

Overall planning of RF infrastructure

Outline of the crab cavity work package within the HL-LHC upgrade including potential collaborators, distribution of R&D tasks, time line for R&D and construction, cost estimate over the duration of the project and man power estimates.

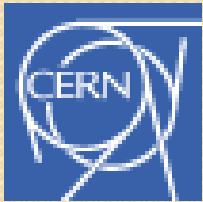
Ed Ciapala, Erk Jensen/CERN

Rama Calaga/BNL & LISI ARP

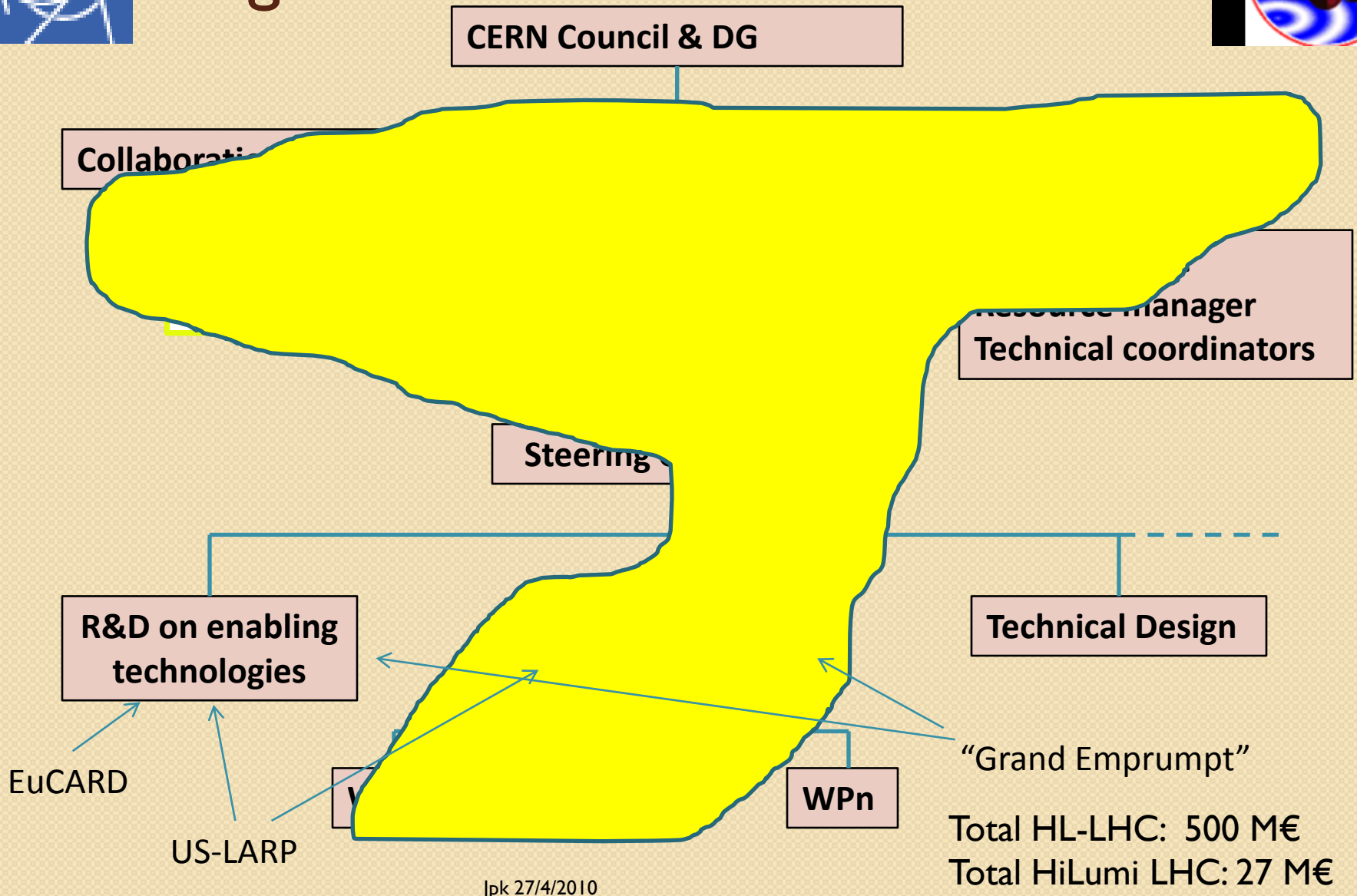
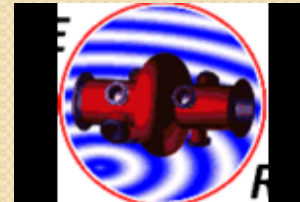
Very preliminary!

Please help us converge!

LHC-CC10, CERN, 16 Dec 2010



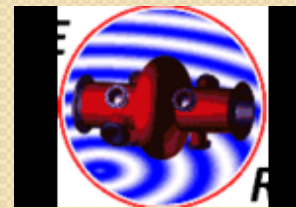
Organization model for HL-LHC



Jpk 27/4/2010



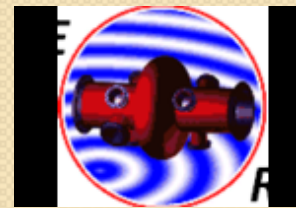
History (1/2)



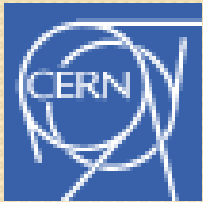
- LHC-CC09 conclusions (excerpt):
 - The potential Lumi increase by CC is significant, CC's for LHC must be pursued.
 - Future R&D should focus on compact cavities
 - Machine Protection issues must be solved!
 - The crab-cavity infrastructure should be included in all LHC upgrades scenarios.
 - What about a KEK-B CC test in SPS?
- Chamonix 2010 (and after):
 - Planning adjusted (skip “phase 1” – go for “phase 2”)
 - Significance of CC project changed from
“extravagant tool” (Lucio) to “essential element”



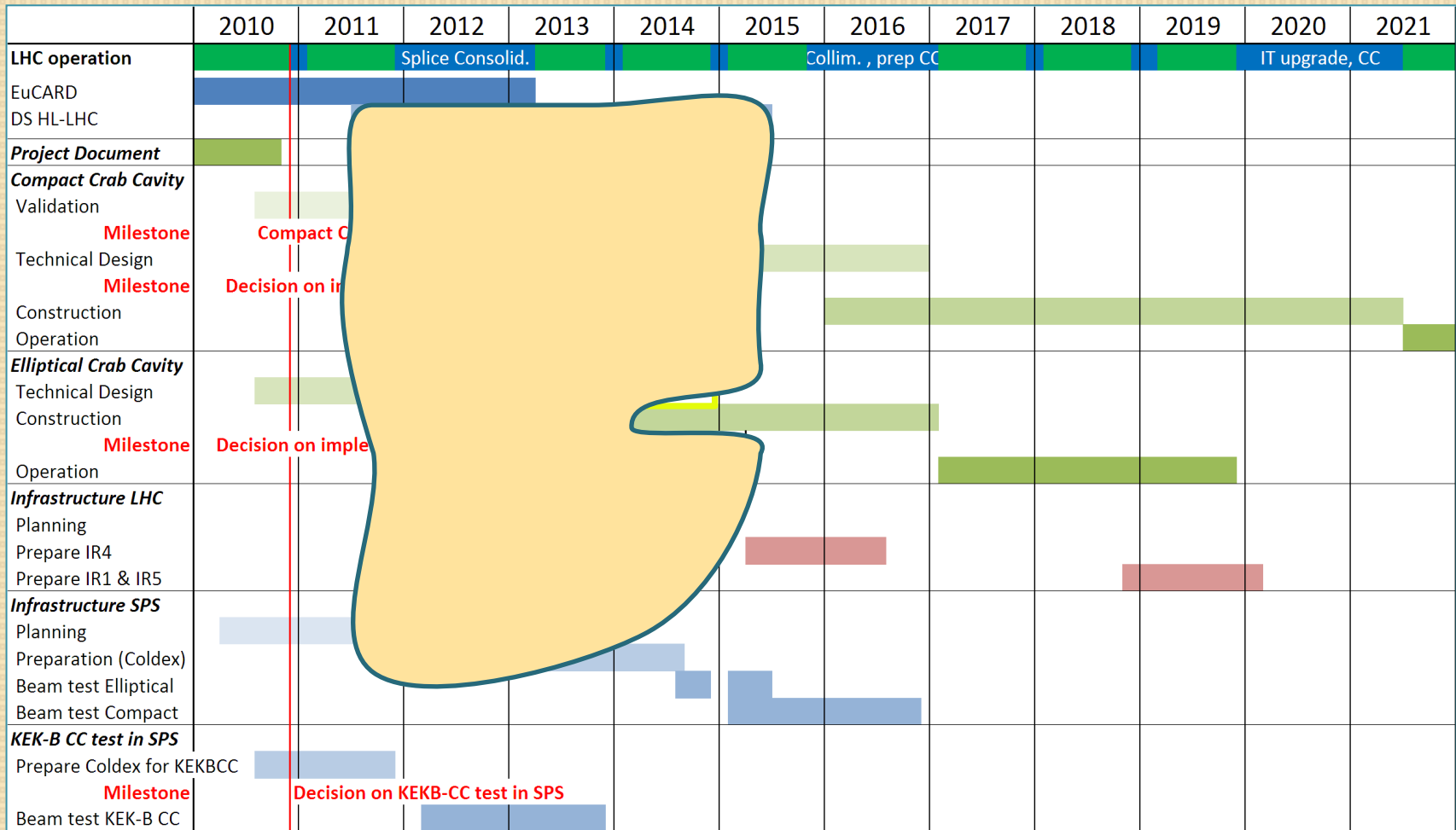
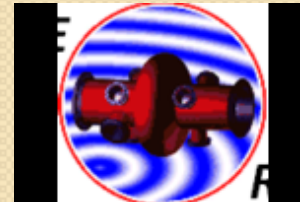
History (2/2)



- **August 2010 – exchange of letters CERN-DoE:**
 - 17/08/10: R. Heuer to D. Kovar, “to express our support for ... (LARP) and to clarify the relevance and priority of some of the activities within this program with respect to the current CERN upgrade plans.”
 - 19/08/10: S. Myers to D. Kovar, a “Mission Statement on Crab Cavities for the LHC Luminosity Upgrade”, complementing the first letter more specifically on the Crab Cavity project.
 - Ed, Erk and Rama started drafting a “project document” describing the needs, the strategy, the estimated planning and resources.
 - The CC’s became a (key) part of the HL-LHC project, led by Lucio Rossi.
- **September 2010 – 25 November 2010:**
 - Formulated, converged on and submitted FP7 Proposal “HiLumi LHC”



The bigger picture

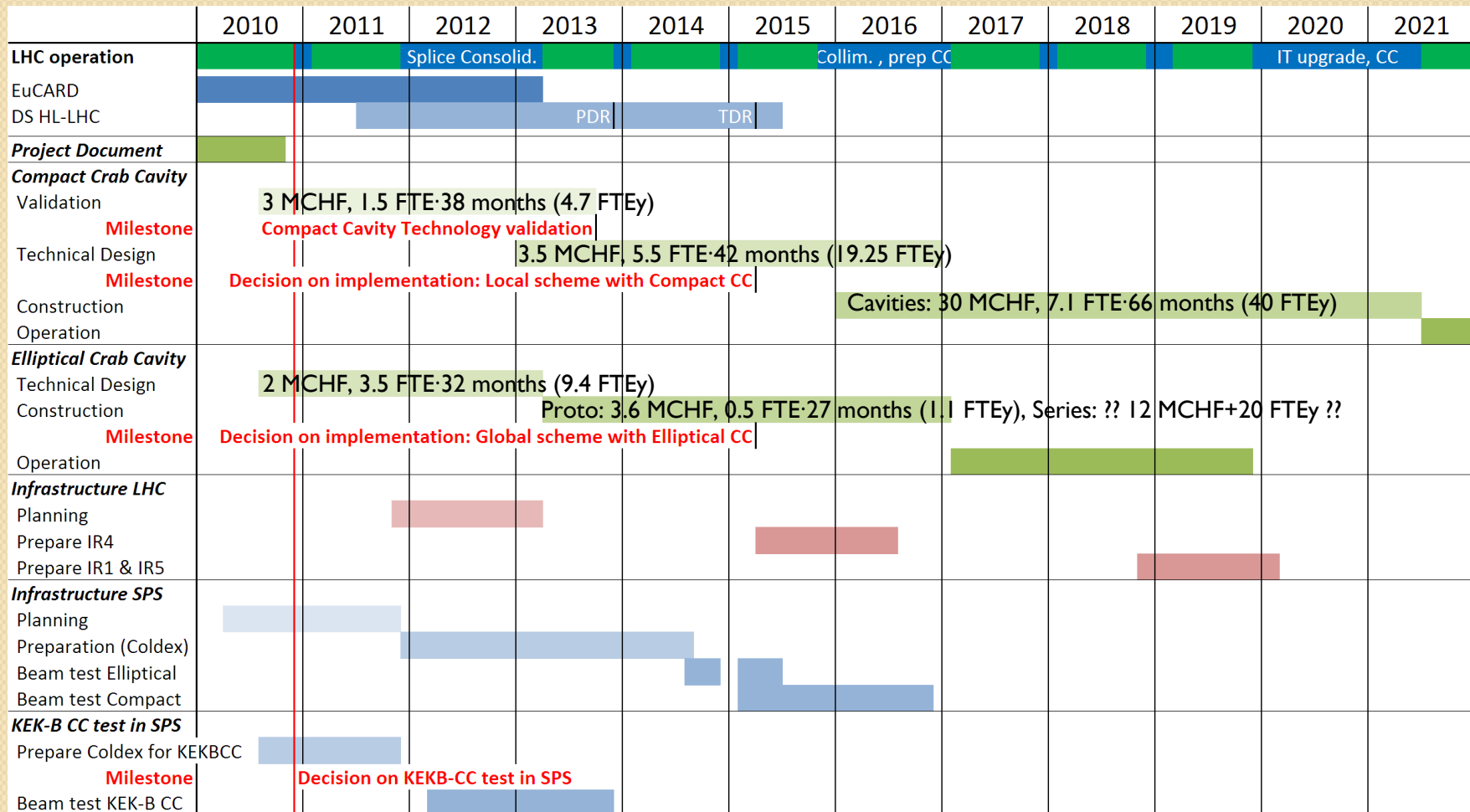
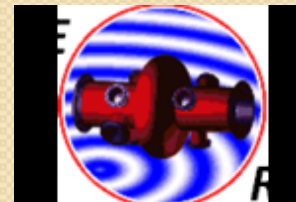


plus: new cryoplant IR4, RF power systems, LLRF, ...

**ATTENTION : NUMBERS!
VERY PRELIMINARY!**



Some first “guesstimates”



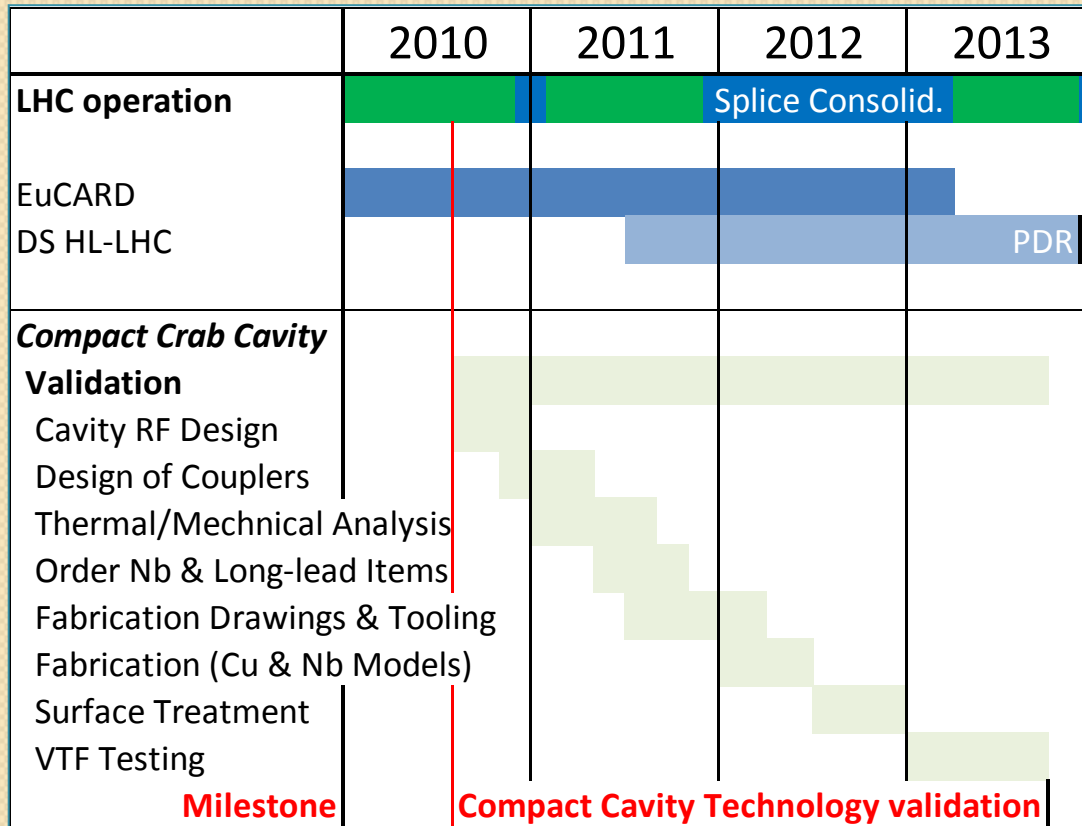
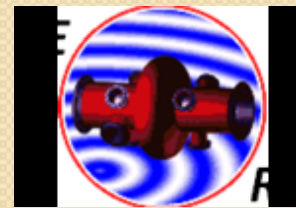
⊕: New cryoplant IR4 (20 MCHF+25 FTEy), Cryomodules PI&5 (40 MCHF+62 FTEy), RF power systems (12 MCHF +3 FTEy), LLRF (1.5 MCHF+7.6 FTEy), Preparation IS SPS & LHC, KEK-B CC test in SPS.

Total (order of magnitude): 100 MCHF + 150 FTEy

FP7 Design Study “HiLumi LHC” WP4: 2.2 MCHF + 40 FTEy



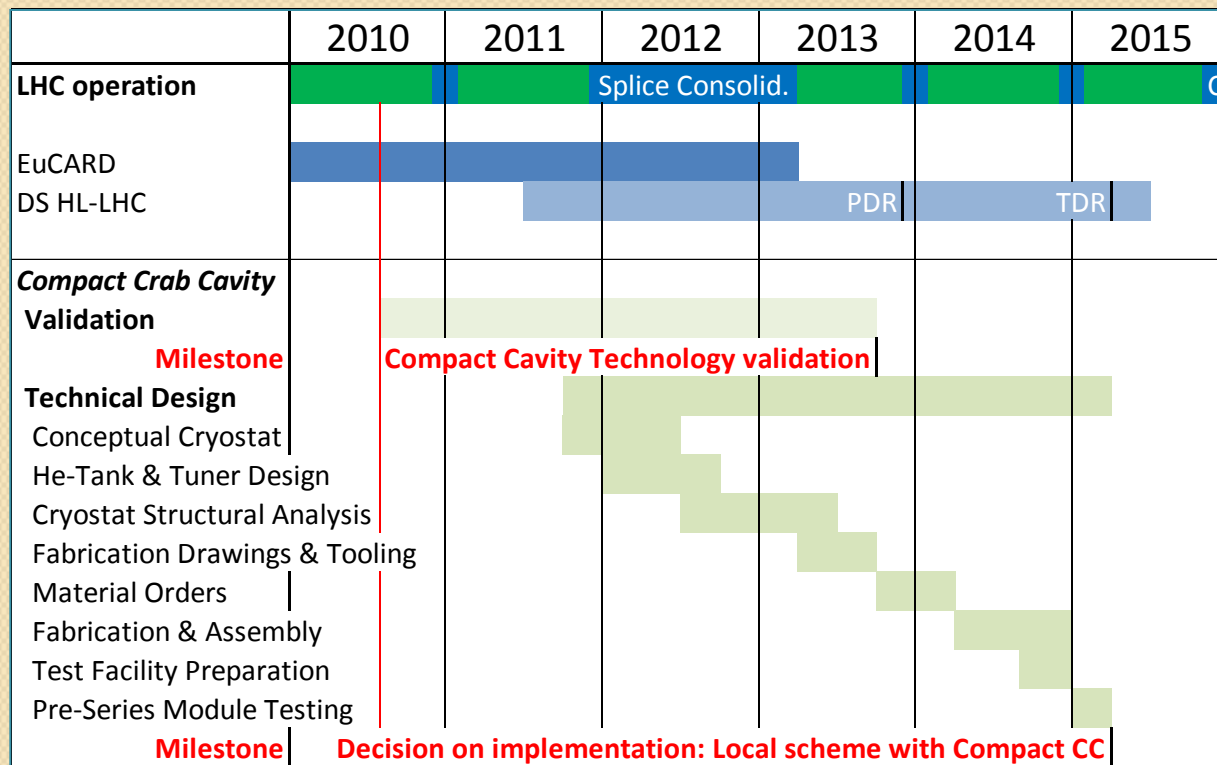
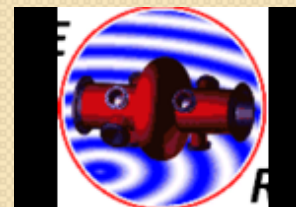
Compact CC validation phase



3 MCHF, 1.5 FTE-38 months (4.7 FTEy)



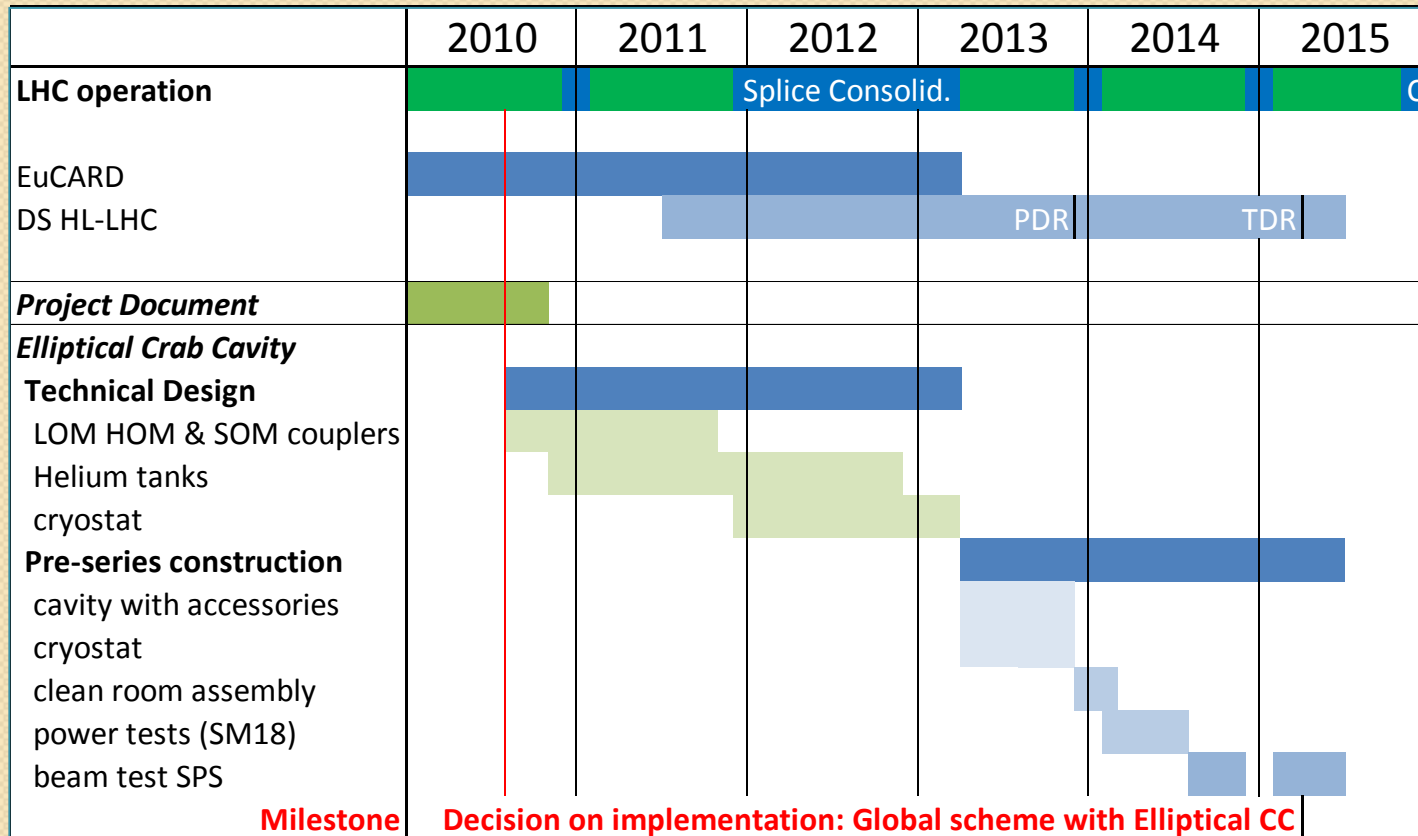
Compact CC Technical Design



Validation phase: 3 MCHF, 1.5 FTE·38 months (4.7 FTEy)
 Technical Design: 3.5 MCHF, 5.5 FTE·42 months (19.25 FTEy)
HiLumi LHC DS:
 Study: 0.576 MCHF 19.5 FTEy
 Initial prototyping: 1.58 MCHF 2.3 FTEy



Elliptical CC Technical Design



Techn. Design: 2 MCHF, 3.5 FTE-32 months (9.4 FTEy)

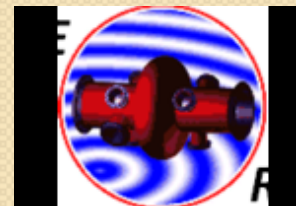
HiLumi LHC DS:

Techn. Design: 0.014 MCHF, 7 FTEy

Pre-Series: 3.6 MCHF, 0.5 FTE-27months (1.1 FTEy)



Later, ... after the FP7 DS:



If Compact CC's can be validated:

	2015	2016	2017	2018	2019	2020	2021
LHC operation		Collim. , prep CC				IT upgrade, CC	
EuCARD							
DS HL-LHC	DR						
Compact Crab Cavity Validation							
Technical Design							
Milestone CC							
Construction							
Preparation for Construction							
Final Fabrication Drawings							
Material Orders							
Fabrication of Cavity-Couplers							
Fabrication of Cryostats							
Surface Treatment & Testing							
Assembly & Quality Assurance							
Delivery & Installation							
Commissioning							
RF/Cryo Commissioning							
Beam commissioning							
Operation							

Cavities alone:
30 MCHF,
7.1 FTE·66 months (40 FTEy)

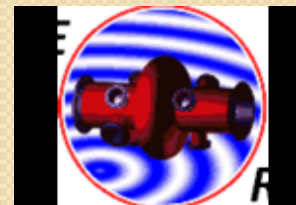
If elliptical crab cavities remain interesting:

	2015	2016	2017	2018	2019	2020	2021
LHC operation		Collim. , prep CC				IT upgrade, CC	
Milestone							
Decision on implementation: Global scheme with Elliptical CC							
Series construction (4 cavities)							
cavities with ancillaries							
cryostats							
RF & power equipment							
low power testing							
power tests							
installation IR4							
Operation							
Commissioning in LHC							
Infrastructure LHC							
Prepare IR4							
Infrastructure SPS							
Beam test Elliptical							

Cavities alone (???:
12 MCHF,
10 FTE·24 months (20 FTEy)



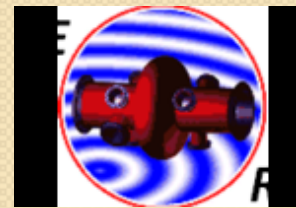
WP4: Tasks (after drastic reduction)



Task 1: Coordination and Communication (CERN, LARP, ULANC)	10 kCHF	8 pm
Task 2: Support studies <ul style="list-style-type: none"> • Tunnel preparation SPS and LHC (CERN) • Local IR layout and spatial integration (CERN, BNL) • Effect of phase noise , LLRF system conceptual design (CERN, ULANC, KEK, BNL, LBNL, SLAC) • RF power system specification (CERN, ULANC) • Operational aspects (how to commission/make invisible) (CERN, CNRS, BNL) • Interlocks and fast Feedback (CERN, LBNL) 	18 kCHF	121 pm
Task 3: Compact Crab Cavity design <ul style="list-style-type: none"> • Cavity and cryomodule specifications (CERN, CEA, CNRS, STFC, ULANC, BNL, FNAL, ODU, SLAC, KEK) • Design optimisation for novel schemes (STFC, ULANC, BNL, ODU, SLAC, KEK) • Conceptual design of SOM, HOM and LOM couplers (STFC, ULANC, BNL, ODU, SLAC, KEK) • Conceptual design of helium tank and cryostat (CEA, CNRS, STFC, ULANC, BNL, FNAL, ODU, SLAC, KEK) • Multipacting simulations of cavity & couplers (STFC, ULANC, ODU, SLAC, KEK) • FEM simulations: mechanical & thermal aspects (STFC, ULANC, BNL, ODU, SLAC, KEK) 	576 kCHF	235 pm
Task 4: Elliptical Crab Cavity Technical design <ul style="list-style-type: none"> • Coupler development and testing (CERN, CNRS, KEK) • Tuner design and mock up on copper models (CERN, • Study of mechanical effects: resonances, microphonics (CERN, • Cavity performance with couplers and horizontal cryostat (CERN, • Performance difference between 2 K & 4 K (CERN, • Cryostat and He Tank Design (CERN, CNRS) 	13.5 kCHF	86 pm
Task 5: Compact Crab Cavity Prototyping and Test <ul style="list-style-type: none"> • Construction of models to refine manufacturing techniques and tooling (CERN, ODU, KEK) • Fabrication of prototype niobium cavity (ODU, KEK) • Make the final CC design down-selection (CERN, ULANC, STFC, all US) 	1,588 kCHF	28 pm



Conclusion



- The overall estimates are very preliminary, but it seems the ball park is 100 MCHF + 15 FTE · 10 y in order to have CC's ready to run in LHC by 2020
- Don't “use” these numbers but give us feedback to help us get a better estimate!
- The FP7 Design Study HiLumi-LHC covers only a small fraction (2.2 MCHF + 10 FTE · 4 y) – it does not even cover the “design study” part of the project.