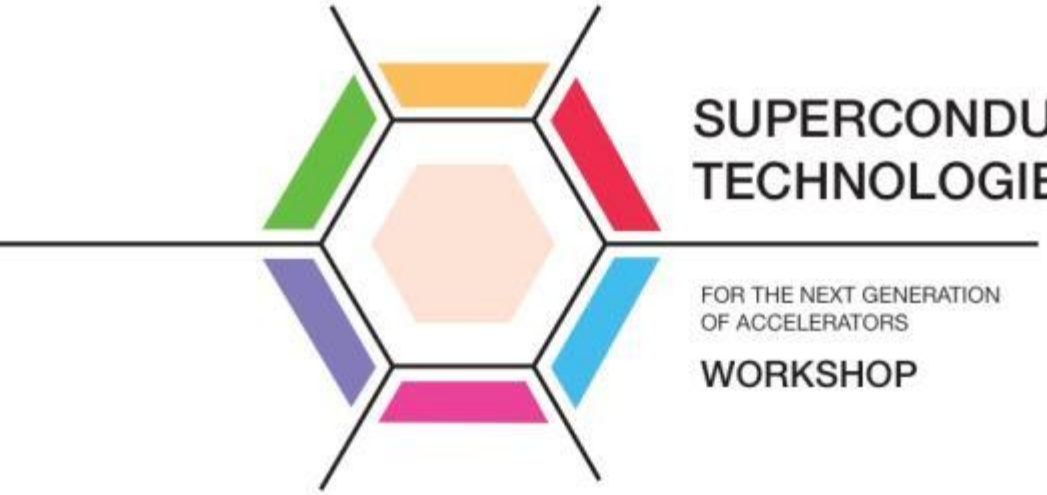


SUPERCONDUCTING TECHNOLOGIES

FOR THE NEXT GENERATION OF ACCELERATORS

WORKSHOP

Lucio Rossi

The High Luminosity LHC Project

High Luminosity LHC

IEEE

CSC

Council on Superconductivity

Distinguished Lecturer 2013

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

Content

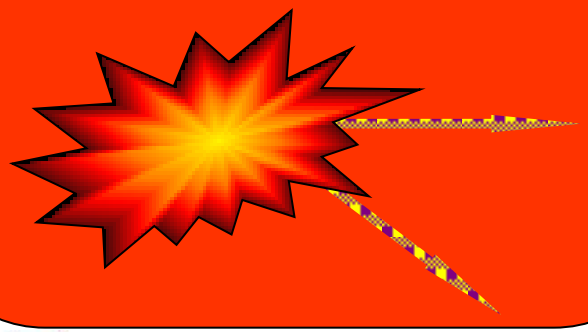
- Energy and luminosty
- Present LHC and luminosity evolution
- Reasons for the upgrade
- Luminosity Upgrade: the main ingredients
- FP7 HiLumi Design Study
- Further evolution: the Energy upgrade
- HL-LHC main technologies

The two Discovery Frontiers

2 routes to new knowledge about the fundamental structure of the matter

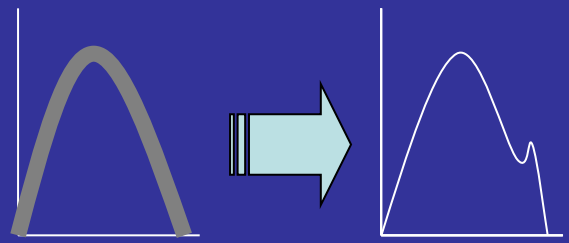
High Energy Frontier

New phenomena (new particles) created when the "usable" energy > mc^2 [×2]



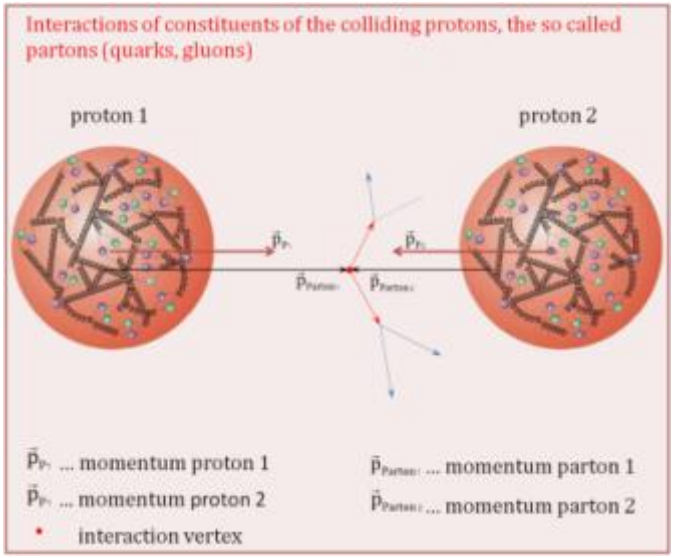
High Precision Frontier

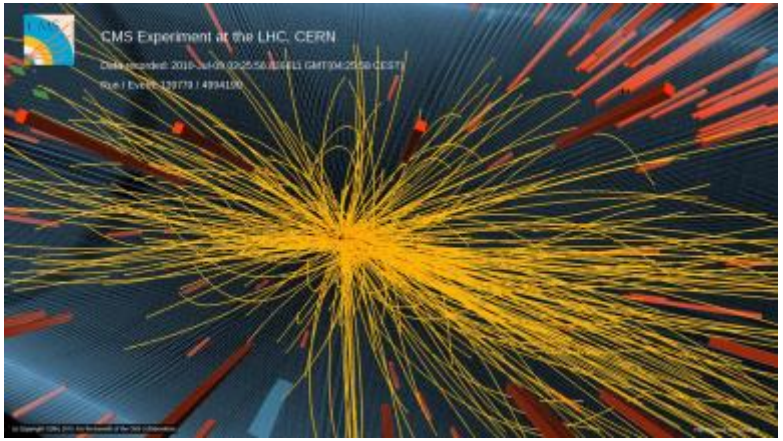
Known phenomena studied with high precision *may* show inconsistencies with theory



LHC and Hadron colliders

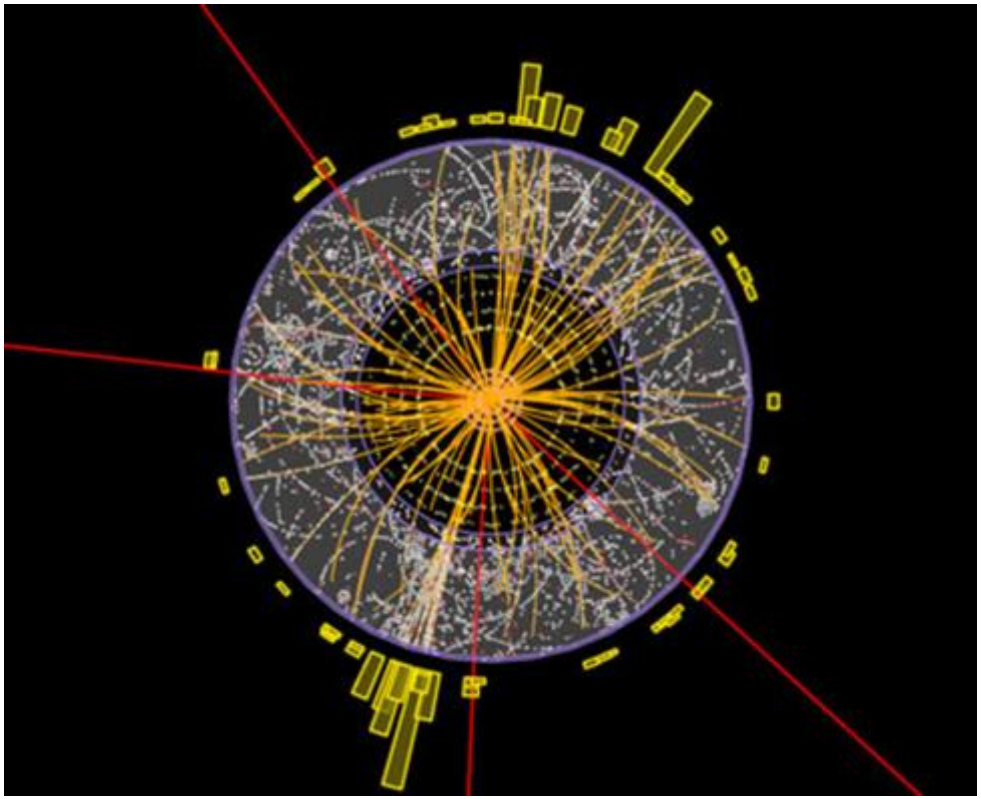
- Hadron colliders are the typical tooling for High Energy Frontiers because the total energy is so large: 8 TeV (and later 14 TeV)
- However all quarks and gluons inside the protons can collide each other → the energy per collision is subdivided : 8 TeV/N
- So there are many events and many traces in a p-p collision





The interesting very rare events

- Interesting events are like a needle in a haystack: very rare.
- A Higgs happens 1 each 10^{12} events!



Luminosity is ∝ to collision rate

- After energy, Lumi is the most importnat parameters of a collider.

Beam current

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

energy

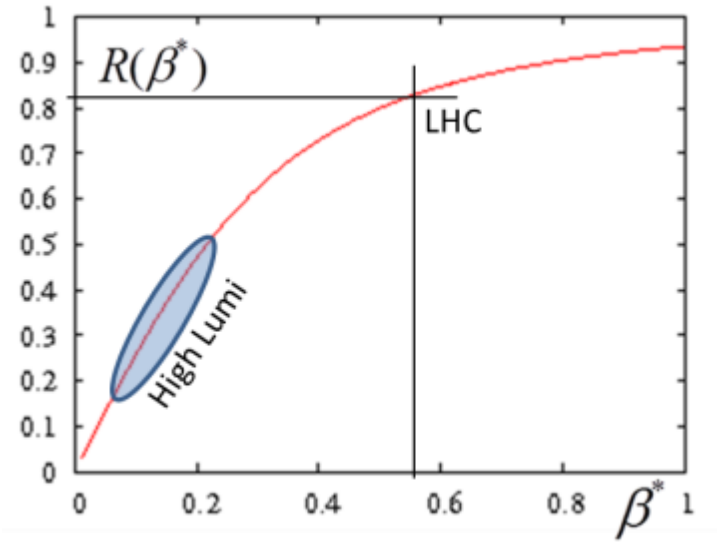
Beam

$$R = \frac{1}{\sqrt{1 + (\frac{\theta_c \sigma_s}{2\varepsilon_n \beta^*}\gamma)^2}}$$

Beam current and emittance: involve Inj chain and whole ring
β* involve «only» 2 IRs, 600 m (but ATS…)

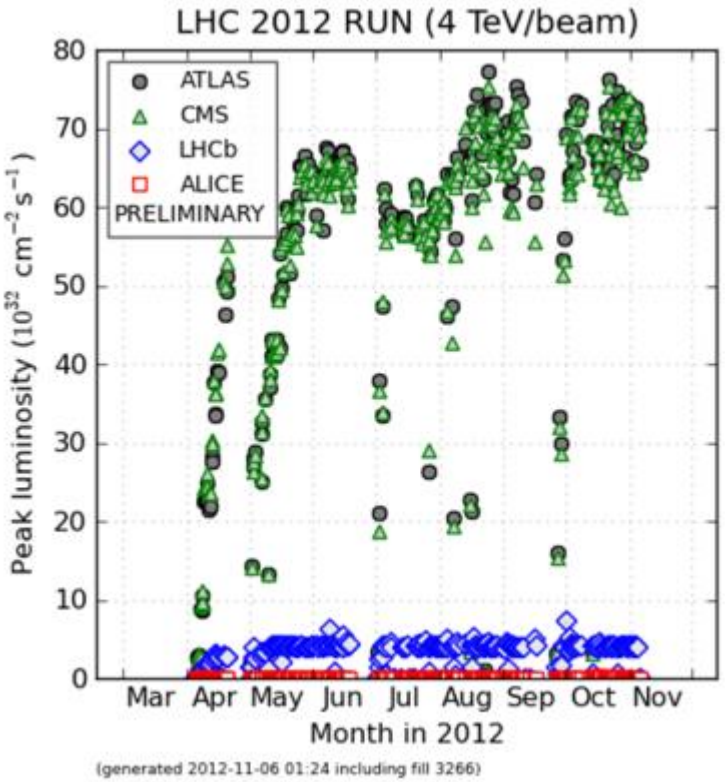
$$L_0 = 1 \cdot 10^{34}\ cm^{-2} s^{-1}$$

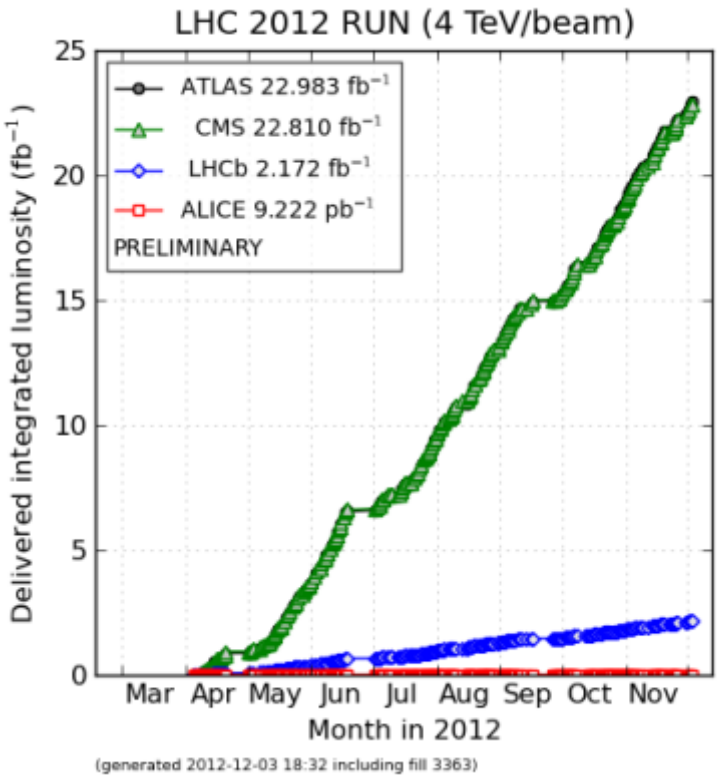
LHC has been designed for L_0
All systems have singularly designed tentatively for ultimate $2L_0$ (almost…)



Integrated Luminosity in LHC (fb^{-1})

In 2011: at 7 TeV accumulated 5.6 fb^{-1}





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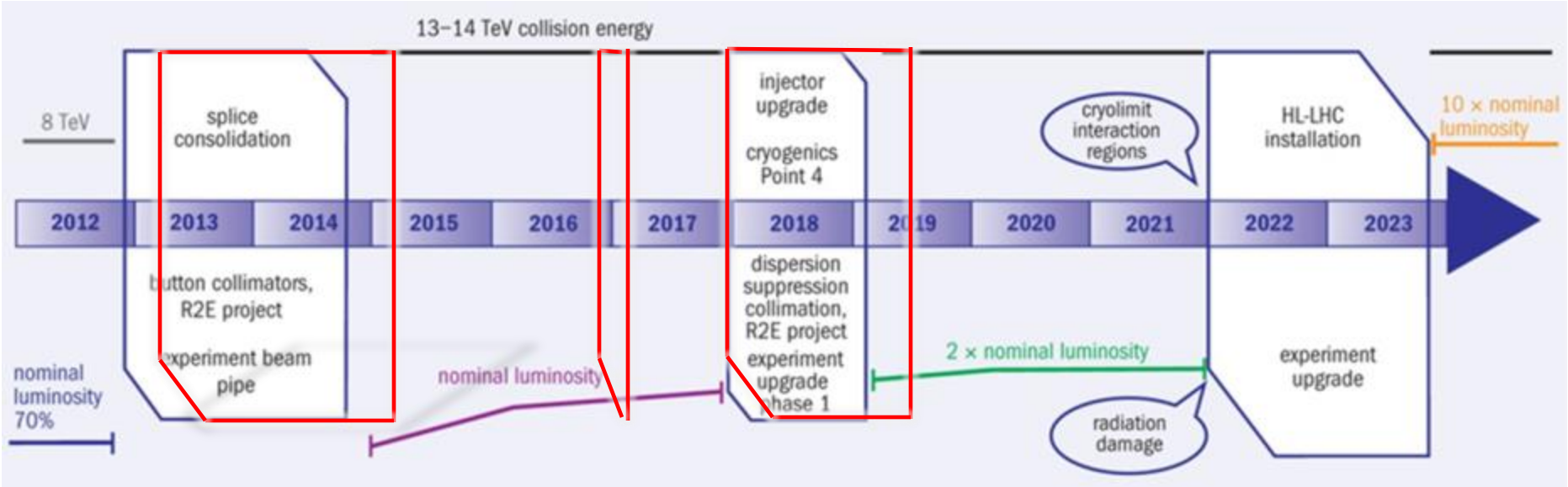
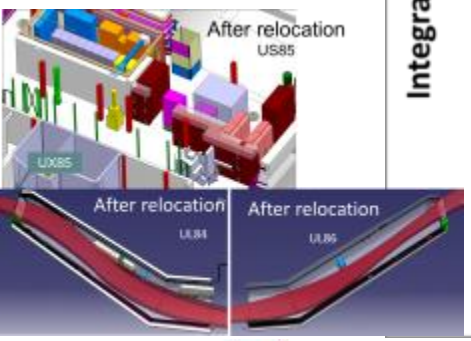
CERN long term plan (ten years)

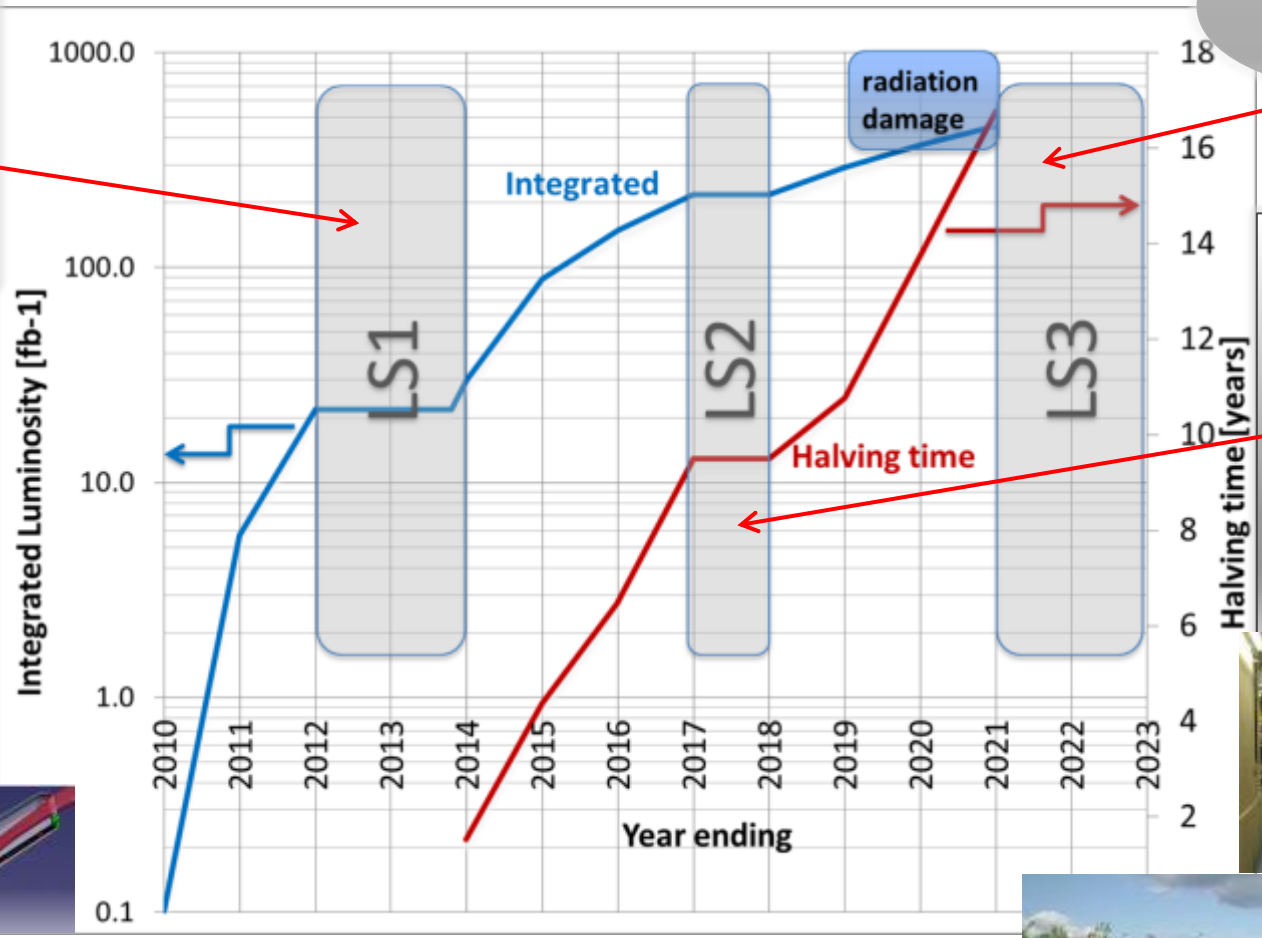


Possible evolution of luminosity

Shut down to fix interconnects and overcome energy limitation (LHC incident of Sept 2008) and



Full upgrade



Shut down to overcome beam intensity limitation (Injectors, collimation

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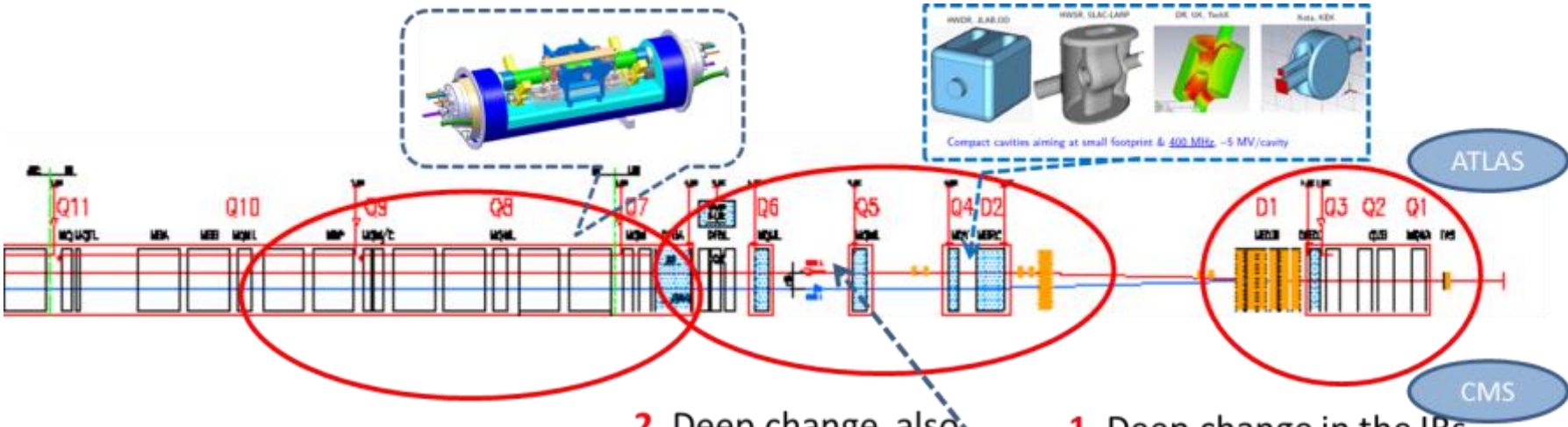
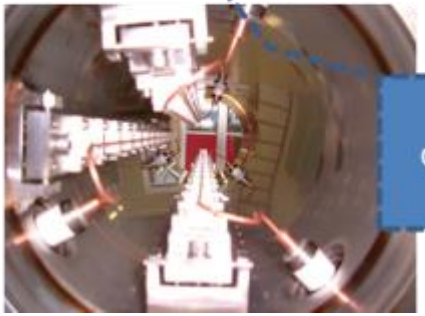
Magnets: 11 T dipoles, 12-13 Quads
Crab Cavities : femtosecond accuracy
SC links: 150-200 kA, 5 kV, 300-700 long
New cryogenic plants and other equipment



3. For collimation we need to change also this part, DS in the continuous cryostat

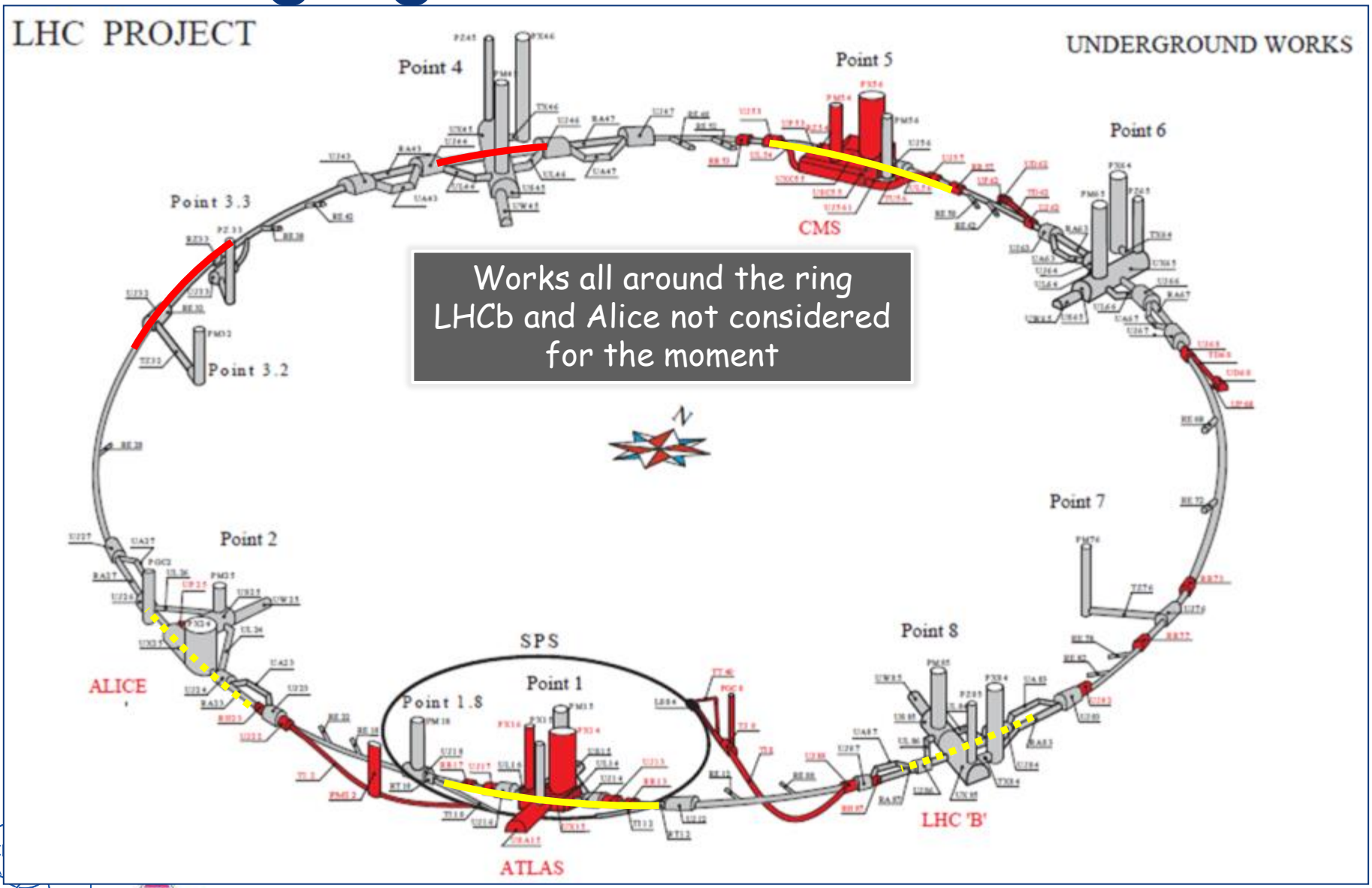
2. Deep change also matching section: Magnets, collimators and CC

1. Deep change in the IRs and interface to detectors; relocation of Power Supply



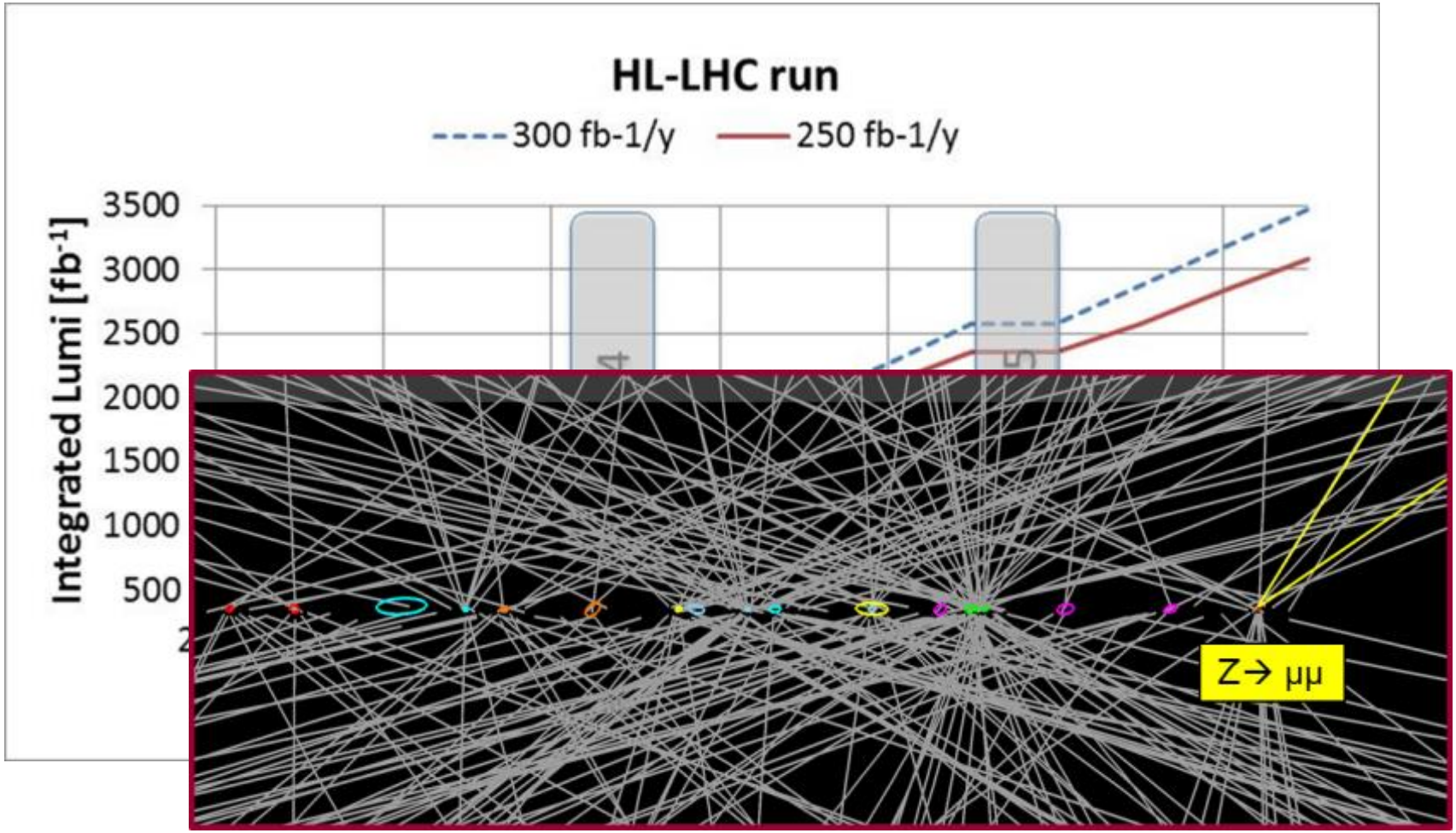
4. LR BB compensation wires

Changing > 1.2 km of LHC…

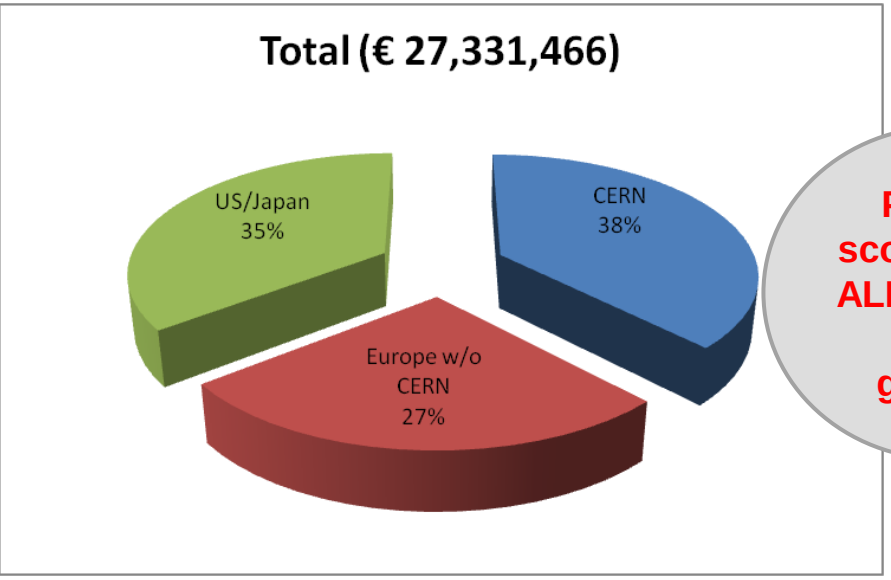


Some of the hardware to change…

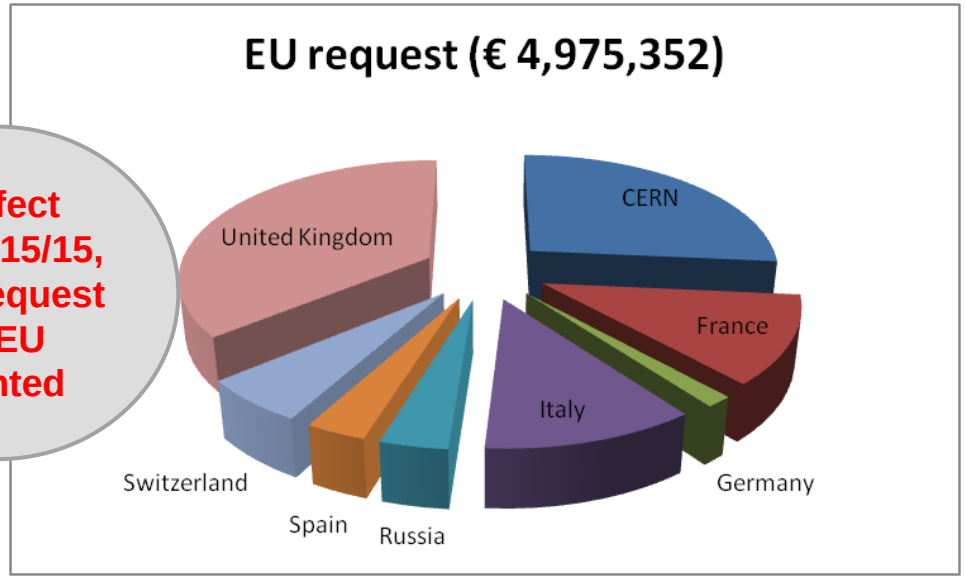
Extending the lifetime of LHC by 10-12 years…



Budget FP7 HiLumi LHC (EU funded Design Study) and the whole project HL-LHC



Perfect score 15/15, ALL request to EU granted



Estimated cost for the the whole HL-LHC over **10 years in M€** (October 2010)
No infrastructure (100 MCHF)

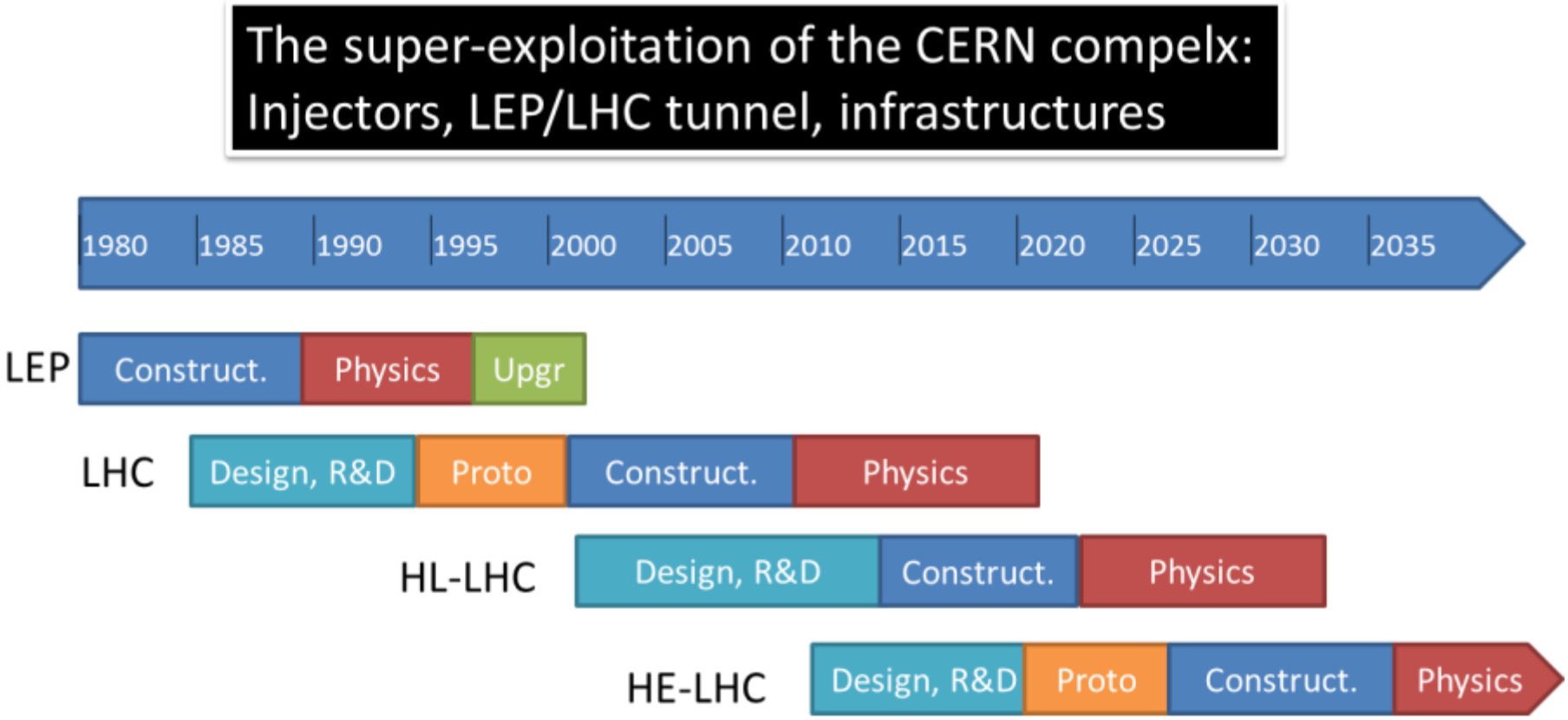
	Design in FP7 HiLumi	Extra effort for Design	R&D and proto	Industrialization & Construction	TOT	Industry
W1-WP6	27	10	50	200	287	160
WP7-12	0	15	30	100	145	80
Other	0	5	10	50	65	40
TOT	27	30	90	350	497	280

List of WP coordinators

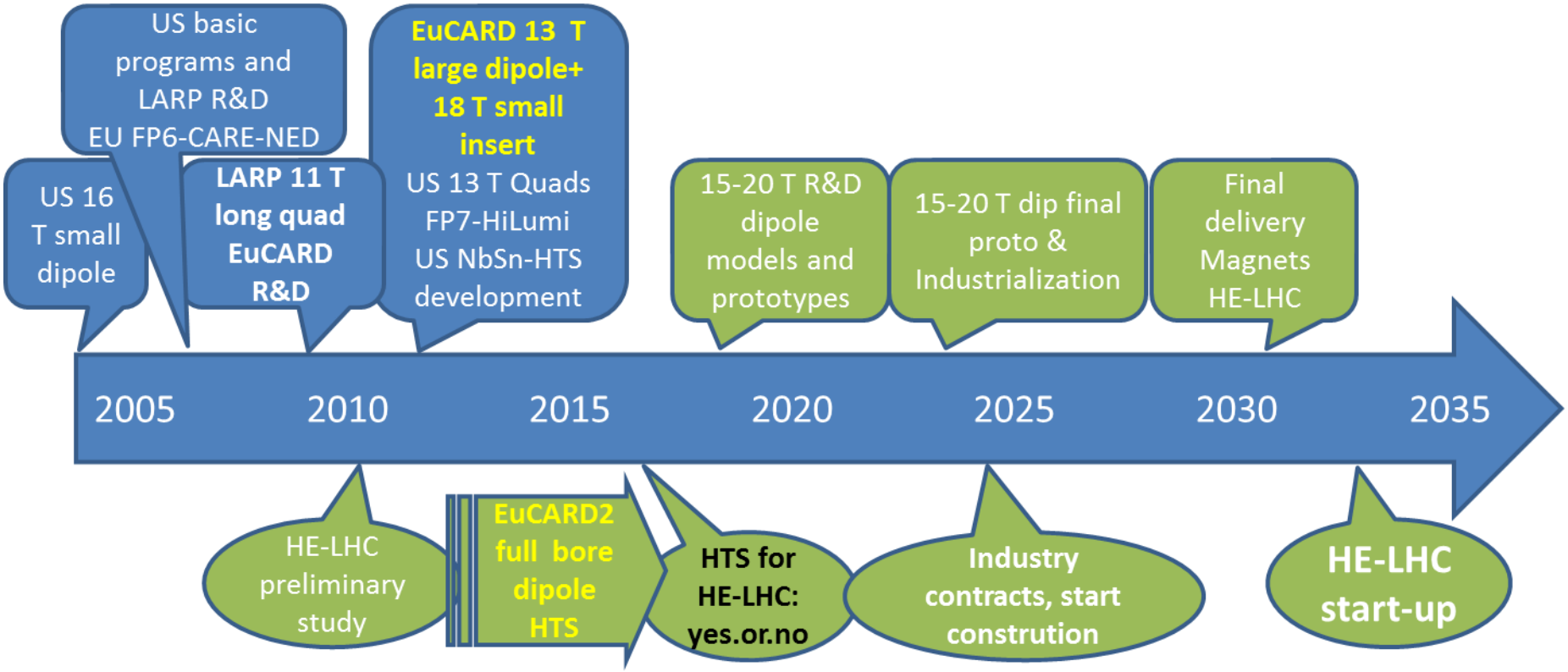
	WP1	WP2	WP3	WP4	WP5	WP6
	MNGT Management & Technical Coordination	APP Accelerator Physics & Performance	MAG Magnet Design	CC Crab Cavities	COL IR Collimation	CP Cold Powering
Coordinator	Lucio Rossi CERN	Oliver Bruning CERN	Ezio Todesco CERN	Erk Jensen CERN	Ralph Assmann CERN	Amalia Ballarino CERN
Co-Coordinator	Oliver Bruning CERN	Andy Wolski UniLIV (UK)	Gianluca Sabbi LBNL (USA)	Graeme Burt UniLAN (UK)	Grahame Blair RHUL (UK)	Francesco Broggi INFN (IT)

WP7 Mach.Protection:	J. Wenninger, R. Schmidt (CERN)
WP8 Coll-Exp Interface:	A. Ball, M. Nessi, H. Burkhart (CERN)
Wp9 Cryogenics:	L. Tavian, R. van den Weelderen (CERN)
WP10 (Energy deposition):	F. Cerutti (CERN), N. Mokhoff (FNAL)
WP11 : 11 T Dipole :	M. Karppinen (CERN, A. Zlobin (FNAL)
WP16 : HFM R&D & FRESCA2 dipole	G. de Rijk (CERN), F. Kircher (CEA)
Saftey, namely RP:	S. Roesler (CERN)
Resource-Cost-Risk Coordinator :	P. Bonnal (CERN)
FP7 HiLumi Administrative Manager:	S. Stavrev (CERN)
Dissemination and outreach :	A. Szberenyi (CERN)

And then? HiLumi isd also a prepration for another larger project: HE-LHC

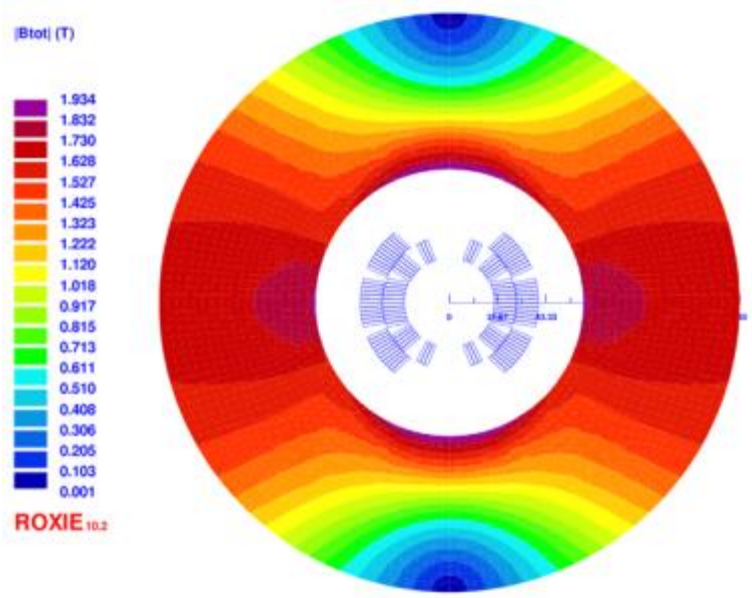


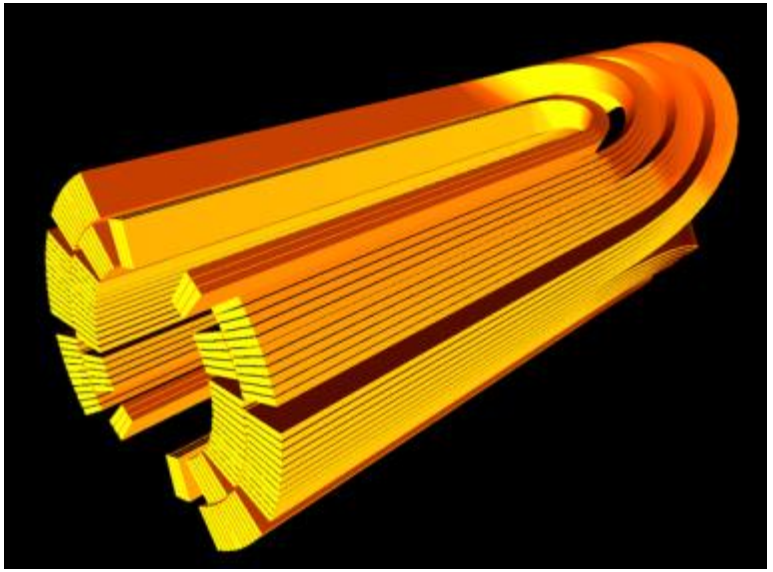
Possible timeline for an HE-LHC



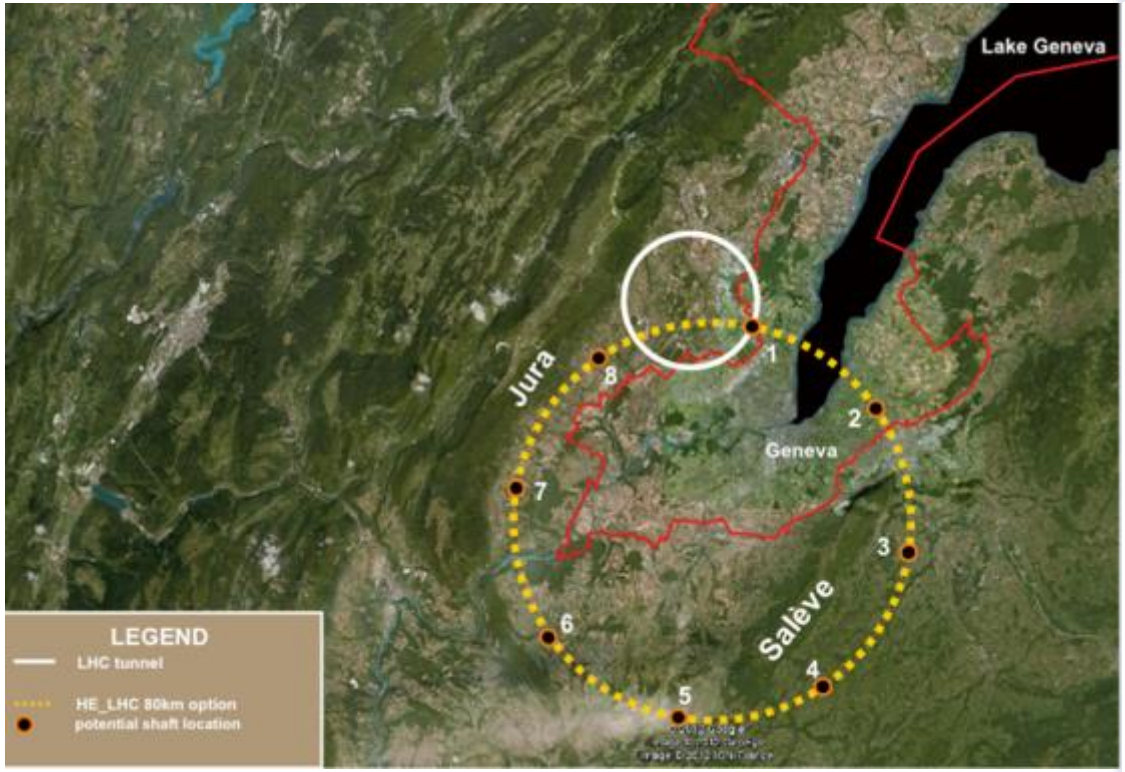
FP7-EuCARD2 program approved start May 2012. WP10-Future Magnets

- Develop 10 kA class HTS accelerator cables
- Test in in a 5 T accelerator quality dipole
- **The aim is one day go into 16-10 T region**





HE-LHC in LHC tunnel or in 80 km new tunnel



Whatever solution, only a vigorous Magnet R&D (and on other equipment)will enable to go beyond LHC energy

LHC tunnel: 16-20 tesla can by 26-33 TeV c.om.

In the 80 km tunnel:For TLEP, then for a superHE-LHC

Optimitation could be at 16 T field level: collision

energy 80 TeV c.o.m.

Or 100 TeV for 20 T dipoles

Much better new infrastructure.

However many costs go linearly, or more, with length. Magnet stored energy, beam energy also a concern

HL-LHC Main Technologies

- Superconductivity technlogies
- Precision and cryogenic mechanics
- Large equipments and tooling
- Ovens for 5-10 m 900 C high accuracy in vacuum
- Power electronics
- Cryogenic plants and cryo-equipment
- New material development for insulator rad-hard
- Advanced «robotics» (or telemanipulation)
- High vacuum
- Infrastructure:
  - Civil engineering (Sc links)
  - Electrical engineering
  - Cooling and Ventilation and basic infrastructure

What's next?

- December 2012: Industry information day (with TIARA/EuCARD): THIS workshop
- June 2013: HL-LHC Project approval by CERN Council(based on EU HEP strategy update of 2013)
- July 2013: Catalog of items under purchase
- December 2013: Set up a forum ITLO to try to get the maximum support form Industry:
  - to communicate and to find partner for new development and then construction
  - Maximize the Industrial return: a goal of the project is also to increment the EU Industry capability
- 2015: Full funding of project, about 750 MCHF including design and prototyping. Secure about 200 MCHF of external collaboration (USA and Japan)
- 2016-2020: construction and test
- 2021: ready for installation