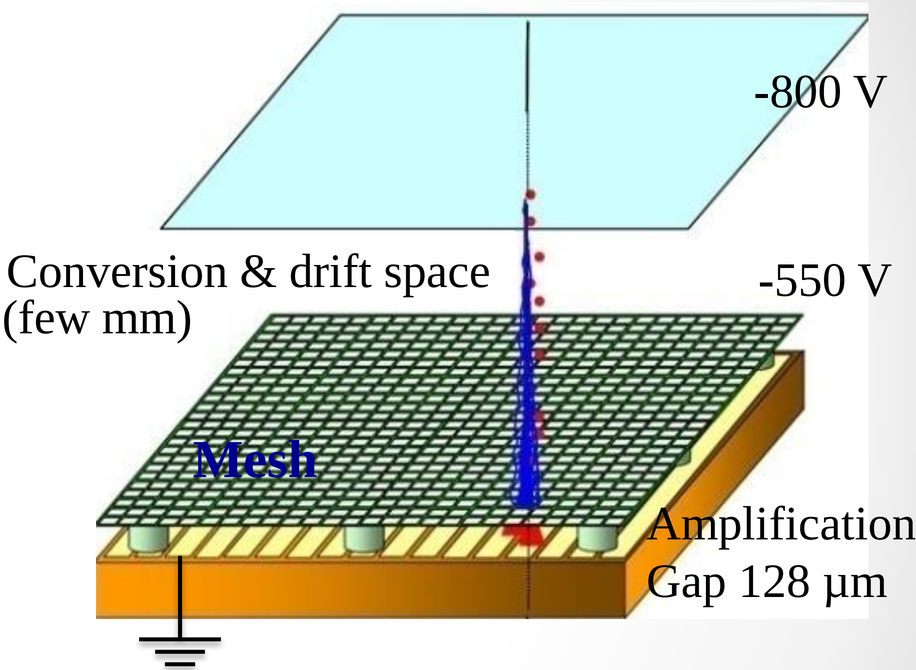
Micro MEsh GASeous Detectors (MicroMegas)

RD51 Electronics school
CERN 3 – 5 February 2014

What are Micromegas ?

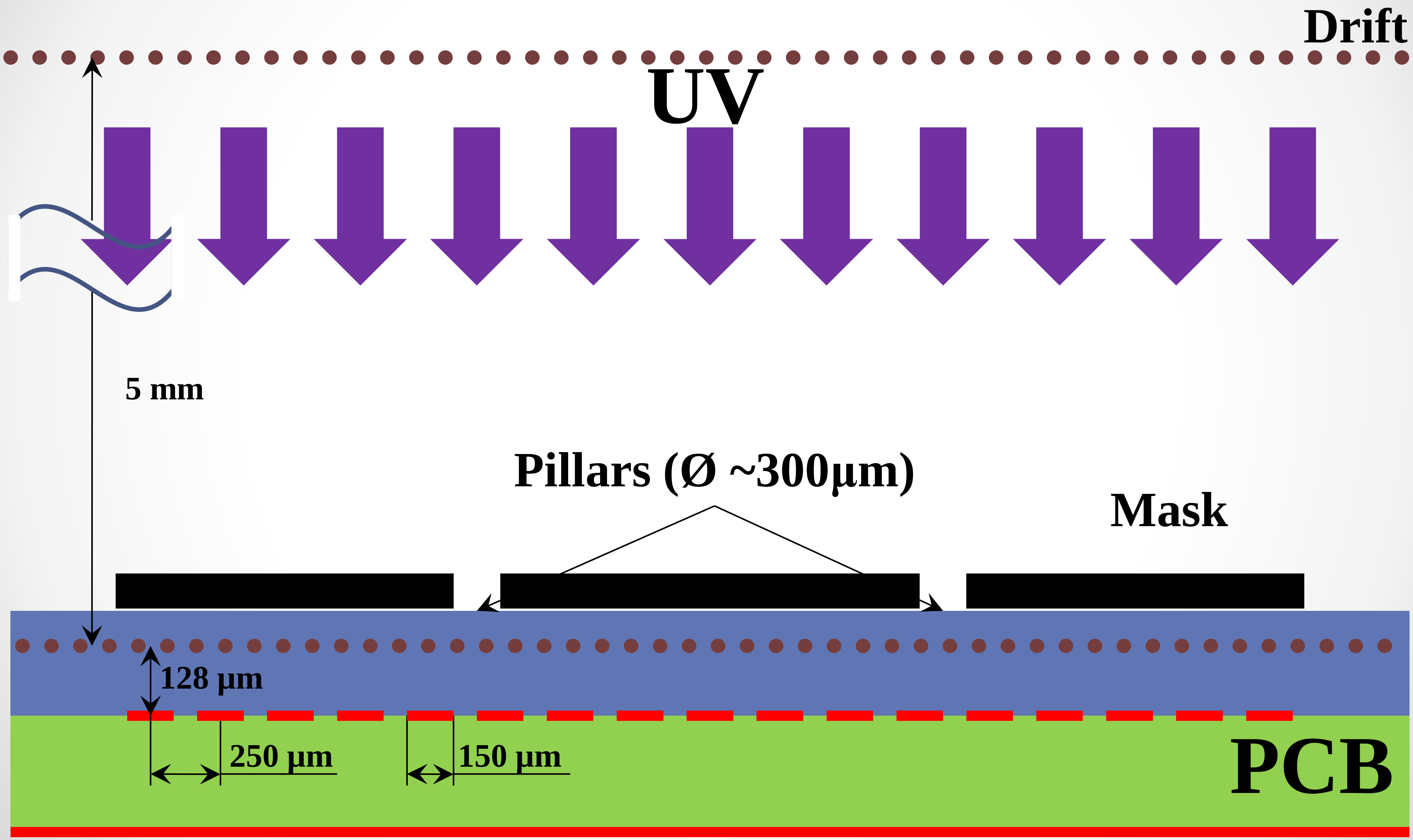
- Micromegas are parallel-plate chambers where the amplification takes place in a thin gap, separated from the conversion region by a fine metallic mesh

- The thin amplification gap (short drift times and fast absorption of the positive ions) makes it particularly suited for high-rate applications



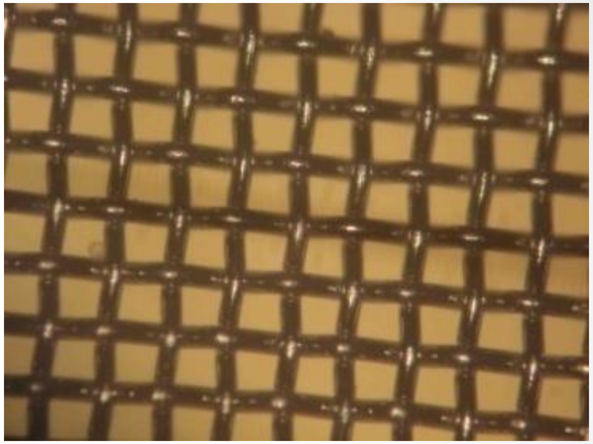
The principle of operation of a MicroMegas chamber

The bulk MicroMegas technique



Bulk MicroMegas structure

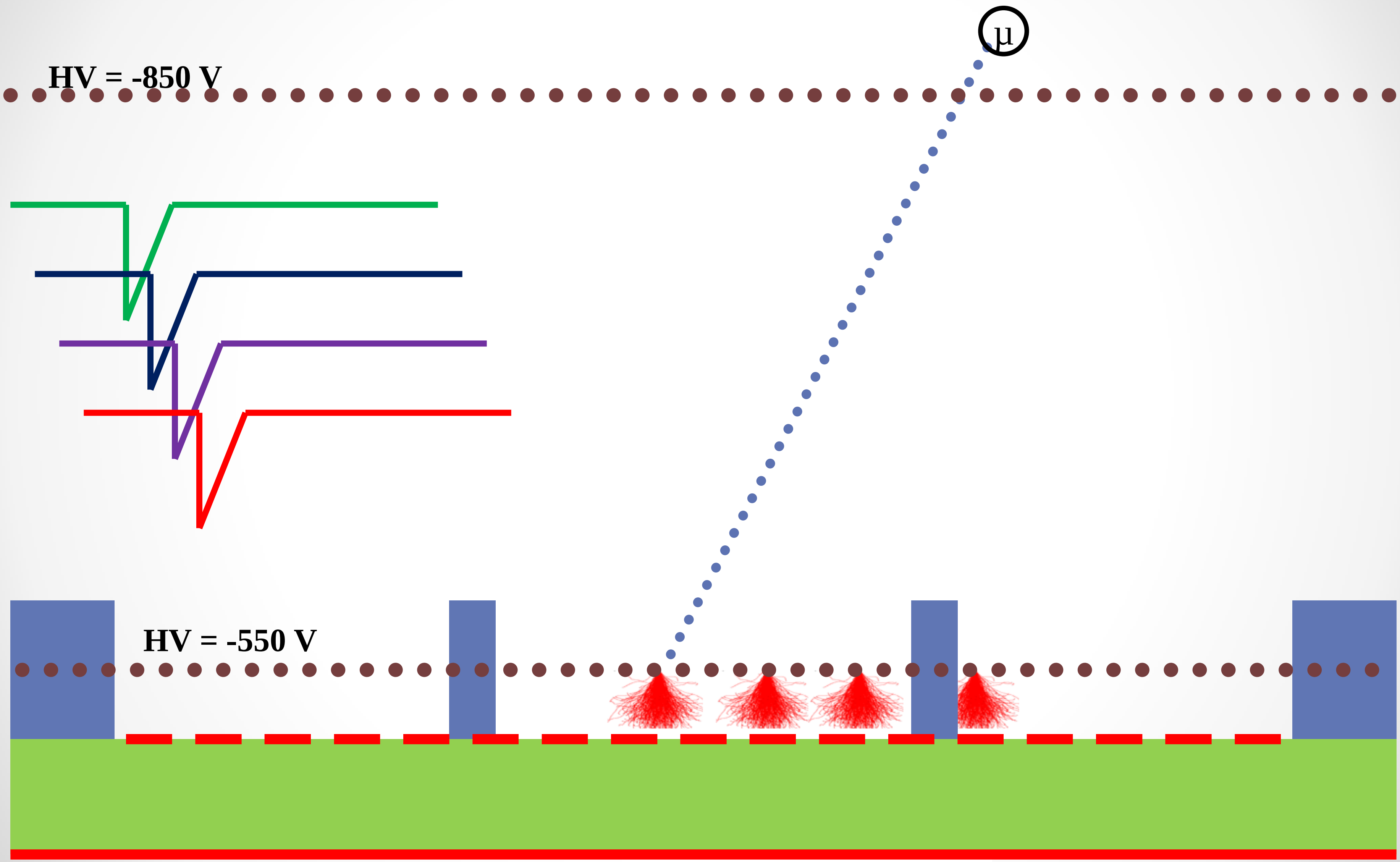
Pillar distance on photo: 2.5 mm



Standard configuration

- Pillars every 5 (or 10) mm
- Pillar diameter ≈350 μm
- Dead area ≈1.5 (0.4)%
- Amplification gap 128 μm
- Mesh: 325 lines/inch

MicroMegas as µTPC



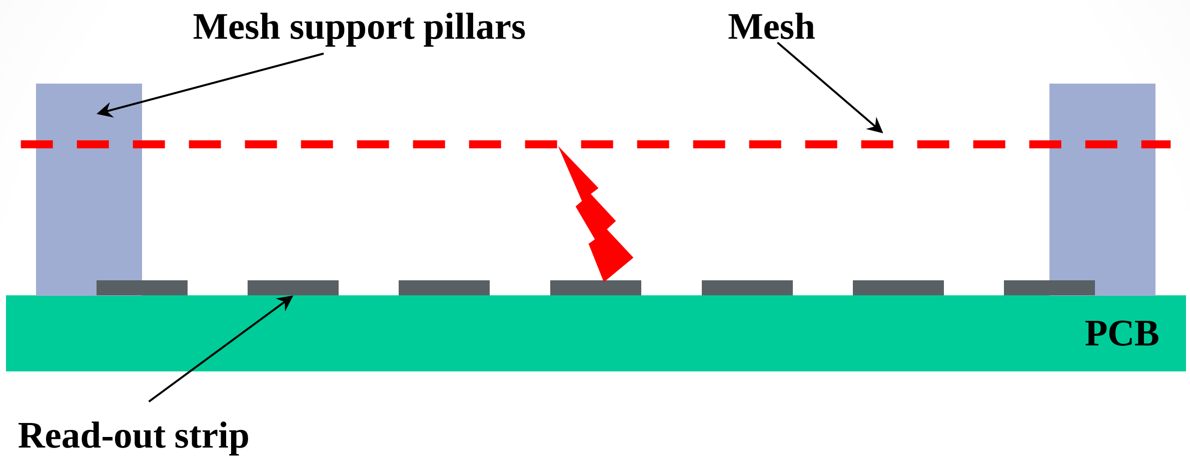
Operating parameters

- Chambers are operating with an Ar:CO_2 (93:7) gas mixture (same gas as MDTs, safe and cheap, no flammable components)
- High Voltage (moderate HV requirements)
  - Mesh: -500 V (amplification field 40-50 kV/cm)
  - Drift-electrode: -800 V (~600 V/cm)
  - Currents in nA range

Performance requirements

- Spatial resolution: ~60 μm
- Angular resolution: ~0.3 mrad
- Good double track resolution
- Trigger capability
- Efficiency: > 98%

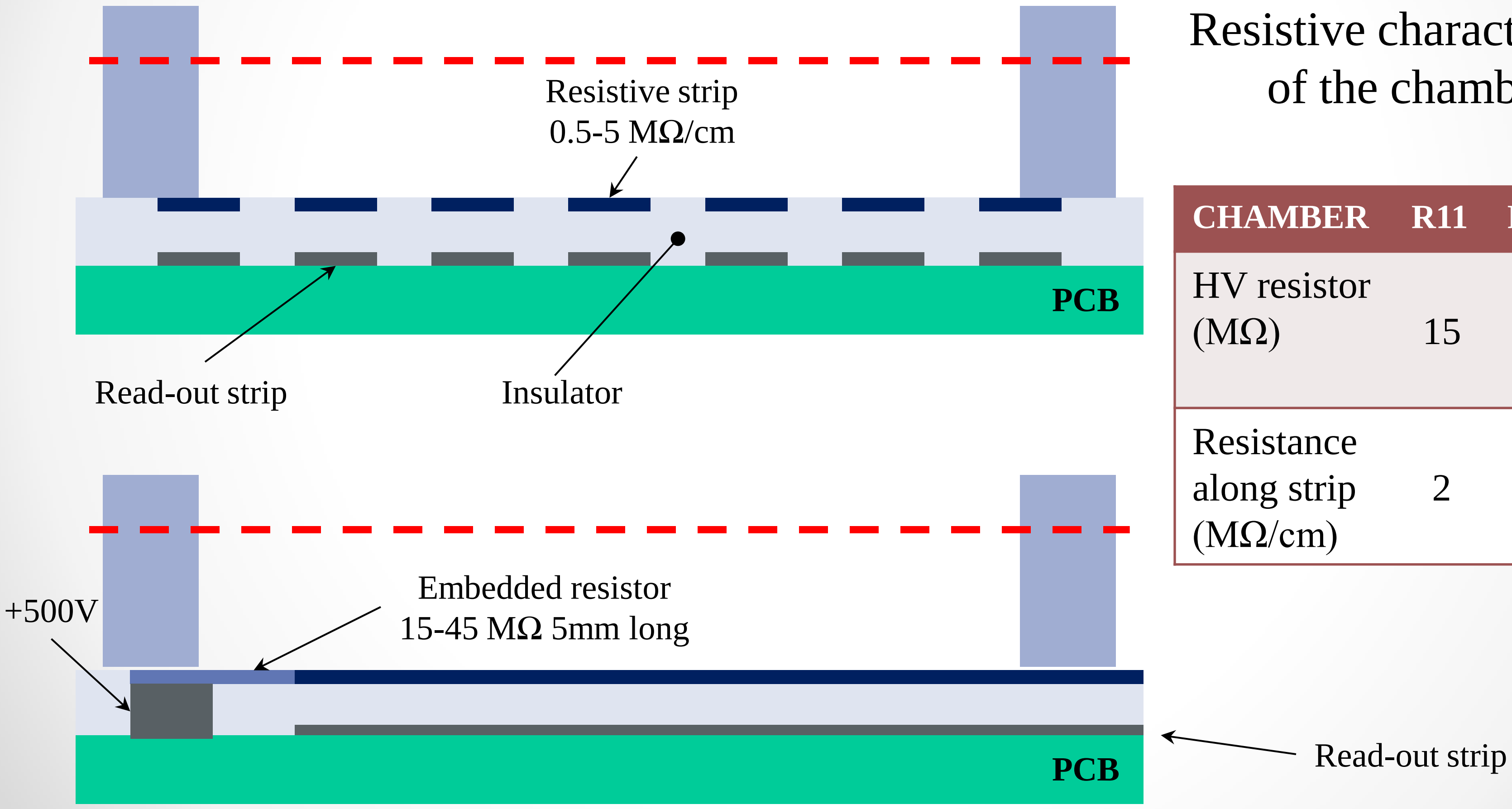
Sparks in the chamber



Sparks between mesh and readout strips may damage the detector and readout electronics and/or lead to large dead times as a result of HV breakdown

Resistive MicroMegas chambers

To avoid spark effect the readout strips were covered with the 64 μm thick insulator layer with resistive strips on top of it connected to the +HV via discharge resistor and mesh is connected to GND



Resistive characteristics of the chambers

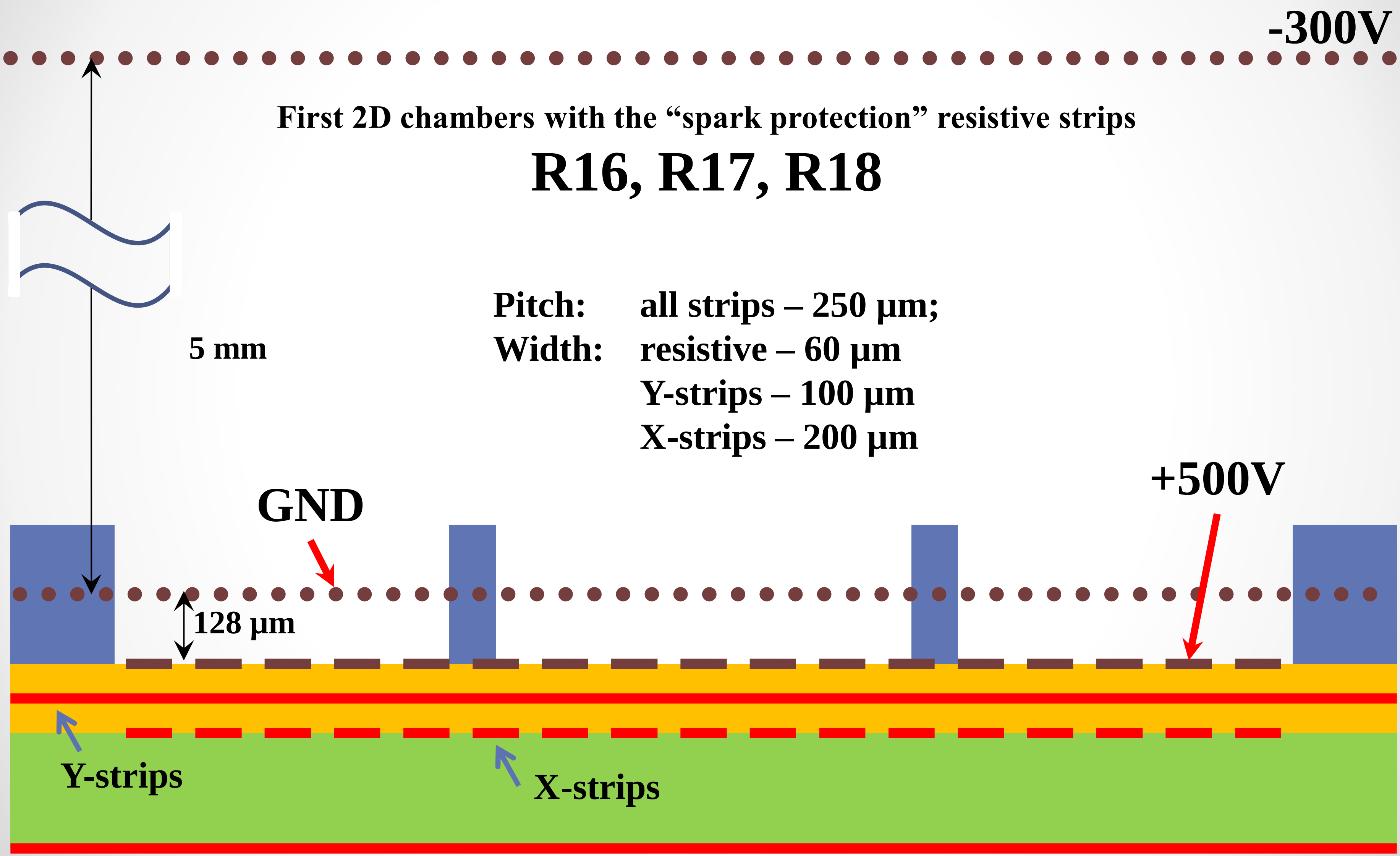
CHAMBER	R11	R12	R13
HV resistor (MΩ)	15	45	20
Resistance along strip (MΩ/cm)	2	5	0.5

Resistive MicroMegas chambers

First 2D chambers with the "spark protection" resistive strips

R16, R17, R18

Pitch:	**all strips – 250 μm;**
Width:	**resistive – 60 μm**
	Y-strips – 100 μm
	X-strips – 200 μm



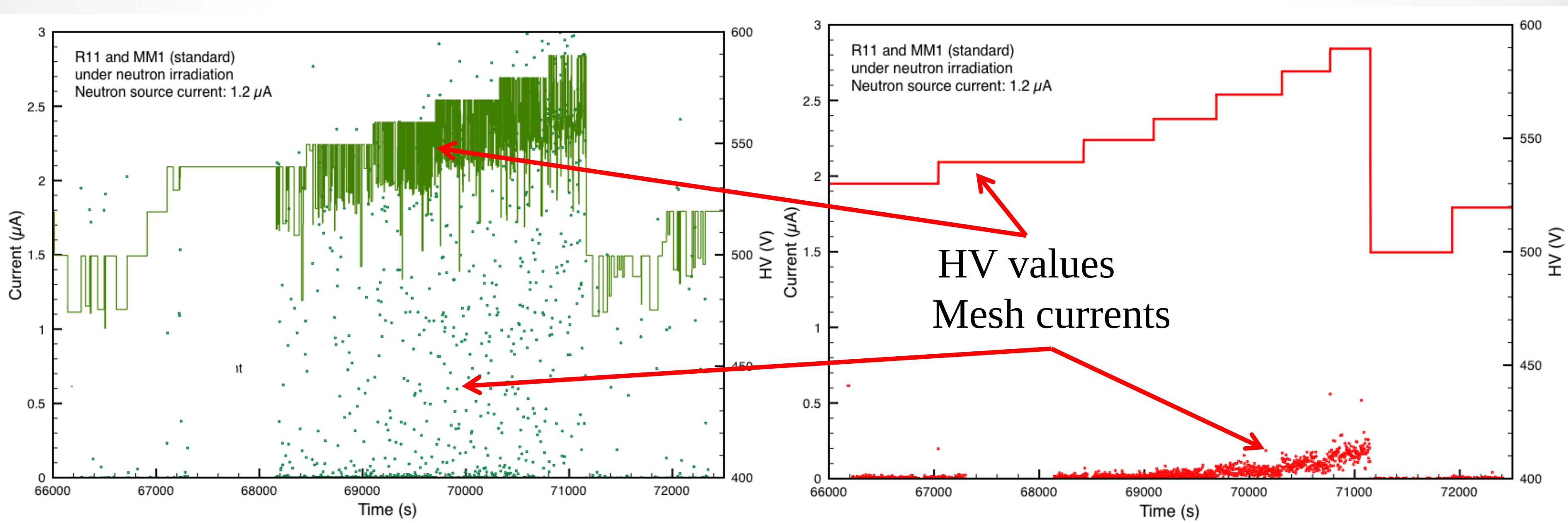
Standard chamber vs resistive

MicroMegas mesh currents and HV drop in neutron beam

Gas: Ar:CO_2 (85:15) Neutron flux: ≈ 10^6 n/cm^2/sec

Standard MM:
Large currents
Large HV drops, recovery time O(1s)
Chamber could not be operated stably

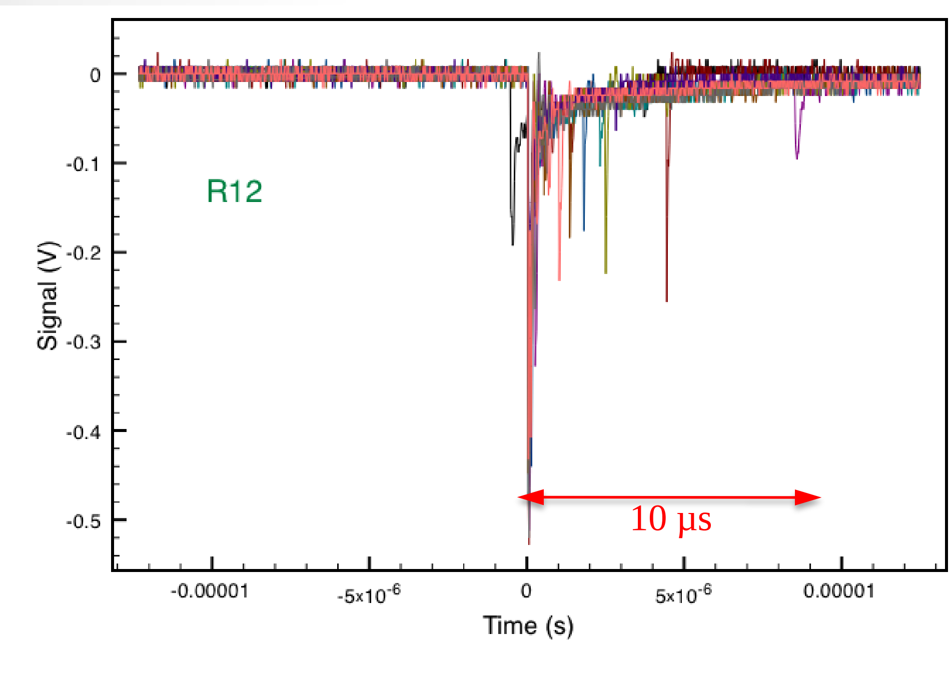
R11:
Low currents
Despite discharges, but no HV drop
Chamber operated stably up to max HV

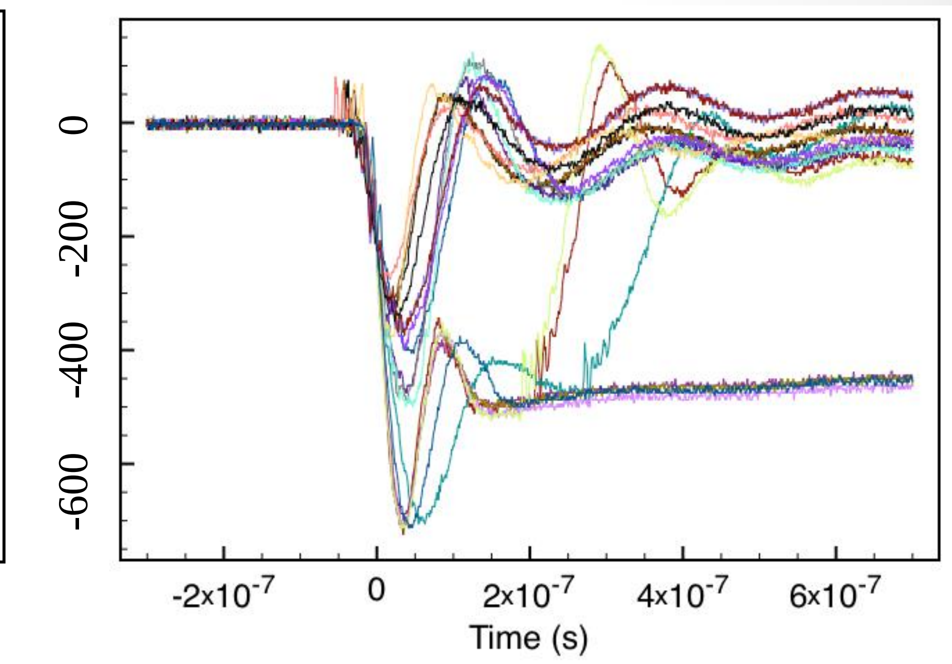


Spark signals resistive vs standard

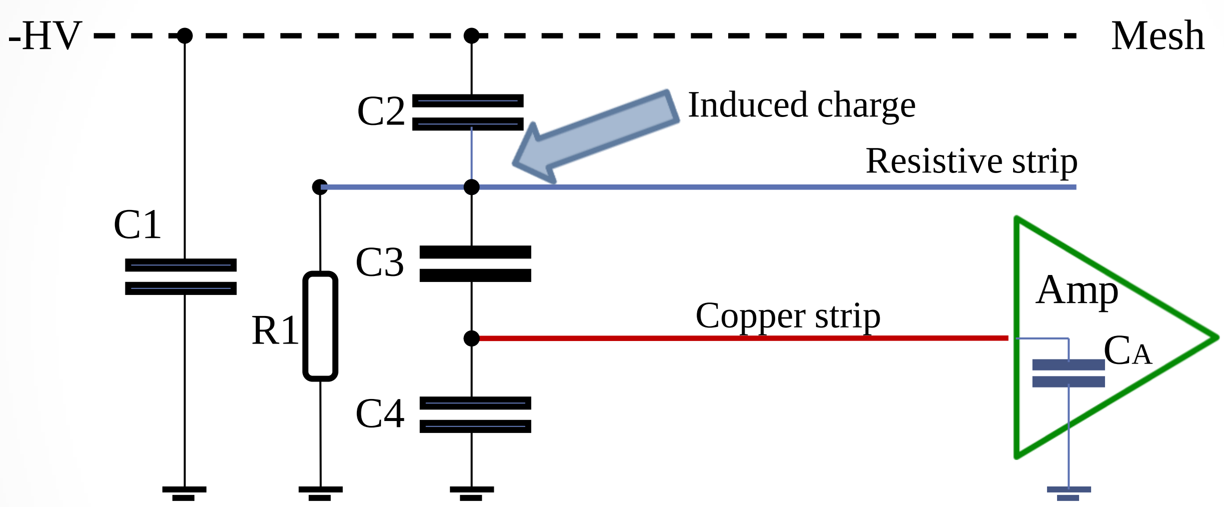
Sparks measured directly on readout strips through 50 Ohm
Several spark signals plotted on top of each other to enhance the overall characteristics

R12 shows 2-3 order of magnitude less signal and shorter recovery time than standard MM





Equivalent scheme of resistive MicroMegas chambers



$C1$ – capacitance Mesh to ground
$C2$ – capacitance R-strip to ground
$C3$ – capacitance R-strip to readout strip
$C4$ – capacitance readout strip to ground
C_A – input capacitance of preamplifier