Kink effects on the FCC-ee beam polarization

I.Koop, BINP, Novosibirsk

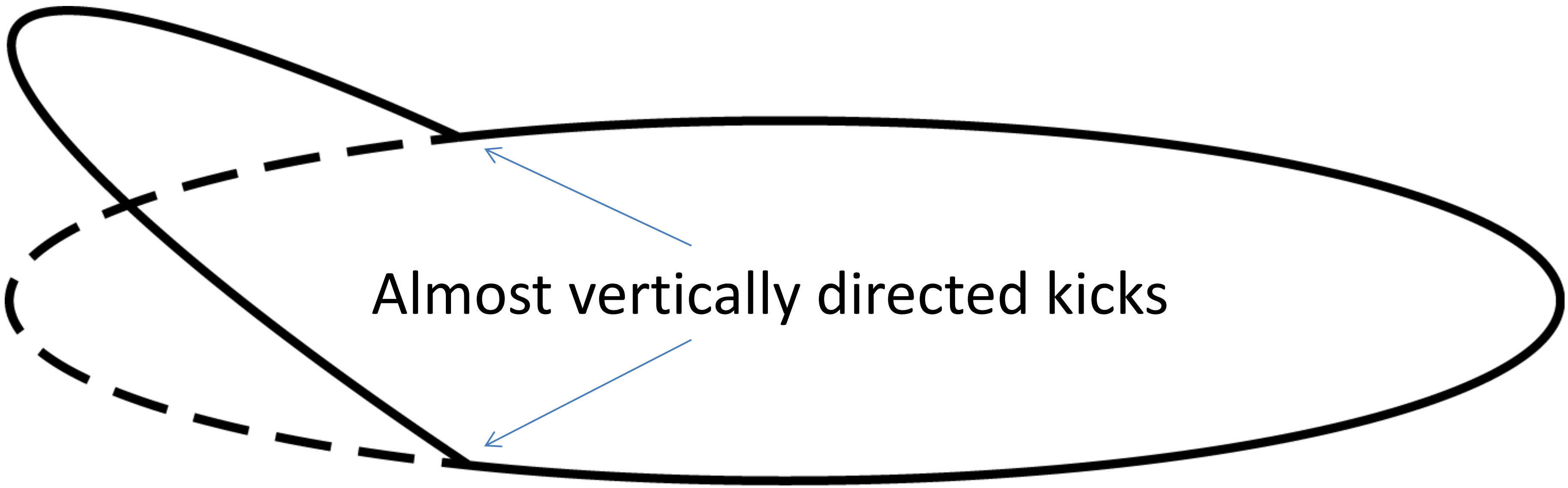
CERN, Geneva, 11.06.2015

Different kink opportunities

1. Simple kink made by two vertical kicks of an orbit:
   - Vertical emittance excitation by these kicks
   - Spin precession stop bands near integer tunes

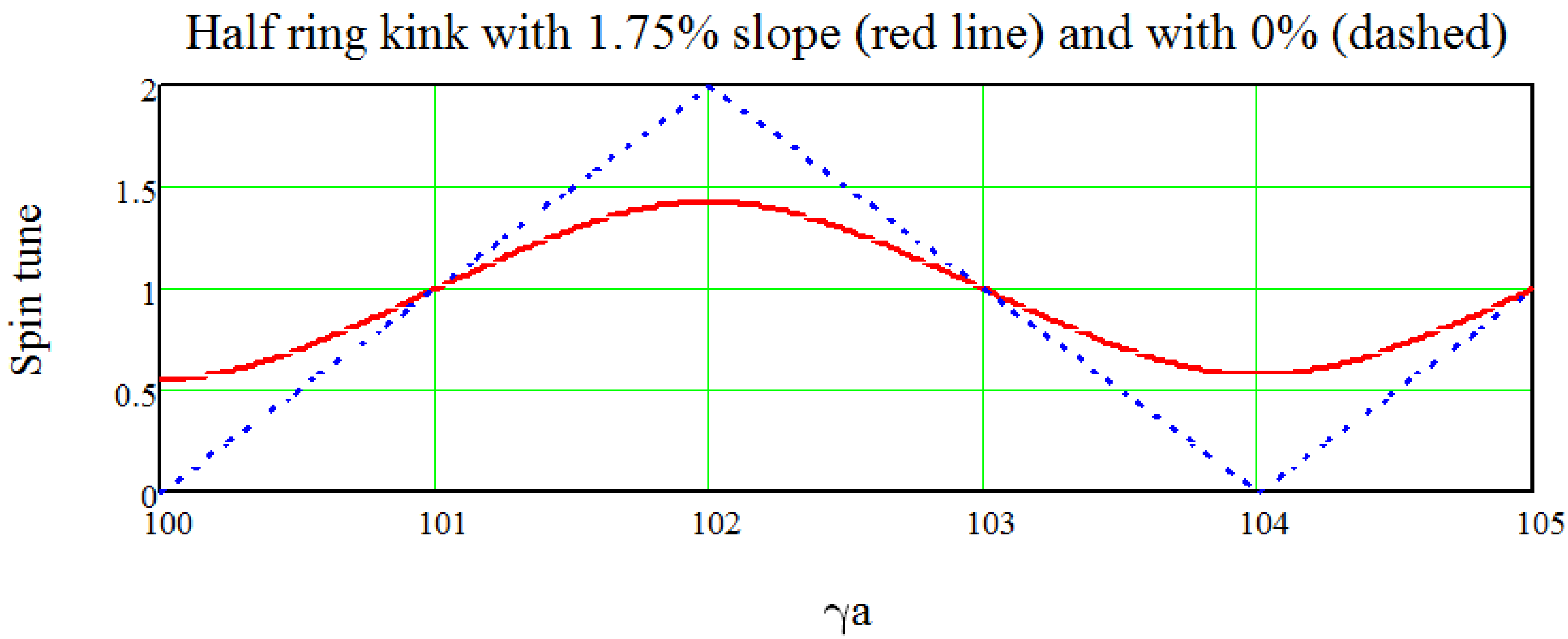
2. Series of twists between inclined arc-segments:
   - No vertical emittance excitation!
   - No additional dipoles
   - Restore perpendicularity of the polarization vector to the bend planes by solenoids
   - No stop bands in the spin precession frequency
   - No fast depolarization!

Simple kink made by vertical bends



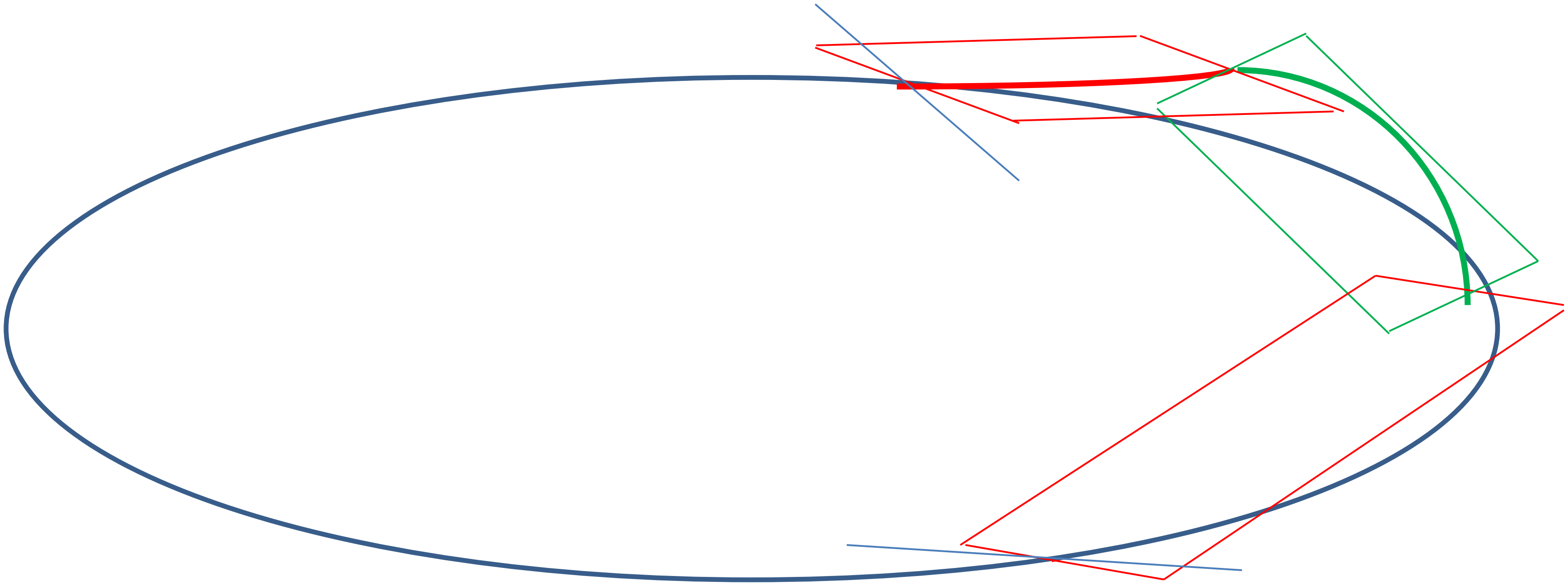
Kicks must be made achromatic to prevent large influence on the vertical emittance.

Spin tune energy dependence in a ring with vertical kicks of the orbit



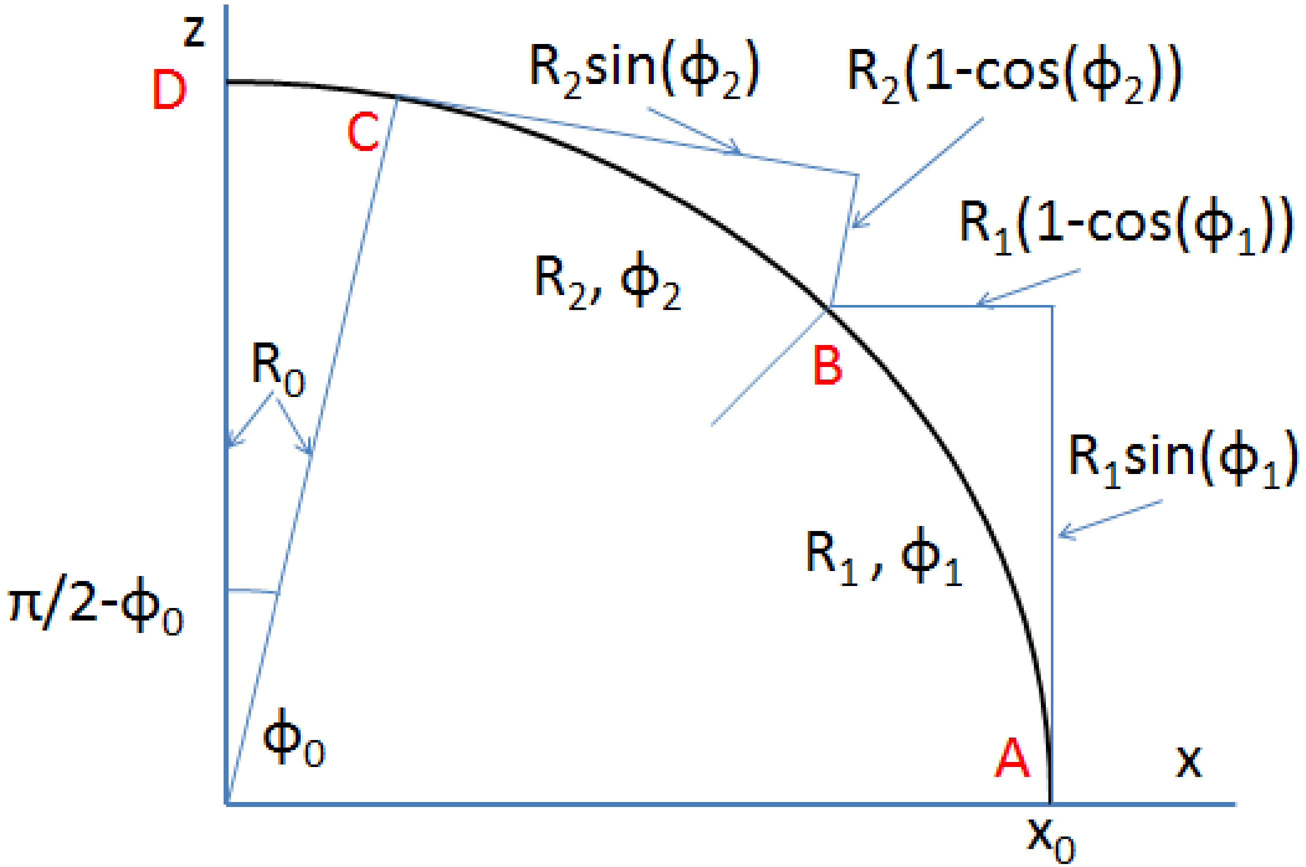
Uncompensated distortion of spin motion, generated by the orbit kicks, made problematic energy determination near all even values of γa, where the derivative *d*ν(E)/*d*E vanishes.
At odd tunes two kicks compensate each other due to π phase between them for the spin precession.

Orbit elevation created by twists of 3 arcs



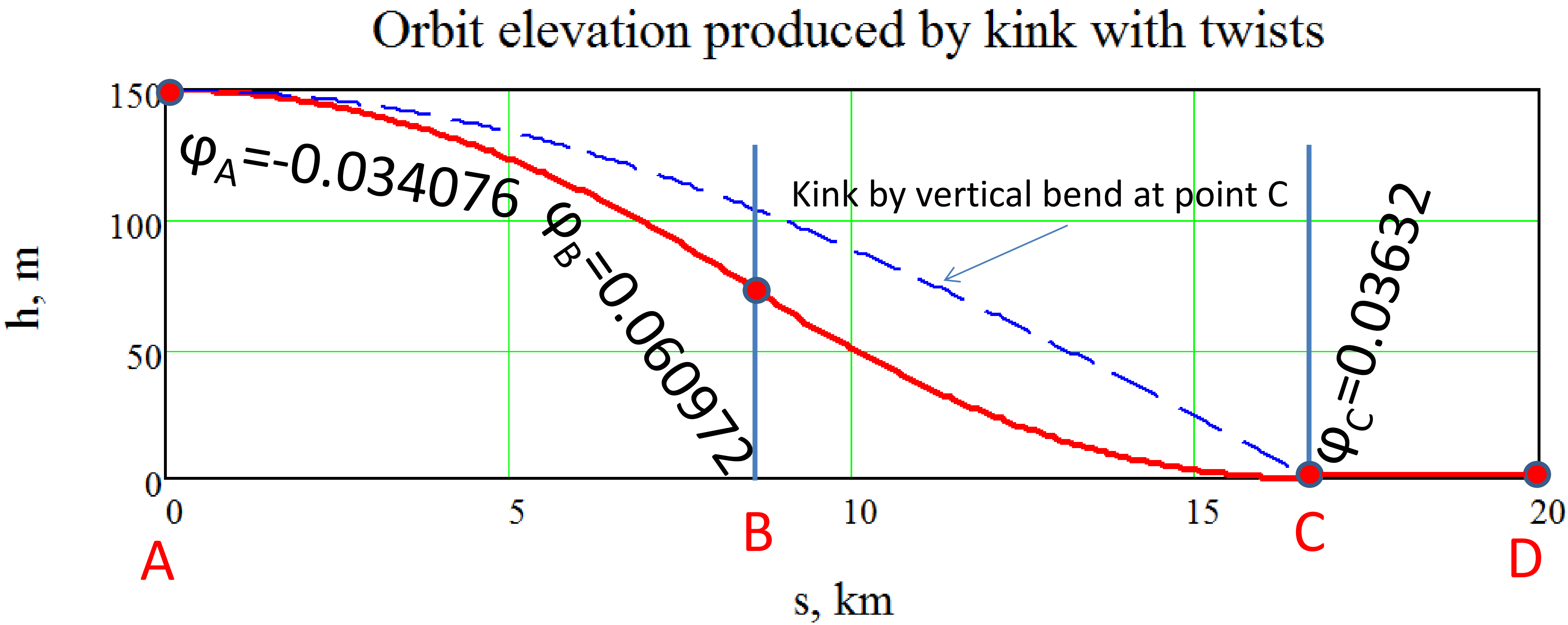
Tree arc segments are rotated around the velocity directions at junction points by different angles, producing, thus, a smooth vertical deflection of an orbit. No additional synchrotron radiation compared to the flat ring option!

Projection of two inclined arcs on xz-plane



Point *A* is at maximal elevation, junction point *B* is at some intermediate level. Arc *C-D* is horizontal, be at zero level. To determine the needed twists one should solve a system of 6 equations, varying ϕ_1, ϕ_2, R_1 and 3 twist angles.

One half of a kink created by two twists



Left half of a kink is mirror symmetric, with points D', C', B', A'. Full kink is made of 3 arcs: the middle one: B'AB, inclined by φ_A, and two symmetrical C'B' and BC. Arcs C'D' and CD are horizontal.

Spin and orbit plane matching

To produce a twist φ of plane of oscillation one can rotate a unity/minus-unity insertion cell by the angle $\varphi/2$ around the longitudinal axis. This is simple, but such insertion do not rotate a spin!

To rotate spin around the longitudinal axis, so that it again becomes perpendicular to a new plane of bending, one shall use a solenoid with the field integral:

$B \cdot L = \varphi/(1+a) \cdot BR$ (a≈0.0016 – electron moment anomaly)

But this solenoid rotates also the plane of oscillations by the angle $\varphi/2(1+a)$. So, the rest of the total twist angle φ shall be provided by the mentioned above the quads insertion rotated by the angle: $\varphi(1+2a)/4(1+a)$.

Then the grows of the vertical emittance will be suppressed!

Conclusion

If kinks are unavoidable, then I strongly recommend to use the proposed above orbit inclination technology with twists elements between the adjacent arc segments.

Spin matching is provided by relatively weak solenoids, which produce near a half of the full twist. Another half of the twist shall be provided by the rotated around the longitudinal axis the unity/minus-unity insertion cell.

As a result, the spin motion becomes not disturbed, same as in flat machine (linear dependence of the spin tune on energy).
Grows of the vertical emittance is also suppressed.