MD2930: Asynchronous Beam Dump Test with Bunched Beam

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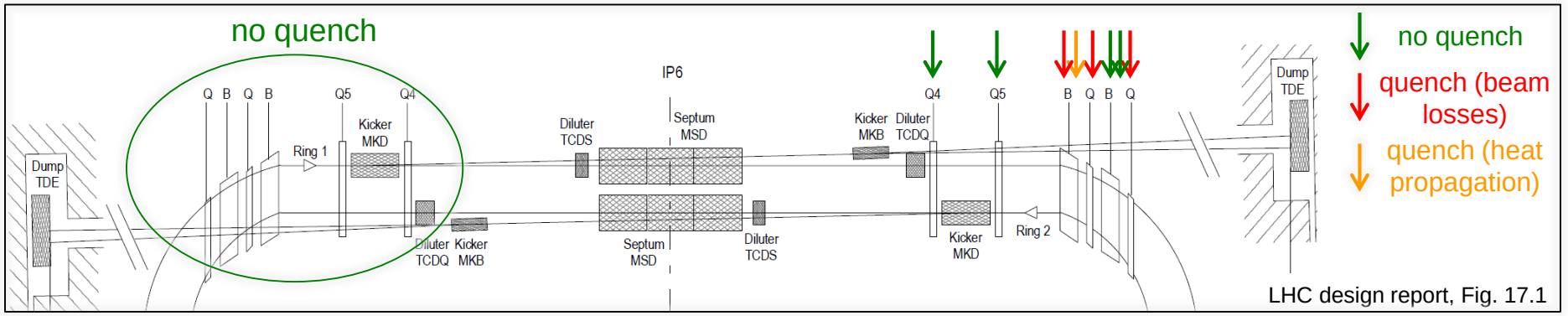
Motivation

- Idea: perform an asynchronous beam dump test *with bunched beam* in the abort gap
- Goal: Verify our understanding of the beam-loss behaviour, and the current beam and FLUKA models under clearly defined conditions.
- Asynch. dump test (2016-05-15): The detailed reconstruction of the event showed that the quench behaviour is not fully understood [1-3].

Magnet	T (K)	ρ_{energy} (mJ/cm^3)	Quench expected?	Quench observed?
MQY.4R6	4.5	30	Yes	No
MQY.5R6	4.5	50	Yes	No
MB.A8R6	1.9	27	Yes	Yes
MB.B8R6	1.9	5	No	(Yes)*
MQML.8R6	1.9	1.5	No	Yes
MB.A9R6	1.9	< 0.1	No	No
MB.B9R6	1.9	< 0.1	No	No
MQM.9R6	1.9	0.25	No	Yes

*quenched due to heat propagation



LHC design report, Fig. 17.1

Preparation of the MD (~2h)

Goal: Allow injection into the abort gap

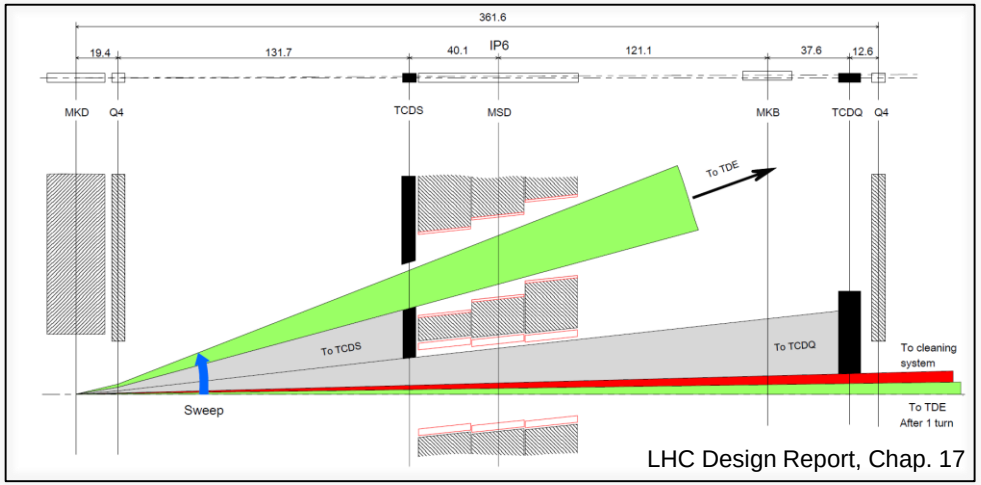
- Modify **variable AGK** (procedure by N. Magnin) [4]
- Disable **abort-gap cleaning**
- Mask **abort-gap interlocks in SIS** that check [5]:
  - LhcMkiAgkLength, AbtFib6Card, MKI kick length settings, LAST_LEGAL_INJECTION_BUCKET
- Disable steps in the **injection sequencer** that check [5]:
  - if first bucket is not after LAST_LEGAL_INJECTION_BUCKET
  - if last bucket is not after LAST_BUCKET
  - MKI kick length
- Mask steps in **SPS_BQM** that check if last injected bunch would be in the abort gap [5]
- Mask in **Injection BIS**:
  - MKI2/8 BETS/AGK/Erratic

[5] D. Jacquet, J. Wenninger, Injection sequencer and SIS protections against incorrect injection requests (into the AG), November 2017

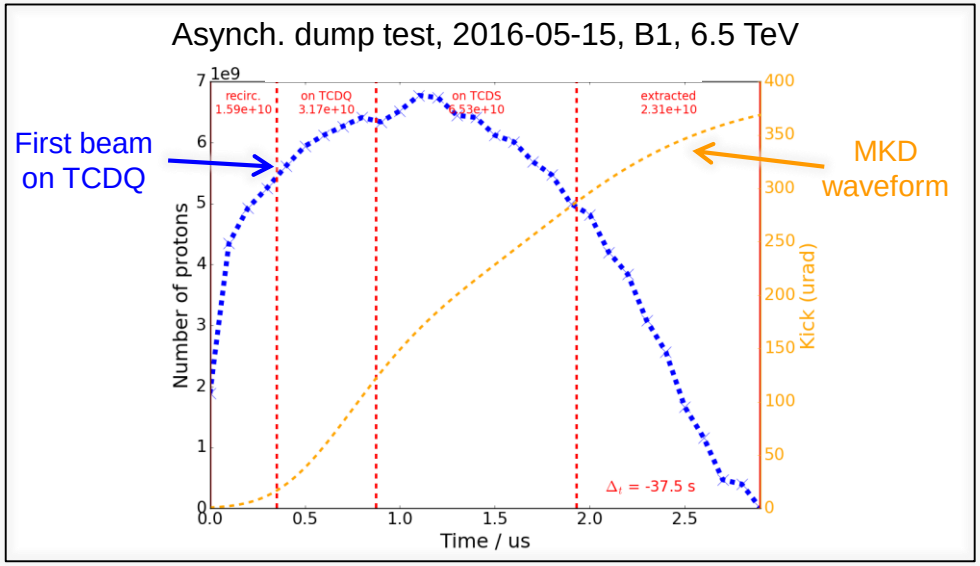
1) Probe abort gap (~2h)

Goal: Validate first bucket to hit the TCDQ

- Pilot bunches
- Injection energy
- Collimators, TCDQ, TCSP at nominal injection position
- Mask Post Mortem? (in case of long waiting time)
- No bump at TCDQ
- Inject *one pilot* into relevant regions of the abort gap (e.g. around the TCDQ edge). Manually dump beam. Check BLM response.
  - a) Test for Beam 1
  - b) Test for Beam 2
- Unmask Post Mortem



LHC Design Report, Chap. 17

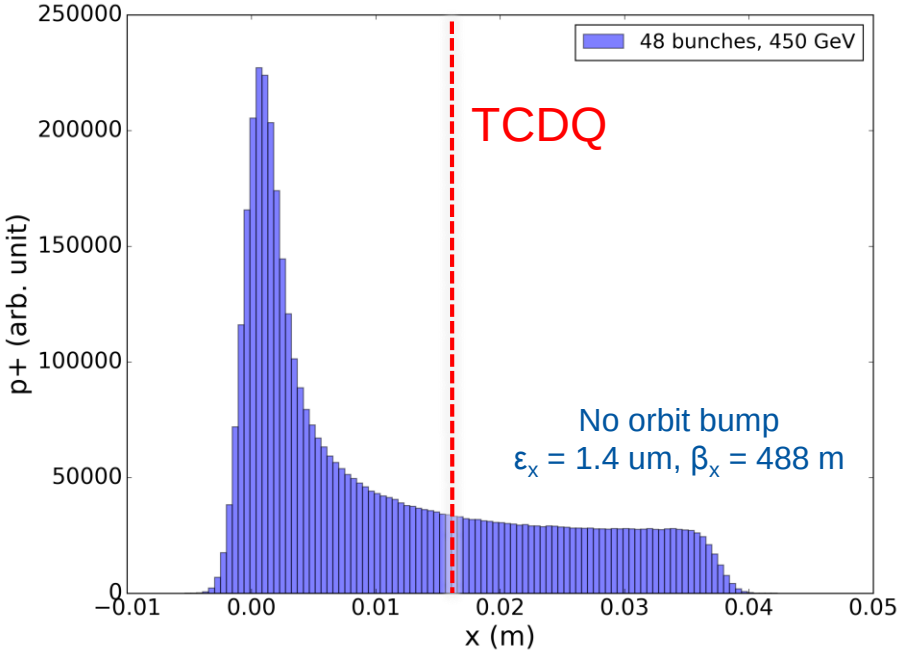


2a) Trains at 450 GeV (~2.5h)

Goal: Verify expectations for loss distribution and energy deposition at injection energy

- BCMS (not 8b4e), injection optics
- Inject *one train of 48 bunches* into the beginning of the abort gap. Dump manually.
- For FLUKA validation, 2 intensity steps are desirable. The procedure of how to reduce the bunch intensity is under discussion between ABT, OP and MPE.
- 4 tests without bump at TCDQ:
- a) ~6e10 p+/bunch (B1/ B2 separately)
- b) ~1.25e11 p+/bunch (B1/ B2 separately)
- Remark: No quench expected. FLUKA results expected shortly before MD.

Simulated particle distribution for train of 48 bunches



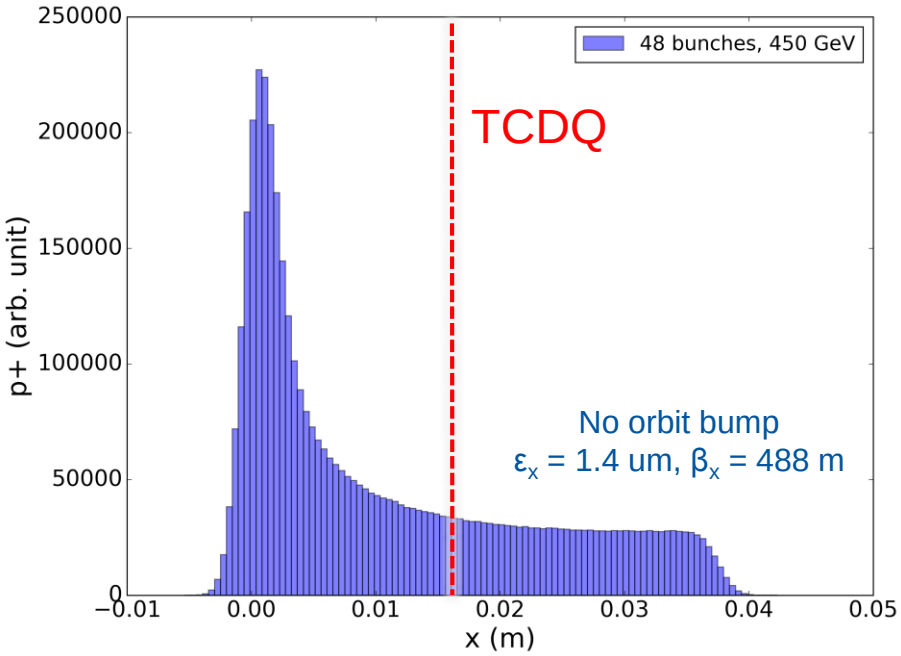
- 13 bunches hitting TCDQ
- 4 bunches hitting TCDS.
- Relatively uniform distribution due to overlapping bunches

2b) Trains at 450 GeV with bump (~1.5h)

Goal: Verify impact of orbit excursion on loss distribution (optional)

- Mask IR6 excursion interlocks in SIS and BIC for both beams **(maskable with unsafe beam?**)
- Put orbit bumps of 2 mm at TCDQ as for normal Asynch. Dump Tests [6]
- 2 tests with bump at TCDQ:
- a) ~1.25e11 p+/bunch (B1/ B2 separately)

Simulated particle distribution for train of 48 bunches

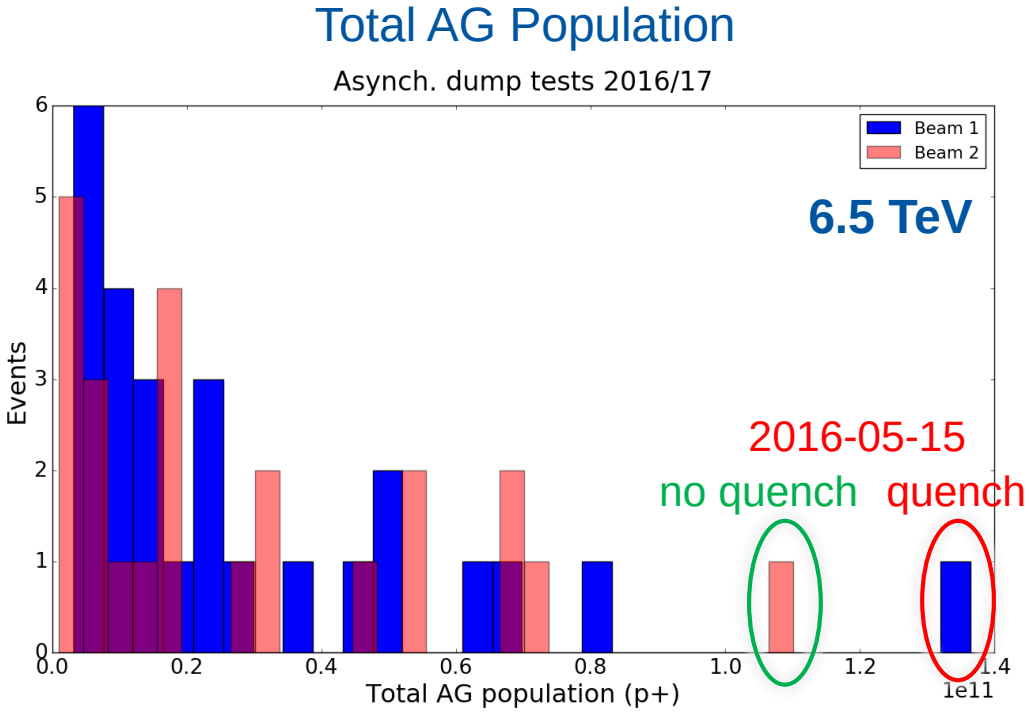


- 13 bunches hitting TCDQ
- 4 bunches hitting TCDS.
- Relatively uniform distribution due to overlapping bunches

3) Single bunch at flat top (~2h)

Goal: Verify expectations for loss distribution and energy deposition at top energy

- FLUKA results expected only shortly before the MD. Therefore, approach: stay below intensity of 2016-05-15 test
- Inject **one pilot bunch** (~1e10 p+) in a bucket close to the TCDQ edge for each beam
- No orbit bump
- Ramp to 6.5 TeV
- Optics: Flat top with 1m beta*
- Manually dump beam
- If time allows: repeat with adjacent bucket



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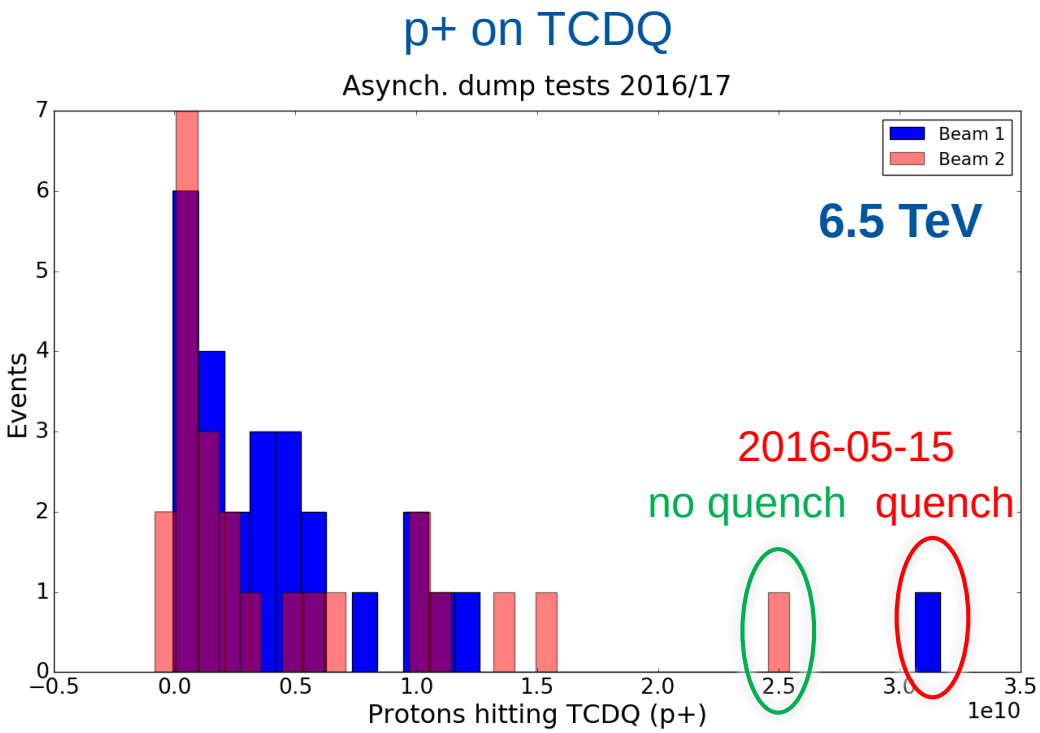

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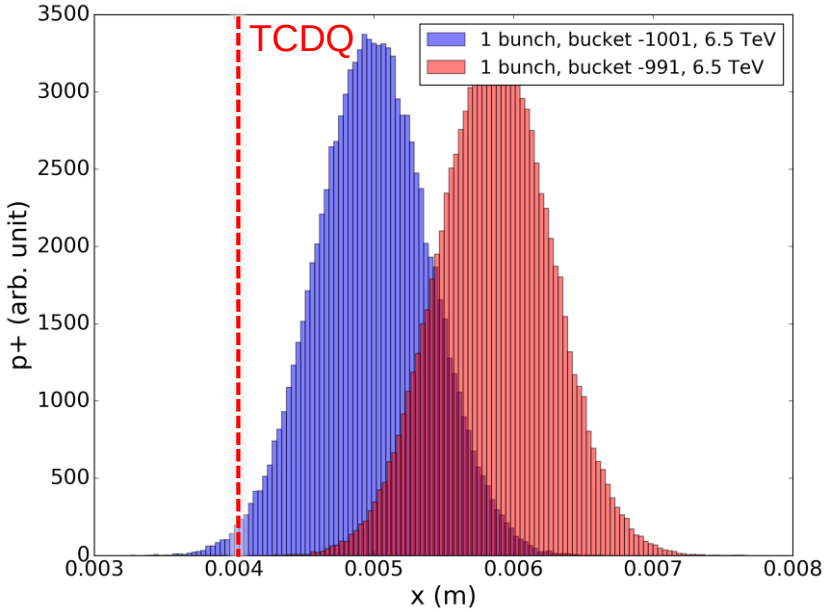
- Ramp to 6.5 TeV
- Optics: Flat top with 1m beta*
- Manually dump beam
- If time allows: repeat with adjacent bucket

Simulated particle distribution for single bunches at 6.5 TeV



No orbit bump
ε_x = 2.3 um, β_x = 489 m

Recovery?

- **If last MD: reset settings of variable AGK**
- If not last MD before YETS: full revalidation with beam (see procedure)
- Risk of magnet quenches in IR6. In this case, additional recovery time of an estimated 4-8 hours might be required.

MD Parameters: Summary

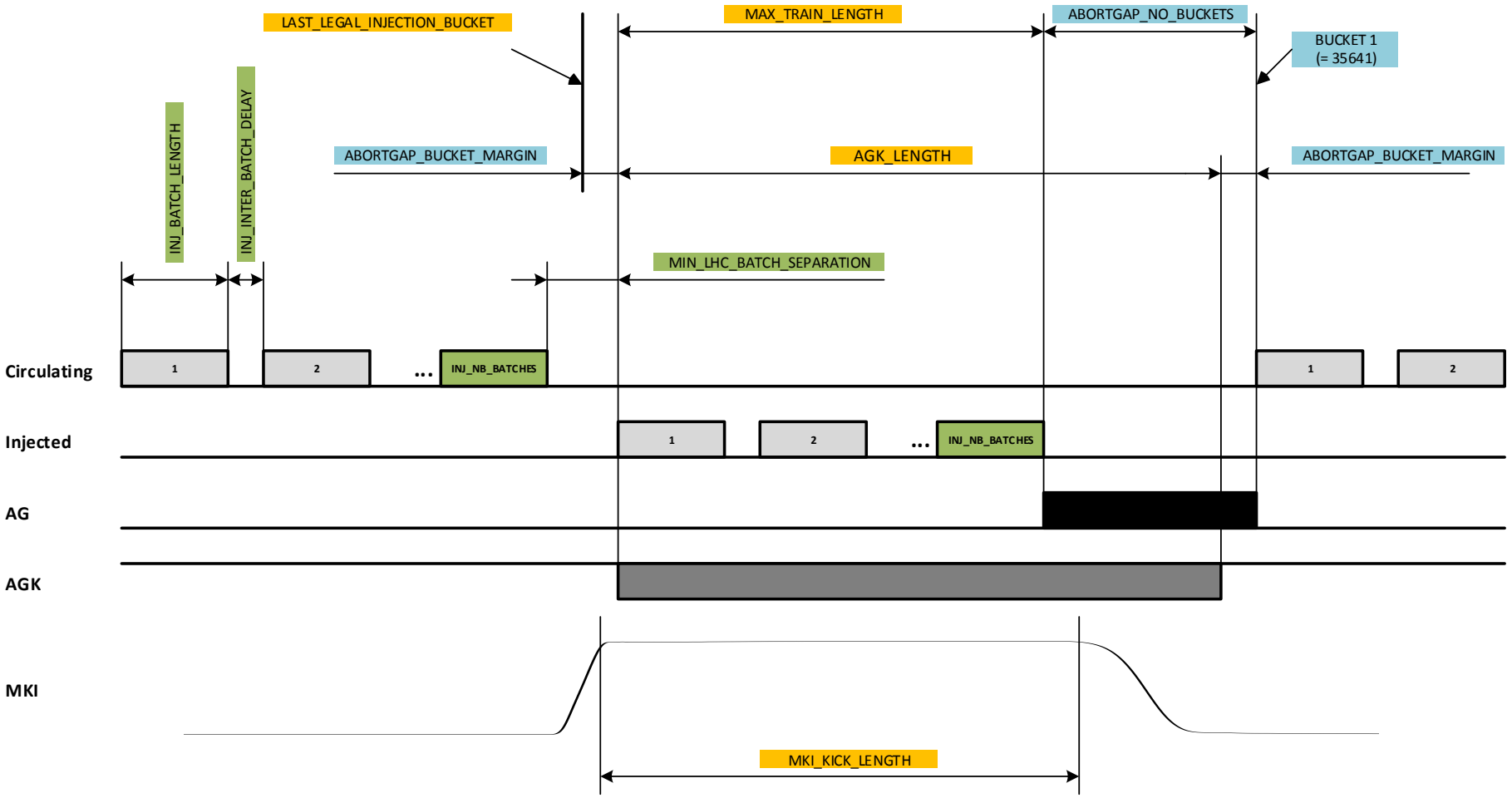
Specie	Protons
Category	Normal MD
Time required [h]	10 hours
Beams required [1, 2, 1&2]	Both
Beam energy [GeV]	Part 1 and Part 2: 450 GeV / Part 3: 6.5 TeV
Optics (injection, squeezed, special)	Part 1 and Part 2: injection optics. Part 3: Flat top with 1m beta*
Bunch intensity [#p, #ions] and Number of bunches	Part 1: Pilots Part 2: Trains of 48 bunches (BCMS) with ~6e10 p+ and trains of 48 bunches (BCMS) with ~1.25e11 p+ Part 3: One pilot bunch
Transverse emittance [m rad]	Nominal values (exact value not critical).
Bunch length [ns @ 4s]	Nominal values.
Optics change [yes/no]	No
Orbit change [yes/no]	No
Collimation change [yes/no]	No
RF system change [yes/no]	No
Feedback changes [yes/no]	No
What else will be changed?	In order to inject into the abort gap, the variable AGK has to be modified before the measurement.
Are parallel studies possible?	No
Other info/requests	Risk of magnet quenches in IR6.

References

- [1] C. Wiesner, Overview of asynch. dump tests 2016/17 and asynch. dump test with quench (2016-05-15), LIBD Meeting, 05.10.2017, https://indico.cern.ch/event/661534/
- [2] D. Wollmann, Magnet quench characteristics and quench levels, LIBD Meeting, 05.10.2017, https://indico.cern.ch/event/661534/
- [3] M. Frankl, A. Lechner, Energy-deposition studies, LIBD Meeting, 05.10.2017, https://indico.cern.ch/event/661534/
- [4] N. Magnin, Operational Procedure, Procedure to change the length of LBDS Abort Gap Keeper, to be published
- [5] D. Jacquet, J. Wenninger, Injection sequencer and SIS protections against incorrect injection requests (into the AG), November 2017
- [6] LHC Operational Procedure, Asynchronous beam dump validation test, EDMS No. 1698830

Thank you for your attention!

Overview of AGK Parameters



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