Realization of the MDC-II Split HV Scheme

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1. Background

Feedthroughs could not stand 4 kV. In order to maintain a reasonable life time and an acceptable data quality, the field wire high voltages had to be lowered by as much as possible. There had been many suggestions from within IHEP and from all over the world:

1. Change the working gas;
2. Replace all sense (and guard) wire feedthroughs,
   apply $+4$ kV on them so that the field wires could be at ground;
3. Cool down the endplates;
4. Split the HVs among sense and field wires, making them ± 2 kV.

Pros and cons :

Option 1: Lower the HVs by $\sim$ 200 V only, the new gas mixture is not as stable as HRS;
2: Would take too long;
3: Difficult to do, may not be sufficient;
4: Many experiments have been using this scheme;
Can be done within a reasonable time;

Great concerns over pick-up noise and deterioration in the dE/dx measurement.

2. Experiments with prototypes

Several experiments were done with two prototypes.

Prototype 1 — multi-layer multi-cell, MDC-I feedthroughs :

- Repaired the prototype;
- Calculated the electrostatic field distributions for a few different HV settings;
- Made preliminary boards for the HV supply and decoupling;
- Saw signals with both the old sense-wire-ground and the new split HV schemes ($+2$ kV, -1800 V);
- With sense-wire-ground scheme, changed the decoupling capacitors, checked the shapes of the signals.

The split HV scheme could work! Due to limitations on the electronics, the influence of the decoupling capacitors on the dE/dx measurement could not be checked.

Prototype 2 — Full-length, MDC-II feedthroughs, HV experienced :
(By Prof. W. Toki of CSU)

- Saw sharp sparking pulses of about 50 mV on field wires, a HV of -2 kV was applied;
- Observed on sense wires induced signals of $\sim 1/20$ the size;
- The sparking signals were reduced by a factor of 20 in height when a capacitor of 10k pf was used as a filter;
- With fresh feedthroughs, no sparking signals were seen when a HV of $+2$ kV was applied.

The clustered noise were indeed due to field wire sparking. And most importantly, the sense wire feedthroughs can hold $+2$ kV! Important modification from Prof. Toki — put capacitors on the field wire HV supply board as filters. These capacitors made the clustered noise to disappear completely even at -1800 V.

3. Experiments on MDC-II

In order to make sure that the split HV scheme works with the real chamber, and to check with the real readout electronics the effect of the decoupling capacitors on the dE/dx measurement, experiments continued on MDC-II itself using 8 cells, 32 channels, in layers 6, 7 and 8.

Results :

- With slight adjustment on the HV's, "normal" signals were seen when the decoupling capacitors were the 10k pf ones; The dE/dx spectra could be made the same as from the old sense-wire-ground scheme;

- At the same HV setting, when the 10k pf decoupling capacitors were replaced by 330 pf ones, the signals were indeed distorted and the dE/dx values were reduced by a certain amount. While nothing could be done to avoid the distortion, the overall reduction in the dE/dx values poses no real threat to the dE/dx measurement and, can be compensated by slightly adjusting the HV setting;

- There were almost no sparking/pick-up noise.

The split HV scheme works !

4. Determine the HV settings

No matter how the HVs are supplied, the voltage difference between the field and sense wires has to be about 4 kV. In order to maintain a reasonable overall lifetime and guarantee acceptable data quality, compromise had to be made on how much HV to apply on each type of wires. This is because:

- If there is too much (negative) HV on field wires, the field wire feedthroughs would deteriorate very fast and the data quality might not be acceptable due to sparking noise;

- If there is too much (positive) HV on sense wires, the sense wire feedthroughs might start to spark very soon and the wires themselves might break because of the very strongly distorted field at the two ends.

Noise runs were then taken with random trigger. Only the field wire HV's were on, all other HV's were off so there should be no real signal but noise. The field wire HV's were changed from -3800 V to -1500 V, the corresponding noise levels were quantified by the percentages, R, of events with noise clusters — a noise cluster was defined to be at least 3×2 adjacent noise cells from at least 3 layers each having at least 2 cells. Results :

HV (V)	-3800	-2000	-1800	-1500
R (%)	40.1	11.2	7.3	0.0

It was decided to run the field wires at about -1800 V.

5. Final designs

Two major modifications:

- Added capacitors on the field wire HV supply board as filters;

- Removed the diode protection on the HV decoupling board,
  because the NH19-6112 hybrid chip has internal protection.

Due to space limitation in layers 1 $\sim$ 3, new preamps were made by Univ. of Hawaii to include the HV decoupling capacitors.

6. Replace feedthroughs & Cooling

By the summer of 1997, in total 16 field wires had become very bad. The feedthroughs could not even stand -2 kV. They were then taken out and the wires replaced. We found:

- All 32 feedthr. were a lot more yellowish than fresh ones;
- Most of the damages could not be seen with naked eyes;
- 3 pieces had big black holes with dimensions of several mm's;
- One had a belt of black wiggles, one had a black spot;
- The worst 5 were all from the east side.

  The reason for this can now be surely attributed to the heat produced by the preamps.

In addition to the split HV scheme, pipelines were laid and wrapped up from outside the detector to the MDC endplates, foreseeing possible need for cooling. During the R scan test run period, experiments were done to blow either cold, dry and clean air or Ar (out of liquid), at a maximum flow of 10 m^3 per hour. The temperature could be lowered by about 1 °C. More work should be done in this respect.

7. Performance

After nearly 2 months of R scan test run, we have

Good news:

- MDC-II was turned on for $\sim$ 40 days, stable;
- HV trips were all caused by beam losses, not MDC itself;
- Little increase in the leakage currents;
- No more clustered noise;
- No pick-up noise from the detector electronics.

The spacial and dE/dx resolutions have been found to be about 220 μm and 8.5% respectively.

A new problem: Many hot channels when the beam current > 25 mA.

The seemingly cause:

- A beam-related signal, 2 components: ~ 30 and ~ 400 MHz;
  The 30 MHz part has bigger impact than the 400 MHz part;
- Stronger in the east side than in the west side;
- Shield the east electrostatic separator with high μ material, the 400 MHz part $\downarrow$ by $\sim 40\%$, the 30 MHz part no change.

Efforts are still being made to track down the source(s) for this 30 MHz radio transmission, to improve the readout electronics and to improve the HV supply system.

8. Lifetime concerns

We are EXTREMELY concerned over the lifetime of our MDC-II, have put several sets of old/new feedthroughs under different HV's to check for leakage current growth. The results conflict :

- The leakage current took off after about 2 months;
- Very little increase after about one year.

Both these two experiments involve fresh feedthroughs and the HVs have both been -2 kV.

The most direct inputs come from the chamber itself:

- *Simple math*

  Up to early 1997, we had run the chamber at -3850 V for about one year off and on, and had to disconnect 15×4 cells.

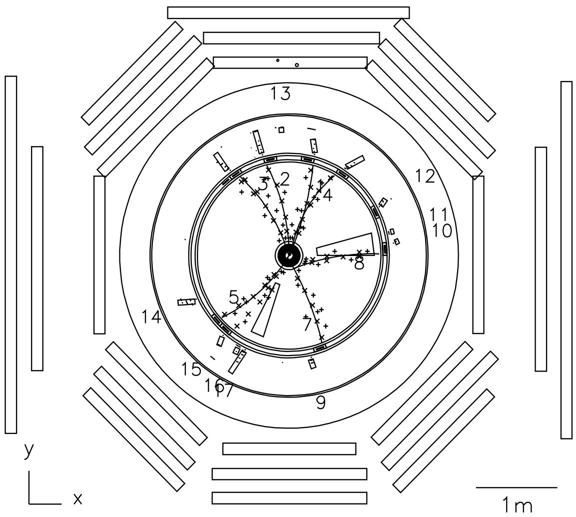
  Now we run the chamber at -1800 V and might be able to expect a $4 \sim 8$ times prolongation in the lifetime, i.e. about $8 \sim 16$ cells to disconnect every year.

- *In real life*

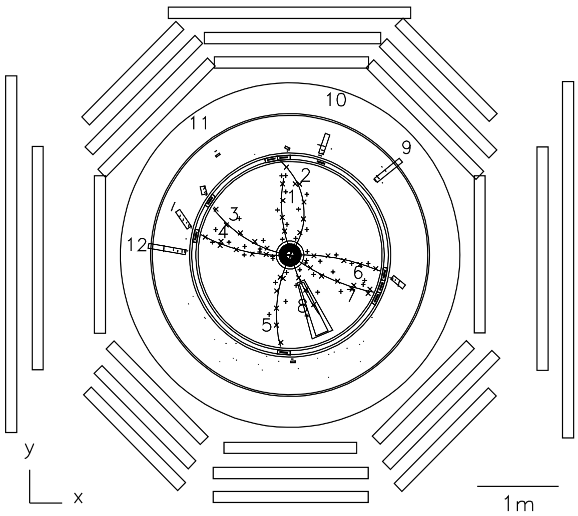
  During the nearly 2 months of R scan test run period, MDC-II was on for a total integrated time of about 40 days, and had been rather stable. There was no need to disconnect any unit.

But still, we are not confident enough.

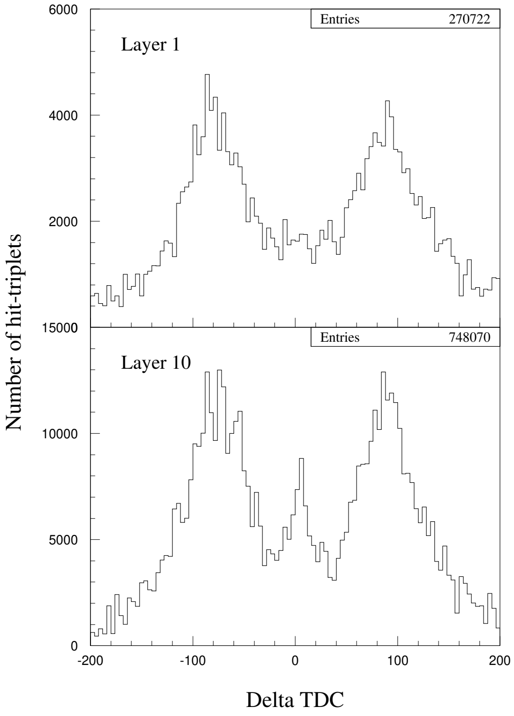
Run: 11436 Event: 382



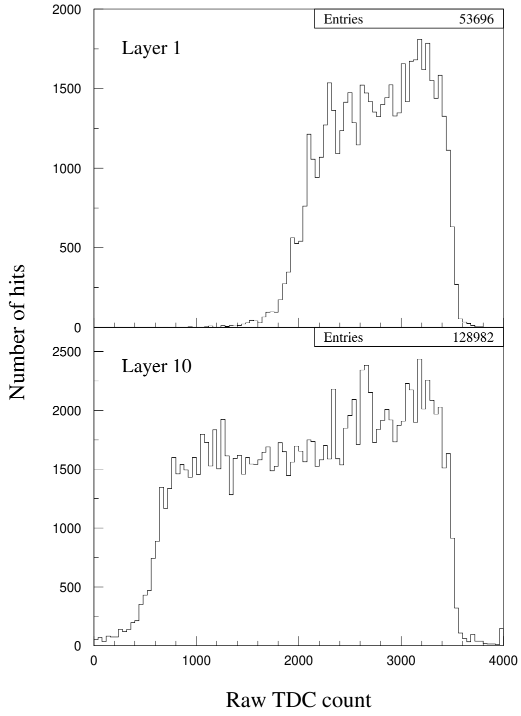
Run: 11441 Event: 16985

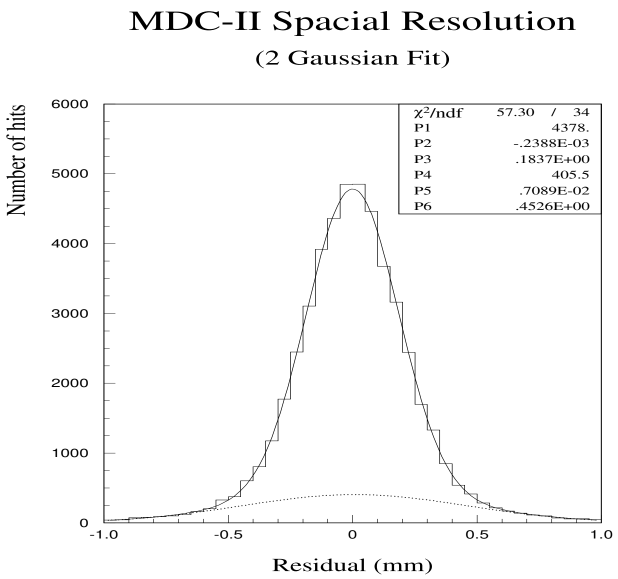


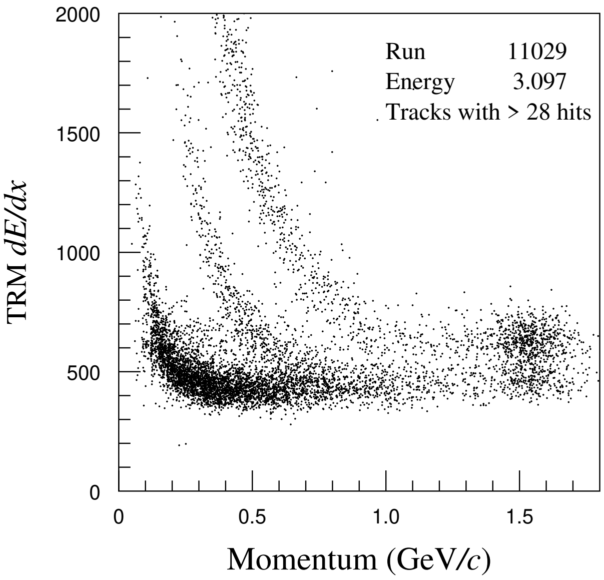
MDC-II Delta_T Distribution

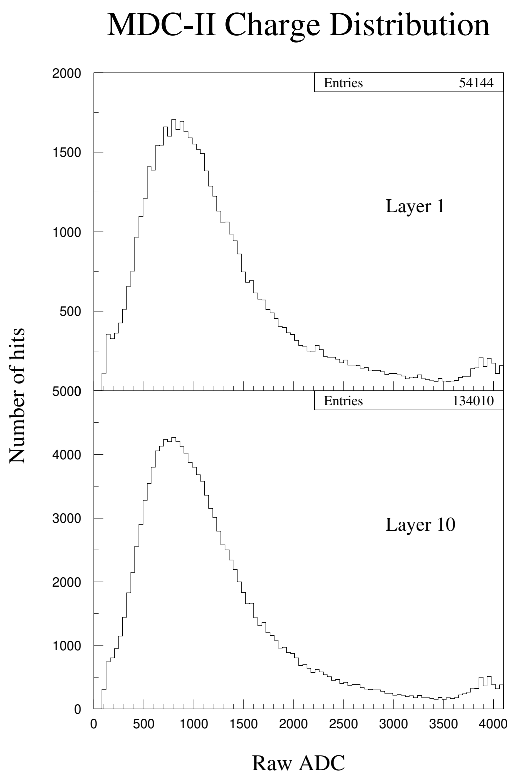


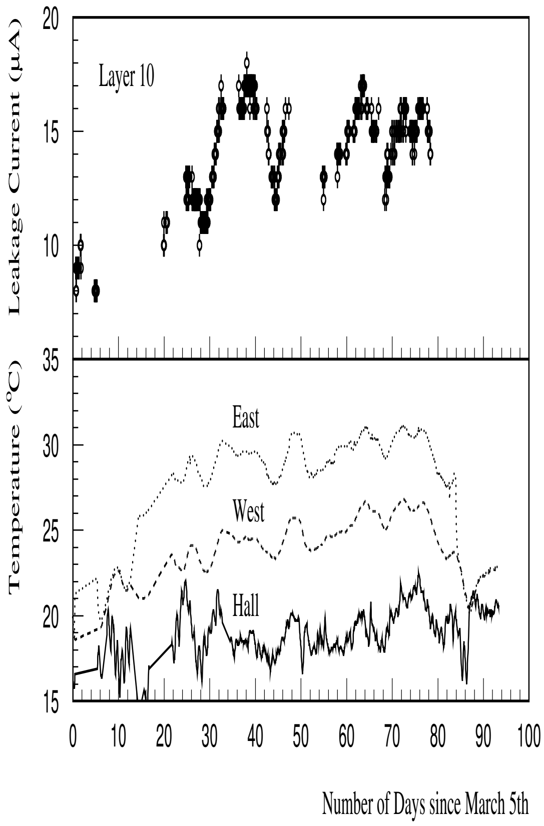
MDC-II Drift Time Distribution




MDC-II Spacial Resolution
(2 Gaussian Fit)
Number of hits
χ^2/ndf 57.30 / 34
P1 4378.
P2 -.2388E-03
P3 .1837E+00
P4 405.5
P5 .7089E-02
P6 .4526E+00
Residual (mm)


Run 11029
Energy 3.097
Tracks with > 28 hits
TRM dE/dx
Momentum (GeV/c)


MDC-II Charge Distribution
Entries 54144
Layer 1
Entries 134010
Layer 10
Number of hits
Raw ADC


Layer 10
Leakage Current (μA)
East
West
Hall
Temperature (°C)
Number of Days since March 5th