Impact of injection kicker failures

LHC Project Report 291, 1999

MKI   TDI

TDI

75 %
~8.5σ
~6σ

Flashover range

125 %

danger for

collimators

TDI

Ground plate

High Voltage Plate

Matching Capacitors

Vacuum tank ⌀540

Ground Conductor

Metallized Ceramic Tube

Damping Resistor

High Voltage Conductor

Ferrite C-Core

MKI

flashover

MKI prototype during assembly

TDI
8.5 σ

InjColls
9 σ ?

ClColls
6 … 7 σ

VERY SIMPLIFIED ESTIMATE (detailed tracking made by HB in InjWG…)

TDI position: 8.5 ± 0.58 σ (4.38 ± 0.3mm), primary collimator setting: 6 σ

Total injected high intensity batches in LHC lifetime:
20 (years) x 200 (days) x 2 (rings) x 2 (fills) x 12 (batches) = $2 \cdot 10^5$

4 MKI magnets per injection: $8 \cdot 10^5$ magnet pulses in LHC lifetime

Measured MKI flashover rate[*] is 2 (+/-2?) flashovers per $4 \cdot 10^5$ pulses,
so assume a rate of 1 per 10^5 pulses, i.e. 8 flashover events in LHC lifetime.

Average deflection per MKI is ~18 σ, for 33 cells, or 0.55 σ /cell

A flashover at cell N produces x2 kick in first N cells, zero in remainder

So flashover needs to happen in cell 6 - 9 or 24-27 for the batch to get a dangerous kick (i.e. one where 6< |total kick| < 9 σ) so probability is 8/33.

Therefore total number of dangerous events during LHC lifetime is 8 * 8/33 = 2.

[*]measured on MKI prototype at 10% overvoltage – electrical contact on capacitors now hopefully improved

Other Issues…

1. From JBJ - will this flashover produce a sweep?

    Yes – rise time and fall time are doubled, so sweep first and last 1μs of beam from zero to the bad value, then back again.

    So… question for CWG/MPWG – should BT investigate triggering dump switch to empty PFN such that failure only lasts 50% of the nominal kick duration (8→ 4μs)?

2. What is effect of systematic component of 1.5 σ injection 'oscillation' (e.g. MKI waveform envelope which produces reproducible beam sweep)? This will provide dilution of impact but also increase risks… – quantification? Take account of in collimator calculations?

3. As mentioned in last CWG minutes (RA) - Transfer lines, Injection system, LHC first turn(s), and all collimators TCDI, TDI, TCDD, TCL, TCS, … be treated together as 1 system as regards collimation for injection process (tolerances, failures, settings, robustness, etc etc etc.) . Functional specification for injection collimation?