DAQ Speed and Run2 Estimates

April 3, 2015

Summary of FADC Development for Faster Performance

Name	Readout	Trigger
Scalers	Scaler S1 (helicity gated), S2 (un-gated)	Delayed nT_Settle
Mott_Sample	Mott FADC (Mode=1), S1, S2, TDC	Mott Detector
Mott_SemiInt	Mott FADC (Mode=7), S1, S2, TDC	Mott Detector
PEPPo_Int	INT FADC, S1, S2	nT_Settle
SemiIntFast	**Mott FADC (Mode=7), BlockLevel=1**	**Mott Detector**
SemiIntBlock	**Mott FADC (Mode=7), BlockLevel=50**	**Mott Detector**
SampleBlock	**Mott FADC (Mode=1), BlockLevel=50**	**Mott Detector**

For DAQ to be faster:

I. No Readout of CAEN V775 TDC or SIS3801 Scalers; only FADC readout

II. Use block readout

Beam Test (Goal: Can we use FADC timing)

- February 9, 2015:
  - Run 8225: Mott_SemiInt, deadtime = 28% at 5.1 kHz
  - Run 8227: SemiIntFast, deadtime = 17% at 5.1 kHz
  - Run 8228: **SemiIntBlock, deadtime = 1% at 5.1 kHz**

Problem handling periodic signals

JLab expert changed FADC firmware

- March 17, 2015:
  - Mott Run 8312: Mott_SemiInt, FADC Delay: Ch8=0,CH9=0,Ch11=4
  - Mott Run 8313: Mott_SemiInt, FADC Delay: Ch8=0,CH9=2,Ch11=4

Still analyzing but problem may not be solved yet

  - Mott Run 8315: Mott_Sample, deadtime = 32% at 5.5 kHz
  - Mott Run 8316: **SampleBlock, deadtime = 4% at 5.5 kHz**

The other option is to readout the raw data and calculate timing in analysis (raw data files will be larger)

Remaining Challenges and Plans

- Show that we can use FADC timing, either:
  - Timing is done in firmware, or
  - Timing is done in analysis
- Otherwise: Keep using TDC but figure out a way to run faster or upgrade to new TDC

- For scalers: we can upgrade to new JLab scalers we have

- **Change decoder to be able to decode Block data**

Au Estimates

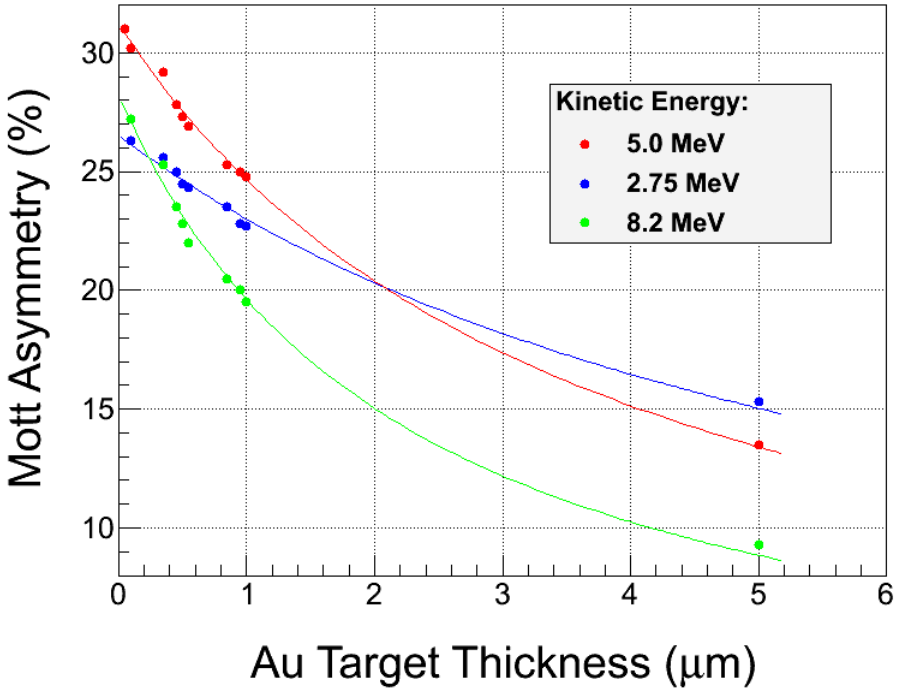
Estimates Assumptions

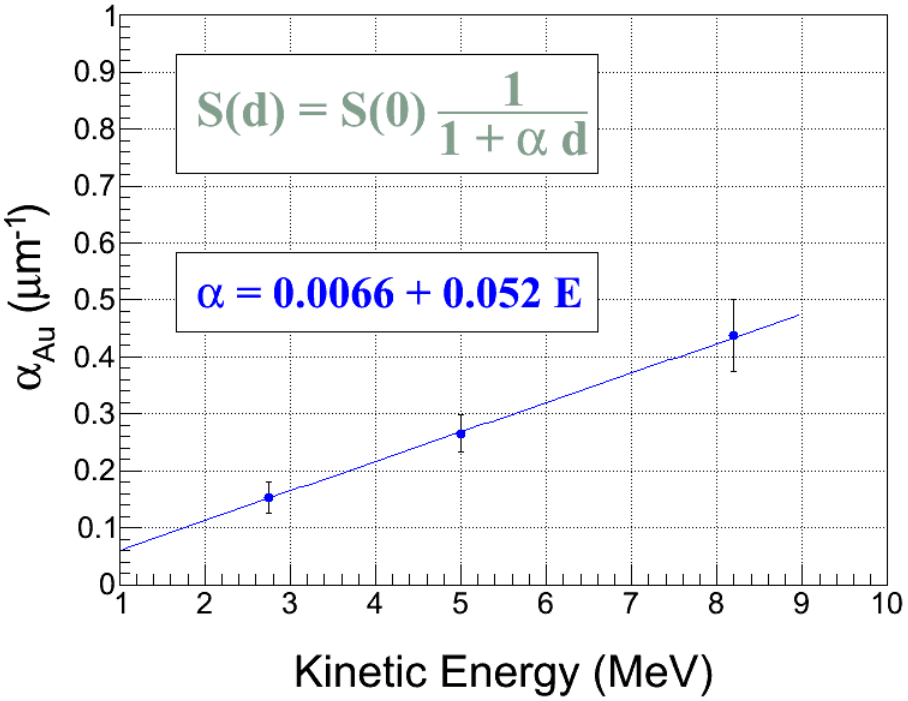
- DAQ rate limit = 2 kHz, deadtime = 15%. Note that any systematic errors due to deadtime cancel to all orders in cross-ratio method – Measured in Run1

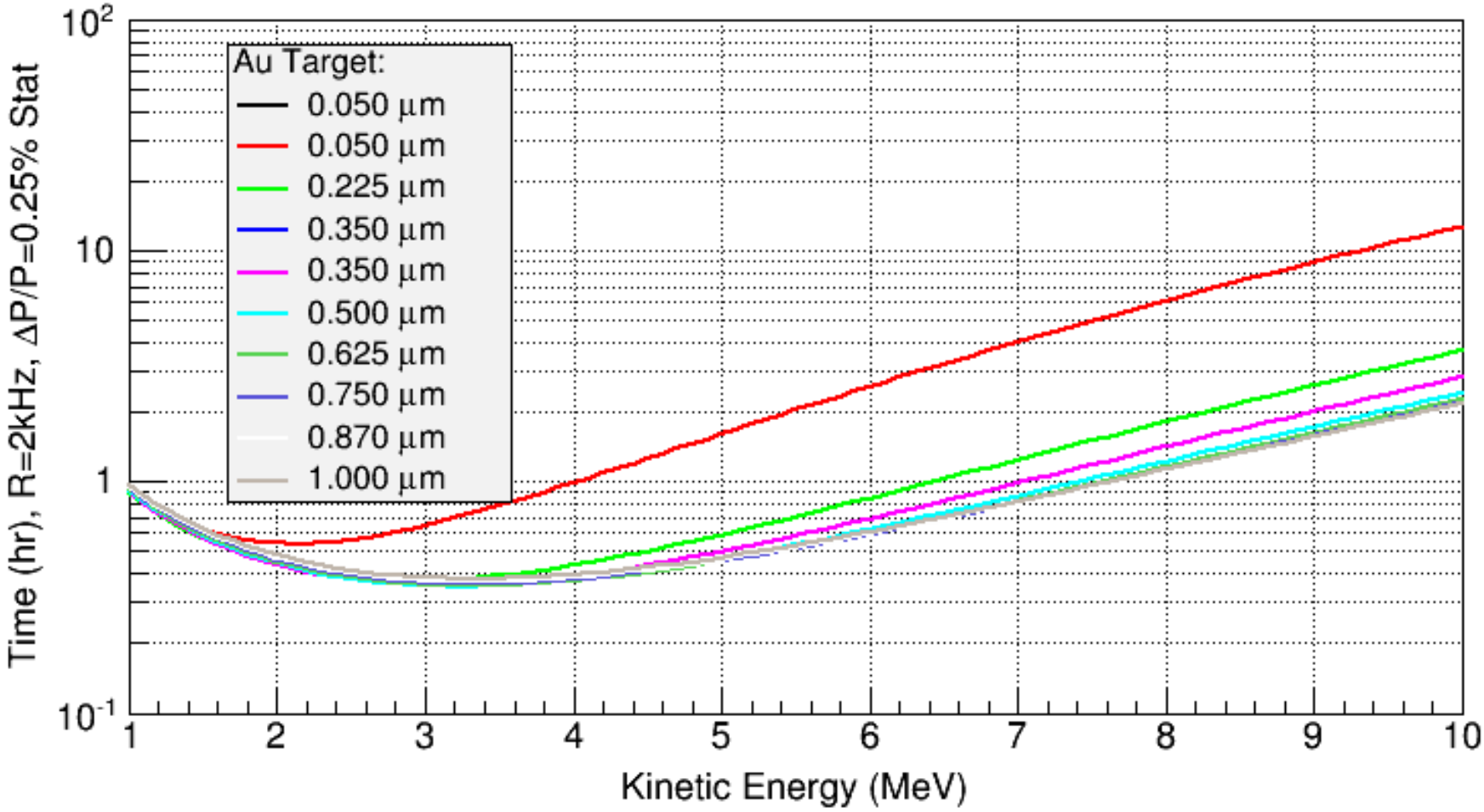
- Current limit of 5 μA

- Dump rate = 100 Hz/μA per detector:
  - Measured during Run1 5 MeV data at
  - Discriminator threshold was 25 mV (or energy of about 1.25 MeV, 2000 FADC channels)
  - Dump dipole magnet was at +5A

Target Thickness Extrapolation






Au Target:
0.050 μm
0.050 μm
0.225 μm
0.350 μm
0.350 μm
0.500 μm
0.625 μm
0.750 μm
0.870 μm
1.000 μm
Time (hr), R=2kHz, ΔP/P=0.25% Stat
Kinetic Energy (MeV)
10²
10
1
10⁻¹
1
2
3
4
5
6
7
8
9
10

3 MeV

T(um) = 0.05	I (uA) = 2.89021	Elas(Hz) = 843.917	Dmp(Hz) = 1156.08	Tot(Hz) = 2000	Tim (h) = 0.642548	N_elas(M#) = 1.95213
T(um) = 0.05	I (uA) = 2.89021	Elas(Hz) = 843.917	Dmp(Hz) = 1156.08	Tot(Hz) = 2000	Tim (h) = 0.642548	N_elas(M#) = 1.95213
T(um) = 0.225	I (uA) = 1.16689	Elas(Hz) = 1533.25	Dmp(Hz) = 466.754	Tot(Hz) = 2000	Tim (h) = 0.373913	N_elas(M#) = 2.06388
T(um) = 0.35	I (uA) = 0.818349	Elas(Hz) = 1672.66	Dmp(Hz) = 327.34	Tot(Hz) = 2000	Tim (h) = 0.356321	N_elas(M#) = 2.14561
T(um) = 0.35	I (uA) = 0.818349	Elas(Hz) = 1672.66	Dmp(Hz) = 327.34	Tot(Hz) = 2000	Tim (h) = 0.356321	N_elas(M#) = 2.14561
T(um) = 0.5	I (uA) = 0.602424	Elas(Hz) = 1759.03	Dmp(Hz) = 240.97	Tot(Hz) = 2000	Tim (h) = 0.354643	N_elas(M#) = 2.24578
T(um) = 0.625	I (uA) = 0.493839	Elas(Hz) = 1802.46	Dmp(Hz) = 197.536	Tot(Hz) = 2000	Tim (h) = 0.359231	N_elas(M#) = 2.331
T(um) = 0.75	I (uA) = 0.418421	Elas(Hz) = 1832.63	Dmp(Hz) = 167.368	Tot(Hz) = 2000	Tim (h) = 0.366475	N_elas(M#) = 2.41781
T(um) = 0.87	I (uA) = 0.364919	Elas(Hz) = 1854.03	Dmp(Hz) = 145.968	Tot(Hz) = 2000	Tim (h) = 0.374954	N_elas(M#) = 2.50264
T(um) = 1	I (uA) = 0.320521	Elas(Hz) = 1871.79	Dmp(Hz) = 128.208	Tot(Hz) = 2000	Tim (h) = 0.385279	N_elas(M#) = 2.59619

5 MeV

T(um) = 0.05	I (uA) = 4.27389	Elas(Hz) = 290.443	Dmp(Hz) = 1709.56	Tot(Hz) = 2000	Tim (h) = 1.59739	N_elas(M#) = 1.67022
T(um) = 0.05	I (uA) = 4.27389	Elas(Hz) = 290.443	Dmp(Hz) = 1709.56	Tot(Hz) = 2000	Tim (h) = 1.59739	N_elas(M#) = 1.67022
T(um) = 0.225	I (uA) = 2.83363	Elas(Hz) = 866.548	Dmp(Hz) = 1133.45	Tot(Hz) = 2000	Tim (h) = 0.585837	N_elas(M#) = 1.82756
T(um) = 0.35	I (uA) = 2.28388	Elas(Hz) = 1086.45	Dmp(Hz) = 913.552	Tot(Hz) = 2000	Tim (h) = 0.497104	N_elas(M#) = 1.94428
T(um) = 0.35	I (uA) = 2.28388	Elas(Hz) = 1086.45	Dmp(Hz) = 913.552	Tot(Hz) = 2000	Tim (h) = 0.497104	N_elas(M#) = 1.94428
T(um) = 0.5	I (uA) = 1.85258	Elas(Hz) = 1258.97	Dmp(Hz) = 741.032	Tot(Hz) = 2000	Tim (h) = 0.460941	N_elas(M#) = 2.08911
T(um) = 0.625	I (uA) = 1.60068	Elas(Hz) = 1359.73	Dmp(Hz) = 640.272	Tot(Hz) = 2000	Tim (h) = 0.452252	N_elas(M#) = 2.21378
T(um) = 0.75	I (uA) = 1.40908	Elas(Hz) = 1436.37	Dmp(Hz) = 563.633	Tot(Hz) = 2000	Tim (h) = 0.45293	N_elas(M#) = 2.34206
T(um) = 0.87	I (uA) = 1.26385	Elas(Hz) = 1494.46	Dmp(Hz) = 505.542	Tot(Hz) = 2000	Tim (h) = 0.458846	N_elas(M#) = 2.46861
T(um) = 1	I (uA) = 1.13691	Elas(Hz) = 1545.23	Dmp(Hz) = 454.765	Tot(Hz) = 2000	Tim (h) = 0.469088	N_elas(M#) = 2.60946

8 MeV

T(um) = 0.05	I (uA) = 4.75761	Elas(Hz) = 96.955	Dmp(Hz) = 1903.05	Tot(Hz) = 2000	Tim (h) = 6.03289	N_elas(M#) = 2.10571
T(um) = 0.05	I (uA) = 4.75761	Elas(Hz) = 96.955	Dmp(Hz) = 1903.05	Tot(Hz) = 2000	Tim (h) = 6.03289	N_elas(M#) = 2.10571
T(um) = 0.225	I (uA) = 4.06748	Elas(Hz) = 373.009	Dmp(Hz) = 1626.99	Tot(Hz) = 2000	Tim (h) = 1.80348	N_elas(M#) = 2.42176
T(um) = 0.35	I (uA) = 3.6856	Elas(Hz) = 525.76	Dmp(Hz) = 1474.24	Tot(Hz) = 2000	Tim (h) = 1.40592	N_elas(M#) = 2.66104
T(um) = 0.35	I (uA) = 3.6856	Elas(Hz) = 525.76	Dmp(Hz) = 1474.24	Tot(Hz) = 2000	Tim (h) = 1.40592	N_elas(M#) = 2.66104
T(um) = 0.5	I (uA) = 3.31241	Elas(Hz) = 675.034	Dmp(Hz) = 1324.97	Tot(Hz) = 2000	Tim (h) = 1.2193	N_elas(M#) = 2.96305
T(um) = 0.625	I (uA) = 3.05466	Elas(Hz) = 778.134	Dmp(Hz) = 1221.87	Tot(Hz) = 2000	Tim (h) = 1.15202	N_elas(M#) = 3.22713
T(um) = 0.75	I (uA) = 2.83413	Elas(Hz) = 866.348	Dmp(Hz) = 1133.65	Tot(Hz) = 2000	Tim (h) = 1.123	N_elas(M#) = 3.50247
T(um) = 0.87	I (uA) = 2.65044	Elas(Hz) = 939.826	Dmp(Hz) = 1060.17	Tot(Hz) = 2000	Tim (h) = 1.11646	N_elas(M#) = 3.77741
T(um) = 1	I (uA) = 2.47654	Elas(Hz) = 1009.38	Dmp(Hz) = 990.616	Tot(Hz) = 2000	Tim (h) = 1.12472	N_elas(M#) = 4.08697

Dump Event Suppression

- Increase discriminator threshold – Tested in Run1
- Study dump dipole (+5A, 0A, -5A) – Tested in Run1 (for thinner foils, 0A or -5A may yield lower dump rate)
- Laser timing veto – Tested on February 9, 2015

Note: Dump rate depends on electron energy (~1/E)

Run2 Strategy

- At 3 MeV:
  - Dump events will be higher due to energy
  - Increase discriminator threshold
  - ➢ Thick foils will benefit from faster DAQ but very little reduction in overall time required for Run2. Here DAQ speed will help with systematic studies, e.g., many short runs with very high statistics for stability study.

- At 8 MeV:
  - Dump events will be lower due to energy
  - Elastic rate is too low to benefit from faster DAQ
  - Suppress dump events will reduce deadtime
  - ➢ Will run at about 5 μA (31 MHz) for all foils (current limited)

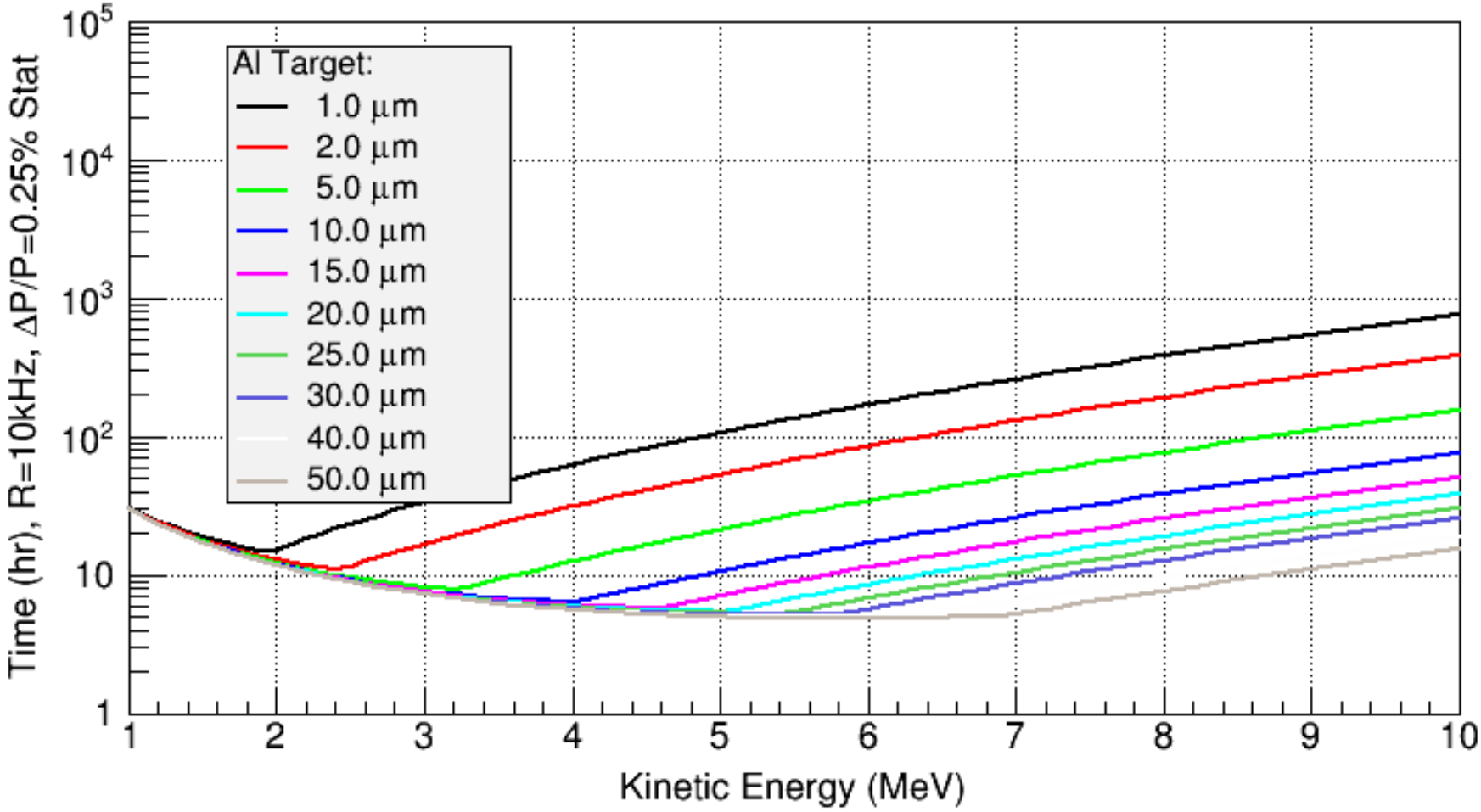
What is a reasonable current limit? Run1 was 5 μA

Al Estimates

Al Estimates Assumptions

- DAQ rate limit = 10 kHz
- Current limit = 40 μA
- Dump rate (with suppression) = 10 Hz/μA per detector
- Target thickness extrapolation: $\alpha_{Al} = 0$

We have to suppress dump events for Al


Al Target:
1.0 μm
2.0 μm
5.0 μm
10.0 μm
15.0 μm
20.0 μm
25.0 μm
30.0 μm
40.0 μm
50.0 μm
Time (hr), R=10kHz, ΔP/P=0.25% Stat
Kinetic Energy (MeV)
10^5
10^4
10^3
10^2
10
1
1
2
3
4
5
6
7
8
9
10

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KE = 3 MeV
       T(um) = 1       I (uA) = 40            Tim (h) = 33.0332
       T(um) = 2       I (uA) = 40            Tim (h) = 16.5166
       T(um) = 5       I (uA) = 32.5581       Tim (h) = 8.11673
       T(um) = 10      I (uA) = 17.4129       Tim (h) = 7.5882
       T(um) = 15      I (uA) = 11.8845       Tim (h) = 7.41202
       T(um) = 20      I (uA) = 9.02061       Tim (h) = 7.32393
       T(um) = 25      I (uA) = 7.26895       Tim (h) = 7.27108
       T(um) = 30      I (uA) = 6.08695       Tim (h) = 7.23584
       T(um) = 40      I (uA) = 4.59317       Tim (h) = 7.1918
       T(um) = 50      I (uA) = 3.68809       Tim (h) = 7.16537

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KE = 5 MeV
       T(um) = 1       I (uA) = 40            Tim (h) = 105.241
       T(um) = 2       I (uA) = 40            Tim (h) = 52.6204
       T(um) = 5       I (uA) = 40            Tim (h) = 21.0482
       T(um) = 10      I (uA) = 40            Tim (h) = 10.5241
       T(um) = 15      I (uA) = 40            Tim (h) = 7.01605
       T(um) = 20      I (uA) = 38.6771       Tim (h) = 5.44202
       T(um) = 25      I (uA) = 31.9297       Tim (h) = 5.27363
       T(um) = 30      I (uA) = 27.1868       Tim (h) = 5.16138
       T(um) = 40      I (uA) = 20.9599       Tim (h) = 5.02105
       T(um) = 50      I (uA) = 17.0539       Tim (h) = 4.93686

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KE = 8 MeV
       T(um) = 1       I (uA) = 40     Tim (h) = 378.985
       T(um) = 2       I (uA) = 40     Tim (h) = 189.492
       T(um) = 5       I (uA) = 40     Tim (h) = 75.7969
       T(um) = 10      I (uA) = 40     Tim (h) = 37.8985
       T(um) = 15      I (uA) = 40     Tim (h) = 25.2656
       T(um) = 20      I (uA) = 40     Tim (h) = 18.9492
       T(um) = 25      I (uA) = 40     Tim (h) = 15.1594
       T(um) = 30      I (uA) = 40     Tim (h) = 12.6328
       T(um) = 40      I (uA) = 40     Tim (h) = 9.47461
       T(um) = 50      I (uA) = 40     Tim (h) = 7.57969
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