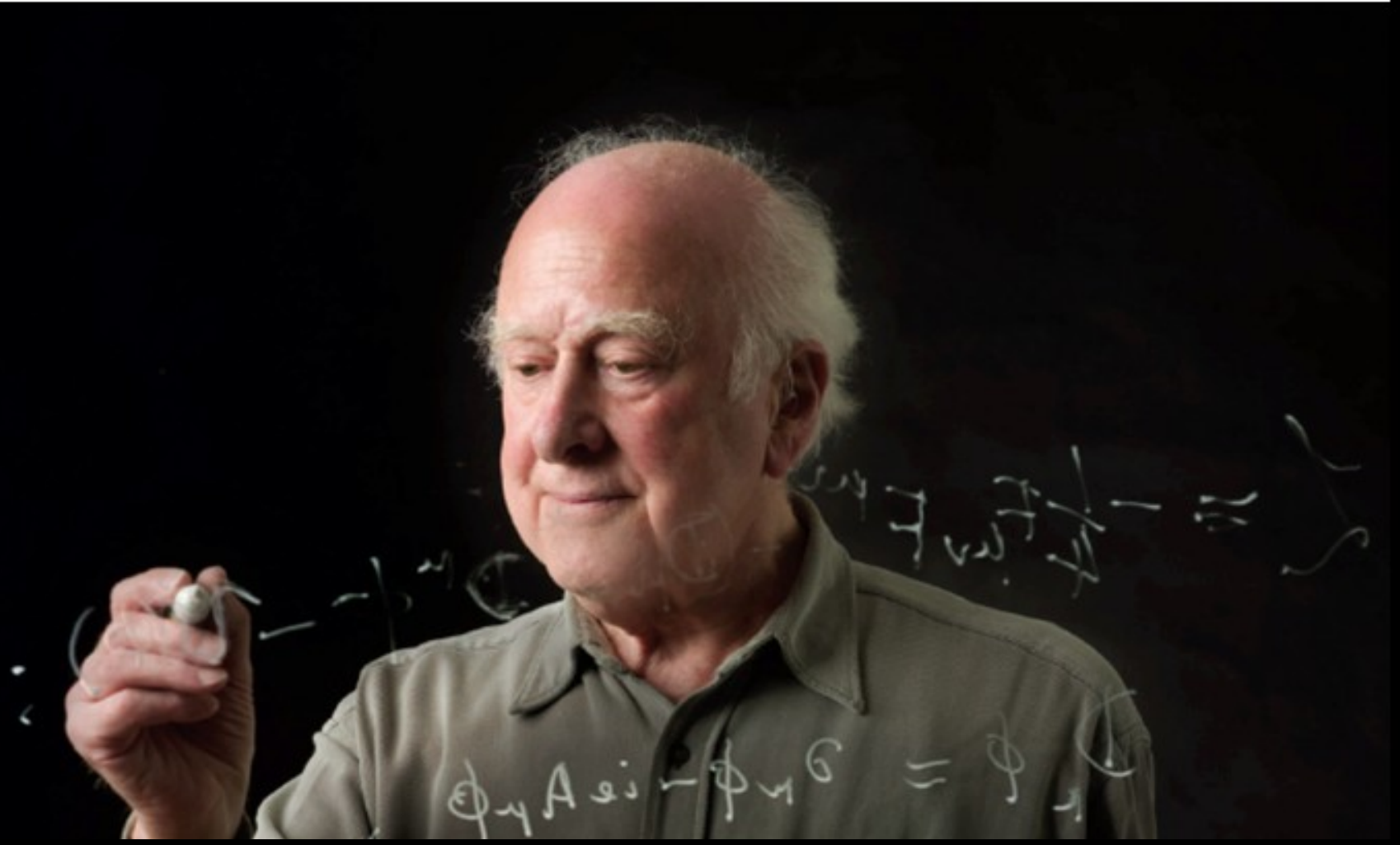
The ATLAS experiment at the CERN-LHC

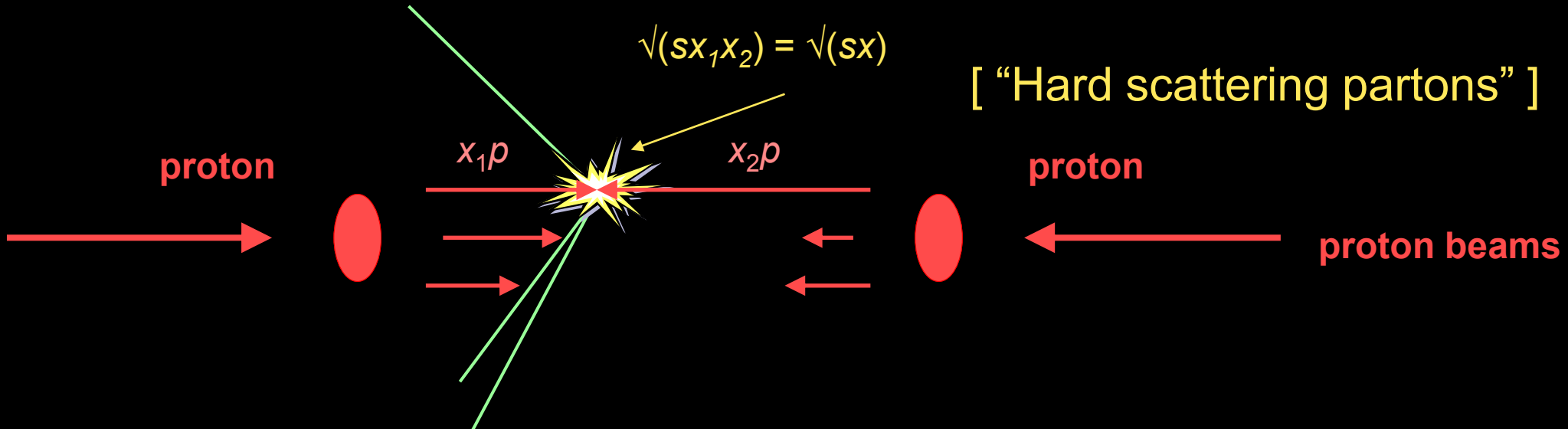
A global project, BIG science!

CERN
May 20th, 2011

Marzio Nessi CERN & University of Geneva
Markus Nordberg CERN

ATLAS EXPERIMENT



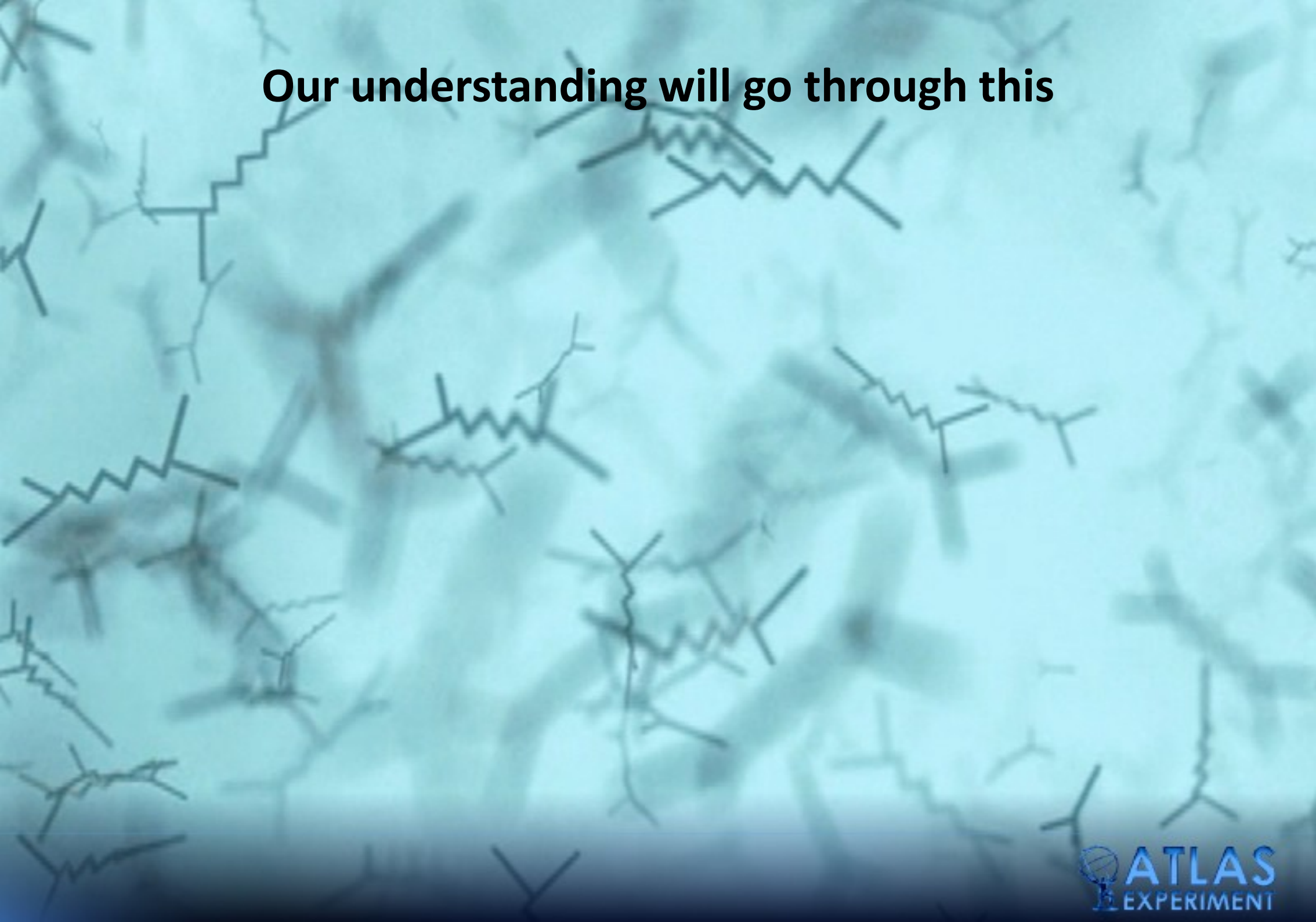


[“Hard scattering partons”]

We know that something is wrong with this picture!

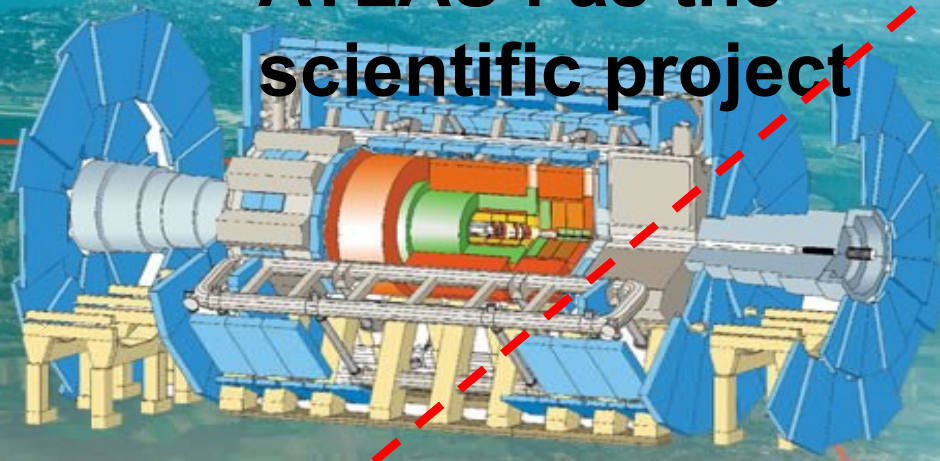
EXPERIMENT

Our understanding will go through this



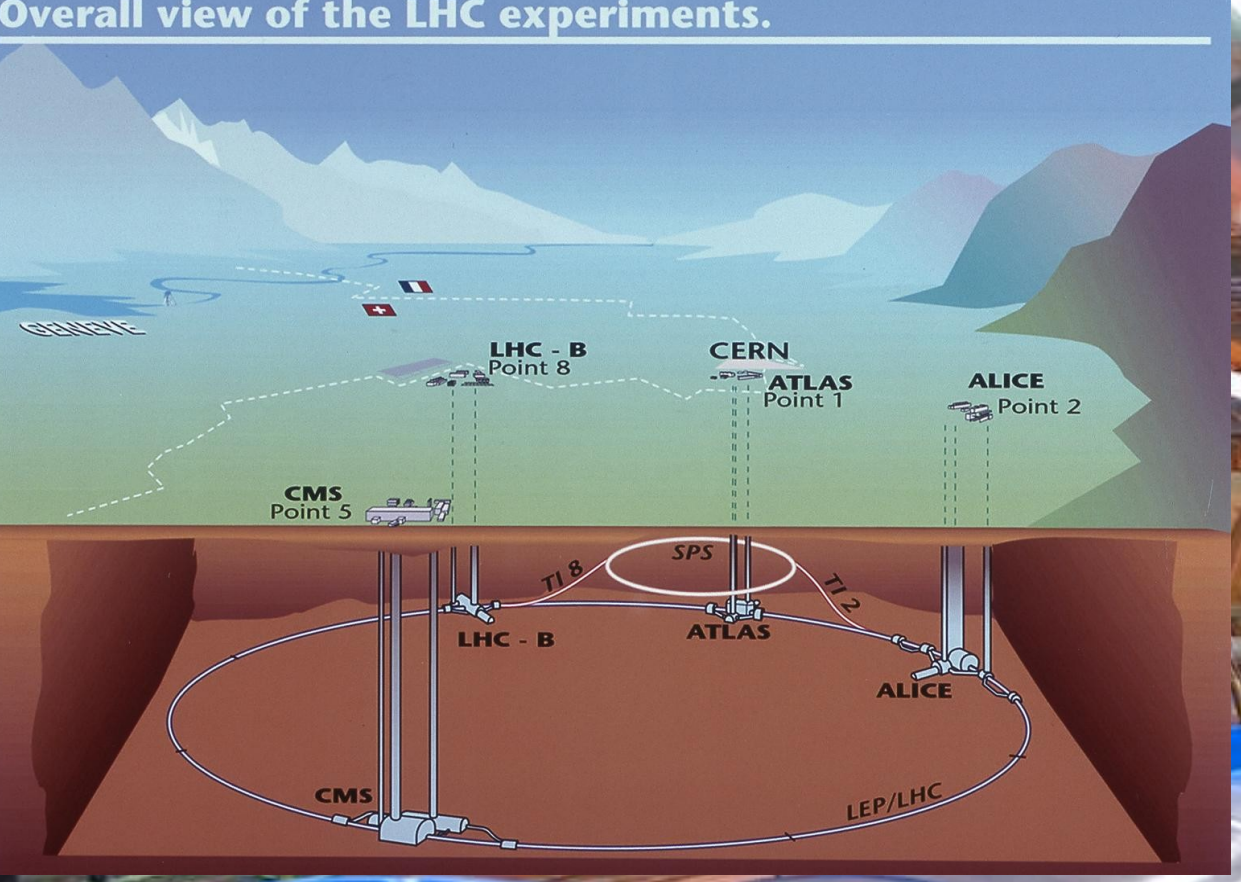
CERN : as the host laboratory

ATLAS : as the scientific project



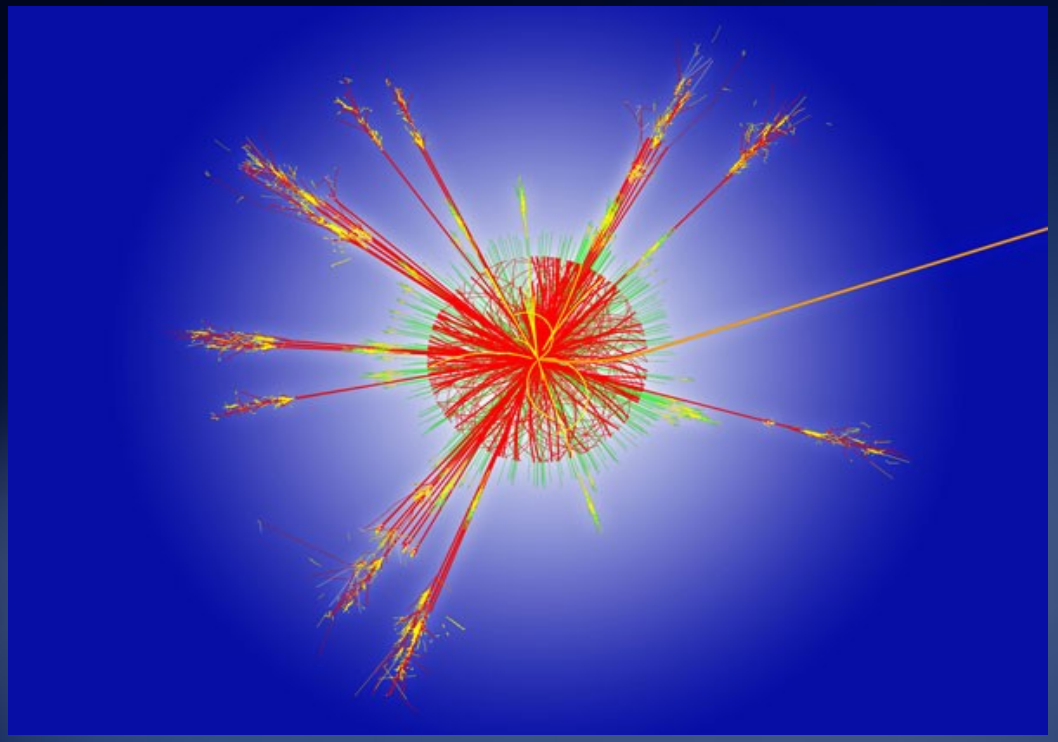
LHC : as the beams facility

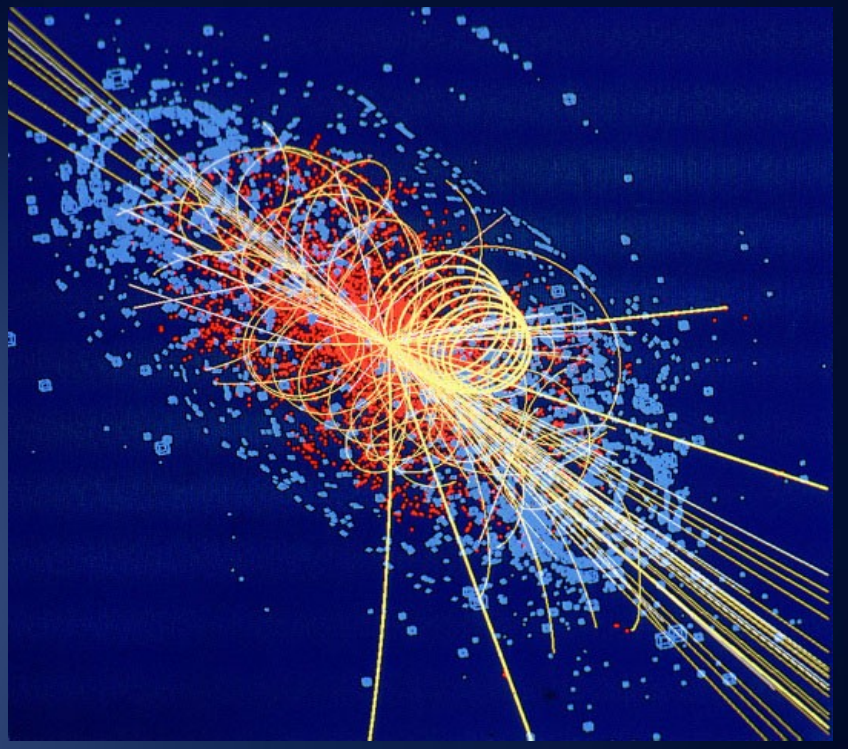
The LHC


Overall view of the LHC experiments.
GENEVE
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC

The hottest spots in the galaxy…

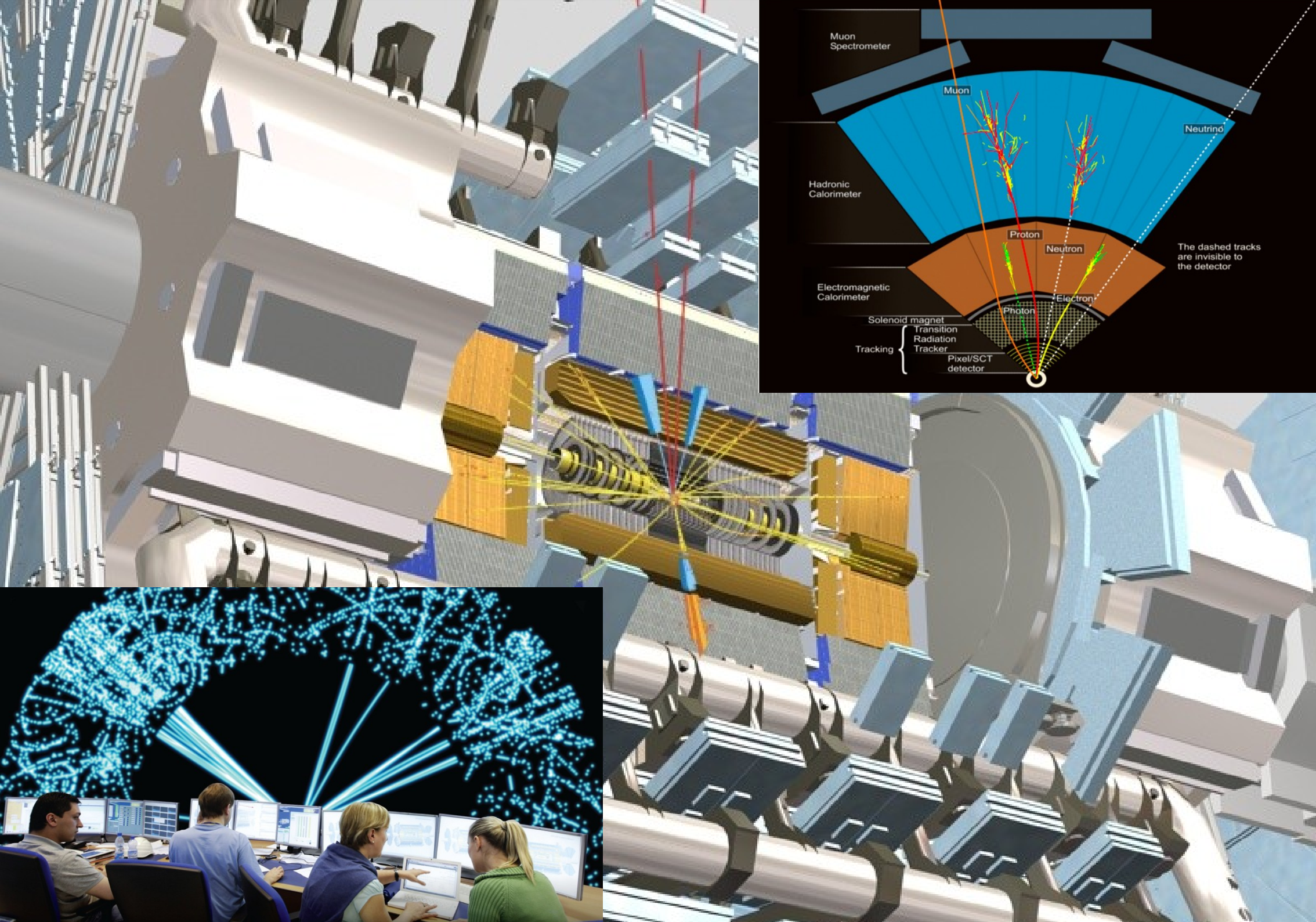
and around it we place a fancy "microscope"





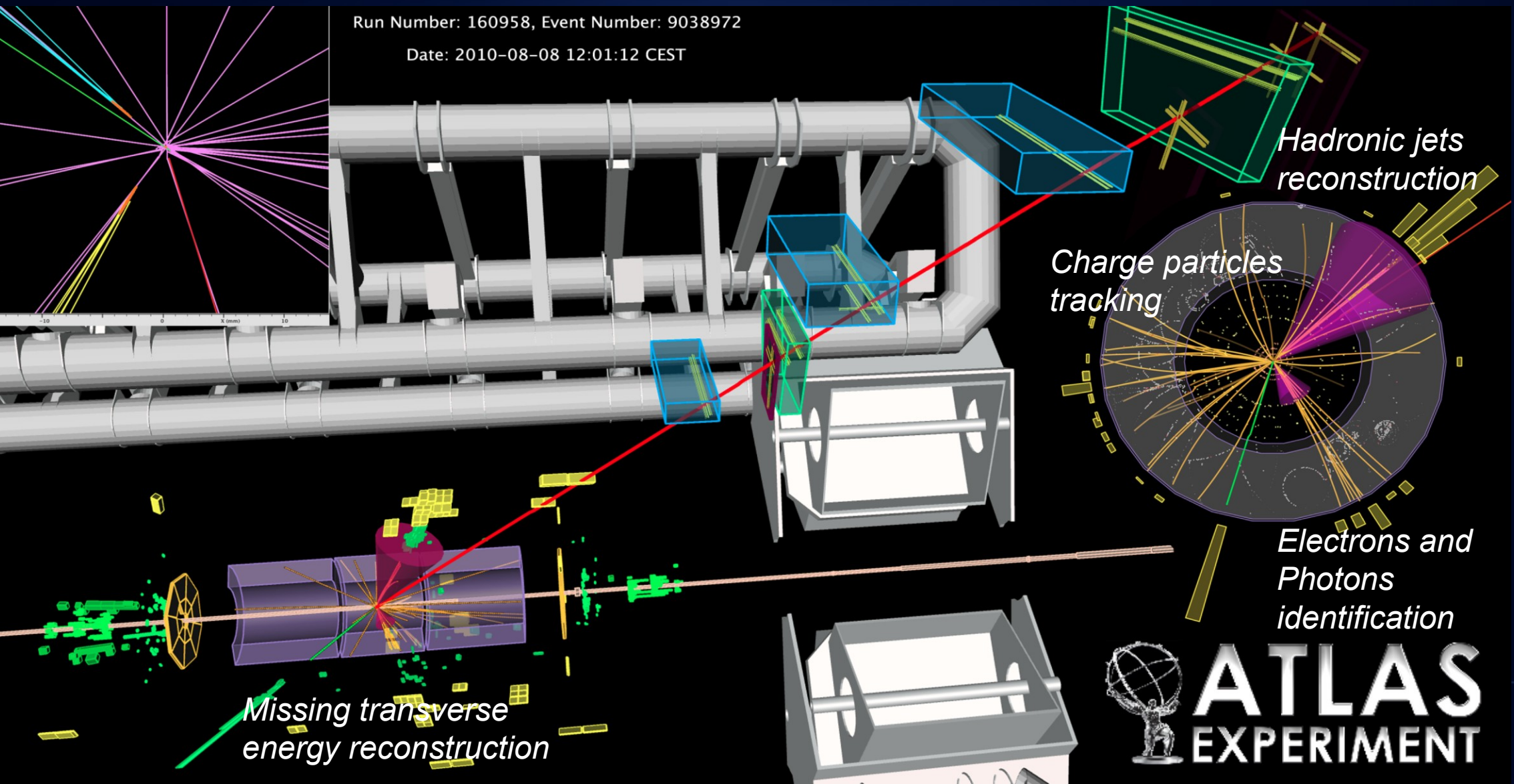
When two beams of protons collide, they will generate temperatures **1000 million times hotter** than the **heart of the sun**, but in a minuscule space.

ATLAS EXPERIMENT

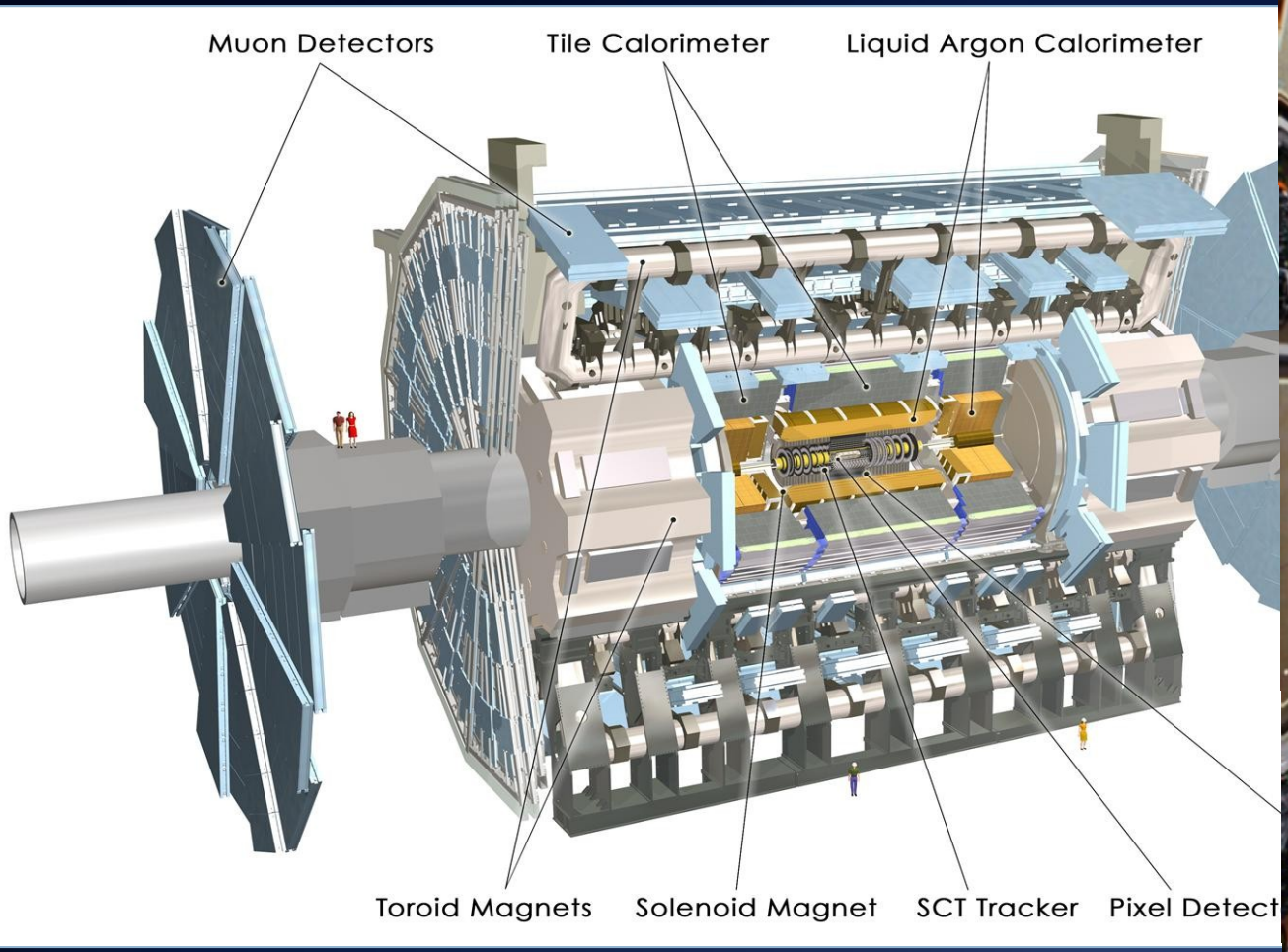

Muon
Spectrometer
Muon
Neutrino
Hadronic
Calorimeter
Proton
Neutron
The dashed tracks
are invisible to
the detector
Electromagnetic
Calorimeter
Electron
Photon
Solenoid magnet
Tracking
Transition
Radiation
Tracker
Pixel/SCT
detector

A collision event (a Top quark candidate)

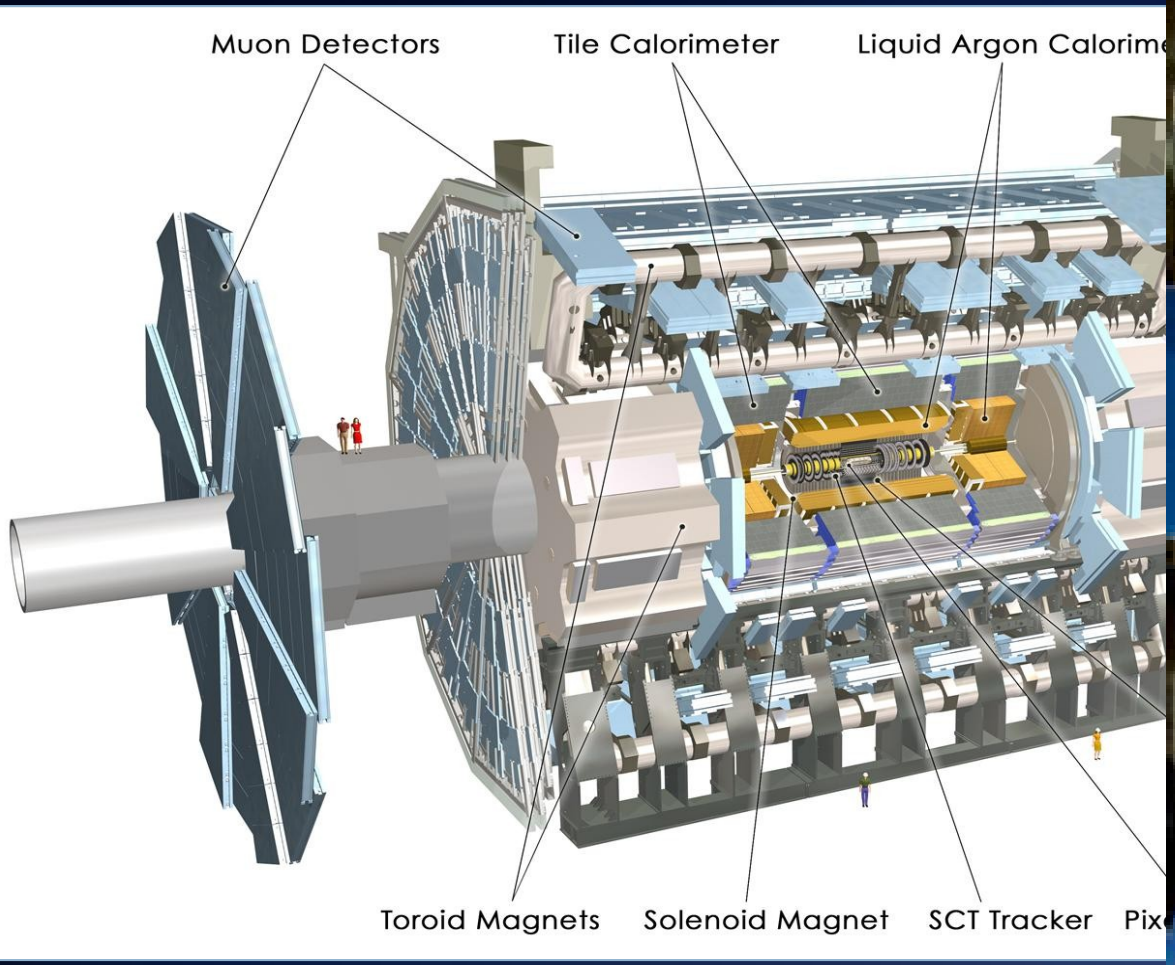
$t\bar{t} \rightarrow e\,\nu\,b\,,\ \mu\,\nu\,b$

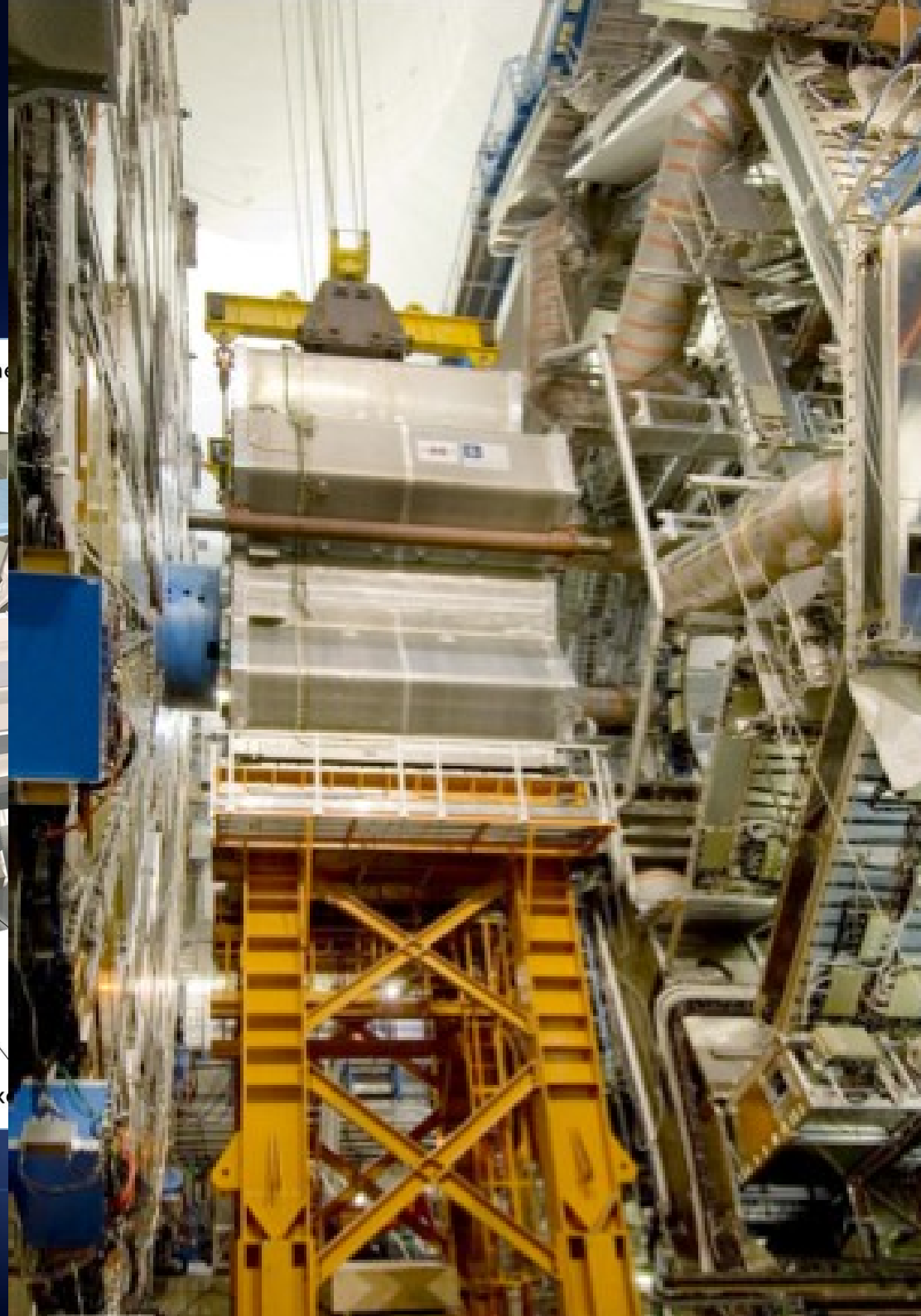


The ATLAS detector

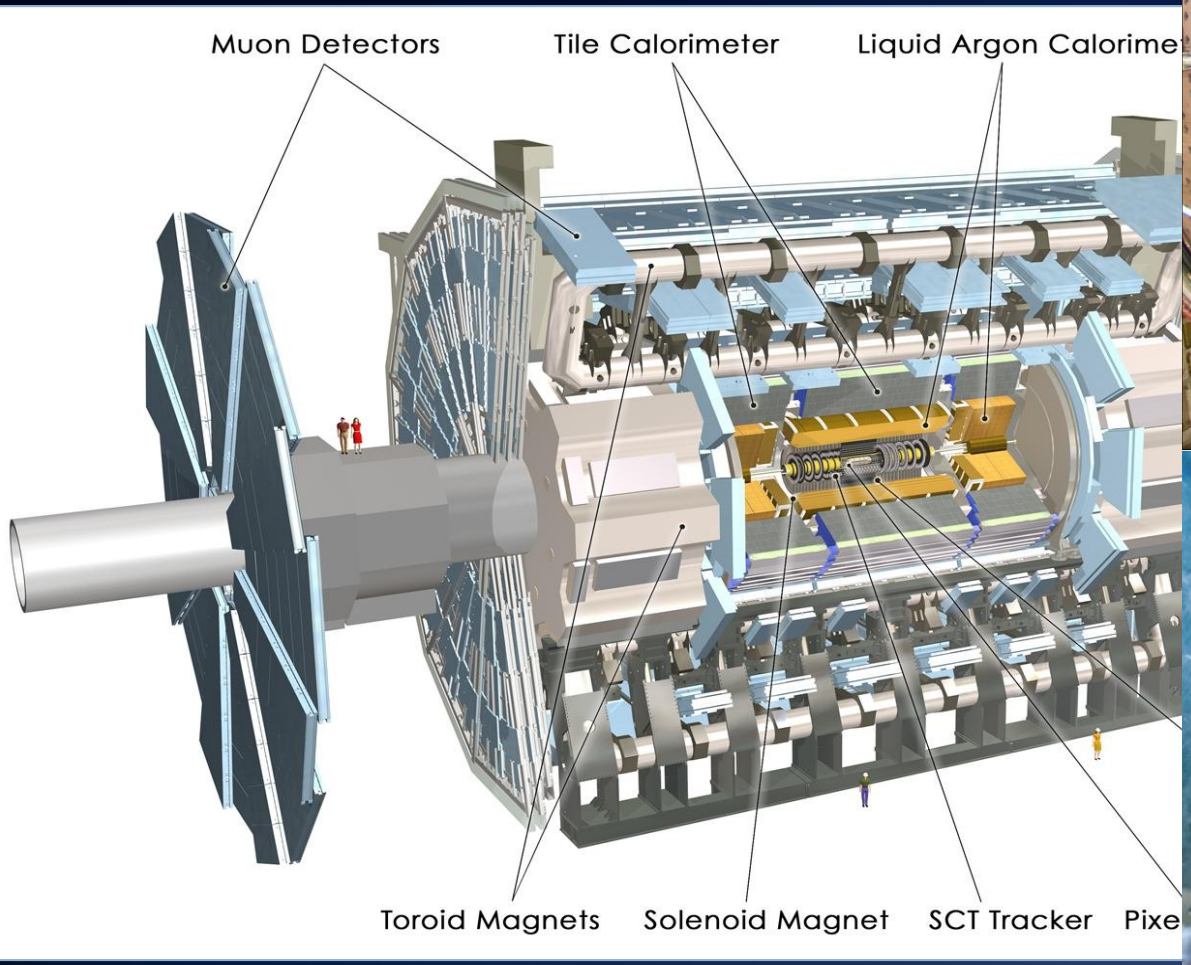


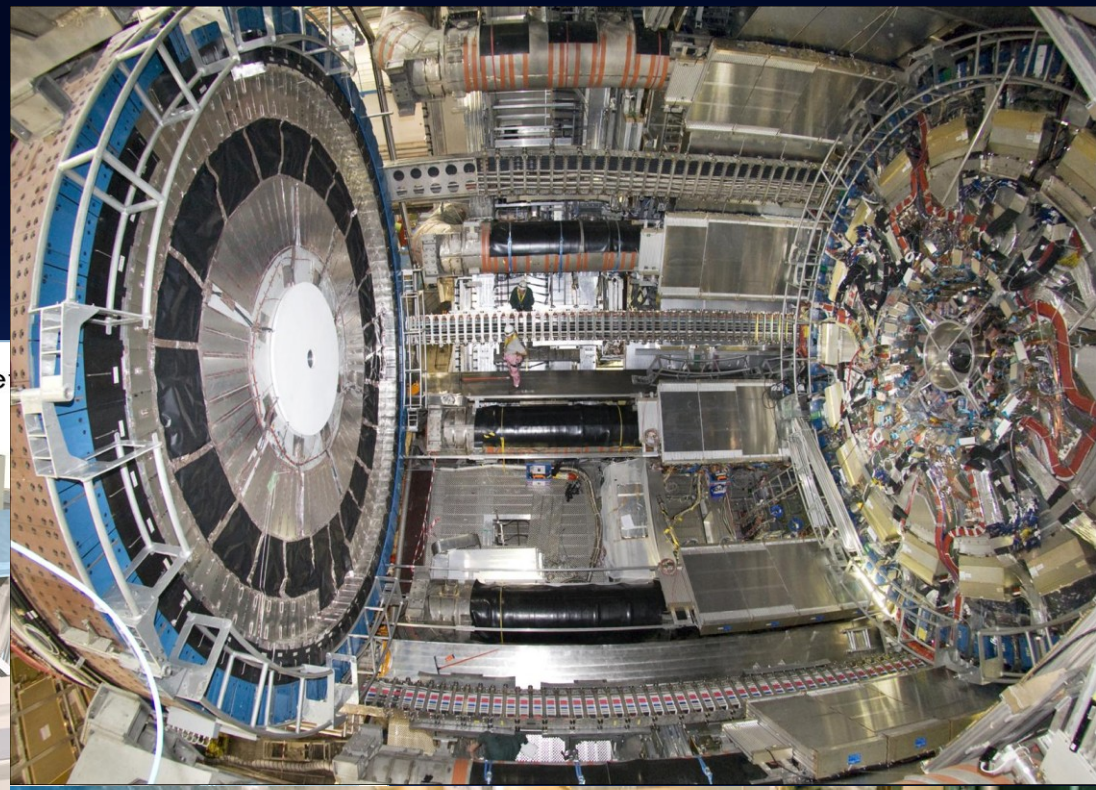
The ATLAS detector





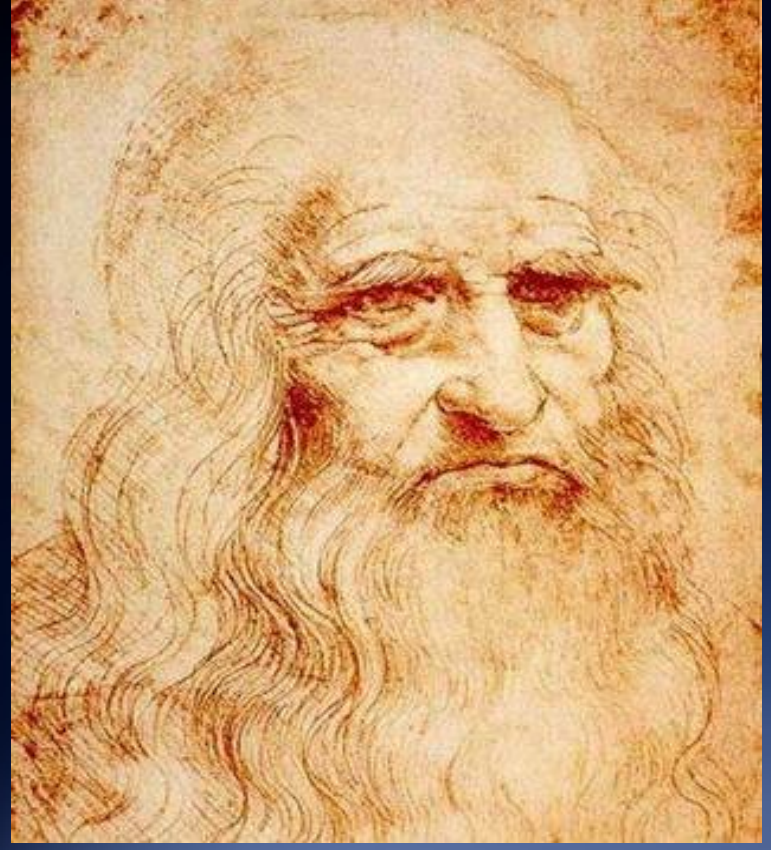
The ATLAS detector



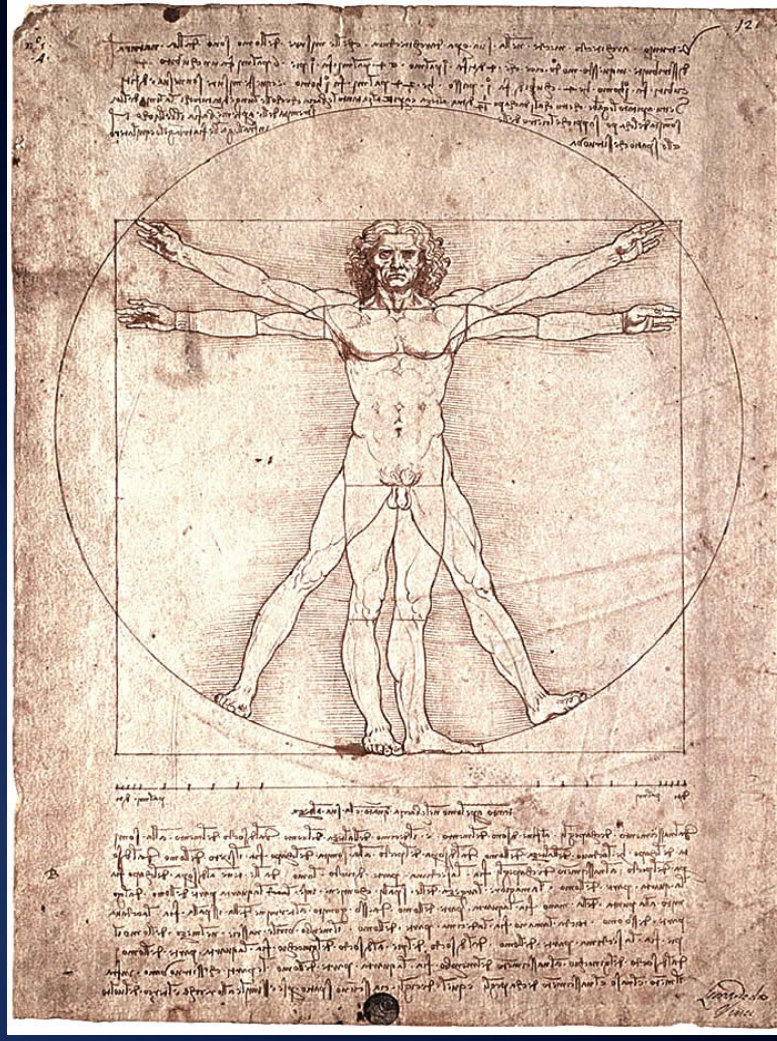


Project ingredients

- A very strong motivation in the entire community towards new physics (this is the real motor !!!)
- A well established collaborative method
- An incredible amount of knowledge within the community in many aspects of modern technology (hardware, micro-electronics, computing and detector techniques) matured over 50 years of HEP history
- A well established Host Laboratory (CERN) capable to assist and support such an effort with the necessary infrastructure



~1510



one man show

ATLAS EXPERIMENT

3030 active scientists:

-- **~ 1830 with a PhD → contribute to M&O share**

-- **~ 1200 students**

~4500 scientists over the last 15-20 years

174 Institutions, 38 Countries

Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Annecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, HU Berlin, Bern, Birmingham, UAN Bogota, Bologna, Bonn, Boston, Brandei Brasil Cluster, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, CERN, Chinese Cluster, Chicag Chile, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, SMU Dallas, UT Dallas, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Edinburgh, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, Göttingen, LPSC Grenc Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Iowa, UC Irvine, Istanbul Bogazici, Johannesburg/Witwatersrand, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW Lon RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michig SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, RUPHE Morocco, FIAN Moscow, ITEP Moscow, MEPhI Moscow, M Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Nagoya, Naples, New Mexico, New York, Nijmegen, Northern Illinois University, BIN Novosibirsk, NPI Petersburg,Ohio SU, Okayama, Oklahoma, Oklahoma SU, Olomouc, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris V and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Rome I, Rome II, Rome II Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, Stockholm KTH Stockholm, Stony Brook, Sydney, Sussex, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Tokyo Tech, Toronto, TRIUMF, Tsukuba, Tufts, Udine/ICTP, Uppsala, UI Urbana, Valencia, UBC Vancouver, Victoria, Waseda, Washington, Weizmann Rehov FH Wiener Neustadt, Wisconsin, Wuppertal, Würzburg, Yale, Yerevan

France	Switzerland
Georgia	Taiwan
Germany	Turkey
Greece	UK
Israel	USA
Italy	CERN
Japan	JINR

ATLAS Collaboration

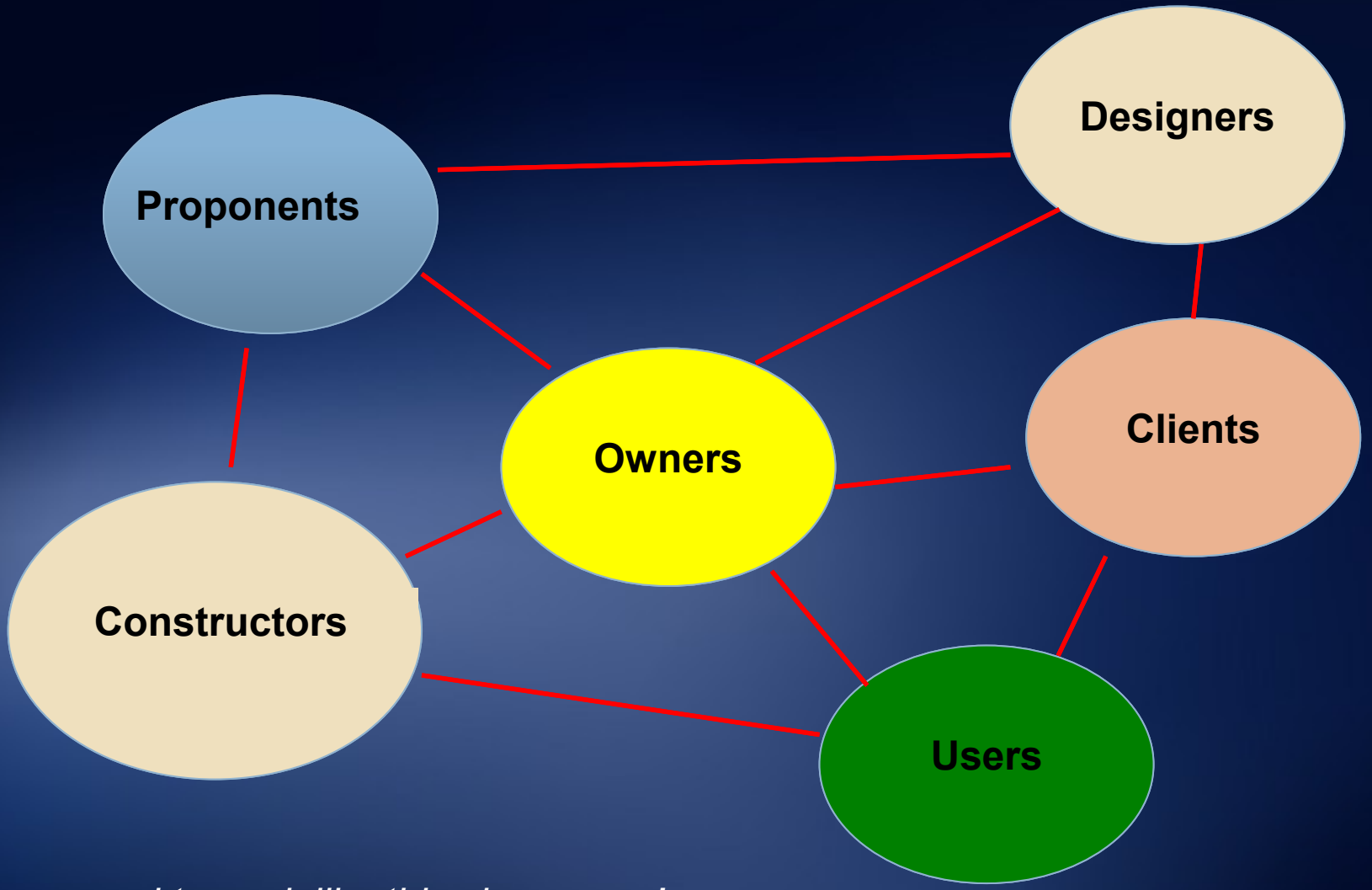
WE ….culture

WE ….culture

opposite to …. I culture


ATLAS
EXPERIMENT

Who are we really ?



We are used to work like this since ever !

… from LOI (letter of intent) to Scientific publications

ATLAS EXPERIMENT

A well established collaborative method

- Highly democratic (individuals, transparency, 1 vote/institution)
- Minimal centralized structures (management, sub-projects)
- Rotation of responsibilities (all positions by election, 2 years)
- Decision making process based on consensus
- Resources flow : bottom up
- Structures and rules evolving in time with the project
- Intense pier reviewing (inside/outside)
- All publications signed by the entire collaboration

ATLAS EXPERIMENT

1 person per institution
Meet 3-4 times per year
Policy making body
Overview/organize all elections

Collaboration Board

Forum for discussions and information sharing
Work distributed in working groups and projects
Daily work steered by Executive Board

ATLAS Plenary Meeting

1 person per funding agency
Meet 2 times per year
Control and release budgets
Approve major strategical choices

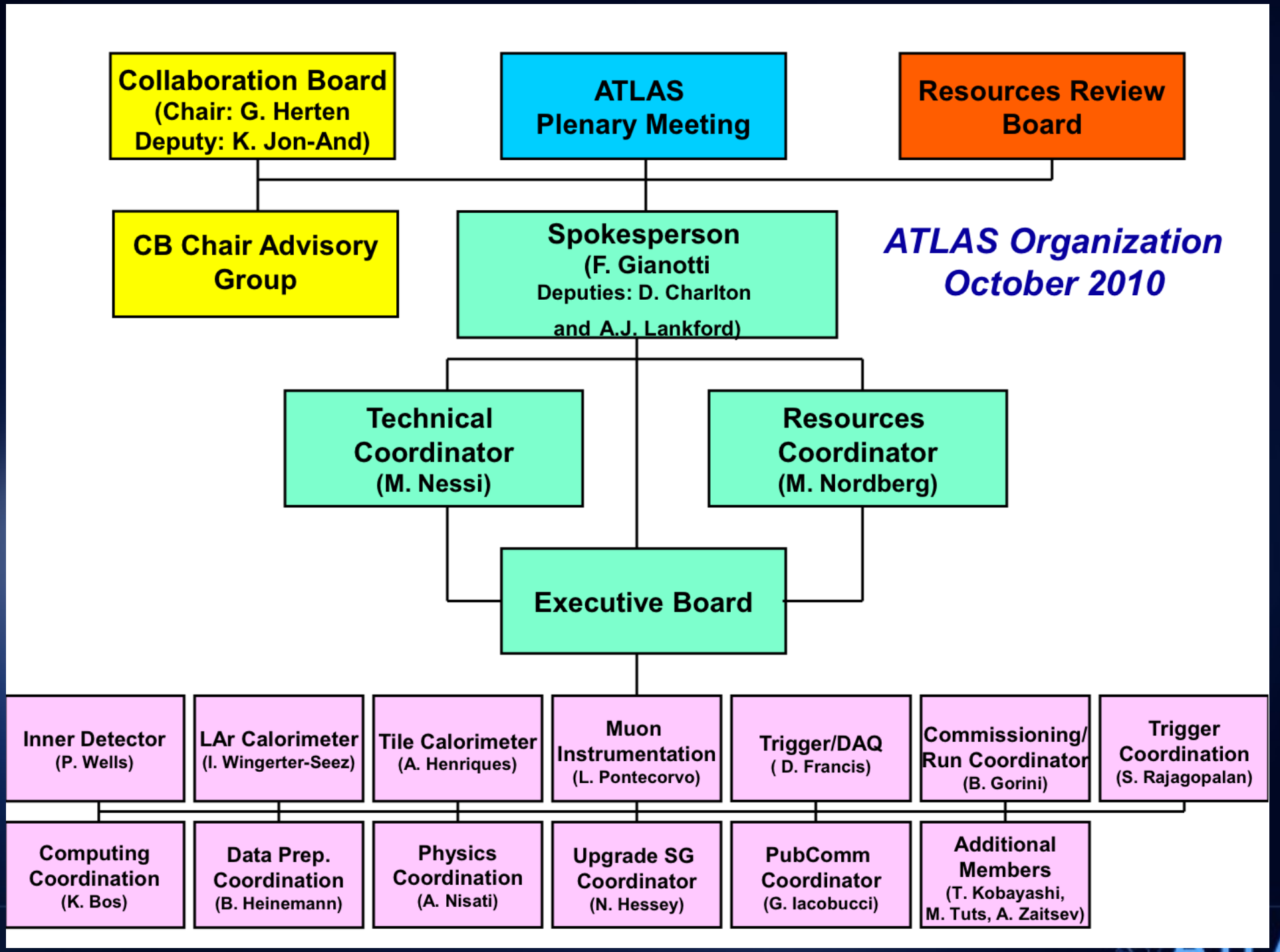
Resources Review Board

Executive Board

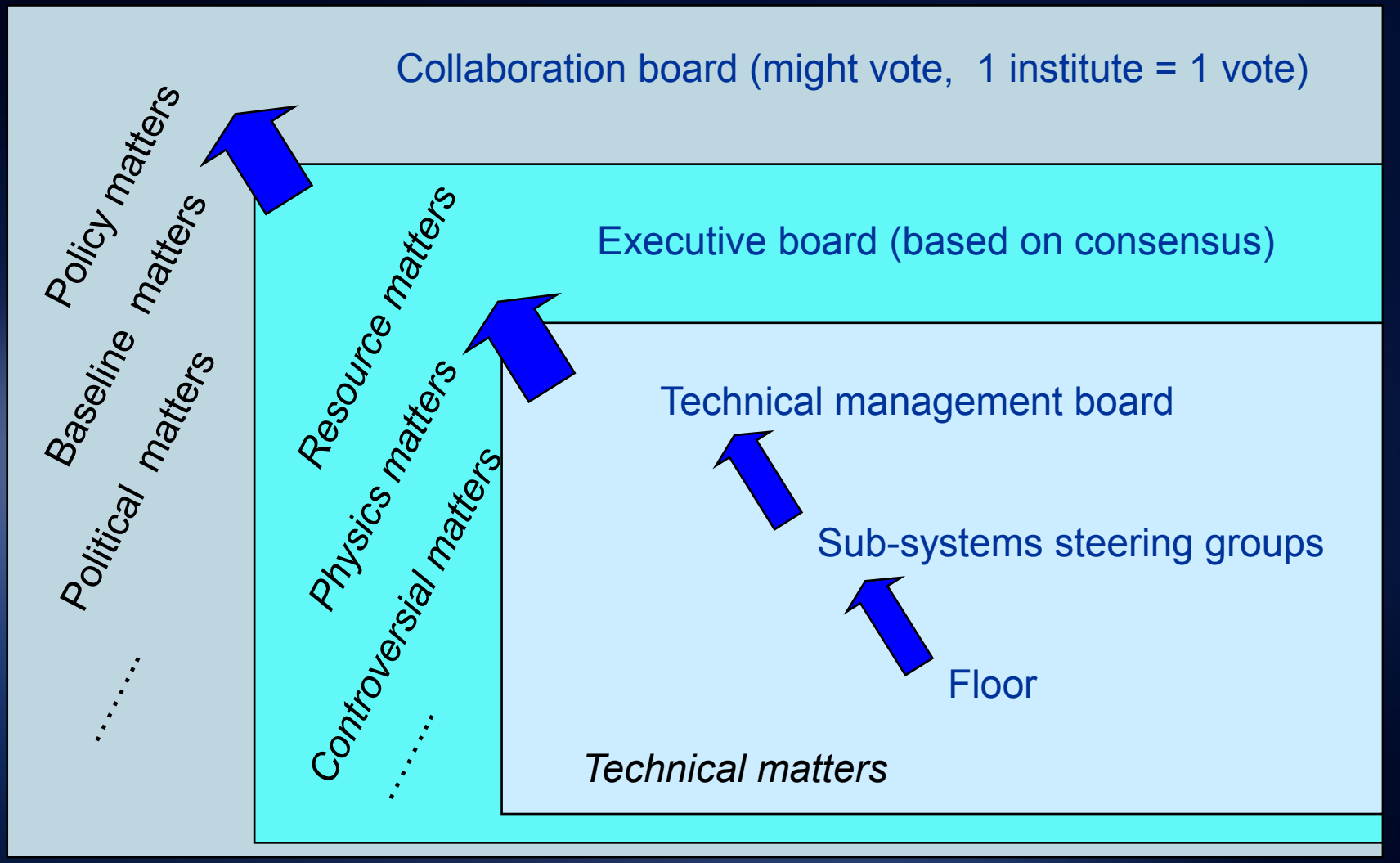
3 central management functions (spokesperson, technical coordinator, resources coordinator)

Project Leaders, Activity Leaders
Substructure organized in projects or activities
Repeat overall structure at project level

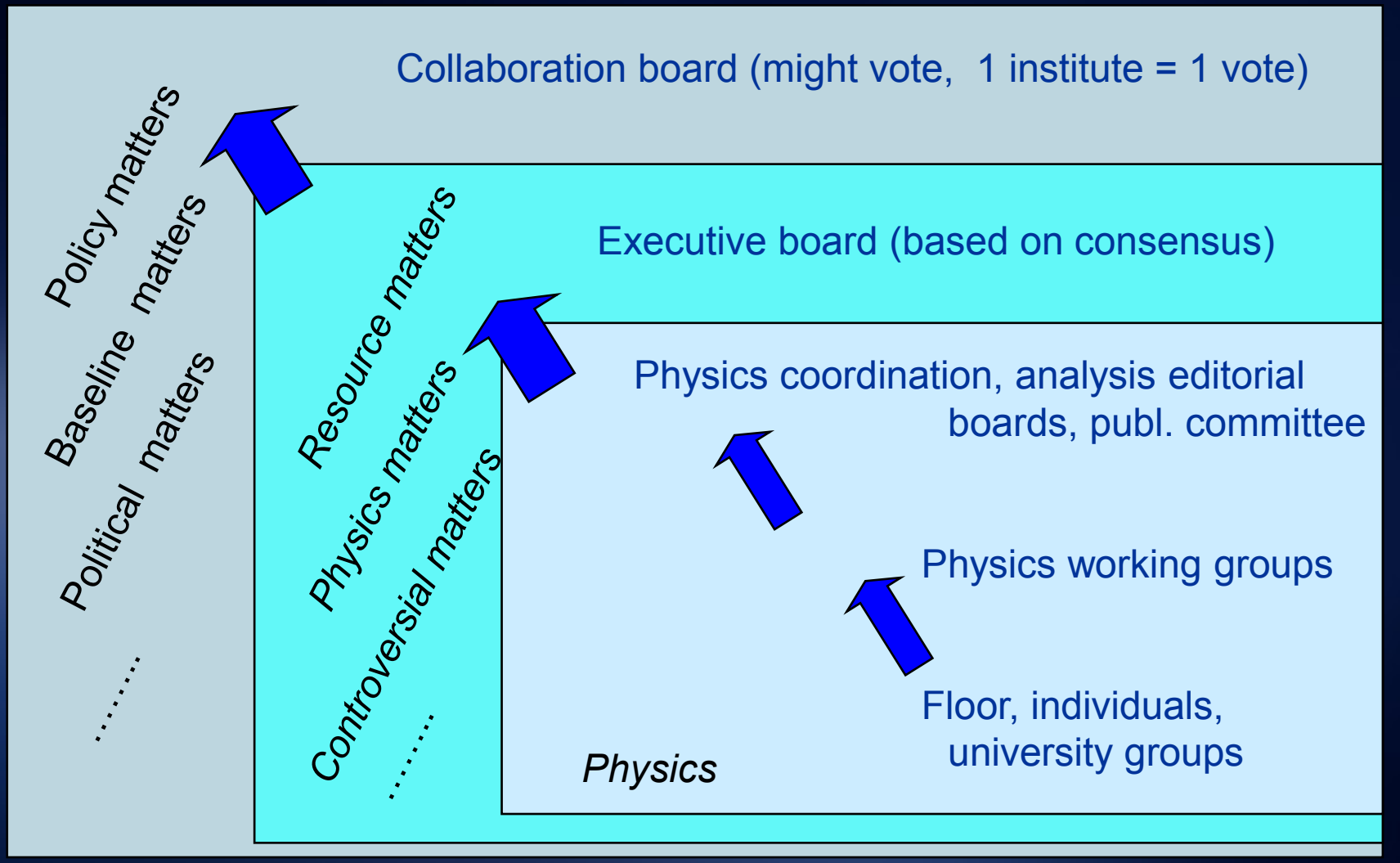
ATLAS EXPERIMENT


Collaboration Board
(Chair: G. Herten
Deputy: K. Jon-And)
ATLAS
Plenary Meeting
Resources Review
Board
CB Chair Advisory
Group
Spokesperson
(F. Gianotti
Deputies: D. Charlton
and A.J. Lankford)
ATLAS Organization
October 2010
Technical
Coordinator
(M. Nessi)
Resources
Coordinator
(M. Nordberg)
Executive Board
Inner Detector
(P. Wells)
LAr Calorimeter
(I. Wingerter-Seez)
Tile Calorimeter
(A. Henriques)
Muon
Instrumentation
(L. Pontecorvo)
Trigger/DAQ
(D. Francis)
Commissioning/
Run Coordinator
(B. Gorini)
Trigger
Coordination
(S. Rajagopalan)
Computing
Coordination
(K. Bos)
Data Prep.
Coordination
(B. Heinemann)
Physics
Coordination
(A. Nisati)
Upgrade SG
Coordinator
(N. Hessey)
PubComm
Coordinator
(G. Iacobucci)
Additional
Members
(T. Kobayashi,
M. Tuts, A. Zaitsev)

Decision making process *(on technical matters)*



Decision making process *(on physics)*



13 pages of Authors / publication

Charged-particle multiplicities in pp interactions at $\sqrt{s} = 900$ GeV measured with the ATLAS detector at the LHC ☆,☆☆

ATLAS Collaboration

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900 GeV
ATLAS
LHC
Minimum bias

ABSTRACT

The first measurements from proton–proton collisions recorded with the ATLAS detector at th
are presented. Data were collected in December 2009 using a minimum-bias trigger during col
at a centre-of-mass energy of 900 GeV. The charged-particle multiplicity, its dependence on tran
momentum and pseudorapidity, and the relationship between mean transverse momentum and ch
particle multiplicity are measured for events with at least one charged particle in the kinematic
$|\eta| < 2.5$ and $p_T > 500$ MeV. The measurements are compared to Monte Carlo models of proton–
collisions and to results from other experiments at the same centre-of-mass energy. The charged-p
multiplicity per event and unit of pseudorapidity at $\eta = 0$ is measured to be 1.333 ± 0.003(s
0.040(syst.), which is 5–15% higher than the Monte Carlo models predict.

2010 Published by Elsevi

1. Introduction

Inclusive charged-particle distributions have been measured in pp and $p\bar{p}$ collisions at a range of different centre-of-mass energi
13]. Many of these measurements have been used to constrain phenomenological models of soft-hadronic interactions and to p
properties at higher centre-of-mass energies. Most of the previous charged-particle multiplicity measurements were obtained by sel
data with a double-arm coincidence trigger, thus removing large fractions of diffractive events. The data were then further correct
remove the remaining single-diffractive component. This selection is referred to as non-single-diffractive (NSD). In some cases, desig
as inelastic non-diffractive, the residual double-diffractive component was also subtracted. The selection of NSD or inelastic non-diffr
charged-particle spectra involves model-dependent corrections for the diffractive components and for effects of the trigger selecti
events with no charged particles within the acceptance of the detector. The measurement presented in this Letter implements a dif
strategy, which uses a single-arm trigger overlapping with the acceptance of the tracking volume. Results are presented as incl
inelastic distributions, with minimal model-dependence, by requiring one charged particle within the acceptance of the measuremer

This Letter reports on a measurement of primary charged particles with a momentum component transverse to the beam dire

ATLAS Collaboration

G. Aad [48], E. Abat [18a,*], B. Abbott [110], J. Abdallah [11], A.A. Abdelalim [49], A. Abdesselam [117], O. Abdinov, B. Abi [111], M. Abolins [88], H. Abramowicz [151], H. Abreu [114], E. Acerbi [89a,89b], B.S. Acharya [162a,162b], M. Ackers [20], D.L. Adams [24], T.N. Addy [56], J. Adelman [173], M. Aderholz [99], C. Adorisio [36a,36b], P. Adrag, T. Adye [128], S. Aefsky [22], J.A. Aguilar-Saavedra [123b], M. Aharrouche [81], S.P. Ahlen [21], F. Ahles [48], A. Ahmad [146], H. Ahmed [2], M. Ahsan [40], G. Aielli [132a,132b], T. Akdogan [18a], P.F. Åkesson [29], T.P.A. Åkess, G. Akimoto [153], A.V. Akimov [94], A. Aktas [48], M.S. Alam [1], M.A. Alam [76], J. Albert [167], S. Albrand [55], M. Aleksa [29], I.N. Aleksandrov [65], M. Aleppo [89a,89b], F. Alessandria [89a], C. Alexa [25a], G. Alexander [151], G. Alexandre [49], T. Alexopoulos [9], M. Alhroob [20], M. Aliev [15], G. Alimonti [89a], J. Alison [119], M. Aliyev, P.P. Allport [73], S.E. Allwood-Spiers [53], J. Almond [82], A. Aloisio [102a,102b], R. Alon [169], A. Alonso [79], J. Alonso [14], M.G. Alviggi [102a,102b], K. Amako [66], P. Amaral [29], G. Ambrosini [16], G. Ambrosio [89a,a], C. Amelung [22], V.V. Ammosov [127,*], A. Amorim [123a], G. Amorós [165], N. Amram [151], C. Anastopoulos, T. Andeen [29], C.F. Anders [48], K.J. Anderson [30], A. Andreazza [89a,89b], V. Andrei [58a], M.-L. Andrieux [55], X.S. Anduaga [70], A. Angerami [34], F. Anghinolfi [29], N. Anjos [123a], A. Annovi [47], A. Antonaki [8], M. Anton, S. Antonelli [19a,19b], J. Antos [143b], B. Antunovic [41], F. Anulli [131a], S. Aoun [83], G. Arabidze [8], I. Aracena, Y. Arai [66], A.T.H. Arce [14], J.P. Archambault [28], S. Arfaoui [29,b], J.-F. Arguin [14], T. Argyropoulos [9], E. Arik, M. Arik [18a], A.J. Armbruster [87], K.E. Arms [108], S.R. Armstrong [24], O. Arnaez [4], C. Arnault [114], A. Artamonov [95], D. Arutinov [20], M. Asai [142], S. Asai [153], R. Asfandiyarov [170], S. Ask [82], B. Åsman [144a,], D. Asner [28], L. Asquith [77], K. Assamagan [24], A. Astbury [167], A. Astvatsatourov [52], B. Athar [1], G. Atoian, B. Aubert [4], B. Auerbach [173], E. Auge [114], K. Augsten [126], M. Aurousseau [4], N. Austin [73], G. Avolio [161], R. Avramidou [9], D. Axen [166], C. Ay [54], G. Azuelos [93,c], Y. Azuma [153], M.A. Baak [29], G. Bacciaglioni [89a], C. Bacci [133a,133b], A.M. Bach [14], H. Bachacou [135], K. Bachas [29], G. Bachy [29], M. Backes [49], E. Badescu [25], P. Bagnaia [131a,131b], Y. Bai [32a], D.C. Bailey [156], T. Bain [156], J.T. Baines [128], O.K. Baker [173], M.D. Baker [24], S. Baker [77], F. Baltasar Dos Santos Pedrosa [29], E. Banas [38], P. Banerjee [93], S. Banerjee [167], D. Banfi [89a,], A. Bangert [136], V. Bansal [167], S.P. Baranov [94], S. Baranov [65], A. Barashkou [65], T. Barber [27], E.L. Barberio, D. Barberis [50a,50b], M. Barbero [20], D.Y. Bardin [65], T. Barillari [99], M. Barisonzi [172], T. Barklow [142], N. Barlow [27], B.M. Barnett [128], R.M. Barnett [14], A. Baroncelli [133a], M. Barone [47], A.J. Barr [117], F. Barrei, J. Barreiro Guimarães da Costa [57], P. Barrillon [114], V. Bartheld [99], H. Bartko [99], R. Bartoldus [142], D. Bartsch [20], R.L. Bates [53], S. Bathe [24], L. Batkova [143a], J.R. Batley [27], A. Battaglia [16], M. Battistin [29],

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N. Massol [4], A. Mastroberardino [36a,36b], T. Mas, H. Matsunaga [153], T. Matsushita [67], C. Mattrave, J.K. Mayer [156], A. Mayne [138], R. Mazini [149], M., F. Mazzucato [49], J. Mc Donald [85], S.P. Mc Kee [87], K.W. McFarlane [56], S. McGarvie [76], H. McGlone, T.R. McMahon [76], T.J. McMahon [17], R.A. McPhe, M. Medinnis [41], R. Meera-Lebbai [110], T.M. Meg, K. Meier [58a], J. Meinhardt [48], B. Meirose [48], C. M, P. Mendez [98], L. Mendoza Navas [160], Z. Meng [1], P. Mermod [117], L. Merola [102a,102b], C. Meroni [89], J. Metcalfe [103], A.S. Mete [64], S. Meuser [20], J.-P., W.T. Meyer [64], J. Miao [32d], S. Michal [29], L. Micu, A. Migliaccio [102a,102b], L. Mijović [74], G. Mikenb, D.W. Miller [142], R.J. Miller [88], W.J. Mills [166], C.M, D. Milstein [169], S. Mima [109], A.A. Minaenko [127], B. Mindur [37], M. Mineev [65], Y. Ming [129], L.M. M, S. Miscetti [47], A. Misiejuk [76], A. Mitra [117], J. Mi, P.S. Miyagawa [82], Y. Miyazaki [139], J.U. Mjörnma, P. Mockett [137], S. Moed [57], V. Moeller [27], K. Mö, S. Mohrdieck-Möck [99], A.M. Moisseev [127,*], R., J. Monk [77], E. Monnier [83], G. Montarou [33], S. M, T.B. Moore [84], G.F. Moorhead [86], C. Mora Herre, G. Morello [36a,36b], D. Moreno [160], M. Moreno L, J. Morin [75], Y. Morita [66], A.K. Morley [86], G. Mor,

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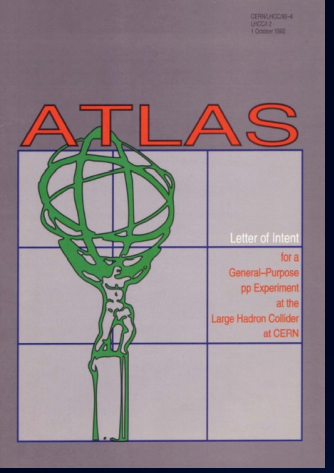
Project Culture

- *There are several underlying sub-cultures in ATLAS*
  - Physics culture versus Engineering culture
  - Hardware oriented culture versus software/computing etc.
  - Sub-system cultures (e.g. ”Calorimeter culture versus Muons culture”)
  - Geographical cultures (“North versus South; West versus East”; languages)
- *Such cultural diversity originates itself from*
  - Global nature of modern high energy physics (38 countries, 70 nationalities)
  - Decentralized nature of resources, diverse funding sources
  - Different ways to account and organize resources
- *Project cycles and dominating cultures*
  - Sub-system/engineering culture more dominant during construction
  - Physics culture very strong during project definition (design); then resurfaces when physics analysis started



LOI
letter of intent
1992

MOU
memorandum o
understanding

RDxx RD20 RD27 RD34

EAGLE

ASCOT

1989

RDyy RD13 RD6 RD3

TP
technical proposal
1994

TDRs
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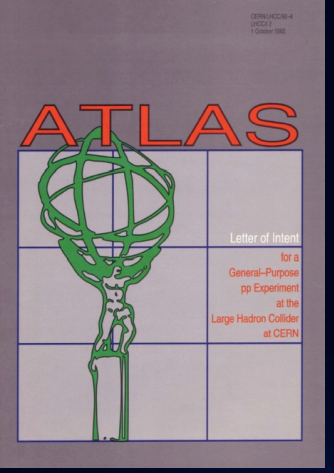
Phase -1

Design Phase

Construction Phase



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RDxx
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MOU
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ASCOT

1989

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RD3

TP
technical proposal
1994

TDRs
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Beam
2008

Phase -1

Design Phase

Construction Phase

Exploitation Phase

Each **TDR** is submitted to a independent review process (international pier review, LHCC committee which report to the CERN research director and not to the ATLAS project)

MOU

Memorandum of Understanding. Gentlemen agreement between collaborating institutes/laboratories, defining the relative responsibility in term of deliverables. In some cases few institutions cluster around the same deliverable, because of its complexity. Who sign up for a deliverable takes a moral, financial and technical responsibility. MOU are then signed by the funding agencies (governments)

ATLAS EXPERIMENT

90% of the technology was fixed in 1992/1993

how is it possible for it to still be at the leading edge in 2011?

- We are not just customers of technology
- We are partners in developing it
- We are often proponents and often drivers
- Our incredible network of universities and national laboratories allows us to have a privileged overview
- Therefore we are favorably seen as potential promoters of spin-offs
- ……

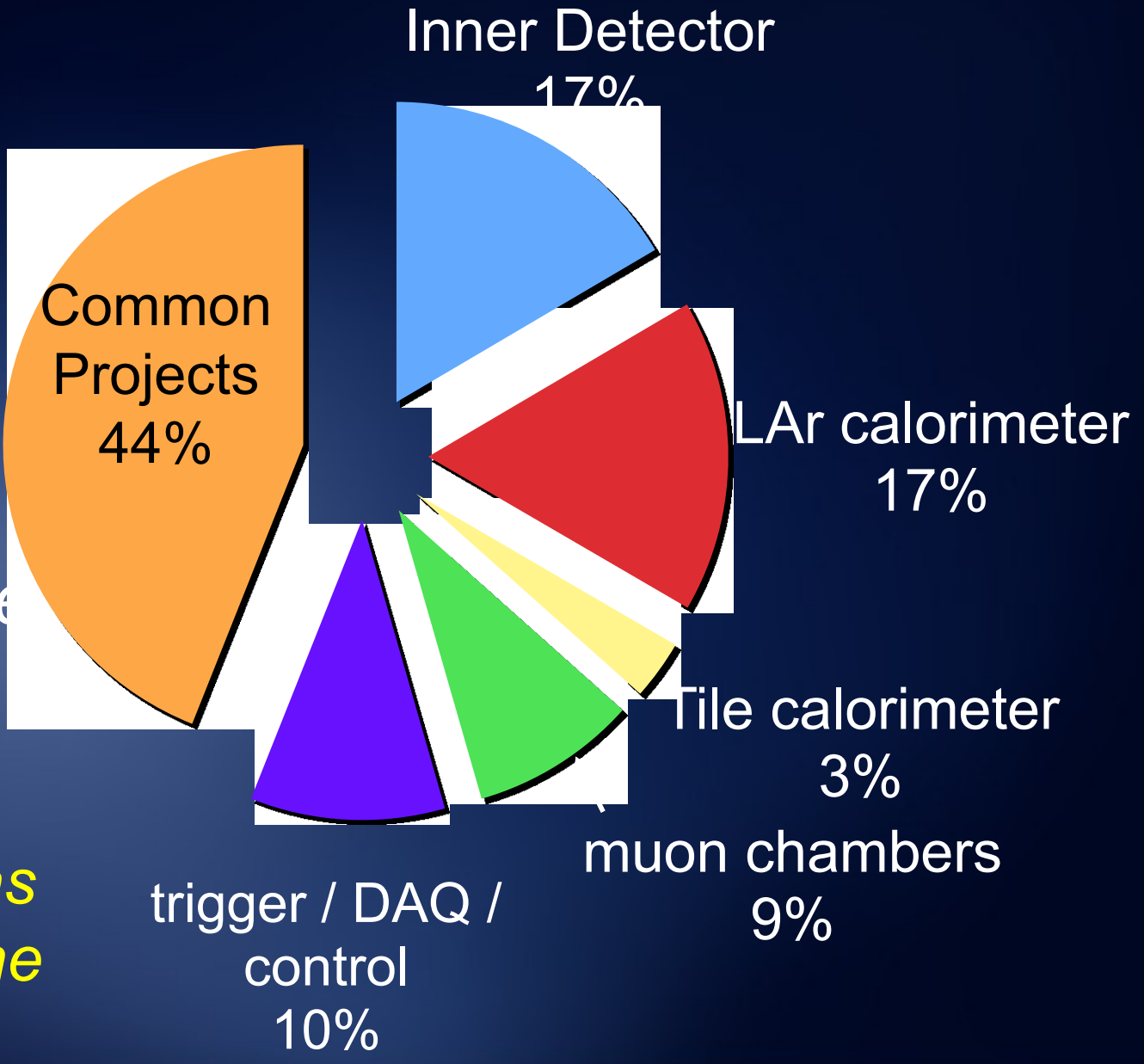
90% of the technology was fixed in 1992/1993

how is it possible to keep flexibility in order to adapt to new needs or findings

- Different stages of the project co-exist during the entire life of the project (R&D, prototyping, engineering design, mass production, tests in particle beams, statistical methods optimization, simulation ….)
- We acquire technology when it is really necessary (see computer power …. which hasn't reached full capacity yet)
- Part of the community is busy keeping the detector and software evolving (upgrade scenarios established for the next 20 years)

CORE Costing (industrial contracts, material, …)

Political figure (~xxx M$) imposed up-front by the CERN directorate



Adopted by all partners as 1996 investments baseline

Offline computing not part of it

ATLAS EXPERIMENT

Institutions deliverables

Organized in detector systems (sensors!)

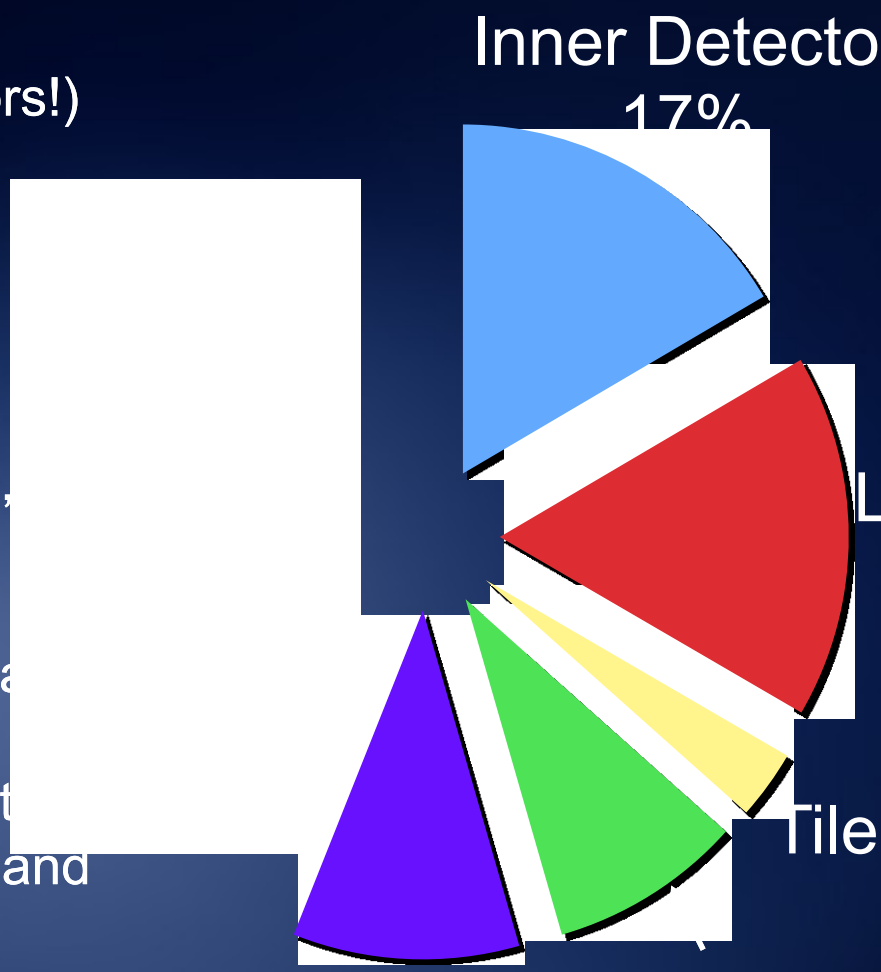
Each system is like a Colloboration of various institutes within the ATLAS Collaboration

Each system has its own organization, management and institutes boards

Each system is responsible to deliver a of ATLAS to central ATLAS + its maintenance and operation. Each syst defines its deliverables (type B costs) and is fully responsible of it

ATLAS monitors the process (quality, schedule), but no central accounting !!

Overcosts and institutions manpower are on the institutions responsibility



ATLAS EXPERIMENT

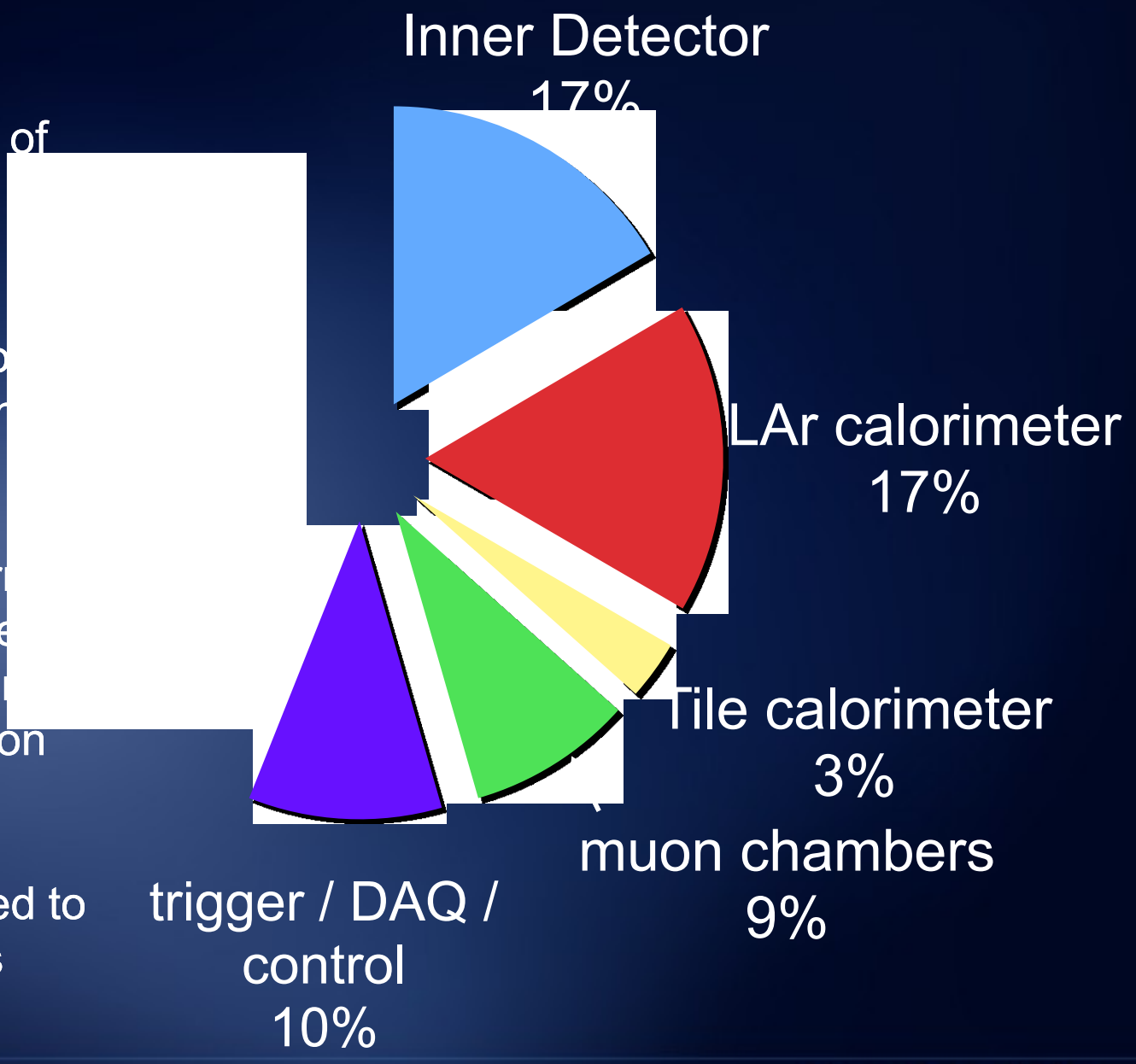
Institutions deliverables

Systems and sub-systems as clusters of various institutions of different funding agencies

Avoiding one funding agency to contro entire process, gives more flexibility ar internal contingency

Central ATLAS organize frequent inter reviews of the process in a very detaile way. Where necessary and in case of problems help is injected using common funds

CERN purchasing infrastructure is used to solve and facilitate industrial contracts where required by institutions clusters



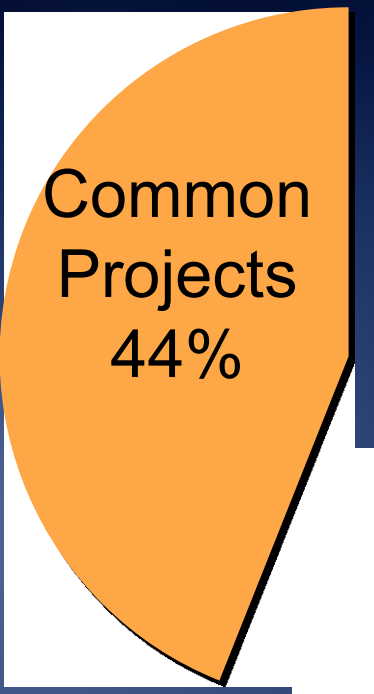
Common Projects

Centrally organized by ATLAS (type A costs)

Every funding agency shares the cost of it (cash or in-kind) through common funds

Full costing, including manpower and engineering

Full accounting reports to RRB (twice/year)



All what can not be handled by individual institutes or clu

Pa on utility:

in services,
CERN,
ogenics, labs,
l structures,
hieldings, control rooms, safety projects, overall commissioning and M&O …

Resources Allocation

- On sub-system level, resources are made directly available by national FAs and consumed by participating institutes at home. The related cost categories and available resources are:
  - R&D, Prototyping, Infrastructure, Personnell
  - Direct material costs e.g. components, production (used for RRB CORE reporting)

- On the Common Fund level, allocation of centralized resources are based on approved project planning and corresponding income collected from FAs as part of their MoU commitments
- CORE resources are monitored and reported in the RRB

- Relationship between time/resources/schedule
  - “Time is our contingency”. The budget has no contingency so very hard to recuperate lost time when encountering technological problems
  - Note: lack of income or resources from a FA at some given moment never actually resulted in a serious delay. In some cases, work got re-organized and responsibilities re-arranged
  - CERN (as Host Lab) permitted temporary budget over drafts, against firm financial pledges

Scheduling

- The schedule has the following structure
  - Top-down (Start-up date of the LHC accelerator)
  - Bottom-up (Sub-system construction and global integration and commissioning)
- Schedule uncertainties and unforeseen change consequences are addressed by
  - Scenario planning; critical path analysis
  - Work package analysis and reformulation
  - Installation simulations
- The schedule format suggests high initial degree of parallelism across the subsystems; later more sequential as components arrive at CERN
- Contingency management
  - No explicit contingency in the schedule planning, a part a 3 months ready for installation early delivery
  - Delays in a given sub-system construction pushes full detector commissioning date accordingly
  - However: Through re-organization of work packages in other sub-systems and changes in priorities, some contingency can be generated, but at the cost of taking some level of risk
  - Main driver of the ATLAS schedule the LHC machine schedule changes

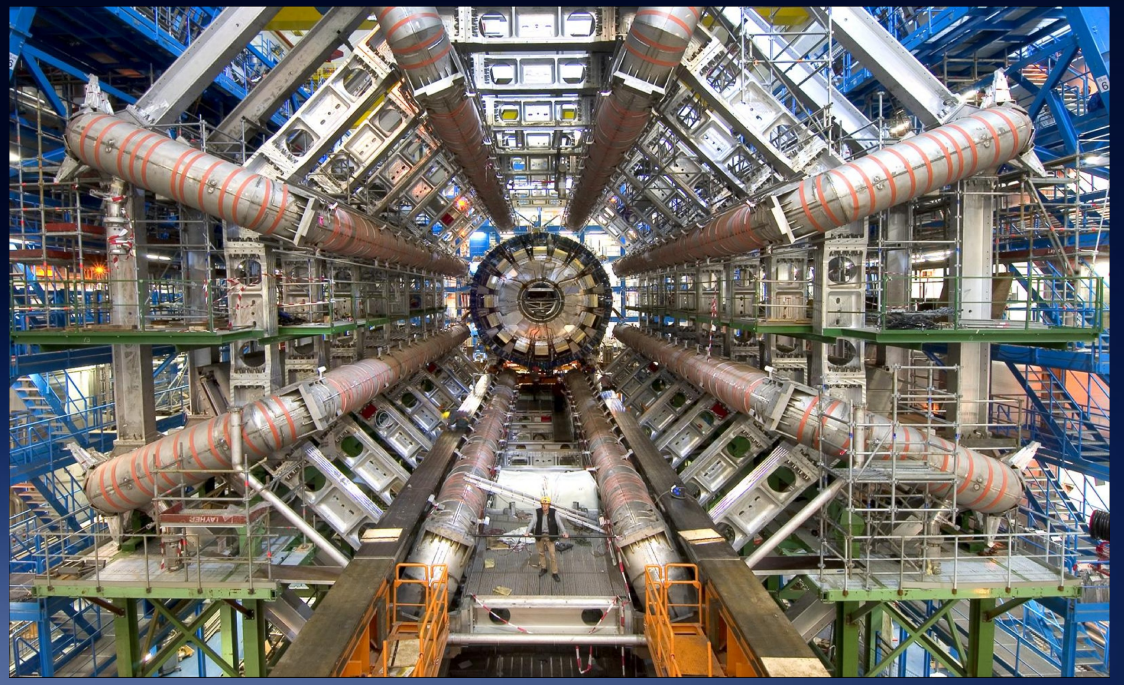
Which technologies did we cover during construction this way?

- Silicon pixel detector (80M channels)
- Silicon strip detector (~100 m2 of silicon micro strips)
- Diamond pixel/strip detectors
- Gas straw detector using transition radiation effect (300000 straws)
- Liquid Argon electromagnetic sampling calorimeter (300 tons)
- Scintillating Tiles calorimeters (42 tons of scintillator, 1100 km of readout fibers)
- Scintillating fibers techniques
- Cerencov counters
- Large area gas drift chambers for muon detection (precision and trigger)
- Radiation hard nsec electronics, mostly digital
- Analog and Digital pipeline
- Optical fibers readouts and transmission
- Superconductivity and cryogenics
- Complex mechanical structures analysis, seismic analysis, composite materials
- Ultra vacuum techniques
- Detectors, cables and electronics cooling
- Large scale connectivity, DC-DC power converters technologies, HV technologies
- PVSS slow control architecture
- Scalar data acquisition and multilevel trigger systems, large computing farms
- GRID environment
- Fancy (spectacular !) transports and logistics

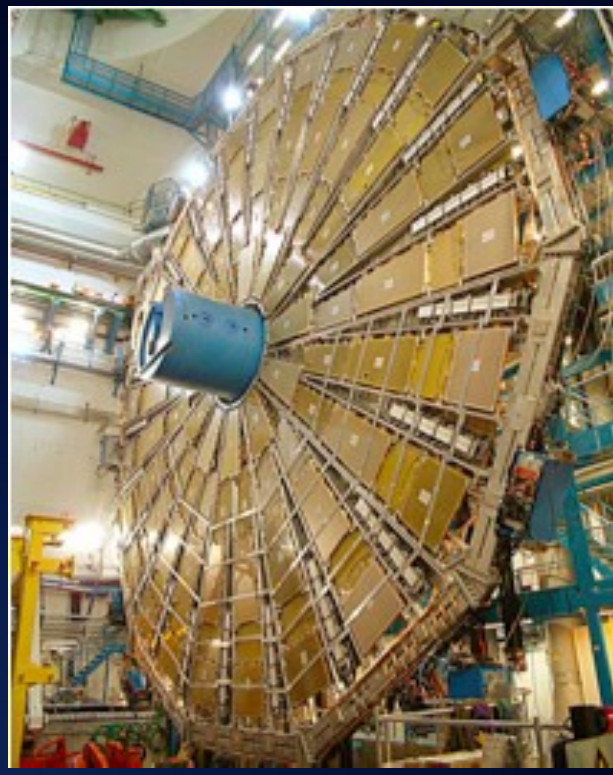
ATLAS EXPERIMENT

HARDWARE examples

civil engineering



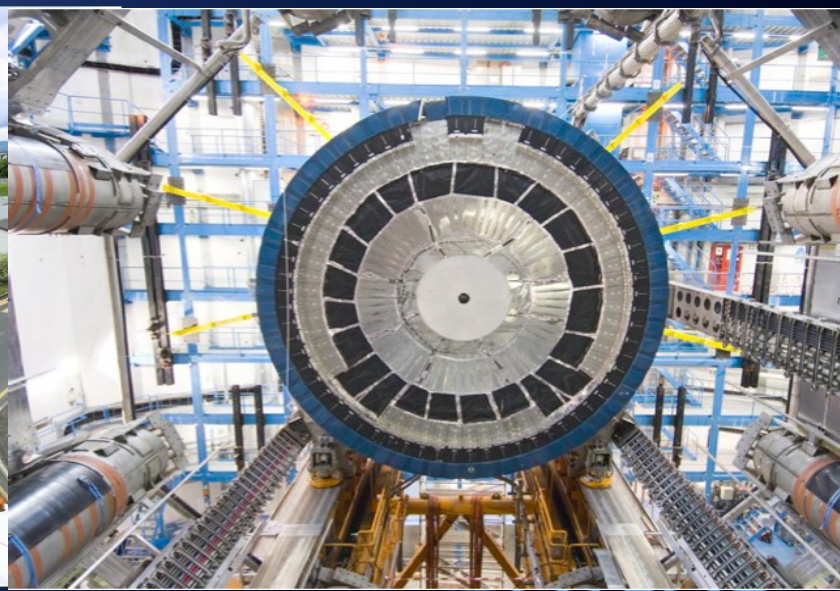
Super-conducting toroidal magnets



Muon big wheels

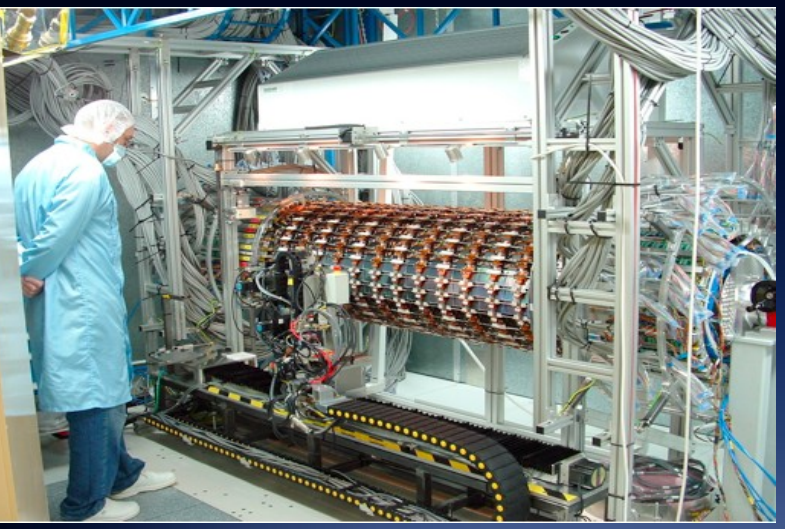
Metal structures

End-cap toroid magnets

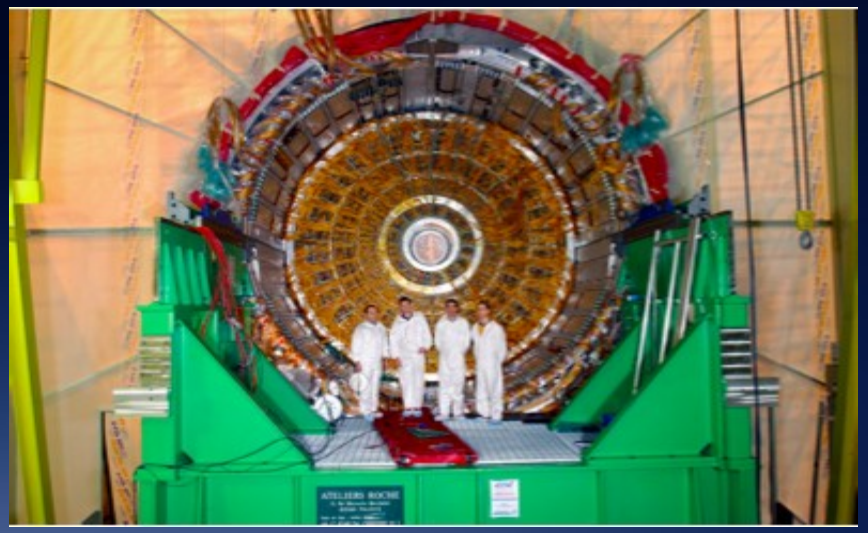


End-cap cryo calorimeters

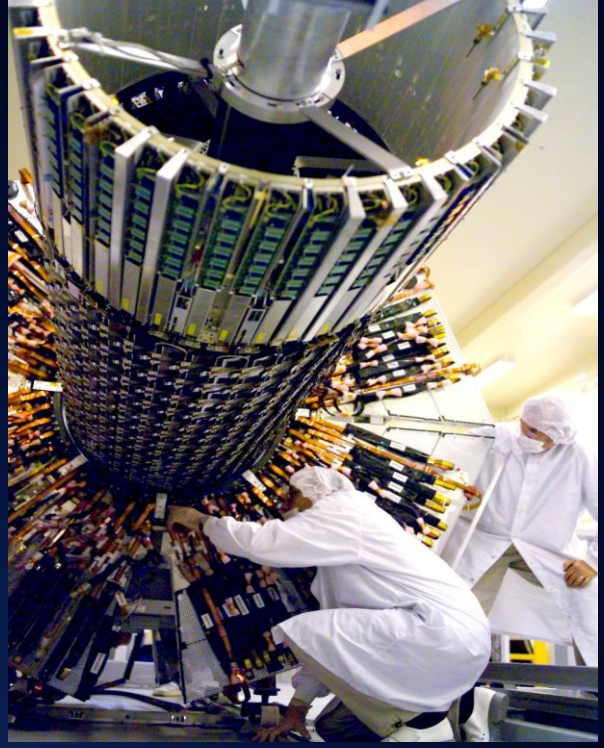
HARDWARE examples



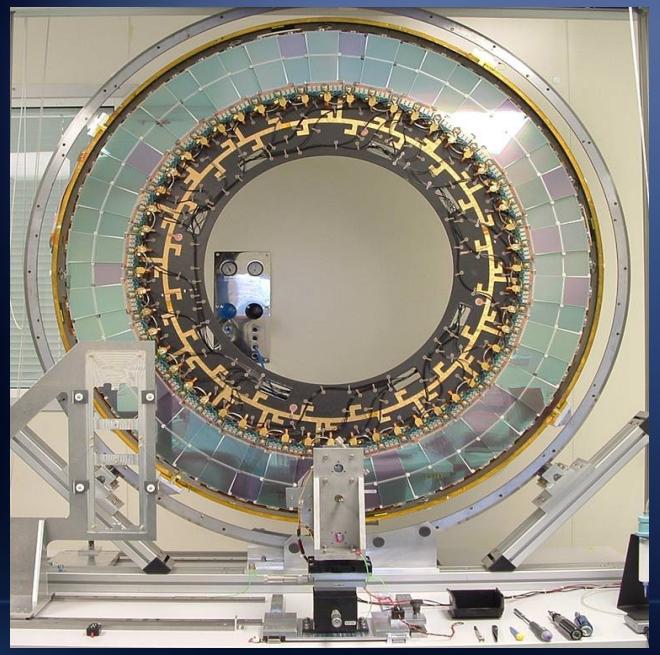
Silicon strip detector



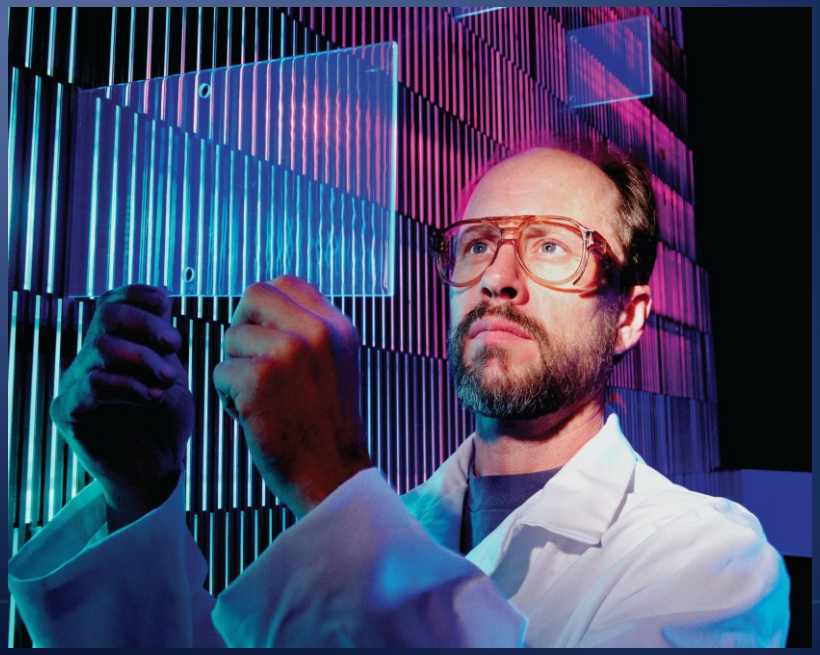
LAr accordion calorimeter



Silicon tracker



Silicon strip disk

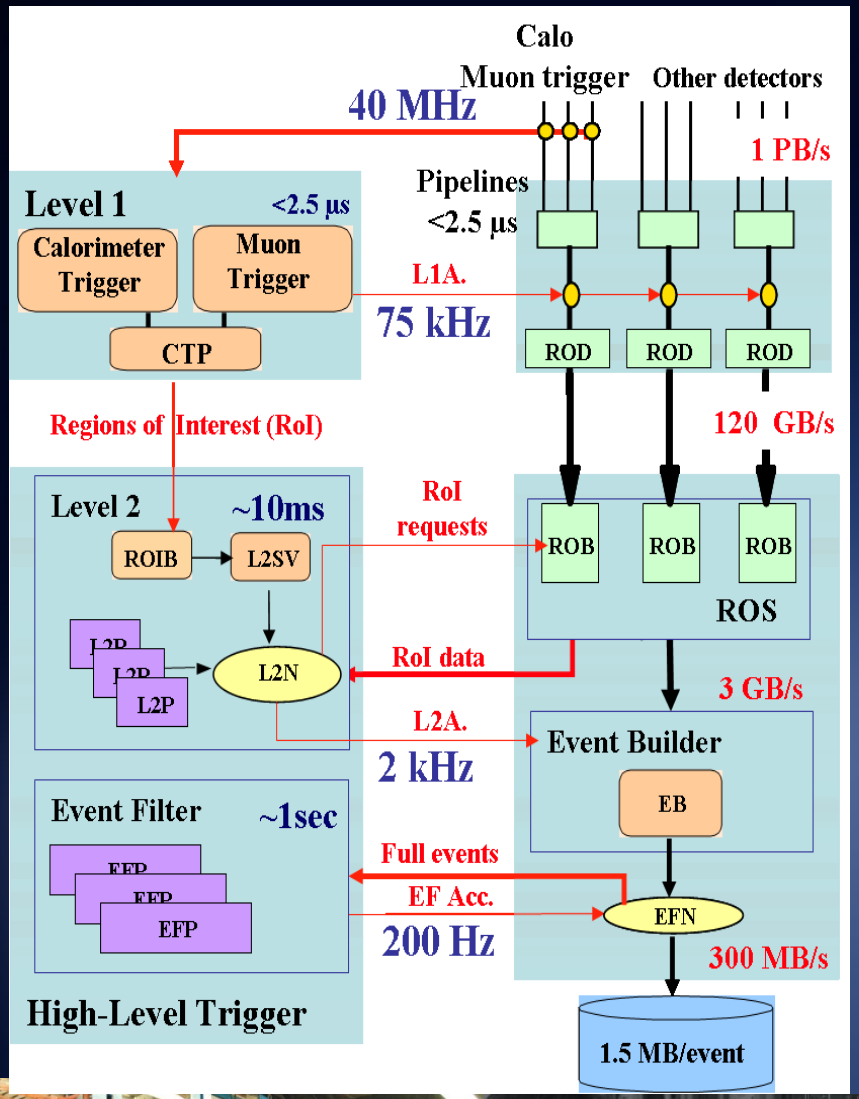


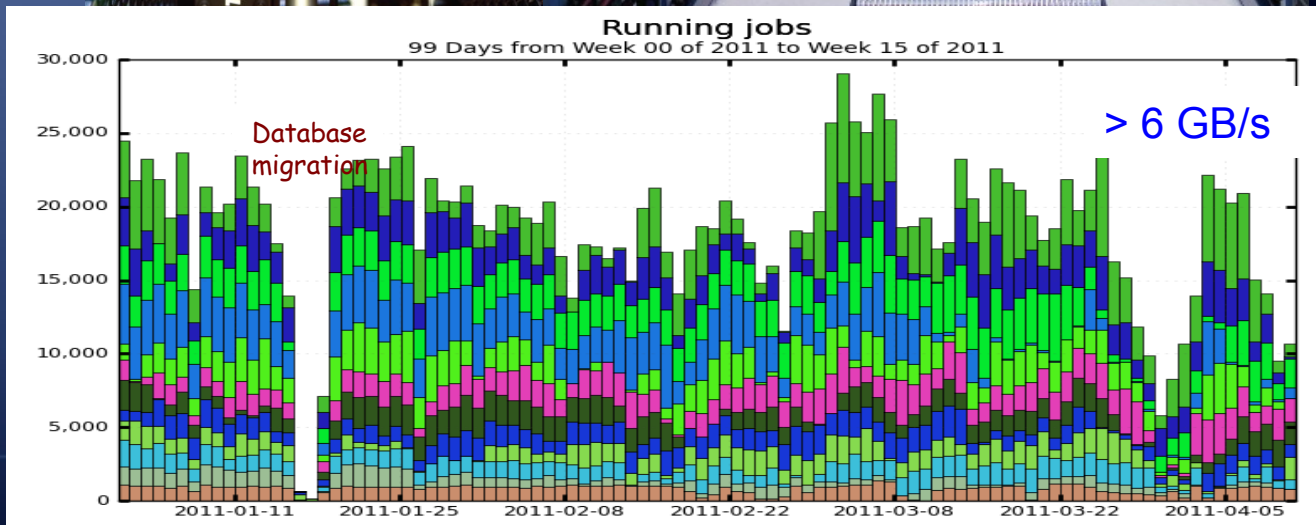
Scintillating tiles calorimeter

Monitored drift tubes

Computing examples

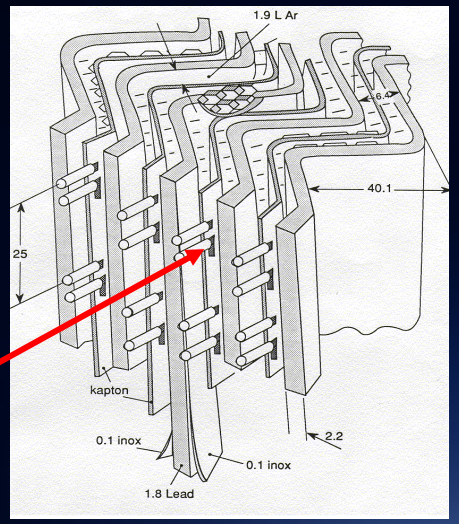
Hardware



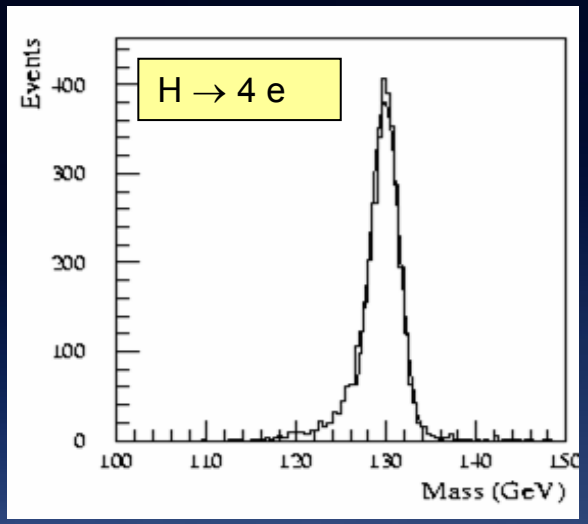


Grid-based analysis in 2011 : > 1100 different users, > 22M analysis jobs

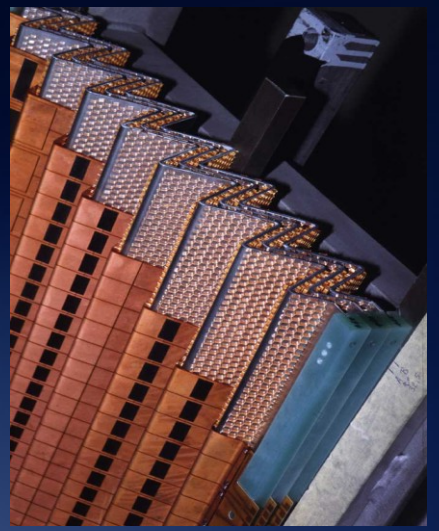
20 years of history



Initial idea

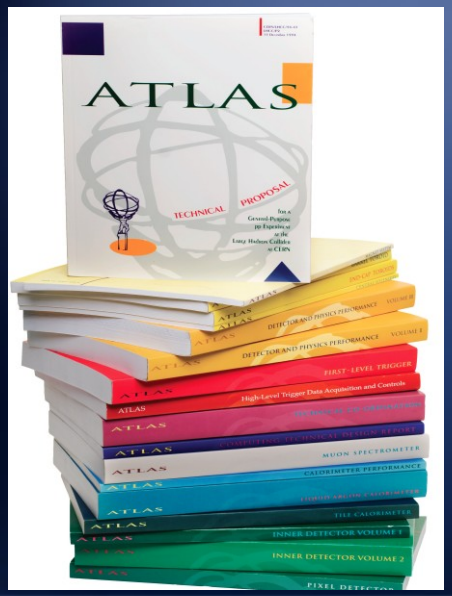


Full GEANT simulation

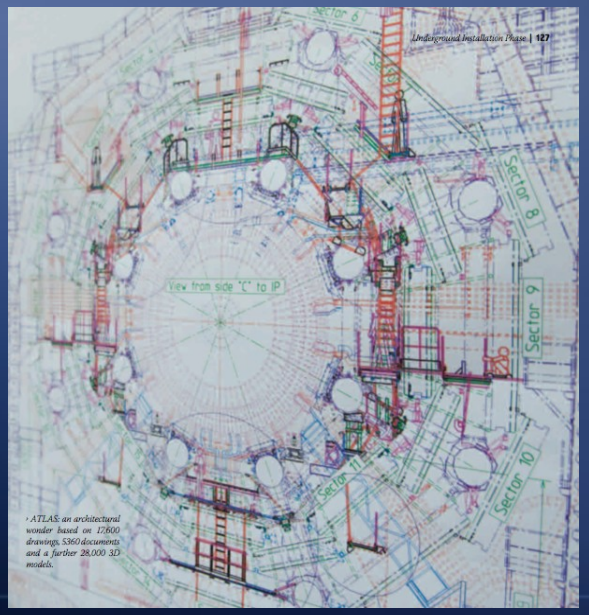


prototyping

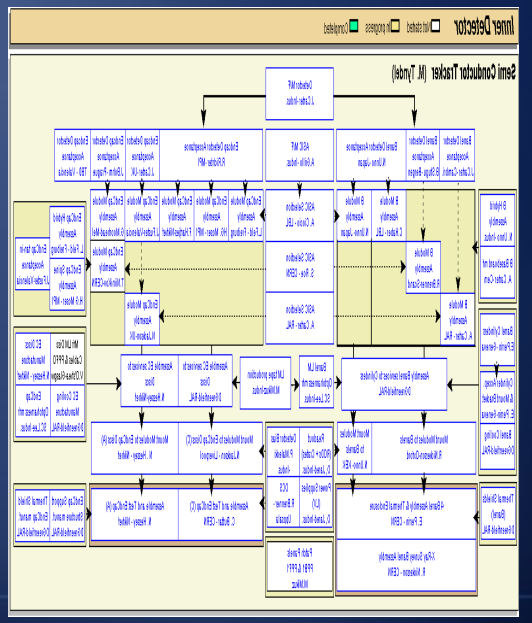
Tests with beams



Full scale design



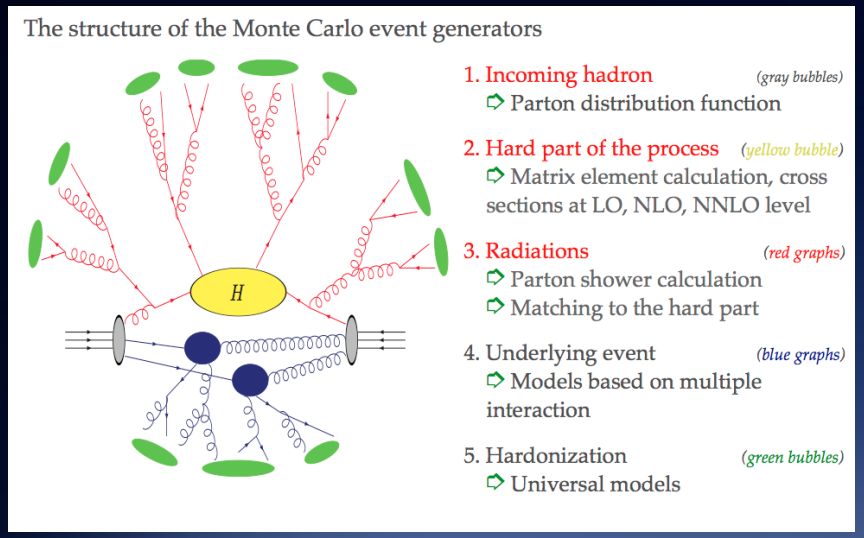
Engineering reviews



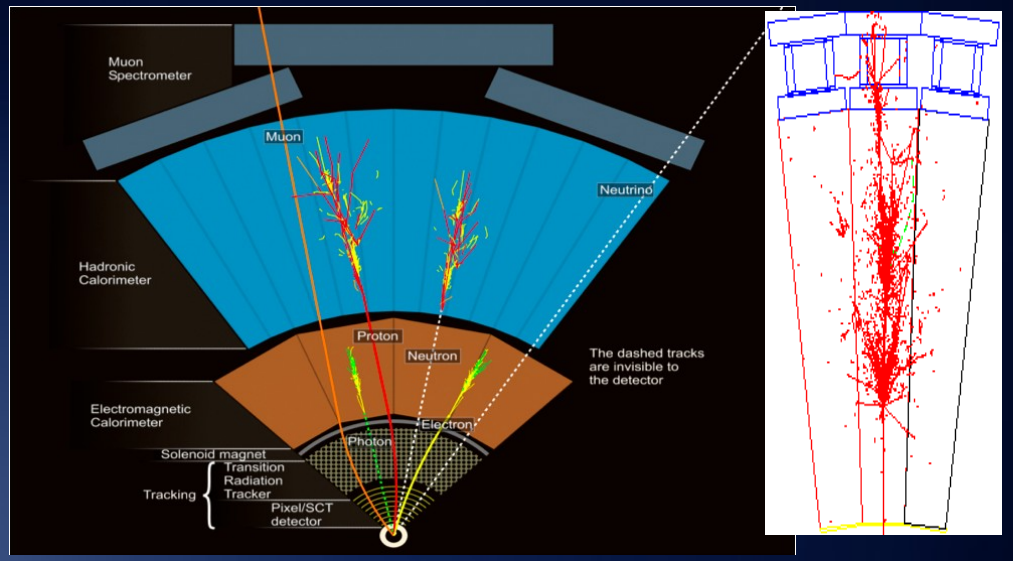
Mass production organization

Surface preassebly and tests

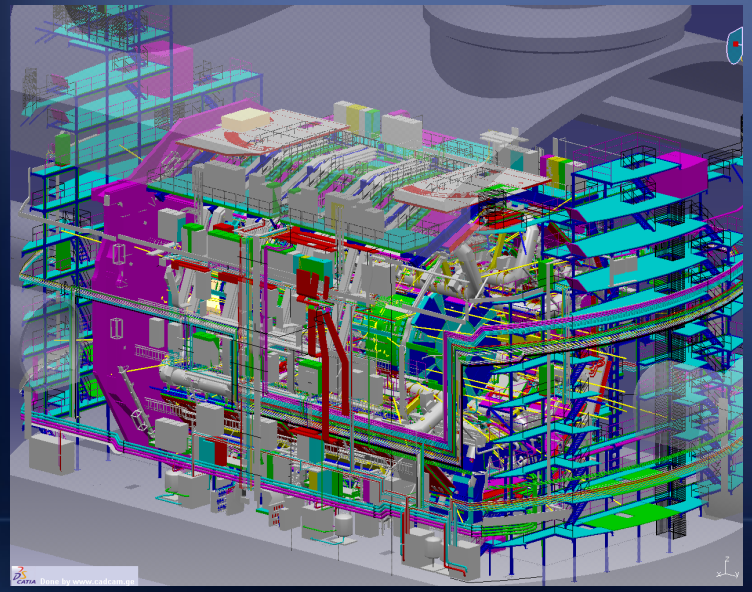
Strong emphasis on simulation ! (from detector design and problem definition, to the final analysis of the data!)



Basics physics processes simulation at the parton level

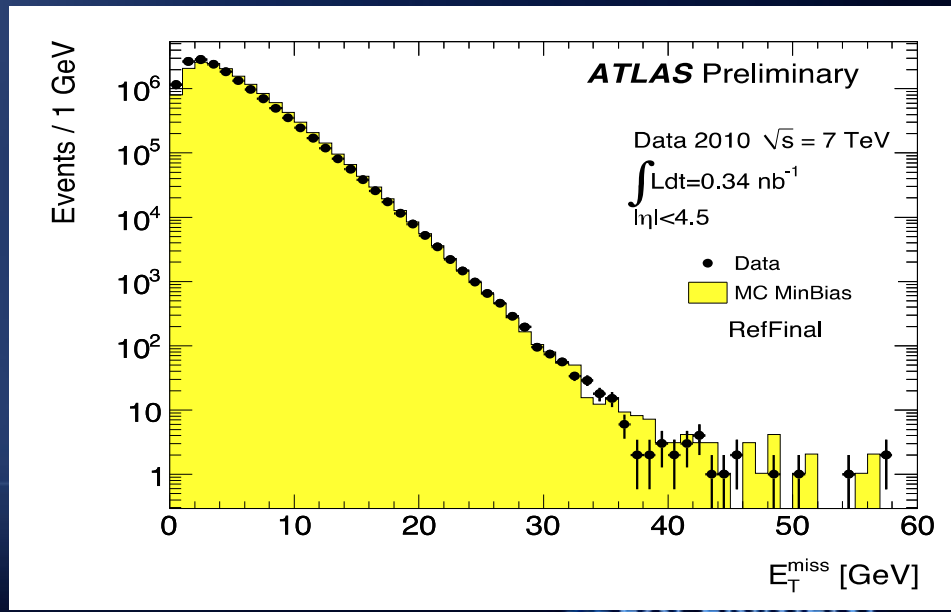


Detector response simulation to visible particles, technology optimization (GEANT)



Engineering simulation of all details via CAD systems

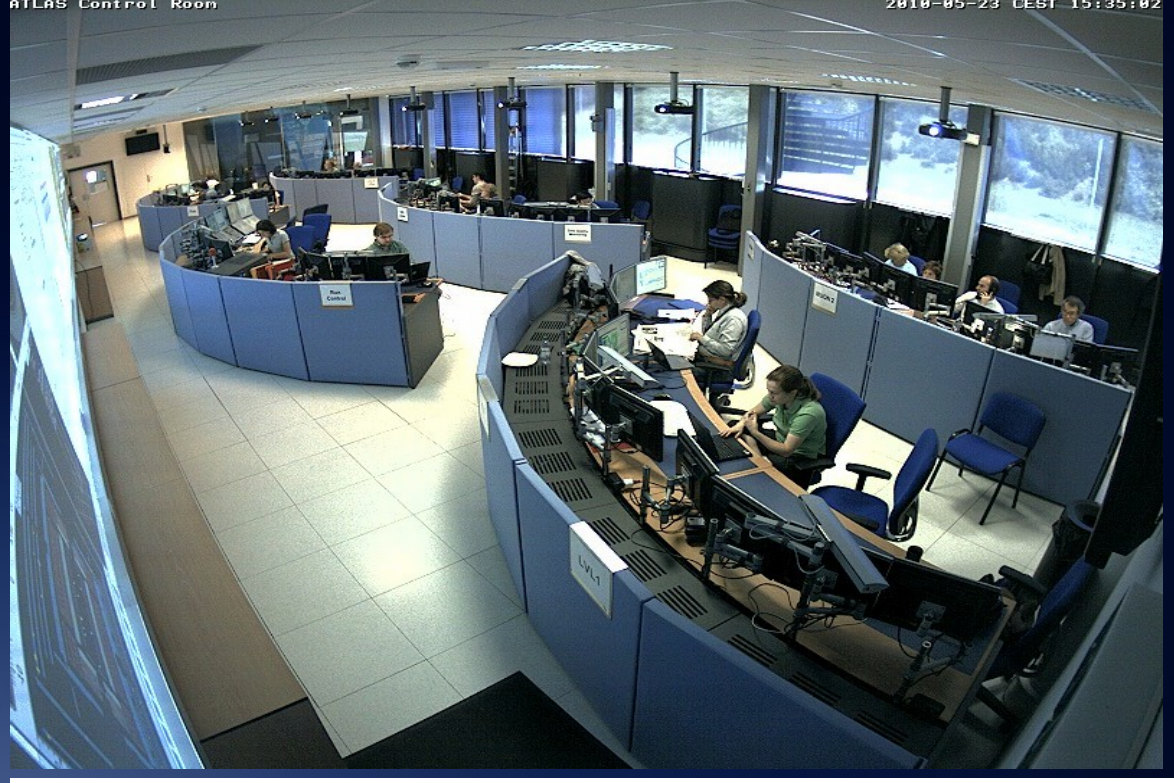
Detailed simulation of the detector response through the physics reconstruction process vs. data (all simulation packages)



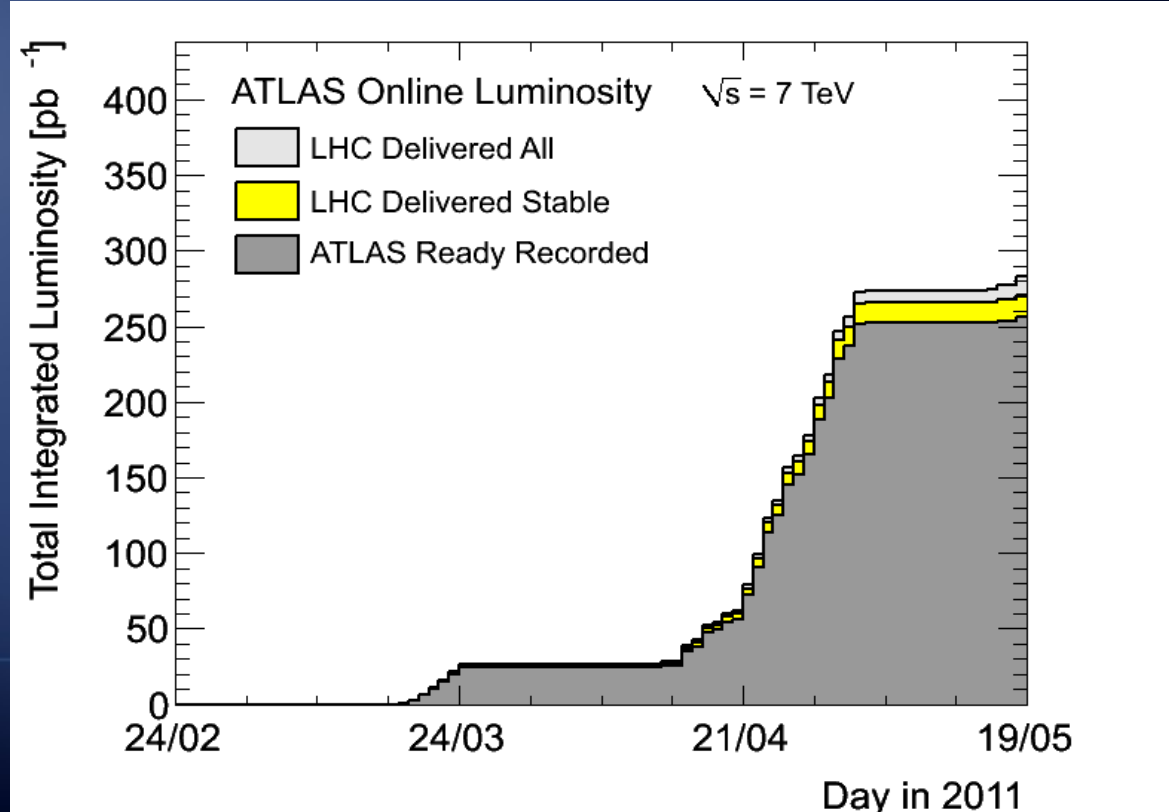
The lessons !

- Push R&D as far as possible
- Bring services in the game in a early stage (power, cabling, piping, cooling, optical transmission, …)
- Do not trusts competitive tendering
- Avoid functional procurements specifications
- Avoid behaviour : “ 20 years ago we did …”
- Allow very critical but constructive opinions
- Avoid single Funding Agencies monopoly on a technology
- Bring out problems at a very early stage, no protection!
- Bring software in as early as possible
- Risk on new technologies (sub-micron vrs establ. nuclear tec.)
- ….

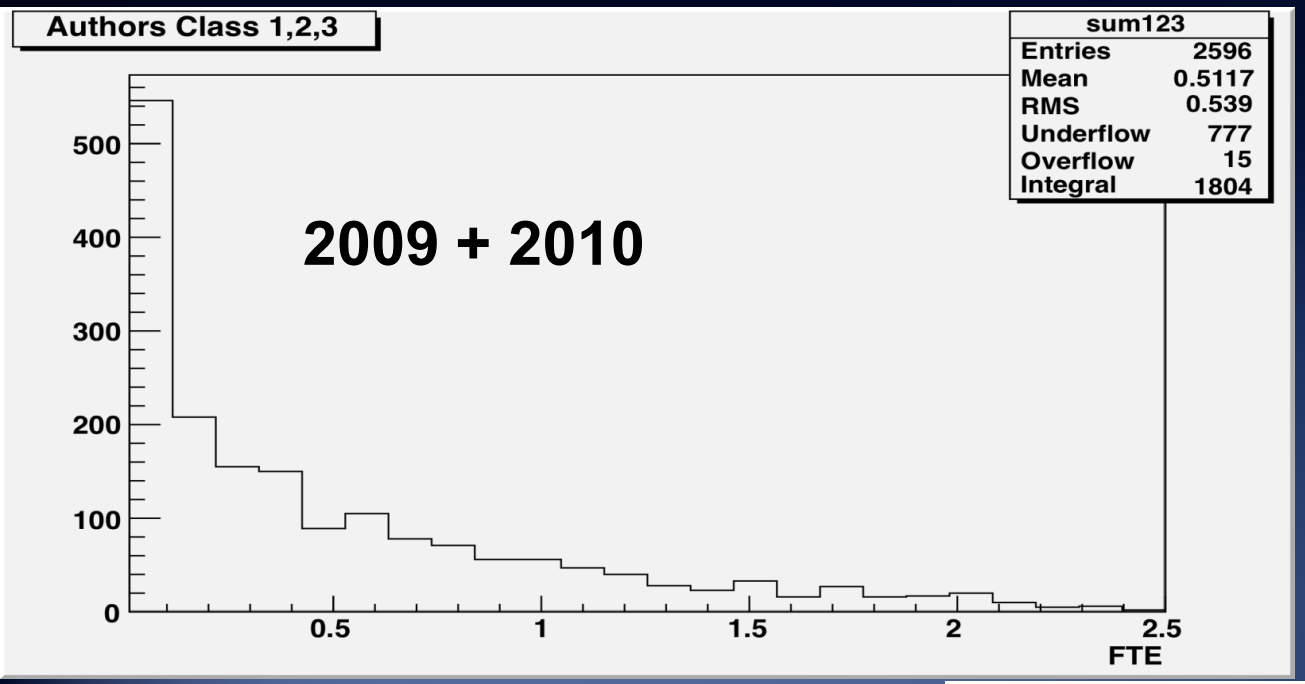
ATLAS EXPERIMENT



Next run (2011-2012) goal : 7 TeV, 5-6 fb^{-1}?



OTP (Operation service tasks support)

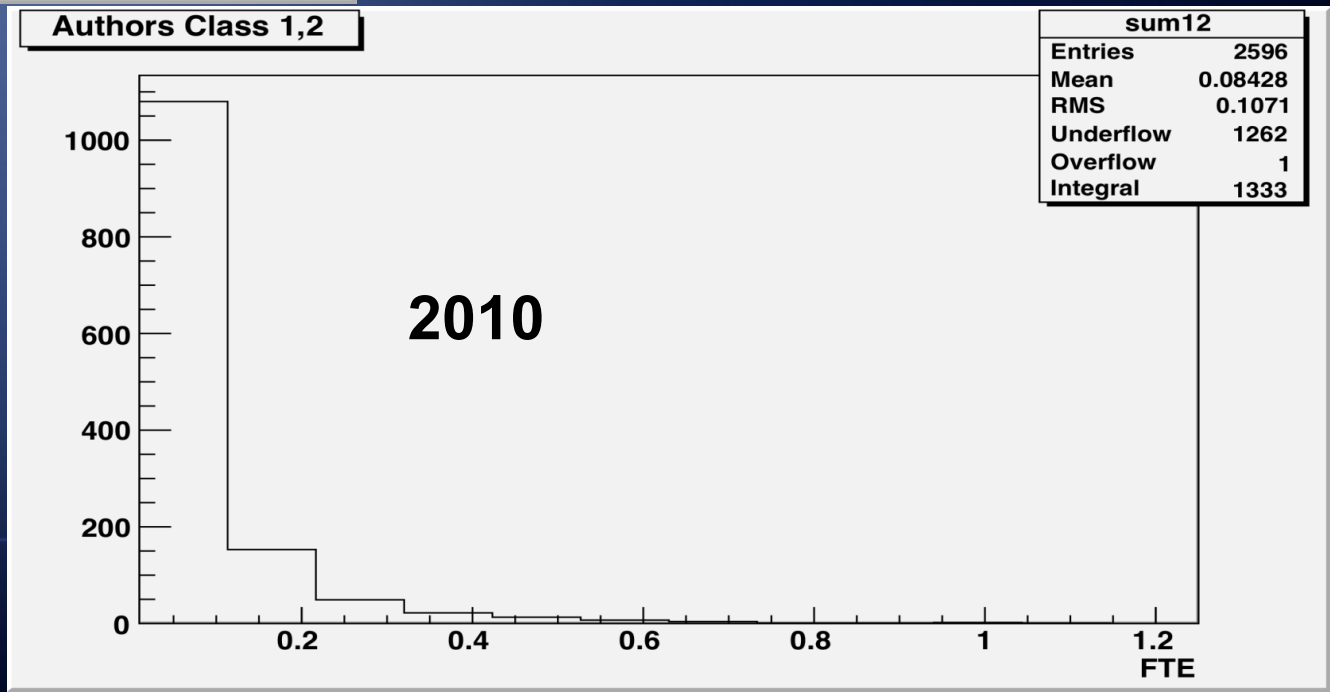


Work organized in 3 classes (1-control room shifts, 2-expert shifts, 3-technical jobs)

1804/2596 active authors are doing service work (OTP) at the 25% level/year

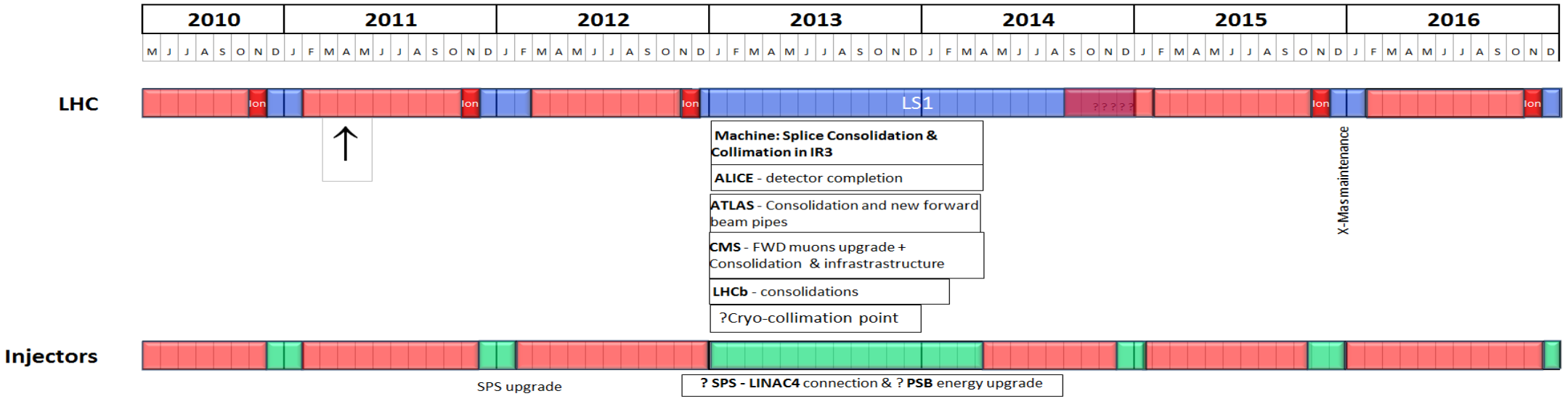
1333/2596 active authors are taking shifts or are acting as experts on call

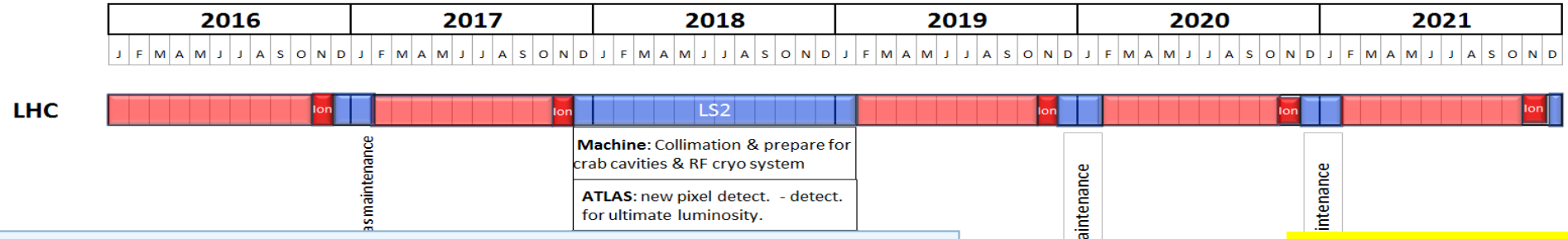
Physics duties for free!



A rich program in front of us

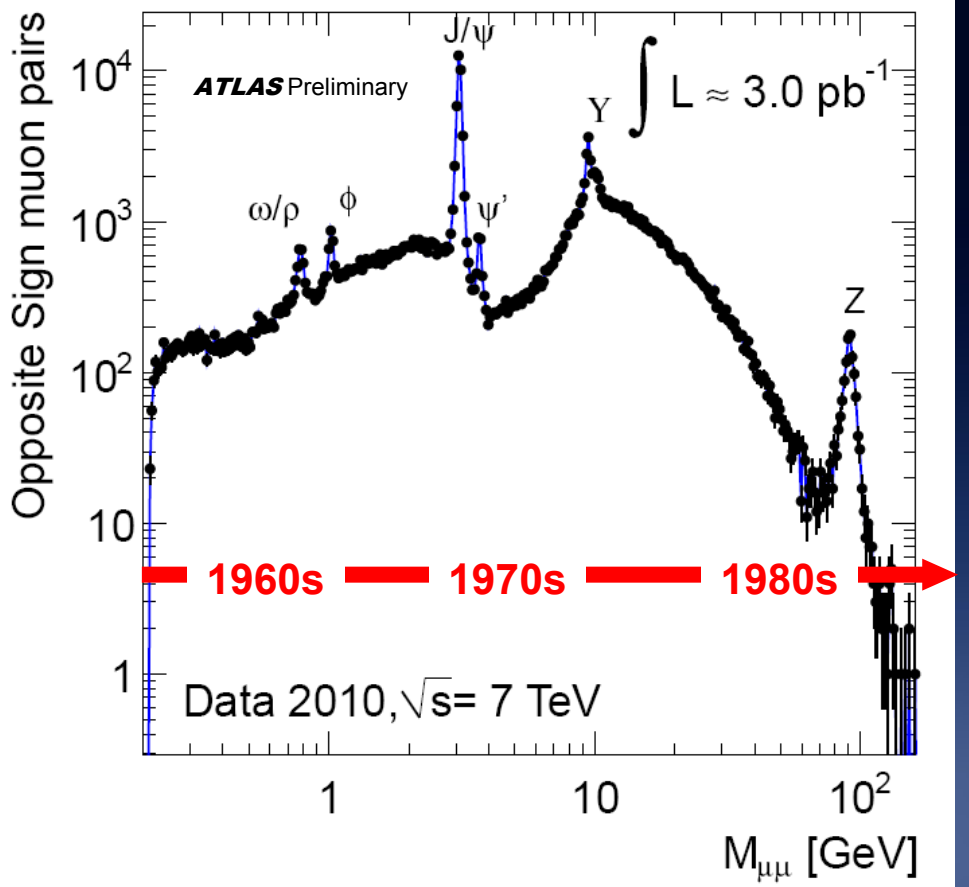
New rough draft 10 year plan

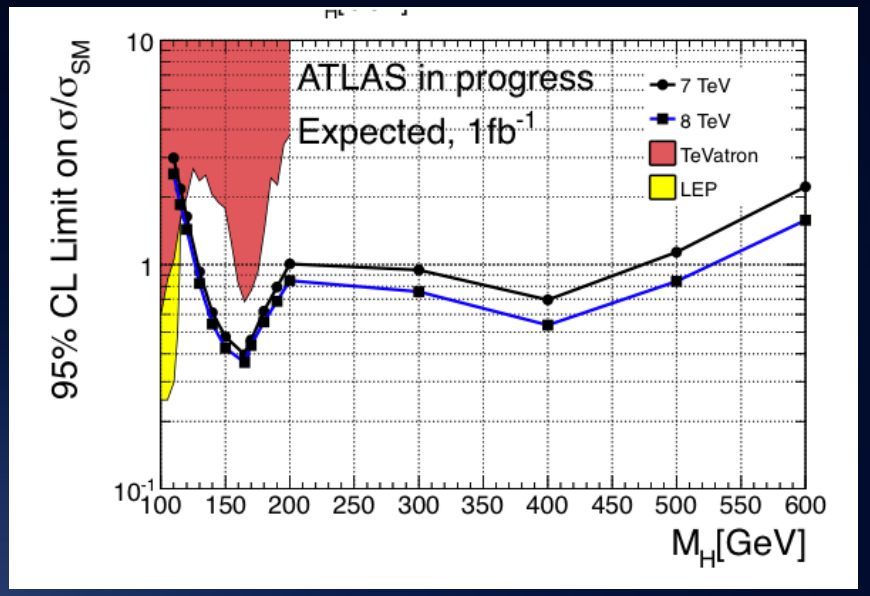


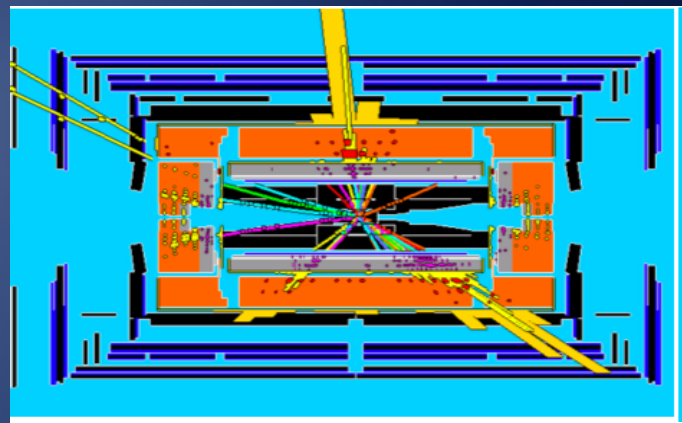


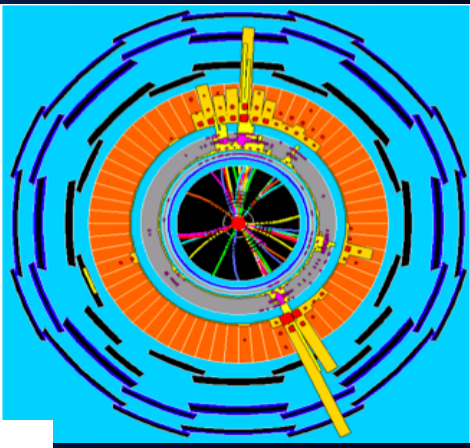
- *Every year 4 weeks of Heavy Ions (8 runs)*
- *Every year a Xmas shutdown for 8-9 weeks*
- *19 m shutdown in 2013/2014 -> LHC to nominal energy*
- *12 m shutdown in 2018 -> Phase 1 upgrade*
- *24 m shutdown in 2022 -> HL-LHC upgrade*

→ Up to 2035

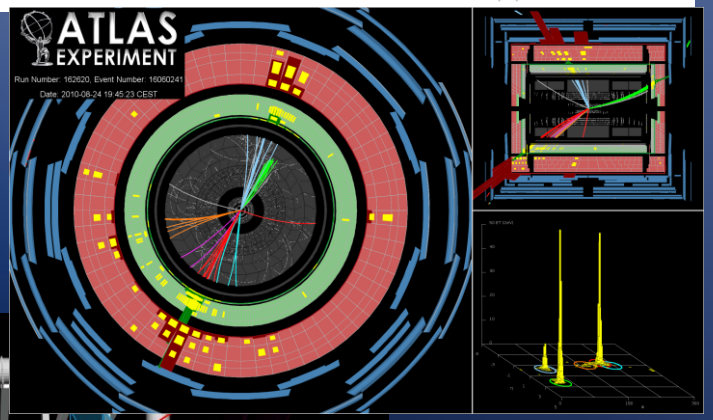


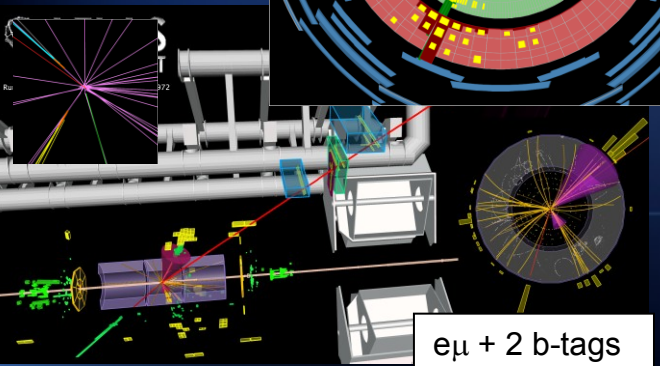






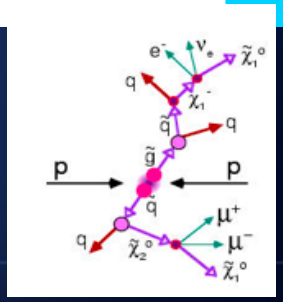
Top quark physics (1990s)



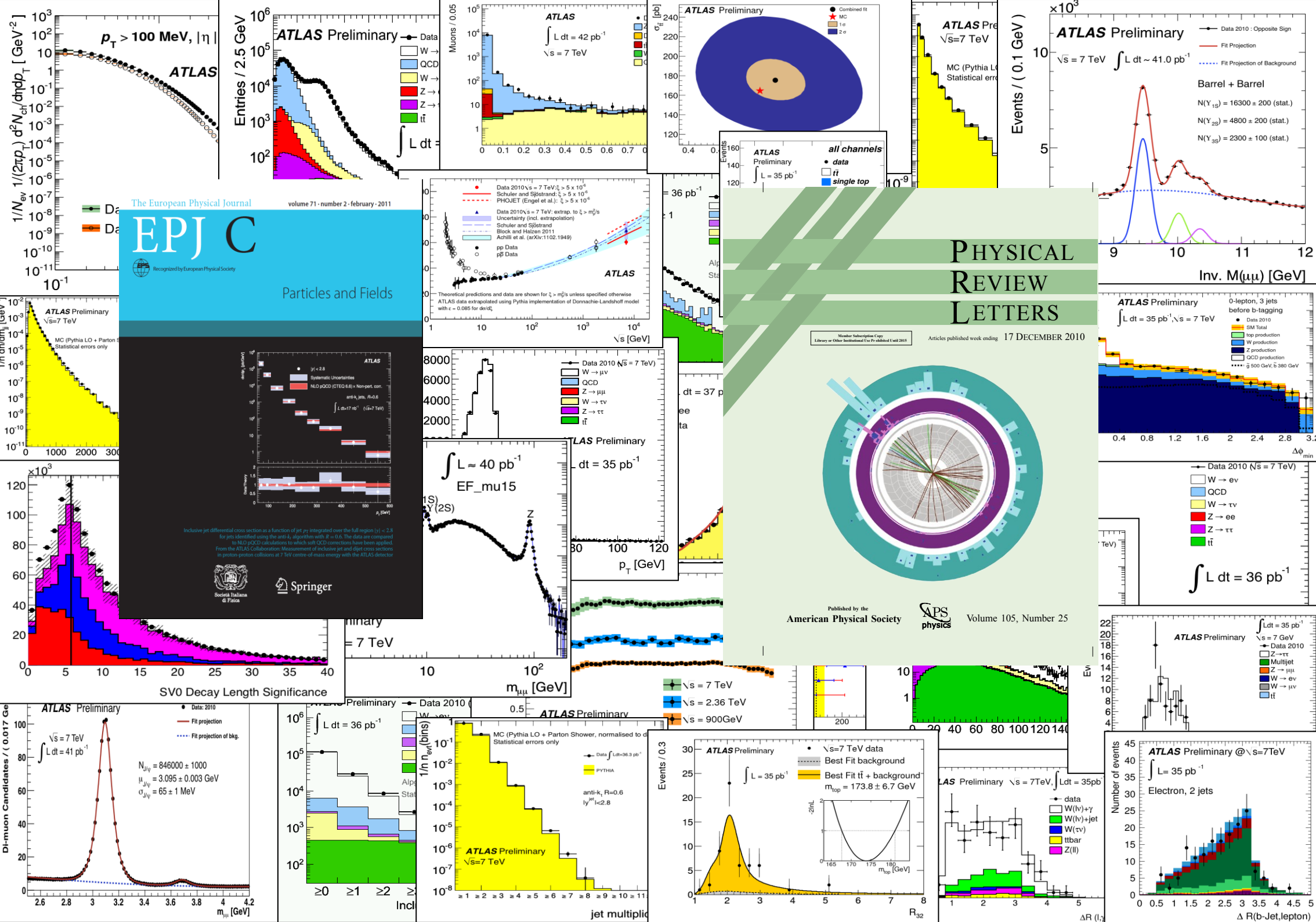


eμ + 2 b-tags

High P_T QCD (1990s)



ATLAS EXPERIMENT


ATLAS
ATLAS Preliminary
p_T > 100 MeV, |η|
$1/N_{ev}\ 1/(2\pi p_T)\ d^2N_{ch}/d\eta dp_T$ [GeV^{-2}]
Entries / 2.5 GeV
Muons / 0.05
$\int$ L dt = 42 pb^{-1}
$\sqrt{s}$ = 7 TeV
$\sigma_{t\bar{t}}$ [pb]
Combined fit
MC
1 σ
2 σ
Events
all channels
data
$t\bar{t}$
single top
$\int$ L = 35 pb^{-1}
Events / (0.1 GeV)
Data 2010 : Opposite Sign
Fit Projection
Fit Projection of Background
$\int$ L dt ~ 41.0 pb^{-1}
Barrel + Barrel
N(Υ_{1S}) = 16300 ± 200 (stat.)
N(Υ_{2S}) = 4800 ± 200 (stat.)
N(Υ_{3S}) = 2300 ± 100 (stat.)
Inv. M(μμ) [GeV]
Data 2010 $\sqrt{s}$ = 7 TeV: ξ > 5 x 10^{-6}
Schuler and Sjöstrand: ξ > 5 x 10^{-6}
PHOJET (Engel et al.): ξ > 5 x 10^{-6}
Data 2010 $\sqrt{s}$ = 7 TeV: extrap. to ξ > m$_p^2$/s
Uncertainty (incl. extrapolation)
Schuler and Sjöstrand
Block and Halzen 2011
Achilli et al. (arXiv:1102.1949)
pp Data
pp̄ Data
Theoretical predictions and data are shown for ξ > m$_p^2$/s unless specified otherwise
ATLAS data extrapolated using Pythia implementation of Donnachie-Landshoff model with ε = 0.085 for dσ/dξ
$\sqrt{s}$ [GeV]
Data 2010 ($\sqrt{s}$ = 7 TeV)
W → μν
QCD
Z → μμ
W → τν
Z → ττ
tt̄
$\int$ L ≈ 40 pb^{-1}
EF_mu15
Z
Υ(2S)
Υ(1S)
p$_T$ [GeV]
m$_{μμ}$ [GeV]
$\int$ L dt = 35 pb^{-1}
$\int$ L dt = 37 p
$\sqrt{s}$ = 7 TeV
$\sqrt{s}$ = 2.36 TeV
$\sqrt{s}$ = 900GeV
0-lepton, 3 jets
before b-tagging
SM Total
top production
W production
Z production
QCD production
g̃ 500 GeV, b̃ 380 GeV
Δφ$_{min}$
W → eν
Z → ee
$\int$ L dt = 36 pb^{-1}
SV0 Decay Length Significance
Inclusive jet differential cross section as a function of jet p$_T$ integrated over the full region |y| < 2.8 for jets identified using the anti-k$_t$ algorithm with R = 0.6. The data are compared to NLO pQCD calculations to which soft QCD corrections have been applied.
From the ATLAS Collaboration: Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector
Società Italiana di Fisica
Springer
The European Physical Journal
volume 71 · number 2 · february · 2011
EPJ C
Recognized by European Physical Society
Particles and Fields
PHYSICAL REVIEW LETTERS
Articles published week ending 17 DECEMBER 2010
Member Subscription Copy
Library or Other Institutional Use Pr ohibited Until 2015
Published by the
American Physical Society
APS physics
Volume 105, Number 25
Data: 2010
Fit projection
Fit projection of bkg.
$\int$ L dt = 41 pb^{-1}
N$_{J/ψ}$ = 846000 ± 1000
μ$_{J/ψ}$ = 3.095 ± 0.003 GeV
σ$_{J/ψ}$ = 65 ± 1 MeV
Di-muon Candidates / (0.017 Ge
m$_{μμ}$ [GeV]
$\int$ L dt = 36 pb^{-1}
MC (Pythia LO + Parton Shower, normalised to d
Statistical errors only
Data $\int$ Ldt=36.3 pb^{-1}
PYTHIA
anti-k$_t$ R=0.6
|y^{jet}|<2.8
1/n n$_{ev}$(bins)
jet multiplic
$\sqrt{s}$=7 TeV data
Best Fit background
Best Fit tt̄ + background
m$_{top}$ = 173.8 ± 6.7 GeV
-2lnL
m$_{top}$ [GeV]
R$_{32}$
$\int$ L= 35 pb^{-1}
Electron, 2 jets
Number of events
Δ R(b-Jet,lepton)
data
W(lν)+γ
W(lν)+jet
W(τν)
ttbar
Z(ll)
$\int$ Ldt = 35 pb^{-1}
$\sqrt{s}$ = 7 TeV
Data 2010
Z→ττ
Multijet
Z → μμ
W → eν
W → μν
tt̄

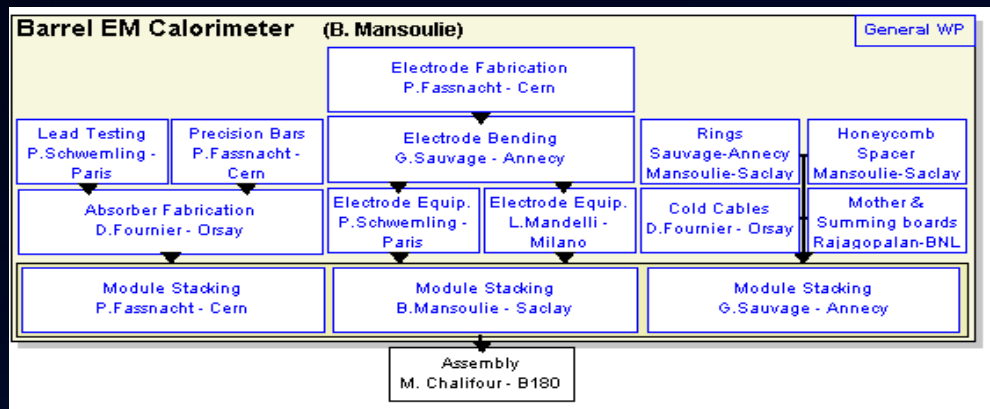
Thanks!

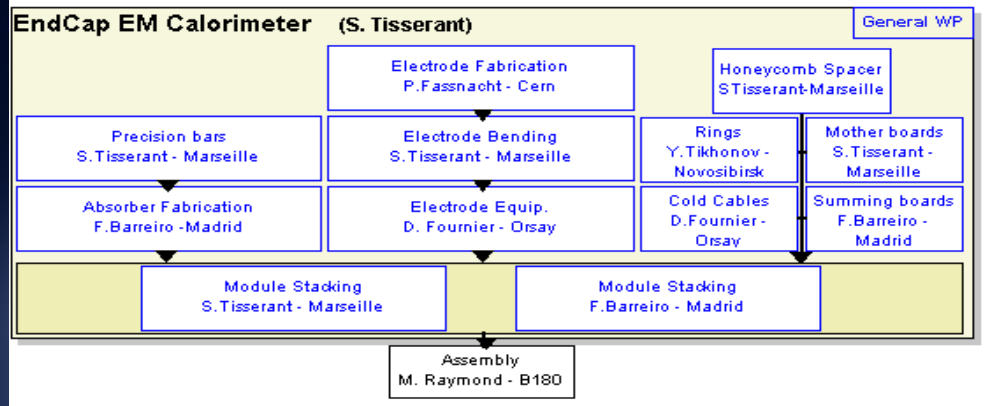
Production tracking

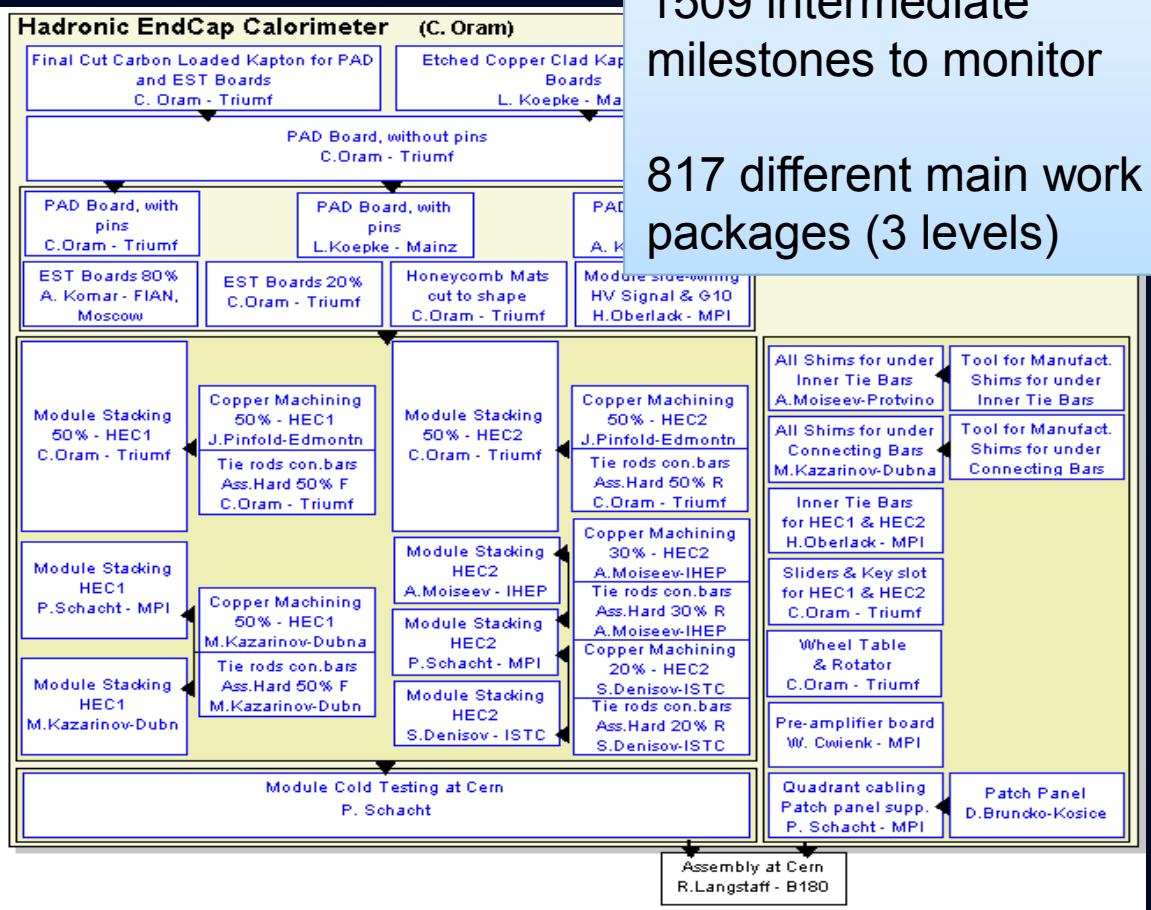
For entire ATLAS :

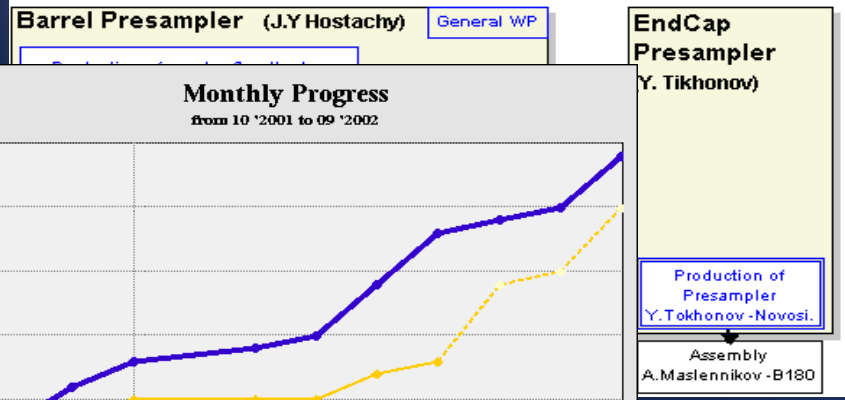
1509 intermediate milestones to monitor

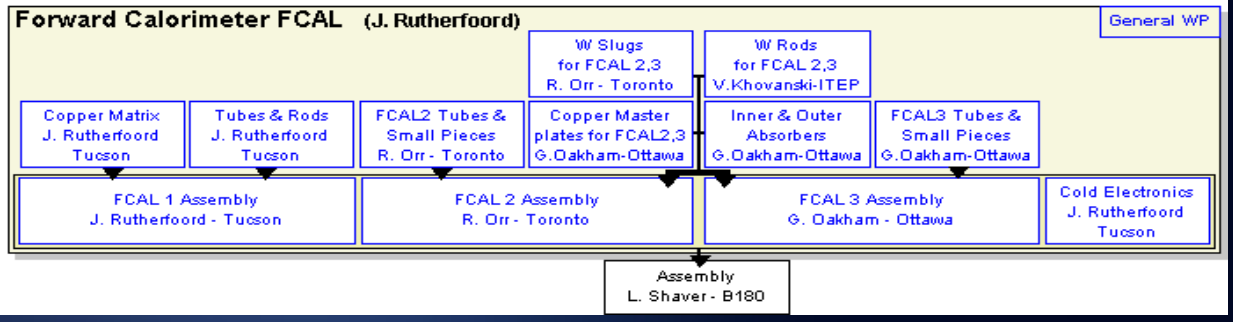
817 different main work packages (3 levels)











Centralized monitoring !!

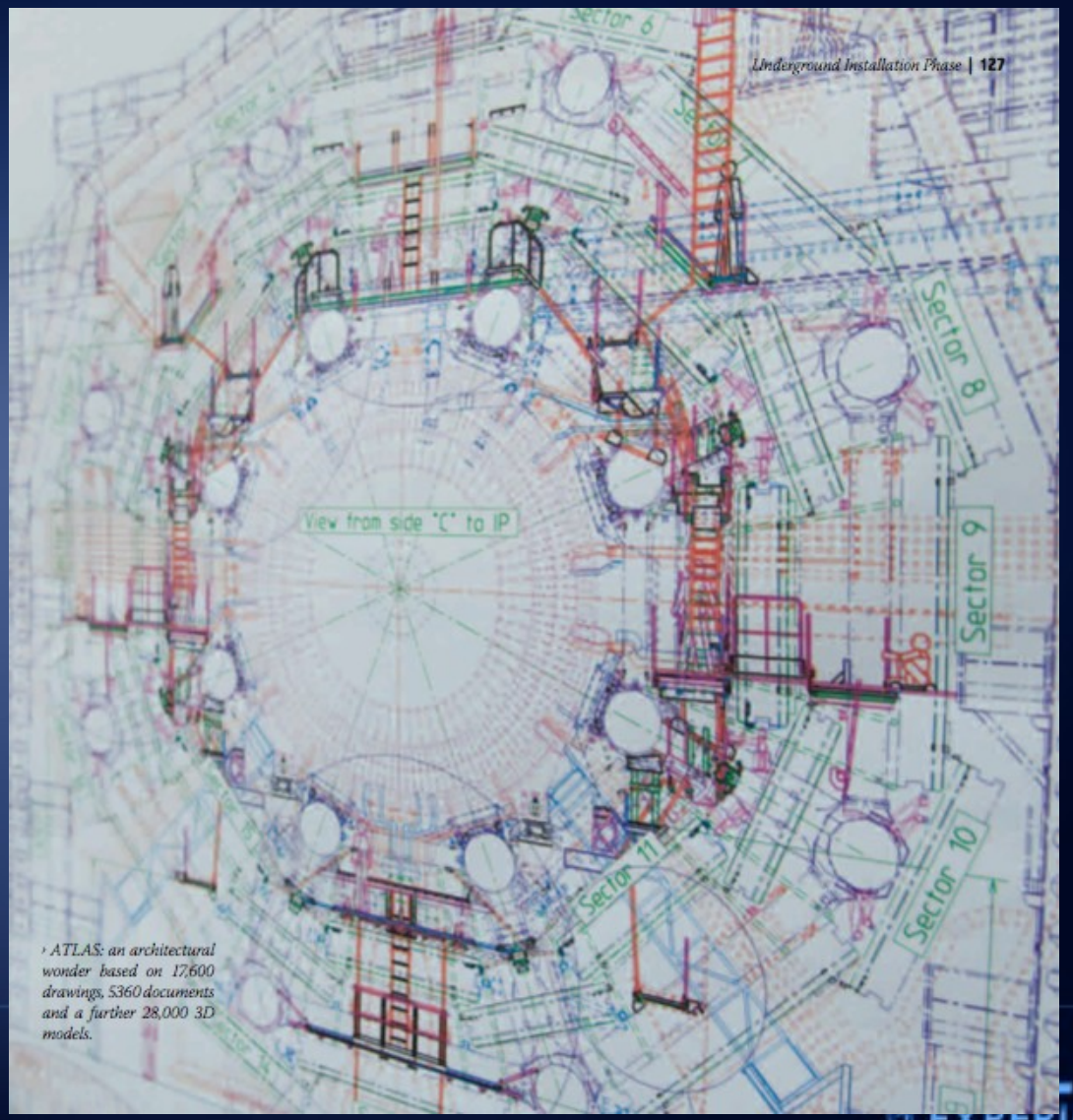
ATLAS EXPERIMENT

Assembled components travel to CERN , a really global project !

ATLAS EXPERIMENT

Underground installation

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



Underground assembly

~ 90M active sensors
~ 7000 tons of detectors
~ 3000 km of cables
~ 2000 tons of temporary supports

Infrastructure

Feet & supports

Barrel Toroid

Barrel Calorimeters

Cables & services

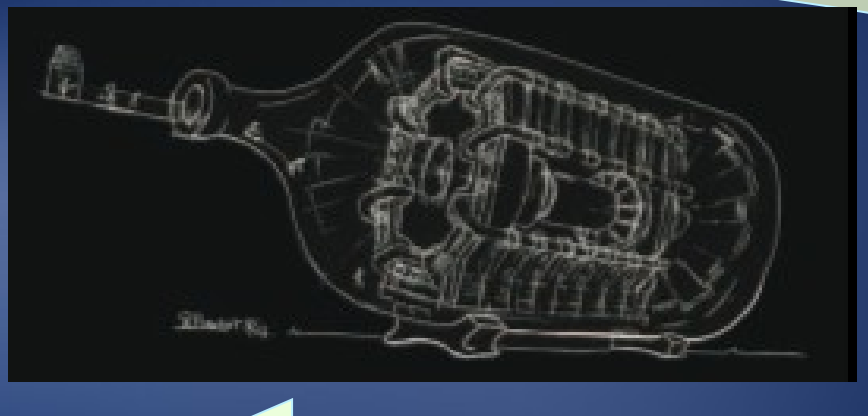
End Cap Calorimeters

Barrel Muon Chambers

Inner Detector

Forward Muon Spectrometer

Mid 2003



July 2008

End Cap Toroids

Shieldings

End Cap Inner Detector

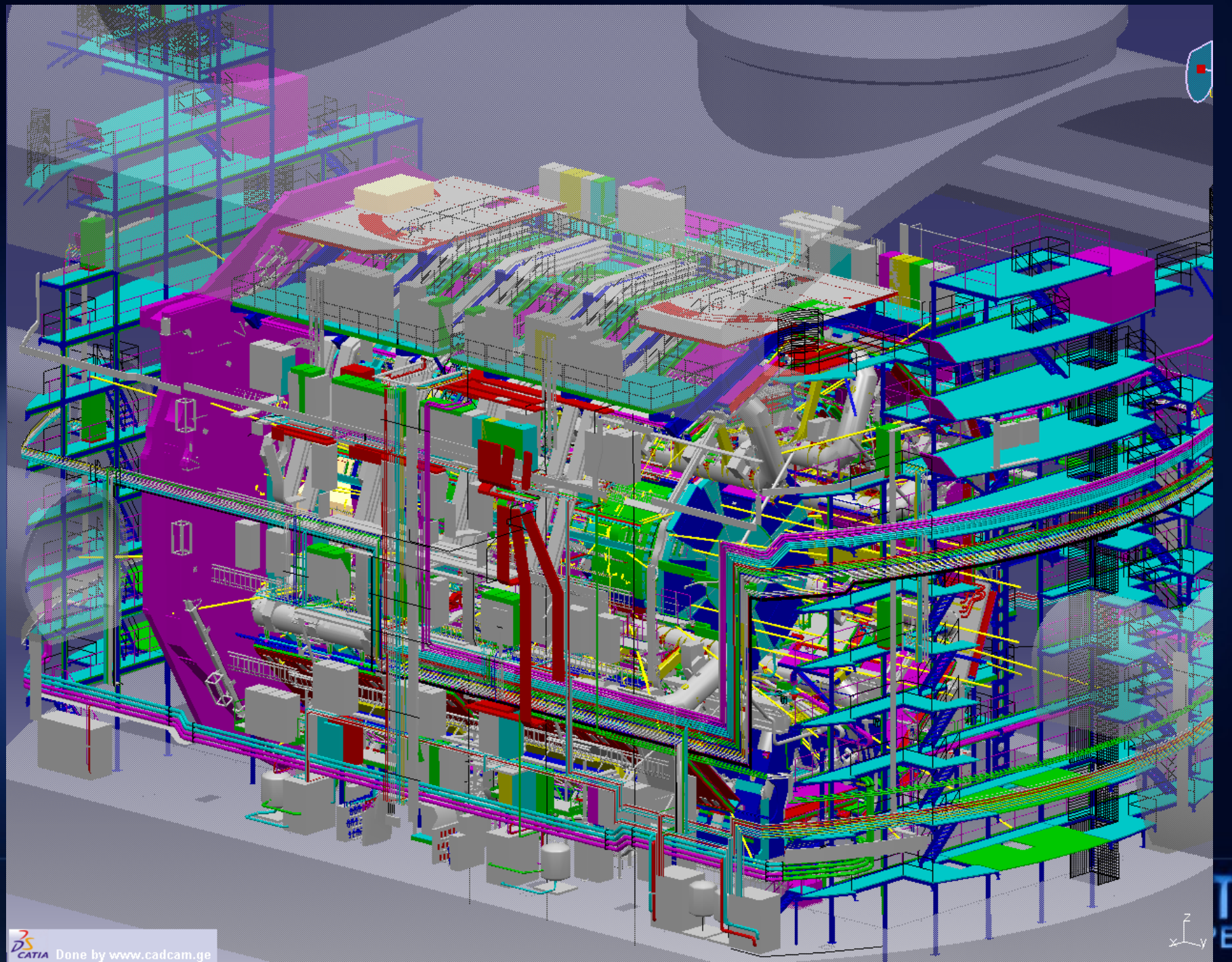
Pixel detector

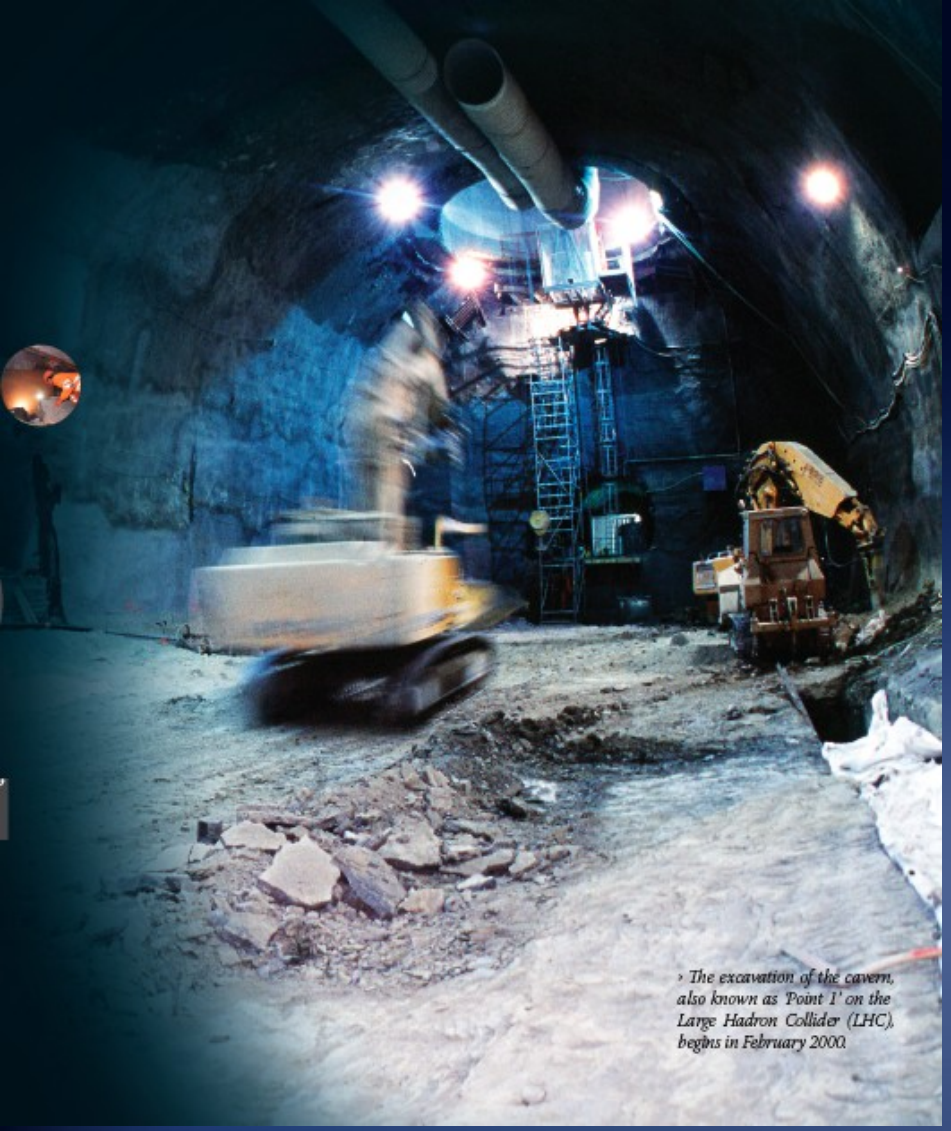
Beam Pipe

Commissioning with cosmics

ATLAS EXPERIMENT

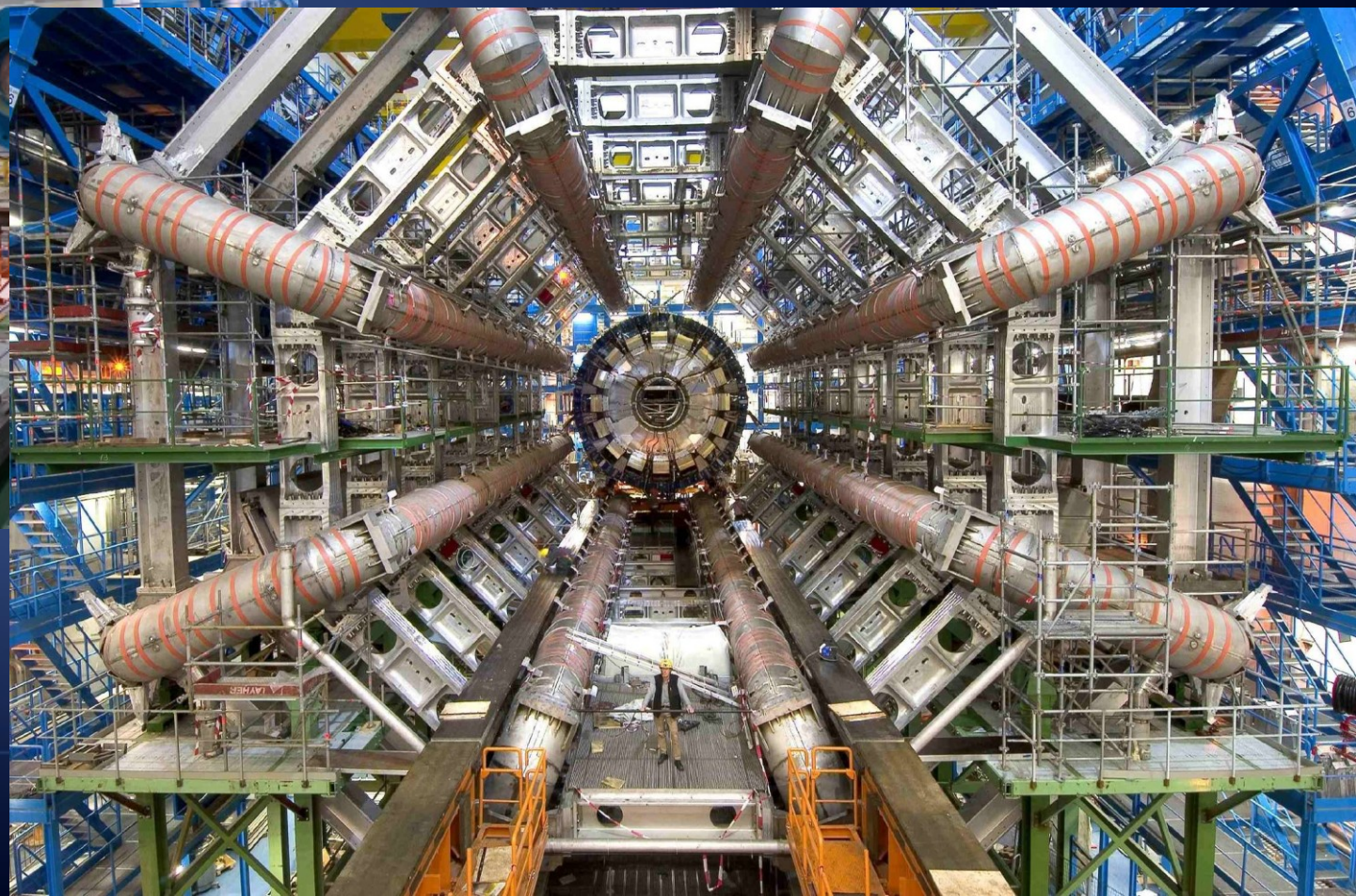
The real detector : main job -> configuration control

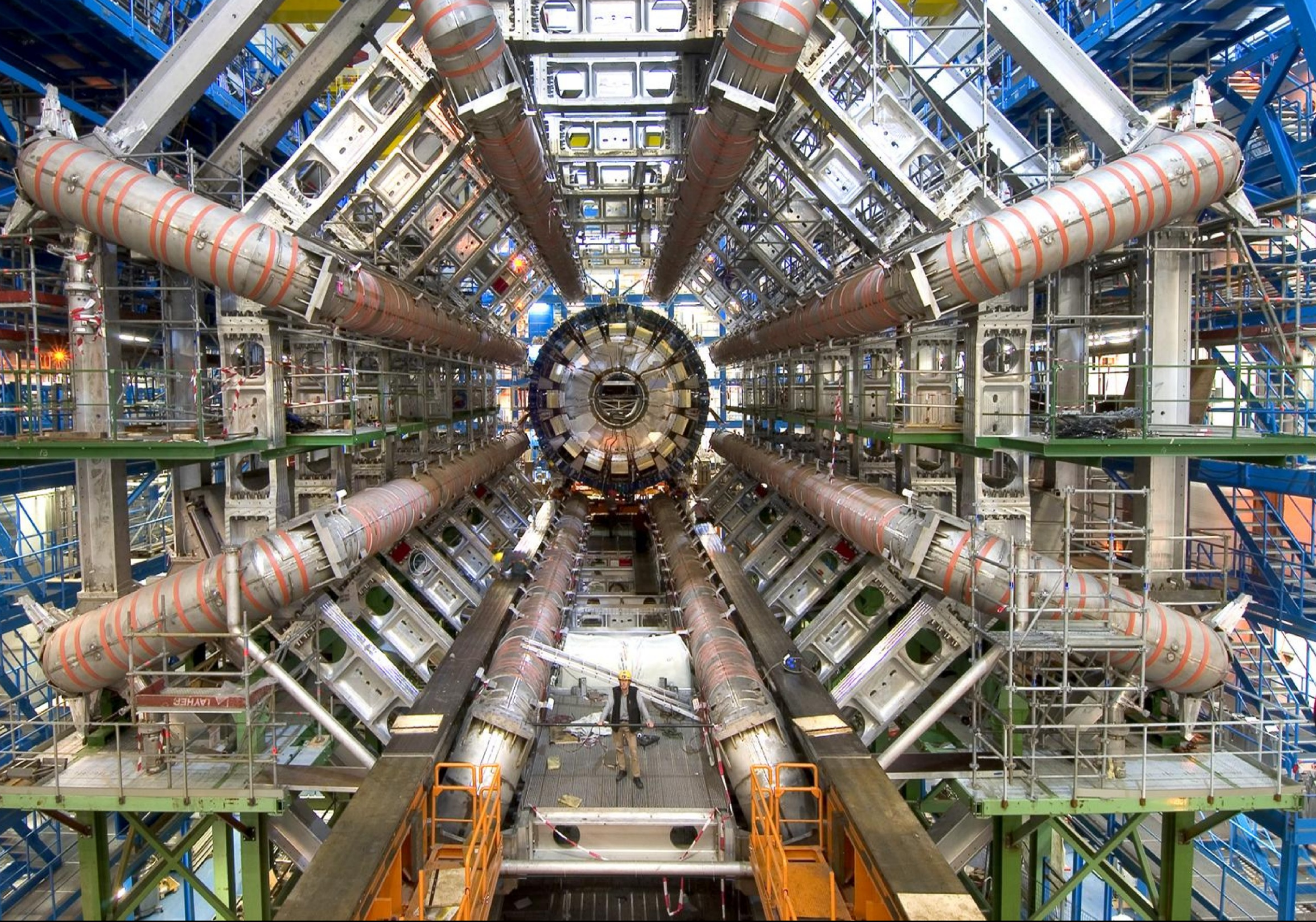


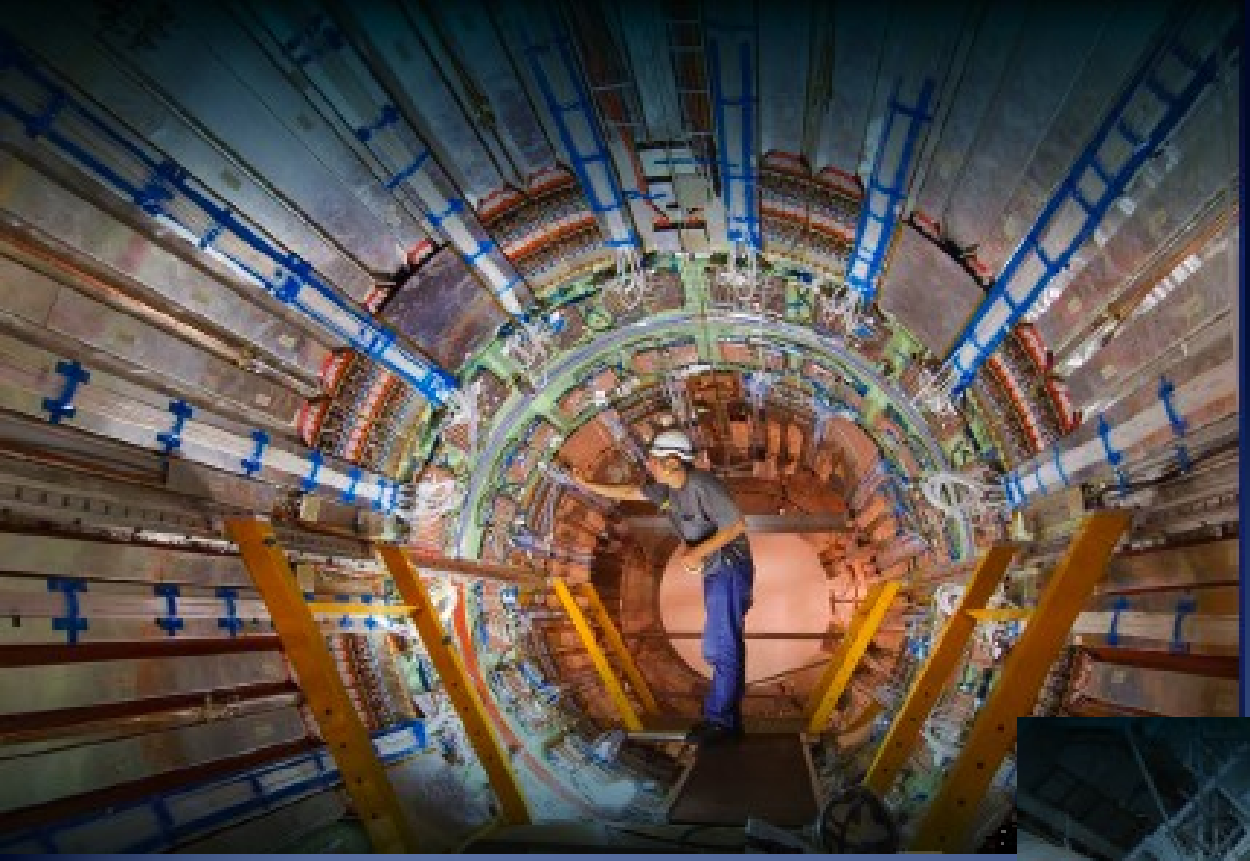


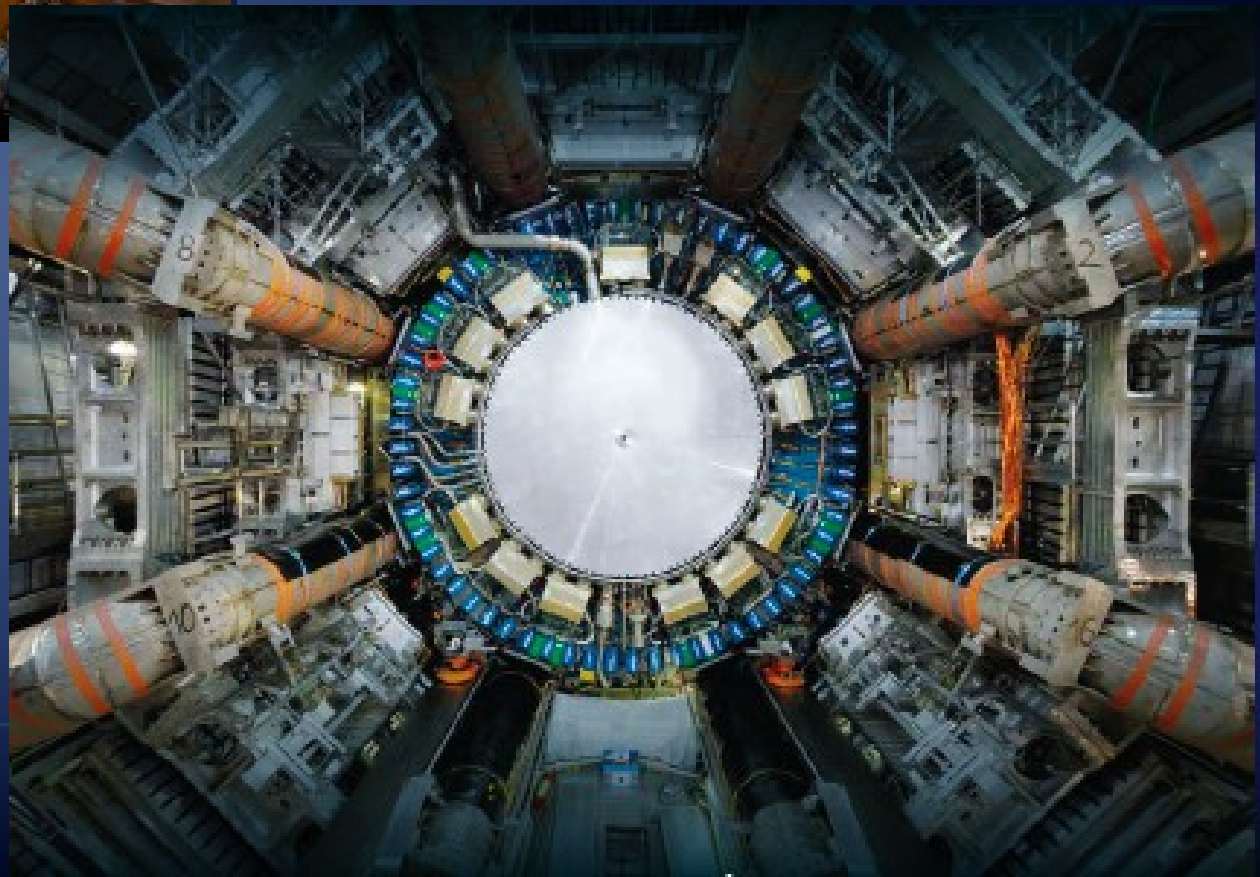
› The excavation of the cavern, also known as 'Point 1' on the Large Hadron Collider (LHC), begins in February 2000.

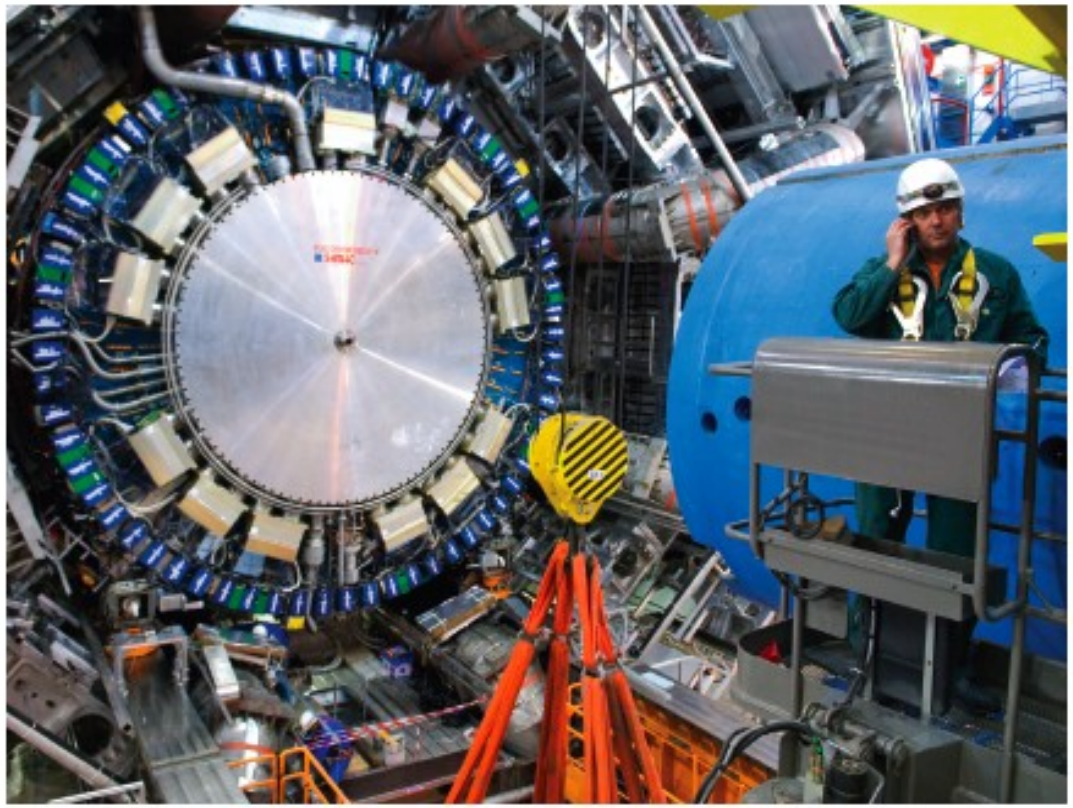

A



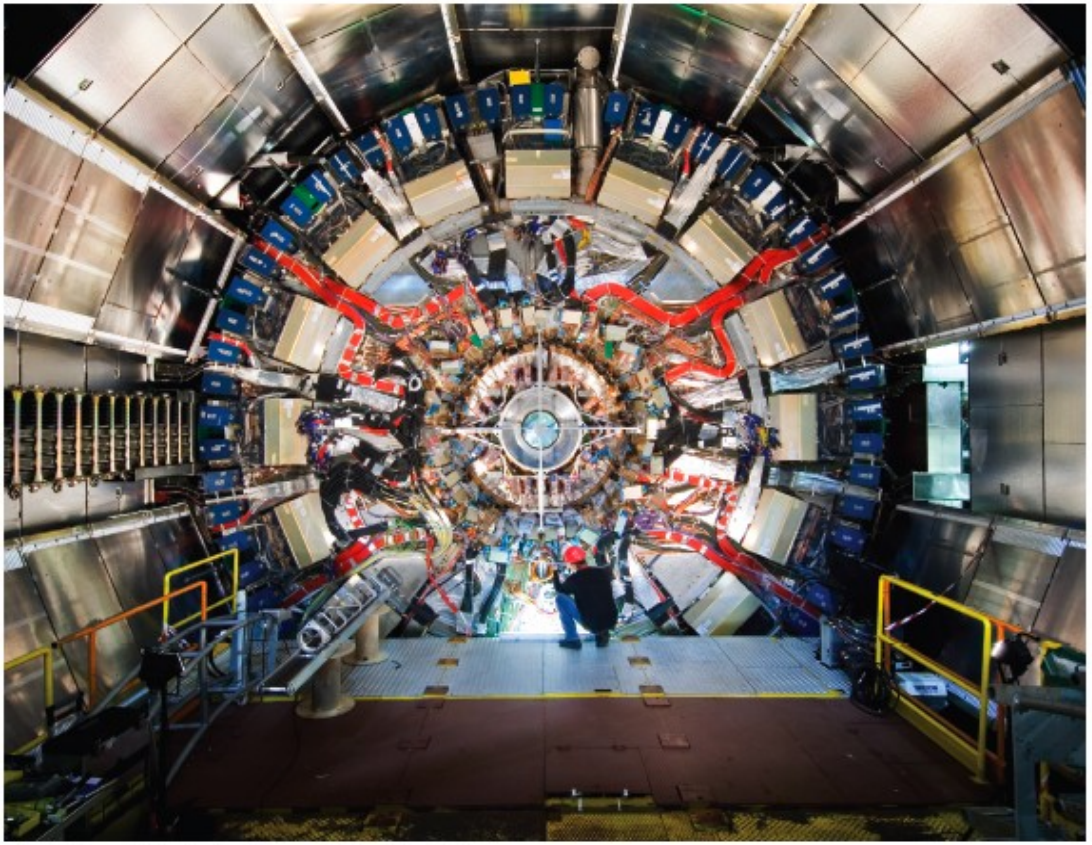




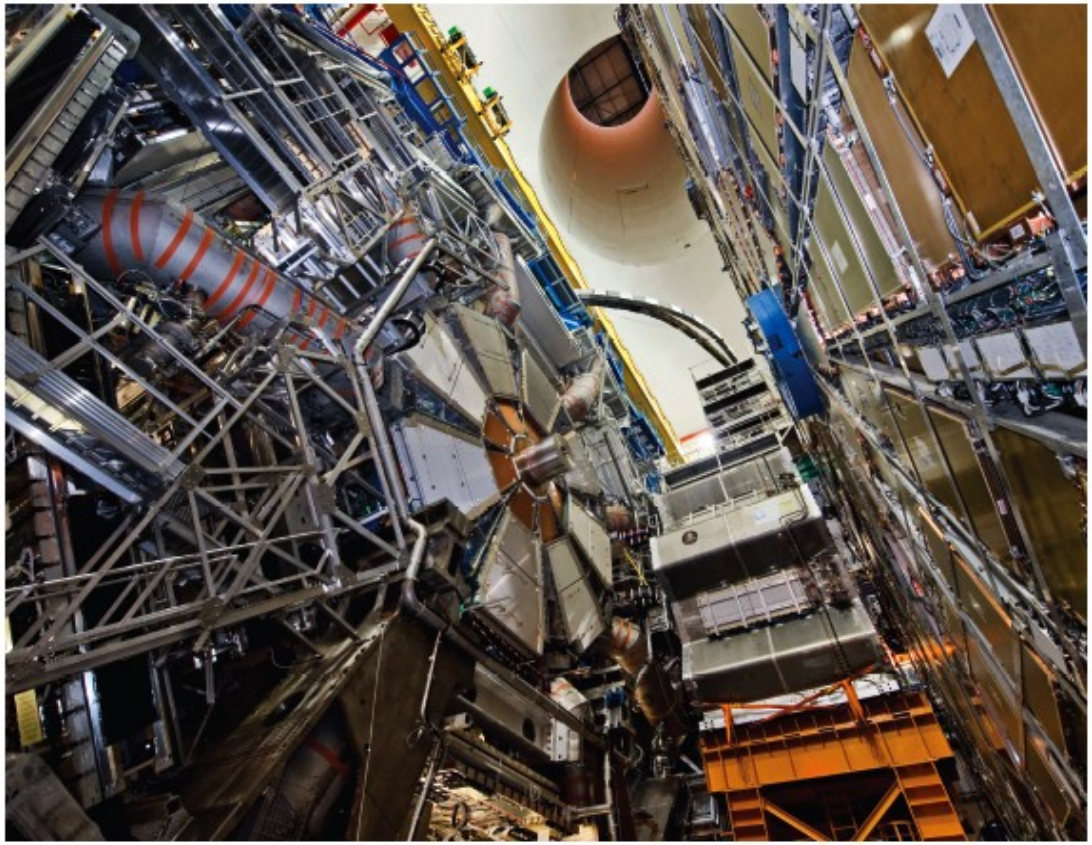




ATLAS EXPERIMENT

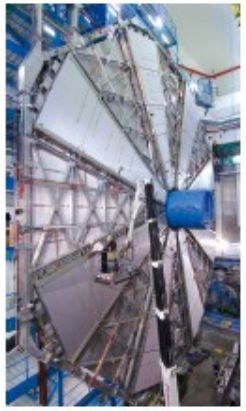
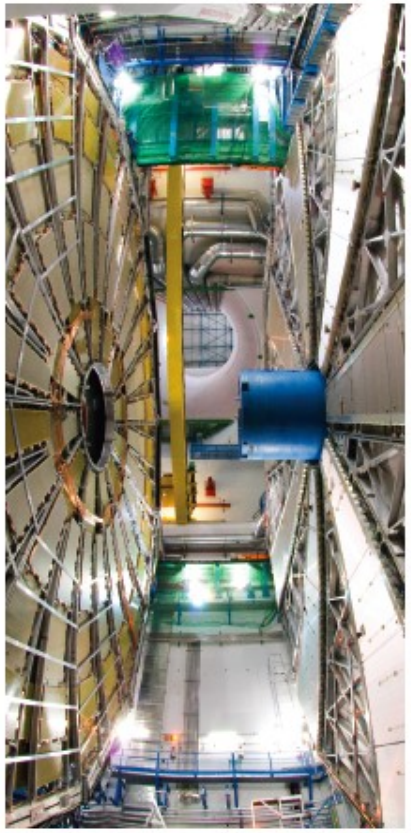


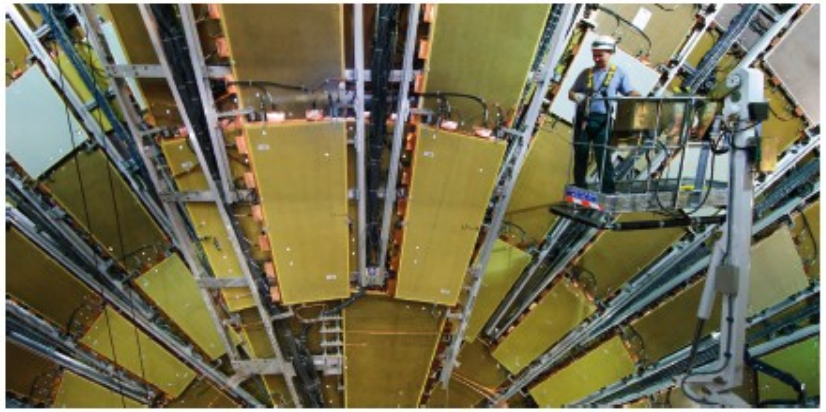
› The first Inner Detector Endcap after complete insertion within the Liquid Argon Cryostat.

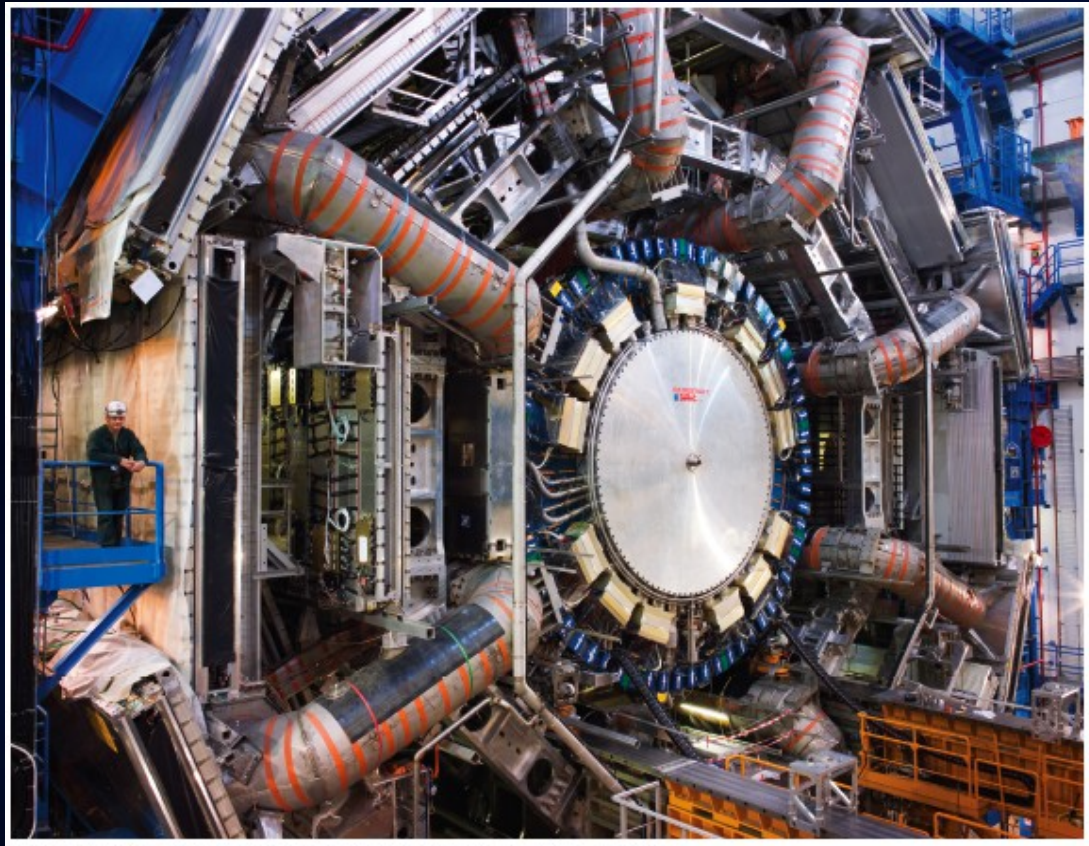


› Before the cavern was fully excavated the LEP accelerator was still running. To save time, engineers decided to cast the cavern ceiling first, temporarily suspending it with steel cables to create the largest suspended vault in the world.

ATLAS EXPERIMENT

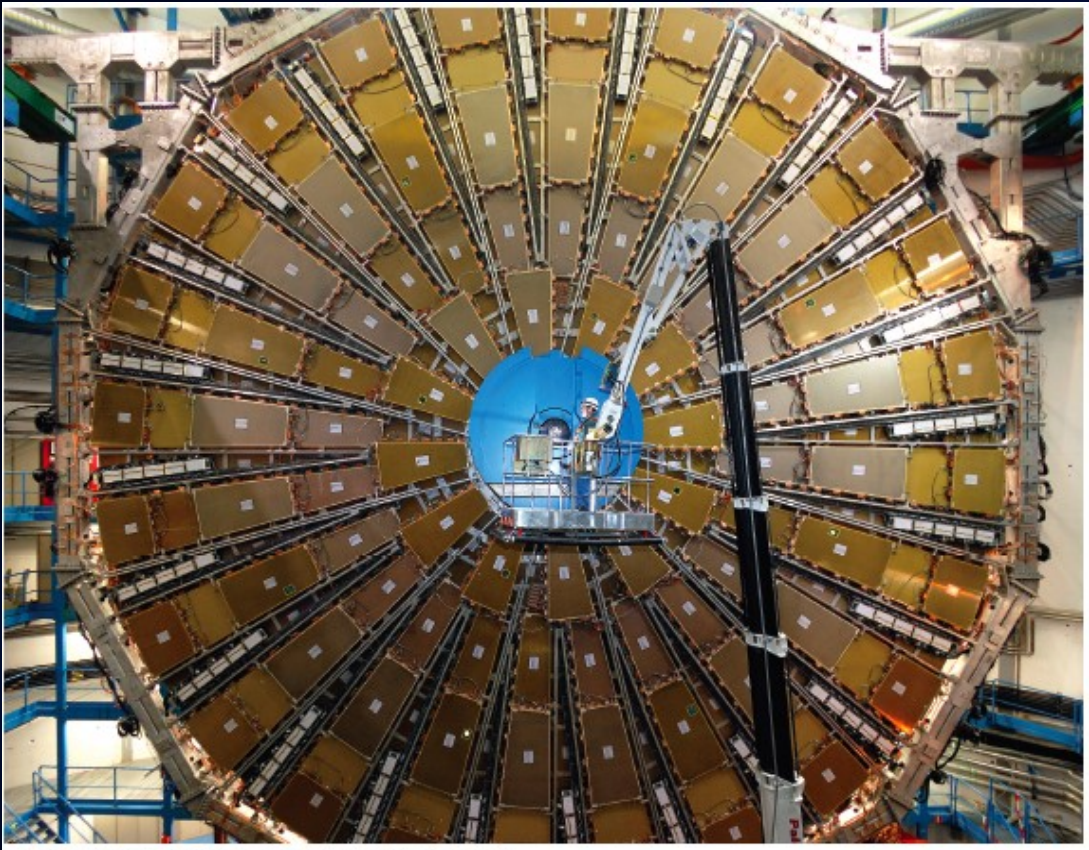
BRUNNHUBER




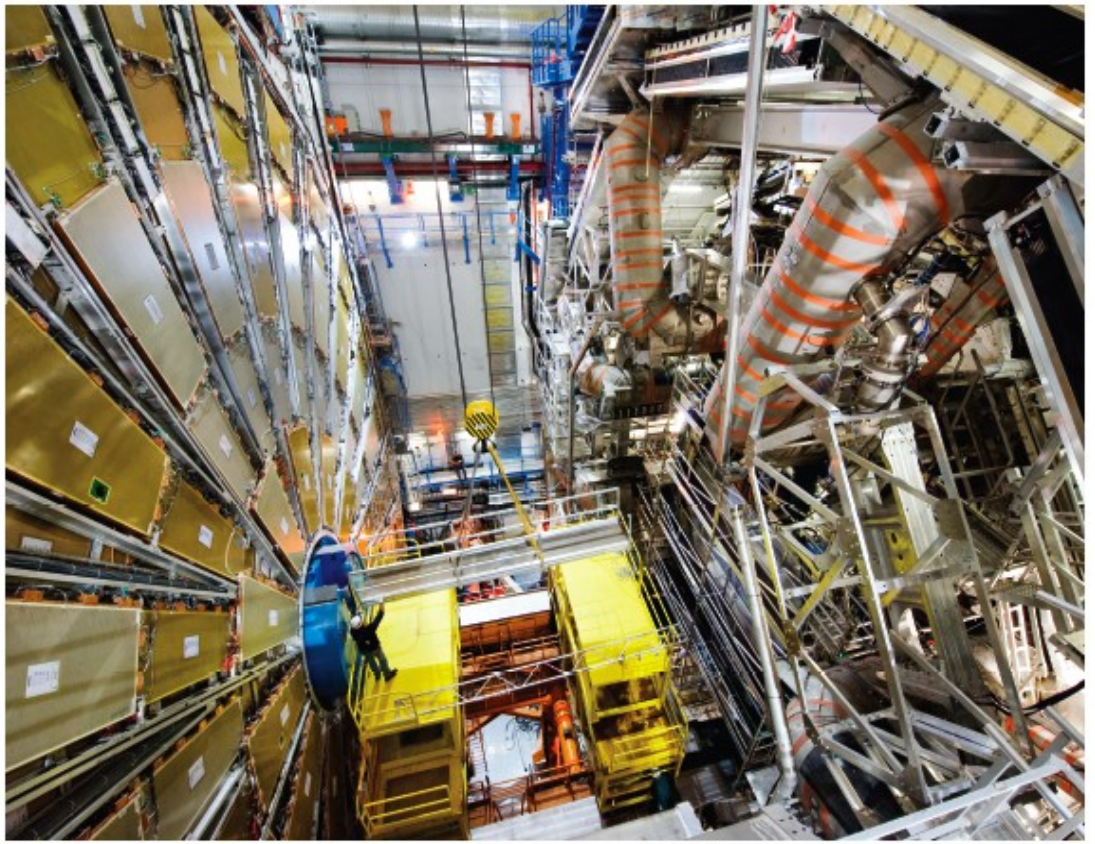
› *Poetry in motion: the endcap calorimeter floats towards its final position on orange air pads. The choreography is flawless.*

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

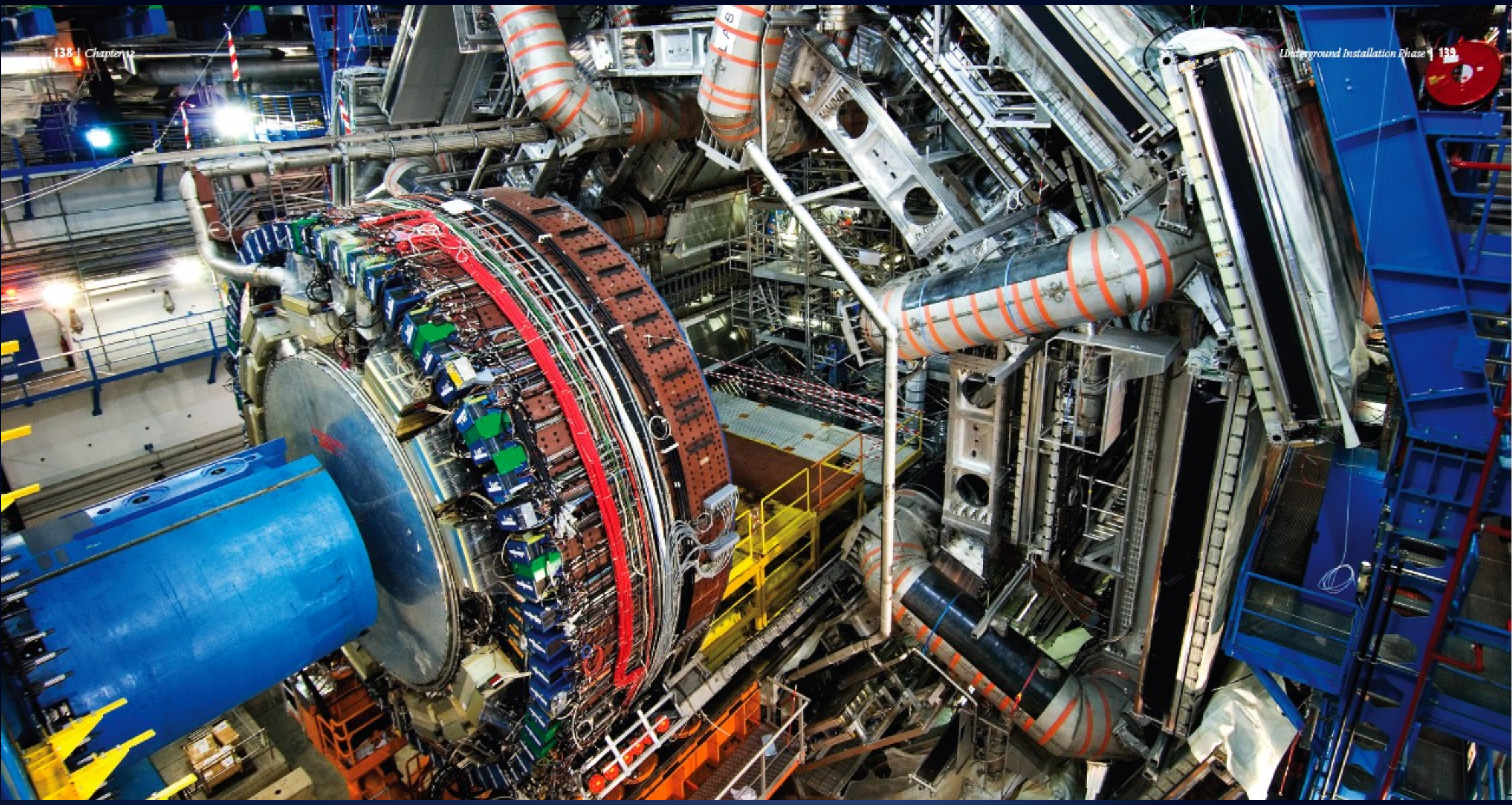
ATLAS EXPERIMENT



› 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.



The engineering process (part 1)

Define physics requirements (L.O.I, Letter of intent)

Design detector with simulation tool (GEANT)

Verify physics performance through full simulation

Construct a prototype and expose it to particle beams, to demonstrate performance

~ 5-6 years (R&D project)

Involve the engineers for a full detector design

Once the design exists, bring it back to physics simulation

Construct a module 0, defining the mass production chain

Validate module 0 in the test beams

Based on this experience, write a technical design report (TDR)

Commit the community via a MOU (a Memorandum Of Understanding)

The engineering process (part 2)

Make plans for mass production, prepare technical specs for procurements

Once ready pass an ATLAS internal readiness review

Funding agencies release funds according to the readiness rev.

Start material procurements, if contract large involve CERN in the administrative process (market survey, tender, adjudication,..)

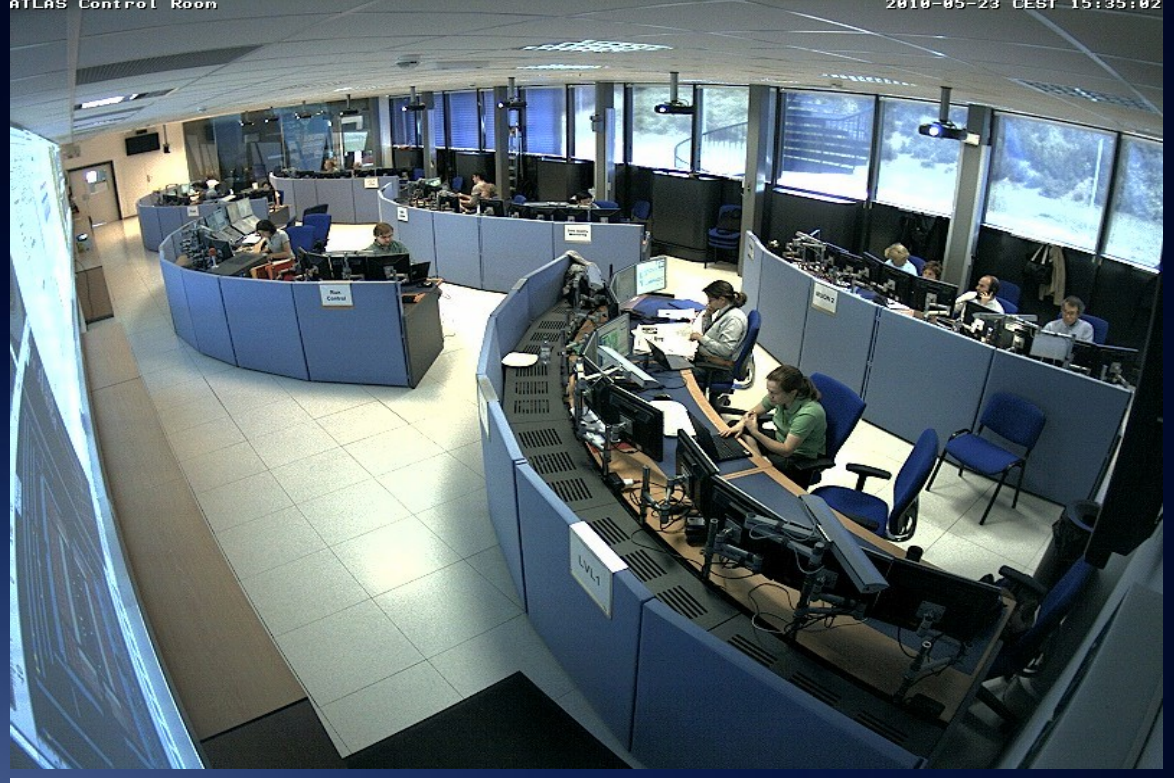
~ 8-10 years of mass production

If production is done in several institutions, clone tooling

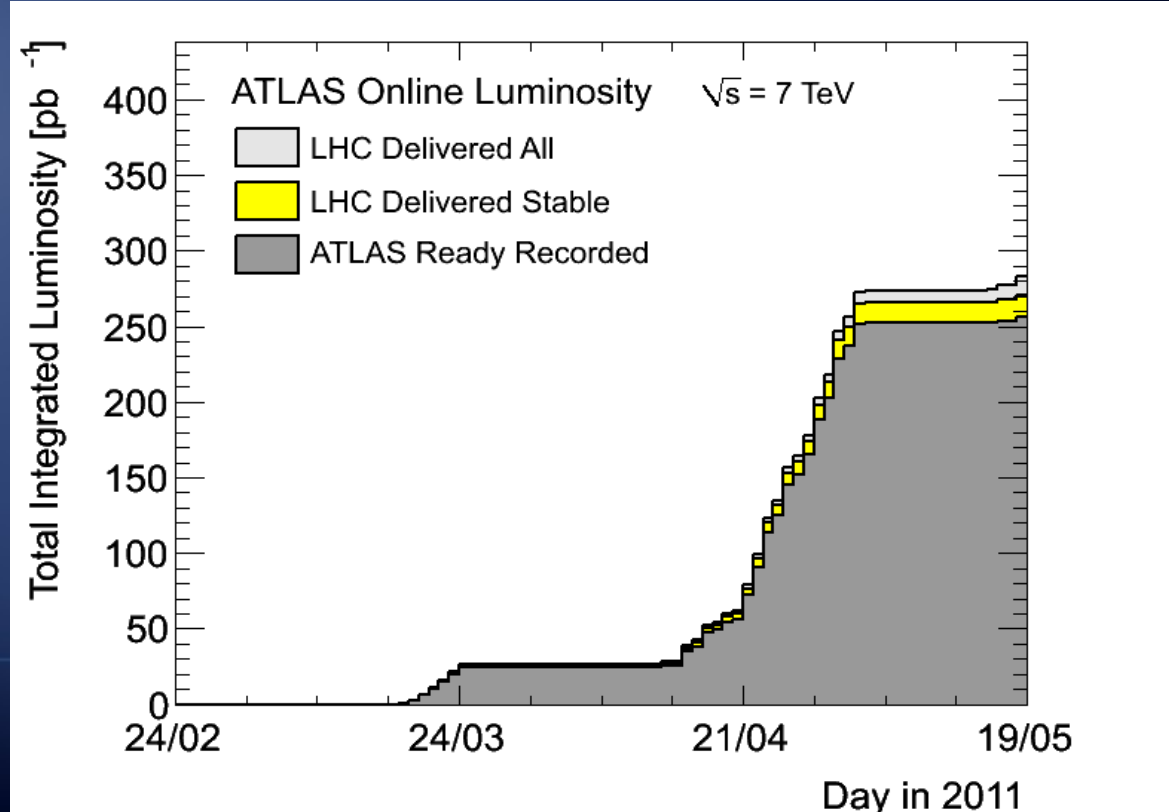
Produce components according to the agreement, ship it to the next step in the production chain

Progress monitored via a dedicated progress tracking tool (PPT)

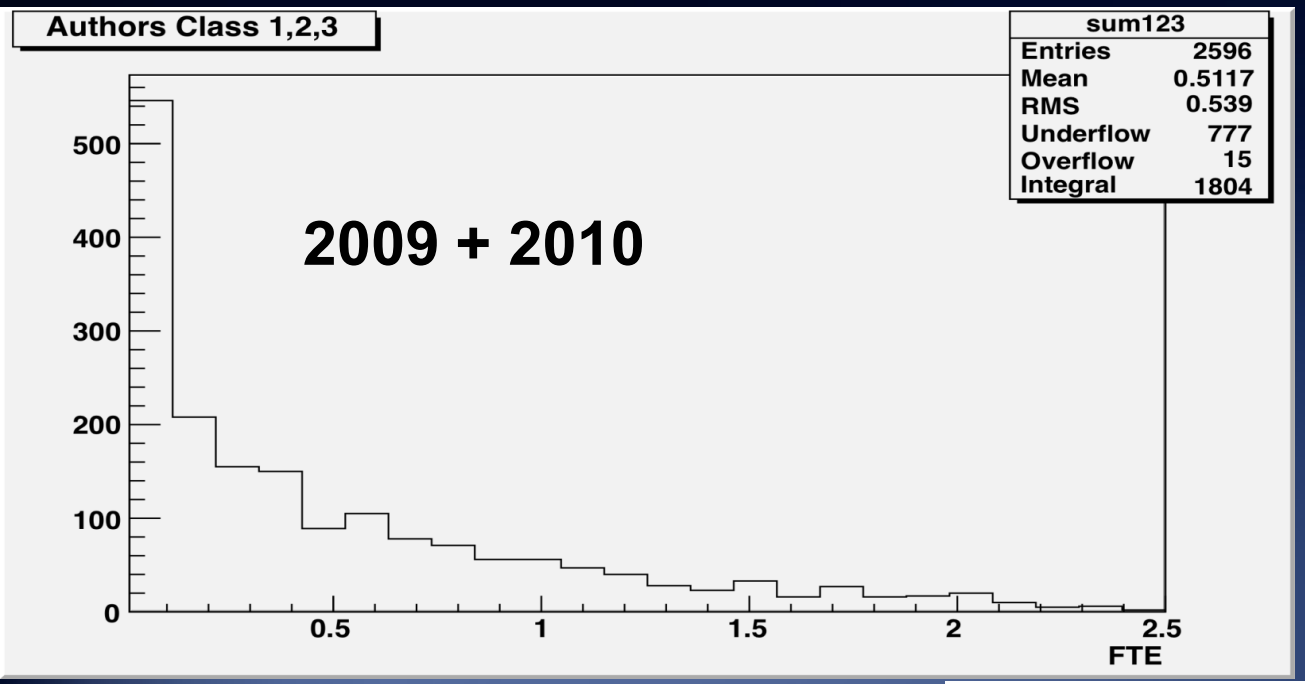
Deliver production to ATLAS at CERN according to an agreed set of ready for installation milestones (normally 3-4 months before needed)



Next run (2011-2012) goal : 7 TeV, 5-6 fb^{-1}?



OTP (Operation service tasks support)

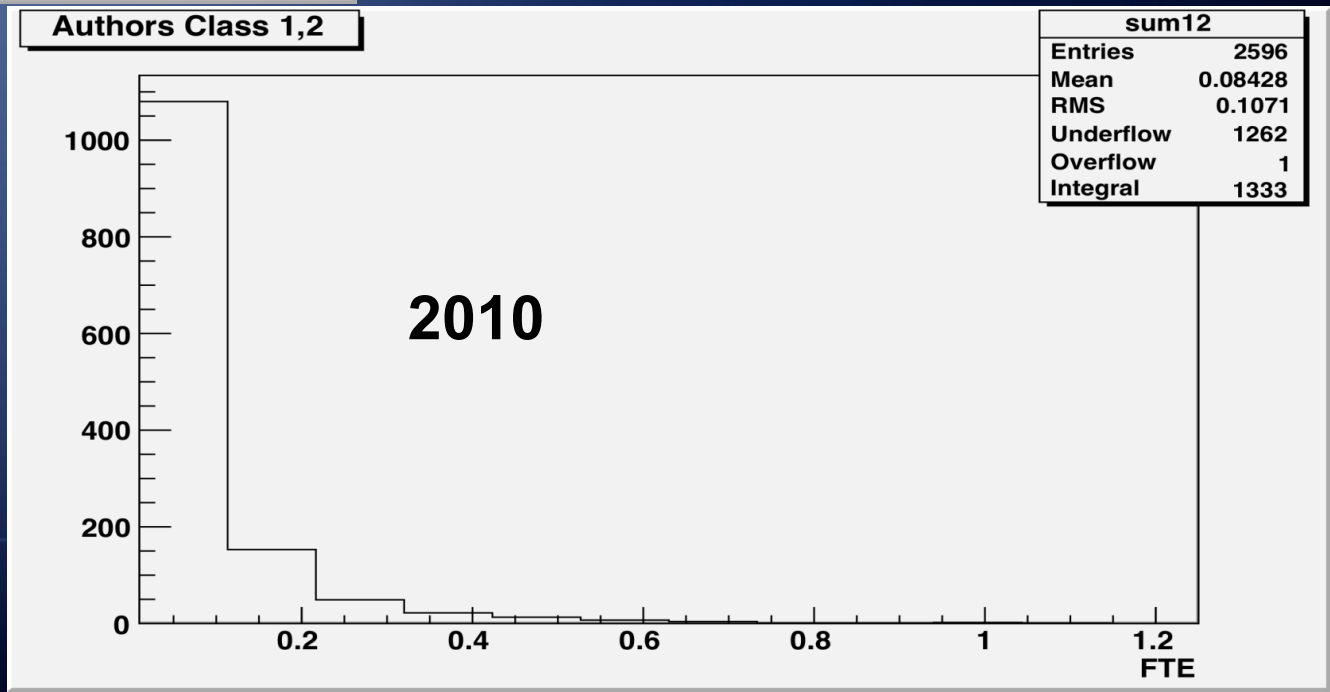


Work organized in 3 classes (1-control room shifts, 2-expert shifts, 3-technical jobs)

1804/2596 active authors are doing service work (OTP) at the 25% level/year

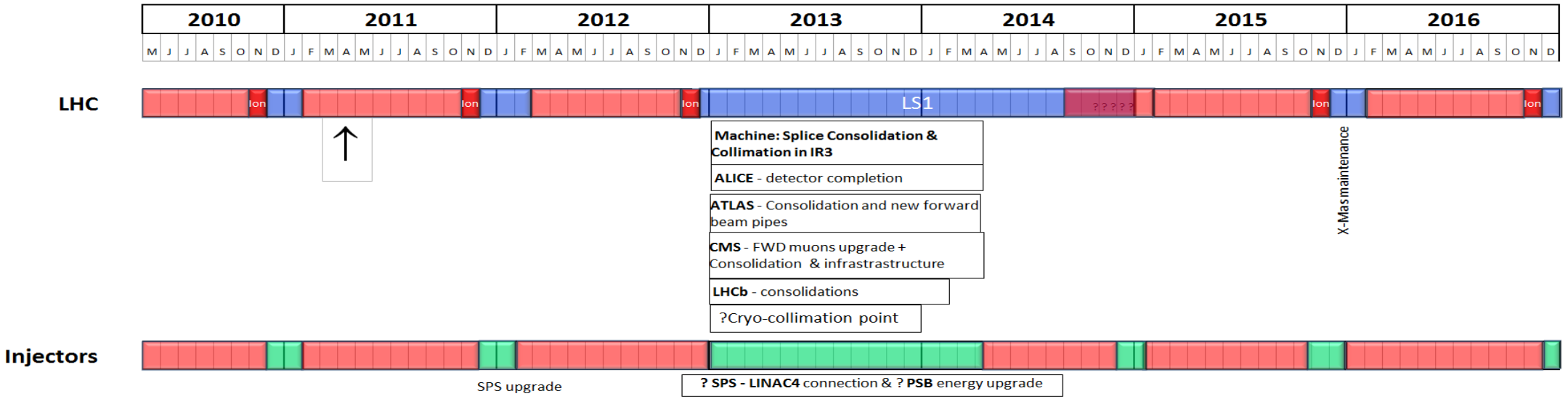
1333/2596 active authors are taking shifts or are acting as experts on call

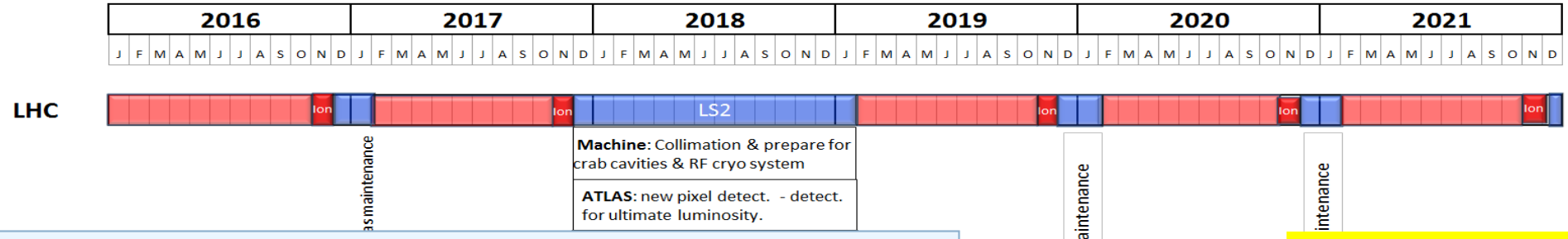
Physics duties for free!



A rich program in front of us

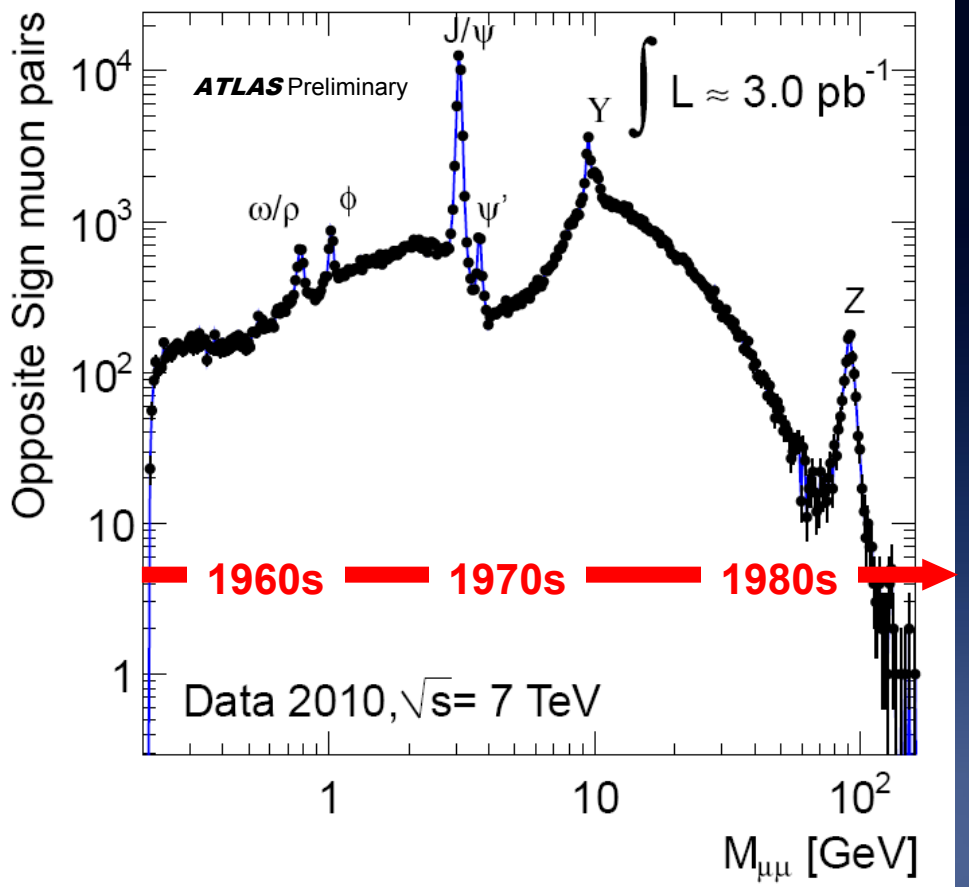
New rough draft 10 year plan

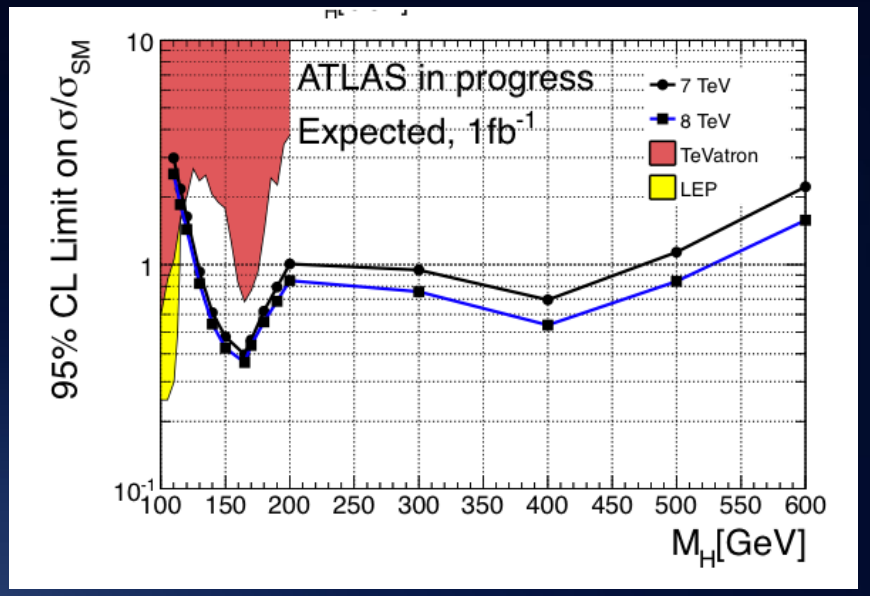


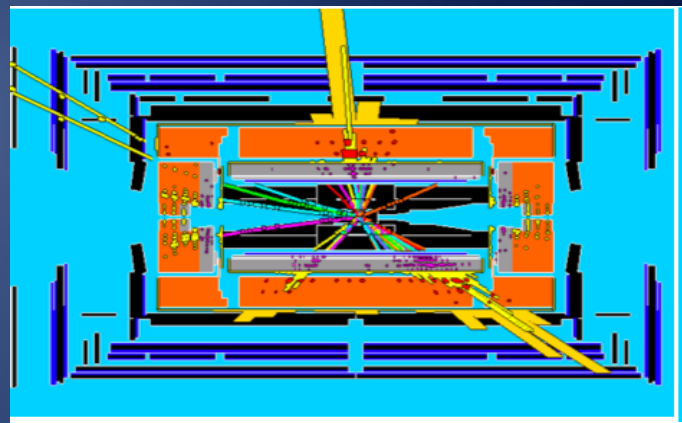


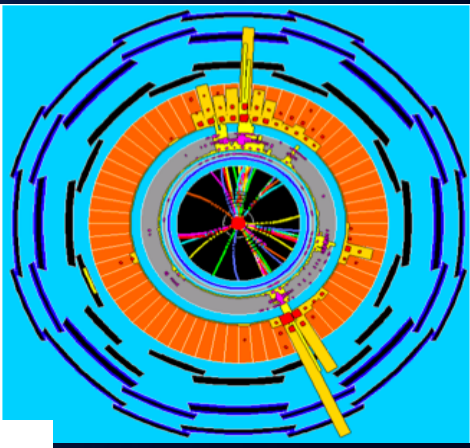
- *Every year 4 weeks of Heavy Ions (8 runs)*
- *Every year a Xmas shutdown for 8-9 weeks*
- *15 m shutdown in 2012/2013 -> LHC to nominal energy*
- *15 m shutdown in 2018 -> Phase 1 upgrade*
- *19 m shutdown in 2022 -> HL-LHC upgrade*

→ Up to 2035

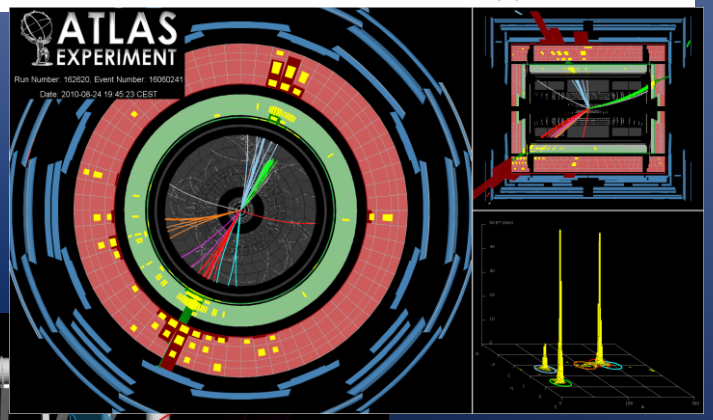


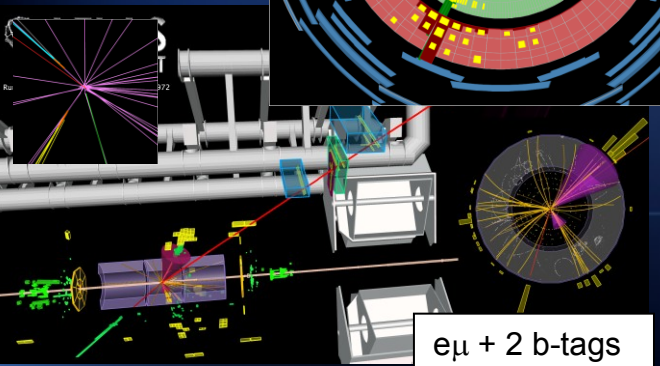






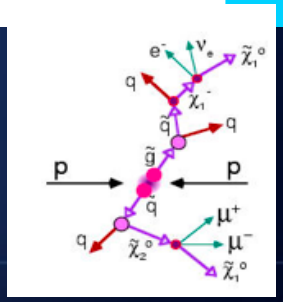
Top quark physics (1990s)



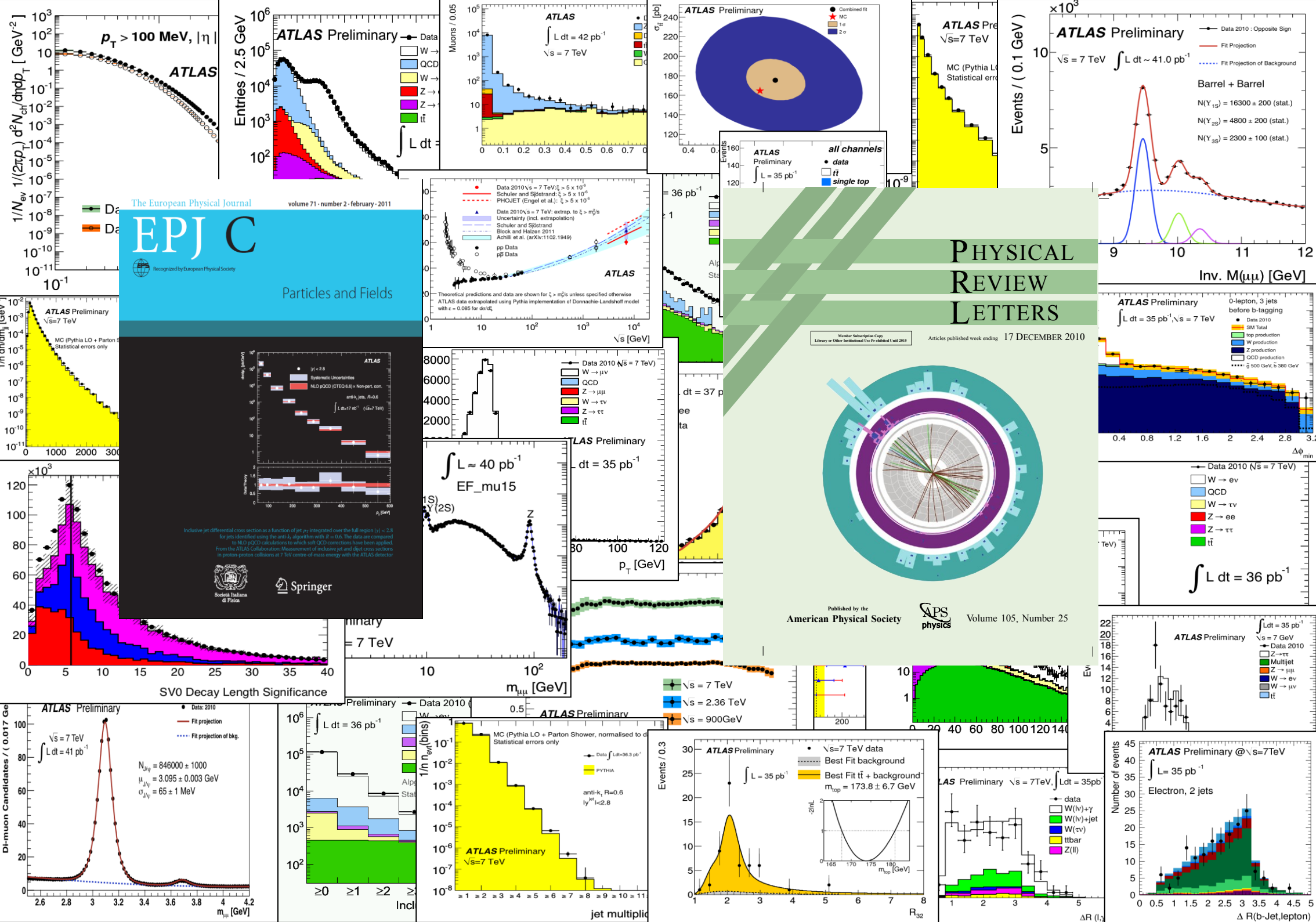


eμ + 2 b-tags

High P_T QCD (1990s)



ATLAS EXPERIMENT


ATLAS
ATLAS Preliminary
p_T > 100 MeV, |η|
$1/N_{ev}\ 1/(2\pi p_T)\ d^2N_{ch}/d\eta dp_T$ [GeV^{-2}]
Entries / 2.5 GeV
Muons / 0.05
$\int$ L dt = 42 pb^{-1}
$\sqrt{s}$ = 7 TeV
$\sigma_{t\bar{t}}$ [pb]
Combined fit
MC
1 σ
2 σ
Events
all channels
data
$t\bar{t}$
single top
$\int$ L = 35 pb^{-1}
Events / (0.1 GeV)
Data 2010 : Opposite Sign
Fit Projection
Fit Projection of Background
$\int$ L dt ~ 41.0 pb^{-1}
Barrel + Barrel
N(Υ_{1S}) = 16300 ± 200 (stat.)
N(Υ_{2S}) = 4800 ± 200 (stat.)
N(Υ_{3S}) = 2300 ± 100 (stat.)
Inv. M(μμ) [GeV]
Data 2010 $\sqrt{s}$ = 7 TeV: ξ > 5 x 10^{-6}
Schuler and Sjöstrand: ξ > 5 x 10^{-6}
PHOJET (Engel et al.): ξ > 5 x 10^{-6}
Data 2010 $\sqrt{s}$ = 7 TeV: extrap. to ξ > m$_p^2$/s
Uncertainty (incl. extrapolation)
Schuler and Sjöstrand
Block and Halzen 2011
Achilli et al. (arXiv:1102.1949)
pp Data
pp̄ Data
Theoretical predictions and data are shown for ξ > m$_p^2$/s unless specified otherwise
ATLAS data extrapolated using Pythia implementation of Donnachie-Landshoff model with ε = 0.085 for dσ/dξ
$\sqrt{s}$ [GeV]
Data 2010 ($\sqrt{s}$ = 7 TeV)
W → μν
QCD
Z → μμ
W → τν
Z → ττ
tt̄
$\int$ L ≈ 40 pb^{-1}
EF_mu15
Z
Υ(2S)
Υ(1S)
p$_T$ [GeV]
m$_{μμ}$ [GeV]
$\int$ L dt = 35 pb^{-1}
$\int$ L dt = 37 p
$\sqrt{s}$ = 7 TeV
$\sqrt{s}$ = 2.36 TeV
$\sqrt{s}$ = 900GeV
0-lepton, 3 jets
before b-tagging
SM Total
top production
W production
Z production
QCD production
g̃ 500 GeV, b̃ 380 GeV
Δφ$_{min}$
W → eν
Z → ee
$\int$ L dt = 36 pb^{-1}
SV0 Decay Length Significance
Inclusive jet differential cross section as a function of jet p$_T$ integrated over the full region |y| < 2.8 for jets identified using the anti-k$_t$ algorithm with R = 0.6. The data are compared to NLO pQCD calculations to which soft QCD corrections have been applied.
From the ATLAS Collaboration: Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector
Società Italiana di Fisica
Springer
The European Physical Journal
volume 71 · number 2 · february · 2011
EPJ C
Recognized by European Physical Society
Particles and Fields
PHYSICAL REVIEW LETTERS
Articles published week ending 17 DECEMBER 2010
Member Subscription Copy
Library or Other Institutional Use Pr ohibited Until 2015
Published by the
American Physical Society
APS physics
Volume 105, Number 25
Data: 2010
Fit projection
Fit projection of bkg.
$\int$ L dt = 41 pb^{-1}
N$_{J/ψ}$ = 846000 ± 1000
μ$_{J/ψ}$ = 3.095 ± 0.003 GeV
σ$_{J/ψ}$ = 65 ± 1 MeV
Di-muon Candidates / (0.017 Ge
m$_{μμ}$ [GeV]
$\int$ L dt = 36 pb^{-1}
MC (Pythia LO + Parton Shower, normalised to d
Statistical errors only
Data $\int$ Ldt=36.3 pb^{-1}
PYTHIA
anti-k$_t$ R=0.6
|y^{jet}|<2.8
1/n n$_{ev}$(bins)
jet multiplic
$\sqrt{s}$=7 TeV data
Best Fit background
Best Fit tt̄ + background
m$_{top}$ = 173.8 ± 6.7 GeV
-2lnL
m$_{top}$ [GeV]
R$_{32}$
$\int$ L= 35 pb^{-1}
Electron, 2 jets
Number of events
Δ R(b-Jet,lepton)
data
W(lν)+γ
W(lν)+jet
W(τν)
ttbar
Z(ll)
$\int$ Ldt = 35 pb^{-1}
$\sqrt{s}$ = 7 TeV
Data 2010
Z→ττ
Multijet
Z → μμ
W → eν
W → μν
tt̄