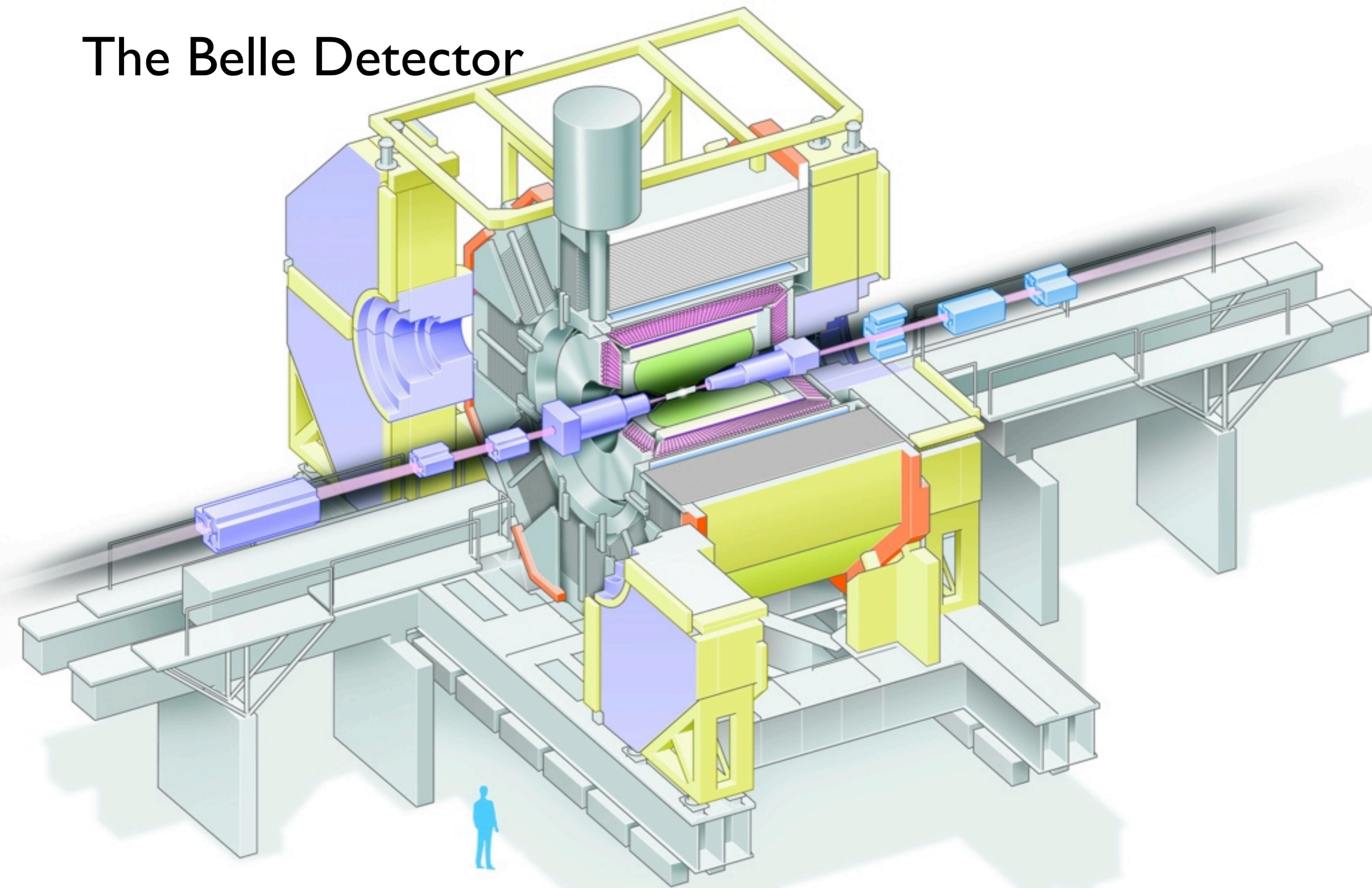


# The Belle Resistive Plate Counters

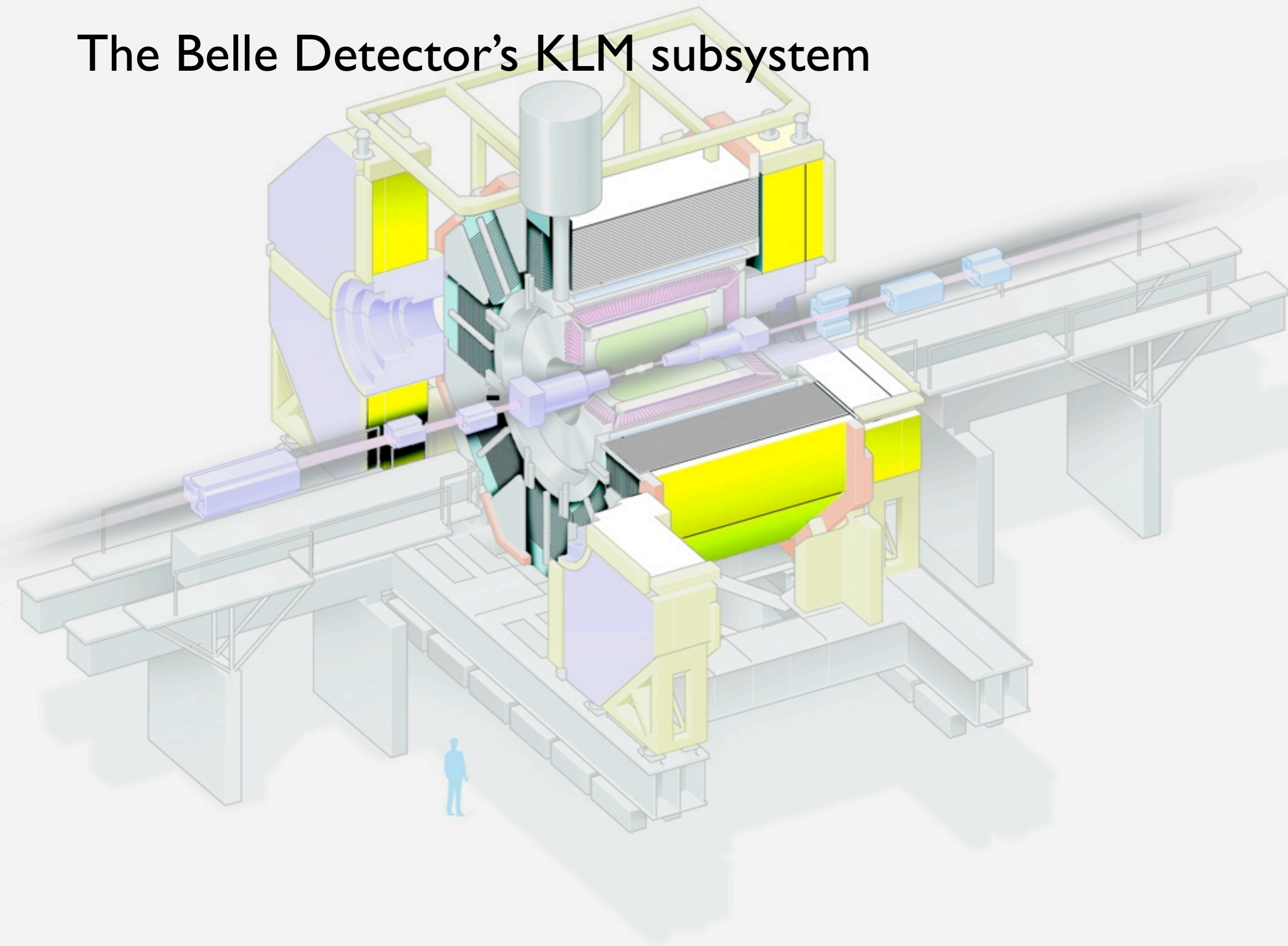
Leo Piilonen, Virginia Tech

*SiD Workshop, FNAL    April 9, 2007*

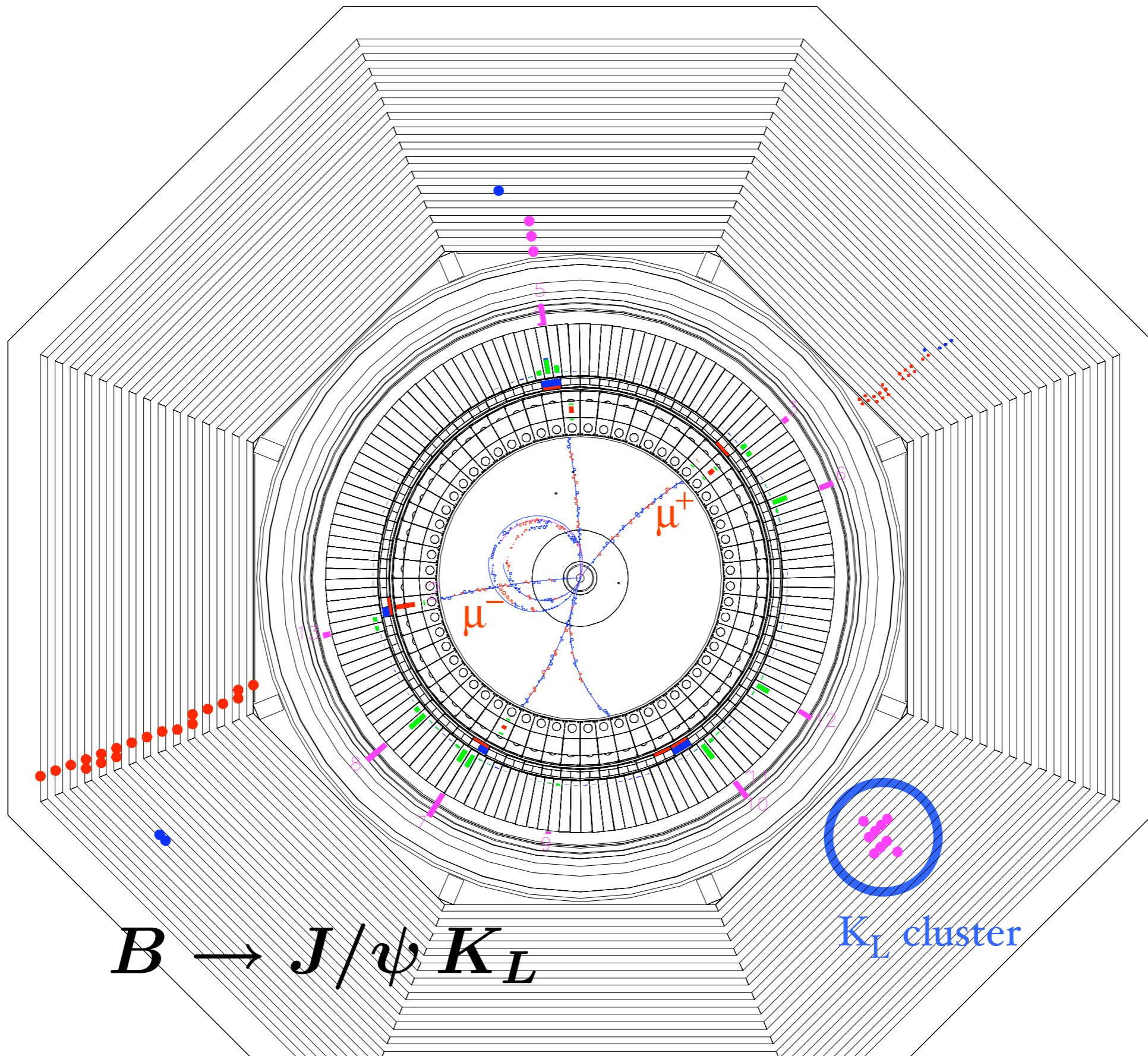
# The Belle Detector



# The Belle Detector's KLM subsystem



RPCs are used in KLM to detect  $\mu$  and  $K_L$  mesons



# An RPC superlayer contains ...



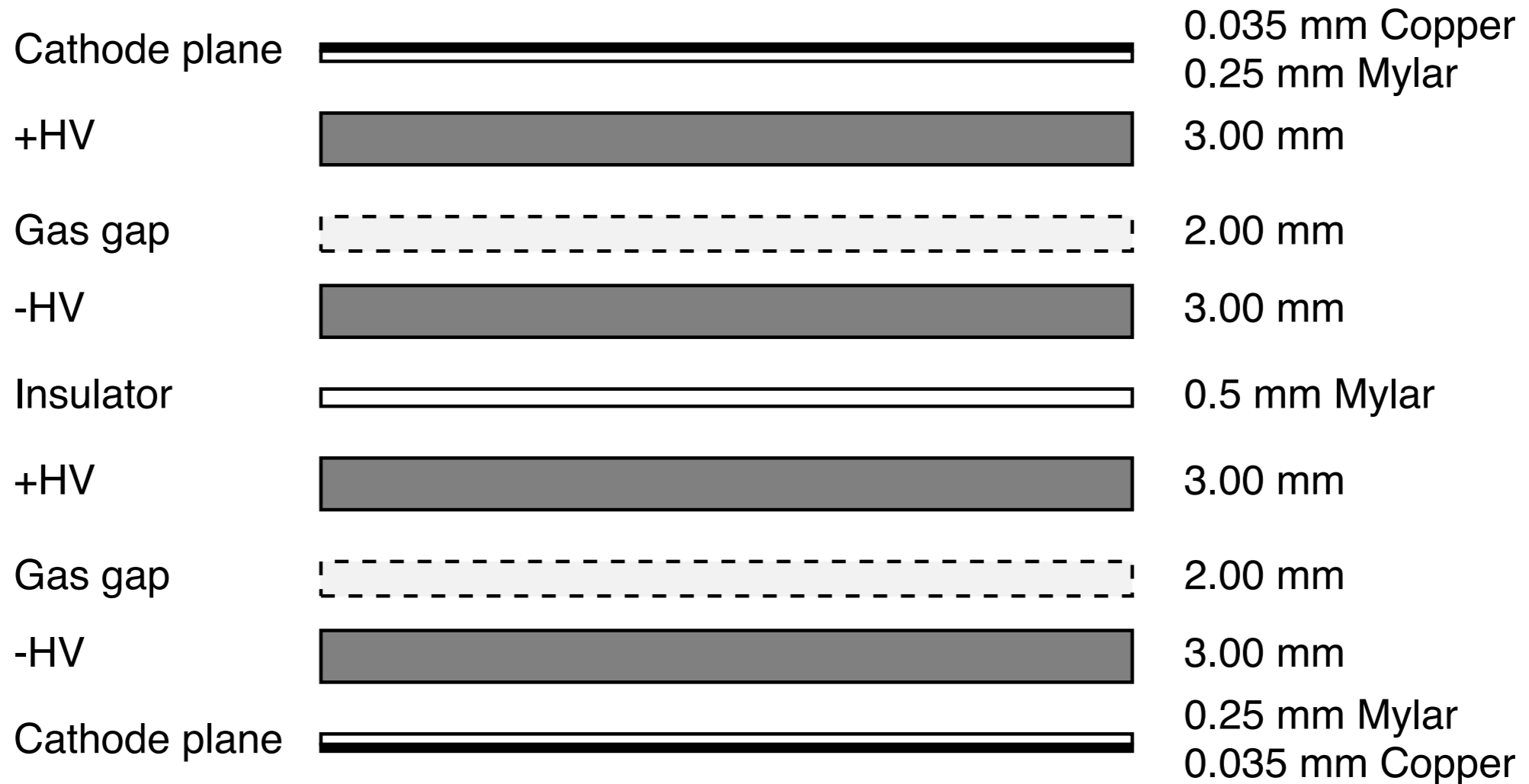
Float-glass electrodes  
 $\rho \simeq 10^{12} \Omega \cdot \text{cm}$

Non-flammable gas:  
62% HFC-134a  
30% argon  
8% butane-silver

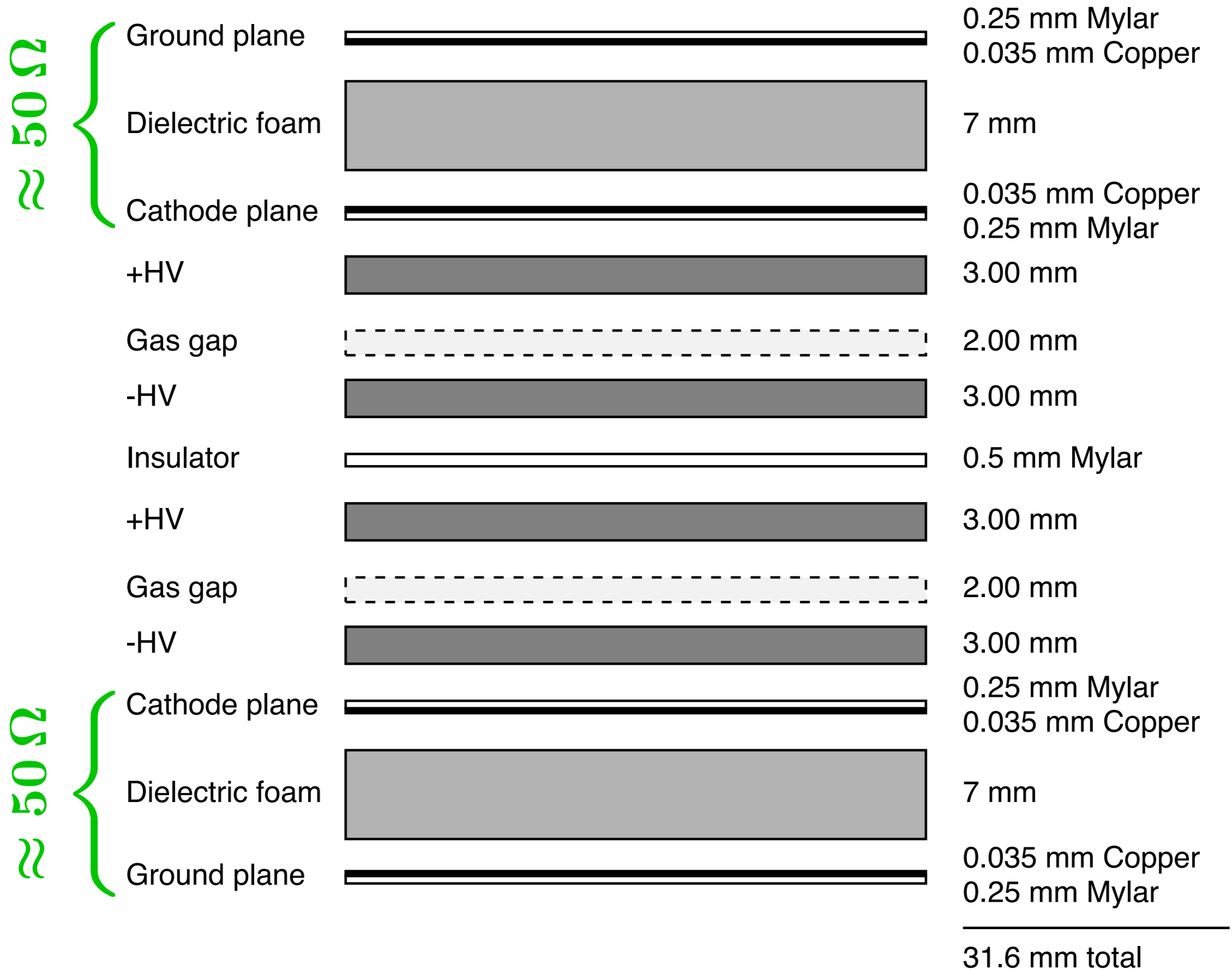
# An RPC superlayer contains two RPCs ...



# An RPC superlayer contains two RPCs and x-y electrodes

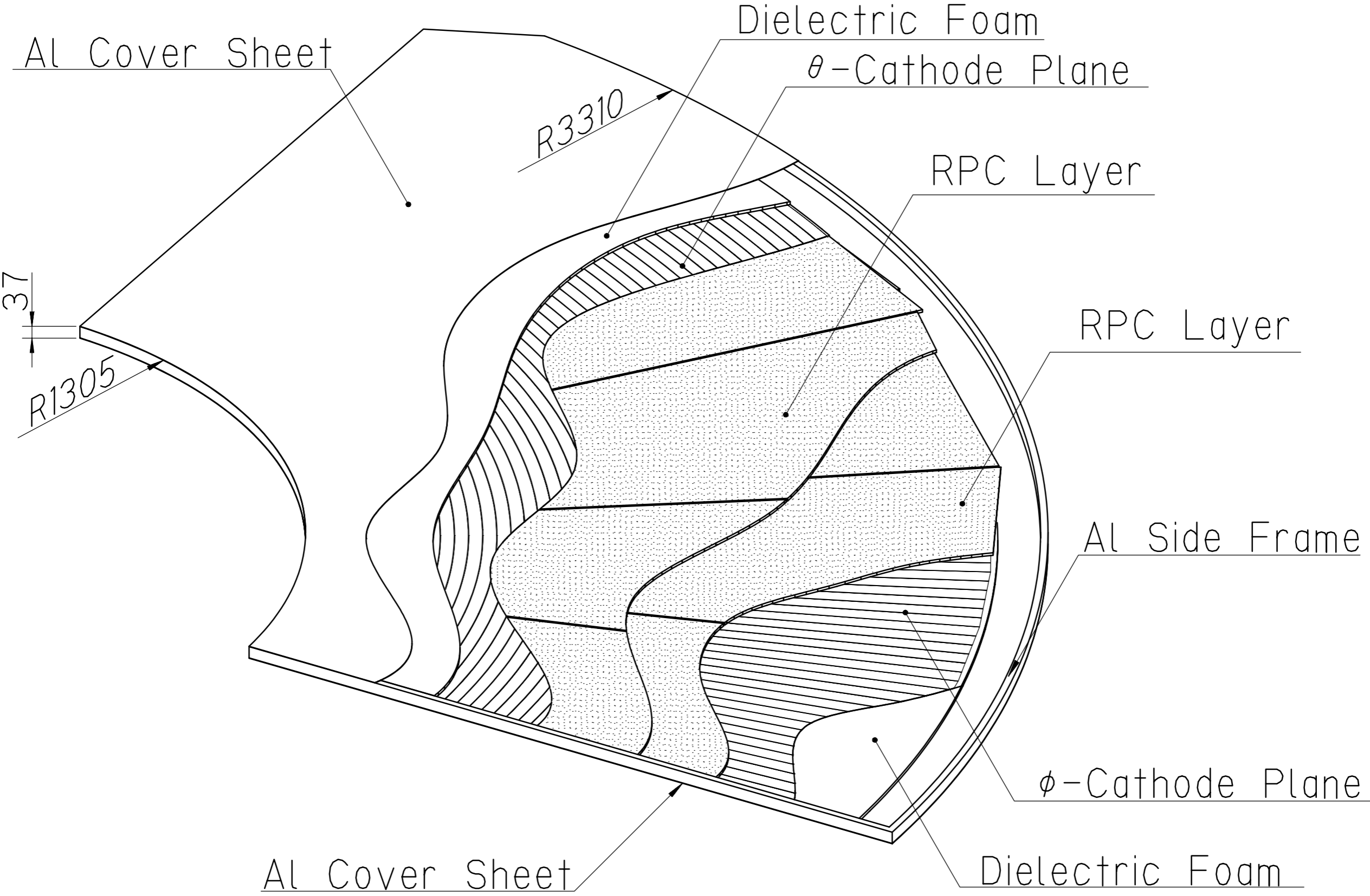


# An RPC superlayer contains two RPCs and x-y electrodes

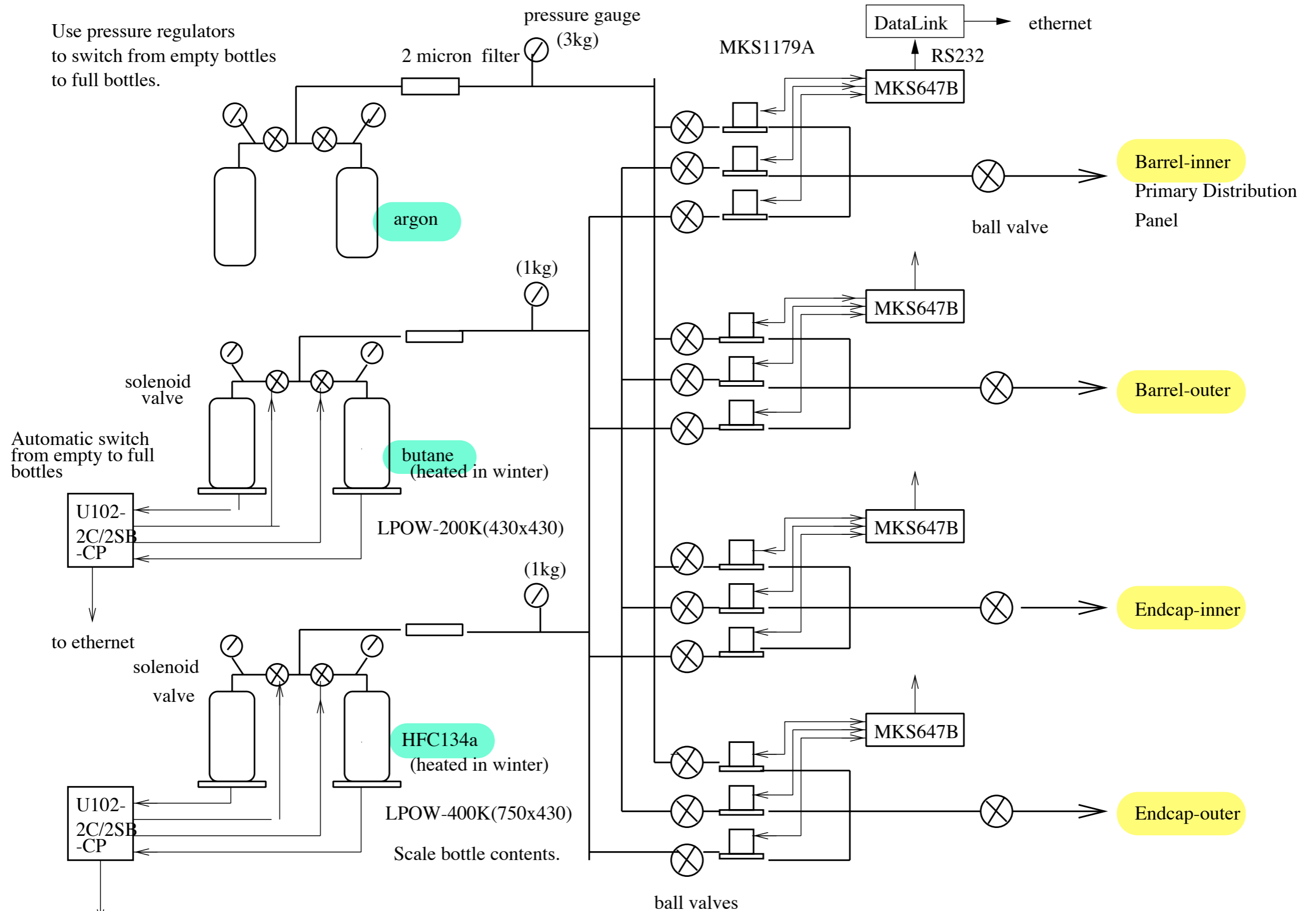




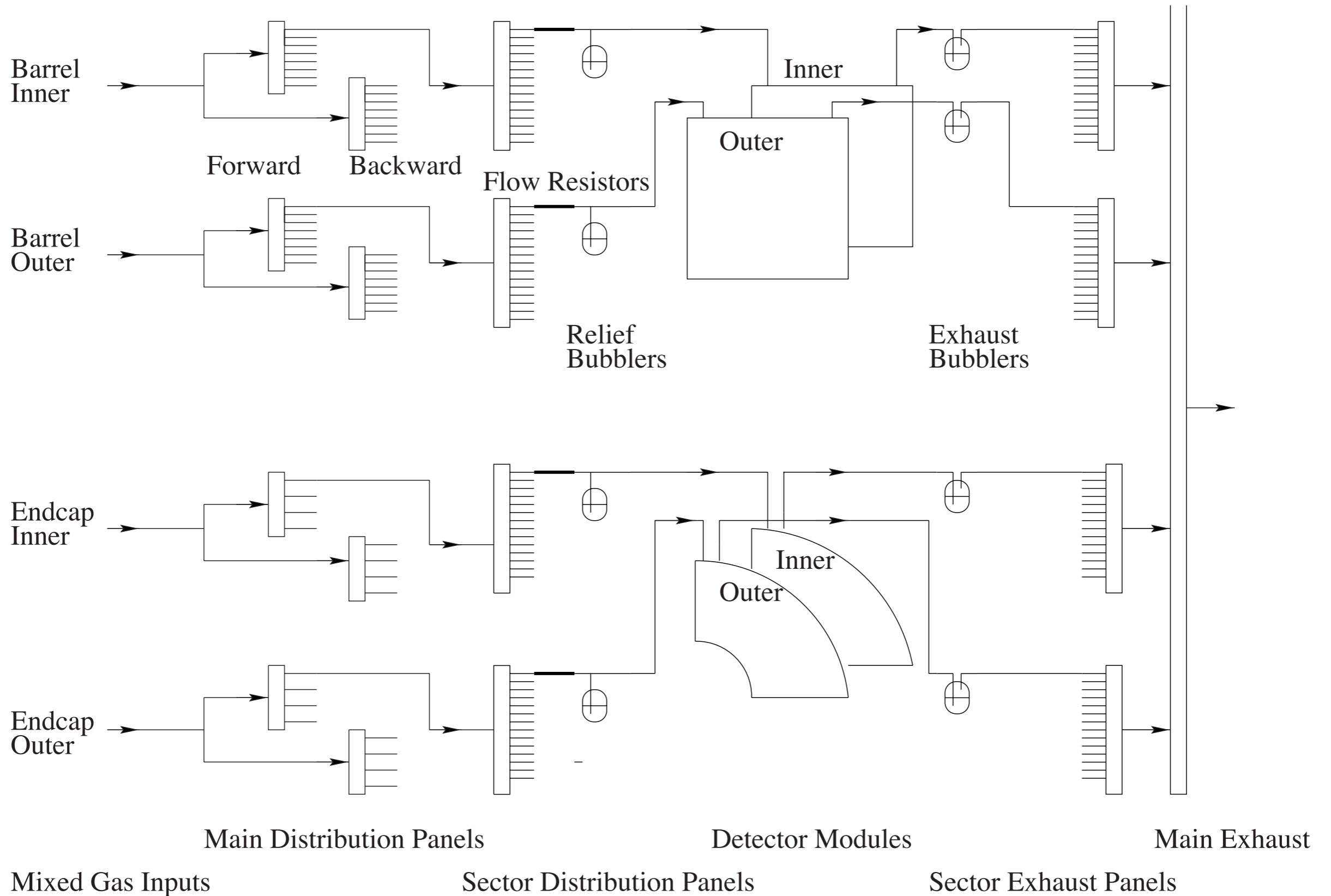
# An endcap RPC superlayer quadrant contains ten RPCs



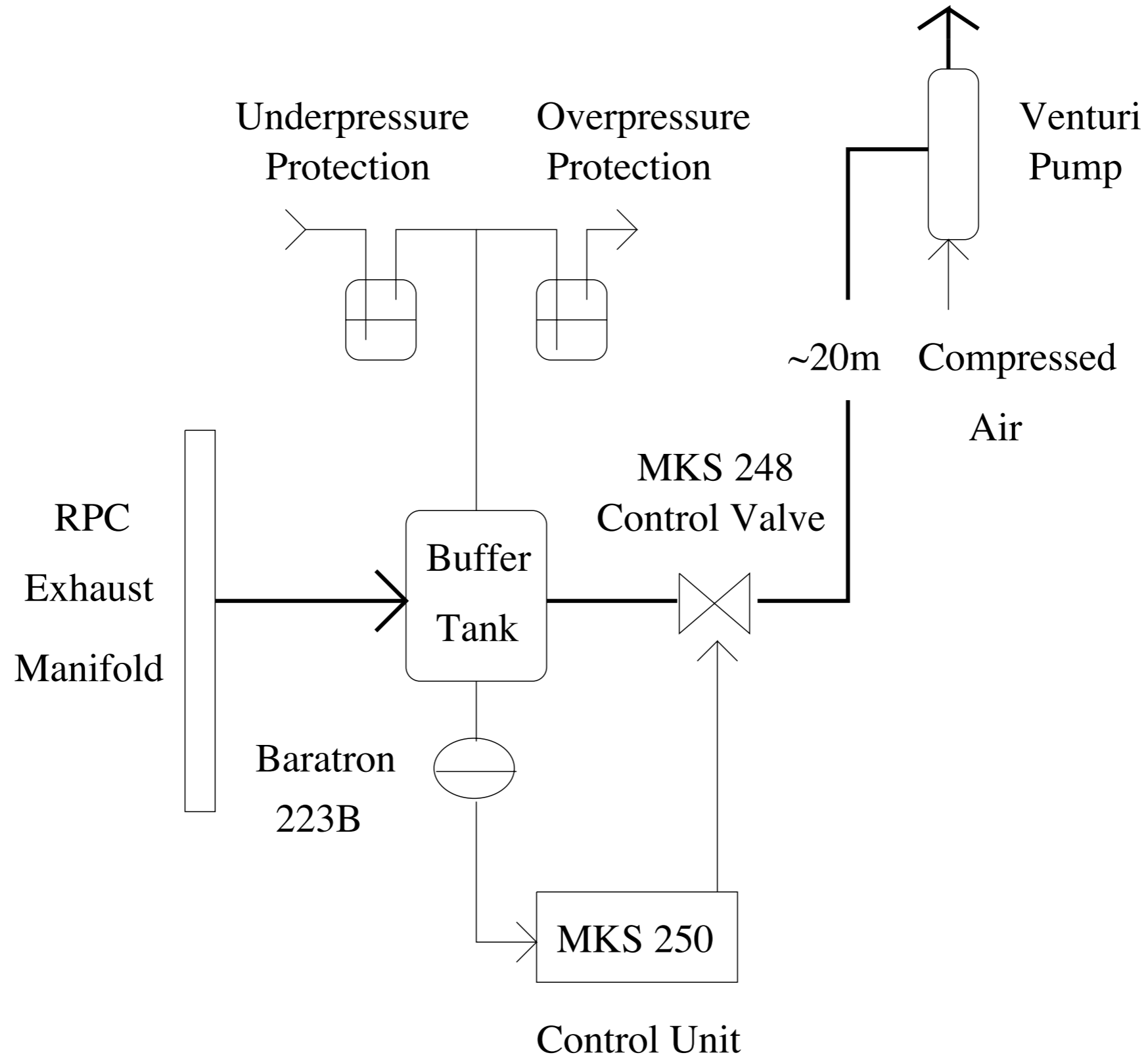
# Gas supply to the four KLM sections



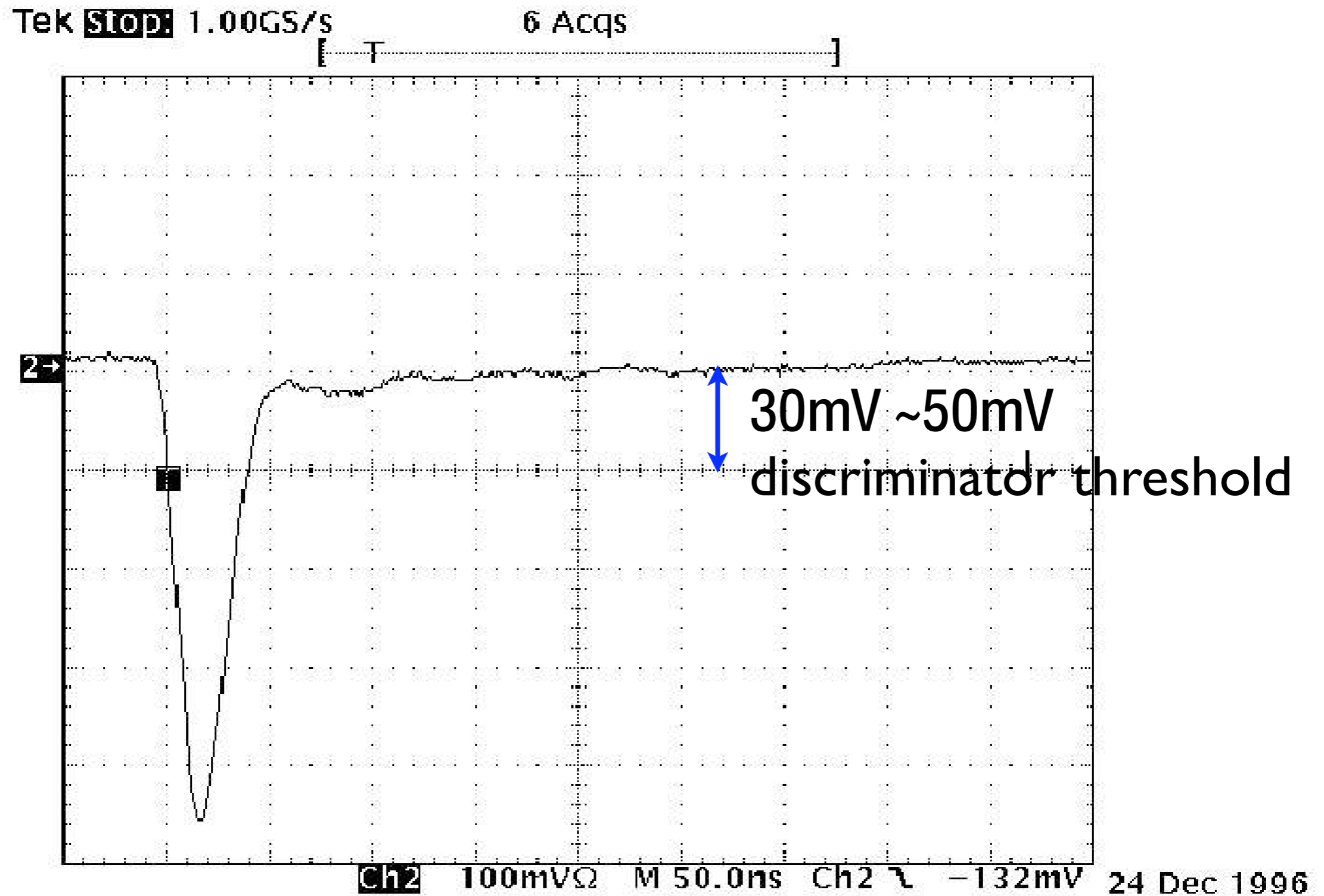
# Gas is distributed to the RPCs in the four KLM sections



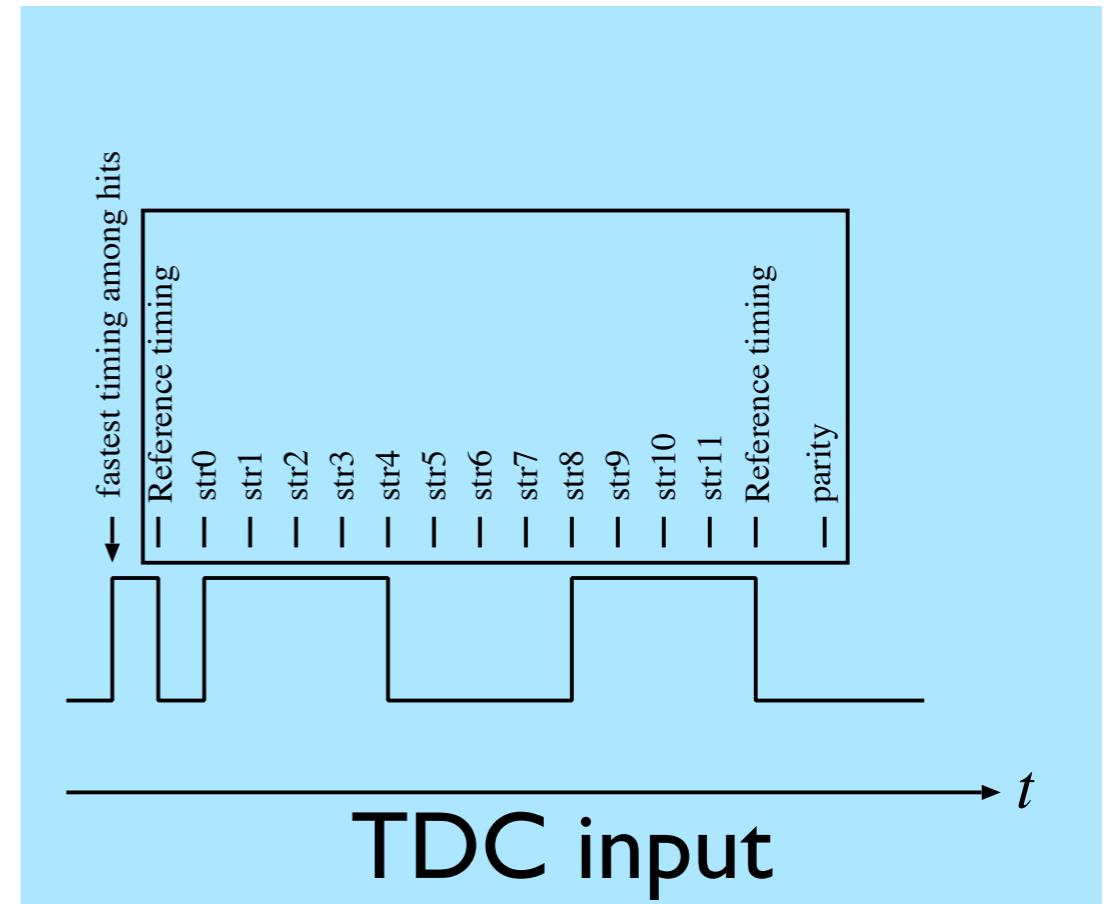
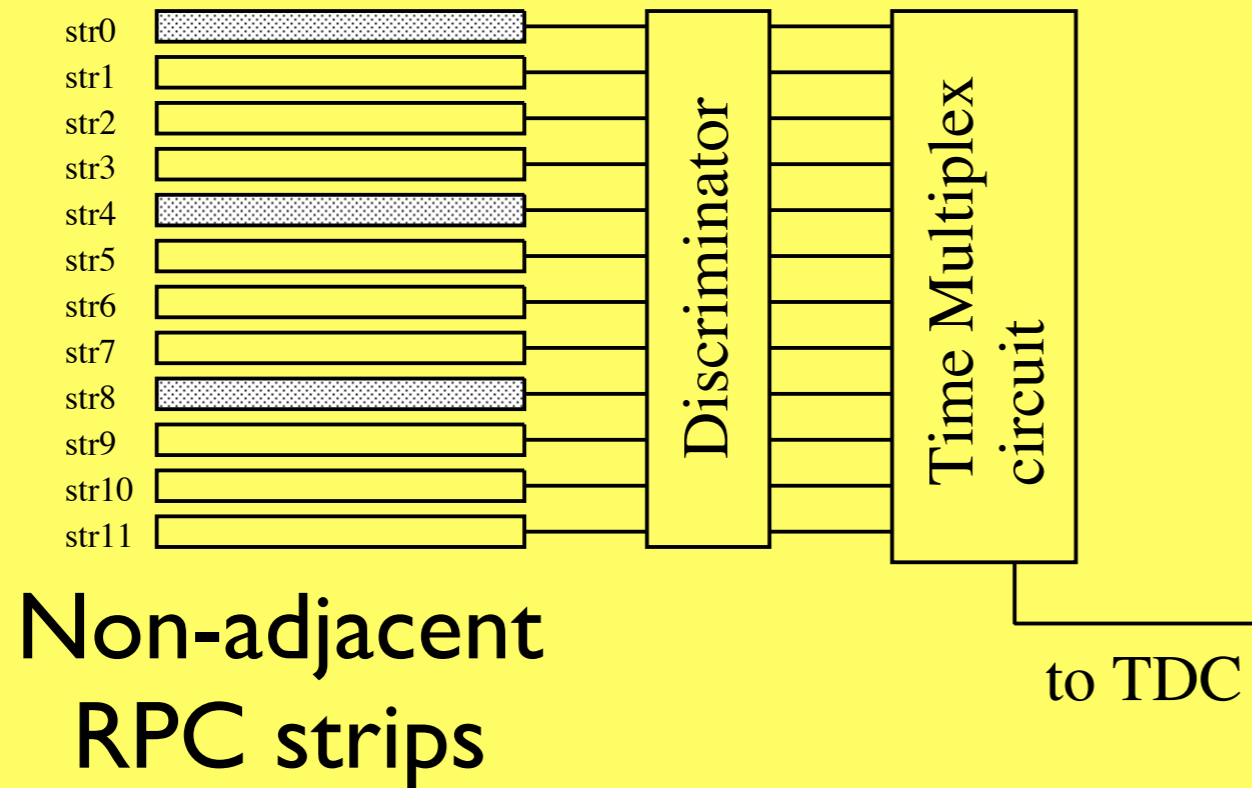
# Gas is exhausted to the surface via a Venturi pump



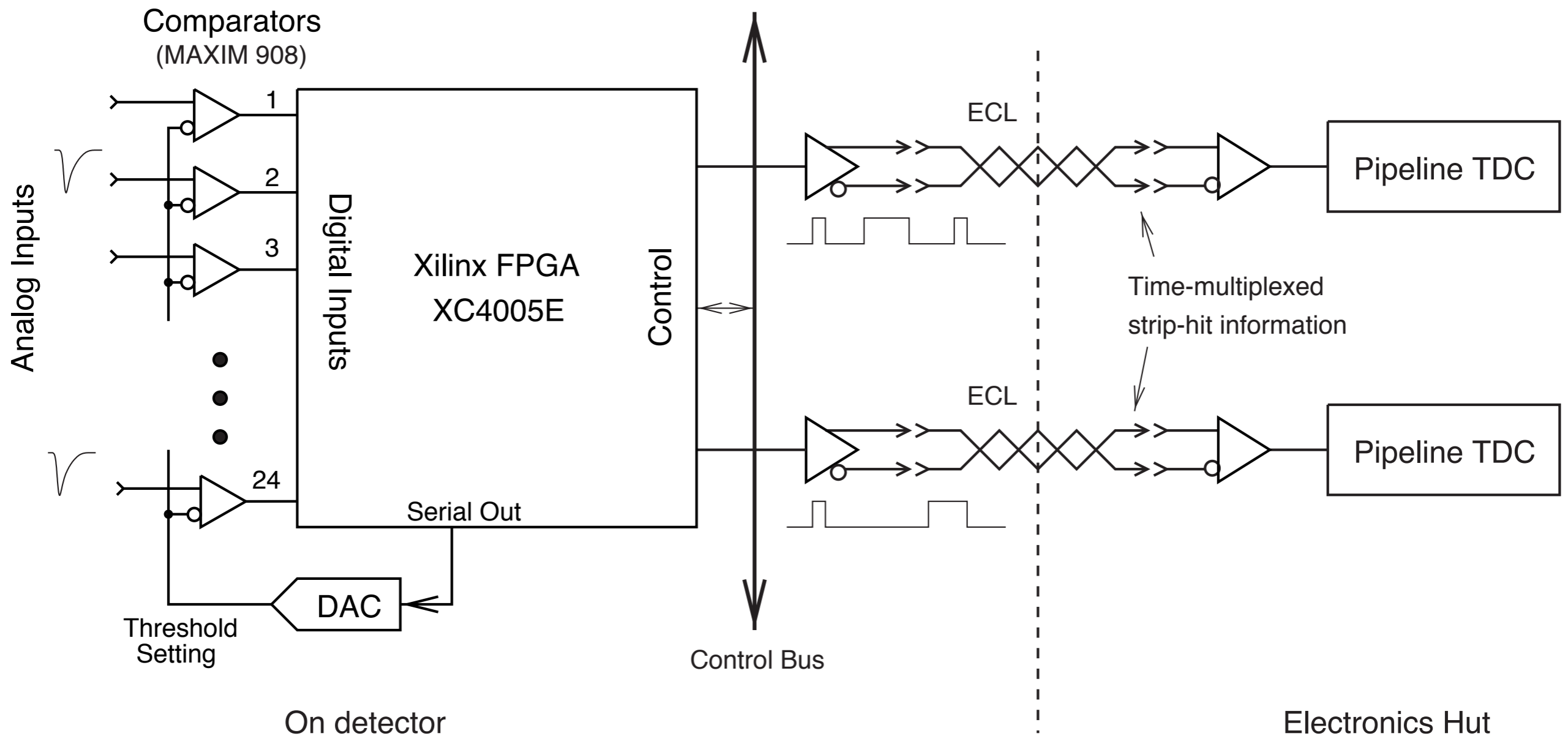
# RPC cathode strip delivers ~200 mV signal



# 12 RPC readout strip hits are multiplexed into one TDC channel

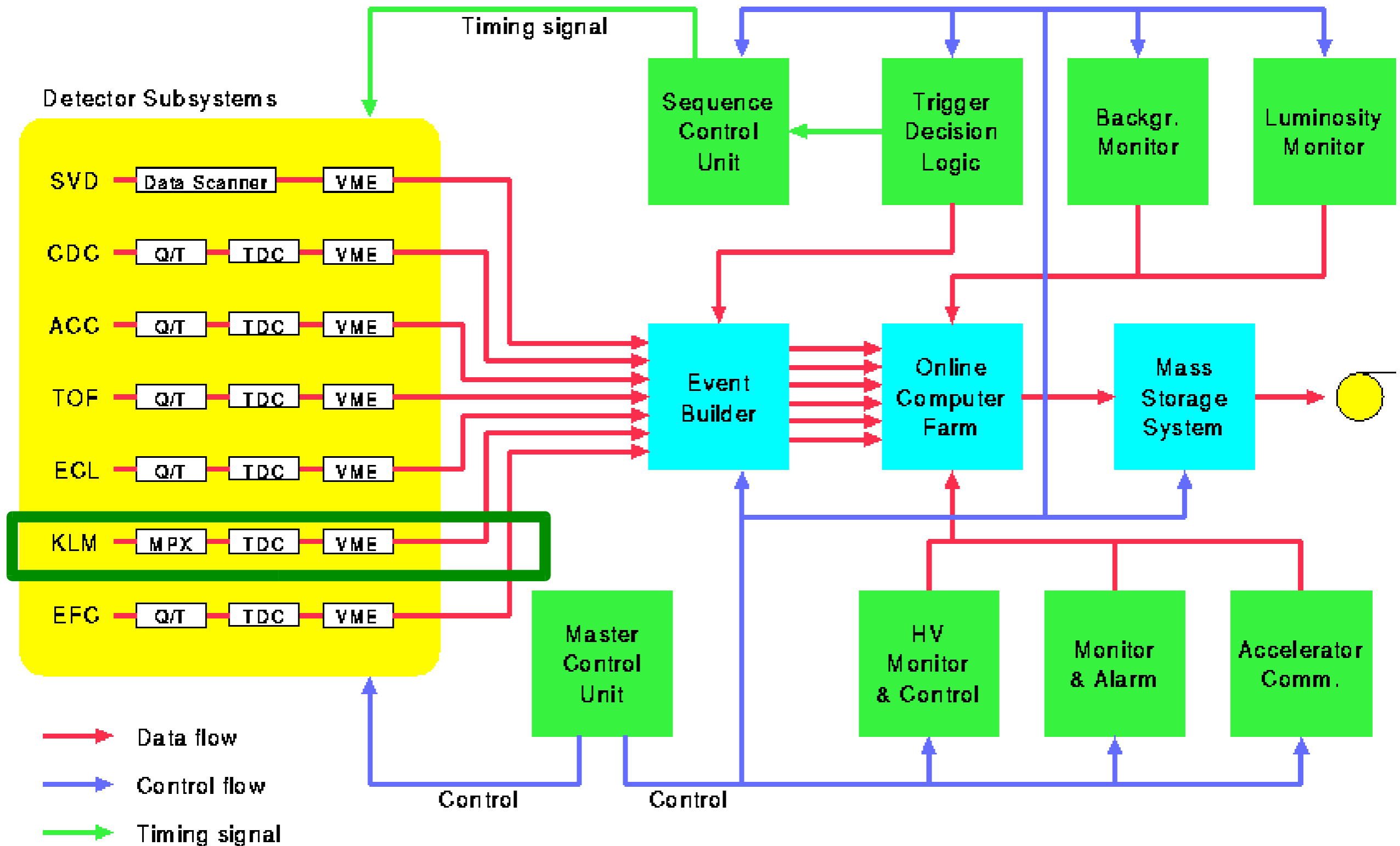


# 12 RPC readout strip hits are multiplexed into one TDC channel



(Princeton design and implementation)

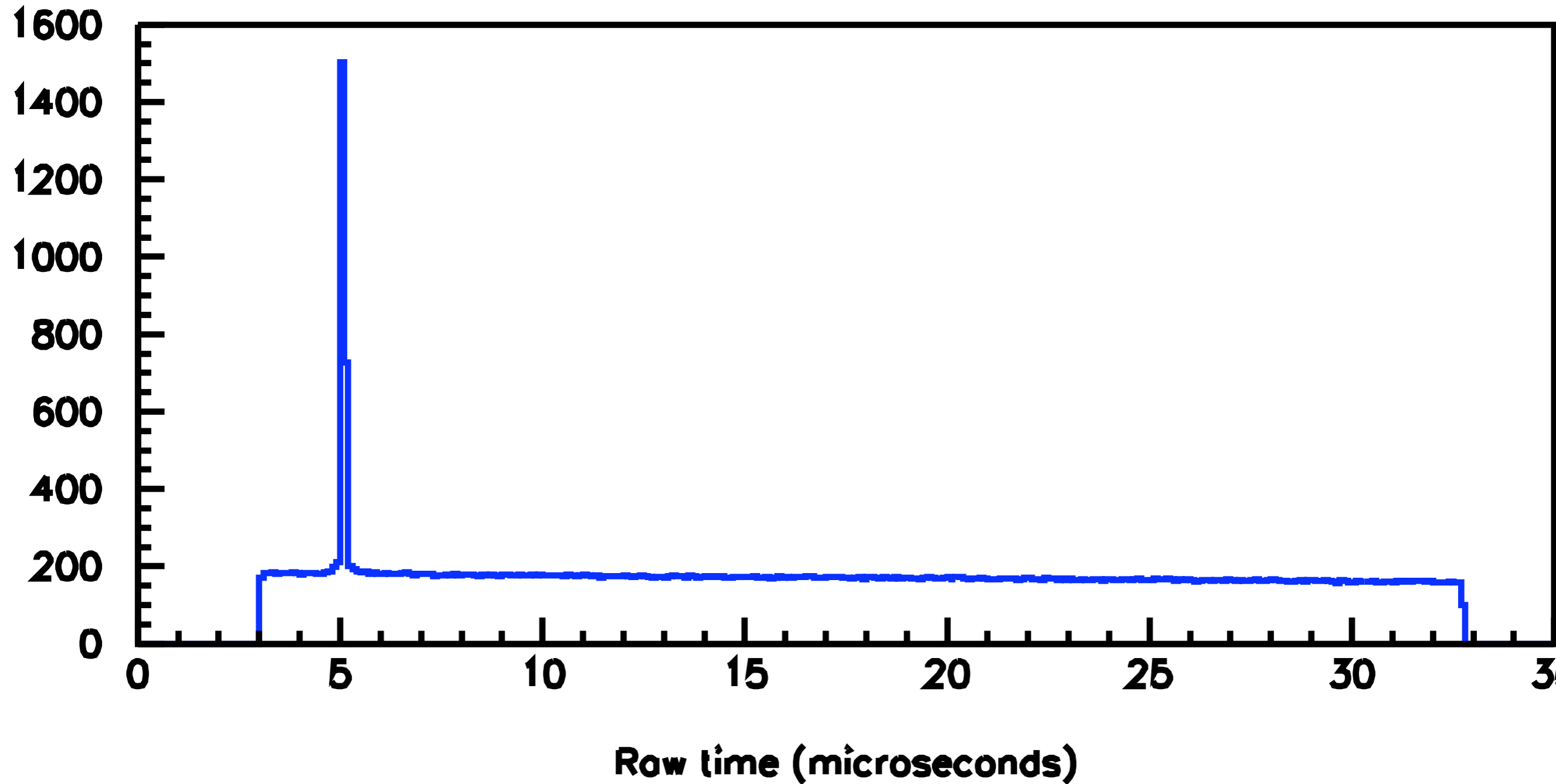
# KLM data within the Belle data acquisition system



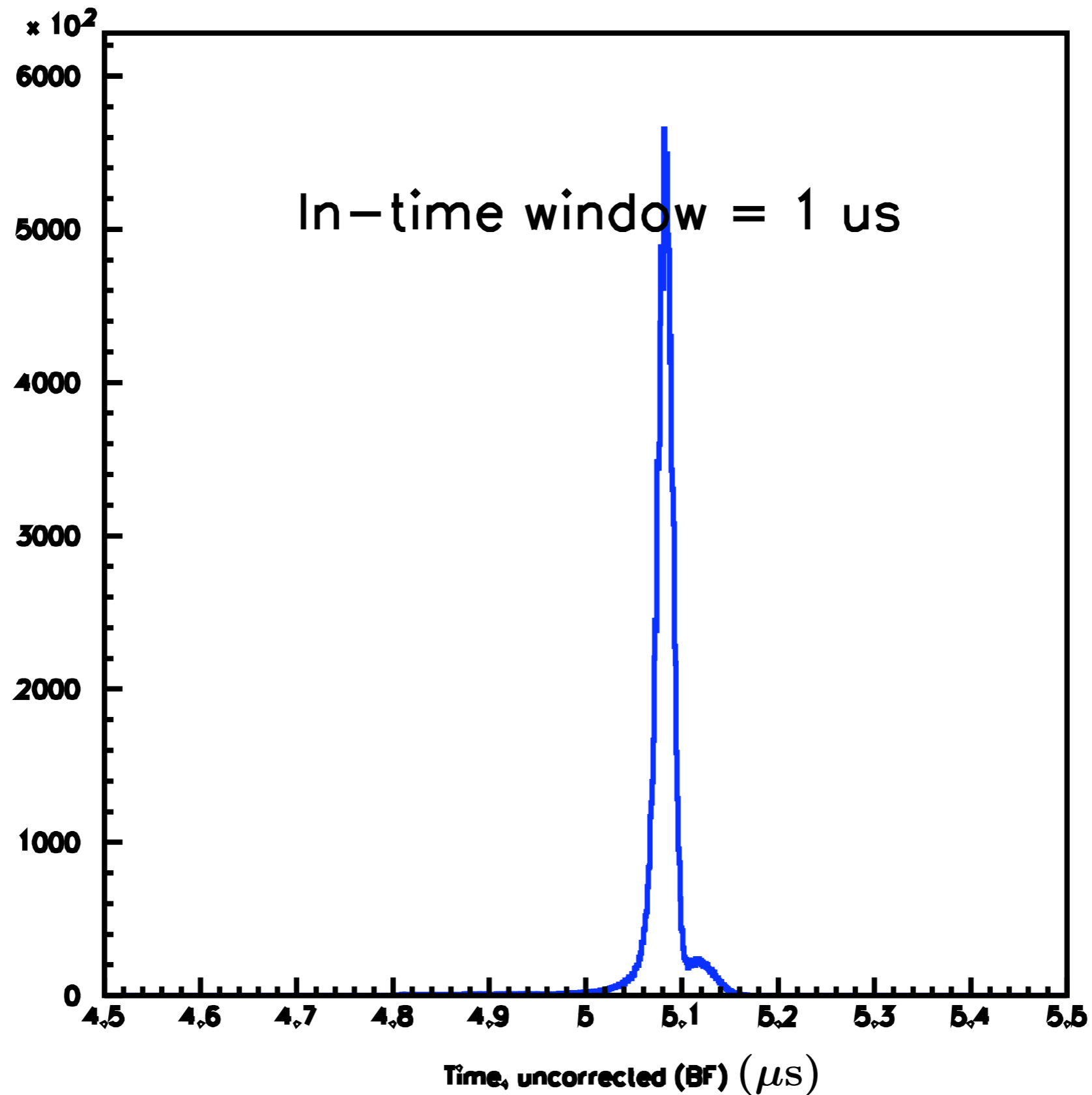


# Readout TDCs see in-time collision hits plus cosmics

$\times 10^2$

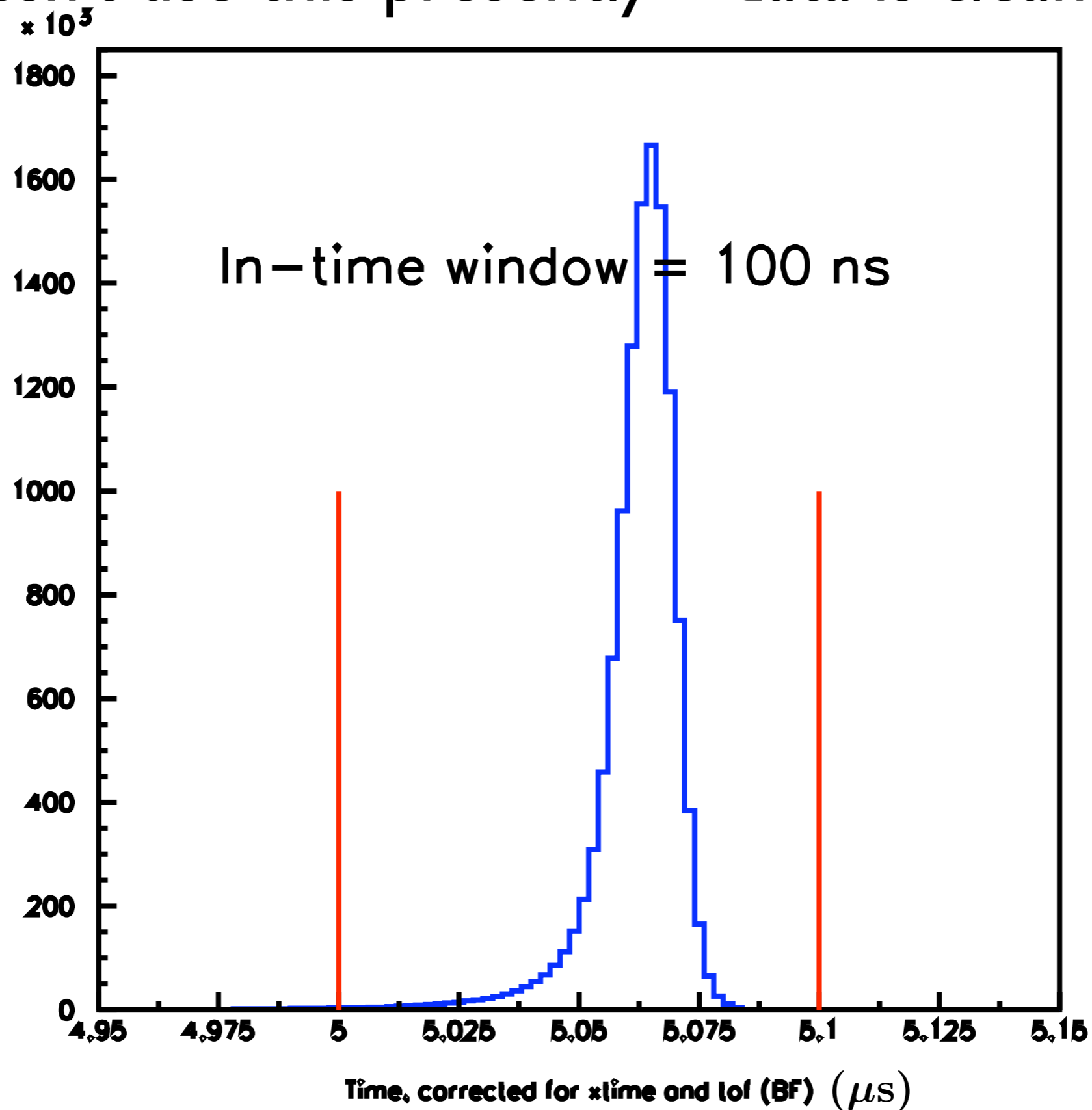


Uncorrected time resolution is  $\sim 200$  ns

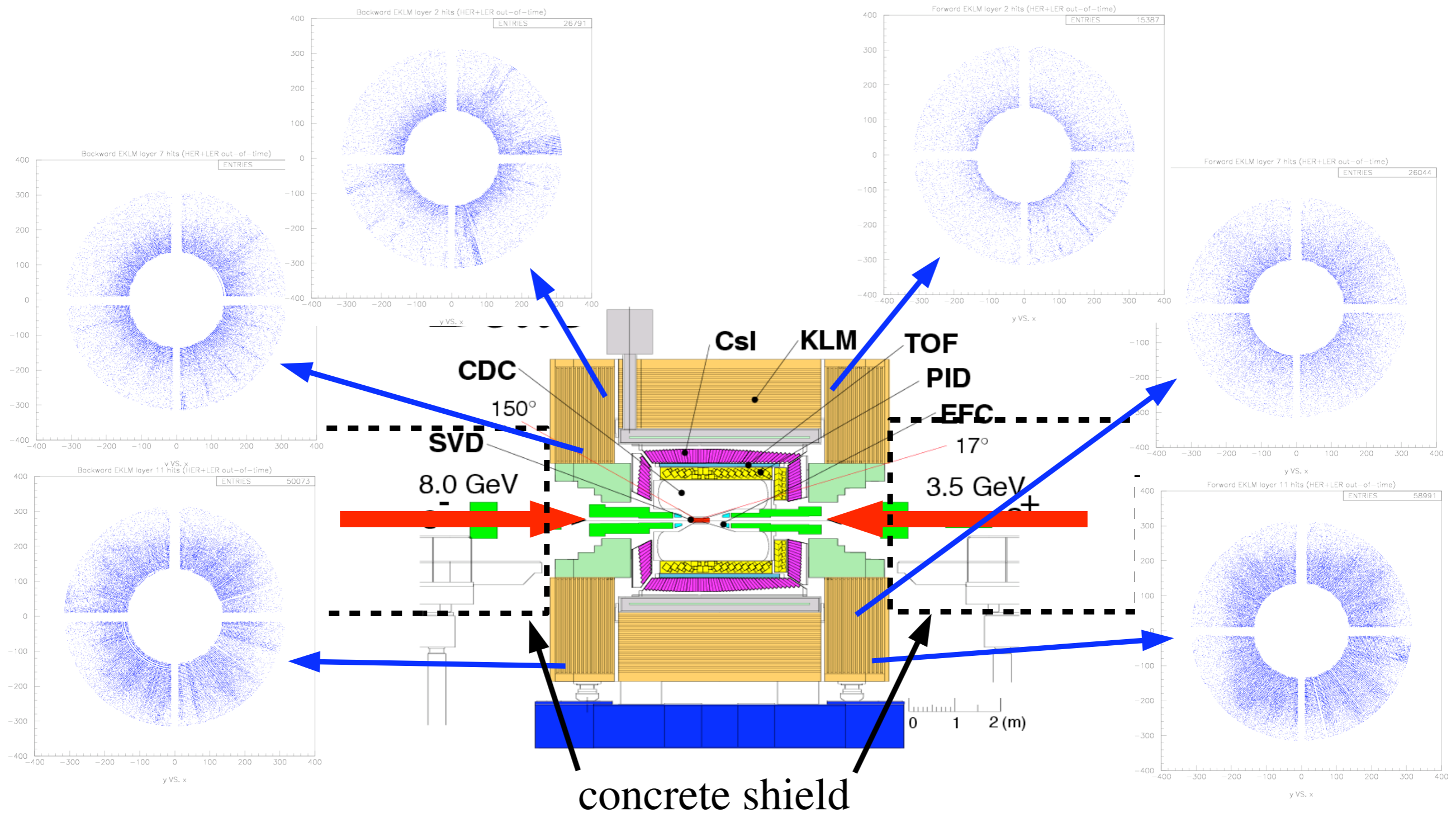


Corrected time resolution is  $\sim 10$  ns

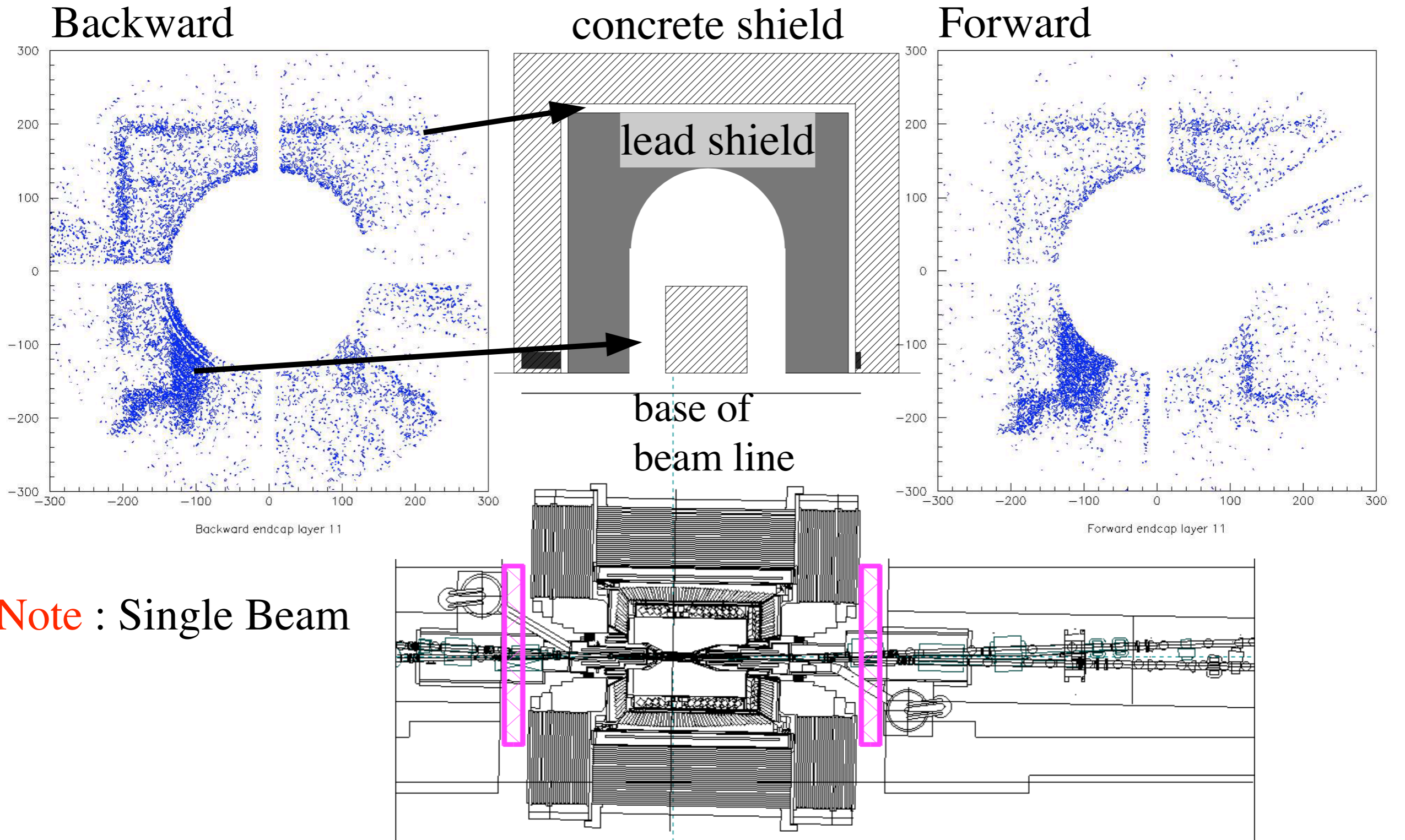
(Belle doesn't use this presently – data is clean enough)



# Beam background (neutrons) illuminates the endcaps

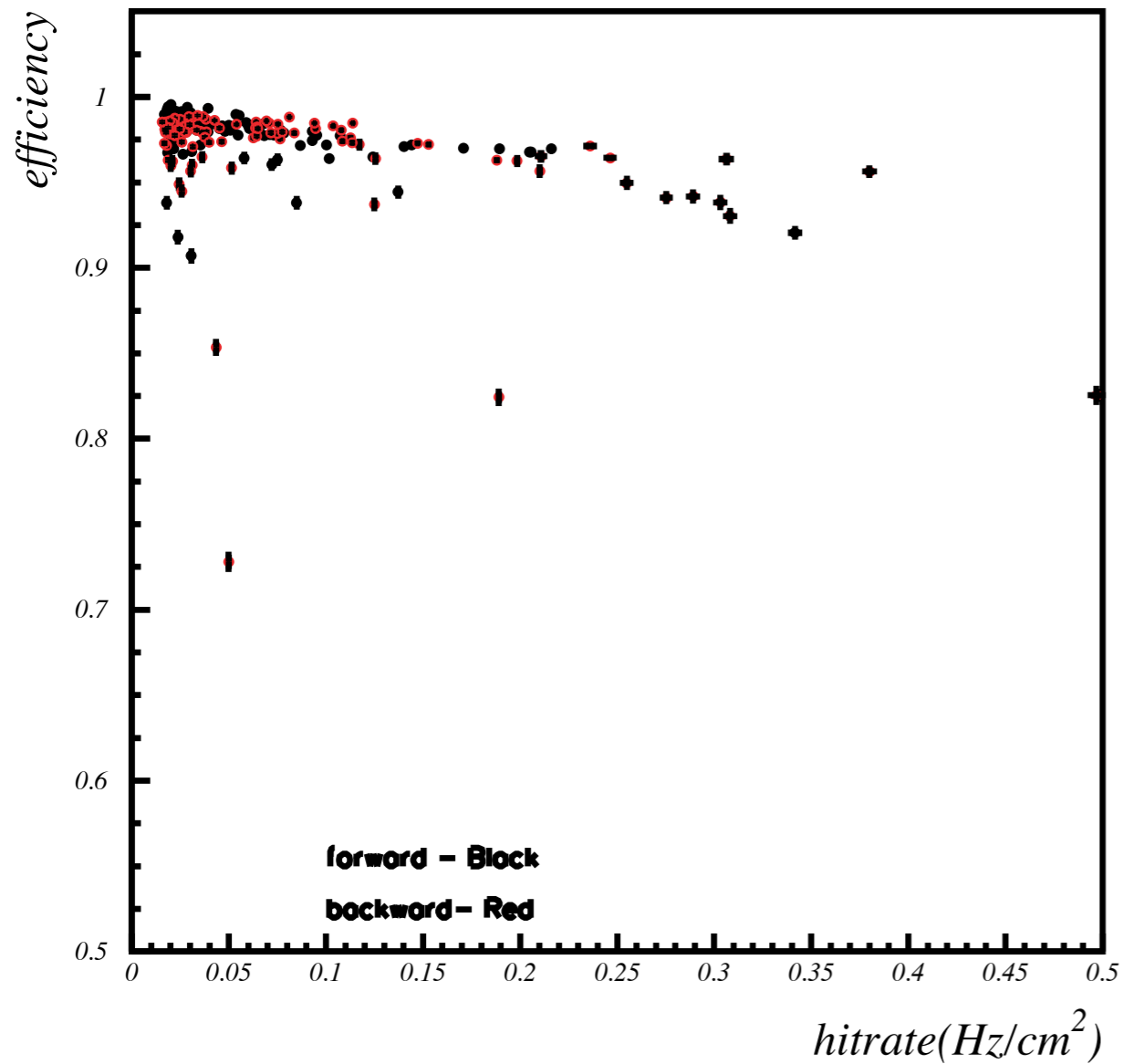


# Beamline structures can be seen in endcap raw-hit distributions

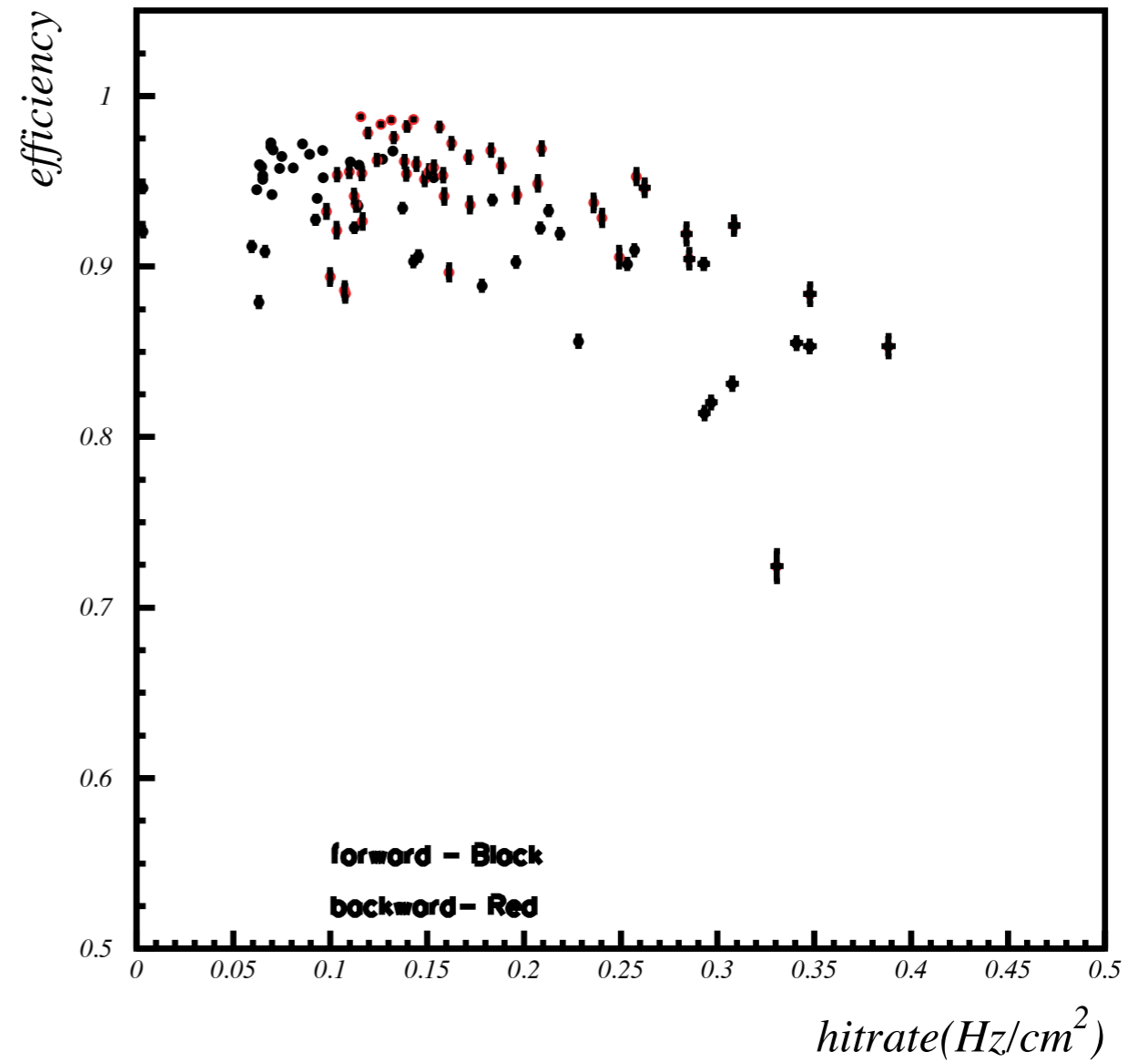


# High glass-electrode resistivity causes efficiency to drop with increased hit rate

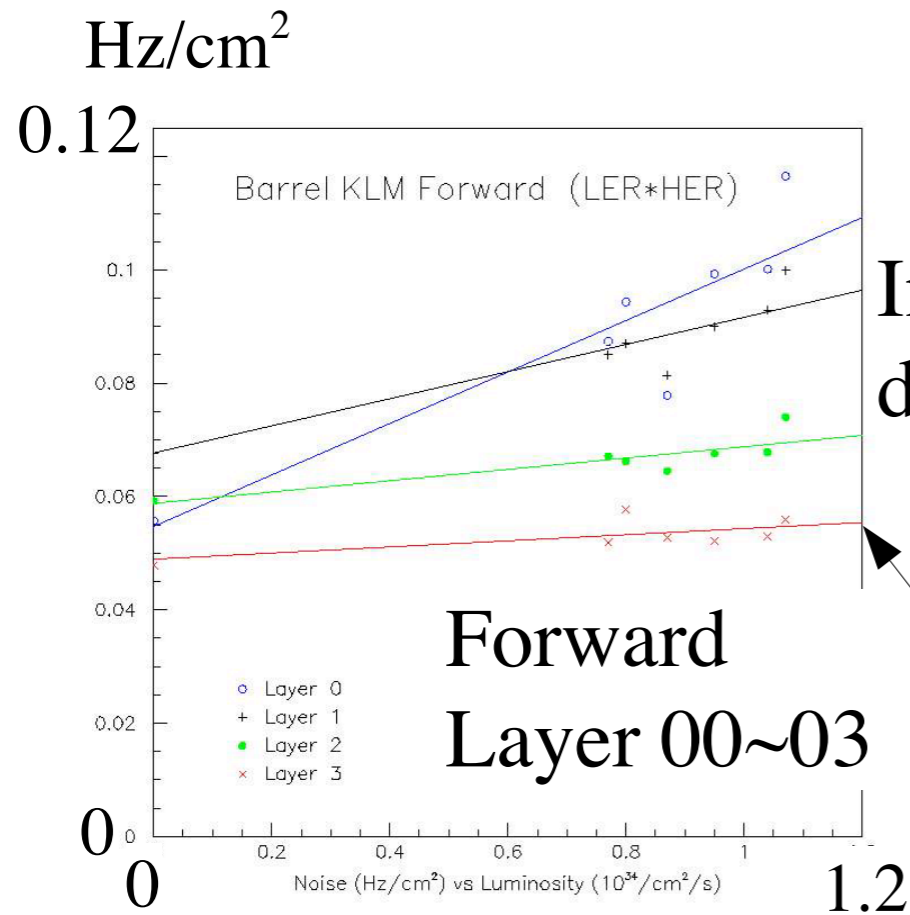
efficiency vs hitrate for barrel



efficiency vs hitrate for endcap

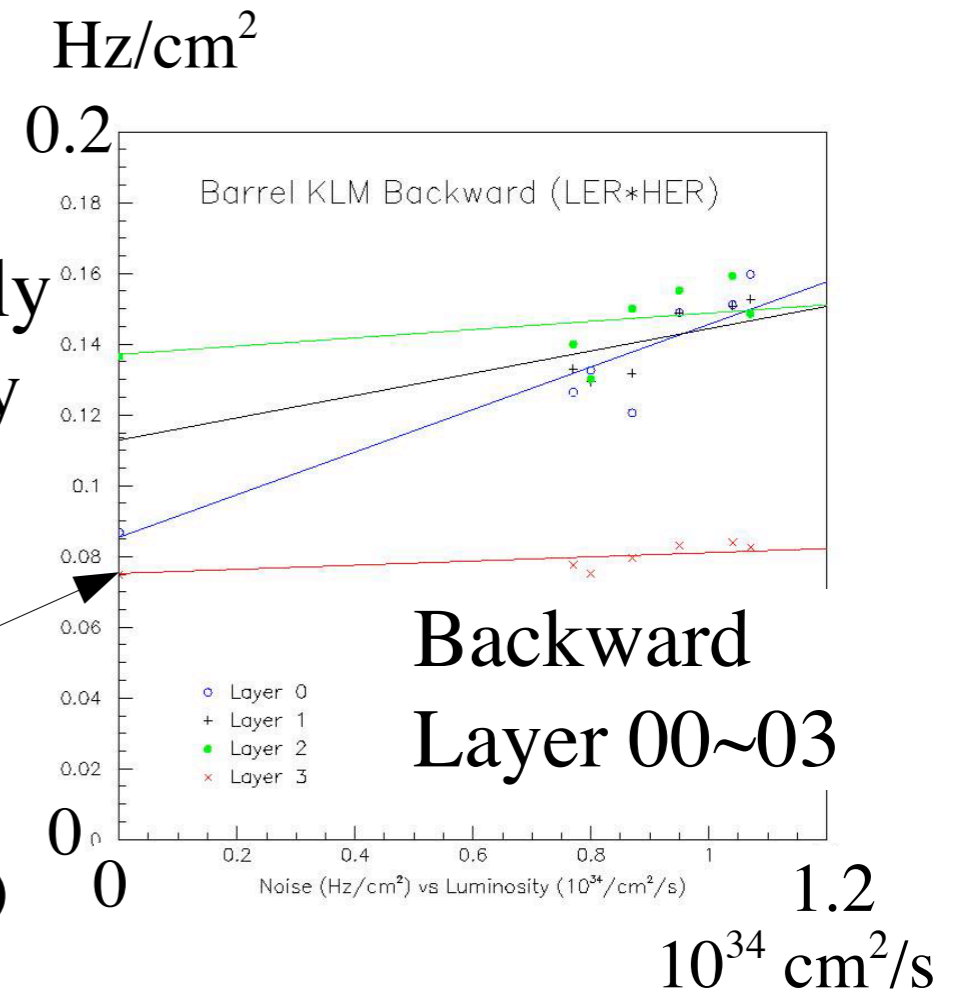


# Barrel hit rate at Super-KEKB luminosity ( $10^{35}/\text{cm}^2/\text{s}$ ) will not degrade efficiency except in innermost layers



Inner 3 layers strongly depend on luminosity

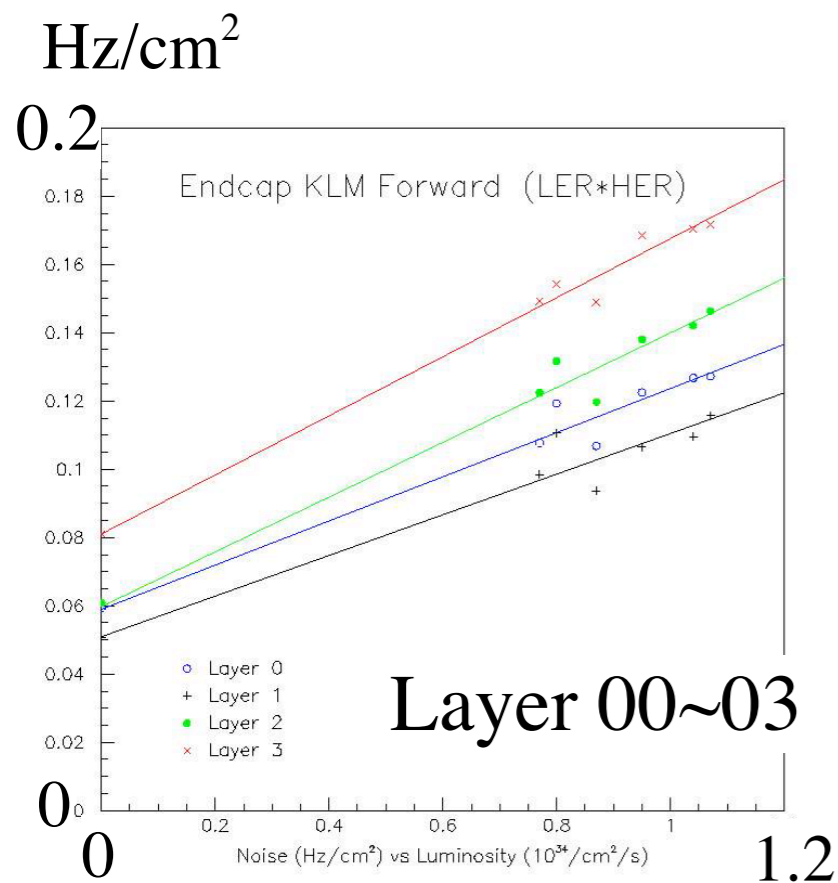
Layer 03  
(4<sup>th</sup> layer from inner)



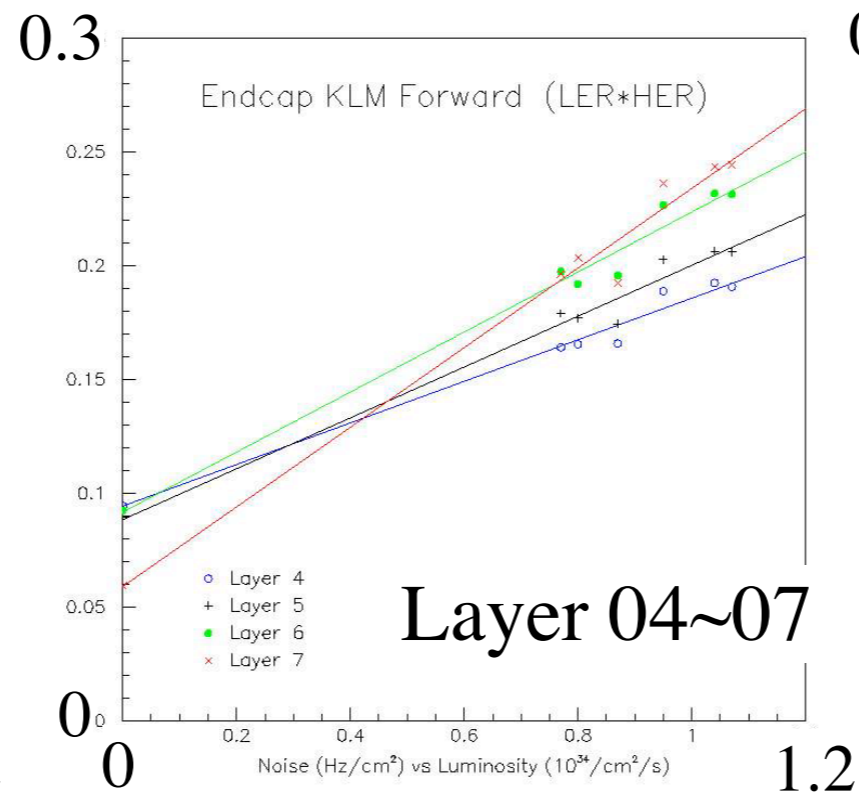
2.5~0.6 Hz/cm<sup>2</sup>  
@ $5 \times 10^{35} \text{ cm}^2/\text{s}$  (Layer 00~02)

3.3~0.8 Hz/cm<sup>2</sup>  
@ $5 \times 10^{35} \text{ cm}^2/\text{s}$  (Layer 00~02)

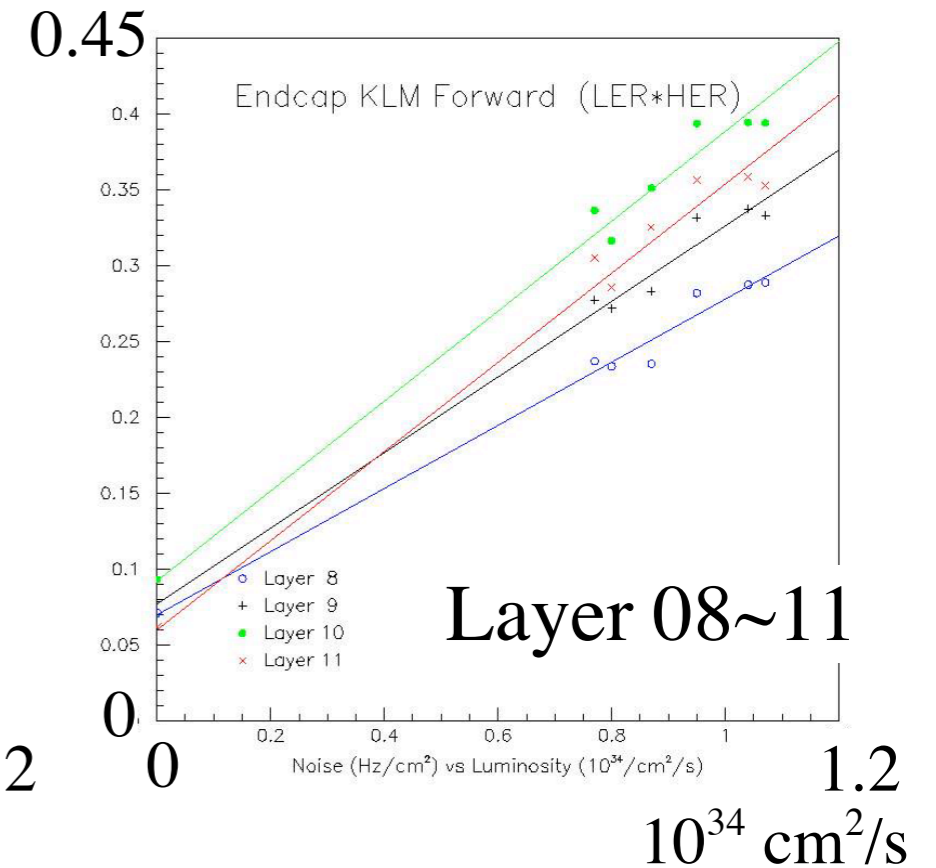
# Endcap hit rate at Super-KEKB luminosity ( $10^{35}/\text{cm}^2/\text{s}$ ) will result in $\sim 0\%$ efficiency



3.1~4.4 Hz/cm<sup>2</sup>  
@ $5 \times 10^{35}$  cm<sup>2</sup>/s



4.7~8.9 Hz/cm<sup>2</sup>  
@ $5 \times 10^{35}$  cm<sup>2</sup>/s



10.6~15.3 Hz/cm<sup>2</sup>  
@ $5 \times 10^{35}$  cm<sup>2</sup>/s



# Summary

- Glass-electrode RPCs have performed well in the Belle KLM subsystem
- No irreversible deterioration seen since commissioning in 1999 [*sensitivity to water vapour in gas corrected by replacing polyolefin gas lines with copper*]
- Extrapolated efficiencies at Super-KEKB luminosity imply that endcap RPCs will have to be replaced [*with scintillators?*]