HL-LHC Technical Committee
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Collimation strategy for active halo excitation at LHC and HL-LHC

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on behalf of the WP5 team

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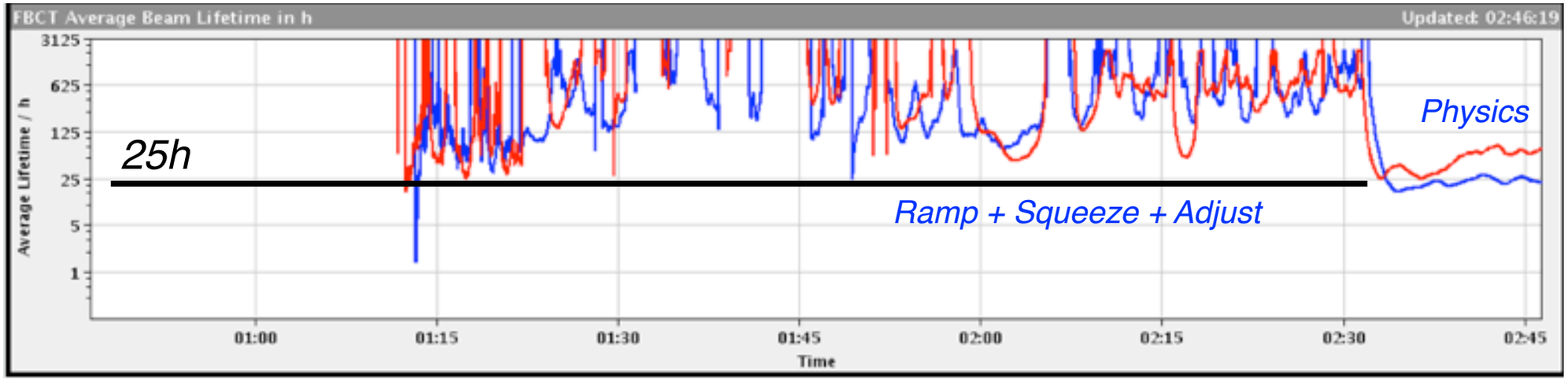
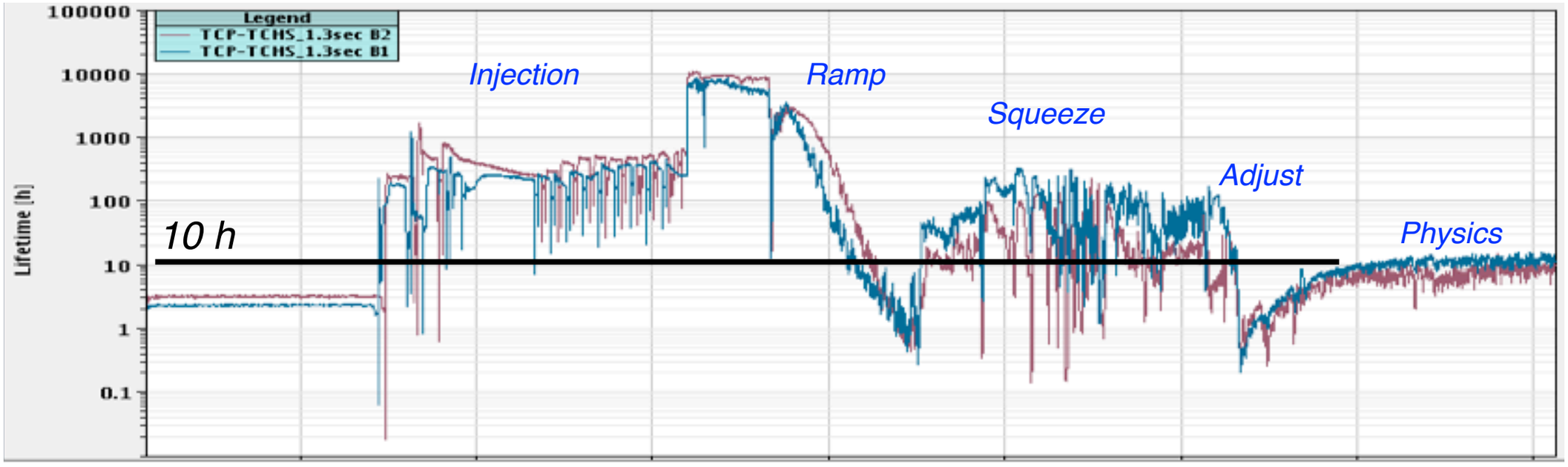
Outline

- Introduction
- Motivations for active halo control
- Hollow e-lens strategy
- Alternative methods

Introduction

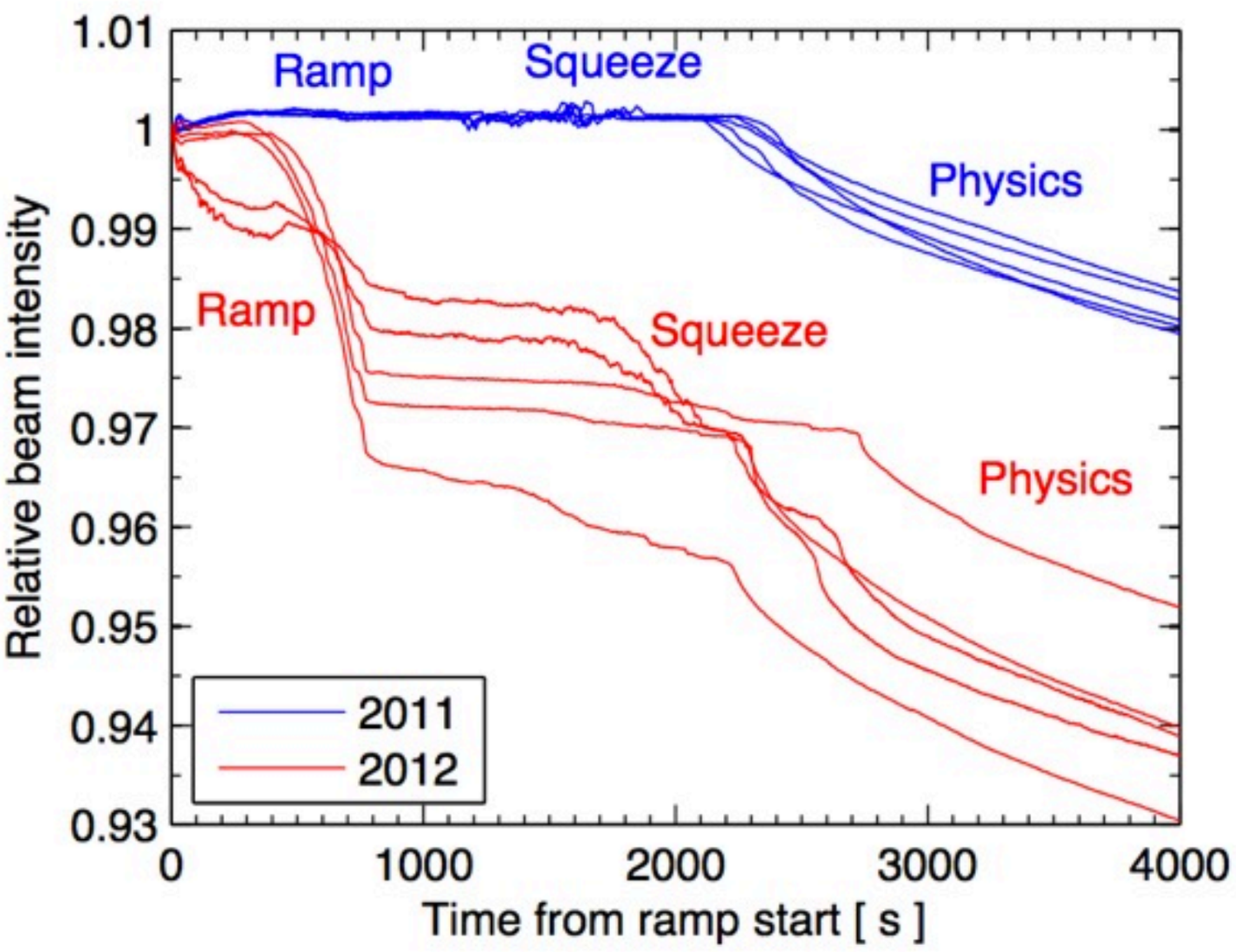
Couple of illustrative examples taken randomly from the LHC elogbook...

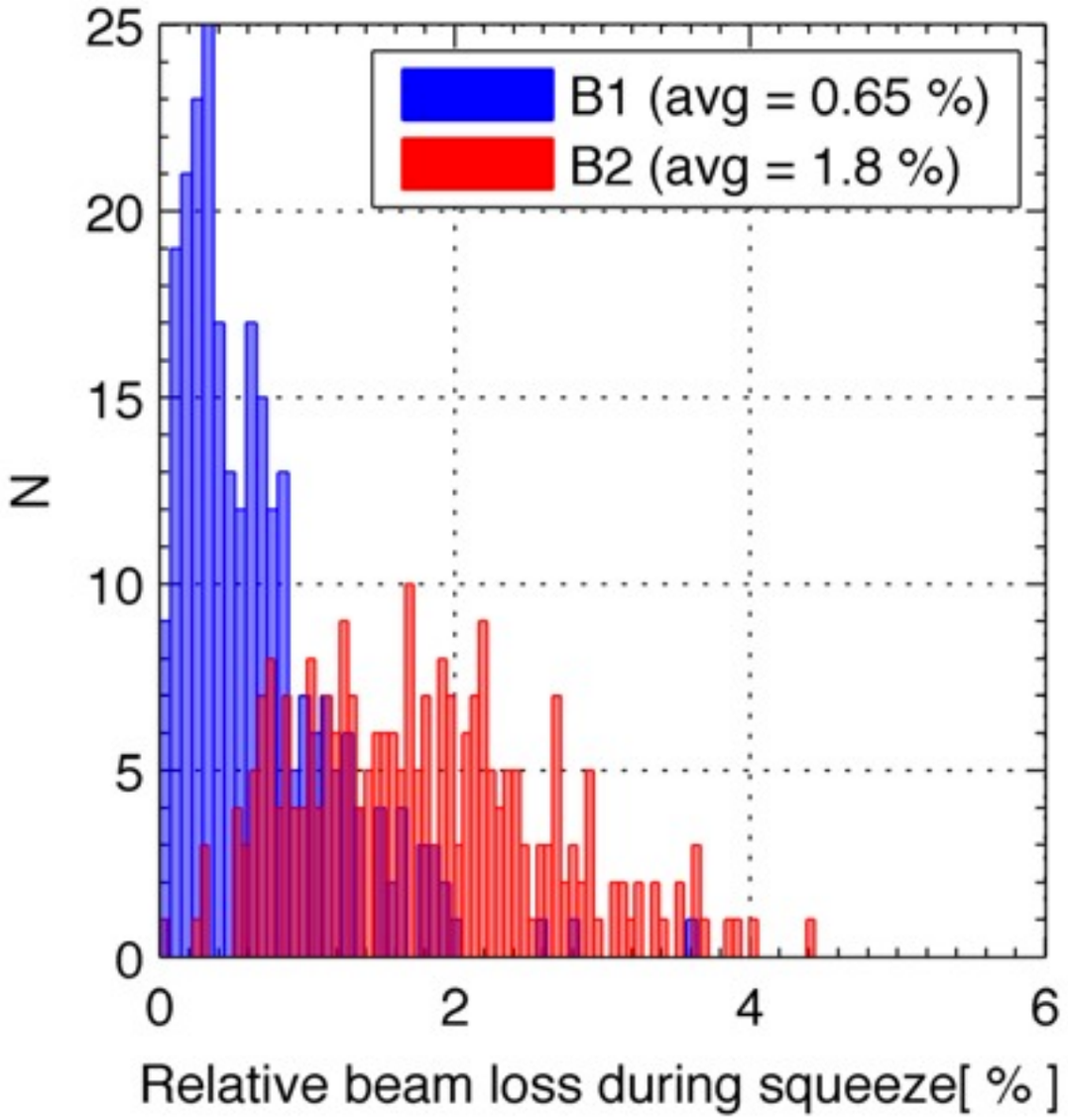




- How will these losses scale at higher energy/intensity (25 ns)?
- Can this be an issue even if we have enough quench margin?
- What other constraints apply for the HL-LHC operation with crab-cavities?

Introduction





- ☑ How v
- ☑ Can t
- ☑ What

The beam losses during operational cycle affected most colliders.

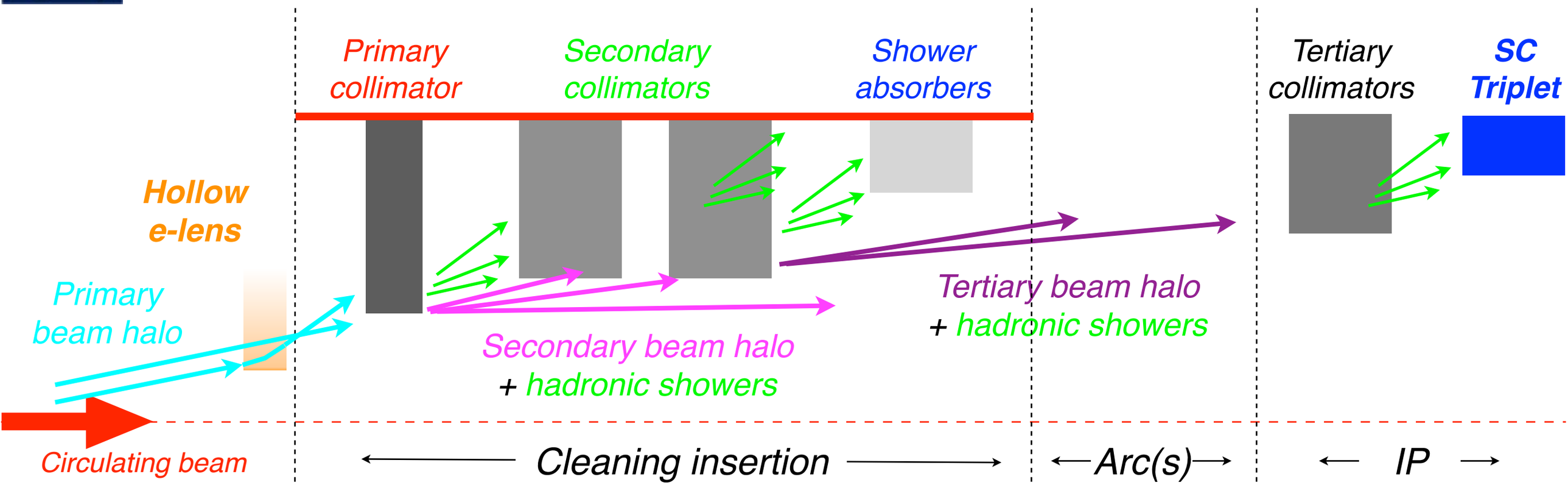
Collimation reviews in the past consistently warned about loss spike!

*Last year's review recommended to pursue **hollow e-lens studies** as a way to mitigate the effects of beam losses.*

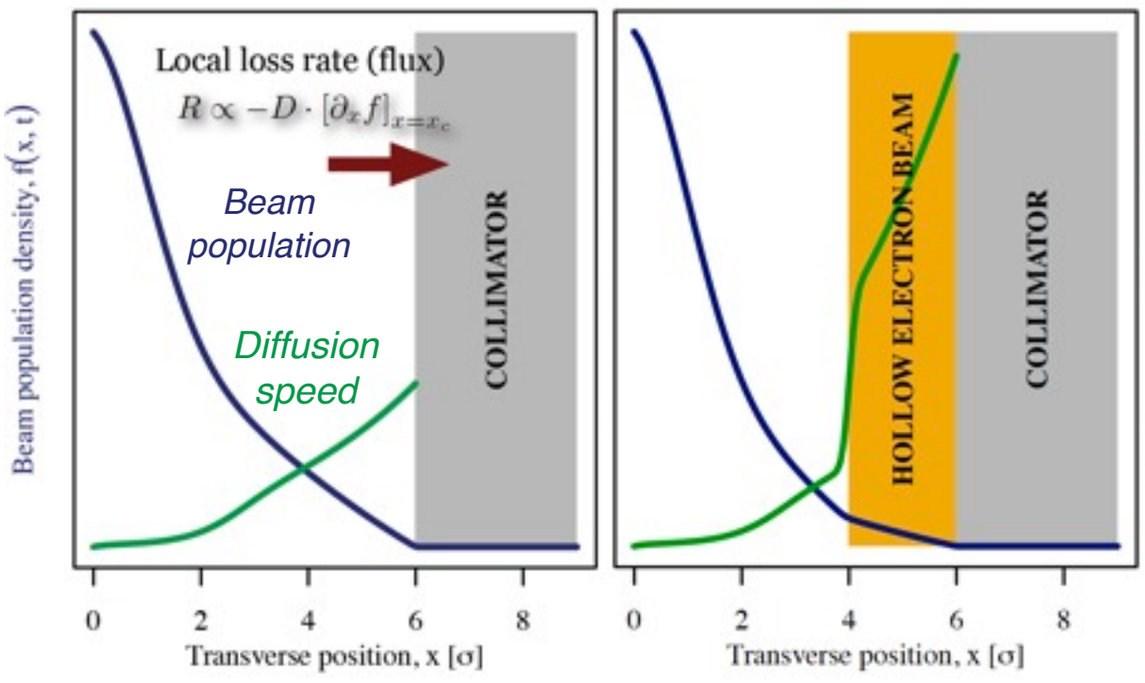
Motivations for active halo control

- **Improve the present LHC collimation:**
  - *Control the flux of primary protons on the collimators, without affecting the beam core;*
  - *Mitigate sudden drops of lifetime (lose halo particles "when we want");*
  - *Reduce the peak loads on the collimators!*
  - *Reduce sensitivity of loss spikes on orbit jitters.*
- **Complement active machine protection techniques for operation with crab-cavities (HL-LHC)**
  - *Control of transverse halo population at amplitudes above 3-4 sigmas deemed crucial for the single-turn failures.*
- **Other potential usages [hollow e-lens only]**
  - *Changing gun types would allow several types of beam manipulations.*
- **Important questions / caveats**
  - ***Do we really need it?*** → *Need to study the post-LS1 performance!*
  - *What validations with LHC beams are required?*
  - *What can we test / deploy before LS2 in case of problems?*
  - *What are the requirements for HL-LHC*

Example: hollow e-lenses



Illustrative scheme



Hollow electron beams allow to selectively (by transverse amplitude) control particle's diffusion speed and halo population.

Alternative methods can also provide, on paper, a similar functionality.

(Recent) timeline for hollow e-lens

- **CERN review in Nov. 2012**

  Brought up technical aspects for installation in LHC or SPS.

- **HiLumi annual meeting in Frascati, end of Nov. 2012**

  Strong message about CERN interest to pursue this option in the future.

- **End of 2012**

  Hollow e-lens item into the US-LARP list of topics (item under observation)!

- **End of Jan. 2013**

  CERN internal executive meeting to propose a strategy based on the technical input of the the review. Decided not to take the Tevatron HW.

- **March 2013**

  Presentation to HLTC and proposal of working plan.

- **April 2013**

  Present CERN strategy to US-LARP CM20 to steer USA contribution.

- **December 2013**

  First draft of CDR by FNAL team

- **May 2014**

  CERN visit to FNAL: HW and engineering teams in contact

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Rationale:
- Convincing experience exists → effort to have MD's at the LHC not justified (installation of FNAL hardware had major impact on LHC cryogenics);
- IF needed after LS1, needed for both beams!
- Available resources better invested in the design of an LHC-optimized device!

Focus of future studies:
- Have a solution for implementation in LS2 (if proved necessary)
- More optimized solutions for the HL-LHC (LS3 implementation)

CERN strategy as of US-LARP-CM20

CERN strategy

Taking into account the present financial situation and the manpower commitment to the LS1 activities, CERN cannot decide now on the installation of the available Tevatron hardware in the SPS or the LHC.

This also takes into account that firm indications of LHC critical performance limitations without scraping, can only become apparent after some operational experience at energies near to 7 TeV.

Rephrasing: Design and engineering specification, possible component test, to be ready for an optimized solution for LS3.
In case of emergency, even for LS2. Adaptation of Tevatron TEL2?

- **Design** of a device optimized for the LHC at 7 TeV (improve integration into the LHC infrastructure and improve instrumentation).
- Actively **participate** to beam tests worldwide on this topic.
  Specifically, CERN endorses the setup of hollow e-beam tests in RHIC.
- Start building **competence at CERN** on the hollow e-beam hardware.
- Continue working on **alternative methods** for halo scraping.
- Work with very high priority on **improving the halo diagnostic** at the LHC.

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Recent updates and comments

- See also a recent ColUSM: *http://indico.cern.ch/event/309889/*
- **FNAL** produced a very satisfactory conceptual design report:
  https://cdcvs.fnal.gov/redmine/documents/683
  "Solid" design based on state-of-the-art (parameters not pushed).
- **EN/MME** will participate to these studies by providing the necessary engineering support - D. Perini as "technical coordinator".
- Ongoing simulation effort with the **ABP collimation team** - see next talk.
- Strong synergy with **BE/BI**:
  Ultimate "hardware owner" of the holl
  Set-up a test stand for e-beam, together with ELENA cooler.

We are on a good track along the plans proposed at this meeting 1 year ago, but much work is still ahead!

- We have organized a **visit** to FNAL before the CM22 to get the hardware and simulations teams at CERN and FNAL in contact!
  Will also discuss RHIC beam tests to address LHC-issues.
  Synergy with the beam-beam long-range compensation: e-beam wires?
- **BUT**: - *Hollow e-lenses can be part of the HL baseline but cannot be implemented in the LHC before LS2!*
  - *In case of problems in the post-LS1 operation (quench limits, lifetime, losses on collimators...), we need **alternative solutions**!*
  - *IF alternatives prove to be equivalent (no core blow-up, equally selective by transverse amplitude,...), they can be taken as baseline.*

Alternatives

- **Two alternative methods** were proposed:
  - *Tune modulation;*
  - *Narrow-band excitation with the transverse damper.*
- We need to address these methods urgently because they might be the **only viable options** for deployment before LS2.
- At our review in Nov. 2012, several **potential drawbacks** of these methods were brought forward in comparison to the hollow e-lens (more details by Roderik):
  - *Can they really leave the beam core untouched?*
  - *Can they be equally "selective" in transverse amplitudes?*
  - *Can we equally well distinguish beams and planes?*
  - *Do we know the bunch-by-bunch tunes well enough, in particular during dynamics machine changes?*
- It is clear that alternative methods must be thoroughly assessed by beam tests at the LHC after the startup in 2015!
- We are working on defining the hardware parameters and scenarios for beam tests in 2015.
  Two "pillars":
  - Simulations: comparatively assess the three methods with the same tools.
  - Measurements: what can we still do in LS1 to ensure that MD's are possible.