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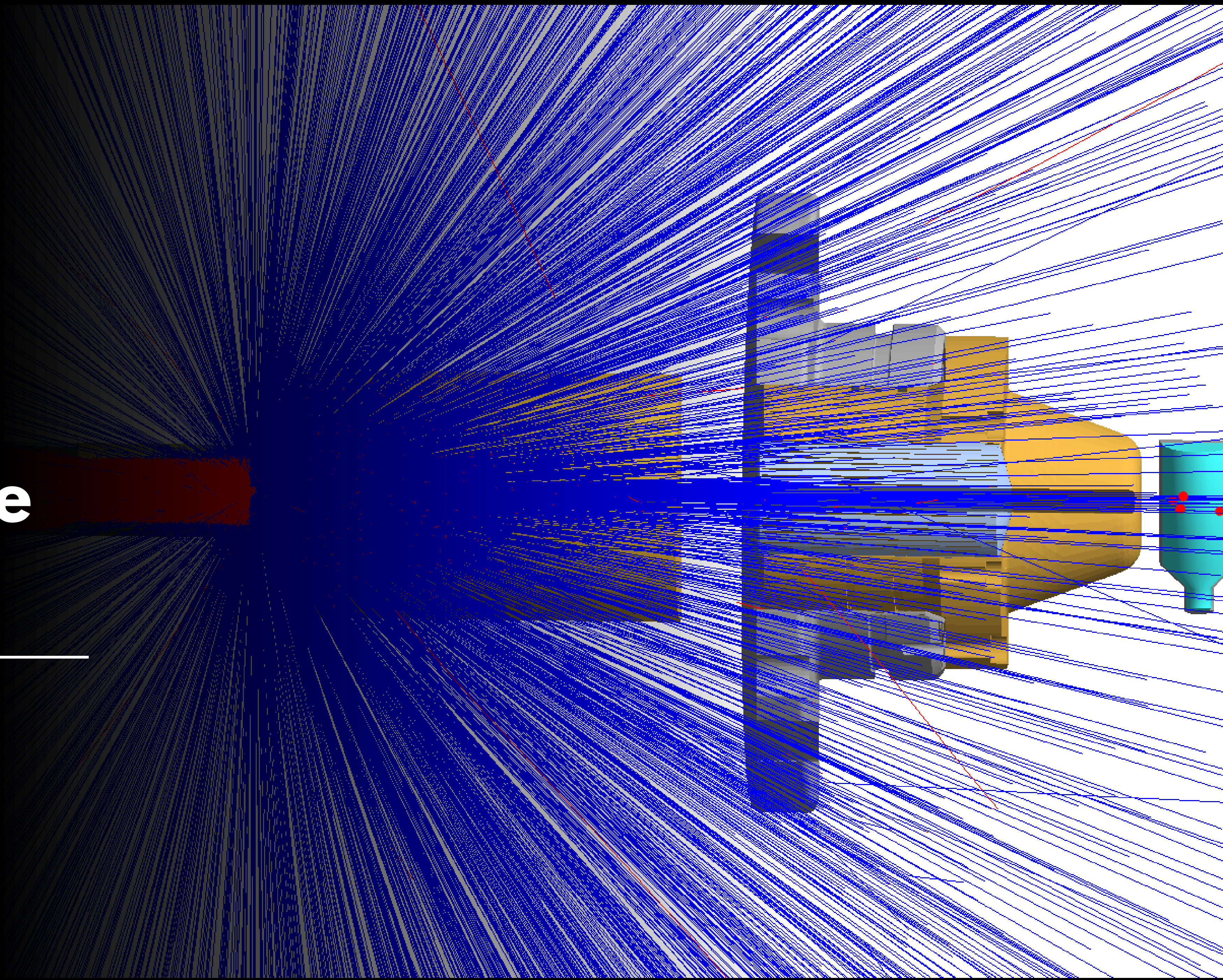

Bubble Update 08/19/2022

David Neto

Analysis Issues from Last Weeks Meeting

- Deadtime
  - On bubble detection from JLab side beam is off 10.0 seconds (returns in ~ns)
  - Bubble Chamber 10 second quench then return to operating pressure (what is additional relaxation time?)
- Cross section
  - The energy at which we measured cross section is not the same as the electron beam kinetic energy.
  - Similarly, the energy error bars are not the same as the ~10 keV limits for the electron beam.

Measuring the cross section of the $^{15}N(\alpha,\gamma)^{19}F$ reaction using a single-fluid bubble chamber. (Draft v10.1)

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(Dated: August 19, 2022)

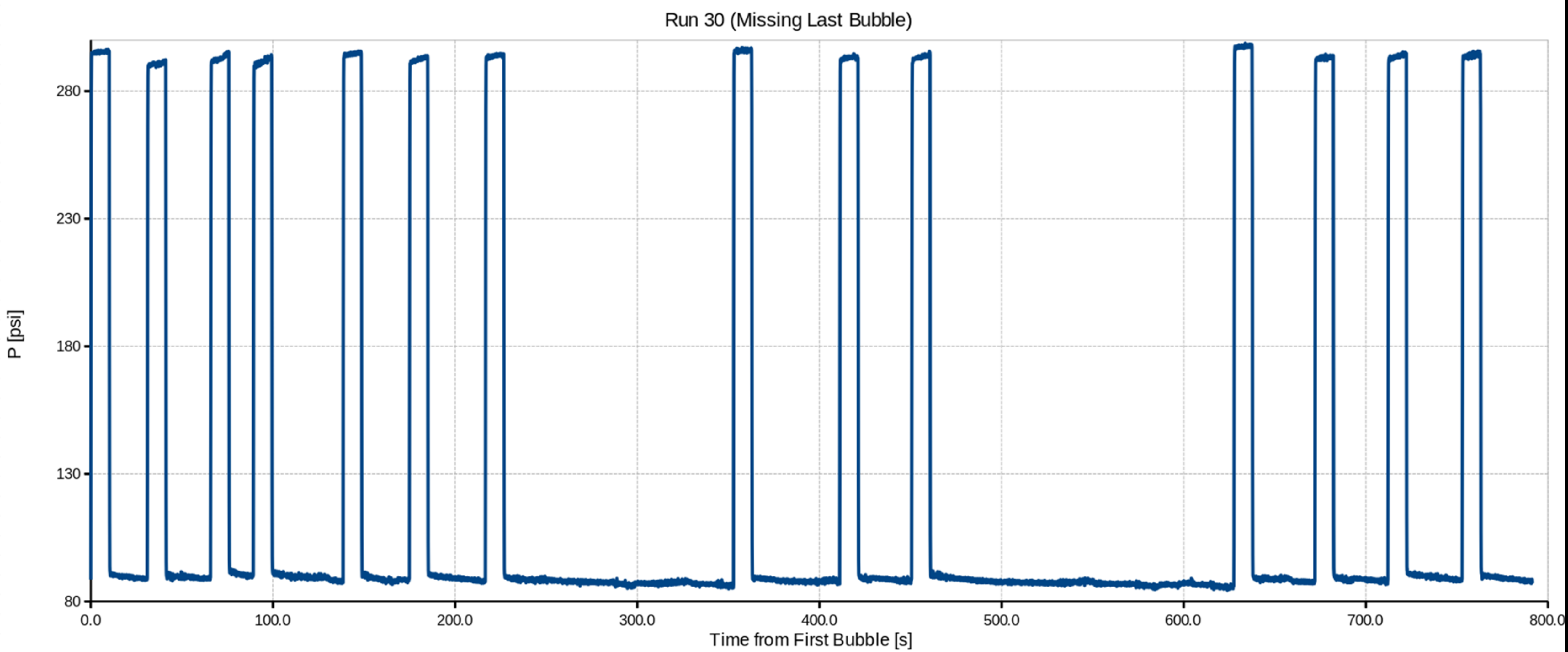
$^{15}N(\alpha,\gamma)^{19}F$ is believed to be the primary means of nucleosynthesis of Fluorine in AGB and Wolf-Rayet stars. In this paper, we present the use of a single-fluid bubble chamber to measure the time-inverse photo-dissociation reaction. Benefiting from increases of the luminosity, over methods using thin-films or gas targets, by several orders of magnitude from both the factor of 10-100 gain from the reciprocity theorem and the use of a thicker liquid target. We will discuss the results of test measurements at the Thomas Jefferson National Accelerator Facility, measuring the cross section of the photodisintegration process $^{19}F(\gamma,\alpha)^{15}N$ by bombarding a superheated fluid of C_3F_8 with bremsstrahlung γ-rays. Simulating the γ-ray beam in GEANT4 and convoluting the γ-ray spectrum with the Breit-Wigner cross section. Using this technique, we measure cross sections of the time-reversed $^{15}N(\alpha,\gamma)^{19}F$ reaction down to the range of $\sim$ 80 picobarns. We also discuss future changes to the experimental setup, potentially pushing measurements down to the single picobarn range.

Deadtime

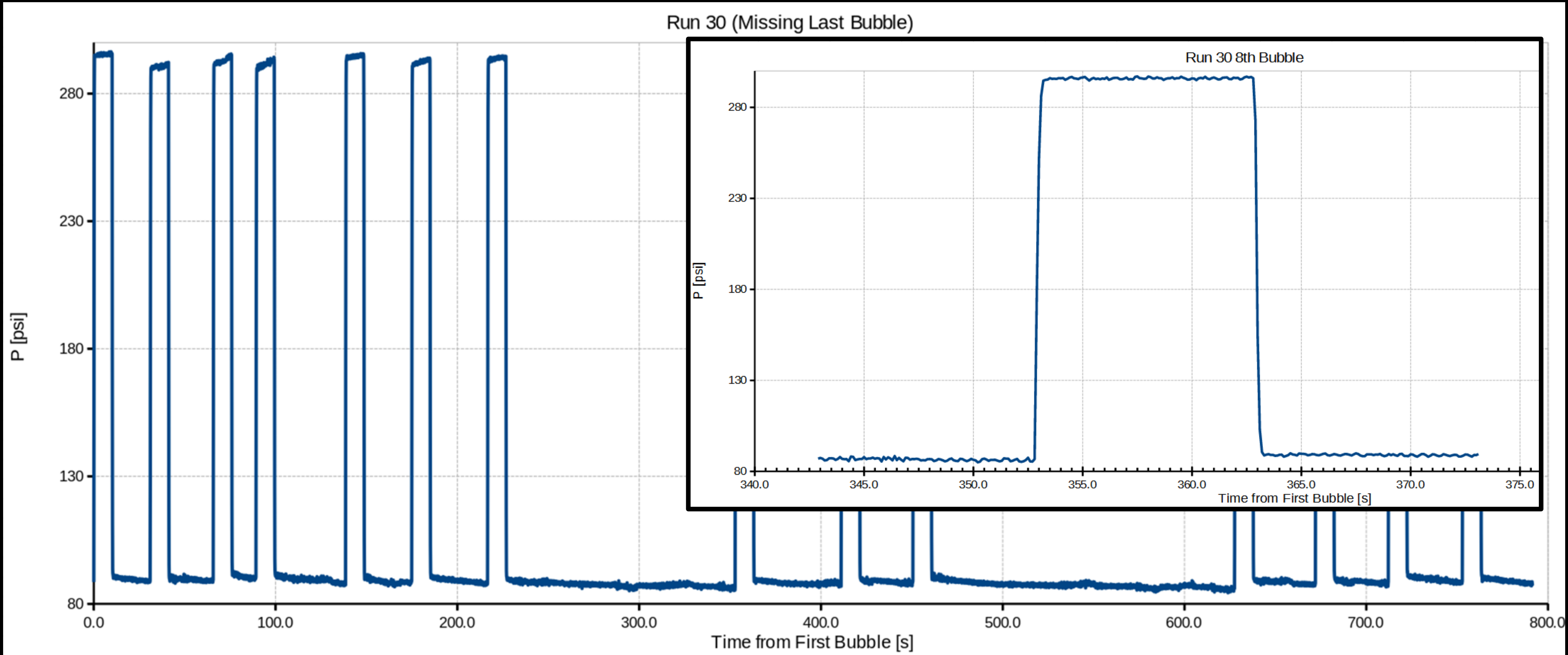
- Unfortunately, only one PT log was recorded with a polling rate every 0.1 seconds (first PT log).
- In addition, this only covers one run.
  - Run 30
  - Cosmics
  - 15 Bubbles
  - Run Time ~800 seconds
  - After last bubble run ended to change warm volume temp on chiller control (however, it looks like PT program wasn't restarted so chamber stayed at high pressure after run).

511.081349	4.911573	89.361111
511.081349	4.915139	89.340817
511.081349	4.910277	88.163780
511.081349	4.924862	88.589948
511.081349	4.919676	88.813180
511.081349	4.921945	89.584342
511.081349	4.945931	89.036411
511.081349	4.934262	88.975530
511.081349	4.914490	88.894355
511.081350	4.905091	89.523461
511.081350	4.912221	89.036411

Deadtime Run 30

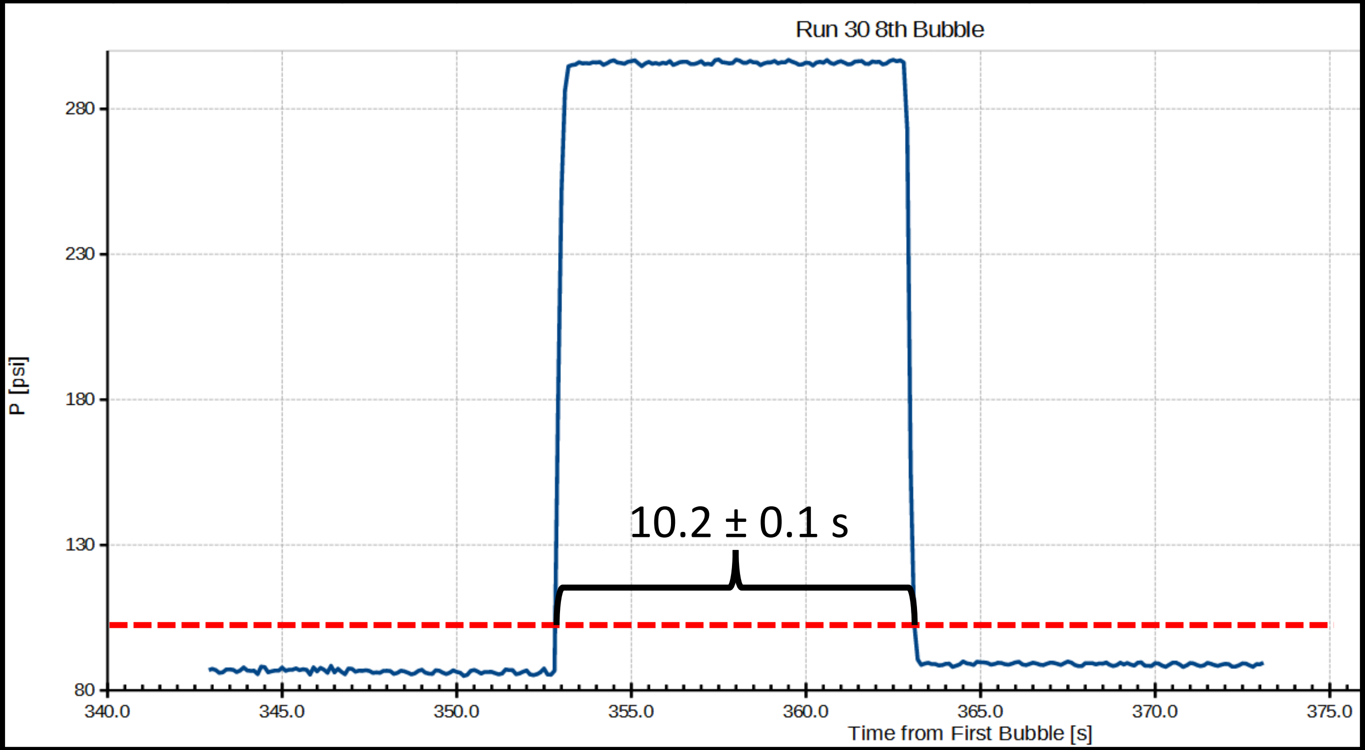


Deadtime Run 30



Deadtime Run 30 Time for P = 100 to P = 100

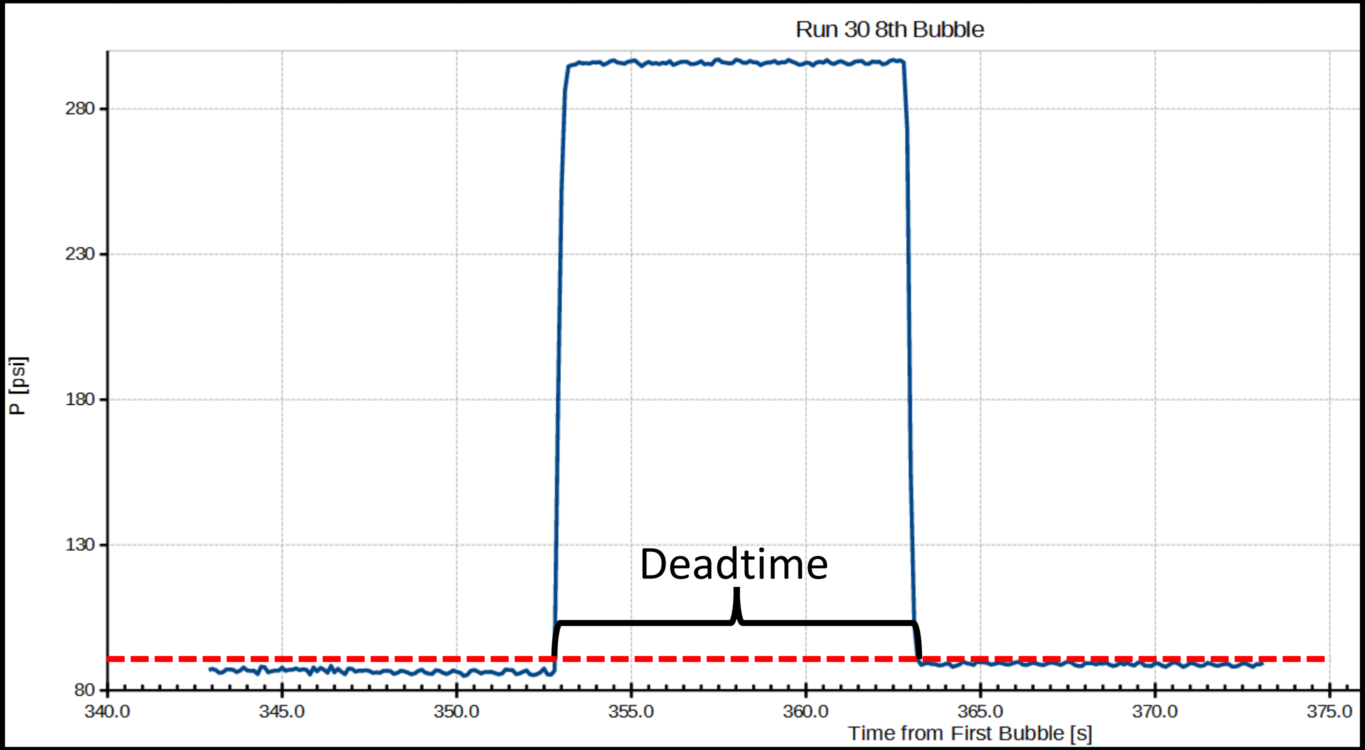
- First simple test
  - Look at time it takes to go from P = 100 psi at start of quench and then back to P = 100 psi when. returning to operating pressure.
  - Every bubble in the run took 10.2 seconds to do so.



Deadtime Run 30 Time Quench to Op P

- In Log, run P ~ 88 psi
- From PT File we find average
  - Only looking at P < 100 psi (otherwise we assume part of quench cycle)
- From PT file we find average operating P = 88.32 ± 1.33 psi

- Define chamber as "Active" for pressures within 2 sigma of average
- For Run 30, "Active" when P < 90.98 psi
- For this run, bubble efficency ~ 70% at 90.98 psi and increases to 100% for P < 89.25 psi



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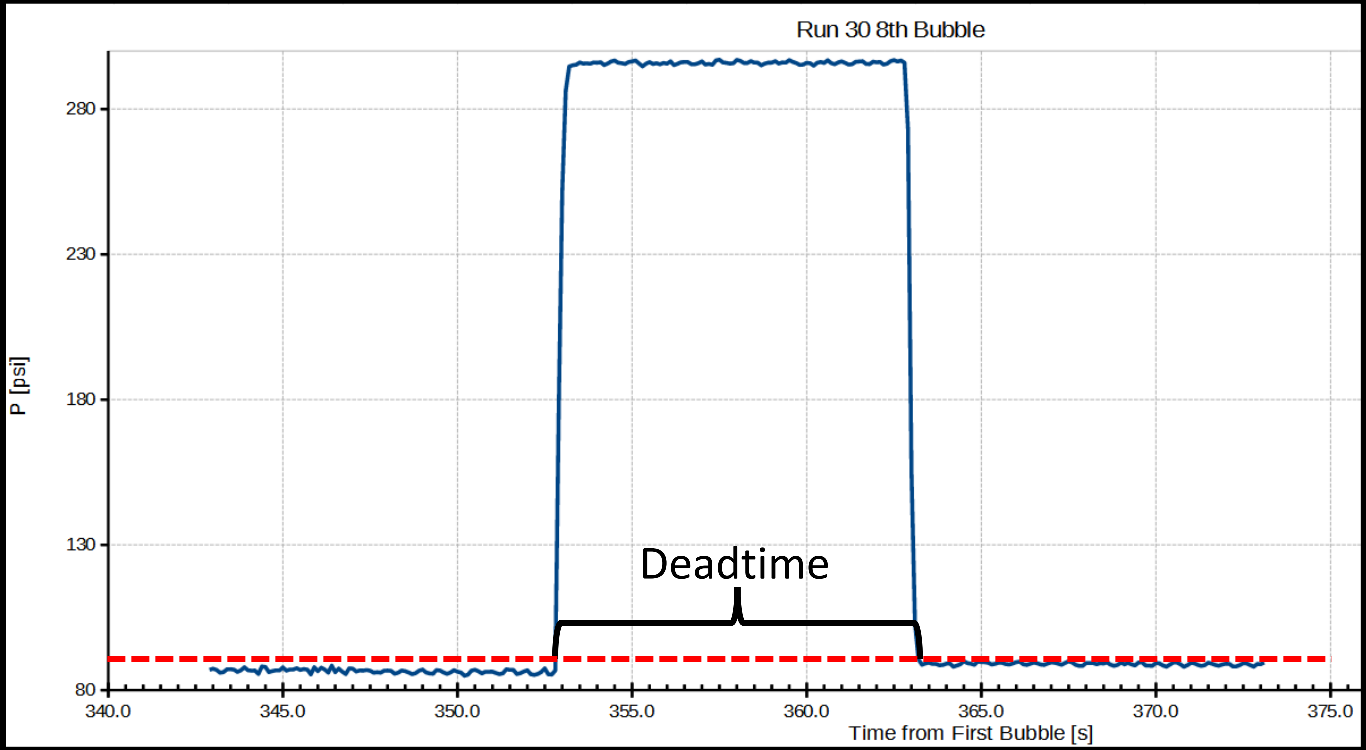
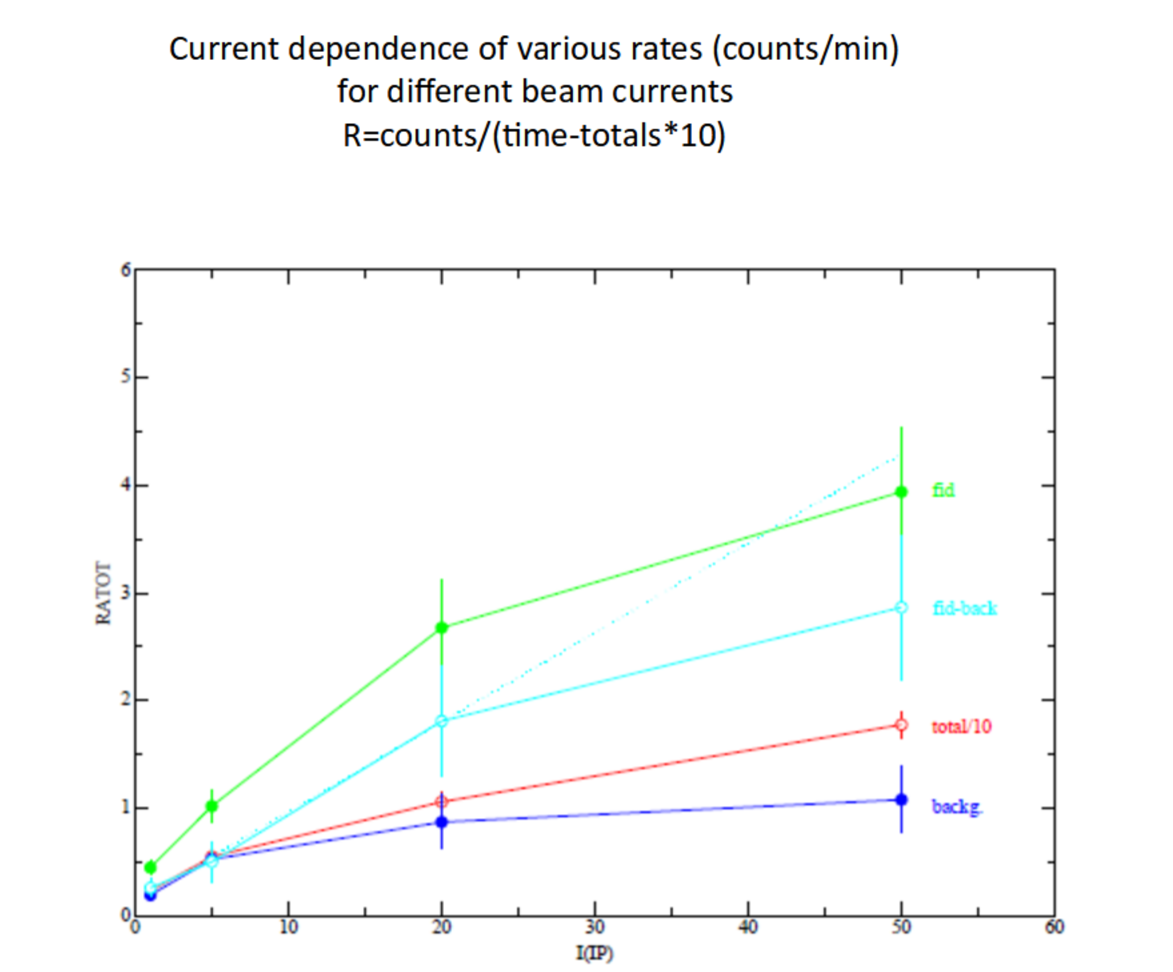
Averaging over all 14 bubbles
Deadtime = 10.5 ± 0.4 s

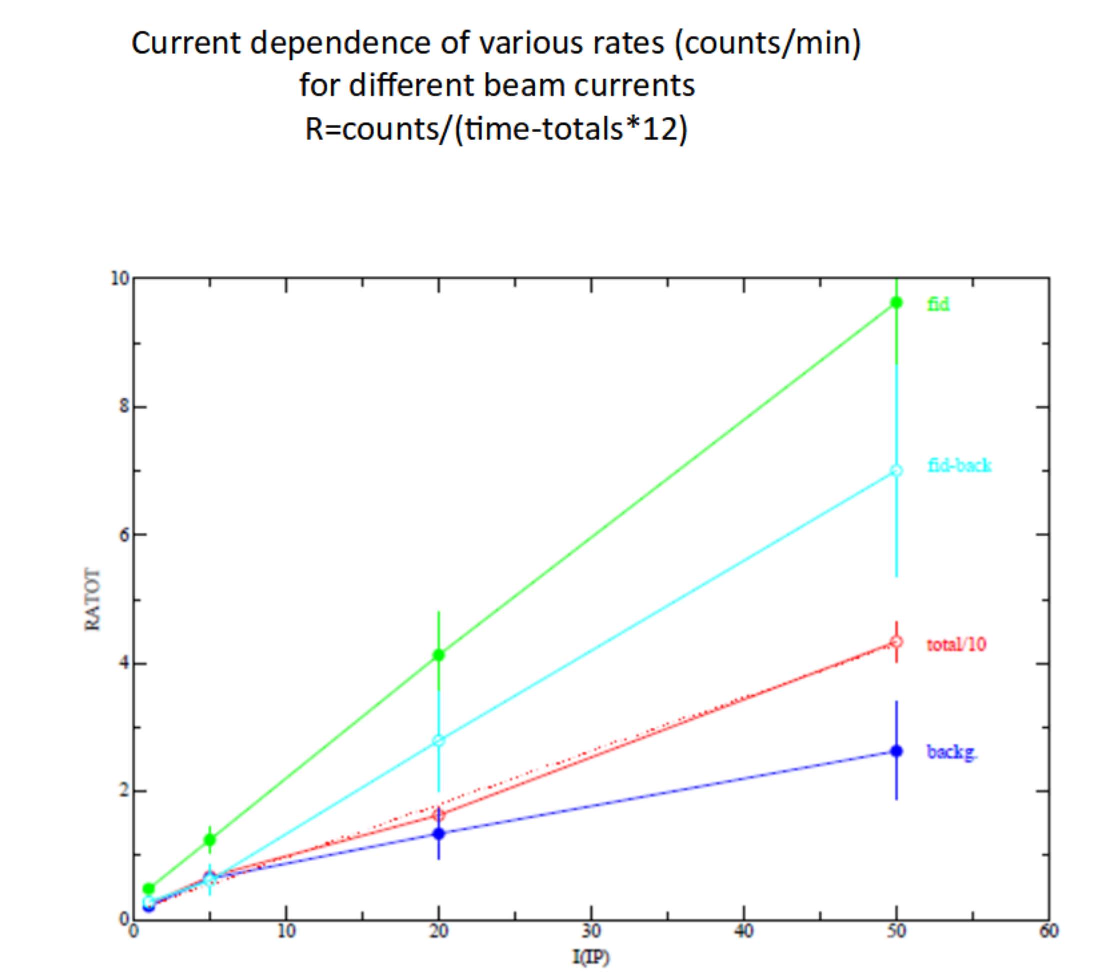


Deadtime (Ernst's Analysis)

Runs 103, 104, 105, 108

From Ernst_Bubble_22June2018.pptx on Bubble Wiki





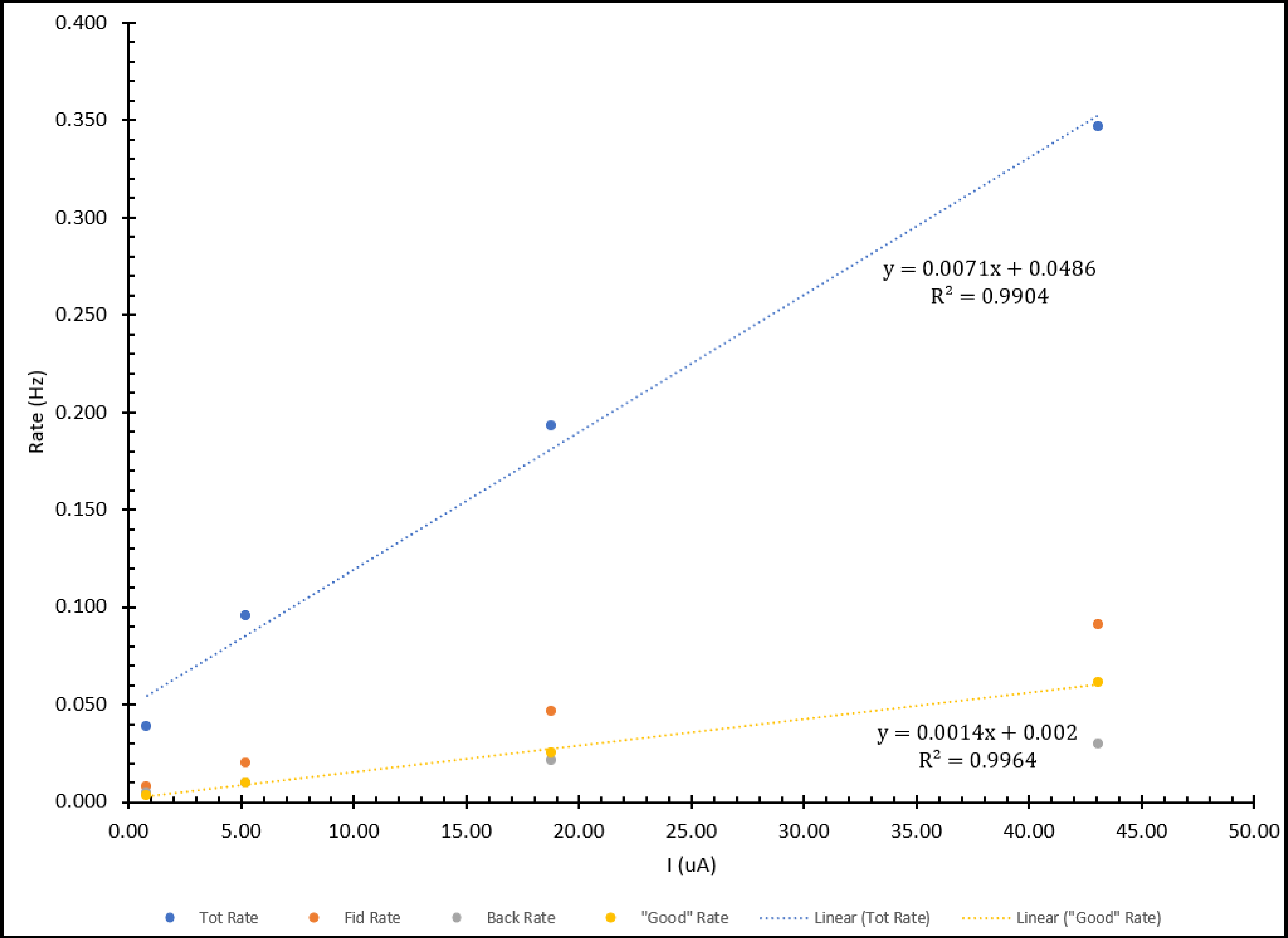
Deadtime

Here, use the average current from EPICS and look at effect of bubble efficiency

							Deadtime = 10.5				Deadtime = 10.5 (Eff Corr)			
Run	I (uA)	Bubble Eff	Tot Time	Tot	F	B	Tot Rate	Fid Rate	Back Rate	"Good" Rate	Tot Rate	Fid Rate	Back Rate	"Good" Rate
108	0.82	1.00	7472	205	43	24	0.039	0.008	0.005	0.004	0.039	0.008	0.005	0.004
105	5.19	0.88	4850	231	48	24	0.095	0.020	0.010	0.010	0.109	0.023	0.011	0.011
104	18.77	0.72	2290	146	35	16	0.193	0.046	0.021	0.025	0.269	0.065	0.029	0.035
103	43.09	0.57	2650	198	52	17	0.347	0.091	0.030	0.061	0.605	0.159	0.052	0.107

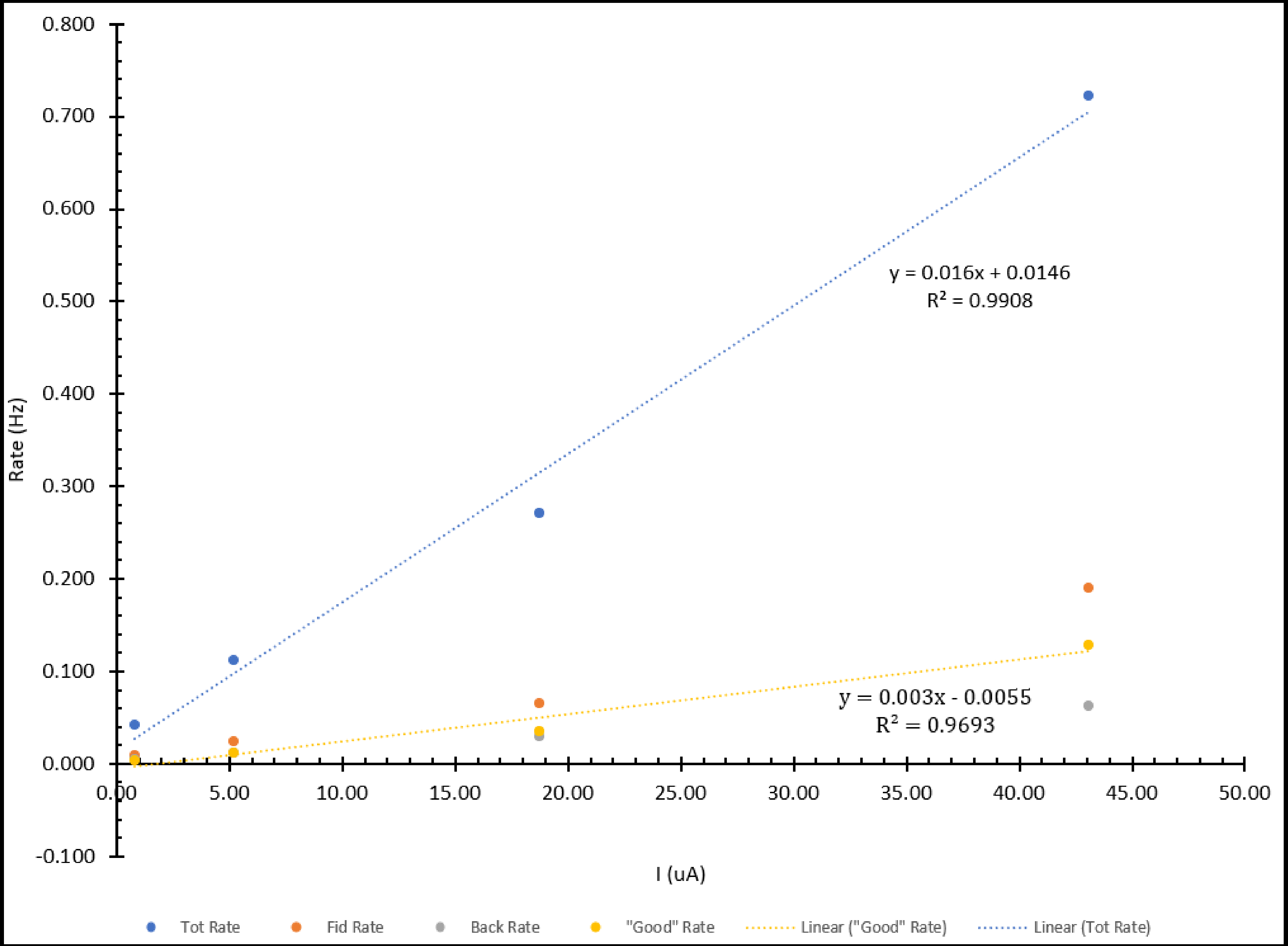
Deadtime

Deadtime = 10.5 s
No Efficiency
Correction



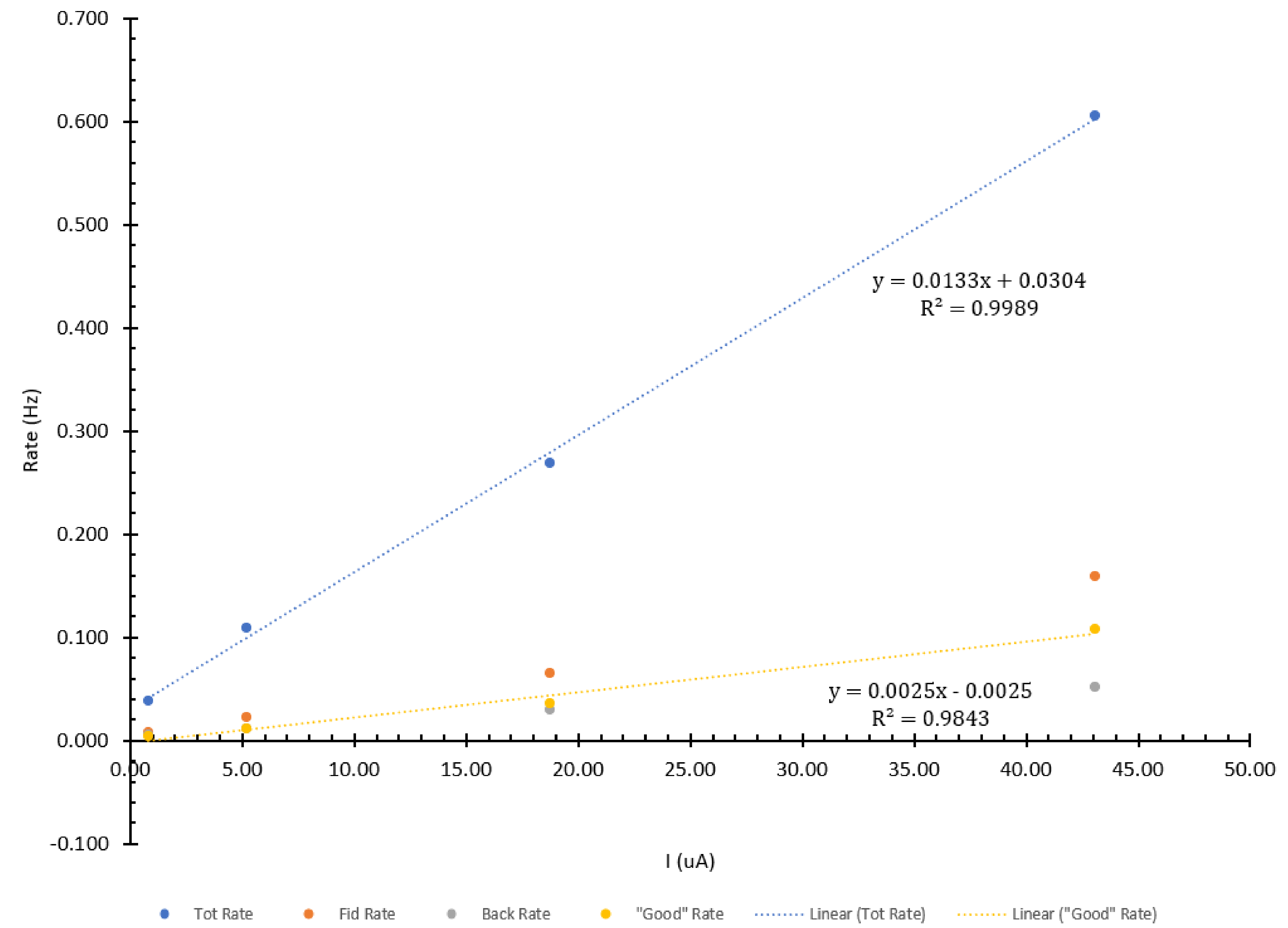
Deadtime

Deadtime = 12.0 s
No Efficiency
Correction



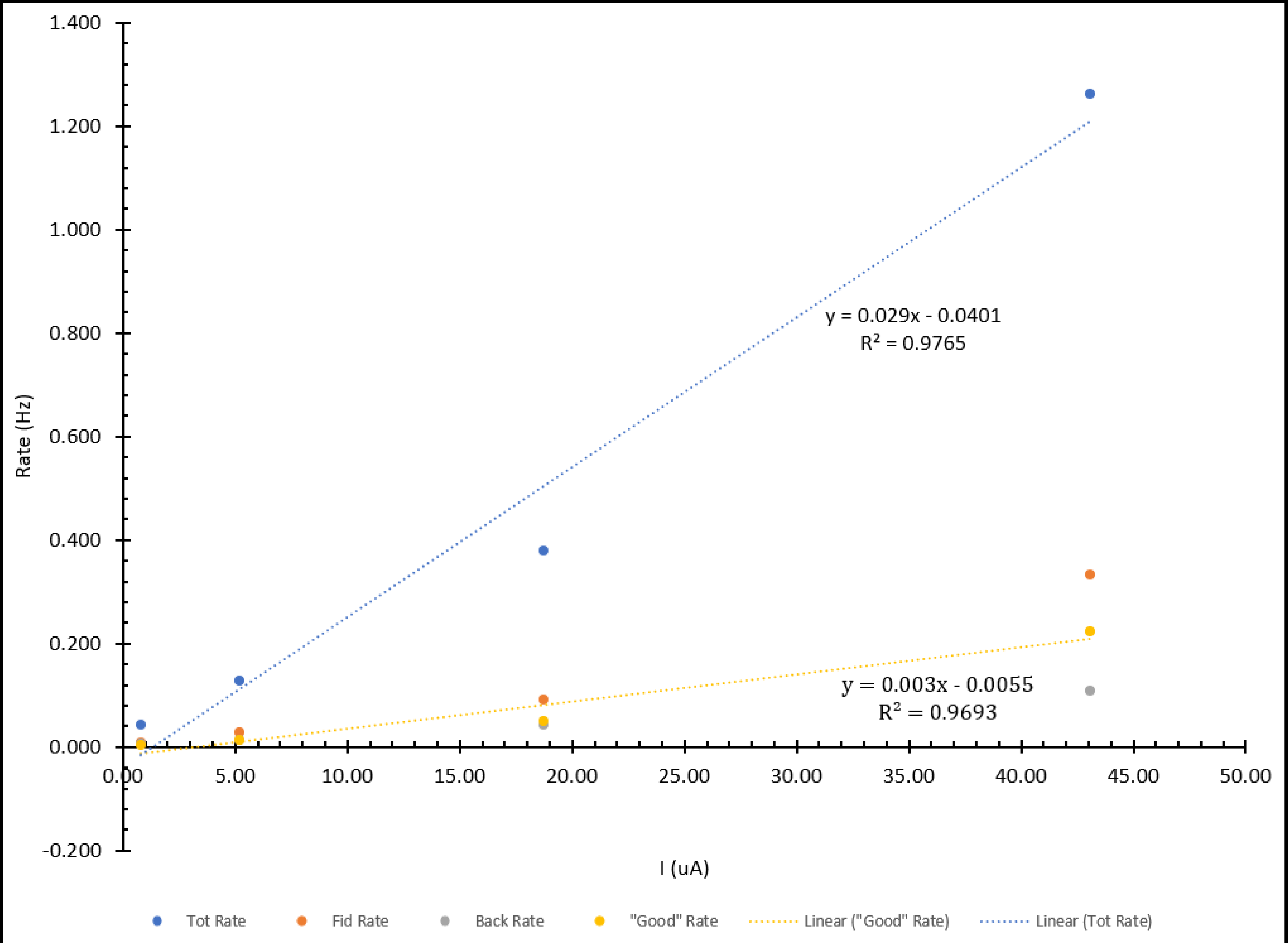
Deadtime

Deadtime = 10.5 s
With Efficiency Correction



Deadtime

Deadtime = 12.0 s
With Efficiency
Correction



Deadtime Summary

- From Run 30 we have a measured deadtime
- Deadtime = 10.5 ± 0.4 s

- Looking at Rate vs Current
  - Little difference between 10.5 and 12 second deadtimes
  - Both show “Linear” relationship (double current should double rate etc…)
  - However, using 10.5 does give a slightly better result (but, to me at least, this would be the definition of “splitting hairs”)

Cross Section Wilmes Data

- Data from 2002 PRC Wilmes paper is transition to 1st excited state at 110 keV
- We measured transition to g.s.
- This data was not included in Wilmes PRC paper but is in the Wilmes thesis (Figure 8.1 top left plot).
- Pulled data from the PDF that we can use in our cross section plot to compare to Wilmes (there are tiny errorbars which I haven't included but will later).

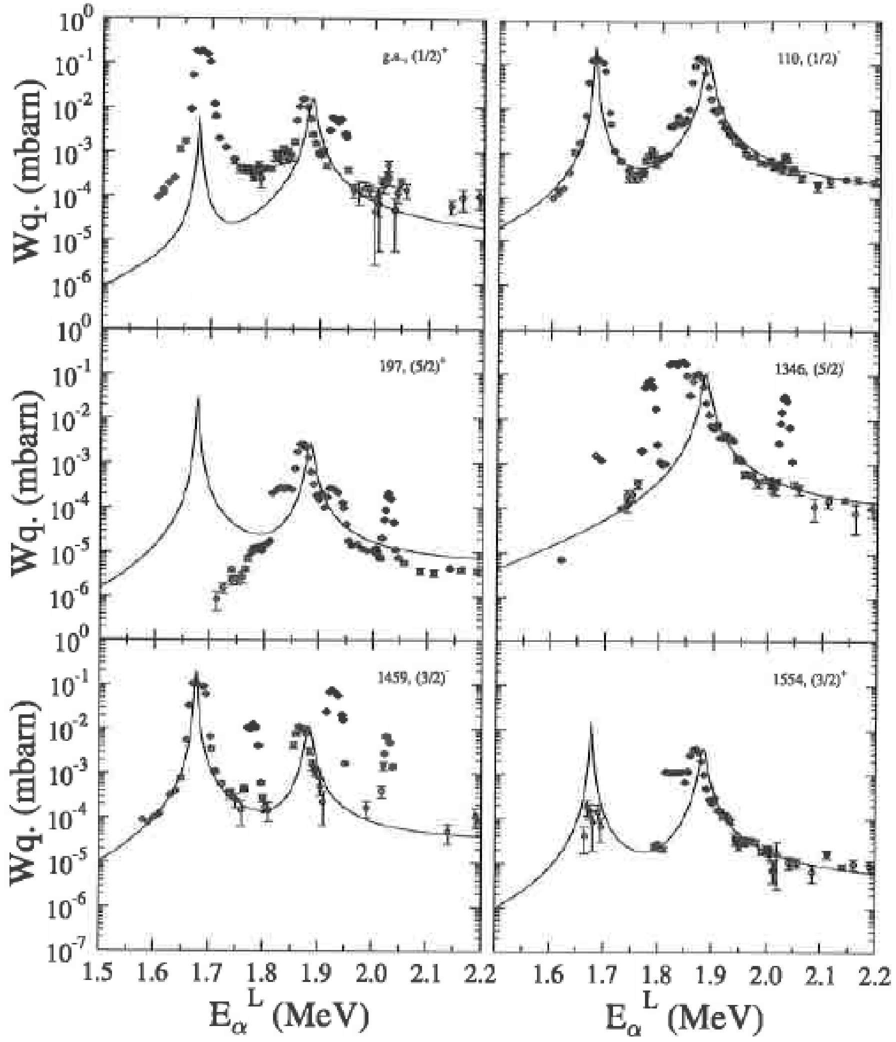
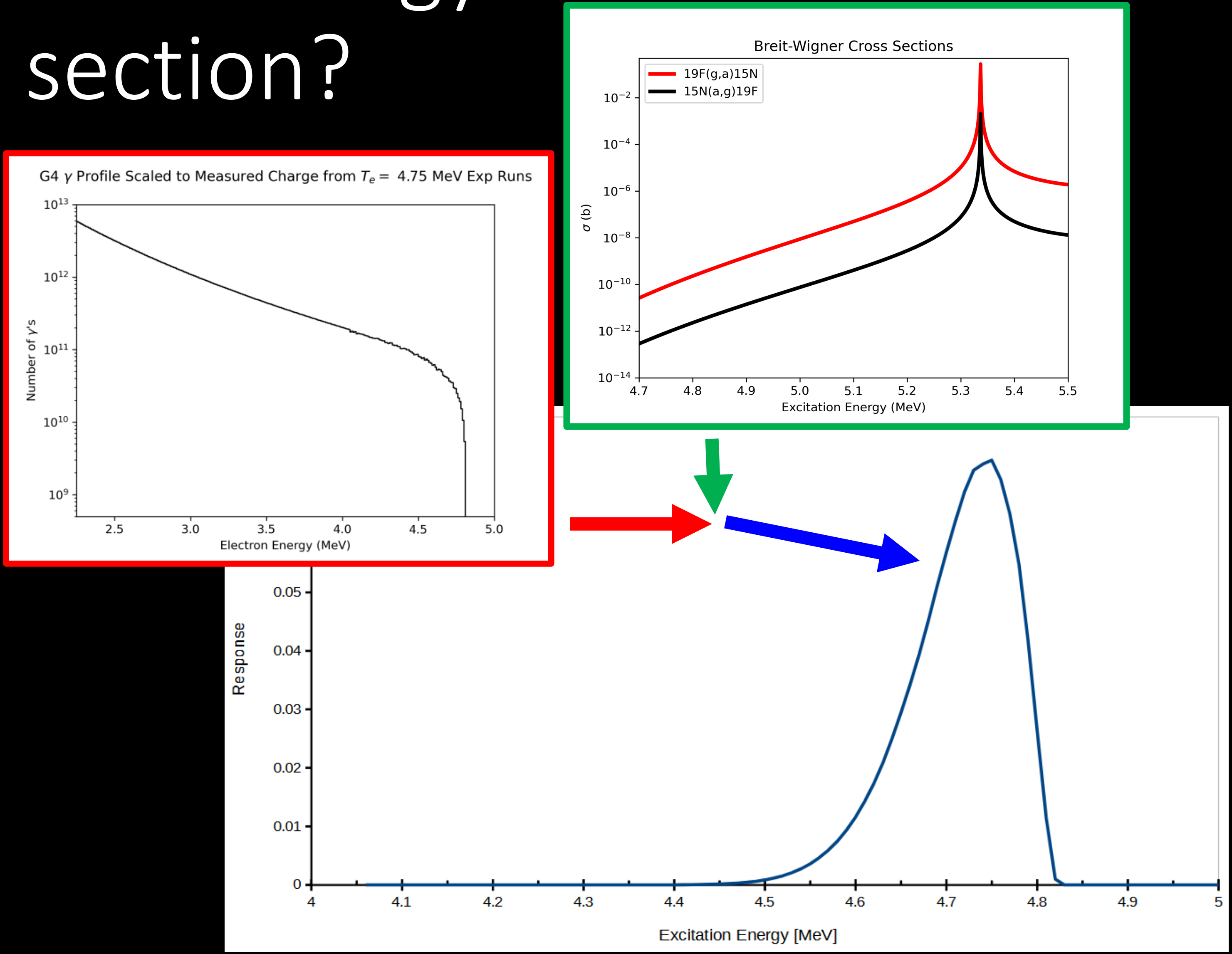


Abbildung 8.1: Vergleich zwischen Rechnung und Messung für die sechs Übergänge R → g.s., 110, 197, 1346, 1459 und 1554. Die Meßdaten wurden in ihrer Amplitude an die Resonanz R(5501) angepaßt.

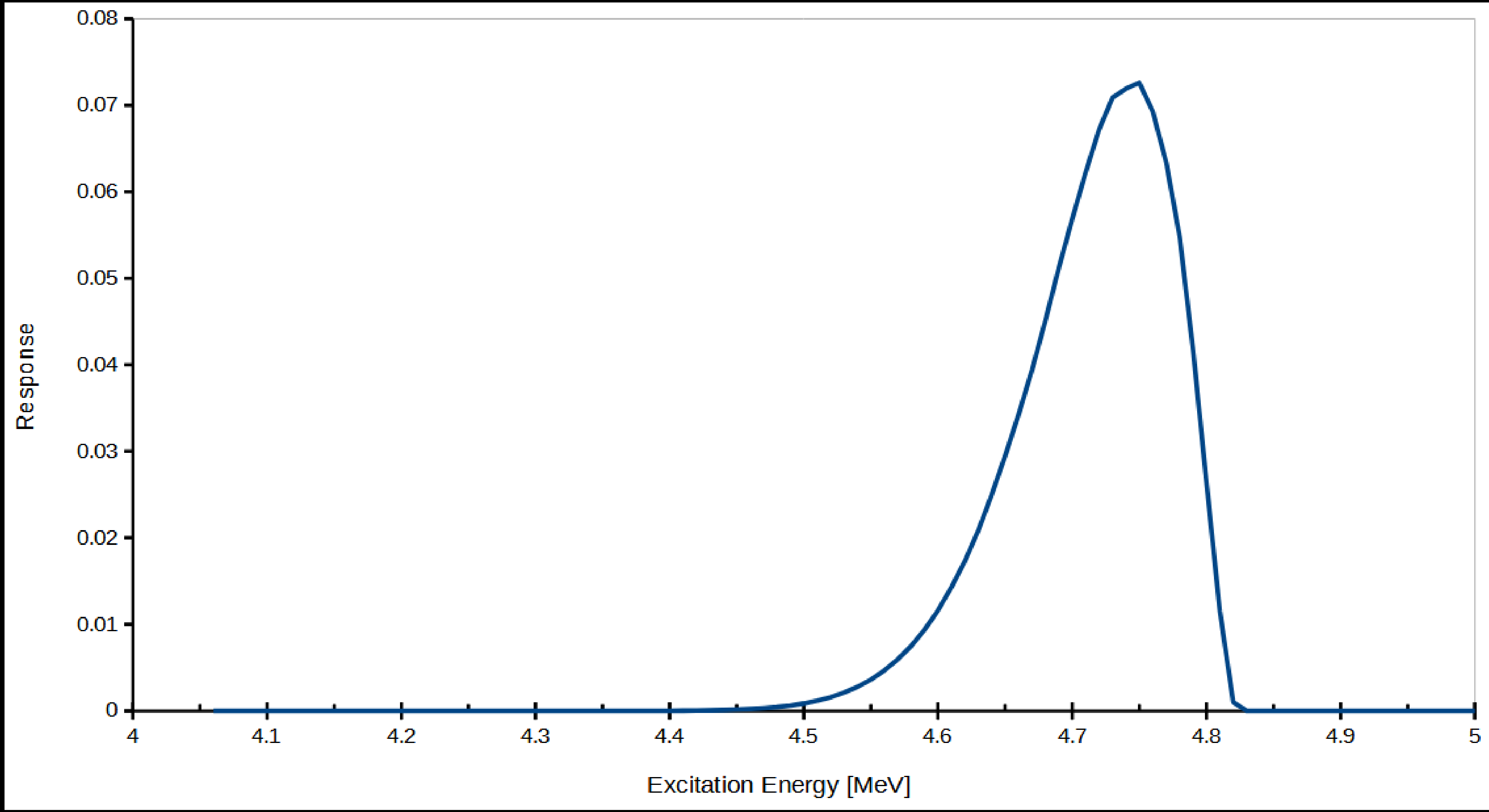
Cross Section: At which energy did we measure the cross section?

- Using the bremsstrahlung profile from Geant4 and the Breit-Wigner cross section.
- Compute the normalized discrete convolution.
- “Signal Response”
- Very similar to how you compute Gamow window.



Cross Section: At which energy did we measure the cross section?

- Here is result for T_e = 4.803 MeV
- Maximum gives energy of measurement
- Full width at half max gives the “1 sigma bars”



Cross Section: At which energy did we measure the cross section?

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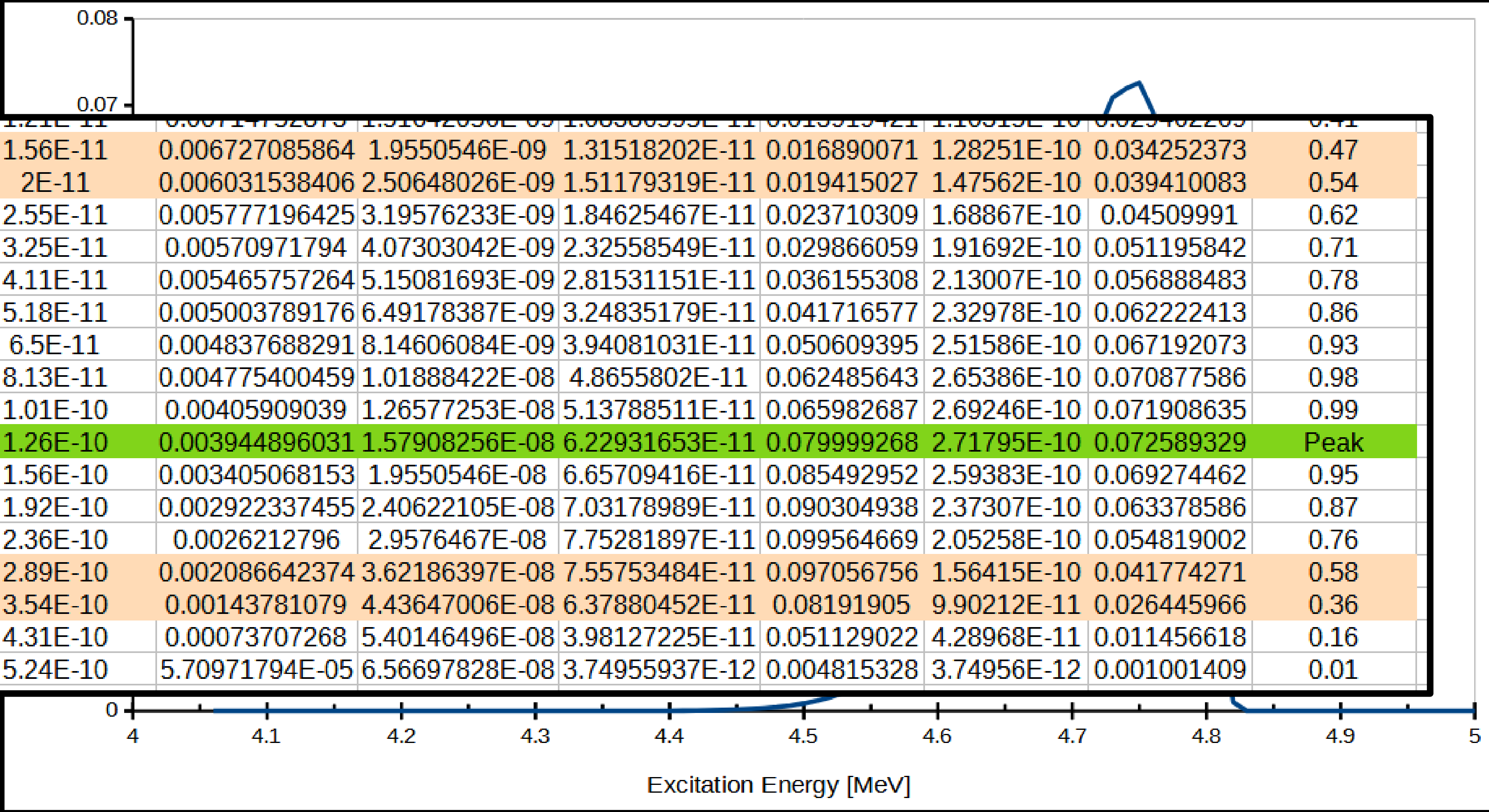
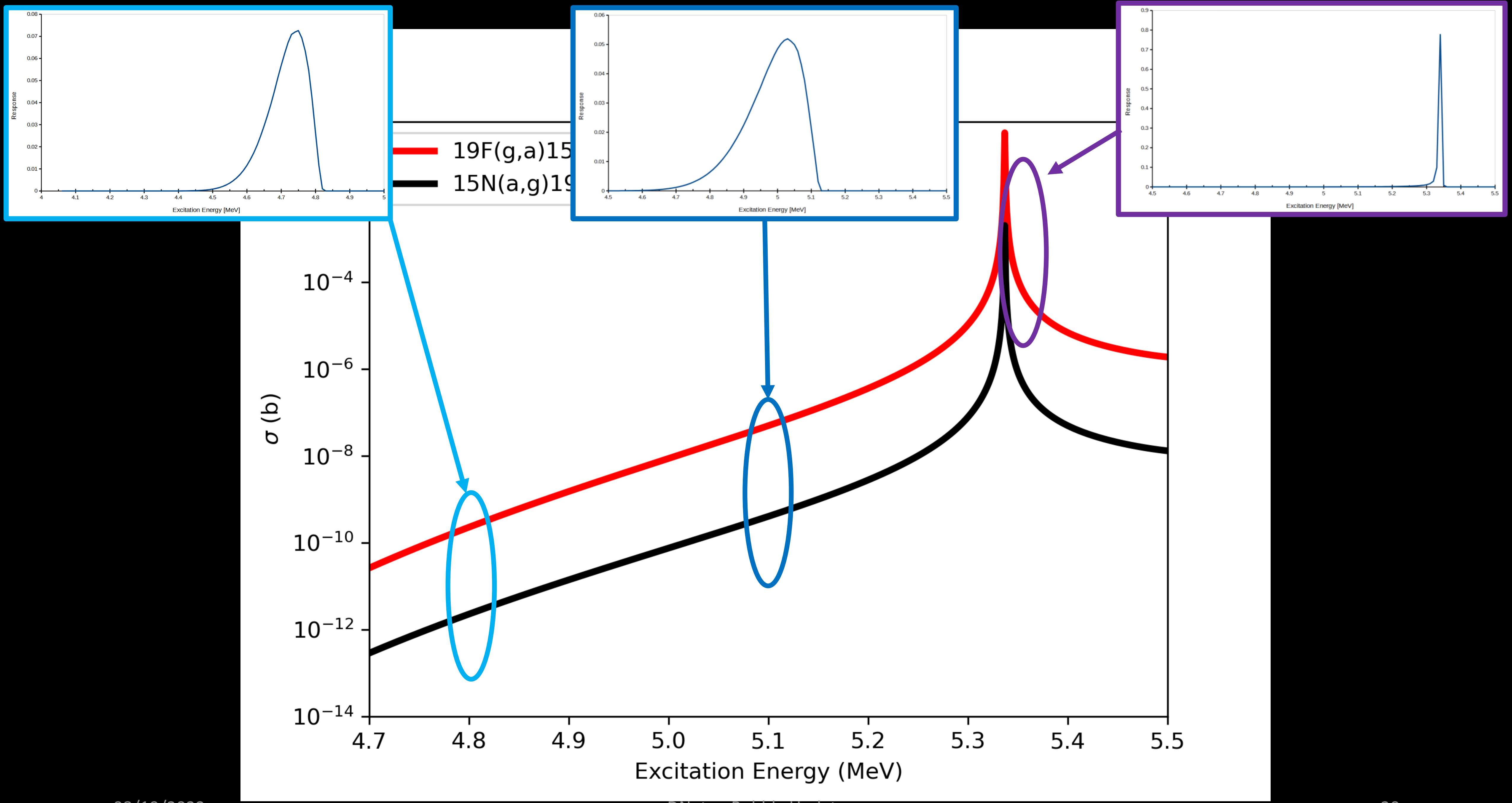


[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4.66	1296	1.56E-11	0.006727085864	1.9550546E-09	1.31518202E-11	0.016890071	1.28251E-10	0.034252373	0.47
4.67	1162	2E-11	0.006031538406	2.50648026E-09	1.51179319E-11	0.019415027	1.47562E-10	0.039410083	0.54
4.68	1113	2.55E-11	0.005777196425	3.19576233E-09	1.84625467E-11	0.023710309	1.68867E-10	0.04509991	0.62
4.69	1100	3.25E-11	0.00570971794	4.07303042E-09	2.32558549E-11	0.029866059	1.91692E-10	0.051195842	0.71
4.7	1053	4.11E-11	0.005465757264	5.15081693E-09	2.81531151E-11	0.036155308	2.13007E-10	0.056888483	0.78
4.71	964	5.18E-11	0.005003789176	6.49178387E-09	3.24835179E-11	0.041716577	2.32978E-10	0.062222413	0.86
4.72	932	6.5E-11	0.004837688291	8.14606084E-09	3.94081031E-11	0.050609395	2.51586E-10	0.067192073	0.93
4.73	920	8.13E-11	0.004775400459	1.01888422E-08	4.8655802E-11	0.062485643	2.65386E-10	0.070877586	0.98
4.74	782	1.01E-10	0.00405909039	1.26577253E-08	5.13788511E-11	0.065982687	2.69246E-10	0.071908635	0.99
4.75	760	1.26E-10	0.003944896031	1.57908256E-08	6.22931653E-11	0.079999268	2.71795E-10	0.072589329	Peak
4.76	656	1.56E-10	0.003405068153	1.9550546E-08	6.65709416E-11	0.085492952	2.59383E-10	0.069274462	0.95
4.77	563	1.92E-10	0.002922337455	2.40622105E-08	7.03178989E-11	0.090304938	2.37307E-10	0.063378586	0.87
4.78	505	2.36E-10	0.0026212796	2.9576467E-08	7.75281897E-11	0.099564669	2.05258E-10	0.054819002	0.76
4.79	402	2.89E-10	0.002086642374	3.62186397E-08	7.55753484E-11	0.097056756	1.56415E-10	0.041774271	0.58
4.8	277	3.54E-10	0.00143781079	4.43647006E-08	6.37880452E-11	0.08191905	9.90212E-11	0.026445966	0.36
4.81	142	4.31E-10	0.00073707268	5.40146496E-08	3.98127225E-11	0.051129022	4.28968E-11	0.011456618	0.16
4.82	11	5.24E-10	5.70971794E-05	6.56697828E-08	3.74955937E-12	0.004815328	3.74956E-12	0.001001409	0.01



19F(g,a)15
15N(a,g)19
σ (b)
Excitation Energy (MeV)
Response
Excitation Energy [MeV]

Cross Section

- Plot Wilmes data to g.s. from Thesis.
- Using new energy points and error bars.

- Need to double check conversion from uC to number of gammas (there maybe an error which is reducing our cross sections by ~40%)
- Issue with two highest measurements do to both being so close to resonance (there electron energies where only 50 keV apart).
- Wilmes data has issues (R Matrix calc will address this).