The HALO Submicrometer Aerosol Inlet (HASI): Design concept and first characterization

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Figure 1. HALO in ML-CIRRUS configuration with HASI (marked)

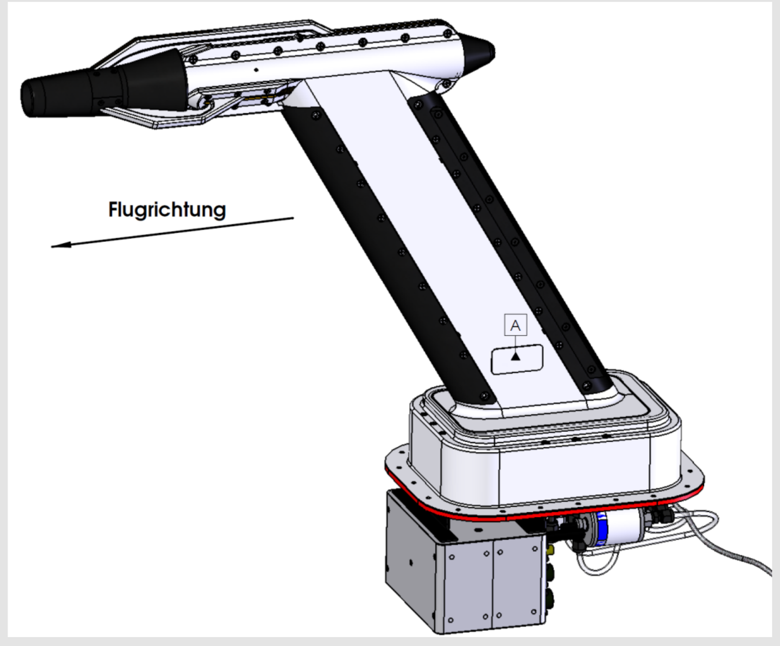


Figure 2. HASI drawing including inlet control unit (ICU) at the bottom

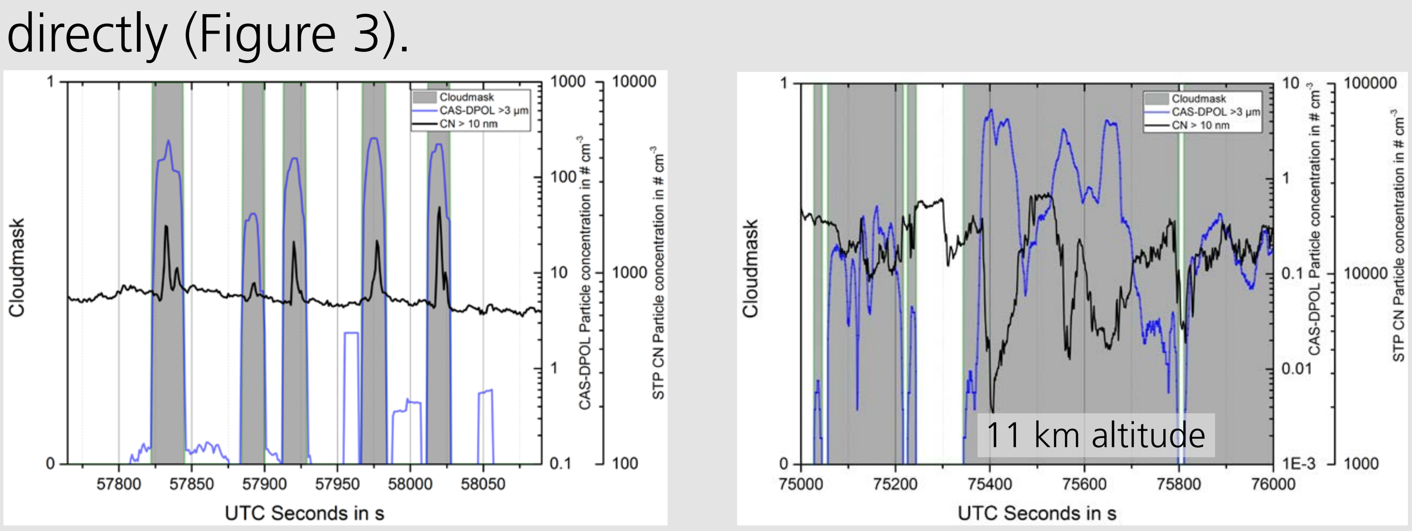
Figure 3. HASI front view cross section

HASI design

- The **HALO Submicrometer Aerosol Inlet (HASI)** was specifically designed for HALO. Its aim is to provide sample flow (up to 30 l/min) to particle instruments in the HALO cabin with minimized particle enhancement or depletion effects for the sub-µm sizes
- HASI was operated during the HALO missions **ML-CIRRUS** and **ACRIDICON**, both in 2014, on the top fuselage positions ApT-12 (Figure 1) and ApT-6, respectively, serving different instruments.
- The air stream is aligned in the inlet and deaccelerated in three stages (Figure 4) by roughly a factor of 40 using:
  - a front **shroud**
  - a **diffusor** in front of the main flow tube
  - small diffusers at the tips of the **4 forward facing sample tubes** which protrude into the deaccelerated air stream inside the main flow tube
- 4 forward facing sample lines (Figures 3, 4, 5, 6) with 2 x 15 l/min and 2 x 5 l/min nominal volume flow rate, in which it is foreseen that the **sample air flow can be regulated** to achieve near-iso-kinetic sampling conditions at the tip of the sampling lines according to the actual speed of the aircraft. Pumps and bypass lines for regulation of the air flows are part of the Aerosol Measurement System (**AMETYST**) in the HALO cabin.
- 1 backward facing sample line (so far unused; Figures 4, 5, 6)
- **Temperature, static and total pressure** measurement in the flow tube.(differential and absolute pressure sensors in ICU)
- Sampling axis is 425 mm off the top fuselage **outside the air-craft's boundary layer** for all possible aperture positions HALO.
- Heaters according to Figure 4, not suitable for complete de-icing.

Inlet artefacts in clouds?

The geometric design of the inlet (sample lines off-axis) should prevent large cloud droplets and ice crystals from entering the sample lines directly (Figure 3).



CPC concentrations (red/black lines) behind HASI during in-cloud sequences (marked grey)

→ In **liquid clouds** obvious **artefacts** (too high CN concentrations)
→ In **ice clouds** interstitial aerosol depleted, which appears **realistic**

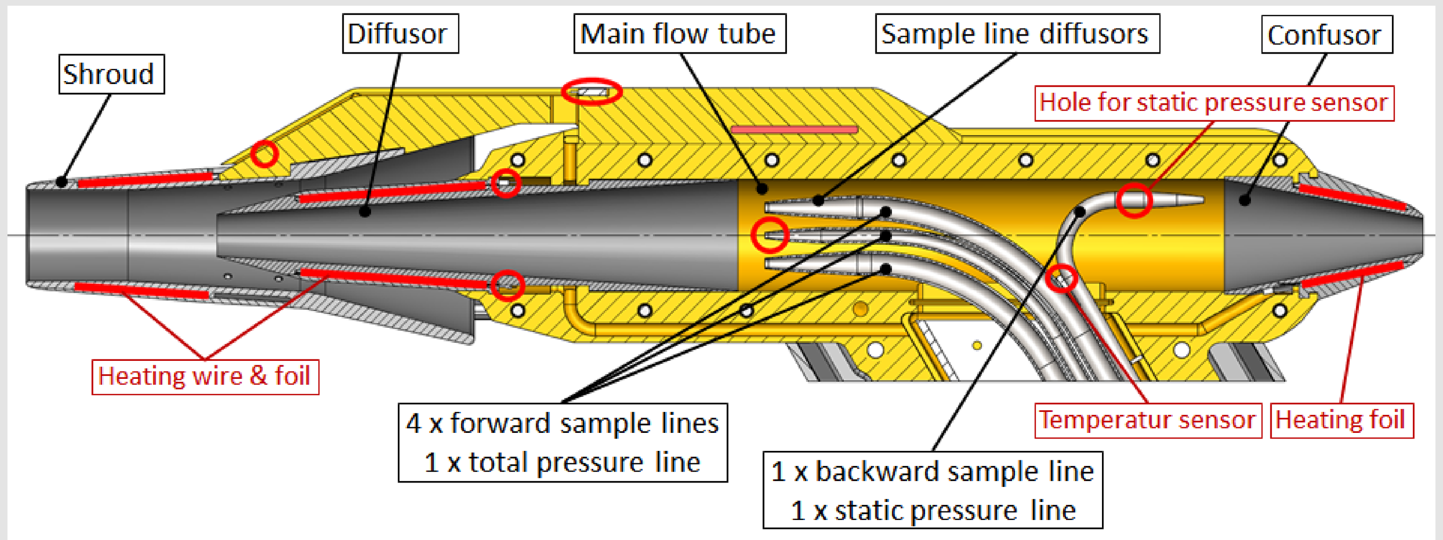


Figure 4. HASI cross section for shroud, diffusor & flow tube

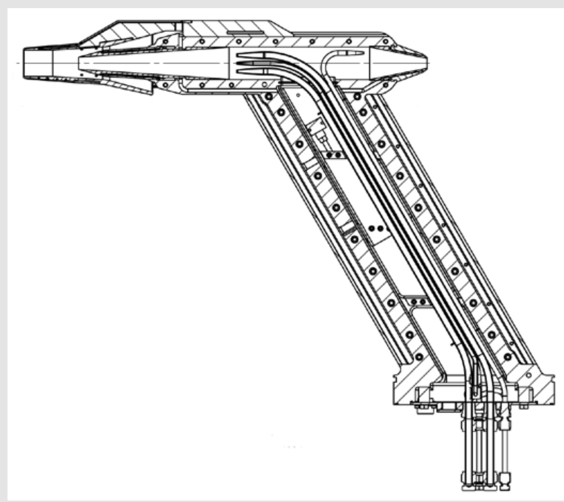


Figure 5. HASI cross section showing sample line layout

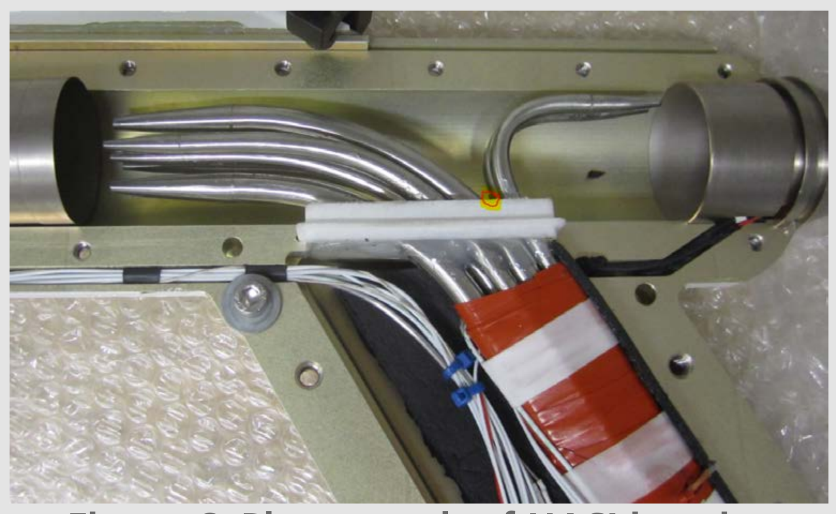
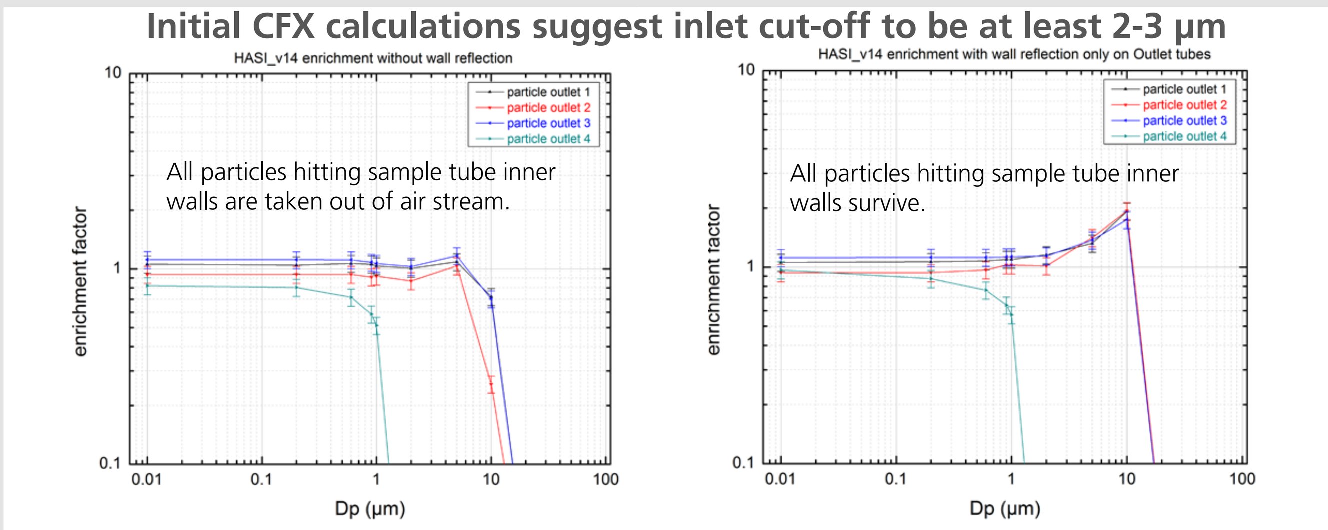


Figure 6. Photograph of HASI interior (position of air stream temperature sensor marked)

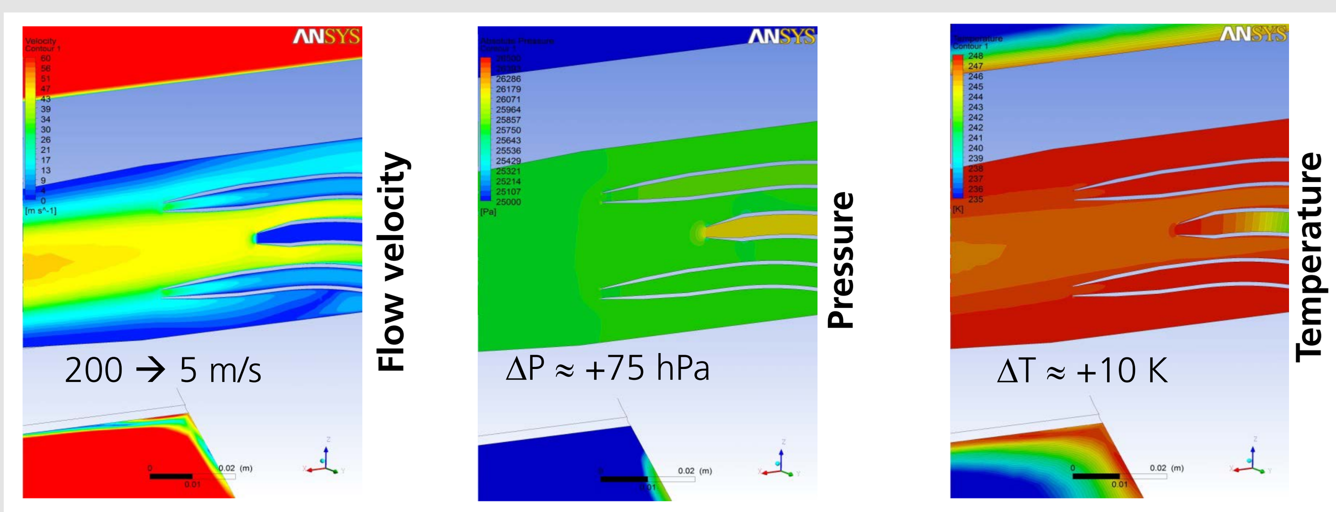
Initial flow modeling

Initial flow modeling of the inlet for flight was done with Ansys CFX software do guideline the design. Results below are for 200 hPa and typical aircraft cruise speed.

Initial CFX calculations suggest inlet cut-off to be at least 2-3 µm



Analysis of first OPC measurements (not shown) appears to confirm approx. 3 µm cut-off



Further numerical flow simulations of the actual final inlet geometry for different aircraft altitudes and speeds are required. Only this will allow the adequate regulation of the sample air flows based on pressure and temperature sensors in the inlet.

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