

The Double Chooz Online System

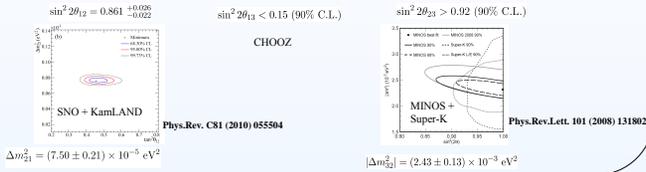
M. Toups – Columbia University, on behalf of the Double Chooz collaboration



Neutrino Mixing

If neutrinos have mass, then flavor mixing can occur: $|\nu_\alpha\rangle = \sum U_{\alpha i} |\nu_i\rangle$
 Our knowledge of neutrino mixing circa 2011 (J. Phys. G: Nucl. Part. Phys. **37** 075021)

$$U = \begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \times \begin{pmatrix} \cos\theta_{13} & 0 & e^{-i\delta_{CP}} \sin\theta_{13} \\ 0 & 1 & 0 \\ -e^{i\delta_{CP}} \sin\theta_{13} & 0 & \cos\theta_{13} \end{pmatrix} \times \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix}$$



Double Chooz



Double Chooz measures $\sin^2 2\theta_{13}$ from the disappearance of reactor $\bar{\nu}_e$ emitted from the Chooz nuclear power plant.

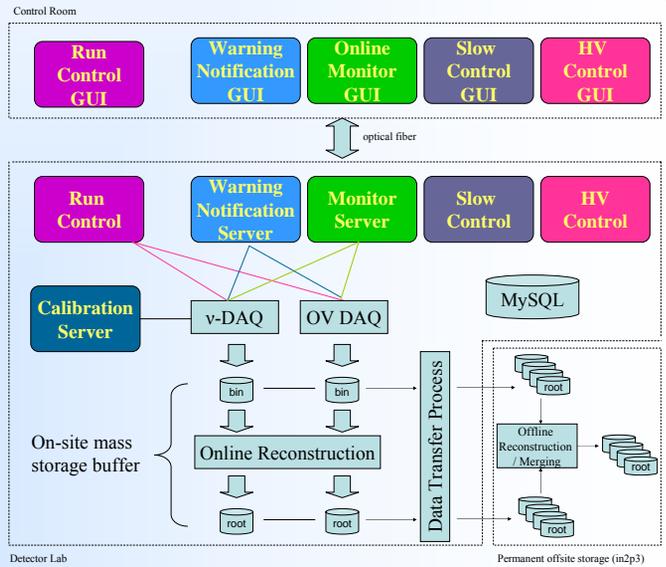
The survival probability for $\bar{\nu}_e$ at distance of ~ 1 km is:
 $P(\bar{\nu}_e \rightarrow \bar{\nu}_e) \approx 1 - \sin^2 2\theta_{13} \sin^2 \left(\frac{1.27 \Delta m^2_{21} L}{E_e} \right)$
 where Δm^2_{21} is in eV^2 , L is in meters, and E_e is in MeV

In 2011, Double Chooz reported **$\sin^2 2\theta_{13} = 0.086 \pm 0.050$**
 Phys.Rev.Lett. 108 (2012) 131801

Overview

A client/server model is used to coordinate actions among several online systems over TCP/IP sockets

- A central run control server synchronizes data-taking among two independent data acquisition (DAQ) systems via a common communication protocol and state machine definition.
- Calibration subsystems are controlled by a calibration server which establishes a connection to one of the DAQs.
- The data are written to buffer disks in the experimental hall and diagnostic information is generated using fast reconstructions
- An automatic data transfer system tracks and manages the relocation of the data files to permanent, offsite storage at in2p3
- Various hardware-level and environmental information are monitored by a slow-control system.
- The DAQs, slow control, and data transfer systems send information to a centralized monitoring server from which diagnostic information can be visualized via a java-based graphical user interface (GUI).
- A warning notification server gathers messages from all online processes and transmits them to a java-based GUI which produces pop-up windows on a remote PC.
- Since access to the experimental site is restricted, all systems have been designed to operate remotely and employ robust exception-handling techniques.



Run Control

Run control system

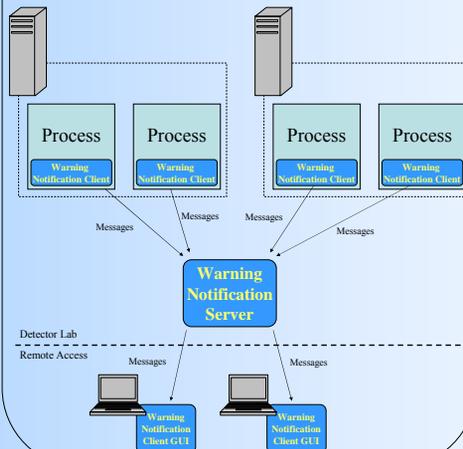
- Central run control server
 - Sends state transition commands to DAQs
 - Sends run configuration to DAQs
 - Manages run length
 - Manages unique run number assignment
 - Stores run information in MySQL database
- v-DAQ/OV DAQ run control
 - Manages individual DAQ state machines (common state definitions)
 - Receives state transition commands from central run control server (common communication protocol)
- Run control Java GUI client
 - User can select a run configuration or a sequence of run configurations
 - Sends run configuration to central run control server



Notification System

Warning message notification system

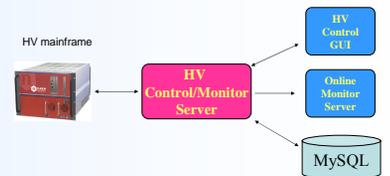
- All online processes built with warning notification client
- Messages sent to centralized server in detector lab via TCP/IP sockets
- Off-site user connects to server via Java GUI client
- Messages produce pop-up windows on remote PC
 - Notification level determines pop-up window behavior



HV Control

HV control/monitoring system

- HV controls is independent from the DAQs
- Monitored values are sent to online monitor.
- Monitored data also stored in MySQL database.



More Details

CHEP 2012 contributions pertaining to the Double Chooz online

- Chang, Pi-Jung. "Double Chooz Physical Environment Monitoring System"
- Franke, Arthur. "The Double Chooz Online Monitor Framework"
- Terao, Kazuhiro. "The Double Chooz Data Streaming"
- Toups, Matt. "The Double Chooz DAQ Systems"

Prior CHEP contributions pertaining to the Double Chooz online

- Maeda, Junpei. "Online data acquisition and the control system for the Double Chooz experiment" J.Phys.Conf.Ser. 331 (2011) 022018
- Konno, T., et al. "Online data monitoring framework based on histogram packaging in network distributed data acquisition systems" J.Phys.Conf.Ser. 331 (2011) 022014