Dear Editor,
the FCAL collaboration is very thankful to the referee. The comments were very helpful to improve the text of the paper. In the following we go through the comments and report the actions done.

Comments to the Author
Comments on EPJ-17-05-77

1.
General comments:
This is a thorough study of a luminometer in the test beam at CERN. The measurements examine the longitudinal and transverse shower profiles. The measurements are reproduced by detailed shower simulations which take into account the geometry of the sensors.

While the paper should be published one is missing a concluding statement on the suitability of the device (or rather the technical approach) for applications for e.g. the ILC. Such a statement should be added.

The statement added is:
The paper demonstrates that major components for a luminometer to be used at a future experiment at CLIC or ILC, developed by the FCAL collaboration, can be operated as a system. The performance in reconstructing electromagnetic showers is well reproduced by Monte Carlo simulations.

Some confusion arises in the discussion of the Moliere radius. The abstract, in particular, makes a statement on a discrepancy which probably is none. It could be interpreted as casting doubt on the basic formalism for the transverse shower shape. I do not think that this is intended. Rather, the geometry of the setup requires the application of a slightly different formula than Eq.4, in which the extra contribution from the air gaps is included. It would be nice if this discussion and the numerical comparison could be added to the discussion at the end of the text.

The statement in the abstract is dropped, since after discussion we do not consider it as essential for this paper. Instead a new paragraph is added to the paper text discussing the difference in the value of the Moliere radius obtained with eqn.(4) (which is removed from the paper) and the full GEANT simulation.

2.
Abstract
p2 line 11
"This value is significantly large than the one obtain from the formula based on the material composition." What does this mean in detail? Any conclusions? See also statement at the bottom.

See above.

3.
p3 line 9
Why does a high rate require low-power electronics ? Please explain in the text.

The text is changed as follows:
Due to the high occupancy originating from beamstrahlung and two-photon processes both calorimeters have to be read out after each bunch crossing. To ensure a low material

budget no cooling infrastructure is foreseen. Hence a dedicated low-power fast readout is developed.

4.
p5 line 30
Jargon: L1 and R1 are introduced before being defined. Define segmentation in radial and azimuth. Pads are connected. How? Electrically?

The text has been changes as follows:
A LumiCal silicon sensor prototype is shown in Figure 5. Its shape is a ring segment of 30^0 and it contains four sectors of 7.5^0 each. The inner radius is 80 mm and the outer radius 195 mm. The thickness of the n-type silicon bulk is 320 μm. The pitch of the p^+ pads is 1.8 mm and the gap between the pads 100 μm. Thin printed circuit boards with copper traces are used as fan-outs. Fan-out traces were bonded to the sensor pads through small holes on one end and to the connector to the FE electronics on the other end. For each sensor the pads 51-64……were connected, as illustrated in Figure 5.

5.
p5 line 47
20 MS/s what is this unit? 20M /s

changed to 20 Megasamples per second.

6.
p7 line 21
as it takes place in the target detector -> as expected for the setup in ILC detectors

text is changed to: as expected for the setup in CLIC and ILC detectors

7.
p9 line 18
"and only a small fraction of multiple track events is acceptable" What is the reason? Rate limitations in the chip or imposed requirements? Please clarify in text.

Text is changes as follows:

Period after “readout.”
Otherwise within the readout time of about 400 μs a second particle may cross the telescope, and the mapping to the electromagnetic shower will become ambiguous.

Additional explanation to the referee:
The complete event of Mimosa 26 consists of 4 consecutive frames, it takes 4x115.2us to read them and it is significantly longer than the readout time of the LumiCal. As explained in the end of section 2.2.2, the BUSY signal was used to veto triggers during the long readout time of the telescope. Collecting events in the way that there is one to one events correspondence between LumiCal and Telescope makes the offline synchronization simpler and more reliable.

8.
p10 line 45
Since particles arrive stochastically an asynchronous mode was used? What is meant by this sentence? Figure 9 suggests a triggered readout, i.e. synchronous with the beam particles.

The text is changes as follows:
The sampling clock of the ADC is running continuously. The trigger for the stochastically arriving beam particles is hence not synchronized with the ADC clock of 20 MHz, leading to an asynchronous sampling.

9.
p12 Figure 11
The different colors should be explained in the caption. Is the signal expected in two samples as suggested from the figure? What is the dip at 400 in the left figure? How can this be derived from a CR-RC filter?

The text in the caption is changed as follows:
Raw amplitudes of two sets of 8 channels, drawn in different colors, as a function of time. One set (left) contains no signal and one (right) shows a signal in two channels (pink and blue).

In addition, the text of section 3.2.1. is changed as follows.
As can be seen in Figure 11, the baseline in raw events varies as a function of time synchronously in all channels. This effect is denoted hereafter as common-mode noise presumably caused by power lines. The initial treatment of the data includes the baseline and common-mode subtraction.

10.
p12 line 39
There seems to be a contradiction: the simplest method is of the highest complexity. Also: probably rather fitting of a theoretical pulse-shape or of an expected pulse shape or similar rather than theoretical fitting.

The text has been changed as follows in line 39:

The method with the highest expected precision is using a pulse-shape fitting with a pre-defined shape.

11.
p12 line 49
There is an unresolved reference in [7,?]

correction done

12.
p14 Figure 14
What is the spike at 300 counts?

The spike disappears when the binning is changed, both to smaller and wider bins. Hence, we consider it as a fluctuation. The figure has been replaced with a different binning.

13.
p15 Figure 16
First, second and third "configuration" should be associated to the geometrical arrangement such as sampling the front middle and rear part of the shower. The figure caption should explain the various colours.

The figure caption has been changed as follows:

The SNR measured in the boards S0 to S3 when placed in configurations 1 (red), 2 (blue) and 3 (black) of the test set-up as explained in Table 1. Left: Channels with MOS-feedback. Right: Channels with R-feedback.

The figure is redone with the same scale in the y-axis. The board S2 with R-feedback has the worst performance. The explanation is given below. We think it is a technical detail not important for the results presented in this paper.

14.
Do you expect a variation of the SNR for the various configurations? Why is S2 significantly worse in R-feedback? I believe this warrants a comment.

This S2 board was of worse quality, in particular biasing currents were not calibrated well (discovered after test-beam). Since R-type channels have smaller gain and significantly higher sensitivity to bias current, the too low bias current affected them significantly why much less in the case of the MOS-channels

15.
p15, line 35
It would be helpful to see indicated whether there is any additional physics implemented in the LUCAS package beyond that of Geant4.

LUCAS describes the geometry and materials of the apparatus in very detail.
All physics processes are simulated by GEANT.

16.
p16, line 39
What is meant by "appropriately adjusted"? How do the shapes compare between the doubly sampled layers. Fig 19 just indicates the means.

The text is changes as follows:
Since the layers 3, 5 and 7 were sampled in both configurations, the uncorrelated uncertainties are reduced by $\sqrt{(2)}$. Concerning the shape, see attached figure at end of answers.

17.
p20 Figure 22
Why is the distribution not centred at zero? Please comment in text.

Comment for the referee:

The reason was a simple offset in the alignment, not being corrected for, since it is not important for the resolution. This offset is now corrected in the figure.

18.

p20 line 47
It is important for the LumiCal operation to achieve the transverse size of the electromagnetic shower as small as possible. -> Maybe:
It is important for the LumiCal operation to achieve the smallest possible transverse size of the electromagnetic shower.

Comment for the referee:
text is changed following your proposal.

19.
p20 line 47
Why do you wish to confine the transverse size (as small as possible)? Please give a word of explanation.

The text is changed as follows:

The shower of single high energy electrons has to be reconstructed on a widely spread background from beamstrahlung and two-photon processes. A small Moliere radius facilitates this reconstruction and extends the range in the polar angle for high performance shower reconstruction.

20.
p21 Figure 23
Is this more than simple geometry from a divergent shower? Or in more general terms should one not restrict the application of eq (4) to thin slabs of material?

A separate paragraph was added.

21.
p 23 Figure 24a
The figure seems to indicate an extra contribution at small energies and the peak is considerably shifted by some 10 MIPs. What is the origin? Doesn't this translate into a >10% uncertainty in contrast to the 5% claimed in the text?

Comment to the referee:

Since it is a logarithmic scale the differences in the tails are nicely visible, being mainly caused by the misidentification of the core pad in a few cases. In the analysis the mean vale of the distribution is used, being different only by one unit with an average of 74, or 1.4 %.

Text added:
The core distribution (m=0) is slightly wider and shifted, most probably due to calibration. However, the mean values of the measured and simulated distributions, used for the calculation, are similar. The difference seen in the low energy part is the result of a small fraction of events (note the logarithmic scale) that misidentify the core position.

22.

p23 Eq 9
After the equation you may consider inserting a text such as "and integrating over the horizontal position X" the vertical energy distribution G_E(Y) is"

The text is changed correspondingly

23.
p23 Eq 10
The equation is easier to read by replacing (\sqrt{(X^2+Y^2)})^2 by (X^2+Y^2)

done

24.
p24 line 16
"For the numerical integration, the normalization integral in denominator of equation (7) must be limited by some finite number." The denominator is physically finite by definition so no action should be needed for a reasonable ansatz/parameters. The statement is technical and simply refers to the integration procedure. By the way, what is this number? Rephrase.

The text is changed as follows:

For the numerical integration, the integration limits of the normalization integral in the denominator of eqn. (7) must be chosen such that the relevant range in r is covered.

Comment to the referee:
The value of the upper limit of r, R=84.5 mm, is given, after some discussion, a few lines below the sentence above.

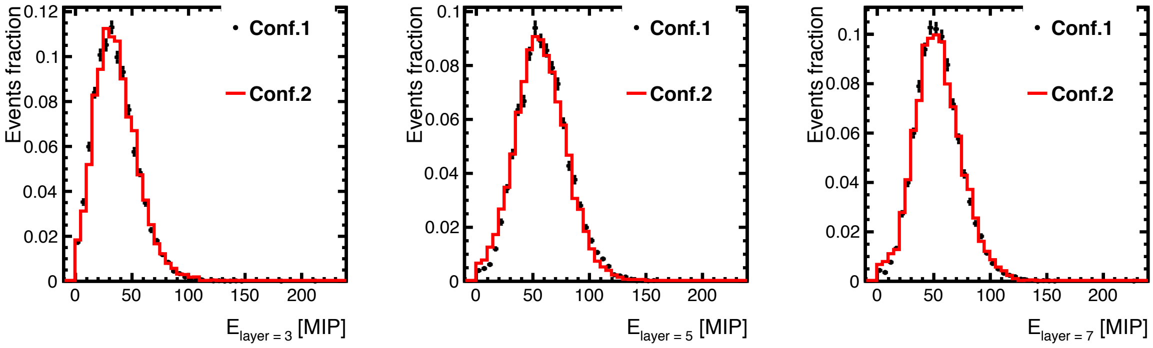
25.
p26 line 39 cc
"The value for the Moliere radius obtained in the measurement is larger due to the large space between the layers creating big air gaps. This supports the necessity of thin sensor layers tightly connected to the absorber plates with minimal air gaps."
I am not sure that I understand this statement. Do you refer to the somewhat trivial statement that the effective Moliere radius of an object composed of multiple thin material layers separated by gaps needs to include the divergence resulting from the air gap? Please compare the value from that calculation with the one extracted from the detailed simulation and discuss.

See answer in #1. We added the following paragraph just before the final results:

It is worth noting that the value obtained by using the formula for composite material given in [25] is lower (~17 mm) than obained from this analysis. This is due to the fact that the composite material formula is not precise enough in the case when the absorber layers are wide compared to their radiation length [35], as was the case in the present setup.

26.
p27 line 4
Somehow one is missing a concluding statement on the suitability of the luminometer of this kind for application on the ILC and elsewhere.

A statement was added in the conclusions (see answer to #1)



Events fraction
Conf.1
Conf.2
$E_{layer = 3}$ [MIP]
$E_{layer = 5}$ [MIP]
$E_{layer = 7}$ [MIP]