Excellent work, very well written and needed paper. Santander's comments below:

Content comments:

1. **More detailed information of the calibration circuit.** The use of the calibration circuit is at the core of this study; however, no detailed information is given concerning the charge injection accuracy or dispersion between pixels, likewise no information is given concerning its radiation tolerance. All over the article, there is the implicit assumption of an ideal calibration circuit un-affected by the irradiation. Can you please estate explicitly how this assumption of *ideality* is supported? In the last paragraph of page 3, where you introduce the calibration circuit for the first time, will be the right place for providing this information.

   I am not aware of a study made on the calibration injection circuit and especially not after irradiation. So, I cannot make a statement about this and don't know of any relevant reference. But this is more a question for Jorgen or Flavio?

2. **Temperature of characterizations**. In most of the cases, the characterization temperature was -10 Celsius degrees, which seems a relative high temperature with respect to the expected operational temperature more close to -20 degrees. Can you justify why you decided to use this temperature for this study? Please, explain this in the text, ideally in page 5, last paragraph.

   I added a sentence: "…approximately -10°, which is the lowest temperature that could be achieved with the cooling systems available for the lab test set-ups."

   2.1. Please state explicitly the temperature in the *noise evaluation* section and *conclusions*.

   DONE.

3. **abstract:** good and bad points of the SYN and DIFF FE are presented, but only an already-corrected disadvantage of the LIN FE is mentioned. Though, the linear front-end is CMS choice.

Added to the abstract: "The Linear front-end had all the studied performance parameters within requirements, but it had the largest time walk."

4. *Low threshold* subsection in page 7.

    4.1. A more suited sub-section title would be *Optimal threshold criteria*.

Just optimal threshold.

    4.2. We advise to state explicitly that the optimal threshold should accommodate to opposed requirements:

- The threshold should be high enough to satisfy the noise occupancy criteria that you introduce in the *low noise* subsection.
- The threshold should be low enough to ensure a very high hit efficiency > 99%.

It somehow does not fit in the text without breaking everything.

    4.3. I would expect to see an optimal threshold depending on the fluence and dose.

?

    4.4. The only experimental input to justify the threshold selection are charge distributions from phase-1 ROC which seem to have a better charge resolution, the pixel size does not matter here, with a moderate fluence around 1e15 n/cm2. They do not provide enough justification to claim that the optimal threshold for the inner layer should be 1000 electrons. Using fine pitch phase-2 sensors readout with R4Sens could be worth to check for getting better estimates of the charge distribution; or, even if the charge resolution is worse, to use the RD53A test beam results.

I don't think we will change plots at this stage.

    4.5. State explicitly the fluence and dose for which you quote the irradiated MPV. Include a reference for these test-beam results.

DONE.

4.6. Overall, this subsection does not justify enough the selection of 1000 and 1200 electrons as threshold in the innermost and outer layers respectively.

Well I don't know how to justify it better, these were the selected values for the evaluation and that's it. Maybe in the operation it will be slightly different.

5. Subsection *dead time*.

5.1. You state 3000 e/TOT_40 as charge resolution for the AFE evaluation, accordingly with figure 18.b, the charge resolution depends on the collected charge; then, what would be the charge for charge resolution quoted.

Here is somehow does not fit, since it is a general value. And in the corresponding section I wrote that it was done with 6000e-.

6. Can you justify the pixel masking criteria, stated in the line 249?

DONE.

7. **In section 6**, a clear explanation of the depence of the charge resolution with the speed of the PA discharge is given (including a simple diagram in figure 17). It would be advisable to explain, and maybe to illustrate too, how the charge resolution depends of the input charge, as It is shown in figure 18.b.

I can add a sketch showing that for the same calibration the TOT increases with input charge (even though I thought it was implicit), however I am not sure is the dependency is linear in all three AFEs? I cannot make a statement there.

8. Section *Late-detected hits*

8.1. Line 399, can you explain the kind of event that were simulated? Physics event, particle gun?

I will ask Ernesto for details.

8.2. The paragraph referring to Time of arrival is somewhat confusing. Assuming that no multiple interactions are allowed in the simulation, that is, almost all the tracks originate from the same primary vertex, after correcting for their

time of flight the arrival time should not be zero? Figure 23 a shows otherwise.

Can you please explain this?

I will ask Ernesto for details.

Minor comments/suggestions:

9. The author should consider replacing term *phase-2 upgrade* with *high-luminosity upgrade* in the paper title and the section 1 name. I think this second term is less jargon and more informative for the non-CMS reader.

   I replaced the "Phase-2" in the main title and section 1 title with "High Luminosity LHC," but after I defined what is Phase-2 in beginning of the paper, I keep using it.

10. Section 3 title is CMS requirements, a more suited title would be Requirements for *Analog Front End.*

    DONE.

11. Subsection *low noise*, a more suitable naming would be *noise occupancy.*

    DONE.

12. *Name of section 4,* though threshold tuning is a common way of referring the threshold equalization, a more specific name as *Equalization of threshold dispersion* would be more advisable for better understanding of the text.

    DONE.

13. links to references and figures do not work in Adobe Acrobat Reader DC either Mozilla browser.

    Euh, I don't have Adobe, in my software all links do work - suggestions?

14. Line 40: i would introduce here the HL-LHC acronym, instead of in line 48, since it is the second time it appears.

I know but it does not fit the sentence, and if I change it then I could not define LHC acronym first.

15. TEPX is the "Tracker Endcap Pixel detector" or "Tracker Extension Pixel detector"?
    Right, it is extension indeed!

16. Line 108: "Three different AFE designs have been proposed within the RD53 project, to allow for comparison and to provide a choice" --> "Three different AFE designs have been proposed within the RD53 project, to compare and provide a choice"

    DONE.

17. Line 187: "The CMS aims" --> "CMS aims"
    DONE.