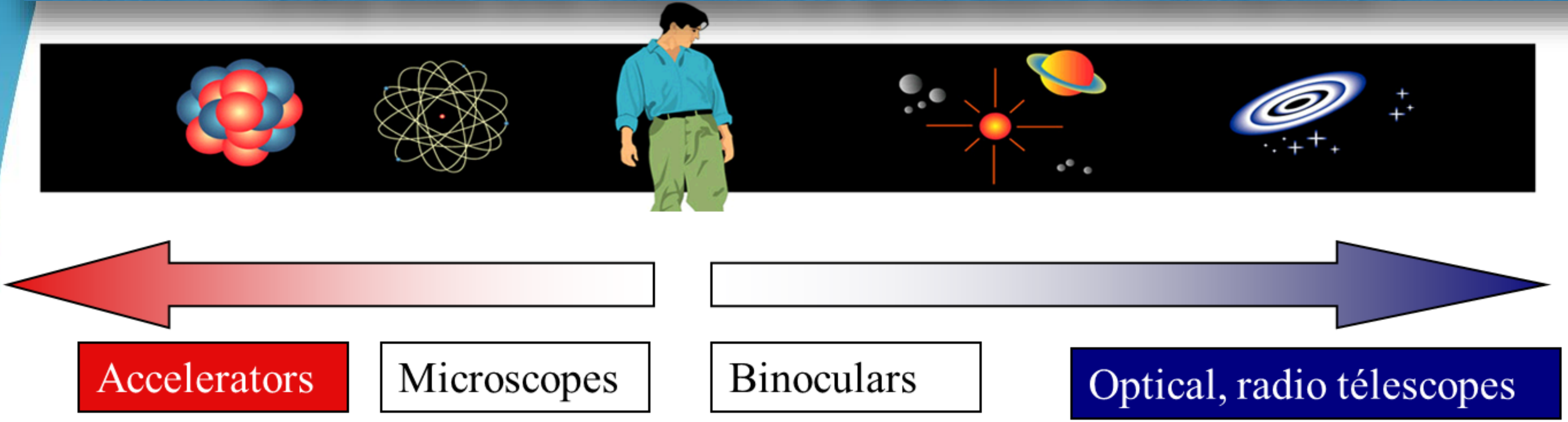
L’avventura del fisico tra scienza e tecnologia: LHC, l’upgrade ad Alta Luminosità e i futuri “magascience projects per acceleratori”

Lucio Rossi – CERN
HL-LHC Project Leader

Conf. Italiana Studenti di Fisica 2019 – unimi- dip di fisica – 8 Marzo 2019

Particle accelerators like generator of very fine light they use the «light», of quantum mechanics



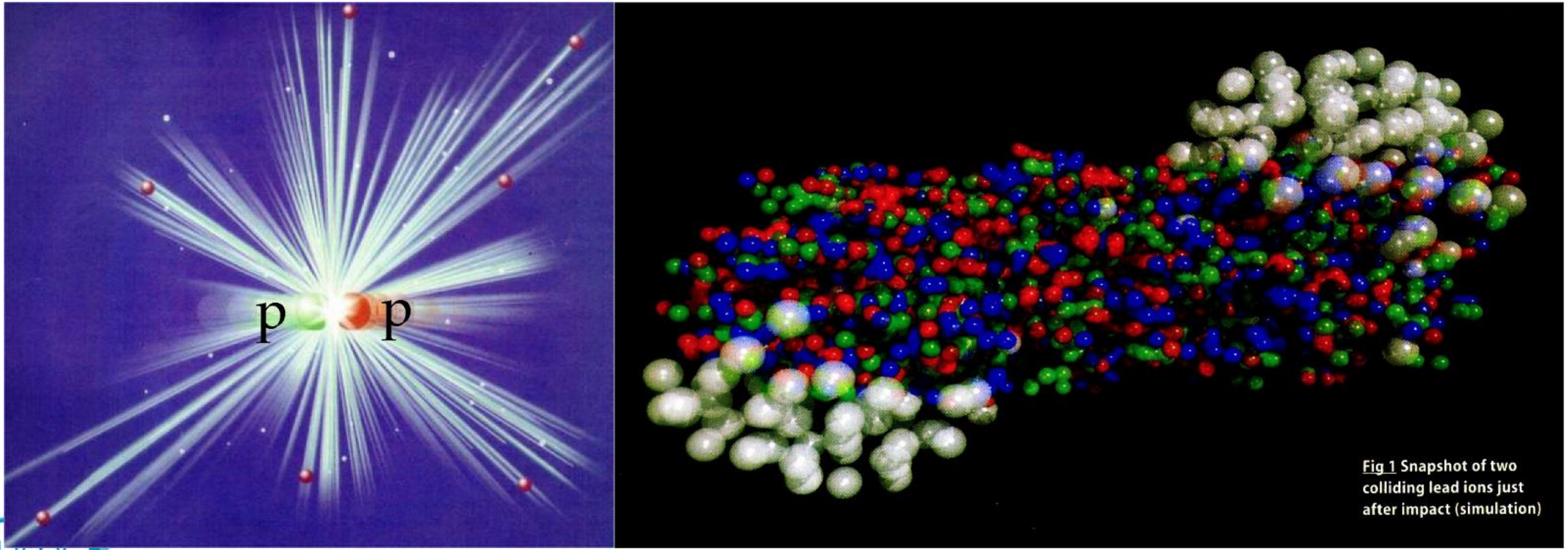
Particle physics looks at matter in its smallest dimensions and accelerators are very fine microscopes or, better, *atto-scopes!*

$\lambda = h/p$; @LHC: $T = 1$ TeV $\Rightarrow \lambda \cong 10^{-18}$ m

CERN AC - Z11 - V11/5/98

Accelerators also a wonderful «time macchines»

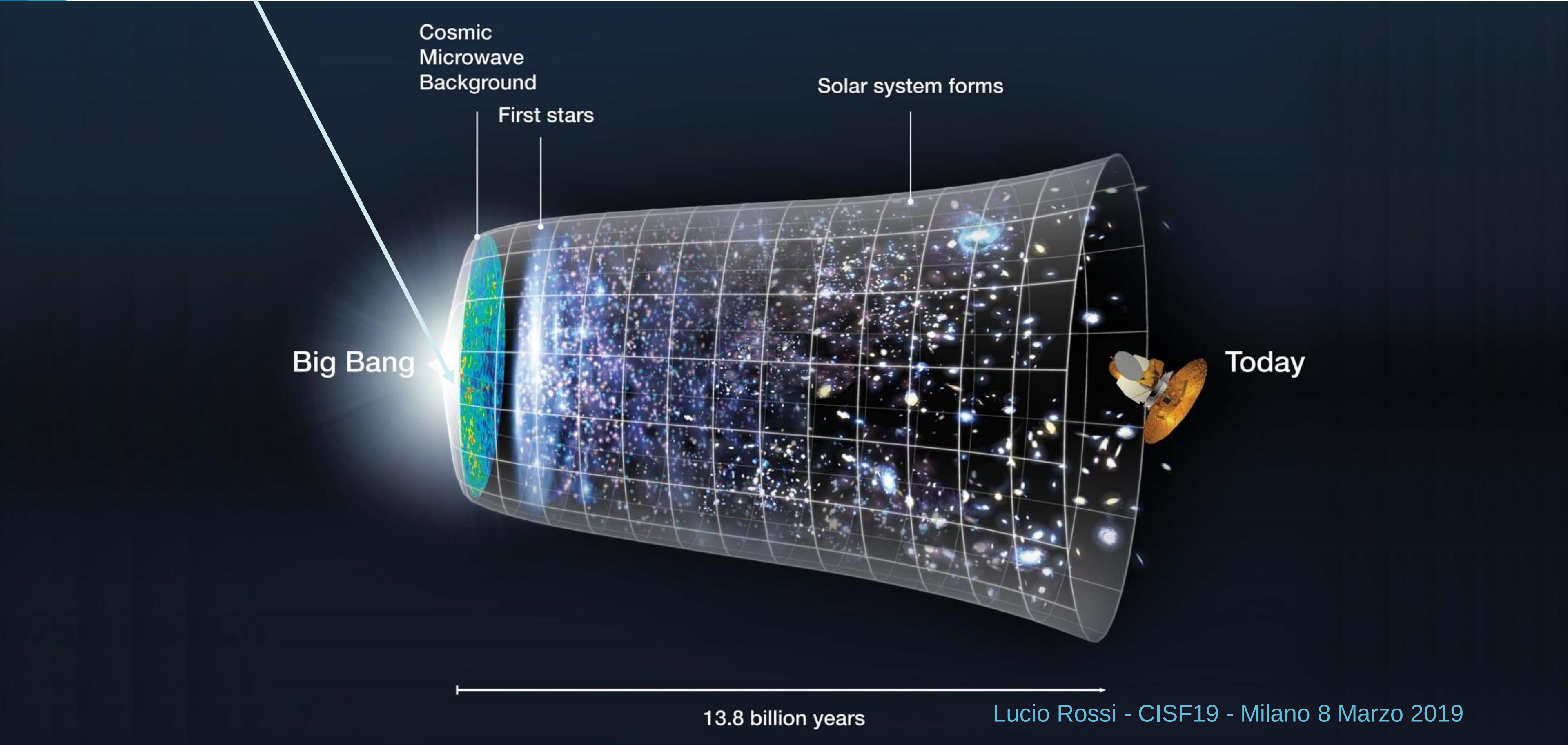
- Trip back toward the Big Bang: $t_{\mu s} \cong 1/E^2_{Gev}$
- $t \cong 1$ ps for single particle creation
- $t \cong 1$ μs for collective phenomena QGS (Quark-Gluon Soup)



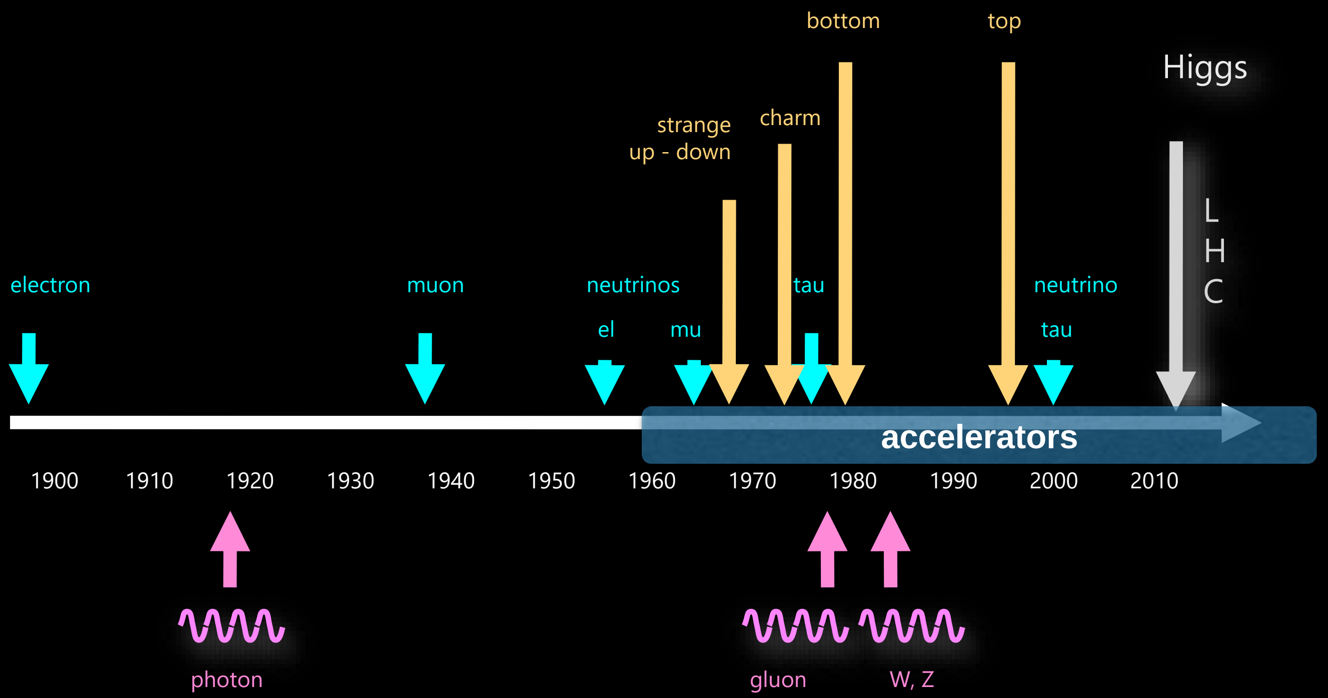
HiLumi HL-LHC PROJECT

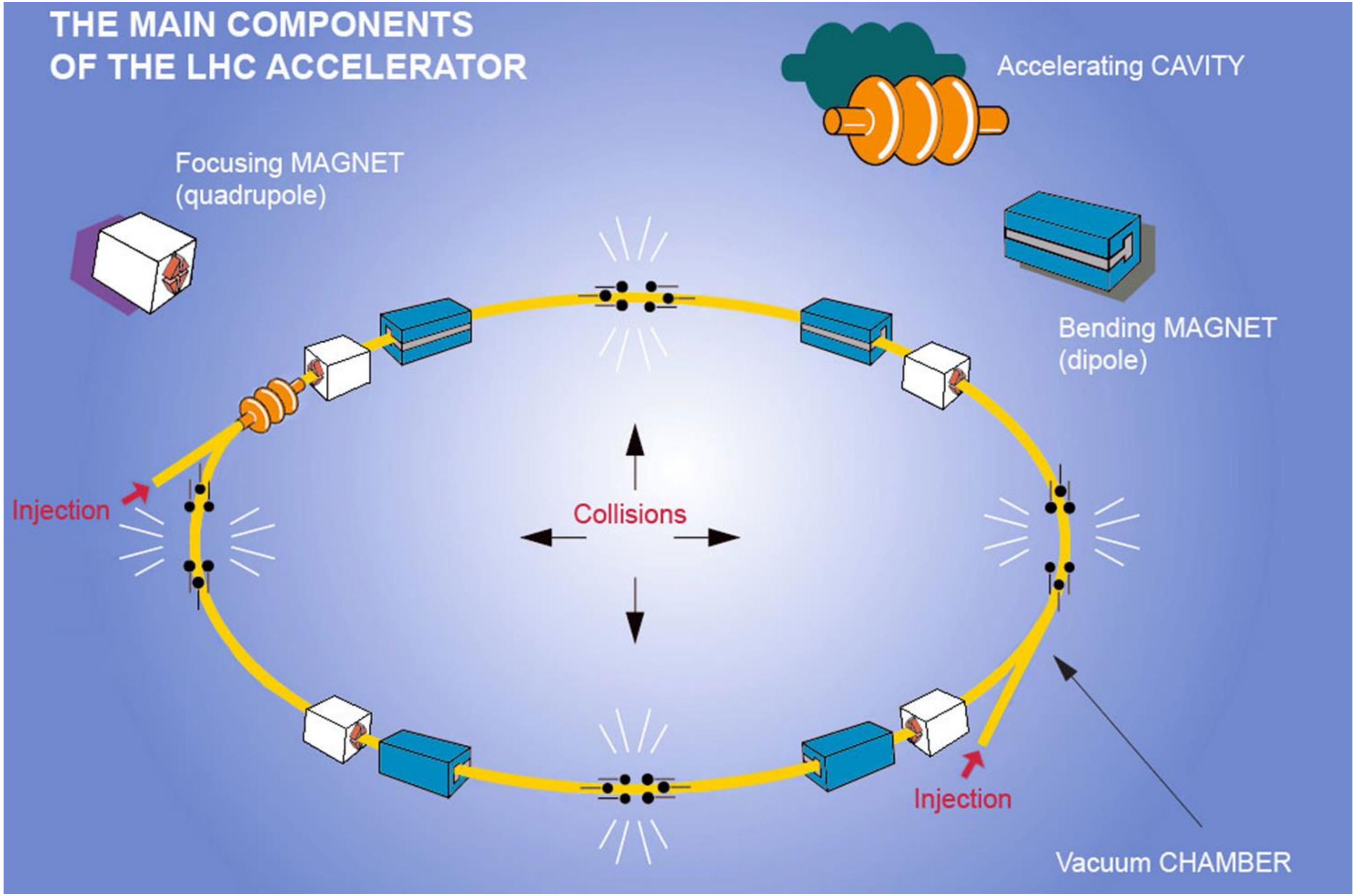
The Universe (and all particles within) is 13.8 billion years old

Particle physics reproduces the conditions of the Universe just after the Big Bang



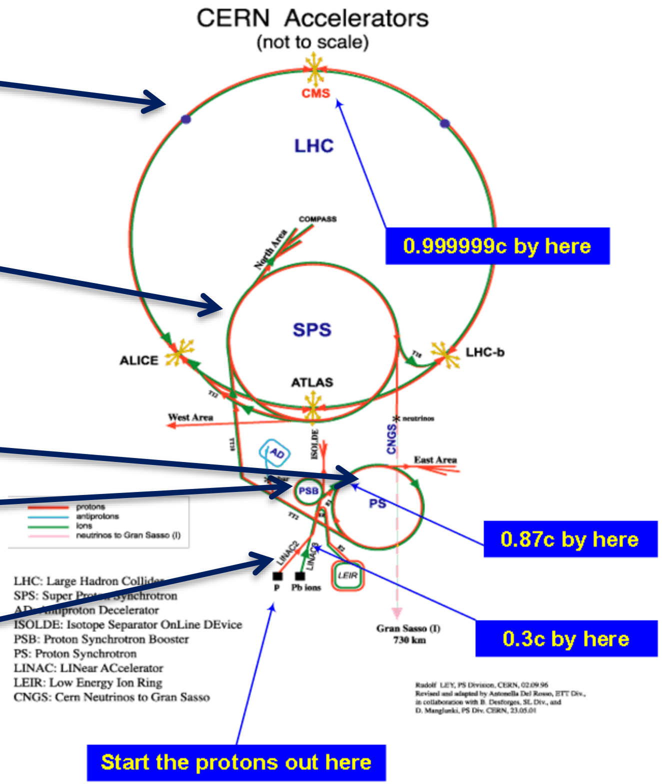
60 years of experiments at accelerators have discovered the set of fundamental particles




THE MAIN COMPONENTS
OF THE LHC ACCELERATOR
Accelerating CAVITY
Focusing MAGNET
(quadrupole)
Bending MAGNET
(dipole)
Injection
Collisions
Injection
Vacuum CHAMBER

CERN proton accelerator chain

- LHC : 2x(0.45 – 7) TeV
- SPS : 26 – 450 GeV
- PS : 1.4 - 26 GeV
- PSB : 0.05 -1.4 GeV
- Linac: 0-50 MeV



SOURCE and LINAC2

Duoplasmatron source

Linac2 : in evidence the accelerating RF structure

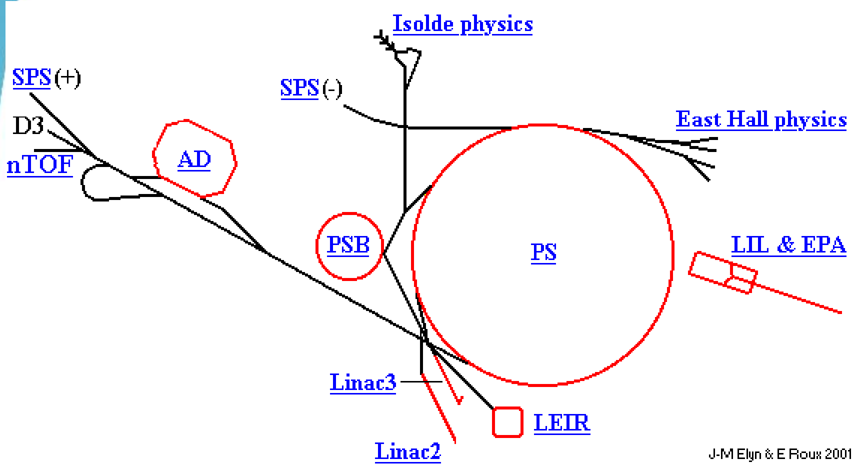
Upgrade : LINAC4 (2016, in use from 2020) H^- and 160 MeV

PSB (Booster): 1.4 GeV

Magnetic structure of PSB
Length : 150 m

Actually are four rings. Each beam is injected in the PS

The PS complex: injector for LHC and more…



HiLumi
HL-LHC PROJECT

SPS: 450 GeV proton beam
(in the 1980's worked as p-pbar)

SPS tunnel (almost 7 km)

SPS complex with experimental

CERN: founded in 1954: 12 European States

"Science for Peace"

Today: 22 Member States

- ~ 2500 staff
- ~ 1800 other paid personnel
- ~ 13000 scientific users

Budget (2017) ~ 1100 MCHF

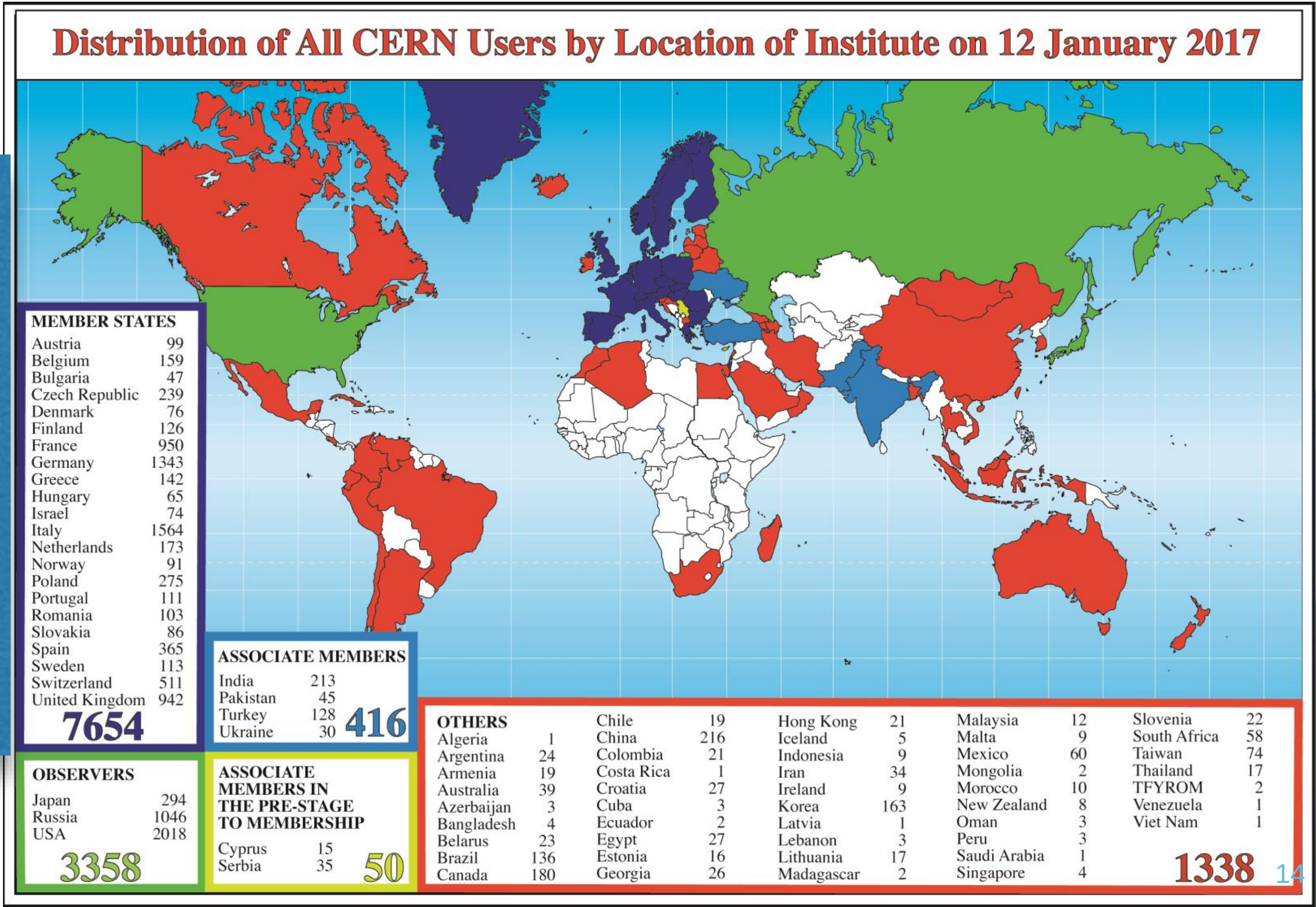
Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom

Associate Member States: India, Pakistan, Turkey, Ukraine

Associate Members in the Pre-Stage to Membership: Cyprus, Serbia

Applications for Membership or Associate Membership:
Brazil, Croatia, Lithuania, Russia, Slovenia

Science is getting more and more global
Note:
CERN is «largest US laboratory»
…



CERN & LHC

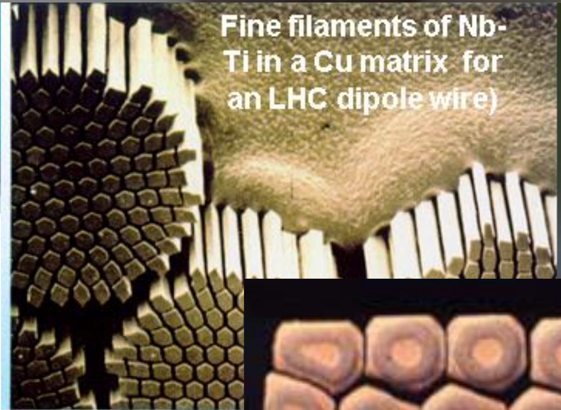
Superconducting LHC

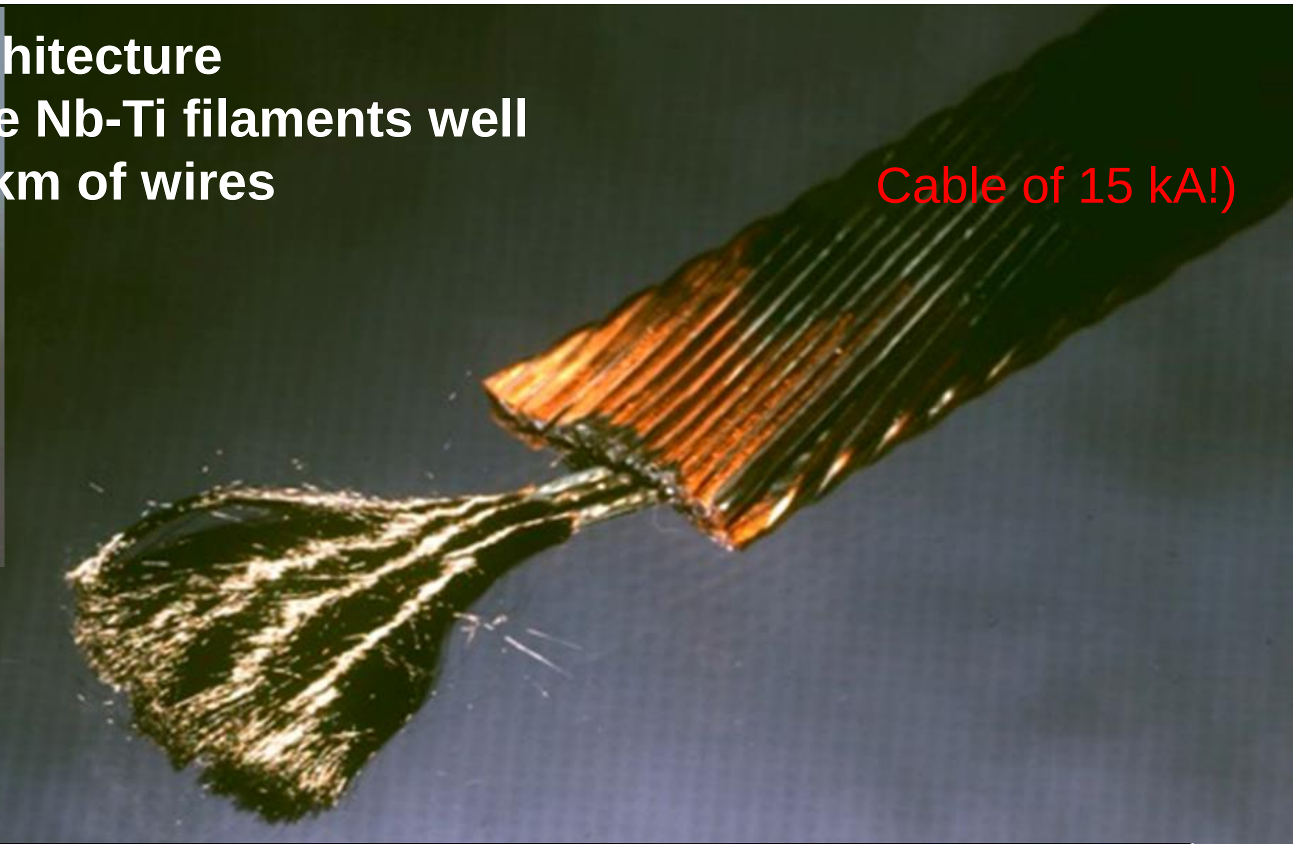
- Tunnel : 27 km
- Field : 8.3 T
- Cryoplant power at the plug: 40 MW: **always on**
- ~ 70 MW for LHC.
- 150 MW for the accelerator complex
- 180 for the whole CERN complex

Normalconducting LHC

- Tunnel 120 km
- Field : 1.8 T
- Dissipated power at collision: ~ 2,200 MW
- Average power (0.4 coefficient): 900 MW only for accelerator

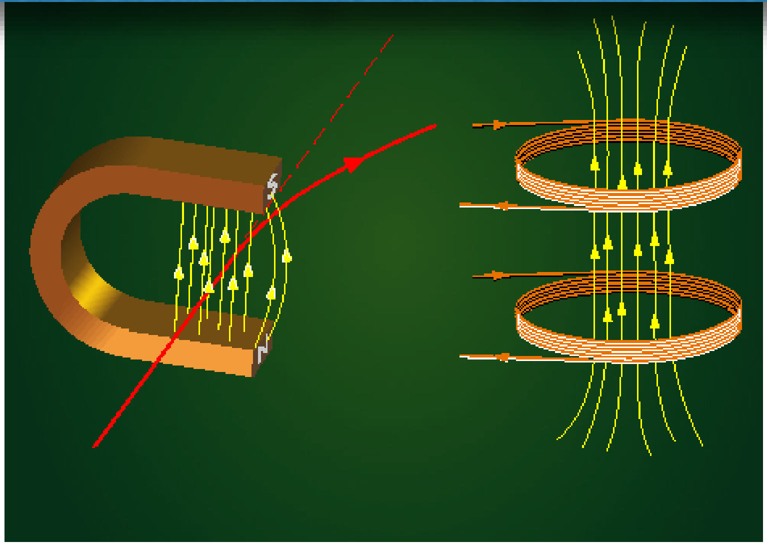
Very complex architecture
Thousands of fine Nb-Ti filaments well separated along km of wires

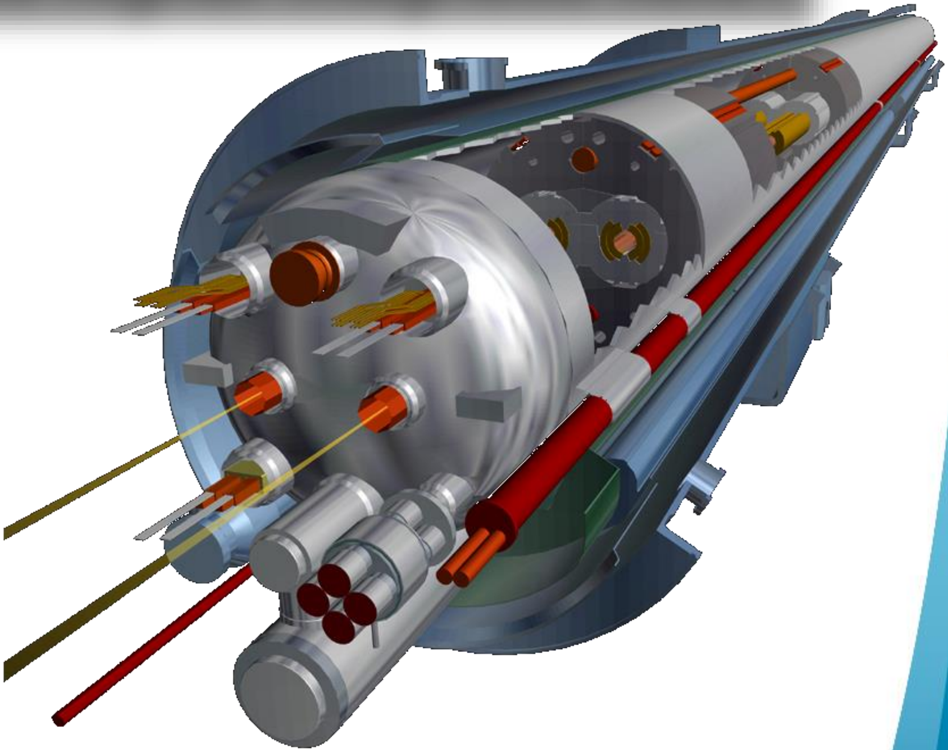




Cable of 15 kA!)

Why looking for higher and higher magnetic field?

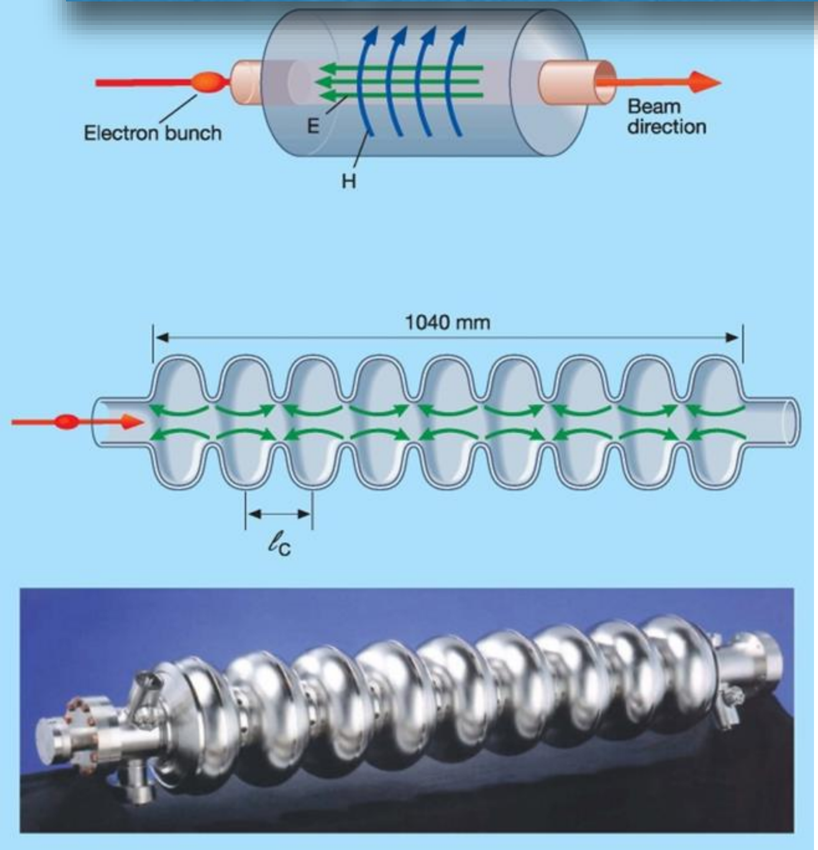




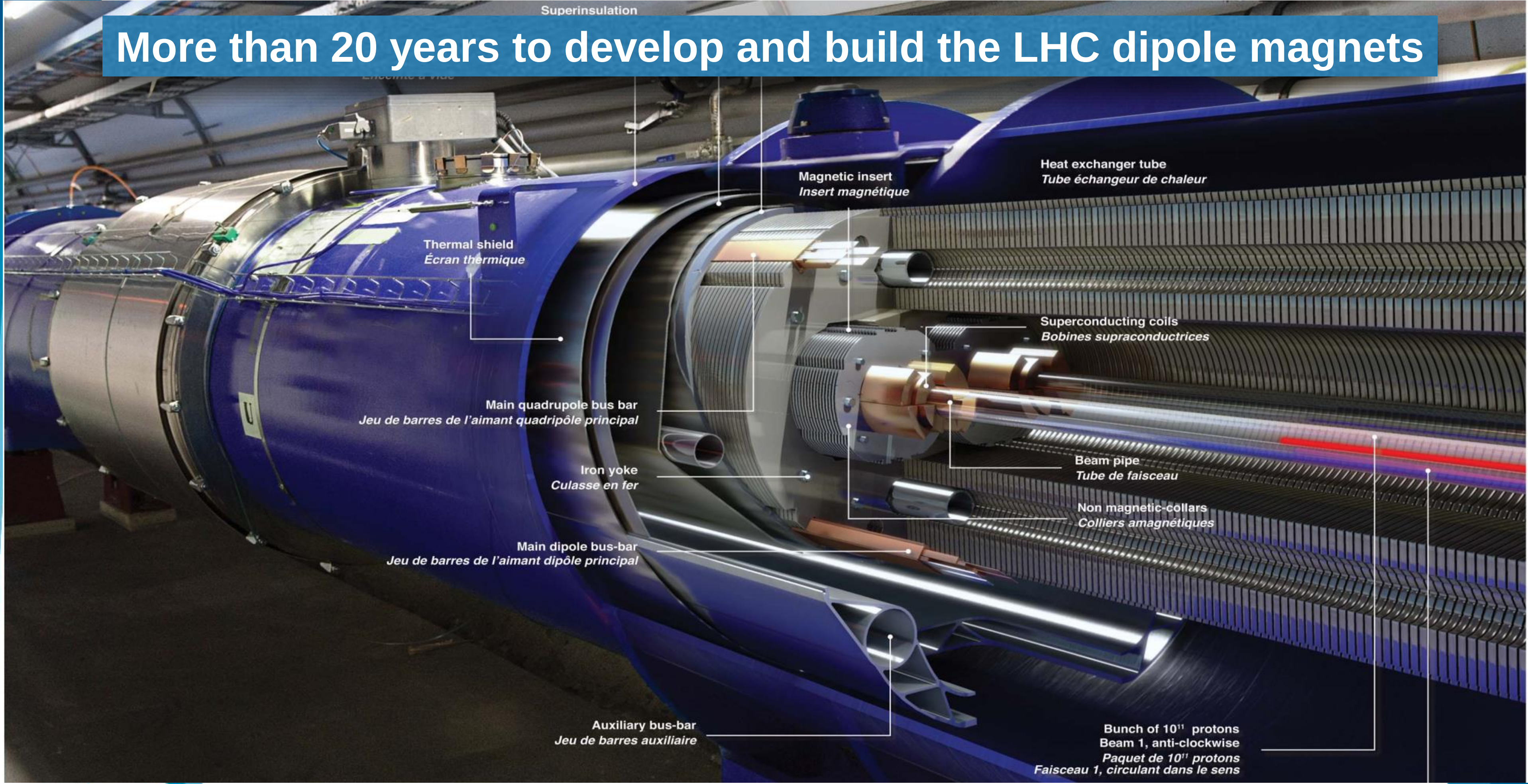
- <u>Circular Accelerators</u>

$$E_{beam} = 0.3 \; \boldsymbol{B} \; r \quad [GeV] \; [T] \; [m]$$

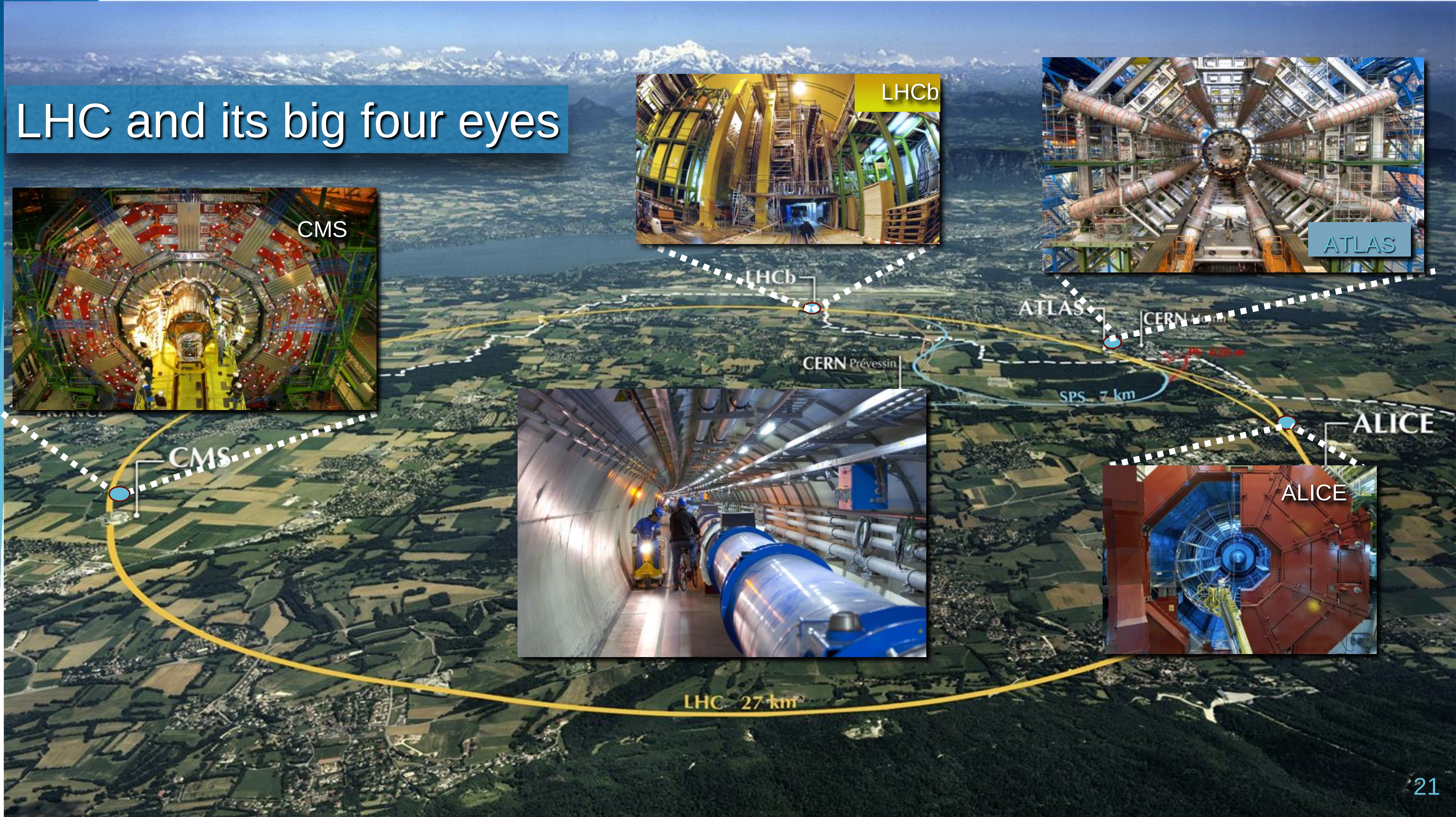
Superconductors (usually pure Niobum) are used to accelerate particles: electric fields in RF cavities

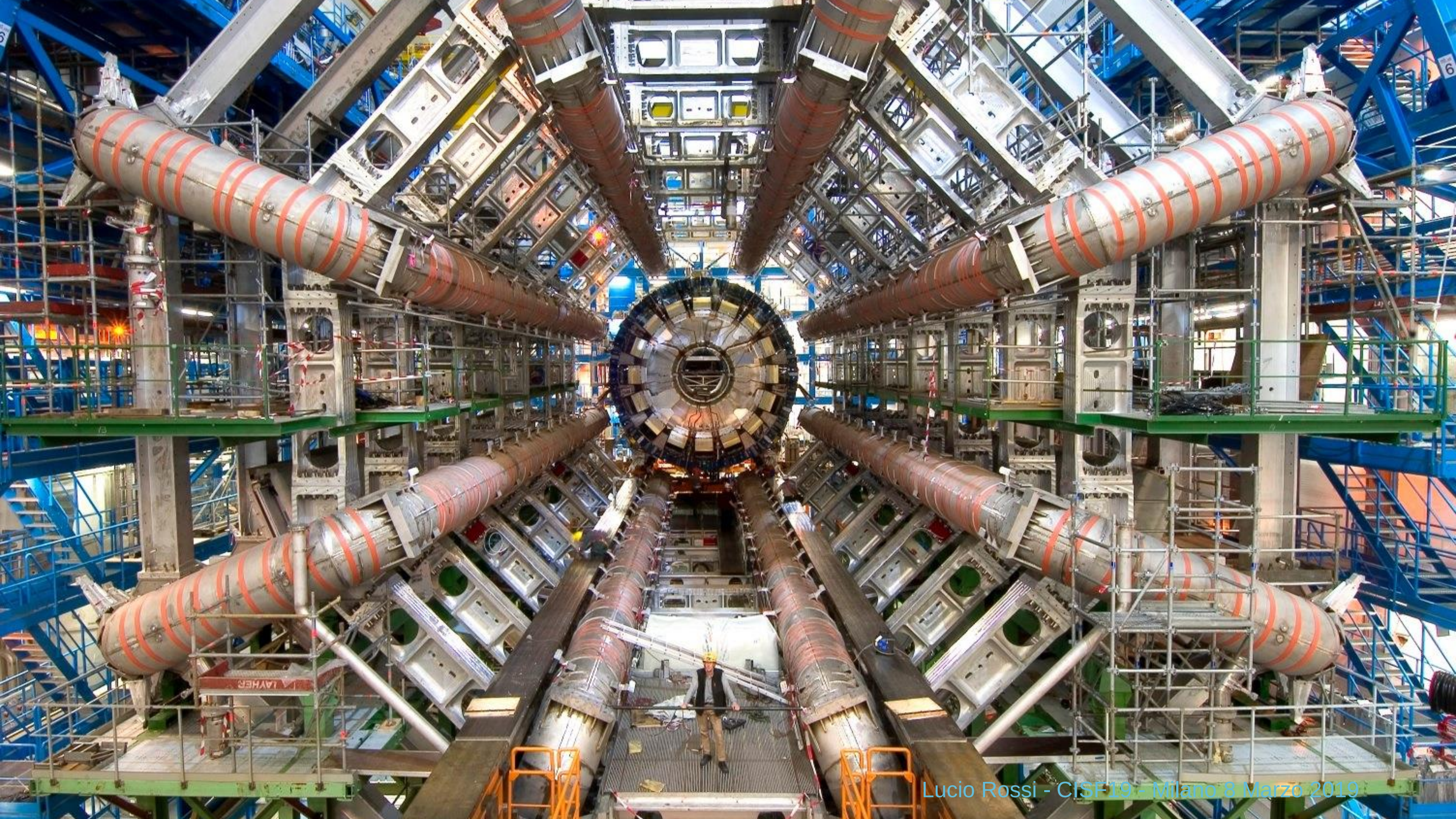


More than 20 years to develop and build the LHC dipole magnets

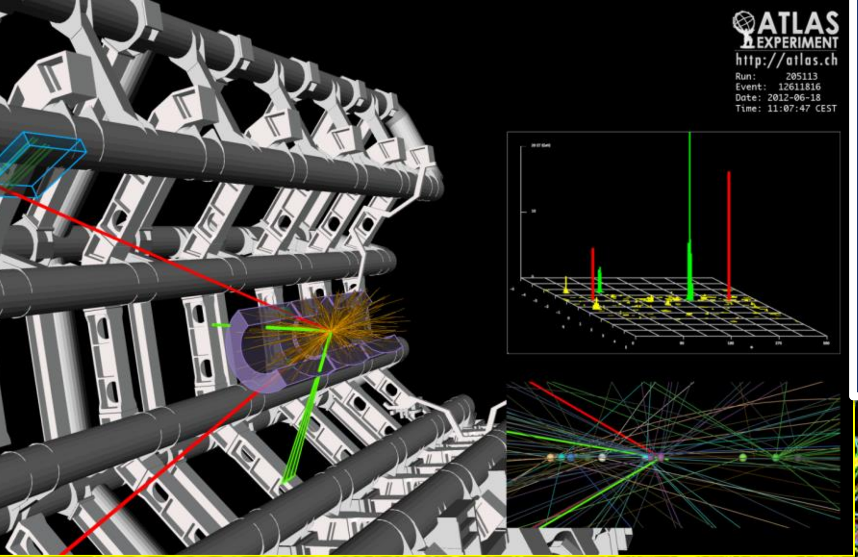


LHC and its big four eyes



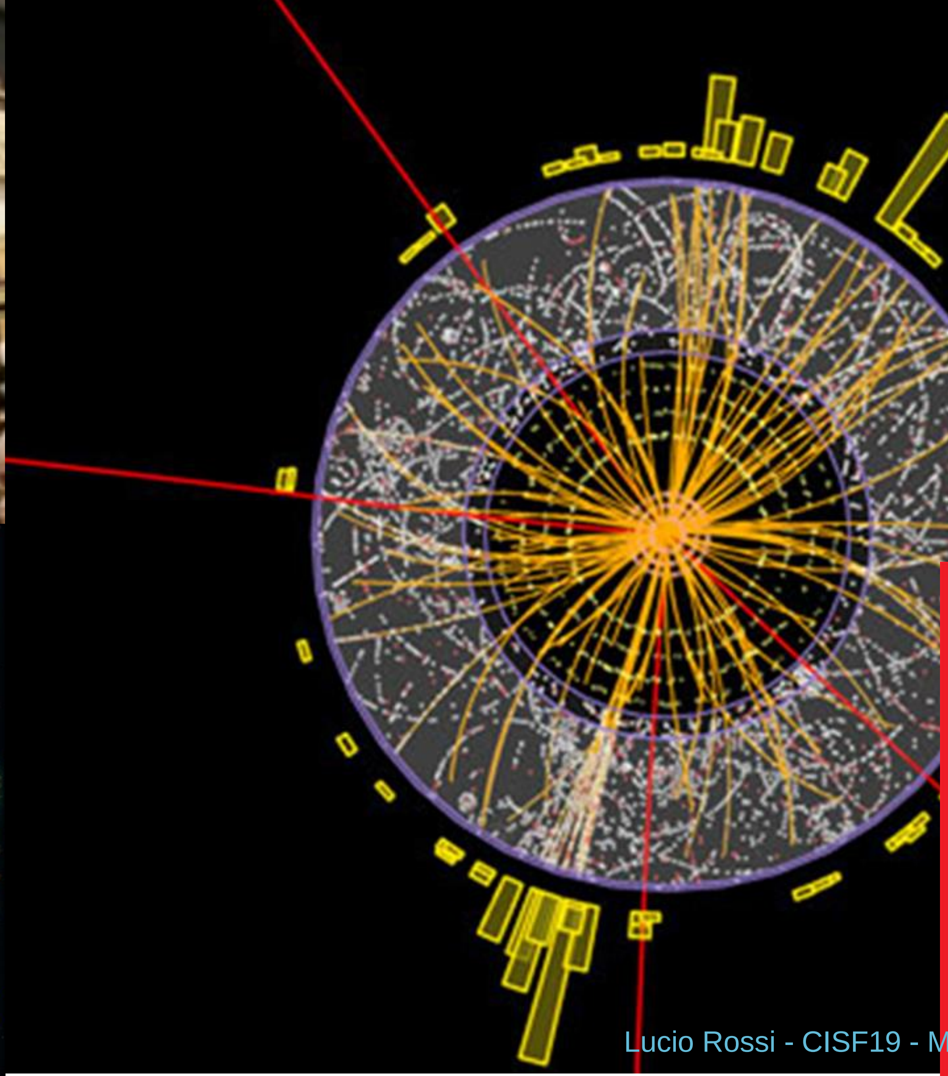


Beams collides 40 MHz
25-50 Pile up
⇒1-2 Billions collisions/s!
Only 1/10 Bil we “can see” a Higgs boson!
It si really searching for the needle in a haystack!



Z→ μμ event from 2012 data with 25 reconstructed vertices


The Economist
JULY 7TH–13TH 2012
Economist.com
In praise of charter schools
Britain's banking scandal spreads
Volkswagen overtakes the rest
A power struggle at the Vatican
When Lonesome George met Nora
A giant leap for science
Finding the Higgs boson



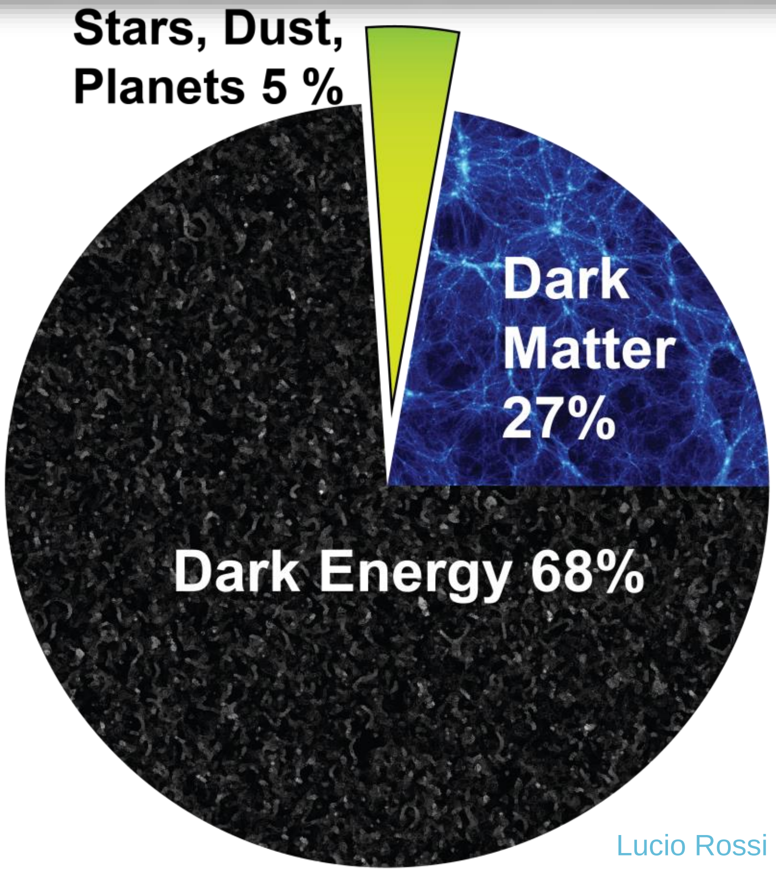

TIME
Nº5
PARTICLE PHYSICIST
FABIOLA GIANOTTI

Prof. Brout

Prof. Englert   Prof. Higgs

…for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles,
and which recently was confirmed **through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider**

So have we finished our quest? NO! Cosmology tells us that we still miss the most!



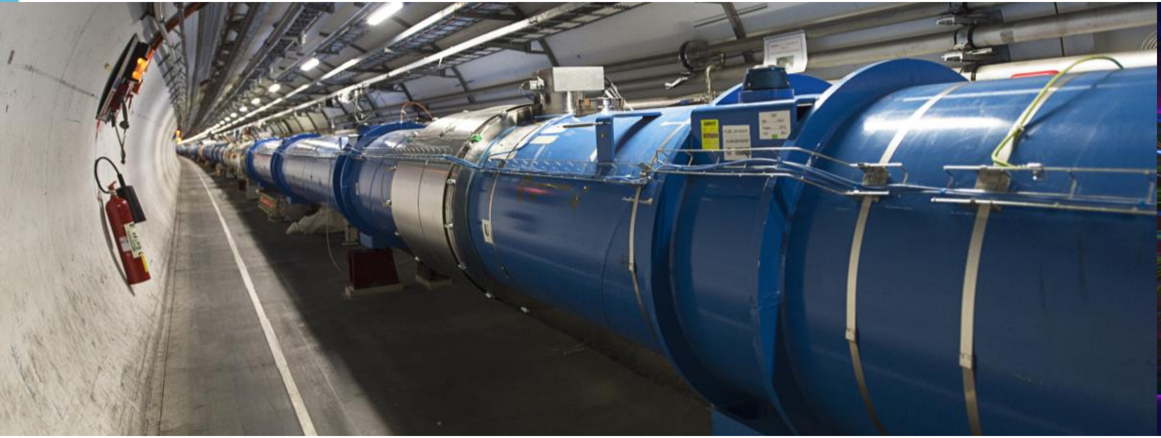
SUPERSYMMERTRY:
A Superworld ahead of us?

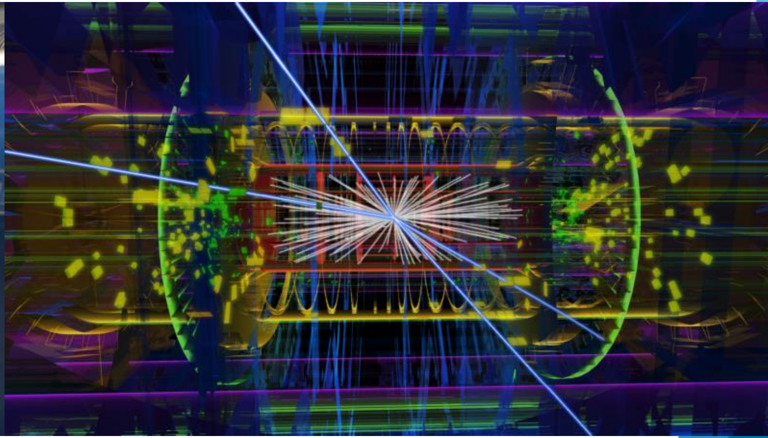
Sheding light on Dark Matter?
More light to see more…

How well works the LHC today?

LHC works very well.

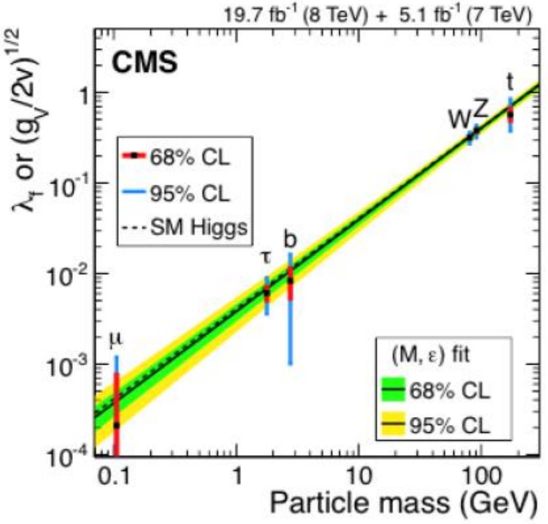
We arrived at 93% of the collision energy for what LHC has been designed for.
(Maybe we will reach 100% in 2021, see a few slides after this one)
And luminosity at peak is almost double than the design of the LHC (of course there were margins); while in integrated luminosity we are about 20% above our objectives.



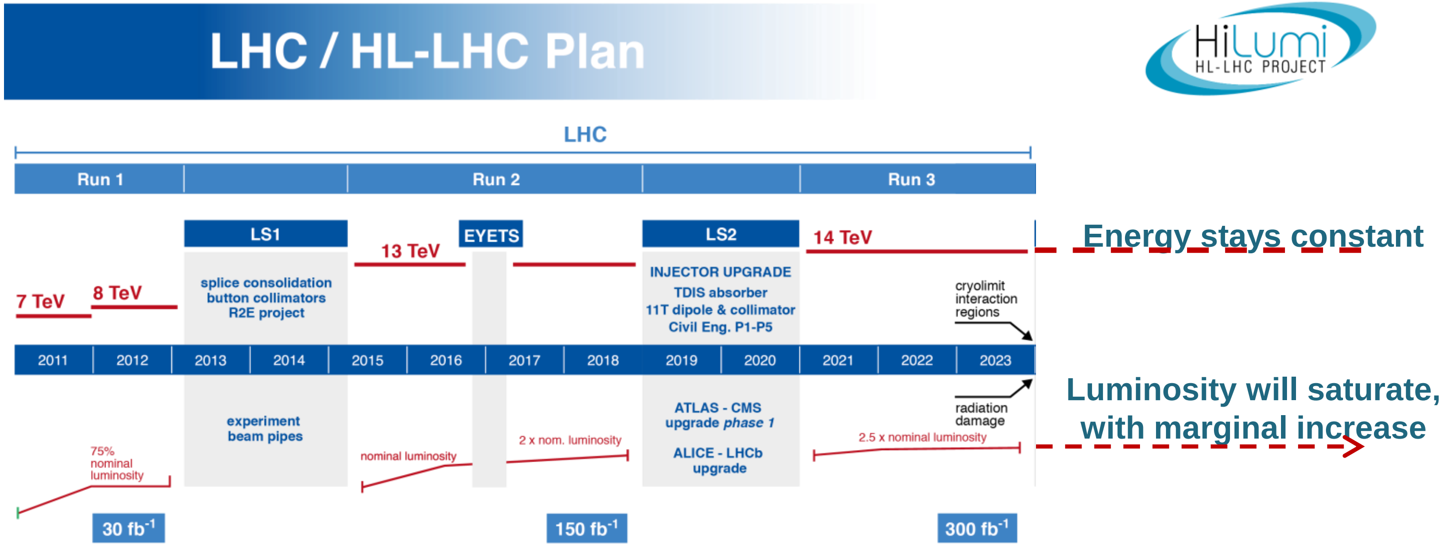


Evolution of energy and luminosity in LHC.

Energy stays constant



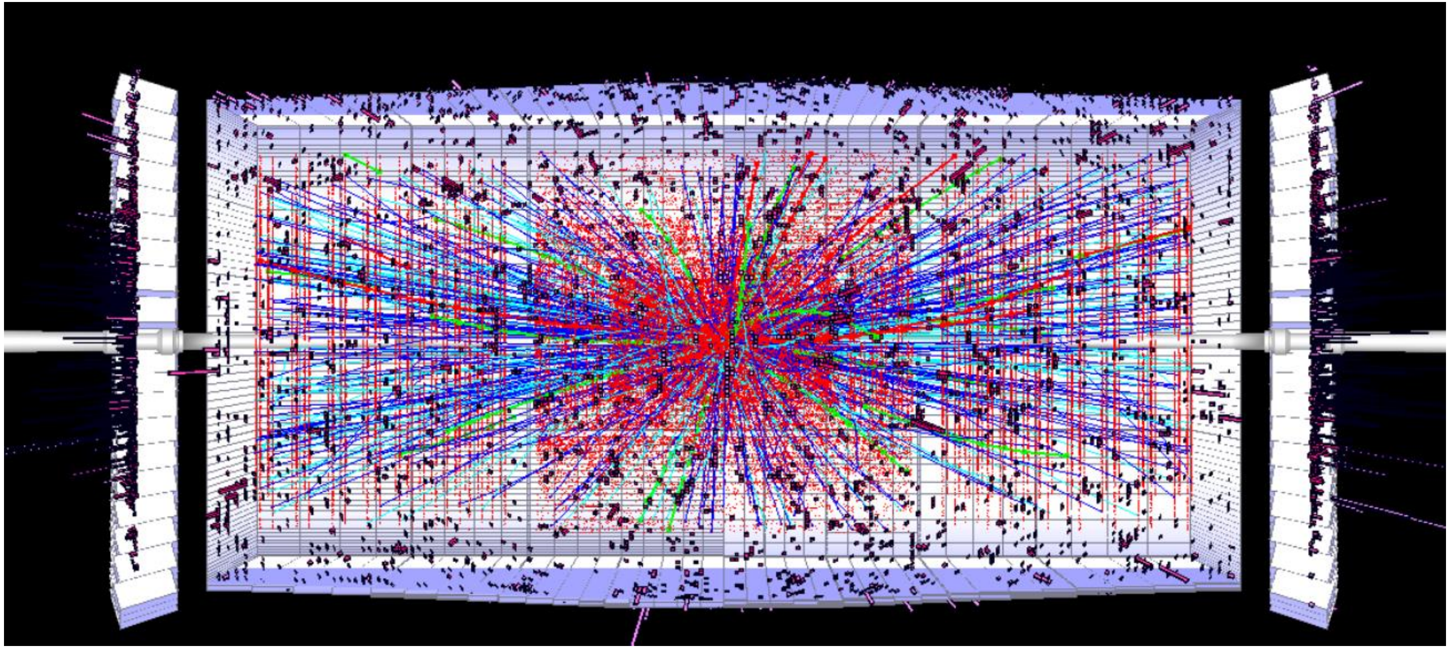
LHC will reach its limit around 2023



At about 2024 we will reach a few limitations (that we knew since the design time of the LHC).

- Radiation damage limit in the magnets near the experiments and inside the experiemnts (Inner Tracker especially)
- Cryogenic limit of the magnets near experiment, (IT quadrupoles), so we need to make different design to increase.
- Change triplets (and experiment IT) needs a very Long Studown → we «profit» to substantially increase **luminosity**

High Luminosity: a bright future for the LHC
Generate more light → machine upgrade
Better eyes to profit of higher luminosity → detector upgrade



Luminosity the main ingredients

$$\dot{N}_{evt} = L \times \sigma_{evt}\,;\, N_{evt} = \int L dt \times \sigma_{evt}$$

$$L_{int}$$

Beam current

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

energy

Beam size

Beam current and emittance: involve injection chain and whole ring
β^* involves «only» 2 IRs, 2x600 m

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

LHC has been designed for L_0 with margin
All systems have ~ designed to withstand $2L_0$ (to be achieved by increasing N_b x 1.5)

Luminosity the main ingredients

$$\dot{N}_{evt} = L \times \sigma_{evt} ; N_{evt} = \int L dt \times \sigma_{evt}$$

$$L_{int}$$

Beam current

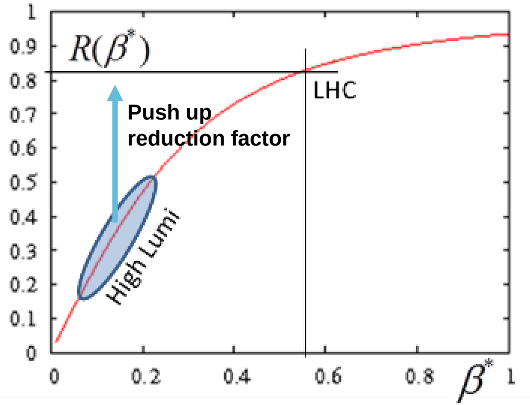
$$L = \gamma \frac{f_{rev}\, n_b\, N_b^2}{4\pi \varepsilon_n \beta^*} R$$

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

energy

Beam size

Beam current and emittance: involve injection chain and whole ring
β* involves «only» 2 IRs, 2x600 m



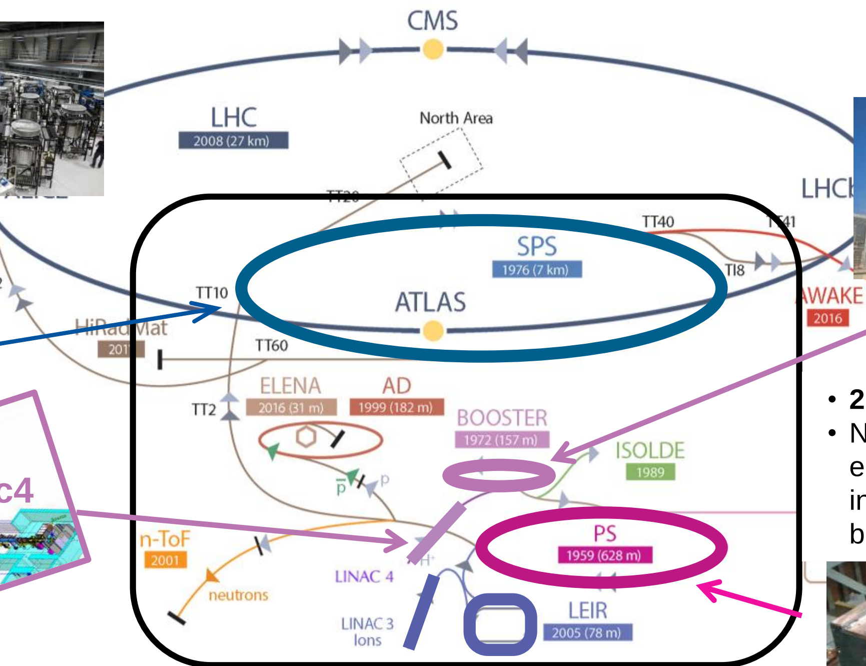
$$L_0 = 1 \cdot 10^{34}\ cm^{-2}s^{-1}$$

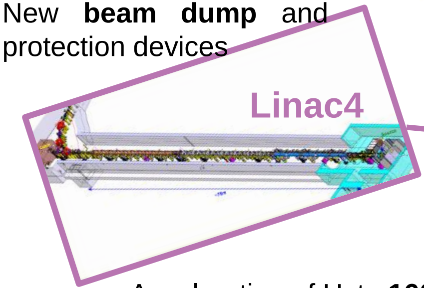
L_0 is the nominal desing lumi of LHC
LHC has been designed for L_0 with margin
All systems have ~ designed to withstand $2L_0$ (to be achieved by increasing N_b x 1.5)

HiLumi HL-LHC PROJECT

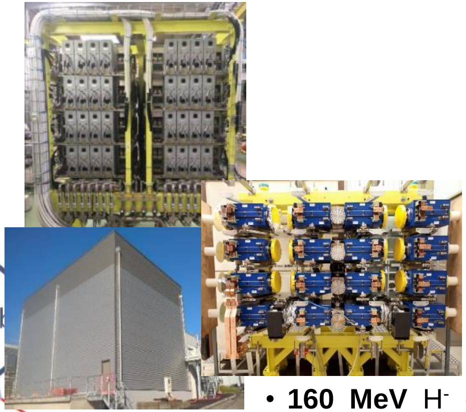
Goals of the LHC Injectors Upgrade project
Doubling protons & high brightness

- Main **RF** system (200 MHz) upgrade
- Longitudinal **impedance** reduction & partial a-C coating
- New **beam dump** and protection devices

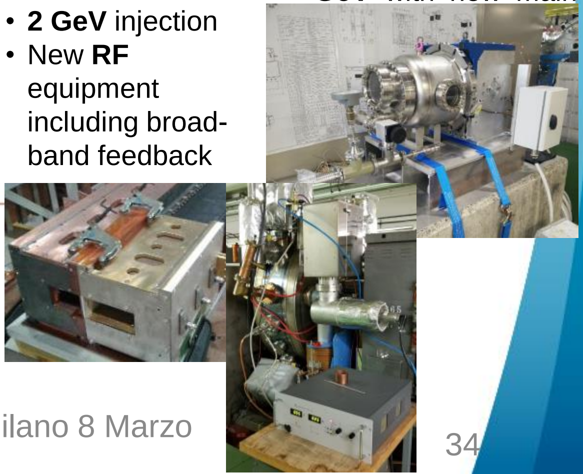




- Acceleration of H$^-$ to **160 MeV**
- Nominal 40 mA within 0.4 μm, Run 3 target 25 mA within 0.3 μm

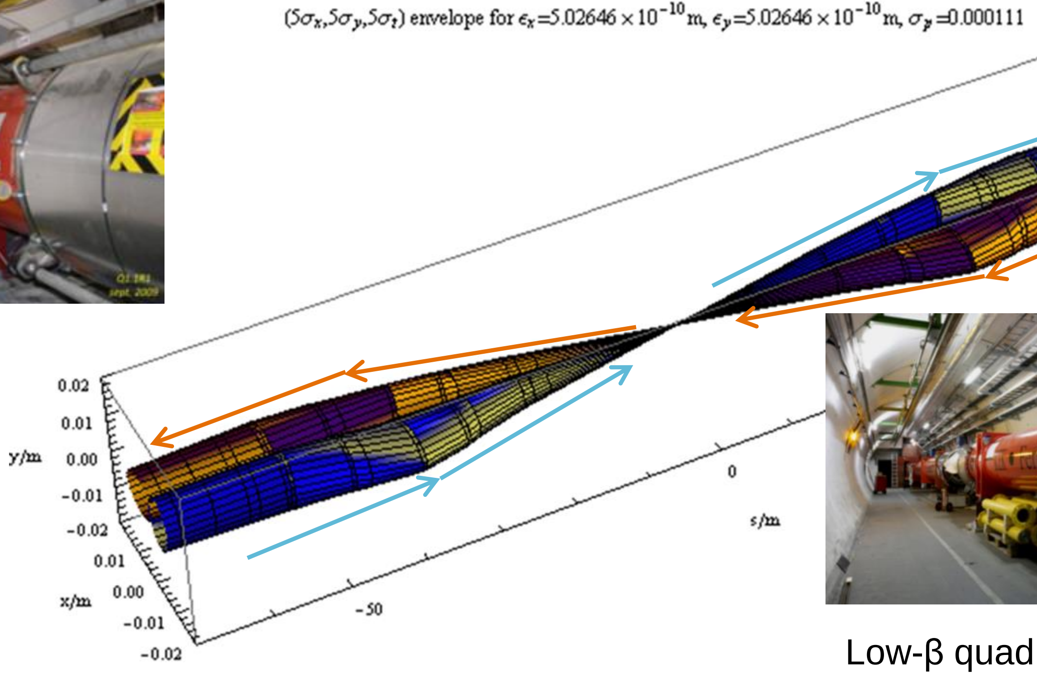


- **160 MeV** H$^-$ charge exchange injection
- Acceleration to **2 GeV** with new main



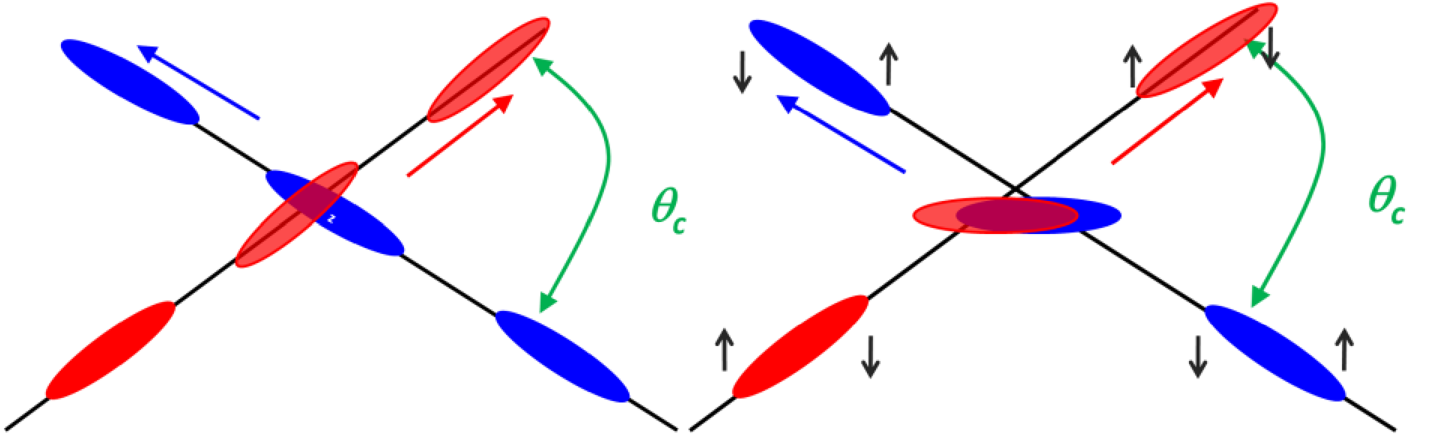
- **2 GeV** injection
- New **RF** equipment including broad-band feedback

Beam envelope scales as 1/√β* at IPs
HL → Reduce β* by a factor four



Low-β quadrupole triplet

Effect of the crab cavities: fs time accuracy!



- **RF crab cavity deflects head and tail in opposite direction so that collision is effectively "head on" and then luminosity is maximized**
- ***Crab cavity maximizes the lumi and can be used also for luminosity levelling: if the lumi is too high, initially you don't use it, so lumi is reduced by the geometrical factor. Then they are slowly turned on to compensate the proton burning***

EC-FP7 funded *HiLumi* design study 2011-15
5 ME from EU; 15 ME from CERN, 30 ME total

High Luminosity LHC

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

CAPACITIES

Short Name	Country	Logo
CERN	Geneva Switzerland	
CEA	Saclay France	
DESY	Hamburg Germany	
INFN	Frascati Italy	
CSIC	Madrid Spain	
EPFL	Lausanne Switzerland	
SOTON	Southampton United Kingdom	
RHUL	London United Kingdom	

Short Name	Country	Logo
STFC*	Daresbury United Kingdom	
ULANC*	Lancaster United Kingdom	
UNILIV*	Liverpool United Kingdom	
UNIMAN*	Manchester United Kingdom	
HUD	Huddersfield United Kingdom	
KEK	Tsukuba Japan	
BINP	Novosibirsk Russia	

*Members of Cockcroft Institute

HiLumi HL-LHC PROJECT

Goal of HL-LHC as fixed in 2010

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_{peak} = **5×10^{34} $cm^{-2}s^{-1}$ with levelling**, allowing:

An integrated luminosity of **250 fb^{-1} per year**, enabling the goal of **L_{int} = 3000 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.

Ultimate performance established 2015-2016: with same hardware and same beam parameters: use of **engineering margins:**

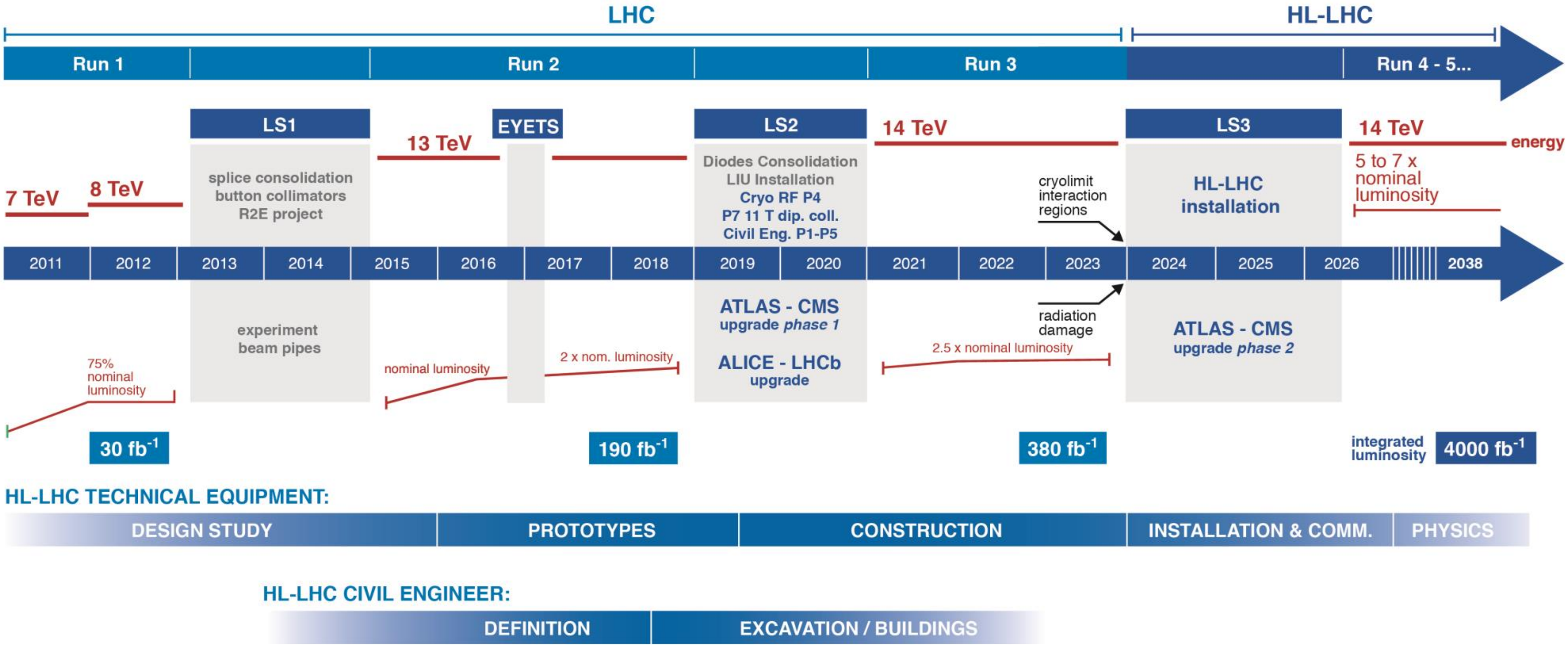
$L_{peak\ ult} \cong 7.5\ 10^{34}\ cm^{-2}s^{-1}$ and **Ultimate Integrated $L_{int\ ult} \sim 4000\ fb^{-1}$**

LHC should not be the limit, would Physics require more…

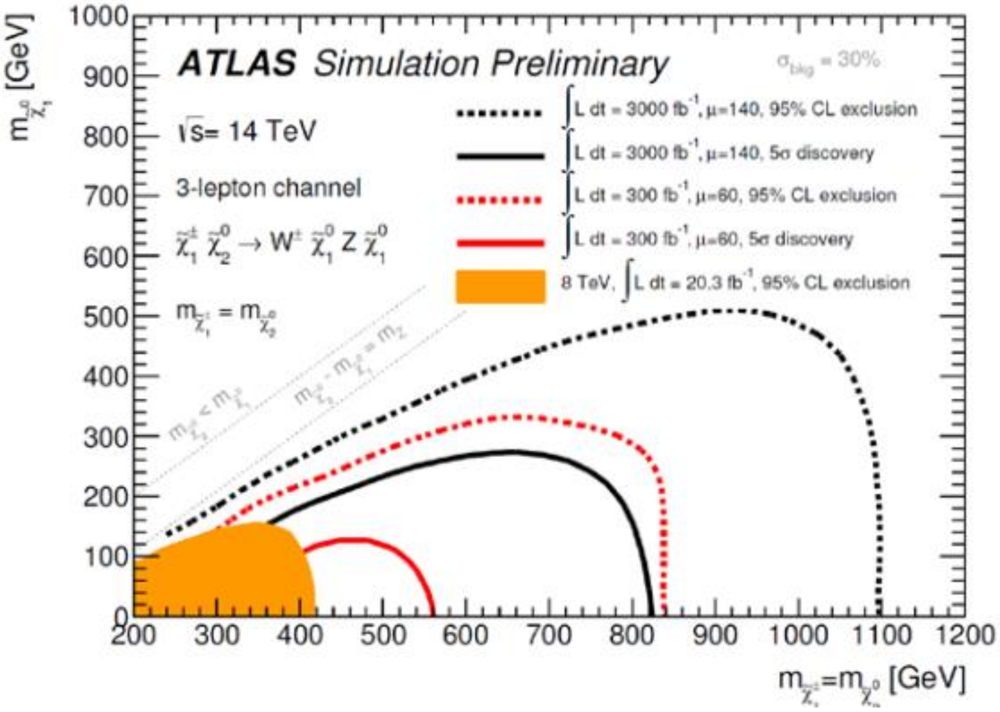
Project approved by CERN Council in June 2016

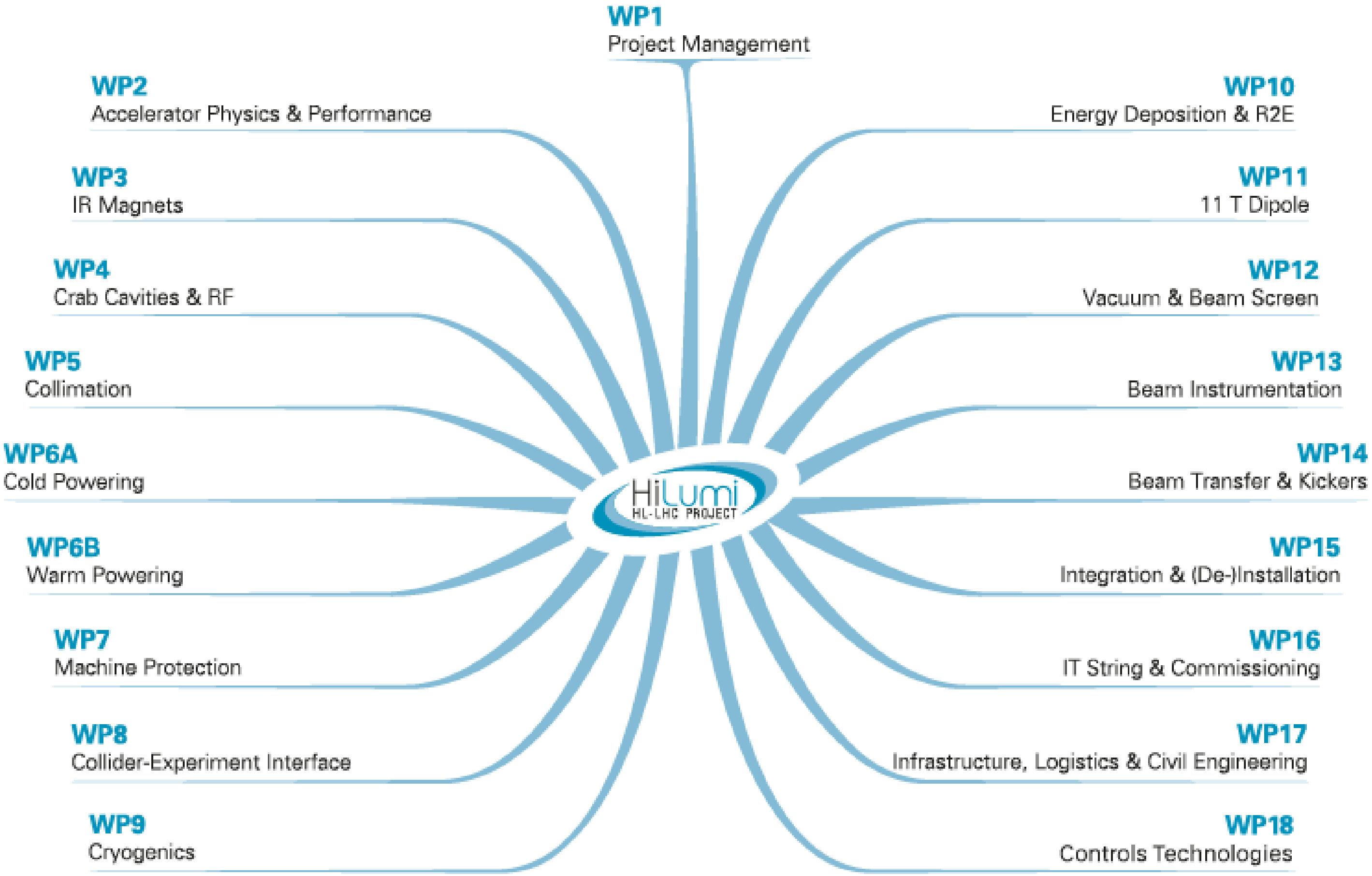
HiLumi HL-LHC PROJECT

LHC / HL-LHC Plan



Example of Physics reach in HL-LHC : direct production of chargino-neutralino pairs




WP1
Project Management
WP2
Accelerator Physics & Performance
WP3
IR Magnets
WP4
Crab Cavities & RF
WP5
Collimation
WP6A
Cold Powering
WP6B
Warm Powering
WP7
Machine Protection
WP8
Collider-Experiment Interface
WP9
Cryogenics
WP10
Energy Deposition & R2E
WP11
11 T Dipole
WP12
Vacuum & Beam Screen
WP13
Beam Instrumentation
WP14
Beam Transfer & Kickers
WP15
Integration & (De-)Installation
WP16
IT String & Commissioning
WP17
Infrastructure, Logistics & Civil Engineering
WP18
Controls Technologies
HiLumi
HL-LHC PROJECT

High Luminosity LHC Project

MEMBER STATES COLLABORATIONS[1]

IR Magnets
CEA Saclay: P. Védrine, L. Quettier, H. Felice
CIEMAT Madrid: J-M. Perez, F. Toral
INFN: A. Zoccoli[2], M. Sorbi[3], P. Fabbricatore[4]

Uppsala University: T. Ekelöf (**Magnets & Crab Cavities Testing**)

UK: R. Appleby[5] (Spokesperson & **Collimation**), G. Burt[6] (**Crab Cavities**), S. Gibson[7] (**Beam Instr.**), Y. Yang[8] (**Cold Powering**)

HL-LHC PROJECT MANAGEMENT

Project Leader: Lucio Rossi, CERN
Deputy Project Leader: Oliver Brüning, CERN
Project Office Manager: Laurent Tavian, CERN
Configuration, QA, Resource Manager: Isabel Bejar Alonso, CERN
Integration: Paolo Fessia & Michele Modena, CERN
Collaborations (in-kind): Beniamino Di Girolamo, CERN
Budget Officer: Benoit Delille, CERN
Safety Officers: Thomas Otto & Christelle Gaignant, CERN
Communication: Isabel Bejar Alonso, CERN
Secretariat: Cécile Noels & Céline Le Bon, CERN

NON MEMBER STATES COLLABORATIONS[1]

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Deputy Project Manager: R. Carcagno, FNAL
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G. Ambrosio, FNAL
Crab Cavities System
A. Ratti, LBNL, L. Ristori, FNAL

KEK - Japan
LHC Upgrade Coordinator: K. Tokushuku
SC D1 Magnet: T. Nakamoto

Work Packages

WP2 Accelerator Physics
Gianluigi Arduini
Rogelio Tomas Garcia

WP3 IR Magnets
Ezio Todesco
Paolo Ferracin

WP4 Crab Cavities & RF
Rama Calaga
Ofelia Capatina

WP5 Collimation
Stefano Redaelli
Roderik Bruce

WP6A Cold Powering
Amalia Ballarino
Vittorio Parma

WP6B Warm Powering
Michele Martino
Jean-Paul Burnet

WP7 Machine Protection
Daniel Wollman
Reiner Denz

WP8 Collider-Experiment Interface
Helmut Burkhardt – F. Sanchez Galan
Sébastien Evrard

WP9 Cryogenics
Serge Claudet
Rob Van Weelderen

WP10 Energy Deposition & R2E
Markus Brugger – Francesco Cerutti

WP11 11 T Dipole
Frédéric Savary
Hervé Prin

WP12 Vacuum
Vincent Baglin
Germana Riddone

WP13 Beam Instrumentation
Rhodri Jones
Thibaut Lefevre

WP14 Beam Transfer
Chiara Bracco
Brennan Goddard

WP15 Integration & (De-)Installation
Paolo Fessia
Michele Modena

WP16 IT String & Commissioning
Marta Bajko – Mirko Pojer

WP17 Infrastructure & Logistics
Laurent Tavian
Beniamino Di Girolamo

WP18 Controls Technologies
Javier Serrano
Eugenia Hatziangeli

[1] In kind contributions
[2] INFN Directorate
[3] INFN Milano LASA
[4] INFN Genova

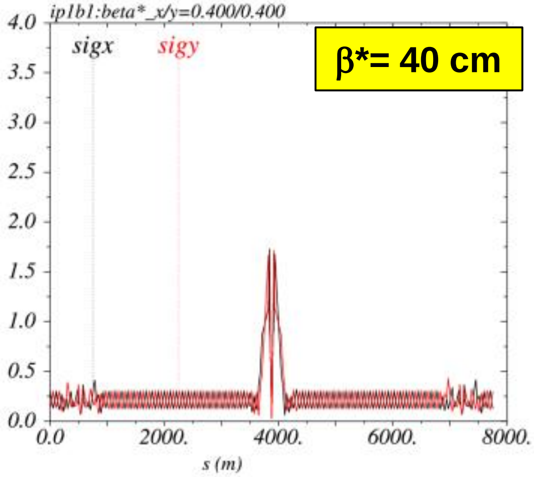
[5] University of Manchester/Cockcroft Institute
[6] Lancaster University/Cockcroft Institute
[7] Royal Holloway/John Adams Institute
[8] University of Southampton
[9] US HL-LHC Accelerator Upgrade Project

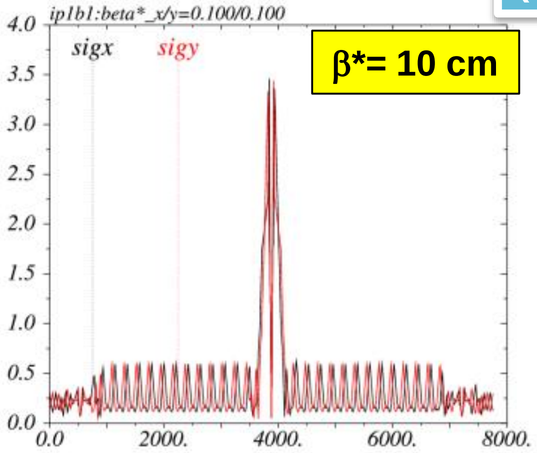
LHC is already much optimized: many accelerator physics challenge: The Achromatic Telescopic Squeezing (ATS) scheme

Small β* is limited by aperture but not only: optics matching & flexibility (round and flat optics), chromatic effects…

A novel optics scheme was developed to reach un-precedent β^* w/o chromatic limit based on a kind of generalized squeeze involving 50% of the ring

(S. Fartoukh)

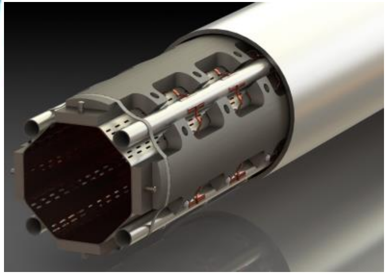


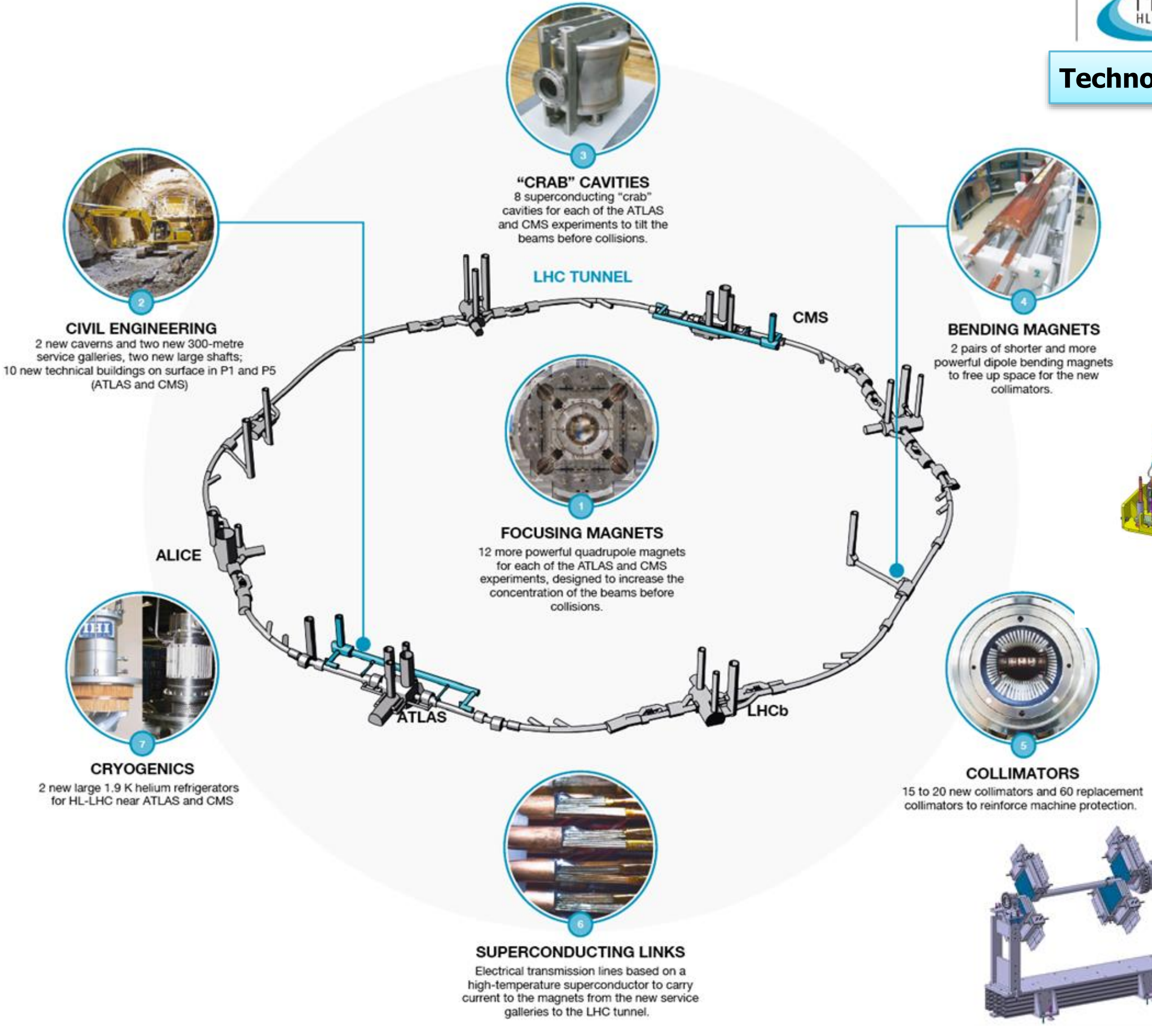


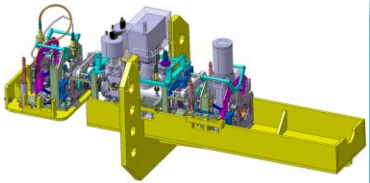
The new IR is sort of 8 km long !

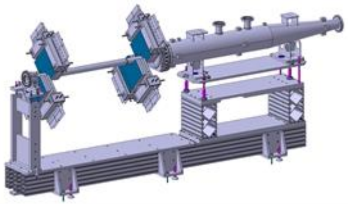
Dealing with pushed particle beam physics, linear and non-linear optics and collective effects: a big challenge for "pushed electromagnetism"

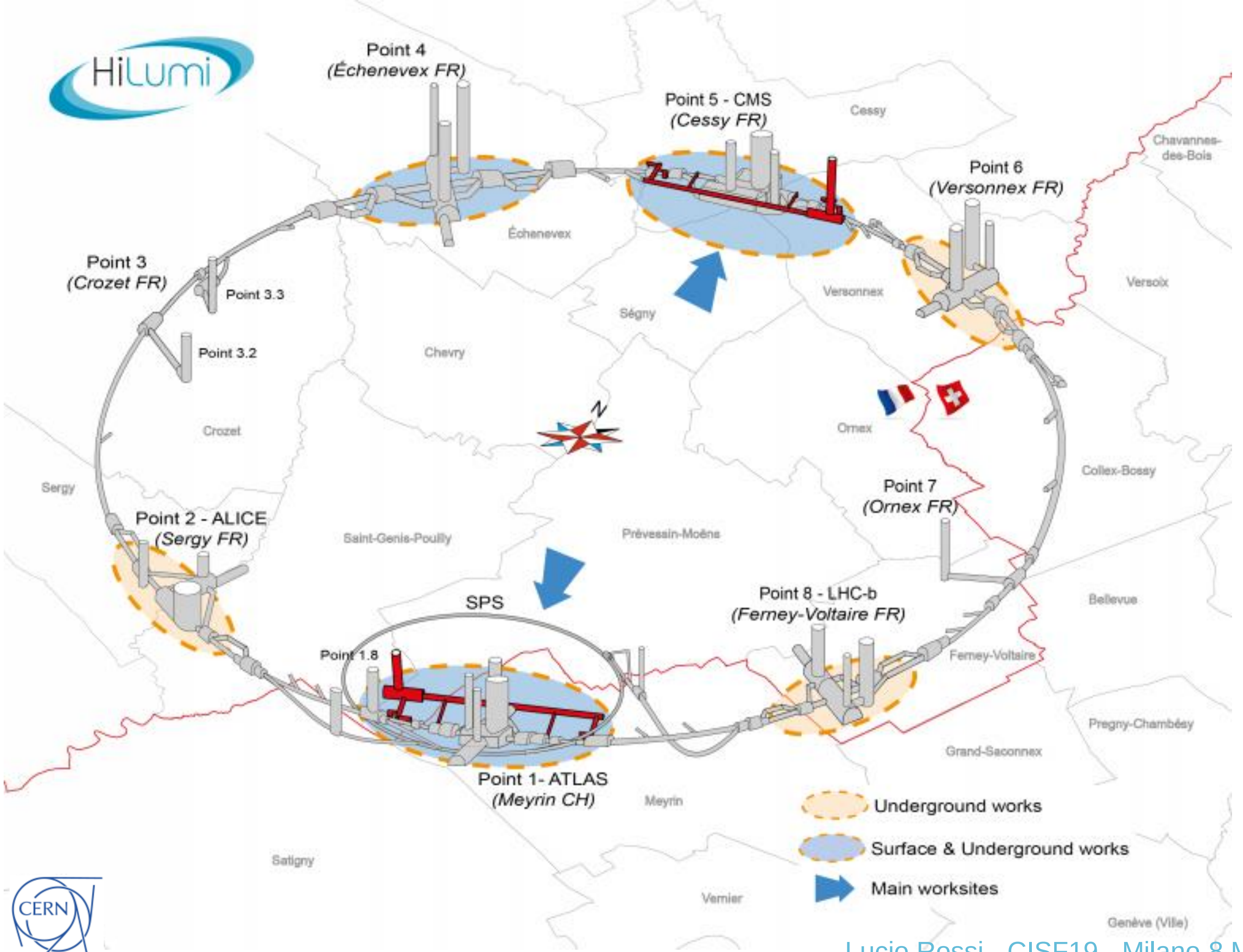
Technology landmarks



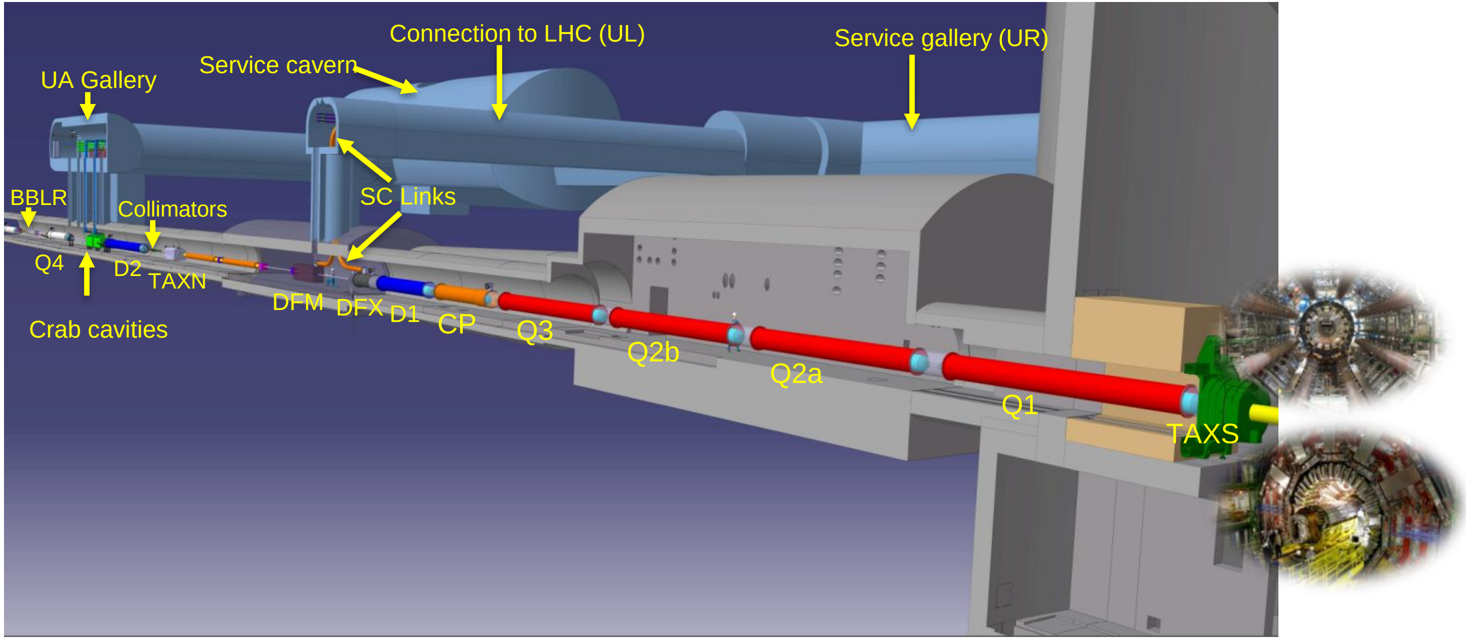






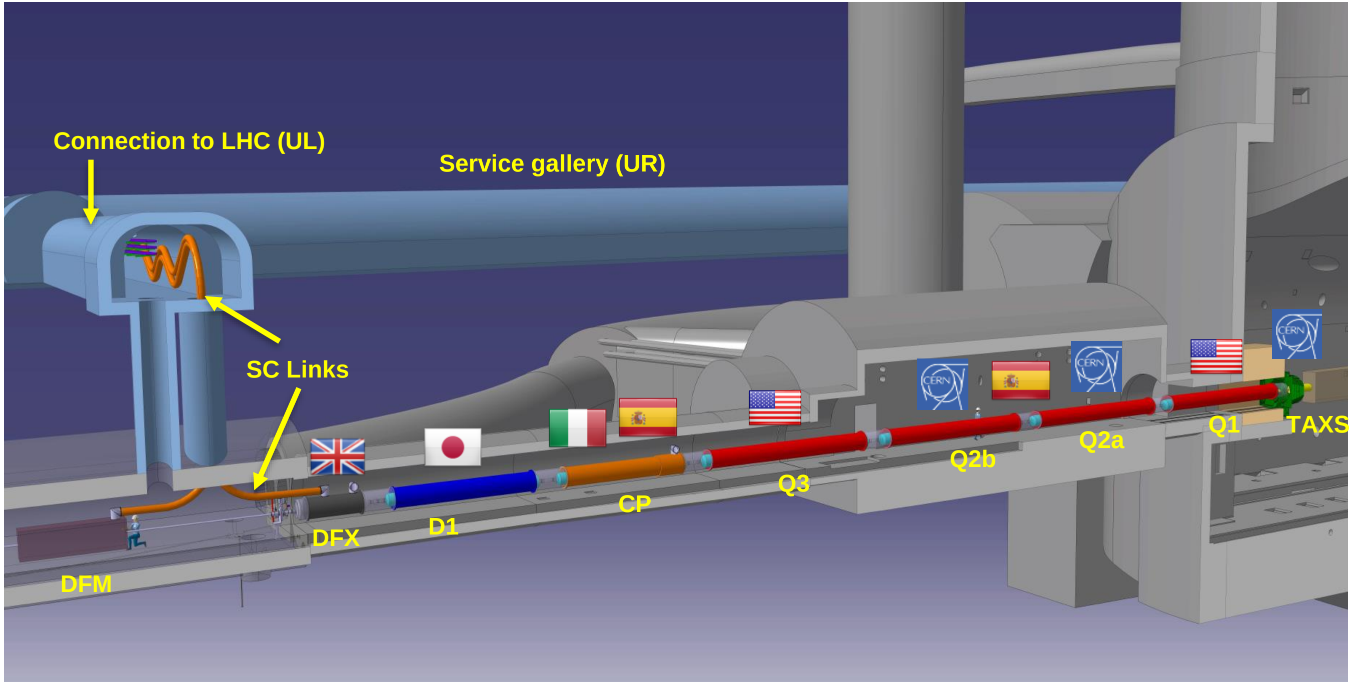

Point 4
(Échenevex FR)
Point 5 - CMS
(Cessy FR)
Cessy
Chavannes-des-Bois
Point 6
(Versonnex FR)
Échenevex
Point 3
(Crozet FR)
Point 3.3
Point 3.2
Ségny
Versonnex
Versoix
Chevry
Crozet
N
Ornex
Collex-Bossy
Sergy
Point 7
(Ornex FR)
Point 2 - ALICE
(Sergy FR)
Saint-Genis-Pouilly
Prévessin-Moëns
SPS
Point 8 - LHC-b
(Ferney-Voltaire FR)
Bellevue
Point 1.8
Ferney-Voltaire
Pregny-Chambésy
Grand-Saconnex
Point 1- ATLAS
(Meyrin CH)
Meyrin
Underground works
Surface & Underground works
Main worksites
Satigny
Vernier
Genève (Ville)

The Insertion Region (till Q4)

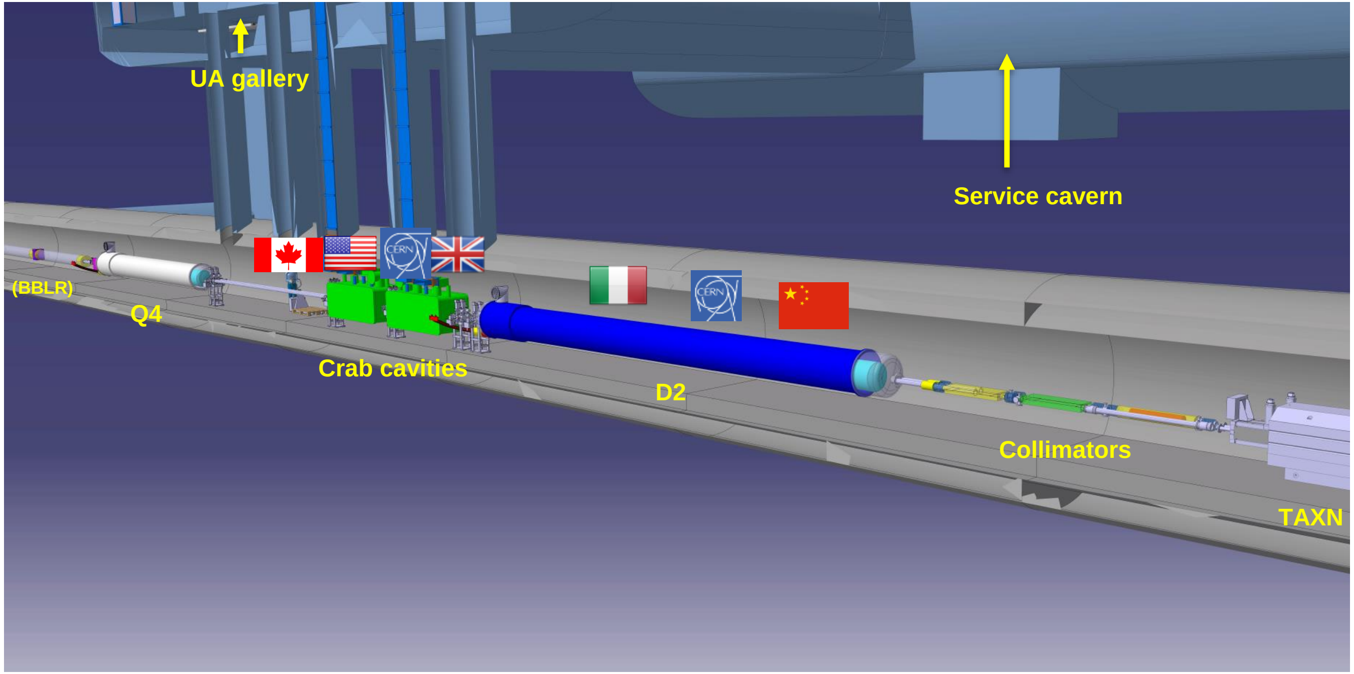


In total about 1.2 km of the LHC will be replaced by new technologies!
Biggest HEP project of this decade, but it has a reasonable size (25-30% of the LHC) to be a test-bed for new technologies…

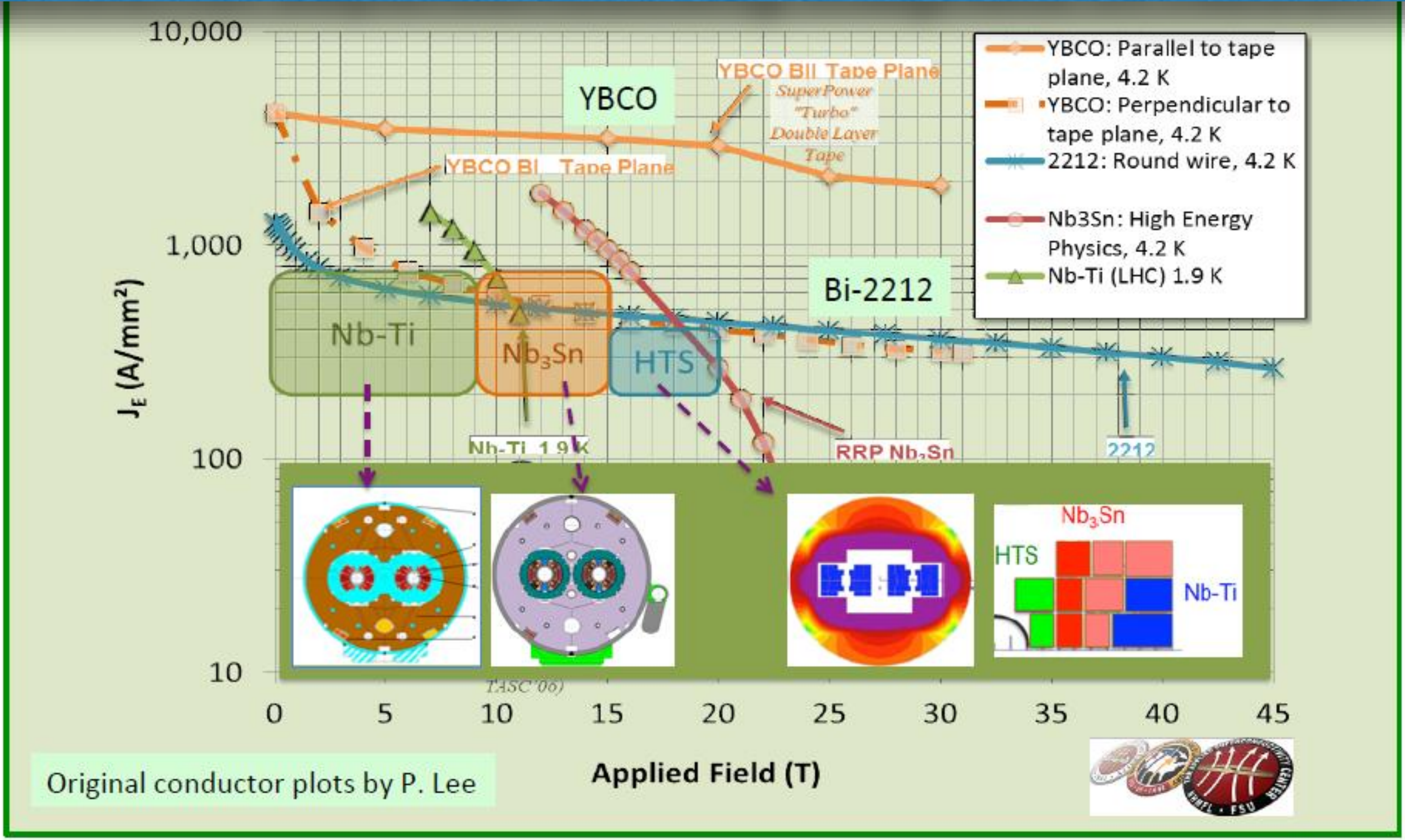
The Inner Triplet region with in-kinds



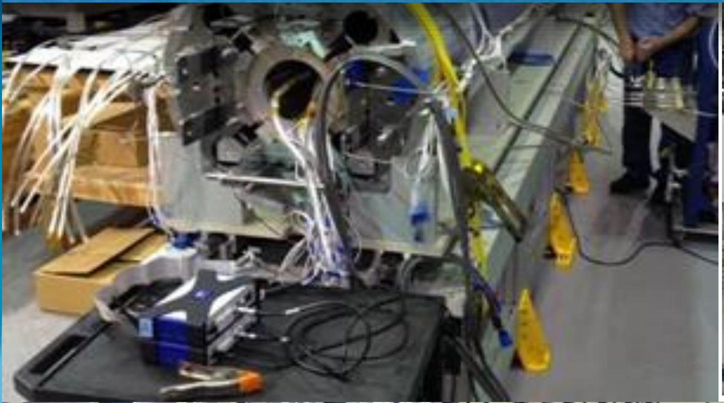
The MS (matching section) region with in-kinds



New technology for High Luminosity LHC: More powerful superconducting magnets in Nb3Sn



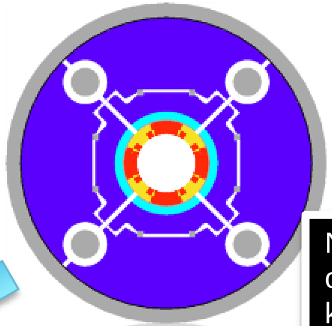
Breaking the LHC limit: high field magnets for HiLumi



LHC low-β quads: steps in magnet technology from LHC toward HL-LHC

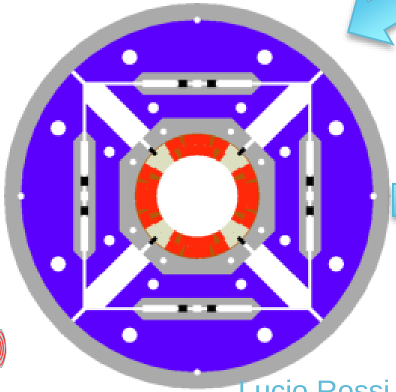
LHC (USA & JP, 5-6 m)
$\varnothing$70 mm, B_{peak}~ 7.7 T
1992-2005

LARP TQS & LQ (4m)
$\varnothing$90 mm, B_{peak}~ 11 T
2004-2010

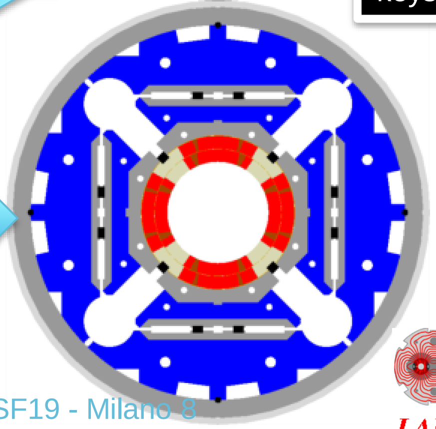


New structure based on bladders and keys (LBNL, LARP)

LARP HQ
$\varnothing$120 mm,
B_{peak}~ 12 T
2008-2014

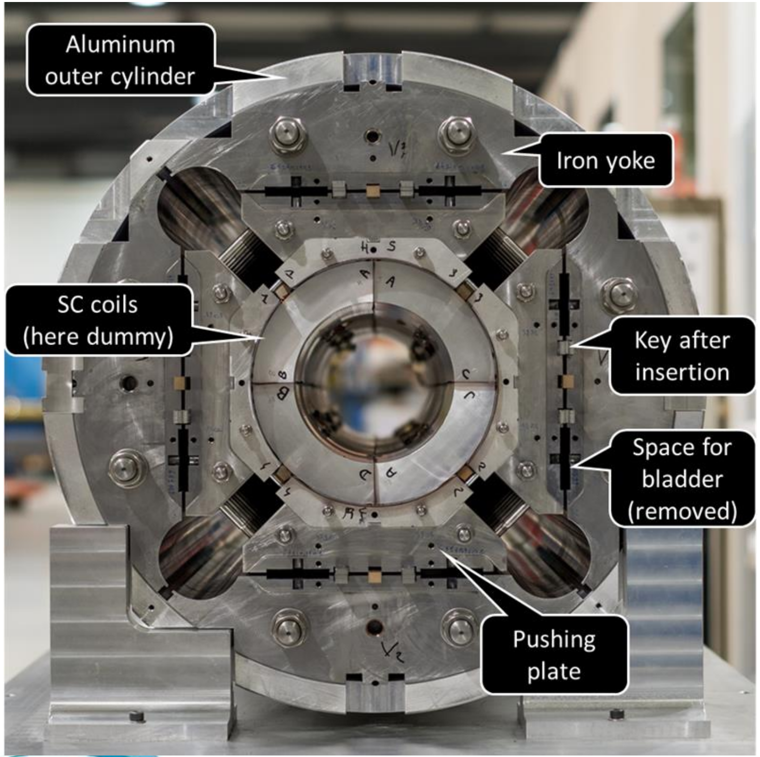


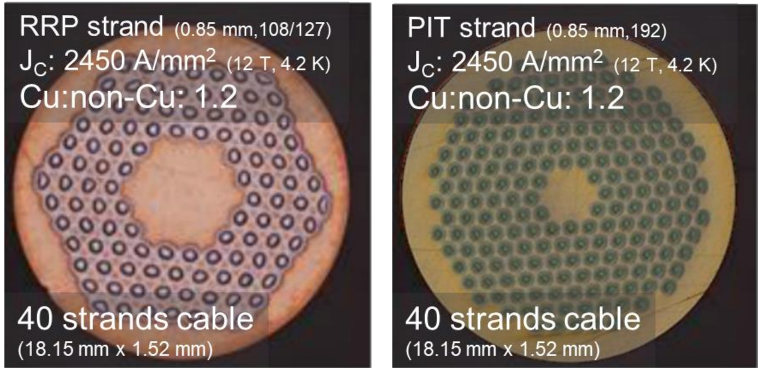
LARP & CERN
MQXF
$\varnothing$150 mm,
B_{peak}~ 11.5 T
2013-2025

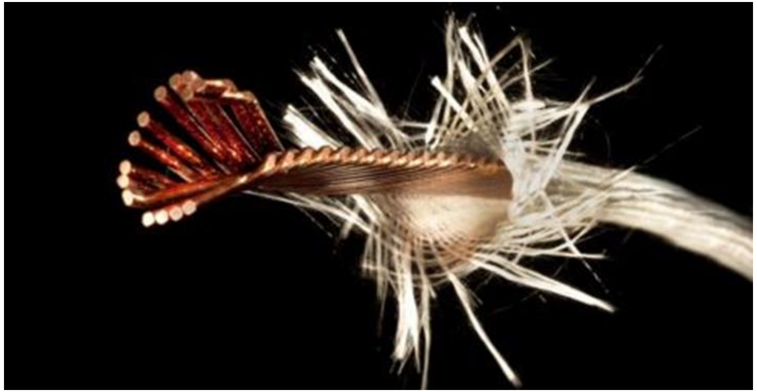


LARP

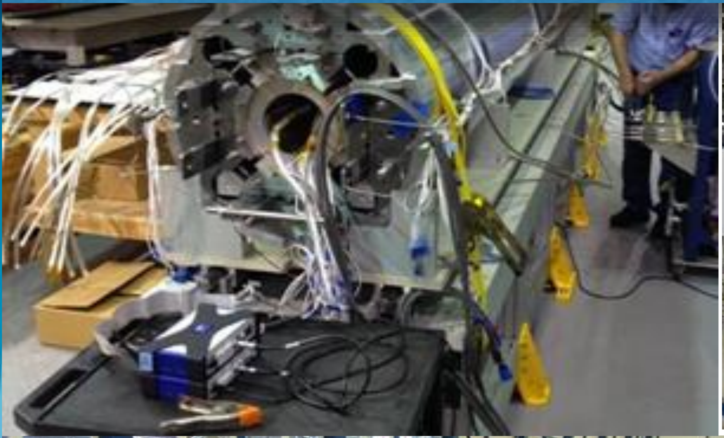
New structure to accomodate brittleness of the Nb_3Sn superconductor



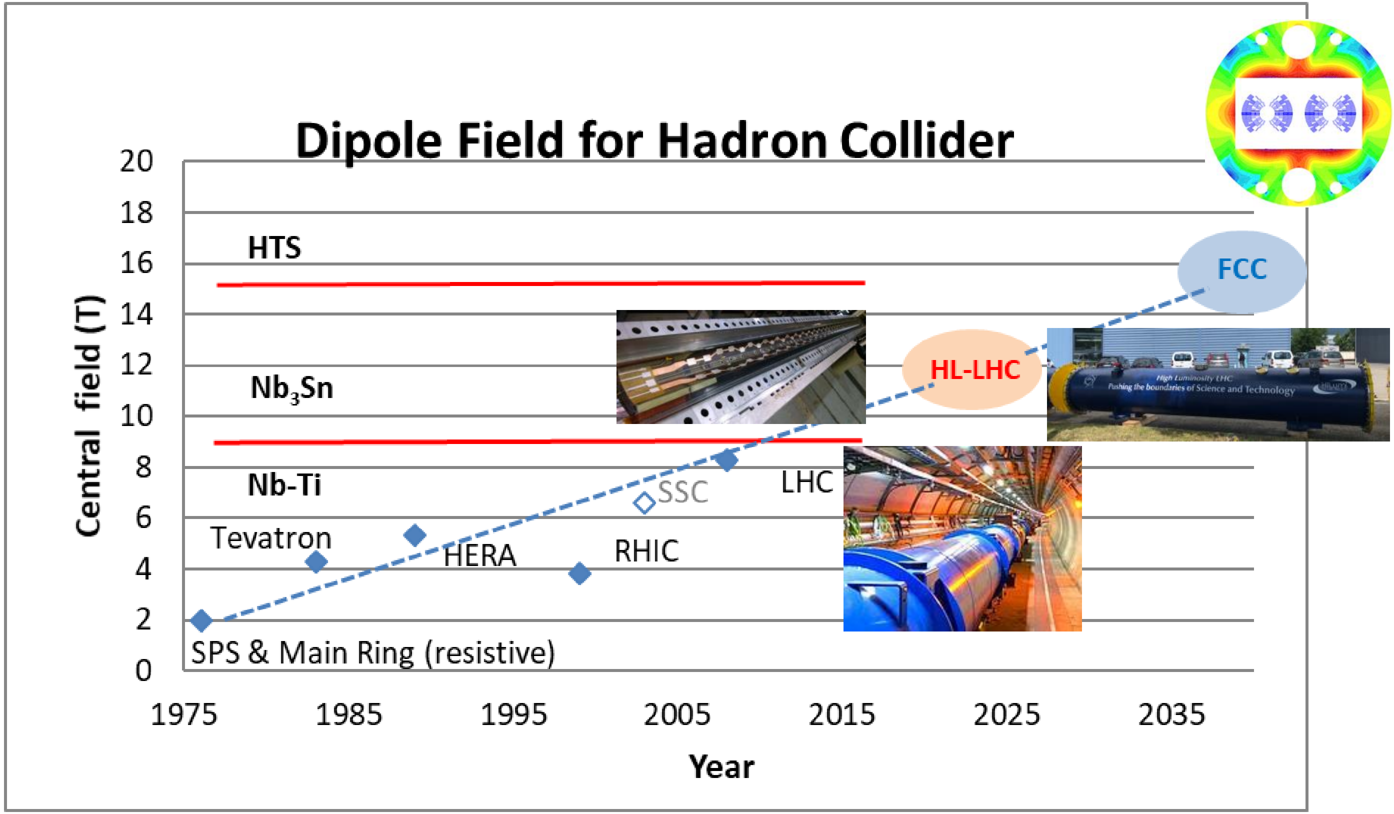




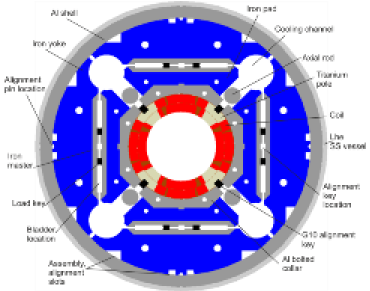
HiLumi: 15 years of R&D to go beyond the technological limit of LHC Nb-Ti



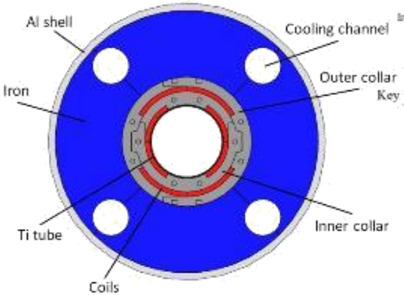
With HiLumi we prepare the technology for a future leap in hadron collider technology…



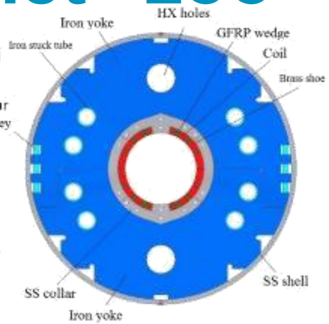
HL-LHC magnet “zoo”



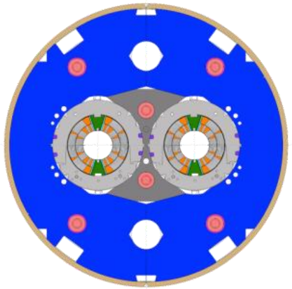
Triplet QXF (LARP and CERN)



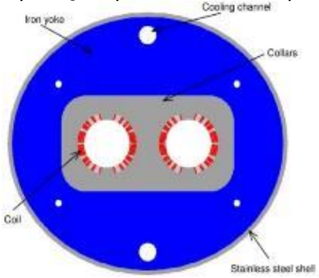
Orbit corrector (CIEMAT)



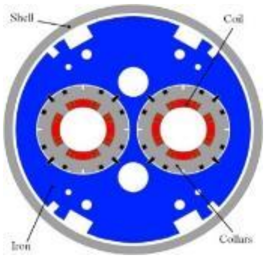
Separation dipole D1 (KEK)



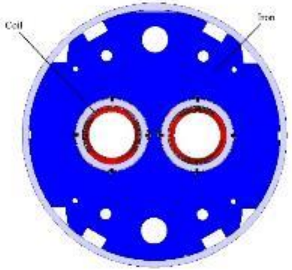
11 T dipole (CERN)



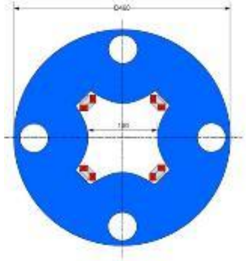
Recombination dipole D2 (INFN)



Q4 (CEA)

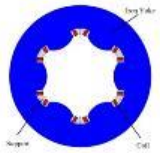


D2/Q4 orbit corrector (CERN)

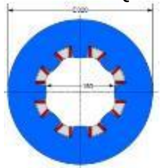


Skew quadrupole (INFN)

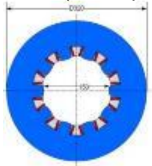
Approximately 150 single magnets and 50 cold masses for HL-LHC



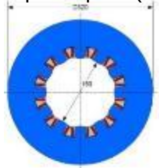
Sextupole (INFN)



Octupole (INFN)



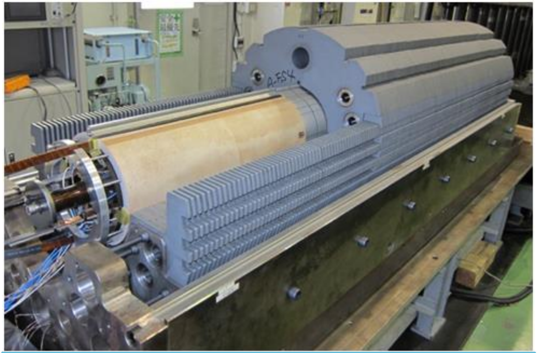
Decapole (INFN)



Dodecapole (INFN)

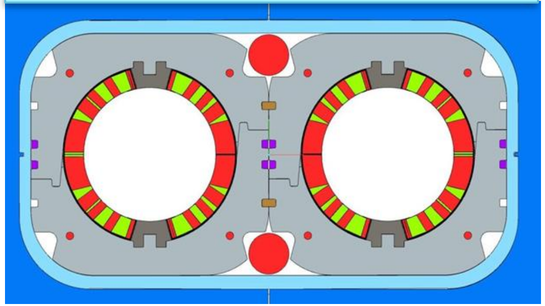
Many magnets designed and manufactured via collaboration

HL-LHC WP3



D1 – KEK
Recent test beyond nominal

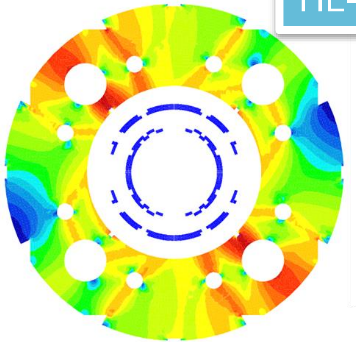
D2 – INFN Genova (model & full proto)



Q4 MQYY – CEA Saclay (QUACO)

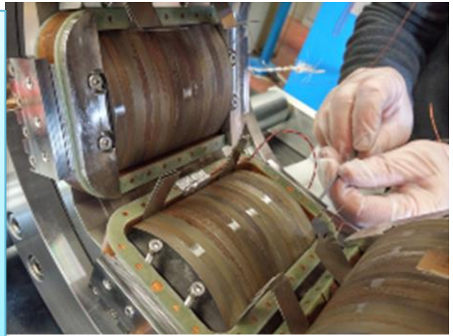
Superferric HO Correctors
INFN-Milano LASA

Test @ 2.17 K (1h @134.4 A i.e. 108% nominal current)
No-training
3 «natural» quenches @241 A, i.e. 97% of short sample limit 4.2 K

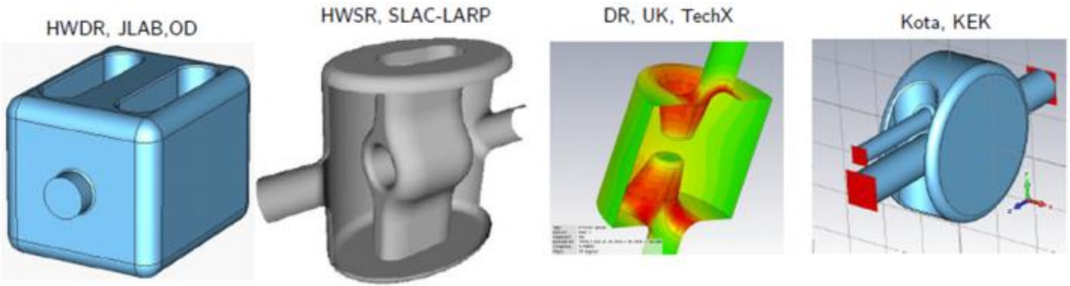


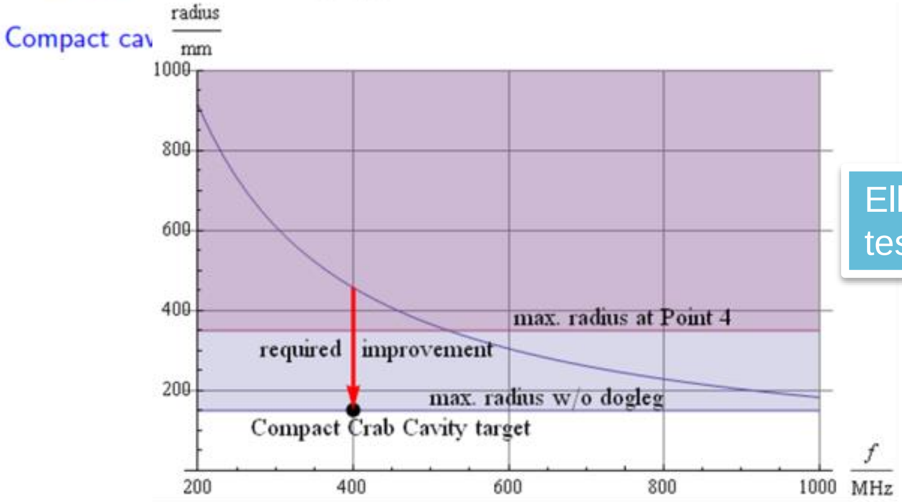
Iron field map when both dipoles are simultaneously powered

Nested orbit correctors – CIEMAT Madrid



Crab Cavity, for p-beam rotation
at 10 fs level!





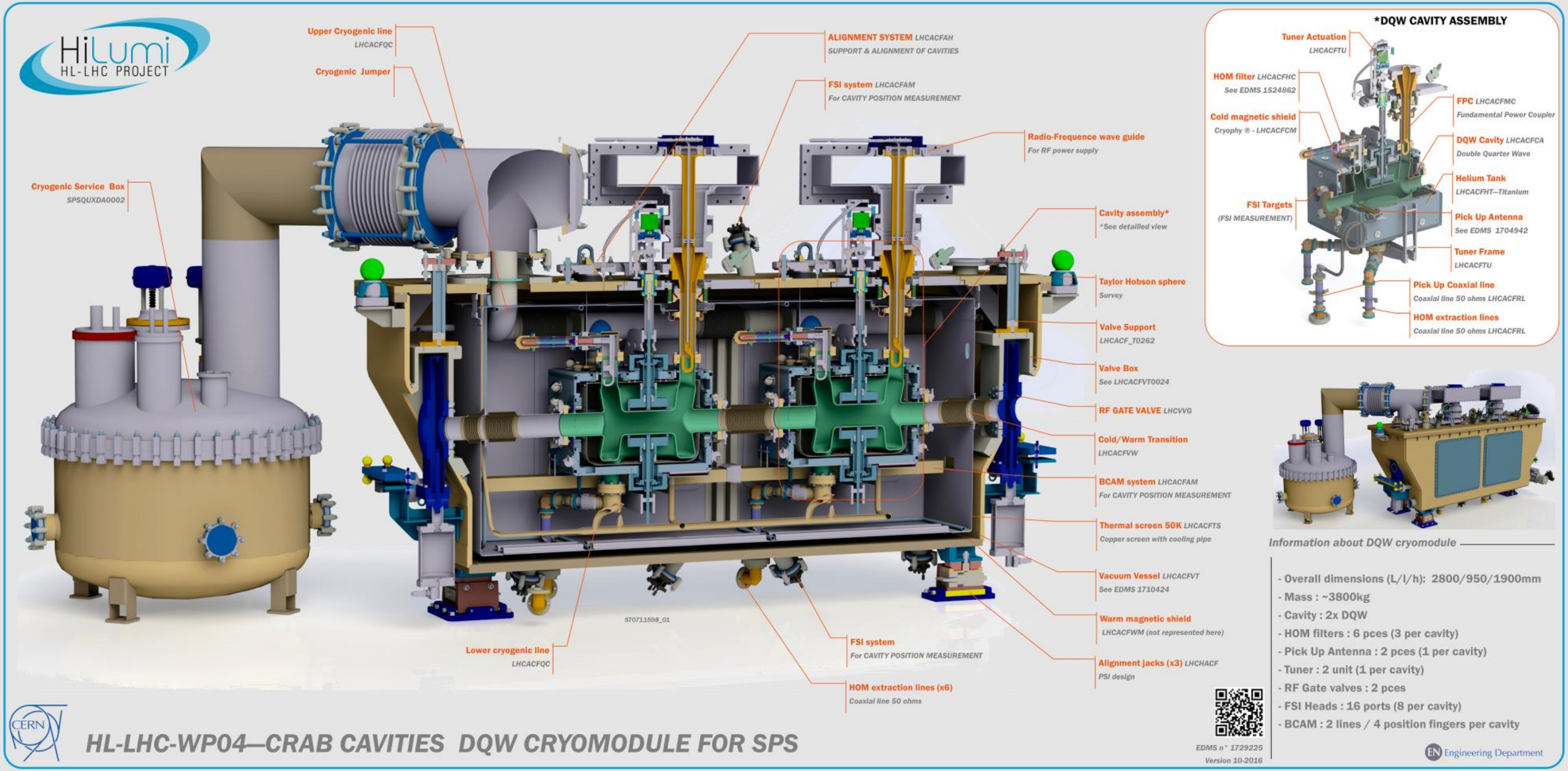
Elliptical type CC has been tested first in KEK 2008

Crab Cavity consruction for SPS test at CERN (DQW type)

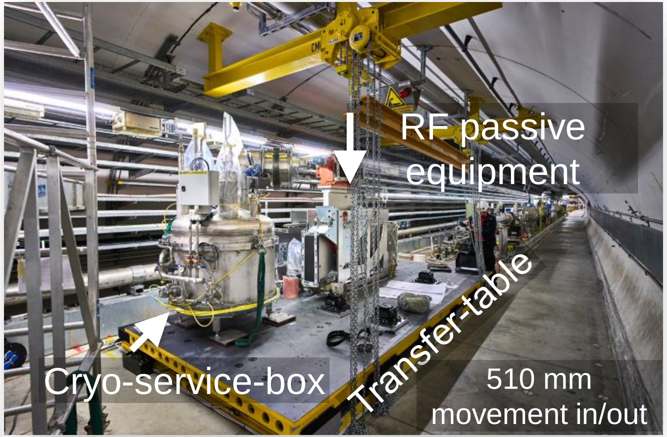
FPC on in Conditioning
Test box & installation of DT

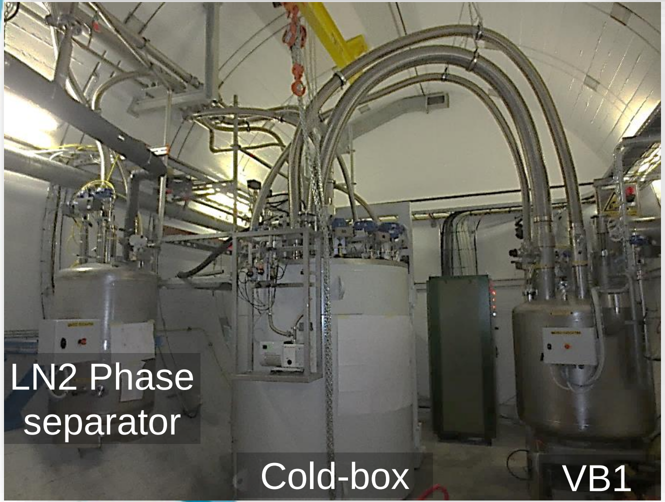
FPC installation onto cavity

String assembly completed
Aug 18, 2017

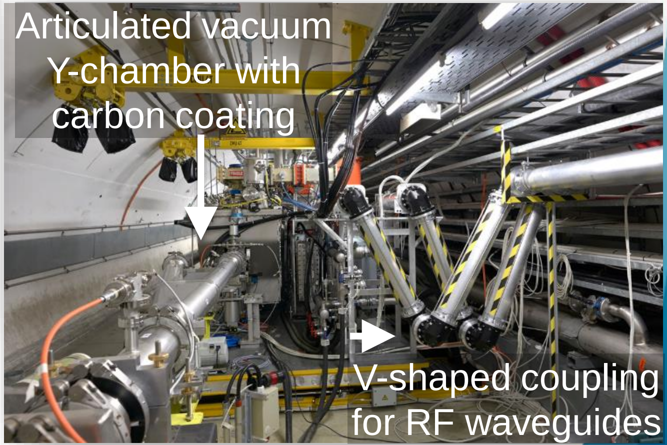

HiLumi HL-LHC PROJECT
Upper Cryogenic line
LHCACFQC
Cryogenic Jumper
ALIGNMENT SYSTEM LHCACFAH
SUPPORT & ALIGNMENT OF CAVITIES
FSI system LHCACFAM
For CAVITY POSITION MEASUREMENT
Radio-Frequence wave guide
For RF power supply
Cryogenic Service Box
SPSQUXDA0002
Cavity assembly*
*See detailled view
Taylor Hobson sphere
Survey
Valve Support
LHCACF_T0262
Valve Box
See LHCACFVT0024
RF GATE VALVE LHCVVG
Cold/Warm Transition
LHCACFVW
BCAM system LHCACFAM
For CAVITY POSITION MEASUREMENT
Thermal screen 50K LHCACFTS
Copper screen with cooling pipe
Vacuum Vessel LHCACFVT
See EDMS 1710424
Warm magnetic shield
LHCACFWM (not represented here)
Alignment jacks (x3) LHCHACF
PSI design
ST0711598_01
Lower cryogenic line
LHCACFQC
FSI system
For CAVITY POSITION MEASUREMENT
HOM extraction lines (x6)
Coaxial line 50 ohms
*DQW CAVITY ASSEMBLY
Tuner Actuation
LHCACFTU
HOM filter LHCACFHC
See EDMS 1524862
Cold magnetic shield
Cryophy ® - LHCACFCM
FSI Targets
(FSI MEASUREMENT)
FPC LHCACFMC
Fundamental Power Coupler
DQW Cavity LHCACFCA
Double Quarter Wave
Helium Tank
LHCACFHT—Titanium
Pick Up Antenna
See EDMS 1704942
Tuner Frame
LHCACFTU
Pick Up Coaxial line
Coaxial line 50 ohms LHCACFRL
HOM extraction lines
Coaxial line 50 ohms LHCACFRL
Information about DQW cryomodule
- Overall dimensions (L/l/h): 2800/950/1900mm
- Mass : ~3800kg
- Cavity : 2x DQW
- HOM filters : 6 pces (3 per cavity)
- Pick Up Antenna : 2 pces (1 per cavity)
- Tuner : 2 unit (1 per cavity)
- RF Gate valves : 2 pces
- FSI Heads : 16 ports (8 per cavity)
- BCAM : 2 lines / 4 position fingers per cavity
CERN
HL-LHC-WP04—CRAB CAVITIES DQW CRYOMODULE FOR SPS
EDMS n° 1729225
Version 10-2016
EN Engineering Department

HL-LHC SPS Test stand for crab-cavities





DQW crab-cavity
cryomodule



HiLumi HL-LHC PROJECT

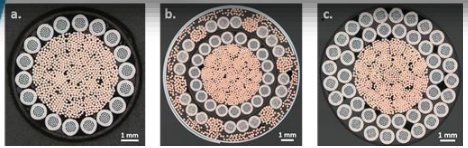
Collimators

TCLD for ions (IP2) ready to be installed in the bypass

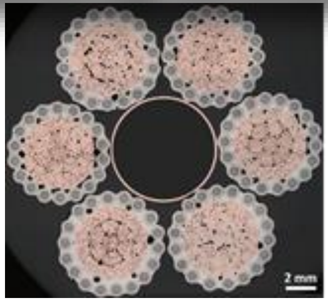
First TCLD jaw prototype in Industry (courtesy of EN/STI)

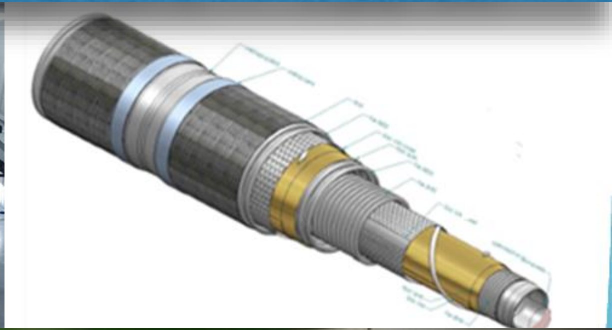
Samples of MoGr (Molybdenum-Graphite) from producer (courtesy of EN/MME)

New superconducting links for 100 kA current – 130 m



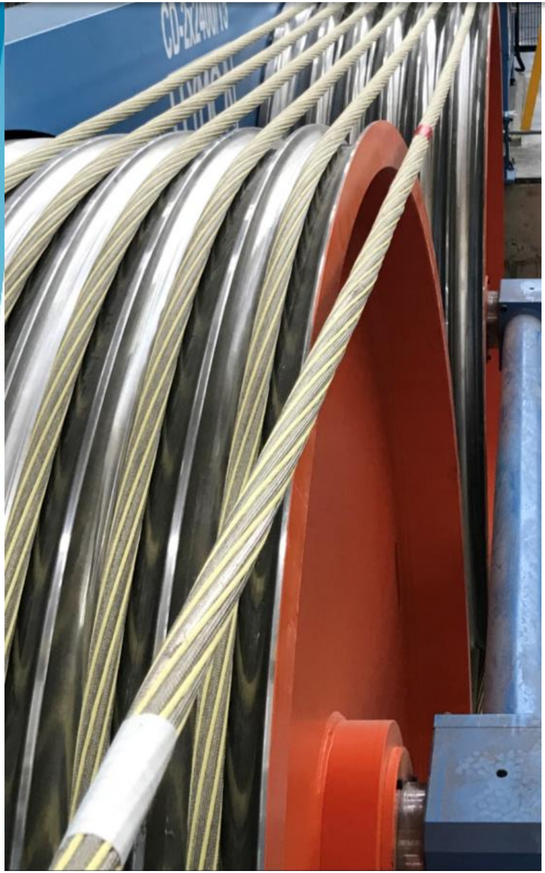
MgB_2
superconductor

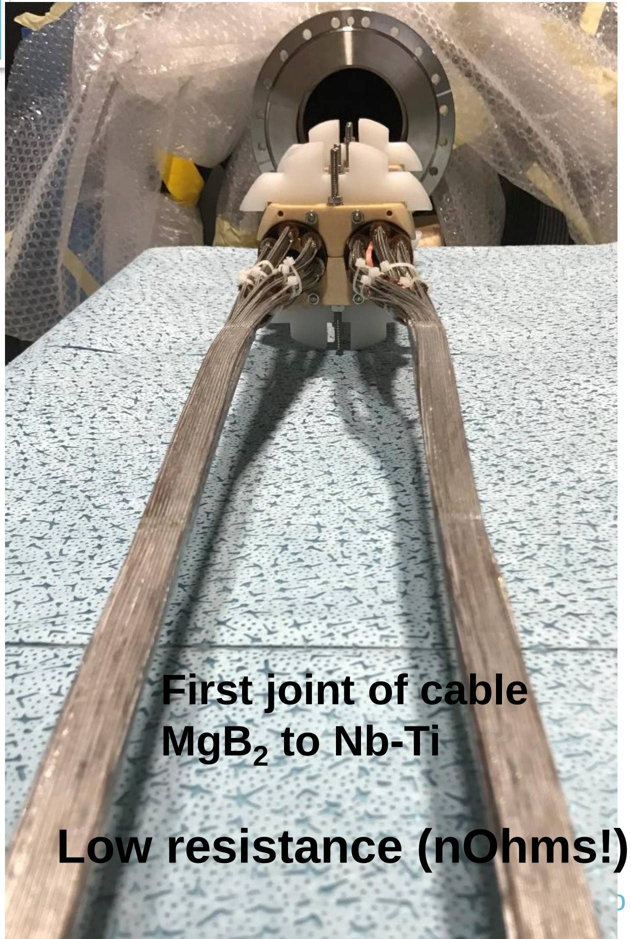




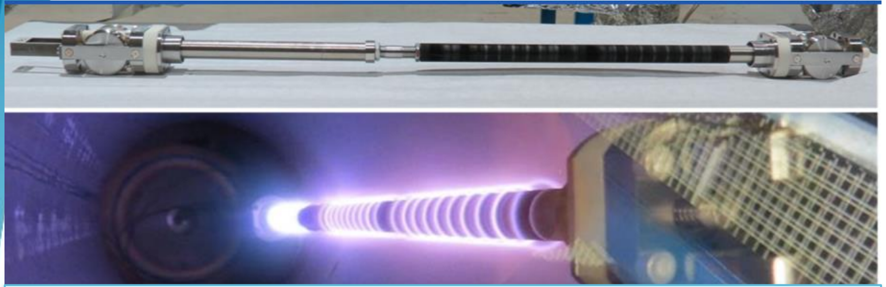
SC Links inside flexible cryostat: first 60 m long prototype 20 kA cable tested at CERN

First long length of 20 kA MgB_2 cable (IT Quad circuit)

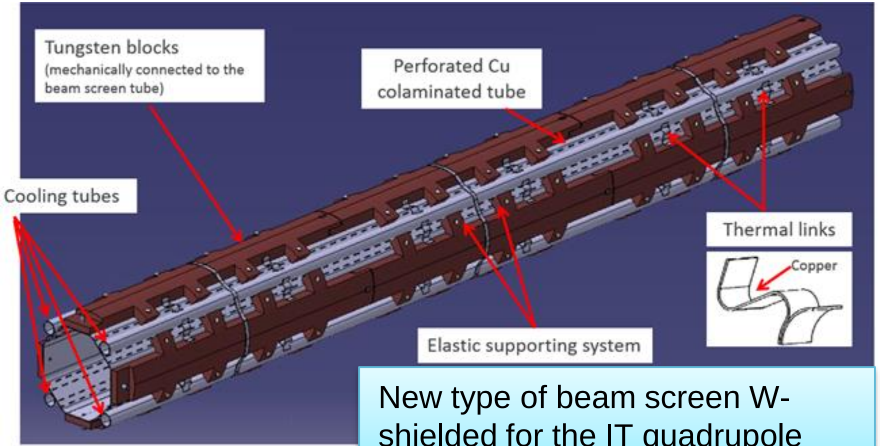




And many other important novelties

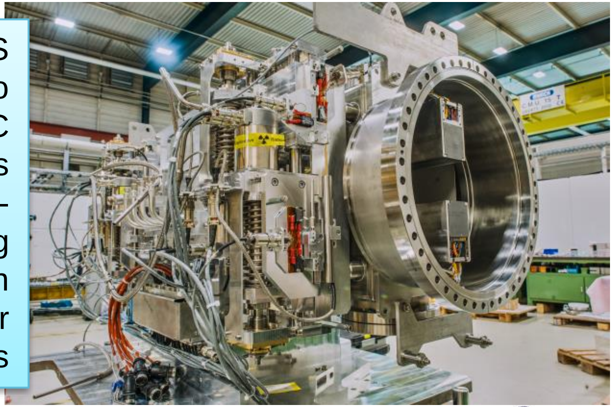


A-Carbon coating of magnet beam screen to fight e-cloud

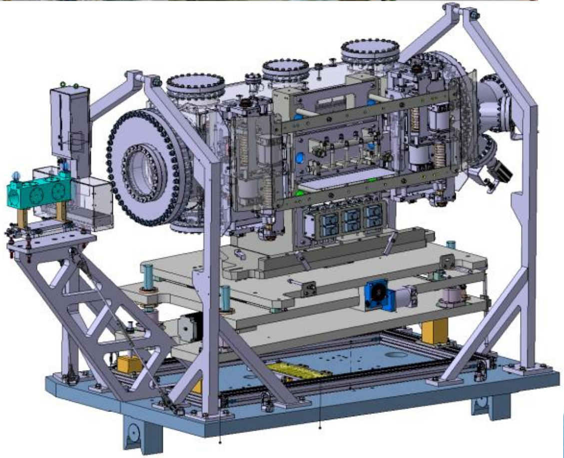


New type of beam screen W-shielded for the IT quadrupole

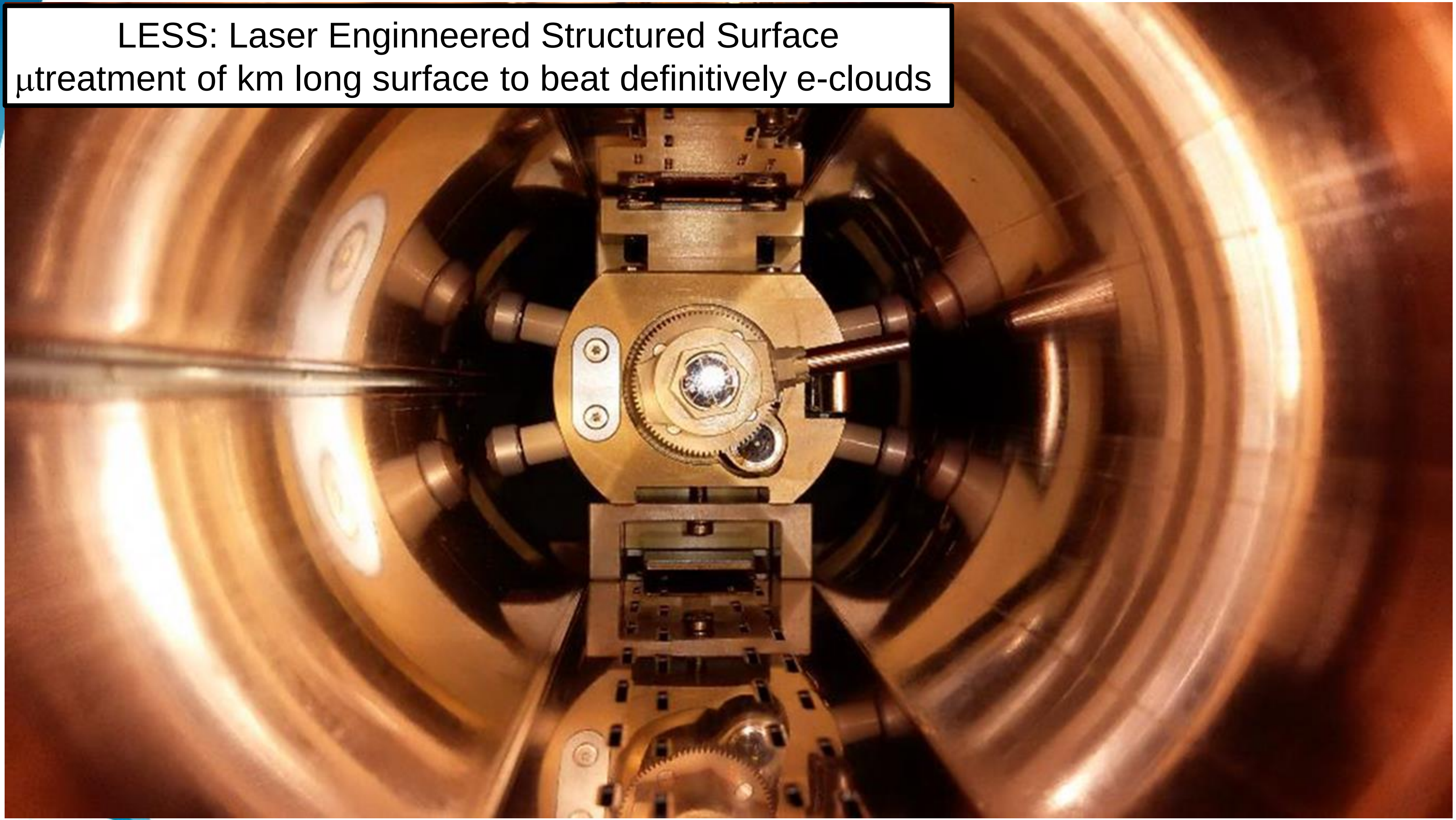
New TDIS absorber to protect SC magnets from mis-firing injection kicker magnets

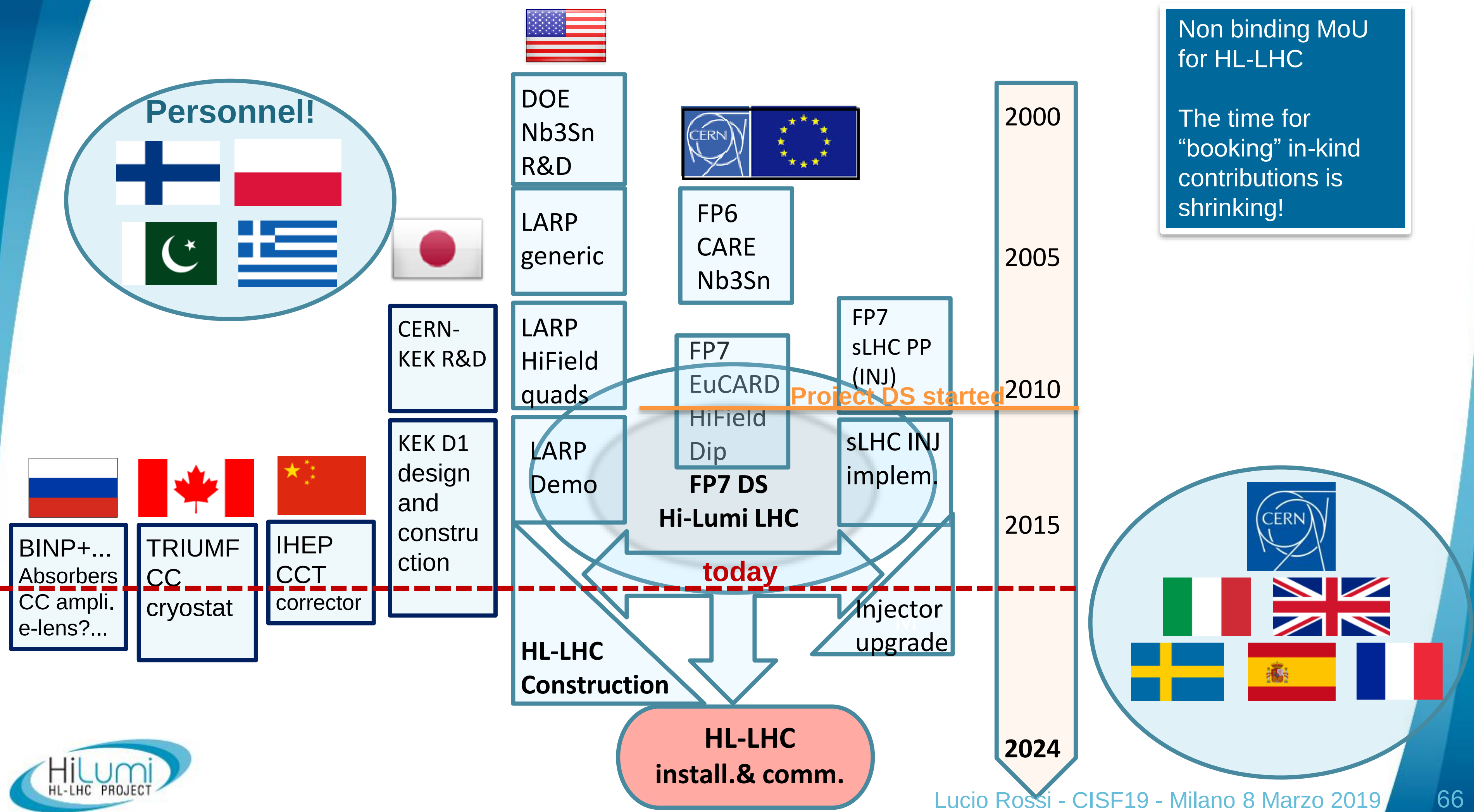


Improving beam diagnostics: BGV detector



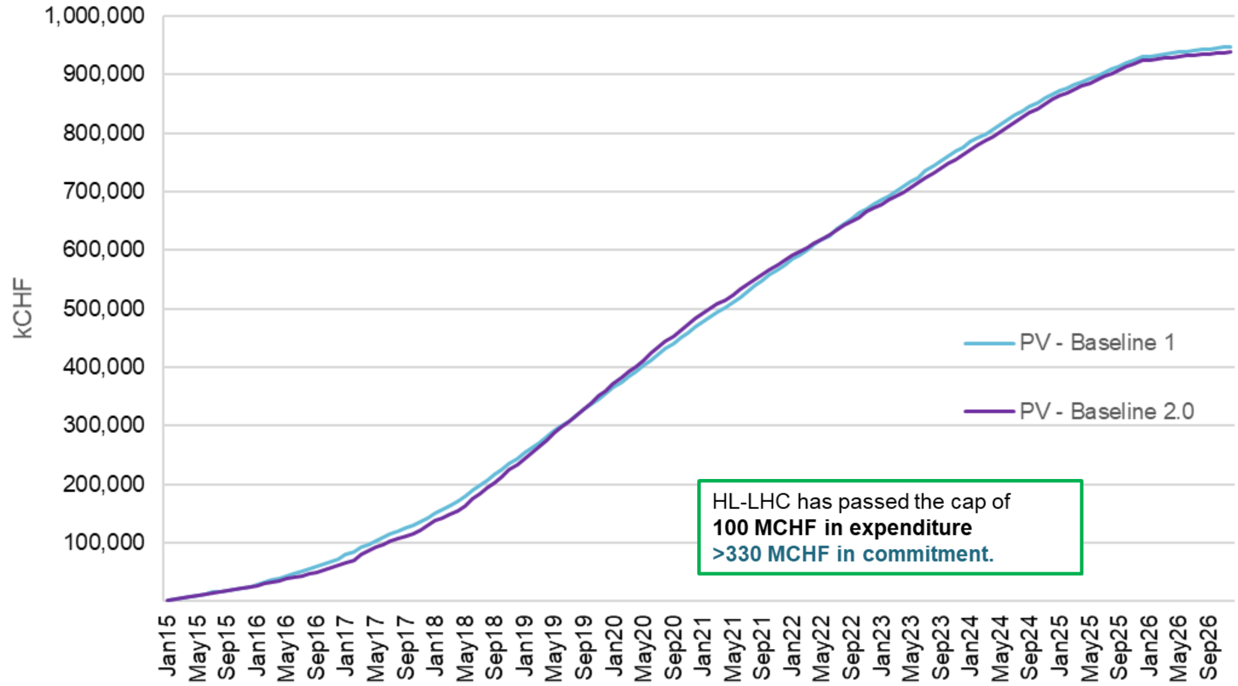
LESS: Laser Enginneered Structured Surface
μtreatment of km long surface to beat definitively e-clouds




Personnel!
DOE Nb3Sn R&D
LARP generic
LARP HiField quads
LARP Demo
CERN-KEK R&D
KEK D1 design and constru ction
FP6 CARE Nb3Sn
FP7 EuCARD HiField Dip
FP7 sLHC PP (INJ)
Project DS started
sLHC INJ implem.
FP7 DS Hi-Lumi LHC
today
Injector upgrade
HL-LHC Construction
HL-LHC install.& comm.
BINP+... Absorbers CC ampli. e-lens?...
TRIUMF CC cryostat
IHEP CCT corrector
2000
2005
2010
2015
2024
Non binding MoU for HL-LHC
The time for “booking” in-kind contributions is shrinking!
HiLumi HL-LHC PROJECT

Recent signed collaborations and in-kinds

About 1 BCHF of material cost
and about 2000 Person-years (200 FTE for 10 years)



No additional budget form Member States. (Excpet the additional exceptional contribution).

Extra-need of people, beyond the 200 people of staff, fulfilled with personnel from MS and NMS project associates (or collaborating associates)

A great effort … but also an investment

Search this site | Search

HL-LHC Industry

Industry Relations and Procurement Website for the HL-LHC project

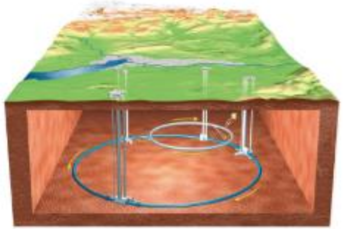
Home | General Info | Procurement Overview | Tendering | Acquisition Timeline | Events | Contact

Building the HL-LHC with the Industry

The HL-LHC Industry Website has been specially designed for all those firms that wish to participate in this ambitious project. We want to share all the relevant information related to the procurement that will be required to accomplish this major upgrade of the LHC.

The industry will have a crucial role and will be heavily involved within the HL-LHC Project since it will be the main source to provide the technologies and equipment that are required to successfully achieve the goals of this upgrade of the LHC.

The HL-LHC will collaborate with many types of industries and businesses to pursue its goals. Knowledge and technology to be developed during the HL-LHC project will make a lasting impact on society.



ILOS

ILOs Portal

HIGHLIGHTS

12 June 2017

BIG SCIENCE BUSINESS FORUM

Big Science Business Forum 2018

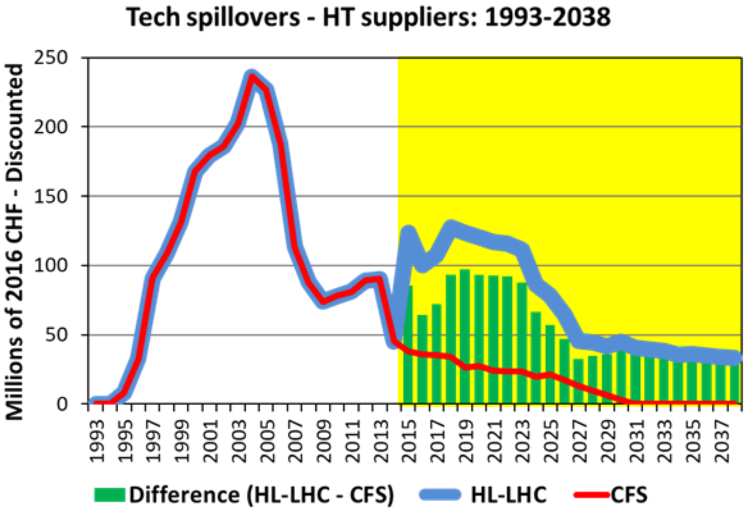
Big Science Business Forum 2018 will be the first one-stop-shop for European companies and other stakeholders to learn about Europe's Big Science organisations' future investments and procurements. CERN event will at thie major event that will be held at Copenhagen on 27 and 28 February 2018.

Read more

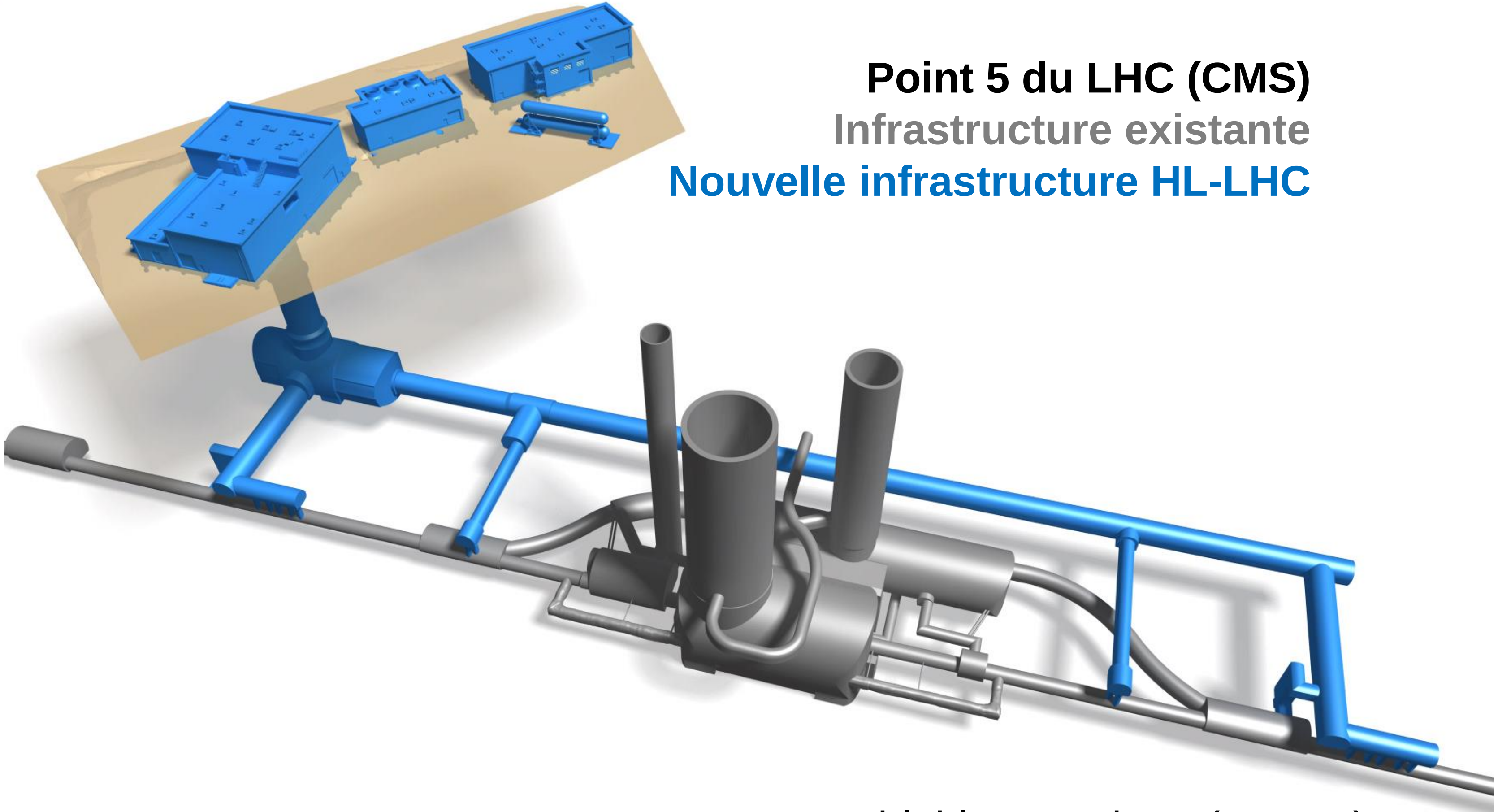
Con un ritorno (economico) per la società

A recent study of the University of Milan Economy Dept, has estimated that for each CHF invested in the HL-LHC there is a net gain for HiTech companies of about 1.7 CHF

- Technology return to industry
- Training
- Public cultural effect
- Publications of scientific articles

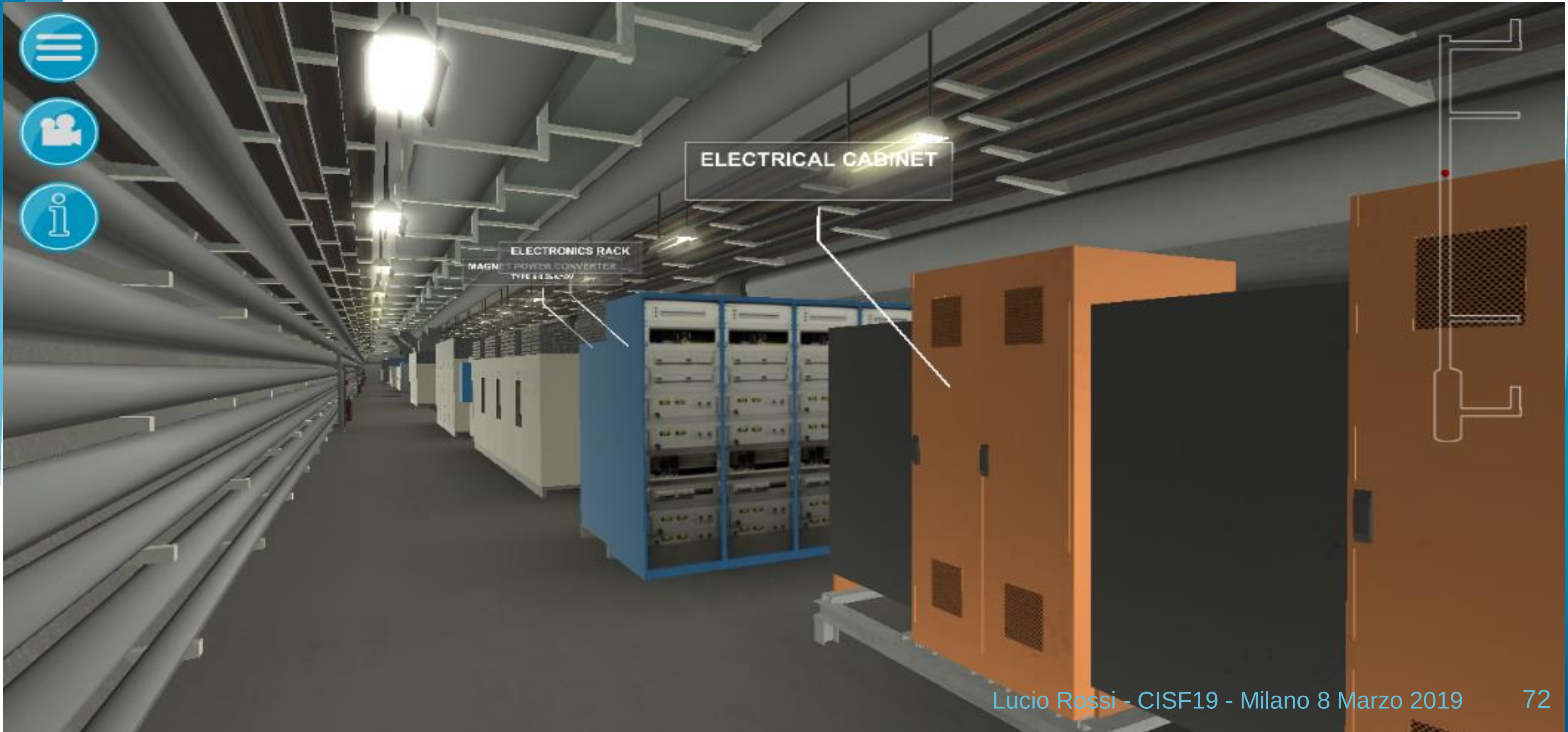


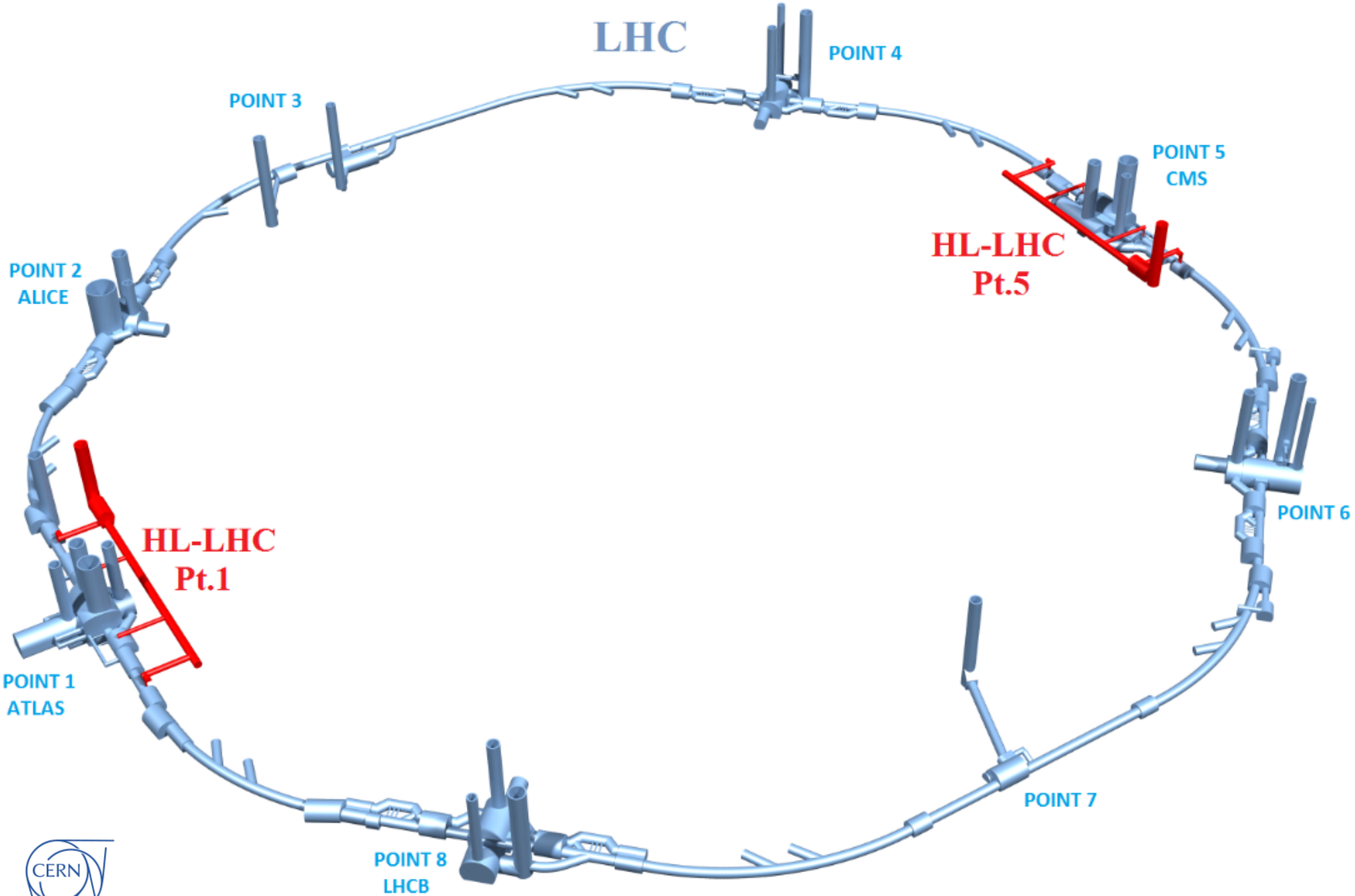
Point 5 du LHC (CMS)
Infrastructure existante
Nouvelle infrastructure HL-LHC



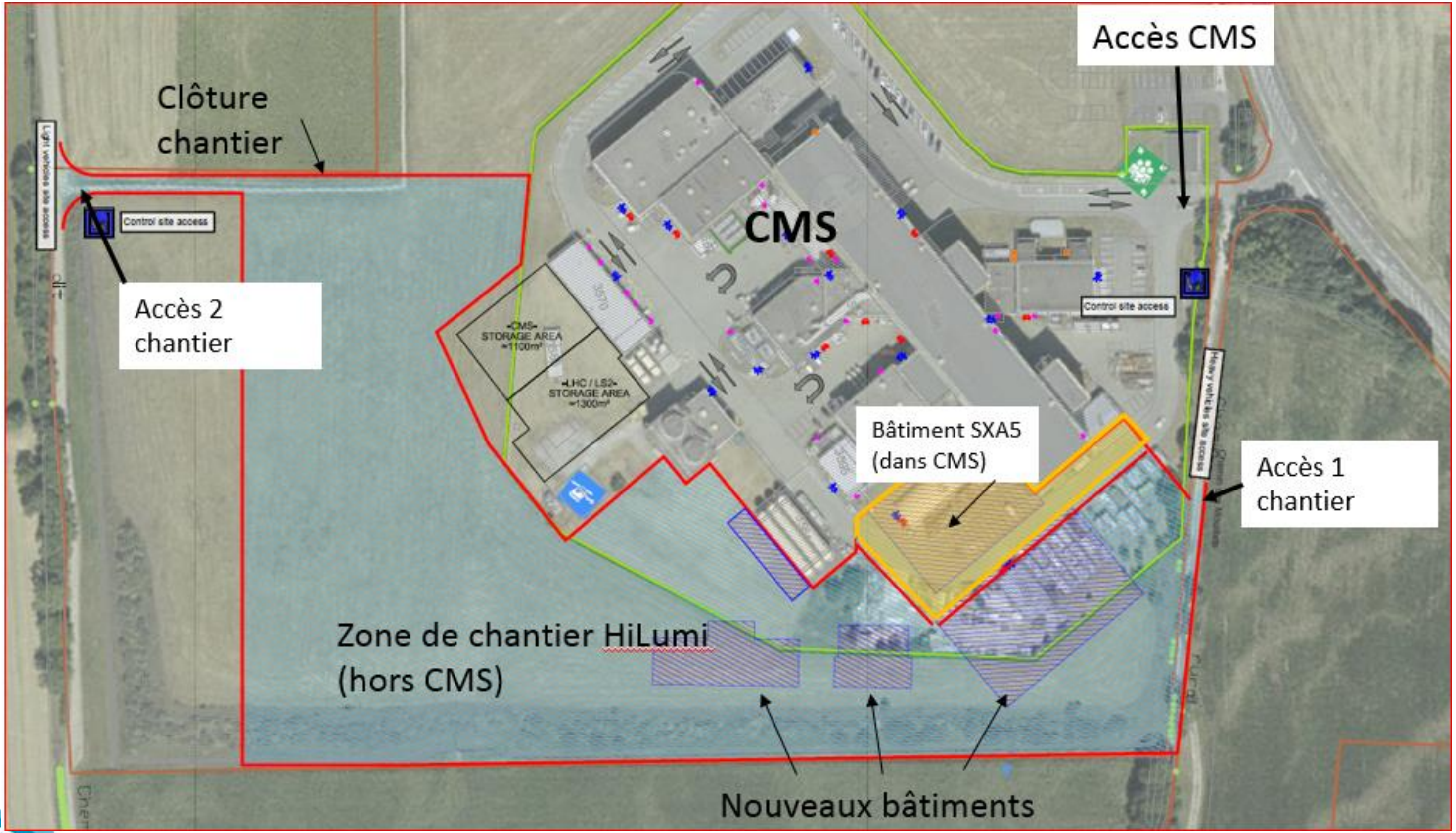
Semblable au point 1 (ATLAS)

2021–2025:Infrastructure preparation




LHC
POINT 4
POINT 3
POINT 5
CMS
HL-LHC
Pt.5
POINT 2
ALICE
HL-LHC
Pt.1
POINT 6
POINT 1
ATLAS
POINT 7
POINT 8
LHCB

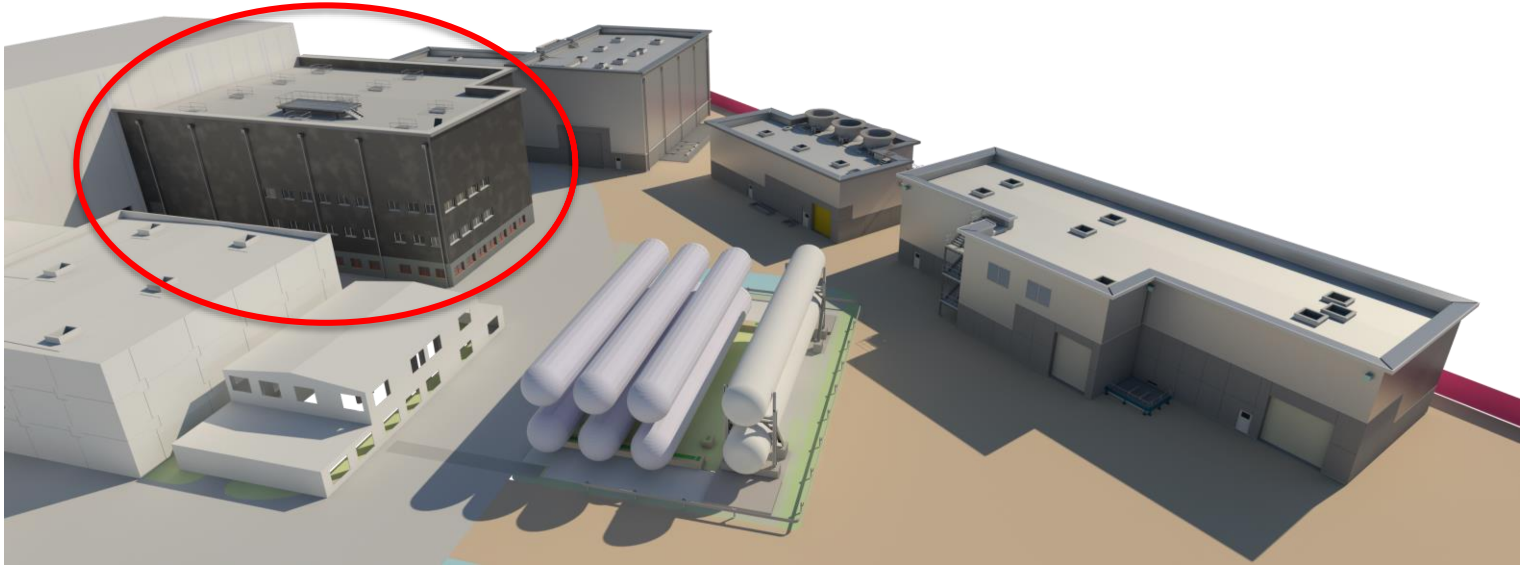
Chantier Point 5 (Installations de chantier 1/3)



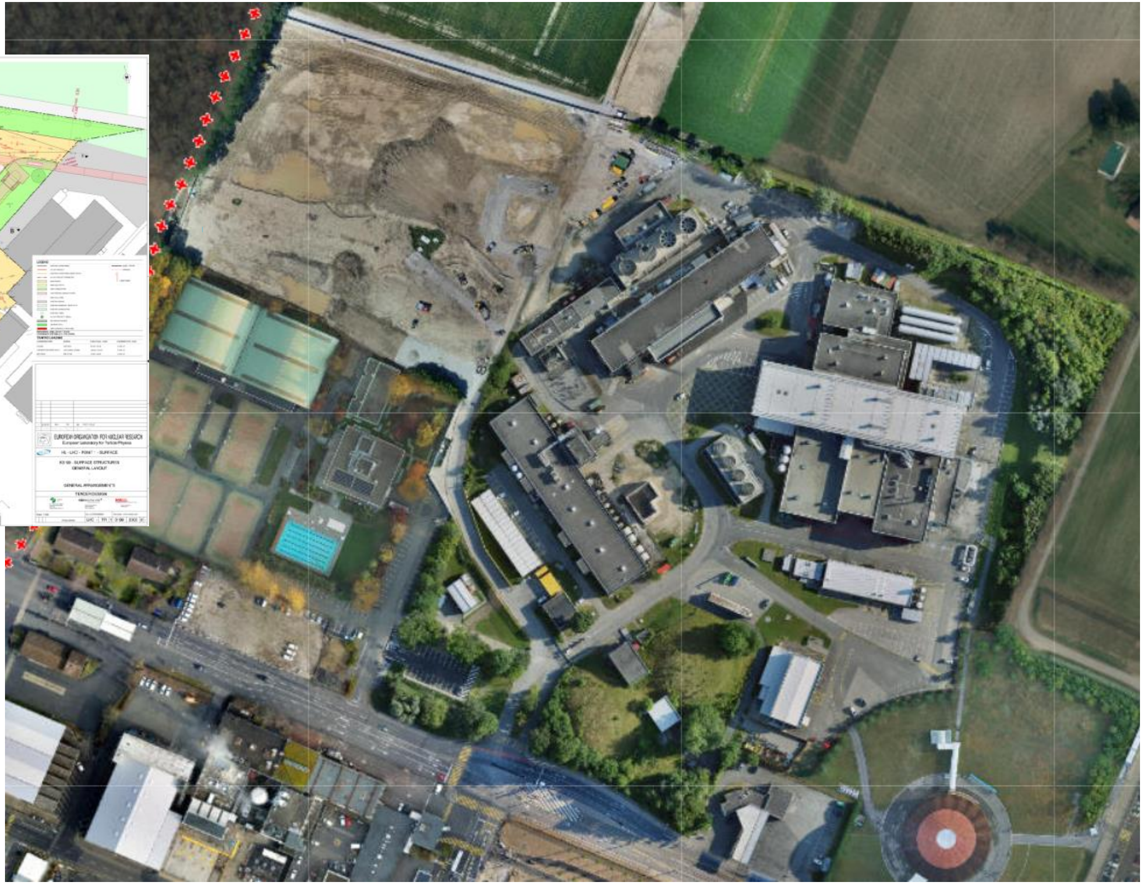
Chantier Point 5 (Installations de chantier 2/3)

Chantier Point 5 (Puits 3/3)

Chantier SXA5

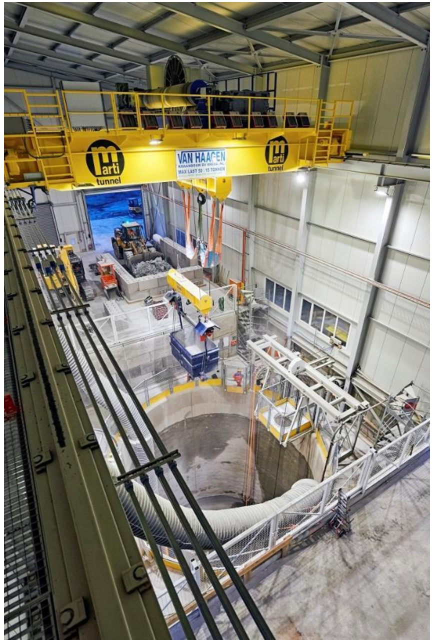


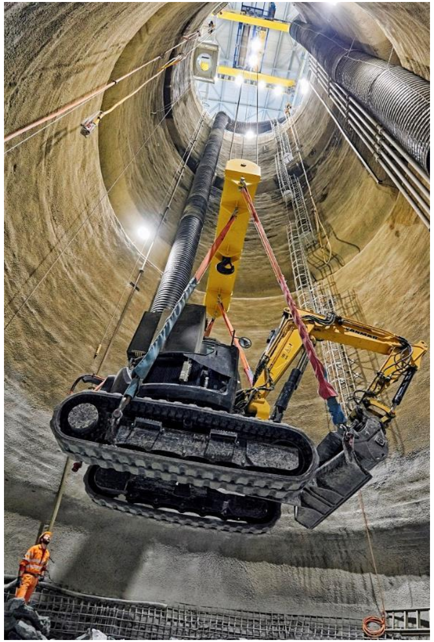
Chantier Point 1



Contract T117 – JVMM – LHC P1 (ATLAS)

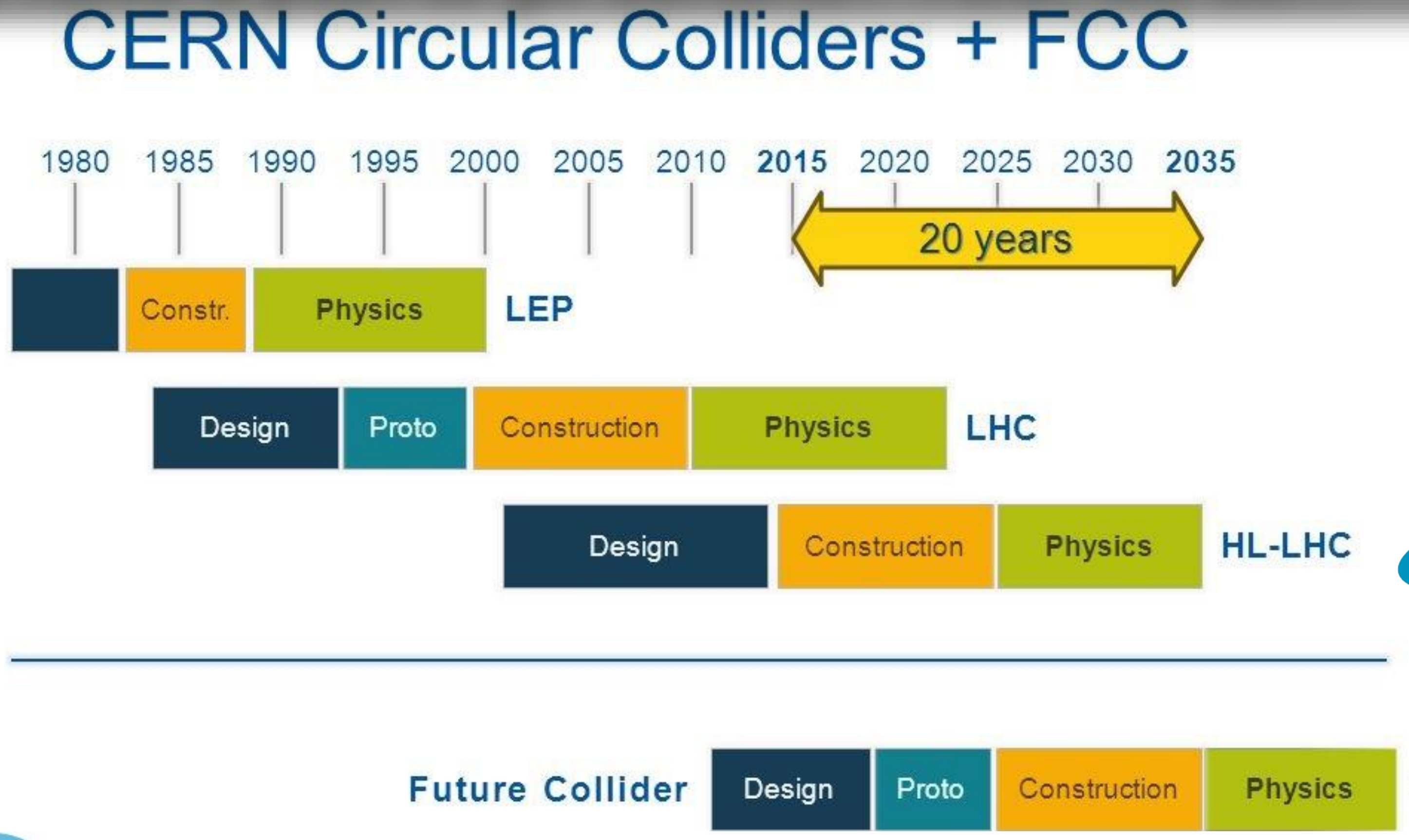
Contract T117 – JVMM – LHC P1 (ATLAS)

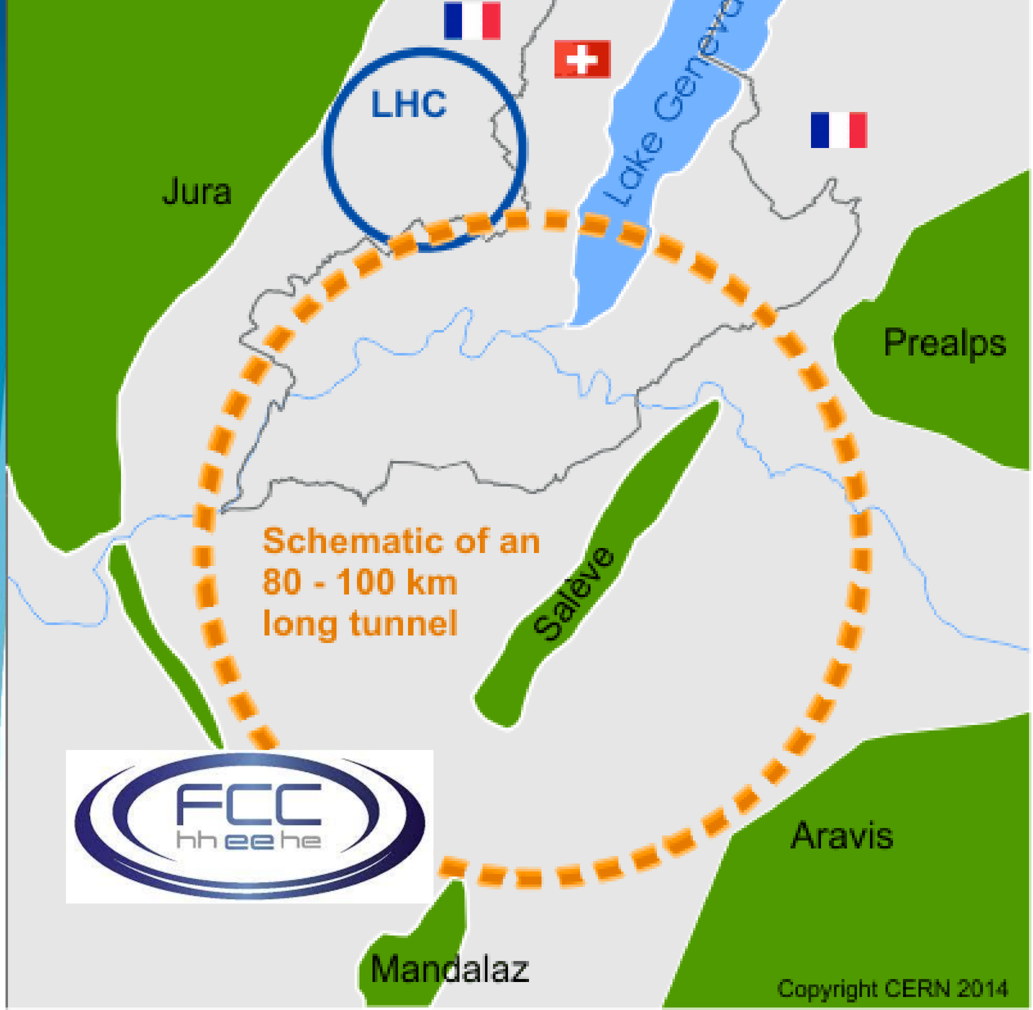




Contract T117 – JVMM – LHC P1 (ATLAS)

Do we have a plan to go behond? YES, we do...





Conceptual design report ~ late 2018

Circular collider in new tunnel

80- 100 km circumference

Circular proton-proton collider

100 TeV collision energy (p+p)

Circular electron-positron collider (VLEP)

(***350 GeV c.m.*** energy, t-tbar threshold)

Lepton-Hadron collider (like HERA)

(***50 TeV p + 100 GeV e***)

Alternatively:

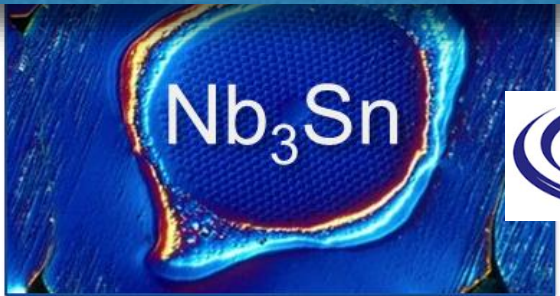
30 TeV p-p collider in LHC tunnel ?

(***16 T magnets***)

Competition? Yes, guess form whom…

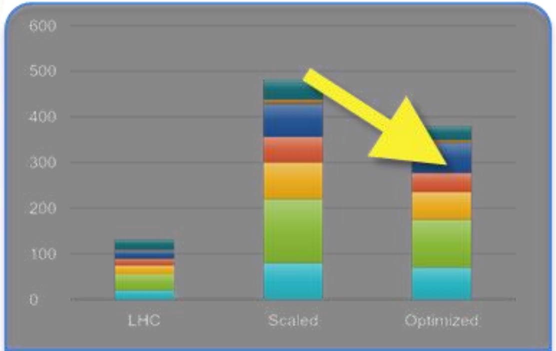
FCC is the natural evolution of HL-LHC with new technology advancement

High-field Magnets



Novel Materials and Processes

Large-scale Cryogenics

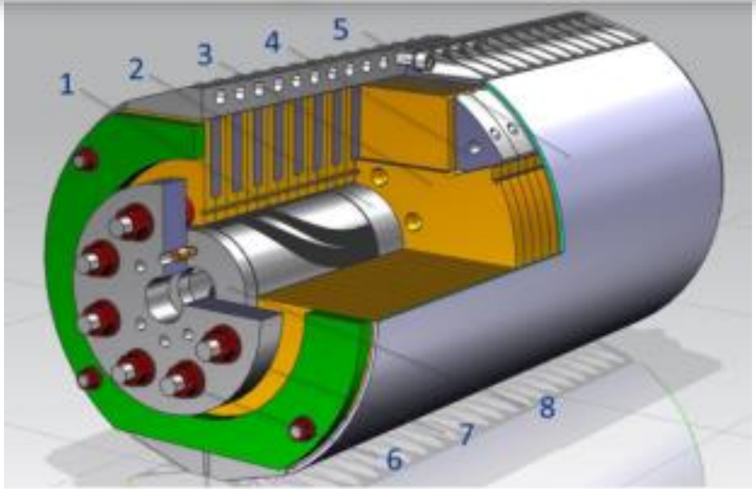


Power Efficiency

Reliability & Availability

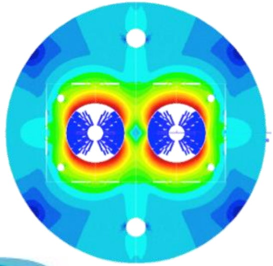
Global Scale Computing

Expanding the Sc limits beyond LHC and HiLumi

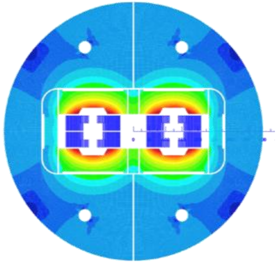


CERN FRESCA2 World record

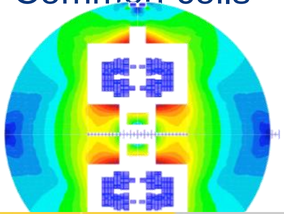
Cos-theta



Blocks



Common coils



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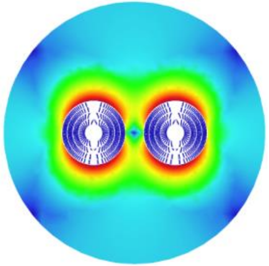
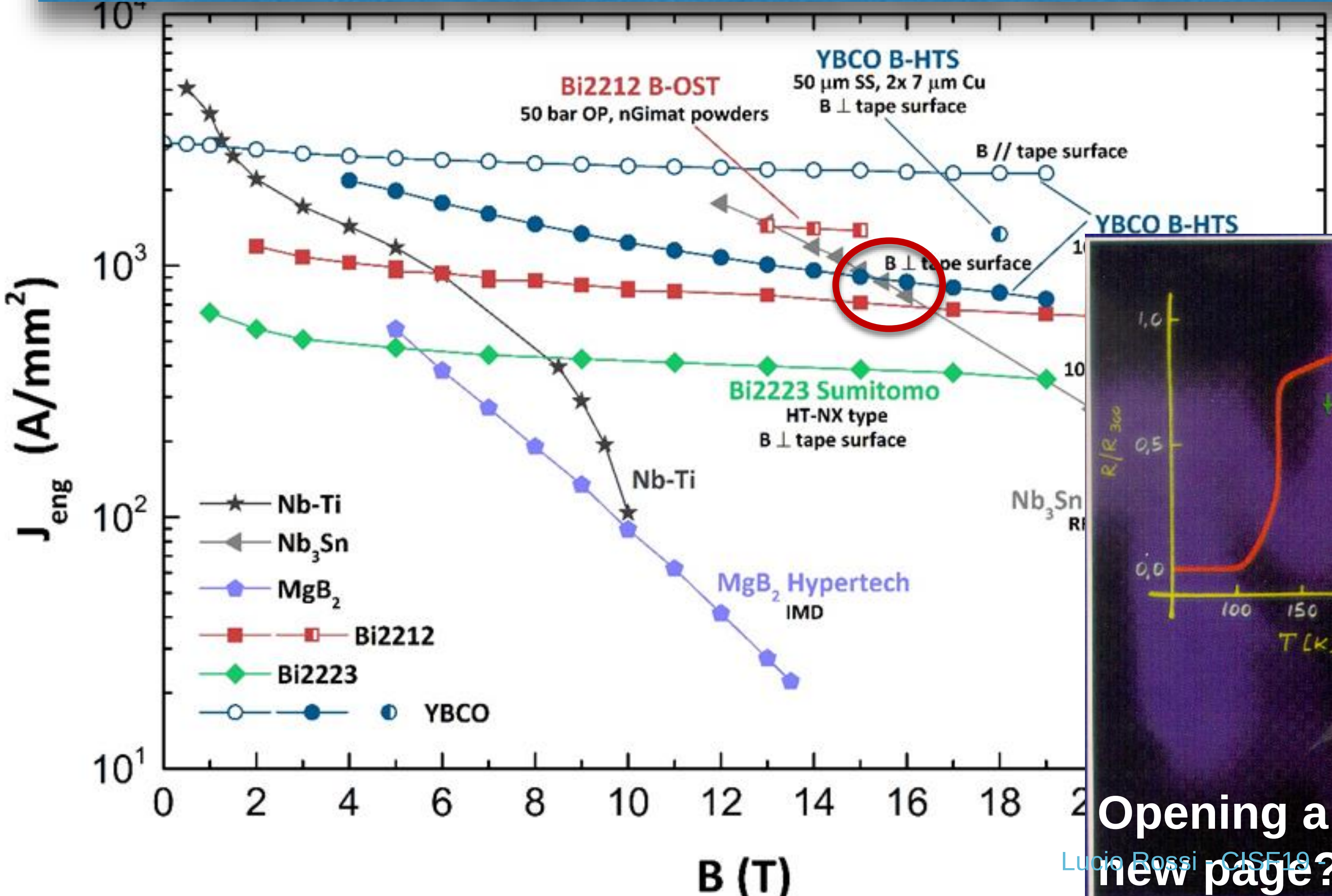
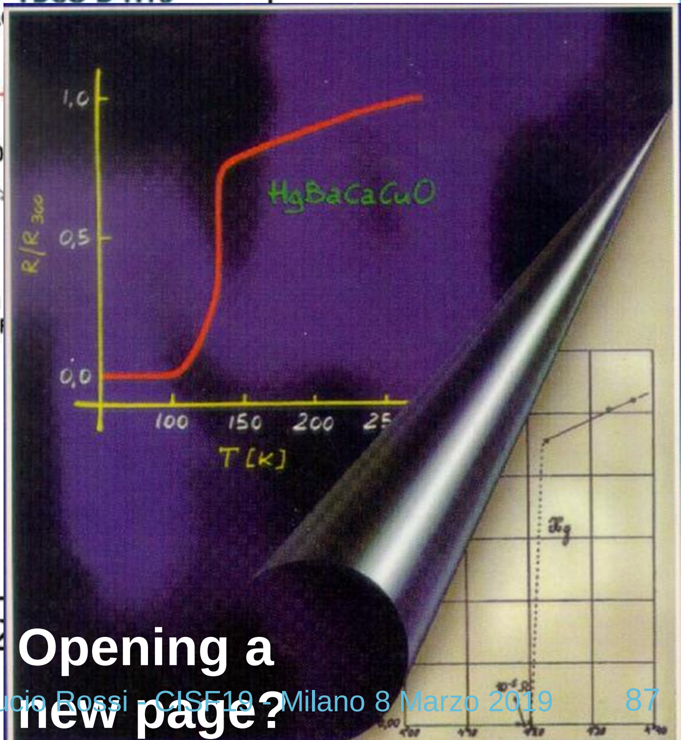
Canted Cos-theta



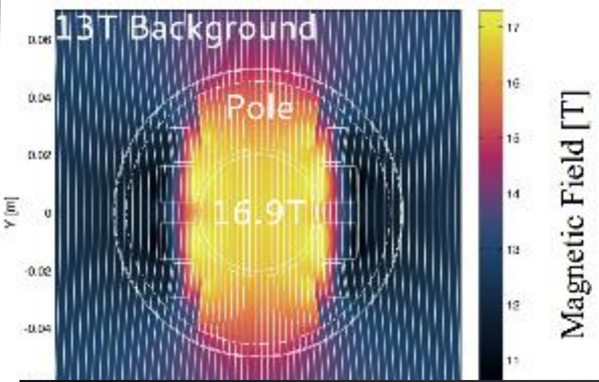
HiLumi HL-LHC PROJECT

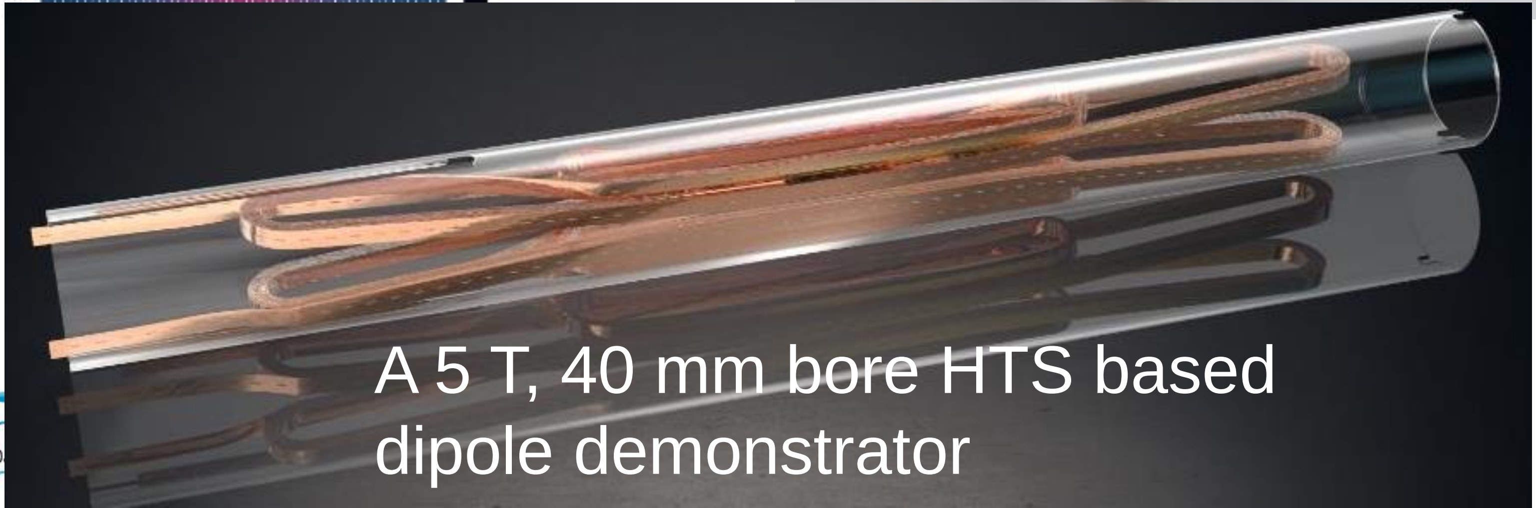
High Temperature Superconductors – HTS: next technology step





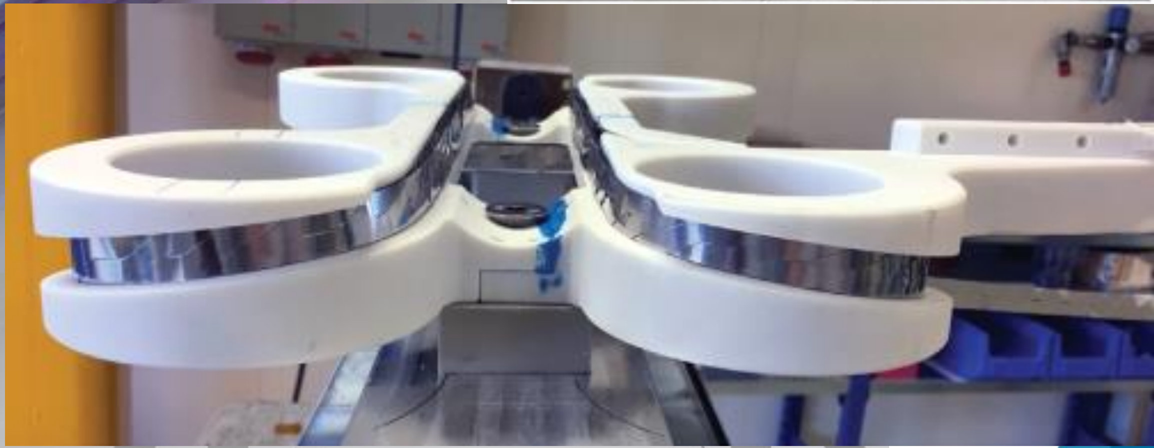
High Temperature Superconductors – HTS
The dream of 20-25 tesla! (2 x HilumiLHC!)



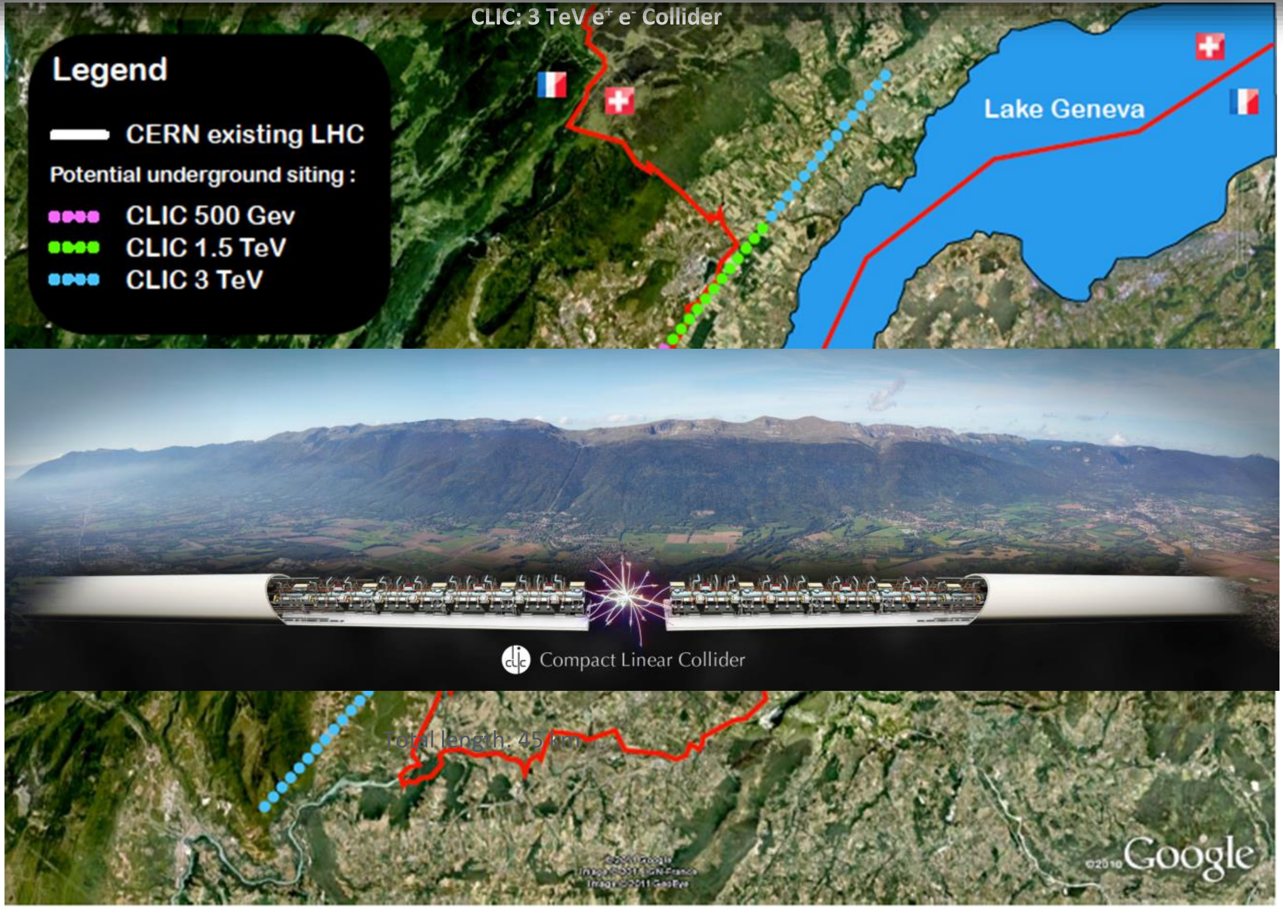


A 5 T, 40 mm bore HTS based dipole demonstrator

Trying the magnets of the future… 20 tesl or more...



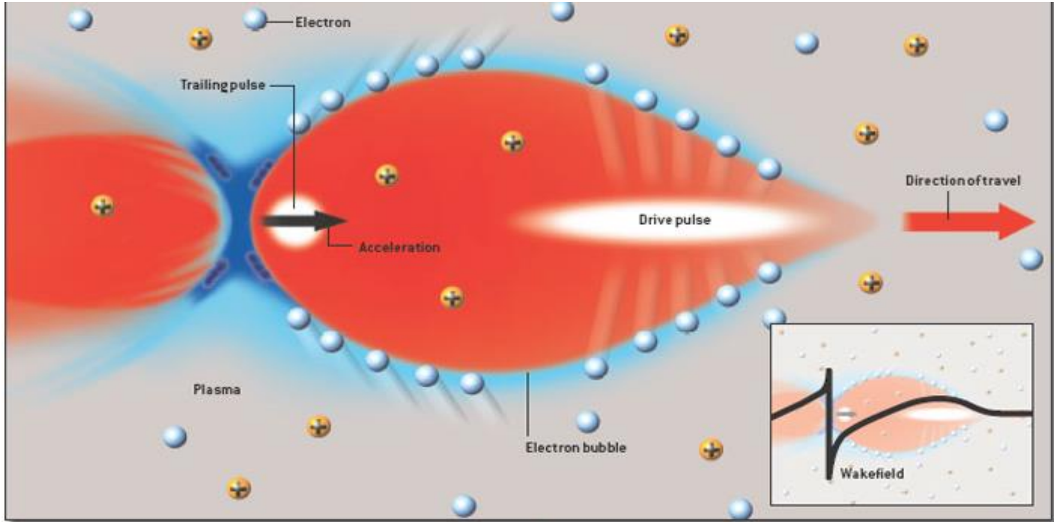
How to go to increase collision energy of constituents



VOLUME 43, NUMBER 4 PHYSICAL REVIEW LETTERS 23 JULY 1979

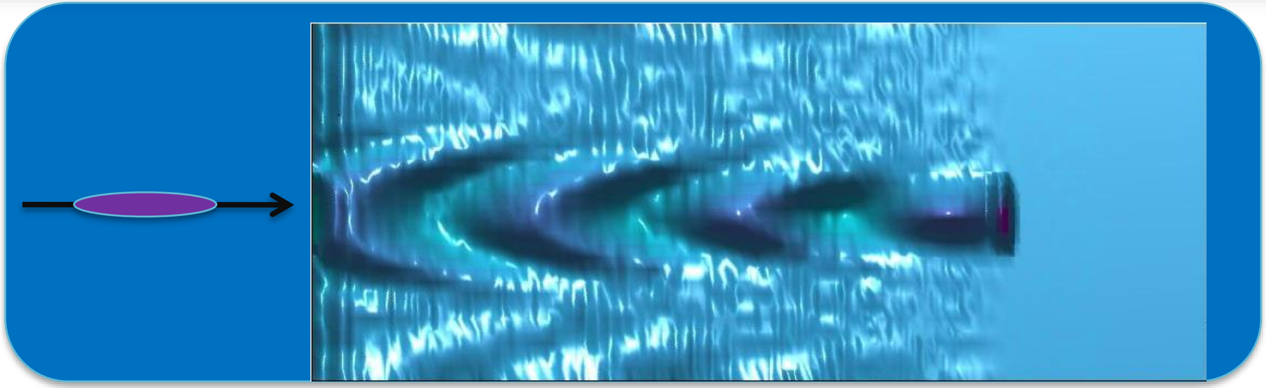
Laser Electron Accelerator

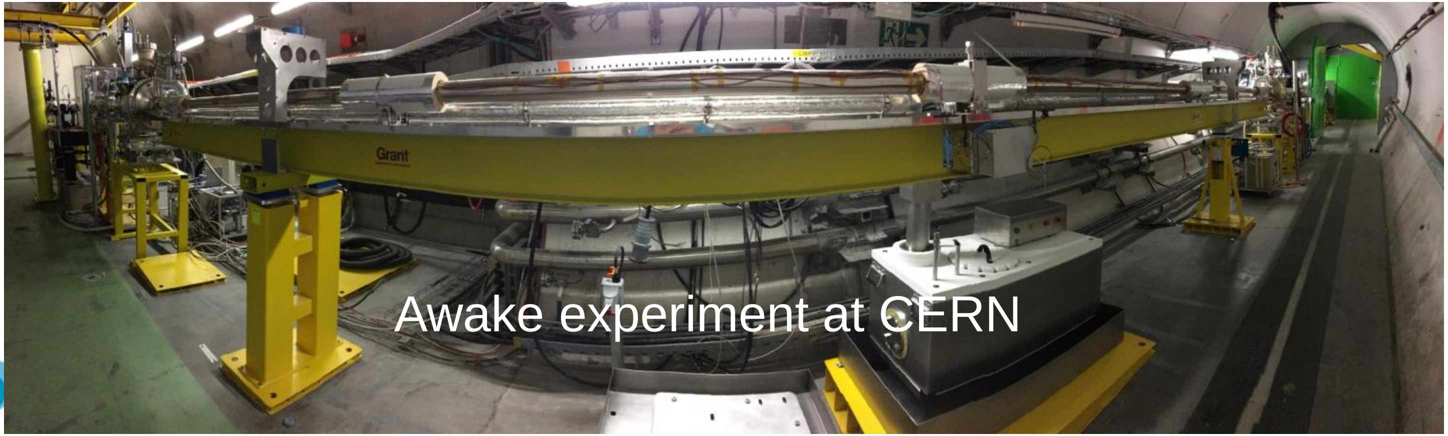
T. Tajima and J. M. Dawson
Department of Physics, University of California, Los Angeles, California 90024
(Received 9 March 1979)



Wakefield accelerator relies on a charge disturbance known as a wakefield to provide the driving force. The drive pulse, which can be a short pulse of either a laser (LWFA) or an electron beam (PWFA), blows the electrons (blue) in an ionized gas, or plasma, outward, leaving behind a region of positive charge (red). Along the axis where the beam propagates, the electric field (plotted below) causes a trailing pulse of electrons injected near the rear of the bubble to feel a very strong forward acceleration.

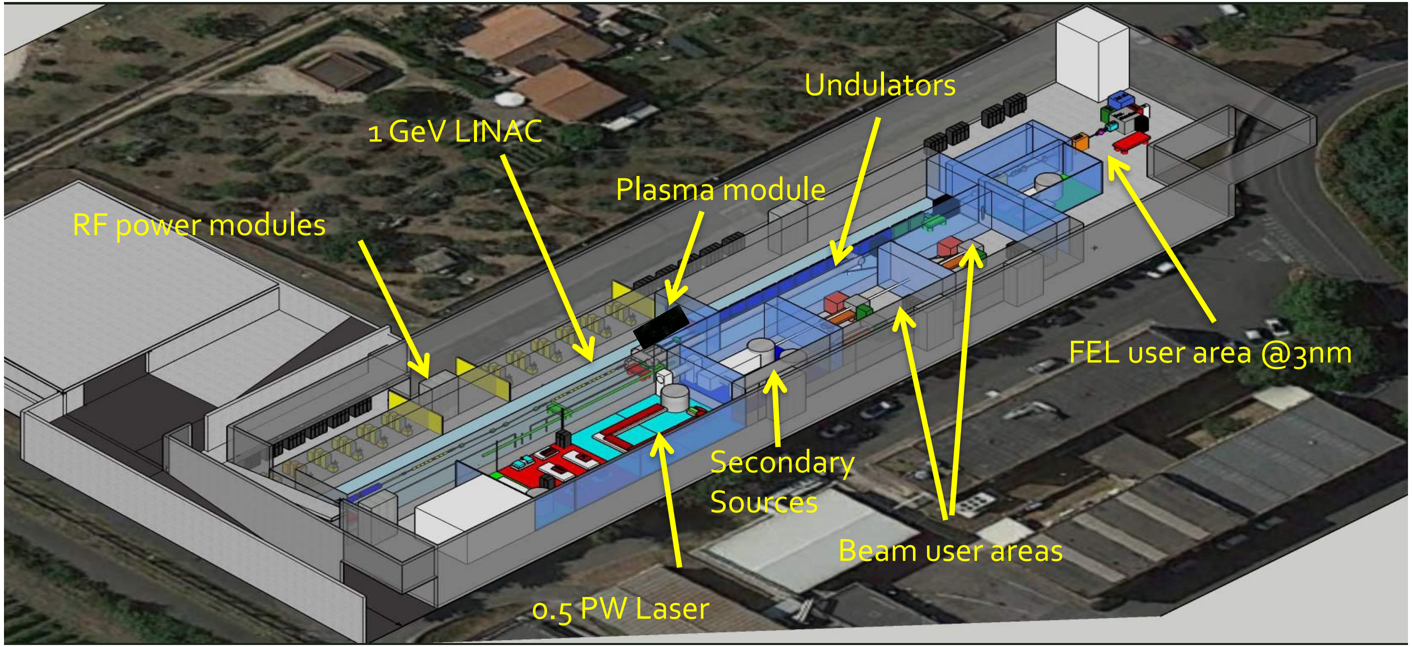
Plasma acceleration: 1000 times smaller… Or 1000 times more powerful?



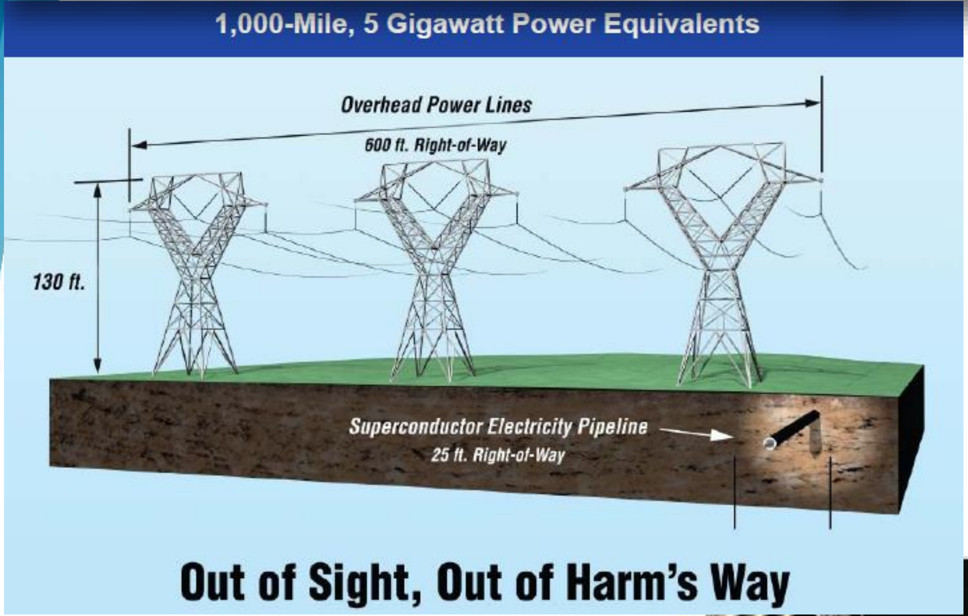


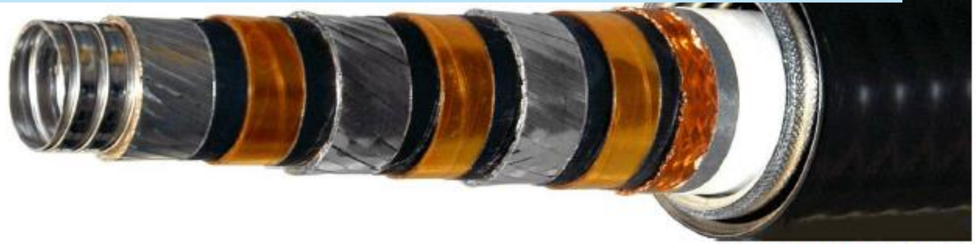
Awake experiment at CERN

EuPRAXIA@SPARC_LAB

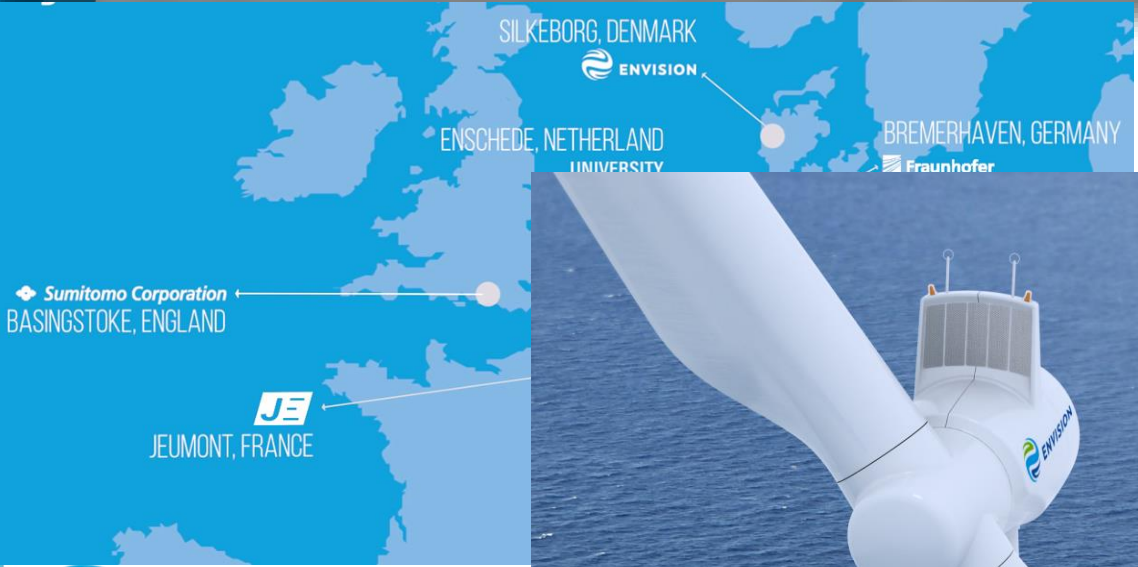


SC and Renewable Energy Technology: Transmission




Courtesy Southwire Company

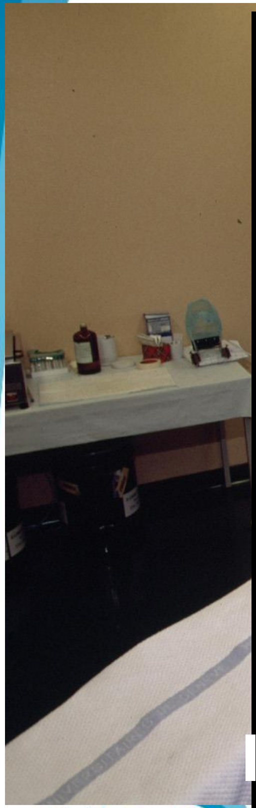
SC and Renewable Energy Technology: wind genrators



ecoswing

AMSC SeaTitan Wind Turbine Generator
Image courtesy of American Superconductor

New medical «eyes»: PET



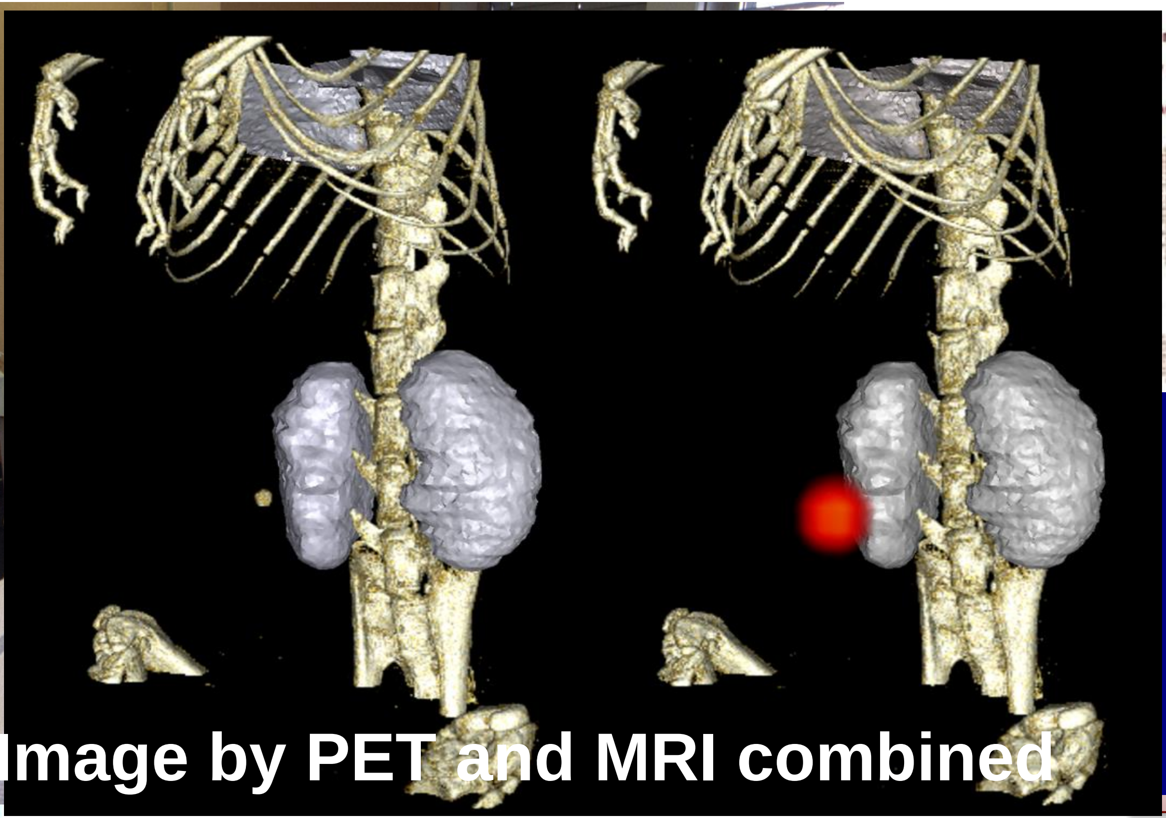
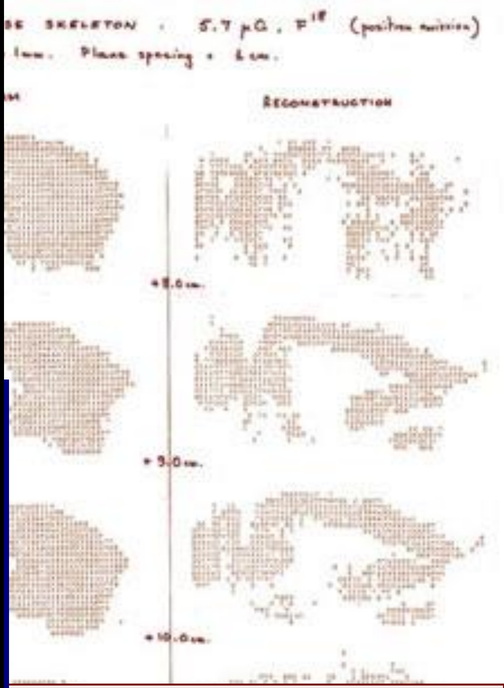


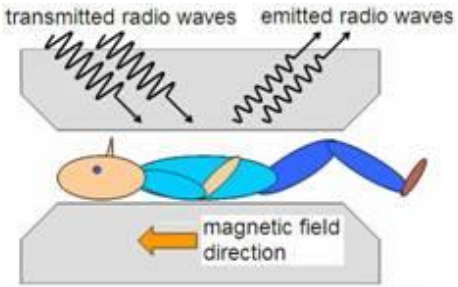
Image by PET and MRI combined

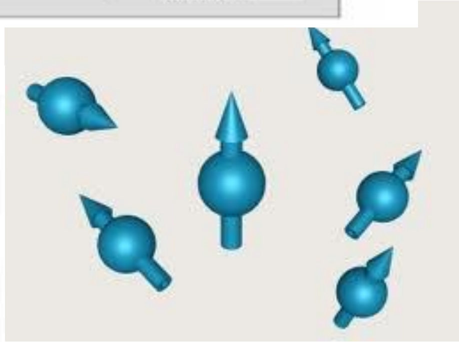


First PET image: CERN, circa 1975

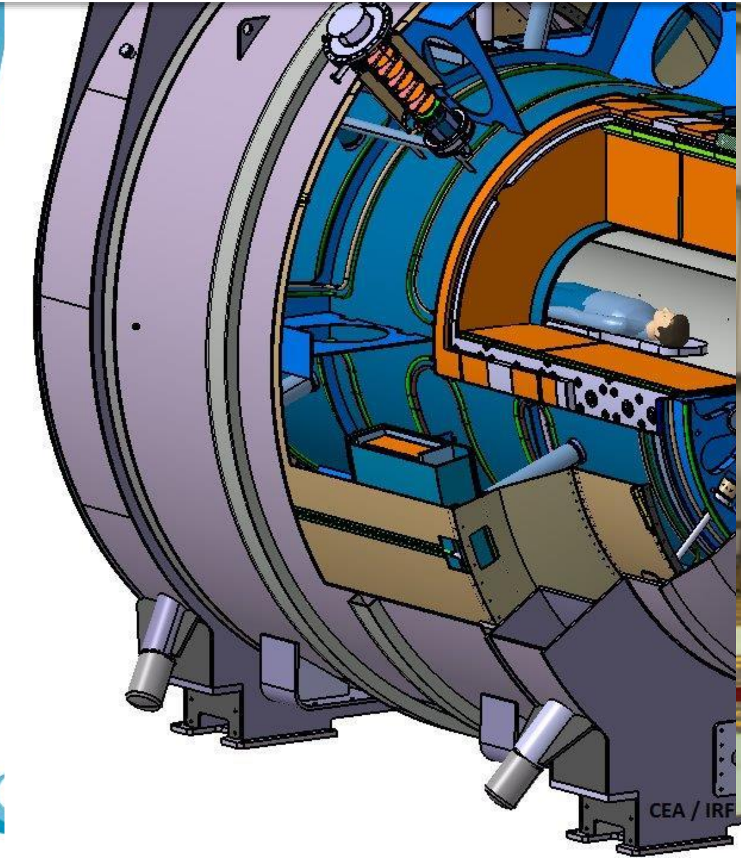
New medical «eyes»: MRI, 2000 large systems/year

An example of an MRI brain scan
Image courtesy of Scott Camazine, MD





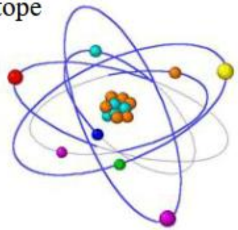
Largest MRI for research: Iseult Magnet for 11.7 T, now under commissioning at Neurospin center in CEA Saclay (Paris)
FUNCTIONAL MRI: breakthrough in cerebral functions



Production of radioisotopes for PET is critical

Radioisotopes in Nuclear medicine

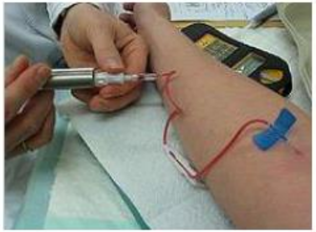
Radioisotope



Radiopharmacy

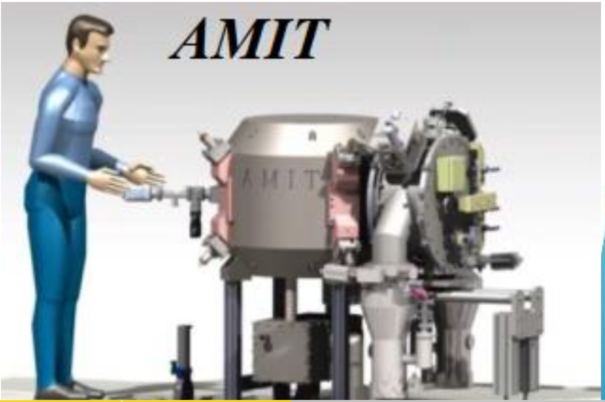
Radiopharmaceutical

A ^{11}C labeled radiopharmaceutical



Localized in some organs or tumors

Last decade crisis in reactor-production



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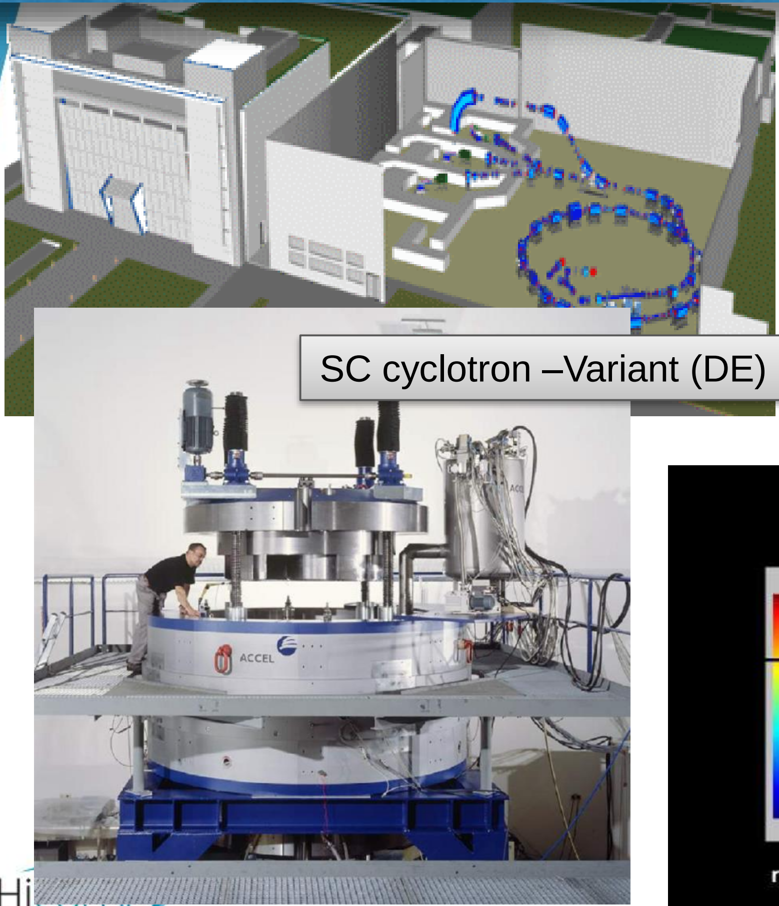
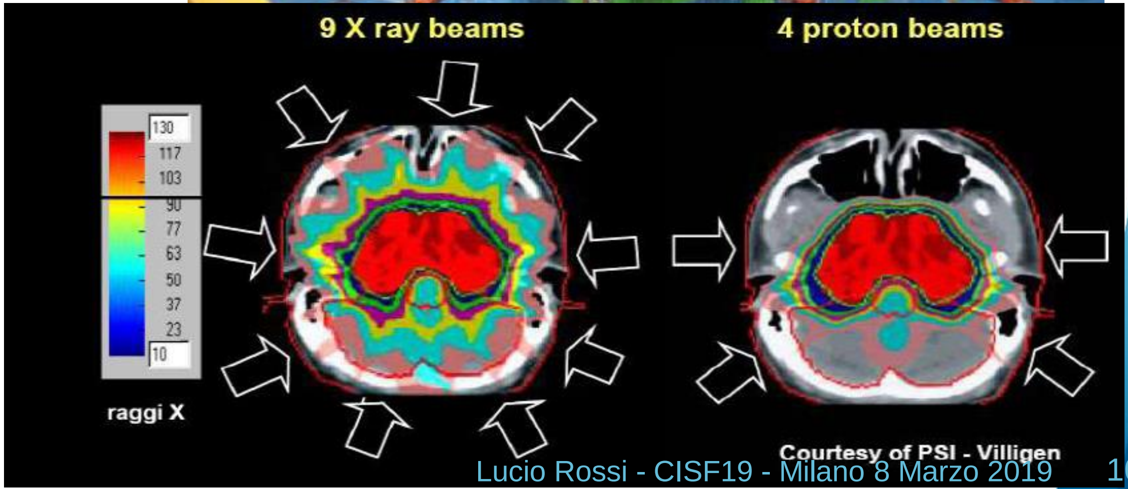
HiLumi HL-LHC PROJECT

Hadron therapy



SC cyclotron –Variant (DE)

Synchrotron in Pavia (CNAU), IT



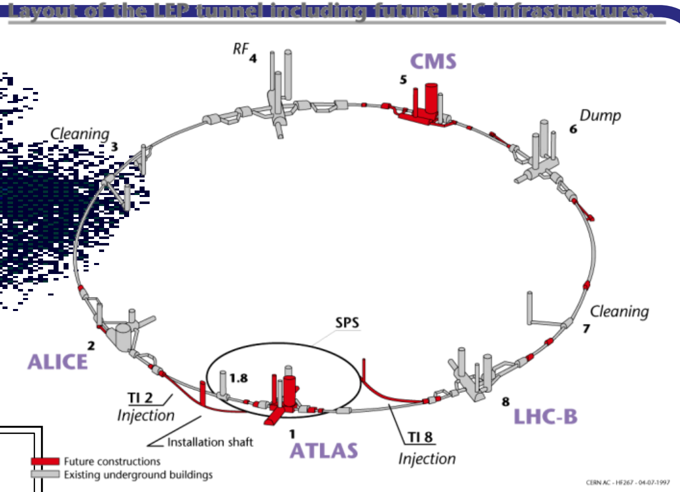
La complessità dei rapporti: LHC

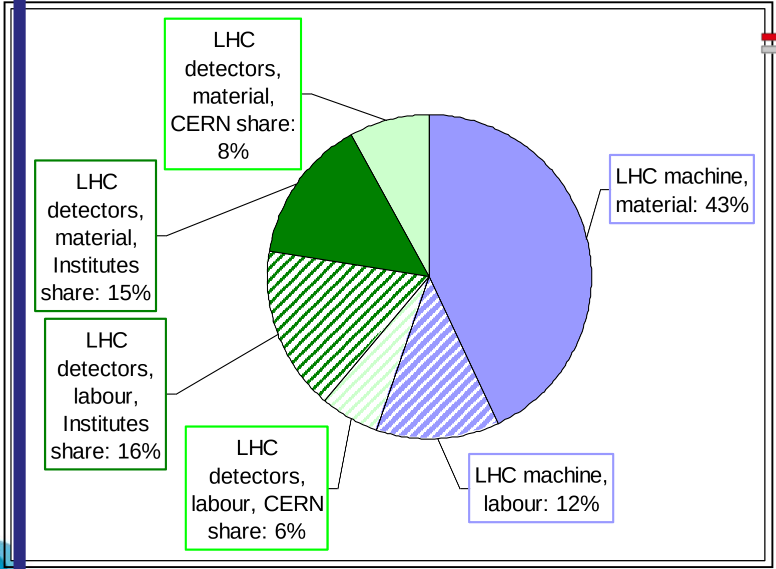
- 500 persone lavorano strettamente sull’anello principale; circa 100 in piu’in altri laboratori
- Altre 500 sul complesso di iniettori e altri servizi tecnici
- Circa 500 per i rivelatori; altri 1500 in altri laboratori e nelle università.
- Certo è molto diverso da quando uno scienziato o un piccolo team di 2-3 ricercatori progetta, costruisce, esegue e analizza un esperimento!

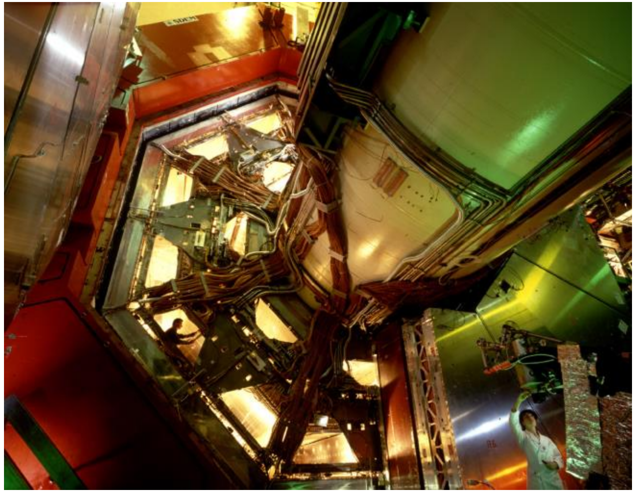
HiLumi
HL-LHC PROJECT

I costi!!

- HL-LHC TOTAL cost incl. ovrh
- 2500 M€ costi (Mach + detect)
- La macchina circa 1500 M€







Alcune novità (?) nei progetti di ricerca

- Attenzione ai costi fino allo spasimo
  - Non basta diminuire il costo iniziale
  - Controlli lungo tutto il progetto
  - Non si riesce piu' a succhiare dal budget ordinario
- E' ancora ricerca? E' ancora entusiasmante?

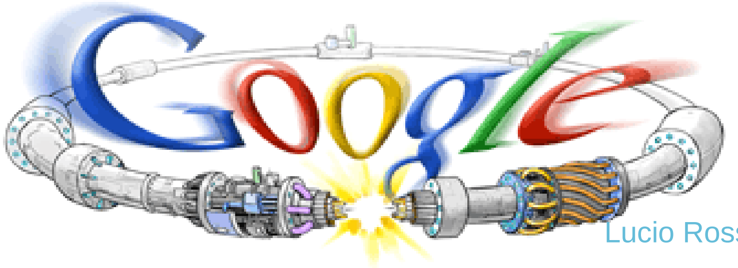
- La responsabilità è molto diluita (eccetto forse ai vertici ?) $\Rightarrow$ meetings!!
- L'aspetto dell'integrazione sia di diverse discipline che personale è molto importante, al punto da rischiare di oscurare l'aspetto di creatività

Cerchi sempre di considerarti «unico»

The Magnet team (with DG!) at the end of LHC magnet Production

The HiLumi team at the collaboration meeting 2018 - CERN

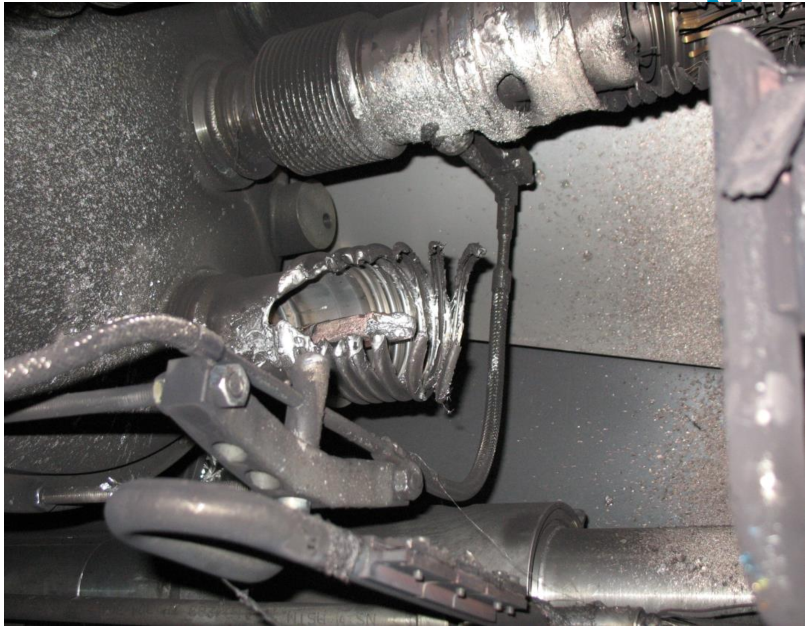
10 settembre 2008: la riuscita

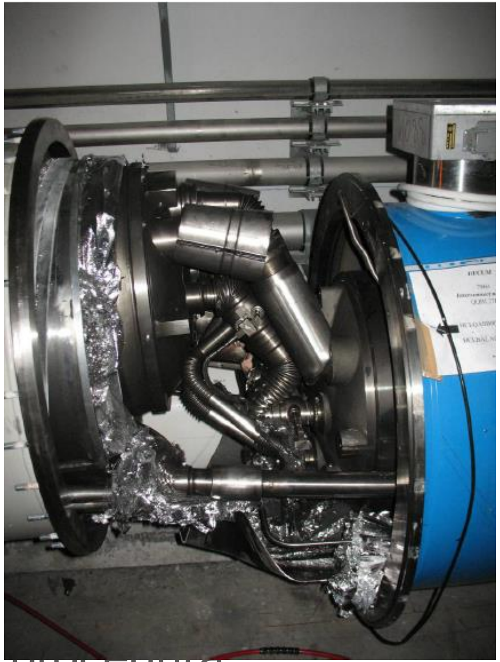


19 settembre 2008:
Il grande guasto: interconnesione

Vedere articolo su http://www.ilsussidiario.net/articolo.aspx?articolo=48957

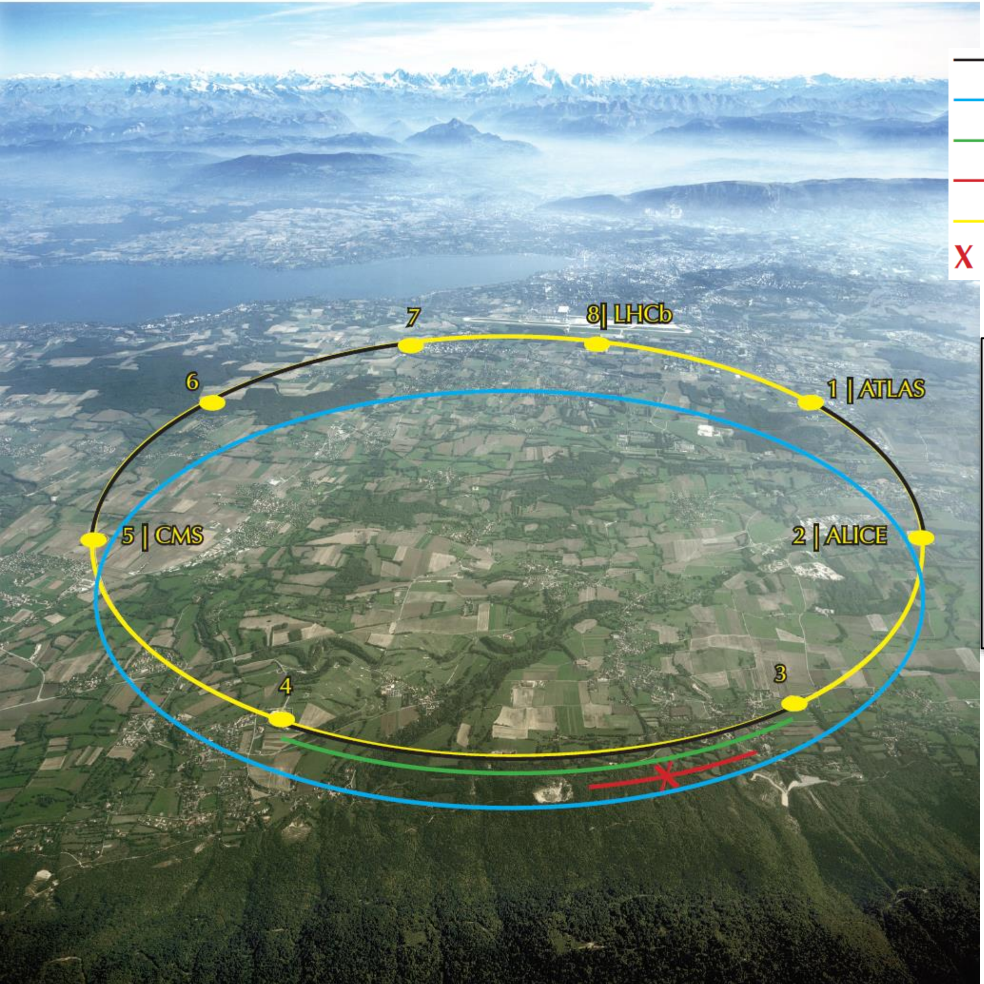
Danni ingenti





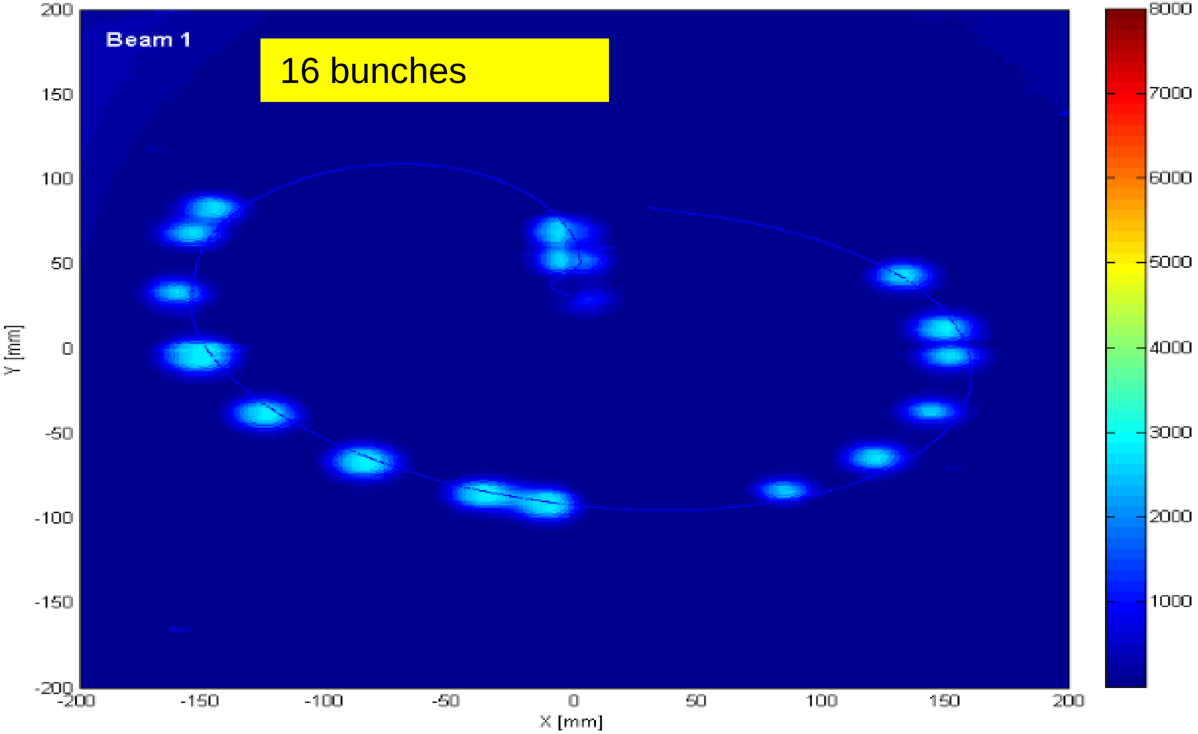
- Un design poco robusto contro difetti di procedura
- Difetti procedura non identificati dal QA
- Mancanza di occhi (diagnostica) per vedere difetti in tempo
- Mancanza di protezione contro guasti collaterali

Dove ha luogo la riparazione



La ripresa:
Coscienza che il bene comune è il solo modo per affermarsi veramente
In questo anche l’errore non è una barriera ma una spinto per andare oltre…

LHC: la ripartenza: il fascio
13 dicembre 2009 : record 2 × 1.18 TeV



L’importanza del Maestro

- Il tramandarsi una tradizione tiene viva la domanda $\Rightarrow$ grandi scuole di fisica
- **Assicura, aiuta, che l’esperienza sia un cammino verso una certezza piu’ grande con un metodo che è quello di tutte le realtà umane positive:**
- Verifica onesta: esperienza
- Dedizione, affezione
- Capacità di lavorare insieme
- Confronto tra l’esperienza e l’ipotesi
- Condivisione risultati: da questo la domanda si alimenta

Thanks!
Questions?