6th HL LHC Parameter and Layout Committee
September 3rd, 2013
CERN, Geneva, Switzerland

Outcome of collimation review and update on upgrade plans

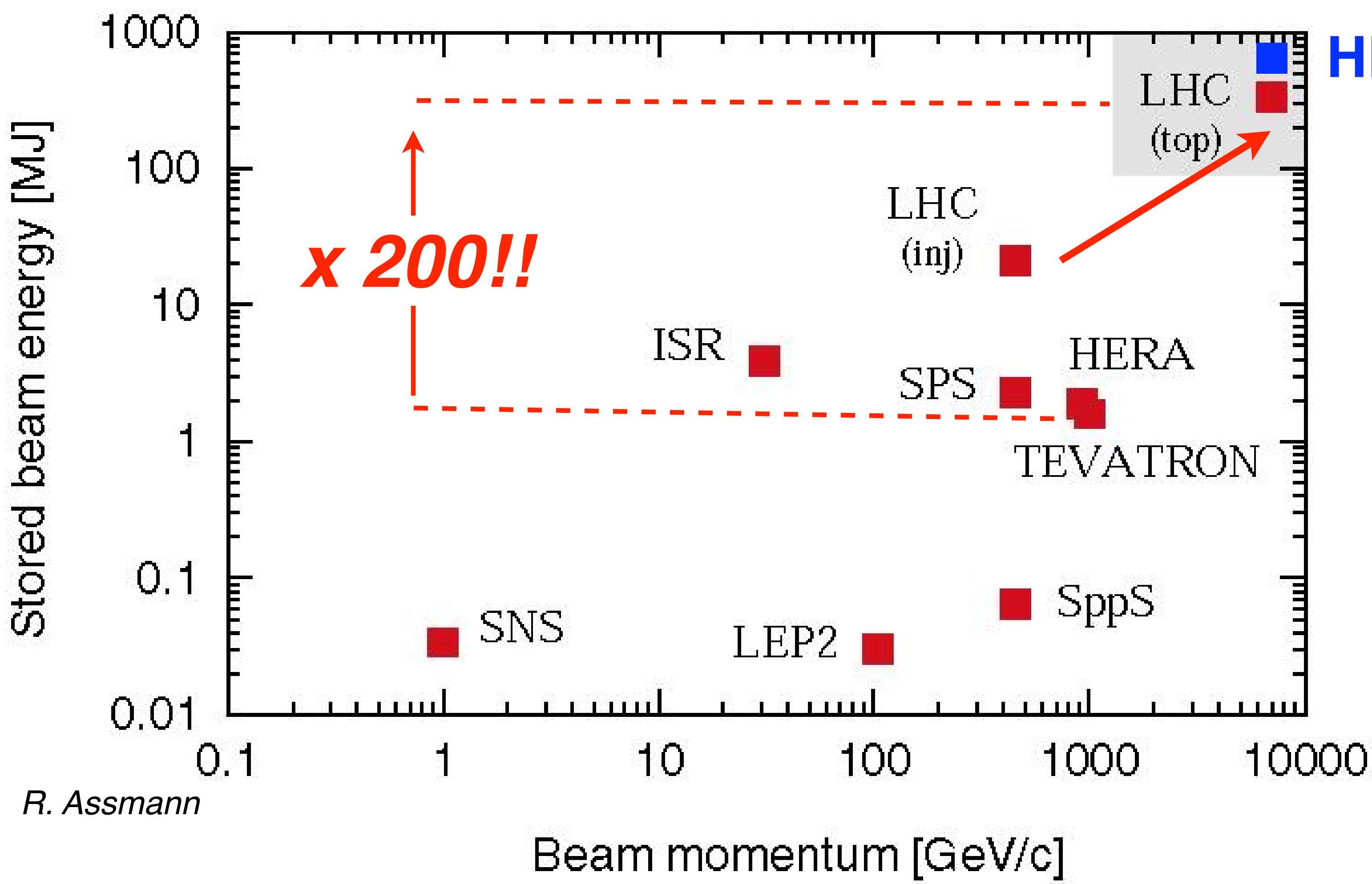
Stefano Redaelli, BE-ABP
on behalf of the LHC Collimation Project team

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

Outline

- Introduction
- Review: scope, agenda, highlights
- Review outcome
- Additional upgrade items
- Conclusions

Introduction



Beam collimation has been considered one of the most critical aspects for the LHC

- Cleaning challenge vs quench
- Big system (OP efficiency)
- Small gaps challenge, impedance

The operational experience at ~1/2 the nominal energy is very good: Cleaning and aperture are very good (as nominal), the machine is stable (1 alignment per year), the magnets almost unquenchable!

Why we still need to worry about collimation for post-LS1?

➛ *Collimation external review organized to ask feedback about a dispersion suppressor (DS) collimation.*

Scope of collimation upgrades

- Improve the **cleaning performance**
  - *- System limitations: dispersion suppressors (DS's)*
  - *- Advanced concepts for halo scraping and diffusion control; crystal collimation.*

→ Focus of May 2013 review

- Improve cleaning of **physics debris**
- Improve **impedance** and **robustness**
  - *- State-of-the-art new material and new designs for secondary collimator jaws*
  - *- Improved robustness at critical locations (like TCTs)*
- Improve **operational** efficiency / machine protection aspects
  - *- **Better beta* reach**, faster collimator alignment;*
  - *- More flexibility for machine configurations (experimental regions).*
- Improve protection of the **warm magnets** in cleaning IRs.
- Be ready to replace **collimators** if they brake or age
  - *- The hardware is designed for 10 y lifetime*
- Achieve **remote handling** in high radiation environment
  - *- Quick collimator replacement in hottest LHC locations*
- **New layouts** in experimental regions for **HL-LHC**
  - *- Re-think IR1/5 collimation*
- New injection / dump colli

Reminder: critical collimator upgrades might have to take place already in LS2!

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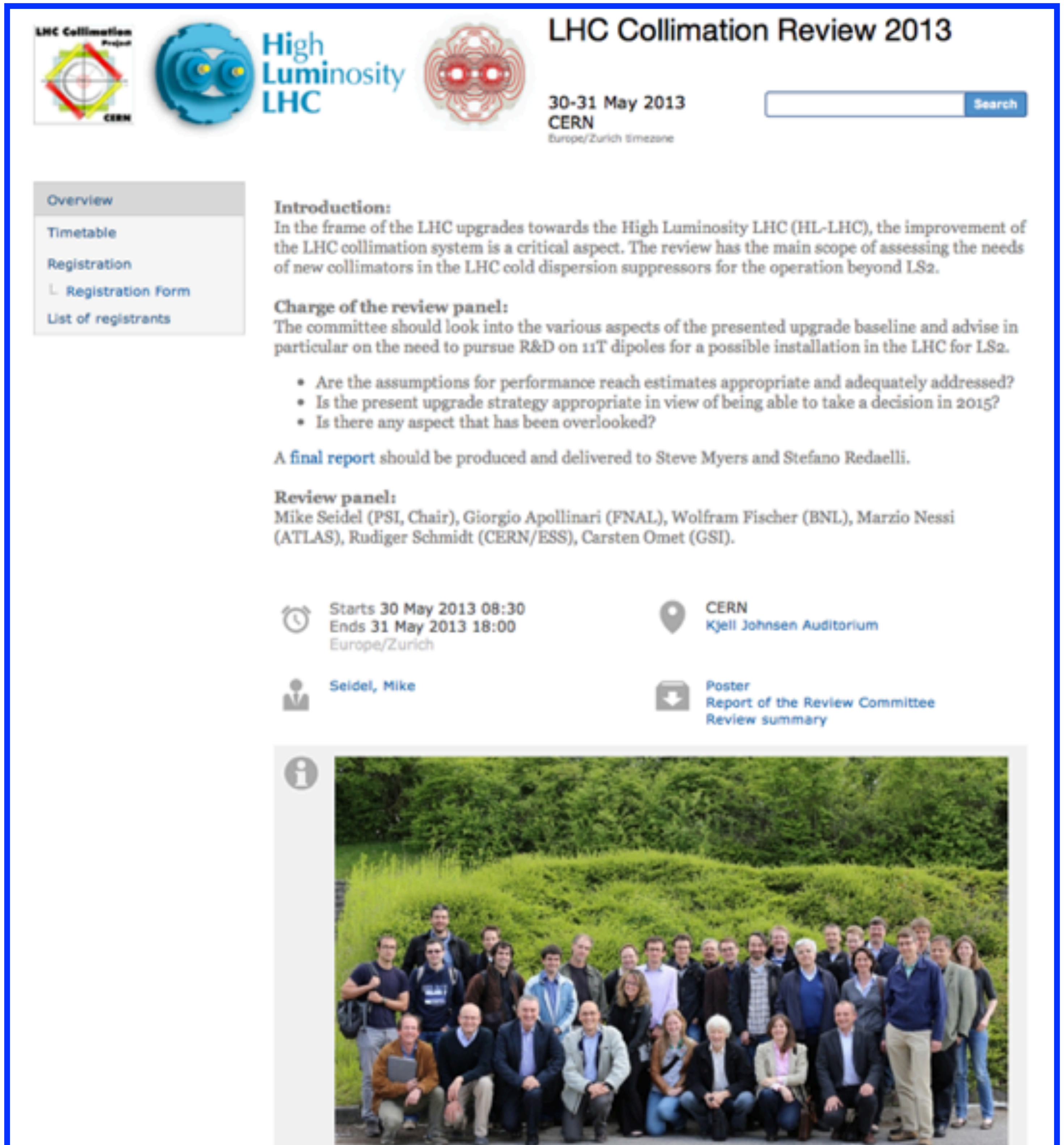
Collimation external review 2013



LHC Collimation Review 2013

High Luminosity LHC

30-31 May 2013
CERN
Europe/Zurich timezone

Search

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Introduction:
In the frame of the LHC upgrades towards the High Luminosity LHC (HL-LHC), the improvement of the LHC collimation system is a critical aspect. The review has the main scope of assessing the needs of new collimators in the LHC cold dispersion suppressors for the operation beyond LS2.

Charge of the review panel:
The committee should look into the various aspects of the presented upgrade baseline and advise in particular on the need to pursue R&D on 11T dipoles for a possible installation in the LHC for LS2.

- Are the assumptions for performance reach estimates appropriate and adequately addressed?
- Is the present upgrade strategy appropriate in view of being able to take a decision in 2015?
- Is there any aspect that has been overlooked?

A final report should be produced and delivered to Steve Myers and Stefano Redaelli.

Review panel:
Mike Seidel (PSI, Chair), Giorgio Apollinari (FNAL), Wolfram Fischer (BNL), Marzio Nessi (ATLAS), Rudiger Schmidt (CERN/ESS), Carsten Omet (GSI).

Starts 30 May 2013 08:30
Ends 31 May 2013 18:00
Europe/Zurich

CERN
Kjell Johnsen Auditorium

Seidel, Mike

Poster
Report of the Review Committee
Review summary

https://indico.cern.ch/event/251588

External review panel:
Mike Seidel (PSI, Chair),
Giorgio Apollinari (FNAL),
Wolfram Fischer (BNL),
Marzio Nessi (ATLAS),
Rudiger Schmidt (CERN/ESS),
Carsten Omet (GSI).

Mandate:
The committee should look into the various aspects of the presented upgrade baseline and advise in particular on the **need to pursue R&D on 11T dipoles for a possible installation in the LHC for LS2**.
- Are the assumptions for performance reach estimates appropriate and adequately addressed?
- Is the present upgrade strategy appropriate in view of being able to take a decision in 2015?
- Is there any aspect that has been overlooked?
A **final report** should be produced and delivered to S. Myers and S. Redaelli.

Review agenda

Introduction to present collimation system and scope of the review

1. The HL-LHC timeline, by Lucio Rossi
2. Introduction to dispersion suppressor collimation, by Stefano Redaelli
3. Present LHC collimator, by Roberto Losito

Estimated performance reach of present LHC collimation for 7 TeV

1. Cleaning performance, by Belen Maria Salvachua Ferrando
2. Setting limits and beta* reach, by Roderik Bruce
3. Impedance, by Nicolas Frank Mounet
4. Collimation cleaning with ATS optics for HL-LHC, by Aurelien Marsili

Estimated performance reach of present LHC collimation for 7 TeV

1. DS collimation for heavy-ion operation, by John Jowett
2. Heat load scenarios and protection levels for ions, by Genevieve Eleanor Steele
3. Energy deposition simulations for quench tests, by Eleftherios Skordis
4. Quench limits: extrapolation of quench tests to 7 TeV, by Arjan Verweij
5. Overview of quench limits for faster time ranges, by Mariusz Sapinski

Status DS collimation (in collision points and cleaning insertions)

1. What do we need to decide now to have Nb3Sn dipoles in LS2? by Luca Bottura
2. Status of 11T dipole program, by Mikko Karppinen
3. Integration options for collimators in the DS zones, by Vittorio Parma
4. Status of the TCLD collimator design, by Alessandro Bertarelli

Collimation plans for the HL era

1. LHC collimation upgrade plans, by Stefano Redaelli

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Status DS collimation (in collision points and cleaning insertions)
1. What do we nee
2. Status of 11T di
3. Integration optio
4. Status of the TC

Collimation plans
1. LHC collimation

"Packed" agenda, focused on the mandate of the review.
Overlook of other upgrade topics concentrated in one single overview talk.
3 closes sessions for discussions within the review panel.

Many thanks to the speakers for the excellent work to prepare the talks!
The analysis of collimation quench tests in Feb. was essentially completed!

DS collimation needs by IR

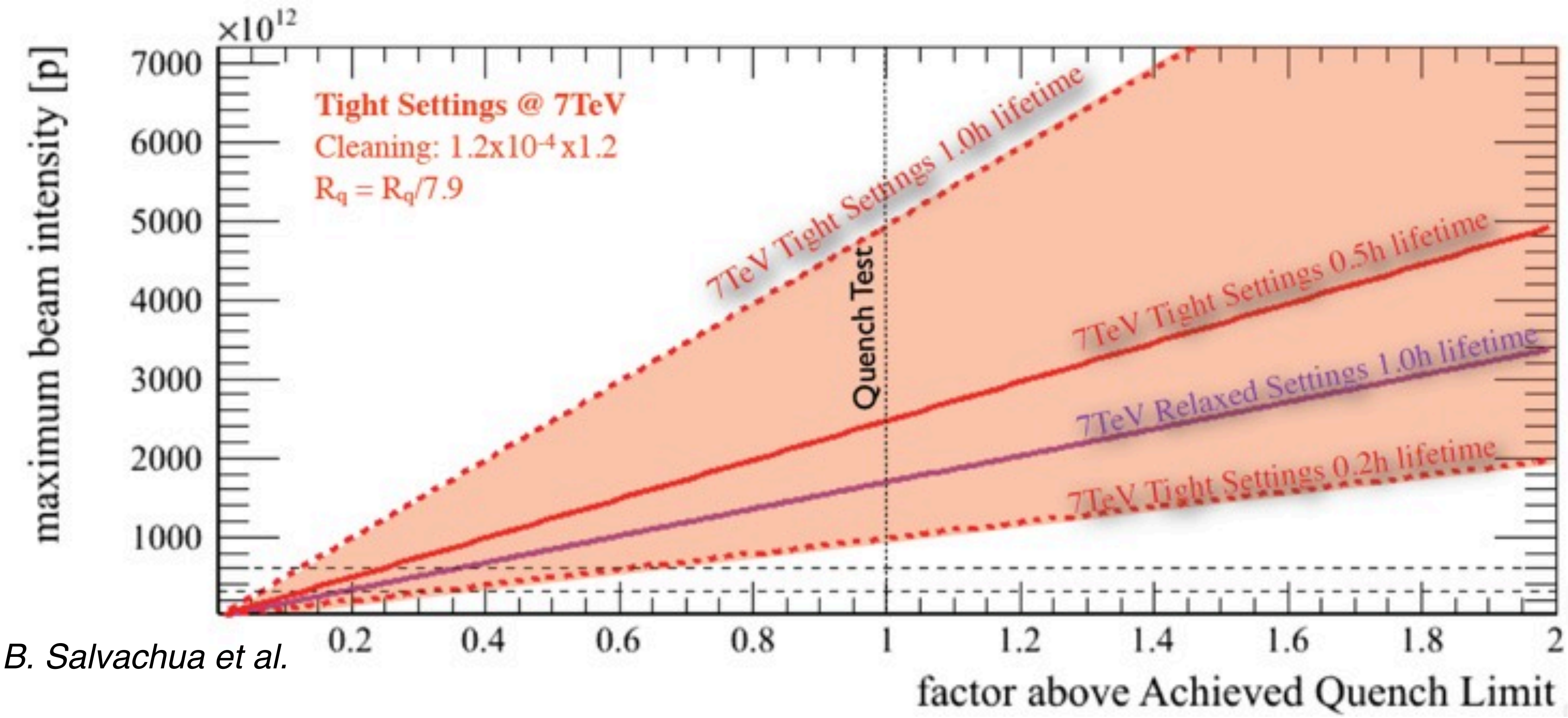
		Until HL-LHC (before LS3) [$L=2.5\times10^{34} cm^{-2}s^{-1}$, $I_{tot}=3.2\times10^{14}$p]		**HL-LHC era** (after LS3) ($L=5\times10^{34} cm^{-2}s^{-1}$, $I_{tot}=6.2\times10^{14}$p)	
		Protons	Ions	Protons	Ions
IR7	Betatron cleaning	**Needed?**	**Needed?**	Needed? with or w/out ATS	Needed?
IR3	Momentum cleaning	Not needed	Not needed	Not needed	Not needed
IR1/5	ATLAS/CMS	Not needed	**Needed**	Needed? Updated layout	Needed
IR2	ALICE	Not needed	**Needed**	Not needed	Needed
IR8	LHCb	Not needed	Not operating	Not needed	Not operating

Goal for the collimation project: have a solution available to address possible cleaning limitations revealed by the post-LS1 operation.
Decide then on which IR the priority should be put on.

Larger uncertainties for HL-LHC era, but more time to decide on DS collimation!

Results on performance reach

- Consider minimum lifetime of 0.2 h based on the 2012 experience
  - *Perhaps pessimistic, but ~10% of fills reached τ_b<0.5-1h!*
  - *Reviewers felt that it could get worse (25ns vs 50ns, higher E, larger impedance)*
- Different models to scale losses to 6.5 TeV: Intensity reach from proton cleaning in IR7 is **3 to 6 times** I_{nom} = 2808x1.15e11p. Less margin at 7 TeV!
- Ions: ALICE luminosity upgrade target is at least a factor 2 above quench limits. Same limitations apply for IR1 and IR5 that have less priority for ion runs.
- No additional limitations in IR1/5 until LS3 from physics debris.



B. Salvachua et al.

All present limitations can be solved by the local DS combined with 11 T dipoles. ***Modular solution*** *suitable for all IRs (unlike moving magnets...).*

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Review report - general comments

2. General observations and comments

Since the last review in 2011 the collimation system has demonstrated an excellent performance for beam cleaning but also in view of the operational reliability. The committee is impressed by the quality and amount of work performed in different areas, to name some:

- Further quench tests via provoked proton losses were encouraged also during the last 2011 review. Such tests were performed and give valuable information for extrapolation to the anticipated operating parameters. The presented results show some margin even when extrapolated to design energy and intensities.

- Collimator jaws with Integrated BPM's were successfully developed further and new collimators with BPM's are ready for installation during the present shutdown. This concept will significantly reduce the setup time, thus saving valuable operation time of LHC and it is a major advancement of the overall collimation concept. Already during the last run the automated setup procedure for the jaws was significantly improved which also led to a reduction of the setup time.

- The committee acknowledges the amount of work already invested by CERN and FNAL in the development of the new Nb_3Sn superconducting magnet with 11T bending field.

- The modelling of the energy deposit in the magnets from beam losses shows generally very good agreement with measurements. This is an excellent achievement, in particular since the simulations require the coupling of different simulation methods, i.e. tracking (SixTrack) and radiation transport computations (FLUKA).

- Another area, where significant progress was made is the testing of materials with beam in the HiRadMat facility. Alternative collimator materials can now be tested efficiently and within reasonable turnaround time under realistic conditions.

Review recommendations (i)

RECOMMENDATION:

- The committee strongly encourages the development and prototyping of one 11 T (5.5 m) dipole magnet, and the cryogenic bypass collimator unit. An early cold test of the almost complete cryogenic bypass may be elucidating alignment issues that could be important for the final application.
- Build at least 4 units (1 unit consists of 2 magnets + bypass + collimator) since this would cover 2 possible cases, as described in section 6 of this report.
- For an LS2 deployment it is clear that serial «learning curves» for making Nb_3Sn coils at CERN and later in EU industries cannot be accommodated. The committee agrees with the early involvement of industrial partners in the assembly of CERN Nb_3Sn prototypes.
- In the US, the continued development of 11 T Nb_3Sn dipoles is being challenged by the needs of IR quadrupole development within the LARP program. However the knowledge acquired in the Nb_3Sn dipole and quadrupole programs are synergetic and can support each other. Develop alternative plans for the first 5.5 m long prototype taking into consideration potential prioritizations in the US Nb_3Sn program.

The collimator (TCLD) will be installed in between two high field magnets and it is supported on the ground. The integration with the cryogenic bypass is challenging since space is tight. A prototype of the cryogenics bypass is available to be cold tested in autumn
to fit the collimator between the magnets in the given spa
somewhat simpler than collimators in warm sections, since
freedom without angular adjustment.

Continue with high priority the development of the 11 T dipoles.

Several options were mentioned to gain longitudinal space for the magnets. One of them is a reduction of the length of the jaw. The committee believes that all information is available to decide on length and material of the collimators.

Review recommendations (ii)

RECOMMENDATION: The committee encourages the team to continue the development of DS collimation units (11T magnets plus collimator) with the aim of installation in LS2. The production of more than a few units in time for installation during LS2 appears to be difficult. The committee suggests building at least four units since this would cover two possible cases:

- Installation of two units in IR2 for ion operation if the luminosity is limited due to beam losses from IR2 collisions (then, two spares would be available)
- Installation of four units in IR7 for proton operation if the assumptions for quench level / beam lifetime are too optimistic and the luminosity is limited due to losses in the IR7 cleaning insertion

RECOMMENDATION: The teams involved in the studies should discuss the different aspects (efficiency of the cleaning for protons/ions, implications on integration and on-going design work), and decide on a solution soon. Later changes of the sectioning within the DS collimator insert will lead to significant additional work for redesigning magnets and collimator. We suggest considering the option of installing a prototype of such collimator in a LHC warm section as a test to gain operational experience.

Prepare production of 4 units: 2 in IR2 + spares or 4 in IR7 if needed.
Push forward the prototyping effort to converge early on design!
Question for me: still need to pursue alternatives (moving magnets)?

Review recommendations (iii)

Extrapolation of the collimation performance from 4 TeV to 7 TeV based on the collimator quench test and accompanying simulations has a number of uncertainties: The quench limit (expected to be reduced by a factor of 4.5), the cleaning inefficiency (expected to increase by more than a factor of 3), and the beam lifetime. While there is reasonable confidence in the prediction of the quench limit and cleaning inefficiency at 7 TeV, there is less confidence in predicting the beam lifetime. With the increase in the energy and luminosity a reduction in the minimum beam lifetime had been observed from 2011 to 2012. A reduction of the minimum beam lifetime cannot be excluded for a number of reasons, e.g.:

- With 25 ns bunch spacing electron clouds may lead to instabilities and fast emittance growth, and increase the UFO rate by an order of magnitude, at least initially.
- The 60% higher collimator impedance may lead to instabilities, in particular at the end of the beta-squeeze period when instabilities have occurred in 2012 and octupoles ran already with the maximum current.
- Yet unknown effects that have an impact on the beam lifetime.

The collimators are the dominant transverse impedance source. Measurements of the tune shift as a function of the opening gap were larger by a factor of 2 compared to calculations. To reduce the

RECOMMENDATION: Complete the analysis of all tests with the objective of a coherent understanding of the quench limits as a function of the loss duration.

RECOMMENDATION: Perform quench tests at high energy, e.g. 6.5 TeV, as soon as possible after the restart of LHC in 2015, including tests with ions.

Uncertainty on beam bahaviour after LS1!
Importance of quench tests and of analysis of measurement data...

Review recommendations (iv)

In order to improve the performance of collimators, new materials were explored. For example Mo-Graphite is of considerable interest and impressive results were obtained. In particular, the HiRadMat facility is an excellent test bed for materials. The committee understood that it is possible to improve the impedance of collimators by coating the surface with a thin Molybdenum layer by about a factor of 10. Coating part of the collimators, e.g. all TCS collimators, would reduce the total impedance in LHC significantly and improve beam stability. This is very promising and should be investigated.

RECOMMENDATION: The team should proceed with further studies on the proposed thin Mo coating, to verify its mechanical stability during grazing beam impact as well as during full impact of a few bunches. A possible impact on adjacent equipment in case of accidental beam impact on a jaw needs also to be taken into account. Another option for reducing the impedance that also could be explored is operation with asymmetric collimator jaw settings. In this scenario the impact on machine protection needs to be discussed.

The longer-term plans with respect to collimation were outlined. Ideas of scraping off halo particles with other methods and an improved understanding of halo formation are being discussed. One option is to use hollow electron beams as it has been demonstrated at FNAL. Other alternatives should be explored, such as tune modulation, crystal collimation etc. The committee considers studies on halo cleaning with different methods for controlling beam losses and for machine protection as very interesting.

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protection a

Push forward and validate with beam tests (HRM) the option of coated MoGR (Molybdenum-Graphite) for reduced impedance. Halo-tuning methods like hollow e-lens should be followed up.

Note: we are also considering this as candidate for robust TCTs!

Review recommendations (v)

RECOMMENDATION: Implement a suitable regular maintenance plan (inspection, cleaning, re-greasing, regular movement in long shutdowns) to reduce this risk. For the future operation, a long-term strategy is needed. Thus it should be considered to change the mechanical design in a proper way (e.g. encapsulating and automatic brush away of dust). A re-qualification of the grease for the increased temperatures during bake out must be done.

Currently, the material of the jaws is CFC. Radiation damage can lead to swelling of the jaw material which results in an uneven surface and ultimately in efficiency degradation, the observation of which is difficult to assign to certain collimator units.

RECOMMENDATION: The committee also recommends inspecting a primary collimator that has seen high beam losses, as this would give important information on potential degradation, e.g. quality of surface.

The committee strongly supports the R&D work, which was started to qualify alternative jaw materials, especially in view of reducing impedance drastically.

Watch out for collimator lifetime! Regular maintenance must be done, identify critical components, inspect collimators taken out of the tunnel. Underlined the importance of radiation tests to keep good performance!

Review: summary

7. Summary and response to charge

1. **Are the assumptions for performance reach estimates appropriate and adequately addressed?**
   In principle yes. While extrapolation of the intensity is rather straightforward, extrapolation of beam energy is more involved, see section 4. The committee underlines the importance of further quench tests at full energy. Only such tests can provide reliable information on the performance reach at full energy.

2. **Is the present upgrade strategy appropriate in view of being able to take a decision in 2015?**
   Yes, as described in the text the strategy of additional DS collimators should be followed and the remaining time should be used to work out a reliable technical solution. Additional information on the system performance should be gained from routine operation and dedicated experiments at 6.5/7 TeV.

3. **Is there any aspect that has been overlooked?**
   The committee sees several risks as described, however no showstoppers were identified.

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- ☑ **Additional upgrade items**

Details of ongoing studies with various collaborations (US-LARP, EuCARD, HiLumi, Kurchatov, ...) in my slides at the review.
Here: what is the impact on the layouts of different LHC IRs?

Scope of collimation upgrades

- ☑ Improve the **cleaning performance**
  - *- System limitations: dispersion suppressors (DS's)*
  - *- Advanced concepts for halo scraping and diffusion control; crystal collimation.*
- ☑ Improve cleaning of **physics debris**
- ☑ Improve **impedance** and **robustness**
  - *- State-of-the-art new material and new designs for secondary collimator jaws*
  - *- Improved robustness at critical locations (like TCTs)*
- ☑ Improve **operational** efficiency / machine protection aspects
  - *- **Better beta* reach**, faster collimator alignment;*
  - *- More flexibility for machine configurations (experimental regions).*
- ☑ Improve protection of the **warm magnets** in cleaning IRs.
- ☑ Be ready to replace **collimators** if they brake or age
  - *- The hardware is designed for 10 y lifetime*
- ☑ Achieve **remote handling** in high radiation environment
  - *- Quick collimator replacement in hottest LHC locations*
- ☑ **New layouts** in experimental regions for **HL-LHC**
  - *- Re-think IR1/5 collimation for new optics options/constrains*
- ☑ New injection / dump collimation → *Injection&dump team: WP14*

Present LHC collimation layout

Two warm cleaning insertions, 3 collimation planes

- **IR3: Momentum cleaning**
  - **1 primary (H)**
  - **4 secondary (H)**
  - **4 shower abs. (H,V)**
- **IR7: Betatron cleaning**
  - **3 primary (H,V,S)**
  - **11 secondary (H,V,S)**
  - **5 shower abs. (H,V)**

Local cleaning at triplets

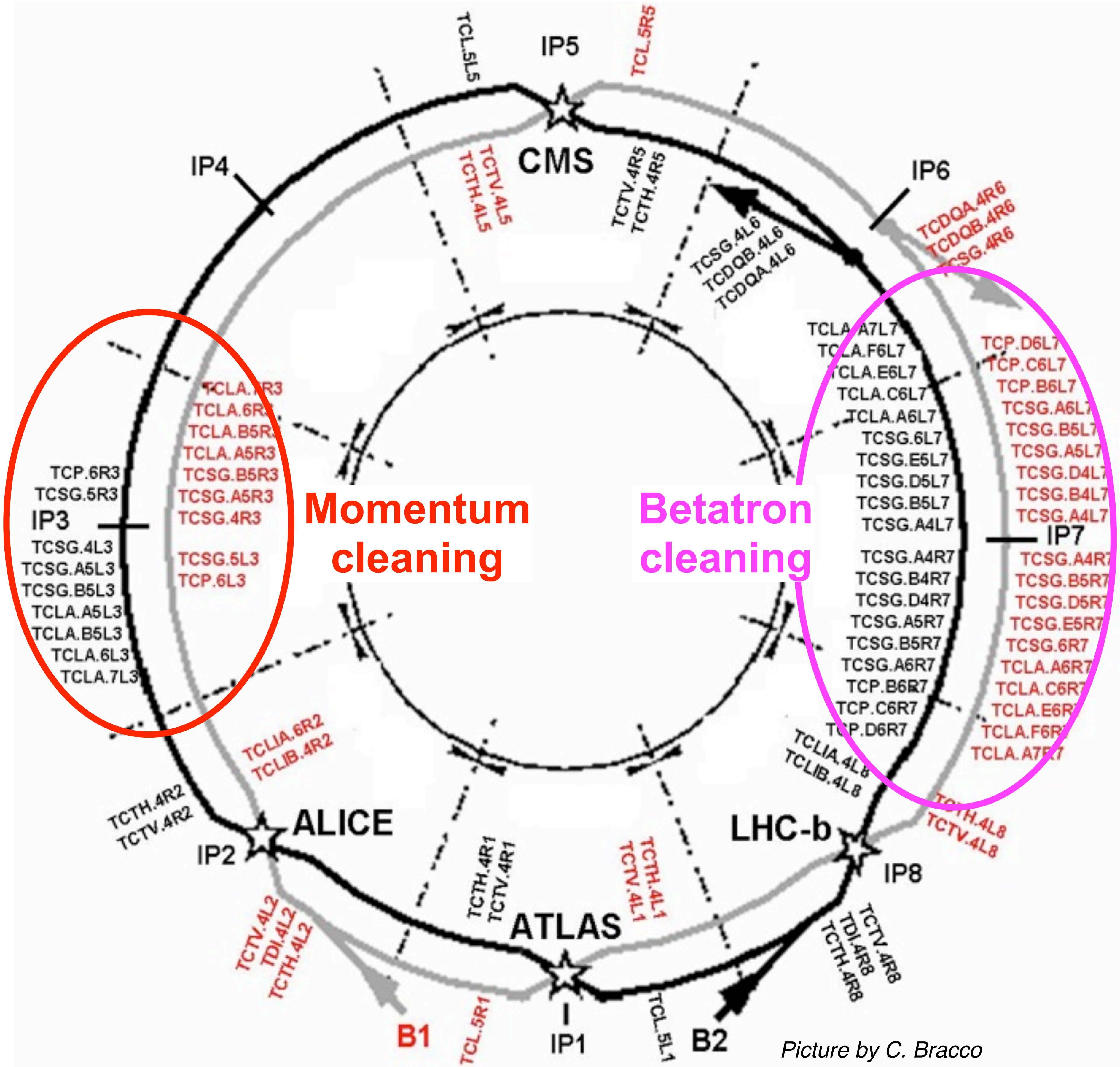
- **8 tertiary (2 per IP)**

Passive absorbers for warm magnets

Physics debris absorbers

Transfer lines (13 collimators)
Injection and dump protection (10)

Total of 108 collimators (100 movable). Two jaws (4 motors) per collimator!



Picture by C. Bracco

LHC collimation after LS1

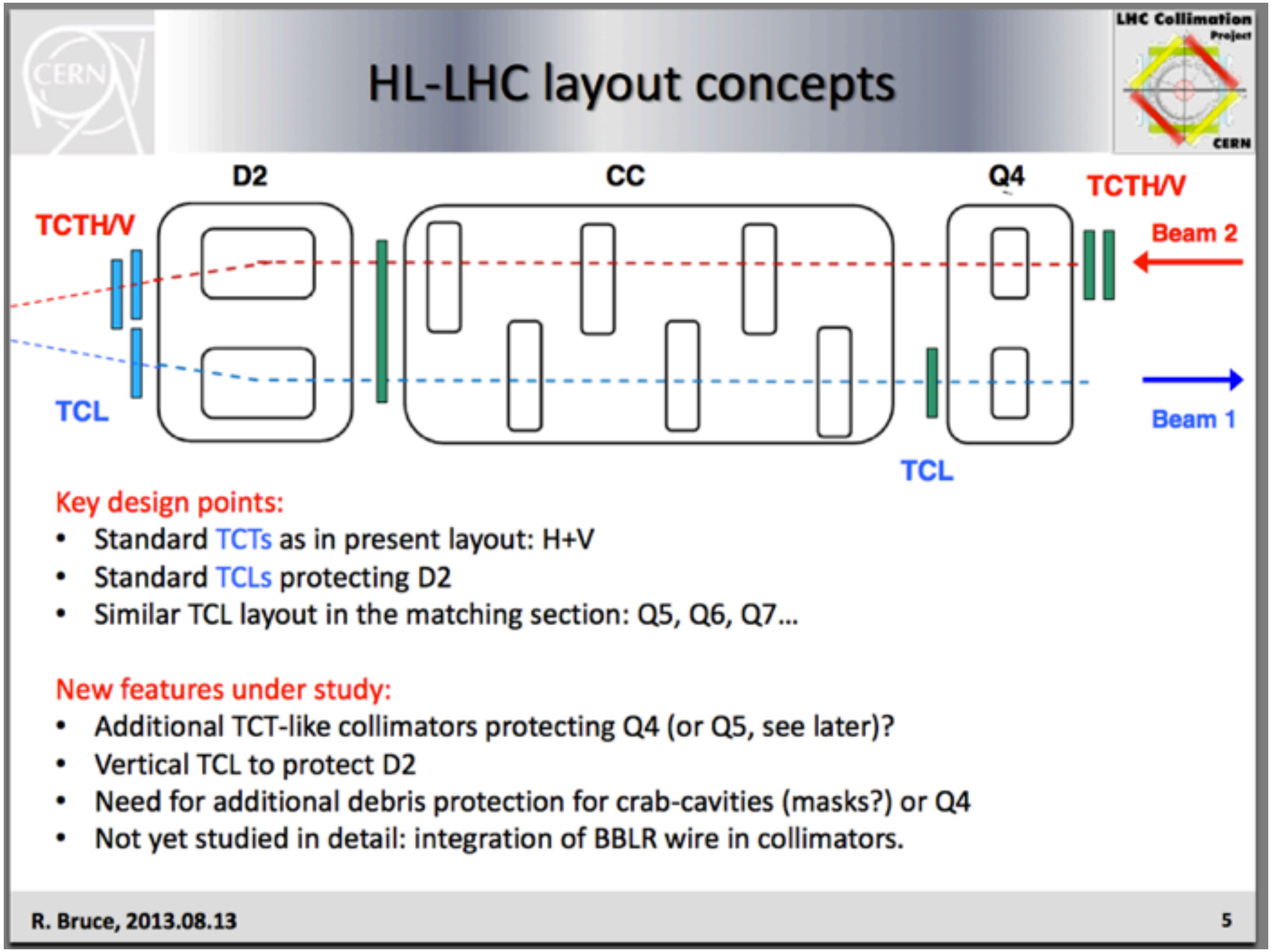
Insertion region	Collimator name	Acronyms	Functionality	Material	End of Run1	Post LS1	New in LS1
IR7: Betatron cleaning	Primary collimator	TCP	Primary betatron cut	CFC	6	6	0
	Secondary collimator - Graphite	TCSG	Secondary betatron cut	CFC	22	22	0
	Shower absorber	TCLA	Absorber of larger-amplitude showers	W	10	10	0
	Secondary collimator - Metallic	TCSM	Secondary betatron cut	MoGr?	0	0	0
	Dispersion suppressor	TCLD	Local dispersion suppressor cleaning	W?	0	0	0
	Passive absorbers	TCAP	Reduce total doses in warm magnets	W	6	6	0
IR3: Momentum cleaning	Primary collimator	TCP	Primary momentum cut	CFC	2	2	0
	Secondary collimator - Graphite	TCSG	Secondary momentum cut	CFC	8	8	0
	Shower absorber	TCLA	Absorber of larger-amplitude showers	W	8	8	0
	Secondary collimator - Metallic	TCSM	Secondary momentum cut	MoGr?	0	0	0
	Dispersion suppressor	TCLD	Local dispersion suppressor cleaning	W?	0	0	0
	Passive absorbers	TCAP	Reduce total doses in warm magnets	W	2	4	2
IR6: beam dump	Primary dump protection	TCSG	Aperture definition for dump protection	CFC	2	0	-2
	Primary dump protection with pickup	TCSP	Aperture definition for dump protection	CFC	0	2	2
	Secondary dump protection	TCDQ	Dump absorption block (one-sided)	C	2	2	0
	Shower absorber	TCLA	Shower absorbers for Q4 and Q5	W	0	0	0
IR1/5: High-lumi experiments	Tertiary collimators	TCTH/V	Local triplet protection	W	8	0	-8
	Tertiary collimators with position pickup	TCTPH/V	Local triplet protection	W	0	8	8
	Physics debris absorbers	TCL	Clean matching section and DS from debris	Cu (W)	4	12	8
	Dispersion suppressor	TCLD	Local dispersion suppressor cleaning	W?	0	0	0
R2: ALICE and B1 injection	Tertiary collimators	TCTH/V	Local triplet protection	W	4	0	-4
	Tertiary collimators with position pickup	TCTPH/V	Local triplet protection	W	0	4	4
	Absorbers for injection protection	TCLIA/B	Auxiliary injection protection devices	C	2	2	0
	Primary injection protection aperture	TDI	Injection protection absorption block	C	1	1	0
	Injection protection mask	TCDD	Movable D1 mask	C?	1	1	0
	Dispersion suppressor	TCLD	Local dispersion suppressor cleaning	W?	0	0	0
R8: LHCb and B2 injection	Tertiary collimators	TCTH	Local triplet protection	W	2	0	-2
	Tertiary collimators (2-in-1 design)	TCTVB	Local triplet protection	W	2	0	-2
	Tertiary collimators with position pickup	TCTPH/V	Local triplet protection	W	0	4	4
	Absorbers for injection protection	TCLIA/B	Auxiliary injection protection devices	C	2	2	0
	Primary injection protection aperture	TDI	Injection protection absorption block	C	1	1	0
	Dispersion suppressor	TCLD	Local dispersion suppressor cleaning	W?	0	0	0
	Physics debris absorbers	TCL	Clean matching section and DS from debris	Cu (W)	0	0	0
TI2/TI8	Injection protection collimators	TCDIH/V	Injection protection in the transfer lines	Gr	13	13	0
				Total	108	118	28
				Movable	100	108	26

Upgrades: CONS vs PIC vs HL

	Motivation for changing / upgrading								
	Performance - cleaning	**Performance - impedance**	**Performance - beta*, effic., prot.**	**Radiation wearing**	**Mechanical wearing**	**General spare policy**	**CONS**	**PIC**	**HL**
TCP			(X)	X	X	X	6		
TCSG		X	X	X	X	X	22?		
TCLA			(X)	X	X	X	10		
TCSM	(X)							22	
TCLD	X	(X)							4
TCAP					(X)	X			
TCP			(X)		X	X	2		
TCSG		(X)	X		X	X	8		
TCLA			(X)		X	X	8		
TCSM								8	
TCLD	X								
TCAP						X			
TCSG			X	X	X	X			
TCSP									
TCDQ									
TCLA		X	X					4	
TCTH/V			X		X	X			
TCTPH/V						X		?	2
TCL	X			X	X	X			
TCLD	X								8
TCTH/V			X		X	X			
TCTPH/V					X	X			
TCLIA/B					X	X	2		
TDI									
TCDD						X			
TCLD	X								
TCTH			X		X	X			
TCTVB			X		X	X			
TCTPH/V					X	X			
TCLIA/B					X				
TDI									
TCLD									
TCL									2
TCDIH/V					X				
							38	34	18

Preliminary: under construction for Consolidation day!

High-lumi insertions: IR1 and IR5



New TCT materials (more robust) to improve triplet protection and beta* reach.

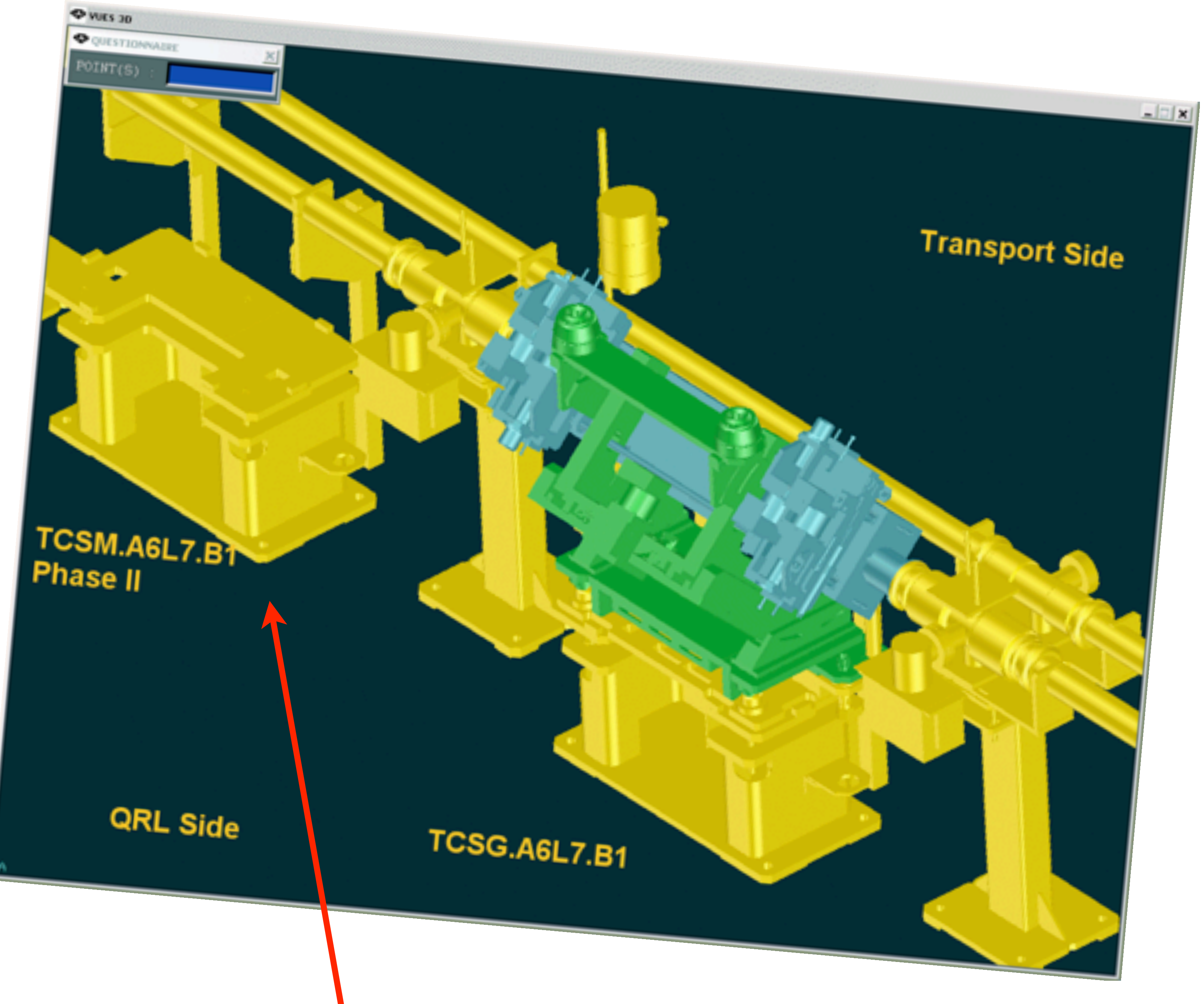
Need layout changes to match the HL requirements. Recently discussed within joint meetings with WP2+WP10.

Important to foresee appropriate space at this stage!

Reminder: in LS1 we plan to install TCL-4 and TCL-6 in addition to the existing TCL-5.
We plan no further changes until LS3 (except possibly improved TCT materials).

Other ongoing studies: BBLR integrated into TCT and TCL collimators for MD studies.

Betatron cleaning: IR7



Slots ready for new collimators!
Can install and test new designs/ materials in IR3/7 without impact on the present system.
Installation in short tech. stops.

Plan to **replace (add) new secondary collimators** with BPMs and reduced impedance.

Aim: prototype to test in the LHC, machine-ready by end of 2015!

Very rich program of prototyping and beam tests (radiation + shock impacts at HRM) with new composite materials.

If appropriate solutions are found, and if needed after LS1, might add up to 22 collimators before LS3!

Presently, no plans for improved primary collimators and absorbers other than standard spare policy; new collimators should have BPM's.

Testing **crystal collimation** concept after LS1.

Ongoing activity with magnet team and FLUKA team: improve the lifetime of warm magnets.

IR3, IR2 and IR8

IR3:
As in IR7, slots are ready to replace (add) new secondary collimators with BPMs and reduced impedance.
No indication that is needed now, but impedance simulations are ongoing.
Might replace TCSG with new design/materials in case of aging.

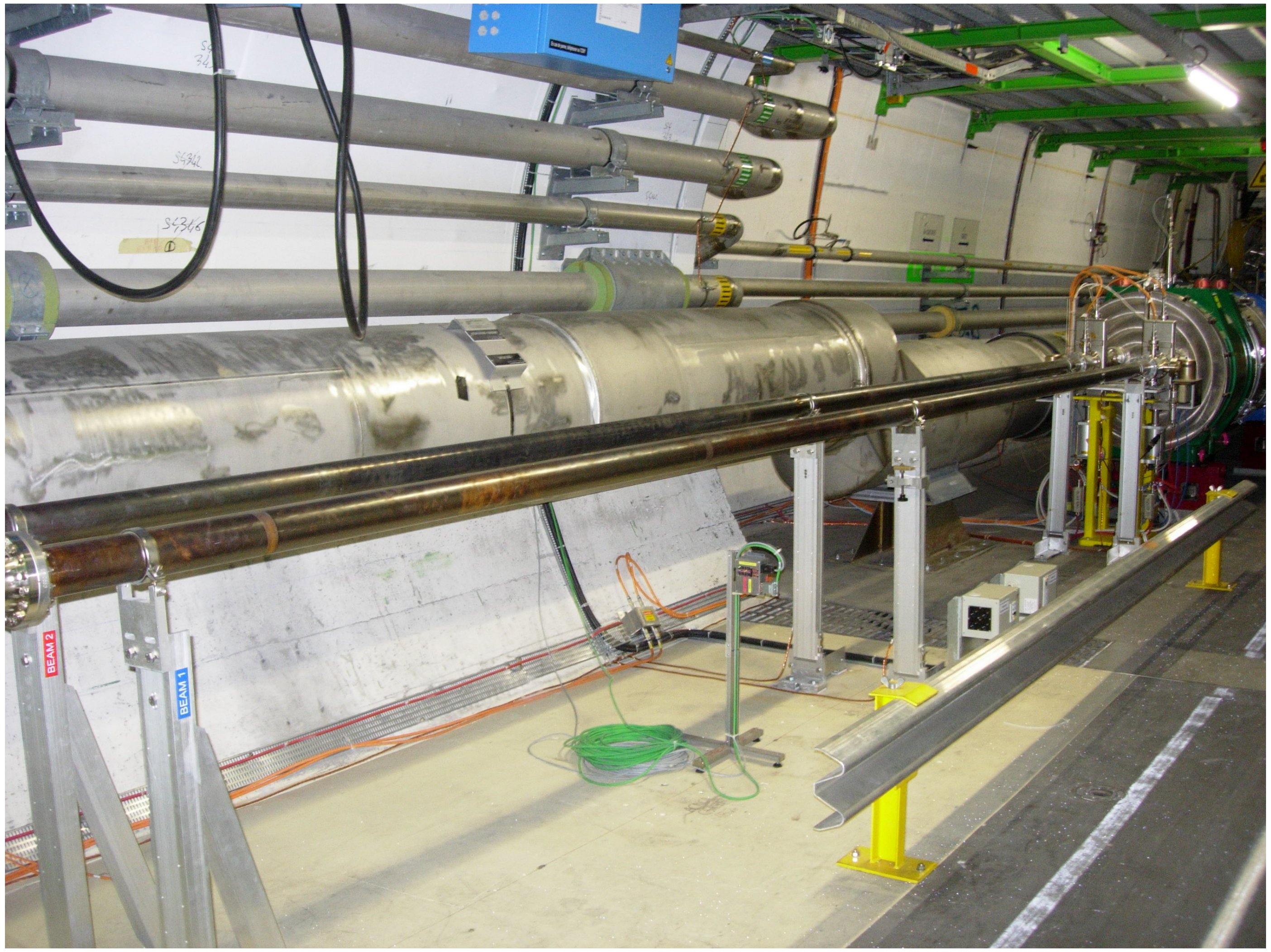
Ongoing activity with magnet team and FLUKA team: improve the lifetime of warm magnets. Actually, intervening in LS1 with new passive absorbers.

IR2:
No specific plans for IR2 upgrade beyond the DS collimators for ions.

IR8:
Considering the possibility to add TCL collimators - energy deposition studies by WP10. (important vacuum layout changes take place in LS1).

RF insertion: IR4

This is the only collimator-free IR, but... candidate location for **hollow e-lens hardware**!



Hollow e-beam: candidate solution for controlling diffusion speed at different transverse amplitudes and improve collimation.
Complementary to present collimation system, no need to be located in IR7.
Need major modifications to cryogenics, so it requires a long shutdown.

Goal: Be ready to start building 2 in ~2015 if experience after LS1 indicates that this will be needed.

Presently: design effort at FNAL within US-LARP. Conceptual design report being prepared (presented at NAPAC by G. Stancari).
Detailed follow up of implementation at CERN: collimation project + EN-MME + BE-BI.
Need to prepared an ECR for space reservatio
Synergy with halo diagnostic studies within HL-

Need strategy for space reservation!

Our strategy

We decided that the **halo control and scraping studies** should be followed up for the LHC and HL-LHC. Hollow lens is a strong candidate but **alternative solutions** to must be addressed to tackle potential problems after LS1.

Within the given constraints for LS1 and due to the major implications to install the Tevatron hardware, we decided not to use the FNAL HW at CERN.

The CERN management fully supports the studies on hollow e-lens and strongly recommends to **focus the presently available resources** towards the **preparation** of a possible **production of 2 hollow e-lens for the LHC**.

- **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 (collimation, BE-BI, EN-MME).
- Work with very high priority on **improving the halo diagnostic** at the LHC.

Conclusions

- The outcome of the external collimation review in May was presented.
  - *For me: very good outcome. Impressive collection of important results!*
- The review panel endorsed important ongoing upgrade works
  - *Strong recommendation to pursed with high priority local DS collimation based on 11 T dipole magnets.*
  - *Impedance issue to be addressed -> new collimator materials*
  - *Other aspects of maintenance of mechanical components also addressed.*
- Our plan: follow up closely the 11 T dipole program (WP11), advance prototyping/testing of cryo bypass, DS collimator, new materials.
  - *Study in parallel the backup option of moving magnets in IR7...*
- But there is much more:
  Other upgrade plans and implications on IR layouts until HL were introduced.
- LHC collimation worked well so far but important uncertainties will be resolved by the operational experience at > 6.5TeV after LS1!
  - *We plan to be ready in 2015 to take decision to address potential issues.*