Hall C Winter Collaboration Meeting

Hall C Software: Status & Outlook

Eric Pooser

Jefferson Lab

1/28/2019

On Behalf of the Hall C Software Working Group

Joint Hall A & C Data Analysis Workshop

- Analysis Workshop held June 25-26, 2018
- Great starting point for new users unfamiliar to the software
- Git Repo for interactive sessions covering wide range of topics

Program

Monday, June 25, 2018

Morning Session

(Chair: Mark Jones)

General

09:00 Welcome -- Ole Hansen
09:05 Overview & Update on Hall A Analysis Software -- Ole Hansen
09:30 Overview & Update of the Hall C Analyzer -- Eric Pooser

Hall A Analysis

10:00 Hall A optics optimization -- Tong Su
10:30 Optics for mistuned spectrometers -- Eric Christy

10:45 Coffee Break

11:00 Beam energy determination -- Doug Higinbotham
11:30 Using MySQL databases in analysis (*) -- Shujie Li
12:00 Tritium replay on farm, analysis organization -- Tyler Hague

12:30 Lunch (on your own)

Afternoon Session

(Chair: Ole Hansen)

Farm Use and Workflow Tools

13:30 Farm Use and Computing Resources Tips and Tricks -- Brad Sawatzky

- Overview of JLab Computing Resources and Tools (*)
- Common problems and how to avoid them
- hcswif: Quick and easy SWIF job submission wrapper (*) -- John Matter
- Question and Answer! (What are your problems, irritations, puzzles?)

15:30 Coffee Break

Using Python for Analysis Part I

15:45 Hall A event visualization using Python-- Tyler Kutz
16:00 Python Analysis Tutorial -- Eric Pooser

17:00 Adjourn

Tuesday, June 26, 2018

Morning Session

(Chair: Eric Pooser)

Hall C Analysis

09:00 Effective Git use (*) -- Steve Wood
10:00 Hall C Spectrometer Optics and Optimization -- Holly Szumila-Vance

10:30 Coffee Break

10:45 Cherenkov Analysis -- Abel Sun
11:10 Calorimeter Analysis -- Vardan Tadevosyan
11:30 Hodoscope Analysis -- Carlos Yero
11:50 Drift Chamber Analysis -- Abishek Karki

12:15 Lunch (on your own)

Afternoon Session

(Chair: Brad Sawatzky)

Intermediate-Level Analysis with ROOT

13:30 Linear analysis -- Mark Jones
14:15 Updates & Introduction to Jupyter Notebooks (*) -- Ole Hansen
14:30 Reading and processing trees (part2) (*) -- Ole Hansen

15:30 Coffee Break

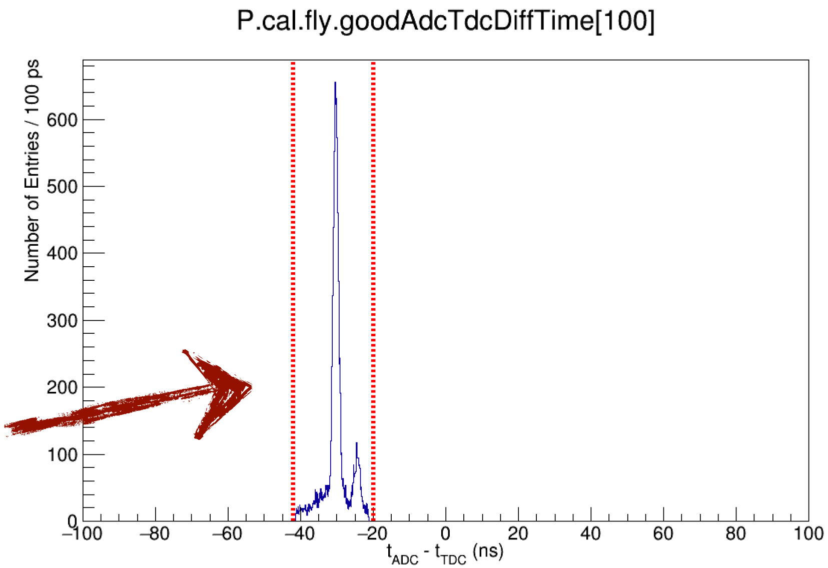
Using Python for Analysis Part II

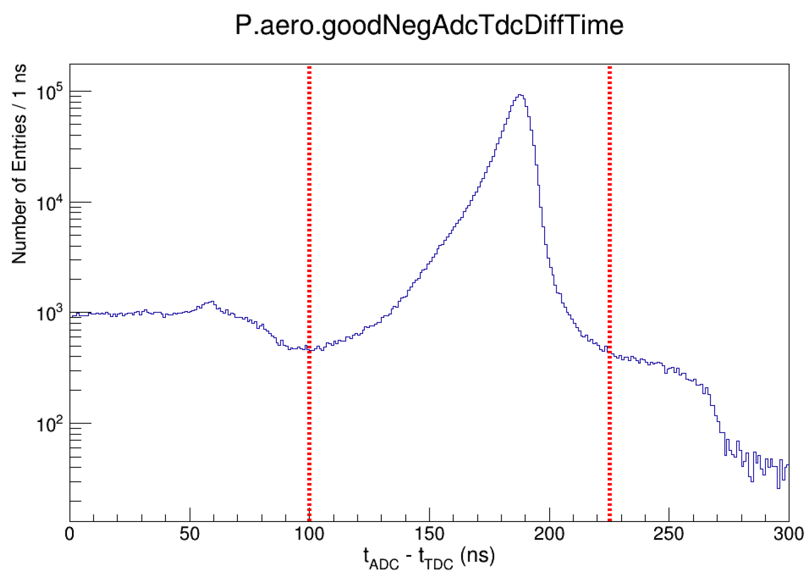
16:00 Python Analysis Tutorial continued (*) -- Eric Pooser

17:00 Adjourn

Updates to HCANA: b1ad79e & 66771fa

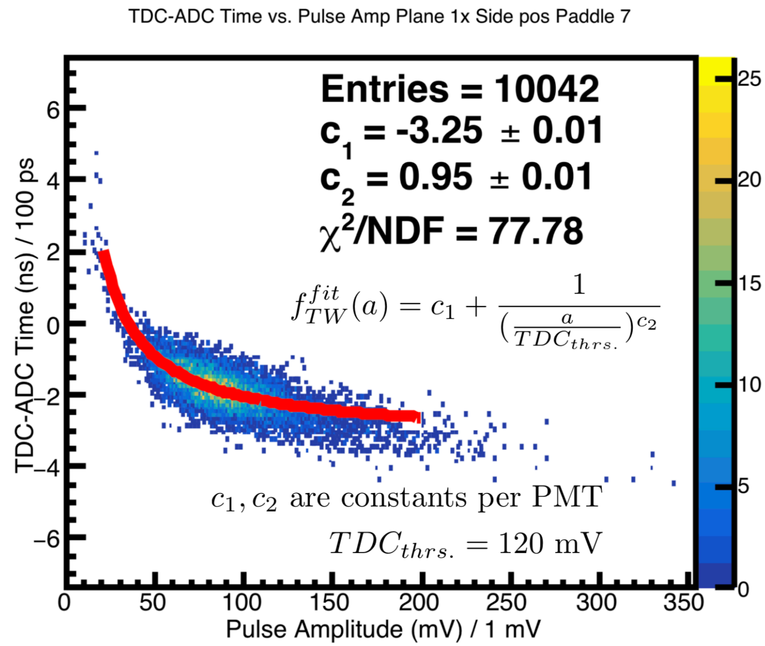
- Per PMT timing cuts have been integrated into both calorimeter and aerogel detector classes
- HMS Calorimeter (**THcShower**)
  - **cal_pos(neg)_adcTimeWindowMin(Max)**
- SHMS Calorimeter (**THcShowerArray**)
  - **cal_arr_adcTimeWindowMin(Max)**
- SHMS Pre-Shower (**THcShower**)
  - **cal_pos(neg)_adcTimeWindowMin(Max)**
- Aerogel (**THcAerogel**)
  - **aero_adcPos(Neg)TimeWindowMin(Max)**
- Determines 'Good' FADC hit for each detector channel
  - One hit per event

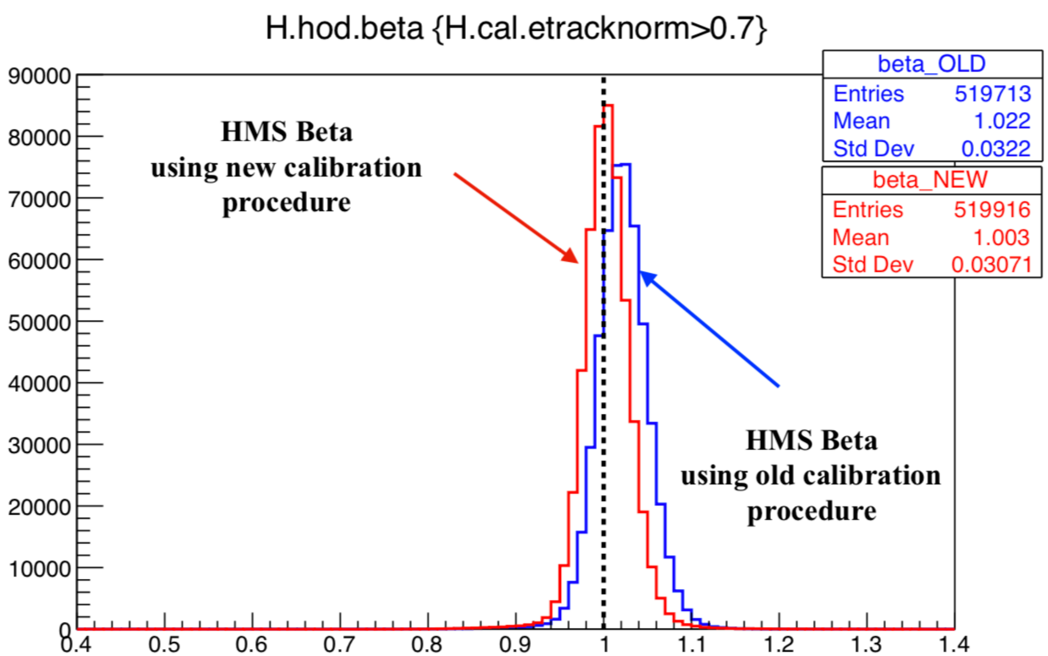


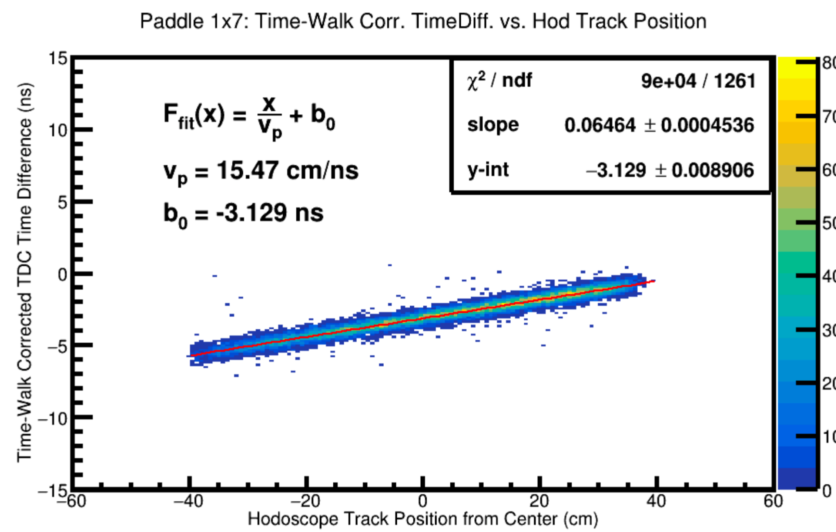


Updates to HCANA: a0d4684

- New hodoscope calibration procedure
- Utilizes FADC timing and pulse amplitude information to perform the time-walk calibration for each PMT
- Decouples calibration procedures into individual components



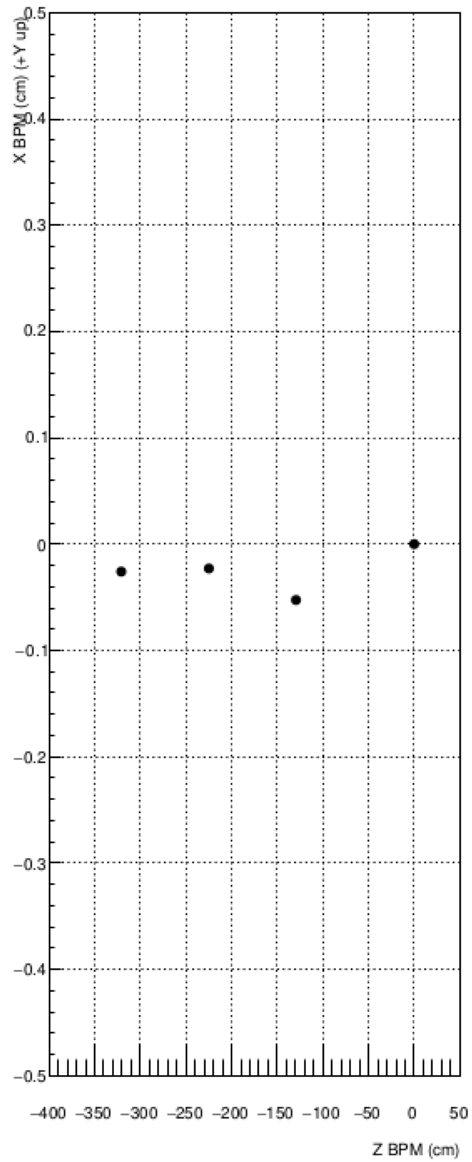


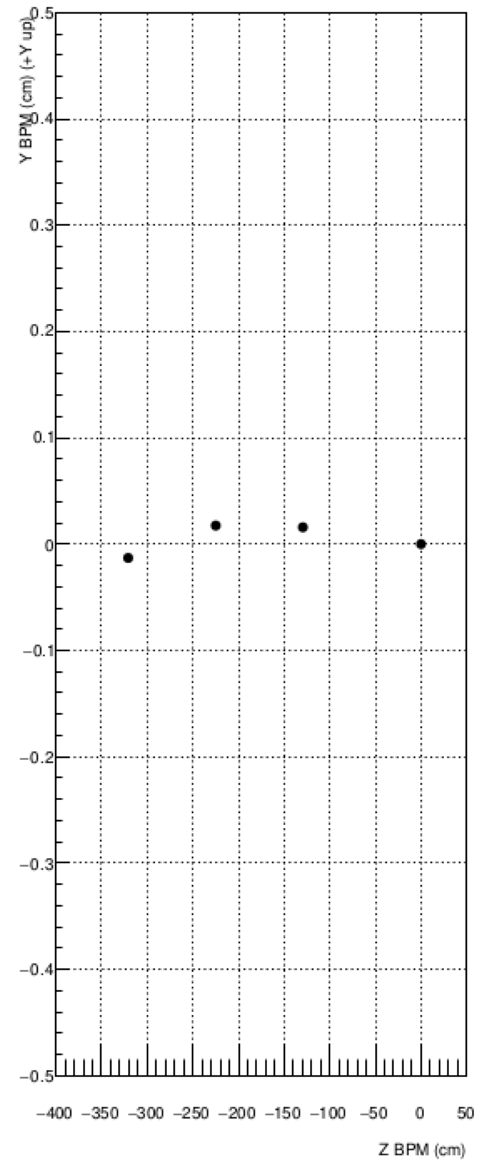


Plots courtesy of Carlos Yero

Updates to HCANA: 7b883c0 & 7837f27

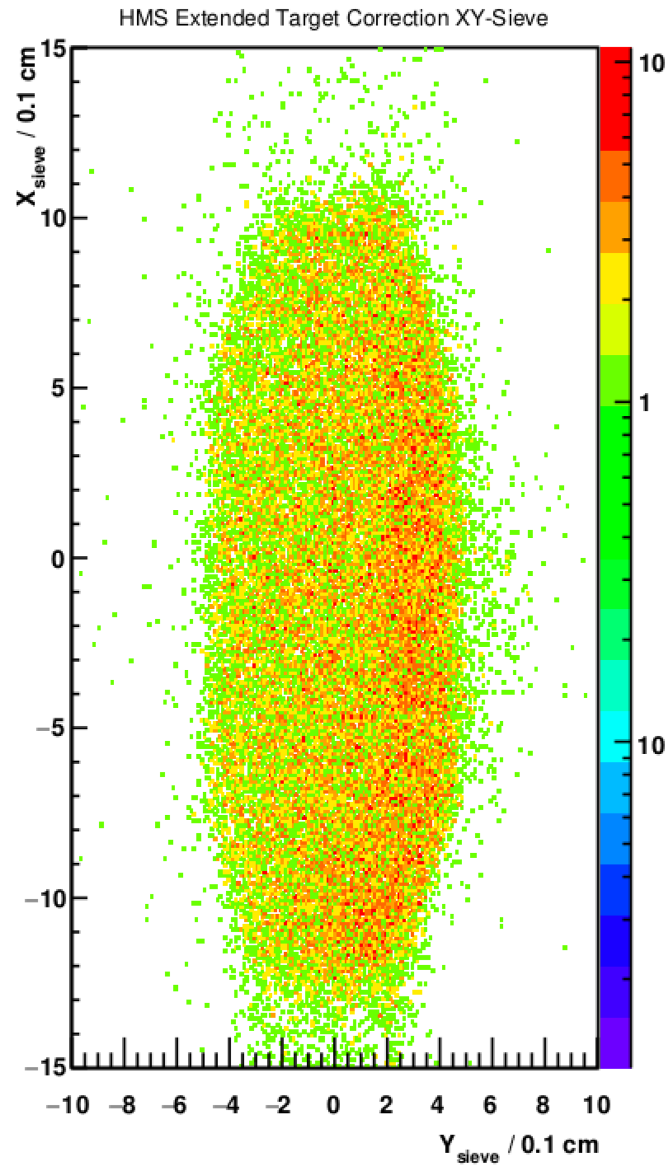
- **THcRaster** has been updated to utilize the BPM information from EPICS
- Calculates the beam position and direction at the target as inferred from the BPMs
- Tree variables for the three BPMs and projection to the target in the EPICS coordinate system have been added
- The calculation of beam at the target utilizes A & C
- Raster variables are now in the EPICS coordinate system as it makes it easier to interpret the carbon hole runs





Updates to HCANA: aa5b54c & 5a55867

- **THcExtTarCor** now has tree variables that calculate **xsieve** and **ysieve** for the spectrometer
- Both **xsieve** and **ysieve** variables are also calculated for the golden track
- The calculations depend on the spectrometer i.e. the SHMS calculation includes a delta dependence when calculating sieve
- **THcHallCSpectromoter** now handles mispointing according to the input angle if the mispointing is not set by a parameter
  - The formula for mispointing comes from fits to surveys
- It is possible to set custom mispointings via **(p)hmisspointing_x(y)** in **standard.kinematics**

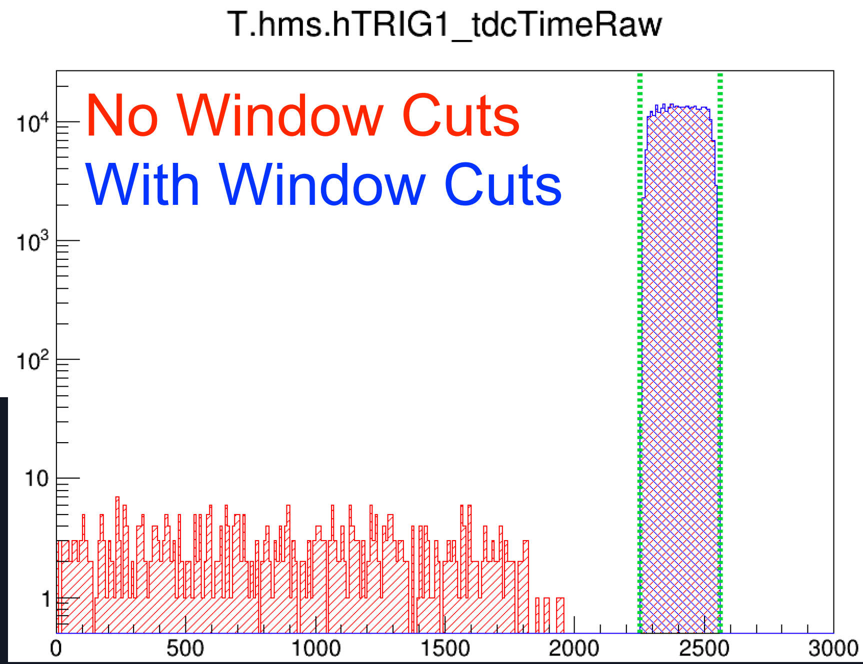


Updates to HCANA: 4a7af64 & 4d4418d

- Drift chamber classes updated to include a per wire sigma parameter
- `(p)h_using_sigma_per_wire` is optional and turned off by default
- When the per wire configuration is not being utilized then the sigma per plane parameters are utilized
- `THcTrigDet` and `THcCoinTime` updated to take in a `vector<string>` to identify which of the trigger detector TDC signals to use for the coincidence timing
- Names must be in order of SHMS ROC1, HMS ROC1, SHMS ROC2, HMS ROC2
  - `tcoin_trigNames = pTRIG1_ROC1 pTRIG4_ROC1 pTRIG1_ROC2 pTRIG4_ROC2`
- Raw TDC to time conversion factor is no longer hard coded in `THcCoinTime` and instead utilizes the `fTdcChanperNS` parameter
  - If more than one hit within window, the last hit is selected
  - If no hit is found in the window then the time is set to zero

Updates to HCANA: 24235e0

- **THcTrigDet** modified to select good TDC hits within some time window
- Hit selection windows exist for all trigger apparatus variables
  - **(p)hVARX_tdcTimeRaw**

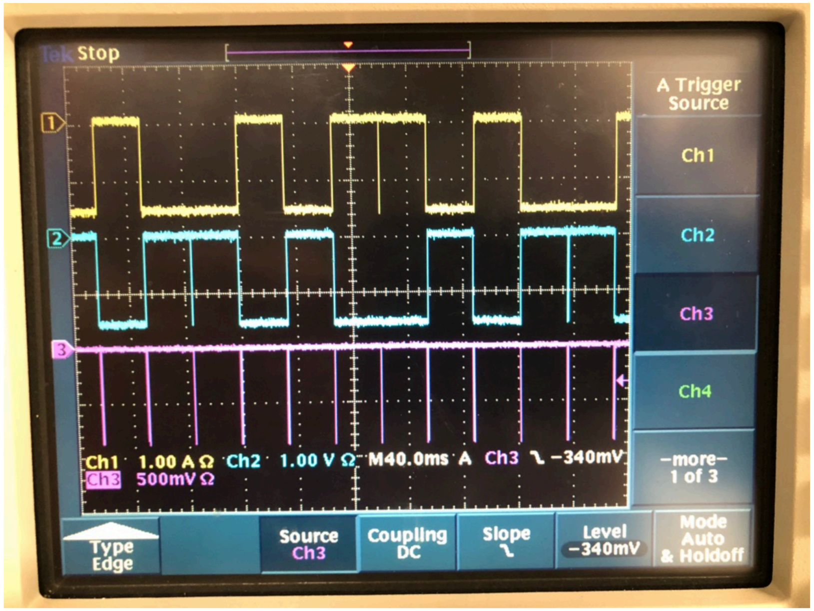


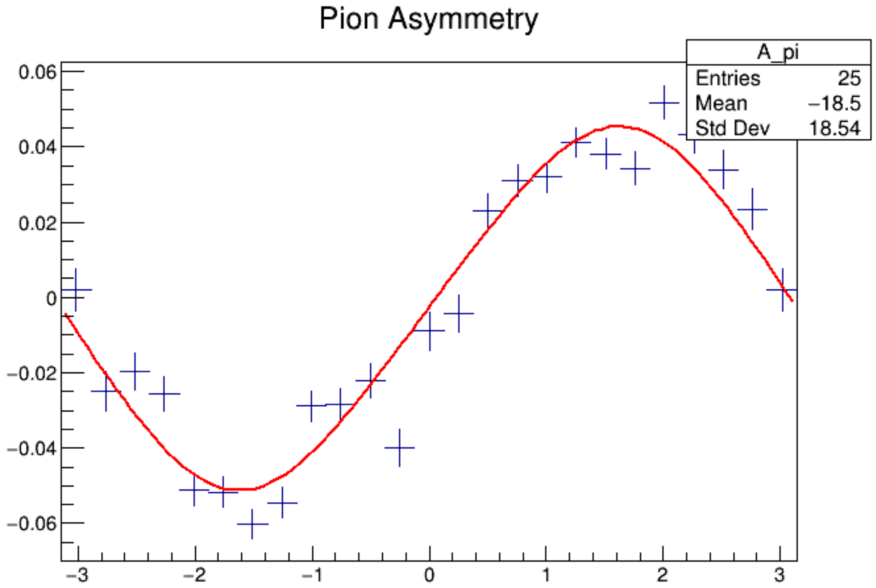
PARAM/TRIG/t(p)hms.param

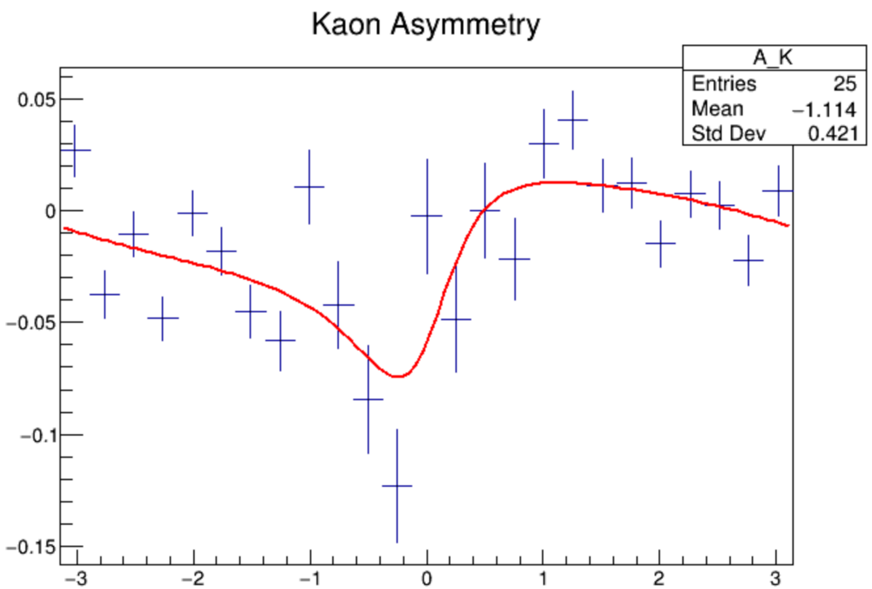
```
t_hms_numAdc = 9
t_hms_numTdc = 53
t_hms_tdcoffset=300.
t_hms_adc_tdc_offset=300.
t_hms_tdcchanperns=0.09766

t_hms_trig_adcrefcut = -4350
t_hms_trig_tdcrefcut = -2000

; bar num:         1     2     3     4     5      6    7    8        9
t_hms_adcNames = "hASUM hBSUM hCSUM hDSUM hPSHWR hSHWR hAER hCER hFADC_TREF_ROC1"

; bar num:        1   2   3   4   5   6   7    8     9     10    11    12    13    14    15    16   17   18      19      20      21      22     23
t_hms_tdcNames = "h1X h1Y h2X h2Y h1T h2T hT1 hASUM hBSUM hCSUM hDSUM hPRLO hPRHI hSHWR hEDTM hCER hT2 hDCREF1 hDCREF2 hDCREF3 hDCREF4 hTRIG1 hTRIG2

t_hms_TdcTimeWindowMin = -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000,
                          -10000, -10000, -10000, -10000, 1400, -10000, -10000, -10000, -10000, -10000,
                          -10000, 2250, -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000,
                          -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000,
                          -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000, -10000,
                          -10000, -10000, -10000

t_hms_TdcTimeWindowMax = 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000,
                          10000, 10000, 10000, 10000, 1710, 10000, 10000, 10000, 10000, 10000,
                          10000, 2560, 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000,
                          10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000,
                          10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000,
                          10000, 10000, 10000
```

Updates to HCANA: 47c908b

- **`THcHelcity`** determines the beam helicity for each event
- By default it is assumed that there is a delayed reporting of 8 cycles and that quartets are used
- See Steve's talk @ 1400!

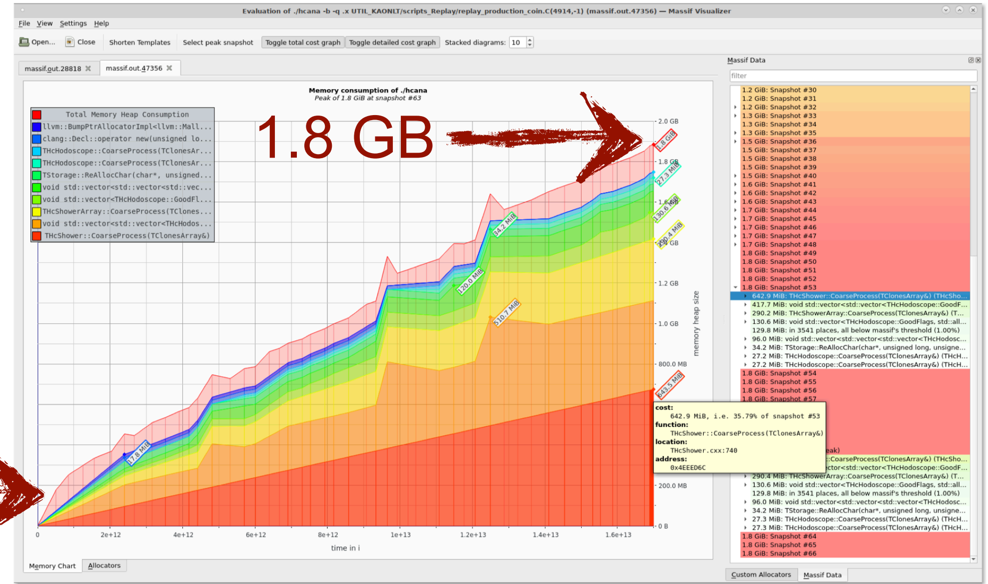


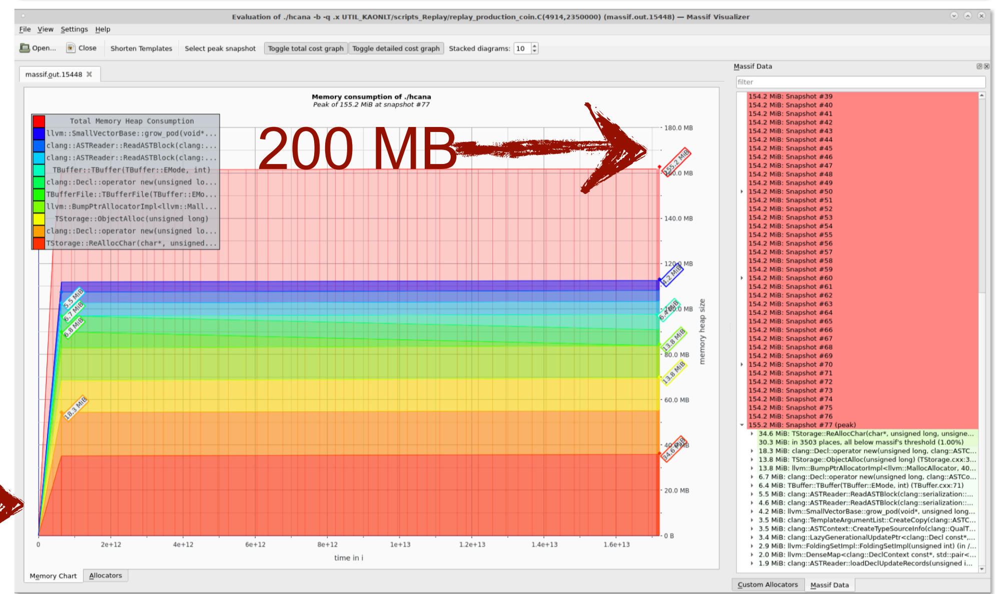




Updates to HCANA: e1f461e

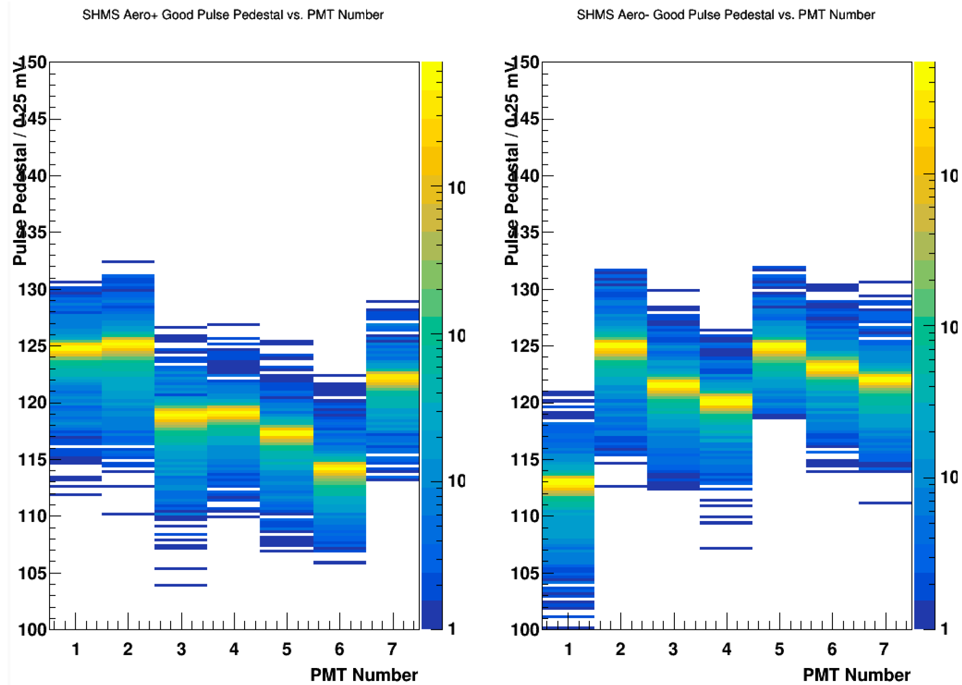
- Large number of memory leaks have been corrected (Ole’s talk)
- Large memory leaks found in **THcShower**, **THcShowerArray**, and **THcShowerHit**
- On average these leaks caused a loss in memory of 420 bytes/event (840 MB / 2M events)
- Many more smaller memory leaks addressed in variety of classes
- Various access errors in **THcHodoscope** and **THcHitList** addressed as well
- Infinitely growing array found in **THcHodoscope**
- Once all fixes were implemented, a flat heap profile is observed

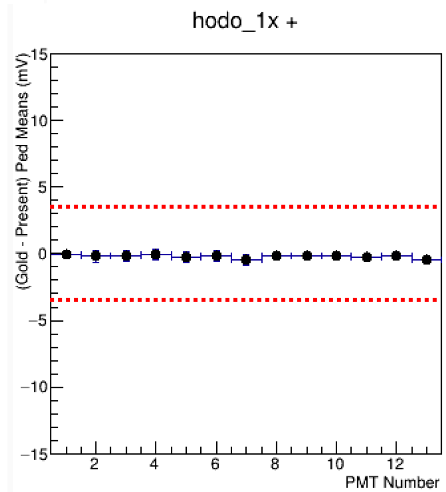


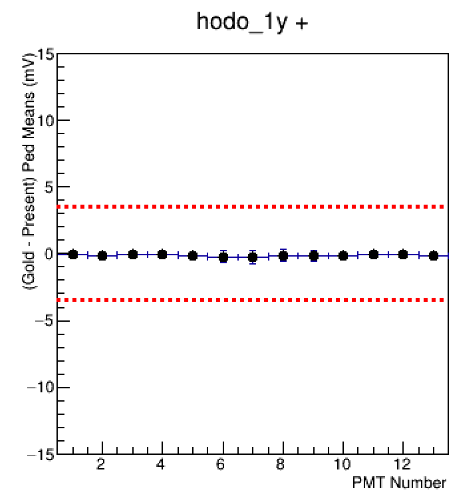


FADC Thresholds & Pedestal Golden Runs

- Thresholds for each FADC channel must be determined on an per channel basis (expert driven task)
- By default all thresholds are set to 10 mV unless request is made
- When new thresholds are set, 'golden runs' for each spectrometer must be symbolically linked to a specific run of choice in the replay ROOTfiles directory
  - `(s)hms_coin_replay_production_golden.root`
- The 'golden' run utilized in the 50k online monitoring to monitor pedestal drifts of all FADC channels
- Critical path item in order to ensure quality of FADC data

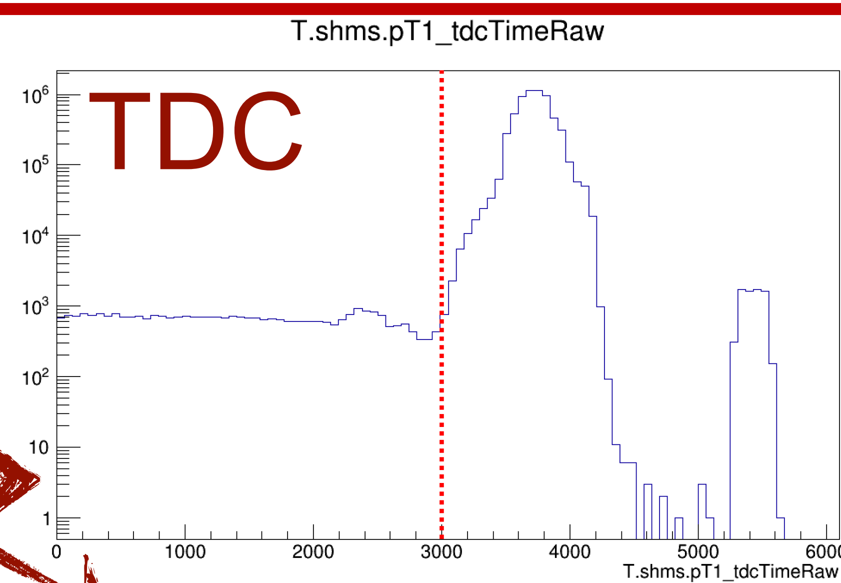


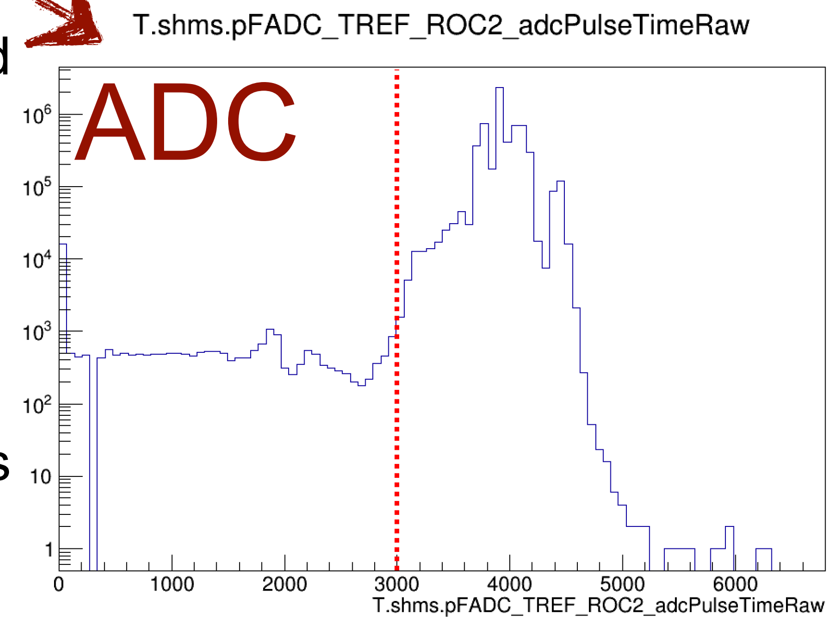




Reference Time Selection

- Prior to any meaningful analysis being conducted, proper reference time selection cuts must be determined and incorporated into the replay
- Reference time selection is dependent on the first TDC/FADC hit in the window which is greater than the associated cut
  - `X_t(a)dcrefcut`
- If no hit is found, then the first hit relative to the beginning of the window will be selected
- TDC cuts are required for both drift chambers and hodoscopes
- ADC cuts are required for all detectors except for the drift chambers
- Which reference time is being utilized for each detector is visible in the detector maps

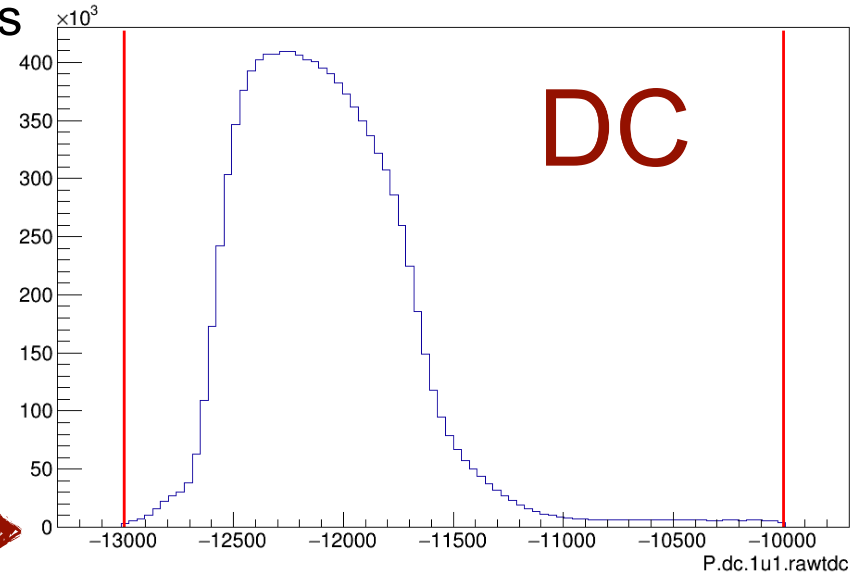




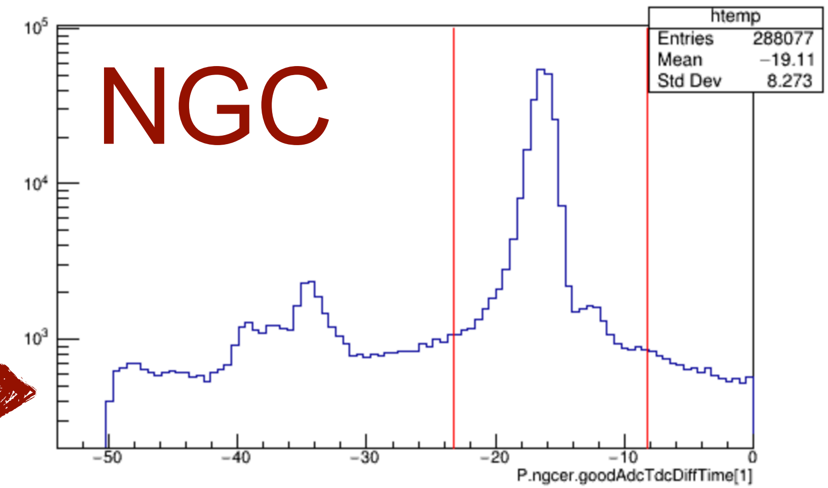
[Simona's Detailed Talk]

TDC & FADC Time Window Cuts

- Prior to interpreting any higher order physics related quantities, both TDC & ADC timing windows must be determined and configured into the replay
- TDC window limits for both the drift chambers and hodoscopes must be set appropriately
  - **Xscin_tdc_min(max)**
  - **Xdc_tdc_min(max)_win**



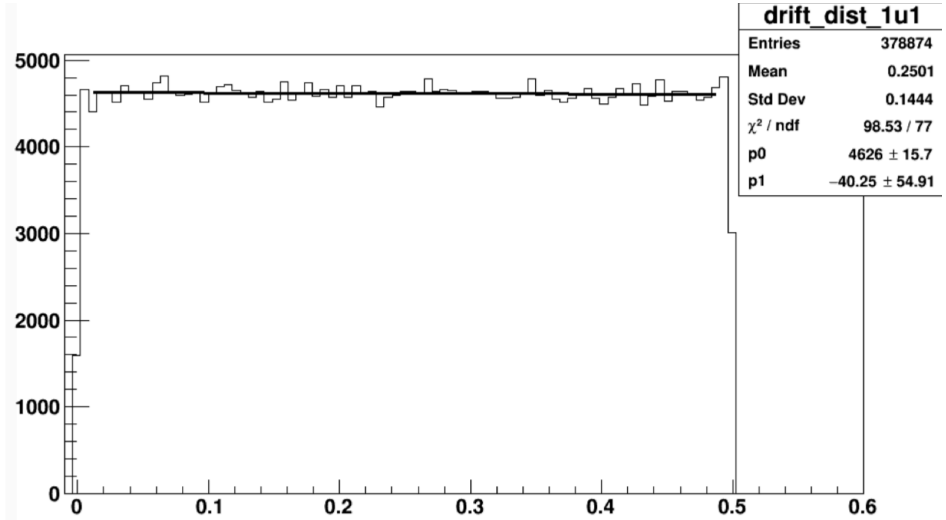
- ADC window limits for each PMT in the stack must be set appropriately so that the analyzer can determine 'good' hits which are utilized in determining physics quantities
  - 'goodAdcTdcDiffTime' variables
  - $t_{pulse} - t_{ref} - t_{start}$
  - **X_adcTimeWindowMin(Max)**

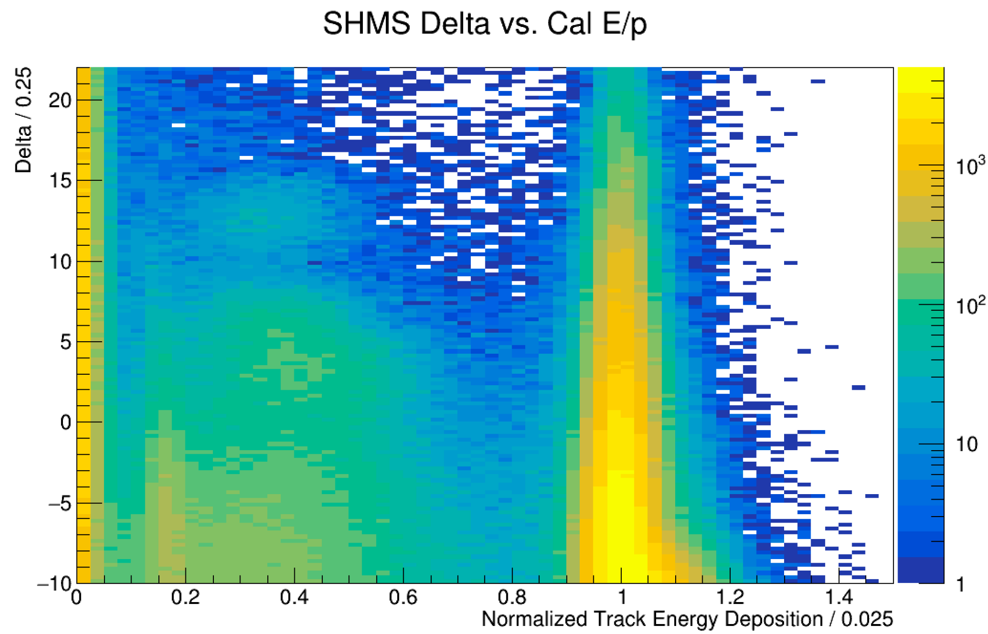


Simona's Detailed Talk

Detector Calibrations

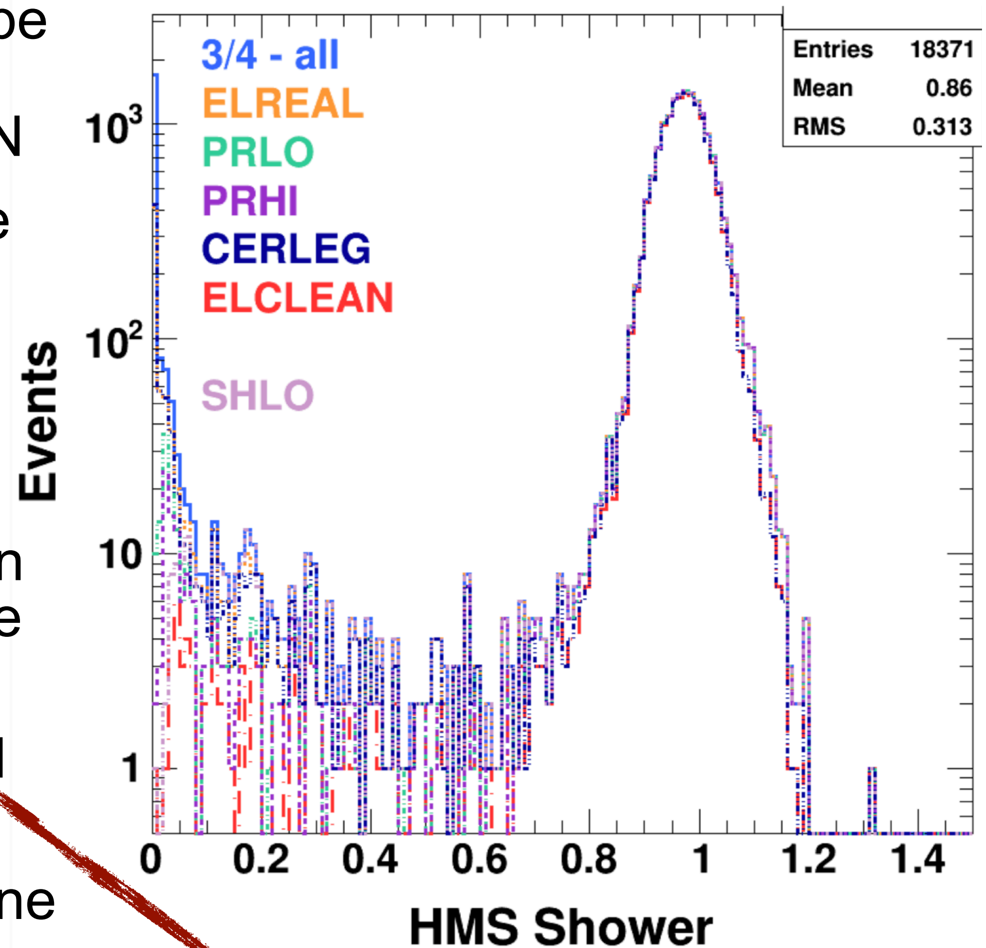
- With the all of the appropriate reference time selection cuts and timing cuts in place, detector calibrations are required
- The hodoscope and Cherenkov detectors do not require new calibrations unless the HV settings have been modified
- The calorimeter and drift chambers will most likely require a new calibration
  - These calibrations are dependent on the kinematic settings
- The calorimeter calibration is required for properly determining the trigger PID thresholds





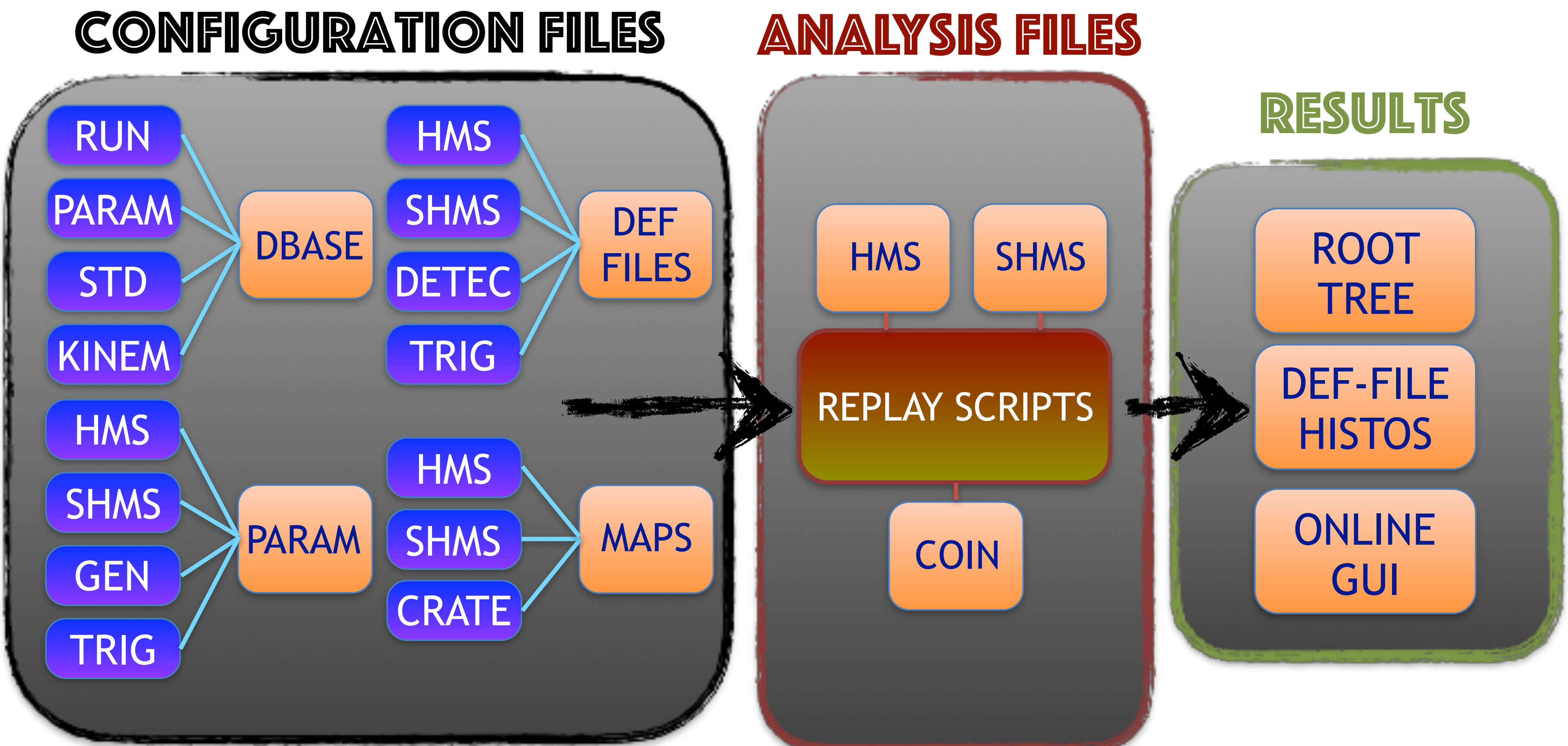
Setting Trigger PID Thresholds

- Setting the hardware thresholds for the various trigger PID legs must be done prior to utilizing the PID triggers i.e. EL-REAL & EL-CLEAN
- Determining the thresholds can be done in a variety of ways
- The current 'online' method:
  - Take 3/4 runs in both spectrometers and check the electron efficiency and the pion rejection by placing cuts on the TDC PID legs
  - Take one run with low pi/e and one run with high pi/e
- An 'offline' method can also be done utilizing the FADC's



Simona's Detailed Talk

Hall C Replay: Current Design



Current Workflow for Online Analysis

- Each run group maintains their own replay repository and workflow
  - Copy of the pre-existing hallc-replay repository
  - Copy of previous run groups replay
  - Custom replay set-up
- The replay repository lives on the cdaq cluster and is run on cdaql1
  - e.g. `/home/cdaq/hallc-online/hallc_replay_jpsi`
- It is highly recommended that changes in the repo be committed and pushed often (minimum once per day)
  - Every user is 'cdaq' and '`rm -rf *`' will happen again!
- The shell command '`go_analysis`' will put the user in the appropriate replay directory and setup the associated environment variables for the experiment currently on the floor
  - The analyzer is actively maintained in hallc-online/hcana
  - This too could be run group specific if there is a need

Current Workflow for Online Analysis

- The current 50k replay and online monitoring is actively maintained by Hall-C staff
- The histograms that are displayed via the online GUI are critical to ensuring that the detectors and track reconstruction are functioning nominally
- The 50k replay infrastructure (analysis scripts & DEF-files) and online GUI is maintained in the hallc-replay repository
  - The current structure to the hallc-replay repo will likely change in the near future
- Changes to the current 50k replay and/or online monitoring histograms are subject to the hallc-replay gate keepers
  - Monitoring histograms are able to be added but not removed unless discussed
- Online monitoring is posted to the web automagically
  - Hall-C Live Page

Online GUI

```
newpage 4 2 logz
title SHMS Hodoscope Pedestals
phodo_1x_good_pped_vs_pmt_pos -nostat
phodo_1y_good_pped_vs_pmt_pos -nostat
phodo_2x_good_pped_vs_pmt_pos -nostat
phodo_2y_good_pped_vs_pmt_pos -nostat
phodo_1x_good_pped_vs_pmt_neg -nostat
phodo_1y_good_pped_vs_pmt_neg -nostat
phodo_2x_good_pped_vs_pmt_neg -nostat
phodo_2y_good_pped_vs_pmt_neg -nostat
```

- The online GUI is a useful tool that interacts nicely with the hallc-replay infrastructure
- Plots the histograms defined in the DEF-files that are filled via the analyzer on an event by event basis
- Executes macros that interact with the ROOT file data

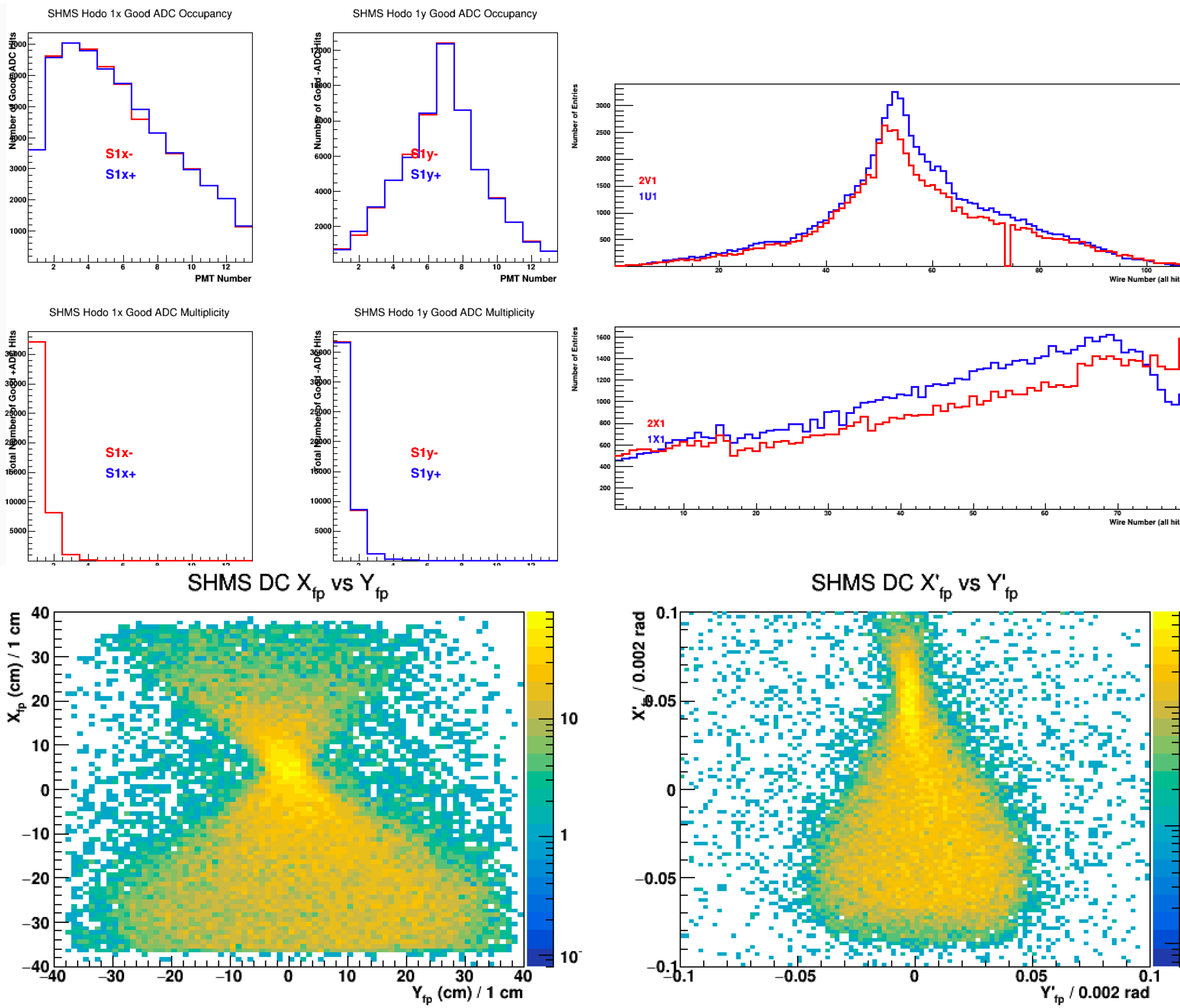
```
newpage 4 2
title SHMS Hodoscope Pedestal Monitoring
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_1x","p",1)' -nostat
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_1y","p",1)' -nostat
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_2x","p",1)' -nostat
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_2y","p",1)' -nostat
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_1x","p",2)' -nostat
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_1y","p",2)' -nostat
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_2x","p",2)' -nostat
macro 'UTIL/GEN/ped_tracking.C("../ROOTfiles/shms_coin_replay_production_golden.root","hodo_2y","p",2)' -nostat
```

```
newpage 2 3
title SHMS Drift Chamber Wire Maps (all hits)
macro UTIL/GEN/overlay2.C("pdc1u1_rawwirenum","pdc2v1_rawwirenum","1U1","2V1")
macro UTIL/GEN/overlay2.C("pdc1u2_rawwirenum","pdc2v2_rawwirenum","1U2","2V2")
macro UTIL/GEN/overlay2.C("pdc1x1_rawwirenum","pdc2x1_rawwirenum","1X1","2X1")
macro UTIL/GEN/overlay2.C("pdc1x2_rawwirenum","pdc2x2_rawwirenum","1X2","2X2")
macro UTIL/GEN/overlay2.C("pdc1v1_rawwirenum","pdc2u1_rawwirenum","1V1","2U1")
macro UTIL/GEN/overlay2.C("pdc1v2_rawwirenum","pdc2u2_rawwirenum","1V2","2U2")
```

- Can be utilized in the online scaler/full replays in order to display information of interest
- 'How-To' PDF

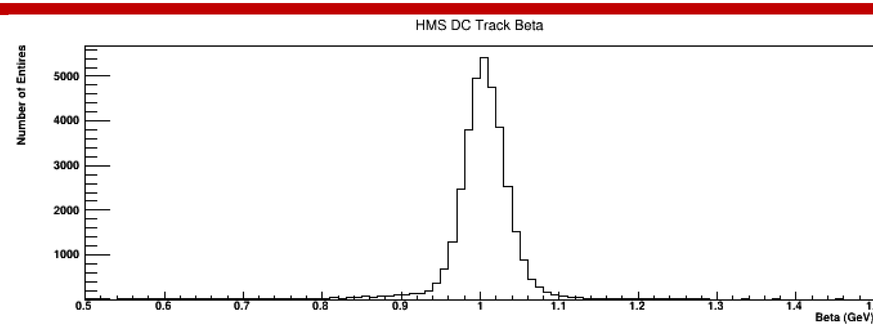
50k Replay Online Monitoring

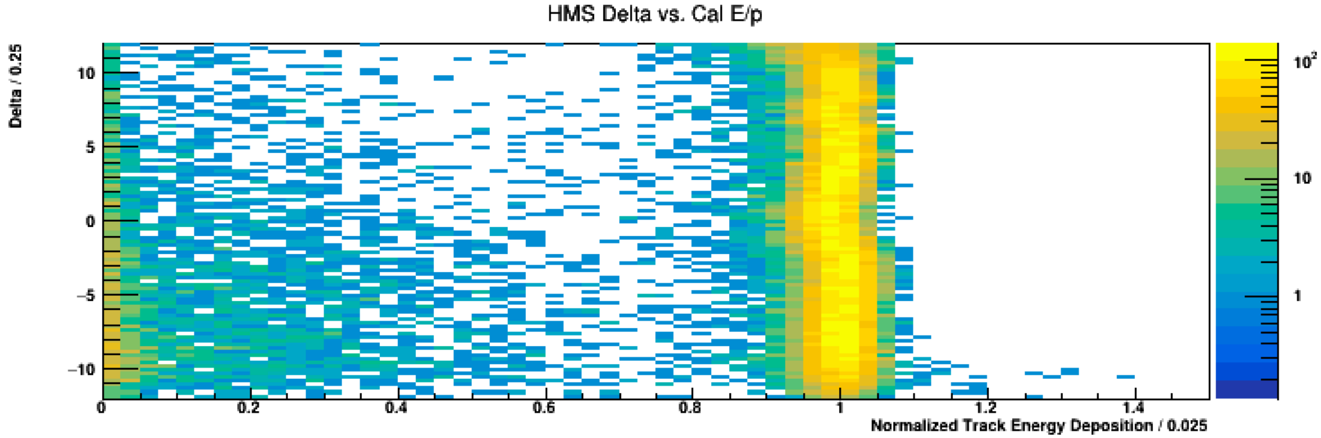
- SHMS Hodoscope ADC Occ/Mult
- SHMS Hodoscope TDC Occ/Mult
- SHMS Hodoscope Pedestals
- SHMS Hodoscope Pedestal Monitoring
- SHMS Drift Chamber Wire Maps (all hits)
- SHMS Drift Chamber Wire Maps
- SHMS Drift Chamber Drift Distance
- SHMS Drift Chamber Drift Time
- SHMS Drift Chamber 1 Efficiency
- SHMS Drift Chamber 2 Efficiency
- SHMS Focal Plane
- SHMS Target Quantites
- SHMS Cherenkov Occ/Mult
- SHMS Cherenkov Pedestals
- SHMS Cherenkov Pedestal Monitoring
- SHMS Cherenkov NPE
- SHMS Calorimeter Occ/Mult
- SHMS Calorimeter Pedestals
- SHMS Pre-Shower Pedestal Monitoring
- SHMS Calorimeter Pedestal Monitoring
- SHMS Drift Chamber Reference Times
- SHMS Trigger Reference Times
- SHMS Fast Raster
- SHMS EPICS BPM
- SHMS Kinematics
- SHMS PID
- SHMS Trigger Pedestal Tracking

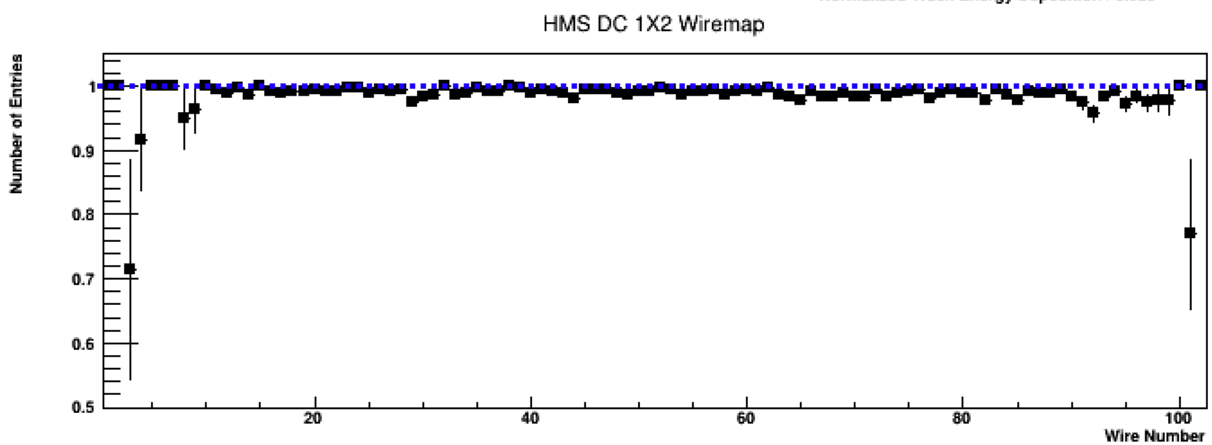


50k Replay Online Monitoring

- HMS Hodoscope ADC Occ/Mult
- HMS Hodoscope TDC Occ/Mult
- HMS Hodoscope Pedestals
- HMS Hodoscope Pedestal Monitoring
- HMS Drift Chamber Wire Maps (all hits)
- HMS Drift Chamber Wire Maps
- HMS Drift Chamber Drift Distance
- HMS Drift Chamber Drift Time
- HMS Drift Chamber 1 Efficiency
- HMS Drift Chamber 2 Efficiency
- HMS Focal Plane
- HMS Target Quantities
- HMS Cherenkov Occu/Mult/Ped
- HMS Cherenkov Pedestal Monitoring
- HMS Cherenkov NPE
- HMS Calorimeter Occupancy
- HMS Calorimeter Multiplicity
- HMS Calorimeter Pedestals
- HMS Calorimeter Pedestal Monitoring
- HMS Drift Chamber Reference Times
- HMS Trigger Reference Times
- HMS Fast Raster
- HMS EPICS BPM
- HMS Kinematics
- HMS PID
- ROC3 Sync Check
- HMS Trigger Pedestal Tracking

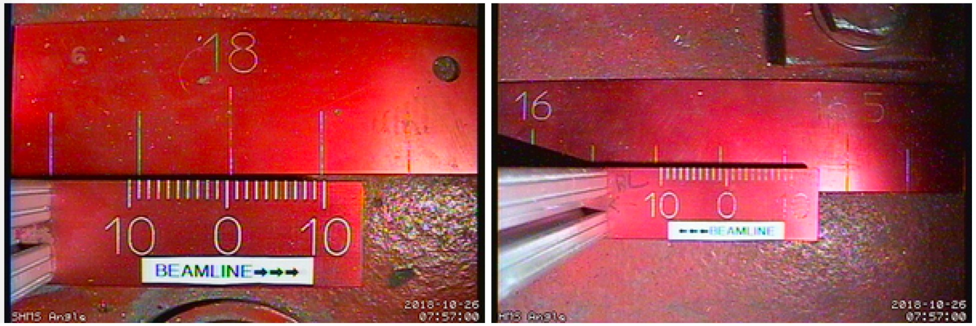






Tools for Online Analysis

- Various tools that facilitate online operations live in the UTIL_OL repository
- Script to extract the angle camera photos for each run
- Script to monitor total accumulated charge in live time
- Script to parse relevant report file data to display to shift crew
- Shell scripts that handle the 50k replay utilized for detector checkout
    - 'run_(s)hms.sh'
    - 'run_coin_(s)hms.sh'




```
Total Time =       0.61 min, Beam on time =    0.60613 min , Total Charge =    2.02345 mC
SHMS T1 rate kHz =  126.57847 , HMS T3 Rate kHz =    8.82208
COIN T5 Rate Hz =  176.89456, COIN Acc Rate Hz =   89.33482
Total Time =       0.67 min, Beam on time =    0.67330 min , Total Charge =    2.24886 mC
SHMS T1 rate kHz =  127.10865 , HMS T3 Rate kHz =    8.80986
COIN T5 Rate Hz =  167.46890, COIN Acc Rate Hz =   89.58472
```

```
=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:

50k COIN SHMS Report File Summary

=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:

Run # :  5466
BCM1 Beam Cut Current :  47.536 uA
BCM2 Beam Cut Current :  47.621 uA
BCM4A Beam Cut Current :  48.303 uA
BCM4B Beam Cut Current :  48.030 uA
BCM4C Beam Cut Current :  48.140 uA
DAQ Pre-Scale Setting SHMS 3/4 : -1
DAQ Pre-Scale Setting SHMS EL-REAL : -1
DAQ Pre-Scale Setting HMS EL-REAL : -1
DAQ Pre-Scale Setting HMS 3/4 : -1
DAQ Pre-Scale Setting HMS EL-REAL x SHMS 3/4 : -1
DAQ Pre-Scale Setting SHMS 3/4 x HMS 3/4 : 1
SHMS TRIG5 Computer Live Time  :  99.9451 % [ -99.9451 %  ]
SING FID TRACK EFFIC             :    0.9358 +-    0.0020
E SING FID TRACK EFFIC           :    0.9503 +-    0.0054
HADRON SING FID TRACK EFFIC      :    0.9376 +-    0.0021
Plane 1 :  0.994473
Plane 2 :  0.995751
Plane 3 :  0.982744
Plane 4 :  0.933330
3_of_4 EFF  :  0.998032
```

Current Workflow for Online Analysis

- Once the 50k detector checkout analysis has concluded, further online analysis is entirely up to the run group
- Previous groups have conducted full replays of each run by analyzing both scaler replays (fast) and physics analyses (slow)
  - Scaler replays for things like accumulated charge, dead time calculations, etc.
  - Physics replays for 'bean counting' and kinematic checks (t vs. ϕ)
- Files corresponding to these analyses MUST live on the RAID disk under an experiment specific directory
  - e.g. `/net/cdaq/cdaql1data/cdaq/jpsizzle/`
- Directories containing analysis files should symlink to common prefix which points to experiment specific location on the RAID disk
  - `OUTPUT -> net/cdaq/cdaql1data/cdaq/jpsizzle/`
  - `ROOTfiles -> OUTPUT/ROOTfiles/`
  - `HISTOGRAMS -> OUTPUT/HISOGRAMS/`

Hall-C Counting House Systems

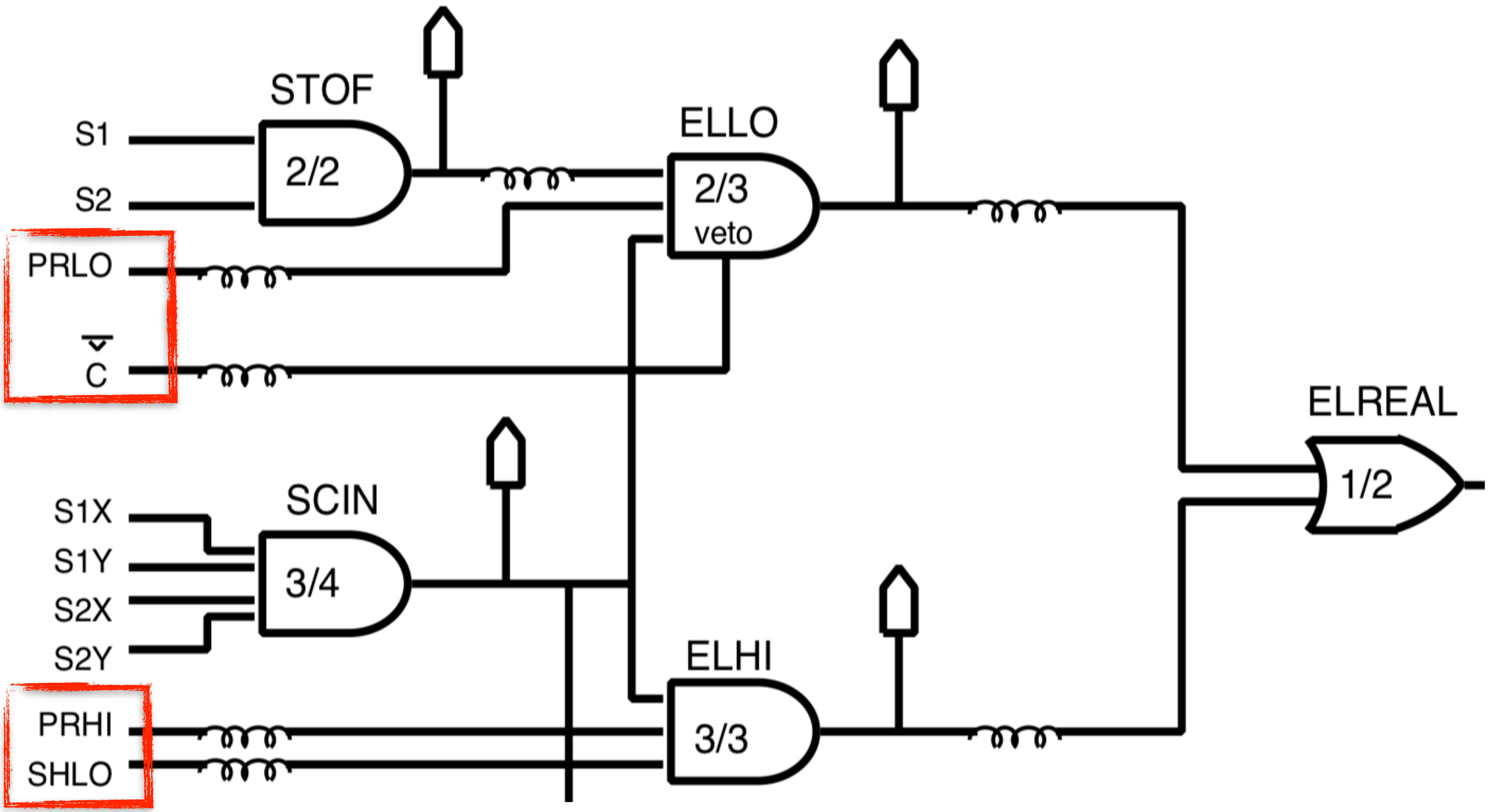
- Individual users can/should create (and work in) their own workspace on cdaql1 e.g. `/home/cdaq/user`
  - Quick replays and sanity checks can be performed here
- All common file systems on the farm are mounted on the cdaq cluster
  - `/site, /apps, /mss, /cache, /work, /group, …`
- Large files (CODA, ROOT, etc.) should not be written to `/home`
  - When shared file systems fill, many things break!
  - Analysis not critical to daily operations should be conducted on the farm
- Backups on the cdaq cluster are automagically conducted each day
- Everything on the cdaq files system (`/home`) are backed up daily at 2300 hrs
  - Identical copy of files system is made
  - No history is saved hence why subversion control via git is so important
- `/home/cdaq/hallc-online/` is backed up in its entirety with time stamps 12 hours out pf phase with the file system backup
  - 7 days of history is saved however large files are omitted

Hall C Winter Collaboration Meeting

Questions?

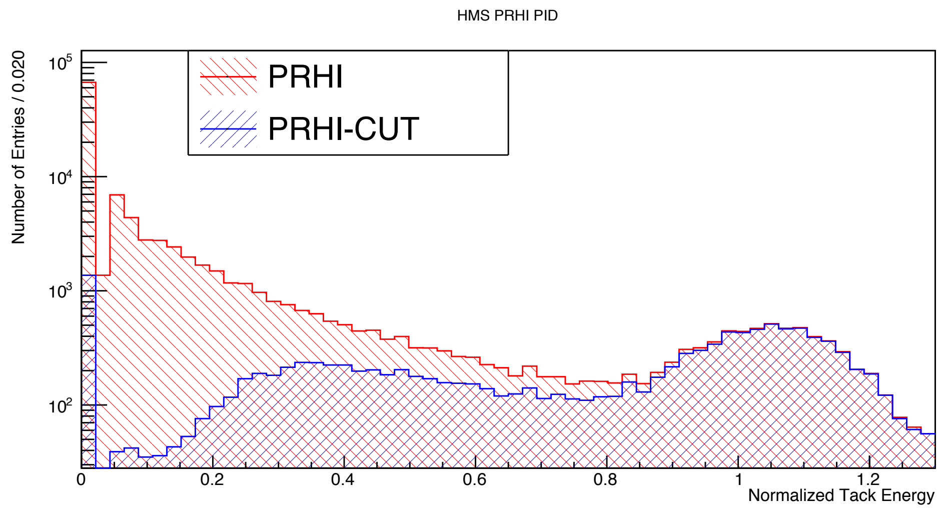
Backup Slides

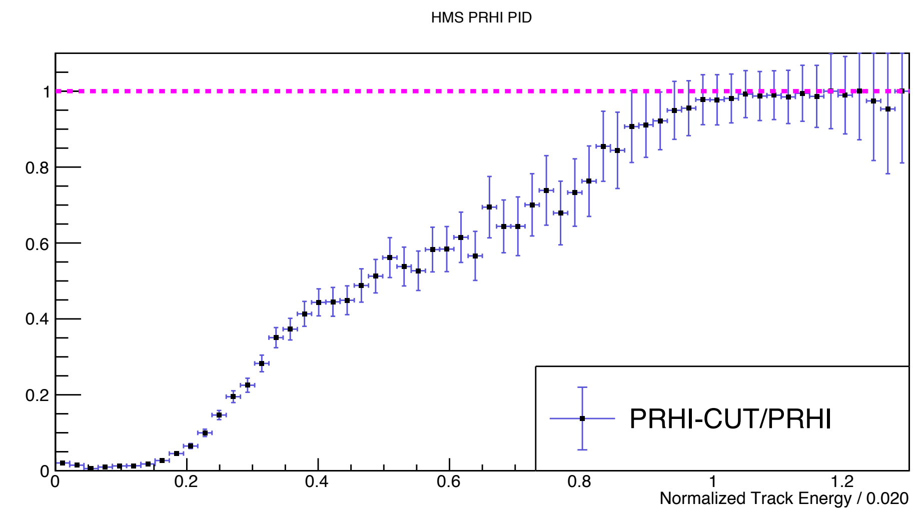
Setting Trigger PID Thresholds



Setting Trigger PID Thresholds

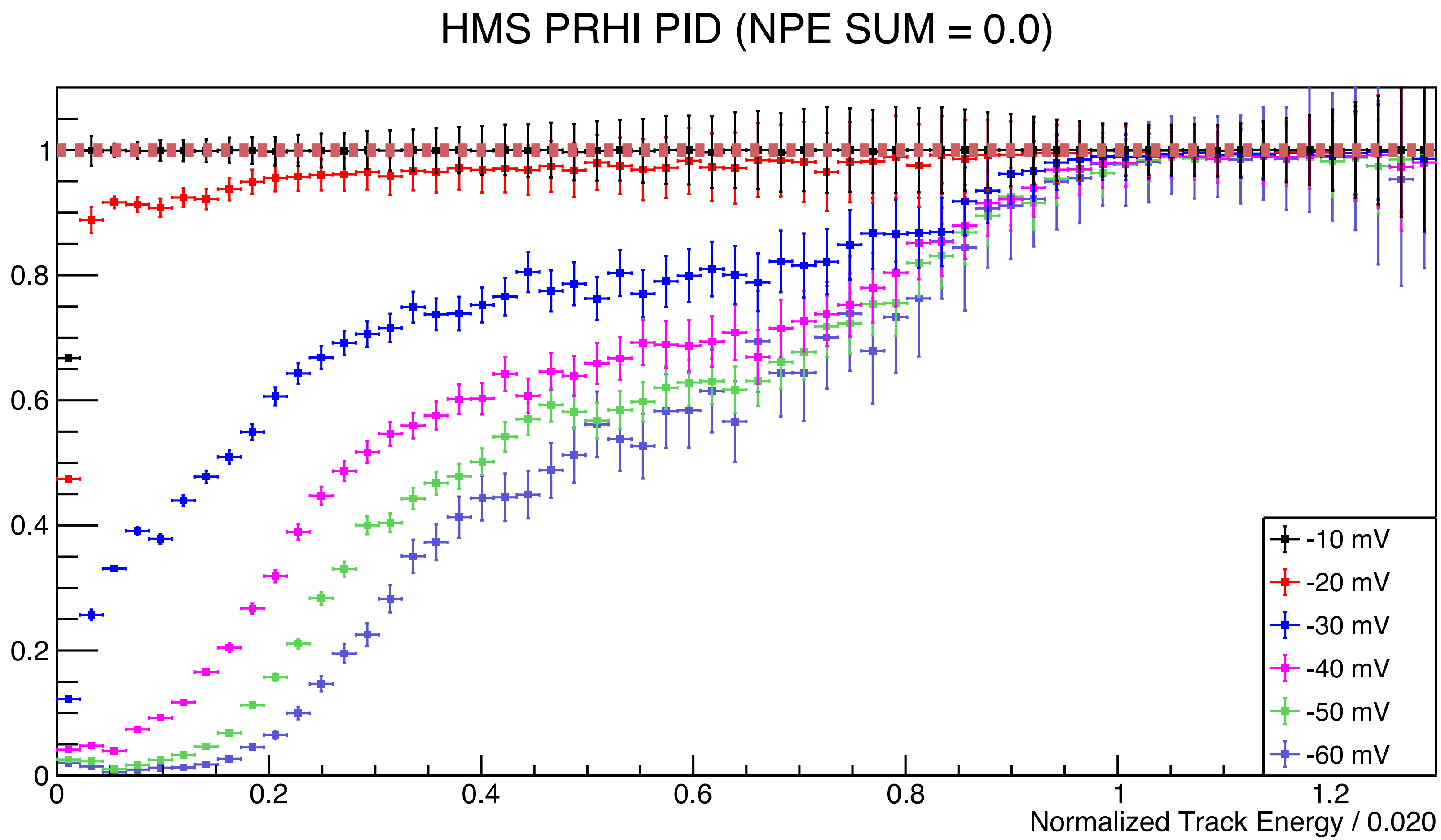
- All trigger PID components reside in scalers, TDC's, and FADC's (where appropriate)
- One can study off-line the effects of imposing hardware discriminator threshold cuts via software cuts
- Consider an example for HMS:
  - E/P in calorimeter
  - Select pions via Cherenkov
  - Cut on PRHI TDC channel
  - Calculate ratio to determine appropriate threshold for pion suppression





Setting Trigger PID Thresholds

- Perform hardware threshold scan of PRHI leg



Setting Trigger PID Thresholds

- Perform software threshold scan of PRHI leg