

Review of the manuscript
"Constraints on New Physics in the Electron $g-2$ from a
Search for Invisible Decays of a Scalar, Pseudoscalar, Vector,
and Axial Vector"

NA64 Collaboration

The manuscript "Constraints on New Physics in the Electron $g-2$ from a Search for Invisible Decays of a Scalar, Pseudoscalar, Vector, and Axial Vector" presents the result of the experiments performed by the NA64 collaboration at CERN in the years 2016, 2017, and 2018. A search for a new generic X boson was performed in the 100 GeV electron scattering off nuclei followed by invisible decay. This paper continues the previous publications of the NA64 collaboration published in PRL 118, 011802 (2017), PRD 97, 072002 (2018), and PRL 123, 121801 (2019).

The manuscript extends the search for a scalar (S), pseudoscalar (P), vector (V) or an axial vector (A) particle while in the previous publications only vector boson was considered. As a result, the NA64 collaboration placed the new bounds on the S, P, V, and A coupling strengths to electrons, and set constraints on the contributions to the electron anomalous magnetic moment α_e . These limits are an order of magnitude more sensitive compared to the current accuracy on α_e from $g - 2$ experiments and recent determination of the fine structure constant. These results are significant achievement in the field.

The manuscript is well organized and clearly written. The technical quality and scientific rigor of the manuscript are very good and the main conclusion is well supported. The references to the literature are adequate. The title and abstract of the article are informative and clear.

There is a misprint in the home Institutions list, the references [10] and [17] are identical:

- 10 State Scientific Center of the Russian Federation Institute for High Energy Physics of National Research Center 'Kurchatov Institute' (IHEP), 142281 Protvino, Russia
- 17 State Scientific Center of the Russian Federation Institute for High Energy Physics of National Research Center 'Kurchatov Institute' (IHEP), 142281 Protvino, Russia

The theoretical introduction is understandable for a nonspecialist. The experimental setup is briefly described. However, the experimental details and trigger descriptions are difficult to understand without schematic view of the setup. I recommend to add the picture

to the paper or at least give clear reference to the article with the detailed description of the experiment and with the same notation.

The trigger condition in Eq. 3 looks like event selection criteria $\overline{ECAL}(\leq E_{ECAL}^{th})$ demands energy deposition in the calorimeter $E_{ECAL} > E_{ECAL}^{th}$. I believe that the trigger condition $\overline{ECAL}(\leq E_{ECAL}^{th})$ has to be changed to $ECAL(\leq E_{ECAL}^{th})$ or $\overline{ECAL}(> E_{ECAL}^{th})$.

Also the sentence below Eq.8

”accepting events with in-time hits in beam-defining counters S_i and clusters in the PS and ECAL with the energy exceeding the thresholds $E_{PS}^{th} \simeq 0.3 \text{ GeV}$ and $E_{ECAL}^{th} \leq 80 \text{ GeV}$, respectively.”

has to be changed to

”accepting events with in-time hits in beam-defining counters S_i and energy in the PS exceeding the threshold $E_{PS}^{th} \simeq 0.3 \text{ GeV}$, and energy in the ECAL below $E_{ECAL}^{th} \simeq 80 \text{ GeV}$.”