How do Large Collaborations Work? Why?

LHC-ATLAS as an Example

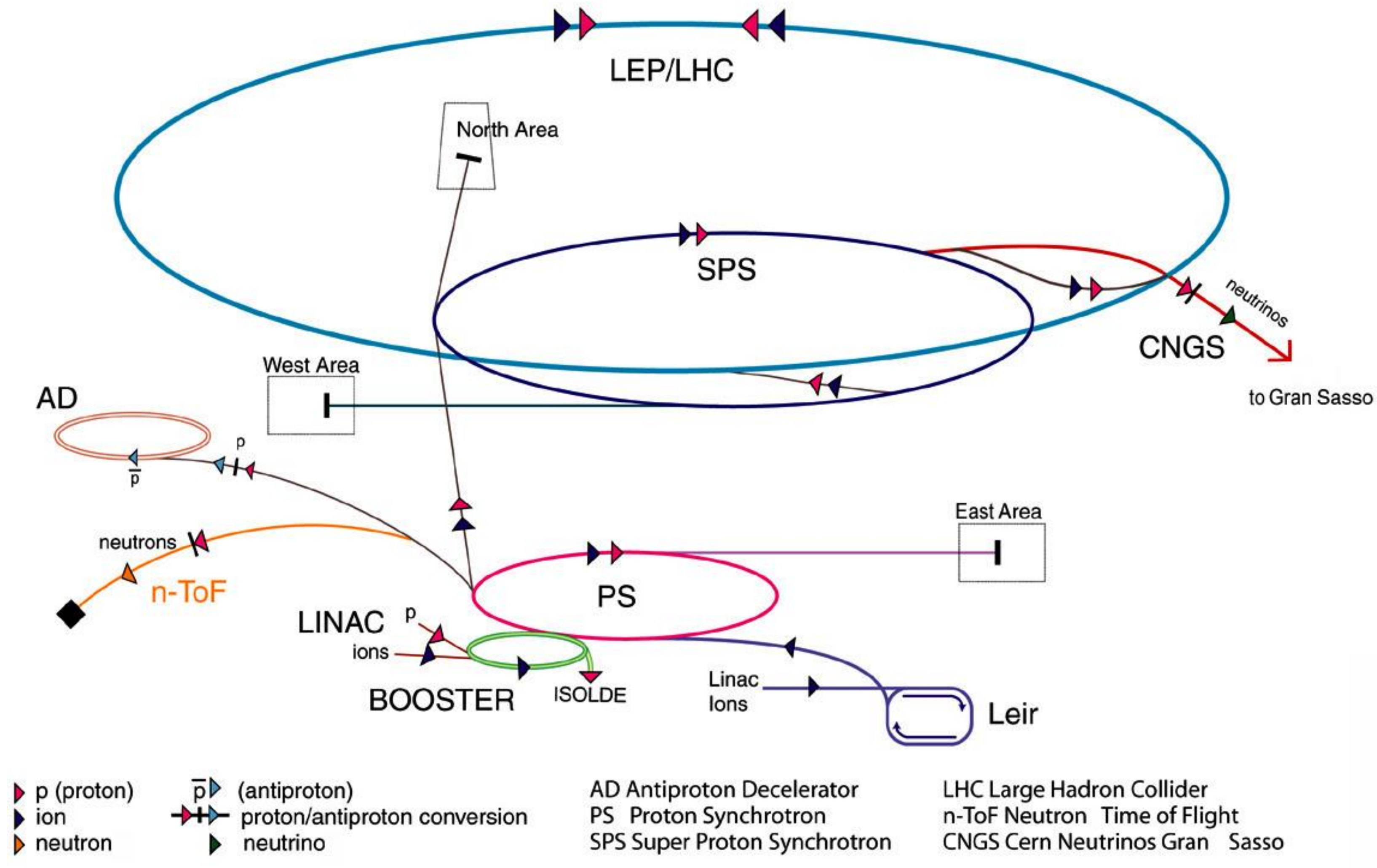
Austrian Chamber of Commerce Workshop

October 18, 2022

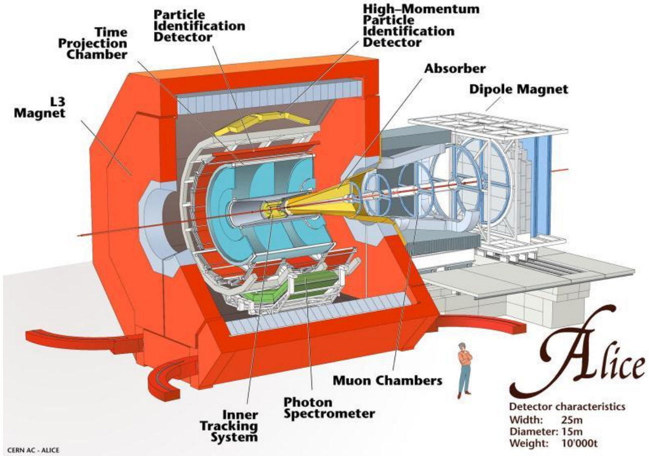
Markus Nordberg, Head of Resources Development

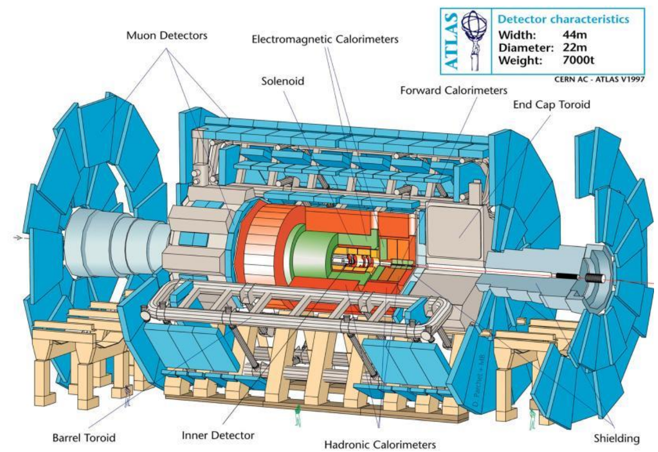
Development and Innovation Unit (IPT-DI)

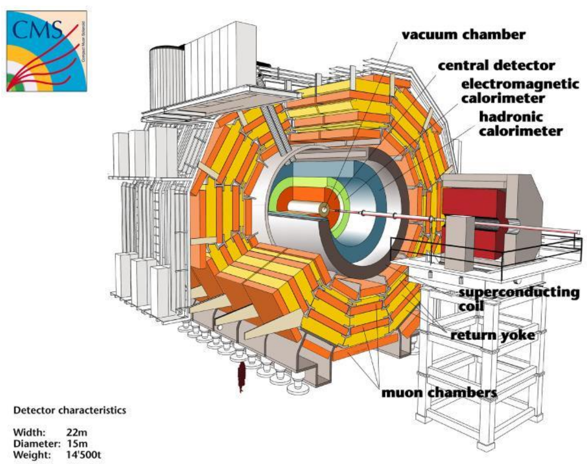
Accelerator chain at CERN, a complex business

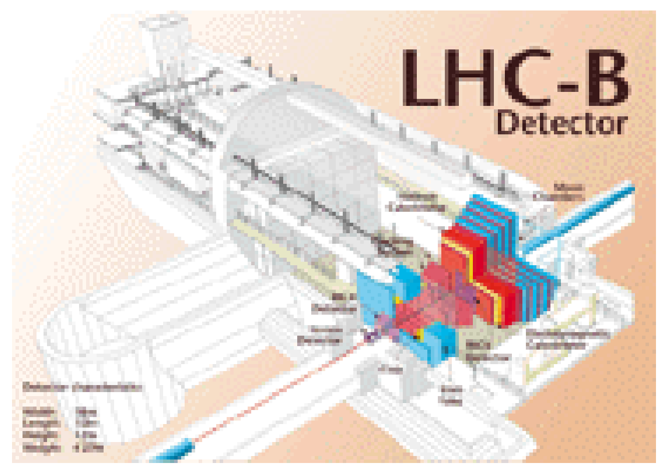


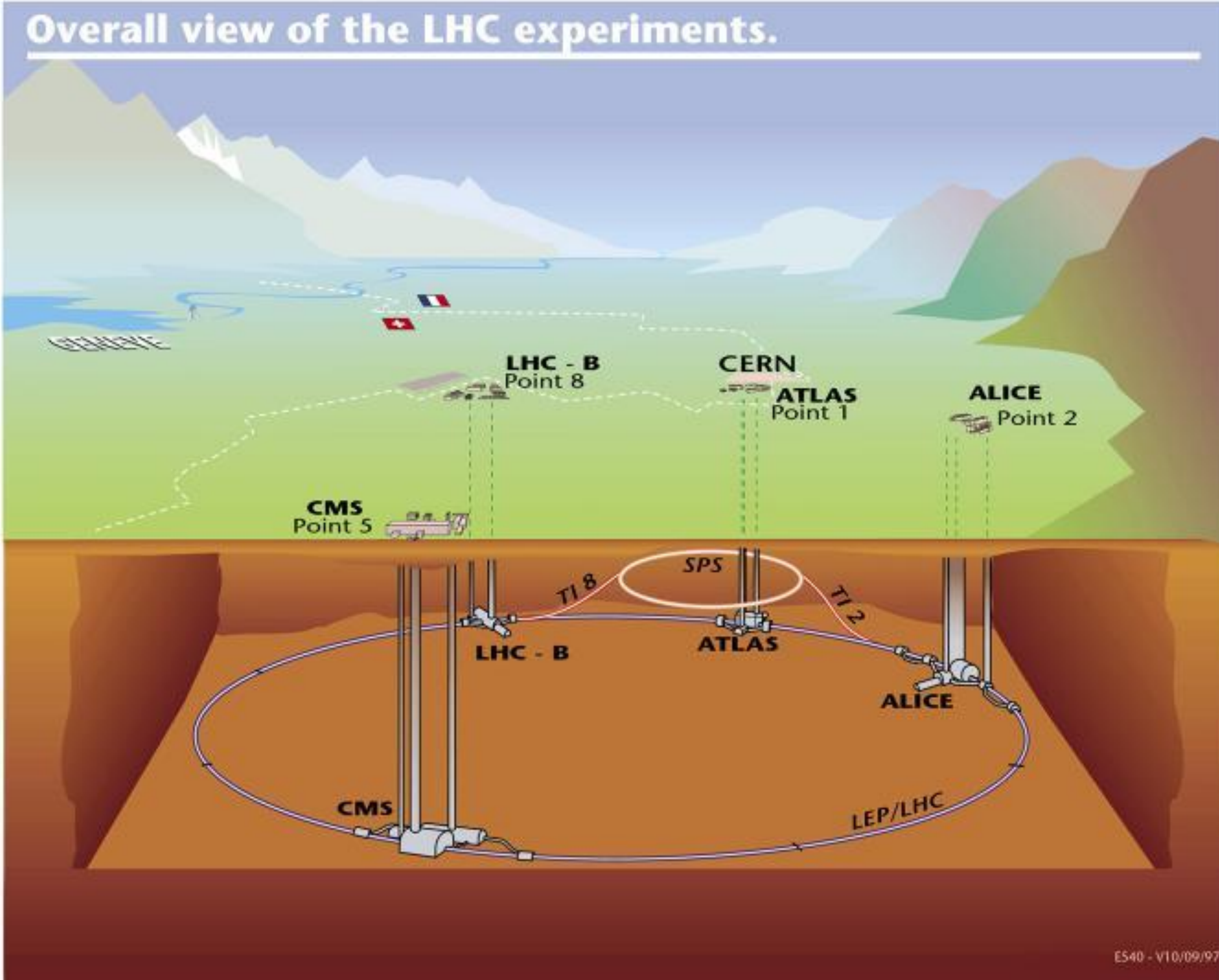
LHC Experiments

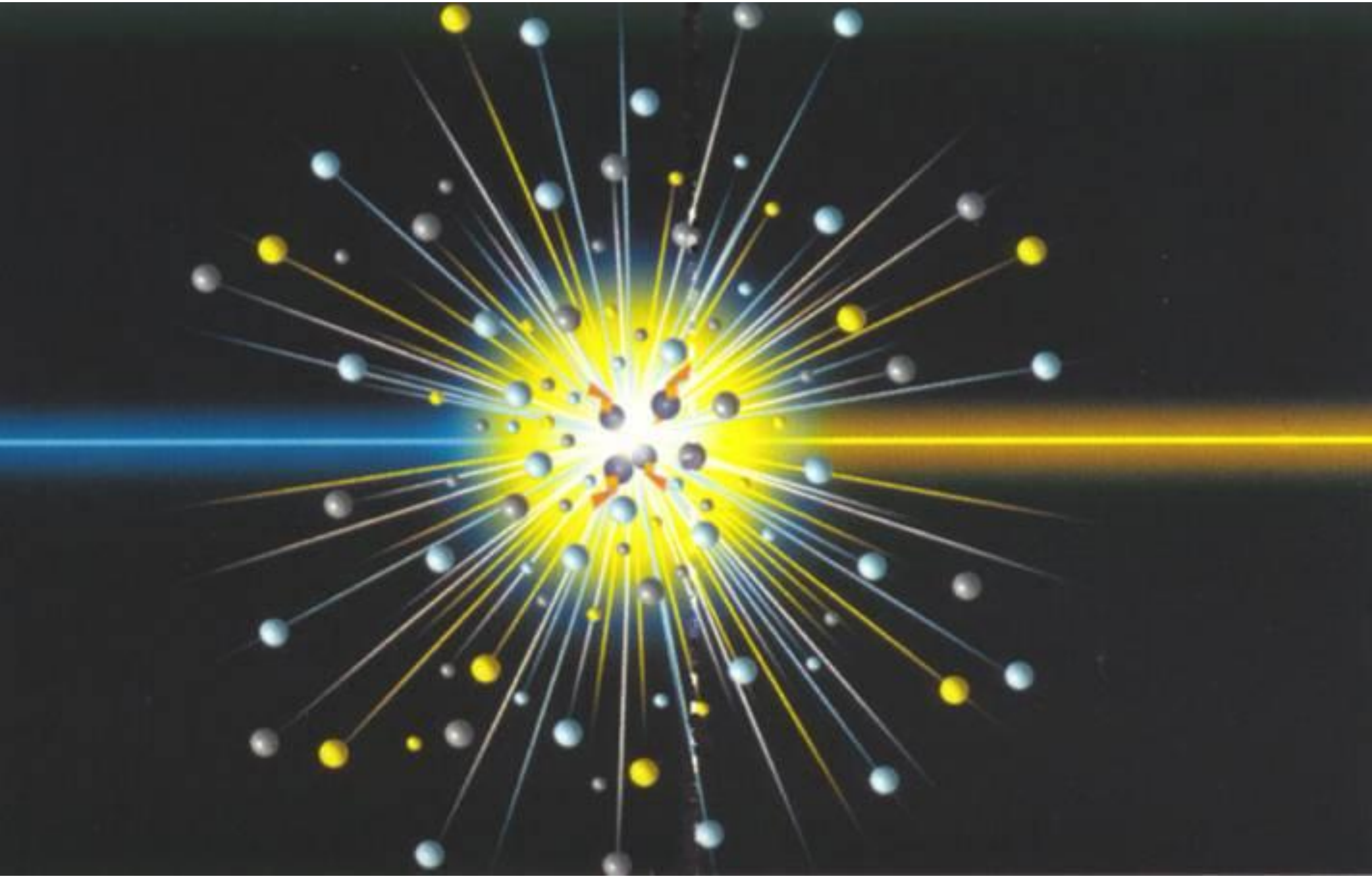


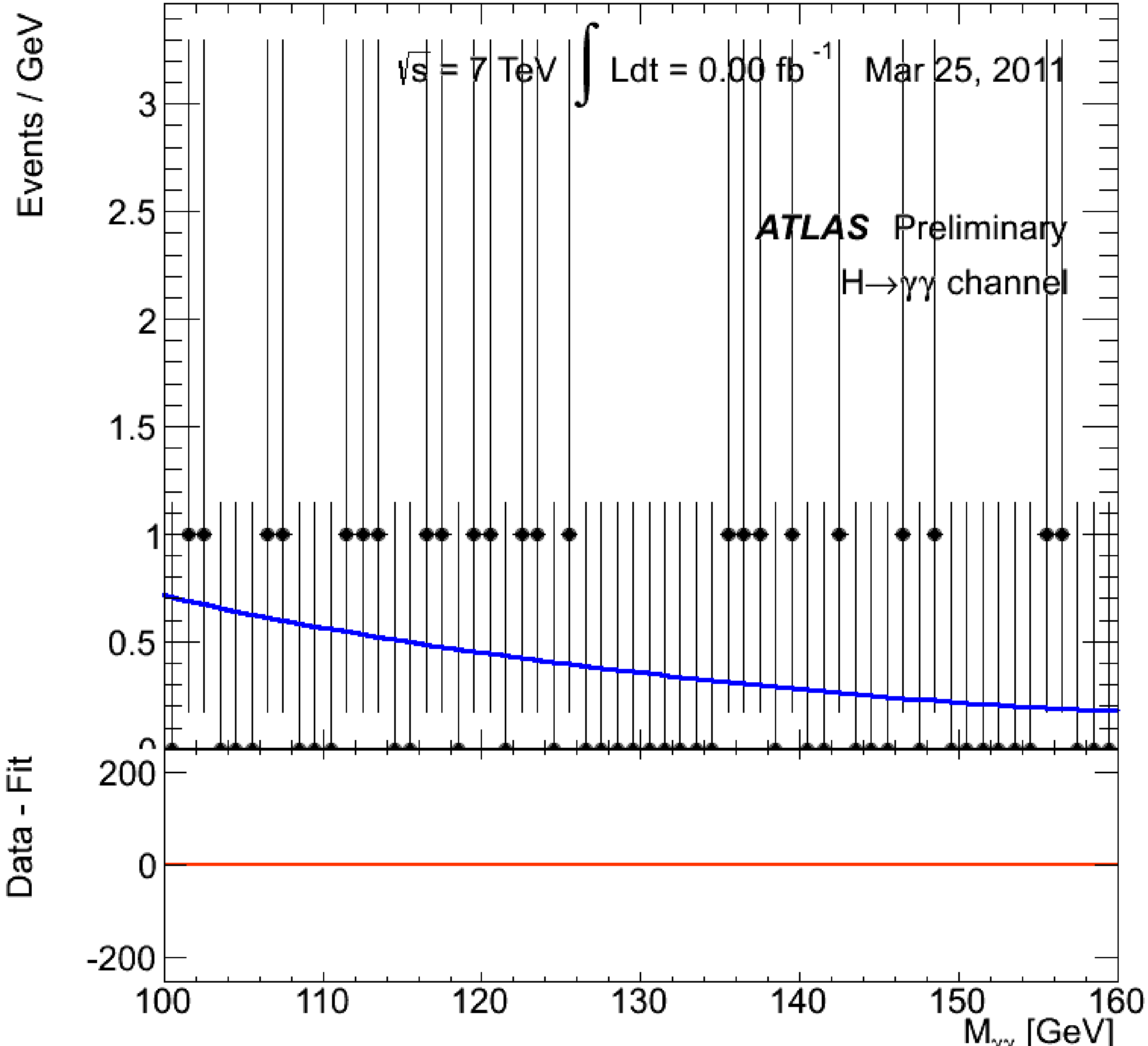







Overall view of the LHC experiments.
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC
E540 - V10/09/97





√s = 7 TeV ∫ Ldt = 0.00 fb -1 Mar 25, 2011
ATLAS Preliminary
H→γγ channel
Events / GeV
3
2.5
2
1.5
1
0.5
0
Data - Fit
200
0
-200
100
110
120
130
140
150
160
Mγγ [GeV]

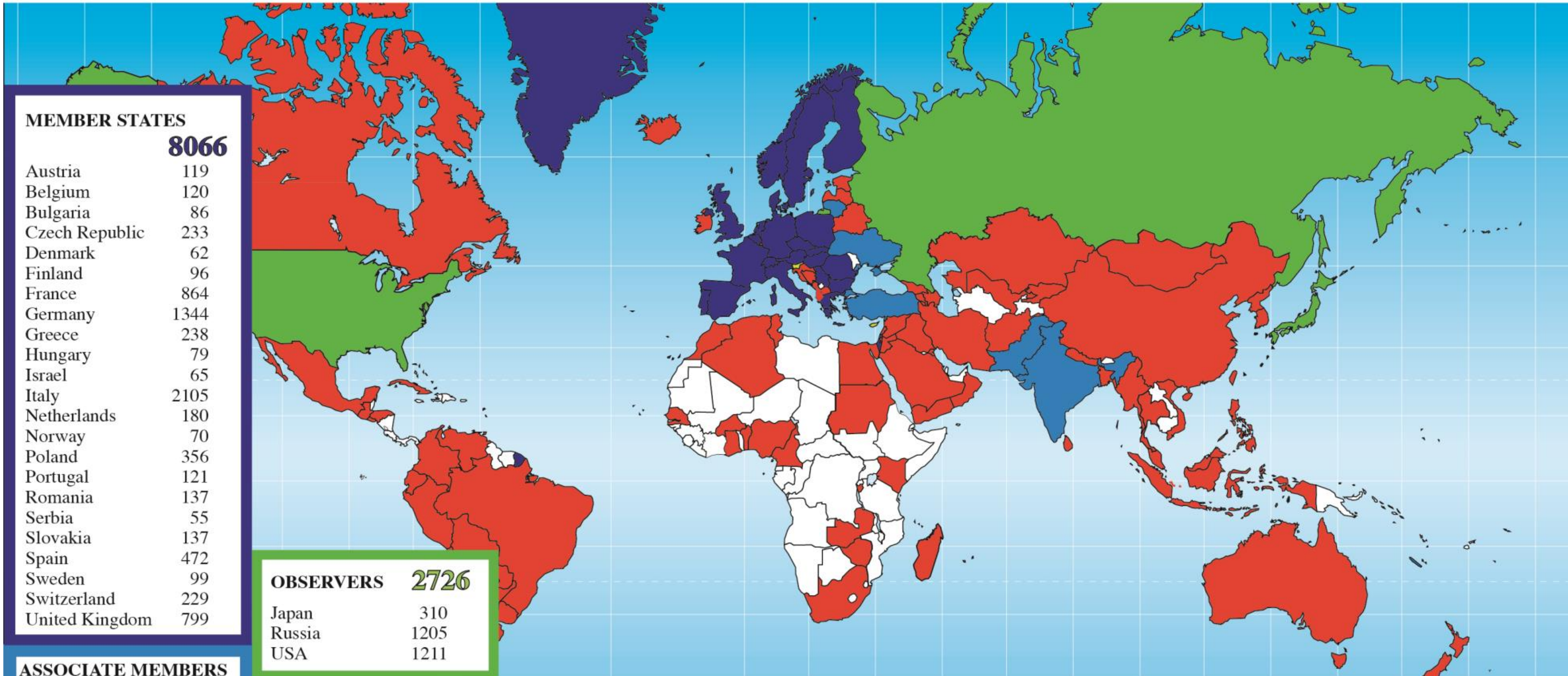

C
D

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 Nationality as of mid-April 2019



MEMBER STATES **8066**

Austria	119
Belgium	120
Bulgaria	86
Czech Republic	233
Denmark	62
Finland	96
France	864
Germany	1344
Greece	238
Hungary	79
Israel	65
Italy	2105
Netherlands	180
Norway	70
Poland	356
Portugal	121
Romania	137
Serbia	55
Slovakia	137
Spain	472
Sweden	99
Switzerland	229
United Kingdom	799

OBSERVERS **2726**

Japan	310
Russia	1205
USA	1211

ASSOCIATE MEMBERS **778**

India	387
Lithuania	39
Pakistan	71
Turkey	165
Ukraine	116

ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP **59**

Cyprus	26
Slovenia	33

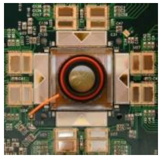
OTHERS **1999**

Albania	4
Algeria	14
Argentina	26
Armenia	22
Australia	36
Azerbaijan	10
Bahrain	1
Bangladesh	8
Belarus	45
Benin	1
Bolivia	3
Bosnia & Herzegovina	3
Brazil	127
Burkina Faso	1
Burundi	1
Cameroon	1
Canada	170
Chile	21
China	576
Colombia	44
Croatia	50
Cuba	16
Ecuador	10
Egypt	27
El Salvador	1
Estonia	15
Georgia	51
Ghana	1
Guatemala	1
Hong Kong	1
Honduras	1
Iceland	4
Indonesia	11
Iran	58
Iraq	1
Ireland	13
Jordan	2
Kazakhstan	10
Kenya	1
Korea	183
Kyrgyzstan	1
Latvia	4
Lebanon	27
Luxembourg	4
Madagascar	1
Malaysia	22
Malta	9
Mexico	85
Mongolia	2
Montenegro	11
Morocco	24
Myanmar	2
Nepal	7
New Zealand	5
Nigeria	4
North Korea	4
North Macedonia	3
Oman	3
Palestine	7
Paraguay	1
Peru	6
Philippines	3
Saint Kitts and Nevis	1
San Marino	1
Saudi Arabia	4
Senegal	1
Singapore	5
South Africa	56
Sri Lanka	10
Sudan	1
Syria	1
Taiwan	56
Thailand	26
Tunisia	4
Uruguay	1
Uzbekistan	3
Venezuela	9
Viet Nam	11
Zambia	1
Zimbabwe	2


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

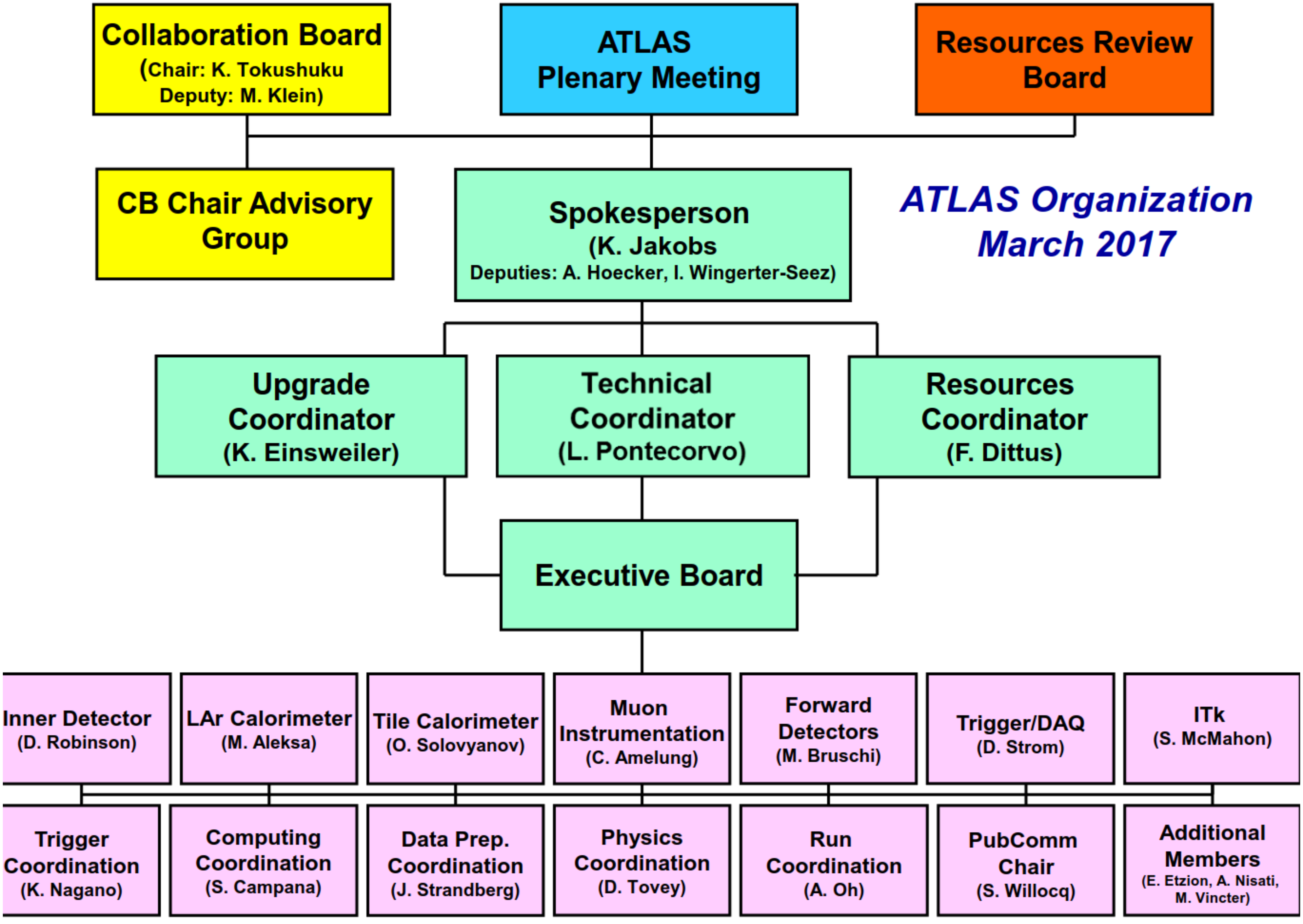
Evolution of Experiments

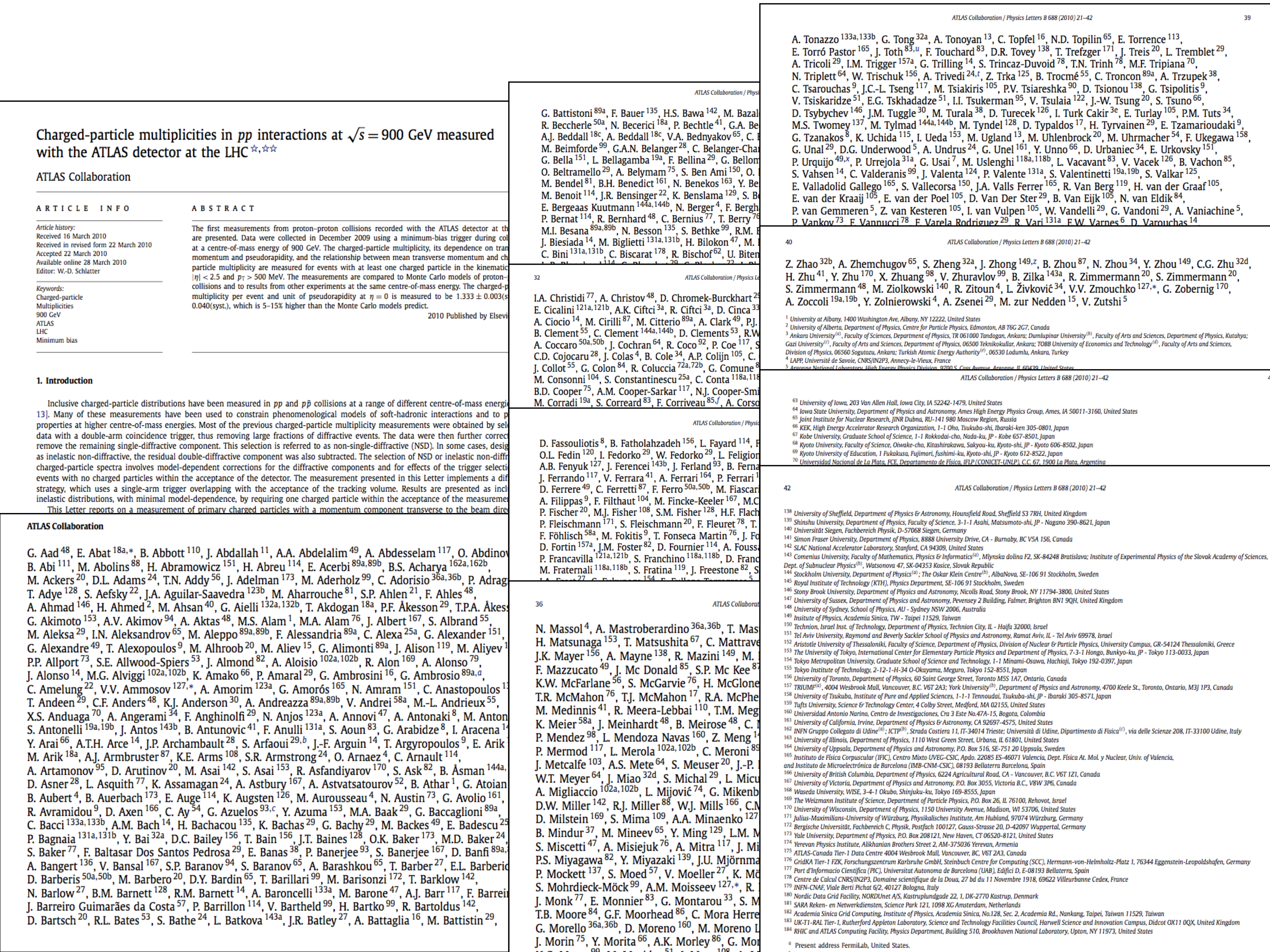


- Initial (conceptual) project planning started by informal, ad-hoc group(s) of interested scientists in mid 1980’s
- Timeline
  - Late 1980’s: Further R&D was needed to prove feasibility of proposed technical concepts. CERN initiated formal, generic detector R&D projects
  - Early 1990’s: Bottom-up 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


Collaboration Board
(Chair: K. Tokushuku
Deputy: M. Klein)
ATLAS
Plenary Meeting
Resources Review
Board
CB Chair Advisory
Group
Spokesperson
(K. Jakobs
Deputies: A. Hoecker, I. Wingerter-Seez)
ATLAS Organization
March 2017
Upgrade
Coordinator
(K. Einsweiler)
Technical
Coordinator
(L. Pontecorvo)
Resources
Coordinator
(F. Dittus)
Executive Board
Inner Detector
(D. Robinson)
LAr Calorimeter
(M. Aleksa)
Tile Calorimeter
(O. Solovyanov)
Muon
Instrumentation
(C. Amelung)
Forward
Detectors
(M. Bruschi)
Trigger/DAQ
(D. Strom)
ITk
(S. McMahon)
Trigger
Coordination
(K. Nagano)
Computing
Coordination
(S. Campana)
Data Prep.
Coordination
(J. Strandberg)
Physics
Coordination
(D. Tovey)
Run
Coordination
(A. Oh)
PubComm
Chair
(S. Willocq)
Additional
Members
(E. Etzion, A. Nisati,
M. Vincter)


Charged-particle multiplicities in pp interactions at √s = 900 GeV measured with the ATLAS detector at the LHC
ATLAS Collaboration
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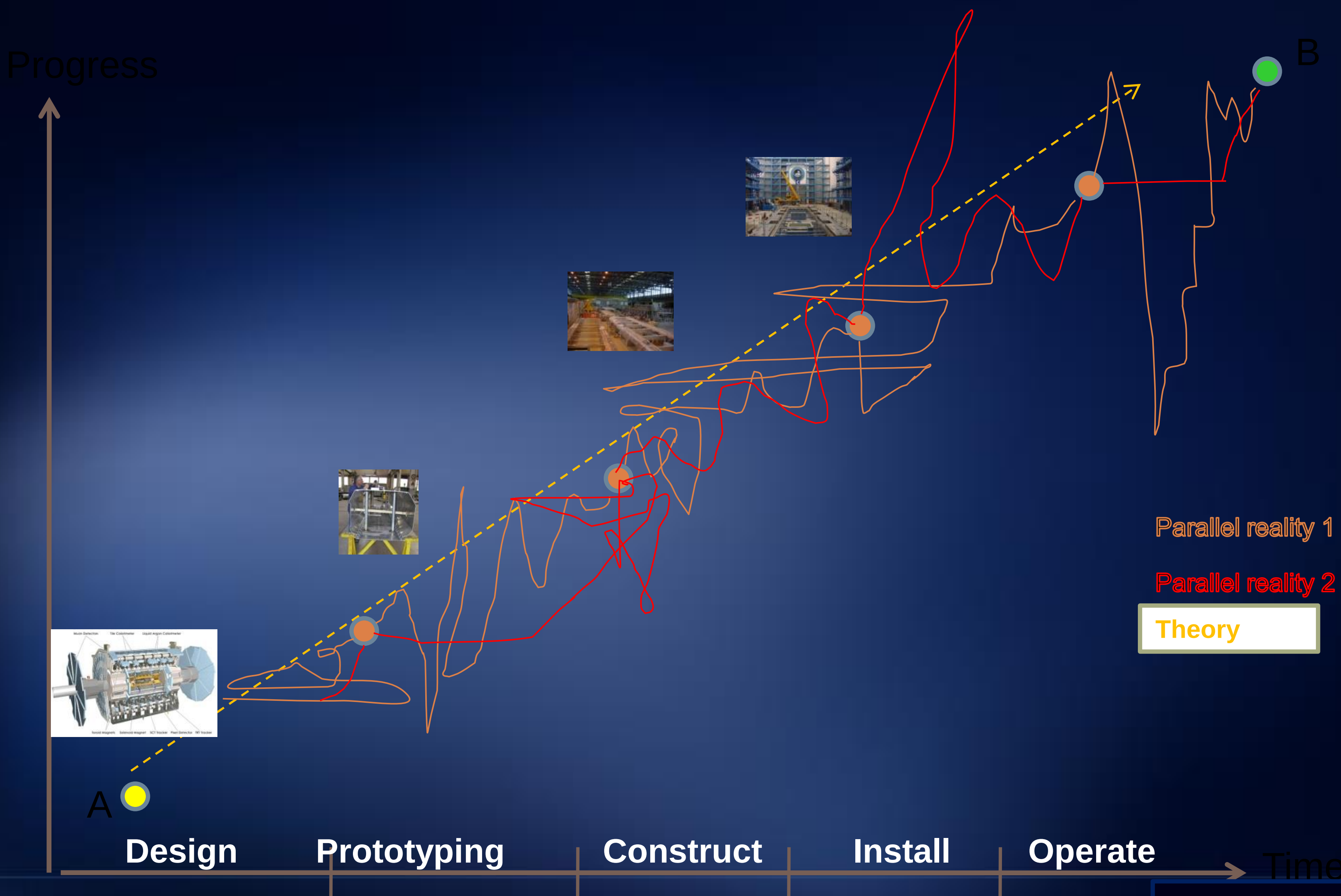
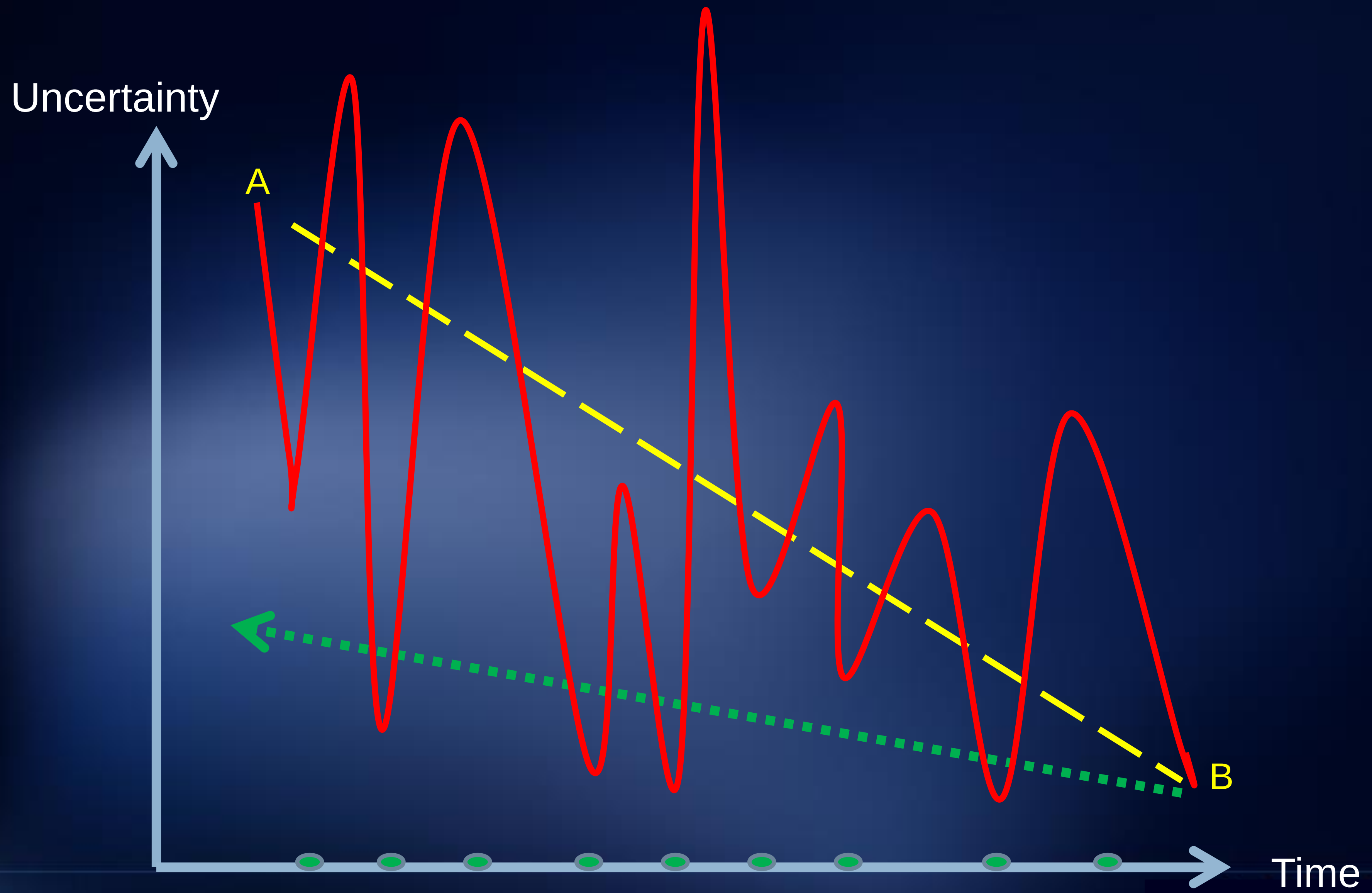
Multiplicities
900 GeV
ATLAS
LHC
Minimum bias
ABSTRACT
The first measurements from proton–proton collisions recorded with the ATLAS detector at th
are presented. Data were collected in December 2009 using a minimum-bias trigger during col
at a centre-of-mass energy of 900 GeV. The charged-particle multiplicity, 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 kinemati
|η| < 2.5 and pT > 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 η = 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 pp̄ 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 correc
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
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
ATLAS Collaboration / Physics Letters B 688 (2010) 21–42
A. Tonazzo 133a,133b, G. Tong 32a, A. Tonoyan 13, C. Topfel 16, N.D. Topilin 65, E. Torrence 113,
E. Torró Pastor 165, J. Toth 83,u, F. Touchard 83, D.R. Tovey 138, T. Trefzger 171, J. Treis 20, L. Tremblet 29,
Z. Zhao 32b, A. Zhemchugov 65, S. Zheng 32a, J. Zhong 149,z, B. Zhou 87, N. Zhou 34, Y. Zhou 149, C.G. Zhu 32d,
H. Zhu 41, Y. Zhu 170, X. Zhuang 98, V. Zhuravlov 99, B. Zilka 143a, R. Zimmermann 20, S. Zimmermann 20,
S. Zimmermann 48, M. Ziolkowski 140, R. Zitoun 4, L. Živković 34, V.V. Zmouchko 127,*, G. Zobernig 170,
A. Zoccoli 19a,19b, Y. Zolnierowski 4, A. Zsenei 29, M. zur Nedden 15, V. Zutshi 5
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
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
a Present address FermiLab, United States.

Implementing Strategy is Not Linear



Absorbing vs. Reducing Uncertainty



1. Vision
2. Commitment
3. Tolerance

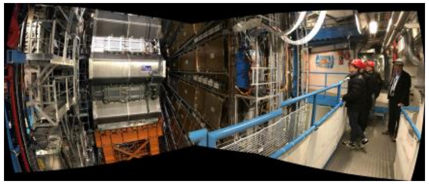
Communitarian Bonds

- 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 <u>no</u> voting

Conclusions

- LHC Experiments are large scientific projects that can be described as
  - Complex, disruptive
  - Global
  - Culturally diverse
  - Shared vision, passion, 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!