HMS Target Boiling Studies

Carlos Yero

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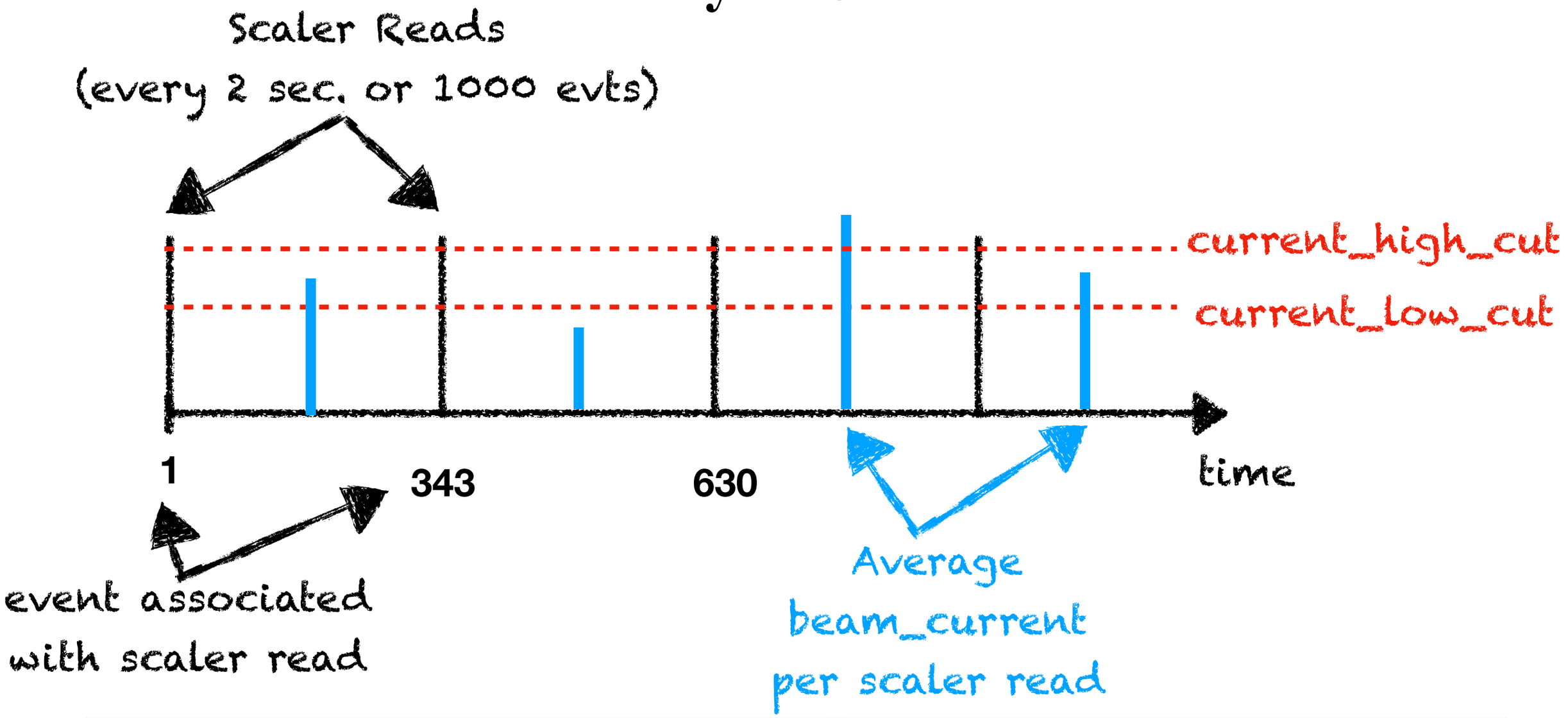
HMS (Singles Mode DAQ)
Angle: 25 deg
Momentum: -4.4 GeV (electrons)
Trigger: HMS EL-REAL (htrig2)

Target Boiling Studies Data Set: Taken on April 02, 2018

Run	Target	Beam Current [uA]
2093	Carbon	60
2094	Carbon	50
2095	Carbon	35
2075	LH2	80
2076	LH2	70
2078	LH2	10
2080	LH2	10
2081	LH2	20
2082	LH2	35
2083	LH2	35
2084	LH2	45
2085	LH2	55
2073	LD2	80
2074	LD2	70
2087	LD2	55
2088	LD2	45
2089	LD2	35
2090	LD2	20
2091	LD2	10

Analysis Outline

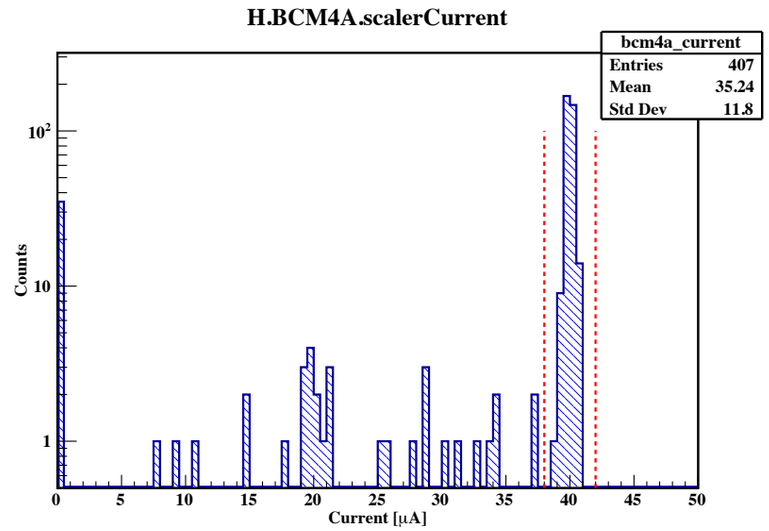


- Loop over each scaler read and require a current cut to count scalers ONLY when beam current is within cut.

- Loop over data events, and associate the event with the scaler current cut to count accepted events ONLY when beam current is within cut.

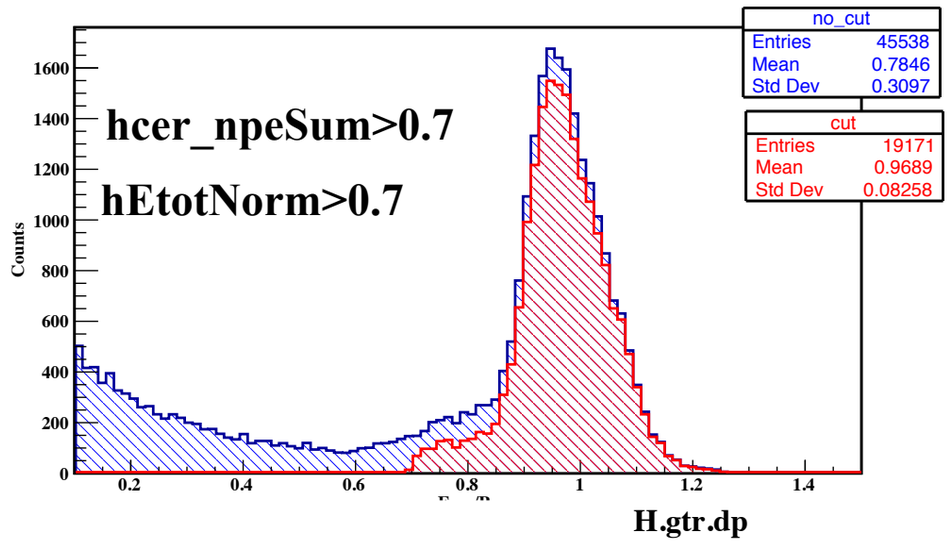
Analysis Outline: Calculating Charge Normalized Yields

$$Y_{scaler} = \frac{N_{scaler}}{Q_{tot}}$$

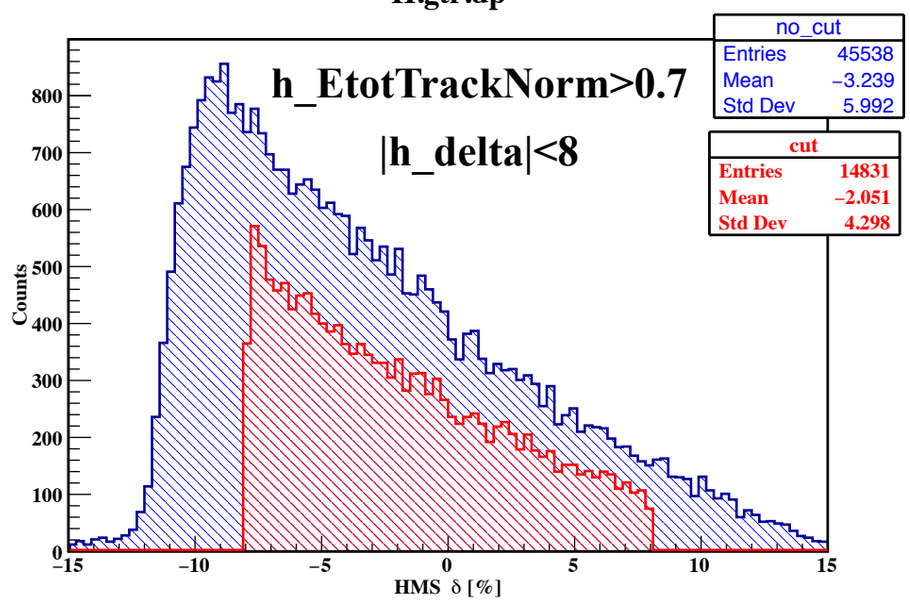


N_{scaler} →HMS trigger scaler counter **ONLY** if BCM scaler current cut passed

$$Y_{no\_track} = \frac{N_{accepted}}{Q_{tot} * \epsilon_{cpuLT}}$$



$$Y_{track} = \frac{N_{accepted}}{Q_{tot} * \epsilon_{cpuLT} * \epsilon_{trk}}$$



$N_{accepted}$ →Integrated Histograms **ONLY** if BCM scaler current cut passed

Analysis Outline: Calculating Charge Normalized Yield

Code Snippet: Scaler Reads Loop

```
239       //Check If BCM4A Beam Current in Between Reads is Over Threshold
240       if(abs(Scal_BCM4A_current-set_current)<current_thrs_bcm4a)
241         {
242
243           //Turn Event Flag ON, if beam current is within threshold
244           evt_flag_bcm4a[i] = 1;
245
246           //Store Quantities that Passed the Current Threshold
247           total_time_bcm4a_cut = total_time_bcm4a_cut + (Scal_time - prev_time);
248           total_charge_bcm4a_cut = total_charge_bcm4a_cut + (Scal_BCM4A_charge - prev_charge_bcm4a);
249           total_hs1x_scaler_bcm4a_cut = total_hs1x_scaler_bcm4a_cut + (hS1X_scaler-prev_hs1x_scaler);
250           total_htrig1_scaler_bcm4a_cut = total_htrig1_scaler_bcm4a_cut + (hTRIG1_scaler-prev_htrig1_scaler);
251           total_htrig2_scaler_bcm4a_cut = total_htrig2_scaler_bcm4a_cut + (hTRIG2_scaler-prev_htrig2_scaler);
252           total_htrig3_scaler_bcm4a_cut = total_htrig3_scaler_bcm4a_cut + (hTRIG3_scaler-prev_htrig3_scaler);
253           total_hedtm_scaler_bcm4a_cut = total_hedtm_scaler_bcm4a_cut + (hEDTM_scaler - prev_hedtm_scaler);
254       }
```

Increment BCMs scalers
(if BCM current is within limits):
-> time
-> charge
-> trigger
-> edtm

Analysis Outline: Calculating Charge Normalized Yield

Code Snippet: Data Event Loop

```
419       //--------Check If BCM4A Current is within limits---------
420       if(evt_flag_bcm4a[scal_read]==1){
421
422
423         //Count Accepted EDTM events
424         if(c_edtm){
425           total_hedtm_accp_cut_4a++;
426         }
427
428         //Count Accepted hTRIG2 events (without EDTM)
429         if(c_htrig2&&c_noedtm){
430           total_htrig2_accp_cut_4a++;
431         }
432
433         if(c_noedtm) {
434
435           //Make Cuts to Count Yield
436           //---Get NON-TRACKING Yield
437         if(c_cerNpesum&&c_etotnorm)
438           {
439             H_hCAL_etotnorm_ntrkY_4a->Fill(hCAL_etotnorm);
440             Y_ntrk_4a++;
441
442           }
443
444         if(c_etottrknorm&&c_hdelta)
445           {
446             H_hDelta_trkY_4a->Fill(hDelta);
447             Y_trk_4a++;
448           }
449
450         //Calculate Electron Tracking Efficiency
451         if(good_elec_did){
452           e_did_4a++;
453         }
454         if(good_elec_should){
455           e_should_4a++;
456         }
457
458       } //end cut on NO EDTM
459
460
461     }
462     //-------------End BCM4A Current Cut----------------
```

Check if data event is within BCM current limits

Increment accepted htrig2 (used to calculate Scaler Yield)

Fill 'non-tracking' histogram (used to calculate non-tracking Yield)

Fill 'tracking' histogram (used to calculate tracking Yield)

Calculate electron tracking efficiency

Analysis Outline: Calculating Charge Normalized Yield

Code Snippet: Live Time, Tracking Efficiencies, Avg. Current, Normalized Yields

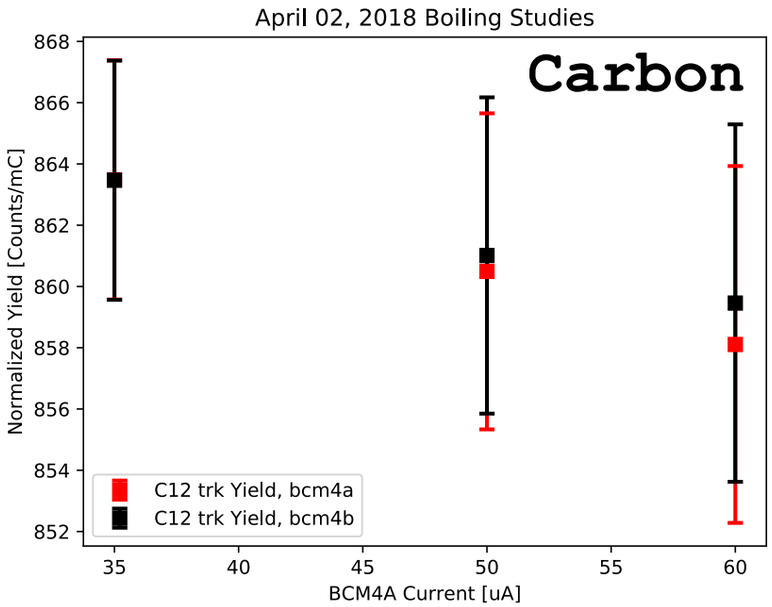
```
563     //Calculate  Live Time
564     //BCM4A
565     cpuLT_bcm4a =  total_htrig2_accp_cut_4a / (total_htrig2_scaler_bcm4a_cut-total_hedtm_scaler_bcm4a_cut);
566     tLT_bcm4a =  total_hedtm_accp_cut_4a / total_hedtm_scaler_bcm4a_cut;

571     //Calculate Tracking Efficiency
572     //BCM4A
573     eTrkEff_bcm4a = e_did_4a / e_should_4a;
574     eTrkEff_err_4a = sqrt(e_should_4a-e_did_4a) / e_should_4a;

579     //Avg Current
580     avg_current_bcm4a = total_charge_bcm4a_cut / total_time_bcm4a_cut; //uA
581     avg_current_bcm4b = total_charge_bcm4b_cut / total_time_bcm4b_cut; //uA
582
```

Relevant Formulas

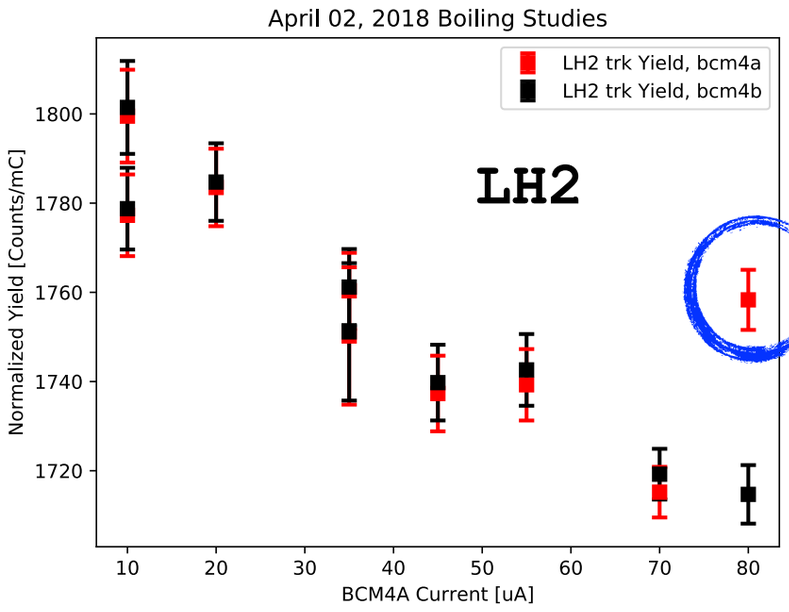
Yield Calculations

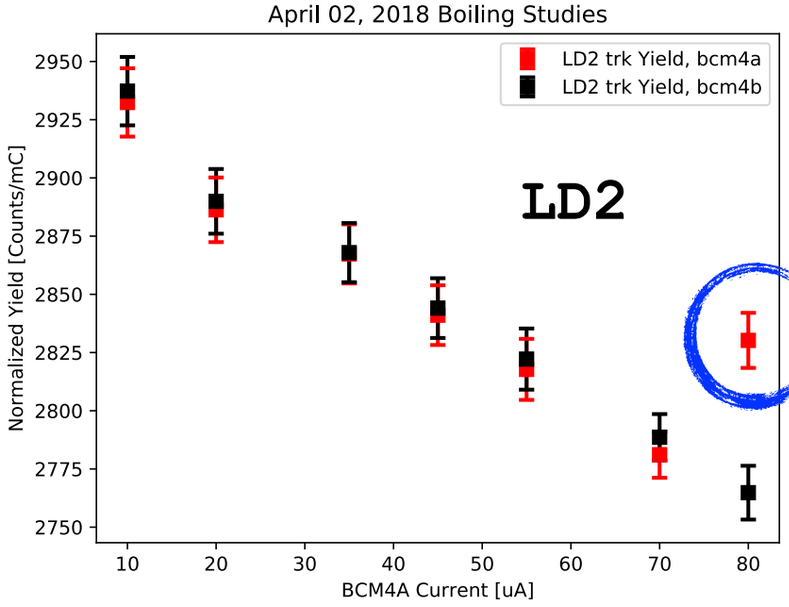
```
//-----SCALER YIELD-----
//BCM4A
scl_Yield_bcm4a = (total_htrig2_scaler_bcm4a_cut-total_hedtm_scaler_bcm4a_cut) / (total_charge_bcm4a_cut);
scl_err_bcm4a = sqrt(total_htrig2_scaler_bcm4a_cut) / total_charge_bcm4a_cut;
//BCM4B
scl_Yield_bcm4b = (total_htrig2_scaler_bcm4b_cut-total_hedtm_scaler_bcm4b_cut) / (total_charge_bcm4b_cut);
scl_err_bcm4b = sqrt(total_htrig2_scaler_bcm4b_cut) / total_charge_bcm4b_cut;


//-----NON-TRACKING Yield---
notrk_Yield = Y_ntrk_4a / (total_charge_bcm4a_cut*cpuLT_bcm4a);

//BCM4A
H_hCAL_etotnorm_ntrkY_4a->Scale(1./(total_charge_bcm4a_cut*cpuLT_bcm4a));
notrk_Yield_bcm4a = H_hCAL_etotnorm_ntrkY_4a->IntegralAndError(H_hCAL_etotnorm_ntrkY_4a->FindBin(0.6), H_hCAL_etotnorm_ntrkY_4a->FindBin(5.), notrk_err_bcm4a);
//BCM4B
H_hCAL_etotnorm_ntrkY_4b->Scale(1./(total_charge_bcm4b_cut*cpuLT_bcm4b));
notrk_Yield_bcm4b = H_hCAL_etotnorm_ntrkY_4b->IntegralAndError(H_hCAL_etotnorm_ntrkY_4b->FindBin(0.6), H_hCAL_etotnorm_ntrkY_4b->FindBin(5.), notrk_err_bcm4b);



//-----TRACKING Yield---
trk_Yield = Y_trk_4a / (total_charge_bcm4a_cut*cpuLT_bcm4a*eTrkEff_bcm4a);
//BCM4A
H_hDelta_trkY_4a->Scale(1./(total_charge_bcm4a_cut*cpuLT_bcm4a*eTrkEff_bcm4a));
trk_Yield_bcm4a = H_hDelta_trkY_4a->IntegralAndError(H_hDelta_trkY_4a->FindBin(-8.), H_hDelta_trkY_4a->FindBin(8.), trk_err_bcm4a);
//BCM4B
H_hDelta_trkY_4b->Scale(1./(total_charge_bcm4b_cut*cpuLT_bcm4b*eTrkEff_bcm4a));
trk_Yield_bcm4b = H_hDelta_trkY_4b->IntegralAndError(H_hDelta_trkY_4b->FindBin(-8.), H_hDelta_trkY_4b->FindBin(8.), trk_err_bcm4b);
```

Normalized Yields vs. Beam Current



Carbon shows 'flat' norm. Yields within uncertainty. This is used as a cross-check before looking at LH2 or LD2.



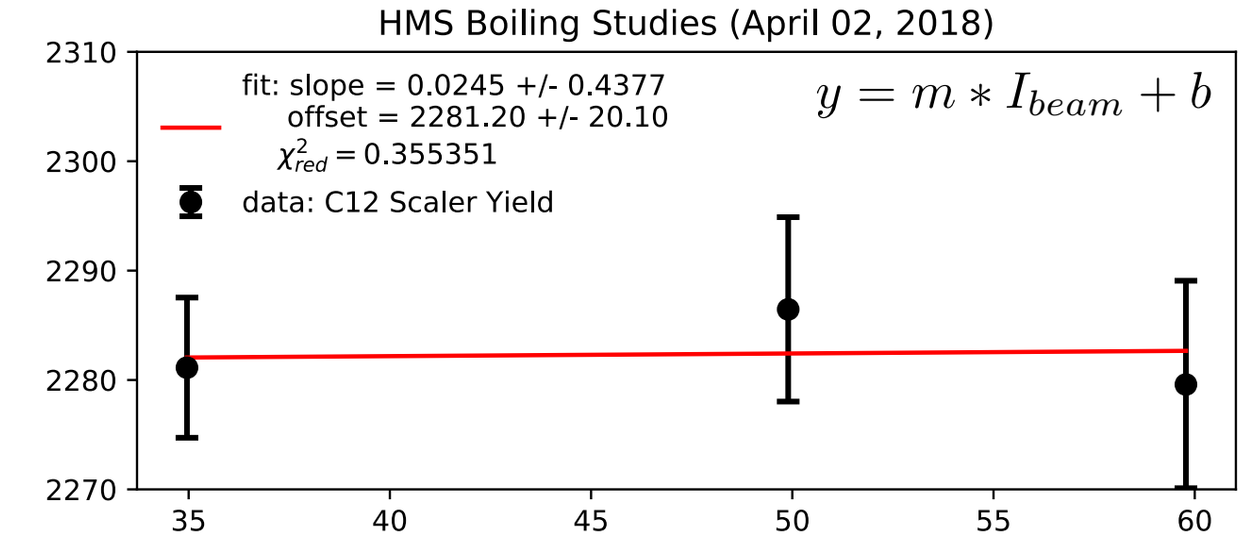


At high current (>75 uA), BCM4A shows signs of saturation.

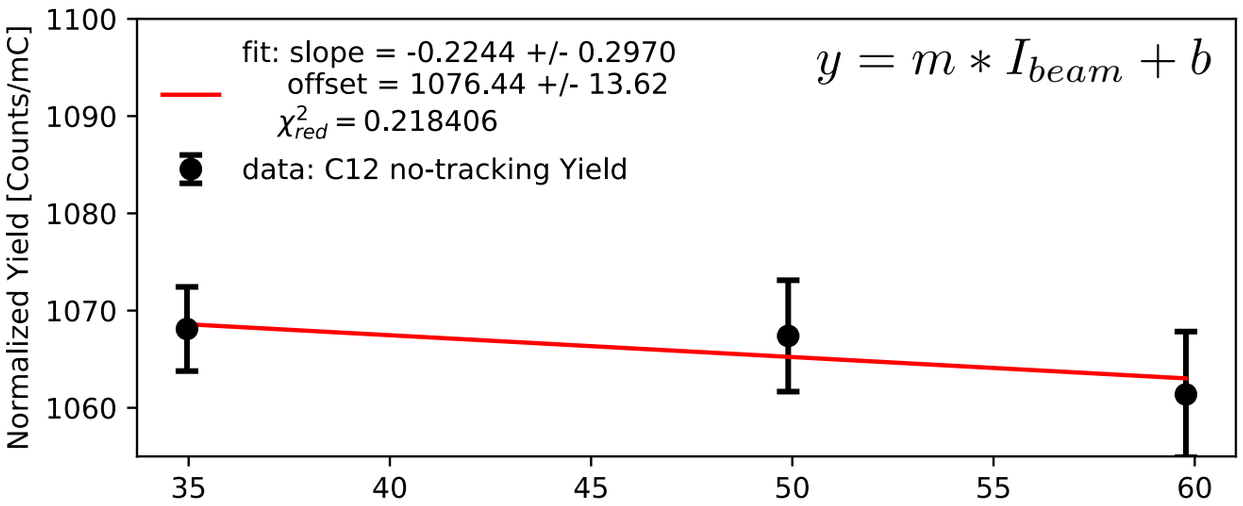
BCM4b was used in these studies.

[See Dave Mack, Deepak and Deb's Talk]

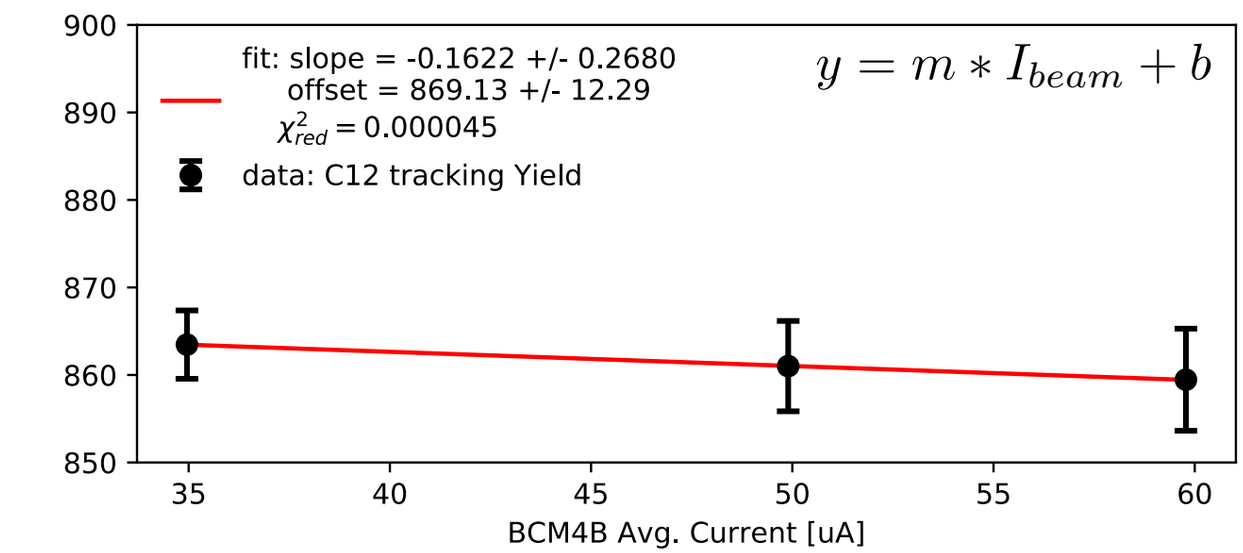
Carbon Normalized Yields vs. Beam Current



Scaler Yields

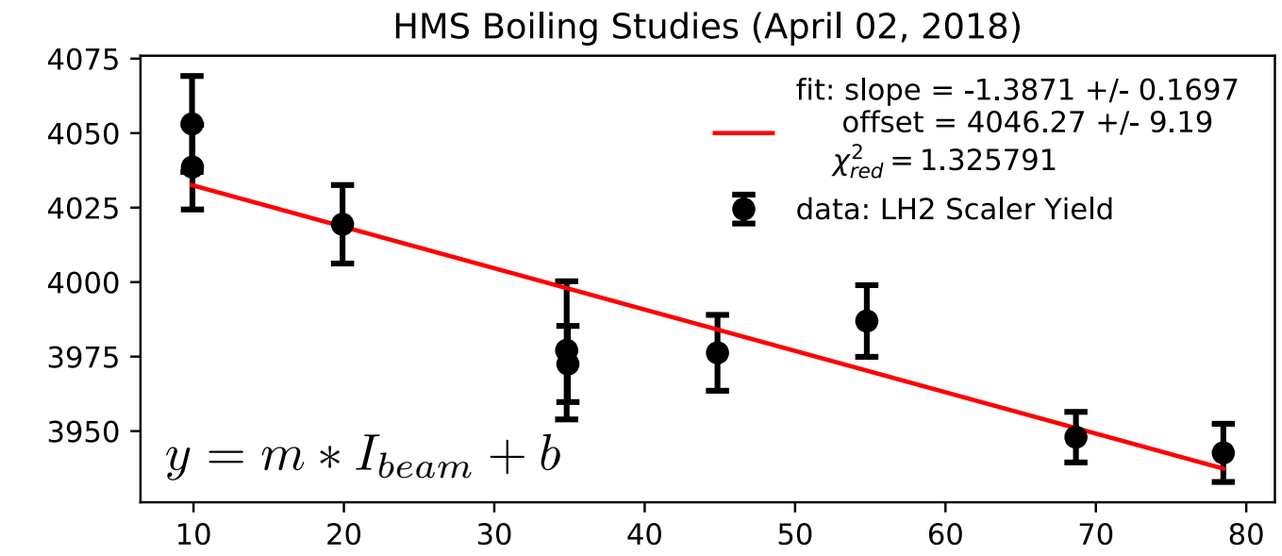


Non-Tracking Yields

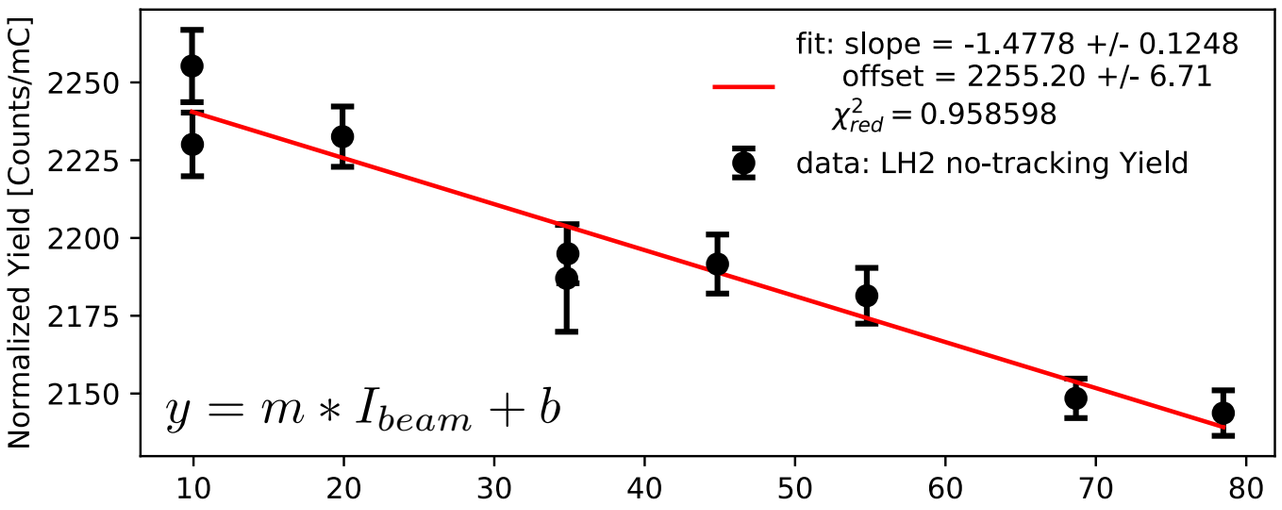


Tracking Yields

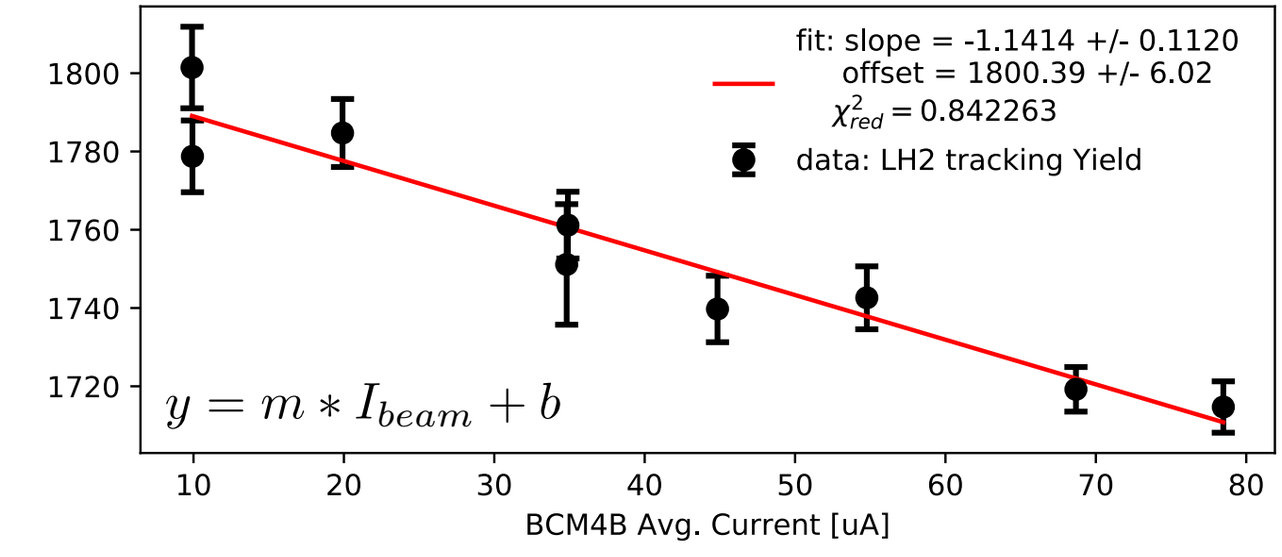
Hydrogen Normalized Yields vs. Beam Current



Scaler Yields

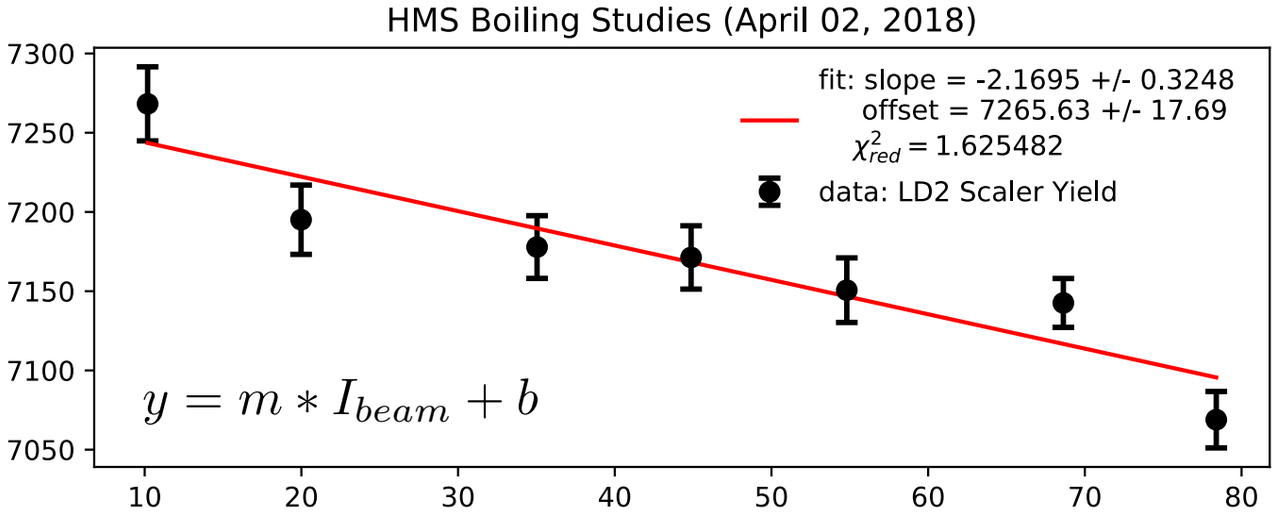


Non-Tracking Yields

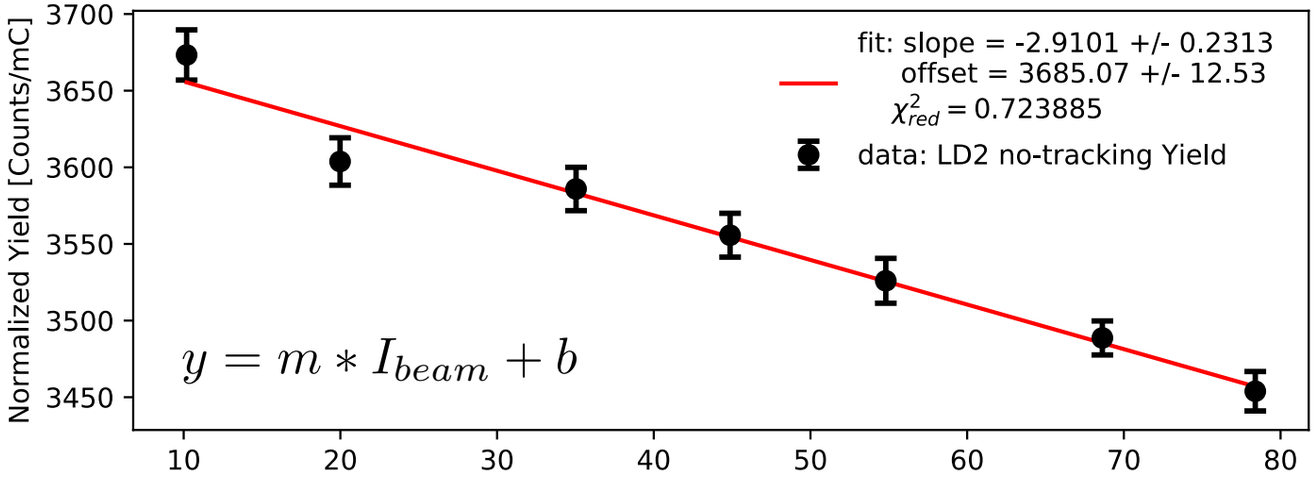


Tracking Yields

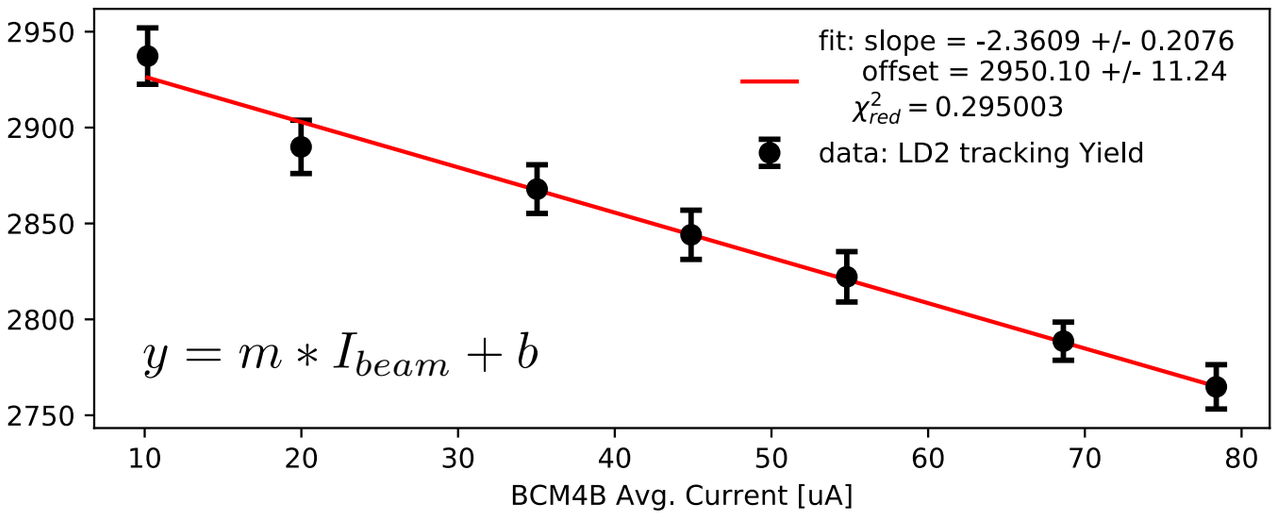
Deuterium Normalized Yields vs. Beam Current



→ Scaler Yields



→ Non-Tracking Yields

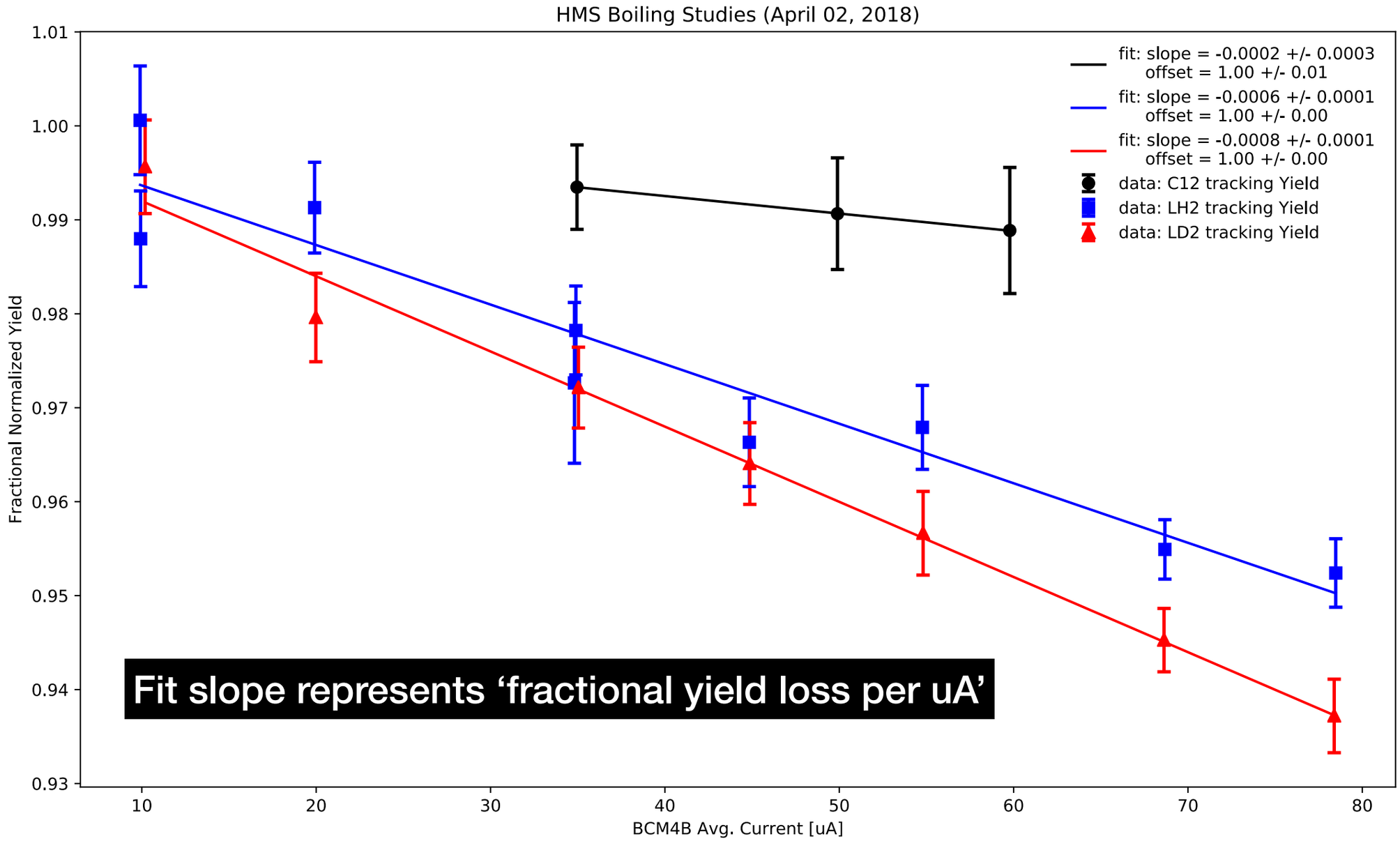


→ Tracking Yields

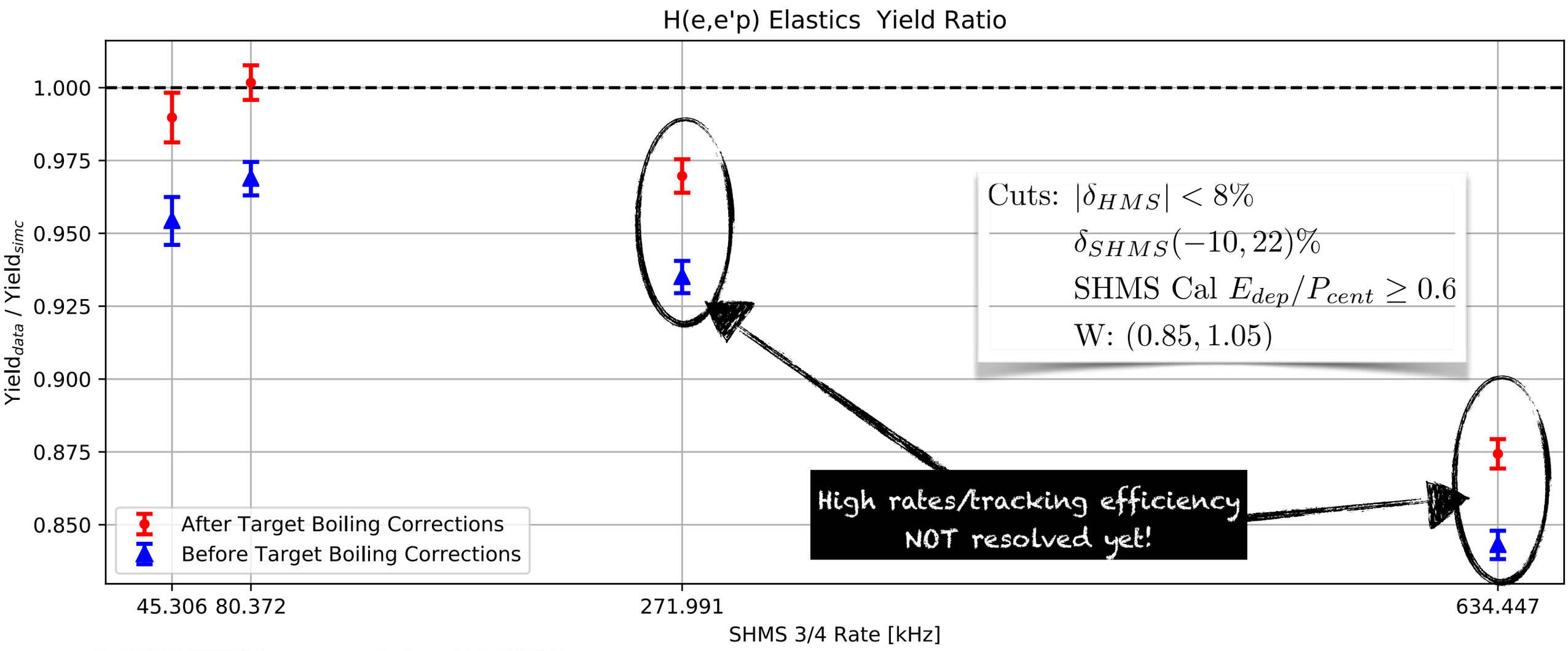
HMS Boiling Studies Results

Divide by the offset parameter to re-normalize data to unity

$$y = m * I_{beam} + b \Rightarrow \frac{y}{b} = \frac{m}{b} * I_{beam} + 1$$



H(e,e'p) Data After Including Target Boiling Corrections



Multiply average beam current by Boiling Fit Slope to estimate the target boiling correction.

Run	SHMS Rate [kHz]	Average Current[uA]	LH2 Slope [1/uA]	Boiling Corr. [%]
3288	80.372	54.8147	-0.0006	3.288
3371	45.305	59.7393	-0.0006	3.584
3374	271.991	59.5961	-0.0006	3.575
3377	634.447	59.6417	-0.0006	3.578

Back-Up Slides

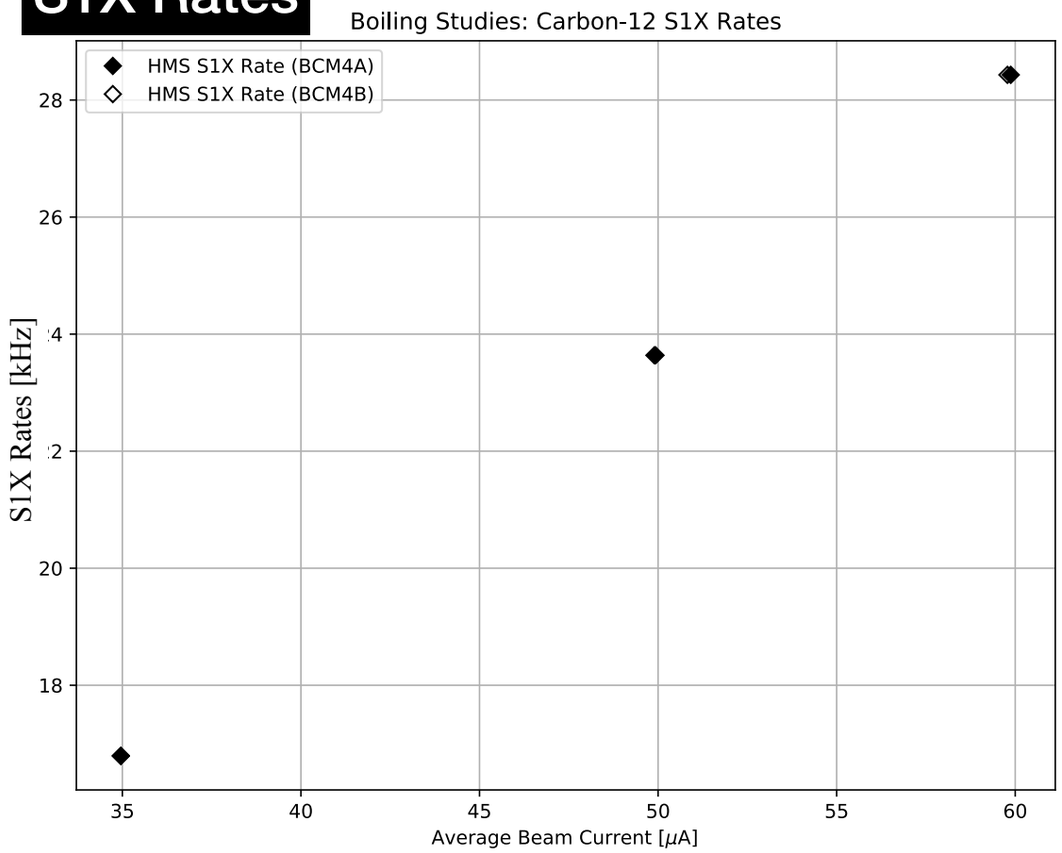
HMS Boiling Studies:

Rates, Efficiencies and Live Time

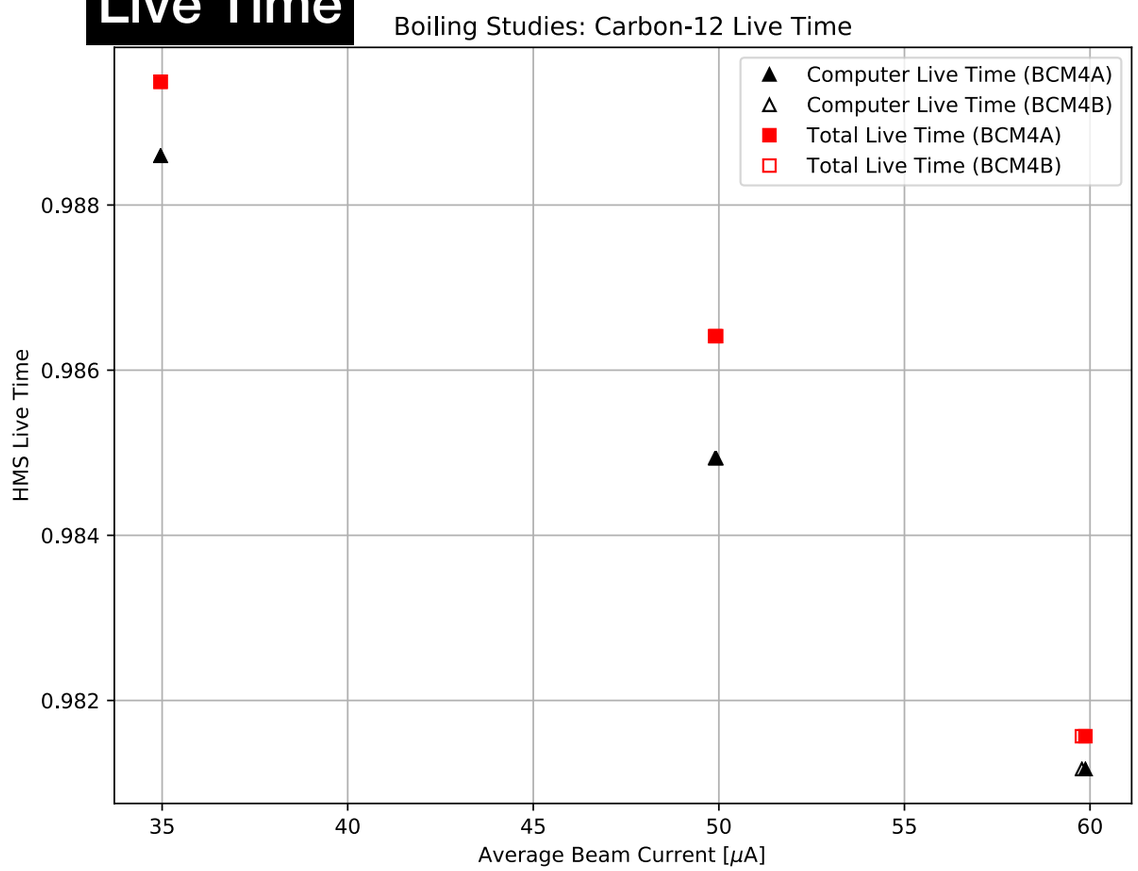
for Carbon, LH2 and LD2

Carbon-12: Rates / Live Times / Tracking Efficiencies

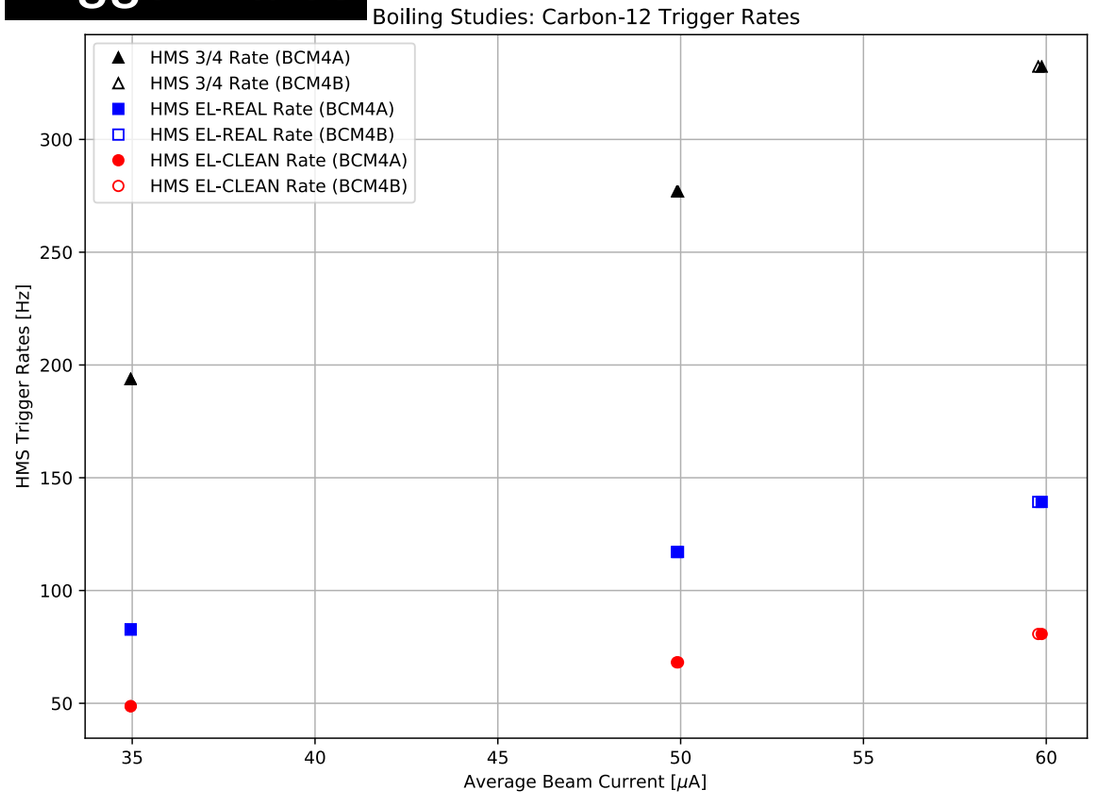
S1X Rates



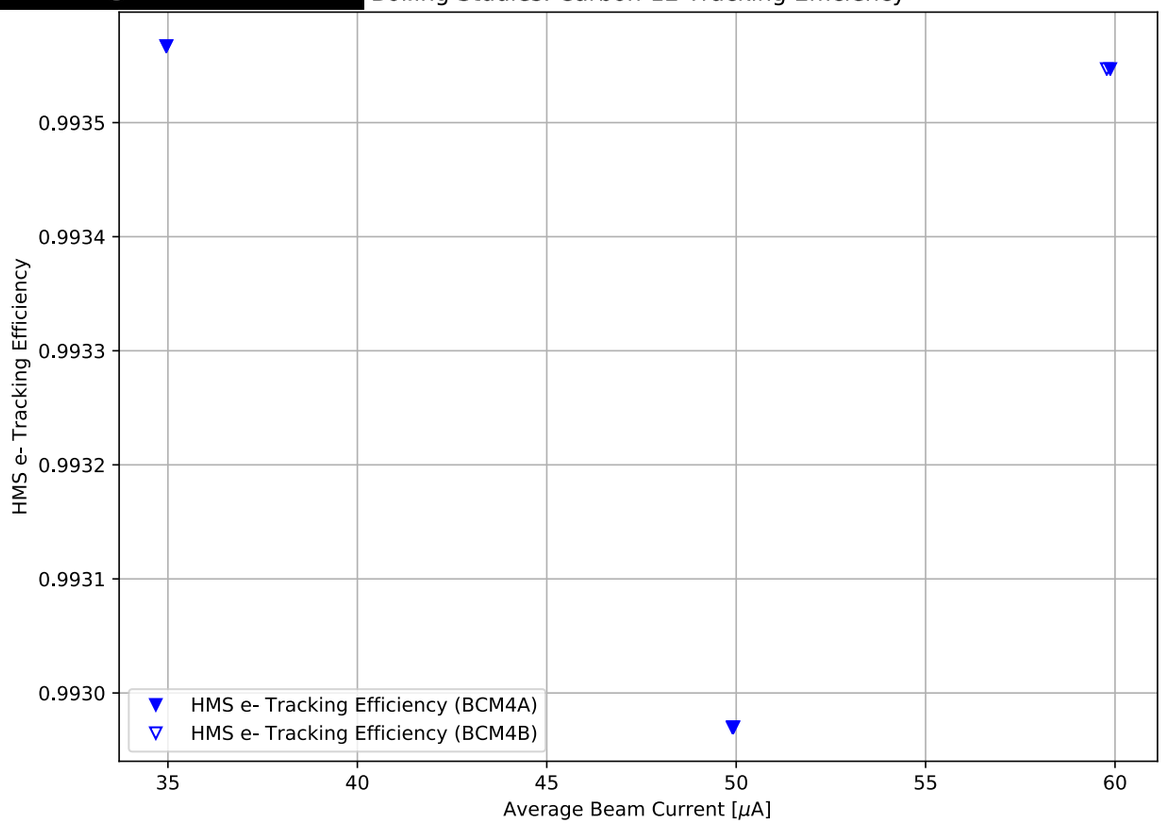
Live Time



Trigger Rates

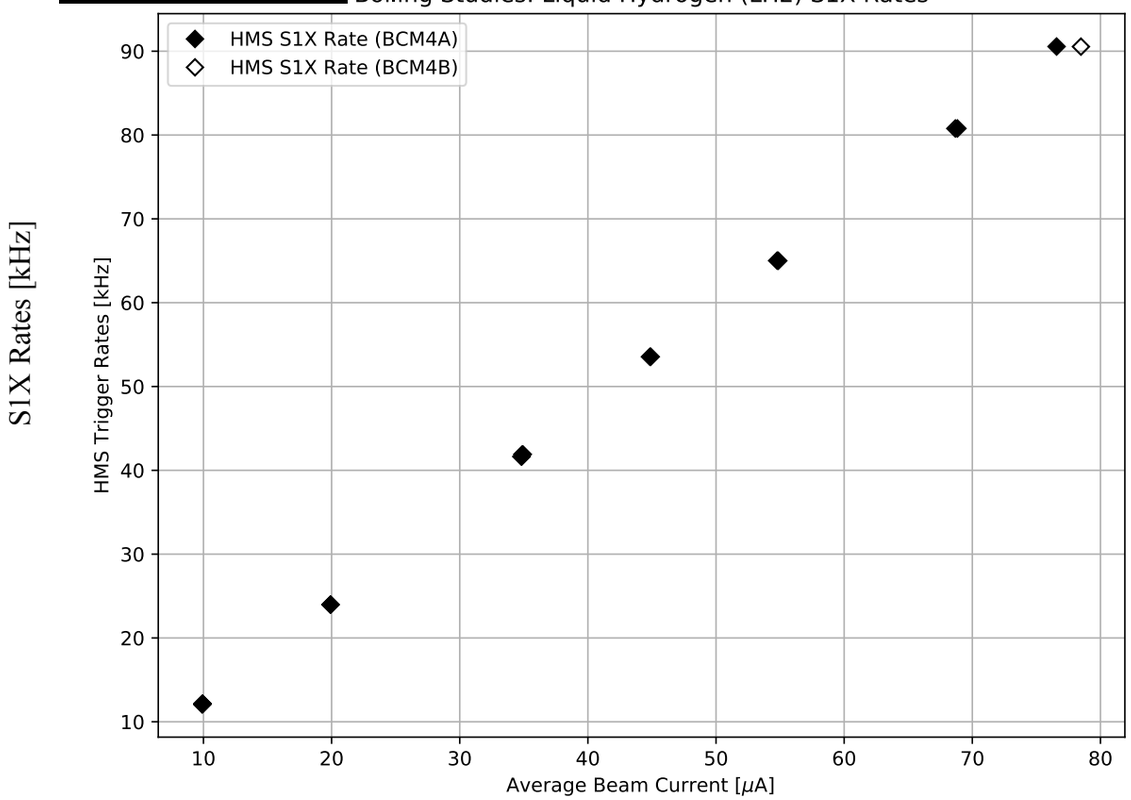


Tracking Efficiencies

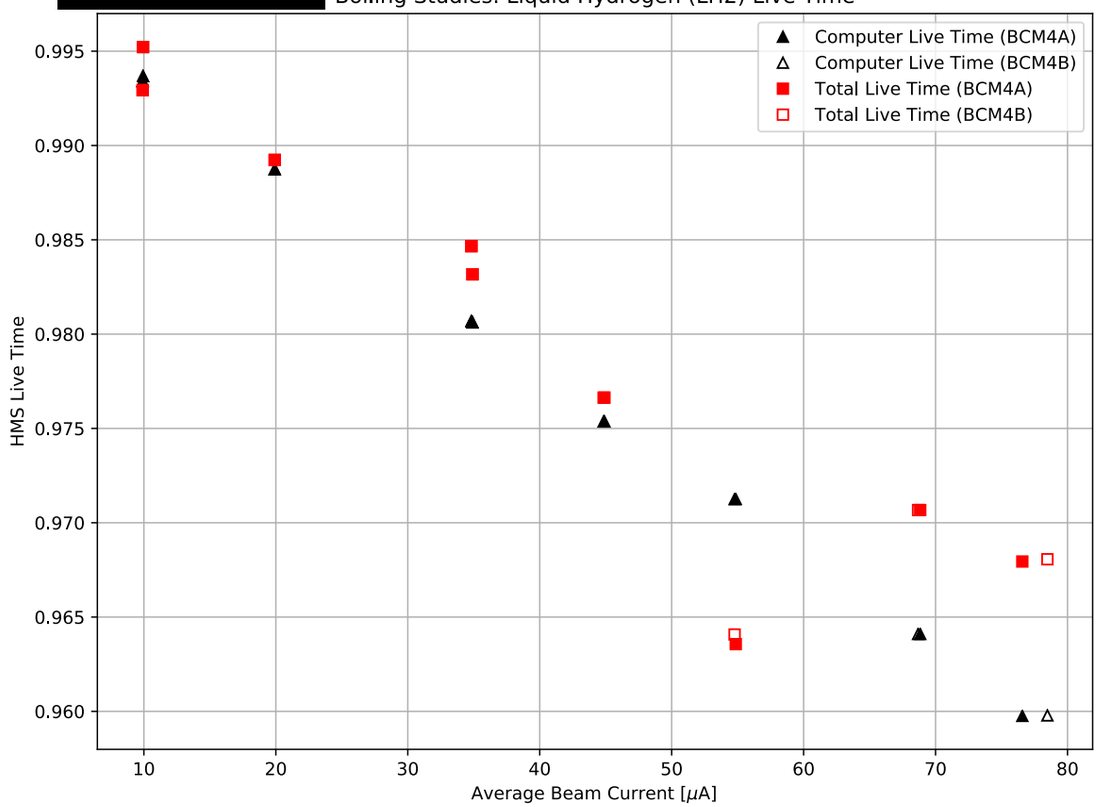


LH2: Rates / Live Times / Tracking Efficiencies

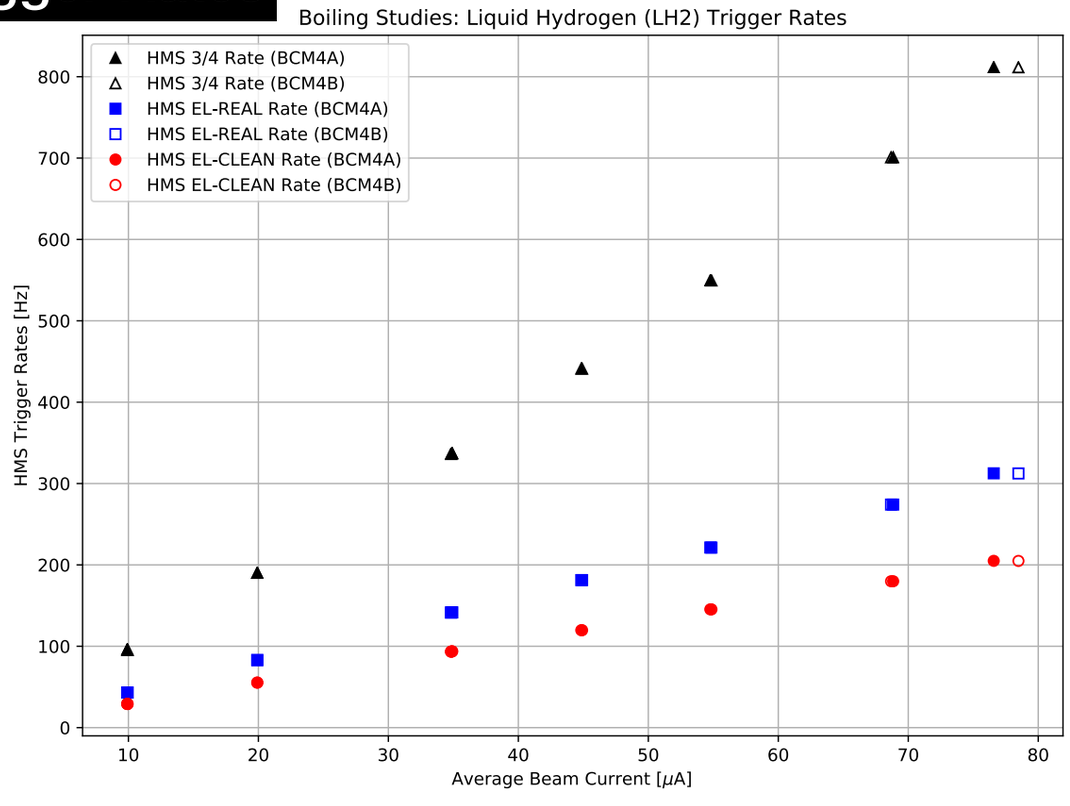
S1X Rates



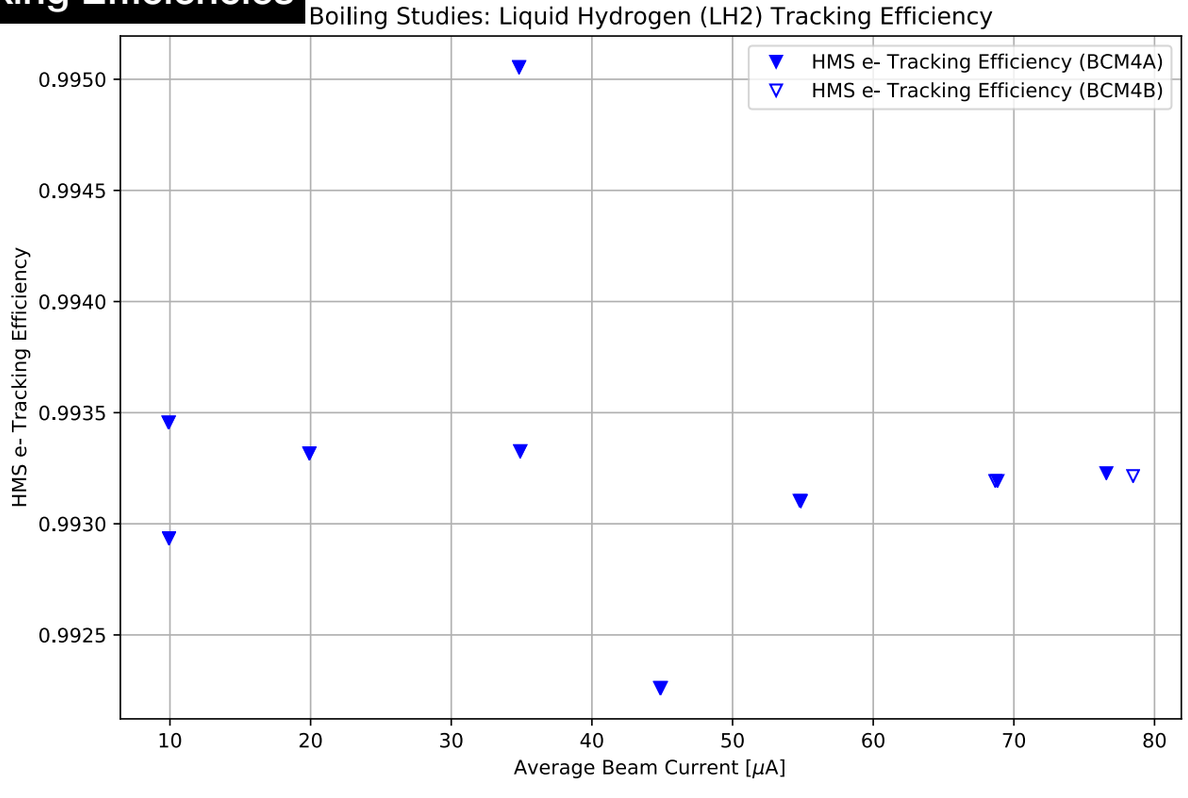
Live Time



Trigger Rates

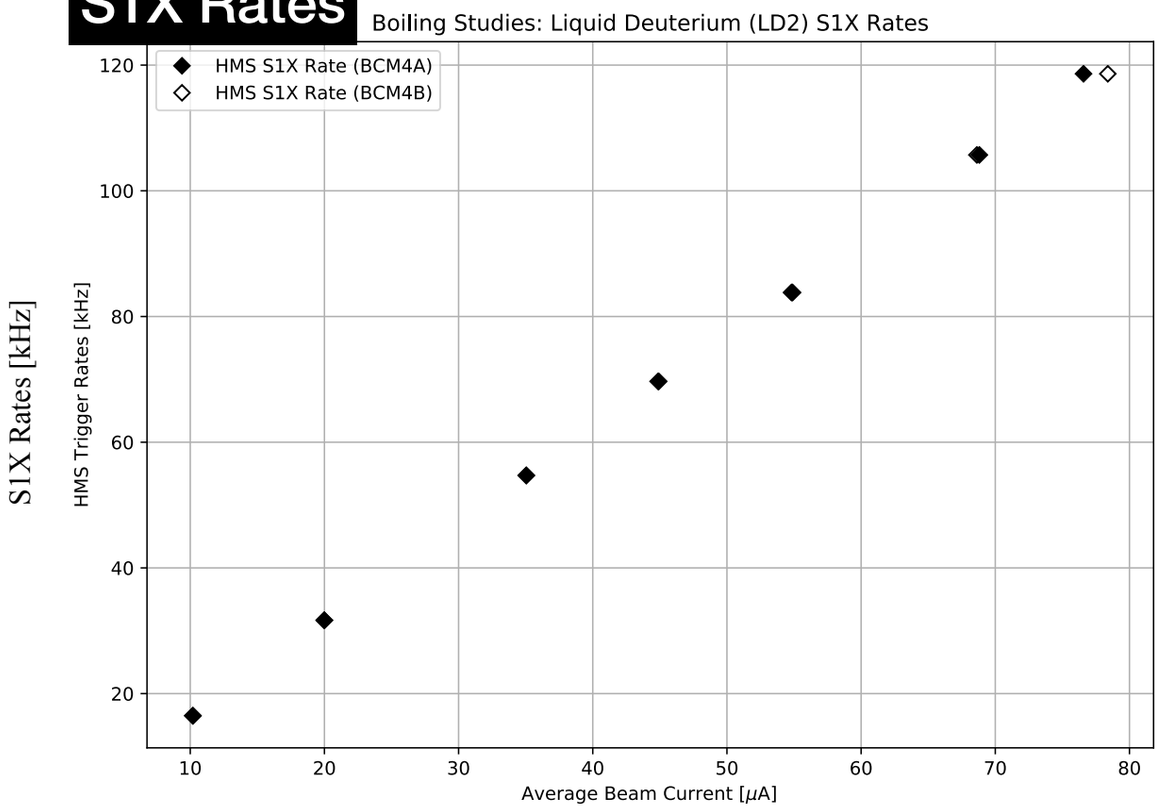


Tracking Efficiencies

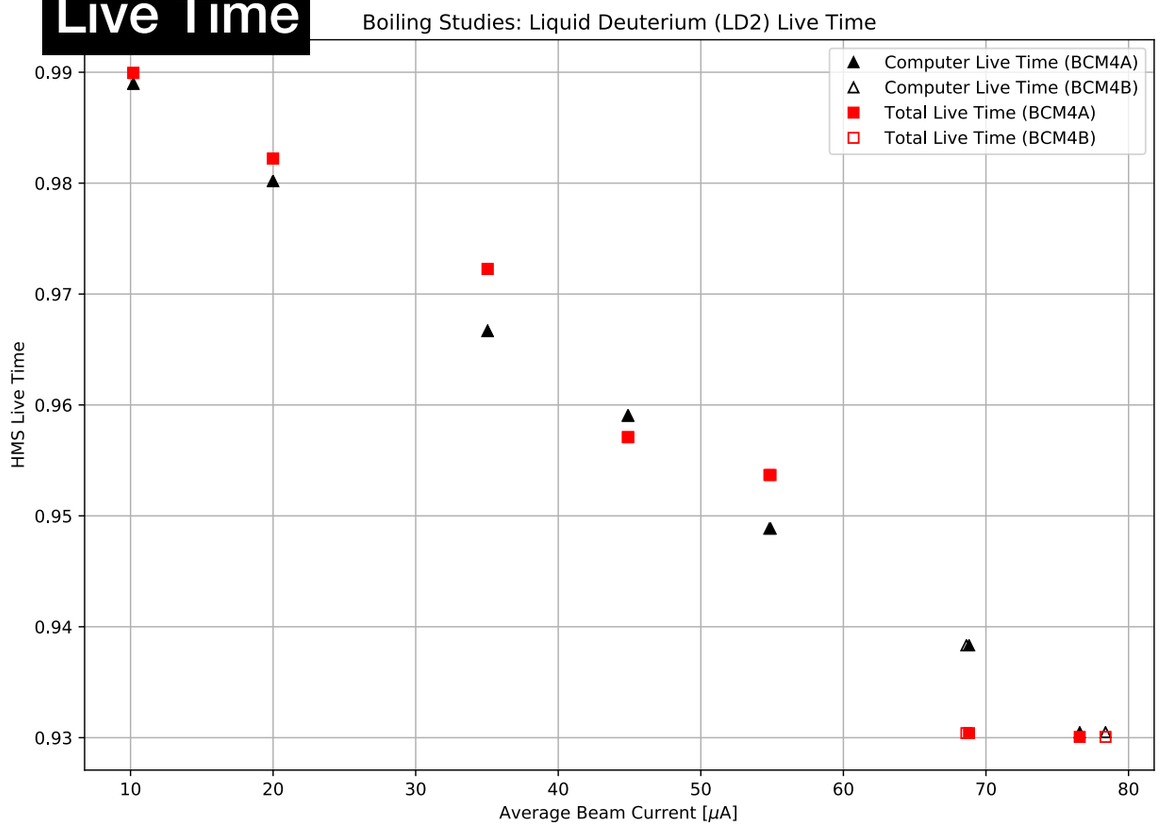


LD2: Rates / Live Times / Tracking Efficiencies

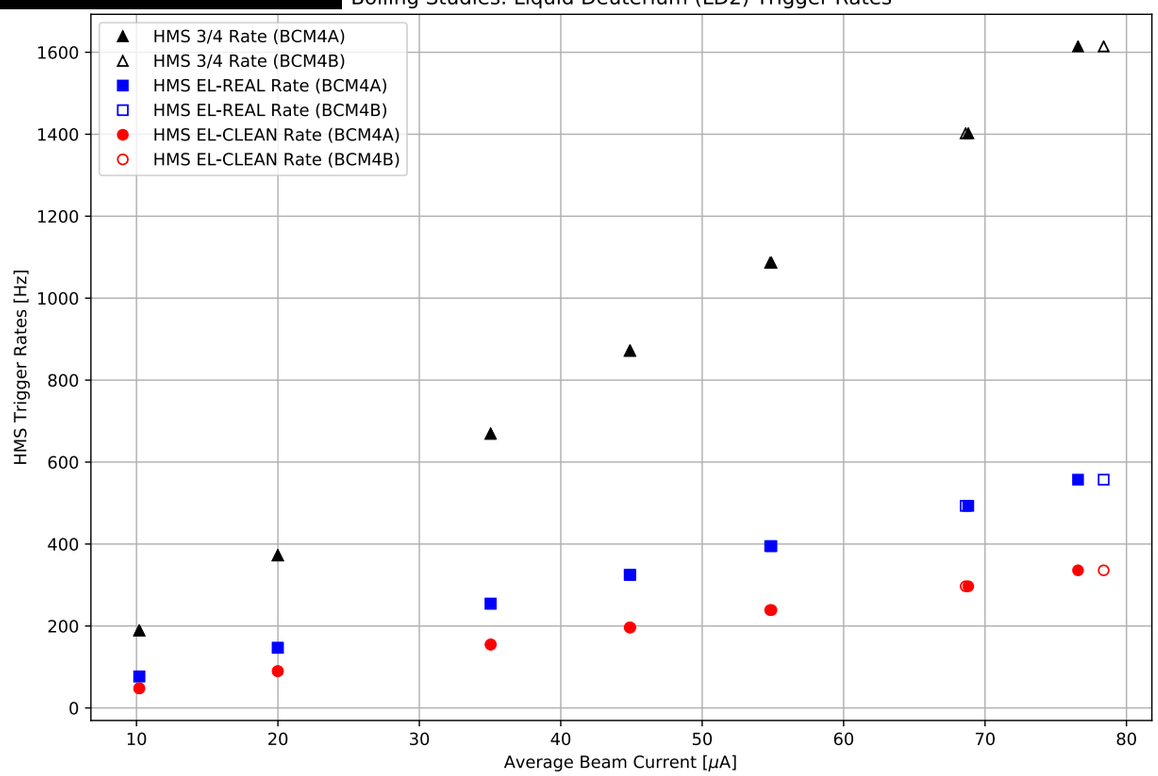
S1X Rates



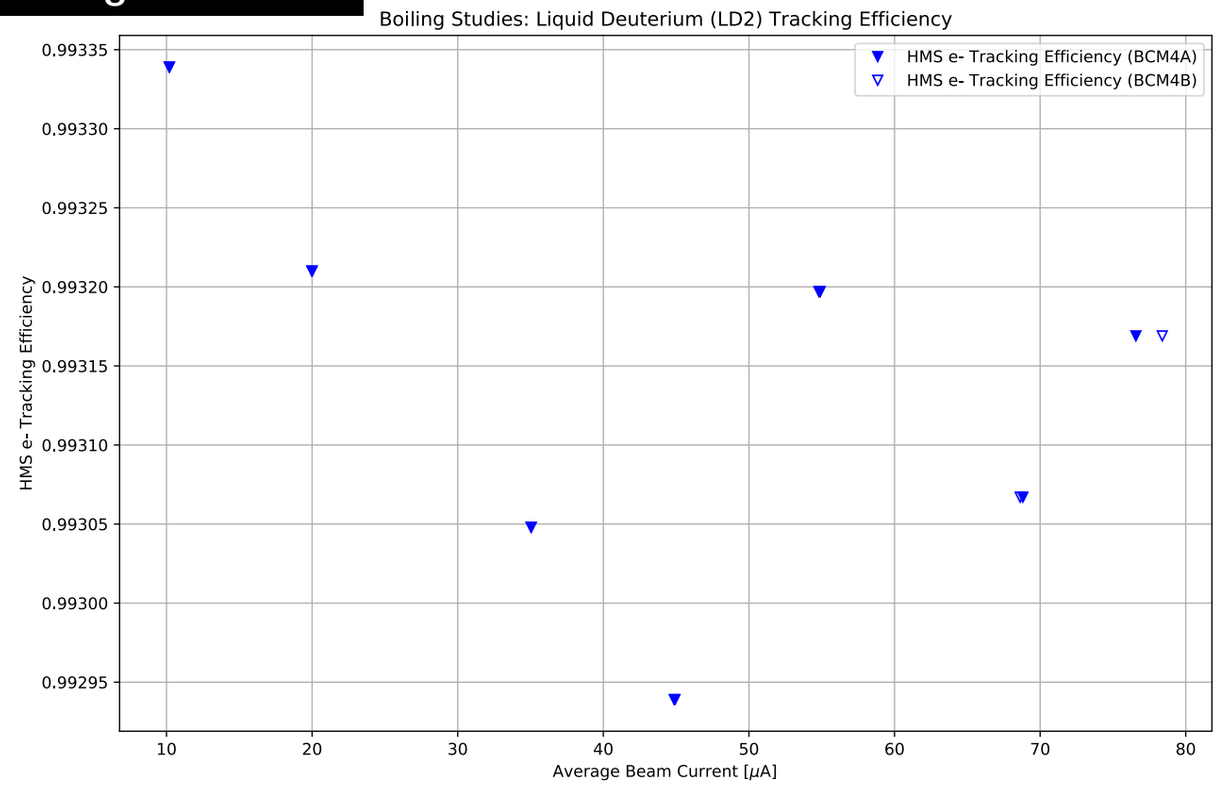
Live Time



Trigger Rates



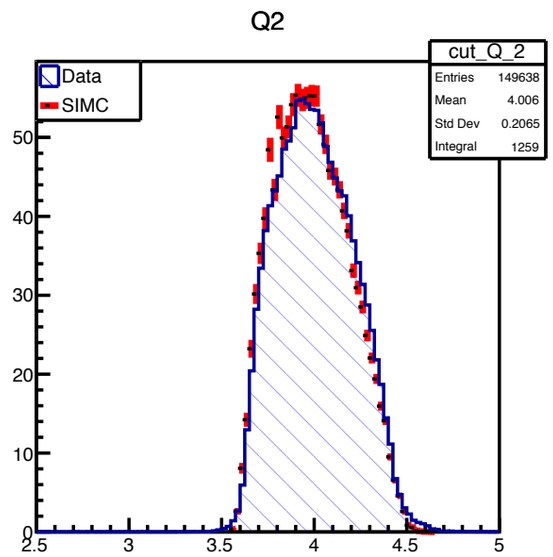
Tracking Efficiencies

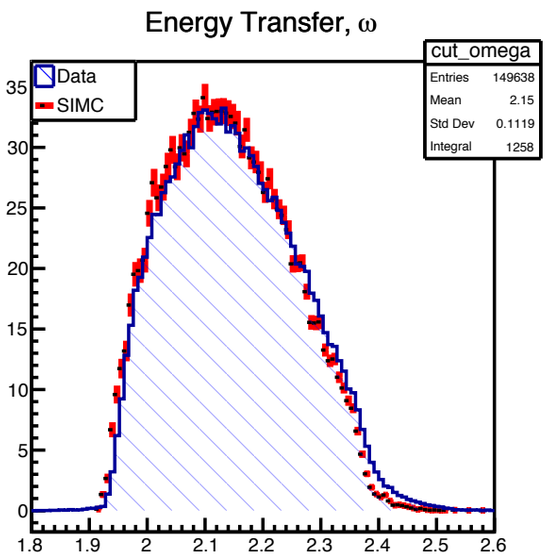


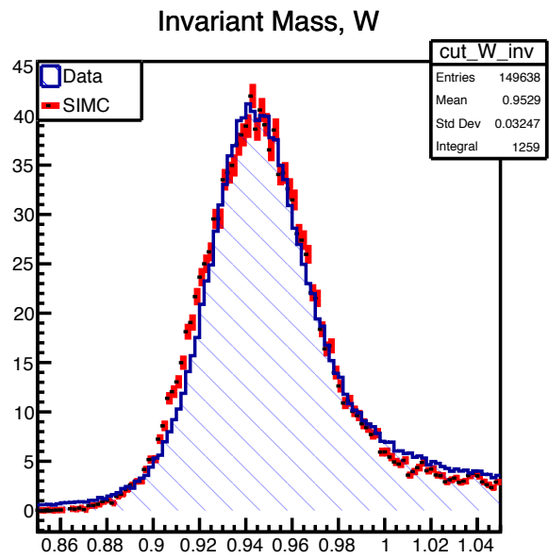
E12-10-003
H(e,e'p) Elastics

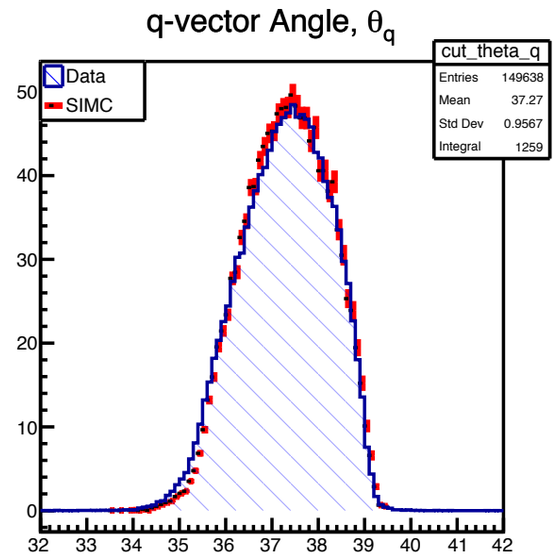
DATA/SIMC
Comparisons

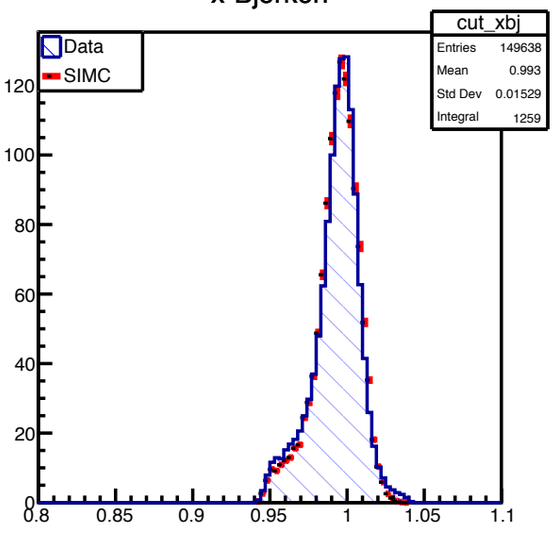
Run 3288

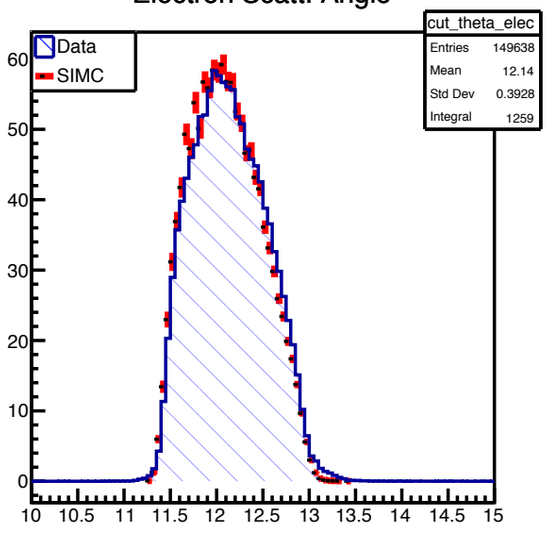

Q2
Data
SIMC
cut_Q_2
Entries 149638
Mean 4.006
Std Dev 0.2065
Integral 1259

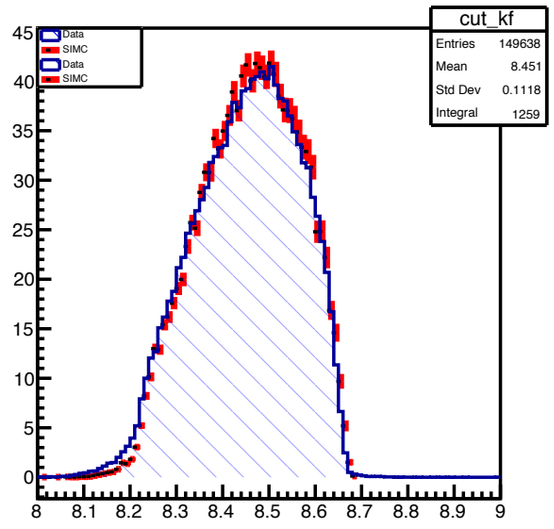

Energy Transfer, ω
Data
SIMC
cut_omega
Entries 149638
Mean 2.15
Std Dev 0.1119
Integral 1258

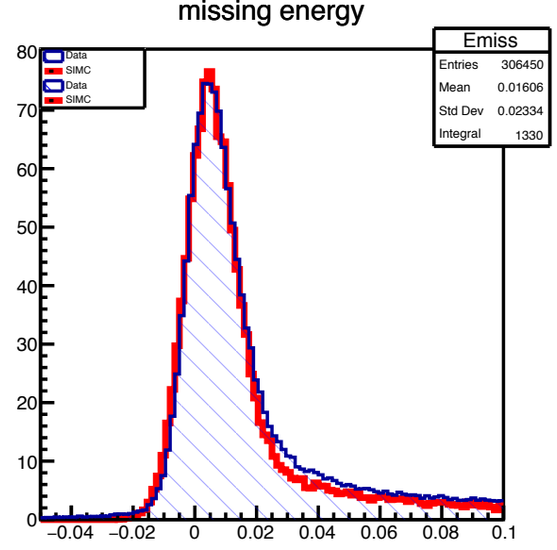

Invariant Mass, W
Data
SIMC
cut_W_inv
Entries 149638
Mean 0.9529
Std Dev 0.03247
Integral 1259


q-vector Angle, θq
Data
SIMC
cut_theta_q
Entries 149638
Mean 37.27
Std Dev 0.9567
Integral 1259

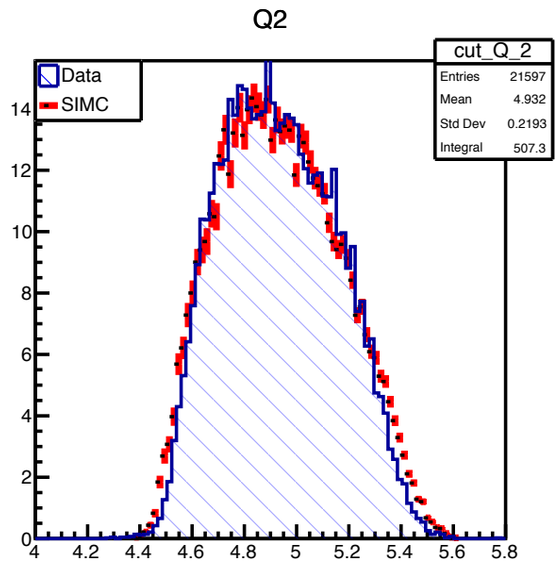

x-Bjorken
Data
SIMC
cut_xbj
Entries 149638
Mean 0.993
Std Dev 0.01529
Integral 1259

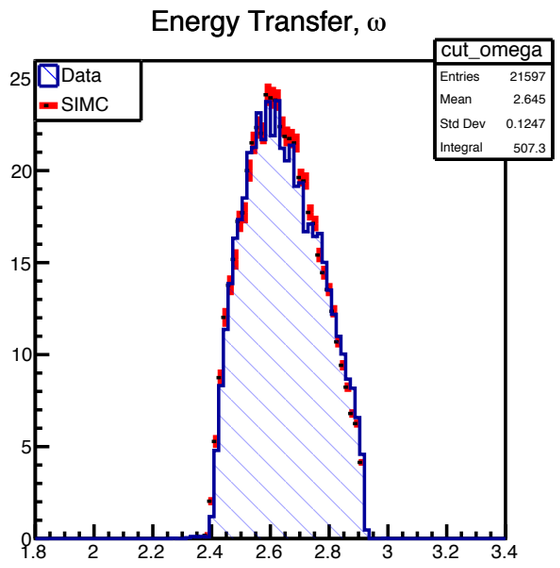

Electron Scatt. Angle
Data
SIMC
cut_theta_elec
Entries 149638
Mean 12.14
Std Dev 0.3928
Integral 1259

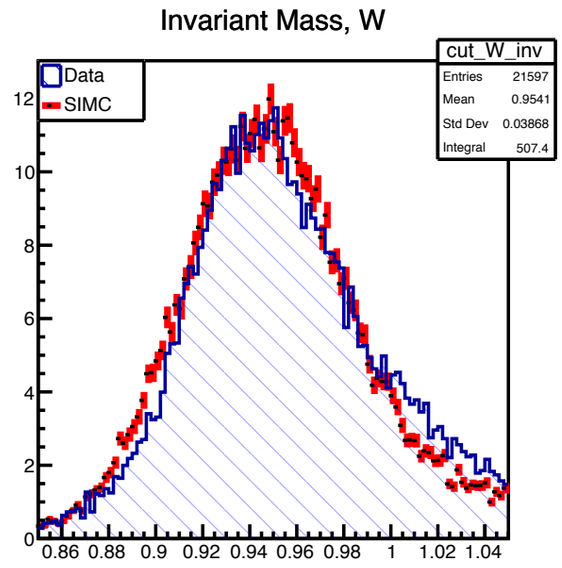

Final e⁻ Momentum
Data
SIMC
Data
SIMC
cut_kf
Entries 149638
Mean 8.451
Std Dev 0.1118
Integral 1259

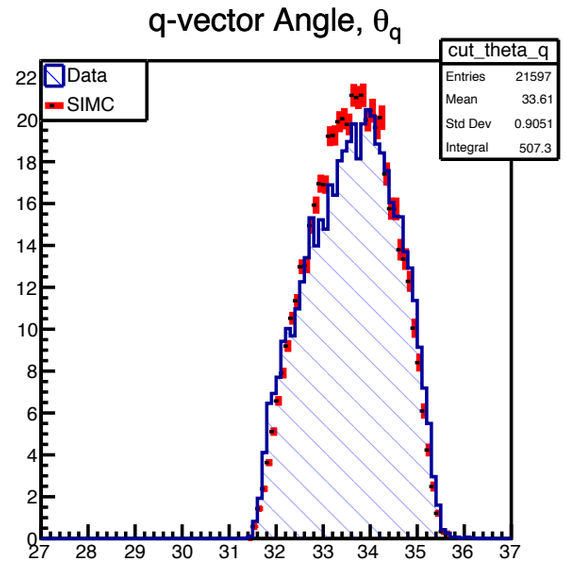

missing energy
Data
SIMC
Data
SIMC
Emiss
Entries 306450
Mean 0.01606
Std Dev 0.02334
Integral 1330

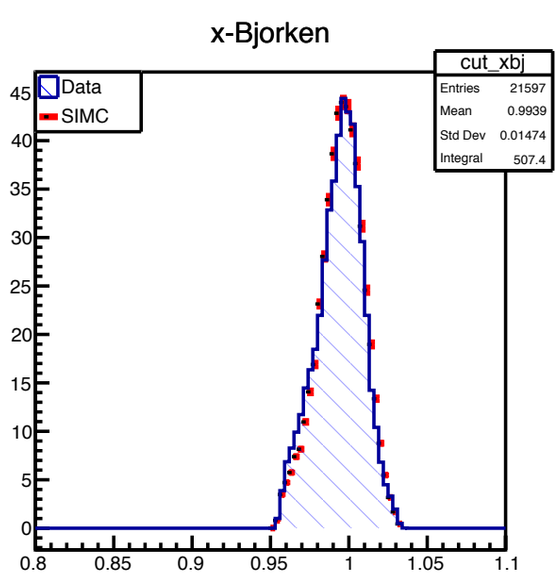
Run 3371

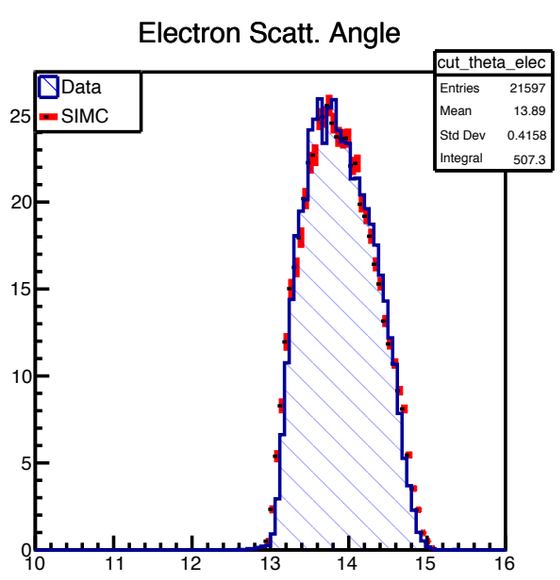

Q2
Data
SIMC
cut_Q_2
Entries 21597
Mean 4.932
Std Dev 0.2193
Integral 507.3

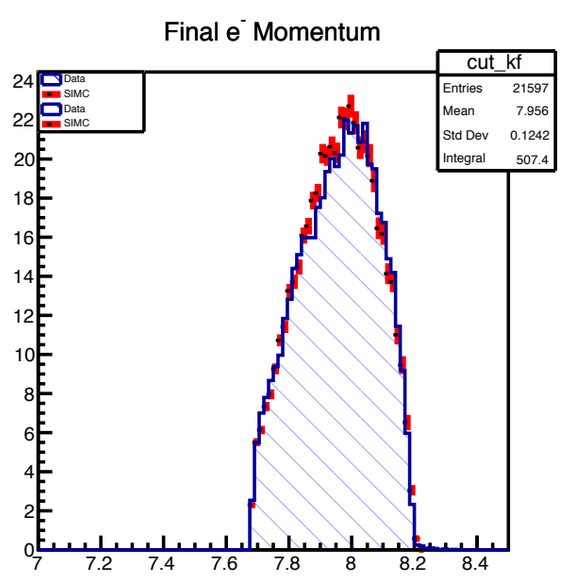

Energy Transfer, ω
Data
SIMC
cut_omega
Entries 21597
Mean 2.645
Std Dev 0.1247
Integral 507.3

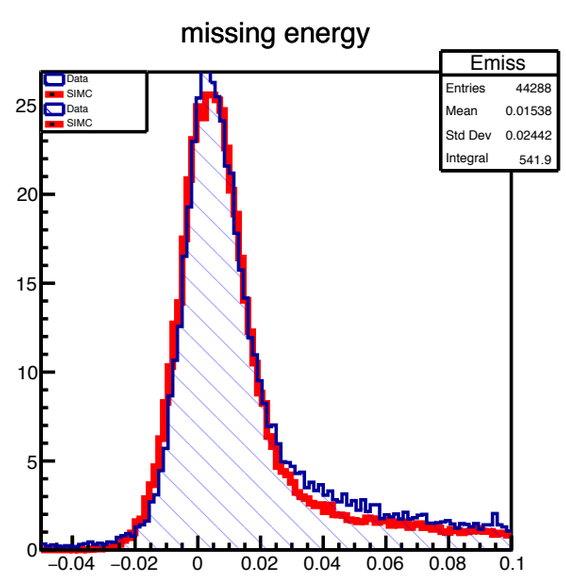

Invariant Mass, W
Data
SIMC
cut_W_inv
Entries 21597
Mean 0.9541
Std Dev 0.03868
Integral 507.4


q-vector Angle, θq
Data
SIMC
cut_theta_q
Entries 21597
Mean 33.61
Std Dev 0.9051
Integral 507.3


x-Bjorken
Data
SIMC
cut_xbj
Entries 21597
Mean 0.9939
Std Dev 0.01474
Integral 507.4

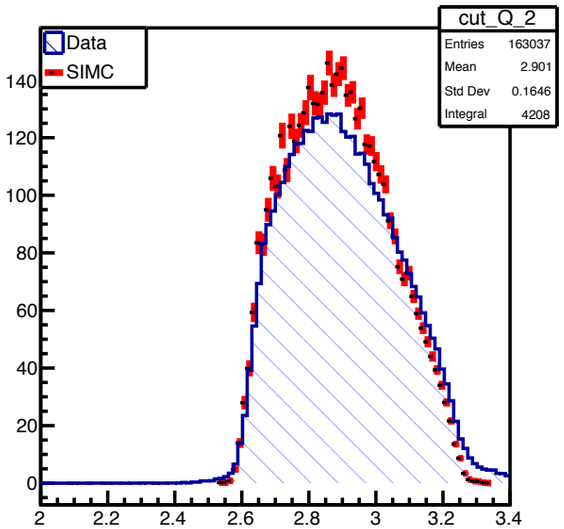

Electron Scatt. Angle
Data
SIMC
cut_theta_elec
Entries 21597
Mean 13.89
Std Dev 0.4158
Integral 507.3


Final e- Momentum
Data
SIMC
Data
SIMC
cut_kf
Entries 21597
Mean 7.956
Std Dev 0.1242
Integral 507.4

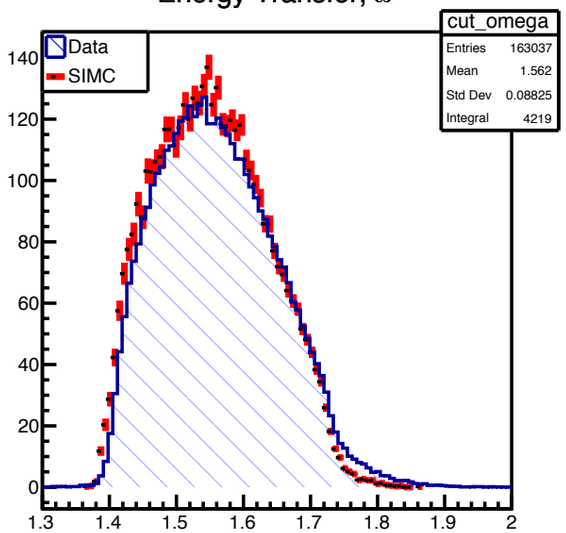

missing energy
Data
SIMC
Data
SIMC
Emiss
Entries 44288
Mean 0.01538
Std Dev 0.02442
Integral 541.9

Run 3374

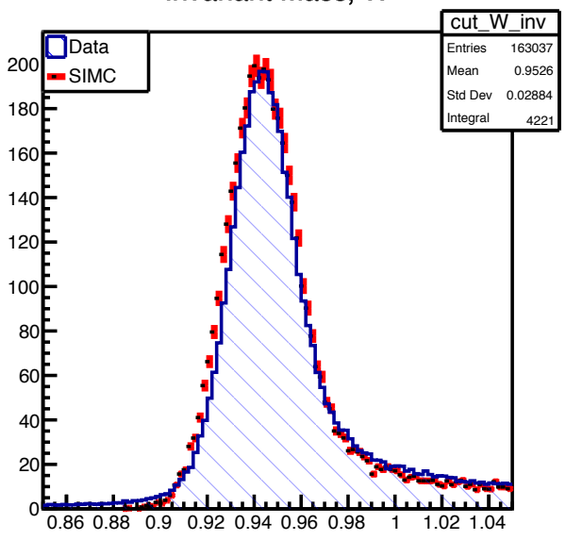
Q2



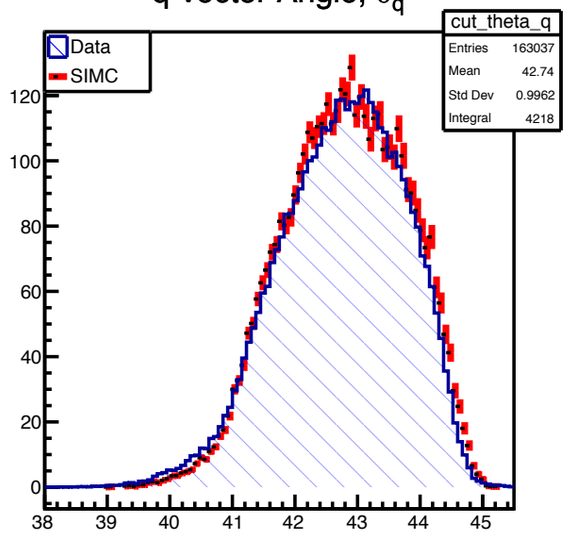
Energy Transfer, ω



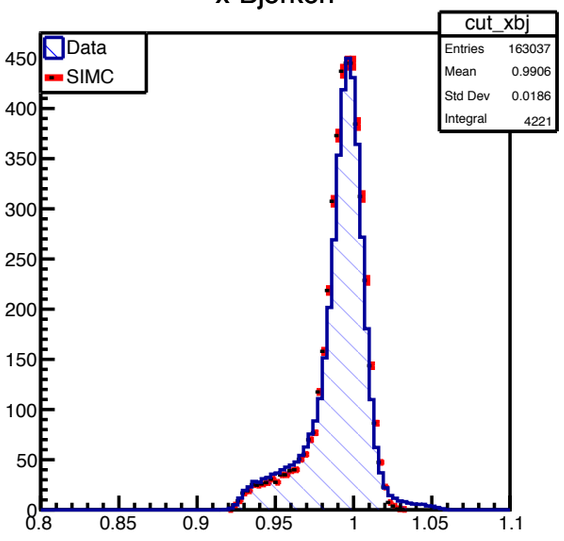
Invariant Mass, W



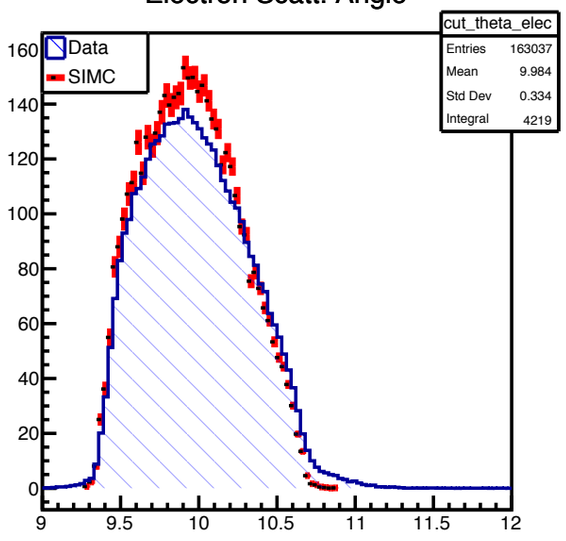
q-vector Angle, θ_q



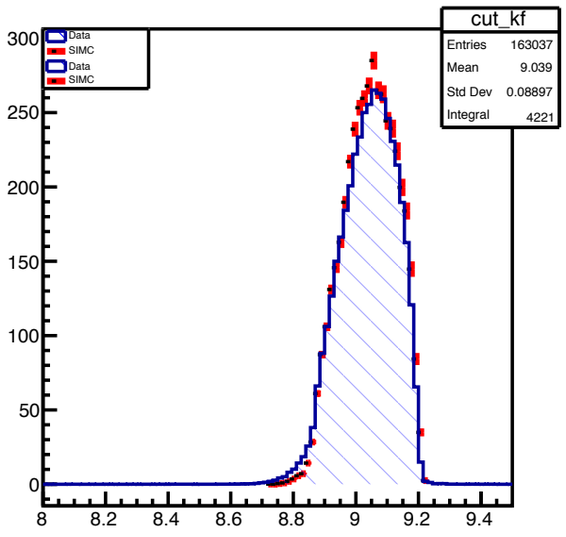
x-Bjorken



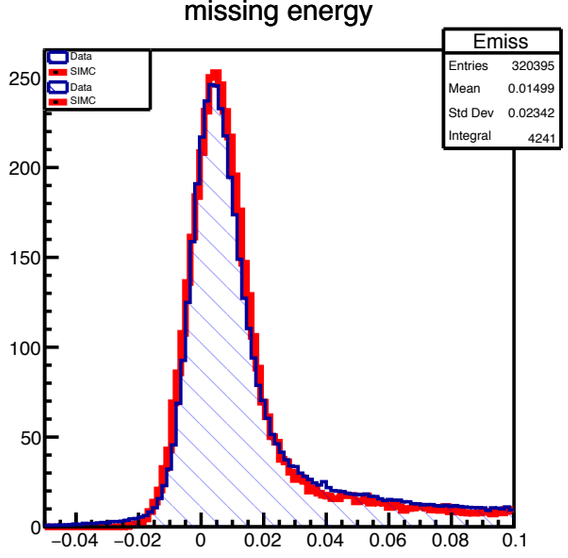
Electron Scatt. Angle



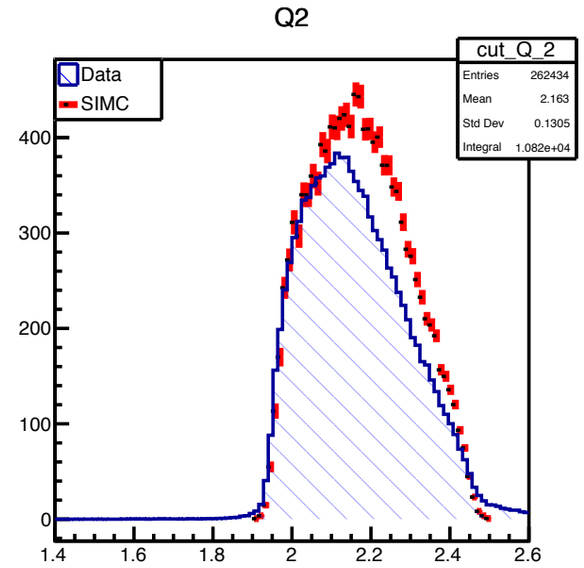
Final e⁻ Momentum

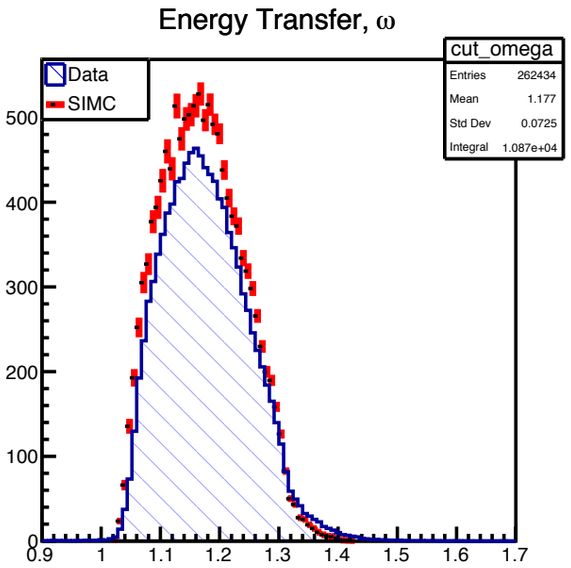


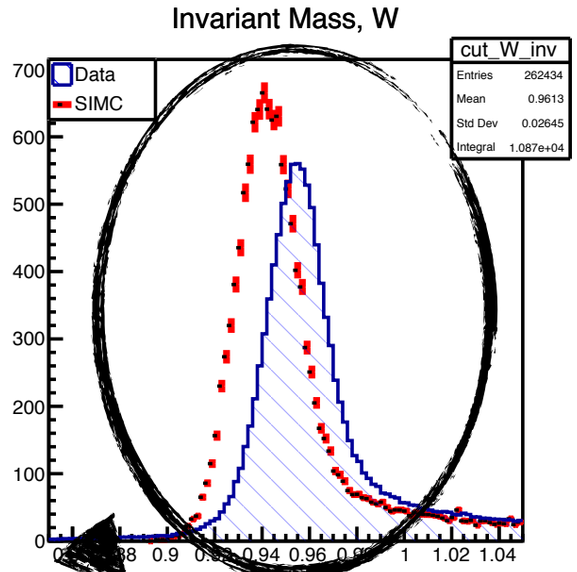
missing energy

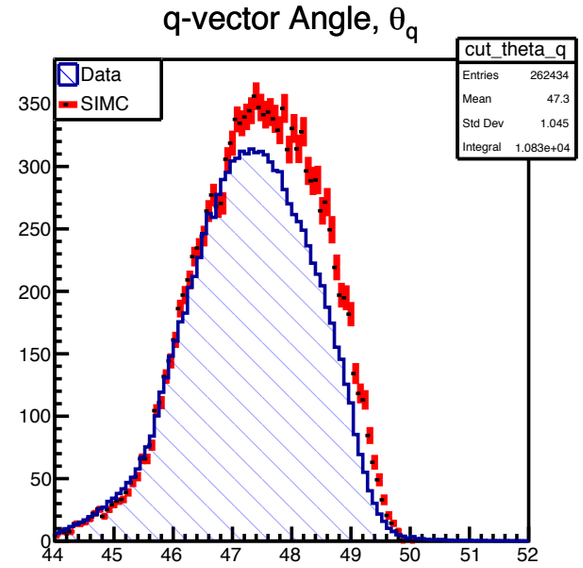


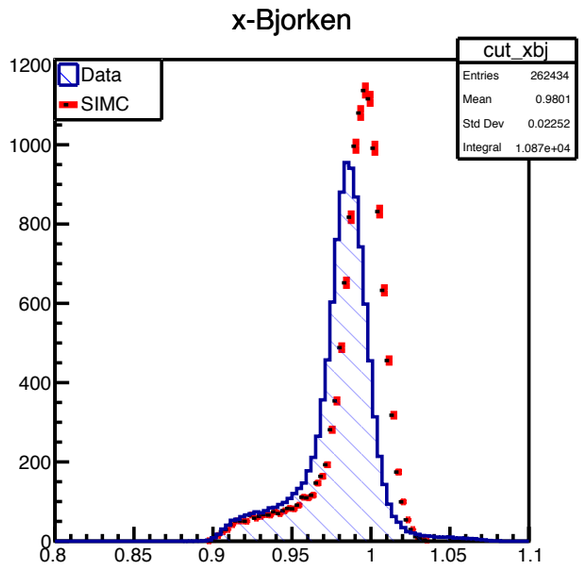
Run 3377

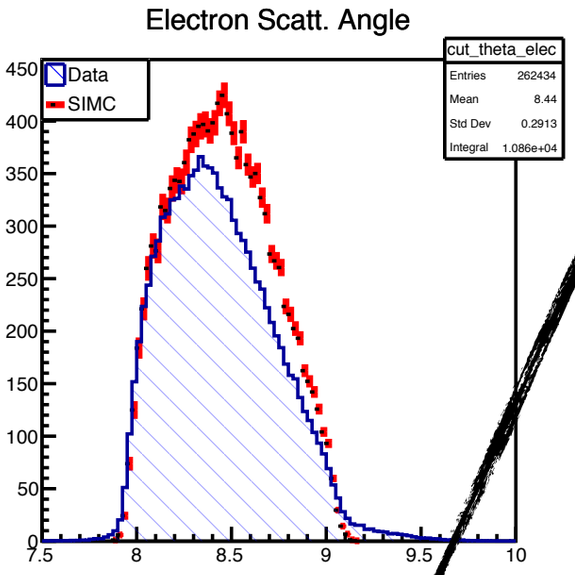


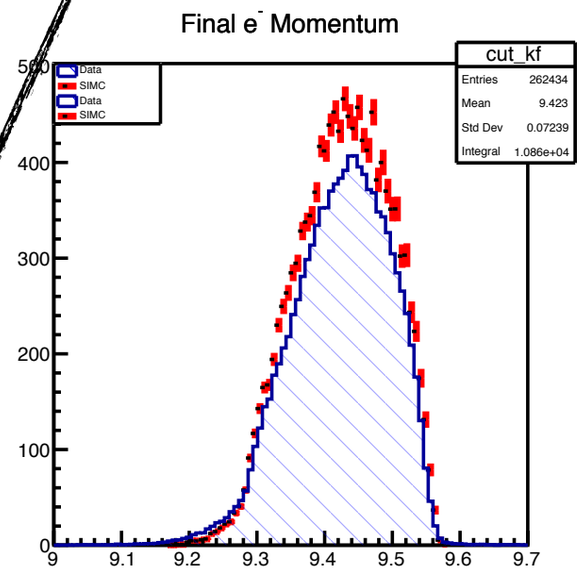


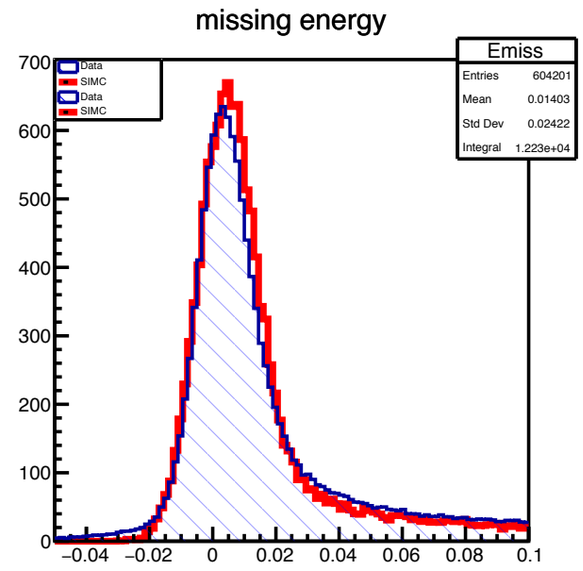












There are several issues with this run:
* Data/SIMC yield disagree ~ 13%
* Alignment issue NOT observed in the other runs