DPHEP: From Study Group to Collaboration.

Data Preservation in High Energy Physics

David South (DESY)
on behalf of the DPHEP Collaboration

arXiv:1205.4667

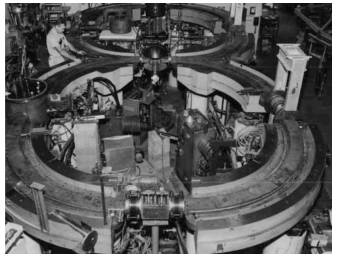
HELMHOLTZ ASSOCIATION

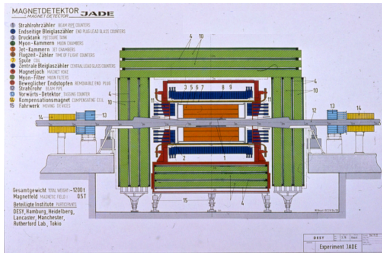
XXI International Workshop on Deep-Inelastic Scattering and Related Subjects
Marseille Congress Centre April 22-26 2013

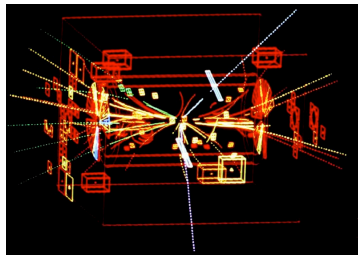
DESY

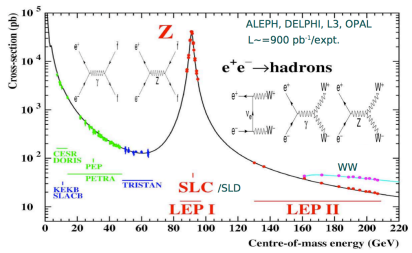
Experimental particle physics in the collider era

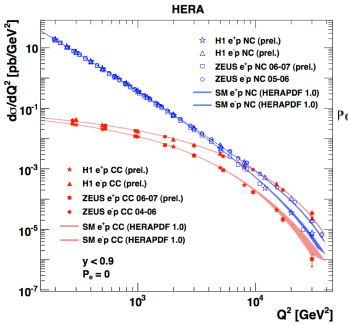
- A wide variety of physics results from many, often very different experiments
- Energy frontier probed with increasingly complex accelerator installations
  - New experiments typically supersede previous, similar ones - but not always
- Growth in size of the necessary international collaborations, as well as the diversity of the data management
- The age of the LHC has truly arrived
  - Belle 2, HL-LHC, and other projects such as the ILC or next e-p/A collider are to come

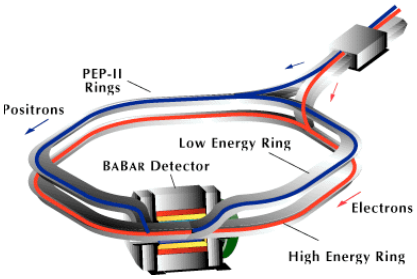


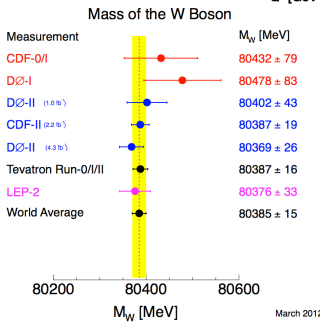


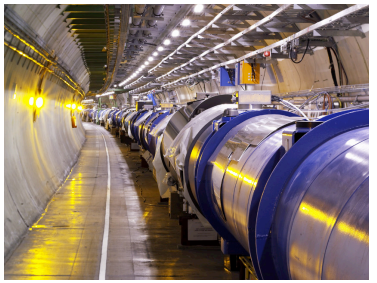




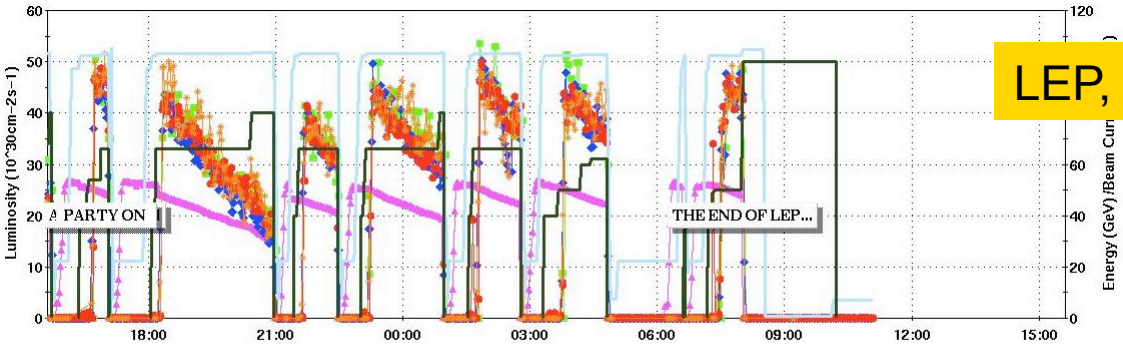




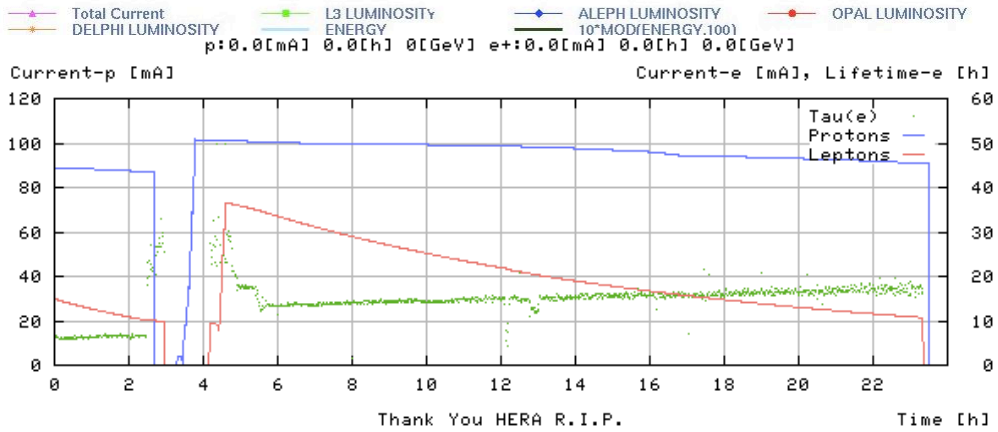




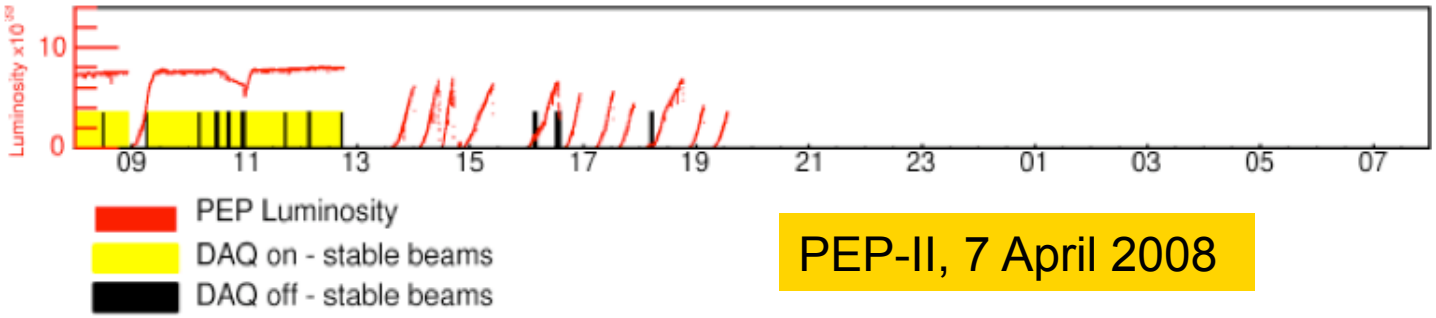
The last years have seen the end of several experiments



LEP, 2 November 2000



HERA, 30 June 2007



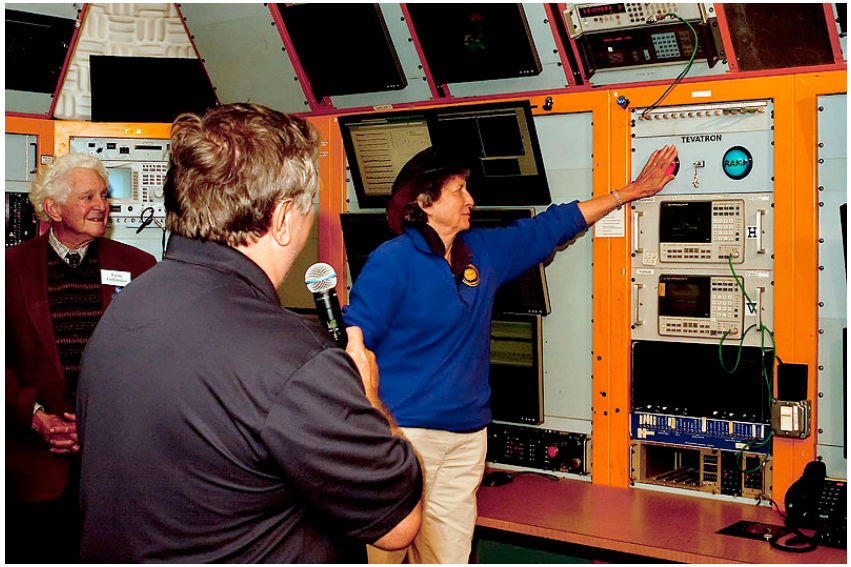
Mon Apr 7
04:34h (19.0%) Stable Beams
04:15h (93.1%) DAQ on
84.6/pb Recorded Lumi
1.3% Deadtime
18s DCH paused (# 4)

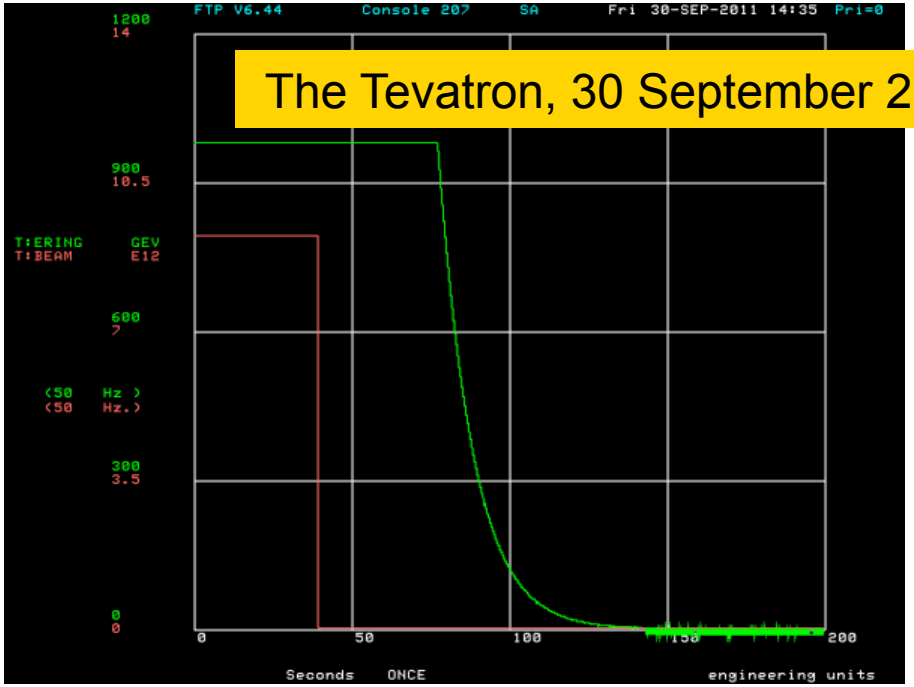
PEP-II, 7 April 2008

The last years have seen the end of several experiments

KEKB, 30 June 2010

The Tevatron, 30 September 2011





What do you do when the collisions have stopped ?

- Finish the analyses! But then what do you do with the data?
  - Until recently, there was no clear policy on this in the HEP community
  - It's possible that older HEP experiments have in fact simply lost the data
- Data preservation, including long term access, is generally not part of the planning, software design or budget of an experiment
  - So far, HEP data preservation initiatives have been in the main not planned by the original collaborations, but rather the effort a few knowledgeable people

- The conservation of tapes is not data preservation!
  - *"We cannot ensure data is stored in file formats appropriate for long term preservation"*
  - *"The software for exploiting the data is under the control of the experiments"*
  - *"We are sure most of the data are not easily accessible!"*

DESY

The difficulties of data preservation in HEP

- Handling HEP data involves large scale traffic, storage and migration
  - The increasing scale of the distribution of HEP data can complicate the task
- Who is responsible? The experiments? The computing centres?
  - Problem of older, unreliable hardware: unreadable tapes after 2-3 years
  - The software for accessing the data is usually under the control of the experiments
- Key resources, both funding and person-power expertise, tend to decrease once the data taking stops
- And a rather key ingredient to all this is: *why do it?*
  - Can the relevant physics cases be made?
  - Who says we want to do this anyway?
  - Is the benefit of all this really worth the cost and effort?

DPHEP: An international study group on data preservation

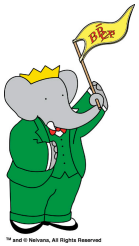
DPHEP Study Group for Data Preservation and Long Term Analysis in High Energy Physics

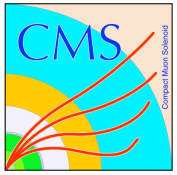
- First contacts established in September 2008
  - Group since grown to over 100 contact persons
  - Endorsed as an ICFA panel since summer 2009
  - Initial make up of the group was driven by the coincidence of the end of data taking at several large colliders – SLAC, HERA, Tevatron - but now has grown to include others including the LHC experiments

- Steering Committee with representatives from all members in addition to an International Advisory Committee

DESY

DPHEP: An international study group on data preservation






Institute of High Energy Physics
Chinese Academy of Sciences



Science & Technology
Facilities Council


dphep.org

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

Home | People | Committees | Subgroups | Workshops | Documents | Work Space | Press

DPHEP

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

Joint DASPOS / DPHEP-7 Workshop at CERN, March 21-22 2013

Publication from May 2012, available here:

Status Report of the DPHEP Study Group: Towards a Global Effort for Sustainable Data Preservation in High Energy Physics

6th DPHEP Workshop at CPPM, Marseille, November 19-21 2012

DPHEP@CHEP2012: DPHEP Session at CHEP 2012, New York, May 24 2012

High Energy Physics experiments initiate with this **Study Group** a common reflection on **data persistency and long term analysis** in order to get a common vision on these issues and create a multi-experiment dynamics for further reference.

The objectives of the Study Group are:

- Review and document the physics objectives of the data persistency in HEP.
- Exchange information concerning the analysis model: abstraction, software, documentation etc. and identify coherence points.
- Address the harware and software persistency status.
- Review possible fundings programs and other related international initiatives.
- Converge to a common set of specifications in a document that will constitute the basis for future collaborations.

Since August 2009, the Study Group is endorsed by ICFA (International Committee for Future Accelerators).

A series of workshops have been held by the Study Group, access to which can be found using the links below.
The 3rd workshop was preceded by a public **symposium**.
The **first DPHEP publication**, containing the initial recommendations of the Study Group was released in December 2009.
This was followed by a more comprehesive, **second publication** in May 2012.

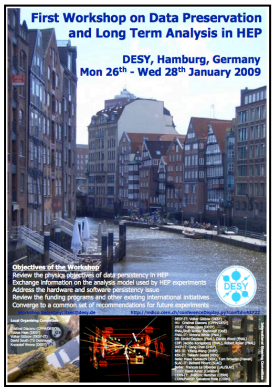
Latest DPHEP Status Report released May 2012, available on arxiv:1205.4667

CERN Courier, April 2009

DESY

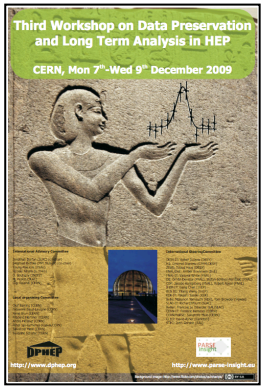
DPHEP: An international study group on data preservation

- Series of DPHEP workshops held since 2009



Jan 2009: DESY

May 2009: SLAC



Dec 2009: CERN

Jul 2010: KEK

May 2011: Fermilab

Nov 2012: CPPM

- The first task of the group was to establish the working directions
  - "To confront data models, clarify the concepts, set a common language, investigate technical aspects, compare with other fields handling large data."

- Initial findings published in an interim report December 2009
  - Focus on four key areas of the study group: Physics Case for Data Preservation, Preservation Models, Technologies, Governance

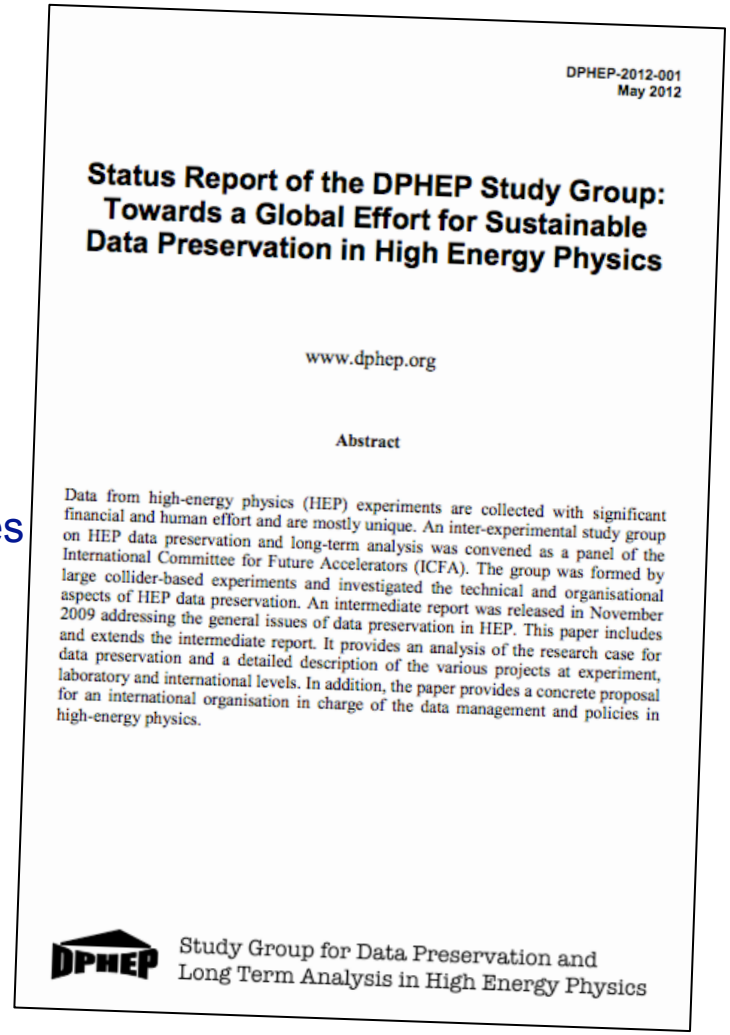
arXiv:0912.0255

Large scale DPHEP publication

- Released May 21st 2012, 93 pages

- Full status report of the activities of the DPHEP study group, including:
  - Tour of data preservation activities in other fields
  - An expanded description of the physics case
  - Defining and establishing data preservation principles
  - Updates from the experiments and joint projects
  - FTE estimates for these and future projects
  - Next steps to establish fully DPHEP in the field

arXiv:1205.4667



DPHEP-2012-001
May 2012

Status Report of the DPHEP Study Group: Towards a Global Effort for Sustainable Data Preservation in High Energy Physics

www.dphep.org

Abstract

Data from high-energy physics (HEP) experiments are collected with significant financial and human effort and are mostly unique. An inter-experimental study group on HEP data preservation and long-term analysis was convened as a panel of the International Committee for Future Accelerators (ICFA). The group was formed by large collider-based experiments and investigated the technical and organisational aspects of HEP data preservation. An intermediate report was released in November 2009 addressing the general issues of data preservation in HEP. This paper includes and extends the intermediate report. It provides an analysis of the research case for data preservation and a detailed description of the various projects at experiment, laboratory and international levels. In addition, the paper provides a concrete proposal for an international organisation in charge of the data management and policies in high-energy physics.

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

DESY

DASPOS

- New initiative in the funded in the US by the NSF, “Data and Software Preservation for Open Science” (DASPOS)
  - Focussed on high energy physics data from the LHC and the Tevatron
  - Complimentary effort to DPHEP, series of workshops focussing on different issues
  - Seventh DPHEP workshop held last month at CERN jointly with DASPOS

DASPOS Workshops

- Use Cases for Archived Data and Software in HEP
- Commonality with other Disciplines
- Data Model and Query Semantics
- Software Sustainability
- Preservation Policy
- Technical Storage Architectures

Data Preservation in High Energy Physics

The DPHEP effort, a Study Group for Data Preservation in High Energy Physics under the auspices of the International Committee on Future Accelerator (ICFA), has produced a study outlining the current state of data preservation within HEP, including an extensive overview of other disciplines. They suggest a series of guidelines for HEP data preservation efforts, as well as a framework for global coordination. Their conclusions include a recognition of the scientific potential for data re-use, especially the desirability to preserve full analysis capability. They also emphasize the urgency required to begin and sustain global, coordinated data preservation efforts.

For the purposes of discussing preservation efforts, the DPHEP studies have identified different types of HEP data that span the full set of possibilities, ranging from publications, metadata, associated documentation of all types, software, digital information (the data themselves) and finally expertise and human resources. Digital information can be categorized by four tiers covering the scope from publications to the raw data and the software used to process it. As outlined by DPHEP, the four tiers are:

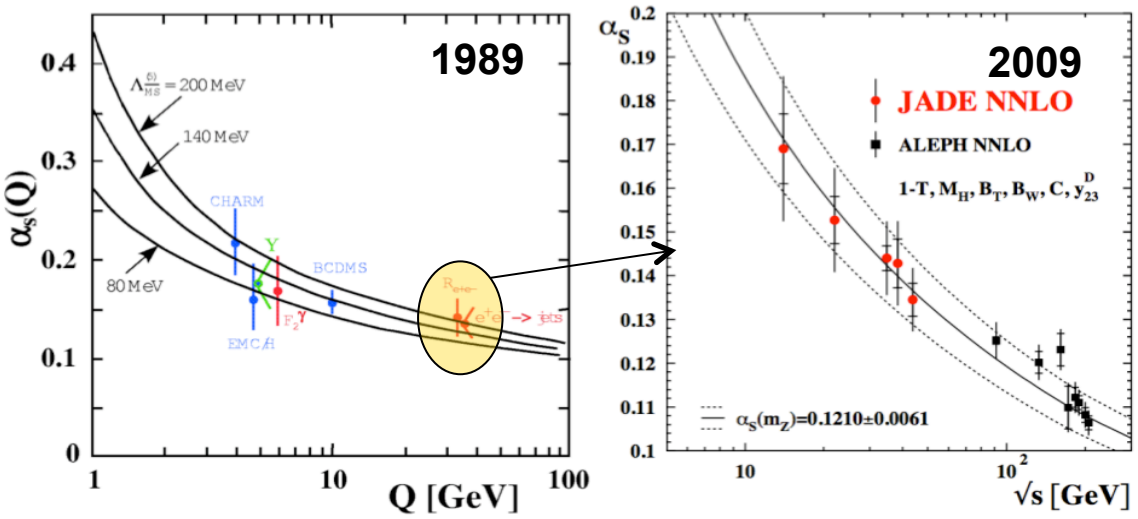
1. Published results, along with additional analysis-related information, leading to more complete documentation of a given analysis
2. Processed data available in a simplified format (i.e., particle four vectors) that can be used for outreach and simplified additional analyses
3. The full processed experimental data and simulated data and the associated software for accessing and analyzing the data
4. The full raw data of the experiment and all of the reconstruction software necessary for processing the data into a form where it can be useful for analysis, as well as the simulation software needed for modeling

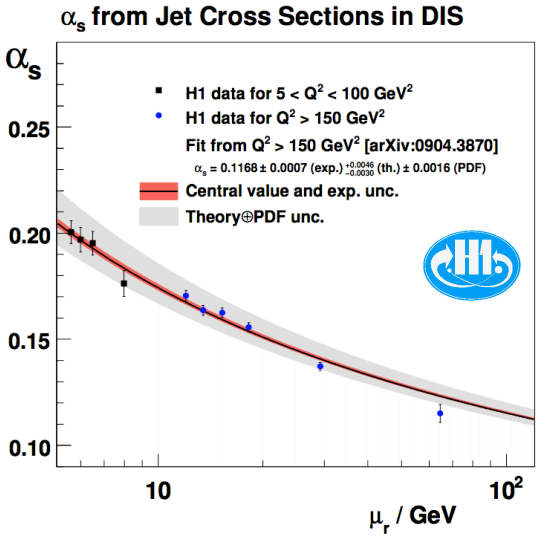
daspos.crc.nd.edu

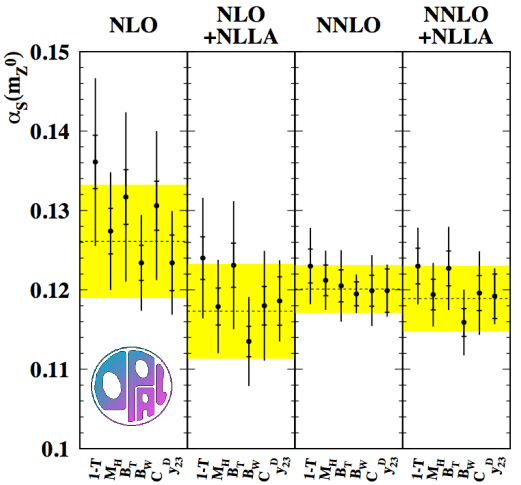
Building the physics case: Reasons to preserve HEP data

- Long term completion and extension of an existing physics program
  - Up to 10% of papers are finalised in the "archival mode"
  - Gain in scientific output of the experiments
- Cross-collaboration and combinations of physics results
  - During the active lifetime of similar experiments at one facility: LEP, HERA, TeVatron
  - And later across larger boundaries: Belle/BaBar, TeVatron/LHC
- Revisit old measurements or perform new ones
  - Access to newly developed techniques, comparisons to new theoretical models
  - Unique data sets available in terms of energy, initial states
- Use in scientific training, education, outreach
  - Simplified formats: associated exercises to perform e.g. composite-particle reconstruction, finding signals in the background, ...

Example: Revisit old measurements or perform new ones

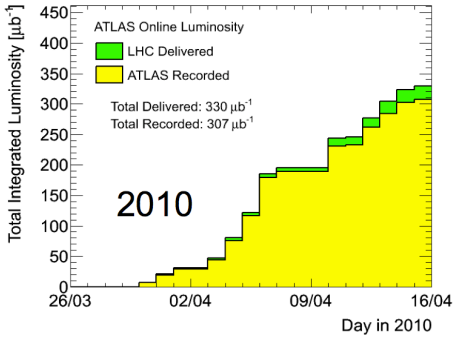




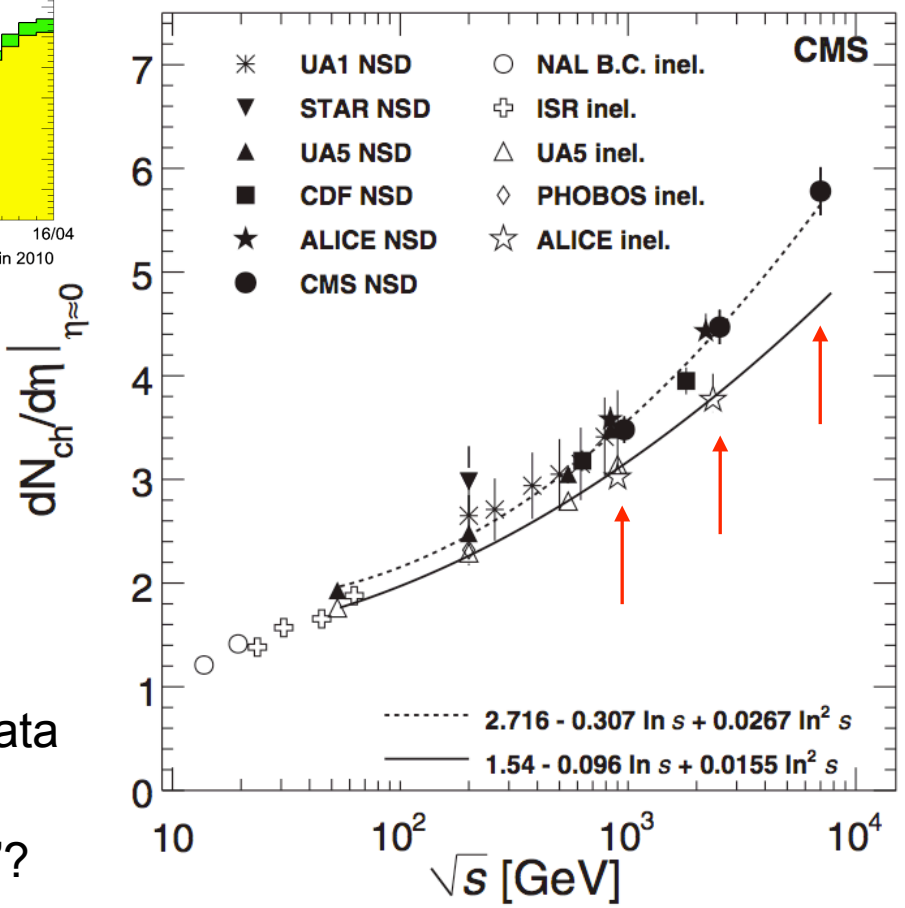


- Access to newly developed techniques, comparisons to new theoretical models
  - History may be repeated with the HERA α_s measurements
- Unique data sets are available in terms of initial state particles and energy
  - If no LHeC or alternative, all he have are the HERA $e^{\pm}p$ data
  - Tevatron $p\bar{p}$ are also unique, A_{FB}, high-x jets, ...
  - Fixed target experiments, ... others, ...

And what about LHC 900 GeV and 2.32 TeV data? 7 TeV data?

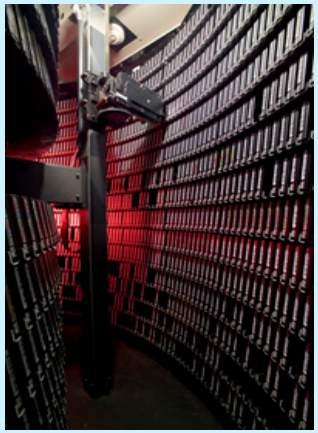


Centre-of-mass Energy	0.9 TeV	2.36 TeV
Selection	Number of Events	
BPTX Coincidence + one BSC Signal	72 637	18 074
One Pixel Track	51 308	13 029
HF Coincidence	40 781	10 948
Beam Halo Rejection	40 741	10 939
Beam Background Rejection	40 647	10 905
Valid Event Vertex	40 320	10 837



- Early LHC measurements made using data at a unique centre of masses
- Is the 2010 low pile up 7 TeV data “safe”?
- What happens to Run 1 data when the 14 TeV collisions come? Something like what happened at the TeVatron?

An important question: What is HEP data?



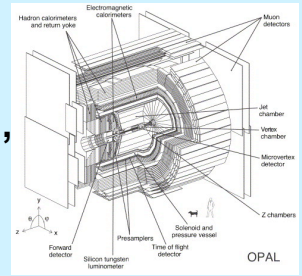
Digital information

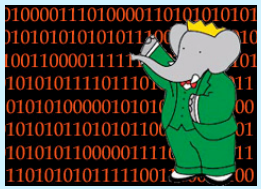
The data themselves, volume estimates for preservation data of the order of a few to 10 PB

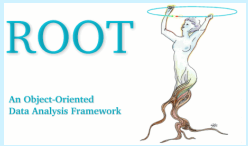
Other digital sources such as databases to also be considered

Software

Simulation, reconstruction, analysis, user, in addition to any external dependencies





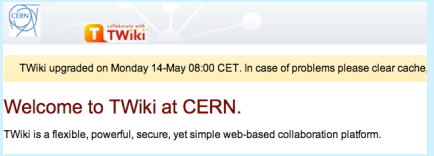


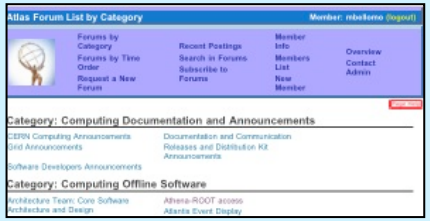
CERNLIB Access

- Access to the CERN Program Library is free of charge to all HEP users worldwide.
- Non-HEP academic and not-for-profit organizations: 1KSF/year

Meta information

Hyper-news, messages, wikis, user forums..





Publications

arXiv.org

INSPIRE

Durham University — Science & Technology Facilities Council

HEPDATA: REACTION DATA Database

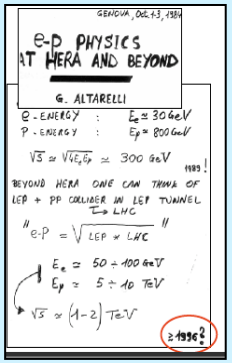
...containing numerical values of HEP scattering data such as total and differential cross sections, fragmentation functions, structure functions, and polarisation measurements, from a wide range of experiments. It is compiled by the **Durham Database Group (UK)** with help from the COMPAS group (Russia,) and is updated at regular intervals.

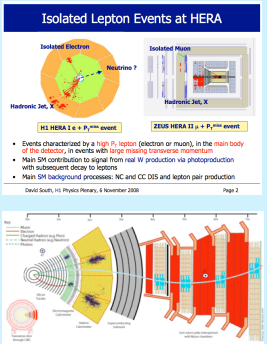
Journal of High Energy Physics

A refereed journal, written, run and distributed by electronic means

Documentation

Internal publications, notes, manuals, slides





Expertise and people

DESY

DPHEP models of HEP data preservation

Increasing cost, complexity and benefits

Preservation Model		Use Case	
1	Provide additional documentation	Publication related info search	**Documentation**
2	Preserve the data in a simplified format	Outreach, simple training analyses	**Outreach**
3	Preserve the analysis level software and data format	Full scientific analysis, based on the existing reconstruction	**Technical Preservation Projects**
4	Preserve the reconstruction and simulation software as well as the basic level data	Retain the full potential of the experimental data	

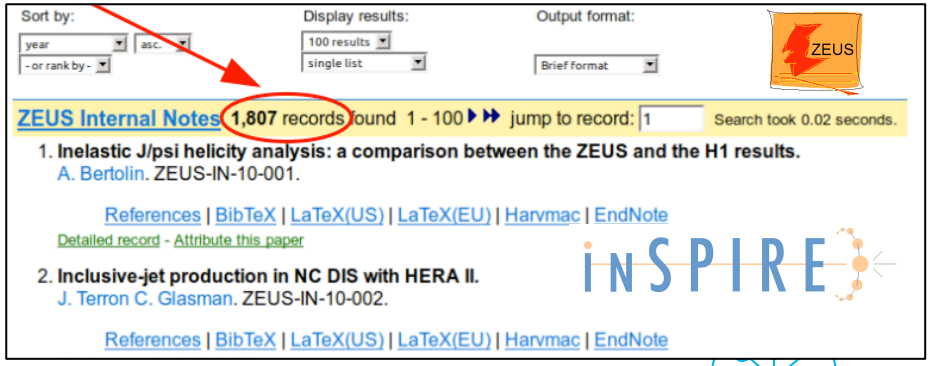
- These are the original definitions of DPHEP preservation levels from the 2009 publication
  - Still valid now, although interaction between the levels now better understood
- Originally idea was a progression, an inclusive level structure, but now seen as complementary initiatives
- Three levels representing three areas:
  - Documentation, Outreach and Technical Preservation Projects

DESY

Level 1: Documentation

- Dedicated documentation task forces set up by many experiments
  - Much material from pre-web days, or using all kinds of web applications
- **Non-digital:** Cataloguing, scanning, photographing older material
  - Papers, notes, drawings, pre-web talks, detector schematics, blueprints, logbooks...
  - New *Virtual Archives* established

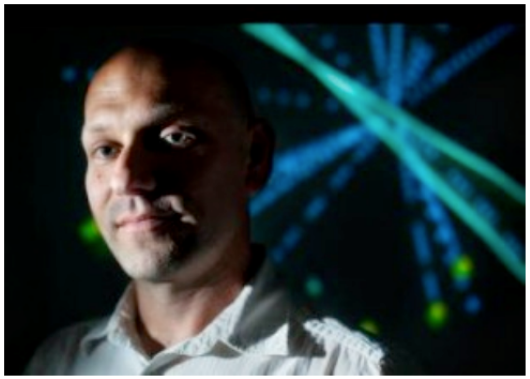
- **Digital:** Securing and consolidating the existing content
  - Online shift tools, detector configuration files, electronic logbooks, detailed run info, web content from out-dated servers with dead links, wikis, meetings, talks, ...
  - Replacement of old web servers by VMs, hosted by the computer centres
  - Replacement of old pages to newer technologies such as wikis
  - Use of external services like INSPIRE for hosting collaboration material



DESY

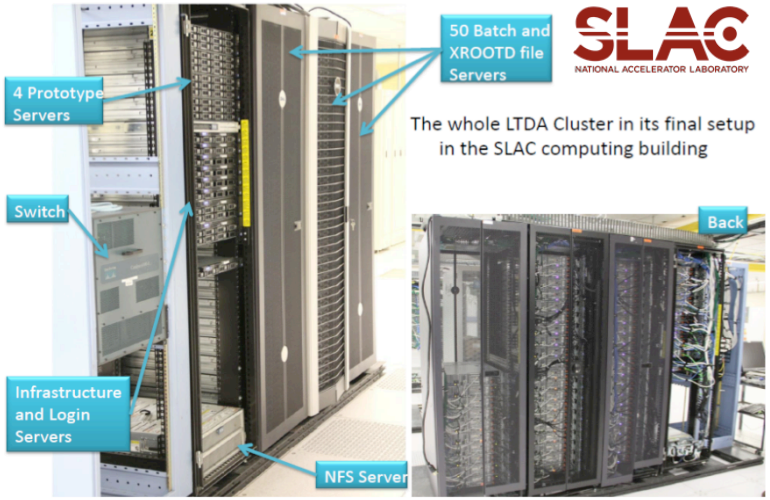
Level 2: Simplified formats for outreach

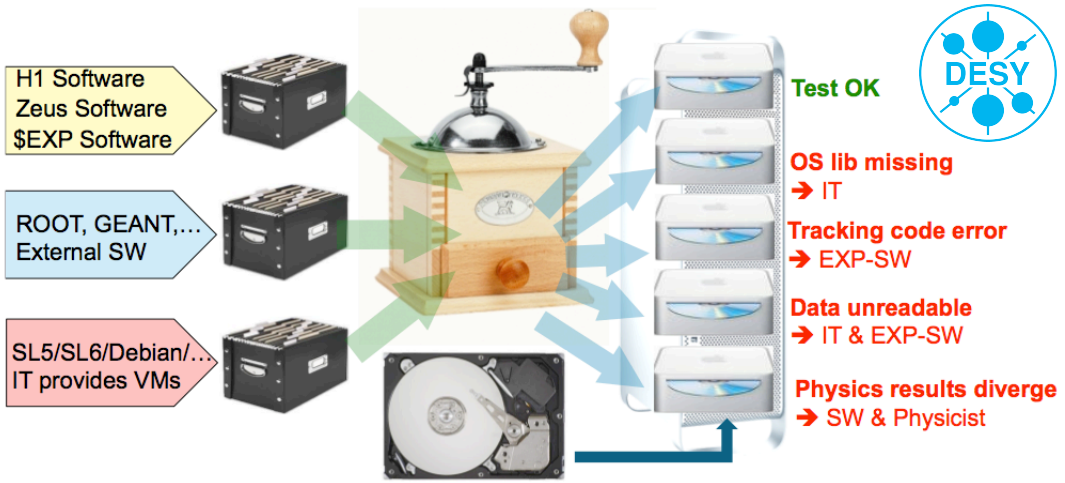
- Within DPHEP and the member collaborations there are generic ideas, such as common formats and user interfaces
  - In terms formats, much can be learned from other fields such as astrophysics or life sciences
- Such outreach formats in HEP are typically based on ROOT, containing particle 4-vectors and simple event information
  - Composite-particle reconstruction, finding signals
  - Initiatives in place at BaBar, Belle and LHC experiments
- Simplified formats also provide an ideal way of transferring data between experiments and theory
  - Allowing new models to be tested on HEP data



Technical projects: Levels 3 and 4

- This is really the main focus of the data preservation effort
  - Access to analysis level data, MC and the analysis level software
  - In addition for level 4 this includes the reconstruction and simulation software
- It's not about the data, but about still being able analyse it
  - Either keep your current environment alive as long as possible
  - Or adapt and validate your code to future changes as they happen
  - Two complimentary approaches taken by BaBar at SLAC and the HERA experiments at DESY, both employing virtualisation techniques, but in different ways





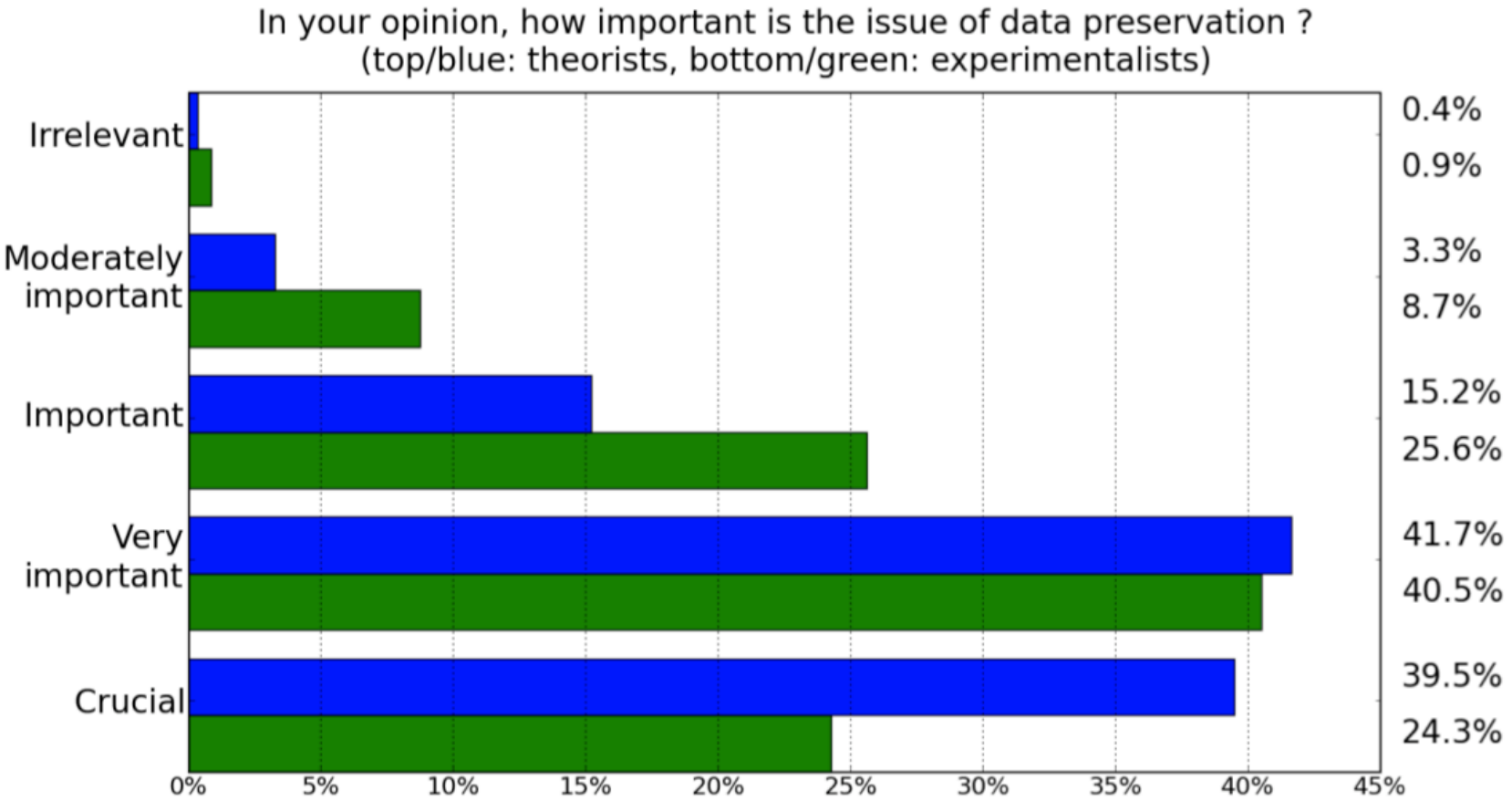
Summary and future working directions of DPHEP

- The DPHEP Study Group has established itself in the HEP community reached a milestone in the publication of the latest report, which contains a comprehensive appraisal of data preservation in HEP
  - Increased participation in the last years, especially from the LHC community
- DPHEP will continue to investigate and take action in areas of coordination, preservation standards and technologies
  - Also in cooperation with other initiatives such as DASPOS, as well as expanding the experimental reach and inter-disciplinary cooperation
- In 2013 DPHEP will make the transition from Study Group to Collaboration
  - Final draft of Collaboration Agreement prepared contributors will be asked to sign during 2013
  - Target upcoming FP8/Horizon2020 EU funding to realise and fully deploy a variety of projects

Status Report of the DPHEP Study Group: http://arxiv.org/abs/1205.46677
Joint DASPOS/DPHEP-7 Workshop, March 2013: https://indico.cern.ch/conferenceDisplay.py?confId=233119
CHEP 2012 talk: http://indico.cern.ch/contributionDisplay.py?sessionId=0&contribId=607&confId=149557
Seminar from November 2011: http://www.desy.de/dvsem/WS1112/south_talk.pdf

EXTRAS

Support for data preservation in the HEP community



PARSE insight
Permanent Access to the Records of Science in Europe

e-infrastructure

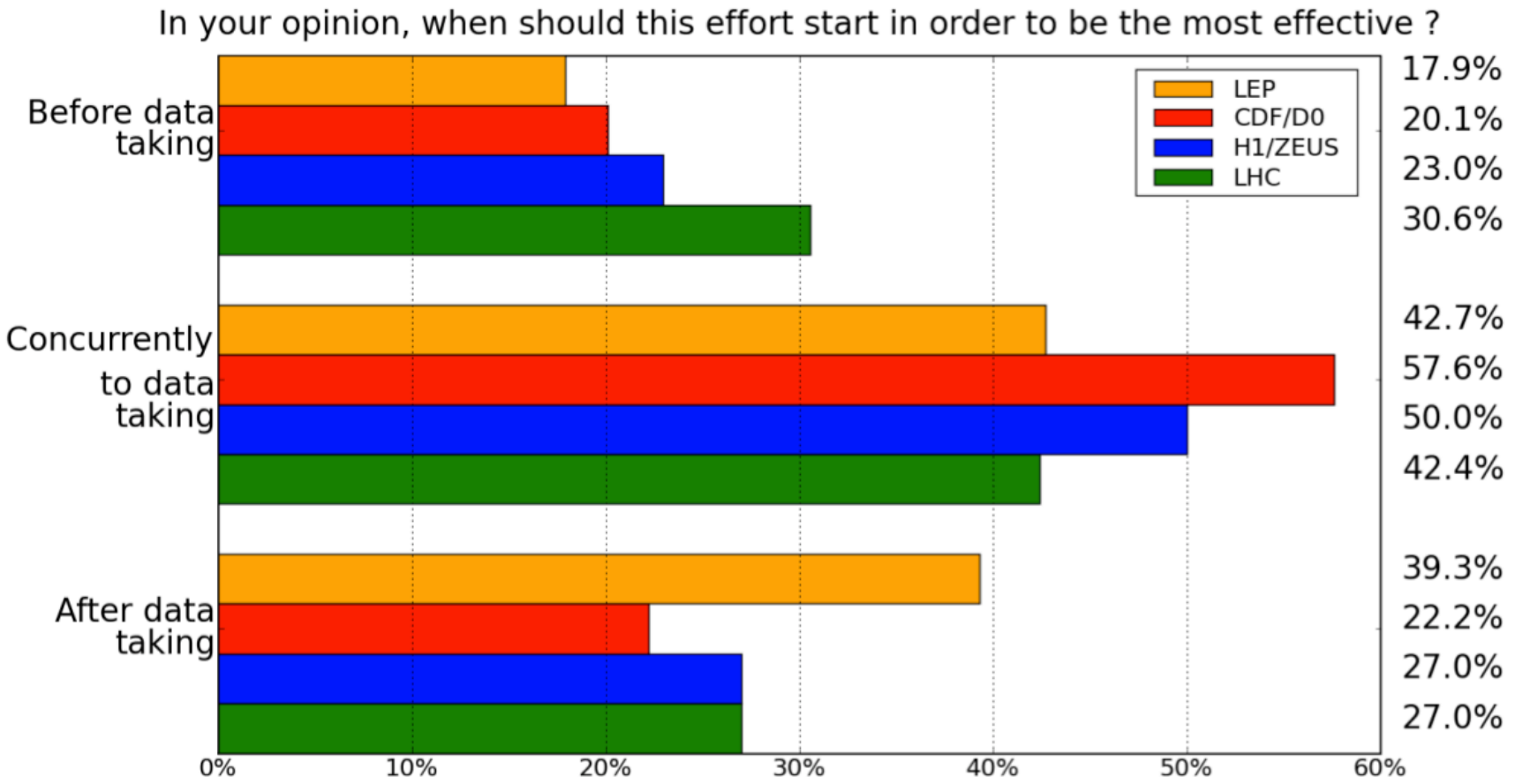
SEVENTH FRAMEWORK PROGRAMME

CERN

arXiv:0906.0485

DESY

Support for data preservation in the HEP community



PARSE insight
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SEVENTH FRAMEWORK PROGRAMME

arXiv:0906.0485

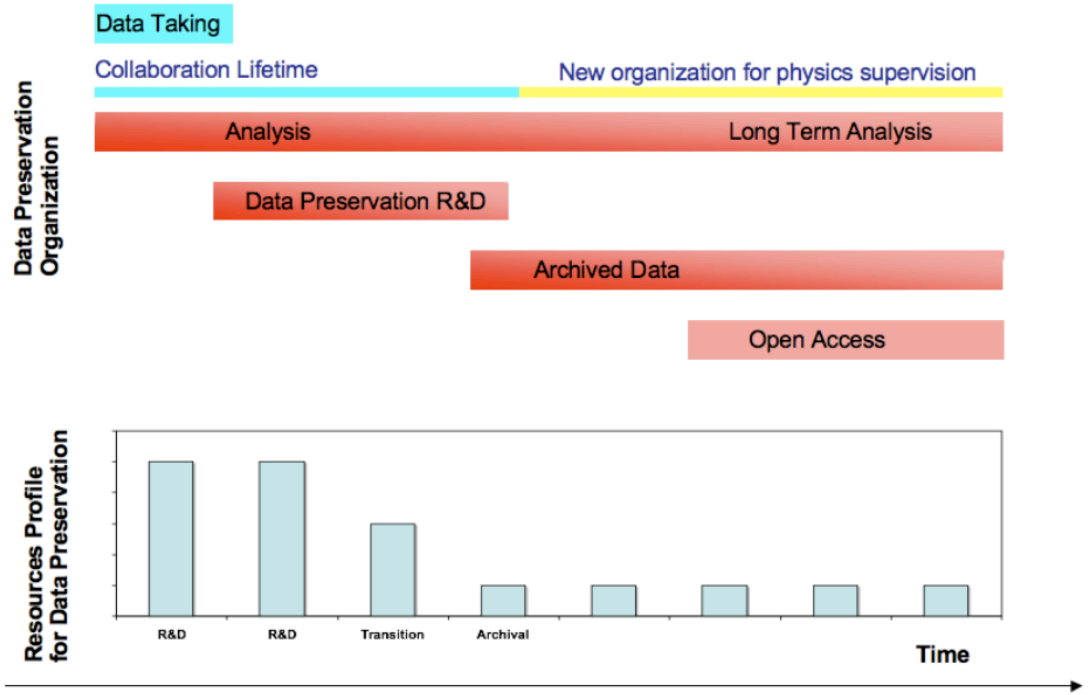
DESY

Transition scenario and resources at the experimental level

- Planning the transition to a long term analysis model

- R&D phase needed to develop the projects for the transition
- Long term custodianship of the physics data

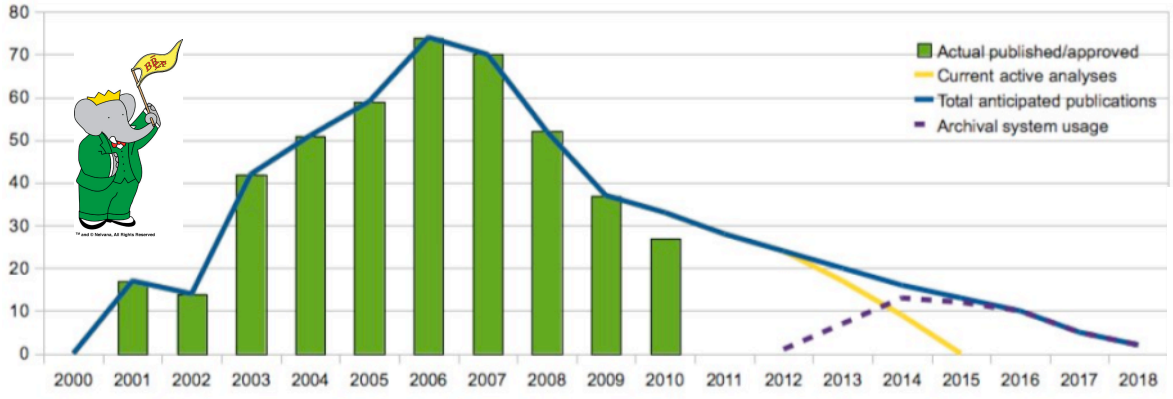
- Resources / experiment
  - Typically a surge of 2-3 FTEs for 2-3 years, followed by steady 0.5-1.0 FTE per experiment/lab
  - This should be compared to 300-500 FTEs for many years per experiment!

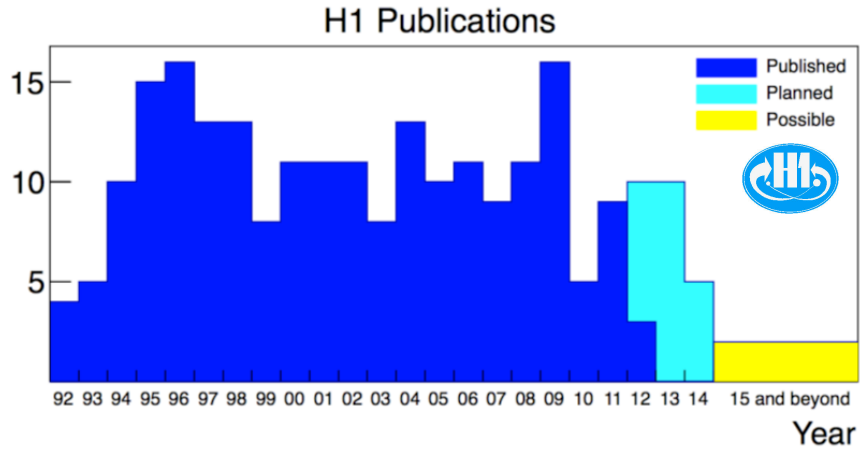


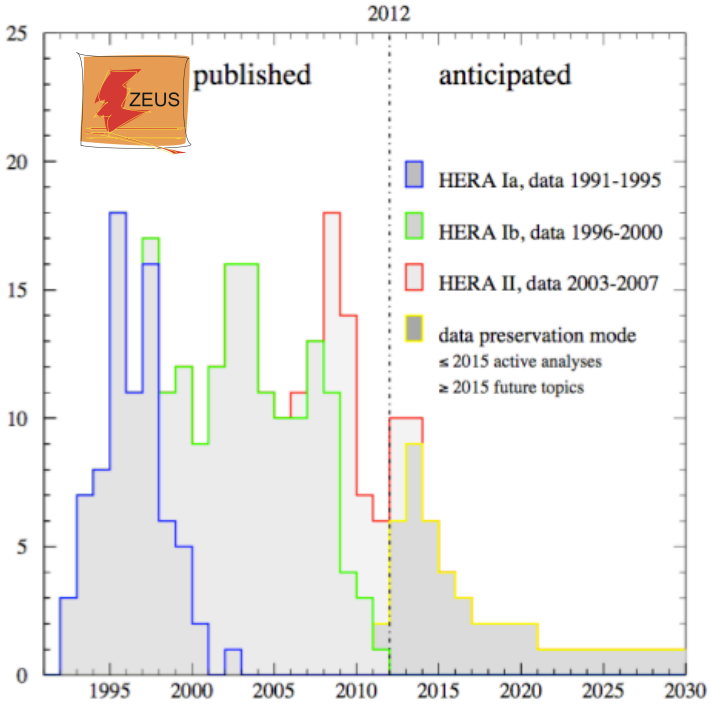
Cost estimates represent typically much less than 1% of the original investment

Scientific return: O(10%) in number of publications

Long term completion of the physics programme

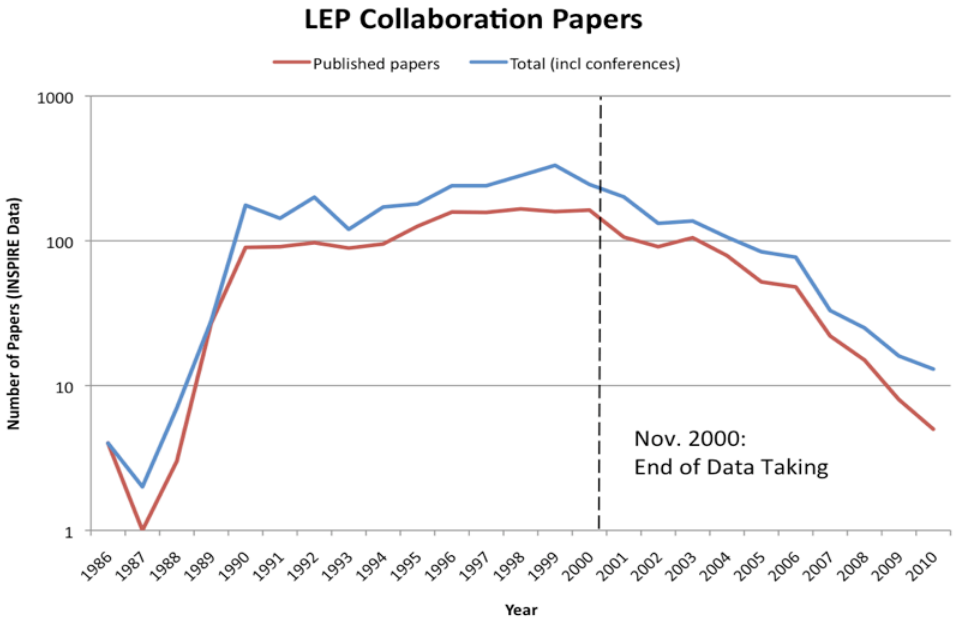


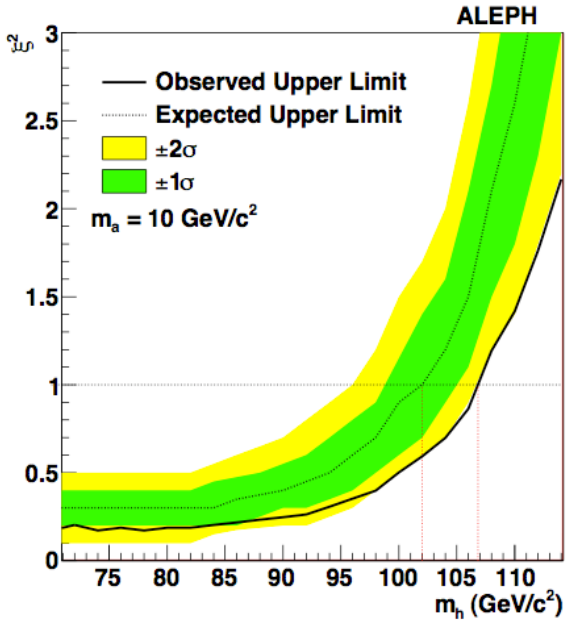




- Similar publication tails predicted by the BaBar, H1 and ZEUS experiments, taking into consideration the plans for data preservation

Long term completion of the physics programme



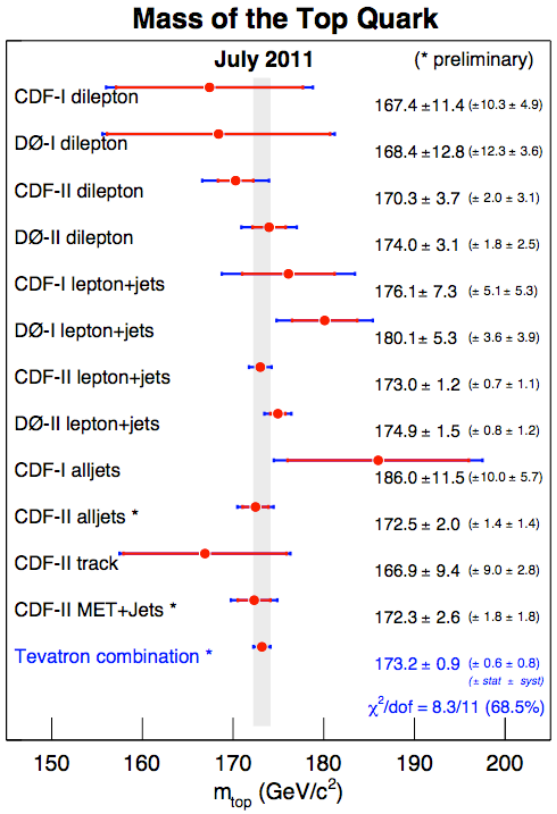


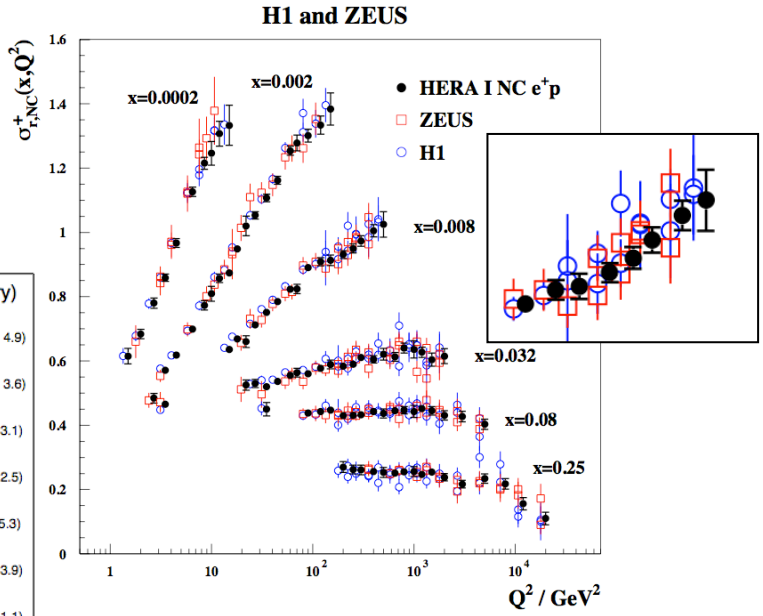
- The publication tail of LEP is long, with new papers still appearing
- Well over 300 papers produced since the end of collisions in 2000
- Recent analysis of LEP data gave unique limits on a novel Higgs model
- Similar, if not longer publication tails predicted by the BaBar, H1 and ZEUS experiments, after taking into consideration the plans for data preservation

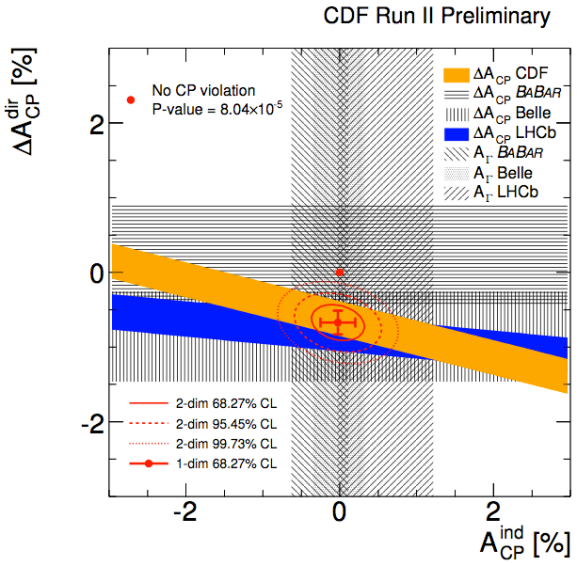
DESY

Cross-collaboration combinations of physics results

- Combination of data from multiple experiments to produce new scientific results
  - Improved precision and increased sensitivity
- Comparison of experimental results
  - Complimentary information from different physics
  - Verification of experimental observations
- Both objectives facilitated by data preservation

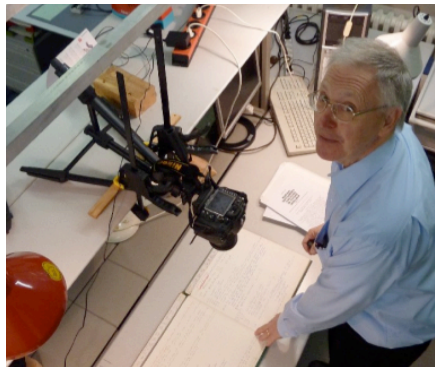






Level 1: Documentation

- The organisation of documentation turns out to be quite a task
  - Dedicated task forces set up by many of the experiments
  - Much material from pre-web days, or using all kinds of web applications
- Non-digital: Cataloguing, organisation, scanning or photographing of appropriate of papers, notes, drawings, talks from pre-web days, detector schematics, blueprints, logbooks, ...
  - New *Virtual Archives* established by the experiments

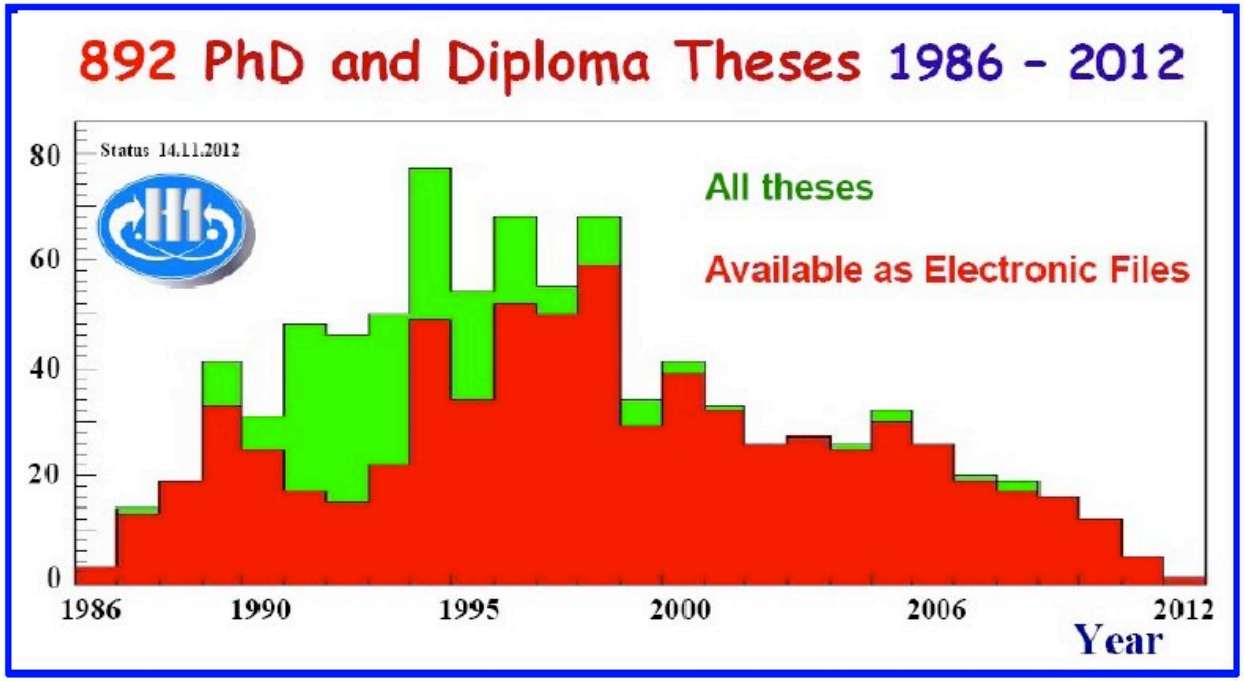


- Digital: Old online shift tools, detector configuration files, electronic logbooks, detailed run information, web content from out-dated servers with dead links, various wikis, meetings, talks, ...
  - Replacement of old web servers by VMs, hosted by the computer centres
  - Replacement of old pages to newer technologies such as wikis (use of (T)wikis much more prevalent in the LHC era)
  - Use of external services for hosting collaboration material

DESY

H1 Theses

- Since October 2010, **106** H1 theses discovered not previously known to the collaboration; **18** since this summer, latest ones only last week
- Scanning and linking these to the official H1 pages is given high priority



- **Currently, of the 892 known H1 theses 197 are not available in electronic form: ~ 22% not available to the H1 community!**

Documentation projects with INSPIRE

- Internal notes from all HERA experiments now available on INSPIRE
  - Experiments no longer need to provide dedicated hardware for such things
  - Password protected now, simple to make publicly available in the future

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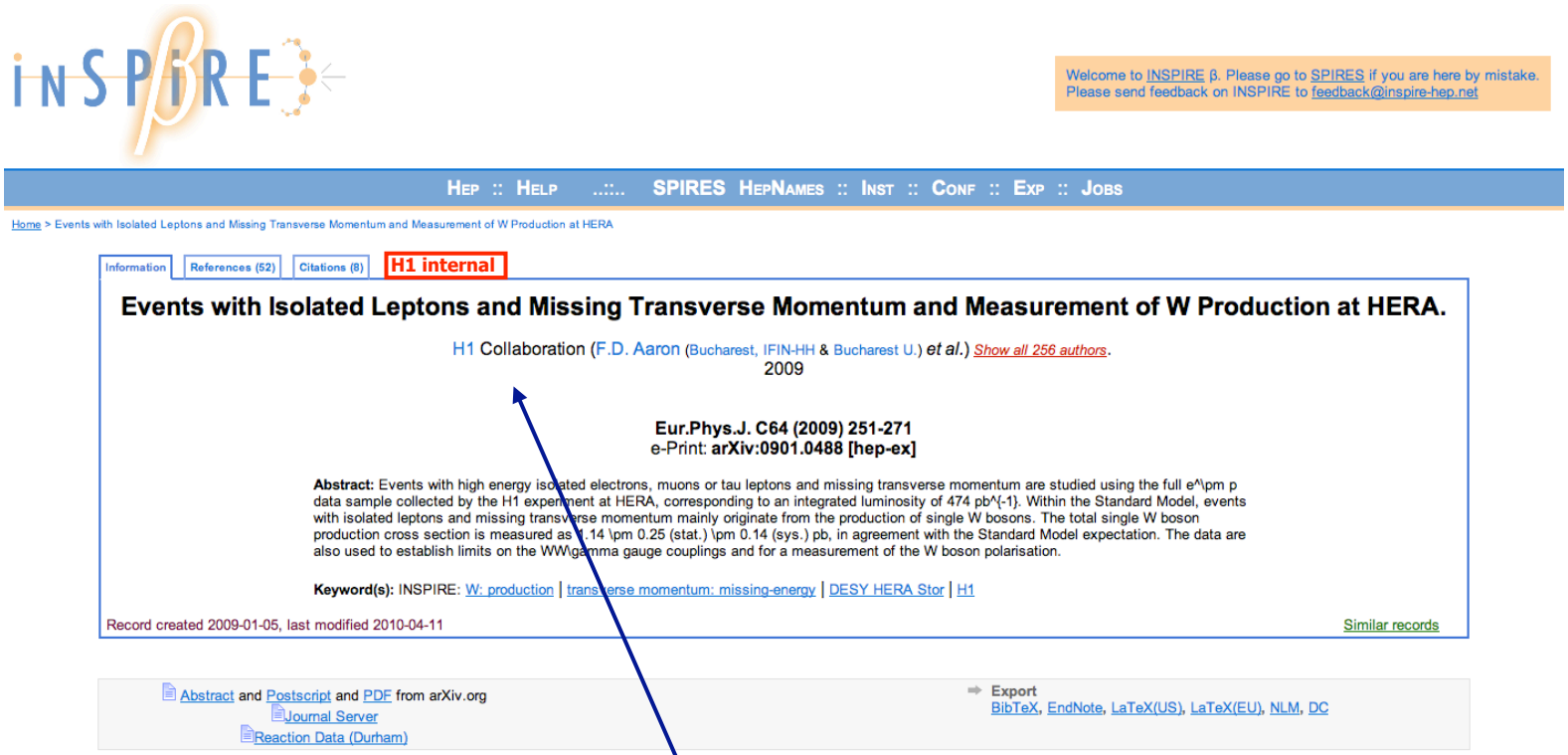
- The ingestion of other documents is under discussion, including theses, preliminary results, conference talks and proceedings, paper drafts, ...
  - More experiments working with INSPIRE, including CDF, D0 as well as BaBar

INSPIRE: Paper histories



- Envisage an additional link for H1 members only
- Provides additional information such as preliminary results, earlier draft versions and documentation from the publication procedure

INSPIRE: Paper histories

Welcome to INSPIRE ?. Please go to SPIRES if you are here by mistake.
Please send feedback on INSPIRE to feedback@inspire-hep.net

HEP :: HELP ..::.. SPIRES HEPNAMES :: INST :: CONF :: EXP :: JOBS

Home > > Search Results

Events with Isolated Leptons and Missing Transverse Momentum and Measurement of W Production at HERA

PUBLICATION HISTORY

Preliminary Results

HEP-EPS 2007 conference paper. | July 2007
Prepared for Deep Inelastic Scattering 2007 | April 2007
Prepared for 42nd Rencontres de Moriond (Electroweak) | January 2007
Prepared for the 62nd DESY PRC | October 2006
ICHEP 2006 conference paper |July 2006
Prepared for the 60th DESY PRC | November 2005
HEP-EPS 2005 conference paper | July 2005
Lepton Photon 2005 conference paper | June 2005
Prepared for Deep Inelastic Scattering 2005 | April 2005
Prepared for the 58th DESY PRC |October 2004
Analysis of High Pt HERA II Data | ICHEP 2004 conference paper | August 2004
High Pt Analysis of the HERA II Data |Prepared for Deep Inelastic Scattering 2004 |April 2004

T0 talks

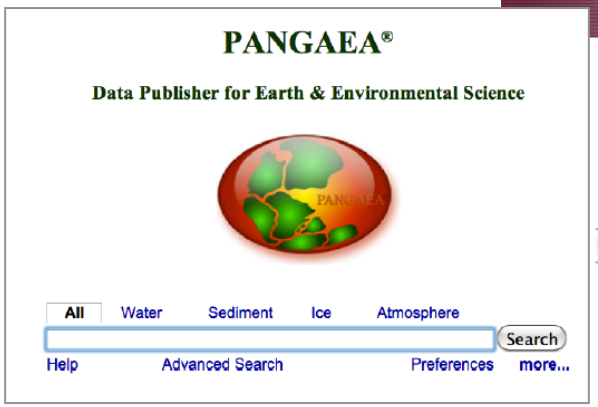
Pre-T0 Talk | 08.02.2008
T0 Talk | 24.07.2008
T0 Addendum | 14.08.2008

Paper Drafts

First Draft | Answers to Draft |15.08.2008
Second Draft | Answers to Draft | 19.11.2008
Referee Report | 20.11.2008
Final Version | 06.01.2009

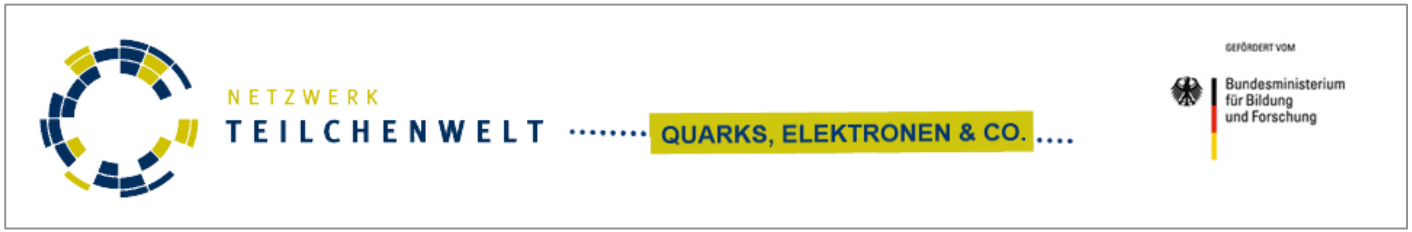
Initiatives in other fields

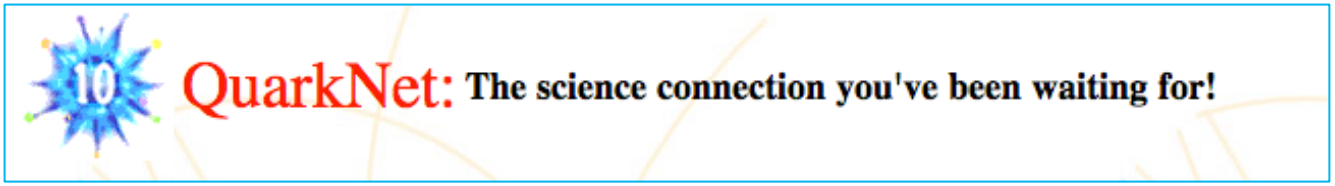
- Data preservation and in particular open access and data sharing are present in other fields such as:
  - Astrophysics, molecular biology, earth sciences, humanities and social sciences

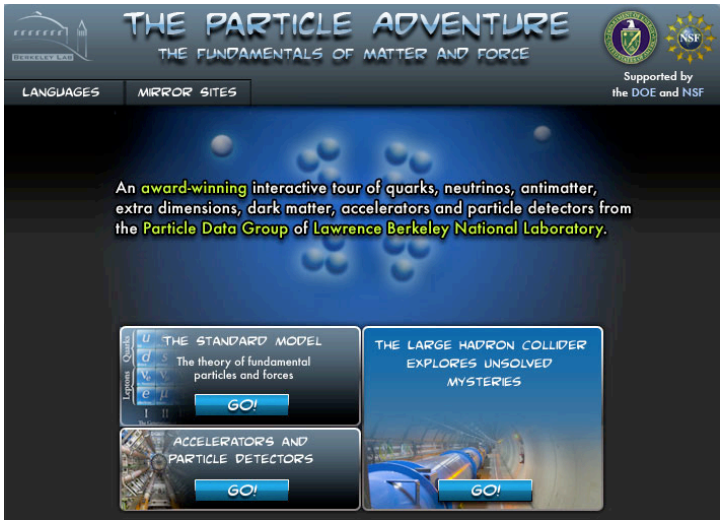


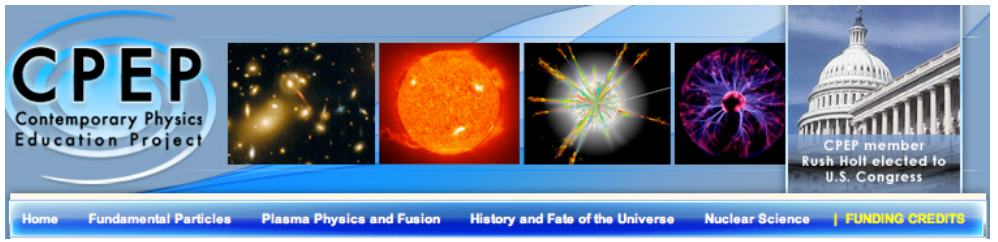
HEP outreach initiatives

- Many initiatives promoting outreach efforts and to improve the public understanding of science in general









Science Hack Day: Increasing the access to LHC data

http://cms.web.cern.ch/news/cms-public-data-activity-scoops-prize-nairobi

CMS public data activity scoops prize in Nairobi

An application using real event data from CMS has won "Best Science" prize in a public "Science Hack Day" held in Nairobi between 13th and 15th April 2012. Science Hack days bring together a wide range of enthusiastic members of the public to create something completely new using existing scientific systems or data.

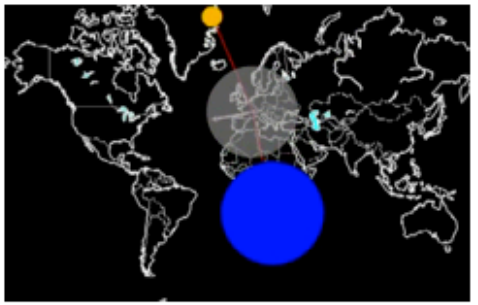
The winning application visualized real CMS di-muon events from the 2011 LHC run, which are made public for use in various educational programmes, such as the IPPOG Masterclasses, Quarknet and I2U2. The application showed an animation of muons produced in CMS superimposed on a map of the world, showing where they would go if they were to continue without stopping (which they don't in reality).

Other prizes were awarded to Leah Atieno, a 15-year-old high-school student, for a voice-controlled walking robot and Denis Munene for a crowd-mapping platform to help promote the fight against malaria.

The Nairobi event, involving 240 developers, is part of broader series of Science Hack Day events. CMS data previously featured in another very successful event in San Francisco.

News article by Gythan Munga, HumanIpo
See photos of the event
Youtube film
Link to more Science hack events
2012-04-20, by Lucas Taylor

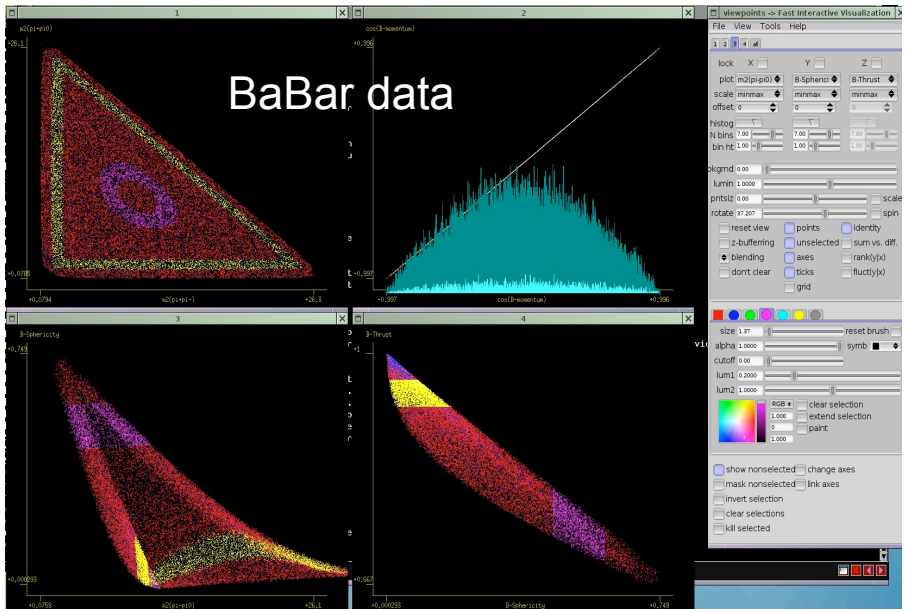
CMS use of public data in a "Science Hack" event in Nairobi. Photo credit: Matt Biddulph, via Flickr

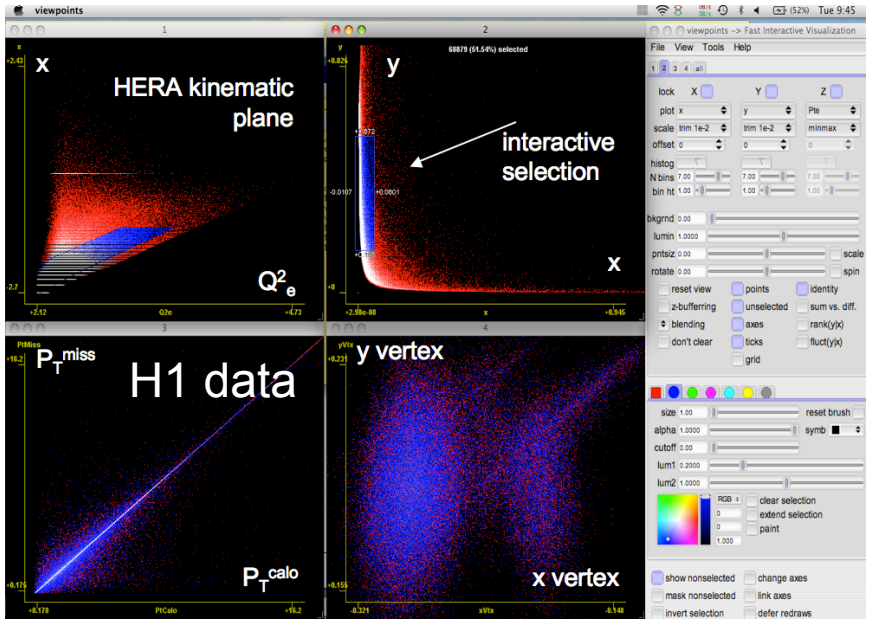


Application developed to visualise where muons from CMS would go if they continued forever

DESY

Some Outreach activity within DPHEP





- One nice collaboration was between BaBar and H1, using the NASA Viewpoints application
- Common format:

  simple text

# Q2e	y	x	PtCalo	PtMiss	Ex	Ptx	Phix	Thx	Ee	Pte	Phie	The	Empz	xVtx	yVtx	zVtx	
377.673	0.174	0.021	2.769	2.769	109.685	15.153	-11.780	8.231	26.226	17.665	164.138	137.656	50.542	-0.237	0.207	2.582	
185.111	0.399	0.005	2.133	2.133	41.933	12.652	87.669	36.327	18.252	10.544	-93.948	144.713	57.878	-0.248	0.192	-12.829	
187.320	0.211	0.009	2.584	2.584	51.742	9.773	78.869	13.682	23.482	12.160	-106.349		148.813	55.164	-0.266	0.208	2.968
264.266	0.508	0.005	0.238	0.360	35.343	11.738	-138.270		64.975	15.984	11.407	41.034	134.465	57.043	-0.225	0.210	5.925
229.056	0.043	0.052	4.204	5.067	65.601	19.196	72.870	17.842	28.485	14.805	-98.351	148.685	58.941	-0.237	0.199	-7.082	
275.596	0.121	0.022	4.277	4.282	78.331	18.413	51.596	14.380	26.750	15.562	-139.235		144.425	55.018	-0.234	0.200	-5.038
240.102	0.183	0.013	3.513	3.434	67.134	17.402	85.049	17.201	24.719	14.004	-92.840	145.491	56.060	-0.266	0.202	-1.606	
451.996	0.209	0.021	1.723	1.723	49.126	17.196	66.018	24.927	25.936	18.913	-114.452		133.180	55.810	-0.259	0.190	-13.705
524.251	0.572	0.009	2.170	2.170	43.738	17.555	171.073	61.182	16.573	14.987	-11.341	115.274	58.543	-0.249	0.208	4.410	
391.944	0.000	0.000	2.107	2.107	183.513	21.270	75.875	6.693	31.602	19.959	-108.713		140.834	58.375	-0.245	0.203	-0.630
201.600	0.212	0.009	4.441	4.441	44.890	17.098	-92.989	27.261	23.578	12.605	86.968	147.683	55.361	-0.243	0.212	7.653	
335.881	0.052	0.064	16.769	16.769	29.256	1.142	-90.021	2.250	29.219	17.848	83.461	142.349	52.723	-0.242	0.214	10.137	
286.039	0.009	0.315	2.514	2.514	194.560	18.922	-83.365	5.616	29.944	16.837	92.126	145.787	56.826	-0.254	0.193	-11.169	
207.703	0.137	0.015	8.095	8.095	84.993	21.487	82.549	15.129	25.701	13.389	-95.886	148.605	53.237	-0.258	0.205	0.895	
387.371	0.358	0.011	1.272	1.272	70.266	15.460	-91.456	17.173	21.232	15.772	93.071	132.027	55.684	-0.236	0.198	-5.242	
855.333	0.509	0.017	2.588	2.588	88.511	23.066	70.622	21.191	21.306	20.499	-110.759		105.828	56.196	-0.237	0.178	-24.198
154.527	0.667	0.002	3.509	3.509	72.273	8.810	174.450	101.604	10.598	7.176	-28.067	137.379	92.478	-0.240	0.207	4.578	
304.756	0.025	0.121	1.622	1.622	120.020	17.765	-145.756		8.522	29.678	17.240	39.272	144.486	55.298	-0.228	0.193	-5.659
278.950	0.627	0.004	3.813	0.726	37.163	9.588	124.342	60.056	12.831	10.205	-53.435	127.311	52.247	-0.243	0.190	-10.069	

HERA data for preservation

Final data reprocessing to mDST completed in 2009

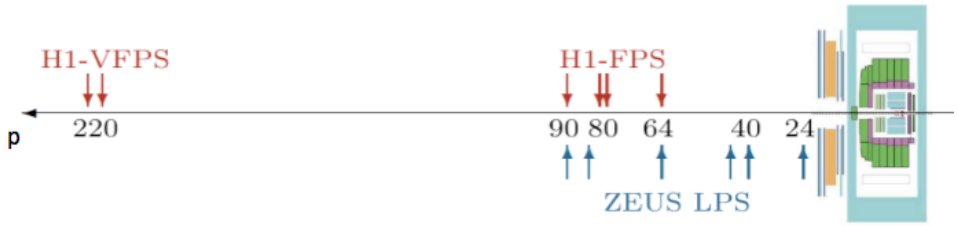
- Basic preserved data format: ROOT based “Common Ntuples”
- Ultimately RAW, MDST data and MC removed from robots, keep only cNuptles
- Final production of data/MC cNuptles started, to be completed early 2013

Final reprocessing (DST-7) of HERA II data in 2009, HERA I done in 2012

- Final version of *common analysis software environment* + *files*, H1OO also done
- Preserve RAW data, as well as DST-7 and H1OO 4.0 versions
- Large MC production of up 2.10^9 events / year, preserved MC sets to be decided

Final data and MC production completed in 2012

- Main format for analysis is the mDST, this is the one to be preserved
- Importantly for HERMES, all data/MC productions now moved to dCache



Dialogue with DESY machine group concerning their HERA data

HERA data for preservation

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Final data and … ted in 2012

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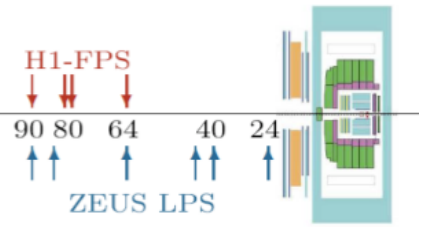
Total for HERA experiments: ~ 1 PB
Data preservation is not about the data!



Dialogue with DESY machine group concerning their HERA data

Long term archival storage for the HERA data

- Dedicated system too costly in both hardware and person-power
- All collaborations now using dCache for mass storage, and this system will continue at DESY-IT for the LHC, photon-physics, others..
  - By using dCache this is completely transparent for user, relying on IT admin work
  - Active check for the data consistency on disk level, tape copy only for the case if disk copy is corrupted; corresponding checks also on the tape (checksum)
  - For data which have no copy on disk: two copies on tapes (different technology old vs new, but both still readable), regular migration to new media
  - Data which should be archived, but not online all the time – re-pack into larger files
- System properties also defined by which data needed “always online”
  - Initial estimates:
    ~ 1 PB in total
  - Different strategies visible

	Online	Not online	Total
H1	~ 250 TB	~ 100 TB	~ 350 TB
ZEUS	~ 250 TB		~ 250 TB
HERMES	~ 40 TB	~ 350 TB	~ 390 TB
Total	~ 540 TB	~ 450 TB	~ 990 TB

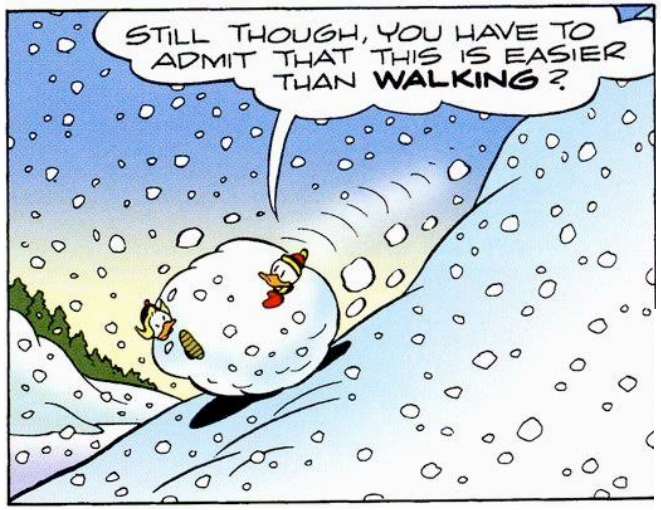
Isn't it obvious, virtualisation will solve everything?

My first and very naïve ansatz

- OK, why don't we just put everything an a virtual machine?
  - Data archival is done elsewhere, just need "to plug that into the VM"
  - Your VM contains everything you need to develop and run code and analysis
- The problem would then be reduced to maintain virtual images, and maintain their ability to run. In the Cloud era, seems like a trivial task
- Problems: Everything in IT is a moving target:
  - Will your network always be the same?
  - Will your access protocol always be the same?
  - Are you sure you do not need new software (e.g. MC generators) that require a new OS?
  - Are you sure your i386/SL4 VM will produce the same results when emulated on a quantum computer in NN years?
  - What about service you need, like CondDB,…
- Naïve virtualization will not work… but still, virtualization can help

Freezing vs rolling

- **Pro Freezing**
  - One-time effort, very small maintenance outside of analysis phase
  - Also allows software w/o code (but might fail with DRM / licensing issues)
- **Cons Freezing**
  - Rely on certain standards and protocols that may evolve
  - Potential performance problems



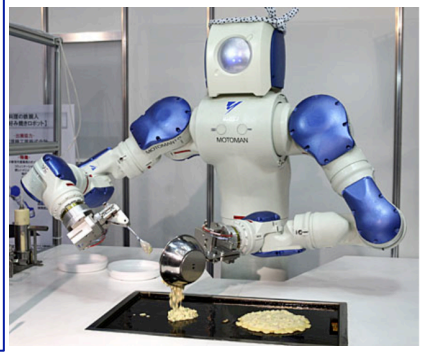
- **Pro Test-driven migration**
  - Usability and correctness of code is guaranteed at every moment
  - Data accessibility and integrity can be checked as well
  - Fast reaction to standard/protocol changes
  - General code quality can improve, as designed for portability and migration
- **Cons Test-driven migration**
  - Needs long-time intervention, more man-power and resources needed
  - Some knowledge of the frameworks must be passed to maintainers

Yves Kemp (DESY-IT)

Pizza Preservation

- Couple of days
  - Fridge
- Couple of month
  - Deep freezer
- Couple of years???
  - Preserve the recipe
  - Practice it often: You will not forget the recipe and you can detect variations in external dependencies

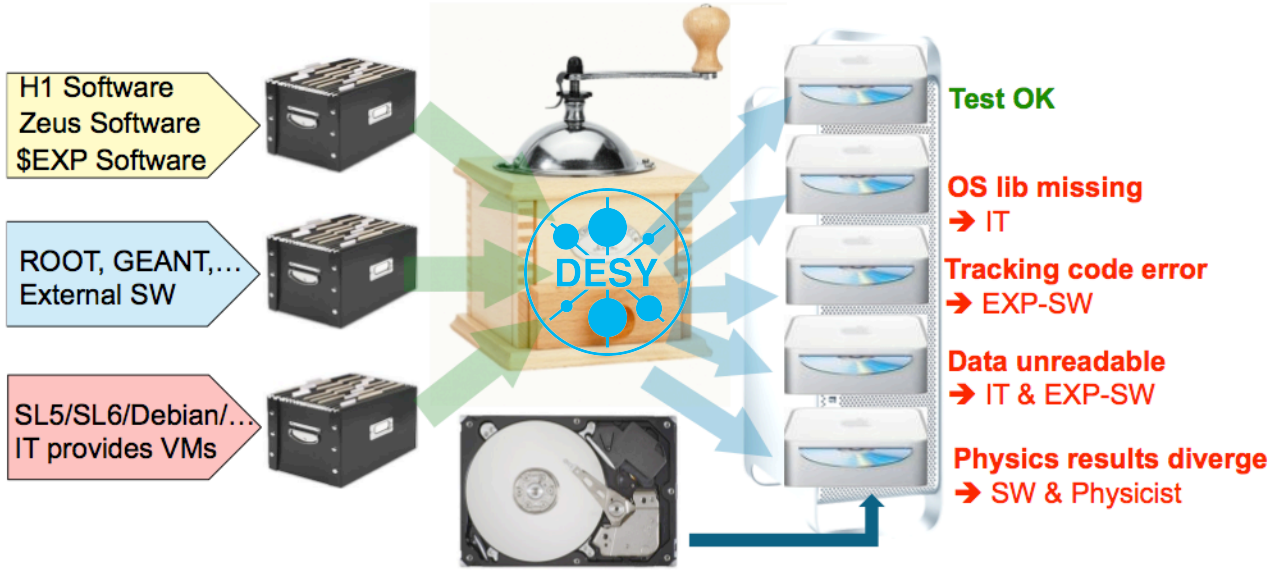
Y. Kemp, D. Ozerov, CHEP 2012



- Whilst freezing the software and environment is easy to do, long term use and correctness of the results not guaranteed
  - Naïve assumption virtualisation solves everything breaks down at the first security hole
- Freezing software is *OK* if the timeline and scope are reduced, but if changes are needed this is more difficult the longer software is frozen
- Better to cook the same recipe again and again (and maybe even allow it to be improved), validating the output *automatically*
  - Virtualisation can help!

DESY

The Software Preservation System @ DESY



- Automated validation system to facilitate future software and OS transitions
  - **Uses virtualisation techniques to repeatedly run well defined tests**
  - **Perform checks of different and evolving environments (OS, s/ware configuration)**
  - **Stand alone system: No hidden dependencies or /afs access etc: rigorous testing**
  - **Automatically check these results against predefined, default values**
  - **Notify when test results differ from these values**
  - **Separate responsibilities of IT and the experiments**

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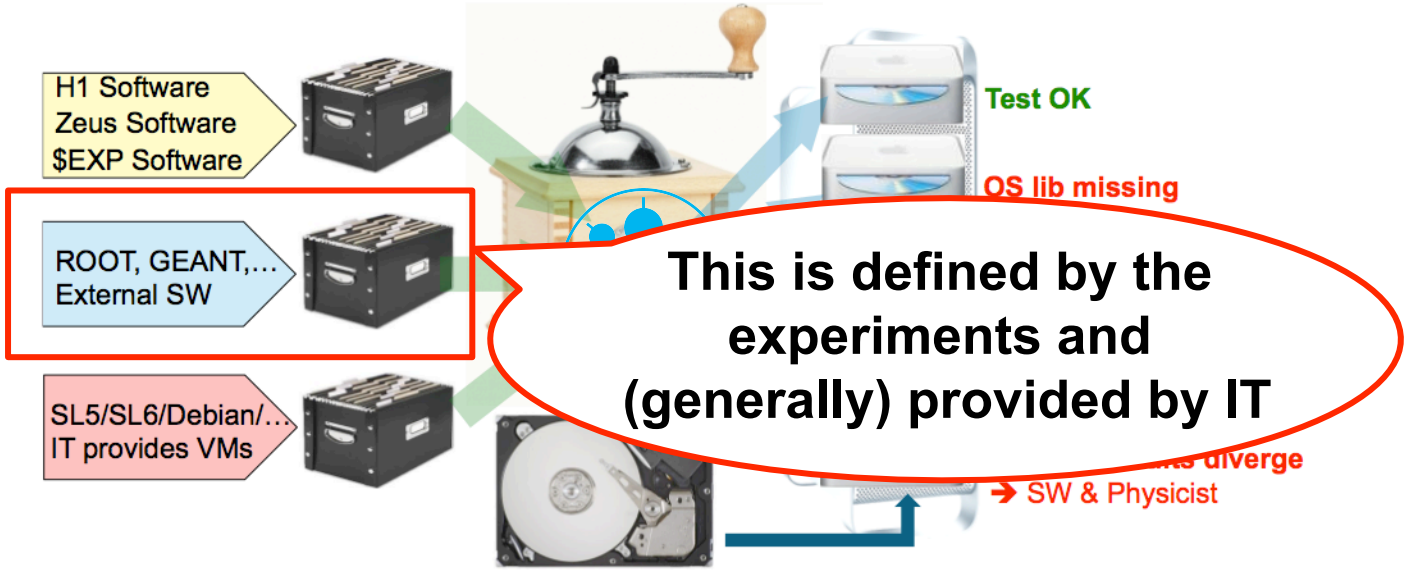

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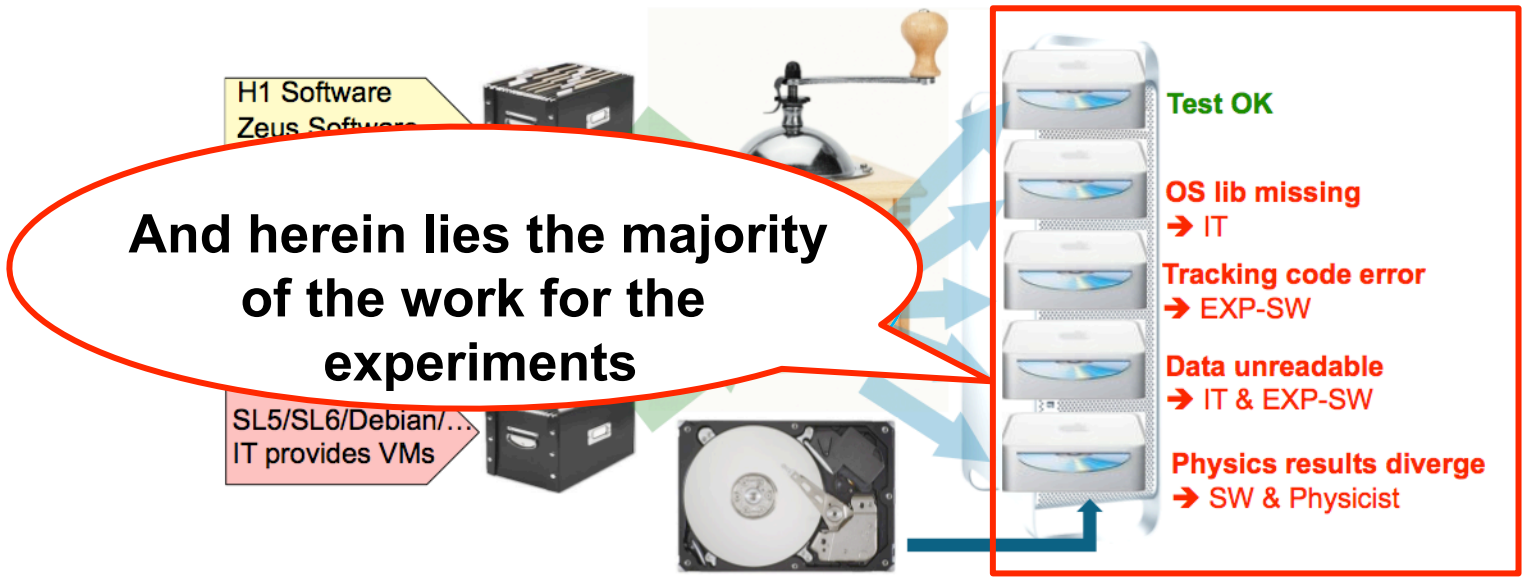

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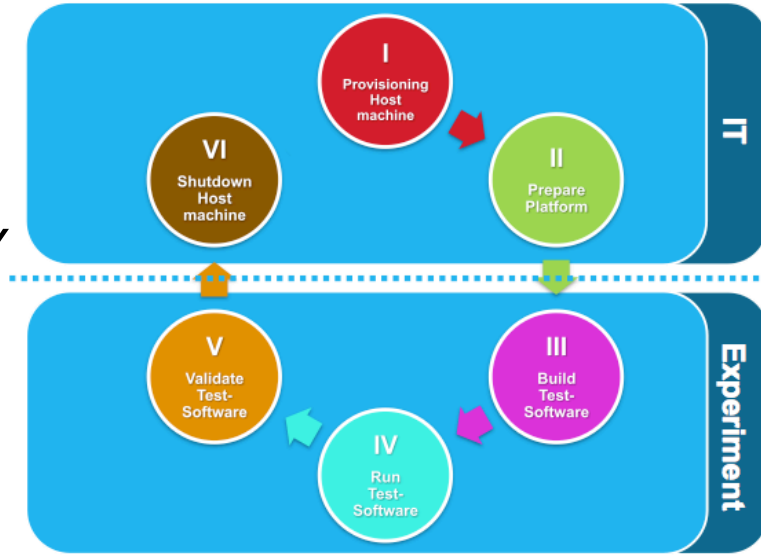
First test runs in pilot project at CHEP 2010

	SL4	SL5	Fedora 13	
ROOT V5.26	-no F77 compiler gfortran found -libX11 MUST be installed	Estimated ROOTMARKS: 1534.29	Estimated ROOTMARKS: 1512.76	Compilation
H1Data analysis	Processed 47243 events with J/Psi candidates Histogram written to jpsi_mods.root	Processed 47243 events with J/Psi candidates Histogram written to jpsi_mods.root	Processed 47243 events with J/Psi candidates Histogram written to jpsi_mods.root	Run pre-compiled tgz using compat libs
ZEUS MC prod	> ls -lh ZEUSMC.HFSZ627.E8954.GRAPE.Z01 4.2 MByte	> ls -lh ZEUSMC.HFSZ627.E8954.GRAPE.Z01 4.2 MByte	> ls -lh ZEUSMC.HFSZ627.E8954.GRAPE.Z01 4.2 MByte	Run pre-compiled tgz using compat libs
HERA-B	Compilation OK / DB connect fails	Compilation OK / DB connect fails	Compilation failed – needs code change	Compilation

The sp-system: Towards the full implementation

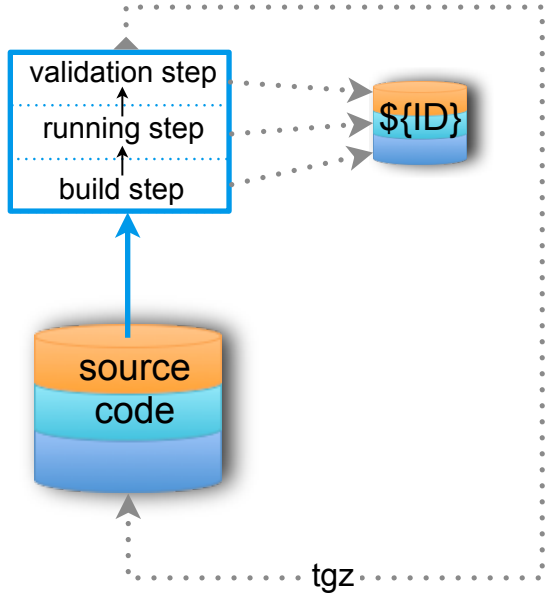
- Pilot project in 2010
  - Single configuration, simple tests
- Full implementation now installed at DESY
- Common baseline of SLD5 / 32-bit achieved in 2011 by all experiments
  - Sound starting point for validation



- Following OS configurations now available in sp-system:
  - sl5.6/64(gcc4.4), sl5.7/32(gcc4.4), sl5.7/64(gcc4.1), sl5.7/32(gcc4.1), sl6.2/64(gcc4.4)
- In addition, to multiple ROOT versions
  - 5.26.00d, 5.28.00c, 5.30.05, 5.32.00, 5.34.01
- 64-bit systems a major step toward migrations to future OS and hardware
  - SL6 will only be supported in 64 bit variant at DESY
  - NFS4.1 technology, to be used in dCache, native only in SL6.2/64 or higher

Running jobs in the `sp-system`

- Initial step
  - Compilation of analysis (level 3) and sim/rec (level 4) software
  - ***Or:*** use tar-balls with pre-compiled software
  - Provide access to software
    - Copy tar-balls to persistent storage
  - All output kept in directory with unique name



DESY

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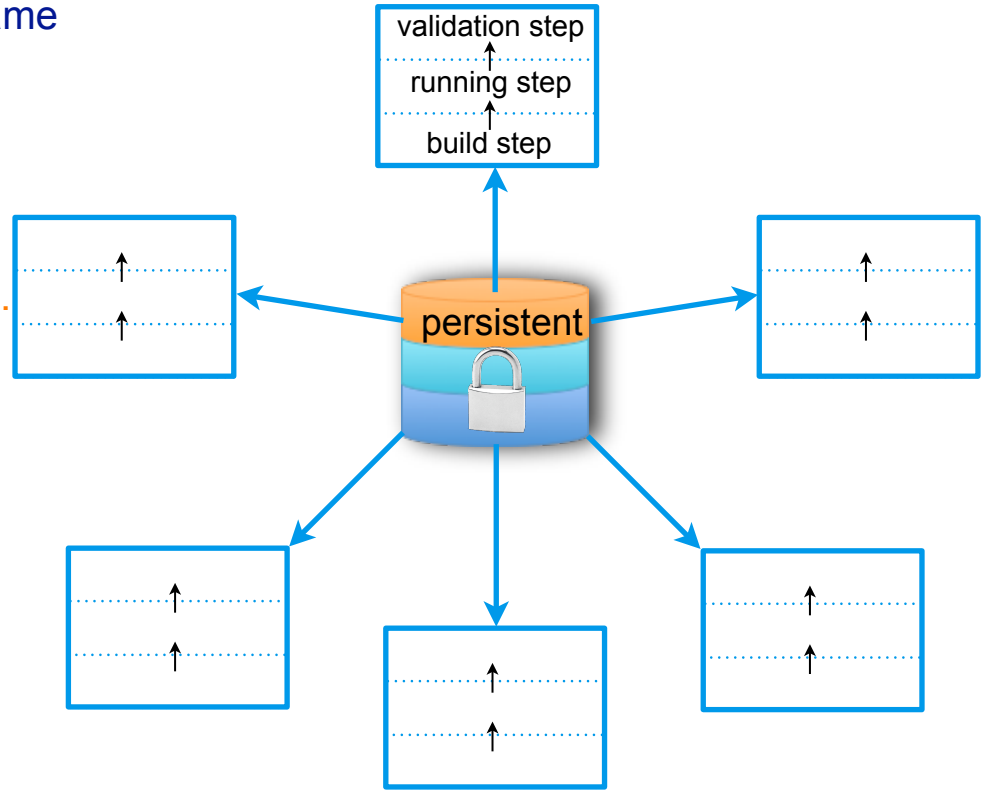
    - e.g. event display, database access, ..



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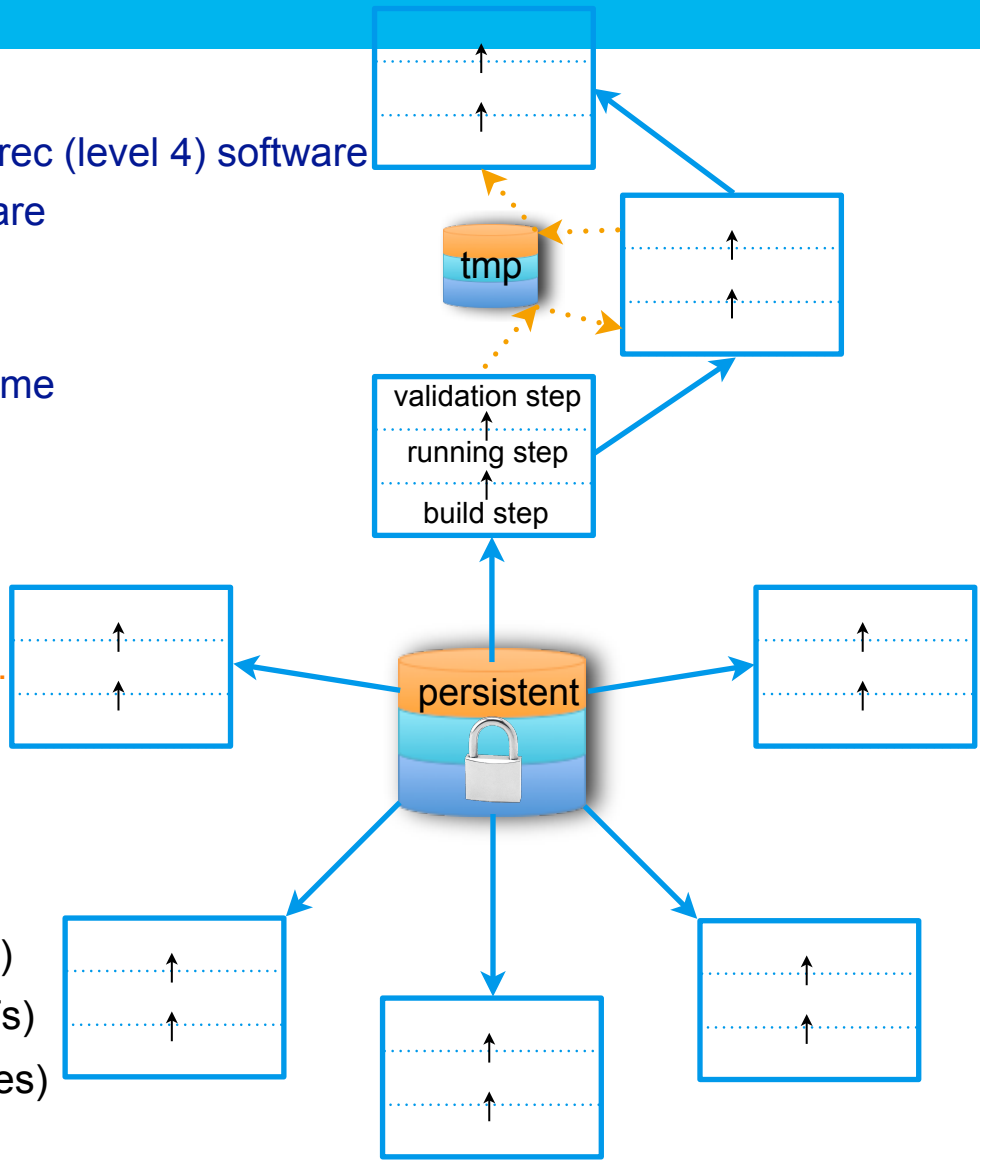
- Run sequential tests
  - Set up software environment
  - Validate file production
    1. MC generation (produce gen files)
    2. Reconstruction (gen. files → DSTs)
    3. Analysis level (DSTs → ROOT files)
  - Tests use output of previous test as input
- Results remain accessible or can be reproduced with identical results



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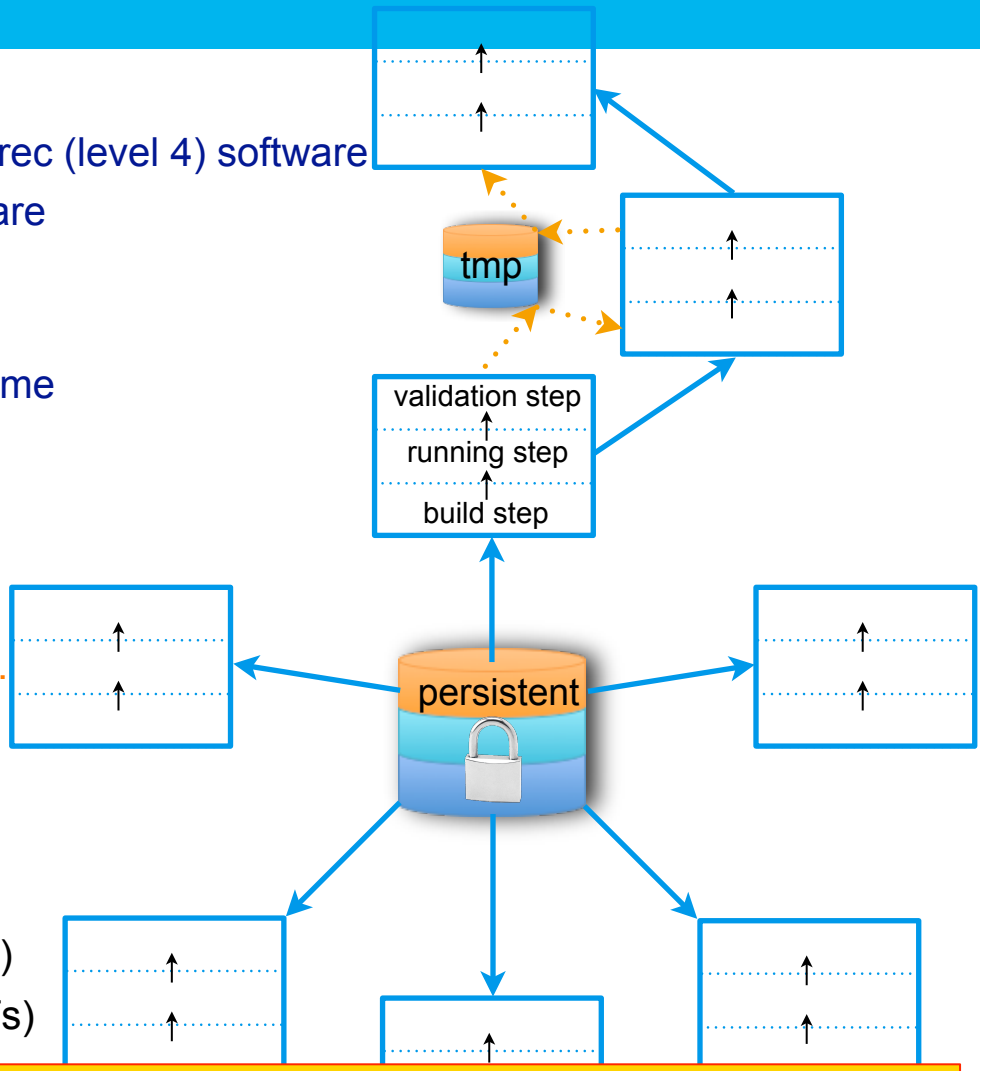
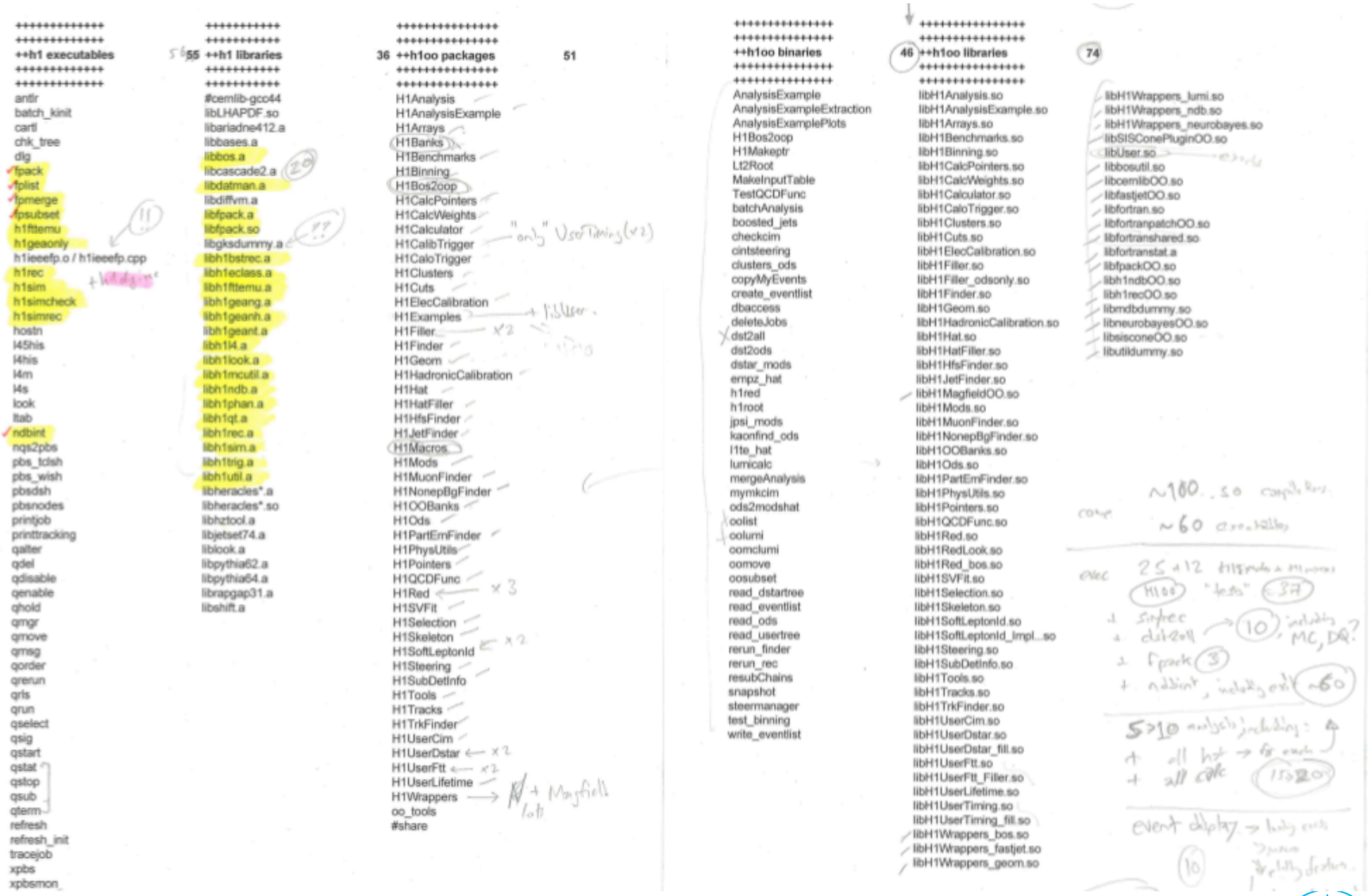


➔ It is essential to have robust definition of complete set of experimental tests

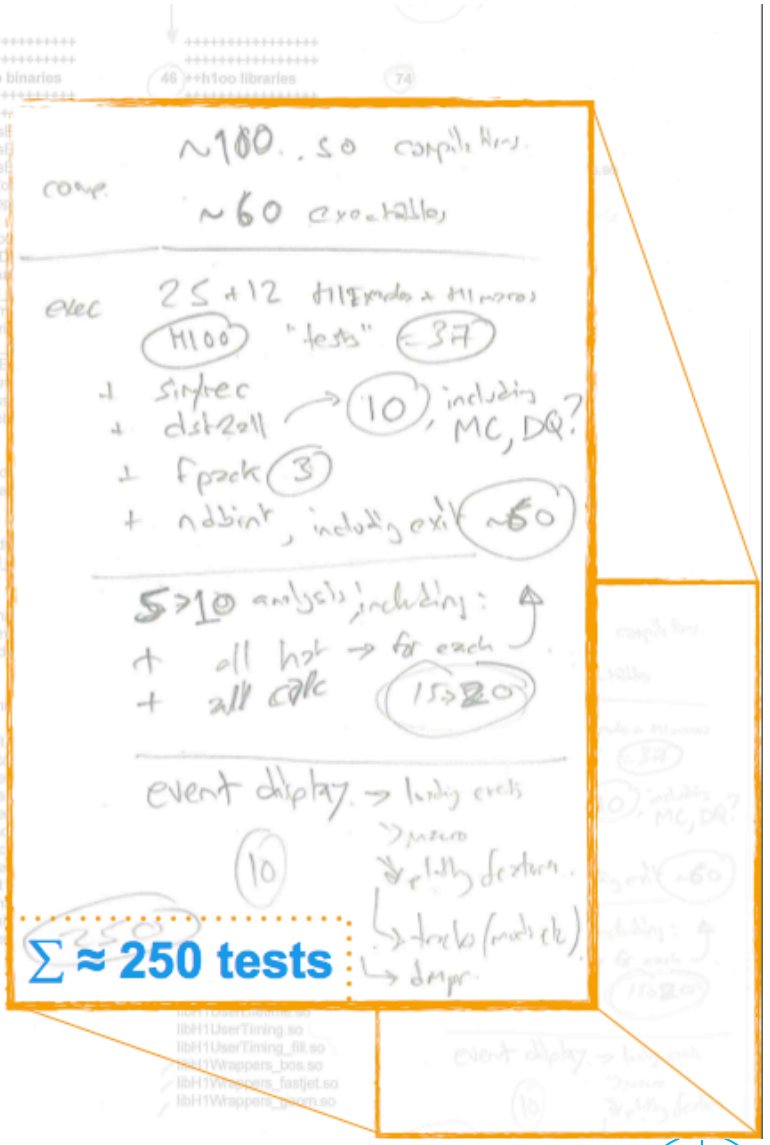
The nature and number dependent on desired preservation level

First sketch of H1 tests

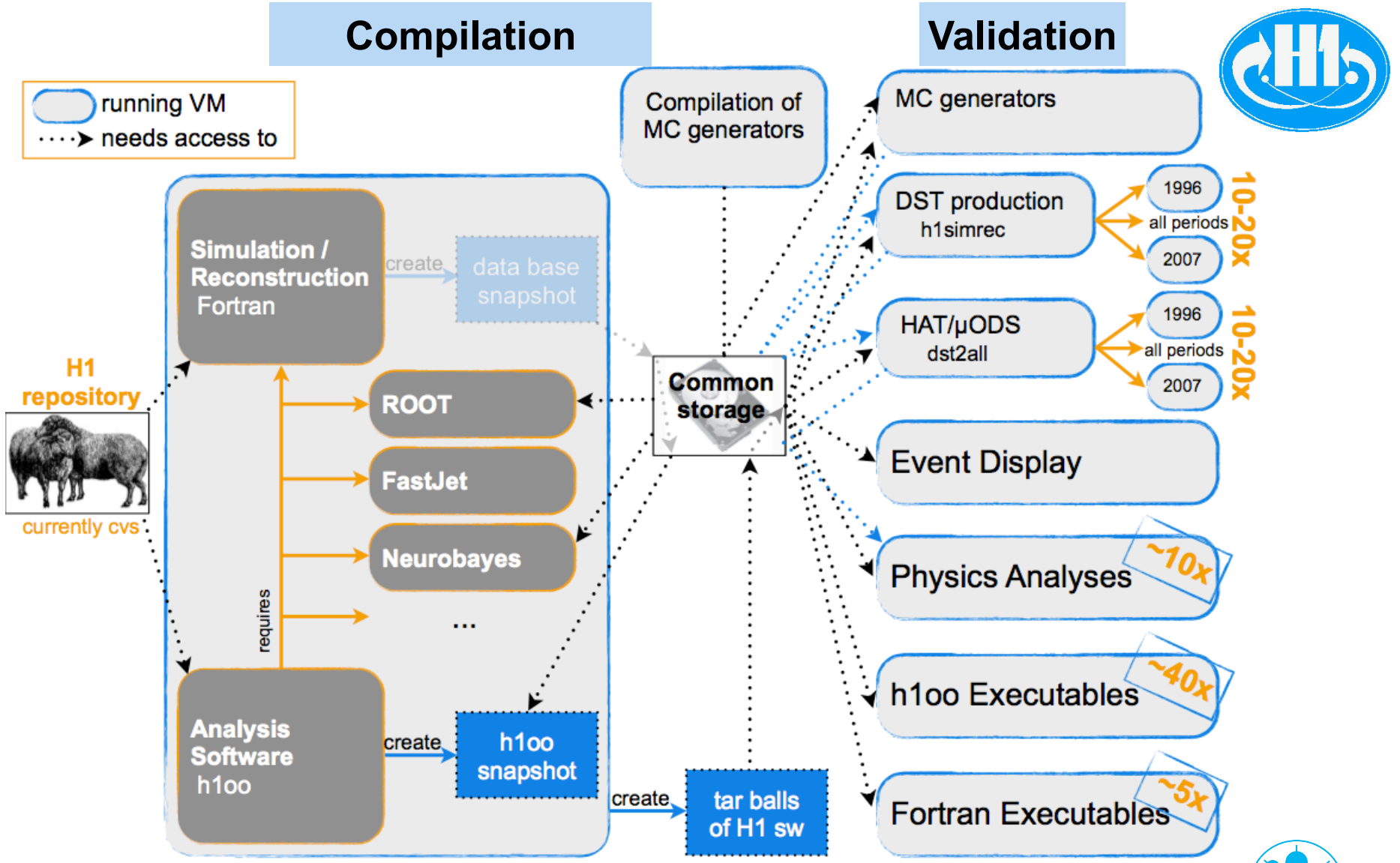


First sketch of H1 tests

- Validate compilation of
  - ~100 (shared) library objects
  - ~60 executables
    - MC generators not yet included
    - most important:
      - simrec - reconstruction / dst production
      - dst2all - h1oo file production
- Validate correct running of
  - 37 x h1oo
  - 4 x fpack, ndb
  - ≥10 x h1simrec → dst2all → analysis
    - One test for every run period + MC / (DQHat)
  - … Let's say about 60 executables
- Run and validate physics analyses
  - (At least) one test for every run period
    - Inclusive & all HAT/H1Calculator variables
  - 5-10 'real' physics analyses
- Check event display



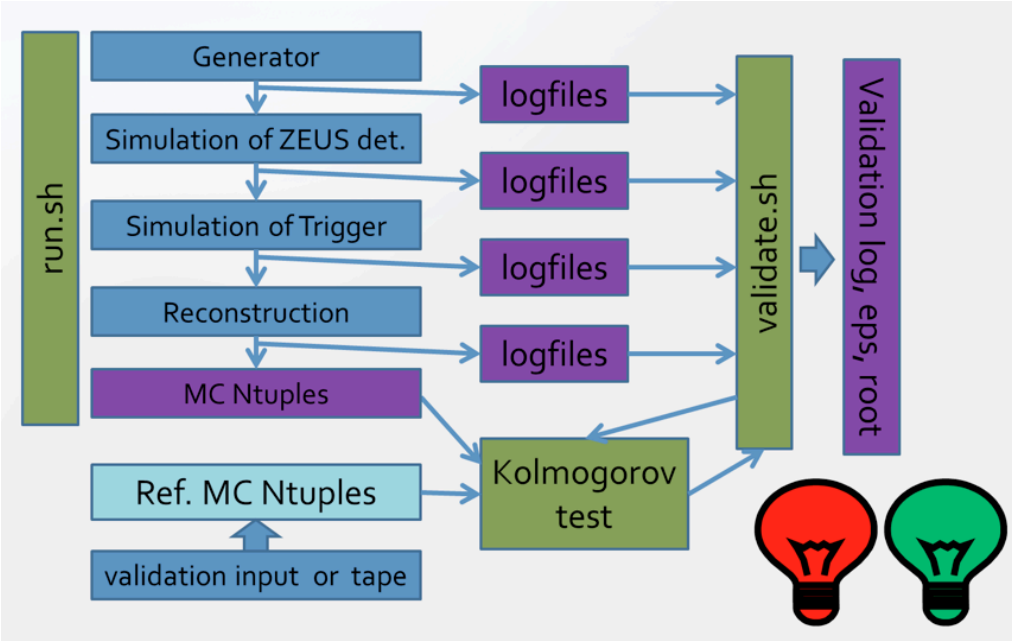
Example structure of experimental tests: H1 (Level 4)



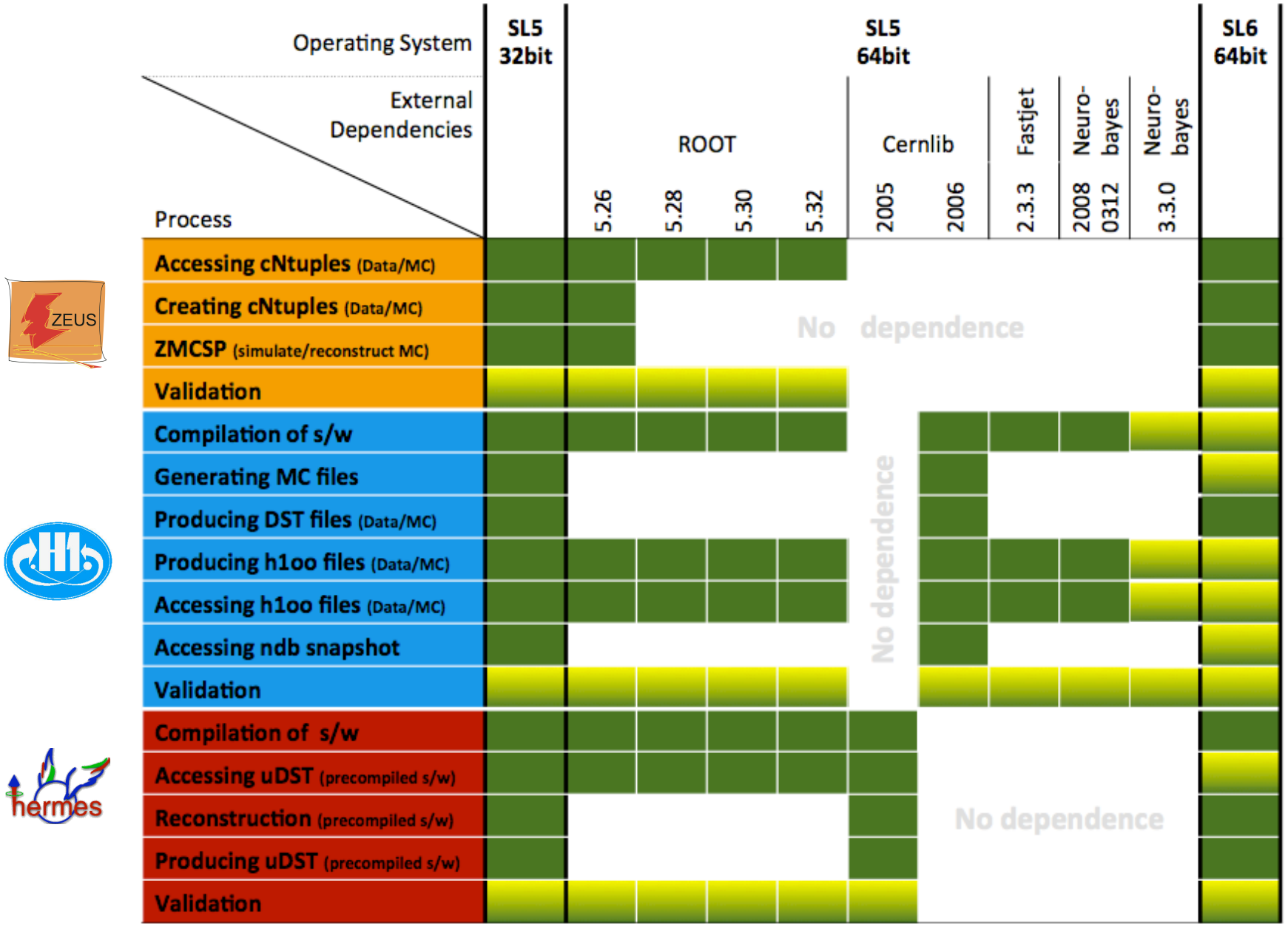
Including compilation of individual packages: about 250 tests planned by H1

Example structure of experiment tests: ZEUS (Level 3 + MC chain)

- ZEUS strategy: use ROOT based analysis level Common Ntuples as data format for preservation – DPHEP level 3
- Only external dependence is ROOT
  - Validation of new ROOT versions included as analysis level tests in the **`sp-system`**
- However, the MC production chain pre-compiled executables will also be preserved as a standalone package
  - **Remaining ZEUS SL3 executables continue to work on the SL6/64 OS**
- In addition, an interface for new generators is developed, which is also included in the validation system



Putting it all together



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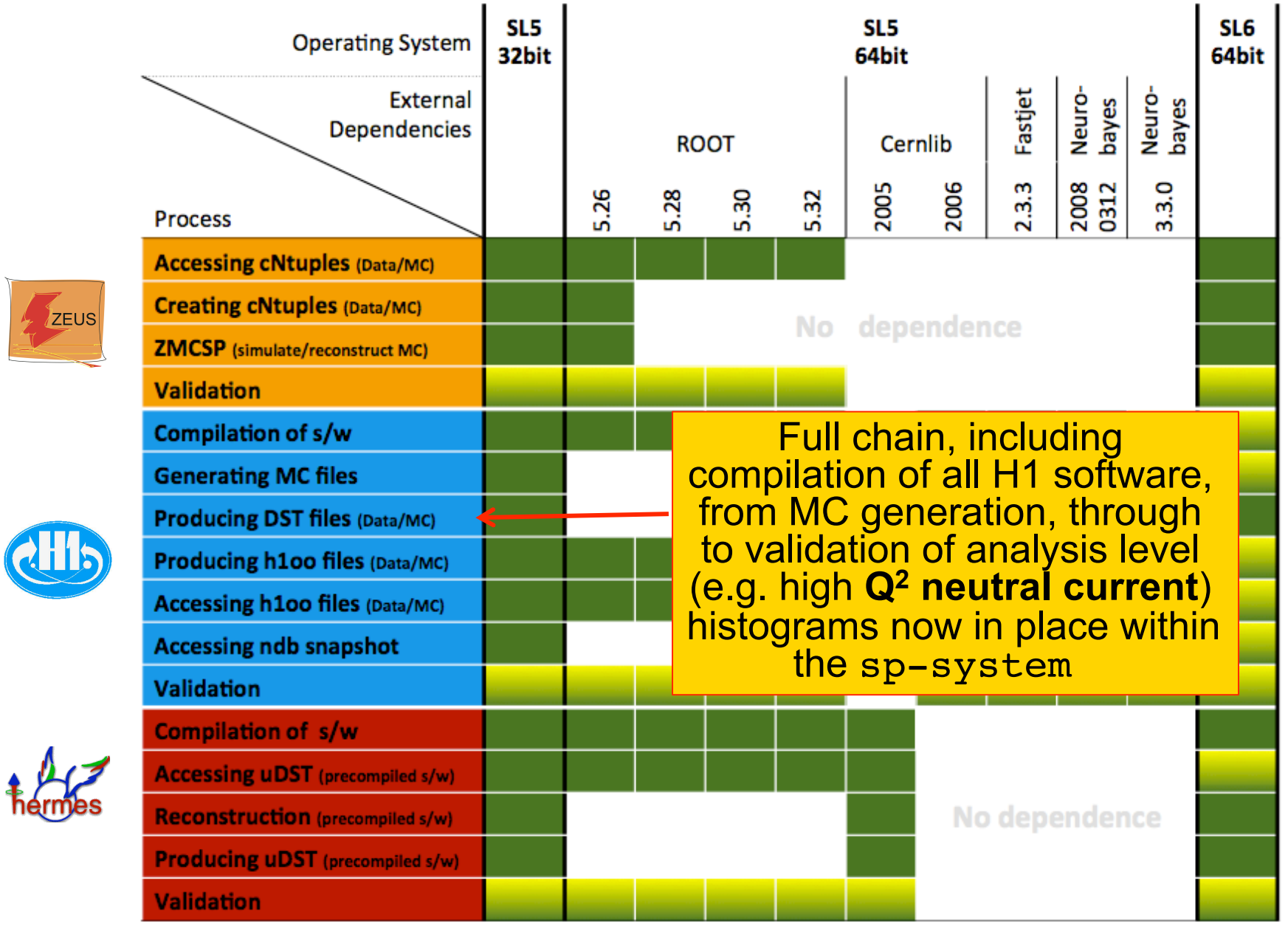

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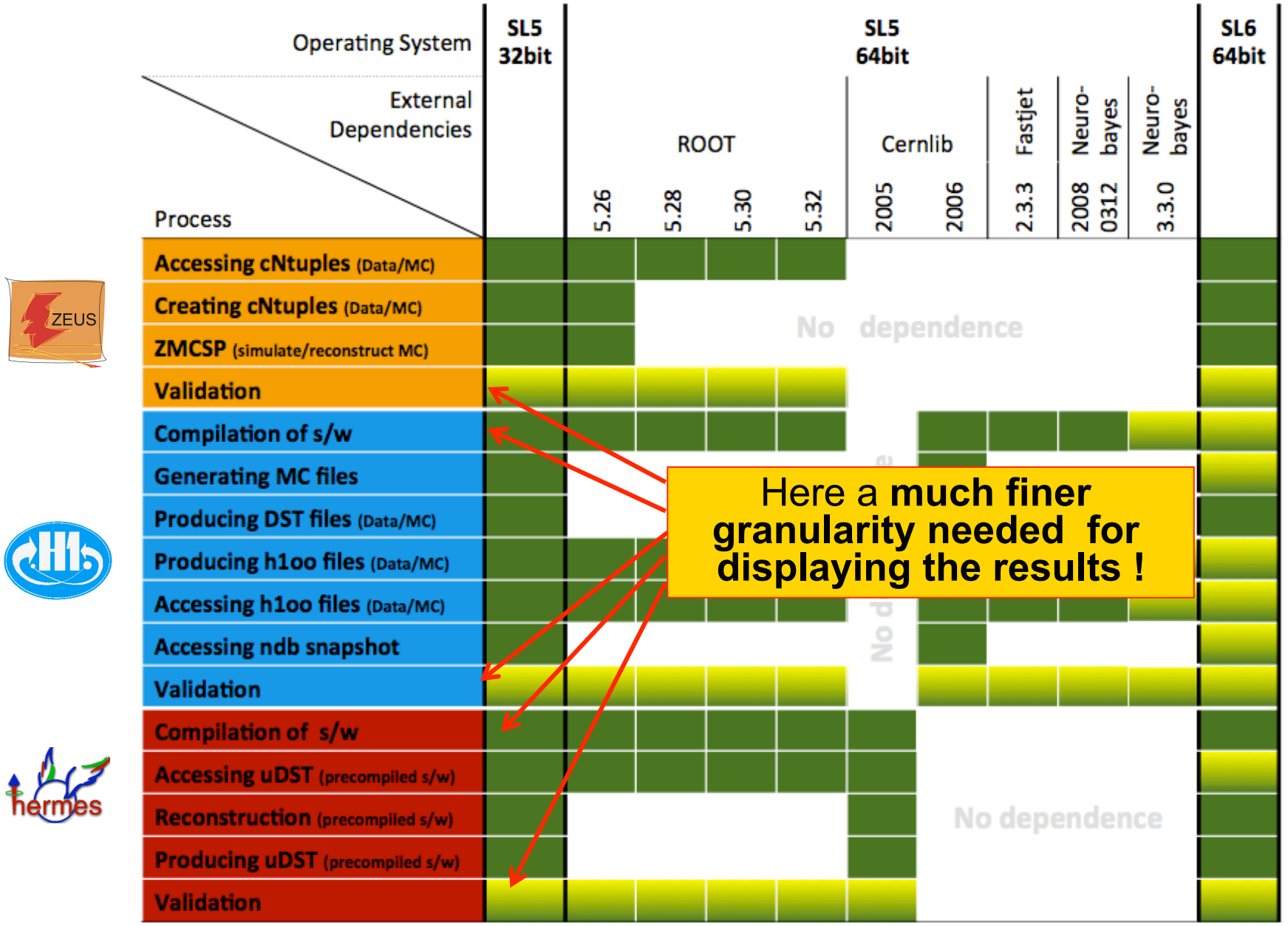
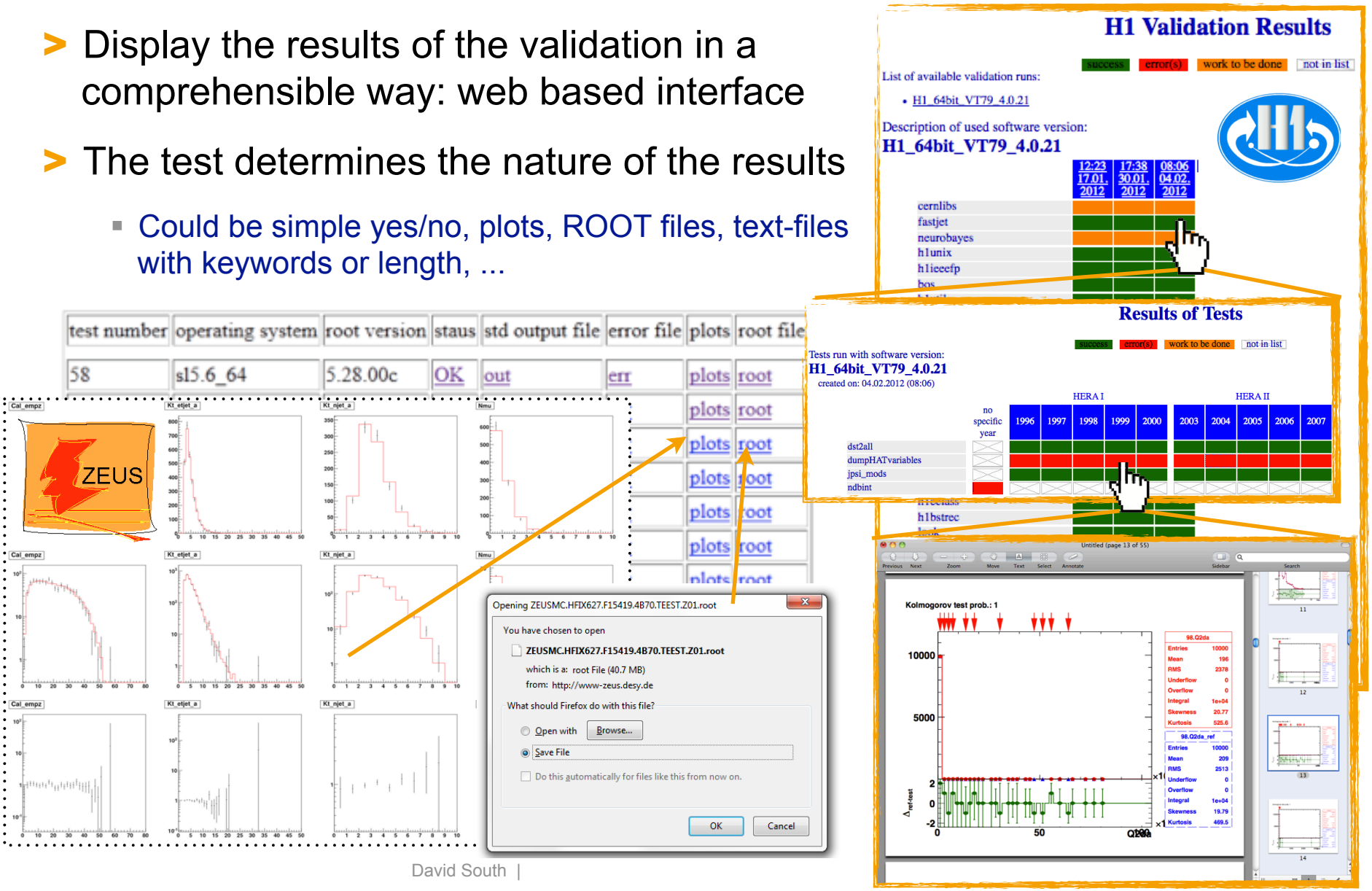
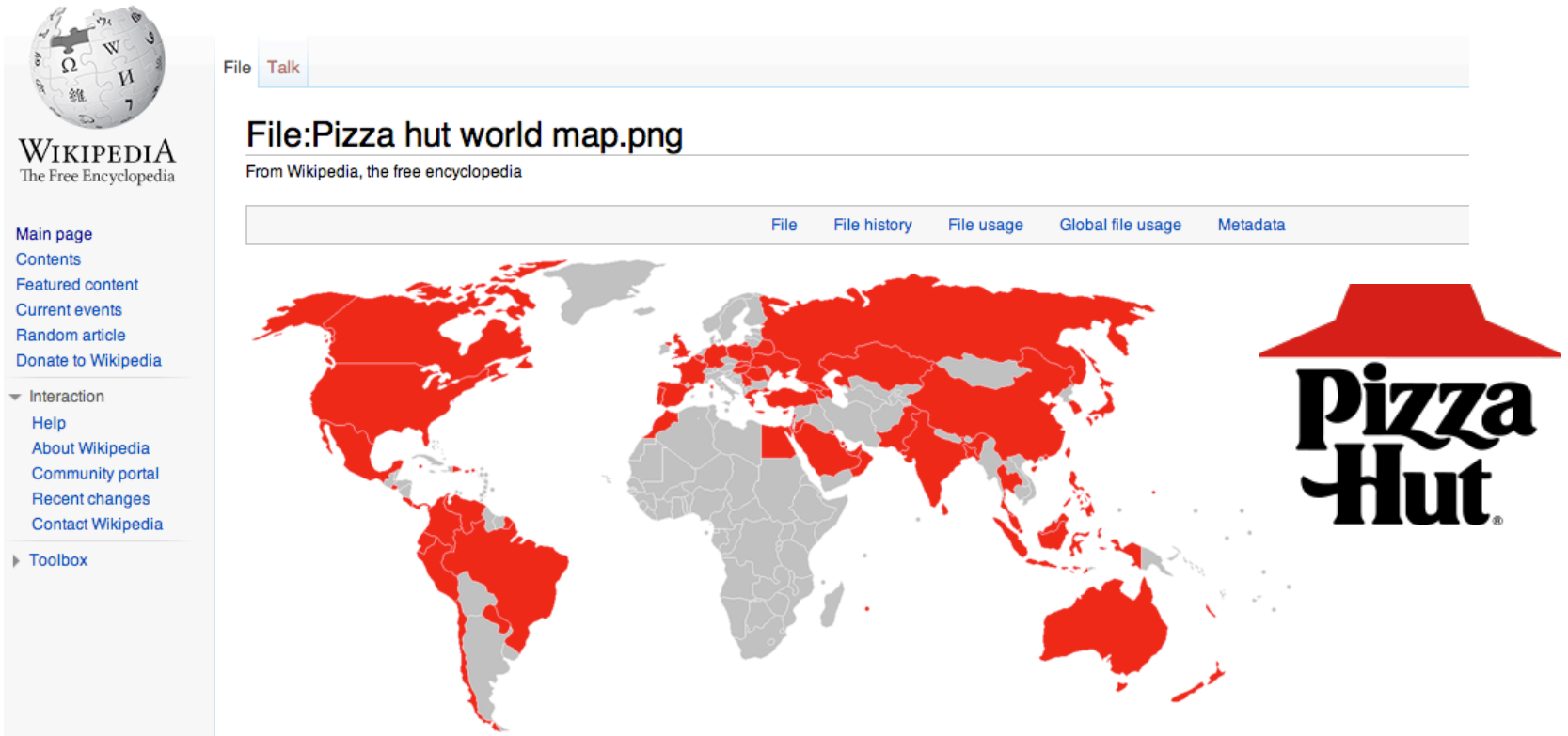


Digesting the validation results

- Display the results of the validation in a comprehensible way: web based interface
- The test determines the nature of the results
  - Could be simple yes/no, plots, ROOT files, text-files with keywords or length, ...

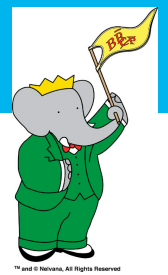


Deployment

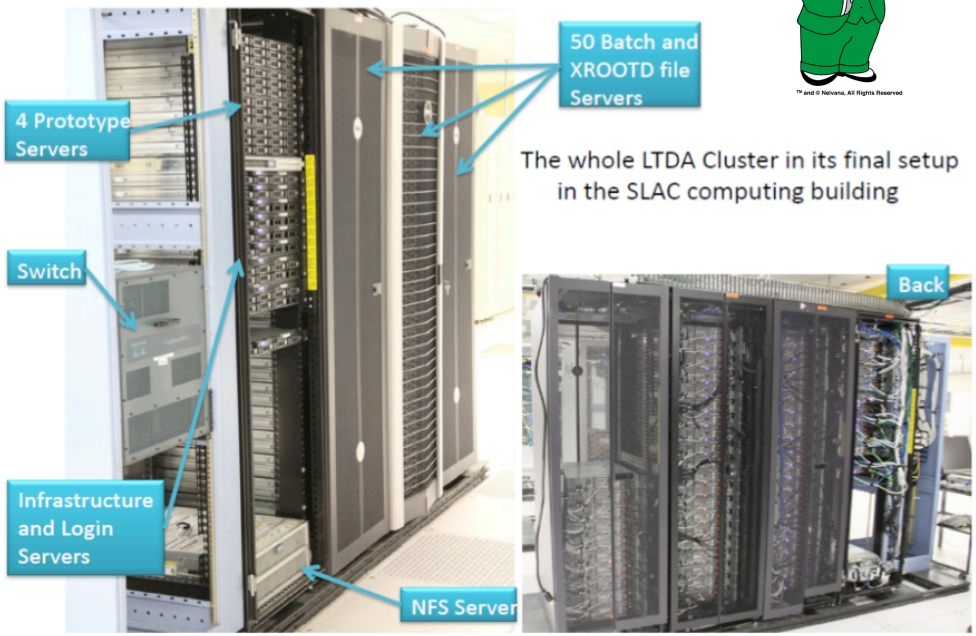


- The whole point of the `sp-system` is ***not*** to provide a future resource for the experiments, but rather to provide a recipe which can be deployed
  - At DESY, this means for example exploring alternative resources such as the local BIRD cluster, the National Analysis Facility (dedicated to LHC, unlikely) or the Grid

The BaBar Long Term Data Access archival system



- New BaBar system installed for analysis until at least 2018
- Isolated from SLAC, and uses virtualisation techniques to preserve an existing, stable and validated platform
- Complete data storage and user environment in one system



- Required large scale investment: 54 R510 machines, primarily for data storage, as well as 18 other dedicated servers
  - Resources taken into account in experiment's funding model during analysis phase!
- From the user's perspective, very similar to existing BaBar infrastructure

DESY

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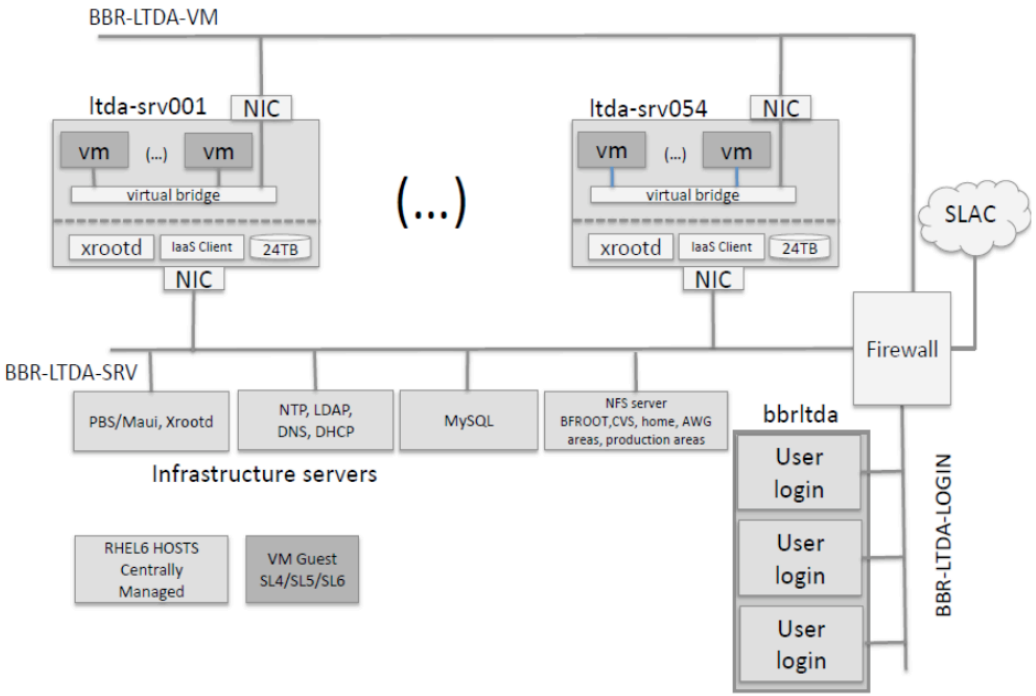
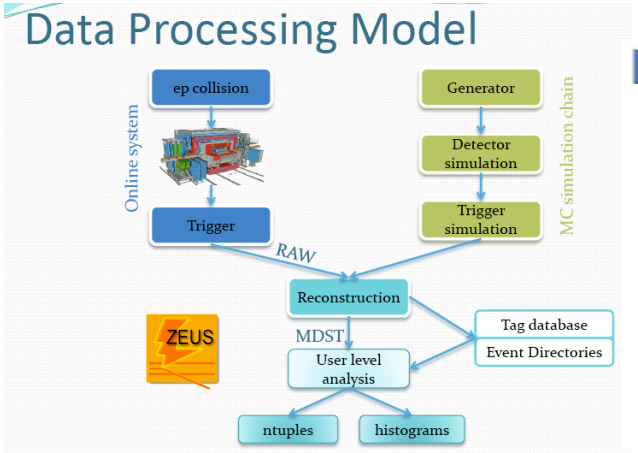
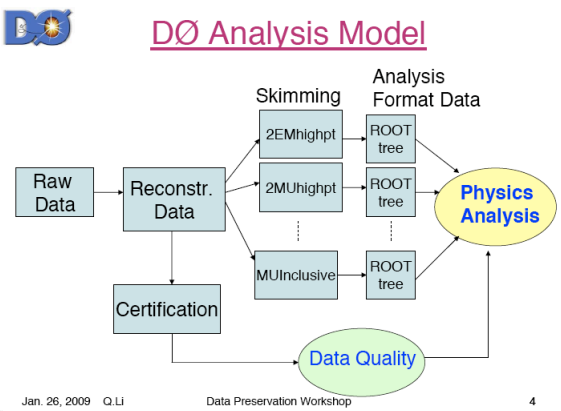


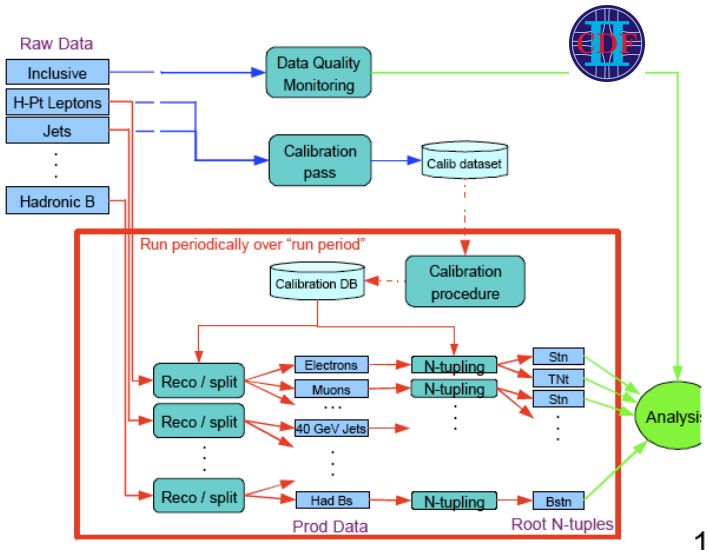
- Crucial part of design is to allow frozen, older platforms to run in a secure computing environment
- *Naïve* virtualisation strategy, not enough
  - Cannot support an OS *forever*
  - Security of system under threat using old versions

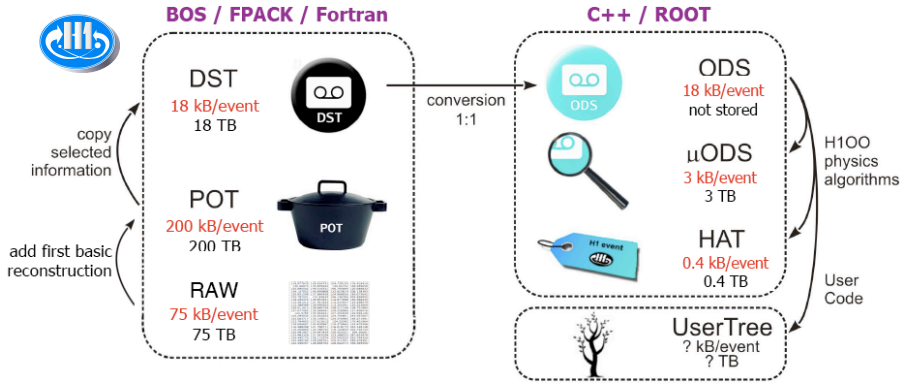
- Achieved by clear network separation via firewalls of part storing the data (more modern OS) and part running analysis (the desired older OS)
- Other BaBar infrastructure not included in VMs is taken from common NFS
- More than 20 analyses now using the LTDA system as well as simulation

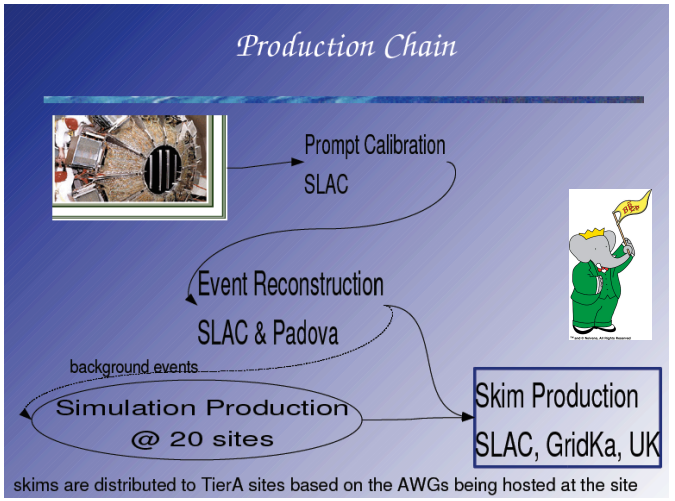
Data analysis models in HEP





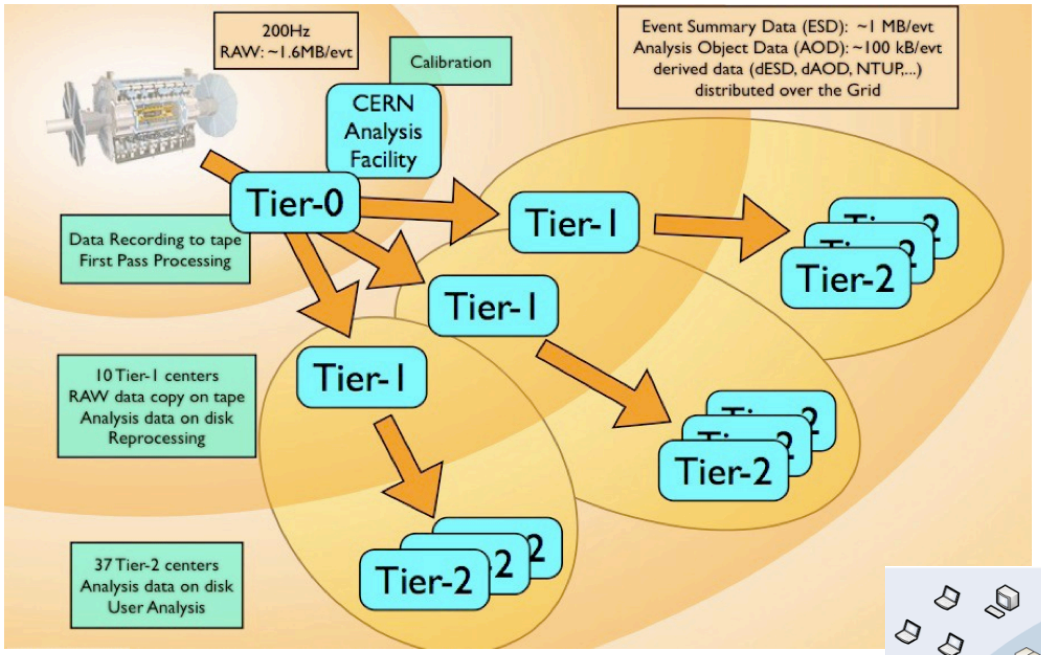


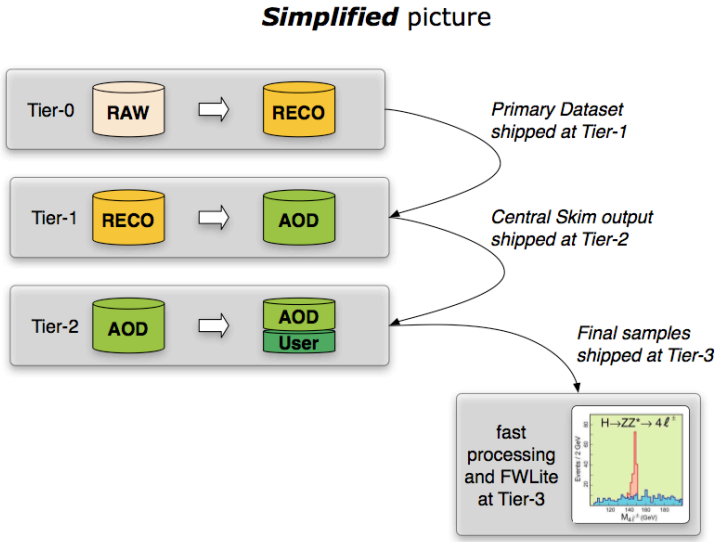


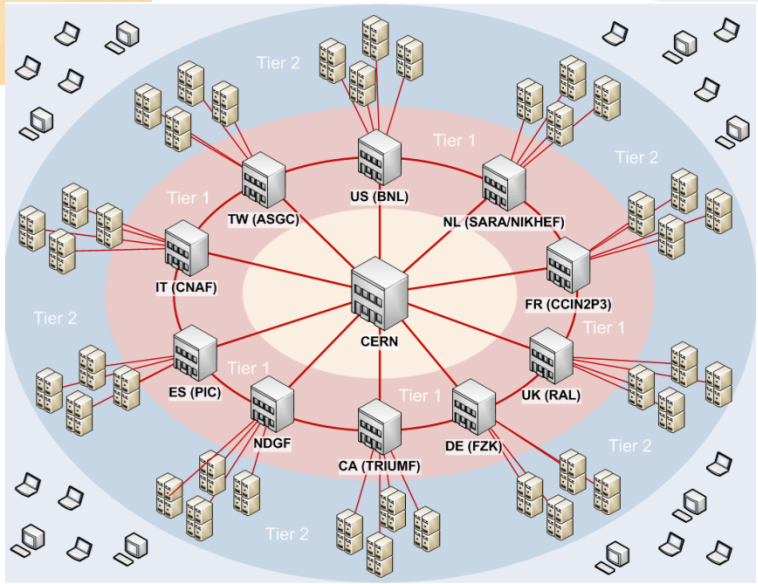


- Complicated, at first glance different
- Familiar descriptions of data analysis chain, from reconstruction to analysis level
  - RAW (→ POT)→ DST → ntuple → analysis

Data analysis models in HEP in the LHC era







- More skims - *yes*
- More distribution - *certainly*
- More complexity - *perhaps..*
- Data placement is key, but analysis-wise it's still very similar to what we had before

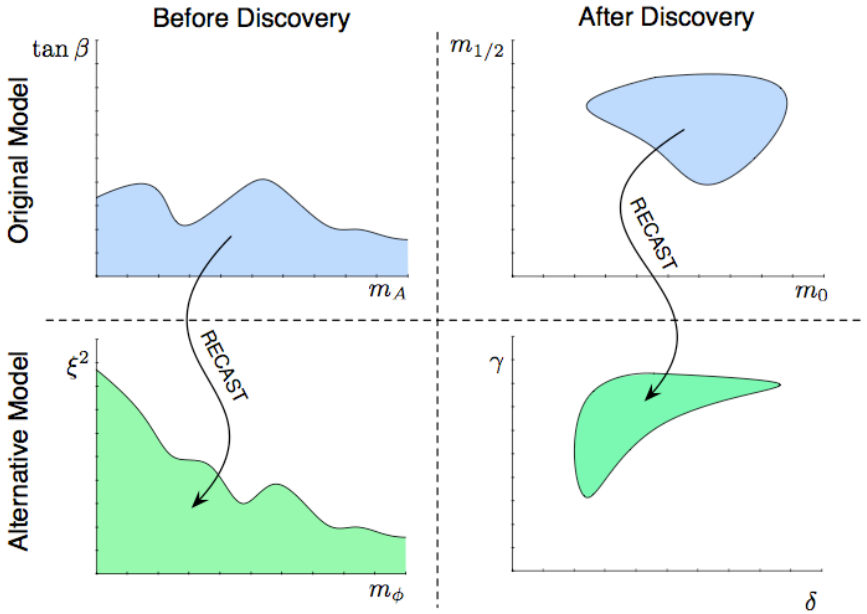
Summary of information from the (pre-LHC) experiments

	BaBar	H1	ZEUS	HERMES	Belle	BESIII	CDF	DØ
End of data taking	07.04.08	30.06.07	30.06.07	30.06.07	30.06.10	2017	30.09.11	30.09.11
Type of data to be preserved	RAW data Sim/rec level Data skims in ROOT	RAW data Sim/rec level Analysis level ROOT data	Flat ROOT based ntuples	RAW data Sim/rec level Analysis level ROOT data	RAW data Sim/rec level	RAW data Sim/rec level ROOT data	RAW data Rec. level ROOT files (data+MC)	Raw data Rec. level ROOT files (data+MC)
Data Volume	2 PB	0.5 PB	0.2 PB	0.5 PB	4 PB	6 PB	9 PB	8.5 PB
Desired longevity of long term analysis	Unlimited	At least 10 years	At least 20 years	5-10 years	5 years	15 years	Unlimited	10 years
Current operating system	SL/RHEL3 SL/RHEL 5	SL5	SL5	SL3 SL5	SL5/RHEL5	SL5	SL5 SL6	SL5
Languages	C++ Java Python	C C++ Fortran Python	C++	C C++ Fortran Python	C C++ Fortran	C++	C C++ Python	C++
Simulation	GEANT 4	GEANT 3	GEANT 3	GEANT 3	GEANT 3	GEANT 4	GEANT 3	GEANT 3
External dependencies	ACE CERNLIB CLHEP CMLOG Flex GNU Bison MySQL Oracle ROOT TCL XRootD	CERNLIB FastJet NeuroBayes Oracle ROOT	ROOT	ADAMO CERNLIB ROOT	Boost CERNLIB NeuroBayes PostgresQL ROOT	CASTPR CERNLIB CLHEP HepMC ROOT	CERNLIB NeuroBayes Oracle ROOT	Oracle ROOT

A multi-preservation level tool: RECAST

arXiv:1010.2506

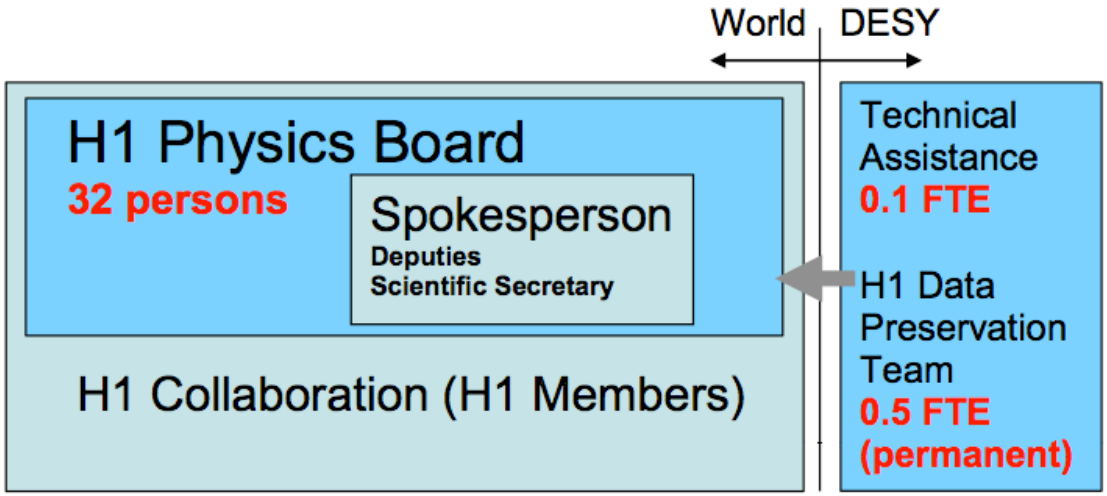
- Framework developed to extend impact of existing analyses
- Complementary approach of analysis archival, encapsulating the full event selection, data, backgrounds, systematics
- Idea is to ***recast*** existing physics search results to constrain alternate model scenarios
  - Complete information from original analysis contained in the data
  - Already performed on ALEPH data, LHC experiments investigating



- RECAST does not fit directly into the DPHEP preservation levels
  - Levels 3 and 4 are in the back-end, containing the complete archived analyses
  - However, only the selection in the publication is preserved, it could also be described as additional information, more like level 1

DESY

Changing face of the HERA collaborations



- H1 moved to a new collaboration management model in July 2012
  - Formation of ***H1 Physics Board***, to replace Collaboration Board (institute based)
  - Future author list policies also set down in new constitution approved by collaboration
- ZEUS (and HERMES) management teams retain same model as before, but similarly to H1 the collaborating institute layer is now removed
  - Remaining physics ZEUS working groups are now consolidated to a single physics group

DPHEP person power requirements

	Project	Goals and deliverables	Resources and timelines	Location, possible funding source, DPHEP allocation
Experiment and laboratory *Priority: 1*	Experimental Data Preservation Task Force	Install an experiment data preservation task force to define and implement data preservation goals.	1 FTE installed as soon as possible, and included in upgrade projects	Located within each computing team. Experiment funding agencies or host laboratories. DPHEP contact ensured, not necessarily as a displayed FTE.
	Facility or Laboratory Data Preservation Projects	Data archivist for facility, part of the R&D team or in charge with the running preservation system and designed as contact person for DPHEP.	1-2 FTE per laboratory, installed as a common resource.	Experiment common person power, support by the host labs or by the funding agencies as a part of the on-going experimental program. A fraction 0.2 FTE allocated to DPHEP for technical support and overall organisation.
Multi-experiment *Priority: 3*	General validation framework	Provide a common framework for HEP software validation, leading to a common repository for experiments software. Deployment on grid and contingency with LHC computing also part of the goals.	1 FTE	Installed in DESY, as present host of the corresponding initiative. Funding from common projects. Cooperation with upgrades at LHC can be envisaged. Part of DPHEP.
	Archival systems	Install secured data storage units able to maintain complex data in a functional form over long period of time without intensive usage.	0.5 FTE	Multi-lab project, cooperation with industry possible. Included in DPHEP person power.
	Virtual dedicated analysis farms	Provide a design for exporting regular analysis on farms to closed virtual farm able to ingest frozen analysis systems for a 5-10 years lifetime.	1 FTE	The host of this working group should be SLAC. Funding could come from central projects and can be considered as part of DPHEP.
	RECAST contact	Ensure contact with projects aiming at defining interfaces between high-level data and theory.	0.5 FTE	Installed with proximity to the LHC, the main consumer of this initiative, with strong connections to the data preservation initiatives that may adopt the paradigms.
	High level objects and INSPIRE	Extend INSPIRE service to documentation and high-level data object.	0.5-1.5 FTE	Installed at one of the INSPIRE partner laboratories.
	Outreach	Install a multi-experiment project on outreach using preserved data, define common formats for outreach and connect to the existing events.	1 FTE central + 0.2 FTE per experiment	A coordinating role can be played by DPHEP in connection with a large outreach project existing at CERN, DESY or FNAL. The outreach contributions from experiments and laboratories can be partially allocated to the common HEP data outreach project and steered by DPHEP.
Global *Priority: 2*	DPHEP Organisation	DPHEP Project Manager	1 FTE	A position jointly funded by a combination of laboratories and agencies.

LEP Paper Tables

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total	2004-2009
ALEPH	46	42	24	34	12	9	4	4	2	**607**	65
DELPHI	64	30	31	58	21	19	7	7	2	**678**	114
L3	51	40	23	52	16	11	5	2	0	**578**	86
OPAL	61	38	32	55	9	11	4	3	2	**675**	84
All	**222**	**150**	**110**	**199**	**58**	**50**	**20**	**16**	**6**	**2538**	**349**

Table 1: Statistics of peer-reviewed publications of the LEP collaborations.

Papers 2004-2009	ALEPH	DELPHI	L3	OPAL	All
Electroweak	17	26	22	24	89
QCD	19	25	19	22	85
Higgs Searches	6	14	8	9	37
SUSY Searches	4	7	5	9	25
Exotica Searches	5	12	10	7	34
Flavour Physics	6	15	4	5	30
Exclusive Channels	3	8	8	2	21
Cosmo-LEP	3	3	6	0	12
Other	2	4	4	6	16
Total	**65**	**114**	**86**	**84**	**349**

Table 2: Distribution of physics topics in LEP publications in the years 2004-2009.