How do Large Collaborations Work? Why?

LHC-ATLAS As An Example

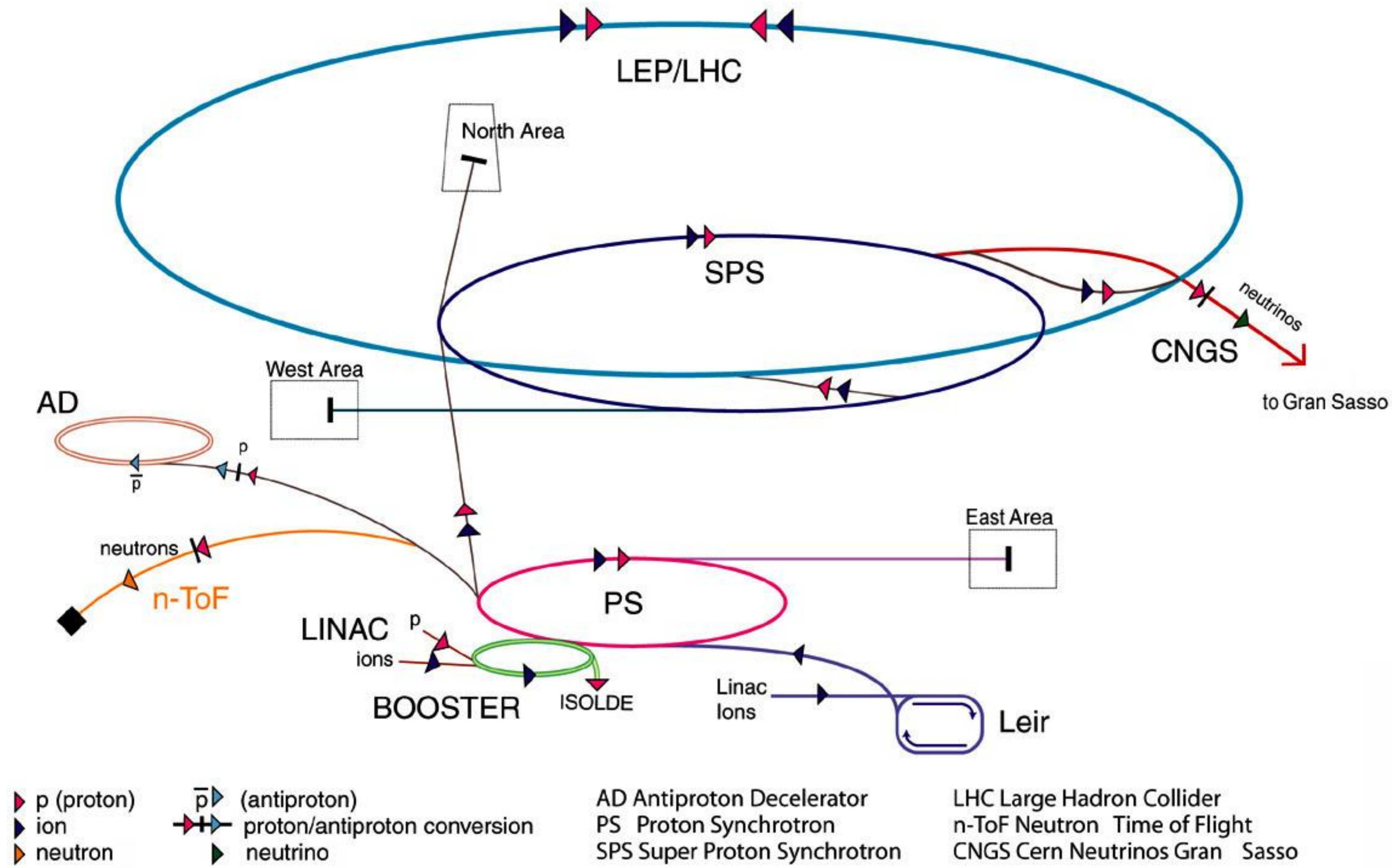
ESADE Executive Management

November 14, 2017

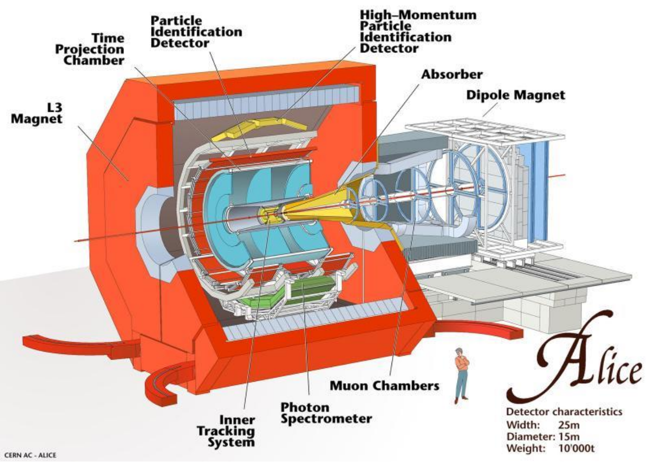
Markus Nordberg, Head of Resources Development

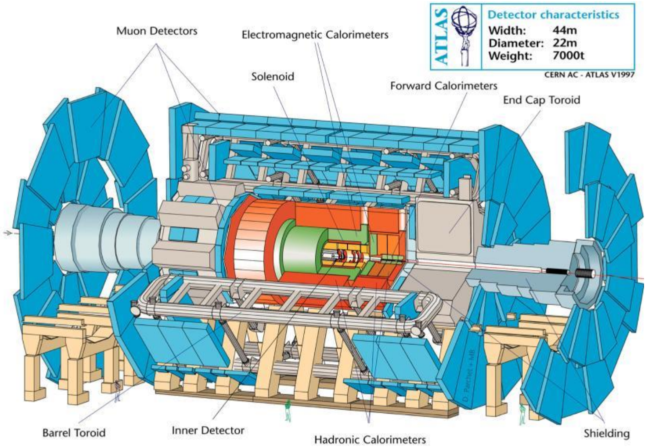
Development and Innovation Unit (IPT-DI)

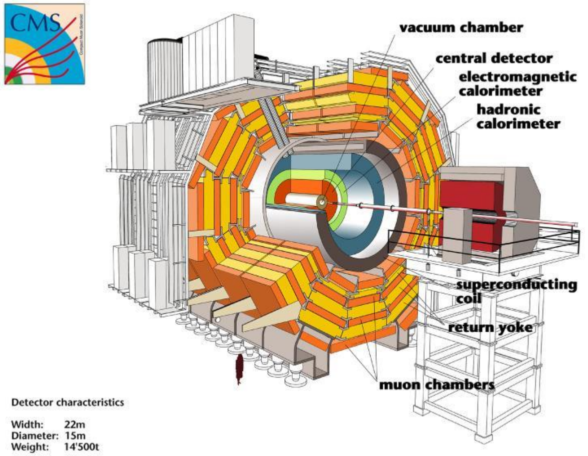
Accelerator chain at CERN, a complex business

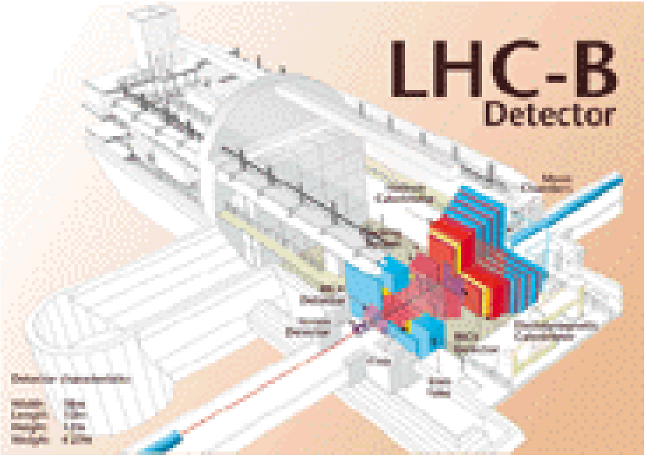


LHC Experiments

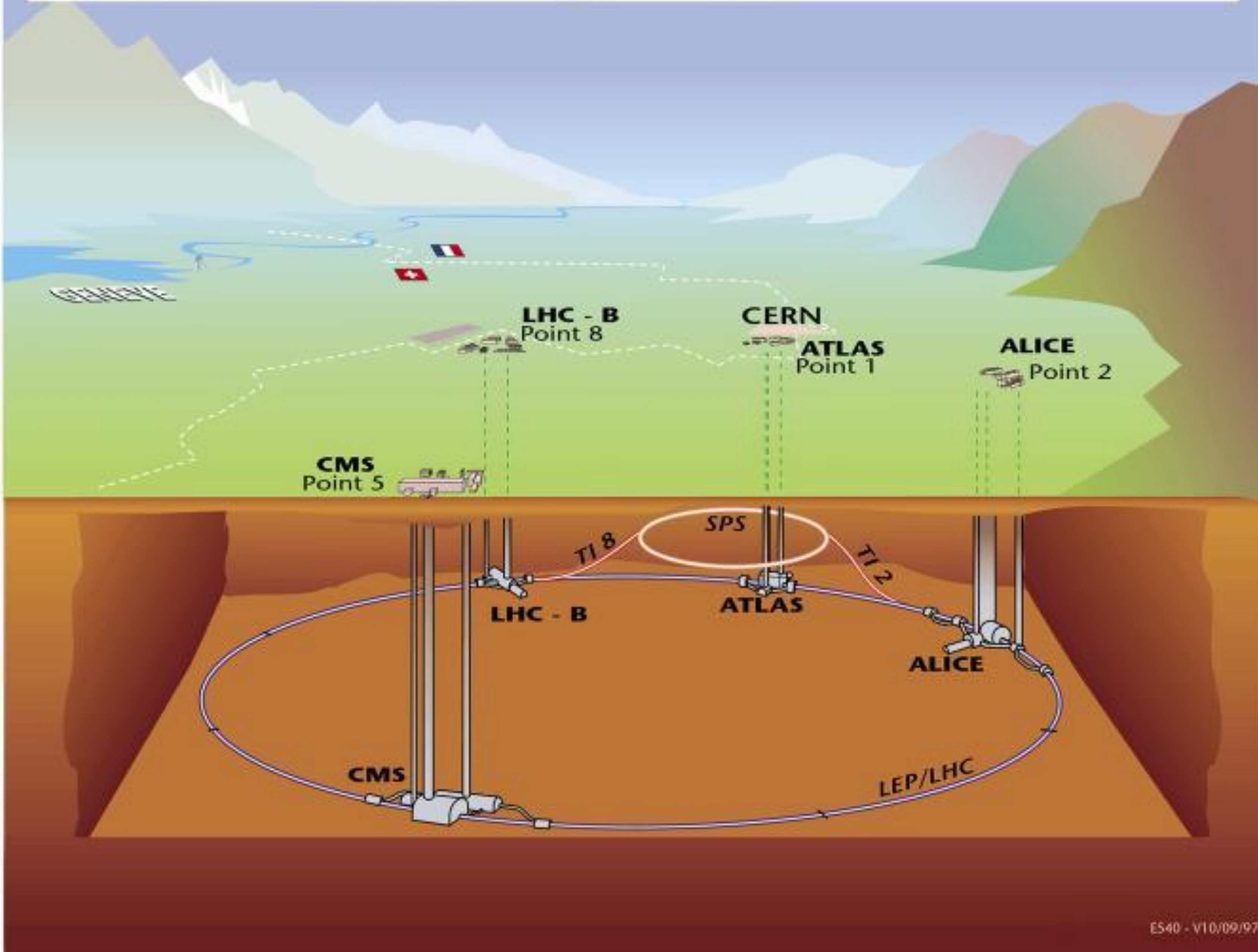


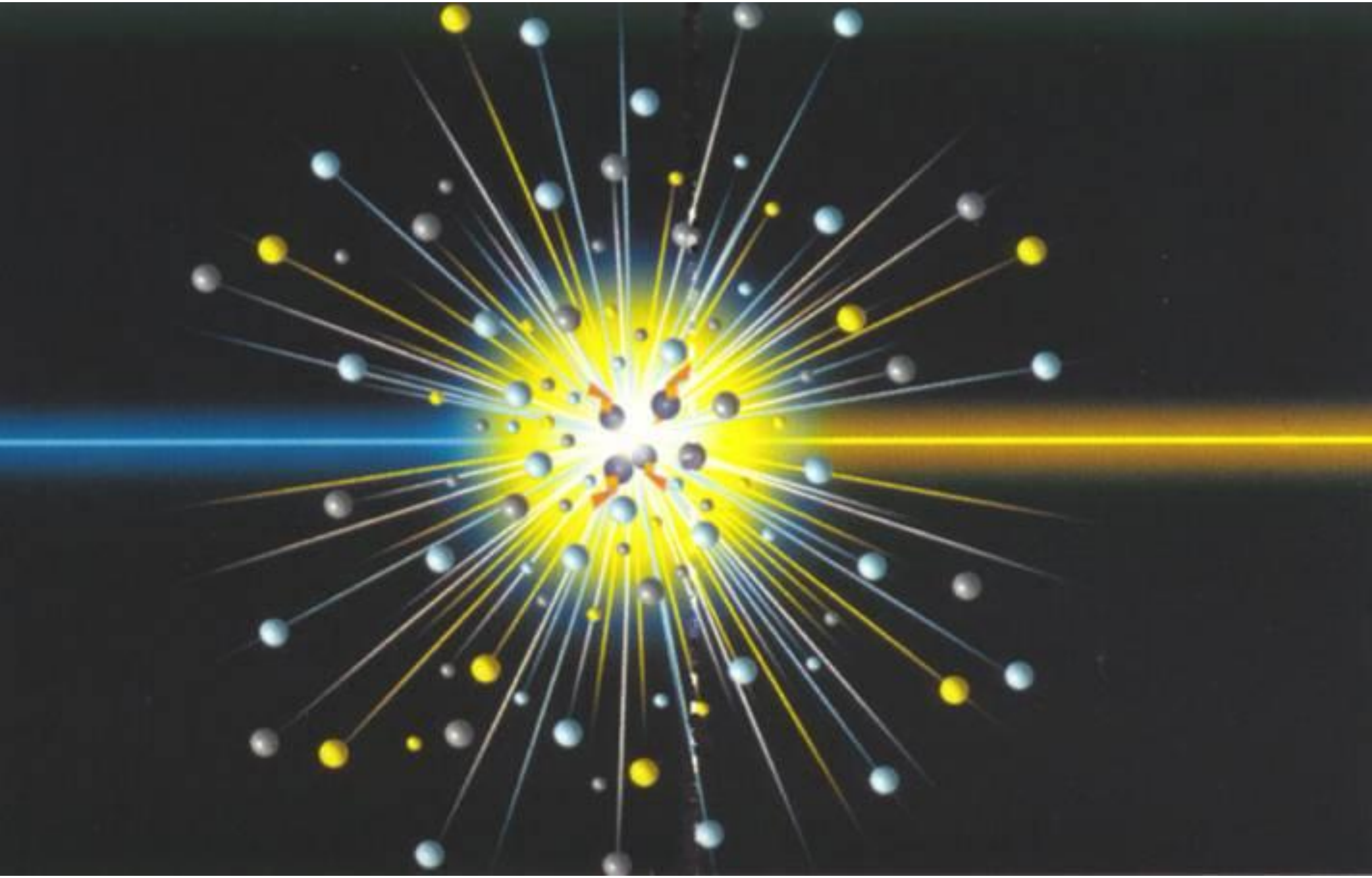


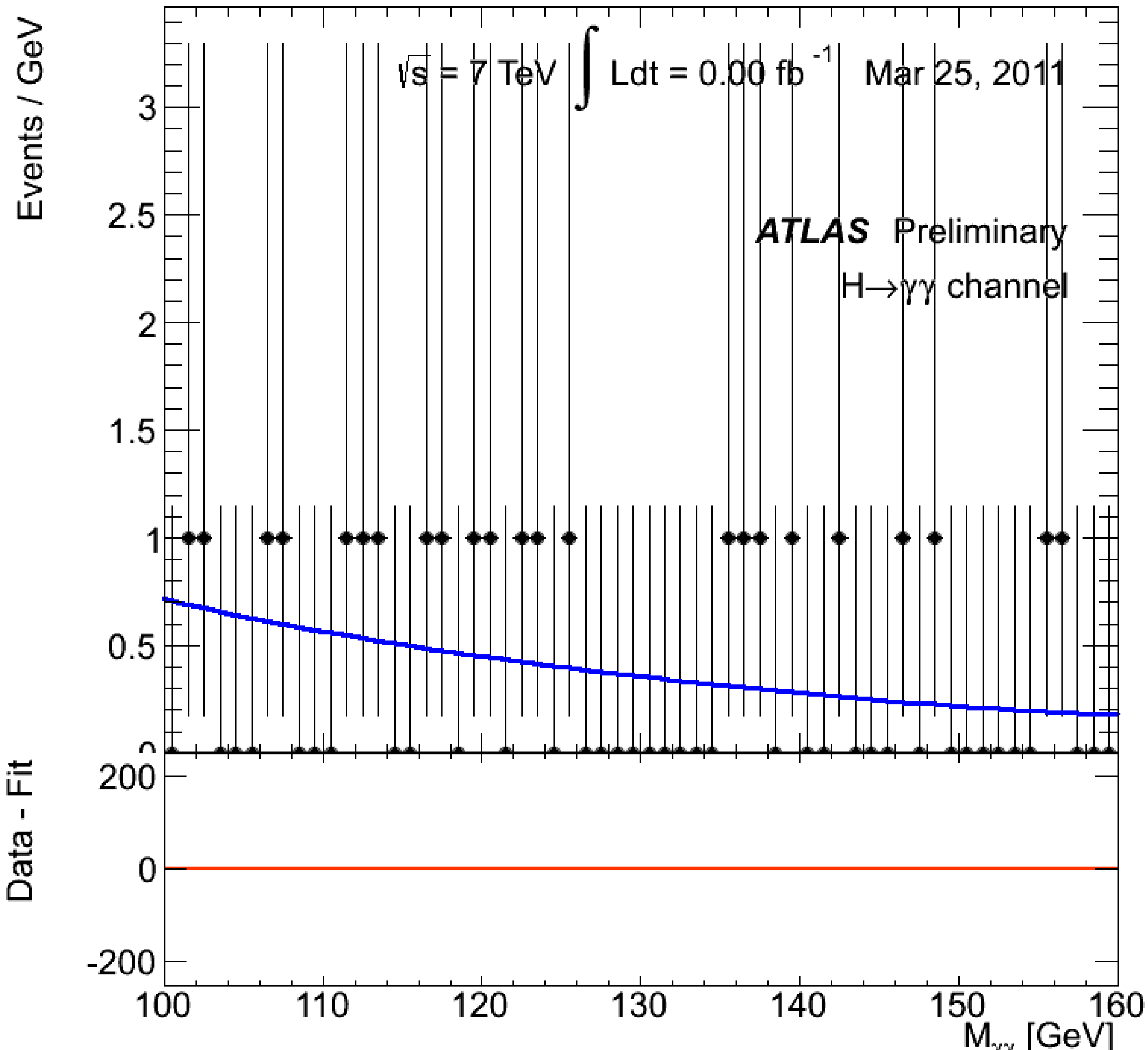




Overall view of the LHC experiments.







√s = 7 TeV ∫ Ldt = 0.00 fb⁻¹ Mar 25, 2011
ATLAS Preliminary
H→γγ channel
Events / GeV
Data - Fit
M_γγ [GeV]

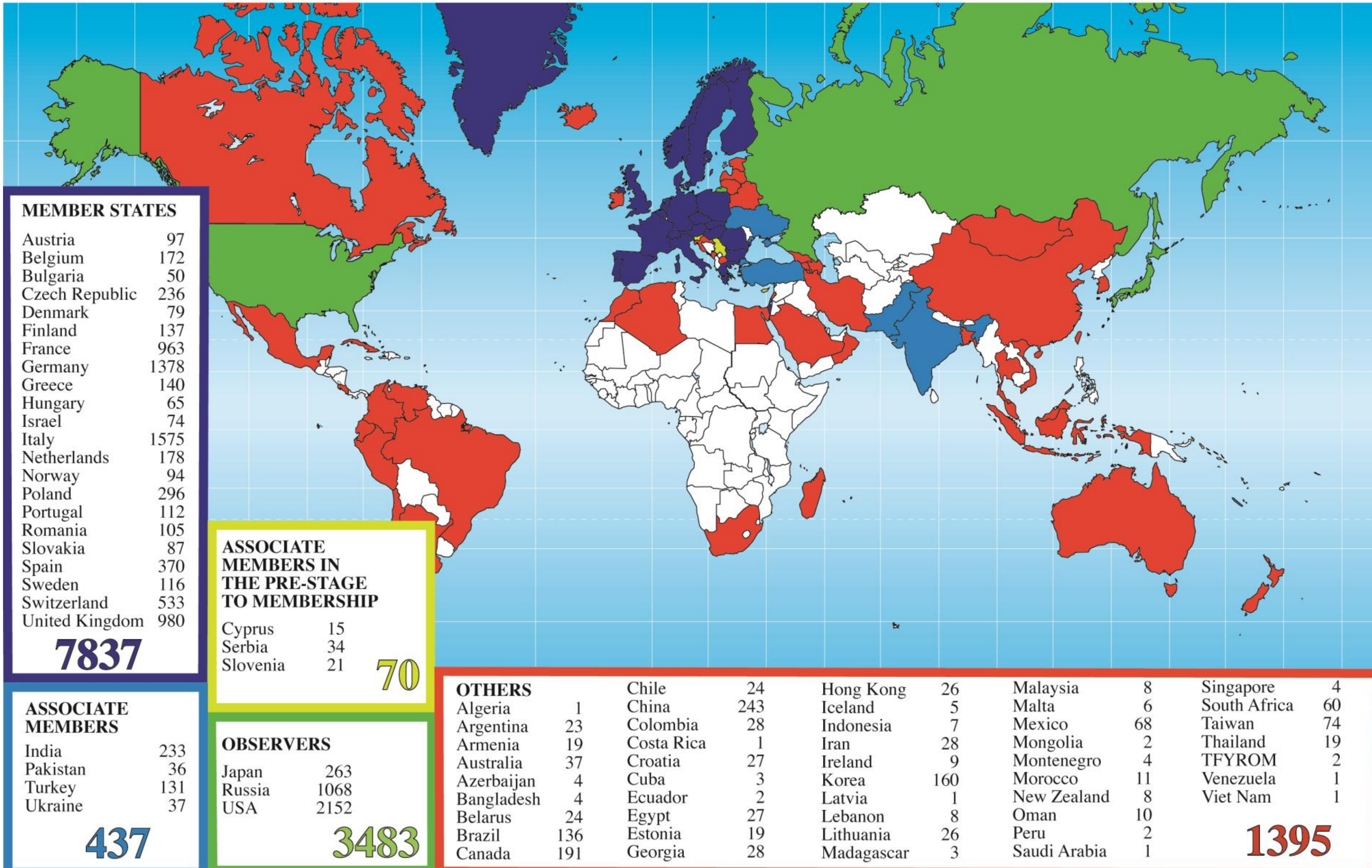

C
D

A GLOBAL PROJECT

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, Brandeis, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, CERN, Chinese Cluster, Chicago, Chile, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, UT Dallas, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, Göttingen, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Irvine UC, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, RUPHE Morocco, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Nagoya, Naples, New Mexico, New York, Nijmegen, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Olomouc, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Ritsumeikan, UFRJ Rio de Janeiro, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, Southern Methodist Dallas, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Toronto, TRIUMF, Tsukuba, Tufts, Udine/ICTP, Uppsala, Urbana UI, Valencia,
UBC Vancouver, Victoria, Washington, Weizmann Rehovot, FH Wiener Neustadt, Wisconsin, Wuppertal, Würzburg, Yale, Yerevan

The project comprises ~4000 people in the collaboration + thousand of industrial relations

Distribution of All CERN Users by Location of Institute on 5 July 2017



MEMBER STATES

Austria	97
Belgium	172
Bulgaria	50
Czech Republic	236
Denmark	79
Finland	137
France	963
Germany	1378
Greece	140
Hungary	65
Israel	74
Italy	1575
Netherlands	178
Norway	94
Poland	296
Portugal	112
Romania	105
Slovakia	87
Spain	370
Sweden	116
Switzerland	533
United Kingdom	980

7837

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP

Cyprus	15
Serbia	34
Slovenia	21

70

ASSOCIATE MEMBERS

India	233
Pakistan	36
Turkey	131
Ukraine	37

437

OBSERVERS

Japan	263
Russia	1068
USA	2152

3483

OTHERS

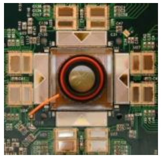
Algeria	1
Argentina	23
Armenia	19
Australia	37
Azerbaijan	4
Bangladesh	4
Belarus	24
Brazil	136
Canada	191
Chile	24
China	243
Colombia	28
Costa Rica	1
Croatia	27
Cuba	3
Ecuador	2
Egypt	27
Estonia	19
Georgia	28
Hong Kong	26
Iceland	5
Indonesia	7
Iran	28
Ireland	9
Korea	160
Latvia	1
Lebanon	8
Lithuania	26
Madagascar	3
Malaysia	8
Malta	6
Mexico	68
Mongolia	2
Montenegro	4
Morocco	11
New Zealand	8
Oman	10
Peru	2
Saudi Arabia	1
Singapore	4
South Africa	60
Taiwan	74
Thailand	19
TFYROM	2
Venezuela	1
Viet Nam	1

1395


JAPAN AIRLINES
JAL
ANA


ATLAS
TECHNICAL PROPOSAL
For a General-Purpose pp Experiment at the Large Hadron Collider at CERN
BARREL TOROID
END CAP TOROIDS
DETECTOR AND PHYSICS PERFORMANCE VOLUME II
DETECTOR AND PHYSICS PERFORMANCE VOLUME I
FIRST-LEVEL TRIGGER
High-Level Trigger Data Acquisition and Controls
TECHNICAL CO-ORDINATION
COMPUTING TECHNICAL DESIGN REPORT
MUON SPECTROMETER
CALORIMETER PERFORMANCE
TILE CALORIMETER
INNER DETECTOR VOLUME 1
INNER DETECTOR VOLUME 2
PIXEL DETECTOR

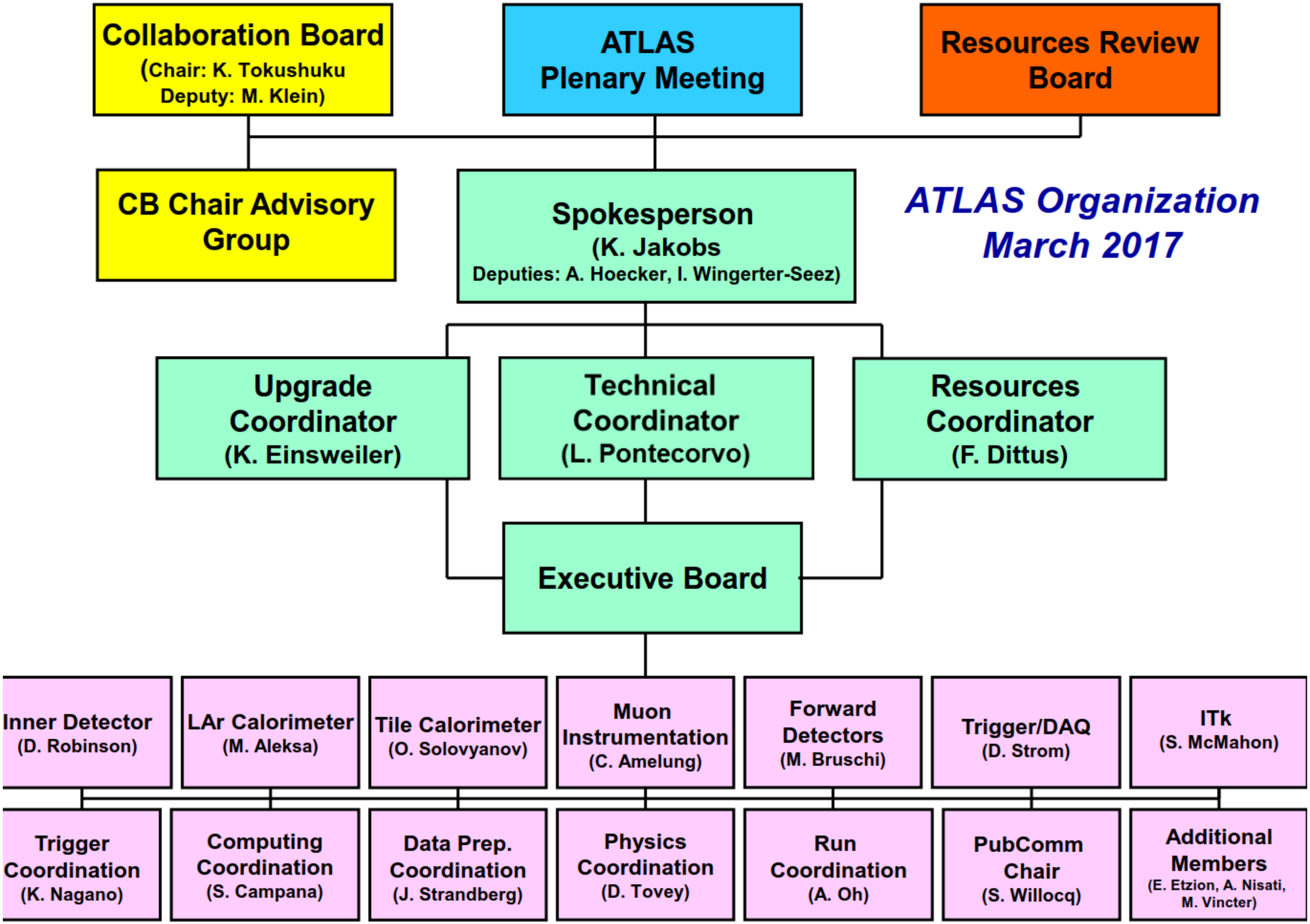
Evolution of Experiments



- Initial (conceptual) project planning started by informal, ad-hoc group(s) of interested scientists in mid 1980’s
- Timeline
  - Late 1980’s: Further R&D was needed to prove feasibility of proposed technical concepts. CERN initiated formal, generic detector R&D projects
  - Early 1990’s: Bottom-up detector proposals; merging into Letters of Intent (LoI, 1992)
  - Mid 1990’s: Technical Proposals (TP,1995); sub-detector prototyping; sub-system Technical Design Reviews (TDRs)
  - Late 1990/Early 2000’s: Approval of Cost Book; signing of MoU; start of detector modules manufacturing (always following a Production Readiness Review PRR and respective TDRs); start of installation at CERN (cavern handed over in 2003)
  - Mid 2000’s: Installation, commissioning of Detectors in the cavern; completed in 2008 for initial runs
- Initial project coordination was implicit and handled by the contact persons for the early proposals. After LoI in 1992, the project coordination was carried out by elected mgmt teams
  - Later on, reporting interactions got defined and set up in the MoU (signed in 1998)

Memorandum of Understanding (MoU)

- The Project Charter is the Memorandum of Understanding (MoU)
- Legally non-binding agreement based on best effort
- Drafted between **CERN** (Host Lab) and **Funding Agencies**, the MoU describes the sharing of detector hardware construction responsibilities and costs
- Relationship between the Host Lab and ATLAS broadly defined
- Fundamental principle of *deliverables* (in-kind contributions)
  - Potluck party
  - Deliverables grouped around **sub-projects**
  - Items not pledged for are pooled centrally, funds collected as “tax”
- The construction cost envelope in 1995 Swiss Francs was 475 MCHF
  - Direct costs, excluding manpower, R&D, institute infrastructure, prototyping, VAT
  - Major exchange rates fixed (e.g. $/CHF=1.1; GBP/CHF =1.8)
  - No centralized budget contingency
  - CERN provides technical infrastructure support, but is also a participating scientific institute
- Project personnel (management, project leaders, coordinators) are elected by the **community**
- Participating institutes have equal voting rights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Group
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(K. Jakobs
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March 2017
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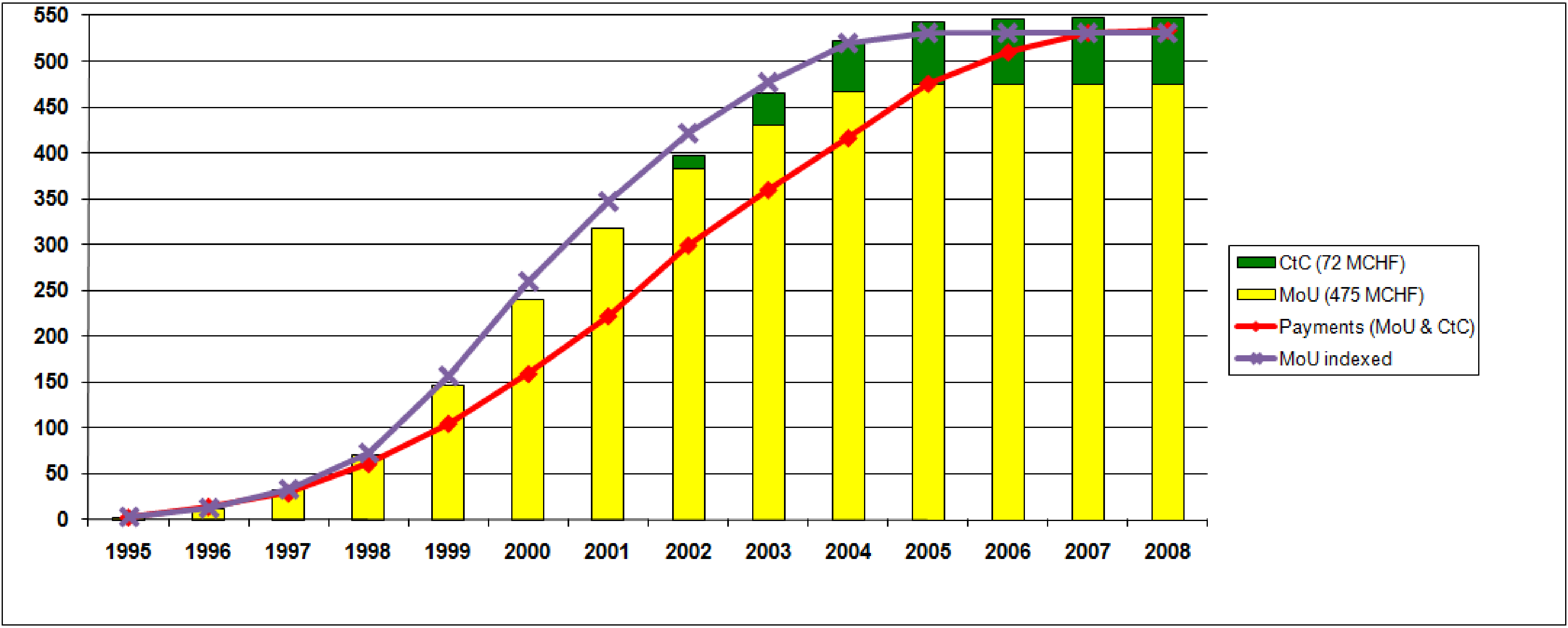
(E. Etzion, A. Nisati,
M. Vincter)

Project Funding at Completion EoY 2008 (ATLAS)



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

ATLAS Collaboration

A R T I C L E I N F O

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ATLAS
LHC
Minimum bias

A B S T R A C T

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 measureme

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. Abreu [114], E. Acerbi [89a,89b], B.S. Acharya [162a,162b]
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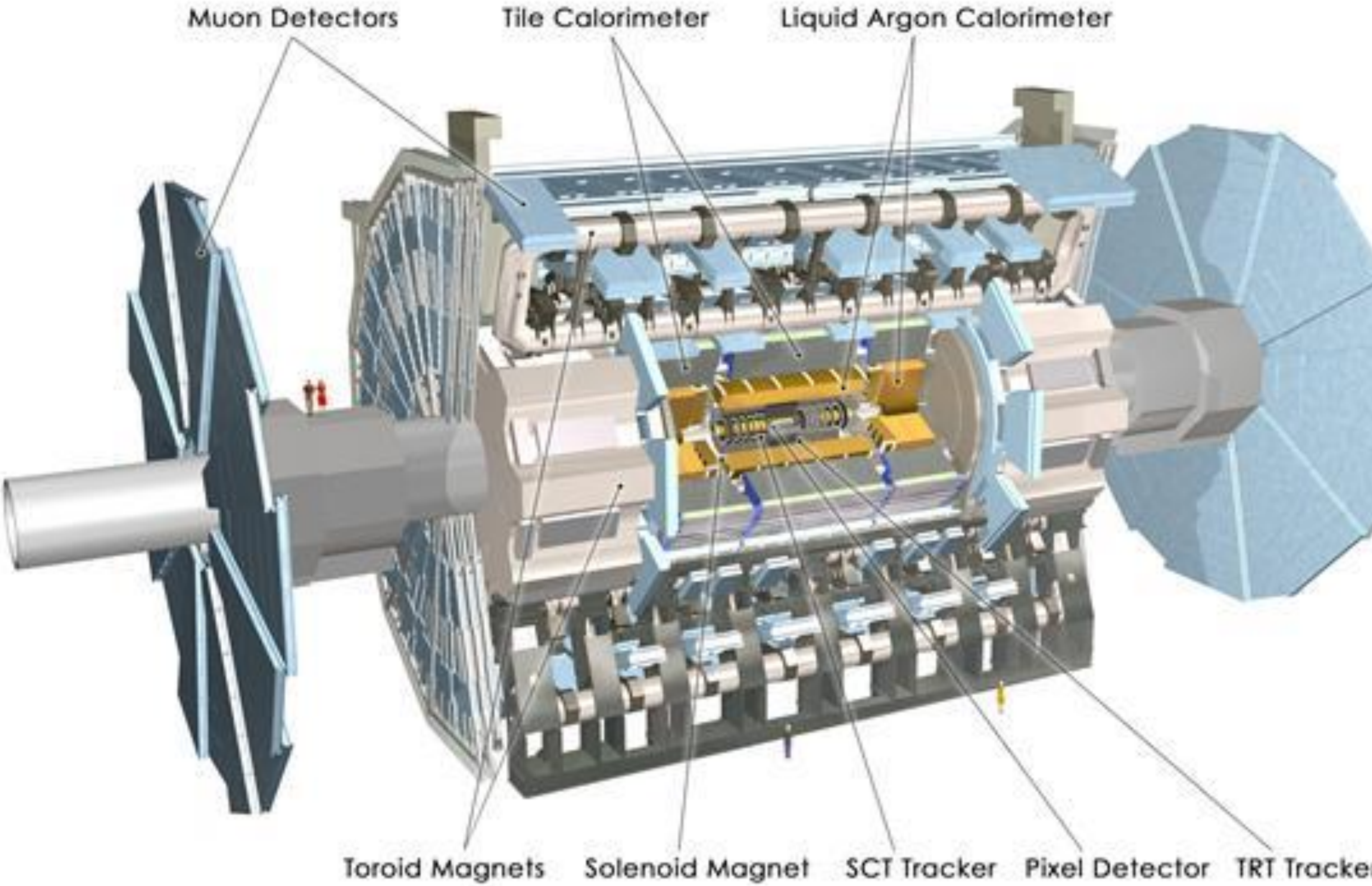
[1] University at Albany, 1400 Washington Ave, Albany, NY 12222, United States
[2] University of Alberta, Department of Physics, Centre for Particle Physics, Edmonton, AB T6G 2G7, Canada
[3] Ankara University[(a)], Faculty of Sciences, Department of Physics, TR 061000 Tandogan, Ankara; Dumlupinar University[(b)], Faculty of Arts and Sciences, Department of Physics, Kutahya; Gazi University[(c)], Faculty of Arts and Sciences, Department of Physics, 06500 Teknikokullar, Ankara; TOBB University of Economics and Technology[(d)], Faculty of Arts and Sciences, Division of Physics, 06560 Sogutozu, Ankara; Turkish Atomic Energy Authority[(e)], 06530 Lodumlu, Ankara, Turkey
[4] LAPP, Université de Savoie, CNRS/IN2P3, Annecy-le-Vieux, France
[5] Argonne National Laboratory, High Energy Physics Division, 9700 S. Cass Avenue, Argonne, IL 60439, United States

[63] University of Iowa, 203 Van Allen Hall, Iowa City, IA 52242-1479, United States
[64] Iowa State University, Department of Physics and Astronomy, Ames High Energy Physics Group, Ames, IA 50011-3160, United States
[65] Joint Institute for Nuclear Research, JINR Dubna, RU-141 980 Moscow Region, Russia
[66] KEK, High Energy Accelerator Research Organization, 1-1 Oho, Tsukuba-shi, Ibaraki-ken 305-0801, Japan
[67] Kobe University, Graduate School of Science, 1-1 Rokkodai-cho, Nada-ku, JP - Kobe 657-8501, Japan
[68] Kyoto University, Faculty of Science, Oiwake-cho, Kitashirakawa, Sakyou-ku, Kyoto-shi, JP - Kyoto 606-8502, Japan
[69] Kyoto University of Education, 1 Fukakusa, Fujimori, fushimi-ku, Kyoto-shi, JP - Kyoto 612-8522, Japan
[70] Universidad Nacional de La Plata, FCE, Departamento de Física, IFLP (CONICET-UNLP), C.C. 67, 1900 La Plata, Argentina

[138] University of Sheffield, Department of Physics & Astronomy, Hounsfield Road, Sheffield S3 7RH, United Kingdom
[139] Shinshu University, Department of Physics, Faculty of Science, 3-1-1 Asahi, Matsumoto-shi, JP - Nagano 390-8621, Japan
[140] Universität Siegen, Fachbereich Physik, D-57068 Siegen, Germany
[141] Simon Fraser University, Department of Physics, 8888 University Drive, CA - Burnaby, BC V5A 1S6, Canada
[142] SLAC National Accelerator Laboratory, Stanford, CA 94309, United States
[143] Comenius University, Faculty of Mathematics, Physics & Informatics[(a)], Mlynska dolina F2, SK-84248 Bratislava; Institute of Experimental Physics of the Slovak Academy of Sciences, Dept. of Subnuclear Physics[(b)], Watsonova 47, SK-04353 Kosice, Slovak Republic
[144] Stockholm University, Department of Physics[(a)]; The Oskar Klein Centre[(b)], AlbaNova, SE-106 91 Stockholm, Sweden
[145] Royal Institute of Technology (KTH), Physics Department, SE-106 91 Stockholm, Sweden
[146] Stony Brook University, Department of Physics and Astronomy, Nicolls Road, Stony Brook, NY 11794-3800, United States
[147] University of Sussex, Department of Physics and Astronomy, Pevensey 2 Building, Falmer, Brighton BN1 9QH, United Kingdom
[148] University of Sydney, School of Physics, AU - Sydney NSW 2006, Australia
[149] Insitute of Physics, Academia Sinica, TW - Taipei 11529, Taiwan
[150] Technion, Israel Inst. of Technology, Department of Physics, Technion City, IL - Haifa 32000, Israel
[151] Tel Aviv University, Raymond and Beverly Sackler School of Physics and Astronomy, Ramat Aviv, IL - Tel Aviv 69978, Israel
[152] Aristotle University of Thessaloniki, Faculty of Science, Department of Physics, Division of Nuclear & Particle Physics, University Campus, GR-54124 Thessaloniki, Greece
[153] The University of Tokyo, International Center for Elementary Particle Physics and Department of Physics, 7-3-1 Hongo, Bunkyo-ku, JP - Tokyo 113-0033, Japan
[154] Tokyo Metropolitan University, Graduate School of Science and Technology, 1-1 Minami-Osawa, Hachioji, Tokyo 192-0397, Japan
[155] Tokyo Institute of Technology, 2-12-1-H-34 O-Okayama, Meguro, Tokyo 152-8551, Japan
[156] University of Toronto, Department of Physics, 60 Saint George Street, Toronto M5S 1A7, Ontario, Canada
[157] TRIUMF[(a)], 4004 Wesbrook Mall, Vancouver, B.C. V6T 2A3; York University[(b)], Department of Physics and Astronomy, 4700 Keele St., Toronto, Ontario, M3J 1P3, Canada
[158] University of Tsukuba, Institute of Pure and Applied Sciences, 1-1-1 Tennoudai, Tsukuba-shi, JP - Ibaraki 305-8571, Japan
[159] Tufts University, Science & Technology Center, 4 Colby Street, Medford, MA 02155, United States
[160] Universidad Antonio Narino, Centro de Investigaciones, Cra 3 Este No.47A-15, Bogota, Colombia
[161] University of California, Irvine, Department of Physics & Astronomy, CA 92697-4575, United States
[162] INFN Gruppo Collegato di Udine[(a)]; ICTP[(b)], Strada Costiera 11, IT-34014 Trieste; Università di Udine, Dipartimento di Fisica[(c)], via delle Scienze 208, IT-33100 Udine, Italy
[163] University of Illinois, Department of Physics, 1110 West Green Street, Urbana, IL 61801, United States
[164] University of Uppsala, Department of Physics and Astronomy, P.O. Box 516, SE-751 20 Uppsala, Sweden
[165] Instituto de Física Corpuscular (IFIC), Centro Mixto UVEG-CSIC, Apdo. 22085 ES-46071 Valencia, Dept. Física At. Mol. y Nuclear, Univ. of Valencia, and Instituto de Microelectrónica de Barcelona (IMB-CNM-CSIC), 08193 Bellaterra Barcelona, Spain
[166] University of British Columbia, Department of Physics, 6224 Agricultural Road, CA - Vancouver, B.C. V6T 1Z1, Canada
[167] University of Victoria, Department of Physics and Astronomy, P.O. Box 3055, Victoria B.C., V8W 3P6, Canada
[168] Waseda University, WISE, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555, Japan
[169] The Weizmann Institute of Science, Department of Particle Physics, P.O. Box 26, IL 76100, Rehovot, Israel
[170] University of Wisconsin, Department of Physics, 1150 University Avenue, Madison, WI 53706, United States
[171] Julius-Maximilians-University of Würzburg, Physikalisches Institute, Am Hubland, 97074 Würzburg, Germany
[172] Bergische Universität, Fachbereich C, Physik, Postfach 100127, Gauss-Strasse 20, D-42097 Wuppertal, Germany
[173] Yale University, Department of Physics, P.O. Box 208121, New Haven, CT 06520-8121, United States
[174] Yerevan Physics Institute, Alikhanian Brothers Street 2, AM-375036 Yerevan, Armenia
[175] ATLAS-Canada Tier-1 Data Centre 4004 Wesbrook Mall, Vancouver, BC, V6T 2A3, Canada
[176] GridKA Tier-1 FZK, Forschungszentrum Karlsruhe GmbH, Steinbuch Centre for Computing (SCC), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany
[177] Port d'Informacio Cientifica (PIC), Universitat Autonoma de Barcelona (UAB), Edifici D, E-08193 Bellaterra, Spain
[178] Centre de Calcul CNRS/IN2P3, Domaine scientifique de la Doua, 27 bd du 11 Novembre 1918, 69622 Villeurbanne Cedex, France
[179] INFN-CNAF, Viale Berti Pichat 6/2, 40127 Bologna, Italy
[180] Nordic Data Grid Facility, NORDUnet A/S, Kastruplundgade 22, 1, DK-2770 Kastrup, Denmark
[181] SARA Reken- en Netwerkdiensten, Science Park 121, 1098 XG Amsterdam, Netherlands
[182] Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, No.128, Sec. 2, Academia Rd., Nankang, Taipei, Taiwan 11529, Taiwan
[183] UK-T1-RAL Tier-1, Rutherford Appleton Laboratory, Science and Technology Facilities Council, Harwell Science and Innovation Campus, Didcot OX11 0QX, United Kingdom
[184] RHIC and ATLAS Computing Facility, Physics Department, Building 510, Brookhaven National Laboratory, Upton, NY 11973, United States

[a] Present address FermiLab, United States.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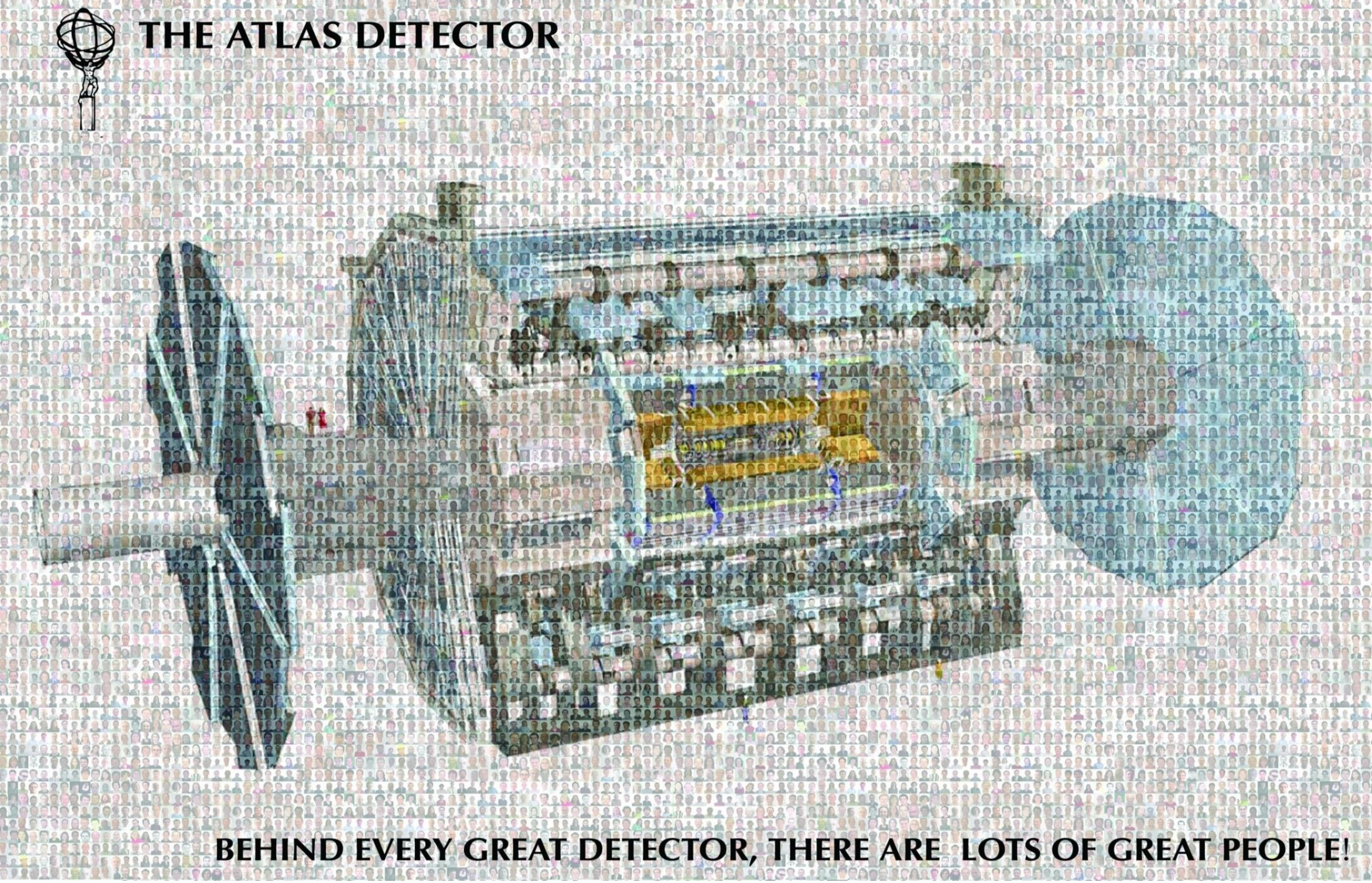
Tile Calorimeter
Liquid Argon Calorimeter
Toroid Magnets
Solenoid Magnet
SCT Tracker
Pixel Detector
TRT Tracker


THE ATLAS DETECTOR
BEHIND EVERY GREAT DETECTOR, THERE ARE LOTS OF GREAT PEOPLE!


1. Vision
2. Commitment
3. Tolerance

1. Vision

2. Commitment

3. Tolerance

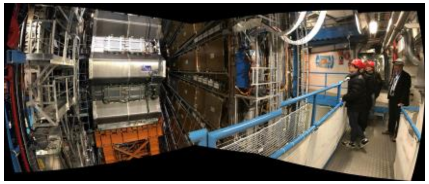
Communitarian Bonds

- Shared Vision
  - One common aim of “Out of this world” discoveries; such as the Higgs
  - Better understanding of the fundamental forces and particle (Big Bang)
- Shared Commitment
  - Passion to “Can-do”
  - Members of Collaborations prepared to solve the encountered technological (and human) challenges
  - Willingness to accept also less glorious tasks for the common good
  - Some have been working for LHC Experiments since mid 1980s…
  - Trust in colleagues fulfilling their commitments (MoU)
- Shared Tolerance
  - Willingness to work together, irrespective of geographical location or language barriers
  - Willingness to share information
  - Principle of “Raw Diamond”

Simple Micro Rules

- Allow people to dream (5% makes already a difference)
- Tolerate diversity
- Let the physics decide, not the hierarchy
- Collaborate and compete
- Question and justify – Respect the Dukes of Doubt rather than Kings of Truth

Simple Macro Rules (2)



- Set up Collaboration structures that respect individual freedom and which do not impose formal authority
- Elect leaders based on technical competence, credibility and trust rather than ego and authority
- Allow ad-hoc expert teams to emerge and quickly respond to encountered scientific and technical hurdles
- Keep everyone on board, give everyone a voice
- Set up peer review processes and arbitration mechanisms

Cultures of Experiments

- There are several underlying sub-cultures in LHC Experiments
  - Physics culture versus Engineering culture
  - Hardware oriented culture versus software/computing etc.
  - Sub-system cultures (e.g in ATLAS,. ”LAr 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 (ca 40 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 starts

How are (tough) decisions made?

- Consensus-driven approach
- Bottom-up approach, in consultation with Experiment management
  - Management can’t dictate, instead coordinates and steers the process
- Keep everyone on board!
- “Factorize” the encountered problems as much as possible
- Working groups come up with alternative solutions, they select and propose the most suitable one
- Leave tough decisions to the last possible moment (without compromising the schedule)
- Collaboration Board approves collaboration actions (one institute, one vote)
- Financial matters approved in the Resources Review Board
  - But I do not recall in ATLAS over 12 years no voting

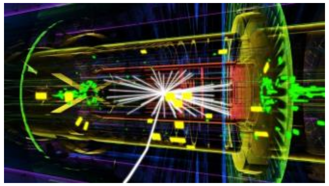
Monitoring and Information Systems

- Collection, recording and reporting of Project performance and progress information
  - Information is regularly collected from the sub-system project leaders for Project stakeholders: Collaboration Board, Executive Board, CERN Mgmt, Research Review Board
- Collected information is submitted to different informatics tools (e.g. EDMS, PPT, CDS, EUCLID/CATIA, OTP, other web-based reporting tools)
- Experiment Mgmt reviews the collected data and summarizes it for reporting
  - Schedule issues, technical performance issues,
  - Organization issues, financial issues
  - Science policies, Project personnel nominations, budgets
  - Project progress, milestones met, encountered technical issues (excluding resources)
  - All resources related matters; project status reports

How to keep members informed and involved?

- Roughly 1 000 members of e.g. ATLAS Collaboration are physically at CERN at any given moment
- How then do we keep the other 2000 – 3000 members informed and involved?
  - Broadcasting of regular weekly common meetings
  - Working groups use Collaborative tools (videoconferencing)
  - Collaboration Weeks ~ 4 times a year
  - Collaboration Board meetings ~ 4 times a year
  - Many email-groups

Anything to Learn From?



- Lessons learned?
  - It can be done ☺
  - But not necessarily best solution for more conventional projects
- What should be changed or improved (for the future)?
  - Handling of contingency
  - Sharing of responsibilities (better mechanisms to ensure deliverables)
- Can it be replicated?
  - Sure; for next generation physics experiments (and not only HEP)…
  - Projects around eScience have similar characteristics (see next slide)
  - Open science/innovation models
  - Industrial R&D management models (laissez-faire)?

Enabling Grids for E-sciencE

LCG

Open Science Grid

ıning = 10525

eScience Infrastructure ingredients

People & Training & skills

e-Libraries Archives/Curation centres

Computers, Comp. aided services

Multidisciplinary Collaborations:
Common objectives
Open sharing
Critical mass
Trust and respect
Declaration of best efforts
Quality Assurance
Service-oriented

Large Data Repositories

interoperable open Software

Communication means

Facilities, Instruments & services

Networks

Courtesy: H F Hoffmann, CERN

09:25:20 UTC

GridPP
UK Computing for Particle Physics

Conclusions

- LHC Experiments are large scientific projects that can be described as
  - Complex
  - Global
  - Culturally diverse
  - Shared vision, commitment and tolerance
  - Efforts made to hear the individual
- They are not managed like a corporation
- Instead,
  - Run by self-managed individuals and teams
  - Have a Spokesperson, not a CEO
  - Guided by engagement, discussions, trial & trust, and justification rather than hierarchical powers or ex-ante directives
  - A challenge for coordination …
- So *what* is it?
  - Your comments and views would be much appreciated!