



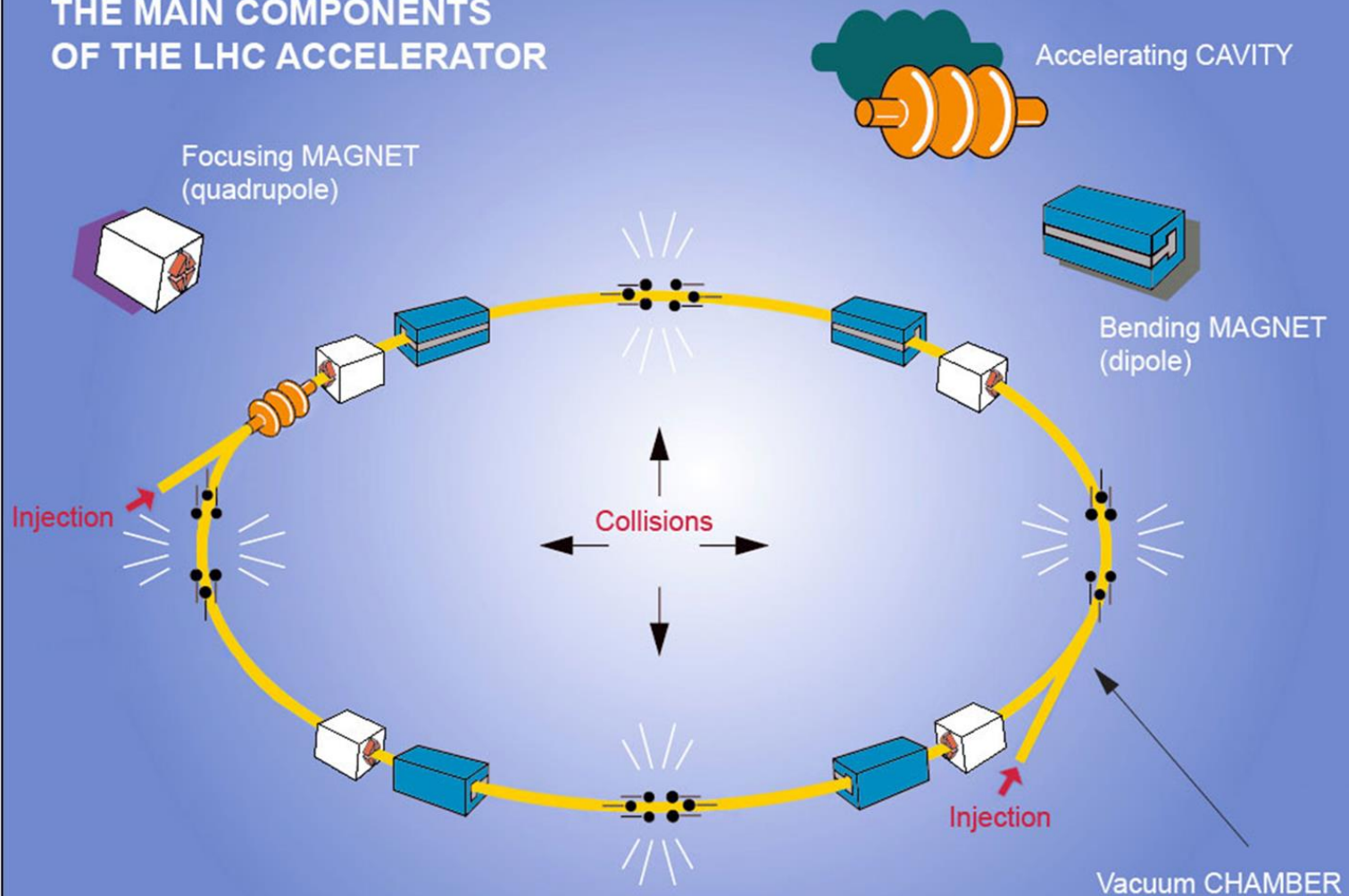
HL-LHC

Lucio Rossi
Project Leader

1st International Workshop of the Superconducting Magnet Test Stands
CERN – Globe of innovation, 13 June 2016

LHC

THE MAIN COMPONENTS OF THE LHC ACCELERATOR



LHC

the largest scientific instrument

LHC dipoles: the collider backbone

- 27 km, p-p at 7+7 TeV
3.5+3.5 start, **4+4 in 2012**
6.5+6.5 TeV in 2015
- 1232 x 15 m Twin Dipoles
- Operational field 8.3 T @ 11.85 kA
(9 T design)
- HEII cooling, 1.9 K with 3 km
circuits (130 tonnes He inventory).
- Field homogeneity of 10⁻⁴ %
bending strength
then 10⁻⁴ %
(9 T design)

All fully cold tested

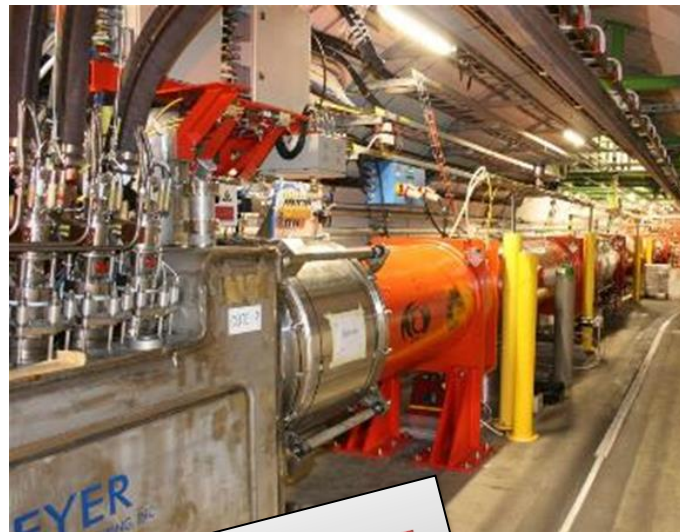
The dipole line in the LHC ring



More than dipoles...

The plethora of SC magnets...

- 392 Main Quads Two-In-One rated for a peak field of 7 T.
- About 100 other Two-in-One MQs
- 32 MQX (low- β) single bore for luminosity (design $L=1 \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$), 70 mm apertures, about 8 T peak field, high quality
- A «zoo» of 7600 «small» Sc magnets (correctors and higher order magnets)
- Total: 9 MJ stored energy (at nominal)
- Large detector magnets



All fully cold tested

Sextupole Magnets

MO Octupole Magnets

MCDO Decapole Octupole Magnets

MQSXA Quadrupole Octupole Sextupole Magnets

SC radiofrequency, Cryogenics,

LHC: much more than magnets...

400 MHz Standing wave RF

- 4 single cell cavities in cryomodule, 2 cryomodules per beam pipe

All fully cold tested

- Gradient 5.5 MV/m nominal (8 MV/m available)
- Nominal 2MV, up to 3 MV at 8 MV/m

Cryo : 8 x 18 kW@4.5K

Collimators: 146



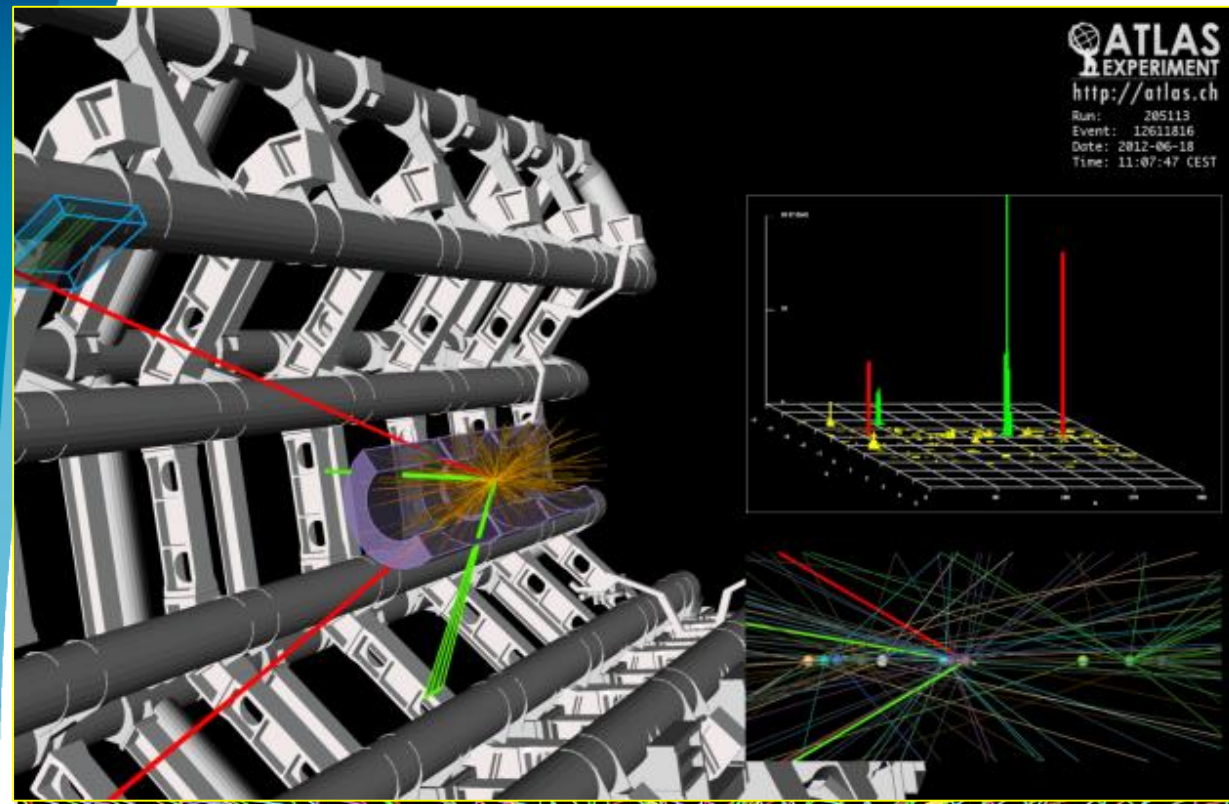
The Betatron Collimation System
(250m long, 44 collimators + absorbers)



ATLAS
EXPERIMENT
<http://atlas.ch>
Run: 205113
Event: 12611816
Date: 2012-06-18
Time: 11:07:47 CEST

The Higgs: the
needle in a
haystack

luminosity:
collision rate)

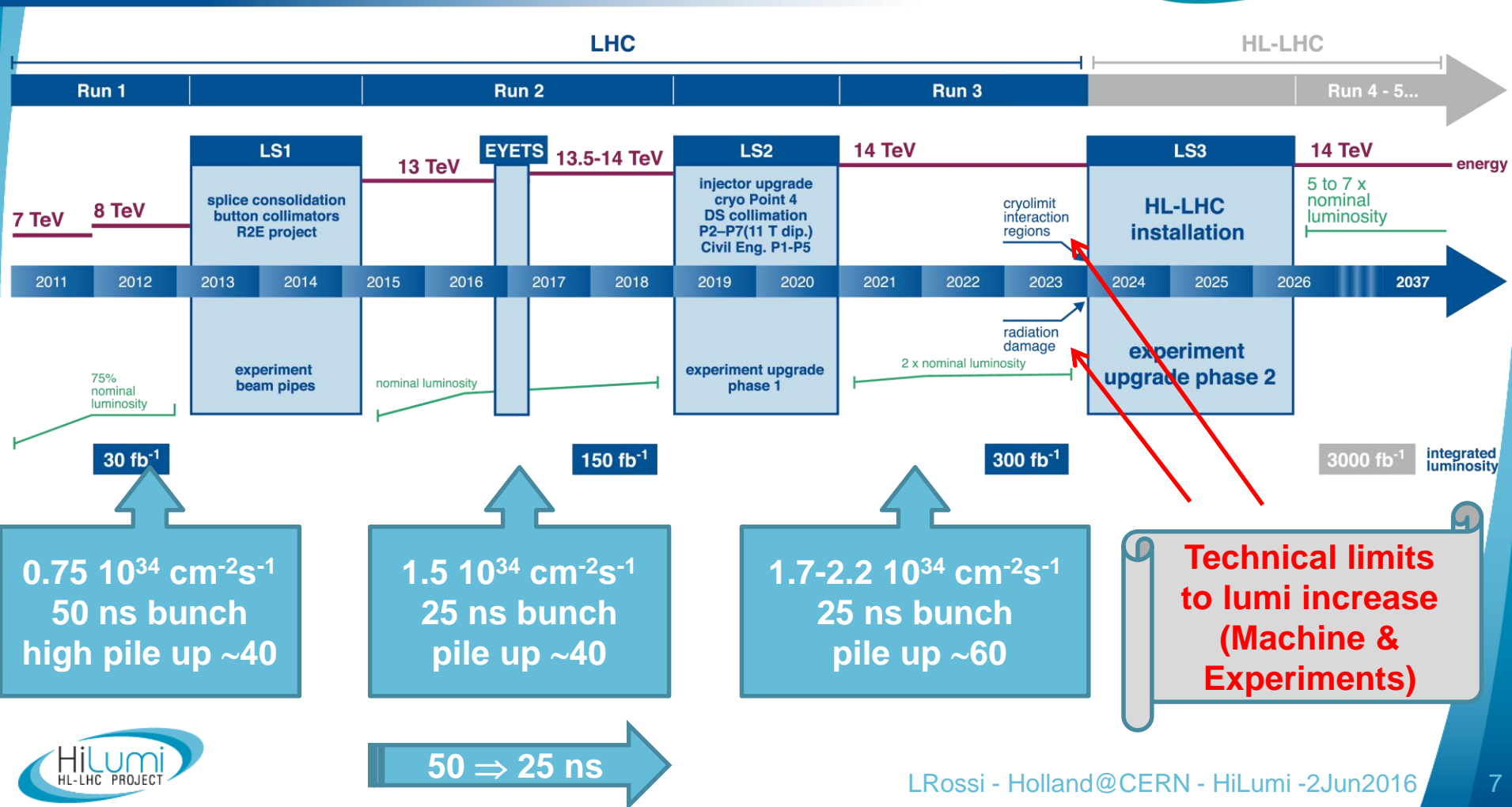


$Z \rightarrow \mu\mu$ event from 2012 data with 25 reconstructed vertices

Why upgrading the LHC?



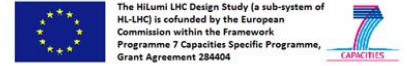
LHC / HL-LHC Plan



The project started in 2010 as EC-FP7 Design Study



From FP7 **HiLumi LHC** Design Study application



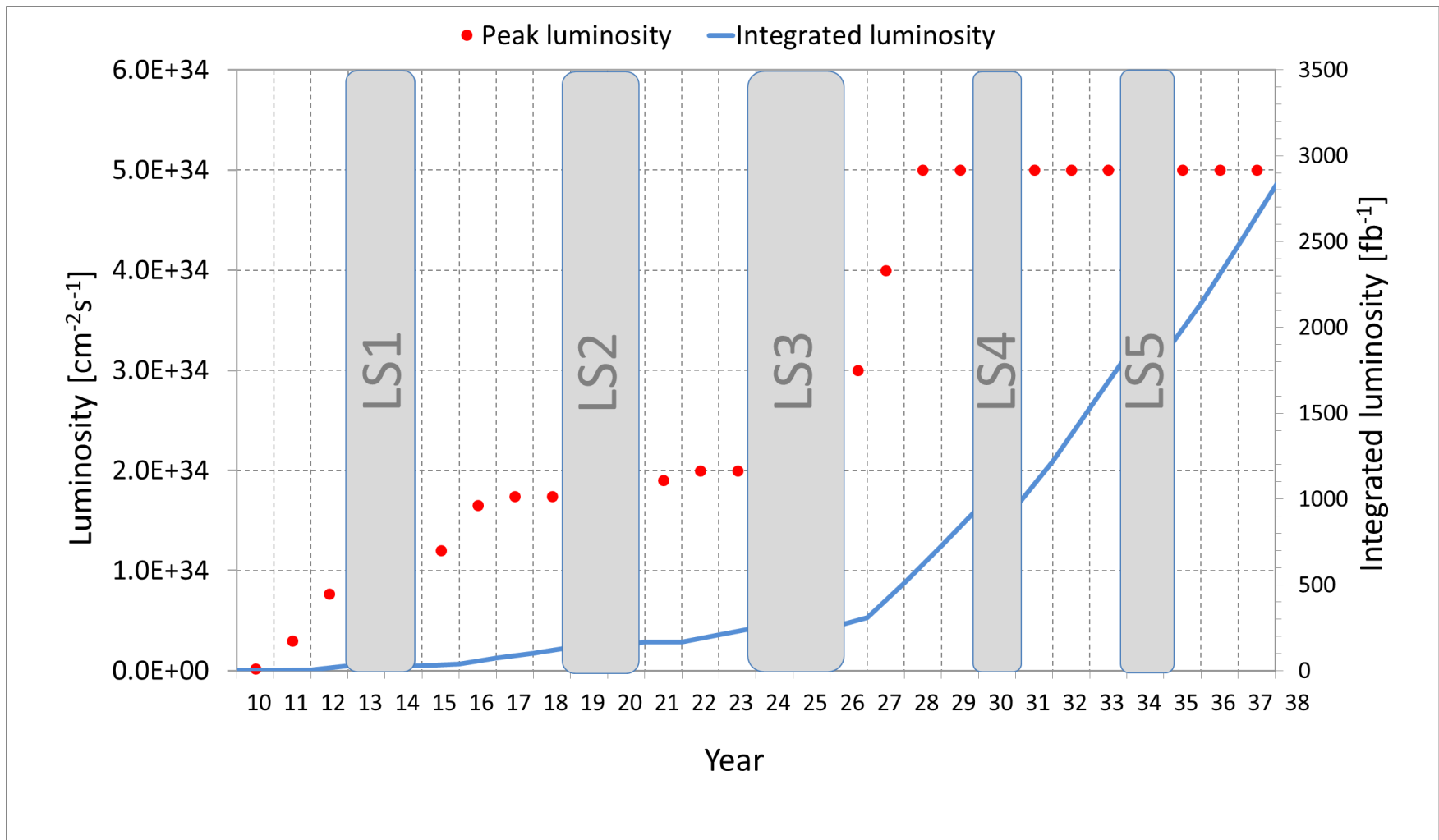
The main objective of HiLumi LHC Design Study is to determine a hardware configuration and a set of beam parameters that will allow the LHC to reach the following targets:

A peak luminosity of $L_{\text{peak}} = 5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ **with levelling**, allowing:

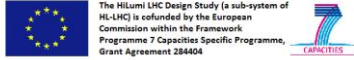
An integrated luminosity of **250 fb⁻¹ per year**, enabling the goal of **$L_{\text{int}} = 3000 \text{ fb}^{-1}$** twelve years after the upgrade.

This luminosity is more than ten times the luminosity reach of the first 10 years of the LHC lifetime.

The bolt advance in luminosity

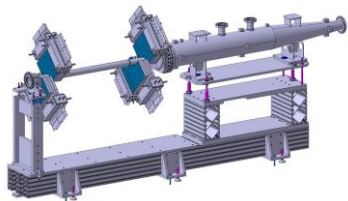


FP7-HiLumi classified as «success story» by EC



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

Cryo@P4



Beam diagnostics
BGV

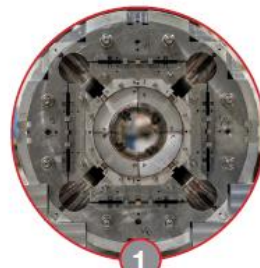
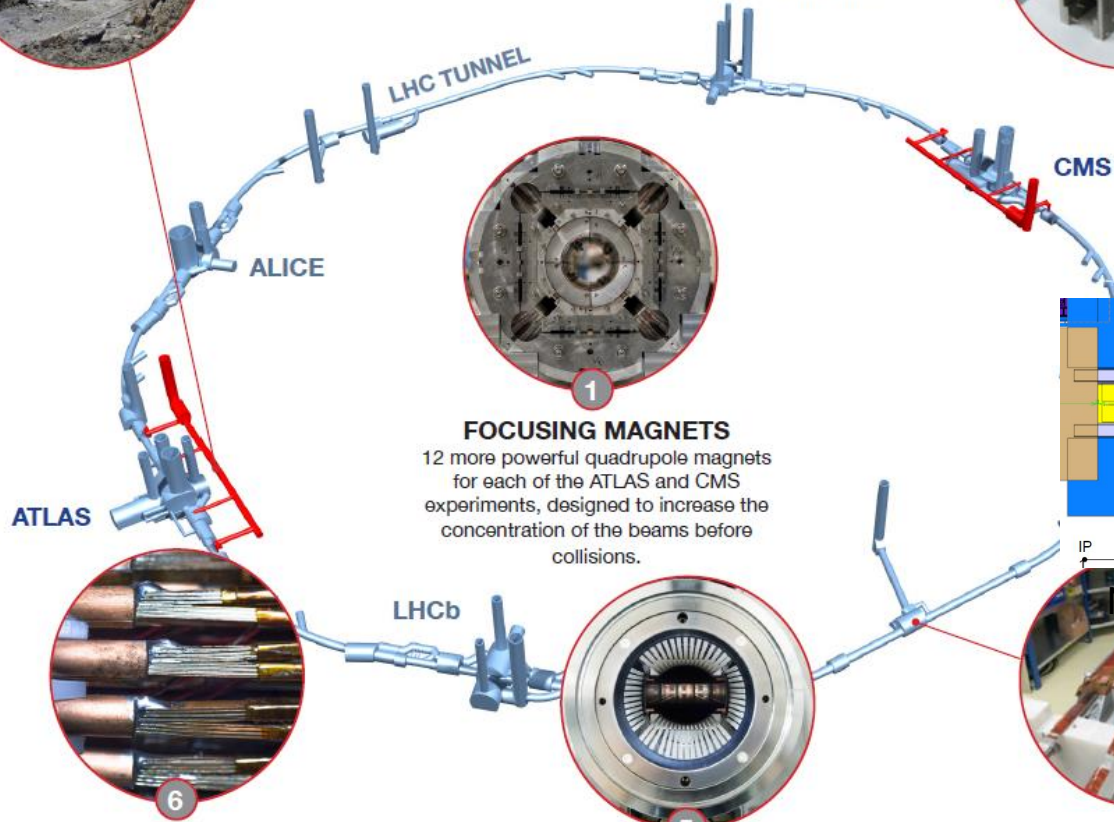


2 CIVIL ENGINEERING
2 new 300-metre service tunnels and 2 shafts near to ATLAS and CMS.

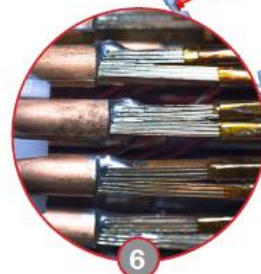


3 "CRAB" CAVITIES
16 superconducting „crab“ cavities for each of the ATLAS and CMS experiments to tilt the beams before collisions.

Cryo@P1-P5



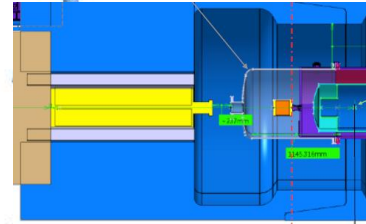
1 FOCUSING MAGNETS
12 more powerful quadrupole magnets for each of the ATLAS and CMS experiments, designed to increase the concentration of the beams before collisions.



6 SUPERCONDUCTING LINKS
Electrical transmission lines based on a high-temperature superconductor to carry current to the magnets from the new service tunnels near ATLAS and CMS.



5 COLLIMATORS
15 to 20 new collimators and 60 replacement collimators to reinforce machine protection.



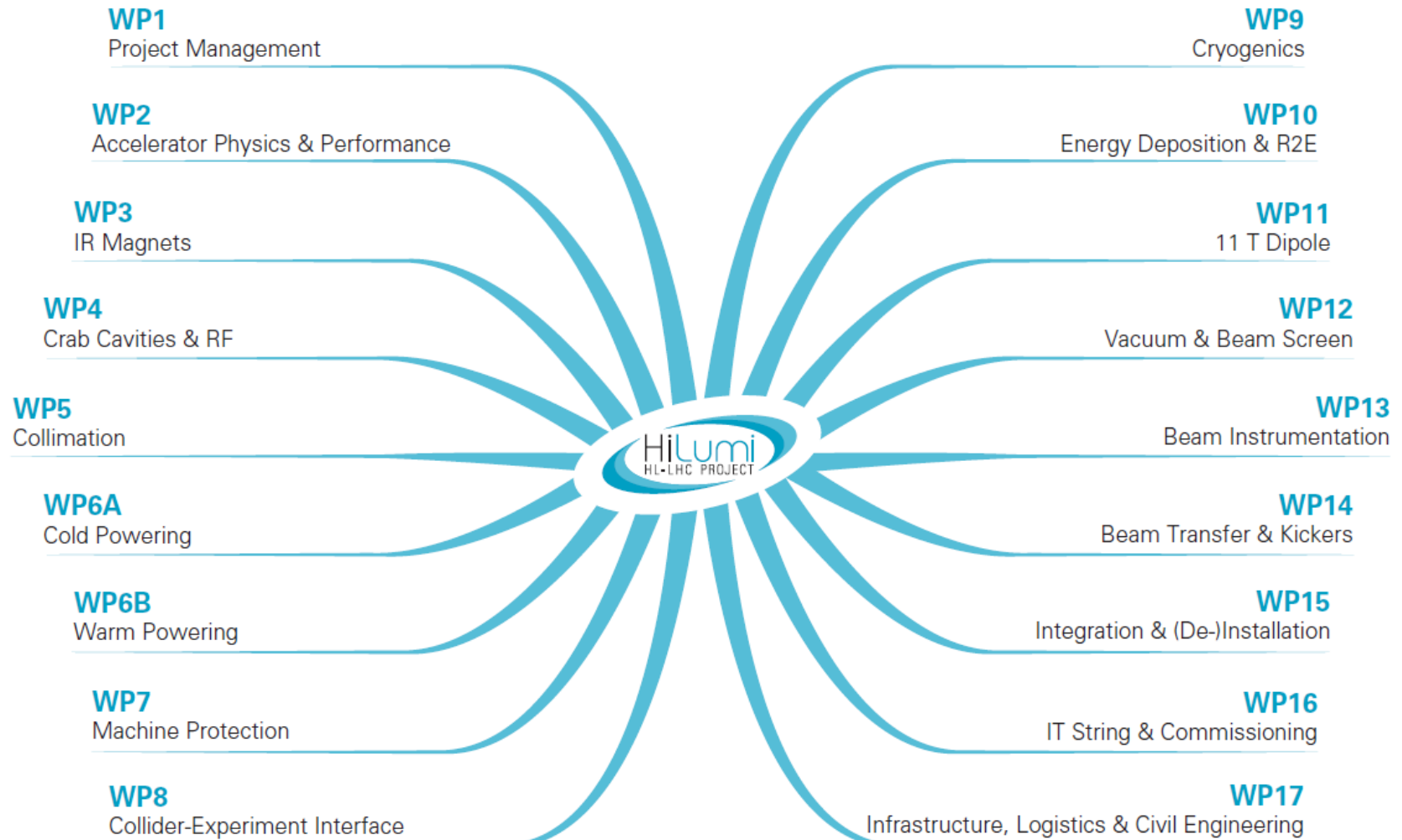
New TAS and VCX



4 BENDING MAGNETS
4 pairs of shorter and more powerful dipole bending magnets to free up space for the new collimators.



HL-LHC project breakdown structure

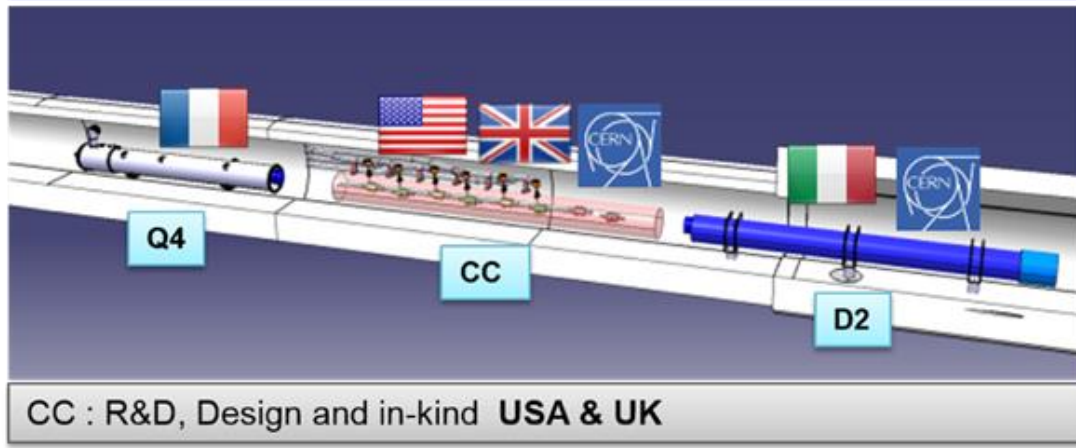
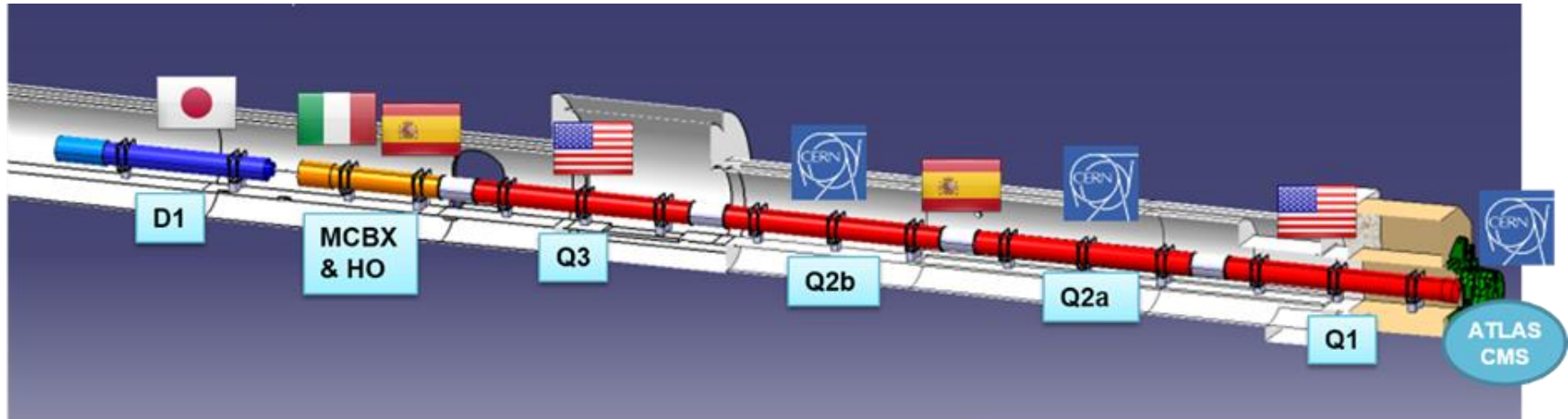


High Luminosity LHC Project



¹ kind contributions
² Cockcroft Institute
³ US HL-LHC Accelerator Upgrade Project

Deep changes in the Inner Triplet region (around ATLAS & CMS experiments)



Q1-Q3 : R&D, Design, Prototypes and in-kind **USA**
 D1 : R&D, Design, Prototypes and in-kind **JP**
 MCBX : Design and Prototype **ES**
 HO Correctors: Design and Prototypes **IT**
 D2 Design **IT**
 Q4 : Design and Prototype **FR**

CC : R&D, Design and in-kind **USA & UK**

International collaborations: an opportunity and a challenge, also for testing!

International collaboration regards also tests

- SM18 @ CERN
 - HiLumi has triggered the SM18 upgrade and pays about half of it.
 - HiLumi IT string is in the plan since 2015 (see talk)
- US/LARP-AUP : FNAL and BNL
- INFN-LASA (Milano)
- UPPSALA univ.
- CEA ?
- More?

HiLumi counts on cryogenic full power tests: no hardware will be installed without test

- First test in the chain is the strand/conductor! Try also to be synergic to these test!
- A Magnet not tested is not worth anything, yet!
- Testing, for HiLumi like for LHC, is integral part of the design-construction-qualification cycle:
 - Validation of design & basic choice
 - Verification of performance and of conformity to specs
 - Most critical acceptance, releasing payment and **transfer of properties** (from Industry or Collaboration)
 - → time and schedule are **IMPORTANT!!!**
 - Anticipate HWC and operation issues (stand-alon test and especially IT string)



Thanks to Marta for orgnaizing this meeting and all of you for the great support to HiLumi