Magnetized Beam Dynamics

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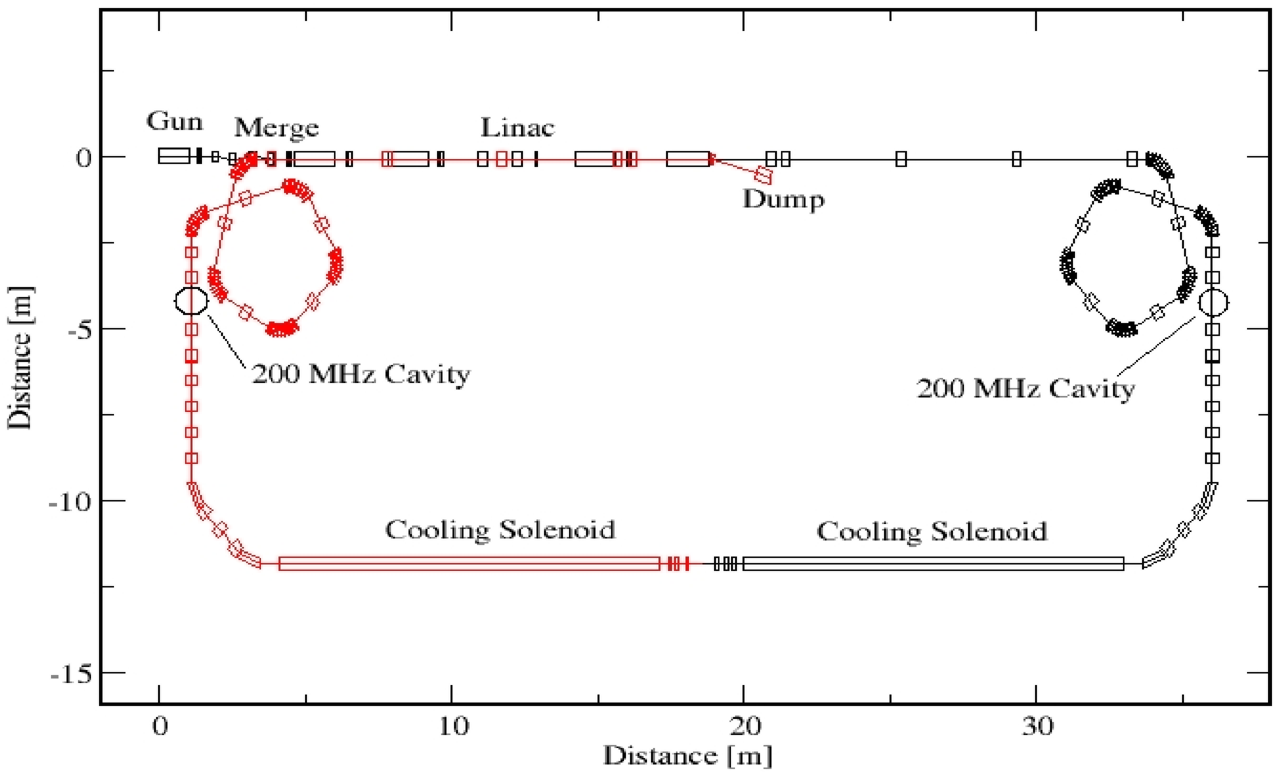
Beam Requirements in the Cooling Section

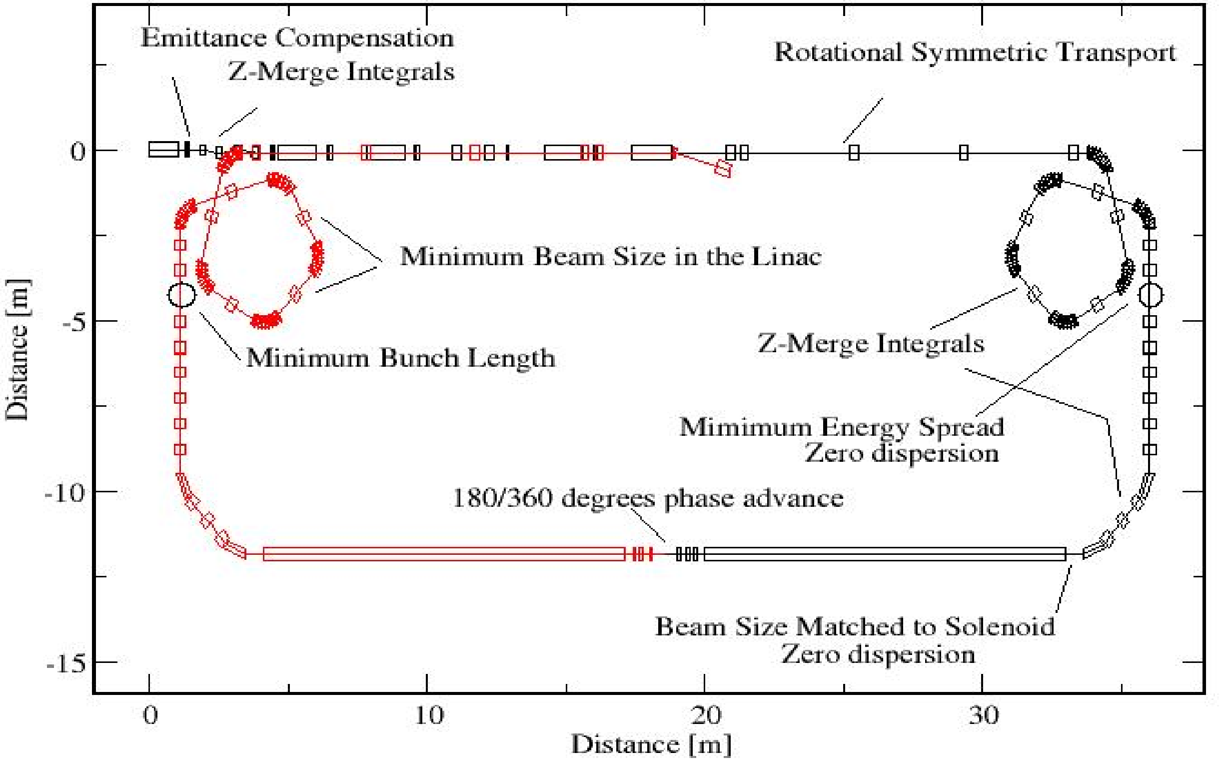
•Bunch charge:	20 nC
•Beam Size:	1 mm max
•Bunch length:	5 cm rms
•Energy spread:	$5 \cdot 10^{-4}$
•Emittance inside the solenoid:	50 mm mrad
•Solenoid Field:	5 Tesla

Layout



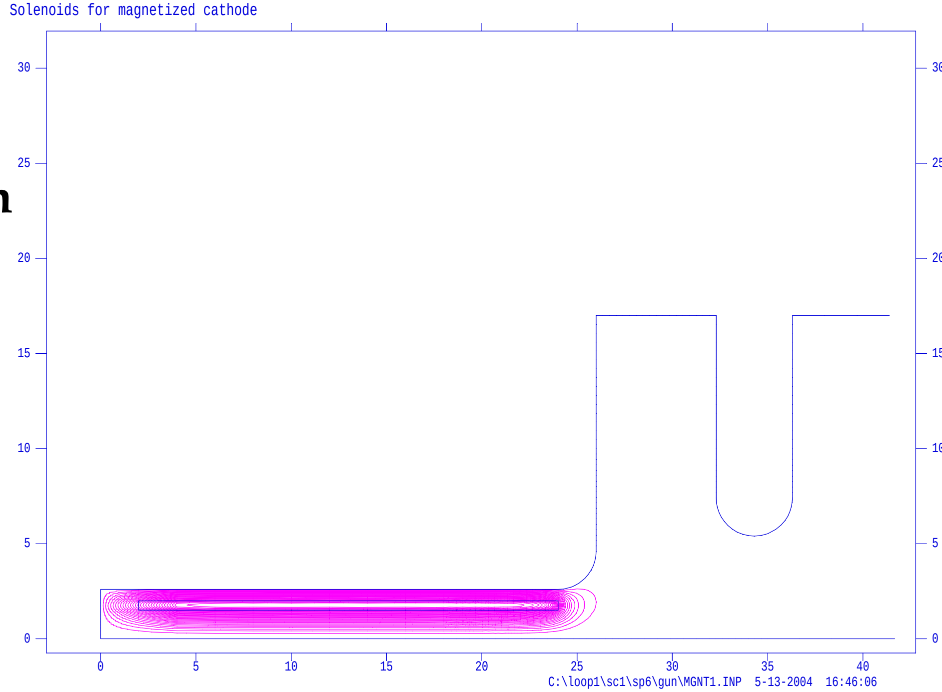
Gun
Merge
Linac
Dump
200 MHz Cavity
200 MHz Cavity
Cooling Solenoid
Cooling Solenoid
Distance [m]
Distance [m]
0
-5
-10
-15
0
10
20
30

Optics elements

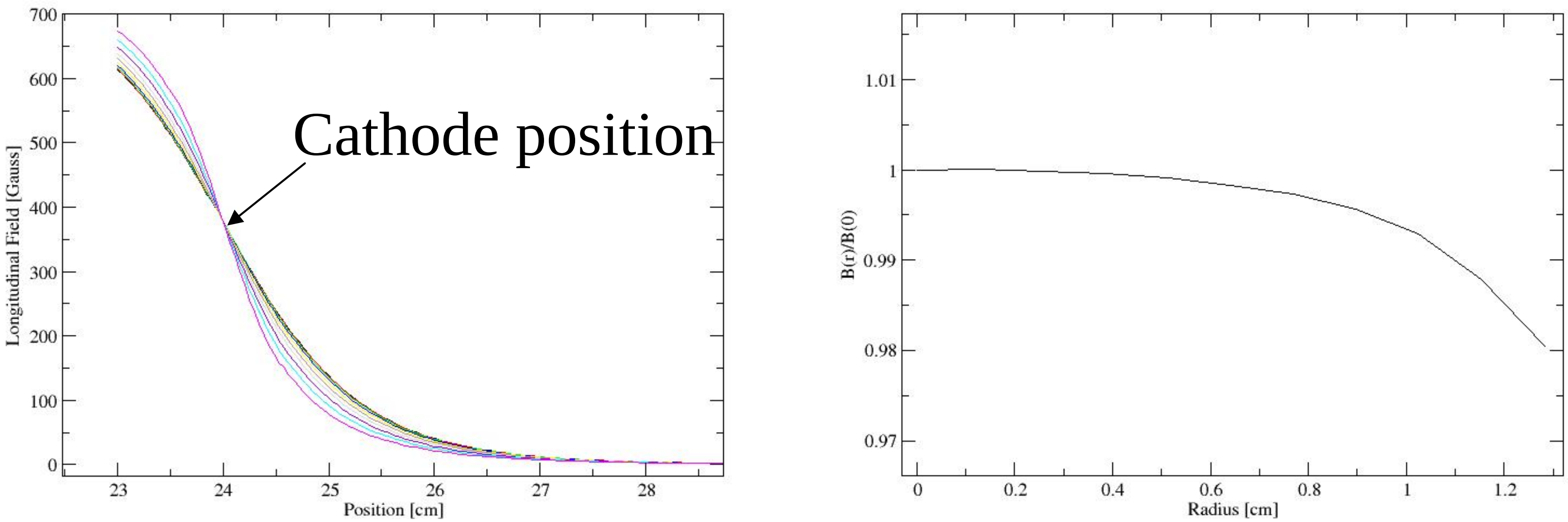


Super-conducting gun

- 1½-cell gun
- 30 MeV/m on the cathode
- 1 MW RF power
- Beam energy 4.75 MeV
  at the gun exit
- Cathode solenoid inside the gun
- 360 Gauss on the cathode
- 400 Gauss on the wall
- Radius on the cathode 1.2 cm
- Laser pulse 63 picoseconds



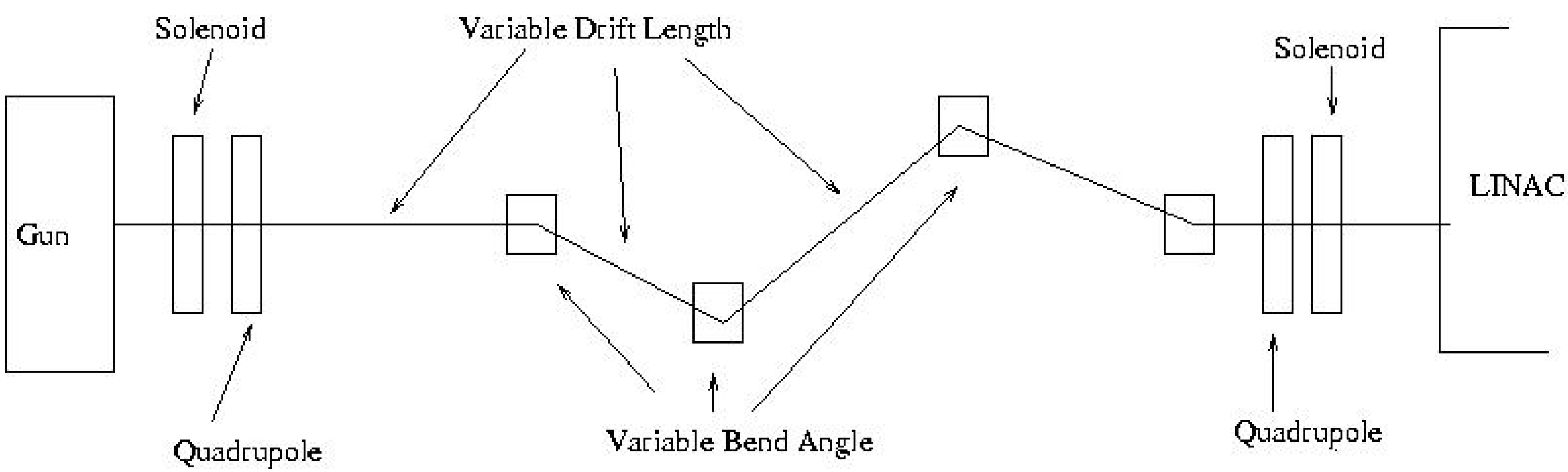
Radial Dependence of the longitudinal Field



The 4D emittance of a beam created with the above solenoid was compared to that of an artificial radius-independent field distribution (obeying Maxwell's laws), using a 12 mm cathode spot. No significant degradation was observed.

Merging system and Emittance Compensation

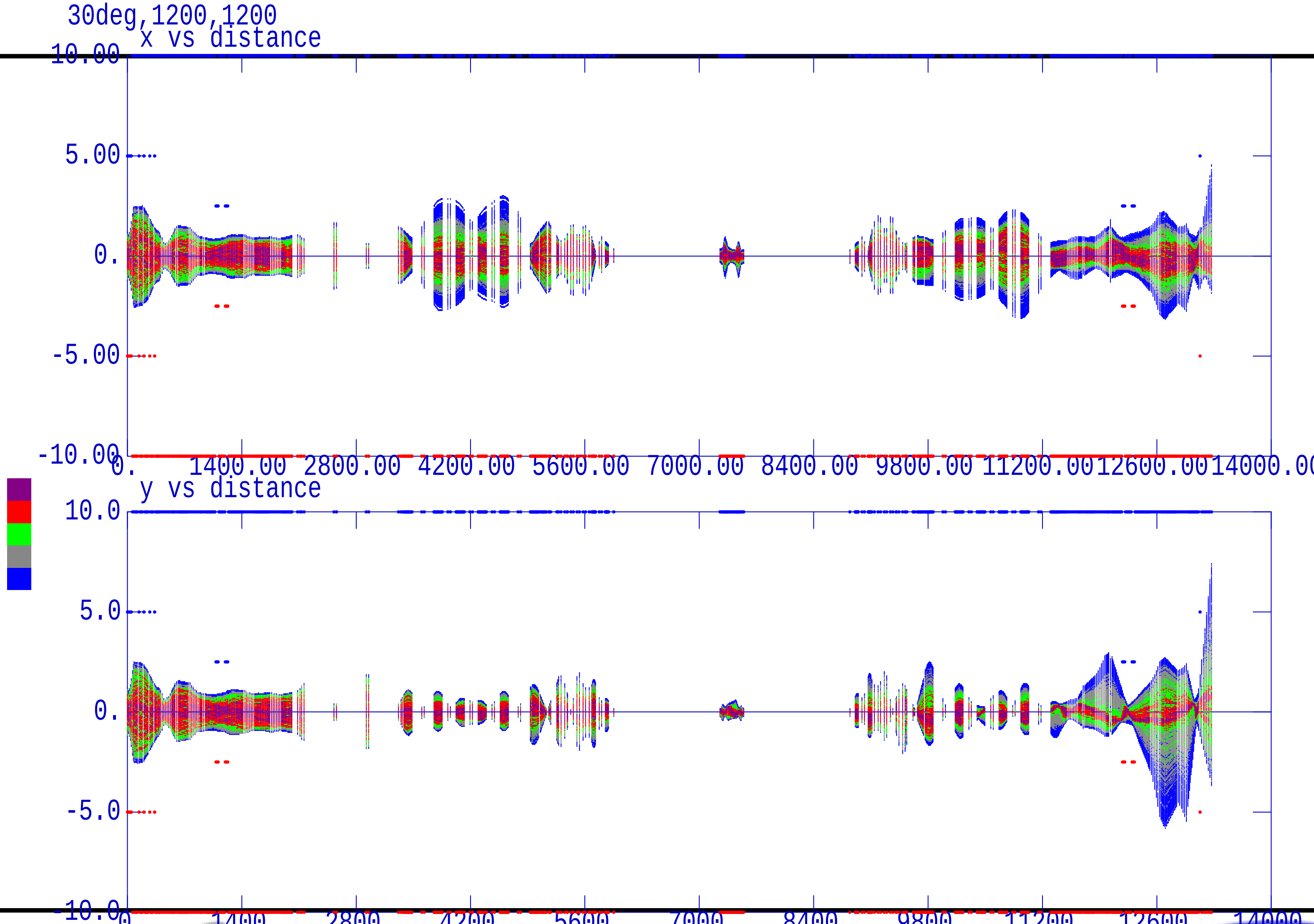
- Z-merge (Litvinenko,Kayran)
- Optimized drifts and angles to make all integrals zero
- Quadrupoles for horizontal and vertical emittance compensation



Stretcher, Merge with Ions, Compressor

- **Stretching the beam to 5 cm inside a 3 inch diameter beam pipe requires 450 degrees of bending magnets.**
- **The last cavity in the linac is miss-phased to increase the energy spread from $4 \bullet 10^{-4}$ to $2 \bullet 10^{-3}$. The tail has more energy.**
- **A 200 MHz cavity at the end of the stretcher reduces the energy spread to $1 \bullet 10^{-4}$. The cavity must be in a dispersion free region.**
- **The Kayran-Litvinenko integrals must be minimized for the stretcher/merger beam line.**
- **Beam size must be kept small to minimize chromaticity**
- **Multipoles must be compensated locally**

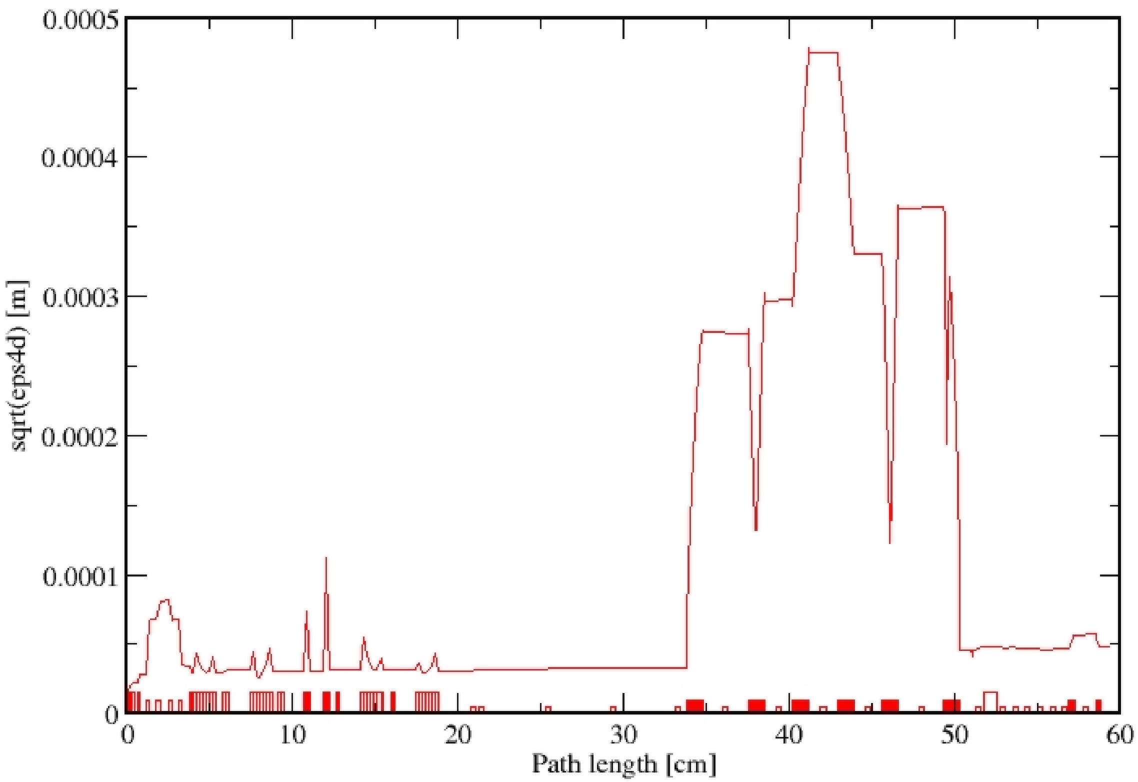
Front to End Simulation: Beam Size



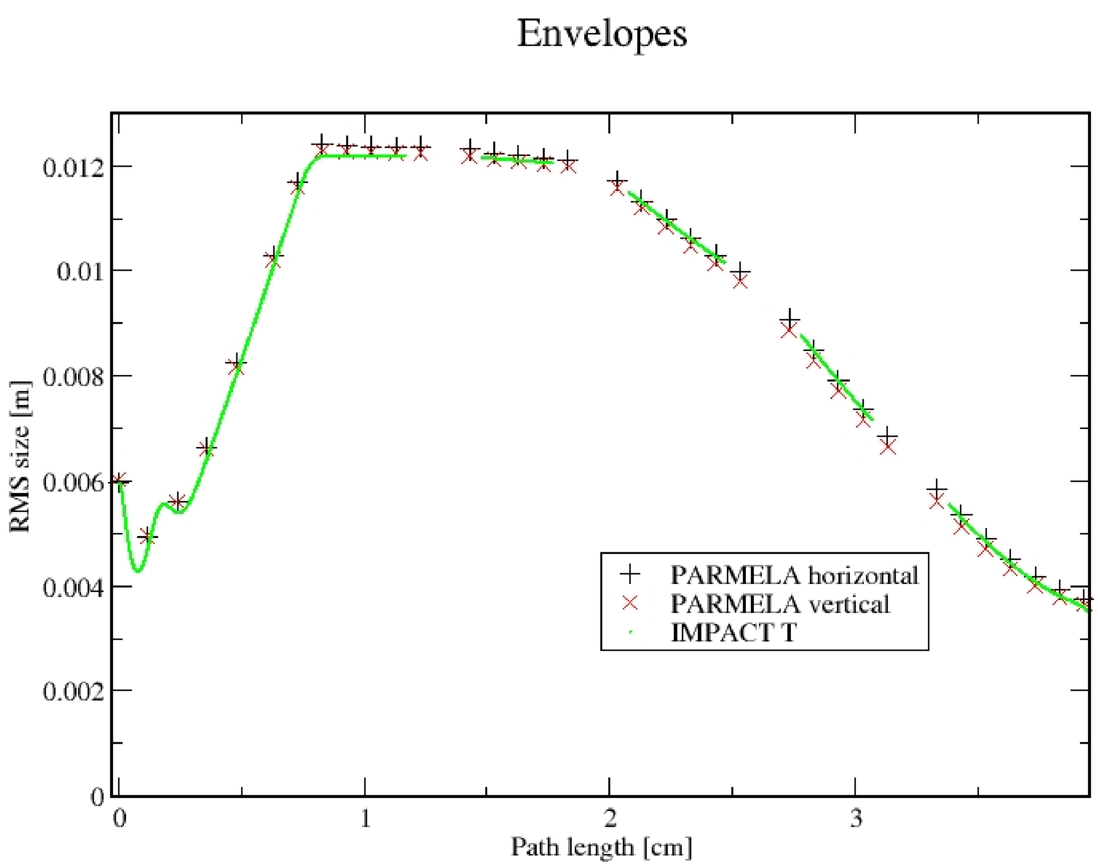
Achieved Beam Quality

- The required emittance was achieved using **elliptical** beam distribution on the cathode:
  - Normalized emittance: 49 mm mrad.
  - Bunch length 5 cm rms
  - Energy spread $1*10^{-4}$
- Using a **beer-can** distribution a normalized emittance it was not possible to get better than 60 mm mrad.

4D Emittance



Comparison PARMELA vs. ImpactT



Conclusion

- The optics for magnetized electron cooling is an extremely complicated system
- The normalized emittance of 50 mm mrad was achieved with careful and time consuming optimization. Further improvement is unlikely
- An elliptical distribution must be used
- Appropriate diagnostics will be necessary
- Using non-magnetized cooling is simpler and cheaper

Conclusion

Daraus folgt nichts, doch soll gern
Wer möchte, was draus folgern

Hans Scheibner

(There is no moral to this story, but you can make one up if you want to.)