Powder Coating with Advanced Electrostatic Fluidized Bed Technique Using Pulsed Corona Charging

Markus Cudazzo, Karlheinz Pulli,
Ulrich Strohbeck, Qiaoyan Ye

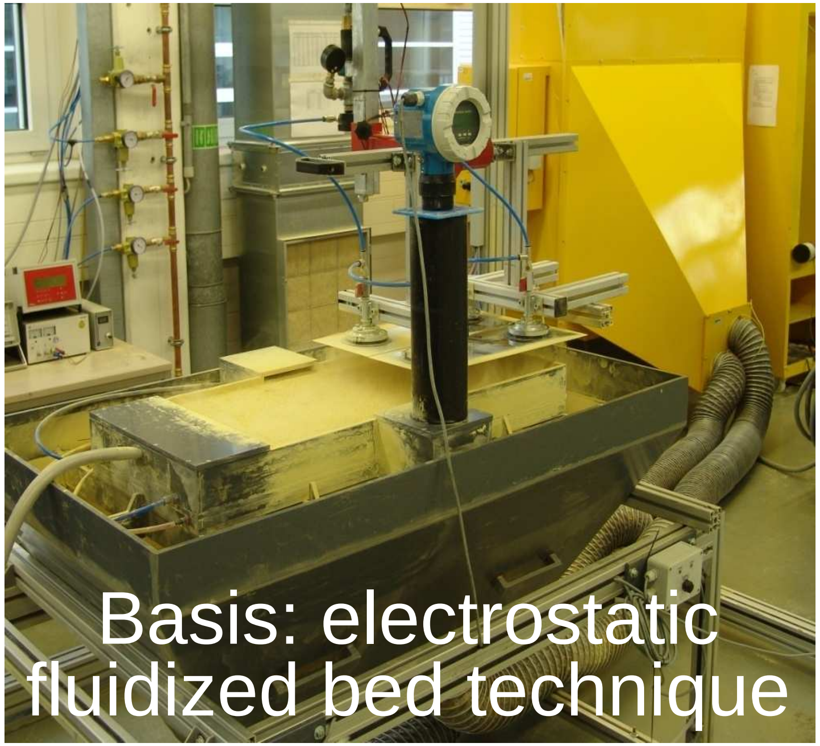
Fraunhofer Institute for Manufacturing Engineering and Automation IPA
Stuttgart, Germany

Fraunhofer
IPA

Applied research at IPA Department of coating technology

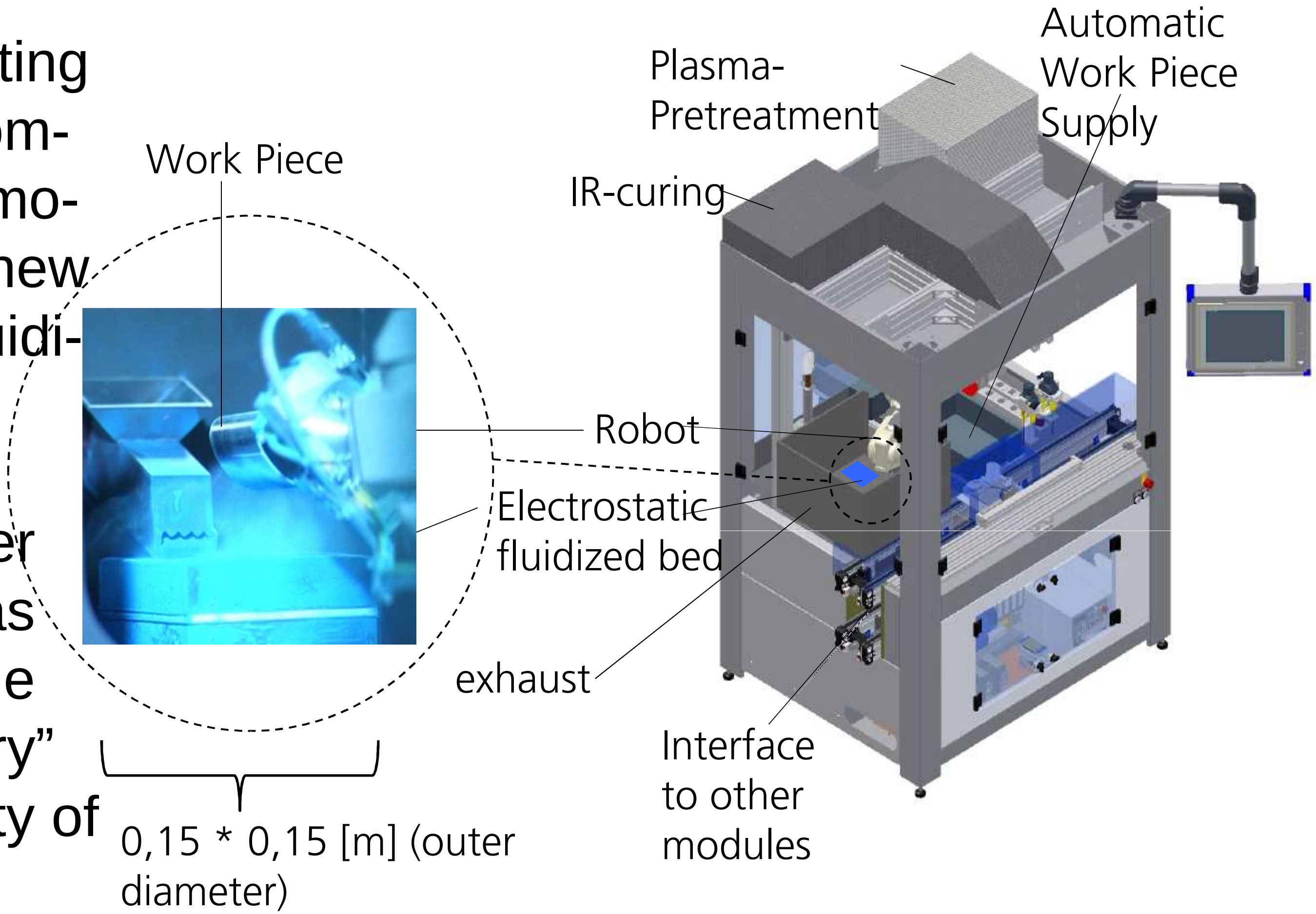
TransApp-technique without spray guns

- Extremely compact
- Suitable for flat parts as well as for several 3-dimensional parts
- Line speed up to 3 m/s
- Marginal overspray and powder segregation
- Compressed air consumption and exhaust air < 1/3 compared to powder coating with spray guns
- Quick color changes



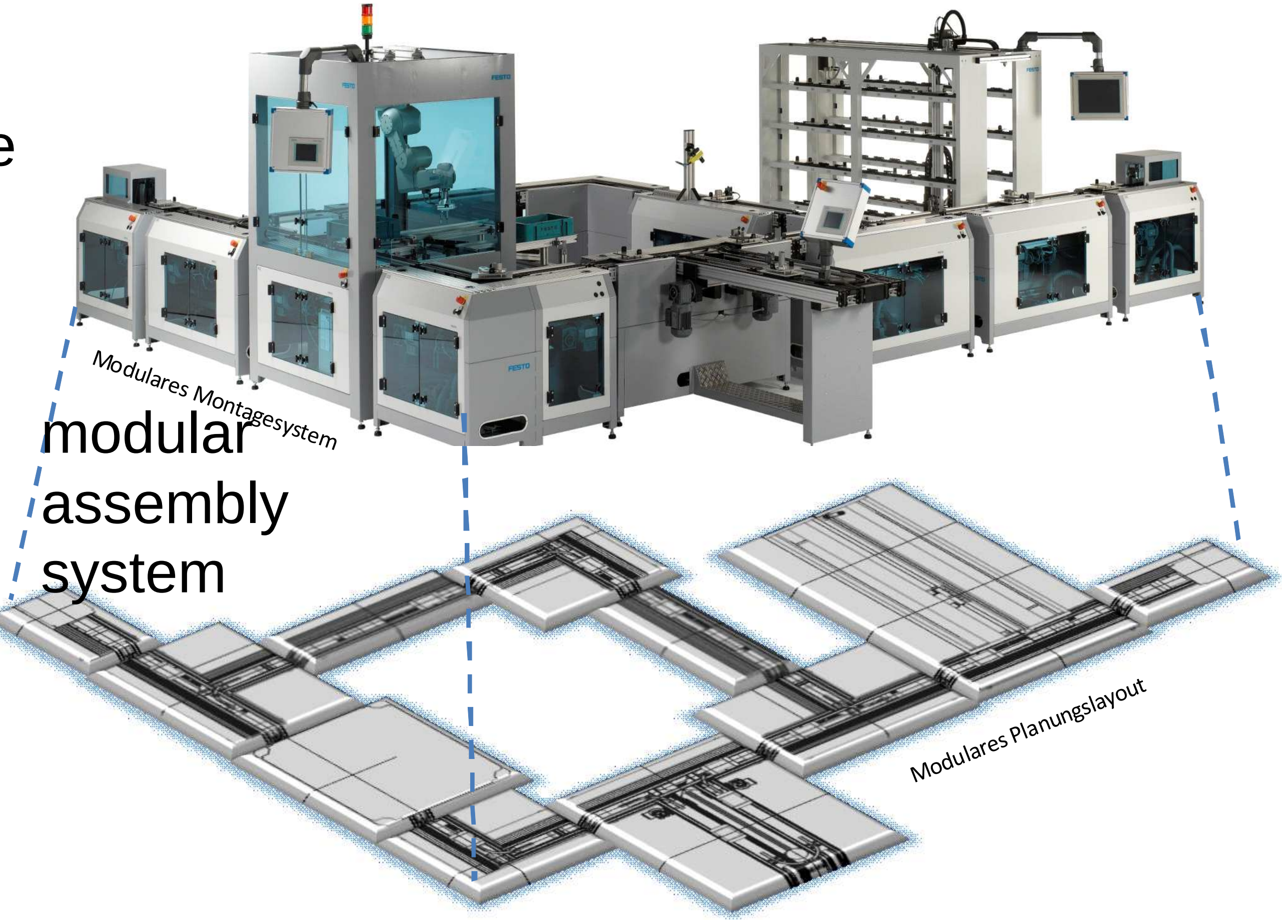
TransApp-technique without spray guns

For demonstrating the extreme compactness and modularity of the new electrostatic fluidized bed technique, a modular powder coating unit was integrated in the “learning factory” at the University of Stuttgart.



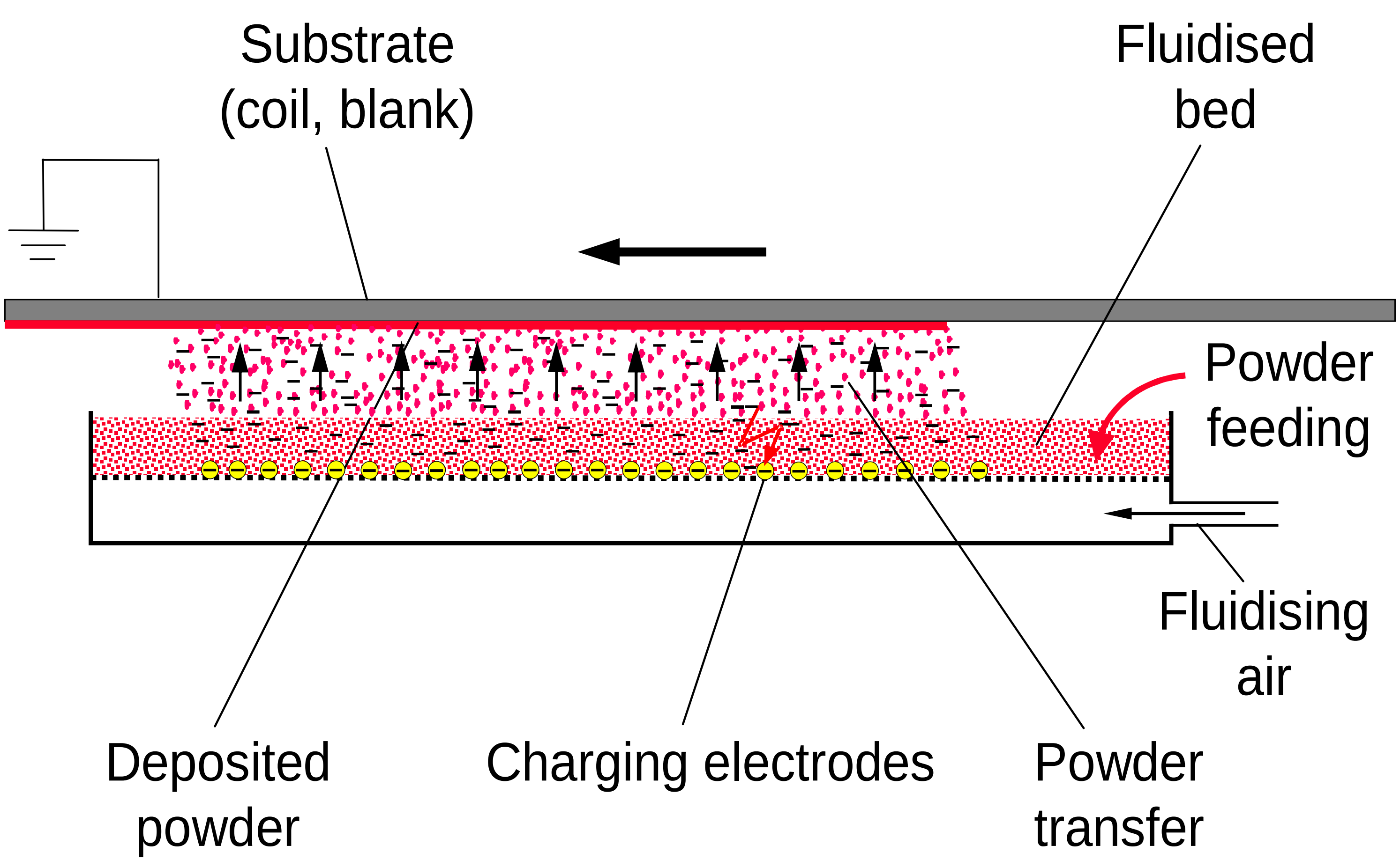
TransApp-technique without spray guns

The reconfigurable “learning factory“ was expanded by a modular powder coating unit based on the electro-static fluidized bed technique



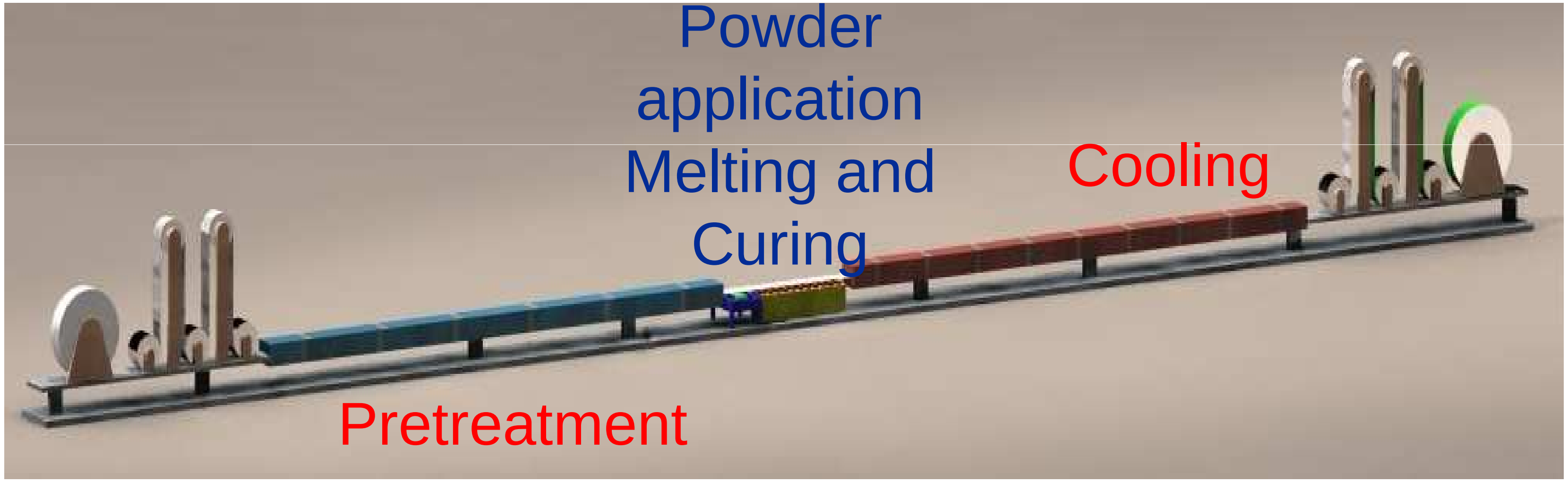
TransApp-technique without spray guns

TransApp-technique without spray guns



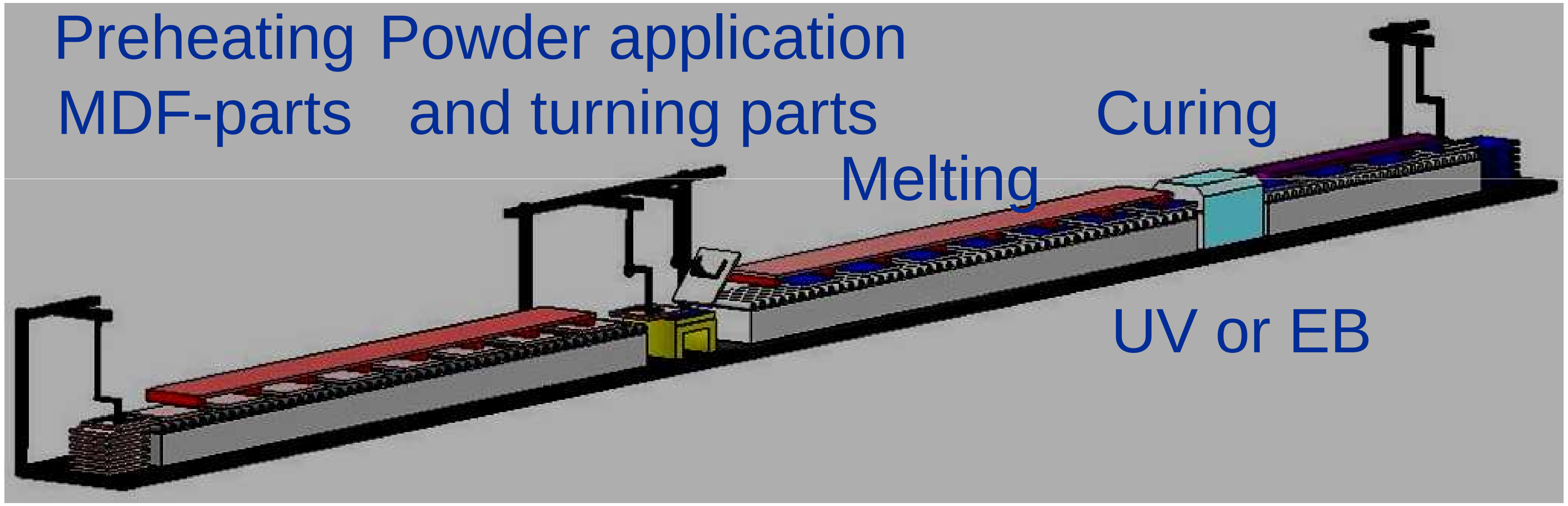
Future Options: High speed powder coating on 2 D parts

Schematic layout of a high speed (> 1 m/s) powder **coil coating** process without spray guns (thermosetting coating powders)



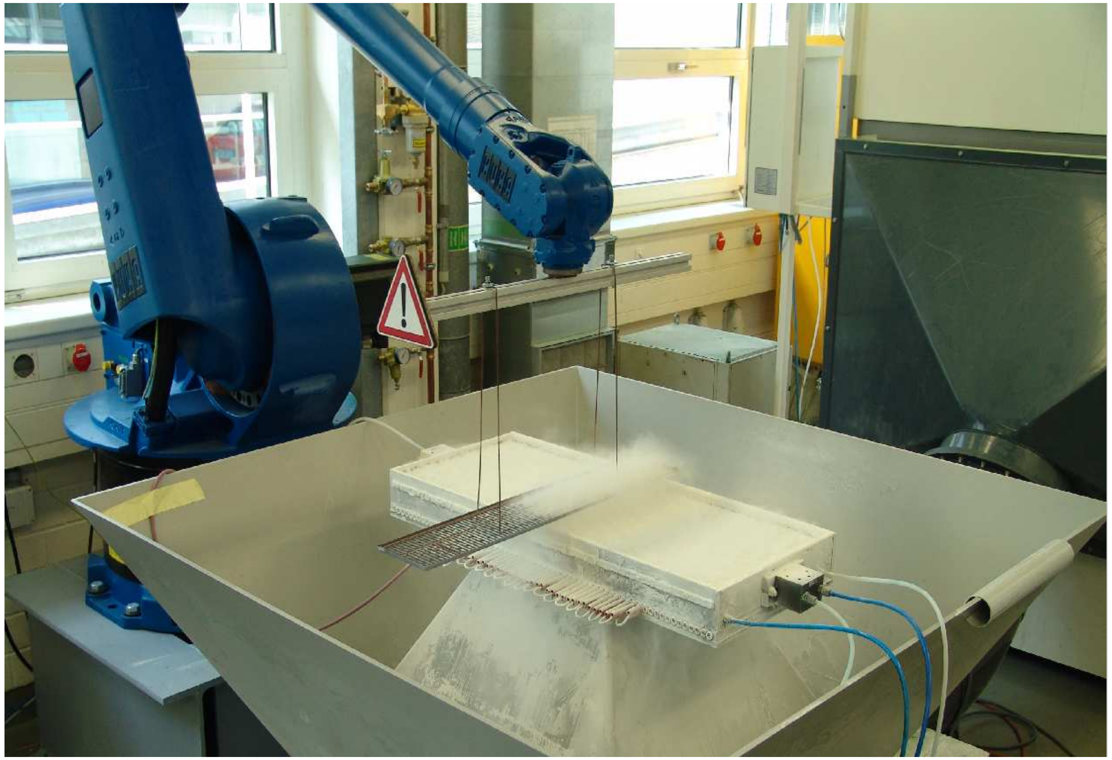
Future Options: High speed powder coating on 2 D parts

Schematic layout of a high speed (> 1 m/s) powder coating process without spray guns (UV- or EB-powders) for **MDF-parts**



Future Options: Compact powder coating on 3 D parts

Trials in the IPA test facility (> 1 m/s) for powder coatings without spray guns (thermosetting coating powders) for **radiator-parts**



Future Options: Compact powder coating on 3 D parts

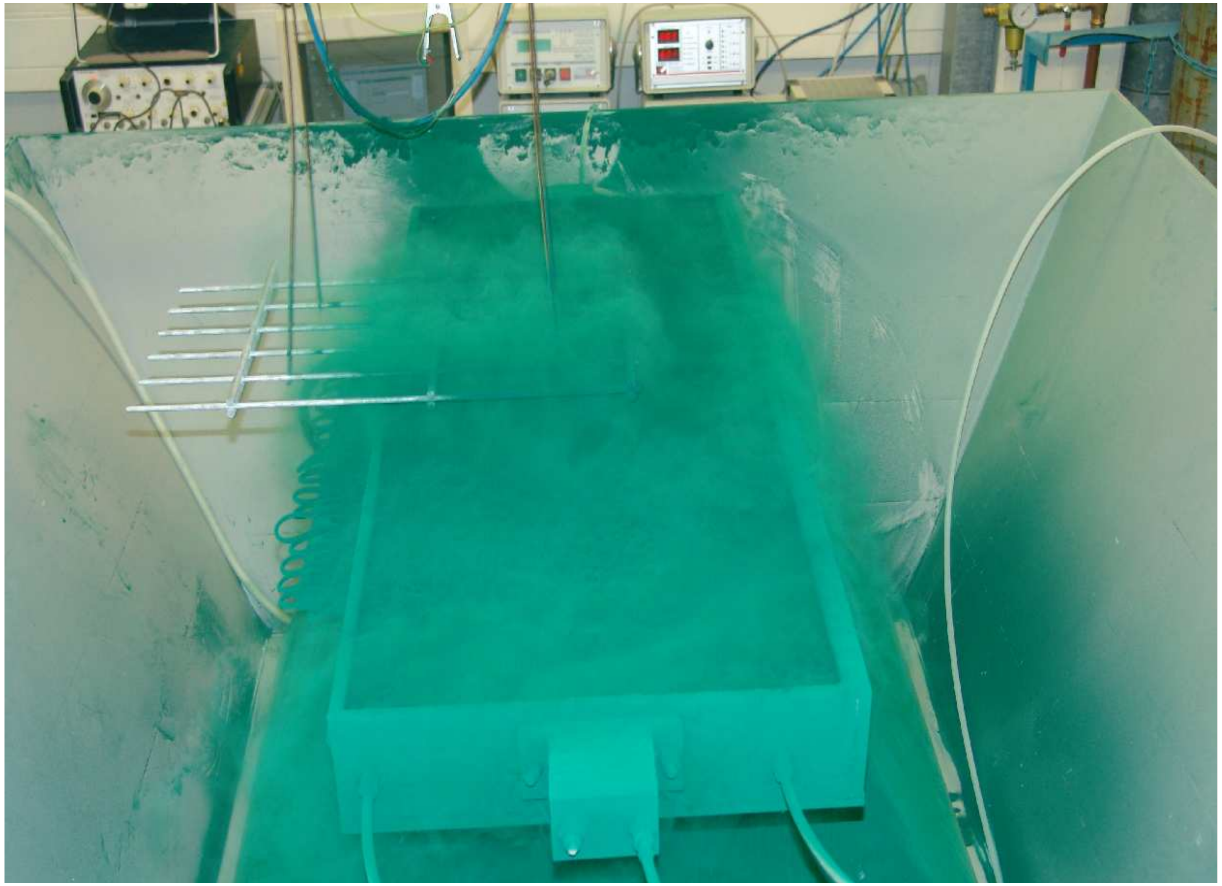
Trials in the IPA test facility for powder coatings without spray guns (thermosetting coating powders) for **helical springs**

Rotation
over
fluidized bed

Future Options: Compact powder coating on 3 D parts

Trials in the IPA test facility for compact powder coatings without spray guns (thermosetting coating powders) for **zinc-plated fences**

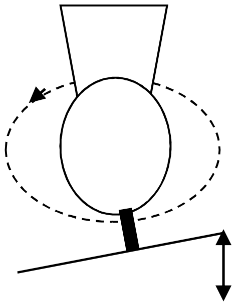
Good penetration into faraday cages

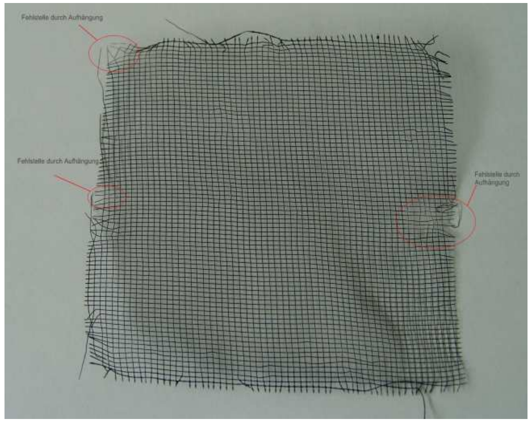


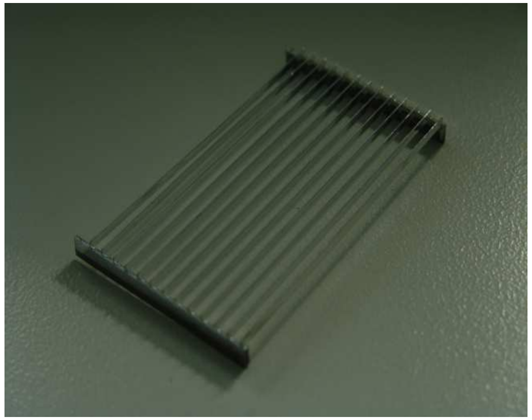
Future Options: Compact powder coating on 3 D parts

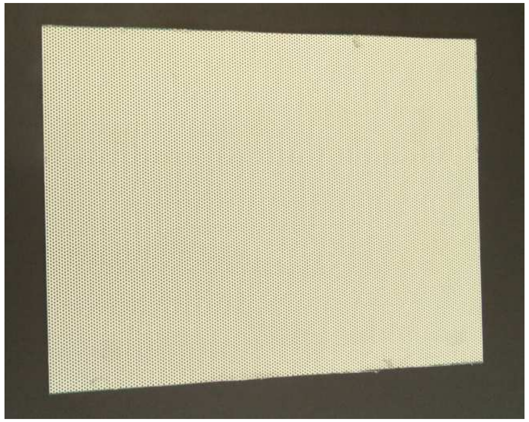
Trials in the IPA test facility for compact powder coatings without spray guns (thermosetting coating powders) for **supporting tissues**, **coverages** or **perforated plates**

Tumbling motion
over
fluidized bed



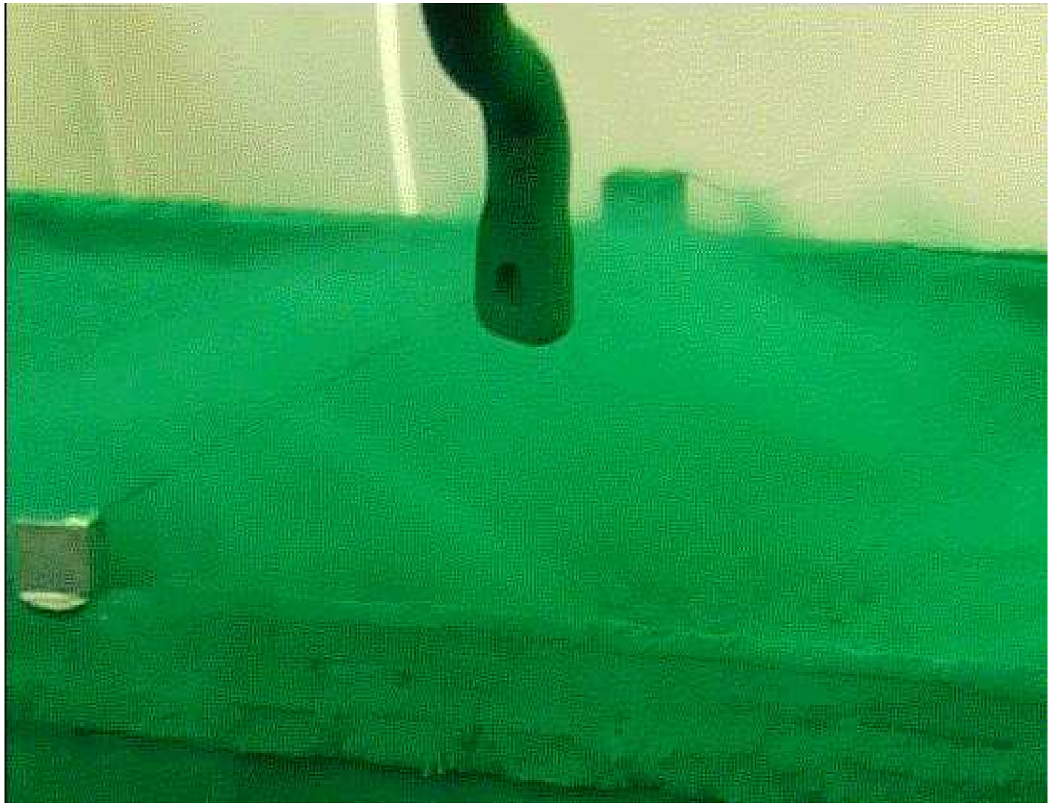






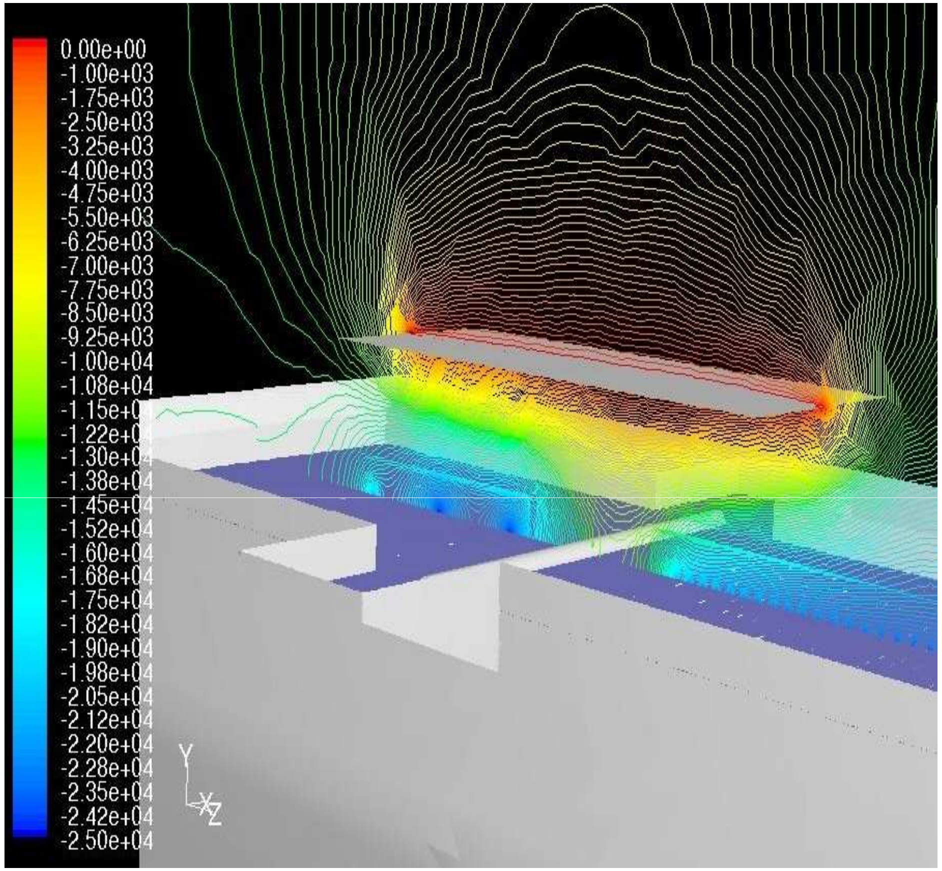
Future Options: Compact powder coating on 3 D parts

Trials in the IPA test facility for compact powder coatings without spray guns (thermosetting coating powders) for **stabilizers**



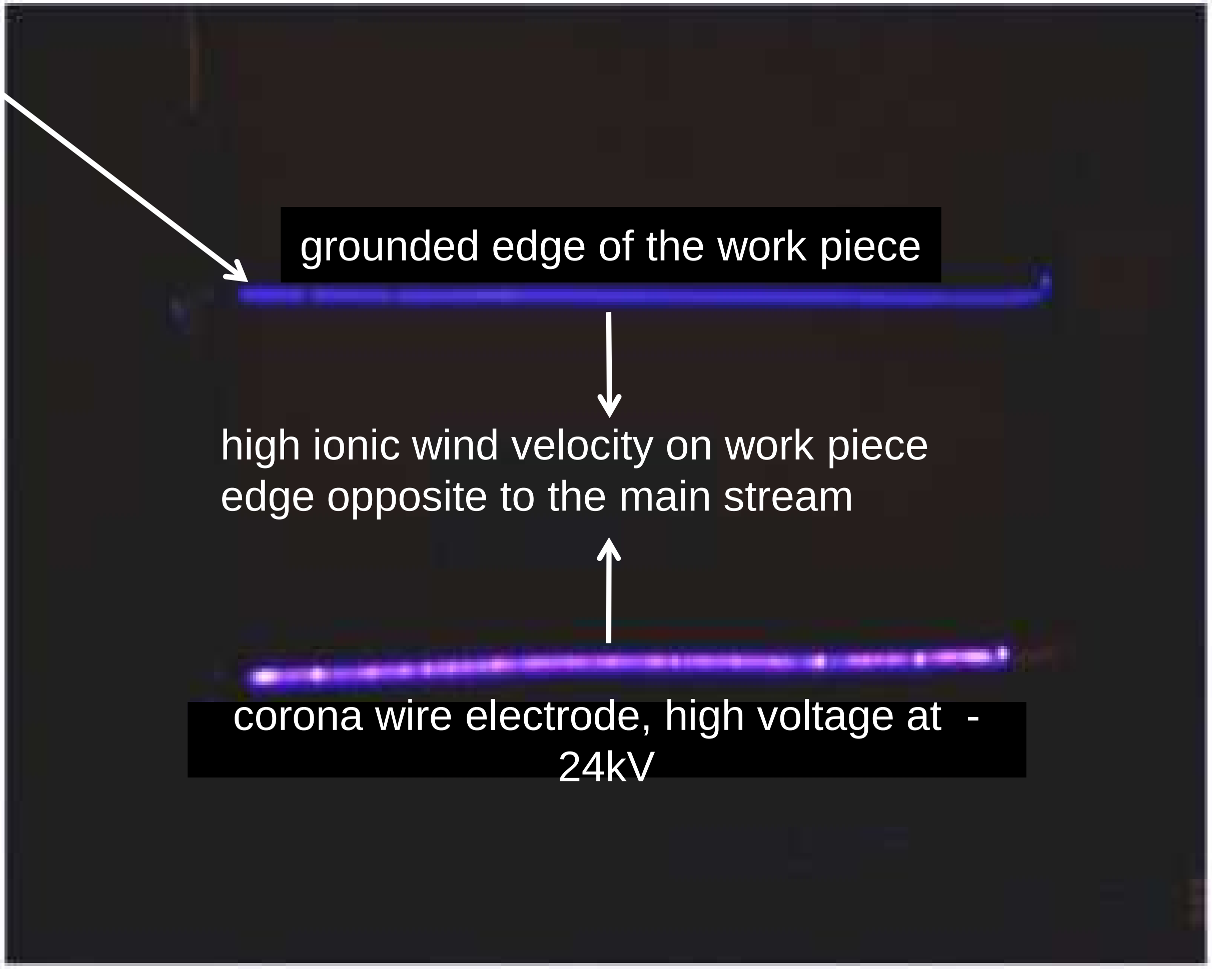
Improvement of the TransApp technique

Optimization of the charging electrodes configuration in the electrostatic fluidized bed by using computer simulation (Fluent)



Improvement of the TransApp technique

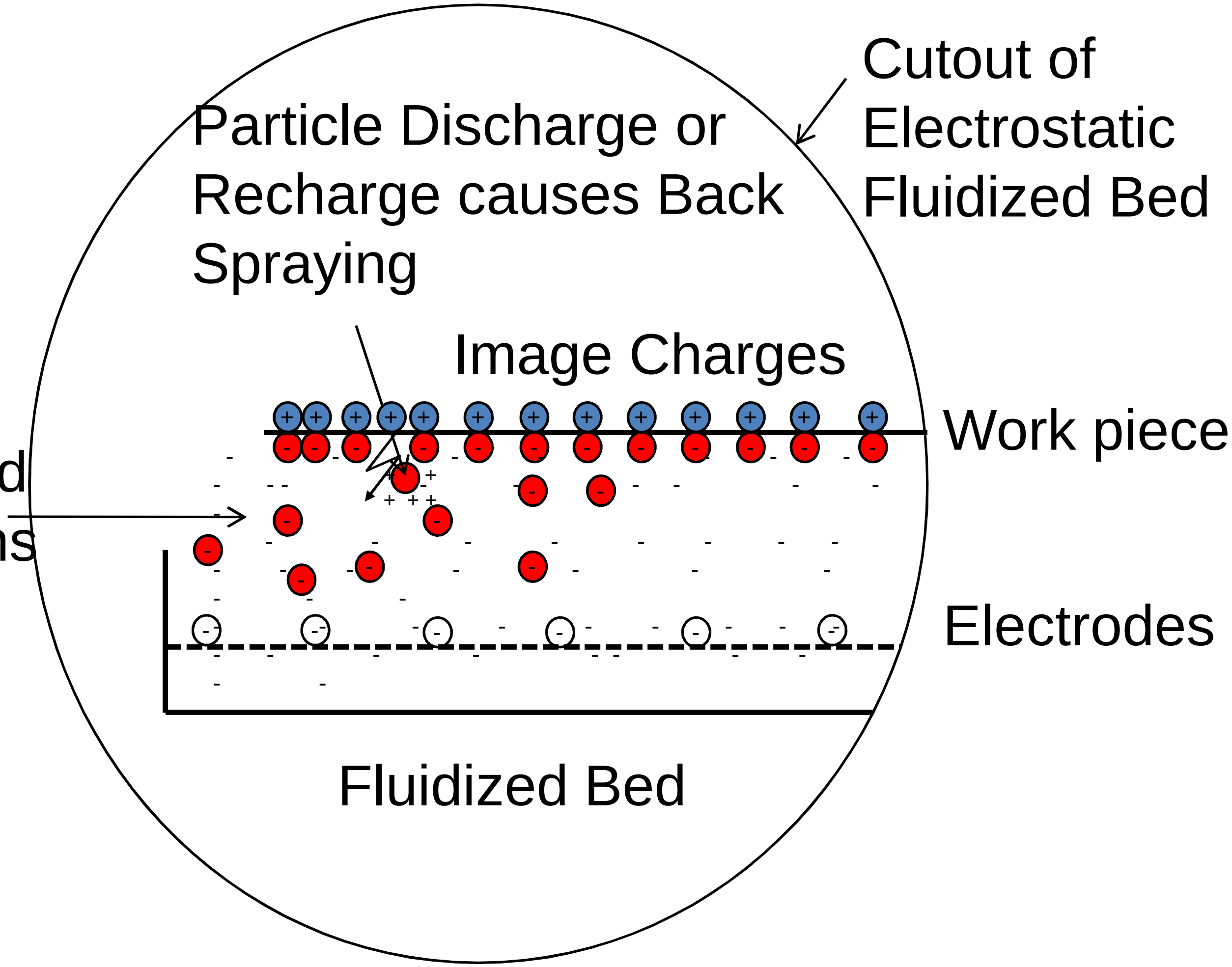
Opposite Corona avoids the Appli-cation of Powder at Workpiece Edges



Improvement of the TransApp technique

Back Spraying tends to high orange peel after powder curing

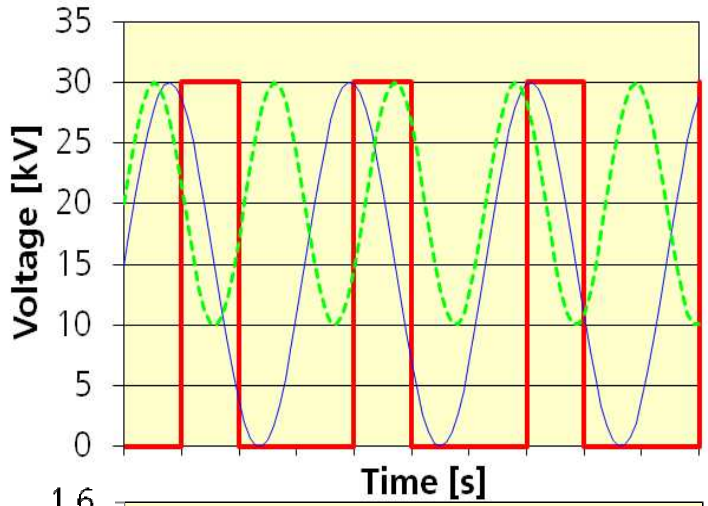
Negatively charged powder and air ions

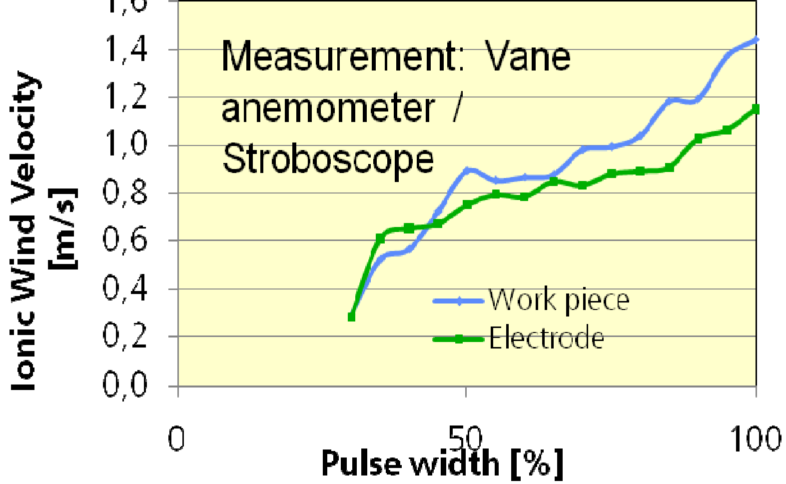


Improvement of the TransApp technique

Best practice to improve edge coating for a better film thickness constance: Use of pulsed high voltage (Rectangle signals with control variable pulse width to minimize ionic wind effect)

Cheapest way to realize rectangle signals: use of a High-voltage series switch

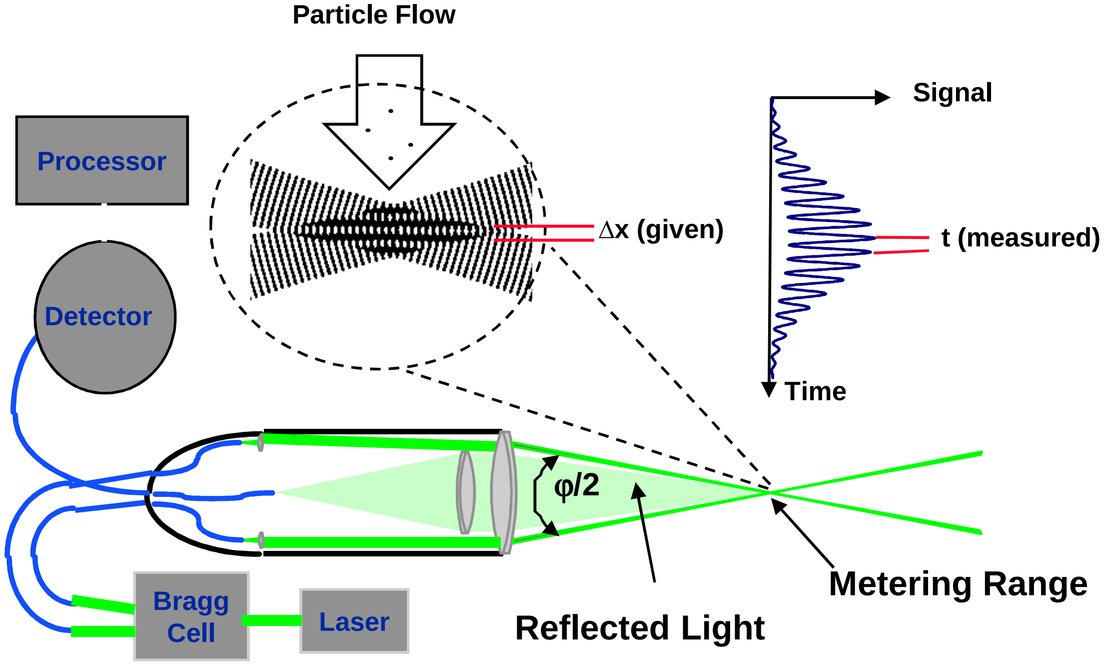




Improvement of the TransApp technique

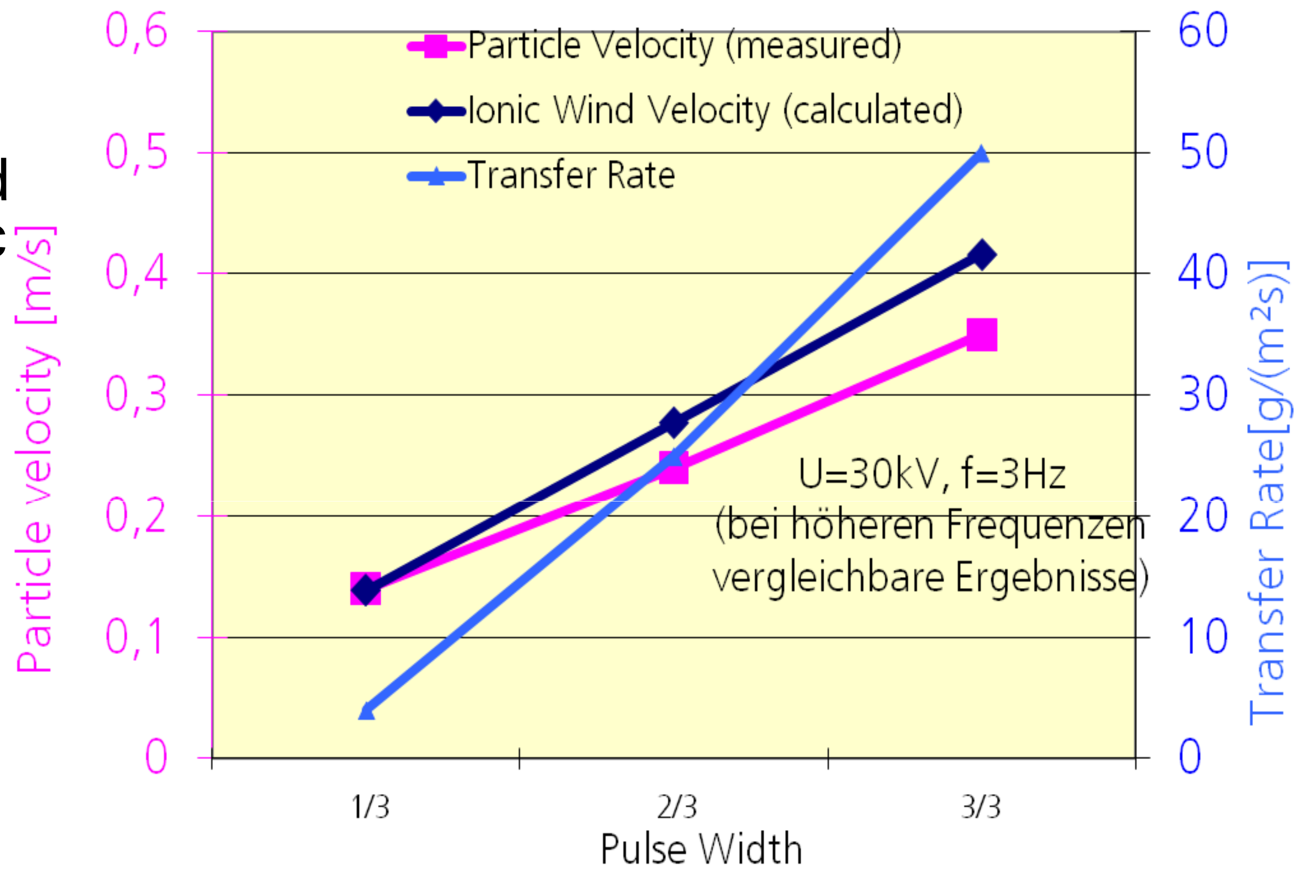
Results of Laser Doppler-Anemometry for measuring the Particle Velocity are based on particle numbers

$$v_P = \frac{f_D \lambda}{2\sin\varphi}$$



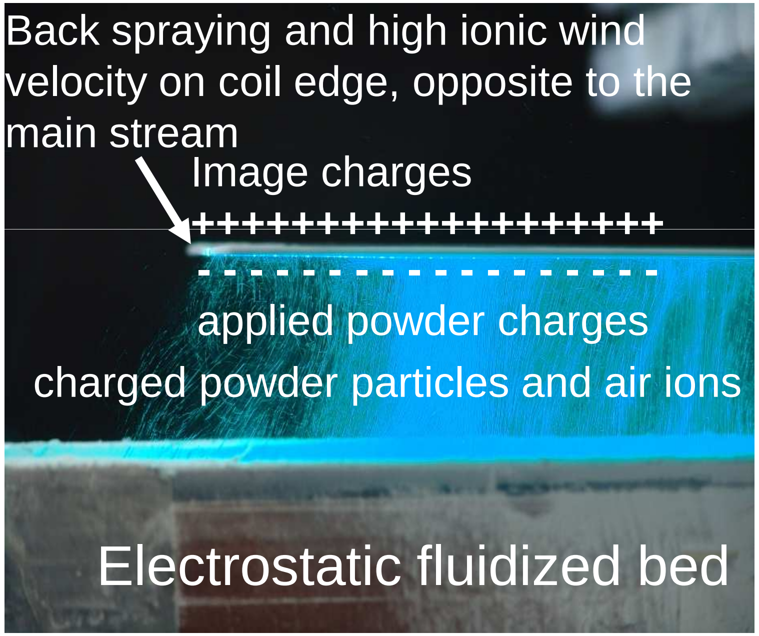
Improvement of the TransApp technique

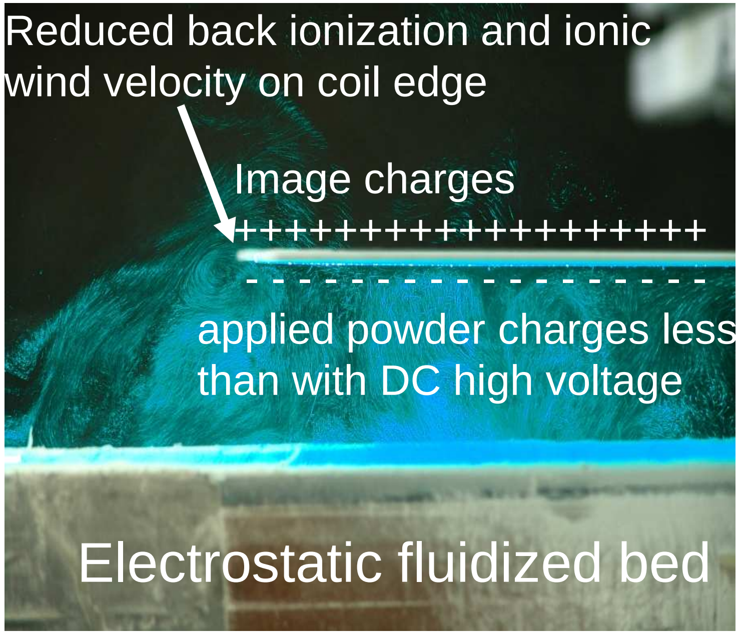
Particle Velocity measured by Laser Doppler-Anemometry and (calculated) Ionic wind velocity are correlating



Improvement of the TransApp technique

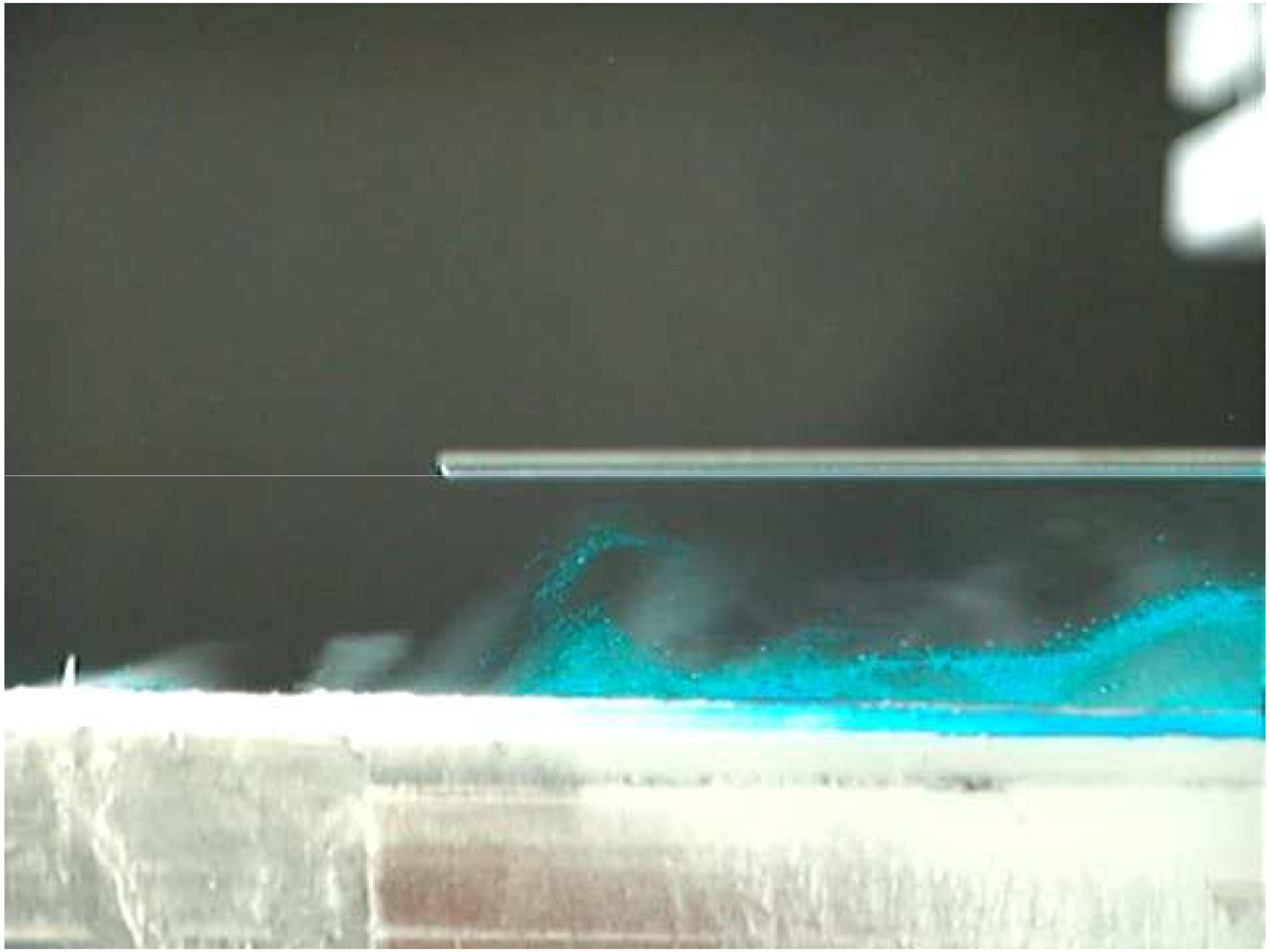
Improving the powder deposition on the coil edge by using pulsed high voltage (picture right) instead of DC high voltage (left); developed in laser light-section





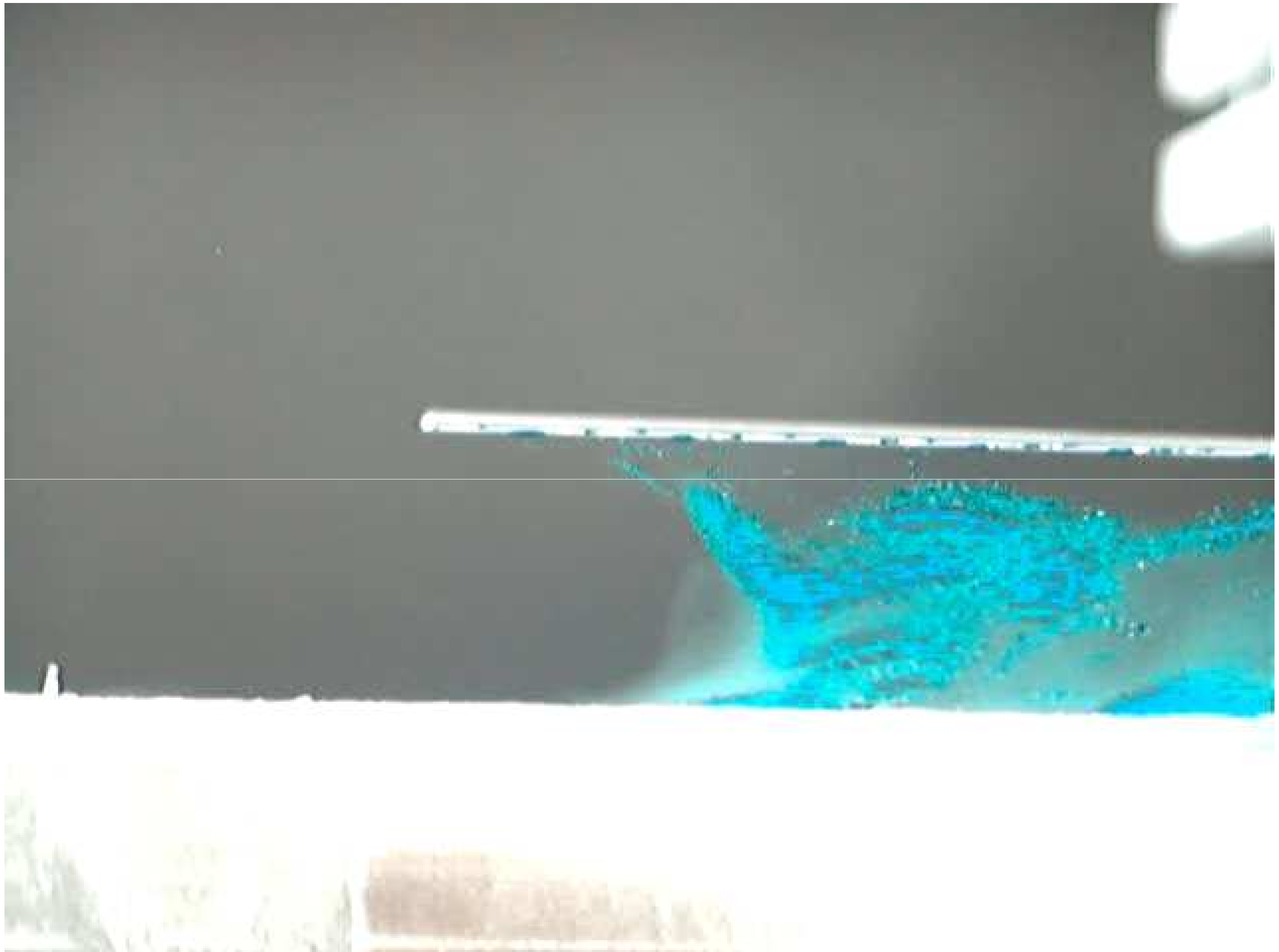
Improvement of the TransApp technique

DC



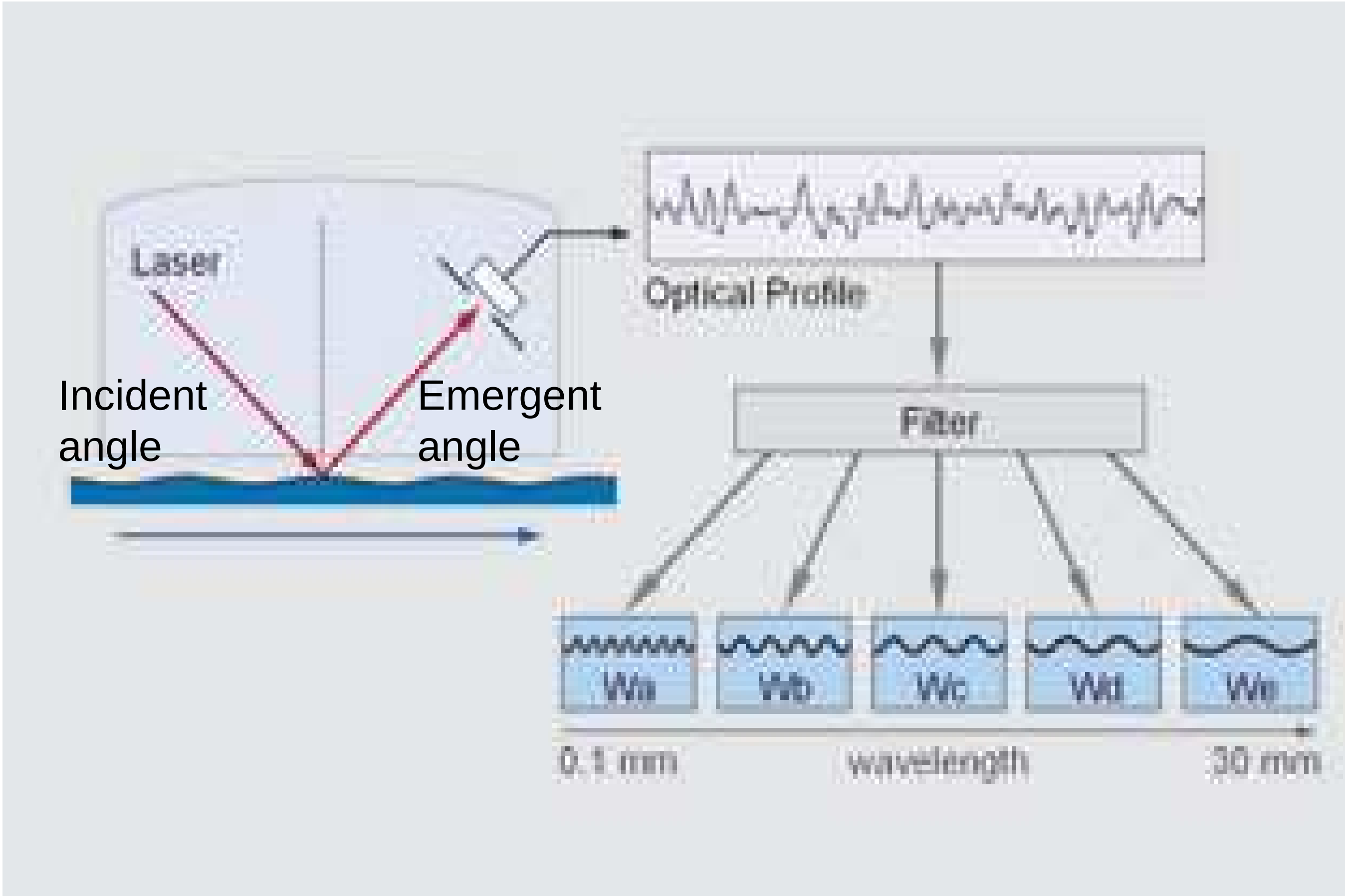
Improvement of the TransApp technique

Pulsed high voltage



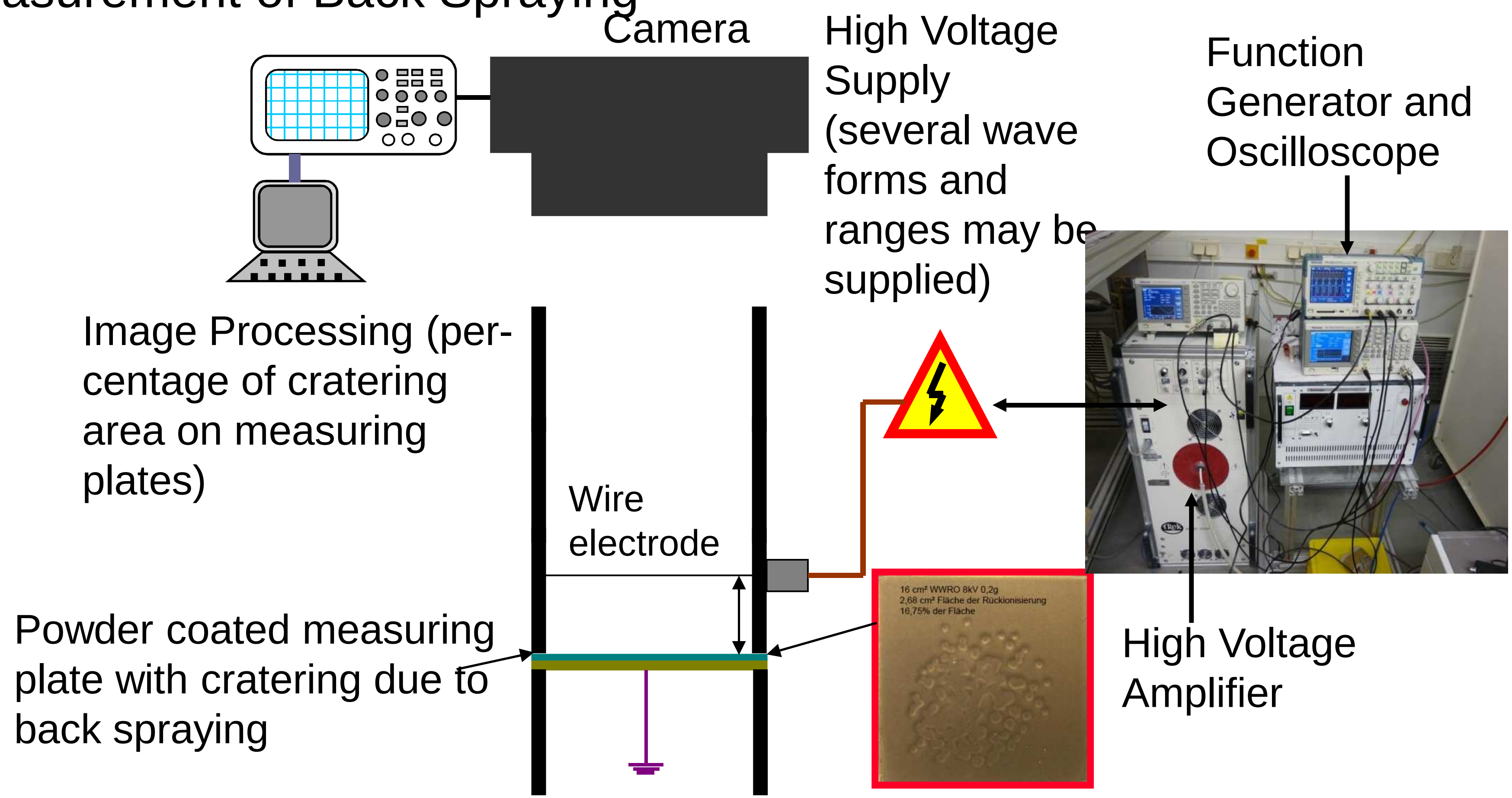
Improvement of the TransApp technique

Orange peel measured by laser optical measurement (Wave Scan)



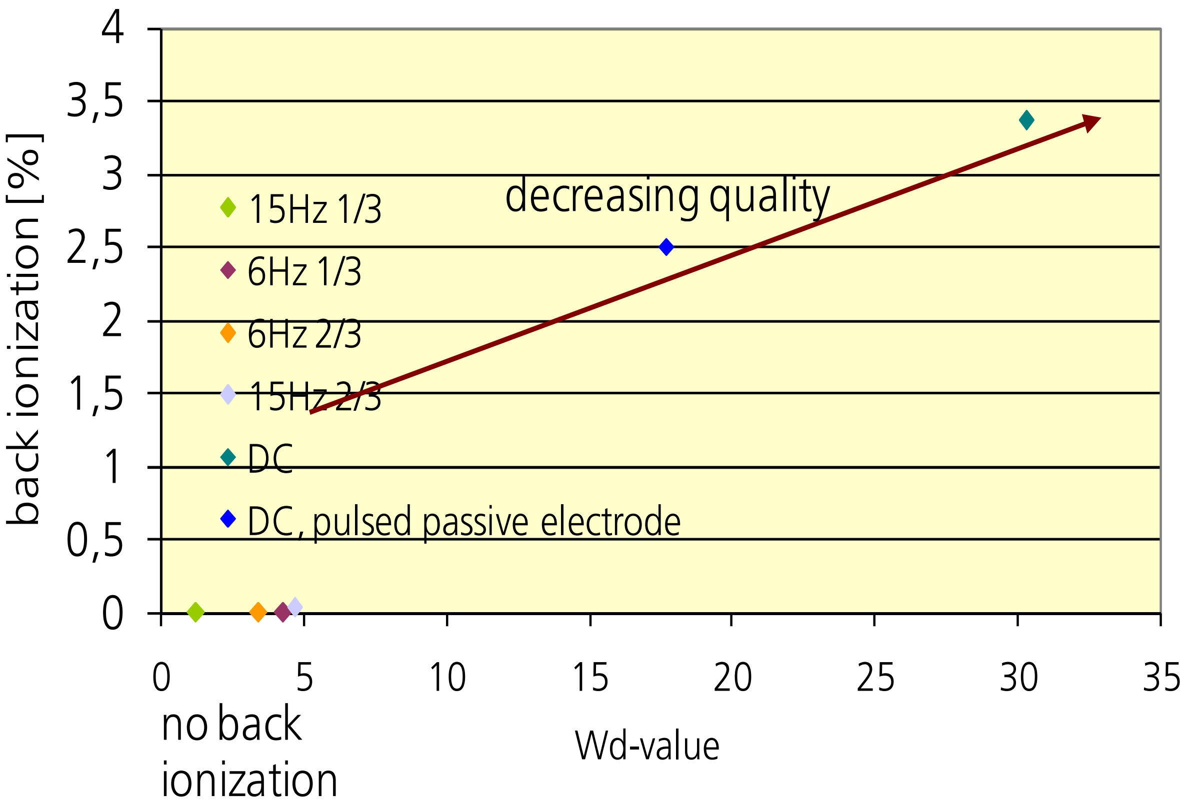
Improvement of the TransApp technique

Measurement of Back Spraying



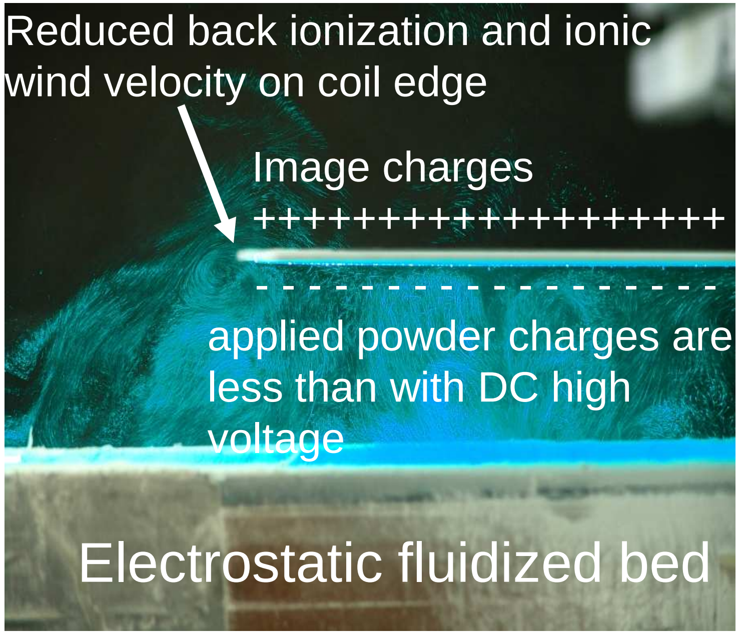
Improvement of the TransApp technique

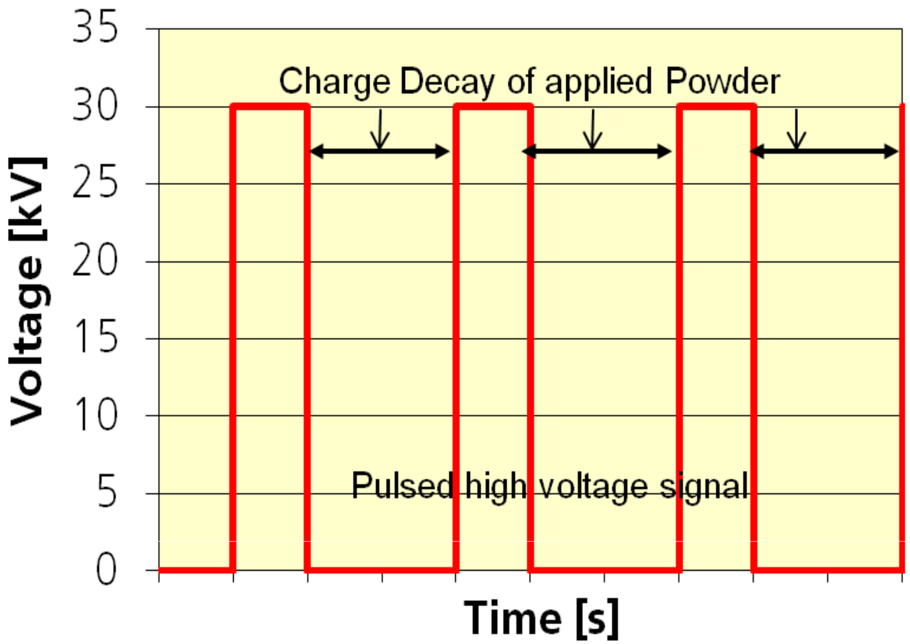
Best practice to improve orange peel:
pulsed high voltage
(rectangle signals)



Improvement of the TransApp technique

Why pulsed high voltage
for a reduced orange peel?





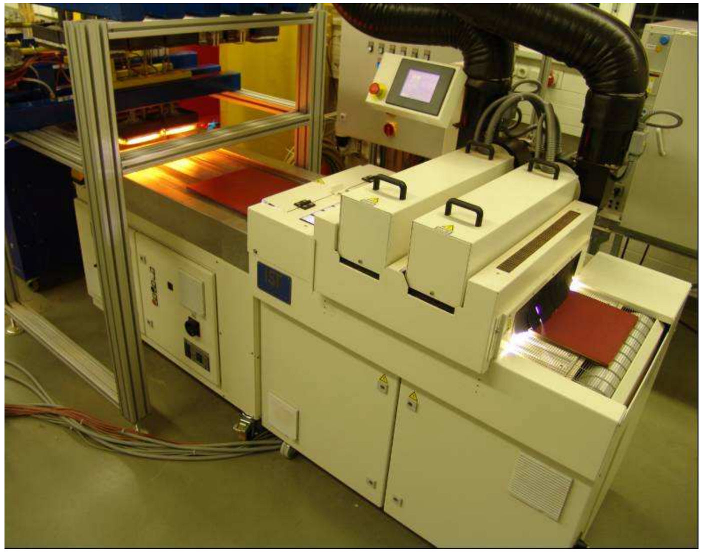
Charges of applied
powder and image
Charges decrease

Overview: Fast melting/ curing of applied powder

- Several kinds of Gas powered IR radiators (right)
- combinations between IR and convection (see below)
- electrical IR radiators with high power densities
- UV- or EB-curing after melting powder with IR (right)

Thermosetting Powders

Radical Polymerizing Powders

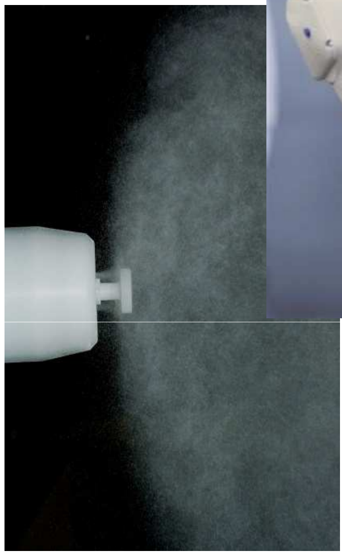


Power densities up to 1000 kW/m²

Summary and Outlook

- Extremely compact lines for flat parts as well as for several 3-dimensional parts maybe designed for future industrial applications, optional for high line speeds up to 3 m/s
- Mutable facilities (for example: Quick color changes) maybe designed with the new technique
- Increasing energy efficiency due to the low amount of pressure air as well as exhaust air
- Increasing material efficiency due to the low film thickness deviations by the use of a pulsed corona
- Development of other future applications of a pulsed corona like conventional powder coating

Other future applications for pulsed corona



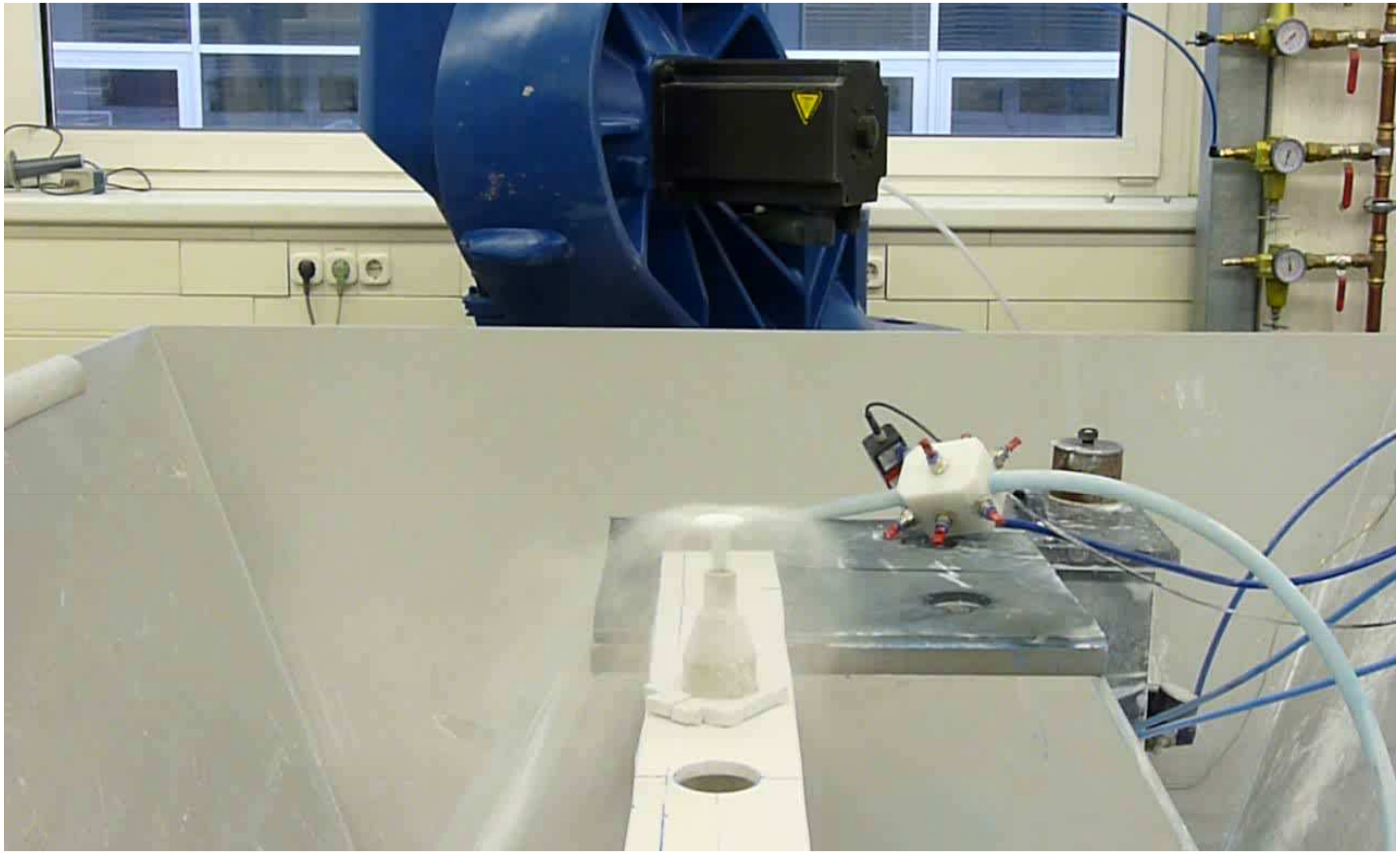
Electrostatic liquid painting

Electrostatic powder spraying

Electrostatic flock-coating

Electrostatic filter

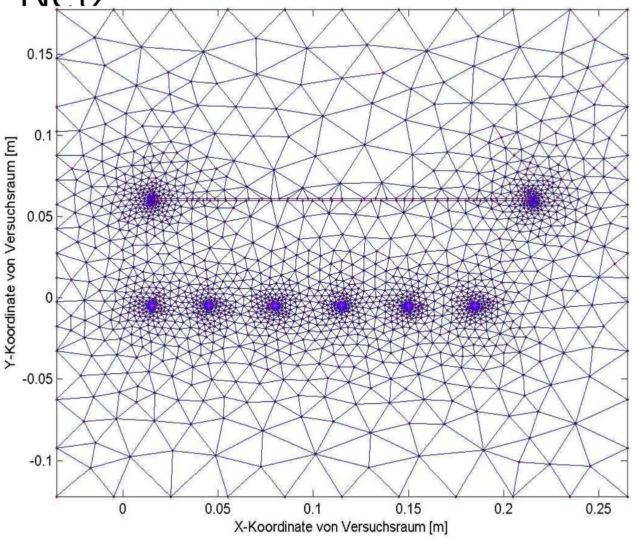
Other future applications for pulsed corona

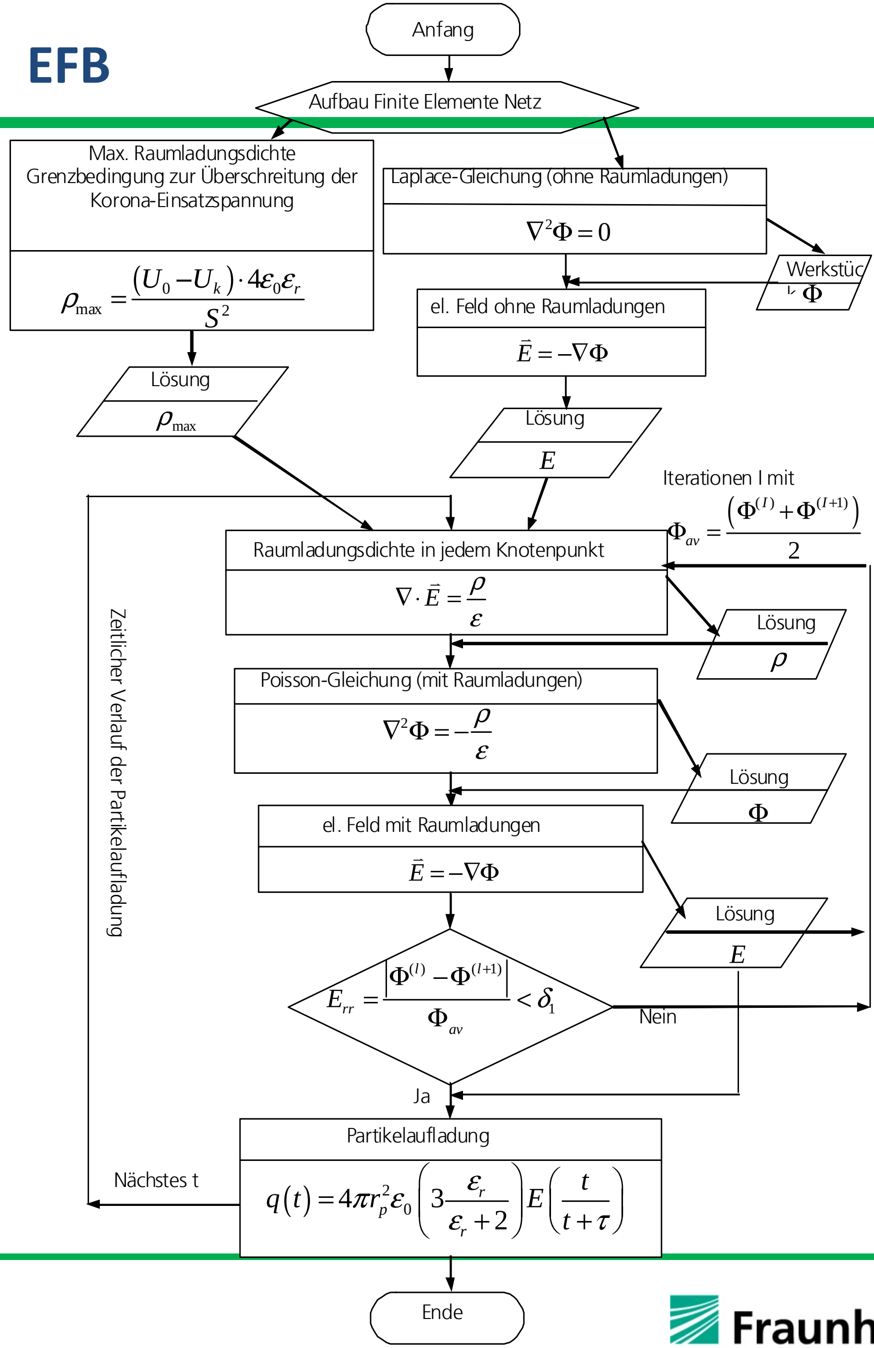


Appendix
EFB

Modellbildung u. Simulation EFB

Ablaufplan u. Finite Elemente Netz





I3/II3 Iterative Optimierung (Modellbildung zur Simulation EFB mit Gleichspannung)

Sättigungsaufladung

$$Q_{\max} = 4\pi r^2 \varepsilon_0 \cdot \left(3\frac{\varepsilon_r}{\varepsilon_r + 2}\right) \cdot E_0$$

Zeitlicher Aufladeprozess für Simulation
(Finite Elemente Methode)

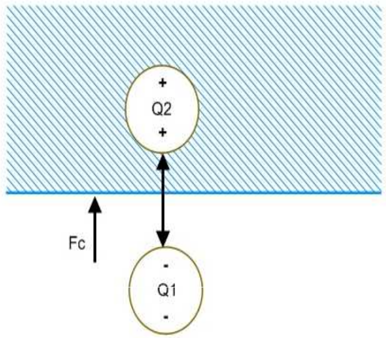
$$\delta q = 4\pi r_P{}^2 \varepsilon_0 \cdot \left(3\frac{\varepsilon_r}{\varepsilon_r + 2}\right) \cdot E \cdot \frac{\tau_A}{t + \tau_A{}^2} \cdot \delta t$$

Raumladung

$$E = \frac{(\Phi_0 - \Phi_P) - \dfrac{\rho S^2}{4\varepsilon}}{x \cdot \ln\left(\dfrac{S}{r_{0korr.}}\right)} + \frac{\rho x}{2\varepsilon}$$

Coulomb'sche Kraft, anziehend / abstoßend je nach Vorzeichen der Ladung

$$F_C = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 \cdot q_2}{\varepsilon_r \cdot a^2}$$



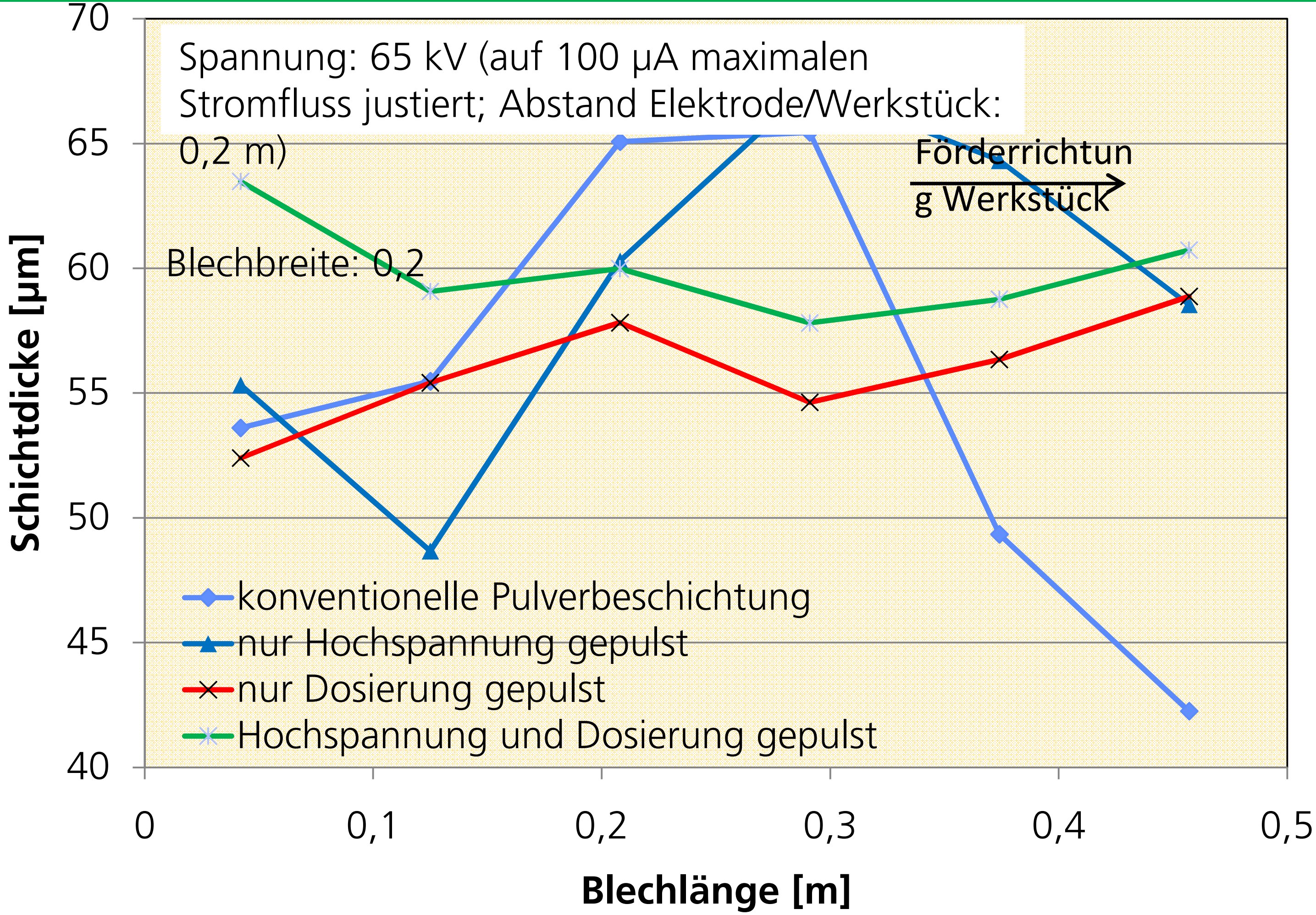
Aerodynamische Kräfte

$$F_R = C_W \underbrace{\frac{\pi}{4}(2r_p)^2}_{\text{Querschnitt}} \underbrace{\left(\frac{1}{2}\rho_L \Delta v^2\right)}_{\text{Energie pro Volumeneinheit}}$$

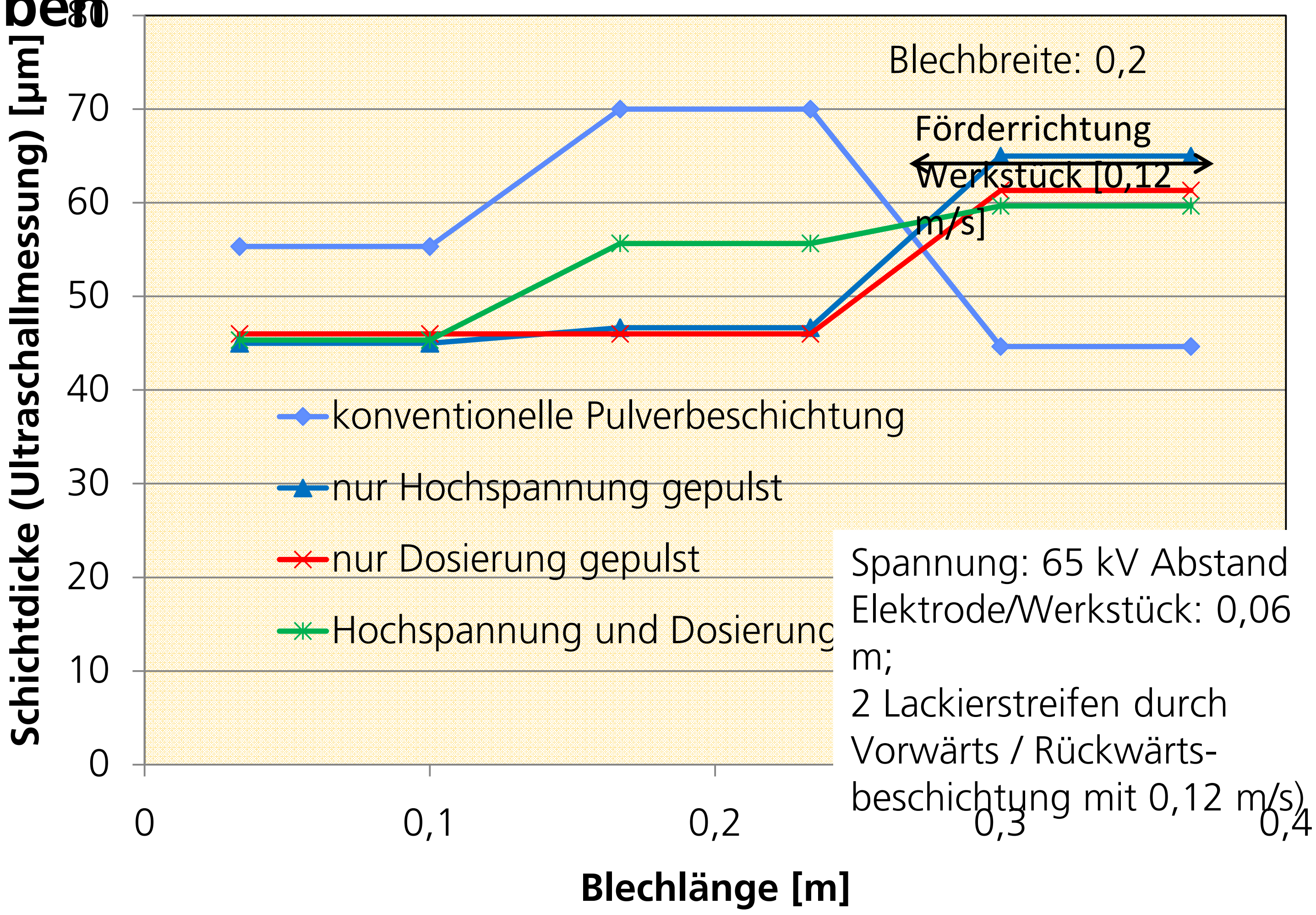
Abhängig von Partikelgröße und Geschwindigkeit über Reynoldszahl

Appendix
EPS

Versuchsergebnisse gepulste Hochspannung/Do-sierung; Flachteil mit Flachstrahl von unten n. oben



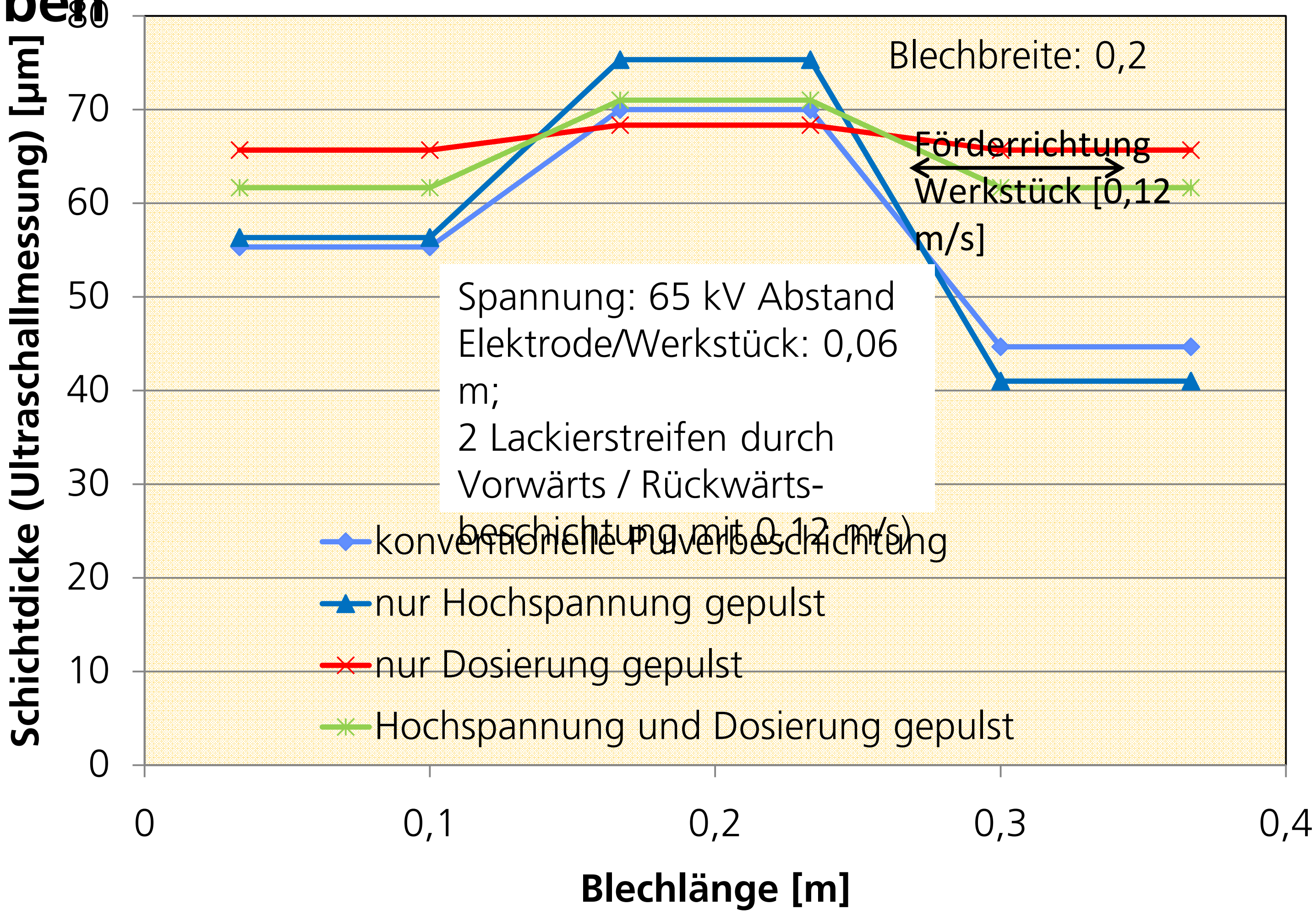
Versuchsergebnisse gepulste Hochspannung/Dosierung; Flachteil MDF mit Prallteller von unten n. oben



5 Hz

Spannung: 65 kV Abstand Elektrode/Werkstück: 0,06 m;
2 Lackierstreifen durch Vorwärts / Rückwärtsbeschichtung mit 0,12 m/s)

Versuchsergebnisse gepulste Hochspannung/Dosierung; Flachteil MDF mit Pralltteller von unten n. oben



10 Hz