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Subject: EMC resolution  
Posted by [binsong](#) on Fri, 11 Oct 2013 12:05:28 GMT  
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hi,  
i find some problems with the EMC energy resolution. Maybe there are some bugs.

I do the simulations for electron and photon with box generator with the latest trunk at both barrel region (80deg--100deg) and forward region (12deg--20deg).

i get the reconstructed energy( $E_{rec}$ ) by using `GetEmcRawEnergy()`,

then i plot  $(E_{mc}-E_{rec})/E_{mc}$  for each simulation.

but i find the resolution  $\sigma/E$  much smaller then the result in TDR:

electron\_barrel: 1.18%  
electron\_forward: 1.58%  
photon\_barrel: 1.07%  
photon\_forward: 1.39%

and in TDR, the resolution for photon at 1GeV is more than 2%.

you can find all the four plots in attachment.

does someone know this problem?

Binsong

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### File Attachments

- 1) [electron\\_barrel\\_1GeV.eps](#), downloaded 423 times
  - 2) [electron\\_forward\\_1GeV.eps](#), downloaded 393 times
  - 3) [photon\\_barrel\\_1GeV.eps](#), downloaded 391 times
  - 4) [photon\\_forward\\_1GeV.eps](#), downloaded 377 times
- 

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Subject: Re: EMC resolution  
Posted by [Dima Melnychuk](#) on Mon, 14 Oct 2013 12:47:47 GMT  
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Hi,

Some additional comments from my side on EMC resolution.

I have more or less the same numbers as Binsong and I tried to look what are main contributions to these numbers.

By the way I used apr13 release of pandaroot for these studies and did simulation for barrel in 30-130 degree range.

So first of all I made a comparison of resolution which includes and does not include digitization.

The resolution without digitization can be obtained if PndEmcMakeDigi class is used for digitization and in emc.par  
UseDigiEffectiveSmearing:Int\_t 0

In this case the resolution is only due to energy leakage below threshold. With single crystal threshold 3 MeV the resolution is 1.08 %

The resolution in my case is obtained from Novosibirsk fit  
(root/pandaroot/trunk/macro/emc/dedicated/fit\_resolution.C)

When digitization is included two additional contributions to resolution are photostatistics and electronics noise. With current parameters in emc.par/all.par photostatistics for case of barrel for 1 GeV photon should give 0.43 % (94 p.e. per MeV and 1.7 excess noise factor). 1.5 MeV noise gives 0.15% contribution accordingly.

Adding these three contribution quadratically  
 $\sqrt{1.08^2+0.15^2+0.43^2}=1.17$  %

Simulation of 50 k photons with digitization included gives 1.20 % resolution which is in agreement with simple estimation.

If we want to compare the results of simulation with prototype measurements the non-uniformity of high yield should be included in simulation and it will give a sizeable effect.

But otherwise it seems that electronics noise and photon statistics are treated reasonably well and I can only imagine that the energy leakage could be underestimated.

Dima

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Subject: Re: EMC resolution  
Posted by [StefanoSpataro](#) on Mon, 14 Oct 2013 15:29:36 GMT  
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If I remember well, after Hossein update, we switched off the non uniformity because there were some problems, but I do not remember which ones.

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Subject: Re: EMC resolution  
Posted by [binsong](#) on Wed, 30 Oct 2013 09:50:05 GMT  
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Hi,

I try to re-put the nonuniformity to 1.

But there is no difference for the resolution.

it is always the same, 1.15%

Binsong

## File Attachments

1) [ele\\_barrel\\_nonuniformity\\_1.eps](#), downloaded 287 times

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Subject: Re: EMC resolution

Posted by [Stefano Spataro](#) on Wed, 30 Oct 2013 13:57:18 GMT

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I noticed Dima has done some modifications to have the old digitization. Could you please update emc folder and try again?

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Subject: Re: EMC resolution

Posted by [Dima Melnychuk](#) on Wed, 30 Oct 2013 14:23:31 GMT

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Some additional results on emc resolution from my side.

First of all after Jifeng put a latest version of digitization by default, (based on code for EMC feature extraction developed at KVI) the energy resolution is different.

I did study for barrel 30-130 degree range, 10 k events, 1 GeV photons.

For new digitization  $\sigma=1.6\%$

For previous digitization  $\sigma=1.2\%$

There are two options for non-uniformity, first is based on measurements and implemented by Christian Hammann,  $\sigma=2.6\%$

And second one (linear non-uniformity) is based on fit to reproduce prototype data and implemented by Hossein Moeini,  $\sigma=2.5\%$ , so both options are very close.

You can use this option with

```
PndEmcHitProducer* emcHitProd = new PndEmcHitProducer();
TString nonuniformityFile=gSystem->Getenv("VMCWORKDIR");
nonuniformityFile+="/macro/params/EmcDigiNoniformityPars2.root";
emcHitProd->SetNonuniformityFile(nonuniformityFile.Data());
```

So non-uniformity definitely affect the result as well as newer digitization.

But you can see if you use non-uniform response the peak position is shifted and calibration/energy correction is necessary. And shift is in different direction for two implementations of non-uniformity. Hossein provided correction for his case but it was for older digitization and newer digitization shift a peak position itself a little bit. So it should be redone.

So I plan to redo energy correction for new digitization with both non-uniformity options and I hope rather soon.

2.6% resolution for 1 GeV photon is what Christian Hammann quoted before as a result in agreement with prototype data.

So when energy correction will be ready the question can be closed.

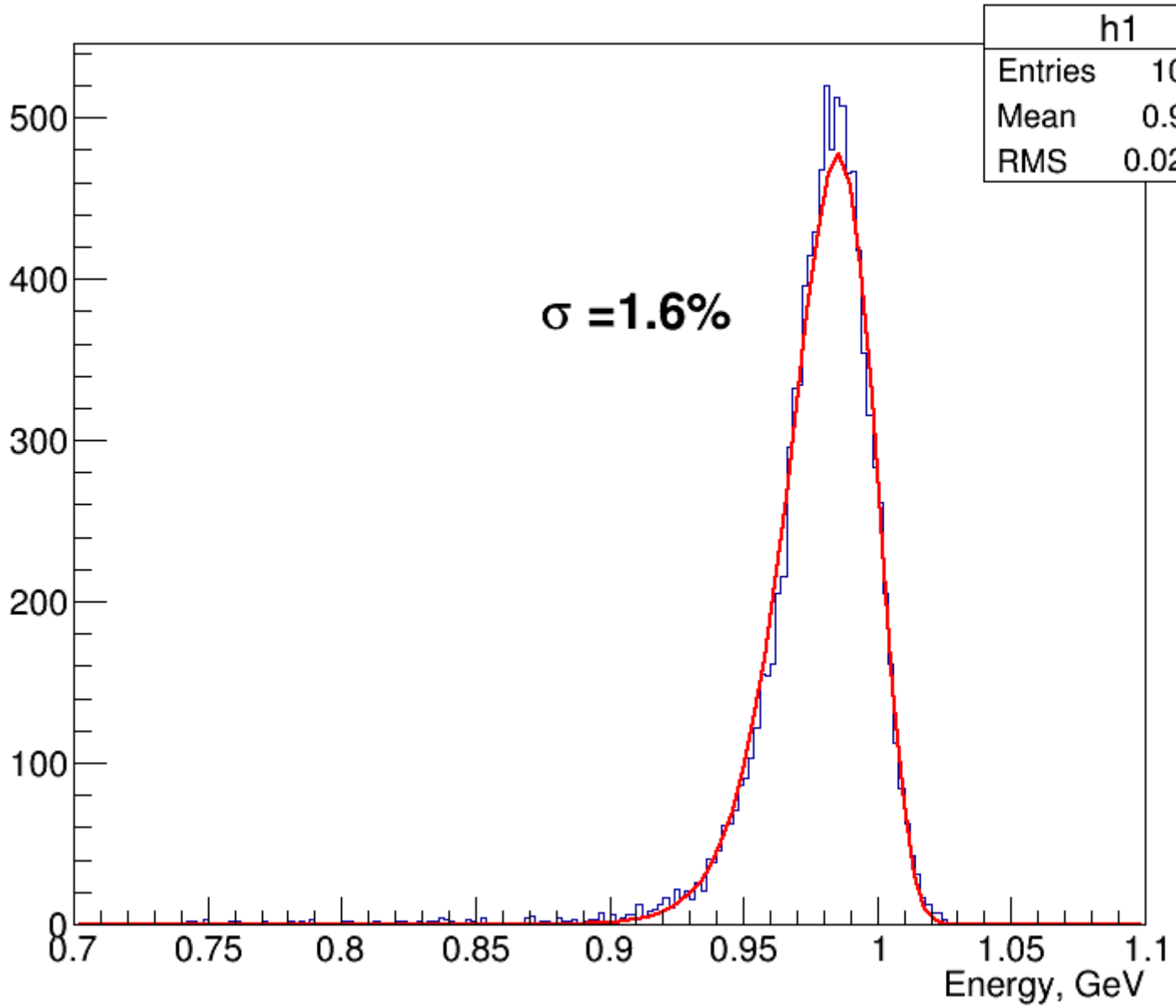
Dima

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### File Attachments

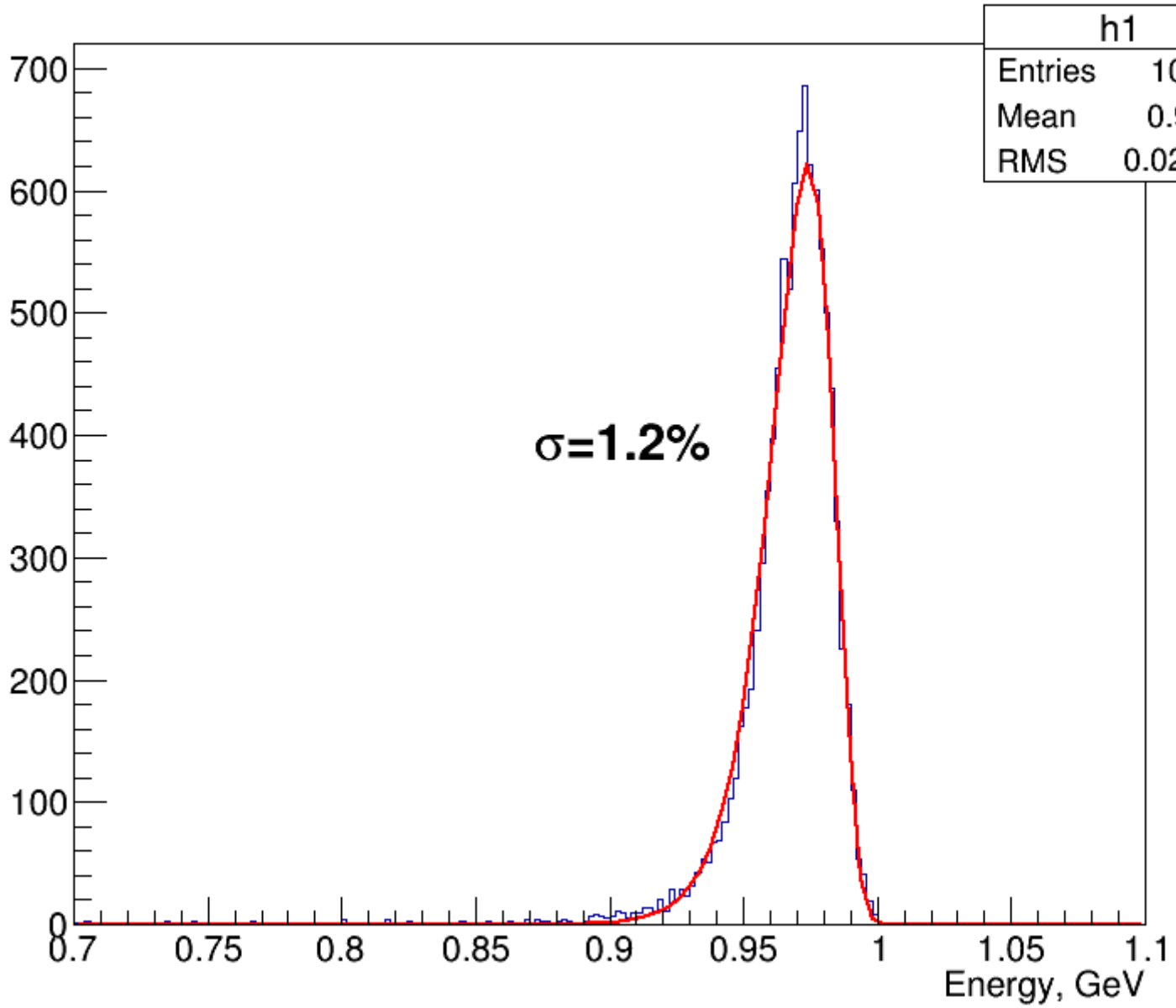
1) [energy1.png](#), downloaded 693 times

# Cluster energy



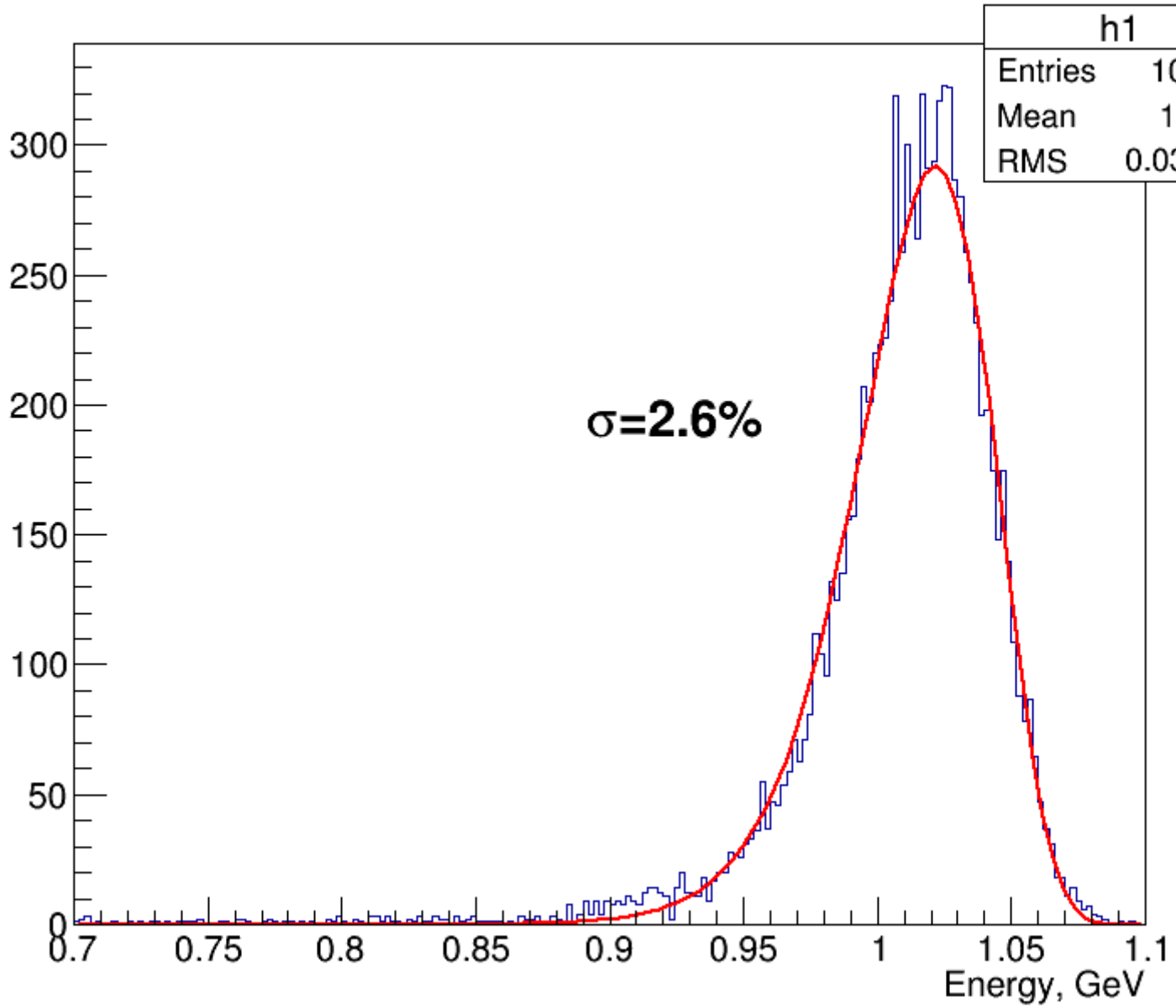
2) [energy2.png](#), downloaded 667 times

# Cluster energy



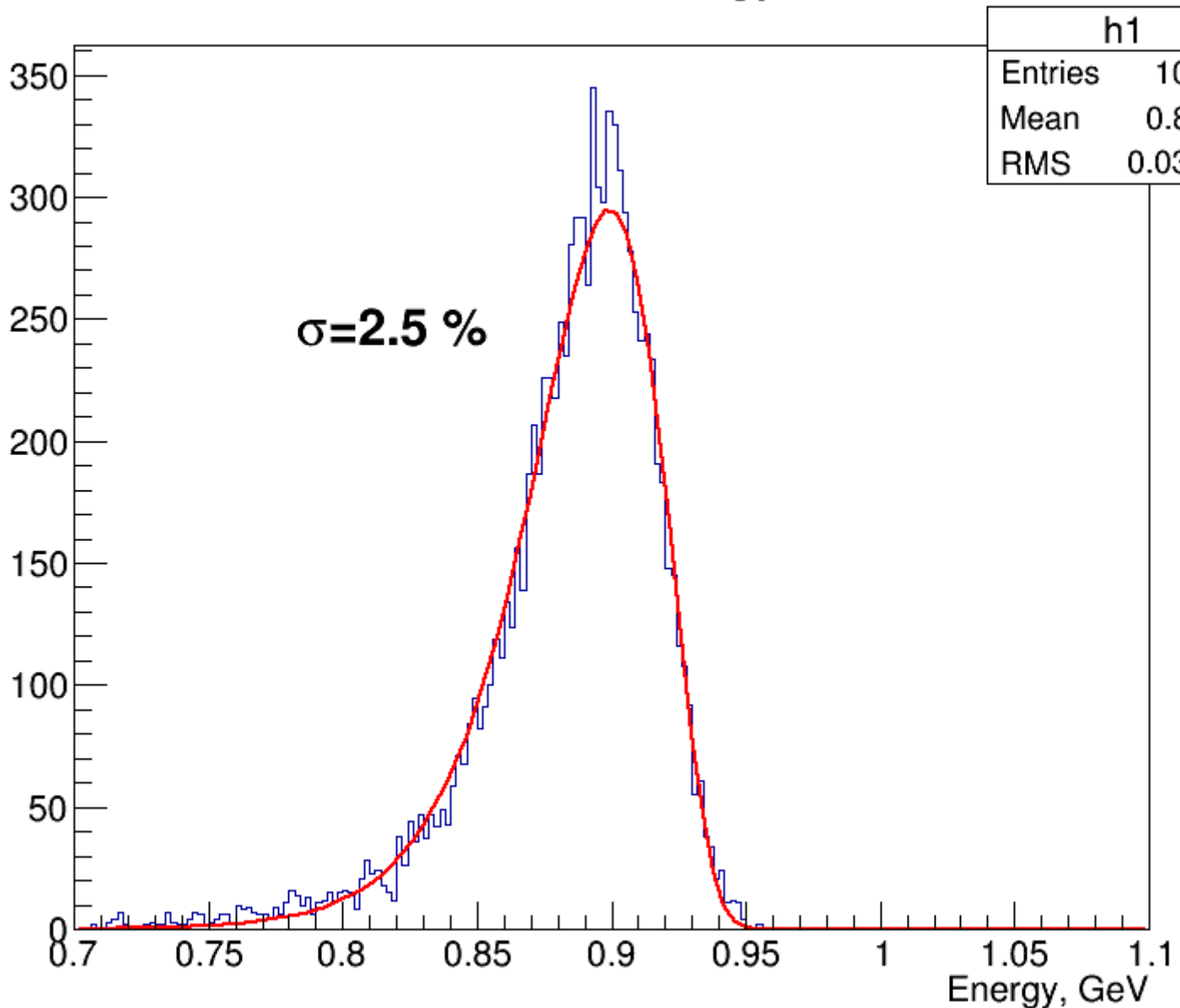
3) [energy3.png](#), downloaded 610 times

# Cluster energy



4) [energy4.png](#), downloaded 734 times

# Cluster energy



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Subject: Re: EMC resolution

Posted by [Ronald Kunne](#) on Wed, 06 Nov 2013 10:13:11 GMT

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Some remarks on the EMC resolution problem.

1) the present EMC PID is two years old, release 14213.

2) I think what should be available in PandaRoot ideally is two versions for the cluster energy  $E_{raw}$  et  $E_{corrected}$ , where  $E_{raw}$  is the cluster energy as close to the value as we will measure it in the experiment, and  $E_{corrected}$  a software corrected value to be used for gamma tracks and Binsong's electron correction

3) At present there are three values  $E_{raw}$  (non-uniformity off), an  $E_{raw}$ (non-uniformity on) et



an Ecalibrated (which is probably wrong, if it uses Eraw). Of these: Eraw(non-uniformity on) represents the best the data as will be measured in the experiment

4) I checked the resolutions using the tuples made recently by Gosia. Eraw and Ecalibrated give resolutions that practically identical and both are too low.

Description of the plot added.

Upper raw: data using Eraw

Lower raw: data using Ecalibrated

1st column: pMC versus (Eemc-pMC)/pMC in %

2st column: profile plot of pMC versus (Eemc-pMC)/pMC in %

3st column: resolution obtained by fitting Gaussians to slices of the 2D histos.

Greetings,

Ronald Kunne

---

Subject: Re: EMC resolution

Posted by [Dima Melnychuk](#) on Wed, 06 Nov 2013 11:35:29 GMT

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Hi,

I have just update emc energy correction parameters for the case of non-uniformity switched on with the latest version of digitization.

I also switched on the use of non-uniformity by default in all.par

The files with correction are in /macro/params/

emc\_correction\_hist\_gamma\_2.root

emc\_correction\_hist\_gamma\_3.root

emc\_correction\_hist\_gamma\_4.root

emc\_correction\_par\_gamma\_2.root

emc\_correction\_par\_gamma\_3.root

emc\_correction\_par\_gamma\_4.root

You use correction like

```
PndEmcAbsClusterCalibrator * calibrator1=
```

```
PndEmcClusterCalibrator::MakeEmcClusterCalibrator(1, 3);
```

And then obtain calibrated energy like

```
cluster_energy_calibrated=calibrator1->Energy(cluster);
```

And here first number stands for the method applied (1 - correction from histogram, 2 - correction from parametrization)

Second number stands for version and here

- 1 - previous version of digitization, no non-uniformity (deprecated)
- 2 - current version of digitization, no non-uniformity
- 3 - current version of digitization, with non-uniformity (should be used by default)
- 4 - current version of digitization, with non-uniformity calculated by Hossein (linear non-uniformity 1.5%, set from the file /macro/params/EmcDigiNoniformityPars2.root)

By the way the macro which produces the last non-uniformity file is  
/macro/emc/dedicated/fill\_nonuniformity\_param.C

Here some plots which demonstrate how applying non-uniformity change reconstructed emc energy. I do not know if it's by accident or by intention of Christian Hammann who provided non-uniformity parameters from measured data in case of barrel EMC correction is almost not needed, i.e. 1 GeV energy peak is centred around 1 GeV. But for endcaps correction is still needed anyway.

For energies in range 0-10 GeV energy versus polar angle

Reconstructed energy of 1 GeV photons

Reconstructed pi0 invariant mass

In this last case the corrected energy gives even slightly worse results.

In PndPidCorrelator.cxx

```
fEmcCalibrator= PndEmcClusterCalibrator::MakeEmcClusterCalibrator(2, 1);
```

should be modified to

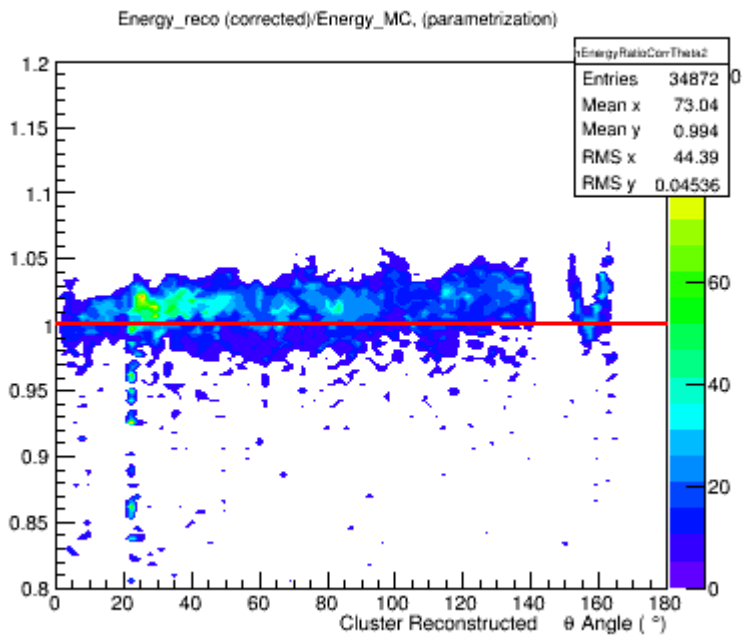
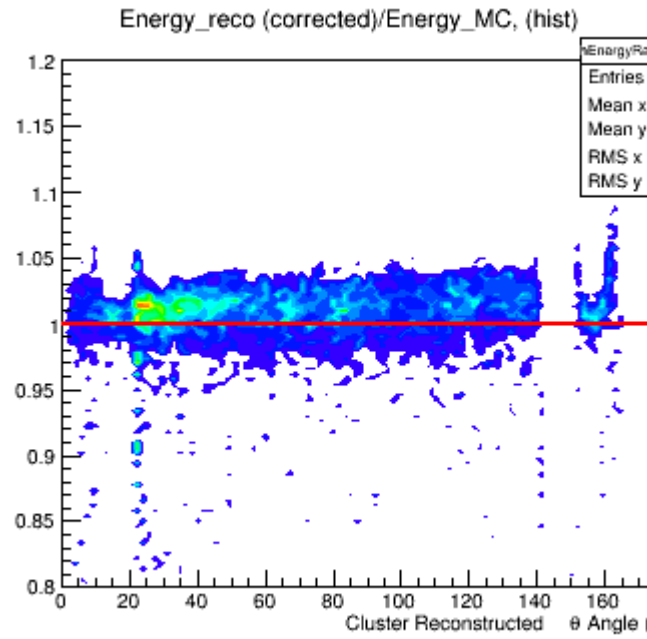
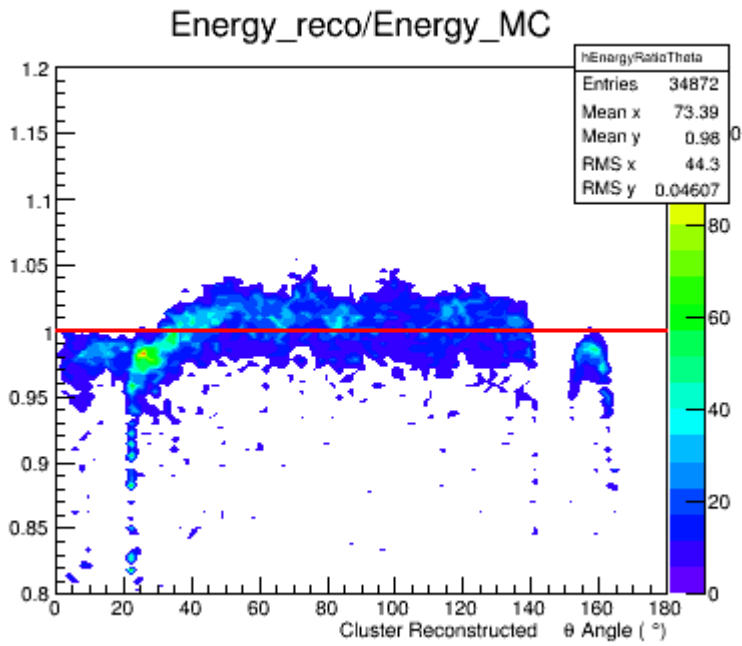
```
fEmcCalibrator= PndEmcClusterCalibrator::MakeEmcClusterCalibrator(2, 3);
```

Dima

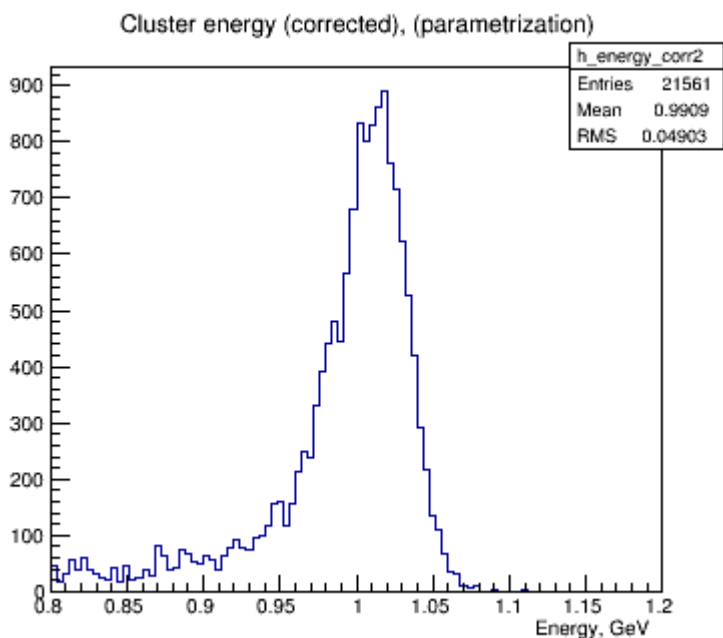
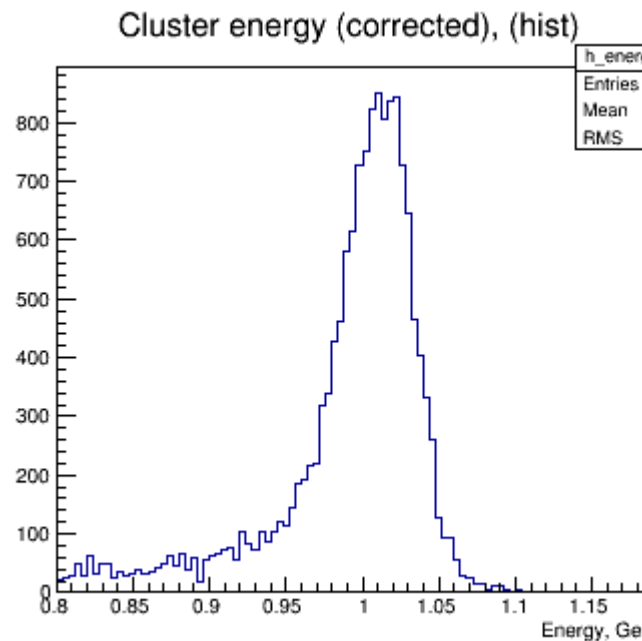
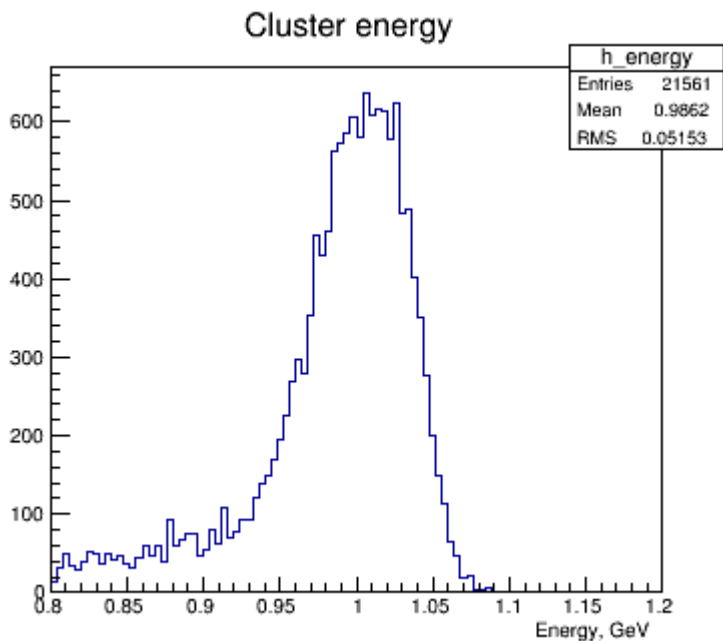
## File Attachments

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1) [e\\_vs\\_theta.png](#), downloaded 750 times

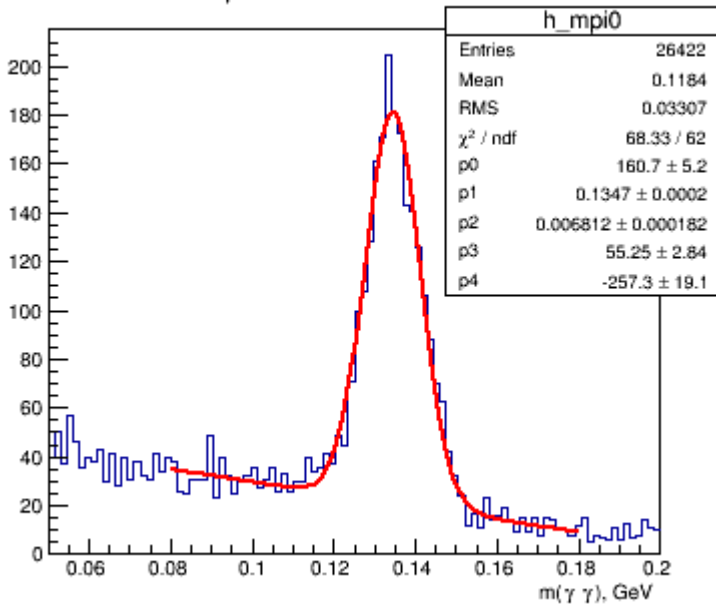


2) [energy\\_1GeV.png](#), downloaded 707 times

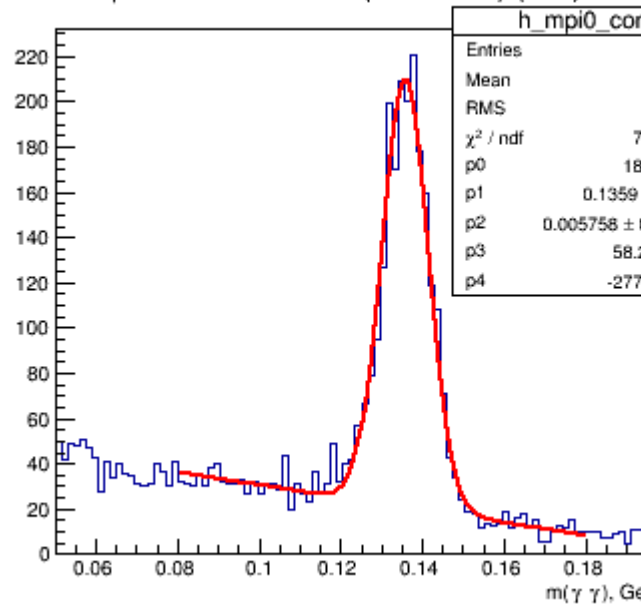


3) [mpi0.png](#), downloaded 694 times

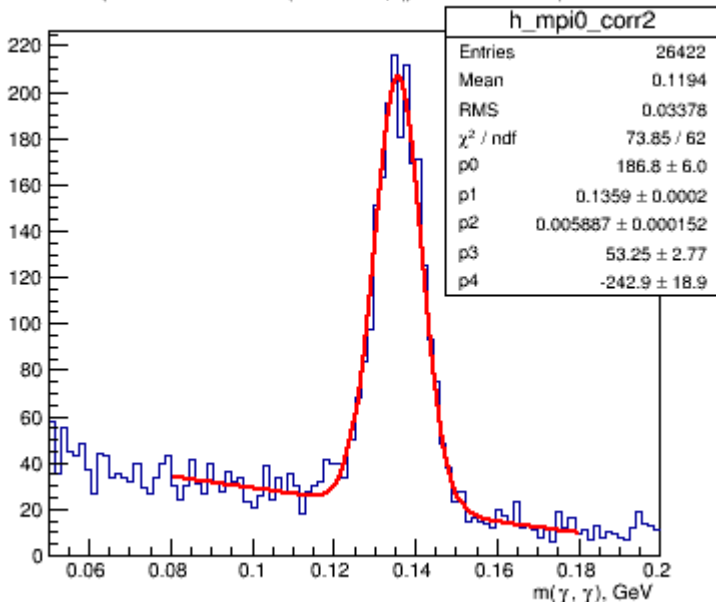
pi0 invariant mass



pi0 invariant mass (corrected) (hist)



pi0 invariant mass (corrected) (parametrization)




---

Subject: Re: EMC resolution

Posted by [Stefano Spataro](#) on Wed, 06 Nov 2013 16:11:25 GMT

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I have just updated the PndPidCorrelator.

Can somebody check the output of the simulation now, to be sure that everything is fine and coherent?

Thanks.

---

Subject: Re: EMC resolution

Posted by [binsong](#) on Fri, 15 Nov 2013 14:10:00 GMT

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hi,

I have checked with the new correlator for electron and photon at 1 GeV/c at Barrel region.

The calibrate energy in EMC seems a little strange, I plot the  $(E_{MC}-E_{Cal})/E_{MC}$ , there is a gap in the peak. (see the figures)

Binsong

#### File Attachments

---

- 1) [photon\\_cal.eps](#), downloaded 248 times
  - 2) [electron\\_cal.eps](#), downloaded 256 times
- 

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Subject: Re: EMC resolution

Posted by [Dima Melnychuk](#) on Fri, 15 Nov 2013 14:24:23 GMT

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Hi Binsong,

Could you make the same plot not with calibrated but with raw energy?  
It would help to understand at what point the gap in the energy distribution appear.

Dima

---

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Subject: Re: EMC resolution

Posted by [binsong](#) on Fri, 15 Nov 2013 14:30:40 GMT

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yes, this is the same plots with raw energy.

Binsong

#### File Attachments

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- 1) [electron\\_raw.eps](#), downloaded 271 times
  - 2) [photon\\_raw.eps](#), downloaded 218 times
- 

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Subject: Re: EMC resolution

Posted by [Dima Melnychuk](#) on Fri, 15 Nov 2013 14:39:22 GMT

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One more clarification.

For which polar angle range in barrel are these plots,  
the whole barrel or more narrow angle range?

Dima

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Subject: Re: EMC resolution  
Posted by [binsong](#) on Fri, 15 Nov 2013 14:49:56 GMT  
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the theta is from 30deg to 130deg, and phi is from 0 to 360.

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Subject: Re: EMC resolution  
Posted by [StefanoSpataro](#) on Fri, 15 Nov 2013 15:23:14 GMT  
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Are you selecting all the clusters or only the ones coming from the primary particles?

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Subject: Re: EMC resolution  
Posted by [binsong](#) on Fri, 15 Nov 2013 15:30:42 GMT  
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only the one from primary track

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Subject: Re: EMC resolution  
Posted by [StefanoSpataro](#) on Fri, 15 Nov 2013 15:35:38 GMT  
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Could you please do a 2D plot as a function of theta?

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Subject: Re: EMC resolution  
Posted by [binsong](#) on Thu, 13 Feb 2014 14:16:08 GMT  
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Dear all,

now the problem is clear. it is due to the nonuniformity.

To obtain a realistic resolution (validated by the PROTO60 results),  
simulations must be done using following parameters in all.par:

```
Use_nonuniformity:1  
Use-Shaped_noise 0
```

The first flag needs to be set to 1 to take into account the observed  
non linearity of the light yield  
in the barrel EMC crystals as a function of the interaction depth.  
The effect is an increase of the sigma of a Nivosibirsk fit from

1.6 (Use\_nonuniformity:0 ) to 2.5 % (with Use\_nonuniformity:1) for photons at 1 GeV with a flat distribution in theta from 30 to 130 deg.

With the second flag set to 0, a more precise description of the electronic noise is obtained, while faster but less accurate results are obtained with the flag set to 1. The effect is an increase of the sigma of a Novosibirsk fit from 2.2 (Use-Shaped\_noise 1) to 2.5 % (Use-Shaped\_noise 0) for a photon at 1 GeV

Before end of november 2013, the standard parameters were "Use\_nonuniformity 0" and "Use-Shaped\_noise 1", leading to a too optimistic resolution, by about a factor 2. Now, the standard setting is "Use\_nonuniformity 1" and "Use-Shaped\_noise 0")

The raw energy includes both effects of the non-uniformity and of the electronic noise. The cluster calibrated energy is deduced using calibration parameters adjusted as a function of theta and energy to reproduce the pi0 mass. By default, the calibration parameter file is the one corresponding to Use\_nonuniformity:1 and "Use-Shaped\_noise 0".

The two attached figures are the results for photon with the new version of pandaroot.

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Subject: Re: EMC resolution  
Posted by [binsong](#) on Thu, 13 Feb 2014 14:17:44 GMT  
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here is another figure for the cal energy