MARATHON Rate Estimations

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1 Introduction

In this reports, we redo the calculation of rates and beam times of the MARATHON experiment with its default settings given in the updated proposal. We also presents the estimation with the optimized settings which pushes the W^2 down to lower values. The detail conditions used in the calculation are indicated in the captions, and also are summarized in the next section.

Table 1, Table 2 and Table 3 give the ^2H, ^3H and ^3He cross-sections and rates comparison between Makis's calculation and our calculations with conditions given below. x_b^{avg} and σ_{avg} are the average values of x_b and cross sections for all Monte-Carlo events within one bin. For BigBite, we list two rates, one of which is the total rate with the momentum acceptance from 1 GeV to 11 GeV. The other number, given after the "/" sign, is the rate with the momentum cut, $|\Delta\delta P| < 4.5\%$, which selects the best physics events. The window rate are also given as a reference and it has no momentum cut as we are interested in the total rates. Doug told me that the BigBite acceptance is not uniform but decreases when the momentum increasing. Hence, this rate is over-estimated by not considering the acceptance effect.

Table 4 summarizes the rates and beam-times for ^2H, ^3H and ^3He with the default settings and the new experimental conditions.The $|\Delta\delta P| < 4.5\%$ cut is applied on BigBite. If we take out BigBite and use only one HRS, we have the new rates and beam-times given in Table 5 with exact the same conditions.

Table 6 has the same settings as Table 5 but takes into account the 10% acceptance reduction because of using SOS and the 15 cm effective target length that the HRS can only cover at moderate large angles. On top of the settings applied in Table 6, Table 7 gives the rates and beam-time if we include the 20% radiative effect and 20% overall detector efficiencies and dead-time.

Table 8 lists the optimized settings, by fixing the HRS central momentum at 4 GeV/c, and changing the angles to obtain the desire x_b values. The highest x_b point remains as the same. The values of W^2 are smaller than ones used in the default settings. Table 9 is the same as Table 8 but replacing the cross section model from F2ALLM97 to F1F2IN09.

2 Experimental conditions

The experimental conditions put into this rate estimation are listed here:

- The acceptance range of the HRS is:

$$|\delta P| < 0.045,\ |\theta_{tg}| < 0.045\ rad,\ and\ |\phi_{tg}| < 0.032\ rad.$$

  Hence, the total phase-space is $P_0 \cdot (2 \cdot 0.045) \times (2 \cdot 0.045) \times (2 \cdot 0.032)\ GeV \cdot sr$.

- The acceptance range of the BigBite is:

$$1 < E' < 11\ GeV/c,\ |\theta_{tg}| < 0.17\ rad,\ and\ |\phi_{tg}| < 0.08\ rad.$$

  Hence, the total phase-space is $(11-1) \times (2 \cdot 0.17) \times (2 \cdot 0.08)\ GeV \cdot sr$. When calculating physics rate, I applied a $|\Delta\delta P| < 4.5\%$ cut.

- The full target length length of 25 cm is used in Table 1 to Table 5. An effective target length (15 cm) for the HRS is used from Table 6 to to Table 9.

- The beam current for ^{2}H is 20 uA, and its density is 0.00496 g/cm^3. The target luminosity of ^{2}H is $2.80 \times 10^{36}\ cm^{-2}s^{-1}$.

- The beam current for ^{3}H is 20 uA, and its density is 0.00324 g/cm^3. The target luminosity of ^{3}H is $1.22 \times 10^{36}\ cm^{-2}s^{-1}$.

- The beam current for ^{3}He is 25 uA, and its density is 0.00372 g/cm^2. The target luminosity of ^{3}He is 1.75×10^{36} $cm^{-2}s^{-1}$.
- A DIS cut, $W^2 > 4.0$ GeV^2, is used to select events when estimating rates. For $x > 0.7$, the cut is reduced to $W^2 > 3.0$ GeV^2.
- The beam-time is estimated by assuming we need at lease 25K events for each x bin.
- The cross section model is calculated with F2. Three models are available now: Eric Christy and Peter Bosted's F1F2IN09 fit, F2ALLM97 and CTEQ-JLab. Current I only use F2ALLM97 here.
  - F1F2IN09 provides F_2^p, F_2^n and F_2^d. It works well at low Q^2. When $Q^2 >\sim 10$ GeV^2, F_2^d becomes negative.
  - F2ALLM97 only provides F_2^p. I used John's R_{np} curve to get F_2^n. It agrees very well with the world data at high Q^2. It doesn't agree with the CLAS6 data at 0.8 GeV^2.
  - CTEQ-JLab (CJ) only provides PDFs. I simply obtained F2 from u, d and s with their charges. There is not any corrections included. I used it to cross check with other models.

3 Conclusions

The following table summarizes the total beam-time in days for different settings given in Table 1 through Table 8. The first row gives the original values in the proposal, and the second row gives the new beam-times recalculated with the old rates and assuming there are 25K event per bin. Numbers in rest of rows are based on new calculation with new experimental conditions shown in the previous section.

Experimental Settings	Total Beam-Time (Days)	Total Beam-Time w/o $x_b = 0.87$ (Days)
HRS+BB with default settings, directly quoted from the proposal	43	35
HRS+BB with default settings, old rates and recalculated with 25K per bin	29	21
HRS+BB with default settings, new rates with no corrections (Table 4)	21	17
Two HRS with default settings, with no corrections (Table 5)	132	96
Two HRSs with default settings, and SOS+Target-Length Corrections(Table 6)	244	177
Two HRS with default settings, with all corrections (Table 7)	381	276
two HRS with optimized settings, at low W^2 values and with all correction (Table 8)	116	11

4 Rate Tables

Table 1: **^{2}H** Cross Section and Rates for d/u Extraction BB and HRS. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). The number after "/" is the BB rate with $|\Delta\delta P| < 4.5\%$ cut. 25 cm Target Length is used for both BB and HRS. Set the minimum hour to be 1. The window rate has no momentum cut. Makis's calculations are also given here for comparing. **The old beam-times are recalculated with the old rates and the requirement of 25K events per-bin**.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	E' (GeV)	θ (Deg)	σ_{old} (nb/sr /GeV)	σ_{new} (nb/sr /GeV)	σ_{avg} (nb/sr /GeV)	old rate Hz(Hour)	new rate &Hour Hz(Hour) (δP+/-4.5%)	window rate Hz
BB	0.87(0.80)	3.10(4.31)	2.07	47.10	N/A	0.0026	0.0122	0.12(57.74)	29.16(1.00)/ 0.28(24.39)	33.47
BB	0.83(0.80)	3.87(4.51)	1.48	57.10	N/A	0.0029	0.0068	0.10(66.49)	3.73(1.86)/ 0.16(44.41)	4.26
BB	0.79(0.78)	4.71(4.89)	1.41	57.10	N/A	0.0059	0.0092	0.18(38.82)	3.81(1.82)/ 0.26(26.69)	4.36
BB	0.75(0.75)	5.25(5.26)	1.58	51.90	N/A	0.0118	0.0167	0.42(16.62)	11.16(1.00)/ 0.57(12.24)	12.80
BB	0.71(0.72)	6.07(5.95)	1.50	51.90	N/A	0.0197	0.0242	0.63(10.94)	11.10(1.00)/ 0.83(8.38)	12.72
BB	0.67(0.68)	6.66(6.51)	1.67	47.10	N/A	0.0377	0.0453	1.37(5.07)	28.96(1.00)/ 1.73(4.02)	33.24
BB	0.63(0.64)	7.22(7.05)	1.90	42.00	N/A	0.0750	0.0886	3.04(2.29)	77.59(1.00)/ 3.84(1.81)	89.19
BB	0.59(0.60)	7.97(7.80)	1.80	42.00	N/A	0.1037	0.1173	4.18(1.66)	76.26(1.00)/ 4.82(1.44)	87.65
HRS	0.55(0.55)	6.78(6.74)	4.00	23.40	N/A	0.9223	0.9886	8.35(1.00)	9.56(1.00)	10.97
HRS	0.51(0.51)	7.32(7.28)	4.00	22.50	N/A	1.3530	1.4376	12.50(1.00)	13.91(1.00)	15.96
HRS	0.47(0.47)	7.84(7.80)	4.00	21.60	N/A	1.9375	2.0428	18.36(1.00)	19.76(1.00)	22.70
HRS	0.43(0.43)	8.39(8.34)	4.00	20.60	N/A	2.8232	2.9504	26.98(1.00)	28.54(1.00)	32.81
HRS	0.39(0.39)	8.92(8.88)	4.00	19.60	N/A	4.0386	4.2108	39.50(1.00)	40.74(1.00)	46.87
HRS	0.35(0.35)	9.42(9.38)	4.00	18.60	N/A	5.6974	5.9246	57.94(1.00)	57.32(1.00)	66.00
HRS	0.31(0.31)	9.94(9.90)	4.00	17.50	N/A	8.2243	8.5338	85.42(1.00)	82.56(1.00)	95.14
HRS	0.27(0.27)	10.48(10.43)	4.00	16.30	N/A	12.1730	12.6074	127.08(1.00)	121.97(1.00)	140.68
HRS	0.23(0.23)	10.98(10.94)	4.00	15.10	N/A	17.9605	18.6295	194.89(1.00)	180.23(1.00)	208.06
								9 Days	6 Days	

Table 2: **^{3}H** Cross Section and Rates for d/u Extraction BB and HRS. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). The number after "/" is the BB rate with $|\Delta\delta P| < 4.5\%$ cut. 25 cm Target Length is used for both BB and HRS. Set the minimum hour to be 1. The window rate has no momentum cut. Makis's calculations are also given here for comparing. **The old beam-times are recalculated with the old rates and the requirement of 25K events per-bin**.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	E' (GeV)	θ (Deg)	σ_{old} (nb/sr /GeV)	σ_{new} (nb/sr /GeV)	σ_{avg} (nb/sr /GeV)	old rate Hz(Hour)	new rate &Hour Hz(Hour) (δP+/-4.5%)	window rate Hz
BB	0.87(0.80)	3.10(4.31)	2.07	47.10	0.0050	0.0031	0.0152	0.09(80.39)	17.05(1.00)/ 0.15(45.02)	33.47
BB	0.83(0.80)	3.87(4.51)	1.48	57.10	0.0055	0.0035	0.0085	0.07(95.06)	2.11(3.29)/ 0.08(81.96)	4.26
BB	0.79(0.78)	4.71(4.89)	1.41	57.10	0.0093	0.0072	0.0116	0.12(56.95)	2.16(3.22)/ 0.14(48.78)	4.36
BB	0.75(0.75)	5.25(5.26)	1.58	51.90	0.0188	0.0147	0.0211	0.28(24.51)	6.44(1.08)/ 0.31(22.15)	12.80
BB	0.71(0.72)	6.07(5.95)	1.50	51.90	0.0285	0.0249	0.0310	0.43(16.22)	6.40(1.09)/ 0.46(15.01)	12.72
BB	0.67(0.68)	6.66(6.51)	1.67	47.10	0.0537	0.0482	0.0586	0.92(7.54)	16.94(1.00)/ 0.97(7.13)	33.24
BB	0.63(0.64)	7.22(7.05)	1.90	42.00	0.1030	0.0970	0.1159	2.04(3.40)	46.02(1.00)/ 2.19(3.17)	89.19
BB	0.59(0.60)	7.97(7.80)	1.80	42.00	0.1430	0.1355	0.1548	2.83(2.46)	45.22(1.00)/ 2.77(2.51)	87.65
HRS	0.55(0.55)	6.78(6.74)	4.00	23.40	1.2700	1.2185	1.3124	5.72(1.21)	5.53(1.26)	10.97
HRS	0.51(0.51)	7.32(7.28)	4.00	22.50	1.8500	1.8048	1.9255	8.58(1.00)	8.11(1.00)	15.96
HRS	0.47(0.47)	7.84(7.80)	4.00	21.60	2.6700	2.6077	2.7592	12.77(1.00)	11.62(1.00)	22.70
HRS	0.43(0.43)	8.39(8.34)	4.00	20.60	3.8300	3.8353	4.0203	18.90(1.00)	16.94(1.00)	32.81
HRS	0.39(0.39)	8.92(8.88)	4.00	19.60	5.4800	5.5348	5.7863	27.92(1.00)	24.38(1.00)	46.87
HRS	0.35(0.35)	9.42(9.38)	4.00	18.60	7.8500	7.8730	8.2067	41.31(1.00)	34.58(1.00)	66.00
HRS	0.31(0.31)	9.94(9.90)	4.00	17.50	11.3000	11.4629	11.9199	61.39(1.00)	50.22(1.00)	95.14
HRS	0.27(0.27)	10.48(10.43)	4.00	16.30	16.6000	17.1169	17.7618	93.03(1.00)	74.83(1.00)	140.68
HRS	0.23(0.23)	10.98(10.94)	4.00	15.10	24.8000	25.4656	26.4607	143.31(1.00)	111.48(1.00)	208.06
								12 Days	10 Days	

Table 3: **^{3}He** Cross Section and Rates for d/u Extraction BB and HRS. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). The number after "/" is the BB rate with $|\Delta\delta P| < 4.5\%$ cut. 25 cm Target Length is used for both BB and HRS. Set the minimum hour to be 1. The window rate has no momentum cut. Makis's calculations are also given here for comparing. **The old beam-times are recalculated with the old rates and the requirement of 25K events per-bin**.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	E' (GeV)	θ (Deg)	σ_{old} (nb/sr /GeV)	σ_{new} (nb/sr /GeV)	σ_{avg} (nb/sr /GeV)	old rate Hz(Hour)	new rate &Hour Hz(Hour) (δP+/-4.5%)	window rate Hz
BB	0.87(0.80)	3.10(4.31)	2.07	47.10	0.0058	0.0047	0.0215	0.13(54.47)	30.20(1.00)/ 0.31(22.23)	41.83
BB	0.83(0.80)	3.87(4.51)	1.48	57.10	0.0067	0.0052	0.0119	0.11(61.12)	3.96(1.76)/ 0.17(40.47)	5.33
BB	0.79(0.78)	4.71(4.89)	1.41	57.10	0.0117	0.0103	0.0161	0.20(35.06)	4.05(1.72)/ 0.28(24.49)	5.45
BB	0.75(0.75)	5.25(5.26)	1.58	51.90	0.0242	0.0207	0.0288	0.47(14.87)	11.70(1.00)/ 0.61(11.32)	15.99
BB	0.71(0.72)	6.07(5.95)	1.50	51.90	0.0370	0.0341	0.0416	0.71(9.76)	11.63(1.00)/ 0.89(7.80)	15.90
BB	0.67(0.68)	6.66(6.51)	1.67	47.10	0.0698	0.0649	0.0772	1.53(4.53)	29.99(1.00)/ 1.84(3.77)	41.55
BB	0.63(0.64)	7.22(7.05)	1.90	42.00	0.1340	0.1279	0.1498	3.40(2.04)	79.43(1.00)/ 4.06(1.71)	111.48
BB	0.59(0.60)	7.97(7.80)	1.80	42.00	0.1830	0.1755	0.1972	4.63(1.50)	78.10(1.00)/ 5.07(1.37)	109.57
HRS	0.55(0.55)	6.78	4.00	23.40	1.6000	1.5484	1.6535	9.22(1.00)	10.00(1.00)	13.71
HRS	0.51(0.51)	7.32	4.00	22.50	2.3100	2.2542	2.3874	13.71(1.00)	14.44(1.00)	19.95
HRS	0.47(0.47)	7.84	4.00	21.60	3.2800	3.2048	3.3692	20.08(1.00)	20.37(1.00)	28.37
HRS	0.43(0.43)	8.39	4.00	20.60	4.6400	4.6342	4.8309	29.31(1.00)	29.21(1.00)	41.01
HRS	0.39(0.39)	8.92	4.00	19.60	6.5200	6.5811	6.8460	42.50(1.00)	41.39(1.00)	58.58
HRS	0.35(0.35)	9.42	4.00	18.60	9.1800	9.2193	9.5671	61.83(1.00)	57.85(1.00)	82.49
HRS	0.31(0.31)	9.94	4.00	17.50	13.0000	13.2101	13.6815	90.39(1.00)	82.73(1.00)	118.93
HRS	0.27(0.27)	10.48	4.00	16.30	18.7000	19.4021	20.0604	134.14(1.00)	121.30(1.00)	175.86
HRS	0.23(0.23)	10.98	4.00	15.10	27.5000	28.4160	29.4278	203.39(1.00)	177.93(1.00)	260.08
								8 Days	5 Days	

Table 4: **^{2}H**, **^{3}H** and **^{3}He** Cross Section and Rates for d/u Extraction with BigBite and HRS. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). 25 cm target length is used. A $|\Delta\delta P| < 4.5\%$ cut is applied on BigBite. No other corrections.

	x_{bj} (x_{bj}^{avg})	W^2 (W_{avg}^2) (GeV^2)	Q^2 (GeV^2)	E' (GeV)	θ (Deg)	σ_{H2} (nb/s /GeV)	σ_{H3} (nb/sr /GeV)	σ_{He3} (nb/sr /GeV)	H2 Rate &Hour Hz(Hour)	H3 Rate &Hour Hz(Hour)	He3 Rate &Hour Hz(Hour)	Total Hour
BB	0.87(0.80)	3.10(4.31)	14.54	2.07	47.10	0.0122	0.0152	0.0215	0.285(24.39)	0.154(45.02)	0.312(22.23)	91.63
BB	0.83(0.80)	3.87(4.51)	14.87	1.48	57.10	0.0068	0.0085	0.0119	0.156(44.41)	0.085(81.96)	0.172(40.47)	166.84
BB	0.79(0.78)	4.71(4.89)	14.17	1.41	57.10	0.0092	0.0116	0.0161	0.260(26.69)	0.142(48.78)	0.284(24.49)	99.97
BB	0.75(0.75)	5.25(5.26)	13.31	1.58	51.90	0.0167	0.0211	0.0288	0.567(12.24)	0.314(22.15)	0.614(11.32)	45.71
BB	0.71(0.72)	6.07(5.95)	12.64	1.50	51.90	0.0242	0.0310	0.0416	0.829(8.38)	0.463(15.01)	0.891(7.80)	31.19
BB	0.67(0.68)	6.66(6.51)	11.73	1.67	47.10	0.0453	0.0586	0.0772	1.727(4.02)	0.974(7.13)	1.840(3.77)	14.93
BB	0.63(0.64)	7.22(7.05)	10.74	1.90	42.00	0.0886	0.1159	0.1498	3.844(1.81)	2.191(3.17)	4.063(1.71)	6.69
BB	0.59(0.60)	7.97(7.80)	10.17	1.80	42.00	0.1173	0.1548	0.1972	4.824(1.44)	2.771(2.51)	5.068(1.37)	5.32
HRS	0.55(0.55)	6.78(6.74)	7.24	4.00	23.40	0.9886	1.3124	1.6535	9.564(1.00)	5.529(1.26)	9.998(1.00)	3.26
HRS	0.51(0.51)	7.32(7.28)	6.70	4.00	22.50	1.4376	1.9255	2.3874	13.908(1.00)	8.112(1.00)	14.435(1.00)	3.00
HRS	0.47(0.47)	7.84(7.80)	6.18	4.00	21.60	2.0428	2.7592	3.3692	19.763(1.00)	11.625(1.00)	20.372(1.00)	3.00
HRS	0.43(0.43)	8.39(8.34)	5.63	4.00	20.60	2.9504	4.0203	4.8309	28.543(1.00)	16.938(1.00)	29.210(1.00)	3.00
HRS	0.39(0.39)	8.92(8.88)	5.10	4.00	19.60	4.2108	5.7863	6.8460	40.736(1.00)	24.378(1.00)	41.394(1.00)	3.00
HRS	0.35(0.35)	9.42(9.38)	4.60	4.00	18.60	5.9246	8.2067	9.5671	57.317(1.00)	34.575(1.00)	57.847(1.00)	3.00
HRS	0.31(0.31)	9.94(9.90)	4.07	4.00	17.50	8.5338	11.9199	13.6815	82.559(1.00)	50.219(1.00)	82.725(1.00)	3.00
HRS	0.27(0.27)	10.48(10.43)	3.54	4.00	16.30	12.6074	17.7618	20.0604	121.969(1.00)	74.831(1.00)	121.295(1.00)	3.00
HRS	0.23(0.23)	10.98(10.94)	3.04	4.00	15.10	18.6295	26.4607	29.4278	180.229(1.00)	111.480(1.00)	177.935(1.00)	3.00
											Total Days	21 (17)

Table 5: **^{2}H**, **^{3}H** and **^{3}He** Cross Section and Rates for d/u Extraction with **only one HRS**. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). 25 cm target length is used. No other corrections.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	Q^2 (GeV^2)	E' (GeV)	θ (Deg)	σ_{H2} (nb/s /GeV)	σ_{H3} (nb/sr /GeV)	σ_{He3} (nb/sr /GeV)	H2 Rate &Hour Hz(Hour)	H3 Rate &Hour Hz(Hour)	He3 Rate &Hour Hz(Hour)	Total Hour
HRS	0.87(0.83)	3.10(3.67)	14.54	2.07	47.10	0.0055	0.0067	0.0098	0.015(460.77)	0.008(866.86)	0.017(414.31)	1741.94
HRS	0.83(0.82)	3.87(4.02)	14.87	1.48	57.10	0.0037	0.0046	0.0066	0.012(588.71)	0.006(1103.09)	0.013(530.82)	2222.62
HRS	0.79(0.79)	4.71(4.70)	14.17	1.41	57.10	0.0065	0.0080	0.0114	0.022(314.95)	0.012(582.76)	0.024(286.49)	1184.20
HRS	0.75(0.75)	5.25(5.23)	13.31	1.58	51.90	0.0128	0.0161	0.0223	0.049(142.00)	0.027(259.96)	0.053(130.15)	532.10
HRS	0.71(0.71)	6.07(6.06)	12.64	1.50	51.90	0.0208	0.0264	0.0360	0.076(91.92)	0.042(166.25)	0.082(85.00)	343.17
HRS	0.67(0.67)	6.66(6.65)	11.73	1.67	47.10	0.0397	0.0509	0.0681	0.160(43.34)	0.090(77.53)	0.172(40.40)	161.28
HRS	0.63(0.63)	7.22(7.20)	10.74	1.90	42.00	0.0784	0.1017	0.1334	0.360(19.29)	0.203(34.13)	0.383(18.13)	71.54
HRS	0.59(0.59)	7.97(7.96)	10.17	1.80	42.00	0.1075	0.1409	0.1817	0.468(14.83)	0.267(25.99)	0.494(14.05)	54.87
HRS	0.55(0.55)	6.78(6.74)	7.24	4.00	23.40	0.9910	1.3155	1.6573	9.587(1.00)	5.542(1.25)	10.021(1.00)	3.25
HRS	0.51(0.51)	7.32(7.28)	6.70	4.00	22.50	1.4378	1.9258	2.3877	13.910(1.00)	8.113(1.00)	14.437(1.00)	3.00
HRS	0.47(0.47)	7.84(7.79)	6.18	4.00	21.60	2.0405	2.7561	3.3655	19.741(1.00)	11.611(1.00)	20.349(1.00)	3.00
HRS	0.43(0.43)	8.39(8.35)	5.63	4.00	20.60	2.9555	4.0274	4.8391	28.592(1.00)	16.968(1.00)	29.259(1.00)	3.00
HRS	0.39(0.39)	8.92(8.87)	5.10	4.00	19.60	4.2059	5.7796	6.8383	40.690(1.00)	24.350(1.00)	41.347(1.00)	3.00
HRS	0.35(0.35)	9.42(9.38)	4.60	4.00	18.60	5.9151	8.1933	9.5521	57.225(1.00)	34.519(1.00)	57.757(1.00)	3.00
HRS	0.31(0.31)	9.94(9.90)	4.07	4.00	17.50	8.5391	11.9275	13.6897	82.610(1.00)	50.251(1.00)	82.775(1.00)	3.00
HRS	0.27(0.27)	10.48(10.44)	3.54	4.00	16.30	12.6062	17.7601	20.0586	121.958(1.00)	74.824(1.00)	121.284(1.00)	3.00
HRS	0.23(0.23)	10.98(10.93)	3.04	4.00	15.10	18.5968	26.4138	29.3768	179.913(1.00)	111.282(1.00)	177.626(1.00)	3.00
											Total Days	264 (191)

Table 6: **^{2}H**, **^{3}H** and **^{3}He** Cross Section and Rates for d/u Extraction with **only one HRS**. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). 15cm Target Length is used and 10% reduction with SOS is applied.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	Q^2 (GeV^2)	E' (GeV)	θ (Deg)	σ_{H2} (nb/s /GeV)	σ_{H3} (nb/sr /GeV)	σ_{He3} (nb/sr /GeV)	H2 Rate &Hour Hz(Hour)	H3 Rate &Hour Hz(Hour)	He3 Rate &Hour Hz(Hour)	Total Hour
HRS	0.87(0.83)	3.10(3.67)	14.54	2.07	47.10	0.0055	0.0067	0.0098	0.008(857.35)	0.004(1613.02)	0.009(770.88)	3241.26
HRS	0.83(0.82)	3.87(4.02)	14.87	1.48	57.10	0.0037	0.0046	0.0066	0.006(1092.48)	0.003(2047.11)	0.007(985.03)	4124.62
HRS	0.79(0.79)	4.71(4.70)	14.17	1.41	57.10	0.0065	0.0080	0.0114	0.012(583.31)	0.006(1079.31)	0.013(530.59)	2193.21
HRS	0.75(0.75)	5.25(5.24)	13.31	1.58	51.90	0.0129	0.0161	0.0224	0.027(261.86)	0.014(479.36)	0.029(240.02)	981.23
HRS	0.71(0.71)	6.07(6.06)	12.64	1.50	51.90	0.0208	0.0265	0.0361	0.041(170.01)	0.023(307.48)	0.044(157.21)	634.70
HRS	0.67(0.67)	6.66(6.65)	11.73	1.67	47.10	0.0397	0.0509	0.0681	0.087(80.24)	0.048(143.54)	0.093(74.79)	298.57
HRS	0.63(0.63)	7.22(7.21)	10.74	1.90	42.00	0.0785	0.1019	0.1336	0.195(35.65)	0.110(63.08)	0.207(33.51)	132.24
HRS	0.59(0.59)	7.97(7.96)	10.17	1.80	42.00	0.1074	0.1407	0.1814	0.252(27.52)	0.144(48.22)	0.267(26.06)	101.80
HRS	0.55(0.55)	6.78(6.74)	7.24	4.00	23.40	0.9900	1.3143	1.6558	5.172(1.34)	2.990(2.32)	5.406(1.28)	4.95
HRS	0.51(0.51)	7.32(7.28)	6.70	4.00	22.50	1.4381	1.9261	2.3882	7.513(1.00)	4.382(1.58)	7.798(1.00)	3.58
HRS	0.47(0.47)	7.84(7.80)	6.18	4.00	21.60	2.0441	2.7610	3.3713	10.679(1.00)	6.281(1.11)	11.008(1.00)	3.11
HRS	0.43(0.43)	8.39(8.35)	5.63	4.00	20.60	2.9537	4.0249	4.8362	15.431(1.00)	9.157(1.00)	15.791(1.00)	3.00
HRS	0.39(0.39)	8.92(8.87)	5.10	4.00	19.60	4.2070	5.7810	6.8401	21.978(1.00)	13.152(1.00)	22.334(1.00)	3.00
HRS	0.35(0.35)	9.42(9.38)	4.60	4.00	18.60	5.9215	8.2023	9.5623	30.935(1.00)	18.661(1.00)	31.222(1.00)	3.00
HRS	0.31(0.31)	9.94(9.90)	4.07	4.00	17.50	8.5293	11.9135	13.6743	44.558(1.00)	27.104(1.00)	44.648(1.00)	3.00
HRS	0.27(0.27)	10.48(10.43)	3.54	4.00	16.30	12.5922	17.7399	20.0367	65.784(1.00)	40.359(1.00)	65.422(1.00)	3.00
HRS	0.23(0.23)	10.98(10.94)	3.04	4.00	15.10	18.6464	26.4852	29.4540	97.412(1.00)	60.255(1.00)	96.170(1.00)	3.00
											Today Days	487 (353)

Table 7: **^{2}H**, **^{3}H** and **^{3}He** Cross Section and Rates for d/u Extraction with **only one HRS**. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). 15 cm Target Length is used and 10% reduction with SOS is applied. 20% RC effect and 20% total efficiencies are considered. F2ALLM97 model is used.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	Q^2 (GeV^2)	E' (GeV)	θ (Deg)	σ_{H2} (nb/s /GeV)	σ_{H3} (nb/sr /GeV)	σ_{He3} (nb/sr /GeV)	H2 Rate &Hour Hz(Hour)	H3 Rate &Hour Hz(Hour)	He3 Rate &Hour Hz(Hour)	Total Hour
HRS	0.87(0.83)	3.10(3.67)	14.54	2.07	47.10	0.0055	0.0067	0.0098	0.005(1343.30)	0.003(2527.33)	0.006(1207.81)	5078.44
HRS	0.83(0.82)	3.87(4.02)	14.87	1.48	57.10	0.0038	0.0046	0.0067	0.004(1699.76)	0.002(3184.74)	0.005(1532.68)	6417.18
HRS	0.79(0.79)	4.71(4.69)	14.17	1.41	57.10	0.0064	0.0080	0.0113	0.008(914.83)	0.004(1692.89)	0.008(832.10)	3439.82
HRS	0.75(0.75)	5.25(5.24)	13.31	1.58	51.90	0.0128	0.0161	0.0224	0.017(409.72)	0.009(750.05)	0.018(375.54)	1535.31
HRS	0.71(0.71)	6.07(6.06)	12.64	1.50	51.90	0.0208	0.0265	0.0361	0.026(265.77)	0.014(480.66)	0.028(245.75)	992.18
HRS	0.67(0.67)	6.66(6.64)	11.73	1.67	47.10	0.0396	0.0508	0.0679	0.055(125.68)	0.031(224.84)	0.059(117.15)	467.67
HRS	0.63(0.63)	7.22(7.20)	10.74	1.90	42.00	0.0784	0.1017	0.1334	0.124(55.79)	0.070(98.71)	0.132(52.44)	206.93
HRS	0.59(0.59)	7.97(7.96)	10.17	1.80	42.00	0.1074	0.1407	0.1814	0.162(43.00)	0.092(75.35)	0.171(40.71)	159.06
HRS	0.55(0.55)	6.78(6.73)	7.24	4.00	23.40	0.9871	1.3103	1.6510	3.300(2.10)	1.908(3.64)	3.450(2.01)	7.76
HRS	0.51(0.51)	7.32(7.28)	6.70	4.00	22.50	1.4349	1.9218	2.3829	4.798(1.45)	2.798(2.48)	4.980(1.39)	5.32
HRS	0.47(0.47)	7.84(7.79)	6.18	4.00	21.60	2.0350	2.7483	3.3566	6.804(1.02)	4.002(1.74)	7.014(1.00)	3.76
HRS	0.43(0.43)	8.39(8.35)	5.63	4.00	20.60	2.9592	4.0327	4.8451	9.894(1.00)	5.872(1.18)	10.125(1.00)	3.18
HRS	0.39(0.39)	8.92(8.87)	5.10	4.00	19.60	4.2079	5.7824	6.8415	14.069(1.00)	8.419(1.00)	14.296(1.00)	3.00
HRS	0.35(0.35)	9.42(9.38)	4.60	4.00	18.60	5.9231	8.2047	9.5648	19.804(1.00)	11.946(1.00)	19.987(1.00)	3.00
HRS	0.31(0.31)	9.94(9.90)	4.07	4.00	17.50	8.5418	11.9314	13.6940	28.559(1.00)	17.372(1.00)	28.616(1.00)	3.00
HRS	0.27(0.27)	10.48(10.43)	3.54	4.00	16.30	12.5983	17.7484	20.0464	42.122(1.00)	25.842(1.00)	41.890(1.00)	3.00
HRS	0.23(0.23)	10.98(10.94)	3.04	4.00	15.10	18.6341	26.4677	29.4346	62.302(1.00)	38.538(1.00)	61.508(1.00)	3.00
HRS	0.23(0.23)	10.98(10.93)	3.04	4.00	15.10	18.6056	26.4265	29.3904	62.207(1.00)	38.478(1.00)	61.416(1.00) Total Days	3.00 762 (552)

Table 8: **^{2}H**, **^{3}H** and **^{3}He** Cross Section and Rates for d/u Extraction with **only one HRS and optimized kinematic settings**. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). 15cm Target Length is used and 10% reduction with SOS is applied. 20% RC effect and 20% total efficiencies are considered.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	Q^2 (GeV^2)	E' (GeV)	θ (Deg)	σ_{H2} (nb/s /GeV)	σ_{H3} (nb/sr /GeV)	σ_{He3} (nb/sr /GeV)	H2 Rate &Hour Hz(Hour)	H3 Rate &Hour Hz(Hour)	He3 Rate &Hour Hz(Hour)	Total Hour
HRS	0.87(0.83)	3.06(3.67)	14.58	2.07	47.10	0.0055	0.0067	0.0098	0.005(1329.87)	0.003(2501.80)	0.006(1195.82)	5027.49
HRS	0.83(0.78)	3.11(3.79)	10.90	4.00	28.82	0.0733	0.0916	0.1285	0.131(53.10)	0.071(97.69)	0.143(48.50)	199.29
HRS	0.79(0.76)	3.64(4.02)	10.38	4.00	28.11	0.0999	0.1258	0.1741	0.244(28.52)	0.133(52.05)	0.265(26.20)	106.76
HRS	0.75(0.74)	4.16(4.32)	9.85	4.00	27.37	0.1399	0.1776	0.2423	0.414(16.77)	0.229(30.34)	0.448(15.50)	62.61
HRS	0.71(0.71)	4.69(4.70)	9.33	4.00	26.62	0.2049	0.2623	0.3524	0.669(10.38)	0.373(18.61)	0.719(9.65)	38.64
HRS	0.67(0.67)	5.22(5.17)	8.80	4.00	25.84	0.3080	0.3980	0.5261	1.030(6.74)	0.580(11.98)	1.099(6.32)	25.04
HRS	0.63(0.63)	5.74(5.70)	8.28	4.00	25.05	0.4645	0.6058	0.7876	1.553(4.47)	0.882(7.87)	1.646(4.22)	16.56
HRS	0.59(0.59)	6.27(6.23)	7.75	4.00	24.23	0.6872	0.9045	1.1572	2.298(3.02)	1.317(5.27)	2.418(2.87)	11.17
HRS	0.55(0.55)	6.79(6.75)	7.22	4.00	23.38	0.9987	1.3260	1.6700	3.339(2.08)	1.931(3.60)	3.490(1.99)	7.67
HRS	0.51(0.51)	7.32(7.28)	6.70	4.00	22.50	1.4348	1.9216	2.3826	4.797(1.45)	2.798(2.48)	4.979(1.39)	5.32
HRS	0.47(0.47)	7.84(7.80)	6.17	4.00	21.59	2.0465	2.7643	3.3752	6.842(1.01)	4.025(1.73)	7.053(0.98)	3.72
HRS	0.43(0.43)	8.37(8.32)	5.65	4.00	20.64	2.9097	3.9635	4.7657	9.729(0.71)	5.771(1.20)	9.959(0.70)	2.61
HRS	0.39(0.39)	8.89(8.85)	5.12	4.00	19.65	4.1498	5.7005	6.7488	13.875(0.50)	8.300(0.84)	14.103(0.49)	1.83
HRS	0.35(0.35)	9.42(9.38)	4.60	4.00	18.60	5.9200	8.2002	9.5599	19.793(0.35)	11.940(0.58)	19.977(0.35)	1.28
HRS	0.31(0.31)	9.94(9.90)	4.07	4.00	17.50	8.5334	11.9191	13.6811	28.531(0.24)	17.355(0.40)	28.589(0.24)	0.89
HRS	0.27(0.27)	10.47(10.43)	3.55	4.00	16.32	12.5154	17.6292	19.9171	41.845(0.17)	25.668(0.27)	41.620(0.17)	0.60
HRS	0.23(0.23)	10.99(10.95)	3.02	4.00	15.06	18.9053	26.8602	29.8557	63.209(0.11)	39.109(0.18)	62.389(0.11)	0.40
											Total Days	232 (21)

Table 9: **^{2}H**, **^{3}H** and **^{3}He** Cross Section and Rates for d/u Extraction with **only one HRS and optimized kinematic settings**. **F1F2IN09** model is used to get a cross check with the F2ALLM97 model. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). 15cm Target Length is used and 10% reduction with SOS is applied. 20% RC effect and 20% total efficiencies are considered.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	Q^2 (GeV^2)	E' (GeV)	θ (Deg)	σ_{H2} (nb/s /GeV)	σ_{H3} (nb/sr /GeV)	σ_{He3} (nb/sr /GeV)	H2 Rate &Hour Hz(Hour)	H3 Rate &Hour Hz(Hour)	He3 Rate &Hour Hz(Hour)	Total Hour
HRS	0.87(0.83)	3.06(3.67)	14.58	2.07	47.10	0.0000	0.0000	0.0047	0.000(0.00)	0.000(0.00)	0.003(2518.28)	2518.28
HRS	0.83(0.78)	3.11(3.79)	10.90	4.00	28.82	0.0804	0.1086	0.1333	0.144(48.15)	0.085(81.83)	0.149(46.46)	176.44
HRS	0.79(0.76)	3.64(4.02)	10.38	4.00	28.11	0.1076	0.1464	0.1781	0.263(26.44)	0.156(44.63)	0.272(25.55)	96.62
HRS	0.75(0.74)	4.16(4.32)	9.85	4.00	27.37	0.1499	0.2047	0.2476	0.443(15.66)	0.264(26.34)	0.458(15.17)	57.17
HRS	0.71(0.71)	4.69(4.69)	9.33	4.00	26.62	0.2142	0.2931	0.3550	0.700(9.92)	0.417(16.64)	0.725(9.57)	36.13
HRS	0.67(0.67)	5.22(5.18)	8.80	4.00	25.84	0.3194	0.4374	0.5312	1.068(6.50)	0.637(10.90)	1.110(6.26)	23.66
HRS	0.63(0.63)	5.74(5.70)	8.28	4.00	25.05	0.4752	0.6506	0.7924	1.589(4.37)	0.947(7.33)	1.656(4.19)	15.90
HRS	0.59(0.59)	6.27(6.23)	7.75	4.00	24.23	0.6991	0.9568	1.1672	2.337(2.97)	1.393(4.98)	2.439(2.85)	10.80
HRS	0.55(0.55)	6.79(6.75)	7.22	4.00	23.38	1.0133	1.3879	1.6909	3.388(2.05)	2.021(3.44)	3.533(1.97)	7.45
HRS	0.51(0.51)	7.32(7.27)	6.70	4.00	22.50	1.4506	1.9913	2.4144	4.850(1.43)	2.899(2.40)	5.045(1.38)	5.20
HRS	0.47(0.47)	7.84(7.80)	6.17	4.00	21.59	2.0750	2.8603	3.4379	6.938(1.00)	4.165(1.67)	7.184(0.97)	3.64
HRS	0.43(0.43)	8.37(8.33)	5.65	4.00	20.64	2.9440	4.0824	4.8467	9.843(0.71)	5.944(1.17)	10.128(0.69)	2.56
HRS	0.39(0.39)	8.89(8.85)	5.12	4.00	19.65	4.1631	5.8167	6.7994	13.919(0.50)	8.469(0.82)	14.208(0.49)	1.81
HRS	0.35(0.35)	9.42(9.38)	4.60	4.00	18.60	5.9012	8.3187	9.5482	19.731(0.35)	12.112(0.57)	19.953(0.35)	1.27
HRS	0.31(0.31)	9.94(9.90)	4.07	4.00	17.50	8.3909	11.9438	13.4372	28.055(0.25)	17.391(0.40)	28.079(0.25)	0.89
HRS	0.27(0.27)	10.47(10.43)	3.55	4.00	16.32	12.0413	17.3144	19.0739	40.260(0.17)	25.210(0.28)	39.858(0.17)	0.62
HRS	0.23(0.23)	10.99(10.95)	3.02	4.00	15.06	17.6063	25.5721	27.5821	58.866(0.12)	37.234(0.19)	57.637(0.12)	0.42
											Total Days	124 (19)

Table 10: **^{2}H, ^{3}H and ^{3}He** Cross Section and Rates for d/u Extraction with **optimized kinematic settings using R-HRS at a lower momentum**. F2ALLM97 model is used. A $W^2 > 4$ cut is applied when calculating the rate ($W^2 > 3$ when x>0.70). 15cm Target Length is used and 10% reduction with SOS is applied. 20% RC effect and 20% total efficiencies are considered.

	x_{bj} (x_{bj}^{avg})	W^2 (W^2_{avg}) (GeV^2)	Q^2 (GeV^2)	E' (GeV)	θ (Deg)	σ_{H2} (nb/s /GeV)	σ_{H3} (nb/sr /GeV)	σ_{He3} (nb/sr /GeV)	H2 Rate &Hour Hz(Hour)	H3 Rate &Hour Hz(Hour)	He3 Rate &Hour Hz(Hour)	Total Hour
HRS	0.87(0.83)	3.06(3.67)	14.58	2.07	47.10	0.0055	0.0067	0.0098	0.005(1341.64)	0.003(2524.00)	0.006(1206.37)	5072.01
HRS	0.83(0.80)	3.40(3.87)	12.30	3.10	34.96	0.0263	0.0327	0.0464	0.045(155.35)	0.024(287.74)	0.049(141.21)	584.30
HRS	0.79(0.78)	3.99(4.19)	11.71	3.10	34.08	0.0383	0.0479	0.0670	0.085(81.73)	0.046(150.03)	0.093(74.76)	306.51
HRS	0.75(0.75)	4.59(4.61)	11.12	3.10	33.18	0.0583	0.0737	0.1014	0.147(47.19)	0.081(85.80)	0.160(43.47)	176.46
HRS	0.71(0.71)	5.18(5.15)	10.53	3.10	32.26	0.0922	0.1176	0.1589	0.239(29.08)	0.133(52.35)	0.257(26.98)	108.41
HRS	0.67(0.67)	5.77(5.74)	9.93	3.10	31.31	0.1444	0.1860	0.2472	0.374(18.56)	0.210(33.08)	0.400(17.35)	68.99
HRS	0.63(0.63)	6.37(6.34)	9.34	3.10	30.34	0.2211	0.2877	0.3757	0.573(12.12)	0.325(21.39)	0.608(11.41)	44.92
HRS	0.59(0.59)	6.96(6.93)	8.75	3.10	29.34	0.3302	0.4337	0.5570	0.856(8.12)	0.489(14.19)	0.902(7.70)	30.01
HRS	0.55(0.55)	7.55(7.52)	8.15	3.10	28.30	0.4855	0.6435	0.8130	1.258(5.52)	0.726(9.56)	1.317(5.27)	20.36
HRS	0.51(0.51)	8.14(8.12)	7.56	3.10	27.23	0.7048	0.9425	1.1718	1.826(3.80)	1.064(6.53)	1.898(3.66)	13.99
HRS	0.47(0.47)	8.74(8.70)	6.97	3.10	26.12	1.0088	1.3608	1.6656	2.614(2.66)	1.536(4.52)	2.697(2.57)	9.75
HRS	0.43(0.43)	9.33(9.30)	6.37	3.10	24.97	1.4453	1.9665	2.3694	3.745(1.85)	2.219(3.13)	3.837(1.81)	6.79
HRS	0.39(0.39)	9.92(9.89)	5.78	3.10	23.76	2.0701	2.8408	3.3695	5.364(1.29)	3.206(2.17)	5.457(1.27)	4.73
HRS	0.35(0.35)	10.52(10.49)	5.19	3.10	22.49	2.9707	4.1113	4.8007	7.698(0.90)	4.639(1.50)	7.775(0.89)	3.29
HRS	0.31(0.31)	11.11(11.08)	4.60	3.10	21.15	4.3001	6.0017	6.8984	11.142(0.62)	6.772(1.03)	11.172(0.62)	2.27
HRS	0.27(0.27)	11.70(11.67)	4.00	3.10	19.73	6.3363	8.9197	10.0893	16.419(0.42)	10.065(0.69)	16.339(0.43)	1.54
HRS	0.23(0.23)	12.30(12.26)	3.41	3.10	18.19	9.5747	13.5952	15.1289	24.810(0.28)	15.341(0.45)	24.501(0.28)	1.02
												269 (57)