We thank Marcus Klingebiel for his helpful comments. These comments helped to substantially improve the manuscript. Below we repeat his comments and give detailed answers in blue.

The manuscript „PHIPS-HALO: the airborne Particle Habit Imaging and Polar Scattering probe – Part 2: Characterization and first results" is the second part of a study presenting a novel aircraft optical cloud probe. This part is focusing on the characterization and the first measurements from the PHIPS-HALO instrument.

The unique part of the PHIPS-HALO is the combination of a polar nephelometer and a stereo imager. Both components together allow for measurements of the microphysical properties and the appropriate angular light scattering function of single particles.

In this manuscript, the authors characterize the main components of the instrument (light scattering detection system, imaging system, electronics) and present some first results from two research campaigns.
For example, the authors explain very clearly why and how they redesigned the fiber-to-MAPMT coupler inside the polar nephelometer in order to avoid optical crosstalk between adjacent channels of the MAPMT, which is an important factor for obtaining reliable measurements. For the imaging system, they introduce a correction method, which is used to correct the oversizing of smaller cloud particles in order to get adequate results.

All in all, the manuscript is very well written and has a clear structure. I would suggest the manuscript to be published after minor revision. This should address the following points:

Major comments

Page 9, Line 26 – 33: You mention that the instrument was used during four aircraft missions. I am wondering how the measurements from the PHIPS-HALO agree with particle measurements from other imaging instruments or another polar nephelometer. I think this is the biggest weakness of the manuscript, because the authors show results from only a single instrument. It would be a beneficial to know if the measurements of the angular scattering function are similar to measurements from another polar nephelometer. The comparison could be done by using homogenous cloud sections. If other instruments were not available on the aircraft, it might be possible to use cloud chamber studies for an instrument intercomparison.

We agree with the reviewer that showing intercomparisons with other cloud probes (especially for the polar nephelometer part of PHIPS-HALO) would be beneficial. Now, there is only one other airborne polar nephelometer existing; the PN from LaMP, Clermont-Ferrand, so occasions to do such an intercomparison are sparse. Therefore, we haven't had yet the possibility to compare the fully functioning PHIPS-HALO with the PN in the field, but did comparisons in the AIDA cloud chamber, though the improved fiber coupler haven't been implemented at that time. The result of this intercomparison is already published in a study by Schnaiter et al. (2016) on the origin of ice crystal complexity in cirrus clouds.

We added the following paragraph to Section 2.2 "Polar nephelometer" to summarise the outcome of this comparison:

"It has not yet been possible to compare the improved polar nephelometer of PHIPS-HALO with the aircraft approved Polar Nephelometer (PN). However, the predecessor PHIPS-HALO nephelometer with the old fiber coupler was compared with the PN for ice particle ensembles generated in cirrus simulation experiments in the AIDA (Aerosol Interactions and Dynamics in the Atmosphere) cloud chamber (Fig. 7 of Schnaiter et al. (2016)). For this comparison the averaged angular scattering functions from PHIPS-HALO were corrected for channel crosstalk and channel sensitivity characteristics as described in Part 1. A reasonable agreement of both instruments were found with maximum deviations in the normalized scattering functions of less than 50%."

Page 10, Line 12 – 28: You point out the advantages of the stereo imager very clearly, but the advantages of the whole PHIPS-HALO instrument in comparison to other instruments is neglected. It would be nice to have a table or a paragraph which summarizes the advantages of this novel cloud probe in comparison with other instruments (FSSP's, Cloud Imaging Probes, holography instruments, etc.).

We think that the paper clearly demonstrates the unique character of PHIPS-HALO. The instrument is primarily designed to provide experimental data on the most fundamental link between the microphysical properties of real atmospheric ice particles and their angular light scattering function on a single particle basis.

Therefore it is hard and simply not justified to talk about advantages or disadvantages of PHIPS-HALO with respect to other cloud probes. We acknowledge that having a section in the paper titled "Advantages of a stereo imager" is not justified without presenting the disadvantages of the PHIPS-HALO imager (with respect to other probes) at the same time. We therefore changed the section title to "Stereo-Microscopic Image Examples" and rephrased the section:

“Before results of the correlated microscopic and angular light scattering measurements are presented, examples of the stereo imaging method are shown to document the quality and information content that can be expected from the PHIPS-HALO imagery acquired under flight conditions. It is important to emphasize here that the stereo imaging method is essential for the overall concept of PHIPS-HALO as it is the basis for the interpretation of single particle angular scattering functions. The method provides not only a three dimensional impression of the imaged particle, but gives also its orientation with respect to the scattering plane. Both information parts are necessary to represent the particle in optical models for simulating its angular light scattering function.

A general problem in two dimensional optical imaging of ice crystals – even in the case of real in focus optical microscopy like used in PHIPS-HALO – is that there are always parts of the particle obscured in the image that makes a representation of its 10 three dimensional geometric structure impossible. In Fig. 11 two examples of skeleton plates are depicted that were sampled by PHIPS-HALO during ACLOUD in ice precipitation underneath a mid-level cloud at temperatures between −10°C and −14°C. These examples nicely demonstrate how the stereo imaging method enhances the microphysical information that can be drawn from the PHIPS-HALO stereo-micrographs of individual ice crystals. The stereo image examples shown in Fig. 11 reveal that these crystals are actually composed of multiple stacked skeleton plates. In the example (b) three hexagonal plates are concentrically stacked along the basal facet, which becomes obvious by inspecting the image of CTA1 (left). Having only the image of CTA2 (right) available, the crystal would have been classified most likely as a single skeleton plate. Although, a stacked plate arrangement is identifiable in CTA2 of example (a), the one side-plane that is radiating in a different direction becomes visible only by imaging the crystal under a different viewing angle as in the case of CTA1. Note that a stereo imaging approach is also used in the 2D-S probe (2 Dimensional Stereo probe, SPEC Inc., Boulder) in which two independent shadowgraph images of the same particle are recorded at a viewing distance of 90°. The examples given in Fig. 11 also show that the enhanced bright field image clarity due to the use of incoherent and monochromatic light as documented in the laboratory versions (Abdelmonem et al., 2011; Schön et al., 2011) is achieved also under flight conditions.”

Page 8, Line 29 -31: You mention a new data acquisition software, but do you use analysis software to identify different kind of particles (plates, columns, etc.)? Do you analyze and sort the particles by hand or do you use some sort of algorithm?

The new data acquisition software is just for the data acquisition and storage, i.e. no further image processing is conducted at this stage. The raw images are processed after flight by our in-house developed analysis software as described in Schön et al. (2011) for area, equivalent diameter, maximum and minimum dimension, aspect ratio, and roundness. A reference to the Schön et al. (2011) paper is given in the first sentence of section 2.3.1. A habit-specific classification of the imaged crystals are conducted by visual inspection of each stereo image.

We acknowledge this by adding "manually selected" to the second and third paragraph of section 3.3.1 "Habit-specific angular scattering functions from ice clouds".

Minor comments

Page 1, Line 12: change "form" to "from"

Corrected.

Page 2, Line 22: Here, you use a headline followed by another headline. It looks strange when there is a headline with no following content.

Section 2 has been reorganized. See our answer to the following comment.

Page 2, Line 23: The paragraph about the "Trigger detector" is included in the subsection "Light scattering detection system". Do you think it is the right place? You should consider putting it before this subsection, because the Trigger also starts the image acquisition (see Page 7, Line 28-29). It means that the Trigger detector initiates the light scattering system and the imaging system.

We agree with the reviewer that the trigger detector represents an important and independent part of the system and should be presented on the same level as the polar nephelometer and the imager parts. We therefore reorganized section 2, which has now the subsections "2.1 Trigger detector", "2.2 Polar nephelometer", and "2.3 Imaging system".

Page 3, Line 8: Is "sensing area" similar to "sample volume"? If it is, change it.

No, sensing area is not the same as sample volume here. However, we acknowledge that the terms were not consistently used in the discussion manuscript and revised the paper for a consistent use of the terms "sensing area", "sensing volume", and "volume sampling rate".

Page 3, Line 9: “roughly” Can you deliver an uncertainty of these droplet diameters?

Changed “roughly” to “77 ± 0.1µm” as this is the exact result from the image analysis.

Page 3, Line 28: You might answer it in Part 1, but are the mirrors heated to avoid condensation?

All the optical components including the off-axis parabola mirrors are heated to avoid condensation. This is already mentioned in section 2.1 of Part 1:

“All optical components are heated to temperatures above the dew point to prevent water condensation on optics or ice aggregation which may clog the air path.”

Page 3, Line 31: You should mention in this sentence for what reason it is not feasible.

As mentioned here this was already reasoned in Part 1. However, we slightly modified this sentence to:

“As reasoned in Part 1, the original concept idea of an additional 1° to 10° measurement at 1° resolution is not feasible with the actual set up, and, therefore, these channels are no longer used.”

Page 4, Line 17 – 18: You show in Figure 2 the redesigned fiber-to-MAPMT coupler and the simulated irradiation. If you additionally show the simulations here before the redesign it would help to explain why you needed a redesign.

We think that the need for a redesign of the fiber coupler was satisfactorily reasoned in section “2.1.2 Polar nephelometer”:

“This [residual optical] crosstalk could be clearly attributed to the fact that the numerical aperture (NA) and the diameter of the PMMA fibers were too large in combination with the minimum distance to the anode array of the MAPMT constrained by the 1.5 mm thickness of the MAPMT protection window. To solve this crosstalk problem the following redesign of the fiber-to-MAPMT coupler was performed.”

Maybe the reviewer is confused by the term “redesign”. Our line of argument here is: 1. The reason for the optical crosstalk was identified (see above). 2. A

redesign of the coupler in terms of the points (a) and (b) given in section 2.1.2 are envisaged. 3. To deduce the best distances between the fiber ends and the gradient index lenses and between the lenses and the MAPMT protection window, optical simulations have to be conducted. 4. The result of this simulations (distances with the best result in terms of crosstalk free light coupling) are used in the **mechanical design** and finally **manufacturing** of the new coupler.

To make this argumentation line more clear we changed the initial sentences of the second paragraph and third paragraph of section 2.2 "Polar nephelometer" to:

"Before a new coupler was manufactured based on this redesign considerations, comprehensive optical engineering simulations had been performed to define the optimal distances between the fiber ends and the index lenses as well as between the index lenses and the MAPMT protection window."

and

"The coupler was then manufactured according to the results of the optical engineering simulations and was characterized in the laboratory."

Page 8, Line 25: "several kHz" Be more specific.

Changed to "13 kHz".

Page 8, Line 31: "QuickUSB library and the library that comes with the camera" Give a reference.

References are given.

Page 9, Line 42: "at least for cirrus cases" What is the typical particle distance between cirrus particles. Does it mean that you can not exclude shattering for liquid clouds?

In cirrus clouds, the inter-particle distances are typically > 10^{-2} m and, therefore, the histogram of the inter-particle arrival times will be bimodal in case particle shattering is occurring (see Korolev and Field, Atmos. Meas. Tech., 8, 761–777, 2015). At higher concentrations representing mixed-phase and liquid clouds, the inter-particle distances can be in the order of the minimum measurable distance defined by the instrument acquisition dead time and the true air speed, and a clear separation of the shattering events in the inter-particle arrival times histogram is no longer possible. To our knowledge the electronic dead time of PHIPS-HALO is comparable to those of other cloud probes, so excluding particle shattering in mixed-phase and liquid clouds is a general problem.

Page 9, Line 27: You should cite the BAMS paper here concerning ML-CIRRUS

http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-15-00213.1

Reference added.

Page 11, Line 5: Change “The two imaged droplets with...” to “The two imaged droplets in Figure 12 with...”

Changed.

Page 12, Line 11: Change “In a first analysis, bullet-rosettes were...” to “In a first analysis, bullet-rosettes (see Figure 14) were...”

Changed.

Page 14, Line 1 – 6: As mentioned before, I think it is time for an intercomparison with other instruments.

See our answers to the major comments 1 and 2 above.

Figure 2b: Legend is too small

Changed.

Caption Figure 2: “nephelometer” not “nephlometer”, ...the the .....

Changed.

Figure 3: The numbers on the axes are too small

Changed.

Figure 3 and 4: Stay consistent with the Figures. For Figure 2 you use “a” for the left and “b” for the right figure. Here you talk about “left”, “right”, “upper” and “lower” panel.

We agree and consistently use now (a) and (b) in the figures and the text describing the figures.

Figure 4: Left and right figure are inconsistent. Labels are different. Brackets around the units are different. Label size is different. Ticks for y-axis are different. The illustrations of the electrical crosstalk levels are different too.

Changed to the same graph style left and right.

Figure 16: Mark the images with numbers or letters. Then you can add these number to the lines of the angular scattering functions. Like in Figure 13.

We addressed this reviewer comment, but realised that the graph of the scattering functions is getting messy when labelling all functions. As a compromise we labeled only two ice scattering functions in the graph and the corresponding images.

All Figures: Stay consistent. Keep [unit] or (unit).

Revised to be consistent in all figures.