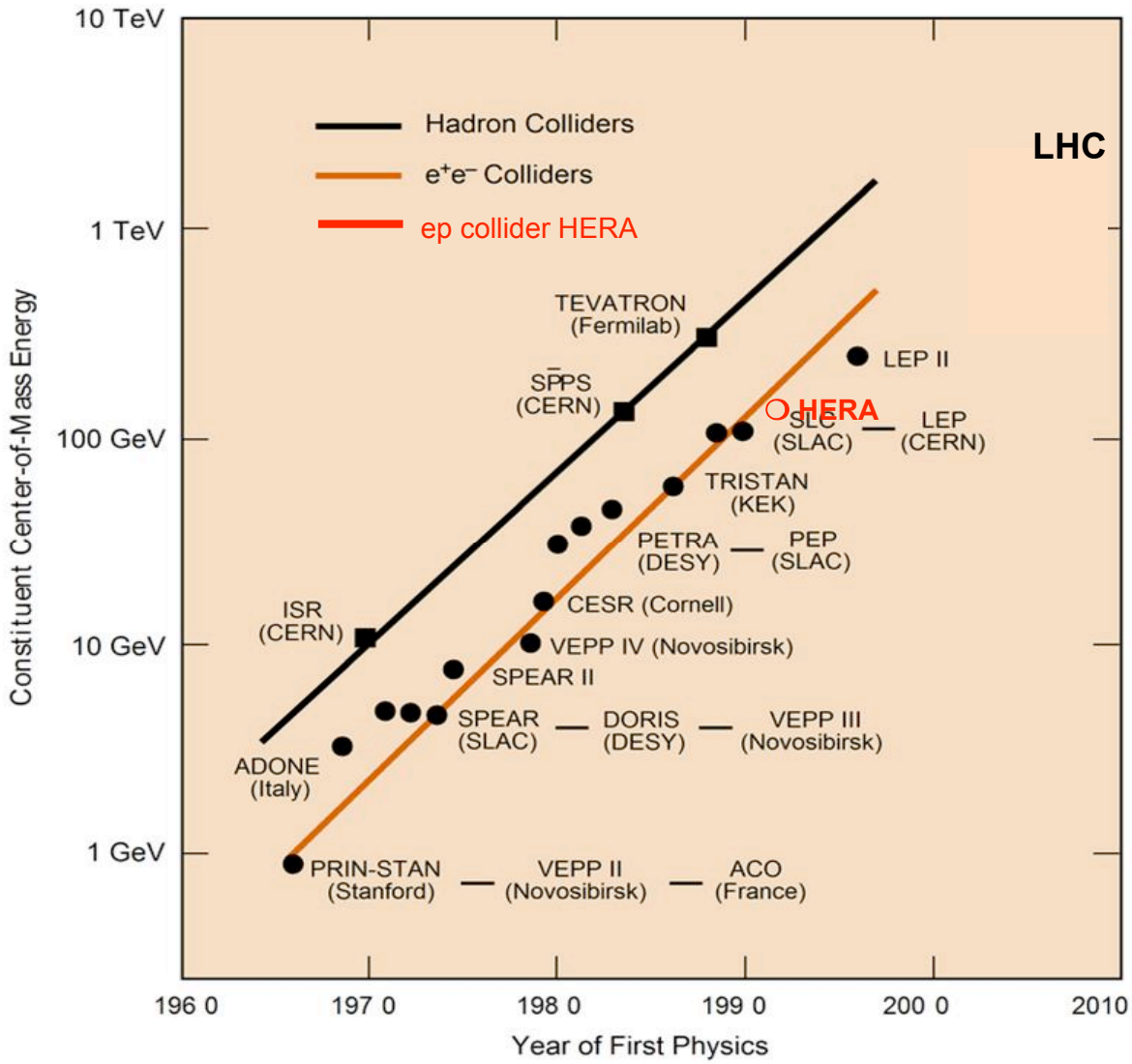
Data Preservation and Long Term Analysis in HEP

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

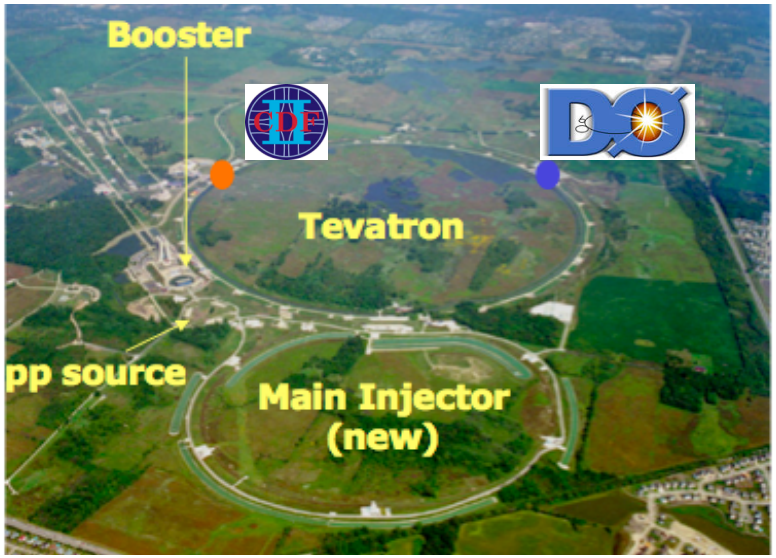
http://www.dphep.org

High Energy Physics



Energy frontier probed with complex experimental installation

On the energy and precision frontiers



The 2010 HEP landscape (colliders)

- LEP 2000

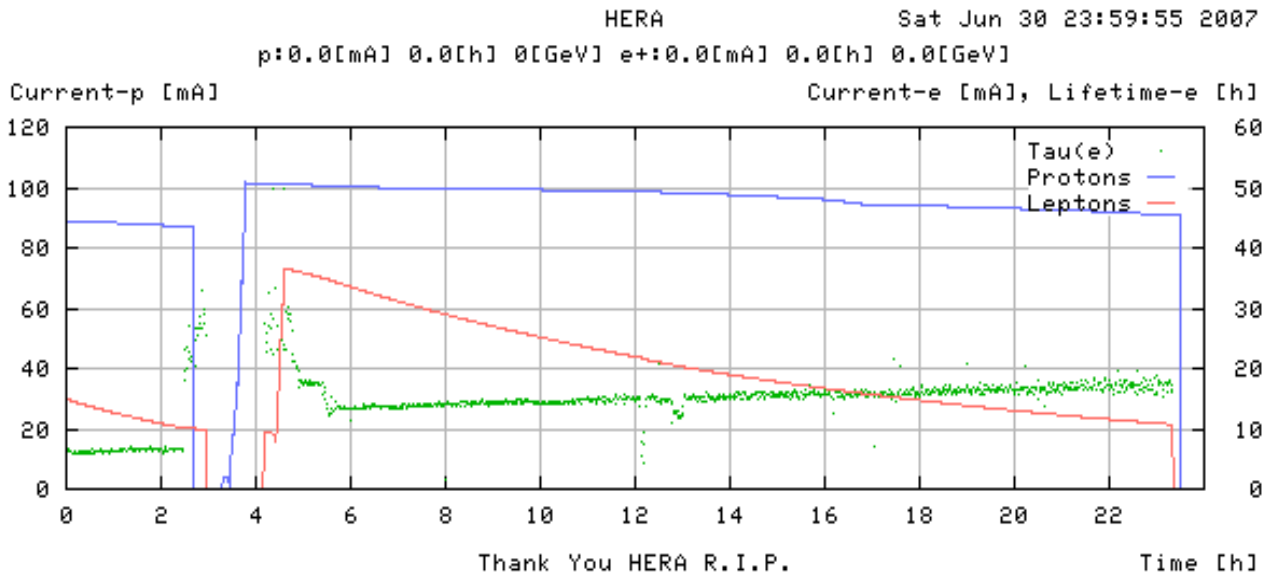
"[…] LEP is scheduled to be dismantled soon so that its 27 km tunnel can become the home for the ambitious LHC proton collider, which is due to come into operation in 2005. "
[CERN Courier, Dec. 1st, 2000]

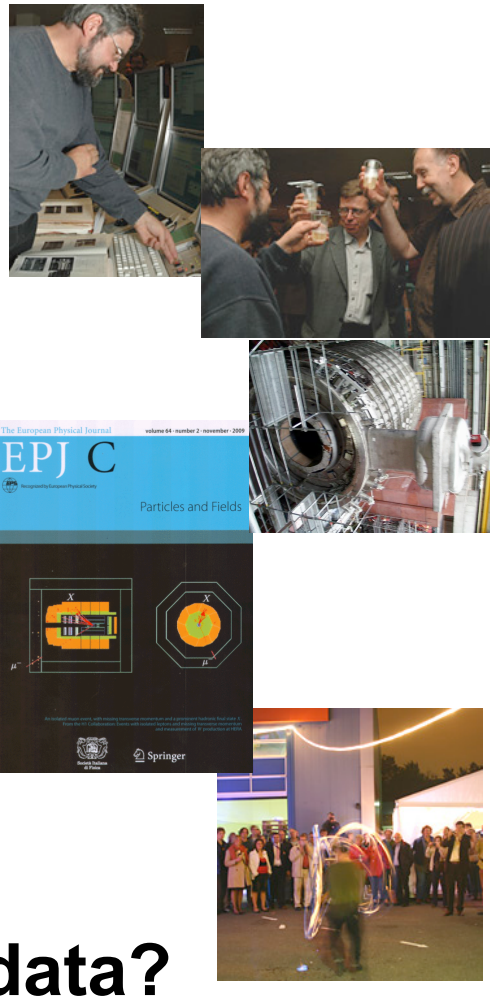
  - No follow-up decided (ILC?) - after 2020
- HERA: end of collisions in 2007
  - No follow-up decided (LHeC?) - after 2020
- B-factories: Babar 2008, Belle->Belle II
  - Next generation in a few years (2013-2017)
- Tevatron: 2011
  - A majority of the physics program will be taken over at the **LHC**
  - However: p-pbar is unique, no follow-up foreseen

HEP experiments data taking encompass 10-15 years, some are unique
What is the fate of the collected data?
(NB: here "data" = full experimental information)

After the end of the data taking:

do a party, dismantle detector, finalise the analyses, re-do a party : ~5 years



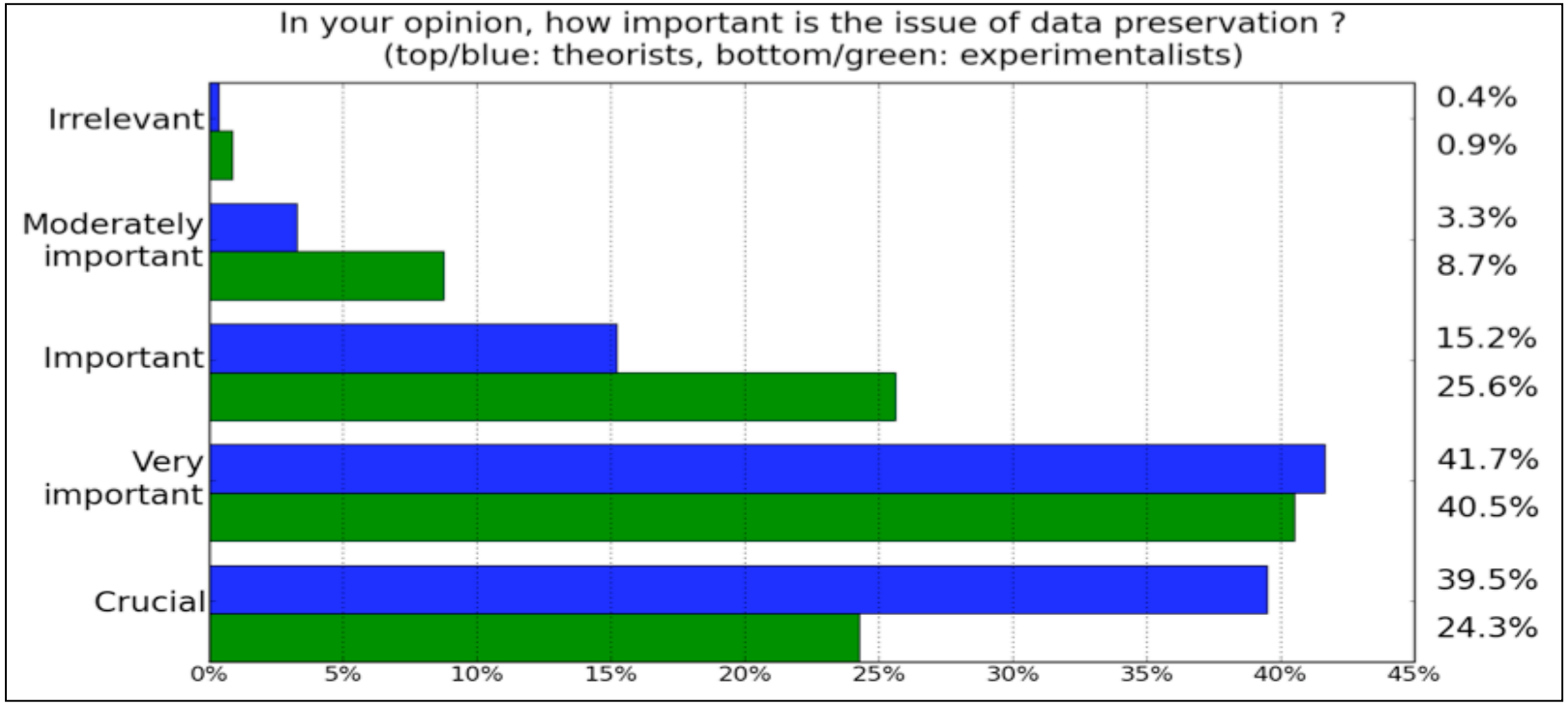


…what do you do with the data?

Data Preservation: support in the HEP community

http://arxiv.org/abs/0906.0485

PARSE.Insight is financed by the European Commission and run at CERN

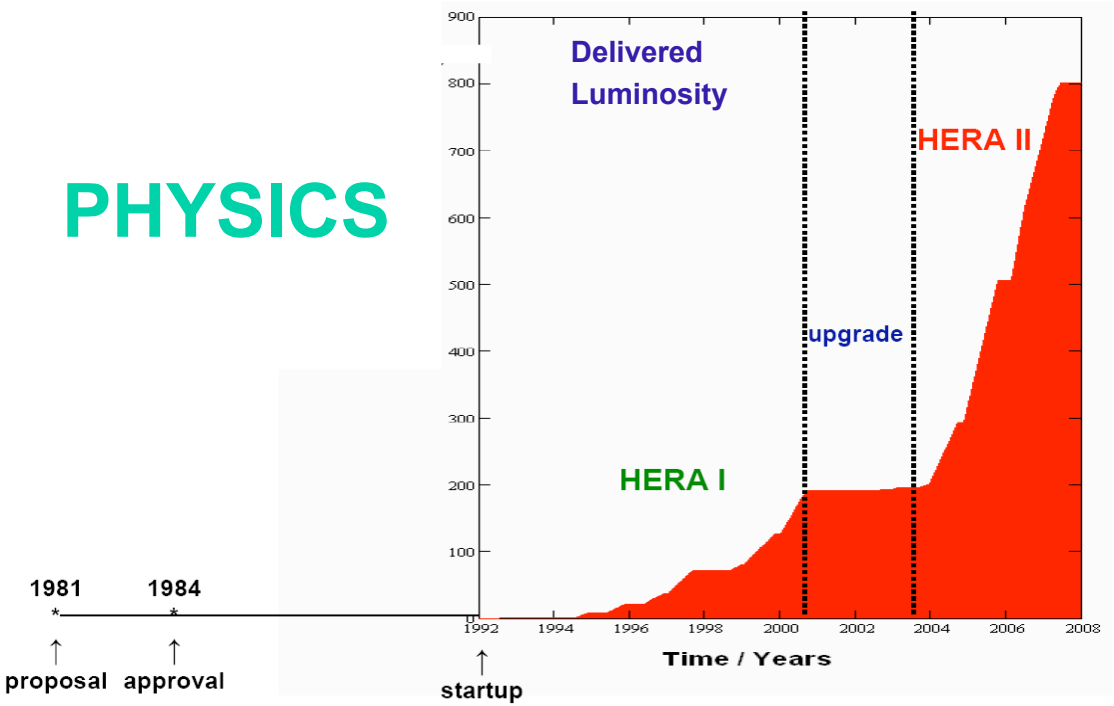


70%: very important or crucial
However, no coherent strategy exists: in general, HEP data is lost

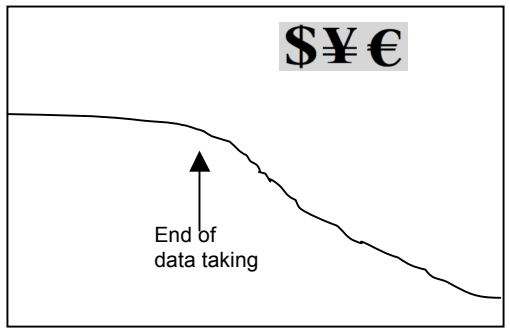
Why is difficult to preserve HEP data?

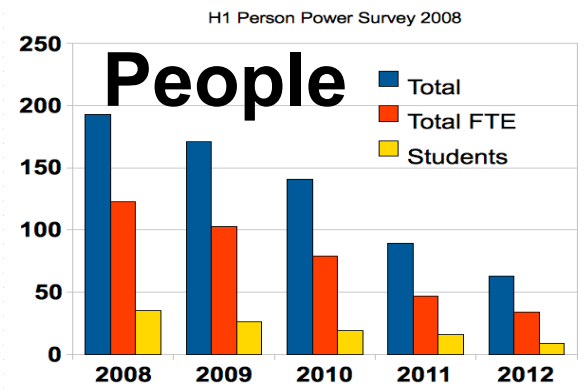
- Good physics is collected at the end, but:
- The resources decrease after the end of data taking
  - Dedicated resources need to be planned

PHYSICS



Funding

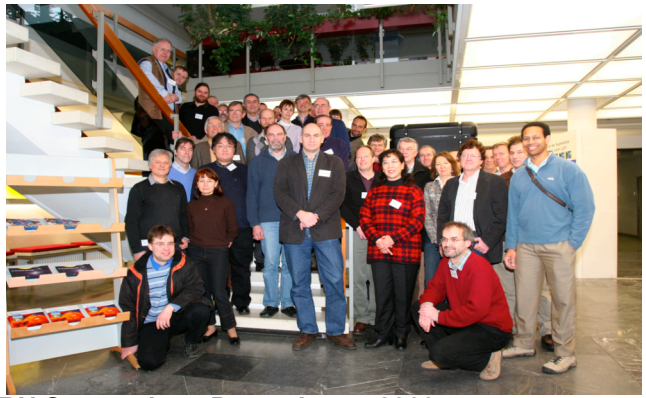




International Study Group on HEP Data Preservation

- Collider Experiments
  - e^+e^-, ep, $p\bar{p}$
- Computing Centers
- Contacts with funding agencies

- About 50 contact persons



Coordination

Chair: Cristinel Diaconu (DESY/CPPM)

Working Groups Convenors:

Physics Case	François Le Diberder (SLAC/LAL)
Preservation Models	David South (DESY) , Homer Neal (SLAC)
Technologies	Stephen Wolbers (FNAL), Yves Kemp (DESY)
Governance	Salvatore Mele (CERN)

International Steering Committee

DESY-IT: Volker Gülzow (DESY)
H1: Cristinel Diaconu (CPPM/DESY)
ZEUS: Tobias Haas (DESY)
FNAL/DoE: Amber Boehnlein (DoE)
FNAL-IT: Victoria White (FNAL)
D0: Dmitri Denisov (FNAL), Stefan Soldner-Rembold (Manchester)
CDF: Jacobo Konigsberg (FNAL), Robert Roser (FNAL)
IHEP-IT: Gang Chen (IHEP)
BES III: Yifang Wang (IHEP)
KEK-IT: Takashi Sasaki (KEK)
Belle: Masanori Yamauchi (KEK), Tom Browder (Hawaii)
SLAC-IT: Richard Mount (SLAC)
BaBar: Francois Le Diberder (SLAC/LAL)
CERN-IT: Frederic Hemmer (CERN)
CERN/PARSE: Salvatore Mele (CERN)
CLEO: David Asner (Carleton)
STFC: John Gordon (RAL)

International Advisory Committee

Chairs: Jonathan Dorfan (SLAC) and Siegfried Bethke (MPI Munich)
Advisers: Gigi Rolandi (CERN), Michael Peskin (SLAC), Dominique Boutigny (IN2P3), Young-Kee Kim (FNAL), Hiroaki Aihara (IPMU/Tokyo)

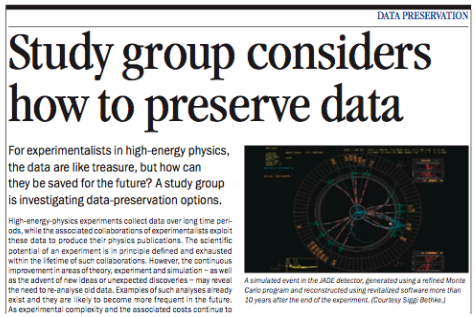
Activity

- Study Group Initiated in September 2008
- Workshops in 2009: DESY, SLAC, CERN (Dec. 7-9)
  - 30-40 participants, experiments represented
  - Confront data models, clarify the concepts, set a common language, investigate technical aspects, compare with other fields (astrophysics)
- Objectives 2009:
  - Report for ICFA
  - Make the report available for debate in the HEP community (released last week arXiv:0912.0255)

DPHEP DESY

DPHEP SLAC NATIONAL ACCELERATOR LABORATORY

DPHEP CERN


DATA PRESERVATION

Study group considers how to preserve data

For experimentalists in high-energy physics, the data are like treasure, but how can they be saved for the future? A study group is investigating data-preservation options.

High-energy-physics experiments collect data over long time periods, while the associated collaborations of experimentalists exploit these data to produce their physics publications. The scientific potential of an experiment is in principle defined and exhausted within the lifetime of such collaborations. However, the continuous improvement in areas of theory, experiment and simulation – as well as the advent of new ideas or unexpected discoveries – may reveal the need to re-analyse old data. Examples of such analyses already exist and they are likely to become more frequent in the future. As experimental complexity and the associated costs continue to

A simulated event in the JADE detector, generated using a refined Monte Carlo program and reconstructed using revitalized software more than 10 years after the end of the experiment. (Courtesy Siggi Bethke.)

CERN Courier, May 2009

Intermediate report released

DPHEP-2009-001
July 30, 2009

Data Preservation in High-Energy Physics

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http://dphep.org

Abstract

Data from high-energy physics (HEP) experiments are collected with significant financial and human effort and are mostly unique. At the same time, HEP has no coherent strategy for data preservation and re-use. An inter-experimental Study Group on HEP data preservation and long-term analysis was convened at the end of 2008 and held two workshops, at DESY (January 2009) and SLAC (May 2009). This document is an intermediate report to the International Committee for Future Accelerators (ICFA) of the reflections of this Study Group.

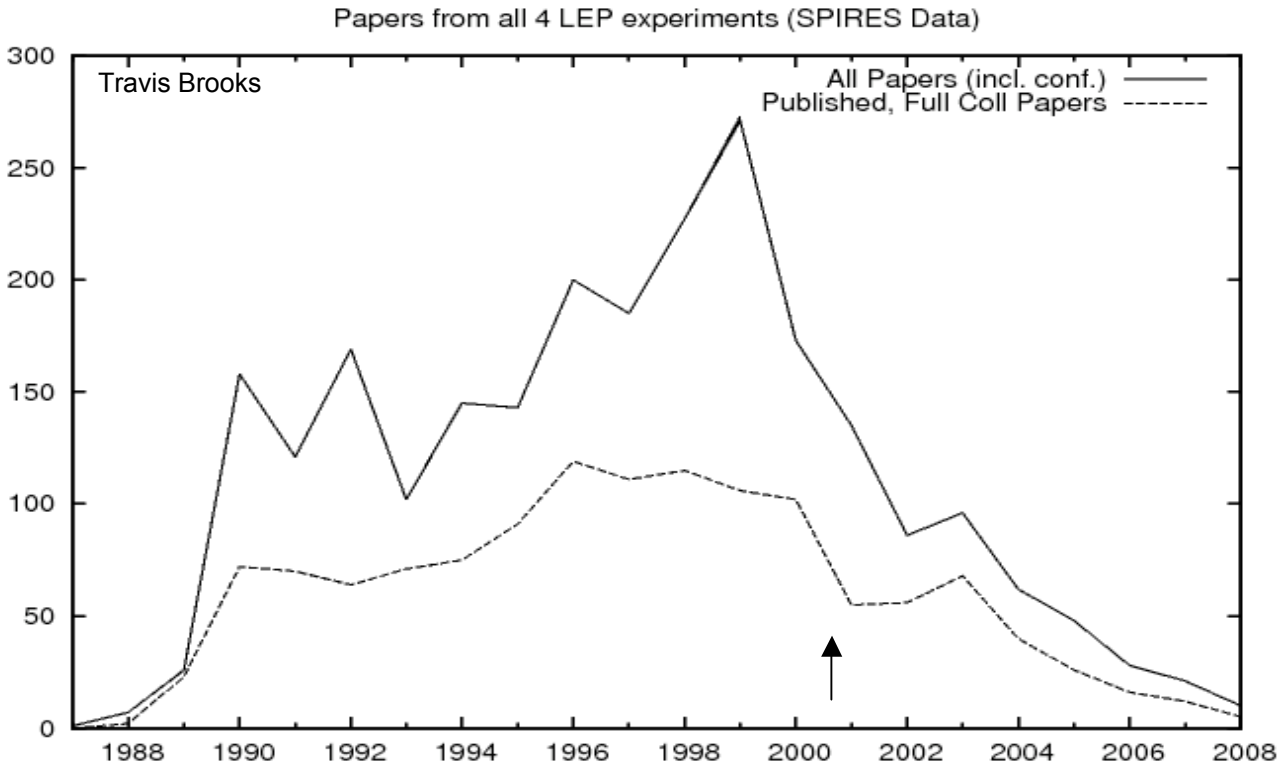
In this this talk: present the main ideas, preliminary recommendations, plans

Physics Case

- Collected data sets are mostly unique and have a true scientific potential
  - Long term completion and extension of the physics program
  - Cross collaborations
  - Data re-use
  - Scientific training, education, outreach

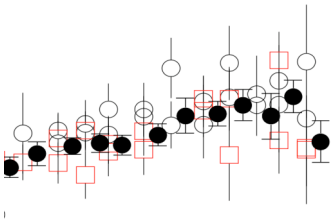
Physics Case I

- Long term completion and extension of the physics program



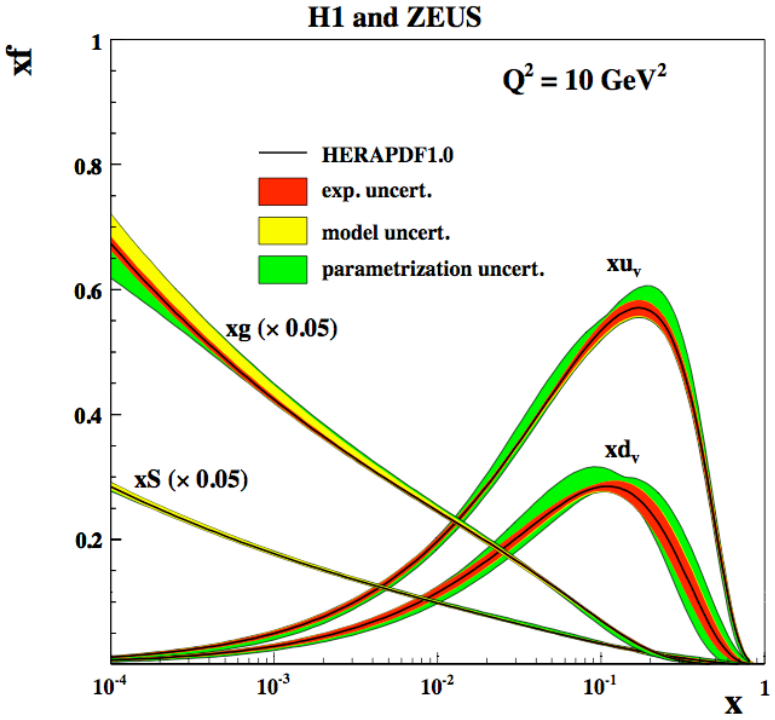
Physics subjects are published after the end of collisions/collaborations
5-10% of the papers are finalized in the “archival mode”

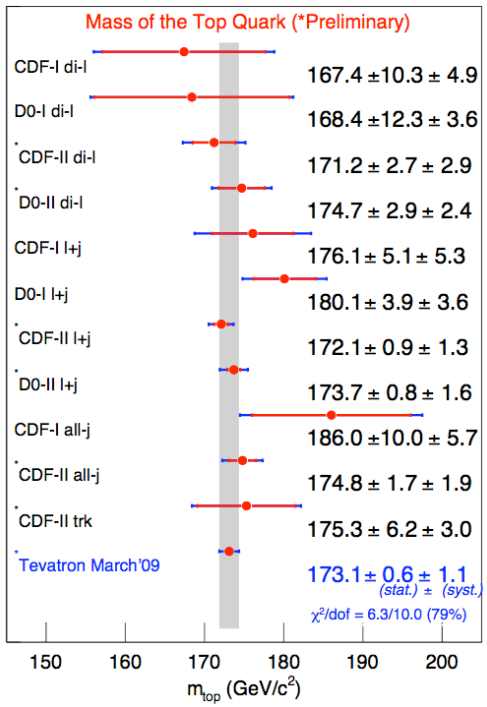
Physics Case II



- Cross collaborations

Already exist at LEP, Tevatron, HERA, Babar+Belle (in progress)

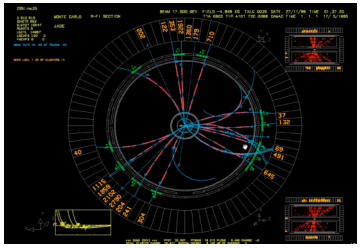




Preserved data would make possible more combined analyses across experiments

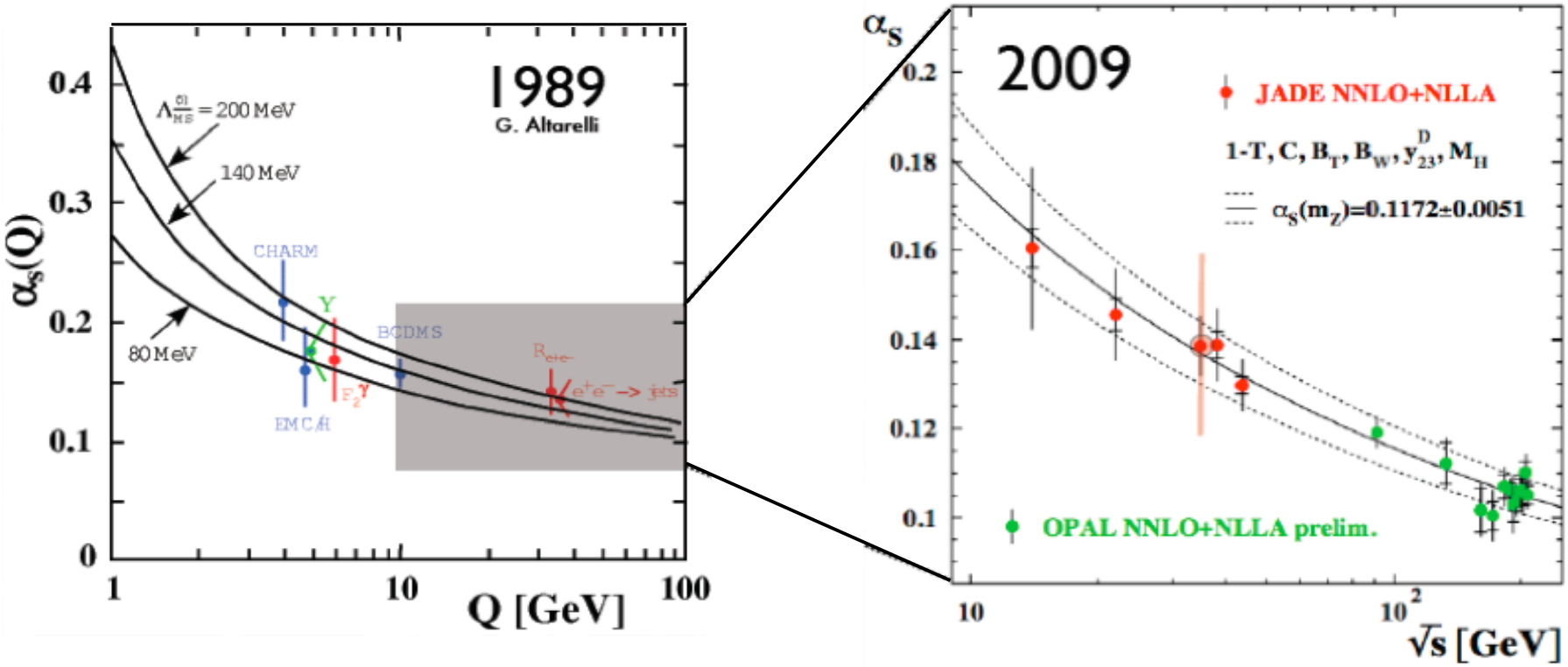
Physics Case III

- Data re-use
  - Improve precision on former measurements
  - apply new and improved theoretical predictions
  - check new physics in the old data samples
  - investigate discrepancies



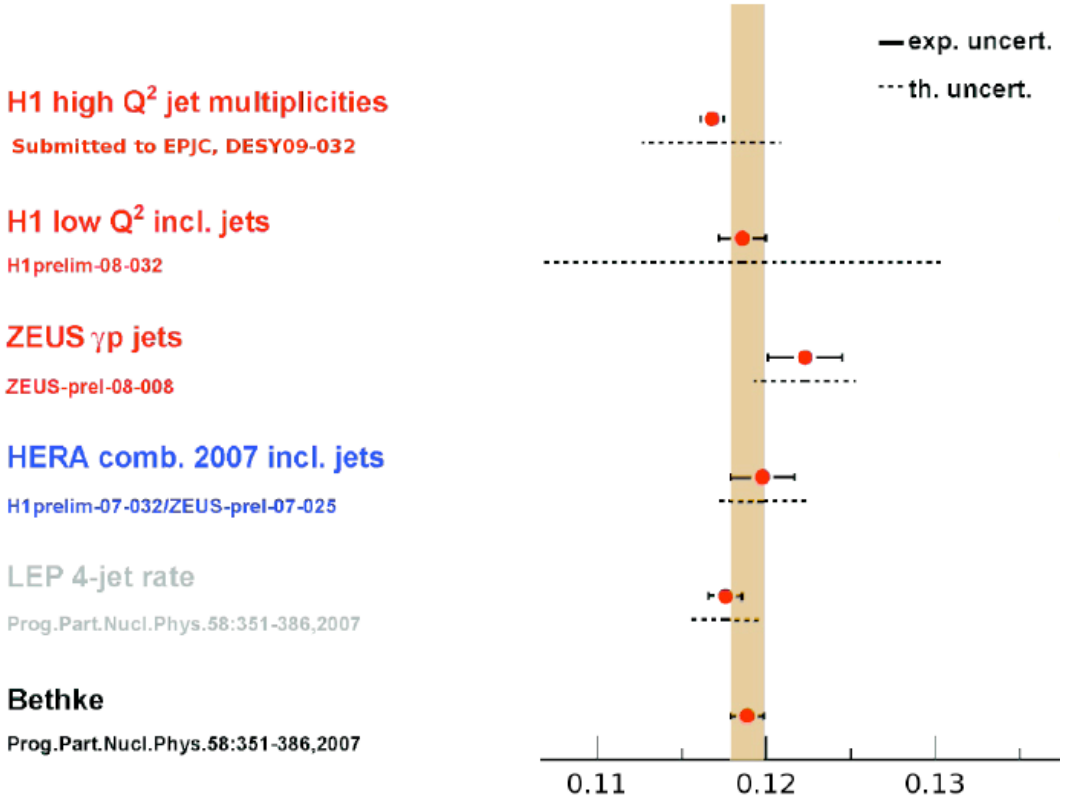
JADE: raw data preservation, software revitalisation individual initiative

10 publications



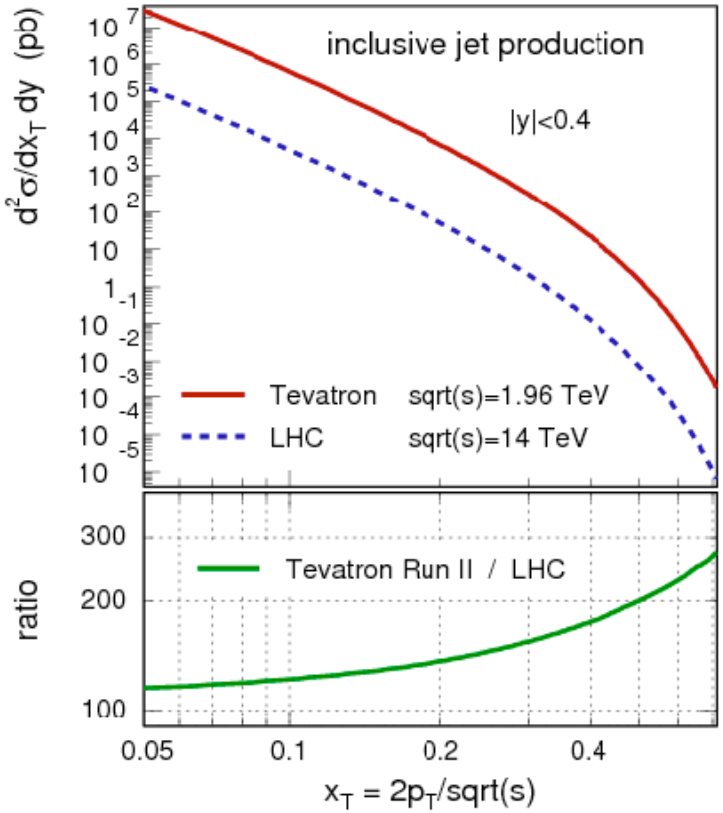
The history may well repeat itself….

- ~10% of the measurements are dominated by non-experimental errors: theory, simulation



Another example: high x constraints from Tevatron

Inclusive Jets: Tevatron vs. LHC



PDF sensitivity:

→ Compare Jet Cross Section at fixed xT = 2pT / sqrt(s)

Tevatron (ppbar)

>100x higher cross section @ all xT

>200x higher cross section @ xT>0.5

LHC (pp)

- need more than 1600fb-1 luminosity to compete with Tevatron@8fb-1
- more high-x gluon contributions
- but more steeply falling cross sect. at highest pT (=larger uncertainties)

→ Tevatron results will dominate high-x gluon for some time …

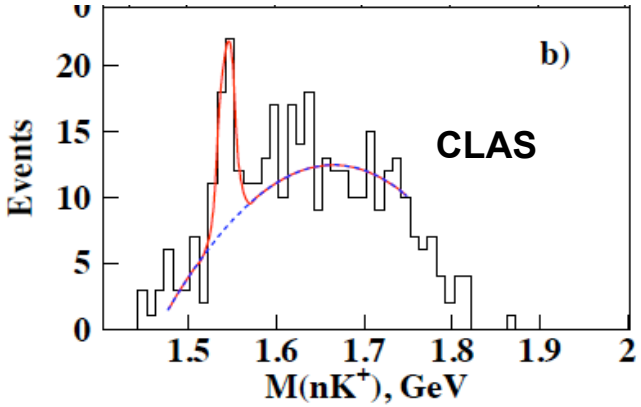
21

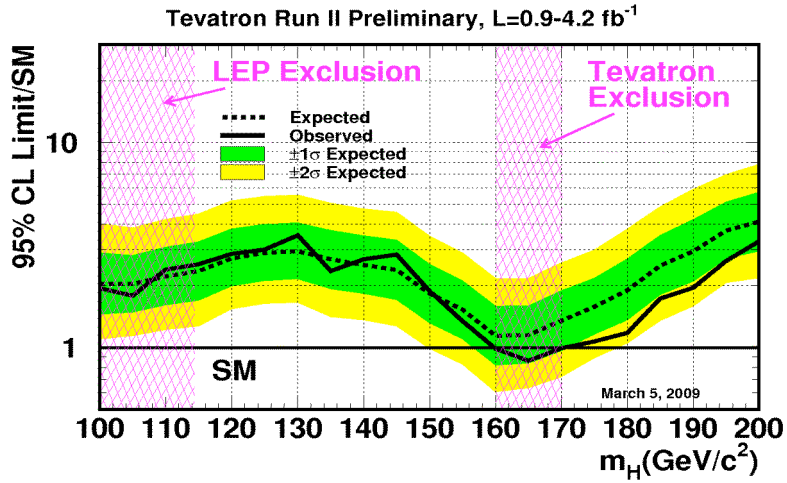
M. Wobisch

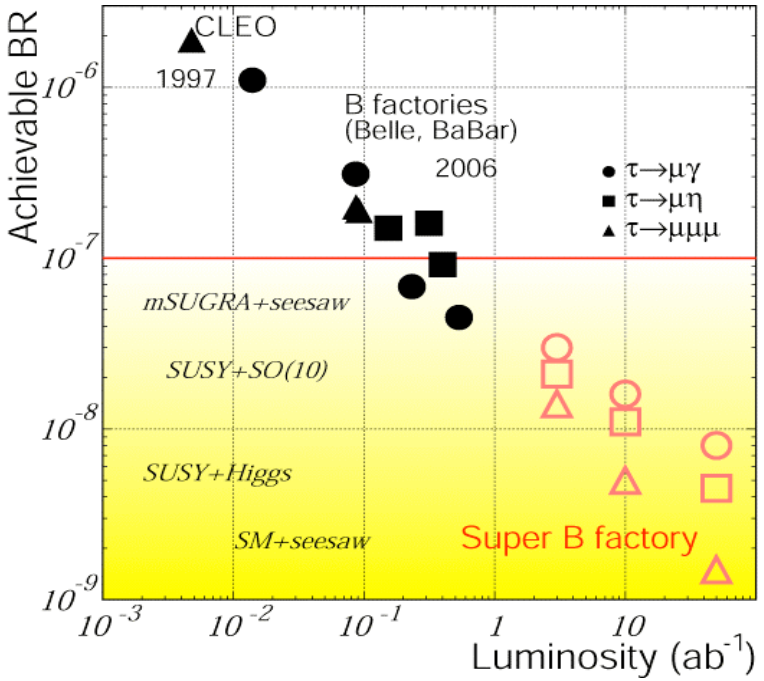
More examples: contingency with future programs

- Tevatron/LHC
- B- and SuperB-factories
- Low energy

...surprises can occur
at lower energies too



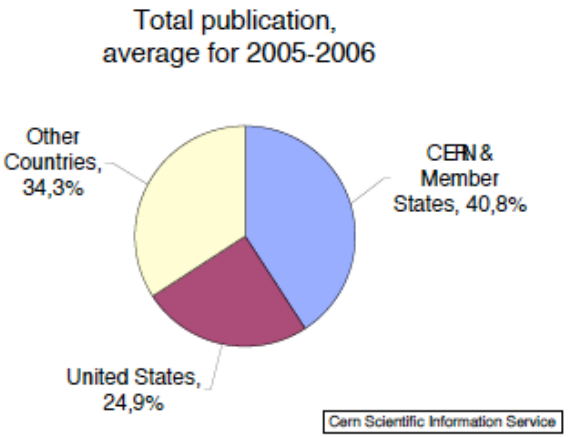


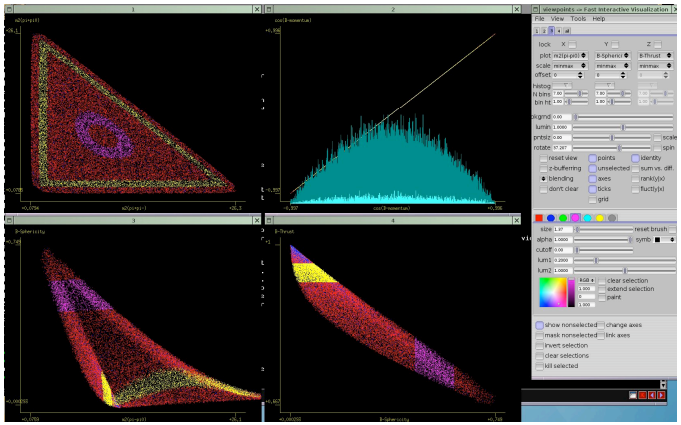


Physics Case IV

- Scientific training, education

Outreach



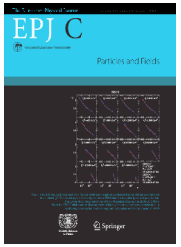


M. Bellis

Improve the overall high level education in HEP

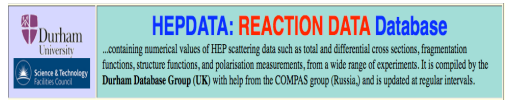
Improve the connection of HEP-emerging countries to HEP data sets

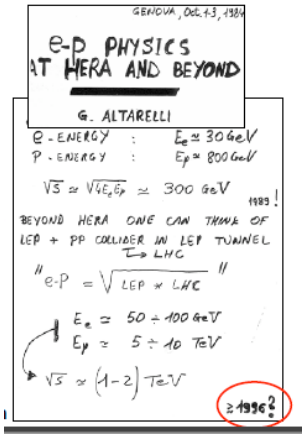
What is “HEP data”?



Journal of High Energy Physics
A refereed journal, written, run and distributed by electronic means

SPIRES → INSPIRE alpha

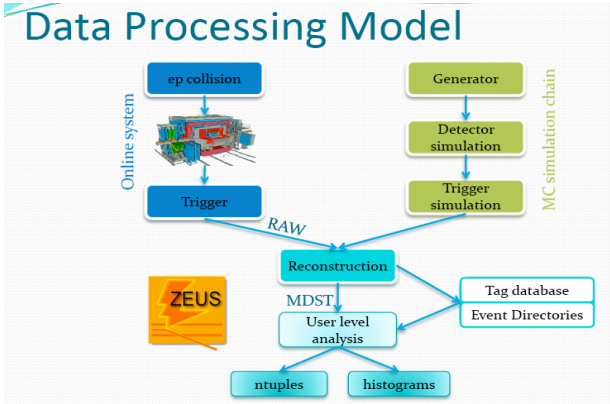


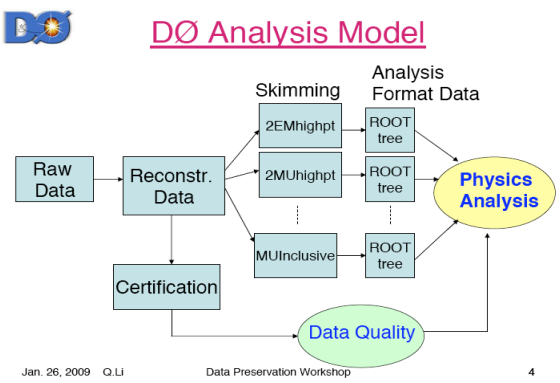


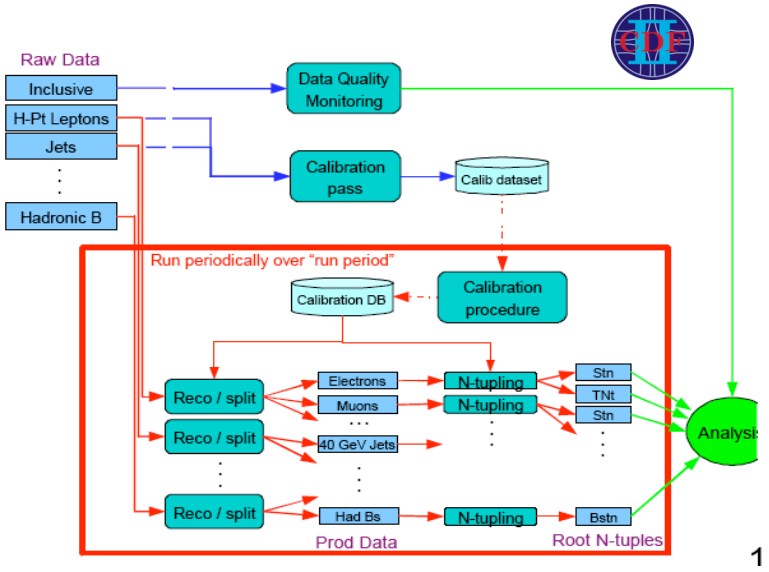
entropy

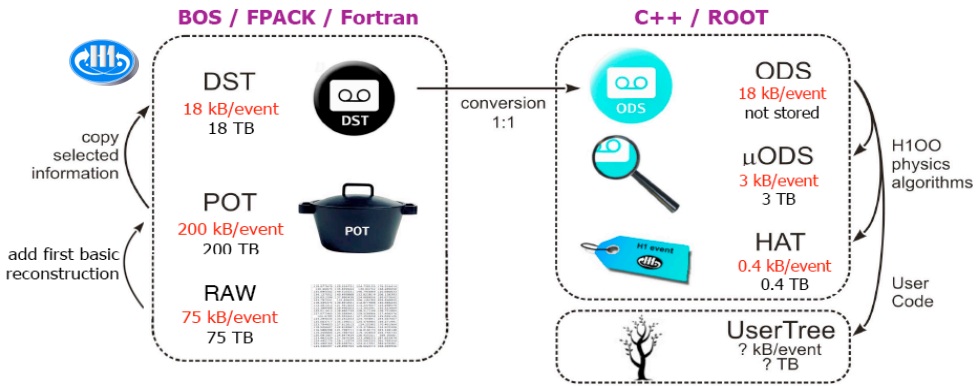
- Publications (journals, arxiv, spires, hepdata….)
- Digital information: event files, database
- Software: simulation, reconstruction, analysis, user
- Documentation: publications, notes, manuals, slides
- “Meta” information: news, messages
- Expertise (people)

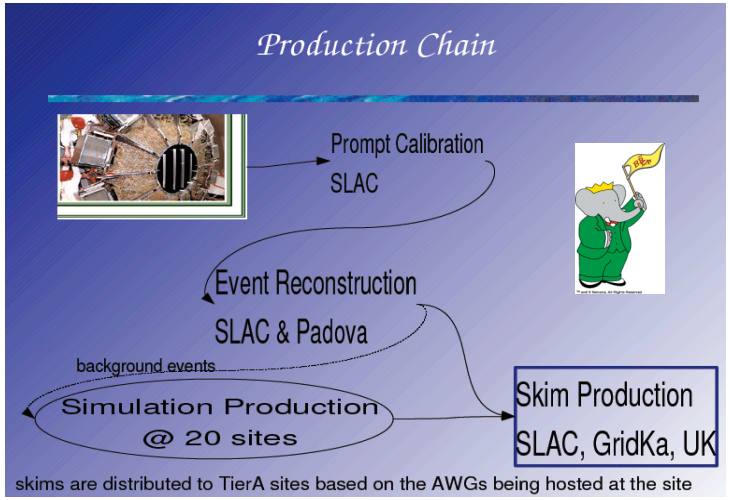
HEP Data Analysis Models







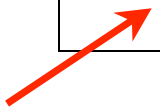




- Familiar descriptions of data analysis chain, from reconstruction to analysis level
  - RAW → POT → DST → *ntuple*

Models of Data Preservation

Preservation Model	Use case
1. Provide additional documentation	Publication-related information search
2. Preserve the data in a simplified format	Outreach, simple training analyses
3. Preserve the analysis level software and data format	Full scientific analysis based on existing reconstruction
4. Preserve the reconstruction and simulation software and basic level data	Full potential of the experimental data



JADE
Babar
H1

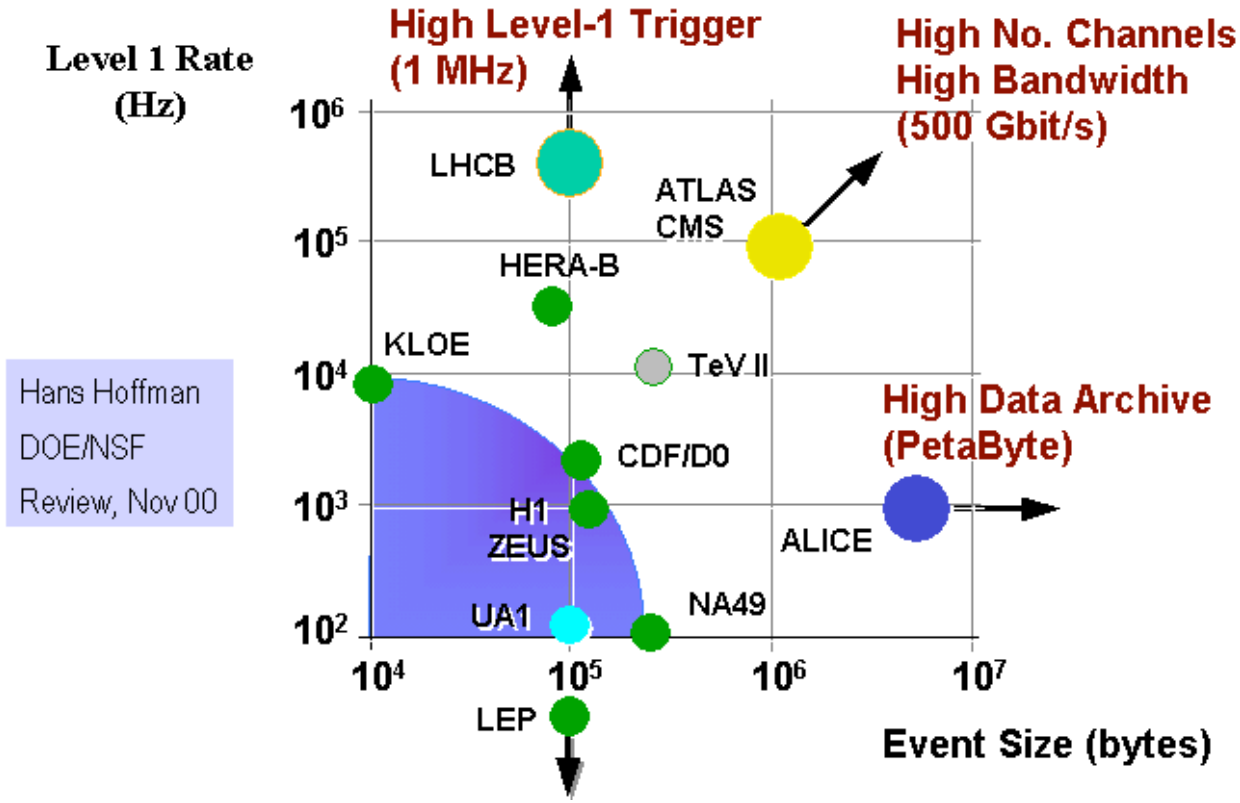
Each level implies an R&D project at experiment level

Technological issues

"Digital information lasts forever -- or five years, whichever comes first."
Jeff Rothenberg, RAND Corp.

- Computing centers are (in principle) able to store the data
  - 0.5 to 10 Pb /exp.
  - Total cost of data storage double current costs: 1 + 1/2 + 1/4 + 1/8 .. = 2
- Technological evolution and data migration
  - Software maintenance is the real issue
  - Preservation, emulation, migration
  - New possibilities: virtualization and cloud computing
- Interface with experiments needs to be defined
  - Procedures, agreements, resources
  - Supervision and custodianship of data sets, archival expertise

Data Samples



Storage technology should be comfortable by the end of the experiment
Migration should be carefully planned

Generic models for Data Preservation

- The HEP models could follow one of the three directions already discussed elsewhere (DPC handbook)
  - Technology preservation

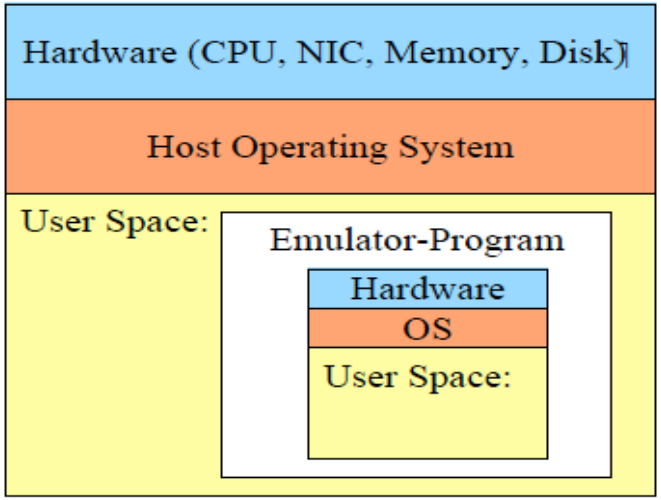
    Freeze the hardware : limited capability, one day it will fall apart however
  - Technology emulation

    Prepare it once (?), migrate the "middleware"
  - Continuous migration

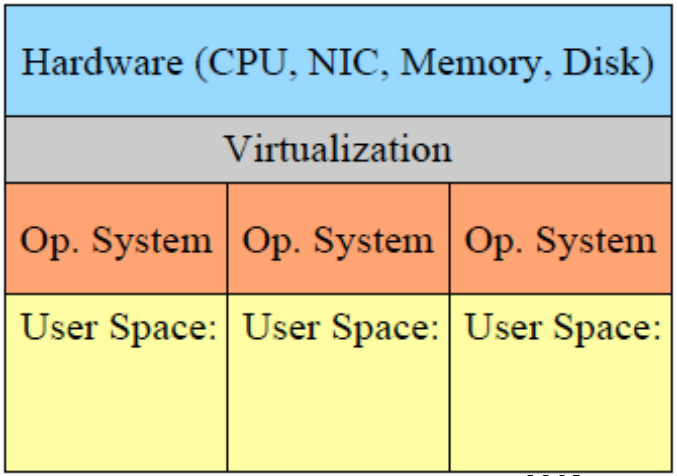
    Follow technology changes (adjust, redesign, recompile etc….)

Emulation and virtualisation

Emulation



Virtualisation



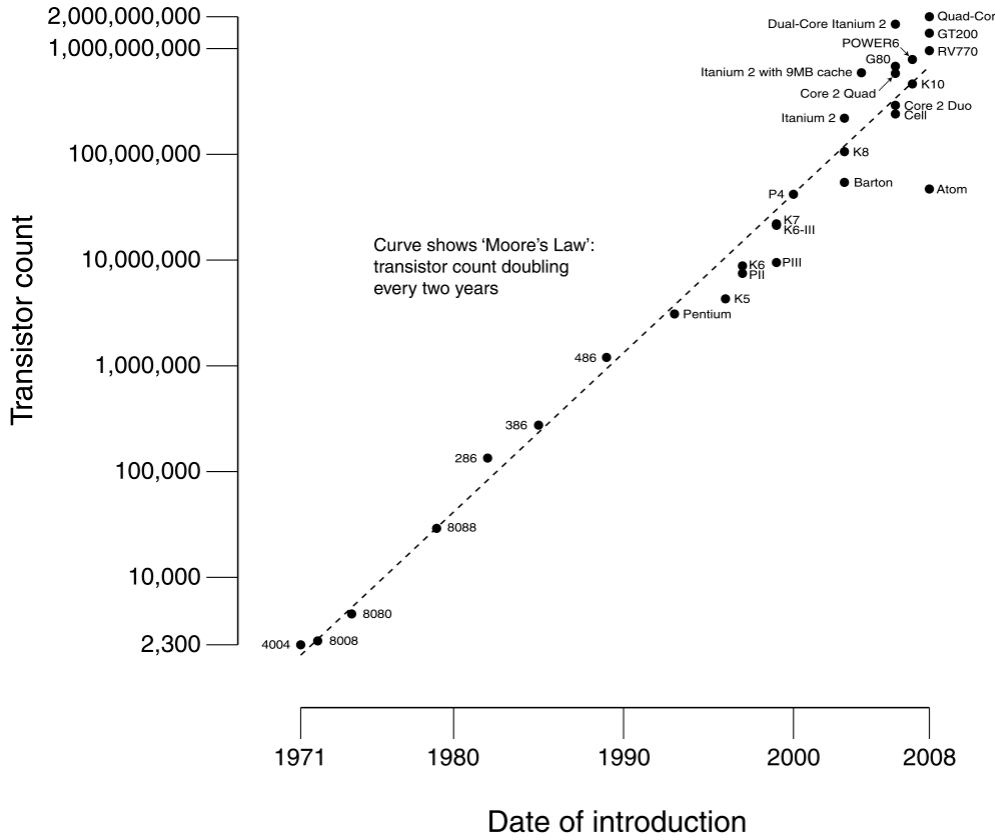
Y.Kemp

An different operating system can be “preserved”
Can a HEP computing environement also be preserved this way?

Computing power

wikipedia

CPU Transistor Counts 1971-2008 & Moore's Law



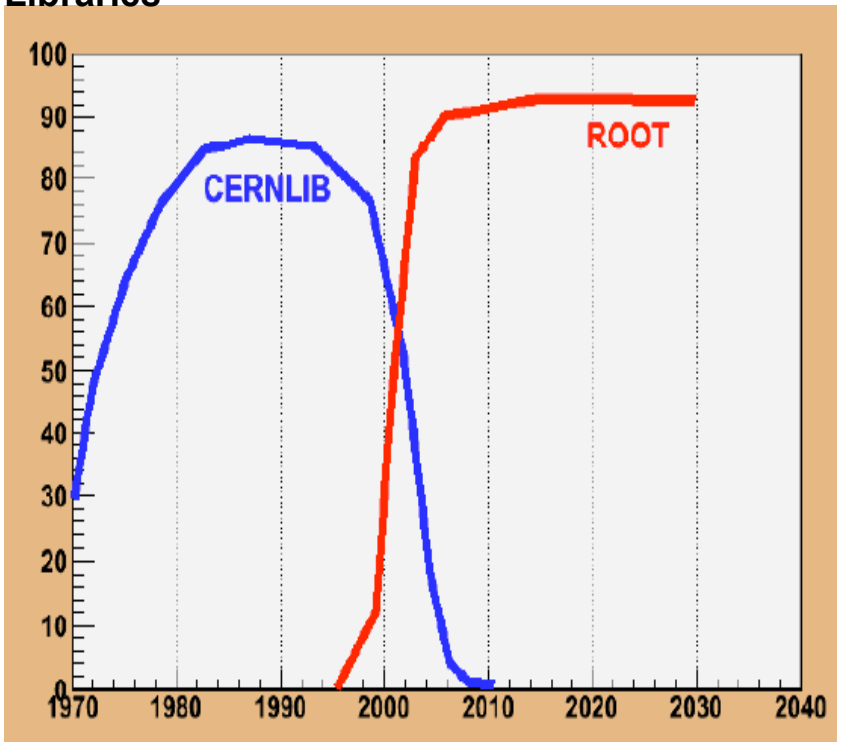
The archival system should be prepared to absorb the technological evolutions

Analysis software

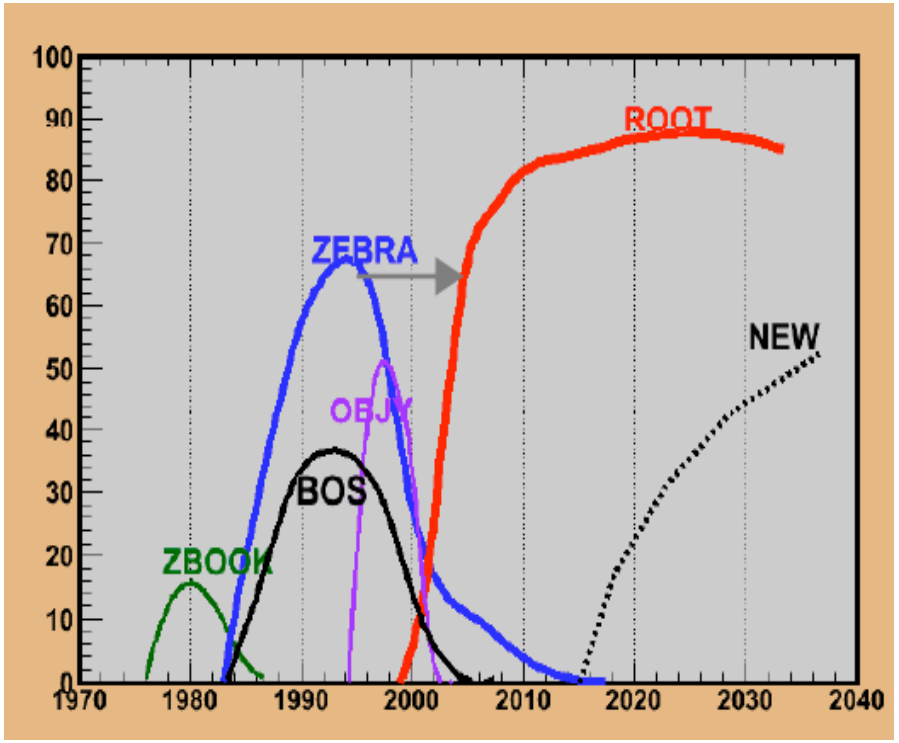
Software is a source of concern: maintainance, migration, validation

"Errors using inadequate data are much less than those using no data at all."
Charles Babbage

Libraries



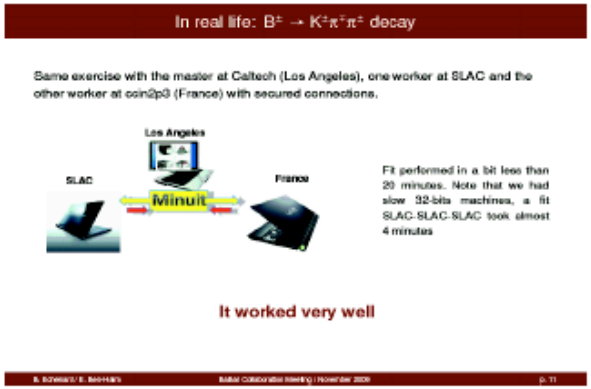
I/O **R. Brun**

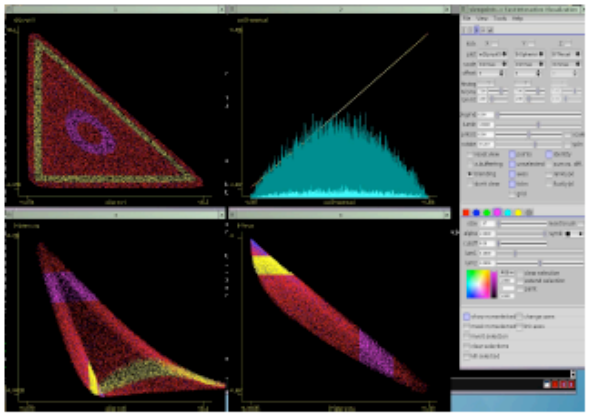


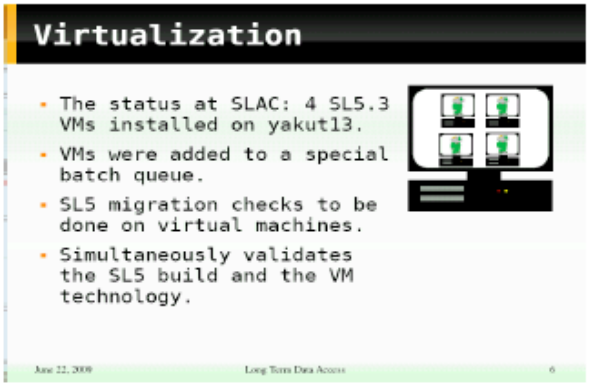
Root offer the needed coherence in the next few decades
Many other dangers: comercial, "ghosts" etc.

An example: Babar Archival project

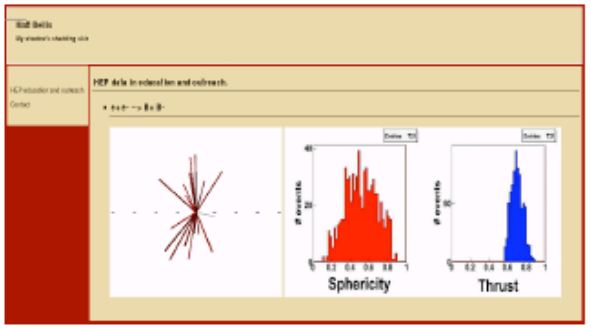
BaBar & Belle collaborating







Outreach tools/data already being used in classrooms



Also major advancements in the use of cloud computing

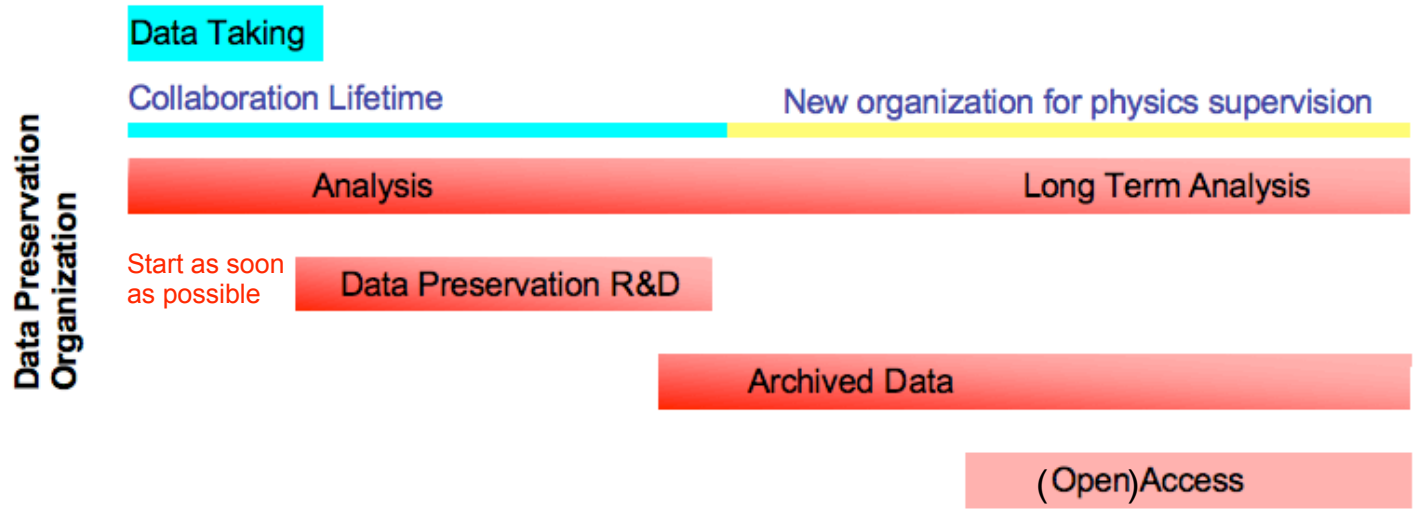
Similar activities at HERA

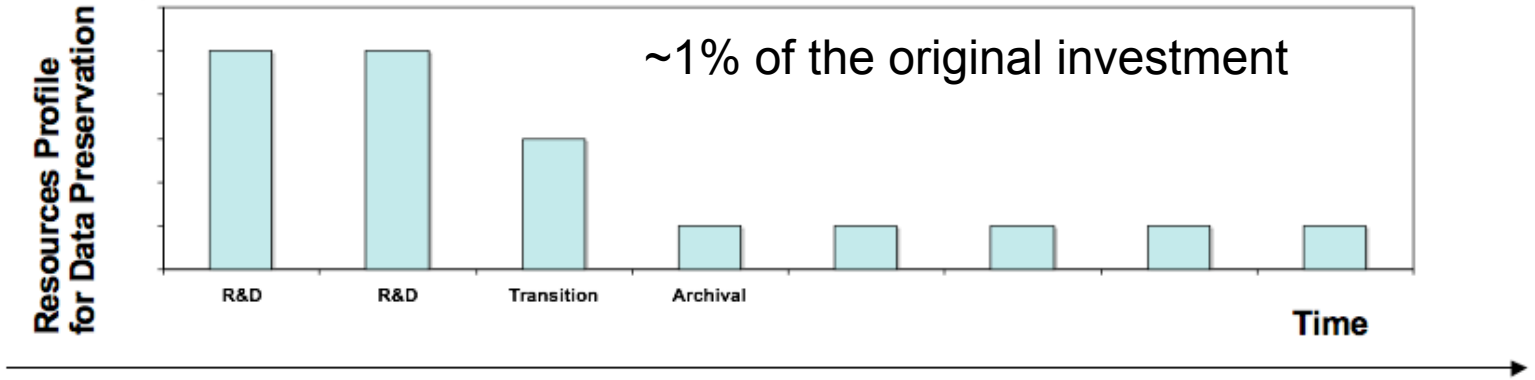
Governance

- Preserved data sets management
  - Scientific supervision of the preserved data sets
  - Authorship and Access to data
  - Channels to outreach and education
  - Endorsement: experiment, laboratory and funding agencies
  - HEP global solutions: common policy and standards

Transition scenario and resources

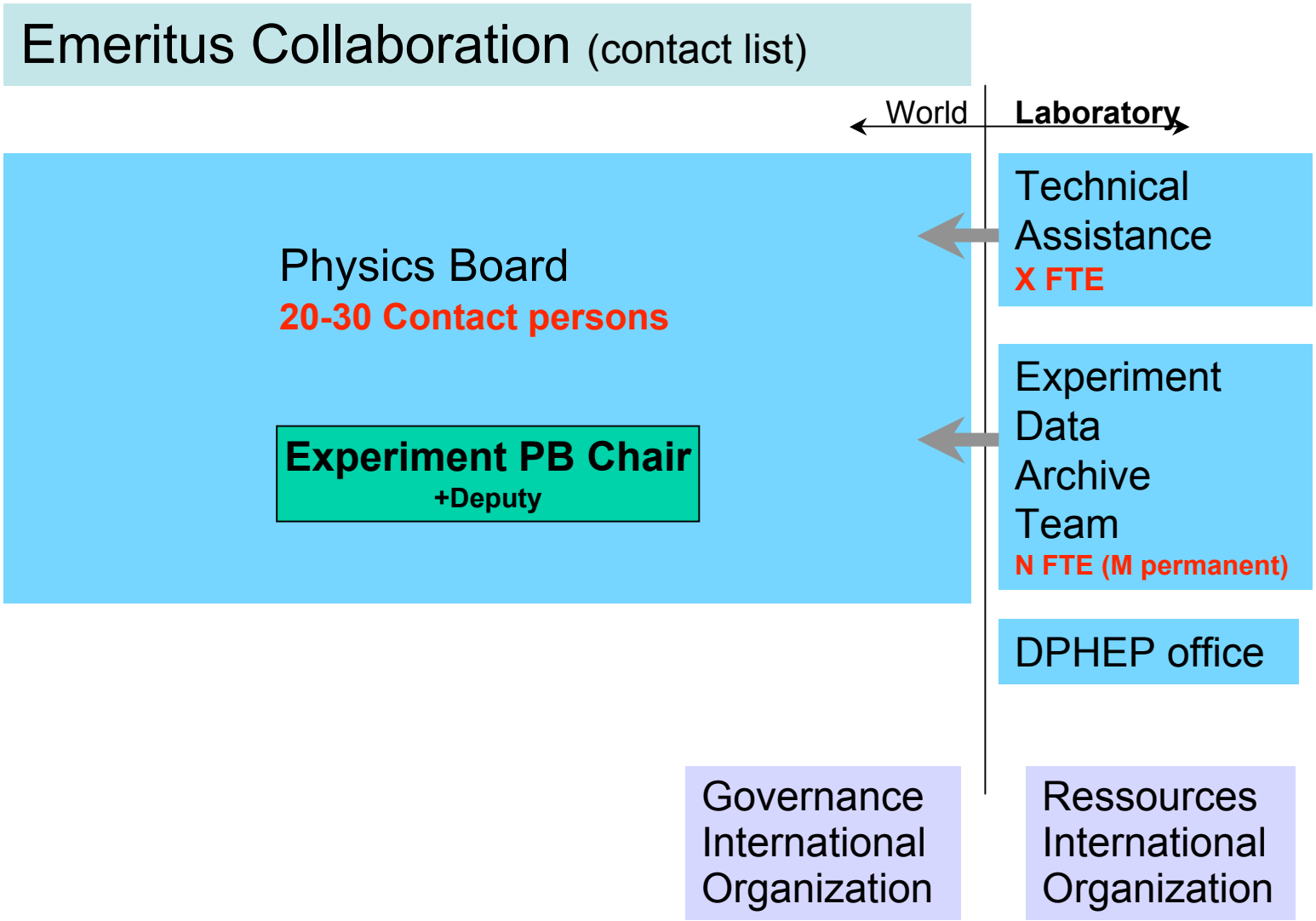
(experiment level)





Towards an International Organization

A long term organization of HEP experiments



Interactions with other fields

- Input is very valuable for HEP, little experience in the field
  - Connections with Data Archivists
  - General projects on digital preservation
  - Astrophysics

A word from archivists

DOE Research and Development Records Schedule

Scientific Data:

- Raw data (all levels)
  - 10 year retention (N1-434-07-01, item 4c(12)
- Evaluated or Summarized data
  - Level 1: permanent retention (N1-434-96-9, item1B13a)
  - Level 2: 25-year retention (N1-434-96-9, item1B13b
  - Level 3: 10-year retention (N1-434-96-9, item1B13c)

Deken -- 2nd Workshop on Data Preservatio

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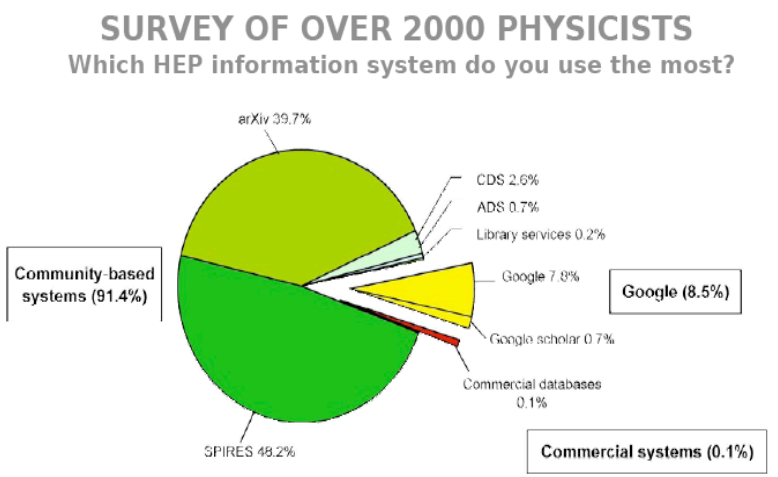
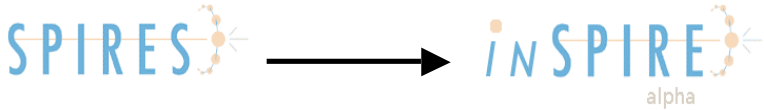




Other fields

- Task forces already in place to address this issue in a generic way
  - e.g. Blue Ribbon, APA, DPC, eSciDir, …

http://www.alliancepermanentaccess.eu
http://brtf.sdsc.edu
(intermediate report and references)

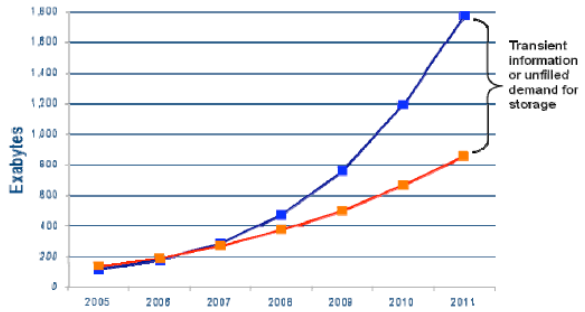


FIGURE 1.3: **Information and Storage**
Source: J. Gantz January 2008 (revised). Used with permission.

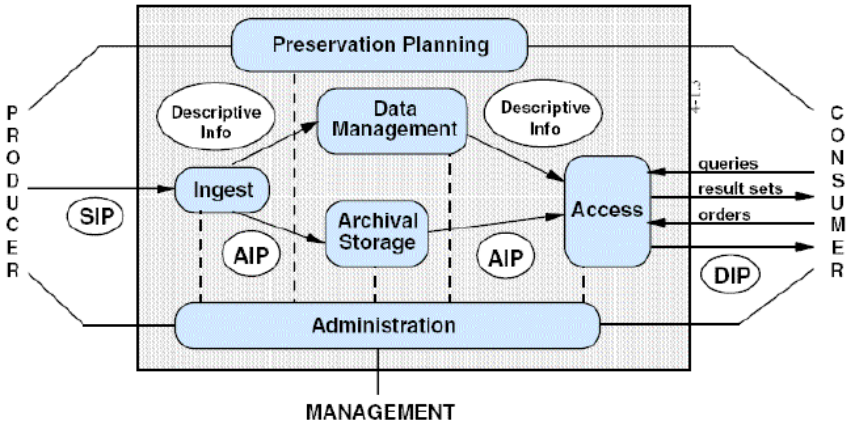
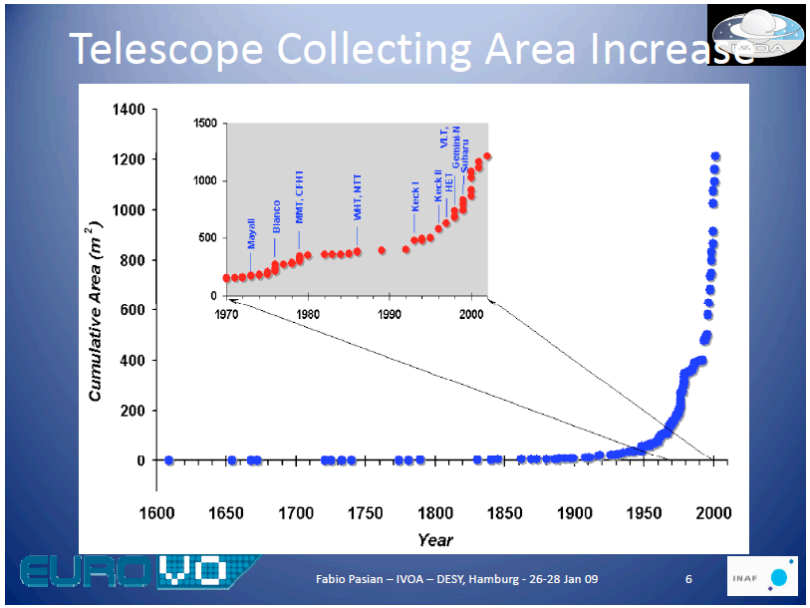
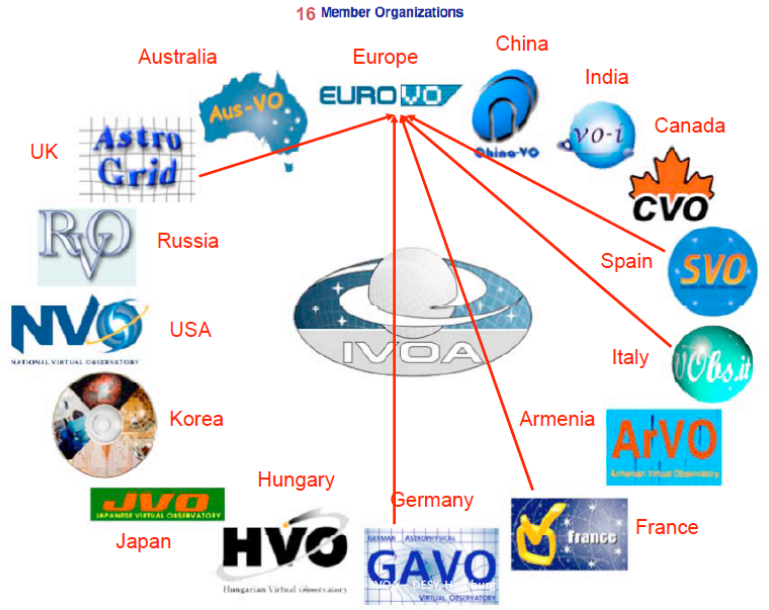


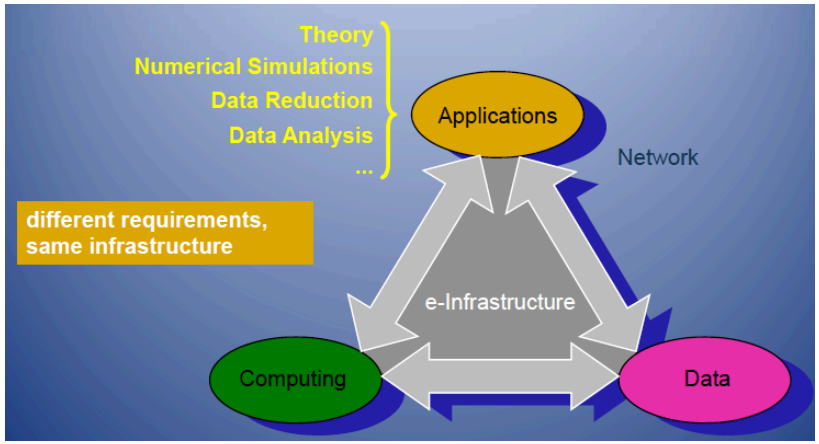
FIGURE 2.1: **The OAIS Reference Model**
http://public.ccsds.org/publications/archive/650x0b1.pdf, Page 4-1.
Source: Consultative Committee for Space Data Systems January 2002.

- Scientific Data is a major component of the ongoing efforts (complexity)
- Some scientific fields are well advanced : astrophysics

Virtual Observatories in Astrophysics



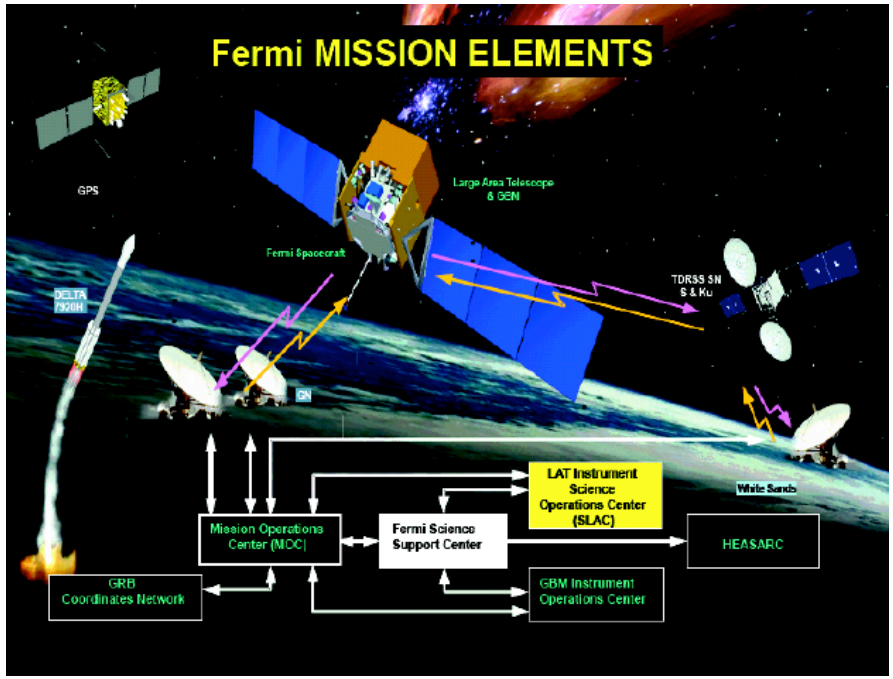


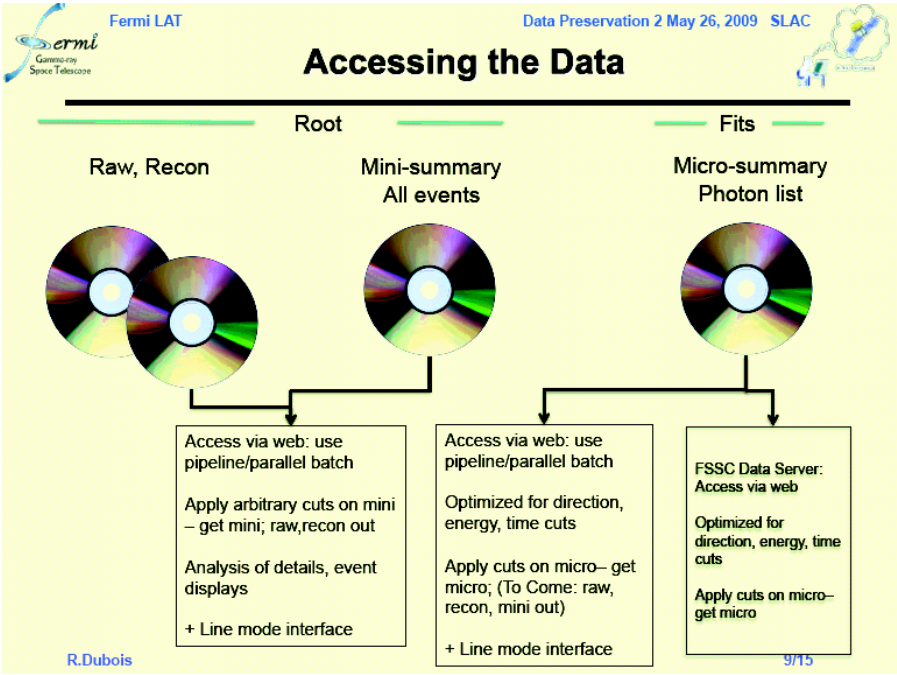


F.Pasian

- Data Archives Inter-operable
- Work on standards and access to
  - Data, simulation, mining techniques
- International, multi-experiment

Open access in astrophysics





LAT Principal Investigator Peter Michelson added: **"The LAT team has made significant discoveries and significant progress in many areas. I expect that the collaboration will continue to come out with the most results, but I also expect others to make discoveries. Releasing this data is good for the project, good for the collaboration, and good for science."**

—Kelen Tuttle

SLAC Today, August 25, 2009

ICFA-DPHEP Recommandations

- ICFA document: A broad reflection on benefits and strategies, a few recommendations
  - Prioritization against other general issues in HEP (new experiments, funding, resources) is **not** addressed at this stage

1. Data preservation beyond the end-date of experiments opens up future scientific opportunities. Given the present status of experimental programs at most facilities, an urgent and vigorous action is needed to ensure data preservation in HEP.
2. Different levels of data preservation and usability are possible. The preservation of the full analysis capability of experiments is recommended, including the preservation of reconstruction and simulation software. A dedicated project in each experiment is needed to assess the corresponding technological requirements.
3. The technological aspects of data preservation are well within the reach of large computing centres in HEP. Nevertheless, an interface to the experiment know-how should be introduced. The most efficient solution would be the creation of a data archivist position, in charge with the preservation of the data analysis capabilities.
4. The preservation of HEP data requires a synergic action of all stakeholders: experimental collaborations, laboratories and funding agencies. A clear and internationally coherent policy should be defined and implemented.
5. An International Data Preservation Forum is proposed as a reference organisation, with the mandate to organise and overview HEP data preservation initiatives; to discuss and propose solutions to technological or policy issues; to evolve into a clearing house for policies for access and re-use of preserved data. The Forum should represent experimental collaborations, laboratories and computing centres.

Feedback from the Advisors

Jonathan Dorfan (SLAC), Siegfried Bethke (MPI Munich), Gigi Rolandi (CERN), Michael Peskin (SLAC), Dominique Boutigny (IN2P3), Young-Kee Kim (FNAL), Hiroaki Aihara (IPMU/Tokyo)

- Very positive feed back to the initiative
- Document more examples of physics case
- Be more quantitative on preservation models
- Clarify the physics supervision and the relation with the open access philosophy
- Encourage full preservation model (level 4) for full physics capabilities and publications
- Associate time scales with the preservation models
- Explore models used in astrophysics
- Strong support to follow a global approach

ICFA decisions

- Support data preservation in high energy physics
- Endorse the International Study Group as an ICFA subgroup
- Nominate a Chair of the subgroup (C.Diaconu 2009/2010)

Milestones for 2009/2010

- Document made public
  - Including advisory committee and ICFA recommendations
- Two workshops DESY and SLAC
  - 7-9 December 2009 (CERN)

    Review proposals for preservation models, more quantitative estimations

    Steps towards global organization
  - Mid 2010

    Prepare blueprint for concrete proposals, including costs estimates
- Prepare for Data Preservation funding programs (EU/DOE/NSF)

Conclusion and outlook

- Data preservation in HEP is important because:
  - It is based on a relevant physics case
  - It is timely, given the experimental situation and plans
  - Enhance the return on investment in the experimental facilities
  - It is most likely cost-effective, provides research at low cost
- Requires a strategy and well-identified resources
- International cooperation is the best way to proceed
  - **Unique** opportunity to build a coherent structure for the **future**