

DRAGON Beam Normalization Study

- Knowing beam current incident on gas target important to DRAGON experiments
- Currently, only possible to measure current by insertion of Faraday cup
 - Process interrupts data collection
- Beta and elastic monitor rates are available during the entire course of a run
 - Wish to determine relation between these rates and the beam current
 - The rates could then act as a continuous monitor of beam current

Aim of Study

1. Determine the calibration constants needed to relate the elastic/beta monitor rates to the beam current

$$N_{\text{el.mon.}} = C_{\text{EM}} \times LT \times (d\sigma/d\Omega) \times P \times N_{\text{beam}}$$

$$N_{\beta} = C_{\beta}(Z_{\text{beam}}) \times F_q \times N_{\text{beam}}$$

$$i(t) = |e| \times q_{\text{in}} \times (dN_{\text{beam}}/dt)$$

$$d\sigma/d\Omega \propto (Z_{\text{beam}} Z_{\text{target}}/E)^2 [1 + \text{resonance}]$$

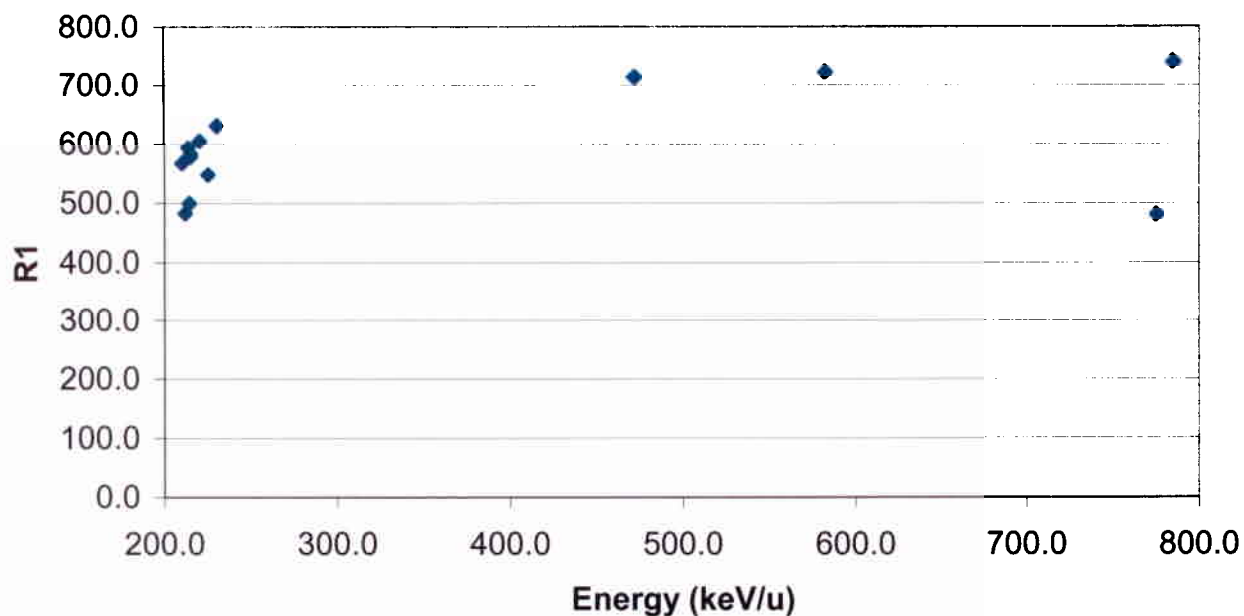
2. Investigate the consistency of these constants
 - Do both monitors measure the same property? Do the constants vary with energy?

Results

- Three different ratios related to C_{EM} and C_{β} were calculated for fourteen runs of a ^{21}Na beam
 - i. R1, ratio of elastic monitor counts to FC4 reading
 - ii. R2, ratio of elastic monitor counts to beta monitor counts
 - iii. R3, ratio of beta monitor counts to FC4 reading
- Results indicate that R2 is the most constant ratio, with both R1 and R3 displaying larger deviations

$$R1 = (\text{Elastics} \times E_{in}^2) / (\text{FC4} \times \text{LT} \times t \times P)$$

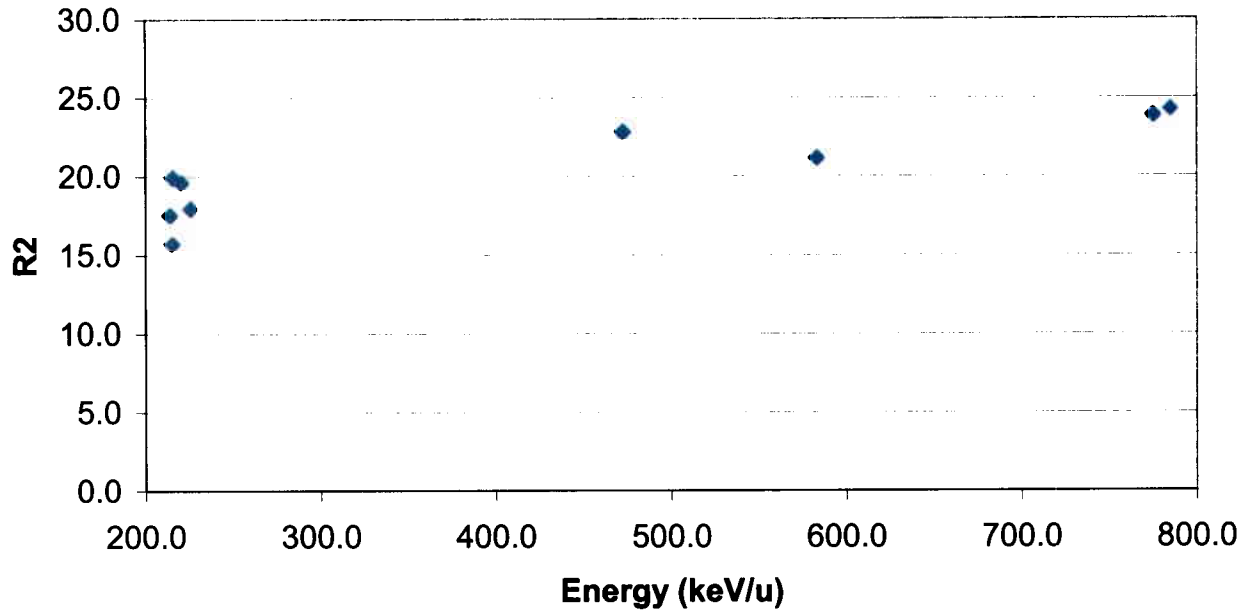
R1 variation with Energy



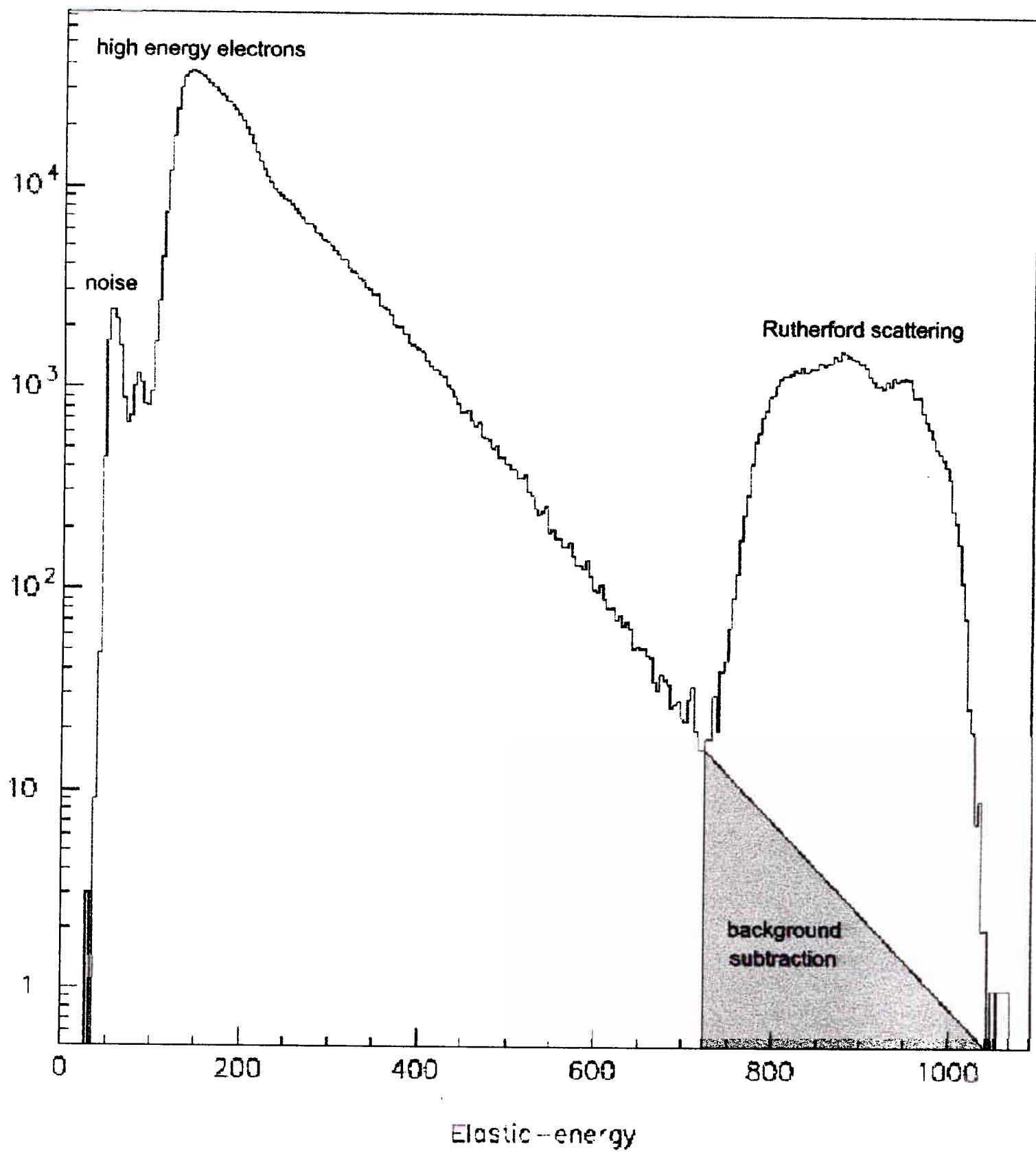
Run	E_{in}	Pressure	FC4 (epA)	Livetime	Time (s)	Elastics	R1
7191	582.7	4.57	480	0.96	326	1421	702.2
7192	582.7	8.12	425	0.96	518	3726	740.6
7193	582.7	6.22	450	0.94	1160	6285	697.7
7194	582.7	6.21	430	0.92	748	4085	753.7
7202	471.9	5.82	387	0.90	696	4511	713.3
7210	784.2	7.42	350	0.95	2266	6696	740.1
7212	784.2	7.35	305	0.95	692	1758	734.6
7238	774.7	7.96	25	0.99	1150	203	540.4
7239	774.7	7.80	16	0.99	744	91	593.1
7240	774.7	7.80	17	1.00	394	21	242.2
7241	774.7	7.80	14	0.99	876	76	481.8
7242	774.7	7.86	13	0.99	1240	117	559.9
7243	774.7	7.73	15	0.99	1766	195	576.9
7244	774.7	7.77	13	0.99	2902	193	400.8

$$R2 = (\text{Elastic} \times E_{in}^2 \times F) / (P \times LT \times \beta \text{ Coincidence})$$

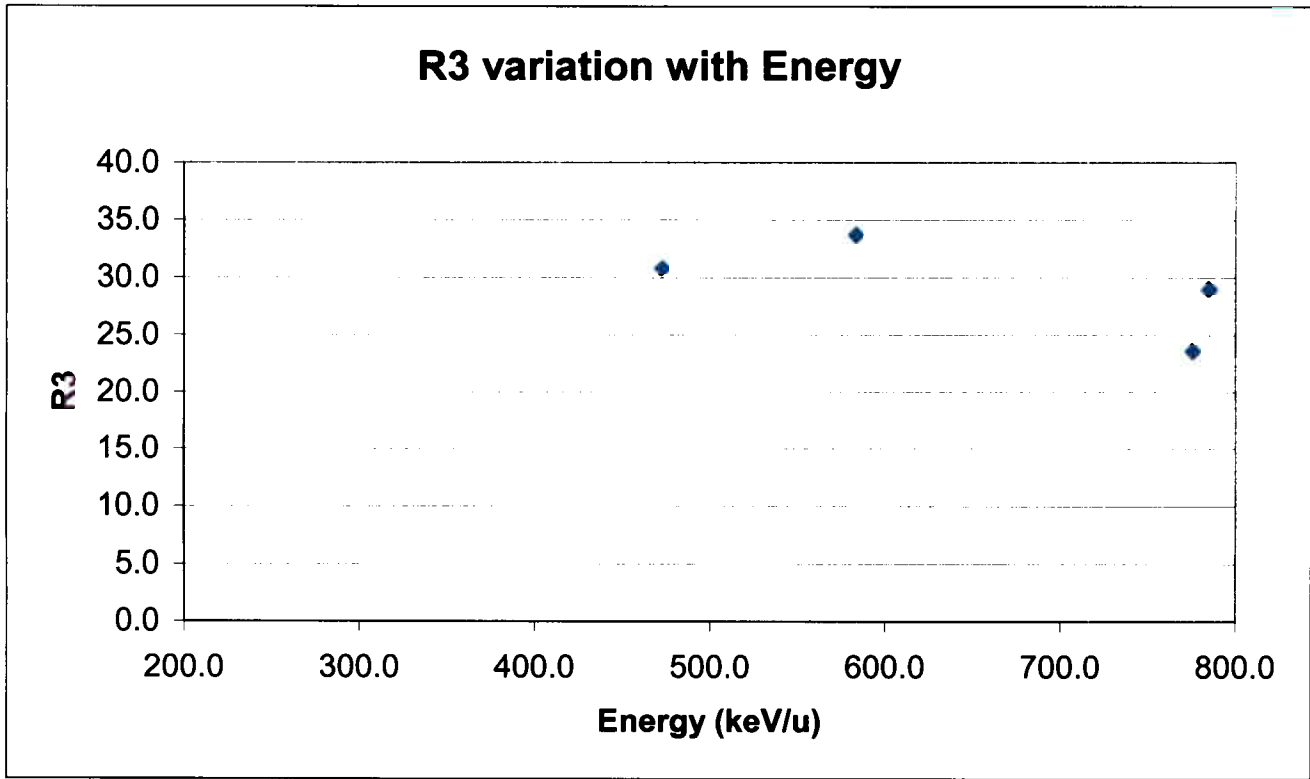
R2 variation with Energy



Run	E_{in}	Pressure	Charge Fraction	Livetime	Elastic	β Scaler	R2
7191	582.7	4.57	0.34	0.96	61904	89.6M	18.3
7192	582.7	8.12	0.46	0.96	103794	91.8M	22.6
7193	582.7	6.22	0.40	0.94	39818	43.6M	21.0
7194	582.7	6.21	0.45	0.92	58324	68.5M	22.7
7202	471.9	5.82	0.41	0.90	71292	55.2M	22.8
7210	784.2	7.42	0.50	0.95	37058	65.5M	24.8
7212	784.2	7.35	0.47	0.95	16651	29.2M	23.7
7238	774.7	7.96	0.50	0.99	3391	4.92M	26.4
7239	774.7	7.80	0.51	0.99	981	1.42M	27.3
7240	774.7	7.80	0.37	1.00	194	3.57M	15.4
7241	774.7	7.80	0.45	0.99	3608	5.31M	23.6
7242	774.7	7.86	0.53	0.99	2946	4.39M	27.4
7243	774.7	7.73	0.42	0.99	1834	2.77M	21.6
7244	774.7	7.77	0.46	0.99	1201	1.74M	24.8



$$R3 = (\beta \text{ Coincidence}) / (\text{FC4} \times t \times F)$$



Run	E_{in}	FC4 (epA)	Charge Fraction	Time (s)	β Scaler	R3
7191*	582.7	480	0.34	326	2.06M	38.5
7192	582.7	425	0.46	518	3.09M	30.7
7193	582.7	450	0.40	1160	7.07M	34.1
7194	582.7	430	0.45	748	4.52M	31.3
7202	471.9	387	0.41	696	3.43M	30.8
7210	784.2	350	0.50	2266	12.0M	30.2
7212*	784.2	305	0.47	692	2.75M	27.7
7238*	774.7	25	0.50	1150	0.27M	18.5
7239*	774.7	16	0.51	744	0.12M	19.4
7240	774.7	17	0.37	394	0.08M	30.6
7241*	774.7	14	0.45	876	0.14M	25.3
7242*	774.7	13	0.53	1240	0.17M	19.8
7243*	774.7	15	0.42	1766	0.32M	29.1
7244*	774.7	13	0.46	2902	0.39M	22.7

* Data had unstable beta monitor readings.

SUMMARY OF RESULTS

Energy	Average R1	Std. Deviation
471.9	713.34570362	
582.7	723.53973989	24.11257593
774.7	485.02346621	116.40985323
784.2	737.34274518	2.74868562
Average:	664.81291373	
Std. Dev.:	104.15024447	

Energy	Average R2	Std. Deviation
471.9	22.75335571	
582.7	21.14391260	1.78065891
774.7	23.76783338	3.92071858
784.2	24.23873484	0.55270924
Average:	22.97595913	
Std. Dev.:	1.18612964	

Energy	Average R3 all data	Std. Deviation	Average R3 stable data only	Std. Deviation
471.9	30.81576868		30.81576868	
582.7	33.66677907	3.0694289	32.05830701	1.48765886
774.7	23.61777905	4.49087089	30.58192893	
784.2	28.95043061	1.26636929	30.21679990	
Average:	29.26268935		30.91820113	
Std. Dev.:	3.66642126		0.69198564	

Recommendations

- At the start of all runs at a new energy, place Faraday cup between MD1 and ED1
- Add up Faraday cup readings for each charge state, and compare them to the elastic monitor count taken for the same time period
 - Provides continuous relationship between beam current and elastic monitor counts even when elastic cross section deviates from pure Rutherford

$$\Sigma Q_i / \text{Elastics} = \text{constant}$$