R-SIDIS Analysis

February 10, 2025

Topics:
1. Analyzer output
2. root tree variables
3. Report file output
4. Normalized yields

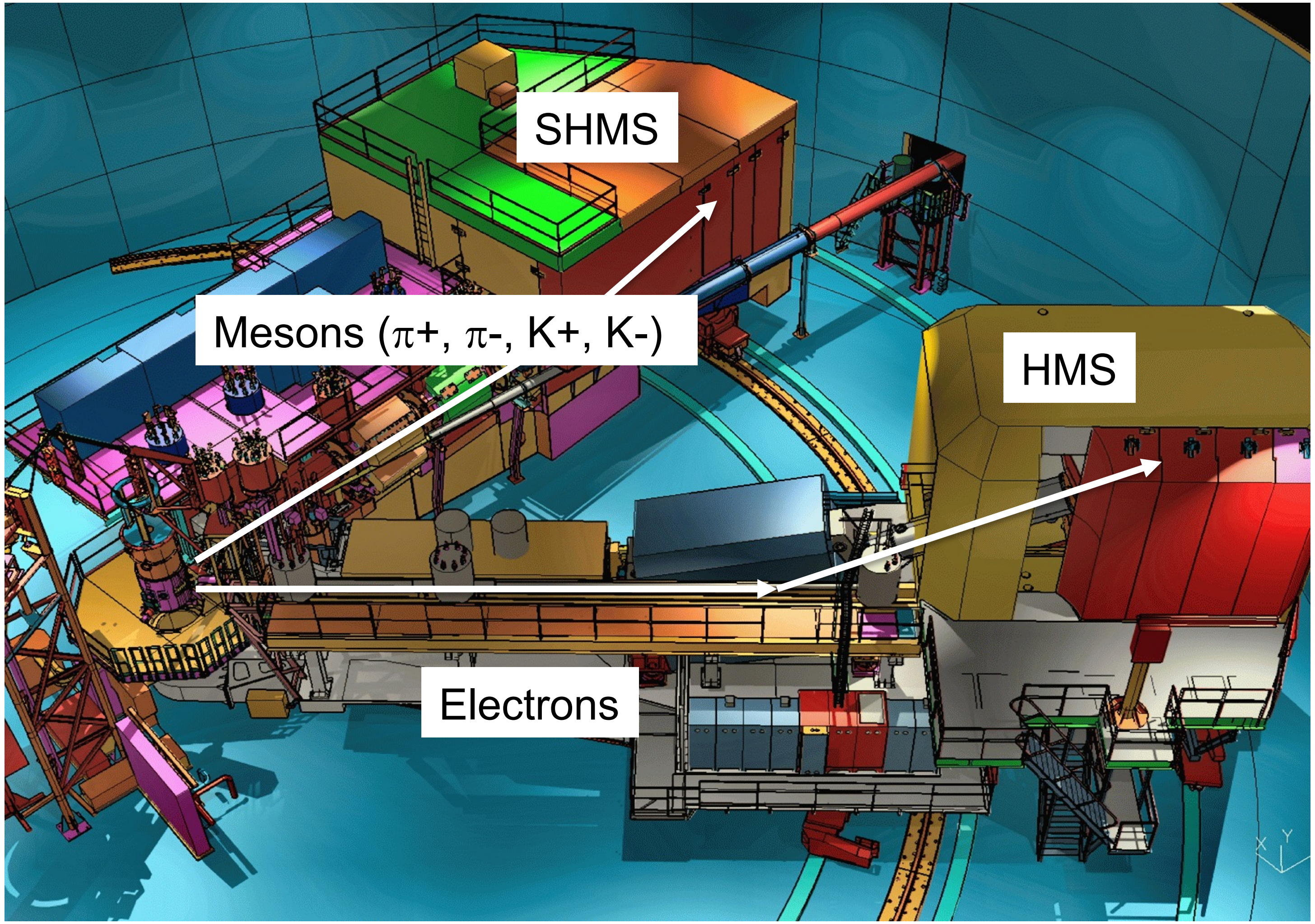
Analysis Flow

- Experiment data stored in CODA file
- Analyzer – "hcana"
  - Based on Hall A PODD analyzer → root/C++ based
- "replay" → collection of scripts and parameter files that use hcana to generate output
  - Convert ADC/TDC signals to calibrated signal sizes and times we can use
  - Make tracks from drift chambers
  - Calculate physics quantities
- Output stored in form of root trees and report files (text)
  - 3 root trees: tracks/ADC/TDC signals, scalers, epics signals
  - Report files include efficiencies, total charge, etc.

SIDIS Configuration

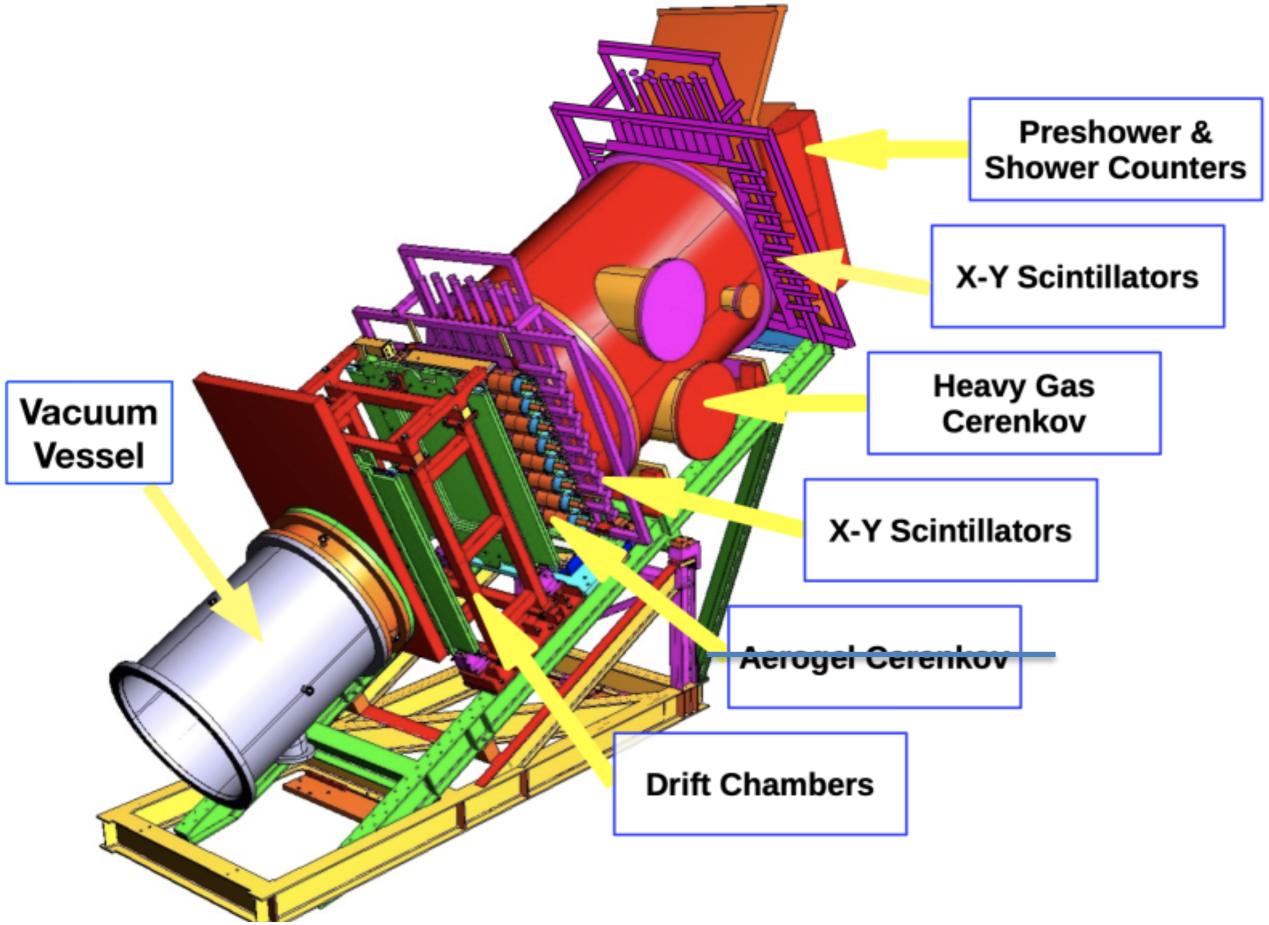
HMS: electron ID, π- rejection

SHMS: *π:K:p* separation via heavy gas and aerogel Cherenkov detectors



HMS (electron) detectors and variables

All the HMS quantities in root tree start with “H”



Tracks (at focal plane):

H.dc.x_fp
H.dc.y_fp ← x/y position at focal plane (cm)
H.dc.xp_fp
H.dc.yp_fp ← dx/dz, dy/dz at focal plane

Focal Plane to Target

Tracks in spectrometer hut used to calculate information at target

$$\begin{pmatrix} \delta \\ x'_{tar} \\ y'_{tar} \\ y_{tar} \end{pmatrix} = \begin{pmatrix} M_{11} & M_{12} & M_{13} & M_{14} \\ M_{21} & M_{22} & M_{23} & M_{24} \\ M_{31} & M_{32} & M_{33} & M_{34} \\ M_{41} & M_{42} & M_{43} & M_{44} \end{pmatrix} \begin{pmatrix} x_{fp} \\ y_{fp} \\ x'_{fp} \\ y'_{fp} \end{pmatrix}$$

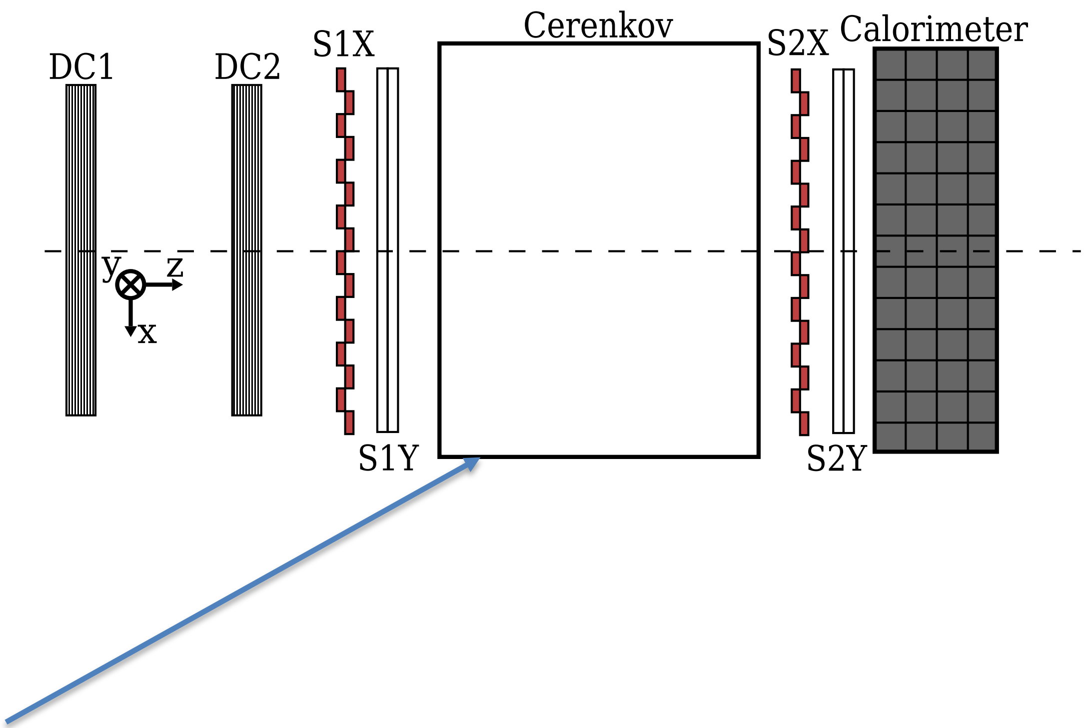
Matrix fit from special optics data

gtr="golden track"

H.gtr.dp = δ = 100*(P_{track} – P_0)/P_0 (in %)
H.gtr.th = x'_{tar} = dx/dz at target
H.gtr.ph = y'_{tar} = dy/dz at target
H.gtr.y = y_{tar} = y at target (in cm)

HMS PID - Cherenkov

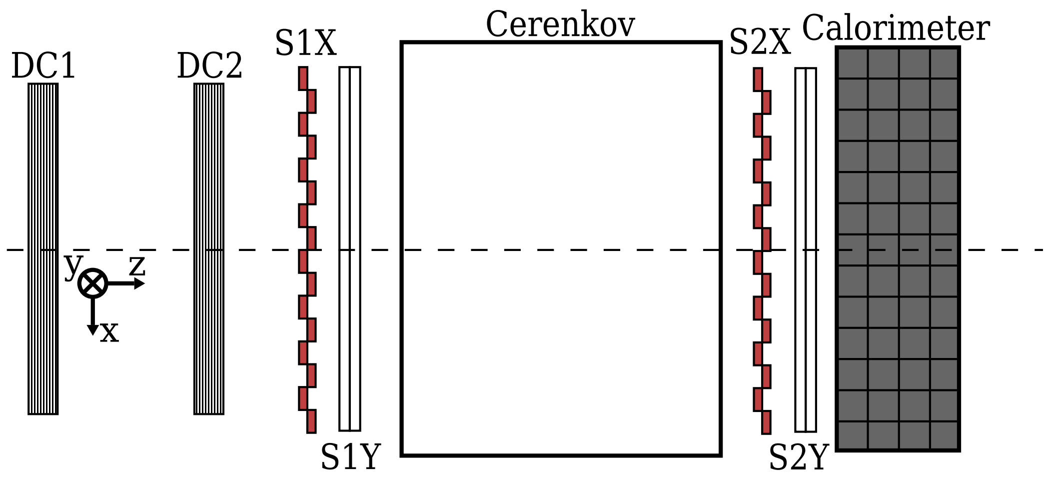
HMS always used for electrons (in this case)
→ Use PID detectors to reject pions/select electrons



HMS Cherenkov detector → H.cer.npeSum → NPE sum over 2 PMTs
For 2018 SIDIS running, used 0.45 atm of C_4F_8O → pion threshold = 4.0 GeV

Typical cut for electrons is H.cer.npeSum>1 or 2

HMS PID - Calorimeter



HMS calorimeter has several signals

→ H.cal.etottracknorm = (total energy deposited in calorimeter for given event)/P_{track} ← Most commonly used

→ H.cal.etracknorm = (total energy deposited associated with track)/P_{track}

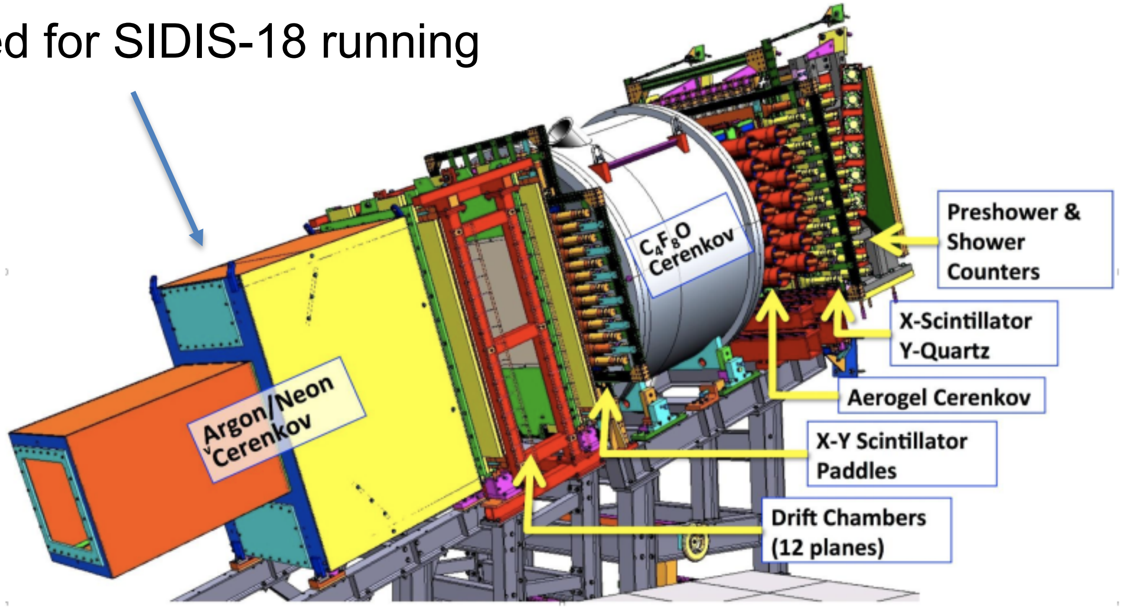
→ H.cal.etotnorm = (total energy deposited in calorimeter for given event)/P_0

H.cal.etotracknorm should be ~ 1.0 for electrons. Typical cut >0.7 or 0.8

SHMS PID – rejecting electrons

Not installed for SIDIS-18 running

For π- SIDIS, need to reject electrons in SHMS
→ Can use similar detectors in SHMS with .not.(electron cuts) → usually tweak to optimize pion efficiency



P.cal.etottracknorm<0.8

P.cal.hgcer.npeSum<1 → for the SIDIS-18 running, the pressure in the HGC was ~1 atm, so pion threshold only 2.7 GeV. Could not use for P>2.7 GeV. Mostly relied on calorimeter for electron rejection

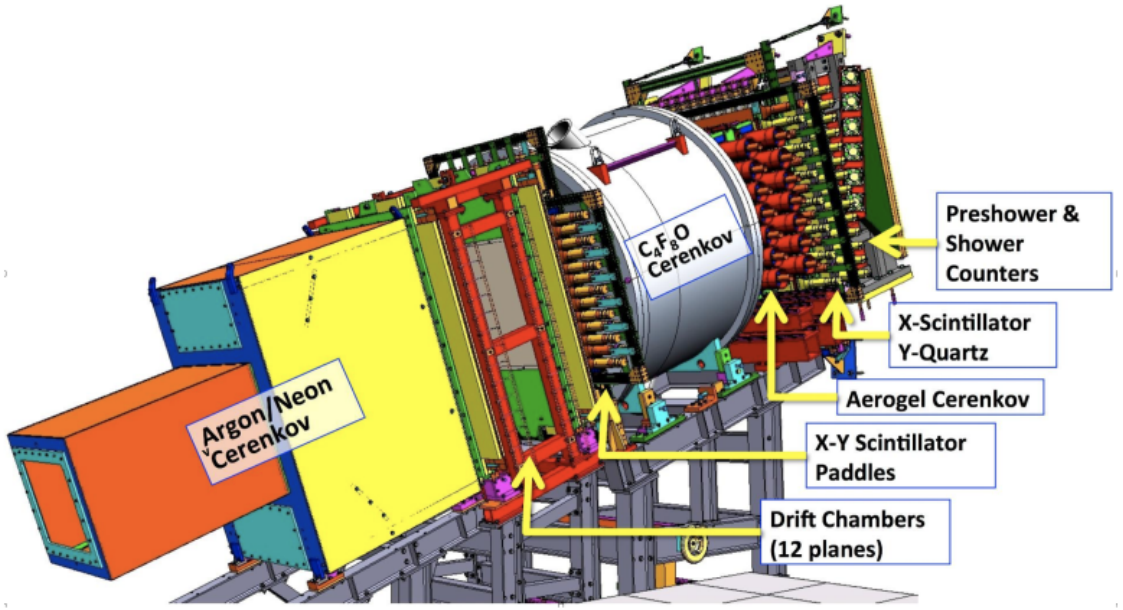
If **NGC** had been present during SIDIS-18, could have use P.ngcer.npeSum cut to reject electrons as well
→ Will be installed for R-SIDIS

SHMS PID – selecting pions

Pion selection in SHMS momentum dependent – uses combination of HGC and aerogel

HGC: C_4F_8O at 1atm (n=1.00135)
→ Pion threshold = 2.7 GeV
→ Kaon threshold = 9.5 GeV
→ Proton threshold = 18 GeV
→ Can be used to separate pions from kaons and protons for all P>2.7 GeV

Aerogel: n=1.015
→ Pion threshold = 0.8 GeV
→ Kaon threshold = 2.84 GeV
→ Proton threshold = 5.4 GeV
→ Can be used to separate pions from kaons for P<2.84 GeV



Typical cuts:
P.hgc.npeSum>1-2 for P>2.7 GeV
P.aero.npeSum>4 for all P

Coincidence Time and Subtracting Randoms

"coincidence time" is difference in arrival time of electron and pion in HMS and SHMS → measured using time from scintillator planes + some corrections due to differing pathlength in the spectrometers

→ RF time structure of beam readily apparent (250 MHz, Δt=4 ns in this case)
→ Real coincidence peak still includes contributions from random coincidences
→ Use random peaks to get measure of contribution under real peak

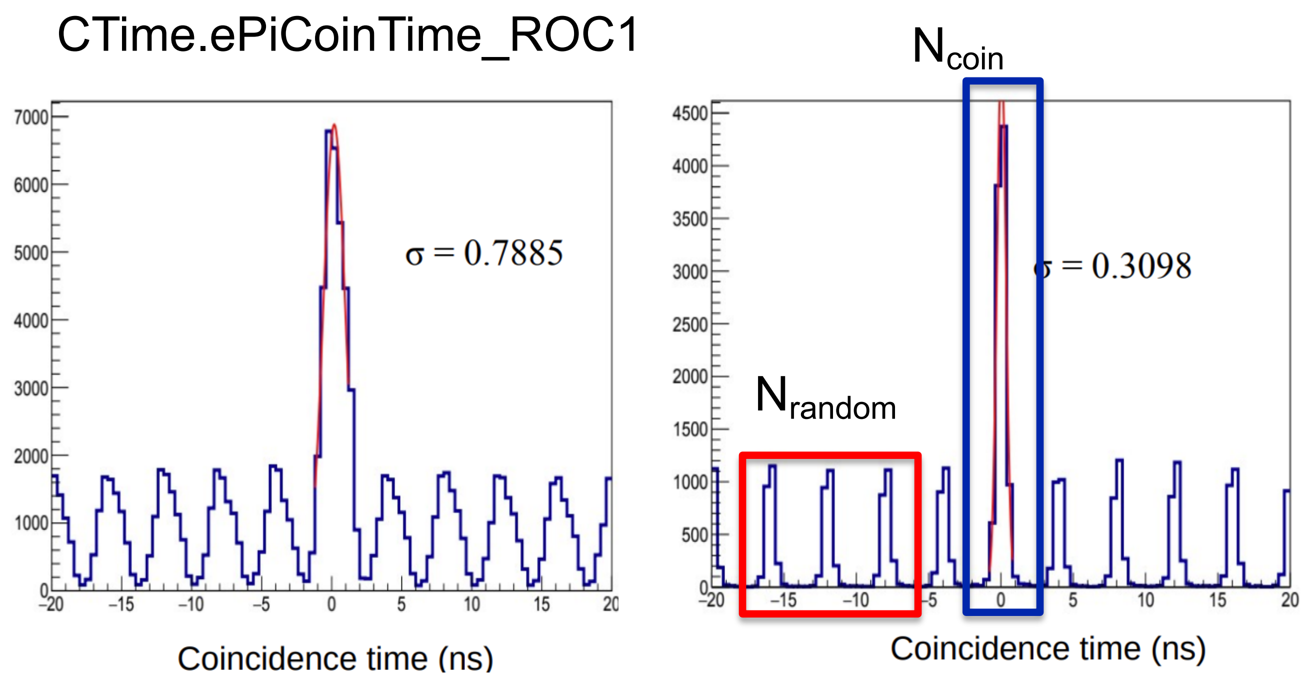


Figure 3.9: The coincidence time spectrum of electron-pion (π^-) coincidences showing the main peak and accidental coincidences for the 2018 fall run period (left) and 2019 spring run period (right) after all the event selection cuts are applied. The resolution of the coincidence time was much better in the spring run period (~ 0.31 ns) than in the fall run period (~ 0.79 ns).

Hem Bhatt's thesis

$$N_{random\text{-}subtracted} = N_{coin} - N_{random}/3$$

Normalization

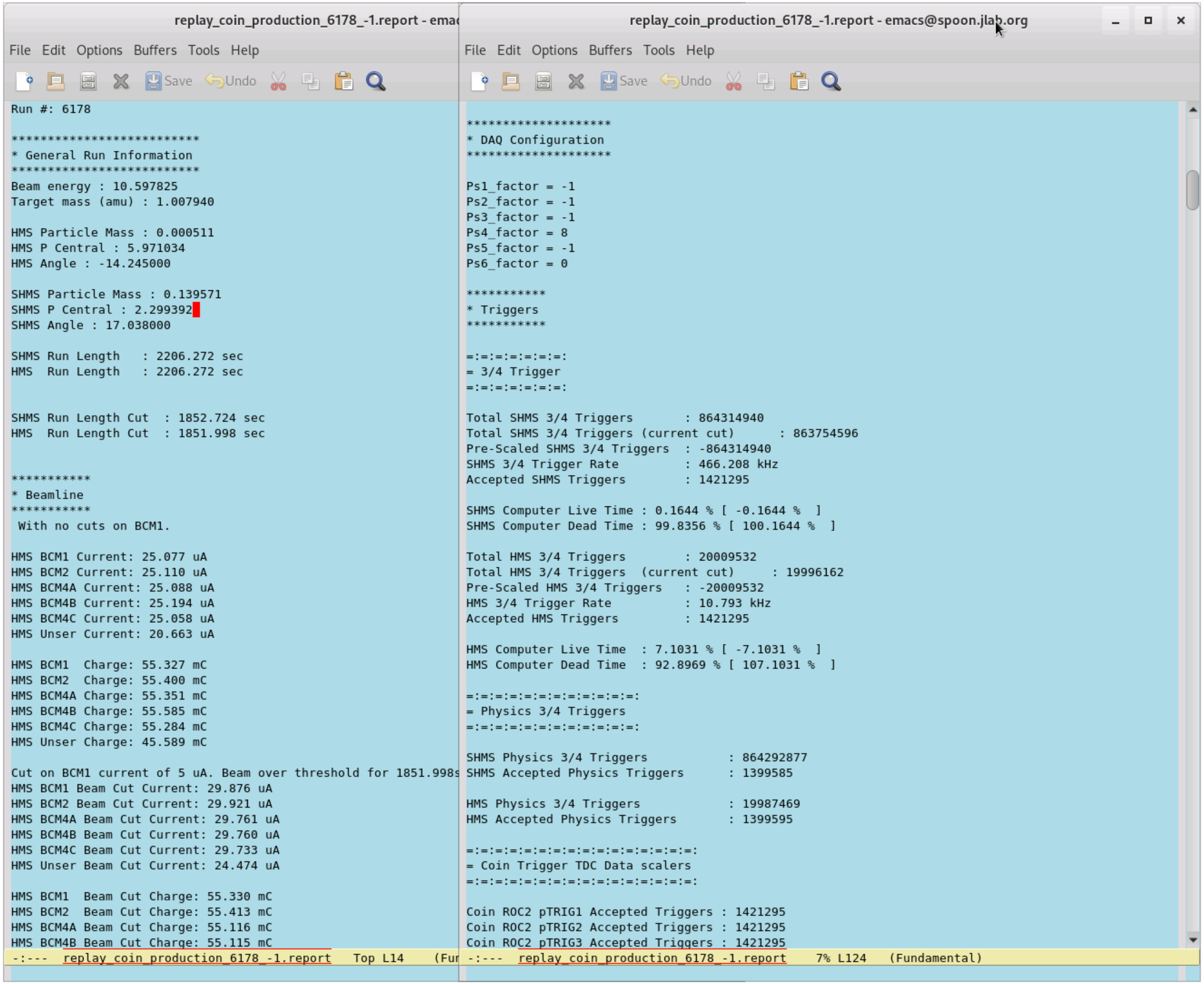
Most quantities needed to get normalized yield can be found in the report files:

→ Charge from your favorite beam current monitor

→ Tracking efficiencies for HMS and SHMS

→ Computer dead time (electronic dead time?)

→ To first order, trigger efficiencies are close to 1.0, so we'll ignore them for now



replay_coin_production_6178_-1.report - emac

File Edit Options Buffers Tools Help

```
Run #: 6178

**************************
* General Run Information
**************************
Beam energy : 10.597825
Target mass (amu) : 1.007940

HMS Particle Mass : 0.000511
HMS P Central : 5.971034
HMS Angle : -14.245000

SHMS Particle Mass : 0.139571
SHMS P Central : 2.299392
SHMS Angle : 17.038000

SHMS Run Length   : 2206.272 sec
HMS  Run Length   : 2206.272 sec


SHMS Run Length Cut  : 1852.724 sec
HMS  Run Length Cut  : 1851.998 sec


***********
* Beamline
***********
 With no cuts on BCM1.

HMS BCM1 Current: 25.077 uA
HMS BCM2 Current: 25.110 uA
HMS BCM4A Current: 25.088 uA
HMS BCM4B Current: 25.194 uA
HMS BCM4C Current: 25.058 uA
HMS Unser Current: 20.663 uA

HMS BCM1  Charge: 55.327 mC
HMS BCM2  Charge: 55.400 mC
HMS BCM4A Charge: 55.351 mC
HMS BCM4B Charge: 55.585 mC
HMS BCM4C Charge: 55.284 mC
HMS Unser Charge: 45.589 mC

Cut on BCM1 current of 5 uA. Beam over threshold for 1851.998s
HMS BCM1 Beam Cut Current: 29.876 uA
HMS BCM2 Beam Cut Current: 29.921 uA
HMS BCM4A Beam Cut Current: 29.761 uA
HMS BCM4B Beam Cut Current: 29.760 uA
HMS BCM4C Beam Cut Current: 29.733 uA
HMS Unser Beam Cut Current: 24.474 uA

HMS BCM1  Beam Cut Charge: 55.330 mC
HMS BCM2  Beam Cut Charge: 55.413 mC
HMS BCM4A Beam Cut Charge: 55.116 mC
HMS BCM4B Beam Cut Charge: 55.115 mC
-:---  replay_coin_production_6178_-1.report   Top L14   (Fur
```

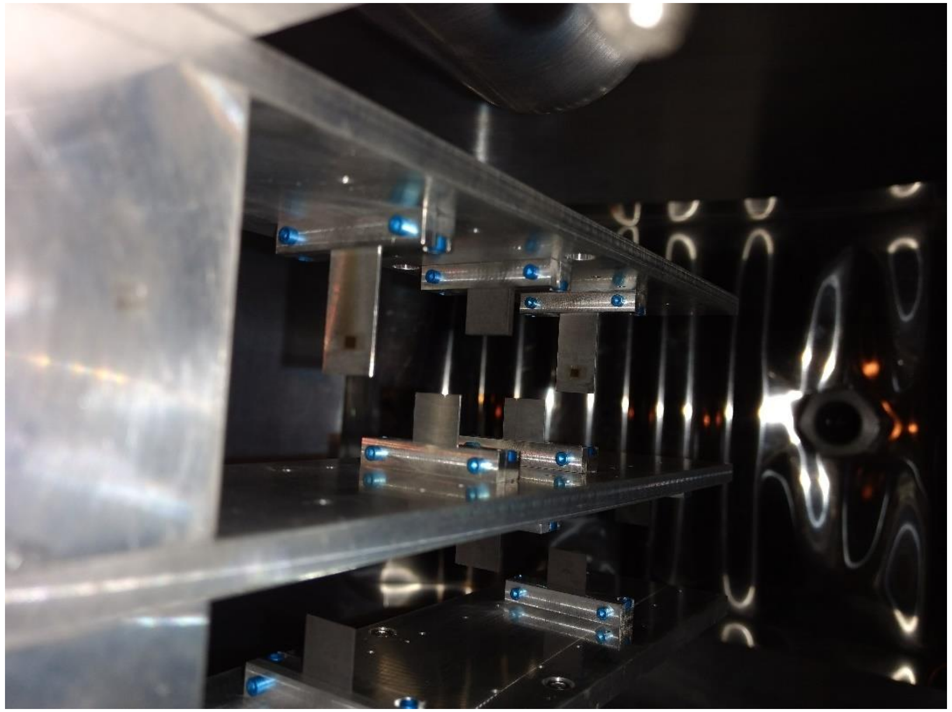
replay_coin_production_6178_-1.report - emacs@spoon.jlab.org

File Edit Options Buffers Tools Help

```
********************
* DAQ Configuration
********************

Ps1_factor = -1
Ps2_factor = -1
Ps3_factor = -1
Ps4_factor = 8
Ps5_factor = -1
Ps6_factor = 0

***********
* Triggers
***********

=:=:=:=:=:=:
= 3/4 Trigger
=:=:=:=:=:=:

Total SHMS 3/4 Triggers       : 864314940
Total SHMS 3/4 Triggers (current cut)      : 863754596
Pre-Scaled SHMS 3/4 Triggers  : -864314940
SHMS 3/4 Trigger Rate         : 466.208 kHz
Accepted SHMS Triggers        : 1421295

SHMS Computer Live Time : 0.1644 % [ -0.1644 %  ]
SHMS Computer Dead Time : 99.8356 % [ 100.1644 %  ]

Total HMS 3/4 Triggers        : 20009532
Total HMS 3/4 Triggers  (current cut)     : 19996162
Pre-Scaled HMS 3/4 Triggers   : -20009532
HMS 3/4 Trigger Rate          : 10.793 kHz
Accepted HMS Triggers         : 1421295

HMS Computer Live Time  : 7.1031 % [ -7.1031 %  ]
HMS Computer Dead Time  : 92.8969 % [ 107.1031 %  ]

=:=:=:=:=:=:=:=:=:=:=:
= Physics 3/4 Triggers
=:=:=:=:=:=:=:=:=:=:=:

SHMS Physics 3/4 Triggers          : 864292877
SHMS Accepted Physics Triggers     : 1399585

HMS Physics 3/4 Triggers           : 19987469
HMS Accepted Physics Triggers      : 1399595

=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:
= Coin Trigger TDC Data scalers
=:=:=:=:=:=:=:=:=:=:=:=:=:=:=:

Coin ROC2 pTRIG1 Accepted Triggers : 1421295
Coin ROC2 pTRIG2 Accepted Triggers : 1421295
Coin ROC2 pTRIG3 Accepted Triggers : 1421295
-:---  replay_coin_production_6178_-1.report   7% L124   (Fundamental)
```

Subtraction of contribution from cell walls

Special aluminum dummy target on target ladder to mimic contribution from LH2 target cell walls
→ Thicker than cell walls to reduce data-taking time, have similar radiative effects as LH2
→ For SIDIS-18, dummy target was **3.82** times thicker than cell walls



Stuff to work on

- Number of coincidences in real peak for pi+
  - Number of random-subtracted coincidences
- Number of coincidences in real peak for pi-
  - Number of random-subtracted coincidences
- ***Predict number of triggers required to get 100,000 good coincidence events for each of the above***
- Calculate charge-normalized (efficiency corrected) random-subtracted yield for each case
- Add subtraction of contribution from cell walls
- Make scripts that can do this