

Transverse Beam Physics in UMER

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Jan 28, 2013

Scope of Transverse Physics

Measure storage ring parameters at a wide range of beam currents for multiturn stored beams

- ***Equilibrium orbits, coherent Tune, natural chromaticities, momentum compaction, lattice dispersion, and betatron functions.***
- ***At beam currents = 0.6, 6, 20, 40, 80 and 100 mA.***

Explore how each of these are impacted by space charge intensity over a wide dynamic range.

Beam Characteristics

Techniques:

- Vary Momentum by changing electron gun voltage.
- Vary all or individual quad currents.
- Shift all dipole currents simultaneously or individually as “kicks.”
- Change beam current by changing gun aperture.

Special Considerations:

1. Beam non relativistic: $\beta = 0.2$, $\gamma = 1.02$ [Can't ignore this!]
2. Energy spread $\leq 20\text{ev}$ at center of beam at injection
3. Bunch length is usually ~ 5 meters (50% duty factor)
4. No Conventional RF or barrier bucket \Rightarrow beam debunches
5. Debunching process causes large energy/momentum deviations in head and tail \Rightarrow beam loss! (Barrier Bucket)
6. Limited number of turns compared to other rings!!!!
7. Other, slower loss mechanisms [target of R&D]

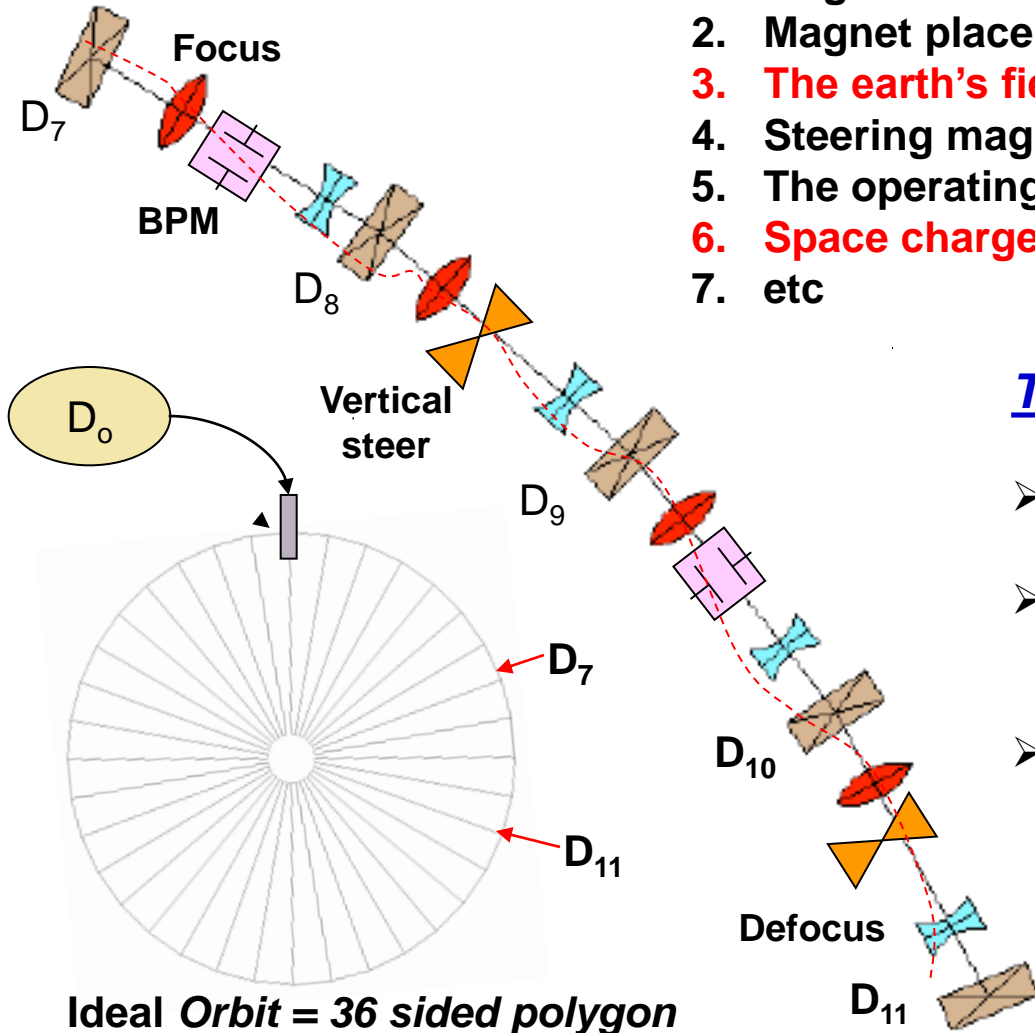
Beam Characterization - The Displaced Equilibrium Orbit

The real equilibrium orbit is determined by:

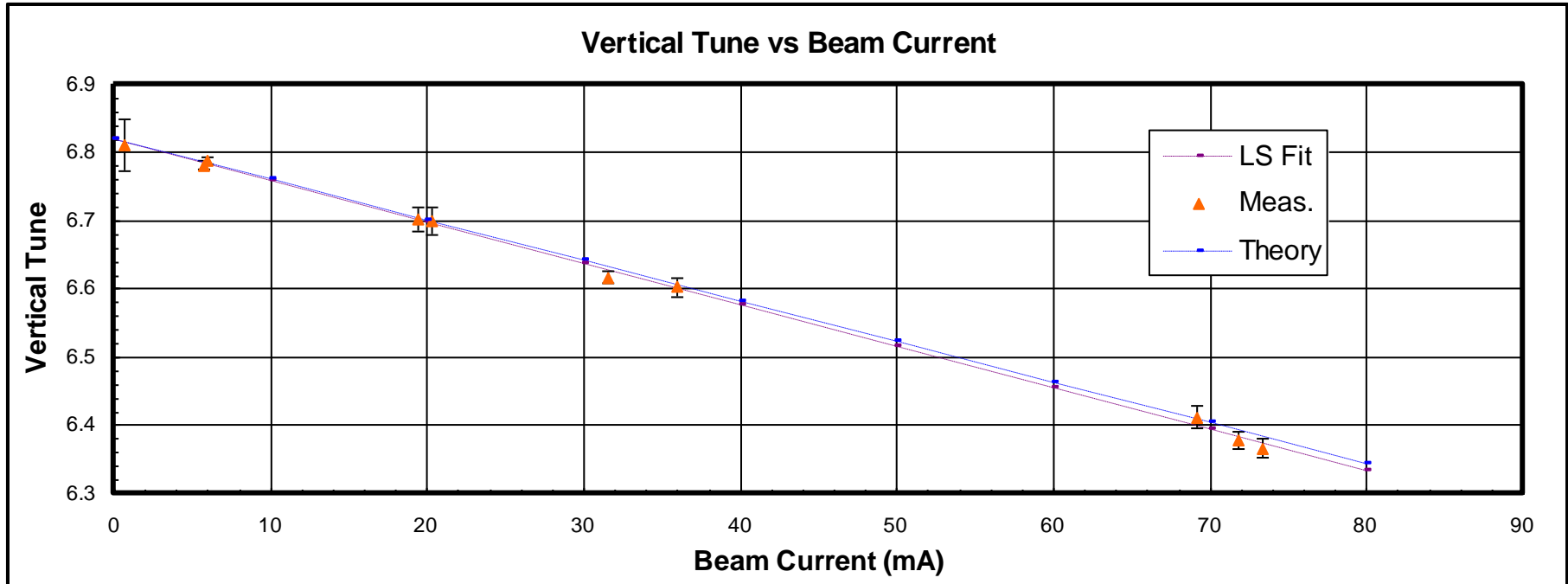
1. Magnetic field errors
2. Magnet placement errors
3. **The earth's field (22% of the bending in UMER)**
4. Steering magnets (correctors to the orbit)
5. The operating central Momentum of the beam
6. **Space charge image forces**
7. etc

Technique - measure beam centroid

- If centroid motion is of small amplitude
- If the displaced equilibrium orbit is close to the center the beam pipe,
- **Then centroid motion may still be described to a reasonable approximation by the single particle model for centroid motion!!!!!!**



Coherent versus Beam Current



To be measured: the effect of being off centered of the beam in the beam pipe?

Summary

In a high space charge environment:

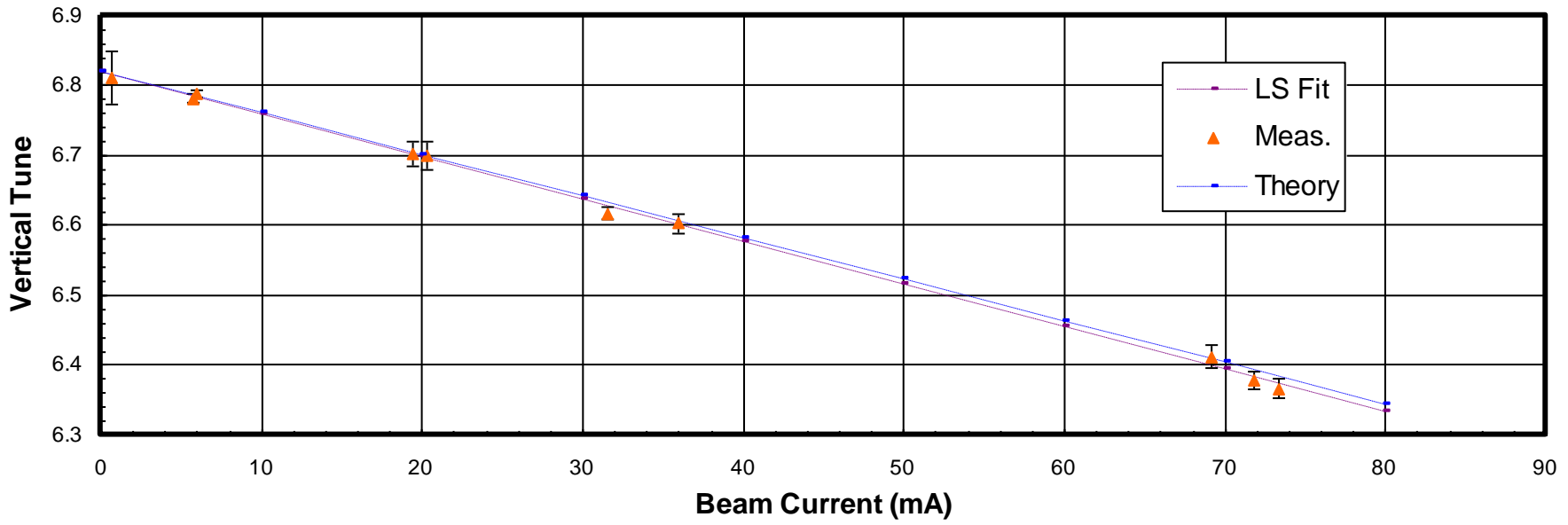
- ✓ We have a basic, working set of 1st turn & multiturn diagnostics
- ✓ We can measure position, equilibrium orbits & tunes
- ✓ We can measure intensity & longitudinal bunch shape
- ✓ We have developed the capability to do momentum scans:
 - Chromaticity
 - Momentum compaction
 - Dispersion
- ✓ We have developed the capability to do tune scans:
 - Find stop bands in presence of space charge.
 - Measure over a wide tune range - integers
 - Measure betatron function by individual quad current scans.

In Conclusion:

A variety of tools specialized for UMER beams have been developed, tested and put into routine use to measure standard beam parameters for the storage ring and to explore the effects of a wide dynamic range of space charge on those parameters!



Vertical Tune vs Beam Current



Tune versus Beam Current

