1.6 cell RF gun optimization for submicron emittance operation

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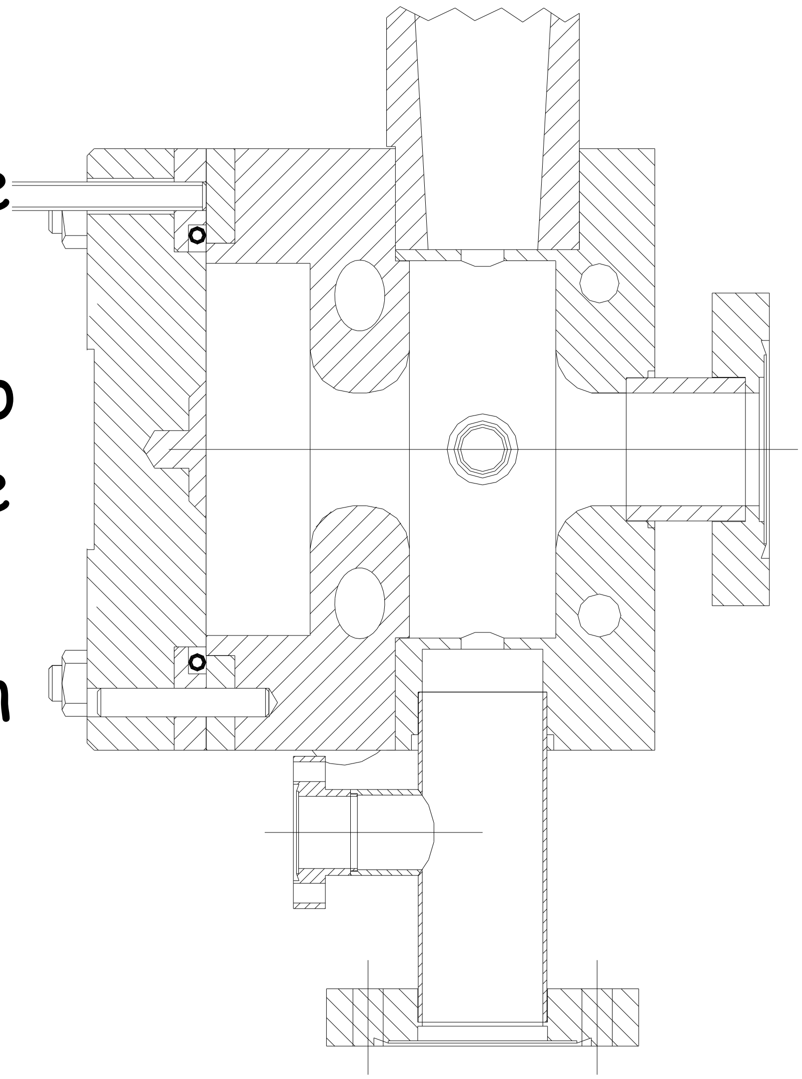
Typical procedure

- Tuners are used to adjust frequency of the full cell
- Cathode plate is used to adjust frequency of the half cell
- Temperature of the gun is used to set resonant frequency
- The 1.6-cell structure has been designed to have a balanced field



Solution for two coupled oscillators

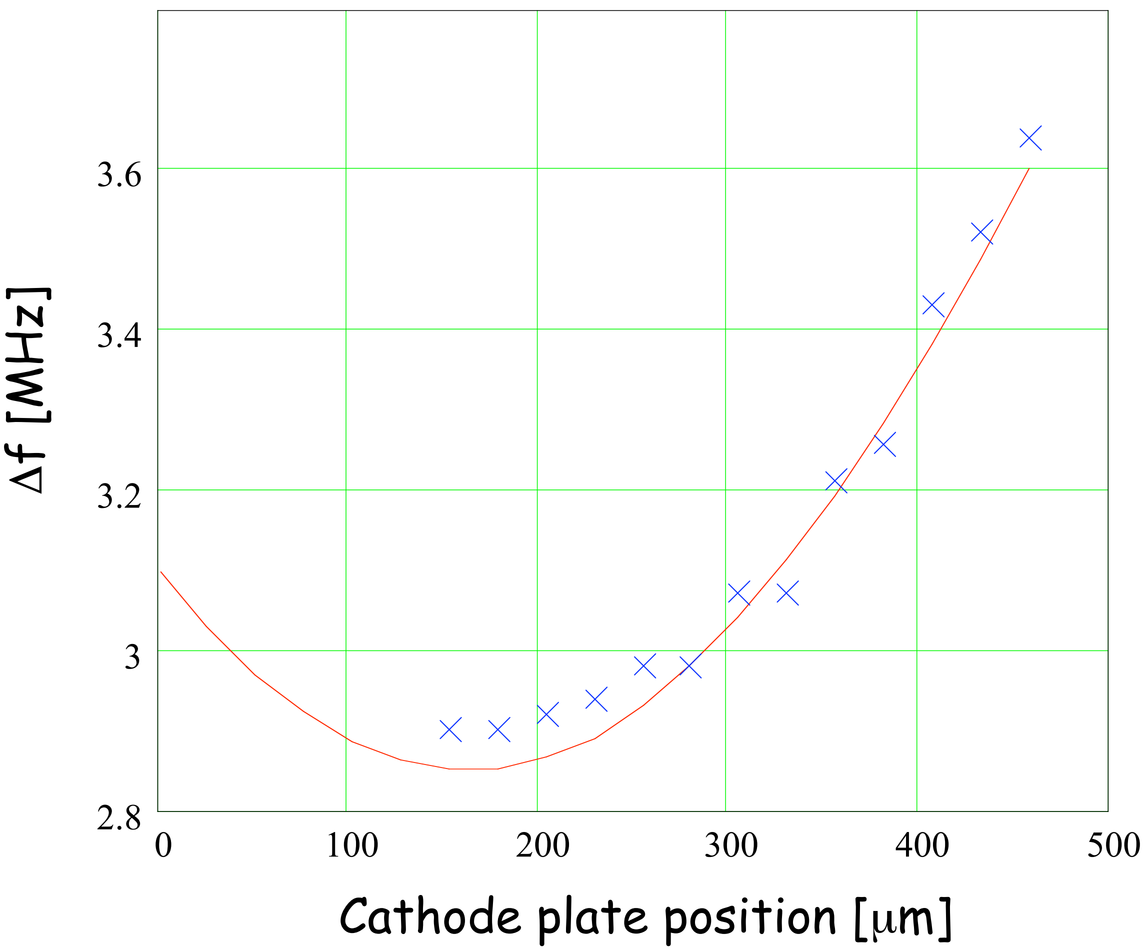
$$\Omega 1(\omega f, \omega h, \alpha) := \sqrt{\frac{\omega f^2 + \omega h^2 - \sqrt{\left(\omega f^2 - \omega h^2\right)^2 + 4 \cdot \alpha^2}}{2}}$$

$$\Omega 2(\omega f, \omega h, \alpha) := \sqrt{\frac{\left(\omega f^2 + \omega h^2\right) + \sqrt{\left(\omega f^2 - \omega h^2\right)^2 + 4 \cdot \alpha^2}}{2}}$$

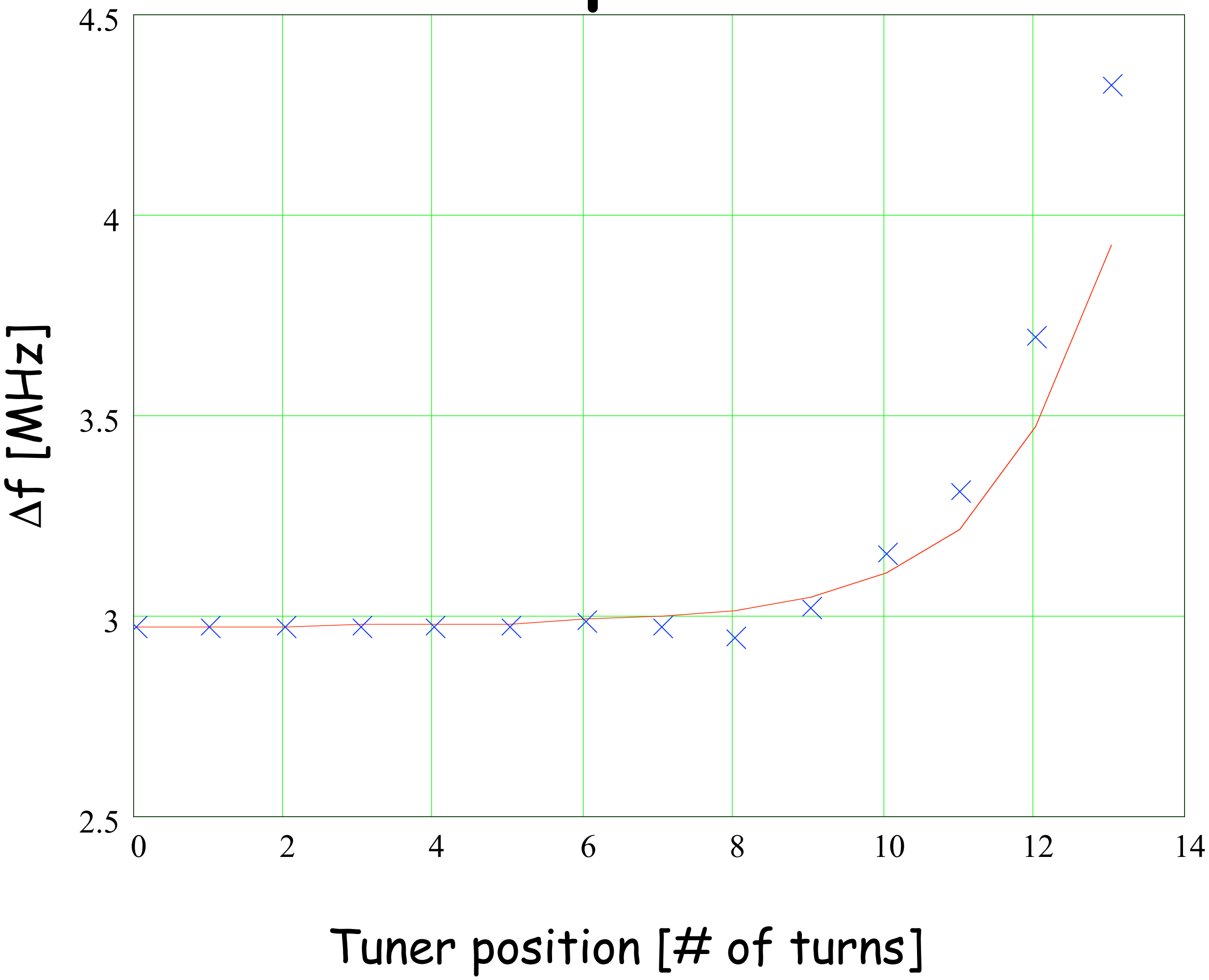
$$\omega h(\Omega\pi, \Omega 0, \omega f) := \sqrt{\Omega\pi^2 + \Omega 0^2 - \omega f^2}$$

$$\alpha(\Omega\pi, \Omega 0, \omega f) := \frac{\sqrt{\left(\Omega\pi^2 - \Omega 0^2\right)^2 - \left(\Omega\pi^2 + \Omega 0^2 - 2 \cdot \omega f^2\right)^2}}{2}$$

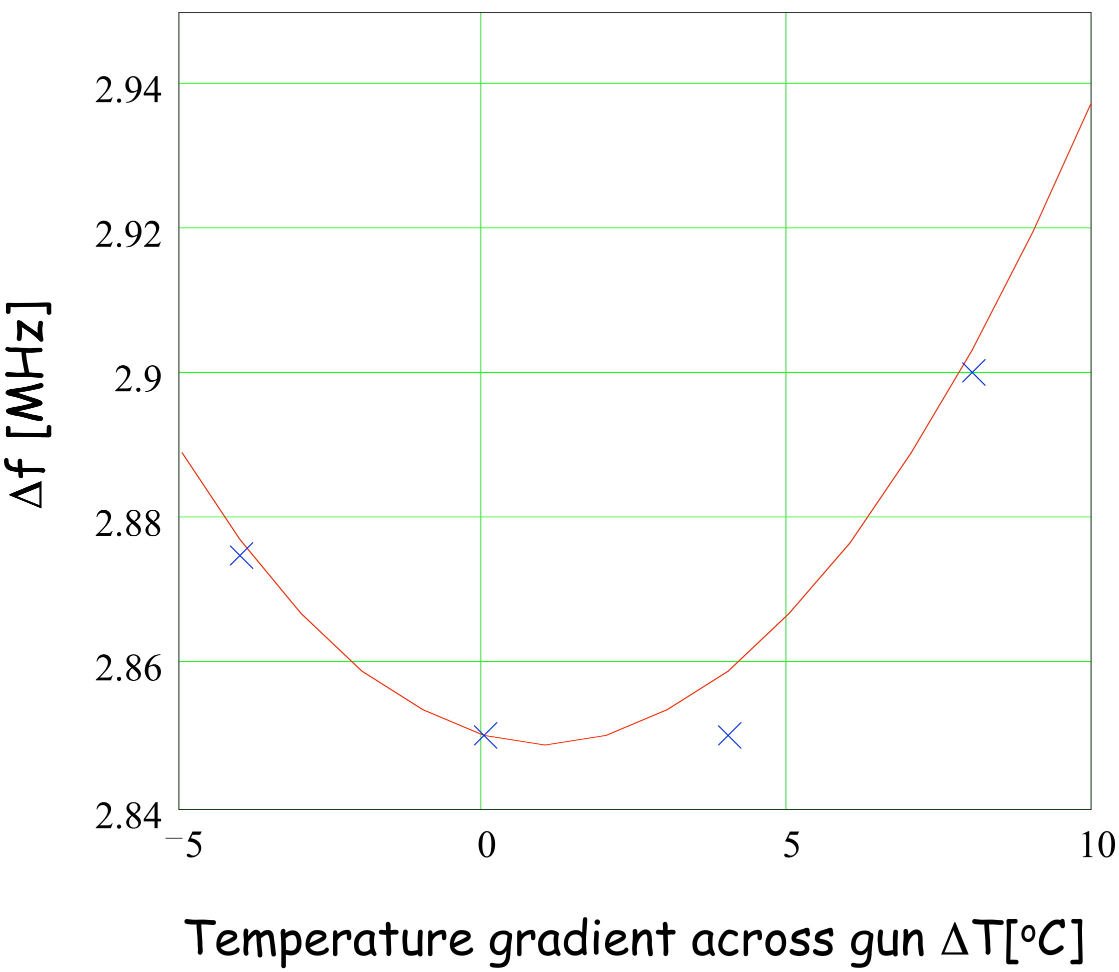
Mode separation as function of cathode plate position



Mode separation as function of tuner position



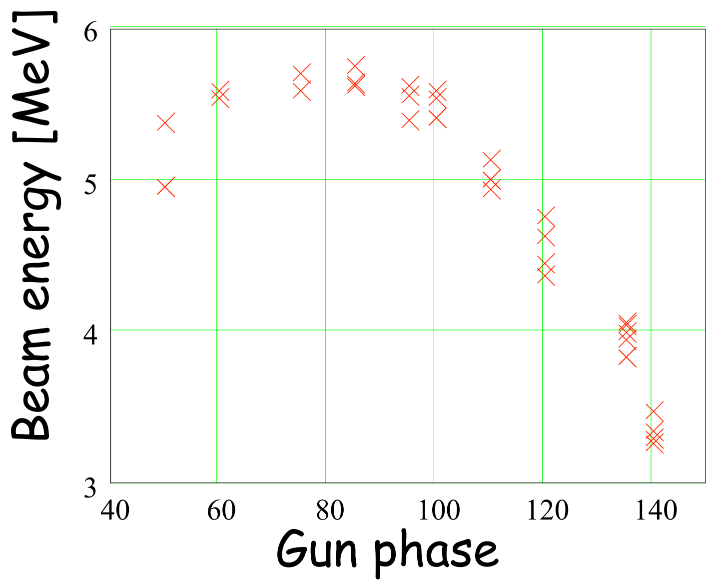
Mode separation as function of temperature gradient

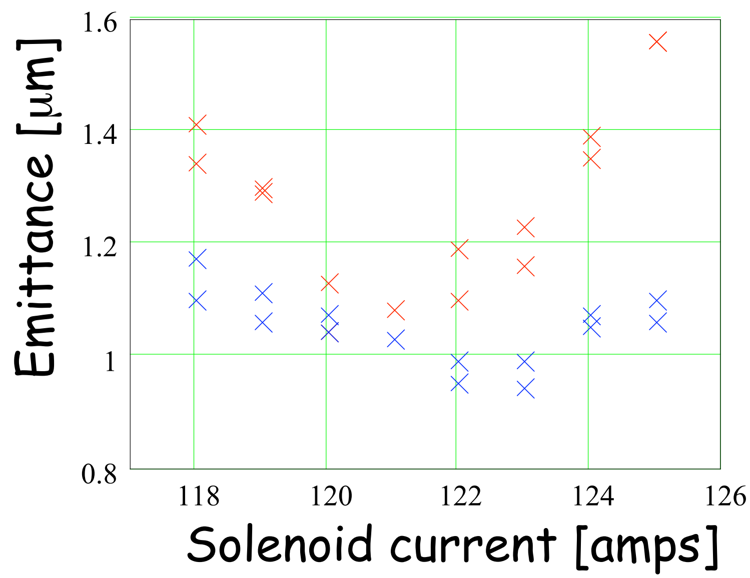


Asymmetric tune-up

- Tuners were limiting gradient in the gun at ~100 MV/m for the balanced gun
- Were turned out to achieve 150 MV/m in the half cell and 110 MV/m in the full cell
- Beam parameters were measured:
  - energy >5.5 MeV
  - ~1 micron emitance for 0.8 nC
  - QE ~2 10^{-4} from a Cu cathode

Beam measurements





Beam charge 0.8 nC and 6.2 ps FWHM pulse length

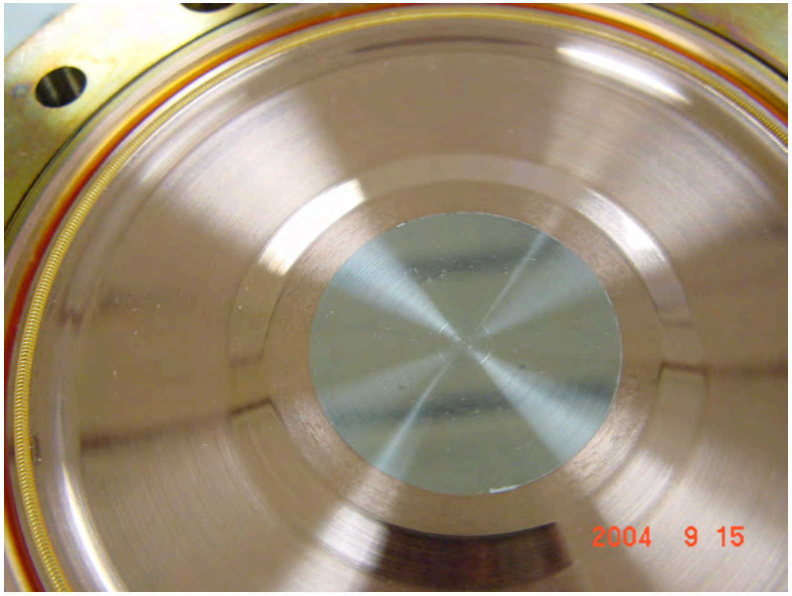
Cathode lifetime

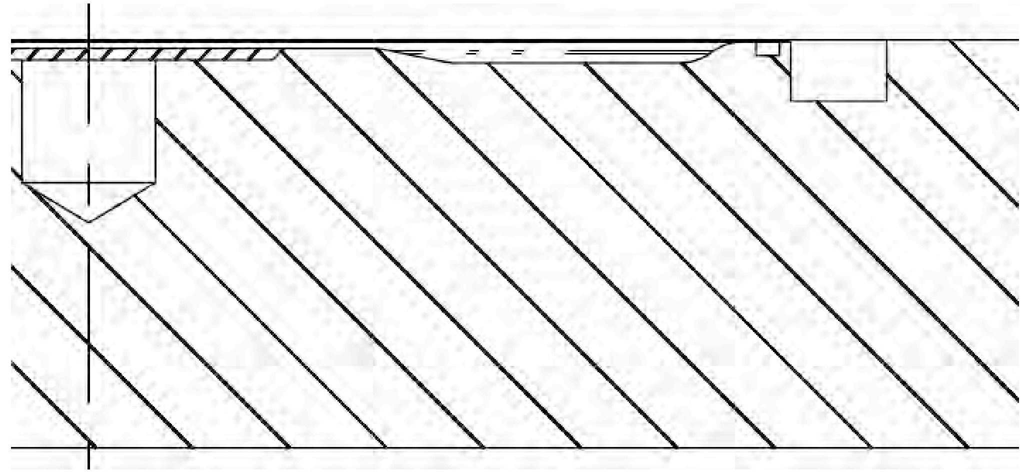
- Cu cathode was replaced with Mg cathode to improve QE.
- Sustained gradient degraded over a period of 3 months by ~30% due to RF seal region.
- Few craters developed over 3 month operations at a very high gradient.

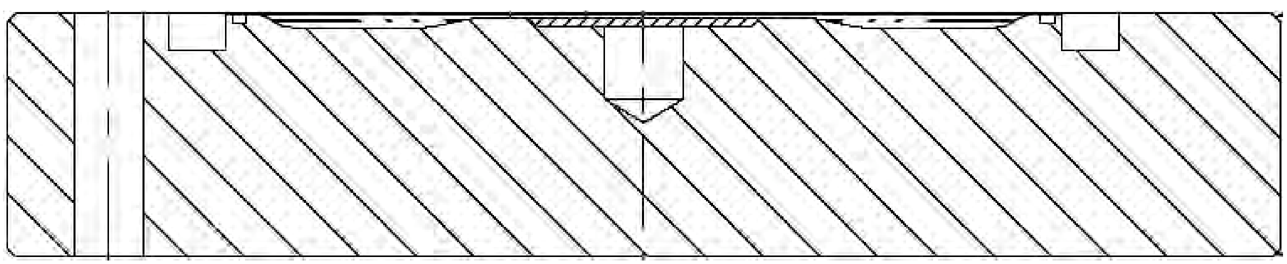
Conclusion

- High gradient leads to better emittance
- Extremely high gradient shortens lifetime of the cathode?
- Use of tuners in the full cell may degrade gun performance
- Three important factors for submicron emittance:
  - laser profile uniformity;
  - alignment of the gun, solenoid and linac;
  - gradient in the gun

Curved cathode and RF seal







Flat shape of the cathode was changed to compensate the effect of the RF seal on the half cell frequency