Gas/HV connection and Temperature influence

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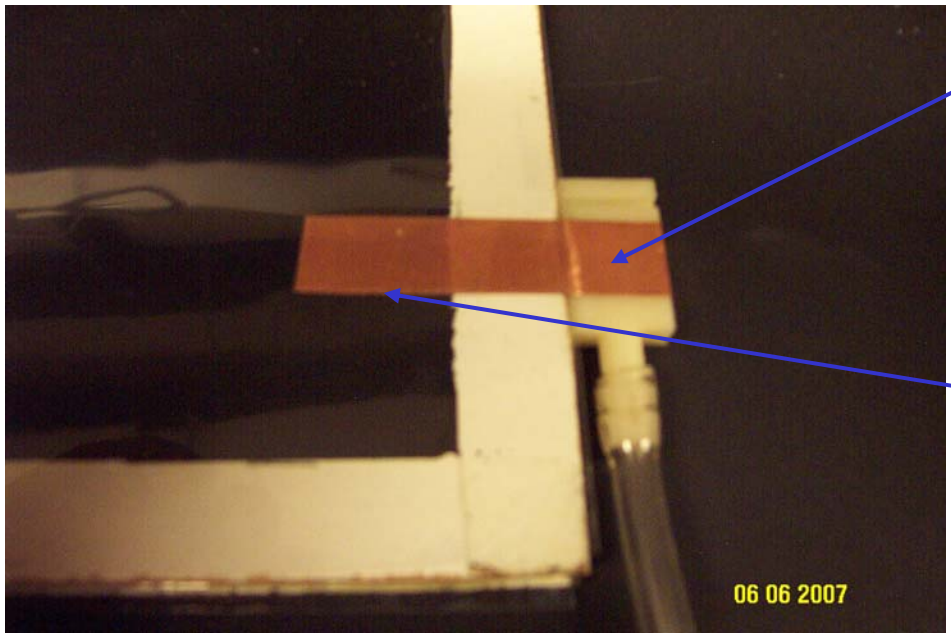
Gas feedthrough and HV connection

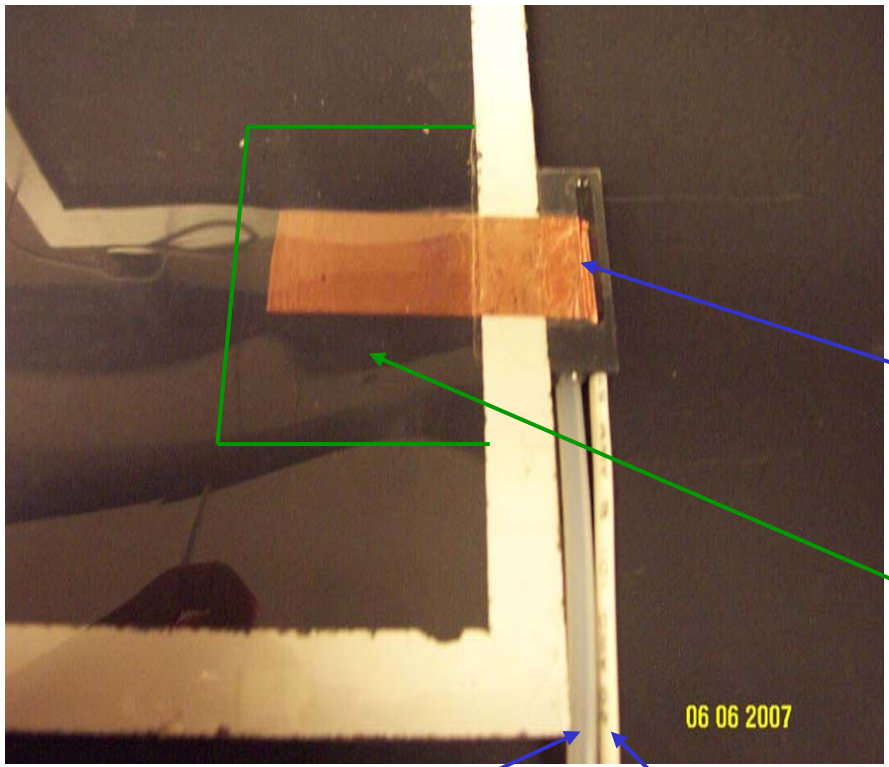
The original BESIII RPC gas feedthrough and HV connection:



HV cable is soldered to the copper tape, then covered with conductive epoxy. Its mechanical strength is weak.

All current is going through the copper tape, then distributed to entire graphite surface. The edges of the copper tape are vulnerable to aging.

New design of the gas feedthrough



Princeton EP Lab Bill Sands has designed a new version of HV/gas feedthrough as shown on the left.

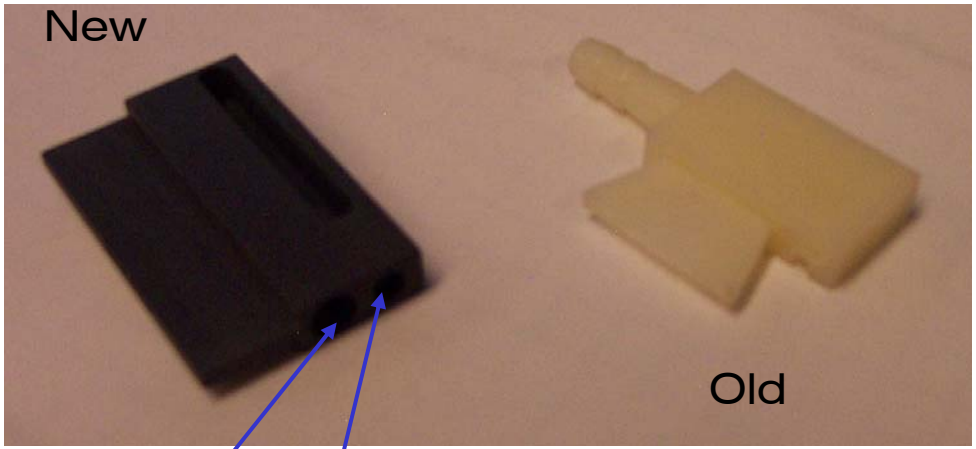
HV cable soldered to copper tape, then use epoxy to fill this slot, thus HV cable has strong mechanical strength.

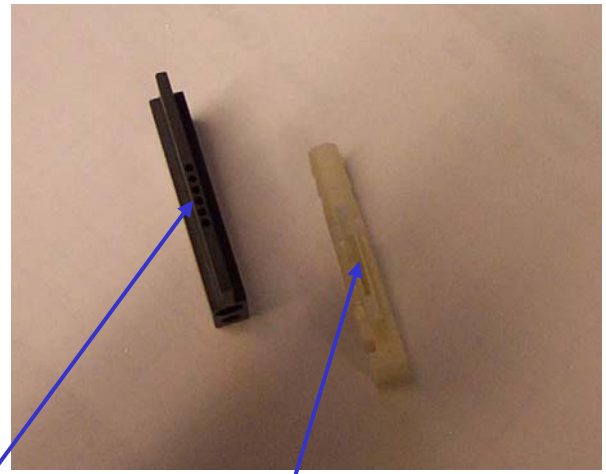
The vicinity of the copper tape will be painted with thicker graphite layer to improve its aging performance.

Gas tubing

HV cable

New designed gas feedthrough





Hole for gas tubing

Hole for HV cable

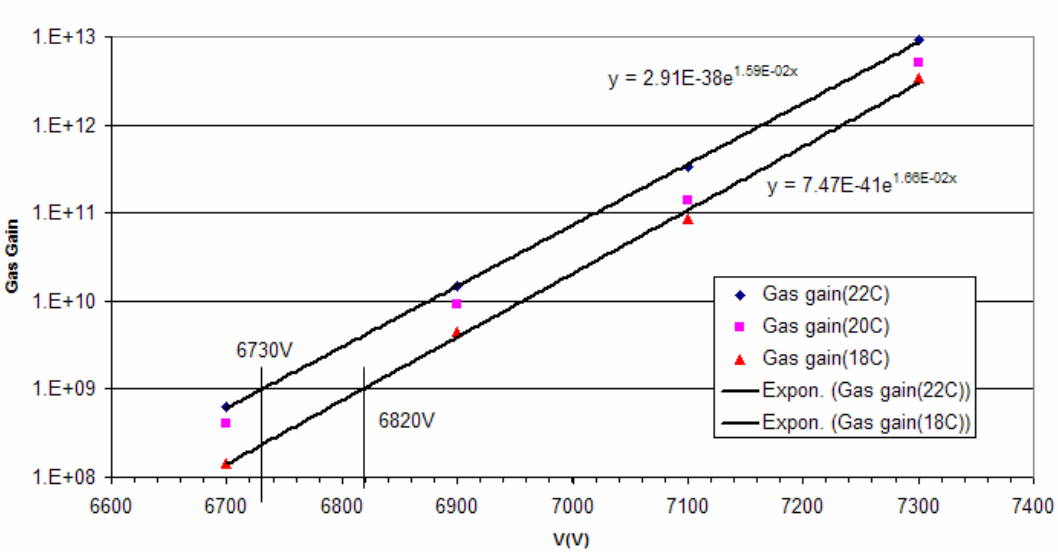
Holes for gas passage, will be modified to a slot as original design.

Slot for gas passage.

Temperature influence – (1) Gas gain

Basic criterion for forming streamer in RPC chamber

In order to be able to enter the streamer mode the gas avalanche has to reach about 10^8 electrons in the head of the avalanche, at this point the space charge effect becomes dominant and the streamer mechanism sets in. The basic criteria for RPC chamber working at streamer mode is the gas gain has to be greater than $5x10^8$, so called Meek's condition.



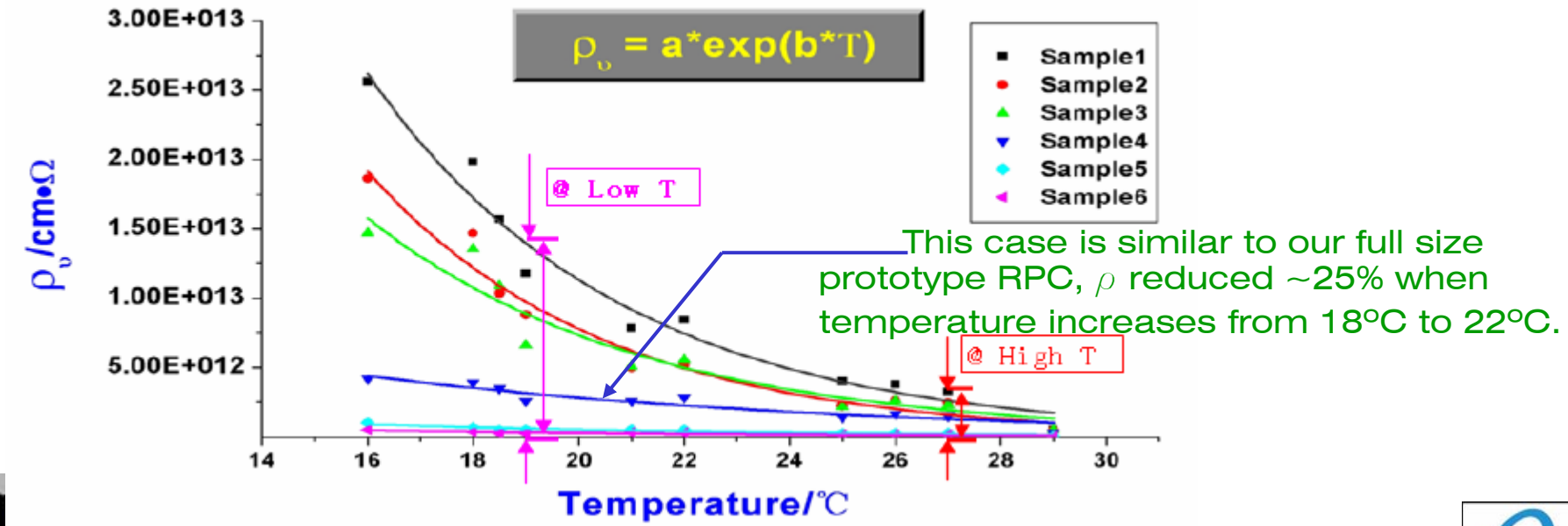
Use CERN program MAGBOLZ 2 to calculate the Townsend coefficient for the gas mix Ar/R134A/Isobutane (50/42/8), then calculate the gas gain. At gain 10^9 the HV are 6820V and 6730V for 18°C and 22°C, respectively. That is 90V difference.

Temperature influence – (2) Bakelite resistivity

As we already noticed from recent IHEP report that temperature also effects the Bakelite resistivity.

For the blue line temperature increases from 18°C to 22°C, the resistivity decreases 25%, thus increases the effective E-field strength, therefore raises gas gain.

IHEP tested resistivity vs. temperature for 6 samples:



Temperature influence – (2) Bakelite resistivity

Assume @ 18°C, ρ = 2.5x10^{12} Ωcm, I = 4x10^{-6}A, 2m^2 area, 4mm total thickness of Bakelite electrodes,

Voltage drop across the Bakelite electrodes,

ΔV = 2.5x10^{12}*0.4/20000*4x10^{-6}=200V;

@22°C, ρ = 1.8x10^{12} Ωcm (dropped by 25%),

ΔV = 1.8x10^{12}*0.4/20000*4x10^{-6}=150V.

The effective voltage drop across the Bakelite electrodes is 50V difference between 18°C and 22°C.

When temperature increases from 18°C to 22°C, combine the gas gain and Bakelite resistivity together, the overall influence on the effective voltage would be 90+50=140V increase.

Usually we operate RPC at a HV that is ~200V above its plateau knee, so 140V won't influence its performance much, but we need to be very careful to control the temperature within +/- 2°C.