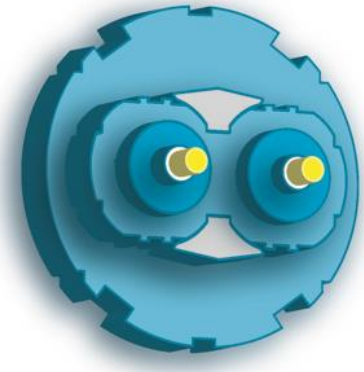
KEK-JAPAN



High Luminosity LHC

LHC Upgrade

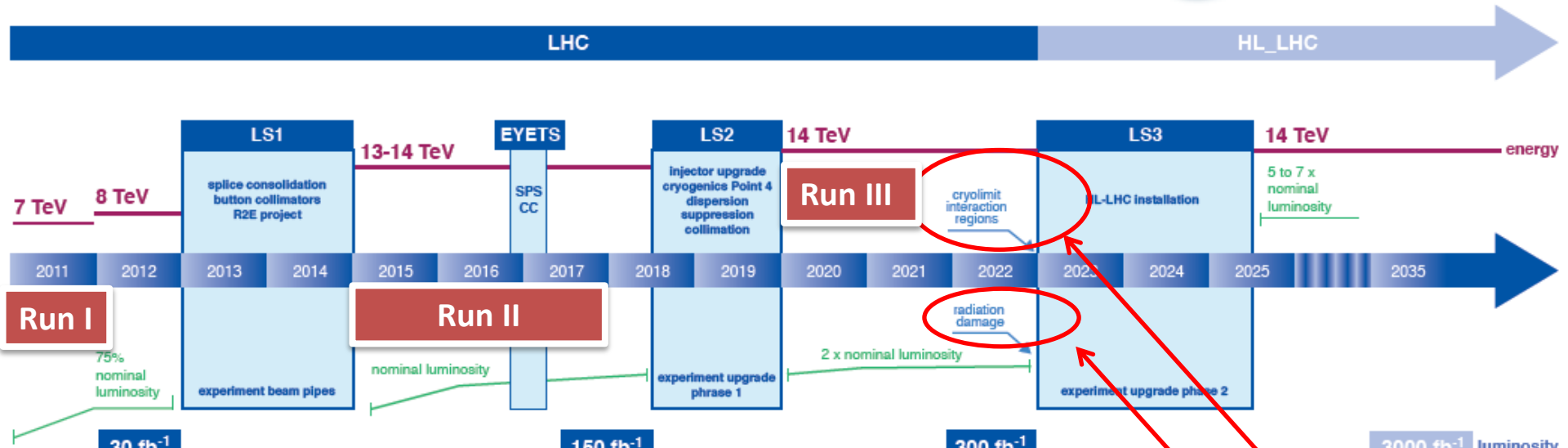
Extracted slides from

Lucio Rossi – CERN
HL-LHC project leader

talk to 9th CERN-KEK committee
21 November 2014 @ KEK

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.

LHC / HL-LHC Plan



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

50 ⇒ 25 ns

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

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

Lumi saturation & Technical bottlenecks:

Plan approved by CERN management upon preparation in HL-LHC Coord Group and RLIUP
See deliverable D1.7 Common LHC time plan

HL-LHC Baseline Parameters
WP2 charge – PLC webpage

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

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
beam separation [σ]	9.4	**12.5**	12.5	11.4
β^* [m]	0.55	**0.15**	0.15	0.15
ε_n [µm]	3.75	**2.50**		3
ε_L [eVs]	2.50			2.50
r.m.s. bunch length [m]				7.55E-02
Piwinski angle			3.14	2.87
Geometric loss factor R0 without crab		**0.305**	0.305	0.331
Geometric loss factor R1 with cr	(0.981)	**0.829**	**0.829**	**0.838**
beam-beam / IP without	3.1E-03	**3.3E-03**	3.3E-03	4.7E-03
beam-beam / IP with Cra	3.8E-03	**1.1E-02**	1.1E-02	1.4E-02
Peak Luminosity without 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 [$cm^{-2}\ s^{-1}$]	(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 f		**138**	146	135
Peak line d		**1.25**	1.31	1.20
Levelling ti		**8.3**	7.6	18.0

LIU required

Impedance, efficiency etc.

New IT Quads & ATS

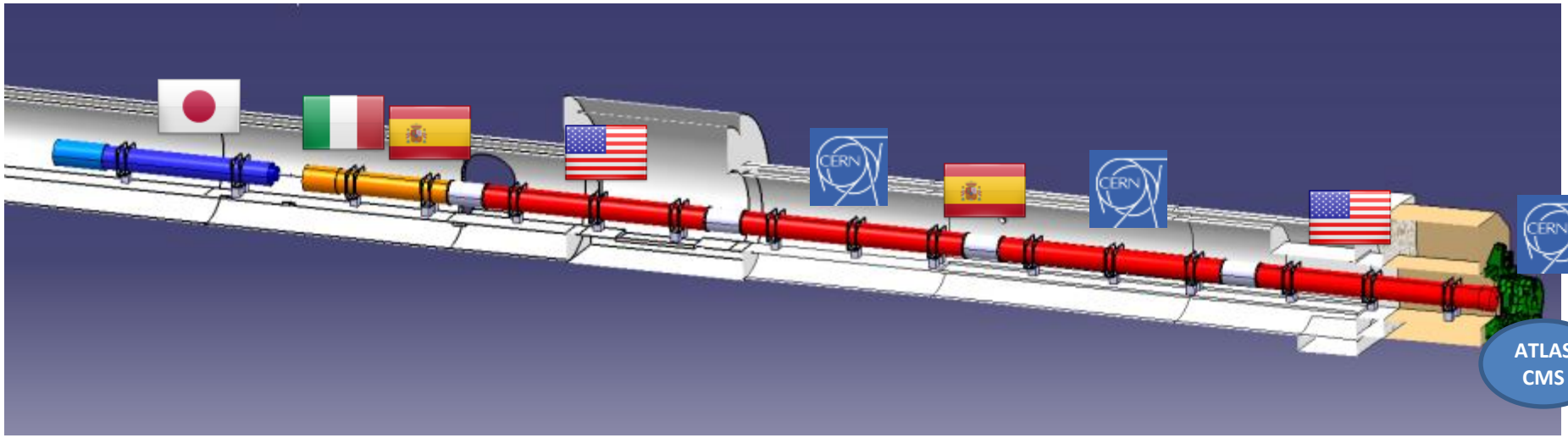
Levelling required

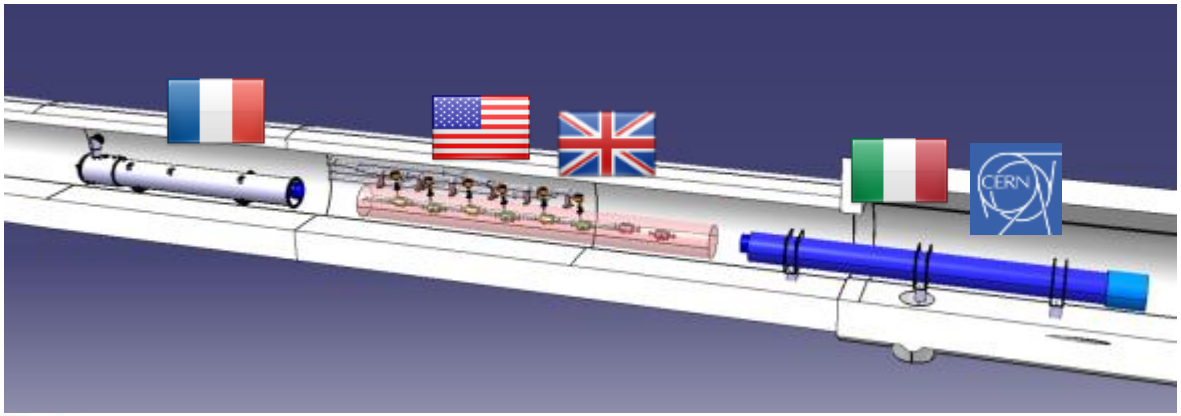
Efficiency requires long fill times (ca. 10h)!

Collision values

This makes 250 fb^{-1}/y a solid goal

In-kind contribution and Collaboration for HW design and prototypes



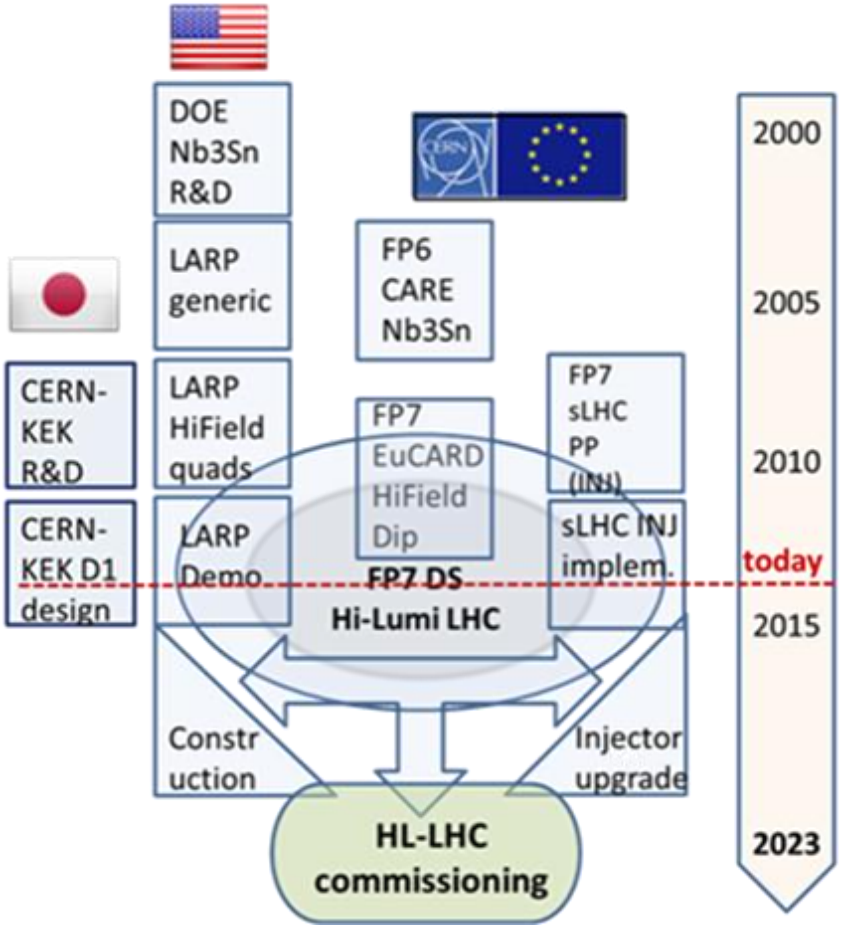


CC : R&D, Design and in-kind **USA**

CC : R&D and Design **UK**

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**
Q4 : Design and Prototype **FR**

Collaborations



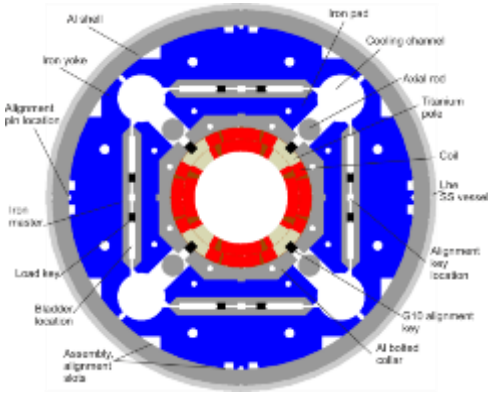
- **In addition to the FP7-HiLumi LHC (CERN contracts):**
- CEA (FR) for Q4 Design & proto (also completion Fresca2 technological demo)
- INFN-Milano (IT): HO Corrector magnets Design and Prototypes
- INFN-Genova (IT): D2 Design
- CIEMAT (ES): IT Orbit corrector magnet (nested) desing and prototype
- UniMan (UK) for collimators
- UniGE (CH), Uni. Bratislava (SK), Twente Univ. (NL) for Nb3Sn
- South Hampton U. (UK) under way for SC links

Preliminary Design Report PDR

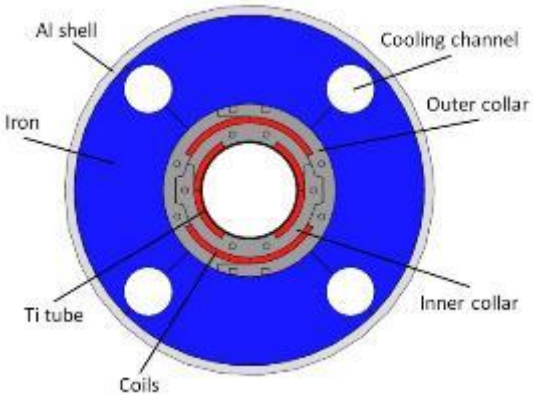
V0 end Nov. For EU
V1 January ’15 after CERN ED approval
V2 March 2015 as CERN yellow report

WP3 the magnet zoo in the IR

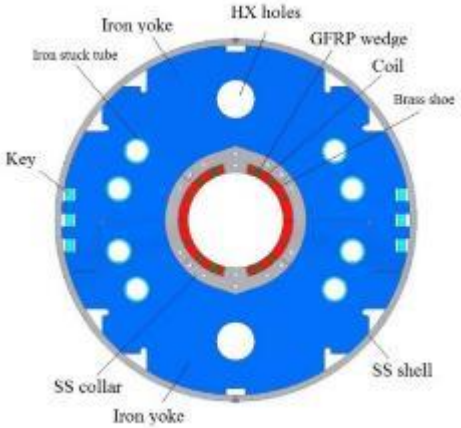
Ezio Todesco



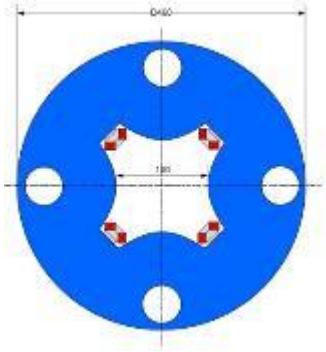
Triplet QXF (LARP and CERN)



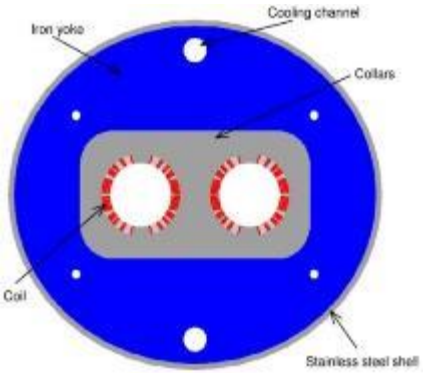
Orbit corrector (CIEMAT)



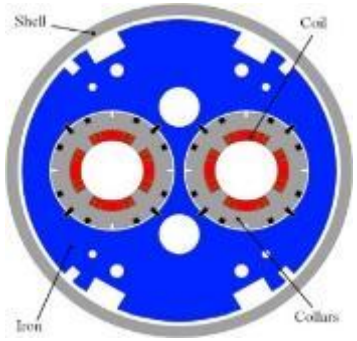
Separation dipole D1 (KEK)



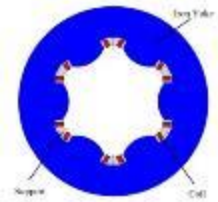
Skew corrector (INFN)



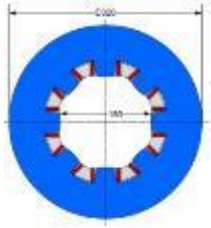
Recombination dipole D2 (INFN design)



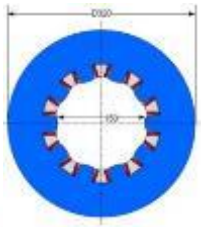
Q4 (CEA)



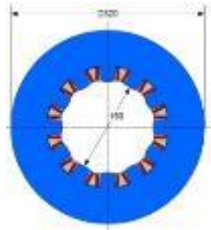
Corrector sextupole (INFN)



Corrector octupole (INFN)



Corrector decapole (INFN)



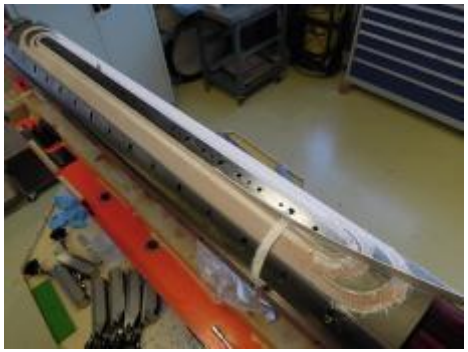
Corrector dodecapole (INFN)

Cross-sections in scale

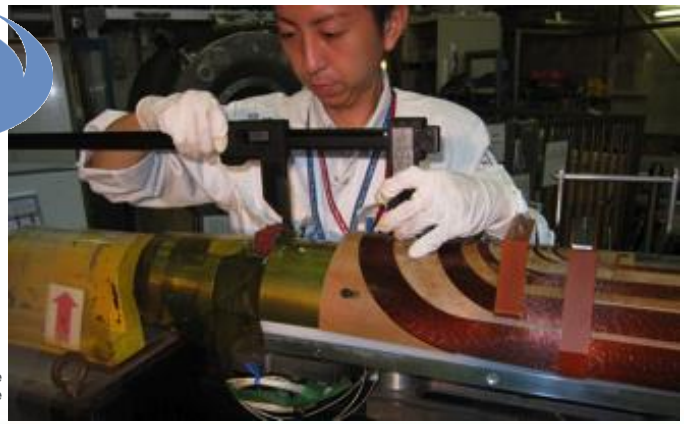
LRos

TRIPLET AND DIPOLES

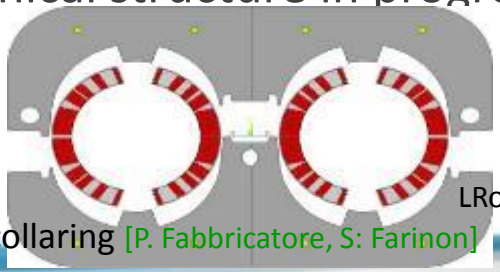
- Triplet
  - First dummy and Nb_3Sn coils manufactured in US and at CERN
  - Cable review done, design in December 2014
  - First quadrupole test in 2015
- Separation dipole D1
  - First Nb-Ti coils being manufactured
  - First test in 2015
- Recombination dipole D2
  - Cross-section defined
  - Mechanical structure in progress



QXF coil wound in US
[G.Ambrosio et al., ASC 2014]

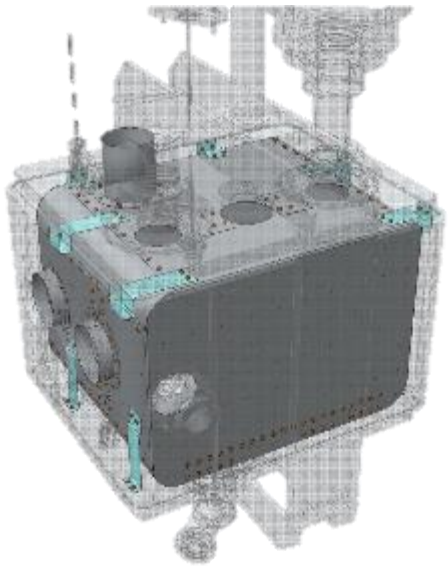


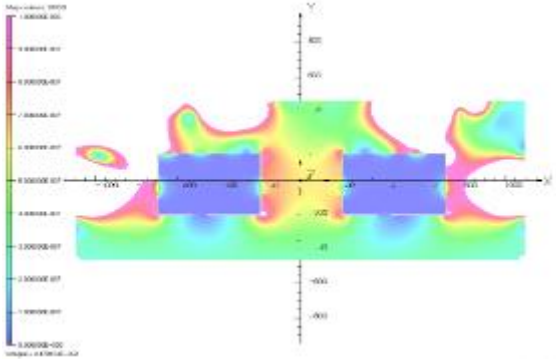
D1 winding at KEK [T. Nakamoto, et al., ASC 2014]

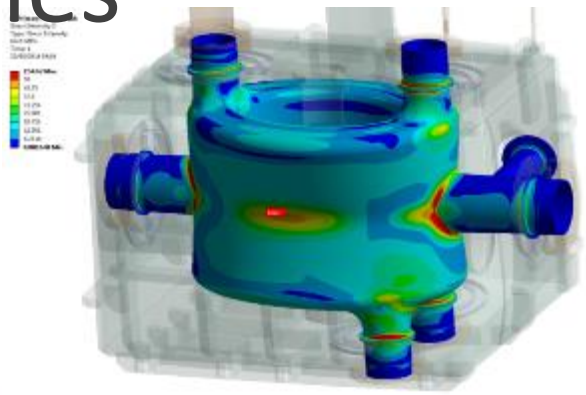


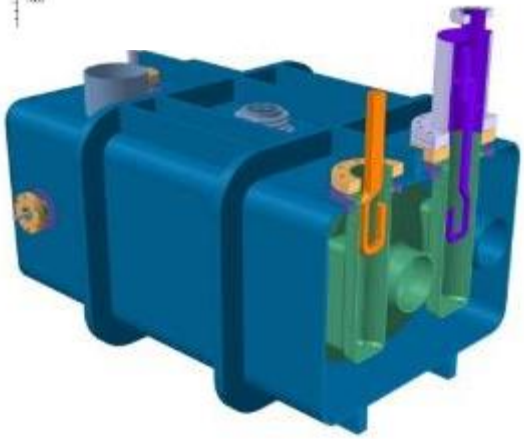
D2 collaring [P. Fabbricatore, S: Farinon]

WP 4 : Dressed Crab Cavities

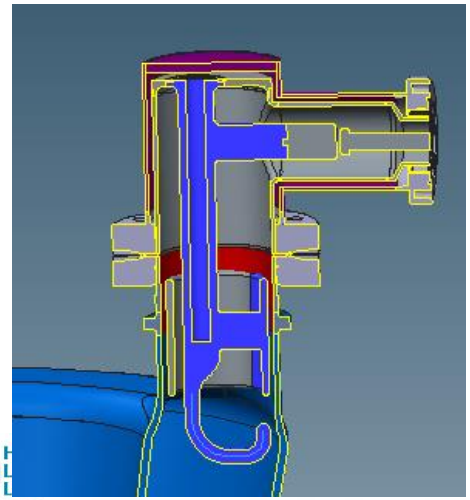


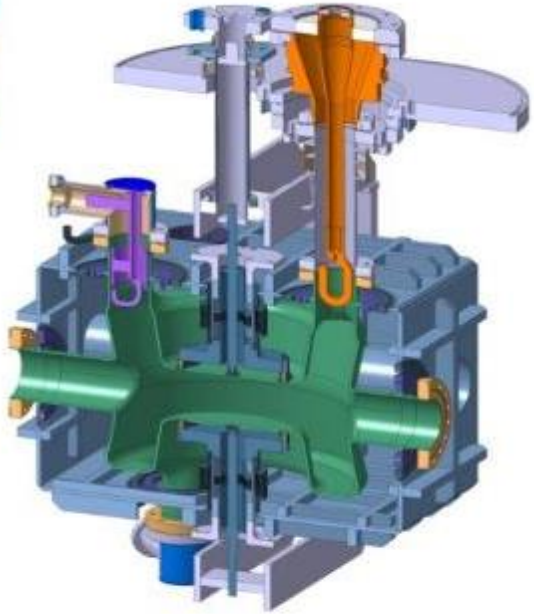






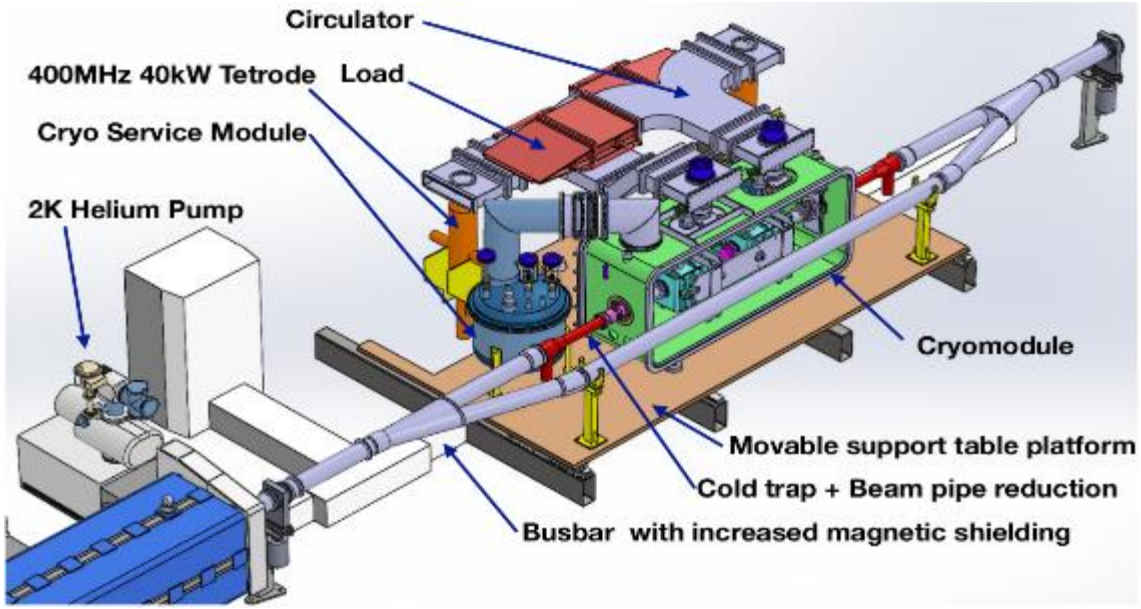
R. Calaga



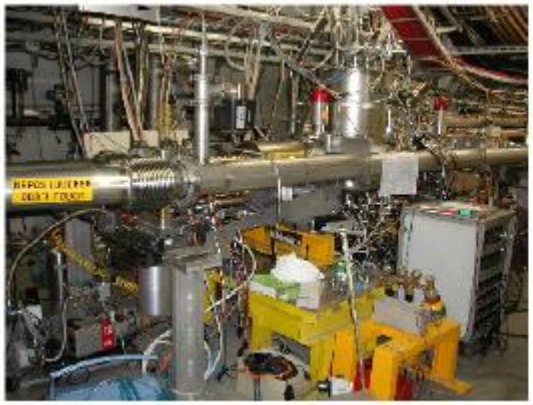


Dressed cavity designs are almost complete.
This includes the cavity, tuner, couplers, magnetic shielding and the LHe vessel.

CC SPS tests



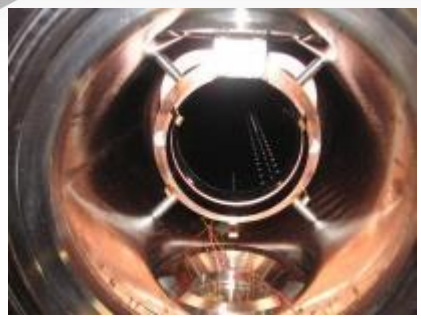
On schedule for install the first cryomodule at the end of 2016 and test in in SPS in 2017 and 2018.

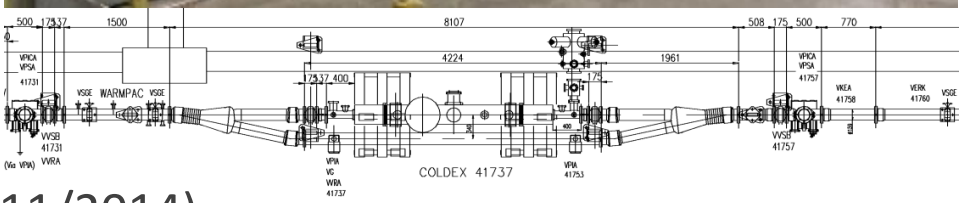


Performance of a-C coated Beam Screen

- Photon stimulated desorption at RT of a-C coating at KEK Photon Factory (E_c = 4 keV)
- COLDEX equipped with a-C coated beam screen held at 50 K

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





- Tests with LHC type beams in SPS (3-9/11/2014):
  - Heat load < 1 W/m
  - Pressure rise < 10^{-8} mbar (mainly H_2)
- 2015: continue characterisation at cryogenic temperature of a-C coating in the laboratory and with COLDEX

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.

Work Package Number	1						
Work Package Title	LHC consolidation, upgrades and R&D for future hadron machines						
Activity Type	Research						
Participant Short Name	CERN	KEK	UoT				
Person-months per Participant:	30	36	12				

Objectives

1. Execution of an intensified Japanese programme at LHC in preparation for future accelerator programmes
2. Advance the preparation for and execution of the European-Japanese collaboration on the High Luminosity LHC upgrade and associated R&D
3. Strengthen the R&D on High field magnets and RF systems for future or upgraded energy- and/or intensity-frontier hadron machines.

Description of Work

The LHC accelerator will run at its full energy from 2015 and Japanese researchers participate in operation, analysis and upgrade projects for both accelerator and detectors. R&D on high field magnets and wideband magnetic alloy RF systems is a key ingredient for upgrading the LHC, and its injectors through the LIU project, and for reaching the goals of the High Luminosity LHC project. These studies are also relevant for the J-PARC accelerators and for a potential very large collider as studied in the context of the FCC programme.

Task 1.1: LHC operation and analysis (CERN, KEK & UoT): Integrate Japanese efforts in operation of LHC machines and detectors at full energy; expected to provide important guidance for future accelerator developments in Europe and Japan.

Task 1.2: The HL-LHC project (CERN & KEK): Engineering design and validation of two short prototype separation superconducting dipoles (D1) followed by construction preparation, construction and test of the 4 final (plus two spare) D1 dipoles for the upgraded LHC insertion regions. Studies for the crab cavities (CC) for the LHC luminosity upgrade, benefitting from operational experience of CC at KEK.

Task 1.3 High field magnet R&D and preparation of future hadron injectors and colliders (CERN & KEK): R&D on the viability of HTS magnets of accelerator/collider quality. Enhance the exchange of staff between CERN and KEK in the context of the LIU project and the J-PARC intensity upgrade studies. Technologies of special interest are Wideband Cavities using Magnetic Alloy, Solid State Amplifiers and Low Level RF.

Deliverables

Month 25 Magnets and Gradients: Report on common R&D results on high field magnets and high gradient structures.

Month 25 Hadrons at high intensity and energy: Report describing R&D results on FCC and J-PARC related activities.

Month 37 Physics at LHC: Report covering main findings at LHC with relevance for future energy frontier accelerator projects.

Month 37 HL-LHC: Status report and final plan of the Japanese contribution to HL-LHC.

Addition collaborations:

- LIU participation
- FCC Design Study
- JPARC