

*Startup Guide*  
*for*  
 *$n^3\text{He}$  Analysis*

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# 1 Resources

All the startup software and manual related to  $n^3He$  experiment can be found from the official git repository with detailed instruction.

The easiest way is to go to n3He wiki ([n3he.wikispaces.com](http://n3he.wikispaces.com)) and then click on software from the left panel.

Alternatively, here is a direct link.

Any new change goes to this git repository. You might want to clone the entire repository and pull periodically to be updated. Or you can also download the last release of only what your are interested in.

---

## 2 Quick start on basestar

On basestar the data is being transferred and saved to the directories:

[/mnt/idata01/data/](#) (run number:1-23661),  
[/mnt/idata02/data/](#) (run number:23662 - ),  
[/mnt/idata03/data/](#) (run number: - )

and the analysis library is compiled in a shared directory [/home/npdg/n3He/libn3He/lib](#)

So a quick start using the compiled library can be as follows from any user account:

1. Add the following lines to the .bashrc file & save it

---

```
if [ -f /home/npdg/n3He/libn3He/bin/thisn3He.sh ]; then  
    . /home/npdg/n3He/libn3He/bin/thisn3He.sh  
fi
```

---

2. Start a new terminal , go to [/home/npdg/n3He/libn3He/analysis/](#) directory & try running sample analysis scripts from ROOT.
3. The data browser GUI (named as n3HeData) can be opened issuing the command [/home/npdg/n3He/n3HeData/n3HeData](#) from the terminal. Copy the binary to your home directory if you will be using the GUI frequently.

Other user specific customization can be achieved following the instruction in the ReadMe file in the respective directory.  
For a local version of the library and data browser please read the corresponding section.

---

### 3 Event length and file size calculation

The event length set in the clean DAQ at 50 KHz sample rate is :830 . Theoretically the maximum possible value is  $50\text{KHz} \times 16.66 \text{ ms} = 833$  samples per T0 .

But 833 event length gives occasional overlap. So we set to 830.

For dirty DAQ at 100 KHz the theoretical number of samples  $100\text{KHz} \times 16.66 \text{ ms} = 1666$

But to avoid overlap we set to 1660.

More over the DAQ has fixed dead time(readout time) of 35 samples(with no averaging) at the end of any event. This amount of time will be missed for every event.

Clean DAQ event length 830 with nacc=16,16 with hi resolution mode=1

Dirty DAQ event length 1660 with nacc=1,1 with hi resolution mode=0

where nacc=n,n indicates how many samples being averaged.

Thus number of sample per event:

Clean DAQ:  $(830-35)/16=49.68 \sim 50$  (1 header + 49 samples)

Dirty DAQ:  $(1660-35)=1625$  (1 header + 1624 samples)

Run Length calculation:

With 25000 T0 per run:

Clean DAQ file size:  $25000 \text{ T0} \times 50 \text{ samples} \times 4 \text{ Byte per sample} \times 48 \text{ Channels} = 240 \times 10^6 \text{ Bytes}$

Dirty DAQ file size (before process):  $25000 \text{ T0} \times 1625 \text{ samples} \times 4 \text{ Bytes per sample} \times 8 \text{ channels} = 1300 \times 10^6 \text{ Bytes}$

Dirty DAQ file seize (after process) :  $25000 \text{ T0} \times 1625 \text{ samples} \times 4 \text{ Bytes per sample} \times 2 \text{ channels} = 325 \times 10^6 \text{ Bytes}$

---

## 4 The data file structure

48 Clean DAQ channels divided into two modules:

Each sample is 4 bytes(in hexdump one contiguous pair consists one sample or 4 bytes). Out of this 32 bit(4 bytes) , our data is 24 bit and remaining least significant 8 bits are channel ID.



```
Terminal - kabir@basestar:~
File Edit View Terminal Go Help
[kabir@basestar ~]$ hexdump /mnt/ldata01/data/run-20673data-21 | head -n 20
00000000 f154 aa55 f154 aa55 f154 aa55 f154 aa55
00000010 0001 0000 0000 0000 0002 0000 0000 0000
00000020 f154 aa55 f154 aa55 f154 aa55 f154 aa55
00000030 0001 0000 0000 0000 0002 0000 0000 0000
00000040 f154 aa55 f154 aa55 f154 aa55 f154 aa55
00000050 0001 0000 0000 0000 0002 0000 0000 0000
00000060 f15f aa55 f15f aa55 f15f aa55 f15f aa55
00000070 0000 0000 0000 0000 0002 0000 0000 0000
00000080 f15f aa55 f15f aa55 f15f aa55 f15f aa55
00000090 0000 0000 0000 0000 0002 0000 0000 0000
000000a0 f15f aa55 f15f aa55 f15f aa55 f15f aa55
000000b0 0000 0000 0000 0000 0002 0000 0000 0000
000000c0 0020 0000 0021 0000 0022 0000 0023 0000
000000d0 0024 0000 0025 0000 0026 0000 0027 0000
000000e0 0028 0000 0029 0000 002a 0000 002b 0000
000000f0 0034 0000 0035 0000 0036 0000 0037 0000
00000100 0038 0000 0039 0000 003a 0000 003b 0000
00000110 003c 0000 003d 0000 003e 0000 003f 0000
00000120 0040 0000 0041 0000 0042 0000 0043 0000
00000130 0044 0000 0045 0000 0046 0000 0047 0000
[kabir@basestar ~]$
```

Figure 1: Typical view of hexdump

The above hexdump to be interpreted as follows:  
With: mod= module ch = channel

```
mod1event1sample1ch0 mod1event1sample1ch1 mod1event1sample1ch3 ..... mod1event1sample1ch8
mod1event1sample1ch9 mod1event1sample1ch10 mod1event1sample1ch11 ..... mod1event1sample1ch16
mod1event1sample1ch17 mod1event1sample1ch18 mod1event1sample1ch19 ..... mod1event1sample1ch23

mod2event1sample1ch0 mod2event1sample1ch1 mod2event1sample1ch3 ..... mod2event1sample1ch8
mod2event1sample1ch9 mod2event1sample1ch10 mod2event1sample1ch11 ..... mod2event1sample1ch16
mod2event1sample1ch17 mod2event1sample1ch18 mod2event1sample1ch19 ..... mod2event1sample1ch23
```



and channel-6 (with sample number) where for ADC channel number starts with 0.

This for Dirty DAQ after the processing,

```
event1sample1Ch0 event1sample1ch1
event2sample1Ch0 event2sample1ch1
... ..
.....
```

Up to N events.

with the first sample of any event being checksum and sample number i.e.  
event1sample1ch0 = checksum.  
event1sample1ch1 = sample number.

---



## 5 ADC count to Volt conversion and time bin

The resolution and device range of a DAQ device determine the smallest detectable change in the input signal. We can calculate the smallest detectable change, called the precision (code width), using the following formula.

$$Precision = \frac{ADCRange}{2^{resolution}}$$

In our ADC each sample is stored in 32 bit and the ADC has a range of +10 V to -10 V.

$$Precision = \frac{20V_{olt}}{2^{32}}$$

Thus  $4.656612873 \times 10^{-9}$  will be the conversion factor from ADC value to volt. Also to throw away the least significant 8 bit out of 32 bit, you can do  $ADCCount >> 8$  in your analysis code.

The time bin depends on the sample rate at which the DAQ is taking data. For the n3He experiment we run the clean DAQs at 50 KHz sample rate and dirty DAQs at 100KHz. Again for clean DAQs 16 samples are averaged to give one sample and for dirty DAQ no averaging is used. Thus for clean (detector) data each time bin corresponds to:

$$16 \times \frac{1}{50KHz} = 320\mu sec$$

And for dirty data it is

$$\frac{1}{100KHz} = 10\mu sec$$

---

## 6 The ADC channel to wire map

Out of 48 clean ADC channels, only 36 ADC channels are connected to the pre-amps. Eventually the ADC channel to detector wire map to be handled by the library. However following is the map for reference:

---

```
Number of layers = 16;
Number of wires per layer= 9;

Layer_to_DAQ_map[Nlayers]={21, 23, 21, 23, 21, 23, 21, 23,
                             22, 24, 22, 24, 22, 24, 22, 24};

Layer_to_ADC_channel_map[16][9] =
{
    {0,1,2,3,4,5,6,7,8},
    {0,1,2,3,4,5,6,7,8},
    {9,10,11,12,13,14,15,16,17},
    {9,10,11,12,13,14,15,16,17},
    {24,25,26,27,28,29,30,31,32},
    {24,25,26,27,28,29,30,31,32},
    {33,34,35,36,37,38,39,40,41},
    {33,34,35,36,37,38,39,40,41},
    {0,1,2,3,4,5,6,7,8},
    {0,1,2,3,4,5,6,7,8},
    {9,10,11,12,13,14,15,16,17},
    {9,10,11,12,13,14,15,16,17},
    {24,25,26,27,28,29,30,31,32},
    {24,25,26,27,28,29,30,31,32},
    {33,34,35,36,37,38,39,40,41},
    {33,34,35,36,37,38,39,40,41},
};
```

---

---

## 7 Setting up local version of n3He analysis library on basestar

Eventually you will want to set up your own version of the analysis library and ROOT environment. This way you can modify any part of the library and add more functionality.

1. Download the source code from here.  
lib3He is the analysis library for n3He experiment.
2. Make any necessary changes in Constants.h file that is required.
3. Do `make` to compile the library.
4. This will produce `libn3He.so` (shared library will be inside lib directory).
5. Place the .so file in a directory under `LD_LIBRARY_PATH` .
6. Now start root and load the Library as: `gSystem->Load("libTree")`  
& `gSystem->Load("libn3He.so")` . (For Online analysis)
7. For analysis from a script if you include TTree.h file then you need not to do `gSystem->Load("libTree")`; Just load `gSystem->Load("libn3He.so")`.  
You need to give full path unless the directory is included in `LD_LIBRARY_PATH`.
8. If you put the `rootlogon.C` file in `macros` directory under Root installation directory, then the library will be loaded automatically and step-6 is NOT necessary.
9. Now from your root script create a Tree by calling: `TTreeRaw *my_tree = new TreeRaw(runNumber#)` or Just `TTreeRaw t(runNumber#)`
10. Do `my_tree->Print()` to print the tree and branch structure.
11. Now do what ever analysis you want using `my_tree` .
12. Try running example analysis scripts in "analysis" directory.
13. To make life easier it's convenient to put the following command into your `~/.bash_profile` or `~/.bashrc` file:

---

```
if [ -f /path/to/libn3He/bin/thisn3He.sh ]; then  
    . /path/to/libn3He/bin/thisn3He.sh  
fi
```

---

Note: This version of the library works both for ROOT 5 and ROOT 6.

---

## 8 Setting up local version of data browser on basestar

1. Download the source code from here.
2. In bin directory: contains just binary files(obtained after doing make) named `n3HeData`.
3. In libn3He directory: Contains all the library required for running the Data check GUI.
4. Modify and compile the library (Unless you have already set up the library): You need to change the Data file directory from `Constants.h` in `libn3He` to appropriate directory. Before you do `make` do: `make clean` in the same directory. and then make a fresh shared binary files after you make any changes.
5. Place `.so` file under `LD_LIBRARY_PATH`: Now make sure the shared library (`libn3He.so`) file is in a directory under your `LD_LIBRARY_PATH`.  
OR, a more professional way is as follows: Open `/libn3He/bin/thisn3He.sh` and define `n3HeROOT` path variable to the location where `libn3He` is located. for example: `n3HeROOT=/home/siplu/libn3He/`  
Now include command in your `.bashrc` file to run `thisn3He.sh` file each time you open the terminal. i.e. include the following lines:  

---

```
if [ -f path_to/libn3He/bin/thisn3He.sh ]; then
    . path_to/libn3He/bin/thisn3He.sh
fi
```

---
6. Produce binary for GUI: To produce a new binary file named `n3HeData`, go to `n3HeData` directory, open makefile and change `LIB_INCLUDE` and `GLIBS` to appropriate location for you and then do `make`. It will produce `n3HeData` binary file in the same directory.
7. Run the GUI: Now run the binary file `n3HeData` by doing `./n3HeData` from your recently compiled version in `/n3He_DAQ_GUI/n3HeData/`.

- Modify the `.desktop` file (included one only for Ubuntu distribution) and `.sh` file in bin directory accordingly and place it in your desktop if you want to run the GUI just by double clicking from your desktop.

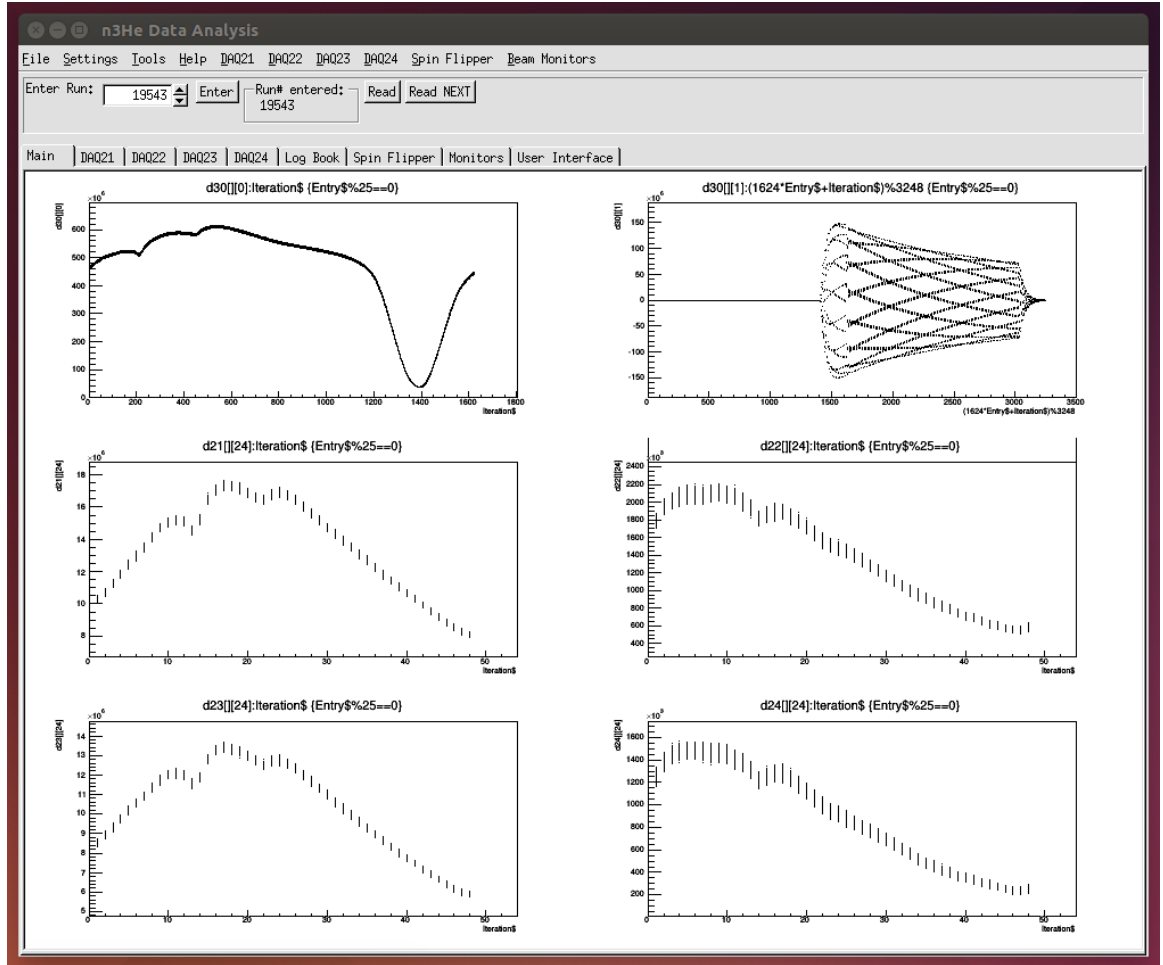


Figure 2: The n3He data browser

## 9 Current tree structure in n3He analysis library

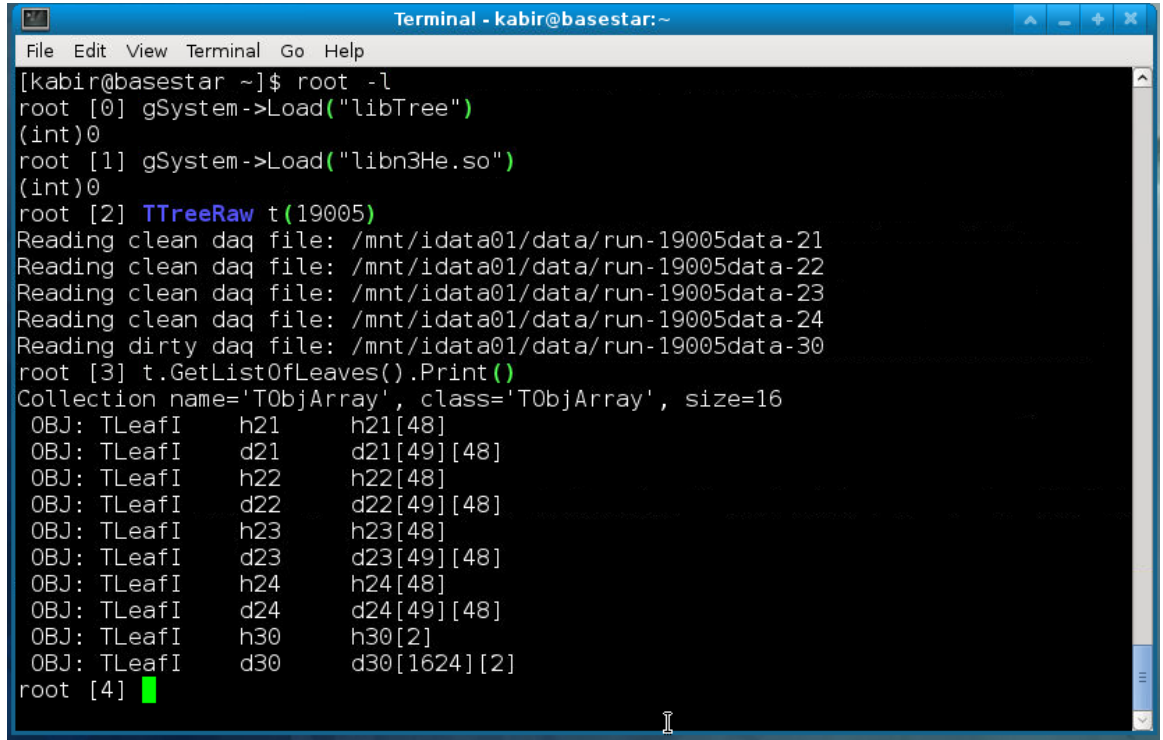
Currently n3He Tree has five branches corresponding to four clean DAQ and one dirty DAQ, following is the leaf list in the n3He Tree.

---

```
DAQ21_LEAF "h21[48]/I:d21[49][48]/I"  
DAQ22_LEAF "h22[48]/I:d22[49][48]/I"  
DAQ23_LEAF "h23[48]/I:d23[49][48]/I"  
DAQ24_LEAF "h24[48]/I:d24[49][48]/I"  
DAQ30_LEAF "h30[2]/I:d30[1624][2]/I"
```

---

where h used to indicate header and d used to indicate detector signal. 21 to 24 are clean DAQs and 30 is dirty DAQ. Clean DAQs contain detector signals. Dirty DAQ (after data processing) ADC channel-0 is monitor-1 signal and ACD channel-1 is RFSF signal.



```
Terminal - kabir@basestar:~  
File Edit View Terminal Go Help  
[kabir@basestar ~]$ root -l  
root [0] gSystem->Load("libTree")  
(int)0  
root [1] gSystem->Load("libn3He.so")  
(int)0  
root [2] TTreeRaw t(19005)  
Reading clean daq file: /mnt/idata01/data/run-19005data-21  
Reading clean daq file: /mnt/idata01/data/run-19005data-22  
Reading clean daq file: /mnt/idata01/data/run-19005data-23  
Reading clean daq file: /mnt/idata01/data/run-19005data-24  
Reading dirty daq file: /mnt/idata01/data/run-19005data-30  
root [3] t.GetListOfLeaves().Print()  
Collection name='TObjArray', class='TObjArray', size=16  
OBJ: TLeafI    h21      h21[48]  
OBJ: TLeafI    d21      d21[49][48]  
OBJ: TLeafI    h22      h22[48]  
OBJ: TLeafI    d22      d22[49][48]  
OBJ: TLeafI    h23      h23[48]  
OBJ: TLeafI    d23      d23[49][48]  
OBJ: TLeafI    h24      h24[48]  
OBJ: TLeafI    d24      d24[49][48]  
OBJ: TLeafI    h30      h30[2]  
OBJ: TLeafI    d30      d30[1624][2]  
root [4] █
```

Figure 3: The n3He leaf list

Now the library always skips the first four or five events since those might NOT be reliable. As a result the number of events in any branch for a typical n3He run is 24996 or 24995(This offset is set dynamically).

```

Terminal - kabir@basestar:~
File Edit View Terminal Go Help
OBJ: TLeafI h30 h30[2]
OBJ: TLeafI d30 d30[1624][2]
root [4] t.Print()
*****
*Tree      :n3He      : n3He raw data
*Entries   : 24996 : Total = 3339 bytes File Size = 0
*          :      : Tree compression factor = 1.00
*****
*Br   0 :b21      : h21[48]/I:d21[49][48]/I
*Entries : 24996 : Total Size= 600 bytes One basket in memory
*Baskets : 0 : Basket Size= 32000 bytes Compression= 1.00
*.....
*Br   1 :b22      : h22[48]/I:d22[49][48]/I
*Entries : 24996 : Total Size= 600 bytes One basket in memory
*Baskets : 0 : Basket Size= 32000 bytes Compression= 1.00
*.....
*Br   2 :b23      : h23[48]/I:d23[49][48]/I
*Entries : 24996 : Total Size= 600 bytes One basket in memory
*Baskets : 0 : Basket Size= 32000 bytes Compression= 1.00
*.....
*Br   3 :b24      : h24[48]/I:d24[49][48]/I
*Entries : 24996 : Total Size= 600 bytes One basket in memory
*Baskets : 0 : Basket Size= 32000 bytes Compression= 1.00
*.....
*Br   4 :b30      : h30[2]/I:d30[1624][2]/I
*Entries : 24996 : Total Size= 600 bytes One basket in memory
*Baskets : 0 : Basket Size= 32000 bytes Compression= 1.00
*.....
root [5]

```

Figure 4: The n3He tree structure



## 10 Sample analysis

Sample online analysis on basestar:

---

```
//OnlineAnalysis.C
//Demo Online Analysis using n3He Library.(By Online I mean 'from
    CINT, doing analysis on the fly, less thoughtful but preferred
    in some conditions')
//Author: Latiful Kabir
//Date: 12/23/14

void OnlineAnalysis()
{
    gSystem->Load("libTree"); //You need to load libTree first in
        order to Load libn3He. This is not necessary if you include
        TTree.h
    gSystem->Load("libn3He.so");

    TTreeRaw *t=new TTreeRaw(19900);
    t->Draw("d21[] [0]:Iteration$");
}
```

---

This script when you run using `root -l OnlineAnalysis.C` will produce the following output:

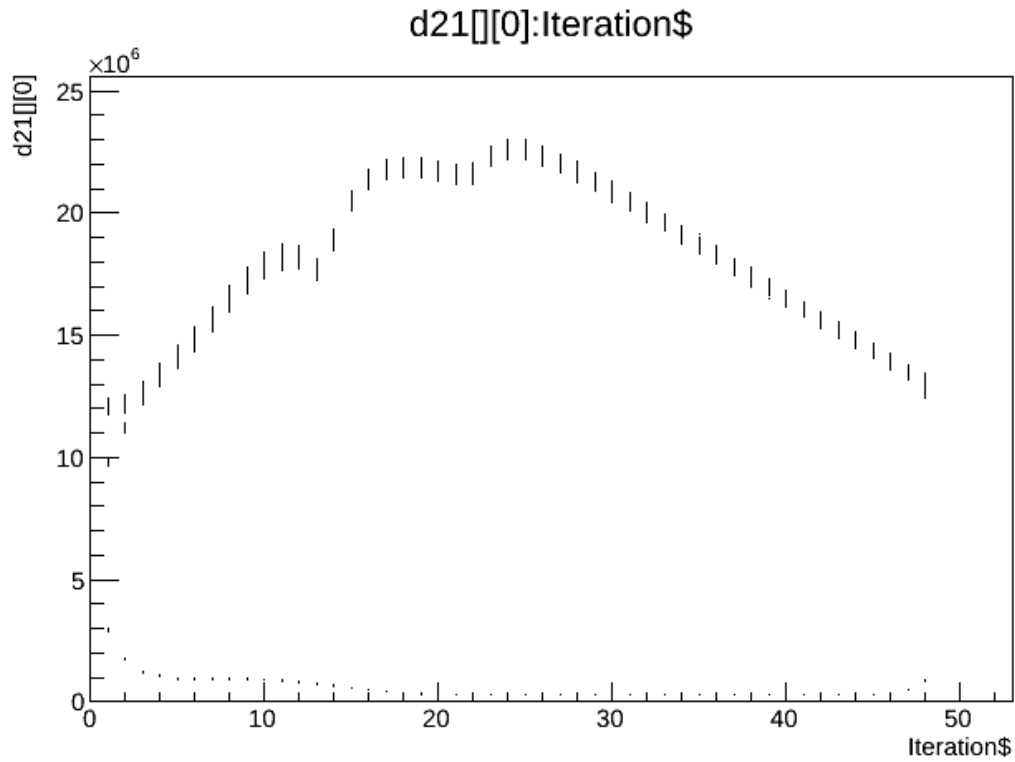


Figure 5: The Output from OnlineAnalysis.C

Sample offline analysis on basestar:

---

```
//OfflineAnalysis.C
//Demo Offline Analysis using n3He Library.(By Offline I mean 'in
    a script more thoughtful and serious analysis unlike from CINT)
//This script shows how to access Tree using SetAddress
// and plots only the all event/pulses of channel-0
//Author: Latiful Kabir
//Date: 01/14/15
//This is the fastest and most preferred method for reading Tree

#include<TTree.h>
#include<TBranch.h>
#include<TGraph.h>
```

```

void OfflineAnalysis(){

    //Load the library unless loaded automatically by ROOT
    gSystem->Load("libTree");
    gSystem->Load("libn3He.so");

    //Create a TTreeRaw object with desired run number
    TTreeRaw *t=new TTreeRaw(17900);
    t->Print(); // Print to see what's inside the Tree
    int ch=0; //Channel to analyze

    //Create a struc buffer to keep your events
    struct myData
    {
        int header[48];
        int det[49][48];
    };

    myData md;

    //Get the branch you want to analyze
    TBranch *b=t->GetBranch("b21");
    b->SetAddress(&md.header[0]);

    //-----

    TGraph *g=new TGraph();

    //Loop through all the events in the run.
    for(int i = 0; i < b->GetEntries(); i++)
    {
        //Load the samples for a event/pulse in buffer
        b->GetEntry(i);

        //Loops through the sample for the loaded event
        for(int k=0; k<49; k++)
            g->SetPoint(i*49+k, i*49+k, md.det[k][ch]);
    }

    g->Draw("AP");
}

```

```
delete t;  
}
```

---

This script when you run using `root -l OfflineAnalysis.C` will produce the following output when zoomed in:

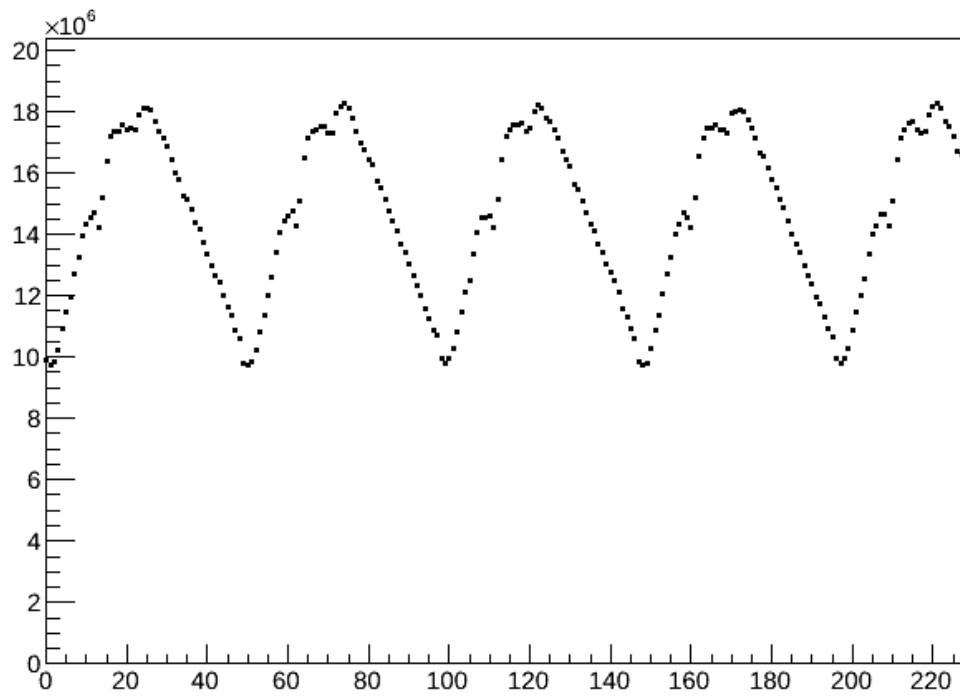


Figure 6: The output from OfflineAnalysis.C

## 11 Reference for TTreeRaw class

The base Class is TTree.

As a result all data and member functions from TTree are automatically inherited. For a list of TTree data and member functions go here

---

public:

```
TString dataPath;
TString *DaqLeaf;
TString *dataFile;
static int module[5];

TBranch *b21,*b22,*b23,*b24,*b30;

void Init(int runNumber);
TTreeRaw(int runNumber);
~TTreeRaw();
```

---

This list will be updated gradually as new functionality is added to the TTreeRaw class.

---