HL-LHC : What is it and What challenges it represents for VSC

V. Baglin on behalf of WP12
CERN-TE-VSC

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

1. Introduction
2. Inner Triplets
3. Layout
4. Crab cavities
5. Collimation
6. SC links and cryogenics
7. Options
8. LS2
9. Summary

1. Introduction

LHC roadmap: schedule beyond LS1

LS2	starting in 2018 (July)	=>	18 months + 3 months BC
LS3	LHC: starting in 2023	=>	30 months + 3 months BC
	Injectors: in 2024	=>	13 months + 3 months BC

- Physics
- Shutdown
- Beam commissioning
- Technical stop

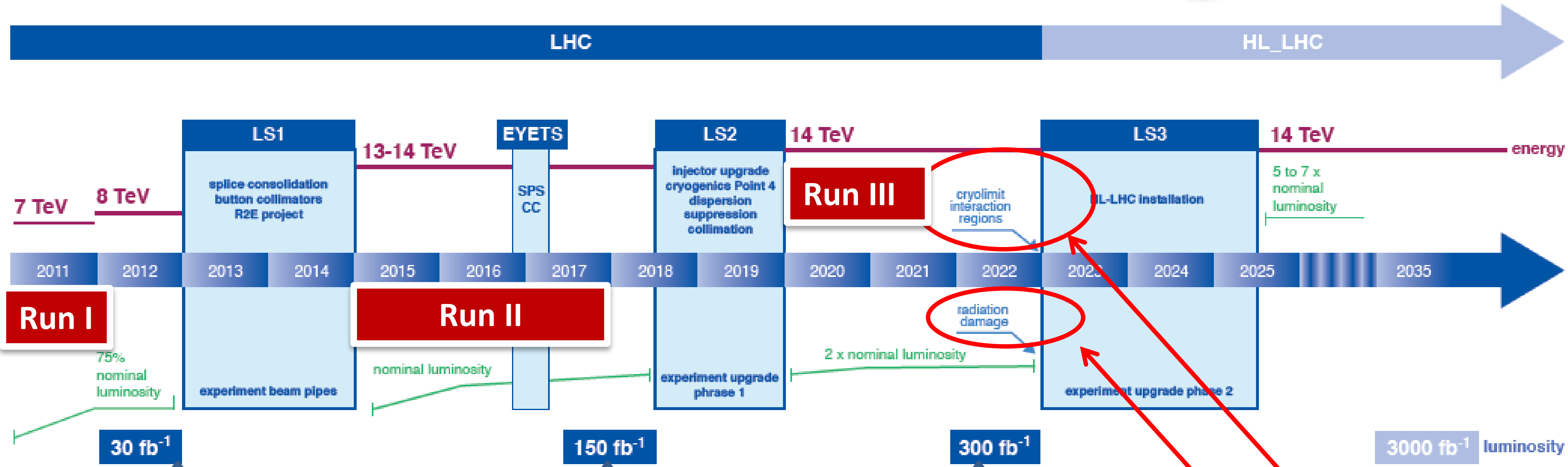
(Extended) Year End Technical Stop: (E)YETS

Goal of 3’000 fb^{-1} by mid 2030ies → **LIU + HL-LHC**

F. Bordry

High Luminosity LHC

LHC / HL-LHC Plan



$0.75\ 10^{34}\ cm^{-2}s^{-1}$
50 ns bunch
high pile up ~40

$1.7\ 10^{34}\ cm^{-2}s^{-1}$
25 ns bunch
pile up ~45

$1.7\text{-}2.2\ 10^{34}\ cm^{-2}s^{-1}$
25 ns bunch
pile up ~60

Lumi saturation & Technical bottlenecks:

$50 \Rightarrow 25$ ns

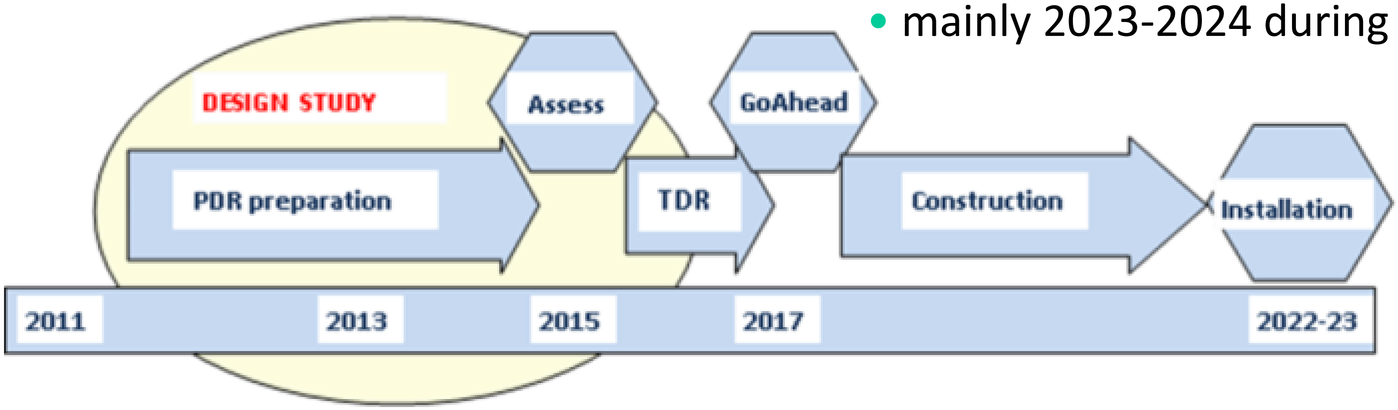
Plan approved by CERN management upon preparation in HL-LHC Coord Group and RLIUP

L. Rossi

High Luminosity LHC

HiLumi Design Study: overview

- **PDR** (preliminary design report) in 2014
- **Cost and Schedule** Review by March 2015
- **TDR** (technical design report) by 2015
- HL-LHC **installation**:
  - 2018-2019 during LS2
  - mainly 2023-2024 during LS3



- 19 Work Packages with 6 WP under the EU funded HiLumi Design Study
- Integration started with vigor as well as Preliminary Technical Specifications and Quality Assurance
- Several upgrades already in LS2: *e.g.* Cryo, SC link P7, Cryo-Collimators with 11 T , MoGr Coll's)
- Proof of main hardware by 2016
- Final Prototypes to be tested by 2017-2018 (IT, D1, D2, LRBBwire, CC)
- Start construction 2017/18 for IT, CC, other main hardware
- IT String test (integration) in 2019-20; Main Installation 2023-24
- Though schedule, but – based on LHC experience – feasible; 6 months shift of LS2 and 1 year shift of LS3 of the new LHC schedule ease the task.
- Cost: 750 MCHF (Material, CERN accounting)

L. Rossi

A real **challenge** for VSC in the coming years !!!

High Luminosity LHC

HL-LHC Baseline Parameters - WP2 charge – PLC

$$L = \gamma \frac{f_{rev}\, n_b\, N_b^{\,2}}{4\pi \varepsilon_n \beta^*} R$$

Parameter	Nominal LHC (design report)	HL-LHC 25ns (standard)	HL-LHC 25 ns (BCMS)	HL-LHC 50ns
Beam energy in collision [TeV]	7	**7**	7	7
N_b	1.15E+11	**2.2E+11**	2.2E11	3.5E+11
n_b	2808	**2748**[1]	2604	1404
Number of collisions at IP1 and IP5	2808	**2736**	2592	1404
N_{tot}	3.2E+14	**6.0E+14**	5.7E+14	4.9E+14
beam current [A]	0.58	**1.09**	1.03	0.89
x-ing angle [μrad]	285	**590**	590	590
β^* [m]	0.55	**0.15**	0.15	0.15
ε_n [μm]	3.75	**2.50**	2.50	3
r.m.s. bunch length [m]	7.55E-02	**7.55E-02**	7.55E-02	7.55E-02
Geometric loss factor R0 without crab-cavity	0.836	**0.305**	0.305	0.331
Geometric loss factor R1 with crab-cavity	(0.981)	**0.829**	**0.829**	**0.838**
Peak Luminosity without crab-cavity [$cm^{-2}\, s^{-1}$]	1.00E+34	**7.18E+34**	6.80E+34	8.44E+34
Virtual Luminosity with crab-cavity: Lpeak*R1/R0 [cm	(1.18E+34)	**19.54E+34**	18.52E+34	21.38E+34
Events / crossing without levelling w/o crab-cavity	27	**198**	198	454
Levelled Luminosity [$cm^{-2}\, s^{-1}$]	-	**5.00E+34**	5.00E34	2.50E+34
Events / crossing (with levelling and crab-cavities for HL-LHC)	27	**138**	146	135
Levelling time [h		**8.3**	7.6	18.0

LIU required

Impedance, efficiency etc.

New IT Quads & ATS

Crab Cavity required

Levelling required

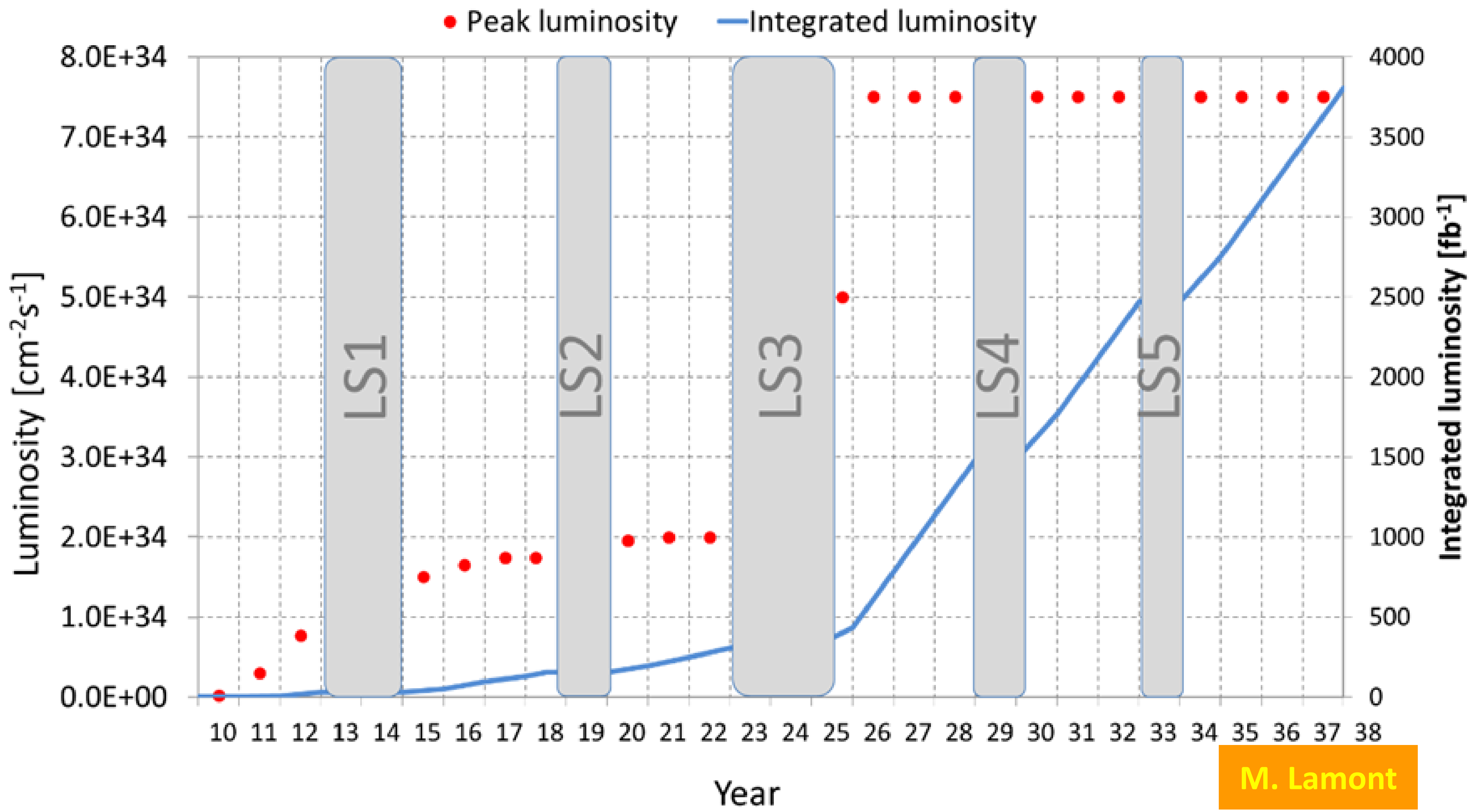
Efficiency requires long fill times (ca. 10h)!

Collision values

L. Rossi

VSC to review performance compatibility with HL-LHC to **identify consolidation** and build **new systems compatible with HL-LHC**

Only with 350 fb^{-1}/y (L_{lev}=7.5 10^{34} and some optimism) the goal is reachable

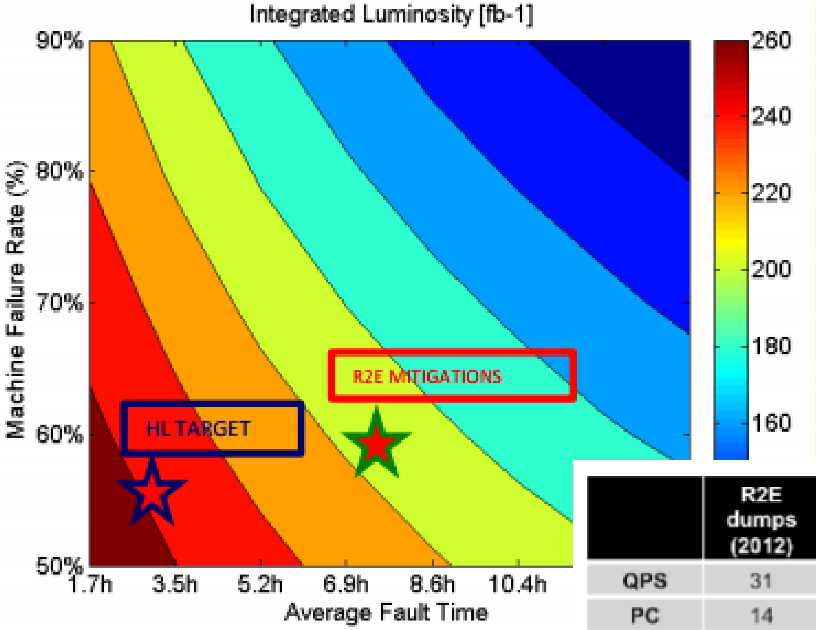


M. Lamont

Quality management of LHC and its injector is **a must** to reach the required **efficiency** (R2E, R2P, spare, performance follow up …)

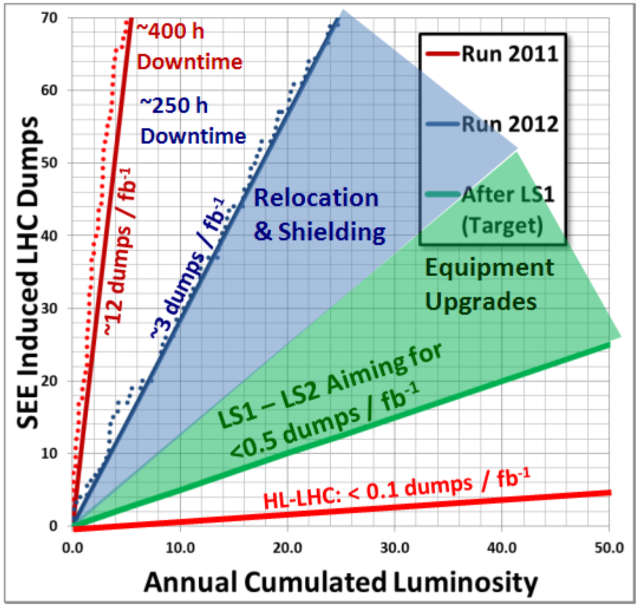
High Luminosity LHC

Availability and Downtime



D. Wolmann

	R2E dumps (2012)	R2E downtime (2012)	Target yearly dumps (HL-LHC)	Target R2E downtime (HL-LHC)
QPS	31	~ 80 h	9	32 h
PC	14	~ 60 h	4	14 h
CRYO	4	~ 70 h	1	3.5 h
Vacuum	4	~ 20 h	1	3.5 h
Other	3	~ 30 h	1	3.5 h

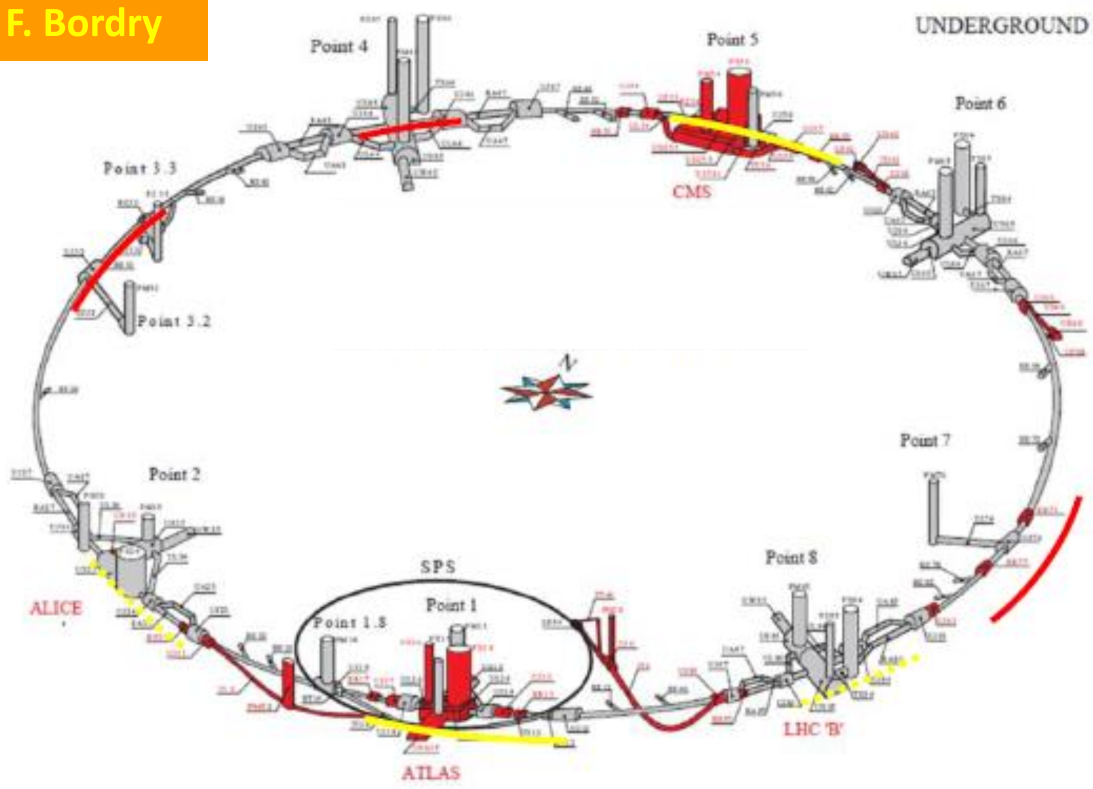


M. Brugger

Upgrade of interlocking system (integration to avoid spurious dump)
Reduction of (generous) of interlock levels
R2E
Robust and reliable equipments
Identification of “fast” repair scenario
Etc.

The HL-LHC Project

F. Bordry



- New IR-quads Nb_3Sn (inner triplets)
- New 11 T Nb_3Sn (short) dipoles
- Collimation upgrade
- Cryogenics upgrade
- Crab Cavities
- Cold powering
- Machine protection
- …

Major intervention on more than 1.2 km of the LHC

Project leader: Lucio Rossi; Deputy: Oliver Brüning

Close collaboration across all the VSC sections is a must

High Luminosity LHC

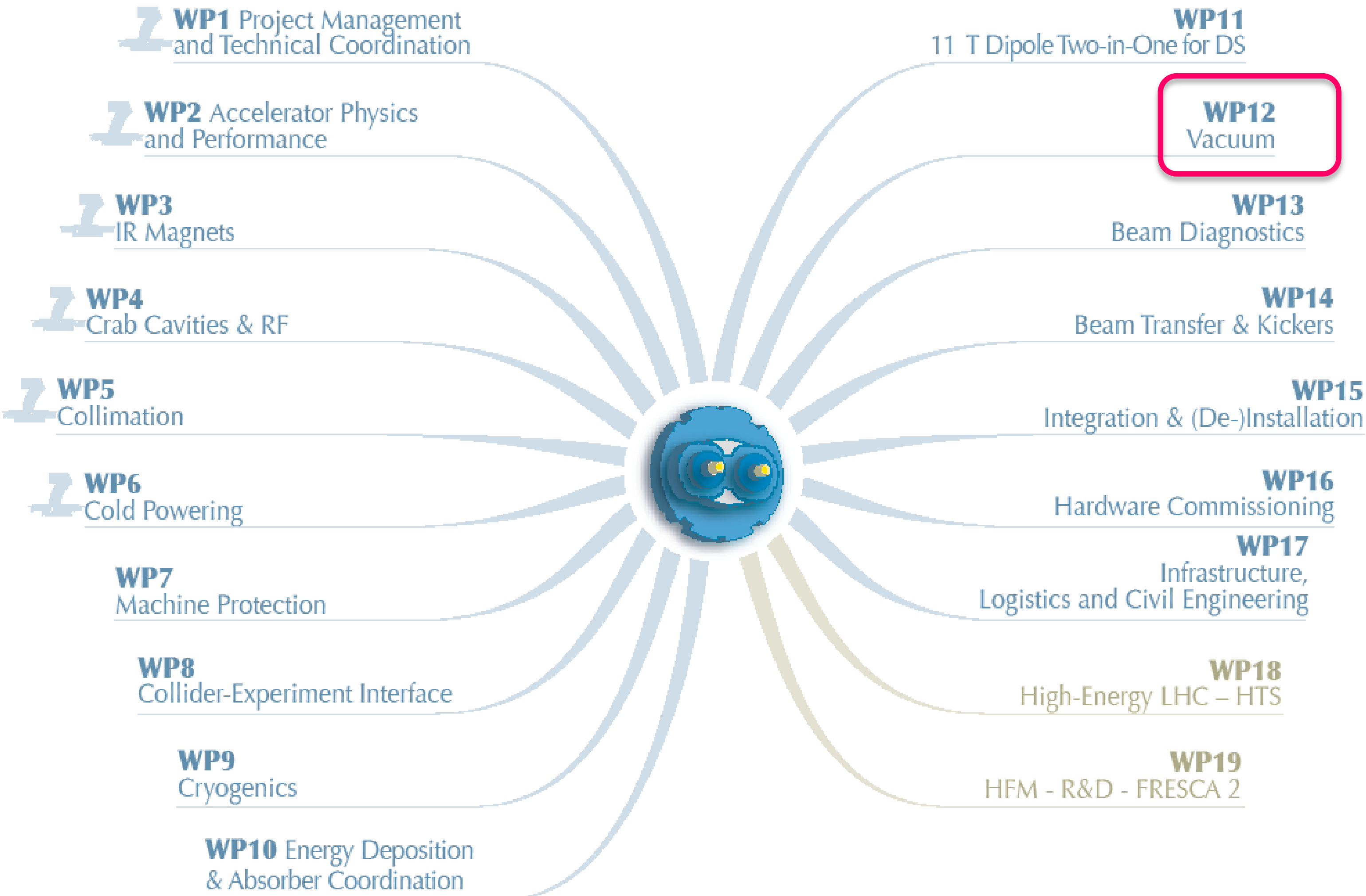
High Luminosity LHC Participants

L. Rossi

Identification of potential partners for future design studies, HL-LHC procurement and installation

Organisation

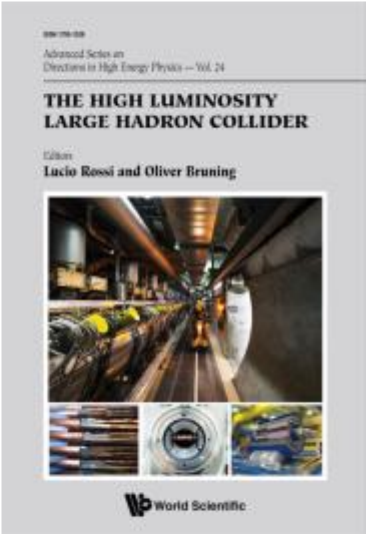
https://espace.cern.ch/HiLumi/default.aspx

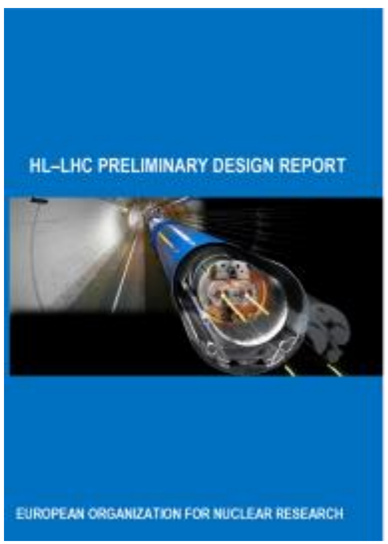


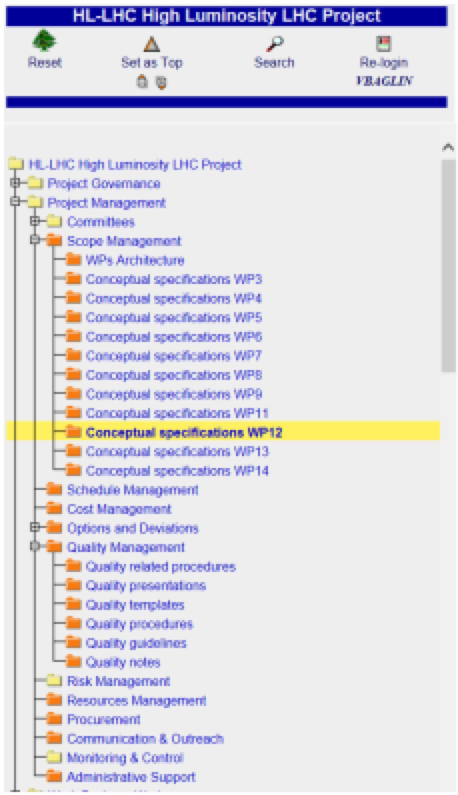
A single point of entry (VB and RK) for a TEAM work across VSC and partners

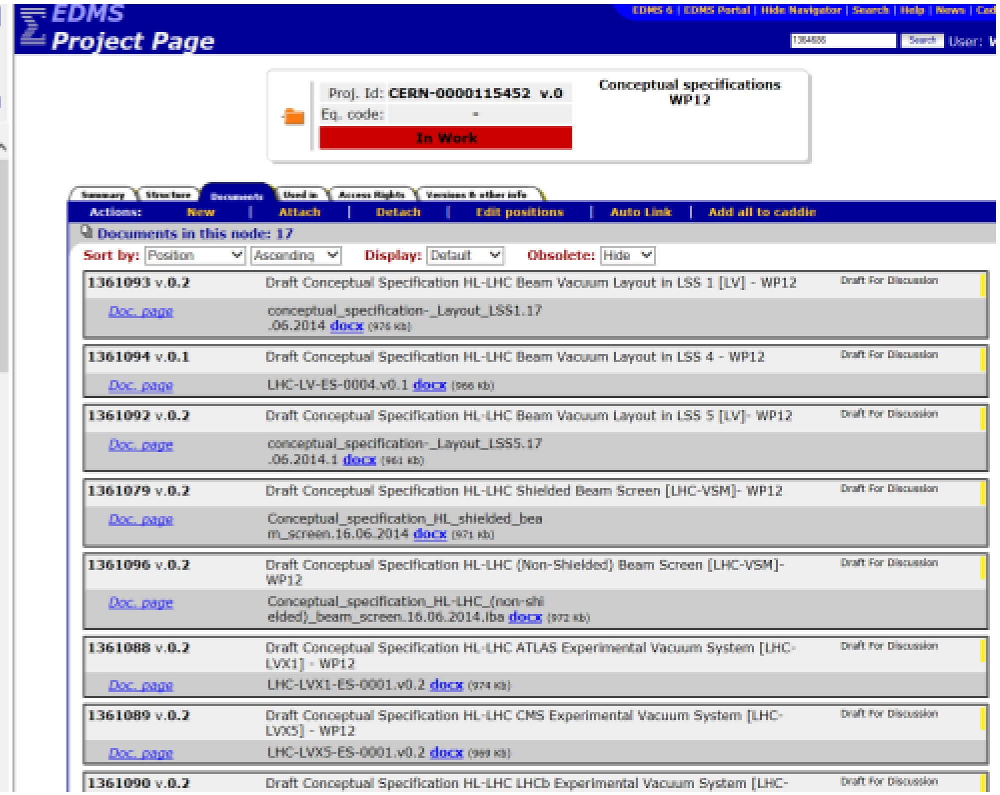
High Luminosity LHC

Documentation









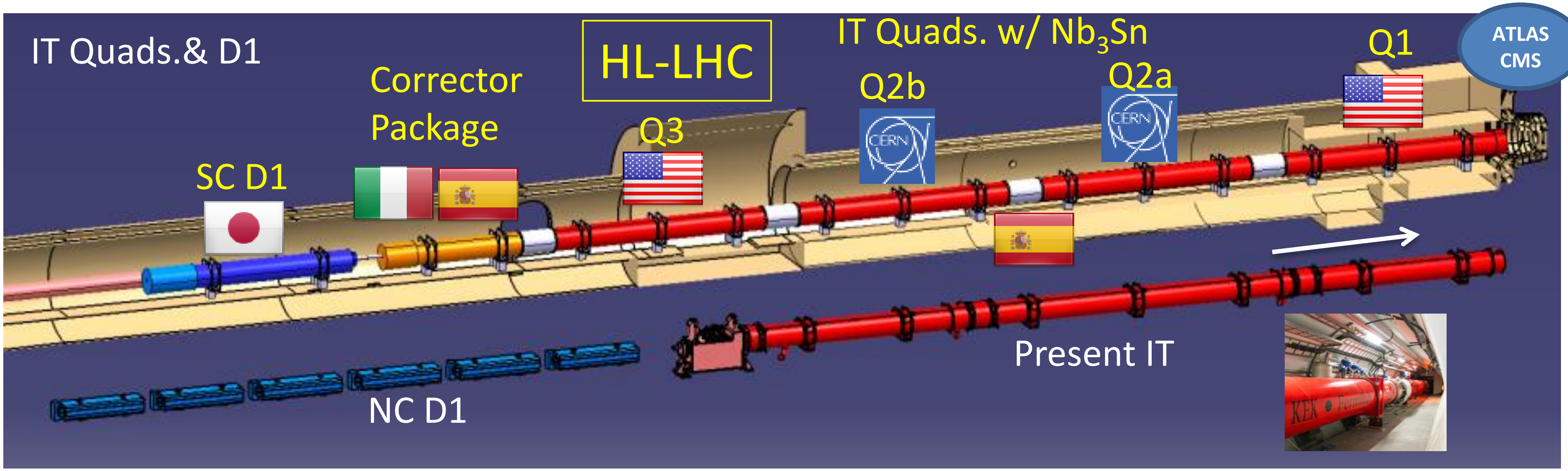
Definition and follow up of HL-LHC TE-VSC project structure is needed

High Luminosity LHC

2. Inner Triplets

Focussing quadrupole and merging dipole

- Decrease beta (*i.e* beam size) at collision point (beta*) from 55 cm to 15 cm



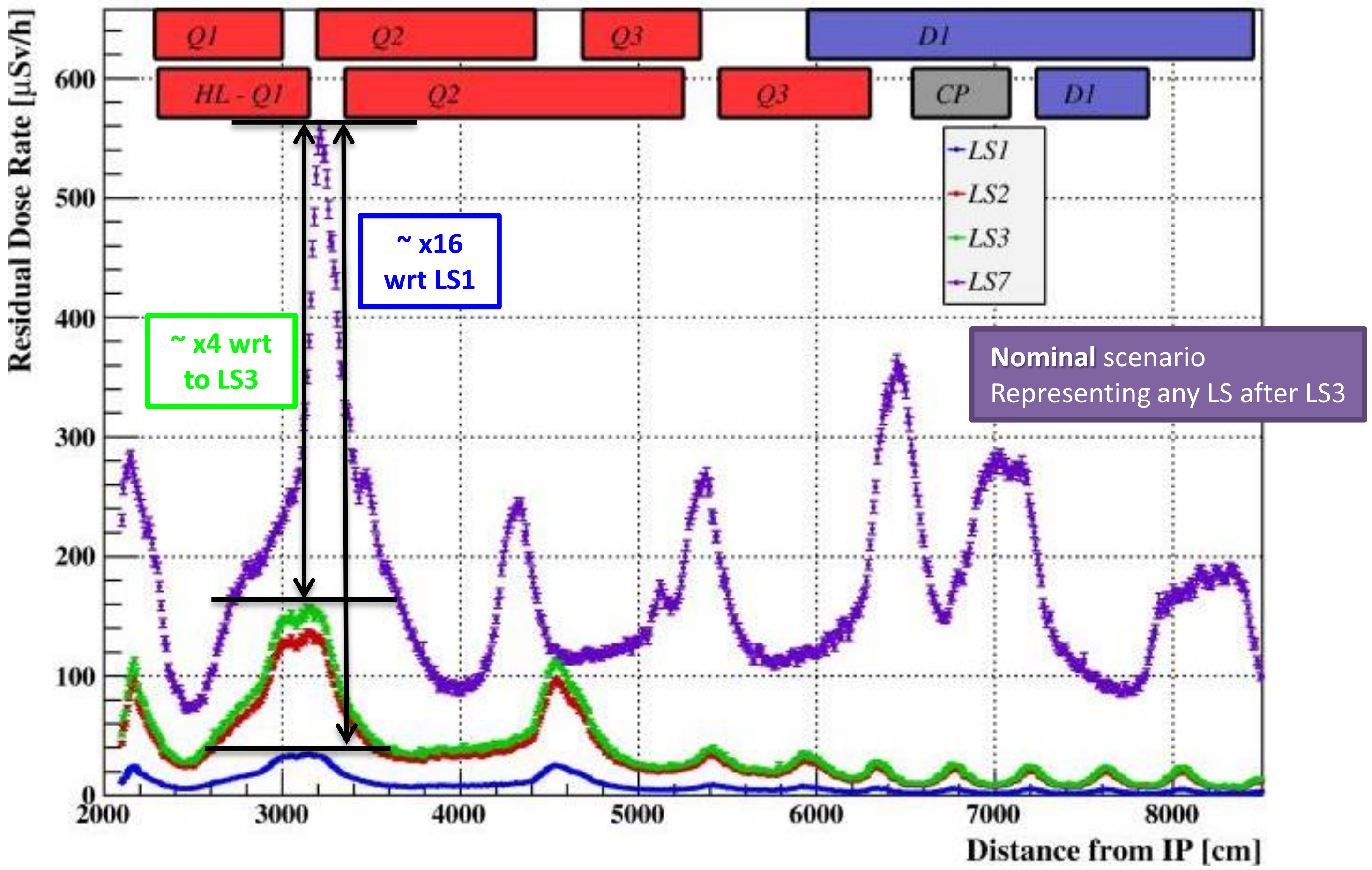
- **New :** Q1, Q2, Q3, CP (corrector package), D1
- All operating at 1.9 K
- Magnet aperture increase in IT quads : 70 mm to 150 mm, 140 T/m
- Superconducting D1 (aperture 150 mm, 5.6 T)

- Present IT+D1 **to be completely removed** (radiation to personnel !!)

- Interconnects to be **redesigned**

Impact of radiation to personnel around IT

- 1 month cooling time, dose rates at 40 cm from the cryostat



C. Adorisio

High Luminosity LHC

Impact of radiation to personnel around IT (2)

- CERN Objective : 3 mSv/year maximum during LS (Rule for Cat B personnel : 6 mSv/y)

- Case study : When ? any LS after LS3, nominal

C. Adorisio

What	Where	How ?	Collective dose (man mSv)	
			1 month cooling time	4 months cooling time
Valve exchange	TAS-Q1	3 teams 5 workers	3	1
PIM exchange	Q1-Q2 IC	6 teams 8 workers	21	8

/2.5

- Estimation of WDP (work dose plan) can also be done for LS3 and the removal of the present inner triplet magnets to optimize the work-methods

- Dose maps available from TAS to D1

Optimisation of design, equipment robustness, intervention procedures (WDP) with use of remote tooling and training of people is **MANDATORY**

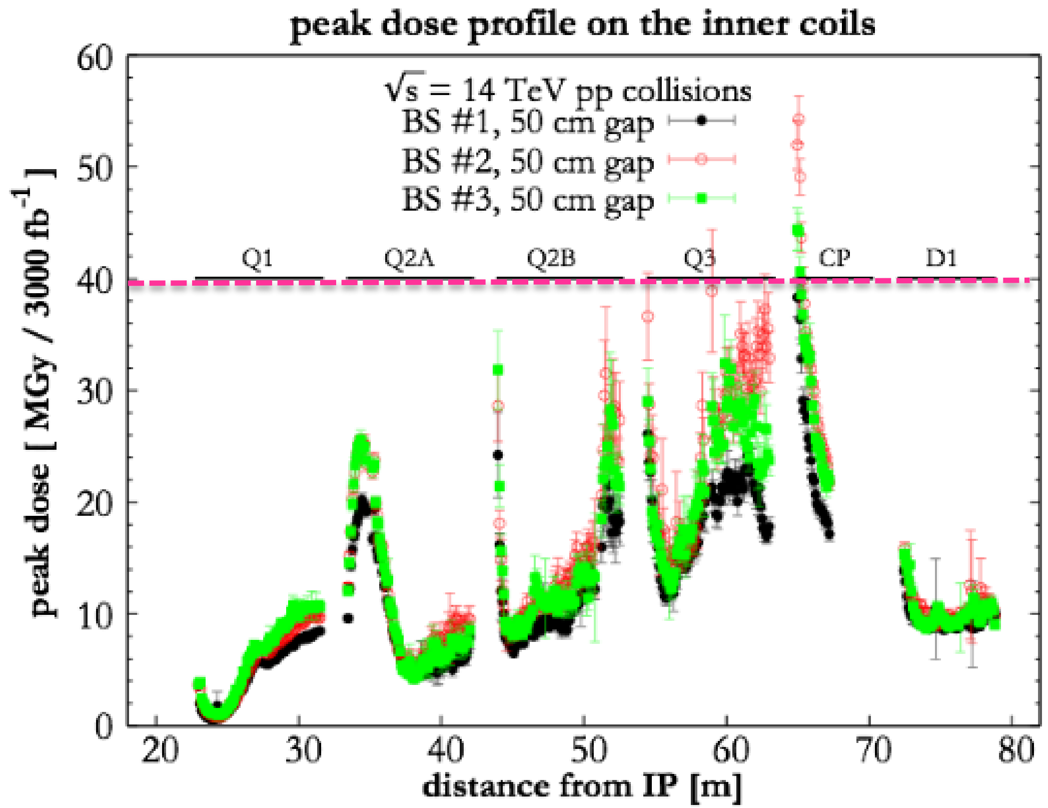
Impact of debris onto IT+D1

- 700 MJ per beam (7 TeV, 2.2 10^{11} ppb, ~ 2800 b)
- 14 kW delivered in collisions, on each side:
  - TAXS absorber with aperture, 54 mm, takes 750 W
  - 5 kW impact the machine ➔ shielding is needed to protect the cold masses

- Target :
  - < 4 mW/cm3
  - < 40-50 mGy

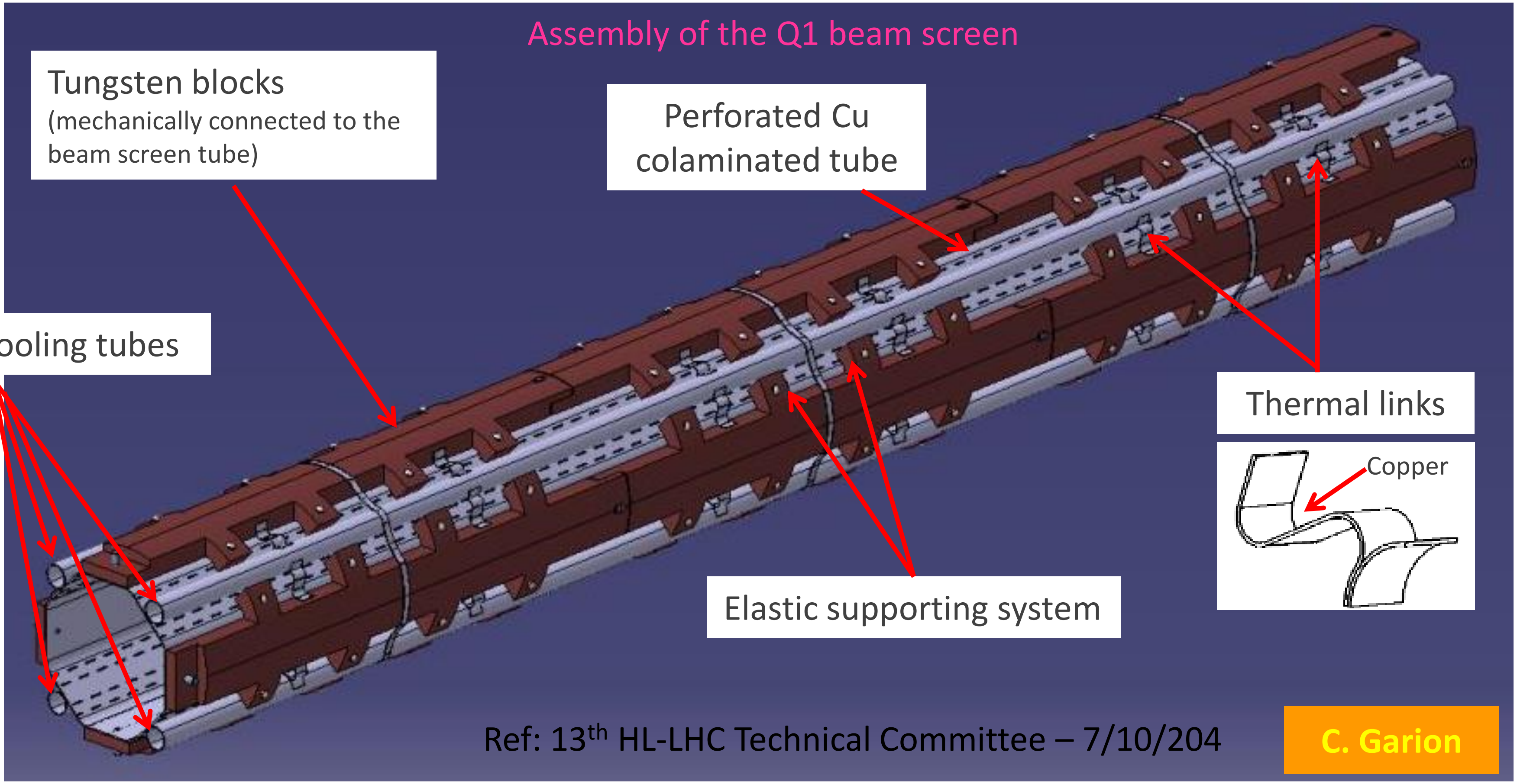
- Mainly Q3 affected
- 1 kW in the cold mass
- 800 W in the beam screen

F. Cerutti



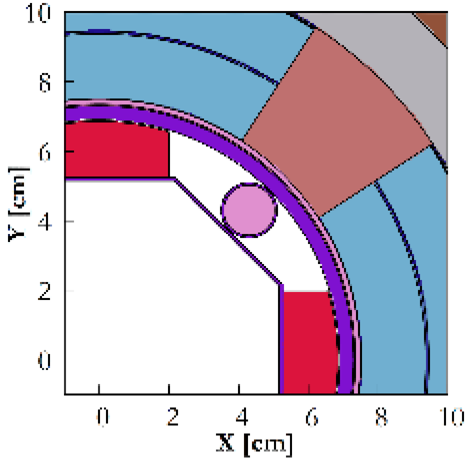
Impact of debris onto IT+D1: shielded beam screen

- Operating temperature : 40 -60 K
- 16 mm absorbers in Q1, 6 mm absorbers from Q2 to D1

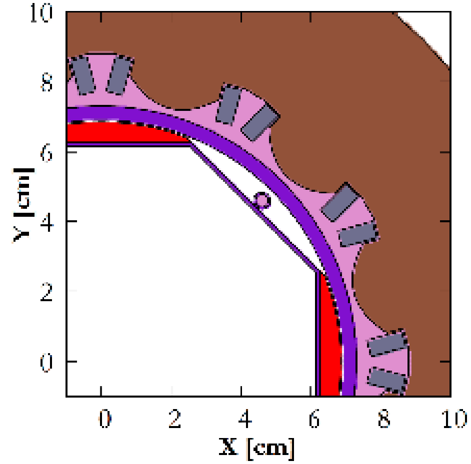


- Design studies underway
- Mechanical analysis : impact of quench, heat transfer, supporting system
- Tests with tungsten prototypes

Impact of debris onto IT+D1: shielded beam screen (2)



16 mm absorber
(Q1)

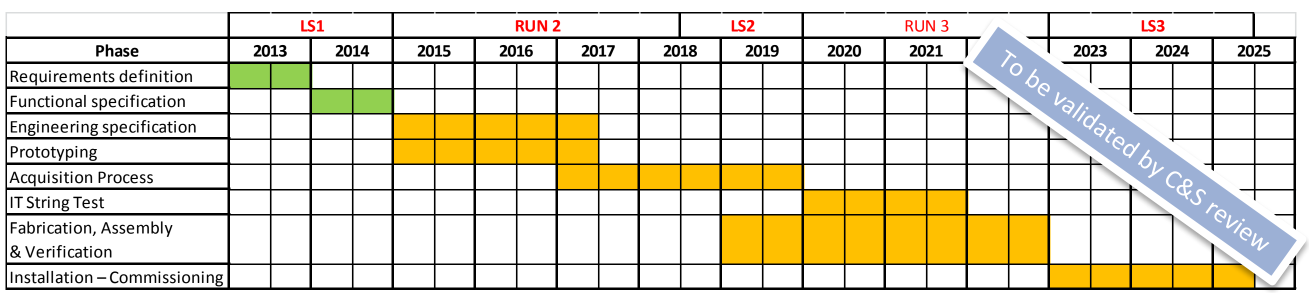


6 mm absorber
(Q2=>D1)

- New cold bores
- Octagonal shape, 4 cooling channels
- ~ 700 kg per Quadrupole

- Q2-Q3 2015: short (1 m long) prototype

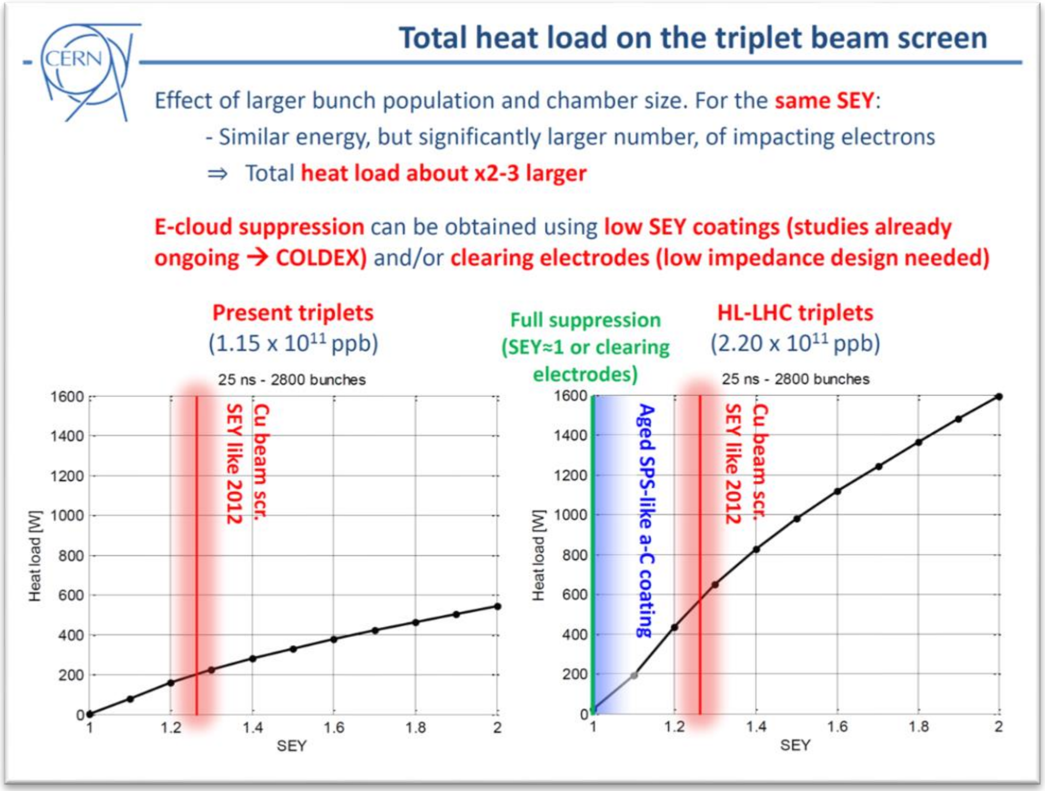
- Defining, controlling tolerances and alignment is a challenge



Engineering specification and prototyping to start by 2015

Impact of electron cloud onto IT+D1: a-C coating

- Extrapolation for the HL-LHC of Run 1 observations predicts large heat load due to electron cloud on the beam screen of the inner triplets
- This increase of heat load will be accompanied by increase of background to the experiments
- To reduce the heat load to ~ 200 W on the beam screen, amorphous carbon (a-C) coating is proposed (SEY~ 1.1)
- This base line must be validated at cryogenic temperature with LHC type beams

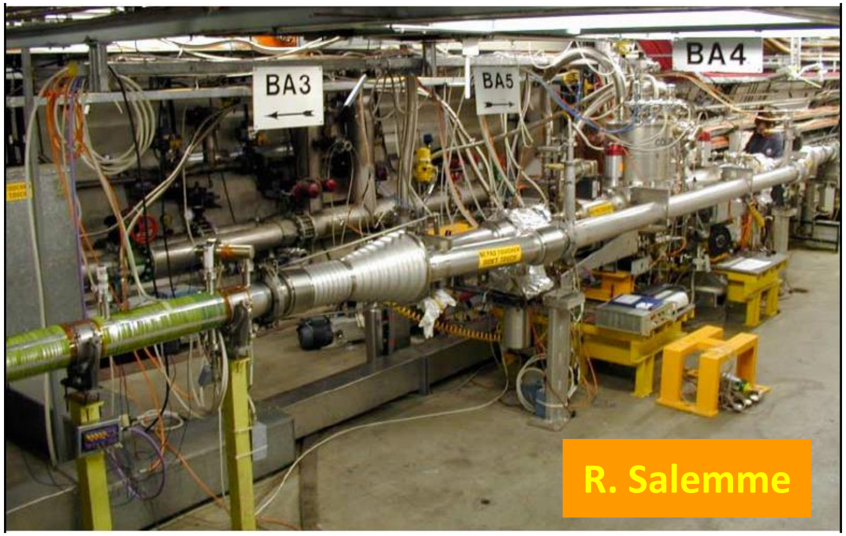


G. Iadarola, G. Rumolo
3rd Joint HiLumi LHC-LARP Annual Meeting, Daresbury
11-15/01/2013

COLDEX in SPS with –a-C coating

- a-C beam screen held at 50 K, 5 k then 10 K while cold bore ~ 4K

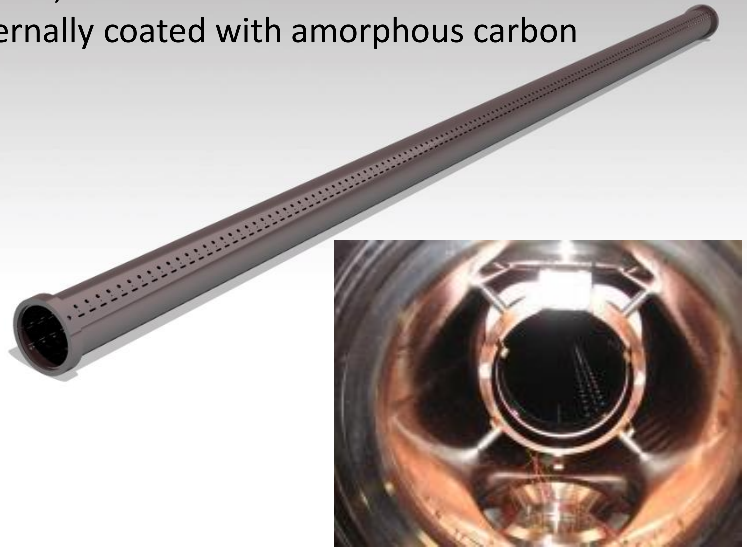
- LHC type beams circulating in SPS (3 9/11/2014):
  - Heat load < 1 W/m
  - Pressure rise < 5 10^{-9} mbar
  - Main gas is H_2



- Refurbishment and operation of COLDEX : strong support and commitment of many CERN groups: TE-CRG, BE-OP, BE-ABP, TE-EPC, EN-ICE

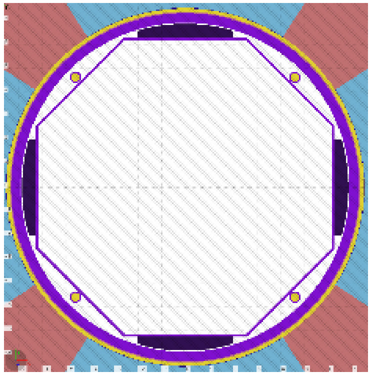
- Thanks to L. Rossi, HL-LHC project leader, crab cavities, WP 4, and cryogenic, WP9, projects for their support to operate COLDEX during 2016

~2.2 m, ID 67 beam screen
Internally coated with amorphous carbon

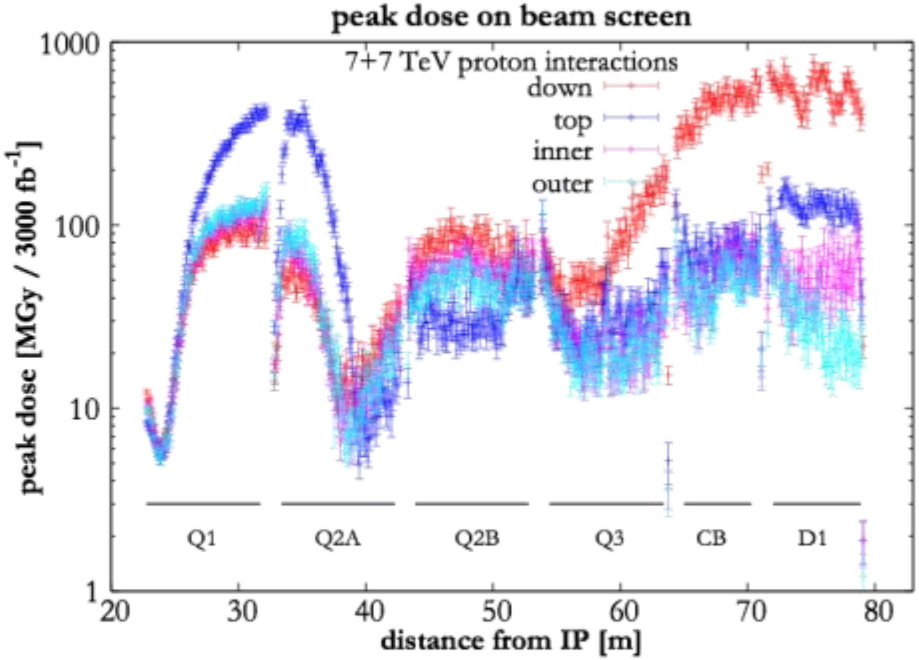


a-C coating validation at cryogenic temperature **must** be continued

Radiation dose to a-C coating and shielded beam screen

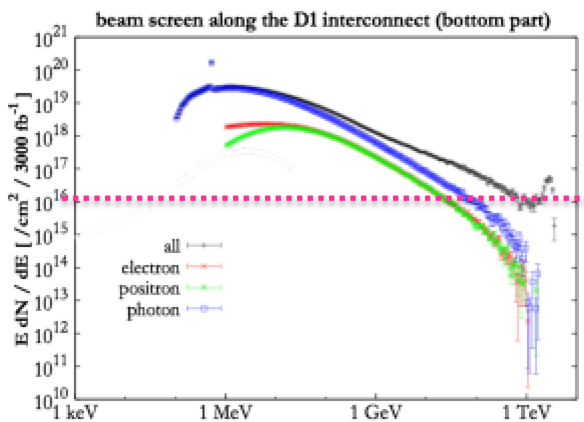


F. Cerutti

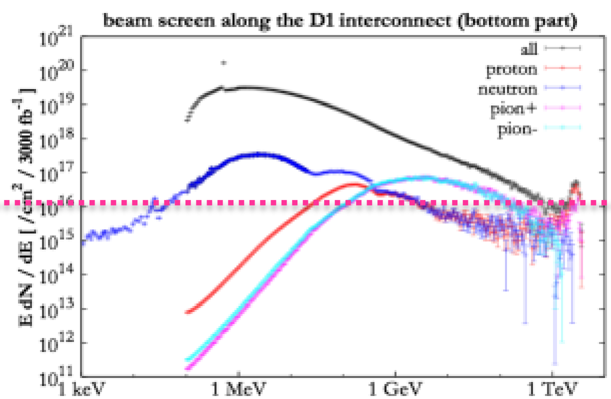


- dose up to GGy
- dominated by electro-magnetic components

Behaviour of a-C coating under irradiation **started**



Electromagnetic



Hadronic

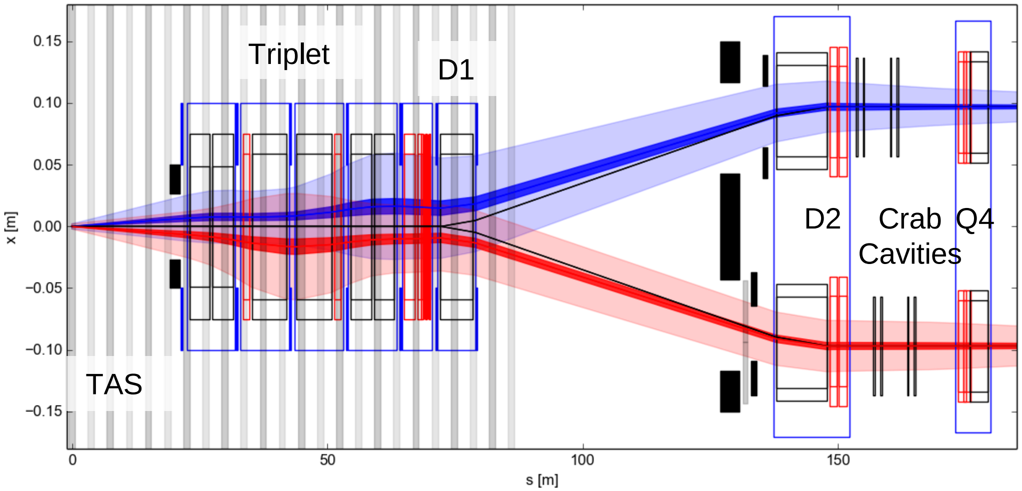
3. Layout

Optics: HL-LHC V1.1

- New optic for HL-LHC : ATS (Achromatic Telescopic Squeezing), blow-up β in the arcs to reduce β*

S. Fartoukh

- New Matching section



Right side of IR1/IR5

R. De Maria

Changes in IR1/5

- TAS aperture reduced .
- Triplet, BPM, corrector layout update.
- D1-D2 length reduction.
- TAN new aperture and separation.
- Displacement Q4 by 10m towards the arc
- 3 to 4 crab cavities per side per beam.
- New MCBRD – MCBYY length and strength
- for crab cavity beam based alignment.
- Additional masks and collimators
- Q5: MQYL to MQY at 200 T/m.

Changes in IR6

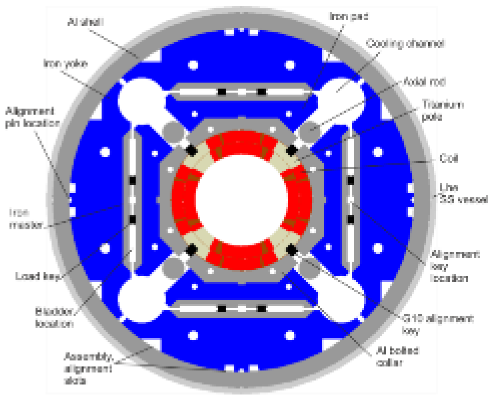
- Q5: MQYL to 2x MQY.

Complete dismounting of LSS1 & 5
New beam screens : procurement !
New layout

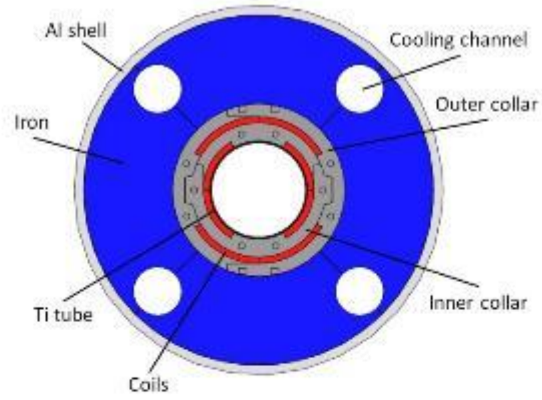
High Luminosity LHC

The magnet zoo in the IR

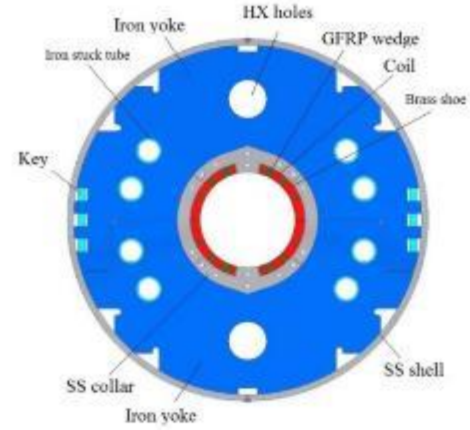
E. Todesco



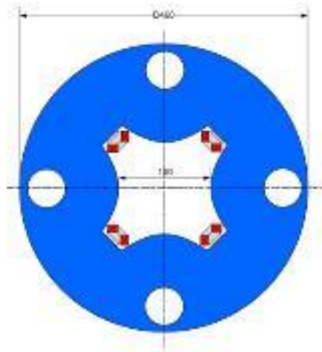
Triplet QXF (LARP and CERN)



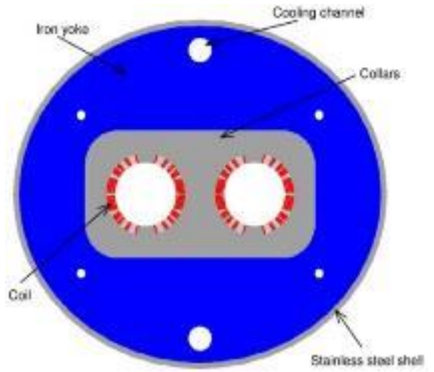
Orbit corrector (CIEMAT)



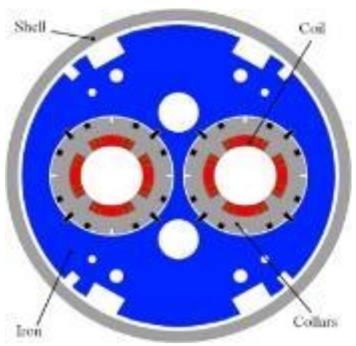
Separation dipole D1 (KEK)



Skew corrector (INFN)

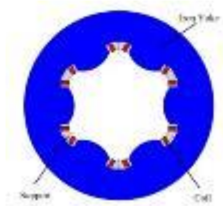


Recombination dipole D2 (INFN design)

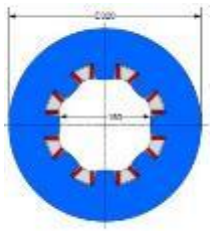


Q4 (CEA)

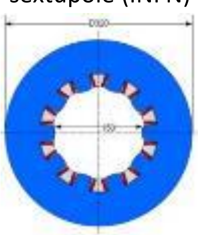
Cross-sections in scale



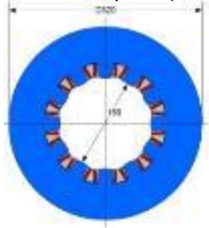
Corrector sextupole (INFN)



Corrector octupole (INFN)

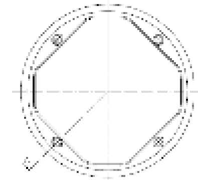


Corrector decapole (INFN)



Corrector dodecapole (INFN)

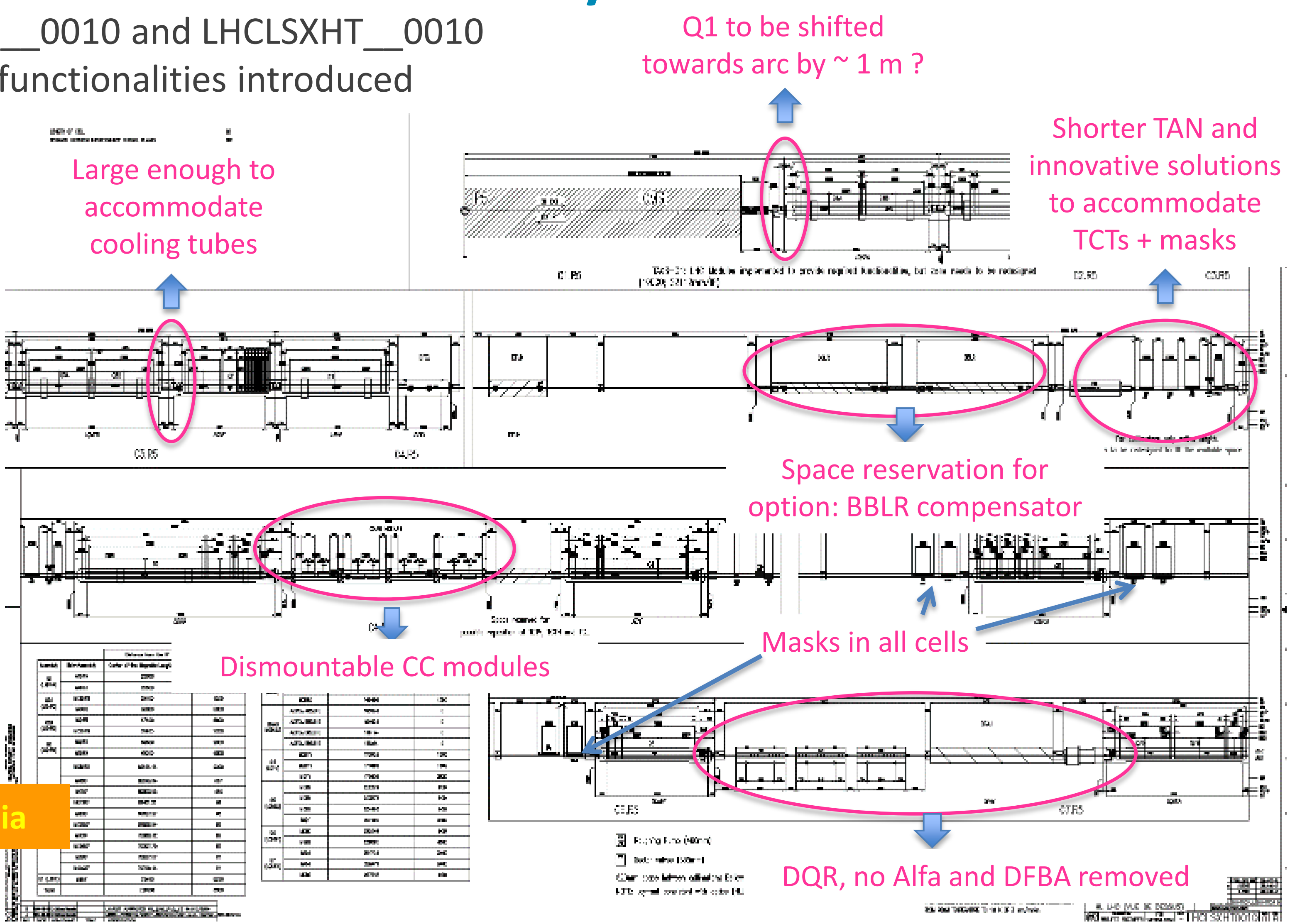
Many beam screens with interconnects and cold warm transitions to be designed, produced & installed



C. Garion

Layout

- LHCLSXH__0010 and LHCLSXHT__0010
- Vacuum functionalities introduced



P. Fessia

Optimisation of areas : TAS-Q1, interconnects, TAN-D2, crab cavities

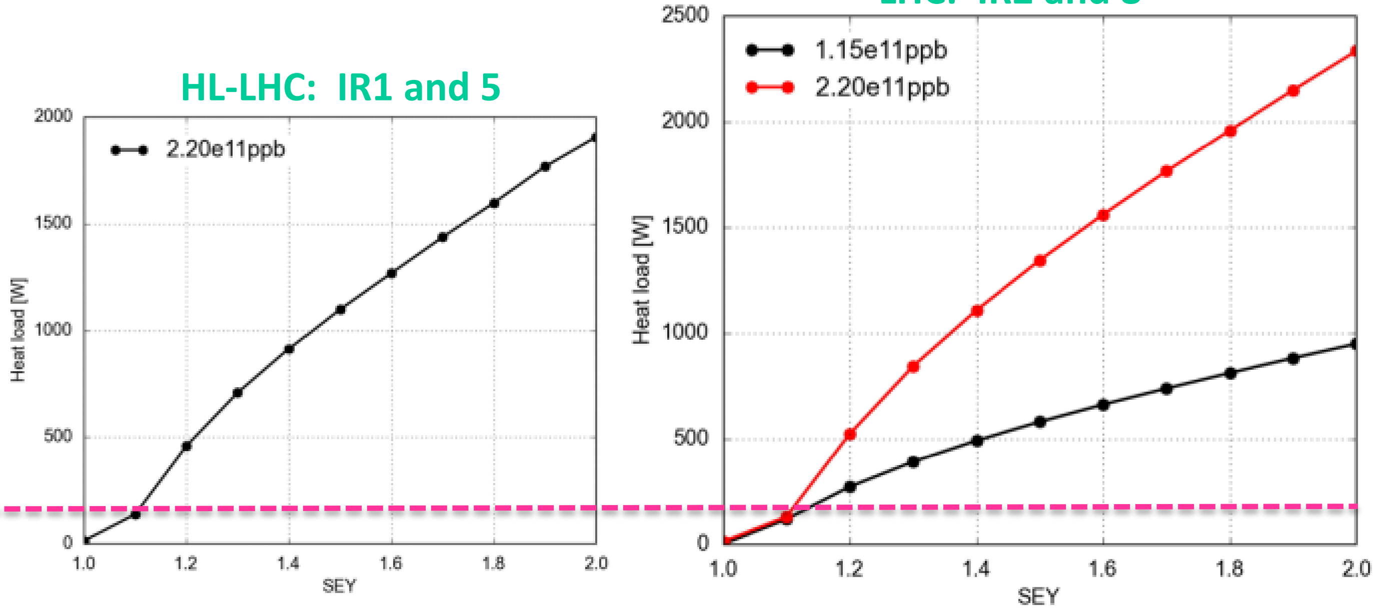
Heat load

- Heat load working group to be resumed in 2015 (WP9)
  - defines necessity on a-C coating with WP2 and WP12

Total heat load on the beam screen cooling circuit IT+D1

HL-LHC: IR1 and 5 **LHC: IR2 and 8**

Acceptable Limit = 100W ?



G. Iadarola

- Need for heat load reduction for the triplets & D1 of IR1/ and IR2/8

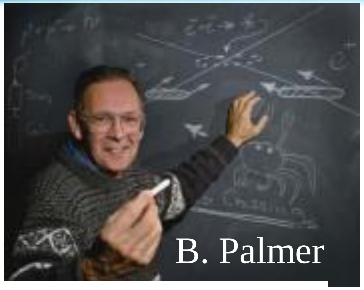
Study *in-situ* coating and **clearing electrodes**
Optimise cooling efficiency
Identify beam screens to be treated for electron cloud

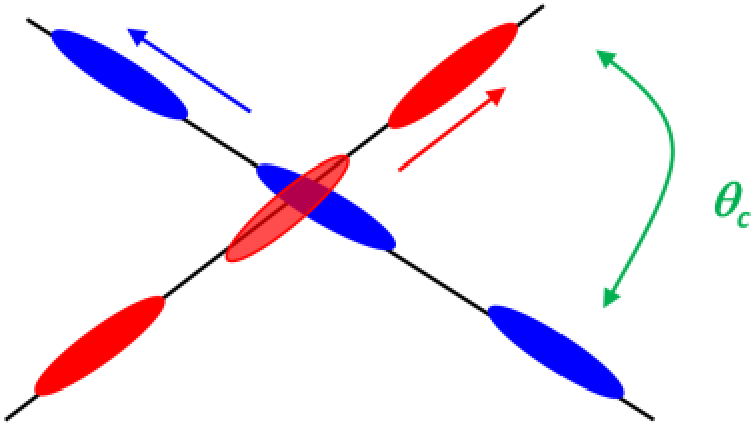
4. Crab cavities

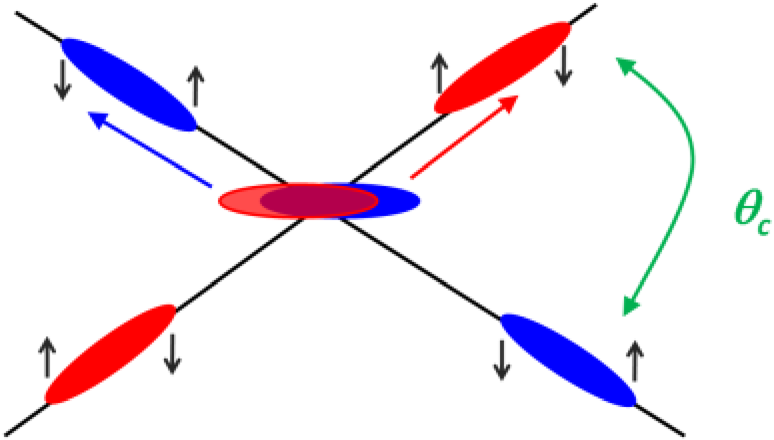
Crab cavities: luminosity

- Increase instantaneous luminosity by a factor 16 by "crabbing" the bunches
- Requires luminosity levelling to minimise number of event per crossing

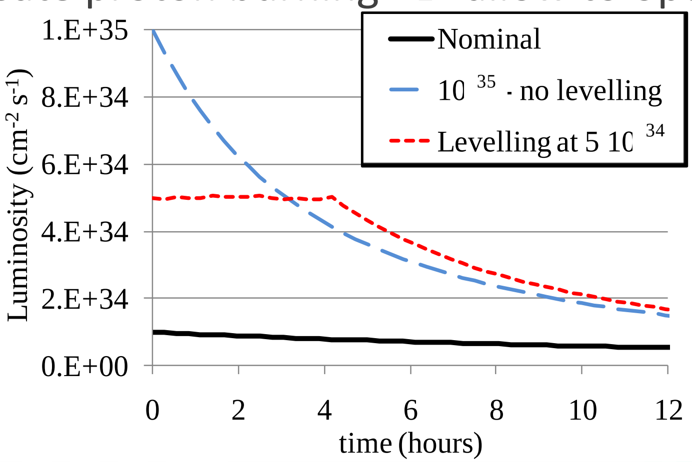
F. Zimmermann, R. Calaga

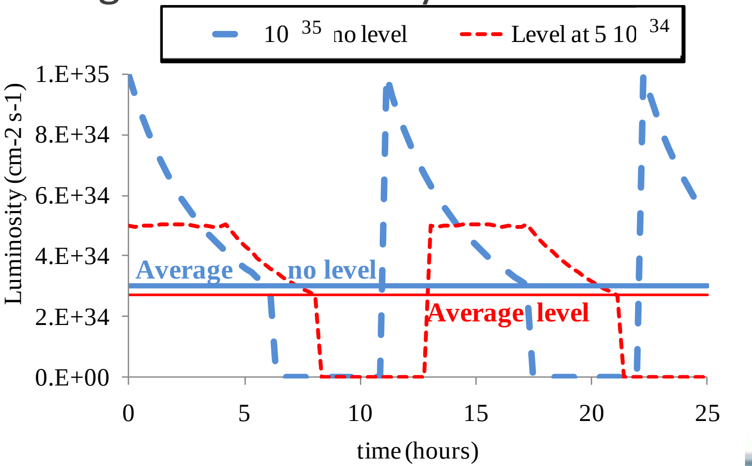






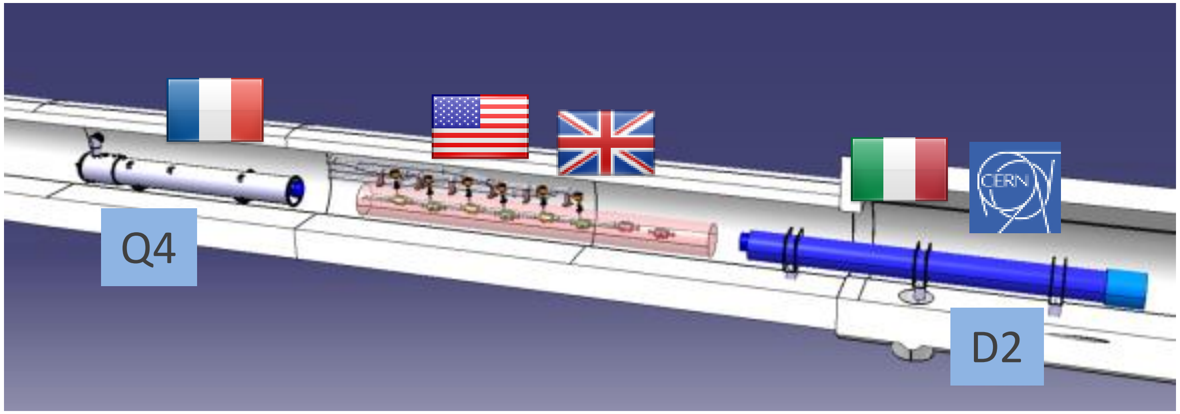
- Crab cavities maximise luminosity and can be used for luminosity levelling:
  - when luminosity is too high, CC are almost off and are slowly turned on to compensate proton burning ➔ allow to optimise integrated luminosity

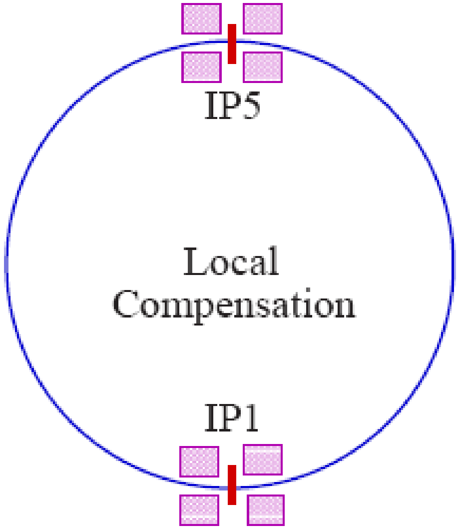




Crab cavities

- Installed on left and right side of IP1 and IP5





- Installed between D2 and Q4
- all CC operating at 2 K

- Two designs to evaluate (RF dipole and double quarter wave cavities)
- Bulk Nb cavities

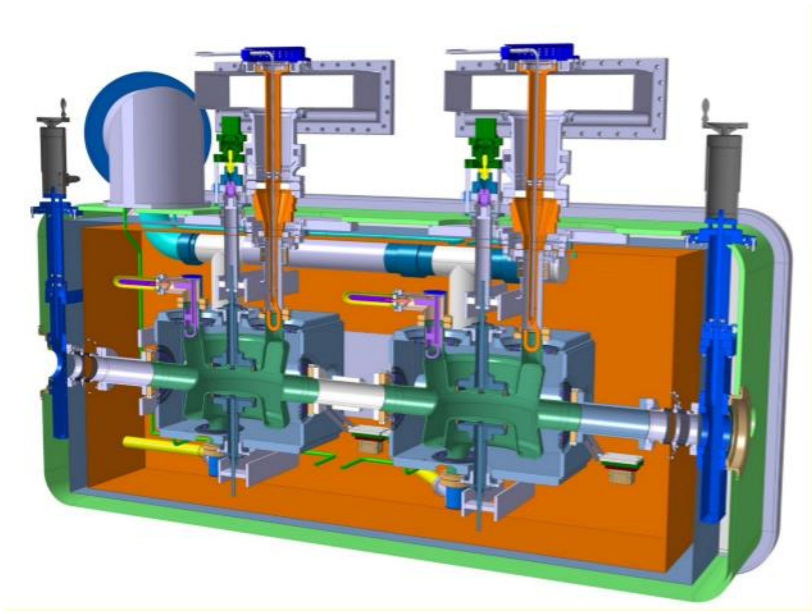
LARP-ODU-JLAB

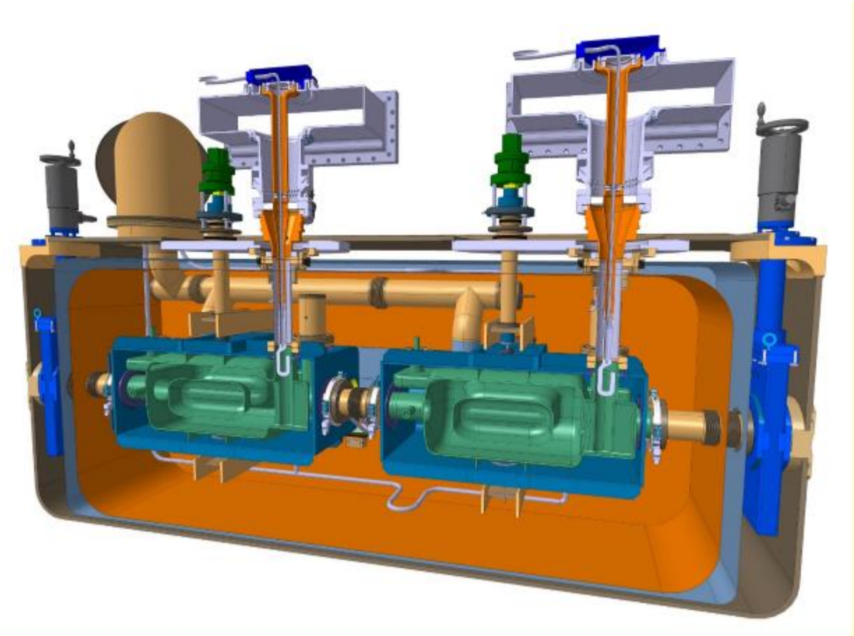
LARP-BNL

High Luminosity LHC

Crab cavities

- Operating pressure ~ 10^{-10} mbar with beams
- Vacuum instrumentation on the modules is under definition
- Drawings and leak detection procedures needs to be validated by VSC





Cryomodules for the DQW (left) and RFD (right) cavities respectively

R. Calaga, O. Capatina

Crab cavities and electron cloud

- Bulk Nb treatment is well defined (EDMS 1389669, 150 micron chemical etching, 600 deg heat treatment, 10-20 micron chemical etching, high pressure water rinsing and finally a 120 deg bake)

- Impact of the electron cloud in the CC modules must be evaluated for:
  - Nb cavity itslef
  - Inter-cavity tube
  - Module cold warm transition

  } Samples needed for qualification

1.1 < Nb film SEY < 1.7

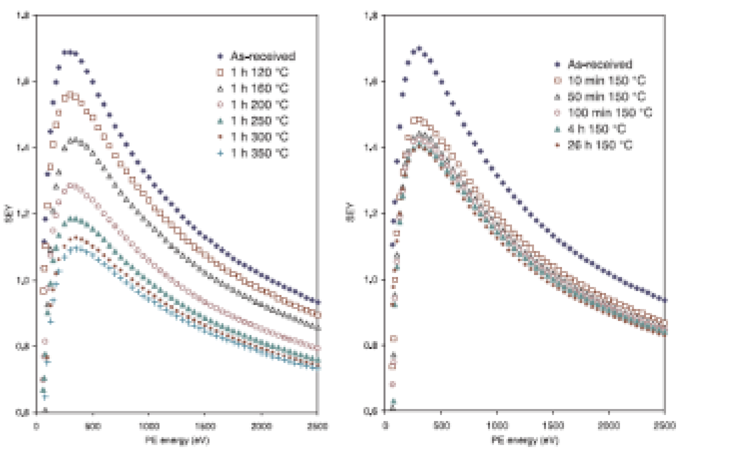
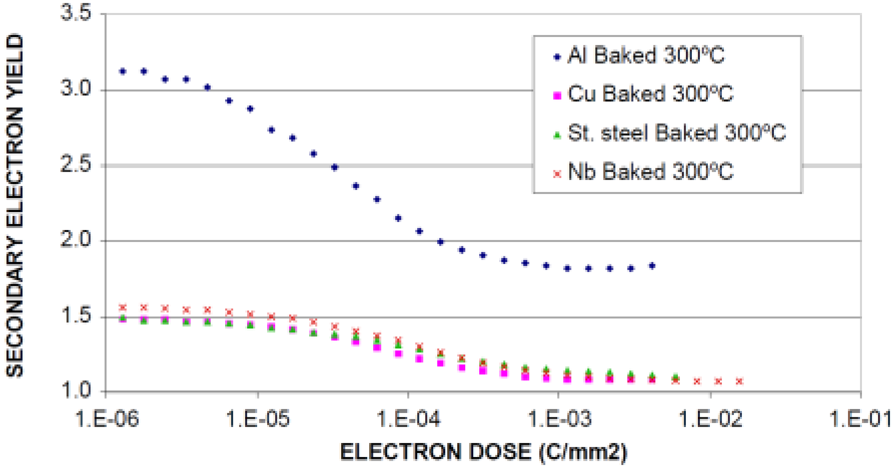


FIGURE 2 SEY vs PE energy of a Nb thin film as a function of heating temperature at 1 h heating time (left plot) and as a function of heating time at 150 °C (right plot)

N. Hilleret *et al.*, Appl. Phys. A 79, 1085-1091 (2003)

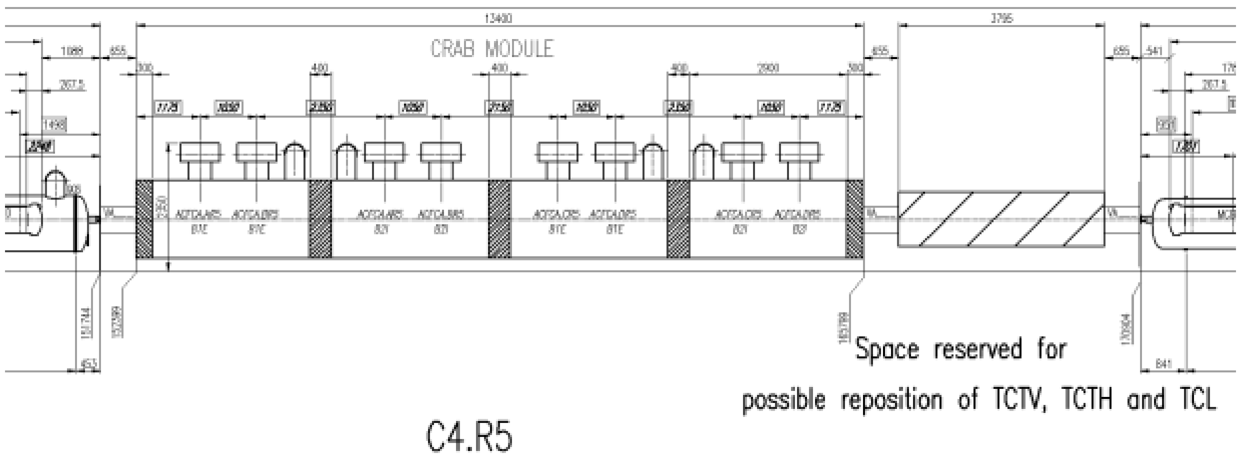
Electron conditioning



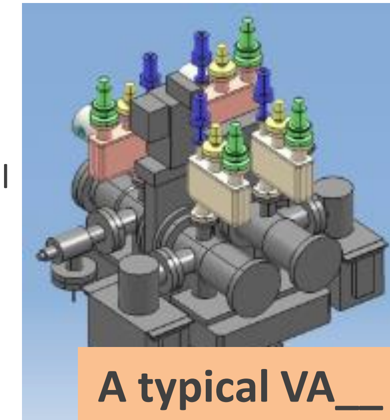
N. Hilleret *et al.* EPAC 2000, Vienna, Austria

Layout D2-Q4

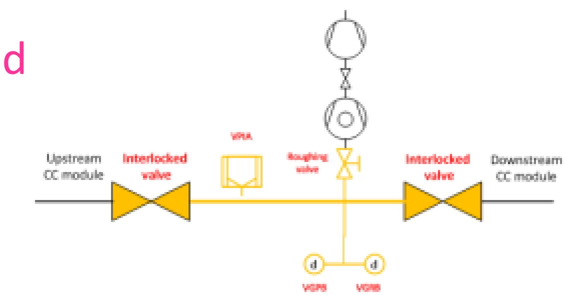
side view



LHCLSXH_0010

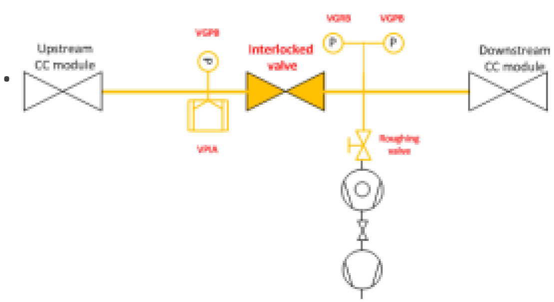


- Room temperature (except CC modules): bakeable and NEG coated



- 4 Sectorised CC modules:
  - Standard sectorisation valves (VA__), length 655 mm, at extremity

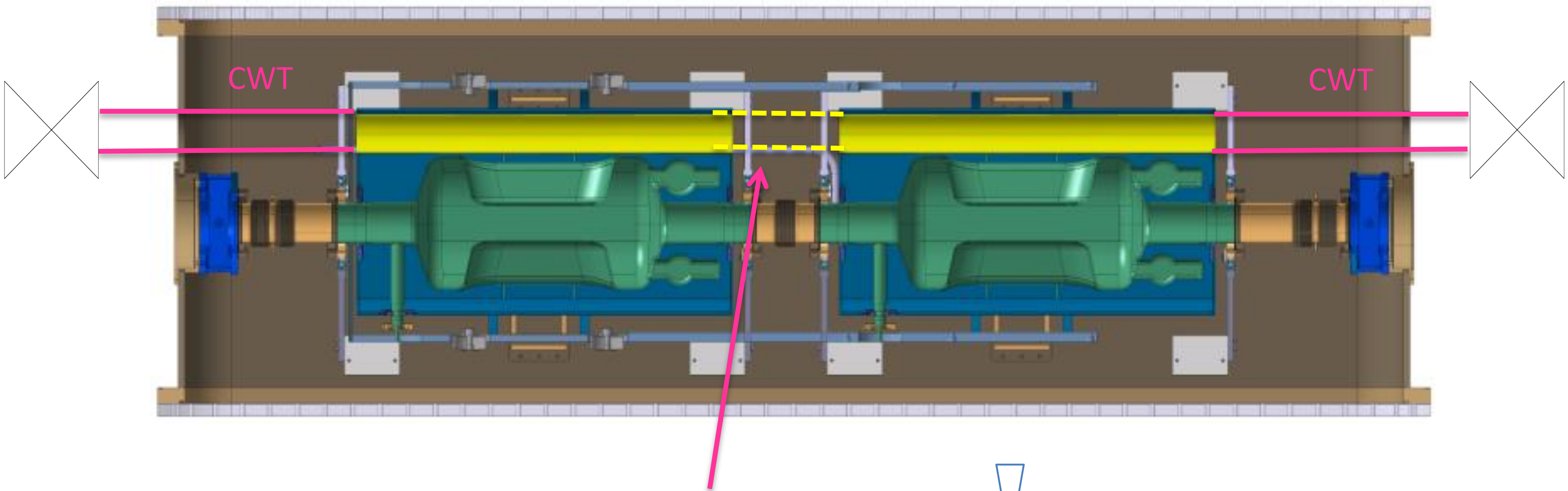
  - Specific sectorisation assembly, length 400, between modules. To be defined & designed. 2 beam line:
    - 2 roughing valve
    - 3 sector valve (beam interlocked)
    - 3 penning gauges + 2 ion pump + 2 pirani gauges



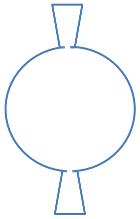
Layout D2-Q4: 2^{nd} beam pipe

- The 2nd beam pipe is held at 2 K and has cold warm transition (CWT) !
- Current material is Nb, diameter limited by space

- In LHC, maximum length without beam screen is < 1 m (to be revised for HL-LHC)
- Detailed studies are needed to comply with vacuum stability and pressure level



A beam screen between
2 cryogenic pipes ?



A beam pipe with
Antechamber ?

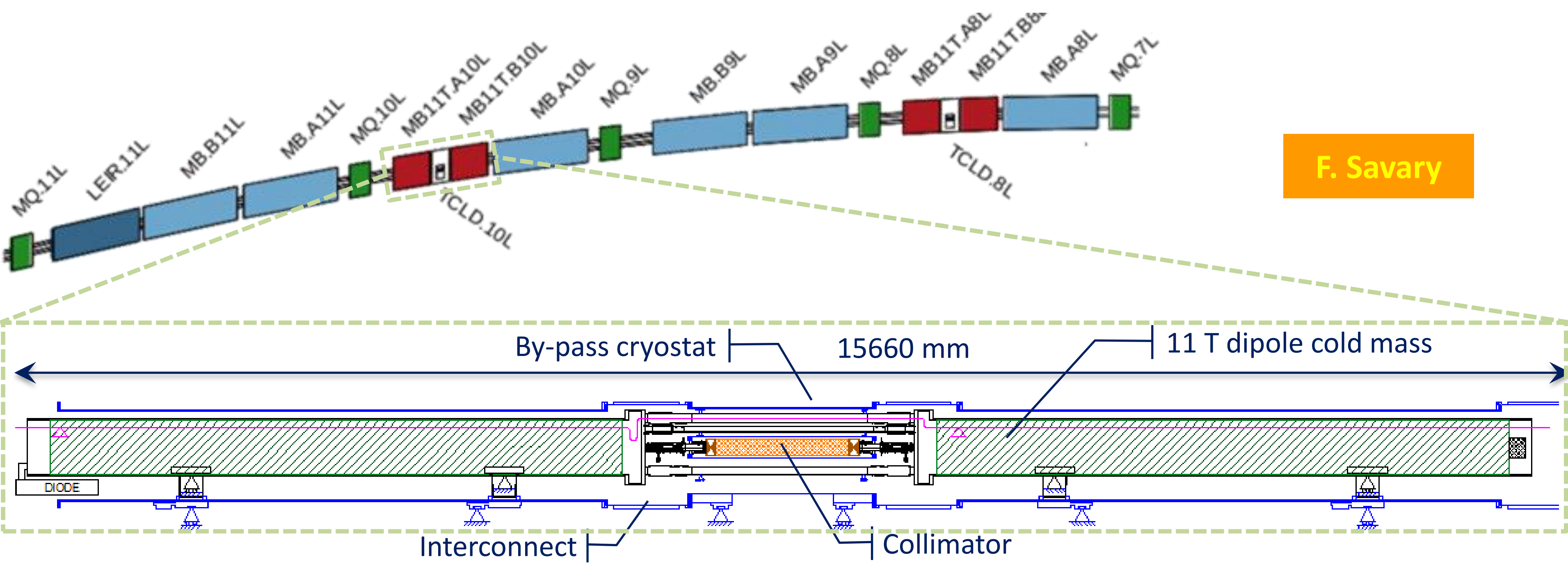
5. Collimation

11 T – DS collimator

- Arc Dispersion Suppressor areas (Q7 to Q11) serve as “energy spectrometer” : a collimator is needed to reduce background to ALICE with ion operation and to reduce beam loss on the cold masses with proton beams

- Using $NbSn_3$ technology, the dipole field can be increased up to 11 T

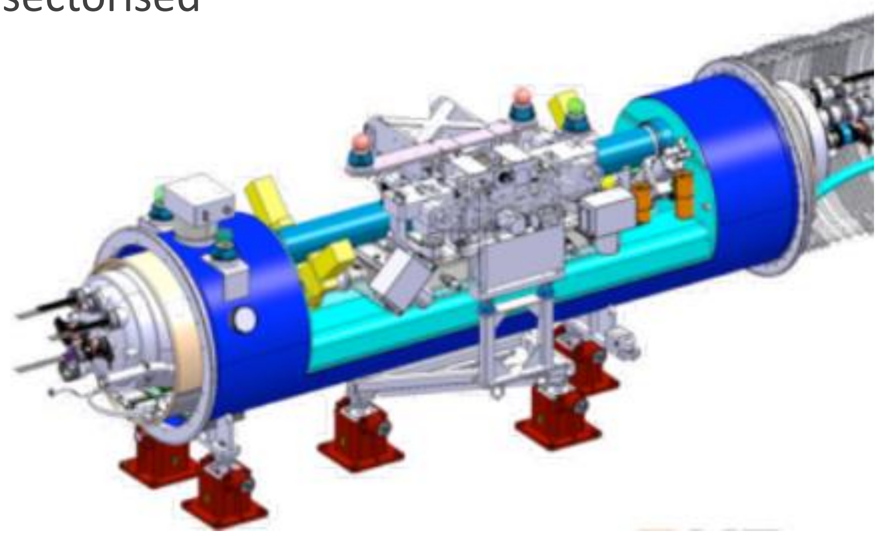
- A standard LHC dipole can be replaced by two 11 T magnets and one collimator (TCLD)



High Luminosity LHC

11 T – DS collimator

- The Target Collimator Long Dispersion suppressor, TCLD, collimator operates at room temperature and is sectorised



F. Savary
S. Redaelli

VSC needs to complete the integration (2nd beam line in particular)
Installation of two assemblies are expected in IP2 (left and right) for LS2 (2018-19)

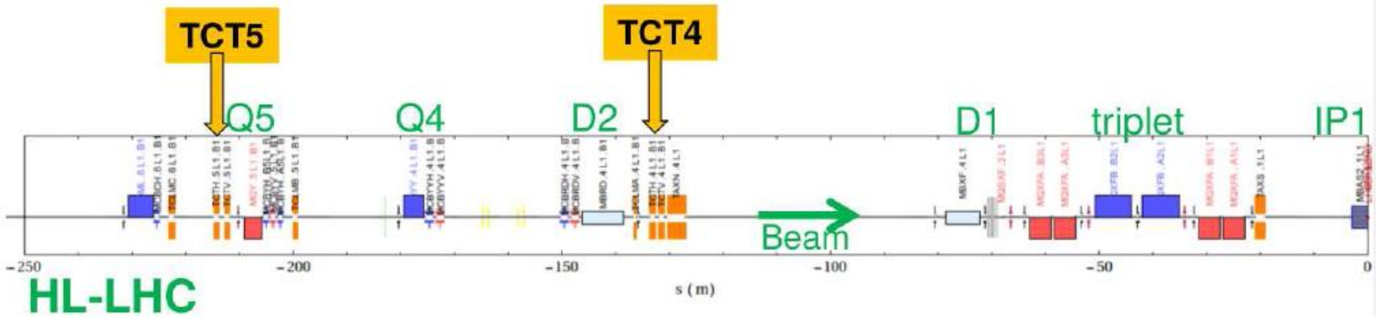
- IR 7: 2 TCLDs per side to improve collimation cleaning
- IR 1/5: 2 TCLDs per side to allow high luminosity

} LS3

High Luminosity LHC

Collimation and protection layout IP1/5

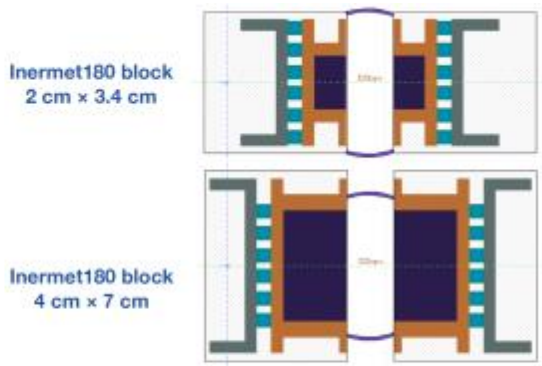
- Tertiary collimators, TCTs, in cell 4 and 5
- Better protection of apertures, asynchronous beam dumps and possible reduction of background to the experiments



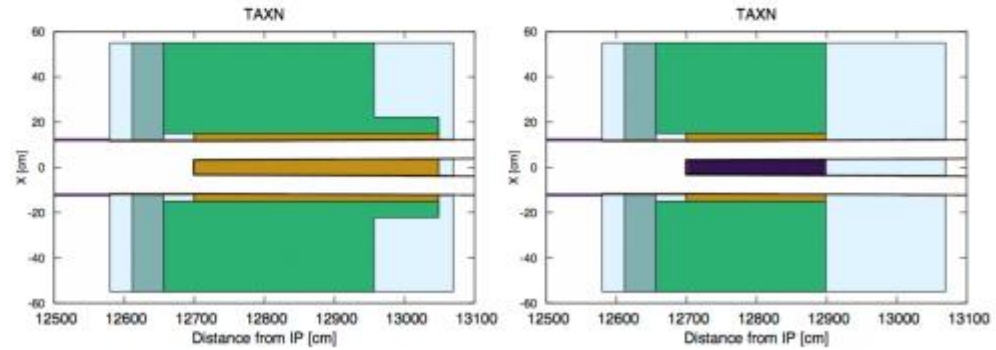
S. Redaelli

- Upgrade of TCL4 mask: design with larger jaws
- TCLX4

- Upgrade of TAXN
- Inserting Inermet180
- Length reduce from 3.5 to ~ 2 m



F. Cerutti,
L. Esposito



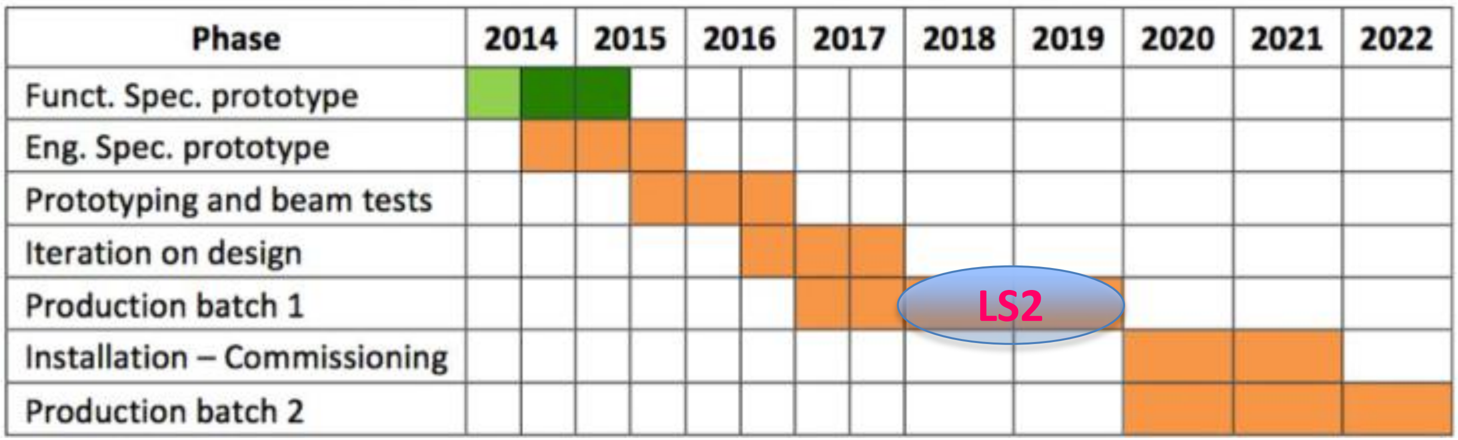
Drawing and performance **validation** on new components **by VSC**
Possible anticipated upgrade during **LS2**

Impedance upgrade

- IR 3/7 : 2nd generation secondary collimators, Target Colimator Secondary Pick-up Metallic, TCSPM, with Molybdenum Carbide Graphite (MoGr) and in jaw beam position monitors.

- Reduce impedance by 90 %, deployment in 2 batches

S. Redaelli

- 

- IR 1/5 : 2nd generation tertiary collimators, Target Colimator Terticary Pick-up Metallic, TCTPM, with Molybdenum Carbide Graphite (MoGr) and in jaw beam position monitors.

- To be installed during LS3 (or during (E)YETS if needed)

Possible future upgrades

- IR 3/7, in the pipe line :
  - Primary collimators, Target Collimator Primary Pick-up, TCPP, with in jaw beam position monitors.
  - Shower absorbers, TCLA
  - Passive absorbers, TCAP

At the end, the **complete LSS3 and LSS7** might be upgraded for HL-LHC during :

- (E)YETS
- LS2
- LS3

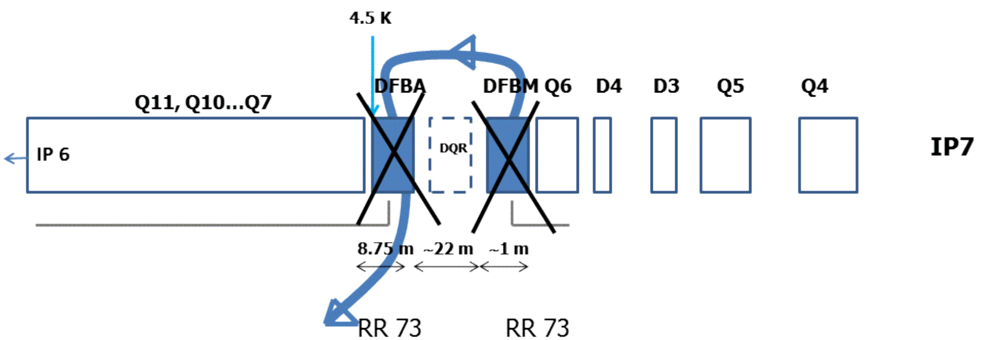
Optimisation of tooling, procedures (with WDP definition) and increase of equipment robustness is **MANDATORY**

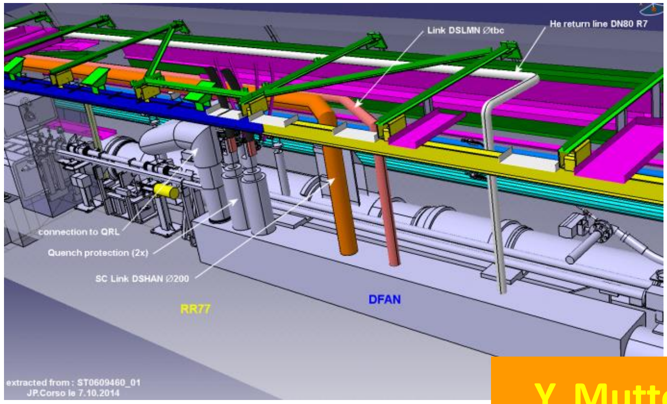
6. SC links and Cryogenics

Superconducting links

A. Ballarino

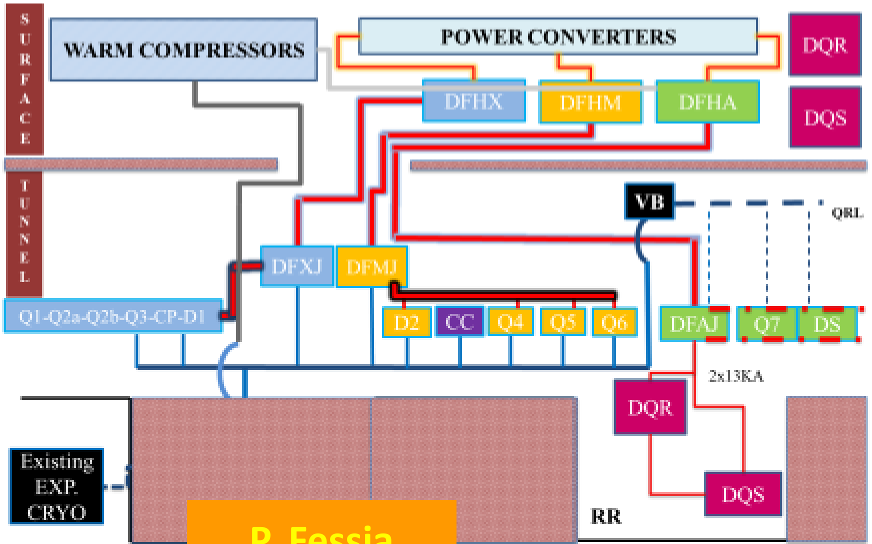
- SC links are used for cold powering systems.
- Provides protection against R2E
- DFAs will replace DFBs
- DFBAs and DFBMs will be removed from LSS7: installation during **LS2**





Y. Muttoni

- DFBA's will be removed from LSS1/5



P. Fessia

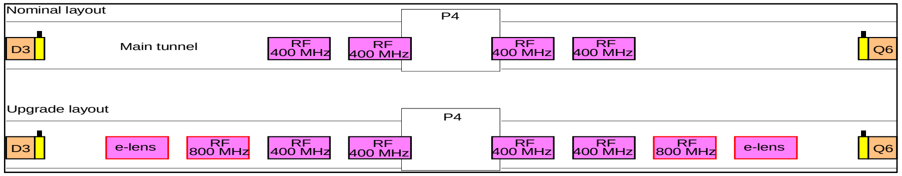
Requires dismounting of vacuum equipments

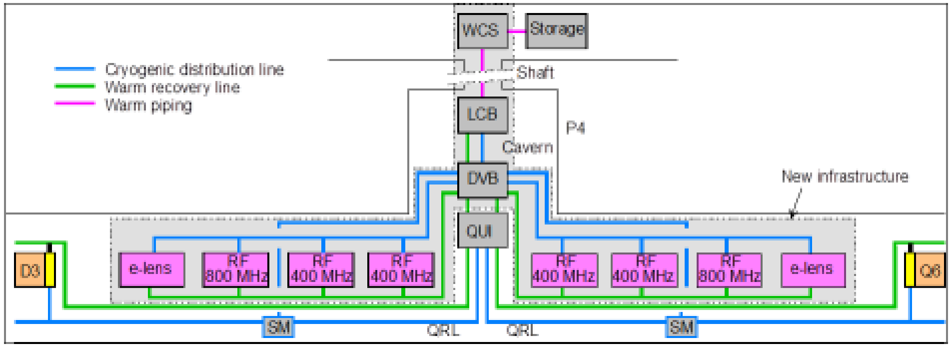
Impact on integration and vacuum layout

Cryogenics

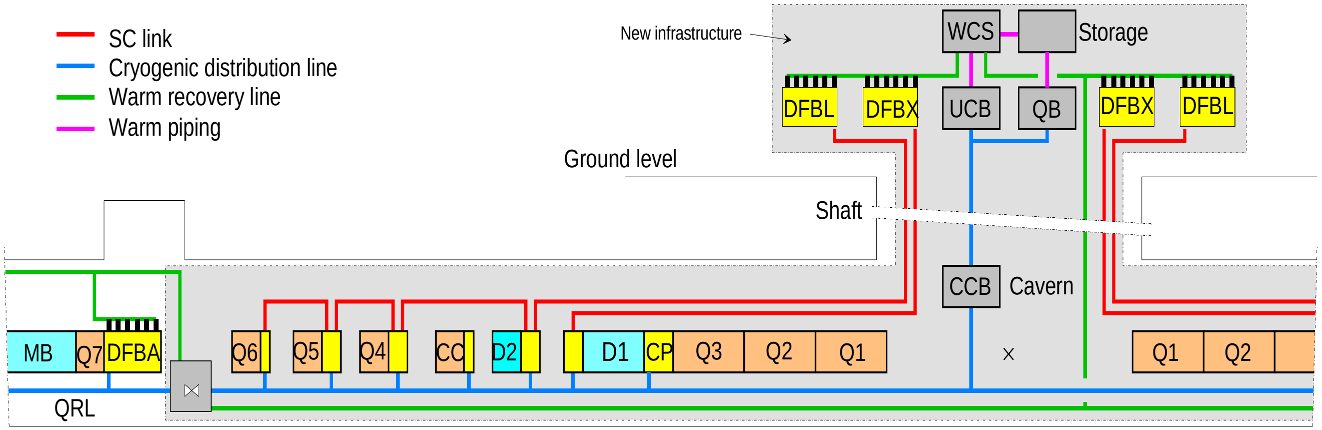
S. Claudet

- Creation of a cryoplant in LSS4 for the RF system: installation **LS2**





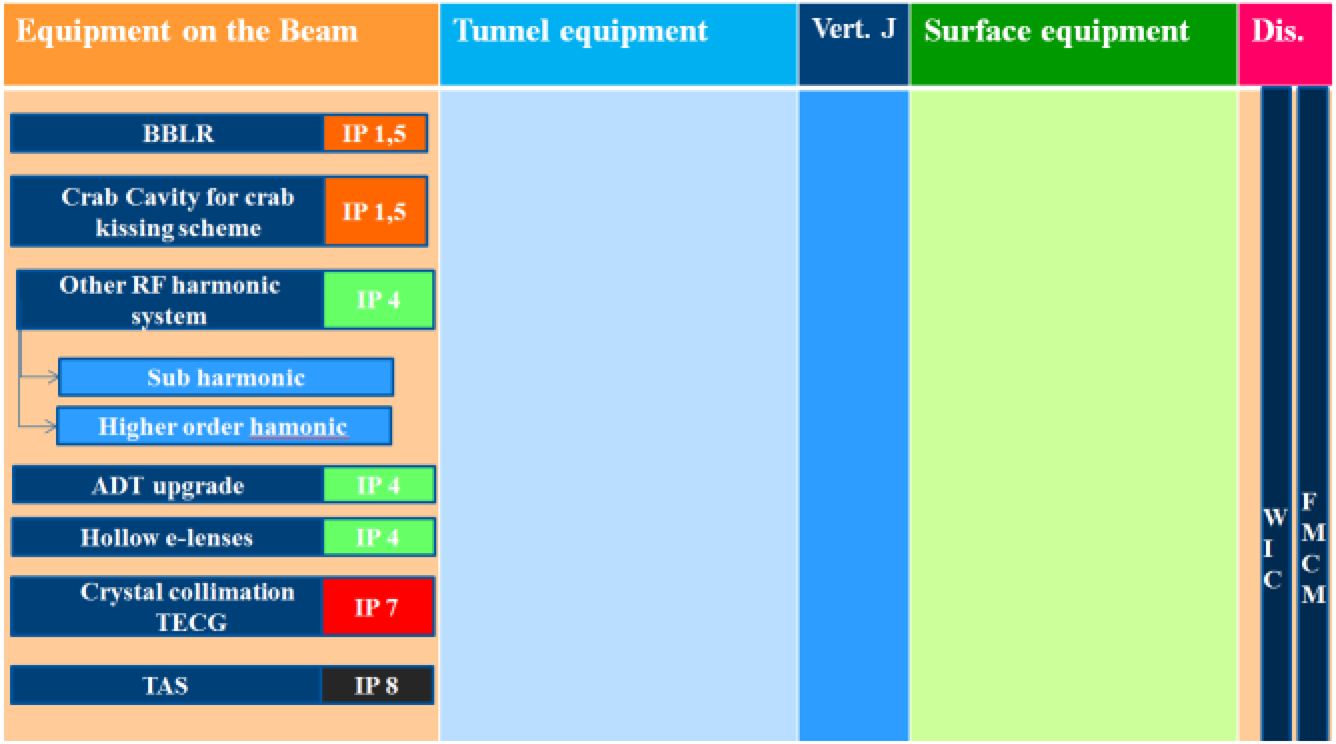
- **LS3:** upgrade of P1 and P5



7. Options:
not in base line
but under study

Options

- in IP1,5, 7 as previously but also IP4 and IP8



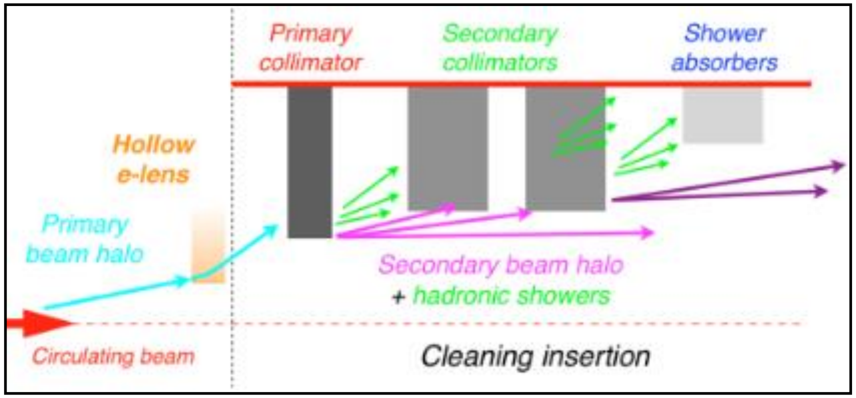
P. Fessia

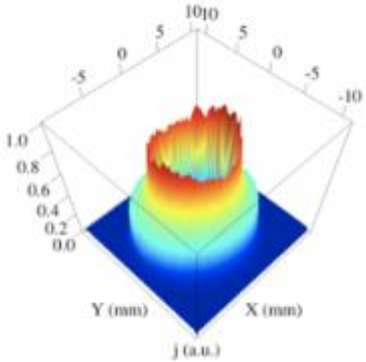
High Luminosity LHC

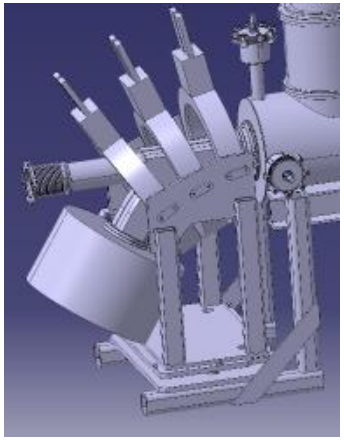
Option: hollow e-lens

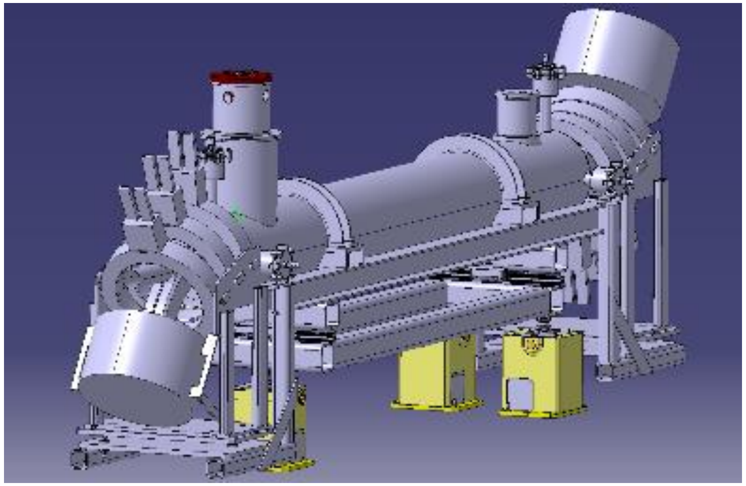
S. Redaelli

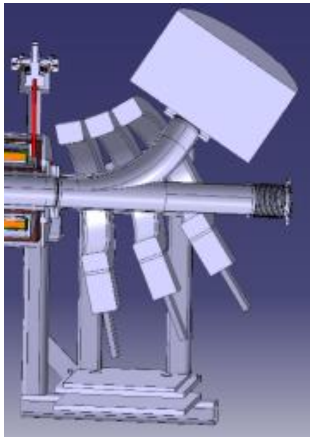
- Hollow electron beams running coaxially to the proton beam will provide an active control of beam halo population and beam loss rate. Installation LS2-LS3











- 5T field
- 3 m long
- RT vacuum system, bakeable

D. Perini

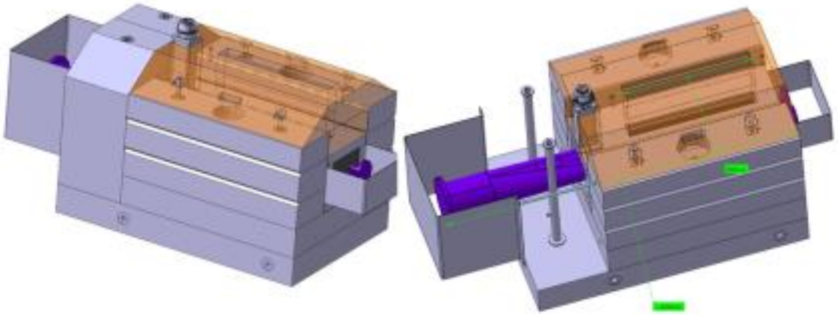
High Luminosity LHC

Option: mini-TAN IP8

I. Efthymiopoulos

- Installation in **LS2 !**
- Protects the D2 from increased luminosity in LHCb
- **Under design:** length ~ 2.2 m

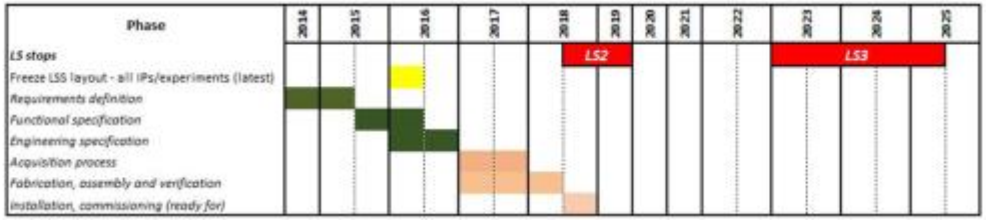
TAXN-IR8, preliminary proposal



- A "mini-TAN" could integrate BRAN, providing the required shielding and simplifying supports, alignment and interferences with vacuum (?).
- Coax integrated, but in any case baking time increased.

F. Sanchez Galan, WP8 meeting 25-11-14

Timeline for the TAXN IP8 baseline scenario - installation during LS2.



Option: cristal collimation

S. Redaelli

- A possible mean to improve collimation cleaning while reducing impedance
- A test bed already (partially) installed in LSS7 !
- More details by the end of 2015 ….

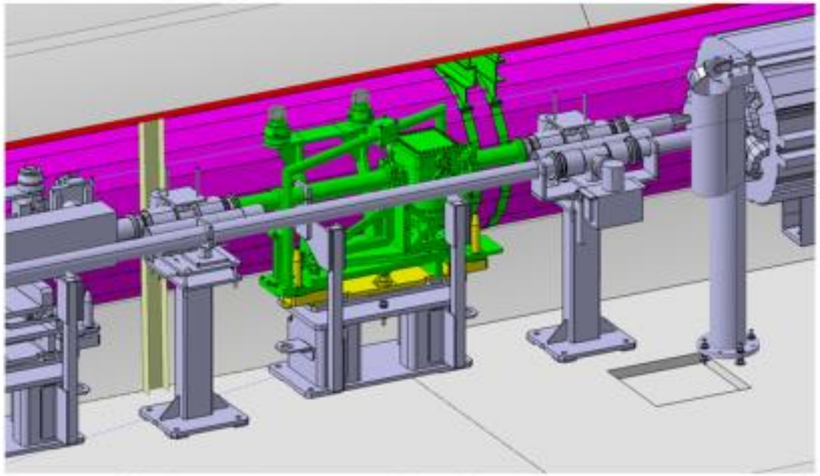


Figure 6: Integration of the horizontal goniometer, including additional beam pipe segments needed to fill the existing collimator slot.

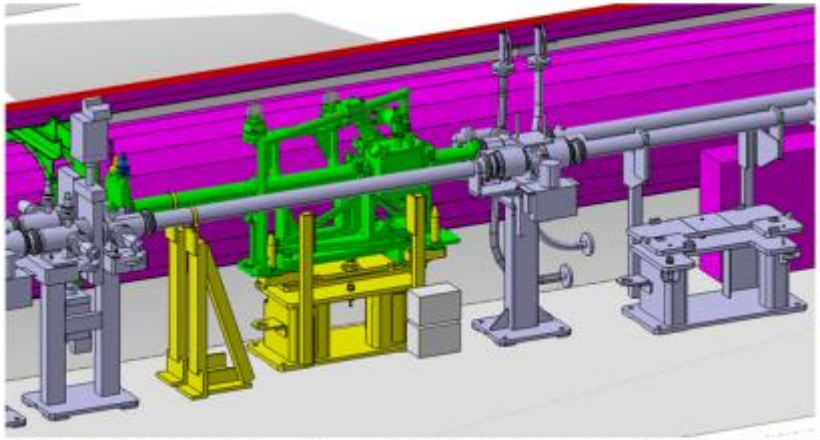


Figure 7: Integration of the vertical goniometer, including additional beam pipe segments needed to fill the existing beam pipe slot.

High Luminosity LHC

Option: BBLR

Y. Papaphilippou

- Vague ideas:
  - **Short term :** Exchange of a TCT with a TCT with embedded wire for **LS2**

Challenge: Embed an **electric wire in a TCTP collimator jaw** to compensate long-range Beam-Beam effects near interaction region

Concept: Insulated wire embedded in Tungsten jaw. Wire is pushed against jaw block by pushrod

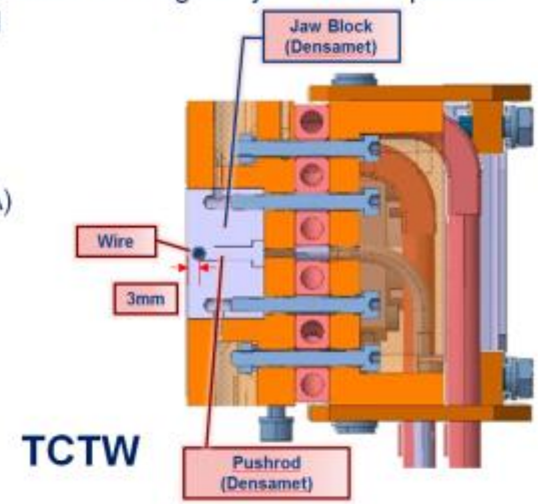
Requirements:

High DC current (up to 350 A)

Thin wire (Ø≤ 2.5 mm)

In-jaw wire (depth ≤ 3 mm)

Maintain TCTP complete functionality



D. Perini

- **Long term:** A co-linear 20 A electron beam located between TAN and D1 ?

H. Schmickler

High Luminosity LHC

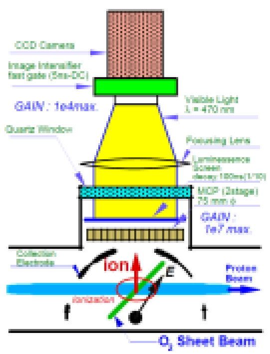
Option: BI

R. Jones

- No schedule but ideas !

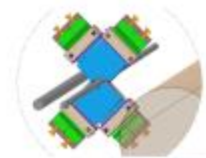
- Halo-diagnostics for HL-LHC

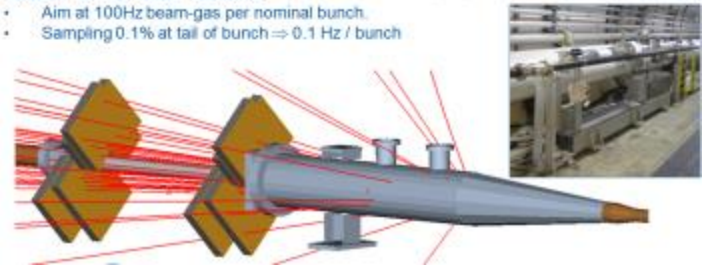
- Being developed by Univ. of Liverpool in collaboration with CERN for CLIC drive beam (A. Jeff)
  - To measure beam profile non-invasively in high power machines
- Two options discussed:
  - Gas Sheet with ionisation profile monitor
    - Also developed by JPARC
  - Scanning gas jet



Gas jet techniques

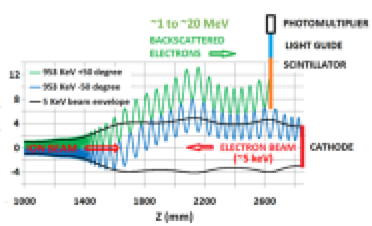
- Collaboration with LHCb, EPFL & Aachen
- No experience with trying to measure the halo at 4-6 sigma
- Need to deconvolve with tail of vertex resolution
- Beam-gas rate will be orders of magnitude smaller at this radial distance
  - Aim at 100Hz beam-gas per nominal bunch
  - Sampling 0.1% at tail of bunch ⇒ 0.1 Hz / bunch





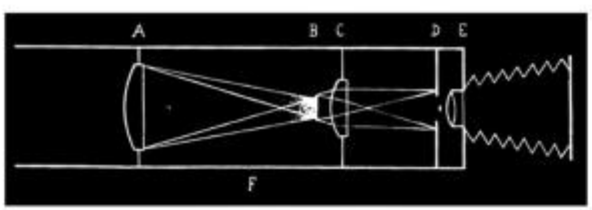
Use of Beam Gas Vertex

- Successful commissioning of electron back-scattering with gold and ^{3}He beams in RHIC (P. Thieberger)
- In combination with hollow electron lens could be ideal halo probe – BUT:
  - Residual gas electrons backscattered by the intense beam core
  - Electrons backscattered when hollow beam crosses proton beam



Use of scattered electrons

- Two methods presented
  - Amplitude Apodiser (P. Evtushenko, JLAB)
  - Coronagraph (T. Mitsuhashi, KEK)
- Synergy with direct exoplanet detection
  - S. Thomas (NASA, Ames)
  - Contrast required ~10^{10} for Earth-like planets



Lyot's Solar Coronagraph, 1936

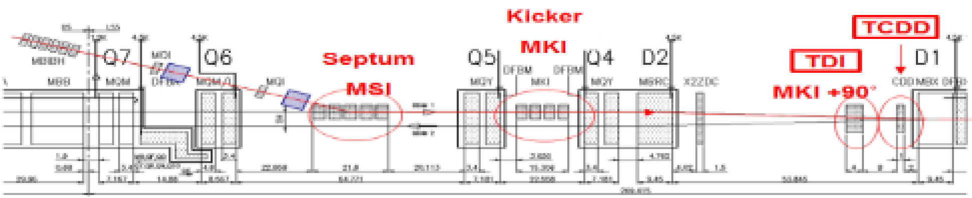
Optical techniques using synchrotron radiation

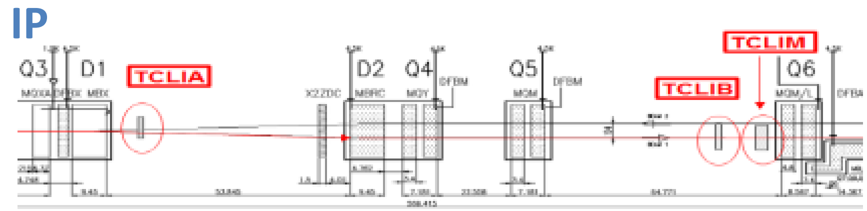
High Luminosity LHC

8. LS2

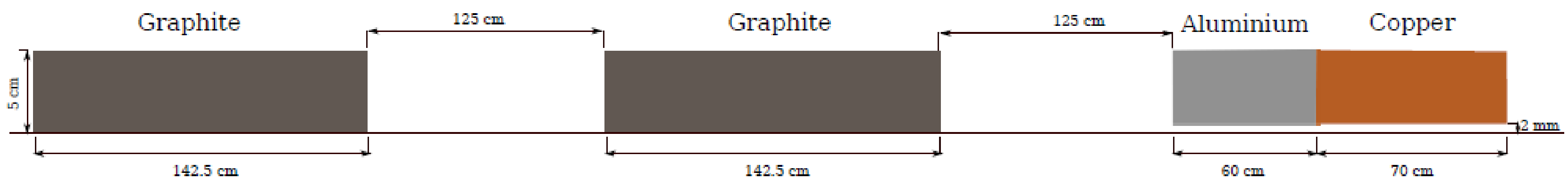
Beam transfer and kickers

J. Uythoven





- Injection protection elements to be installed in **LS2**
  - TDIS can have about same integrated absorber length as present TDI
    - Preliminary design: two modules with low Z absorber + one module with high Z absorber
    - TDI interferometry on the way to be installed during run II
    - 3 x 1.5 modules
      - 2 x low Z material (graphite) + 1 x high Z material



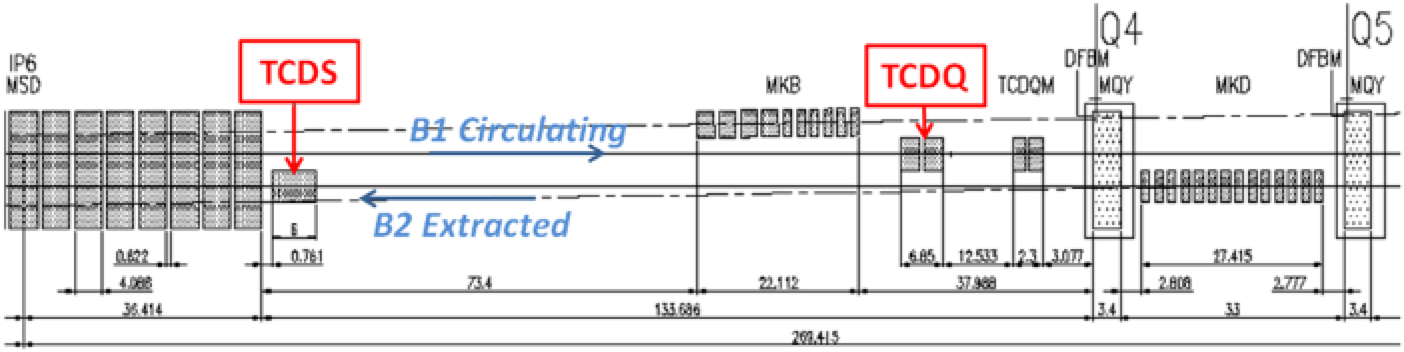
- TCDD aperture reduction possibly necessary to protect D1
  - D1 damage limit required, decision end 2014
- TCLIA and TCLIB likely not replaced for protection reasons
  - However TCLIA IP2 larger opening because of ALICE ZDC?

These upgrades must be **compatible with HL-LHC**

High Luminosity LHC

Beam dumping system

J. Uythoven



- To be potentially upgrade in LS3 only

  - Verification of TCDS for HL-LHC beams: will likely need to be upgraded.
  - Check the already modified TCDQ : further upgrade not foreseen in the baseline.
  - Check TDE heating after multiple dumps – nitrogen venting.
  - Check TDE window – if this is an issue, might need to change dilution pattern. This is not part of the HL-LHC baseline.

High Luminosity LHC

Kickers and electron cloud

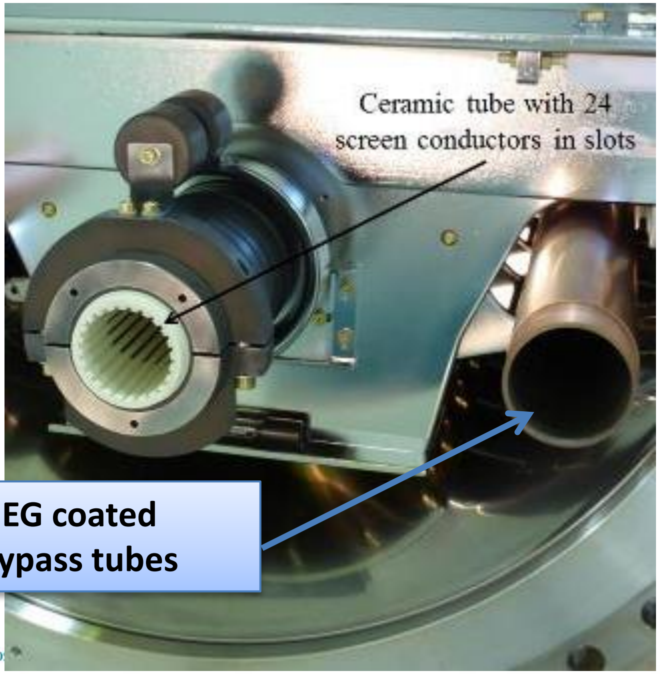
J. Uythoven, M. Barnes

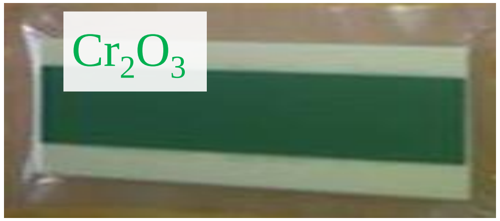
- LS1 MKI bypass tubes NEG coated, as nearby equipment.

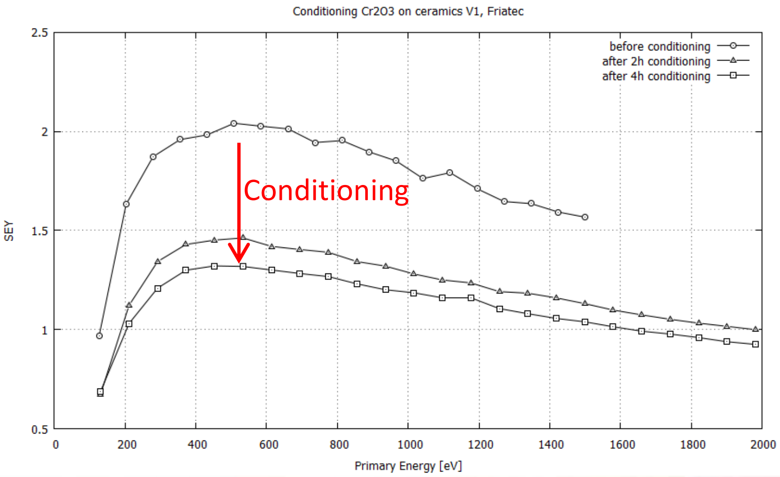
- Ceramic tube can still be an issue with SEY values 6 – 10. Required SEY < 1.4
- Cr_2O_3 coated ceramics SEY ≈ 2, conditioned to < 1.4

- Contract placed to develop application method for Cr_2O_3 coating of MKI ceramic chamber to reduce SEY. If successful apply on prototype magnet

- Looking for position in machine for passive prototype





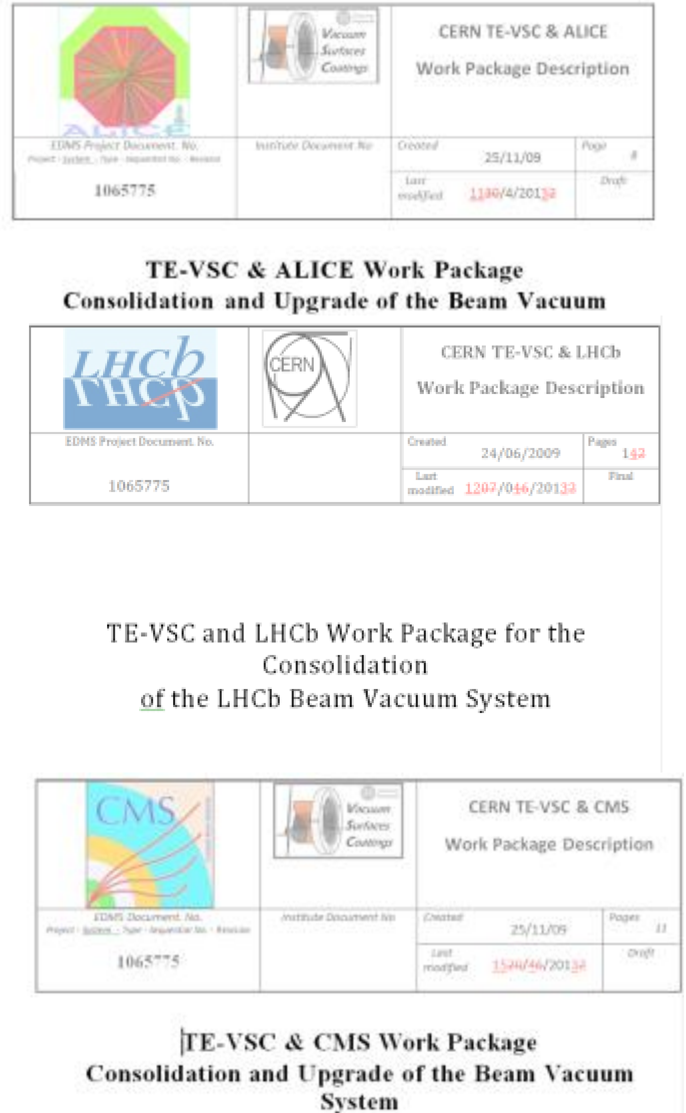


LHC Experiments upgrades

M. Gallilee

- Work packages for LS2 (EDMS 1065775)
- Reduced ALICE Be beam pipe
- New VErtex LOcator for LHCb
- Replacement of stainless steel to Aluminum chambers for CMS

These upgrades must be **compatible with HL-LHC** (EDMS 13601088-91)


CERN TE-VSC & ALICE

Work Package Description

EDMS Project Document No. 1065775

Created 25/11/09

TE-VSC & ALICE Work Package

Consolidation and Upgrade of the Beam Vacuum

CERN TE-VSC & LHCb

Work Package Description

EDMS Project Document No. 1065775

Created 24/06/2009

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

CERN TE-VSC & CMS

Work Package Description

EDMS Document No. 1065775

Created 25/11/09

TE-VSC & CMS Work Package

Consolidation and Upgrade of the Beam Vacuum System

9. Summary

Summary

- HL-LHC is a vast project
- Installation will be in two phases : **LS2 AND LS3**
- Design already started in many fields
- Next important milestone is **Cost and Schedule Review**: 9-10-11 March 2015
    - CONS project to be distinguish for HL-LHC project

	LHC	HL-LHC
Beam intensity	1.7 10^{11} ppb	2.2 10^{11} ppb
Peak Luminosity	2.2 10^{34} cm^{-2} s^{-1}	7.5 10^{34} cm^{-2} s^{-1}

Consolidation | HL-LHC

- Technical design report, TDR, by 2015

High Luminosity LHC

High Luminosity LHC

Thank you for your attention

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.

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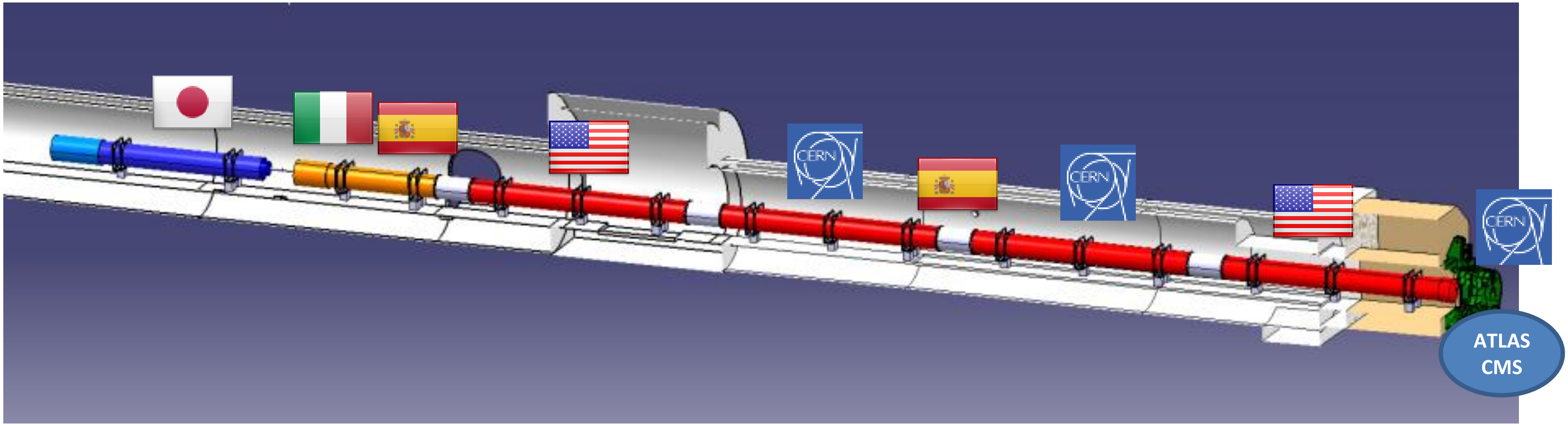
Focussing quadrupole and merging dipole

- Decrease beta (*i.e* beam size) at collision point (beta*) from 55 cm to 15 cm



- **New :** Q1, Q2, Q3, CP (corrector package), D1
- all operating at 1.9 K
- Present IT+D1 **to be completely removed** (radiation to personnel !!)
- Interconnects to be **redesigned**

High Luminosity LHC