Summary of the LHC Computing Review

http://lhc-computing-review-public.web.cern.ch

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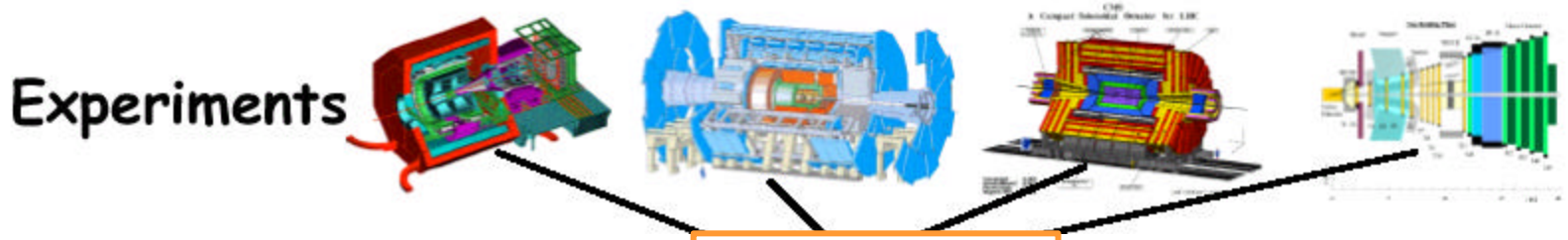
The Scale

- Data taking rate : 50,100, 200 Hz (ALICE, ATLAS-CMS, LHCb)
- Raw event size: 0.15 / 1 / 1-25 MB (LHCb/ATLAS-CMS / ALICE)
- Total raw data storage: 7.0 PB/yr
- Total simulated data storage: 3.2 PB/yr
- World-wide tape storage: 28.5 PB/yr — 40 million CD-Rom's
- World-wide disk storage: 10.4 PB/yr — 100k disks @ 100 GB
- World-wide CPU capacity: 7350 kSI95 — 360k today's PCs
- WAN bandwidth (Tier-0/-1): 5000 Mbps — 4 experiments

Multi-Tier Hierarchical Model



Tier-0 1

CERN

Tier-1 ~5
(national)

Region I

Region F

Region UK

Region D

CERN

Tier-2 ~15
(regional)

Institute

Institute

Institute MAP

Institute

Institute

Tier-3 ~50
Desktop server

Institute Server

Institute Server

Institute Server

Institute Server

Multi-Tier Model (MONARC)

- Tier 0 (CERN)
  - Production centre for real data, large storage capacity
  - Data distribution to Tier 1s (AOD, samples of RAW+ESD)
- Tier 1 (CERN)
  - Physics analysis
  - Production centre for simulation (shared with regional centres)
- Tier 1 regional centres
  - Production centre for simulation
  - Data storage and distribution (robotics and network)
  - Physics analysis
  - Collaboration wide resource (GRID) - access policy needed!
- Tier 2 – special facilities for restricted production work
  - Production analysis and simulation samples, physics analysis
  - Data distribution to Tier 1 (network)
- Distribution guideline – 1/3 each for Tier 0, Tier 1, Tier 2

Rates and Installed Capacities

	ALICE	ATLAS	CMS	LHCb	Total
Event size (MB)	25	2	1	0.125	
Raw data/year (PB)	2.7	8.1	1.7	0.25	13.0
MC data/year (PB)	0.2	1.5	1.2	0.36	3.3
Tape at CERN (TB)	3200	8959	1540	912	14611
Disk at CERN (TB)	534	410	1143	330	2417
CPU at CERN (kSI95)	824	690	820	225	2559
Tape worldwide (TB)	4700	19800	10500	2800	37900
Disk worldwide (TB)	1600	2570	5900	1100	11070
CPU worldwide (kSI95)	1758	1944	2907	925	7535
WAN Tier0/Tier1 (Mb)	1500	1500	1500	310	4810

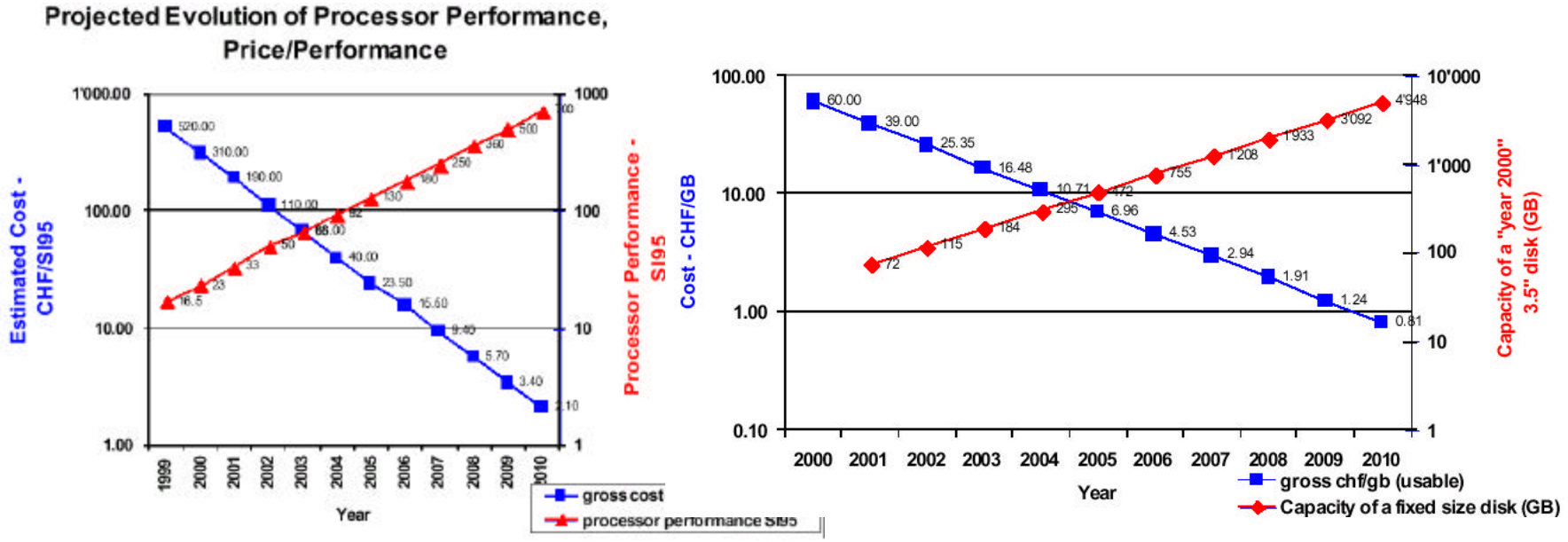
See spreadsheets for details of LHCb numbers

lhcb-comp.web.cern.ch/lhcb-comp/computingmodel/Requirements&Costs/requirements.htm

Hardware costs

- Hardware costs of initial setup of LHC distributed computer centres (Tiers 0, 1 and 2) is 240 MSFr
  - LHCb cost estimate is 27 MSFr i.e. ~11% of total
- CERN-based Tier 0/Tier 1 centre ~ 1/3 of total
- Significant uncertainties in performance of LHC, detectors, triggers, backgrounds, algorithms etc.
- Investment for initial system to be spent in 2005, 2006 and 2007 in ~equal portions (30,30,40)
- Maintenance & Operations (M&O) of LHC computing system
  - Rolling replacement within constant budget
  - Requires ~1/3 of initial investment per year (~80 MSFr)
  - Includes steady evolution of capacity
- Current cost estimates based on forecast evolution of price and performance of computer hardware

Hardware costs of CERN Computing '05-'07



Units kCHF	ALICE	ATLAS	CMS	LHCb
CPU	11069	10667	12667	3479
Disk	2188	1907	5314	1535
Robotic Tape	3200	9407	1617	958
Shelf Tape	0	0	1816	214
Total Cost	18073	23692	23135	7040

LHCb Tier-1/2's 20152 kSFr (74%)

Common Prototype

- Intended to setup a common prototype as a joint project
  - Experiments, CERN, major regional centres all involved
  - Reaching ~50% (in complexity) of overall computing structure of 1 of the large LHC experiments by ~2003/4
- Use as testbed to test at realistic scales
  - Scalability tests of CPU and I/O performance
  - Evaluate new technologies - Copper gigabit; new tapes, IA-64
  - Software tests – fabric management, grid middleware
- To be used in LHCb data challenges
  - Stress test of data processing software – simulation, reconstruction and analysis
  - Stress test of production tools
  - Stress test of 'chaotic' access patterns to event database via analysis jobs
  - Perform data challenges of increasing size and complexity
    - July '02, July '03, 'July '04

Software

- Insufficient support for simulation packages and analysis tools (e.g. FLUKA and ROOT)
- Core software teams in experiments severely understaffed
- Planned reduction of CERN-IT staff incompatible with CERN-based LHC computing system and software support

Manpower needs (FTEs) for CORE Software

	2000 Have (miss)	2001	2002	2003	2004	2005
ALICE	12(5)	17.5	16.5	17	17.5	16.5
ATLAS	23(8)	36	35	30	28	29
CMS	15(10)	27	31	33	33	33
LHCb	14(5)	25	24	23	22	21
Total	64(28)	105.5	106.5	103	100.5	99.5

Only computing professionals counted

CERN/IT - current staff complement	187
- minimum required to run centre	157
- predicted complement in 2006	137

Manpower LHCb Core software and Computing

Task	Profile	2000	2001	2002	2003	2004	2005
Software Framework basic software components	Engineer	**8(3)**	**9(4)**	**8(3)**	**6(2)**	**5(1)**	**5(1)**
Application Frameworks simulation,reconstruction,analysis, event display	Physicist	**6(2)**	**9(4)**	**9(4)**	**8(4)**	**8(4)**	**8(4)**
Software Support code mgt & distribution, testing, quality control, documentation, production tools	Engineer	**2(0)**	**4(1)**	**4(1)**	**4(1)**	**4(1)**	**4(1)**
Computing Facilities Event Filter Farm, LAN, CDR, GRID, OS management	Engineer	**3(1)**	**3(2)**	**3(2)**	**5(3)**	**5(3)**	**5(3)**
Total CORE Computing		**19(6)**	**25(11)**	**24(10)**	**23(10)**	**22(9)**	**22(9)**

Manpower DAQ and ECS

Task	Profile	2000	2001	2002	2003	2004	2005
Readout Unit and detector links	Engineer	**2(0)**	**2(1)**	**2(1)**	**2(1)**	**2(1)**	**2(1)**
Event Building	Engineer	**2(0)**	**2(0)**	**3(1)**	**3(1)**	**3(1)**	**2(1)**
Timing and Fast Control (TFC)	Engineer	**1(0)**	**2(0)**	**2(0)**	**2(0)**	**1(0)**	**1(0)**
ECS interface to electronics	Engineer	**0(0)**	**1(1)**	**1(1)**	**1(1)**	**0(0)**	**0(0)**
Hardware support and installation	Technician	**0(0)**	**0(0)**	**0(0)**	**1(1)**	**1(1)**	**1(1)**
Data monitoring framework and DAQ applications	Engineer	**0(0)**	**0(0)**	**0(0)**	**2(2)**	**2(2)**	**2(2)**
Controls framework, database and applications	Engineer	**1(0)**	**3(1)**	**3(1)**	**4(2)**	**4(2)**	**4(2)**
Operations	Physicist	**0(0)**	**0(0)**	**0(0)**	**0(0)**	**1(1)**	**2(2)**
Total DAQ/ECS		**7(0)**	**10(3)**	**11(4)**	**15(8)**	**14(8)**	**14(9)**

General recommendations

- Setup committee (SC2) to oversee LHC Computing Project composed of highest level software and computing management in experiments, CERN-IT and regional centres to oversee the deployment of the entire LHC computing infrastructure
  - Response from CERN management in preparation
- Each collaboration must prepare an MoU for LHC computing describing funding and responsibilities for hardware and software including human resources.
- Interim MoUs or software agreements should be setup by the end of 2001 to ensure appropriate development of the software
  - CMS have in mind an IMoU
  - ATLAS have pursued the idea of formal software agreements for some time

Software Projects

- Software Framework (GAUDI)
  - Event model – development and optimisation
  - Detector description – development and optimisation of geometry
  - Scripting component to allow interactive analysis based on PYTHON
  - Grid services
  - Data management (event data, conditions data, bookkeeping)
- Software support
  - software test, quality and performance; data quality monitoring
  - Documentation support : workbooks, templates, web
- Computing Facilities
  - Development of analysis model
  - Control and management of event filter farm
  - Technical support at pit – farm, LAN, installation, commissioning etc
- Physics application frameworks
  - Simulation program – project leader
  - High Level Trigger - project leader, HLT framework
  - Analysis Program – project leader
  - Event Display – project leader

DAQ/ECS Projects

- Readout unit, links – engineer
- Event builder prototyping and testing
- ECS interface to electronics (CC-PC) – software engineer
- Slow controls software framework and utilities
- Configuration databases and utilities
- Hardware support and installation ; from '03
- Data monitoring framework and utilities ; from '03
- DAQ applications – run control, error handling ;from '04
- Operations – LHC interface, utilities; from '04

Observations and conclusions

- Waiting for response from CERN management
  - guidelines on construction and cost sharing of prototype
  - timescale for Computing TDR and MoU
  - allocation of additional new effort to IT and experiments
  - role and composition of SC2 and timescale for launch
    - Data management project already in preparation
- Communication with funding agencies
  - Discussions at LHCC, RRBs - preparation of IMoU
  - Responsibilities for core software (sharing policy)
  - Advance notice of long term computing plan (cost sharing)
  - Policy of access to centres outside CERN
- Preparation of distributed computing infrastructure
  - Development of analysis model – physics use-cases
  - Development of grid services – integration in GAUDI
  - Preparation of data challenges

Missing Manpower for CORE Computing

- Provision of core software and computing infrastructure is a collaboration wide responsibility
- Entering intensive development phase now – commitments needed soon
- Agreement on how to share responsibilities will greatly facilitate process of filling missing roles

Formal

Informal

1. IMoU approach (CMS) – sharing algorithm based on number of scientists
2. Software Agreements (ATLAS) – formal contracts whereby an institute agrees to take responsibility for a project
3. Level of effort – a country (or institute) agrees to maintain a contribution of n FTEs for core computing activities