

Muon Results from the EMEC/HEC Combined Run corresponding to the ATLAS Pseudorapidity Region $1.6 < |\eta| < 1.8$.

ATLAS Liquid Argon EMEC/HEC Collaboration

C. Cojocaru, J. Pinfold, J. Soukup, M. Vincter

University of Alberta, Edmonton, Canada

V. Datskov, A. Fedorov, N. Javadov¹, V. Kalinnikov,
S. Kakurin, M. Kazarinov, V. Kukhtin, E. Ladygin, A. Lazarev,
A. Neganov, I. Pisarev, E. Serochkin, S. Shilov, A. Shalyugin,
Yu. Usov

Joint Institute for Nuclear Research, Dubna, Russia

D. Bruncko, R. Chytraccek, E. Kladiva, P. Strizenec

*Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice,
Slovakia*

F. Barreiro, G. Garcia², F. Labarga, S. Rodier³, J. del Peso

Physics Department, Universidad Autónoma de Madrid, Spain

M. Heldmann, K. Jakobs⁴, L. Koepke, R. Othegraven,
D. Schroff, J. Thomas, C. Zeitnitz

Institut für Physik der Universität Mainz, Mainz, Germany

P. Barrillon⁵, C. Benchouk, F. Djama, F. Henry-Couannier,
L. Hinz⁶, F. Hubaut, E. Monnier, C. Olivier, P. Pralavorio,
M. Raymond, D. Sauvage⁷, C. Serfon, S. Tisserant, J. Toth⁸

*Centre de Physique des Particules de Marseille, Univ. Méditerranée, Marseille,
France*

G. Azuelos, C. Leroy, R. Mehdiyev¹

Université de Montréal, Montréal, Canada

A. Akimov, M. Blagov, A. Komar, A. Snesarev, M. Speransky,
V. Sulin, M. Yakimenko⁷

Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia

M. Aderholz, T. Barillari, H. Bartko, W. Cwienk, A. Fischer,
J. Habring, J. Huber, A. Karev⁹, A. Kiryunin¹⁰,
L.Kurchaninov¹⁰, S. Menke, P. Mooshofer, H. Oberlack,
D. Salihagic¹¹, P. Schacht

Max-Planck-Institut für Physik, Munich, Germany

T. Chen, J. Ping, M. Qi

University of Nanjing, Nanjing, China

W. Aoulthenko, V. Kazanin, G. Kolatchev⁷, W. Malychev,
A. Maslennikov, G. Pospelov, R. Snopkov, A. Shousharo,
A. Soukharev, A. Talychev, Y. Tikhonov

Budker Institute of Nuclear Physics, Novosibirsk, Russia

S. Chekulaev, S. Denisov, M. Levitsky, A. Minaenko,
G. Mitrofanov, A. Moiseev⁷, A. Pleskatch, V. Sytnik¹²

Institute for High Energy Physics, Protvino, Russia

M. Losty, C.J. Oram, M. Wielers

TRIUMF, Vancouver, Canada

P.S. Birney, M. Fincke-Keeler, I. Gable, T.A. Hodges,
T. Hughes, T. Ince, N. Kanaya, R.K. Keeler, R. Langstaff,
M. Lefebvre, M. Lenckowski, R. McPherson¹³

University of Victoria, Victoria, Canada

H.M. Braun, J. Thadome

University of Wuppertal, Wuppertal, Germany

Abstract

A full azimuthal ϕ -wedge of the ATLAS liquid argon end-cap calorimeter has been exposed to particle beams in the energy range $6 \text{ GeV} \leq E \leq 200 \text{ GeV}$ at the CERN SPS. The angular region studied corresponds to the ATLAS impact position around the pseudorapidity interval $1.6 < |\eta| < 1.8$. The muon results are presented and compared to Monte Carlo predictions.

1 Introduction

The results from the EMEC/HEC combined run concerning electrons and pions have been already presented [1]. Previous beam runs with individual set-ups of the electromagnetic [2,3], hadronic [4] and forward calorimeters respectively provided important information on the stand-alone performance. They also contributed substantially to the assessment of the production quality of the calorimeters or modules.

Details of this beam test set-up, data analysis and MC simulations can be found in [5]. It should be stressed, that the set-up did not reproduce the exact ATLAS projective geometry. The beam was incident perpendicular to the face of the calorimeters, rather than tilted at an angle corresponding to the ATLAS impact region $1.6 < |\eta| < 1.8$. This tilt angle has a major impact on the performance of muons: a larger number of read-out cells contributes to the muon signal therefore increasing the electronic noise [6] contribution substantially. This hold in particular for the EMEC. Here the relevant results for the ATLAS set-up are given in [2].

¹ On leave of absence from IP, Baku, Azerbaijan

² Now at "Instituto Nicolas Cabrera", U.A.M. Madrid, Spain

³ Supported by the TMR-M Curie Programme, Brussels

⁴ Now at University of Freiburg, Freiburg, Germany

⁵ Now at Imperial College, University of London, London, United Kingdom

⁶ Now at Université de Lausanne, Faculté des Sciences, Institut de Physique des Hautes Energies, Lausanne, Switzerland

⁷ deceased

⁸ Also at KFKI, Budapest, Hungary, Supported by the MAE, the HNCfTD (contract F15-00) and the Hungarian OTKA (contract T037350)

⁹ On leave of absence from JINR, Dubna, Russia

¹⁰ On leave of absence from IHEP, Protvino, Russia

¹¹ On leave of absence from University of Podgorica, Montenegro, Yugoslavia

¹² Now at University of California, Riverside, USA

¹³ Fellow of the Institute of Particle Physics of Canada

2 Muon Results

For the analysis of muons only those read-out cells, which are on the muon trajectory, have been selected. This yields typically 3 to 5 channels for the HEC and 10 for the EMEC (second and third longitudinal segment). The muons are not reconstructed in the first EMEC segment, which has narrow strips only. The non-pointing set-up requires, especially for the EMEC, a larger number of read-out cell for reconstruction in comparison to [2] when a projective beam test set-up was used. The cluster algorithm used for the electron and pion reconstruction would yield an efficiency of typically 25 % if the related σ -thresholds were unchanged. This selection would bias the data and has therefore not been used. Extracting the event timing from the particle response in the individual channels ('Global event timing') is for muons rather difficult. Therefore in this case the TDC information has been used directly. The total response for muons of 150 GeV in the EMEC (second and third longitudinal layer) and the corresponding noise distribution are shown in Fig. 1. The line shows the fit to the data using the Landau distribution convoluted

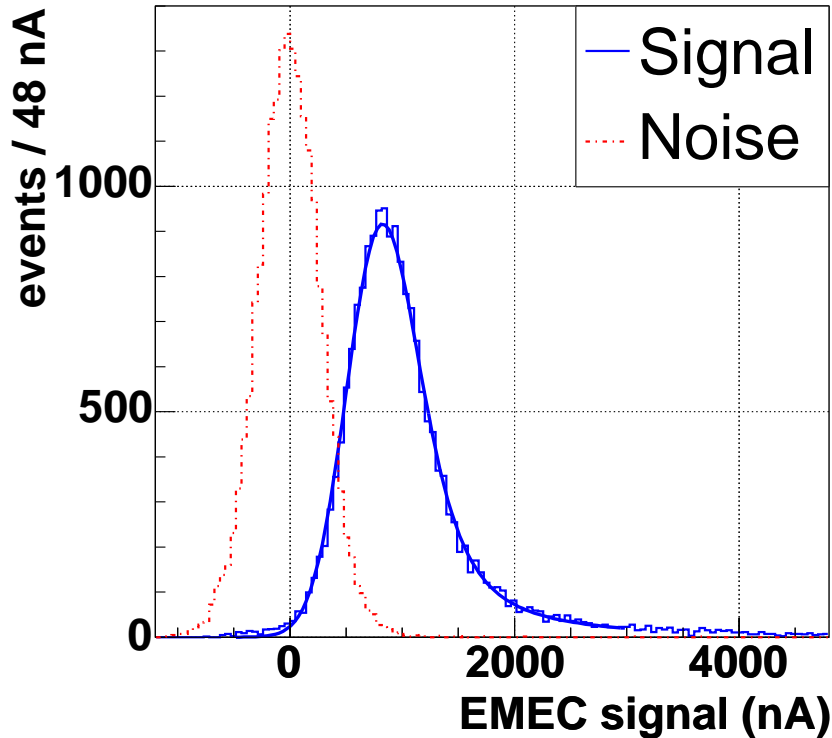


Fig. 1. Muon signal in the second and third EMEC layer for muons of 150 GeV and the corresponding noise distribution. The line for the data shows the result of the fit using a convolution of the Landau distribution with the gaussian noise distribution. The corresponding gaussian noise distribution (dashed histogram) is also shown for the noise.

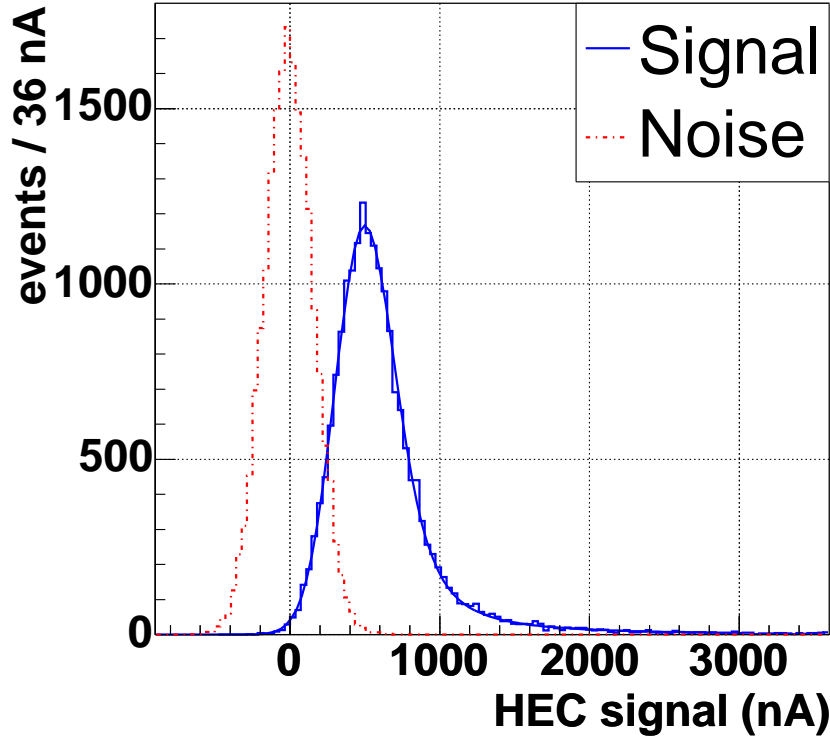


Fig. 2. Muon signal in the HEC for muons of 150 GeV and the corresponding noise distribution. The line for the data shows the result of the fit using a convolution of the Landau distribution with the gaussian noise distribution. The corresponding gaussian noise distribution (dashed histogram) is also shown for the noise.

with the gaussian distribution representing the noise. The gaussian noise as obtained from the fit to the noise is also shown. The most probable value of the muon energy deposition is $727 \pm 4 [nA]$ in the EMEC (layer 2 and 3), corresponding to a mean value of $1353 \pm 29 [nA]$. This yields a signal to noise ratio in the EMEC (layer 2 and 3) for the most probable (mean) signal of 2.62 ± 0.02 (4.87 ± 0.10).

The corresponding distributions for the HEC are shown in Fig. 2. The line shows the fit to the data using the Landau distribution convoluted with the gaussian distribution representing the noise. The gaussian noise as obtained from the fit to the noise is also shown. The most probable value of the muon energy deposition is $440 \pm 2 [nA]$ in the HEC, corresponding to a mean value of $732 \pm 10 [nA]$. This yields a signal to noise ratio in the HEC for the most probable (mean) signal of 2.51 ± 0.03 (4.18 ± 0.07).

In the beam test set-up the impact angle of particles is 90° at all impact points. This is different from the ATLAS situation, where the read-out structure is ‘pseudo-pointing’ in η . Therefore the number of read-out channels required for energy reconstruction in the beam test set-up is increased and along with

it the noise contribution to the muon signal as well. In addition, only three rather than four longitudinal segment of the HEC are available, worsening again the signal to noise ratio.

The muon data have been compared to the MC prediction. The noise as seen in the related read-out cells has been added (gaussian) to the MC, the model used was GEANT 4 [11,12]. Figs. 3 and 4 show the EMEC and HEC data respectively and the MC expectations. The agreement between data and MC

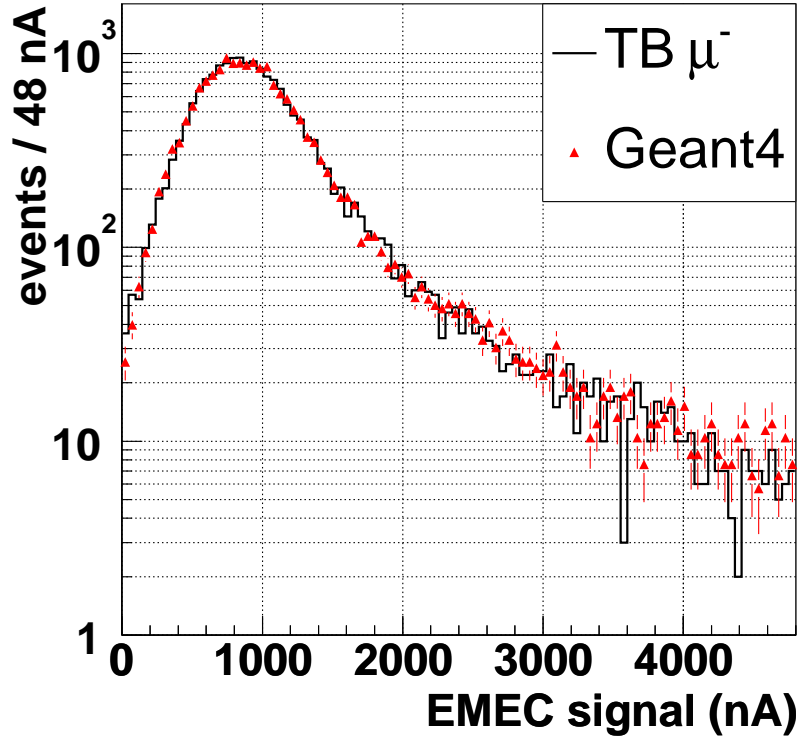


Fig. 3. Comparison of the muon signal (150 GeV) in the EMEC (layers 2 and 3) with the MC prediction. The solid histogram shows the data, the triangles the MC prediction.

is rather good for the HEC, for the EMEC there are small deviations visible in the tails. The deviation at low signals might be due to residual non-gaussian noise contributions.

Finally the (e/μ) ratio can be extracted from the data: it is the ratio of the detector response for the same total energy deposited in the detectors. For muons the energy deposited has been obtained from MC simulations. For the HEC we have to correct for the energy lost in the given read-out cell due to resistive cross talk to the neighbouring cells. Using calibration data, where each single calibration generator is pulsed separately, in comparison to the standard situation, where all generators are pulsed in parallel, we estimate this correction to be 4 %, with a systematic error of ± 2 %. An additional systematic

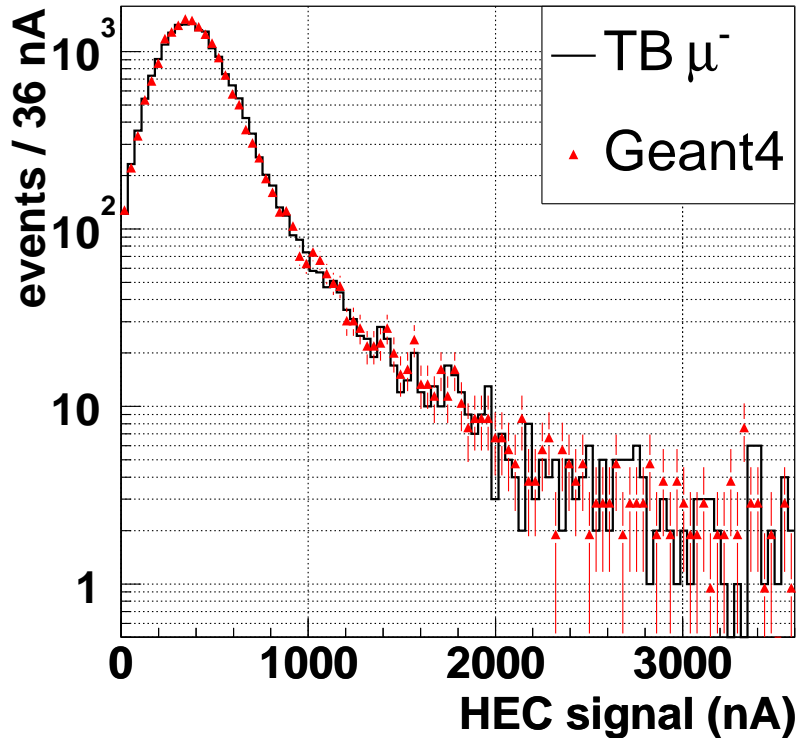


Fig. 4. Comparison of the muon signal (150 GeV) in the HEC (layers 1 and 2) with the MC prediction. The solid histogram shows the data, the triangles the MC prediction.

error of $\pm 2\%$ we assign to the electromagnetic energy scale. Thus we obtain for the HEC, using the definition of the most probable value, $(e/\mu) = 0.98 \pm 0.01 [stat.] \pm 0.04 [sys.]$. This has to be compared with the MC prediction of 0.92 ± 0.01 (GEANT 4) or 0.91 ± 0.01 ([4], GEANT 3 [8–10]). For the EMEC, using again the most probable value, one obtains $(e/\mu) = 0.80 \pm 0.01 [stat.] \pm 0.01 [sys.]$. This has to be compared with the MC prediction of 0.69 ± 0.01 (GEANT 4). The MC predictions are lower for both, the HEC as well as the EMEC. This corresponds to a smaller observed response, in particular for the EMEC, than expected from simulations. Part of this might be due to residual cross talk effects or difficulties in the reconstruction of very low signals.

3 Conclusions

Muon data of the EMEC/HEC combined run have been analyzed and compared to MC (GEANT 4) predictions. The agreement between data and MC is rather good in general. However in the EMEC response there are small deviations visible in the tails of the distributions. Finally the (e/μ) ratio can be extracted from the data. We obtain for the HEC, using the definition of the most probable value, $(e/\mu) = 0.98 \pm 0.01$ [stat.] ± 0.04 [sys.]. This has to be compared with the MC prediction of 0.92 ± 0.01 (GEANT 4) or 0.91 ± 0.01 ([4], GEANT 3). For the EMEC, using again the most probable value, one obtains $(e/\mu) = 0.80 \pm 0.01$ [stat.] ± 0.01 [sys.]. This has to be compared with the MC prediction of 0.69 ± 0.01 (GEANT 4). The MC predictions are lower for both, the HEC as well as the EMEC.

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