LHCb Processing requirements

Focus on the first year of data-taking

Report to Management and Resources Panel

24 March 2000

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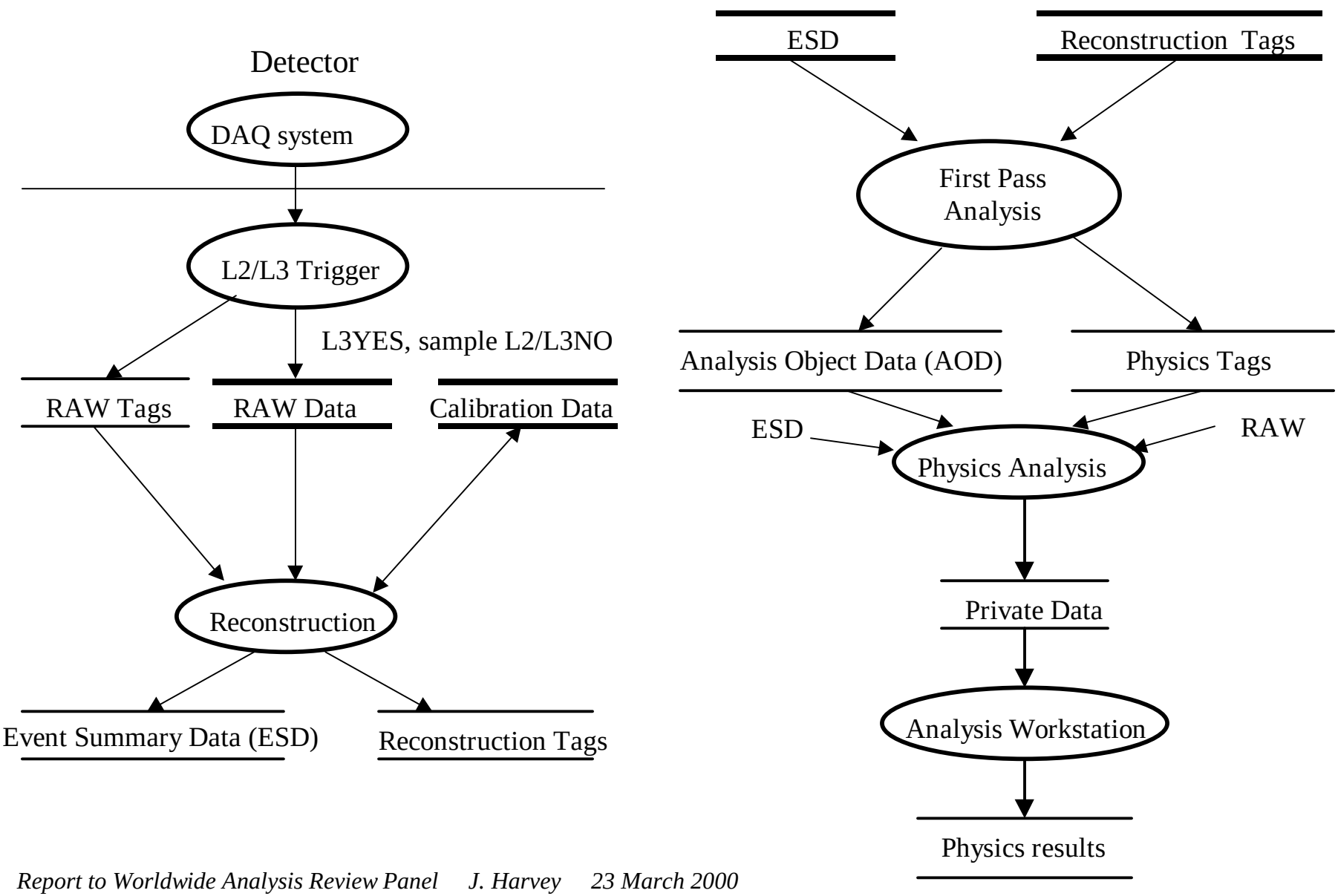
Talk Outline

- Dataflow model
- Data processing and storage requirements
- Baseline computing model
- Data processing at CERN
- The first 6 months - calibration needs
- Impact on processing requirements
- Manpower
- Conclusions

General Comments

- LHCb Technical Notes in preparation
  - LHCb answers to the SPP questions
  - Baseline Model of LHCb's distributed computing facilities
- Baseline model reflects current thinking
  - based on what seems most appropriate technically
  - discussions are just starting
- Open meeting of the collaboration April 5-7
  - feedback and changes can be expected

Dataflow Model

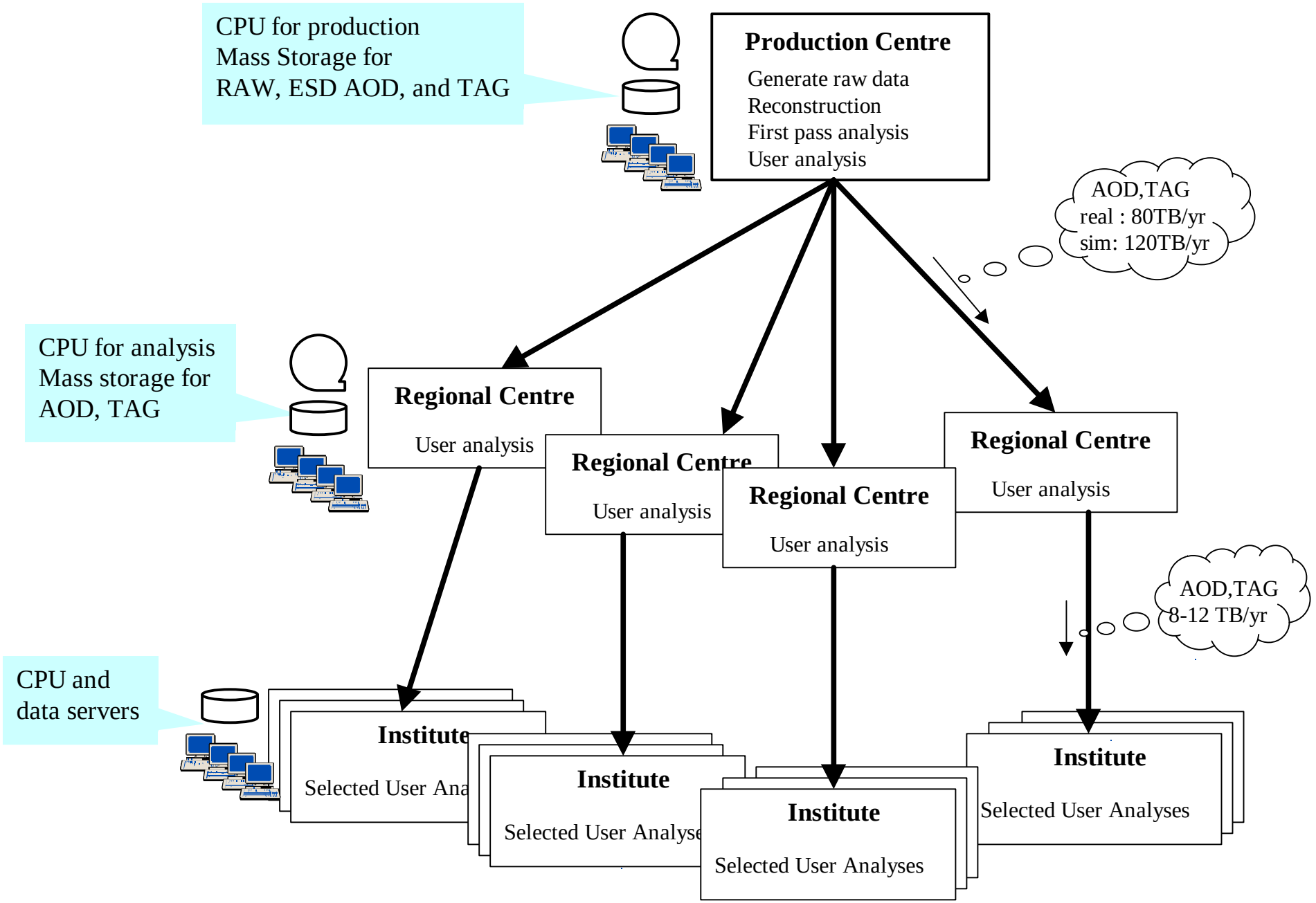


Real Data Processing Requirements

Length of period	120 days	10^7 secs	
LHC duty cycle	50%		
Event rate stored	200 Hz	10^7 per day	10^9 per year
RAW data size	100 kB/event	1 TB/day	100 TB/yr
ESD data size	100 kB/event	1 TB/day	100 TB/yr
AOD data size	20 kB/event	0.2 TB/day	20 TB/yr
TAG data size	1 kB/event	0.01 TB/day	1 TB/yr
L2 trigger CPU	0.25 SI95sec/event	@40 kHz	10,000 SI95
L3 trigger CPU	5 SI95sec/event	@5 kHz	25,000 SI95
Reconstruction CPU	250 SI95sec/event	@200 Hz	50,000 SI95
First Pass Analysis	5 SI95/event	2.10^8 in 2 days	5000 SI95
User analysis at RC	20 SI95sec/event		10,000 SI95
User analysis CERN	20 SI95sec/event		20,000 SI95

Simulation Requirements

RAWmc data size	200 kB/event	200 TB/10^9 events
Generator data size	12 kB/event	12 TB/10^9 events
ESD data size	100 kB	100 TB/10^9 events
AOD data size	20 kB/event	20TB/10^9 events
TAG data size	1 kB/event	1 TB/10^9 events
CPU power	~100,000 SI95 signal events	~400,000 SI95 background events


CPU for production
Mass Storage for
RAW, ESD AOD, and TAG
Production Centre
Generate raw data
Reconstruction
First pass analysis
User analysis
AOD,TAG
real : 80TB/yr
sim: 120TB/yr
CPU for analysis
Mass storage for
AOD, TAG
Regional Centre
User analysis
Regional Centre
User analysis
Regional Centre
User analysis
Regional Centre
User analysis
AOD,TAG
8-12 TB/yr
CPU and
data servers
Institute
Selected User Ana
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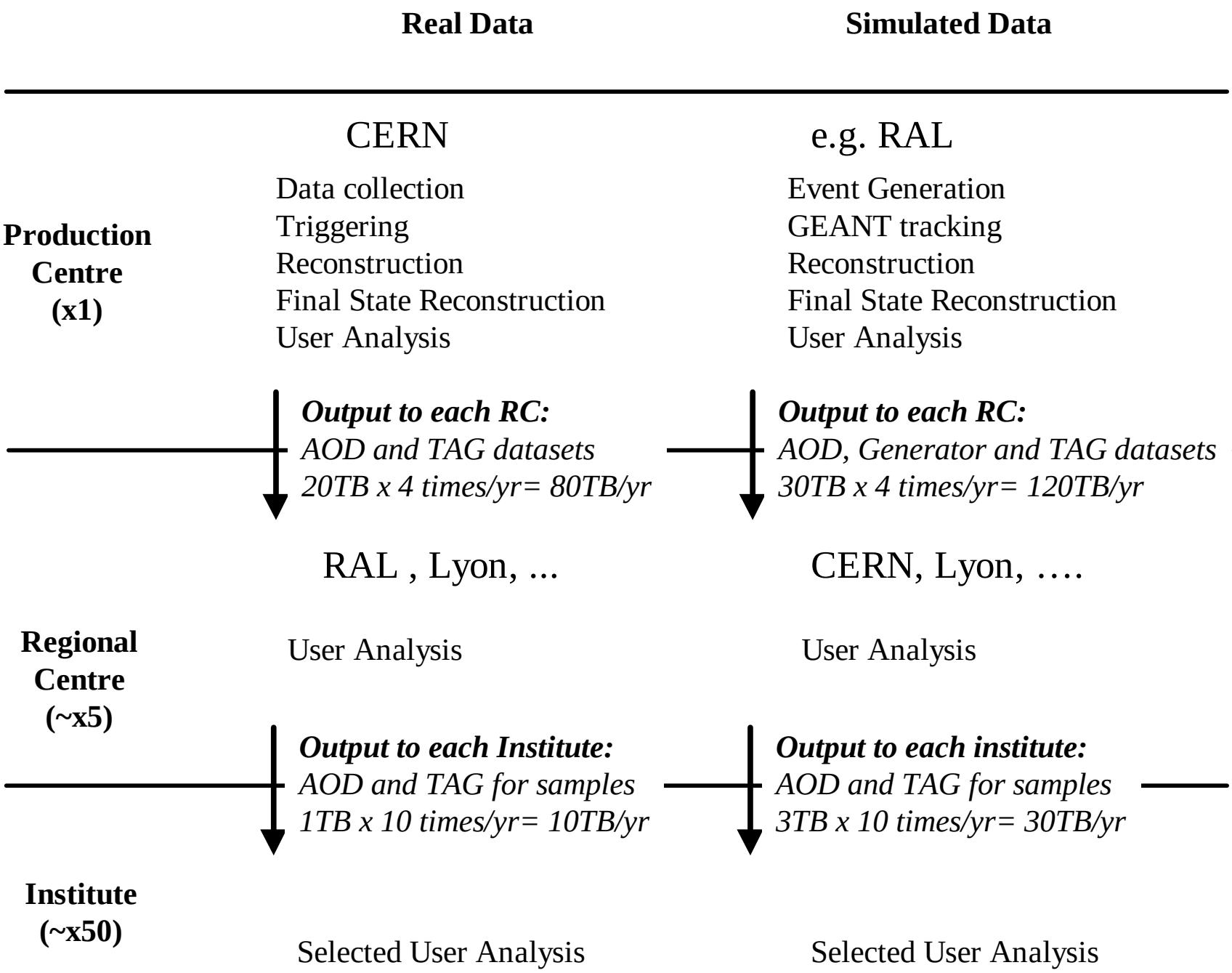
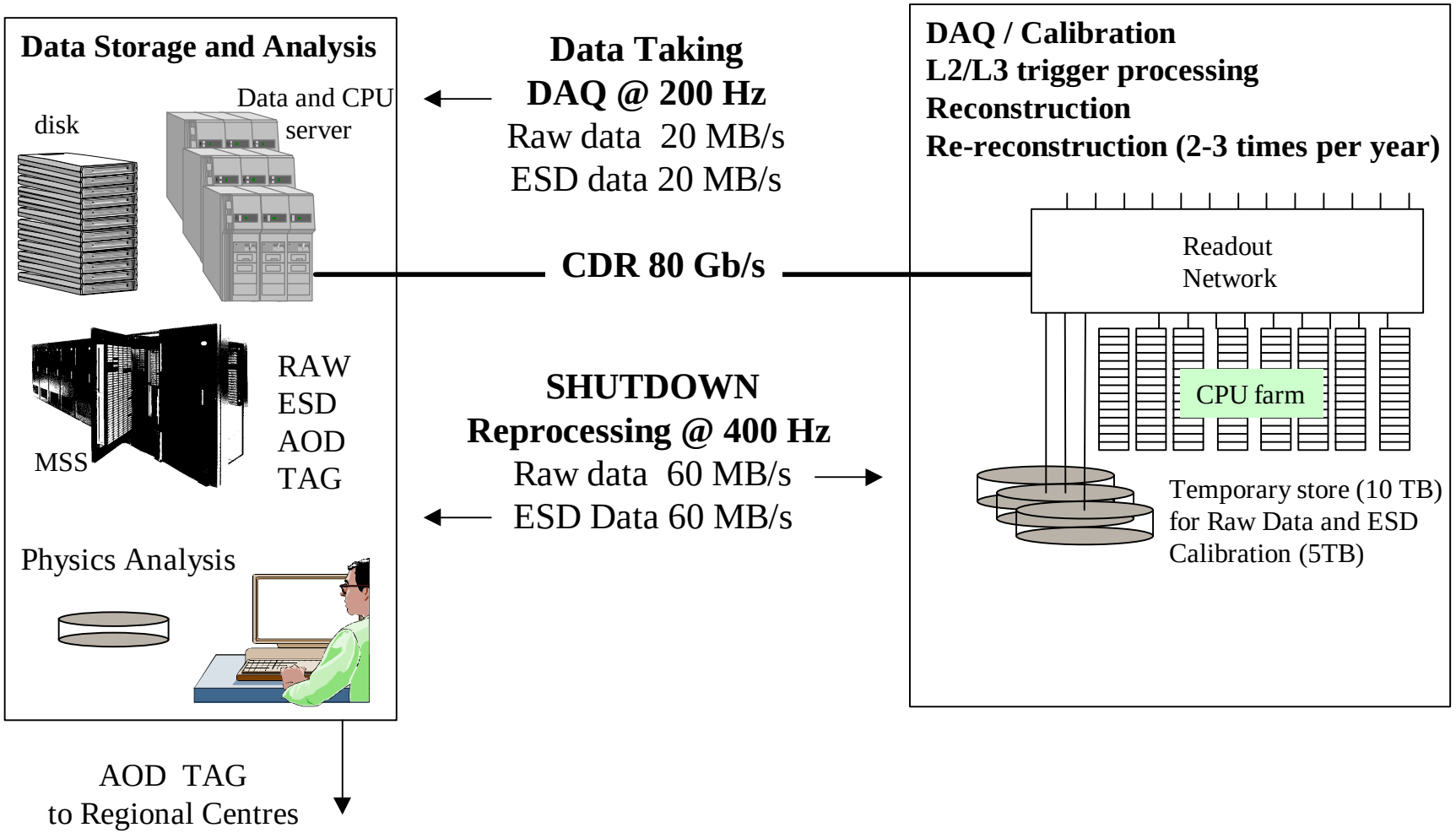

Real Data
Simulated Data
CERN
e.g. RAL
Production Centre (x1)
Data collection
Triggering
Reconstruction
Final State Reconstruction
User Analysis
Event Generation
GEANT tracking
Reconstruction
Final State Reconstruction
User Analysis
Output to each RC:
AOD and TAG datasets
20TB x 4 times/yr= 80TB/yr
Output to each RC:
AOD, Generator and TAG datasets
30TB x 4 times/yr= 120TB/yr
RAL , Lyon, ...
CERN, Lyon, ….
Regional Centre (~x5)
User Analysis
User Analysis
Output to each Institute:
AOD and TAG for samples
1TB x 10 times/yr= 10TB/yr
Output to each institute:
AOD and TAG for samples
3TB x 10 times/yr= 30TB/yr
Institute (~x50)
Selected User Analysis
Selected User Analysis

Compute Facilities at CERN

CERN Computer Centre

Experiment - LHC Pit 8



Facility at Pit - Requirements

CPU Farm	~100,000 SI95
Disk storage event buffer	> 10 TB
Disk storage calibration and secondary data	>5TB
CDR link capacity (80 Gb/s)	1 Gb/s

CERN Computer Centre Requirements

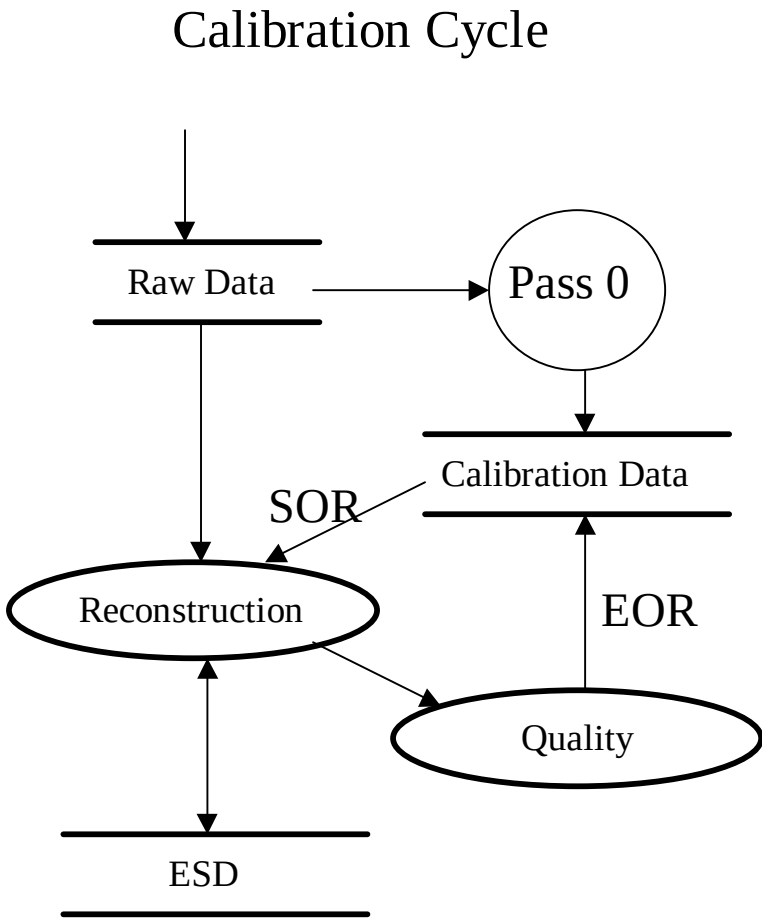
RAW data storage	100 TB/yr
Copy RAW data storage	100 TB/yr
ESD data storage	100 TB/yr
AOD data storage	20 TB/yr
TAG data storage	1 TB/yr
AODmc, Generator storage	120 TB (30 TB imported 4 times/yr)
TAGmc data storage	4 TB (1 TB imported 4 times/yr)
Total data storage	~500 TB / yr
CPU for First Pass analysis	5000 SI95
CPU for user analysis	20,000 SI95
AOD TAG export	20 TB x 4 reprocessings x 5 Regional centres
AOD TAG import	124 TB/yr

LHCb - the first 6 months

- Assumptions
  - we will get our full nominal luminosity $2.\ 10^{32}$ (x1)
  - the LHC duty cycle will be lower - assume 25% (x 0.5)
  - datataking will start end June - assume 60 days in 2005 (x0.5)
- Factors
  - commission high level triggers
  - commission reconstruction software
  - understand calibration and alignment
- Consequences
  - stream of "pass-all" events to study trigger candidates (x1)
  - as trigger improves b sample will get richer
  - lots of re-reconstruction (x 2)

Calibration

- Decide what a run is...
  - 10^7 events per day
  - 2 x 10 hour fills per day
  - 5. 10^6 events per fill
  - 5 runs per fill (~2 hrs - data quality)
  - 10^6 events per run or 100 GB
- Calibration
  - VELO - 1 short run (5 mins) at SOR for alignment
  - RICH - P,T changes can be detected and corrected in real time
  - PASS 0 correct for defects
  - Quality - identify all 'dead wires' etc and input at start of next run



Calibration - Alignment

1. Start from survey

(Following steps use real data)

2. Alignment and calibration of trackers
   - ➢ vertex, inner, outer, muon
3. Cross alignment between different trackers
   - ➢ vertex, inner, outer, muon
4. Alignment and calibration of other detectors with well-measured tracks
   - ➢ calorimeters and RICH detectors

❑ Within 1 month of start of datataking we expect to have good understanding of alignment and calibration of the detector

Calibration - Alignment

- Will need intensive effort to understand strange alignment effects
- Run after reconstruction - use reconstructed track information ("second order calibration")
- Not CPU intensive - ~25 SI95sec / event
- Estimate we require 10^6 events (2 hours of datataking)
- Repeat alignment after interventions on the detector
  - 2-3 times per year
- Re-process whole data sample after new alignment completed
  - estimate ~ 5-6 complete re-processings in first year instead of 2-3 (x2 increase)

Simple Analyses

- Must be ready to do interesting physics measurements since we run with full luminosity
- B_d -> J/Ψ K_s is straightforward
  - can be studied “online” as data are recorded
  - results compared with measurements from BaBar and BELLE
- Other channels need very good understanding of the detector
  - B_s -> $D_s K$ needs excellent understanding of vertex detector
  - results may not come promptly with the data

Impact on CPU needs

- High Level Triggers
  - Full luminosity implies full L2/L3 capacity needed from day 1
  - corresponds to 10000 SI95 (L2), 25000 SI95 (L3)
- Reconstruction :
  - 0.5 (duty cycle) x 0.5 (days) x 2 (reprocessings) = 0.5
  - implement half reconstruction capacity in first year
  - corresponds to 25000 SI95
  - install full capacity for second year
  - benefit from improvements in performance
  - **NB farm will be a heterogeneous system**

Impact on CPU needs

- Analysis
  - reduced event sample (x 0.25)
  - intensive development of analysis algorithms
  - extra load at CERN in the first months before distributed computing model is fully operational
  - incentive to turn around the full analysis quickly (~2 days)
  - assume need full analysis power available from day 1
  - corresponds to 20,000 SI95
  - repeat analysis every week - 10 reprocessings
    - 25 TB of data if all are kept

Costs

- CPU Power
  - 80,000 SI95
  - 12 SFr / SI95
  - 1 million SFr
- Data storage
  - 0.25 10^9 events
  - 25 TB RAW + 25TB ESD + 25 TB AOD = 75 TB
  - Tape - 0.5 SFr / GB ~40,000 SFr
  - Disk ~3 SFr / GB x 40 GB (active) = ~120,000 SFr

Assignment of responsibility

- Understood in LHCb institutes building subdetectors also take responsibility for development and maintenance of software
- The detector TDRs are in preparation now
- MOU after TDRs

TDR Schedule

❑ Magnet	Dec 1999
❑ Vertex	Apr 2001
❑ ITR	Sep 2001
❑ OTR	Mar 2001
❑ RICH	Jun 2000
❑ Muon	Jan 2001
❑ Calorimeter	Jul 2000
❑ TriggerL0/L1	Jan 2002
❑ DAQ	Jan 2002
❑ Computing	Jul 2002

Manpower for Software

Activity	Need	Have	Miss	Type
Software frameworks	12	7	5	E/P
Software support	5	2	3	E
Muon software	6	6	0	P/E
Muon trigger	2	2	0	P
Tracking	6	6	0	P
Vertex	6			P/E
Trigger (L0,L1,L2,L3)	7	3	4	E/P
Calorimeter (ECAL,HCAL,PREShower)	8	8	0	P
RICH				
Total	52+	34+	12+	

Flat profile in time. Missing manpower needs to be acquired now

Manpower for facilities and operations

Project Leader	1 FTE
Compute farm	2 FTE
Network	0.5 FTE
Storage, media, bookkeeping	0.5 FTE
Servers, desktop, OS	2 FTE
➢ use services of outsource contract	
Control room infrastructure	1 FTE
Utilities for day to day operation	0.5 FTE
Training shift crews, documentation	0.5 FTE
Link person for LHC machine	1 FTE
Total	**9 FTEs**

Time profile - 3 FTEs by 2002, remainder by 2004