Ray tracing with the program *TRACK*

(from beam transport magnets to cyclotrons)

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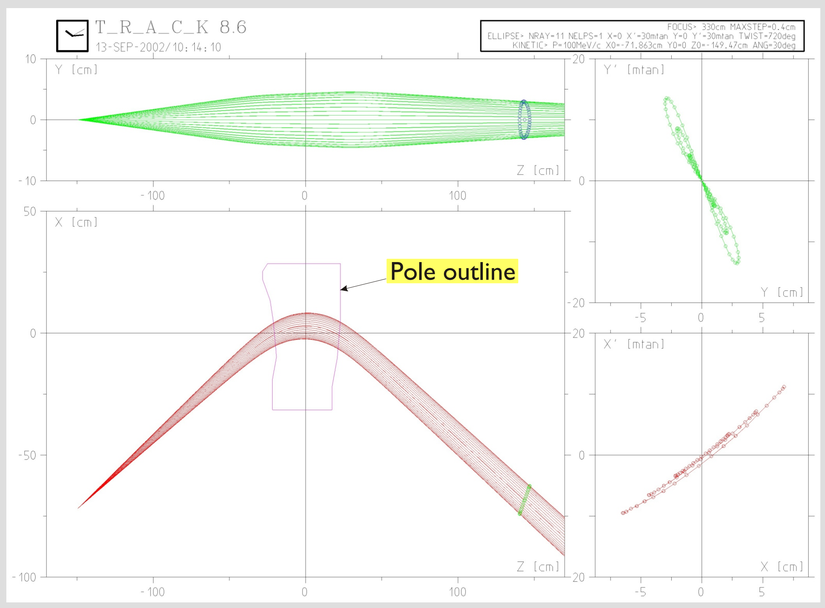
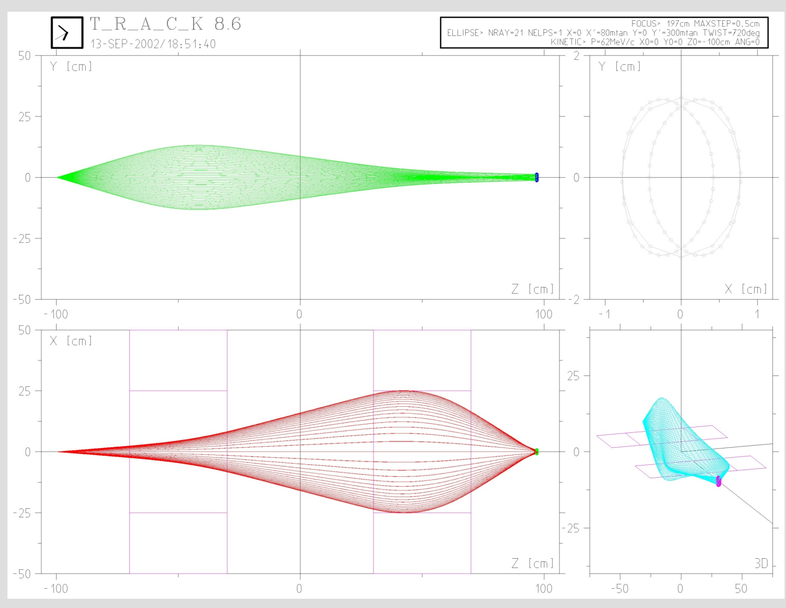
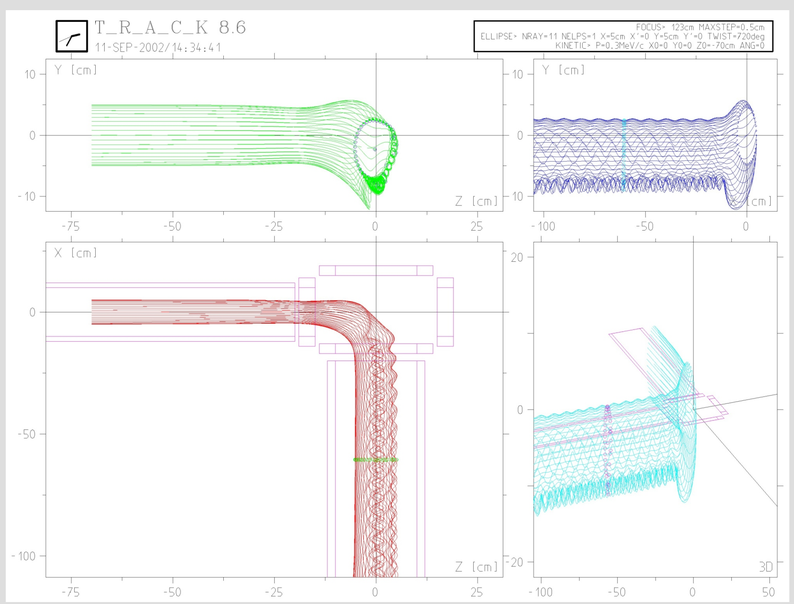
TRACK is a charged particle tracking program written and maintained by the Magnet Section of the Paul Scherrer Institute (PSI) in Switzerland. The tracking algorithm used in the program is based on the analytical solution of the equation of motion and therefore provides fast and very accurate ray tracing. The analysis of ion-optical properties with *TRACK* can be performed on cases with either separate or combined magnetic and electric fields in space. This allows for studies of individual magnets, systems such as particle separators and even complete beam lines. Calculations are performed with zero-emittance uniformly distributed rays or with a randomly generated set of rays covering the full beam phase space. Visualisation of the results includes a 3D trajectory view, orthogonal trajectory projections on the principal planes, projection on the beam axis, beam phase ellipses, beam cross section and display of various field components along the particle path. Numerical data can also be easily exported for external analysis. We have recently introduced time-varying electric and magnetic fields. Using this option, *TRACK* has been successfully applied for various studies on a 250 MeV proton cyclotron.



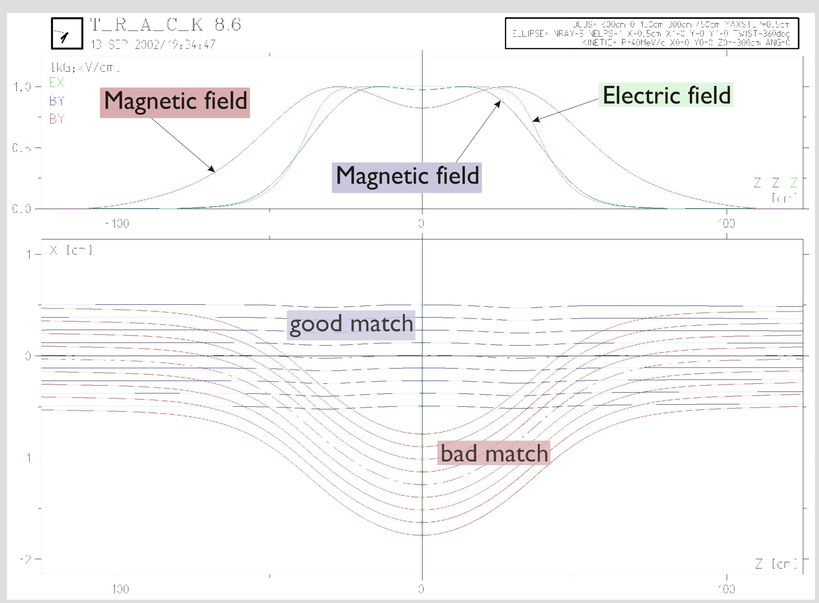
Phase space plots of zero-emittance beam ellipses.
3D analysis of a bending magnet with edge angles and curvatures.



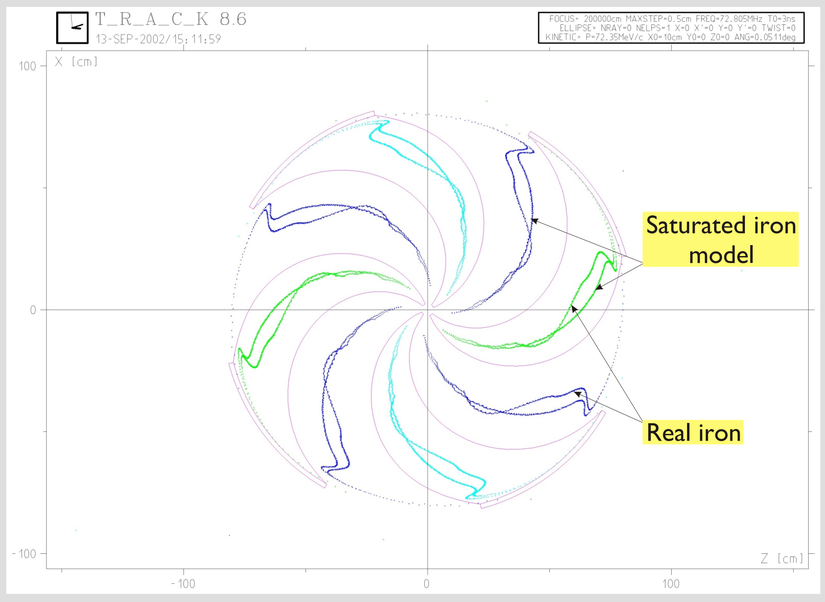
Cross section plot of zero-emittance beam ellipse with 3D view.
Large aperture quadrupole doublet with higher harmonic corrections.



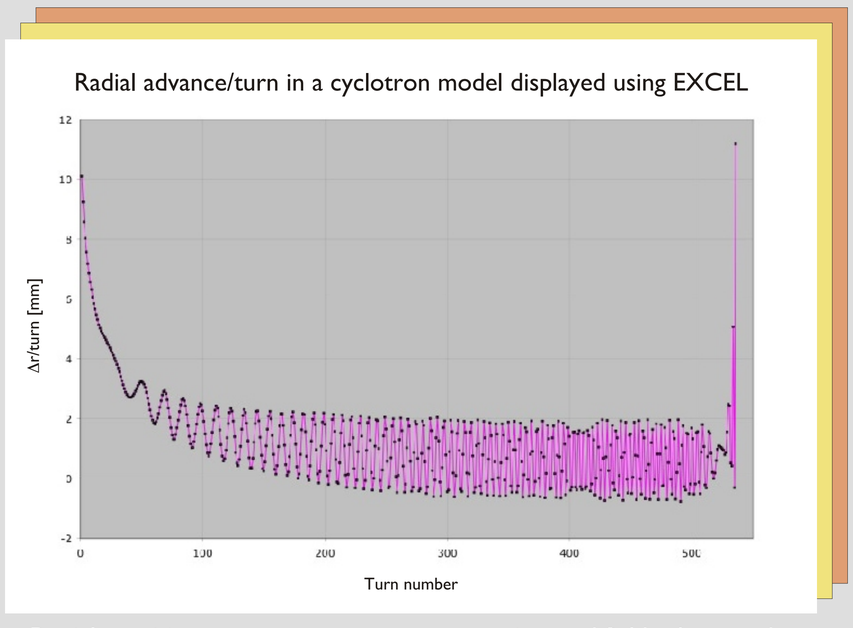
Orthogonal trajectory projections on the principal planes with 3D view.
Tracking a beam of low energy particles through a system of 6 solenoids.



Electric and magnetic fields as seen by the particle are shown.
A cross field device (particle separator); well and badly matched cases.



Space-time diagram of the reference track in a cyclotron mid-plane.
Particle positions are marked when the RF field is at peak or zero.



Particle position, momentum vector, energy, time and field values can be saved during the tracking for further analysis with other software.

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