A Detector Scenario
for the Muon-Collider Cooling Experiment

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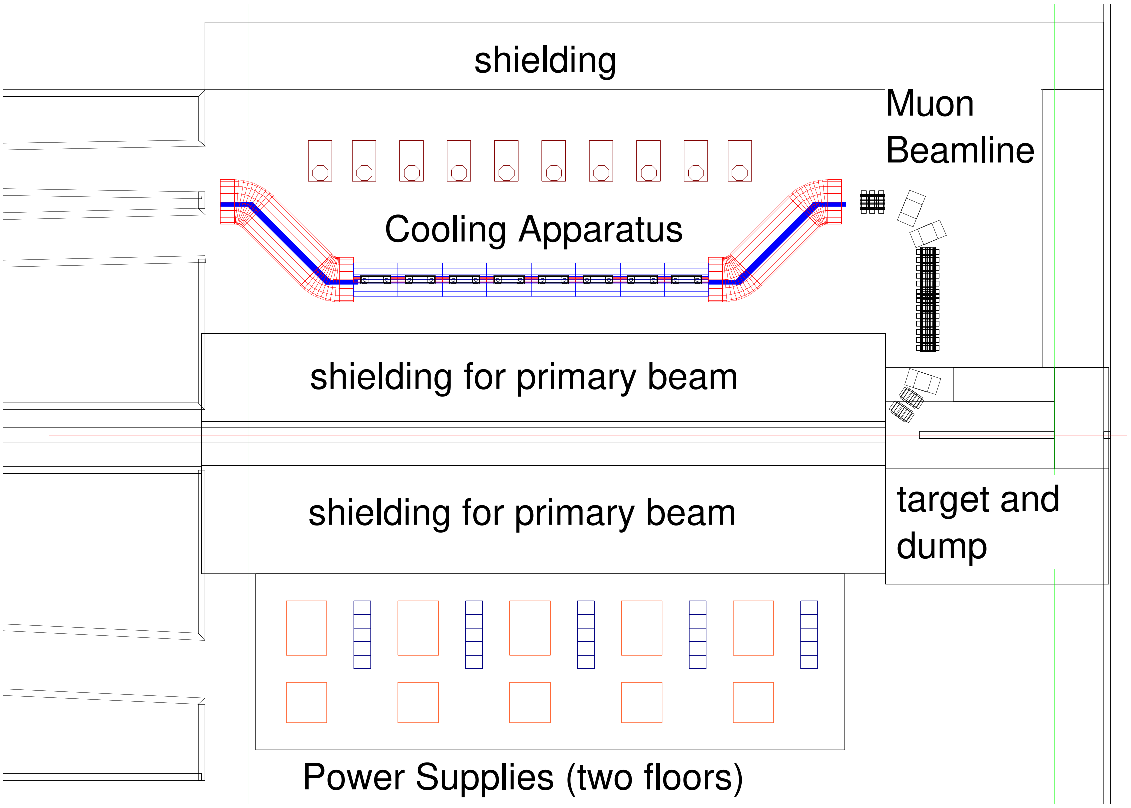
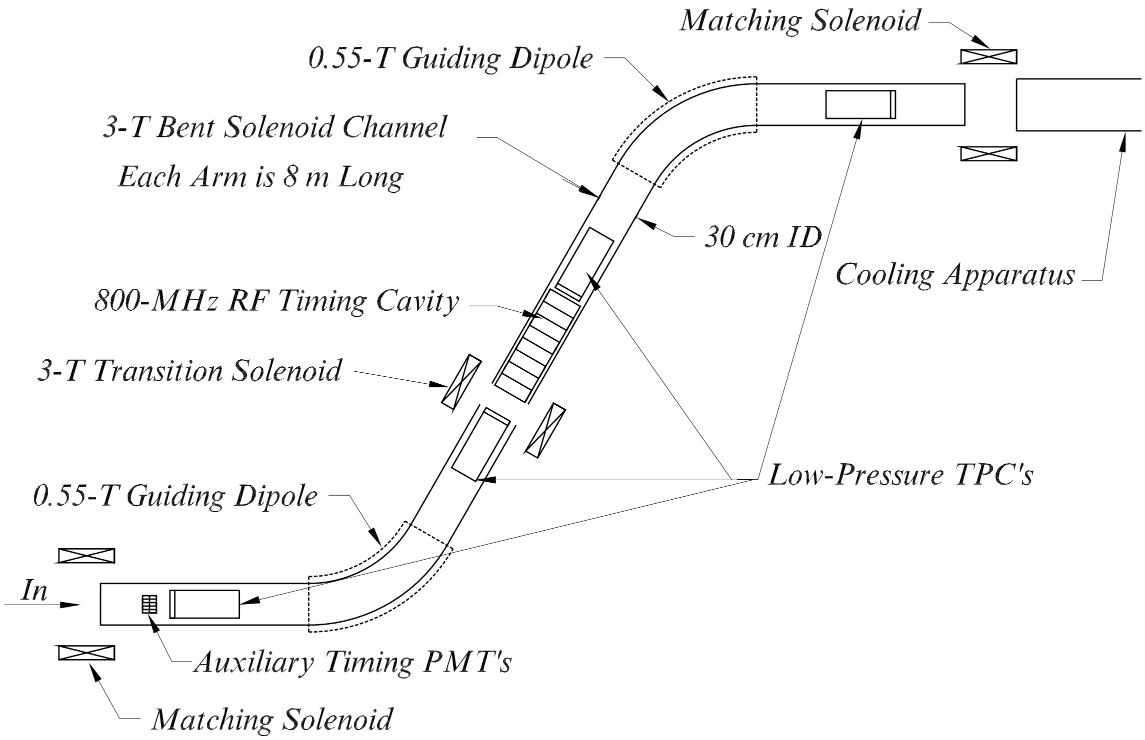
Goal: Measure the emittance of the muon beam to 3% accuracy before and after the muon cooling apparatus.

Possible site: Meson Lab at Fermilab:



Measure 6-D emittance before and after cooling:



Overview

Measure muons individually, and form a virtual bunch in software:

$\Rightarrow$ Must know timing to $\approx$ 10 psec to select muons properly phased to the 800-MHz RF of the cooling apparatus.

$\Rightarrow$ Use RF accelerating cavity to correlate time with momentum.

$\Rightarrow$ Must measure momentum 4 times.

[$\Rightarrow$ Must also have coarse timing ($\lesssim$ 300 psec) to remove phase ambiguity.]

Large transverse emittance, $\epsilon_{N,x} = 1500\pi$ mm-mrad:

$\Rightarrow$ Confine the muon beam in a 3-Tesla solenoid channel.

$\Rightarrow$ All muon detection in the 3-T field.

$\Rightarrow$ Use bent solenoids (toroidal sectors with guiding dipoles) for momentum dispersion.

Muon momentum = 165 MeV/c:

⇒ Larmor period of 1.15 m sets scale for detector arrangement.

⇒ Resolution limited by multiple scattering.

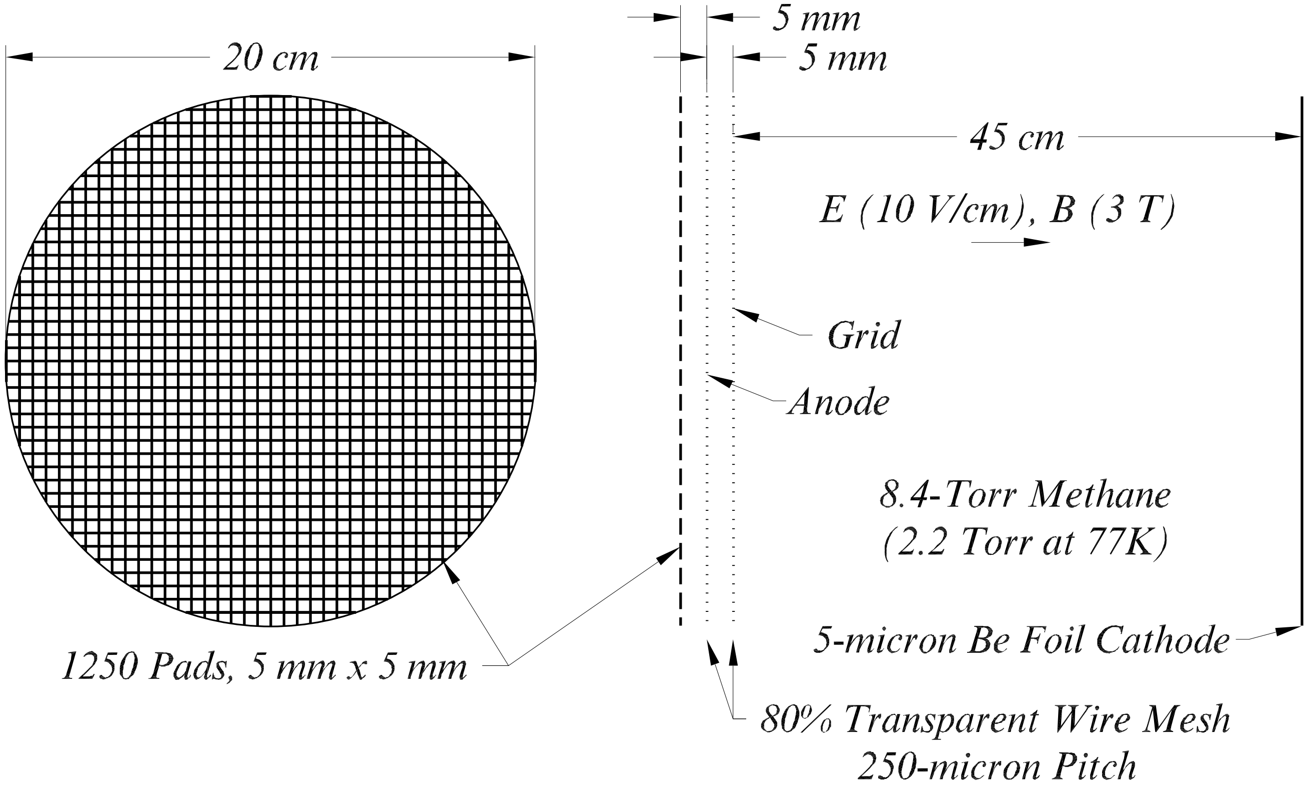
⇒ Perform tracking in a low-pressure gas.

3-T magnetic field ⇒ simplest if detector $\mathbf{E} \parallel \mathbf{B}$.

⇒ **Time Projection Chambers** (TPC's)

Higher momentum muons ⇒ higher B and/or larger radius magnets.

Time Projection Chamber



- Two TPC's in same pressure vessel for each of 4 momentum spectrometers.
- Low gas pressure ⇒ low operating voltage.
- 1250 cathode pads, 50-MHz timing sampling.
- Analog pipeline via 512-deep switched-capacitor arrays.
- No trigger: capture entire 10 μsec window.
- Could process $\approx$ 10 tracks $\Rightarrow\approx$ 1 MHz rate capability.

Diffusion

Mean free path longer at low pressure ⇒ larger diffusion!

$$\text{Spatial smearing;} \qquad \sigma = \sqrt{2Dt} = \sqrt{\frac{2Dz}{v_d}}.$$