The Readout Structure for the Micro TPC

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The idea of developing a Micro TPC vertex detector for the STAR experiment at RHIC grew from the challenge of coping with the high track density environment of heavy-ion collisions. Tracking of low-momentum particles may be compromised by their strong multiple coulomb scattering passing through silicon devices. The momentum resolution for these particles will be poor and secondary vertices may be hidden, especially ones from open charm. Being filled with gas, the Micro TPC has a radiation length 5 times lower than STAR's Silicon Vertex Tracker (SVT).

Simulations have been performed to figure out if the unavoidable loss in position resolution of the Micro TPC, relative to the SVT, can be compensated by the lower multiple scattering. The vertex position resolution found is 40 µm in r_φ, 200 µm in z, with a two-track resolution of 600 µm in r_φ and a few mm in z. Calculations, taking into account these results and multiple scattering, show a vertex resolution in r_φ for the Micro TPC twice as good as for the SVT. This very good position resolution for a gas detector is reached using Micro Strip Gas Chambers (MSGC) as readout structures on the Micro TPC endcap, and dimethyl-ether (DME) [1] as the TPC gas.

MSGC chips, having very low noise, due to integrated on-chip electronics, have been developed and successfully tested. We have achieved gains up to 200 in Ar-CO_2 (75/25) with an r.m.s. noise of 80 e^-, and an energy resolution of 18% (FWHM) for an ^{55}Fe X-ray source [2]. This performance will be sufficient to achieve the required position resolution. However, these chips are easily damaged by any micro-discharges in the gas, which makes them too unreliable enough for long-term operation.

We are thus working on the so-called gas electron multiplier (GEM) [3], that provides a new simple preamplification structure and makes it possible to run the MSGC at a lower gas gain. We may even hope to run the MSGC chips with no gas amplification at all, according to the recent results from CERN where they achieved a gas gain of 2000 in pure DME. Figure 1 shows how the MSGC and GEM can be associated. To understand the features and behaviors of different GEM geometries, electric-field simulations have been performed, as well as tests with GEM foils. We hope to be able to manufacture our own foils soon, fitting their geometry to our requirements.

Footnotes and References

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[1] Morgan Burks et al., *"Electron Drift Parameter in Dimethyl Ether,"* NIM A385 (1997) 519.

[2] Morgan Burks et al., "*A Gas Microstrip Detector with Low Noise Preamplifier/Shaper Integrated on a Common Silicon Substrate,*" NIM (to be published).

[3] F. Sauli, "*GEM: A new concept for electron amplification in gas detectors,*" NIM A386 (1997) 531.

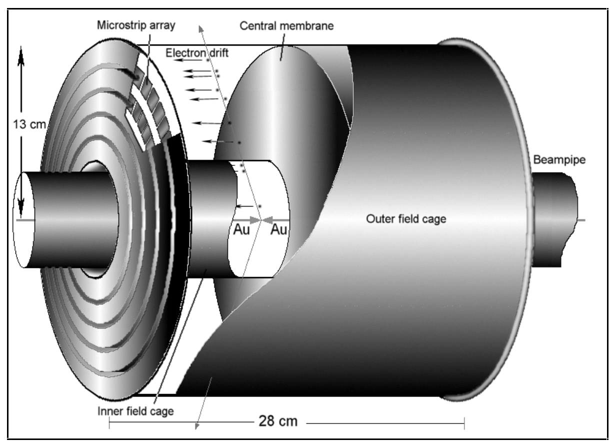

Fig. 1. Schematic view of the Micro TPC.

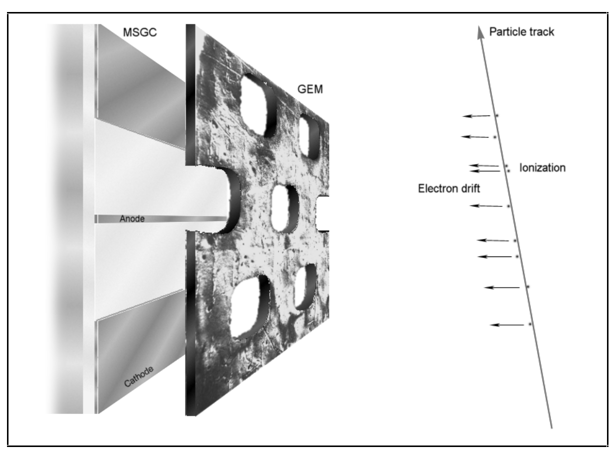

Fig. 2. GEM and MSGC readout structure.