LHC Timing Requests Overview

SL/BT

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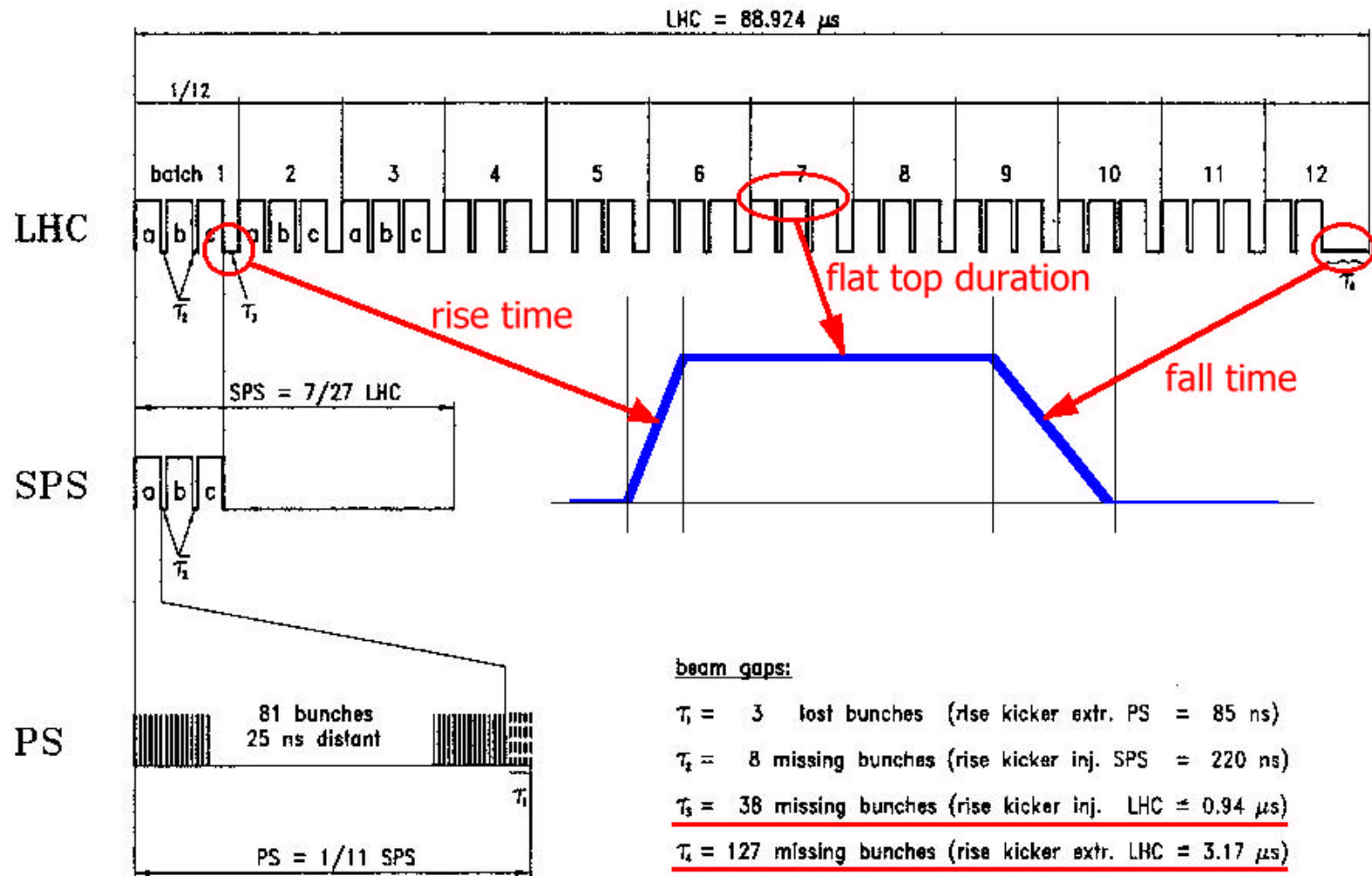
Equipment

- Injection kickers
  - MKI
- Extraction kickers
  - MKD, MKBH, MKBV
- Q measurement kickers
  - MKQH, MKQV
- Aperture measurement kickers
  - MKAH, MKAV

Injection Kickers: Layout

- Two systems
  - MKI2 (TI2) & MKI8 (TI8)
- Each system
  - 4 magnets
  - 4 MAIN switches
  - 4 PFNs
  - 4 DUMP switches
  - 2 resonant charging power supplies

Injection kickers: bunch disposition

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Injection Kickers: Location

	MKI2	MKI8
Magnet	RA23	RA87
Power Electronic	UA23	UA87
Control Electronic	UA23 SR2	UA87 SR8

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Injection Kickers: Timing

- Beam synchronisation (1ns)
  - Circulating beam
  - Injected beam
- Internal delay compensation (1ns)
  - Thyratron anode delays
  - Thyratron switching characteristic delays
  - Cable and Time-of-flight delays
- Kick length control (5ns)
  - Thyratron trigger

Injection kickers: Timing (cont.)

- Resonant charging control (ms)
  - Kick strength setting
  - Trigger
- Data acquisition
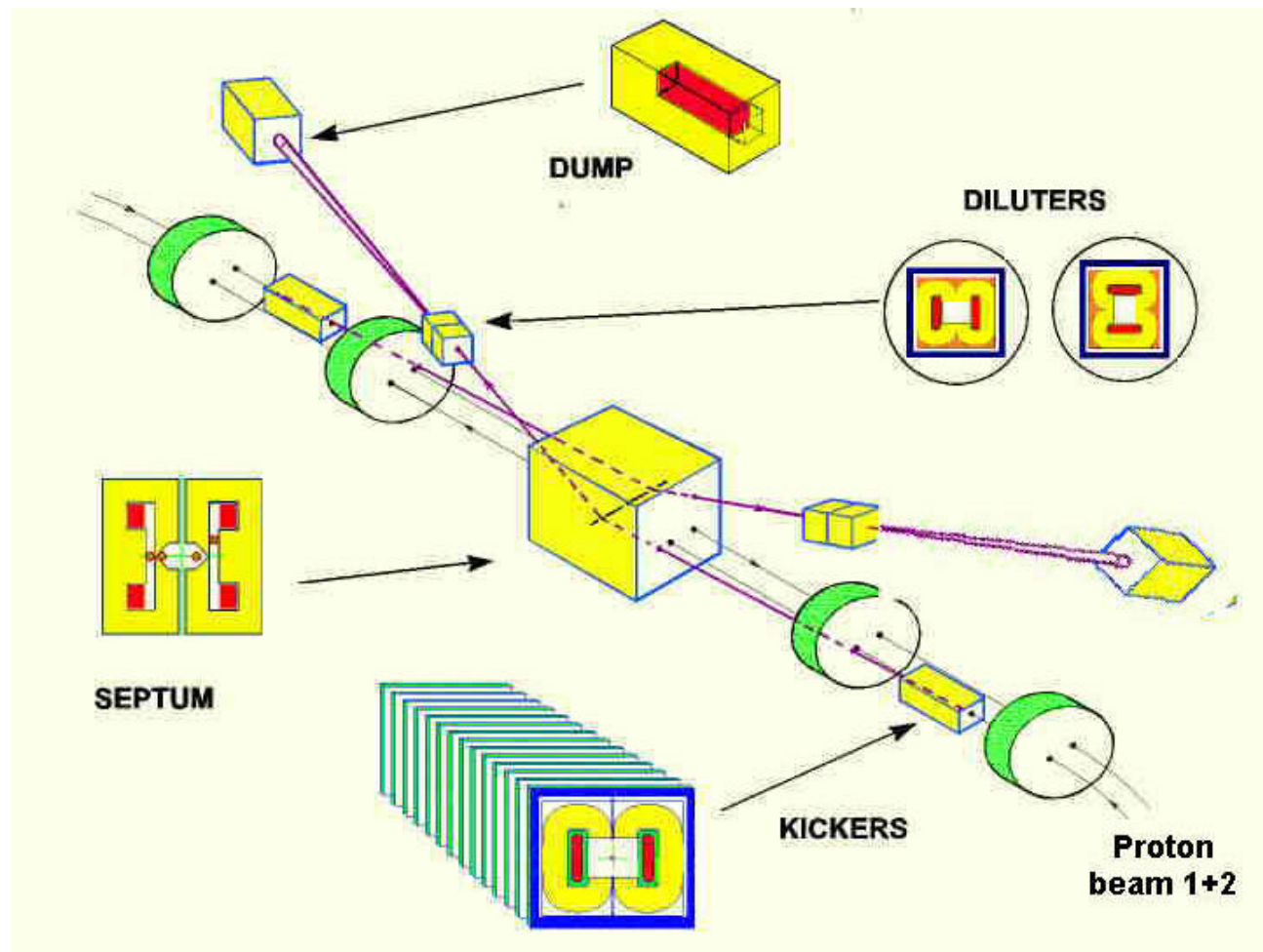 - Settings : ms
  - Kicks : ns

Injection Kickers: Timing (cont.)

- Link with SPS extraction kickers
  - MKE4 & MKE6
- Inhibition
  - LHC Injection
  - SPS Extraction
- Correlation between slow and fast timings
  - Interlock

Extraction system

- ## Extraction kickers

  – 14 generators/ring

- ## Vertical dilution kickers

  – 6 generators/ring

- ## Horizontal dilution kickers

  – 4 generators/ring

Extraction System: Layout

DUMP

DILUTERS

SEPTUM

KICKERS

Proton beam 1+2

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Extraction system: Locations

	MKD Ring1	MKB H/V Ring1	MKD Ring2	MKB H/V Ring2
Magnet	RA63	RA67	RA67	RA63
Power Electronic	UA63	UA67	UA67	UA63
Control Electronic	UA63 SR6	UA67 SR6	UA67 SR6	UA63 SR6

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Extraction System: Timing (1)

- Type of extraction
  - Scheduled, emergency, repetitive (inject and dump)
- Synchronisation with circulating beam
  - 5ns precision
  - Extraction kicker
    - Rising edge of kicker (~3µs) in circulating beam gap
  - Dilution kicker
    - Less critical (synchronised with extraction kicker)

Extraction System: Timing (2)

- Synchronisation with beam energy (~1 ms)
  - Tracking system
    - reference
    - interlock

- Post-mortem analysis & data logging
  - During injection, ramp, physics….
    - ms
  - During extraction procedure (beam dumping)
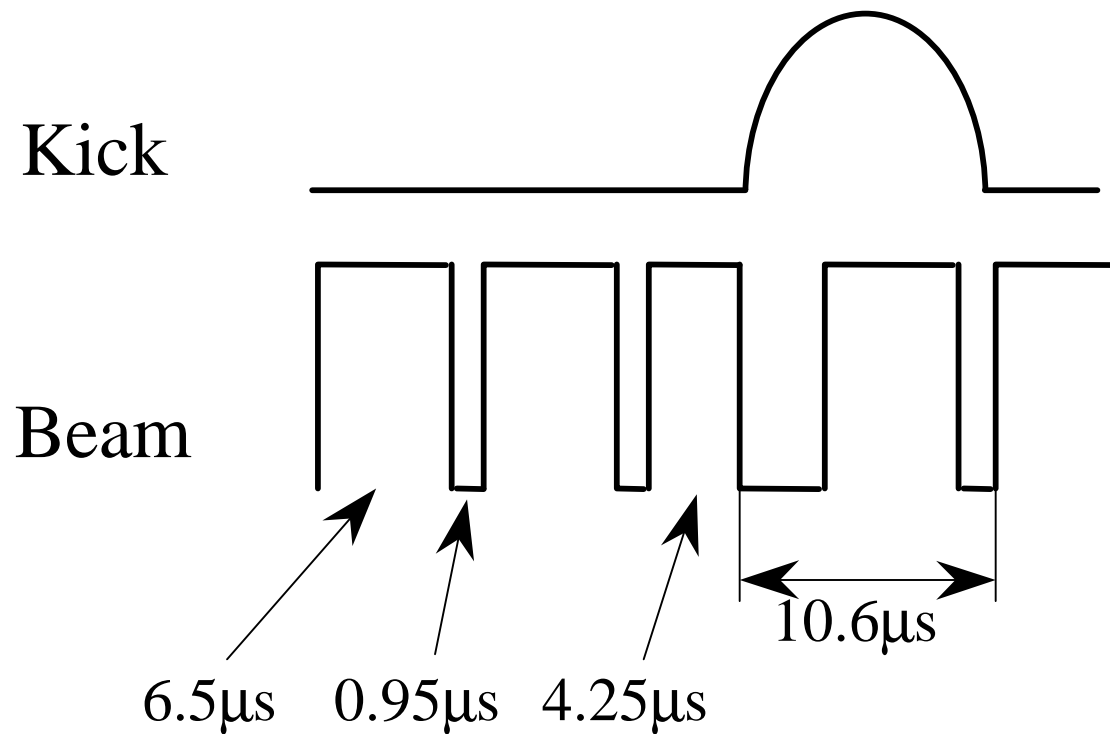   - μs (ns)

Extraction system: Timing (3)

- Internal delay compensation (ns)
  - GTO switching characteristic delays
  - Cable length delays
  - Beam time-of-flight delays
- Timing distribution
  - Redundant
  - Determinist
  - Fail safe/Fault tolerant

Aperture measurement kickers

- Two generators per ring
  - Horizontal
  - Vertical
- Pulse shape
  - 1/2 sine, 10us at base
- Dynamic kick range: 32
  - Hor. Max. deflection angle: 15.85 µrad
  - Ver. Max. deflection angle: 9.15 µrad

Aperture measurement: bunch disposition

Kick

Beam

6.5μs   0.95μs   4.25μs

10.6μs

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Aperture measurement kickers

- Synchronisation
  - Circulating beam (~5ns)
  - Beam instrumentation (data acquisition)
  - Beam energy (~ms)
    - Interlock
    - Operating range
- Type of measurements
  - Single shot
  - Continuous (repetition rate = 0.2 Hz)
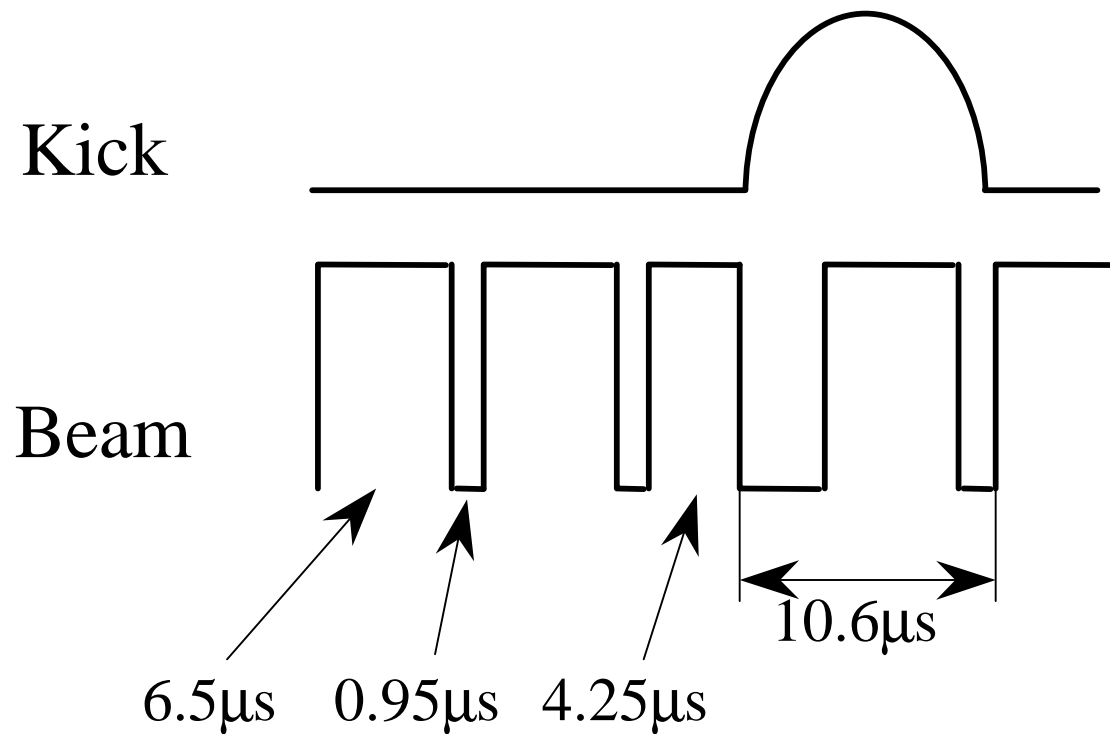
Aperture Measurement Kickers

	MKA H/V Ring1	MKA H/V Ring2
Magnet	RA63	RA67
Power Electronic	UA63	UA67
Control Electronic	UA63 SR6	UA67 SR6

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Q measurement kickers

- Two generators per ring
  - Horizontal
  - Vertical
- Pulse shape
  - 1/2 sine, 10us at base
- Dynamic kick range: 32
  - Hor. Max. deflection angle: 0.527 μrad
  - Ver. Max. deflection angle: 0.304 μrad

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Q measurement: bunch disposition

Kick

Beam

6.5μs   0.95μs   4.25μs

10.6μs

Q measurement kickers

- ## Synchronisation
  - Circulating beam (~5ns)
  - Beam instrumentation (data acquisition)

- ## Type of measurements
  - Single shot
  - Continuous (fmeas > frev)

Q Measurement Kickers

	MKQH/V Ring1	MKQH/V Ring2
Magnet	RA63	RA67
Power Electronic	UA63	UA67
Control Electronic	UA63 SR6	UA67 SR6

Conclusions (1)

- Fast and Slow timing
  - Actual functionalities of MTG and pre-pulse distributions seems to fulfil our basic requirements

- Few amount of events are needed for the control of the LHC kickers

- More important parameter is the LHC revolution frequency

but...

Conclusions (2)

- Need for a redundant, fail save and/or fault tolerant timing distribution system for the LHC extractions

- Need also for a deterministic timing distribution (which, where, when)

  - Fast & slow timing
  - Revolution frequency

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Conclusions (3)

- Synchronisation procedure with other equipment must determined
  - continuous data acquisition and logging
  - beam post-mortem synchronisation

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