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# Aircraft engine non-volatile particle emission measurements with PEGASOR Particle Counter

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# Overview

- Background
- PEGASOR Particle Counter (PPC)
- Intended use of PPC and consequences
- Test application in new engine test cell at SR Technics, Switzerland
- PPC installed on long sampling line
- Additional pumping solution
- First test with experimental setup
- Questions

# Background

20 years ago

- Swiss Aviation Law Art. 58: Emissions of aircraft engines shall be checked! (irrespective of size and type)
- Includes small engines where sparse data exist → Cost efficiency of testing?
- In 2004-2008, used automotive «garage – type» equipment for gaseous emissions
- Particle Emissions? Cost?
- Meanwhile «garage – type» particle counters are available
- Added PEGASOR low cost particle counter for (sort of) nvPM number, GMD estimation and nvPM mass estimation

# PEGASOR Particle Counter

## Specifications

| | |
|---|---|
| Range | 30–100,000,000 #/cm³ |
| Sensitivity | 30–1,500 #/cm³ depending on sampling rate and averaging |
| Particle size | 10–300 nm for PM and Dp.<br>10 nm – 1 µm for PN and LDSA. |
| Sampling rate | 1–10 Hz |
| Response time | 0.2 s |
| Sample flow rate | 5.5 lpm |
| Output data | Particle number, LDSA and mass concentration, particle median size |
| Data communication | Bluetooth, RS-232, USB, Ethernet |
| Dimensions | 495 x 340 x 185 mm |
| Weight | 9.1 kg without the heated sampling line |

Actually 12 lpm at instrument exhaust (Ref. 0°C, 1013mbar)


- Hot exhaust measurement

  (Sensor 200°C)
- Internal dilution with Hepa-filtered ambient air
- VPR, periodical technical inspection PTI requirement with Tetracontaine reached at 190°C

  (METAS)
- Sensor:

  Corona Charger + Electrometer

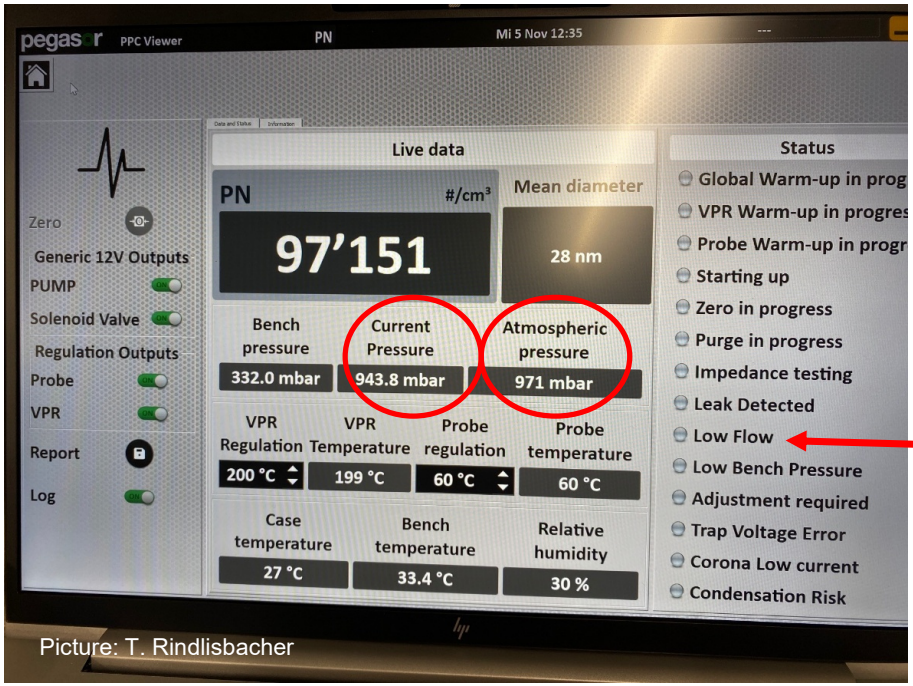
Source: Pegasor Brochure
Erkka Saukko, ETH NPC 2024

# Intended use and consequences

Picture: Pegasor

- Compact light-weight design does not contain a strong pumping system
- Intended for vehicle exhaust tube sampling with super-short line, which provides non-negative sampling pressure
- But mind **long sampling lines** not only for particle loss, but also pressure drop!

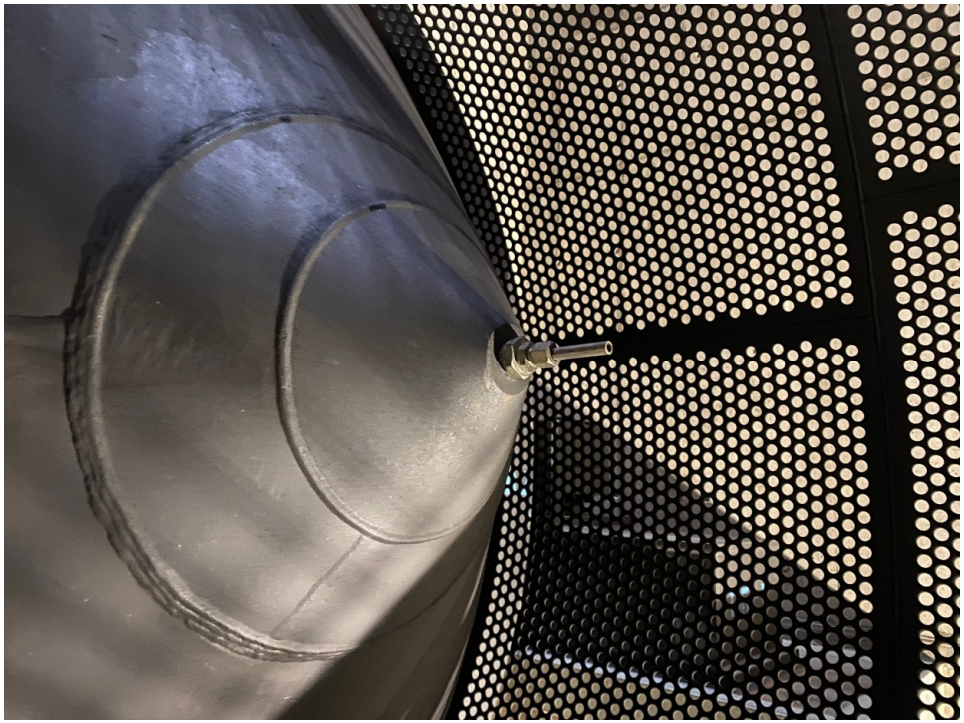
Direct attachment in ARP nvPM system does not work. Look at diagnostic page:



Picture: T. Rindlisbacher

«Current pressure» **must be equal to** «Atmospheric pressure». Unfortunately, **no warning**

# Application in new SRT engine test cell (probe 30m downstream of engine exit)



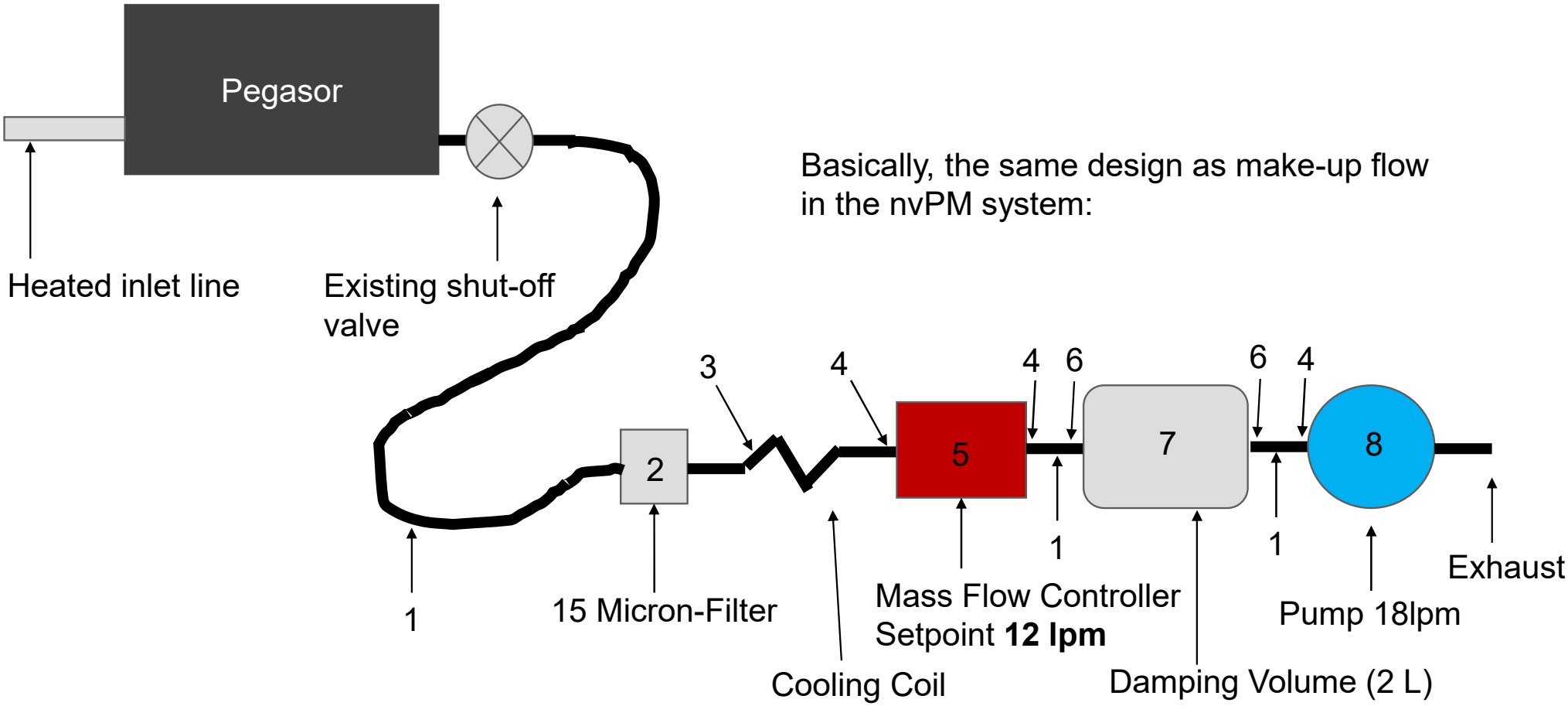
25m straight through 8mm ID sampling line to instruments

Pictures: T. Rindlisbacher

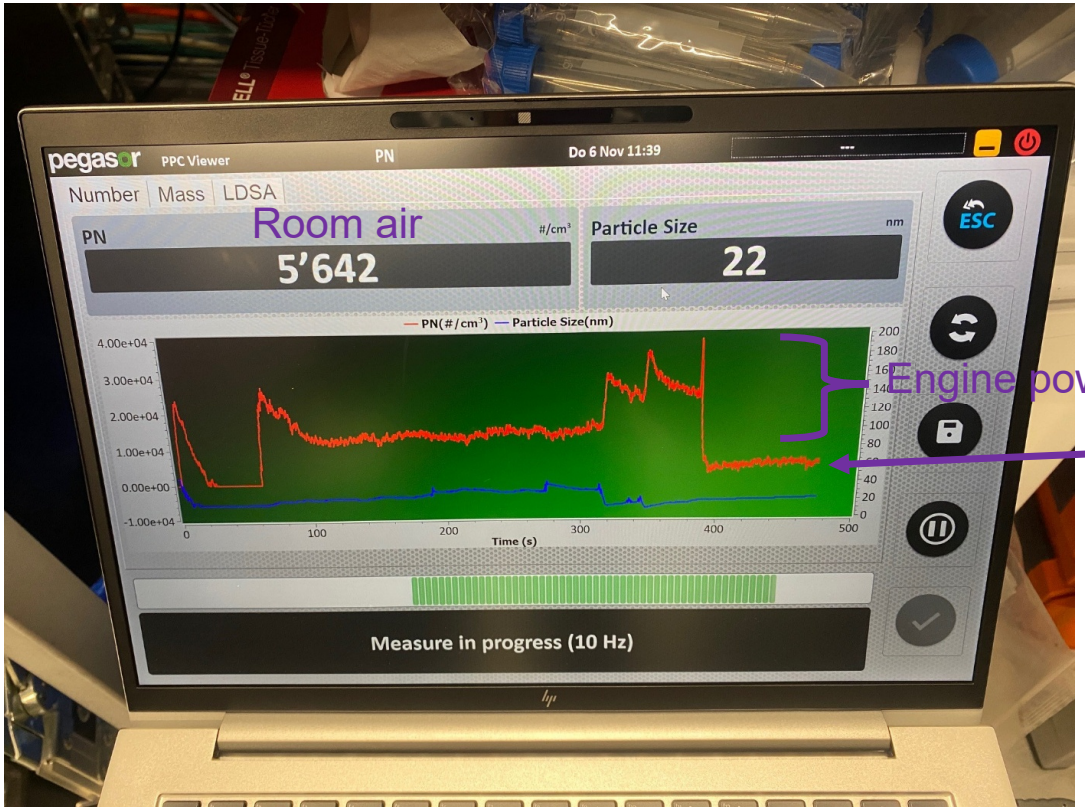
# PPC installed on long sampling line

- The sample flow plus the dilution flow in the PPC add up to 12 lpm (0°C, 1013mbar) at the instrument exhaust.
- Proposed solution to provide enough flow: Attach a controlled pumping system to the PPC exhaust, which regulates the total flow to 12 lpm (0°C, 1013mbar)
- Solution discussed with Pegasor (Erkka Saukko) and successfully tested (see next slides)
- When engine thrust increases, the sampling line may provide enough pressure and in this situation, the additional pumping system may be removed.
- In any case, «current pressure» should be equal to «atmospheric pressure» for reliable measurements (PPC designators)

# Additional pumping solution

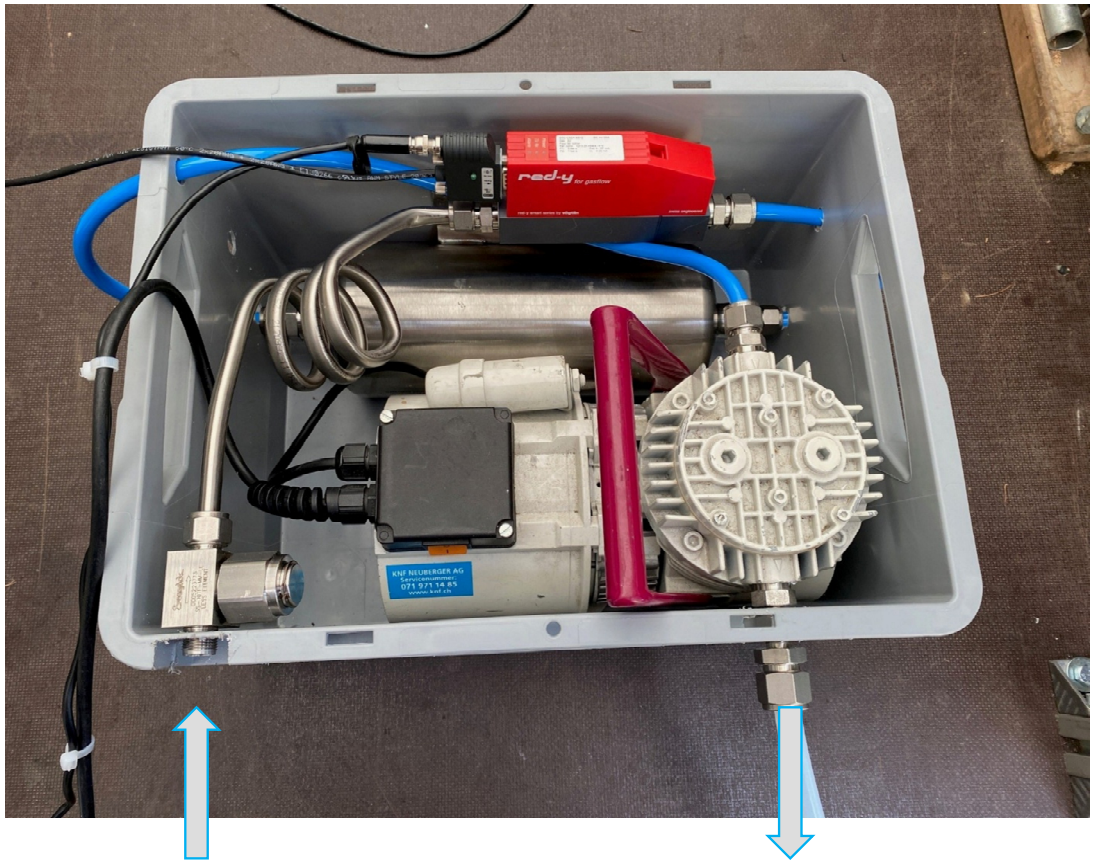


# First test with experimental setup (without pump damping volume)


Pictures: T. Rindlisbacher

# Additional pumping solution

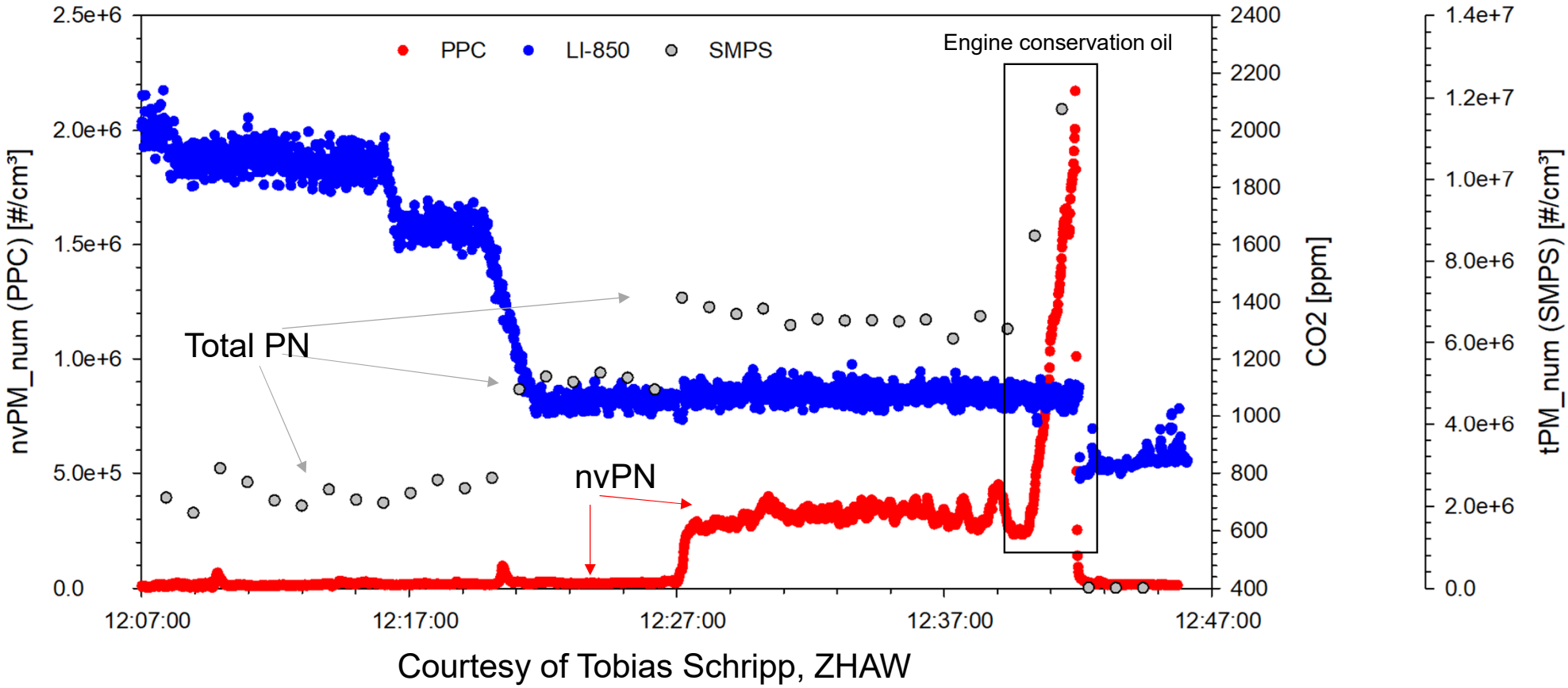



from Pegasor exhaust

Pump exhaust

Installation in a transport box,
as of February 2026

# 30m downstream measurement: PPC, TSI SMPS and LI-850 ($CO_2$) in parallel




Courtesy of Tobias Schripp, ZHAW

# Questions?

# Das BAZL

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