ATLAS @ LHC, a new level of complexity

Marzio Nessi, CERN

~ 20 years ago we started dreaming about TeV Collisions and the LHC project started

My goal today is to share with you some feelings about this adventure and might be give you my memory on the way we have realized it over the years

By no means I would like to give you the impression that I am trying to give a lecture. I think there are no rules in this fields, imagination and creativity come first

Nevertheless I hope at the end you will get the feeling that such enterprises are not random events, but are the results of visions and a lot of care! Might be some of this might inspire you in your new adventure!

✓ Today we are able to answer questions we were not able to formulate 25-30 years ago when I was a student:

- What is dark matter? How is it distributed in the universe?
- Is there an other level of constituents?
- Why mass?
- Is our understanding of general relativity correct at all scales?
- Will quantum mechanics fail at very short distances?
- Origin of CP violation of baryons, what about the proton lifetime?
- ….

✓ *The more we progress, the longer will be the gap between the reformulation of the fundamental questions in our understanding of nature and its complexity. This gap is already ~ equal to the useful professional lifetime of a human being. Experimental projects are getting very complex!*

Standard Model of

FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model summarizes the current knowledge in Particle Physics. It is the quantum theory that includes the theory of strong interactions (quantum chromodynamics or QCD) and the unified theory of weak and electromagnetic interactions (electroweak). Gravity is included on this chart because it is one of the fundamental interactions even though not part of the "Standard Model."

FERMIONS matter constituents spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor	Mass GeV/c²	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0
e electron	0.000511	–1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	–1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	–1

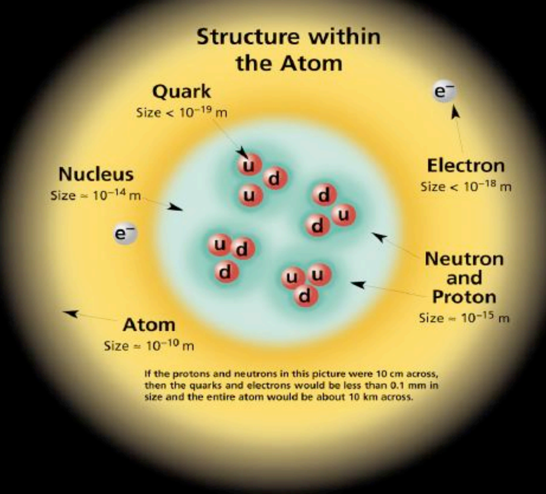
Quarks spin = 1/2

Flavor	Approx. Mass GeV/c²	Electric charge
u up	0.003	2/3
d down	0.006	–1/3
c charm	1.3	2/3
s strange	0.1	–1/3
t top	175	2/3
b bottom	4.3	–1/3

Spin is the intrinsic angular momentum of particles. Spin is given in units of $\hbar$, which is the quantum unit of angular momentum, where $\hbar = h/2\pi = 6.58\times10^{-25}$ GeV s $= 1.05\times10^{-34}$ J s.

Electric charges are given in units of the proton's charge. In SI units the electric charge of the proton is 1.60×10^{-19} coulombs.

The **energy** unit of particle physics is the electronvolt (eV), the energy gained by one electron in crossing a potential difference of one volt. **Masses** are given in GeV/c^2 (remember $E = mc^2$), where 1 GeV $= 10^9$ eV $= 1.60\times10^{-10}$ joule. The mass of the proton is 0.938 GeV/c^2 $= 1.67\times10^{-27}$ kg.



If the protons and neutrons in this picture were 10 cm across, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

BOSONS force carriers spin = 0, 1, 2, ...

Unified Electroweak spin = 1

Name	Mass GeV/c²	Electric charge
γ photon	0	0
W^-	80.4	–1
W^+	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1

Name	Mass GeV/c²	Electric charge
g gluon	0	0

Color Charge

Each quark carries one of three types of "strong charge," also called "color charge." These charges have nothing to do with the colors of visible light. There are eight possible types of color charge for gluons. Just as electrically-charged particles interact by exchanging photons, in strong interactions color-charged particles interact by exchanging gluons. Leptons, photons, and ***W*** and ***Z*** bosons have no strong interactions and hence no color charge.

Quarks Confined in Mesons and Baryons

One cannot isolate quarks and gluons; they are confined in color-neutral particles called **hadrons**. This confinement (binding) results from multiple exchanges of gluons among the color-charged constituents. As color-charged particles (quarks and gluons) move apart, the energy in the color-force field between them increases. This energy eventually is converted into additional quark-antiquark pairs (see figure below). The quarks and antiquarks then combine into hadrons; these are the particles seen to emerge. Two types of hadrons have been observed in nature: **mesons** $q\bar{q}$ and **baryons** qqq.

Residual Strong Interaction

The strong binding of color-neutral protons and neutrons to form nuclei is due to residual strong interactions between their color-charged constituents. It is similar to the residual electrical interaction that binds electrically neutral atoms to form molecules. It can also be viewed as the exchange of mesons between the hadrons.

PROPERTIES OF THE INTERACTIONS

Property \ Interaction	Gravitational	Weak (Electroweak)	Electromagnetic (Electroweak)	Strong: Fundamental	Strong: Residual
Acts on:	Mass – Energy	Flavor	Electric Charge	Color Charge	See Residual Strong Interaction Note
Particles experiencing:	All	Quarks, Leptons	Electrically charged	Quarks, Gluons	Hadrons
Particles mediating:	Graviton (not yet observed)	W^+ W^- Z^0	γ	Gluons	Mesons
Strength relative to electromag for two u quarks at: 10^{-18} m	10^{-41}	0.8	1	25	Not applicable to quarks
Strength relative to electromag for two u quarks at: 3×10^{-17} m	10^{-41}	10^{-4}	1	60	
for two protons in nucleus	10^{-36}	10^{-7}	1	Not applicable to hadrons	20

Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$

Baryons are fermionic hadrons.
There are about 120 types of baryons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c²	Spin
p	proton	uud	1	0.938	1/2
$\bar{p}$	anti-proton	$\bar{u}\bar{u}\bar{d}$	–1	0.938	1/2
n	neutron	udd	0	0.940	1/2
Λ	lambda	uds	0	1.116	1/2
Ω^-	omega	sss	–1	1.672	3/2

Mesons $q\bar{q}$

Mesons are bosonic hadrons.
There are about 140 types of mesons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c²	Spin
π^+	pion	$u\bar{d}$	+1	0.140	0
K^-	kaon	$s\bar{u}$	–1	0.494	0
ρ^+	rho	$u\bar{d}$	+1	0.770	1
B^0	B-zero	$d\bar{b}$	0	5.279	0
η_c	eta-c	$c\bar{c}$	0	2 .980	0

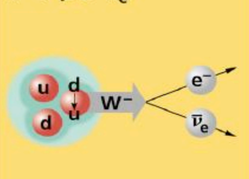
Matter and Antimatter

For every particle type there is a corresponding antiparticle type, denoted by a bar over the particle symbol (unless + or – charge is shown). Particle and antiparticle have identical mass and spin but opposite charges. Some electrically neutral bosons (e.g., Z^0, γ, and $\eta_c = c\bar{c}$, but not $K^0 = d\bar{s}$) are their own antiparticles.

Figures

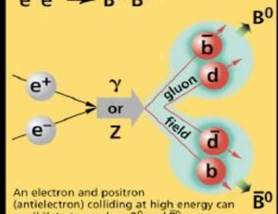
These diagrams are an artist's conception of physical processes. They are ***not*** exact and have ***no*** meaningful scale. Green shaded areas represent the cloud of gluons or the gluon field, and red lines the quark paths.

$n \rightarrow p\, e^-\, \bar{\nu}_e$



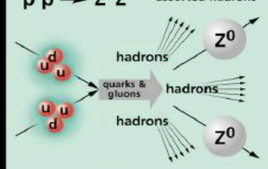
A neutron decays to a proton, an electron, and an antineutrino via a virtual (mediating) W boson. This is neutron β decay.

$e^+e^- \rightarrow B^0\, \bar{B}^0$



An electron and positron (antielectron) colliding at high energy can annihilate to produce B^0 and $\bar{B}^0$ mesons via a virtual Z boson or a virtual photon.

$p\, p \rightarrow Z^0 Z^0$ + assorted hadrons



Two protons colliding at high energy can produce various hadrons plus very high mass particles such as Z bosons. Events such as this one are rare but can yield vital clues to the structure of matter.

The Particle Adventure

Visit the award-winning web feature *The Particle Adventure* at
http://ParticleAdventure.org

This chart has been made possible by the generous support of:
U.S. Department of Energy
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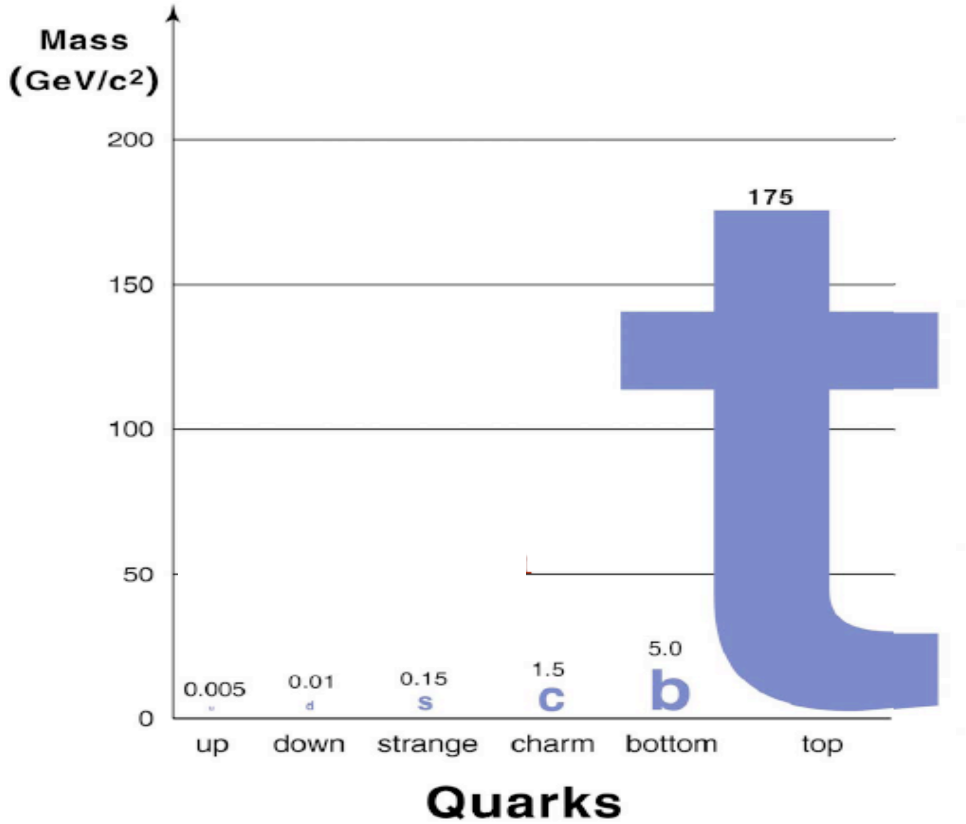
Stanford Linear Accelerator Center
American Physical Society, Division of Particles and Fields
BURLE INDUSTRIES, INC.

http://CPEPweb.org

A most basic question is why particles (and matter) have masses (and so different masses)

The mass mystery could be solved with the 'Higgs mechanism' which predicts the existence of a new elementary particle, the 'Higgs' particle (theory 1964, P. Higgs, R. Brout and F. Englert)



Peter Higgs

The Higgs (H) particle has been searched for since decades at accelerators, but not yet found…

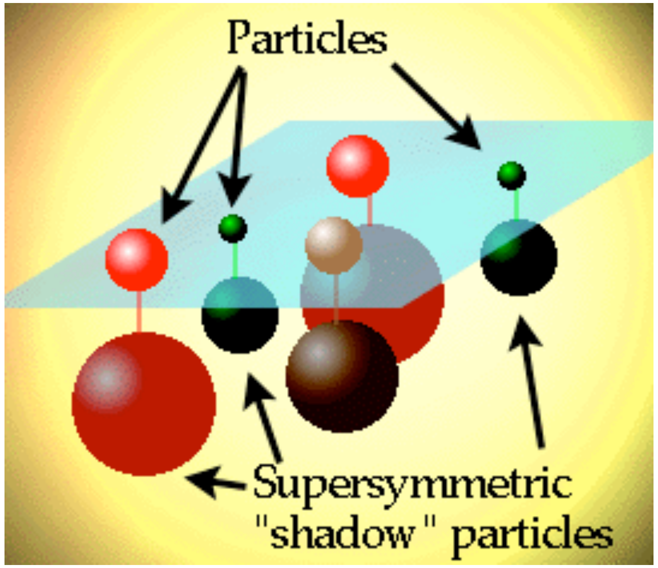
Supersymmetry (SUSY)

Establishes a symmetry between fermions (matter) and bosons (forces):

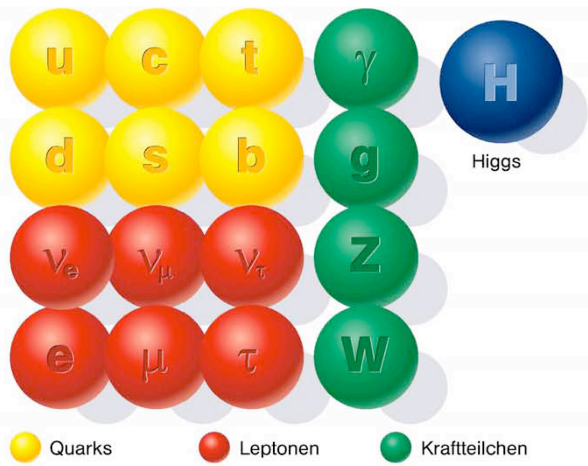
- Each particle p with spin s has a SUSY partner $\tilde{p}$ with spin s -1/2

- Examples

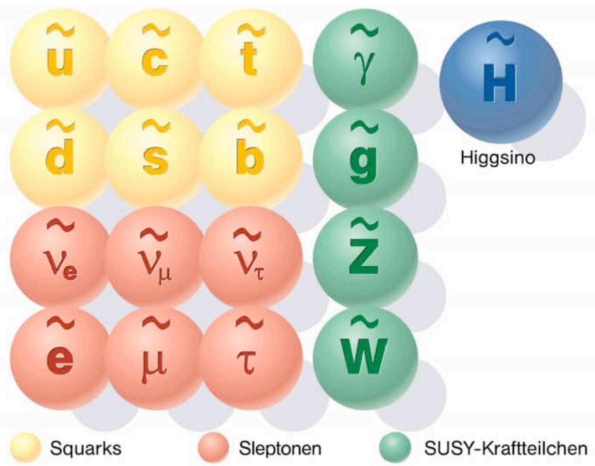
	q (s=1/2)	$\tilde{q}$ (s=0)	squark
	g (s=1)	$\tilde{g}$ (s=1/2)	gluino



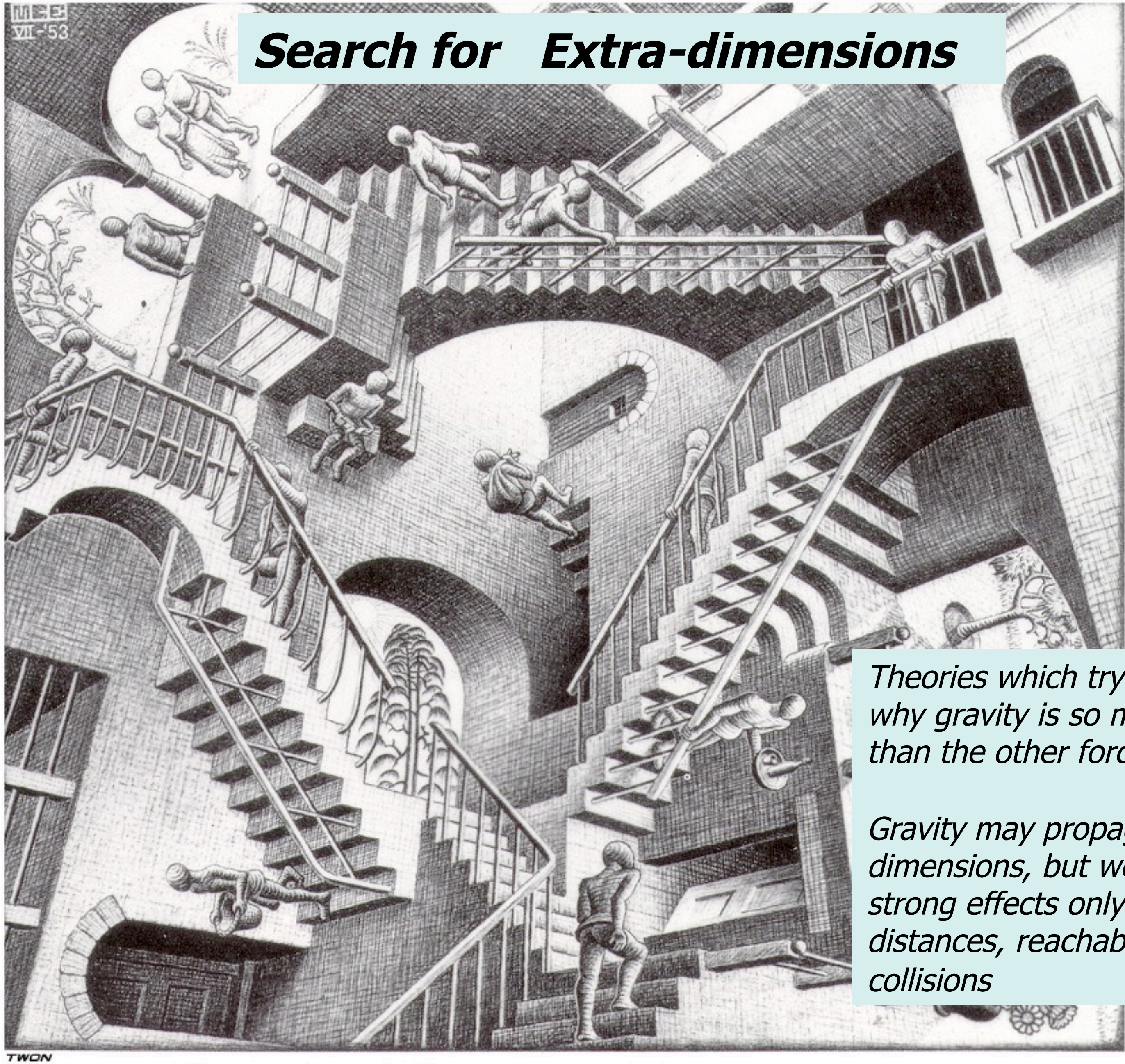
Our known world



Maybe a new world?



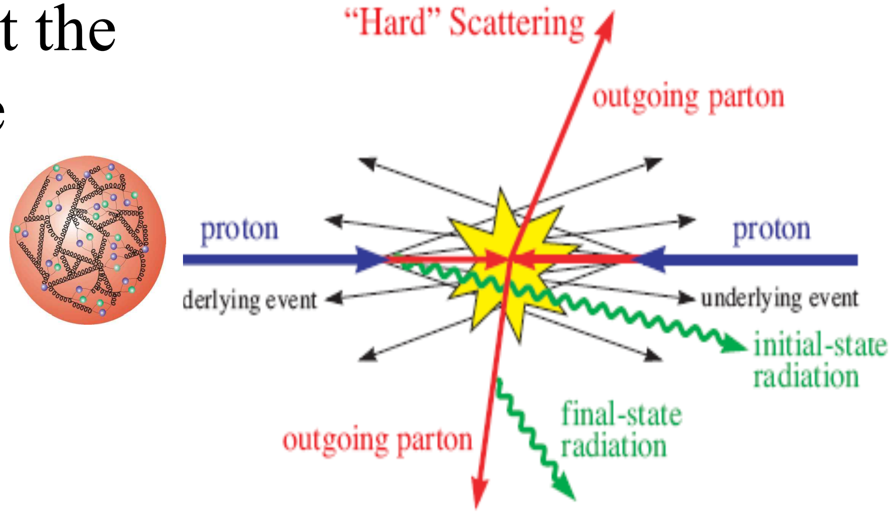
Search for Extra-dimensions

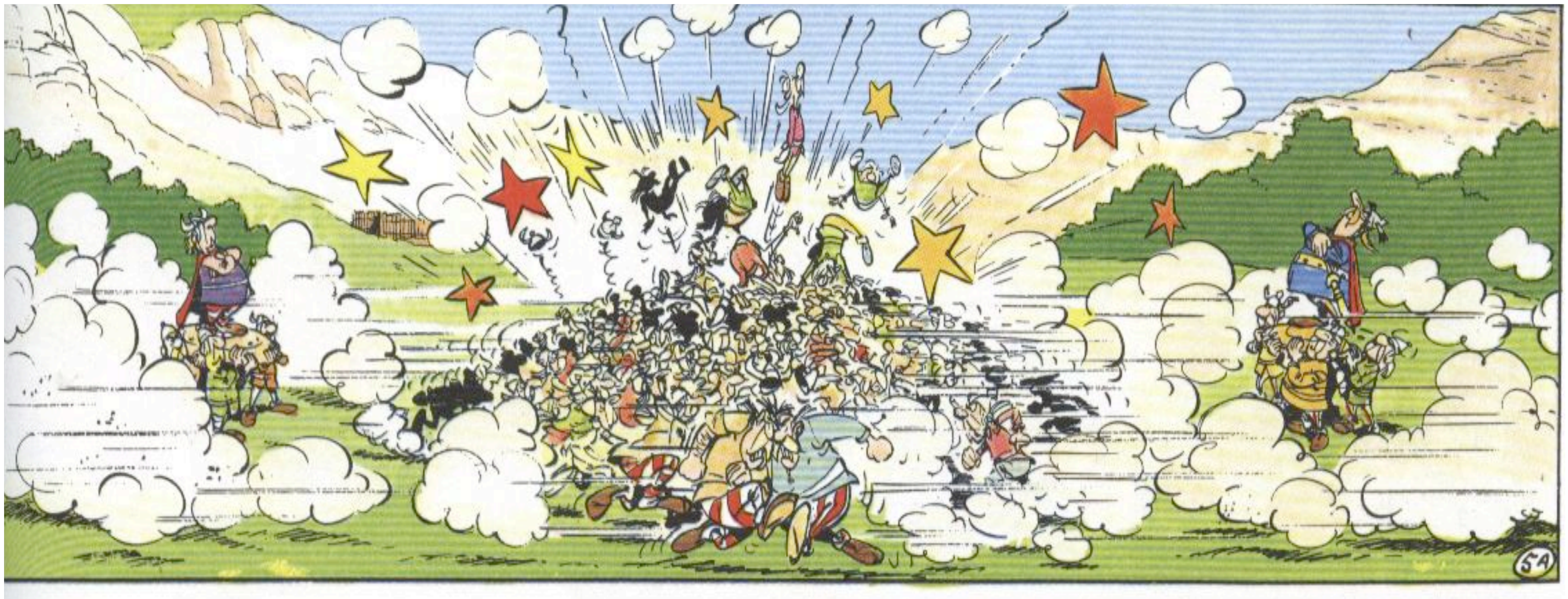


Theories which try to explain why gravity is so much weaker than the other forces

Gravity may propagate in 4+n dimensions, but we could see strong effects only at very small distances, reachable in TeV collisions

LHC project at the TeV scale





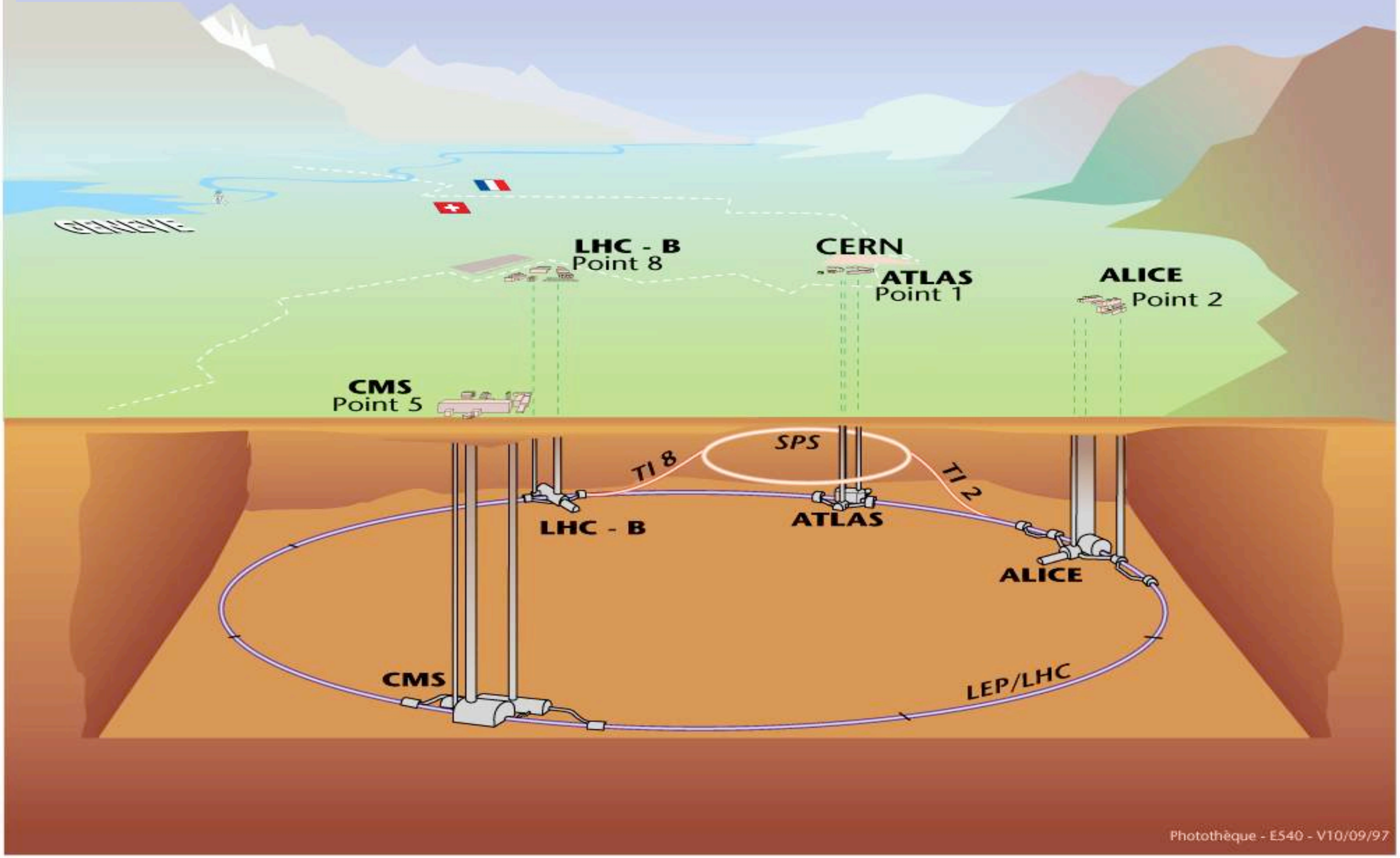
LHC Ingredients

A powerful particle accelerator to explore the TeV energy domain

Particle detectors capable of exploring the new physics reach

An host laboratory capable of handling such an infrastructure/technology

The LHC experiments (ATLAS, CMS : pp multipurpose, LHCb : b physics, ALICE : heavy ions)



What's new ?

The technical and scientific complexity. We (HEP community) have never done something so challenging (at least a factor 10 from what was done before)

The resources necessary (material and manpower) are by far too much for a local community. We speak about a global project of several billions $, with ~ 10k people directly involved and 60-70 nations participating

The time scale is very long. ~30 years from the first conceptual design, to the final data exploitation with full statistics

How to manage / organize all this?

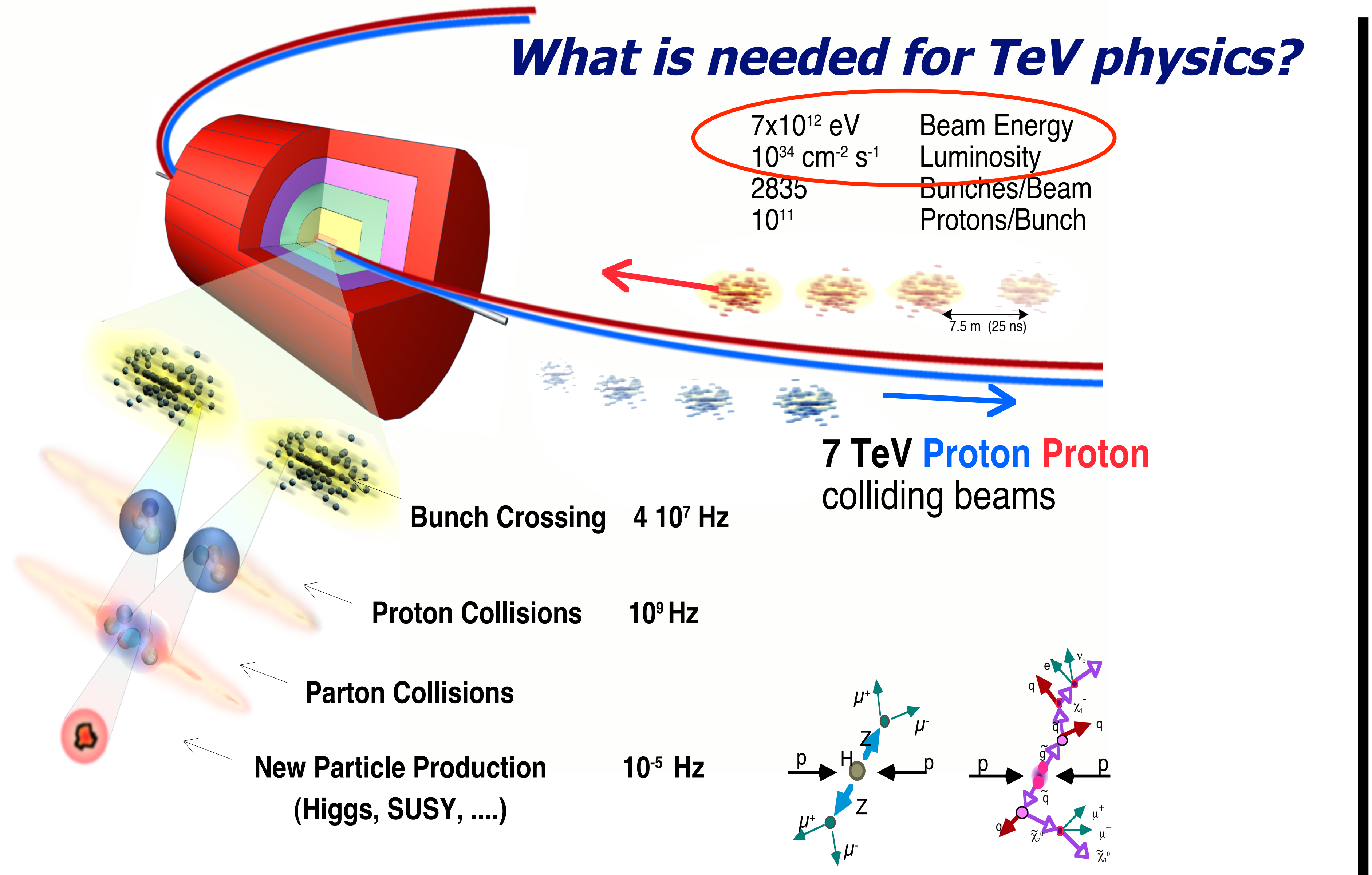
Within the LHC project we have at least 2 different basic and different approaches:

The LHC accelerator : built by CERN in cooperation with a few non CERN member state nations (Russia, US, India, ….). CERN centric management, CERN funding + special external fundings (Russia, US, …)

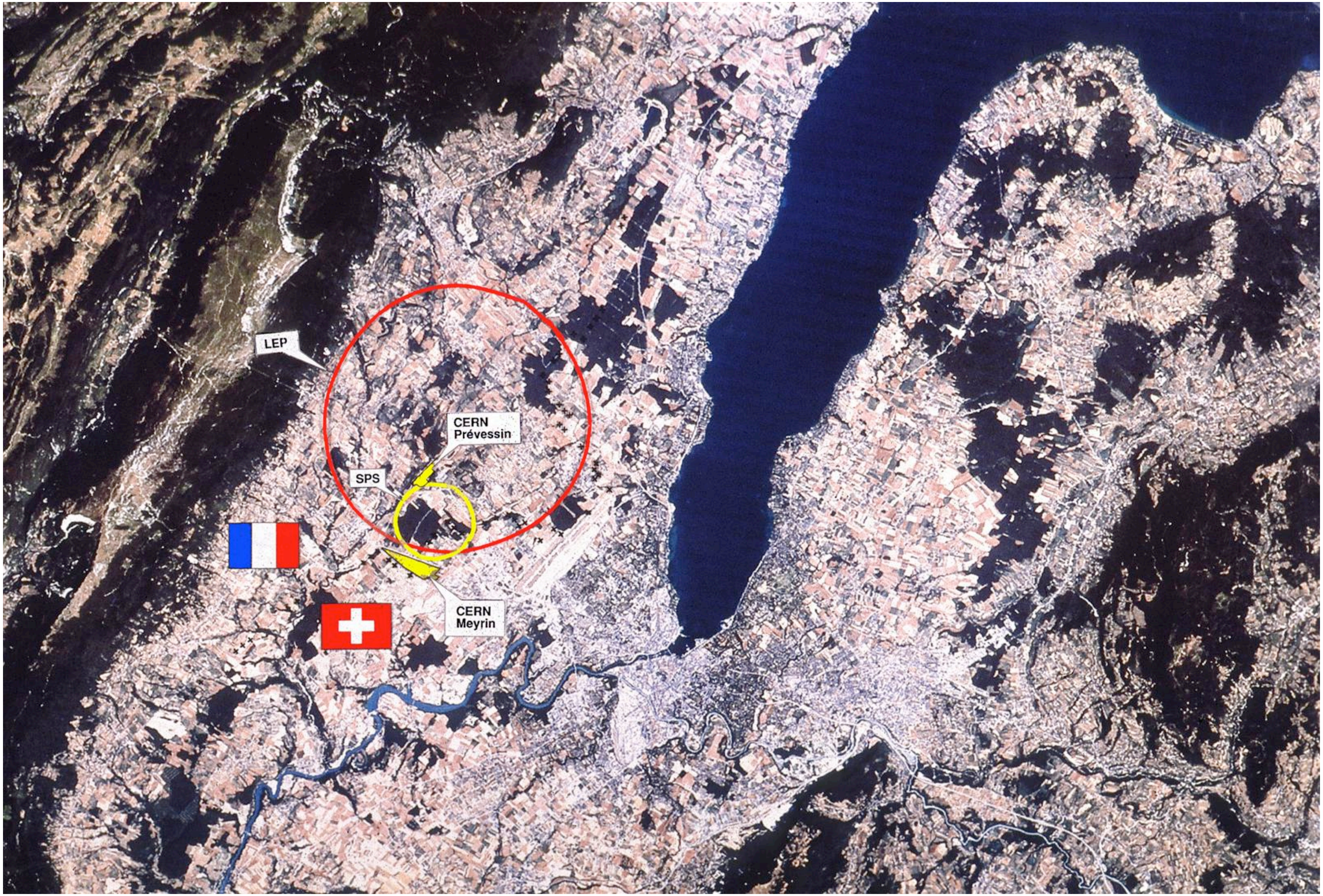
The experiments : built by international scientific collaborations, hosted by CERN as host lab. Funding 20% CERN, 80% from the participating funding agencies

The LHC technical challenge

What is needed for TeV physics?



Selection of 1 event in 10,000,000,000,000



LEP
CERN
Prévessin
SPS
CERN
Meyrin

The LHC machine

The Large Hadron Collider is a 27 km long collider ring housed in a tunnel about 100 m underground near Geneva

The full LHC accelerator complex

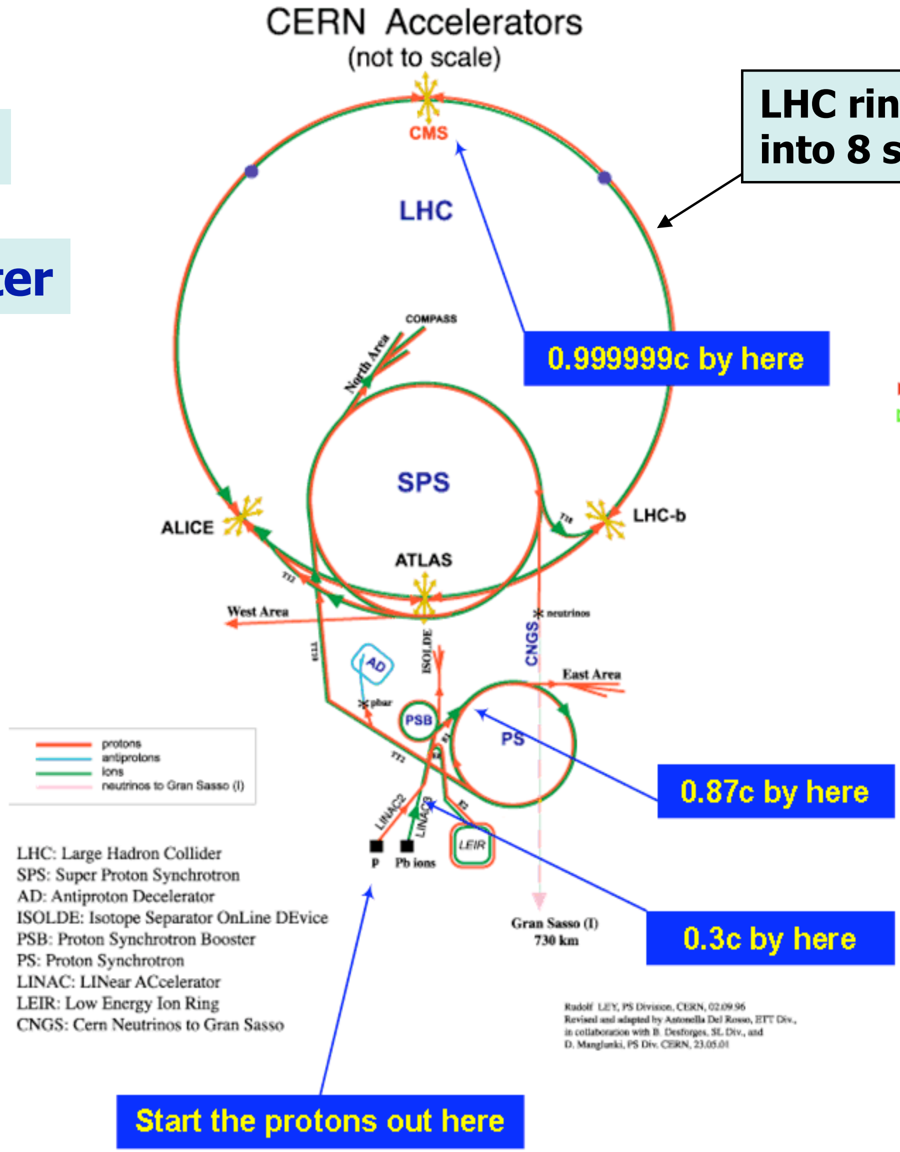
Linac

Booster

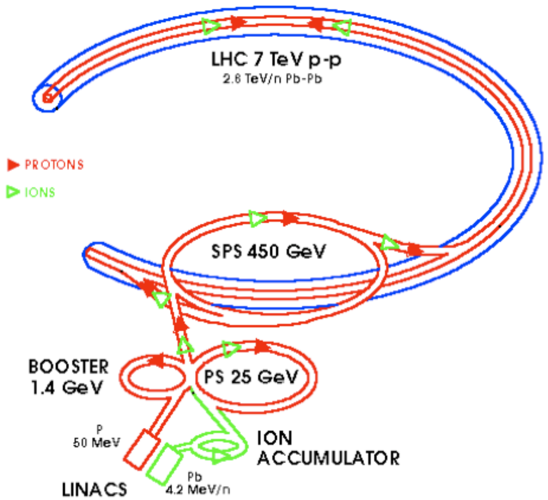
PS

SPS

LHC

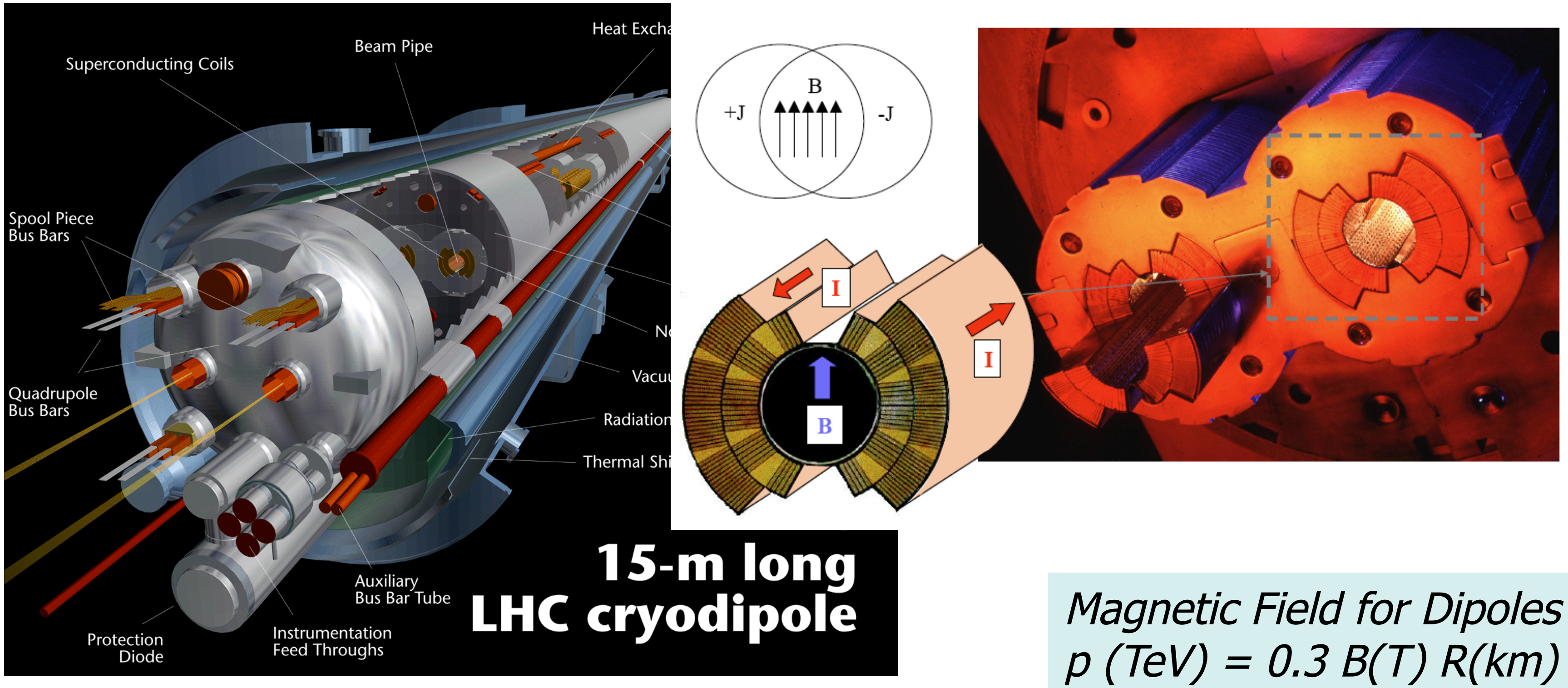


LHC ring is divided into 8 sectors



> 50 years of CERN history still alive and operational

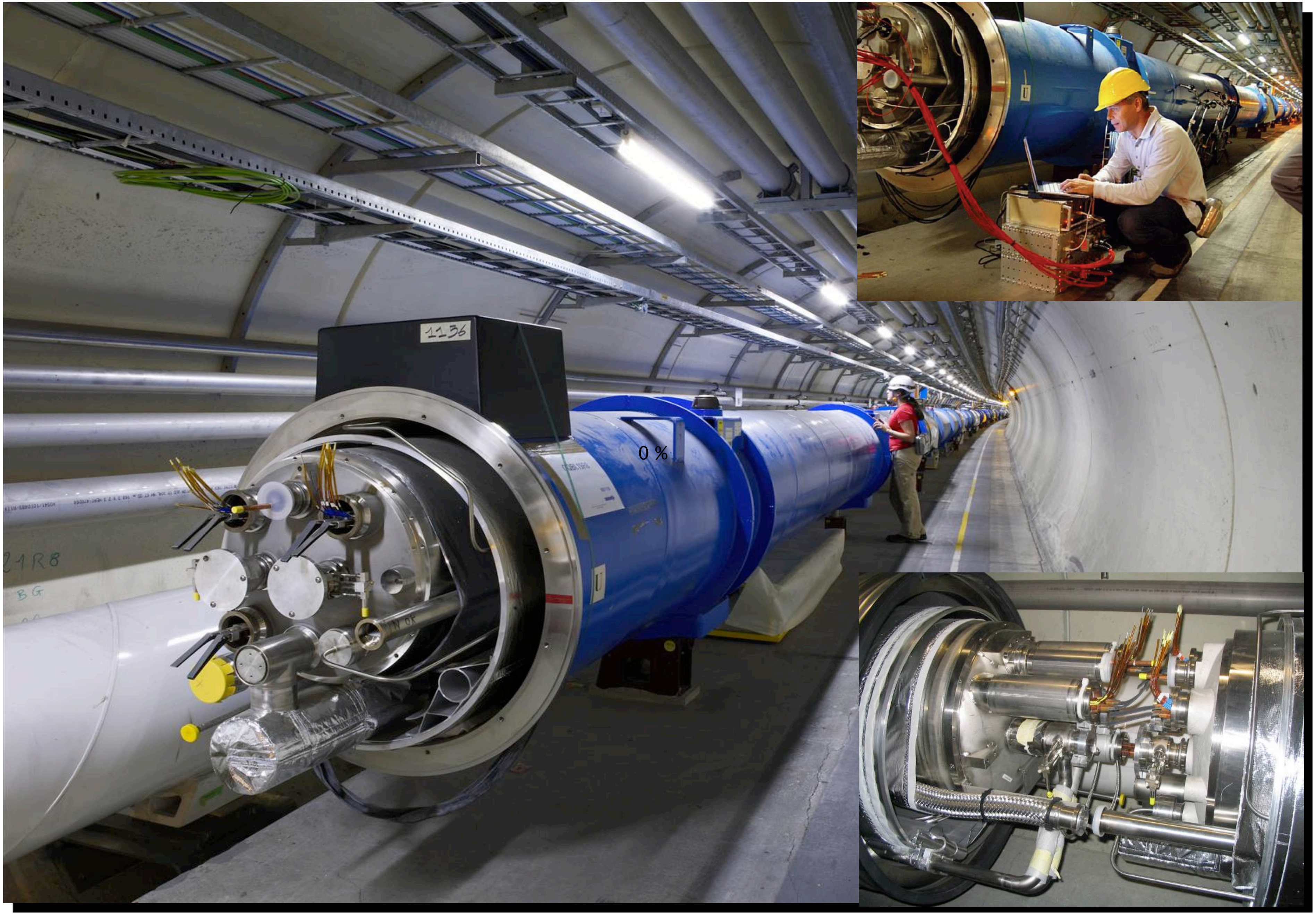
Bending Magnets



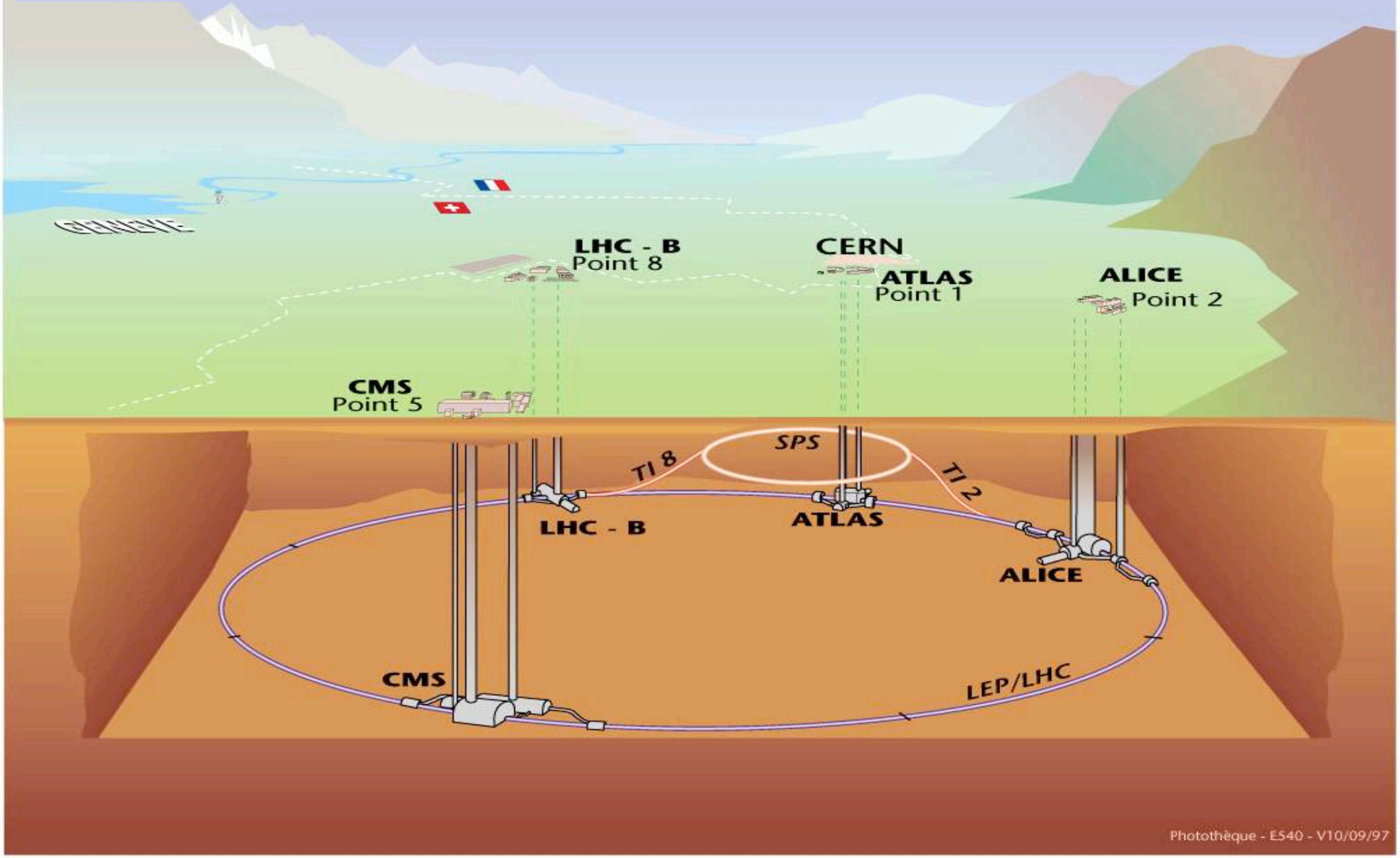
LHC magnets are cooled with pressurized superfluid helium at 1.9 K

Magnetic Field for Dipoles
p (TeV) = 0.3 B(T) R(km)

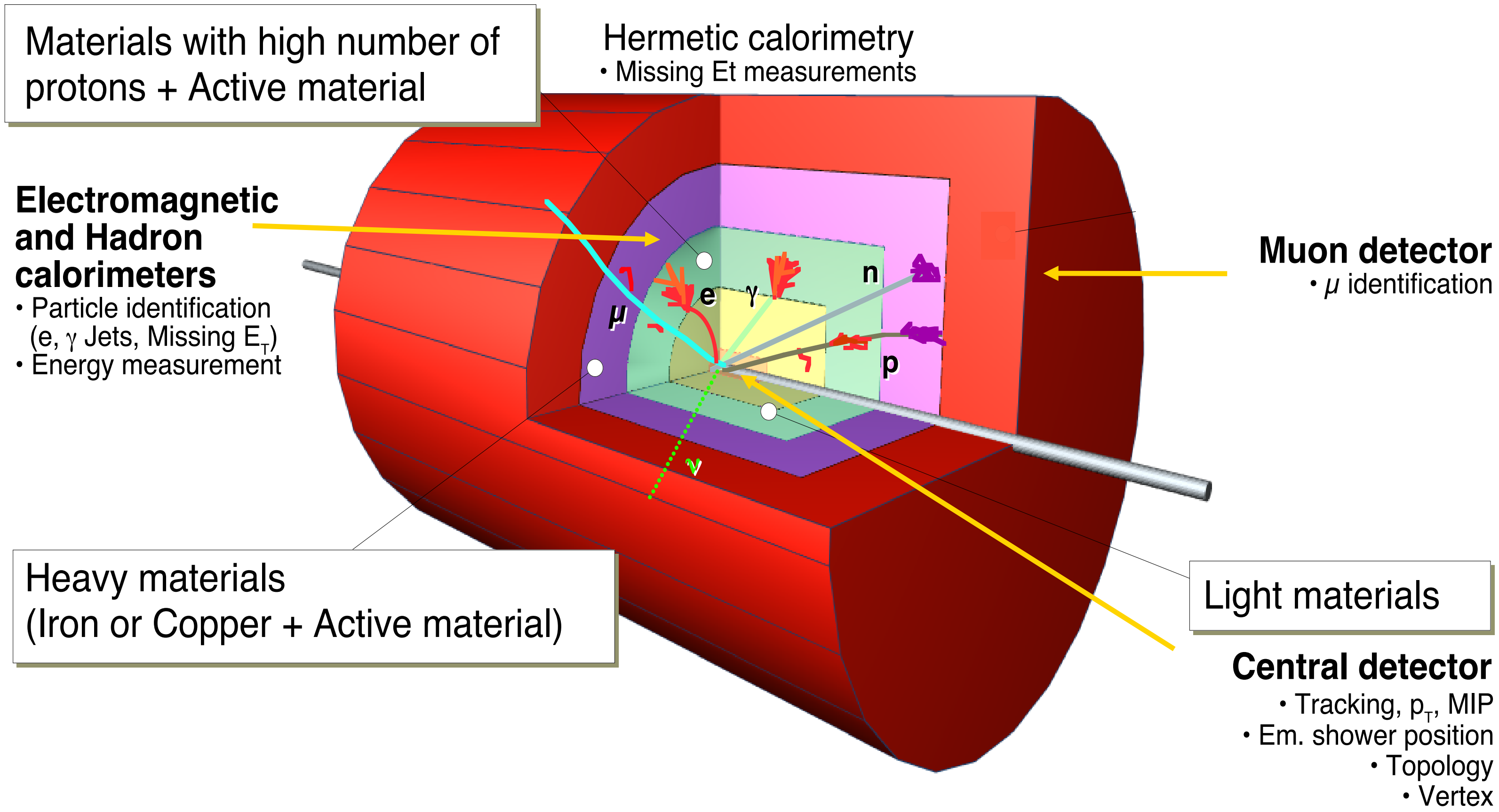
For p = 7 TeV and R = 4.3 km
⇨ B = 8.4 T
⇨ Current 12 kA


1136
0 %
21R8
BG

The LHC experiments (ATLAS, CMS : pp multipurpose, LHCb : b physics, ALICE : heavy ions)

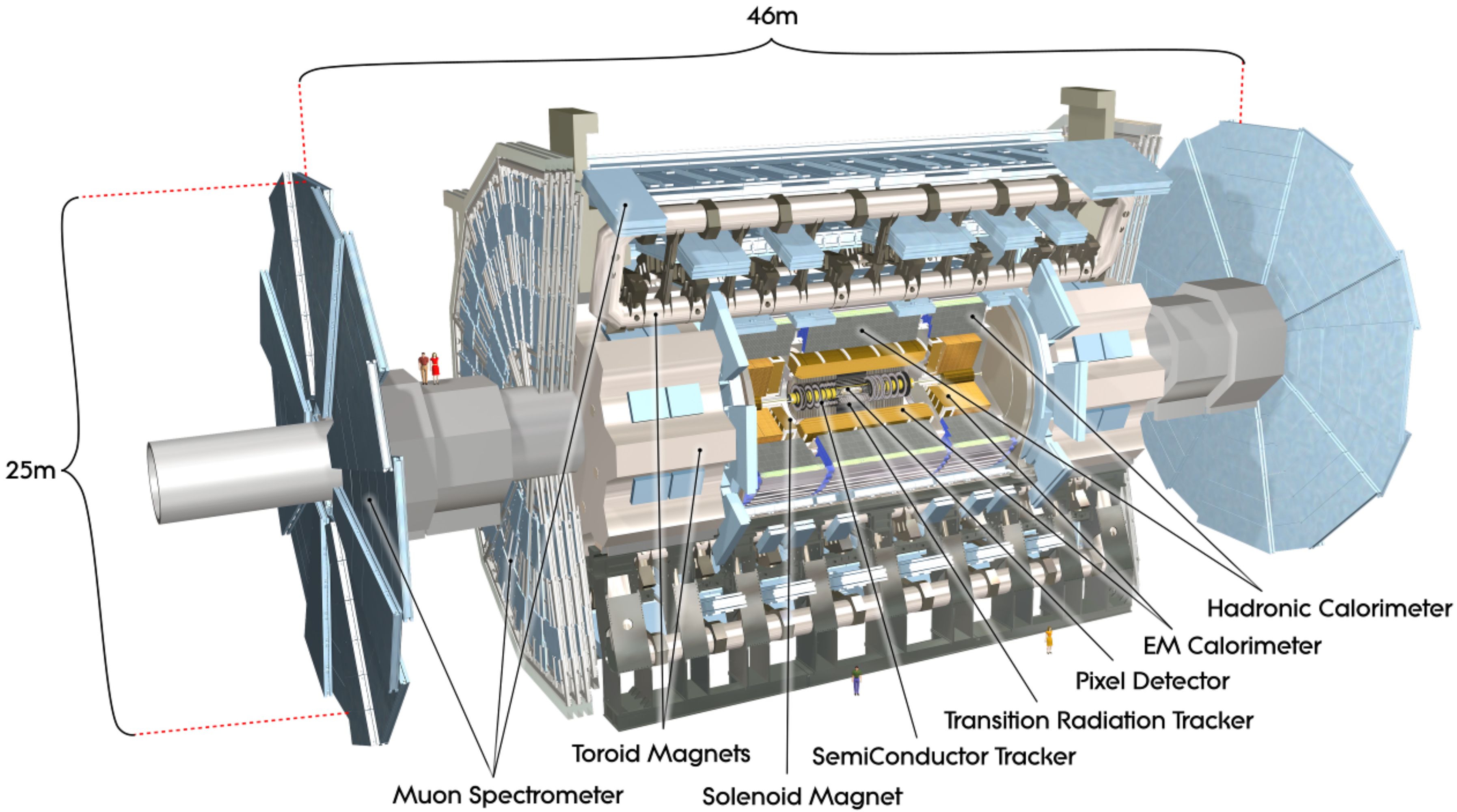


Typical elements of a collider detector

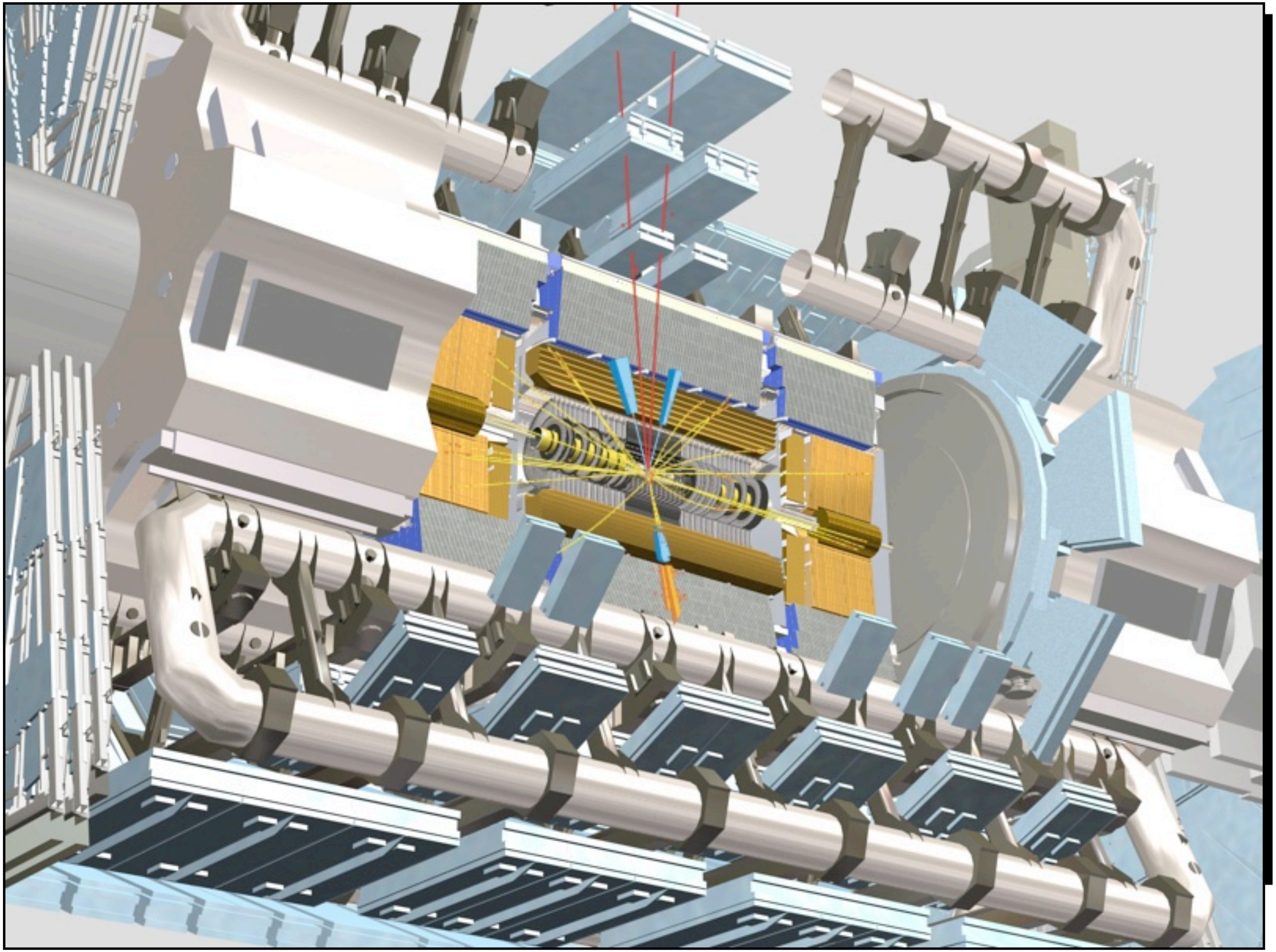


Each layer identifies and enables the measurement of the momentum or energy of the particles produced in a collision

ATLAS



Overall weight	*~7000 Tons*
Active channels	*10^8*
Readout frequency	*40Mhz*

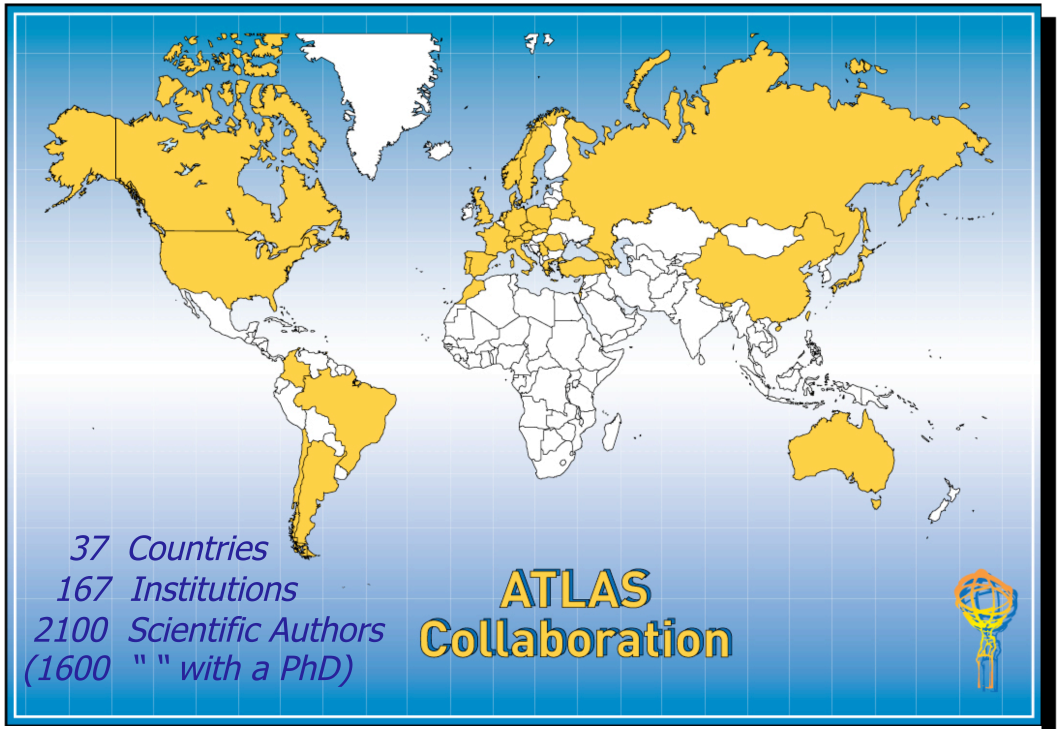


How huge is ATLAS

- **Size of detectors**
  - *Volume 20 000 m^3*
  - *80 million pixel readout channels near vertex*
  - *> 100 m^2 of active Silicon tracker*
  - *175 000 readout cells for LAr EM calorimeter*
  - *1 million channels and 20 000 m^2 area of muon chambers*
  - *> 3000 km of cables/fibers*
  - *Very selective trigger/DAQ system*
  - *Large-scale offline software and worldwide computing (GRID)*

- **Time-scale** *will have been about 25 years from first conceptual studies (Lausanne 1984) to solid physics results confirming that LHC will have taken over the high-energy frontier from Tevatron (early 2009?)*

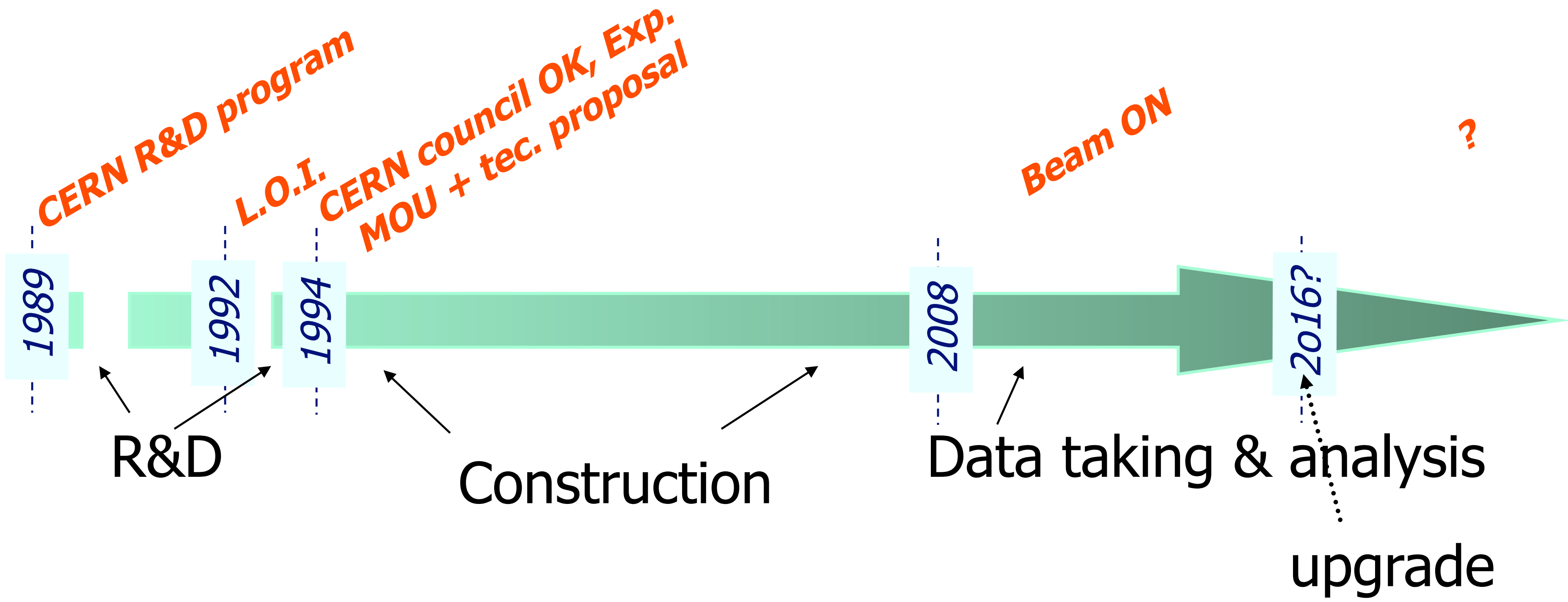
A thoroughly Collaborative Effort



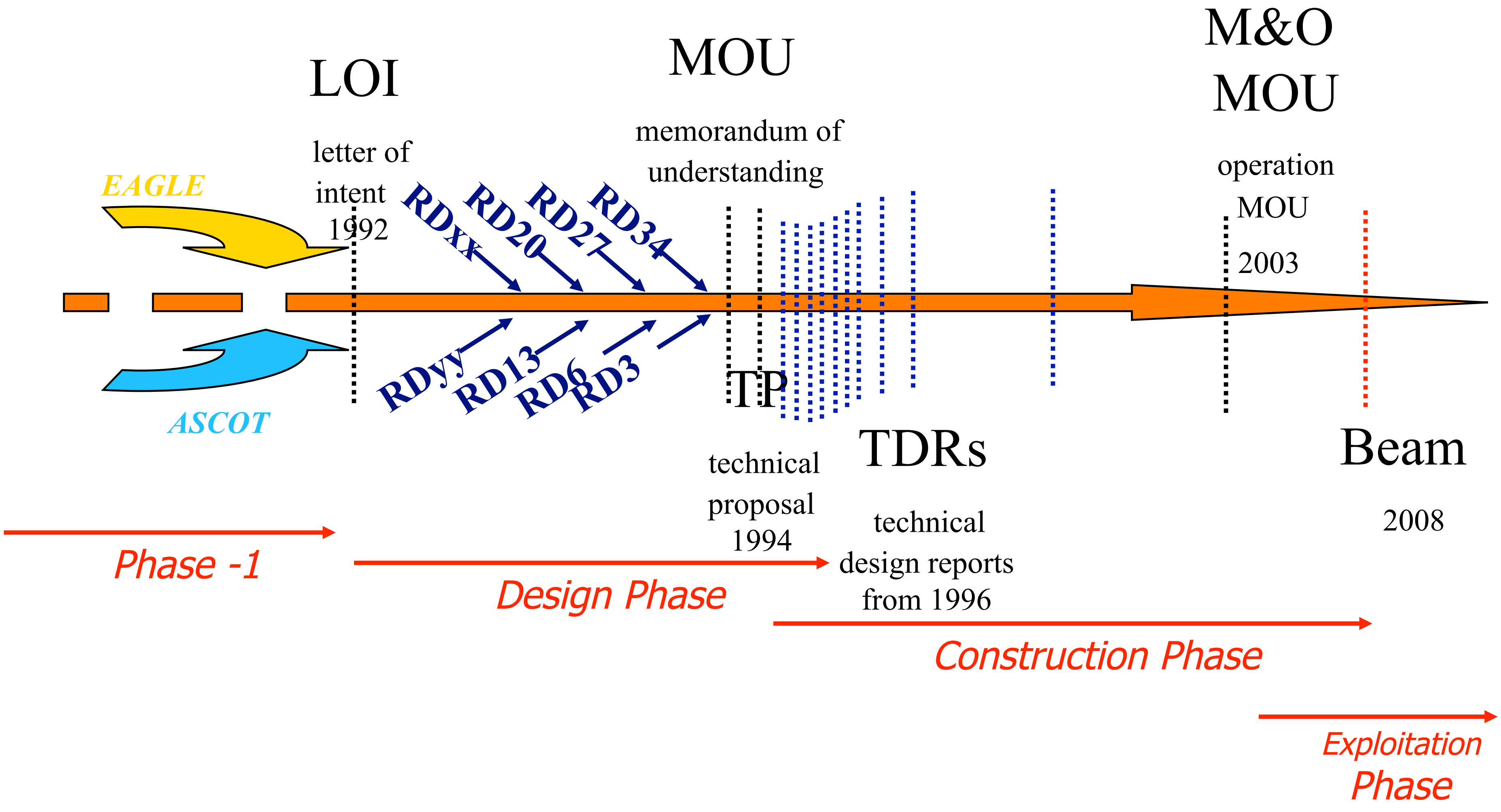
… which was there from the early '90 for design and tuning of technologies, then for construction, for writing software, setting up computing and now for debugging, operating and then analyzing the huge amount of data the detector will produce

First technical paper describing the detector just written, ~2700 authors + ~1000 technical staff

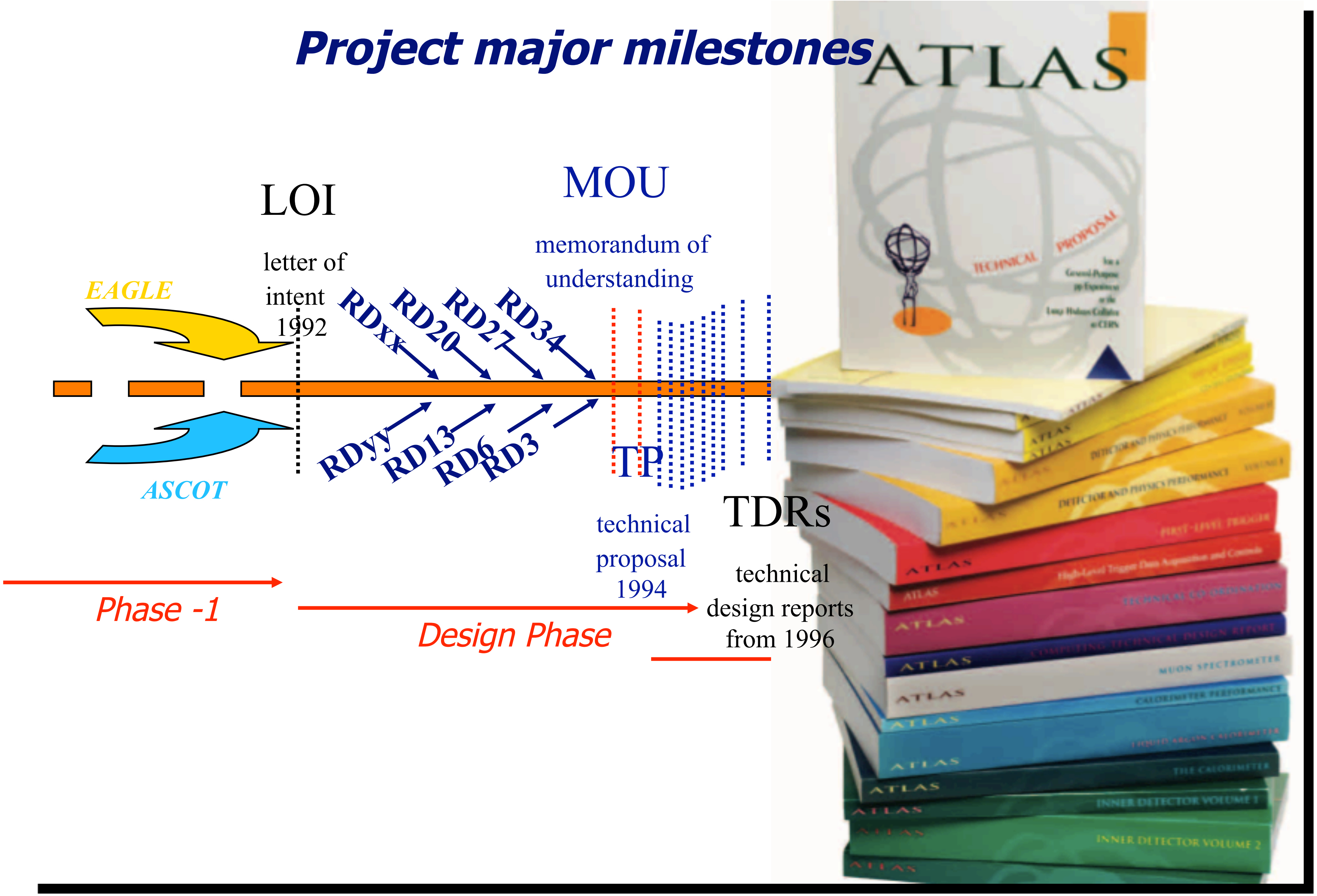
LHC project milestones



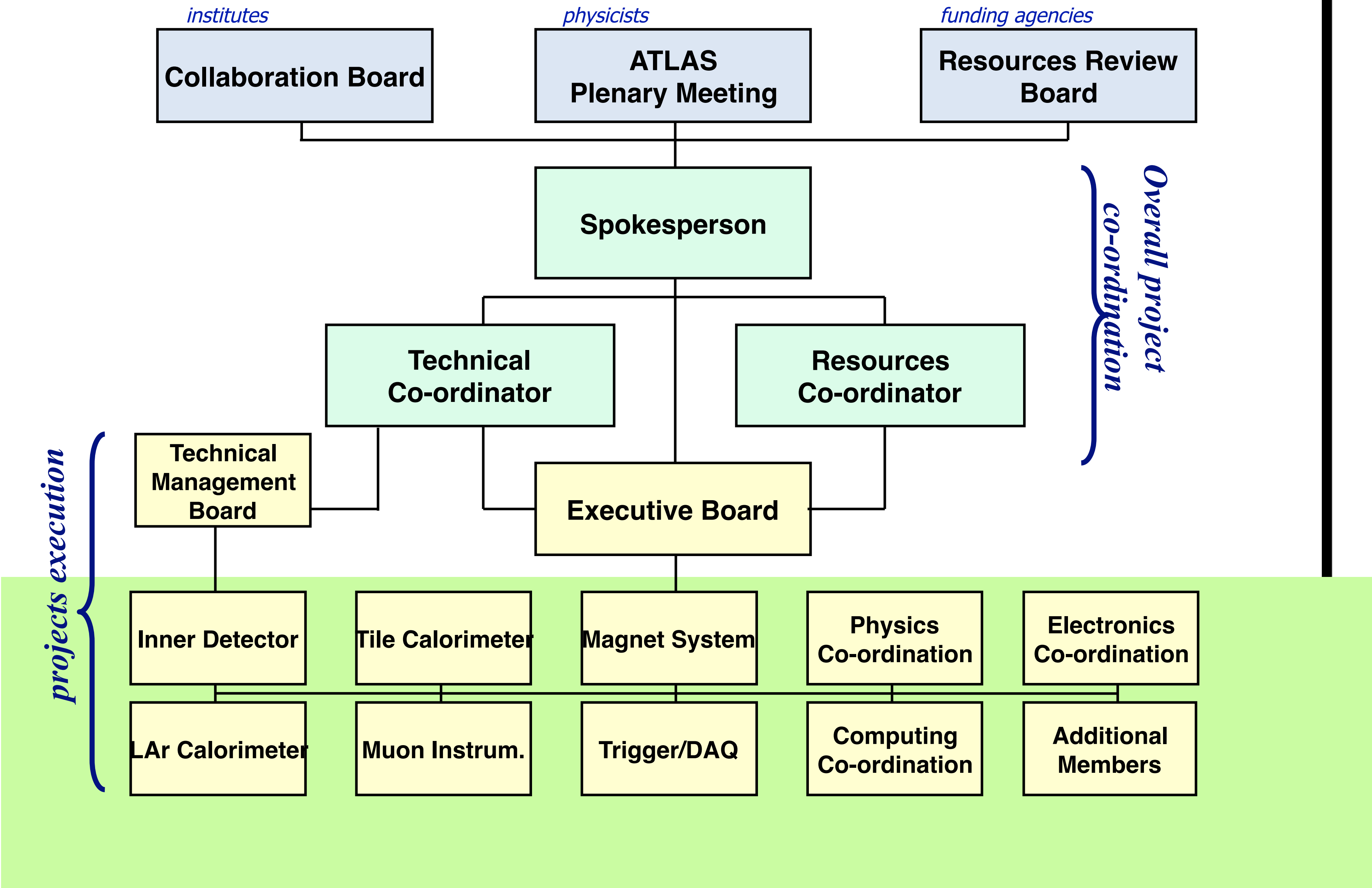
Project major milestones



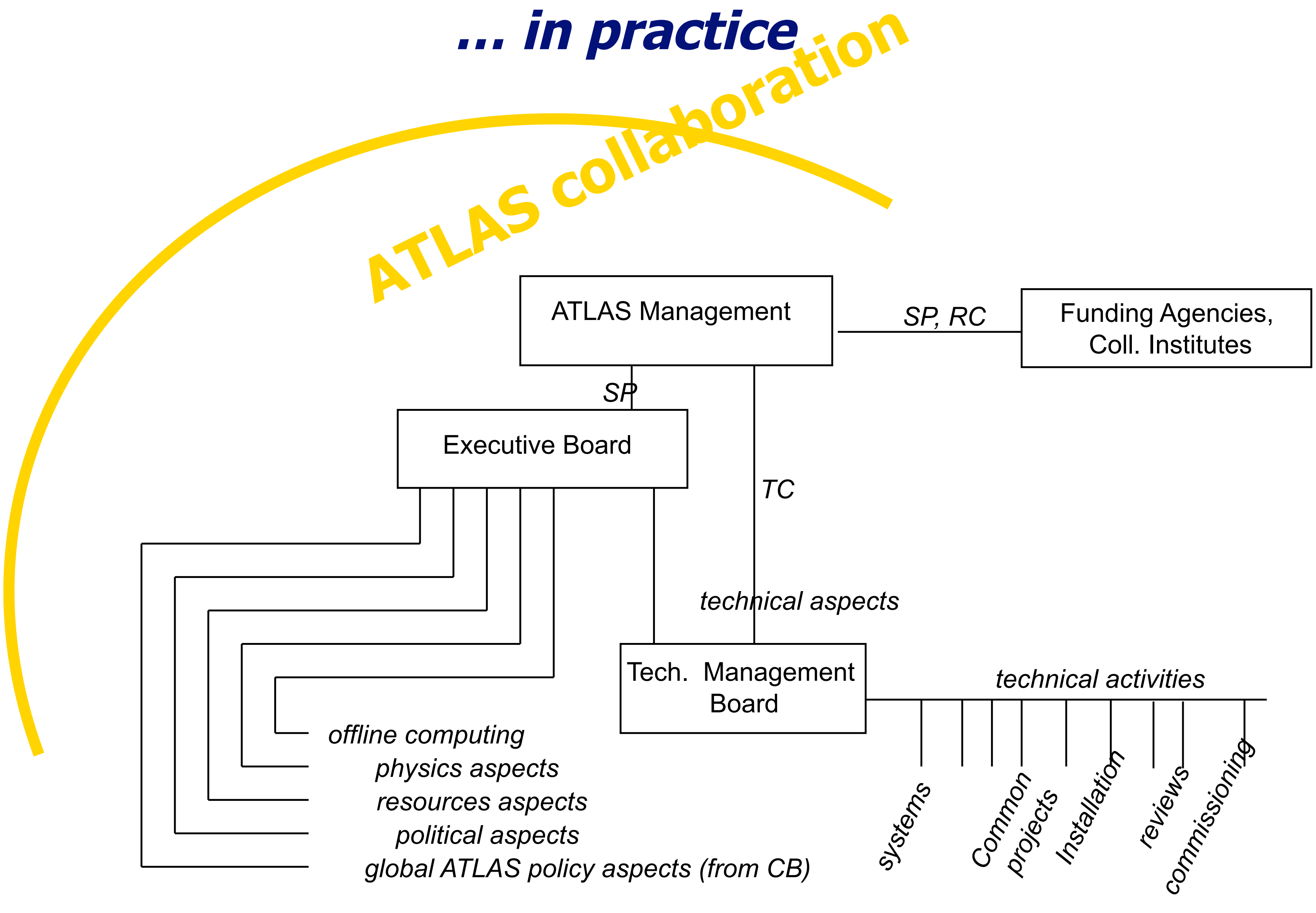
Project major milestones



Project management



… in practice



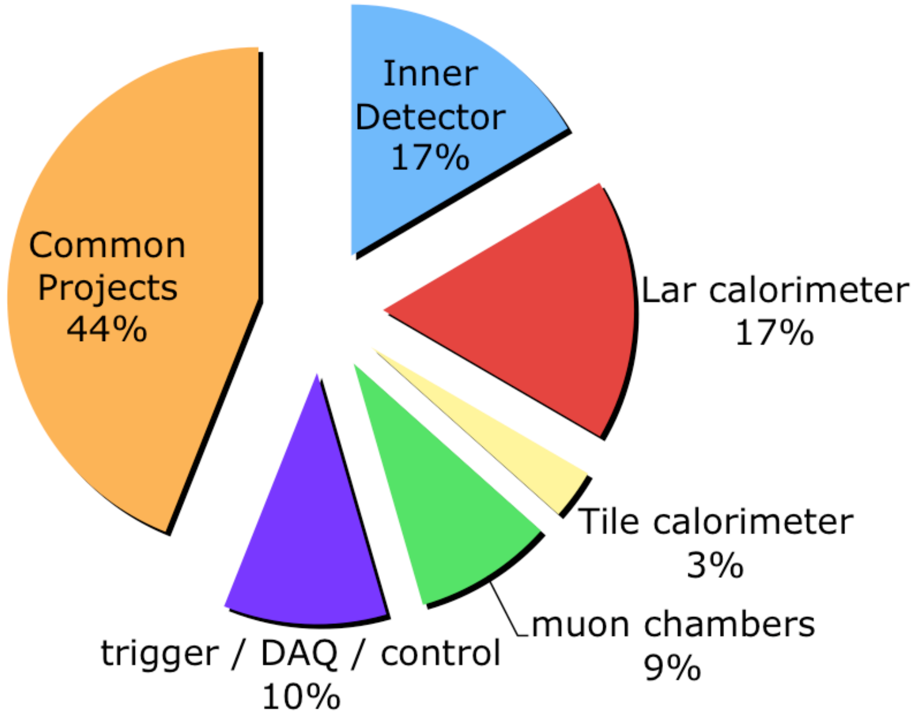
ATLAS collaboration
ATLAS Management
SP, RC
Funding Agencies, Coll. Institutes
SP
Executive Board
TC
technical aspects
Tech. Management Board
technical activities
offline computing
physics aspects
resources aspects
political aspects
global ATLAS policy aspects (from CB)
systems
Common projects
Installation
reviews
commissioning

CORE costs

Project factorization:

a- 5 Active systems

b- Common projects



% represents the CORE value (material and industrial contracts) as defined in 1994 and revised in 1998

Common projects includes:

- *Magnets*
- *Cryogenics*
- *Supports and shieldings*
- *Services/infrastructure*
- *Installation underground*
- *Central engineering, safety and project office*

Active systems production & operation

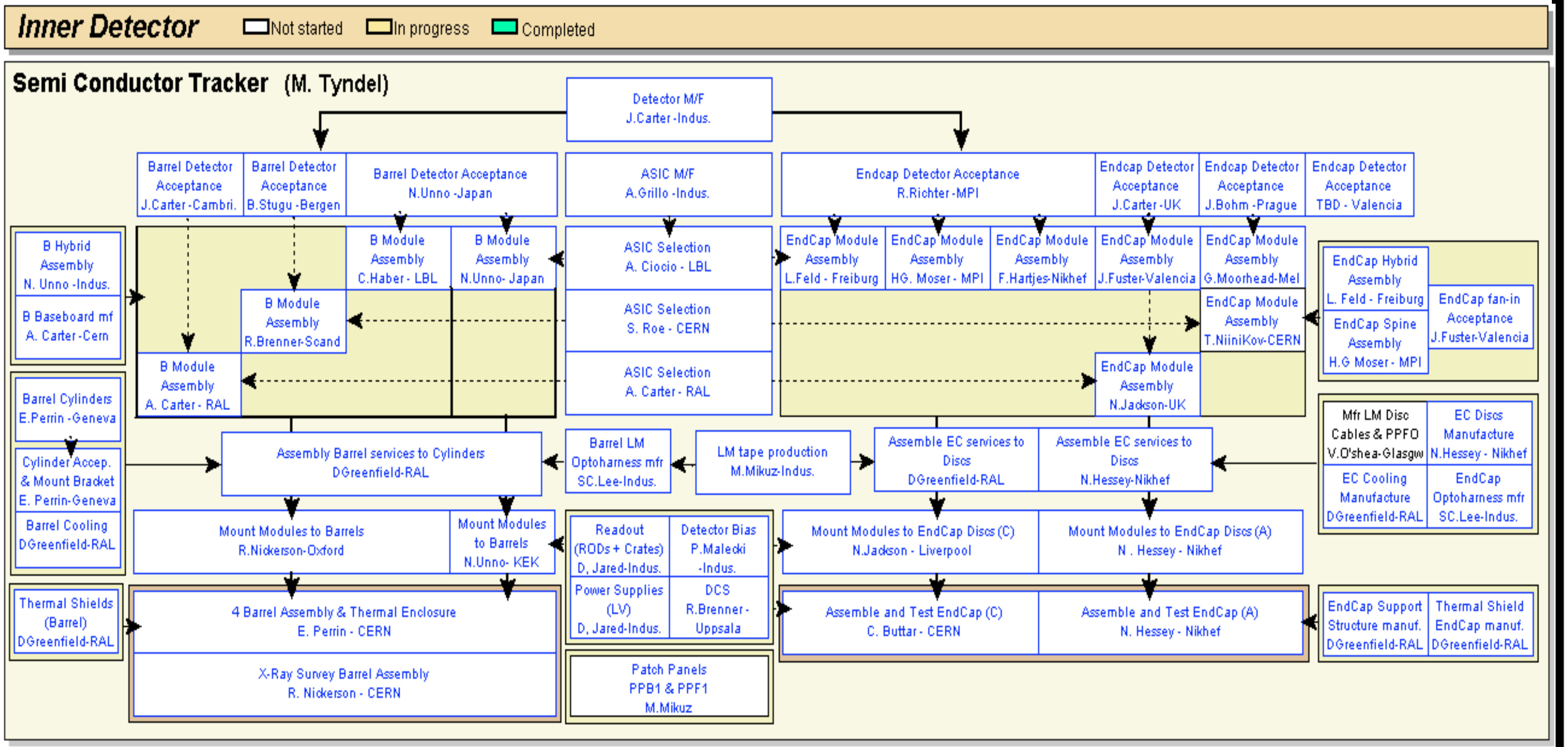
- ✓ *Work organized by detector systems and subsystems. These have a internal organization similar to the central ATLAS, with a Project Leader and Collaborating Institutes*
- ✓ *Execution and financial responsibility with the Institutes who have subscribed (MOU) to a given job or work package. Concept of deliverables. Each institution is fully responsible for its deliverables to the systems. No central accounting is done for it*
- ✓ *The ATLAS Technical Coordinator monitors the timely and technical execution of the work though reviews, reports and visits*

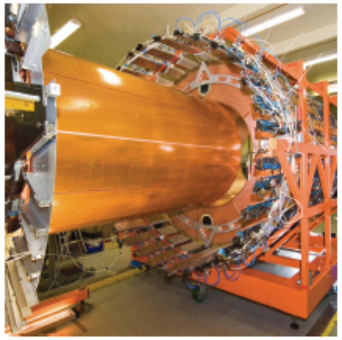
Active systems production & operation

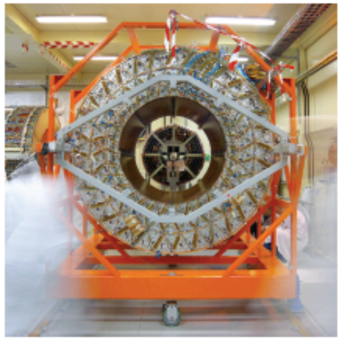
✓ Detectors deliverables :

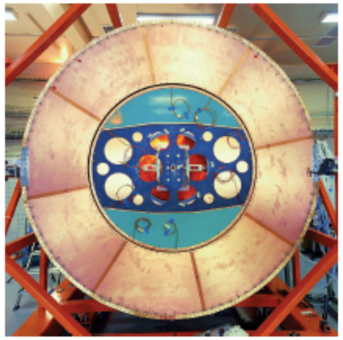
- Strong commitments from the individual institutes
- Often institutes cluster together (3-5) to be more efficient
- QC monitor and schedule organization done within the detector systems
- Central ATLAS (via TC) monitors the overall schedule of components, organizes continuous reviews and acts on problems/risks
- The largest industrial contracts are executed via CERN (case B type of contracts), in particular when institutes cluster together. Technical follow-up of the contracts is done by the system people. CERN requires a transfer of risks and liability to the institutes involved, as well a financial guaranty. Previous to each contract there is an internal ATLAS agreement organized and formalized by the ATLAS resource coordinator, where the details of each case is mentioned
- Central ATLAS acts just when problems degenerate and contracts risk to be compromised, we had just a few cases (30-40 over ~1500 WP) !

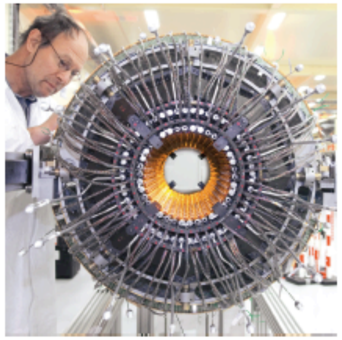
Project tracking



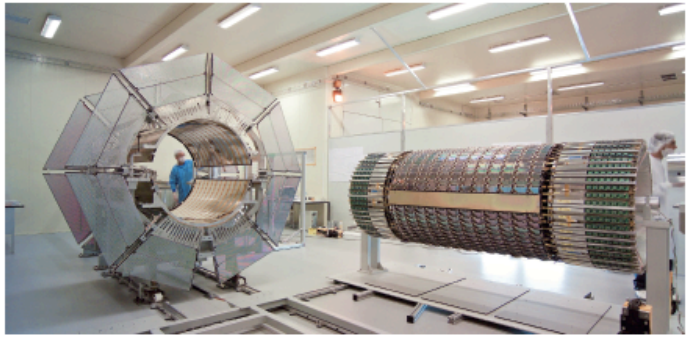


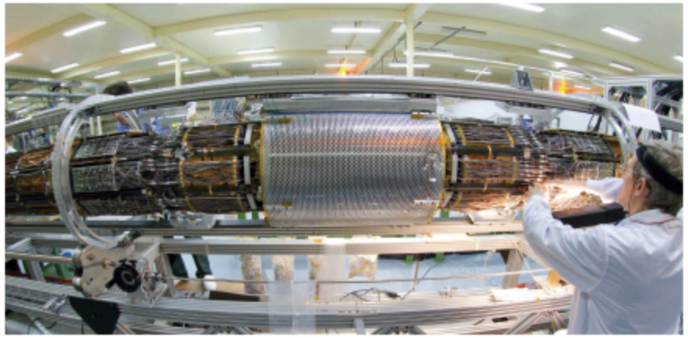


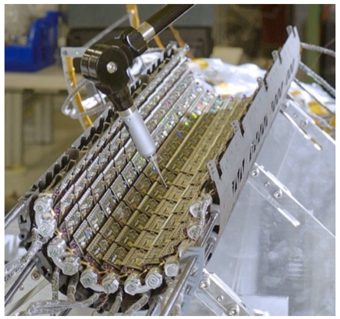


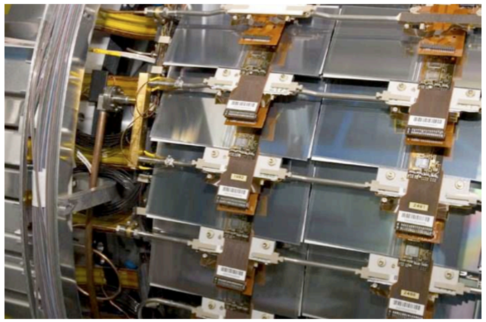


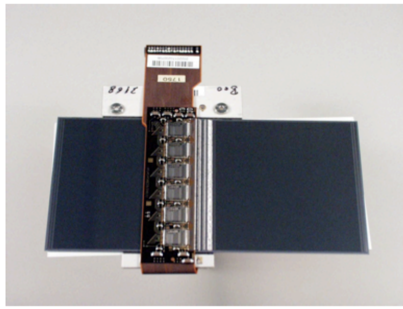
› ***Inner Detector***
Russian dolls: the Semi Conductor Tracker (SCT) is inserted into the Transition Radiation Tracker (TRT), in turn inserted into the Barrel Cryostat. The Pixels come very last.

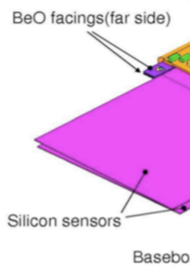


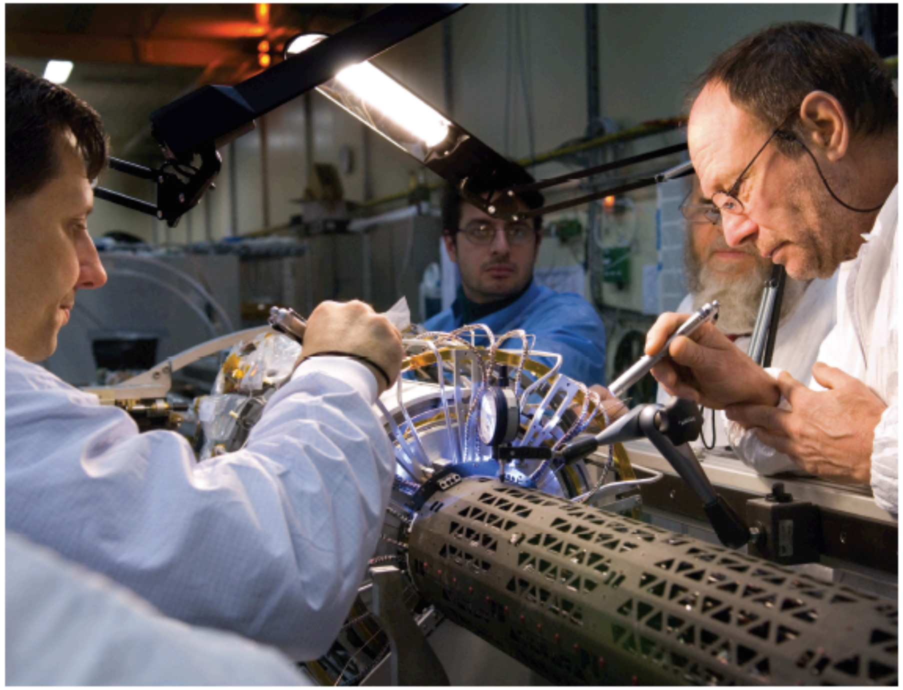




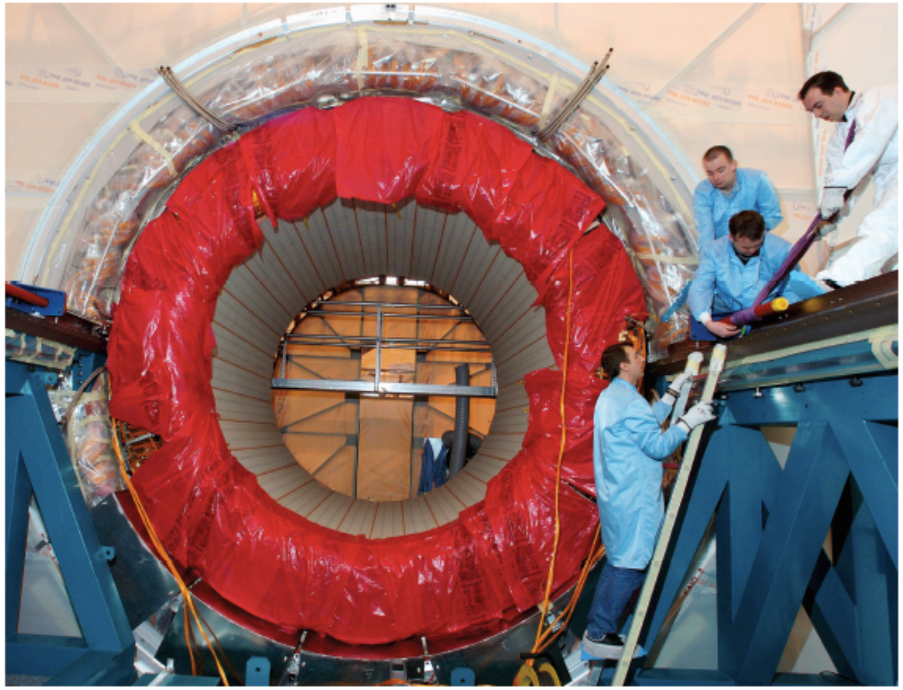




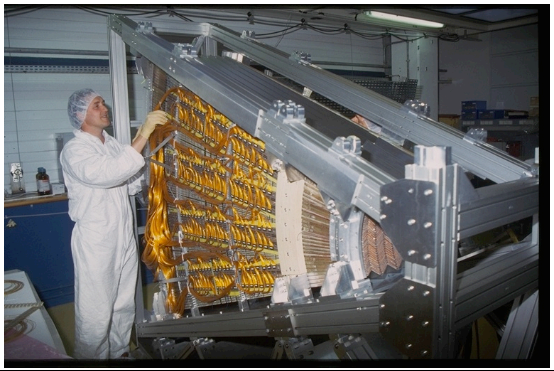


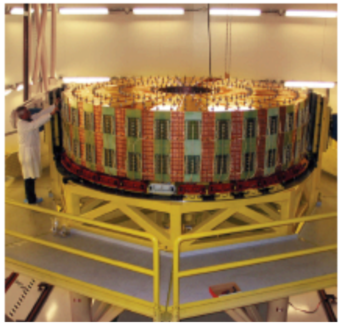


› *The Pixel Detector is the smallest of the Russian dolls; however, for technical reasons,*

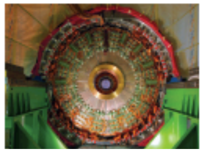


› *The Electromagnetic Calorimeter's first half-barrel is one of the earliest components to*

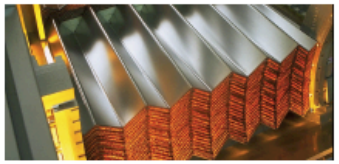


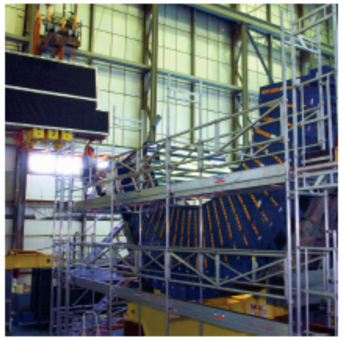


› ***Liquid Argon Calorimeter***
600 kilometres of cables connect the calorimeters to the read out. Once they are installed in their cryostats they are no longer accessible.

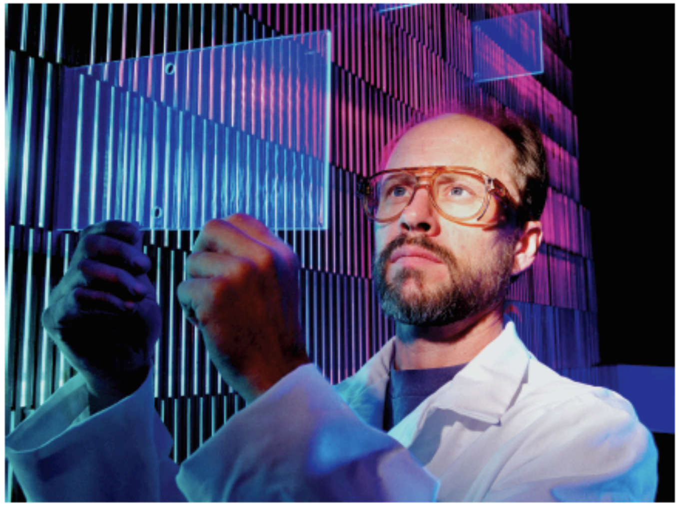


› ***Liquid Argon Calorimeter***
The 'accordion' calorimeter is composed of 4000 electrode-absorber layers in ultra pure liquid Argon to maximise stability, granularity and speed.

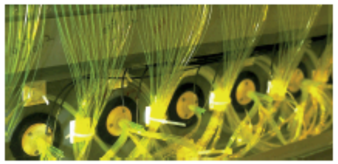




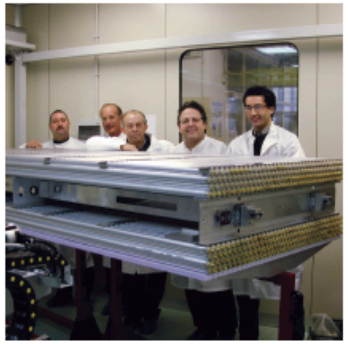
› ***Tile Calorimeter*** - Module after module is carefully stacked and surveyed to form a perfect eight-meter tall cylinder, each part placed with millimetre accuracy.

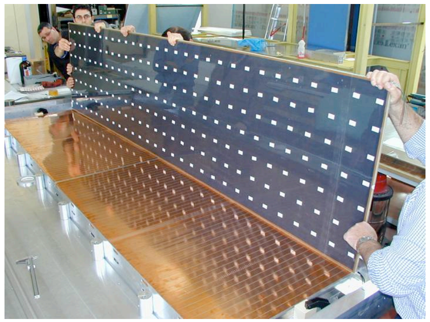


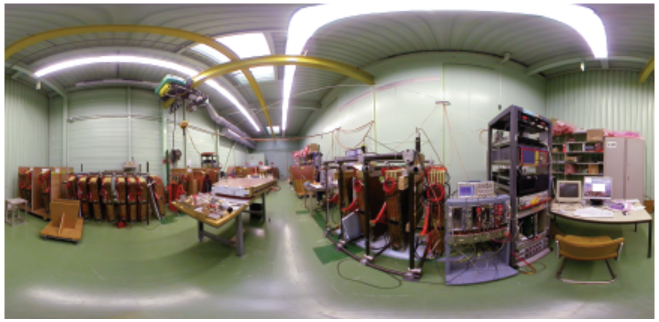
› ***Tile Calorimeter*** - Half a million pieces of blue scintillator plastic, 187'000 pieces of green fibre and half a million plates of steel make up the multi-layered tile calorimeter.



› ***Muons*** - The total surface of the muon chambers amounts to 20'000 m², roughly the size of three FIFA approved international football fields.







Common projects

- ✓ *Work organized centrally be the Technical Coordination. Funding organize centrally via common funds (collecting cash or in-kind contributions)*

- ✓ *TC organizes a project structure with Project Leaders and work organizations for each major item (magnets, cryogenics, infrastructures, shieldings, gas, cooling, beam pipe, structure, safety projects ….)*

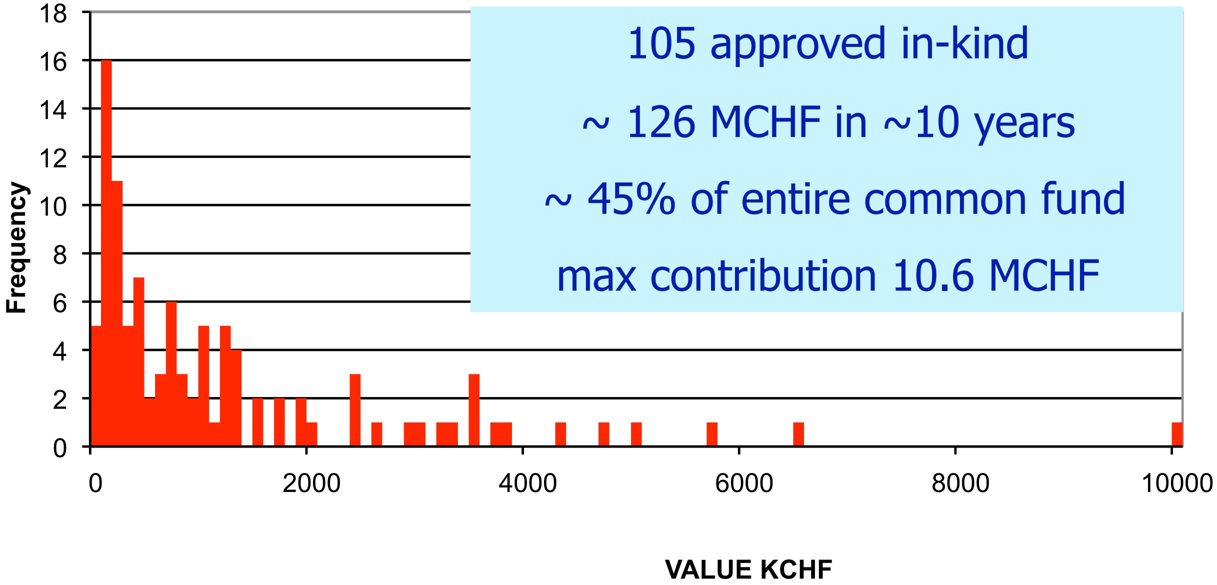
- ✓ *TC reports to EB and Collaboration board. He proposes in-kind contribution for approval to RRB (resource review board). In-kind contributions for engineering packages or components delivery.*

- ✓ *Common funds very important in problem solving. In many cases this was the only real power of the central management*

Common Projects

- Within one project the engineering, quality follow-up is often given to major ATLAS institutions, either in-kind or via dedicated engineering contracts. (Example : CEA got an engineering ATLAS contract for the design and construction follow-up of large parts of the barrel toroid, this was a CERN contract done on ATLAS common fund money)
- QC monitor and schedule organization done by the project organization (TCn or engineering institutes). In few cases the monitoring of a contract was given to a specialized firm
- Many of these contracts are large and span over long delivery periods. We have experienced many relation problems with firms. Several contracts had to be stopped.
- When problems have diverged we have brought back the work at CERN and we have finished the project our self with ATLAS manpower
- Practically all common project contracts, even if in-kind, have been done using CERN as contractual partner. Just few major institutions in EU, Japan, US and Russia are capable of being independent. CERN contracts have often simplified the tax exemption conditions
- All relations, duties between ATLAS partners have always been formalized in advance via internal ATLAS agreement, signed by the involved institutes leaders and ATLAS TC, RC …. in particular for in-kind contributions

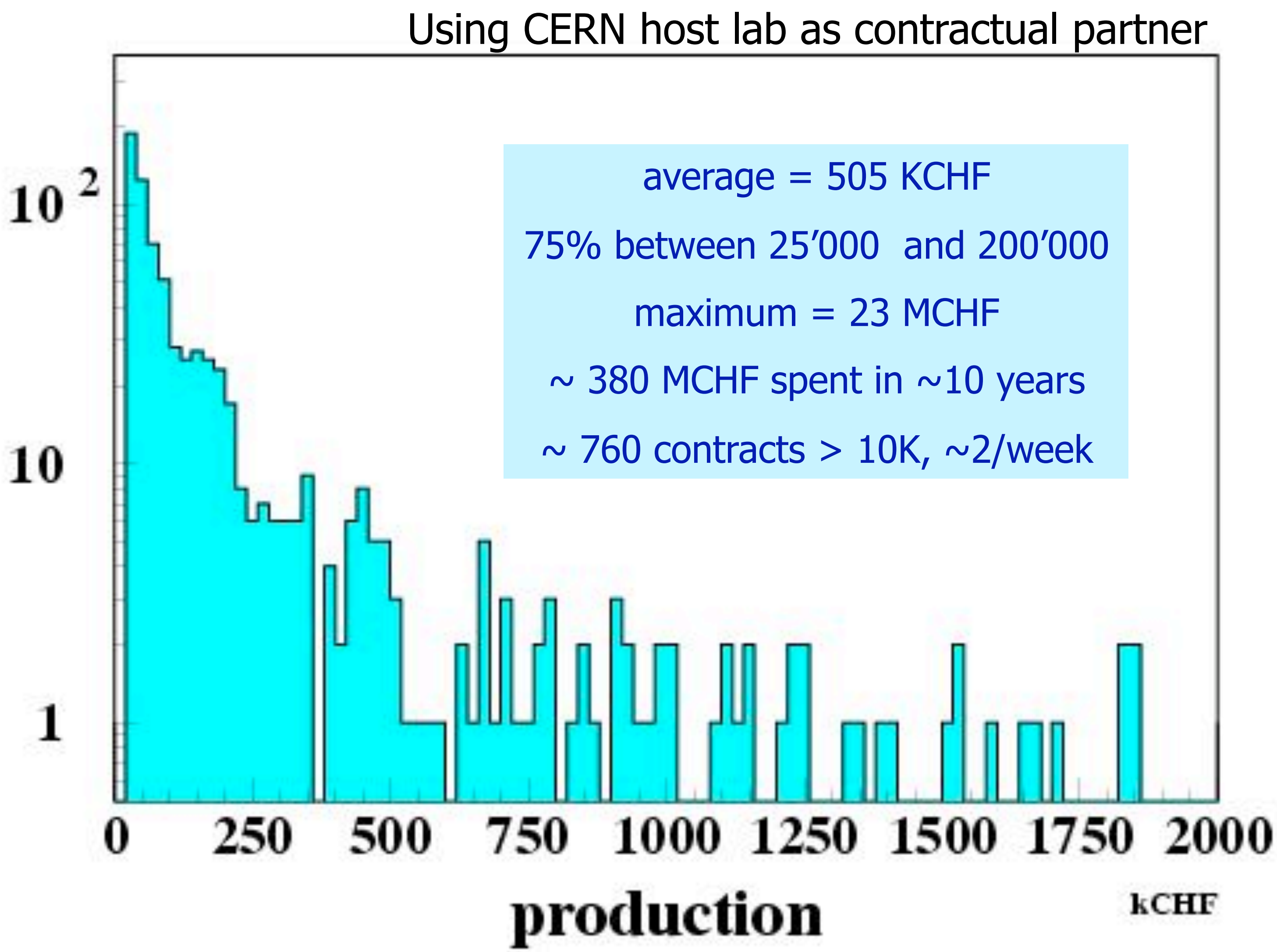
In Kind Contributions



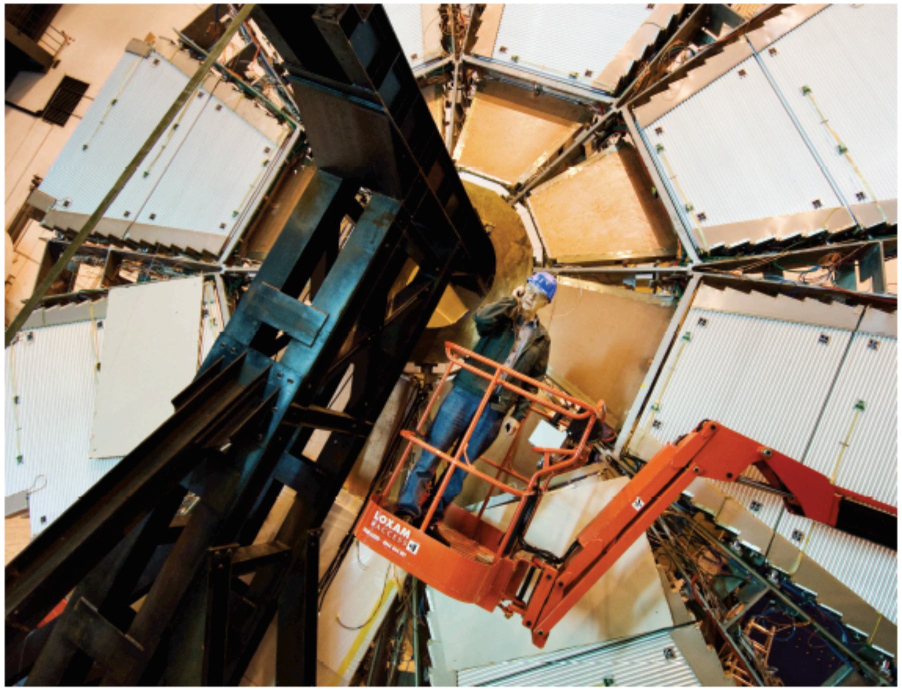
- ✓ very strong pressure from RRB to have in-kind contributions, for many nations this was easier then providing cash. Important return to home industries

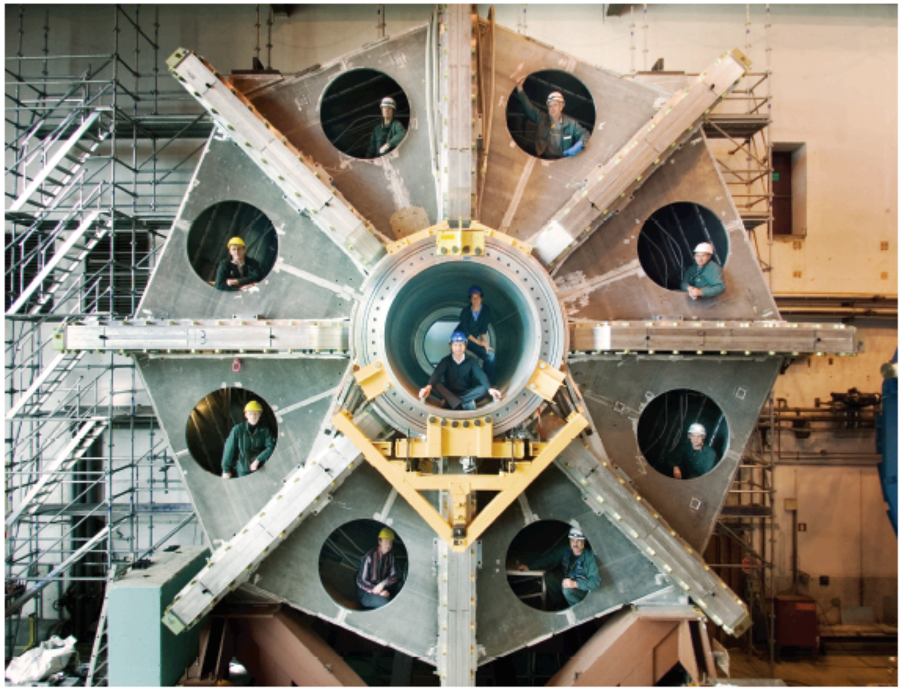
- ✓ When financial problems, then in-kind was re-adjusted or a central cash contribution was done

Example : material procurement (1997-2006)

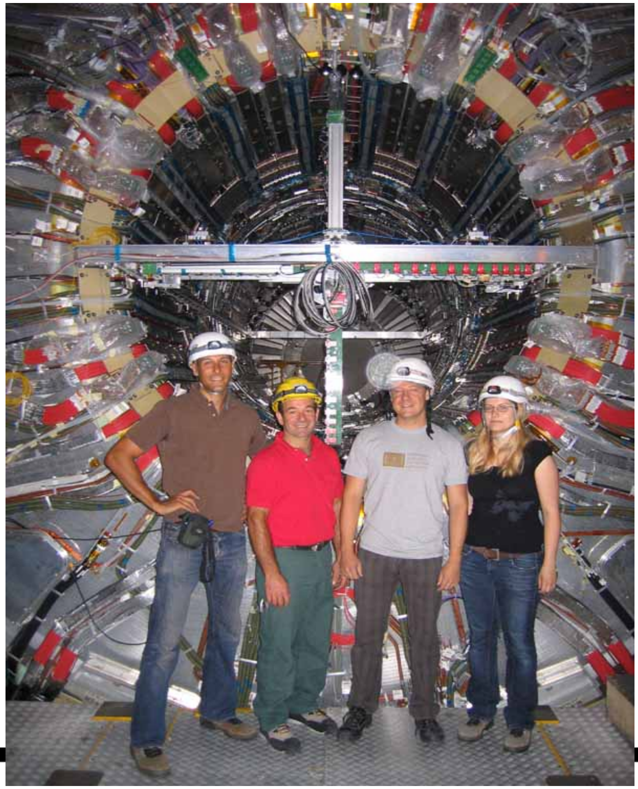
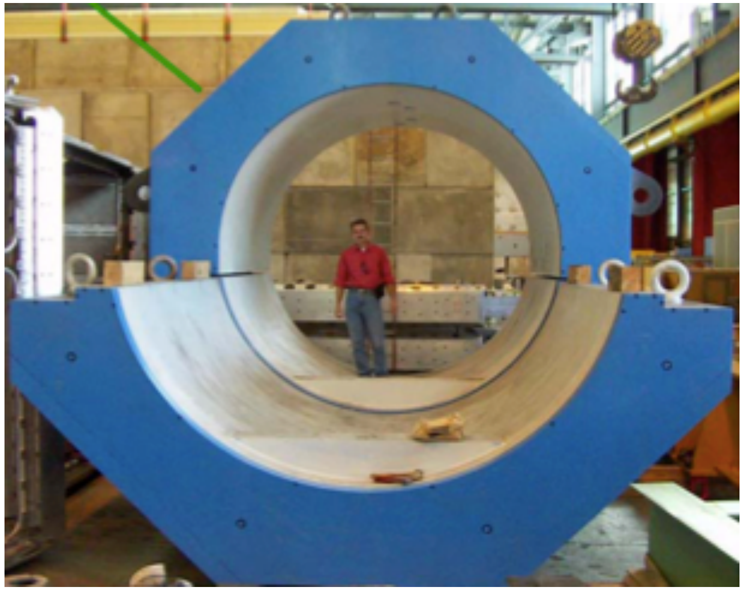


› ***Magnets.*** The huge Barrel Toroid coils are assembled and tested on the CERN site before their short but epic journey across the road to the ATLAS cavern, while the superconducting Solenoid travelled all the way from Japan.


LOXAM

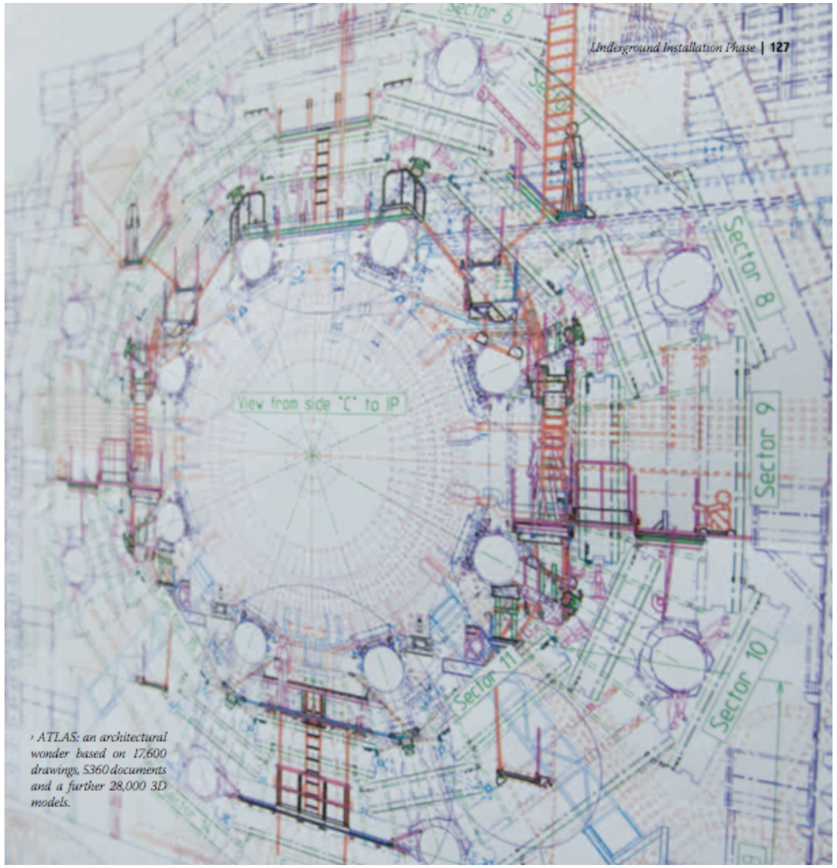




Underground installation

Gigantic 20’000 m^3 3-D puzzle … 5 years of work



Installation underground (2003-2008)

~ 7000 tons of detectors
~ 3000 km of cables
~ 2000 tons of temporary supports

Mid 2003

Infrastructure

Feet & supports

Barrel Toroid

Barrel Calorimeters

Cables & services

End Cap Calorimeters

Barrel Muon Chambers

Inner Detector

Forward Muon Spectrometer

End Cap Toroids

End Cap Inner Detector

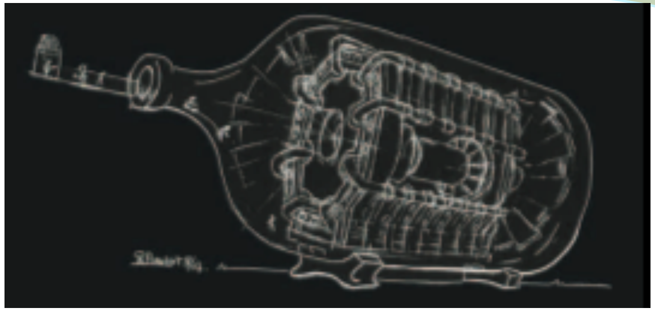
Shieldings

Pixel detector

Beam Pipe

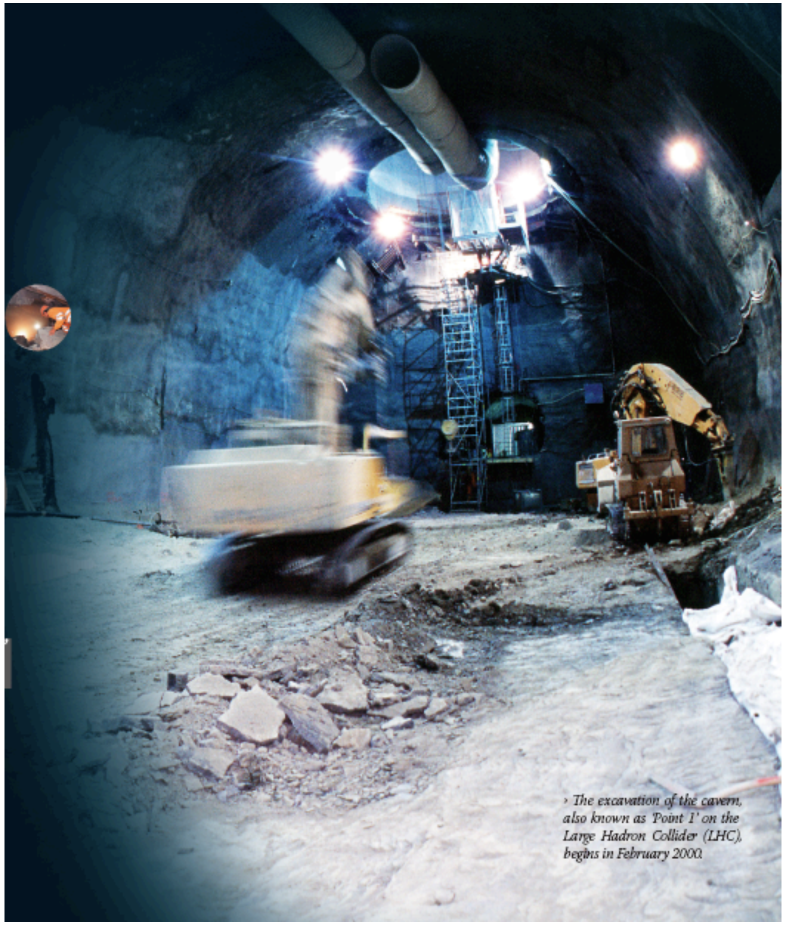
Commissioning with cosmics

July 2008

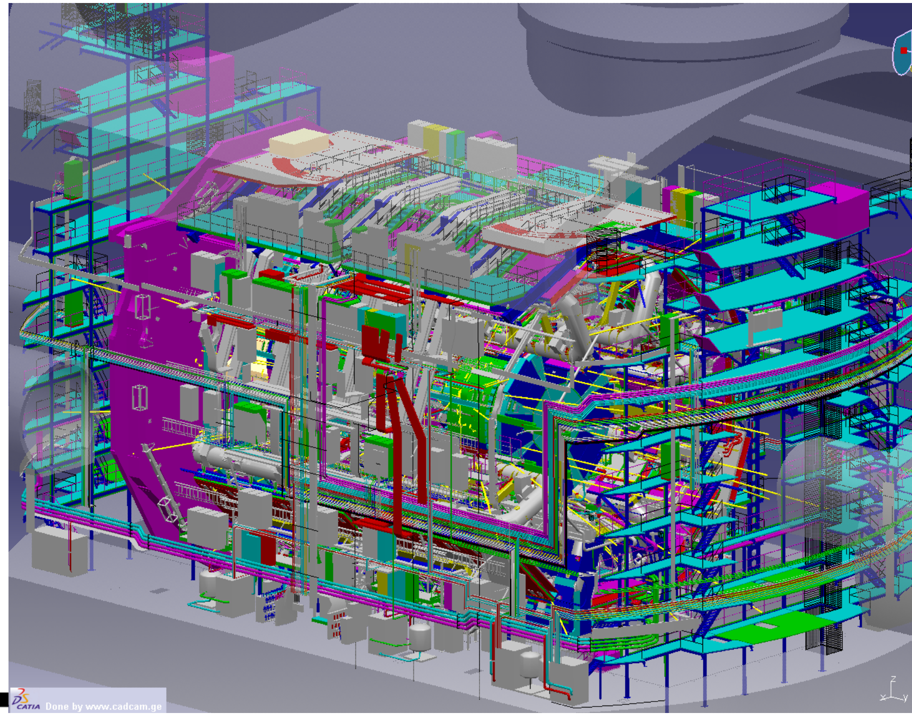


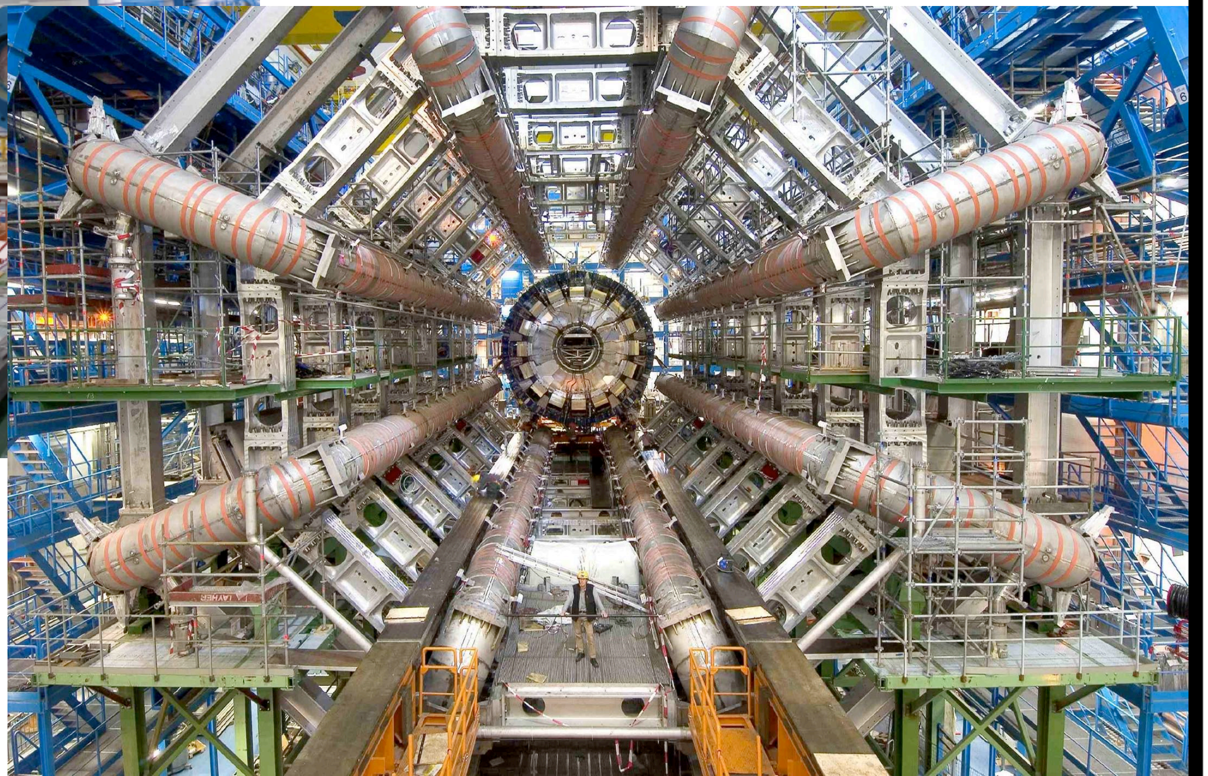
Ingridients

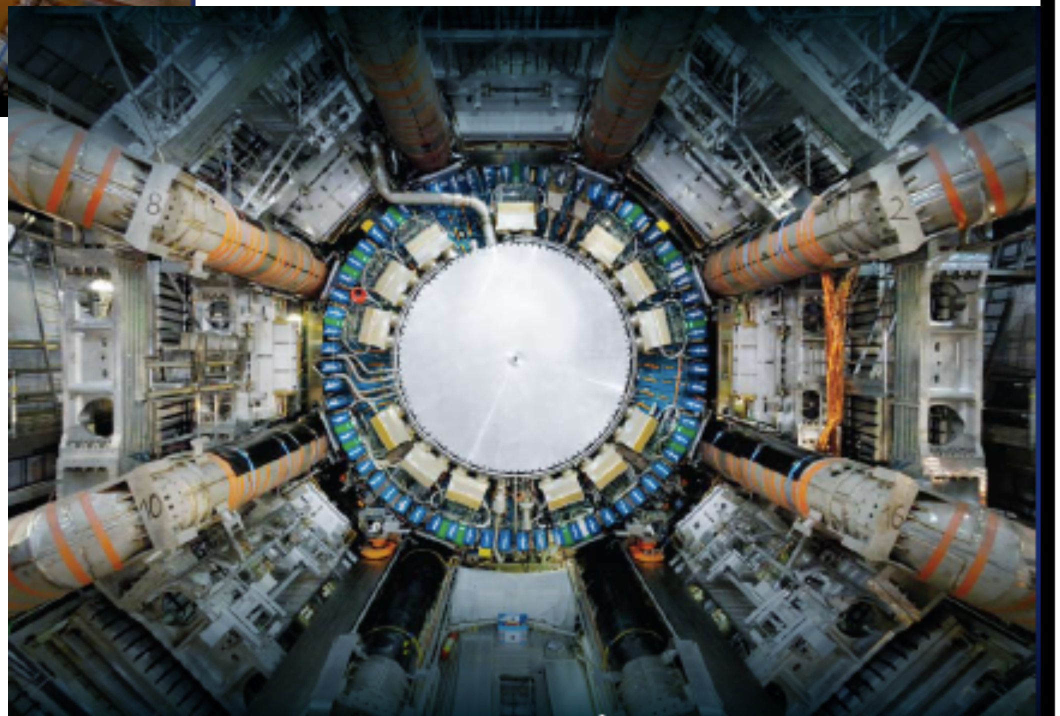
- ✓ a superb configuration control office (3d models, envelops, installation scenari, as built drawings, installation layout) …. engineers + designers
- ✓ a tuned procurement machinery …. for a lot of small/medium contracts …. concept of 3 months delivery readiness for all detector assemblies
- ✓ qualified and motivated installation teams (crane drivers, tecs, cabling teams, …) ~ 1000 technicians over the entire period
- ✓ a safety organization which organize the work, anticipate problems and monitor execution (formal work packages organization)
- ✓ a flexible and courageous steering team capable to invent solutions when problems or work stops
- ✓ a set of high-tech experts capable to immediately operate what installed to look for problems

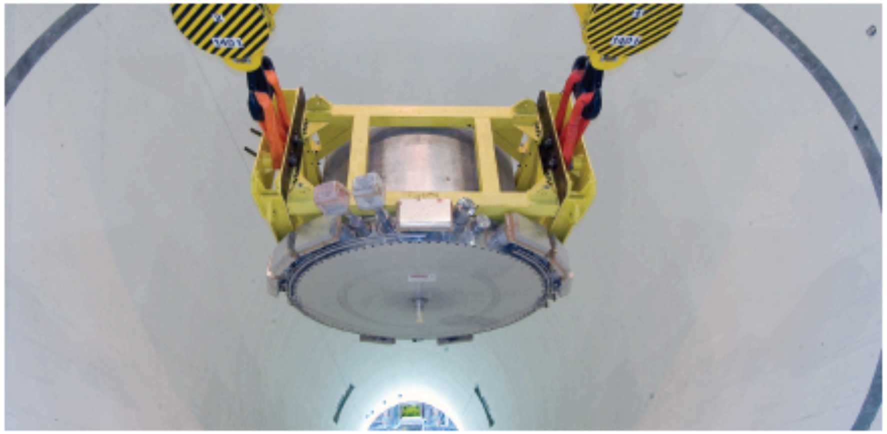


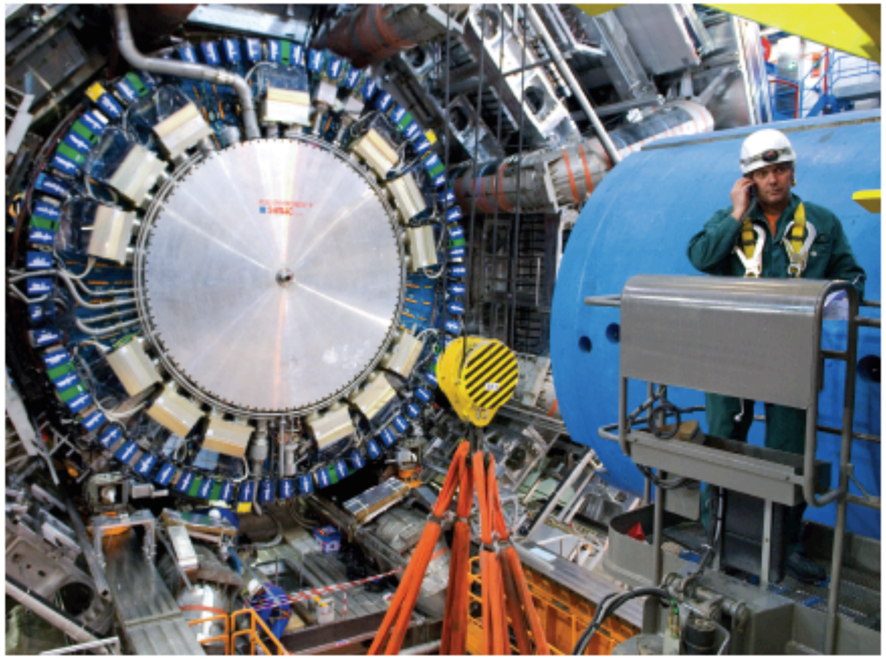
› The excavation of the cavern, also known as 'Point 1' on the Large Hadron Collider (LHC), begins in February 2000.

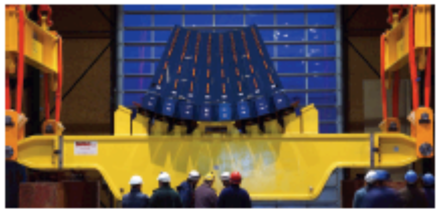


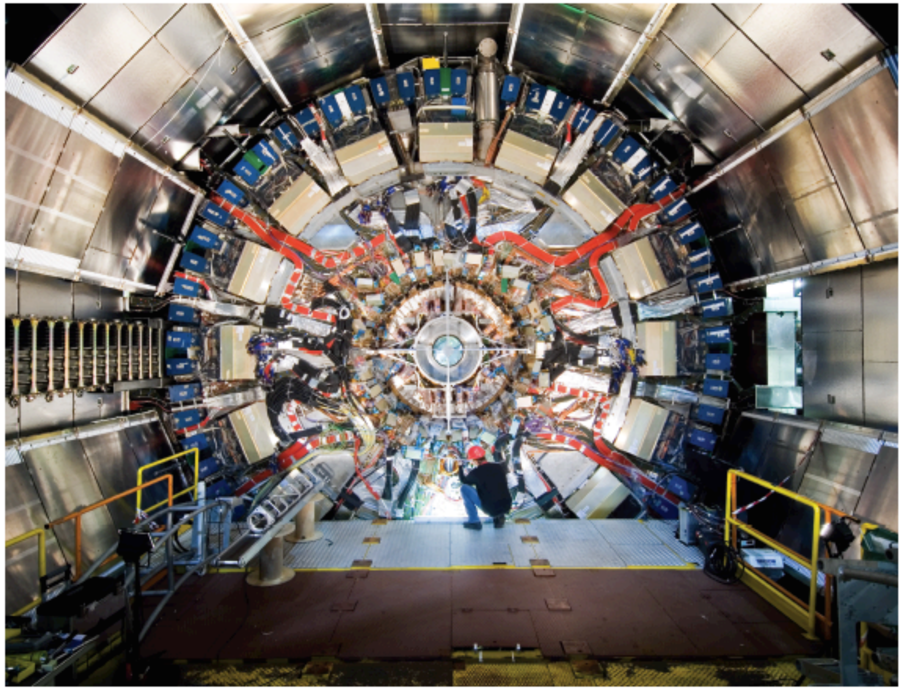






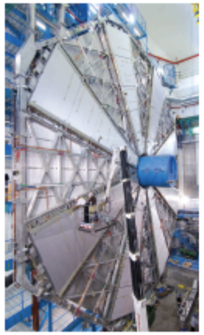


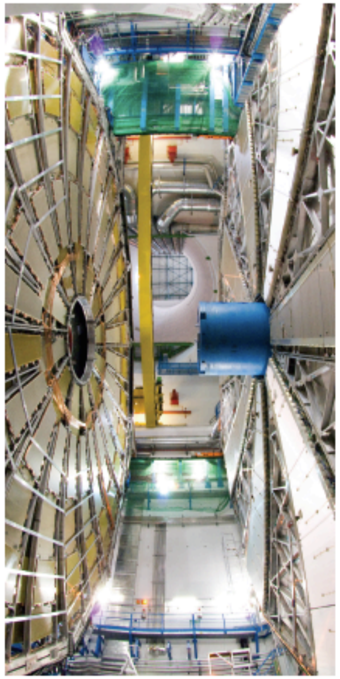


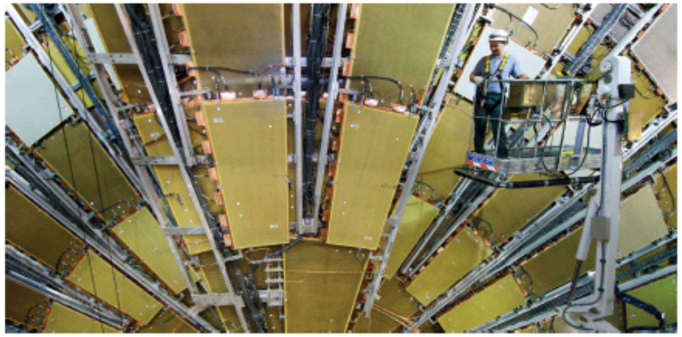


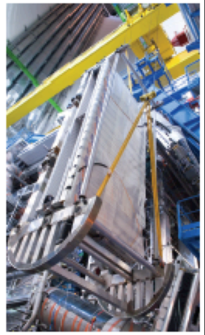
› The first Inner Detector Endcap after complete insertion within the Liquid Argon Cryostat.

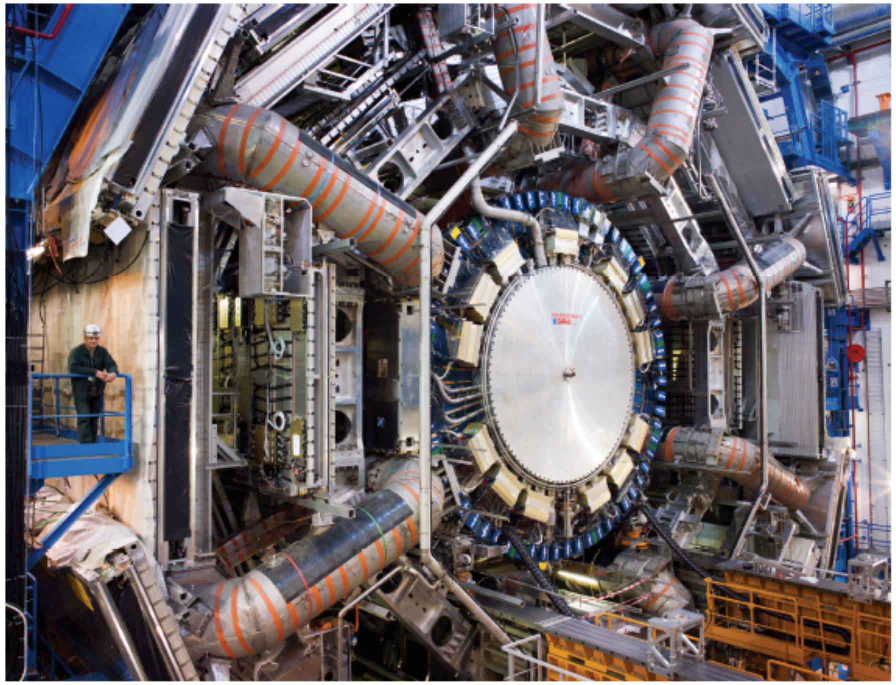
› Before the cavern was fully excavated the LEP accelerator was still running. To save time, engineers decided to cast the cavern ceiling first, temporarily suspending it with steel cables to create the largest suspended vault in the world.



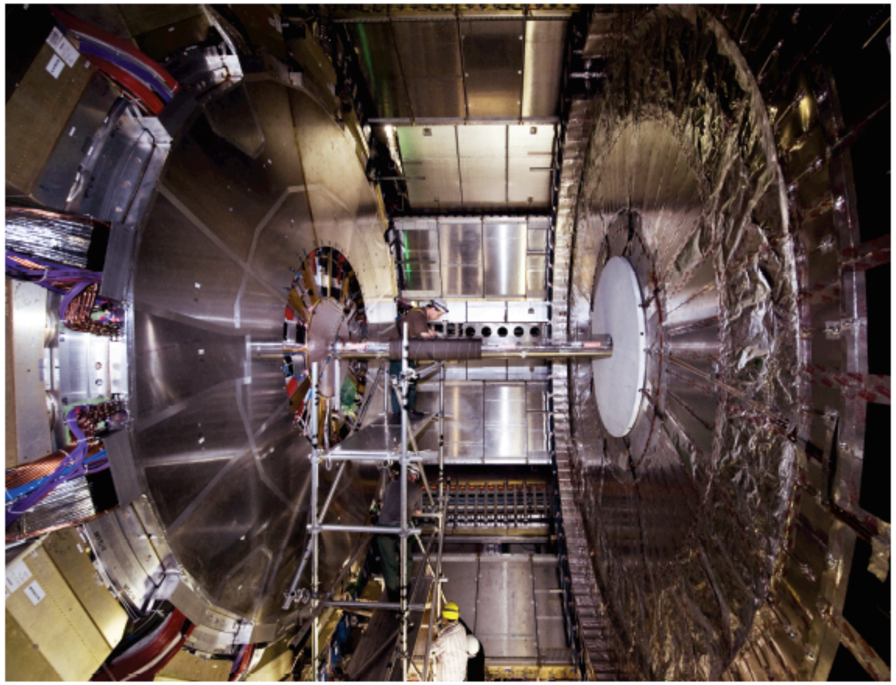




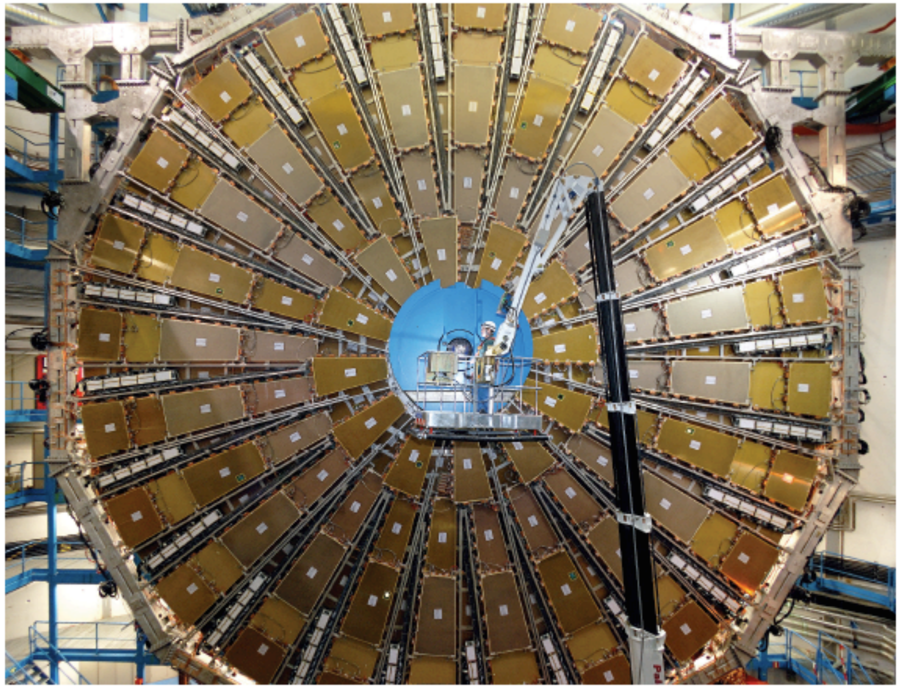




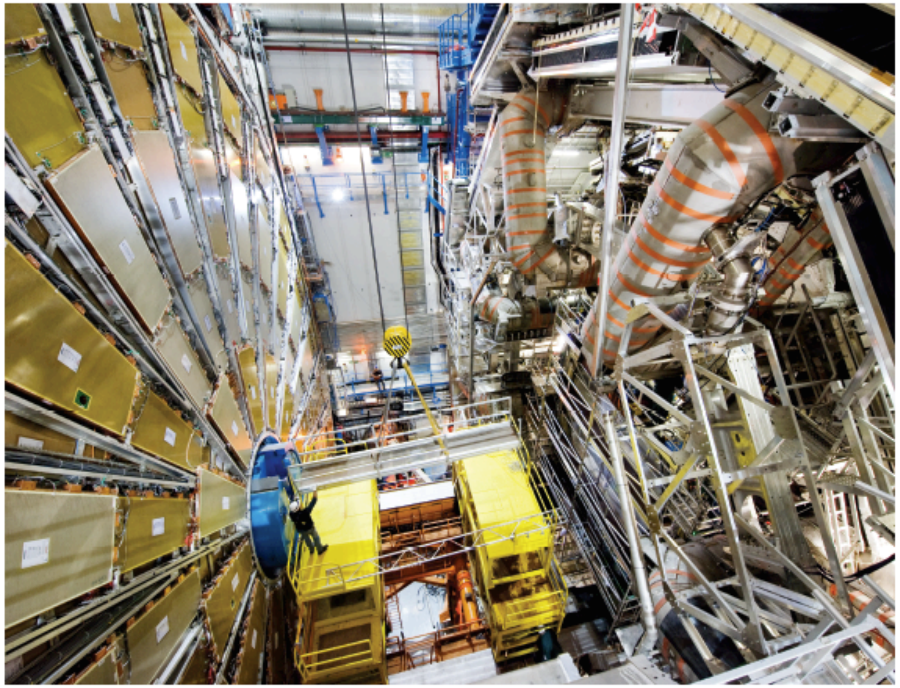
› *Poetry in motion: the endcap calorimeter floats towards its final position on orange air pads. The choreography is flawless.*



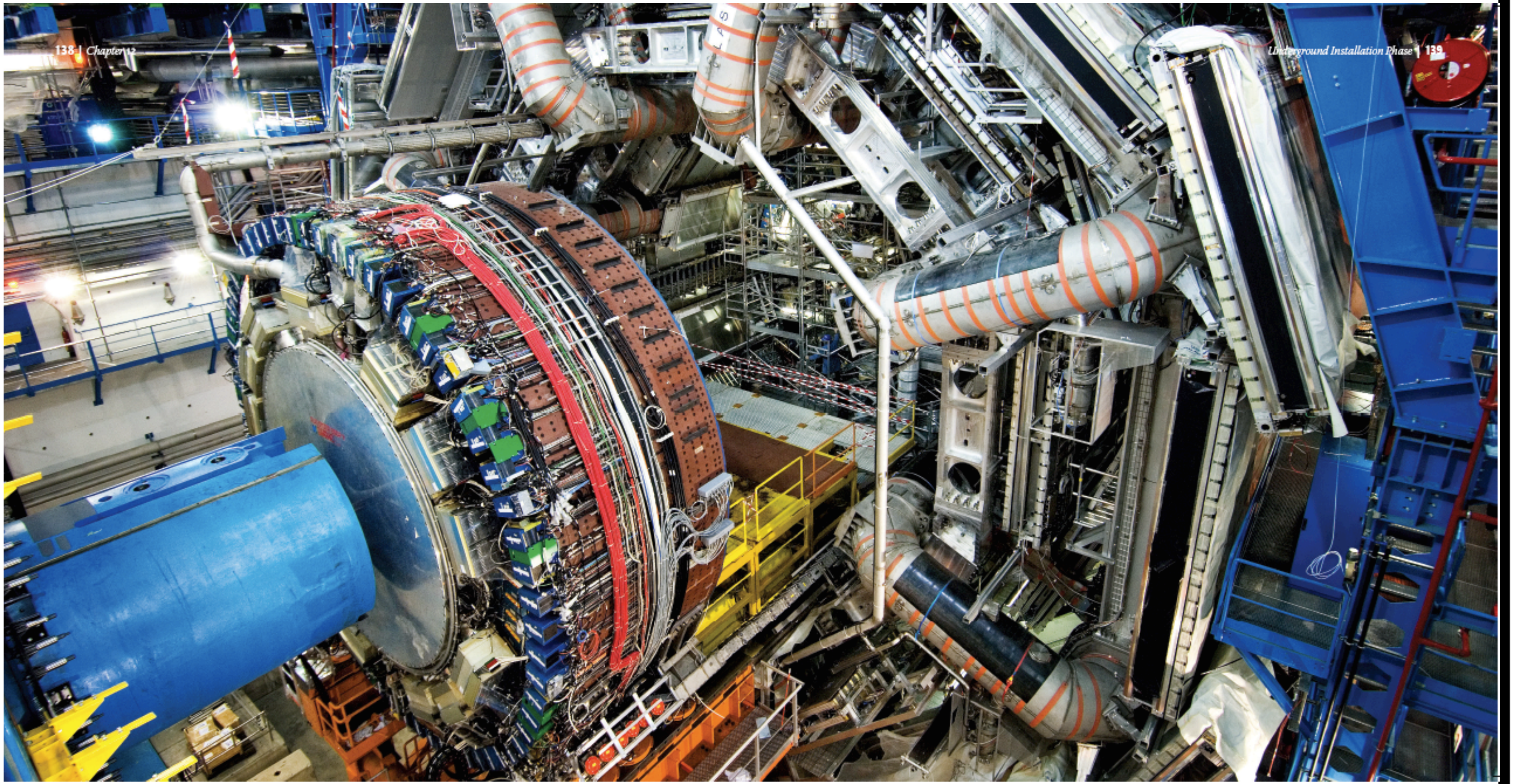
› *The vacuum in the 27km beam pipe that runs through ATLAS has an atmospheric pressure ten times lower than the atmosphere on the moon.*



› Each of the six Big Muon Wheels is composed of 16 segments, lowered individually into the cavern and then assembled together to form a circle.



› Professional crane drivers performed some of the most nerve-racking work with often only a few millimetres to manoeuvre pieces into place.

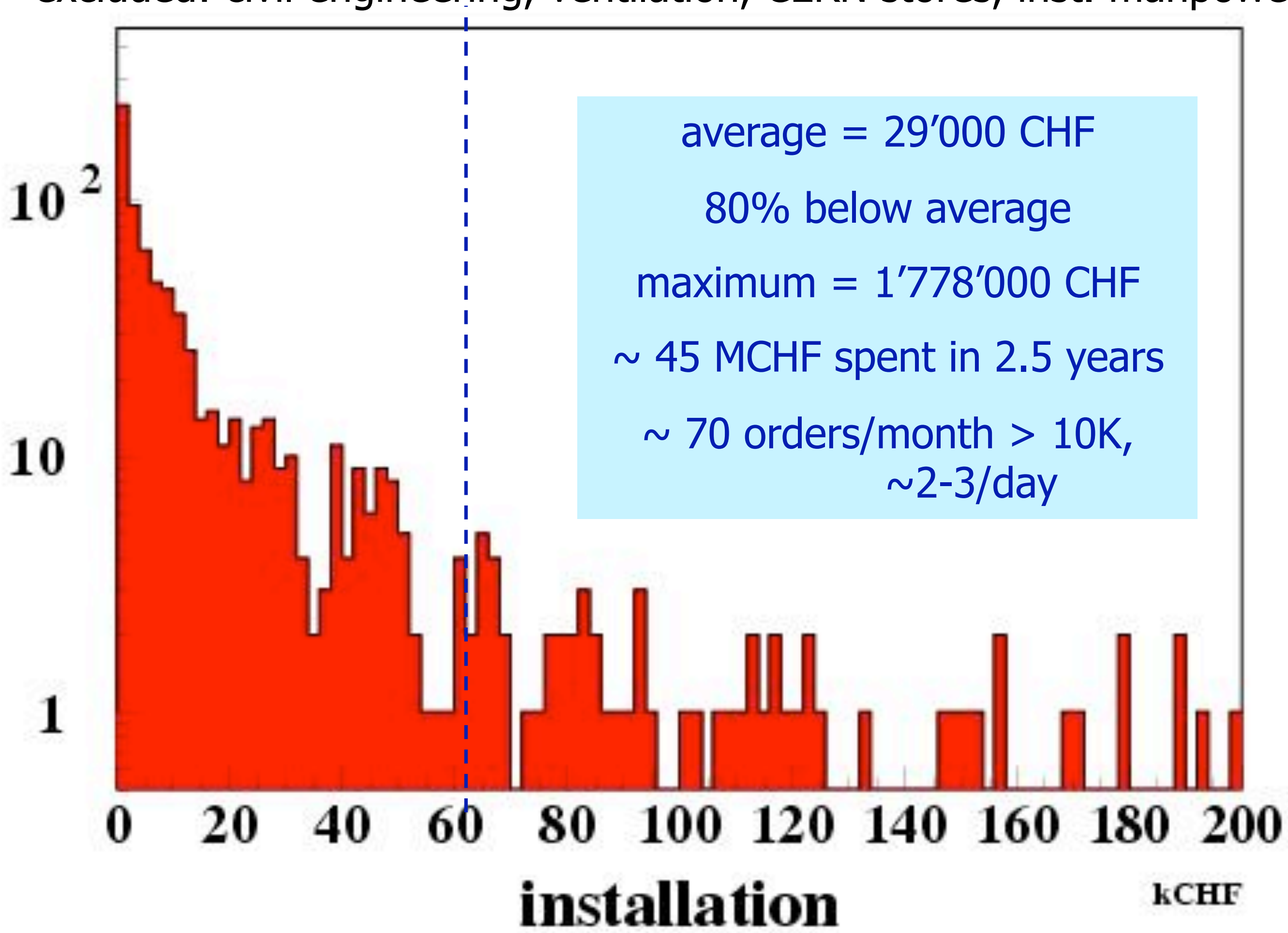


Day by day organization

- Many small contracts (<50KCHF), ~500 producers, needing to deploy manpower in the Geneva area and in a very peculiar environment (underground)
- For more standard work (large infrastructures, structures, ventilation, cryo supply,..) standard procurement process guided by CERN service groups …. Lower bidder approach created a lot of problems and over-costs. Too often the job had to be completed by local firms (example: lifts, air conditioning,…)
- Important was to get simple material via CERN stores, even better via selected suppliers (catalog items) … if not the administrative load and delays are becoming impossible
- Some jobs like transport, craning, scaffolding …. required access to specialized firms, better if selected by the host lab via frame contracts ….
- Lower bidder approach unpractical below 200 KCHF. No time to correct production errors and no time or resources to send people all around Europe to check quality
- Local firms or firms with a lot of CERN experience have been the best and more cost effective solution, when manpower was involved

Example: installation costs (2004-2006)

excluded: civil engineering, ventilation, CERN stores, inst. manpower



- Very intense period (6/7d, 12/24h)
- Always delivery dependent
- Flexible schedule
- Intense procurements periods, requires host lab support

Day by day organization

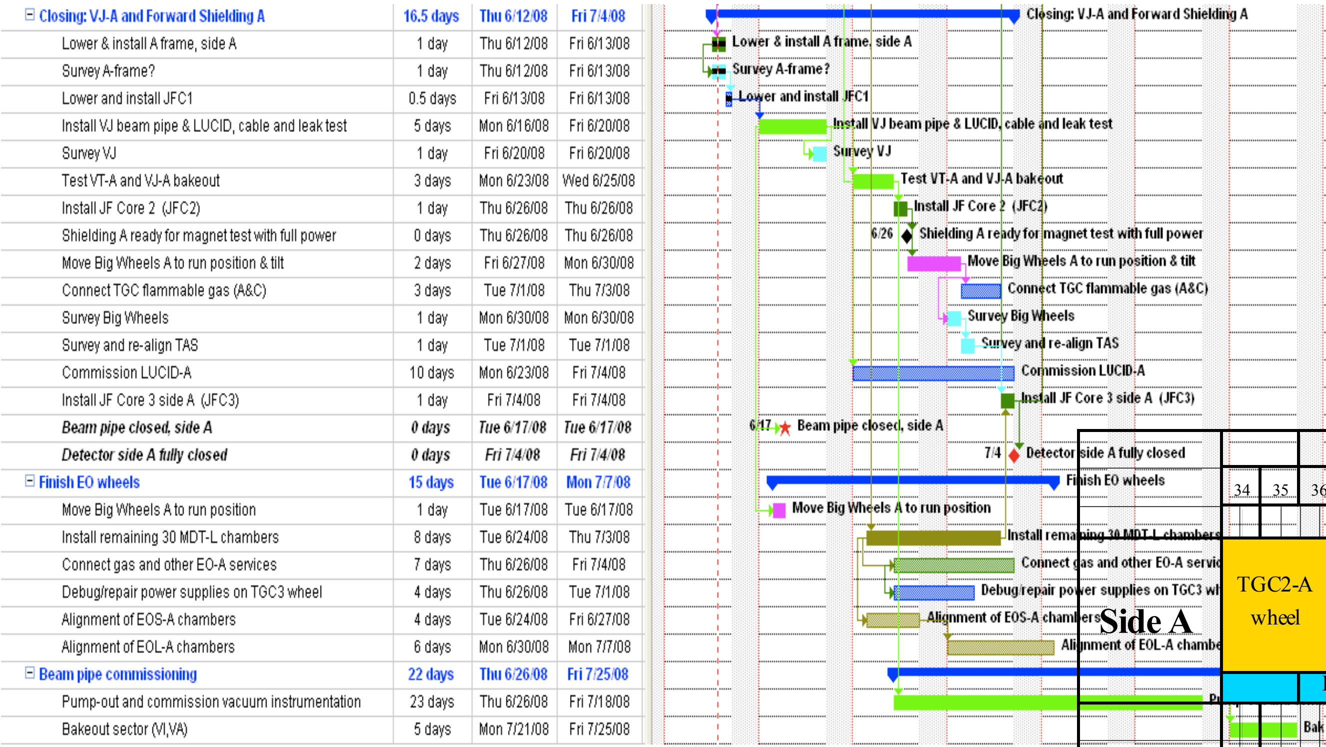
- We decided that all manpower work inside the active detector (including toroids) is better done by manpower coming from the collaboration (part of this as in-kind contribution). These people are better trained, more motivated and of higher education

- Institutions are sending on request manpower to CERN for a limited amount of time to work on assembly. ATLAS central funds are paying for their stay at CERN (cash or in-kind). Rotation is a must and requires a good core team of technical CERN staff

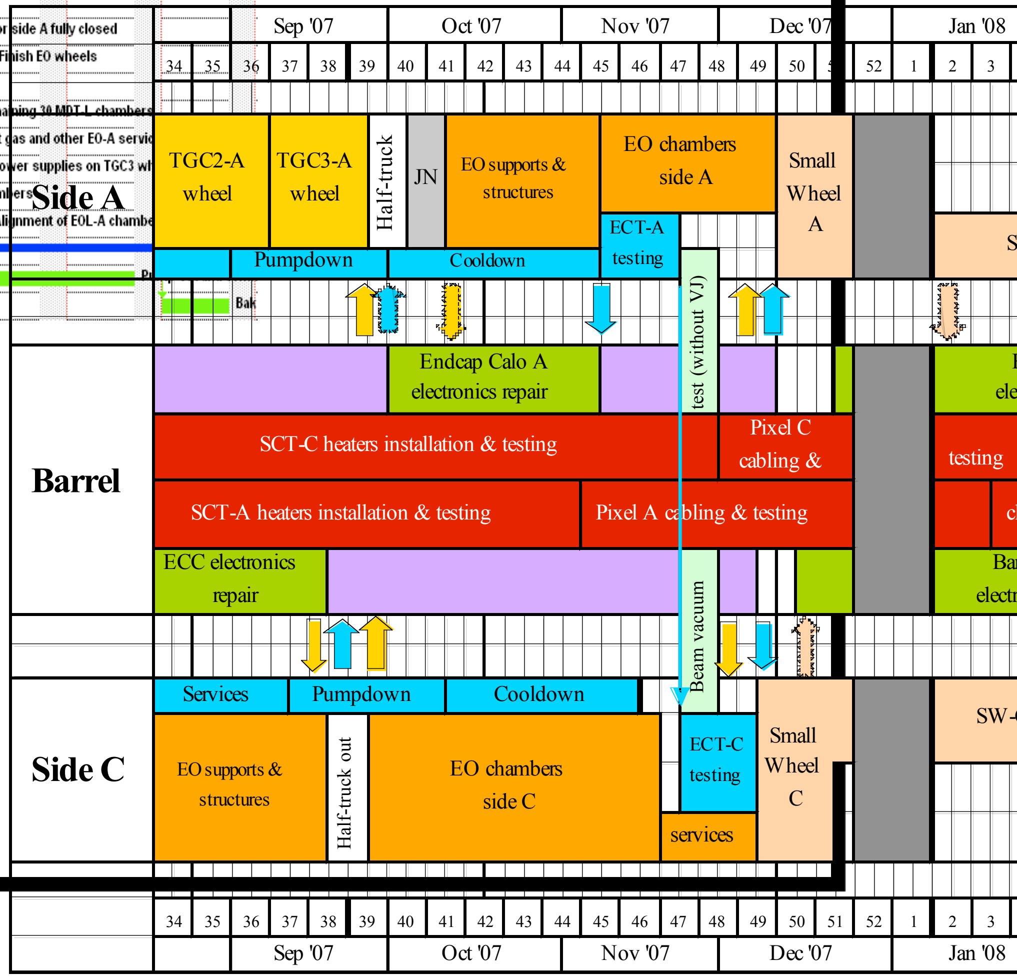
- This solution has proven to be very cost efficient (time and money)

- …. But it creates a challenge in organization and logistic (housing, cars, travels, insurances, …)

- Work supervision and organization is then the key issue



Closing: VJ-A and Forward Shielding A	16.5 days	Thu 6/12/08	Fri 7/4/08
Lower & install A frame, side A	1 day	Thu 6/12/08	Fri 6/13/08
Survey A-frame?	1 day	Thu 6/12/08	Fri 6/13/08
Lower and install JFC1	0.5 days	Fri 6/13/08	Fri 6/13/08
Install VJ beam pipe & LUCID, cable and leak test	5 days	Mon 6/16/08	Fri 6/20/08
Survey VJ	1 day	Fri 6/20/08	Fri 6/20/08
Test VT-A and VJ-A bakeout	3 days	Mon 6/23/08	Wed 6/25/08
Install JF Core 2 (JFC2)	1 day	Thu 6/26/08	Thu 6/26/08
Shielding A ready for magnet test with full power	0 days	Thu 6/26/08	Thu 6/26/08
Move Big Wheels A to run position & tilt	2 days	Fri 6/27/08	Mon 6/30/08
Connect TGC flammable gas (A&C)	3 days	Tue 7/1/08	Thu 7/3/08
Survey Big Wheels	1 day	Mon 6/30/08	Mon 6/30/08
Survey and re-align TAS	1 day	Tue 7/1/08	Tue 7/1/08
Commission LUCID-A	10 days	Mon 6/23/08	Fri 7/4/08
Install JF Core 3 side A (JFC3)	1 day	Fri 7/4/08	Fri 7/4/08
Beam pipe closed, side A	*0 days*	*Tue 6/17/08*	*Tue 6/17/08*
Detector side A fully closed	*0 days*	*Fri 7/4/08*	*Fri 7/4/08*
Finish EO wheels	15 days	Tue 6/17/08	Mon 7/7/08
Move Big Wheels A to run position	1 day	Tue 6/17/08	Tue 6/17/08
Install remaining 30 MDT-L chambers	8 days	Tue 6/24/08	Thu 7/3/08
Connect gas and other EO-A services	7 days	Thu 6/26/08	Fri 7/4/08
Debug/repair power supplies on TGC3 wheel	4 days	Thu 6/26/08	Tue 7/1/08
Alignment of EOS-A chambers	4 days	Tue 6/24/08	Fri 6/27/08
Alignment of EOL-A chambers	6 days	Mon 6/30/08	Mon 7/7/08
Beam pipe commissioning	22 days	Thu 6/26/08	Fri 7/25/08
Pump-out and commission vacuum instrumentation	23 days	Thu 6/26/08	Fri 7/18/08
Bakeout sector (VI,VA)	5 days	Mon 7/21/08	Fri 7/25/08



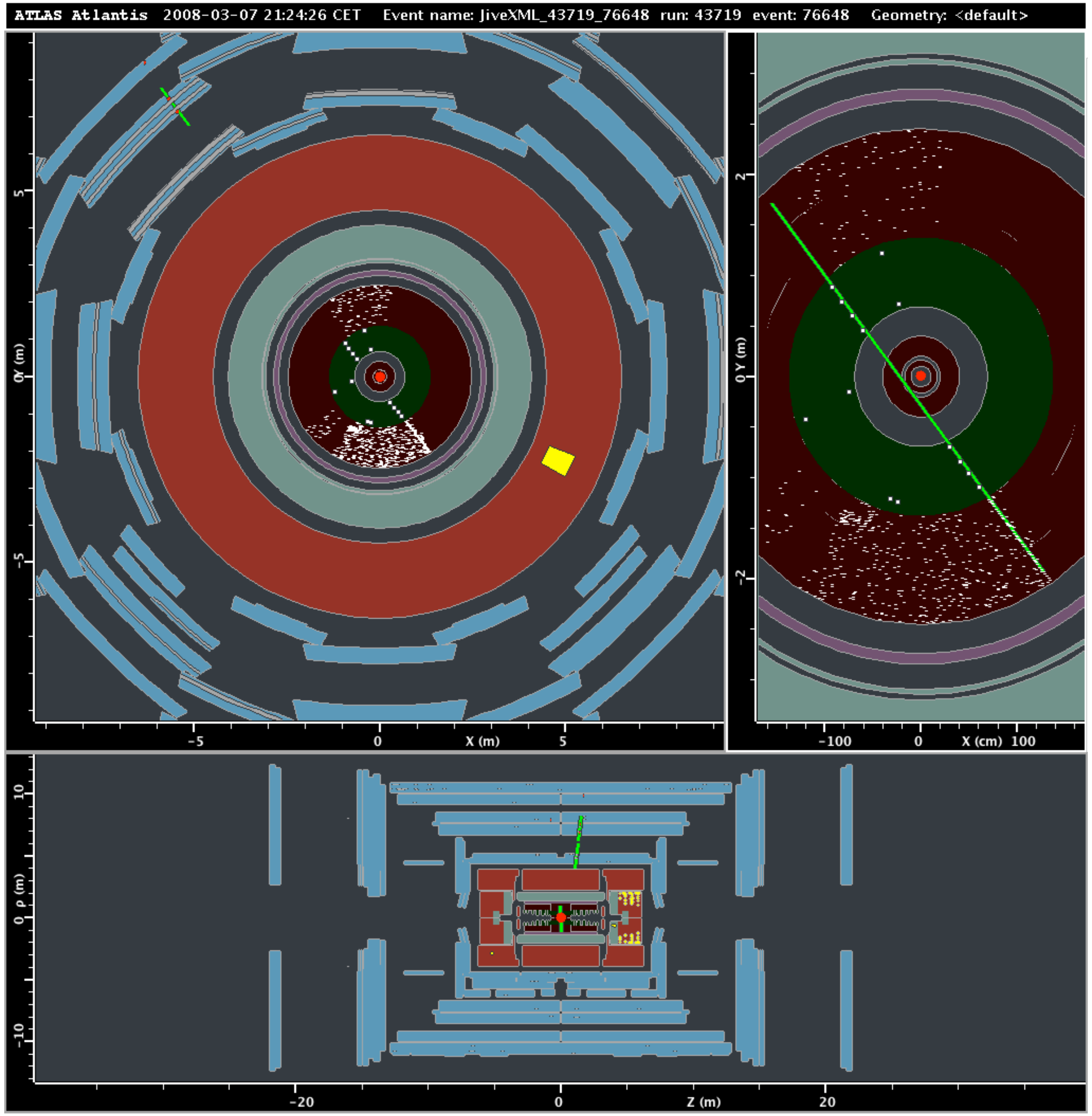
Schedules that evolve, adapt and inform the various partners with different approaches

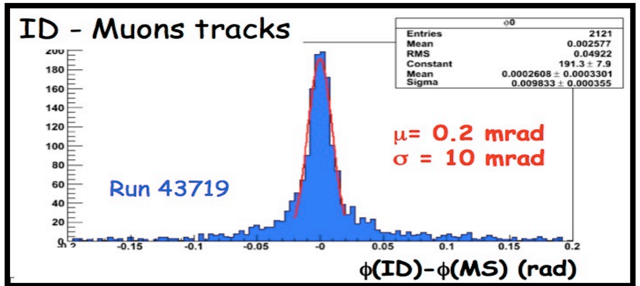
.... in the final phase we issue a new schedule every week with 0.5d granularity

Today we are practically ready

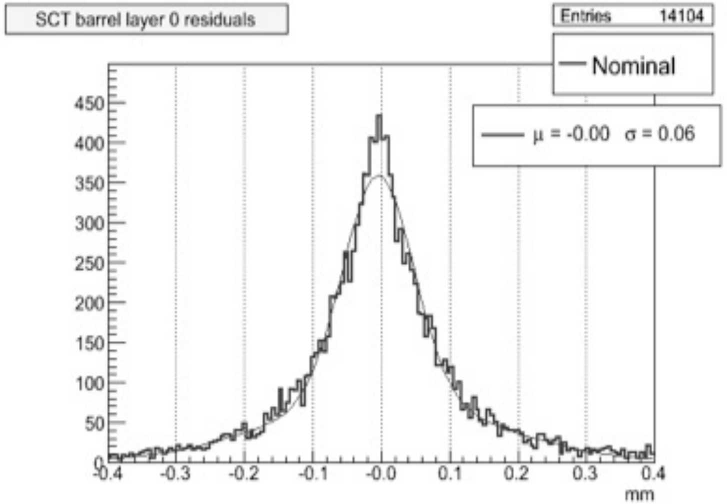
- All components are in place. The barrel detector is closed
- We are doing some last connections, testing components, turning on electronics, cleaning the cavern before closing
- Most of the detector is taking cosmics data, the data flow chain is functioning and we are just testing the distribution of the data to the desk of the physicist and the calibration chain
- It will take us, once we have beam, few years to fully understand the detector response and be able to be sure that we discriminate real signals from combinatory background
- We will also need to better and better calibrate our detector response such to reach the final performance and make use of all the fancy hardware


ATLAS Control Room





Phi difference SCT+TRT, RPC track segment



Run first alignment checks
~ 5000 tracks

SCT residuals (GlobalChi2)
σ~65μm without alignment.