



*LHC Optics Measurements and
Correction Review:*

**Future operation of the aperture
kicker MKA**

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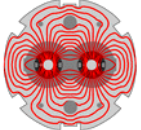
Thanks to the Rogelio Tomas and Frank Schmidt for
quantifying the dreams, the TE/ABT group for
quantifying the limits and Markus for the MPS aspects



A brief history of the MKA

- Machine Protection Review 11 – 13 April **2005**
 - Close-out (M.Harrison):

LHC machine protection close-out	Will the protection system have the required safety ?
<ul style="list-style-type: none">• As designed it should. Two caveats:<ul style="list-style-type: none">- The Committee strongly queries the utility of a device such as the aperture kicker given the potential risk inherent in it's operation.- In a similar vein the use of fast vacuum valves is also something that needs to be carefully justified.	



Machine Protection Review 2005

■ In phrases (from the review report):

The Committee offers two caveats. The request from the accelerator physics section for an aperture kicker to measure dynamic aperture appears to present an unjustifiable risk. As described, this device would be capable of producing a single turn, 5 σ , beam deflection at top energy. An uncontrolled firing of this device could cause serious consequences that the machine protection system would be unable ameliorate. If there is indeed a need to measure the dynamic aperture directly at high energies then the Committee suggests that a slower acting resonant device such as an A.C. dipole be considered instead. (The Committee notes that HERA has chosen not to use a full aperture kicker for similar reasons.)

■ Based on presentation (J.Uythoven, 2005):

The slide features the CERN logo in the top left corner. The title 'MKA Aperture Kicker' is displayed in large yellow text. A list of 'Specified Parameters' is provided in yellow text. On the right side, a flow diagram shows a box with 'Max kick spec. for 3.3 kV, Power converter = 4.0 kV' pointing down to a box with '⇒ 6.3 σ', which in turn points down to a box with '⇒ 24.4 σ'.

MKA
Aperture Kicker

- ◆ Specified Parameters
 - ◆ Kick pulse length about 45 μs : half of the machine
 - ◆ Max kick strength at 7 TeV beam energy: 5.2 σ
 - ◆ Max kick strength at 450 GeV beam energy: 20.1 σ

Max kick spec. for 3.3 kV, Power converter = 4.0 kV

⇒ 6.3 σ

⇒ 24.4 σ



Follow-up of the 2005 review

- Reduce the maximum kick of the MKA
- Use with 'Set-up Beam' only
 - Maskable BIS input which is always false
- Keys in the CCR



- ◆ **But: Safe beam flag is not guaranteed safe; it is not SIL3**
- ◆ **Additional safety measures are required:**
 1. **Check on Safe Beam Flag by the MKA PLC**
 2. **Procedures including a key in point 4**

Not done



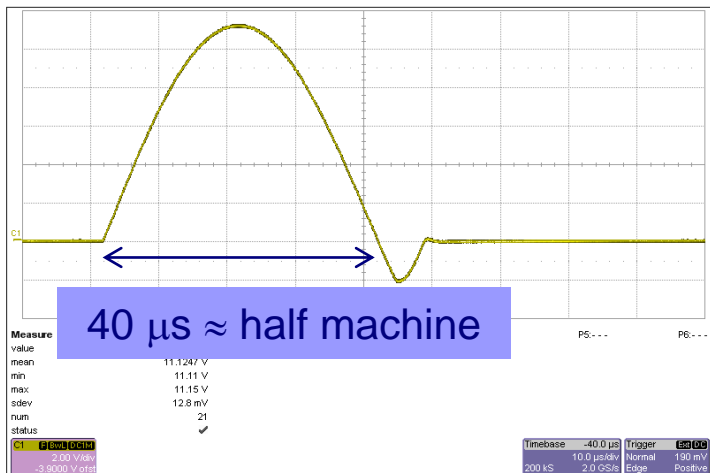
What was finally installed

- ≤ 2011 : asked for 5σ kick at 500 GeV
 - Max voltage 864 V: 1.4σ at 7 TeV and 5.3σ at 450 GeV
 - Power converter of 1 kV: 1.6σ at 7 TeV 6.1σ at 450 GeV
 - MKA connected to always active, maskable BIS input
 - Key in CCR to switch between MKQ, AC-dipole and MKA
- 2012: Asked for 15σ kick at 450 GeV
- Modifications to the triggering and electrical circuits
 - Max voltage **1.8 kV**: kick of **14.5σ at 450 GeV, 3.7σ at 7 TeV** ($\epsilon_n = 3.75 \mu\text{m}$)
 - Power converter of **4 kV**: kick of 32.2σ at 450 GeV, 8.2σ at 7 TeV
 - MKA remained connected to maskable BIS input
 - Key in CCR, as above
 - MKA operation disabled in tunnel, **need access before and after use:**

.....this involves removing all the main plugs from the Heinzinger 4kV supplies that feeds the MKA system and to place a 'lockout' sticker across the plug socket.



2012: MD procedures, EDMS # 1210692



Measured waveform for modified MKA as used in 2012

All 4 MKAs were modified: B1 & B2, H & V

4. PROCEDURES TO BE FOLLOWED DURING THE MD

The following procedures are proposed during the MD for B2

Description	Check
1. Access to enable MKA. Make local test pulse to check functionality. MKA maximum voltage limited to 1.8 KV on the 2 MKAs of B2.	VS / JU
2. Check safe beam flag threshold at 5e10 protons. Turn the keys to MKA position for the 2 MKAs of B2.	EIC / JU
3. Retract all collimators, except TCPs at 12 sigma. Check beam permit / collimator interlocking.	EIC / JU
4. Pulse the 2 MKAs of B2 and check the waveforms and timing	JU
10. Put keys back to MKQ and remove keys.	JU
11. Access to disable MKA.	JU

Access



Post LS1 - requirements

- Requirements (Frank, Rogelio):
 - Requirements not that different from 2012: operation up to 1.8 kV
 - Present procedure including the access is acceptable for an MD of about once per year
 - Avoids discussion if the “Set-up Beam Flag” is safe enough after possible LS1 upgrades. The MKA remains highly dangerous (see 2005 review).
 - Use 1: Dynamic aperture with 450 GeV beams
 - 1.8 kV kick strength is sufficient for 450 GeV aperture measurements, might have another MD request for 2015
 - Double kick (2 x half machine) was not used so far, as gain at 450 GeV is limited
 - Use 2: For higher beam energies a multiple of small 1σ kicks could be interesting for tune and chroma measurements -> move back to configuration before 2012
 - Use 3: If Dynamic Aperture issues at 6.5 TeV, one needs to re-discuss even stronger kicks, > 1.8 kV which will require a hardware upgrade, and the related machine protection items



Post LS1 – On offer

- On offer:
 - All 4 systems can run up to about 1.9 kV, but any higher value will need a significant amount of work, presently not foreseen
 - On top of any safety concerns
 - The Set-Up beam flag is not foreseen to be much safer after LS1:
 - No redundancy for beam current and energy measurement
 - Distribution by the timing system
 - MZ: ” ...*an upgrade of the SMP system to the needed dependability is far from obvious*” and not foreseen for LS1
 - If the access procedure is too limiting and strong kicks not required, one can go back to the 1 kV power converters, limited at 600 - 864 kV (changes in circuits and current measurements relative to before 2012)
 - Upon request can investigate the max rep rate of 1 minute -> temperature measurements of critical components ?
 - Installation of Beam Energy Tracking System (BETS) on the MKA which allows for maximum MKA kick depending on the energy. Inhibit kick if requested kick is too large.



Conclusions on future operation of MKA

- Requirements to the system have not fundamentally changed
- Machine protection issues neither
- ABP to **choose** desired configuration for start-up:
 - 1.8 kV with access constraints (15 σ kick at 450 GeV)
 - 0.6 kV without access constraints (5 σ kick at 450 GeV)
 - > 1.8 kV presently not foreseen – MKA and MPS limits
- If multiple, small kicks at higher energies are of a strong interest the 1 minute pause between pulses can be investigated upon request
- Future: BETS on MKA being considered