Performance quality monitoring system (PQM) for the Daya Bay experiment

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On behalf of the Daya Bay Collaboration

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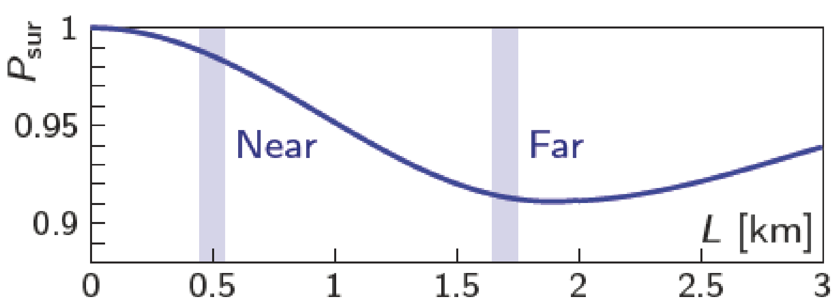
The Daya Bay Experiment

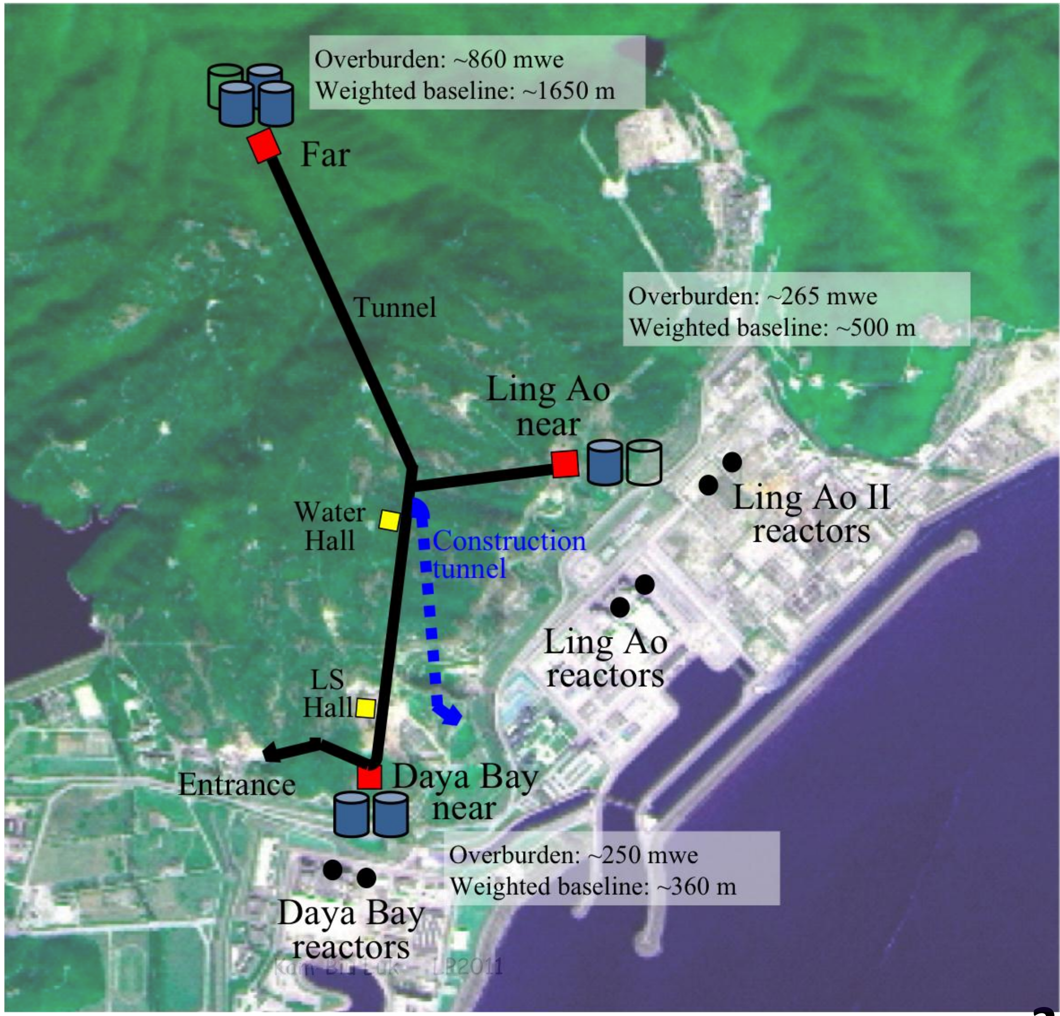
Daya Bay is a reactor neutrino experiment designed to measure $\sin^2 2\theta_{13}$ to 0.01 at 90% CL

- **6 reactor cores, 17.4 GW_{th}**
- **Relative measurement**
  - **2 near sites, 1 far site**
- **Multiple detector modules**
- **Good cosmic shielding**

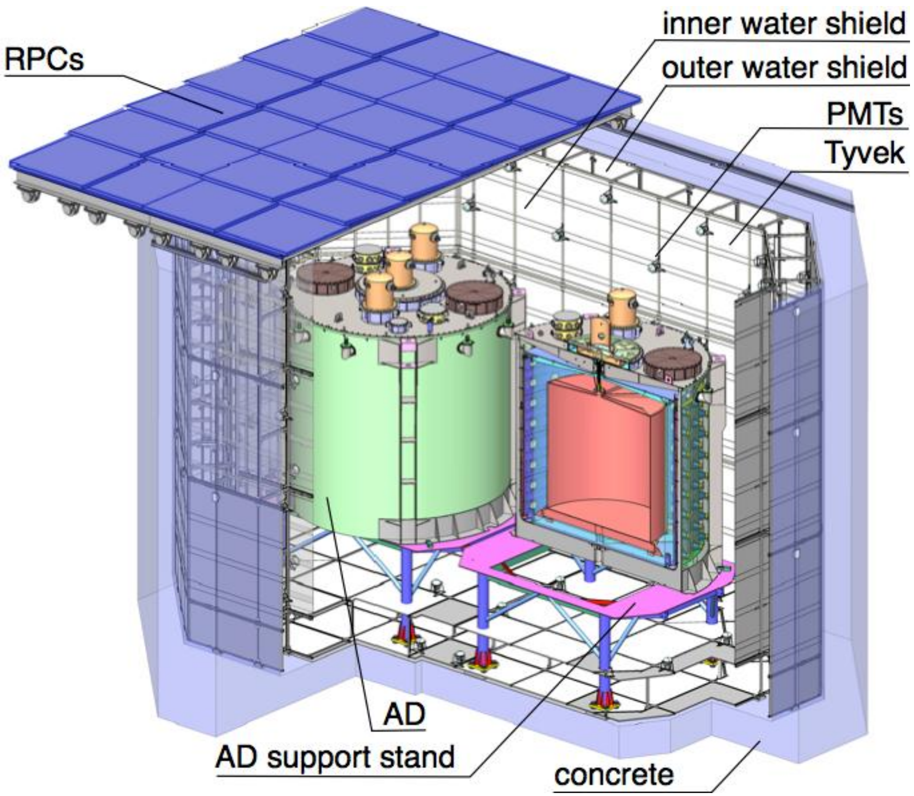
Table 1. Vertical overburden, muon rate R_μ, and average muon energy $<E_\mu>$ of the three EHs.

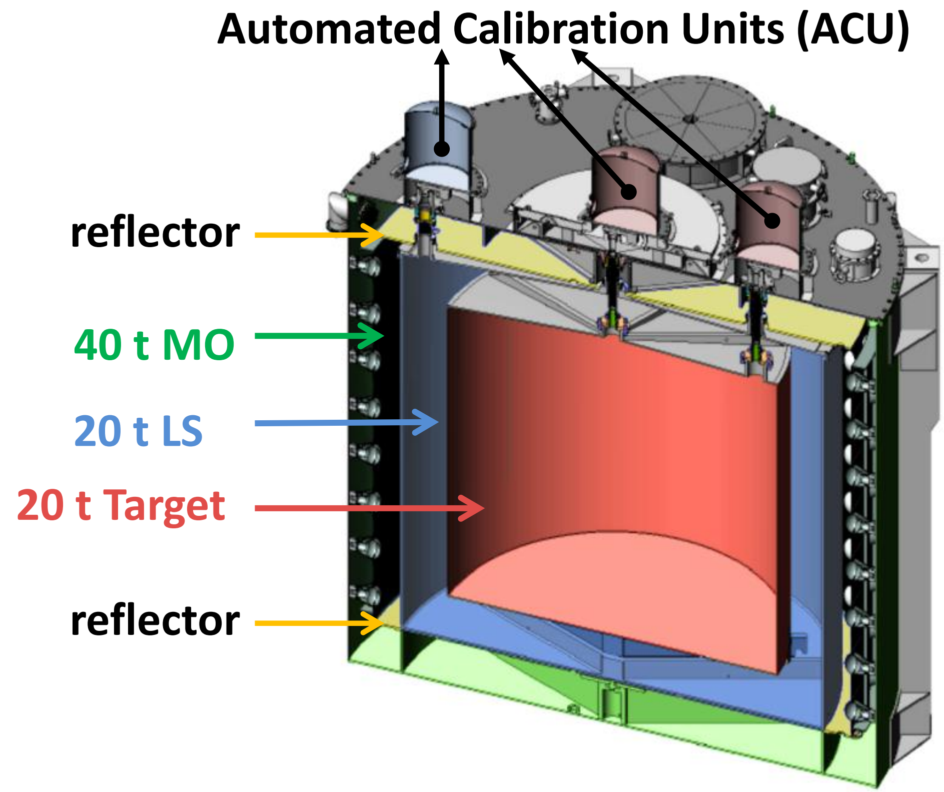
	overburden (m.w.e)	R_μ (Hz/m^2)	$<E_\mu>$/GeV
EH1	250	1.27	57
EH2	265	0.95	58
EH3	860	0.056	137





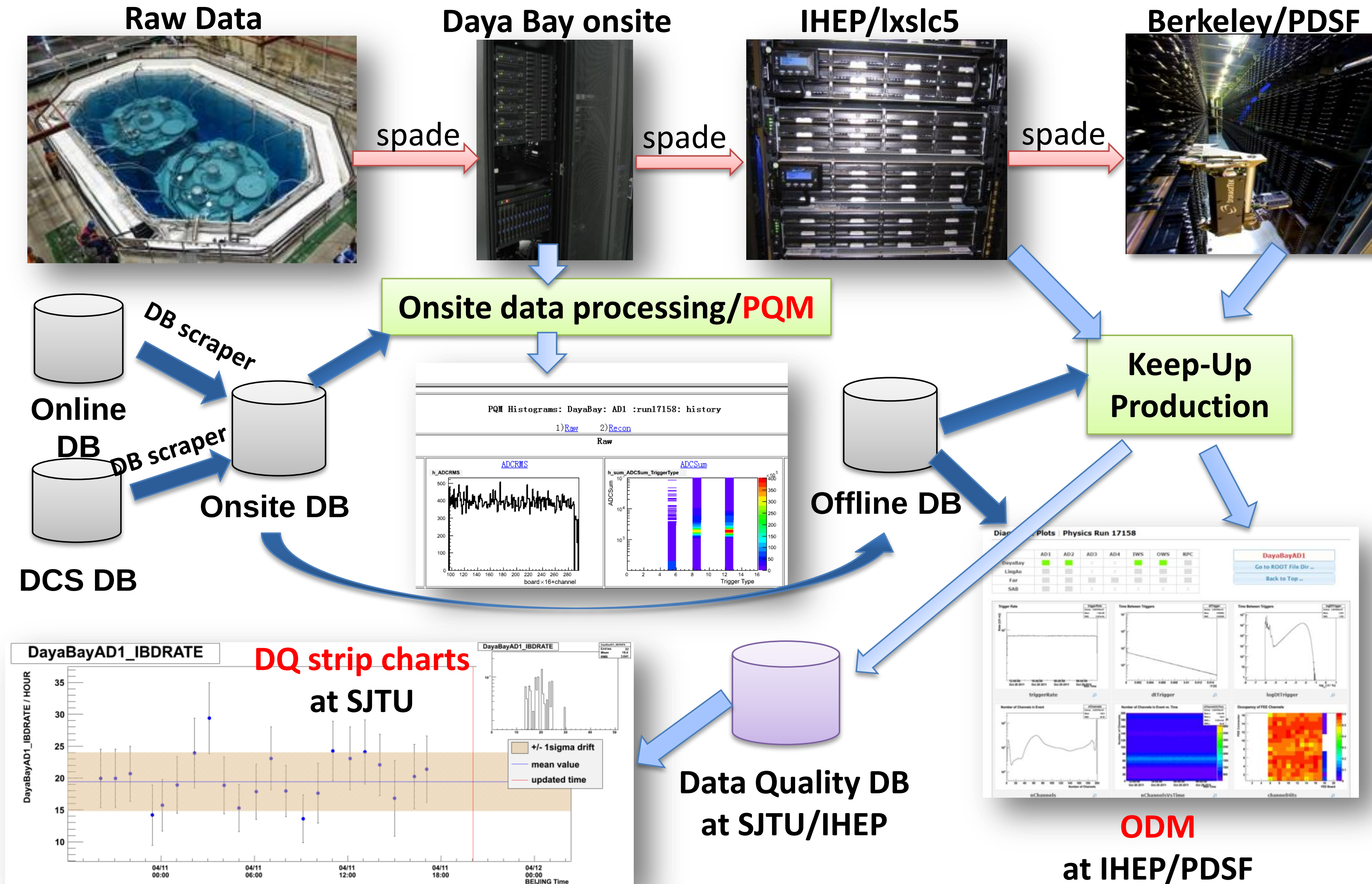
The Daya Bay Detectors





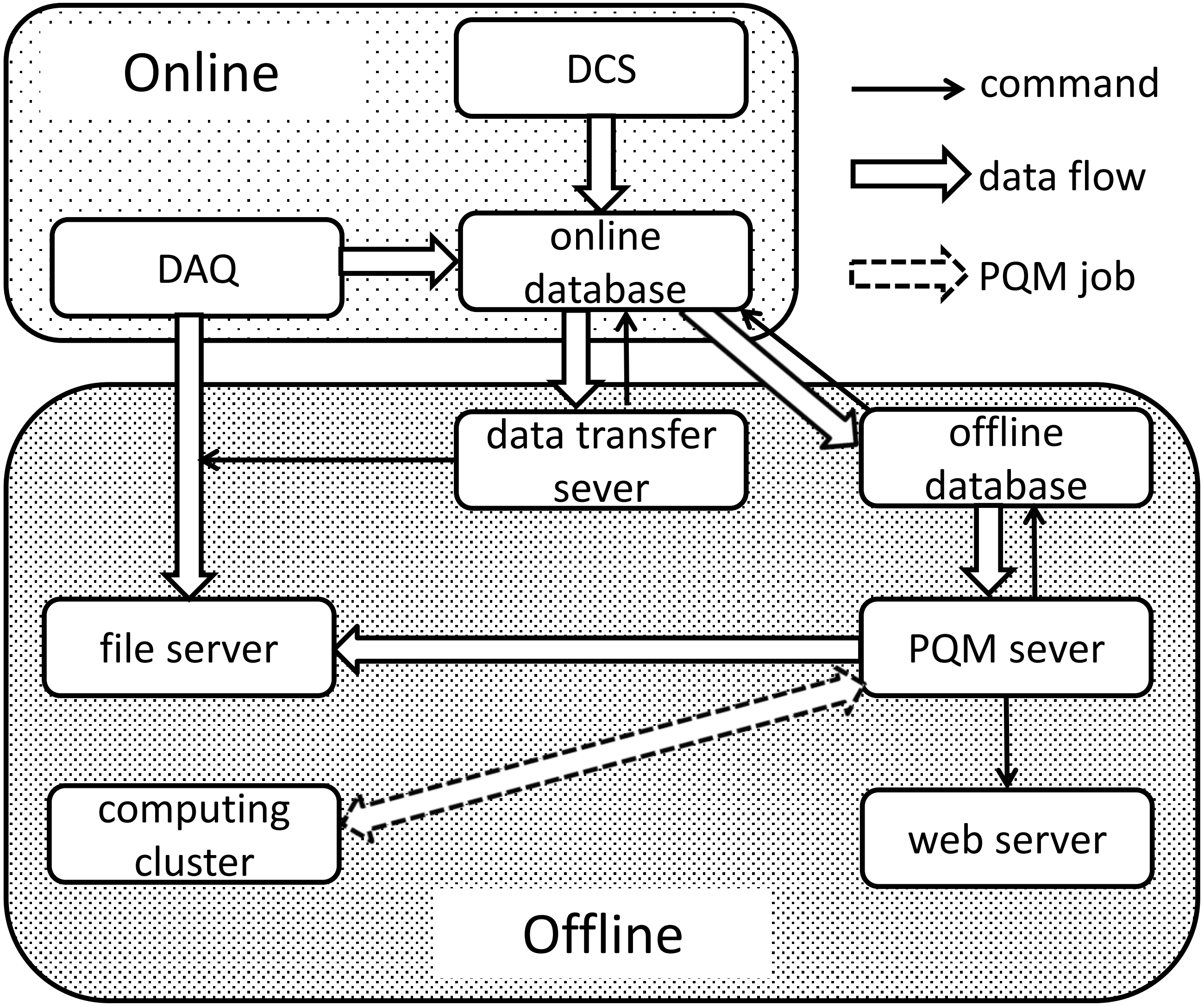
- **Multiple Anti-neutrino Detector (AD) modules to reduce syst. err.**
  - **Far: 4 modules， near: 2 modules**
- **Multiple muon detectors to reduce veto eff. uncertainties**
  - **Water Cherenkov： 2 layers**
  - **RPC： 4 layers at the top + telescopes**

A global picture



Offline computing environment

- **Online DB**
  - **Raw data file info. (DAQ)**
  - **Hardware info. (DCS)**
- **Offline DB**
  - **Raw data file info.**
  - **Calib. constants**
  - **etc.**
- **Portable Batch System (PBS)**
  - **Allocating jobs**



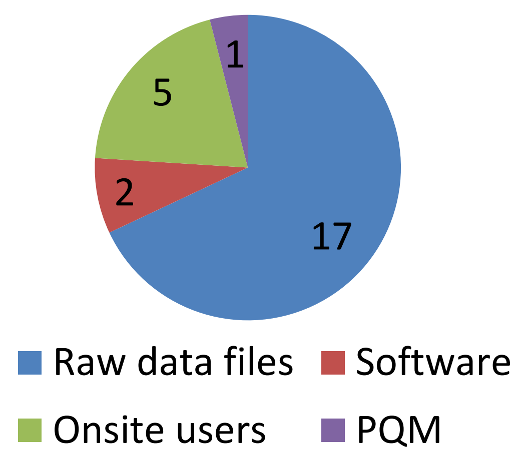
Offline computers at Daya Bay

- **Data volume**
  - **~320 files/day, ~1GB/file**
- **11 servers**

	EH1	EH2	EH3
Event rate (kHz)	~1.2	~1.0	~0.6

	Description
File Server	Storage of raw data files
Data Transfer Server	Transferring raw data files from DAQ to the File Server
Offline Database Server	Extracting info. from online DB. and archiving calib. constants.
PQM Servers (pqm1-2)	pqm2 for backup
User Farms (farm1-5)	Running user jobs
Web Server	Displaying figures produced by the PQM

Offline Disk Volume (~25 TB)



56 cores in total, 16 of them are dedicated for PQM

- **CPUs**
  - **8 cores/server**

pqm1, farm1-2	Intel (R) Xeon (R) E5506 @2.13 GHz
pqm2, farm3-5	Intel (R) Xeon (R) E5420 @2.50 GHz

The PQM

- **Requirements**
  - **High-level histograms for monitoring sub-detectors and data quality**
  - **Process data asap.**
  - **Process multi-data-stream**
    - **3 EHs with independent data stream**
- **Developed analysis modules in the NuWa framework**
- **Define many high-level histograms for different purposes**
- **Developed a Control Script for running the PQM**

Offline software

- **NuWa**
  - **Employs Gaudi's event data service**
  - **Provides the full functionality for simulation, recon. and physics analysis**
  - **Job modules**
  - **Recon. algorithms based on the charge pattern of the PMTs.**
  - **Auto-building system using the Bitten plug-in of trac.**
- **Analysis modules in PQM**
  - **Four modules**
    - **Two for histograms of elec. channel info. and calibrated PMT info of ADs and the water shields**
    - **One for histograms of reconstruction level**
    - **The other one for the RPCs**
  - **Flexible to add more modules (supernova trigger analysis module)**
  - **Dynamically creating histograms**
    - **Different configuration in 3 EHs**
    - **Reducing file volume**
    - **Improving processing speed**

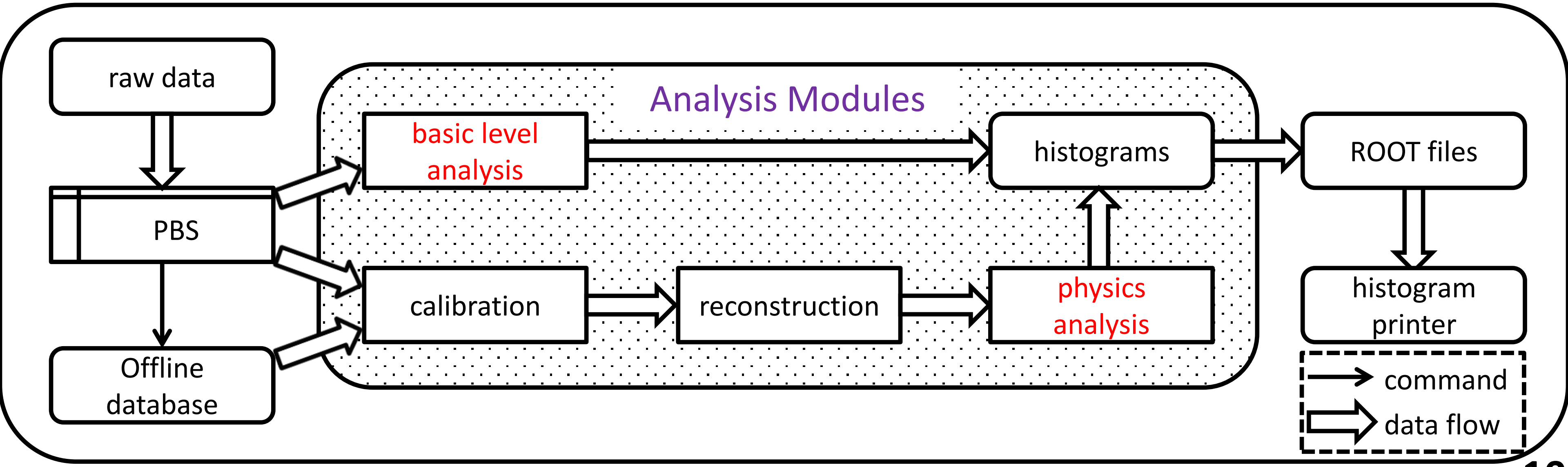
Histograms Produced by PQM

Detector Unit	Level	Histograms
PMT	Basic	Mean of ADC, TDC and preADC, RMS of ADC, TDC and preADC, ΔADC, dark noise, dark rate and TDC vs channel ID, hit rates, ADC sum vs. trigger types, ADC sum, number of blocked triggers vs. run time, number of channels, trigger types
	Reconstruction	y vs. x, z vs. radius, energy, energy vs. radius, energy vs. z, event rate vs. radius, event rate vs. z
RPC	Basic	Patch map, trigger rate map, map of fraction of triggers with >8 strips, trigger rate vs. run time and time interval for 4-fold coincidence, time interval between system triggers, efficiency maps of each layer, layer efficiency, FEC error types vs. run time, RTM error types vs. run time, layer hit maps, hit number vs. strip ID, number of triggered layers per readout module, number of triggered modules per system trigger, singles rate map for each layer, singles rate, system trigger rate vs. run time

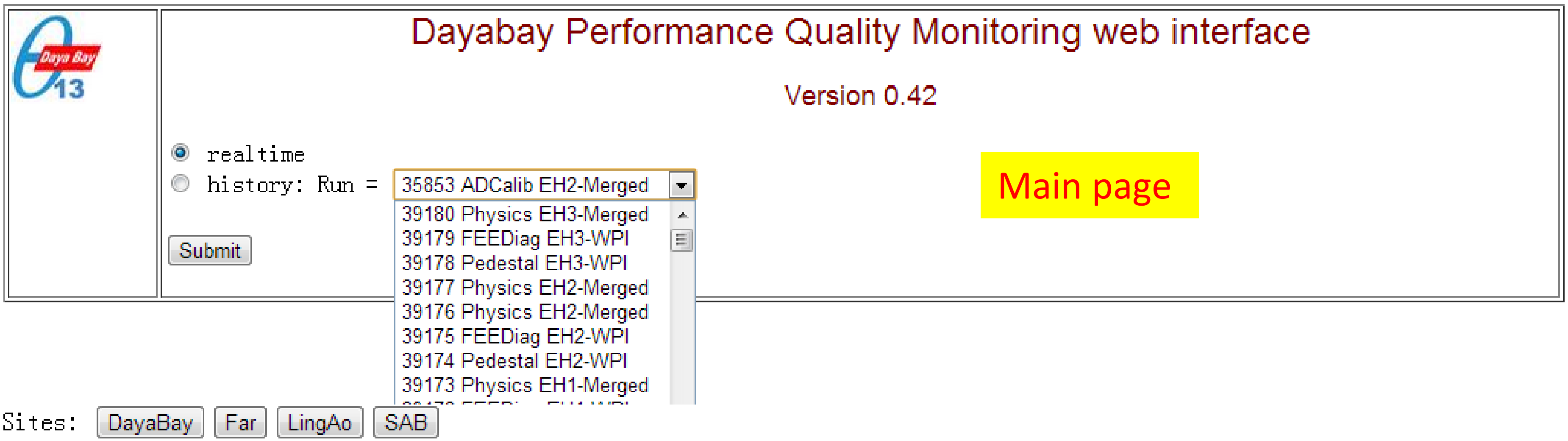
Table 1. The histograms produced by analysis modules in PQM for monitoring detector performance and data quality.

Data Flow of the PQM

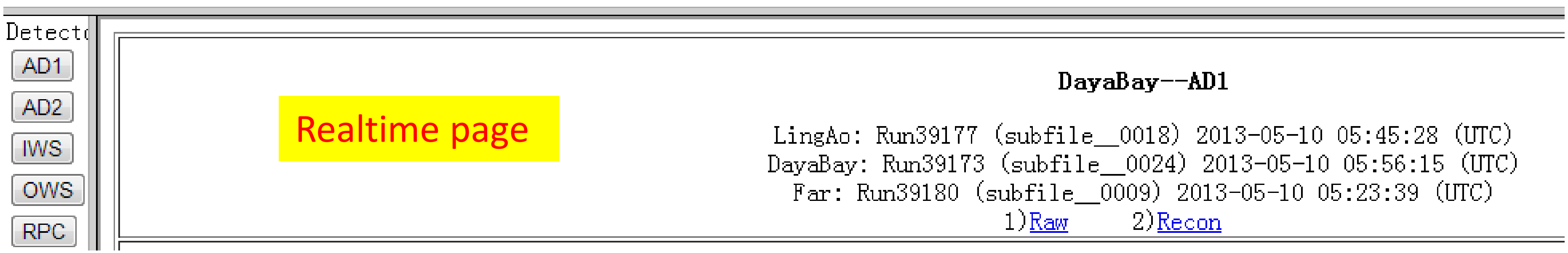
- **Control script**
  - **In Python language**
  - **In charge of the logic of the PQM running**
  - **Queries the offline DB (~10 s) and submit jobs to the PBS**
  - **Sending signal to the Web Server for web display**
  - **Save ROOT files for each run to the File Server**
- **Using latest calib. constants for recon.**
- **Figures are displayed in around 40 minutes**



Web Display



Dayabay Performance Quality Monitoring web interface
Version 0.42
realtime
history: Run =
35853 ADCalib EH2-Merged
39180 Physics EH3-Merged
39179 FEEDiag EH3-WPI
39178 Pedestal EH3-WPI
39177 Physics EH2-Merged
39176 Physics EH2-Merged
39175 FEEDiag EH2-WPI
39174 Pedestal EH2-WPI
39173 Physics EH1-Merged
Submit
Main page
Sites:
DayaBay
Far
LingAo
SAB



AD1
AD2
IWS
OWS
RPC
Realtime page
DayaBay--AD1
LingAo: Run39177 (subfile__0018) 2013-05-10 05:45:28 (UTC)
DayaBay: Run39173 (subfile__0024) 2013-05-10 05:56:15 (UTC)
Far: Run39180 (subfile__0009) 2013-05-10 05:23:39 (UTC)
1)Raw
2)Recon

Example Histograms

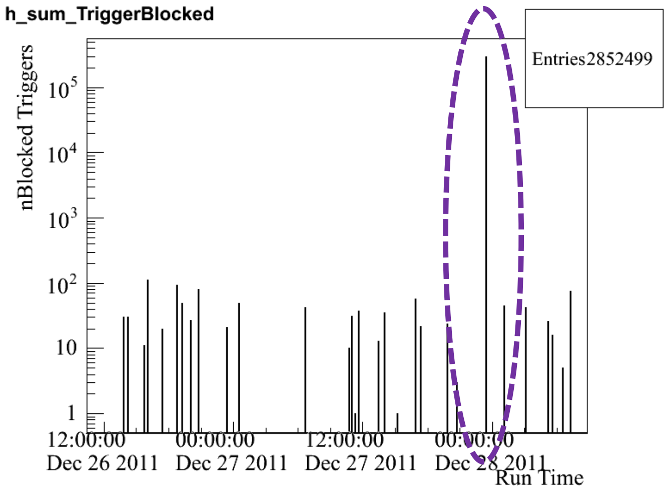


Fig. 1 Number of blocked triggers in one event vs. run time

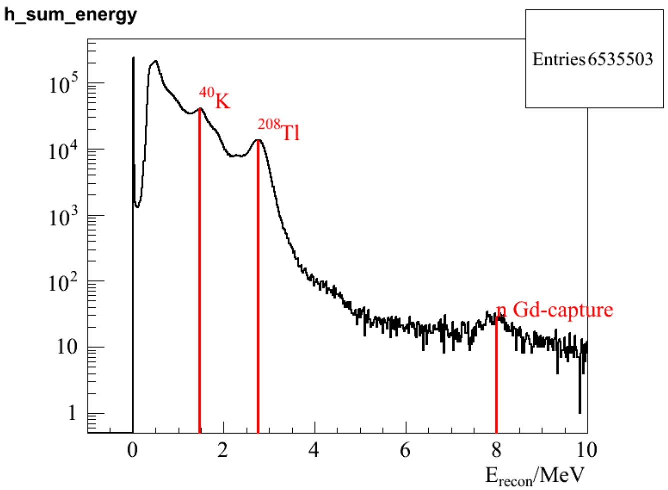


Fig. 2 Reconstructed energy distribution for all triggers in one AD

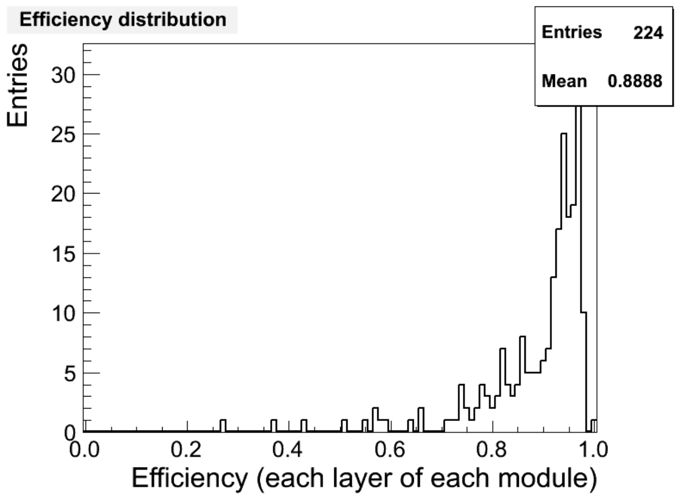


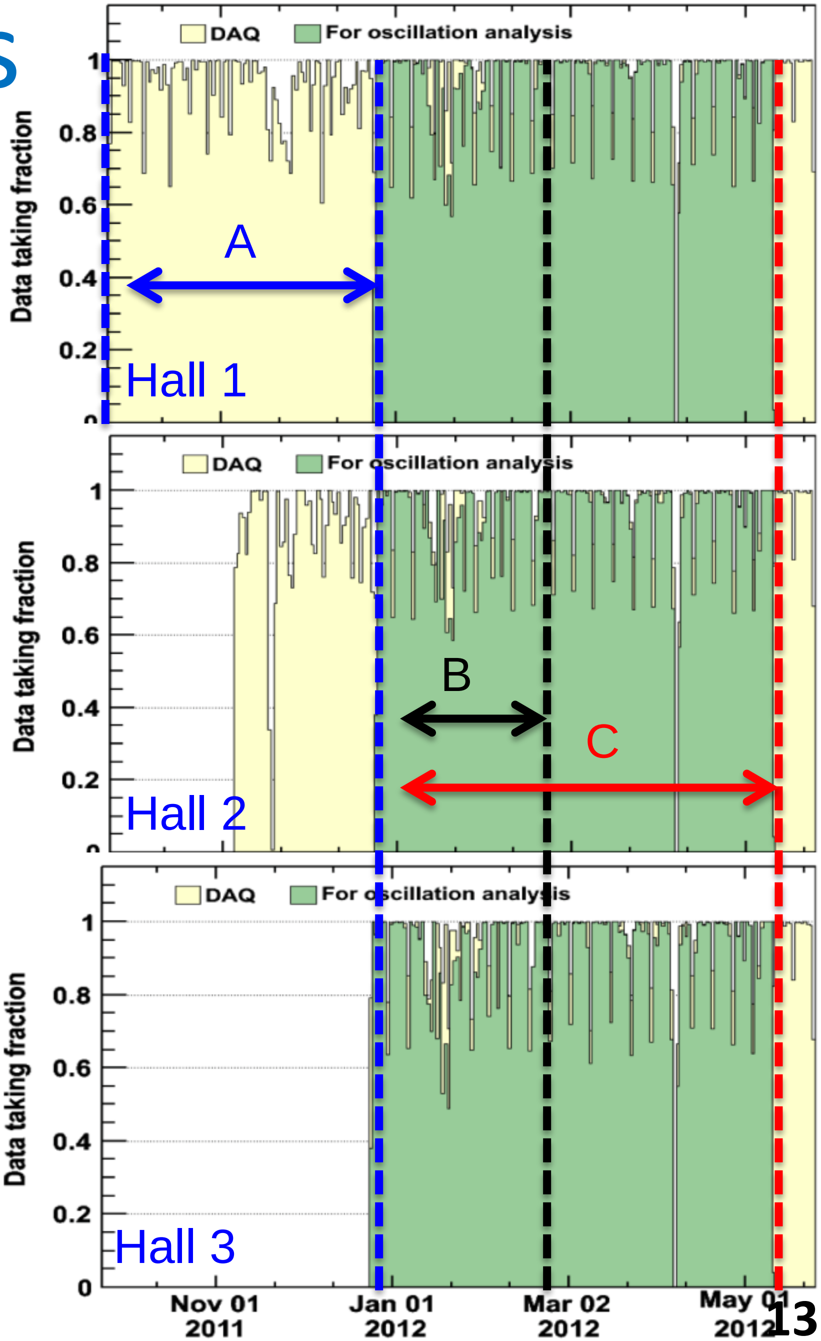
Fig. 3 Layer efficiency distribution of the RPCs in one EH

- **Figures produced by the PQM can be compared with standard ones defined by the Data Quality Working Group (DQWG)**
- **Shift crew report possible problems to the DQWG**

Data Taking Status

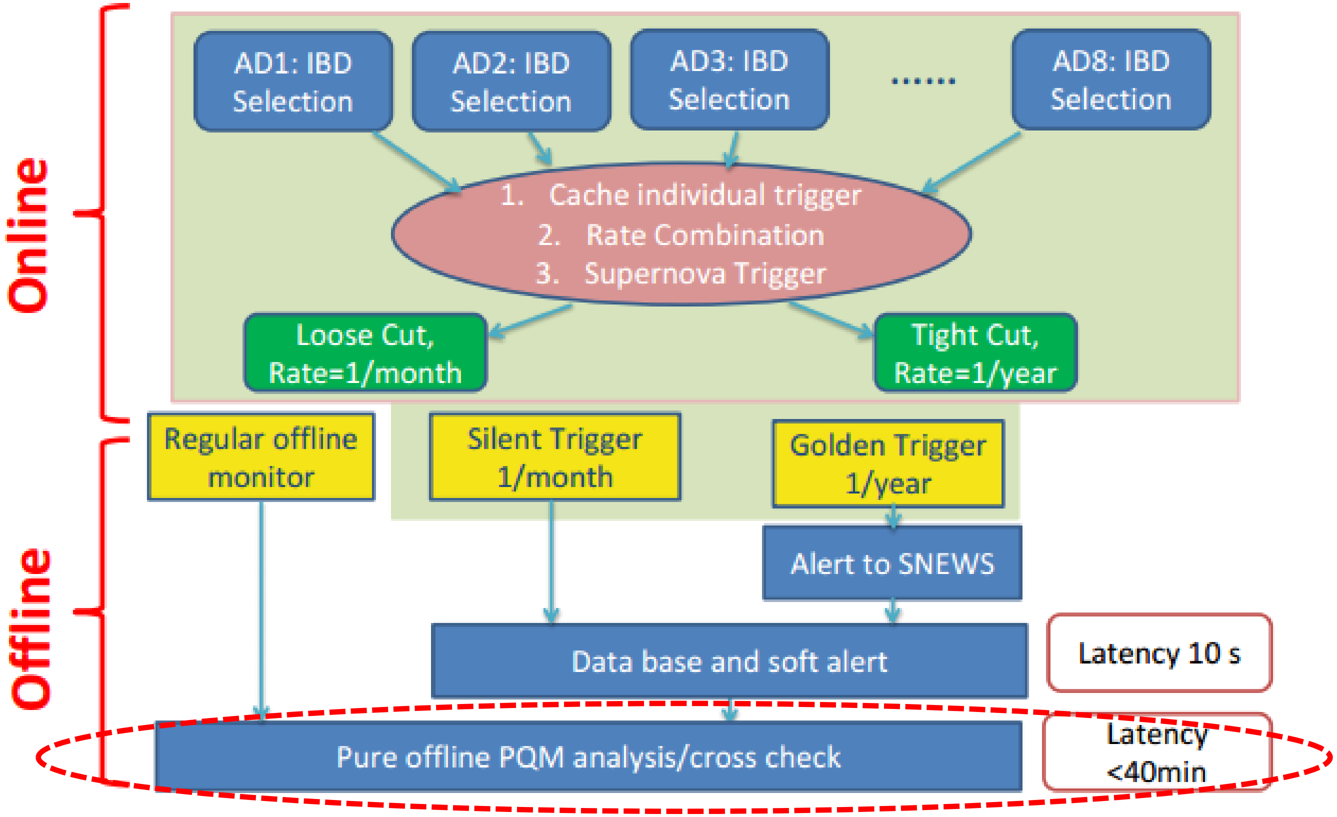
- **A→Two Detector Comparison:**
  Sep. 23, 2011 – Dec. 23, 2011
  Nucl. Inst. and Meth. A 685, 78 (2012)
- **B→First Oscillation Result:**
  Dec. 24, 2011 – Feb. 17, 2012
  Phys. Rev. Lett. 108, 171803 (2012)
- **C→Updated analysis:**
  Dec. 24, 2011 – May 11, 2012
  Chinese Physics C37, 011001 (2013)

  - Data volume: 40TB
  - DAQ eff. ~ 96%
  - Eff. for physics: ~ 94%



The PQM in Daya Bay's SNEWS

- **Collaborators from Tsinghua University are developing supernova trigger in Daya Bay experiment**
- **Offline analysis will be implemented in the PQM**



Thanks Hanyu WEI for providing me the diagram. More details in his talk '[Supernova Trigger in the Daya Bay Reactor Neutrino Experiment]' in Track 2.

Summary

- The PQM has been developed for monitoring sub-detectors and data quality.
- Data processing by the PQM is running smoothly at Daya Bay
- Analysis figures can be displayed about 40 minutes after the DAQ closes the raw data file.
- Playing an important role for the data taking.
- Will implement SN trigger in the PQM.