Review of Proposed LHC Collimation Work in DS for 2012

chaired by Steve Myers (CERN)

Thursday 08 July 2010 from **09:00** to **15:30** (Europe/Zurich)
at CERN (160-1-009)

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09:00 - 09:20	Project Overview *20'* Speaker: Ralph Assmann (CERN)	
09:20 - 09:30	Discussion *10'*	
09:30 - 09:45	Expected gains from 2012 Work *15'* Speaker: Stefano Redaelli (CERN)	
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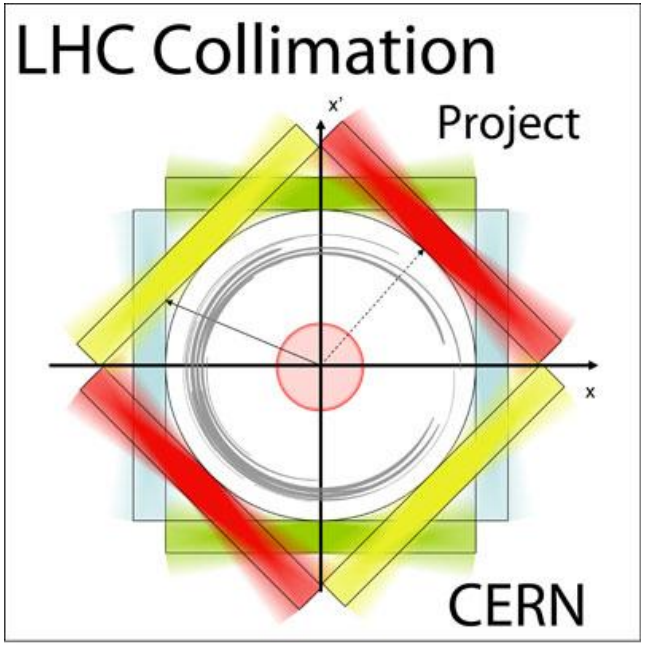
Charge

- Review the overall priorities and the schedule defined in the LHC collimation project.
- Review the work in the dispersion suppressors, proposed for 2012.
- Take a decision on starting the work for a 2012 collimation upgrade in IR3.
  - Upgrade of DS.
  - Installation of vertical collimators into IR3 warm part.

Project Overview



R. Assmann, CERN

8/7/2010

Review on 2012 DS Work

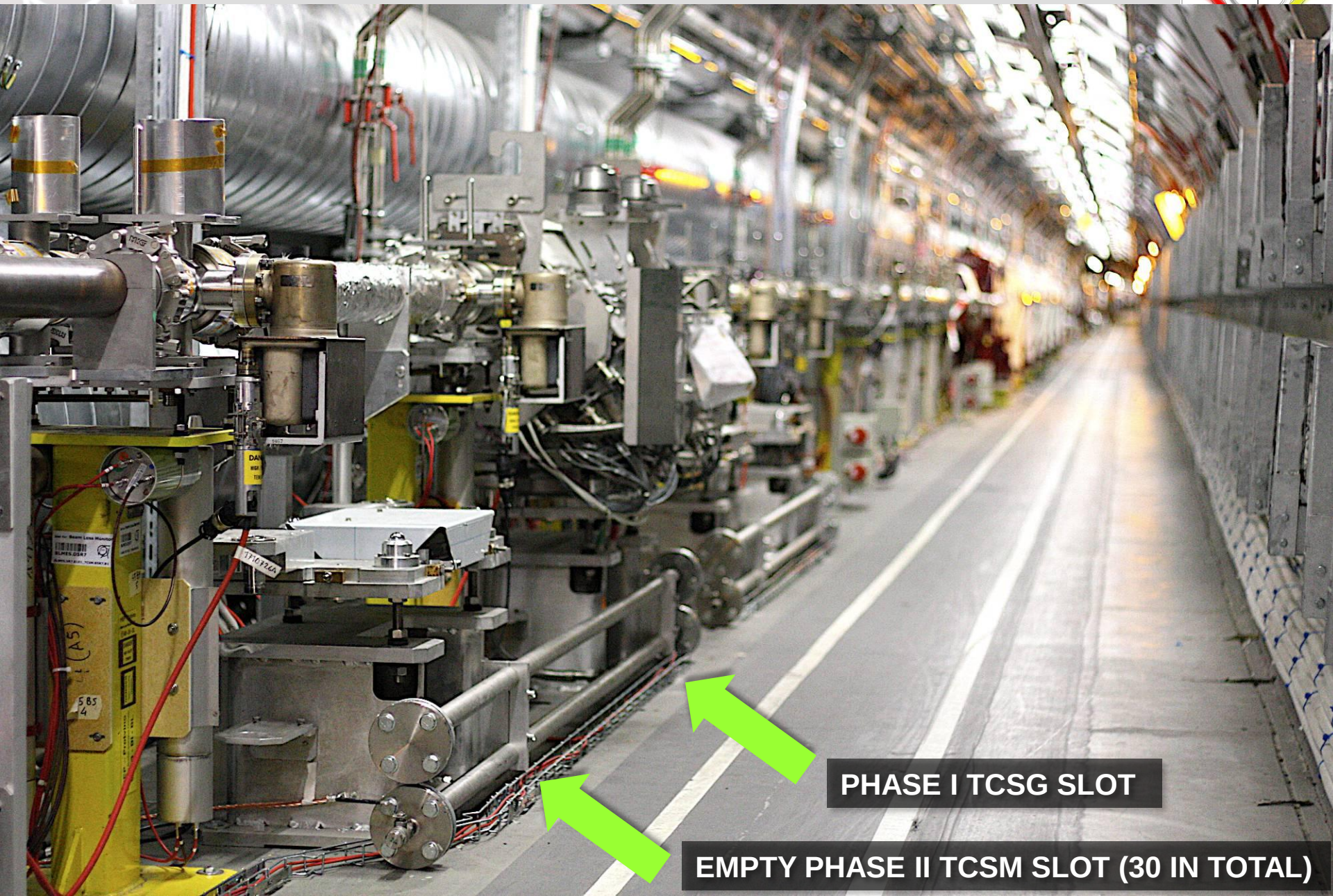
Acknowledgements

- I am very glad we are here and are having this review today (no matter what decision is taken in the end).
- This was made possible by the **hard work of many colleagues**:
  - Thanks to the project engineers A. Bertarelli and O. Aberle.
  - Thanks to V. Parma and J.P. Tock for giving crucial TE support.
  - Thanks to T. Weiler, A. Rossi, S. Redaelli, J. Jowett, D. Wollmann, G. Bellodi, F. Cerruti, V. Vlachoudis, V. Boccone, E. Metral, N. Mounet, … for studies
  - Thanks to all members of the technical WG led by V. Parma and A. Bertarelli: Delio Duarte Ramos, Thierry Renaglia, Rob Van Weelderen, Vincent Baglin, Alessandro Masi, Katy Foraz.
  - Thanks to group leaders involved: R. Folch, R. Losito, L. Rossi, O. Bruening, M. Lamont, M. Jimenez, …

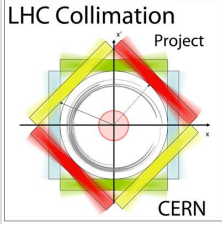
Introduction

- Collimation project put in place by S. Myers and E. Chiaveri in 2002 to find & implement adequate solution for LHC collimation.
- Goal: "**Best possible system for LHC startup, upgradeable to reach nominal and ultimate performance**" → no change in SC areas allowed!
- Highest priority on system robustness and radiation hardness. Compromises on impedance, cleaning efficiency, remote handling, advanced operational diagnostics, air activation, … accepted.
- Collimation construction included tunnel preparations for advanced collimators (~5 MCHF investment).
- Collimation upgrade started as R&D project in 2008, supported by new initiative funds and EU grants.
- Decision on construction envisaged after first LHC beam experience.
- **Now it is time to decide on construction if we want this upgrade in place for ~2015/6.**

Collimation is Designed for Upgrades!



Overall Collimation Plan



Interim collimation system (2013 – 2015)

Inefficiency: 0.002 %

β^* ~ 1 – 2 m

Gain ~100 in R2E (IR7→IR3)

$L \leq 5 \times 10^{33}$ cm^{-2} s^{-1}

> 2 days per setup

Full collimation system (2016 onwards)

Inefficiency: 0.0004 %

β^* ~ 0.55 m

L not limited

30 s per setup

2015/16 shutdown

2012 shutdown

Initial collimation system (2009 – 2011)

Inefficiency: 0.02 %

β^* ~ 2 m

R2E limits in IR7

> 4 days per setup

Details presented in past LMC's, Chamonix, external collimation reviews, CERN Machine Advisory Committee, …

Not repeated here!

Interim Collimation 2013

1. **Collimation upgrade in IR3 dispersion suppressors** to capture p losses due to single-diffractive scattering and to capture ion losses (removes highest predicted and highest measured loss).
2. **Collimation upgrade in IR3 warm insertion** (10 vertical collimators added) to add flexibility for relocating losses from IR7 to IR3 (SEE limitations).
3. Prepare work for 2015/16 collimation upgrades.

Gain: Hope to reach nominal intensity and up to half nominal luminosity. Lower complexity. Smaller horizontal impedance. Higher cleaning efficiency.

Price to pay: Twice larger vertical impedance, additional loss spike in IR5 and higher losses at tertiary collimators.

IR3 upgrade is an excellent step forward but no miracle solution.

Full Collimation 2016

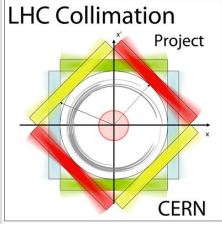
1. **Collimation upgrade in IR7 and IR2 dispersion suppressors** to capture p losses due to SD scattering and to capture ion losses.
2. **Installation of advanced collimators** (mostly into prepared empty slots) to allow non-destructive and very fast collimator setup, compatible with LHC stability and small β^* (0.55m)

   SLAC very moti… …technology chosen for … …tailed" (e-mail associate lab director B. …

Not discussed today!

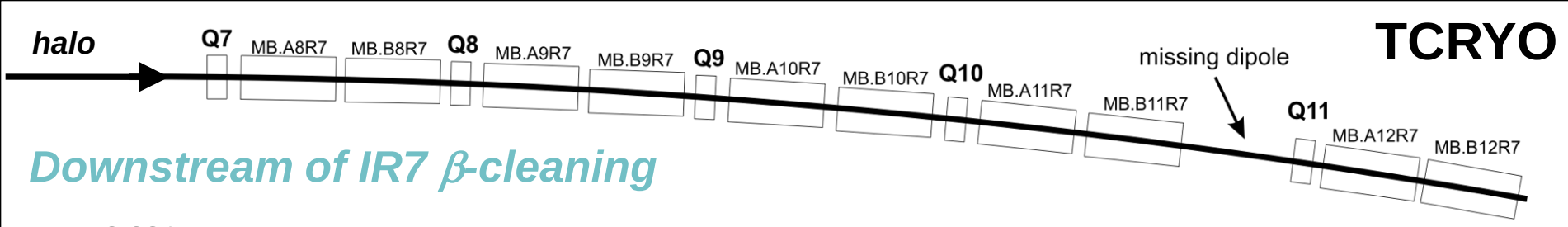
3. **Collimation upgrade in IR1 and IR5** for luminosity-induced losses from collisions (install 4 already produced Cu collimators).
4. **Collimation upgrade in IR2** for ZDC acceptance issue. EARLIER???
5. **Remote handling and air bypass** operational in IR7.
6. **Additional tungsten absorbers in IR6** dump protection system to improve local cleaning.

Dispersion Suppressor Work



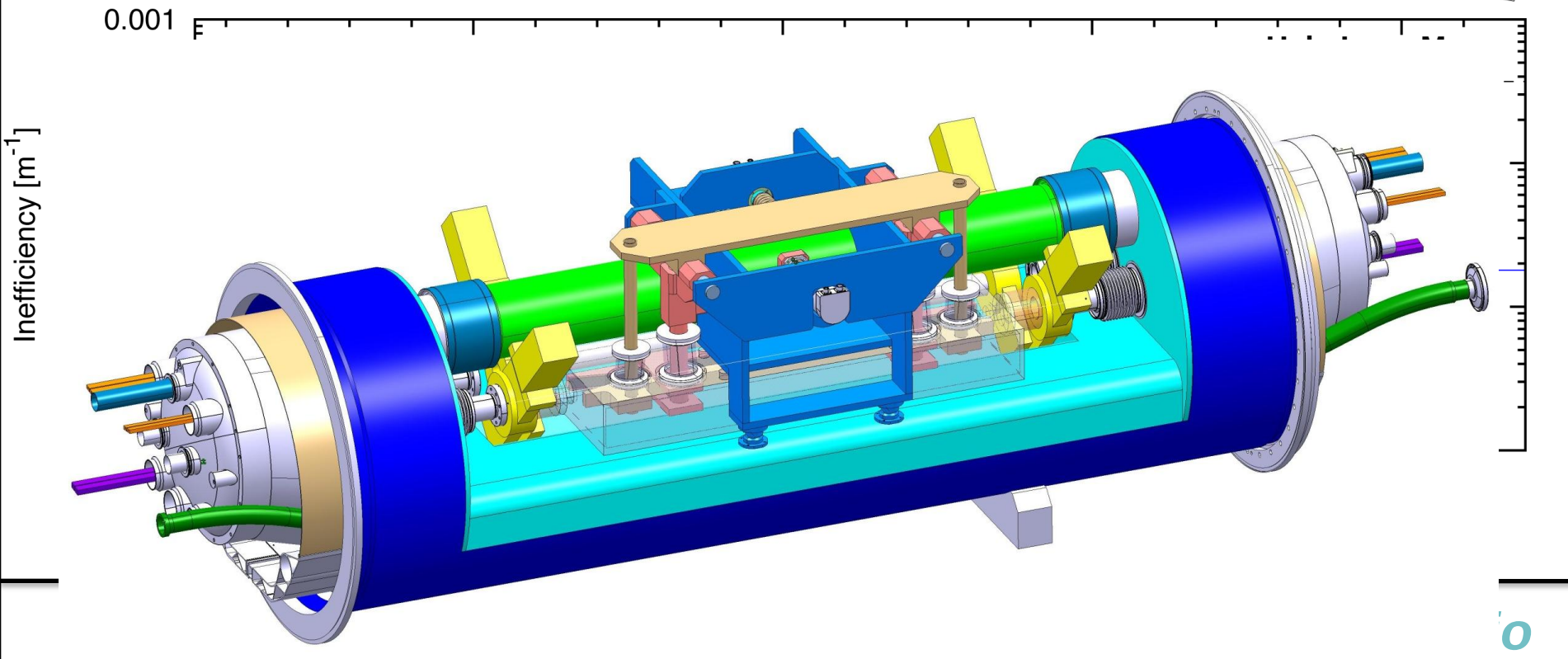
- Addresses a very **basic limitation of the LHC collimation** system: protons lose energy when hitting matter, ions dissociate and fragment!
- Could not be addressed before: collimation started very late in the game and SC areas of LHC were frozen.
- Note that this is nothing exotic: other accelerators had this (e.g. LEP2 added collimators into dispersion suppressors).
- **A solution without new SC magnets was proposed:** allows collimation readiness for nominal and ultimate beams by 2015/6 at latest (if we start).
- Other solutions are nice but would come much later (e.g. shorter magnets with collimator in front).

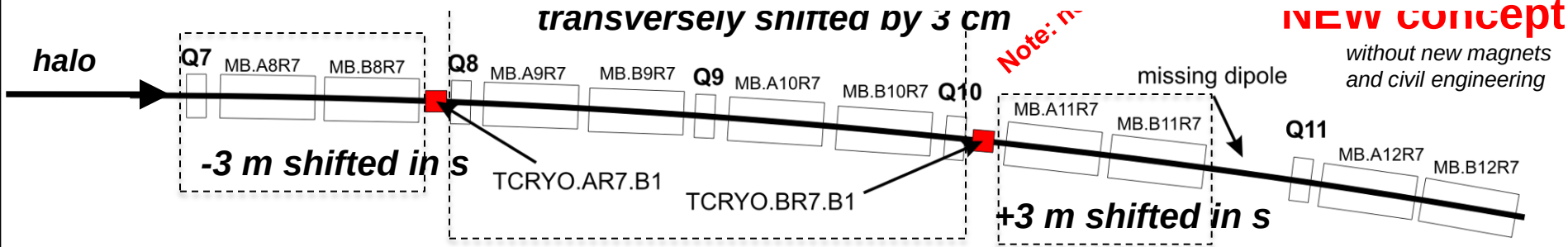
➔ What – Where – Why



TCRYO

Downstream of IR7 β-cleaning





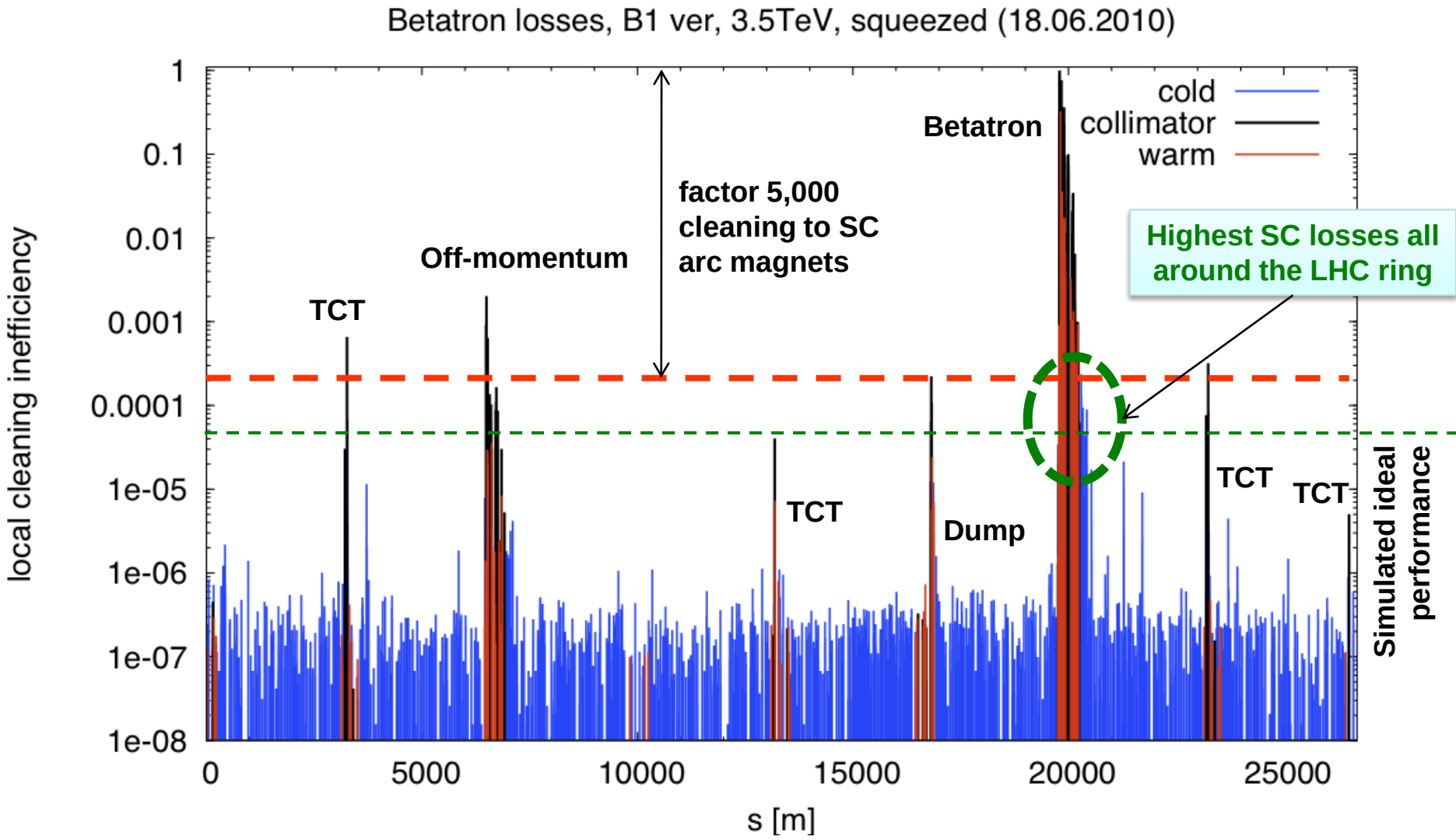
transversely shifted by 3 cm

Note:

NEW concept

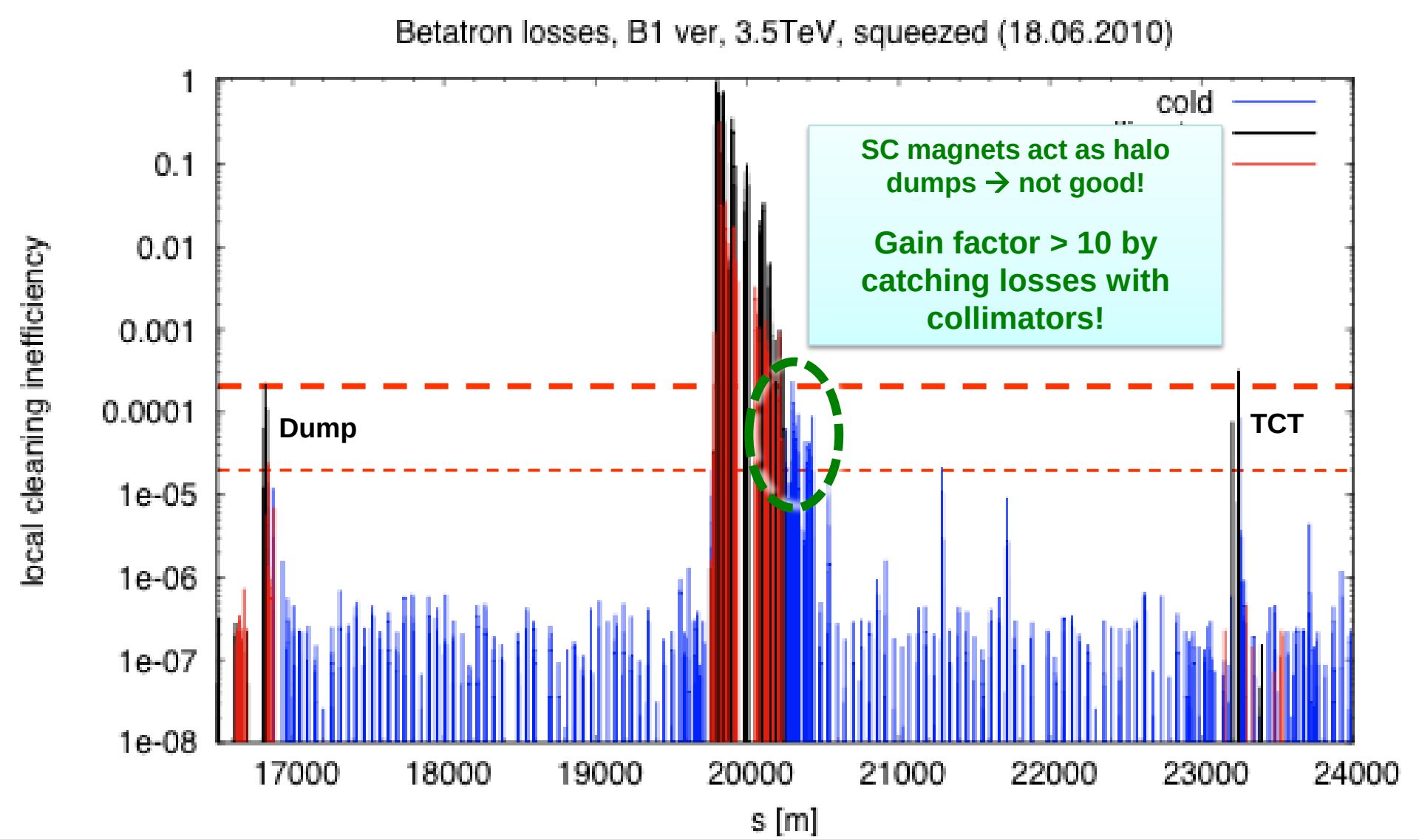
without new magnets and civil engineering

Is This a Real Problem? Look at Measurements! (Beam 1, Vertical Plane, 1.3s)



Zoom into Betatron Cleaning Region

(Beam 1, Vertical Plane, 1.3s)

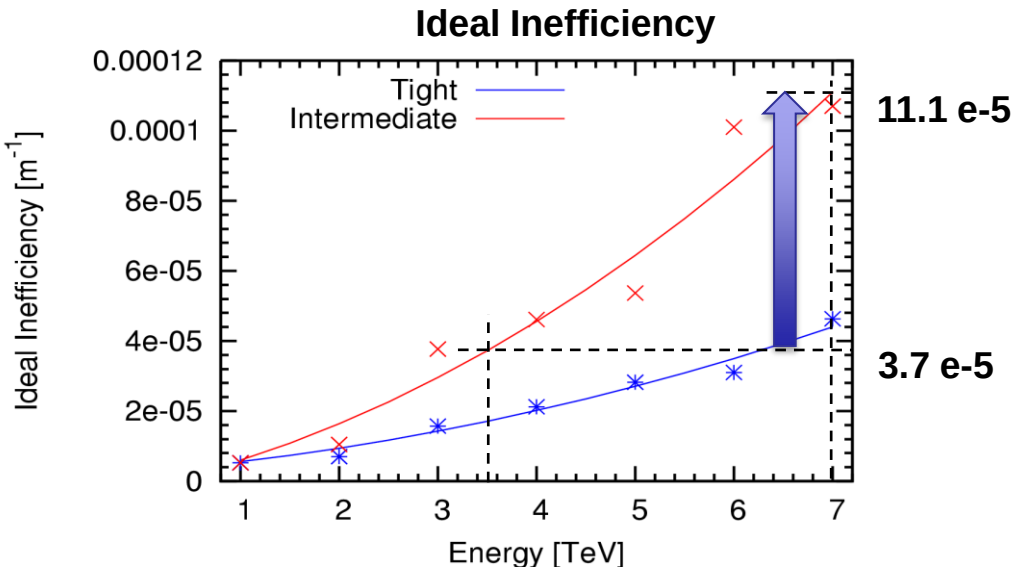


Is the LHC Cryo-Collimator Feasible?

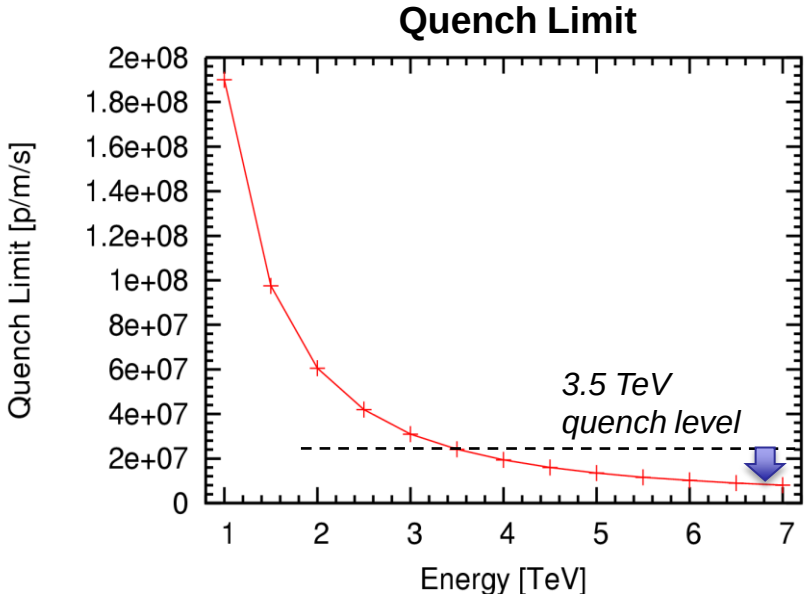
- The technical WG has identified a cryo-collimator solution:
  - Fits into 4.5 m slots.
  - Has **no visible show-stopper**.
  - Four units **can be built until November 2012**.
  - Allows to **close the cryostat by March 2013** (limited by resources).
- Accelerator physics and shower studies have been performed:
  - **Optics has been matched for 4.5 m slots** and aperture checked.
  - **LHC performance** (efficiency, impedance) has been simulated.
  - **Feasibility and important gains** have been verified (few drawbacks as well).
- **The solution is technically feasible but time is very tight.**

How Long Can We Live Without Cryo-Collimators?

- For sure not forever!
- Losses will always hit the same spots in the same magnets! SC magnets are very bad as collimators: quench, radiation damage, …
- Situation will be **much worse at 7 TeV**! Loose factor ~10.

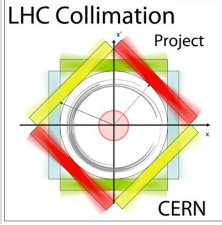


→ **Factor 3 higher leakage!**



→ **Factor 3 lower quench limit!**

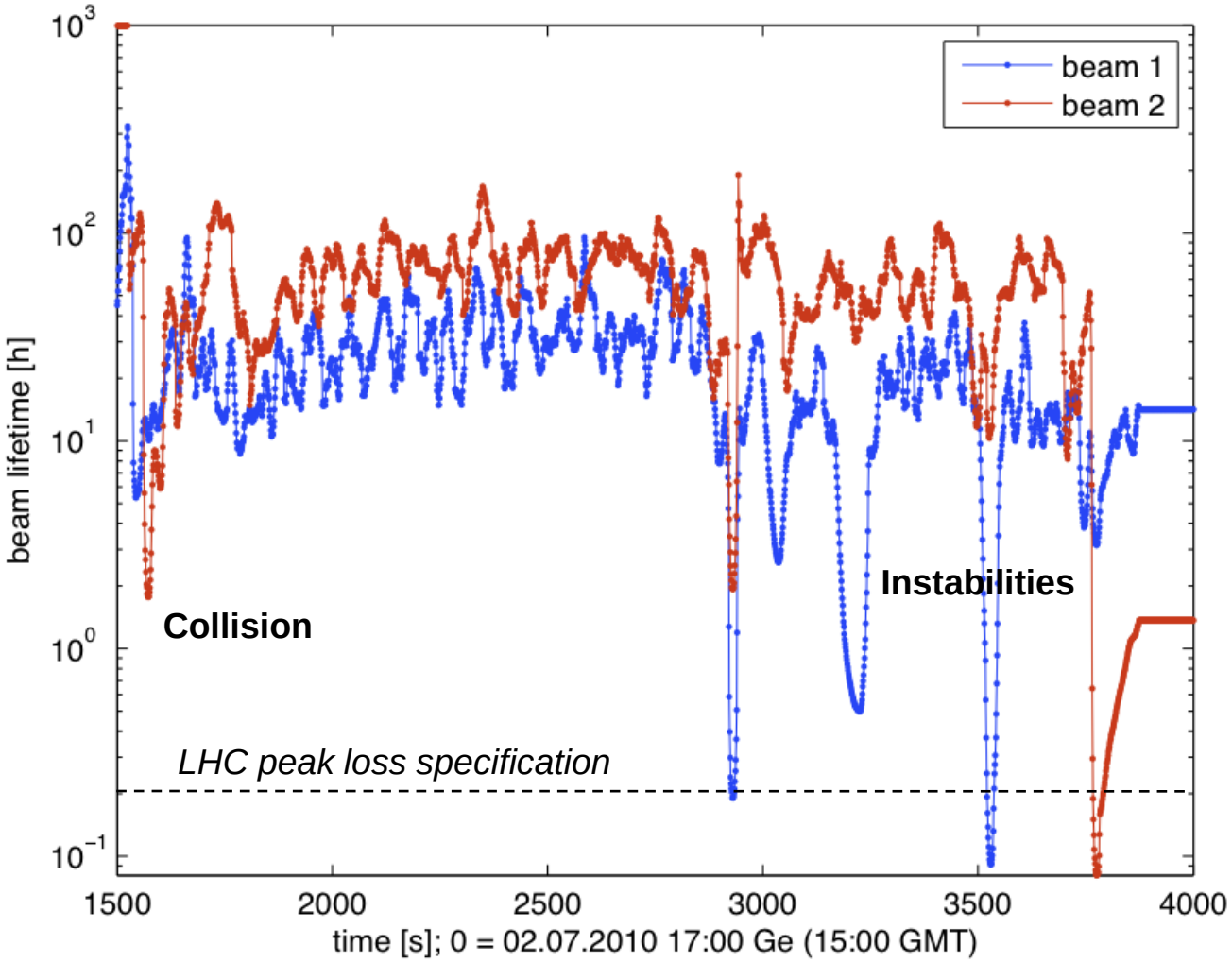
How Long Can We Live Without Cryo-Collimators?



- Depends all on assumptions on loss rates.
- **Specified maximum loss rate is 0.1 %/s** of total beam intensity (0.2 h beam lifetime for up to 10s).
- Drastic losses observed: **up to 26 %/s**.
- In every physics fill, that I looked at, we see losses above the specification during the cycle.
- Likely not better for more bunches:
  - Higher impedance.
  - Long-range beam-beam effects.
- I think nobody can predict the future losses in detail (also not me).
- Fact: **Presently we profit from the high collimation efficiency as it allows us pushing intensity much more efficiently (no quenches).**

Beam Lifetime Example

(6 nominal bunches in collision)



Note:

Lifetime calculation employs a running average.

Minimum beam life-times for short losses are overestimated by factor ~5.

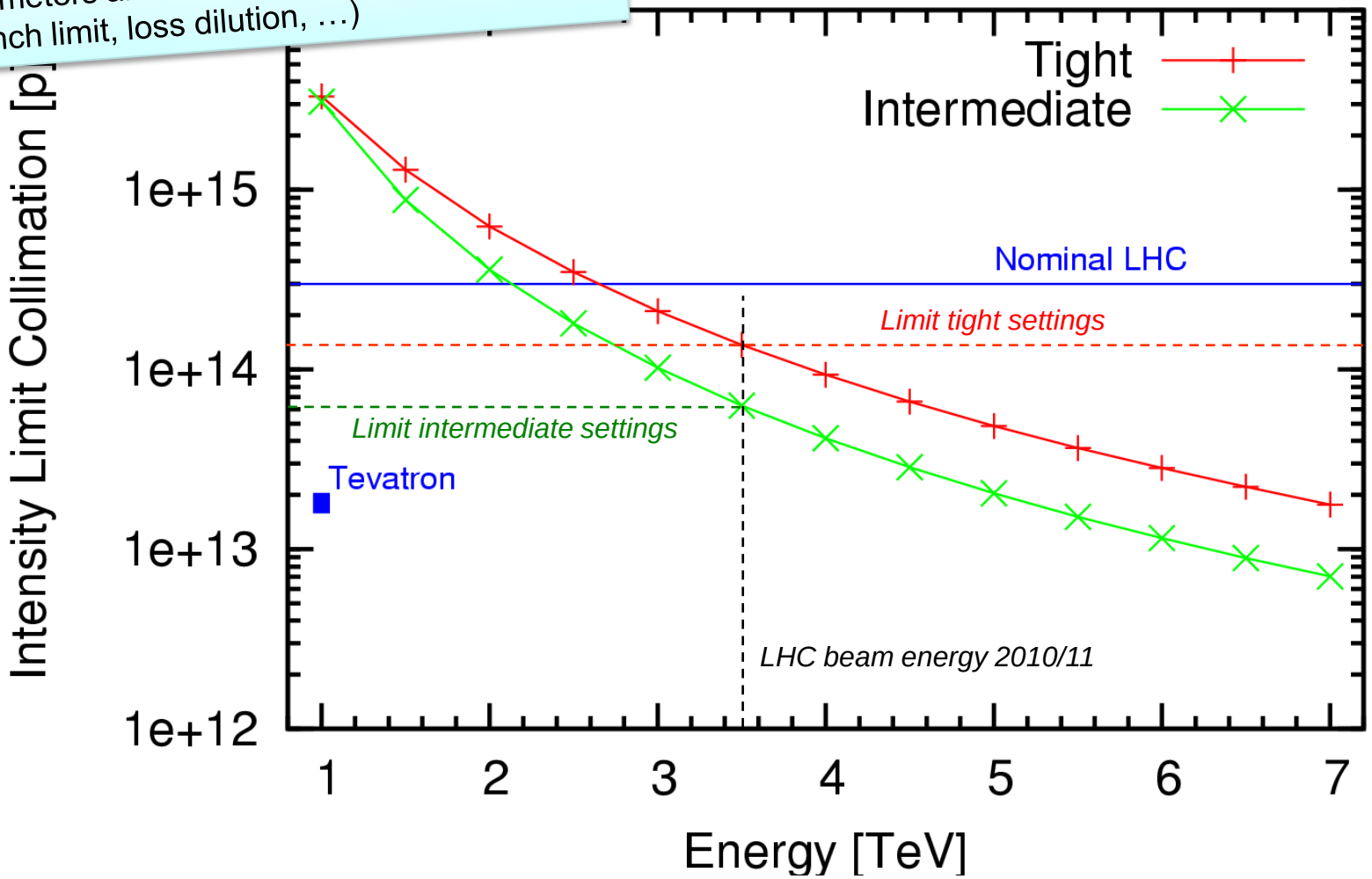
Spikes have factor ~5 lower beam lifetime!

Short but long enough to quench!

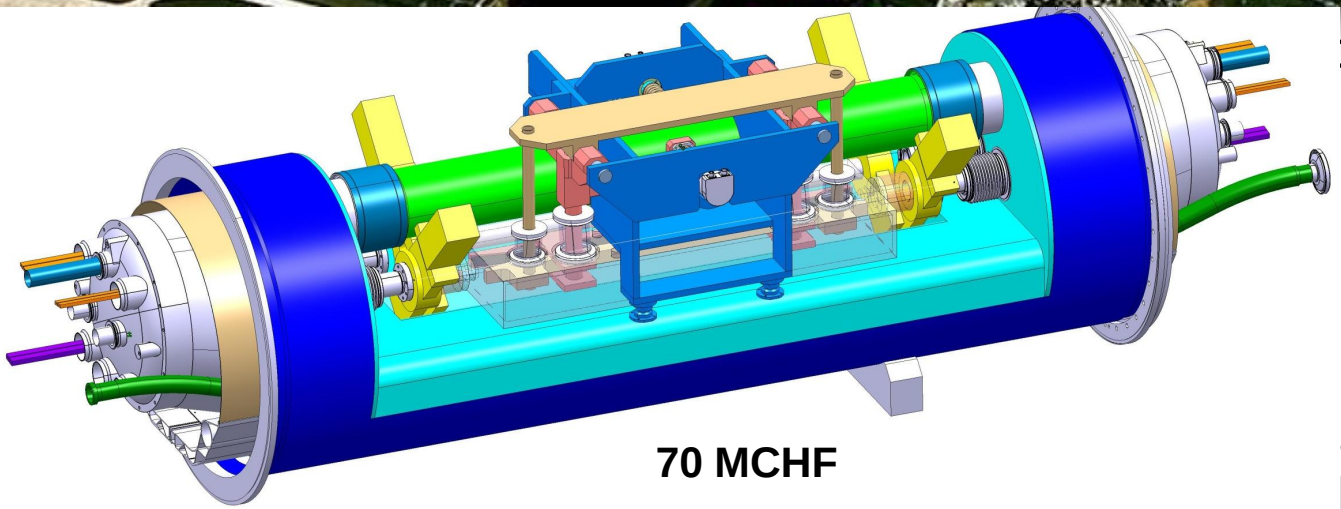
Will improve but at the same time long-range BB effects, e-cloud, higher impedance, … will kick in.

Prediction: Intensity Limit with Initial Collimation vs Energy *(LMC 19.3.2009)*

Significant uncertainties. Will improve as more parameters are verified in operation (e.g. quench limit, loss dilution, …)



Do We Need the Best Brakes?



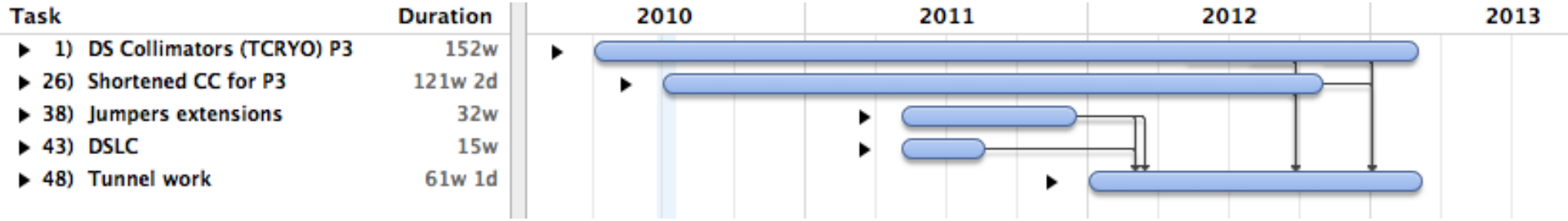
70 MCHF

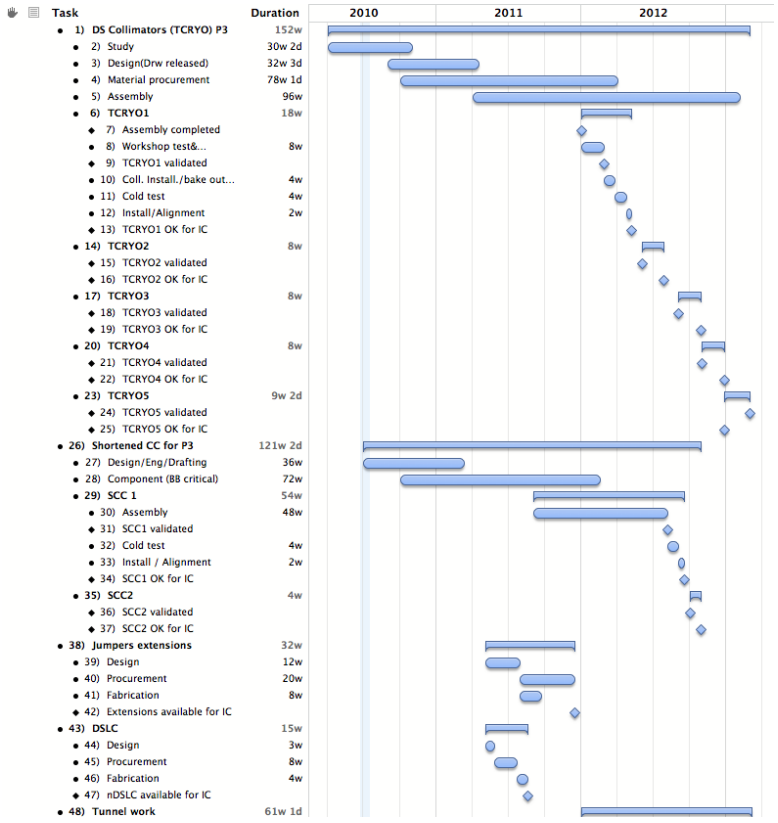
faster and safer! Do
brake!

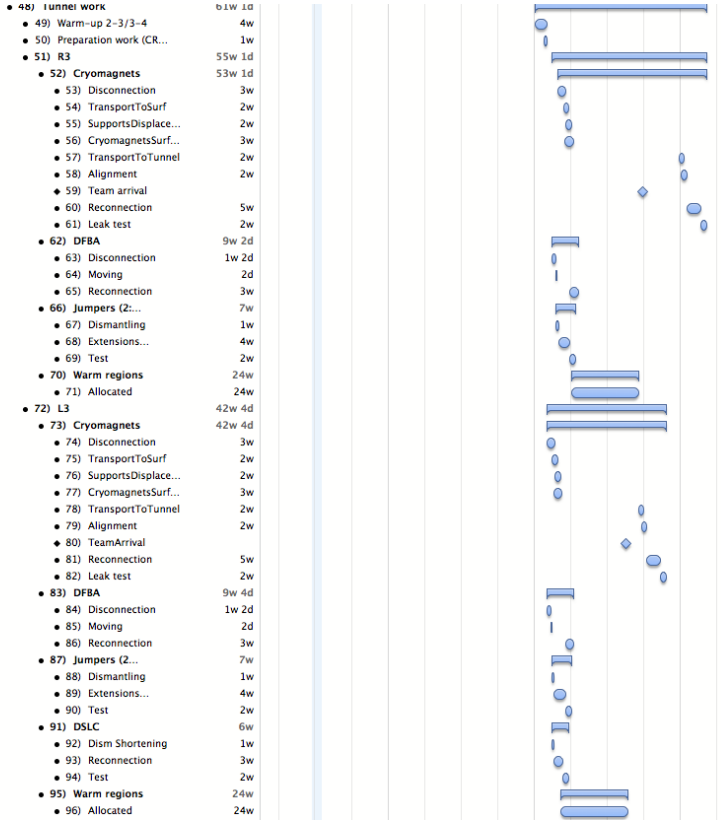
not complain but if

f the LHC except that
ar 1% of the LHC!

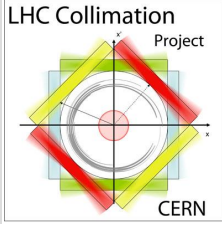
Can we do it? Possible but tight!





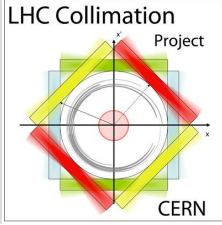


Risk Assessment



- In case we do not continue and LHC loss remains at/beyond specification:
  - Cryo-collimators will for sure not be ready for 2012/13 shutdown.
  - Risk to be limited in luminosity reach after 2012/13 shutdown: we could be ready for 7 TeV after heavy work and then deliver insufficient luminosity.
  - **Risk to limit LHC discovery potential in 2013 – 2016 due to long known collimation features (DS collimators were installed for LEP2).**
  - Risk from upgrading dispersion suppressors for 3 IR's in parallel during 2015/16!
  - Risk to do a larger than required upgrade in 2015/6 without IR3 experience.
- In case we push forward now and LHC losses can be very much reduced:
  - **Loss of resources** for design and preparation of cryo-collimators. Installation plans can still be stopped in Summer 2011 (one year from now).

Possible Impact from IR3 Experience on Overall Collimation Plan



- Parts of the collimation upgrade plan must in any case be implemented:
  - IR collimation upgrades for high luminosity in 2015/6
  - IR6 improvements in 2015/6
  - IR2 dispersion suppressor upgrade in 2015/6 for ion luminosity
  - Advanced collimators for non-destructive and fast setup in 2015/6
- However, the IR7 upgrade details might be strongly affected:
  - **Maybe IR3 can take over parts of IR7 functionality permanently?**
  - Less or no losses in IR7 could avoid need for remote handling, air duct, air conditioning, replacement of warm IR7 magnets, replacement of IR7 collimators (due to radiation damage), …
- **The early 2012/13 implementation of an IR3 upgrade will give time to explore the performance reach with this system and to minimize IR7 work!**

Our Proposal

1. Decide to move ahead for collimation upgrade in IR3 dispersion suppressors as fast as possible. Implement the warm collimator solution.
2. Decide to move ahead for upgrade of warm IR3 insertion with vertical collimators.
3. Decide to start designing, prototyping and building required hardware.
4. Agree on goal to achieve readiness for 2012/3 installation. There is hope but we cannot guarantee it.
5. Agree on decision date for actual installation in Summer 2011. This decision will take into account operational experience in 2011.
6. Decide on ALICE request for 2012/3 upgrade of IR2 collimation (2 additional collimators).

➔ **Decisions are now required. No decision is the same as a no!**

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