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NIM A refree commentS
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Ms. Ref. No.: NIMA-D-19-00217
Title: Development of an alpha-particle imaging detector based on a low radioactive micro-time-projection chamber
Nuclear Inst. and Methods in Physics Research, A

Dear Dr. Ito,

I have received the reviewers' comments on your paper that are appended below. They have advised that your manuscript requires a major revision before it can considered for publication.

If you decide to revise the work, please submit a list of changes or a rebuttal against each point raised when you submit the revised manuscript.
The revision should be submitted by
29 Jun 2019

Revisions that do not address reviewer comments point-by-point will not be considered.

To submit a revision, please go to https://ees.elsevier.com/nima/ and click "login" underneath the journal title banner. You may then type in your user name/password and click "Author Login."

Your username is: ito.hiroshi@crystal.kobe-u.ac.jp
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On your Main Menu page is a folder entitled "Submissions Needing Revision". You will find your submission record there. Also, the reviewer(s) may have uploaded detailed comments on your manuscript. Click on the "Submissions Needing Revision" from your main menu, then click on "View Reviewer Attachments" to access any detailed comments from the reviewer(s) that may have been included.

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With best regards,

Daniela Bortoletto, PhD
Editor
Nuclear Inst. and Methods in Physics Research, A

NOTE: While submitting the revised manuscript, please double check

the author names provided in the submission so that authorship related changes are made in the revision stage. Any authorship-related change after acceptance will involve approval from co-authors and respective editor handling the submission and this may cause a significant delay in publishing your manuscript.

Reviewers' comments:

Reviwer 1 . See attachment

Reviewer #2: Overall well written article that will be of interest to the community of low background detection, dark matter, and 0vBB experiments. Thank you. Please address the following:

This manuscript would benefit from a thorough grammatical review.

Line 3, abstract, change to "impurities" since referring to multiple impurities
Introduction, second paragraph, it seems there should be reference to more comprehensive studies of contamination in 0vBB experiments such as those in EXO-200 or Majorana Demonstrator assay papers.
Line 12, change to "reproduce"
Line 54, change "has not an" to "does not have a"
Line 56, perhaps change "might be contaminated to" to "may be associated with"
Line 79, change to stainless-steel vessel
Line 83, shouldn't these units be cm?
Line 85, add the
Line 86, how polished?
Line 89, shouldn't these units be cm?
Line 94, what is the source and purity of the CH4 gas?
Line 96, perhaps sate the source of the copper since you mention later it contains U and Th.
Line 101, change from "was" to "were"
Line 122, remove "a"
Line 128-129, perhaps simply state the desired pressure ± %
Lines 141-148, awkward wording, consider revising
Line 151, shouldn't these units be cm?
Line 226, change "tack" to "track"
Paragraph beginning at line 298 is awkward, please revise
Line 306, calculated to a detection efficiency of…
Line 310, uncertainty
Line 311, statistical
Line 314, shouldn't these units be cm?
Line 323, in the region
Line 326-330, this is confusing. It appears the background from one region was used to normalize the other region, and that result was checked by comparison of the two regions. This is a circular argument.
Line 372, the statement "Assuming the alpha spectrum is constituted only from 232Th or 238U, the impurity is estimated to be 6.0 ± 1.4 or 3.0 ± 0.7 ppm, respectively" comes out of nowhere with no explanation or how it was calculated. This needs elaboration.
Line 391, units needed

Line 393, sample alphas?
Line 394-398, the comparison of error rates and the impact to the sensitivity needs clarification here.
Line 414-415, this varies with radioisotope so such a statement needs to be more specific.
Line 417, specify the cooling is for radon suppression and be specific regarding "material with less impurities".
Line 422, sentence should read "With these improvements, the detector would achieve the performance goal".

Review of the manuscript:

Development of an alpha-particle imaging detector based on a low radioactive micro-time-projection chamber

This paper addresses one of the most important challenges in new rare-event-searches experiments: The use of high-radiopurity materials and the determination of their intrinsic radiopurity. With this aim authors present a new experimental setup to measure the alpha contamination of samples based on their previous experience. Due to the importance of the radiopurity screening in this kind of experiments, the presentation of this setup and its preliminary results is important for the community so this work is worth publishing in this journal.

In general, the work is presented in clear way providing main information. However, since it is the first time the detector is presented, this article will become the reference paper to be referenced in further publications. In that sense some details are missing all along the manuscript, so authors are requested to complete the information as indicated in comments following this text including some additional figures. This additional information will complete the manuscript to be suitable for publication.

In addition other minor comments are also indicated.

List of comments and corrections to implement

Abstract:

Line 2: detector material → detector materials

Line 3: radioactive impurity → radioactive impurities

Line 3: isotopes in the → isotopes of the

Line 4: of surface radioactiviy: An alpha-particle → of surface and bulk radioactivity: Focused on the first one, an alpha-particle

1. Introsuction

Line 3: nonbarionic → non-barionic

Line 5-6: no direct detection of dark matter has yet been reported → any direct detection has yet been detected

Line 8-12: Although the DAMA group has observed the annual modulation with a significance of 9.3σ as the dark matter contribution [1], other groups such as XENON1T[2] and LUX [3] did not reproduced the signal.
→Although the DAMA group has observed the annual modulation of dark matter particles in the galactic halo with a significance of 9.3σ [1], other groups such as XENON1T[2] and LUX [3] did not reported compatibles results.

Line 18-19: (micro-TPC) and the main background is surface alpha particles → (micro-TPC), being the main background surface alpha particles

Line 20: material → materials

Line 24: (it is its own → (i.e. it is its own

Line 25-26: and provides the absolute neutrino mass → REMOVE

Line 26-29: The GERDA … yet to be observed → Experiments like GERDA [6] and KamLAND-Zen [7] have been able to set a lower limit on the half-life over 10^{25} yr at 90%CL by using 76 Ge and 136 Xe, respectively, but no positive signal of the 0νββ process has not be observed yet.

Line 32: precedes the measurement with at → set lower limits at
Line 33 and 34: $T_{1/2}$ → $T_{1/2}(0\nu\beta\beta)$

Line 35-36: and a contamination of ^{208}Tl and ^{214} Bi in the detector dominates the background → For this experiment background is dominated by the ^{208}Tl and ^{214}Bi contamination present in the double beta emitter source foils

Line 38: impurities with sensitivity → impurities in these foils with a sensitivity

Line 46: material → materials

Line 55-57: For example, the impurities might be contaminated to the electrodes in a pattern making process→ For example the impurities can be in a particular location due to the manufacturing process.

Line 68-69: the study is concluded → main conclusions are presented

2. Alpha-particle imaging detector based on gaseous micro-TPC

Line 77: μ-PIC, a gas circulation → μ-PIC as readout, a gas circulation

Line 79: stainless-vessel → stainless-steel vessel

2.1 Setup and configuration

This section requires a complete revision including more details about some of the components and the associated discussion. For example:

- Drift plane: What is the thickness?

- Mesh: Thickness of the wires? Pitch (holes size)? Transparency? How could the transparency affects on the detection efficiency since it could stop alphas?

- The pressure was set at 0.2 bar as a result of the optimization between the expected track length and the detector stability... → Any reference that supports this? If not more details are needed

Figure 1 caption: Photographic of detector → Photography of the experimental setup

Figure 1 caption: A more detailed caption would be advisable.

Figure 2 caption: Indicate the field cage would be advisable.

2.3 Gas circulation system

Line 122: protect a against → Not understandable: Rewrite

Line 124: circulate meter → Flow-meter

Line 126-129: The gas pressure was monitored to ensure the stable operation of the circulation system and as maintained within an increase of ~ 2% for several weeks. → The gas pressure was monitored to ensure the stable operation of the circulation system, operating within a variation of ~ 2% for several weeks.

Line 145-148: However, because the alpha particles were expected to be emitted from the sample, the drift-along coordinate of the emission point was assumed to be the position of the drift plate.

→ More discussion is advisable for this sentence. Why this assumption is true? Is there any reference talking about mean free path of alphas in gas?

3. Performance check

3.2. Energy calibration

The whole point requires a major revision including Figure 4. Some questions to address:

What is the used fit? Gaussian? Landau+Gaussian?

How was the Energy scale in Figure 4 obtained? It has been included after calibration? It would be more representative to leave ADC counts. If the energy axis is left some discussion about quenching etc is required

Vertical axis of Figure 4 should be Counts / N MeV (or / N ADC units if the horizontal axis is changed)

3.3. Event reconstruction

Line 176-177: The open circles are data → The open circles correspond to hits registered in data

Line 194: is a number → is the number

Line 196-197: shift, and rotation and the angle→ shift, the rotation angle

Line 201: determining → determine

Line 202: is a bit confusing to understand the direction $\theta = 90^{o}$, please clarify using $\theta = 90^{o}$ (i.e. parallel/perpendicular to the μ-PIC plane)

Line 203: sample → REMOVE

3.4. Track-sense determination

Line 208: αs → α's check it and change it all along the text.

Line 213: are the μ-PIC and the directions are mostly → is the μ-PIC so the directions of α's coming from this component are mostly

Line 232: How t_p is determined? Are the registered pulses fitted? An explanation to this question is necessary

Line 240: Fdwn has two peaks → This is a strong statement looking at Figure 6. rewrite this sentence in a more conservative way.

Line 245-248: The selection efficiency of $F_{dwn} > 0.5$ was estimated to be 0.964 ± 0.004 in the source-α spectrum while the radon background was reduced to half

→Why $F_{dwn} > 0.5$ has been chosen? Does it provides the best efficiency values? If this is the explanation an scanning of the Efficiency vs F_{dwn} should have been done, please add information about that.

Lines 267-273: An additional figure illustrating the projections and the fits done to obtain the quoted resolution must be included.

3.6 Efficiency of event selection → It is empty!!! please revise indexing

3.7 Detection and selection efficiency

Line 304: and thus the it was negligible → considering it negligible

Line 311: radioactivity and the statistic error is negligible → radioactivity, being the statistical error negligible

3.8.1 Setup

Line 317: The setup → A photograph of the sample position over the setup mesh

Line 318: The live time → The measurement live time

Line 342: is consistent → is compatible at less than 1 σ (Based on the numbers provided in lines 339 and 340 both values are compatible at 0.84 σ)

Figure 9: If I understood correctly from the text, spectra correspond to upward-oriented alpha-particles. Please check

Line 377: How long were the measurements using HPGe detector? It MUST be indicated for further sensitivity discussion.

Figure 10 and 11 should be changed in order

Figure 10: Why region 1 (sample) has the same orientation than region 2 (drift plate hole)? Looking the photography of Figure 8 sample is rotated with respect to whole. An explanation about this must be include in the text (section 3.8.3)

4. Discussion

Line 391: Add units to 3×10^{-3}

Line 405: detection area → detection area, limited by the μ-PIC

Line 434-435: with the one by another measurement → with the one obtained by a measurement done with a HPGe detector

To have a more clear idea of the potential of this detector a more detailled discussion putting together the uncertainties of the measurement and the measurement times with the alpha detector and the HPGe detector must be included. Taking from the text results are:

Time

μ-PIC: 75.85 hours

HPGe: ??

232Th

μ-PIC: 6.0 +/- 1.4 ppm

HPGe: 5.84 +/- 0.03 ppm

238U

μ-PIC: 3.0 +/- 0.7 ppm

HPGe: 2.31 +/- 0.02 ppm