Dear reviewers,

I hope all is well with you during these unprecedented times and thank you for quickly reviewing this manuscript. We greatly appreciate your feedback.

We incorporated your suggestions into the manuscript and made numerous minor grammatical improvements. In this letter our responses to your feedback are in green. If a change is simple and does not necessitate a response, we simply respond with “done”. Lastly, we tracked changes for substantial edits, but we did not track minor grammar improvements.

Sincerely,

Mykhaylo (Mike) Shumko

Reviewer #1 Evaluations:  
Science Category (Required): Science Category 2  
Presentation Category: Presentation Category B  
Key Points (Required): Yes  
  
Reviewer #1 (Comments to Author (shown to authors):  
  
This paper uses the SAMPEX HILT (for >1 MeV electron detection) data to quantify microburst duration as a function of activity level and L, MLT. Microbursts are fit with a combination of a Gaussian profile and a linear fit (to account for slope in baseline), and care is taken to remove bad fits caused by overlapping microbursts. Results are important towards further establishing the connection between microbursts and their likely cause - chorus waves. This paper shows that microburst duration spatial and activity-dependent variability is similar to that of chorus, as previously reported.  
  
I don't have any major issues with the results, but a number of minor changes are needed before this paper can be published. These include the presentation of results, explanation of methodology and results, etc.  
  
  
Main comments regarding data presentation:  
  
I think there should be some changes in how the results are presented.  
Figure 3 presents L,MLT duration distributions separated into percentiles. Not sure I understand the reason for dividing into percentiles here since the distribution in 2a has a smooth (Gaussian) functional form. Maybe if it showed distinct populations (bump on tail) then you'd want to separately analyze the different populations. However, it just seems to be a continuously varying population. As such, I would expect a,b,c in Fig3 to be very similar, and they are. I think it should be enough to just show the L/MLT distribution of all the microbursts and mention that there is little variation based on FWHM duration.

Out initial intention with plotting the 25th, 50th, and 75th percentiles was to identify any asymmetries, such as the bump on tail that you refer to. We agree with your suggestion. Given the smooth distribution in Fig. 2 and the redundancy in Fig. 3a-c, we removed the two panels showing the 25th and 75th percentile distributions.  
  
Figure 4 would likely benefit from a plot showing L slices at various MLTs in order to see the "subtle" duration trend discussed around L225. Currently, these subtle trends are very difficult to see in Fig 4 (as the paper points out)

We plotted the distribution in other ways to highlight this subtle trend. We made the following two versions of Fig. 4. The left version shows the median microburst duration as a function of L-shell for all microbursts, and the right version shows the microbursts categorized by MLT into two regions. With our attempts, the plot appears more haphazard, so we kept the plot as is and expanded on that sentence: “The microburst duration trend in L-shell is subtle: the median microburst duration increases from 85 to 106 ms between L=4 and 5.5 and then decreases to 90 ms at L=7. This subtle trend is most evident in Fig. 4a.”

Chart

Description automatically generated

Other comments:  
Title page: Dual affiliations should be listed with a separate number. Also affiliation 3 comes before 2. Done  
  
L46: Bonnell is incorrect reference - it's also missing from biblio. This appears to be a misunderstanding due to the pdf format. Bonnel is the 4th author of the Li et al., 2009 paper, and appears next to the year. This is due to AGU’s Latex formatting style that included the first four authors of that paper.  
  
L51-53: Consider separating low and high altitude references. Done

L55: ; should be , Done

L75: remove comma Done

L76: remove "a" Done

L77: Breneman17 wasn't a direct (one-one) link. Rather, they associated a bunch of rising tone chorus to a bunch of microbursts during an extremely close conjunction showing that chorus (in general) causes microbursts.

You’re correct, we rewrote the sentence to convey that Breneman et al., 2017 “associated chorus rising tone elements to microbursts”.  
  
L81: Sentence should end with "?" Done  
  
L87: Suggest: "Therefore, we used SAMPEX data to quantify the distribution of relativistic microburst durations as a function of L-shell, MLT, and the Auroral Electrojet index"

##### Thank you for the suggestion. It is very concise, and we replaced two original sentences with your version. L93: No commas needed, I think. Would also suggest: For this study, we used... Done L106: I think this should be combined with the text in 3.1. Left to itself, it reads like a jotted-list. That was our intention with those two sentences: to provide a brief outline of the entire methodology. To be more concise, we decided to remove the sentences altogether and add “In the first/second step…” to the beginning of sections 3.1 and 3.2. "Straight line" is vague. Maybe "superposed with a linear fit"? Irrelevant due to the above comment. L127: Remove paragraph break We left the break as is because it introduces the topographic prominence method---described in the following paragraph, and the fit method---described right after the prominence method description. We think that this sentence eases the reader into the description of the two methods. Do you agree? L130: Confusing sentence b/c you start by defining duration and then switch to defining prominence. We clarified that sentence.

##### L135-136: Not sure what you're saying here. We clarified that sentence, and the nearby sentences. L138: Maybe point out that Fig 1a is an example of this Done L139: I don't understand this. Do you mean "superposed with a straight line fit for the microburst base"? Or something like that? You are correct: we added “…for the background counts at and around the microburst” at the end of that sentence. L145: To be clear, are these the initial parameter guesses? That sentence did not intend to describe the initial parameter guesses, but rather something related: how many data points to use for the fit. We clarified that sentence.

##### L156-159: A bit nit-picky, but is "perfect" fit the right way to say this for R^2=1? I think it's more of a statement that the data are such that you can have high confidence in your fit. i.e. all the data points fall directly on the mean line. Not a big deal, just maybe think about the exact wording... We agree and we clarified the wording.

##### L167: these criteria Done L177: distribution Done L200: I think that "marginalized" isn't the right word to use here since all the usage I can find online has to do with marginalization of people or cultural groups. You could also consider adding this as two panels to Fig 3.

Also, since this requires an entire figure there should be a more nuanced explanation of it.

We agree that the recent use of the word marginalize has a strong negative meaning, however it is a technical term in probability theory. If necessary, we added a “summed over” parenthetical for clarification. <https://en.wikipedia.org/wiki/Marginal_distribution>

L206: Need an intro sentence here that summarizes the main points, as well as a sentence that justifies the focus on the burst detection parameter discussed in the current first sentence.  
  
Is there some particular reason that the burst detection parameter would be less sensitive to abnormally long microbursts as opposed to abnormally short ones? --> you discuss this in the next sentences, but probably you should motivate the concern about long microbursts first.

Thank you for pointing this out. We added a summary paragraph at the beginning of the discussion section. The last sentence in this paragraph motivates why we need to understand the burst parameter sensitivity to various microburst durations.  
  
L214: change wording: "it longer overlaps with just the microburst" Done  
  
L225-229: I recall that chorus durations tend to be longer at higher L due to less magnetic field line curvature near the equator, allowing for cyclotron interaction to occur with a specific resonant population over a larger distance before the interacting electrons fall out of resonance.

We are unaware of a published study that quantified the chorus duration as a function of L shell. One of our collogues investigated this for us and found that chorus durations increase with L shell. Their study was limited to a few months of RBSP data and is not published, so we do not elaborate on it in the manuscript.  
  
L227: Should reference Fig4b when discussing the MLT trend Done  
  
L237: I find this sentence confusing. Maybe: "These previous results on chorus durations combined with our results in microburst durations thus indicate that their durations roughly double from midnight to noon MLT. However, the chorus durations are about 3x longer than the microbursts..."

Thank you for your suggestion. We incorporated it into the discission section.  
  
L239: fix "Aa s" Done  
  
L243: Any guesses as to the duration discrepancy b/t chorus and microbursts?

This is likely due to the short region where the electrons are in resonance with the chorus wave. This, together with the relatively smaller velocity dispersion of relativistic electrons along the field line (relative to nonrelativistic electrons) result in shorter relativistic microburst duration. This is backed up modeling by Miyoshi et al. 2020 who predicted that the microburst duration is longer at lower energies due to velocity dispersion. We addressed a similar question by the other reviewer and added “This scaling is consistent with Miyoshi et al. 2020 who predicted a similar duration difference between chorus rising tone element and relativistic microburst durations” to the discussion section.  
  
L243: Please comment on this. By scale factor do you mean 250ms/95ms ~ 3 for AE>300nT and 500ms/130ms > 3 for AE<100 nT?

We clarified that sentence to say that the “the change in microburst duration is relatively smaller than the change in chorus duration.”  
  
L248: Be clear that you are talking about the upper value of the absolute value of the magnetic latitude Done  
  
L250: Perhaps mention that the Saito results are simulations Done  
  
L251: probably should explain what you mean by "model configurations" We meant different model parameters.  
  
L257: absolute value of latitude Done  
  
L271: duration Done  
  
L272: Be clear that previous work found that chorus durations double in MLT, not this paper. Done  
  
Figure 1: "lines" should probably be "curves" Done

Reviewer #2 Evaluations:  
Science Category (Required): Science Category 2  
Presentation Category: Presentation Category B  
Key Points (Required): Yes  
  
Reviewer #2 (Comments to Author (shown to authors):  
  
Shumko et al.  
"Duration of individual relativistic electron microbursts: A probe into their scattering mechanism"  
  
This paper investigates the duration of relativistic electron microbursts measured by the SAMPEX satellites. The authors found that the duration of the relativistic electron microbursts depends on the MLT. Comparing with the duration of chorus elements as shown in previous studies, they found that the rising tone element duration is roughly 3 times longer that the microbursts. The results of this paper are interesting and important to understand the origin of relativistic electron microbursts. However, before recommends the publication, I have a couple of comments which the authors may consider.  
  
Major Comments:  
Paragraph of Line 257  
In general, chorus waves are generated near the magnetic equator and then propagate to the higher latitudes, except for the minimum-B pockets at the dayside magnetosphere. If high-latitude chorus waves come from the equator, I suppose that duration of both low-latitude/high-latitude chorus waves are almost same. Are there any reason to consider different duration of low-latitude/high-latitude chorus waves?

I have a feeling that I am missing the point that the reviewer (Miyoshi?) made.

We wrote this paragraph mainly to explore the possibility that the microburst duration trend in MLT can be explained if high- and low-latitude chorus waves scattered microbursts differently. We did not consider the detailed physical reasons for the difference but conducted a thought experiment on how a hypothetical difference in chorus-electron scattering will manifest in our results.

As we point out, we did not find strong evidence of distinct scattering modes for microbursts observed at midnight and noon MLT. To clarify this paragraph, we modified the sentence starting on L260 (original manuscript) to “Thus, it is tempting to conclude that the microburst duration trend in MLT could be attributed to some difference in how low and high latitude chorus waves scatter MeV electrons.”

Paragraph of Line 251  
Recent simulation study by Miyoshi et al.[2020] showed that the duration of bursts depends on electron energy (Figure 2). Currently, the authors used SAMEX data to measure >1 MeV electrons. Does the SAMPEX observation show the duration of 1 MeV electrons or multiple energies? If multi-energy electrons contribute to the measured duration, the distribution of duration are not simply related to chorus element durations. Could you add this point in discussion?

Since HILT measures electrons with multiple energies, we added “Care must be taken when comparing our results to theory: HILT measured multi-energy microburst electrons above 1 MeV, and the microburst duration at each energy can have different drivers” to this paragraph.

Both Miyoshi et al. 2020 and Chen et al., 2020 predict different microburst duration as a function of energy. We observe this by eye with the FIREBIRD-II data, but we left this out due to the GRL text limit and our vague qualitative observations. We will carefully study this soon.   
  
And Miyoshi et al.[2020] shows that multiple interactions with several elements of chorus bursts modifies duration of individual burs even if elements with same duration resonant with electrons, which means that the relationships between duration of chorus and microbursts are not simple. Results of this study show that durations of chorus elements are longer than microbursts elements, which is consistent with causal relationship between chorus and microbursts. I suggest that the authors include this point in discussions.

Thank you for pointing this out. We looked closely at Figures 2 and 3 in Miyoshi et al. 2020 and confirmed that the relativistic microburst duration is qualitatively shorter than the 0.3 s chorus rising tone element duration. We added “This scaling is consistent with Miyoshi et al. 2020 who predicted a similar duration difference between chorus rising tone element and relativistic microburst durations” to the discussion section.