

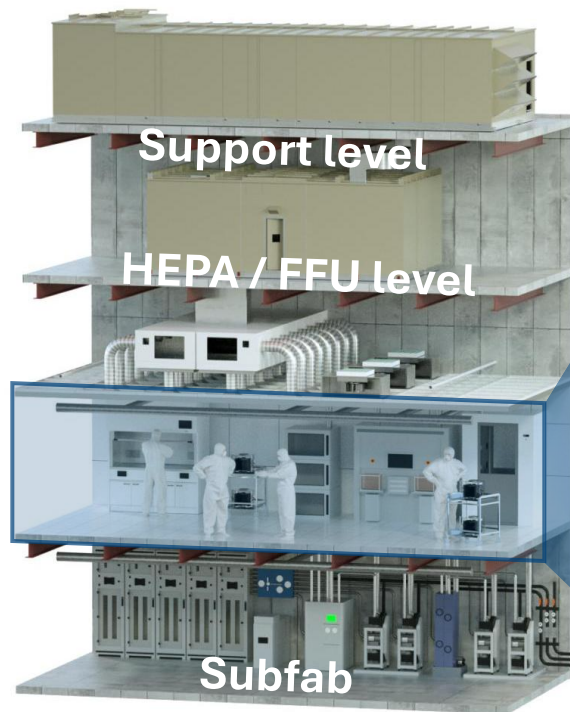
# Comparison of Particle Shedding from Different Fan Technologies for ISO Class 1 Environments

1. **How many particles** do different fan technologies shed?
2. Which fan, under which **conditions** could operate inside **ISO 1**?

Dr. Ivana Ferstera  
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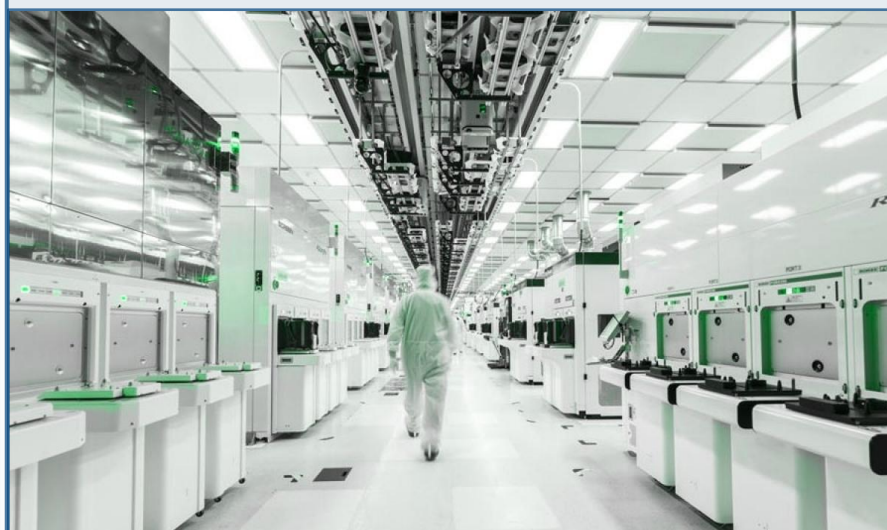
# Semiconductor Manufacturing

## Emerging Applications for Maglev Fans



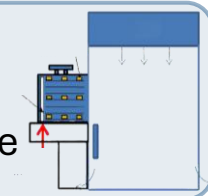
Source: DwyerOmega

### Cleanroom – ISO Class 1



| Class | Maximum Particles/m³ |         |         |         |       |       |
|-------|----------------------|---------|---------|---------|-------|-------|
|       | >0.1 um              | >0.2 um | >0.3 um | >0.5 um | >1 um | >5 um |
| ISO 1 | 10                   |         |         |         |       |       |

ISO Class 1  
mini-environments  
→ fan inside clean zone

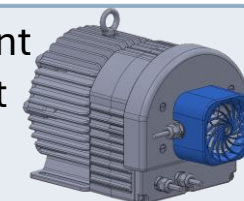


Air knife drying  
→ no expensive CDA



Source: ibcworld

Cooling of equipment  
→ no filter, compact



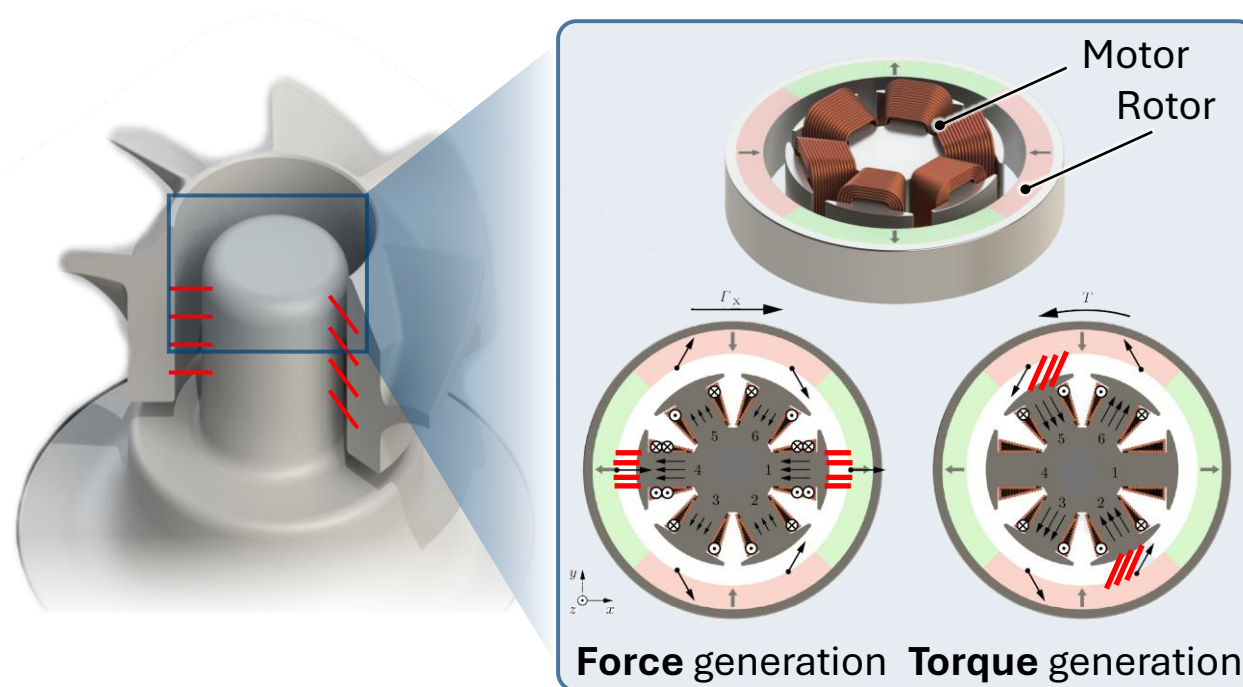
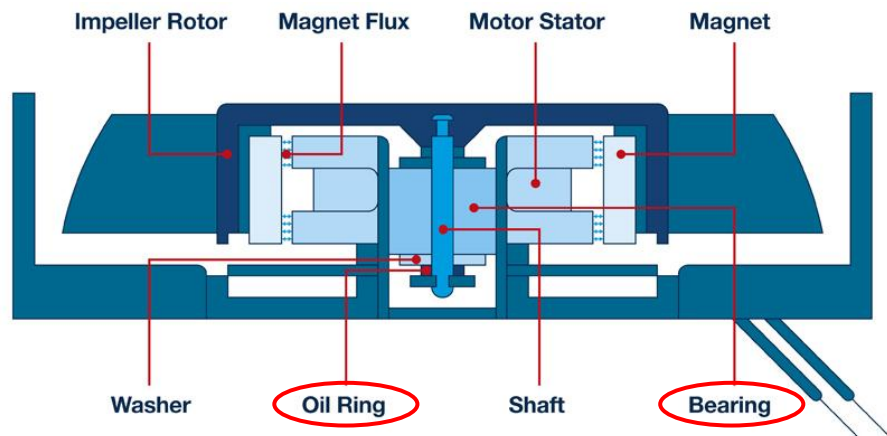
➤ Towards contamination-critical air handling with **maglev fans**

# Fan Bearing Technologies

## Mechanical Bearing vs. Magnetic Levitation

- Mechanical contact
- Bearing wear over lifetime
- Lubrication required

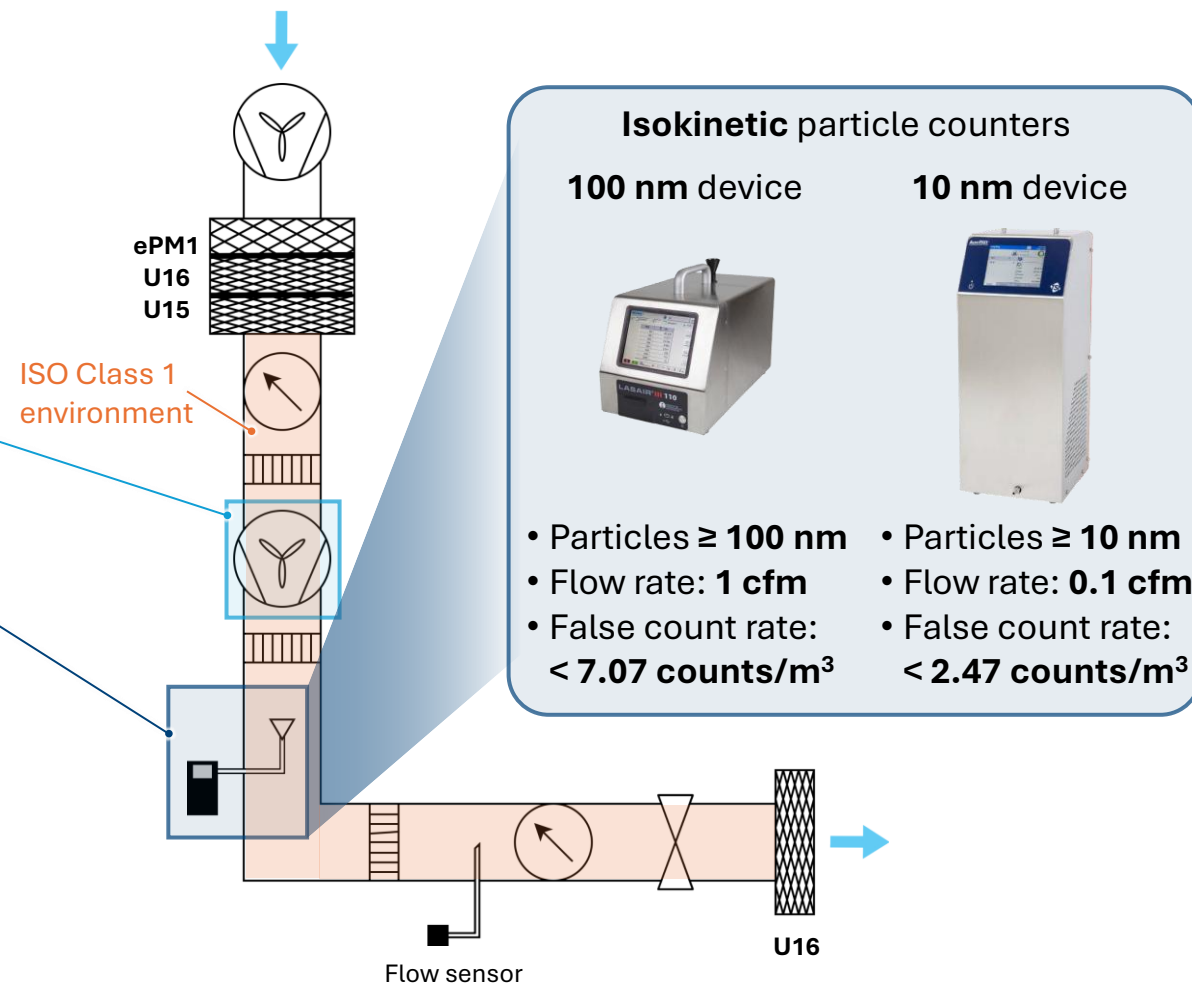
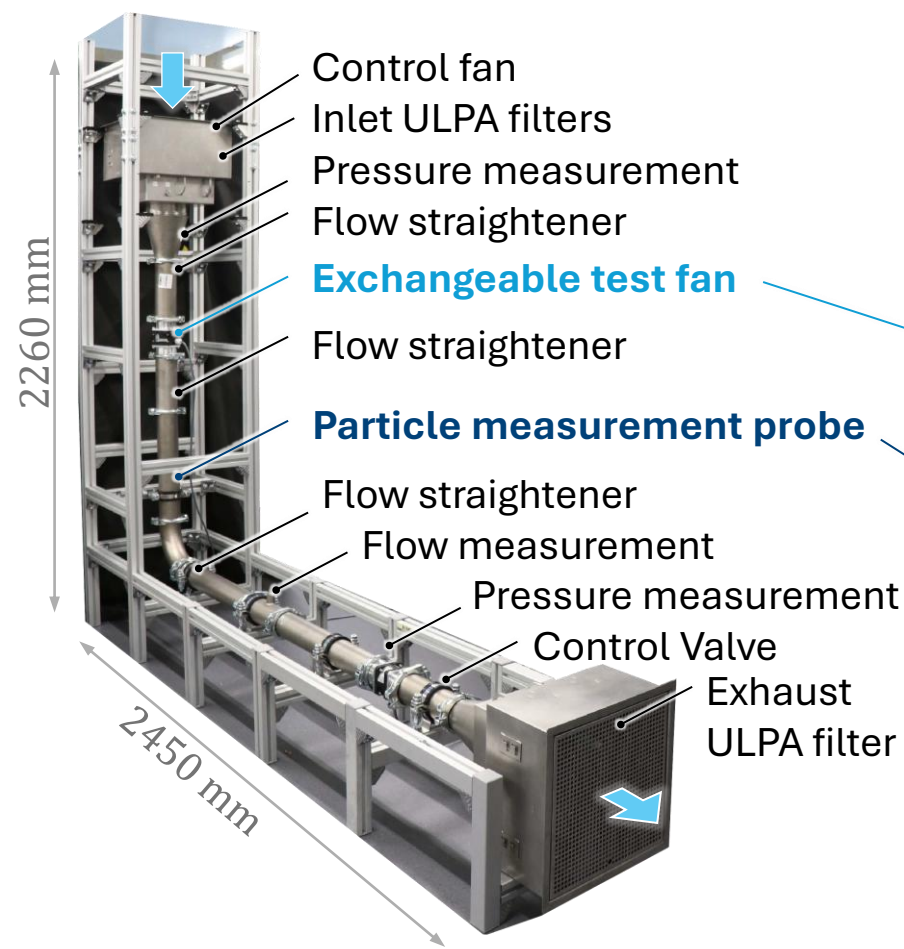
- **Contact-free** rotor suspension
- **No mechanical wear**
- **No lubrication** required



➤ How do **different fan technologies** compare regarding **particle shedding**?

# Test Bench

## Experimental Setup

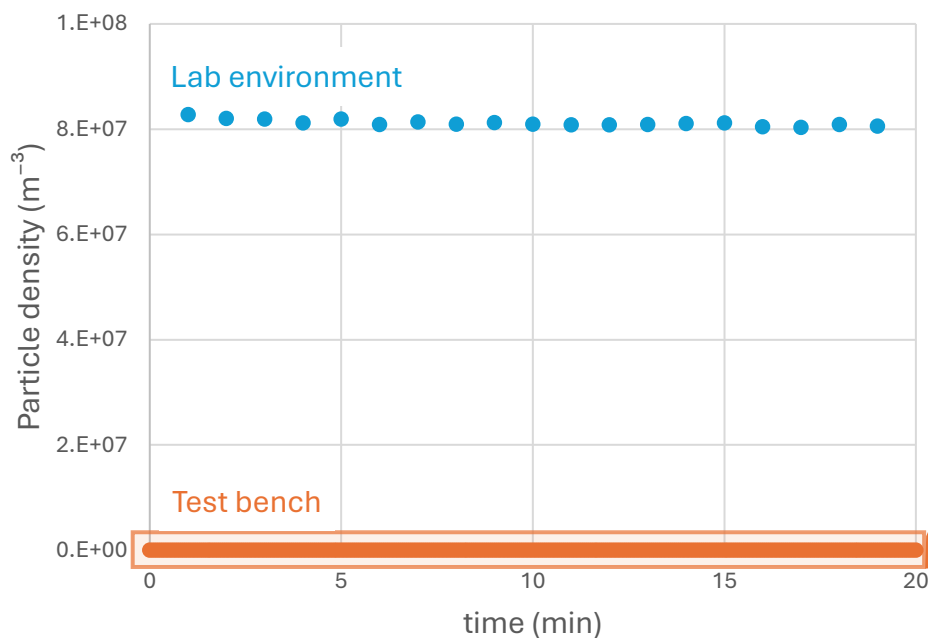


➤ Test bench validation required

# Test Bench

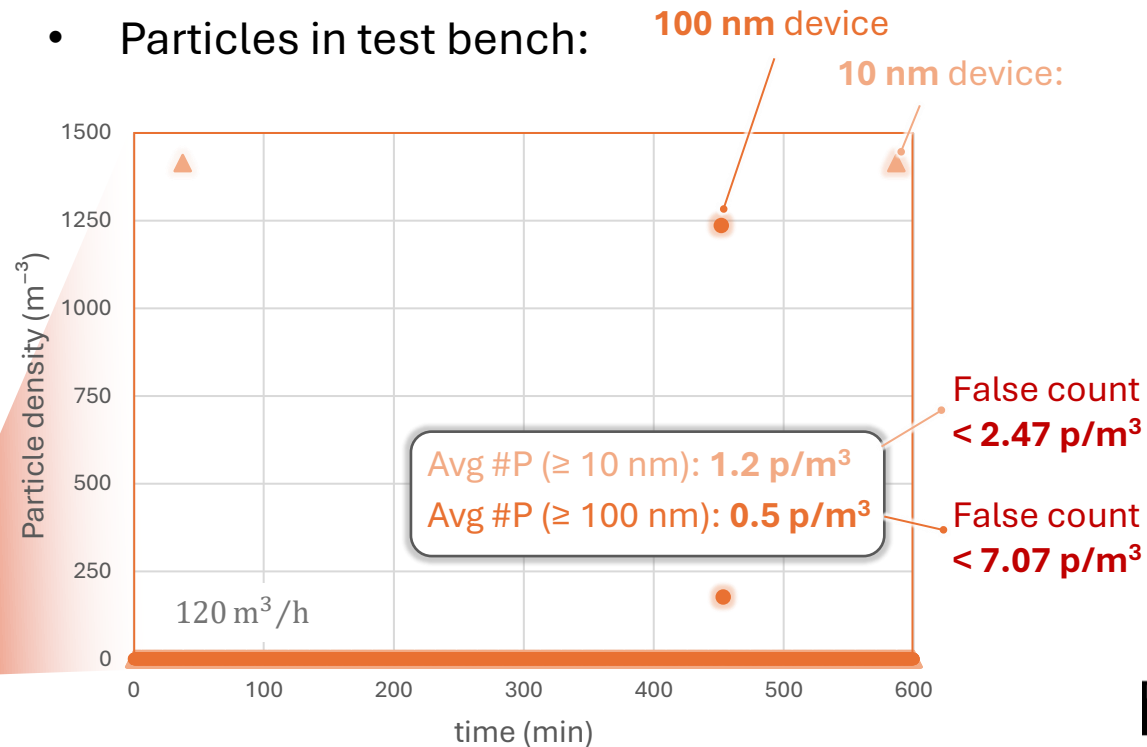
## Background Qualification

- Particles in lab environment & test bench:

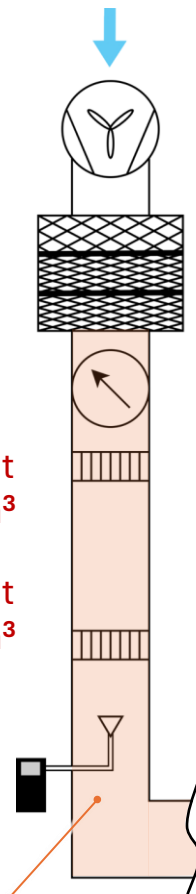


- **Lab environment**  
**> 80 million** particles/ $\text{m}^3$  ( $\geq 100 \text{ nm}$ )  
 ➔ high particle concentration

- Particles in test bench:



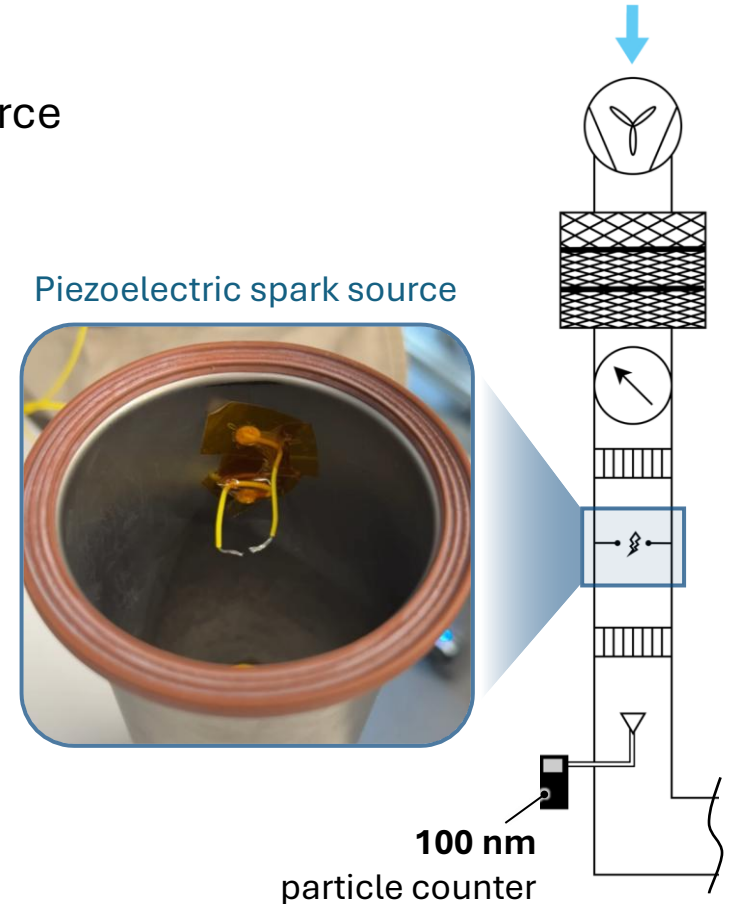
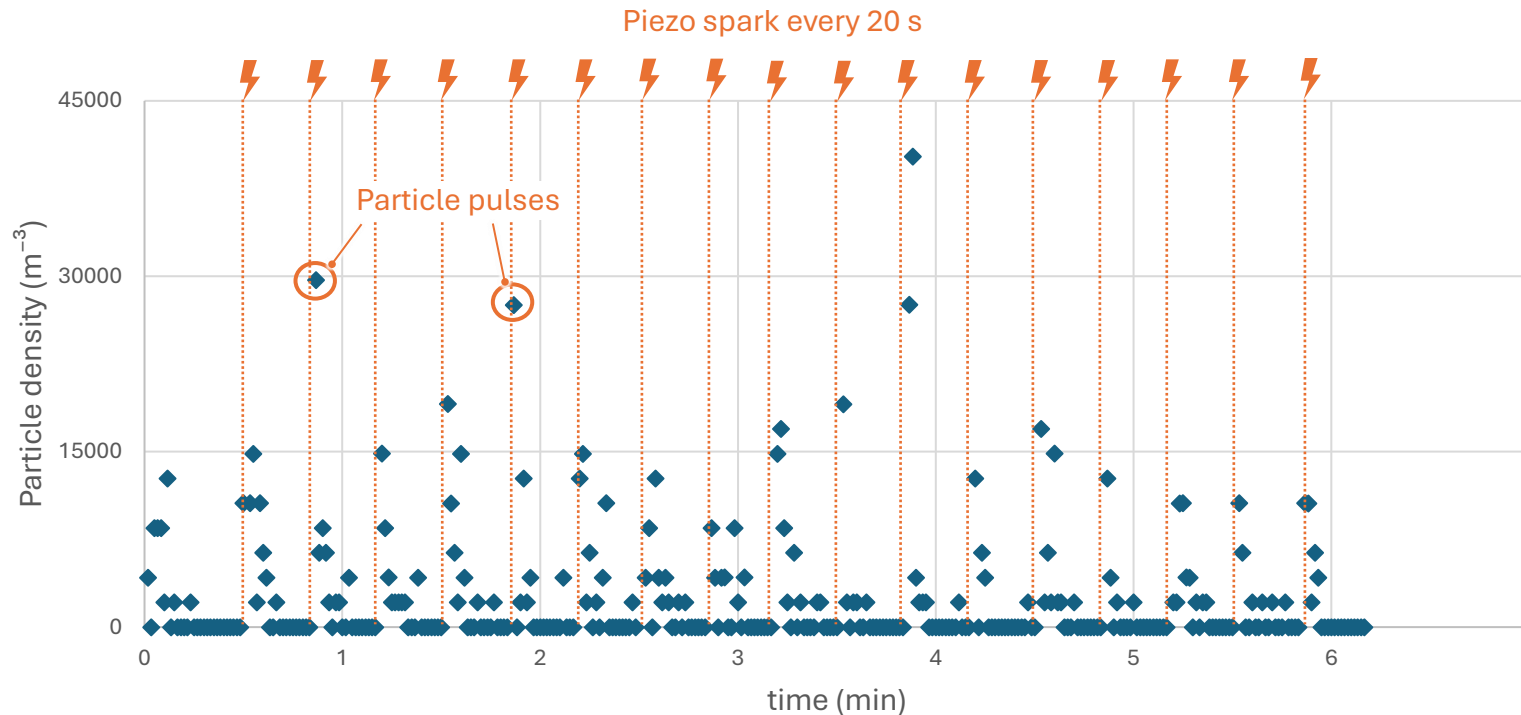
- **Test bench**  
**< 10** particles/ $\text{m}^3$  (100 nm)  
 ➔ **ISO Class 1 background achieved**



## Test Bench

# Particle Measurement Verification

- **100 nm particle pulses** generated every **20 s** using piezoelectric spark source

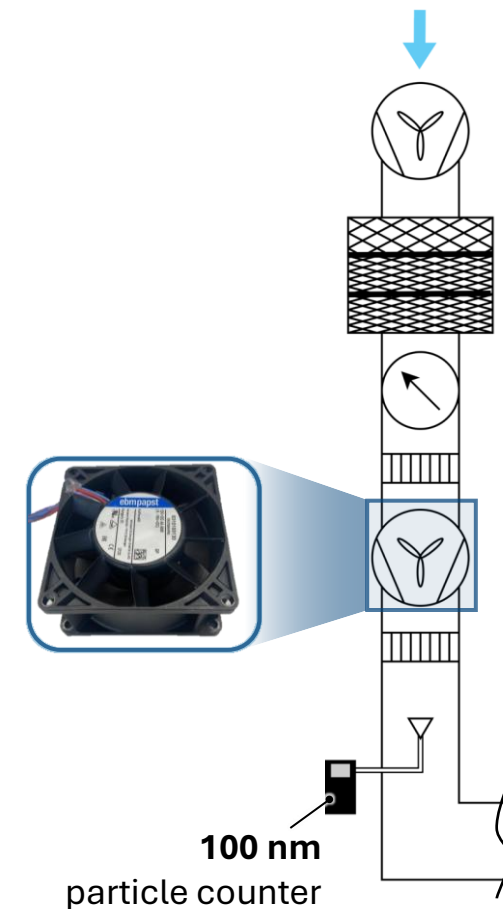
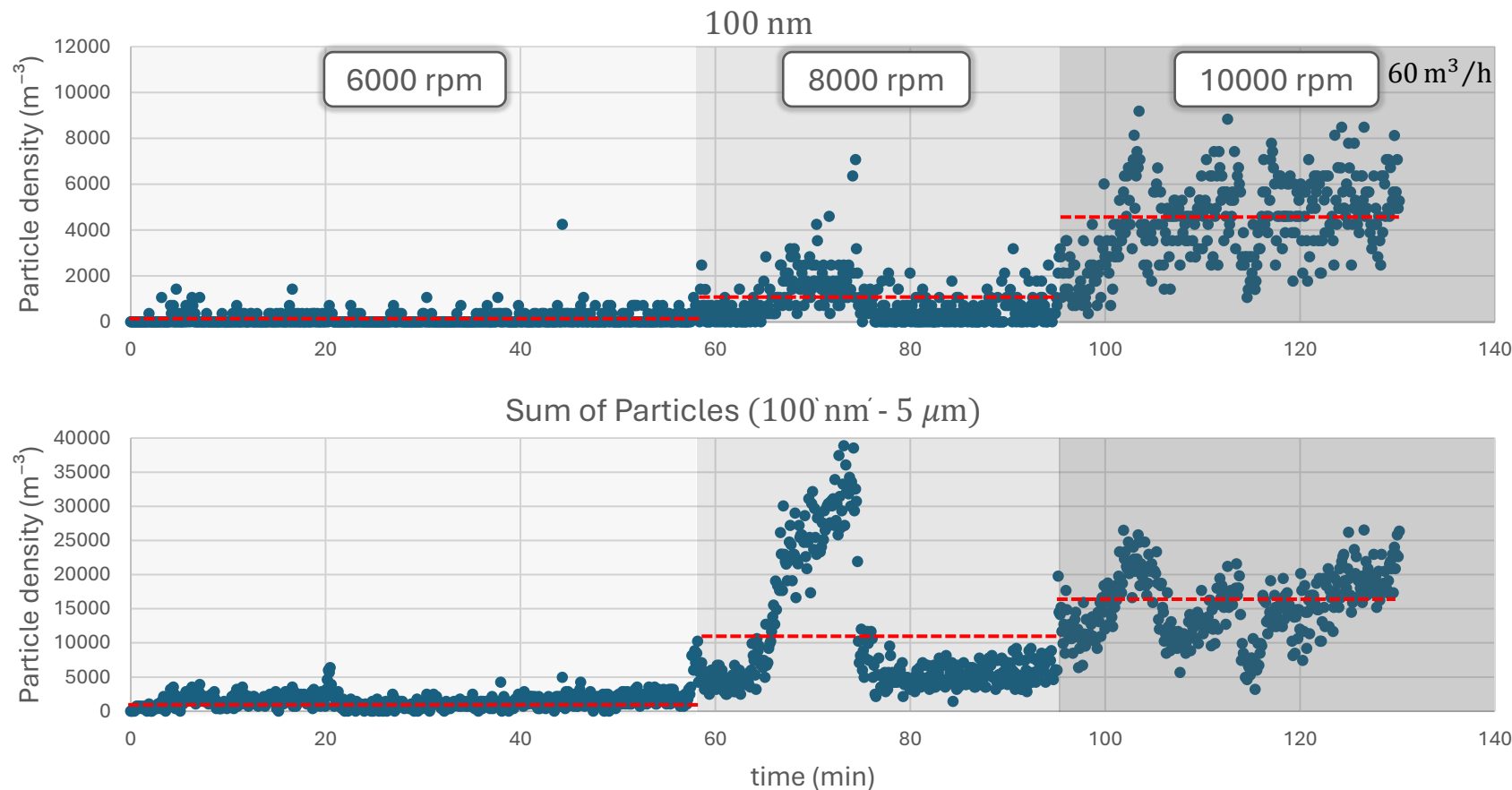


➤ Controlled particle emissions were detected

Results – 100 nm data

# Ball Bearing, Open-Design Fan

- Operating conditions: 6000 rpm, 8000 rpm & 10'000 rpm

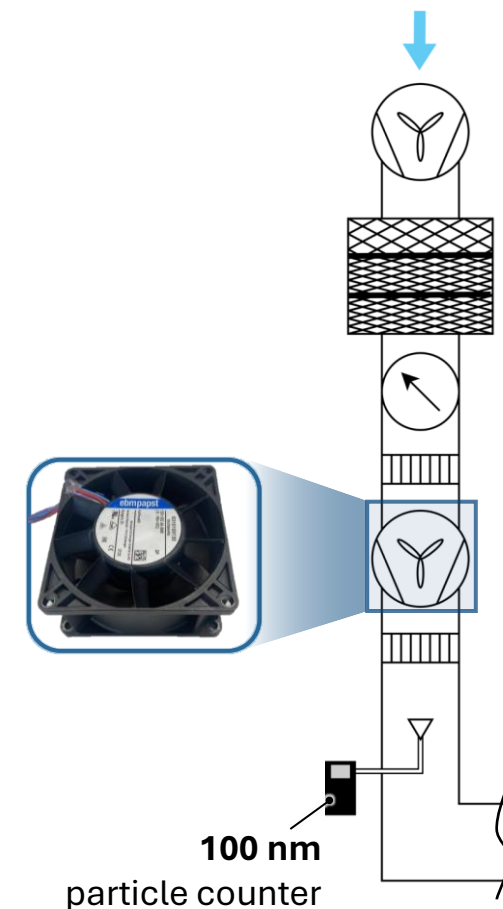
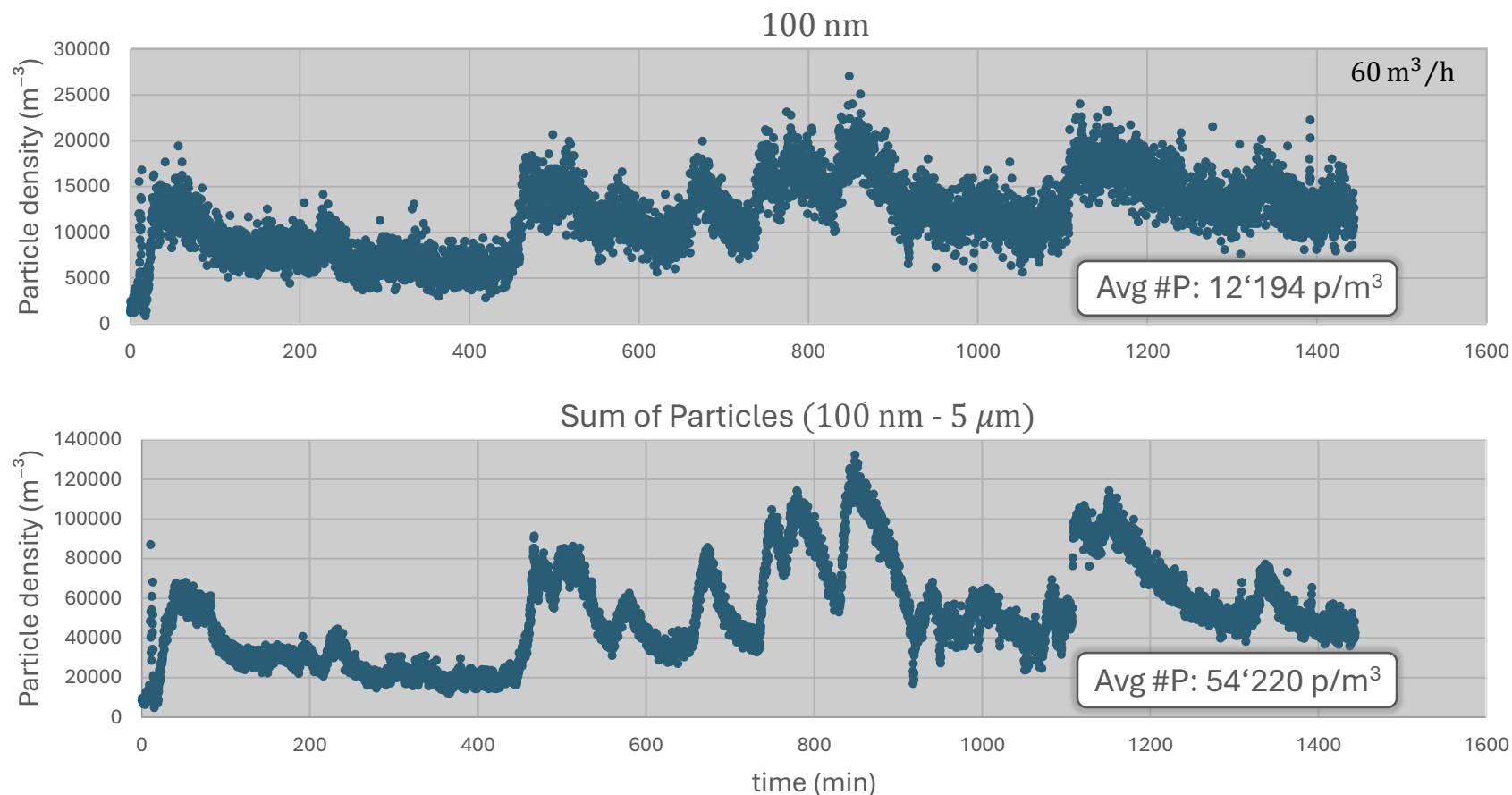


➤ Increasing particle emission with fan rotational speed

## Results – 100 nm data

# Ball Bearing, Open-Design Fan

- Operating conditions: **10'000 rpm** for ca. **27 h**

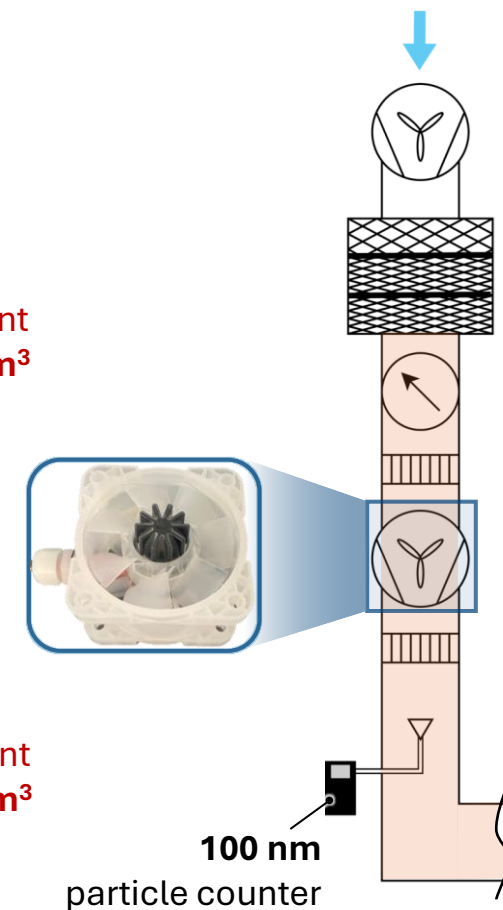
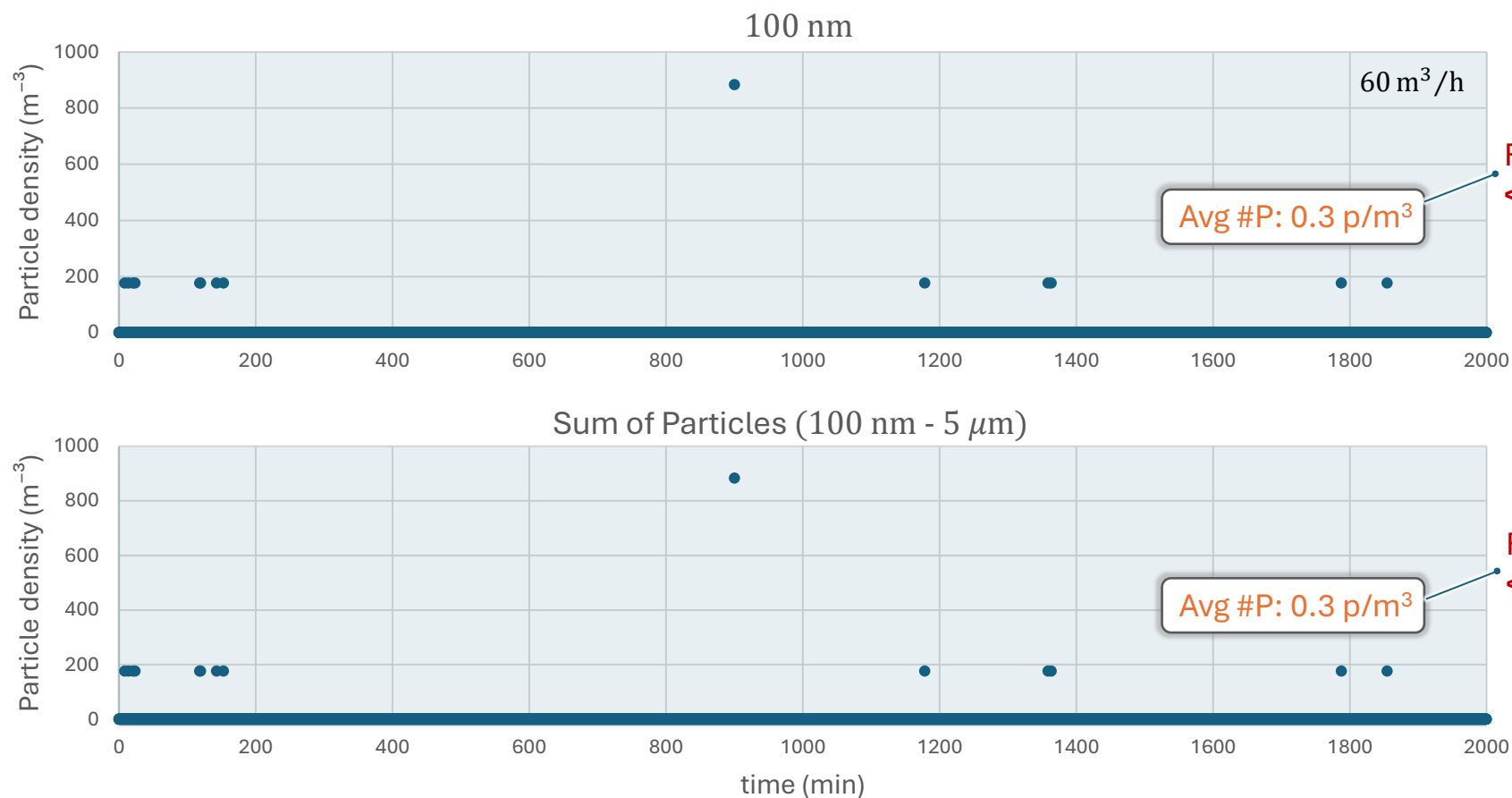


➤ Fluctuating particle emission → particle concentration at 10krpm corresponds to **ISO Class 5**

# Results – 100 nm data

## Maglev Fan

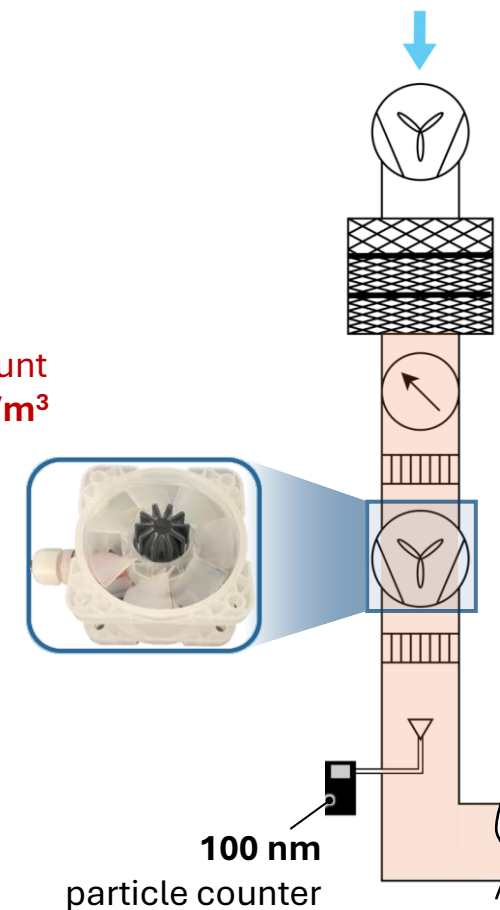
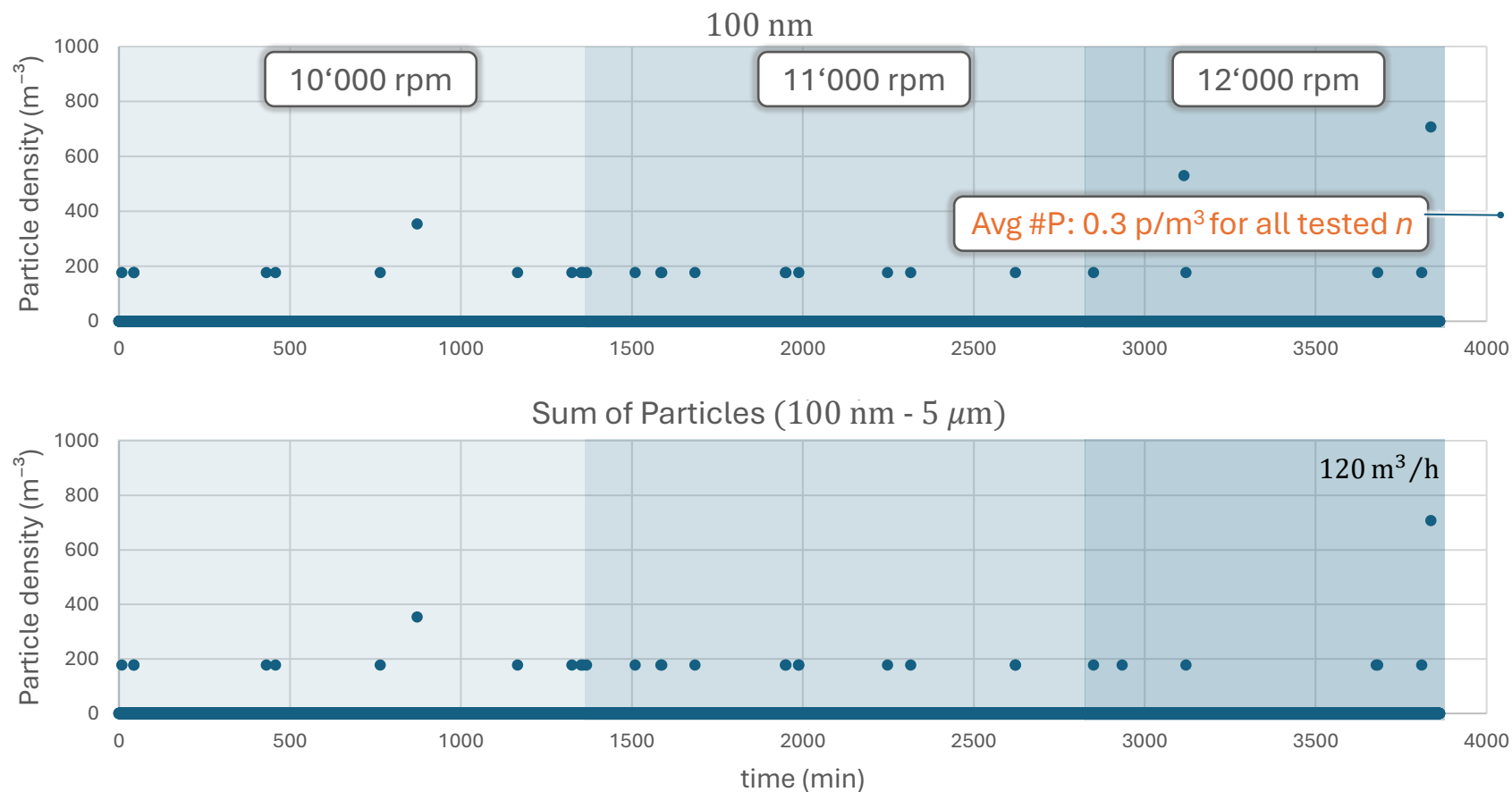
- Operating conditions: **10'000 rpm** for ca. **33 h**



➤ Emitted particle concentration corresponds to **ISO Class 1**

# Results – 100 nm data Maglev Fan

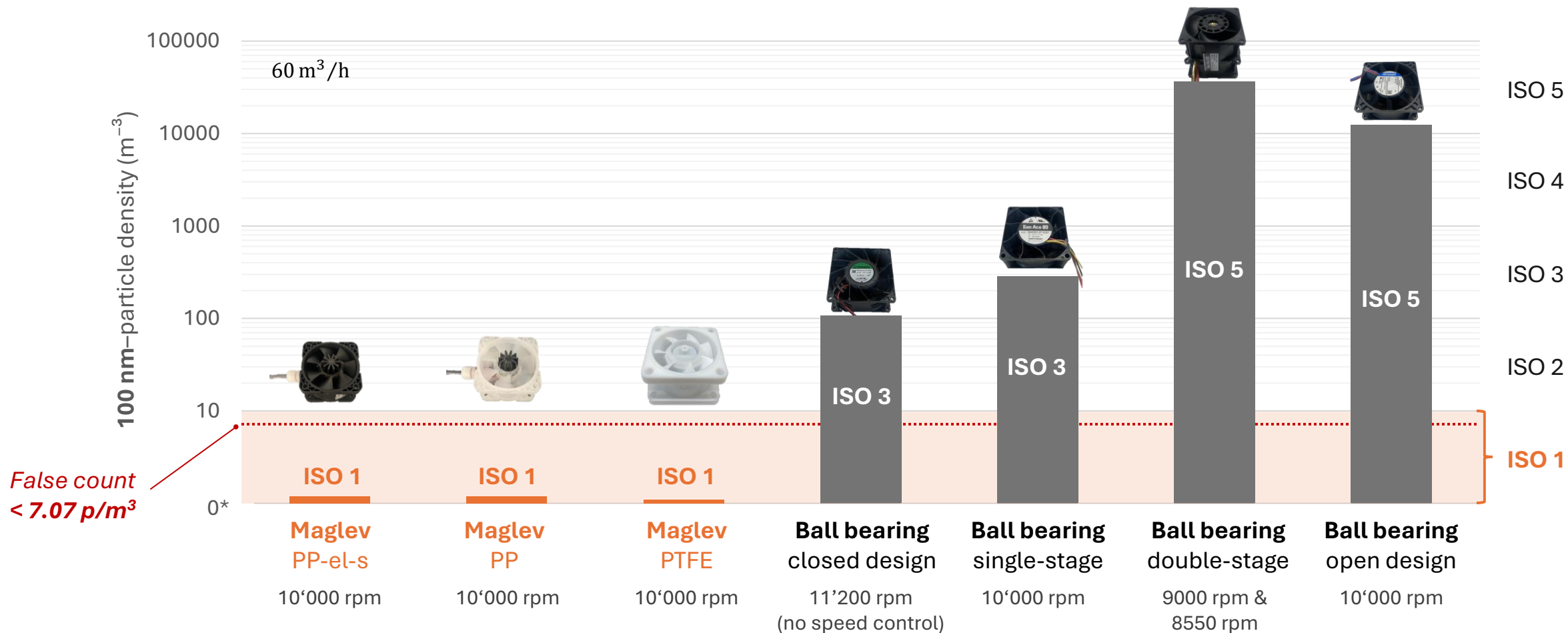
- Operating conditions: **10'000 rpm, 11'000 rpm and 12'000 rpm** for ca. **63 h**



➤ **ISO Class 1** particle concentration achieved at all tested rotational speeds

Results – 100 nm data

# Fan Technologies Classification at ~ 10'000rpm

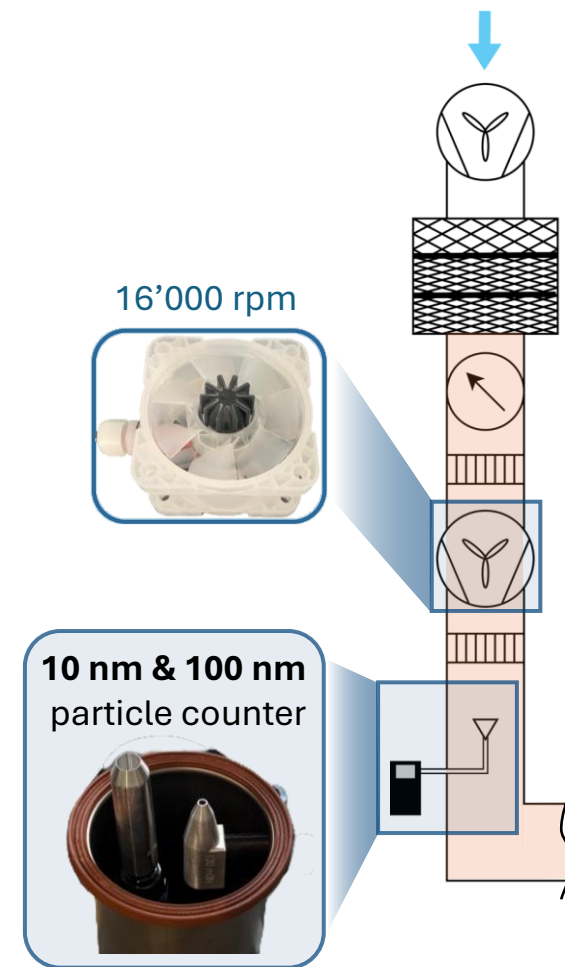
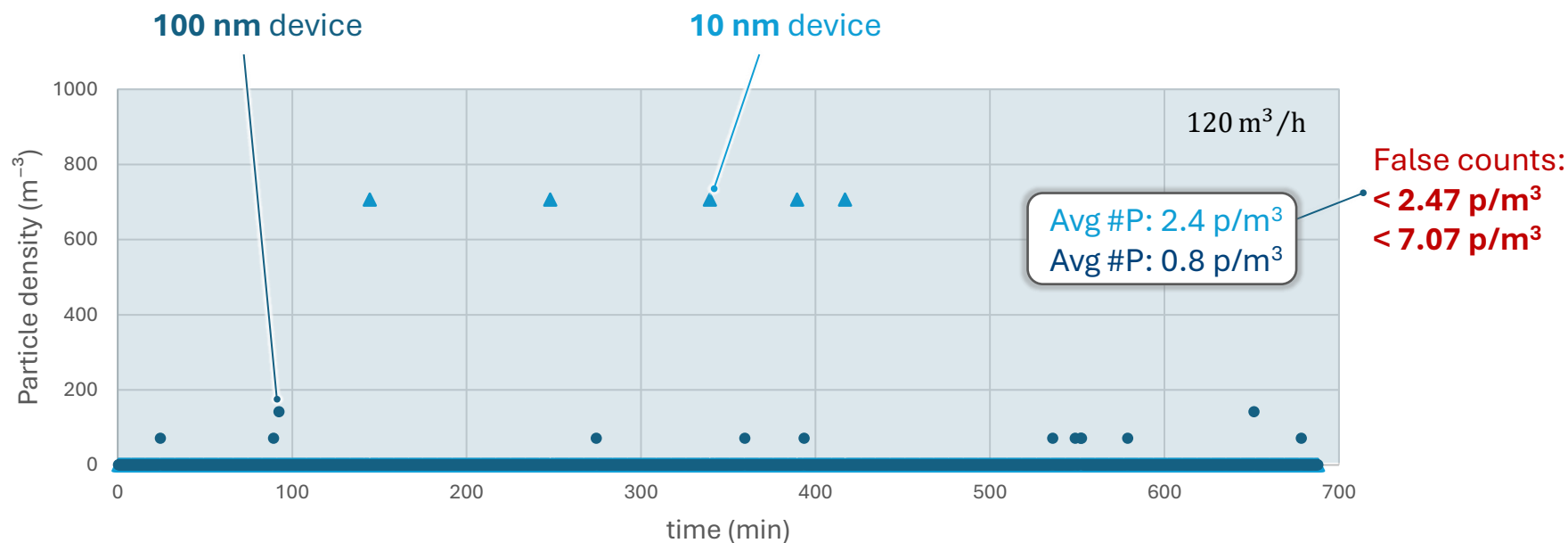


\* For better visualization, the logarithmic y-axis begins at 10, while values below are shown on a linear scale.

# Results – 10 nm & 100 nm data

## Maglev Fan at 16'000 rpm

- Operating conditions: **16'000 rpm** for ca. **12 h**



- Similar results obtained at **10'000, 12'000 and 14'000 rpm**
- **No significant generation of particles in the 10–100 nm size range by maglev fan**

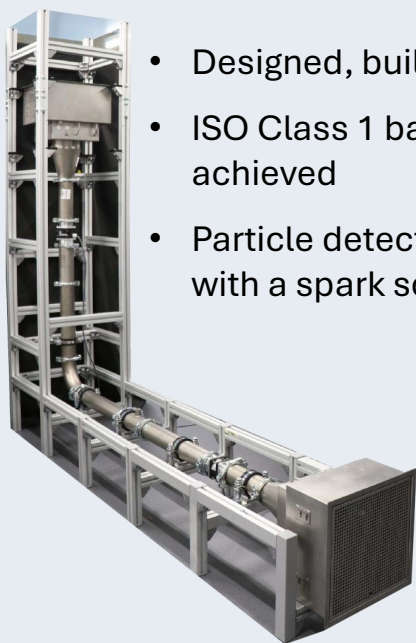
## Results

# Tested Maglev Fans – Summary

| Variable studied             | Range tested                                                                   | ISO Class |
|------------------------------|--------------------------------------------------------------------------------|-----------|
| Fan material                 | PP-el-s<br>PP<br>PTFE                                                          | ISO 1     |
| Fan speed                    | 10'000 – 16'000 rpm<br>incl. cycling operation                                 | ISO 1     |
| Fan operating time           | Up to 5 days continuous                                                        | ISO 1     |
| Flow rate                    | 60 m <sup>3</sup> /h<br>120 m <sup>3</sup> /h                                  | ISO 1     |
| Particle measurement devices | Optical Particle Counter (≥ 100 nm)<br>Condensation Particle Counter (≥ 10 nm) | ISO 1     |

# Summary

## Test bench



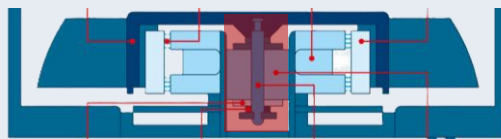
- Designed, built and validated
- ISO Class 1 background achieved
- Particle detection verified with a spark source

## Mechanical-bearing fans

Continuously shed particles – amount depends on:

- 100x** Fan housing – open vs. closed
- 4x** Single vs. dual stage
- x<sup>2</sup>** Fan speed

→ ISO Class 3-5



## Maglev fans

- ISO Class 1 compliant under all tested operating conditions
- No relevant emission in the 10-100 nm range.

→ Inside ISO Class 1 Cleanroom

### Enabling technologies

- Mini-environments
- Air knife drying
- Cooling of equipment

# Thank you!

Dr. Ivana Ferstera  
Scientific Advisor, Levitronix

Levitronix®  
**CMP & Ultrapure**  
Chemicals Conference  
Taiwan **2026**