SLHC –PP WP6

LHC IR UPGRADE - PHASE I

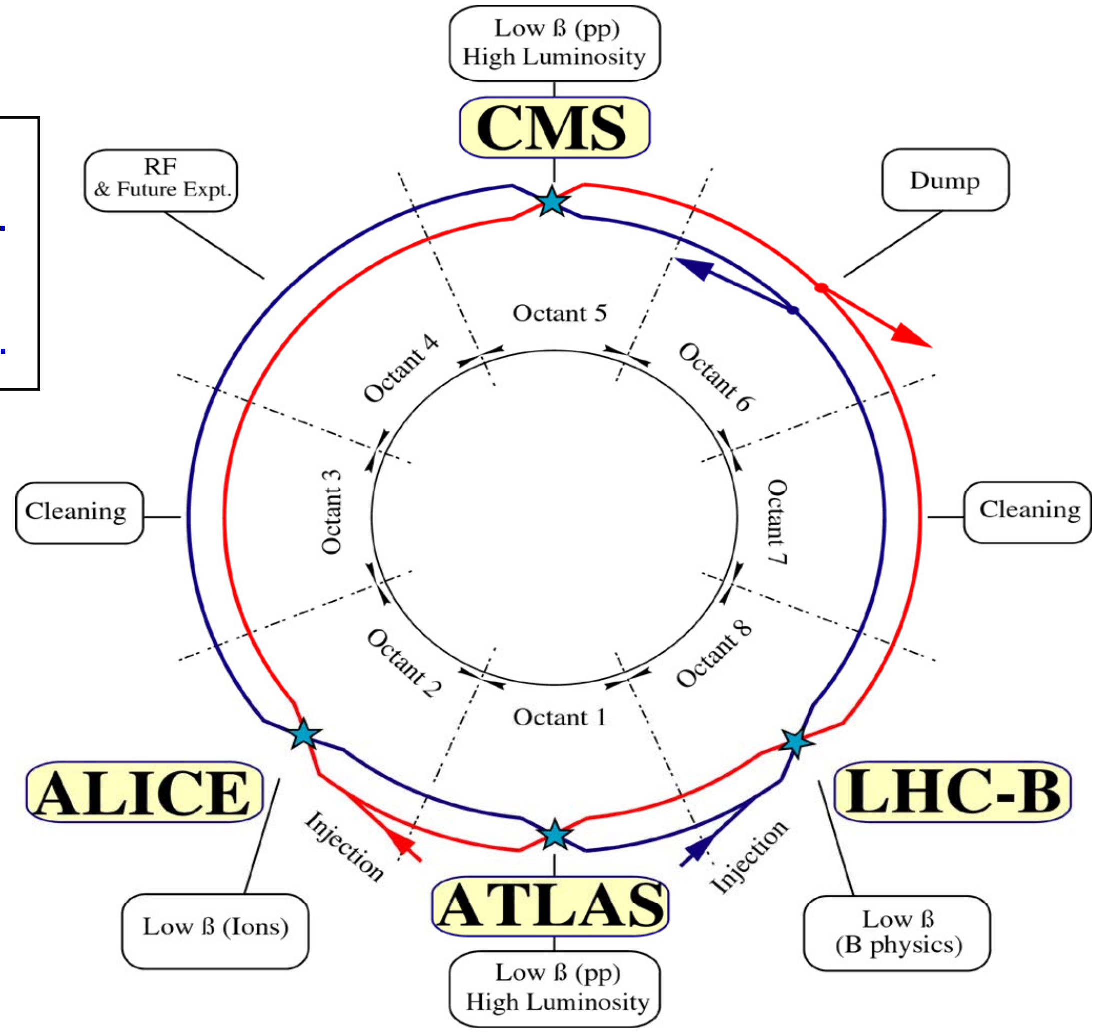
Summary

- The present triplet and the tunnel reality
- The goal of LHC IR Upgrade - Phase I
- The emerging layout
- Preliminary parameters of the low-β quadrupoles and correctors
- EU-FP7 SLHC-PP WP6
  - Objectives
  - Participants
- Proposal for organizing the activities – discussion

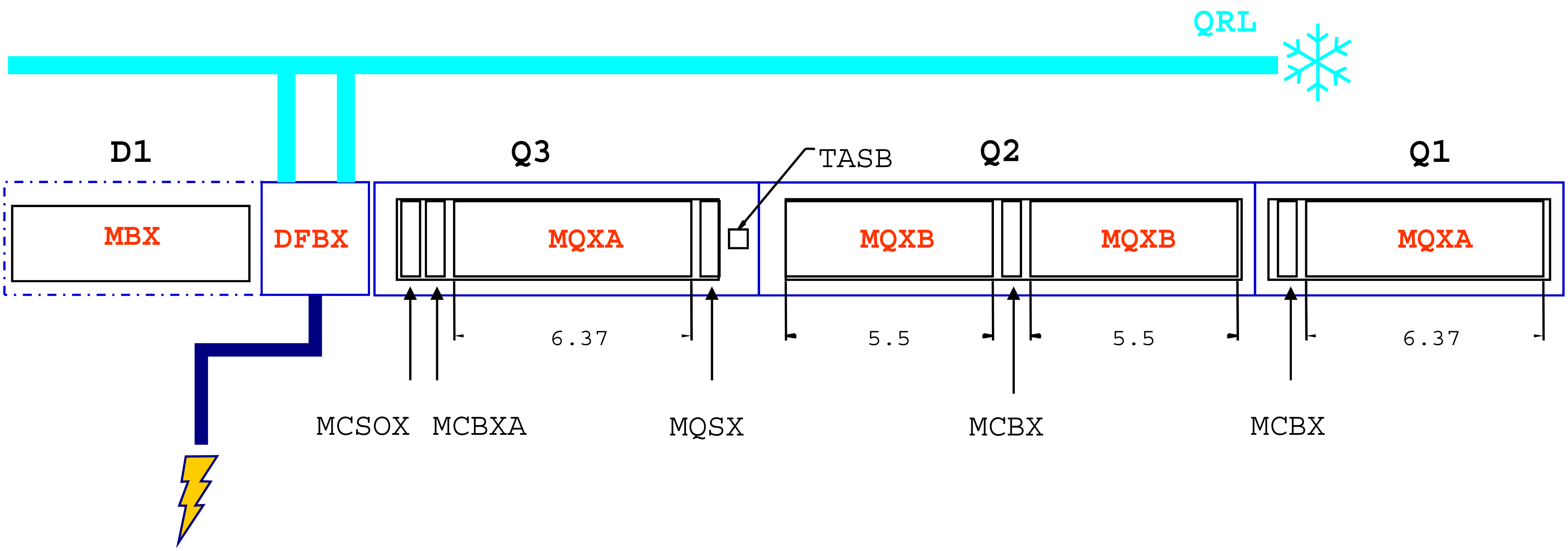
LHC Insertions

Experimental insertions in points 1, 2, 5, 8 contain low-beta triplets.

In total, eight triplets are installed.



The LHC low-β triplet



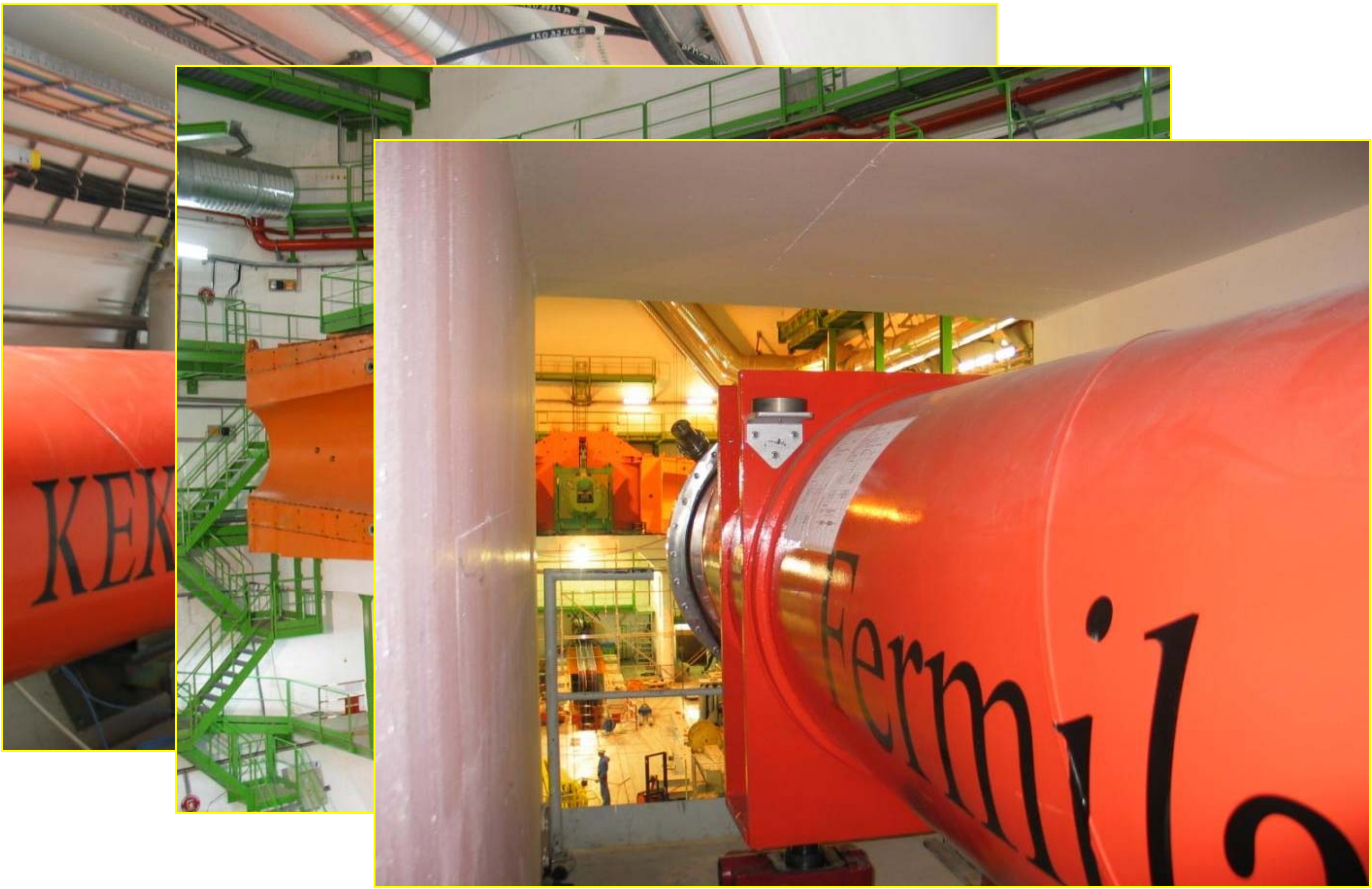
IR 1 and 5, D1 is a normal conducting dipole.

Triplets were designed and built by a collaboration of five laboratories: BNL, CERN, Fermilab, KEK, LBNL.

Low-β triplet – full view

Low-β triplet in IP1

Low-β triplet in IP5



LHC IR Upgrade - Phase I

Goal of the upgrade:

Enable focusing of the beams to β*=0.25 m in IP1 and IP5, and reliable operation of the LHC at 2 10^{34} $cm^{-2}s^{-1}$ on the horizon of the physics run in 2013.

Scope of the Project:

1. Upgrade of ATLAS and CMS interaction regions. The interfaces between the LHC and the experiments remain unchanged at ± 19 m.
2. Replace the present triplets with wide aperture quadrupoles based on the LHC dipole cables (Nb-Ti) cooled at 1.9 K.
3. Upgrade the D1 separation dipole, TAS and other beam-line equipment so as to be compatible with the inner triplet aperture.
4. The cooling capacity of the cryogenic system and other main infrastructure elements remain unchanged.
5. Modifications of other insertion magnets (e.g. D2-Q4) and introduction of other equipment in the IR to the extent of available resources.

The emerging concept

Triplet:

- Composed of four cryo-quadrupoles of similar length (~ 8 m).
- Cold bore+beam-screen engineered as magnet protection elements. The beam screen cooled at 40-60 K.
- Interconnections (He-pipes, PIM and BS) identical in IR1 and IR5.
- Dipole and multipole correctors lumped in a separate cryo-unit located in between D1 and Q3.

Powering

- Each magnet protected separately. Energy extraction included in the main circuit.
- All delicate equipment moved into shielded areas. DFBX linked to the triplet through a link (HTS or LTS).

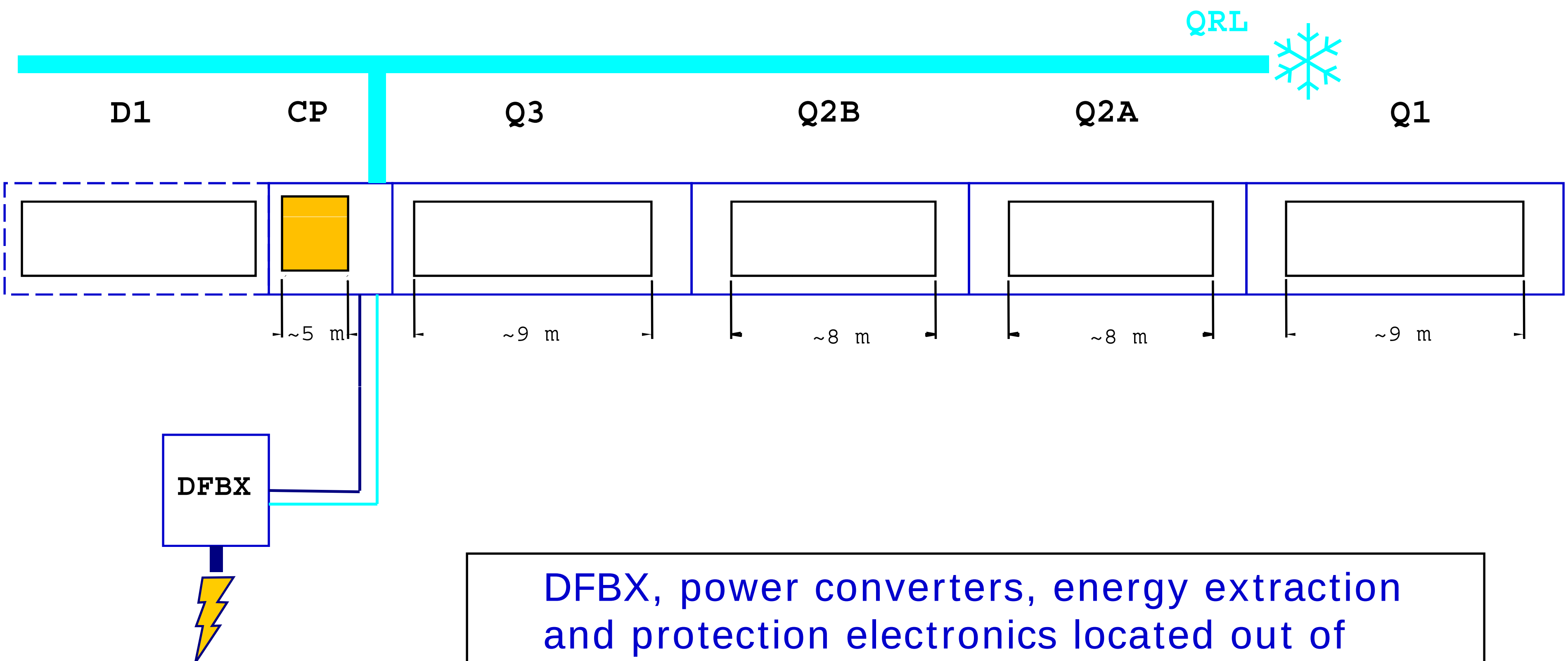
Matching Section

- D2, Q4 and Q5 moved by about 15 m towards the arc to improve the flexibility of the insertion.

Low-beta quadrupoles

- The ultimate parameters: β^*=0.25 m, n1=7, using definitions for nominal LHC. This leads to a beam-stay-clear of ~95 mm and coil ID of ~ 110 mm.
- Magnet aperture and length to take into account optimal use of existing cable.

The emerging layout



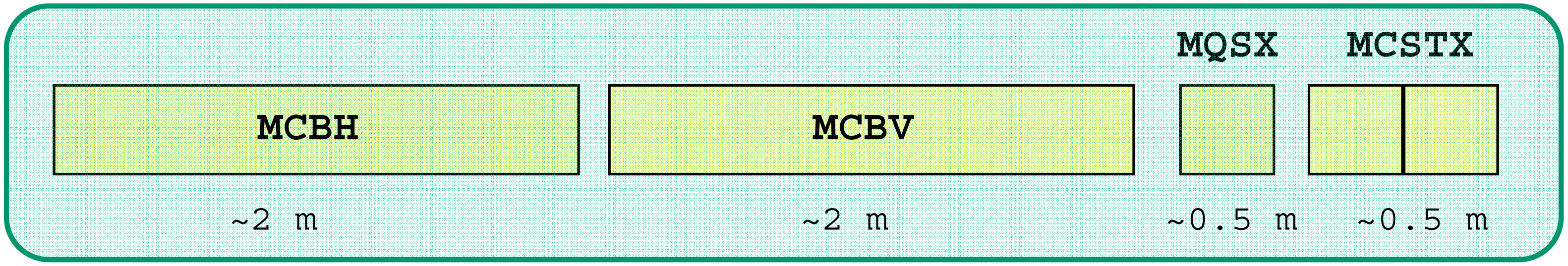
DFBX, power converters, energy extraction and protection electronics located out of tunnel, in a shielded area.

Quadrupoles powered in series at 11 kA.

All correctors powered at 600 A.

A possible corrector cryo-unit CP

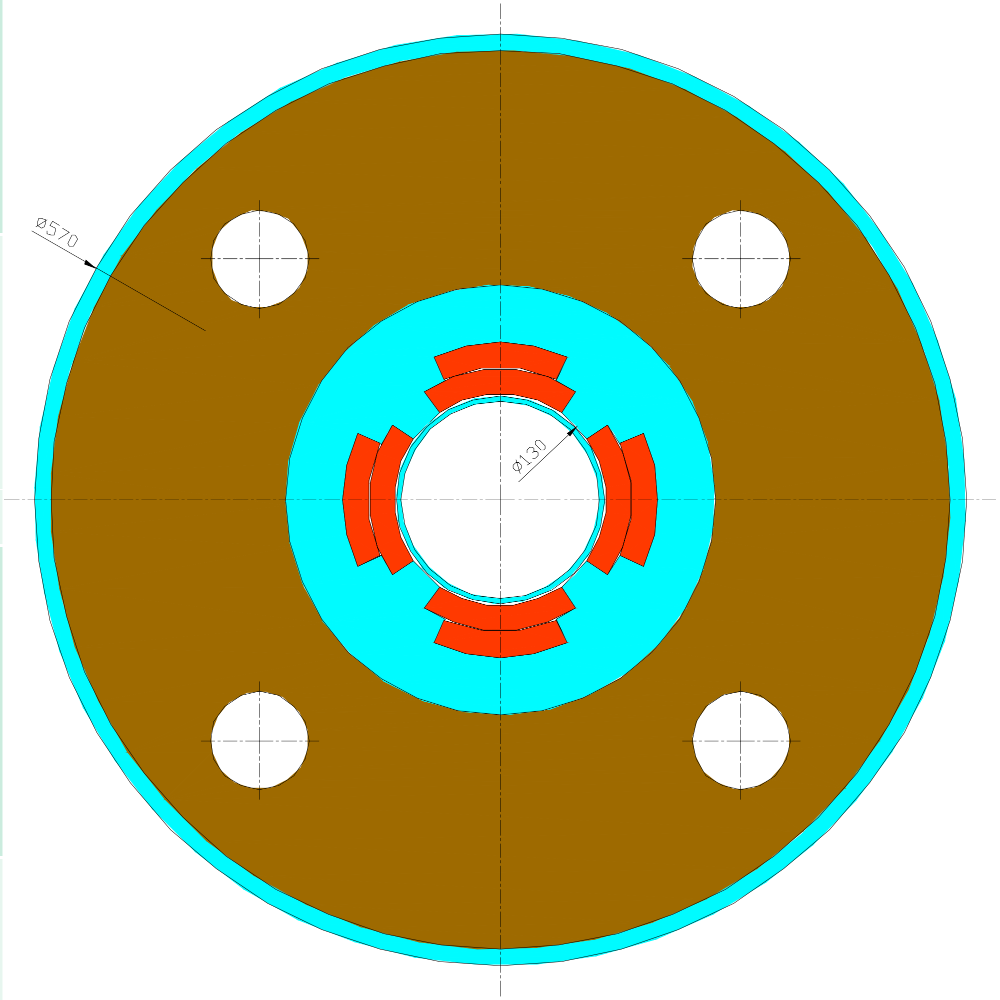
CP: a cold mass containing all correctors



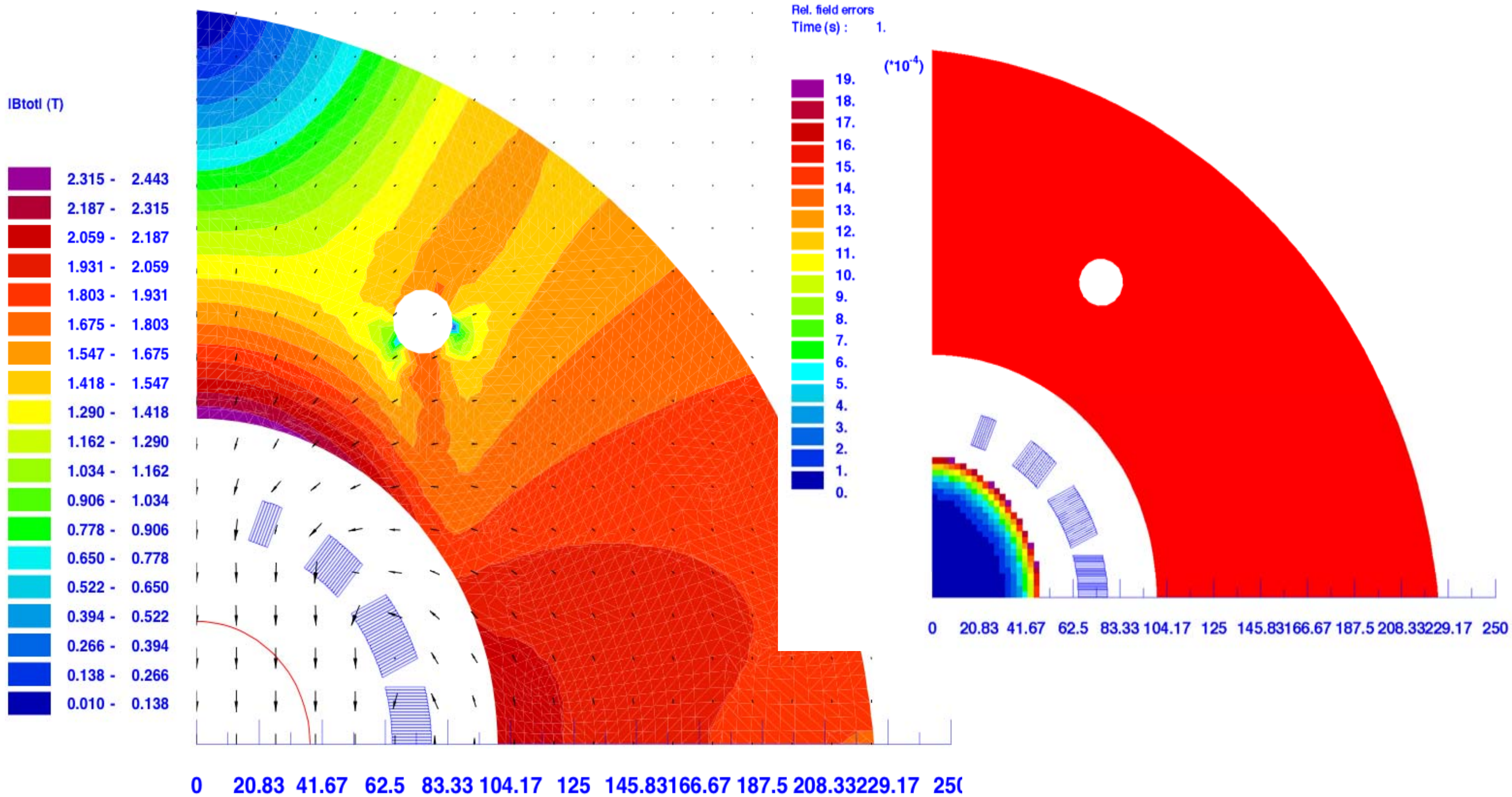
	Current	Integrated strength (field)	Aperture (identical to quads)
MCBX	+/- 600A	~ 6 Tm/ (~3 T)	110-130mm
MQSX (a2)	+/- 600A	~ 20 T (~40 T/m)	110-130mm
MCSX (b3)	+/- 100A	~ 0.01 Tm (~0.05T@17mm)	110-130mm

Preliminary Low-β Quadrupole parameters I

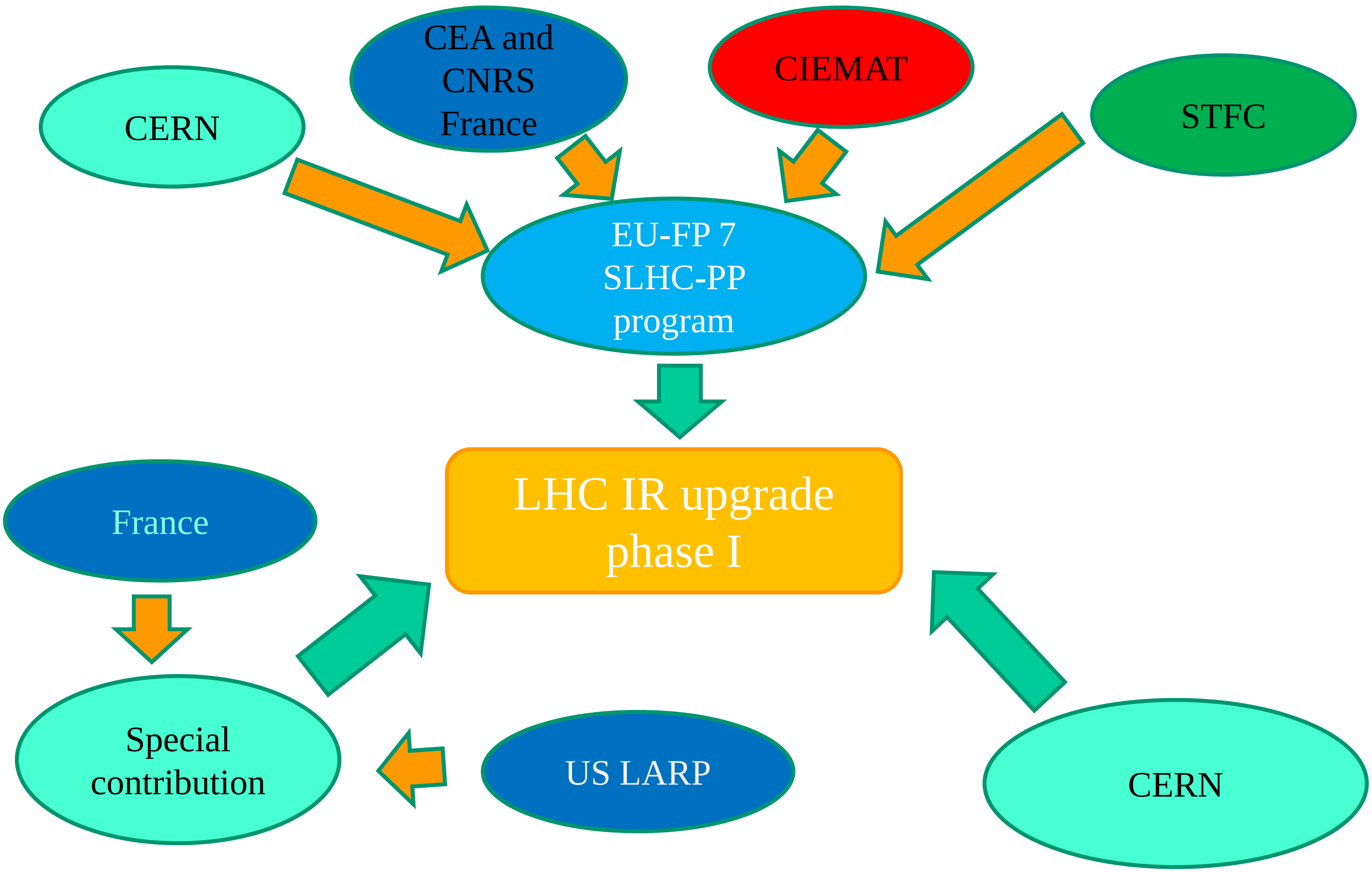
Fixed parameters	
Sc cable	LHC dipole cables (detailed parameters in LHC Design report, CERN-2004-003, p.157.)
Collar material	Nippon Steel YUS 130 thickness 3mm. Material according to spec LHC-MMS/98-198/G03 EDMS n.102691
Yoke material	Cockerill Low Carbon Steel thickness 5.8 mm. Material according to spec IT-2421/LHC
Cold mass outer diameter	570 mm (iron yoke 550mm and shell thickness 10 mm).



Phase I MCBXH



A joint R&D and construction effort



Development of Nb-Ti quadrupole magnet prototype

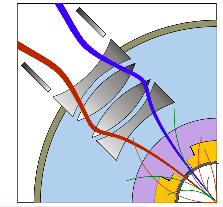
Objectives

- Designing the Nb-Ti quadrupole for the interaction regions of the LHC upgrade for higher luminosity.
- Manufacturing and cold testing a one meter long model of Nb-Ti quadrupole to qualify the procedure retained and the actual field quality
- Constructing and testing a full scale prototype made of a complete quadrupole with the cryostat and the correctors, as a basis for preparing the manufacture of the 16 quadrupoles needed for the high-luminosity interaction regions S-ATLAS andCMS2.

Laboratory contribution

	Task 6.1 **Design of advanced Nb-Ti SC quadrupole**	**Task 6.2\Construction and testing of short models**	**Task 6.3** **Construction and testing of a full scale prototype**
CERN	Coordination Magnet design Cryostat design	Coordination Coil manufacturing Cold mass assembly Cold test Corrector cold test	Coordination Long prototype quad Cryostating
CEA-Saclay	Magnet design	Coil manufacturing	Assist CERN in long quad assembly
CIEMAT	Corrector design	Manufacturing corrector short model	Corrector prototype manufacturing
CNRS-IN2P3	Cryostat design		Cryostat manufacturing Cryostat tooling design
STFC	Corrector design	Manufacturing corrector short model	Corrector prototype manufacturing

SLHC-PP WP6: timescale



Deliverables task 6.1	Description	Nature	Delivery date	
6.1.1	Basic design of the triplet	R	M12	01/04/2009
6.1.2	Complete Interaction region design	R	M36	01/04/2011

Deliverables task 6.2	Description	Nature	Delivery date	
6.2.1	Construction of model	D	M18	01/10/2009
6.2.2	Assessment of the design	R	M24	01/04/2012

Deliverables task 6.2	Description	Nature	Delivery date	
6.3.1	Construction corrector magnet package	P	M26	01/06/2012
6.3.2	Prototype quadrupole magnet	P	M32	01/12/2011
6.3.3	Test of complete quadrupole prototype	R	M34	01/02/2012

SLHC-PP WP6: timescale milestone

Milestones	Description	Nature	Delivery date	
6.1	Qualification of magnet component	O	M08	01/12/2008
6.2	Basic magnet design	O	M10	01/02/2009
6.3	Complete cold mass design	O	M18	01/08/2009
6.4	Complete cryomagnet design	O	M22	01/02/2010
6.5	Cryogenic and power test of the model	O	M22	01/02/2010
6.6	Electrical test of collared coil	O	M28	01/08/2010
6.7	Cold test of cornet	O	M28	01/08/2010

Program of 1st activities

- CIEMAT: evaluate feasibility of the MCBX corrector with a 600 A current:
  - CERN would provide 1st conceptual design
  - CIEMAT perform quench protection analysis and mechanical analysis
- STFC: evaluate feasibility of the MQSX corrector with a 600 A current
  - STFC would provide 1st conceptual design
  - STFC perform quench protection analysis and mechanical analysis
- CEA-Saclay
  - detailed mechanical analysis of the low beta quad when a 1st set of main parameters (aperture, collar thickness and conductor distribution have been fixed)
  - Participation in model coil winding (model length ~ 3m).
- CNRS-IN2P3: pre-study of integration of cold masses and cryostat