- LEB Working Group
- Necessary timeline of LEB studies
- Experimental Work Packages
- Summary

The HiLumi LHC Design Study (a sub-system of HL-LHC) is co-funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

Introduction to the LEB Working Group

- **The working group shall be composed of a member from each experimental collaboration, plus vacuum, survey, collimation, accelerator physics, safety and machine coordination.**

- **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. LEB was initially for phase I and II, now need to consider longer term timeline (LS3 and beyond) with close interface between experiments and machine.**

- **Mandate covers Q1 to Q1 for all new beam vacuum components and their associated supports, alignment, and access equipment. The mandate also extends to beam vacuum related issues of new experiments in the LHC machine regions.**

- **Interface with collimation to evaluate impact on experiments.**

- **Approval shall be requested from the LMC [LHC Machine Committee].**

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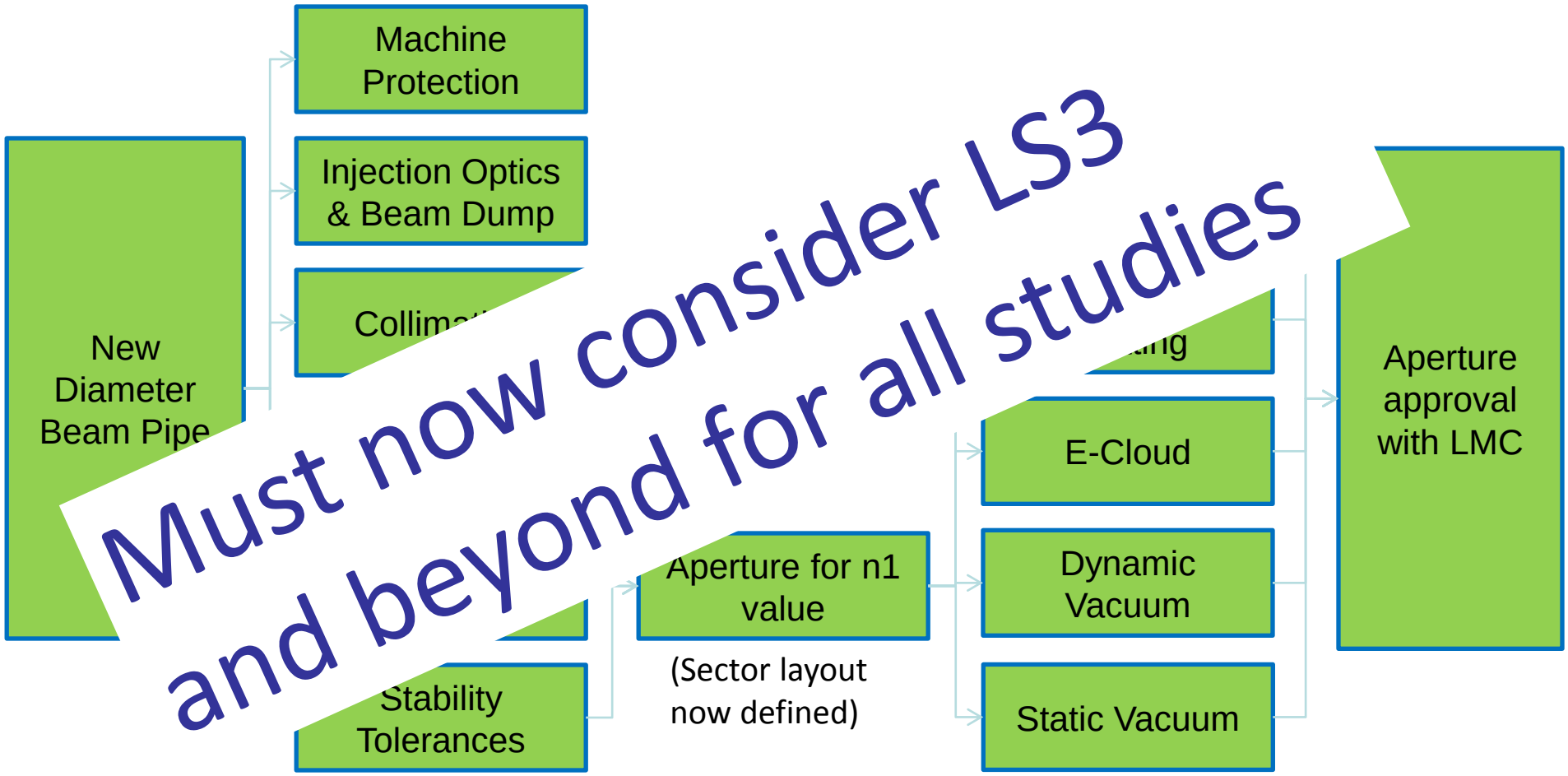
LEB Standard Approvals Route



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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)

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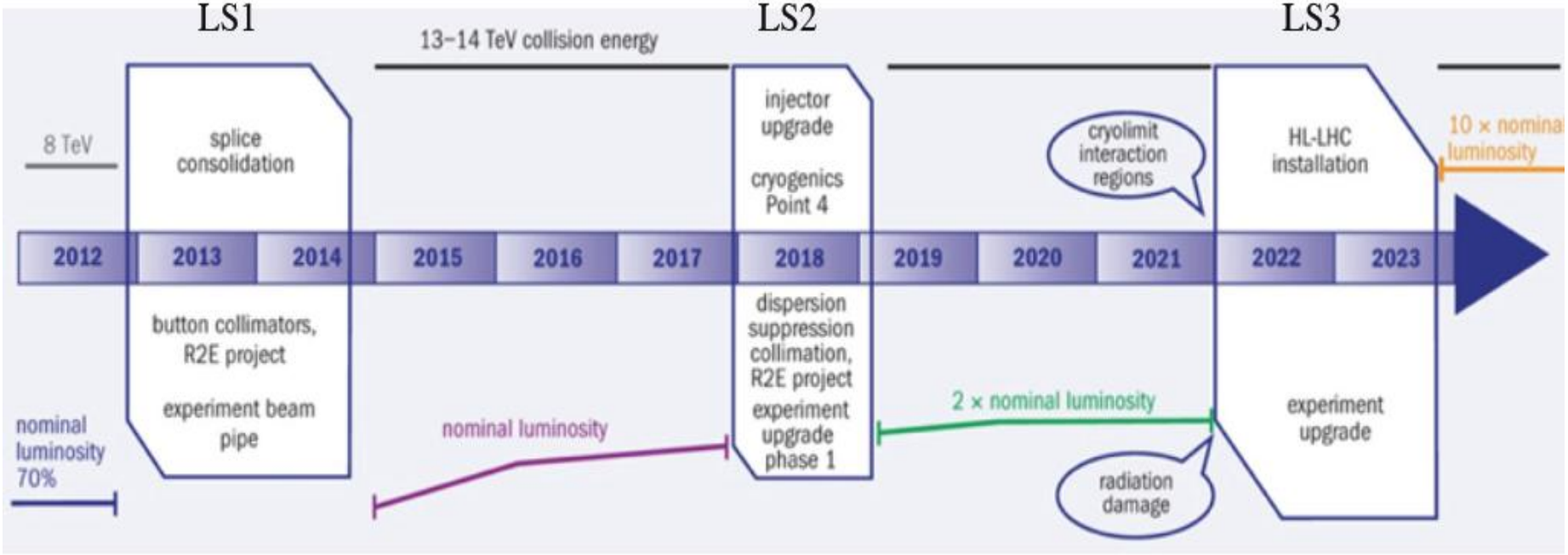
Timeline of Studies

Familiar chart showing timeline for HL-LHC



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

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Timeline of Studies

Activity		Requested completion date	Project Schedule
			2012 S1 / 2012 S2 / 2013 S1 / 2013 S2 / 2014 S1 / 2014 S2 / 2015 S1 / 2015 S2 / 2016 S1 / 2016 S2 / 2017 S1 / 2017 S2 / 2018 S1 / 2018 S2 / 2019 S1 / 2019 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?	

Reserved for the experiments - LS1 schedule discussions

Reserved for the experiments - LS2 schedule discussions

Notes on current LEB studies

ALICE Central Chamber:

a) Aperture verified that for assumed parameters. 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.

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Timeline of Studies

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	S1	S2
Consolidation																		
	CMS central carbon support	End 2012																
	LHCb UX85/2 and UX85/3 support optimisation	End 2012																
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	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?																

Reserved for the experiments - LS1 schedule discussions

Reserved for the experiments - LS2 schedule discussions

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. To be presented at LMC on 12 Dec 2012.

Timeline of Studies

Activity		Requested completion date	Project Schedule
			2012 S1 / 2012 S2 / 2013 S1 / 2013 S2 / 2014 S1 / 2014 S2 / 2015 S1 / 2015 S2 / 2016 S1 / 2016 S2 / 2017 S1 / 2017 S2 / 2018 S1 / 2018 S2 / 2019 S1 / 2019 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	
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	Replace LHCb upstream copper chamber with alu	2015	
	VELO Upgrade	end 2012	
	Approval of new vacuum chamber materials	2017?	

Reserved for the experiments - LS1 schedule discussions

Reserved for the experiments - LS2 schedule discussions

Notes on current LEB studies

Experimental supports:

a) Current and new experimental supports will be discussed for LS1 as part of the experimental layouts.

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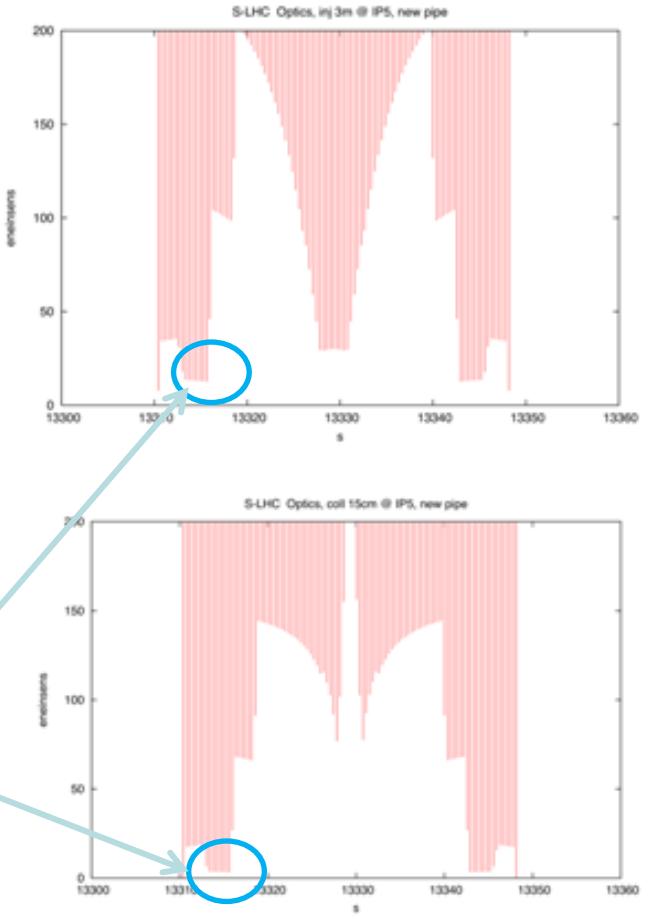
Estimates of HL-LHC IP5 Apertures with Current Tols.

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

new beam pipe

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

new beam pipe

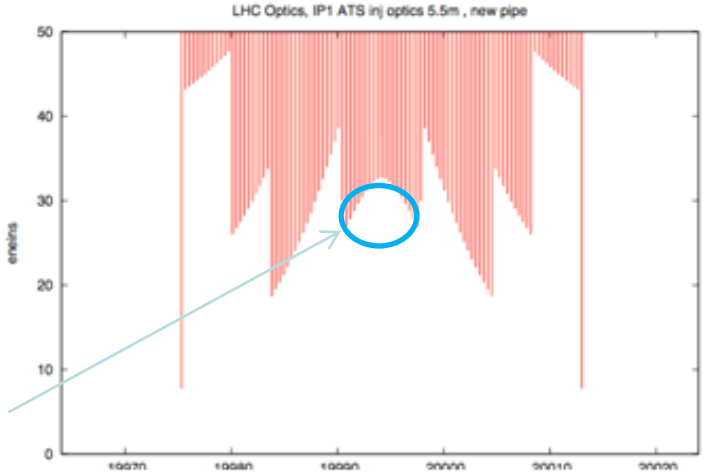


Require changes to forward regions (larger aperture) covered in work package CM 2.2.4/2.3.1

Thanks to Bernhard Holzer for the slides

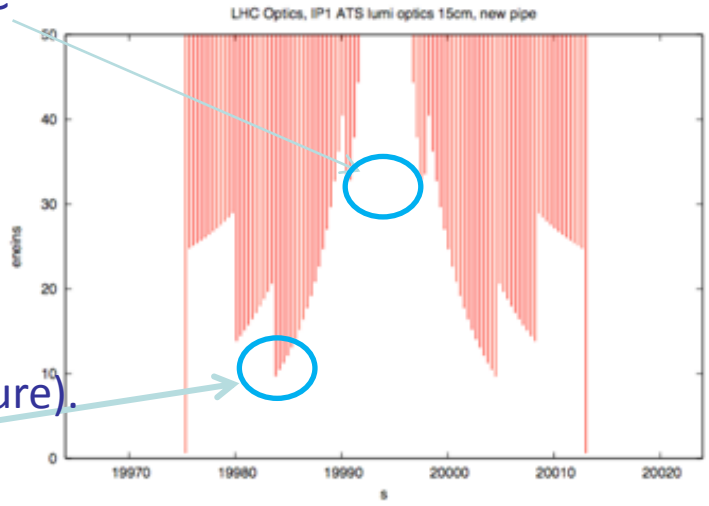
Estimates of HL-LHC IP1 Apertures with Current Tols.

aperture upgrade optics injection, 5.5m new beam pipe



Even though aperture ok for central regions – full study to be added to determine compatibility with HL-LHC

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

Radiation Protection

Area Classification	Dose limit	Ambient dose equivalent rate (permanent place)	Ambient dose equivalent rate (low-occupancy areas)
Non-designated area	**1 mSv/y**	**< 0.5 µSv/h**	**< 2.5 µSv/h**
Supervised area	**6 mSv/y**	**< 3 µSv/h**	**< 15 µSv/h**
Simple controlled area	**20 mSv/y**	**< 10 µSv/h**	**< 50 µSv/h**
Limited stay area			**< 2 mSv/h**
High radiation area			**< 100 mSv/h**
Prohibited area			**> 100 mSv/h**

ATLAS workers are in category B (CERN rule ➔Do not exceed 6 mSv/ year)

ATLAS dose goal ➔Do not exceed 2 mSv/ year
➔**No exposure more than 50 µSv / day**

➔ Restrict activities for a few hours (max 20 hours per year) in regions between 20 and 50 µSv/hour and under strict supervision

➔ Make use of individual shielding if possible to gain a factor 2 (2 cm Fe equivalent gains a factor 2)

➔ Robotize interventions in regions > 50 µSv / hour

Experiment specific radiation goals – example for PT1

(Extracted from ATLAS workshop – Olga Beltramello)

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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) LS2 (alu) LS3 (alu)	150 30 100
VT	LS1 (steel) LS2 (alu) LS3 (alu)	120 24 80
VJ	LS1 (steel) LS2 (steel) LS3 (steel)	180 350 1200
TAS+JN	LS1 LS2 LS3	300 600 2000

These estimated doses highlight the need for reduced intervention times and remote handling.

*First estimates based on the following assumed run conditions:
For LS1: 20 fb-1, max pick luminosity 6x10^33;
For LS2 : 70 fb-1, max pick luminosity 10^34;
For LS3 : 350 fb-1, max pick luminosity 2 x 10^34.

Timeline of Studies

Activity		Requested completion date	Project Schedule																	
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			S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Consolidation																		
	CMS central carbon support	End 2012																
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	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?																

Reserved for the experiments - LS1 schedule discussions

Reserved for the experiments - LS2 schedule discussions

Notes on current LEB studies

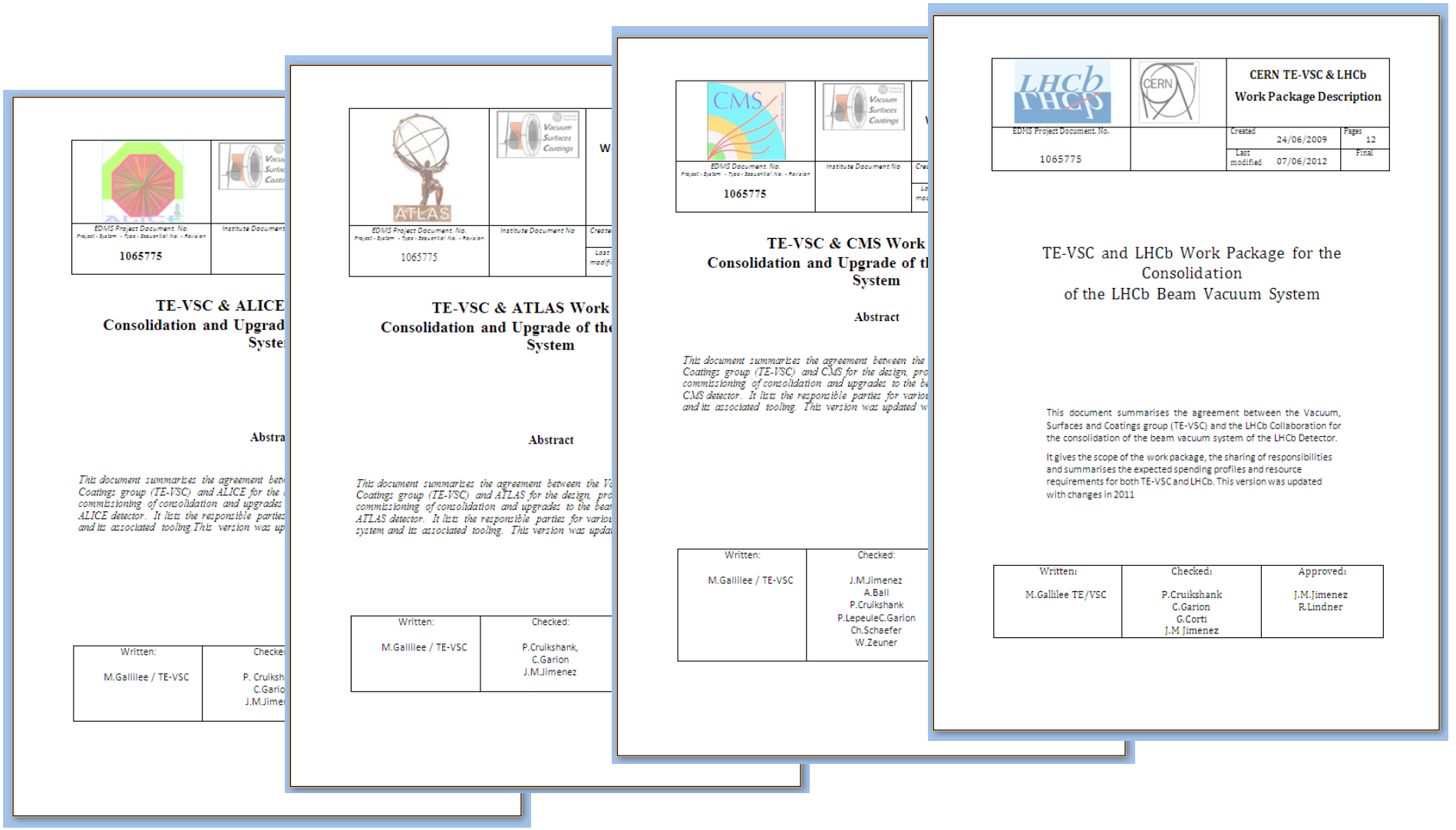
CMS and ATLAS linked with HL-LHC:

a) New forward chambers will be studied for CMS and ATLAS in order to accommodate the new beam size;

b) New TAS chambers and alignment systems will be studied to allow for the new radiation environment;

c) From studies so far, in terms of the machine, impedance and vacuum seem to be the most critical areas of focus for stable HL-LHC operation.

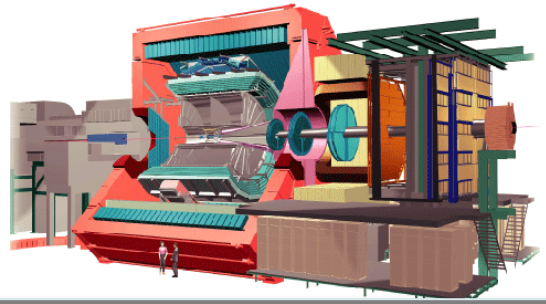
Experimental areas – Work Packages



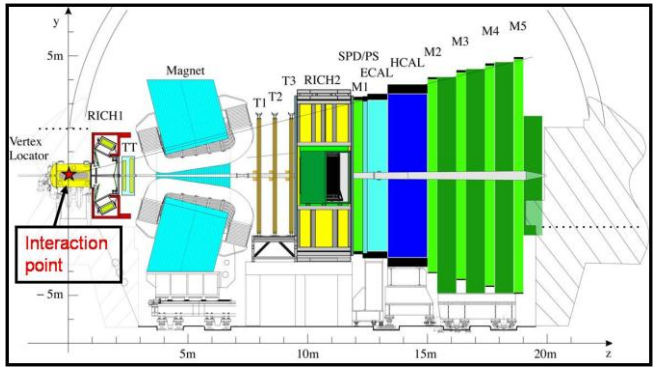
See EDMS node: https://edms.cern.ch/document/1065775/4 for all Work Packages

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



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

NOTE1: For ALARA

NOTE2: Aperture study with LEB

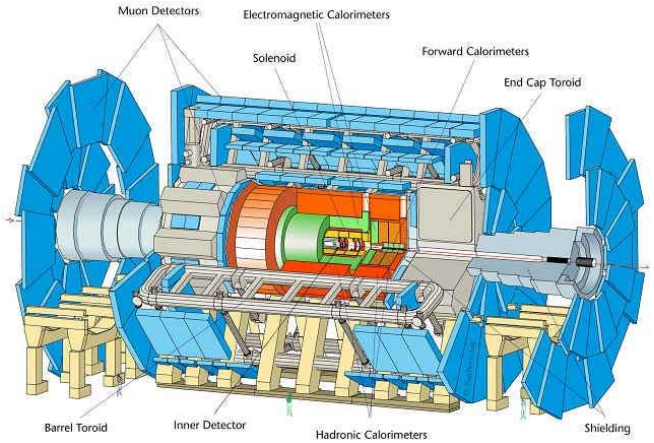
NOTE3: Aperture study with LEB

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
2.2.2	ATLAS	New beryllium VI chamber + supports
2.2.3	ATLAS	New, aluminium VA chambers + supports
2.2.4	ATLAS	New, aluminium VT chambers + supports
2.2.7	ATLAS	Development of new forward chambers
2.3.1	ATLAS	New VJ chambers for TAS replacement
2.3.2	ATLAS	New AFP Hamburg beampipe



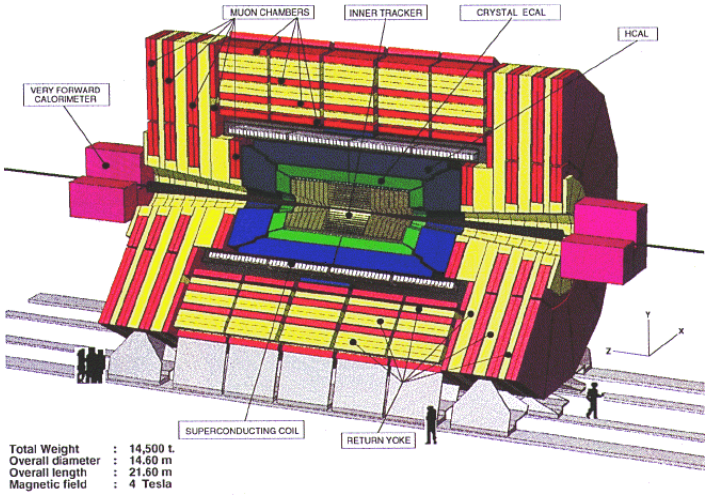
NOTE1: Supports for ALARA

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	← NOTE1: For ALARA
2.1.5	CMS	Second gas injection system	
2.2.1	CMS	New beryllium central pipe + supports	NOTE2: Already approved new central chamber with reduced aperture to be installed in LS1
2.2.4	CMS	New CT2 pipes	
2.3.1	CMS	New forward pipes for TAS replacement	← NOTE3: For ALARA and aperture increase
2.3.2	CMS	New HPS Hamburg beampipe	
2.3.3	CMS	Development of AlBeMet Trial Chamber	← 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

NOTE2: For ALARA

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

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

Summary

- Work Packages and LEB studies outlined with respect to HL-LHC upgrade;
- Vacuum chamber apertures in ATLAS and CMS forward regions must be studied to accommodate new beam after LS3;
- Smaller beampipes will be installed in ATLAS and CMS during LS1 – need to include a study from the machine side to determine whether these are fully acceptable for HL-LHC;
- For the Hi-Lumi experiments, evolution of activation will mean the need to study remote handling and improved intervention times;
- HL-LHC upgrade is two-way agreement between experiments and machine. Both need to work for HL-LHC to be a success, for example ATLAS and CMS central chambers!

Many thanks for your attention!

Questions?