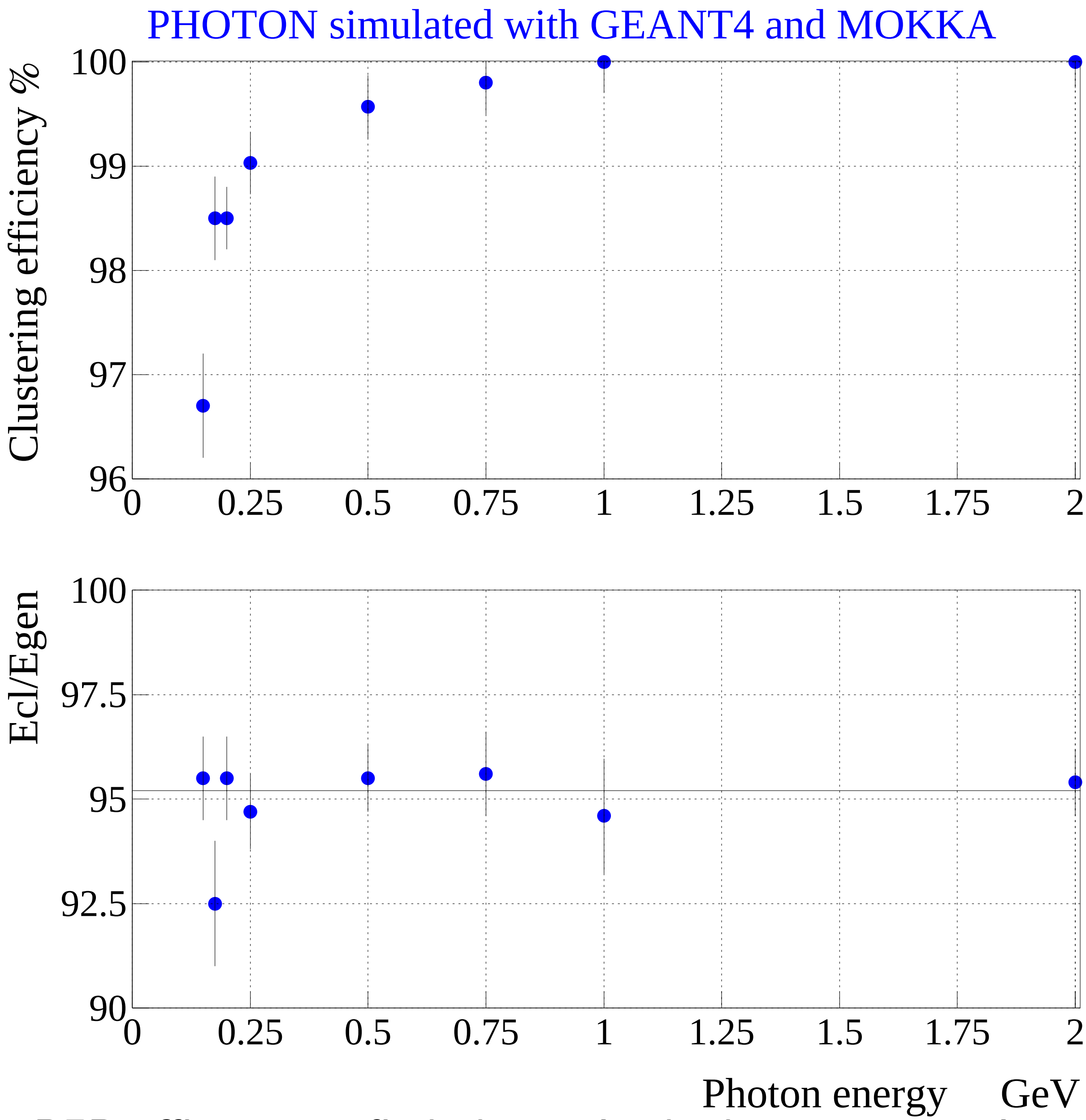
projected COG to entrance of the ECAL to Pad position

- **Tests**

- Use of MOKKA

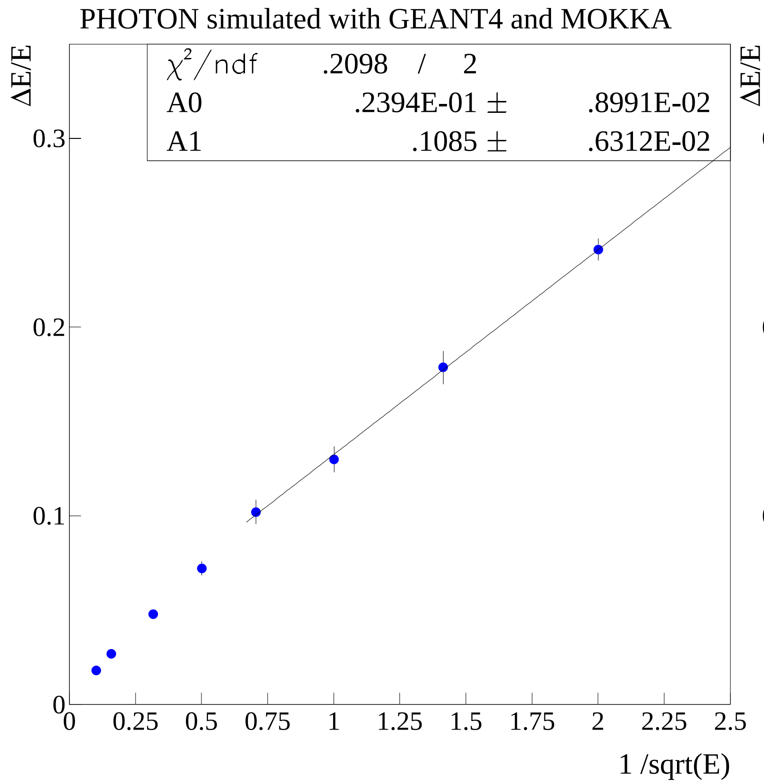
- Simulate photons from 0.15 to 100 GeV

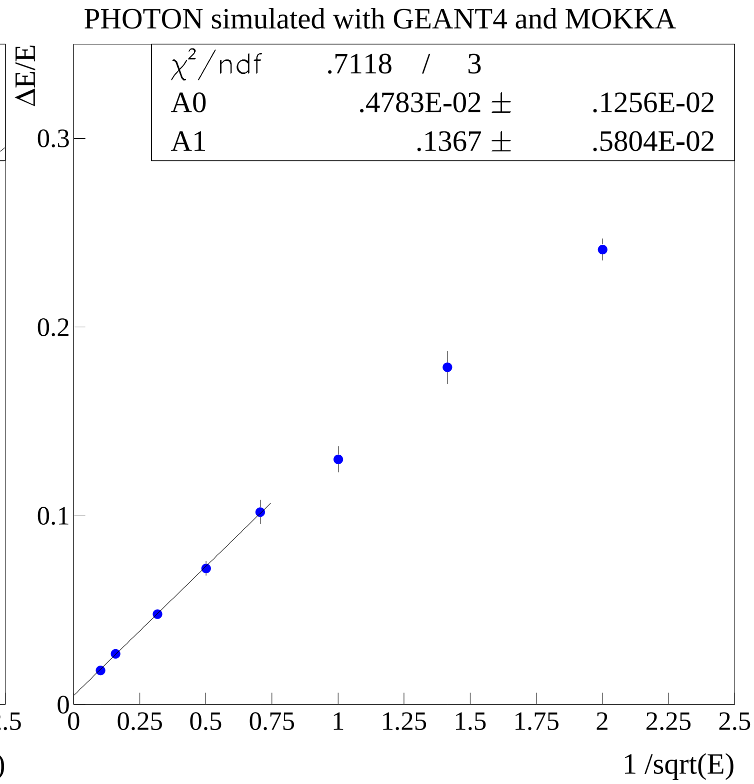
Results from simulation

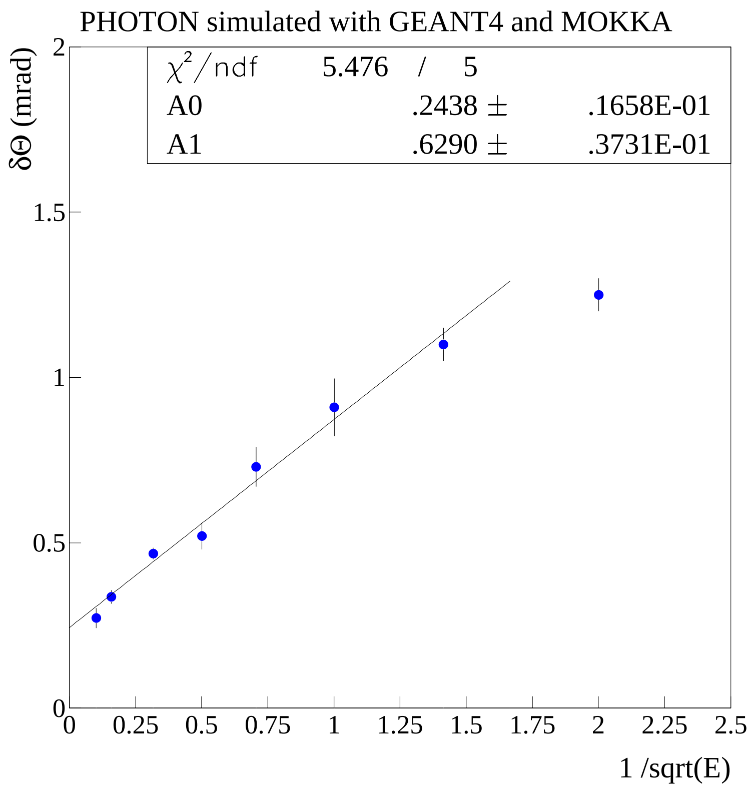


1 - PFD efficency to find photon in the low energy region
About 99% above 0.25 GeV
2 - rate of fake electromagnetic cluster (created from fluctuation of an electromagnetic shower)
About few per mill - 4 10^{-3} at 0.5 to 9 10^{-3} at 100. GeV
3 - fraction of the total energy in the cluster
Stable and 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 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
β**=.99**

Thus d_{ij} is defined as

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

- $\underline{d_{ij}}$
  - **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)

EMILE: Clustering

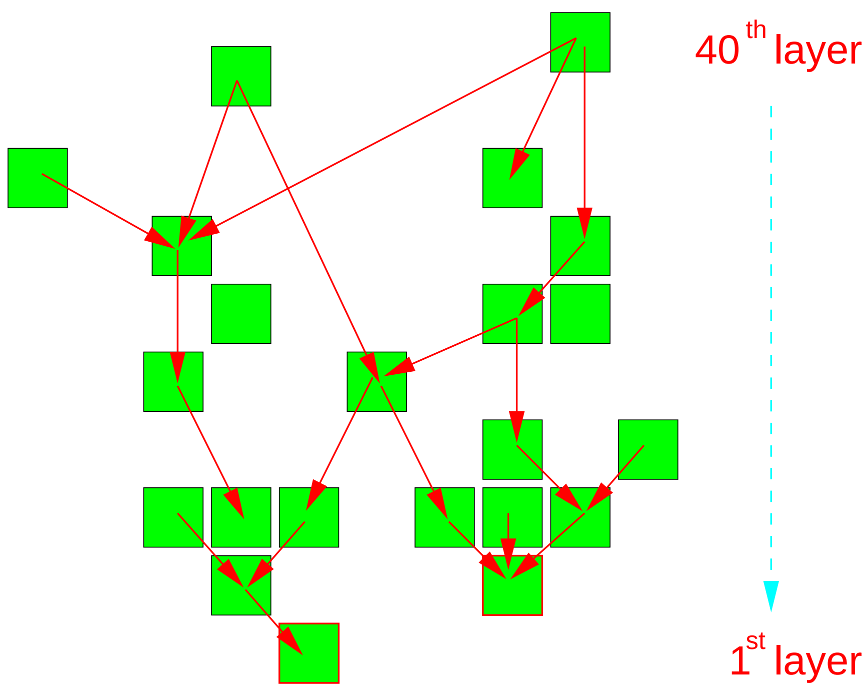
- <u>Clustering</u>

– **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

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

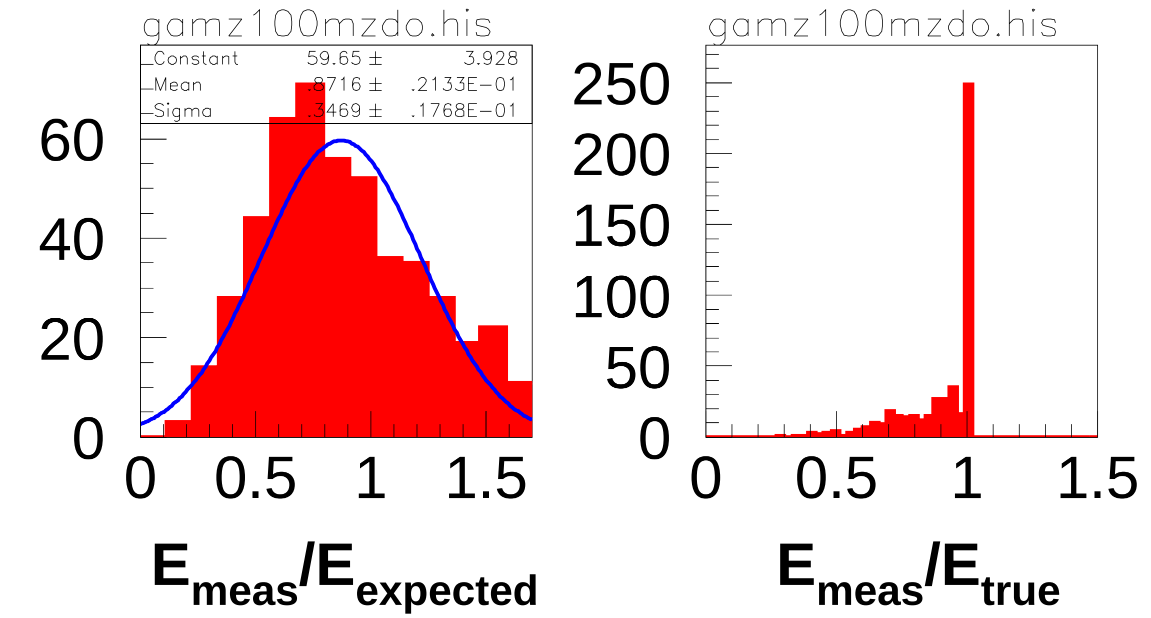
where D_{entry} stands for the Distance from the center of the detector and the terminal pad point, and $D^{a,b}_{core}$ is the distance between the barycenter of the cluster *a* and *b*.

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

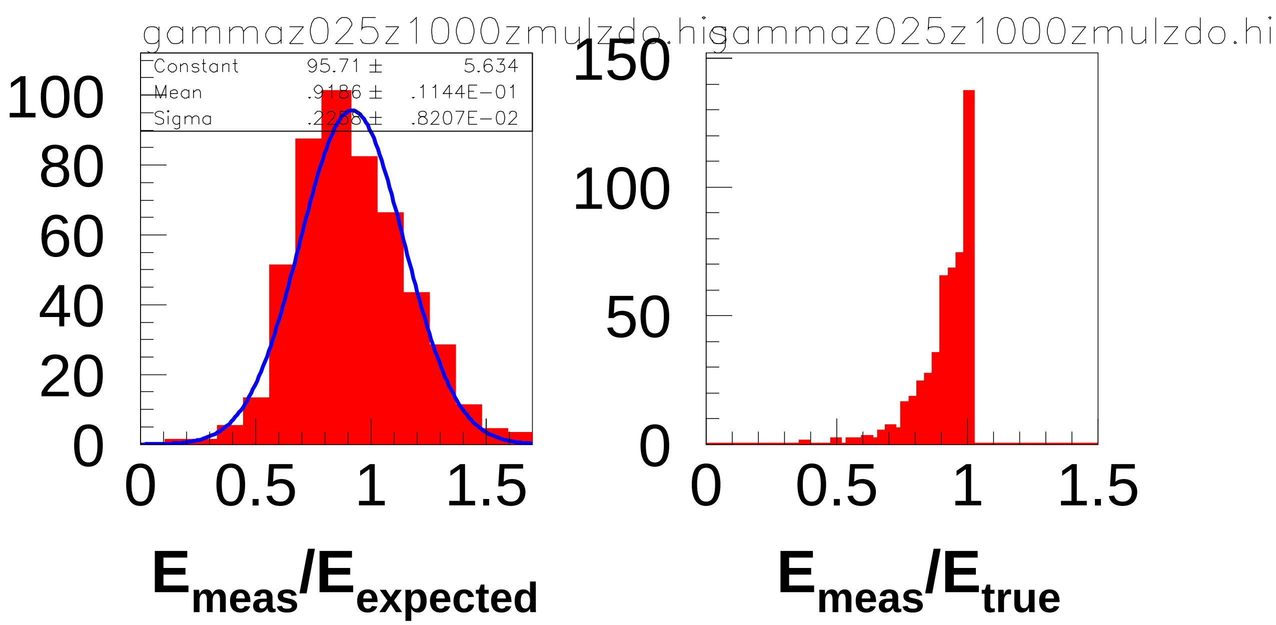
• Tests

Projective Geometry
Isolated Photons from 100 MeV up to 15 GeV

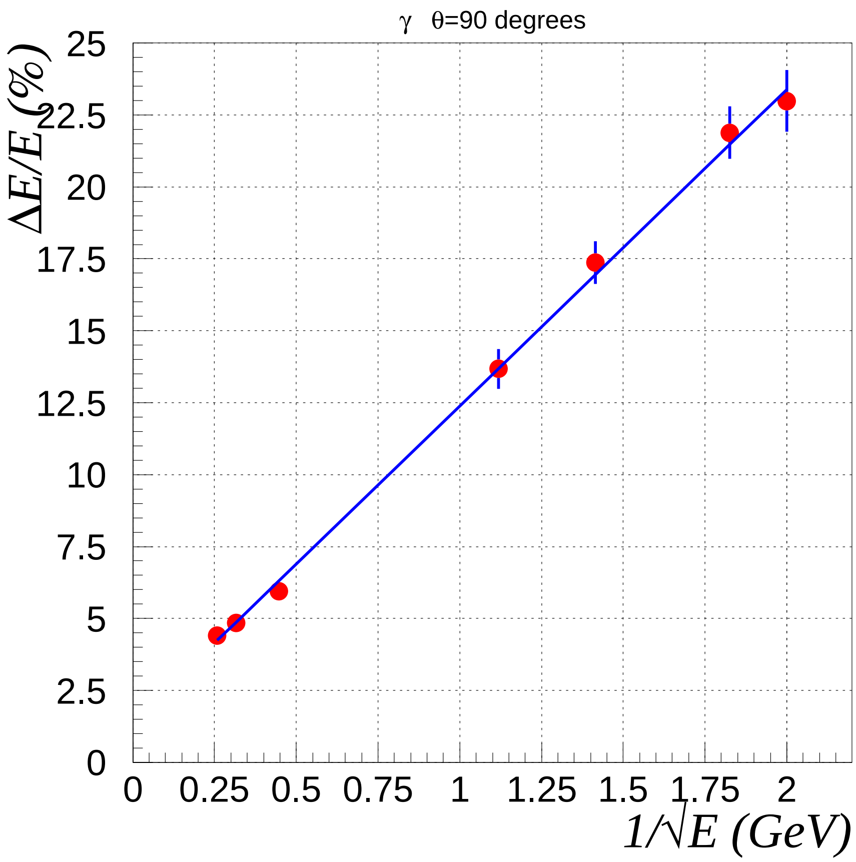
E_γ = 100 MeV



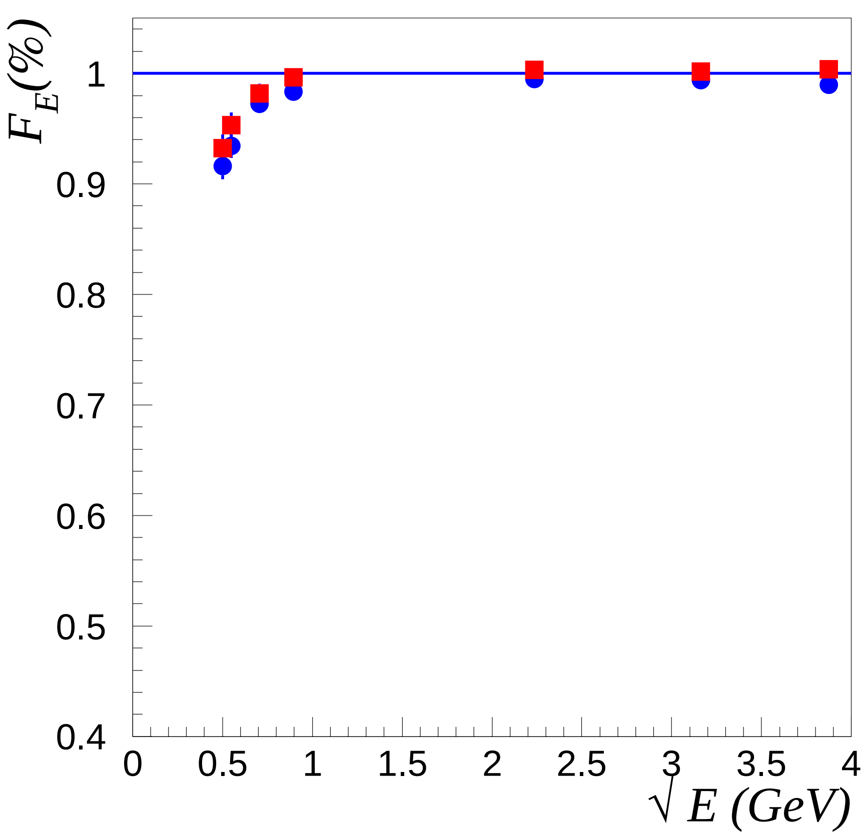
E_γ = 250 MeV



First Preliminary Results

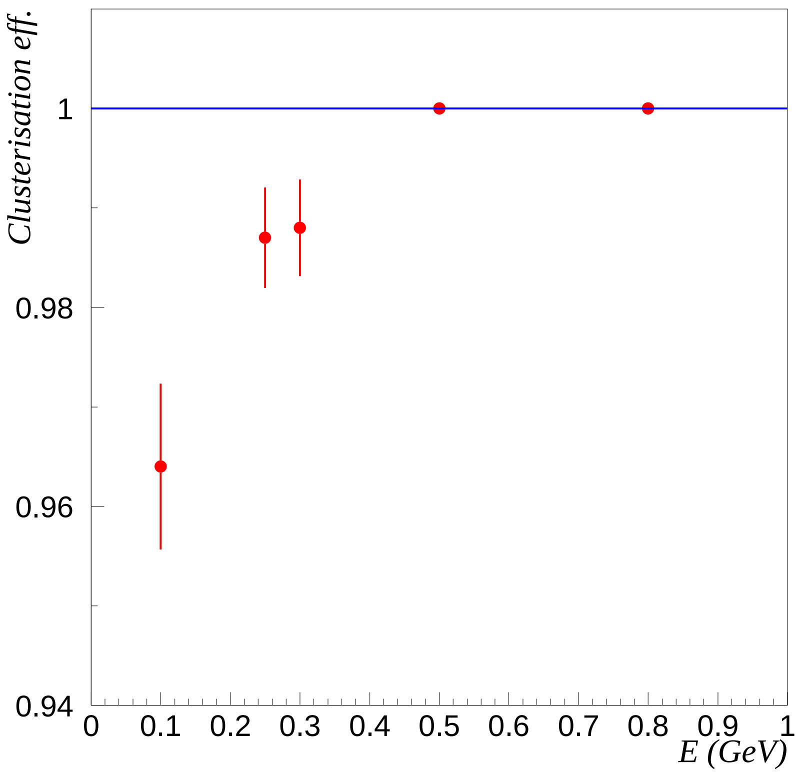


$\Delta E/E$=
(11.± 0.3)% $/\sqrt{E}$
+(1.4±0.2)%



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

First Preliminary Results



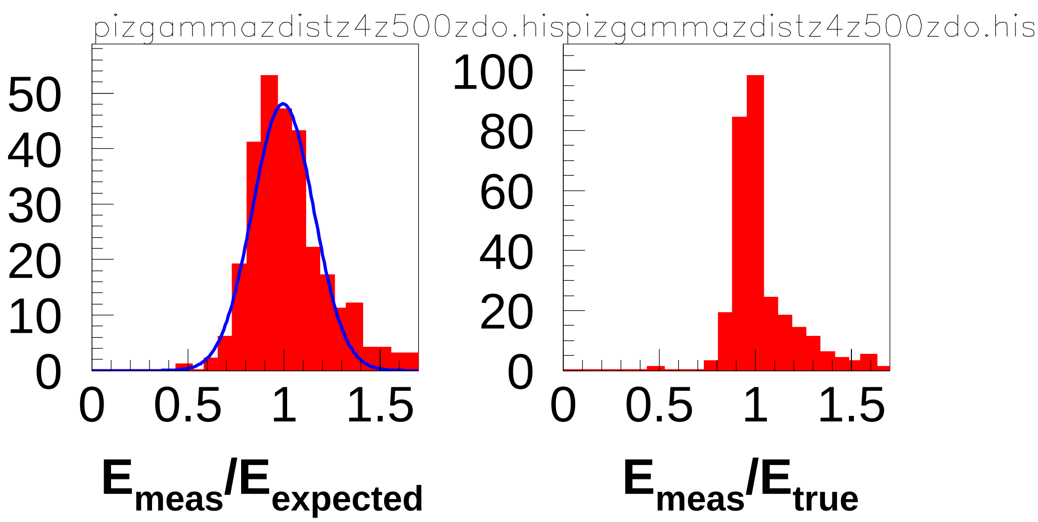
- Tests
- Photons with noise coming from π^+

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

Typically E_γ=1 GeV and E_π=10 GeV
Distance is 4, 3 and 2 cm

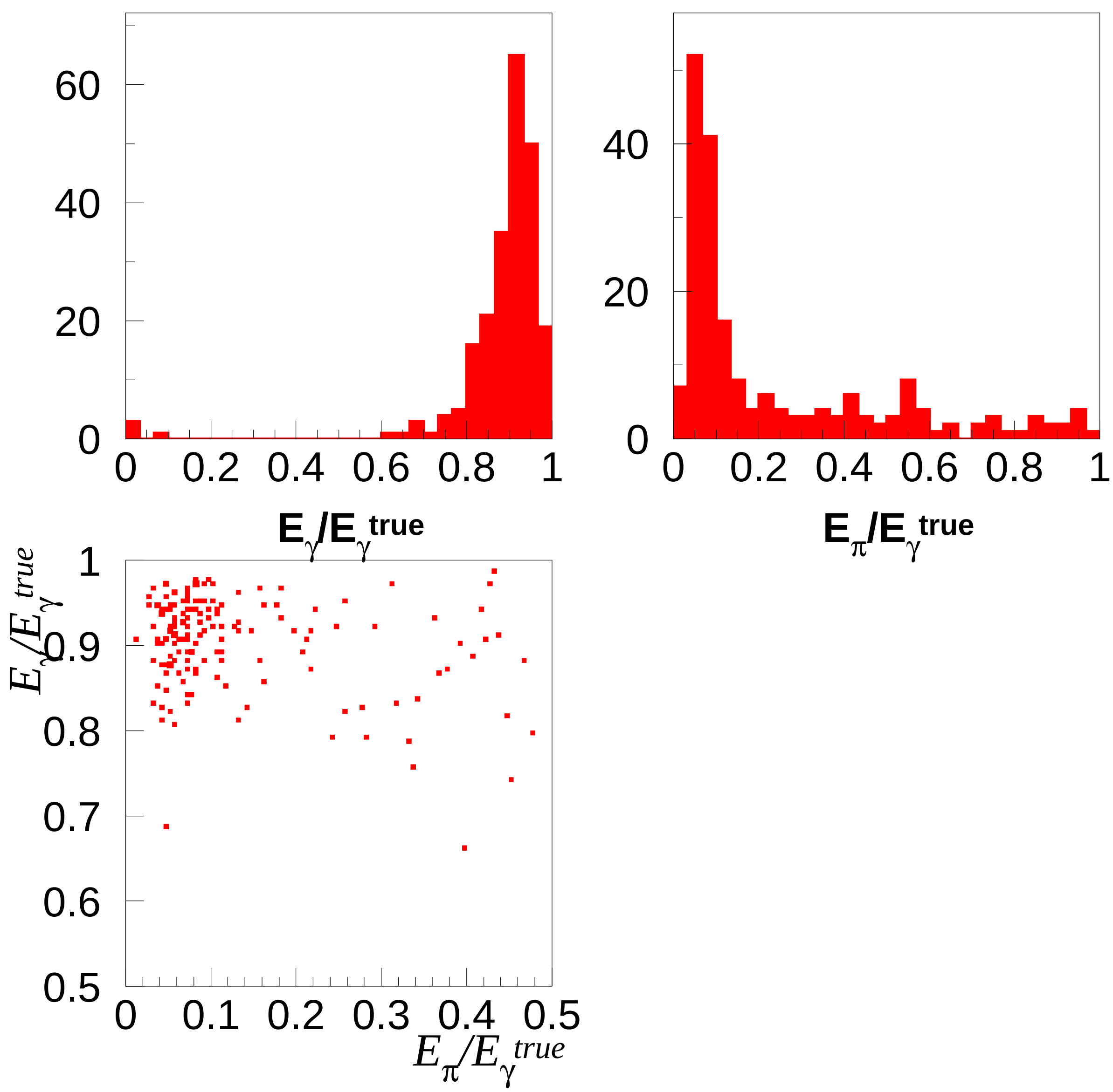
The clusters matching the MC photon direction are considered as photons

@ 4 cm



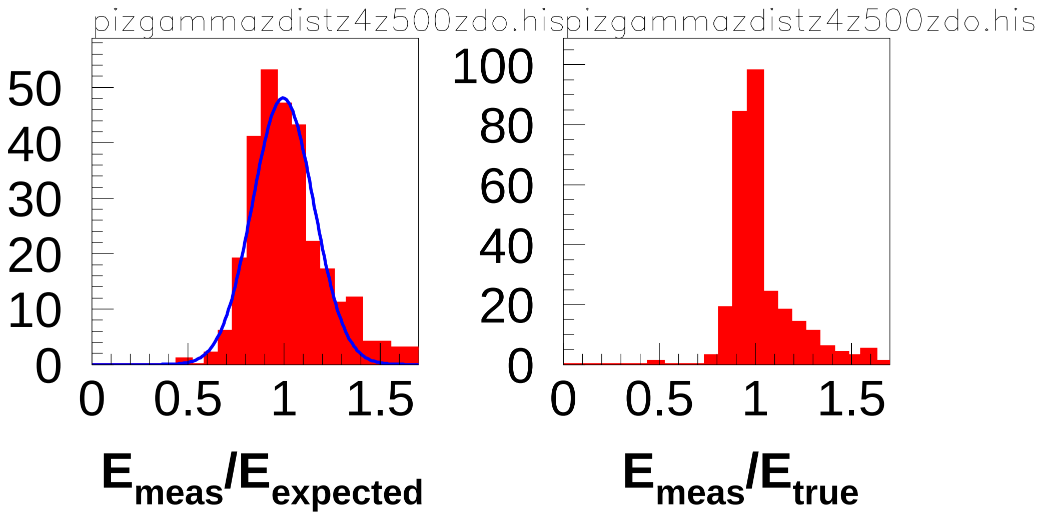
Photons With Pions

The clusters matching the MC photon direction are considered as photons

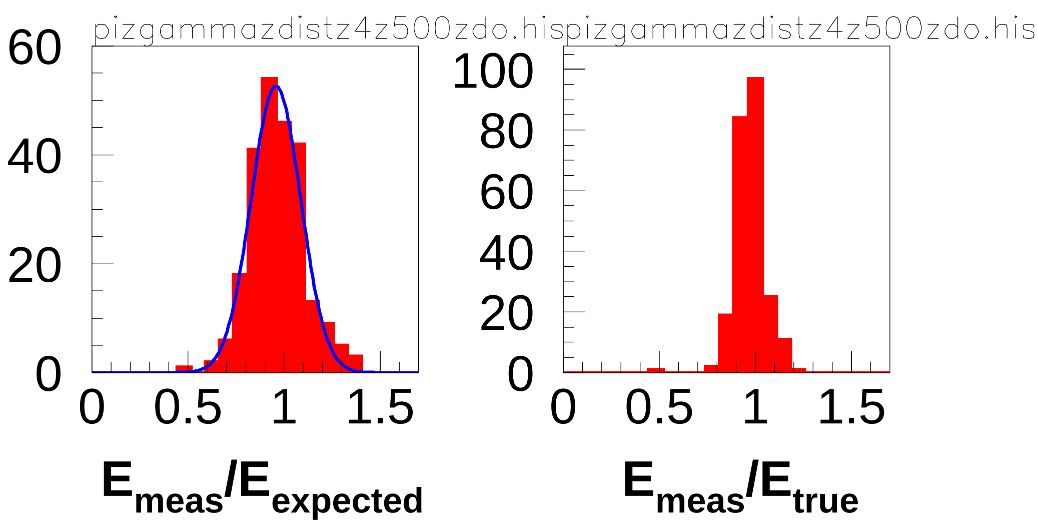


Photons With Pions

Photon with Pions
@ 4 cm



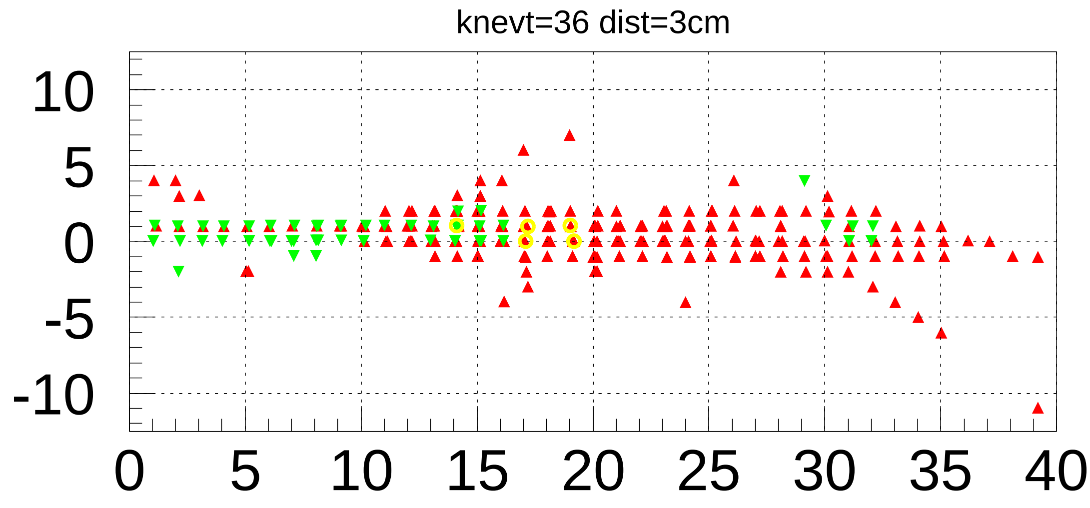
to Simulate the Photon-Id a cut on $(E_{e.m.}/E_{meas})_{cluster}$ is applied
The cut is 'tuned'[(1)] to render the distribution gaussian

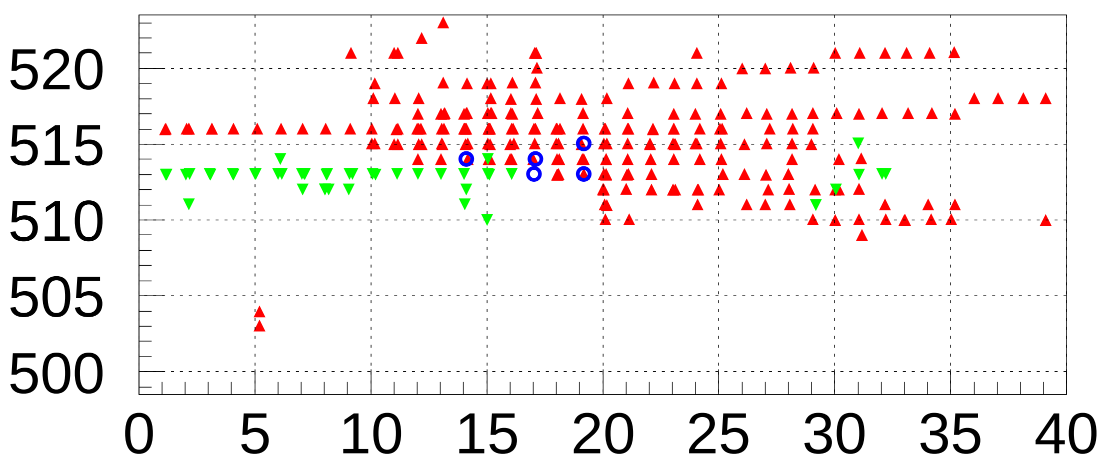


(1) **typically .75**

Photons With Pions

Display @ 3 cm

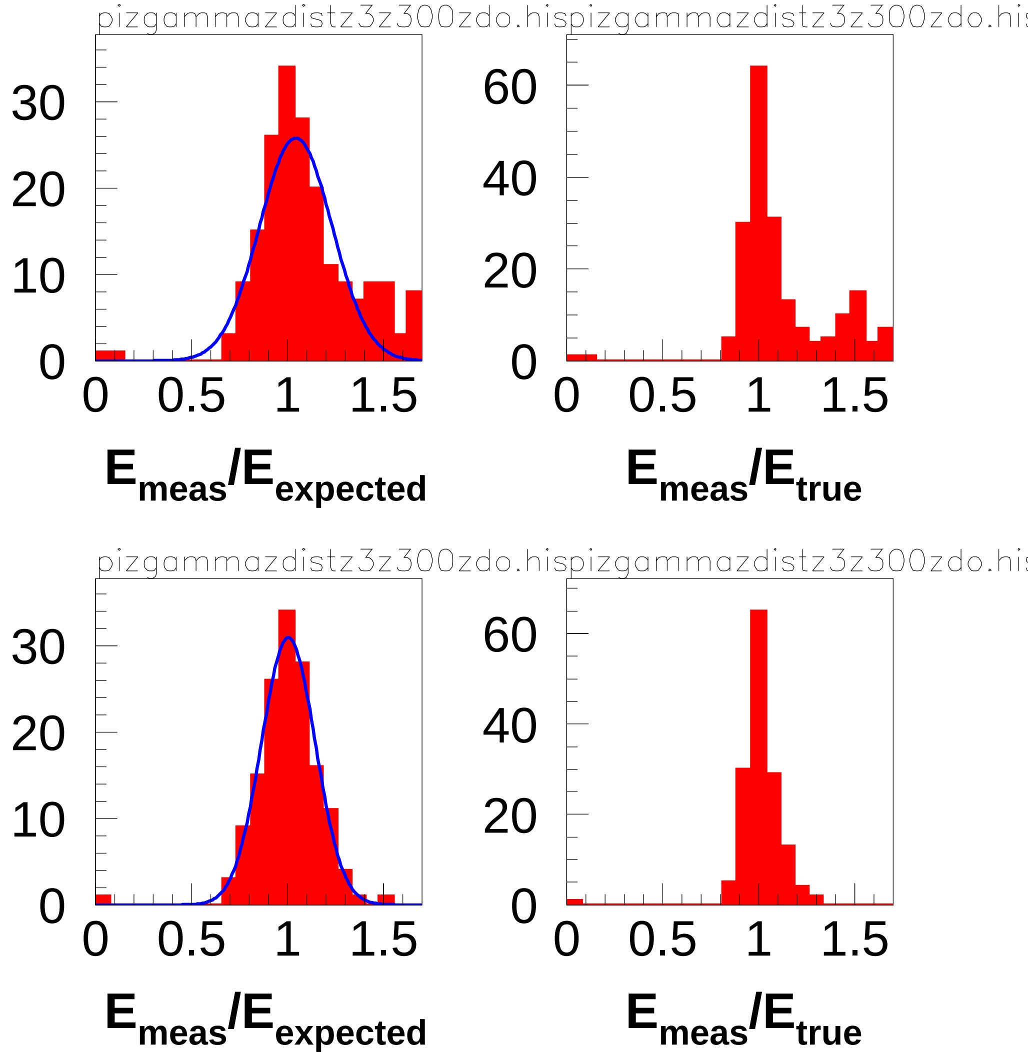




knevt		E_{meas}	E_π	E_γ	*the*	*phi*	*lay*	E_π^{true}	E_γ^{true}
36	1	2.768	1.413	1.355	0	513	1	6.071	1.478
36	2	.014	.001	.013	-2	511	2	6.071	1.478
36	3	.265	.240	.025	0	510	15	6.071	1.478
36	5	2.870	2.785	.086	1	516	1	6.071	1.478
36	6	.033	.033	.000	-11	510	39	6.071	1.478
36	7	.403	.403	.000	-2	503	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

First Preliminary Results

Photon with Pions @ 3 cm



With such assumptions Preliminary Results are

@ 4cm ϵ_γ**=80%**
@ 3cm ϵ_γ**=50%**
@ 2cm ϵ_γ**=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)*