Although not very original in its contents, the paper has the merit of gathering in a single document the lore of good practices in lidar optical design arising from different sources and being put into effect in the EARLINET community. However, in my opinion it needs some modifications to make it more clear, emphasize some key points, clarify others and correct some mistakes. In particular more guidance for the reader through the presented formulas should be given, highlighting the important points they are exposing. Two particular points should be more emphasized in my opinion: a) the importance of the system imaging the entrance pupil of the telescope onto the surface of the photodetector, to eliminate the effect of response inhomogeneities over the surface; b) the constraint on the receiver field of view imposed by the acceptance angle of the interference filter (see specific remark No. 22b). Detailed remarks follow.

General remarks

1. The paper makes an extensive (perhaps excessive) use of acronyms, which makes it difficult to follow. If reducing the use of acronyms is not possible, at least a table explaining their meaning should be introduced at the beginning or the end of the paper.

2. Throughout the paper the term “primary mirror” seems to be used as synonymous of “telescope”. This should be revised. While it is true that for a Newtonian telescope the focal length will be that of its primary mirror, this is not true for Cassegrainian telescopes also used in many lidar systems.

3. The approximation of the transmitted beam by a truncated cone for the purposes of the paper should be justified (see specific remark No. 4)

4. Although in general very good, the English writing should undergo a revision to polish some expressions.

Specific remarks:

1. Page 1, line 9: the concept of “final receiving unit” should be clarified.

2. Page 1, sentence starting on line 26: “Systematic errors are mostly linked to the estimation of temperature and pressure profiles along with the wavelength dependence parameter required in Raman technique”. This seems to be too exclusive. On the one hand, interferences caused by the laser source in the analog receiving channels can be also a cause of systematic error. On the other hand, the sentence may be contradictory of some of the effects discussed in the paper (e.g. range-dependent overlap factor), which would also lead to systematic errors.

3. Page 2, sentence starting on line 10: “however without being able to provide any information related to depolarization retrievals, due to the usage of paraxial optics formalism.” I don’t see why the use of paraxial optics precludes dealing with depolarization retrievals. I would rather think that the paper is just not aimed at treating depolarization issues.

4. Page 2, sentence starting on line 13 about the overlap function: “it [the overlap function] describes the fraction of the laser beam cross section contained within the receiver field of

view". It should be made more precise what "contained within the receiver field of view" means. In this respect, fig. 1a is not very clear. *RFOV* is defined as the half angle of a cone with apex on the center of the telescope aperture, but a cone with apex on the lower edge is used to define the full overlap distance. Moreover, further developments seem to imply that the beam is "hard" limited by its divergence, with no energy outside it. This would seem to exclude from the treatment the widely used Gaussian beam approximation. Considerations about the approximations assumed should be included in the discussion. Probably a "generous" definition of the beam width, as the width that contains a high percentage of the energy would help in overcoming this issue.

5. Page 2, line 15: it makes me a little uneasy that the laser beam divergence is called *TFOV* (which I understand would stand for transmitter field of view). In my opinion the field of view is a parameter that is mainly used to specify receiver systems, so using it for a beam divergence may be confusing. Why not keep the term "beam divergence" and, if an acronym is necessary, just *BD*?

6. Page 2, sentence starting on line 27: "multiple scattering effects have to be taken into account especially for cases where non-spherical particles are suspended in the atmosphere (Wandinger, 1998; Wandinger et al., 2010)". I'm not sure that from the cited references it can be generally drawn that multiple scattering effects have to be taken into account *especially* in the presence of non-spherical particles. Please check if this is a general conclusion.

7. Page 3, sentence starting on line 1: "Such IFFs have recently become commercially available with small *BW* of the order of 0.17 nm (*FWHM*) at visible spectrum (Alluxa)". A more precise reference than just the manufacturer should be given for such filters.

8. Page 3, sentence starting on line 2: "A significant drawback of these filters is that a decrease bandwidth can be caused when the acceptance angle ($A_{IFF}^{\max.}$) is decreased as well, which in turn limits the possible *DOF*." I find the sentence obscure; wouldn't it be the other way around, i.e, the narrow bandwidth causes a small acceptance angle? Please rephrase it to make it clearer.

9. Page 3, line 8: among the cited references related to the determination of the overlap function, the following one should be added: T. Halldórsson and J. Langerholc, "Geometrical form factors for the lidar function," *Appl. Opt.*, vol. 17, no. 2, pp. 240–244, 1978."

10. Page 4, 1st paragraph of section 2: I have a couple of issues with this paragraph: 1) on line 5 the "field of view of the telescope" is mentioned. I think the term "field of view of the receiver setup" would be more appropriate, as the field of view is determined by the telescope focal length *and* by the field stop diameter; 2) the values of the assumed focal length and field stop diameter producing the stated 1.25 mrad field of view in the example (which seems to be the same taken again in Section 3) are missing.

11. Page 4, section 2.1: the text continuously refers to fig. 1 to describe the optical layout. In this figure the layout elements are identified as L1, S1, L2, etc. These identifications should also be used in the text for the benefit of the reader.

12. Page 4, lines 22-23: it should be emphasized that the modeling of the transmitted beam by the truncated cone implied by the description is an approximation.

13. Page 4, sentence starting on line 23: "the backscattered light is collected by the primary mirror of a telescope, with a focal length *FT* and clear aperture *DT*." The sentence is somewhat ambiguous in that it is not clear if the focal length *FT* is that of the telescope or that of the primary mirror. Both focal lengths are the same for Newtonian telescopes, but not for Cassegrainian ones. It should me made clear that *FT* is the focal length of the telescope.

14. Page 4, sentence starting on line 25: "The *RFOV* (half angle) of the telescope is determined by a diaphragm *FOVD* (usually a circular iris), with diameter D_{FS} centered on the optical axis, and mounted behind the primary mirror of the telescope." The field diaphragm will not only be mounted behind the primary mirror of the telescope, but also behind the secondary one. More specifically, according to fig. 1b and to Eq. (2), it is mounted on the telescope focal plane. Moreover I think this would be the place to insert the equation $RFOV = \frac{D_{FS}}{2 \times FT}$ (see also remark No. 22b).

15. Page 4, line 30: the paraxial approximation assumes that rays are not too distant of the system axis and that their angles with respect to that axis are small. Chromatic aberration has instead to do with the dependence of the refractive index on wavelength. Therefore I don't think that the paraxial approximation implies neglecting chromatic aberration. Likewise, focal blur of the telescope is not necessarily associated to departures of the paraxial approximation: it appears when imaging points not sufficiently far away from the telescope, even under the paraxial approximation.

16. Page 5, sentence starting on line 1: "Initially, the rays collected by the primary mirror are coming both from far (parallel to the optical axis) and near range (with an inclination determined by the *RFOV*); (green and blue lines in Fig. 1b respectively), focused on its focal plane and thus spatially filtered by *FOVD*." I have two remarks to this sentence: 1) In my opinion, what distinguishes rays coming from points on the far or near range is not that they are parallel to the system axis or not, but rather that they are parallel between themselves or not. Rays coming from far-range points close to the field-of-view limit will be slant, yet parallel between themselves. 2) Moreover, the expression "with an inclination determined by the *RFOV*" seems to imply an action of the *RFOV* on the rays. Probably the author means that *RFOV* determines the maximum inclination of the rays (whether from far or near range) that will pass through the field diaphragm. The sentence should be rephrased to be more accurate.

17. Page 5, sentence starting on line 5: "The collimated far and near range rays are producing an intermediate image (II), the so called eye-relief plane, at a distance Z_{II} behind the collimating lens". The sentence is ill-constructed, as it says that the intermediate image being produced at II is the eye-relief plane; in fact the eye-relief plane is where the image is being formed, and that image is that of the entrance pupil.

18. Page 5, sentence starting on line 9: "At this point the image projected by the telescope becomes sharper and is independent on the lidar range". Remark related to the previous one:

it should be said that this image is that of the entrance aperture. No wonder it does not depend on the lidar range, as the position of entrance aperture is fixed.

19. Page 5, line 19: “principal” should be “principle”.

20. Page 5, lines 23-25. Again the first sentence seems to imply that the beam is “hard” limited in width, not accounting for, for example, Gaussian beams (see remark No. 4). I think that the second sentence “For those ranges, the extreme points of the telescope mirror and consequently each point of the telescope, detect the laser pulse entirely and with the same collecting efficiency” can be simplified by saying that, for ranges where full overlap occurs, any ray coming from a point in the illuminated volume and reaching the telescope aperture will pass through the field diaphragm. The purpose of last sentence (“This is true for small inclination angles of the laser central axis towards the telescope axis (A_{tilt})” is also obscure: what would happen if A_{tilt} were not small? Perhaps the overlap factor could decrease for farther ranges after reaching a peak? (see remark No. 22a)

21. Page 6, Eq. (2): the symbol A_{IFF} used in this equation seems not to have been previously defined. Probably it corresponds to the $A_{IFF}^{\max}$ defined on line 5 of page 5. Please check for consistence in the symbols. I’m not sure that A_{IFF} is always given the same meaning (maximum acceptance angle, or angle of the rays arriving at the interference filter?).

22. Page 6, line 12: “but the SNR become lower”. It should be pointed out that this will only happen in daytime operation.

23. Page 6 and ff: I find there is a lack of guidance for the reader to grasp the constraints implied by the equations. For example:

a) I think an important constraint is missing, namely $A_{tilt} + TFOV \leq RFOV$. Otherwise, even if full overlap is reached in some range, the beam will eventually exit the full-field-of-view-zone. This, together with the condition that the denominator of Eq. (1) must be positive to have $DFO > 0$, i.e. $RFOV - TFOV + A_{tilt} > 0$, leads to the condition $RFOV - TFOV \geq 0$. Something about this is said later (Eqs. (14) to (16)), when an optimum A_{tilt} is defined, but I think it should be somehow anticipated here and a warning about these design trade-offs be given.

b) It seems to me that, in spite of the explanation below it, the meaning of Eq. (2), which is to find the limit imposed on the receiver field of view by the maximum acceptance angle of the interference filter, would be clearer if written as

$$RFOV = \frac{D_{FS}}{2 \times FT} \leq \frac{Fcol}{FT} \times A_{IFF}$$

c) I don’t see the meaning of the logical inference implied by “And thus” between Eqs. (3) and (4). Eq. (4) can be found from (1) and (2) without the need of (3).

24. Page 6, line 11: the sentence “the $RFOV$ is determined by the laser and the telescope parameters and becomes larger with shorter DFO values” sounds a little puzzling in that sense

that it seems to imply a causality relationship between *DFO* and *RFOV*, the short *DFO* being the cause of a wide *RFOV*, while it is rather the contrary: it's because the *RFOV* is large that *DFO* is small.

25. Page 7, sentence starting on line 8: "here expressed for the minimum and maximum focal length of the telescope with given *DFO*". Does the author mean "with given *RFOV*"?

26. The block of Eqs. (8) is difficult to understand because Z_{II} is not properly defined (see remark No. 17). Moreover, to make the comprehension easier it should be said that $\frac{RFOV}{A_{IFF}}$ has been substituted for $\frac{Fcol}{F_T}$ in the Z_{II} expression.

27. Figure 2: 1) The caption should explain what the different panels are intended to demonstrate and the meaning of the different symbols (Dii, Fobj, Zobj, etc.); are all the panels really necessary? 2) The formulas on the top right of the different panels do not convey easily understandable information to the reader: they should be either explained if relevant, or removed if not. 3) What identifies rays coming for point in far or near range is not their being parallel or not to the axis, but their being parallel or not between themselves; in my opinion the green rays on the two top panels correspond rather to on-axis points and the blue ones to off-axis points.

28. Page 8, line after Eq. (10): it is not clear what the author calls "eyepiece". In this line it seems the term designates the combination of lenses L3 and L4 ("The rays […] are guided through the eyepiece (lenses L3 and L4 in Fig. 1b and Fig. 2 respectively)"), but the used terminology, calling *Fobj* the focal length of L3 and *Feye* the focal length of L4 would lead think that what's called "eyepiece" is L4 (and L3 "objective", by the way). This should be clarified. In addition, the meanings of *Fobj* and *Feye* should be explained in the text and in the caption of fig. 2.

29. Page 8, second line after Eq. (10): "creating the second intermediate image plane at a distance Z_3". It would be more precise to say "creating the final image of the entrance pupil at distance Z_3"; there are not more images after this one.

30. Page 8: the paragraph starting after Eq. (13) "PMTs suffer from a non-uniform spatial response of their effective surface…" is crucial for the optical layout being described. This is the reason why one wants to create an image of the telescope aperture on the surface of the photodetector. This should be stressed and the idea be expressed earlier in the paper, perhaps appearing in the abstract and in the introduction.

31. Page 8, sentence starting on line 10: "At this place (distance Z_3 behind the eyepiece), the image of the lidar beam does not move with the lidar distance, and the spatial intensity distribution over the PMTs active surface does not change". Remarks: 1) What's the "lidar beam"? Maybe the author means the "laser beam". What is meant by "lidar distance"? "Distance to the lidar" would be more precise. 2) The sentence is anyway misleading: at Z_3 behind the eyepiece (or lens L4) the optical system is not forming an image of the beam, but an image of the telescope aperture, therefore spreading the light coming from illuminated points in the atmosphere uniformly over the photodetector surface. Lidar systems that image

the laser beam onto the photodetector surface suffer from the inhomogeneities mentioned earlier.

32. Page 8, sentence starting on line 11: “In addition, an advantage of using makes the detection surface rather insensitive…” . Something is missing after “using”.

33. Page 9, line 14: “are provided in the following paragraph (Section 3)”. Remark: “are provided in Section 3” would suffice.

34. Page 10, sentence starting on line 5: “and 180 mm above the optical axis”. For the sake of generality it would be better “and 180 mm from the optical axis”.

35. Fig. 4: it is not clear what the 5 diagrams of fig. 4a correspond to. Do they correspond to rays coming from 10 different points, 5 in the far range and 5 in the near range, at different positions within the receiver field of view? Whatever they correspond to, it should be said both in the text and in the figure caption. Note as well that a and b are missing to identify figs. 4a and 4b.

36. Page 10, sentence starting on line 22: “For example, ZEMAX simulations revealed that telescope’s primary mirror is focusing the near and far field rays at different planes (Fig. 5)”. This seems to be ascribed to aberration effects (“the inability of paraxial approximation to take into account all kinds of possible aberrations, in contrast to ZEMAX simulation”). However this simply results from the paraxial formula relating object and image positions (by the way, given in the first equation of equation block (17); in fact this effect seems to be taken into account in Section 7). A simple calculation shows that, for a thin lens of 600 mm focal length, the image of a point at 10000 m from the lens will be at 600.04 mm from the lens plane, while the image of a point at 257 m will be at 601.40 mm, the difference being 1.37 mm, very close to the 1.40 mm indicated in Fig. 5. So the effect seems to be explained by paraxial optics. As to the ensuing discussion on where the field stop should be placed, in my opinion it should be dropped: the displacement of the image point being a paraxial effect, it has already been implicitly taken into account in the previous developments.

37. I don’t understand Section 4. It starts by saying that “An axial shift of Z_1 is leading to a shift of the A_{IFF}”, then that the shift is produced by displacing L3. But in my understanding (although not completely clear due to some possible notation inconsistences, see remark No. 21) A_{IFF} is the acceptance angle of the interference filter, so I don’t see how it can be affected by the shift of a lens. Even if A_{IFF} refers to the angle with respect to the axis of the rays exiting L2, it cannot be changed by the displacement of an element coming after it.

38. I’m not sure section 5 is relevant, as, in my opinion, its conclusions are implicit in the considerations of the previous sections: the field stop, together with the telescope focal length, determines the receiver field of view, and all the rays reaching the telescope aperture coming from illuminated points in the full field of view zone, as defined in fig. 2 of Stelmaszczyk et al. 2005, will pass through the field stop. Moreover there are some inaccuracies:

a) Page 11, line 20: “assuming that the primary mirror of the telescope is an ideal thin positive lens”. Again this seems to assume a Newtonian telescope, which is not always the case.

b) Page 12, line 7: “The image height y_i becomes zero for an object projected from infinity.” This is true for objects at finite distance from the axis, but, without further clarifications, the sentence can contradict Eqs. (18) and (19), where, even if $z_b \to \infty$, x_i and y_i do not tend to 0. This is because for divergent and/or tilted beams, farther points in the beam are at farther distances of the axis (i.e. x_b / z_b and y_b / z_b remain constant).

39. Page 12, sentence starting on line 13: “from the emitted laser beam to its projection on the photomultiplier”: this may lead to think that the laser beam is imaged onto the photomultiplier surface, which is not the case in the considered setup (see remark No. 29)

40. Page 12, sentence starting on line 16: “The usage of IFF with small bandwidth for background suppression is limited by their small acceptance angle in near field”. The acceptance angle of an interference filter is independent of where the rays originate, whether in the near range or in the far range. I think that “in the near field” should be removed.