Photon reconstruction in CMS

Application to H→γγ

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Outline

Short description of ECAL in CMS

Expected H→γγ signal

Getting a uniform response from the ECAL

Validation with test beam data

Summary and perspectives

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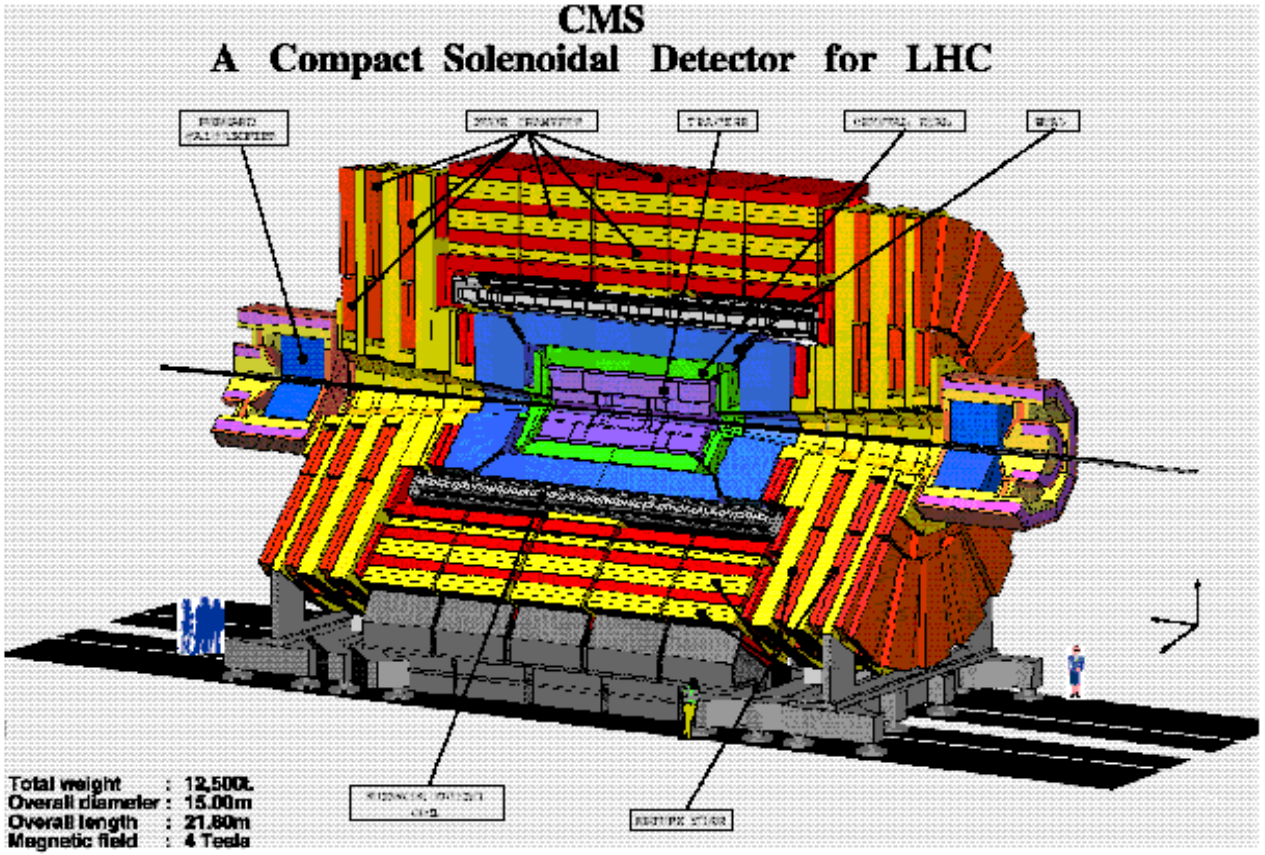
CMS, a general purpose LHC detector



Split 49

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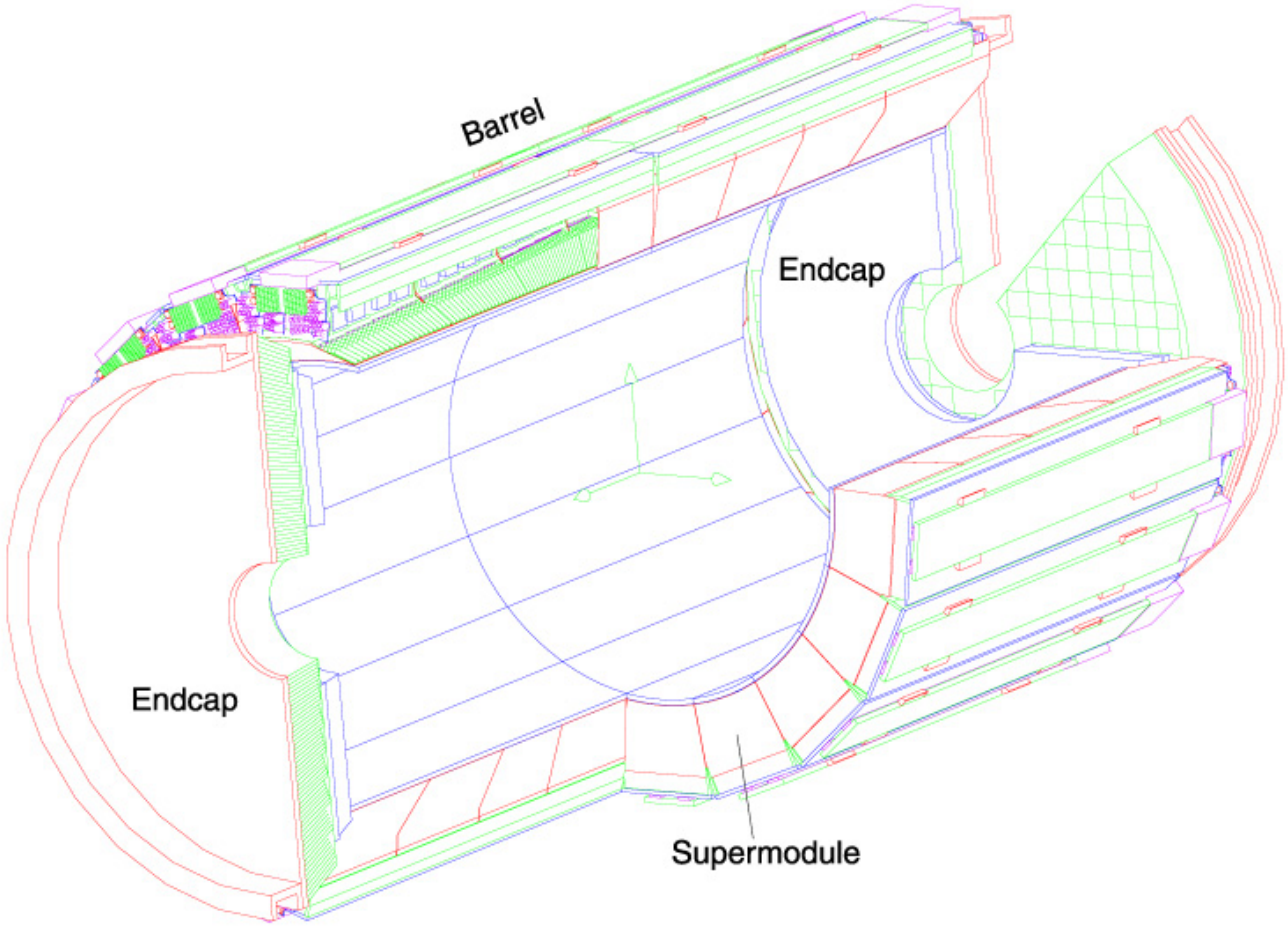

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Start with a simple case

example:

120 GeV Higgs,

2γs unconverted ~ 40% of events

both γs in the barrel ~ 40% of them

↙16% of total events

The position of the vertex is assumed to be well measured

In the following, we will concentrate on photon reconstruction in these events

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We expect the following
contributions to the resolution :

Stochastic term from containment	1.5 % /√E
Photostatistics	2.3 % /√E
Total stochastic	2.7 % /√E
Constant term from containment	< 0.2 %
Longitudinal non uniformity	0.3 %
Calibration	0.4 %
Total constant term	0.55 %

Assume 50 MeV noise per crystal

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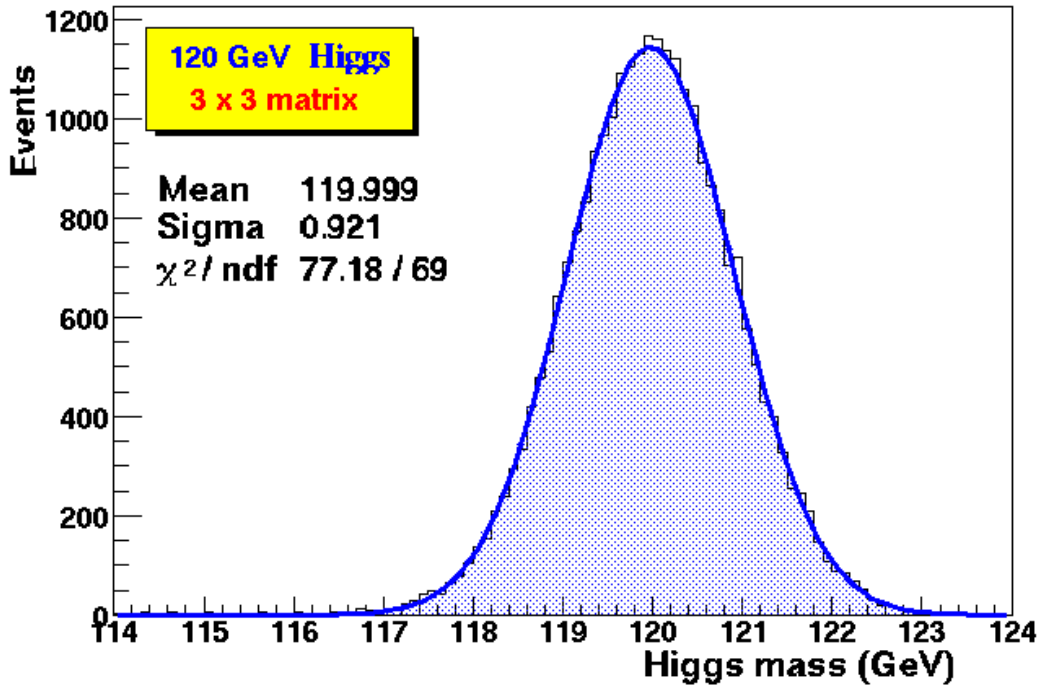
Assuming a uniform response of the barrel
we would expect for the reconstructed mass:



but …

* all contributions from resolution and noise included

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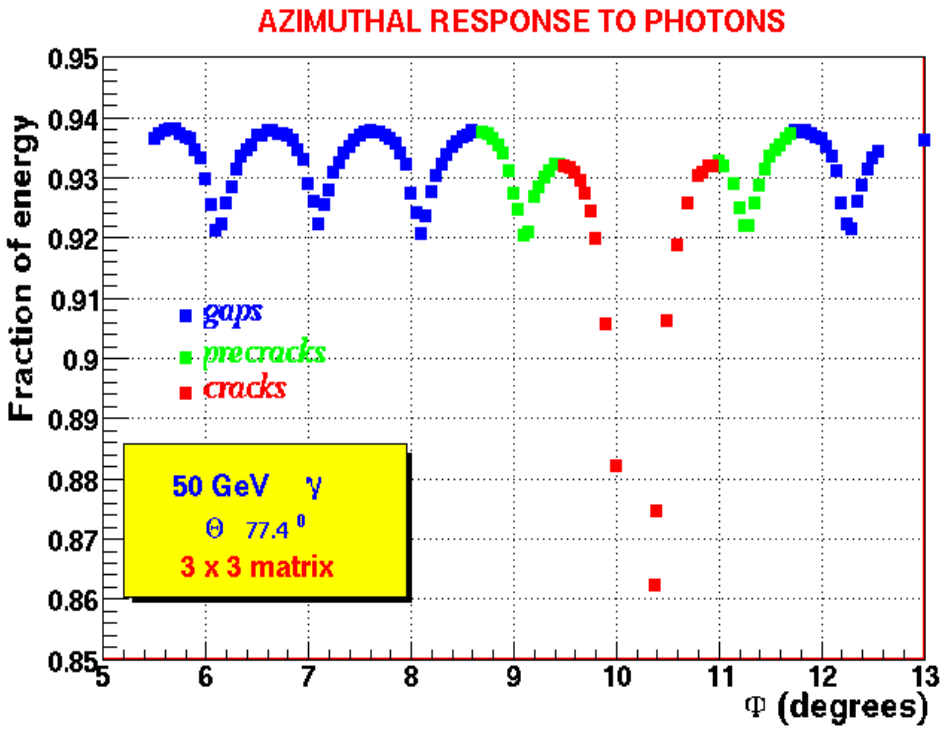
Because of the segmentation of the ECAL,
the particles "see" the inter-crystal gaps

For example,
in the azimuthal coordinate :



and similarly in the polar coordinate

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The crack structures correspond
to the space between 2 adjacent supermodules

18 in the azimuthal coordinate
7 in the polar coordinate

The gap structures correspond
to the space between 2 adjacent crystals

342 in the azimuthal coordinate
162 in the polar coordinate

The pre/post-crack structures correspond
to the gaps preceding or following a crack

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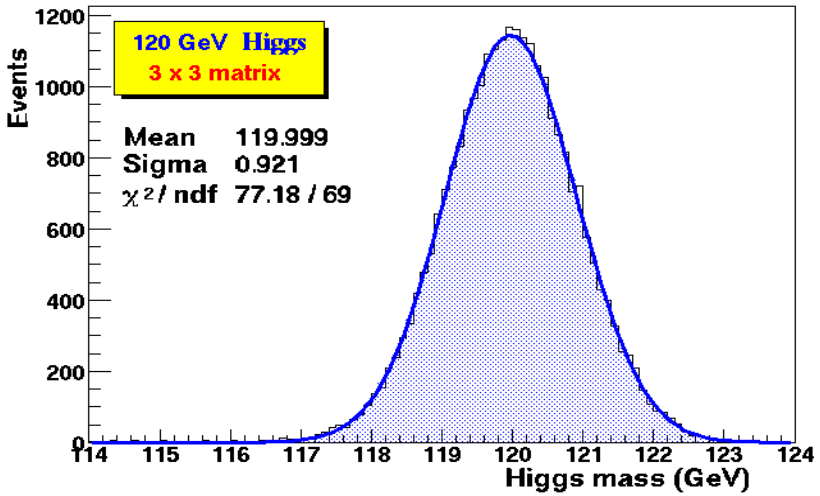
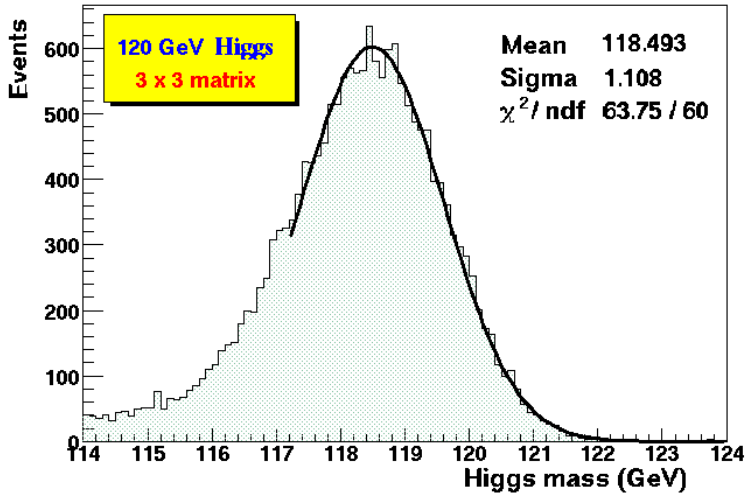
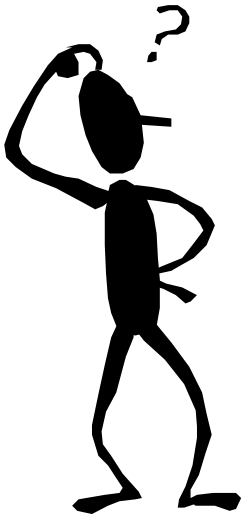
This results in a shift of the expected distribution and a degradation of its Shape :







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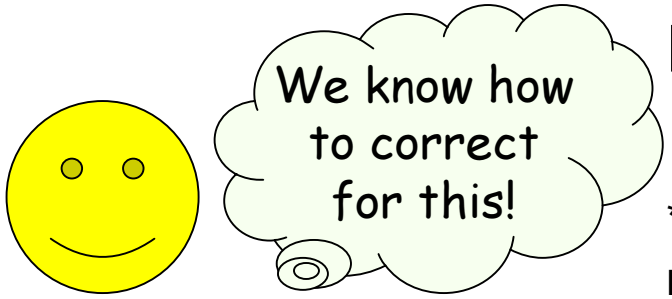
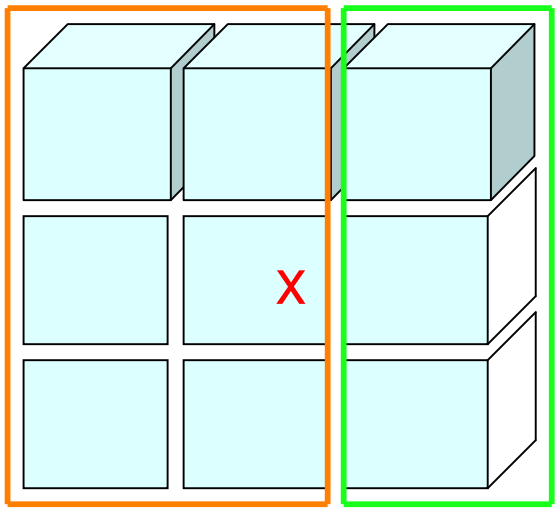


Let's define the parameter

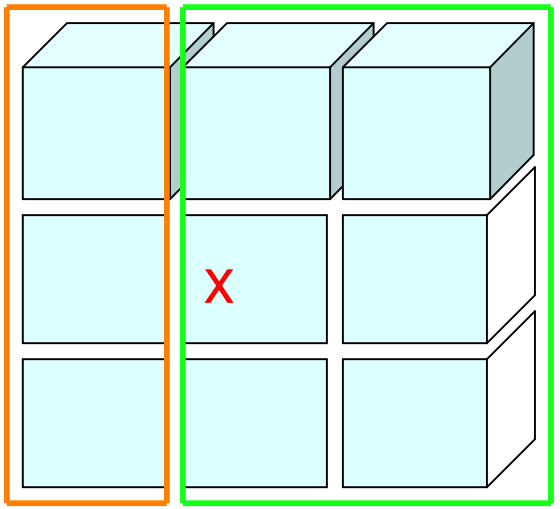
Log (E2/E1)

* the method has been published in 3 CMS notes (TN 96_014, NOTE 1997_087, NOTE 1998_032)

3 x 3 matrix example



(5x 5 has also been studied)



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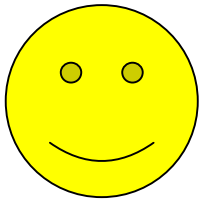
The shape of the structures we have defined as
gaps, pre/post-cracks, cracks
can be parameterised as
simple polynomial functions of the parameter Log (E2/E1)



They are independent of the photon energy from 10 to 120 GeV

They are independent of the angular range over the ECAL barrel acceptance

↙ example

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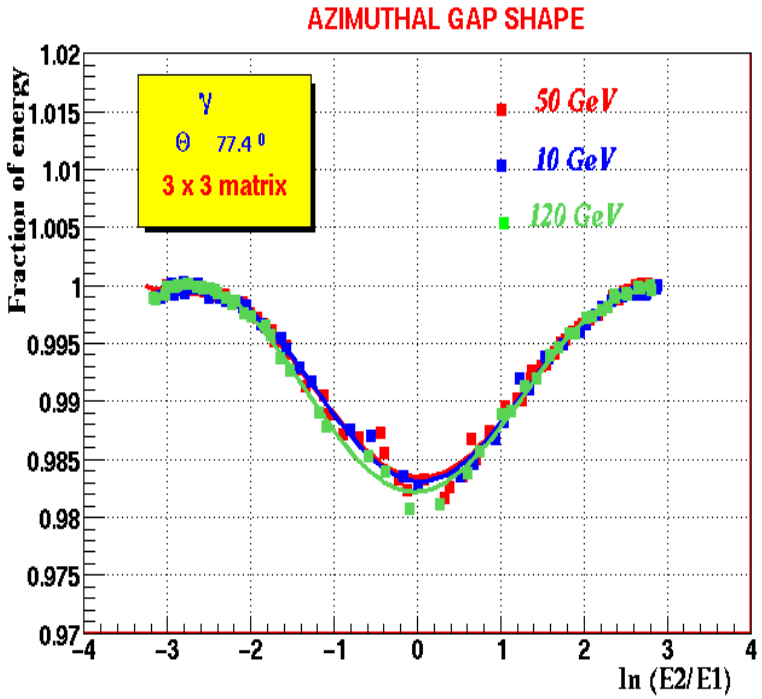
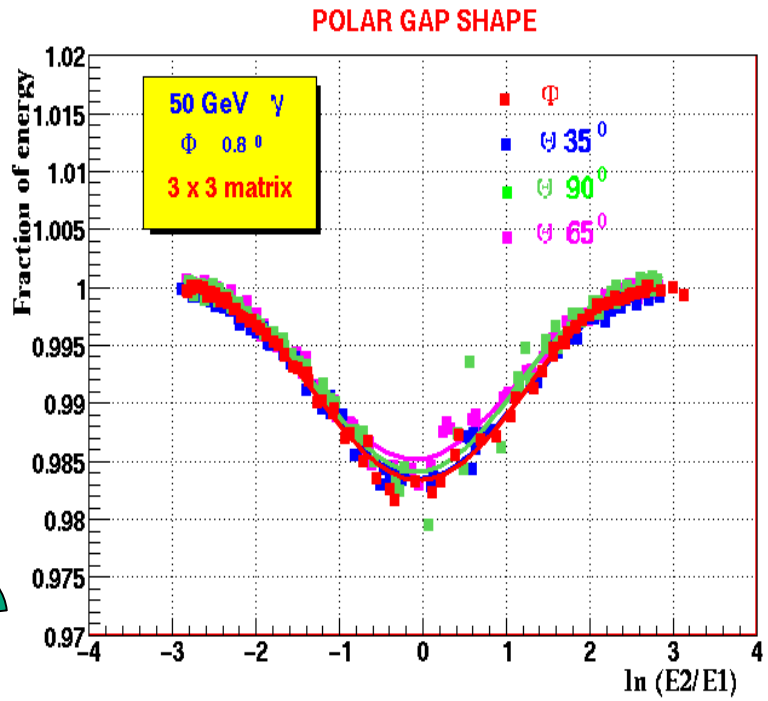


Independent of energy
from 10 to 120 GeV



Independent of the
angular range
within CMS acceptance

* the depth of the structures is less important for larger clusters such as 5x5 matrices for example

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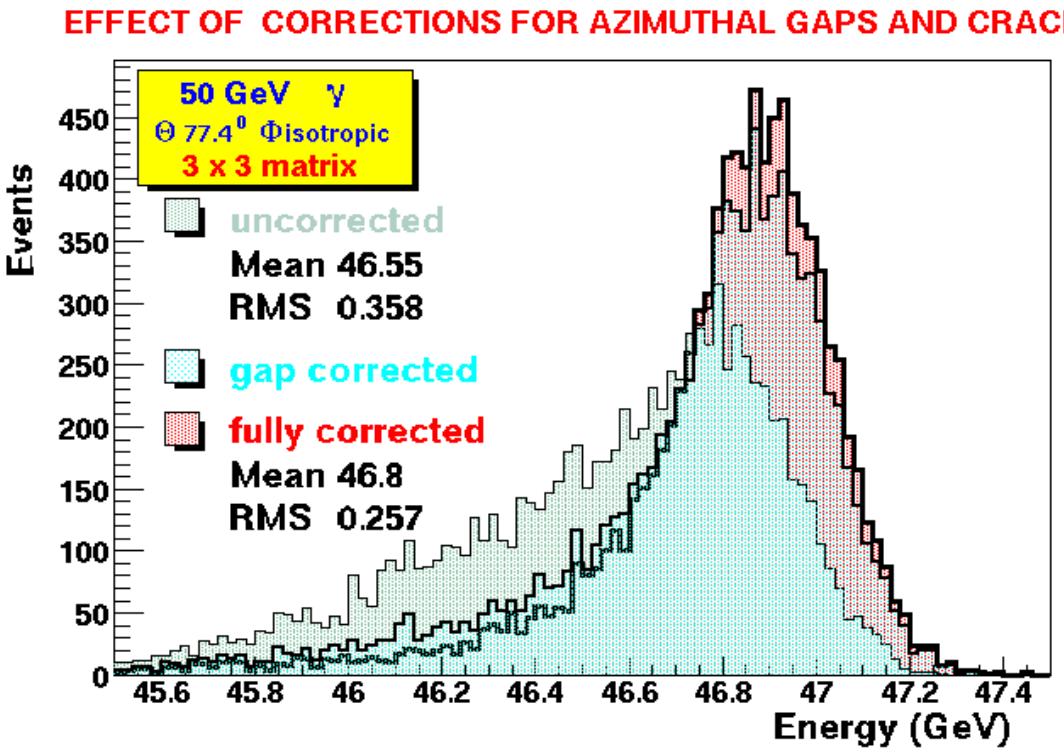
Cracks are deeper than gaps but they are fewer

↙gaps have a larger contribution to the degradation of the photon energy:



The expected energy deposition for an impact point in the center of a crystal is recovered

* Containment factor not included

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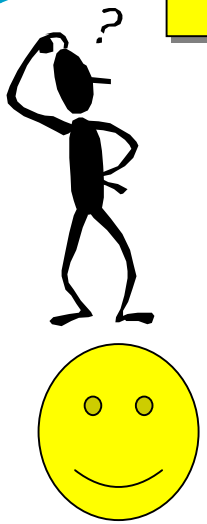
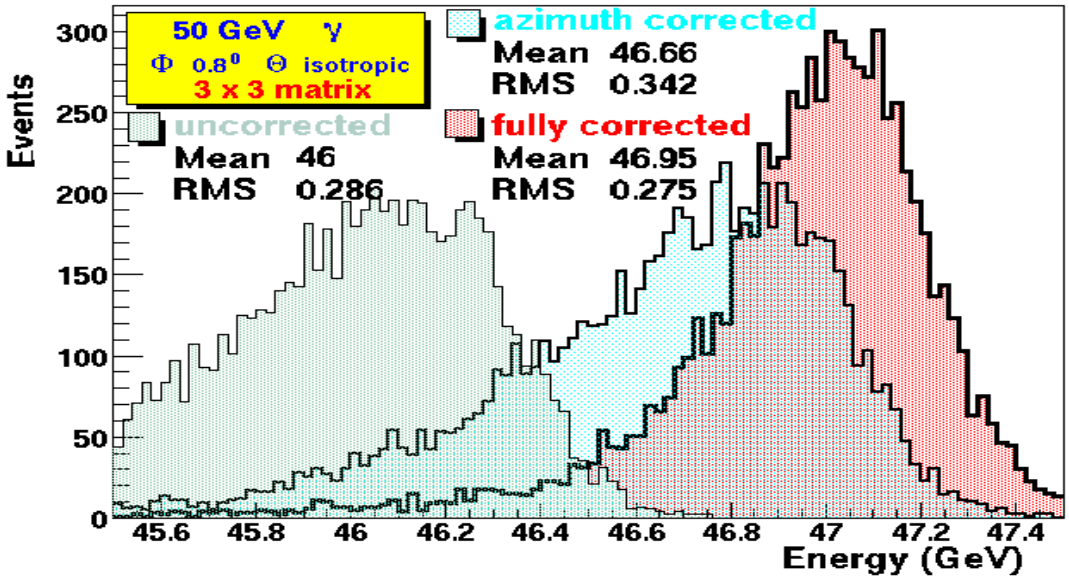


What happens if the impact point is in a gap or crack region in both coordinates simultaneously?

Still we can recover the expected energy deposition

EFFECT OF CORRECTIONS FOR POLAR & AZIMUTHAL GAPS & CRACKS



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We have managed to get
a uniform response from the ECAL barrel

But so far we have exercised the method
over simulated data

What about "real" data?

↙ Test beam data:

Azimuthal scan with 120 GeV electrons (year 2000)

* the matrix was not positionned as in the experiment
  ↙ the electrons see deeper gaps than expected

Polar scan with 120 GeV electrons (year 2002)

** in the absence of magnetic field, electrons
can be used to test photon corrections

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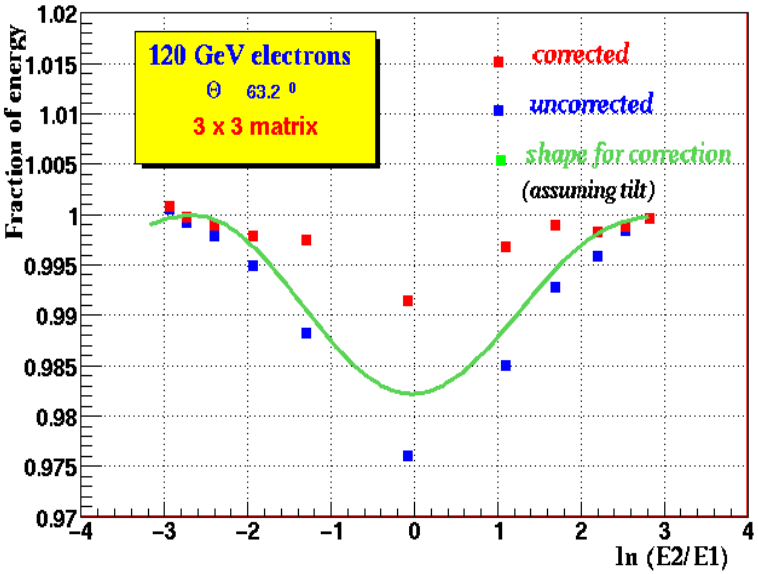
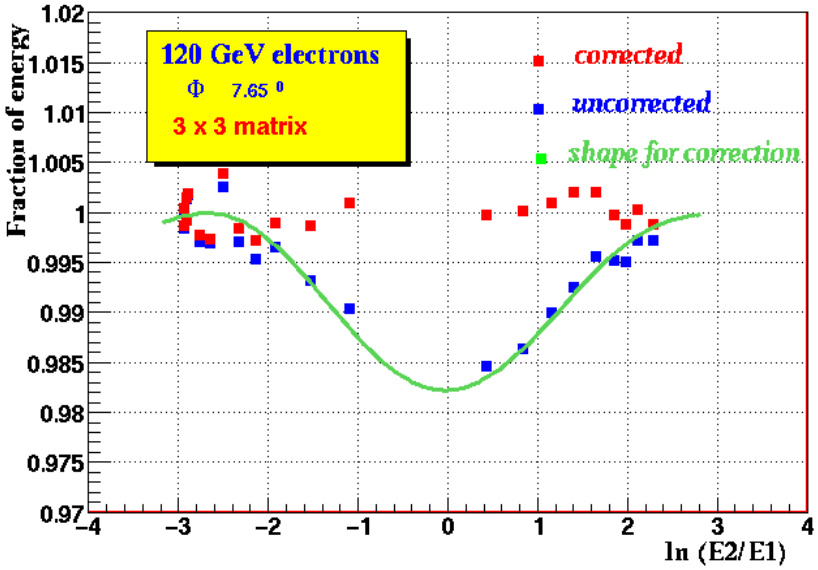
EFFECT OF AZIMUTHAL GAP CORRECTIONS ON TEST BEAM DATA



The gap is deeper than expected
↙the corrected energy is
too low in the same proportion

EFFECT OF POLAR GAP CORRECTIONS ON TEST BEAM DATA



Uniformity within 2 to 3‰ can be recovered

We are confident in this procedure

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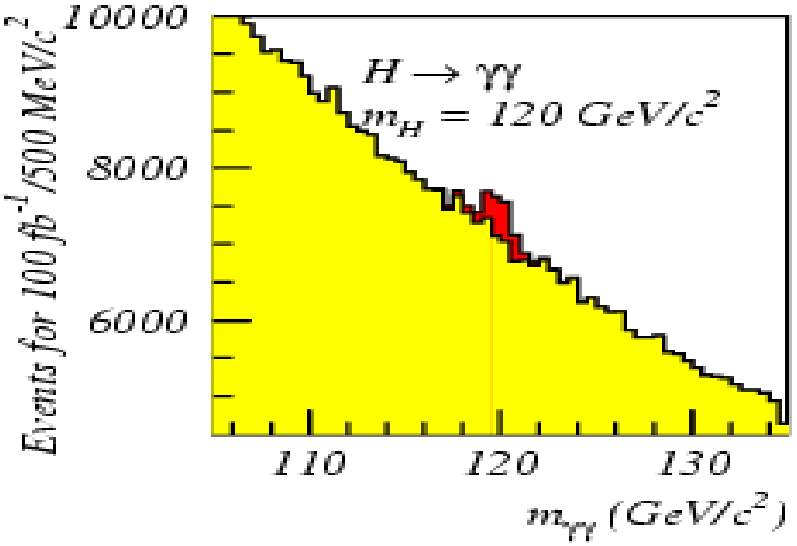
Remember the small signal above a high background for this decay mode !

For 120 GeV Higgs,

*using a old background evaluation , including endcaps & converted photons

We obtain a rough estimate of signal and background in a mass window of 1 σ



	S	B	S/B	S/√B
L = 100 fb^{-1} $m_{\gamma\gamma} < m_H \pm 1\sigma$	1766	29576	0.06	10.3

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Summary

The mentionned notes are currently being updated with the final CMS geometry

It is possible to get a uniform response from the ECAL barrel within 2 to 3‰

The procedure is independent of
the photon energy from 10 to 120 GeV
the angular range in the CMS acceptance

The input peak value is recovered

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Perspectives

A similar procedure can be applied to the ECAL end-caps

Uniform response to electrons and positons in the magnetic field can be reached in a similar manner

With better understanding of the latter, converted photons will be included too

Ultimately we expect a more accurate peak value and a higher significance for H→γγ with the same integrated luminosity.

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