Conceptual Design Review LHC Phase II Collimation

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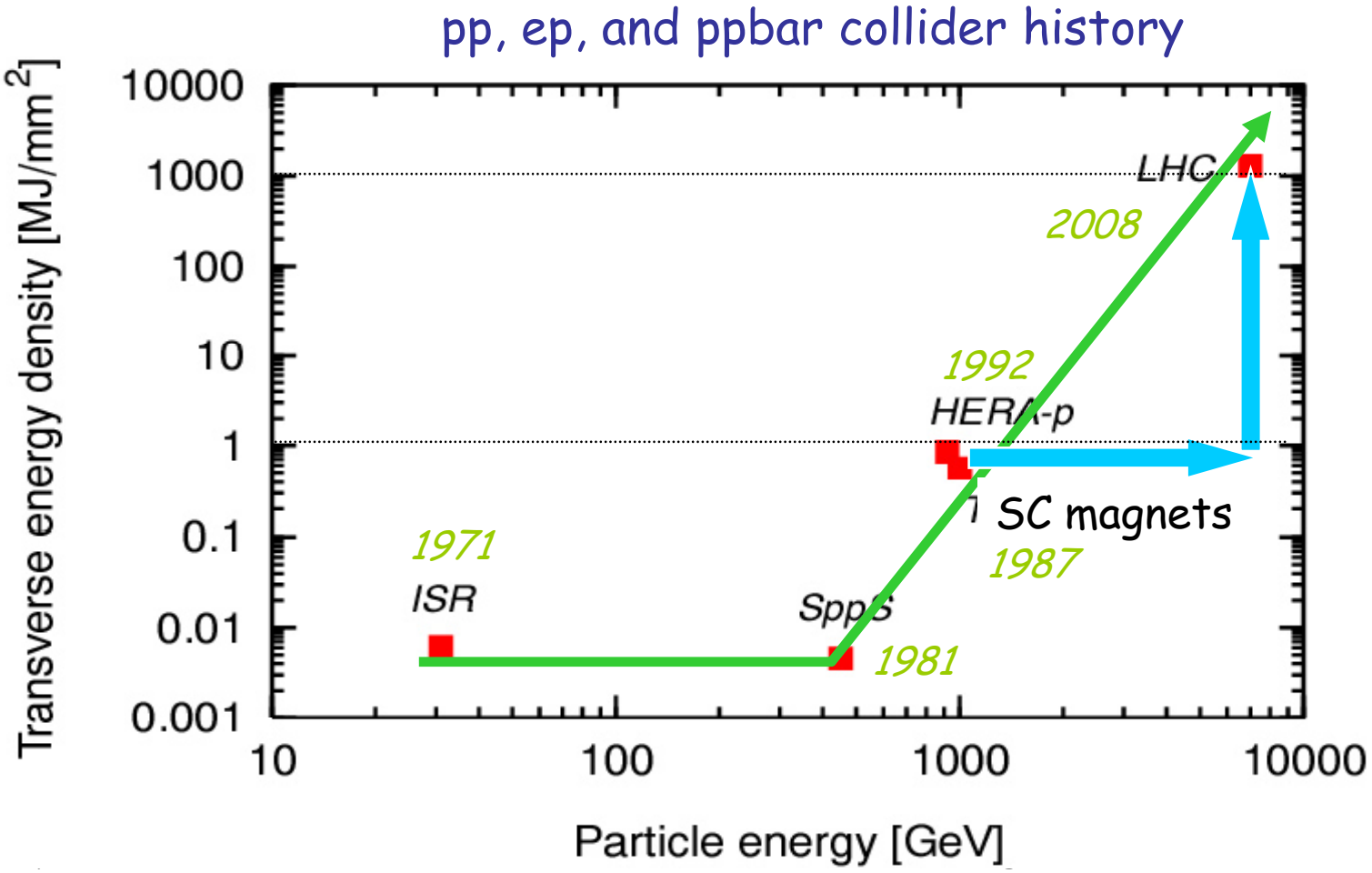
Machine Protection Aspects

MPS @ LHC

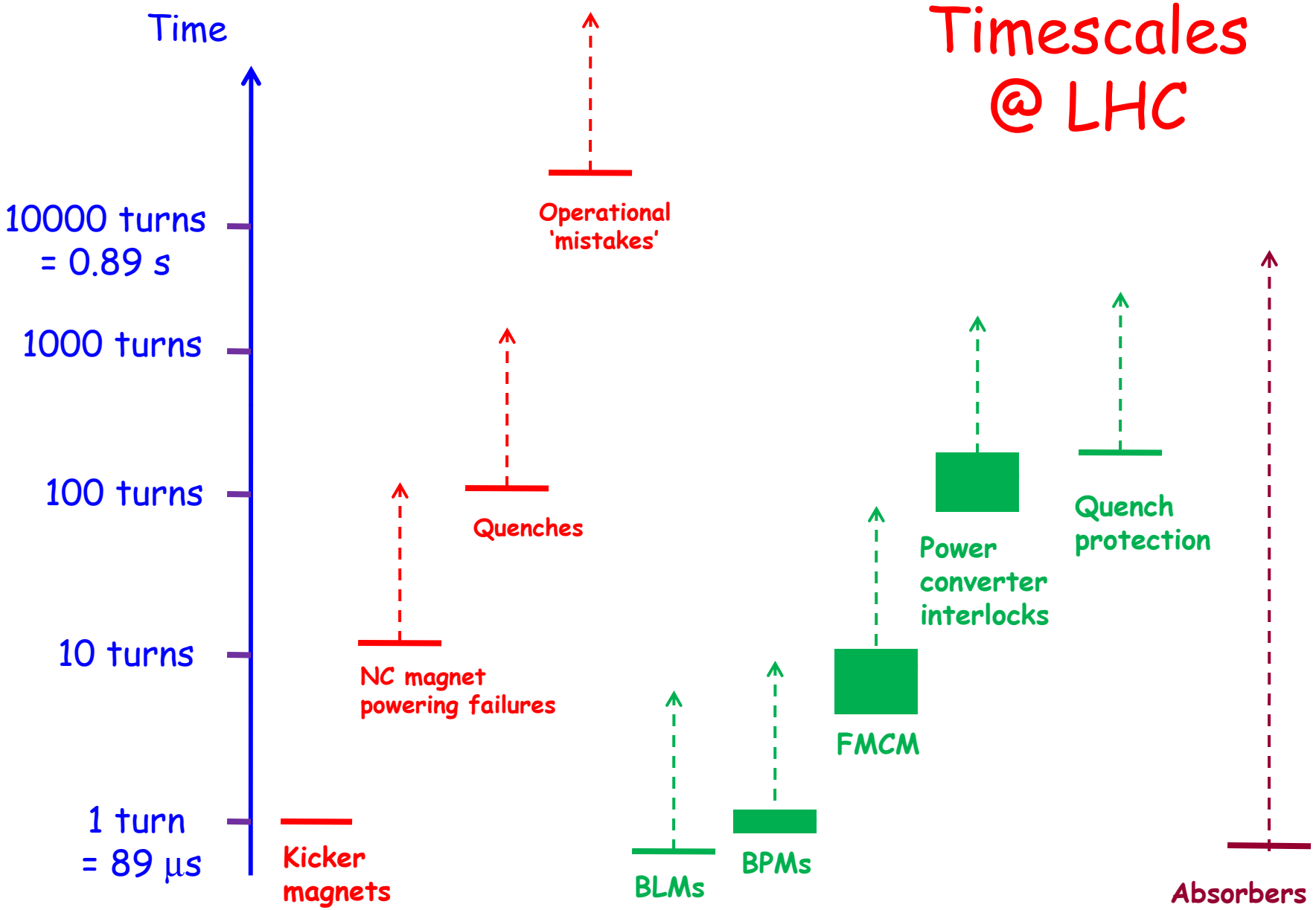
- The MPS at the LHC must fulfill the daunting task of protecting the LHC against a beam with 200 times more stored energy than present state-of-the-art.



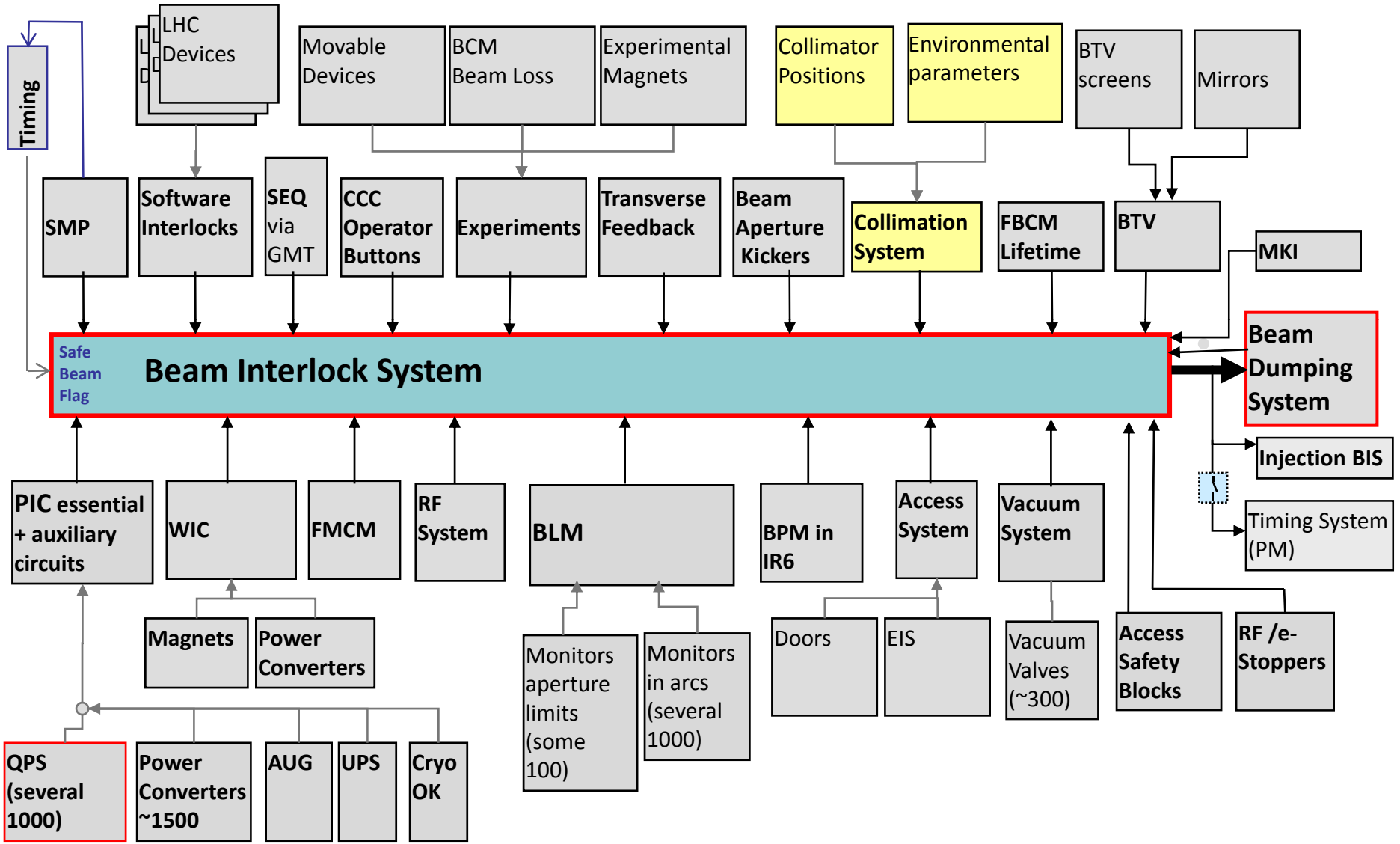
MPS @ LHC

- Coordinated MPS activities started ~2001 and progressed alongside with the collimation system that also underwent a major re-design (Copper → Carbon).
- A large effort went into the analysis and simulation of failures and into the design of a redundant protection wherever this was possible.
  - Example: Most critical normal-conducting magnet circuits were protected by ad-hoc fast failures detection systems ('FMCM').
- A major uncertainty is the knowledge of damage limits for many components (in particular SC magnets !!).
  - What beam intensity is safe at 7 TeV? Present assumption is that even the smallest bunch should be handled with care…
  - We are clearly lacking experimental tests.

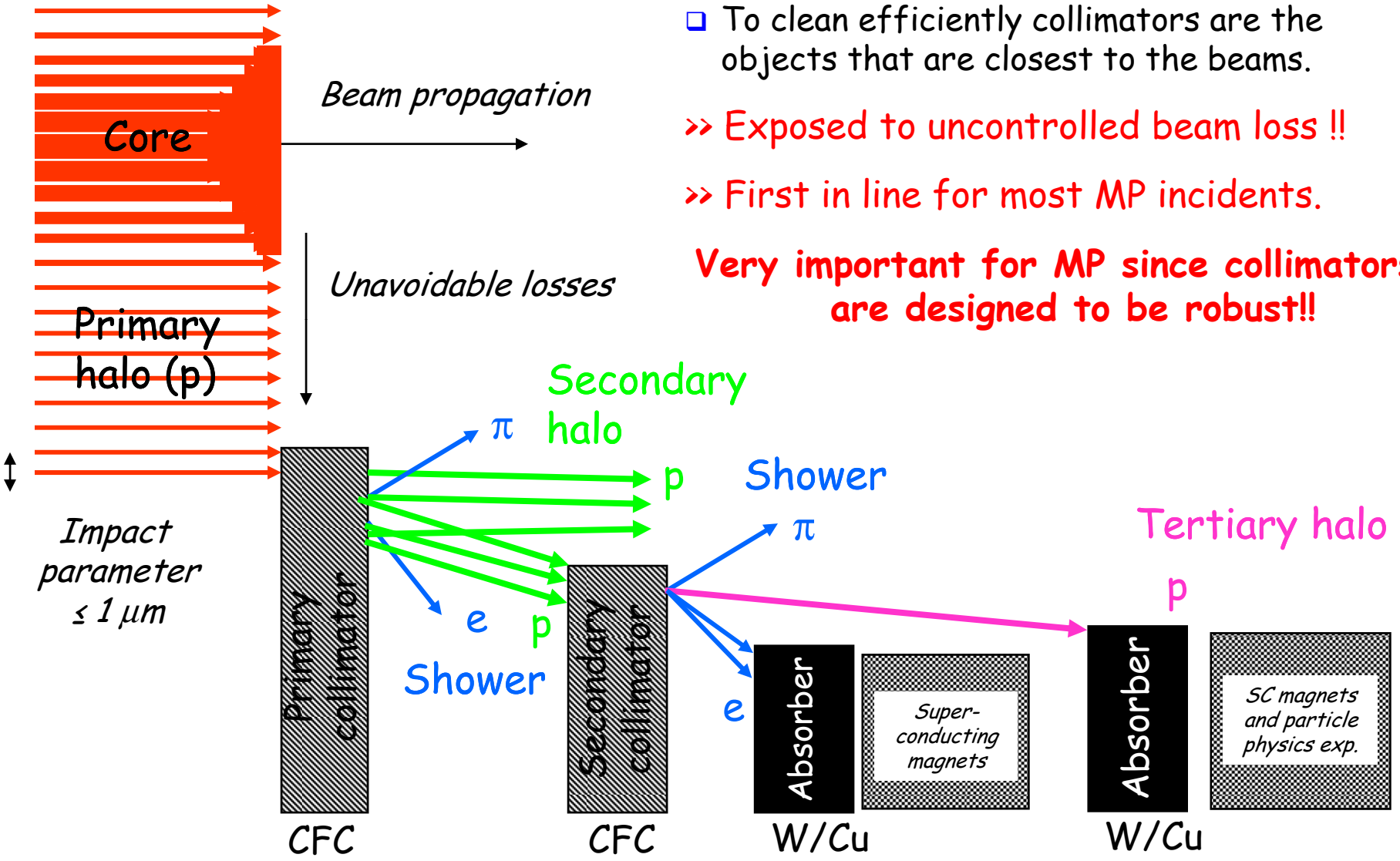
Timescales @ LHC



Collimators & BIS



Multistage cleaning & protection



- To clean efficiently collimators are the objects that are closest to the beams.

» Exposed to uncontrolled beam loss !!

» First in line for most MP incidents.

Very important for MP since collimators are designed to be robust!!

MPS Failure Categories

- Single turn (single-passage) beam loss
  - 'Failures' of kicker magnets (injection, dump or aperture).
    - Asynchronous beam dumps.
  - Injection failures.

>> Collimators are very exposed and must survive impacts:

- Injection : 450 GeV beam of 2 MJ.
- Asynchronous dump : ~ 5-10 bunches, ~1 MJ at 7 TeV.

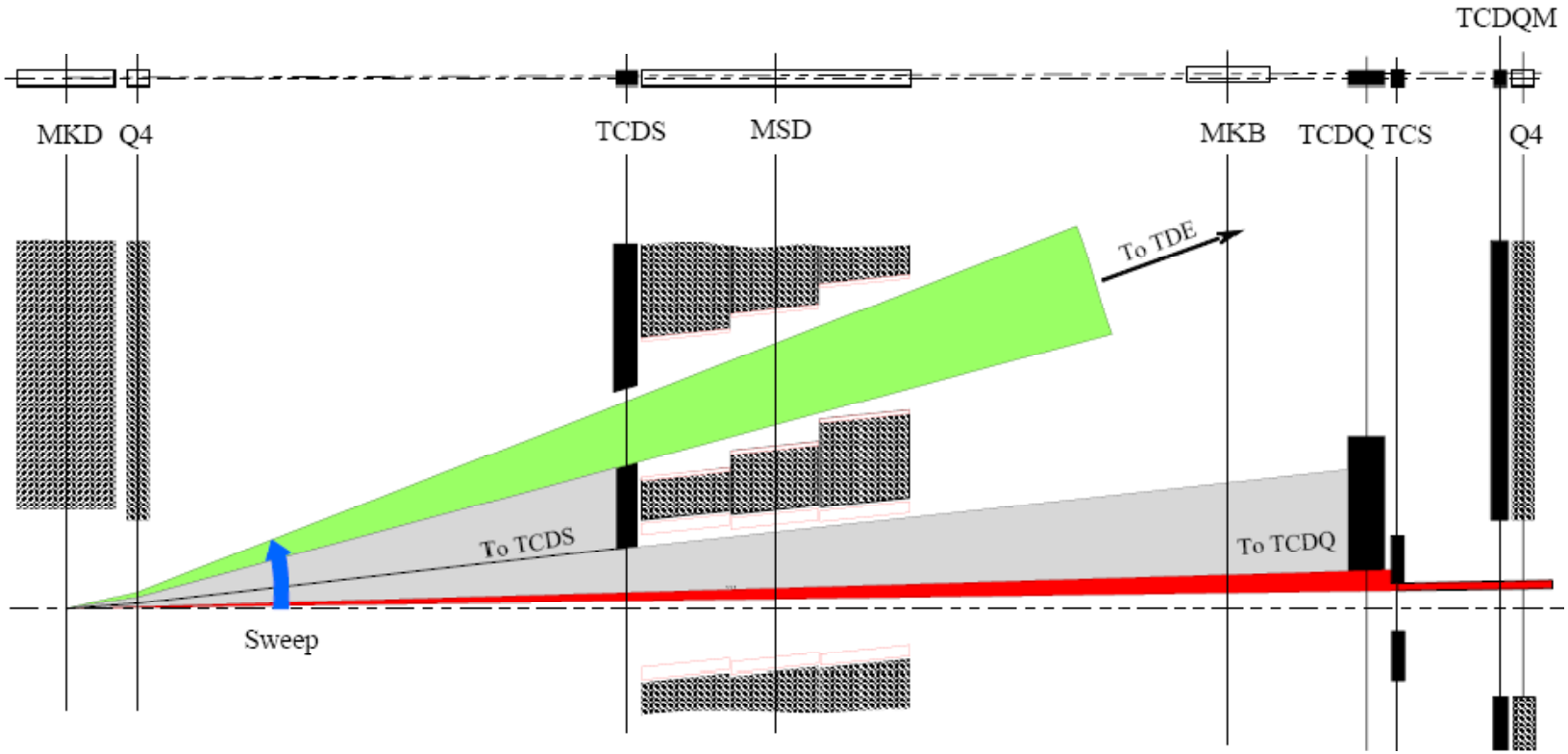
- Beam loss over many turns (fastest ~ 20-30 turns)
  - Simulations with nominal phase 1 collimators indicate that collimators are hit first in the large majority of cases: collimators very effectively define the machine aperture.
    - Exceptions : local bumps.
  - BLMs at or downstream of collimators used to trigger dump.

Asynchronous dumps

Protection in the event of an asynchronous firing of one of the 15 dump kickers (expected ~ 1 / year):

- Moveable graphite absorber TCDQ, plus secondary collimator (TCS).
- Tertiary collimators protect the triplets (mainly IR5) against beam leaking out of absorbers + coll.

Issue : TCDQ is single sided, protection against beam moving away from the jaw is far from perfect (hard limit from TCS may not be sufficiently tight).



Simulation result example

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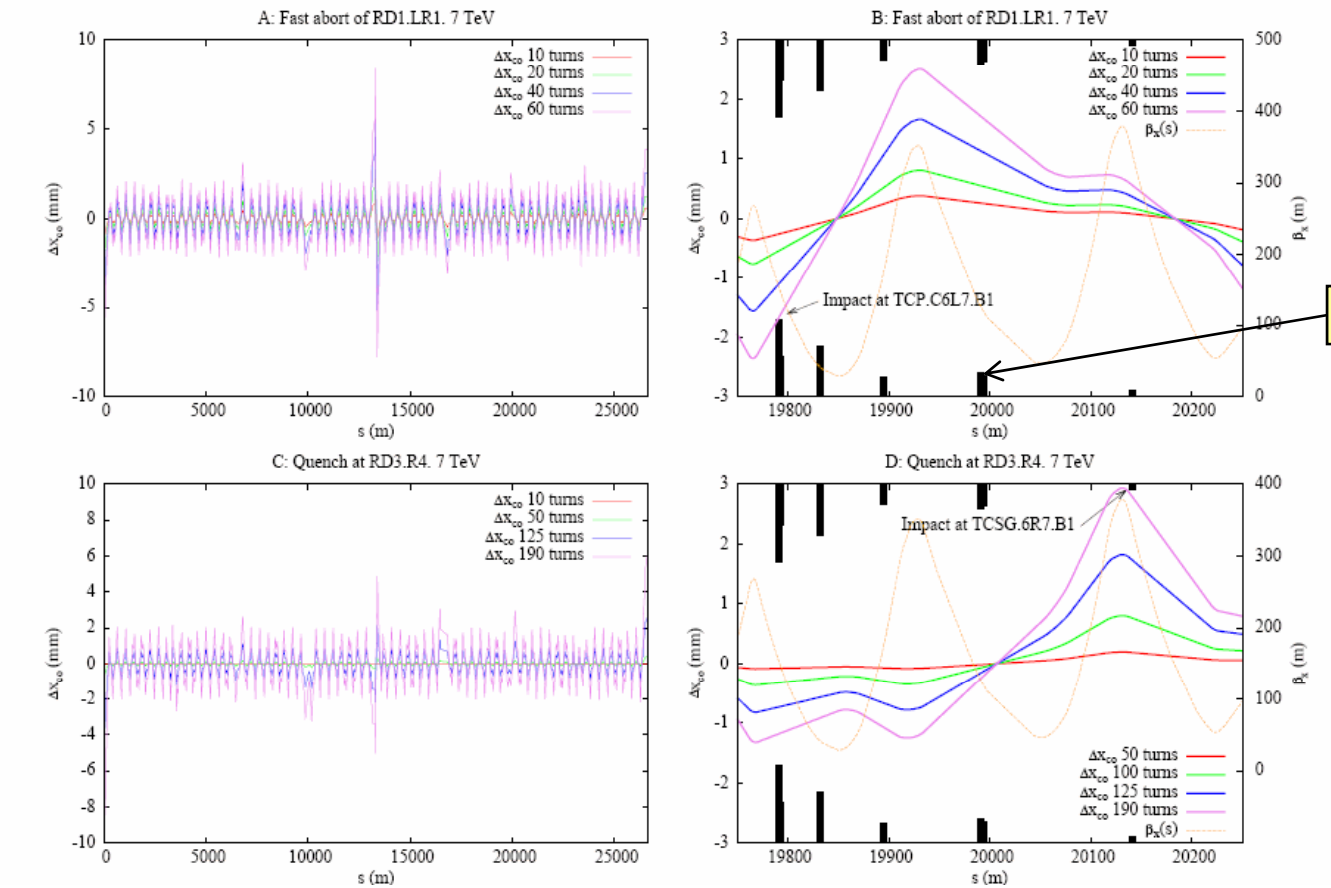
Orbit along the ring

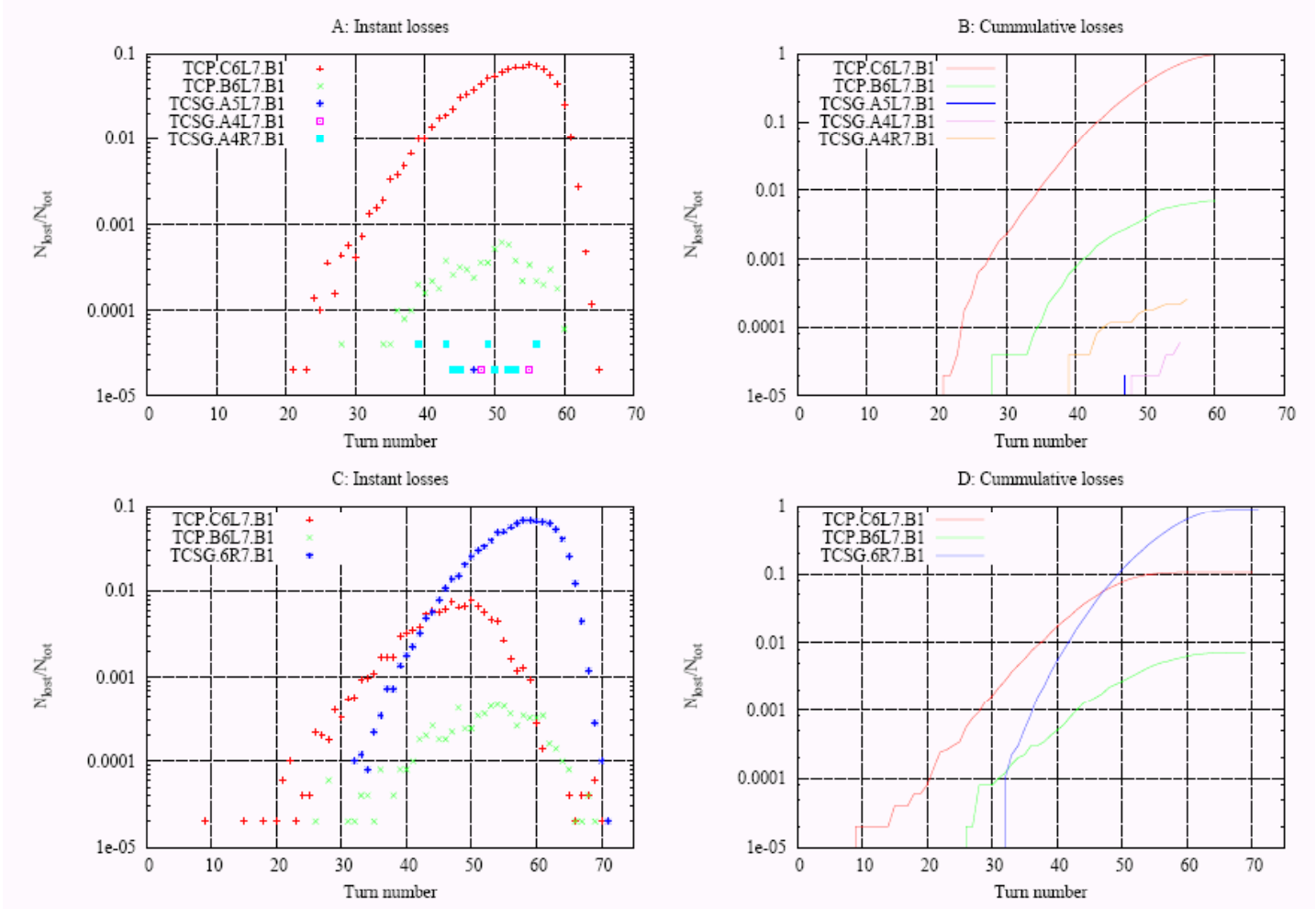
Orbit around collimators



Collimator jaw

Simulation result example

Integrated loss on the collimators during powering failures



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Phase II Collimation

- Phase II collimation may lead to an increase of the stored energy by a factor 10 or more.
  - Phase II primary and secondary collimators must be robust.
  - One should not count at the same time on an increase of current and a reduced impact of failures on the collimators.
    - By that time we will have experience with MP at the LHC, but it is not evident that it allows relaxing robustness.

- Integrated BPMs.
  - Excellent for positioning the beam and ensuring jaws are centered.
  - One should consider:
    - upgrading the secondary collimators behind the TCDQ absorbers to improve the protection against asynchronous beam dumps.
    - the possibility of defining a fast interlock on the beam position inside the collimators.

Summary

- The LHC MPS relies heavily on (robust) collimators for passive protection and as interceptors in case of uncontrolled beam loss, even more so when the intensity will go up with phase II.
  - Collimators define the aperture !
- To be sure that a collimator is robust experimental validation is more than an asset!
  - Test facility would be of interest to many people, and not just at CERN.
- The integrated BPM solution should be contemplated for the collimators at the TCDQ (+ TCDQ itself…) and to develop a fast interlock on the beam position (at least for selected jaws).