



LEB summary on upgrades/changes to exp. beam pipes

- **Introduction to the LEB Working Group**
- **Exp. Zones**
- **LEB Timeline of requested changes**
- **Estimated apertures (IR1 & IR5)**
- **Estimated radiation evolution – IR1 as example**
- **TAS and forward detectors**
- **Summary**



Introduction to the LEB Working Group

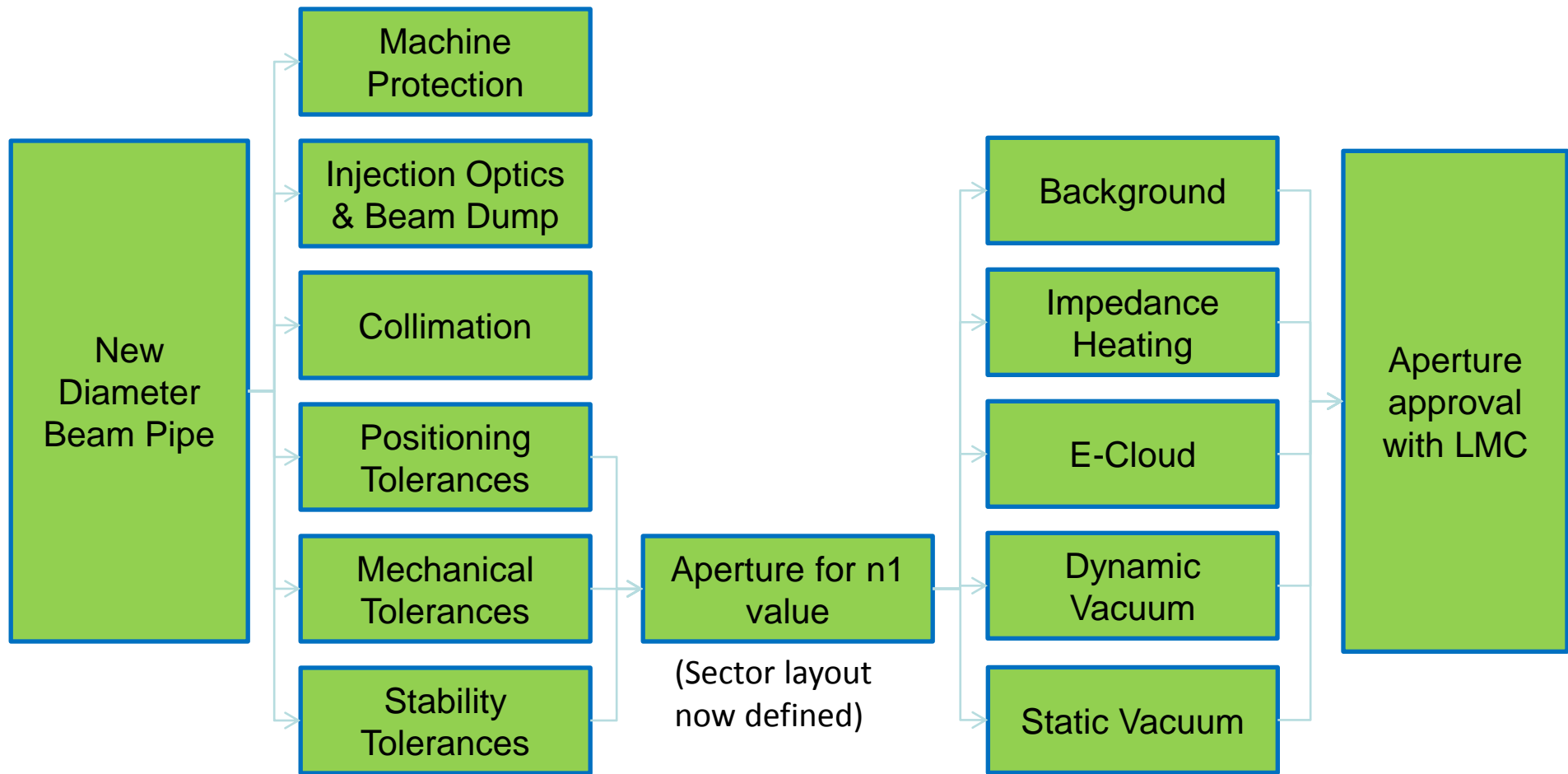
- Define, set priorities and follow-up the activities for the consolidation and upgrade (phase I and II) of the experimental vacuum sectors in the LHC.

Within the sector between Q1 and Q1, the mandate covers all topics required to ensure the implementation and operation all new beam vacuum components and their associated supports, alignment, and access equipment. This includes definition of apertures, specification and follow-up of R&D and design. The mandate also extends to beam vacuum related issues of new experiments in the LHC machine regions.

- The group should interface with the IR upgrade project and collimation project to ensure the impact on machine and experiment performance is properly evaluated.

- The working group shall request approval from the [LHC Machine Committee]. It shall be composed of a member from each experimental collaboration, plus representatives from vacuum, survey, collimation, accelerator physics, safety and machine coordination.

LEB Standard Approvals Route

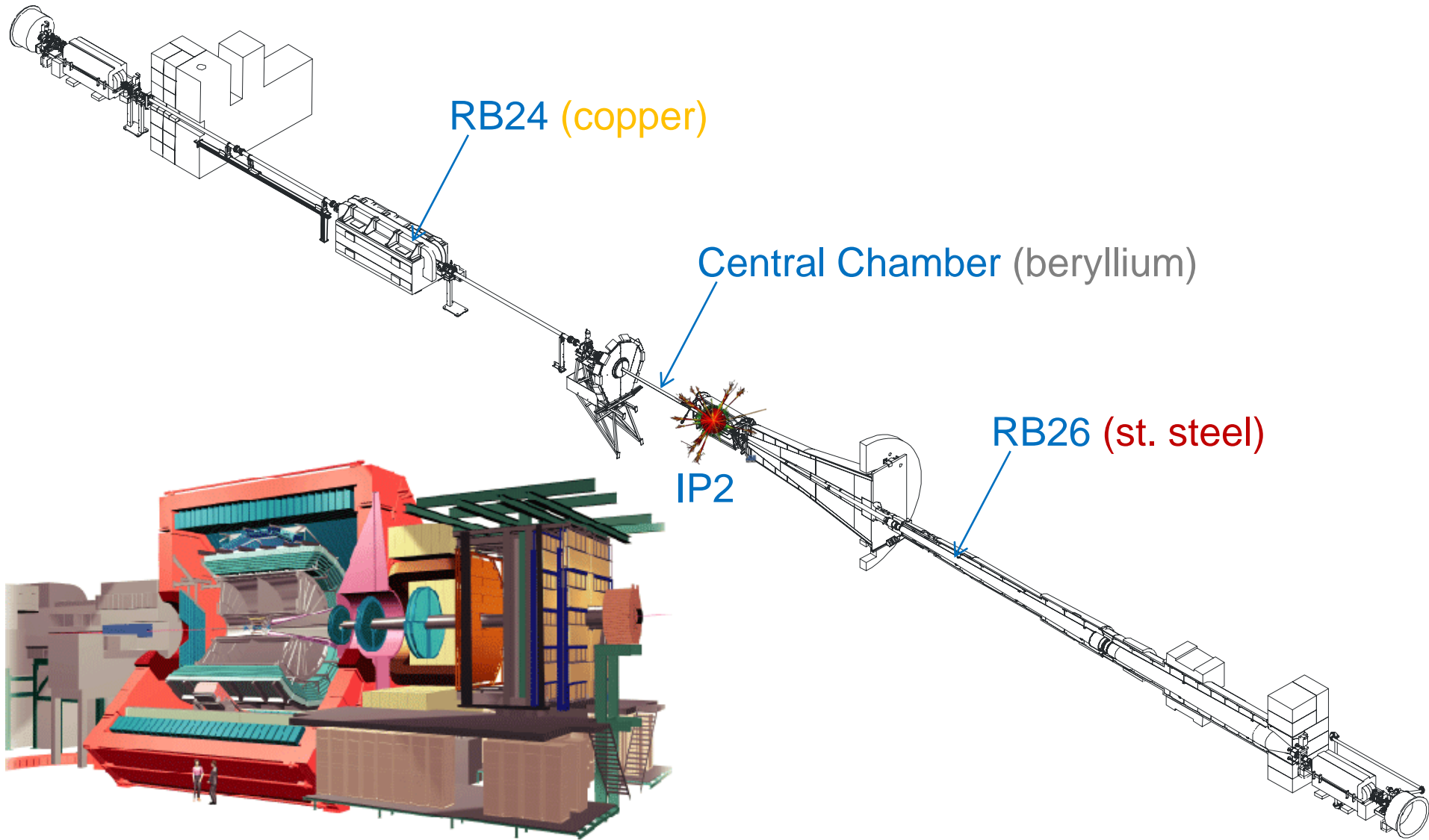




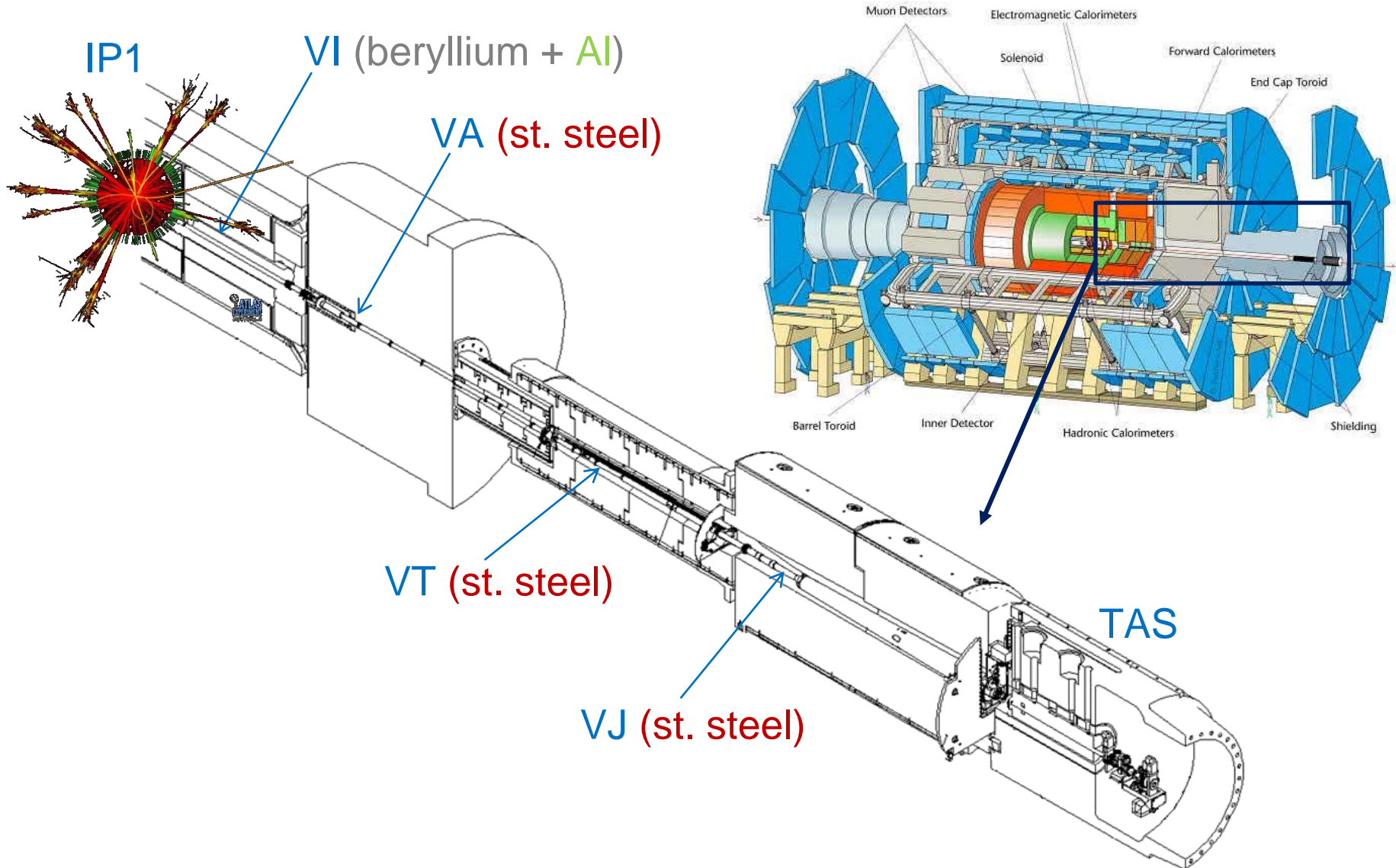
Approvals Summary Table

Approval required	Responsible
Aperture for high and low beta (LHC)	BE/ABP (M.Giovannozzi)
Aperture for high and low beta (HL-LHC)	BE/ABP (B.Holzer)
Injection optics & Beam Dump	TE/ABT (C. Bracco & B. Goddard)
Machine protection	BE/OP (J. Wenninger)
Impedance Heating	BE/ABP (E.Metral, B.Salvant)
E-cloud, dynamic and static vacuum	TE/VSC (V.Baglin, G .Lanza)
Background	BE/ABP (H. Burkhardt)
Collimation	BE/ABP (S. Redaelli)
Positioning Tolerances	BE/ABP (J-C.Gayde, A Behrens)
Mechanical Tolerances	TE/VSC (M.Gallilee)
Stability Tolerances	BE/ABP (J-C.Gayde, A Behrens and Technical Coordinators)

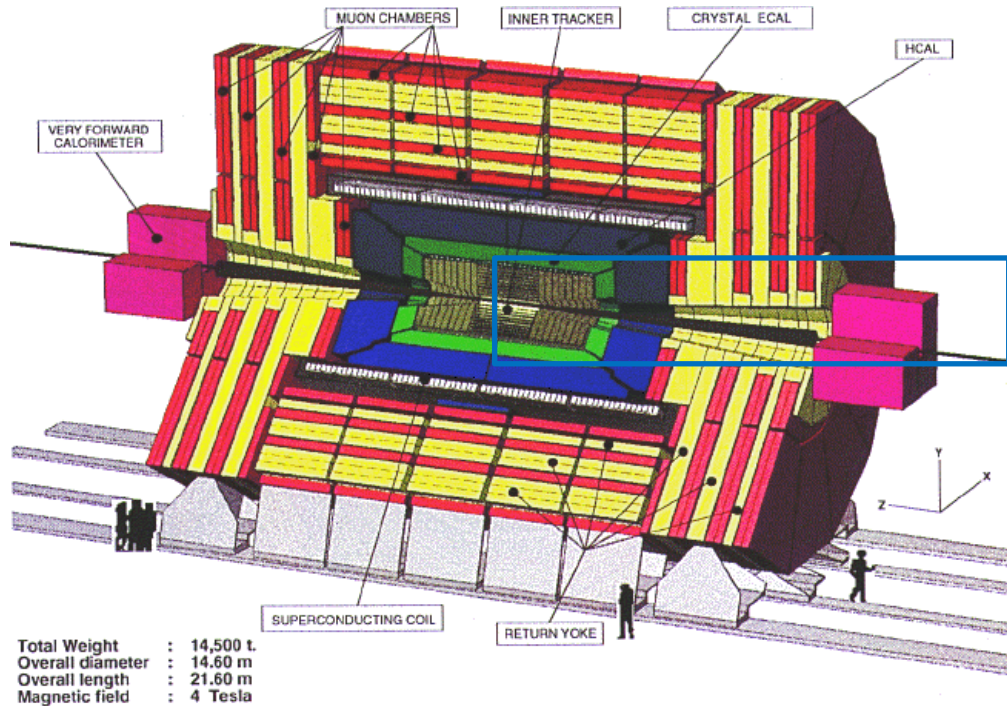
Current experimental areas - ALICE



Current experimental areas - ATLAS



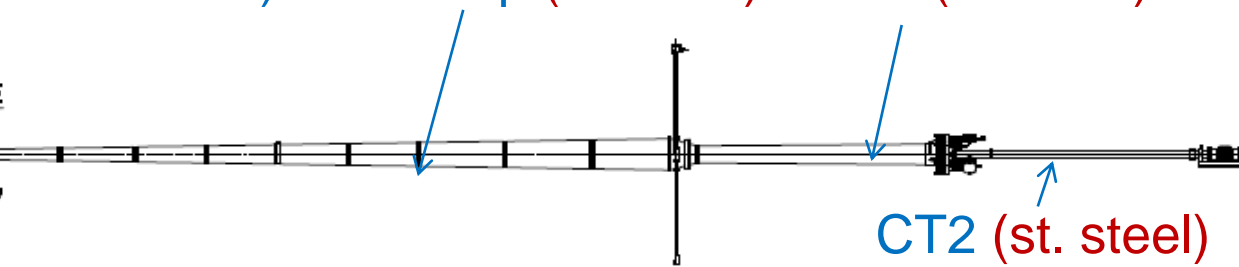
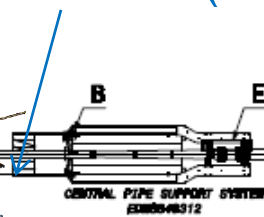
Current Experimental areas - CMS



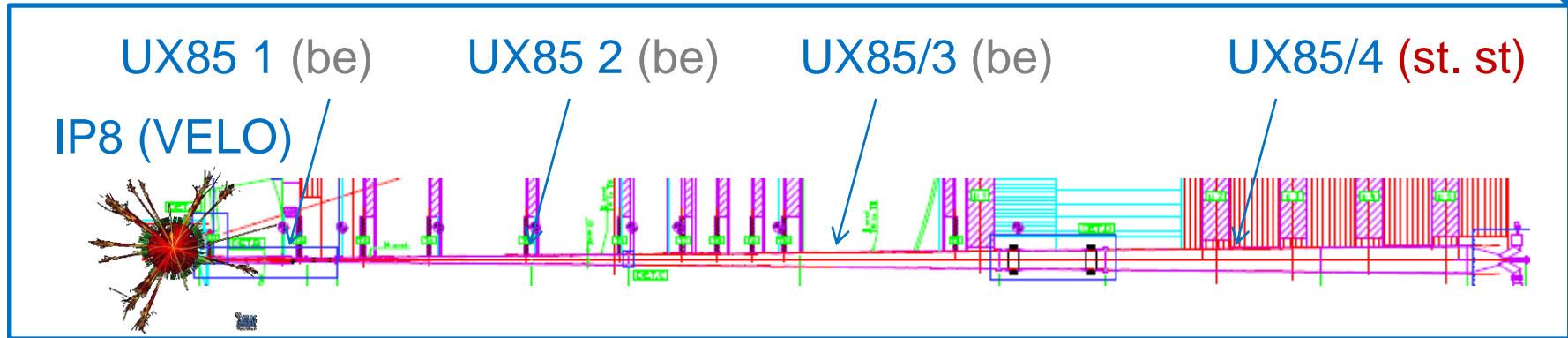
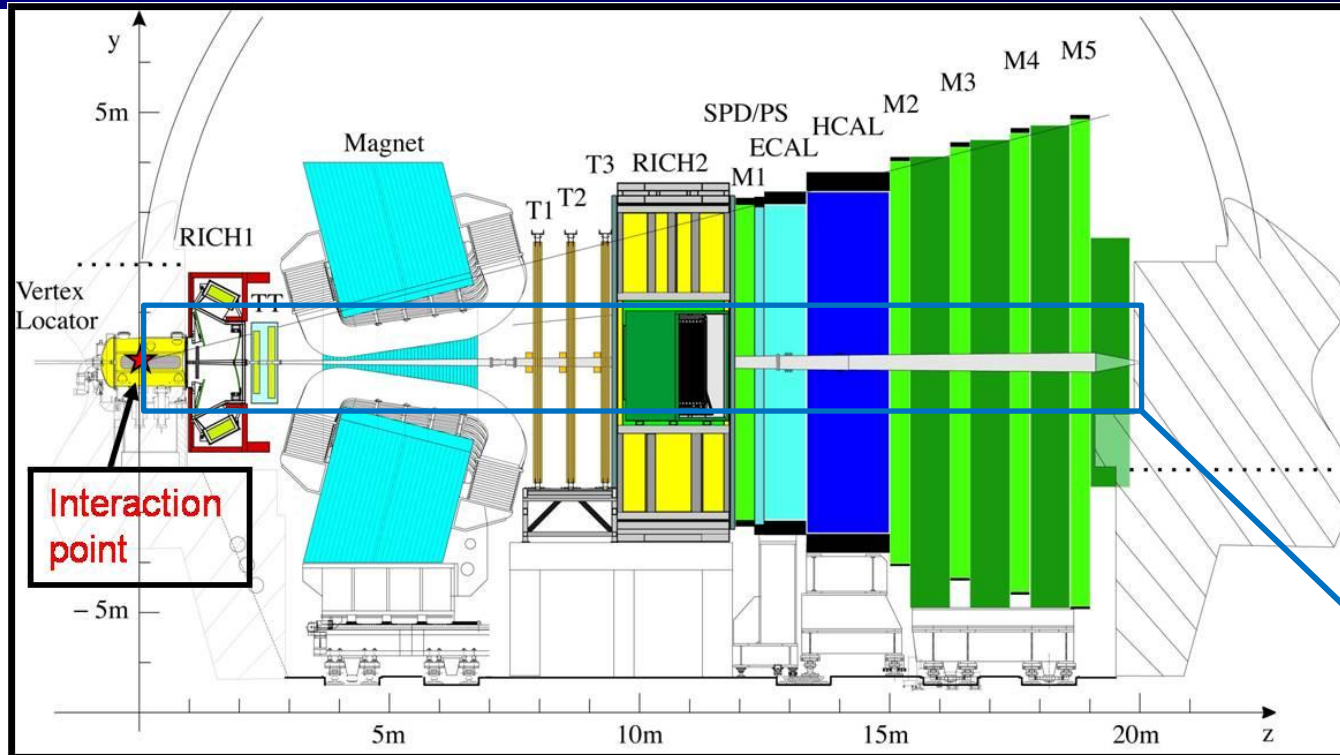
Central chamber (be + st. steel)
IP5

Endcap (st. steel)

HF (st. steel)



Current Experimental areas - LHCb





Current Experimental areas - Features

- All chambers, wherever possible, are NEG coated to reduce secondary electron yield.
- Tolerances are now s-dependant, meaning that they take into account differences in machining tolerances and alignment. The central chambers have much tighter machining tolerances than forward chambers. See EDMS <https://edms.cern.ch/document/1210518/3> (Record of Experimental Aperture Changes through the LEB Committee) for full layouts.
- Chambers manufactured from various materials
 - Central – beryllium;
 - Forward – Stainless steel, aluminium, copper;
 - Tending towards less activated materials, such as aluminium for the forward regions;
 - Post LS1, ATLAS will be all Be and Al except the VJ chambers (st.st).



Experimental areas – Work Packages

EDMS Project Document No. Project System - Type - Identifier No. - Revision	Institute Document No.
1065775	

TE-VSC & ALICE Consolidation and Upgrade of the System

Abstract

This document summarizes the agreement between the Coatings group (TE-VSC) and ALICE for the commissioning of consolidation and upgrades to the ALICE detector. It lists the responsible parties and its associated tooling. This version was updated in 2011.

Written:	Checked:
M.Gallilee / TE-VSC	P. Cruikshank C.Garion J.M.Jimenez

		W
EDMS Project Document No. Project System - Type - Identifier No. - Revision	Institute Document No.	Created
1065775		Last modified

TE-VSC & ATLAS Work Consolidation and Upgrade of the System

Abstract

This document summarizes the agreement between the Vacuum Surfaces and Coatings group (TE-VSC) and ATLAS for the design, production, commissioning of consolidation and upgrades to the beam vacuum system and its associated tooling. This version was updated in 2011.

Written:	Checked:
M.Gallilee / TE-VSC	P.Cruikshank, C.Garion J.M.Jimenez

		W
EDMS Document No. Project System - Type - Identifier No. - Revision	Institute Document No.	Created
1065775		Last modified

TE-VSC & CMS Work Consolidation and Upgrade of the System

Abstract

This document summarizes the agreement between the Coatings group (TE-VSC) and CMS for the design, production, commissioning of consolidation and upgrades to the beam vacuum system and its associated tooling. This version was updated in 2011.

Written:	Checked:
M.Gallilee / TE-VSC	J.M.Jimenez A.Ball P.Cruikshank P.Lepeule C.Garion Ch.Schaefer W.Zeuner

		CERN TE-VSC & LHCb Work Package Description	
EDMS Project Document No.		Created	Pages
1065775		24/06/2009	12
		Last modified	Final
		07/06/2012	

TE-VSC and LHCb Work Package for the Consolidation and Upgrade of the LHCb Beam Vacuum System

This document summarizes the agreement between the Vacuum Surfaces and Coatings group (TE-VSC) and the LHCb Collaboration for the consolidation of the beam vacuum system of the LHCb Detector.

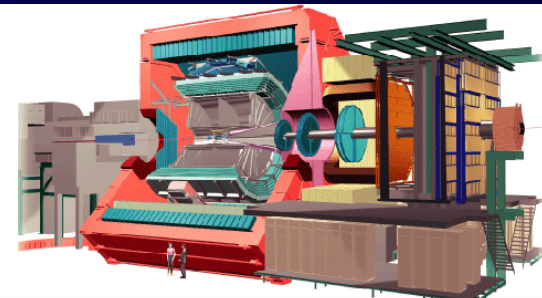
It gives the scope of the work package, the sharing of responsibilities and summarises the expected spending profiles and resource requirements for both TE-VSC and LHCb. This version was updated with changes in 2011.

Written:	Checked:	Approved:
M.Gallilee TE/VSC	P.Cruikshank C.Garion G.Corti J.M.Jimenez	J.M.Jimenez R.Lindner

See EDMS node: <https://edms.cern.ch/document/1065775/4> for all Work Packages

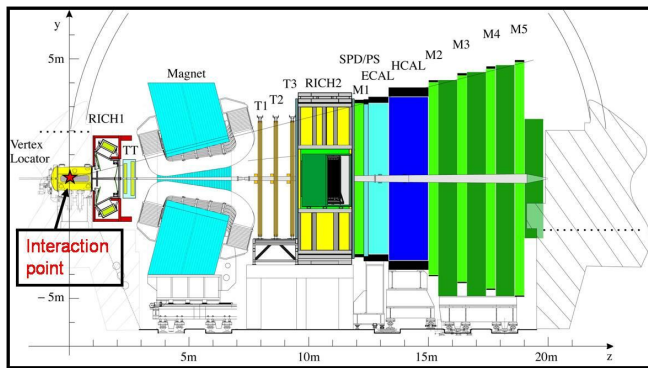
<https://espace.cern.ch/te-vsc-upgrades/default.aspx>

Experimental areas – ALICE & LHCb WPs



WP #	Experiment	Title
2.2.1	ALICE	New central beryllium pipe from LS2 onwards
2.2.4	ALICE	Replace RB24 with Copper tubes from 2017- LS2 (if TPC removed)

Highlighted future LEB studies to be considered for HL-LHC



NOTE1: For ALARA

NOTE2: Aperture study with LEB

NOTE3: Aperture study with LEB

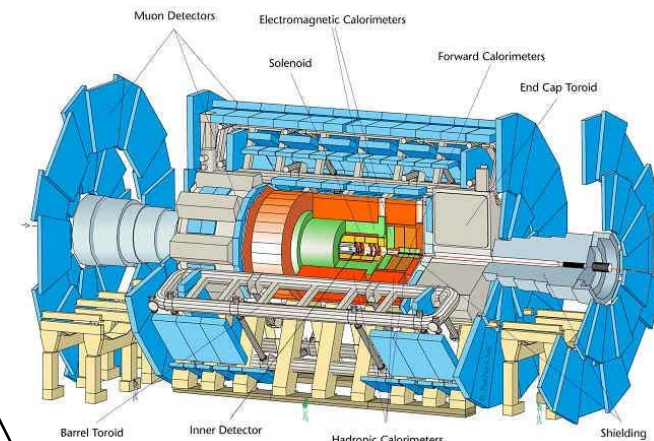
WP #	Experiment	Title
2.1.5	LHCb	VELO chamber spare system
2.1.1	LHCb	Replacement UX85/3 be chamber
2.1.2	LHCb	Spare aluminium bellows
2.1.6	LHCb	Replace UX85/4 bellows + load sensors
2.1.4	LHCb	Completion of spare chambers
2.1.3	LHCb	Bakeout equipment for UX85/3
2.1.7	LHCb	Replace upstream copper chamber with aluminium
2.2.1	LHCb	New supports for UX85/2 and UX85/3
2.2.2	LHCb	VELO upgrade and/with reduced aperture
2.2.4	LHCb	Closer Detectors for UX85/1

See EDMS node: <https://edms.cern.ch/document/1065775/4> for all Work Packages

Experimental areas – ATLAS WPs

Highlighted future LEB studies linked to HL-LHC

WP #	Experiment	Title
2.1.1	ATLAS	Spare for small diameter beryllium pipe
2.1.3	ATLAS	ALARA for interventions
2.2.8	ATLAS	Development of 47mm ID flange New beryllium VI chamber + supports
2.2.2	ATLAS	New, aluminium VA chambers + supports
2.2.3	ATLAS	New, aluminium VT chambers + supports
2.2.4	ATLAS	New, aluminium VT chambers + supports
2.2.7	ATLAS	Development of new forward chambers New VJ chambers for TAS replacement
2.3.1	ATLAS	TAS replacement
2.3.2	ATLAS	New AFP Hamburg beampipe



NOTE1: Supports for ALARA

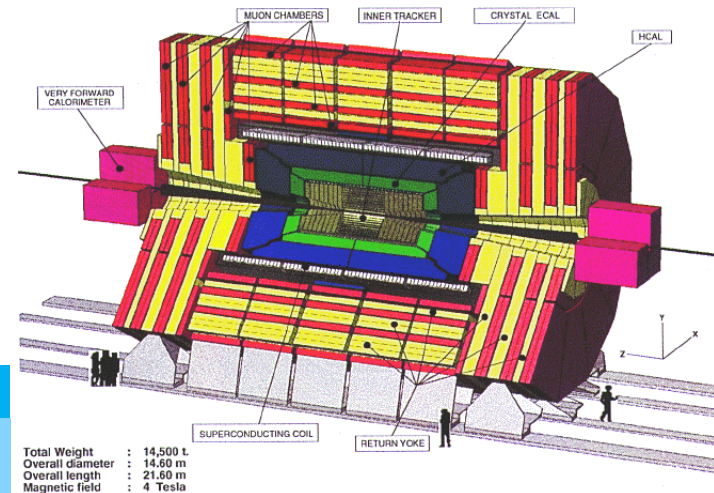
NOTE2: Already approved VI with reduced aperture to be installed in LS1

NOTE3: For ALARA and aperture increase

See EDMS node: <https://edms.cern.ch/document/1065775/4> for all Work Packages

Experimental areas – CMS WPs

Highlighted future LEB studies linked to HL-LHC



WP #	Experiment	Title
2.1.1	CMS	Spare endcap pipe
2.1.3	CMS	Study interventions under vacuum
2.1.4	CMS	Integrity of forward chambers
2.1.5	CMS	Second gas injection system New beryllium central pipe + supports
2.2.1	CMS	
2.2.4	CMS	New CT2 pipes New forward pipes for TAS replacement
2.3.1	CMS	
2.3.2	CMS	New HPS Hamburg beampipe Development of AlBeMet Trial Chamber
2.3.3	CMS	

← NOTE1: For ALARA

NOTE2: Already approved new central chamber with reduced aperture to be installed in LS1

← NOTE3: For ALARA and aperture increase

← NOTE4: For ALARA

See EDMS node: <https://edms.cern.ch/document/1065775/4> for all Work Packages



Experimental areas – LHC Machine & Shared WPs

Highlighted future LEB studies linked to HL-LHC

NOTE1: For aperture increase

WP #	Experiment	Title
-	LHC machine	New TAS chambers
-	LHC machine	New remote flange for TAS
-	LHC machine	New VAX sub-sector
-	LHC machine	Remote flanges and handling for experiments
-	LHC machine	TAS alignment and bellows re-design

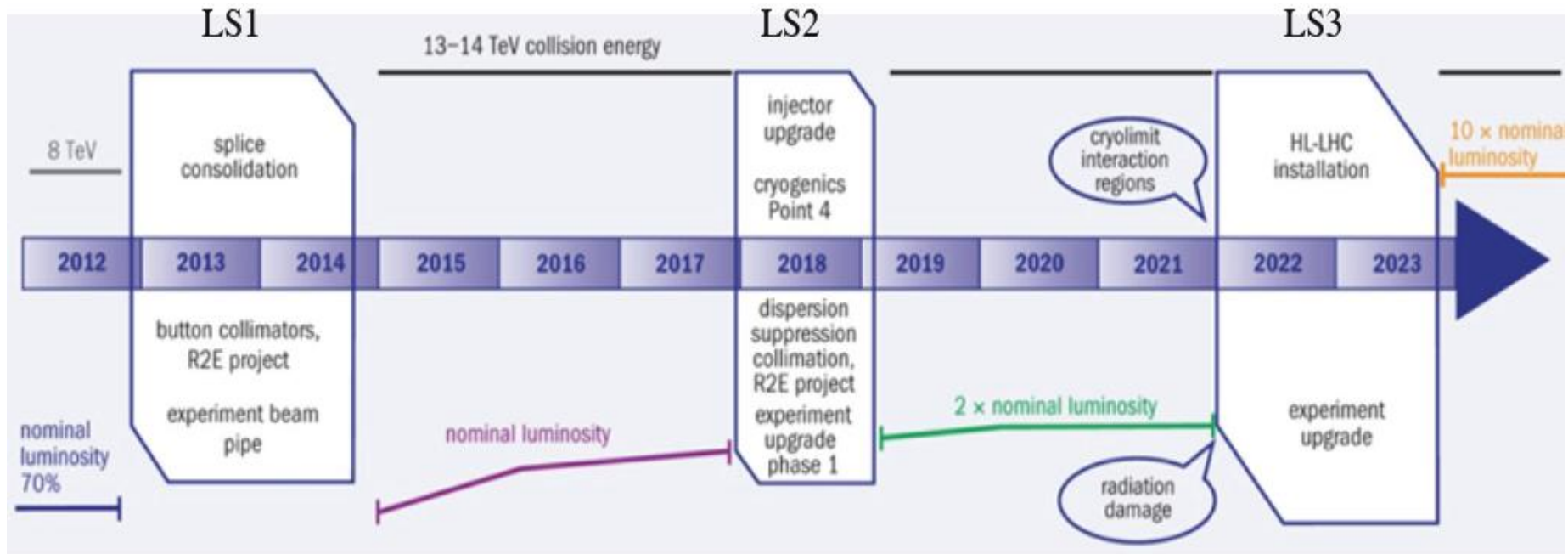
NOTE2: For ALARA

WP #	Experiment	Title
2.2.5 (ATLAS) 2.2.2 (CMS + ALICE)	ALICE, ATLAS, CMS	Development of next gen. chambers
2.2.6 (ATLAS) 2.2.3 (ALICE, CMS, LHCb)	ALICE, ATLAS, CMS, LHCb	Development of new materials

See EDMS node: <https://edms.cern.ch/document/1065775/4> for all Work Packages

Timeline of Studies for Requested Changes

Familiar chart showing timeline for HL-LHC



L. Rossi HL-LHC-Coord_03, 16/7/2012



Timeline of Studies for Requested Changes

Activity	Requested completion date	Project Schedule																	
		2012		2013		2014		2015		2016		2017		2018		2019			
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2				
Consolidation																			
	CMS central carbon support																		
	LHCb UX85/2 and UX85/3 support optimisation																		
	New Supports for ATLAS																		
Upgrade																			
	ALICE smaller diameter beryllium chamber																		
	LHCb smaller diameter UX85/3																		
	New CMS and ATLAS forward chambers																		
	New CMS CT2 chambers																		
	New ATLAS VJ chambers for LS2/HL-LHC																		
	New TAS chambers for CMS and ATLAS																		
	TAS Alignment and bellows re-design																		
	Replace LHCb upstream copper chamber with alu																		
	VELO Upgrade																		
	Approval of new vacuum chamber materials																		
Exp beampipes in LSS (subgroup of LTEX)																			
	ATLAS AFP																		
	CMS HPS																		

Reserved for the experiments - LS1 schedule

Reserved for the experiments - LS2 schedule

Notes on current LEB studies

ALICE Central Chamber:

- a) Massimo verified that for the 'parameters he assumed' the proposed ALICE aperture is OK. Now to confirm with the machine (John Jowett) and the HI-LHC people, whether these parameters are OK to provide the upgraded heavy ion luminosity.
- b) The questions whether the aperture is compatible with HL-LHC is still to be verified.
- c) ALICE have to study the implications on background of the new beampipe.



Timeline of Studies for Requested Changes

Activity	Requested completion date	Project Schedule																	
		2012		2013		2014		2015		2016		2017		2018		2019			
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2				
Consolidation																			
CMS central carbon support	End 2012		■	■															
LHCb UX85/2 and UX85/3 support optimisation	End 2012		■	■															
New Supports for ATLAS	End 2012		■	■															
Upgrade																			
ALICE smaller diameter beryllium chamber	First study mid 2012		■	■	■														
LHCb smaller diameter UX85/1	First study mid 2012		■	■	■														
New CMS and ATLAS forward chambers	by LS2										■	■	■	■					
New CMS CT2 chambers	by LS2										■	■	■	■					
New ATLAS VJ chambers for LS2/HL-LHC	by LS2										■	■	■	■					
New TAS chambers for CMS and ATLAS	2015									■	■								
TAS Alignment and bellows re-design	2015									■	■								
Replace LHCb upstream copper chamber with alu	2015																		
VELO Upgrade	end 2012		■																
Approval of new vacuum chamber materials	2017?												■	■					
Exp beampipes in LSS (subgroup of LTEX)																			
ATLAS AFP	End 2012		■	■															
CMS HPS	End 2012		■	■															

Reserved for the experiments - LS1 schedule

Reserved for the experiments - LS2 schedule

Notes on current LEB studies

LHCb UX85/1 and VELO:

- a) UX85/1 has been studied and is compatible with LHC and HL-LHC parameters. LHCb studying background in experiment.
- b) VELO upgrade study started. Massi to explain this to HL-LHC PLC today.

Timeline of Studies for Requested Changes

Activity	Requested completion date	Project Schedule																	
		2012		2013		2014		2015		2016		2017		2018		2019			
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2				
Consolidation																			
CMS central carbon support	End 2012		■	■															
LHCb UX85/2 and UX85/3 support optimisation	End 2012		■	■															
New Supports for ATLAS	End 2012		■	■															
Upgrade																			
ALICE smaller diameter beryllium chamber	First study mid 2012		■	■	■														
LHCb smaller diameter UX85/1	First study mid 2012		■	■	■														
New CMS and ATLAS forward chambers	by LS2										■	■	■	■					
New CMS CT2 chambers											■	■	■	■					
New ATLAS VJ chambers for LS2/HL-LHC	by LS2										■	■	■	■					
New TAS chambers for CMS and ATLAS	2015								■	■									
TAS Alignment and bellows re-design	2015								■	■									
Replace LHCb upstream copper chamber with alu	2015																		
VELO Upgrade	end 2012			■															
Approval of new vacuum chamber materials	2017?														■	■			
Exp beampipes in LSS (subgroup of LTEX)																			
ATLAS AFP	End 2012		■	■															
CMS HPS	End 2012		■	■															

Reserved for the experiments - LS1 schedule

Reserved for the experiments - LS2 schedule

Notes on current LEB studies

AFP and HPS:

- a) Studying these new Hamburg beampipes in under the framework of LTEX/LEB;
- b) Impedance reduction studies ongoing to be compatible with machine;
- c) Statement from AFP is that it will be removed before LS3.

Estimates of HL-LHC IP5 Apertures with Current Tols.

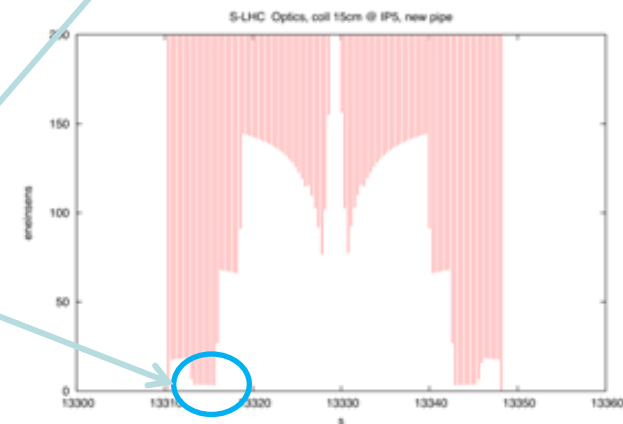
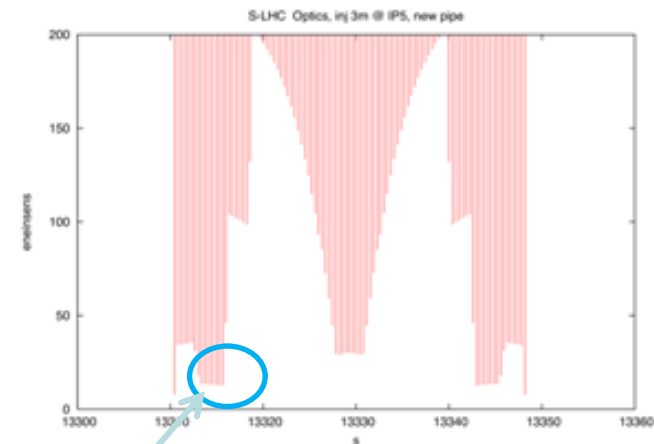
HL-LHC (ATS) , injection optics 5.5m IP5

new beam pipe

HL-LHC (ATS) , collision optics 15cm IP5

new beam pipe

Require changes to forward regions (larger aperture) covered in work package CM 2.2.4/2.3.1

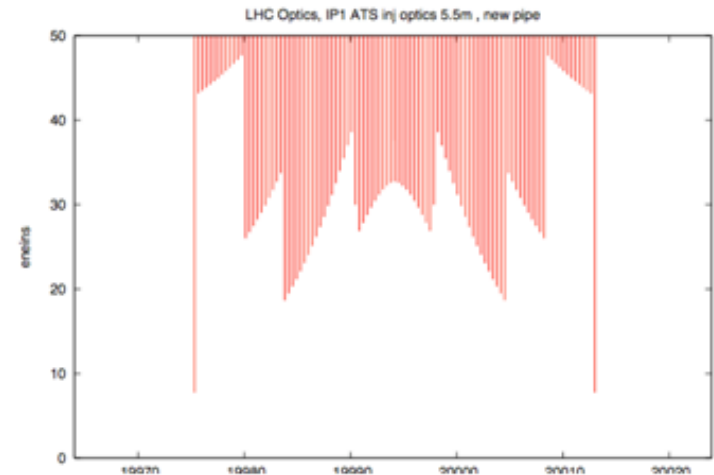


Thanks to Bernhard Holzer for the slides

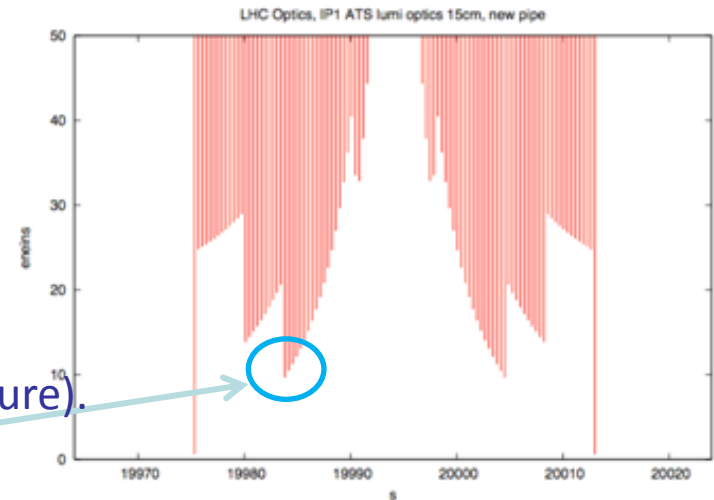


Estimates of HL-LHC IP1 Apertures with Current Tols.

*aperture upgrade optics injection,
5.5m new beam pipe*



*aperture upgrade optics lumi,
15cm new beam pipe*



Require changes to forward regions (larger aperture).
Covered in work package AT 2.2.7/2.3.1

Thanks to Bernhard Holzer for the slides



Estimated radiation evolution – Point 1 as example

First estimated* ATLAS dose rates After 42 days cooling for LS1, LS2, and LS3

Zone	Period	Maxi Dose (micro Sv/h) per system at contact, at beam line (R=0)
VA	LS1 (steel)	150
	LS2 (alu)	30
	LS3 (alu)	100
VT	LS1 (steel)	120
	LS2 (alu)	24
	LS3 (alu)	80
VJ	LS1 (steel)	180
	LS2 (steel)	350
	LS3 (steel)	1200
TAS+JN	LS1	300
	LS2	600
	LS3	2000

These estimated doses highlight the need for remote handling. For the Hi-Lumi experimental chambers, ALARA will become synonymous with remote handling in the future!

*First estimates based on the following assumed run conditions:

For LS1: 20 fb-1, max pick luminosity 6×10^{33} ;

For LS2 : 70 fb-1, max pick luminosity 10^{34} ;

For LS3 : 350 fb-1, max pick luminosity 2×10^{34} .



TAS and Forward Detectors

- TAS change in CMS and ATLAS (remote handling required due to activation);
 - Introduce TAS for LHCb due to increased luminosity;
 - Possible new ZDC at recombination 'Y' chamber for ATLAS if heavy ion run extends past LS3;
 - TOTEM (T1 9m, T2 13.5 m, RP 147, RP 220);
 - ALFA (RP 240);
 - ATLAS APF 220 – LS1;
 - CMS HPS 210? – LS1;
 - FP420 for LS2 – natural extension of AFP and HPS;
 - Proposed low beta experiment at IR3 or IR7.
-
- HL-LHC upgrade is a two-way agreement between experiments and machine. HL-LHC WG8 organising workshop in November to request all experimental change requests relating to the machine to ensure a full overview.

Information gathered in collaboration with the LTEX working group



Summary

- Work Packages and LEB studies outlined with respect to HL-LHC upgrade;
- Vacuum chamber apertures in ATLAS and CMS forward regions will grow to accommodate new beam after LS3;
- Main experimental requests are to accommodate HL-LHC from ALARA and aperture;
- Some requests for smaller apertures at IP (ALICE and LHCb) – ATLAS and CMS will install smaller central chambers in LS1;
- For the Hi-Lumi experiments, ALARA will become synonymous with remote handling in the future due to activation;
- Requests for new forward detectors (AFP, HPS), subsequently FP420.
- HL-LHC upgrade is two-way agreement between experiments and machine. WG8 workshop will ask for full overview of experimental change requests.



Many thanks for your
attention!

Questions?