

# HMS Target Boiling Studies

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HMS (Singles Mode DAQ)

Angle: 25 deg

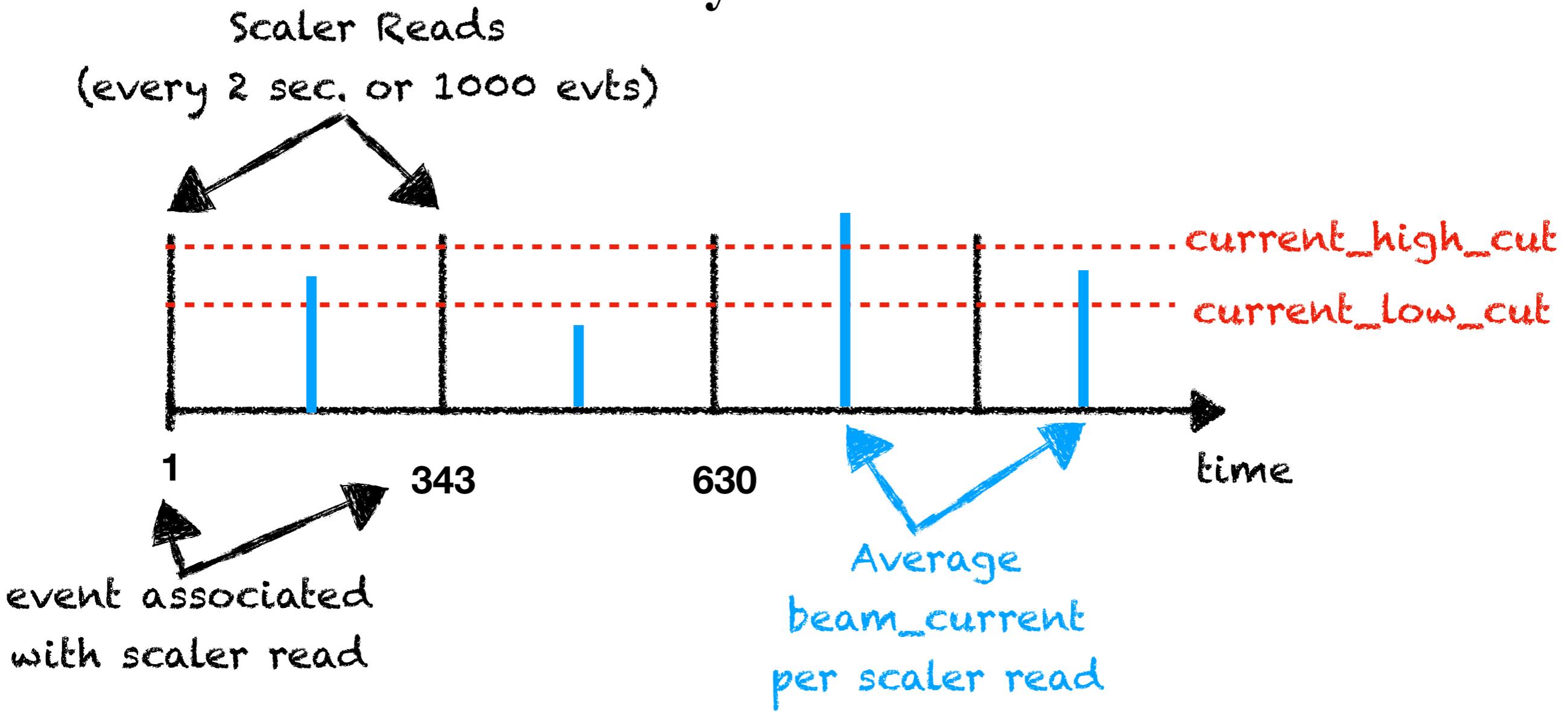
Momentum: -4.4 GeV (electrons)

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



- 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<sup>4</sup>

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

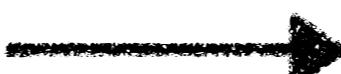


$N_{scaler}$  → HMS trigger scaler counter **ONLY** if  
BCM scaler current cut passed

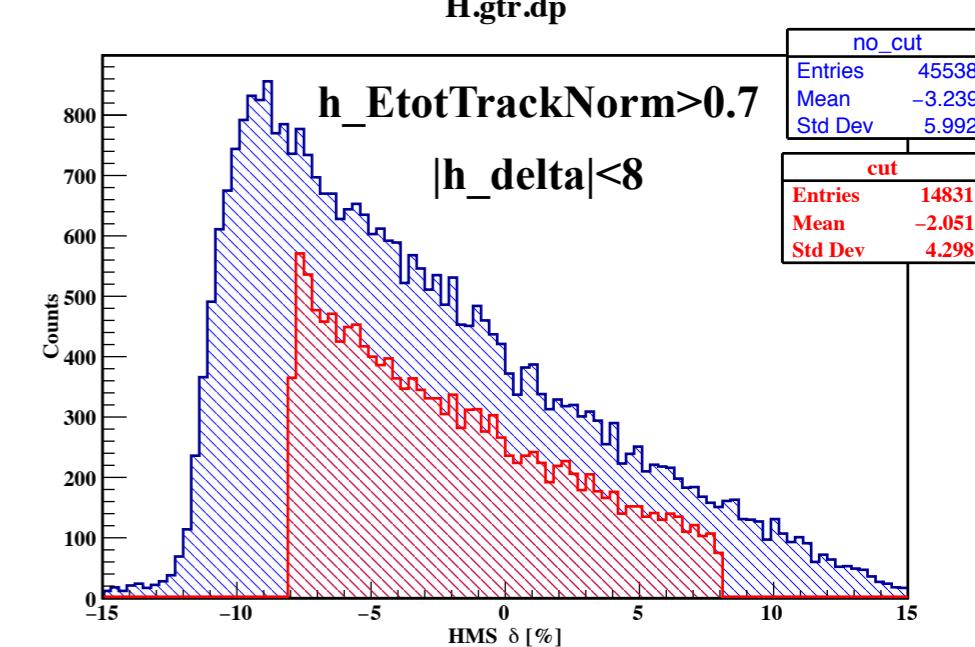
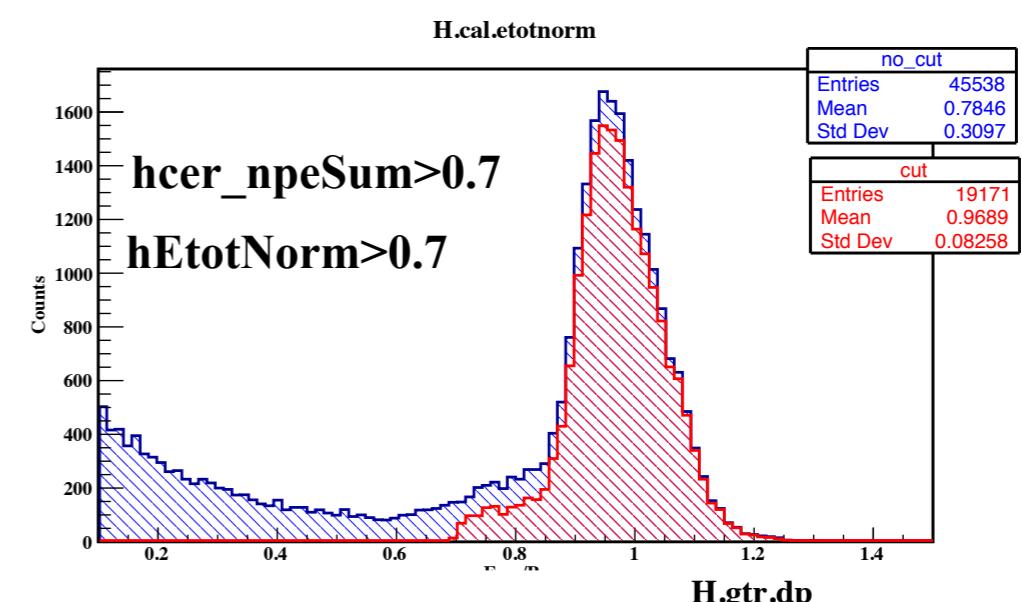
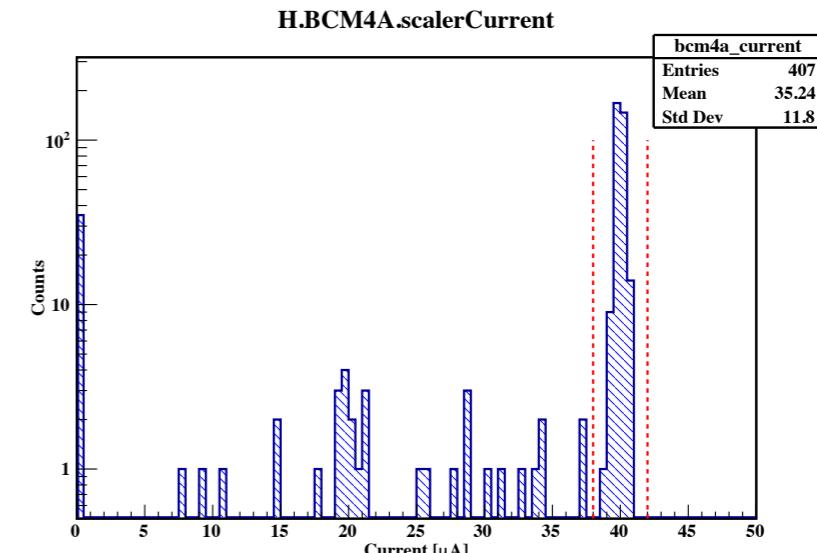
$$Y_{no\_track} = \frac{N_{accepted}}{Q_{tot} * \epsilon_{cpuLT}}$$



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



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



# Analysis Outline: Calculating Charge Normalized Yield 5

## 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 <sup>6</sup>

## Code Snippet: Data Event Loop

```
419 //-----Check If BCM4A Current is within limits-----  
420 if(evt_flag_bcm4a[scal_read]==1){  
421  
422     //Count Accepted EDTM events  
423     if(c_edtm){  
424         total_hedtm_accp_cut_4a++;  
425     }  
426  
427     //Count Accepted hTRIG2 events (without EDTM)  
428     if(c_htrig2&&c_noedtm){  
429         total_htrig2_accp_cut_4a++;  
430     }  
431  
432     if(c_noedtm) {  
433  
434         //Make Cuts to Count Yield  
435         //---Get NON-TRACKING Yield  
436         if(c_cerNpesum&&c_etotnorm)  
437         {  
438             H_hCAL_etotnorm_ntrkY_4a->Fill(hCAL_etotnorm);  
439             Y_ntrk_4a++;  
440         }  
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 <sup>7</sup>

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
```

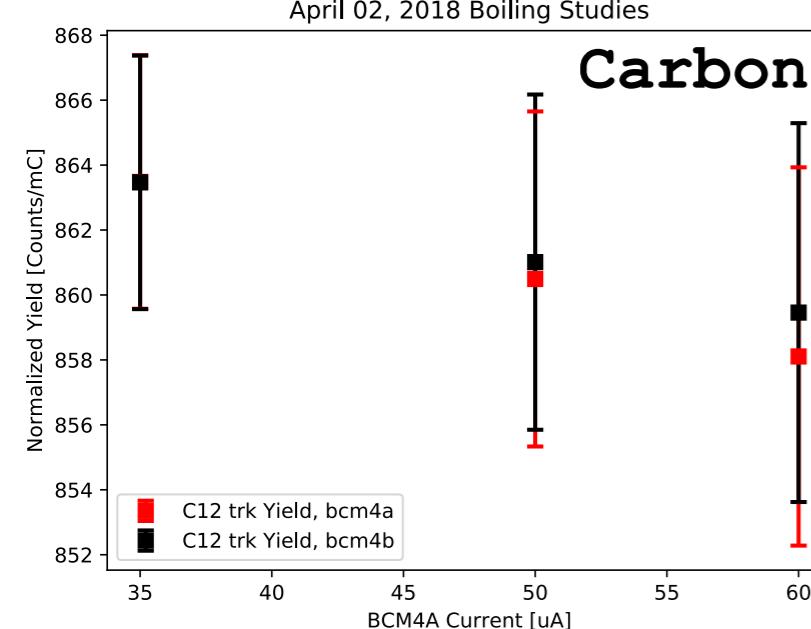
Relevant  
Formulas

## Yield Calculations

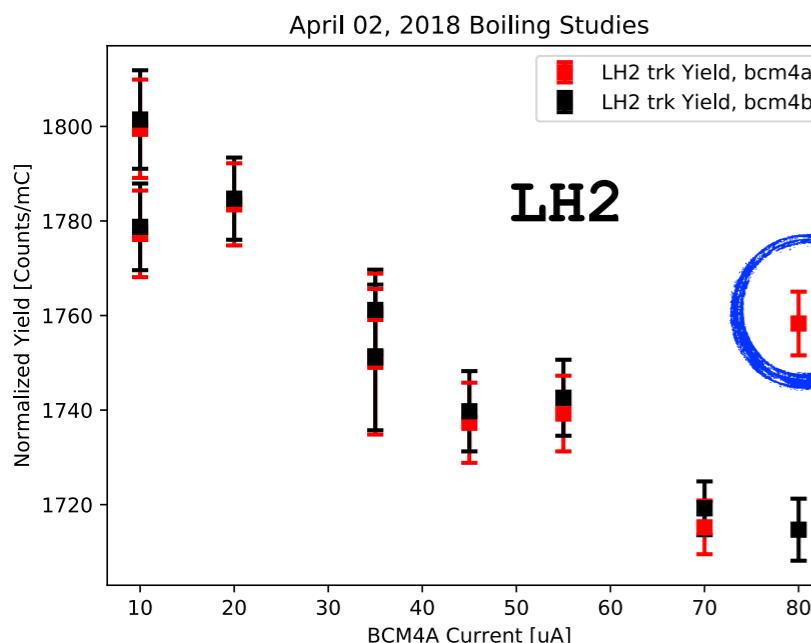
```
-----SCALER YIELD-----  
//BCM4A  
scl_Yield_bcm4a = (total_htrig2_scaler_bcm4a_cut-total_hedtm_scaler_bcm4a_cut) / (total_charge_bcm4a_cut);  
scl_err_bcm4a = sqrt(total_htrig2_scaler_bcm4a_cut) / total_charge_bcm4a_cut;  
//BCM4B  
scl_Yield_bcm4b = (total_htrig2_scaler_bcm4b_cut-total_hedtm_scaler_bcm4b_cut)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

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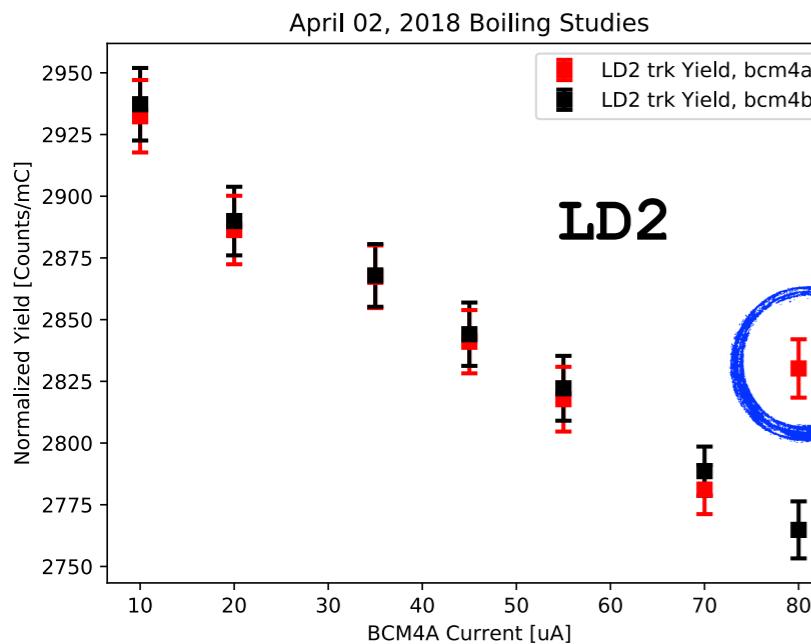


Carbon shows 'flat' norm. Yields within uncertainty. This is used as a cross-check before looking at LH2 or LD2.



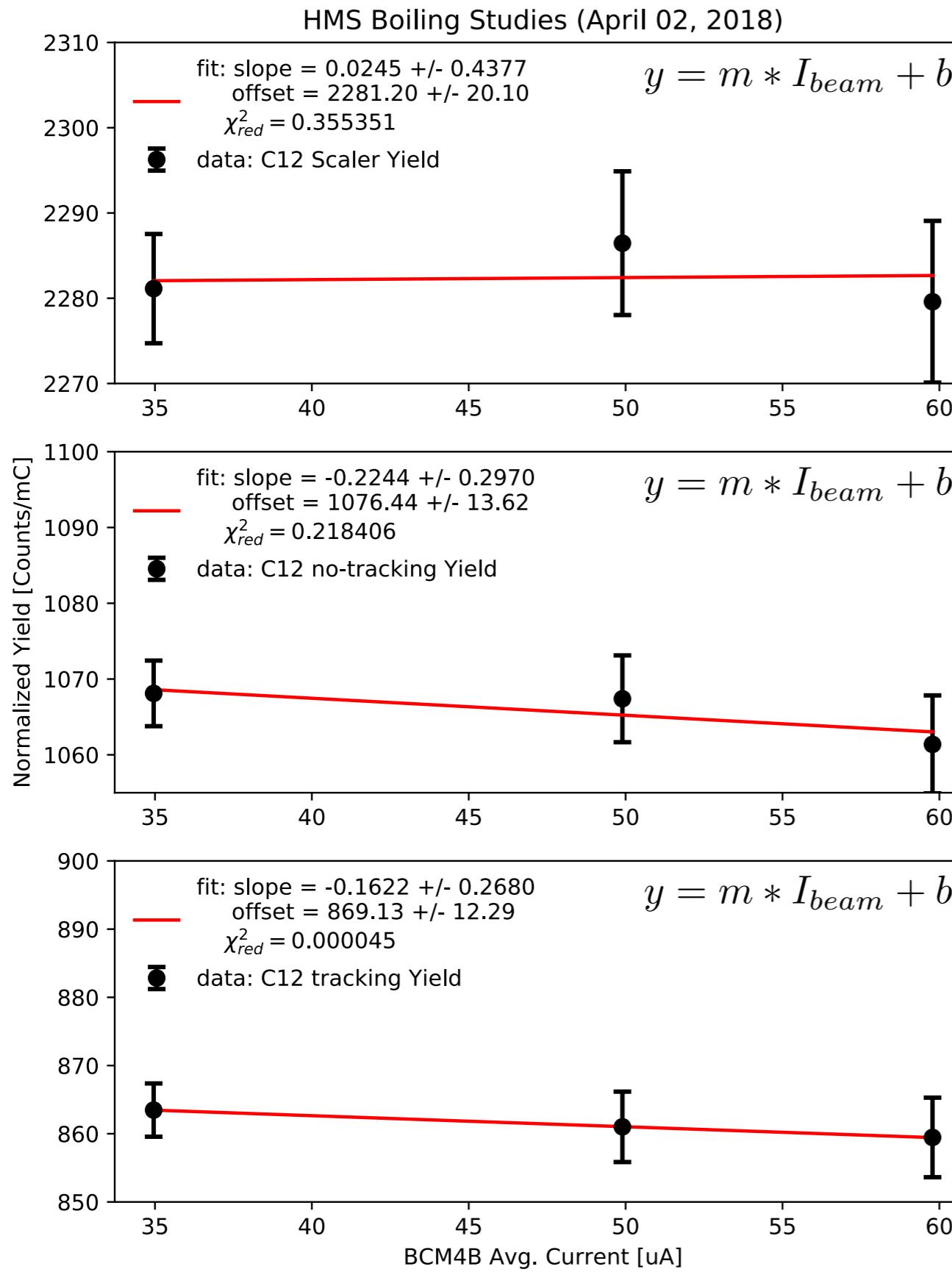
At high current ( $>75 \mu$ A), BCM4A shows signs of saturation.

BCM4b was used in these studies.



See Dave Mack, Deepak and Deb's Talk

# Carbon Normalized Yields vs. Beam Current



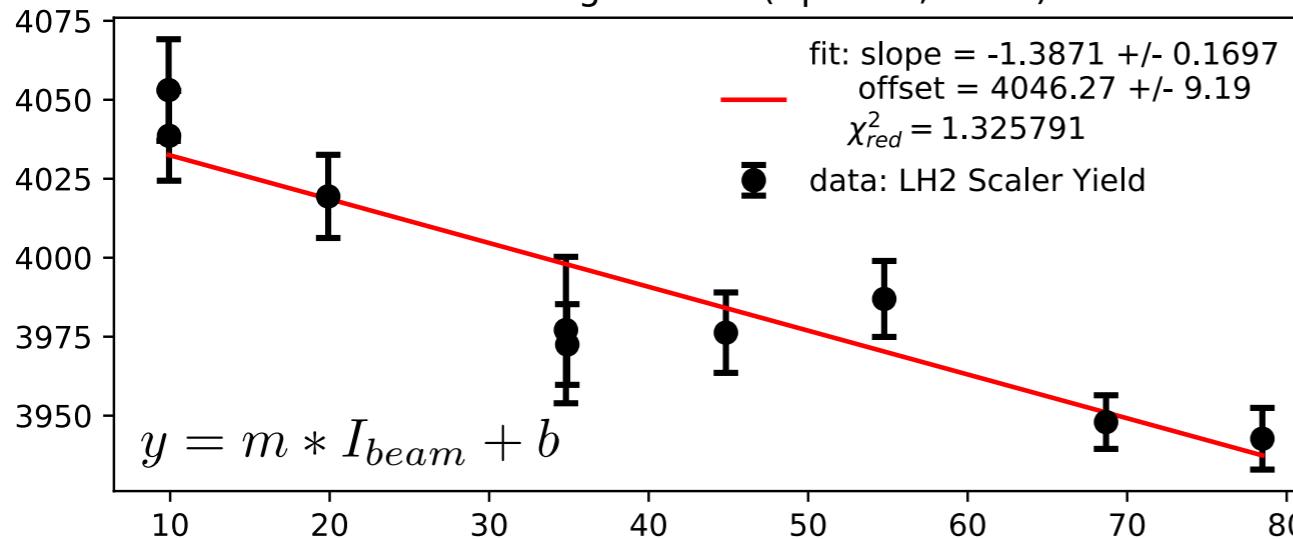
→ **Scaler Yields**

→ **Non-Tracking Yields**

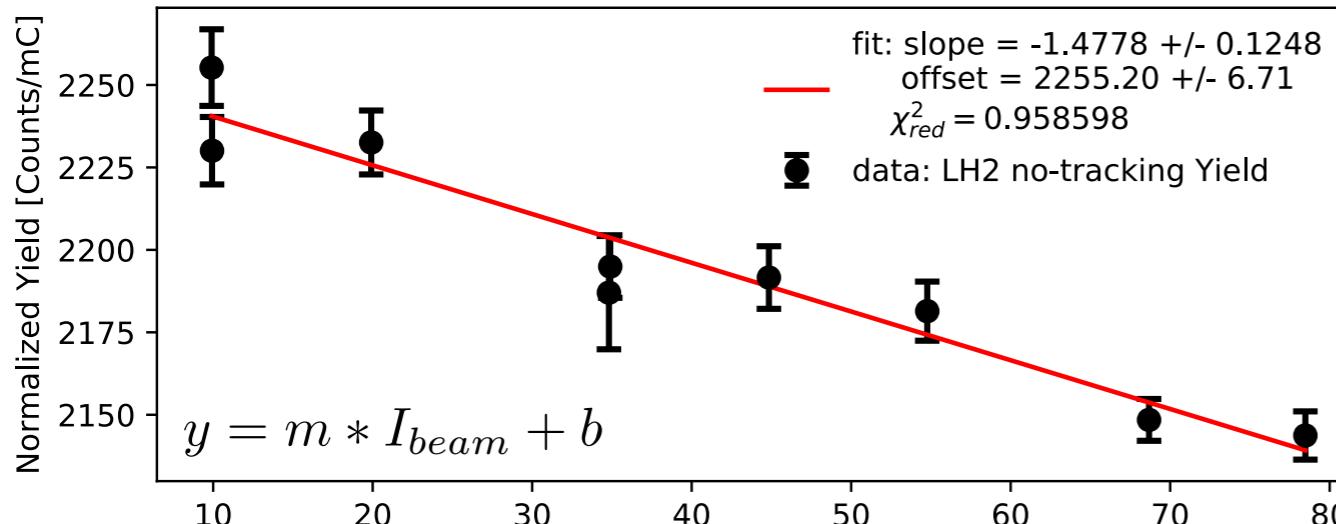
→ **Tracking Yields**

# Hydrogen Normalized Yields vs. Beam Current

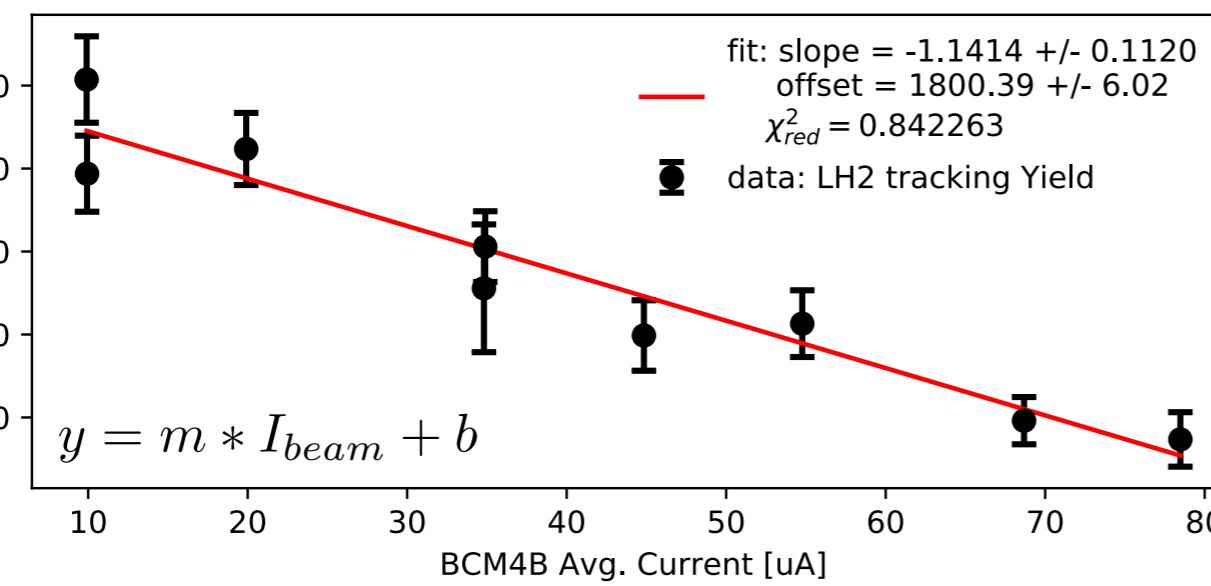
HMS Boiling Studies (April 02, 2018)



→ **Scaler Yields**



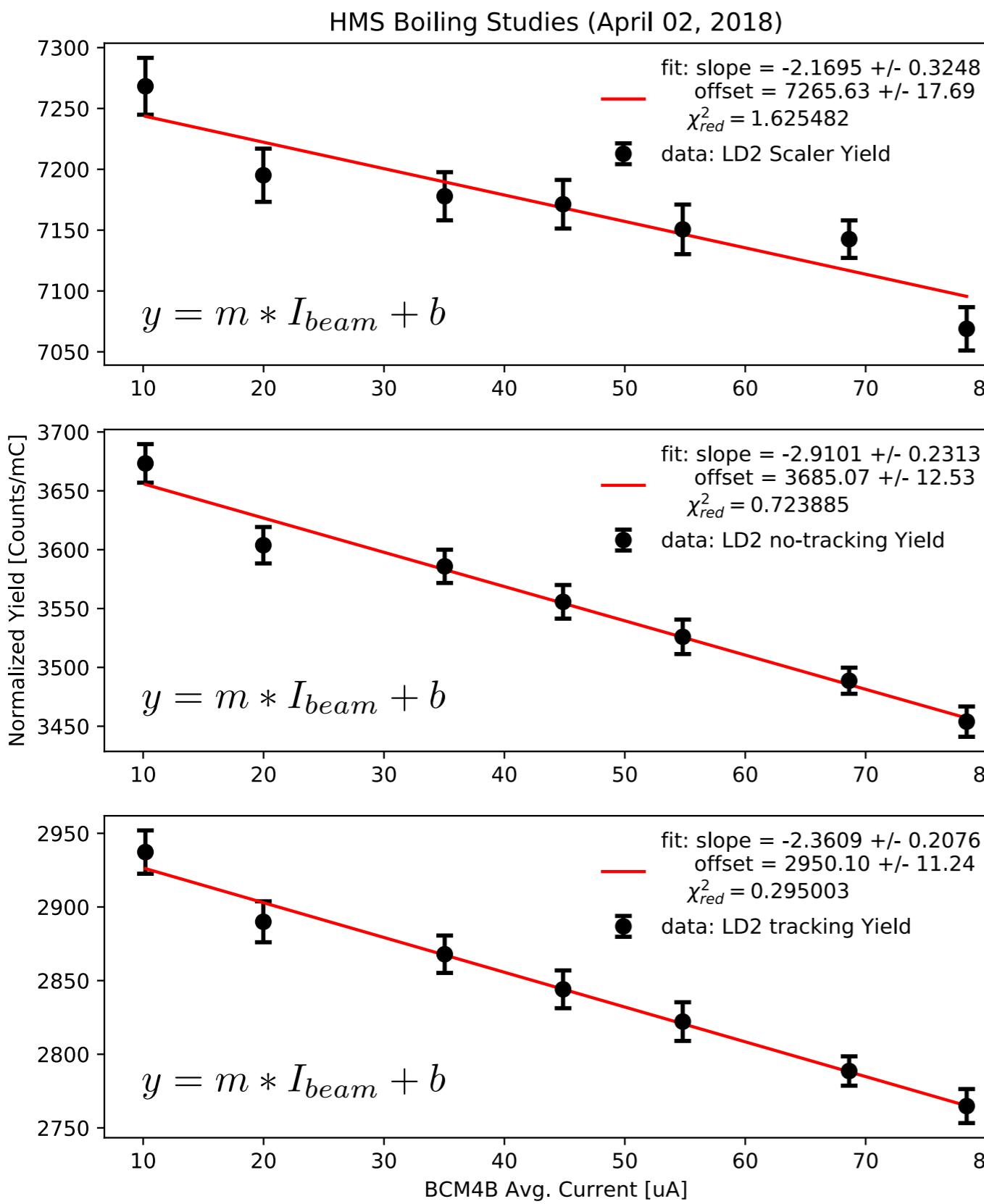
→ **Non-Tracking Yields**



→ **Tracking Yields**

# Deuterium Normalized Yields vs. Beam Current

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→ **Scaler Yields**

→ **Non-Tracking Yields**

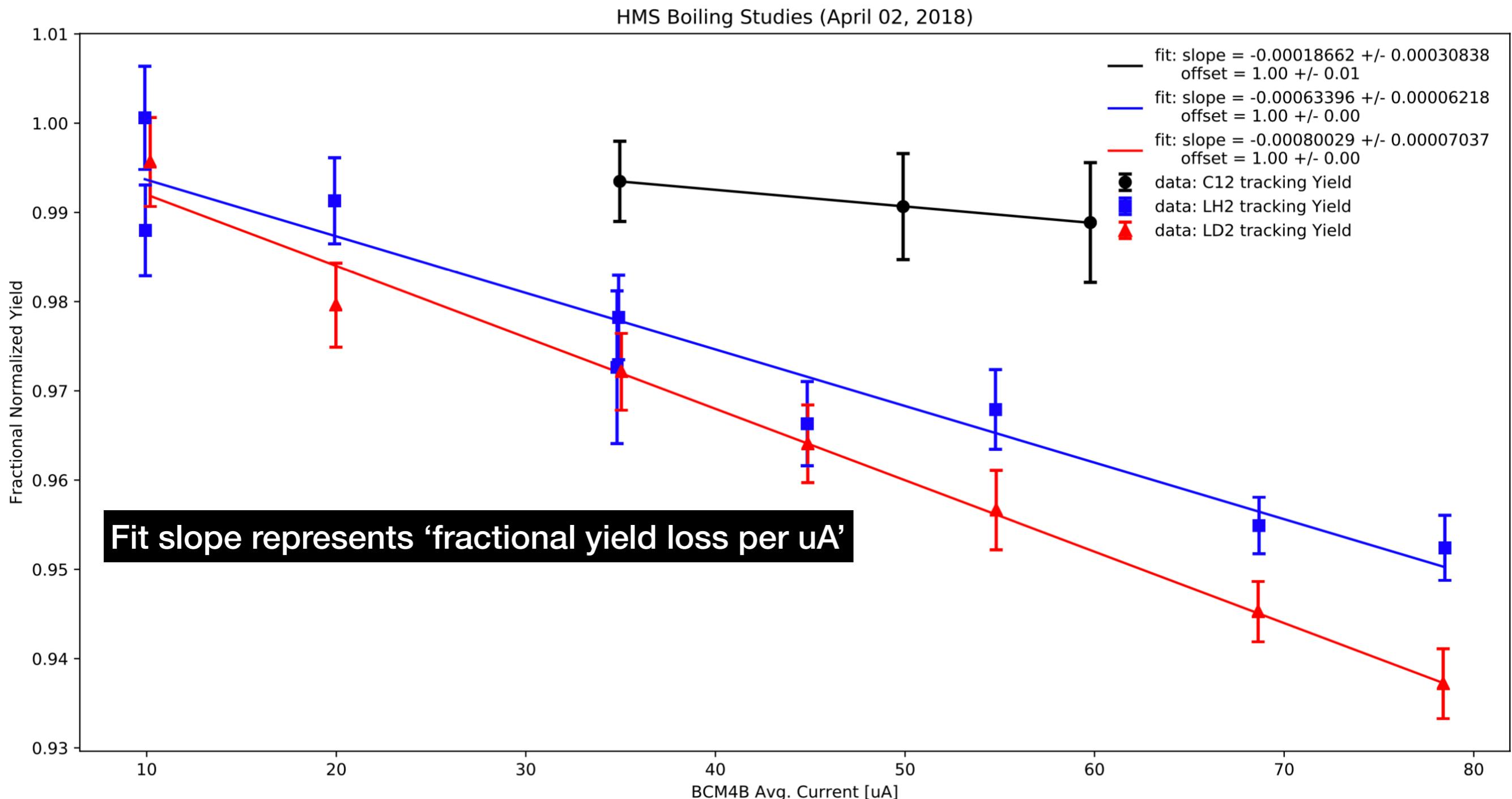
→ **Tracking Yields**

# HMS Boiling Studies Results

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



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



## HMS Boiling Studies FIT Results

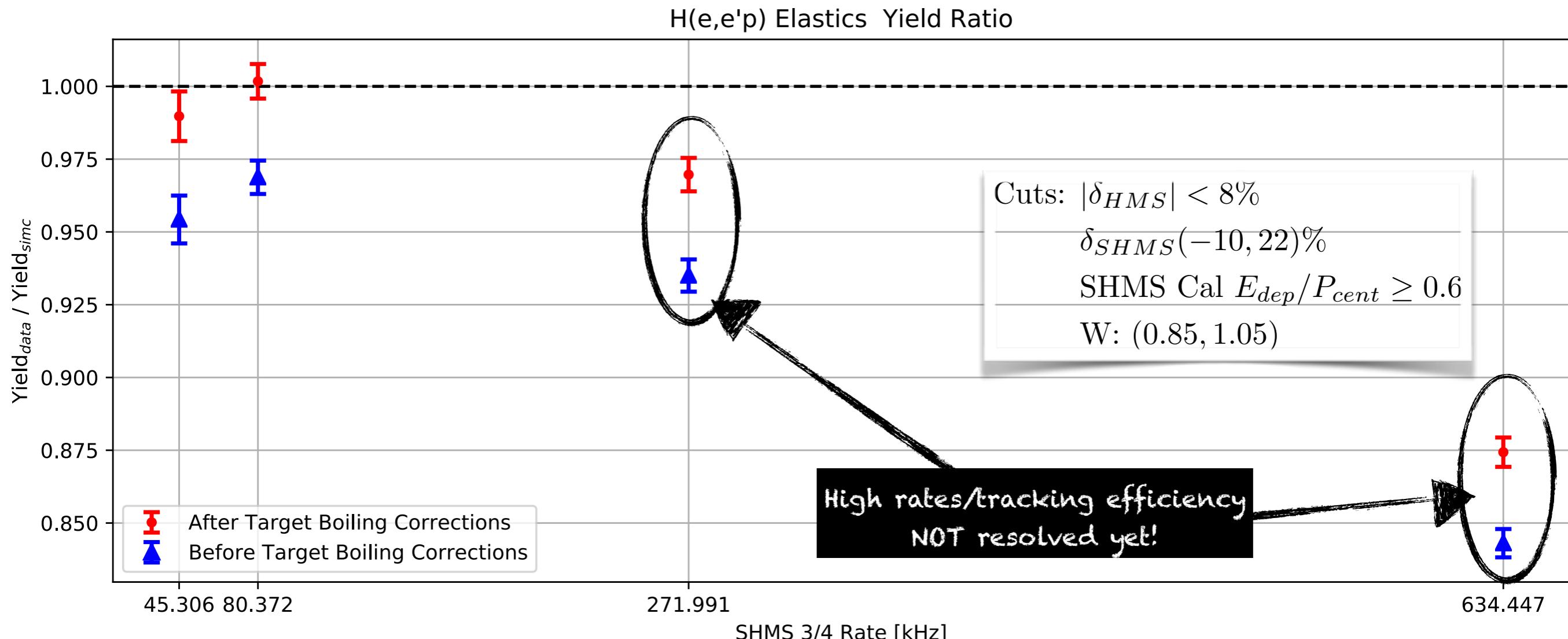
To summarize the previous slide with the final target boiling results, the fractional yield loss per micro-amp for each target is:

Carbon: –  $0.00018662 \pm 0.00030838$

LH2: –  $0.00063396 \pm 0.00006218$

LD2: –  $0.00080029 \pm 0.00007037$

# 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

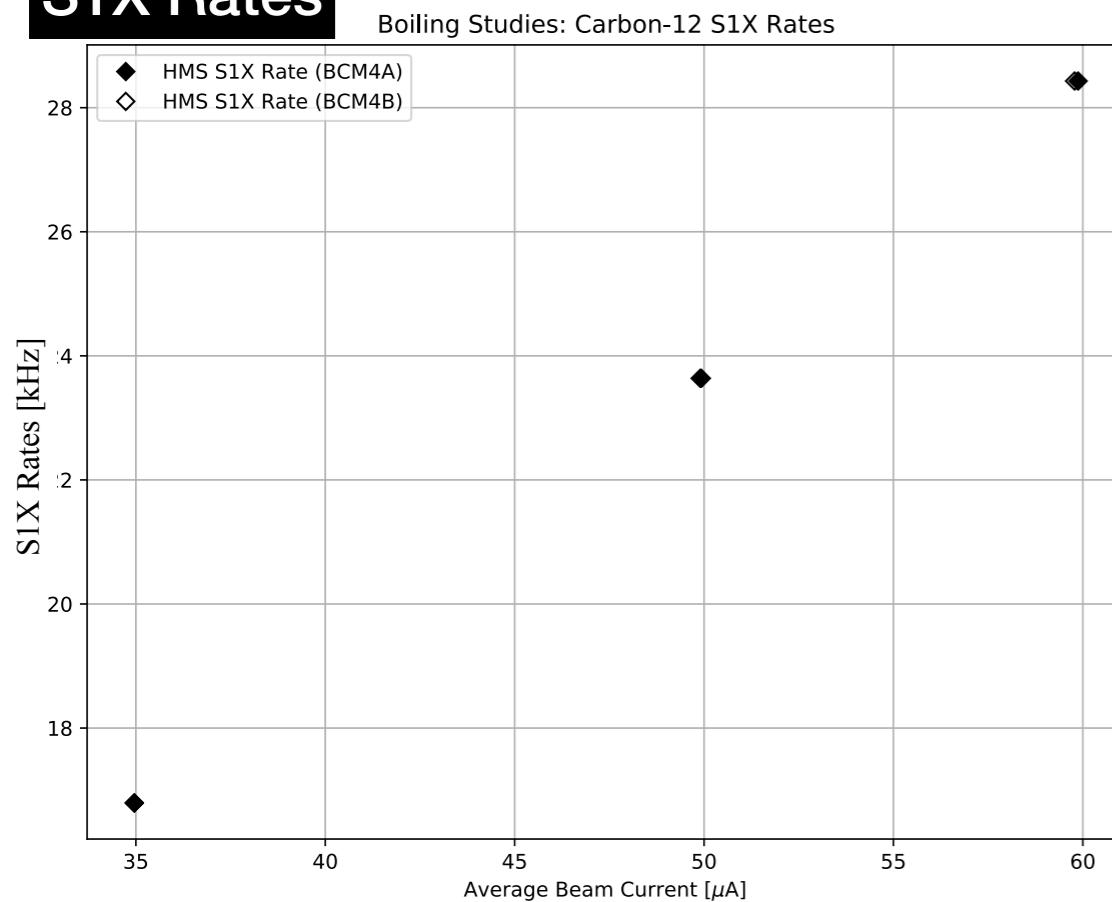
# **HMS Boiling Studies:**

## **Rates, Efficiencies and Live Time**

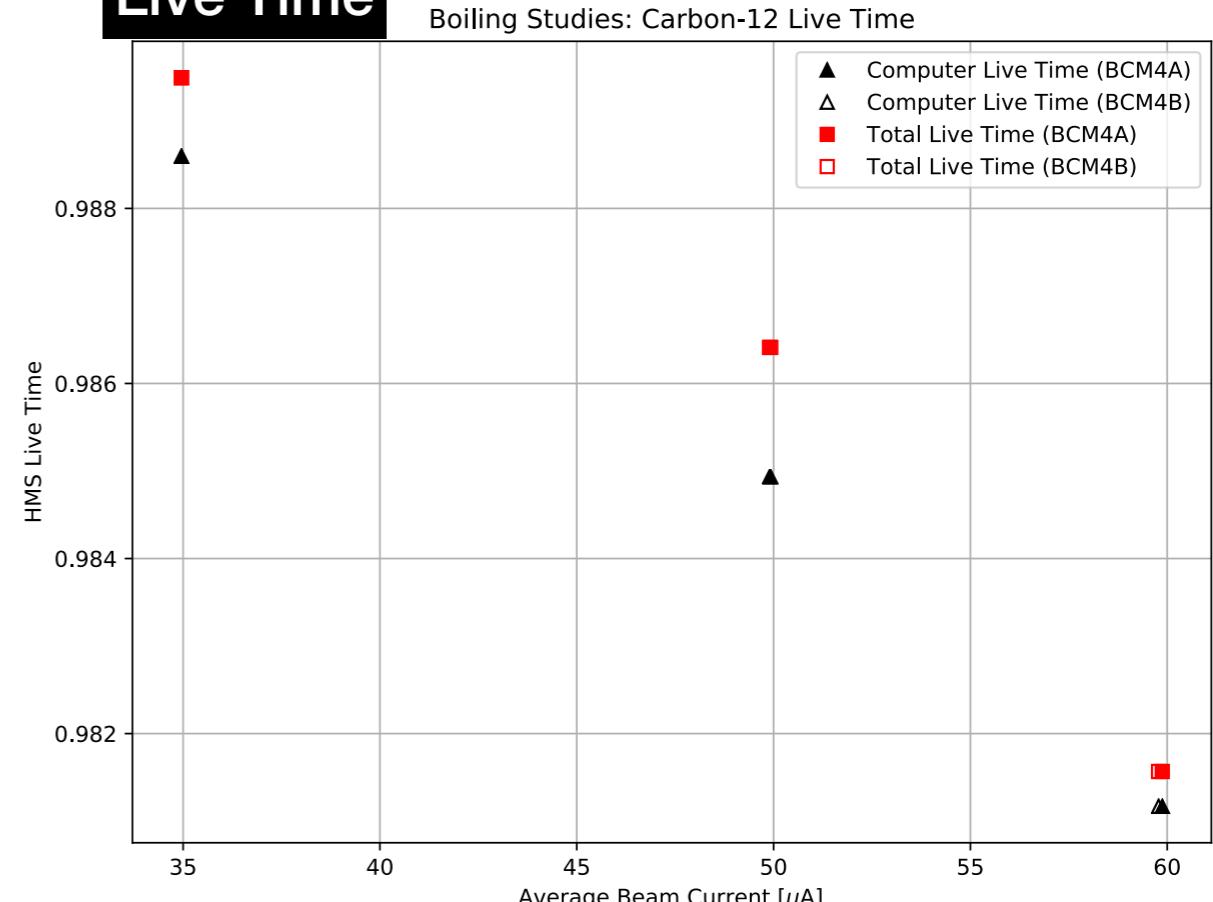
### **for Carbon, LH<sub>2</sub> and LD<sub>2</sub>**

# Carbon-12: Rates / Live Times / Tracking Efficiencies

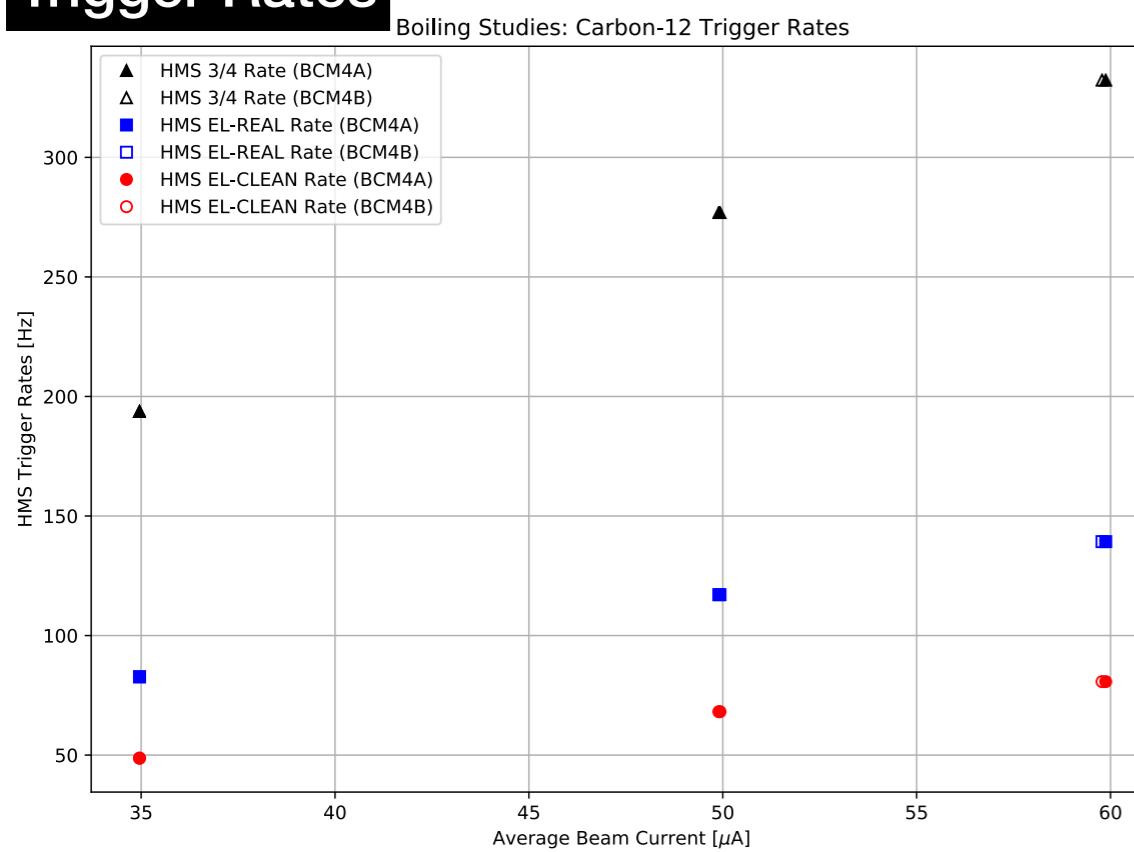
## S1X Rates



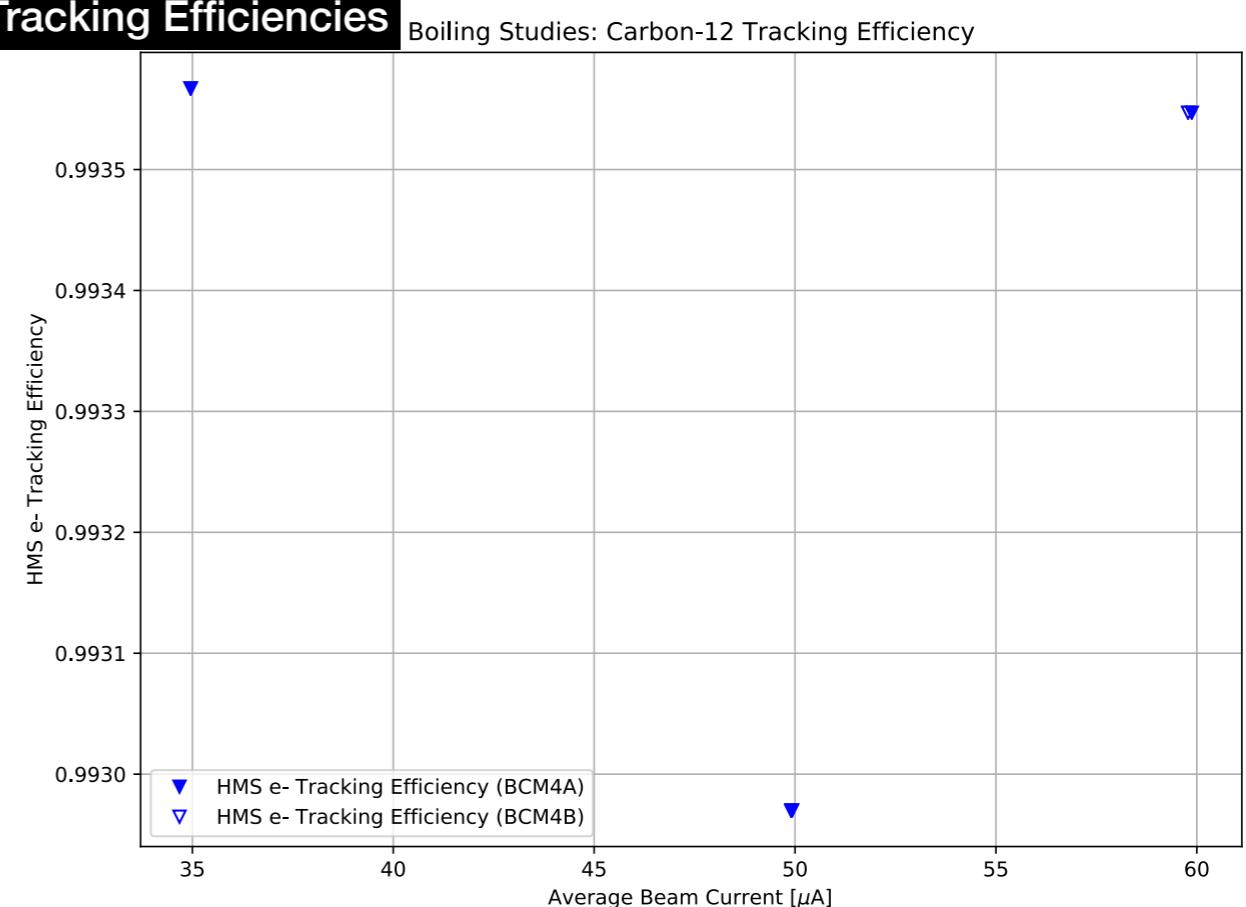
## Live Time



## Trigger Rates



## Tracking Efficiencies

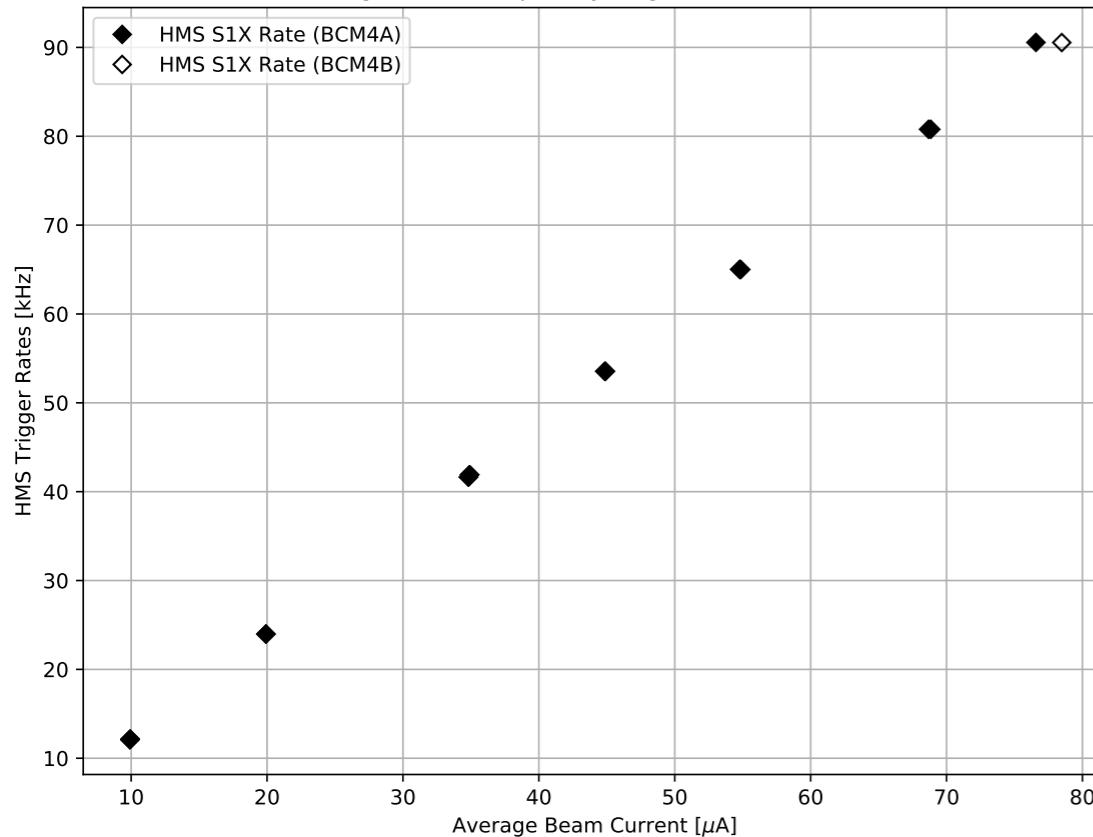


# LH2: Rates / Live Times / Tracking Efficiencies

## S1X Rates

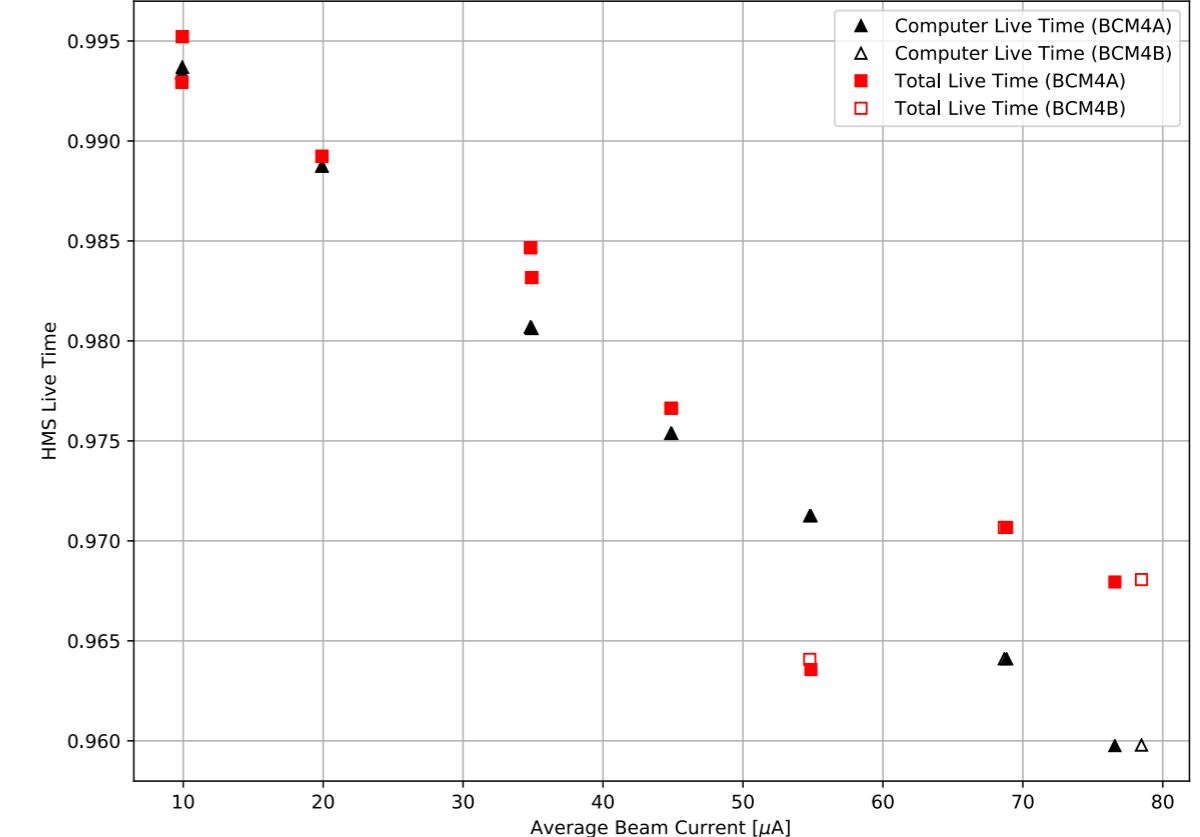
Boiling Studies: Liquid Hydrogen (LH2) S1X Rates

S1X Rates [kHz]



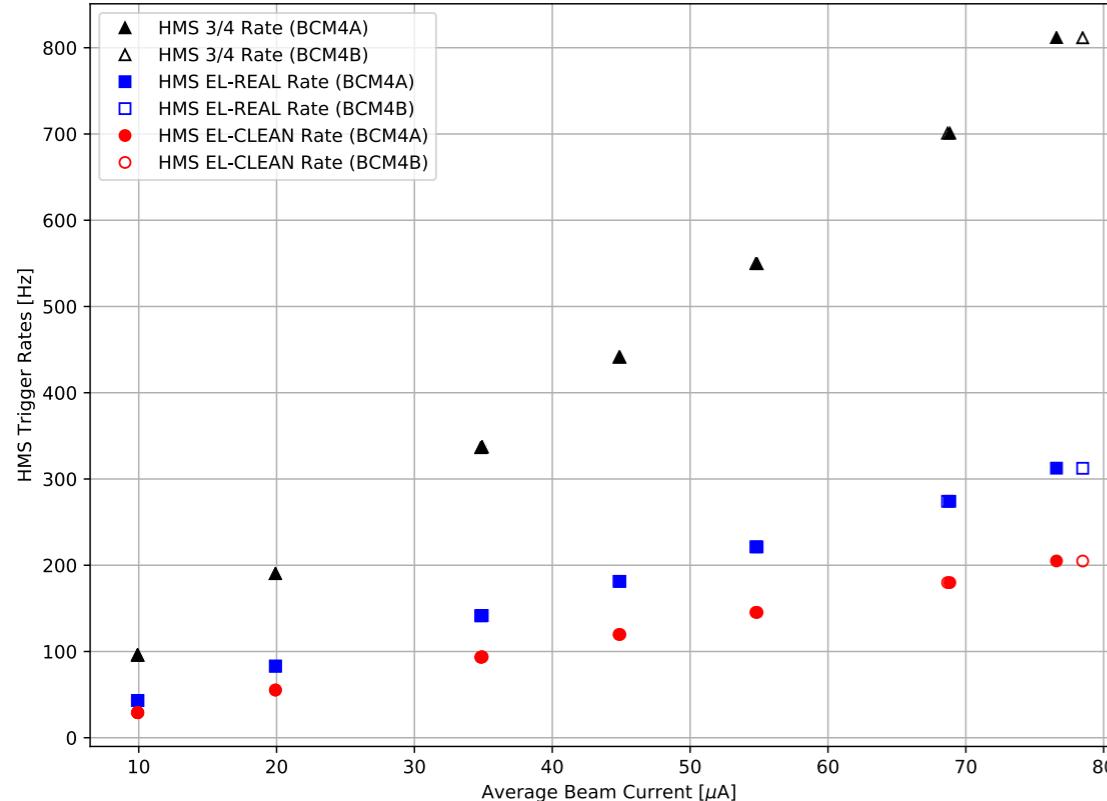
## Live Time

Boiling Studies: Liquid Hydrogen (LH2) Live Time



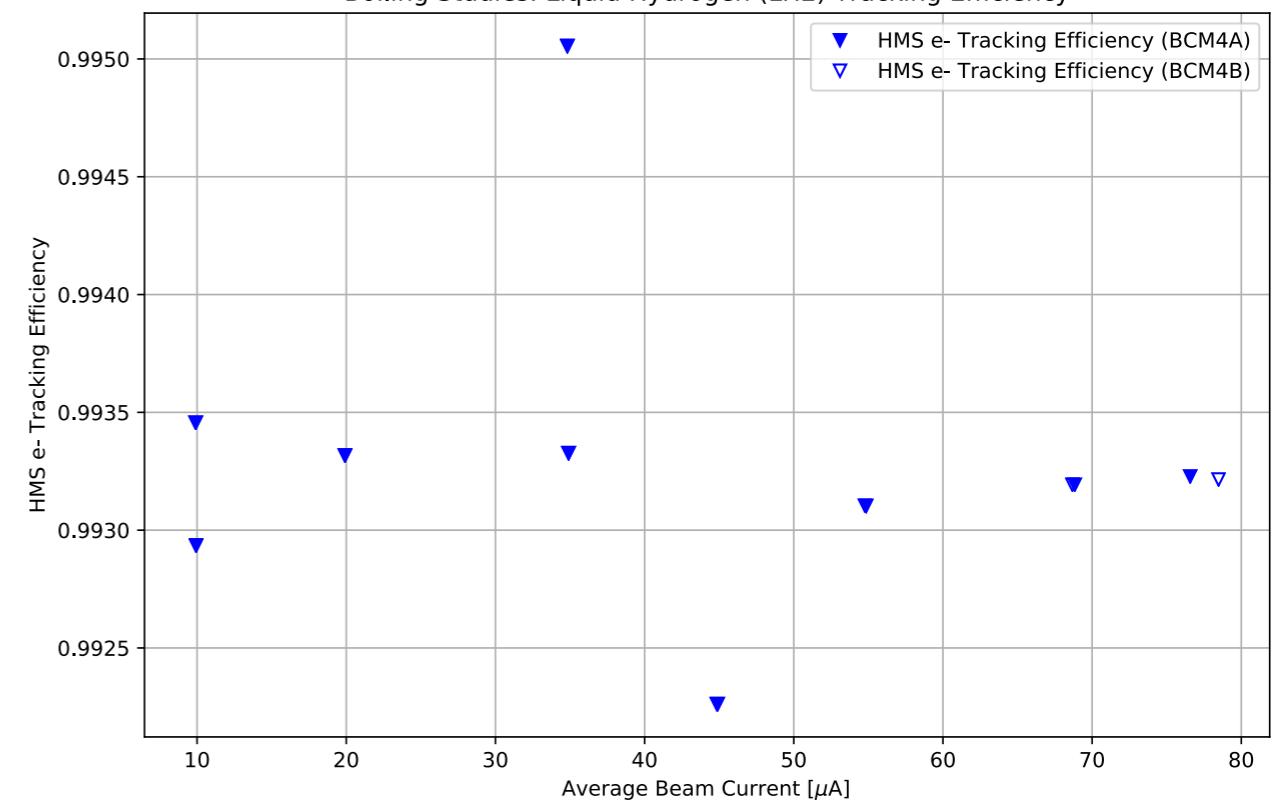
## Trigger Rates

Boiling Studies: Liquid Hydrogen (LH2) Trigger Rates



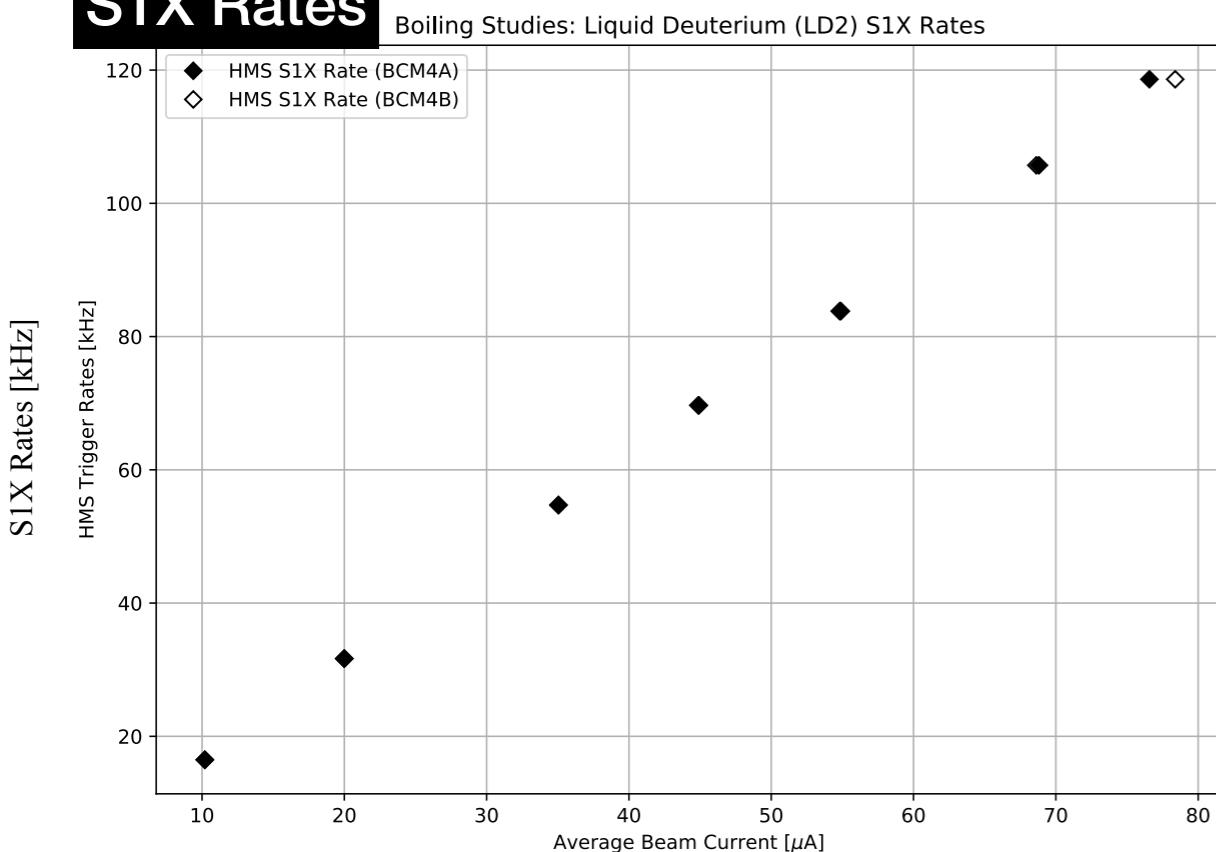
## Tracking Efficiencies

Boiling Studies: Liquid Hydrogen (LH2) Tracking Efficiency

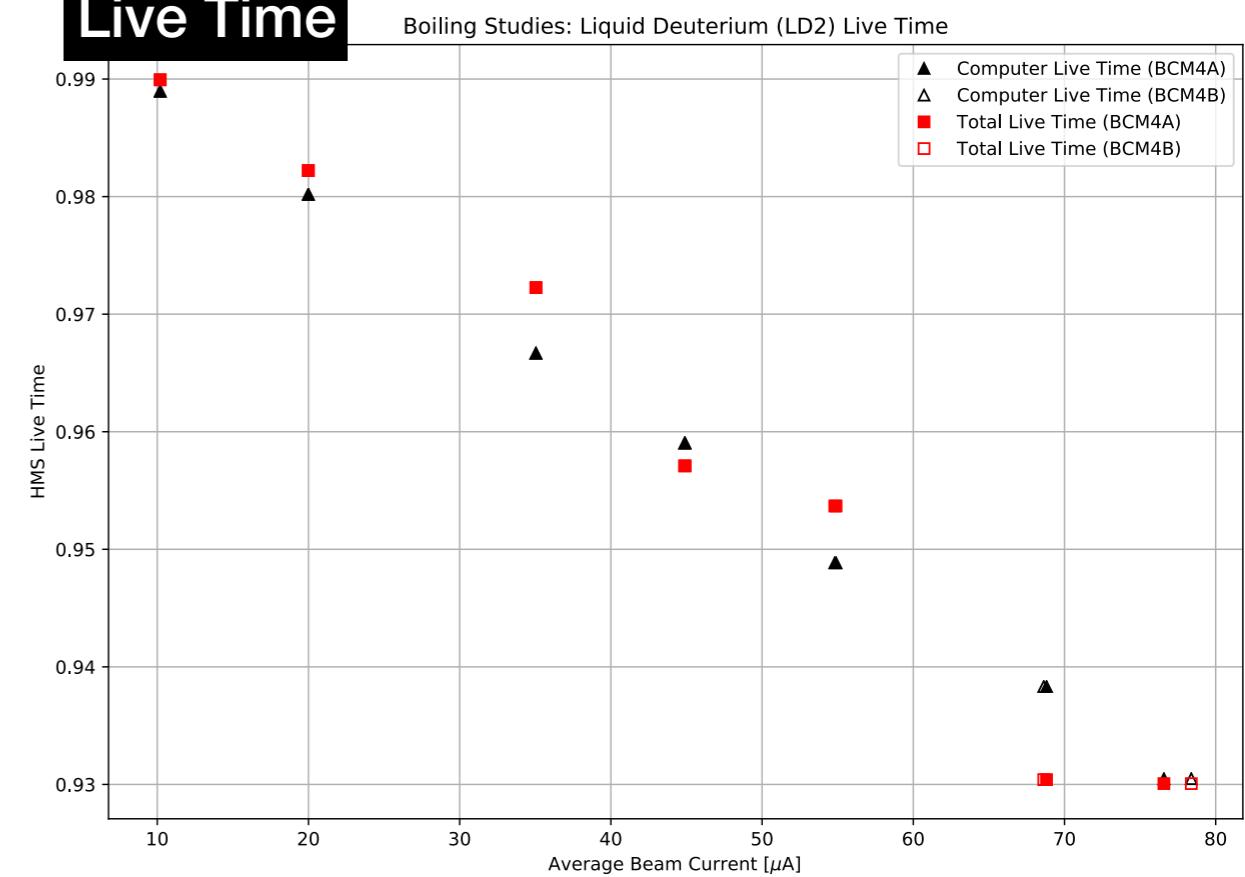


# LD2: Rates / Live Times / Tracking Efficiencies

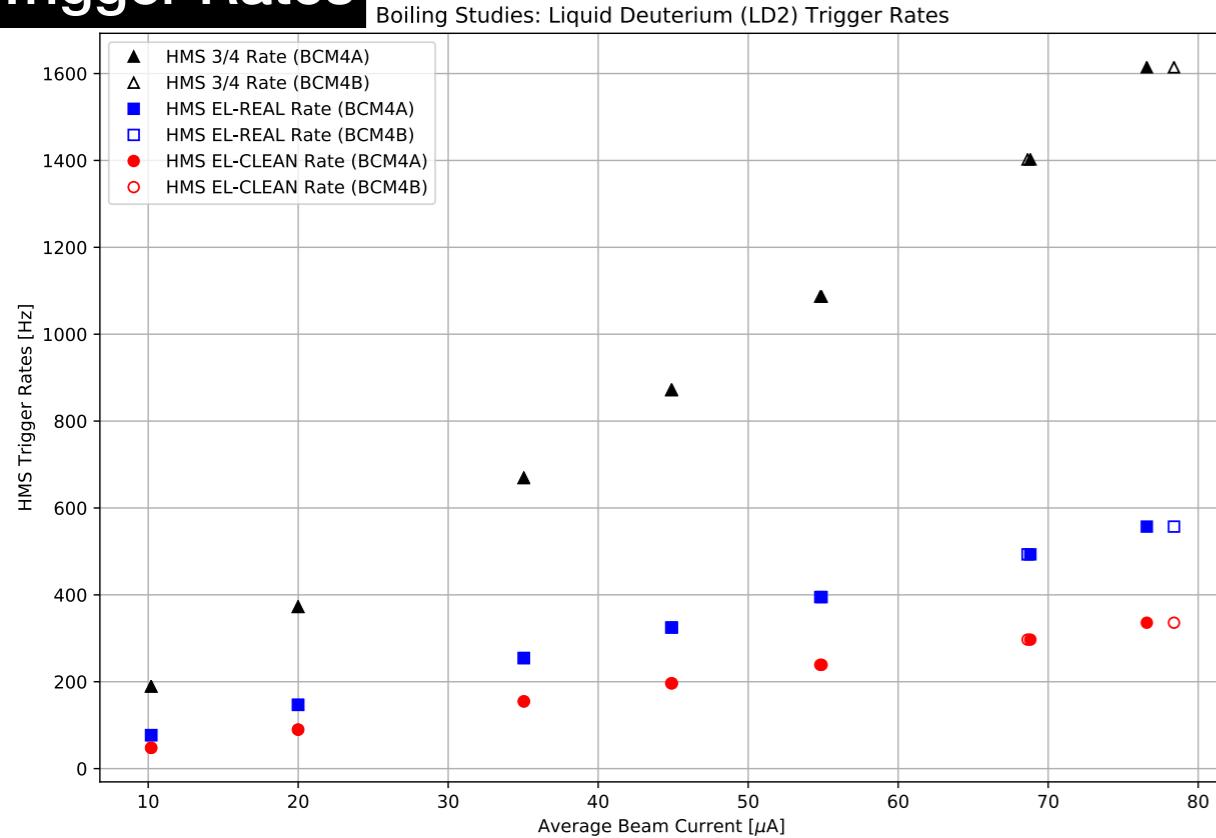
## S1X Rates



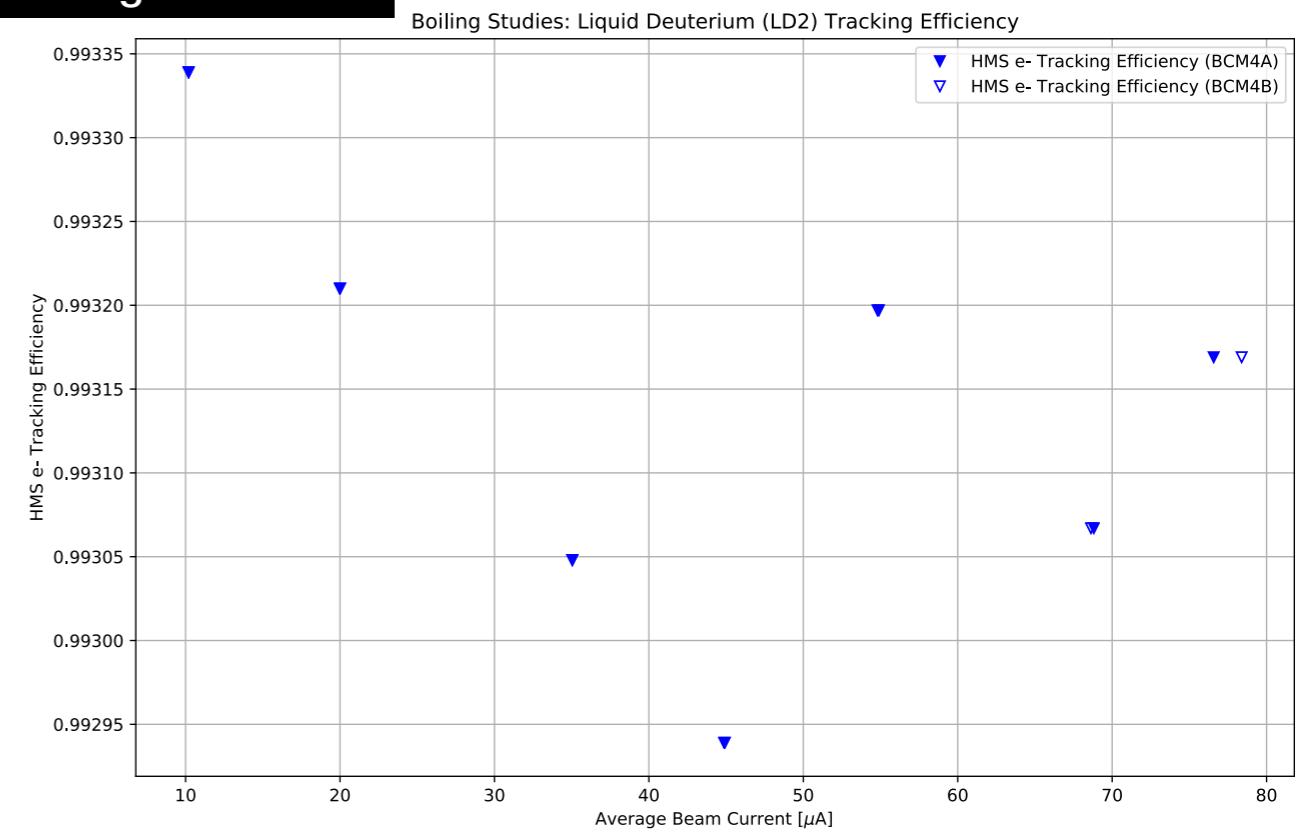
## Live Time



## Trigger Rates



## Tracking Efficiencies

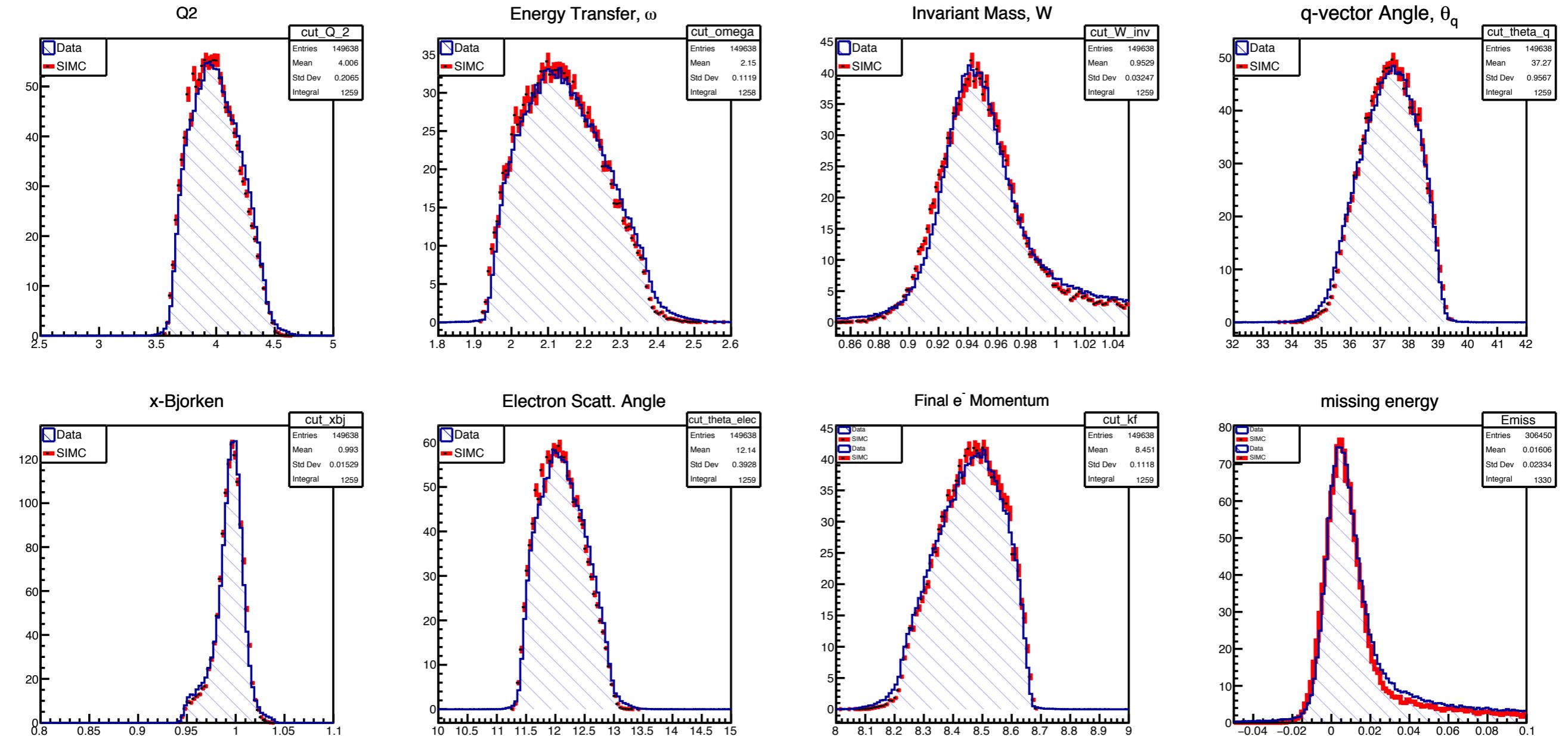


**E12-10-003**

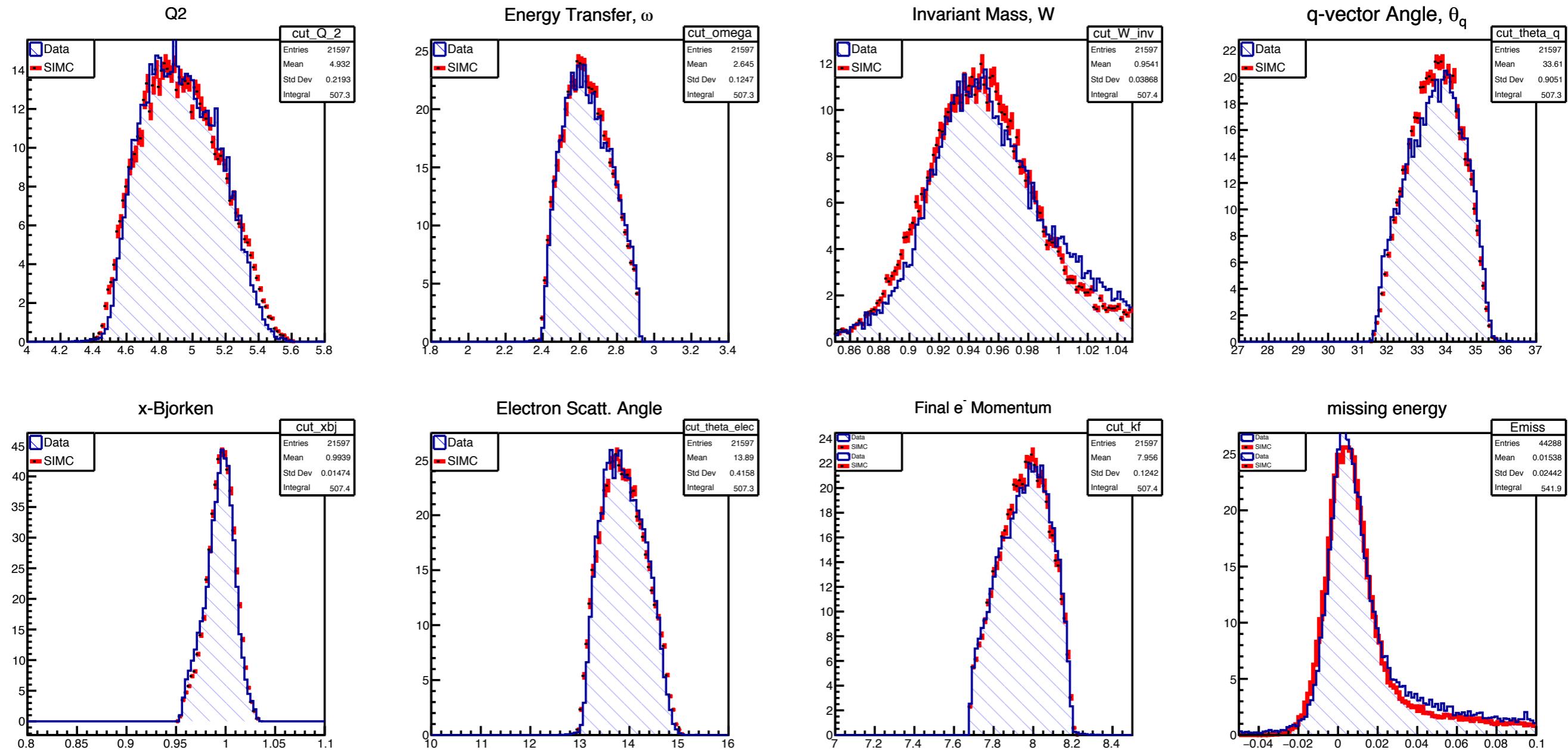
**H(e,e'p) Elastics**

**DATA/SIMC  
Comparisons**

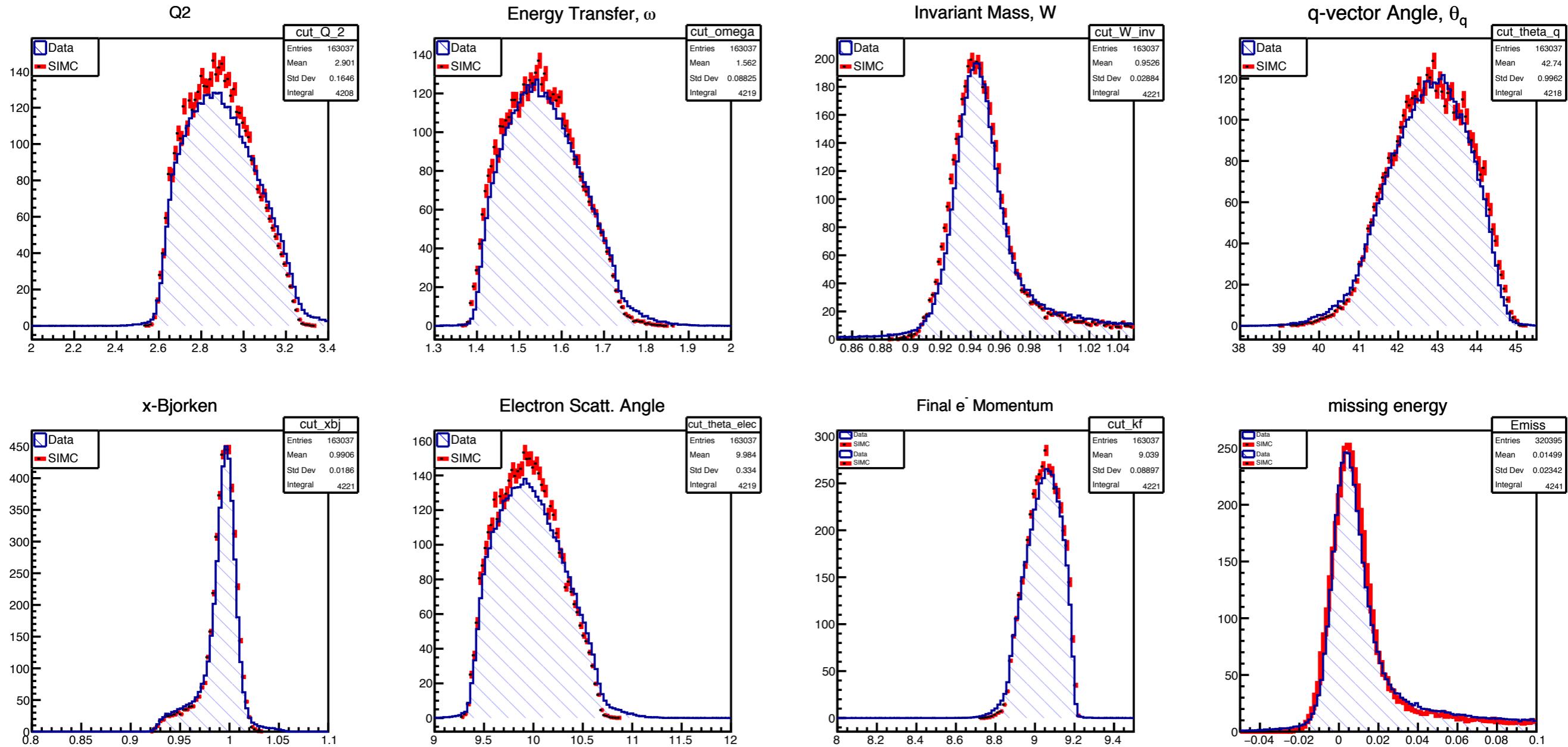
# Run 3288



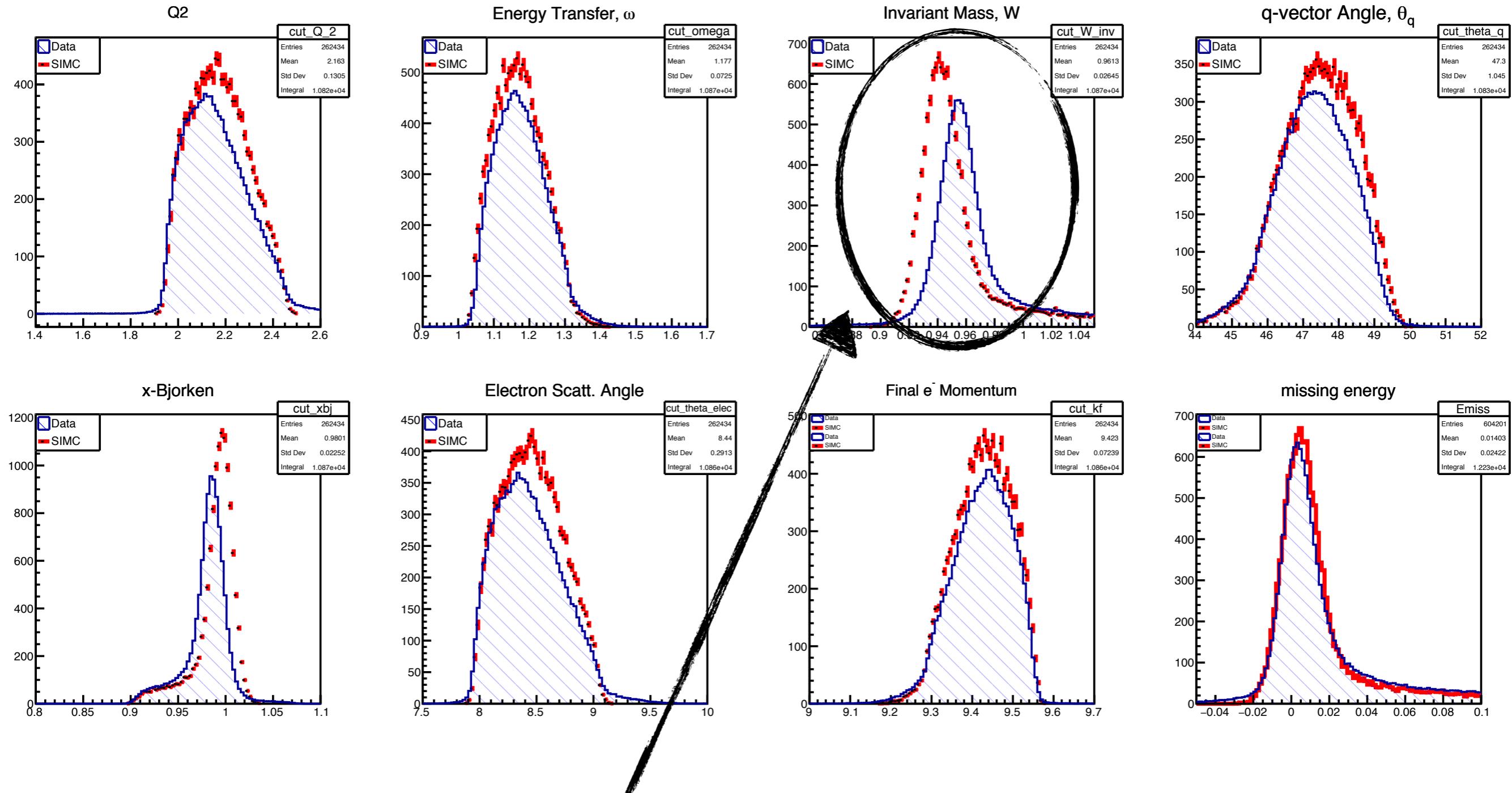
# Run 3371



# Run 3374



# Run 3377



There are several issues with this run:

- \* Data/SIMC yield disagree ~ 13%
- \* Alignment issue NOT observed in the other runs