

# Study of a Direct Conversion of Wind Energy into Electricity



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# What is Wind Energy?

State of the Art | Principle | Particle Production | Prototype | Results and Perspectives

- The wind is a form of solar energy
- Irregular but with a strong potential
- Wind turbine converts wind energy into electricity



- What are the Wind turbine limits ?
  - Cut-out speed (usually 25 m/s)
  - Noise pollution
  - High cost + High maintenance

How to solve these issues ?

# Current Wind Turbines

State of the Art | Principle | Particle Production | Prototype | Results and Perspectives



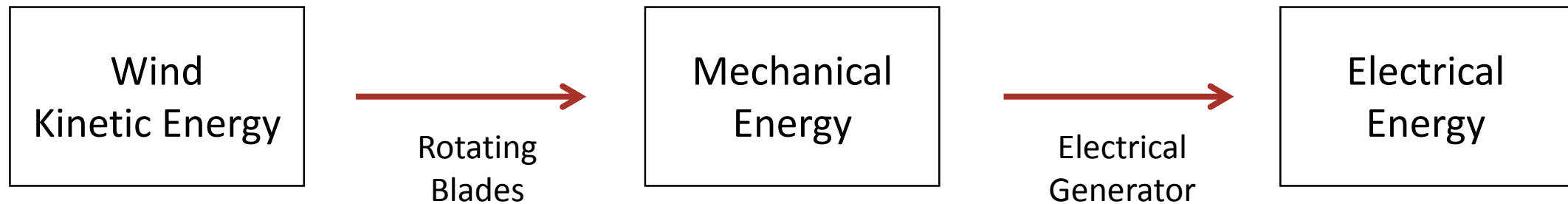
Wind turbine farm in Saint-Félix-Lauragais  
Haute Garonne (2011)



Floating vertical axis wind turbine  
*VERTIWIND Project*



Offshore wind turbine farm in Denmark  
Siemens, 2013



# What about a Bladeless system ?

State of the Art | Principle | Particle Production | Prototype | Results and Perspectives

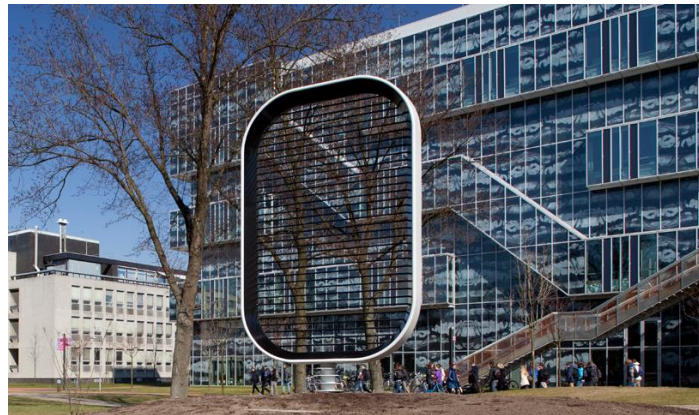
Wind  
Kinetic Energy

~~Mechanical  
Energy~~

Electrical  
Energy

# What about a Bladeless system ?

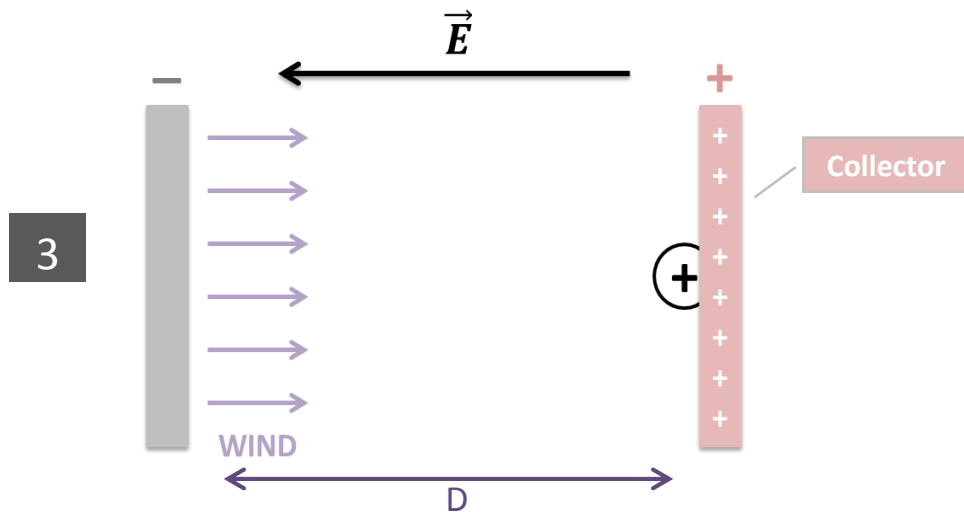
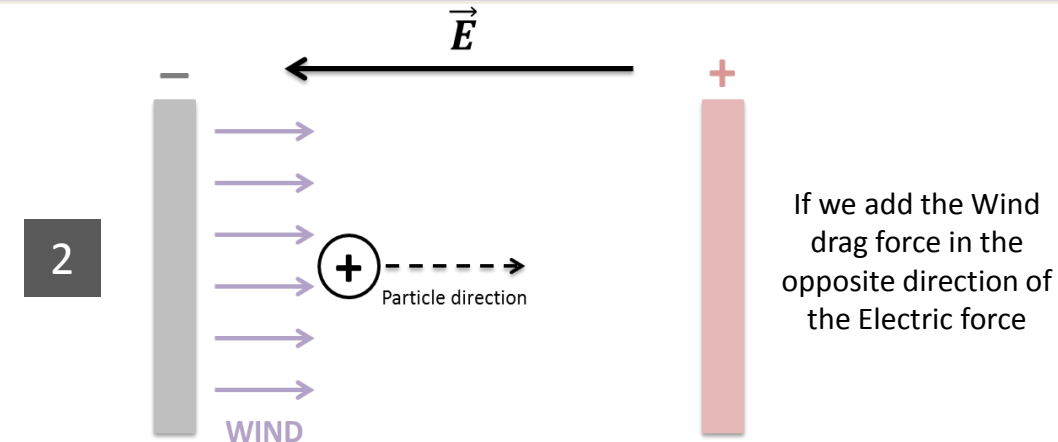
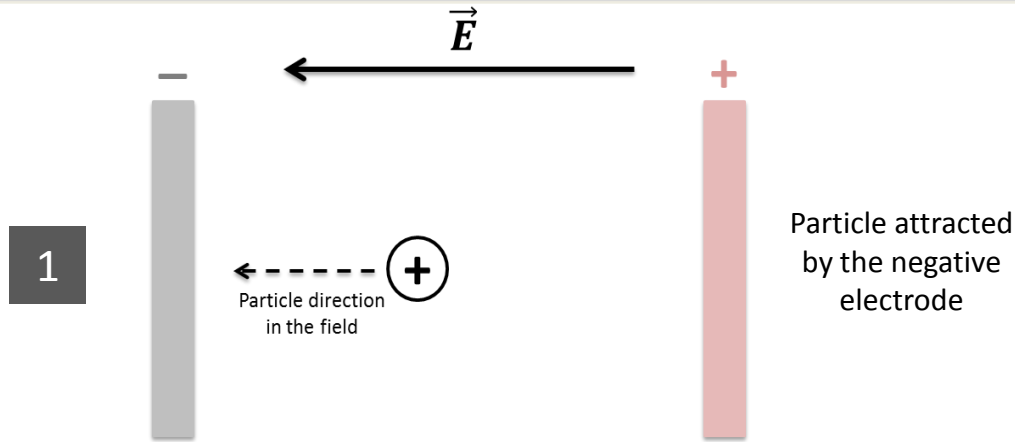
State of the Art | Principle | Particle Production | Prototype | Results and Perspectives



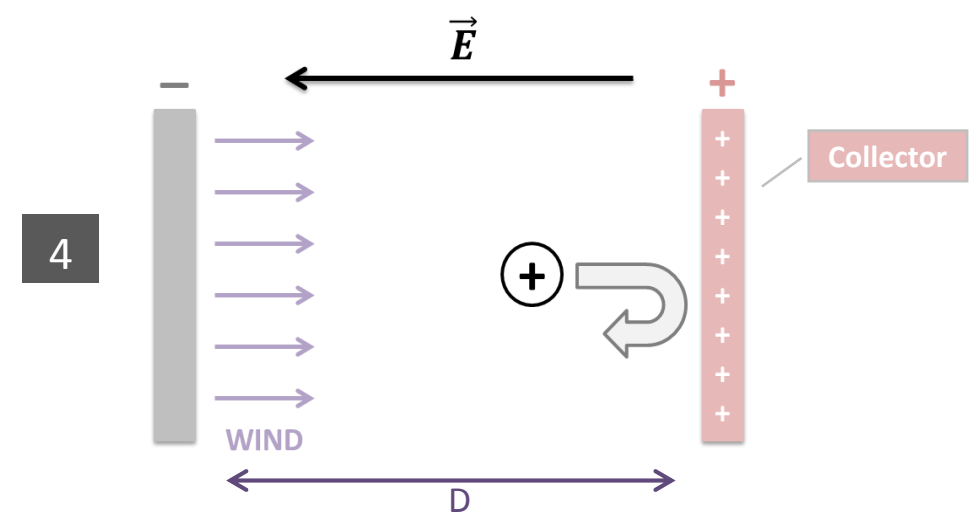
Prototype from Delft University

# How does this work ?

State of the Art | Principle | Particle Production | Prototype | Results and Perspectives



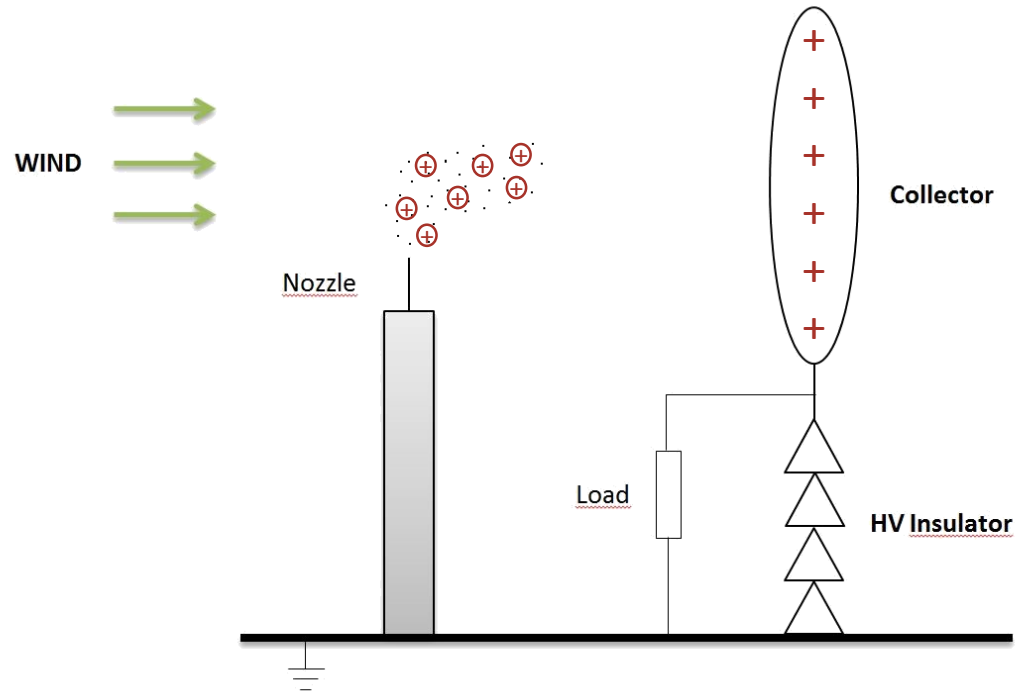
- Collector potential  $V_+$  rises  $\rightarrow \|\vec{E}\|$  rises
- Works as long as  $\|\vec{F}_{wind}\| > \|\vec{F}_E\|$



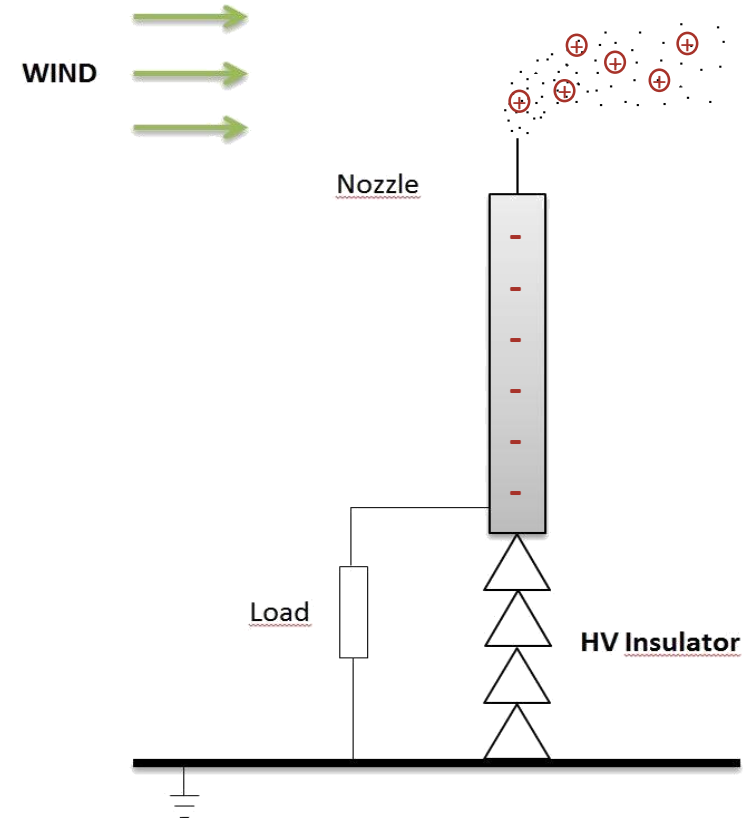
- U-turn of the particle if  $\|\vec{F}_{wind}\| < \|\vec{F}_E\|$
- Loss of the charged particle

# How would it look like ?

State of the Art | **Principle** | Particle Production | Prototype | Results and Perspectives



System with a collector



Isolated system without a collector



# How can you obtain charged particles ?

State of the Art | Principle | **Particle Production** | Prototype | Results and Perspectives

What do we need?

- **Efficient** creation of charged particles with **suitable properties**
- Liquid particles → no need for recycling
- Production of a **large number** of particles at **very low energy consumption**

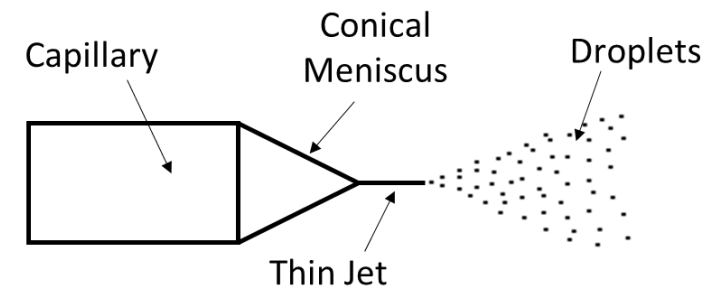
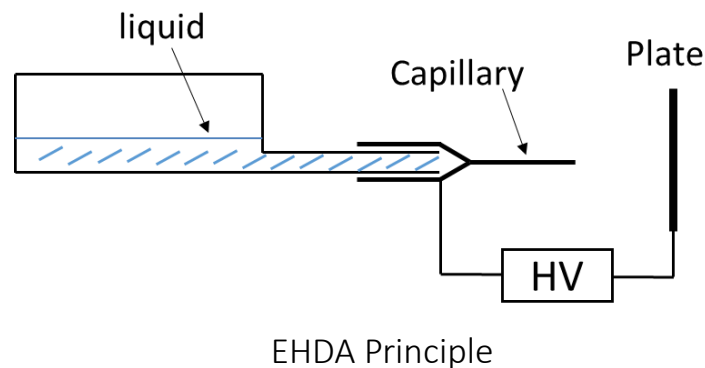
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→ **EHDA** (Electro-Hydro-Dynamic Atomization)



# What are the limitations ?

State of the Art | Principle | **Particle Production** | Prototype | Results and Perspectives

- Reducing the ion mobility  $\mu = f(q, d)$
- Controlling the particle size: **monodisperse** particles or a **stable sized distribution**
- For liquid particles  $\rightarrow$  the **Rayleigh limit**

$$q_{max} = 2\pi * \sqrt{2\gamma\epsilon_0 * d^3}$$



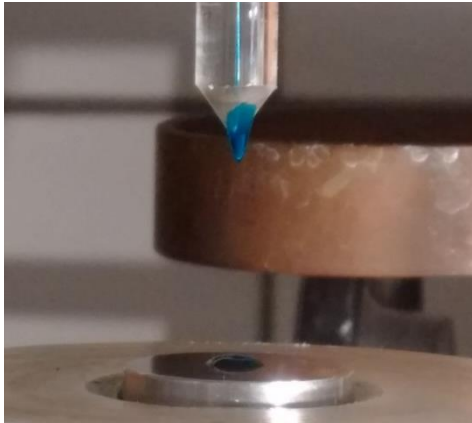
Instability of a droplet  
at the Rayleigh limit  
*Denis Duft, and al.*

- **Evaporation** of liquid during flight  $\rightarrow$  decrease of the particle size
- Collisions between charged and neutral particles in air  $\rightarrow$  fragmentation / neutralization

$\rightarrow$  Ensure better coupling between particles and the wind  
 $\rightarrow$  Multi-Injectors system

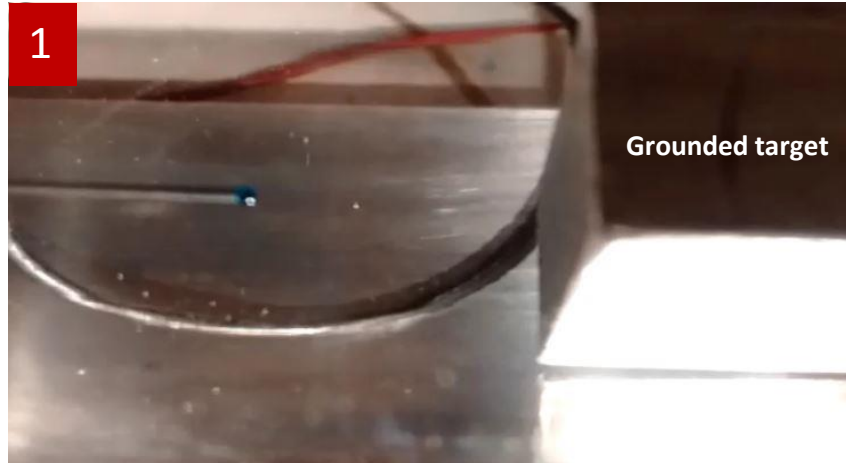
# Electrospray Experiments

State of the Art | Principle | **Particle Production** | Prototype | Results and Perspectives



Charged particles emitted from a cone

*Glass capillary with a metallic wire inside*

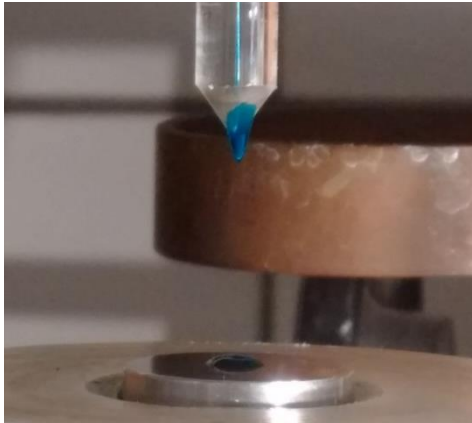


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Grounded target

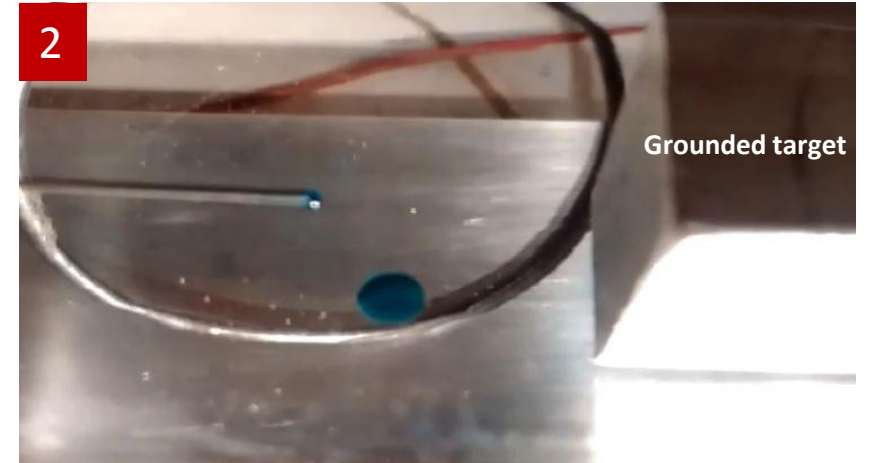
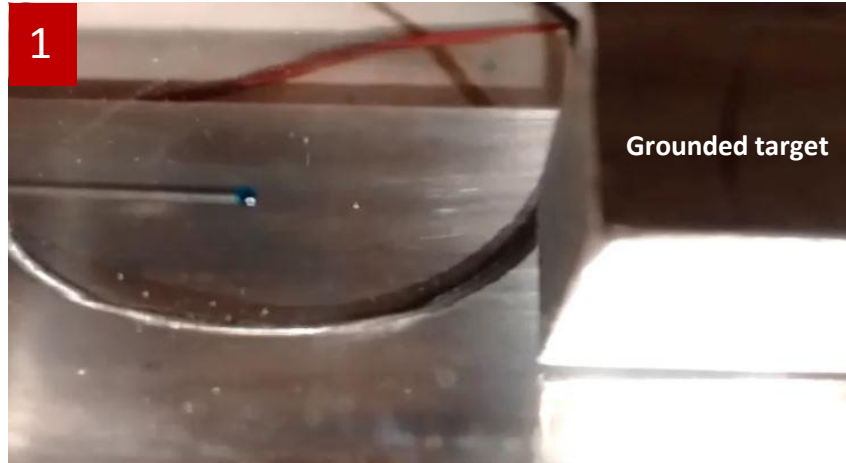
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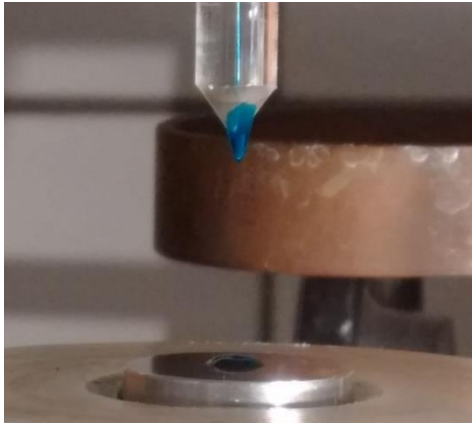
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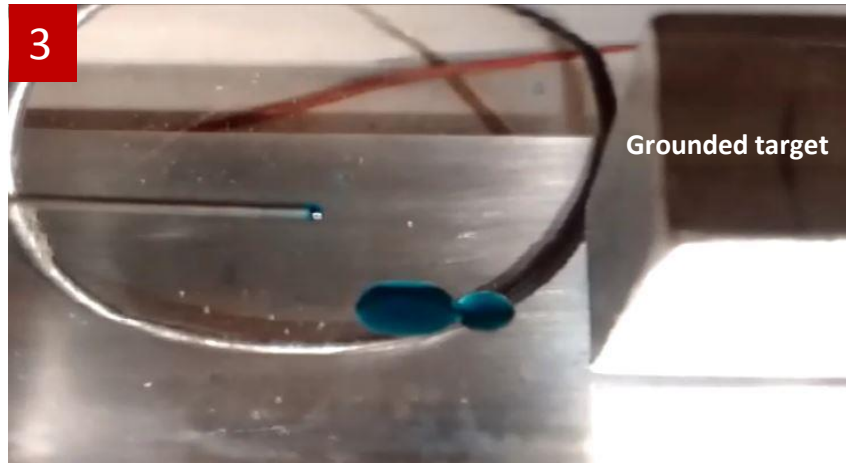
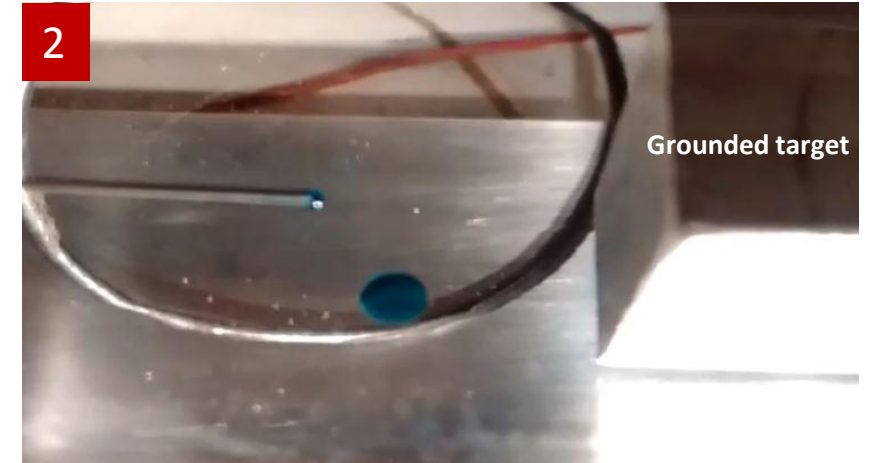
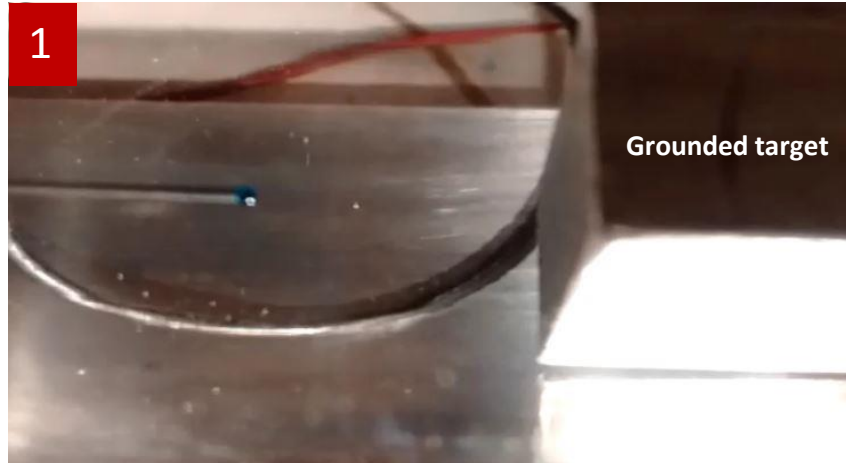
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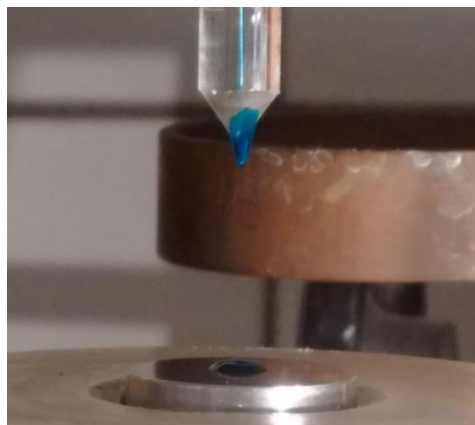
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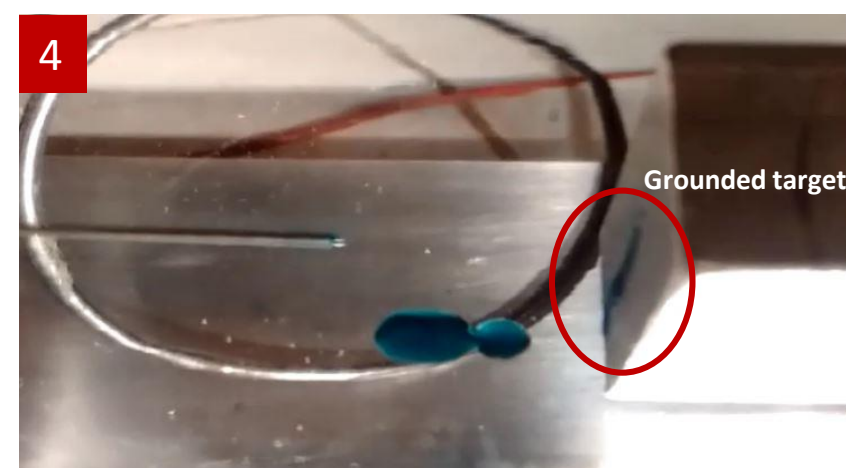
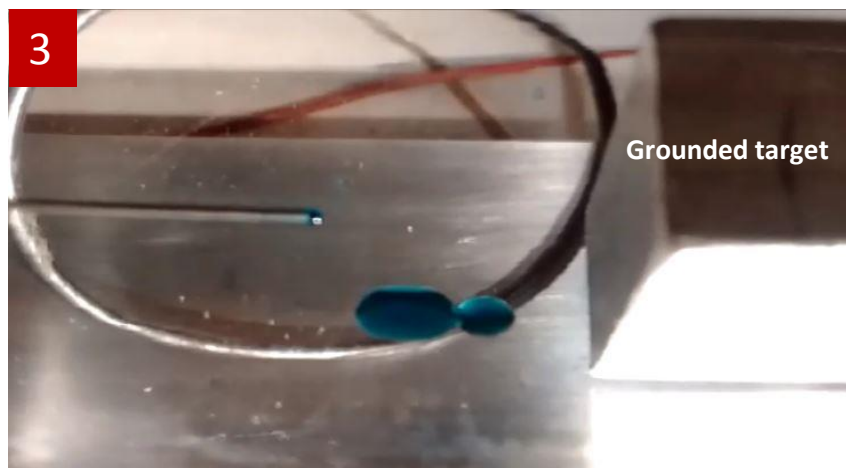
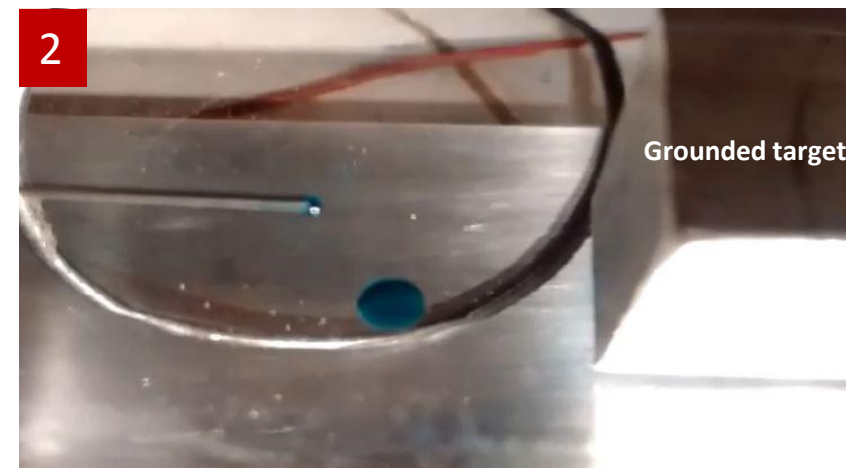
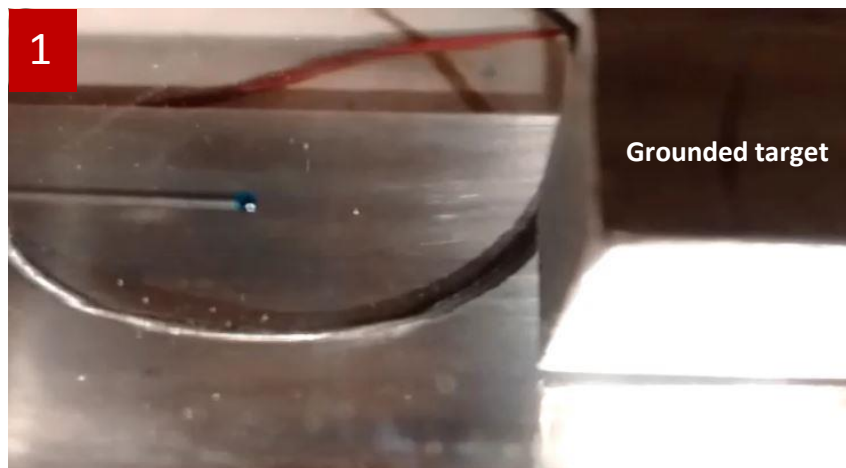
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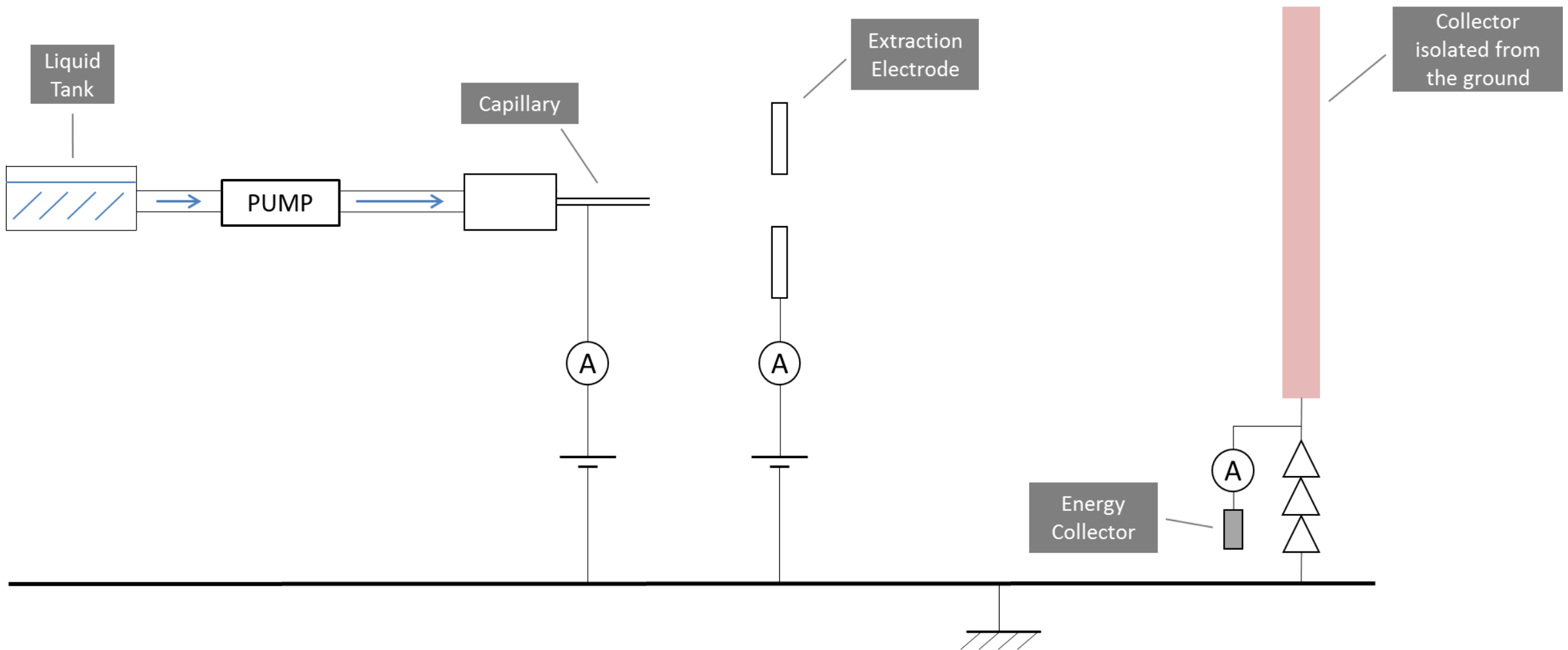
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# Prototype Design

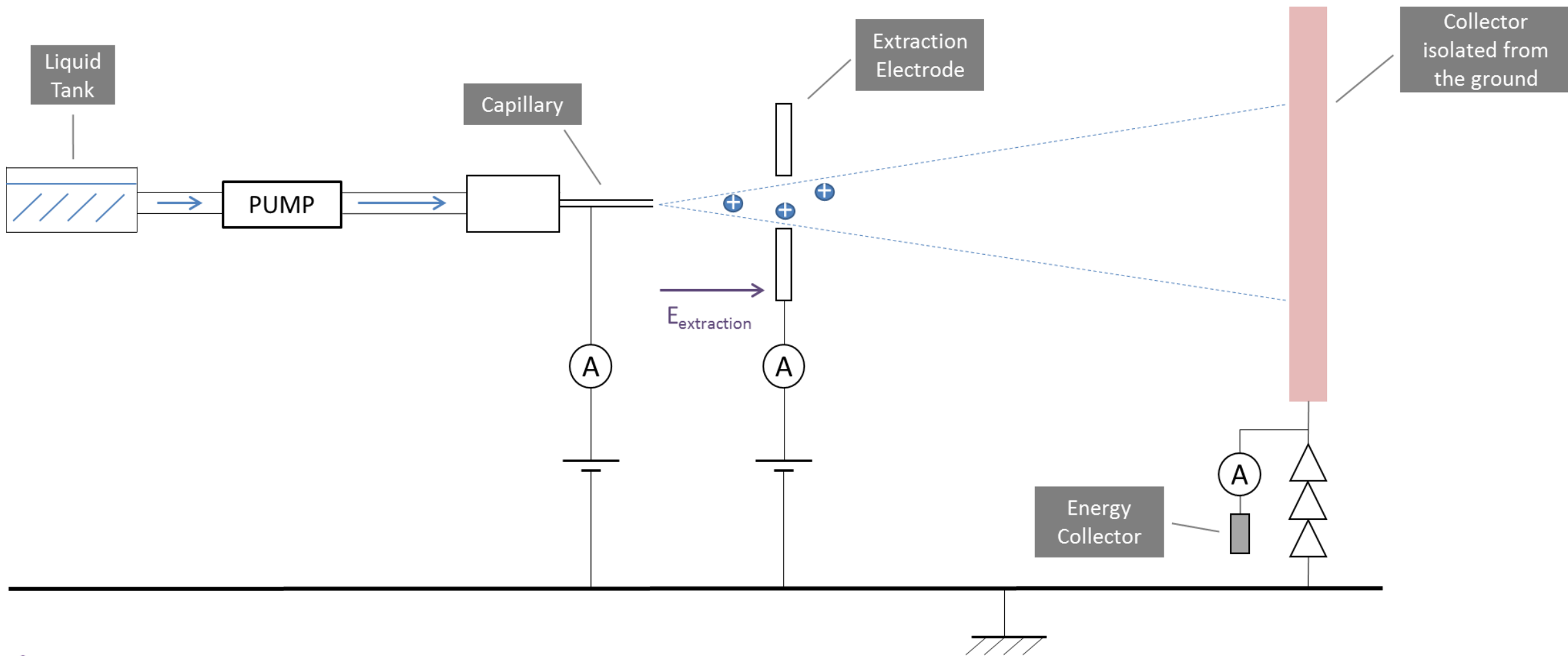
State of the Art | Principle | Particle Production | **Prototype** | Results and Perspectives





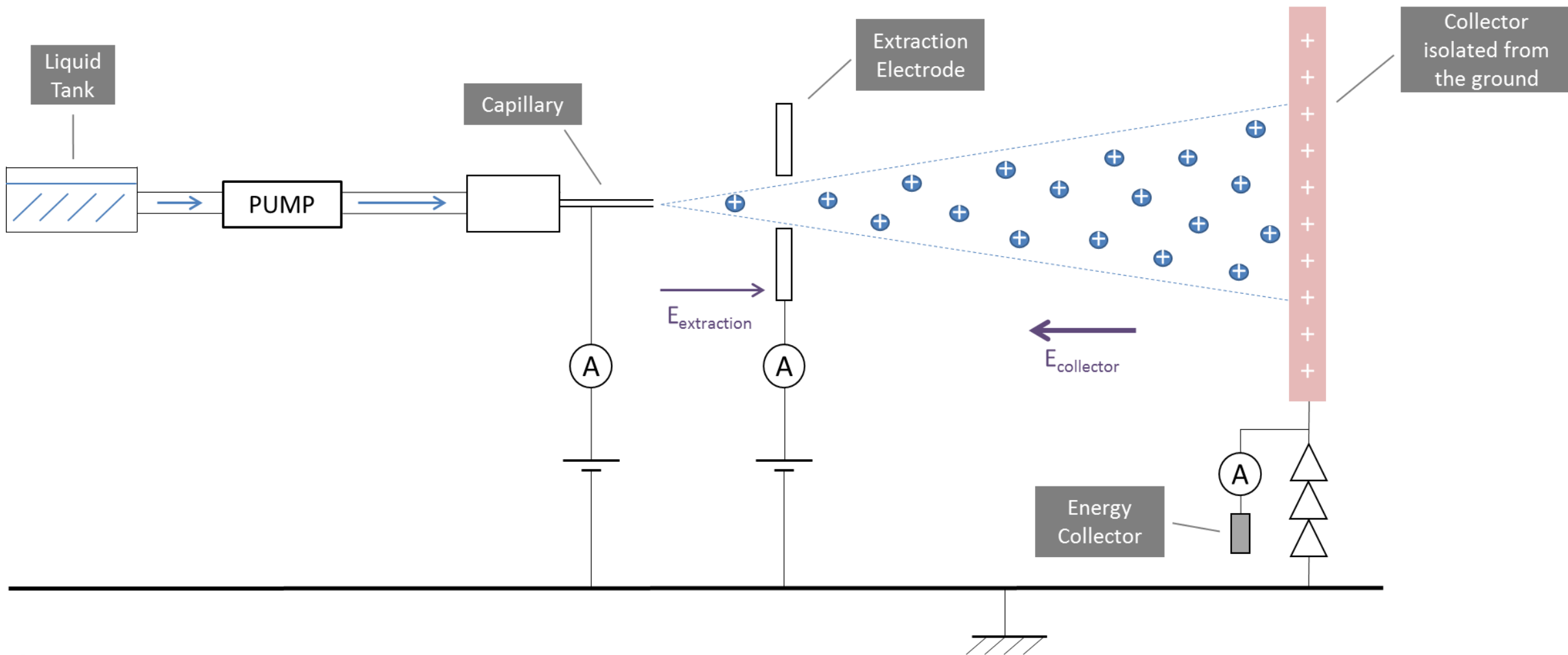
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State of the Art | Principle | Particle Production | **Prototype** | Results and Perspectives



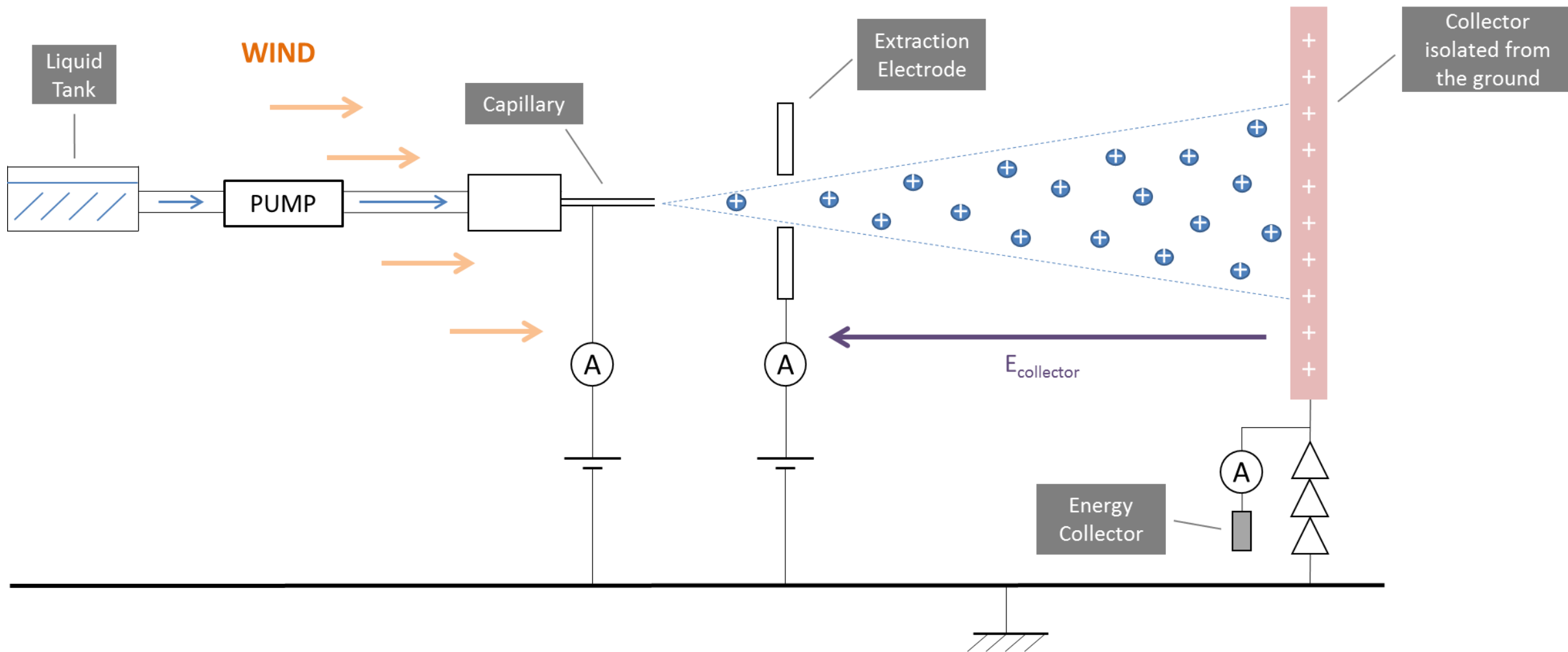
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State of the Art | Principle | Particle Production | **Prototype** | Results and Perspectives



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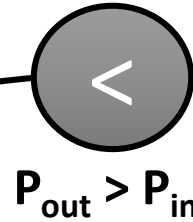


# Some Results: The EWICON Project

State of the Art | Principle | Particle Production | Prototype | **Results and Perspectives**

Outputs of the **Electrostatic Wind Energy Converter** project led at Delft University

= Power Supplies HV  
+  
Pump



=  $P_{out} / (P_{in} + P_{max\ wind})$

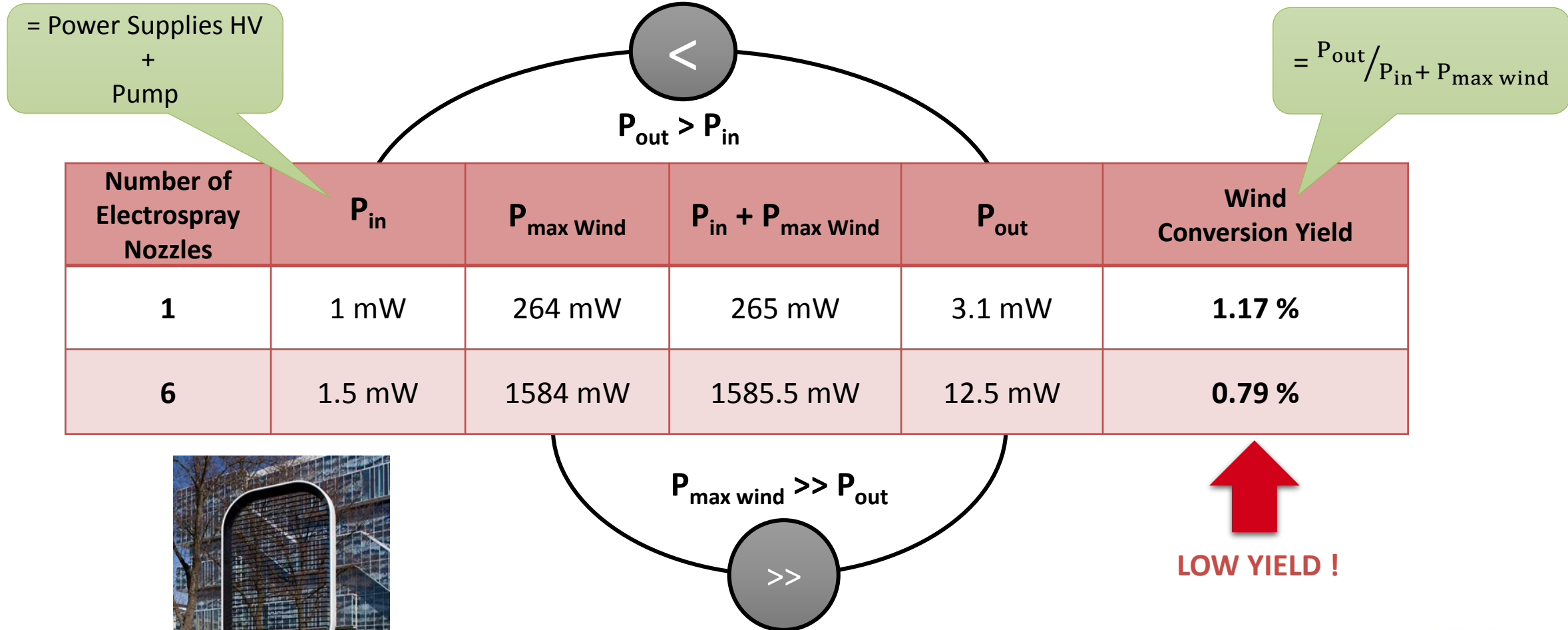
Number of Electro spray Nozzles	$P_{in}$	$P_{max\ Wind}$	$P_{in} + P_{max\ Wind}$	$P_{out}$	Wind Conversion Yield
1	1 mW	264 mW	265 mW	3.1 mW	1.17 %
6	1.5 mW	1584 mW	1585.5 mW	12.5 mW	0.79 %



# Some Results: The EWICON Project

State of the Art | Principle | Particle Production | Prototype | **Results and Perspectives**

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# Next Steps

State of the Art | Principle | Particle Production | Prototype | **Results and Perspectives**

## To be improved

## How ?

Increasing the wind conversion yield

Decreasing the ion mobility

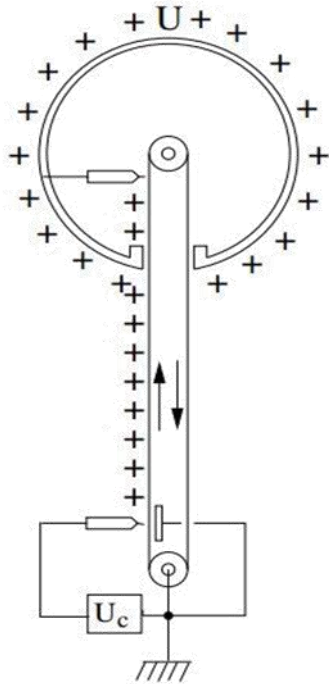
Removing the interaction between the injector nozzles

Designing better shielding  
Studying extraction simulations

A new prototype is being designed to improve these points

# Other possibilities

State of the Art | Principle | Particle Production | Prototype | Results and Perspectives



Van de Graaff Generator



Wind Energy Converter

A new kind of Van de Graaff !



Pelletron Generator from NEC  
(ANDROMEDE Project)

# The Dream Team !



**THANK YOU !**





# The Dream Team !



**THANK YOU !**



# Recoverable Power

For a given wind speed

