

Microwave Design for an Electron Cloud Detector in a Quadrupole Magnet

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• The electron cloud (EC) density n_e in the quadrupole field may be smaller than the EC density outside the quadrupole.

• The EC density that is *trapped* in the quadrupole field is less than 10% of the the EC density with the beam present.

• So, we need to make the microwave detection sensitive *primarily* to the EC density that is within the quadrupole field.

• This will allow (for example) the difference in the spectra with/without the clearing bunch to be measured.





- The sensitivity is proportional to the integral of the density n_e times the electric field squared E_0^2 according to the equation below.
- Ideally, we would like E_0^2 to be non-zero *only* inside the main quadrupole field.





- The mode with the lowest frequency is the TE_{11} .
- Below is a snapshot of this mode when *E* is maximum with vertical orientation.





- With a tapered pipe, the resonant field extends for some distance into the taper.
- We need to estimate how much of the resonant field is outside of the quadrupole magnetic field. (This will interfere with the signal from the trapped electrons.)



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Quad Detector at 15W

Begin the Transition from Round to Oval Beam-pipe Inside of the Quadrupole Magnetic Field





Quad Detector at 15W

Available Space for Wall Flux Detectors

• If the quadrupole is modified in the same way as Q03W (2005), there is nearly one inch of clearance between the beam-pipe and the quadrupole iron.





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"Plenty of Space" for the Wall Flux Detector(s)

- The collectors might be connected to SMA feedthroughs without the need for a stripline section.
- If we assume that the EC density is uniform longitudinally over some range, the positions of three flux detectors could be staggered (as shown below).





Summary

- In order to measure only the EC density in the quadrupole field, the taper should begin inside the quadrupole iron.
- To maximize the microwave signal, the electrodes need to be near the longitudinal center of the beam-pipe (but not exactly, so that even modes can be measured).
- The vertical taper should provide resonances with horizontal E_0 .
- We need to investigate modes with vertical E_0 (and other orientations).
- There is space to install wall flux detectors without the need for a stripline.
- Wall flux detectors could be staggered longitudinally.



Quad Detector at 15W

Other Considerations

- What information about the transverse distribution can be obtained?
- The distribution of electrons is VERY non-uniform in the quadrupole.
- An external magnetic field that is perpendicular to the resonant electric field can reduce the sensitivity of the microwave measurement. Can we calculate this???
- How do we either compensate for this or *measure* the distribution?
- Do we want to use TE_{11} in different orientations? the TM_{01} mode?





Quad Detector at 15W

Other Considerations

• Do we want information on the EC density n_e versus longitudinal position (for example, in the fringe field of the magnet)?

• If the we produce and evanescent mode, can E_0 of TE₁₁ have an arbitrary orientation?

