

# **Farming Data for the HyperCP Experiment**

**A small experiment handling a large dataset**

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International Conference on  
**Computing in High Energy and Nuclear Physics**  
Beijing, China, September 05, 2001

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## Why Search for CP Violation in Hyperon Decays?

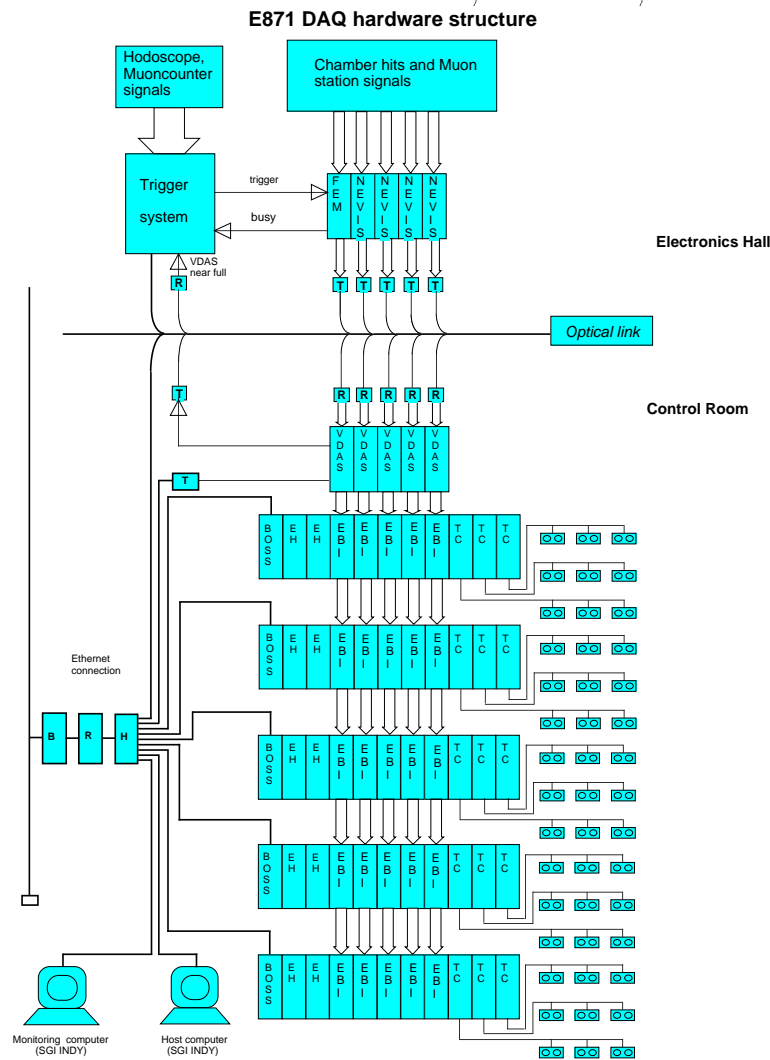
- After 35 years of experimental effort we still know very little about  $CP$  violation:
  - The origin of  $CP$  violation remains unknown. There is little hard evidence that it is explained by the standard model.
  - There is no compelling evidence of  $CP$  violation outside of the decays of the  $K_L$  and B systems.
- The asymmetry is potentially large: up to several  $\times 10^{-3}$ .
- Hyperon  $CP$  violation is not the same as  $CP$  violation in kaon or B decays!
- $CP$  violation is too important, and experimental evidence is too meagre, not to examine every possible manifestation of the effect.

*“To extract useful information and constraints on new physics, results from hyperon decays, K-decays, and B-decays will have to be pooled and confronted with models on a case by case basis.”*

S. Pakvasa

# HyperCP Data Acquisition System

- Highest rate DAQ in the world.
- Maximum trigger rate of about 100,000 events per second.
- Sustained data logging rate of 27 MB/s onto 27 Exabyte 8705 tapes.
- All custom front ends: no CAMAC, Fastbus, or VME.



## *HyperCP Yields*

- In two runs, 1997 and 1999, we took the largest data sample ever by a particle physics experiment: **231 billion** events, **29,401** tapes, and **119.5 TB** of data.

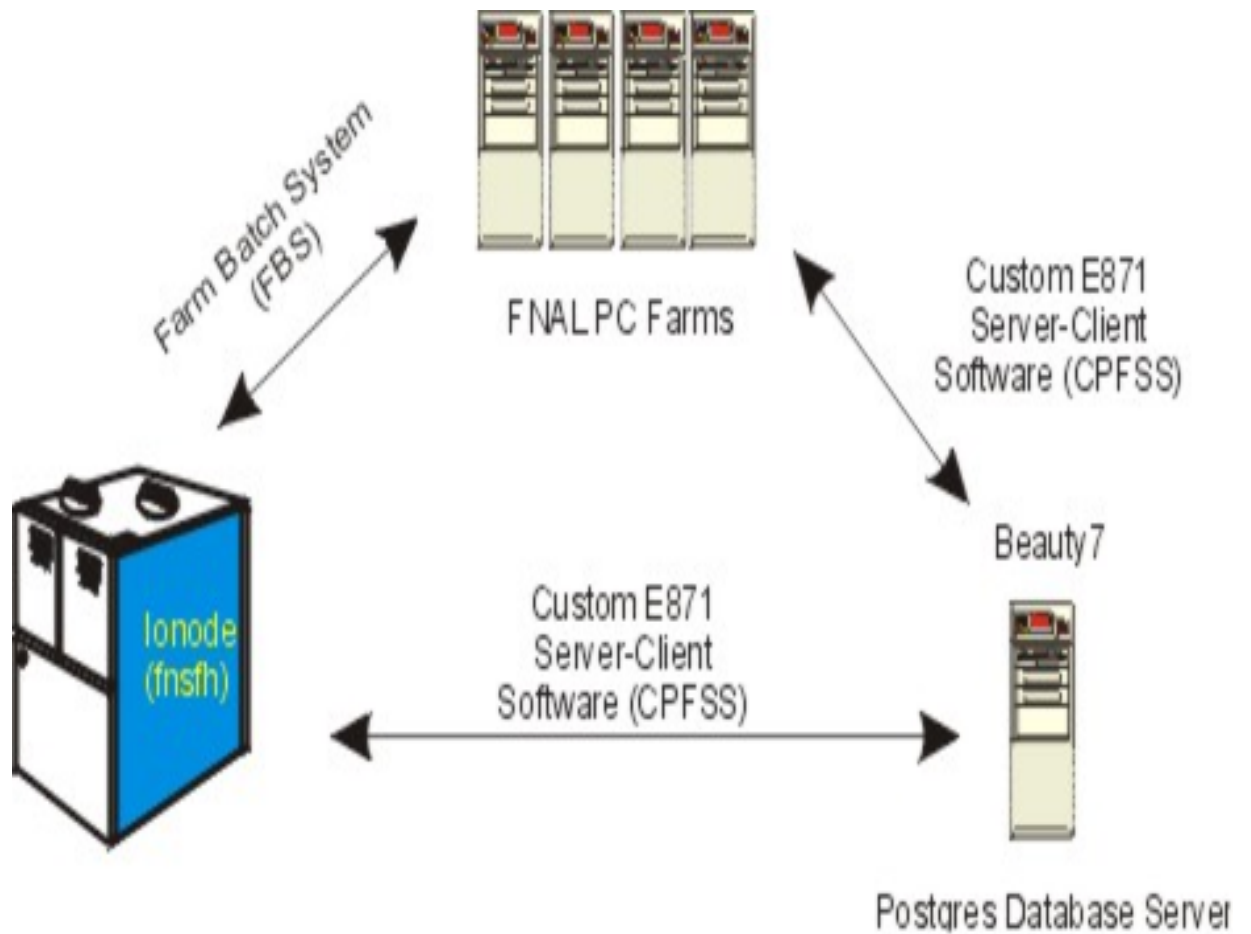
Events			
Trigger	Channeled beam polarity		Total
	+	−	
Cascade	$80 \times 10^9$	$40 \times 10^9$	$120 \times 10^9$
All	$157 \times 10^9$	$74 \times 10^9$	$231 \times 10^9$

Number of Reconstructed Events			
Type	Channeled beam polarity		Total
	+	−	
$\Xi \rightarrow \Lambda\pi$	$0.46 \times 10^9$	$2.0 \times 10^9$	$2.46 \times 10^9$
$K \rightarrow \pi\pi\pi$	$0.39 \times 10^9$	$0.16 \times 10^9$	$0.55 \times 10^9$
$\Omega \rightarrow \Lambda K$	$5.0 \times 10^6$	$14 \times 10^6$	$19 \times 10^6$

- We expect a statistical precision of:

$$\delta A_{\Xi\Lambda} \approx 2 \times 10^{-4}$$

# The *HyperCP* Data Processing Farm

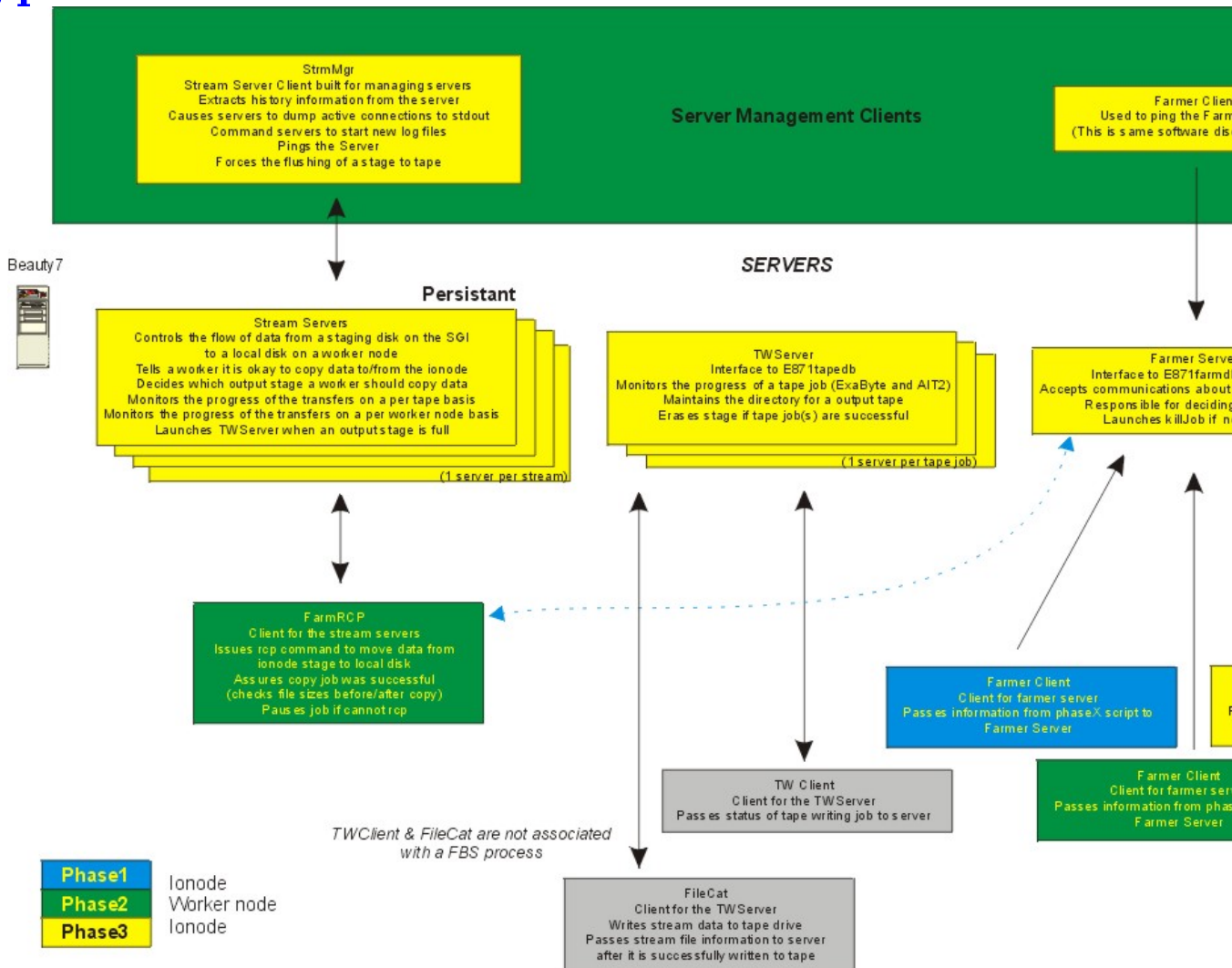


- **I/O nodes:** Distribute the data in parallel to two independent processing systems.
- **Farm Control System:**
  - Submitting jobs and monitors their output.
  - Using HyperCP Farm Software System(CPFSS) to track jobs status and history.
  - Maintaining databases.
  - Farmer Server running on Beauty7: submit jobs, log the progress of them, direct the end of job tasks and manages the stages with input and output. Communicate to the server about the status of the performed tasks from both I/O node and PC workers.
- **PC Farms/Worker Nodes:** 55 dual-processor Linux-based PCs that the data analyzing code is running on.
- **Stages:** 70 I/O stages on FNSFH and 27 on FNSFO. Each stage is 5 GB and used to store data temporarily. A stage is cleaned up and unlocked after the data is copied to tape.

- **Tape Drives:**

- Exabyte tape drives: load input raw data tapes and output data tapes for some output streams.
- Two AIT2 tape drives: used on FNSFH and FNSFO to copy output data to 50-GB AIT2 tapes.

- **HyperCP Farm Software:**





## • Job Structure:

- Raw data is read from an Exabyte drive and split into 10 equal files on a staging disk on the I/O node.
- The 10 input files are copied to local disks on 10 worker nodes (PCs).
- The analysis job is executed on the 10 PCs.
- Results from the analysis job are moved from the local disk to output stage on the I/O nodes.
- When an output stage is full, it is flushed to output tape and the stage is released for next job.

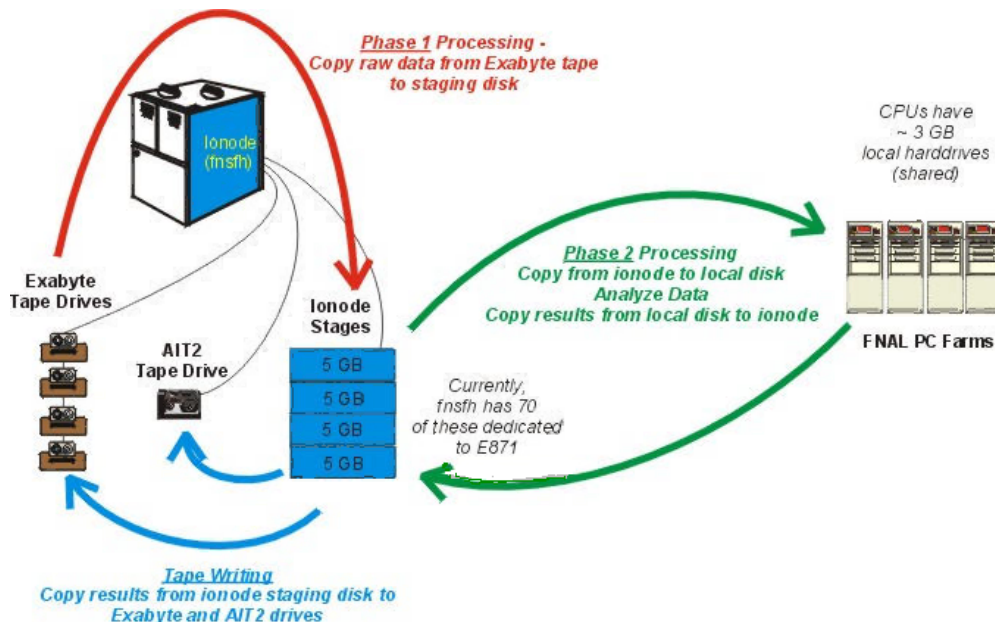


Fig.4. The flow of farm data.

Scripts Phase0, Phase1, Phase2, and Phase3 are responsible for the tasks of a job.

- **Phase0:** A csh script launched from Beauty7 (by `rsh`) but runs on the I/O node.
  - \* Build a short script used by FBS.
  - \* Launch the farm batch job using `farms submit [script name]`. Script name is built by the phase0 script.
- **Phase1:** A csh script which runs on the I/O node:
  - \* Allocating an input tape drive on the I/O nodes.
  - \* Requesting the tape passed by Beauty7 to be placed in the tape drive.
  - \* Mounting a tape on the tape drive.
  - \* Running the code `rawSplit` which is responsible for
    - Reading data from the input tape drive.
    - Splitting the data into 10 worker files.
    - Writing the data onto a stage on the I/O node.

- **Phase2:** A script which is launched onto 10 worker nodes by FBS:
  - \* Copying a file from the input stage on the I/O node to the local disk on the PC.
  - \* Setting up the environment needed by the E871 analysis code.
  - \* Running the analysis code.
  - \* Copying the stream output to the appropriate staging disks on the I/O node.
- **Phase3:** A csh script launched on the I/O node and It's responsible for cleaning up the job.

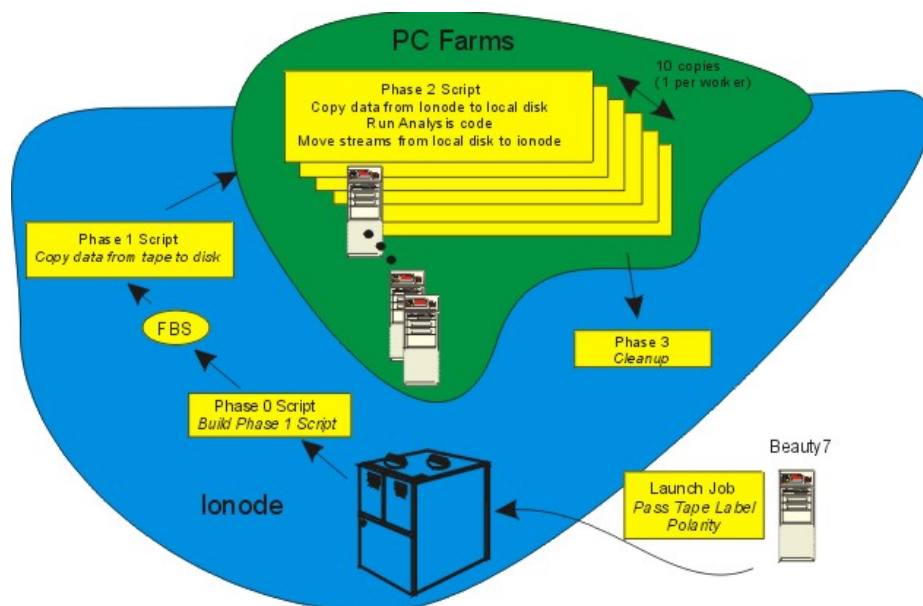


Fig.5. The structure of a job.

- **Database:**

PostgreSQL Database is used on the farm to store job information, log files, and statistics.

- **e871farmdb:** Contains the detailed messages of a job for the three phases: for example, the time the job was submitted, when it started on which I/O node, the tape label for this job, and fail or succeed for each phase.
- **e871tapedb:** Contains the tables of input tapes and output tapes.
- **phase2sumdb:** Contains a summary for each job submitted.

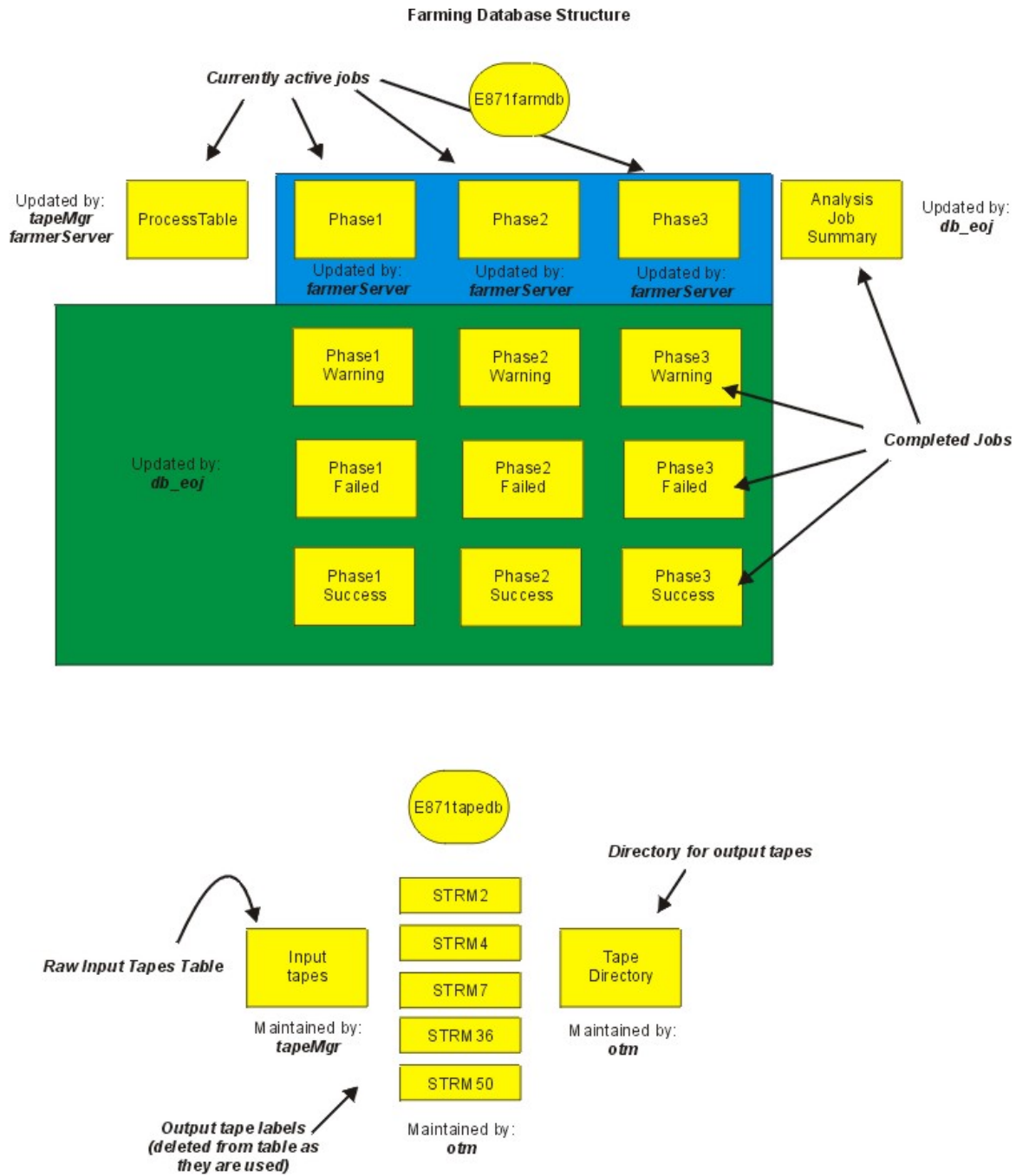


Fig.6. E871 farm Database.

- **Farm Monitoring Web Page:**

- Built by Perl CGI scripts.
- Self-refreshing and display the status of farming, job history, and statistics.
- Error messages and resubmitting 'fail' job.
- Electronic-Log book.
- Allowing non-expert farmers to monitor farm processes.

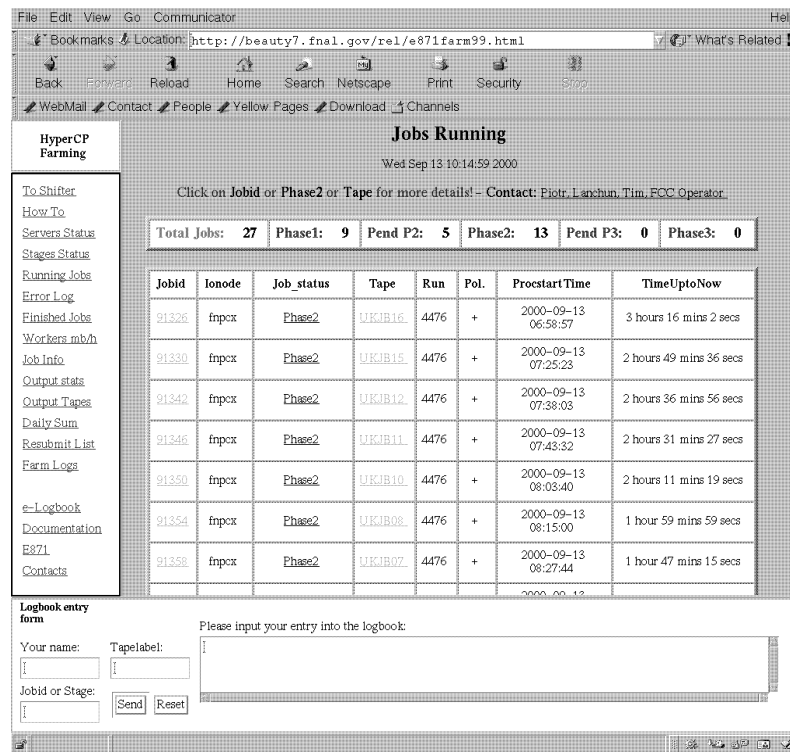


Fig.7. Running jobs on farm monitoring web page.

File Edit View Go Communicator Help

Bookmarks Location: <http://beauty7.fnal.gov/rel/e871farm99.html> What's Related

Back Forward Reload Home Search Netscape Print Security Stop

WebMail Contact People Yellow Pages Download Channels

### HyperCP Farming

To Shifter  
How To  
Servers Status  
Stages Status  
Running Jobs  
Error Log  
Finished Jobs  
Workers mb/h  
Job Info  
Output stats  
Output Tapes  
Daily Sum  
Resubmit List  
Farm Logs  
e-Logbook  
Documentation  
E871  
Contacts

## Jobs Completed

Wed Sep 13 10:12:42 2000  
Contact: Piotr Lanchan, Tim, FCC Operator

Jobs from [ ] hours to [ ] hours ==>

**Jobs from 0 to 12 hours!**

<b>Jobs from 0 to 12 hours:</b>	<b>Total: 46</b>	<b>Success: 46</b>	<b>Failed: 0 = 0(P1) + 0(P2) + 0(P3)</b>
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Jobid	Ionode	Job_status	Tape	Run	Pol.	CompleteTime	Time
91313	fnsth	SUCCESS	UKJB13	4476	+	2000-09-13 09:50:30	6 hours 45 mins 28 secs
91314	fnsth	SUCCESS	UKJB20	4476	+	2000-09-13 09:39:34	6 hours 35 mins 13 secs
91310	fnsth	SUCCESS	UKJB21	4476	+	2000-09-13 09:20:33	6 hours 36 mins 49 secs
91302	fnsth	SUCCESS	UKJB23	4476	+	2000-09-13 09:05:51	6 hours 48 mins 34 secs
91298	fnsth	SUCCESS	UKJB24	4476	+	2000-09-13 08:52:45	6 hours 55 mins 54 secs
91294	fnsth	SUCCESS	UKJB25	4476	+	2000-09-13 08:38:05	7 hours 6 mins 48 secs

**Logbook entry form**

Please input your entry into the logbook:

Your name:  Tapelabel:

Jobid or Stage:

100%

Fig.8. Completed jobs on farm monitoring web page.

# Data Processing

- **Tasks for Shifters:**

- Monitor the jobs status through the web page.
- Debug the fail job based on the information on the web page. Resubmit it if the tape is good.

The screenshot shows a web browser window with the following content:

- Browser Title:** HyperCP Farming
- Address Bar:** http://beauty7.fna1.gov/re1/e871farm99.html
- Page Title:** Failed Jobs to be Resubmitted
- Date/Time:** Tue Jul 24 23:44:16 CDT 2001
- Total numbers:** 1
- Table:**

Jobid	Job_status	Tape	CompleteTime	Resubmit
134206	FAILED P1	UKBN11	2000-12-24 14:12:51	PermDelete or TempDelete
- Logbook entry form:**

Your name:   
Tapelabel:   
Jobid or Stage:   
   
Please input your entry into the logbook:

Fig.9. Failed jobs on farm monitoring web page.



- **Tasks for Experts:**

- Debug the failed jobs that a shifter can't fix.
- Check the data in the output tapes is consistent with the database.

# Farm Results

A total of 29,843 tapes were processed and finished during

June 2000  $\implies$  May 2001

- **Statistics:**

**ALL jobs Since Farming Started up to 2001-07-09 16:43:51**

Ionode	Total Jobs	Success Jobs	Failed Jobs
<b>FNSFH &amp; FNSFO</b>	<b>29843</b>	<b>29416</b>	<b>427 = 405(P1) + 20(P2) + 2(P3)</b>
<b>ENSFH</b>	<b>23748</b>	<b>23441</b>	<b>307 = 291(P1) + 14(P2) + 2(P3)</b>
<b>ENSFO</b>	<b>6095</b>	<b>5975</b>	<b>120 = 114(P1) + 6(P2) + 0(P3)</b>

Pol.	Tape	inEvents	Cas	Cas/inEvent(%)	Omega	Lambda	K2pi	K3pi
+	20013	1.57296e+11	4.58028e+08	0.29119	4.86469e+06	1.16625e+09	2.02540e+09	3.91349e+08
-	9390	7.39327e+10	2.03259e+09	2.74924	1.41199e+07	2.33804e+09	6.92850e+08	1.63499e+08

Pol.	Tape	inEvents	Strm2	Strm4	Strm6	Strm7
+	20013	1.57296e+11	1.35178e+10	3.03022e+09	8.42732e+07	6.78841e+08
-	9390	7.39327e+10	1.26919e+10	1.40144e+09	4.49946e+07	5.48303e+08

Jobid	Ionode	Job_status	Tape	Run	Pol.	CompleteTime	Time
134206	fnsth	FAILED.P1	UKBN11	4022	+	2000-12-24 14:12:51	14 mins 50 secs
131082	fnsth	FAILED.P1	UKC256	4053	-	2000-12-16 21:50:49	3 mins 58 secs

**Logbook entry form**

Please input your entry into the logbook:

Your name:  Tape label:

Jobid or Stage:

Fig.10. Farm statistics.

- **Output Tapes:**

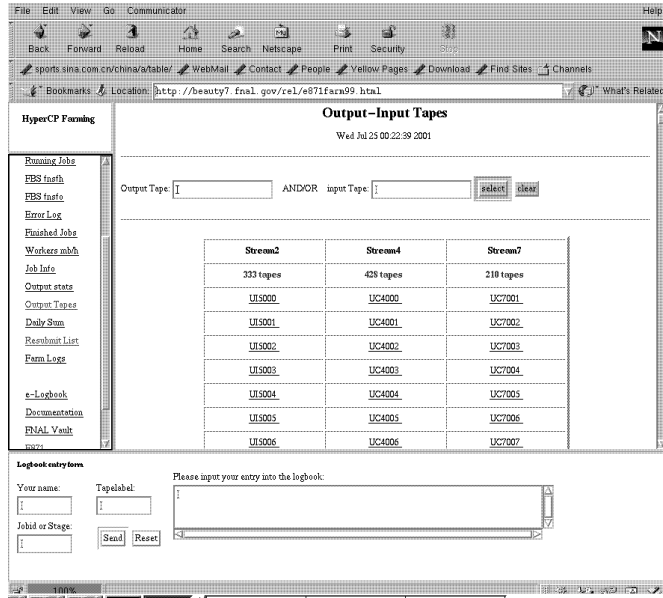


Fig.11. Output tapes from farm.

- **Histograms from the Farm:**

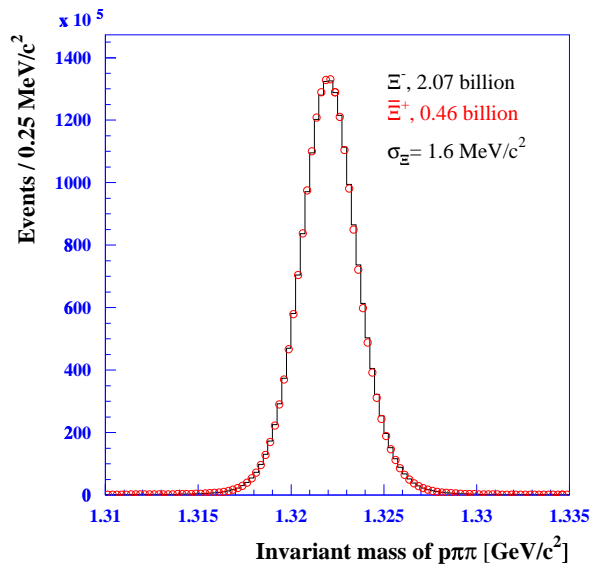


Fig.12. Mass distribution of  $\Xi^-$  and  $\Xi^+$ .

## Conclusion

- HyperCP farm is very efficient, well-organized, and easy to monitor.
- All the log information from the farm processing is easily accessible.
- The reconstructed DST data and 36 million histograms are now ready for the  $CP$ -violation study as well as a number of other physics studies.