Non-Linear Injection Kicker -
Latest News

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Content of the Talk

• Brief Introduction to Kentaro Harada’s Idea
• Our First Try and the Prize We Paid
• Actual Design of the Kicker Magnet
• Field Measurements
• Beam-Based Measurement Technique
• Results
• Summary
Single Kicker Injection with Vanishing On-Axis Field

In-vacuum stripline-type design

4 wires with 200A each

Thermal and Vacuum Problems: Temperature at the outside of the kicker tank increased within 20-30 min to 60° C with $I_{mb}=300$ mA or $I_{sb}=15$ mA, along with severe vacuum degradation

Beam Dynamics Issues: Except for vacuum related beam blow-up no coupled bunch instability was observed, measured loss factor

After the tests the kicker had to be removed

Helge Rast found the cause: a too thin Ti-coating of the ceramics

Injection Efficiency: all kicker configurations have shown 80 % efficiency – could be further optimized, stored beam was far more stable
Figure 3: Sectional view of kicker magnet structure, second magnet design.
**Evolution of Design:** 4 conductors, 4 coils, with ceramics support and vacuum pipe profile.

Final design with bore of vacuum pipe and titanized ceramics support.

**Specifications:**
- \( B_y \max. \geq 20 \text{ mT} \), depiction in [G], \( 1 \text{ G} = 1 \times 10^{-4} \text{ T} \)
- \( B_y \max. \) at \( y = 0 \) and \( x = +10 \text{ mm} \)
- \( B_y \min. \) at \( y = 0 \) and \( x = -10 \text{ mm} \) (symmetry condition)
- \( B_x = 0 \) along \( y = 0 \)
Magnetic Field Measurement vs. ANSYS Calculation

Problem: Reliable and precise B-field measurements in small bores.

Horizontal By-Magnetic Field inside Non-linear Kicker Magnet at y = 0 mm

- By-field calculation with ANSYS
- By-field measurement of magnet structure in vacuum vessel [error 10%]
Realization of Magnet and Connections

Schematics of Electrical Connections

Options for Coil Interconnections
- 2 top and 2 bottom coils in series using 1 transducer respectively (installation until August 2013).
- 4 coils in series on 1 transducer as shown in the picture (installation since August 2013).
Symmetry by Positioning of Coils and Connections
Measurement Technique – Used Initially

- 4-kicker injection bump optimized for small orbit perturbation
  - Injection efficiency ~ 80%

- Single, non-linear injection kicker – not fully optimized:
  - Horizontal < 60 μ
  - Vertical < 15 μ
  - Injection efficiency ~ 80% up to 300 mA

- Dedicated bunch-by-bunch BPM-electronics, noise limits resolution
Libera-Brilliance BPM-Electronics + MatLab analysis of turn-by-turn data
Measurement Technique – Used Recently

Libera-Brilliance BPM-Electronics + MatLab analysis of turn-by-turn data
Spatial Variation of the Fields Determined Experimentally

Top and bottom coils powered serially in pairs – poor adjustment of current pulses (a few percent different)
Top and bottom coils powered serially in pairs – poor adjustment of current pulses (as good as possible identical)
Top and bottom coils powered in series – the 4 currents are identical
Vertical perturbations: can be made vanishingly small in the vertical plane: < 1 μm

Horizontal perturbations: ~3 μm is the minimum, in a quite small area

Linear dependence could be related to a quadrupolar field component
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Summary

**Kicker magnet and pulsed PS work fine:** no thermal problems and kicker serves as back-up solution

**Injection Efficiency:** all kicker configurations have shown 80 % efficiency – without much optimization, could be further improved

**Orbit perturbations:** $< 1 \mu m$ vertically and $\sim 3 \mu m$ horizontally

**Field distribution:** need time for more studies and wider line scans

We plan to reduce the pulse duration and investigate the impact of induced eddy currents

And we will continue our collaboration with

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Max IV