Deadtime Analysis

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1 Review of deadtime studies

The deadtime needs to be computed for each run: the purpose of this analysis was to check if the deadtime was computed correctly. To check the livetime (LT) or deadtime (DT), Mongi began by studying the effects of the livetime and prescale variation for DVCS rates with fixed current. He was successful in applying a correction factor for the DVCS scaler-based rates using the MasterOR LT, and was able to recover the DVCS rates within 1%. The next part of the deadtime analysis was to study the effects of beam current variation and deadtime on DVCS rates by using run 13418 (Kin 48-4, Spring 2016). We noticed a beam current dependence still present in the normalized DVCS scaler rate (or ARS Valid Rate) and DIS scaler rate. To solve the current dependence issue, we began to look at the event-based rates in which we could apply cuts and obtain the DVCS production rate per current. As there was still a current dependence (not present in DIS rates) by applying the necessary cuts (old and newer cuts via Hashir's Event-Selection Algorithm) for DVCS rates, we looked for ways to remove the random coincidences or accidentals. This led us to studying the time coincidence distribution of photons, electrons and accidentals in the calorimeter clusters. Removing the accidental contribution from the DVCS event-based rates has resolved the current dependence problem for DVCS rates, and they are in agreement better than 1%.

1.1 Beam Current Variation

In order to verify the deadtime for DVCS rates, runs that have beam current variation within the same kinematic settings should be recoverable when normalized with the current and livetime. The run currently being used to verify the deadtime and thus recover the DVCS rates is 13418. This run was taken in Spring 2016 and belongs to kinematic 48_4, and has three different currents at 10 μA, 15 μA, 20 μA with a LH_2 target, as shown in Figure 1 through a Beam Current Monitor (BCM) during the run.

The studies on beam current variation for run 13418 began by using the scaler for the autovalidation rate (ARS Valid Rate) representing the DVCS production rate in Hz[4], as shown in Equation 6. However, the ARS Valid rate

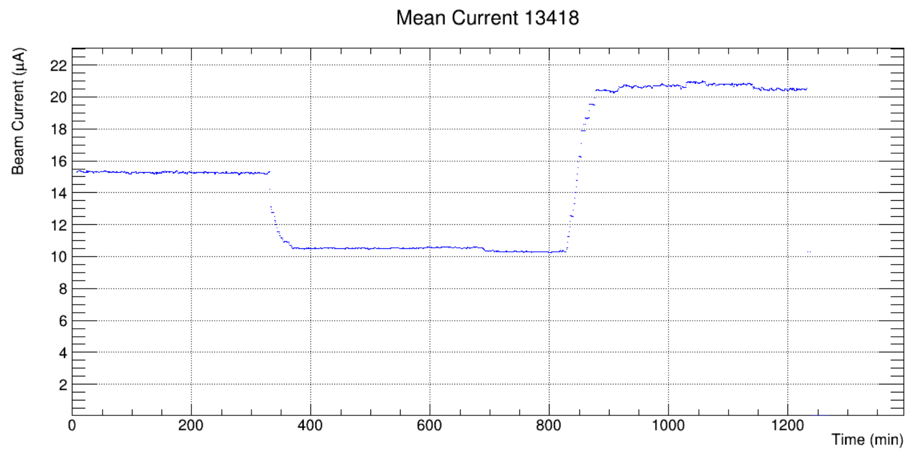


Figure 1: Mean currents shown at 10, 15, 20 μA for run 13418.

(DVCS scaler rate) after normalization with current and S2m&&Cer LT was still scaled to the current. As a result, the study shifted gear to look at the data from run 13418 event-by-event and apply cuts to select good DVCS events as shown in Equation 7, in addition to hardware and software corrections to recover the rates to better than 5%.

Other runs of interest to check the beam current dependence on the deadtime are 12985 (15 μA) and 12901 (10 μA), part of kinematic 48_3.

1.2 Trigger Setup and Scalers

Scalers corresponding to each active trigger for the run were read out to determine the number of live events and total events. The trigger formed with DVCS rates was the S2m and Cherenkov detectors, with simultaneous signals forming a trigger indicating a DIS or a DVCS event, as shown by Figure 2.

Internal scalers have a "gated_accum_" or "accum_" prefix in the root tree, whereas external scalers have a"cpt" prefix.

2 Using Live and Raw scalers: deadtime and livetime

The deadtime is defined as the ratio of the number of live events going into the electronics or computers to the total number of events. The deadtime and livetimes can be computed for each trigger. The live and raw events are best represented by live and raw internal/external scalers. Equation 1 is used calculate the raw rate. Equation 2 is used to calculate the livetime, and subsequently

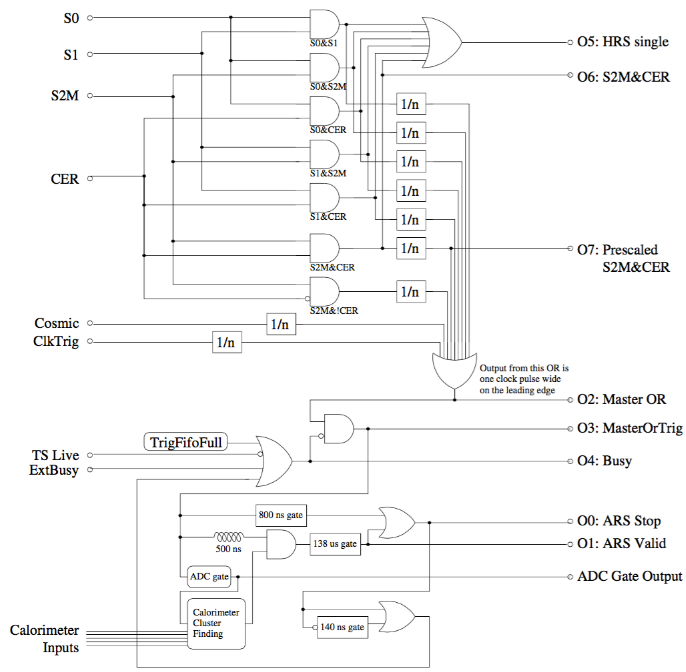


Figure 2: Internal trigger setup for the DVCS-3 experiment in Hall A, Spring 2016

the deadtime using Equation 3:

$$Raw\ rate = \ Live\ rate \times \frac{1}{1 - Deadtime} \tag{1}$$

$$Livetime = \frac{Live\ scaler\ rate}{Raw\ scaler\ rate} \tag{2}$$

$$Deadtime = 1 - Livetime \tag{3}$$

One may ask, which triggers can and should we use for the livetime (deadtime)? From Mongi's studies in the past, the main DVCS trigger S2m&&Cer could be used as we are studying DVCS production rates. The scalers in the root tree to calculate the livetime for S2m&&Cer is shown for internal scalers in Equation 4 and in Equation 5 for external scalers[1]. Both external and internal scalers (used for S2m&&Cer LT too) are in agreement within 1%: we can use

[1]More details about scalers and corresponding leaves in the root tree can be found in my wiki page: `http://www.vsl.cua.edu/cua_phy/index.php/MainPage:Nuclear:DVCS-3#Trigger_Diagrams`.

Rates and LT	0 (μA)	10.61 (μA)	15.32 (μA)	20.53 (μA)
S2m&Cer live (Hz)	13.17	120.7	181.4	253.4
S2m&Cer raw (Hz)	13.25	123.0	186.7	264.0
Master OR live (Hz)	19.79	124.8	187.0	260.6
Master OR raw (Hz)	19.90	127.4	192.8	272.0
S0 live (Hz)	128.4	1910	2751	3659
S0 raw (Hz)	129.2	1943	2825	3795
S2m live (Hz)	344.4	6039	8704	1.160E4
S2m raw (Hz)	346.2	6141	8927	1.202E4
S2m $\frac{live}{raw} = LT$	0.9948	0.9835	0.9750	0.9647
S0 $\frac{live}{raw} = LT$	0.9944	0.9832	0.9737	0.9641
Master OR $\frac{live}{raw} = LT$	0.9944	0.9796	0.9700	0.9580
S2m&Cer $\frac{live}{raw} = LT$	0.9936	0.9811	0.9715	0.9598

Table 1: Table showing raw and live rates from triggers and livetimes for S2m&&Cer, Master OR, S0, S2m. All livetimes are pedestal subtracted, e.g raw and live rates when beam current is < 0.8 μA in run 13418 and subtracted during the run. We used S2m&&Cer LT as our Livetime correction for DVCS rates.

either for the LT calculation. This was also demonstrated in Mongi's previous studies[2].

$$\textit{S2m\&\&Cer LT (internal)} = \frac{cptS2M\_CER\_Live}{cptS2M\_CER} \tag{4}$$

$$\textit{S2m\&\&Cer LT (external)} = \frac{gated\_accum\_dvcs\_scaler_15}{accum\_dvcs\_scaler\_15} \tag{5}$$

We could have used the livetime correction from S0, S2m, and Master OR as they have a livetime agreement better than 1%[3]. Updated rates and livetimes for these triggers are shown in Table 1. The different livetimes corresponding to the ones in Table 1 are shown as a function of the beam current in Figure 3.

- S0 with live/raw scalers $\frac{gated\_accum\_dvcs\_scaler\_s0}{accum\_dvcs\_scaler\_s0} = \textit{S0 LT}$
- S2m with live/raw scalers $\frac{gated\_accum\_dvcs\_scaler\_s2}{accum\_dvcs\_scaler\_s2} = \textit{S2m LT}$
- MasterOR with live/raw scalers $\frac{gated\_accum\_dvcs\_scaler\_24}{accum\_dvcs\_scaler\_24} = \textit{MasterOR LT}$

$$\textit{DVCS Scaler Raw Rate } (Hz) = \frac{cptARSValid}{\textit{103.7 kHz clock steptime}} \tag{6}$$

[2]Mongi's elog entry here for internal and external scaler agreement: `https://hallaweb.jlab.org/dvcslog/12+GeV/415`

[3]See Mongi's elog entry for more information on different trigger livetimes and agreement: `https://hallaweb.jlab.org/dvcslog/12+GeV/437`

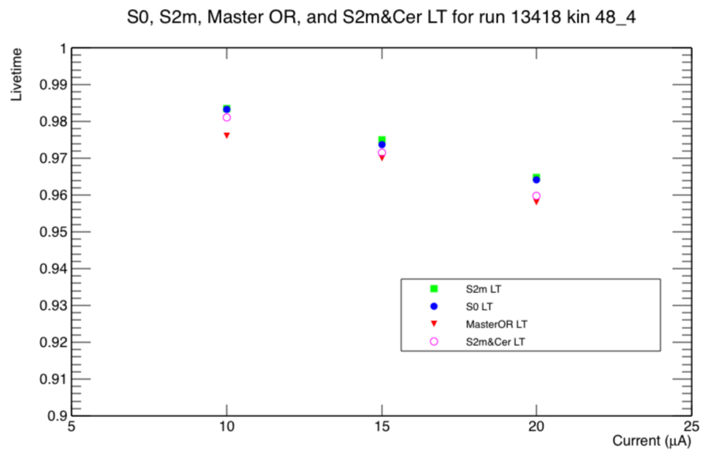


Figure 3: Livetimes of S2m, S0, Master OR and S2m&&Cer shown as a function of mean currents at 10, 15, 20 μA for run 13418.

$$\textit{DVCS Event-based Raw Rate } (Hz) = \frac{GoodEventCut\&TDCcut\&(triggerPatternWord\&0x00100 == 256)}{\textit{103.7 kHz clock steptime}} \tag{7}$$

The livetime and the 103.7 Hz clock (located in the LHRS in the DVCS crates) steptime is used to normalize the DVCS rates as shown in Equation 7. This was also done with the previous DVCS scaler-based rate (autovalidation rate from ARS Valid)[4] calculations and is done for the event-based DVCS rate as shown in Equation 6.

3 DVCS Event-based rates + new cuts

Hashir's DVCS3 Event Selection Algorithm[5] was used to apply good electron cuts in both the DVCS rates and accidental calculations. The "GoodEventCut" was applied to all rates and includes:

- single tracking cut (L.tr.n==1) and cuts on the u1,v1,u2,v2 planes of the Vertical Drift Chamber (VDC)
  - $u1 == 1\&\&u2 == 1\&\&v1 == 1\&\&v2 == 1$
  - $(u1 > 1\&\&u2 == 1\&\&v1 == 1\&\&v2 == 1)||(u1 == 1\&\&u2 > 1\&\&v1 == 1\&\&v2 == 1)||(u1 == 1\&\&u2 == 1\&\&v1 > 1\&\&v2 == 1)||(u1 == 1\&\&u2 == 1\&\&v1 == 1\&\&v2 > 1)$

[4] More info on the previous DVCS scaler-based or ARS Validation rate is in Mongi's elog entry here: `https://hallaweb.jlab.org/dvcslog/12+GeV/436`.

[5] More information on Hashir's cuts is in the elog entry here: `https://hallaweb.jlab.org/dvcslog/12+GeV/487`.

- Cherenkov detector photoelectron channel peak or Cherenkov amplitude sum: $L.cer.asum\_c > 150$ (accepting more than 1.5 photoelectrons).
- Pion Rejector cut (PR)
  - $L.prl1.asum\_c$: PR layer 1 > 60% of full energy peak
  - $L.prl2.asum\_c$: PR layer 2 > 20% of full energy peak
- Target Vertex Cut for Spring 2016 data: corrects for scattering against aluminum walls of target e.g. target vertex is set to be 6.5 cm from target center
- Alexa's R Function cut for kin 48_4

Additionally, cuts on the Time-to-Digital Converter (TDC) and triggerPatternWord were made:

- TDC cut: $tdc\_val[27] - tdc\_val[7]/10 < -24$
- TriggerPatternWord cut for DIS: $TPW\&0x00080 == 128$
- TriggerPatternWord cut for DVCS: $TPW\&0x00100 == 256$

In addition to Hashir's good event cuts, another correction for missed events after passing the tracking cuts must be applied to the whole analysis. For kinematic 48_4, this correction factor was 1.06 and was applied to the number of events contained in all the rates. All new cuts and rates are shown in Table 2.

4 Waveform Analysis and Clustering

Waveform analysis is a method that works to extract the amplitude of a pulse coming from the ARS (Analog Ring Sampler), which is used to sample events and record from active triggers. The analysis was done using libraries unique to DVCS such as TARSWave.h anc TEventCalo.h. The waveform analysis detects pulses coming from the ARS based on the energy of photons hitting blocks in the calorimeter, and fits to a one or a two-pulse wave using the χ^2 value. If the χ^2 for the fitting is very high, the waves are fit to a two pulse.

After the two-pulse fit from the waveform analysis, the clustering of the blocks in the DVCS calorimeter determined the "good" photon. All cuts and corrections were applied during the clustering, including Hashir's good electron cuts for DVCS events.

5 Accidental Studies

The ultimate goal of this analysis was to correct the deadtime by obtaining an accidental rate from the coincidence and accidental timing in the calorimeter

	0 (μA)	10.61 (μA)	15.32 (μA)	20.53 (μA)
S2m&Cer LT	0.9936	0.9811	0.9715	0.9598
No cuts (Hz)	17.78	103.7	166.0	244.4
Tracking Cut (Hz)	0.5410	53.49	83.16	116.1
Tracking&TDC&Cer (Hz)	0.3570	49.01	76.19	106.6
Tracking&TDC&Cer&PR&VtxCut (Hz)	0.2642	33.33	51.35	72.40
GoodEventCut&TDC (Hz)	0.1650	20.69	31.75	44.86
No cuts $(Hz/\mu A)$	n/a	9.773	10.83	11.90
Tracking Cut $(Hz/\mu A)$	n/a	5.042	5.429	5.653
Tracking&TDC&Cer $(Hz/\mu A)$	n/a	4.619	4.973	5.190
Tracking&TDC&Cer&PR&VtxCut $(Hz/\mu A)$	n/a	3.141	3.352	3.527
GoodEventCut&TDC $(Hz/\mu A)$	n/a	1.950	2.073	2.185
GoodEventCut&TDC&DIS (Hz)	n/a	13.66	19.48	26.09
$\frac{GoodEventCut\&TDC\&DIS}{I}$ $(Hz/\mu A)$	n/a	1.288	1.272	1.271
$\frac{GoodEventCut\&TDC\&DIS}{I\times S2m\&Cer\ LT}$ $(Hz/\mu A)$	n/a	1.313	1.310	1.324
ARS Valid rate (Hz)	16.61	96.40	154.3	227.4
$\frac{ARS\ Valid\ Rate}{I}$ $(Hz/\mu A)$	n/a	9.086	10.07	11.08
$\frac{ARS\ Valid\ Rate}{I\times S2m\&Cer\ LT}$ $(Hz/\mu A)$	n/a	9.262	10.37	11.54
GoodEventCut&TDC&DVCS (Hz)	n/a	20.86	31.92	45.02
$\frac{GoodEventCut\&TDC\&DVCS}{I}$ $(Hz/\mu A)$	n/a	1.966	2.083	2.193
$\frac{GoodEventCut\&TDC\&DVCS}{I\times S2m\&Cer\ LT}$ $(Hz/\mu A)$	n/a	2.004	2.146	2.284

Table 2: Table showing all live, raw and normalized rates with all cuts and corrections applied. GoodEventCut includes Track&TDC&Cer&PR&VtxCut&Rfunction cuts. All raw rates are normalized with the 103.7 kHz clock from LHRS in DVCS crate. DIS rates have GoodEventCut & TDC & DIS (triggerPatternWord) cuts applied, DVCS rates have GoodEventCut & TDC & DVCS (triggerPatternWord) cuts applied and have units Hz. All rates are pedestal subtracted, e.g rates and Livetime taken when beam current is < 0.8 μA during the run. DIS normalized rates had a $<$ 1% agreement per 10 μA , and DVCS normalized rates had a 13% agreement per 10 μA and a 6 to 7% agreement per 5 μA. Note that the normalized DIS rates have almost no current dependence, whereas the DVCS normalized rates do.

clusters, and "subtract" it from DVCS event rates (shown in Table 2). The clustering of the blocks in the calorimeter provided time spectra based on a clustering energy threshold set for each block, $E_\gamma > 1.5$ GeV or the "triggerSim" threshold[6].

Accidentals make up most of the background and are present in the rates. Accidentals are any photons and electrons from the DVCS calorimeter and LHRS that are NOT in coincidence. Real coincidences occur when photons and electrons are simultaneously in coincidence with one another, with each coincidence considered a "signal", also known as a DVCS event. Accidentals or random coincidences scale with the beam current (μA) squared (I^2) shown in Equation 9 where a is a constant. The signal or real coincidences scale directly with the beam current shown in Equation 8 where b is a constant. The beam current dependence for the signal and accidentals are shown by the relationship in Equation 10.

$$Signal\ (ns) = a \times I \tag{8}$$

$$Background\ (ns) = b \times I^2 \tag{9}$$

$$\frac{Signal}{Background} = \frac{a \times I}{b \times I^2} = \frac{a}{b \times I} \tag{10}$$

5.1 Coincidence Time Selection: Main Coincidence and Accidental Windows

The main coincidence peaks that are centered at [-2,2] and [-3,3] represents the photons, electrons and accidentals, as shown in Figure 4 for all three currents. Taking the area under the coincidence peak gives the background which contains both the real coincidences and accidentals, as shown in Equation 12. Equation 11 is used to determine the signal or real coincidences by subtracting the background.

$$Signal\ or\ real\ coincidences = Integral\ of\ main\ coincidence\ peak\ of\ 4\ (or\ 6)\ ns - Integral\ of\ accidental\ 4\ (or\ 6)\ ns\ peak \tag{11}$$

$$Integral\ of\ main\ coincidence\ peak = Background \tag{12}$$

To account for higher statistical uncertainty than in past analyses using the 4 ns windows, the accidental windows were extended to 6 ns and compared. Any 6 ns window from [-11,11] could have been chosen with respect to the peaks, but for statistical purposes different scales of windows were chosen, compared

[6]Previously this threshold was set to 1.0 GeV, but after Mongi and Frederic's ADC calibration for each kinematic (December 2017), the noted energy threshold for kinematic 48_4 was used. See the elog entry here: `https://hallaweb.jlab.org/dvcslog/12+GeV/489` for more information.

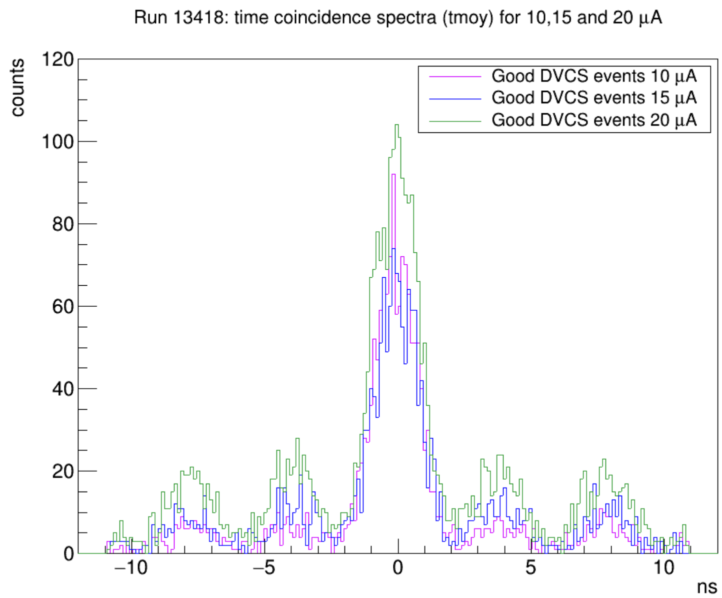


Figure 4: DVCS time coincidence spectra at all three different currents, with all events passing the Good Event cut in the clustering. The events in this range of [-3,3] is equivalent to the total amount of hits in the calorimeter including photons, electrons and background. The accidentals must be chosen in the same range as the main coincidence peak of 6 ns, such as windows at [5,11] and [-11,-5].

and averaged. Accidental windows were in the range [-11,-5] and [5,11] for a 6 ns range, and [-10,-6] and [6,10] for a 4 ns range.

Using the relationship between the signal, background and current in Equation 10, we can derive the signal to background ratio using Equation 13.

$$\frac{Signal}{Background} = \frac{Background - Accidental\ peak}{Background} \tag{13}$$

The ratios of the real coincidences (signal) to the background were calculated using Equation 13 for each current. Results are in the "Avg 6 ns acc sig/back ratio"and "Avg 4 ns acc sig/back ratio" rows for each current shown in Table 3.

The different scaled windows in Table 4 are presented to demonstrate higher statistical uncertainty in the 4 ns windows (including less good events per ns) as compared with the extended 6 ns accidental windows (including more good events per ns). The events in the [-2,2] range in the coincidence spectrum are used together with the 4 ns mean of [-10,-6] & [6,10] to obtain the signal to background ratios via Equation 13 (shown in Tables 3 and 4). The results in the 6 ns, [5,11] & [-11,-5] mean row were calculated using 13 with the 6 ns main coincidence window and the mean value of events in [6,10] and [-10,-6] (shown in

Time coincidence window cuts	10 μA	15 μA	20 μA
Raw time coincidence window [-11,11]	1920	2126	3530
4 ns, [-2,2] main coincidence window	1324	1225	1843
6 ns, [-3,3] main coincidence window	1384	1320	2006
6 ns, [-11,-5] accidental window	164.3	228.9	451.6
4 ns, [-10,-6] accidental window	135.7	181.3	372.1
6 ns, [5,11] accidental window	173.8	236.4	449.4
4 ns, [6,10] accidental window	145.2	202.5	384.8
6 ns, [5,11] & [-11,-5] mean	169.1	232.7	450.5
4 ns, [-10,-6] & [6,10] mean	140.5	191.9	378.4
6 ns mean accidentals & coincidences in [-3,3]: *signal/background*	0.8779	0.8237	0.7754
4 ns mean accidentals & coincidences in [-2,2]: *signal/background*	0.8939	0.8434	0.7947

Table 3: Table showing accidentals and the coincidence window of 4 ns at [-2,2] and 6 ns at [-3,3], rounded to the nearest significant figure. The accidentals are from window cuts made on the time coincidence spectrum (tmoy), and are not normalized with the current. The "6 ns, [5,11] & [-11,-5] mean" and "4 ns, [-10,-6] & [6,10] mean" rows contain the averages of the accidentals in [-11,-5] and [5,11] for the former and [-10,-6] and [6,10] for the latter.

Time coincidence window cuts	10 μA	15 μA	20 μA
4 ns, [-2,2] main coincidence window: *events/ns*	331.0	306.3	460.8
6 ns, [-3,3] main coincidence window: *events/ns*	230.7	220.0	334.3
6 ns, [-11,-5] accidental window: *accidentals/ns*	27.38	38.16	75.26
4 ns, [-10,-6] accidental window: *accidentals/ns*	33.92	45.32	93.02
6 ns, [5,11] accidental window: *accidentals/ns*	28.97	39.40	79.41
4 ns, [6,10] accidental window: *accidentals/ns*	36.31	50.62	96.20
6 ns, [5,11] & [-11,-5] mean: *mean accidentals/ns*	28.18	38.78	75.08
4 ns, [-10,-6] & [6,10] mean: *mean accidentals/ns*	35.11	47.97	94.61
6 ns mean accidentals & coincidences in [-3,3]: *signal/background*	0.8779	0.8237	0.7754
4 ns mean accidentals & coincidences in [-2,2]: *signal/background*	0.8939	0.8434	0.7947

Table 4: Table showing scaled accidentals/ns of the accidental windows and the events/ns of the coincidence windows of 4 ns at [-2,2] and 6 ns at [-3,3] rounded to the nearest significant figure. The discrepancy between the two main coincidence windows ranges from 32 % to 36 % with decreasing current. The discrepancy between the mean of the two accidental windows ranges from 21 % to 23 % with increasing current. The windows chosen for the correction of DVCS rates were the 6 ns main coincidence [-3,3], with the 6 ns mean accidentals. The scaling of events per ns did not affect the DVCS calculation as we only use the signal/background ratios to perform the subtraction of accidental contributions from DVCS rates.

I (μA)	S2m&&Cer LT	DIS Normalized Rate	DVCS Normalized Rate	DVCS 4 ns $\frac{signal}{background}$	DVCS Normalized Rate corrected (4 ns)	DVCS 6 ns $\frac{signal}{background}$	DVCS Normalized Rate corrected (6 ns)
10.61	0.981	1.313	2.004	0.8939	1.791	0.8779	1.759
15.32	0.971	1.310	2.146	0.8434	1.810	0.8237	1.767
20.53	0.960	1.324	2.284	0.7947	1.815	0.7554	1.771

Table 5: DIS rates have GoodEventCut & TDC & DIS (triggerPatternWord) cuts applied, DVCS rates have GoodEventCut & TDC & DVCS (triggerPatternWord) cuts applied and normalized with the S2m && Cer livetime, and have units ($\frac{Hz}{\mu A}$). DIS normalized rates had a $<1\%$ agreement per 10 μA , and DVCS normalized rates had a 13% agreement per 10 μA and a 6 to 7% agreement per 5 μA, the same agreement from the old rates shown in Table **??**. The DVCS 4 ns signal/background ratios applied to the DVCS normalized rates result in a discrepancy of 1.33% per 10 μA and $<1\%$ per 5 μA.The DVCS 6 ns signal/background ratios applied to the DVCS normalized rates result in a discrepancy of 0.68% per 10 μA and $<0.33\%$ per 5 μA.

Tables 3 and 4). Extending the accidental and main coincidence windows from 4 ns and 6 ns is best representative of DVCS production events as it includes the full main coincidence and accidental peaks.

5.2 Signal and background DVCS Rates

The signal (from the 6 ns main coincidence [-3,3]) to background (from accidental windows [-11,-5] and [5,11] accidentals averaged) ratio in Table 3 computed using Equation 13 was multiplied by the DVCS raw rates (Hz) from Table 2. Then we normalized each $DVCSrawrate(Hz) \times \frac{signal}{background} ratio$ to its corresponding beam current and S2m&&Cer Livetime summarized in Equation 14.

$$DVCS\ normalized\ rate\ corrected = \frac{DVCS\ rate\ (Hz) \times DVCS\ signal\ to\ background\ ratio}{I\ (\mu A) \times S2M\&\&Cer\ LT} \quad (14)$$

In general, DVCS rates were corrected using the format in Equation 14. More detailed calculations of the DVCS corrected rates for 10, 15 and 20 μA are shown in Equations 15,16 and 17. By the subtraction of the accidental contribution via application of the signal to background ratio using the 6 ns windows to the DVCS normalized rates, we were able to achieve a 0.68% discrepancy per 10μA and a 0.33% discrepancy per 5 μA for DVCS normalized rates in run 13418. A comparison of old rates to corrected rates is shown in Figure 7, along with a comparison of the previously analyzed ARS valid rates.

$$DVCS\ corrected\ normalized\ rate\ at\ 10\ \mu A = \frac{20.86\ Hz \times 0.8723}{10.61\ \mu A \times 0.981} = 1.759\ \frac{Hz}{\mu A} \quad (15)$$

$$\textit{DVCS corrected normalized rate at 15 } \mu A = \frac{31.92\ Hz \times 0.8237}{15.32\ \mu A \times 0.971} = 1.767\ \frac{Hz}{\mu A} \quad (16)$$

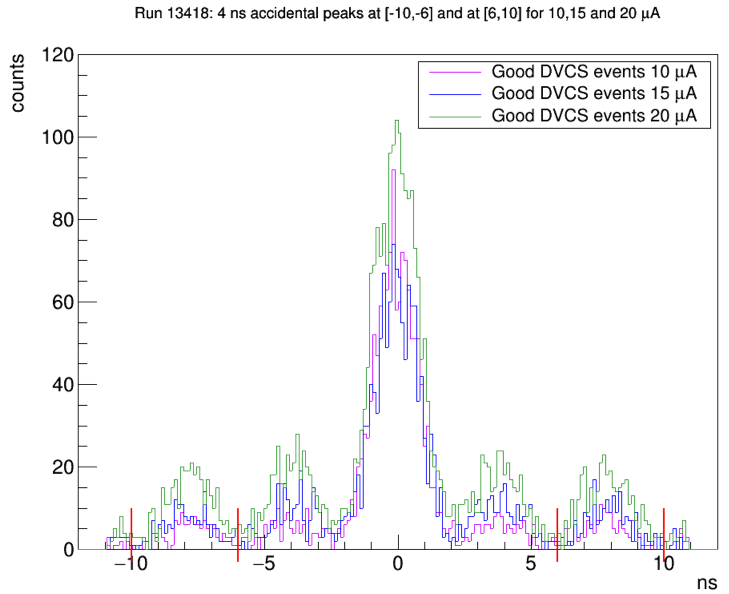
$$\textit{DVCS corrected normalized rate at 20 } \mu A = \frac{45.02\ Hz \times 0.7554}{20.53\ \mu A \times 0.960} = 1.771\ \frac{Hz}{\mu A} \quad (17)$$

6 Summary and outlook

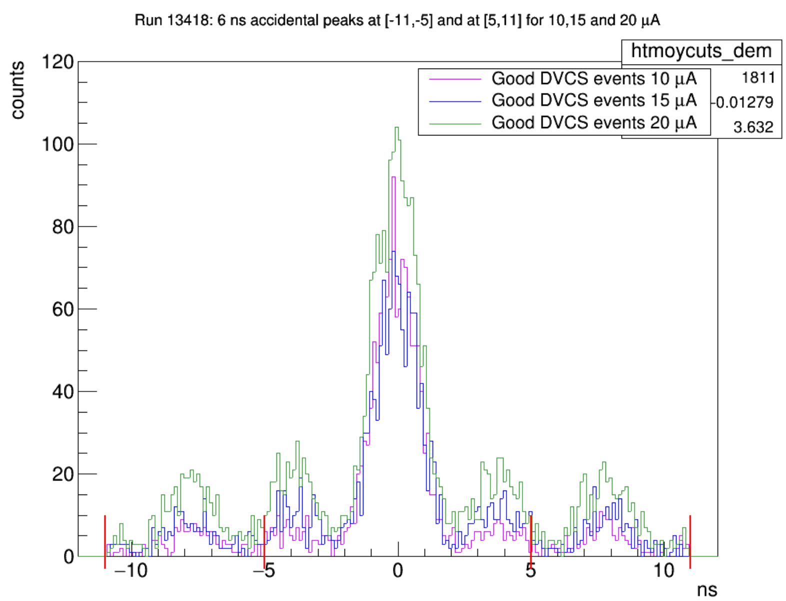
Since the DVCS normalized rates were dependent on the current despite normalization with the current, the accidentals coming from the DVCS calorimeter and the Left High Resolution Spectrometer (LHRS) were subtracted from the DVCS rates to minimize the current dependence and recover the rates. Corrected DVCS rates are shown in Table 5 after the application of the signal/background ratios to eliminate the accidentals from the DVCS rates. There is a 0.68 % agreement per 10 μA and 0.33% agreement 5 μA for run 13418.

A possible way is to verify this analysis and check for reproducibility is to look for runs at different currents with the same kinematics (as there are no other individual runs at different currents that we know of) for future deadtime studies. So far, these include 12985 (15 μA) and 12901 (10 μA) which are part of kinematic 48_3. Note that Mongi had looked at other runs in the past using runs 10555 (4.8 μA),10595 (7.2 μA),10640 (9.7 μA),10622 (6.8 μA) (Carbon run) and found that the rates are recoverable to better than 1%.

A previous analysis used active DIS triggers in the accidental subtraction as there was no known way at the time to subtract the accidental contribution from the DVCS rates. That analysis was performed before applying Hashir's cuts and performing the two-pulse waveform analysis. Photons in coincidence with electrons, or DIS and DVCS events, are detected in the clustering process in the calorimeter, after the waveform analysis. Hashir's Good event cuts were applied during the clustering process thus representing a good photon from the calorimeter, and a good electron from the LHRS.



(a)



(b)

Figure 5: DVCS time coincidence spectra, with all events passing the Good Event cut in the clustering. Accidental peaks (red) that are 4 ns wide are in the range [-10,-6] and [6,10] for 10, 15, 20 μA. Accidental peaks (red) that are 6 ns wide are in the range [-11,-5] and [5,11] for 10, 15, 20 μA. The integral over this range has the total amount of hits including photon, electron and background. Accidentals shown in red at [-10,-6] for 10, 15, 20 μA.

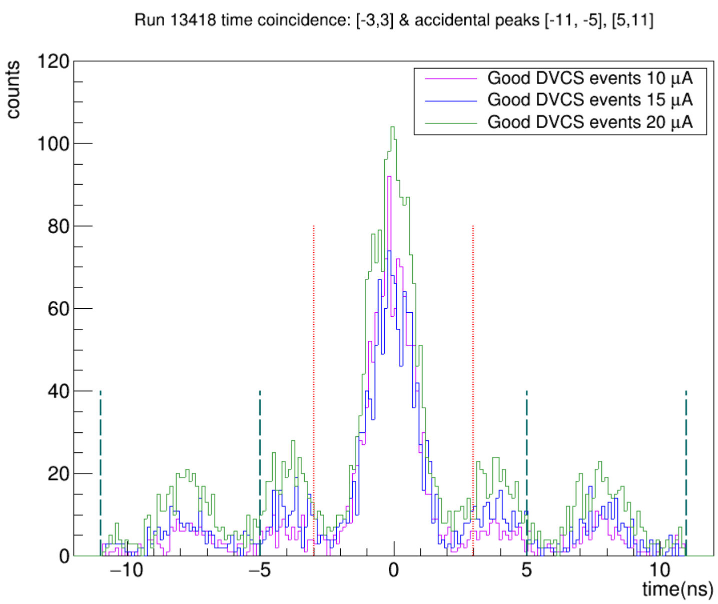
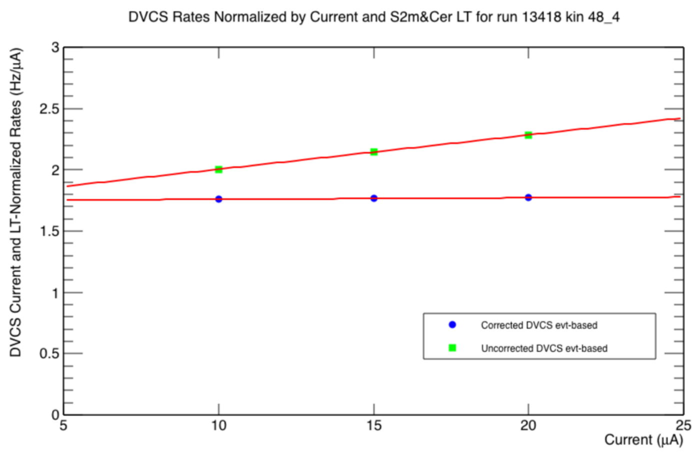
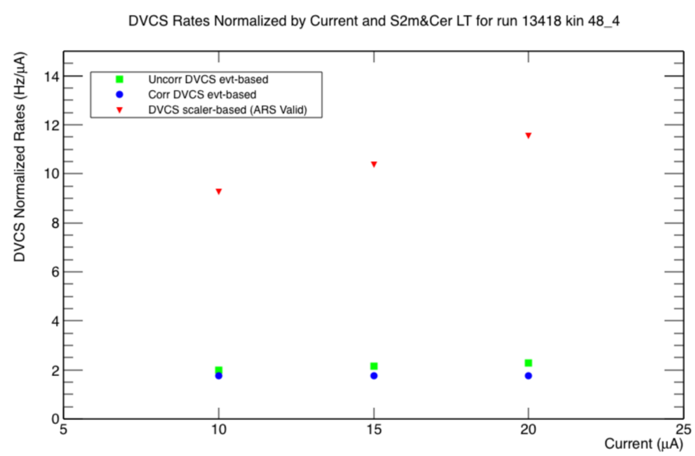


Figure 6: DVCS time coincidence spectra, with all events passing the Good Event cut in the clustering. Main coincidence peaks are highlighted and shown at [-3,3] for 10, 15, 20 μA. The events in this range is equivalent to the total amount of hits in the calorimeter including photons, electrons and background.



(a)



(b)

Figure 7: (a) DVCS normalized rates at 10, 15, 20 μA shown before (green) and after the background subtraction with 6 ns main coincidence and accidental windows (blue): rates were corrected to agree better than 1%. (b) Plot comparing DVCS event-based rates and the previous DVCS scaler-based (ARS Valid) Rates.