Aging effect in the BESIII Main Drift Chamber

Liu Kai
Introduction

• MDC in BESIII
  – cylindrical chamber with 43 layers of sense wires
  – helium based mixture gas(He/C$_3$H$_8$=60:40)
  – average gas gain $\sim 3 \times 10^4$

• Aging effect
  – obvious gain decrease
  – some cells tripping all the time
  – including anode and cathode aging
Indicator of the aging effect

- The aging effect depends on the total radiation dose, which has positive correlation with hit rate and cell accumulated charge.

Fig. 1 Single wire hit rate each year as a function of MDC layer

mainly beam related background

Fig. 4 Accumulated charge of the cells as a function of MDC layer in each year
Anode aging effect
Physics Picture of Anode Aging

gas polymer condenses on the sense wire

– cause gain loss due to

• the increased effective diameter of the sense wire
• reduction of electric field due to charge accumulation on the insulating layer.

– worse pulse-height resolution

• variation of the deposit thickness along the sense wire.
Influence on MDC performance

--gain decrease

- Get from Bhabha sample in real data
- assuming the gain in 2009 to be one
- The relative gain shows the gain decreases year by year.

Gain loss and worse pulse-height resolution cause lower hit efficiency in real data, which has a positive correlation with the tracking efficiency.
Cathode Aging Effect
Physics Picture of Malter effect

- Insulating polymer deposits on cathode
  - Prevents neutralization of positive ions
  - A positive charge surface near cathode
    - Strong electric field
      - Electrons being extracted from cathode
        - Most: Recombine with positive ions immediately
        - Some: Drift to anode
          - Continuous, self-sustaining local discharge without external irradiation
            - Avalanches at sense wire
              - More positive ions produced, back to cathode
                - Enhanced electric field of insulating layer
Influence on MDC performance

• BESIII drift chamber met the Malter effect in January 2012.
  – lots of cells, especially inner layers, tripped when taking data.
  – the large current did not disappear even after stopping the beam irradiation, until the high voltage in the cell was powered off.

➤ neighboring cells share the same field (cathode) wires, Malter discharge spread fast in the inner chamber
  • more and more affected cells that cannot work.
Solution Method

• From February 27 to March 30, added 5% CO₂ to the operating gas
  – but gas gain lost obviously (23%)

• Since April 1, about 0.2% water vapor, which replaced the previous CO2, added to the operating gas.
  – worked well
  – gain decreased about 9%.
  – No Malter discharge has been observed since then
Summary

• After many years' data taking, the Main Drift Chamber meets aging effects.

• **For anode aging**
  – the cell gain decreases year by year
  – the influence on data is *under control* and *could be calibrated*

• **For Cathode aging**
  – seriously affect the data taking
  – solved by changing the operating gas

• **If you need to use the 2012 Psip data sample, be careful!**
  – for example, Ryuta's work. two charged pions should be reconstructed in MDC.