

Field experiences with the APMON particle deposition monitor

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- Application of Particle Deposition Rate monitoring
- APMON
- APMON PRO
- Data from real-time particle deposition monitoring
- Field experiences
- Technology of Sense

Particle Deposition Monitoring

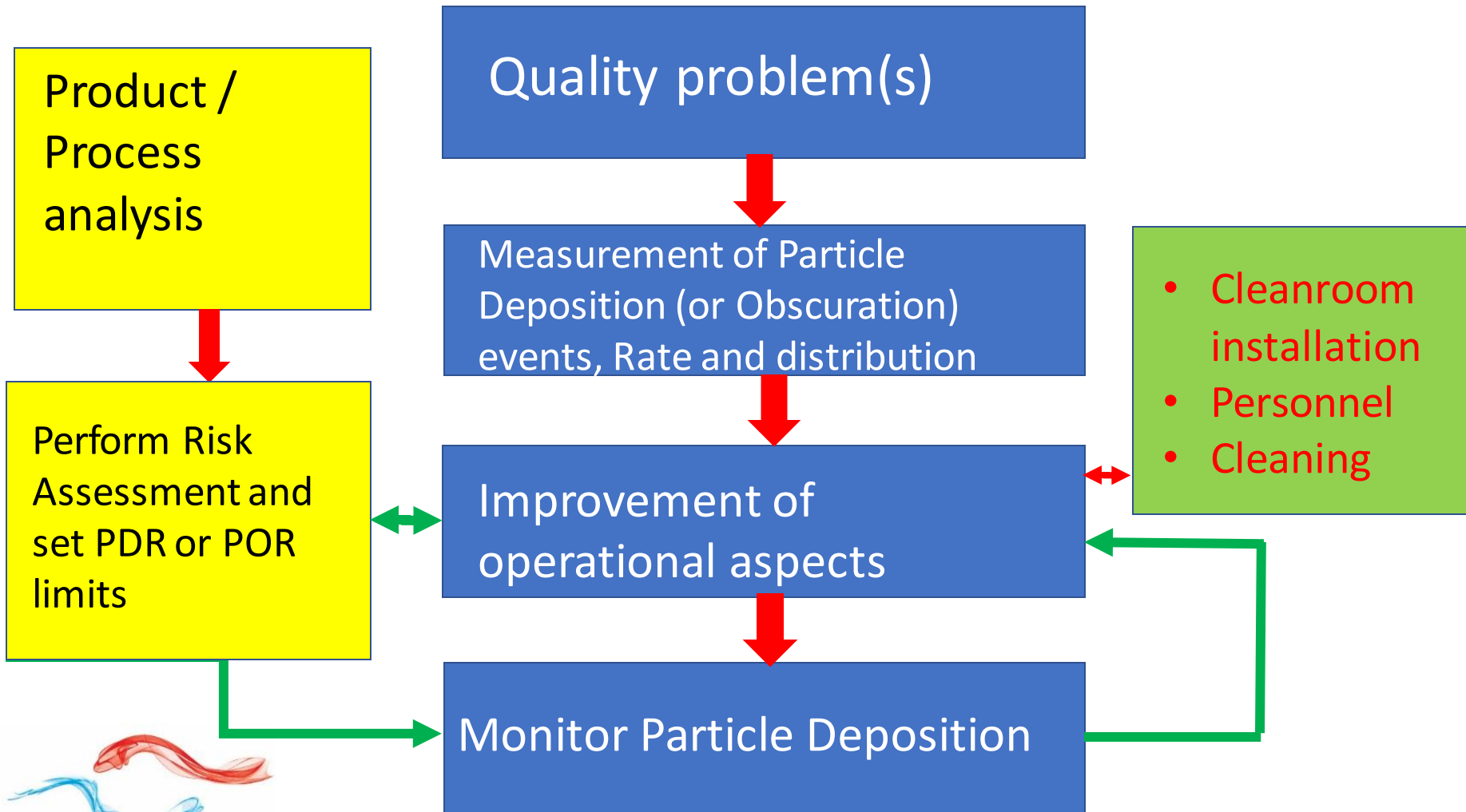
- Shows the risk of surface contamination by depositing macro particles ($> 15 \mu\text{m}$), which is not shown by airborne particle counting.
- This can be measured by:
 - Distributing, collecting and measuring witness plates
 - Realtime with particle deposition sensors at critical locations.
- **Witness plate** analysis gives:
 - Particle Fall Out
 - Particle size distribution
- **Real time particle deposition monitoring:**
 - Shows also when it occurred (no particle deposition in 'at rest' conditions)
 - Gives Particle Deposition Rate and Particle Obscuration
 - Does not need an operator to perform the measurements
 - Helps to find causes of particle deposition and to evaluate measures to reduce the risk of contamination

Real-time monitoring of particle deposition

- Automatic measurement of deposition of particles on sensors provides new information on cleanrooms in operation.
- Every period (5, 10 or 15 minutes) the number of particles $> 15 \mu\text{m}$ deposited on the sensor are counted and measured (size D and PAC in % or ppm).
- Particle Deposition Rate (PDR) and Obscuration Rate (POR) is calculated and determines contamination risk.
- It shows the invisible impact of various activities in the neighbourhood of the critical location.



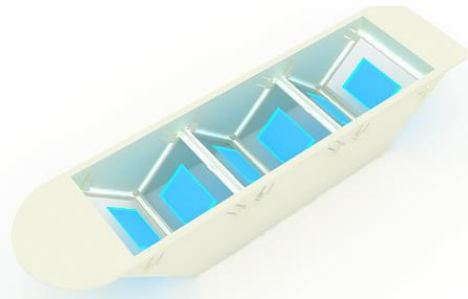
Application of Particle Deposition Monitoring



Advanced Particle Deposition MONitor APMON and APMON PRO



24/7 Monitoring Particle Events

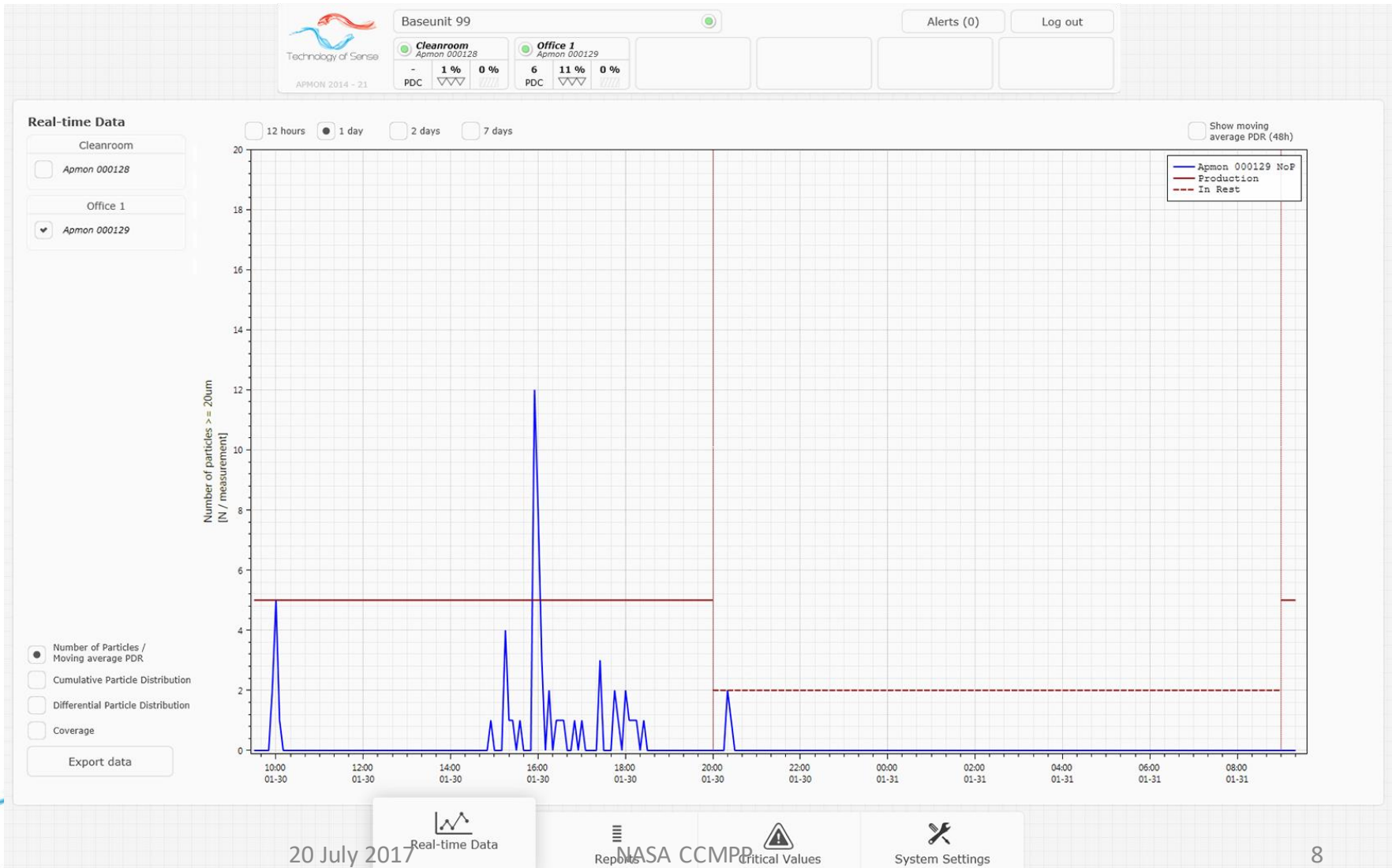


Real-time particle deposition monitoring data

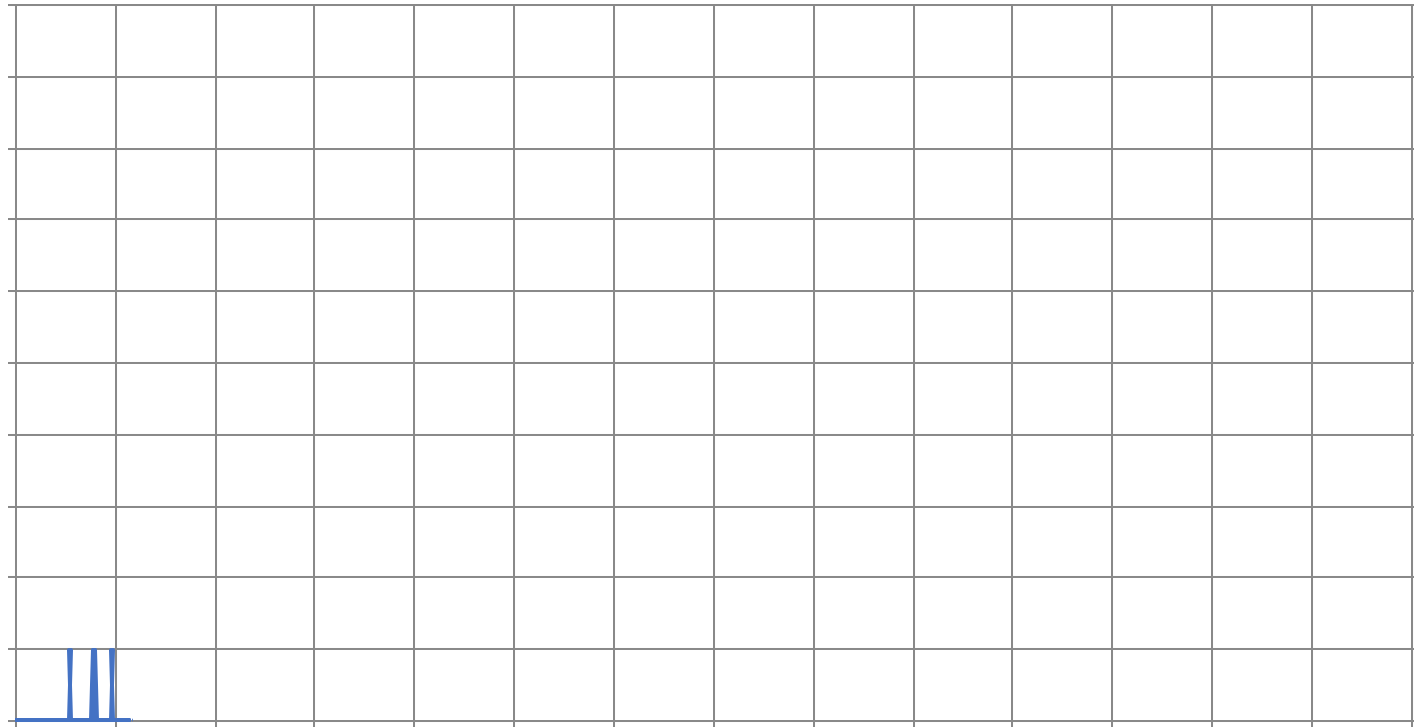
- Number of particles in time
- Obscuration (coverage) increase in time
- Particle size distribution
- Obscuration vs particle size
- Relation with operational factors:
 - Entry of people, good and equipment
 - Discipline and working methods
 - Cleaning
- Particle obscuration rate to be used in risk assessment
- Particle deposition rate to be used in risk assessment



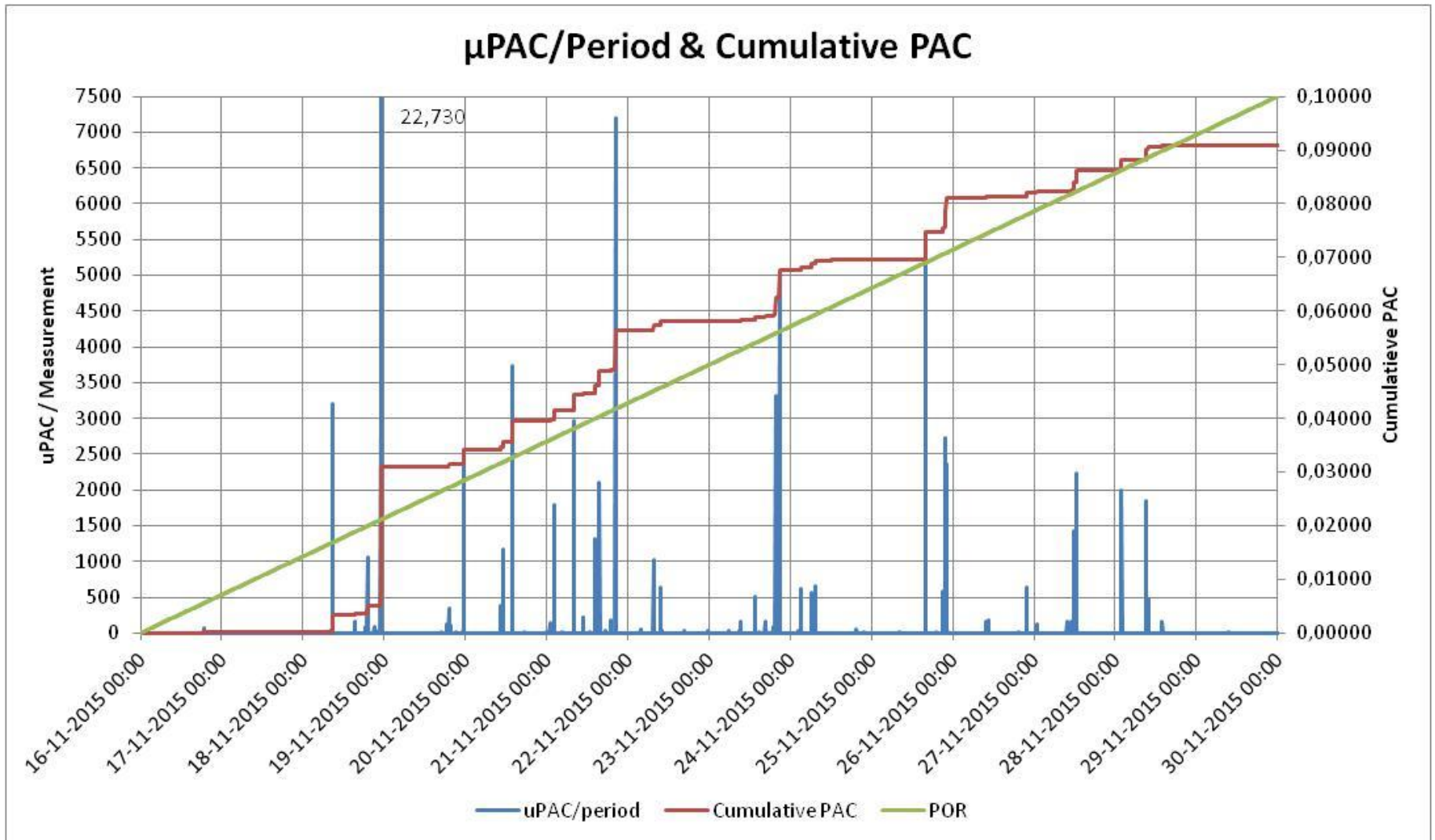
Number of particles > 15 μm per 5 minutes



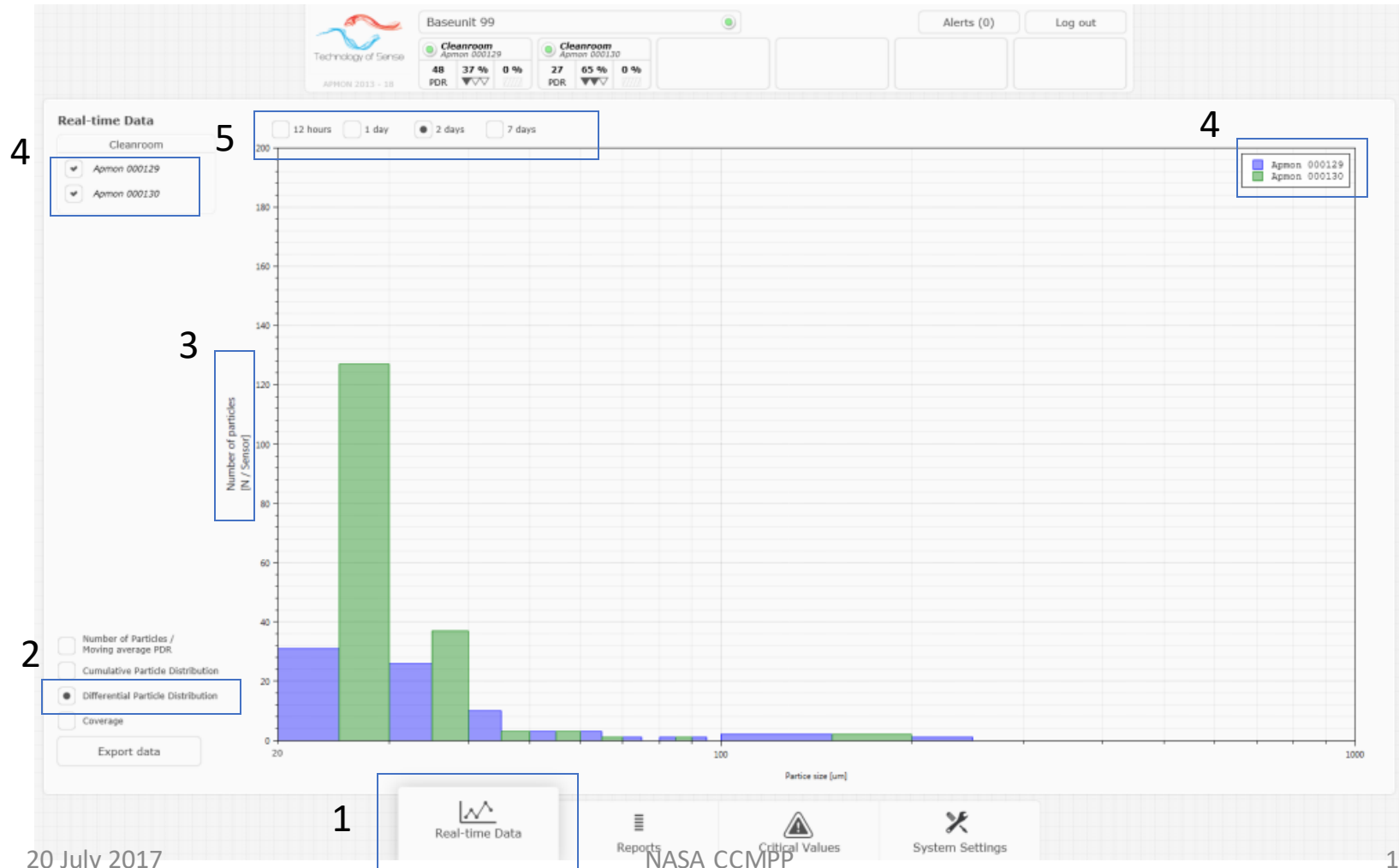
Real-time particle deposition



Real-time obscuration

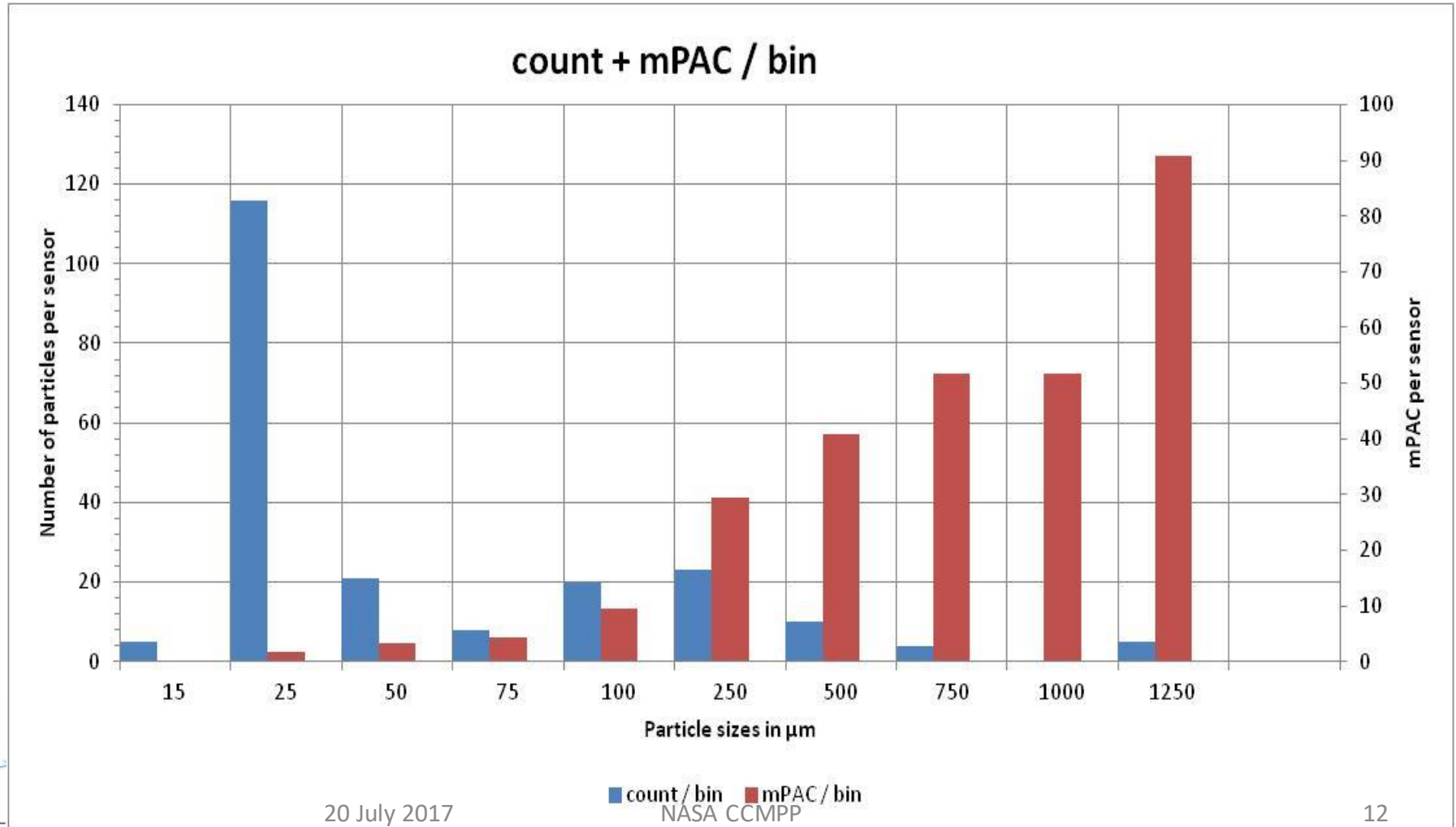


Differential Particle Distribution, Real-time data

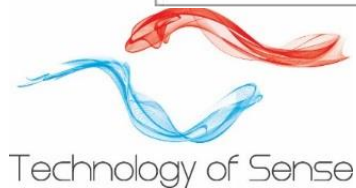
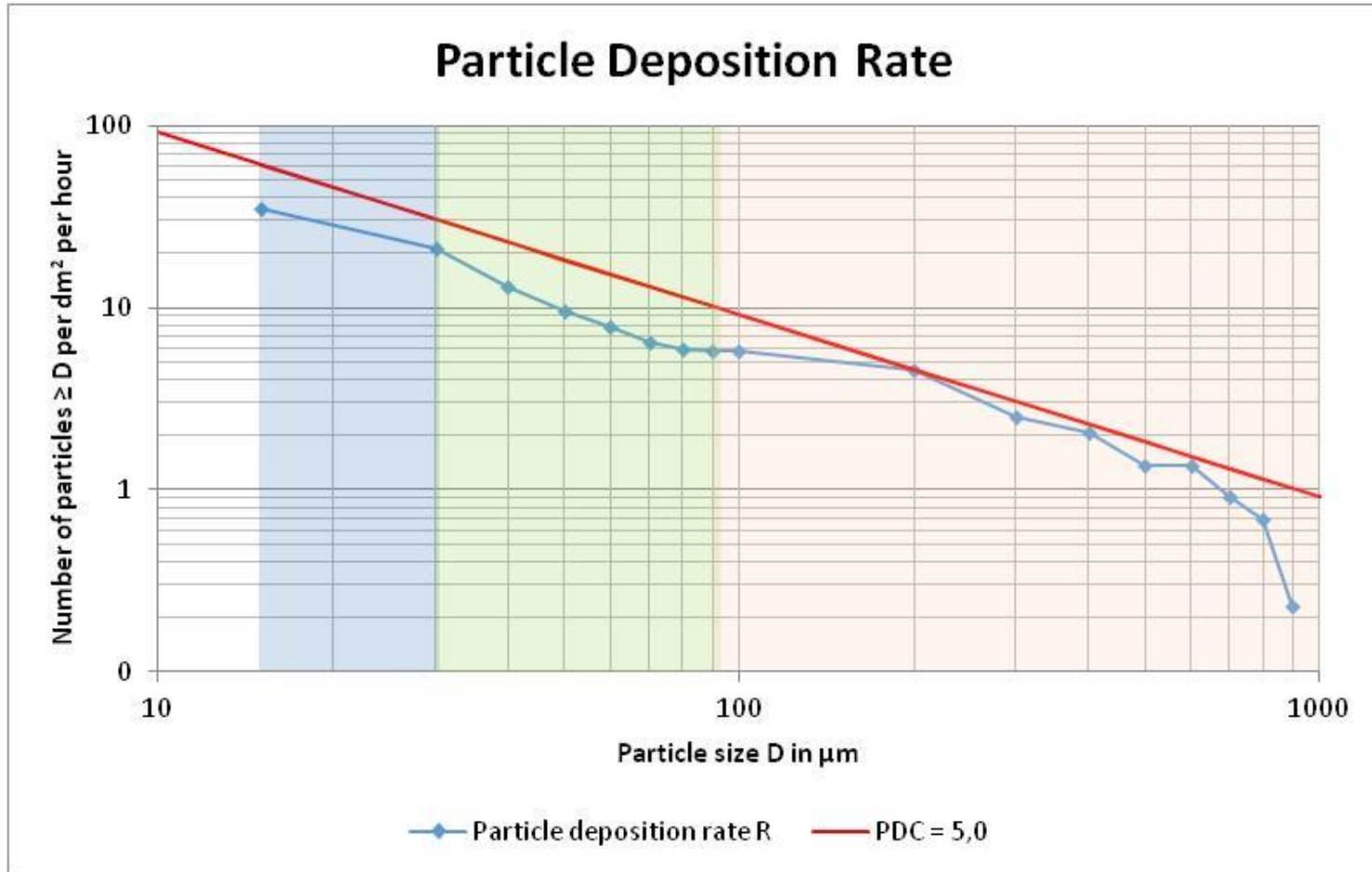


Particle size distribution

Differential particle and obscuration distribution



Particle Deposition Rate in a PDR 1 000 cleanroom

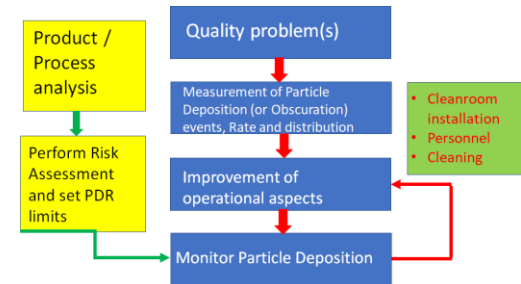


PDR 1.000 means 100 particles $\geq 10 \mu\text{m}$ or 20 particles $\geq 50 \mu\text{m}$ or 10 particle $\geq 100 \mu\text{m}$ per dm^2 per hour

Risk Assessment

Particle Deposition Rate **PDR** in number of particles $\geq 25 \mu\text{m}$ per m^2 per hour

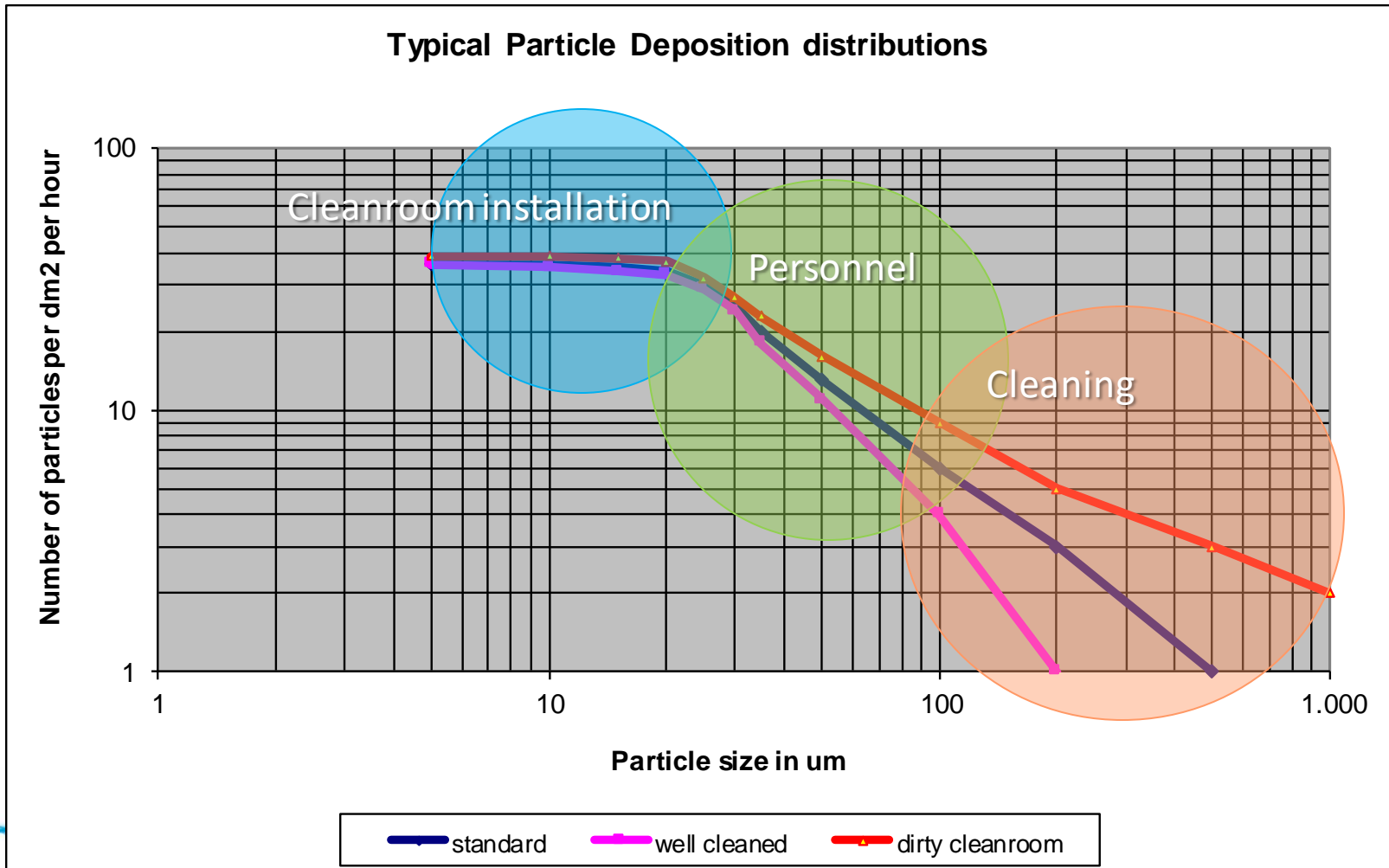
- Deposited particles $\geq 25 \mu\text{m} = \text{PDR} * A * T$
- Product area A in m^2
- Time of exposure T in hours



Particle Obscuration Rate **POR** in PAC or ppm per hour

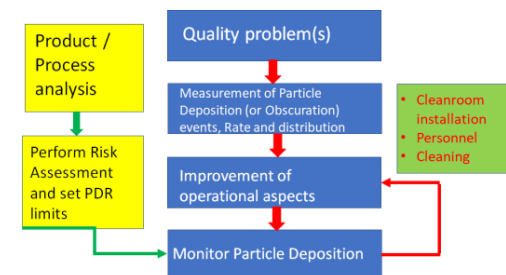
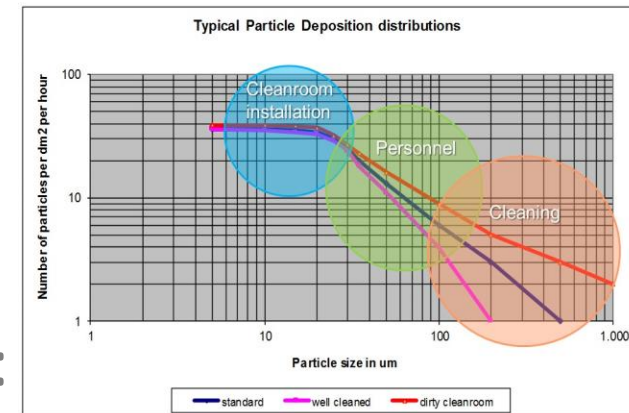
- 1 PAC = 10 000 ppm (μm^2 per mm^2 or mm^2/m^2)
- Particle Fall Out or Obscuration = $\text{POR} * A * T$

Cumulative size distribution of deposited particles



Relation with operational factors

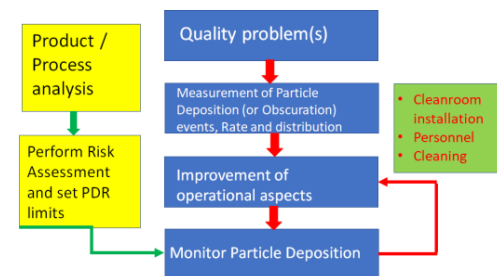
- **< 30 μm** : impact of cleanroom installation
- **30-100 μm** : impact of people and logistics:
 - Number of people
 - Garments and changing procedures
 - Discipline and working methods
 - Transfer of goods
- **> 100 μm** : impact cleaning program:
 - Cleaning of large surfaces by cleaners
 - Cleaning of workplaces tools and equipment by operators
 - Cleaning of incoming goods



Improve Operational Quality

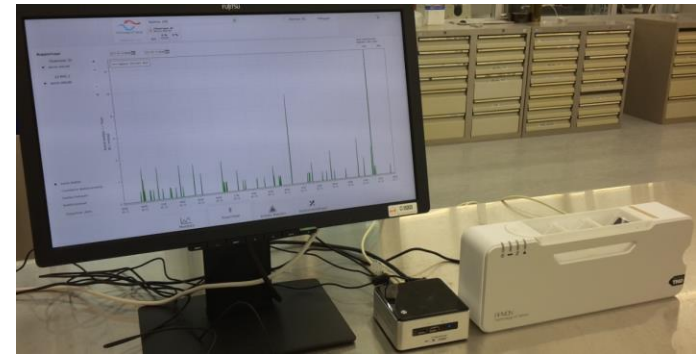
Improve impact cleanroom operation:

- Reduce number of people and/or
- Quality garments, changing procedure and discipline
- Transfer of goods into cleanroom
- Cleaning by cleaners
- Cleaning by operator
- Remove unnecessary surfaces
- Make personnel aware of their impact
- *See presentation Koos Agricola*



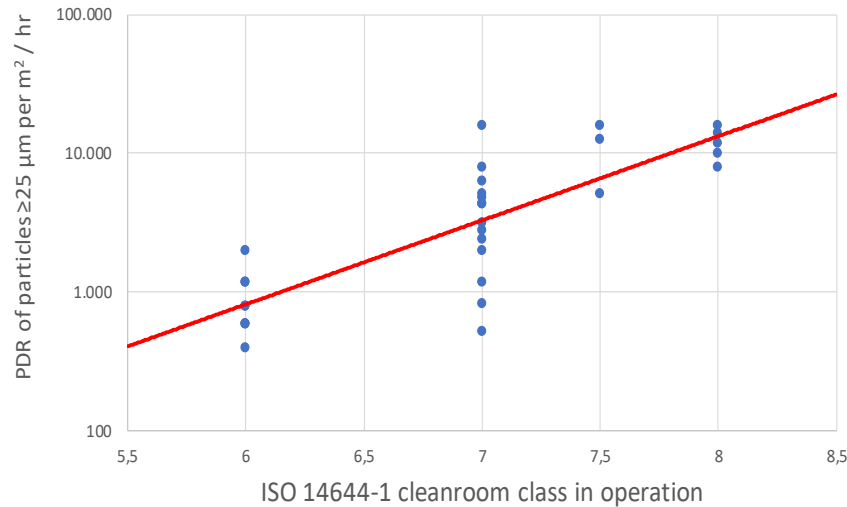
APMON field experiences

- Cleanrooms with operators/personnel
- ISO 5-8 in operation
- Fed Std 100 to 10 000 in operation
- Observed important factors
 - Number of people
 - Garment use (type and frequency)
 - Entry procedures for people and goods
 - Cleaning program (methods and frequencies)
 - Working methods
- In almost all cases particle deposition was much higher than expected!



Industries

Comparison of Particle Deposition Rate (PDR) data with cleanroom classes



APMON data by Technology of Sense

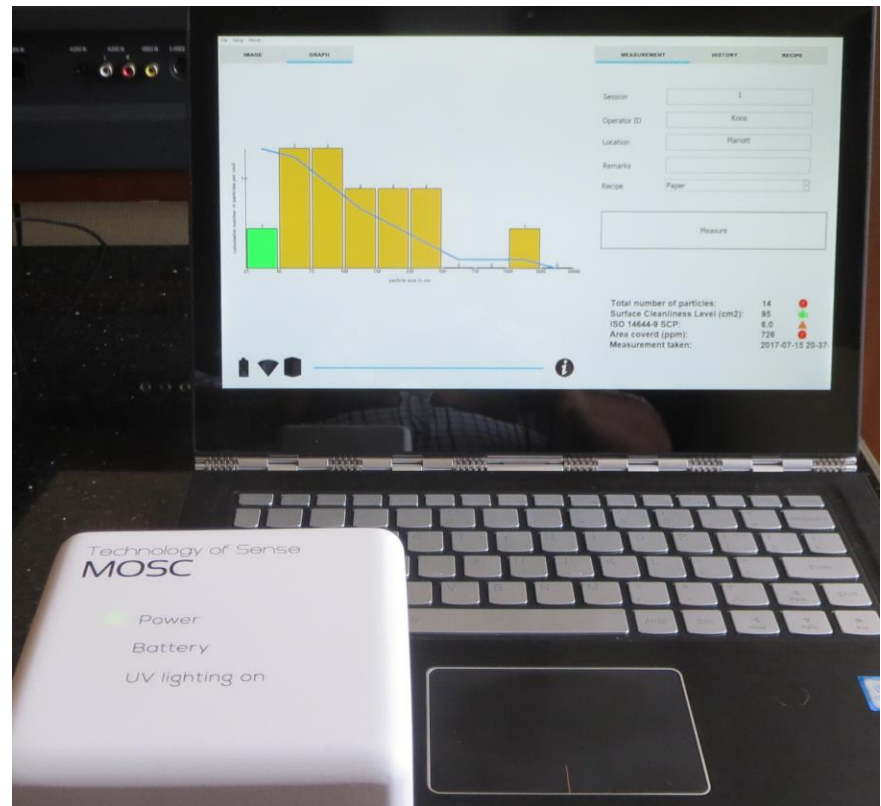
Industry	Country	Particle Deposition Rate of Particles ≥ 25 μm/m ² /hr	ISO 14644-1 class (ISO 5=FS class 100)
Displays	South Korea	400	6
Technical products	Switzerland	520	7
Technical products	Netherlands	600	6
Technical products	South Korea	600	6
Technical products	Netherlands	600	6
Displays	Netherlands	800	6
Electronics	South Korea	800	6
Measuring room	United Kingdom	840	7
(Aero)space industry	Netherlands	1.200	7
Displays	South Korea	1.200	6
Optical products	Germany	1.200	6
Medical products	Germany	2.000	6
(Aero)space industry	Switzerland	2.000	7
Electronics	USA	2.400	7
Electronics	Switzerland	2.800	7
(Aero)space industry	USA	3.200	7
Electronics	Germany	4.400	7
Displays	South Korea	4.400	7
Medical products	United Kingdom	4.800	7
Medical products	Germany	5.200	7
Technical products	USA	5.200	7,5
Electronics	USA	6.400	7
Particle accelerator	Germany	8.000	7
Automotive industry	Germany	8.000	8
Automotive industry	United Kingdom	10.000	8
Automotive industry	Germany	12.000	8
Medical products	Netherlands	12.800	7,5
Automotive industry	Germany	14.000	8
Technical products	Taiwan	16.000	7,5
Electronics	Germany	16.000	8
Electronics	Thailand	16.000	7



20 July 2017

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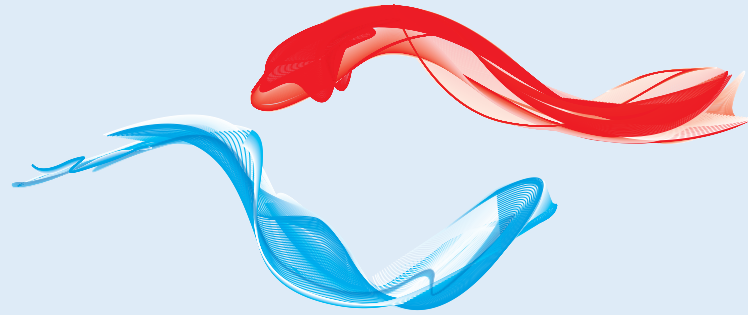
- Focus on operational quality of cleanrooms
- Monitoring
 - Surface cleanliness
 - MOSC
 - Particle deposition
 - APMON
 - APMON PRO



The APMON demonstrates the impact of cleanroom use

- Determining contamination risk at various locations:
 - Improve operational quality
 - Reduce exposure
- Investigation of operational aspects on particle deposition rate
- Investigation working methods
- Determining cleaning frequency
- Setting PDR / POR limits
- Monitoring
- Creating personnel awareness





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Monitoring Operational Quality in Cleanrooms

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