

HMS Target Boiling Studies

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May 16, 2019

HMS (Singles Mode DAQ)

Angle: 25 deg

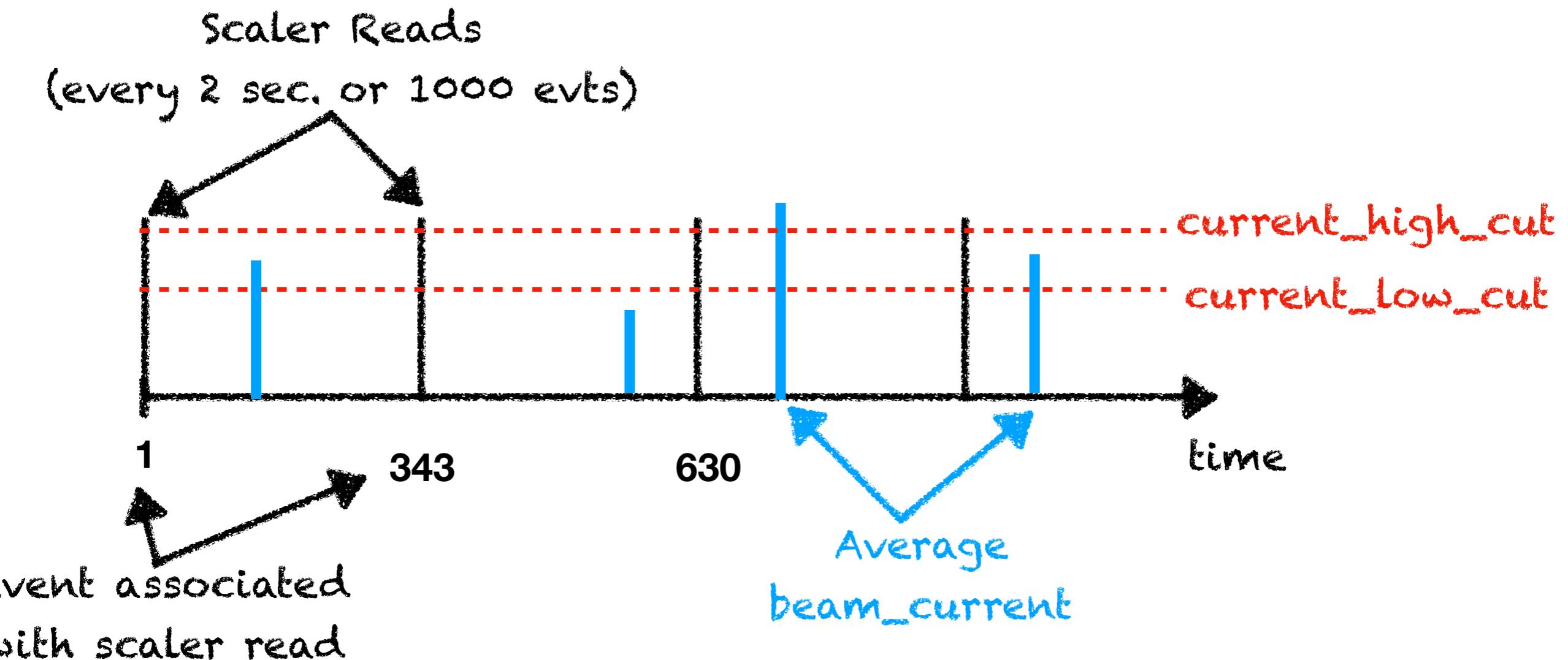
Momentum: -4.4 GeV (electrons)

Trigger: HMS EL-REAL (htrig2)

Target Boiling Studies Data Set: 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



- ⑥ Loop over each scaler read and require a current cut to count scalers **ONLY** when beam current is within cut.
- ⑦ 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

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

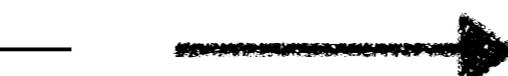


N_{scaler} → HMS trigger scaler counter **ONLY** if
BCM scaler current cut passed

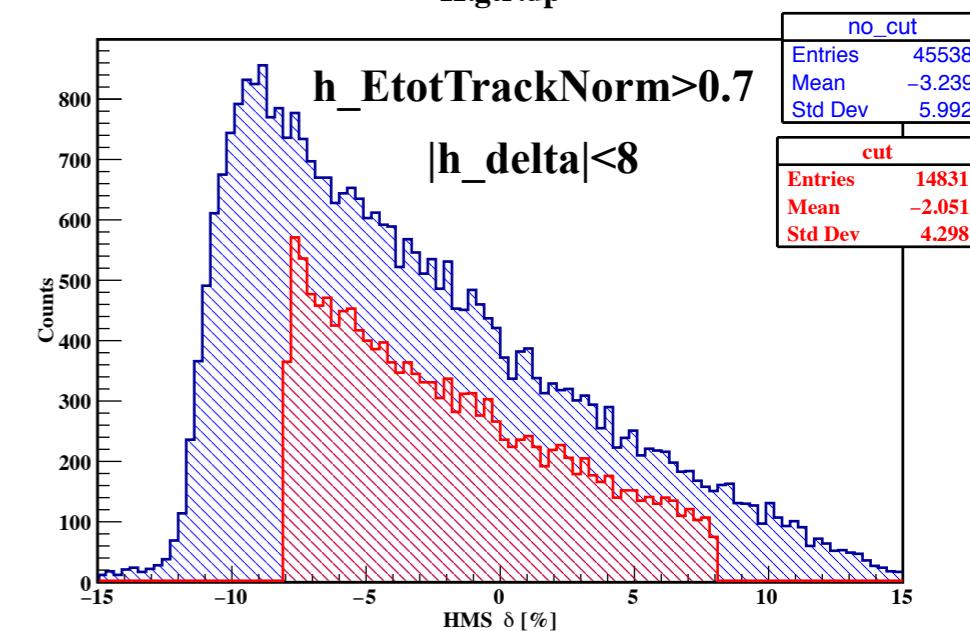
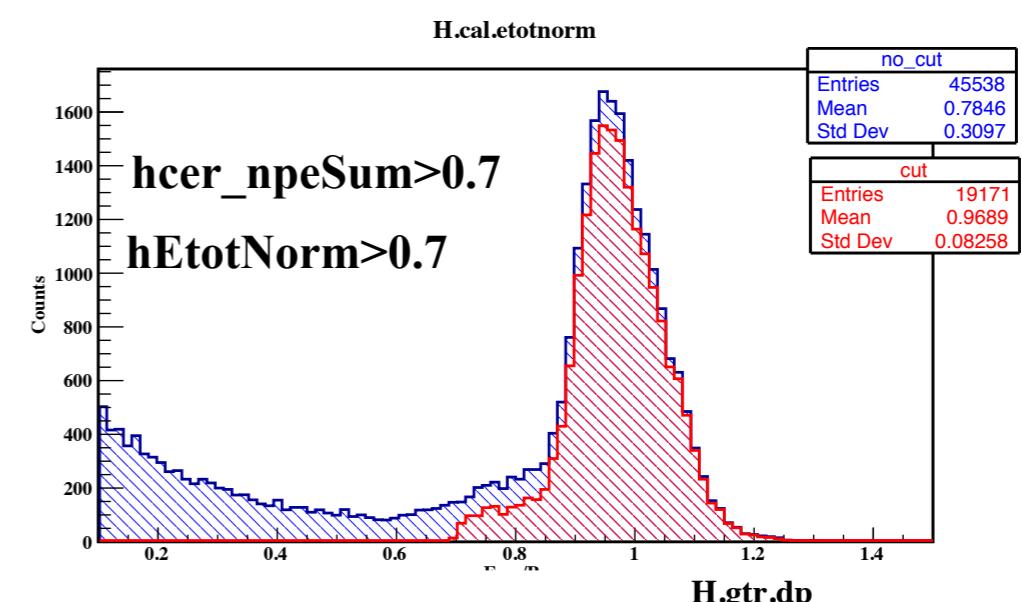
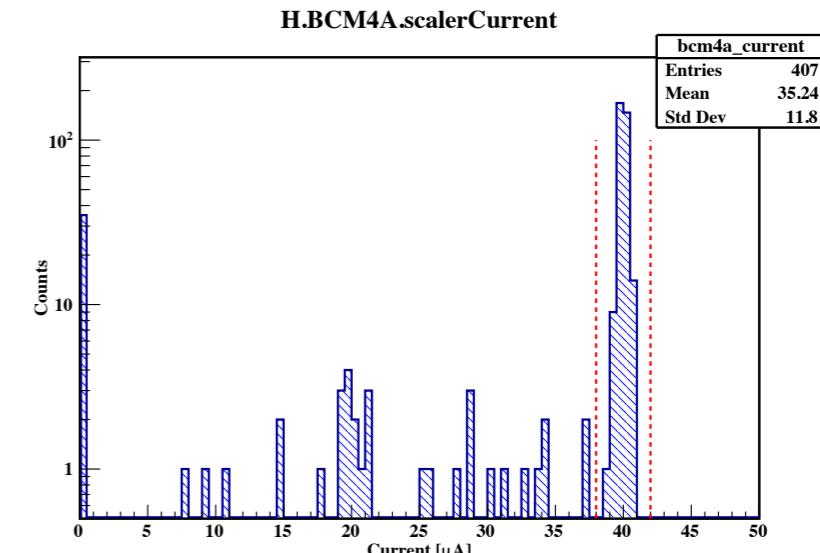
$$Y_{no_track} = \frac{N_{accepted}}{Q_{tot} * \epsilon_{LT}}$$



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



$N_{accepted}$ → 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 scaler
(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

//-----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);

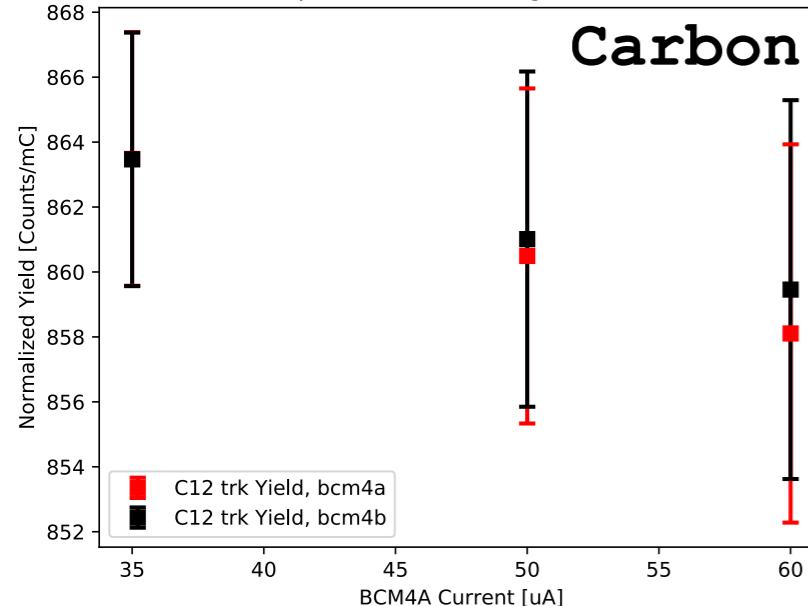
//BCM4A
H_hCAL_etotnorm_ntrkY_4a->Scale(1./(total_charge_bcm4a_cut*cpuLT_bcm4a));
notrk_Yield_bcm4a = H_hCAL_etotnorm_ntrkY_4a->IntegralAndError(H_hCAL_etotnorm_ntrkY_4a->FindBin(0.6), H_hCAL_etotnorm_ntrkY_4a->FindBin(5.), notrk_err_bcm4a);
//BCM4B
H_hCAL_etotnorm_ntrkY_4b->Scale(1./(total_charge_bcm4b_cut*cpuLT_bcm4b));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

```

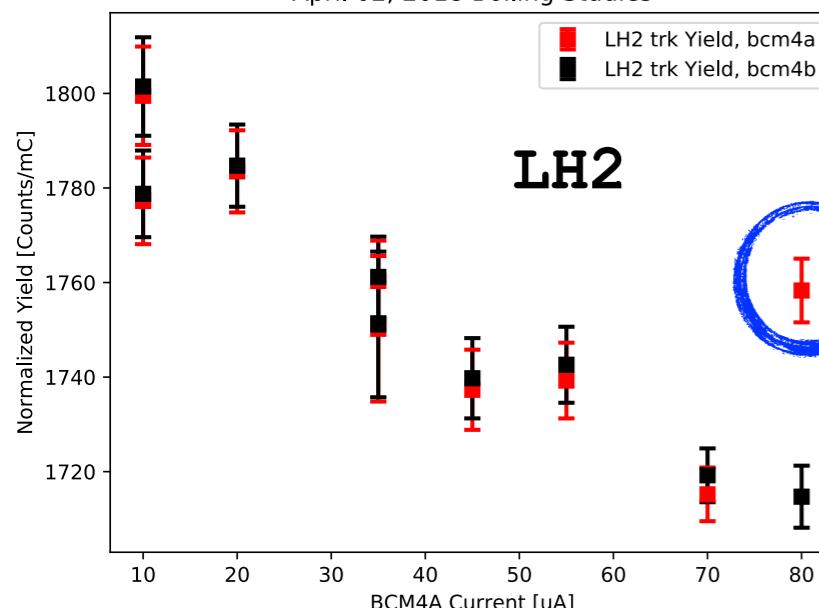
Normalized Yields vs. Beam Current

April 02, 2018 Boiling Studies



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

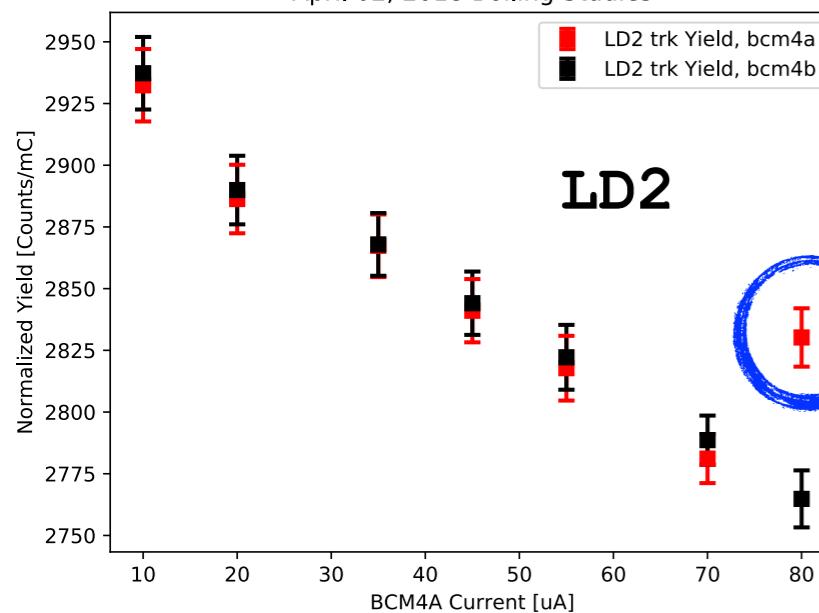
April 02, 2018 Boiling Studies



At high current ($>75 \mu$ A), BCM4A shows signs of saturation.

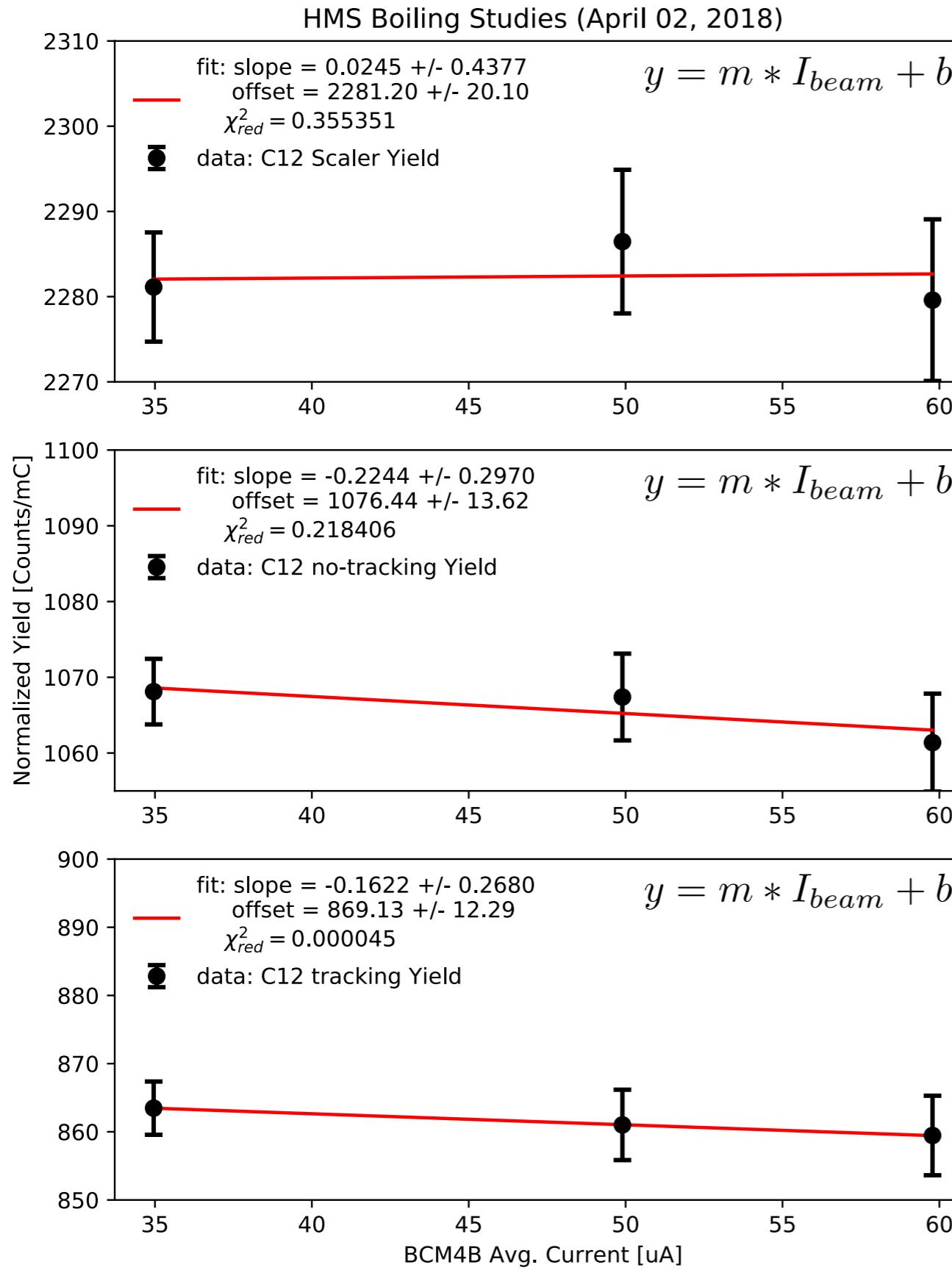
BCM4b was used in these studies.

April 02, 2018 Boiling Studies



See Dave Mack, Deepak and Deb's Talk

Carbon Normalized Yields vs. Beam Current



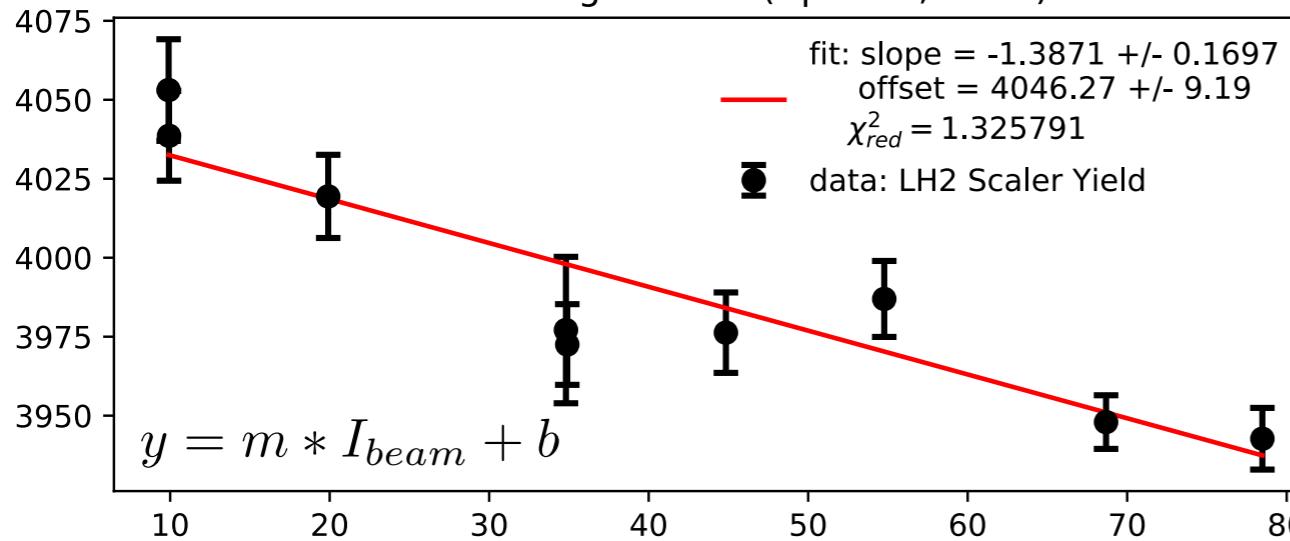
→ **Scaler Yields**

→ **Non-Tracking Yields**

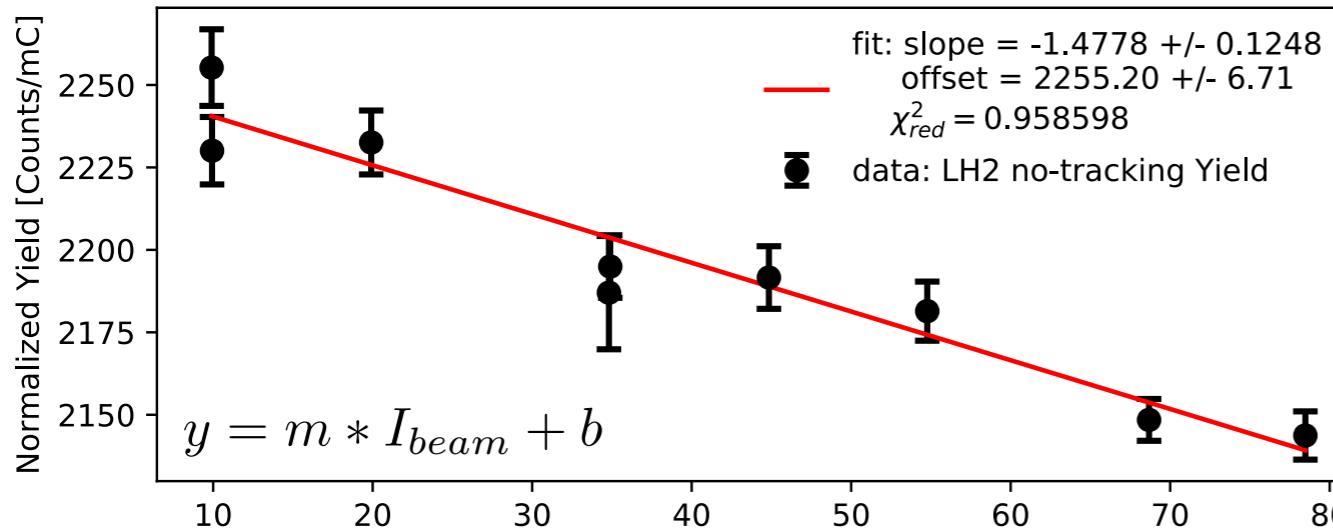
→ **Tracking Yields**

Hydrogen Normalized Yields vs. Beam Current

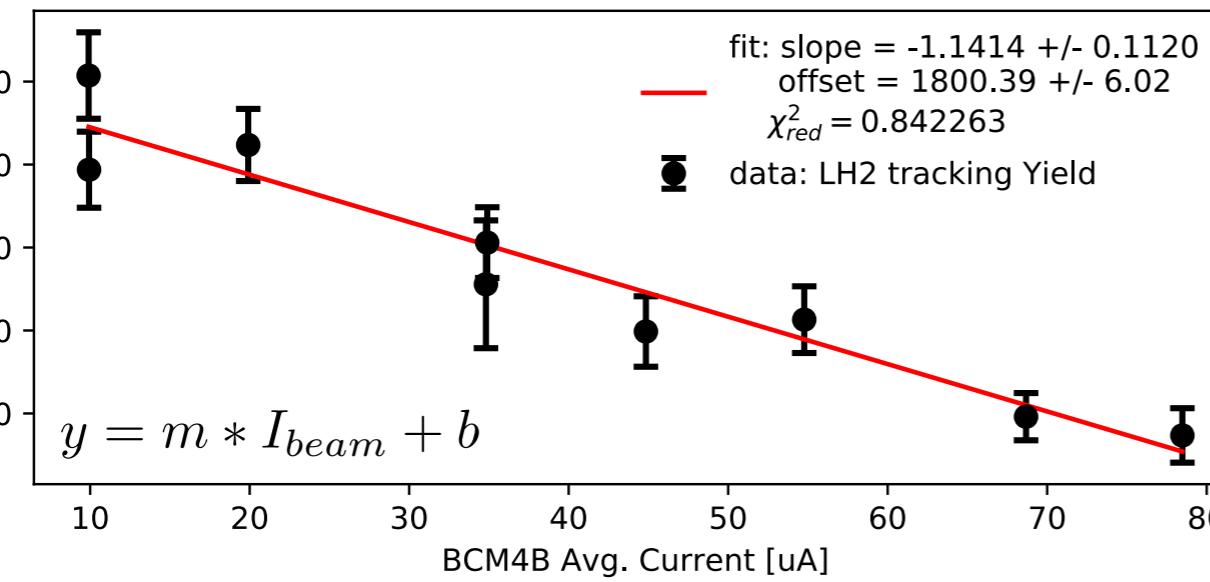
HMS Boiling Studies (April 02, 2018)



→ **Scaler Yields**

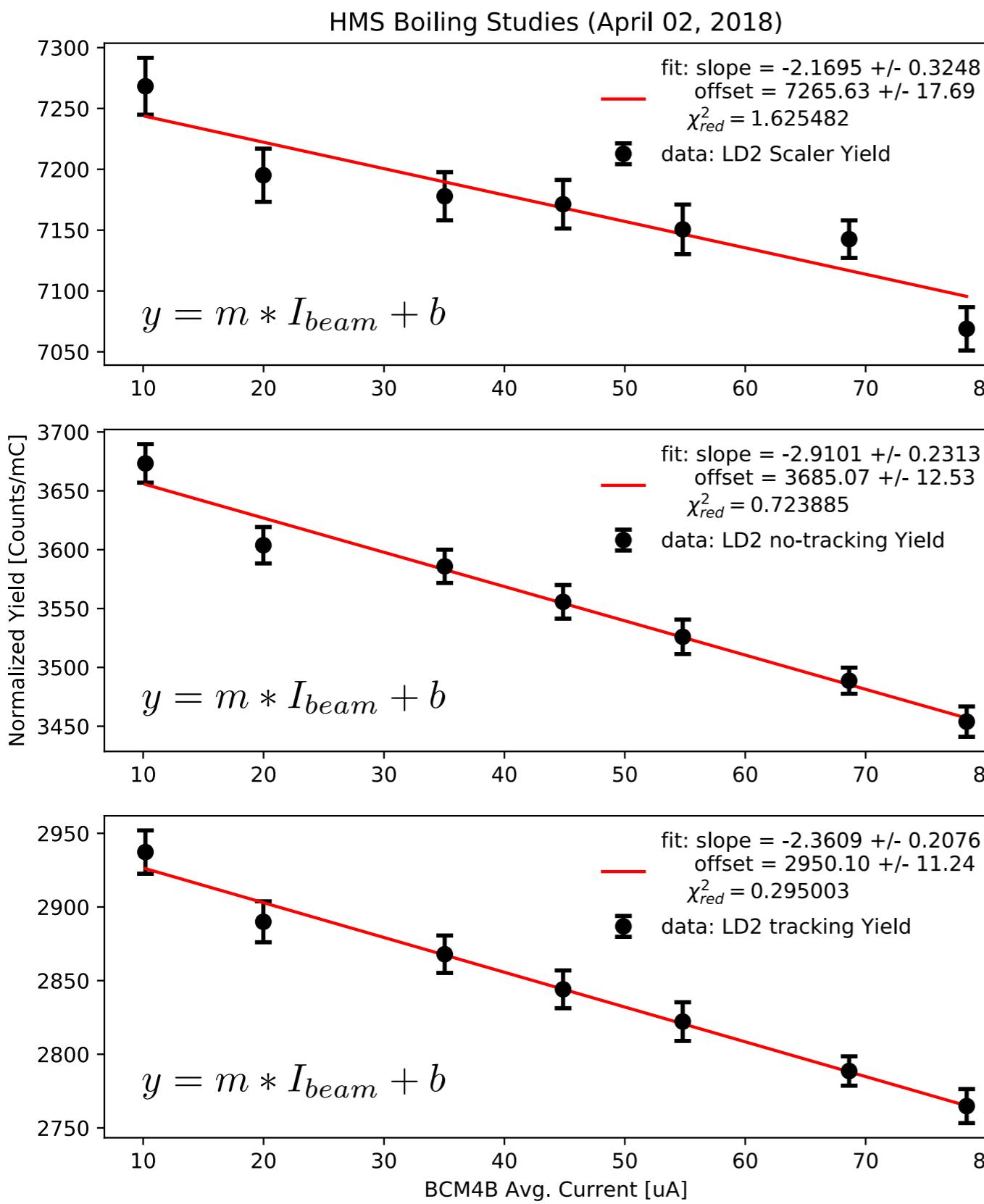


→ **Non-Tracking Yields**



→ **Tracking Yields**

Deuterium Normalized Yields vs. Beam Current



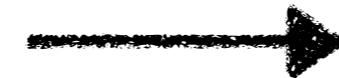
→ **Scaler Yields**

→ **Non-Tracking Yields**

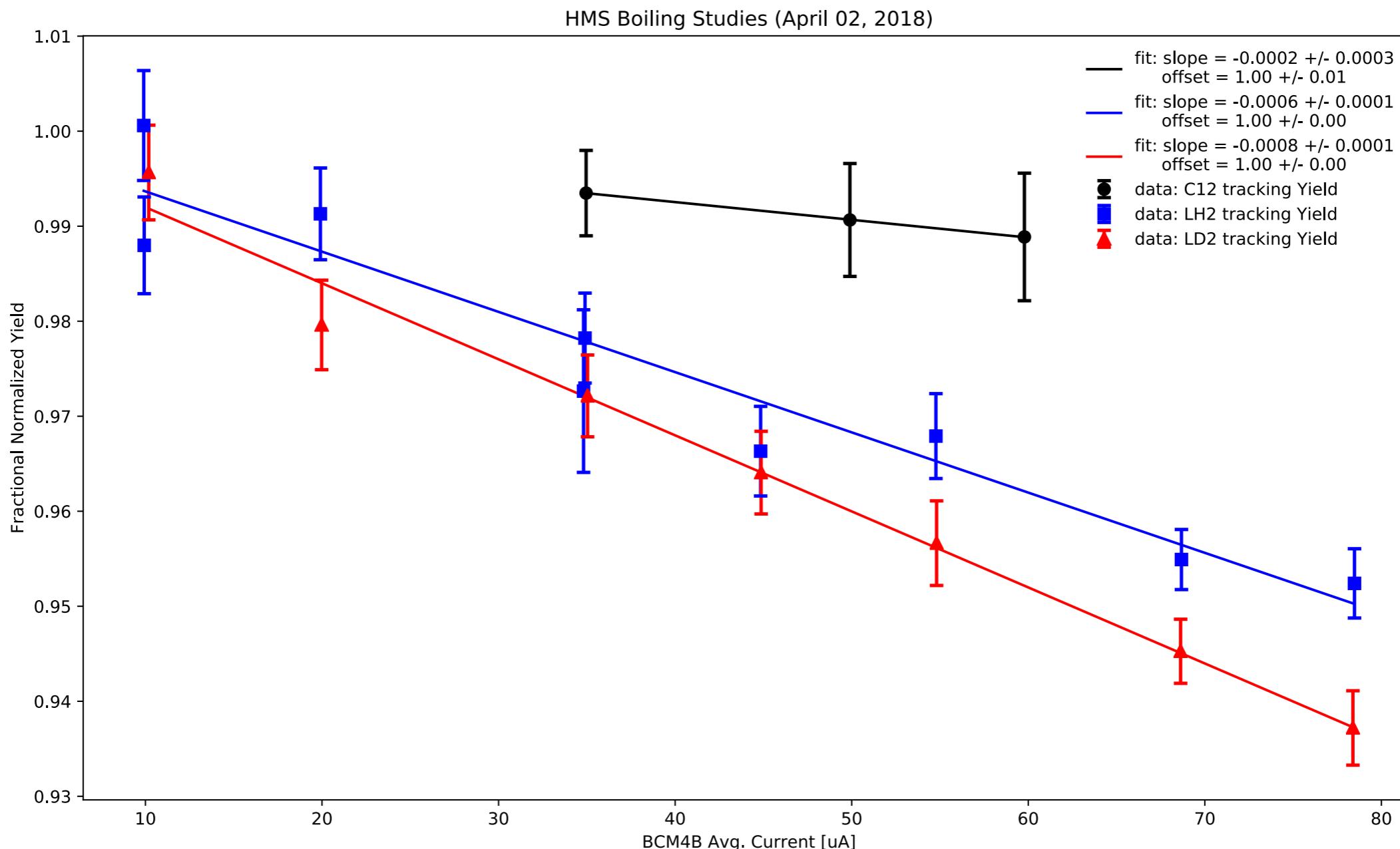
→ **Tracking Yields**

HMS Boiling Studies Results

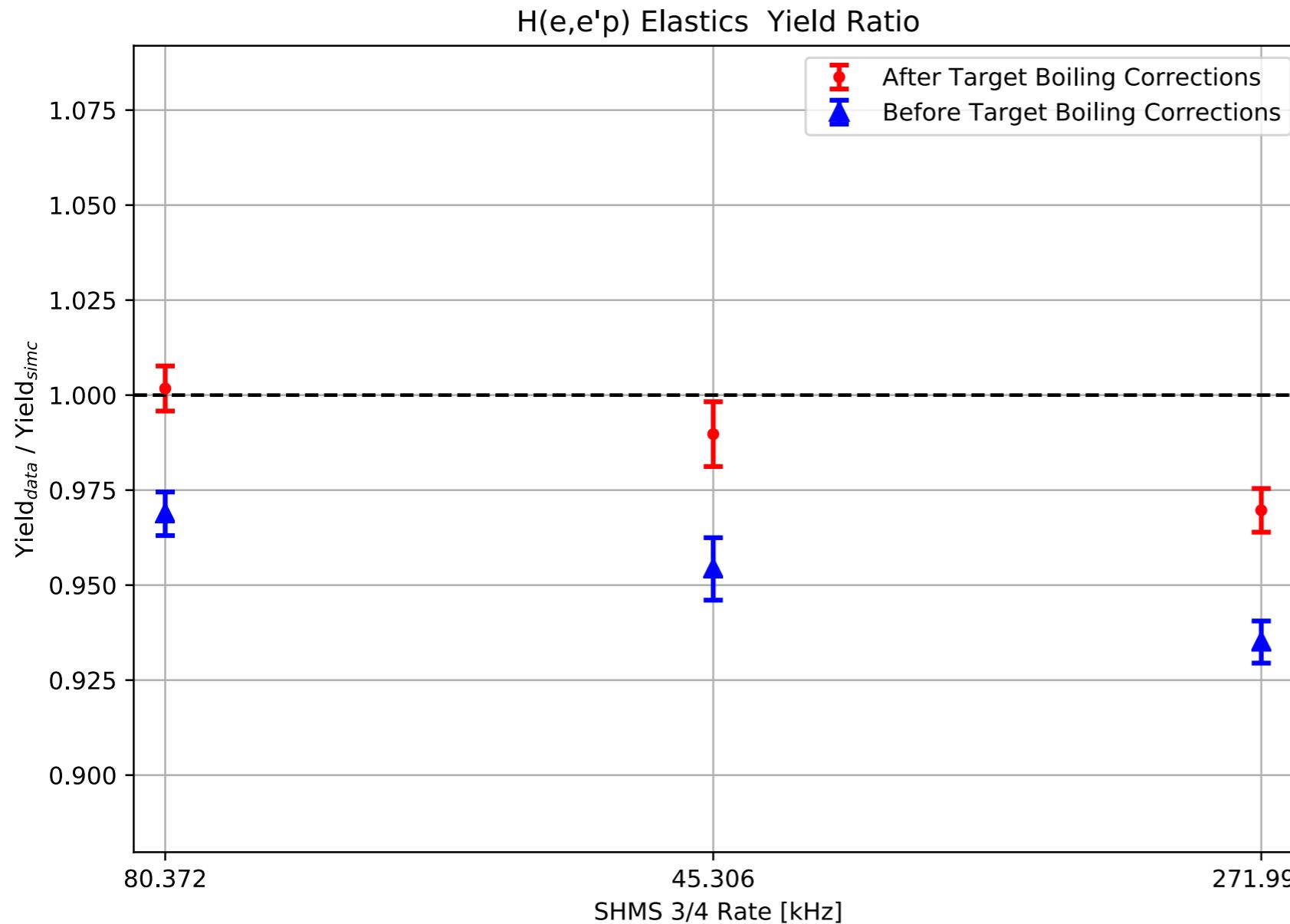
Divide by the offset parameter
to re-normalize data to unity



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



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



Cuts: $|\delta_{HMS}| < 8\%$
 $\delta_{SHMS}(-10, 22)\%$
 $SHMS \text{ Cal } E_{dep}/P_{cent} \geq 0.6$
W: (0.85, 1.05)

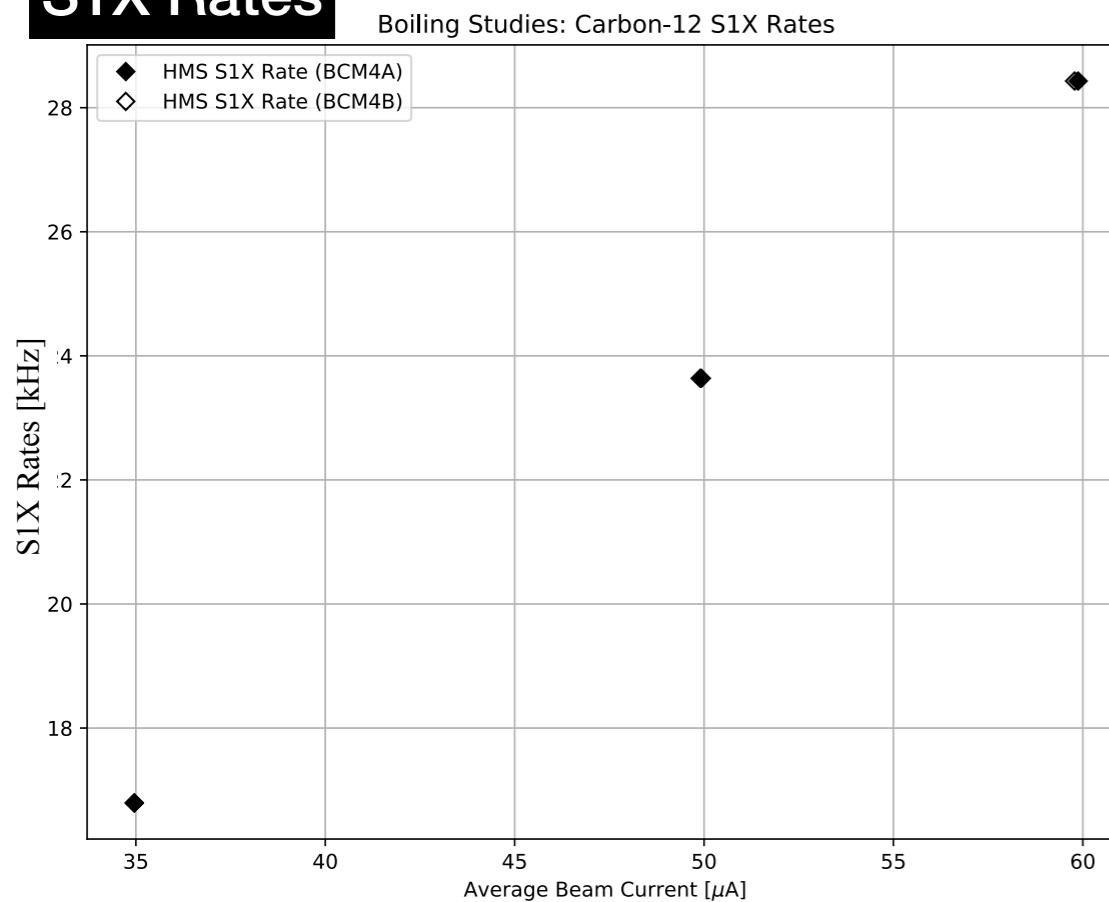
Multiply average beam current by Boiling Fit Slope to estimate the target boiling correction.

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

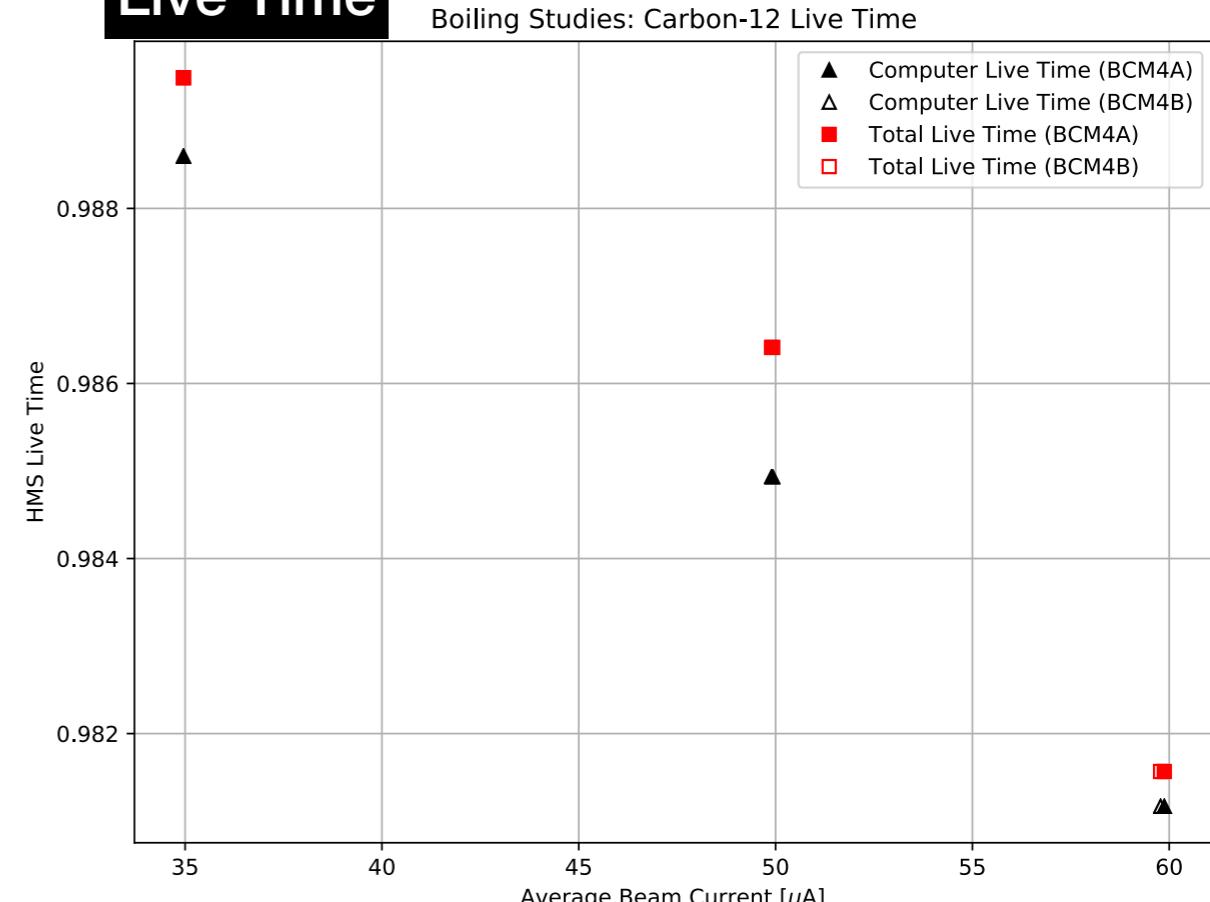
Back-Up Slides

Carbon-12: Rates / Live Times / Tracking Efficiencies

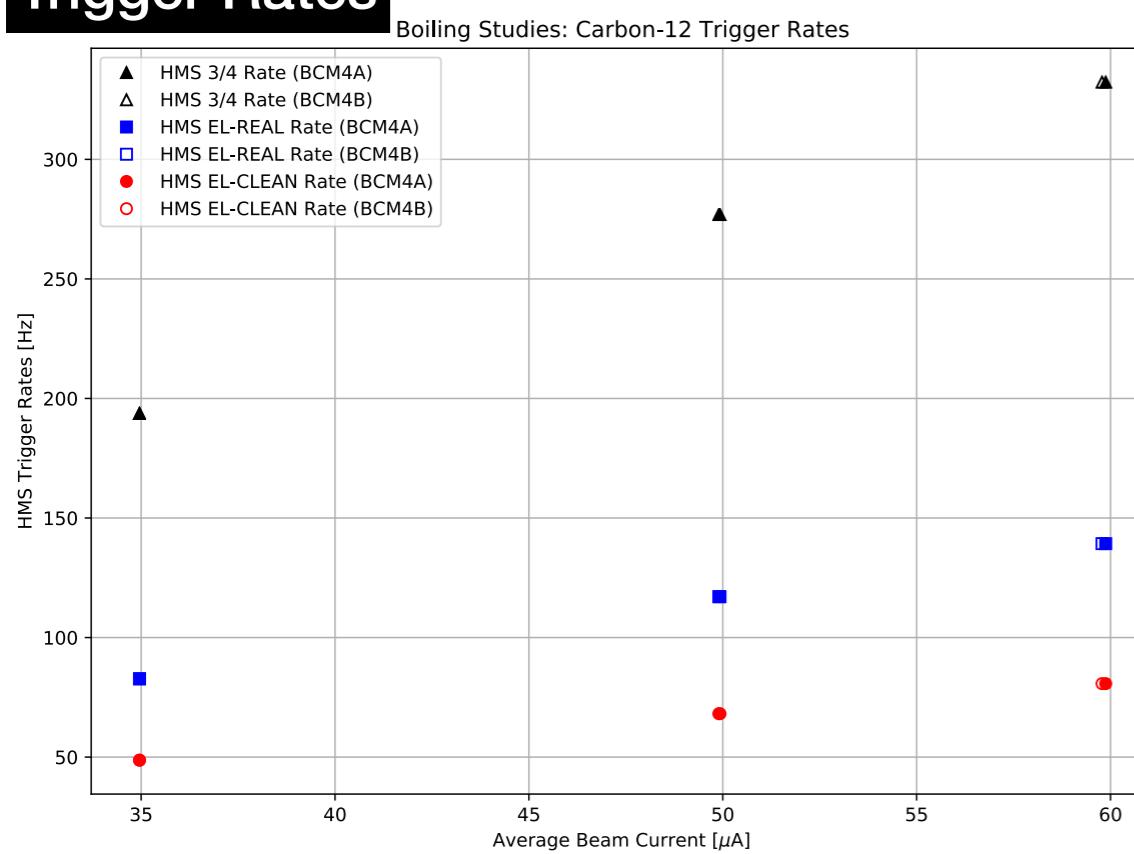
S1X Rates



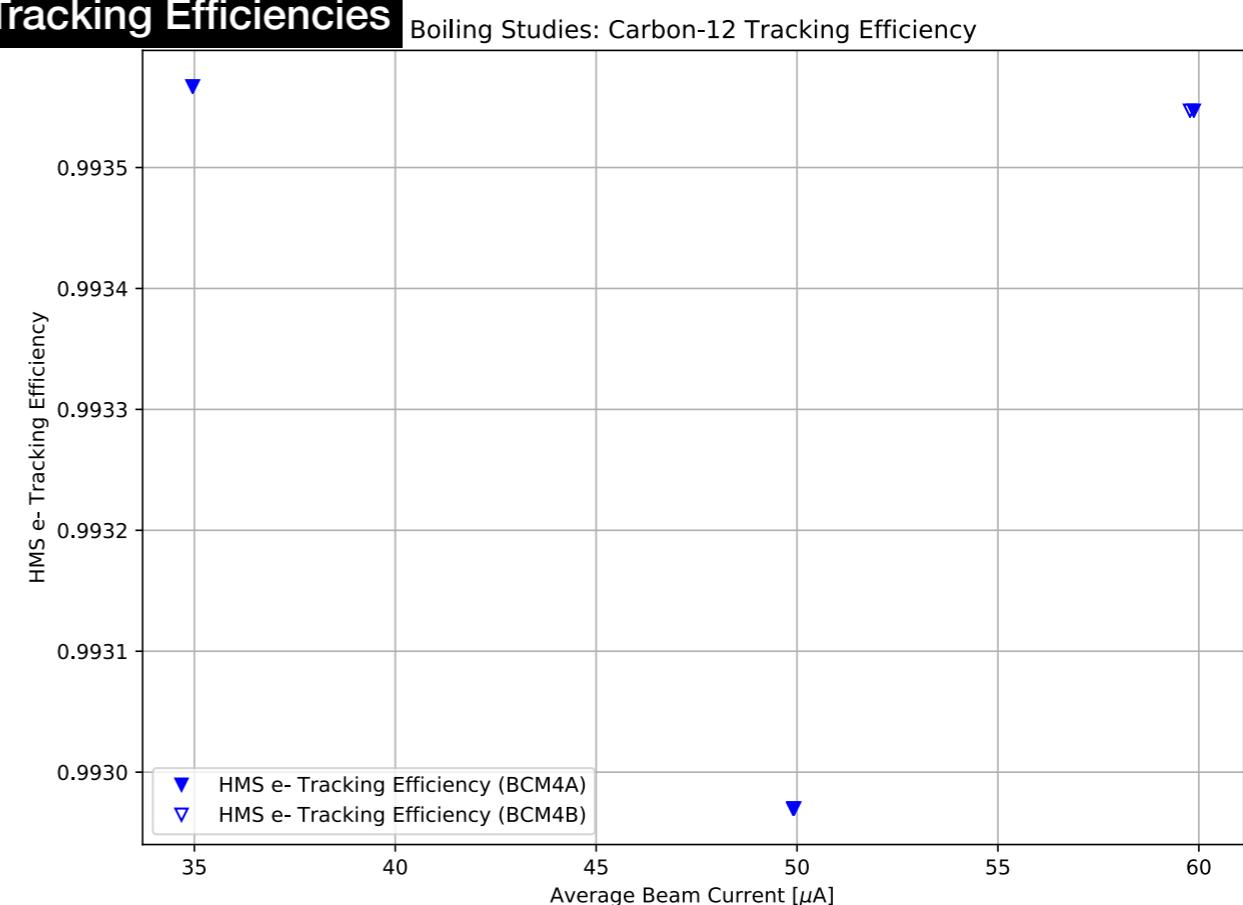
Live Time



Trigger Rates



Tracking Efficiencies

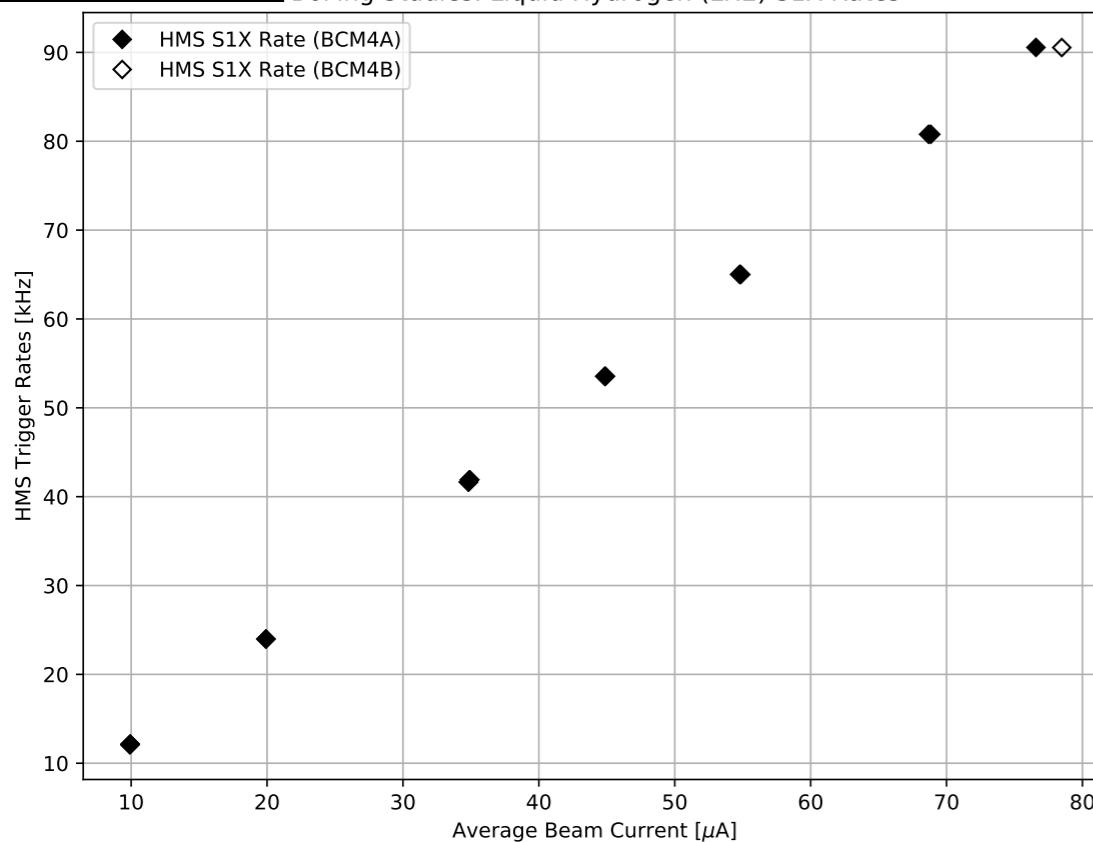


LH2: Rates / Live Times / Tracking Efficiencies

S1X Rates

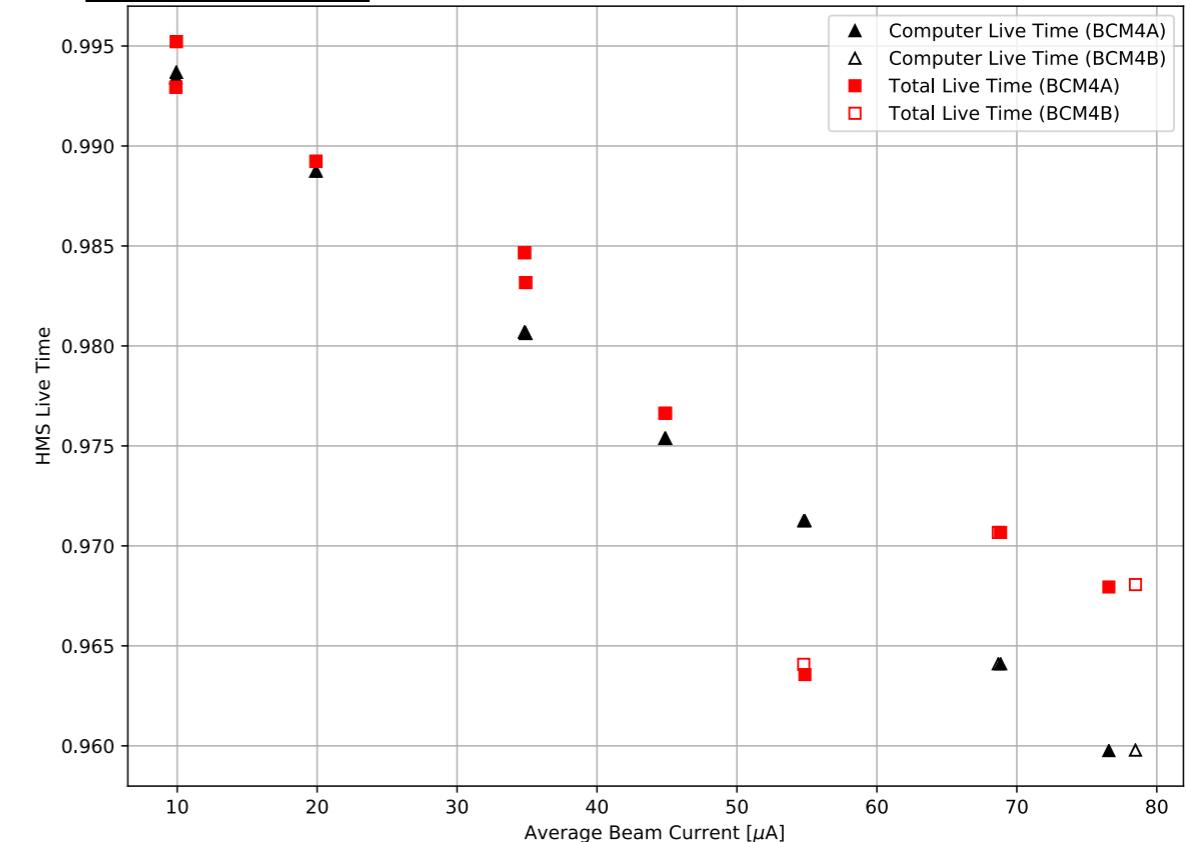
Boiling Studies: Liquid Hydrogen (LH2) S1X Rates

S1X Rates [kHz]



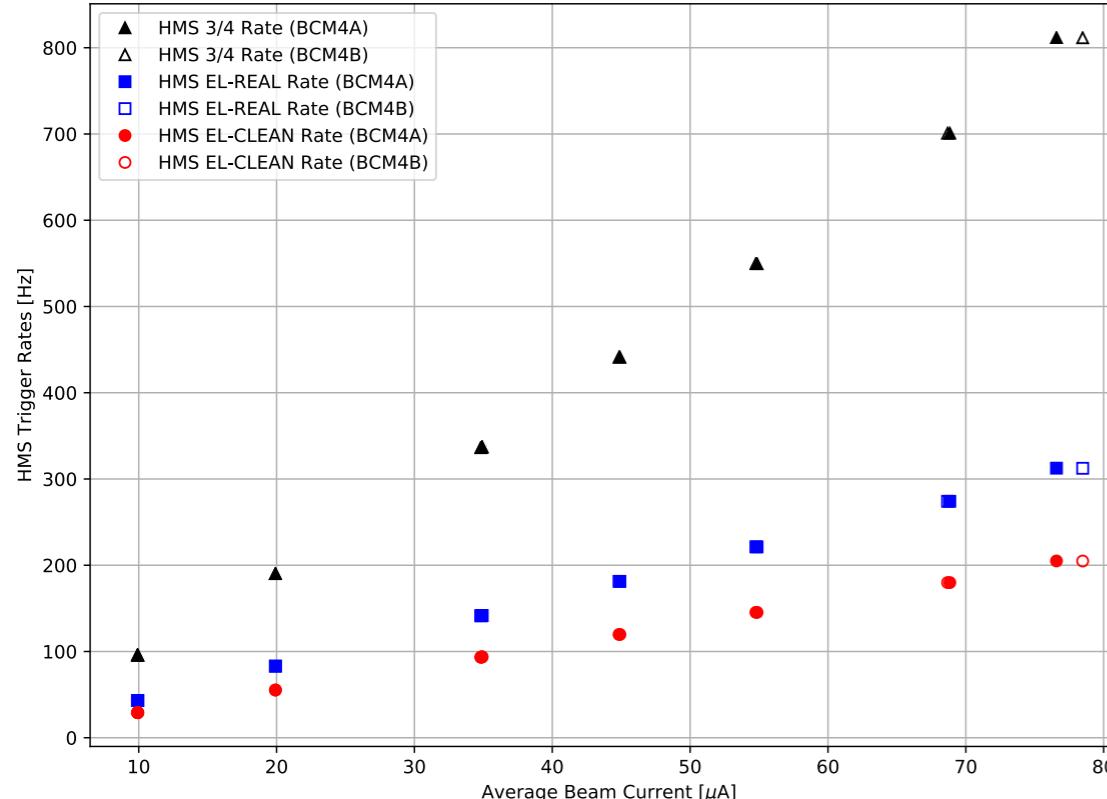
Live Time

Boiling Studies: Liquid Hydrogen (LH2) Live Time



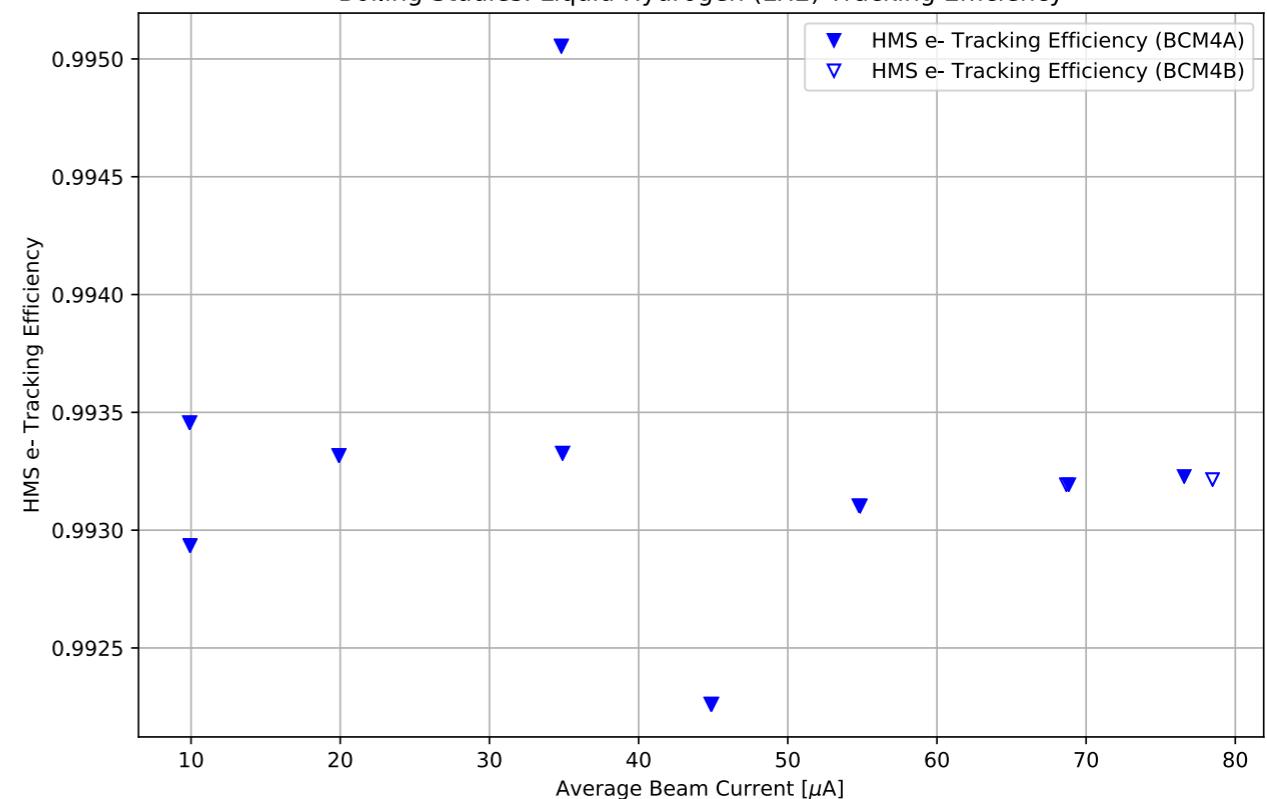
Trigger Rates

Boiling Studies: Liquid Hydrogen (LH2) Trigger Rates



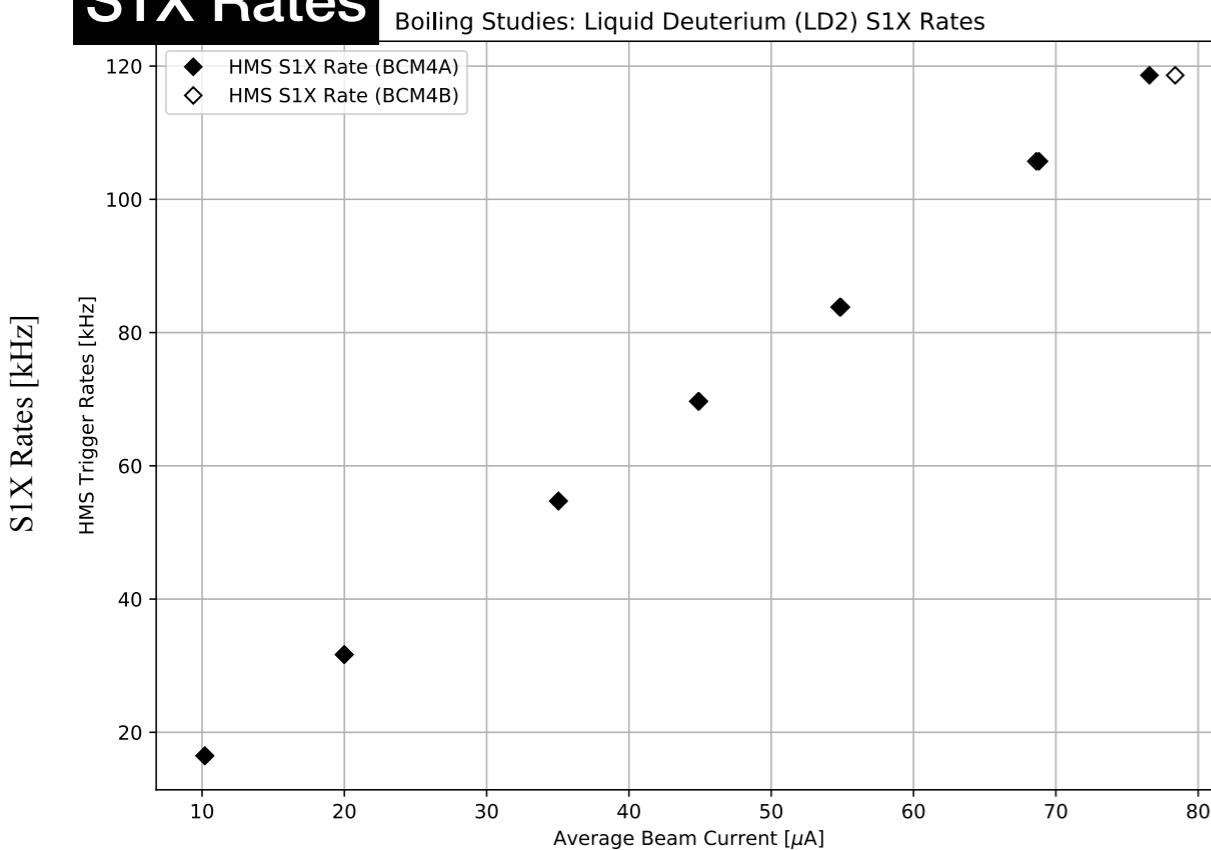
Tracking Efficiencies

Boiling Studies: Liquid Hydrogen (LH2) Tracking Efficiency

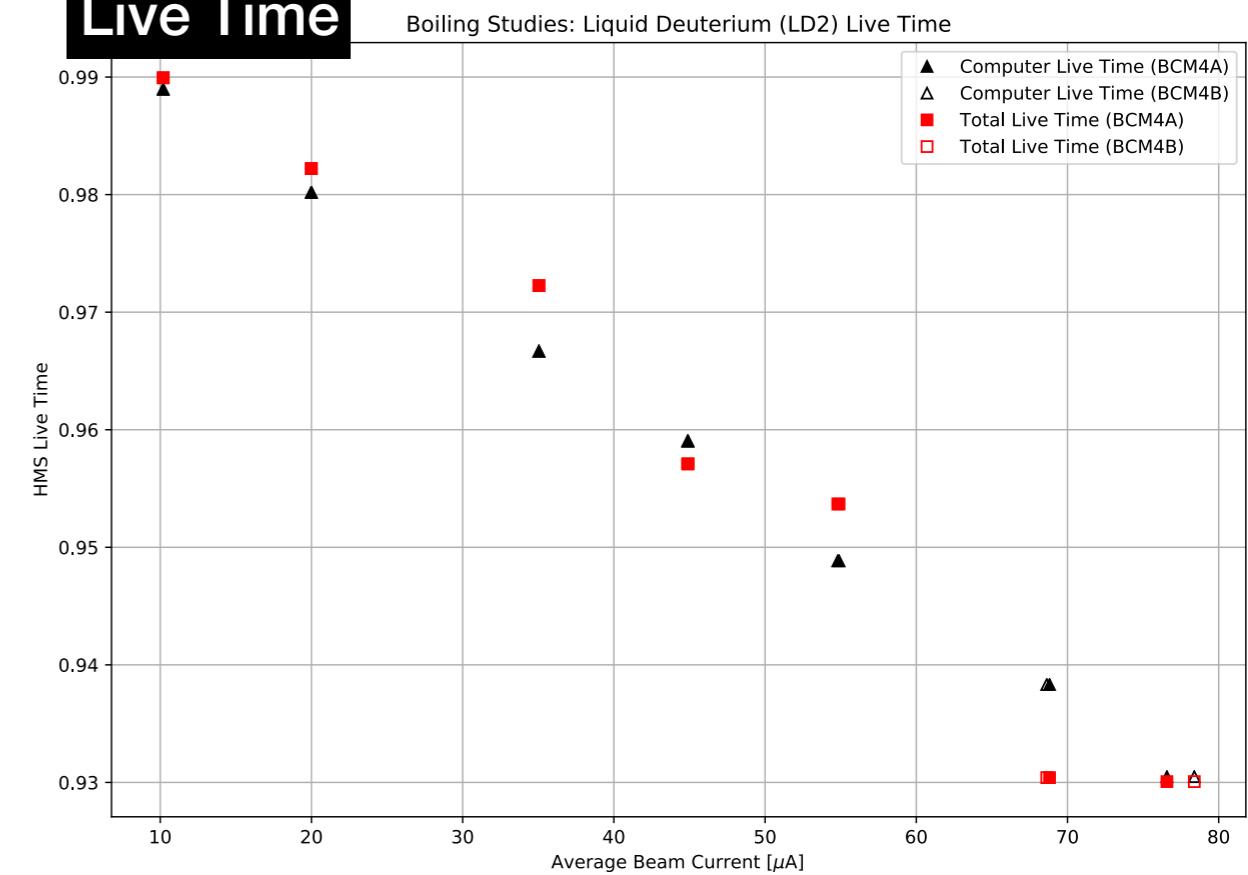


LD2: Rates / Live Times / Tracking Efficiencies

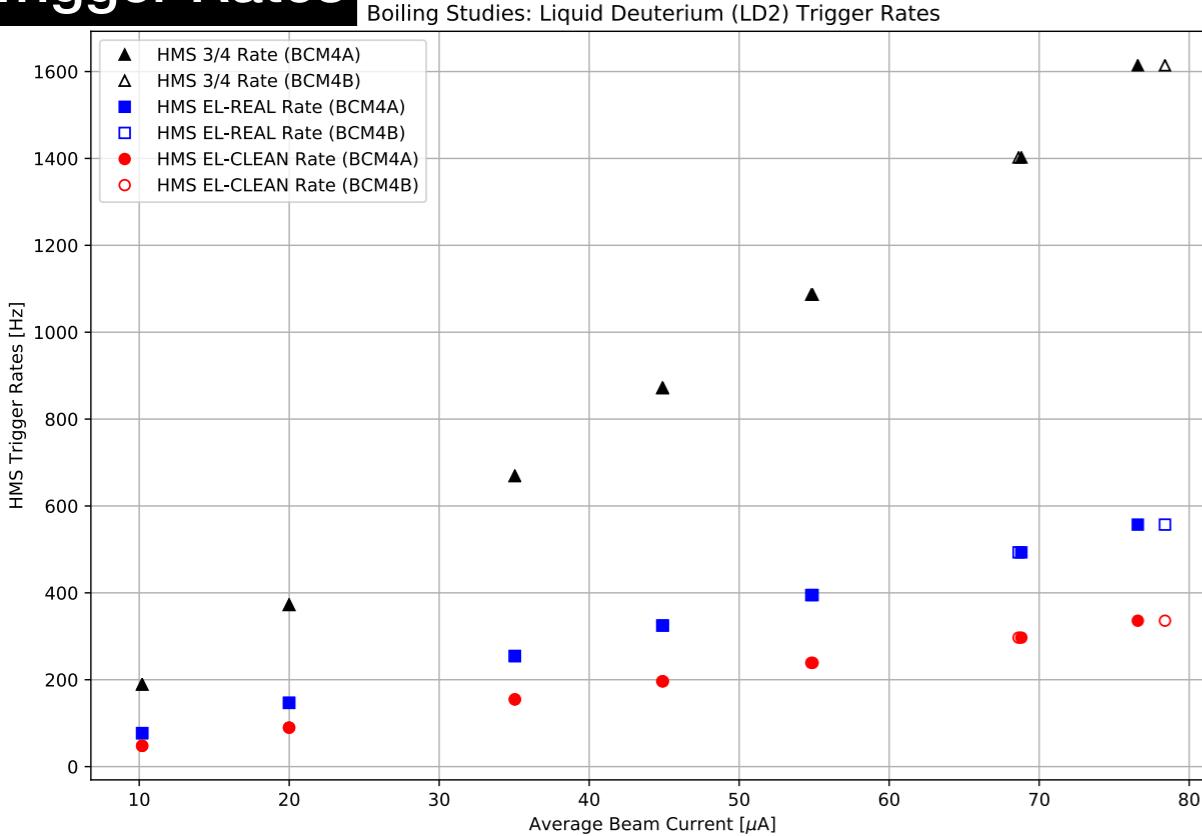
S1X Rates



Live Time



Trigger Rates



Tracking Efficiencies

