جامعة نيويورك ابوظبي
NYU | ABU DHABI

HV and calibration system of the PTOLEMY detector

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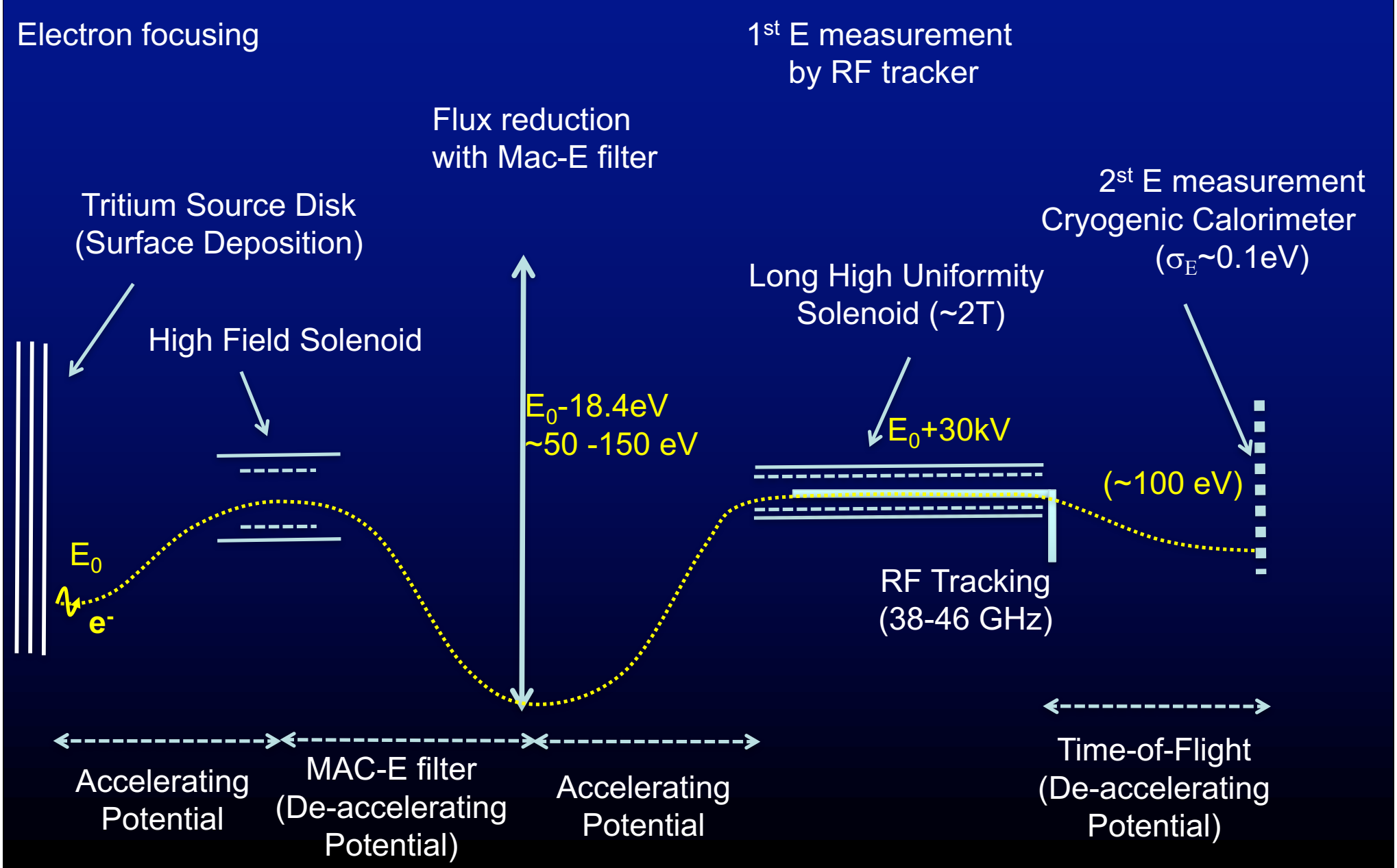
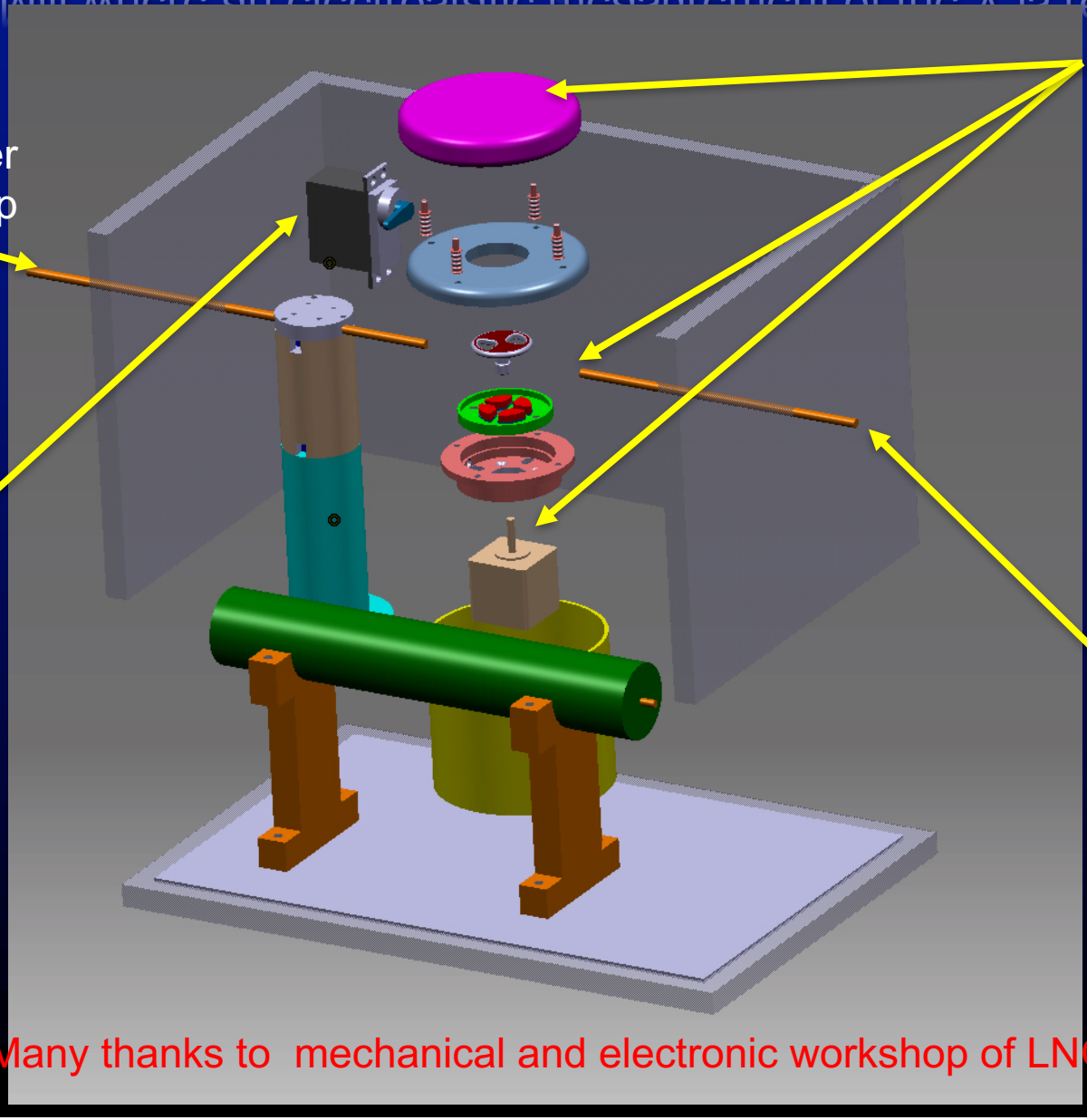
PTOLEMY Experimental Layout



Schematic drawing of the HV system

Field Mill where an electrostatic measurement of the V is realized



Standard HV power supply to charge up the electrodes.

Computer driven actuator

Exploded view of the field mill where the electrostatic measurement of V is realized.

Electrodes bias point

Many thanks to mechanical and electronic workshop of LNGS

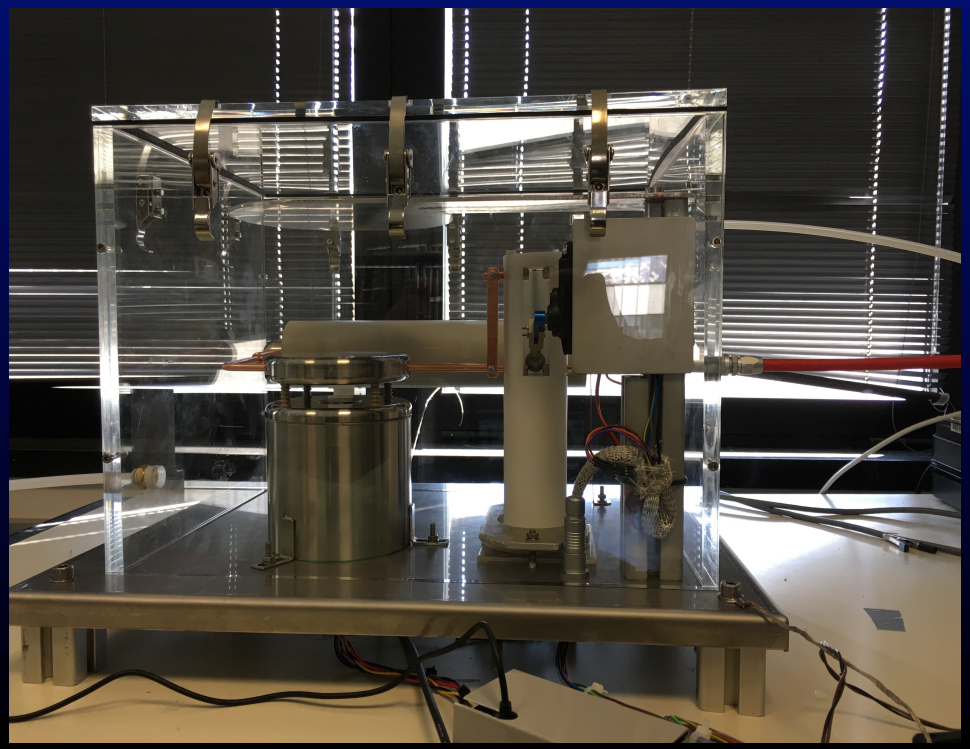
HV biasing and monitoring system of the PTOLEMY detector electrodes

Voltage provided by a locking capacitor

→ not a resistive divider

Field Mill voltage monitoring

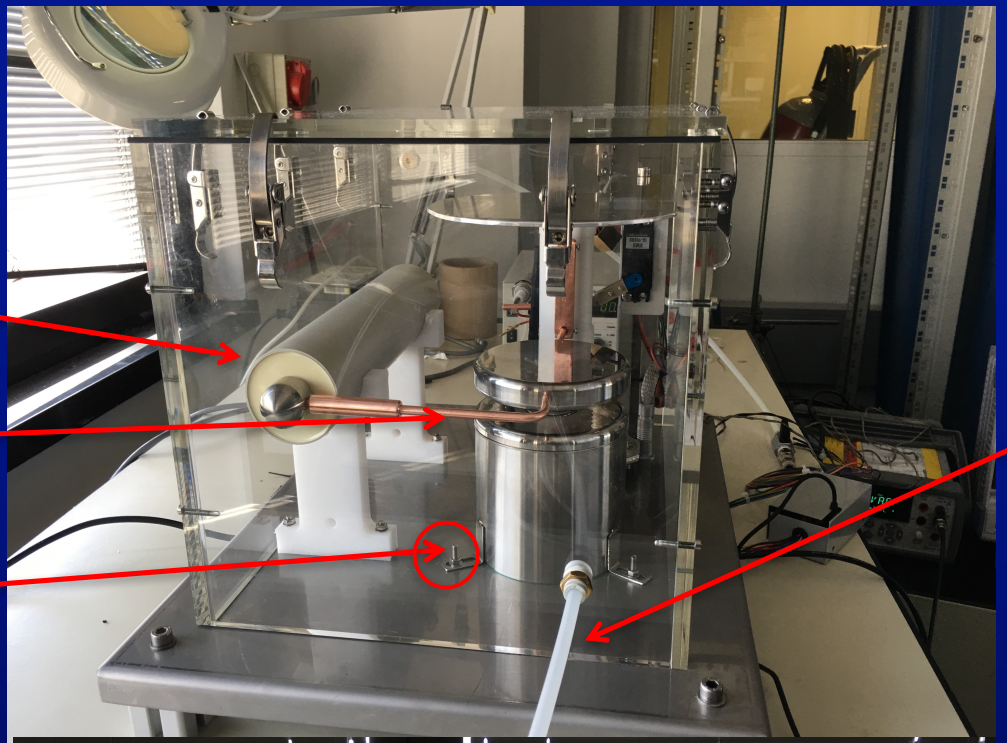
→ On path to supersede all precision voltage systems



Locking capacitor 200 nF

Connection to the Field Mill

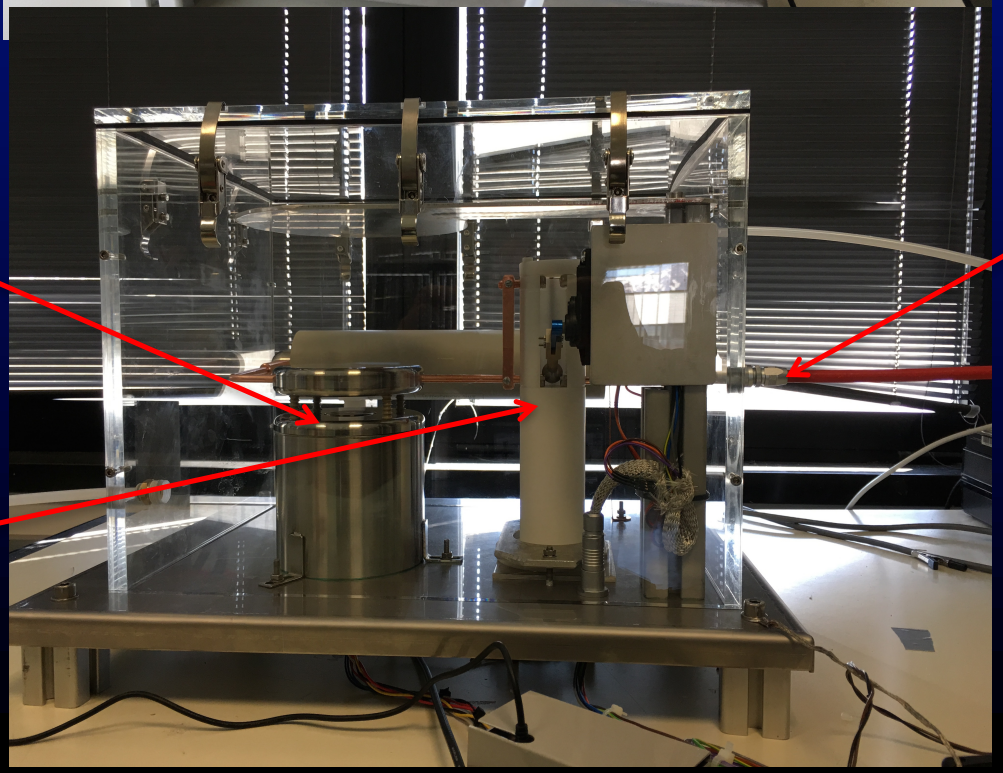
Detector/electrode side. The HV connection is still missing.



Dry N pipe.
In future also SF6 to prevent discharge in air.
The plexi-box is also important for safety.

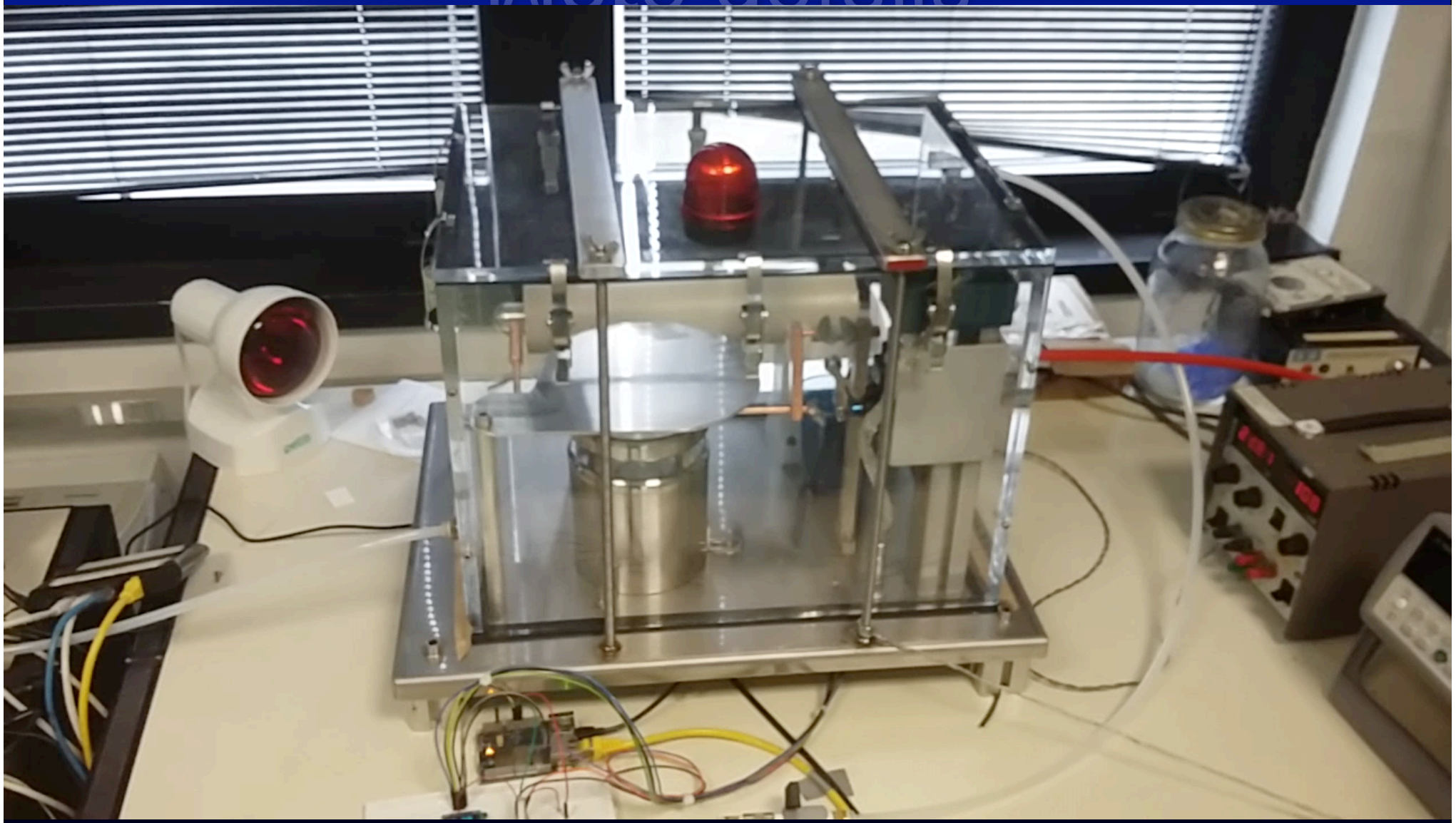
Side view of the Field Mill

HV switch to charge up the capacitor (bottom position), to discharge (yop). Normal position (middle) while measuring.

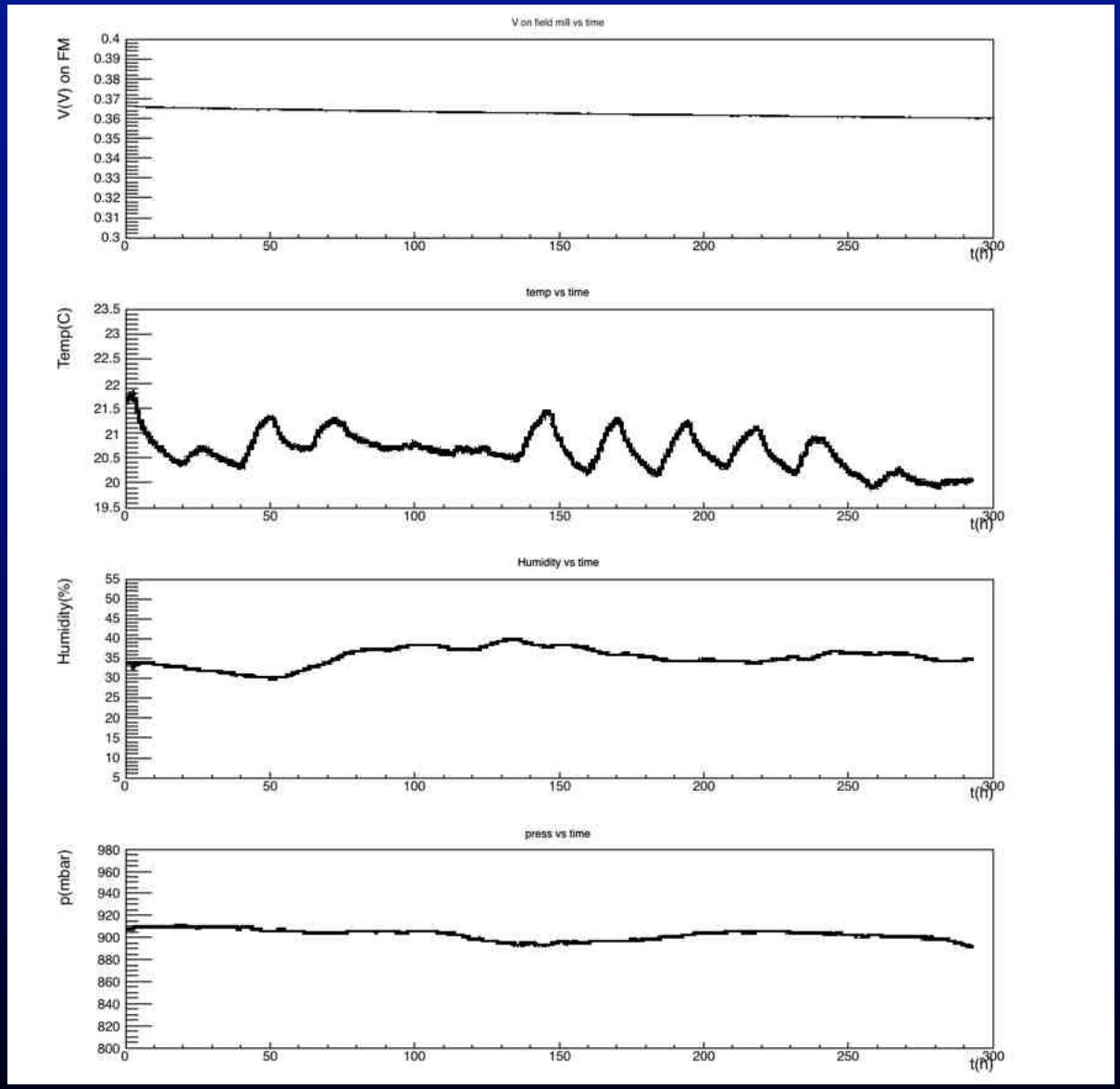


Connection to DC power supply

More details



What we measure



Voltage proportional to the bias voltage of the electrode (5000 V in this case)

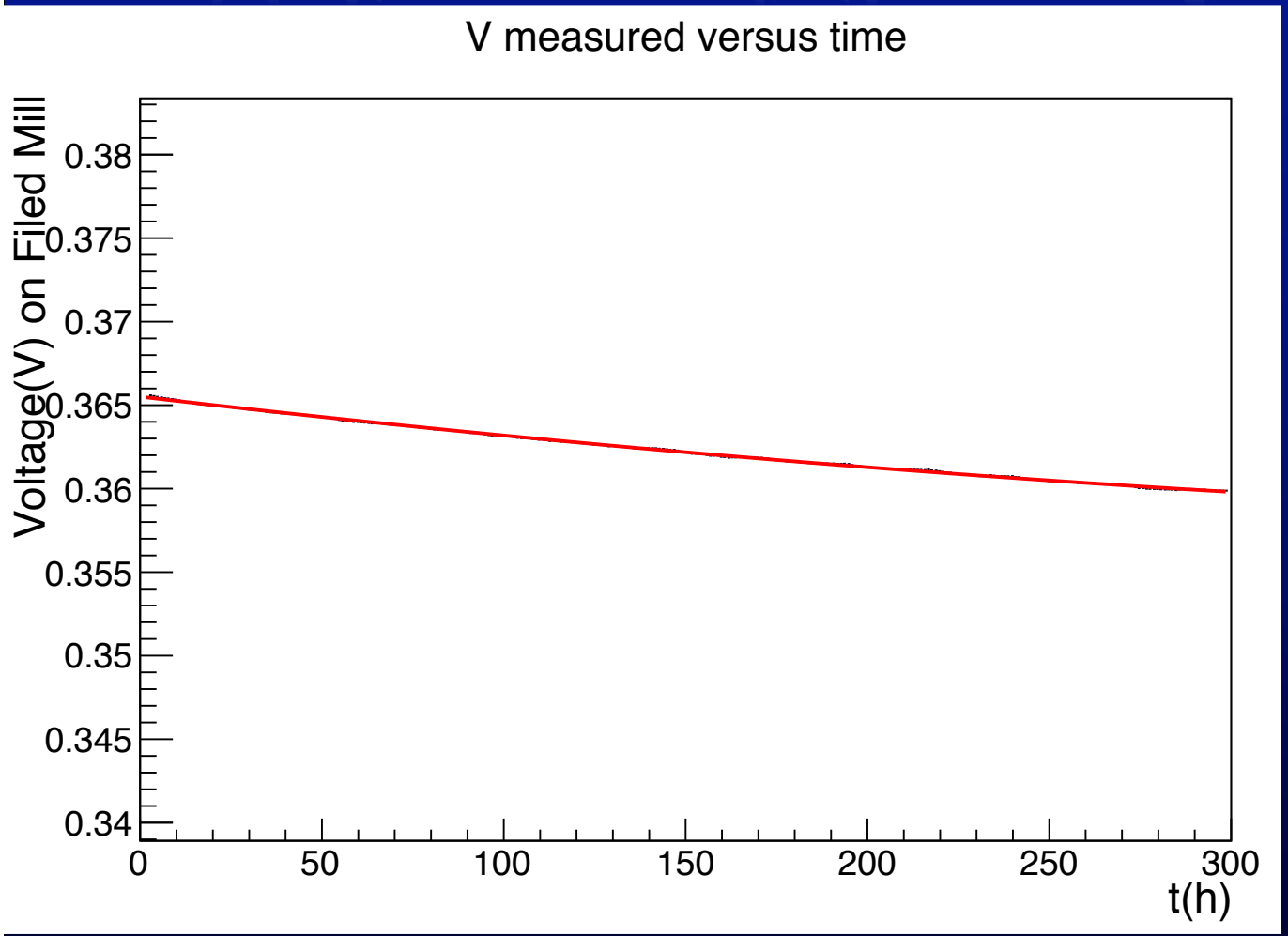
T of the environment

Humidity

Pressure

Two issues to investigate and fix: long decay time and signal variation correlated to T instability.

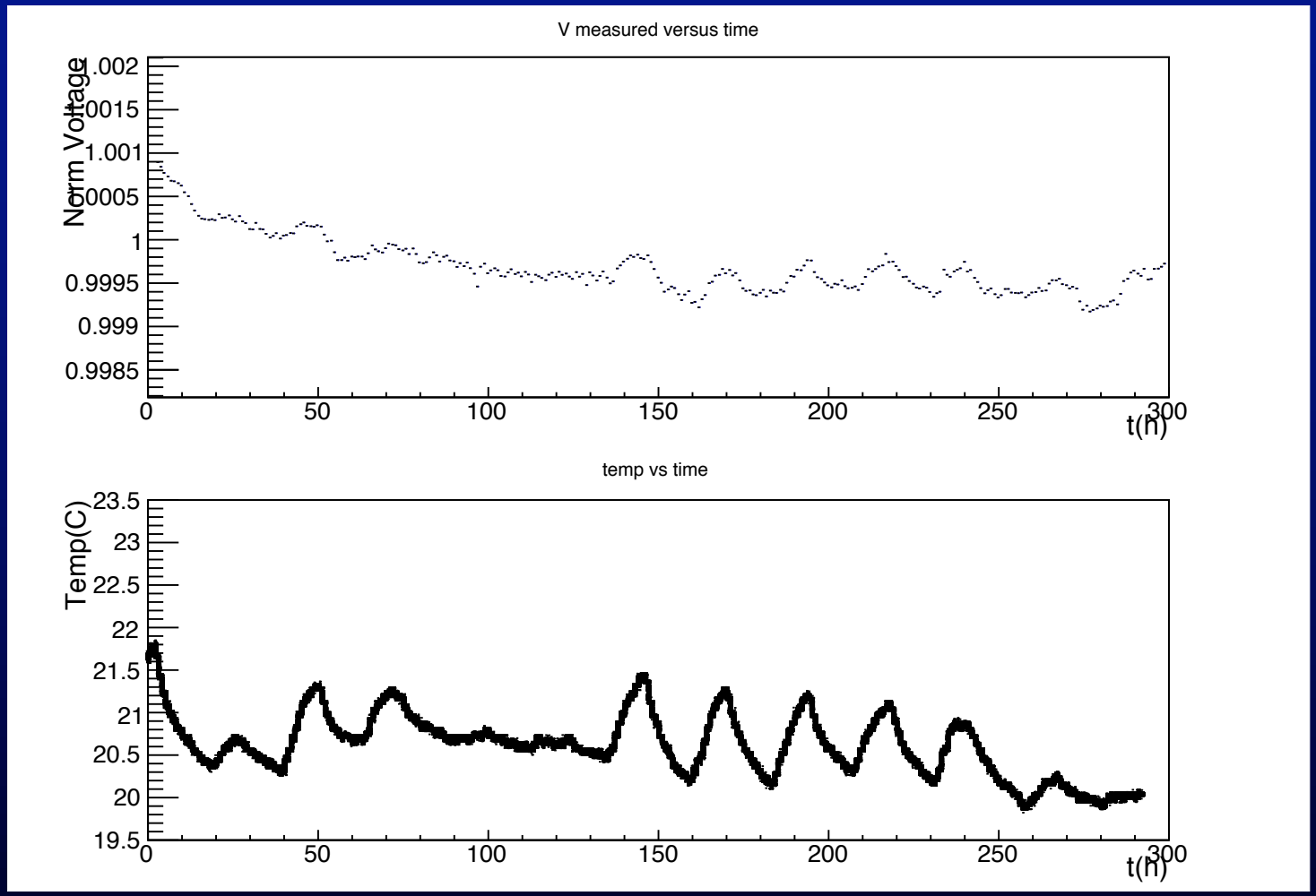
Voltage variation as function of T



Quadratic function Fit? No reason for such a behavior. We expect an exp decay if the internal capacitor leak is the main responsible of the decay.
The second order pol behavior is probably the result of two linear decay with different rate.

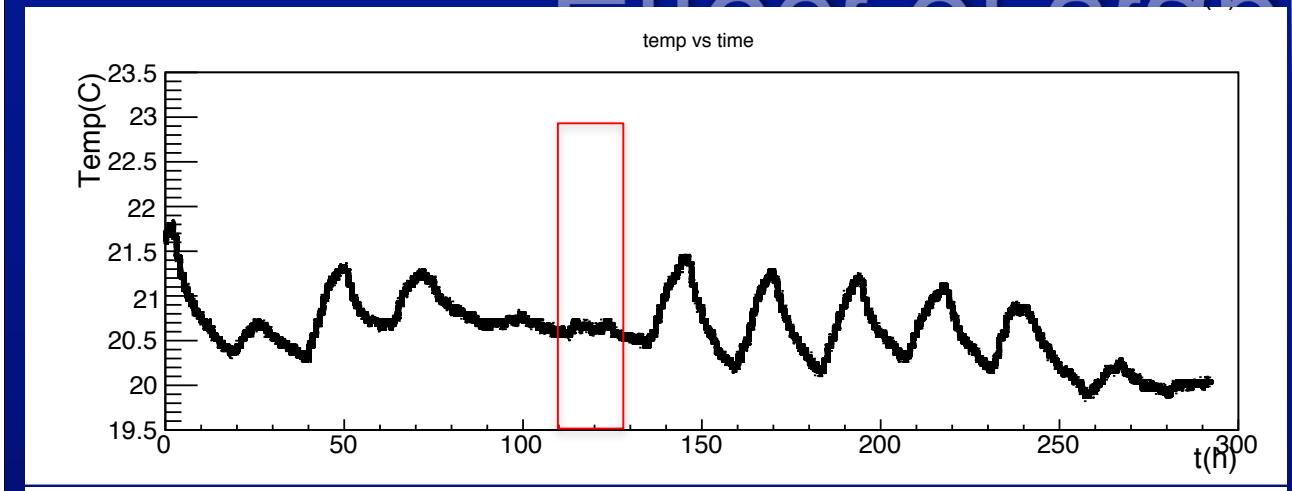
Mean decay rate 2x 10^{-5} V/h at 5000 V bias voltage corresponding to ~ 0.3 V/h Discharge of the electrode.

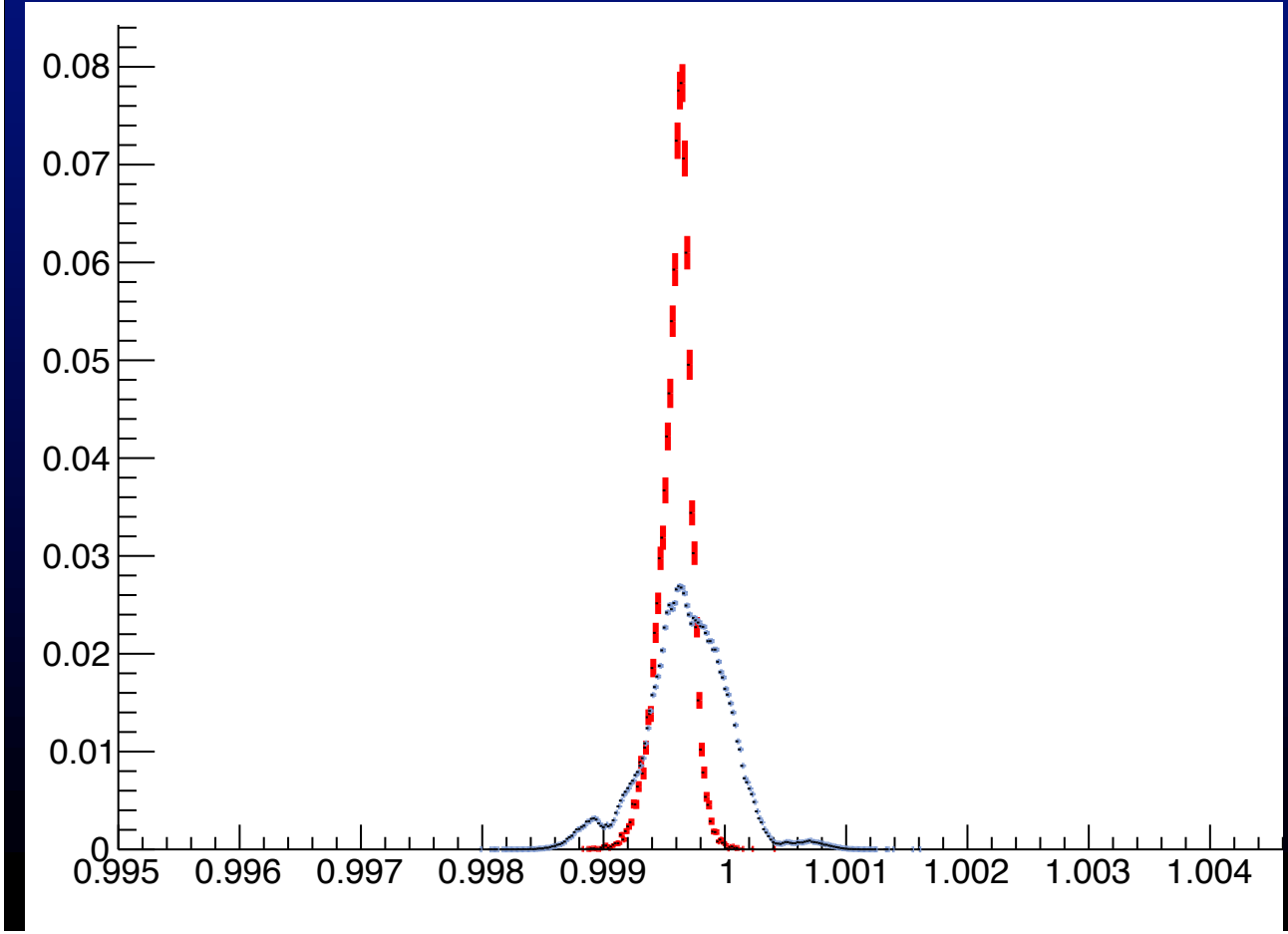
Voltage variation correlated to T



Temperature stabilization is necessary. We aim at having 0.1 C stability. This should be sufficient to reach 10^{-6} signal stability that we aim at achieving.

Effect of stable T



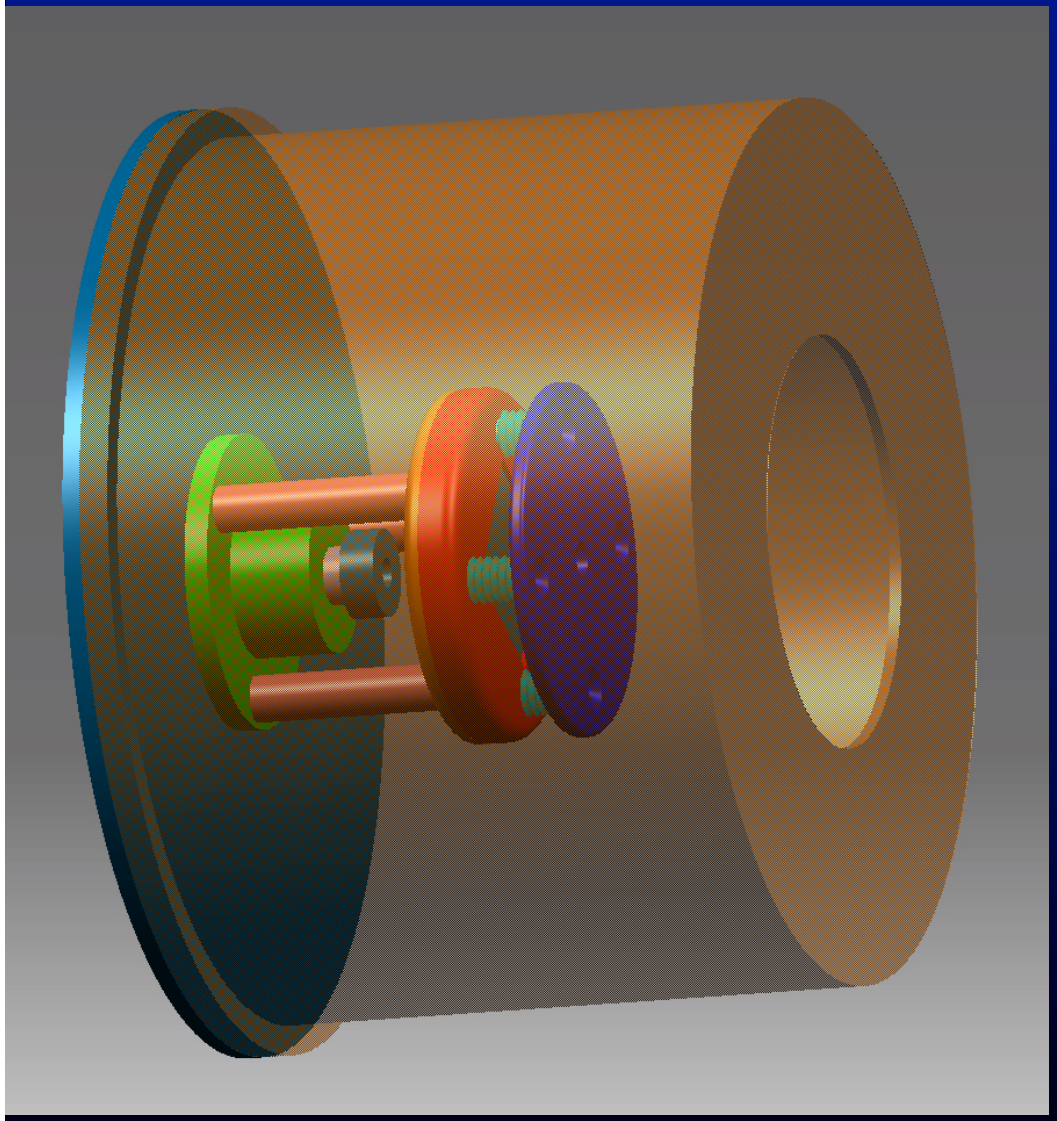


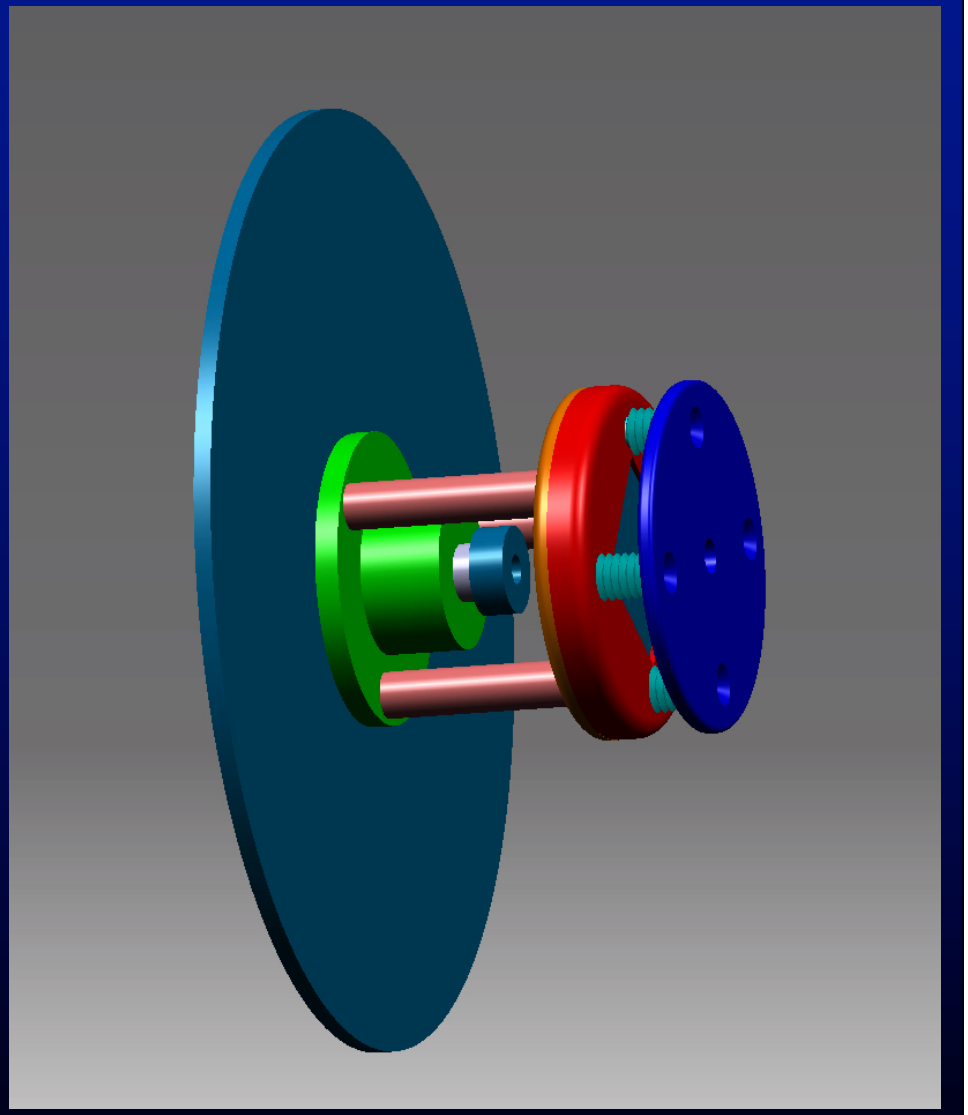
Which are next steps

- Test in vacuum to definitively check if air ionization by cosmic rays and Rn decays have an effect on the voltage stability.
- Test underground to prof if ionization on electrodes has an effect.
- A T stabilization system is needed. We are working on it.
- Improve the grounding of the shutter.
- We think that performance one order of magnitude better than the present one is in a reach.

How to check efficiency and energy scale.

E-gun

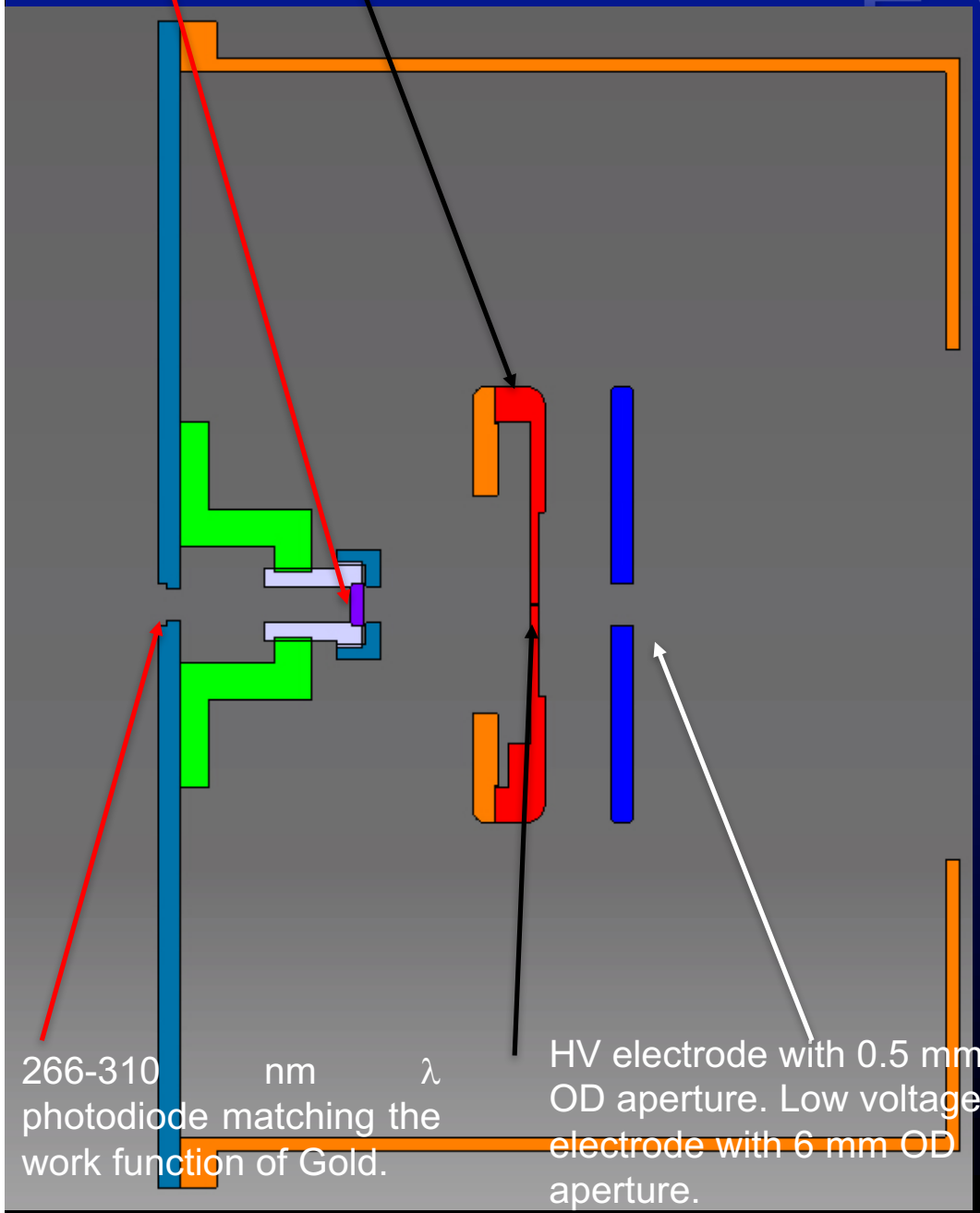




E-gun

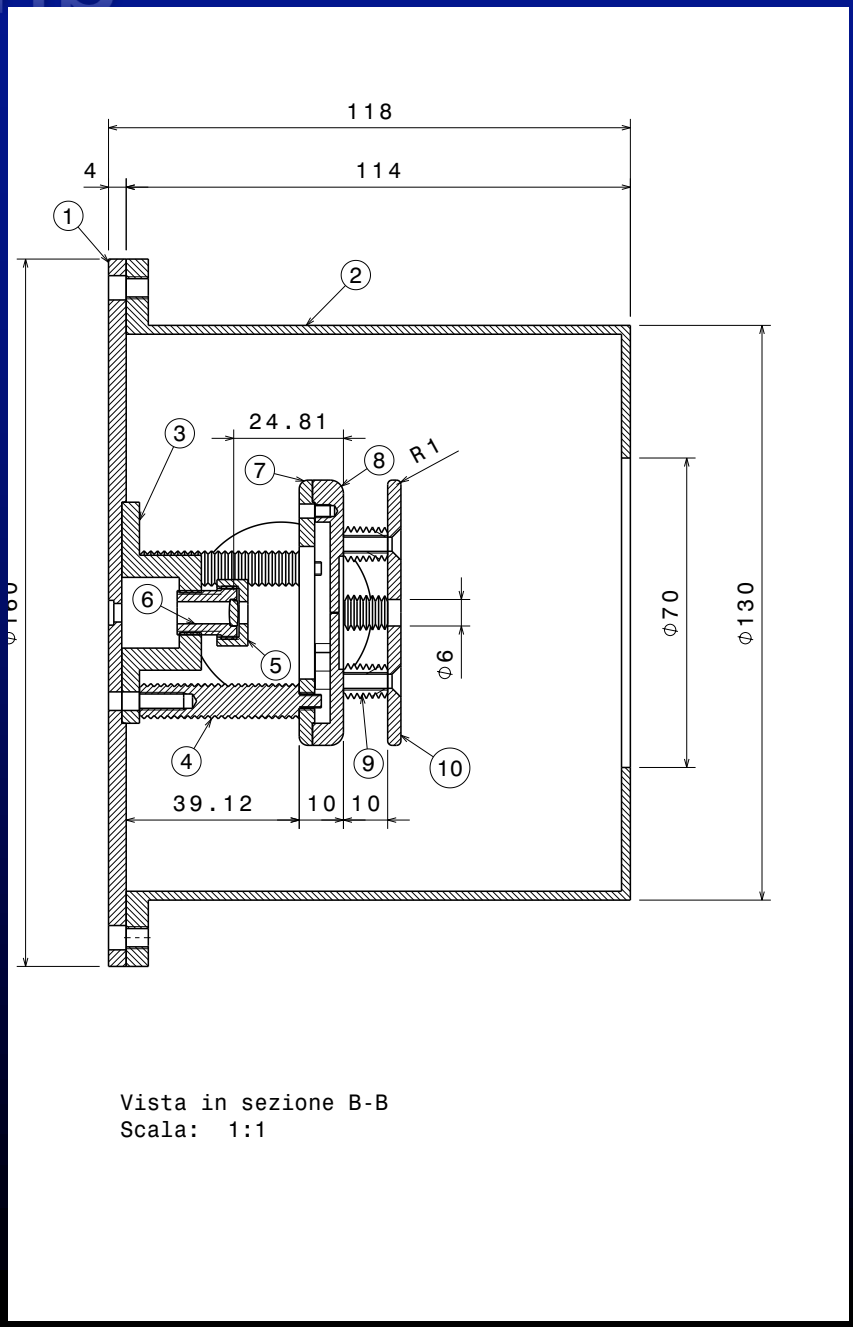
Focusing lens

Seat for quartz window coated with Gold



266-310 nm λ photodiode matching the work function of Gold.

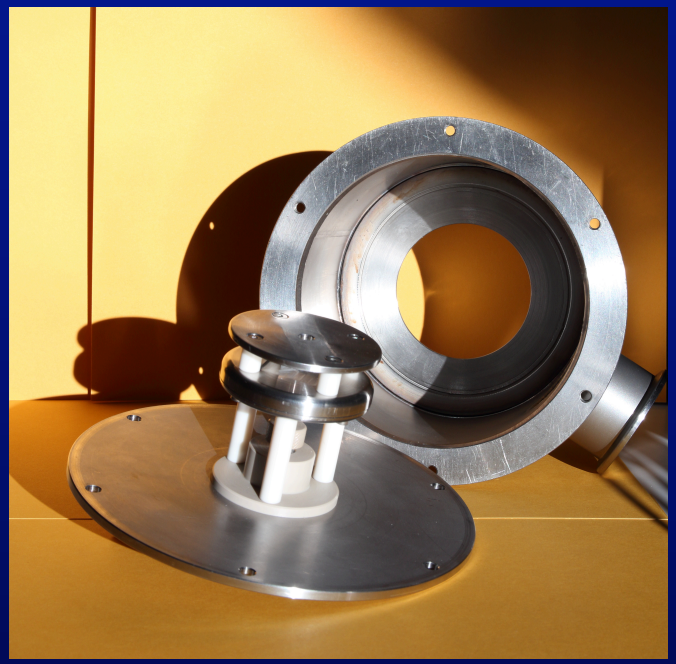
HV electrode with 0.5 mm OD aperture. Low voltage electrode with 6 mm OD aperture.

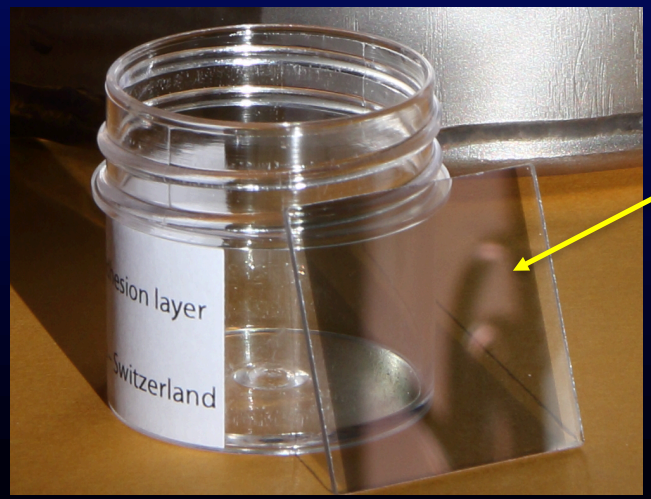


Vista in sezione B-B
Scala: 1:1

Construction and assembling ongoing

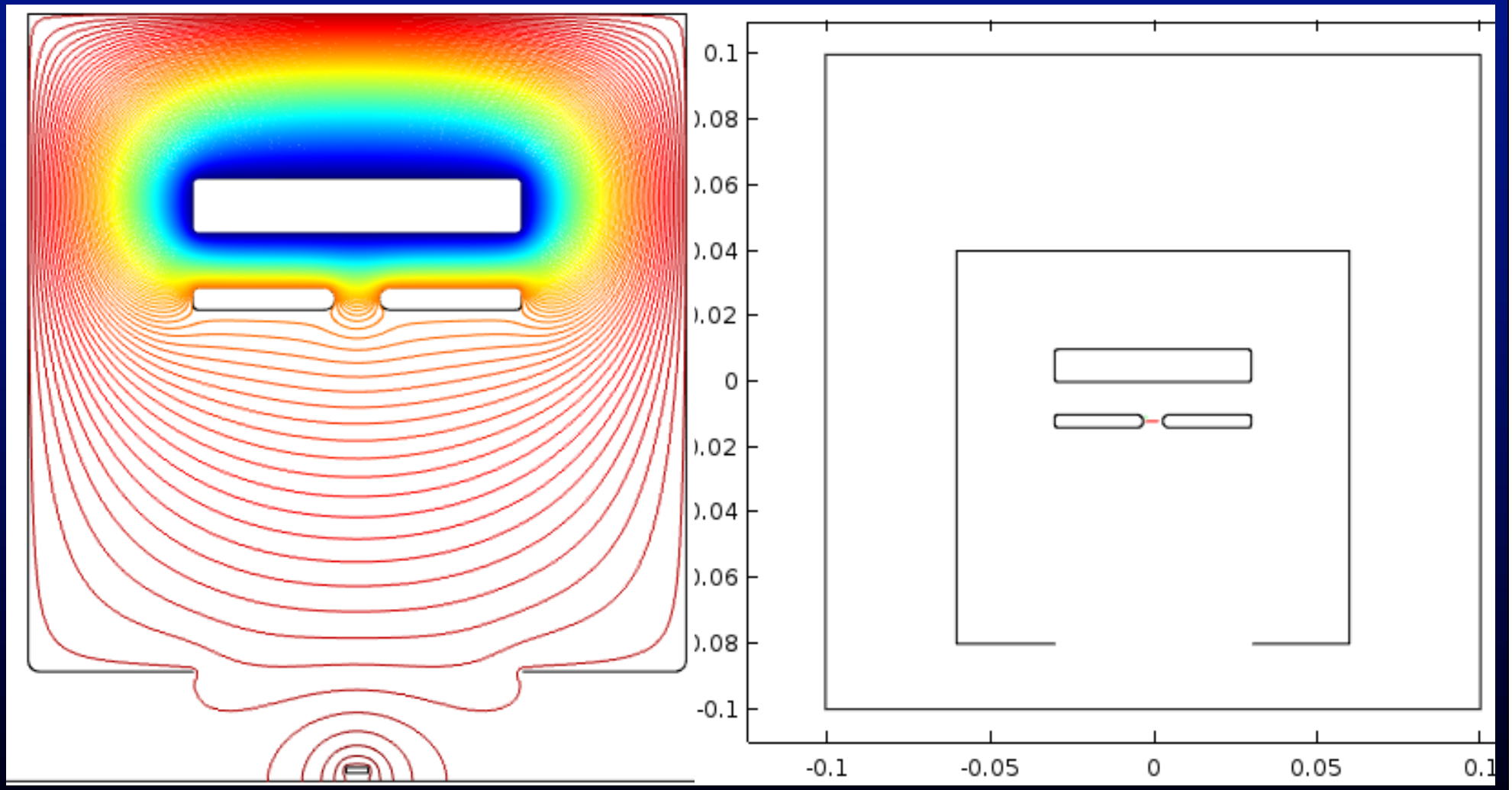
Beam direction



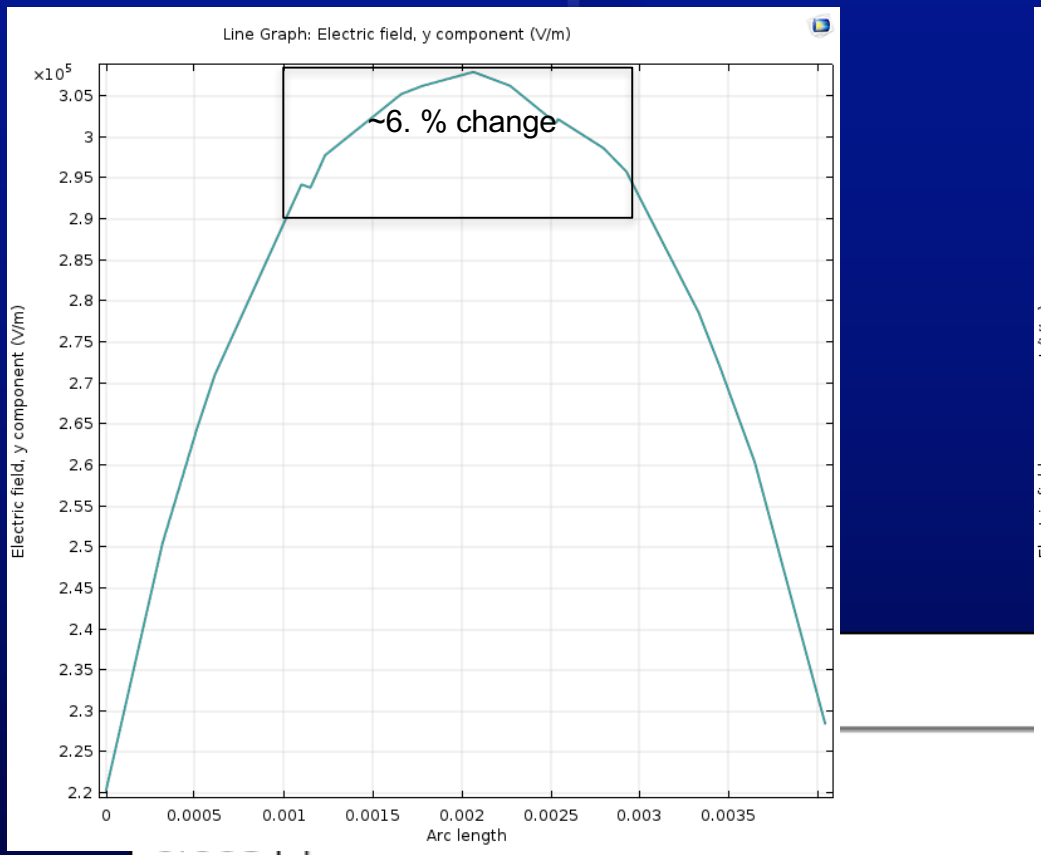


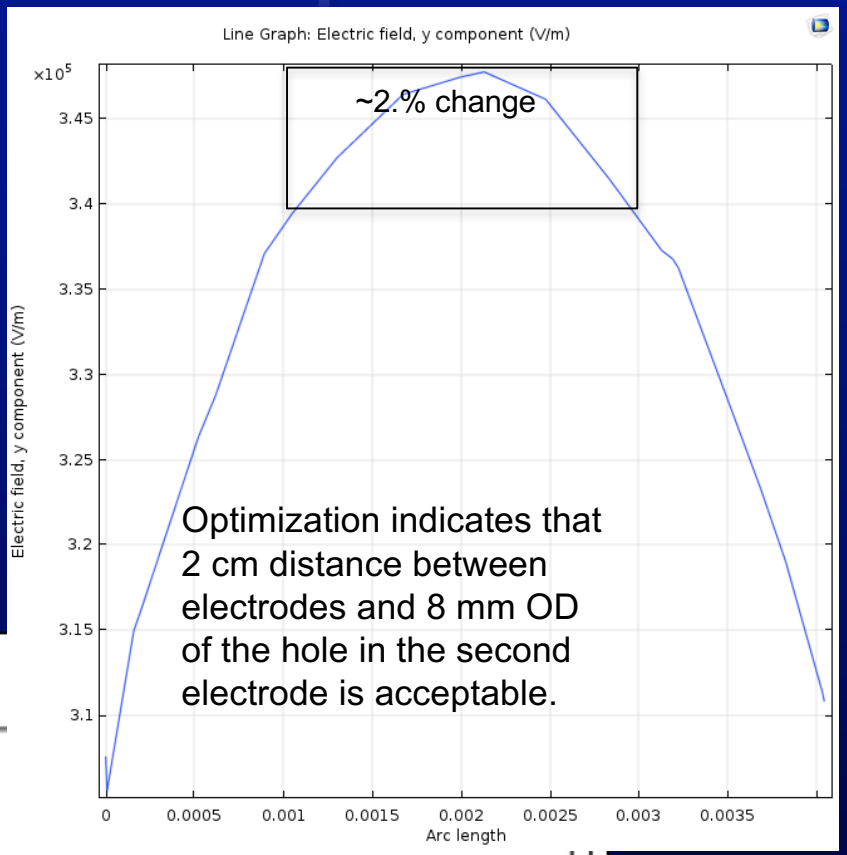
Quartz support with
Gold coating (10 nm)
Kindly provided by
Chris. Tully from Princeton.

E-field simulation

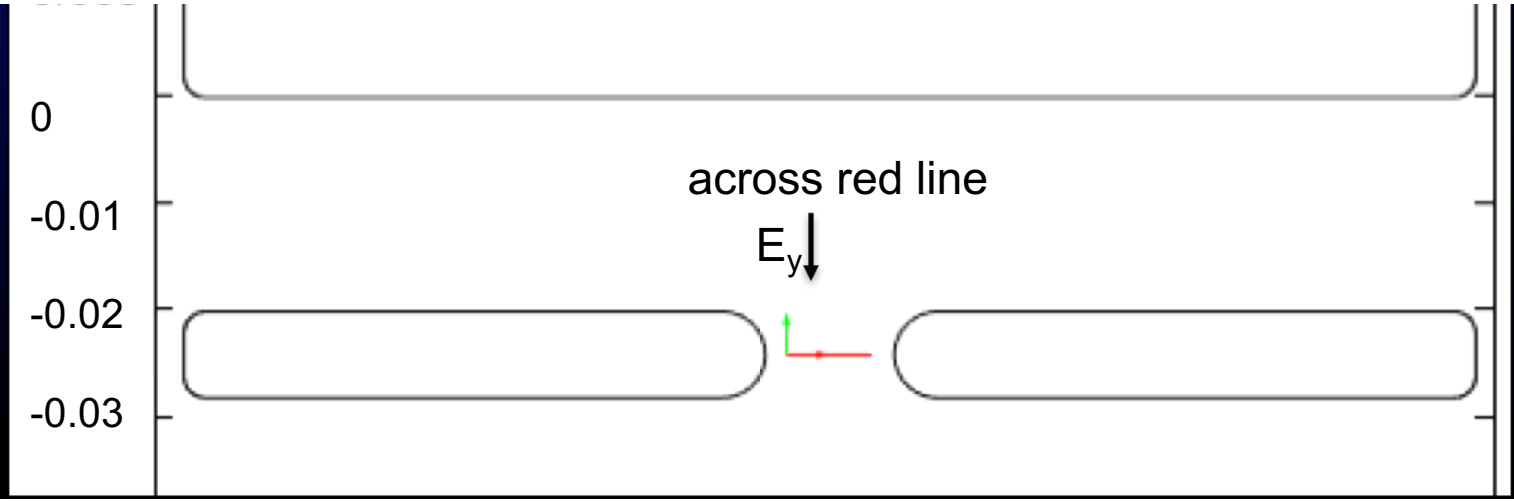


Ey-component





Optimization indicates that 2 cm distance between electrodes and 8 mm OD of the hole in the second electrode is acceptable.



To Conclude

- Good idea inherited by KATRIN collaboration.
  (Behrens, J., Ranitzsch, P.CO., Beck, M. et al. Eur. Phys. J. C (2017) 77: 410.)
- Part of eV in energy distribution can easily be achieved. We aim at achieving ~ 0.1 eV
- A system to trigger the out coming electrons is mandatory for precise measurement of the efficiency of the PTOLEMY detector. More options are under consideration such as Josephson Junction or also more classical setup (Novelty feature w.r.t. KATRIN device).