Large Collaborations

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Deepest thanks for information to the Spokespersons of
Atlas – Fabiola Gianotti
CMS – Guido Tonelli
CDF – Rob Roser, Giovanni Punzi
BaBar - Michael Roney
LHCb - Pierluigi Campana
Belle - Thomas Browder, Toru Iijima , Yoshi Sakai

Thanks to Paul Grannis for providing his Panofski Prize talk

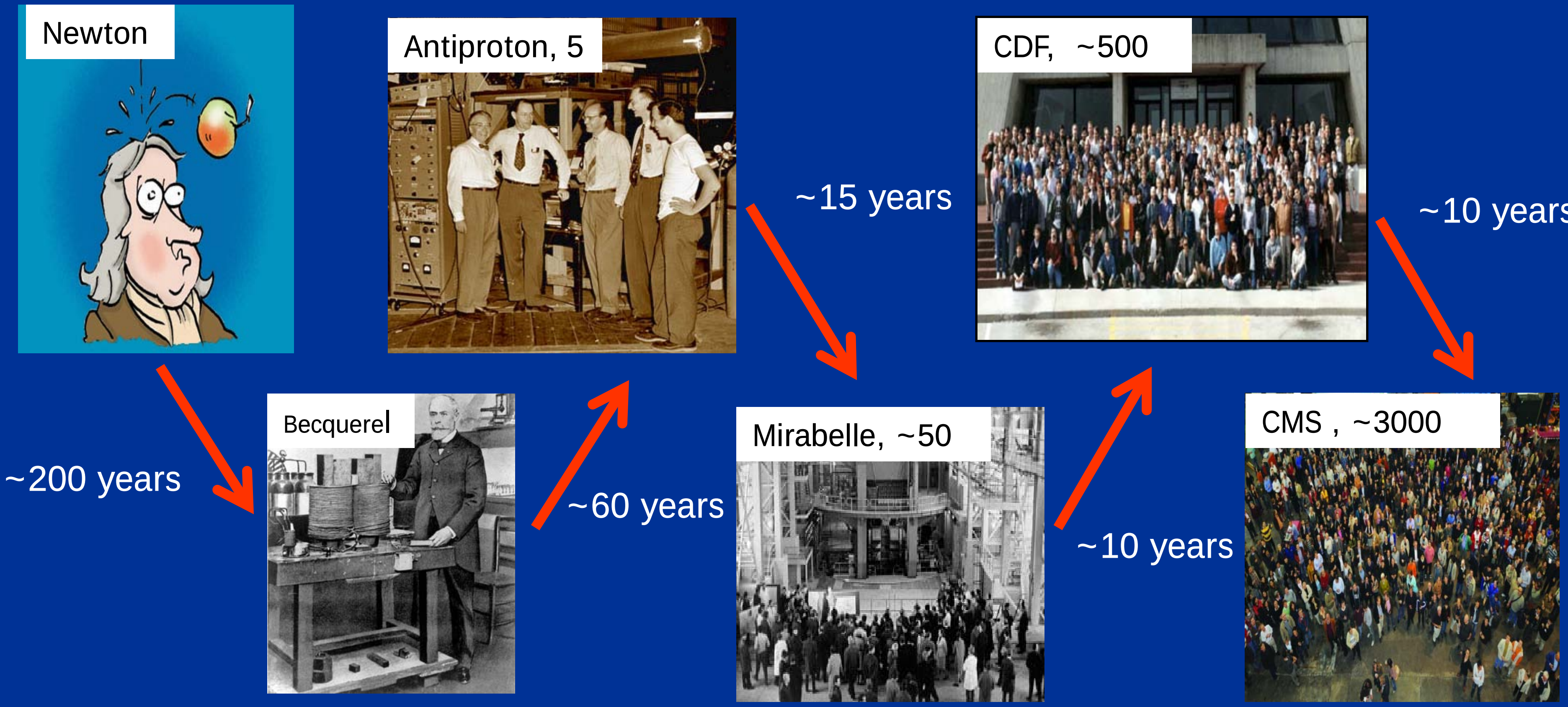
Talk Outline

- Formation of large particle physics collider collaborations
- Features of large collaborations
- How large collaborations work
- Successes of large collaborations
- Challenges of large collaborations
- Concluding remarks

Disclaimers

- Seven collaborations selected are my choice to provide examples in order to illustrate generic conclusions
  - There are collaborations not mentioned: from SppS, LEP, SLC, HERA and many others
- We are discussing “large” – 100’s of scientists - collider collaborations
  - Many principles are similar for other accelerator and non accelerator based experiments
- DØ is used as an example in quite a few cases as I am spokesperson for the collaboration for the last 5+ years
- All comments represent my own opinion, while many are discussed with colleagues

History of Scientific Collaborations



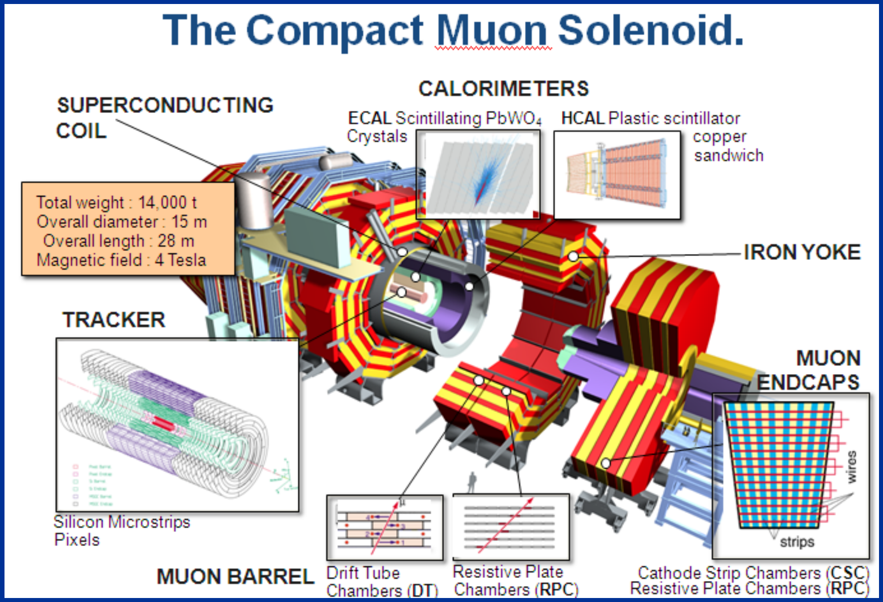
- **Over last ~40 years we saw tremendous increase in size of the groups working jointly in experimental (particle) physics**
- **Driven by revolution in science and technology all over the world in the second half of XX century**

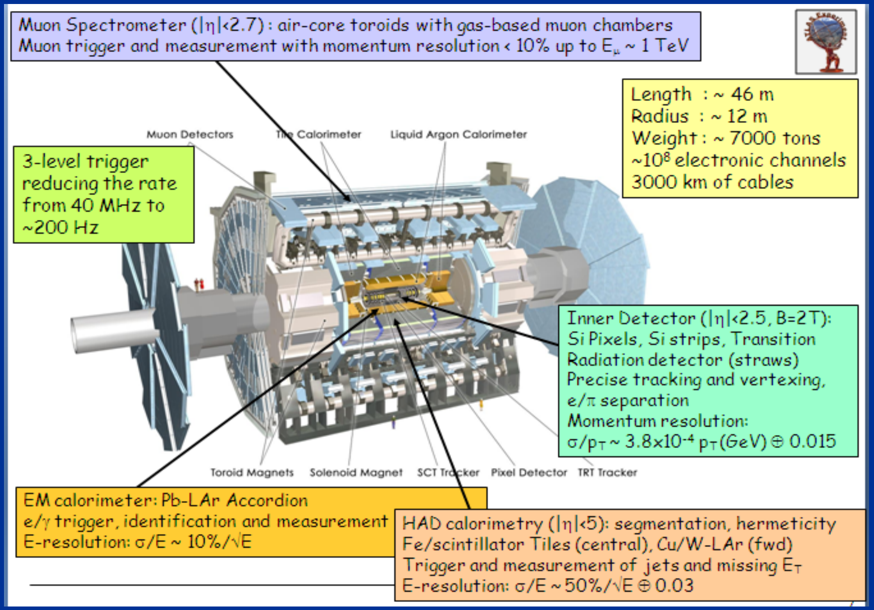
Large Collaborations – Why and How

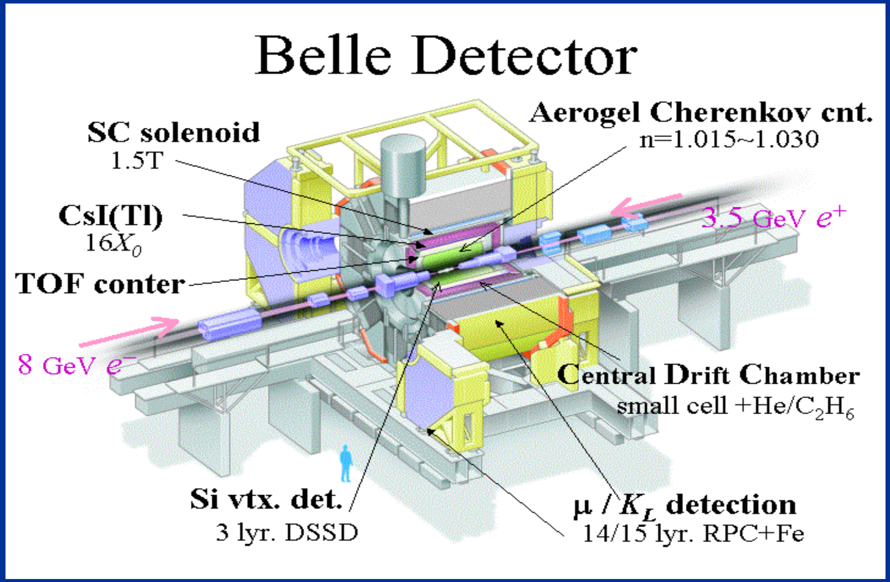
- Large detectors and complex data analysis to address fundamental questions of particle physics require large collaborations
- Limited number of places to do the experiments, at accelerator centers, stimulated large multi-purpose detectors
  - Especially true for collider experiments
- Opportunity to share resources, experience and costs between groups and countries

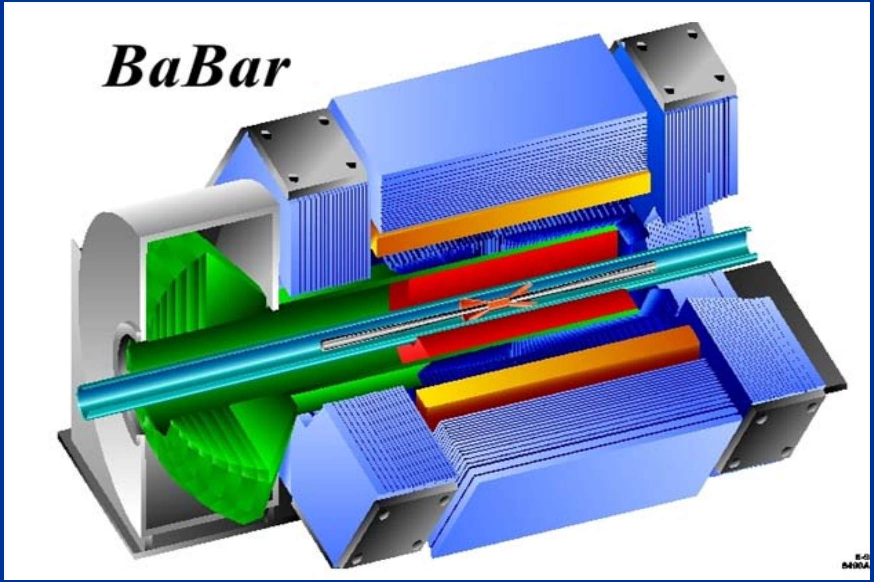
- Original formation of large collaborations is not a well defined process
- Usually starts from semi-formal interactions between scientists in response to the proposals for experiments at new / existing accelerator
- Initial stage is often orchestrated by laboratories directors
- Once the collaboration is formed – functioning becomes more predictable

Complex Detectors



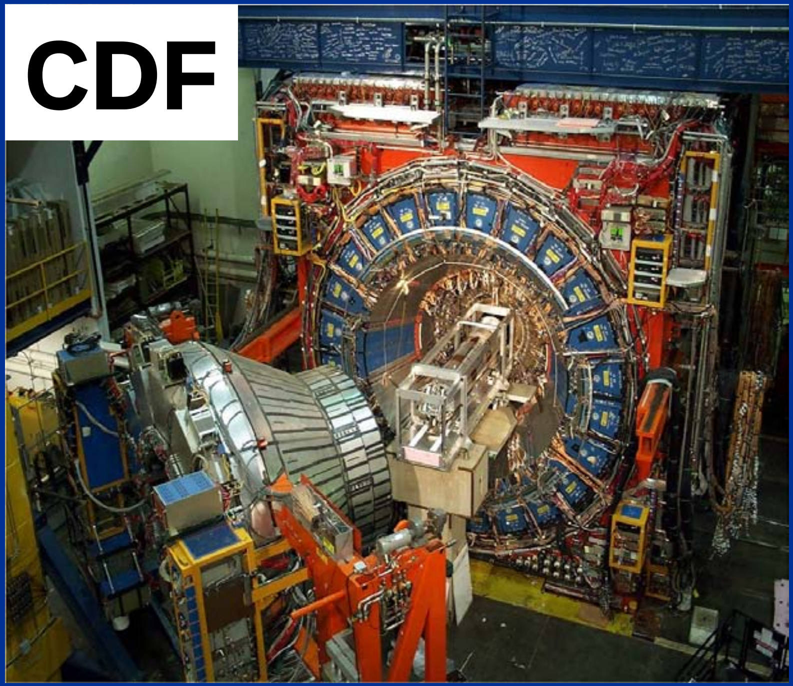


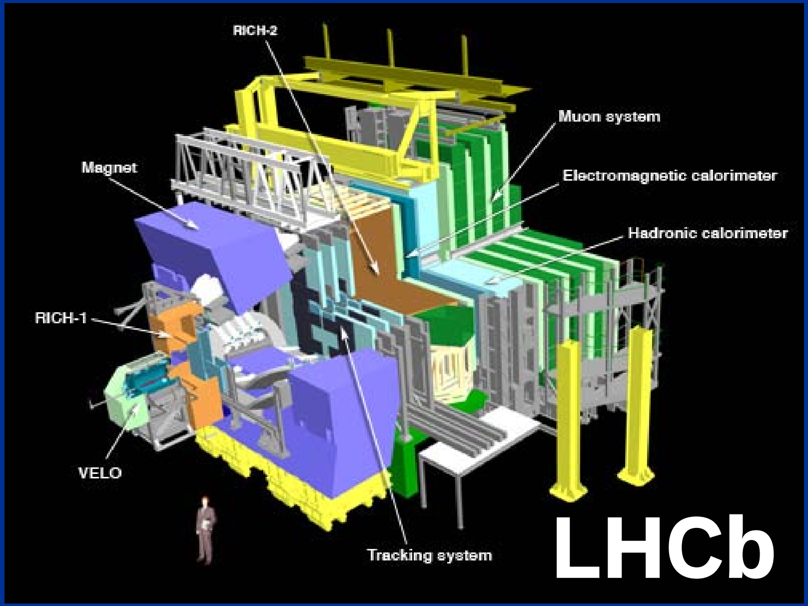




Many millions of channels, $100's millions cost, 5-10+ years to build

Particle Detectors





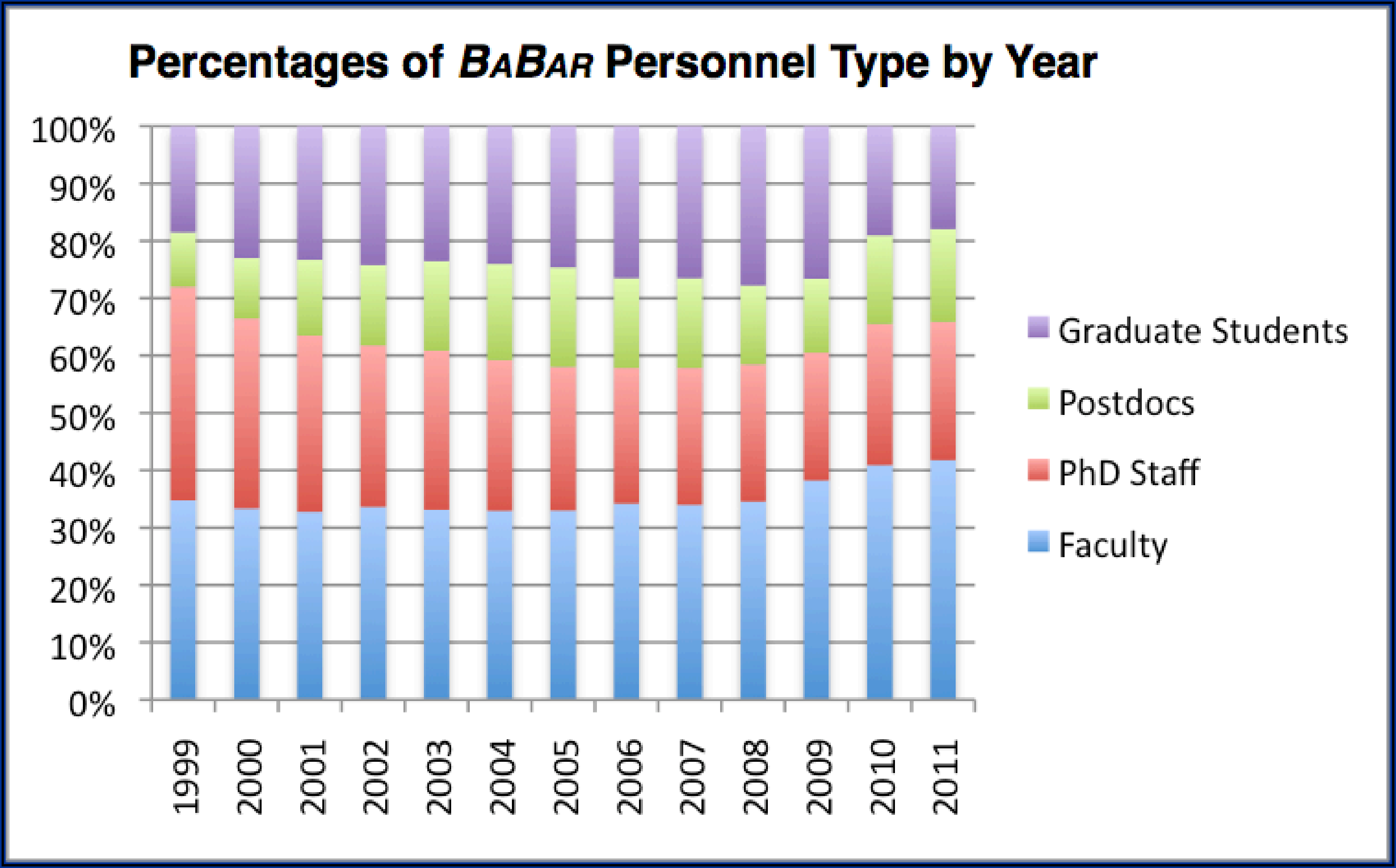
Developing new detection methods, electronics, triggering, technology

Large Collaborations

Collaboration	Start Year	Number of scientists	Countries
CDF	1979	~500	~ 15
DØ	1983	~500	~ 20
BaBar	1993	~400	~ 12
Belle	1993	~400	~ 15
LHCb	1998	~600	~ 12
ATLAS	1992	~3000	~ 40
CMS	1992	~3000	~ 40

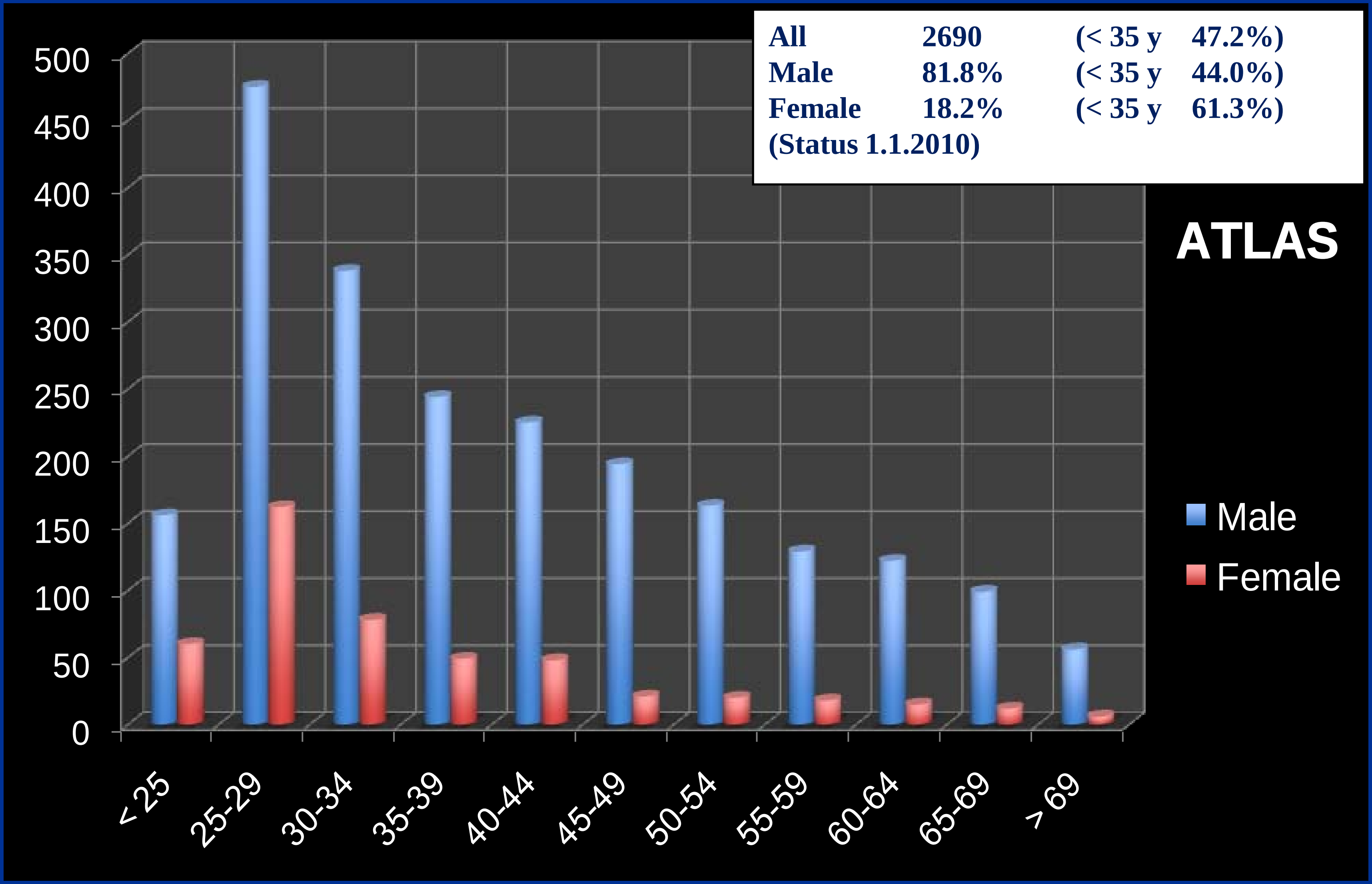
- **Number of groups involved**
  - **~50 at B factories**
  - **~100 at the Tevatron**
  - **~200 at the LHC**
- **Time between start of the collaboration and data taking**
  - **~6 years for B factories**
  - **~8 years for the Tevatron**
  - **~15 years for the LHC**
- **Data taking period length is usually correlated with construction time**

Collaborations Composition



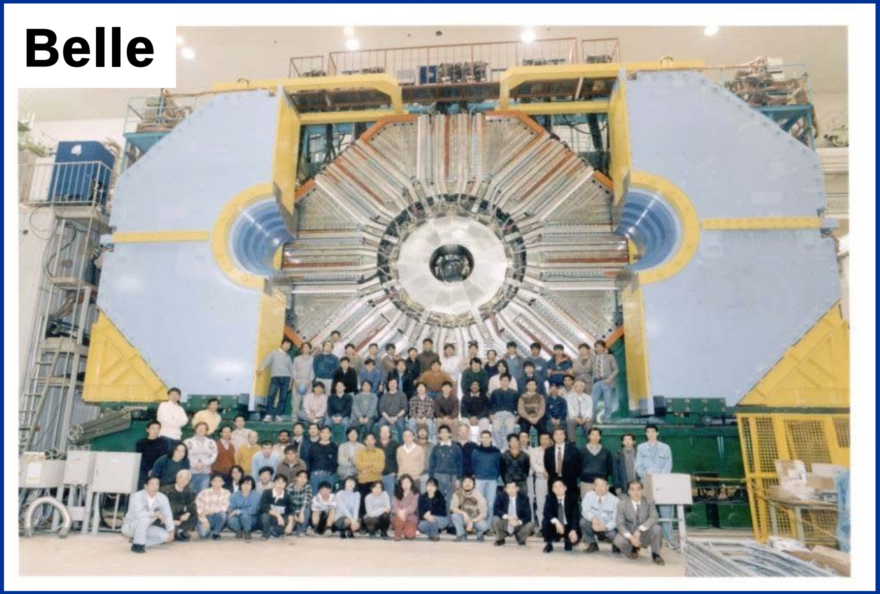
- For majority of collaborations ~35% are young scientists: students and postdocs
  - Healthy fraction for education/mentoring
- Composition of the collaboration changes during life of the experiment: design/construction, data taking/analysis, final data analysis

Collaborations Composition



- **Large fraction of young scientists**
- **Healthy trend in female / male composition**

Scientists of the Collaborations



How Collaborations Work

- No financial dependence, police, prisons…
- Have to develop “laws” which are accepted democratically via vote
- Pretty detailed “Constitutions” describing all critical elements of the collaborations life
  - Organization
  - Elections
  - Analysis / review of results
  - Membership and authorship
  - Talks at conferences
- Constitutions are evolving in time
- Why to follow the rules?
  - To become productive and succeed!

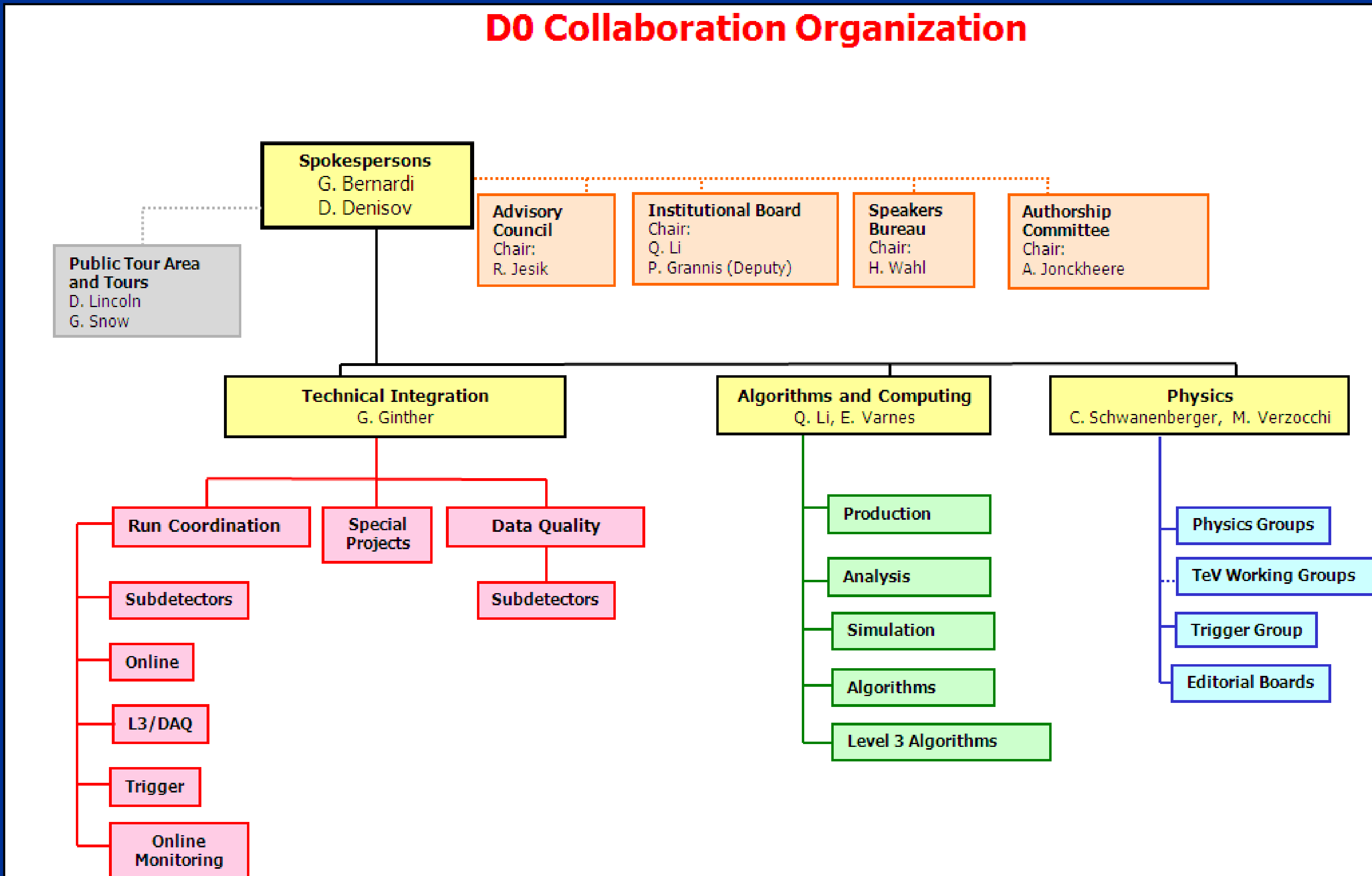
July 30, 2011 - change log at bottom

Contents   DØ Governance Document

1. Introduction
2. Spokespersons
3. Institutional Board
4. Advisory Council
5. Management issues
6. Committees

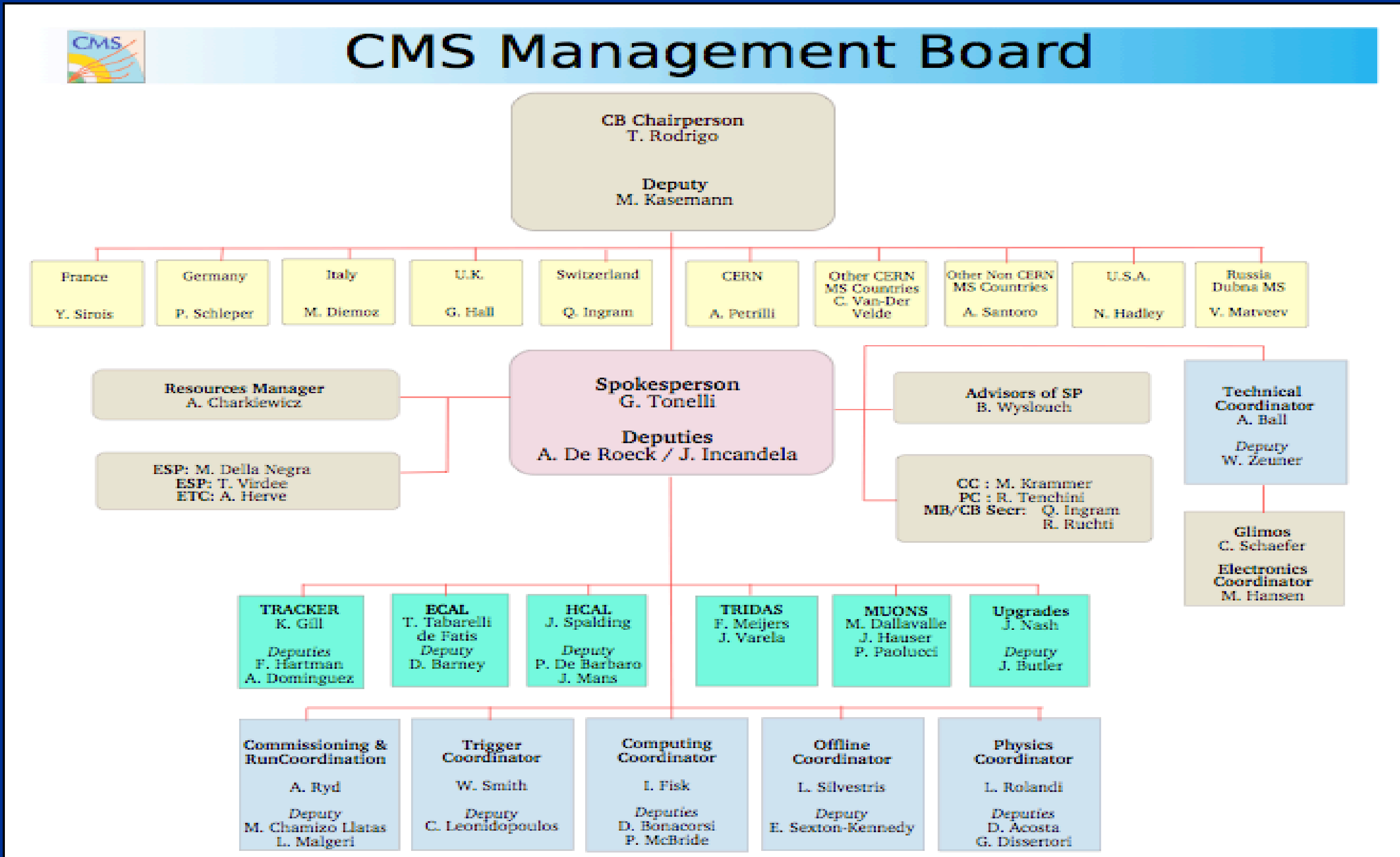
- Appendix I: Guidelines for Authorship Committee
- Appendix II: Specific Criteria for becoming a DØ author
- Appendix III: Guidelines for Publications and Editorial Boards
- Appendix IV: DØ Speakers Bureau
- Appendix V: Policy on DØ Talks at Meetings
- Appendix VI: Admission of Senior Colleagues into DØ
- Appendix VII: Guidelines on Duties of Representatives to the IB
- Appendix VIII: Criteria for Papers with Limited Authorship
- Appendix IX: Preferential Voting in DØ Elections
- Appendix X: Spokesperson Election Timetable

Collaborations Organization



- **Each box has its own organizational structure involving 10's of scientists**
- **Clear responsibilities/authority in all areas of the collaboration life**

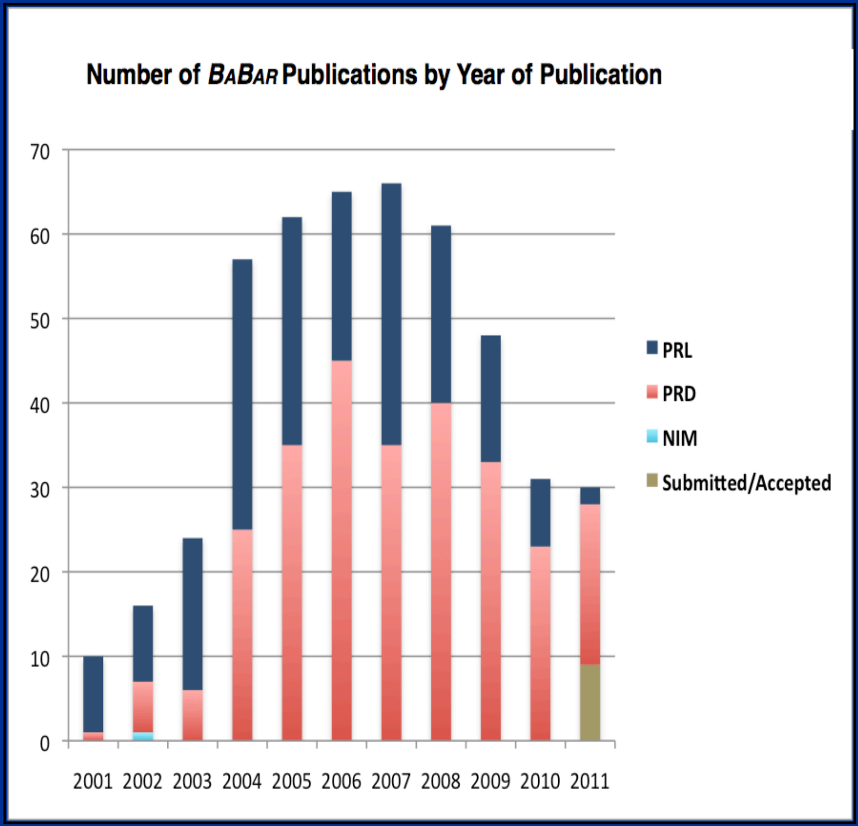
Collaborations Organization

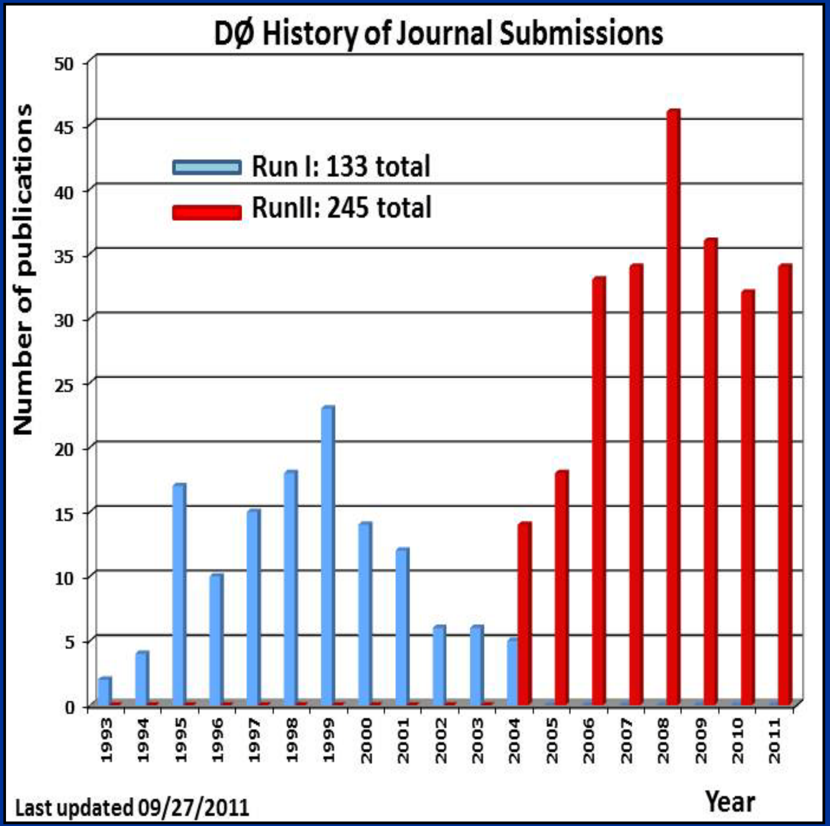


- **In most cases there are legislative and executive branches**
  - **Details vary between collaborations, while all have Spokesperson(s)**

Publications and PhDs

- Publications is one of the most important outputs of the collaborations
- Rate of publications is healthy reaching ~100/year for LHC experiments





- Educating next generation of scientists – number of PhDs already defended
  - Belle and BaBar ~500, Tevatron ~1000, LHC ~1000

Successes of Large Collaborations

- **Exciting physics results – Standard Model is nearly complete**
  - See excellent summaries on the first day of this Seminar
  - Discoveries, high precision measurements, searches for new particles and interactions
- **Training of 1000's of young scientists**
  - Propagation of excellent education to all members of the collaborations
- **Productive international cooperation**
  - Even during tensions in relations between countries
- **Place for smaller groups/countries to participate in world class research**
- **High efficiency scientific organization which serves as an example for other fields**

Alternatives to Large Collaborations?

- **Many small experiments**
  - Expensive infrastructure, especially for colliders
  - 4π geometry requires large detectors
  - Multipurpose detectors are flexible to adjust to new/unexpected changes in physics priorities
- **"Telescope use model"** – professionals build/support the detector, small groups come for short periods to perform experiments/analyze data
  - Detectors are complex/unique, require experts to run
  - Detectors construction teams are motivated by physics to be done later
  - Reconstruction/analysis require deep understanding of the detectors
  - Short runs are usually not useful as best results are obtained on full data sets due to statistical limitations
- **Professional teams** of scientists employed by the host laboratory
  - Expensive even for large laboratories
  - No students/postdocs
  - No access to international resources

- **In all cases over last ~40 years large international collaborations are the best option to obtain best physics results**

Some Challenges of the Large Collaborations

- Long construction/operation time
  - No wide experience in different areas by young scientists
  - Physics priorities might change making design not optimal
- Complexity
  - Promotes specialization in narrow areas
  - Few see "overall picture"
- Management overhead
  - Stability of collaboration organization/rules minimizes impact
- Limited number of talks at major conferences
  - CDF/DØ each get ~200 talks per year or 1 talk per 2 years per collaborator
  - As number of talks at major conferences is about constant above rate means ~1 talk per collaborator in 10 years for ATLAS/CMS
  - More meetings with parallel/poster sessions and/or specialized conferences will be useful

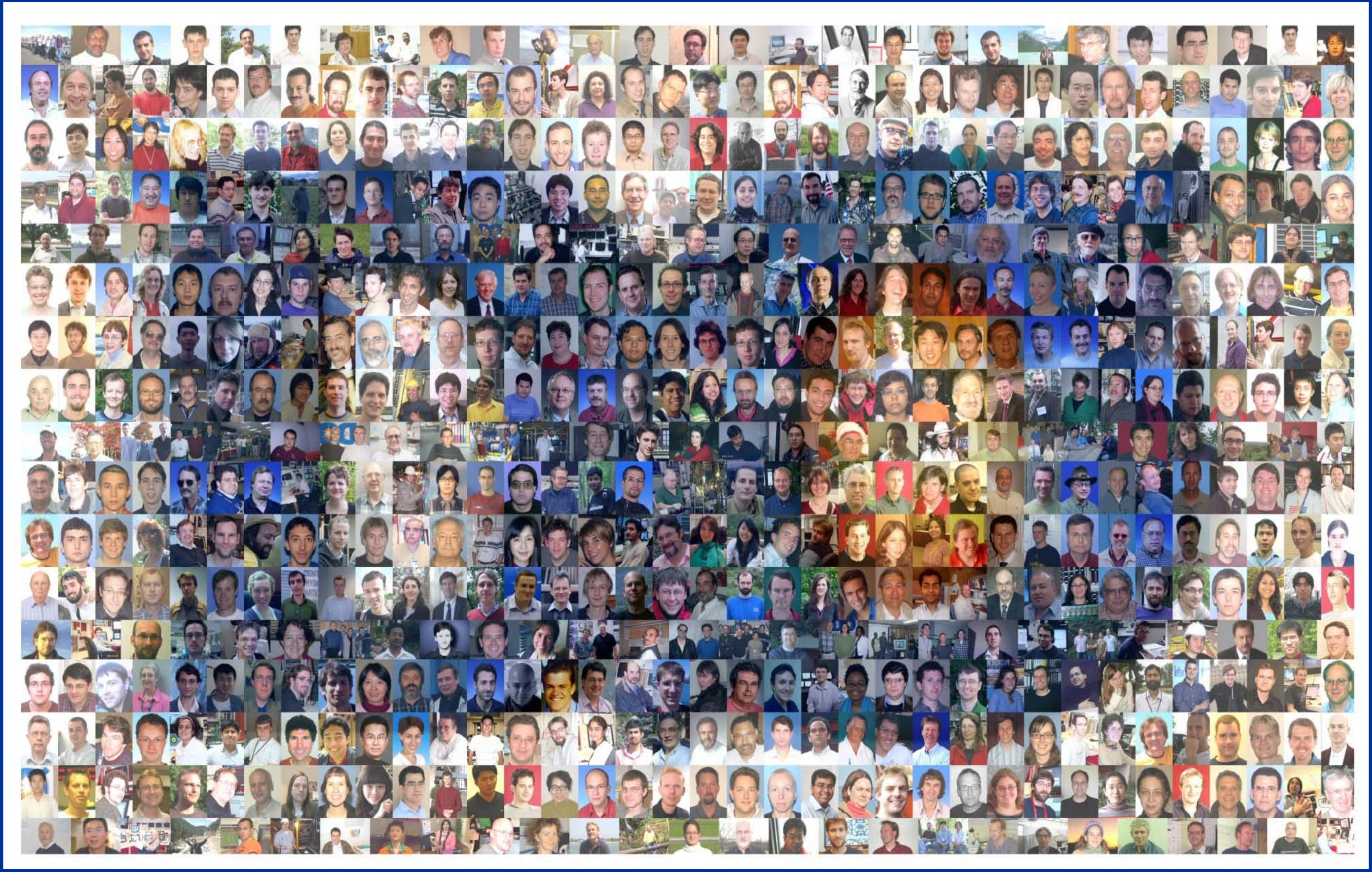
Publications and Authorship Rules

- Authorship is a long standing concern in particle physics due to long author lists
- IUPAP C11 formed working group in 2005 to analyze this topic
  - Basic APS principle is “Authorship should be limited to those who have made significant contributions to the concept, execution, or interpretation of research. All those who contributed in this way should be offered the opportunity to be listed as authors.”
  - After study of many different cases/options working group came to conclusion that current collaborations practices are in agreement with APS principles and provided some specific recommendations (clear rules, documentation, etc.)
- All experiments have clear procedures for collaborator becoming an author
  - Helps newcomers to contribute to the experiment
  - Belle has a few interesting variations
- Author list is critical for keeping collaborations together
  - We are all authors of the papers we publish!
- Have to explain reasons for long lists to promotion/awards committees
- Number of publications in referenced journals per collaborator per year
  - ~0.2 for smallish fixed target experiments
  - ~0.1 for Tevatron collaborations
  - ~0.03 for LHC collaborations with ~100 publications per year
  - Right metric? Something to worry about?

How to Recognize Individuals?

- No differentiation based on the author list
- Elections are only for (very) few top positions
  - All appointed leadership positions is an important recognition as collectively collaborations want to succeed
- Feedback/recommendation letters based on personal experience working together
  - Harder in large collaborations
- Talks at major conferences
  - Selection is based on consensus of many senior collaboration members
- Competition within collaborations
  - In general useful as individuals “work harder”
  - “Game rules” must exist and senior members must set examples
  - Well defined tasks/responsibilities to reach common goal
    - Often more “art” then “science”…
  - Specific negative cases require management involvement
  - Critical for all people in the collaboration to know each other – friendship reduces potential issues greatly

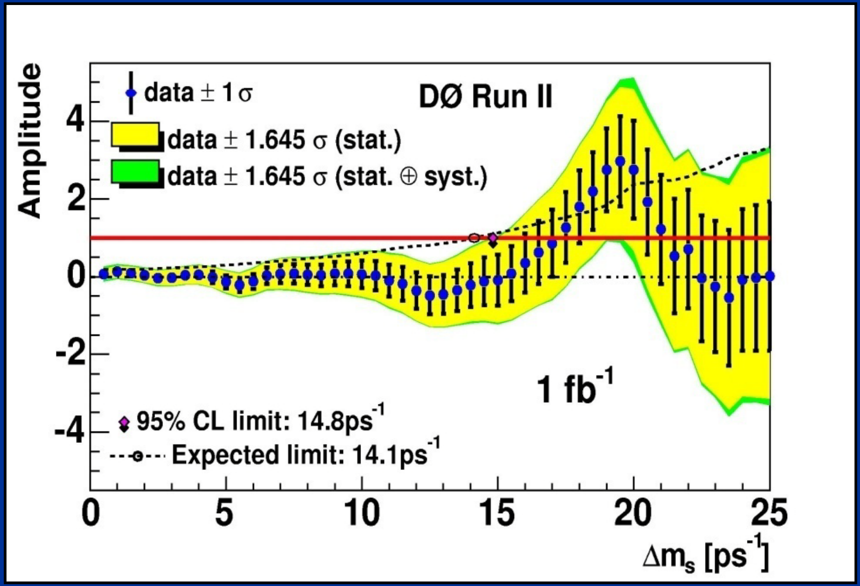
How Many of Your Collaborators Do You Know?

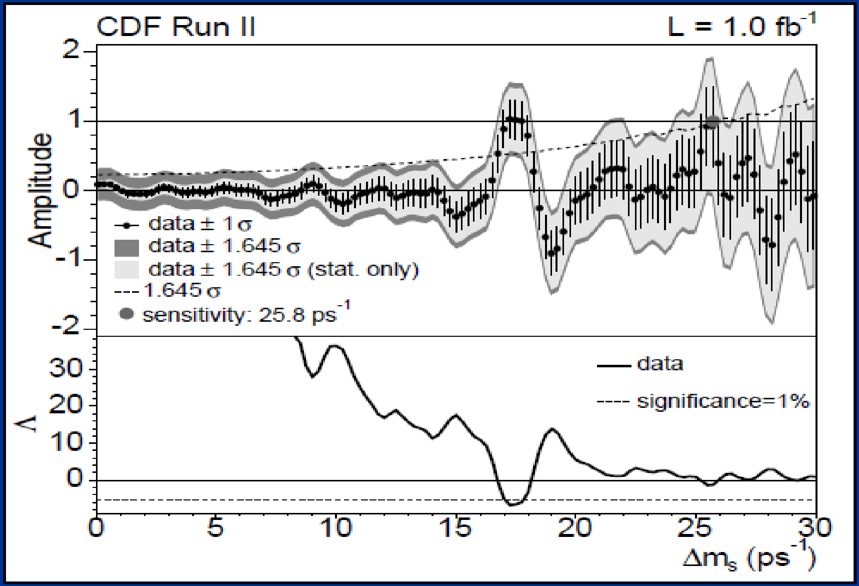


Close communication between all collaborators is very important!

Interaction Between Collaborations

- **Competition and verification are important**
  - The field gets solid results faster
  - Very exciting especially for young scientists
    - B_s oscillation observation at the Tevatron is an excellent example: first double sided limit by DØ triggered evidence by CDF within a few months and discovery within half a year
- **Competition could lead to un-healthy situations and hard feelings, to minimize**
  - Develop detailed rules in advance
  - Play by rules
  - If issues happen get help of a "referee" and keep high ground





Preservation of Data

- **Large and expensive experiments accumulate wealth of data over their lifetime**
  - **Data preservation for internal and at some point external use has to be considered**
- **International Study Group on Data Preservation (DPHEP, ICFA Panel)**
- **Initial Goals (2009)**
  - **Confront data models**
  - **Clarify the concepts, set a common language**
  - **Investigate technical aspects**
  - **Compare and connect to other fields: astrophysics, life sciences, libraries**
- **Achievements and plans**
  - **First concept publication in November 2009**
  - **2 dedicated, laboratory-based projects: SLAC/BaBar + DESY/HERA**
  - **2011/2012: Blueprint proposal, common projects: virtualization, inSpire**

DPHEP Study Group for Data Preservation and Long Term Analysis in High Energy Physics

FNAL 2011

Large HEP Collaborations

- Particle physics was/is on the forefront of creating and productively operating large international collaborations
- In other fields (nuclear physics, astronomy, biology) similar collaborations are working as well

- Reasons for our field to be so successful with large collaborations
  - Addressing fundamental topics in physics requires large detectors
  - Large detectors require large team of scientists to run and analyze data
  - Large laboratories serving as home place for collaborations and strongly supporting collaborations
  - Lack of financial interests from the final results
  - Plenty of exciting work for all involved
  - Share of data/results: access to data, common author list
  - Education of young scientists
  - Past successes of large collaborations: W/Z discoveries, etc.
  - Well thought through organization and rules
  - Healthy interest of countries in international cooperation and fundamental science

Concluding Remarks

- Large international collaborations are created due to complexity, cost and duration of modern particle physics experiments necessary to learn Nature at small distances
  - Driven by physics
- Collaborations are very productive in education of young scientists
  - And not only for high energy physics
- High energy physics organization and experience with collaborative efforts are invaluable for other fields
- There are challenges: recognition of especially young scientists, management overhead, publications rate, talks at major conferences
  - None look major or unsolvable
- Probability of even larger collaborations look remote at this time
  - ~30,000 members? The whole field?
  - Have to find other ways to progress
- Continued efforts and innovations are needed to keep large collaborations healthy
- Tremendous amount of knowledge obtained in particle physics over last ~40 years would not be possible without large collaborations
  - They are here to stay!