DC-DC Converters
The High Voltage System for EEE MRPC chambers

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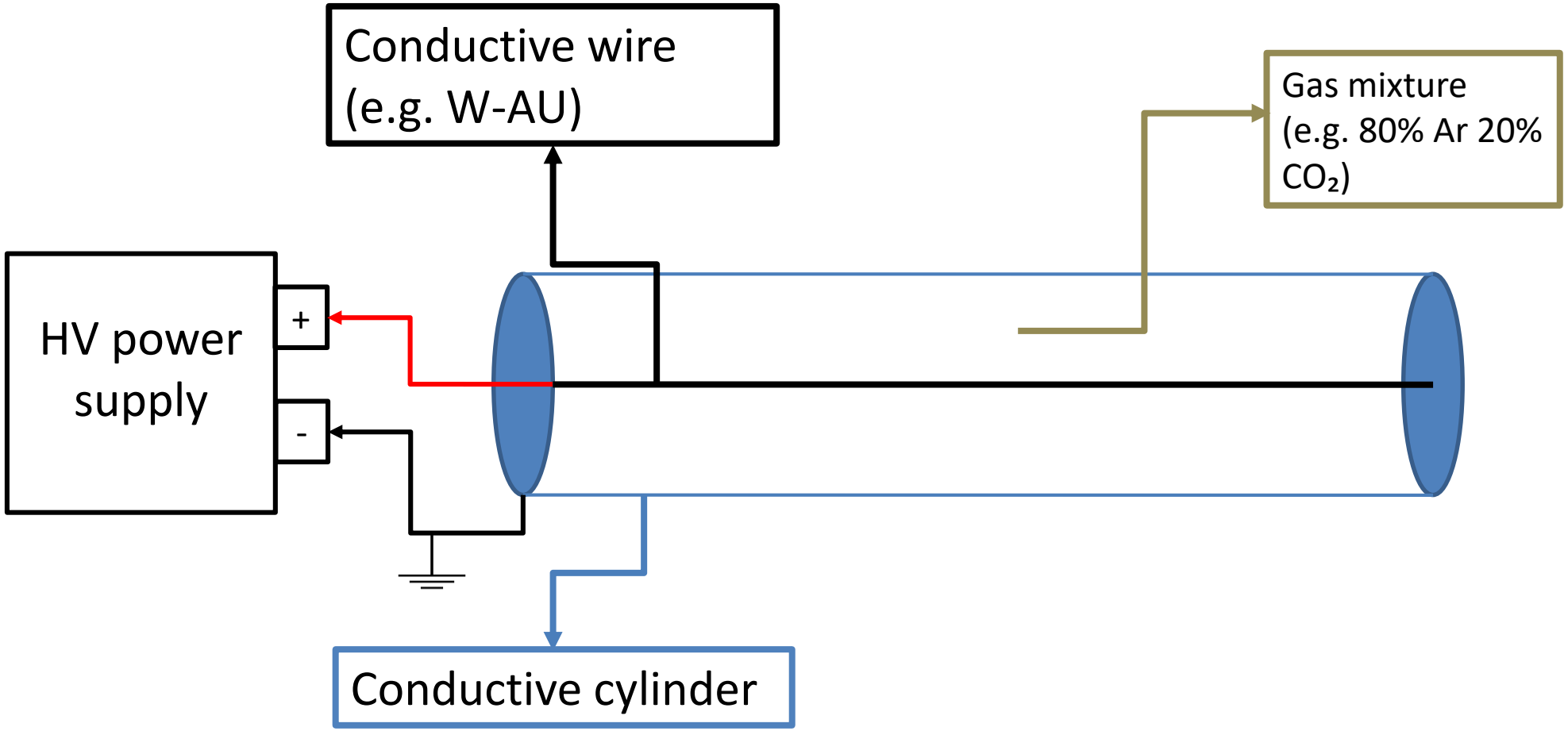
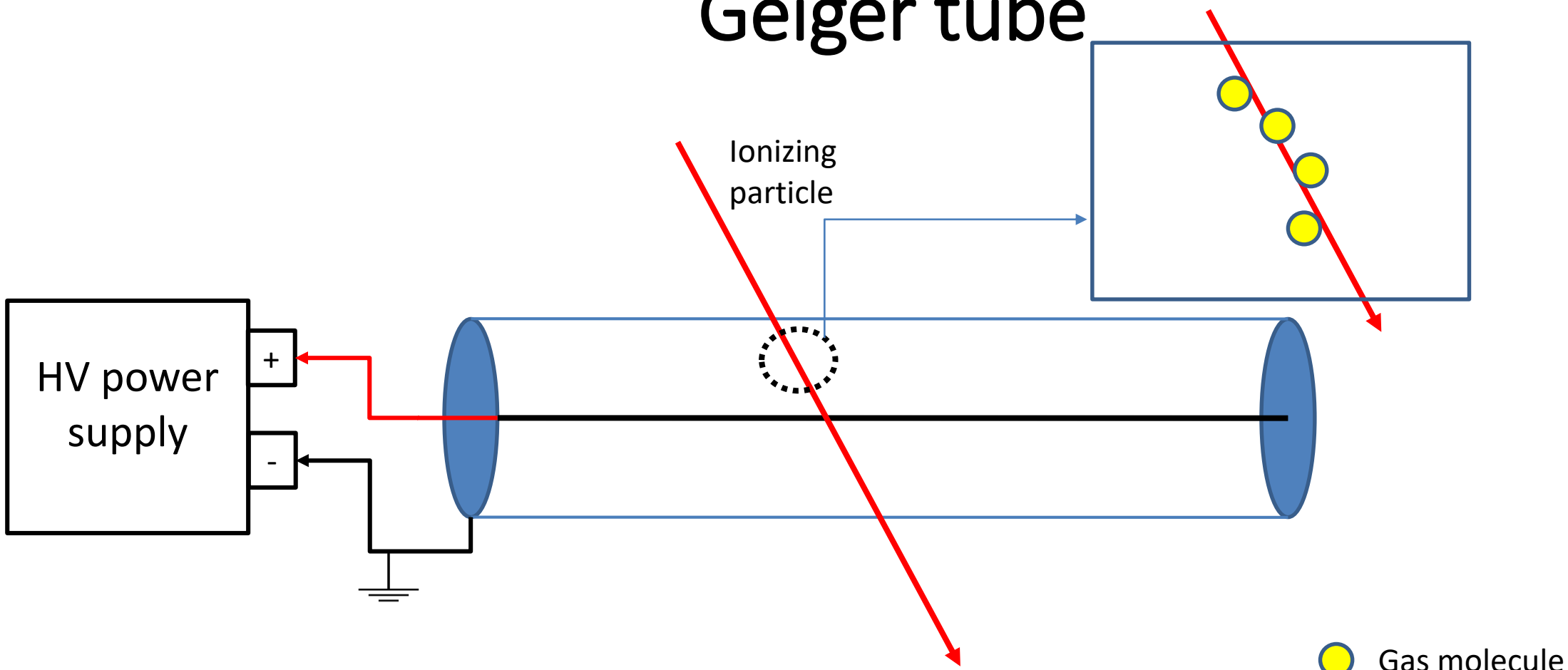
Why do we need High Voltage in a gas detector?

A little example: **Geiger tube**



Geiger tube

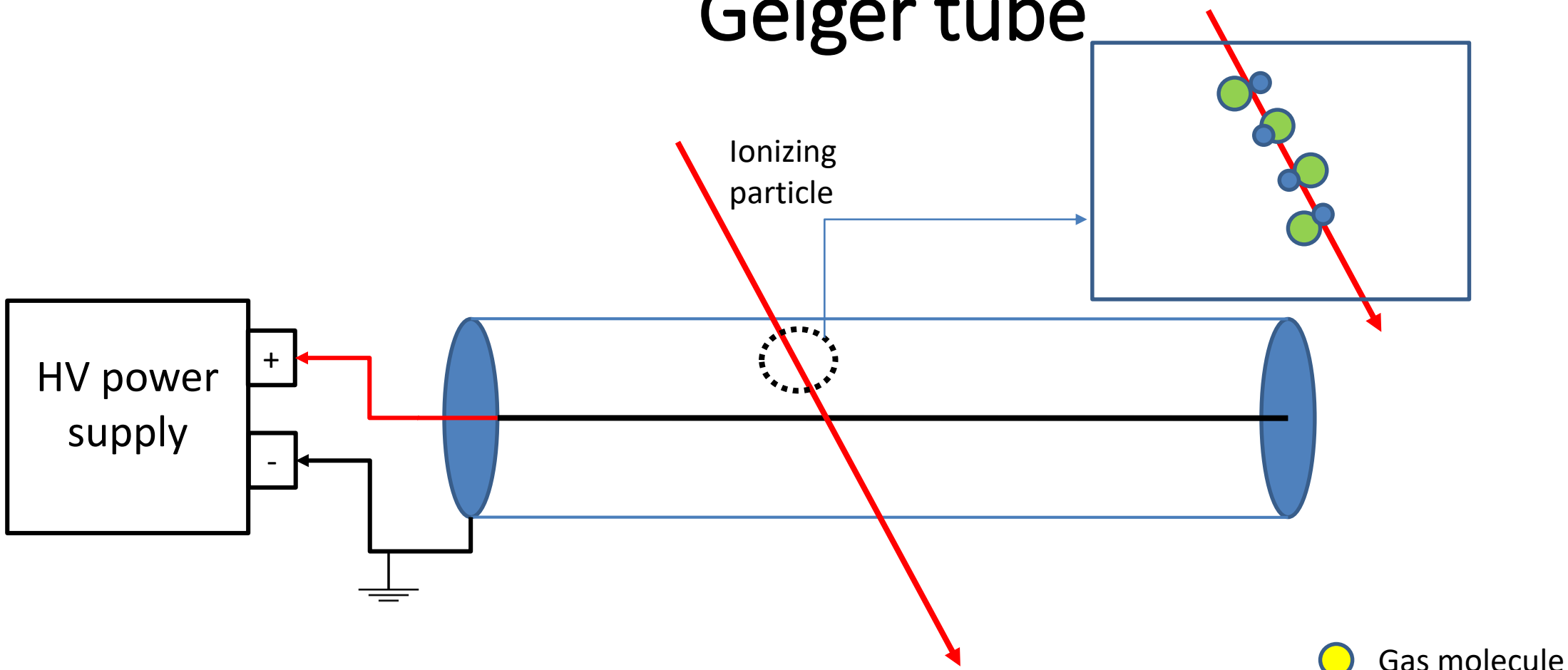


Gas molecule

Positive ion

Electron

Geiger tube



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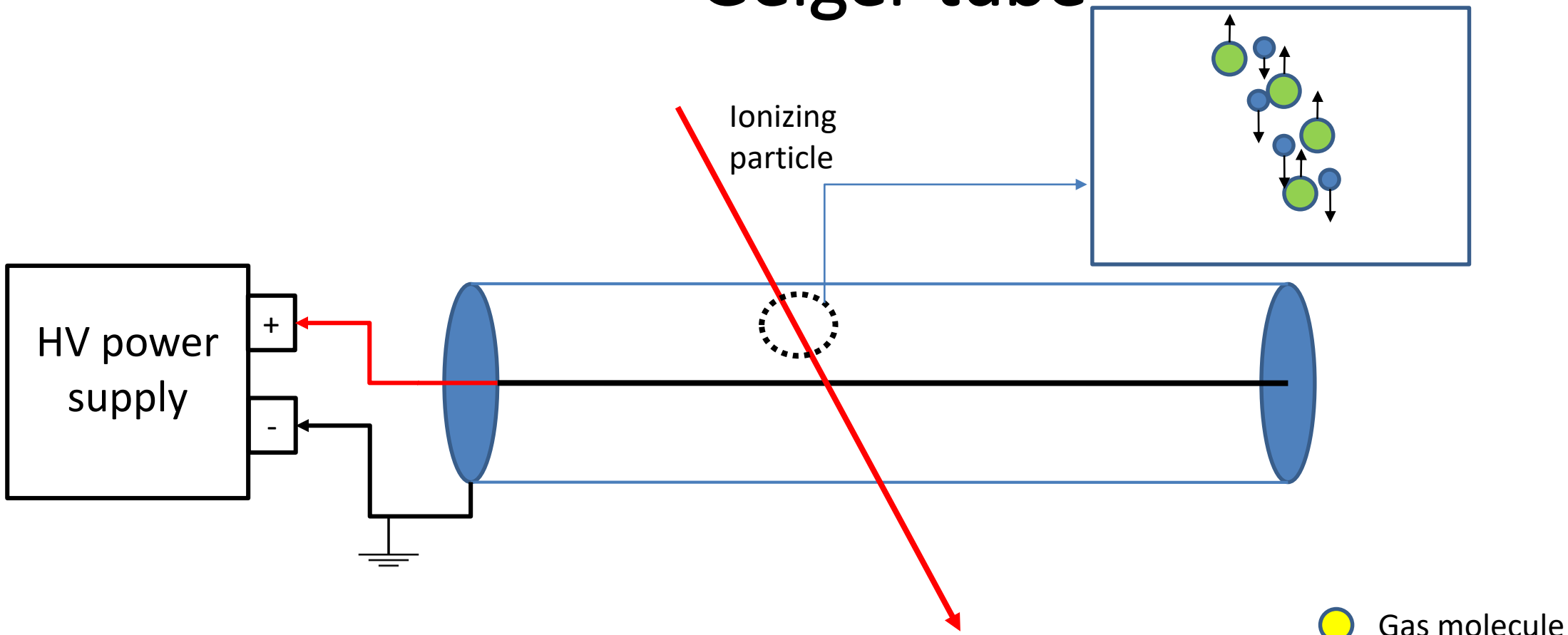

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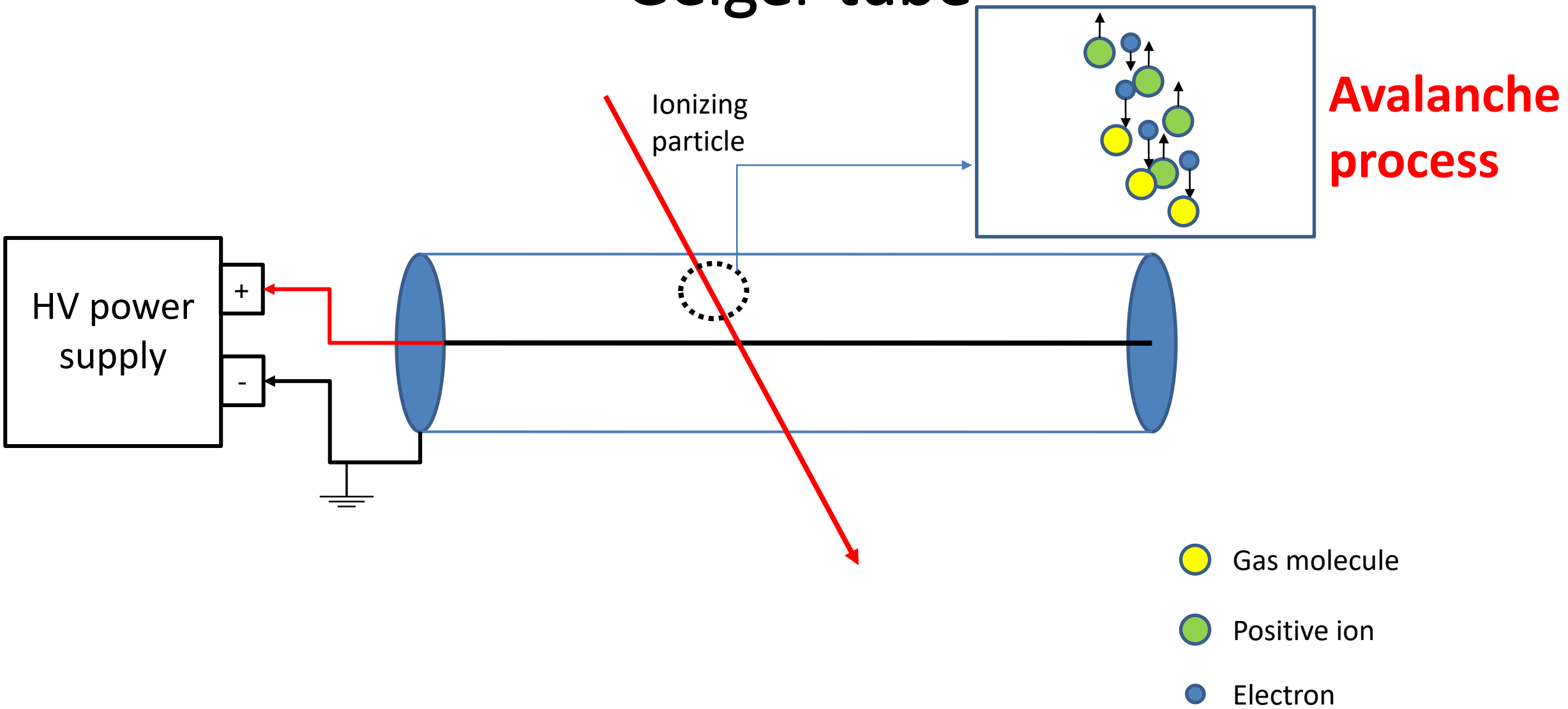
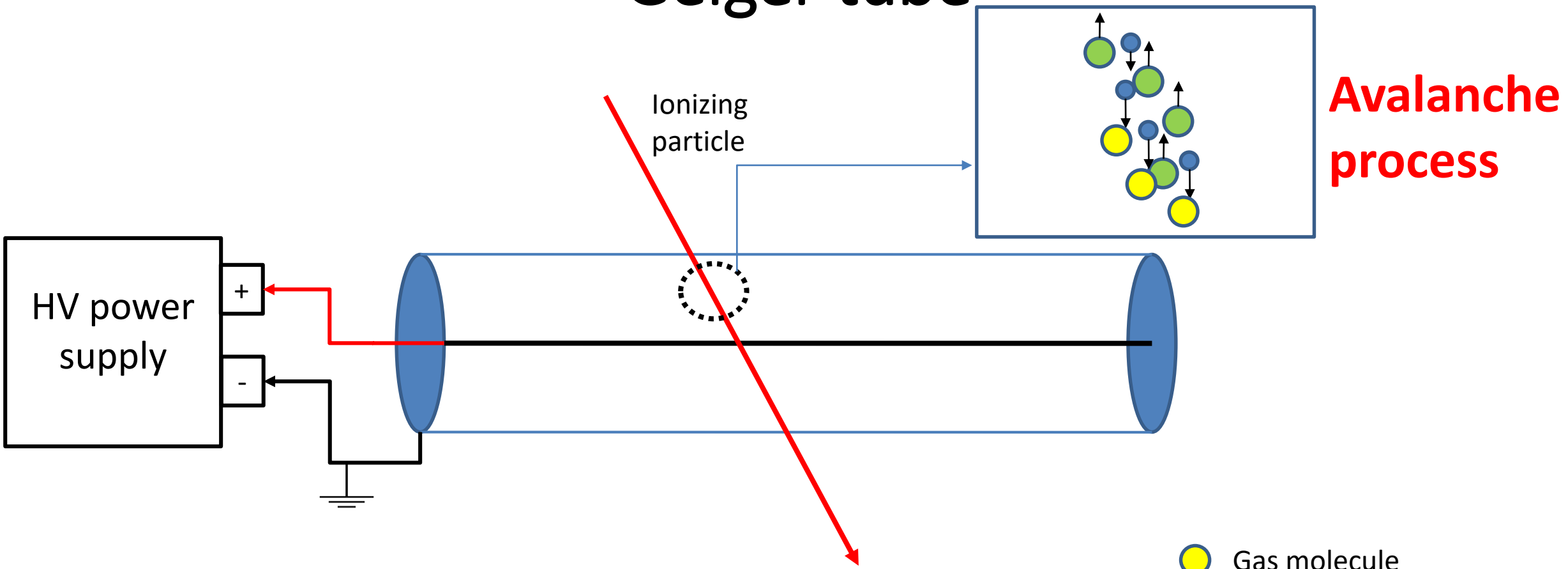

Ionizing particle
HV power supply
+
-
Avalanche process
Gas molecule
Positive ion
Electron

Geiger tube



Avalanche process

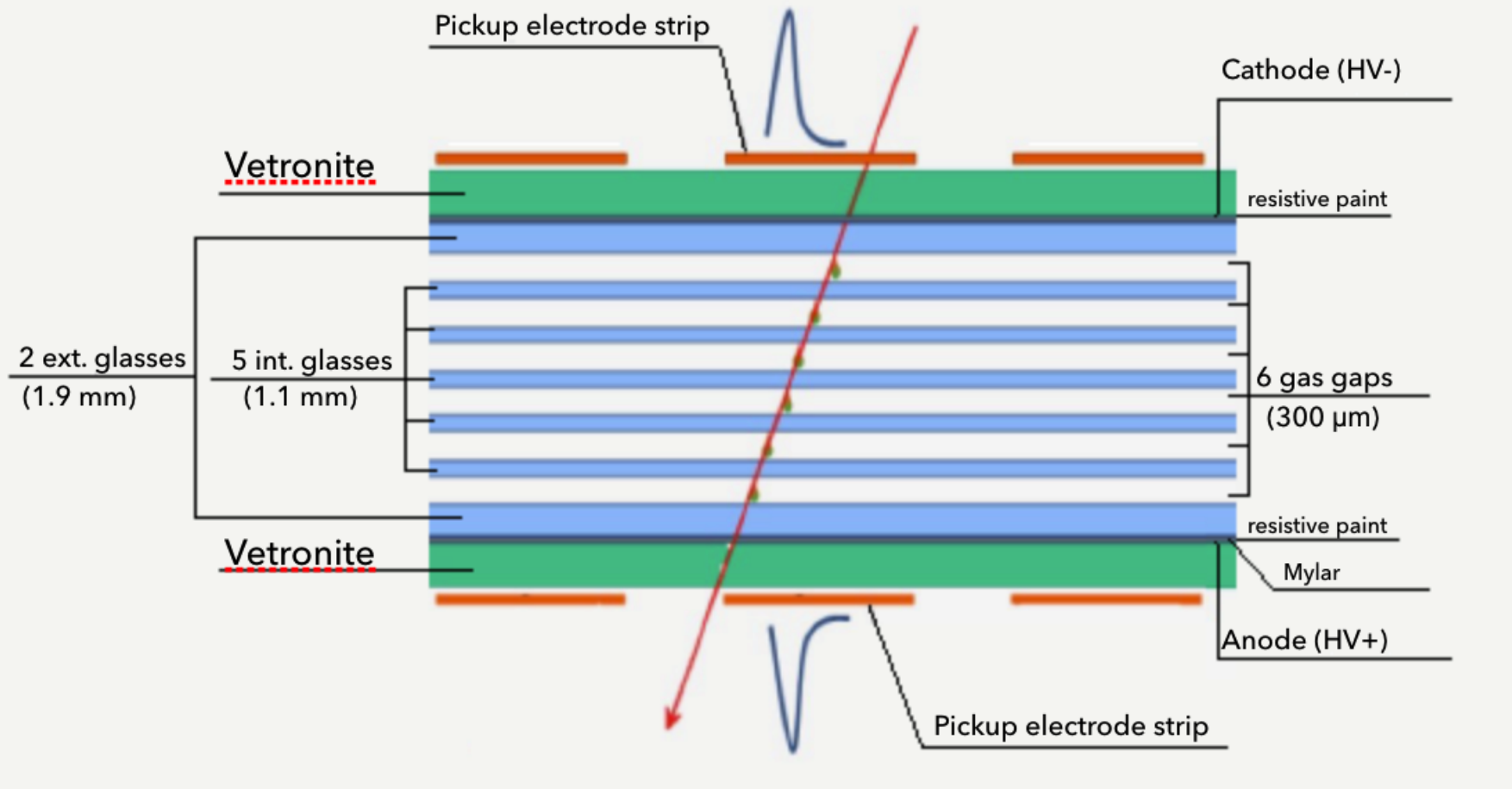
Accelerated charge particles produce current → Detectable signal

Gas molecule

Positive ion

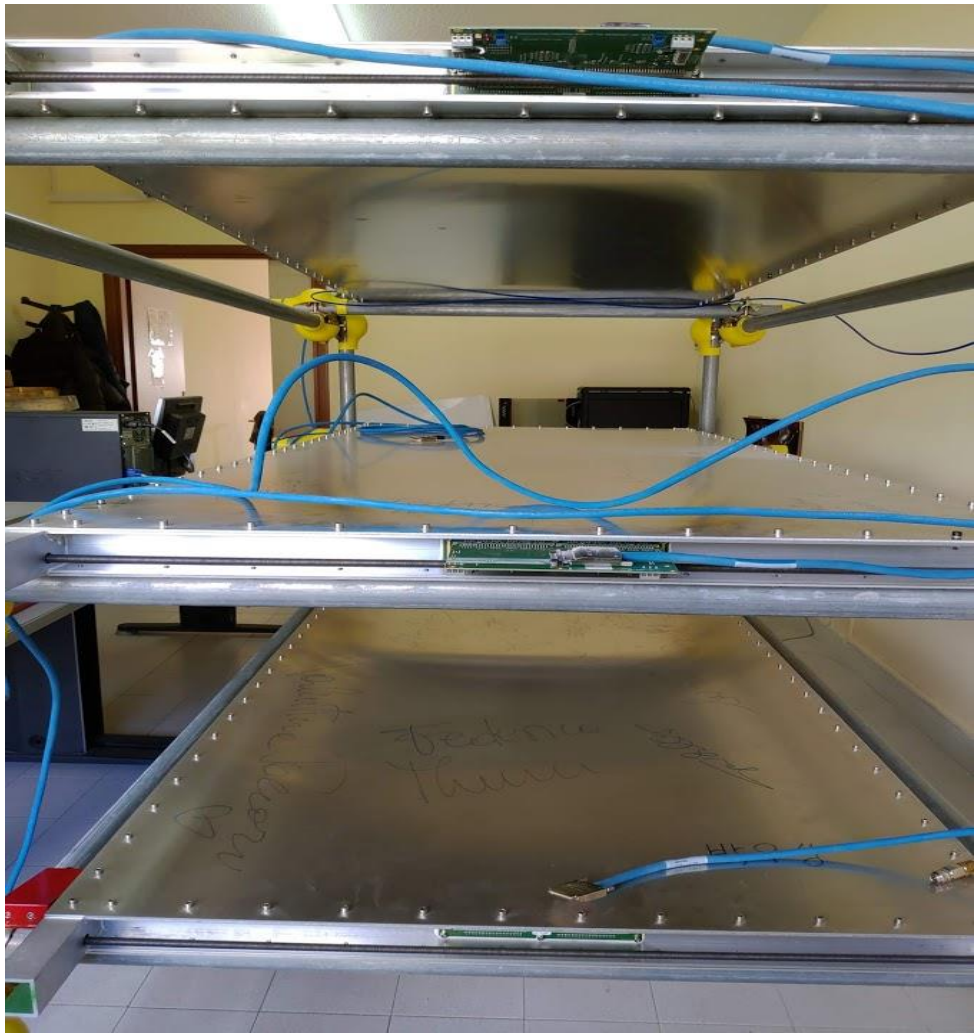
Electron

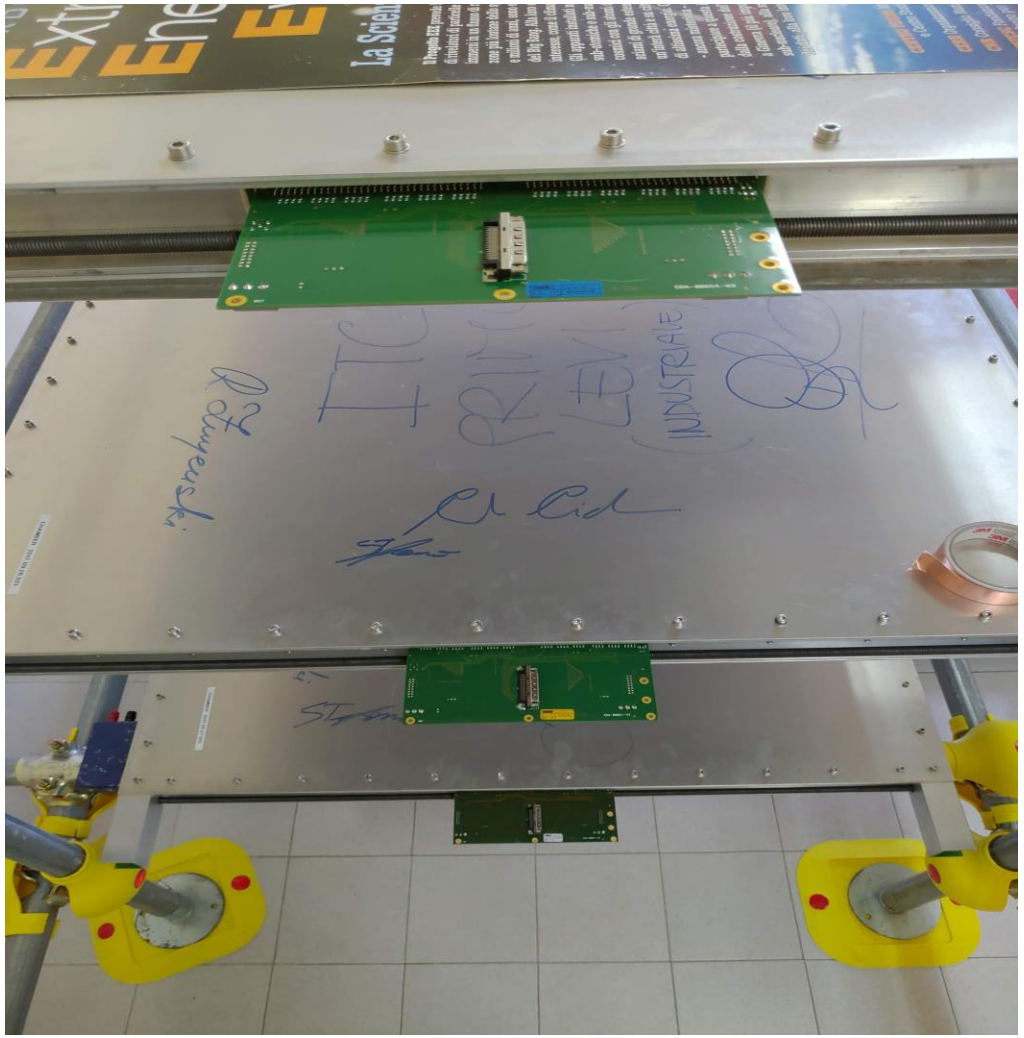
MRPC detector



- External glasses @HV
- Induced charge on internal glasses
- Gaps filled with:
  - 98% R-134A
  - 2% SF6
- Same ionization process into every gap
- Induce current onto readout strips

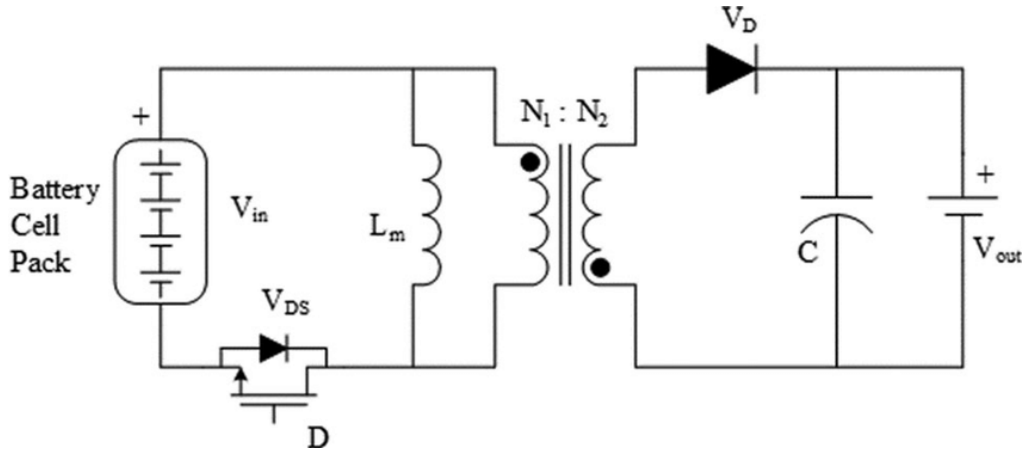
MRPC detector @ Levi





The HV power supply for the EEE MRPC

- The HV power supply used for the EEE project are made with DC-DC converters for both the positive and negative supply.
- The DC-DC are built into small metal boxes which are directly plugged into the chamber.
- This greatly increases the safety of the detector because there are not high voltage cables that connect from an external power supply.
- The HV power supplies are built around the EMCO Q series high voltage DC-DC converter.



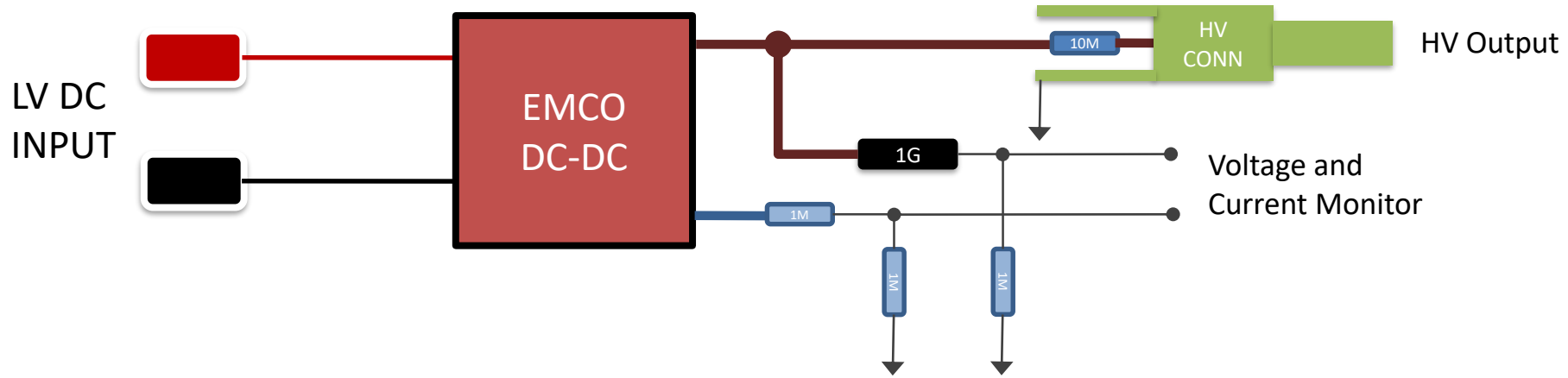
The figure shows a basic schematics of a DC-DC converter: an input DC voltage is transformed to AC with an oscillator (a mosfet in this example) and then applied to a transformer. The output voltage is then rectified with a diode and filtered by a capacitor. **The ratio N2/N1 of the transformer coils determines the ratio between Vout and Vin.**

EMCO Q Series High Voltage DC-DC

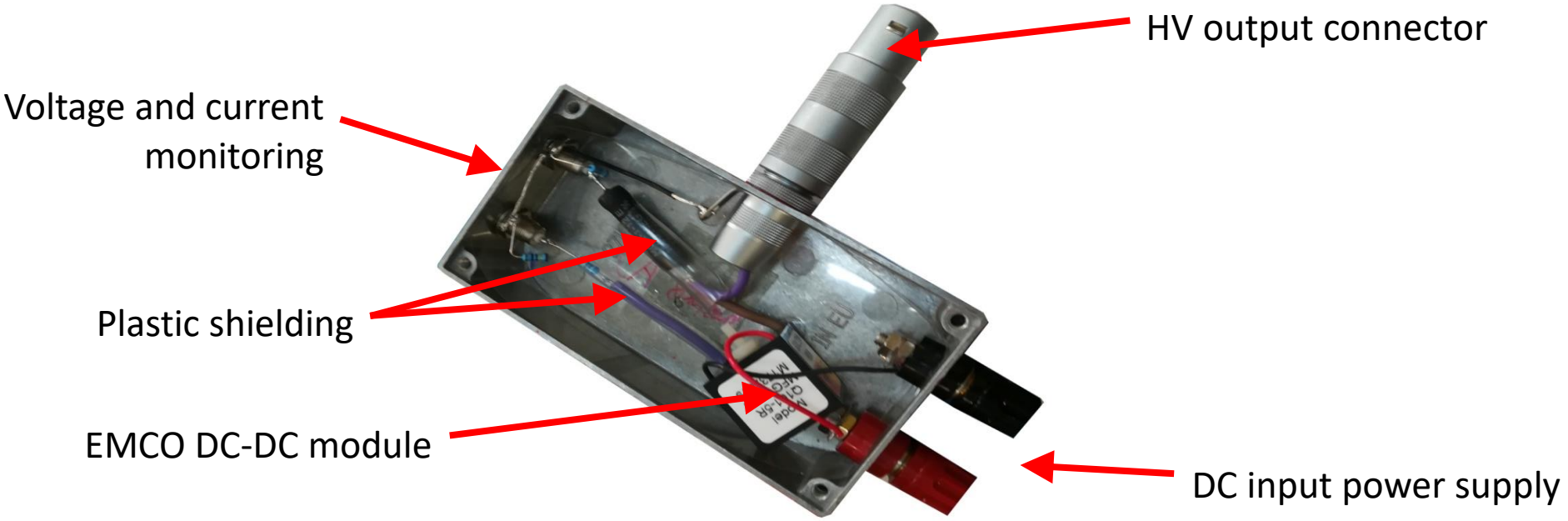
- DC to High Voltage DC Converters
- Isolated Output Voltage is Proportional to Input Voltage
- Ultra-Miniature
- Low Turn On Voltage: < 0.7VDC
- 100V to 10kV Output Voltage
- Positive or Negative
- Very Low I/O Leakage Current
- Reversible Polarity
- Low Noise, Quasi-Sinewave Resonant Oscillator
- MTBF > 3 Million Hours

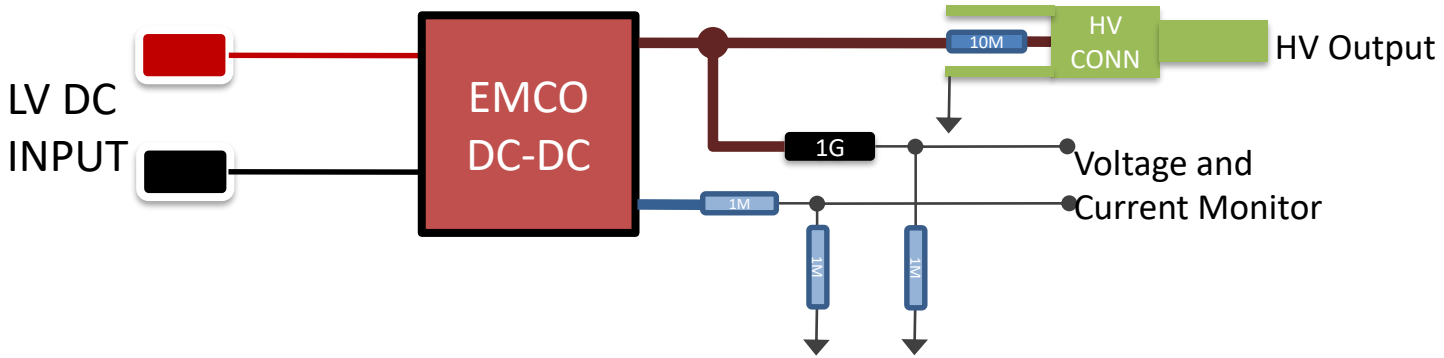
The converters used for the MRPC have an output power of 0.5W.

Schematic of the HV power supply



Layout of the HV power supply

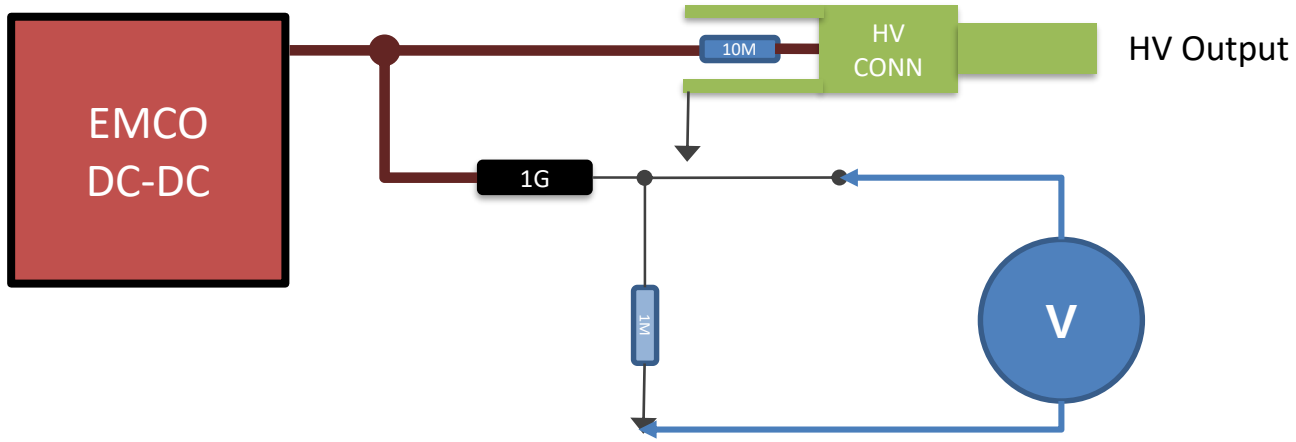




LV input

- The LV input can change from 0.7V to 5V (typically we use 4V to 5V for MRPC chambers);
- To power on a telescope we need at least 3 LV channels for DC-DC converters + 1 LV channel for the FE;
- Both a commercial LV power supply or a custom EEE LV-PS can be used;
- Lecce’s custom EEE LV-PS has a voltage and current monitoring that allows us to read the voltage applied to the chambers.

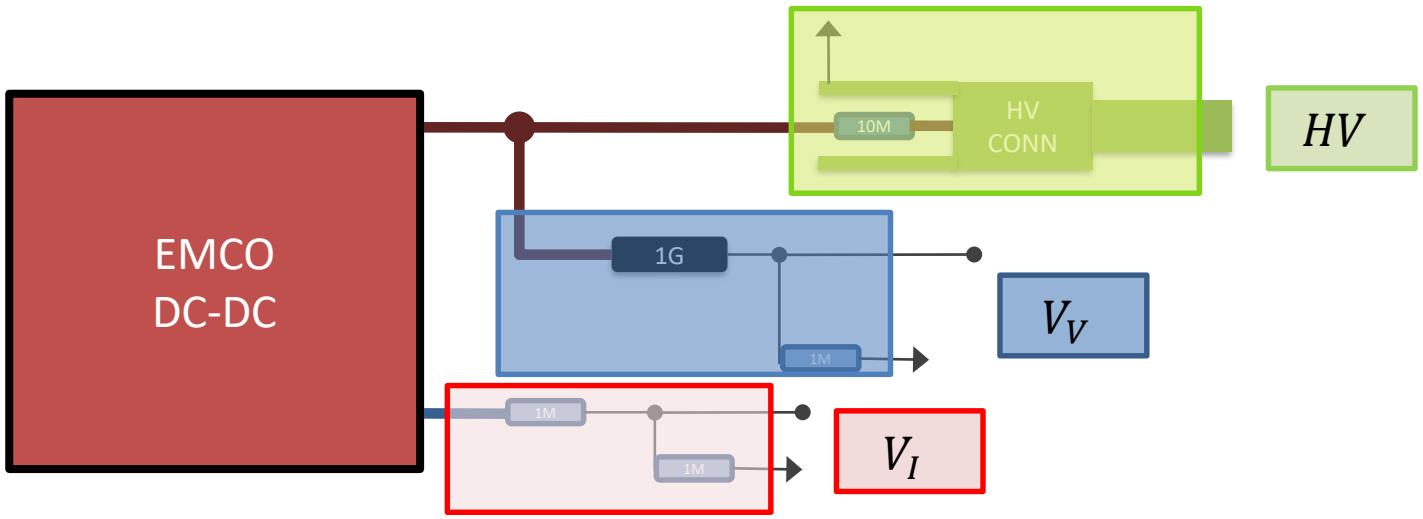
Voltage monitoring



$$V_V = HV \frac{1M\Omega}{10^3 M\Omega + 1M\Omega} \cong \frac{HV}{10^3}$$

$$\boldsymbol{HV \cong V_V \cdot 10^3}$$

Current monitoring



$$|I_I| = I_{HV} + I_V$$
$$I_{HV} = |I_I| - |I_V|$$

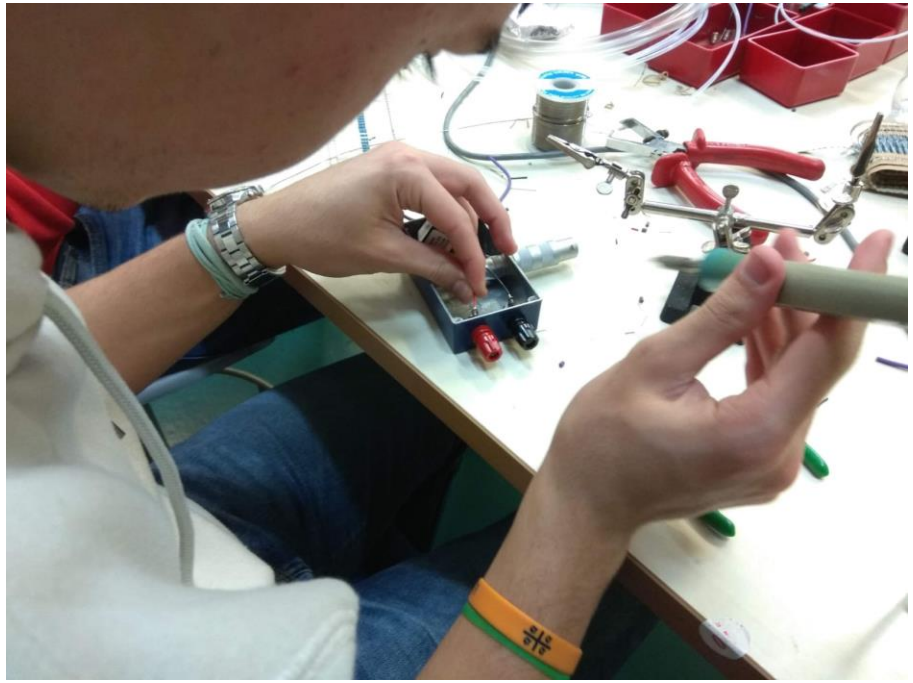
On the practical side

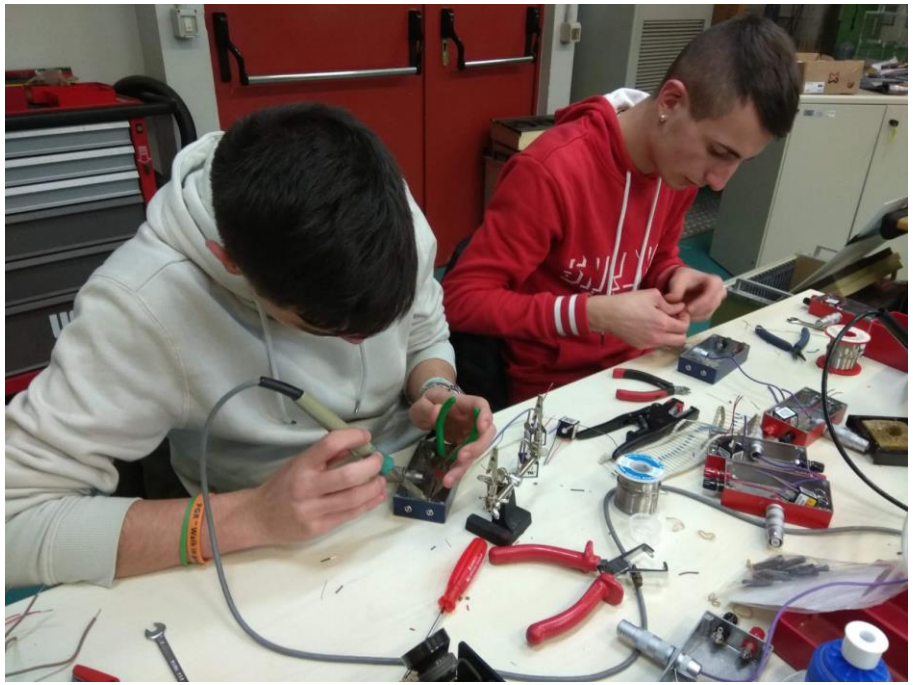
$$\mathbf{I}[A] = \frac{|\boldsymbol{V_I}[\boldsymbol{V}]| - |V_V[V]|}{\mathbf{10^6}}$$

Lecce's custom LV-PS interface

- Low voltage can be driven directly from PC
- LV sense and HV can be monitored via UI

Levi’s team at work





Conclusions

We have worked at the EEE laboratory of the INFN – Cagliari from October to December 2018, with a team of 5 students: Michele Cabras, Marco Canneva, Simone Carboni, Riccardo Onnis, Fabio Porcu.
During this period we have successfully assembled 60 modules, 30 for the positive power supply and 30 for the negative power supply.

Only a few of them have shown a problem of discharge into the high voltage connector caused by the wire of the 10 MΩ which was left too long. The problem on these modules was solved adding a plastic tube to shield the wire and the resistor inside the connector.

We wish to thanks our teacher Prof.ssa Sandra Fiori,
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THANK YOU!