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Specifications of the Low-Pressure TPC for the Muon Cooling Experiment

This document will present detailed specification for the Time Projection Chamber system to be used in the Muon Cooling Experiment. *This early version presents mainly the dimensions of the TPC.*

1 Introduction

The overall layout of the muon cooling experiment [1] is sketched in Fig. 1. The cooling apparatus is preceded and followed by a set of detectors [2] that measure all six phase-space coordinates of individual muons. The "before" arm of detectors is shown in somewhat greater detail in Fig. 2.

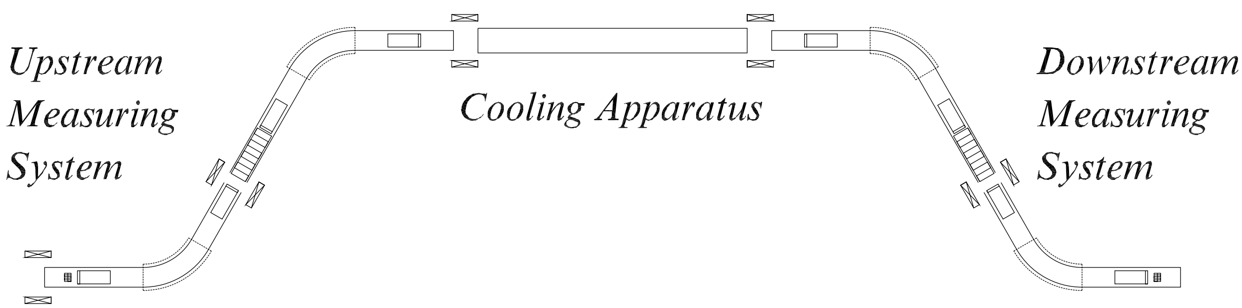

Figure 1: Top view of the layout of the detectors and a 3-T, 30-cm-diameter bent solenoid muon channel surrounding the muon cooling apparatus. Each detector arm is about 8 m long.

Each detector arm consists of two spectrometers that use bent solenoids for momentum dispersion and time projection chambers (TPC's) for tracking. The two spectrometers in an arm surround an 805-MHz rf cavity which imparts a momentum increment to a muon proportional to the time offset of the muon with respect to the zero-field rf phase. Measurement of the muon momentum before and after the rf cavity should determine the muon timing to 8 ps [2].

This document emphasizes the TPC's, whose functional form is shown in Fig. 3.

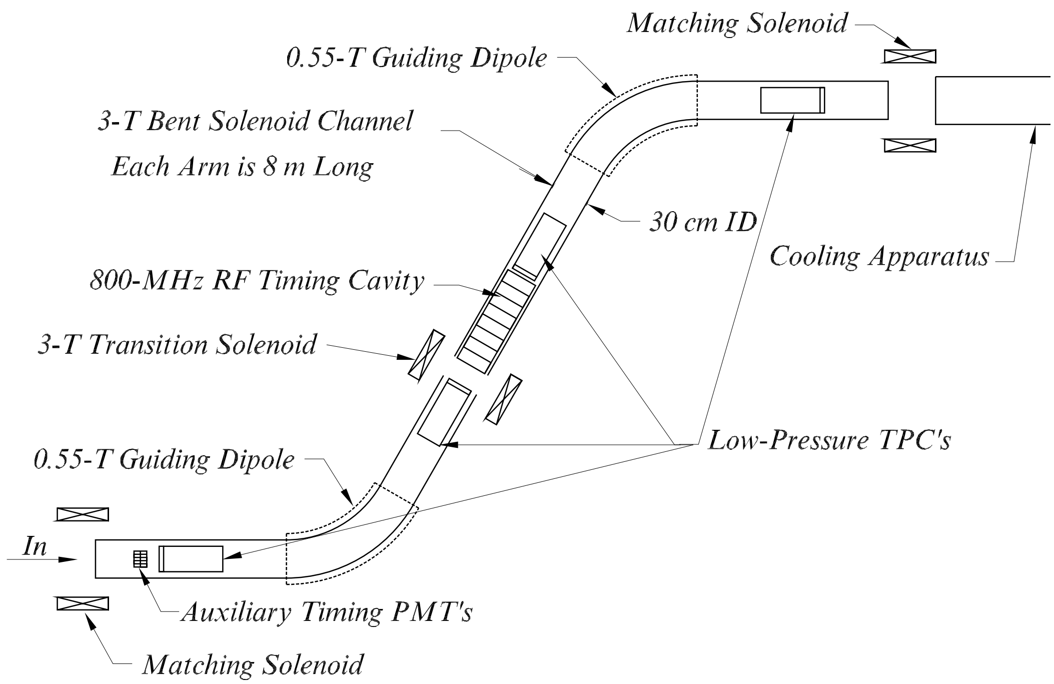

Figure 2: Layout of the 'before' arm of the detector. Vertical guiding dipole fields of 0.55 T are superimposed on the solenoid bends to keep the central trajectory in the horizontal plane.

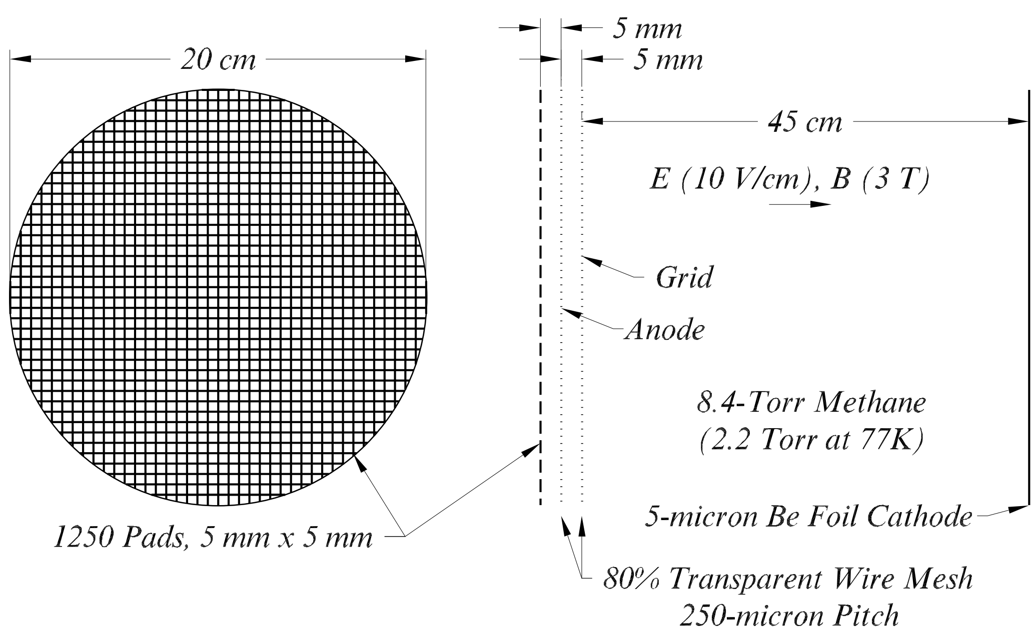

Figure 3: Sketch of the low-pressure time projection chamber.

2 TPC Dimensions

The active volume of each TPC is a cylinder 20 cm in diameter and 45-50 cm long. The TPC resides inside a superconducting solenoid with field of 3-4 T, which field holds throughout each detector arm.

The inside diameter of the superconducting solenoid that contains the rf cavity must be at least 30 cm to accommodate the cavity.

We propose that the superconducting solenoids that contain the TPC's also have 30-cm inner diameter. This will result in better field uniformity over the 20-cm-diameter active volume of the TPC's, and will permit the TPC front-end electronics to be mounted on the TPC endplate inside the magnet.

Preliminary sketches of the TPC plus front-end electronics are shown in Figs. 4 and 5. We plan to use the FEE readout card [3], shown in Fig. 6, that was developed for the STAR TPC. Each TPC will have 40 32-channel FEE cards for a total of 1280 channels.

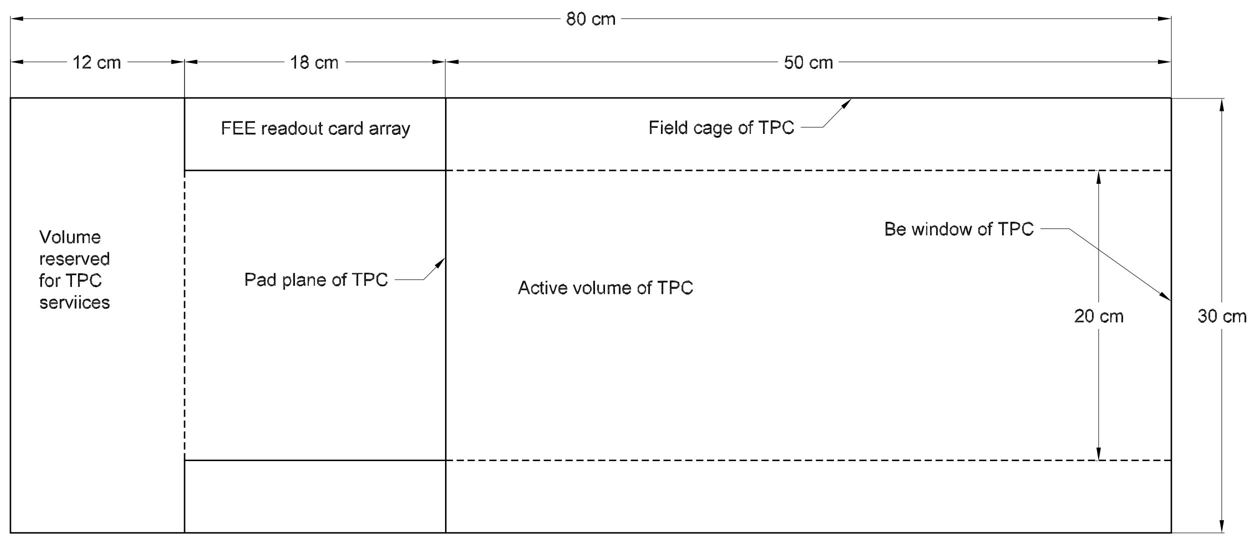

Figure 4: Plan view of the TPC plus front-end electronics.

The FEE cards can be arrayed in the 5-cm annulus between the 10-cm-radius TPC active volume and the 15-cm inner radius of the superconducting magnet. We wish to reserve 30 cm of space along the beam next to the pad plane of each TPC to accommodate the 18-cm-long FEE cards, plus distribution of readout cables, cooling lines and other chamber infrastructure.

3 Requirement for Magnetic Field Uniformity

The typical requirement for uniformity of the magnetic field on a TPC is that $\int \mathbf{B} \cdot d\mathbf{l}$ be constant to within a few parts in 10^4 on any line parallel to the chamber axis within its active volume. This requirement is very demanding, and may be difficult to meet in the proposed magnetic channel containing bent solenoids.

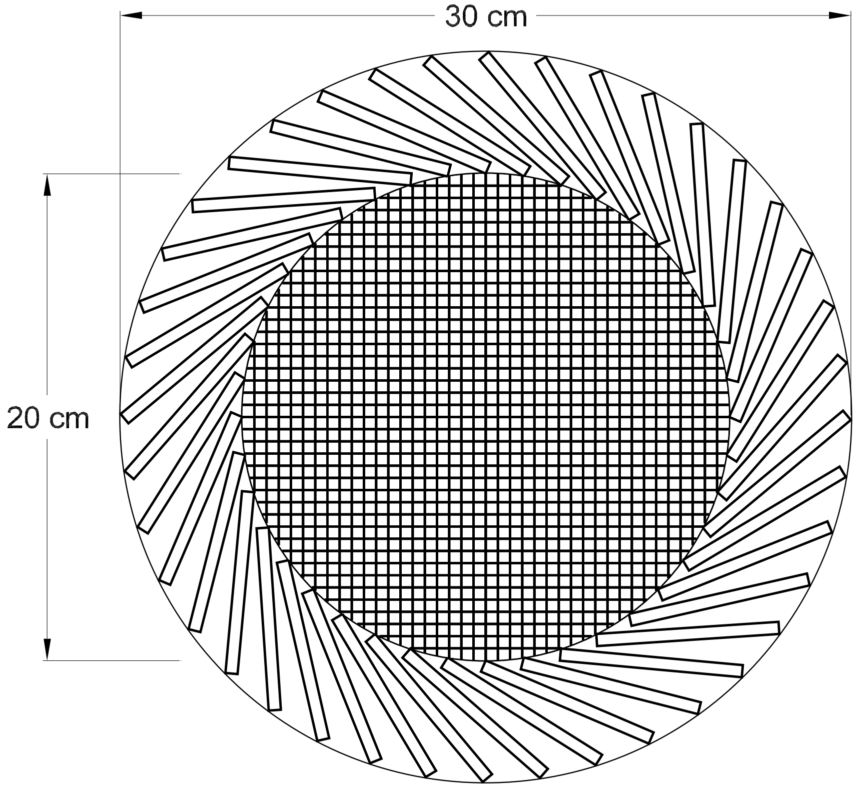

Figure 5: End view of the TPC plus 40 front-end electronics cards that process 32 channels each.

We are reviewing this requirement, and will discuss it further in the near future.

References

[1] C.M. Ankenbrandt *et al.*, *Ionization Cooling Research and Development Program for a High Luminosity Muon Collider*, (April 15, 1998), http://physics.princeton.edu/~mcdonald/mumu/muc/muc0001.pdf

[2] C. Lu *et al.*, *A Detector Scenario for the Muon Cooling Experiment*, Princeton/$\mu\mu$/97-8 (July 24, 1997), http://physics.princeton.edu/mumu/mumu-97-8.pdf

[3] S.R. Klein *et al.*, *Front End Electronics for the STAR TPC*, IEEE Trans. Nuc. Sci. **NS43**, 1768 (1996); http://physics.princeton.edu/~mcdonald/examples/detectors/klein_ieeetns_43_1768_96.pdf

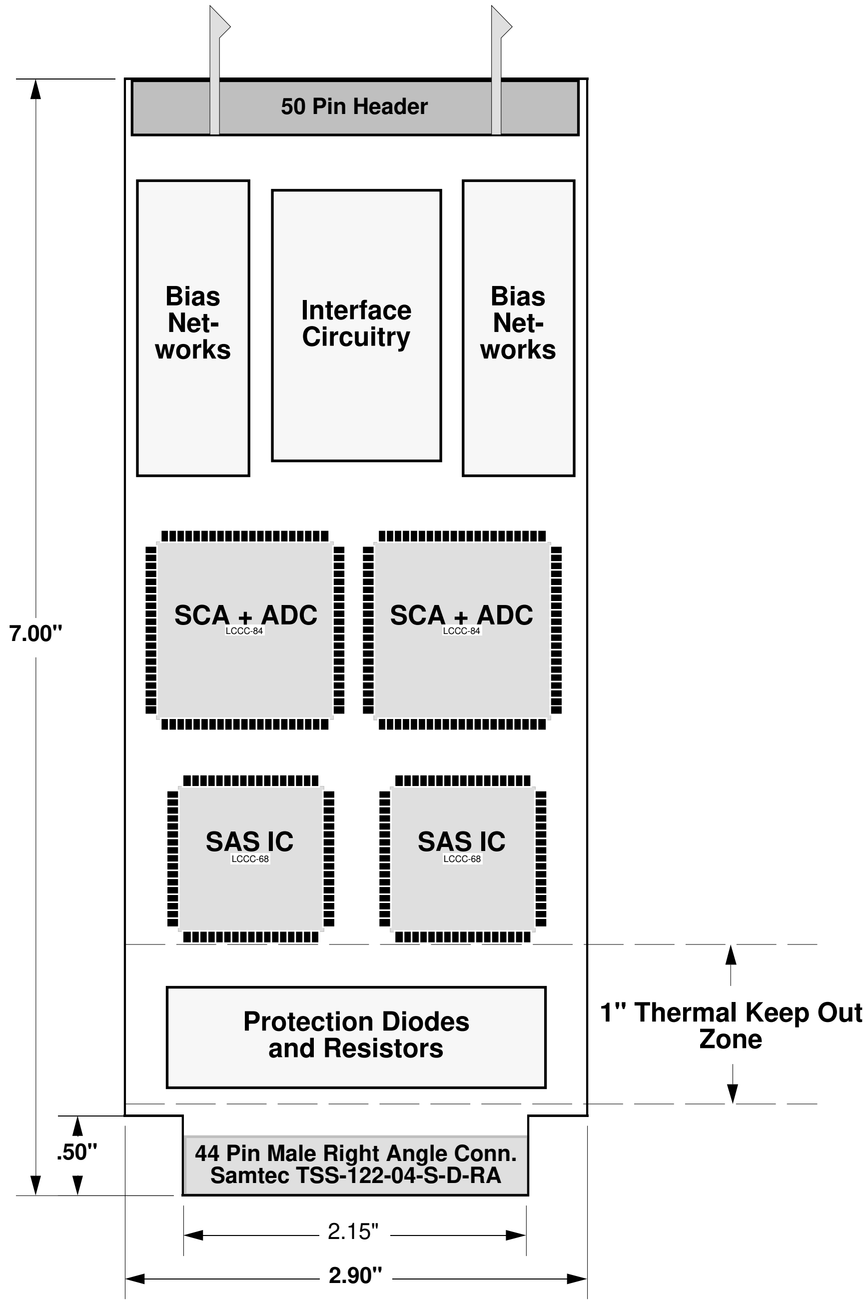

Figure 6: The STAR TPC front-end electronics readout card (FEE).