BELLE DAQ System
- Status and Future-

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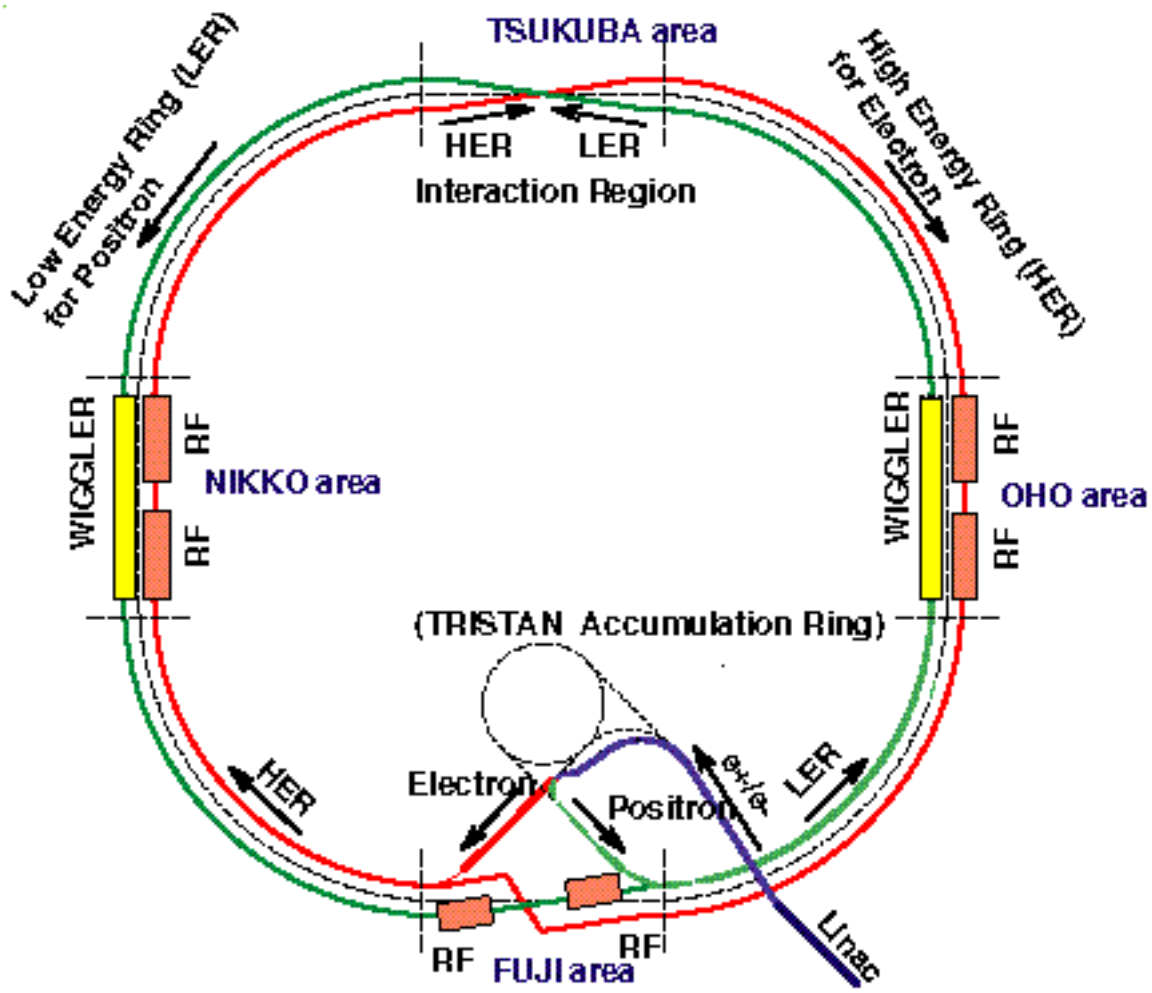
representing BELLE DAQ group

Contents:

CHEP2000, Padova

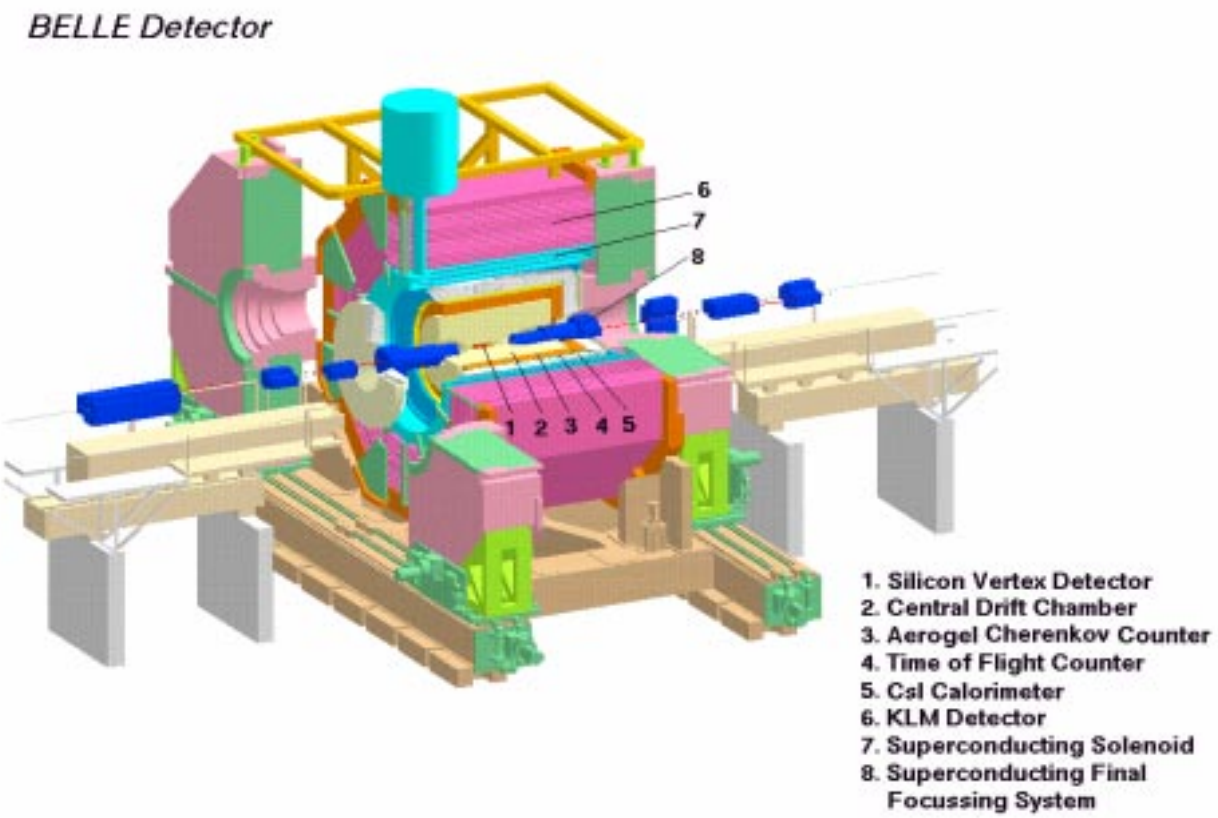
1. Introduction

B-factory experiment @ KEK : KEKB / BELLE



KEKB: The accelerator for KEK B-factory:

- being built reusing ex-TRISTAN tunnel
- e+e- collider with two separate rings
- asymmetric collision
  3.5GeV (e+) x 8.0 GeV (e-)
- design luminosity:
  1.0×10^{34} /cm^2/sec

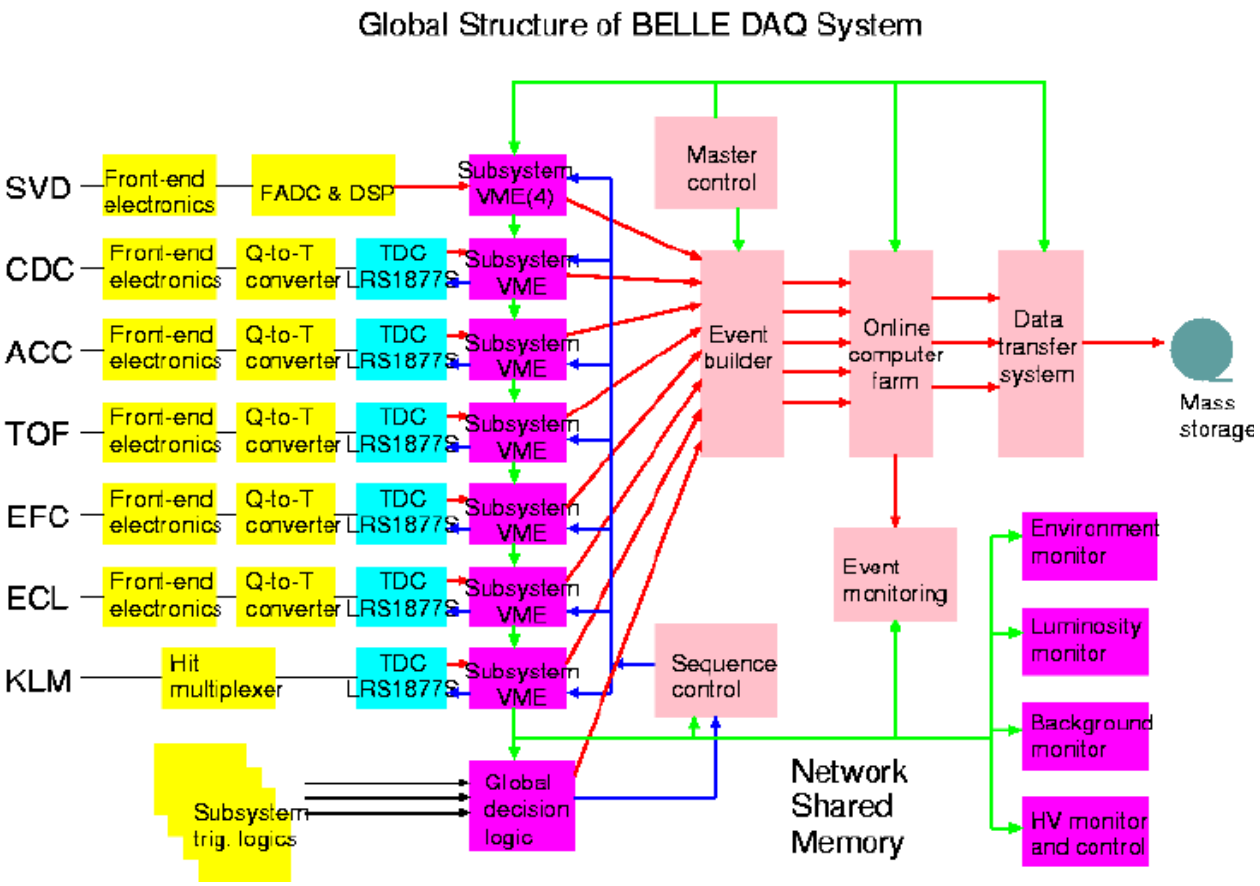


Typical trigger rate : ~ 200Hz (max.500Hz)
Typical raw data size : 30KB/event

↓

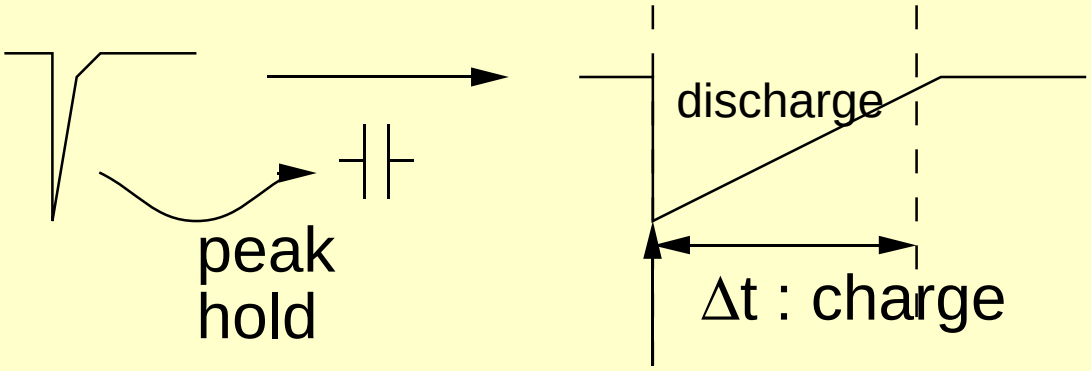
Requirement:
> 15MB/sec throughrate
@ 500Hz

2. Architecture



2.1 Frontend Readout

*based on Q-to-T conversion + multihit TDC



t0: signal timing

Q-to-T : LeCroy MQT300
TDC : LeCroy LRS1877S

used for most of detectors
CDC, ACC, TOF, EFC, ECL

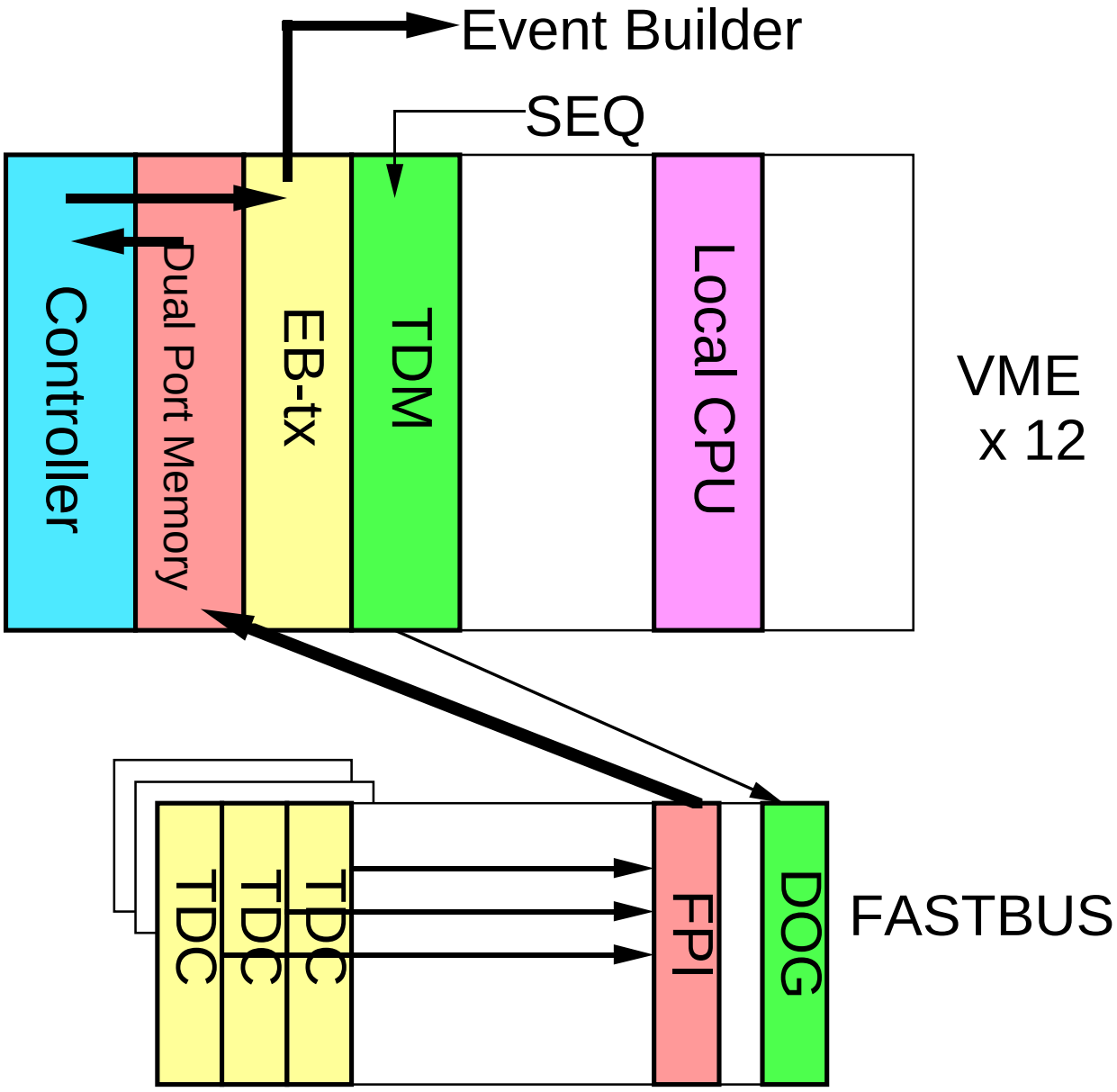
KLM: "hit" timing on strips
-> serialized by multiplexor and
read by TDC (to reduce # of ch.)

SVD: FADC + DSP system

* Control of readout sequence

- Timing is generated by
"Sequence Controller (SEQ)"
by receiving trigger from GDL
- Timing signal
->sent to "Timing Distributor(TDM)"
on each subsystem

2.2 Readout Subsystem



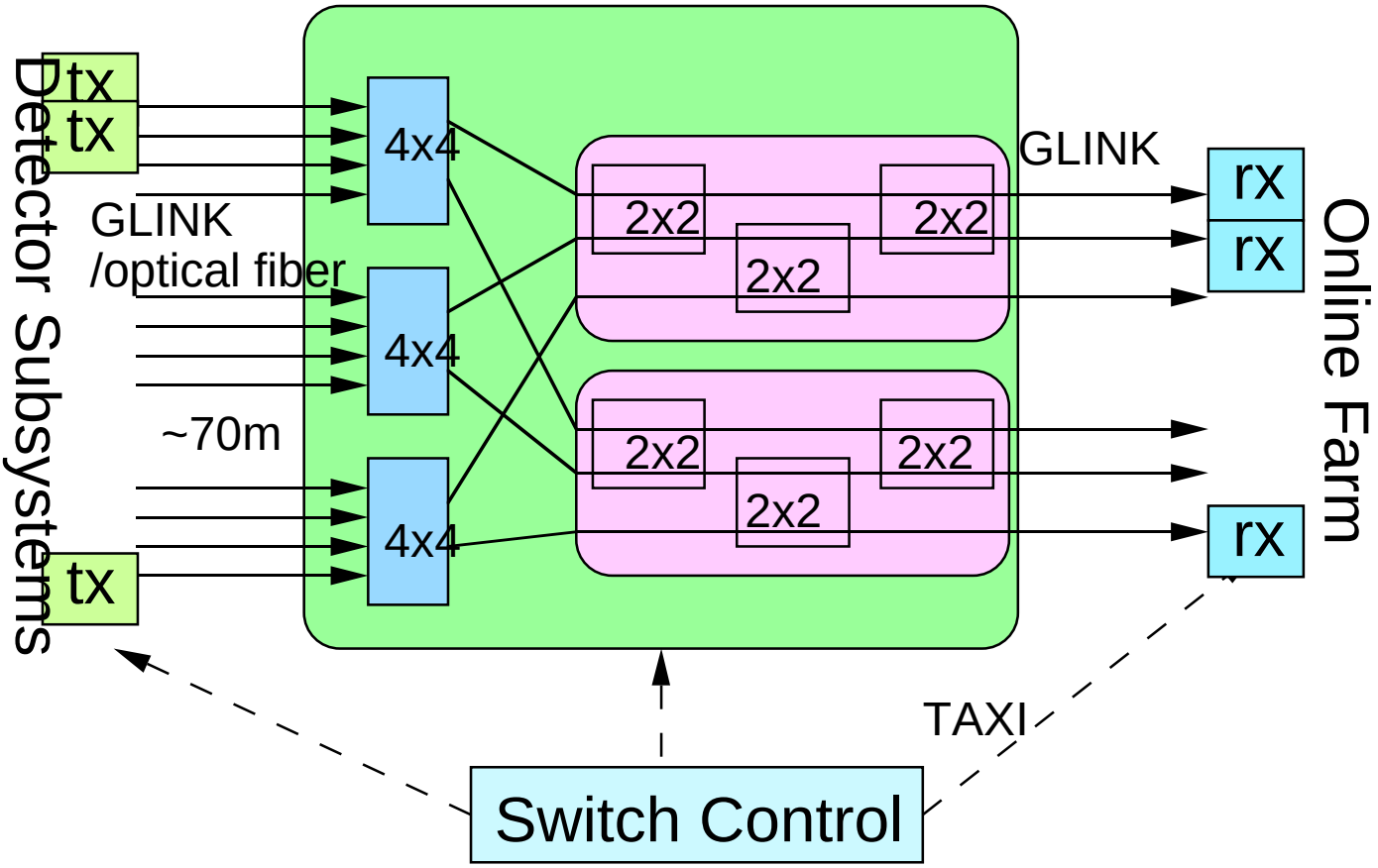
FPI (Fastbus Processor Interface)

Performance :

FASTBUS->Dual Port Memory : 5.5MB/sec
FASTBUS->EB-tx : 3.5MB/sec

2.3 Event Builder

* 12 inputs / 6 outputs
* built by combining 4x4 and 2x2 barrel shifting ECL-signal switches
* external switch control

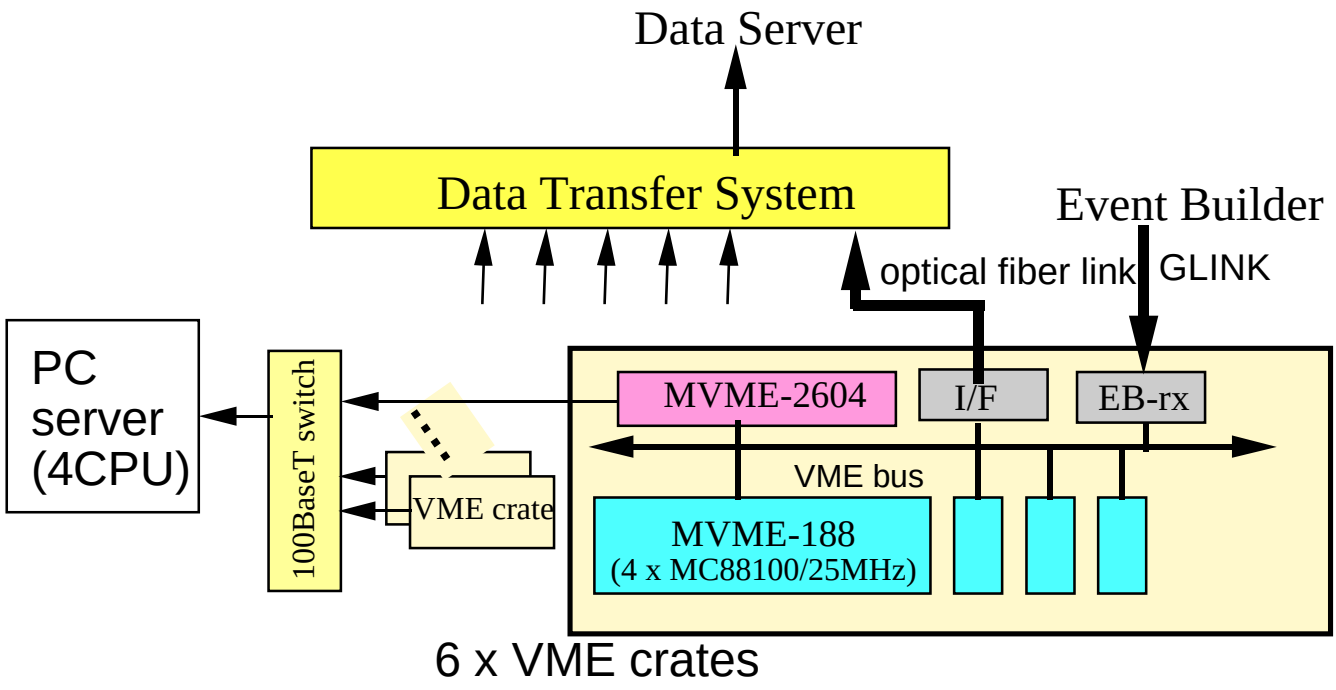


Performance :

maximum switching speed : 30KHz
maximum transfer rate : 160MB/sec
(w/o VME access on tx/rx)
transfer rate in BELLE DAQ :
4 MB/sec/link, >15MB/sec in total

2.4 Online Farm / Event Monitoring

* consists of 6 VME crates housing 96 chips of MC88100 -> parallel processing
  Total CPU power : ~2500 MIPS
* events are sampled and sent to a PC server for data monitoring

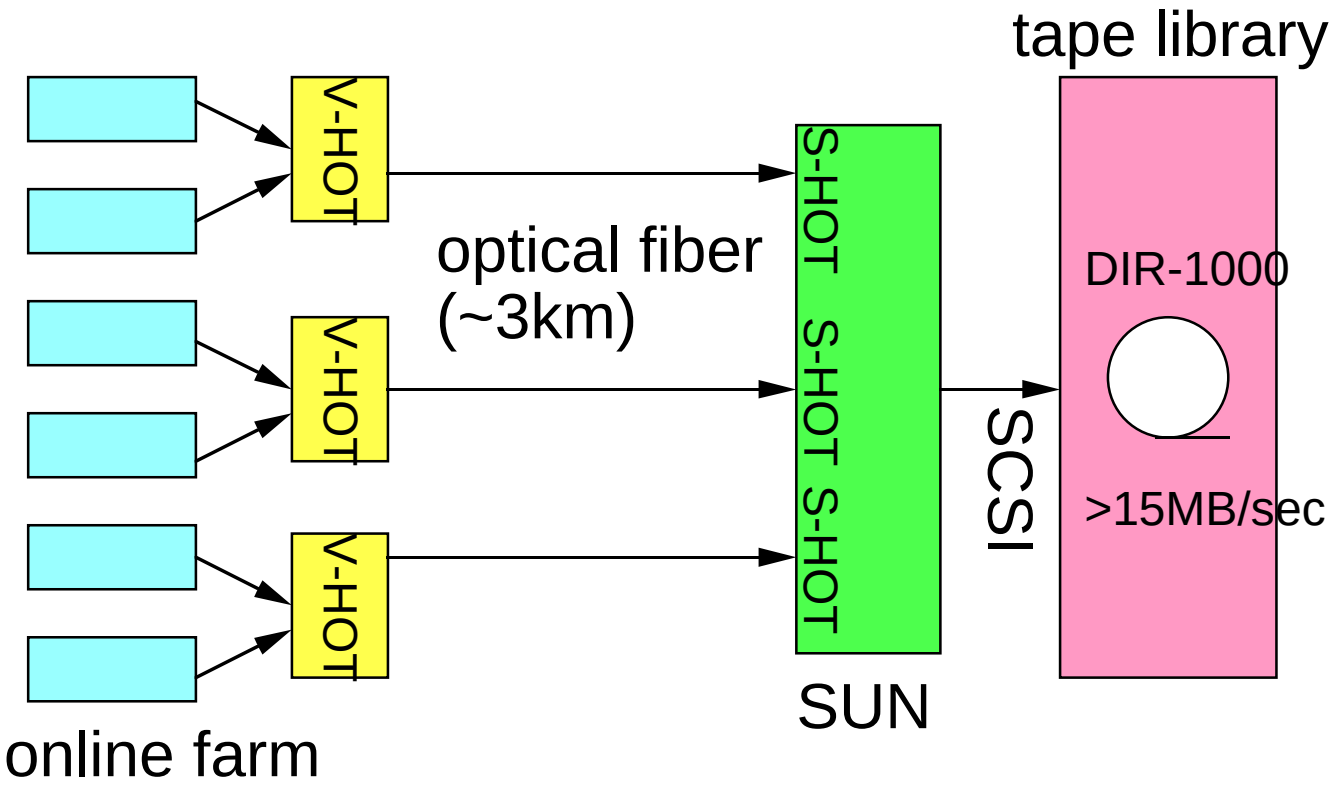


Performance:

maximum transfer speed : 3MB/crate
(only data formatting on farm)
maximum sampling rate to PC server:
50Hz @ 30KB/sec

2.5 Data Transfer System

* send data to computer center and write them onto tape
* Fujitsu built this system using
  protocol : Fujitsu-grown (reflective memory)
  physical connection : TAXI/ATM over optical fiber



Performance :

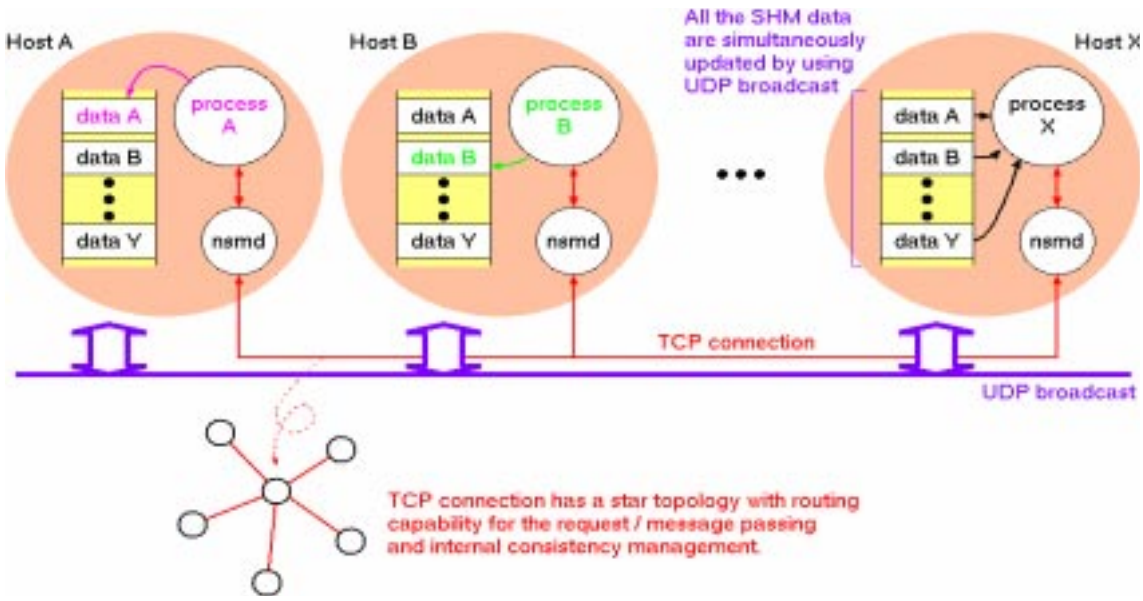
~ 8MB/sec/link
> 15MB/sec in total

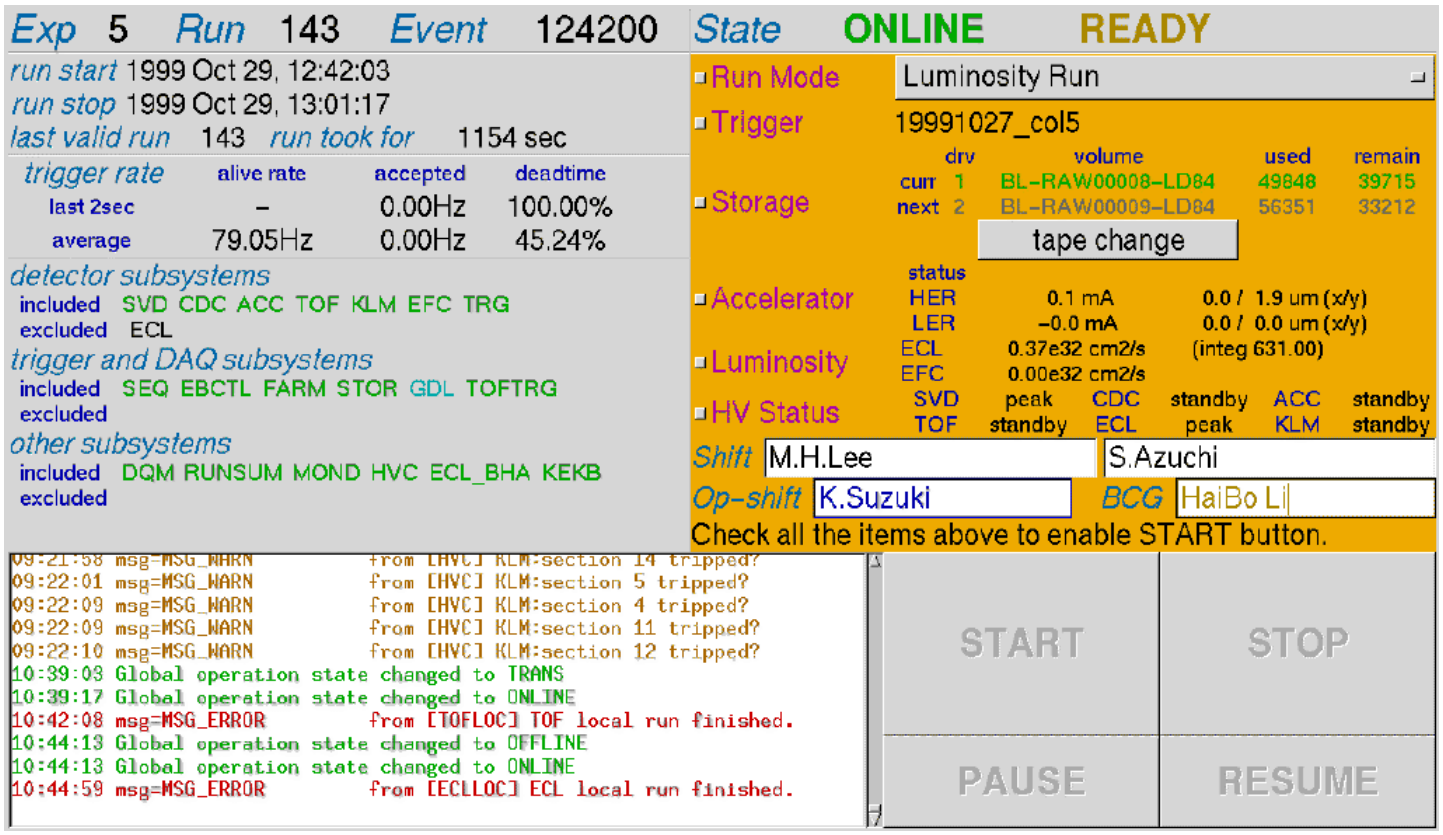
2.6 Run Control

* Run control is done by a closed Ether/FastEther network

* A home−grown communication software called "NSM (Network Shared Memory)" is used.
  −> provides facilities:
  - calls functions on remote node by sending a message
  - shared memory extended over network space

* Both of run control and monitoring are done using NSM




Exp 5 Run 143 Event 124200
State ONLINE READY
run start 1999 Oct 29, 12:42:03
run stop 1999 Oct 29, 13:01:17
last valid run 143 run took for 1154 sec
trigger rate alive rate accepted deadtime
last 2sec – 0.00Hz 100.00%
average 79.05Hz 0.00Hz 45.24%
detector subsystems
included SVD CDC ACC TOF KLM EFC TRG
excluded ECL
trigger and DAQ subsystems
included SEQ EBCTL FARM STOR GDL TOFTRG
excluded
other subsystems
included DQM RUNSUM MOND HVC ECL_BHA KEKB
excluded
Run Mode
Luminosity Run
Trigger
19991027_col5
Storage
drv volume used remain
curr 1 BL-RAW00008-LD84 49848 39715
next 2 BL-RAW00009-LD84 56351 33212
tape change
Accelerator
status
HER 0.1 mA 0.0 / 1.9 um (x/y)
LER -0.0 mA 0.0 / 0.0 um (x/y)
Luminosity
ECL 0.37e32 cm2/s (integ 631.00)
EFC 0.00e32 cm2/s
HV Status
SVD peak CDC standby ACC standby
TOF standby ECL peak KLM standby
Shift M.H.Lee S.Azuchi
Op-shift K.Suzuki BCG HaiBo Li
Check all the items above to enable START button.
09:21:58 msg=MSG_WARN from [HVC] KLM:section 14 tripped?
09:22:01 msg=MSG_WARN from [HVC] KLM:section 5 tripped?
09:22:09 msg=MSG_WARN from [HVC] KLM:section 4 tripped?
09:22:09 msg=MSG_WARN from [HVC] KLM:section 11 tripped?
09:22:10 msg=MSG_WARN from [HVC] KLM:section 12 tripped?
10:39:03 Global operation state changed to TRANS
10:39:17 Global operation state changed to ONLINE
10:42:08 msg=MSG_ERROR from [TOFLOC] TOF local run finished.
10:44:13 Global operation state changed to OFFLINE
10:44:13 Global operation state changed to ONLINE
10:44:59 msg=MSG_ERROR from [ECLLOC] ECL local run finished.
START
STOP
PAUSE
RESUME

3. Event Processing on BELLE DAQ system

- Fast event processing is done on
  * Online Computer Farm
  * PC server (for sampled events)

3.1 Online Farm Processing

Purpose :
1) Formatting of event data
   ("Panther" format for offline analysis)
2) Fast event reconstruction
3) L3 trigger

* Event processing framework on online farm

- the same framework as that used for offline analysis (B.A.S.F.).
- program development is done in offline environment

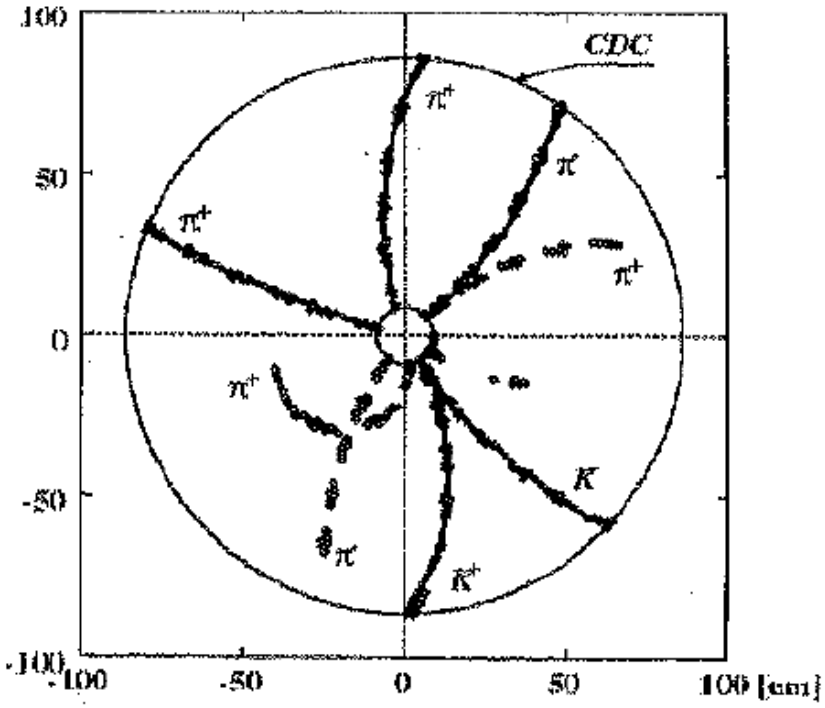
* Fast Reconstruction

Fast track reconstruction is done using track trigger information

− track finding is done using track trigger info.
− track fitting using wire position
  * no x−t relation is used

−> the performance is being studied for the use in L3 trigger
(L3 trigger is not yet turned on.)

- $b\bar{b}$ event



Level 3 Trigger Performance

- Processing speed of Fast Tracker
  * tested in beam runs (>200Hz)
    (executed on Online Farm)
  -> no deadtime (due to fast tracker) was observed.

- L3 performance
  * currently tested in offline analysis using real data

Reduction factor for L1-triggerd events : 0.38
- this is enough for us.
  + L1 trigger is already tight enough
    -> typically 200Hz, Max 500Hz

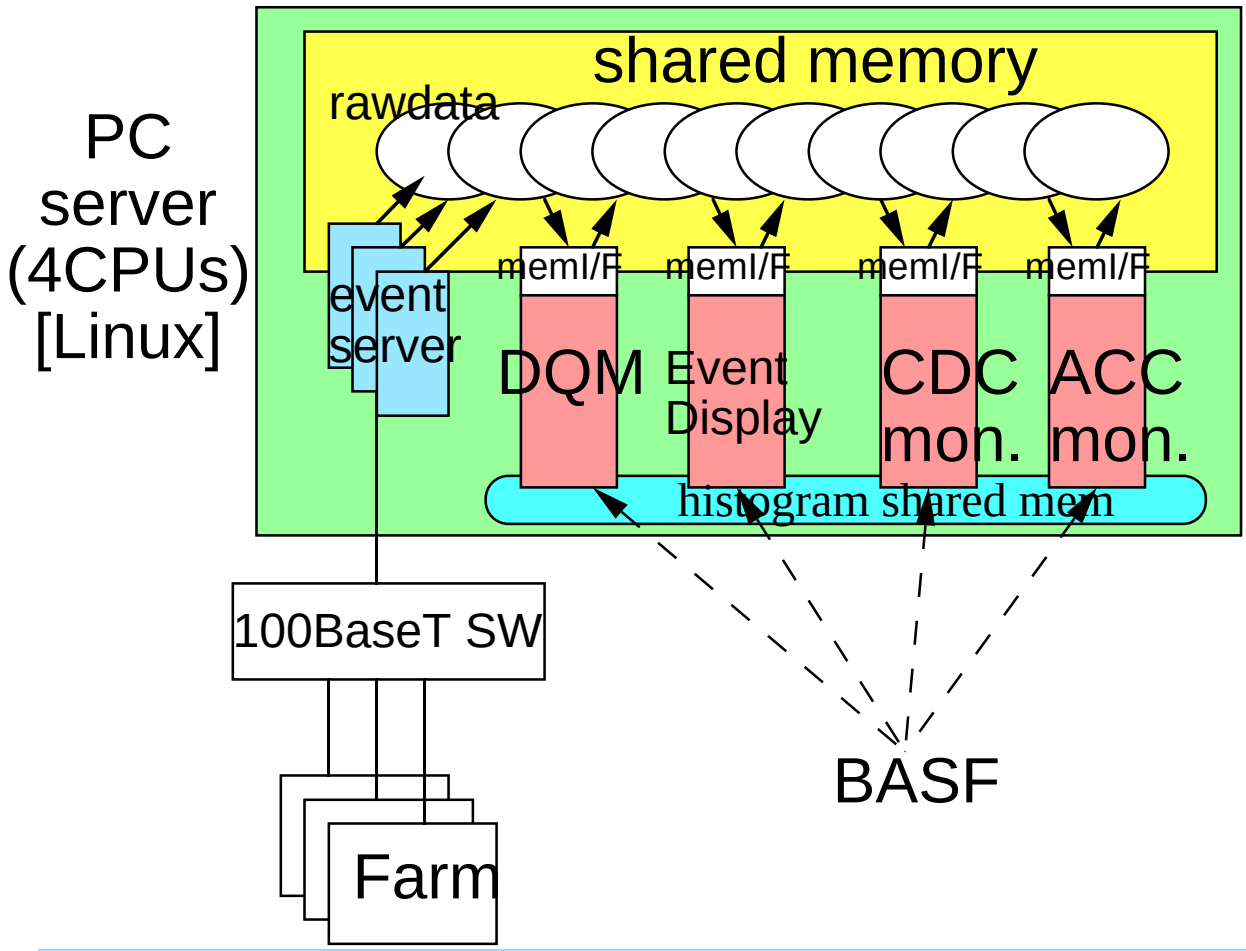
Efficiency:

Hadronic	: 95.5%
$\mu^+\mu^-$	: 89.2 %
$\tau^+\tau^-$	: 79.6%

-> planning to turn-on L3 trigger soon

3.2 Event Monitoring

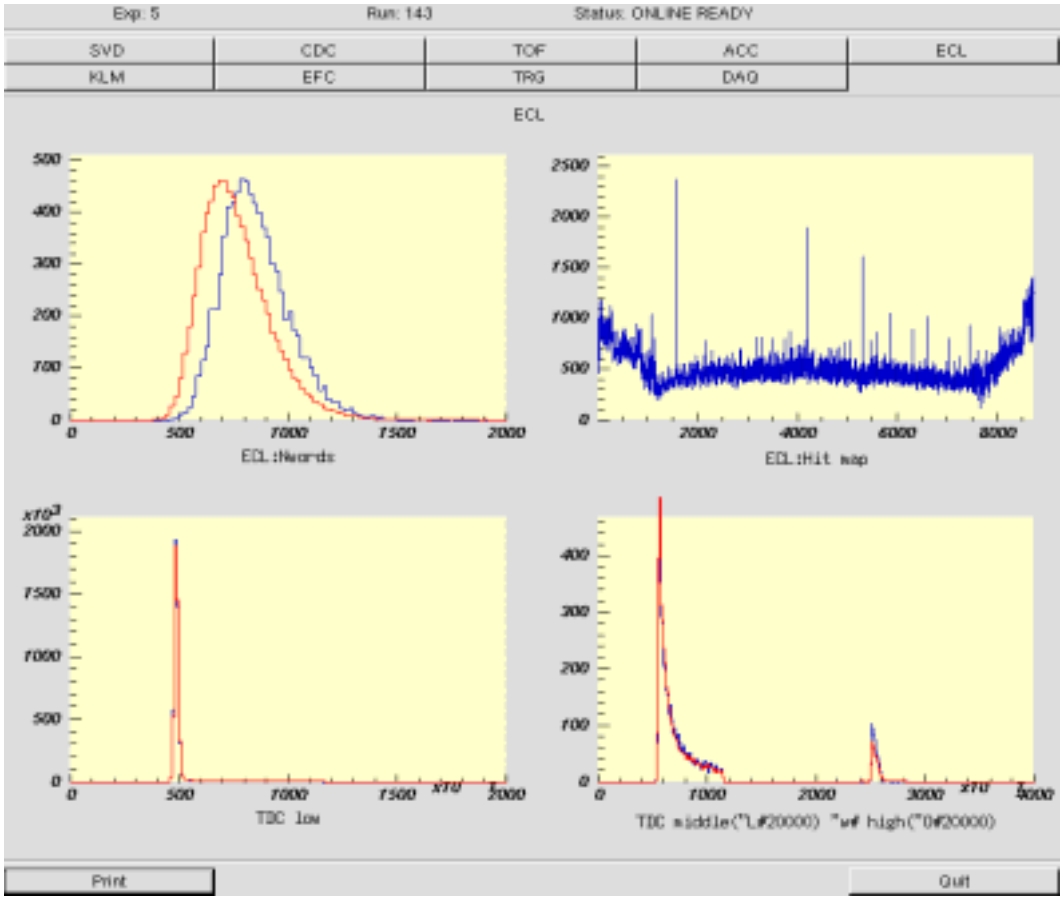
* Events are sampled from online farm via FastEthernet.

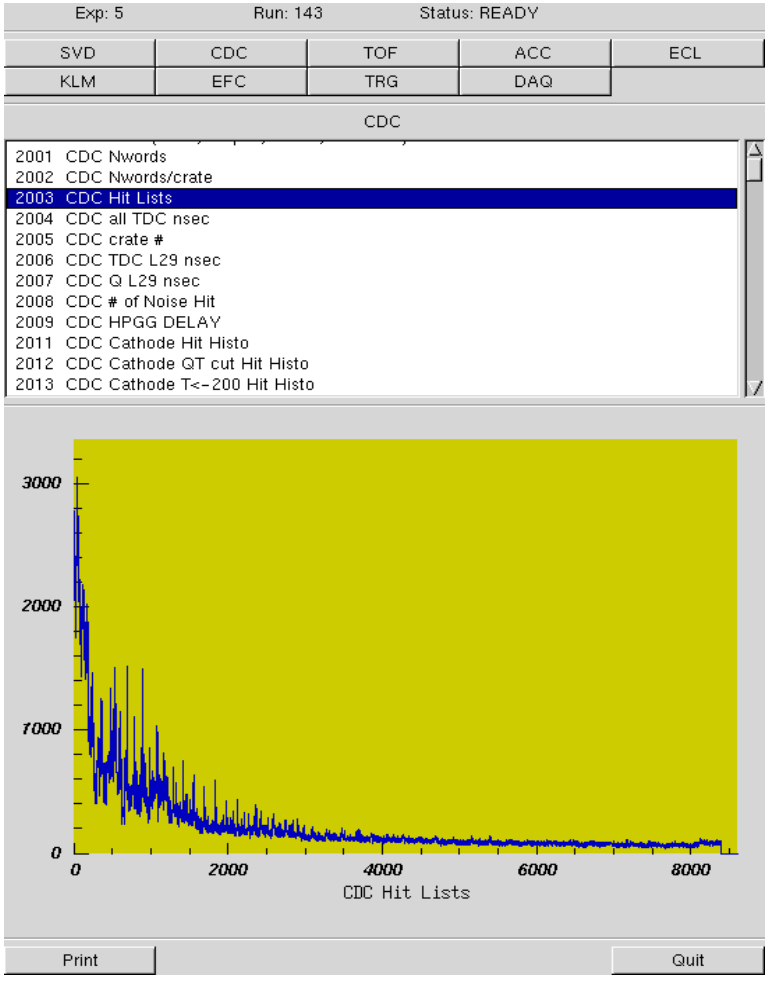


* Sampled raw data are "queued" in the shared memory ("nova" buffer manager)

* Events in the "queue" can be retrieved by multiple analysis frameworks (BASF) attached to the shared memory.
  - Data Quality Monitor (DQM)
  - Event Display

* Each program attached to shared mem. can be started/stopped at any time without affecting on other attached programs.


Exp: 5
Run: 143
Status: ONLINE READY
SVD
CDC
TOF
ACC
ECL
KLM
EFC
TRG
DAQ
ECL
ECL:Nwords
ECL:Hit map
TDC low
TDC middle("L#20000) "w# high("0#20000)
Print
Quit


Exp: 5
Run: 143
Status: READY
SVD
CDC
TOF
ACC
ECL
KLM
EFC
TRG
DAQ
CDC
2001 CDC Nwords
2002 CDC Nwords/crate
2003 CDC Hit Lists
2004 CDC all TDC nsec
2005 CDC crate #
2006 CDC TDC L29 nsec
2007 CDC Q L29 nsec
2008 CDC # of Noise Hit
2009 CDC HPGG DELAY
2011 CDC Cathode Hit Histo
2012 CDC Cathode QT cut Hit Histo
2013 CDC Cathode T<-200 Hit Histo
CDC Hit Lists
Print
Quit

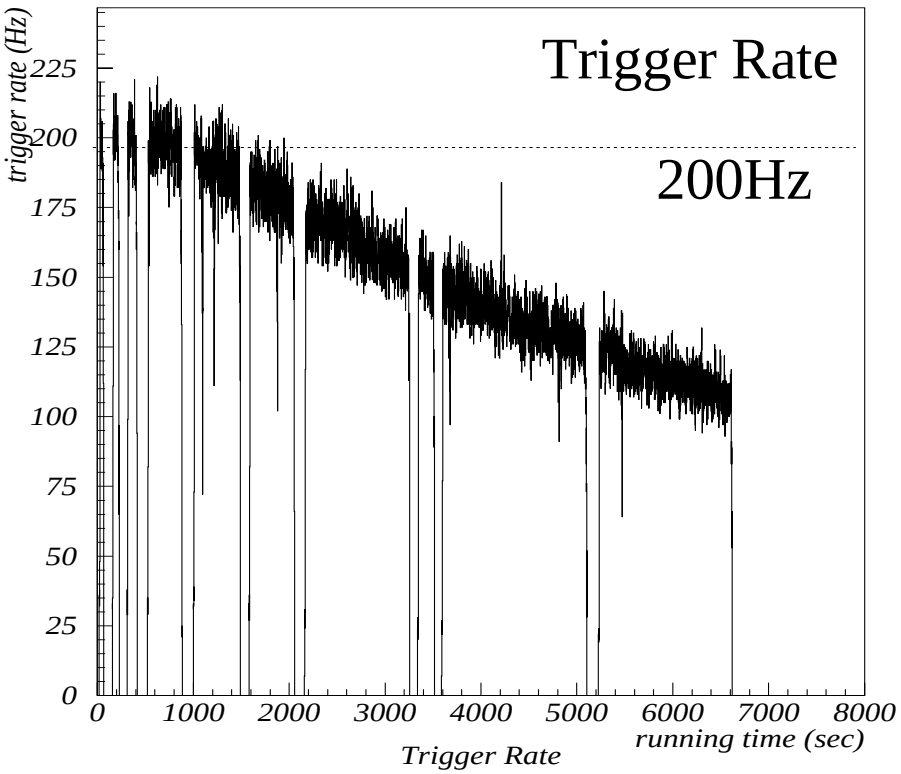
4. Overall Performance

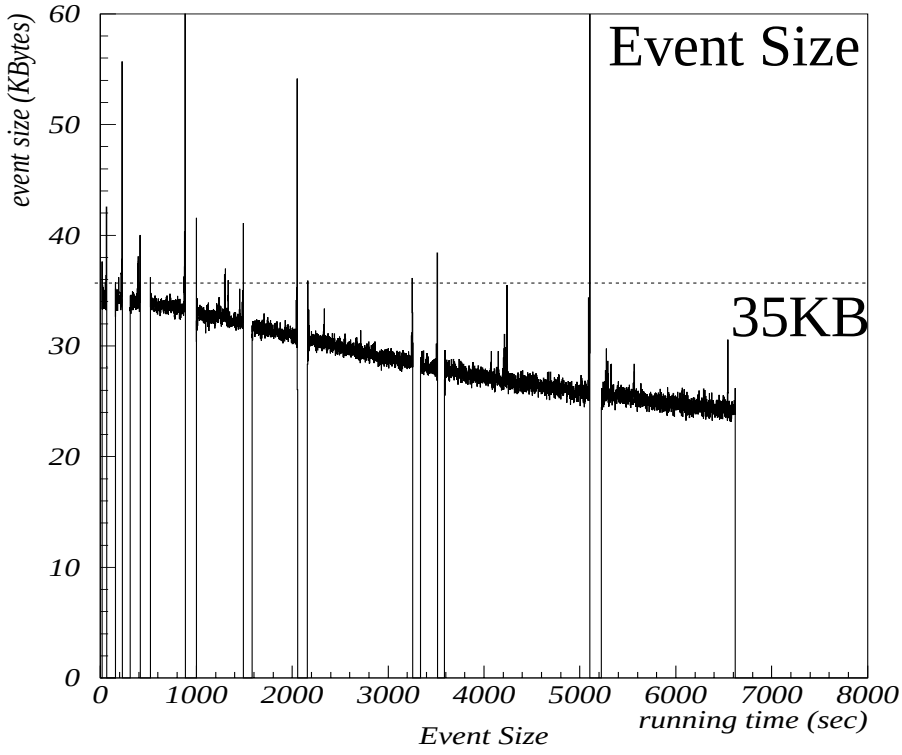
Current condition:
Trigger rate : 100 - 250 Hz
Event Size : 25 - 35 KB/event

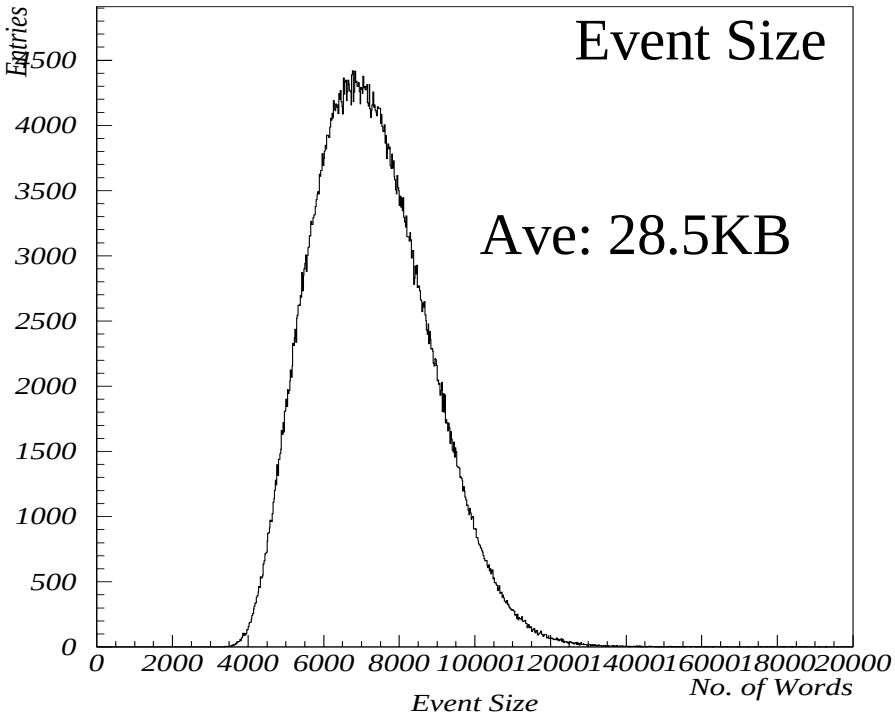
Average : 28.4KB
CDC : 9.2KB
SVD : 9.6KB
ECL : 3.5KB
KLM : 2.0KB

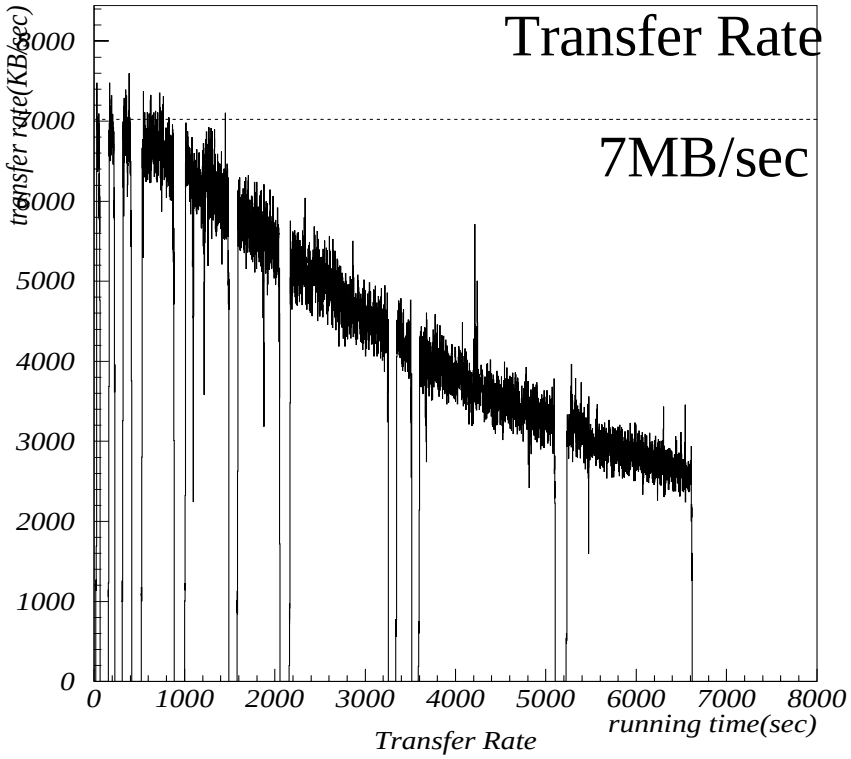
DAQ deadtime : less than 4% @ 250Hz
- mostly FASTBUS/VME readout speed

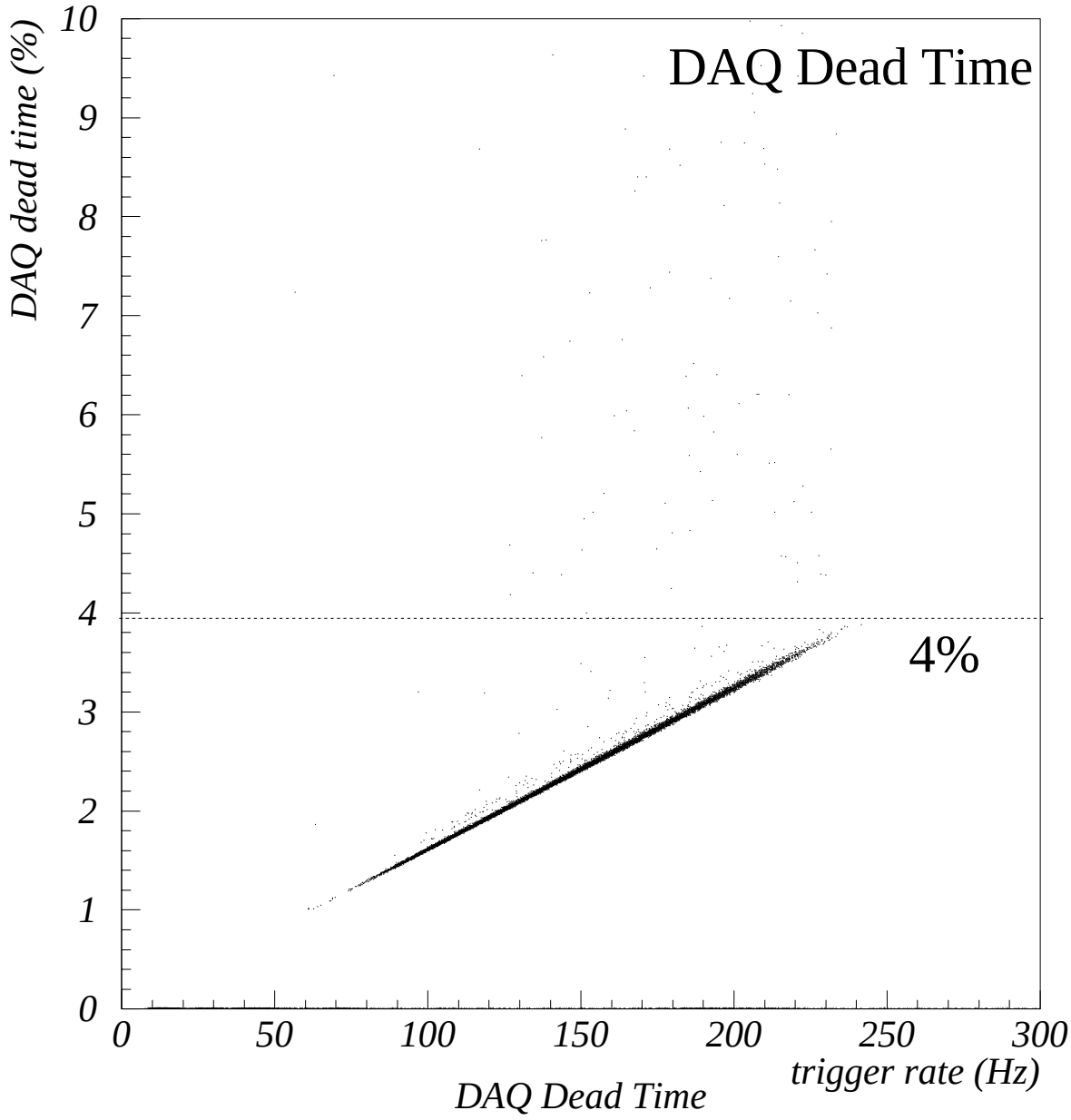
Error rate : < 0.05%
- error in TDC readout
- parity error in the trasfer
from FASTBUS to VME


Trigger Rate
200Hz
trigger rate (Hz)
0
25
50
75
100
125
150
175
200
225
0
1000
2000
3000
4000
5000
6000
7000
8000
running time (sec)
Trigger Rate


Event Size
35KB
event size (KBytes)
0
10
20
30
40
50
60
0
1000
2000
3000
4000
5000
6000
7000
8000
running time (sec)
Event Size

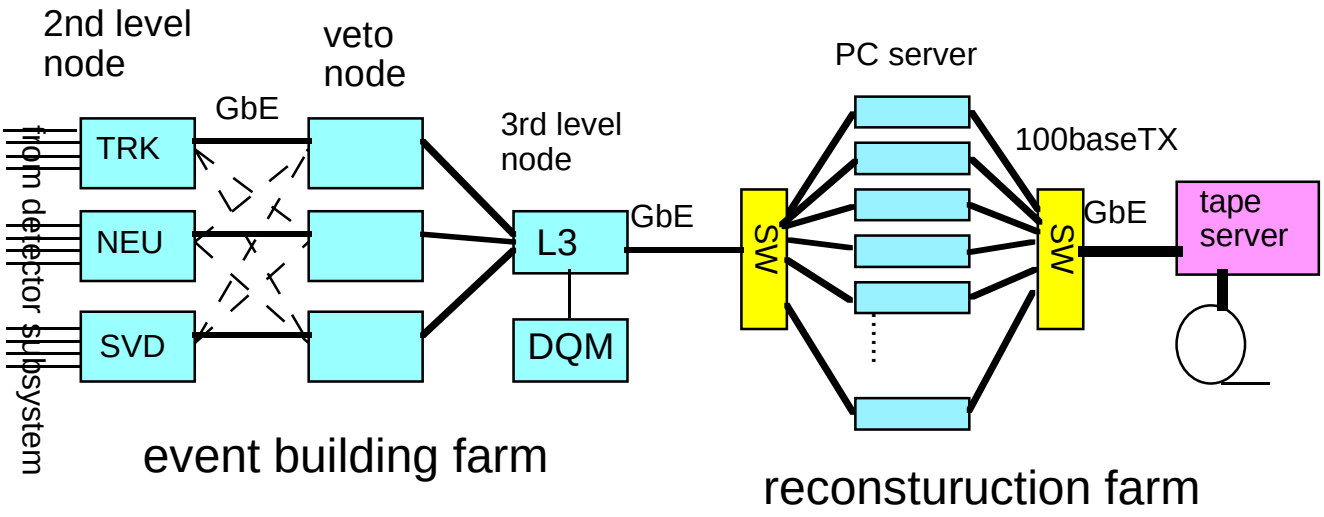

Event Size
Ave: 28.5KB
Entries
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0 2000 4000 6000 8000 10000 12000 14000 16000 18000 20000
No. of Words
Event Size


Transfer Rate
7MB/sec
transfer rate(KB/sec)
6000
5000
4000
3000
2000
1000
0
0 1000 2000 3000 4000 5000 6000 7000 8000
running time(sec)
Transfer Rate


DAQ Dead Time
DAQ dead time (%)
10
9
8
7
6
5
4
3
2
1
0
4%
0
50
100
150
200
250
300
trigger rate (Hz)
DAQ Dead Time

5. Plan for upgrade

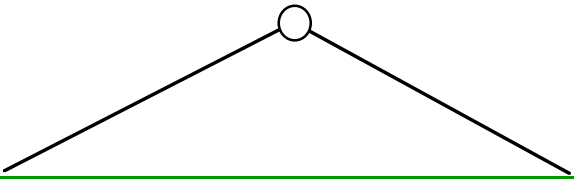
- current problems
  * difficulty in long-term maintainance
    Online Farm / Event Builder / Recording System
    <- old fashioned, home-grown
  * processing power for L3 trigger is not enough
  * needs semi-realtime reconstruction facility for L4 trigger



- based on PC-servers(4CPU/Linux) connected via Fast/Gigabit Ethernet
- no network switch for event building
  -> point-to-point connection

R&D is in progress
This system will replace the current system in early 2001.

6. Summary



- The BELLE DAQ system was built and is now working succesfully in the beam runs.

- Each component in the system achieved the expected performance.

- The overall performance in the beam run condition was measured:
  event size : ~30KB, trigger rate < 250Hz
  -> DAQ Dead Time < 4%

- L3 trigger scheme on Online Farm is now in preparation

- Data monitoring on a Linux-driven SMP PC server using events sampled over network is successfully working.

- Upgrade project is in progress. The DAQ system will be replaced in early 2001.