The degradation of feedthroughs in BES-II main drift chamber

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1 Introduction

BES-II main drift chamber is a cylinderical chamber. The total length is 3.8 meters with 2.30 meters in diameter. There are 10 super-layers and 804 drift cells. The total number of wires is 22936. The time and charge signals of the inject charged particles could be measured in the same time.

The BES-II main drift chamber is a China-U.S.A. collaboration project. The outer cylinder, end-plates and feedthroughs were supplied by U.S.A. Other parts were made in China. The chamber was wired,assembled and tested in IHEP,Beijing.

2 Characteristics of the BES-II main drift chamber

This chamber works well at beginning,especially after modifying the high voltage system in last summer. It's stable. The leakage current and pick-up noise are low. 250,000 cosmic ray and about 2.0 millions J/Psi events have been taken with reasonable low threshold. The characteristics of the chamber are following:

1).Survey and alignment:

2).Parallelism of the two end-plates: 0.81mm.

3).The maximum tolerance of the concentricity of the inner diameter of the position hole to the feedthrough outer diameter is less than 0.07 mm.

4).Wire tension distribution(Fig.1)

field wires : sigma =2.31

potential and guard wire: sigma =1.43

sense wire : sigma =2.36

thick field wire: sigma =3.09

5). Gas leakage rate: 0.05

6). Space resolution:

From $\delta = \frac{(t_1+t_2)}{2} - t_2$ distribution (Fig2) is: $\sigma_x = 0.172 - -0.196mm$

From residual of the track is: $\sigma_x = 0.190 - -0.210mm$

7).The efficiency of single wire is 97.2

8).The momentum resolution from the BhaBha events in J/Psi energy range is 47.6 MeV for MDC itself and 38.9MeV with the Vc together(Fig3)

9).The uniformity of the pulse height from 40 samplings is good (RMS/mean=25.9

3 Test of the degradation of feedthroughs

A few months after the chamber was commissioned,high amount of dark current and random noise were developed. This fault has been traced to the feedthroughs after every effort was made to examine it.

1). Prototype tests:

According to the design of BES-II Main drift chamber,a prototype has been made with the same feedthroughs. There are 6 drift cells in it. The length of the wire is 2.0 meters. The chamber was filled with air and the operating high voltage was 4.0 KV. The temperature of the environment is about 19.5 degree C.

A).The dark current in the prototype began to rise after 21 days reaching to 69 micro A 10 days after that.(Fig 4)

B).The outer surface of the end-plates and the top part of the feedthroughs have been cleaned with ethanol and dried in room temperature air. The curve of dark current vs high voltage is shown in Fig.5. The amount of dark current didn't change any after the cleaning. It means that the dark current is not caused by the surface leakage of the end-plates.

C).Put the high voltage on half number of wires, the amount of dark current decrease to half. for 1/4 of the wires, the amount of dark current became 1/4 also. It means that the dark current is not from any individual wire. It's from every one.

D).Solder out half number of the wires from feedthroughs(72 feedthroughs) and another group of feedthroughs(66 pieces) still keep wires. The amount of dark current dropped to $40\mu A$ for the wire less feedthroughs and 39 micro A for the group of feedthroughs which still hold wires when we put 4.0 KV high voltage on the two groups respectively. It means that the dark current has nothing to do with the wires.It came from feedthroughs definitely.

E).Seven feedthroughs of the prototype have been sparked through the Delrin wall after 46 days. It strongly indicate that the degradation of BES-II main drift chamber is caused by the feedthroughs.

2). Examination of random noise:

The wave forms of the random noise were watched on the prototype by an oscilloscope. The result is shown in Fig. 6 The test period of those pictures is 5 minutes. Picture in Fig. 6a was taken without any high voltage. It's background Fig. 6b shows the picture when the 4.0 KV high voltage put on the feedthroughs. The big different between Fig. 6a and Fig. 6b mean that the random noise was caused by the feedthrough failing too.

3).Comparison test

The high voltage tests of BES-I and BES-II MDC feedthroughs has been done. The materials of this two kind of feedthroughs are all Delrin. The BES-I feedthroughs were produced in Suzhou with molding injection. BES-I feedthroughs have the same design as BES-II's but they were made into two pieces which have almost the same length then glued together with epoxy.

Two groups of BES-II feedthrough were tested. They have almost the same number and the high voltage were 4.0 KV and 4.5 KV respectively. The BES-I feedthroughs were tested with exactly the same conditions of BES-II's.

The group of 4.5 KV BES-II feedthrough began drawing 1.0 micro A dark current after 10 days and group of 4.0 KV drawing 1.0 micro A after 12 days.

The amounts of dark current of BES-II feedthroughs continued to rise after 50 days reaching 55 micro A (4.5 KV group) and 37 micro A (4.0 KV group) respectively.In the mean time, amount of dark current of BES-I feedthroughs whatever 4.0 KV group or 4.5 KV group continued to keep 0 micro A.

Seven feedthroughs in 4.5 KV group and 3 feedthroughs in 4.0 KV group of BES-II have been sparked through the Delrin wall.

The feedthroughs of BES-I MDC did not manifest itself the same fault of BES-II's. The degradation of the BES-II feedthroughs may be caused by the technology of molding injection.

4).Test of temperature effect

Put two groups of BES-II feedthroughs and a digital thermometer into the thermostat. The two groups of feedthroughs have operated on the high voltage 4.0 KV and 4.5 KV respectively for 50 days. They are drawing the dark curent of course. The temperature of the thermostat could be changed from -20 to 70 degree C with the tolerance of + - 0.5 degree C.

Measure the relationship between high voltage and dark current for each testing temperature after setting the test point 4 hours. The result is shown in Fig. 7.

The temperature plays an important role in the dark current. The temperature is higher, the amount of dark current is bigger. Reducing the temperature is a powerful method to decrease the dark current.

5).Inspection of the feedthroughs before installation

The constant inspection and testing of the feedthroughs have been done before usage

A).Inspect 5000 feedthroughs with a 5.0 KV Megohm meter, the resistance close to infinite for every testing one.

B).Put 6.0 KV high voltage on the feedthroughs for 8 hours, the amount of dark current is 0 micro A.

C).Put 4.25 KV high voltage on the field wire feedthroughs and measure the dark current during the wiring. The total numbers of 13,576 feedthroughs have been tested, none is failure.

4 Possible solutions:

1).The best way to overcome the difficulty of BES-II is to build a new drift chamber,since most of the feedthroughs were injured.

2).Repair the existing chamber with split high voltage system. This is, I would say, only an expedient measure to meet an emergency. Nobody knows for how long the chamber could last.

The idea of split high voltage system is following: Split the 3.8 KV which was put on the field wire in the existing chamber into two parts, for an example, 1.8 KV on the field wires and 2.0 KV on the sense wires. Of course, the high voltage on potential wires and guard wires should be changed either.

There are several essential conditions for using the split high voltage system:

A).Amount of dark current should be low enough at the lower high voltage. Fig. 8 shows the changing of dark current with time for the existing chamber which operated at 2.0 KV. The amount of dark current shown in Fig. 7 may be acceptable for the split H.V. system.

B).The random noise should be low enough at lower high voltage. Talbe. 1 shows the results. It's reasonable low comparing to the value of BES-I. Dr. Zhu Qiming will give the detail.

C).The drift electric field and the gain of the same wires should close to the value of existing H.V. system which is verified. Dr. Dehong Zhang will report the detail.

D).Most important, how long the feedthroughs could last, who will give the result?

The testing of new potential boards and sense wire boards for the split high voltage system has been done with a prototype. Dr. Song will give the report.

5 Conclusion

The poor performance of the BES-II main drift chamber is caused by the degradation of feedthroughs. This fault did not manifest itself until after the feedthroughs exposure high voltage for several months. Higher temperature may be exacerbating this effect.The aging effect of feedthroughs may be caused by the mold injection process. The best way to solve the difficulty of BES-II is to build a new drift chamber.The split H.V. method is only an expedient measure to meet an emergency.