E08-014:

The inclusive SRC isospin and $x > 2$ experiment under the Qweak constraints

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I. KINEMATICS

After taking into account the Qweak linac energy setting ($E_{linac} = 1.1$ GeV/pass) and using Eq.1, I prepared tables of with the two energy options: 3.362 GeV (see Table I) and 4.462 GeV (see Table II).

$$E_{beam} = N_{pass} * E_{linac} + \frac{0.065 * E_{linac}}{1.2} \tag{1}$$

The goal of this "exercise", at this time, is to re-tune the kinematics to get the same (x,Q^2) coverage and the same precision as in the original proposal.

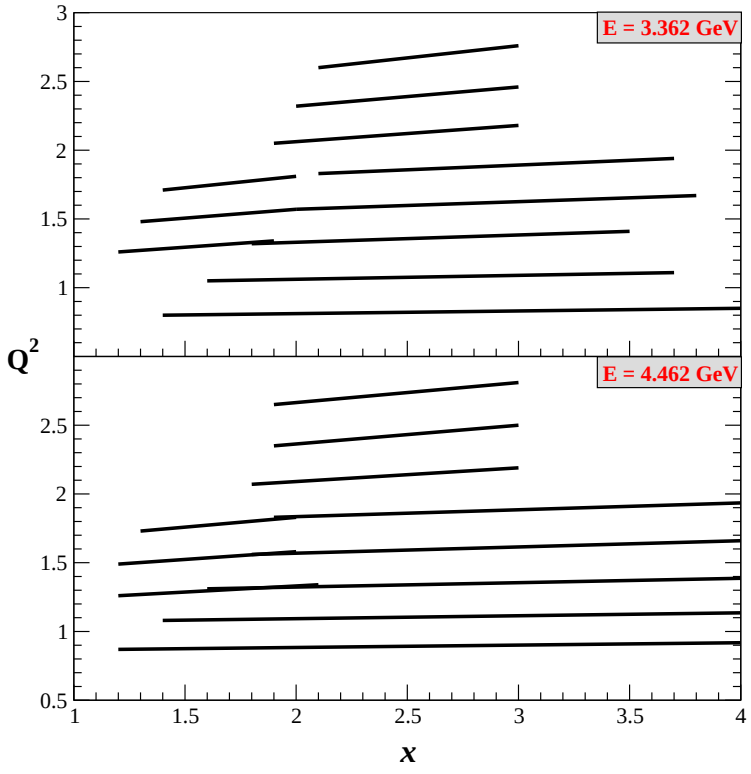

FIG. 1: Kinematic coverage (for $\delta P/P = 3\%$) of the 3-pass and 4-pass alternatives

A. The 3-pass option: E = 3.362 GeV

TABLE I: List of kinematics for left and right HRS and estimated beam time needed for the proposed experiment per HRS. The right HRS running is simultaneous to the left HRS running, and so does not increase the total time needed.

θ (deg)	E' (GeV)	x_{range}	Q^2_{range} (GeV/c)^2	Tg	I (μA)	psc	R_{tot} (Hz)	R_{phys} (Hz)	time (hrs)	Total (hrs)
16.0	3.155	1.4-4.0	0.80-0.85	^{3}He	60.0	6	2918.461	285.584	3.0	
				^{2}H	60.0	8	3392.797	259.116	3.2	
				^{4}He	60.0	11	3371.874	426.499	1.6	
				^{12}C	80.0	7	3309.297	617.093	1.1	
				^{40}Ca	40.0	3	2958.205	575.055	1.0	
				^{48}Ca	40.0	3	2803.359	546.988	1.0	**10.9 (L)**
18.5	3.110	1.6-3.7	1.05-1.11	^{3}He	60.0	1	1490.721	179.613	3.6	
				^{2}H	60.0	1	1691.744	178.168	2.9	
				^{4}He	60.0	2	1795.004	258.047	2.1	
				^{12}C	80.0	1	2366.358	480.524	1.1	
				^{40}Ca	40.0	1	916.961	195.108	2.4	
				^{48}Ca	40.0	1	871.882	185.885	2.5	**14.6 (L)**
21.0	2.905	1.2-1.9	1.26-1.34	^{3}He	60.0	2	1815.977	288.702	3.6	
				^{2}H	60.0	2	3494.107	514.916	2.9	
				^{4}He	60.0	2	3494.651	657.664	1.3	
				^{12}C	80.0	2	2067.113	578.130	1.4	
				^{40}Ca	40.0	1	1575.404	446.184	1.8	
				^{48}Ca	40.0	1	1488.662	422.499	1.8	**12.8 (R)**
21.0	3.055	1.8-3.5	1.32-1.41	^{3}He	60.0	1	219.813	28.474	4.5	
				^{2}H	60.0	1	225.513	0.000	0.0	
				^{4}He	60.0	1	541.496	82.829	1.3	
				^{12}C	80.0	1	362.722	77.377	1.4	
				^{40}Ca	40.0	1	140.793	31.798	3.0	
				^{48}Ca	40.0	1	133.995	30.324	3.1	**13.3 (R)**
23.0	2.855	1.3-2.0	1.48-1.57	^{3}He	60.0	1	746.858	117.450	4.5	
				^{2}H	60.0	1	1160.056	174.418	3.6	
				^{4}He	60.0	1	1580.001	297.175	1.6	
				^{12}C	80.0	1	963.193	268.455	1.7	
				^{40}Ca	40.0	1	373.860	105.049	4.4	
				^{48}Ca	40.0	1	354.315	99.694	4.6	**20.4/2**
23.0	3.035	2.0-3.8	1.57-1.67	^{3}He	60.0	1	33.566	3.774	9.0	
				^{2}H	60.0	1	26.211	0.000	0.0	
				^{4}He	60.0	1	84.325	11.645	2.7	
				^{12}C	80.0	1	59.369	11.046	2.7	
				^{40}Ca	40.0	1	22.854	4.787	5.9	
				^{48}Ca	40.0	1	21.783	4.584	6.1	**26.4/2**
25.0	2.795	1.4-2.0	1.71-1.81	^{3}He	60.0	1	202.120	34.289	9.0	
				^{2}H	60.0	1	277.680	45.642	7.2	
				^{4}He	60.0	1	452.676	91.717	3.2	
				^{12}C	80.0	1	280.530	83.941	3.5	
				^{40}Ca	40.0	1	109.929	33.060	8.8	

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θ (deg)	E' (GeV)	x_{range}	Q^2_{range} (GeV/c)^2	Tg	I (μA)	psc	R_{tot} (Hz)	R_{phys} (Hz)	time (hrs)	Total (hrs)
				^{48}Ca	40.0	1	104.339	31.407	9.2	**40.9/2**
25.0	2.995	2.1-3.7	1.83-1.94	^{3}He	60.0	1	7.231	0.734	18.0	
				^{2}H	60.0	1	3.339	0.000	0.0	
				^{4}He	60.0	1	18.534	2.399	5.3	
				^{12}C	80.0	1	13.532	2.308	5.5	
				^{40}Ca	40.0	1	5.237	1.047	11.8	
				^{48}Ca	40.0	1	5.001	1.005	12.3	**52.9/2**
27.0	2.885	1.9-3.0	2.05-2.18	^{3}He	60.0	1	6.254	0.847	36.0	
				^{2}H	60.0	1	5.464	0.000	0.0	
				^{4}He	60.0	1	15.509	2.521	10.6	
				^{12}C	80.0	1	10.252	2.369	11.0	
				^{40}Ca	40.0	1	4.072	0.994	23.6	
				^{48}Ca	40.0	1	3.881	0.950	24.5	**105.7/2**
29.0	2.835	2.0-3.0	2.32-2.46	^{3}He	60.0	1	1.766	0.230	63.0	
				^{2}H	60.0	1	1.229	0.000	0.0	
				^{4}He	60.0	1	4.413	0.704	18.6	
				^{12}C	80.0	1	2.937	0.666	19.2	
				^{40}Ca	40.0	1	1.178	0.286	41.3	
				^{48}Ca	40.0	1	1.123	0.274	43.0	**185.1/2**
31.0	2.790	2.1-3.0	2.60-2.76	^{3}He	60.0	1	0.451	0.054	63.0	
				^{2}H	60.0	1	0.162	0.000	0.0	
				^{4}He	60.0	1	1.146	0.175	18.6	
				^{12}C	80.0	1	0.778	0.168	19.2	
				^{40}Ca	40.0	1	0.317	0.075	41.3	
				^{48}Ca	40.0	1	0.303	0.072	43.0	**185.1/2**
							Total time needed			**335 hours/HRS (14 days)**
							removing highest Q^2 settings			**242 hours/HRS (10 days)**

B. The 4-pass option: E = 4.462 GeV

TABLE II: List of kinematics for left HRS only and estimated beam time needed for the proposed experiment.

θ (deg)	E' (GeV)	x_{range}	Q^2_{range} (GeV/c)^2	Tg	I (μA)	psc	R_{tot} (Hz)	R_{phys} (Hz)	time (hrs)	Total (hrs)
12.5	4.215	1.2-4.1	0.87-0.92	^{3}He	60.0	19	3394.705	336.484	2.0	
				^{2}H	60.0	43	3487.746	252.132	3.6	
				^{4}He	60.0	34	3405.182	439.466	1.1	
				^{12}C	80.0	20	3369.976	661.546	0.6	
				^{40}Ca	40.0	8	3146.157	643.284	0.6	
				^{48}Ca	40.0	7	3388.984	696.798	0.5	**8.4**
14.0	4.185	1.4-4.2	1.08-1.14	^{3}He	60.0	3	2575.047	230.168	2.4	
				^{2}H	60.0	4	2969.557	209.532	2.5	
				^{4}He	60.0	5	3284.015	379.683	1.2	
				^{12}C	80.0	3	3390.845	583.107	0.7	
				^{40}Ca	40.0	2	1960.060	348.856	1.0	
				^{48}Ca	40.0	2	1857.849	331.808	1.1	**8.9**
15.5	4.005	1.2-2.1	1.26-1.34	^{3}He	60.0	4	3348.316	491.168	2.4	
				^{2}H	60.0	10	3253.758	406.485	4.8	
				^{4}He	60.0	7	3352.176	589.355	1.5	
				^{12}C	80.0	4	3354.347	885.330	0.9	
				^{40}Ca	40.0	2	2503.492	674.818	1.2	
				^{48}Ca	40.0	2	2357.416	637.694	1.2	**12.0**
15.5	4.155	1.6-4.1	1.31-1.39	^{3}He	60.0	1	971.503	106.242	3.0	
				^{2}H	60.0	1	1138.554	109.195	2.4	
				^{4}He	60.0	1	2318.684	303.854	0.9	
				^{12}C	80.0	1	1501.396	282.552	0.9	
				^{40}Ca	40.0	1	586.344	114.191	2.0	
				^{48}Ca	40.0	1	557.460	108.752	2.0	**11.2**
17.0	3.930	1.2-2.0	1.49-1.58	^{3}He	60.0	2	1952.049	279.609	3.0	
				^{2}H	60.0	3	2686.474	342.105	3.6	
				^{4}He	60.0	3	2427.904	417.319	1.6	
				^{12}C	80.0	2	2131.221	547.606	1.2	
				^{40}Ca	40.0	1	1613.868	421.587	1.5	
				^{48}Ca	40.0	1	1523.382	399.046	1.5	**12.4**
17.0	4.120	1.8-4.0	1.56-1.66	^{3}He	60.0	1	178.553	19.552	6.0	
				^{2}H	60.0	1	188.194	0.000	0.0	
				^{4}He	60.0	1	437.800	56.709	1.8	
				^{12}C	80.0	1	288.849	52.935	1.8	
				^{40}Ca	40.0	1	112.967	21.693	3.9	
				^{48}Ca	40.0	1	107.504	20.682	4.1	**17.6**
18.5	3.860	1.3-2.0	1.73-1.83	^{3}He	60.0	1	1041.971	149.733	6.0	
				^{2}H	60.0	1	1834.216	241.122	4.8	
				^{4}He	60.0	1	2082.090	360.162	2.1	
				^{12}C	80.0	1	1246.988	321.253	2.3	
				^{40}Ca	40.0	1	478.830	124.904	5.8	
				^{48}Ca	40.0	1	453.023	118.417	6.2	**27.2**
18.5	4.085	1.9-4.1	1.83-1.94	^{3}He	60.0	1	34.682	3.440	12.0	

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θ (deg)	E' (GeV)	x_{range}	Q^2_{range} (GeV/c)^2	Tg	I (μA)	psc	R_{tot} (Hz)	R_{phys} (Hz)	time (hrs)	Total (hrs)
				^{2}H	60.0	1	32.434	0.000	0.0	
				^{4}He	60.0	1	85.768	10.321	3.5	
				^{12}C	80.0	1	57.709	9.721	3.7	
				^{40}Ca	40.0	1	22.572	4.112	7.9	
				^{48}Ca	40.0	1	21.499	3.930	8.2	**35.3**
20.0	3.955	1.8-3.0	2.07-2.19	^{3}He	60.0	1	29.561	3.823	24.0	
				^{2}H	60.0	1	31.998	0.000	0.0	
				^{4}He	60.0	1	72.148	10.960	7.1	
				^{12}C	80.0	1	46.518	10.199	7.3	
				^{40}Ca	40.0	1	18.408	4.132	15.7	
				^{48}Ca	40.0	1	17.517	3.936	16.4	**70.5**
21.5	3.905	1.9-3.0	2.35-2.50	^{3}He	60.0	1	7.734	0.959	42.0	
				^{2}H	60.0	1	7.902	0.000	0.0	
				^{4}He	60.0	1	18.935	2.780	12.4	
				^{12}C	80.0	1	12.258	2.595	12.8	
				^{40}Ca	40.0	1	4.867	1.063	27.6	
				^{48}Ca	40.0	1	4.633	1.013	28.6	**123.4**
23.0	3.850	1.9-3.0	2.65-2.81	^{3}He	60.0	1	2.175	0.258	42.0	
				^{2}H	60.0	1	2.015	0.000	0.0	
				^{4}He	60.0	1	5.347	0.761	12.4	
				^{12}C	80.0	1	3.476	0.714	12.8	
				^{40}Ca	40.0	1	1.387	0.297	27.6	
				^{48}Ca	40.0	1	1.321	0.283	28.6	**123.4**
							Total time needed			**450.3 (19 days)**
							removing highest Q^2 settings			**327 hours/HRS (14 days)**

C. Overhead time

	Estimate	3.362 GeV time(hrs)	4.462 GeV time(hrs)
HRS angle change	0.5hr/change	2.5 (5 changes) × 3(or 4)	3.5 (7 changes) × 3(or 4)
Target motion	10min/motion	6.7	7.3
Cryo-target change	8hr/change	16	16
Optics	0.5hr/angle	3.5	4
Dummy run	15% of ^{3}He time	32.5	22
BCM calibration		2 × 1	
Energy measurement		1 × 2	
Boiling study		8	
Rate-dependence tests		4	
Intial checkout		8	
TOTAL		90	84

TABLE III: Summary of the overhead time needed for the two energy options.

II. DENSITIES AND THICKNESSES OF THE TARGETS

Target	T(K), P(psia), L(cm)	Thickness(g/cm^2)
^{2}H	22.0, 22.0, 20.0	3.35
^{3}He	8.0, 200.0, 20.0	1.38
^{4}He	8.0, 200.0, 20.0	2.28
Al Entrance	N/A, N/A, 0.035	0.09
Al Exit	N/A, N/A, 0.035	0.09
Al Wall	N/A, N/A, 0.035	0.09

TABLE IV: Aluminum window/wall thickness and running conditions of the cryo-target (from D. Meekins)

Target	T (K)	P (psia)	length (cm)	RL (g/cm^2)	I^{limit} (μA)
^{2}H	22.0	22.0	20.0	3.35	60.0
^{3}He	8.0	200.0	20.0	1.38	60.0
^{4}He	8.0	200.0	20.0	2.28	60.0
	thickness (cm)				
^{12}C	0.50			0.95	80.0
^{40}Ca	0.43			0.66	40.0
^{48}Ca	0.43			0.66	40.0

TABLE V: Cryo-target characteristics from D. Meekins (top part) and, solid targets and their characteristics asked for this proposal (bottom part).

III. LIST OF ISSUES

1. The cryo-targets
   (a) one cryo-target cooled at a time
   (b) density of the target: can we have Qweak running at lower current for about a week while we run all our cryo-targets ? → this would imply an increase in our overhead !
   (c) Will we need to take optics data each time we move the HRSs ?
2. The calcium targets
   (a) 95.23% enriched ^{48}Ca from ORNL
   (b) purchase glove-box
   (c) ORNL making our ^{48}Ca: should somebody visit ORNL soon to give the specs of what we want ?
   (d) Possiblility of a test run with ^{40}Ca (but not during PREX: all slots are full): check beam current limit and oxydation level during manipulation (w/o oil layer).
   (e) Could we live with a thin coating layer on the calcium targets ?
   (f) How are we going to measure the thickness and uniformity of the calcium foils ?
3. The beam current
   (a) How much current will we be able to get ?

(b) ...

4. The Linac energy

   (a) On the schedule, it is 1.1 GeV/pass

5. The experiment schedule

   (a) ^{48}Ca should be installed just before we run and removed just after we are done → Shall we push to run first ?

   (b) 9 days of TBA on Qweak side during our run

   (c) compromises might be possible time-to-time with Qweak to run our cryo-targets. We can optimize our running with permanent dialogue with Qweak.